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Catch per unit effort (CPUE) analyses and characterisation of the South Island commercial freshwater eel fishery, 1990–91 to 2022–23

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PLAIN LANGUAGE SUMMARY

Presented in this report are standardised catch per unit effort (CPUE) analyses and fishery characterisation for the South Island commercial freshwater shortfin and longfin eel fisheries for the years 1991 to 2023. The fisheries within nine catchments or management areas that are commercially fished are described along with trends in abundance of both eel species, where sufficient data exist, over this 33 years period.

The main South Island longfin commercial fisheries are concentrated along rivers in Otago, Southland and Westland and the main shortfin fisheries are focussed on coastal lakes and river mouths such as Te Waihora (Lake Ellesmere) and Lake Brunner.

Before introduction into the Quota Management System in 2001, shortfin abundance indices showed clear declines for Otago (AV) and Southland (AW), but in Westland (AX) there was an overall increase in abundance. After 2001 there were slight increases in shortfin abundance in AV and AW and a clear increasing trend for AX. Te Waihora (AS1), after 2001, showed a steep increase in abundance before levelling off for a few years, followed by a fast and steep decline after which it was variable with no clear trend.

Shortfin stock status is as follows:
AV and AX - No target has been set for shortfin, but stock status is unlikely (<40%) to be below the soft limit.
AW - No target has been set for shortfin, but stock status is about as likely as not (40–60%) to be below the soft limit.
AS1 - Unlikely to be at or above the target B*msy* for shortfin, but unlikely (<40%) to be below the soft limit.

Longfin abundance showed clear declines before 2001 for AV and AW, but in AX it progressively increased over time. After 2001 abundance for AV and AW was generally stable but with increasing trends in recent years, whereas AX showed an overall trend of increasing abundance.

Longfin stock status is as follows:
AV and AX - No target has been set for longfin, but stock status is unlikely (<40%) to be below the soft limit.
AW - No target has been set for longfin, but stock status is very unlikely (<10%) to be below the soft limit

EXECUTIVE SUMMARY

Beentjes, M.P. (2025). Catch per unit effort (CPUE) analyses and characterisation of the South Island commercial freshwater eel fishery, 1990–91 to 2022–23.

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This report presents the results of a standardised catch per unit effort (CPUE) analysis and fishery characterisation for the South Island commercial freshwater eel fishery (*Anguilla australis*, shortfin; *A. dieffenbachii*, longfin) for the fishing years 1991 to 2023 (1990–91 to 2022–23), updating the previous analyses by four years. Fishery characterisations were carried out by species for each of nine South Island eel statistical areas (ESAs Nelson AN, Marlborough AP and south Marlborough AQ combined, north Canterbury AR, Te Waihora AS, south Canterbury AT, Waitaki AU, Otago AV, Southland AW, and Westland AX). Standardised CPUE analyses were carried out only for the four areas AV, AW, AX, and AS, as there was insufficient fishing activity and data from the remainder.

Total groomed estimated catch data from Catch Effort Landing Returns (CELR), Eel Catch Effort Returns (ECER), and the Electronic Reporting System (ERS) were used in the CPUE analyses. Estimated catch data from CELR data were excluded from the analysis if they contained errors that could not be resolved. After grooming, the estimated catch retained in the analyses was 93% of the total reported landed catch. The trends in estimated and landed eel catch were similar, indicating that estimated catch was likely to be proportional to total landed catch, and hence suitable for CPUE analysis.

Standardised and unstandardised CPUE analyses were carried out for the four data rich ESAs (AV, AW, AX, and AS) for the period before introduction of South Island eels into the Quota Management System (pre-QMS, 1991 to 2000), and after introduction to the QMS (post-QMS, 2001 to 2023). CPUE analyses were carried out on core fishers' estimated catch for individual species (longfin and shortfin) for each ESA, except AS1(Te Waihora – lake excluding concession area) which was restricted to shortfin. Standardised CPUE analyses used a Generalised Linear Model (GLM) fitted to non-zero catches, where the response variable was estimated daily catch weight. The four variables permit, target, lifts, and month were included in nearly all models, with month generally explaining the least variability. The variable target species accounted for differences in fishing gear and deployment when targeting one or the other species.

Shortfin standardised indices showed clear declines in pre-QMS CPUE for Otago and Southland, but in Westland there was an overall increase in CPUE. For post-QMS shortfin analyses there were slight trends of increasing CPUE in Otago and Southland and a clear increasing trend for Westland. Te Waihora post-QMS shortfin in AS1 showed a steep increase in CPUE before levelling off between 2011 and 2014, followed by a steep decline until 2016 after which it was variable with no clear trend. Shortfin stock status is as follows: AV and AX - No target has been set for shortfin, but stock status is unlikely (<40%) to be below the soft limit; AW - No target has been set for shortfin, but stock status is about as likely as not (40–60%) to be below the soft limit; AS1 - Unlikely to be at or above the target B*msy* for shortfin, but unlikely (<40%) to be below the soft limit.

For the data-rich areas longfin standardised indices showed clear declines in pre-QMS CPUE for Otago and Southland, but in Westland the CPUE increased over time. Post-QMS indices for Otago and Southland were generally stable with increasing trends in recent years, whereas Westland showed an overall trend of increasing CPUE. Longfin stock status is as follows: AV and AX - No target has been set for longfin, but stock status is unlikely (<40%) to be below the soft limit; AW - No target has been set for longfin, but stock status is very unlikely (<10%) to be below the soft limit.

1. INTRODUCTION

This report presents the results of catch per unit effort analyses (CPUE) for freshwater eels (*Anguilla australis* and *A. dieffenbachii*) for South Island eel statistical areas (ESAs; Table 1). The analyses cover the fishing years 1990–91 to 2022–23 (33 years), and update previous similar analyses (Beentjes & Bull 2002, Beentjes & Dunn 2003, 2008, 2013, 2015, Beentjes 2021).

The research presented in this report was undertaken under Fisheries New Zealand project EEL202302 which had the following contracted objectives:

1. To characterise South Island commercial eel fisheries.
2. To analyse CPUE trends in the South Island commercial eel fisheries (LFE and SFE 11, LFE and SFE 12, LFE and SFE 13, LFE and SFE 14, LFE and SFE 15, and LFE and SFE16) using data up to the end of the fishing year 2022–23.
3. To determine the proportion of longfin habitat fished commercially[1]

1.1 Commercial fishery

The commercial freshwater eel fishery in New Zealand developed in the late 1960s and landings consist of both the endemic longfin eel (*Anguilla dieffenbachii*) and the native shortfin eel (*A. australis*), which is also found in southeast Australia, Tasmania, New Caledonia, Lord Howe Island, and Norfolk Island (McDowall 2000). Catches from the north of the North Island can include the occasional Australian longfin eel (*A. reinhardtii*), which is primarily found on the east coast of Australia, but also in temperate Islands around the Southwestern Pacific.

Total New Zealand eel landings peaked in 1972 at about 2100 t and from 1972 to 1999 fluctuated with no clear trend (Figure 1) and the annual average was about 1300 t (Fisheries New Zealand 2024). After 1999, catches have progressively declined to a post-peak time series low of 214 t in the most recent fishing year (2022–23), for which there are complete catch data. Shortfin landings have been about double that of longfin for the last 30 years (Figure 1).

Prior to 2000 there was initially little difference between the reported longfin and shortfin catches in the South Island, but over the last 20 years, shortfin landings have exceeded those of longfin, comprising about two-thirds of the South Island landed eel catch (Figure 1). South Island catches of both species have gradually declined since the mid-1990s. Shortfin catch stabilised with the introduction of the Quota Management System (QMS) in the 2000–01 fishing year but has declined sharply in the last five years with the lowest landed catch on record in 2022–23 when only 3 t was landed (Figure 1). Longfin landings have fluctuated more than eight-fold over the last 10 years (before 2022–23) with the smallest catch of 5 t recorded in the most recent fishing year. The exceptionally low catches for both species in 2022–23 are an anomaly and largely due to the closure of the Mossburn Enterprises factory in Kennington, responsible for processing virtually all South Island longfin landed catch and a high proportion of shortfin catch, mostly outside of Te Waihora. This, coupled with the decision by Independent Fisheries Ltd to stop receiving eels from Te Waihora, resulted in a virtual cessation to the fishery for both species in 2022–23. South Island eel catches in 2023–24 were processed by SouthFish Ltd at an historical eel factory (Gould Aquafarms) close to Te Waihora using the stock and plant from Mossburn Enterprises. It is important to note that the reduction in catch of both species, but particularly longfin, was not necessarily related to a decline in abundance, but more to do with a contraction and reduction in effort, and factory closures.

Longfin are widespread throughout the South Island, but the largest catches are from Southland, South Otago, Northern Westland, and Marlborough (Wairau River catchment). The bulk of the South Island shortfin landings are from Te Waihora and Lake Brunner, but also from coastal lakes, lower river reaches, and estuaries (Beentjes & Chisnall 1997, 1998, Beentjes 1999, 2011, 2013, 2019, 2022).

[1] Objective 3 is reported in Beentjes & Shankar (in prep).

The trends of declining landings preceded the introduction of eels into the Quota Management System (QMS) in both the North Island (2005) and South Island (2001) and are, in part, a result of effort restrictions imposed on the fishery in the early 1990s.

Quota Management System (QMS)

The New Zealand eel fishery was introduced into the Quota Management System (QMS) in stages, beginning with the South Island on 1 October 2000, with six Quota Management Areas (QMAs, Figure 2) and Total Allowable Commercial Catches (TACCs) set for shortfin and longfin species combined (ANG 11–ANG 16). In 2017, shortfin and longfin in the South Island were split into separate stocks (SFE 11–SFE 16 and LFE 11–LFE 16). The shortfin total South Island TACC was set at 242 t and the longfin TACC at 81 t, representing a net 98 t (23%) reduction in the South Island total eel TACC (see Figure 1). Further, the longfin TACCs in LFE 11–LFE 14 were set at a nominal 1 t, which is only sufficient to allow for longfin bycatch in the shortfin target areas. This 1 t longfin TACC has effectively closed the longfin target fishery in the north and north-east of the South Island. At the same time (2017) the TACC in Te Waihora was increased from 122 to 134.2 t.

1.2 Catch Reporting

The introduction of the Catch Effort Landing Return (CELR) in October 1989 replaced the Fisheries Statistics Unit (FSU) eel returns. Data quality for the first two years of the CELR system was poor (Jellyman 1993, Beentjes & Willsman 2000), and the data from the 1990 fishing year were not suitable for inclusion in this analysis. The CELR form was replaced by an Eel Catch Effort Return (ECER) and an Eel Catch Landing Return (ECLR) on 1 October 2001. Changes to the new forms included dedicated fields for shortfin and longfin estimated catch, the removal of target species, and EEU (unidentified species) was removed as a valid species code. Before this last change, the proportion of total eel catch recorded as EEU ranged from about 0% (Te Waihora, ESA 21 and AS) to 83% (AD, Waikato), although the EEU code tended to be used more often in the North Island. The electronic reporting system (ERS) replaced the paper forms (ECER and ECLRs) beginning in mid-2019 but had fully transitioned by the 2019–20 fishing year. There are some variables recorded in the ERS that were not recorded in the ECER form, i.e., start lifting position, finish lifting position, soak time, fyke net baited, vessel use, net type specific to te Waihora (EFN) and target species; or in the ECLR form, i.e., catch (estimated weight and numbers) of eels over the maximum legal size of 4 kg (destination ‘G’). Conversely the ERS no longer records ‘catcher ID’ which provided the initials of the person fishing the permit in ECERs.

Eel Statistical Areas for reporting catch effort data were changed from numeric codes (1–23) to alpha codes (AA–AZ) in July 2000 (Table 1, Figure 3). The ESA boundaries were virtually unchanged except ESA 14 which was divided into Marlborough and South Marlborough (AP and AQ). In this report, ESAs are referred to by the current alpha codes, although some previous analyses used the numeric codes. Table 1 shows the relationship between ESAs (numeric and alpha), QMAs, and area names.

1.3 Fyke nets specification

In the South Island, shortfin fyke nets are usually unbaited and have very long leaders, whereas longfin nets are smaller overall, have short leaders, and are usually baited (Beentjes & Dunn 2015) (Figure 4). South Island shortfin fyke nets are commonly used in ponds, lagoons, and receding flood waters and capture few longfin, even if present. The long leader on shortfin nets tends to guide or direct eels into the net as they travel along riverbanks or out of flooded backwaters, i.e., there is often no attractant. Longfin fyke nets are commonly used in streams, rivers, and lakes and catch few shortfin, even if present. For detailed descriptions and specifications of South Island fyke nets see Beentjes & Dunn (2015).

In contrast, in the North Island the same type of fyke net is routinely used for both shortfin and longfin and these nets are baited, regardless of target species (Beentjes & McKenzie 2017). Bait is placed either at the leader or in the codend. A longer leader, however, may sometimes be used when targeting shortfin.

Nets are generally about 2.5 m in length, have two valves, and a D ring about 600 mm high and 600 mm wide. Smaller versions of these fyke nets are sometimes used in small creeks. For detailed descriptions and specifications of the North Island fyke net see Beentjes & McKenzie (2017).

2. METHODS

2.1 Catch and effort data extraction and grooming

In this report fishing years are referred to by the second year, e.g., 1990–91 is referred to as 1991.

In the freshwater eel fishery, the catch of each species is estimated by visual inspection of catches in the fyke nets or in holding bags; standard fish bins containing separated species are not used. Estimates of catch and effort for each day's fishing were recorded on CELR forms up to 30 September 2001, and then on ECERs after that date, although there was a transition period in early 2002 when either form was accepted. From 1 October 2019 paper forms were replaced with the electronic reporting system (ERS) using smartphone or tablet (Android or iOS) devices with the mobile logbook app installed. The most common platform for collecting commercial eel fishery data is *eCatch*. The eCatch app submits data to FishServe (the QMS data handling service) over cellular or wifi connections via eCatch Servers.

The catch and effort data used in this report were extracted from the Fisheries New Zealand Enterprise Data Warehouse (EDW) and for each daily record (=fishing event) from fishing years (1 October to 30 September) 1991 to 2023 for all South Island ESAs. The following variables were extracted.

CELR (1991 to 2002)
- Date nets were lifted
- Permit number (encrypted)
- Vessel registration number
- Location landed
- Method
- Form number
- Eel statistical area (ESA)
- Number of net lifts
- Nets in the water at midnight
- Target species
- Total weight (weight of shortfin, SFE; longfin, LFE; unidentified, EEU; and bycatch)
- Weight of individual species (includes SFE, LFE, EEU, and bycatch species)

ECER (2002 to 2019)
- Date nets were lifted
- Permit number (encrypted)
- Method
- Eel statistical area (ESA)
- Number of net lifts
- Estimated catch weight of shortfin (SFE)
- Estimated catch weight of longfin (LFE)
- Catcher ID

ERS (2020 to 2023)
- Start date- date at start of nets lifted
- Start time – time at start of first net lift
- Start position – latitude and longitude of first net lift
- Finish date- date at finish of nets lifted
- Finish time – time at finish of last net lift

- Finish position – latitude and longitude of last net lift
- Method (FN, EFN, EP, FP)
- Number of net lifts
- Estimated catch weight of shortfin (SFE)
- Estimated catch weight of longfin (LFE)
- Target species
- Soak time
- Fyke-net baited-yes or no
- Is vessel used – yes or no (ERS potting only)

Data were also extracted from CLRs (catch landing returns), ECLRs (eel catch landing returns) and the ERS disposal reports on landed catches by fishstock, and destination types. Of most interest were destination codes 'L' (landed to an LFR), 'X' (legal sized eels 220 to 4000 g returned to the water alive), and G (eels above the maximum size limit returned alive).

Analyses catch effort data set

In the current analyses, estimated catch and effort data were extracted from ECERs for the years 2002 to 2019 (18 years) and from the ERS for 2020 to 2023 (four years) for all South Island ESAs, groomed for errors or missing data, and appended to the existing groomed data sets from CELR data, creating a time series for each ESA from 1991 to 2023 (33 years) (Table 2). The CELR data were not re-extracted because considerable effort and resources were applied to the original manual error checking and grooming of these data (Beentjes & Willsman 2000, Beentjes & Bull 2002, Beentjes & Dunn 2003). The transition from CELR to ECER to ERS is considered to have had no effect on the continuity of the way in which estimated catches and effort data are recorded, because all three data collection types record estimated catch of shortfin and longfin eels, the number of nets set per day and the statistical area where eels were caught. The only real difference is that EEU (unclassified) which was an acceptable code recorded on CELRs, was not recorded on ECER forms or under the ERS, so all data can be used in the species-specific analyses. This is the first CPUE analyses for freshwater eels in New Zealand that includes ERS data.

Data grooming

There were no deletions of ECER or ERS catch effort records and all data were retained in the current characterisation analyses. If the variable 'number of net lifts' was missing, equal to zero, or unrealistically large (over 199 lifts), the median number of lifts from that fishing year was imputed for that record. Methods recorded as missing (N=269) or as EP (eel pot) (N= 41) were converted to FN (fyke net). The final groomed data set comprised 59 234 records from 1991 to 2023 and all South Island ESAs (AN, AP-AQ, AR, AS, AT, AU, AV, AW, AX; Figure 3).

Catcher ID

The encrypted permit number represents the Fisheries New Zealand *Permit Holder FIN Number* (CELR) and *Client Number of Permit Holder* (ECER and ERS). A permit holder is entitled to employ others to fish on their permit (=catcher), and hence one permit number may have catch landed from more than one fisher. It was more usual, however, for the permit holder to also be the person listed as the catcher on ECERs. The attribute 'catcher' was recorded on ECERs from 2002 to 2019 and was used in previous post-QMS CPUE analyses as a predictor variable. Catcher is not recorded in the ERS and could not be used in the current CPUE analyses.

Environmental variables

Mean daily river flow data for some key rivers from each ESA were obtained from regional councils and the NIWA hydrological database and were used as a predictor variable (NIWA Water Resources and Climate Archive) (Appendix 1). When river flow data from more than one river per ESA were used in standardised CPUE analyses, they were treated as separate variables. When river flow data were not recorded, the median value from the month was imputed for that record.

Moon phase was included as a possible explanatory term to account for changes in catchability with changes in the lunar cycle. The relative phase (0–1) of the moon (moon cycle) was determined for each record in the data set based on the date of each record, using an algorithm from Meeuse (1998).

For Te Waihora, the variables 'lake level' and 'lake opening status' (open or closed) were included in the standardised CPUE analyses (Appendix 1) as predictor variables.

The previous CPUE analyses included freshwater water quality data (water temperature, dissolved oxygen, water clarity, pH, dissolved nitrates, and dissolved phosphates), however these variables were not accepted by the GLM model as predictors in the key data rich areas and have not been included in the current analyses as predictor variables.

Reconstructed target species

Target species was recorded on CELR forms, removed from ECER forms, and then included in ERS effort reporting. To allow target species to be included in the GLM model as a predictor variable over all years, target species was reconstructed for all 59 234 records from CELR and ERS target species and species proportions using a simple optimisation to evaluate the best proportion to use (Cohen's kappa coefficient). The resulting level of concordance was a measure of how well the constructed target species matched that recorded on CELRs and ERS. Target species was reconstructed for all records, including those from CELR and ERS data. A 'common sense' default minimum value of 80% was used for the kappa coefficient for some cases because higher values tended to assign too many records to the category 'either', when kappa was above 80%.

2.2 Fishery characterisation analyses

The fishery in each ESA was characterised before the CPUE analyses from the continuous time series of raw data from 1991 to 2023. This included: outputs for each species (and sometimes total eels) on estimated catch by year, month, and ESA; target species records by year; median daily lifts per year; percent zero catch per year; geometric mean of positive catch per lift per year; and total lifts and catch per year when targeting that species.

ERS 2020 to 2023 position data that shows the start and finish location of the sets plotted on a South Island map at high resolution (0.04-degree squares) were presented to the Eel Working Group on 17th December 2024. However, Fisheries New Zealand Data Confidentiality rules only allow publication of these data in the following summarised form:

- *Latitudes and longitudes (maps or any other means of display) are truncated to a 1 degree level of resolution if they refer in any way to the magnitude of catches;*
- *Latitudes and longitudes (maps or any other means of display) are truncated to a 0.2 degree level of resolution if they do not refer in any way to the magnitude of catches;*
- *Information that identifies specific vessels or people is removed including any unique system identifiers of vessels or people (includes companies);*
- *Vessel attributes (e.g. length, breadth, tonnage, nationality etc.) are removed;*
- *Data is grouped such that no group contains data less than 3 vessels or 3 persons (includes companies).*

Plotting the catch location at the acceptable 0.2-degree level of resolution and restricting data to that representing 3 persons in each cell, results in little of the data being shown and is of no value in understanding the spatial nature of the eel fishery, hence these maps are not presented. The spatial distribution is, however, described in Beentjes & Shankar (2025).

2.3 CPUE analyses

2.3.1 Pre- and post-QMS data analyses

Analyses for shortfin and longfin were carried out separately, for the pre-QMS and post-QMS datasets, for four key areas with sufficient data and fishers (i.e., ESAs AX, AV, AW, and AS1). Although pre-QMS CPUE indices are unchanged from the previous analyses (see Beentjes 2021), they were rerun and presented for completeness for these four data rich areas. Analyses for Te Waihora were restricted to shortfin eels in AS1 (outside the concession area) from 2001 onwards when the codes AS1 and AS2 were introduced enabling reporting of catches from inside and outside the concession area (see Section 2.3.4). Characterisations were carried out and presented for these ESAs for all years (1991 to 2023).

For the remaining five areas (ESAs AN, AP-AQ, AR, AU, and AT) there were no CPUE analyses carried out as this has been done previously for pre-QMS datasets and is unchanged (see Beentjes 2021), and for post-QMS there were insufficient data to support meaningful analyses. Fishery characterisations, however, were carried out and presented for all years (1991 to 2023) for these data poor areas.

South Island CPUE analyses were carried out on the continuous time series up until 2006 (Beentjes & Dunn 2008) after which analyses were split into pre- and post-QMS (Beentjes & Dunn 2013). The rationale for this was that following the introduction of South Island eels into the QMS in 2001, there was generally a reduction in both numbers of fishers and catch. Further, it was suspected that some of the post-QMS new entrants had previously fished for existing permit holders under a fishing agreement and hence were not, strictly speaking, new entrants. It was not possible to link the identity of South Island fishers pre- and post-QMS because the ECER form, which includes a field identifying fishers that landed the catch, did not come into effect until mid-2002, more than a year after South Island eels were introduced into the QMS. This permit linking approach is used in the North Island CPUE analyses where eels were introduced into the QMS on 1 October 2004, three years after reporting by the ECER form came into effect (Beentjes & McKenzie 2017, Beentjes 2020).

2.3.2 Unstandardised CPUE analyses

Unstandardised CPUE analyses were carried out for each South Island data rich ESA for pre- and post-QMS shortfin and longfin eels (i.e., AS, AV, AW, and AX), and are presented as the geometric mean of positive catch/total lifts per year for core fishers. The core fisher unstandardised CPUE indices are plotted alongside the standardised CPUE indices.

2.3.3 Standardised CPUE analyses

Core fishers

For each ESA, standardised CPUE analyses were conducted separately for shortfin and longfin eels, except Te Waihora where sufficient data were available for shortfins only (see Section 2.3.4). A selection criterion was applied to each data set restricting data analysis to core fishers (identified by permit number). Shortfin core fishers were defined as those who recorded a total catch (all eels) of 1000 kg or more over all years and landed eel catch in at least three years. Longfin core fishers were defined in the same way, but by using only longfin catch data.

The GLM model (non-zero catch)

Estimates of year effects and associated standard errors were obtained using a forward stepwise Generalised Linear Model (GLM) (McCullagh & Nelder 1989), with the log of the daily-estimated-positive-catch of core fishers modelled as the response variable. Using daily estimated catch as the response variable and number of net lifts per day as a possible predictor allows the model to estimate non-linear relationships between catch and effort.

The GLM model used a normal error model and identity link function, and the response variable was the log-transformed positive daily estimated catch of core fishers. This implies a multiplicative model, i.e., the combined effect of two predictors is the product of their individual effects. The predictor variables offered to the model were fishing year, permit number, number of lifts, month (season), river flow (for selected rivers within each ESA analysis), lake level and lake open/closed status (Te Waihora only), target species (reconstructed), and moon phase. Variables were treated as categorical, except daily number of lifts (logged) and daily mean river flow (not logged), which were fitted as continuous 3rd-order polynomials.

A stepwise regression procedure was used to fit the GLM of daily estimated catch on these predictor variables. The relative year effect from the model was then interpreted as the CPUE index and presented using the canonical form, scaled to have a mean of 1.0. Model fits were investigated using standard residual diagnostics. Plots of model residuals and fitted values were investigated for evidence of departure from model assumptions. Influence step plots and coefficient-distribution-influence plots (CDI) were used to interpret the standardisation effects of explanatory variables (Bentley et al. 2012).

The stepwise fitting method began with a basic model in which year was the only predictor and iteratively included predictors until there was insufficient improvement in the model. For all analyses, the improvement in the residual deviance, i.e., (new deviance − old deviance) / (saturated deviance − null deviance) and termed R^2, was used as the criterion for including predictors. At each step, the predictor giving the greatest improvement in R^2 was included, providing that its inclusion resulted in an improvement in R^2 of at least 0.5%.

The inclusion of first-order interaction terms was considered, but it was found that they generally required many additional degrees of freedom and often appeared to have a spurious effect. Interactions tended to be between permit number (typically the most important predictor) and the other variables. These interactions appeared to reflect variability in predictor variables among fishers rather than relative changes in the CPUE index.

Zero catch records

Records with a catch of zero for either species occur in the following ways:

1. Fishers who record zero for one species are often fishing habitat preferred by the other, and, without including habitat or target species as explanatory variables, the models are unable to account for this behaviour. Habitat is not recorded on the catch and effort forms, but target species was reconstructed and included in the current analyses (see below). These are valid zeros.
2. Where catches comprise a mix of the two eel species, small proportions of one species are likely to be recorded as zeros because fishers tend to estimate catches based on a visual inspection of unsorted catches at the riverbank. The legitimacy of these recorded zeros cannot be verified, and not all are valid zeros.
3. There are many records before 2002 where eels were reported as EEU (unspecified species) and hence for these records shortfin and longfin catches are given a value of zero in the input data even though it is clearly not zero, but unknown. These are invalid zeros.

In a previous analyses of North Island CPUE up to 2015, valid zeros were investigated using a binomial model that estimated the probability of a non-zero catch, with a binomial response and logit link function (Beentjes & McKenzie 2017). The GLM and binomial models were then combined to give a combined CPUE index. These binomial CPUE analyses were rejected by the Eel Working Group on the basis that target species could not be included as a predictor variable without resulting in biased indices, because catch composition was used to determine target species. Binomial CPUE analyses were consequently not carried out for subsequent North Island and South Island CPUE analyses (Beentjes 2020, 2021), or in the current analyses.

2.3.4 Te Waihora analyses

The migration area (concession area) was introduced in 1996 in Te Waihora to allow fishers to legally harvest undersized migrating male shortfin eels during February and March each year (Figure 5).

However, catches for this area were not distinguished from those caught elsewhere in the lake until 1 October 2000 when specific area codes were introduced for the migration area (AS2) and the lake excluding the migration area (AS1). Consequently, CPUE analyses for Te Waihora were carried out from fishing year 2001 onward, and only for shortfin eels which make up more than 99% of the catch. Before then there was no accurate way to identify catches that were from AS1 or AS2. Analyses were carried out only for AS1 because of the seasonal nature of the AS2 fishery for which indices are unlikely to be reliable. 'Lifts' was included as a predictor variable, because, although the fishers progressively moved to using fewer larger shortfin fyke nets, the transition had largely been completed by 2001.

2.4 Reporting of destination 'X' (legal-sized eels released)

The weight of all eels of legal size (220–4000 g) caught and released by commercial fishers, was required to be reported as part of the total estimated catch recorded on ECERs, and then later recorded on ECLRs under the destination code 'X'. It was revealed at the Eel Working Group Meeting in April 2017 (EELWG 2017-06) that some fishers may have been incorrectly recording only their retained legal-sized eels on the ECERs. The confusion by eel fishers around this rule relates to the lack of destination code 'X' as a legitimate code on ECLRs until about 2008, when Fisheries New Zealand sent out an information pamphlet explaining how to correctly report eel catch on statutory forms. Destination 'X' released eels are also recorded in the ERS disposal report, again with the implicit assumption that the estimated catch on the water includes all legal sized eels, some of which may have been released and reported under destination 'X'. In the current analyses, catch recorded under destination 'X' was investigated and compared to the landed weight.

2.5 Reporting of destination 'G' (eels over 4kg released)

The estimated weight and number of eels over the legal maximum size of 4 kg, caught and released by commercial fishers, has only been recorded by Fisheries New Zealand since the introduction of the ERS in 2020, and is reported in the disposal report under destination code 'G'. In the current analyses, catch recorded under destination code 'G' was investigated and compared to the landed weight for longfin only, because eels of this size are invariably longfin, and female.

3. RESULTS

3.1 Descriptive analyses

3.1.1 Groomed data versus landed catch

A comparison of total groomed estimated catch for the South Island (extracted from CELRs, ECERs and the ERS) with the reported landed catch (Fisheries New Zealand 2024) is shown in Figure 6. The groomed total estimated eel catch, including unidentified (EEU), was considerably less than the landed catch before 2001, in some years by as much as 30%, after which estimated and landed catch were generally similar in trend and magnitude. This is because the quality of the earlier CELR data before 2001 was poor and between 6 and 11% of records were rejected resulting in a lower total estimated catch over this period than was actually caught and landed (Beentjes & Dunn 2003). Overall, total groomed estimated eel catch, used in the characterisation and CPUE analyses over the 33-year time series, was 93% of the total reported landed catch for the South Island. With the introduction of the ECER form in 2002, the quality of the eel fishery catch effort data improved significantly and deletions to the extracted catch effort data sets have been negligible. Despite the removal of data from the early years through grooming, the total eel estimated and landed catches have the same temporal trend (Figure 6), and support the use of estimated catch as the response variable in CPUE analyses.

When plotted by species, before 2002, the estimated catch as a proportion of the landed catch is less than for total catch because EEU is not included (Figure 6). Before 2002, however, the landed catch data by species is not of a high standard and is only estimated (prorated) because landed weights by species were not recorded at this time. For both shortfin and longfin, there is a good match from 2002 onward, particularly longfins.

3.1.2 Spatial and temporal distribution of species catch

The number of records and aggregate catch by species for each of the nine ESAs over the 33-year time series are shown in Table 2 and Figure 7. The proportions of estimated catch reported as SFE, LFE, or EEU in each ESA for all years combined are shown in Table 3. Overall, the total South Island catch from 1991 to 2023 was 42.4% longfin, 53.9% shortfin, and 3.8% EEU (Table 3). Northern South Island and Westland ESAs had relatively high proportions of annual catch recorded as EEU compared to the east coast and southern South Island where it was low to negligible, whereas in Te Waihora (ESA 21, AS) no catch was reported as EEU (Table 3, Figure 7). From 2001 onward, EEU was not recorded in any ESA with all catches reported by species (LFE or SFE); this pre-dates the introduction of the ECER by one year, after which EEU was no longer a valid code (Figure 8). Ignoring EEU, within each ESA shortfin were the dominant species in northern South Island ESAs (AP-AQ, AR, AT), and in Te Waihora (AS) virtually all the catch was shortfin (Table 3, Figure 7). In contrast, longfin dominated the species mix in Nelson (AN), Westland (AX), southern ESAs Waitaki and Otago (AU and AV), and particularly Southland (AW). Most of the shortfin catch (64%) was taken from Te Waihora (ESA AS), and most longfin catch from Southland (AW), Westland (AX), and Otago (AV) with contributions of 38.9%, 20.5%, and 17.9%, respectively (Table 3, Figure 7).

Declining trends in estimated catch before about 2000 are not a result of the deletions of problematic catch records from CELRs, and are clearly evident in landed catches as well (see Figure 6). There was a trend of declining estimated catch of all South Island eels from 1992 to about 2000, after which catch was comparatively stable followed by a steep decline from 2014 to 2023 (Figures 6 and 8). The estimated catch of shortfin declined slightly until about 2000 after which it was generally stable until 2017, followed by a steep decline with 2023 the lowest in the time series (Figures 6 and 8). Estimated longfin catch declined until 2009, followed by an increase, and then a steady decline with 2023 the lowest in the time series (Figures 6 and 8). Longfin catches are often related to fluctuating market demands (Beentjes 2019). Reasons for these trends in catches are discussed in Section 4.1.

3.2 Reporting released legal-sized eels (destination code 'X')

Any legal-sized eels caught and returned alive to the water must still be recorded by fishers on ECERs and ECLRs. Release of legal sized eels can occur when fishers have insufficient ACE (Annual Catch Entitlement) to cover the catch, or processors do not have markets for certain size categories. For example, if a fisher catches 100 kg of legal-sized eels (220–4000g) and chooses to release 10 kg to the water, the fisher must record 100 kg on the ECER (estimated catch), and then 100 kg on the ECLR, split between 90 kg under destination code 'L' (estimated catch landed), and 10 kg under 'destination code 'X' (estimated catch released), of which the latter does not count against the fisher's ACE. In this way, if the forms are correctly filled out by fishers, the sum of ECLR destination code 'L' and destination code 'X' should approximate the sum of ECER estimated catch, assuming catch estimates are accurate. For the ERS the same reporting protocols apply, with estimated catch reported on the catch report and the landed catch (L) and destination 'X' catch reported on the disposal report.

In the South Island, destination code 'X' was first used in 2008 for both shortfin and longfin (Figure 9). For shortfin its use has been erratic with the largest catches released and reported under destination code 'X', in 2009, 2011, and 2017, accounting for 15%, 16%, and 11% of the shortfin landed catch (destination L), respectively (Figure 10). Destination X' releases for shortfin were virtually all in Te Waihora (SFE13) (Figure 9). Longfin catches reported under destination 'X' were highest in 2017 and 2018, accounting for 23%, and 32% and of the longfin landed catch (destination L), respectively, and in 2023 when landed catch was the lowest, destination X accounted for 75% of landed catch (Figures 9 and 11). For Longfin, ‘Destination X’ releases were across all QMAs but most common in Te Waihora (LFE13) (Figure 9).

If legal-sized eels were returned alive and correctly recorded as destination code ‘X’ on ECLRs by all fishers, then the total estimated catch on ECERs should theoretically be greater than the landed catch on ECLRs, by the amount recorded under ‘Destination X’. This largely occurred for longfin where the difference was only 0.2 to 2 tonnes for the last 10 years when destination code ‘X’ was used the most, and within the bounds of errors likely from estimating the retained catch, and that released at the riverbank. For shortfin the difference was highly variable between years and difficult to interpret, but indicates that for the years when substantial amounts of catch were coded as ‘Destination ‘X’, the estimated catch of legal-sized eels did not include all eels that were released. Some of the problems interpreting shortfin data relate to the frequent mismatches between landed and estimated catches that were much larger than could be ascribed to destination code ‘X’ release and more to do with misreporting. There may also be some fishers who released legal-sized eels but failed to record these on either the ECER, or the ECLR as destination ‘X’. The net effect of not recording released legal sized eels is to bias CPUE down because the effort (number of nets) remains the same whereas the legal estimated catch is under-reported.

3.3 Reporting released over 4 kg eels (destination code ‘G’)

Any eels over the maximum legal size limit of 4 kg (all female longfin) are required to be released alive, and have been recorded in the ERS since 2020 under destination ‘G’ by total weight and number. Catches of these eels were mostly from LFE 15 (Otago/Southland) where over 2 tonnes of longfins were released in each of 2020 and 2021 (Figure 12). Destination ‘G’ releases represented about 5%, 6%, 3%, and 3% of the Southland Island longfin landed catch (destination L) from 2020 to 2023 respectively, (Figure 13), assuming that these were reported accurately by all fishers. Although requested, no data were provided by Fisheries New Zealand on the numbers of eels released and recorded under Destination ‘G’.

3.4 Form type, target species, baiting, vessel use, and soak time

Estimated catch was reported on CELRs from 1990 to 2001, ECERs from 2002 to 2019, and in the ERS after that (Figure 14).

For the eel fishery the ERS collects information on target species (SFE or LFE), baiting practice (yes or no), vessel use (yes or no), and soak time (hours), none of which were collected on ECERs.

Target species was recorded on CELRs, dropped from ECERs, and is now, once again, recorded in the ERS catch report (Figure 15). Although there was no target species recorded from 2002 to 2019 in ECERs, this is shown by default as EEU (unidentified) (Figure 15). In the CELRs, EEU was sometimes used in place of SFE or LFE.

Baiting of fyke nets was common when longfin eels were the target species (60 to 80% fishing events), and less common when targeting shortfin (5 to 35% of fishing events), although there is an increasing trend in the latter (Figure 16).

Vessel use was more common for shortfin targeted fishing (75 to 85% of fishing events) than longfin (10 to 40% of fishing events) (Figure 17). This reflects the need to target shortfin in Te Waihora and Lake Brunner using vessels, whereas it is often more practical and economical to fish from the riverbank for longfin.

Mean soak time was similar for both species with a wide range from about 30 to 50 hours (Figure 18). Soak time can depend on weather and river conditions which can impact the ability to return to pick up nets the next day as is the standard practice.

3.5 Fishery characterisation and CPUE analyses by ESA

The number of records (including those with zero catch) and estimated catch of shortfin, longfin, and unidentified eels are presented in Table 2. For the data-poor areas (ESAs AN, AP-AQ, AR, AT, and AU), the characterisation of the fishery was updated to 2023 (Appendices A to E). For the data-rich key areas (ESAs AX, AV, AW, and AS1 shortfin) the characterisation of the fishery was updated to 2023, followed by the CPUE analyses (pre- and post-QMS) and diagnostics for shortfin, and longfin, in that order (Appendices F to I).

In the fishery characterisations, before 2001 when EEU was used as a valid reporting species code, species specific catch data (SFE and LFE) may not be fully representative of the fisheries, i.e., for example, fishers using the species codes in favour of the generic EEU code may have targeted and landed more of one species than the other, biasing the catch data.

3.5.1 Nelson (ESA AN)

Fishery characteristics 1991–2023

Catch – Reported annual estimated eel catches in Nelson were variable with little or no catch in some years including the last four years (Figure A1). Combined catch of both species declined markedly in 1997 and catches have been variable but relatively low since that time. A high proportion of catch (46%) was reported as unidentified (EEU) before 2001, particularly before 1996 when it was about half, but the EEU code was not used after 2000 (Figure A1). Nelson contributed 1.2% of the total South Island shortfin catch and 3.9% of the longfin catch over the 33-year time series (Table 3). Longfin were the dominant species in the catch (LFE 49%, SFE 20%, EEU 31%), although in recent years shortfin have dominated (Table 3, Figure A1).

Season – The Nelson eel fishery for both species is seasonal, with few catches in the winter months June to August (Figures A2 and A3).

Target species – Longfin was the dominant target species (reconstructed) before 2004, after which it was more even before moving toward a mainly shortfin target fishery in recent years, to the extent that there was no targeting for longfin in 2019 (Figure A4).

Lifts – The median number of lifts per day was variable but overall shows a trend of increasing in the mid-1990s, declining in the mid-2000s, and then increasing again (Figure A5).

Zeros – There were very few zero records for total catch, which suggests that there were negligible trips where eels were not caught (Figure A6). The very high proportion of zeros for shortfin before 1996 indicates that it was seldom caught, consistent with targeting mainly longfin during this time. Similarly, the low proportion of zeros in the last few years also reflects a move toward targeting shortfin. Overall, however, there were no clear trends in the proportion of zeros for total catch, shortfin, and longfin.

Targeted catch versus lifts – The shortfin catch per year when targeting shortfin or either species, and the associated number of lifts per year, indicate that shortfin catch is strongly correlated with effort with the same peaks and troughs (Figure A7). The equivalent longfin plot also indicates that catch is strongly correlated with effort (Figure A8).

3.5.2 Marlborough (ESAs AP and AQ)

Fishery characteristics 1991–2023

Catch – Reported annual estimated eel catches were variable, but they declined sharply after 1999 with negligible or zero catch in four of the last eight years (Figure B1). Half the catch (50%) was reported as unidentified (EEU) before 2001, but EEU was not used after 2000 (Figure B1). Marlborough contributed 4% of the total South Island shortfin catch and 3% of the longfin catch over the 23-year time series (Table 3). Shortfin was the dominant species in the catch (SFE 41%, LFE 30%, EEU, 29%), although in some years the catch was a more even mix (Table 3, Figure B1).

Season – The Marlborough eel fishery for both species was seasonal, with few catches in the winter months June to August (Figures B2 and B3).

Target species – Target species was masked by the high reporting of EEU before 2001, but after this time target was roughly evenly divided between shortfin and longfin, and the high proportion of the target category 'either', supports this observation (Figure B4). Except for 2023, there has been no targeting for longfin in the last eight years.

Lifts – The median number of lifts per day was stable over the time series until 2018 at about 25 lifts per day, after which it dropped to about 5 lifts per day (Figure B5).

Zeros – There were no zero records for total catch, indicating that eels were caught on all trips (Figure B6). The variable proportions of zeros for both species tend to reflect the target behaviour. When one species was the dominant target species the proportion of zeros declined for that species, and vice versa. Notwithstanding the years with no catch, there were no trends in the proportion of zeros for total catch, shortfin, and longfin.

Targeted catch versus lifts – The shortfin catch per year when targeting shortfin or either species, and the associated number of lifts per year, indicate that shortfin catch is strongly correlated with effort with the same peaks and troughs (Figure B7). The equivalent longfin plot also indicates that catch is strongly correlated with effort (Figure B8).

3.5.3 North Canterbury (ESA AR)

Fishery characteristics 1991–2023

Catch – Reported annual estimated eel catches were variable, but declined sharply after 1995 until 2009, when the catch of each species was less than one tonne (Figure C1). Catches then progressively increased, peaking in 2013 before declining again, with negligible catch in all but one of the last eight years and there was no catch recorded in the last two years. A high proportion of catch (15%) was reported as unidentified (EEU) before 2001, but EEU was not used after 2000 (Figure C1). North Canterbury contributed 6% of the total South Island shortfin catch and 6% of the longfin catch over the 33-year time series (Table 3). In most years, shortfin was the dominant species in the catch (SFE 51%, LFE 38%, EEU 11%) (Table 3, Figure C1).

Season – The north Canterbury eel fishery for both species was seasonal, with few catches in the winter months June to August (Figures C2 and C3).

Target species – The main target species has alternated between shortfin and longfin until about 2009, and the high proportion of the target category 'either' supports this observation (Figure C4). Shortfin have been the main target species in the last 14 years, notwithstanding years with no catch.

Lifts – The median number of lifts per day has generally been declining over the time series from about 25 to 15 lifts per day (Figure C5).

Zeros – There were very few zero records for total catch, indicating that there were few trips where eels were not caught (Figure C6). The variable proportions of zeros for both species tend to reflect the target behaviour. When one species was the dominant target species the proportion of zeros declined for that species, and vice versa. There were no trends in the proportion of zeros for total catch, shortfin, and longfin.

Targeted catch versus lifts – The shortfin catch per year when targeting shortfin or either species, and the associated number of lifts per year, indicate that shortfin catch is strongly correlated with effort showing the same peaks and troughs (Figure C7). The equivalent longfin plot also indicates that catch is strongly correlated with effort (Figure C8).

3.5.4 South Canterbury (ESA AT)

Fishery characteristics 1991–2023

Catch – Reported annual estimated eel catches in south Canterbury were variable, but overall they declined steadily after 1996, with relatively little catch after 2014, and no catch in 2019 (Figure D1). Only 3% of the catch was reported as unidentified (EEU) before 2000, after which this code was not used (Figure D1). South Canterbury contributed 3.6% of the total South Island shortfin catch and 4.4% of the longfin catch over the 33-year time series (Table 3). The species mix was roughly even (SFE 49%, LFE 48%, EEU 3%) (Table 3, Figure D1)

Season – The south Canterbury eel fishery for both species is seasonal, with few catches from May to September (Figures D2 and D3).

Target species – Target species was roughly evenly divided between shortfin and longfin, and the high proportion of the target category 'either' before 2014 supports this observation (Figure D4).

Lifts – The median number of lifts per day, while variable up to 2001, generally declined from about 25 a day up to 2001 to about 15 a day after that time, with the lowest effort in the last two years (Figure D5).

Zeros – There were very few zero records for total catch, which suggests that there were negligible trips where eels were not caught and the proportion of zeros was similar for shortfin and longfin (Figure D6). The variable proportions of zeros for both species tend to reflect the target behaviour. When one species is the dominant target species the proportion of zeros declined for that species, and vice versa. There were no clear trends in the proportion of zeros for total catch, shortfin, and longfin.

Targeted catch versus lifts – The shortfin catch per year when targeting shortfin or either species, and the associated number of lifts per year, indicate that shortfin catch is strongly correlated with effort with the same peaks and troughs (Figure D7). The equivalent longfin plot also indicates that catch is strongly correlated with effort (Figure D8).

3.5.5 Waitaki (ESA AU)

Fishery characteristics 1991–2023

Catch – Reported annual estimated eel catches in Waitaki were highly variable, declining markedly after 2000 with the exception of 2012 to 2014 (Figure E1). There was no catch in 2010, 2020, 2021 and negligible catch in 2005. Only 4% of the catch was reported as unidentified (EEU) before 1998 after which this code was not used (Figure E1). Waitaki contributed 1.2% of the total South Island shortfin catch and 3.8% of the longfin catch over the 33-year time series (Table 3). Longfin was the dominant species in the catch over the 33-year time series (LFE 70%, SFE 29%, EEU 2%) (Table 3, Figure E1).

Season – The Waitaki eel fishery for both species was seasonal, with few catches in June to October (Figures E2 and E3).

Target species – Target species was dominated by longfin except in 2009 when only shortfin were caught, and in two of the last seven years when shortfin was targeted more (Figure E4).

Lifts – The median number of lifts per day was variable, but no trend was apparent over the time series, and averaged about 30 lifts per day (Figure E5) although effort was markedly lower in the last two years.

Zeros – There were very few zero records for total catch, which suggests that there were negligible trips where eels were not caught (Figure E6). The variable proportions of zeros for both species tend to reflect the fisher targeting behaviour. When one species was the dominant target species the proportion of zeros declined for that species, and vice versa. There were no trends in the proportion of zeros for total catch, shortfin, and longfin.

Targeted catch versus lifts – The shortfin catch per year when targeting shortfin or either species, and the associated number of lifts per year, indicate that shortfin catch is strongly correlated with effort with the same peaks and troughs (Figure E7). The equivalent longfin plot also indicates that catch is strongly correlated with effort (Figure E8).

3.5.6 Otago (ESA AV)

Fishery characteristics 1991–2023

Catch – Reported annual eel estimated catches in Otago were variable and dropped off markedly after 1996 from about 70 t to 30 t and continued to decline over the time series with the lowest catches in the last two years of less than 5 tonnes (Figure F1). The decline is most marked for longfin. Only 1.4% of the catch was reported as unidentified (EEU) before 2000 and EEU was not used after 1999 (Figure F1). Otago contributed 5.4% of the total South Island shortfin catch and 17.9% of the longfin catch over the 33-year time series (Table 3). Longfin was the dominant species in the catch (LFE 72%, SFE 28%, EEU 0.7), although in two of the last eight years more shortfin than longfin was caught (Table 3, Figure F1).

Season – The Otago eel fishery for both species was seasonal, with few catches in the winter months June to August, and the months either side of winter (May and September) (Figures F2 and F3).

Target species – Longfin was clearly the dominant target species every year except in 2009, 2016, and 2019 (Figure F4). The relatively high proportion of target category 'either' indicated that many catches were not dominated by either species.

Lifts – The median number of lifts per day was stable over the time series at about 30 lifts per day (Figure F5), although effort was markedly lower in the last two years.

Targeted catch versus lifts – The shortfin catch per year when targeting shortfin or either species, and the associated number of lifts per year, indicate that shortfin catch is strongly correlated with effort with the same peaks and troughs (Figure F6). The equivalent longfin plot also indicates that catch is strongly correlated with effort (Figure F7).

Zeros – There were few zero records for total catch, indicating that eels were caught on nearly all fishing events (Figure F8). The proportion of records with zero longfin catch increased, whereas that for shortfin was stable. For both species, this is a reflection of the targeting behaviour. With the move to increased targeting of shortfin relative to longfin, the proportion of zeros increased for longfin.

Otago (AV) shortfin pre-QMS CPUE indices (1991–2000)

Unstandardised catch rates – The geometric mean of catch per lift from the pre-QMS shortfin raw data overall shows no trend before 2001 (Figure F9).

Core fishers – The relative shortfin catch by all fishers and those that qualified as core fishers is shown in Figure F10. The shortfin core data selection used in the CPUE analyses retained 98% of the catch (129 t) and seventeen of the twenty-two original fishers.

Standardised CPUE – The standardised CPUE index for Otago pre-QMS shortfin differed from that of the unstandardised catch rates (core fisher data) (Figure F11) with a decline until 1999, before increasing in 2000. The variables permit, target, lifts, and month were included in the model and explained 61% of the variation in CPUE (Appendix 2). The shortfin core fisher catch ranged from about 7 to 18 tonnes per year and does not follow the same trend as the CPUE indices (Figure F11). Standardised indices and 95% confidence intervals are tabulated in Appendix 3.

The model residual diagnostics were "acceptable" with no severe violations of normality assumptions (Figure F12). Model step-plots showed "permit" had the strongest standardisation effect on the index (Figure F13). Addition of the term "target" results in only a minimal standardisation shift in the index (Figure F13). CDI plots for each of the model predictor variables are shown in Figures F14–F17.

Otago (AV) shortfin post-QMS CPUE indices (2001–2023)

Unstandardised catch rates – The geometric mean of catch per lift from the shortfin post-QMS raw data after 2001 overall shows a steady increase and this is steep after 2014 till 2019 (Figure F9). The shortfin catch in the last two years is negligible and is unlikely to be indicative of abundance in AV.

Core fishers – The relative shortfin catch by all fishers and those that qualified as core fishers is shown in Figure F18. The shortfin core data selection used in the CPUE analyses retained 77% of the catch (97 t) and eight of the thirty-two original fishers.

Standardised CPUE – The standardised CPUE for Otago post-QMS shortfin was variable with peaks and troughs, but the indices were consistently higher in the most recent years, disregarding the last two years when catch was negligible and the indices are unlikely to be indicative of abundance in AV (Figure F19). The core fishers unstandardised index and catch tend to broadly mirror the standardised indices. The variables permit, target, lifts, and month were included in the model and explained 74% of the variation in CPUE (Appendix 2). Standardised indices and 95% confidence intervals are tabulated in Appendix 3.

The model residual diagnostics were "acceptable" with no severe violations of normality assumptions (Figure F20). Model step-plots showed "permit" had the strongest standardisation effect on the index (Figure F21). Addition of the -term "target" results in only a minimal standardisation shift in the index (Figure F21). CDI plots for each of the model predictor variables are shown in Figures F22–F25.

Otago (AV) longfin pre-QMS CPUE indices (1991–2000)

Unstandardised catch rates – The geometric mean of catch per lift from the longfin pre-QMS raw data up to 2000 shows no trend (Figure F9).

Core fishers – The relative longfin catch by all fishers and those that qualified as core fishers is shown in Figure F26. The longfin core data selection used in the CPUE analyses retained 99% of the catch (420 t) and nineteen of twenty-six original fishers.

Standardised CPUE – Standardised and unstandardised CPUE for Otago pre-QMS longfin core fishers both showed declines until 1996 after which indices were stable (Figure F27). Catch from core fishers followed a broadly similar trend. The variables permit, lifts, target, and month were included in the model and explained 61% of the variation in CPUE (Appendix 2). Standardised indices and 95% confidence intervals are tabulated in Appendix 3.

The model residual diagnostics were "acceptable" with no severe violations of normality assumptions (Figure F28). Model step-plots showed "permit" had the strongest standardisation effect on the index (Figure F29). Addition of the effort-term "lifts" resulted in only a minimal standardisation shift in the index (Figure F29). CDI plots for each of the model predictor variables are shown in Figures F30–F33.

Otago (AV) longfin post-QMS CPUE indices (2001–2023)

Unstandardised catch rates – The geometric mean of catch per lift from the longfin post-QMS raw data after 2000 shows a slight increasing trend over time (Figure F9).

Core fishers – The relative longfin catch by all fishers and those that qualified as core fishers is shown in Figure F34. The longfin core data selection used in the CPUE analyses retained 87% of the catch (260 t) and 13 of forty-three original fishers.

Standardised CPUE – The standardised CPUE for Otago post-QMS longfin was stable until 2015 after which it steadily increased (Figure F35). The unstandardised index for core fishers tends to mirror the standardised indices. The longfin catch by core fishers ranged from about 1 to 29 tonnes per year and does not follow the same trend as the CPUE indices. The variables target, lifts, permit, and month were included in the model and explained 67% of the variation in CPUE (Appendix 2). Standardised indices and 95% confidence intervals are tabulated in Appendix 3.

The model residual diagnostics were “acceptable” with no severe violations of normality assumptions (Figure F36). Model step-plots showed that the addition of log-lifts had a marked standardisation effect on the index (Figure F37). CDI plots for each of the model predictor variables are shown in Figures F38–F41. The model predicted standardisation influence between log-lifts showing a non-linear influence on log-catch (Figure F39).

3.5.7 Southland (ESA AW)

Fishery characteristics 1991–2023

Catch – Reported annual eel estimated catches were 90–120 t per year until 1995 after which they declined and were then stable at about 40–60 t with a sharp increase between 2009 and 2013, followed by a steady decline, with only a few tonnes caught in 2023 (Figure G1). The declines are most marked for longfin. Only 0.5% of the catch was reported as unidentified (EEU) before 2001, but EEU was not used after 2000 (Figure G1). Southland contributed 7% of the total South Island shortfin catch and 39% of the longfin catch over the 33-year time series (Table 3). Longfin was the dominant species in the catch in all years (LFE 81.2%, SFE 18.6%, EEU 0.2) (Table 3, Figure G1).

Season – The Southland eel fishery for both species was seasonal, with few catches in late autumn to early spring (May to September) (Figures G2 and G3).

Target species – Longfin was the clearly dominant target species every year (Figure G4).

Lifts – The median number of lifts per day was stable at about 30 lifts per day, declining slightly after 2016 to around 20 lifts per day (Figure G5).

Targeted catch versus lifts – The shortfin catch per year when targeting shortfin or either species, and the associated number of lifts per year, indicate that shortfin catch is strongly correlated with effort with the same peaks and troughs (Figure G6). The equivalent longfin plot also indicates that catch is strongly correlated with effort (Figure G7).

Zeros – There were few zero records for total catch, indicating that eels were caught on nearly all fishing events (Figure G8). There were no trends in the proportion of records with zero catch for either species.

Southland (AW) shortfin pre-QMS CPUE indices (1991–2000)

Unstandardised catch rates – The geometric mean of catch per lift from the shortfin pre-QMS raw data overall shows a clear declining trend before 2001 (Figure G9).

Core fishers – The relative shortfin catch by all fishers and those that qualified as core fishers is shown in Figure G10. The shortfin core data selection used in the CPUE analyses retained 93% of the catch (136 t) and twelve of the twenty-five original fishers.

Standardised CPUE – The standardised CPUE index for Southland pre-QMS shortfin differed from the unstandardised catch rates (core fisher data) (Figure G11), with a decline until 1997, before increasing. The variables permit, lifts, target, and month were included in the model and explained 75% of the variation in CPUE (Appendix 2). The shortfin core fisher catch ranged from about 4 to 27 tonnes per year and does not follow the same trend as the CPUE indices (Figure G11). Standardised indices and 95% confidence intervals are tabulated in Appendix 3.

The model residual diagnostics were “acceptable” with no severe violations of normality assumptions (Figure G12). Model step-plots showed that ‘permit’ had strongest standardisation effect on the index, followed by the addition of lifts (Figure G13). CDI plots for each of the model predictor variables are shown in Figures G14–G17.

Southland (AW) shortfin post-QMS CPUE indices (2001–2023)

Unstandardised catch rates – The geometric mean of catch per lift from the shortfin post-QMS raw data overall shows a clear increasing trend, excluding 2023 when catch was negligible (Figure G9).

Core fishers – The relative shortfin catch by all fishers and those that qualified as core fishers is shown in Figure G18. The shortfin core data selection used in the CPUE analyses retained 95% of the catch (158 t) and 17 of the 36 original fishers.

Standardised CPUE – The standardised CPUE for Southland post-QMS shortfin was variable but showed an overall slight trend of increasing CPUE until 2020 before declining, although the last three years had little catch (0.4–4 t) and are therefore unlikely to be indicative of abundance (Figure G19). The standardised CPUE was mirrored by the unstandardised catch rates (core fisher data). The variables target, lifts, permit, and month were included in the model and explained 66% of the variation in CPUE (Appendix 2). The shortfin core fisher catch ranged from about 4 to 15 tonnes per year and generally follows the same trend as the CPUE indices, but more variable (Figure G19). Standardised indices and 95% confidence intervals are tabulated in Appendix 3.

The model residual diagnostics were "acceptable" with no severe violations of normality assumptions (Figure G20). Model step-plots showed that the addition of target and lifts had a marked standardisation effect on the index reducing some of fluctuation evident in the standardised index (Figure G21). CDI plots for each of the model predictor variables are shown in Figures G22–G25.

Southland (AW) longfin pre-QMS CPUE indices (1991–2000)

Unstandardised catch rates – The geometric mean of catch per lift from the longfin pre-QMS raw data overall shows no trend before 2001 (Figure G9).

Core fishers – The relative longfin catch by all fishers and those that qualified as core fishers is shown in Figure G26. The longfin core data selection used in the CPUE analyses retained 97% of the catch (630 t) and sixteen of the twenty-eight original fishers.

Standardised CPUE – The standardised CPUE index for Southland pre-QMS longfin was similar to the unstandardised catch rates (core fisher data), with a clear decline until 1999, before increasing (Figure G27). The variables permit, lifts, month, and target were included in the model and explained 50% of the variation in CPUE (Appendix 2). The longfin core fisher catch ranged from about 40 to 90 tonnes per year and followed the same trend as the CPUE indices (Figure G27). Standardised indices and 95% confidence intervals are tabulated in Appendix 3.

The model residual diagnostics were "acceptable" with no severe violations of normality assumptions (Figure G28). Model step-plots showed that the addition of permit and lifts had the most effect on the standardisation of the index (Figure G29). CDI plots for each of the model predictor variables are shown in Figures G30–G34.

Southland (AW) longfin post-QMS CPUE indices (2001–2023)

Unstandardised catch rates – The geometric mean of catch per lift from the longfin post-QMS raw data overall shows no clear trend until after 2018 when catch per lift increased, although the catch in 2023 was negligible (2 t) and this year is not likely to be indicative of abundance (Figure G9).

Core fishers – The relative longfin catch by all fishers and those that qualified as core fishers is shown in Figure G34. The longfin core data selection used in the CPUE analyses retained 95% of the catch (885 t) and 21 of the 39 original fishers.

Standardised CPUE – The standardised CPUE for Southland post-QMS longfin, shows no consistent trend until a steep increase after 2018, although the catch in 2023 was negligible (2 t) and this year is not likely to be indicative of abundance (Figure G35). The standardised CPUE is mirrored closely by the unstandardised catch rates (core fisher data) (Figure G35). The variables lifts, target, permit, and month were included in the model and explained 65% of the variation in CPUE (Appendix 2). The longfin core fisher catch ranged from about 16 to 70 tonnes per year (excluding 2023) and generally follows the same trend as the CPUE indices until about 2011 when catch rose steeply for two years then declined (Figure G35). Standardised indices and 95% confidence intervals are tabulated in Appendix 3.

The model residual diagnostics were "acceptable" with no severe violations of normality assumptions (Figure G36). Model step-plots showed that the addition of lifts had a marked standardisation effect on the index reducing some of fluctuation evident in the standardised index (Figure G37). CDI plots for each of the model predictor variables are shown in Figures G38–G41.

3.5.8 Westland (ESA AX)

Fishery characteristics 1991–2023

Catch – Reported annual estimated longfin catches in Westland were variable but show a steady decline over the entire time series from 50 to 70 t in the early 1990s, to lowest catches in the last six years (8 to 18 t), with no catch in 2023 (Figure H1). Shortfin estimated catches were variable without trend, averaging about 10 t (Figure H1). Only 7% of the catch was reported as unidentified (EEU) before 2001, but EEU was not used after 2000 (Figure H1). Westland contributed 8% of the total South Island shortfin catch and 20% of the longfin catch over the 33-year time series (Table 3). Longfin was the dominant species in the catch (LFE 64.6%, SFE 31.9%, EEU 3.4%), over the time series although from 2009 catches have been more balanced, reflecting the decline in longfin catch (Table 3, Figure H1).

Season – The Westland eel fishery for both species was seasonal, with few catches in the winter months of June to August (Figures H2 and H3).

Target species – Longfin was the dominant target species, although in the last ten years the proportion of fishing records with shortfin as the target increased to the extent that in 2017, 2020 and 2022 there was more targeting of shortfin than longfin (Figure H4).

Lifts – The median number of lifts per day was stable at about 20 lifts per day, declining in the last few years (Figure H5).

Targeted catch versus lifts – The shortfin catch per year when targeting shortfin or either species, and the associated number of lifts per year, indicate that shortfin catch is strongly correlated with effort with the same peaks and troughs (Figure H6). The equivalent longfin plot also indicates that catch is strongly correlated with effort (Figure H7).

Zeros – There were few zero records for total catch, indicating that eels were caught on nearly all fishing events (Figure H8). The proportion of records with zero longfin catch increased over time, whereas for shortfin it decreased. For both species, this reflected the target behaviour, i.e., the move to increased targeting of shortfin relative to longfin.

Westland (AX) shortfin pre-QMS CPUE indices (1991–2000)

Unstandardised catch rates – The geometric mean of catch per lift from the shortfin pre-QMS raw data is variable and overall shows no trend (Figure H9).

Core fishers – The relative shortfin catch by all fishers and those that qualified as core fishers is shown in Figure H10. The shortfin core data selection used in the CPUE analyses retained 96% of the catch (119 t) and six of the fifteen original fishers.

Standardised CPUE – The standardised CPUE for Westland pre-QMS shortfin was generally flat until 1997 after which it rose sharply and differed from the unstandardised catch rates (core fisher data) (Figure H11). The variables permit, target, lifts, and month were included in the model and explained 77% of the variation in CPUE (Appendix 2). The shortfin core fisher catch ranged from about 3 to 22 tonnes per year and does not follow the same trend as the CPUE indices (Figure H11). Standardised indices and 95% confidence intervals are tabulated in Appendix 3.

The model residual diagnostics were "acceptable" with no severe violations of normality assumptions (Figure H12). Model step-plots showed that "permit" had the strongest standardisation effect on the index (Figure H13). Addition of target results in only a minimal standardisation shift in the index (Figure H13). CDI plots for each of the model predictor variables are shown in Figures H14–H17.

Westland (AX) shortfin post-QMS CPUE indices (2001–2023)

Unstandardised catch rates – The geometric mean of catch per lift from the shortfin post-QMS raw data is variable but shows an overall increasing trend (Figure H9).

Core fishers – The relative shortfin catch by all fishers and those that qualified as core fishers is shown in Figure H18. The shortfin core data selection used in the CPUE analyses retained 95% of the catch (250 t) and eight of the 21 original fishers.

Standardised CPUE – The standardised CPUE for Westland post-QMS shortfin showed an overall trend of increasing CPUE until 2010 after which it was flat followed by a marked increase in 2019 before declining again; overall the time series trend is that CPUE has been increasing from 2001 to 2022, with no catch in 2023. (Figure H19). The unstandardised catch rates (core fisher data) showed a similar but more variable pattern. The variables permit, target, lifts, and Grey River flow were included in the model and explained 70% of the variation in CPUE (Appendix 2). The shortfin core fisher catch ranged from about 4 to 30 tonnes per year and does not follow the same trend as the CPUE indices (Figure H19). Standardised indices and 95% confidence intervals are tabulated in Appendix 3.

The model residual diagnostics were "acceptable" with no severe violations of normality assumptions (Figure H20). Model step-plots showed permit had the strongest standardisation effect on the index (Figure H21). Addition of the effort-term lifts results in only a minimal standardisation shift in the index (Figure H21). CDI plots for each of the model predictor variables are shown in Figures H22–H25.

Westland (AX) longfin pre-QMS CPUE indices (1991–2000)

Unstandardised catch rates – The geometric mean of catch per lift from the longfin pre-QMS raw data is variable and overall shows no trend (Figure H9).

Core fishers – The relative longfin catch by all fishers and those that qualified as core fishers is shown in Figure H26. The longfin core data selection used in the CPUE analyses retained 94% of the catch (409 t) and eleven of the sixteen original fishers.

Standardised CPUE – Standardised CPUE and Westland unstandardised catch rates (core fisher data) for pre-QMS longfin showed no clear trends although the last index (2000) was the highest in the time series (Figure H27). Catch from core fishers, in contrast, showed a declining trend from about 50 t to 25 t per year. The variables permit, lifts, target, and month were included in the model and explained 64% of the variation in CPUE (Appendix 2). Standardised indices and 95% confidence intervals are tabulated in Appendix 3.

The model residual diagnostics were "acceptable" with no severe violations of normality assumptions (Figure H28). Model step-plots showed that permit had the strongest standardisation effect on the index (Figure H29). Addition of the effort-term lifts results in only a minimal standardisation shift in the index (Figure H29). CDI plots for each of the model predictor variables are shown in Figures H30–H33.

Westland longfin post-QMS CPUE indices (2001–2023)

Unstandardised catch rates – The geometric mean of catch per lift from the longfin post-QMS raw data was variable, but overall was increasing, excluding 2022 where negligible catch was taken (Figure H9).

Core fishers – The relative longfin catch by all fishers and those that qualified as core fishers is shown in Figure H34. The longfin core data selection used in the CPUE analyses retained 89% of the catch (356 t) and ten of the 27 original fishers.

Standardised CPUE – The standardised CPUE for Westland post-QMS longfin showed an overall trend of increasing CPUE over the time series, notwithstanding the last two years 2022 and 2023 when negligible and zero catches were taken, respectively (Figure H35). The unstandardised catch rates (core fishers) tend to follow the same pattern from 2007 onward. The catch from core fishers shows a general decline over time from 30 to 0.7 t per year. The variables permit, lifts, and target were included in the model and explained 68% of the variation in CPUE (Appendix 2). Standardised indices and 95% confidence intervals are tabulated in Appendix 3.

The model residual diagnostics were "acceptable" with no severe violations of normality assumptions (Figure H36). Model step-plots showed that permit had the strongest standardisation effect on the index (Figure H37). Addition of the effort-term lifts results in only a minimal standardisation shift in the index (Figure H37). CDI plots for each of the model predictor variables are shown in Figures H38– H40.

3.5.9 Te Waihora

ESAs 21, AS1, and AS2 fishery characteristics (1991–2023)

ESA 21 included the entire lake before codes AS1 and AS2 were introduced in 2001. Thereafter, AS1 includes the fishery within the entire lake outside the shortfin male migration concession area, and AS2 the portion of the lake inside the migration area which operates only for the months of February and March (see Figure 5). Te Waihora is essentially a shortfin fishery and longfin are often voluntarily released by fishers. In the 33-year time series, shortfin was by far the dominant species in the catch (SFE 98.2%, LFE 1.8%) (Table 3, Figure I1). No catch in Te Waihora was reported as unidentified (EEU). Catches were especially low in 1994, the year a minimum legal size (MLS) of 140 g was introduced, increasing by 10 g per year until 2002 when it reached the national MLS of 220 g (Figure I2). Reported estimated annual eel catches for the combined AS1 and AS2 were variable with two-fold differences between some years but no overall trend until the last three years when catches steadily declined with only 24 t caught in 2023, compared to the average about 108 t before this period (Figure I2). The TACC and ACE can be taken from either AS1 or AS2, and before 2019, on average about two-thirds of the catch was provided by AS1 and one-third by AS2 (AS1 65.0%, AS2 35.0%), after which there was negligible or no catch from AS2. Te Waihora has contributed nearly two-thirds of the South Island shortfin catch over the 22-year time-series (Table 3).

Season – The Te Waihora shortfin fishery was seasonal, with few catches in late autumn to early spring (April to September) (Figure I3). The AS2 part of this catch was mostly taken in February-March.

Target species – Shortfin is the dominant target species in all years and virtually all catches (Figure I4).

Lifts – The median number of lifts per day steadily declined, initially as fishers changed to using larger but fewer nets. More recently, as catch rates increased, even fewer of the large nets were used. Over the entire 33-year time series the median number of nets declined from about 40 to only a few lifts per day from 2010 to 2013, before increasing again to eight nets in 2019 onward (Figure I5). The change to large nets occurred before 2001 when the AS1 CPUE time series began.

Te Waihora AS1 fishery characteristics (2001–2023)

AS1 includes the Te Waihora fishery outside the migration area (AS2), which was established in 1996, but separate reporting codes were not introduced until 2001 and hence the beginning of the time series is taken from 2001 when catch location could be positively identified. This also coincides with the year that South Island eels, including Te Waihora, were introduced into the QMS.

Catch – Reported annual eel catches in ESA AS1 averaged 70.5 t per year, ranging from 24 to 135 t with no trend until the last three years when catches steadily declined with only 24 t caught in 2023

(Figure I6). In all 23 years of the time series, shortfin was the dominant species in the catch (SFE 97.2%, LFE 2.8%) with no trend in species proportions.

Season – The AS1 shortfin fishery was seasonal, with few catches in late autumn to early spring (April to September) (Figure I7).

Target species – Shortfin was the only target species in all years (Figure I8).

Lifts – The median number of lifts per day in AS1 declined from about 20 in 2001 to a few in 2013 and 2014 before increasing again with a median of about eight lifts from 2019 onward. The decline was not due to a change in net type but the deployment of fewer nets to ensure that daily catches were manageable (Figure I9).

Targeted catch versus lifts – The shortfin catch per year when targeting shortfin or either species, and the associated number of lifts per year, indicate that shortfin catch is weakly correlated with effort (Figure I9). Catch remained reasonably stable despite a large reduction in effort from 2001 to 2003.

Zeros – There were very few zero records for total catch or shortfin in AS1, which suggests that there were few trips where eels, including shortfin, were not caught (Figure I11). There were substantially more catches that had little or no reported longfin in the catch, but this has been declining over time. Although legal-sized longfin are generally voluntarily released by fishers, they are still required to be recorded on ECERs and recorded against destination code 'X' on ECLRs if they are not landed.

Unstandardised catch rates – The geometric mean of catch per lift from the AS1 shortfin raw data shows an initial strong increasing trend, levelling off from 2010 to 2014, before steeply declining until 2016 after which it is flat before declining again in 2020 and then increasing in 2022 (Figure I12). Overall, the mean shortfin catch rate ranged from about 5 to 150 kg per lift.

Te Waihora AS1 shortfin post-QMS CPUE indices (2001–2023)

Core fishers – The relative shortfin AS1 catch by all fishers and those that qualified as core fishers is shown in Figure I13. The shortfin core data selection used in the CPUE analyses retained 96% of the catch (1561 t) and eight of the thirteen original fishers (Figure I13).

Standardised CPUE – The standardised CPUE for Te Waihora post-QMS shortfin in AS1, with the exception of the slight drop in 2010, showed a steady and progressive increase in CPUE until 2014 followed by a steep decline until 2016 after which it varied without a trend (Figure I14). The index was closely mirrored by the unstandardised catch rates for core fishers (Figure I14). Catch, however, shows no relationship to either of these indices and ranged from about 25 to 130 t per year. The variables lifts, month, and permit were included in the model and explained 51% of the variation in CPUE (Appendix 2). Target species was not included as a predictor variable because shortfin was always the target species. Standardised indices and 95% confidence intervals are tabulated in Appendix 3.

The model residual diagnostics were "acceptable" with no severe violations of normality assumptions (Figure I15). Model step-plots showed that the addition of lifts had a marked standardisation effect on the index, reducing some of the fluctuation evident in the standardised index and increasing the index from 2011 to 2014 (Figure I16). CDI plots for each of the model predictor variables are shown in Figures I17–I19.

4. DISCUSSION

This report presents updated catch per unit effort analyses for the South Island commercial freshwater eel fishery from 1991 to 2023 carried out at the level of eel statistical area for four data rich areas (AV, AW, AX, and AS). For Te Waihora, analyses were carried out only for AS1 (the lake) from 2001 onward when codes were introduced to distinguish catches from AS2 (migration area). Analyses were split between pre- and post-QMS to be consistent with the previous analyses (Beentjes & Dunn 2013, 2015, Beentjes 2021). For the data poor areas (AN, AP_AQ, AR, AT, and AU), the characterisations were updated and no CPUE analyses were carried out.

4.1 Catch and species distribution

Estimated catch in CPUE analyses

In the freshwater eel fishery, the catch of each species is estimated by visual inspection of catches in the fyke nets or in holding bags, rather than standard fish bins containing separated species. There is therefore the possibility that in catches dominated by one species, the minor catch may be overlooked or underestimated. Overall, total groomed estimated catch used in the CPUE analyses was 93% of the total reported landed catch for the South Island (see Figure 6). The data before 2002 had 6–11% of records removed because of errors in CELR reporting (Beentjes & Dunn 2003) and 5% of records that reported estimated catch as EEU were also excluded from the analyses. From 2002 onward, with the introduction of the ECER, no records were removed from the analyses during grooming and estimated catch was similar to the landed catch. The estimated catch is therefore likely to be proportional to total landed catch throughout the time series, and hence suitable for inclusion in CPUE analysis.

The use of species code EEU

Reported catch of EEU before 2001 presents problems in catch and effort analyses for individual species, but this is unlikely to have altered overall interpretations of any trends because EEU comprised only 5% of records. The extent to which EEU, rather than LFE or SFE, was recorded by fishers varied between regions (see Figure 7). A high proportion of the catch was recorded correctly by species where one species was dominant, e.g., Southland and Te Waihora. The introduction of South Island freshwater eels into the Quota Management System on 1 October 2000 required fishers to be more diligent in completing the CELR form, which resulted in improved quality of catch and effort data, e.g., there are no records of EEU being used in 2001 with all catches being identified to species. Replacement of the CELR form with the ECER and ECLR on 1 October 2001 did not give the option of recording EEU; thus, there have been no records of EEU in the catch and effort data since 2000. Hence, the code EEU has no bearing on the post-QMS CPUE analyses.

Trends in catches

The estimated eel catch of all South Island eels from 1992 to about 2000 has declined and though it appears to be mostly due to the decrease in longfin estimated catch (see Figure 8), the landed catch of both shortfin and longfin shows a clear decline in the early 1990s (see Figure 1). This difference may have resulted from data grooming deletions of shortfin from estimated catch and fishers coding catch to EEU rather than shortfin. The general trend of declining estimated eel catches in the 1990s is evident in all ESAs except Te Waihora which has maintained a reasonably stable catch over the 33-year time series, with the exception of the last few years when catches declined dramatically (see Figures A1 to I1). The continued decline in eel catch up to 2020 cannot be attributed to the introduction into the QMS in 2001 because quotas were set for both species combined (ANG) and were never caught (see Figure 1). The decline after 2016 was, in part, a result of the split of ANG into separate stocks (LFE and SFE) in 2017 with TACCs in LFE 11–LFE 14 set at a nominal 1 t, rendering these areas economically unviable from a fishery perspective. In addition, international markets for eels have been poor in recent years. The steep decline in the last three years was a direct result of the permanent closure of the only South Island eel processor, Mossburn Enterprises Ltd, in late 2022. The stock and plant was sold to SouthFish and moved to an historical factory (Gould Aquafarms) in Leeston, about 5 km from Te Waihora where processing of eels resumed. In March 2024 the Leeston factory was taking all shortfin from fishers with a preference for larger eels, and longfin over 700 g, which were exported live to China. Fishers have been requested to avoid fishing in longfin habitat and focus effort on areas where shortfin are more abundant. There is also no current market for the undersize shortfin migrant males, that have historically been taken from the Concession Area (AS2), hence the low or zero catch in Te Waihora AS2 in the last few years (see Figure I2). The result of the closure of Mossburn Enterprises in 2022 has been that fishing effort and hence catches declined over this period with historically low South Island catches in 2021, 2022 and particularly 2023, where some ESAs recorded negligible or zero catch (Figure 8). The expectation is that catches will increase again as more eels are processed at the Leeston factory.

Species distribution

All South Island ESAs have both shortfin and longfin reported catches, but in general shortfin was the dominant species in Te Waihora and northeast areas (AP-AQ, AR), whereas longfin was dominant everywhere else, particularly in the south and west (see Figure 7). The bulk of the shortfin catch in ESA AX is from Lake Brunner on the Arnold River, the next most important shortfin fishery in the South Island after Te Waihora (Beentjes 2019, 2022).

4.1.1 Te Waihora catch

Te Waihora catches from 1991 to 2019 were variable with no trend, followed by the steep decline in the last three years up to 2023 (see Figure I1), which as explained above was a result of the permanent closure of the only South Island eel processor, Mossburn Enterprises Ltd, in late 2022. There was a very large catch in 1992 (exceeding the controlled fishery limit of 121 t), and sharp drops in 1994 when the minimum legal size was introduced to the lake (140 g increasing by 10 g a year until 220 g was reached in 2001) and in 2000, the year before the fishery was introduced into the QMS. There appears to be a reciprocal relationship between catches from the migration area (AS2) and outside the migration area (AS1), i.e., high catches in AS2 coincided with low catches in AS1 and vice versa, an outcome of having the total catch capped (controlled fishery until 2000, then a TACC from 1 October 2000, under the QMS). The catch in AS2 overall contributed about a third of the shortfin catch from Te Waihora up until 2016, but in the last seven years this has declined markedly, with no catch in 2019 and 2023. The reasons for this, up to 2018, were due to several factors including lack of markets for shortfin eels under 400 g, timing of the male migration in relation to lake openings, and the closure of Independent Fisheries Ltd at the end of 2017–18. Independent Fisheries Ltd was the only company that processed the smaller migrating male shortfin eels from Te Waihora and the SouthFish factory at Leeston currently has no interest in processing eels of this size. The shortfin TACC in Te Waihora (SFE 13) was increased from 122 t to 134.2 t in 2017, presumably in response to the previous CPUE analyses which indicated a steep increase before levelling off from 2012 to 2014 (Beentjes & Dunn 2015, Beentjes 2021).

4.2 Reporting of released legal-sized eels under destination 'X'

A potential issue relating to the correct reporting of the estimated catch is the release and reporting of legal-sized eels. Fishers are entitled to return eels of legal size (220 g to 4000 g) to the water, but are still legally required to include them on the catch effort section of the previous ECER, and the current ERS. The estimated catch of legal-sized released eels was also required to be reported as destination code 'X' in the catch landing ECLR destination field, and currently in the ERS disposal record. This may occur when there is no market for a particular species and/or size grade, or if the fisher has insufficient ACE. Hence, it is likely that many legal sized shortfin and longfin were caught and released, and it is assumed that they were correctly reported on ECERs, ECLRs and the ERS as destination code 'X'. There is also a voluntary code of practice to release longfin eels caught that are in a migratory condition and if these are of legal size, it is assumed that they are included in the destination 'X' reporting.

Initially, fishers throughout New Zealand were thought to not always be compliant in reporting of released legal-sized eels on ECERs, but this has improved and fishers are thought to be generally reporting correctly (Beentjes 2020, 2021). The South Island analyses (this report) indicated that destination code 'X' has been used more in some years than others and most often in SFE 13 (Te Waihora) for both species (see Figure 9). Analyses (not presented) indicate that released longfin were more often correctly recorded on ECERs, ECLRs and the ERS as destination code 'X' than were shortfin. This may be related to the poor market for small shortfin below 400 g which were graded out and released in Te Waihora; some of these eels were not recorded in the estimated catch (ECERs) but were recorded as destination code 'X' (ECLRs).

Since 2017, the TACCs for longfin in LFE 11, LFE 12, and LFE 14 were reduced to 1 tonne so some release of longfin caught as bycatch of targeting shortfin and recorded as destination code 'X' would be expected. There were, however, no strong indications of this except in LFE 11 where from 0.2 to 1.8 t of longfin catch were assigned to destination code ‘X’ since 2017 (see Figure 9). Destination ‘X’, accounted for as much as 15% of the shortfin landed catch in a couple of years, but was generally around a few percent (Figure 10). In contrast, for longfin, Destination ‘X’ accounted for over 30% and 75% of the landed catch in 2018 and 2023 respectively, although catches in 2023 were very low at less than 6 tonnes (Figure 11).

The implications of incorrectly reporting estimated catch are that the effort (i.e., number of fyke nets) would be fully recorded, but the total amount of catch associated with that effort would not always be recorded. If non-reporting of released legal-sized eels is significant then the estimated catch and CPUE indices would be conservative. Discussions with Te Waihora fishers indicate that the correct use of destination code ‘X’ is not well understood and attempts to quantify the extent of misreporting of released eels on the estimated catch are unlikely to be successful. From about 2008 when the use of destination ‘X’ was introduced in the eel fishery, the shortfin landed catch was not always correlated with the estimated catch, particularly in 2009 and 2010, most likely due to incorrect reporting of destination ‘X’ released eels (see Figure 6). For longfin, however, landed and estimated catches were well correlated in all years since 2008, so the effect of incorrect reporting seems to be trivial for this species (see Figure 6). If markets and demand for specific size grades and species continue to fluctuate, or ACE is not available to cover the catch, then destination ‘X’ is likely to be used more often by fishers.

To ensure compliance, ongoing fisher education by Fisheries New Zealand about correctly reporting destination ‘X’ catch in the ERS is desirable. This could be augmented by more explicit explanatory notes in the ERS, auto-checking routines built into the reporting software, and implementing error checking business rules when returns are entered into the Fisheries New Zealand catch and effort database by FishServe.

4.3 Release of eels over the legal size (4 kg)

In the South Island since 1996, longfin female eels over 4 kg have been legally required to be returned to the water on capture. These eels were not required to be reported on ECERs or ECLRs because they did not fall within the legal-size limit (220 g to 4000 g). The full extent of these over 4 kg longfin eel releases is unknown but voluntary recording of these data in 2014 by South Island eel fishers indicated that over 1400 longfins over 4 kg were caught and released, some of which were as large as 16 kg (Bill Chisolm, pers. comm.).

Fishers completing ERS electronic logbooks (from 2020) are required to record the number and weight of eels caught over the maximum legal size (4 kg) and released in the Disposal Report (see Figure 12). The ERS records indicate that the largest catch and release of over 4 kg eels was in 2020 and 2021 with about 2.5 to 3 tonnes each year, mostly from Otago/Southland (LFE 15) (see Figure 12). For the South Island overall, Destination ‘G’ releases represented from 3% to 6% of the longfin landed catch with no trend over the four years from 2020 to 2023 (see Figure 13). Although total catches of over 4 kg eels were less in QMAs with a 1 tonne TACC (LFE 11 to LFE 14), relative to the landed catch the proportions are much higher. For example, in LFE 11 in 2020 and 2023 the catch of eels over 4 kg was one third to one half that of the landed catch.

4.4 Escape-tube modifications

The legal escape-tube size in the South Island was increased from 25 mm to 31 mm in 1997. The 25 mm diameter tube was designed to allow eels smaller than 220 g (minimum legal size, MLS) to escape from fyke nets if captured (see Figure 4), although in practice eels below the MLS were often caught. A 31 mm escape tube can be expected to retain eels larger than about 300 g, hence the South Island pre-QMS CPUE for both species may be conservative for a few years after 1997 because eels that were previously retained as catch were able to escape. This change in regulations should not have influenced trends in post-QMS CPUE because the time to grow from 220 to 300 g is about 2 years, based on average length increments of 2.5 cm per year. More recently, some fishers in the South Island have used larger escape tube sizes, mainly 38 mm, but one fisher has used 42 mm to retain eels closer to the 700 g longfin minimum weight required by SouthFish. The escape tube size is to some extent dependent on the diameter of plastic pipe that is available commercially. The impact of using a larger escape tube in fyke nets on CPUE would be to reduce catch with the same effort, and hence initially reduce the indices, followed by an associated increase once the smaller eels recruit to the fishery. Longterm trends should therefore not be impacted. Escape tube diameter used by fishers was added to the ERS effort reporting in 2024–25 and will be available for future analyses.

4.5 Fyke net specifications and fishing practices

It is important in any fishery being monitored to understand the type of fishing gear being used, the specifications of the gear, and how the gear operates to catch fish. Any changes to gear that might affect the catchability and hence CPUE should be documented and be considered during any presentation of results that use catch and effort data. Fishing method options available on ECERs were fyke net (FN), eel potting/hinaki (EP), fish trap (FP), or other—options for method ‘other’ were set net, ring net, cod pot, or inshore drift net, and of these, only set net was occasionally used in the Firth of Thames for targeting freshwater eels. Fishers completing ERS electronic logbooks from April 2019 are required to record effort on a generic ‘Potting form’ also used by blue cod and rock lobster fishers and for target species freshwater eels, the methods available to select are FN, EP, FP, and EFN (Ellesmere fyke net).

Fyke net method was recorded on nearly all South Island ECERs, and ERS catch reports. The fyke net fishing gear in the South Island, based on available information, has remained unchanged over the time series of CPUE, with the exception of Te Waihora where larger modified nets replaced the standard shortfin fyke net around 2000. Although the shortfin and longfin fyke nets are broadly similar, each net is specifically designed and deployed to target a different species, although there is bycatch of longfin in shortfin nets and vice versa (see Figure 4). If there are changes to these net specifications in the future, it will be important to have this documented.

Target species selected in South Island tends to reflect the composition of eels in the habitat fished. For example, in coastal shallow lakes such as Te Waihora, target species is 100% shortfin whereas fishing in river estuaries and coastal regions can be a mix of target shortfin or longfin, and fishing in upper river catchments and high-country lakes will exclusively target longfin.

It has generally been considered that only longfin nets are baited, however the results from the ERS indicate that baiting of shortfin nets is occurring but not to the extent of longfin (see Figure 16). That some longfin nets were not baited suggests that shortfin or longfin fyke nets are not always used exclusively to target shortfin or longfin respectively.

Vessel use was more common for shortfin targeting reflecting the need to use vessels to target shortfin in lakes Te Waihora and Lake Brunner, the key shortfin fisheries in the South Island (see Figure 17). Fishing from the riverbank is more common for targeting longfin, most likely because this is more practical and economical for this species.

Standard soak time practice is for nets to be left overnight to fish but results from the ERS indicated that longer periods of about 30 to 50 hours are common (Figure 18). The longer soak times most likely depend on weather and river conditions which can impact the ability to return to pick up nets the next day.

4.6 CPUE analyses

4.6.1 Standardised CPUE analyses

Standardised CPUE indices (pre- and post-QMS) summary plots for the data rich areas (ESAs AX, AV, and AW) are shown in Figure 19. For AS1, only post-QMS analyses were carried out (Figure 20). These indices only apply to areas that are commercially fished.

The standardised CPUE analyses take into account the effects that the variables lifts, permit, season (month), moon phase, river flow, target species, and lake level and opening (Te Waihora only) may have had on the raw catch rates (see Appendix 2). The four variables permit, target, lifts, and month were included in nearly all pre-QMS models, with month generally explaining the least variability of the four in the models (see Appendix 2). The target species variable is an important predictor because of the differences in fishing gear and deployment when targeting one or the other species. The finding that month affects catch rates is understandable since water temperature varies seasonally and eel catch rates have been found to decline markedly in winter (Jellyman 1991, 1997) and there is little or no fishing and processing of eels in the South Island in the winter months. The inclusion of permit in all models also indicates the importance of fisher experience and/or ability and this is shown in the influence plots. Lifts was included because it is the key indicator of relative effort. River flow, and moon phase entered some models, but these were generally the last variables to be included and tended to be from areas where there were few data and few fishers. Despite the inclusion of explanatory variables into the model there was little difference between the plotted trends of the unstandardised and the standardised CPUE indices for about half of the models.

For Te Waihora, lifts, month, and permit were accepted as model predictors. Target species was not relevant in this area because the fishery is 100% shortfin target. The environmental variables lake level and time of lake opening were offered to the AS1 shortfin model, but were not accepted in the model.

Shortfin standardised CPUE summary

For the data-rich areas (AV, AW, AX, and AS1), shortfin standardised indices showed clear declines in pre-QMS CPUE for Otago (AV) and Southland (AW), but in Westland (AX) there was an overall increase in CPUE (see Figure 19). For post-QMS shortfin the very low catches in recent years invalidate the associated indices, and trends described below ignore these years (i.e., AV 2022 and 2023; AW, 2021–23; AX, 2023). Excluding Te Waihora, post-QMS shortfin showed slight trends of increasing CPUE in Otago and Southland and a clear increasing trend for Westland (Figure 19). Te Waihora post-QMS shortfin in AS1 (lake outside concession area) showed a steep increase in CPUE before levelling off between 2011 and 2014, followed by a steep decline until 2016 after which it was variable with no clear trend (Figure 20). For shortfin in Te Waihora, the target B_{MSY}-compatible proxy was based on the mean CPUE for the period 2006–07 to 2009–10, and stock status was considered to be unlikely (< 40%) to be at or above B_{MSY} (Fisheries New Zealand 2025).

Longfin standardised CPUE summary

For the data-rich areas (AV, AW, and AX,), longfin standardised indices showed clear declines in pre-QMS CPUE for Otago (AV) and Southland (AW), but in Westland (AX) the CPUE increased over time (Figure 19). For post-QMS longfin the very low catches in recent years invalidate the associated indices, and trends described below ignore these years (i.e., AV 2022 and 2023; AW, 2021–23; AX, 2023). Post-QMS longfin indices for Otago (AV) and Southland (AW) were generally stable followed by an increasing trend from about 2015, whereas Westland (AX) showed an overall trend of increasing CPUE over the time series (Figure 19).

4.6.2 Factors influencing CPUE trends

South Island (excluding Te Waihora)

The total lifts per year steadily declined in the South Island since the 1990s reflecting a progressive reduction in the number of fishers over time (for example, see Figures F6, F7, G6, G7, H6, H7). The introduction of eels to the QMS in 2001 resulted in a further reduction in numbers of fishers and hence effort, and there was a transition in the fishery from long-term existing fishers to ‘new entrants’. The TACC (ANG for both species combined) introduction in 2001 had little impact on the catches at the time and since then, because TACCs were never caught except for Te Waihora shortfin.

Based on interviews with longfin fishers in the South Island, about 32% of the South Island longfin river and lakes habitat accessible to longfin eels, was commercially fished from 2010 to 2014 (Beentjes et al. 2016). This proportion of fished longfin habitat was re-estimated for the period 2020 to 2023 from ERS fishing event positional data recorded as latitude and longitude, with a revised proportion of 13% (Beentjes and Shankar in prep). The reduction in area fished by over one-half was due to a number of factors including the split into separate stocks (LFE and SFE) in 2017 with TACCs in LFE 11–LFE 14 set at a nominal 1 t. The closure of Mossburn Enterprises eel processing factory in late 2022 also had a major impact on effort in 2022 and 2023.

The shortfin fishery shows clear signs of recovery in Otago and Southland, following declines, whereas Westland shortfin CPUE has improved in both pre- and post-QMS time series and given that the bulk of the catch is taken from Lake Brunner, the reasons may be related to the productivity of the lake. The longfin CPUE trends are similar in Otago and Southland with indications of recovery post-QMS in recent years only, whereas Westland longfin CPUE has improved over both time series.

Despite the trends of smaller catches and reduced effort, the recovery of the commercial fishery with increased abundance appears to be only modest. Fishers tend to return to the same fishing locations on a regular basis, in effect cropping the population. These areas also tend to be the closest, most economic to fish and often require long-standing arrangements with landowners for access. With the increase in numbers of large longfins over the maximum legal size (4 kg) many areas are likely to be uneconomic to fish because of the numbers of these eels in the catch that need to be graded out and released, particularly in those areas where the longfin TACC was capped at 1 tonne. For areas that are not commercially fished (i.e., 87% of the longfin habitat), the abundance and size structure of eels is likely to be much different.

Te Waihora

Te Waihora was managed as a controlled fishery with a capped catch limit of 136.5 t, fished by 11 permit holders, before the introduction of the QMS regime in 2001 with a TACC set at 122 t. Fisher numbers also declined as quota was purchased and aggregated and only about two or three fishers remain actively fishing in 2023. Shortfin eels were known to be very small in Te Waihora before 1978, a result of unrestricted access, no MLS, and no catch limits. The introduction of a minimum legal size (MLS) of 140 g in 1994, increasing by 10 g per year until 2002 when it reached the national MLS of 220 g, was because there were few large eels in the lake at that time and it was considered that setting the initial MLS any higher would have essentially closed the fishery.

Shortfin CPUE in AS1, more than any other South Island area, increased dramatically from 2002 to 2011, before levelling off for a few years and then declining steeply within two years before stabilising (see Figure 20). A commercial fisher in 2014 (Clem Smith pers. comm.) confirmed that catches were strikingly better in the years when CPUE was steeply increasing, and that nets were sometimes ‘tied-off’ several hours after setting to prevent any more eels entering the net. This was done to reduce the size of the catch which became unmanageable from a single net landed into a small vessel. Eel condition was reported to be poor in the period directly after the drop in CPUE, and common bully (*Gobiomorphus cotidianus*) numbers had declined markedly, both signs of a reduction in lake productivity. The current eel condition is ‘reasonable’ but bully numbers have not recovered (Clem Smith pers. comm.).

A standalone CPUE analysis for Te Waihora shortfin in AS1 carried out up to 2012, included sections on ecology of the lake, history of management, and eel fishery characterisation (Beentjes & Dunn 2014), as well as plausible reasons for the dramatic increase in CPUE in AS1. In summary, it was suggested that the fishery had experienced a progressive improvement in yield per recruit as the MLS incrementally increased over time. Beentjes & Dunn (2014) also analysed eel size in the lake in the 1990s compared with that up to 2018 and demonstrated that the size of commercially caught eels had substantially increased over time, and the CPUE peak was associated with a period when the average size of shortfin eels was at its highest, supporting the concept of an improved yield per recruit (Figure 21). The lake experienced enhanced nutrient loading from the growing number of dairy farms surrounding the lake. The short-term effect may have been increased productivity of phytoplankton and benthic epiphytic algae.

5. ACKNOWLEDGMENTS

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7. TABLES

Table 1: Eel Quota Management Areas (QMAs) for longfin (LFE) and shortfin (SFE) eel, current eel statistical areas (ESA, from October 2001), and the associated historical numeric Eel Statistical Areas (ESA, up to September 2001). The QMA code ANG was used for shortfin and longfin species combined in the South Island before 1 October 2016.

	QMA		ESA (alpha) (after 1 Oct 2001)		ESA (numeric) (before 1 Oct 2001)
Area	LFE	SFE			
Northland	LFE 20	SFE 20	AA		1
Auckland	LFE 20	SFE 20	AB		2
Hauraki	LFE 21	SFE 21	AC		3
Waikato	LFE 21	SFE 21	AD		4
Bay of Plenty	LFE 21	SFE 21	AE		5
Poverty Bay	LFE 21	SFE 21	AF		6
Hawke's Bay	LFE 22	SFE 22	AG		7
Rangitikei-Wanganui	LFE 23	SFE 23	AH		8
Taranaki	LFE 23	SFE 23	AJ		9
Manawatu	LFE 22	SFE 22	AK		10
Wairarapa	LFE 22	SFE 22	AL		11
Wellington	LFE 22	SFE 22	AM		12
Nelson	LFE 11	SFE 11	AN		13
Marlborough	LFE 11	SFE 11	AP	}	14
South Marlborough	LFE 12	SFE 12	AQ	}	14
Westland	LFE 16	SFE 16	AX		15
North Canterbury	LFE 12	SFE 12	AR		16
South Canterbury	LFE 14	SFE 14	AT		17
Waitaki	LFE 14	SFE 14	AU		18
Otago	LFE 15	SFE 15	AV		19
Southland	LFE 15	SFE 15	AW		20
Te Waihora (outside-migration area)	LFE 13	SFE 13	AS1	}	21
Te Waihora migration area	LFE 13	SFE 13	AS2	}	21
Chatham Islands	LFE 17	SFE 17	AZ		22
Stewart Island	LFE 15	SFE 15	AY		23

Table 2: **Eel statistical areas, regions, and the number of records (equivalent to the number of fisher days), and estimated catch for shortfin, longfin, and unidentified eels from 1991 to 2023. These are the groomed estimated catch data used in the CPUE analyses. ESA, eel statistical area.**

			Estimated catch (t)			
ESA	Region	Records	Shortfin	Longfin	Unidentified	Total
13 (AN)	Nelson	2 559	63	158	99	321
14 (AP and AQ)	Marlborough	3 468	184	132	127	443
15 (AX)	Westland	10 743	410	831	44	1 285
16 (AR)	North Canterbury	4 431	315	233	65	613
17 (AT)	South Canterbury	3 594	187	180	11	378
18 (AU)	Waitaki	1 614	64	155	4	223
19 (AV)	Otago	9 100	279	725	7	1 011
20 (AW)	Southland	12 168	362	1 577	4	1 943
21 (AS1 and AS2)	Te Waihora (lake and migration area)	11 498	3 291	62	0	3 352
Totals		59 175	5 155	4 054	361	9 570

Table 3: **Percent of estimated species catch within and among eel statistical areas from combined years 1991 to 2023. These are the groomed data used in the CPUE analyses. ESA, eel statistical area; LFE, longfin; SFE, shortfin; EEU, unclassified.**

	Percent species catch within ESA				Percent species catch among ESA			
ESA	SFE	LFE	EEU		Total	SFE	LFE	EEU
13 (AN)	19.8	49.4	30.8	100	3.3	1.2	3.9	27.4
14 (AP and AQ)	41.5	29.8	28.7	100	4.6	3.6	3.3	35.2
15 (AX)	31.9	64.6	3.4	100	13.4	8.0	20.5	12.2
16 (AR)	51.4	38.0	10.6	100	6.4	6.1	5.7	18.0
17 (AT)	49.5	47.6	2.9	100	4.0	3.6	4.4	3.1
18 (AU)	28.7	69.6	1.6	100	2.3	1.2	3.8	1.0
19 (AV)	27.5	71.7	0.7	100	10.6	5.4	17.9	2.1
20 (AW)	18.6	81.2	0.2	100	20.3	7.0	38.9	1.1
21 (AS1 and AS2)	98.2	1.8	0.0	100	35.0	63.8	1.5	0.0
Overall	53.9	42.4	3.8	100	100	100	100	100

8. FIGURES

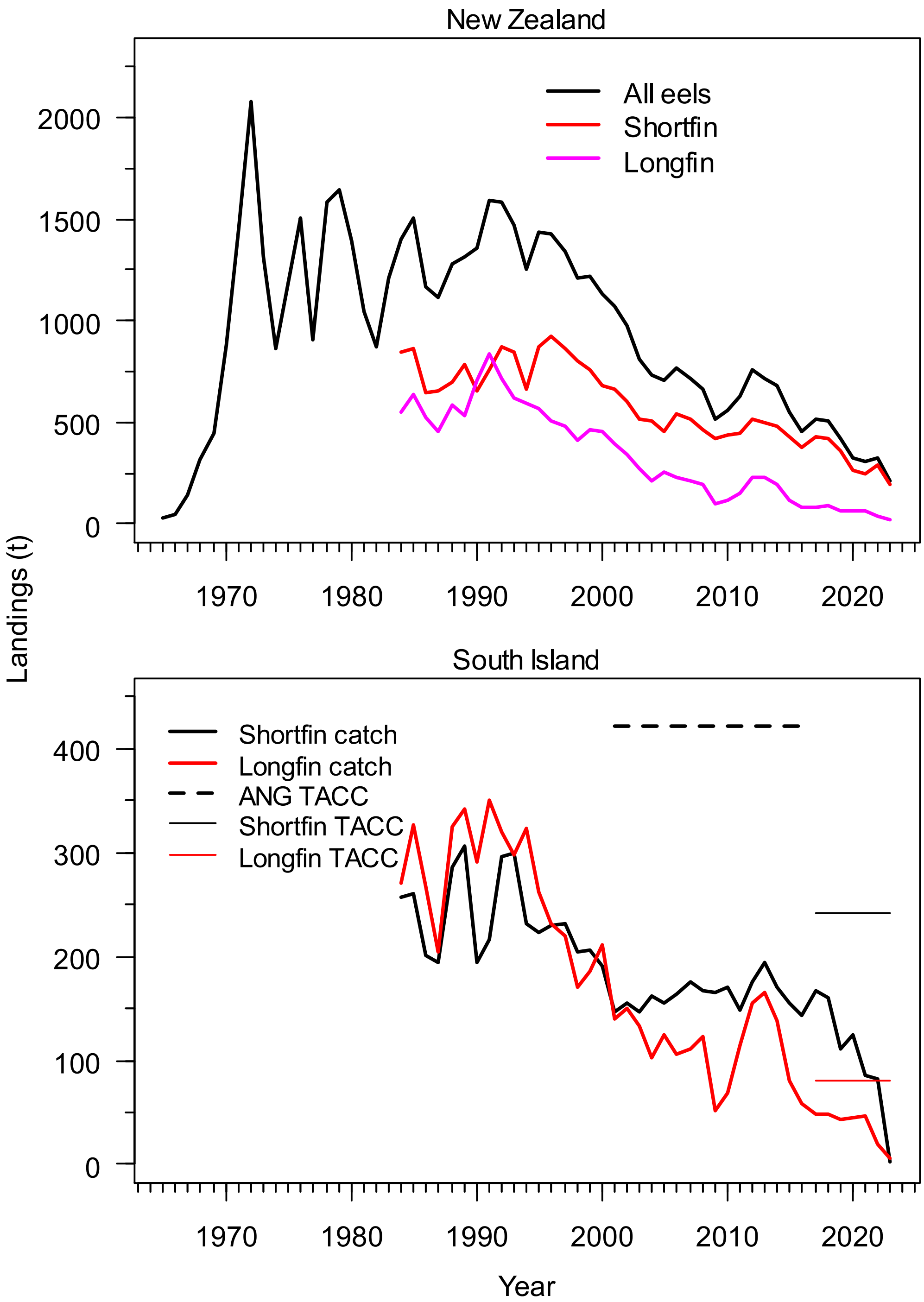

Figure 1: Landed catches of shortfin and longfin eels, and Total Allowable Commercial Catch (TACC) for each species up to 2022–23. Data are shown by calendar year up until 1988 and by fishing year from 1988–89 onward (data from Fisheries New Zealand 2024). These catches are based on MAF Fisheries Statistics Unit (FSU), Licensed Fish Receiver Returns (LFRR), Quota Management Reports (QMR), and Monthly Harvest Returns (MHR).

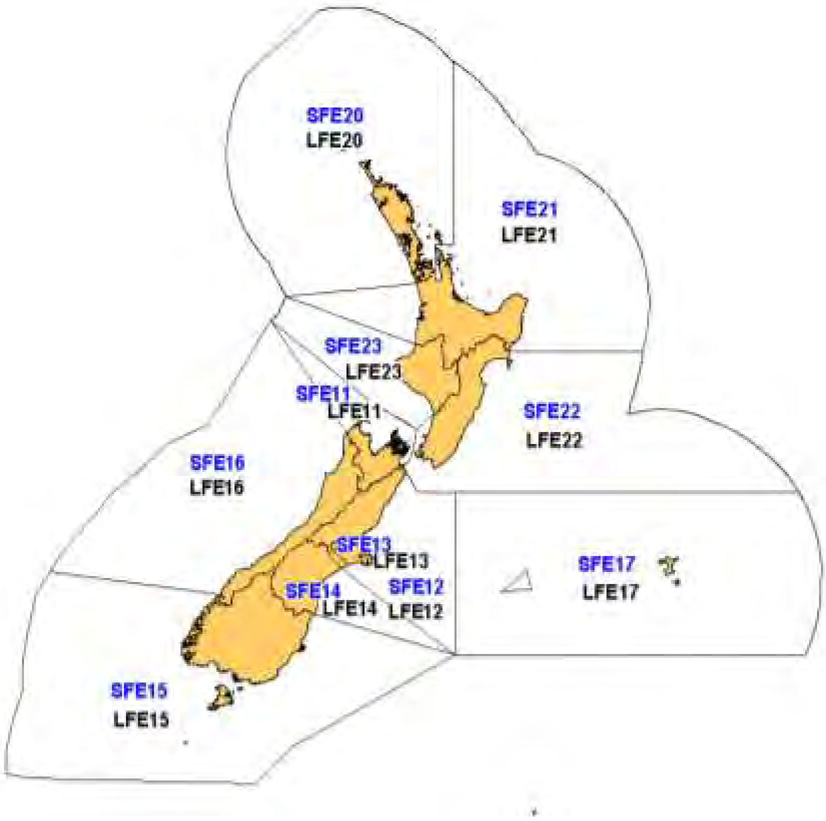

Figure 2: Quota Management Areas for the New Zealand eel fishery (see Table 1 for breakdown by eel statistical areas). Shortfin stocks are denoted by the prefix SFE, and longfin by LFE. (Figure from Fisheries New Zealand 2024).

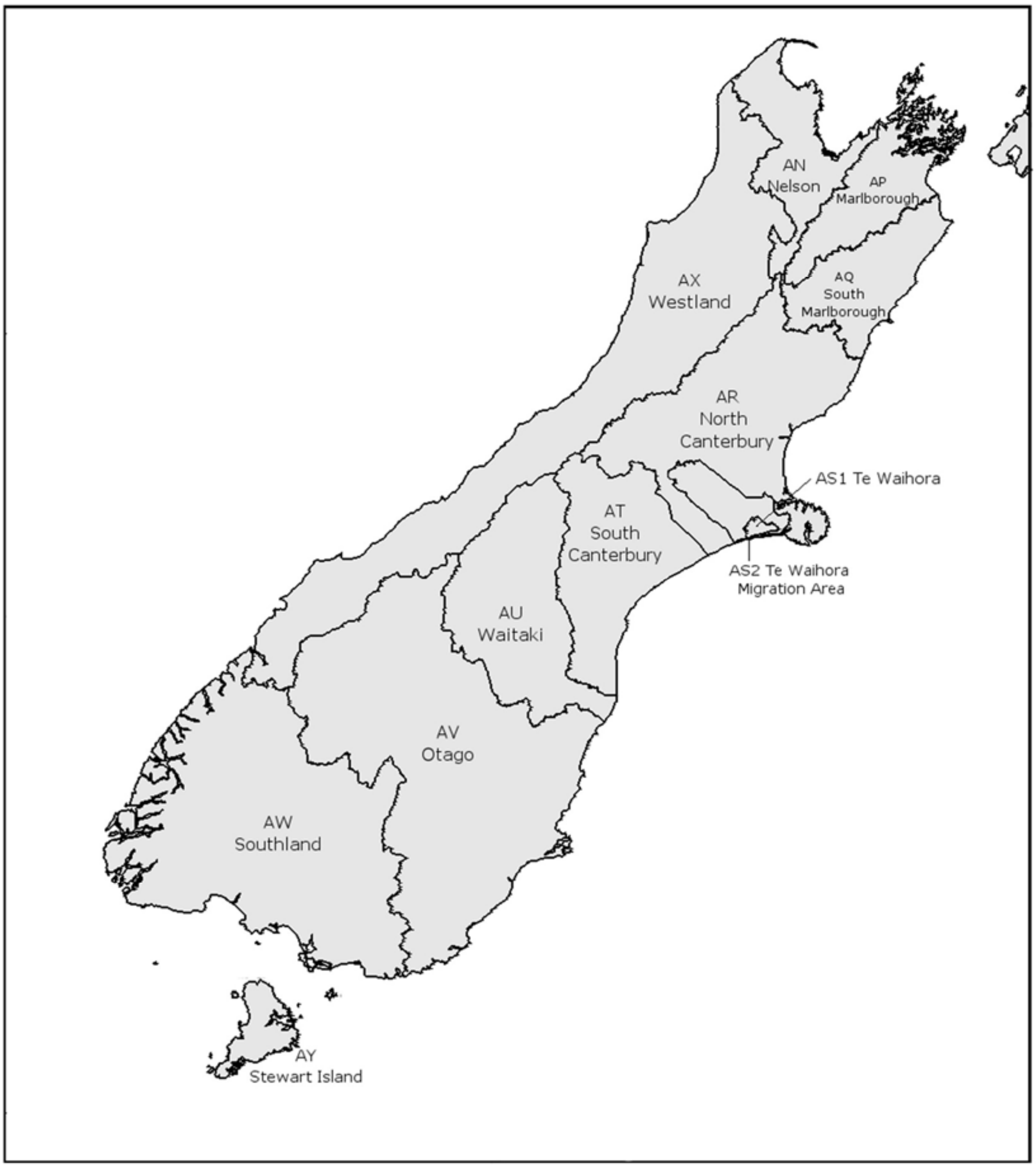

Figure 3: South Island eel statistical areas (ESAs). See Table 1 for old ESA numeric codes 13 to 23.

Figure 4: Photograph of standard South Island longfin (foreground) and shortfin (background) eel fyke nets side by side. Photos by Mike Beentjes taken at Mossburn Enterprises, Invercargill (February 2014).

Figure 5: Google Earth map of Te Waihora (Lake Ellesmere). The eel statistical areas AS1 (lake) and AS2 (migration area) are shown as well as the location of the site where the lake is periodically opened to regulate lake level.

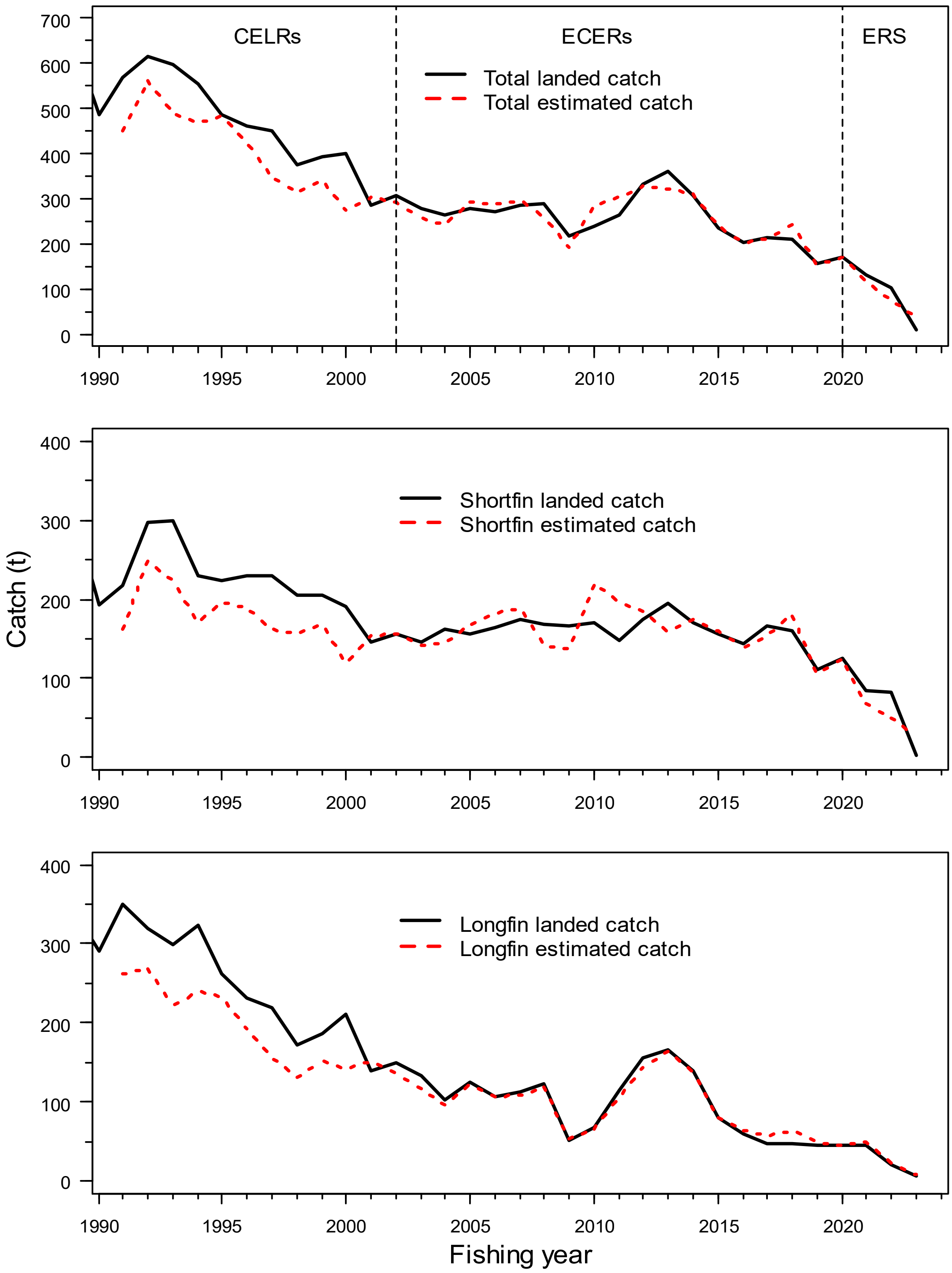

Figure 6: South Island groomed estimated commercial catch of all eels (top), shortfin (middle), and longfin (bottom) from 1991 to 2023, and landed catch from 1990 to 2023. Estimated catches are from Catch Effort Landing Returns (CELR), Eel Catch Effort Returns (ECER), and the Electronic Reporting System (ERS). The landed catches (total eels) are from processors/LFRR/QMR from 1990 to 2001 with shortfin and longfin catch pro-rated using species proportions from CELRs and ECERs, and from Eel Catch Landing Returns (ECLRs) and the ERS after that time when species was reported for landed catches (Fisheries New Zealand 2024). Dates shown represent the end of the fishing year, i.e., 1991 = 1990–91 fishing year.

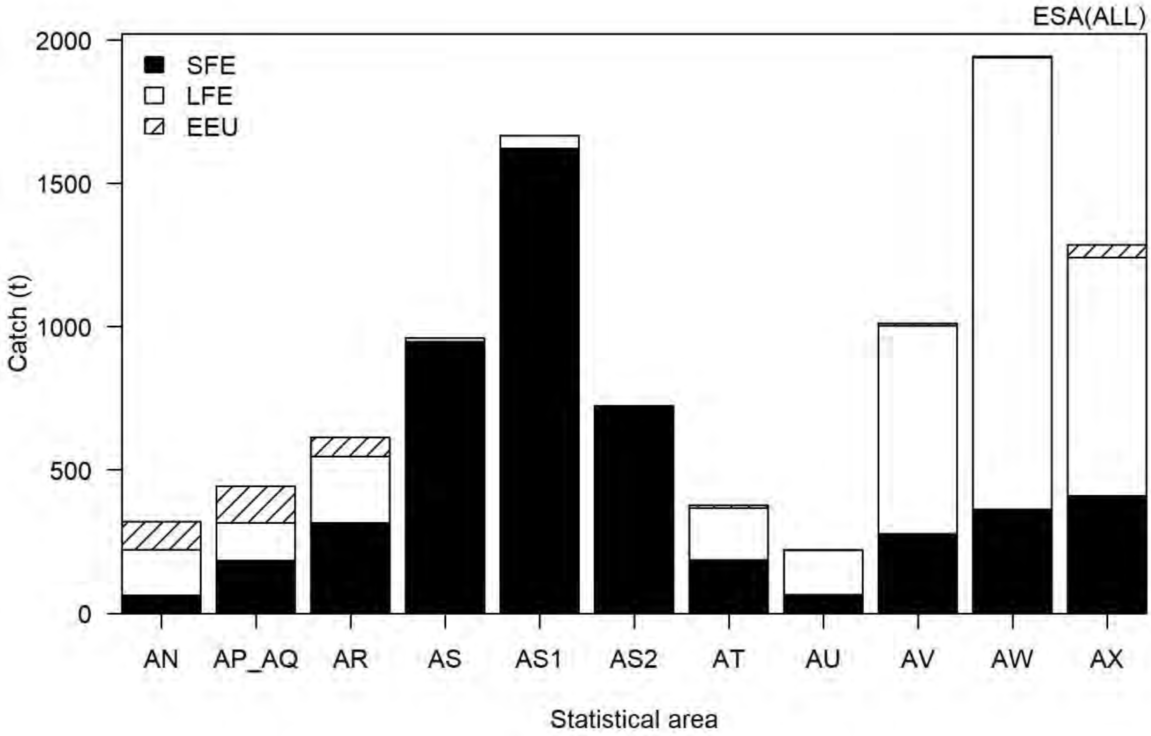

Figure 7: South Island total estimated commercial catch of shortfin (SFE), longfin (LFE), and unclassified eel catch (EEU) by eel statistical area for the fishing years 1991 to 2023. Eel statistical area AS includes catch from Te Waihora before 2001 when specific area codes were introduced for the migration area (AS2) and the lake excluding the migration area (AS1).

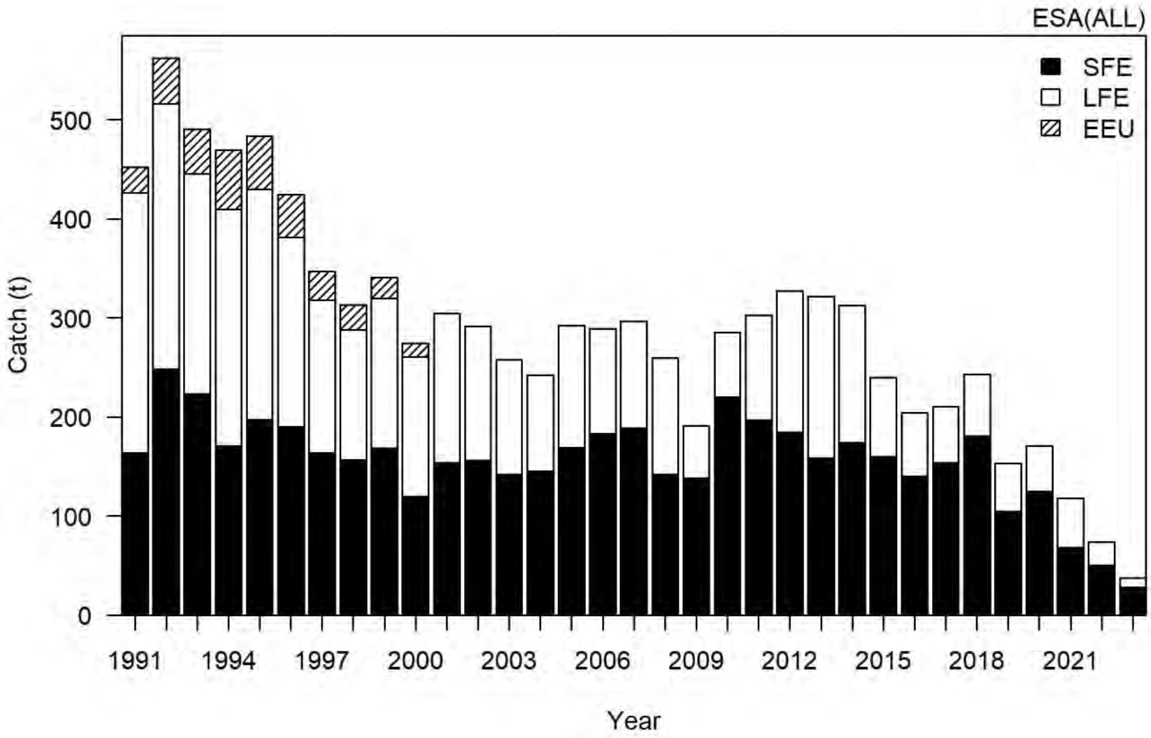

Figure 8: South Island total estimated commercial catch of shortfin (SFE), longfin (LFE), and unclassified eel catch (EEU) for the fishing years 1991 to 2023.

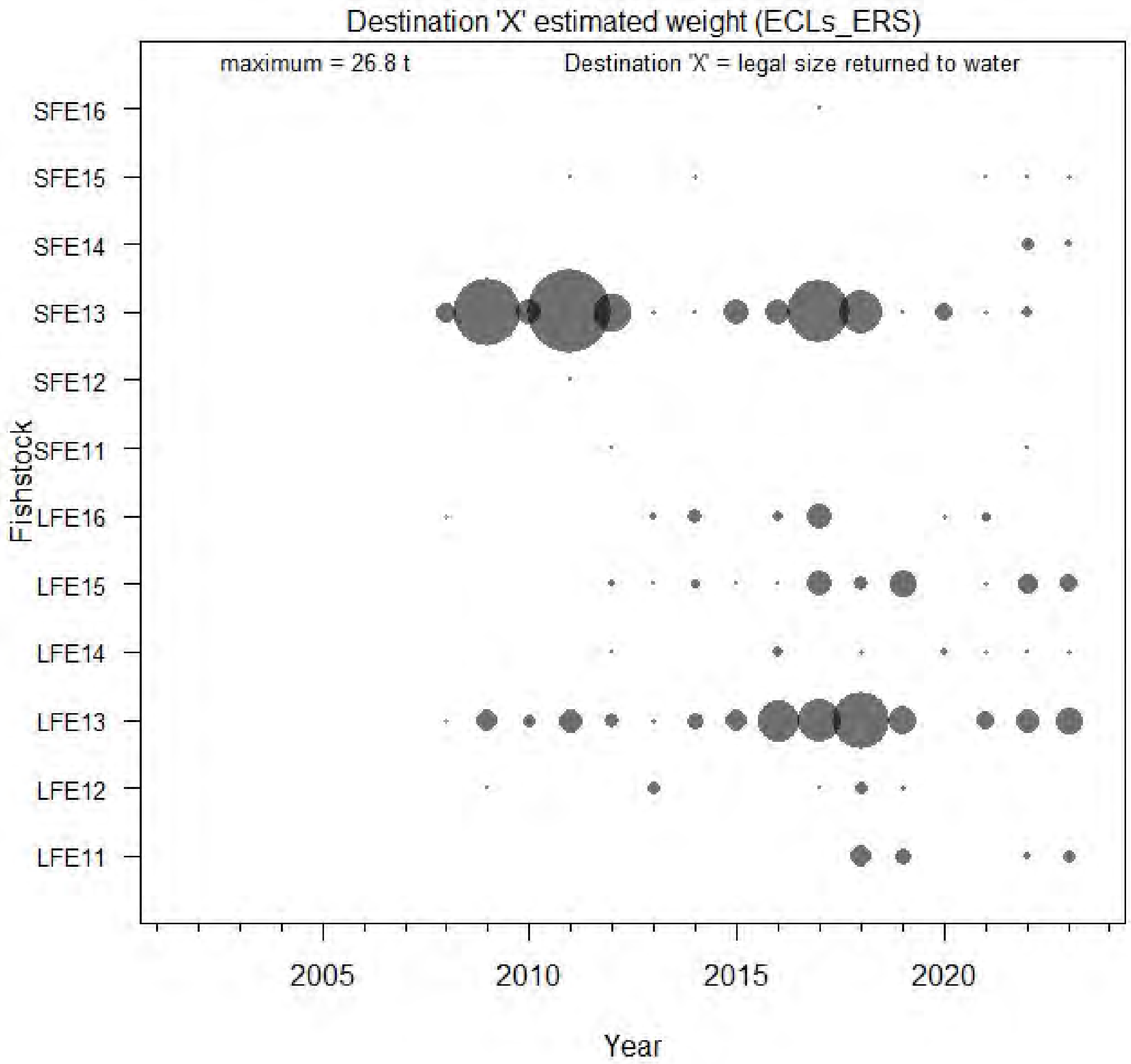

Figure 9: Estimated catch of eels by South Island Quota Management Area recorded against destination code 'X' on ECLRs from 2001 to 2019 and on the ERS from 2020 to 2023. Destination code 'X' eels are those of legal size (220–4000 g) returned to the water, and where weight is estimated at point of capture.

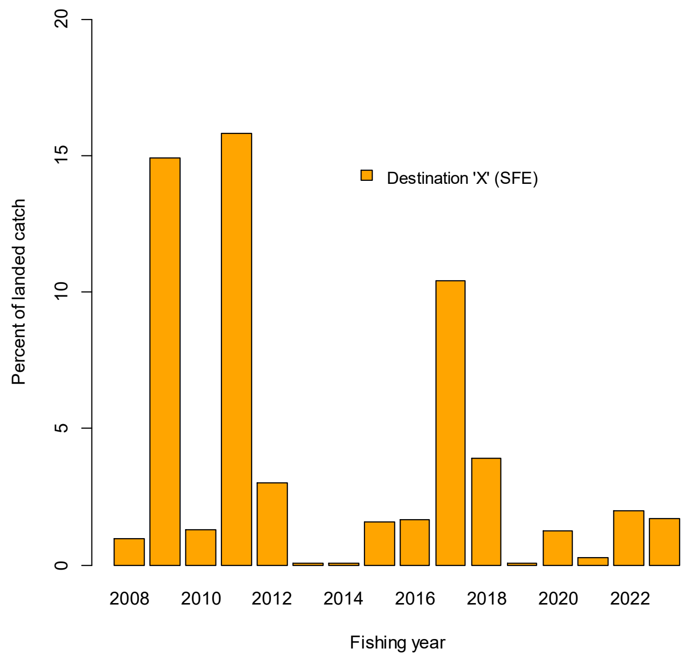

Figure 10: South Island percent of landed catch (destination 'L') that is destination 'X' by fishing year, for shortfin eels. Data from ECLRs from 2008 to 2019 and the ERS from 2020 to 2023. Destination code 'X' eels are those of legal size (220–4000 g) returned alive to the water, and where weight is estimated at point of capture.

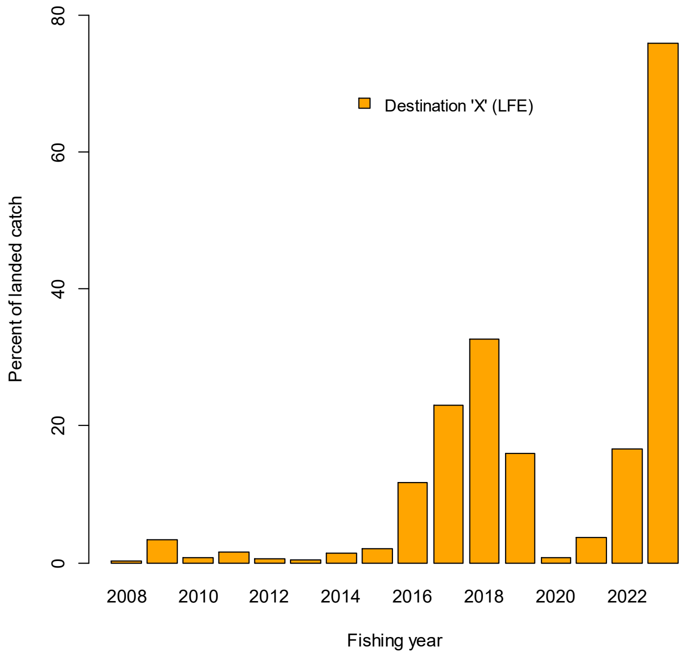

Figure 11: South Island percent of landed catch (destination 'L') that is destination 'X' by fishing year, for longfin eels. Data from ECLRs from 2008 to 2019 and the ERS from 2020 to 2023. Destination code 'X' eels are those of legal size (220–4000 g) returned alive to the water, and where weight is estimated at point of capture.

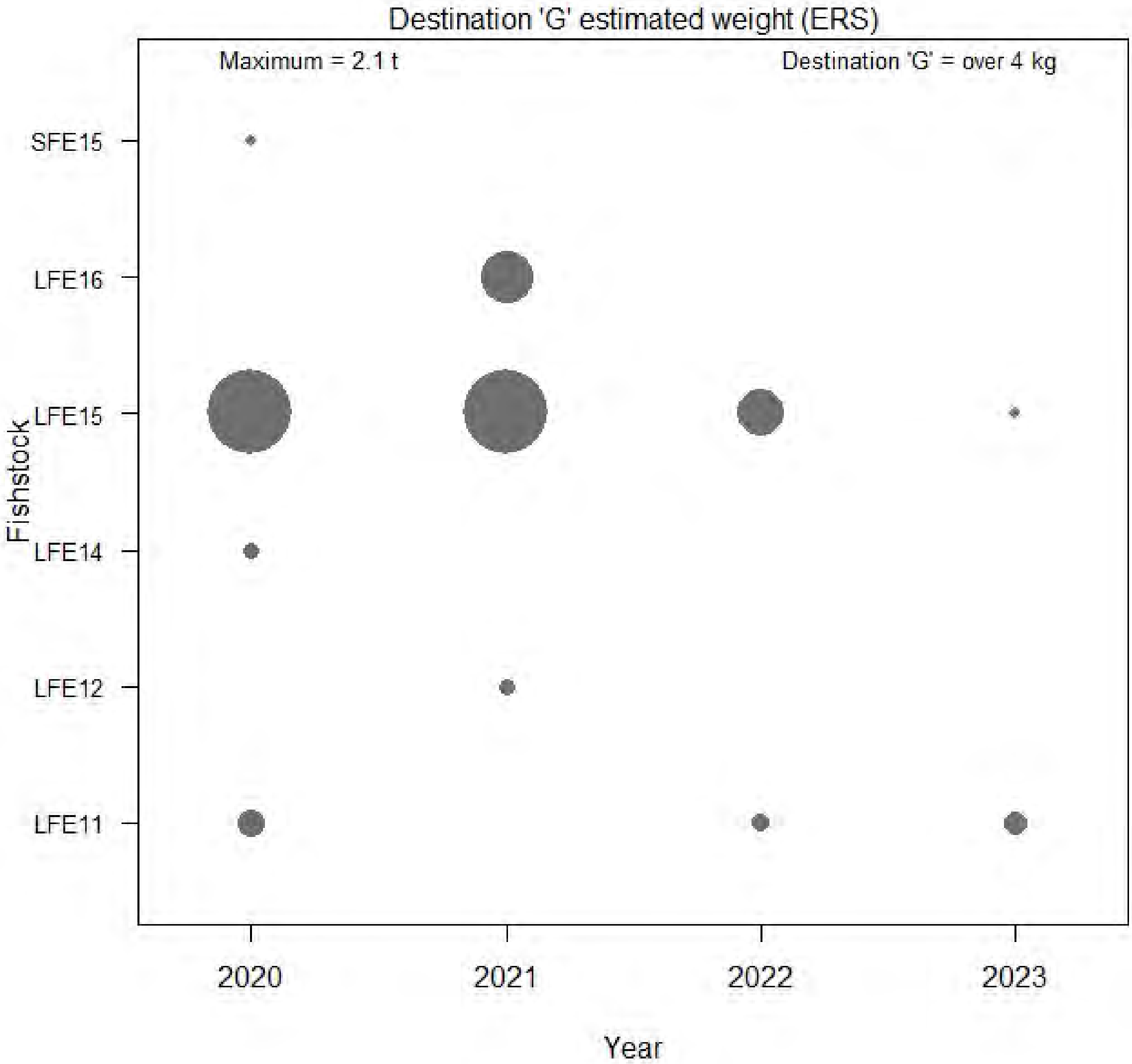

Figure 12: South Island estimated catch of eels by South Island Quota Management Area recorded against destination code 'G' in the ERS from 2020 to 2023. Destination code 'G' eels are those over the legal maximum size of 4 kg returned alive to the water, and where weight is estimated at point of capture. These are all longfin female eels as longfin males and shortfin eels of both sexes do not grow to this size. The SFE 15 catch in 2020 is likely to be a reporting error and is probably from LFE 15.

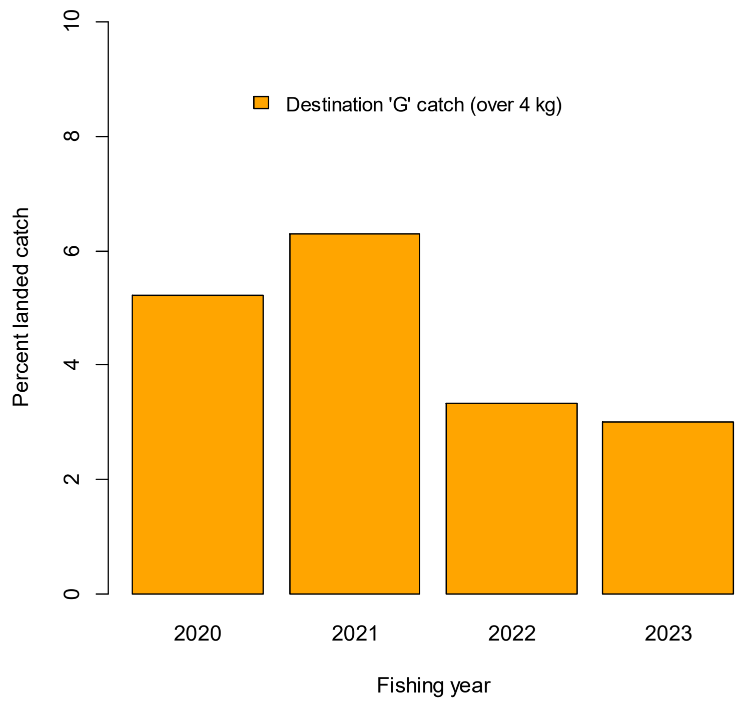

Figure 13: South Island percent of landed catch (destination 'L') that is destination 'G' by fishing year, for longfin eels recorded in the ERS from 2020 to 2023. Destination code 'G' eels are those over the legal maximum size of 4 kg returned alive to the water, and where weight is estimated at point of capture. These are all longfin female eels as longfin males and shortfin eels of both sexes do not grow to this size.

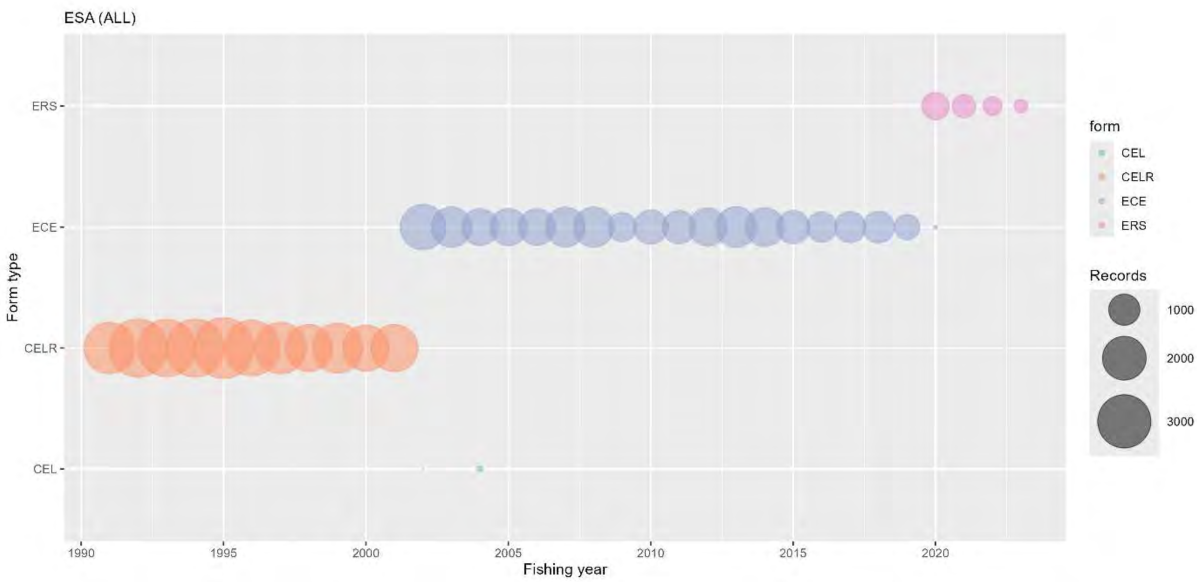

Figure 14: South Island catch effort reporting form type records from 1990 to 2023. CELR, Catch Effort Landing Return; ECE, Eel Catch Effort Return; ERS, Electronic Reporting System. The CEL records are likely to be CELR.

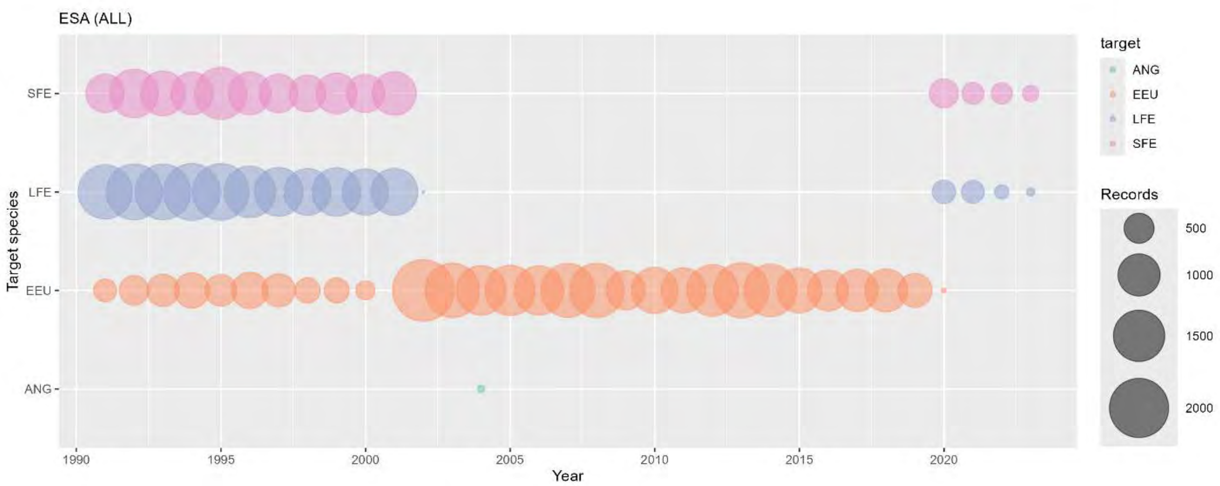

Figure 15: South Island target eel species records by species from 1990 to 2023. Target species was recorded on CELRs, dropped from ECERs, and again recorded in the ERS catch report. SFE, shortfin, LFE, longfin, EEU, unidentified, ANG, Anguilla.

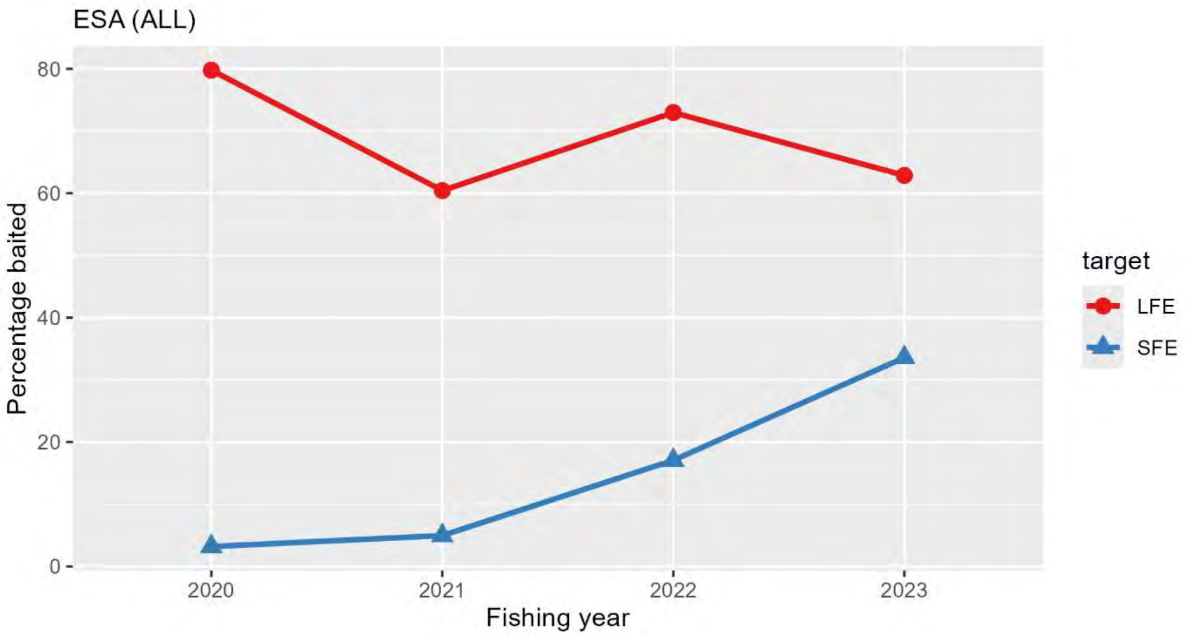

Figure 16: Percent of fishing events (sets) in the South Island eel fishery baited by target species from 2020 to 2023 (ERS data).

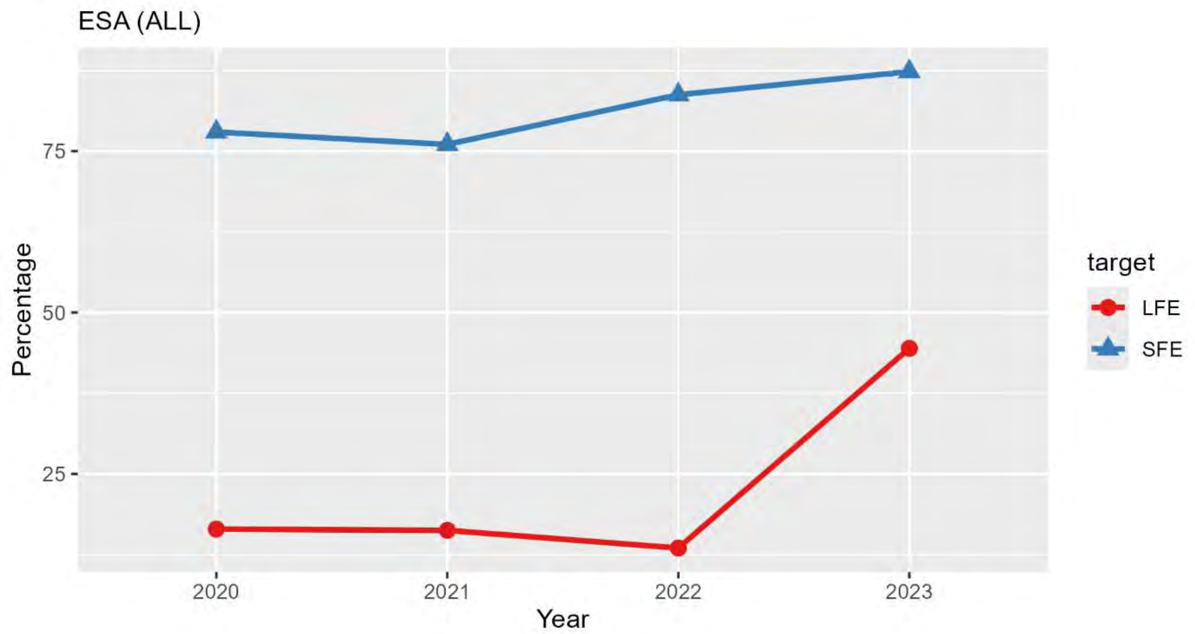

Figure 17: Percent of fishing events (sets) using a fishing vessel in the South Island eel fishery by target species from 2020 to 2023 (ERS data).

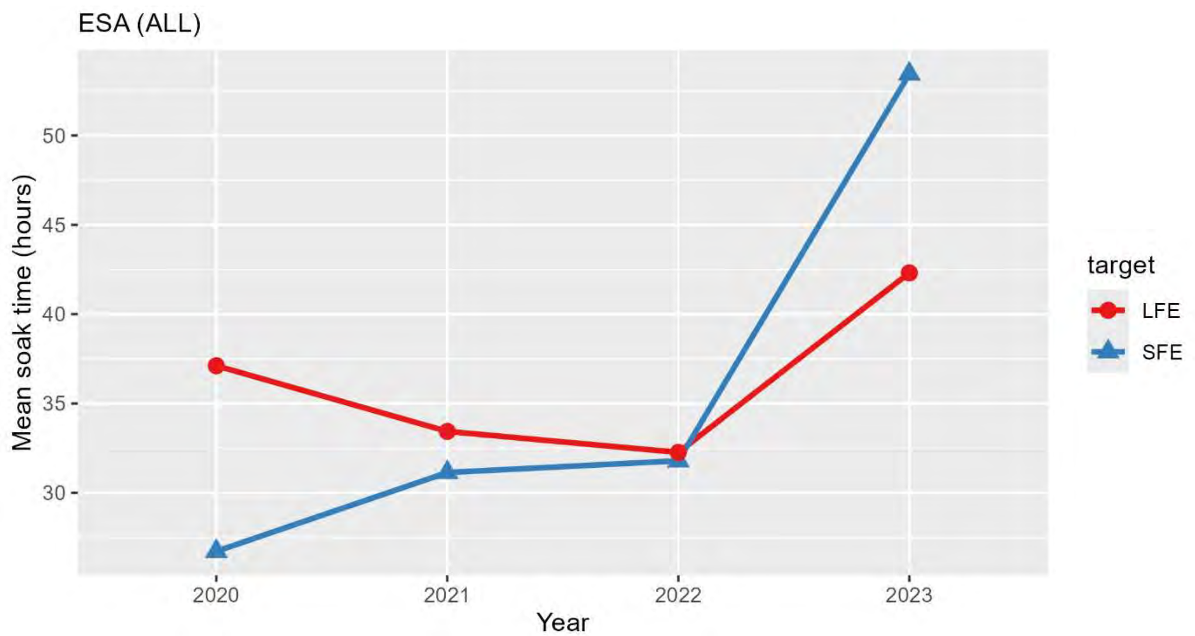

Figure 18: Mean soak time for fishing events (sets) in the South Island eel fishery by target species from 2020 to 2023 (ERS data).

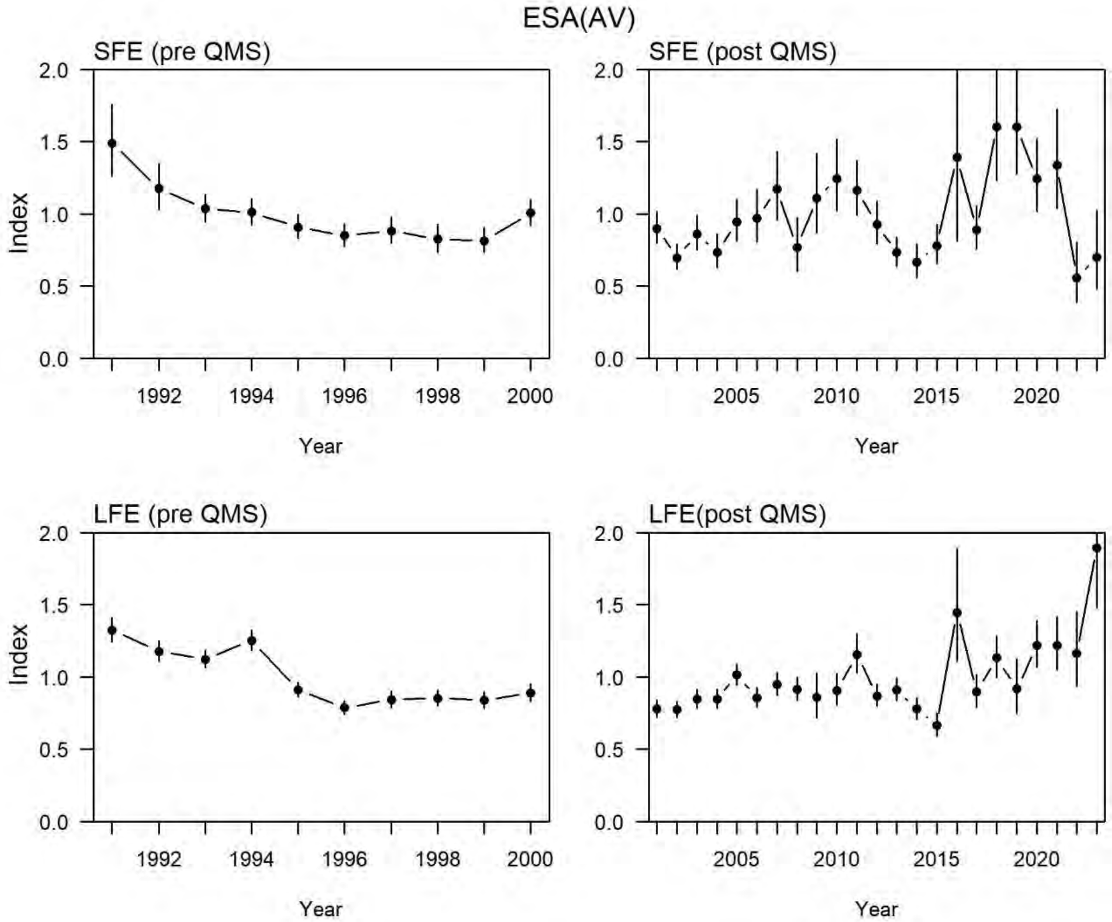

Figure 19: Standardised CPUE indices for shortfin and longfin eel for the fishing years 1991 to 2000 (pre-QMS) and 2001 to 2023 (post-QMS) for data-rich areas (AV, AW, AX) (continued on next two pages).

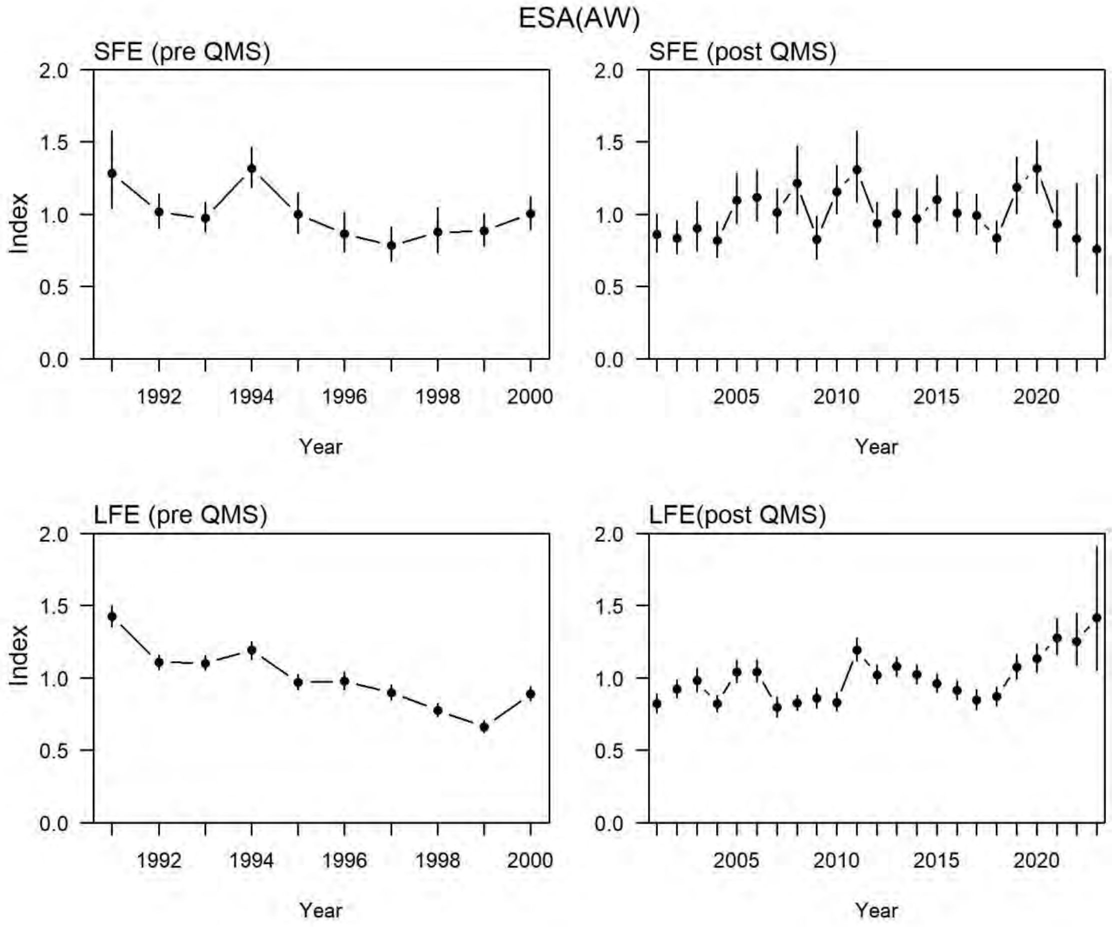

Figure 19 – *continued.*

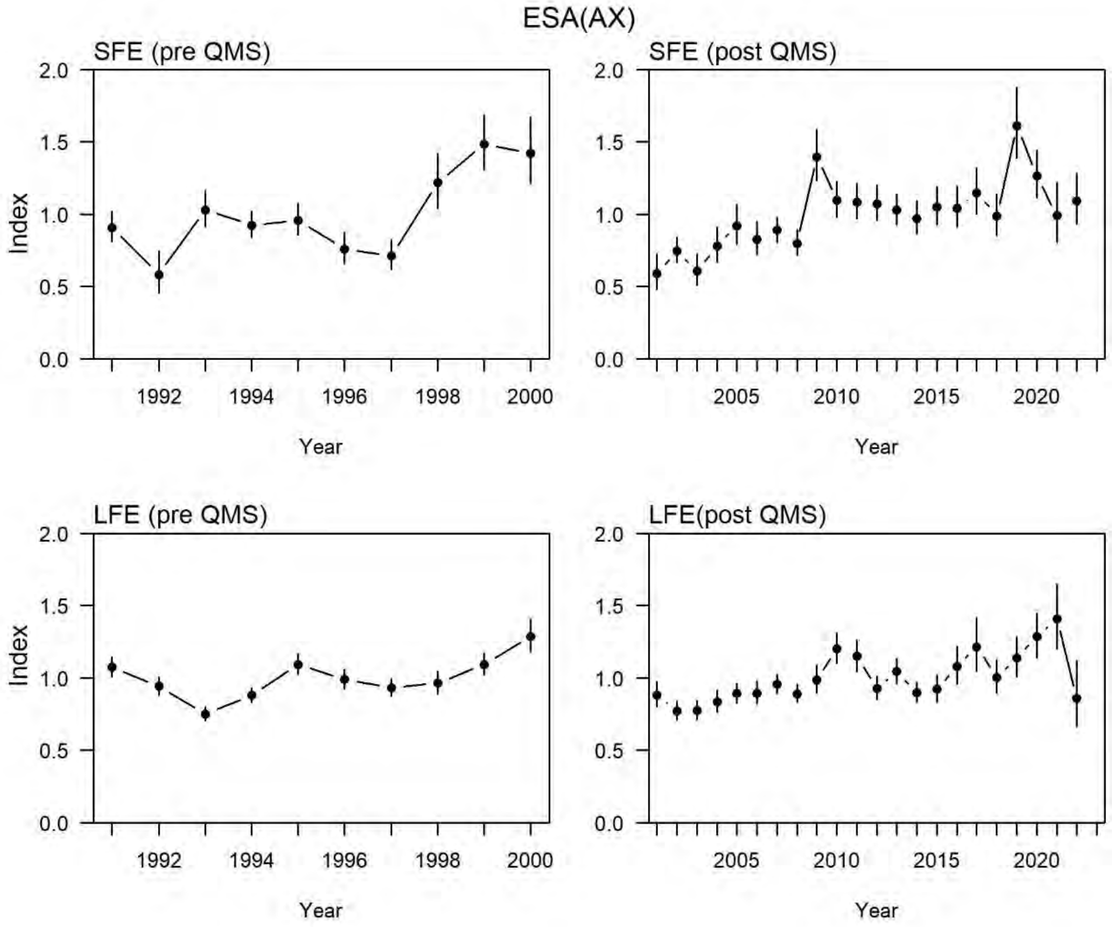

Figure 19 – ***continued.***

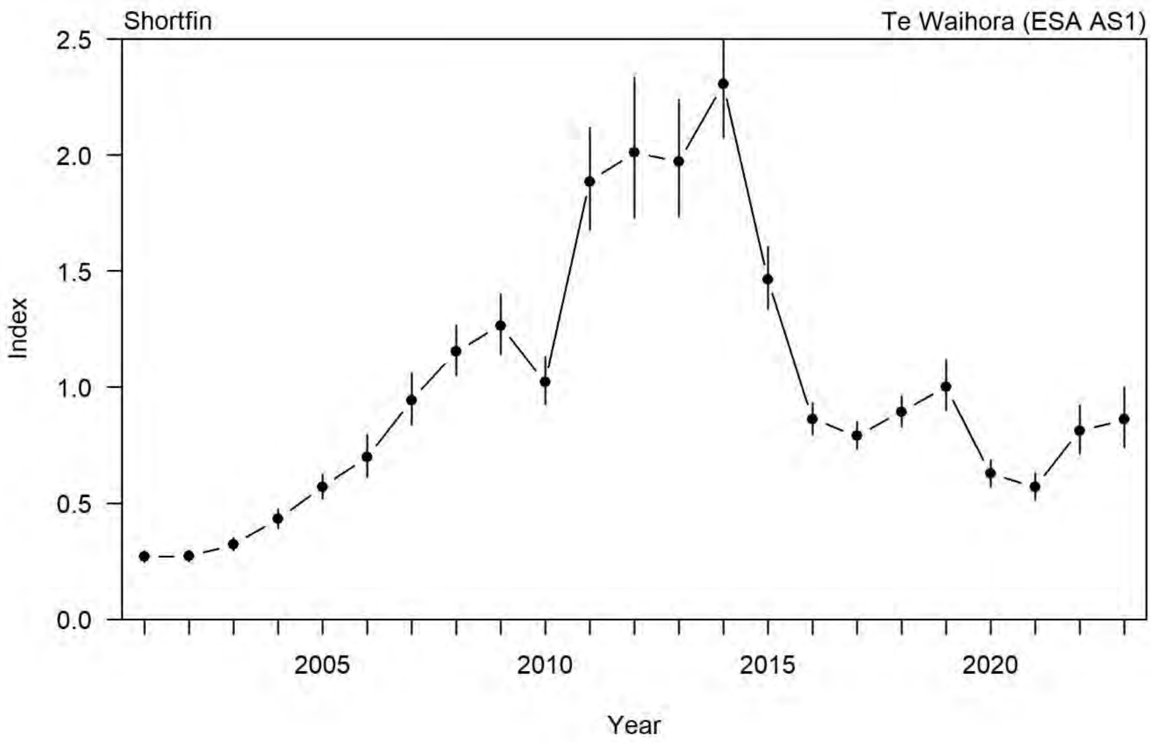

Figure 20: Standardised CPUE indices for shortfin in Te Waihora AS1 from 2001 to 2023 (post-QMS).

Figure 21: Size grade proportions of shortfin eels harvested from Te Waihora AS1 (lake) from 1996 to 1998, and from 2011 to 2018. The data from 2011 to 2018 are from eel processors Levin Eel Trading Ltd (LET) and Mossburn Enterprises Ltd. The data from 1996 to 1998 are the equivalent size grades estimated from the length of eels taken during commercial catch sampling of the commercial catch from Te Waihora (Figure from Beentjes 2021).

9. APPENDICES (TABLES)

Appendix 1: Daily mean river flow data used in the standardised CPUE analyses. *Te Waihora level and if lake was open or closed to the ocean.

Region	ESA	River/lake	Site location	Source
Westland	15 (AX)	Buller River	Site 93203 at Te Kuha	NIWA
		Grey River	Site 91401 at Dobson	NIWA
		Hokitika River	Site 90612 at Gorge	NIWA
Otago	19 (AV)	Clutha River	Site 75207 at Balclutha	NIWA
		Taieri River	Site 74308 at Outram	Otago Regional Council
		Waipori River	Site 74321 at Berrick	Otago Regional Council
Southland	20 (AW)	Mataura River	Site 77519 at Seaward Downs	Environment Southland
		Aparima	Site 78901 at Thornbury	Environment Southland
		Oreti River	Site 78601 at Wallacetown	Environment Southland
		Waiau River	Site 79701 at Tuatapere	NIWA/Meridian
Te Waihora	AS	Selwyn River	Site 68001 at Whitecliffs	NIWA
		Te Waihora*	Site 68302 at Taumutu*	Environment Canterbury

Appendix 2: Predictor variables and R^2 values from GLM stepwise regression analysis for pre- and post- QMS CPUE analyses for data rich areas. Variables are shown in order of acceptance by the model with associated cumulative R^2 value. Only variables entered in the model are shown. LFE, longfin; SFE, shortfin.

Region	Species	Variable	R^2 Pre-QMS	Variable	R^2 Post-QMS
ESA AV	SFE	fish.year	0.05	fish.year	0.14
		permit	0.44	permit	0.58
		target_est	0.52	target_est	0.67
		poly(log(lifts), 3)	0.60	poly(log(lifts), 3)	0.73
		month	0.61	month	0.74
	LFE	fish.year	0.06	fish.year	0.10
		permit	0.37	target_est	0.42
		poly(log(lifts), 3)	0.50	poly(log(lifts), 3)	0.59
		target_est	0.60	permit	0.65
		month	0.61	month	0.67
ESA AW	SFE	fish.year	0.05	fish.year	0.06
		permit	0.60	target_est	0.42
		poly(log(lifts), 3)	0.70	poly(log(lifts), 3)	0.58
		target_est	0.73	permit	0.65
		month	0.75	month	0.66
	LFE	fish.year	0.02	fish.year	0.06
		permit	0.25	poly(log(lifts), 3)	0.45
		poly(log(lifts), 3)	0.46	target_est	0.57
		month	0.49	permit	0.63
		target_est	0.50	month	0.65
ESA AX	SFE	fish.year	0.13	fish.year	0.20
		permit	0.64	permit	0.55
		target_est	0.73	target_est	0.64
		poly(log(lifts), 3)	0.77	poly(log(lifts), 3)	0.69
		month	0.77	poly(Grey_flow, 3)	0.70
	LFE	fish.year	0.06	fish.year	0.12
		permit	0.51	permit	0.43
		poly(log(lifts), 3)	0.59	poly(log(lifts),3)	0.59
		target_est	0.63	target_est	0.68
		month	0.64		
ESA AS1	SFE	–	–	fish.year	0.19
		–	–	poly(log(lifts), 3)	0.40
		–	–	month	0.47
				permit	0.51

Appendix 3: CPUE indices for data rich areas by ESA for shortfin and longfin, pre- and post-QMS. CI, 95% confidence intervals; s.e., standard error; CV, coefficient of variation; –, insufficient data. 1991 represents 1990–91 fishing year. (Continued over next three pages)

ESA AV

Shortfin

Pre-QMS						Post-QMS					
		Confidence intervals						Confidence intervals			
Year	Index	Lower	Upper	s.e.	CV	Year	Index	Lower	Upper	s.e.	CV
1991	1.51	1.28	1.79	0.08	0.08	2001	0.94	0.83	1.06	0.06	0.06
1992	1.20	1.05	1.37	0.07	0.07	2002	0.73	0.64	0.82	0.06	0.06
1993	1.05	0.96	1.15	0.05	0.05	2003	0.90	0.78	1.03	0.07	0.07
1994	1.03	0.94	1.12	0.04	0.04	2004	0.77	0.65	0.90	0.08	0.08
1995	0.92	0.84	1.01	0.05	0.05	2005	0.99	0.85	1.15	0.08	0.08
1996	0.87	0.79	0.95	0.05	0.05	2006	1.01	0.84	1.22	0.09	0.09
1997	0.90	0.81	0.99	0.05	0.05	2007	1.22	1.00	1.49	0.10	0.10
1998	0.84	0.75	0.94	0.06	0.06	2008	0.80	0.63	1.02	0.12	0.12
1999	0.83	0.75	0.92	0.05	0.05	2009	1.16	0.90	1.48	0.12	0.12
2000	1.02	0.94	1.12	0.04	0.04	2010	1.30	1.06	1.58	0.10	0.10
						2011	1.22	1.03	1.43	0.08	0.08
						2012	0.97	0.83	1.13	0.08	0.08
						2013	0.76	0.66	0.88	0.07	0.07
						2014	0.70	0.59	0.83	0.09	0.09
						2015	0.81	0.69	0.97	0.09	0.09
						2016	1.45	0.84	2.49	0.27	0.28
						2017	0.93	0.79	1.10	0.08	0.08
						2018	1.67	1.28	2.17	0.13	0.13
						2019	1.67	1.33	2.10	0.11	0.11
						2020	1.30	1.06	1.59	0.10	0.10
						2021	1.39	1.08	1.80	0.13	0.13
						2022	0.58	0.40	0.84	0.18	0.18
						2023	0.73	0.50	1.07	0.19	0.19

Longfin

Pre-QMS						Post-QMS					
		Confidence intervals						Confidence intervals			
Year	Index	Lower	Upper	s.e.	CV	Year	Index	Lower	Upper	s.e.	CV
1991	1.35	1.26	1.43	0.03	0.03	2001	0.80	0.74	0.86	0.04	0.04
1992	1.20	1.13	1.27	0.03	0.03	2002	0.80	0.74	0.85	0.04	0.04
1993	1.14	1.08	1.21	0.03	0.03	2003	0.87	0.80	0.94	0.04	0.04
1994	1.27	1.21	1.35	0.03	0.03	2004	0.87	0.80	0.94	0.04	0.04
1995	0.93	0.88	0.98	0.03	0.03	2005	1.04	0.97	1.12	0.04	0.04
1996	0.80	0.75	0.85	0.03	0.03	2006	0.88	0.82	0.95	0.04	0.04
1997	0.86	0.80	0.92	0.03	0.03	2007	0.97	0.89	1.06	0.04	0.04
1998	0.87	0.81	0.93	0.03	0.03	2008	0.94	0.86	1.03	0.04	0.04
1999	0.85	0.80	0.91	0.03	0.03	2009	0.88	0.74	1.06	0.09	0.09
2000	0.91	0.85	0.97	0.03	0.03	2010	0.93	0.83	1.05	0.06	0.06
						2011	1.19	1.06	1.33	0.06	0.06
						2012	0.89	0.82	0.97	0.04	0.04
						2013	0.94	0.86	1.02	0.04	0.04
						2014	0.80	0.73	0.88	0.05	0.05
						2015	0.68	0.60	0.77	0.06	0.06
						2016	1.49	1.14	1.94	0.13	0.13
						2017	0.92	0.82	1.05	0.06	0.06
						2018	1.16	1.02	1.32	0.06	0.06
						2019	0.94	0.77	1.16	0.10	0.10
						2020	1.25	1.10	1.43	0.07	0.07
						2021	1.25	1.08	1.46	0.08	0.08
						2022	1.20	0.96	1.49	0.11	0.11
						2023	1.95	1.52	2.49	0.12	0.12

ESA AW

Shortfin

Pre-QMS						Post-QMS					
		Confidence intervals						Confidence intervals			
Year	Index	Lower	Upper	s.e.	CV	Year	Index	Lower	Upper	s.e.	CV
1991	1.30	1.06	1.60	0.10	0.10	2001	0.87	0.75	1.01	0.08	0.08
1992	1.03	0.91	1.16	0.06	0.06	2002	0.84	0.74	0.97	0.07	0.07
1993	0.99	0.89	1.10	0.05	0.05	2003	0.91	0.75	1.10	0.09	0.09
1994	1.33	1.20	1.48	0.05	0.05	2004	0.83	0.71	0.96	0.08	0.08
1995	1.01	0.88	1.17	0.07	0.07	2005	1.11	0.95	1.30	0.08	0.08
1996	0.88	0.75	1.03	0.08	0.08	2006	1.13	0.97	1.32	0.08	0.08
1997	0.79	0.68	0.92	0.07	0.07	2007	1.03	0.88	1.19	0.08	0.08
1998	0.89	0.74	1.06	0.09	0.09	2008	1.23	1.01	1.49	0.10	0.10
1999	0.90	0.79	1.02	0.06	0.06	2009	0.84	0.70	1.00	0.09	0.09
2000	1.01	0.91	1.13	0.06	0.06	2010	1.17	1.02	1.35	0.07	0.07
						2011	1.32	1.10	1.59	0.09	0.09
						2012	0.95	0.82	1.10	0.07	0.07
						2013	1.02	0.87	1.19	0.08	0.08
						2014	0.98	0.81	1.19	0.10	0.10
						2015	1.11	0.97	1.28	0.07	0.07
						2016	1.02	0.89	1.17	0.07	0.07
						2017	1.00	0.87	1.15	0.07	0.07
						2018	0.84	0.74	0.97	0.07	0.07
						2019	1.20	1.02	1.42	0.08	0.08
						2020	1.33	1.16	1.53	0.07	0.07
						2021	0.94	0.76	1.18	0.11	0.11
						2022	0.84	0.58	1.23	0.19	0.19
						2023	0.77	0.46	1.29	0.26	0.26

Longfin

Pre-QMS						Post-QMS					
		Confidence intervals						Confidence intervals			
Year	Index	Lower	Upper	s.e.	CV	Year	Index	Lower	Upper	s.e.	CV
1991	1.46	1.38	1.54	0.03	0.03	2001	0.83	0.77	0.90	0.04	0.04
1992	1.13	1.08	1.18	0.02	0.02	2002	0.93	0.87	1.00	0.03	0.03
1993	1.13	1.07	1.18	0.02	0.02	2003	0.99	0.91	1.08	0.04	0.04
1994	1.22	1.16	1.28	0.03	0.03	2004	0.83	0.78	0.89	0.03	0.03
1995	0.99	0.94	1.05	0.03	0.03	2005	1.05	0.98	1.13	0.04	0.04
1996	1.00	0.94	1.06	0.03	0.03	2006	1.06	0.98	1.14	0.04	0.04
1997	0.92	0.87	0.97	0.03	0.03	2007	0.81	0.74	0.88	0.04	0.04
1998	0.79	0.75	0.84	0.03	0.03	2008	0.84	0.79	0.89	0.03	0.03
1999	0.68	0.64	0.72	0.03	0.03	2009	0.87	0.80	0.95	0.04	0.04
2000	0.91	0.86	0.96	0.03	0.03	2010	0.84	0.78	0.91	0.04	0.04
						2011	1.21	1.13	1.29	0.03	0.03
						2012	1.03	0.97	1.10	0.03	0.03
						2013	1.09	1.03	1.16	0.03	0.03
						2014	1.04	0.97	1.10	0.03	0.03
						2015	0.97	0.91	1.04	0.03	0.03
						2016	0.93	0.86	0.99	0.04	0.04
						2017	0.86	0.79	0.93	0.04	0.04
						2018	0.88	0.82	0.95	0.04	0.04
						2019	1.09	1.00	1.18	0.04	0.04
						2020	1.15	1.05	1.25	0.04	0.04
						2021	1.29	1.18	1.43	0.05	0.05
						2022	1.27	1.10	1.46	0.07	0.07
						2023	1.44	1.07	1.93	0.15	0.15

ESA AX

Shortfin

Pre-QMS						Post-QMS					
		Confidence intervals						Confidence intervals			
Year	Index	Lower	Upper	s.e.	CV	Year	Index	Lower	Upper	s.e.	CV
1991	0.95	0.84	1.06	0.06	0.06	2001	0.61	0.49	0.74	0.10	0.10
1992	0.61	0.47	0.78	0.12	0.12	2002	0.77	0.68	0.87	0.06	0.06
1993	1.07	0.95	1.21	0.06	0.06	2003	0.63	0.53	0.75	0.09	0.09
1994	0.96	0.87	1.06	0.05	0.05	2004	0.80	0.69	0.94	0.08	0.08
1995	1.00	0.89	1.12	0.06	0.06	2005	0.94	0.81	1.10	0.08	0.08
1996	0.79	0.68	0.91	0.07	0.07	2006	0.85	0.74	0.97	0.07	0.07
1997	0.74	0.64	0.86	0.07	0.07	2007	0.91	0.83	1.01	0.05	0.05
1998	1.27	1.09	1.48	0.08	0.08	2008	0.82	0.73	0.92	0.06	0.06
1999	1.55	1.36	1.76	0.06	0.06	2009	1.44	1.27	1.63	0.06	0.06
2000	1.48	1.26	1.74	0.08	0.08	2010	1.12	1.00	1.26	0.06	0.06
						2011	1.11	0.99	1.25	0.06	0.06
						2012	1.10	0.98	1.23	0.06	0.06
						2013	1.06	0.95	1.17	0.05	0.05
						2014	1.00	0.89	1.12	0.06	0.06
						2015	1.08	0.95	1.22	0.06	0.06
						2016	1.07	0.93	1.23	0.07	0.07
						2017	1.18	1.03	1.36	0.07	0.07
						2018	1.01	0.88	1.17	0.07	0.07
						2019	1.66	1.43	1.93	0.08	0.08
						2020	1.30	1.14	1.48	0.06	0.07
						2021	1.02	0.83	1.25	0.10	0.10
						2022	1.12	0.96	1.32	0.08	0.08

Longfin

Pre-QMS						Post-QMS					
		Confidence intervals						Confidence intervals			
Year	Index	Lower	Upper	s.e.	CV	Year	Index	Lower	Upper	s.e.	CV
1991	1.08	1.02	1.16	0.03	0.03	2001	0.89	0.81	0.99	0.05	0.05
1992	0.95	0.89	1.02	0.03	0.03	2002	0.78	0.72	0.85	0.04	0.04
1993	0.76	0.71	0.81	0.03	0.03	2003	0.78	0.72	0.85	0.04	0.04
1994	0.89	0.84	0.94	0.03	0.03	2004	0.84	0.77	0.92	0.04	0.04
1995	1.10	1.03	1.18	0.03	0.03	2005	0.90	0.84	0.97	0.04	0.04
1996	1.00	0.93	1.07	0.03	0.03	2006	0.91	0.83	0.99	0.04	0.04
1997	0.94	0.88	1.00	0.03	0.03	2007	0.97	0.90	1.04	0.03	0.03
1998	0.97	0.90	1.06	0.04	0.04	2008	0.90	0.84	0.97	0.04	0.04
1999	1.10	1.03	1.18	0.03	0.03	2009	1.00	0.90	1.10	0.05	0.05
2000	1.30	1.19	1.42	0.04	0.04	2010	1.22	1.11	1.33	0.04	0.04
						2011	1.16	1.06	1.28	0.05	0.05
						2012	0.94	0.86	1.02	0.04	0.04
						2013	1.06	0.97	1.15	0.04	0.04
						2014	0.91	0.84	0.98	0.04	0.04
						2015	0.93	0.85	1.03	0.05	0.05
						2016	1.09	0.97	1.23	0.06	0.06
						2017	1.23	1.06	1.43	0.08	0.08
						2018	1.01	0.90	1.14	0.06	0.06
						2019	1.15	1.02	1.30	0.06	0.06
						2020	1.30	1.15	1.47	0.06	0.06
						2021	1.43	1.22	1.67	0.08	0.08
						2022	0.87	0.67	1.14	0.13	0.13

ESA AS1

											Shortfin
					Pre-QMS						Post-QMS
		Confidence intervals						Confidence intervals			
Year	Index	Lower	Upper	s.e.	CV	Year	Index	Lower	Upper	s.e.	CV
1991	–	–	–	–	–	2001	0.318	0.292	0.347	0.04	0.04
1992	–	–	–	–	–	2002	0.321	0.295	0.349	0.04	0.04
1993	–	–	–	–	–	2003	0.380	0.348	0.414	0.04	0.04
1994	–	–	–	–	–	2004	0.510	0.462	0.562	0.05	0.05
1995	–	–	–	–	–	2005	0.674	0.614	0.740	0.05	0.05
1996	–	–	–	–	–	2006	0.824	0.722	0.940	0.07	0.07
1997	–	–	–	–	–	2007	1.114	0.989	1.255	0.06	0.06
1998	–	–	–	–	–	2008	1.362	1.241	1.495	0.05	0.05
1999	–	–	–	–	–	2009	1.493	1.347	1.655	0.05	0.05
2000	–	–	–	–	–	2010	1.207	1.092	1.334	0.05	0.05
						2011	2.227	1.982	2.502	0.06	0.06
						2012	2.374	2.043	2.758	0.07	0.08
						2013	2.329	2.050	2.645	0.06	0.06
						2014	2.722	2.448	3.027	0.05	0.05
						2015	1.729	1.577	1.896	0.05	0.05
						2016	1.019	0.942	1.103	0.04	0.04
						2017	0.933	0.866	1.005	0.04	0.04
						2018	1.056	0.981	1.137	0.04	0.04
						2019	1.183	1.060	1.320	0.05	0.05
						2020	0.740	0.675	0.812	0.05	0.05
						2021	0.673	0.608	0.745	0.05	0.05
						2022	0.958	0.842	1.090	0.06	0.06
						2023	1.016	0.874	1.182	0.08	0.08

Appendices A to I

Plots of South Island eel fishery characterisation by Eel Statistical Area (AN, AP-AQ, AR, AT, AU, AV, AW, AX, AS), and CPUE analyses (AV, AW, AX, AS1) from 1991 to 2023. The plots are shown by ESA, with shortfin first followed by longfin for CPUE plots.

ESA AN (Nelson)

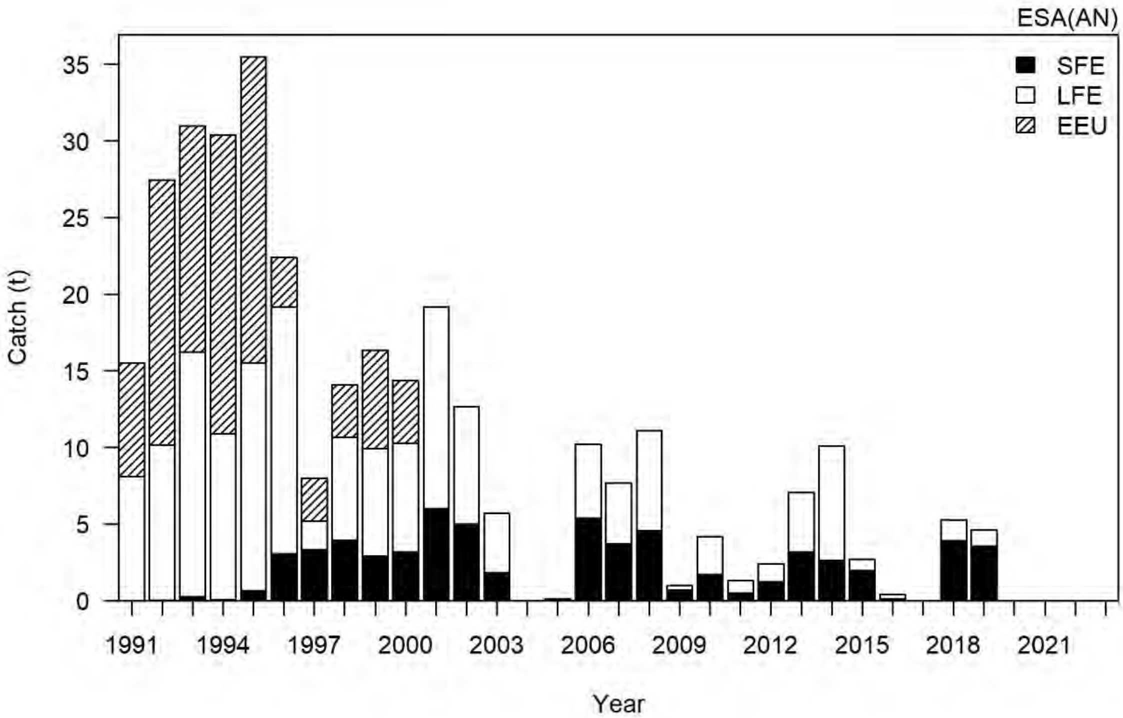

Figure A1: Total estimated commercial catch of shortfin (SFE), longfin (LFE), and unclassified eel catch (EEU) for the years 1990–91 to 2022–23 (ESA(AN)).

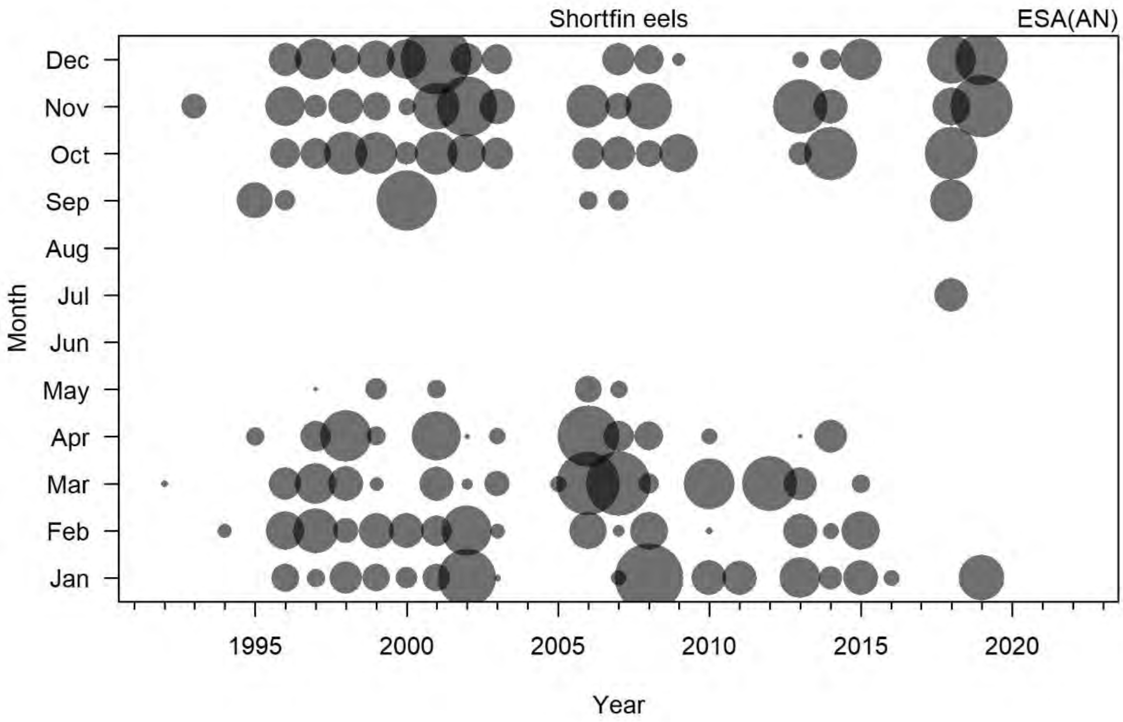

Figure A2: Shortfin eel catch by month for the years 1990–91 to 2022–23 (ESA(AN)).

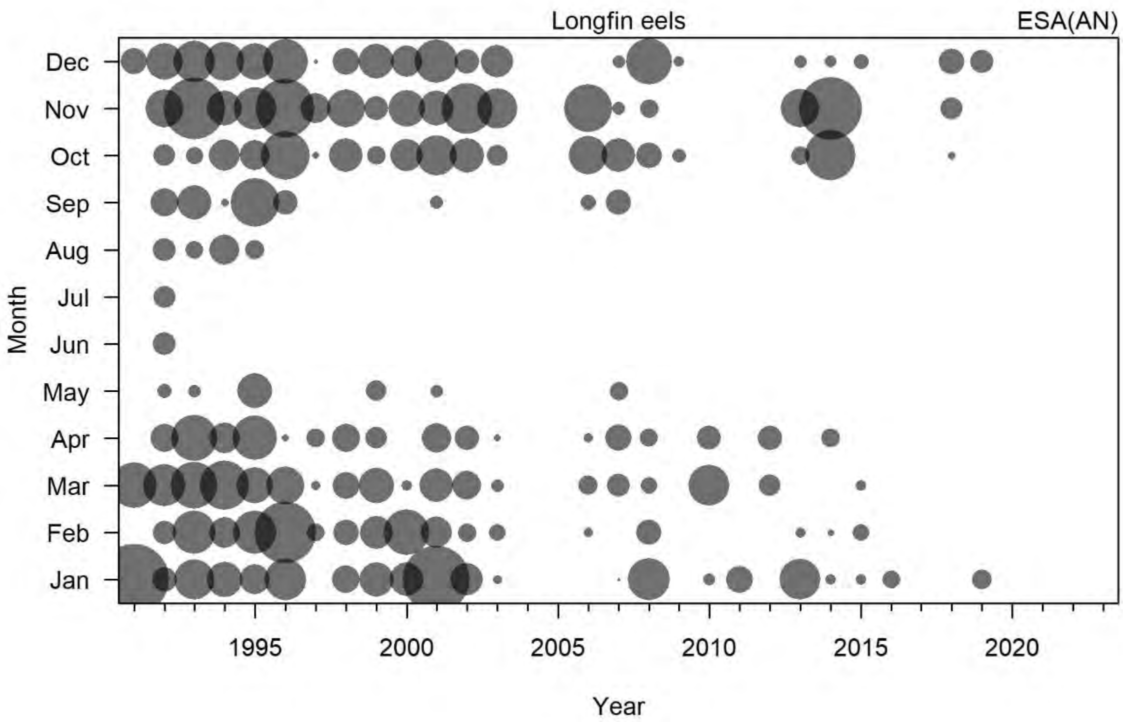

Figure A3: Longfin eel catch by month for the years 1990-–91 to 2022–23 (ESA(AN)).

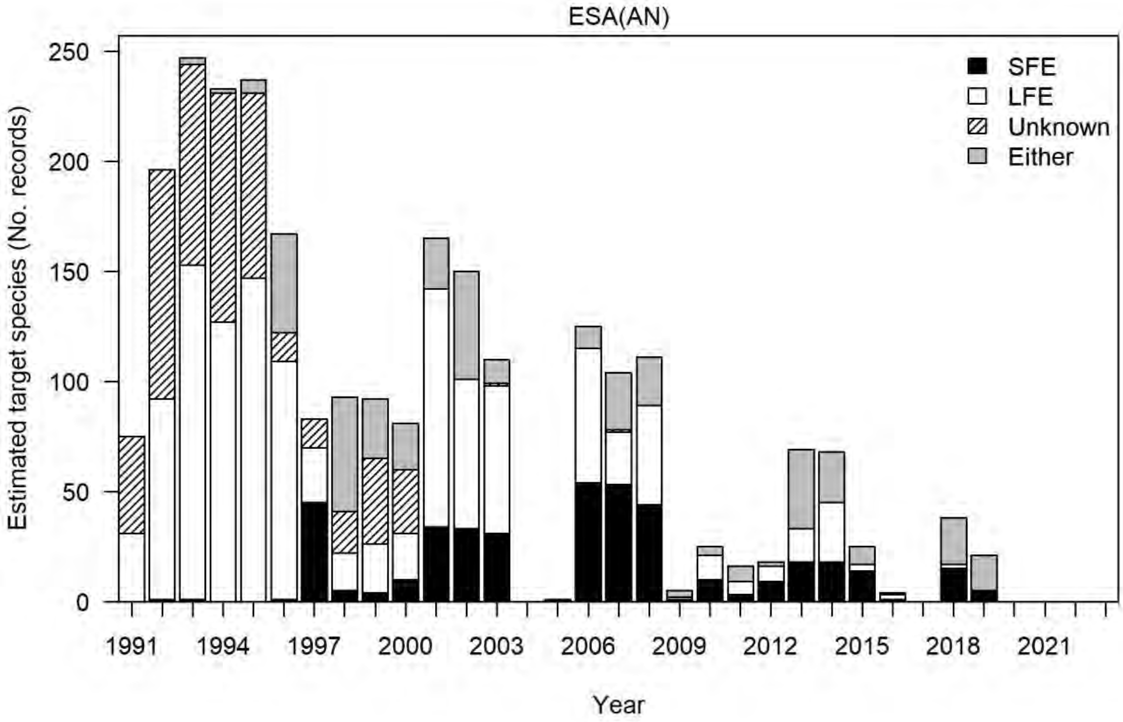

Figure A4: Reconstructed target species for the years 1990–91 to 2022–23 (ESA(AN)).

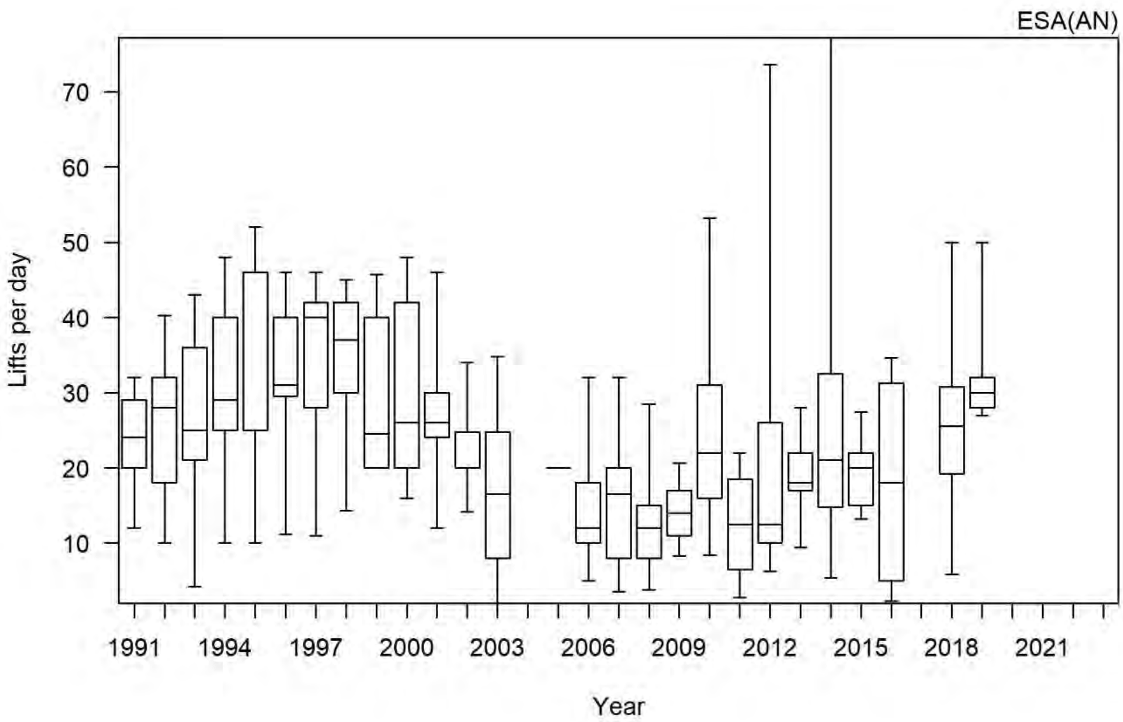

Figure A5: Total lifts per day for the years 1990–91 to 2022–23. The horizontal line is the median, the top and bottom of the box are the interquartiles (25th and 75th), and error bars are the 95th percentile range (ESA(AN)).

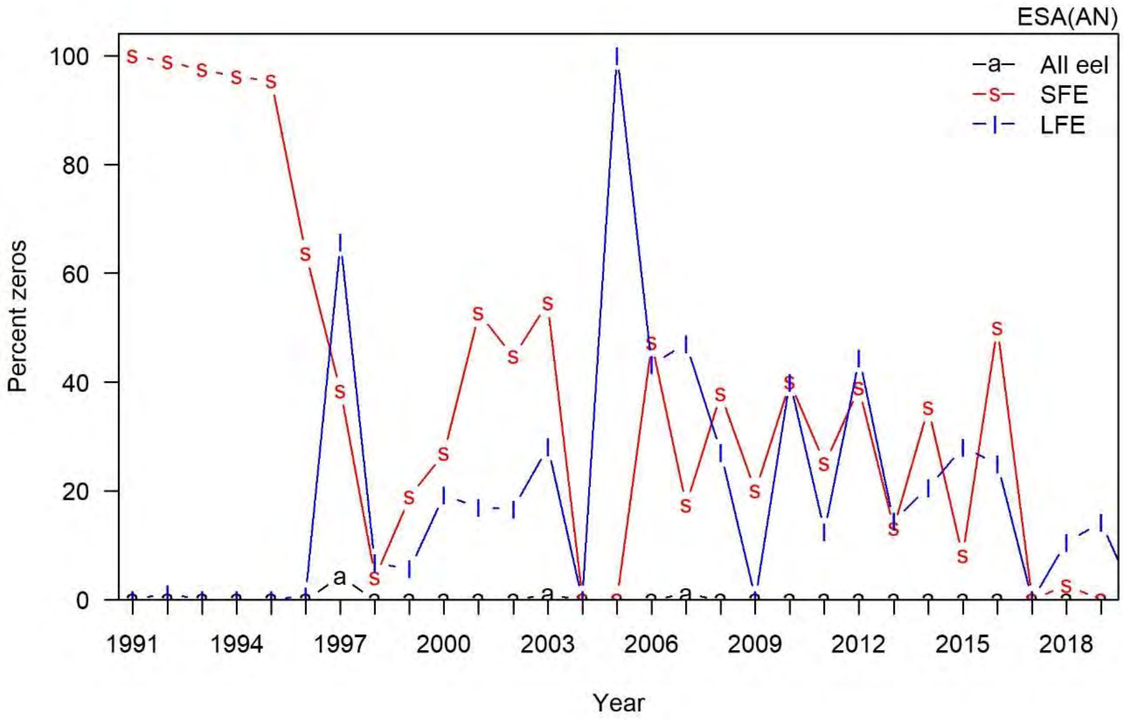

Figure A6: Proportion of valid zero records for all eels, shortfin (SFE), and longfin (LFE) catch for the years 1990–91 to 2022–23. Excludes zeros associated with reporting EEU (unclassified) (ESA(AN)).

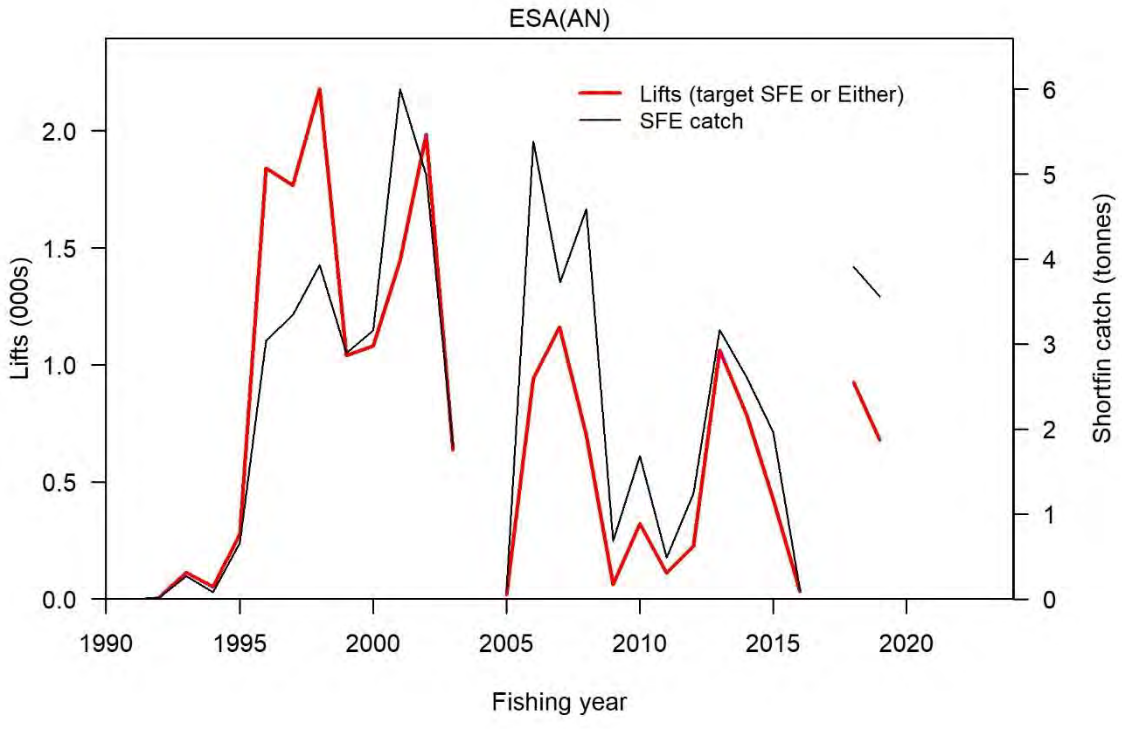

Figure A7: Total lifts and shortfin catch when target species was 'shortfin' or 'either' for the years 1990–91 to 2022–23 (ESA(AN)).

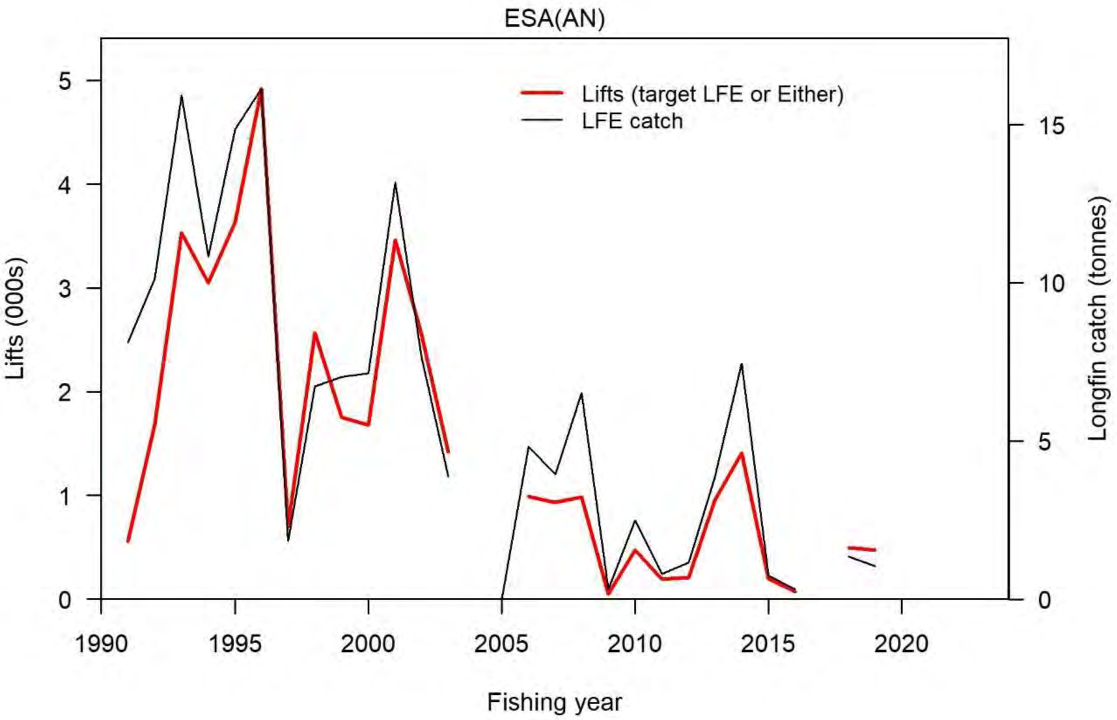

Figure A8: Total lifts and longfin catch when target species was 'longfin' or 'either' for the years 1990–91 to 2022–23 (ESA(AN)).

ESA AP-AQ (Marlborough)

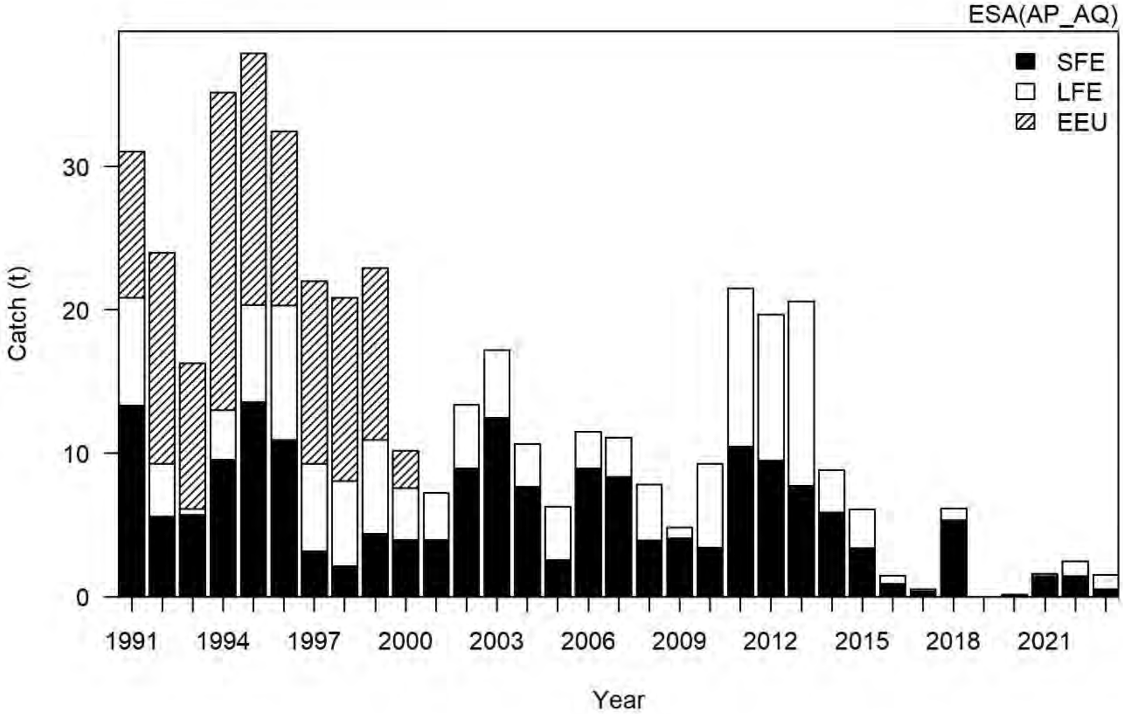

Figure B1: Total estimated commercial catch of shortfin (SFE), longfin (LFE), and unclassified eel catch (EEU) for the years 1990–91 to 2022–23 (ESA(AP_AQ)).

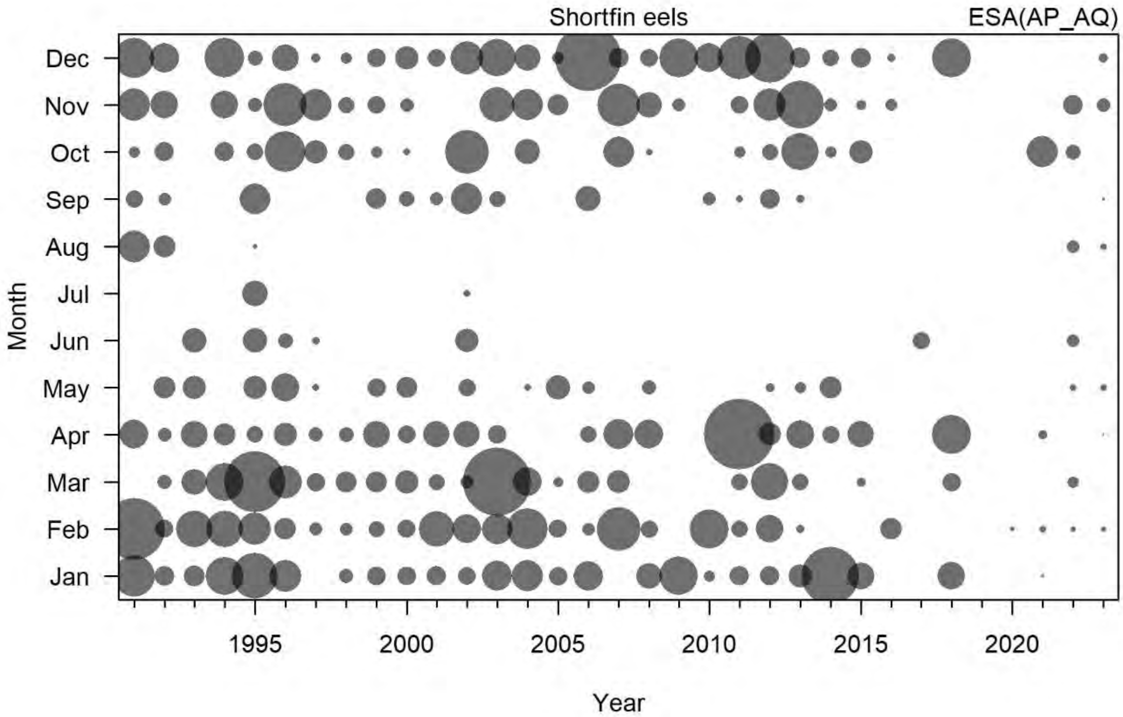

Figure B2: Shortfin eel catch by month for the years 1990–91 to 2022–23 (ESA(AP_AQ)).

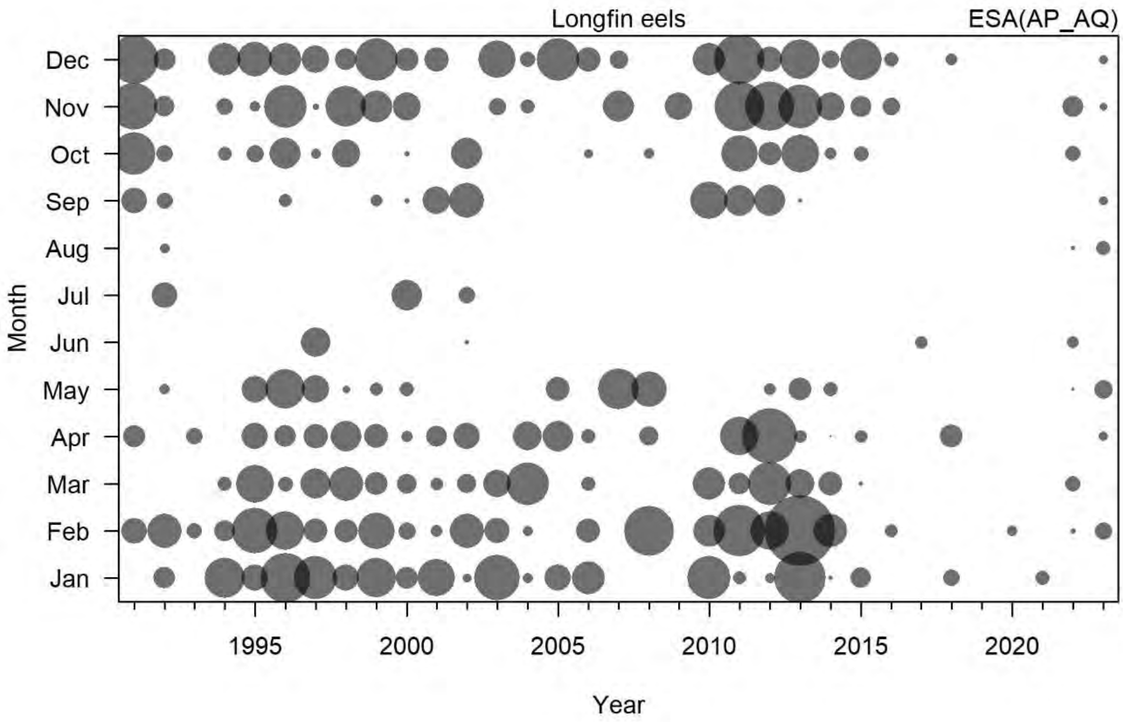

Figure B3: Longfin eel catch by month for the years 1990–-91 to 2022–23 (ESA(AP_AQ)).

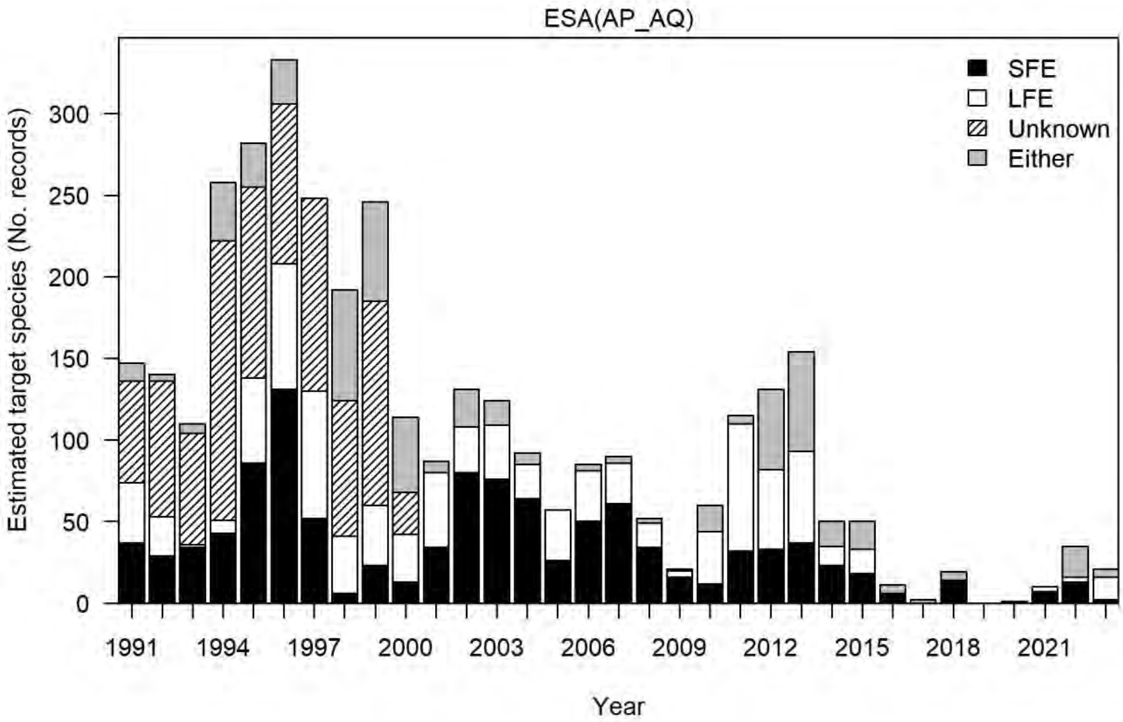

Figure B4: Reconstructed target species for the years 1990–91 to 2022–23 (ESA(AP_AQ)).

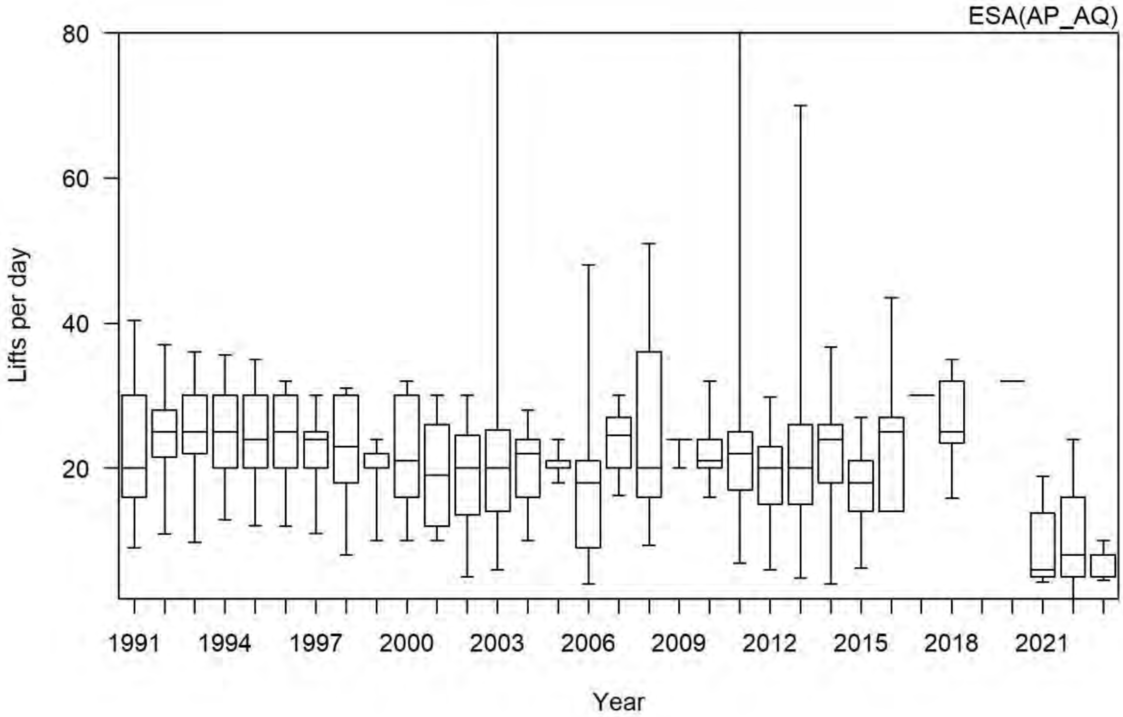

Figure B5: Total lifts per day for the years 1990–91 to 2022–23. The horizontal line is the median, the top and bottom of the box are the interquartiles (25th and 75th), and error bars are the 95th percentile range (ESA(AP_AQ)).

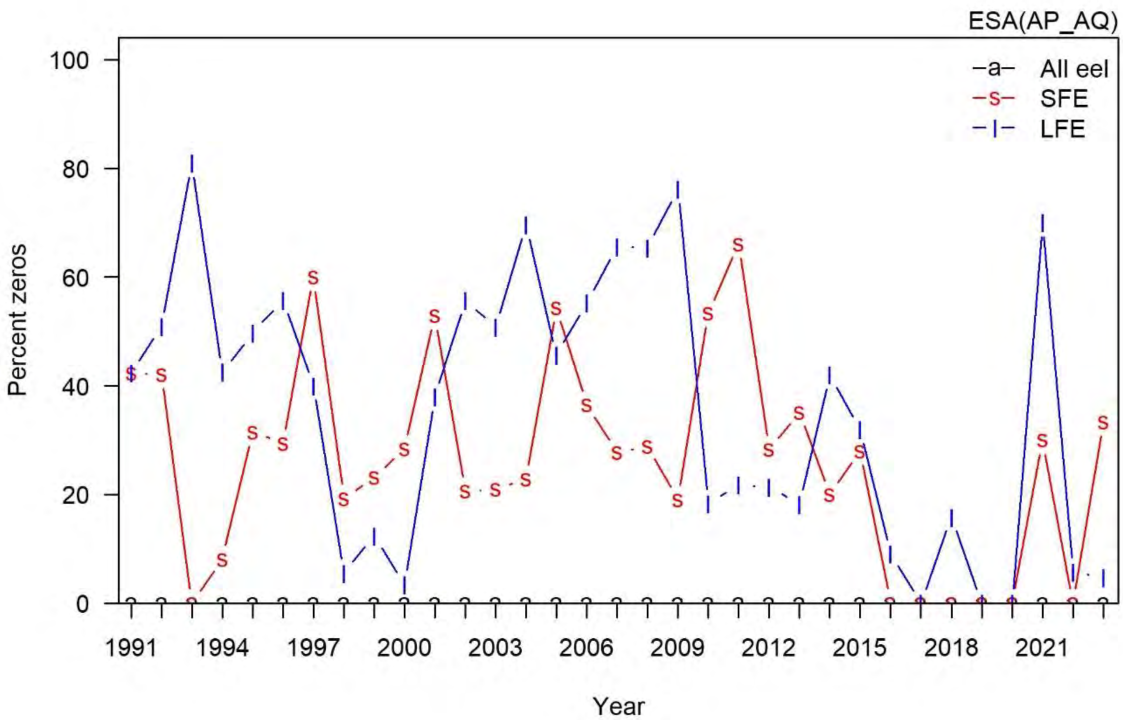

Figure B6: Proportion of valid zero records for all eels, shortfin (SFE), and longfin (LFE) catch for the years 1990–91 to 2022–23. Excludes zeros associated with reporting EEU (unclassified) (ESA(AP_AQ)).

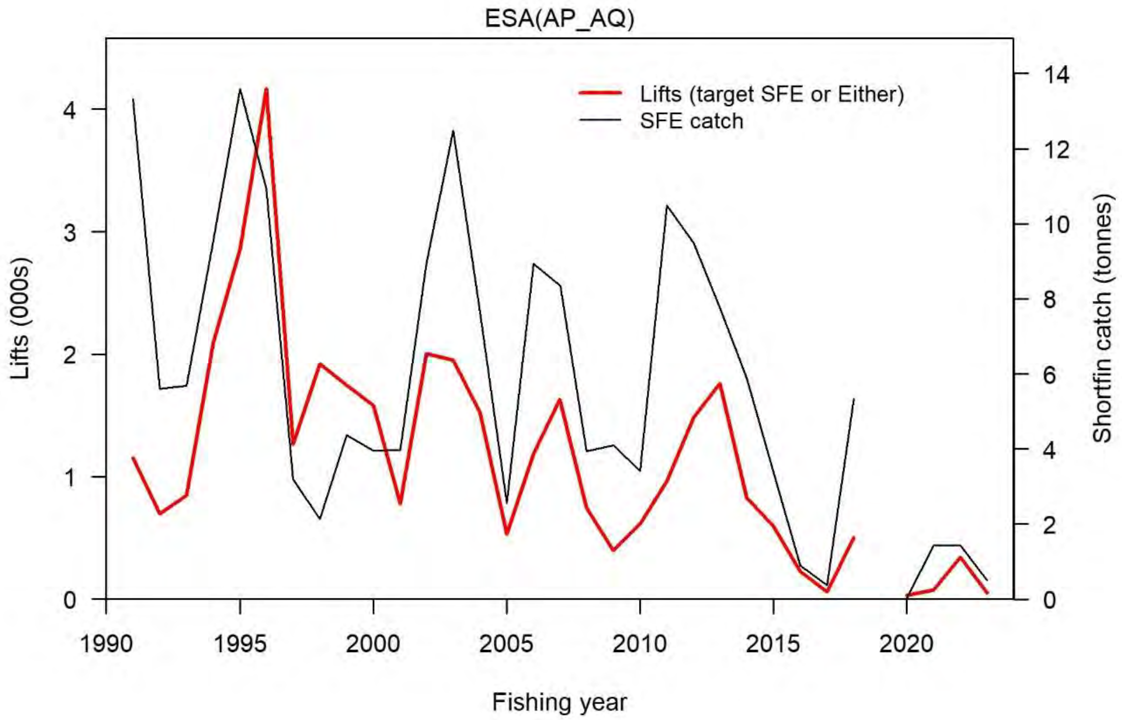

Figure B7: Total lifts and shortfin catch when target species was 'shortfin' or 'either' for the years 1990–91 to 2022–23 (ESA(AP_AQ)).

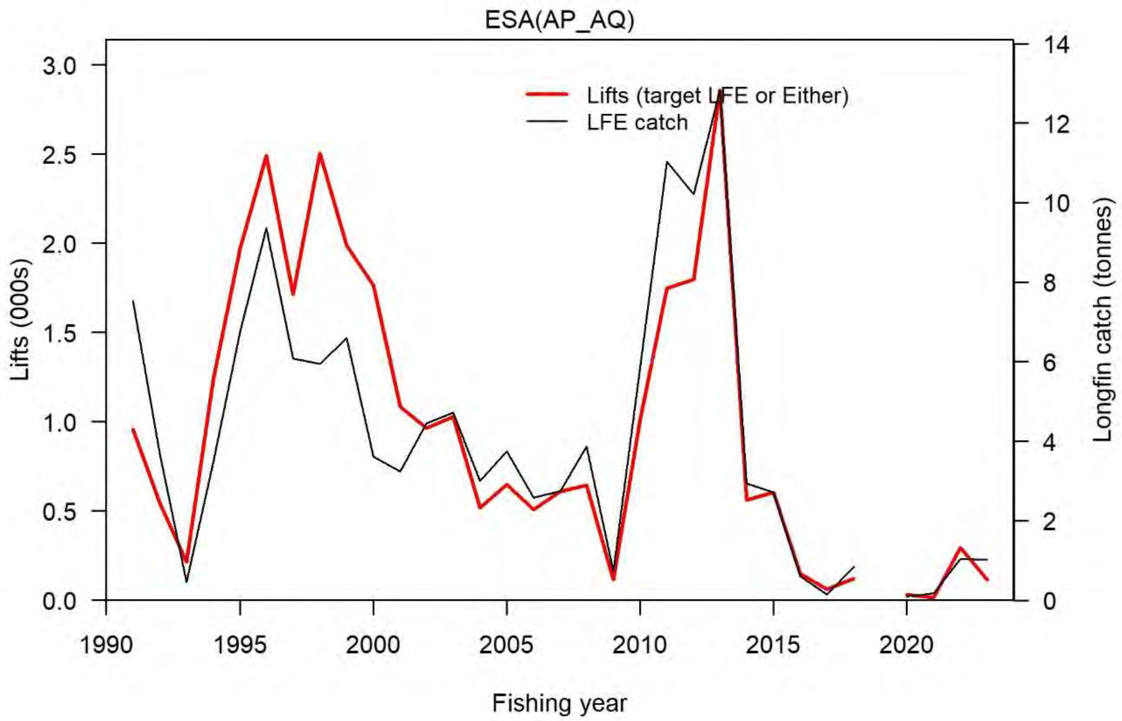

Figure B8: Total lifts and longfin catch when target species was 'longfin' or 'either' for the years 1990–91 to 2022–23 (ESA(AP_AQ)).

ESA AR (north Canterbury)

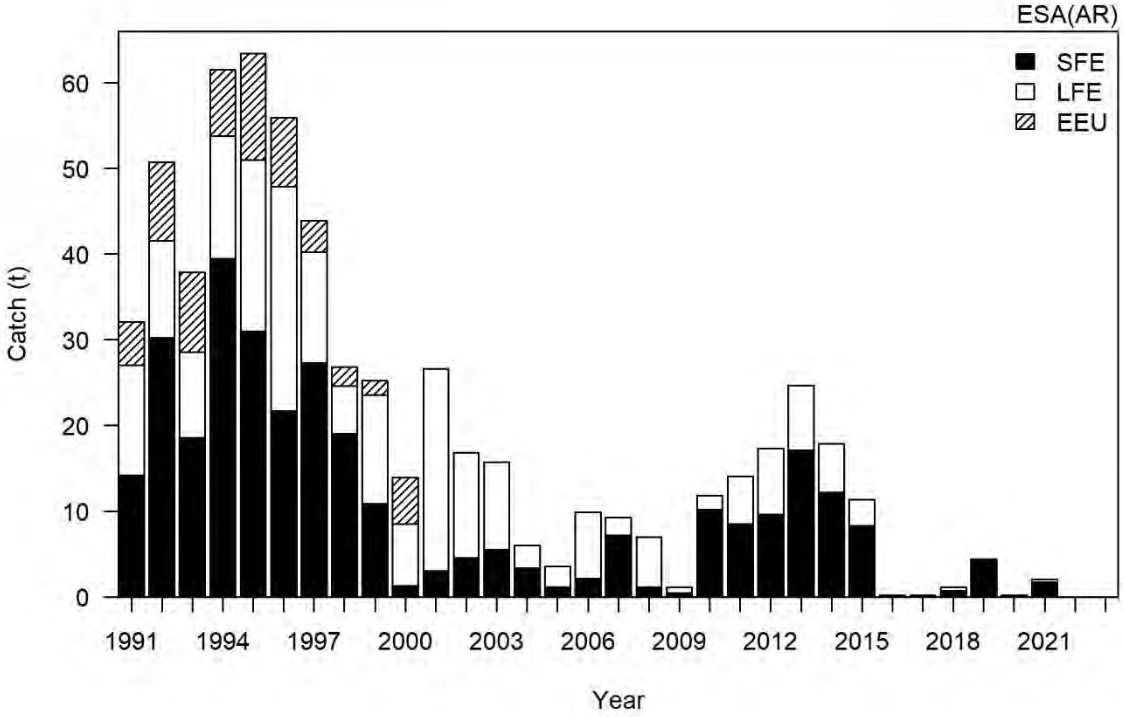

Figure C1: Total estimated commercial catch of shortfin (SFE), longfin (LFE), and unclassified eel catch (EEU) for the years 1990–91 to 2022–23 (ESA(AR)).

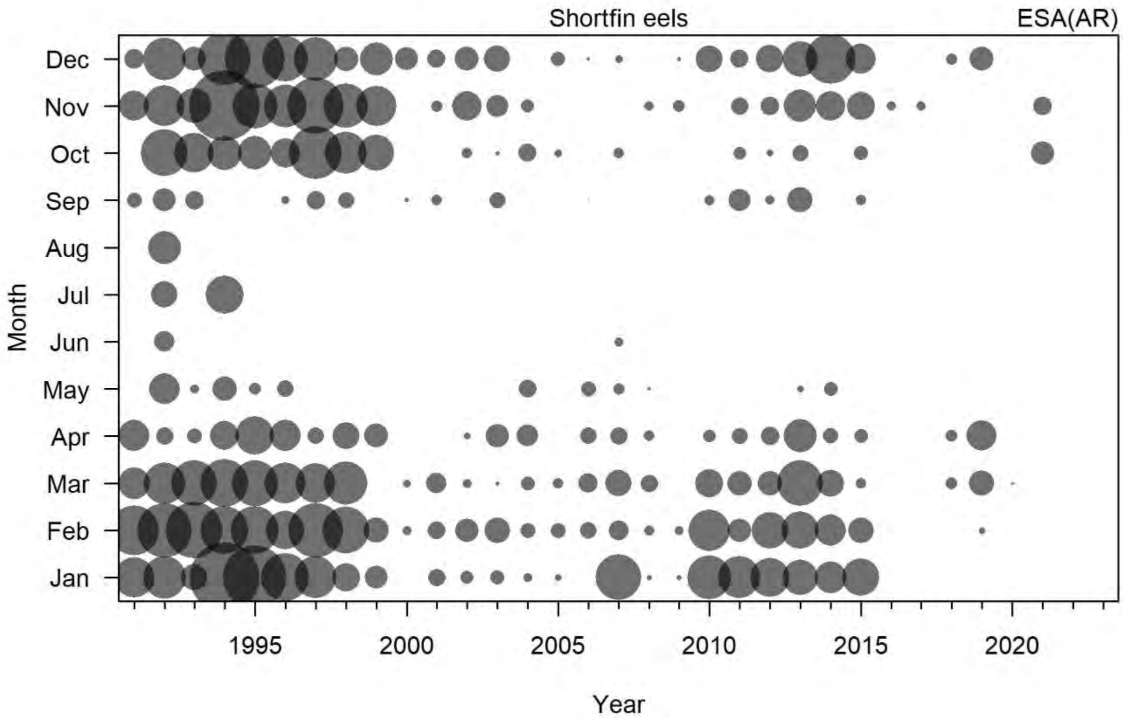

Figure C2: Shortfin eel catch by month for the years 1990–91 to 2022–23 (ESA(AR)).

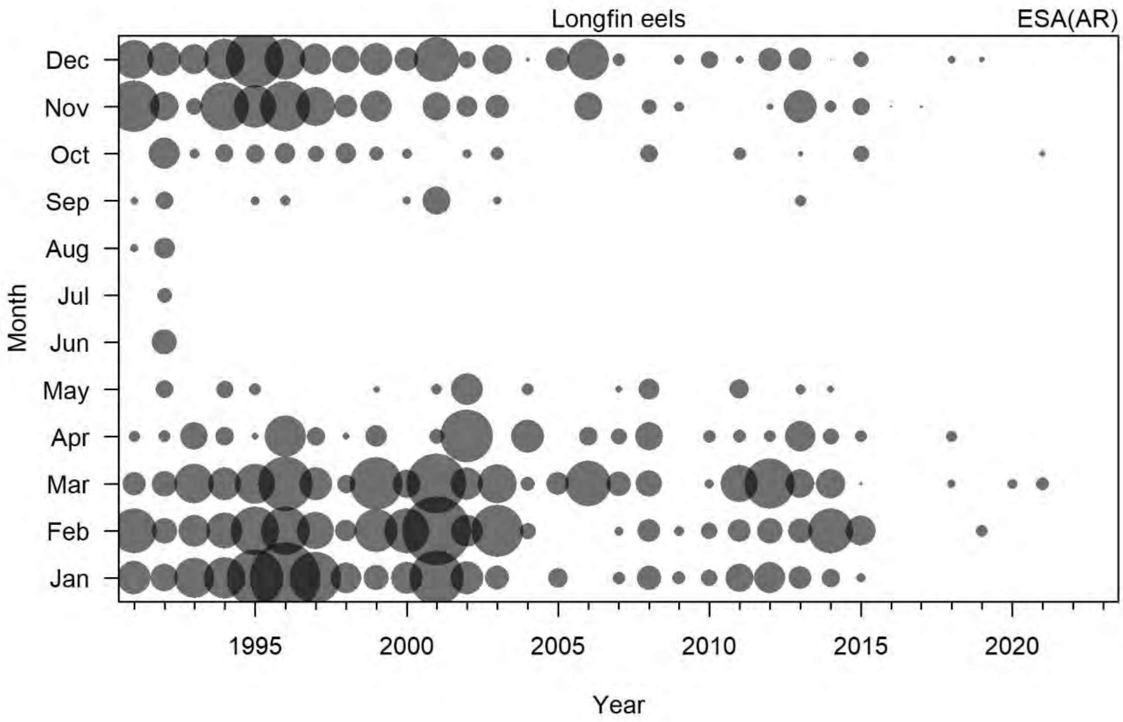

Figure C3: Longfin eel catch by month for the years 1990–-91 to 2022–23 (ESA(AR)).

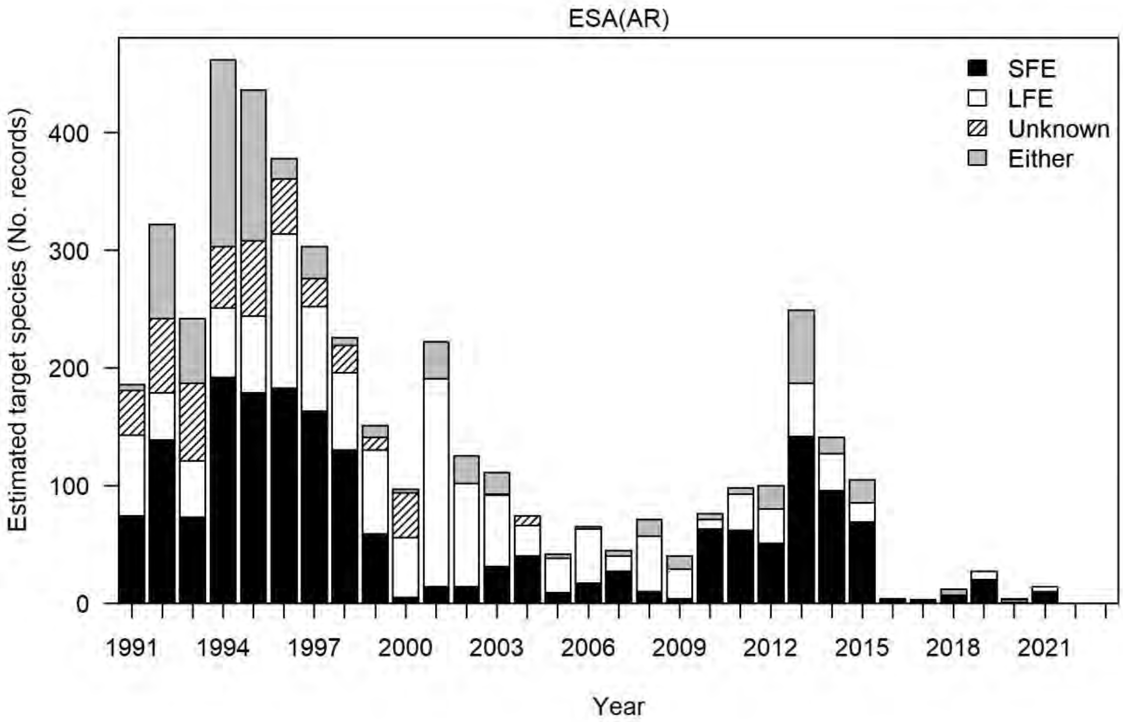

Figure C4: Reconstructed target species for the years 1990–91 to 2022–23 (ESA(AR)).

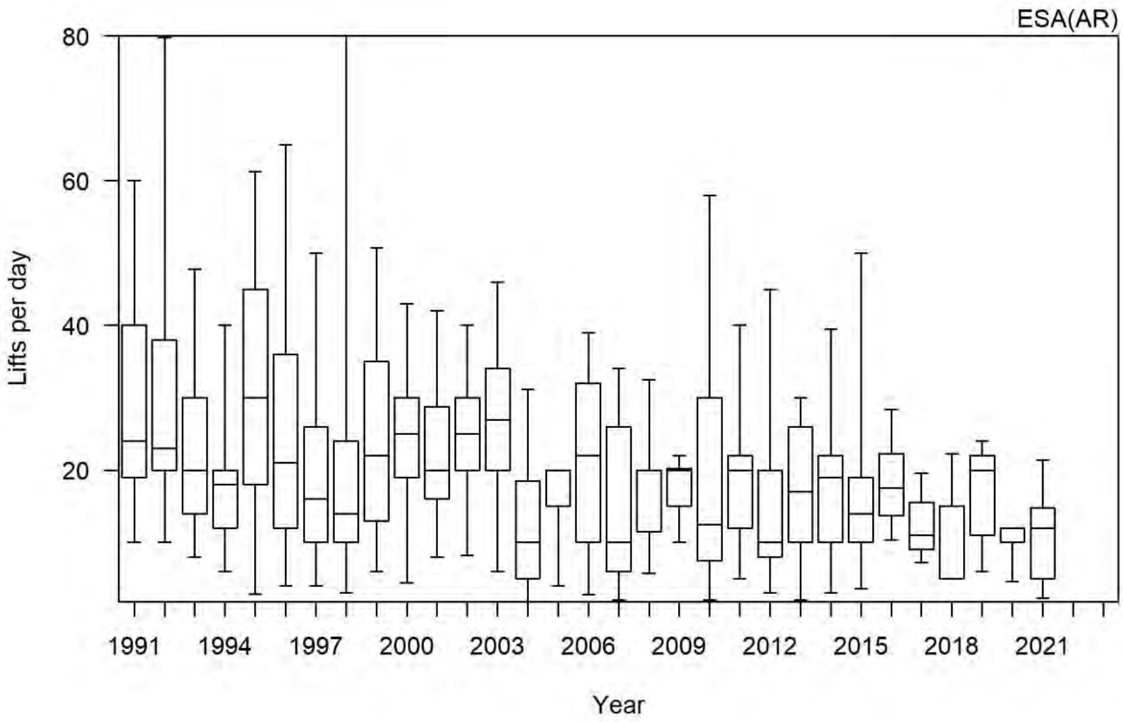

Figure C5: Total lifts per day for the years 1990–91 to 2022–23. The horizontal line is the median, the top and bottom of the box are the interquartiles (25th and 75th), and error bars are the 95th percentile range (ESA(AR)).

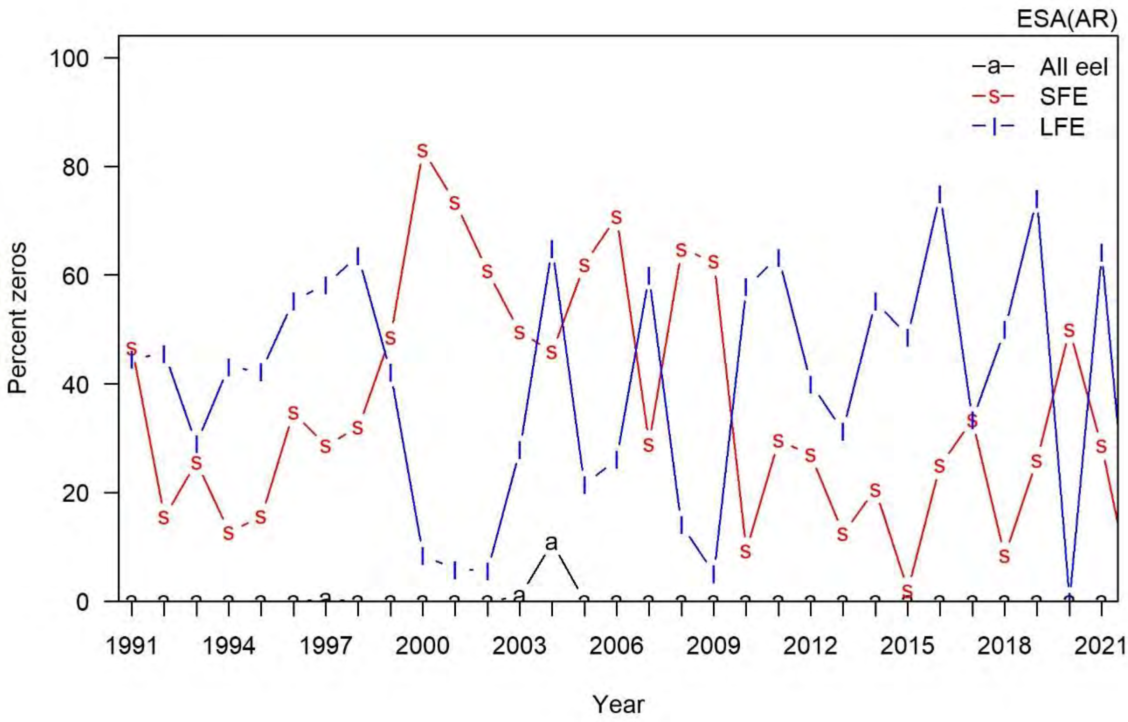

Figure C6: Proportion of valid zero records for all eels, shortfin (SFE), and longfin (LFE) catch for the years 1990–91 to 2022–23. Excludes zeros associated with reporting EEU (unclassified) (ESA(AR)).

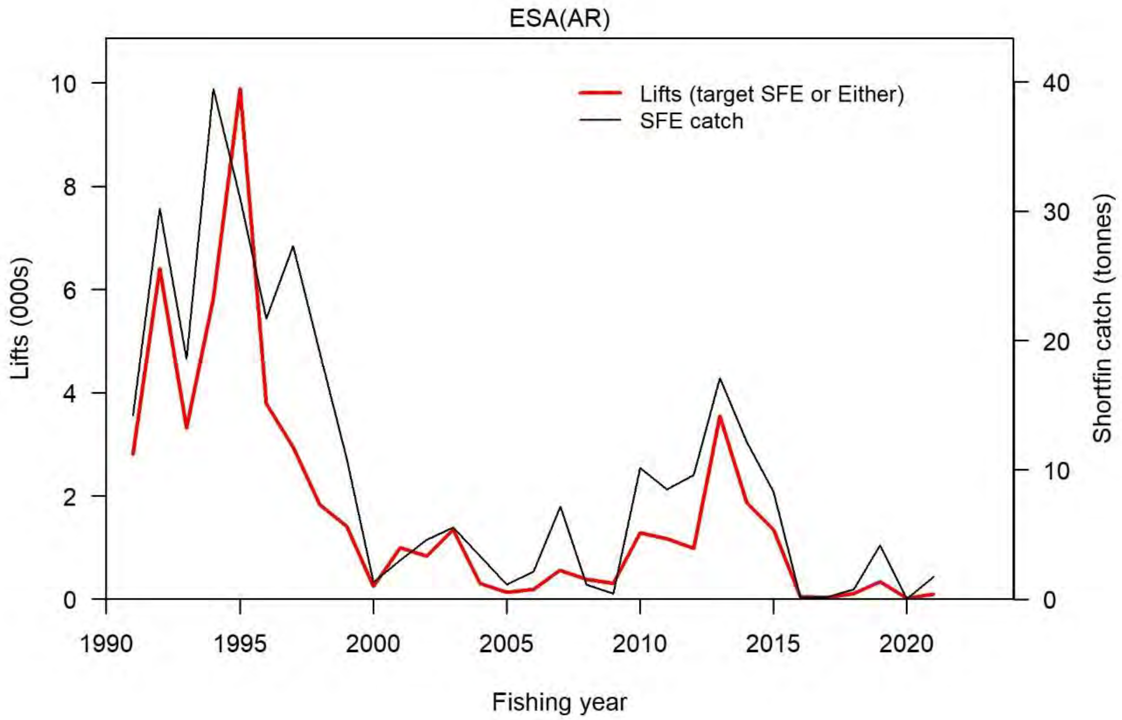

Figure C7: Total lifts and shortfin catch when target species was 'shortfin' or 'either' for the years 1990–91 to 2022–23 (ESA(AR)).

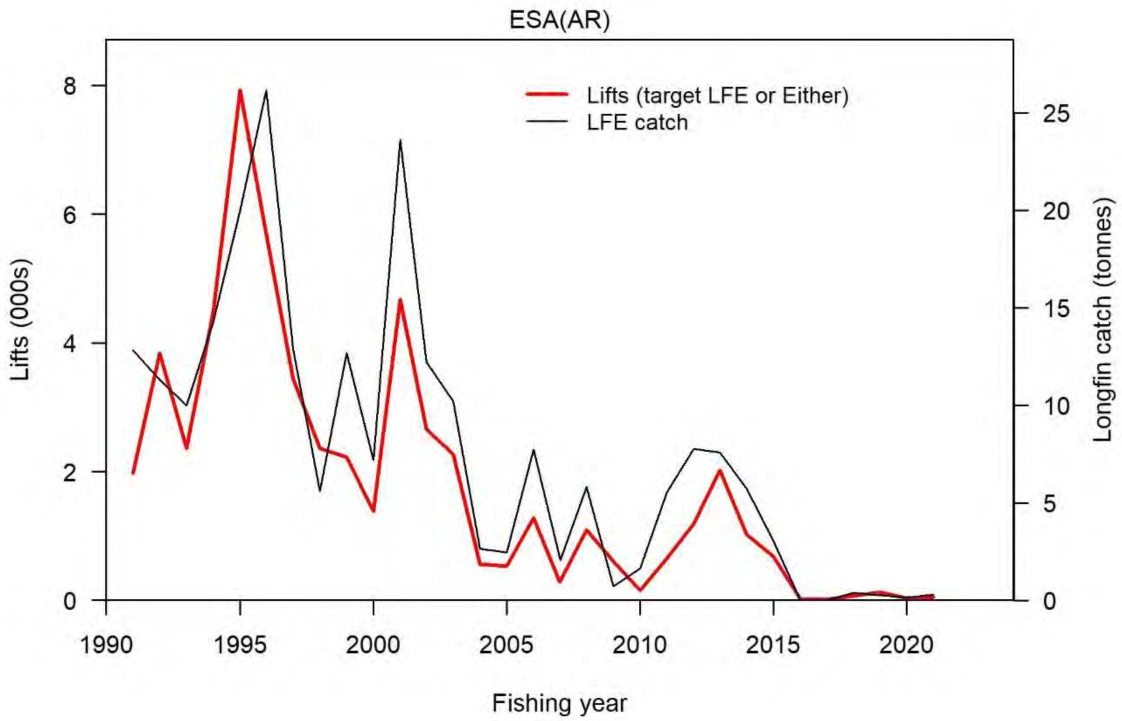

Figure C8: Total lifts and longfin catch when target species was 'longfin' or 'either' for the years 1990–91 to 2022–23 (ESA(AR)).

ESA AT (south Canterbury)

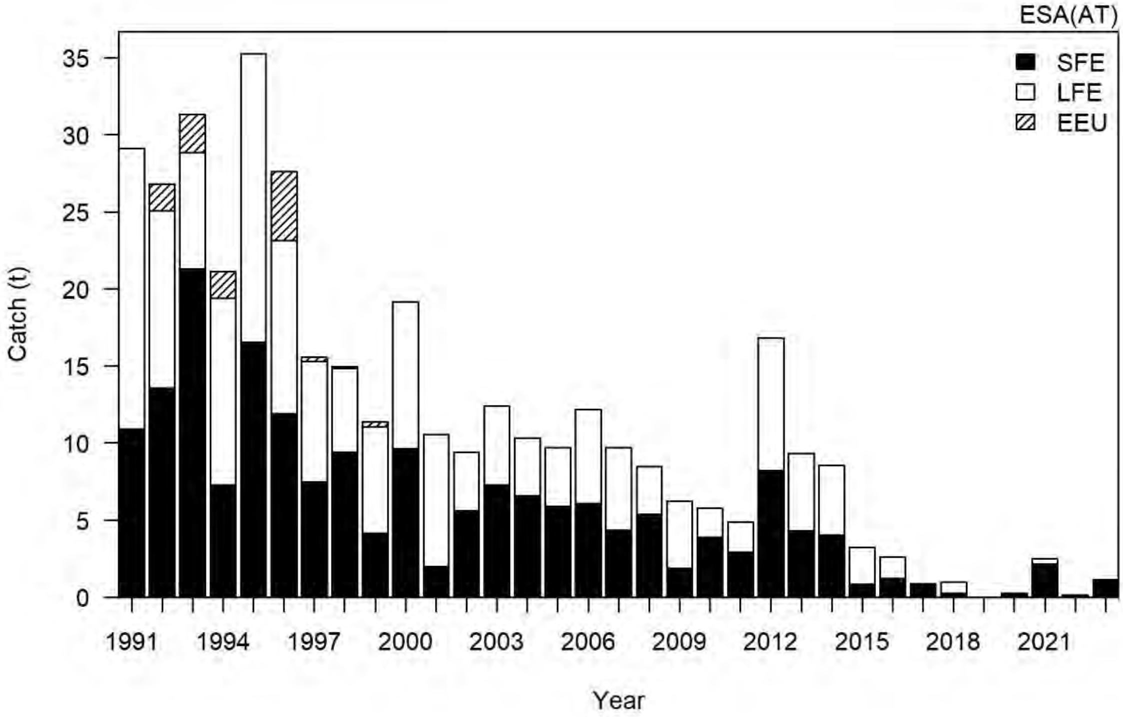

Figure D1: Total estimated commercial catch of shortfin (SFE), longfin (LFE), and unclassified eel catch (EEU) for the years 1990–91 to 2022–23 (ESA(AT)).

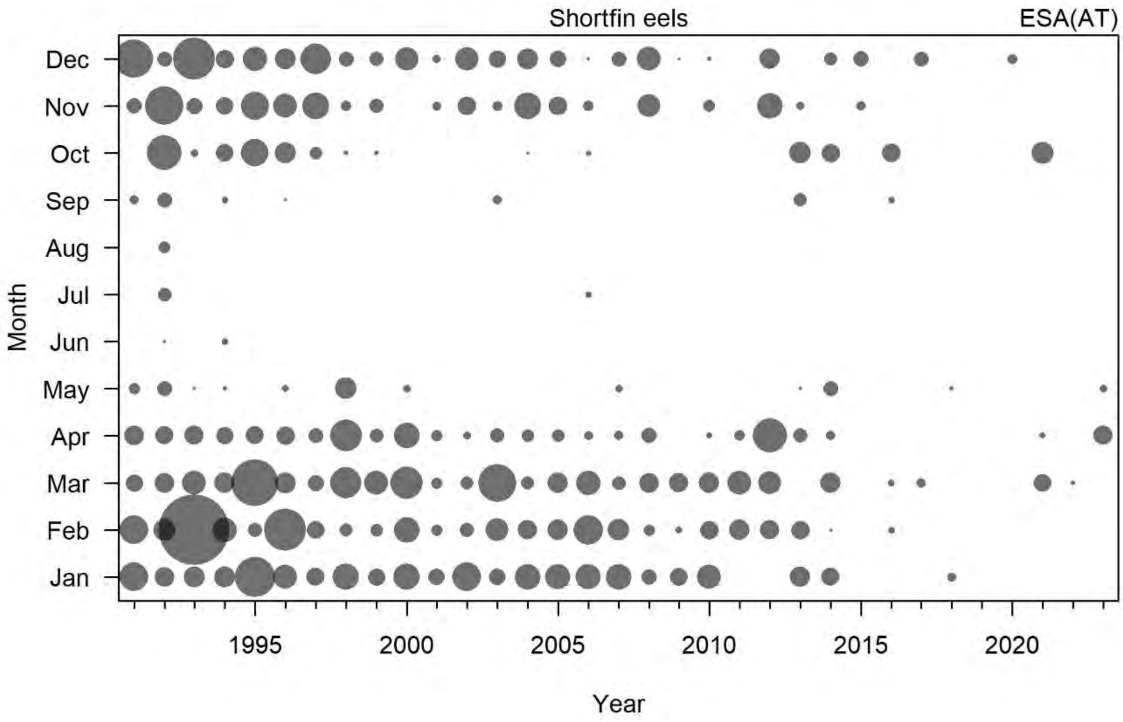

Figure D2: Shortfin eel catch by month for the years 1990–91 to 2022–23 (ESA(AT)).

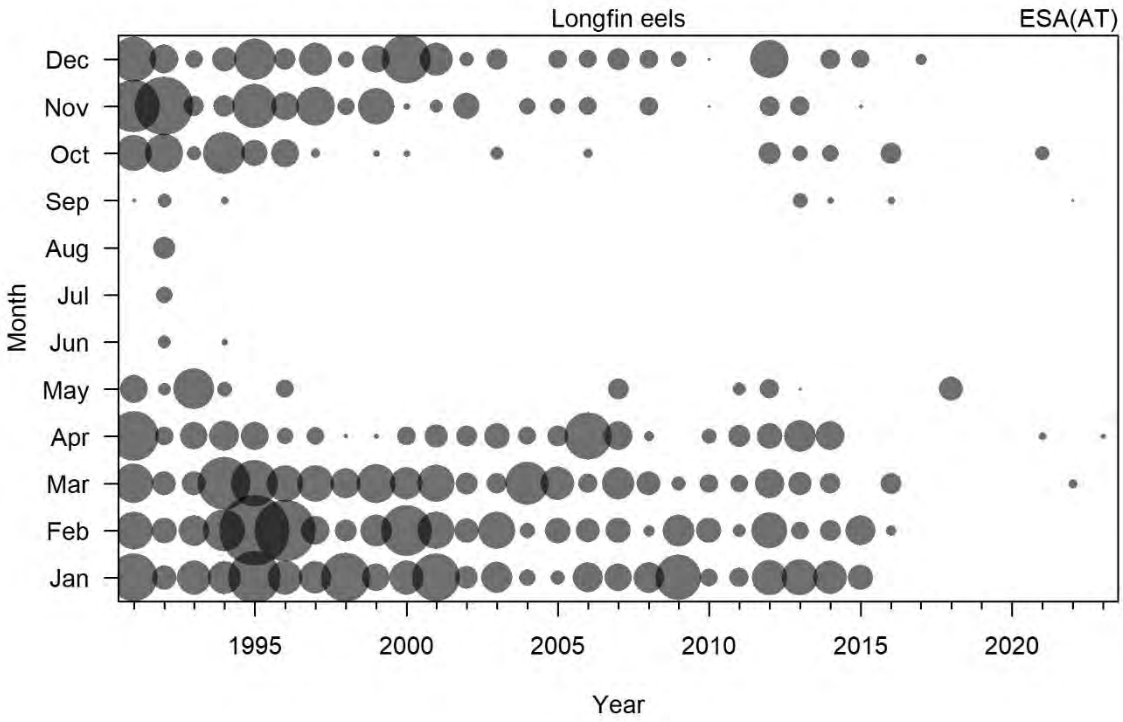

Figure D3: Longfin eel catch by month for the years 1990–-91 to 2022–23 (ESA(AT)).

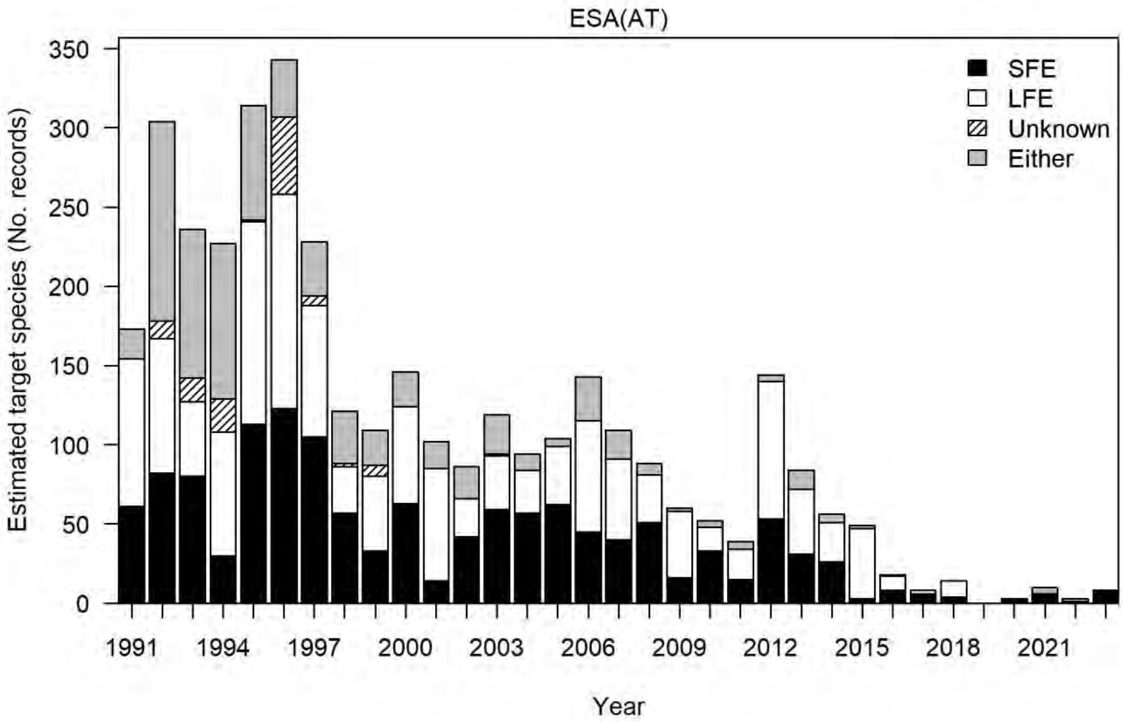

Figure D4: Reconstructed target species for the years 1990–91 to 2022–23 (ESA(AT)).

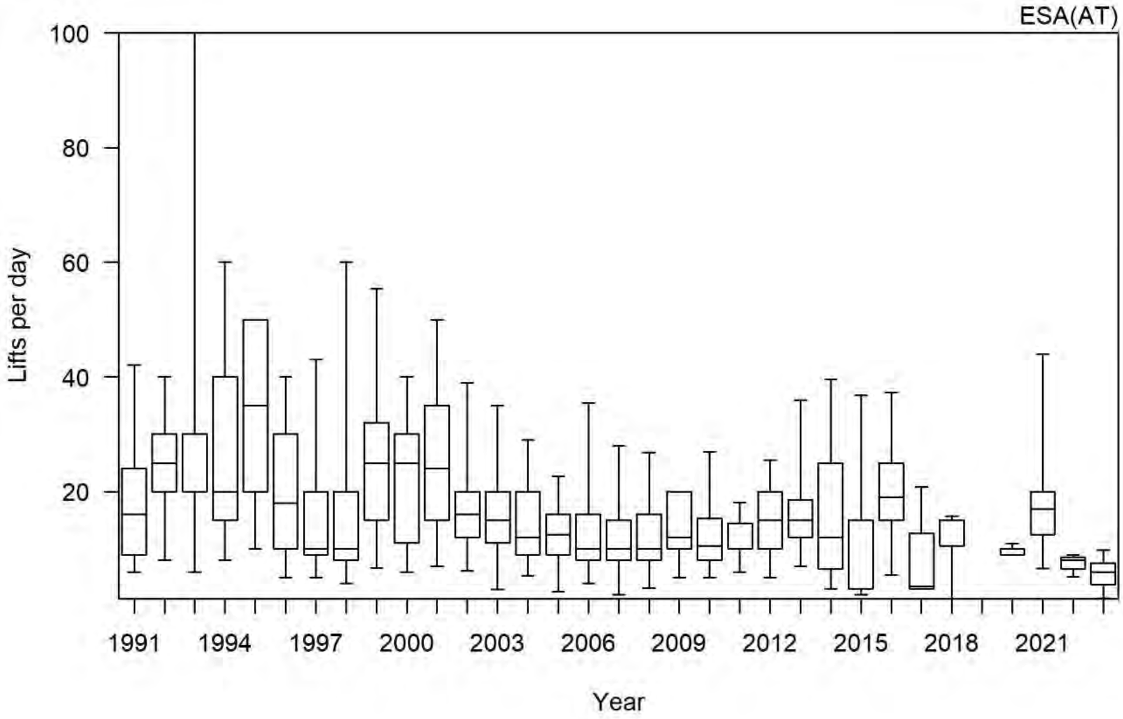

Figure D5: Total lifts per day for the years 1990–91 to 2022–23. The horizontal line is the median, the top and bottom of the box are the interquartiles (25th and 75th), and error bars are the 95th percentile range (ESA(AT)).

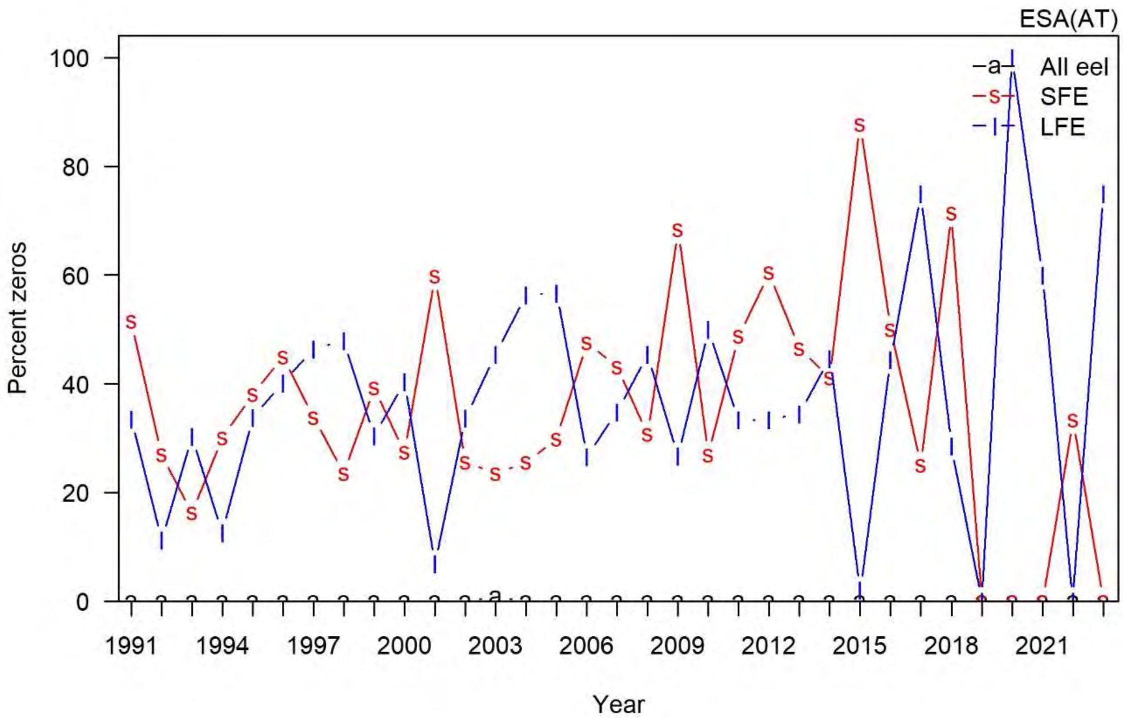

Figure D6: Proportion of valid zero records for all eels, shortfin (SFE), and longfin (LFE) catch for the years 1990–91 to 2022–23. Excludes zeros associated with reporting EEU (unclassified) (ESA(AT)).

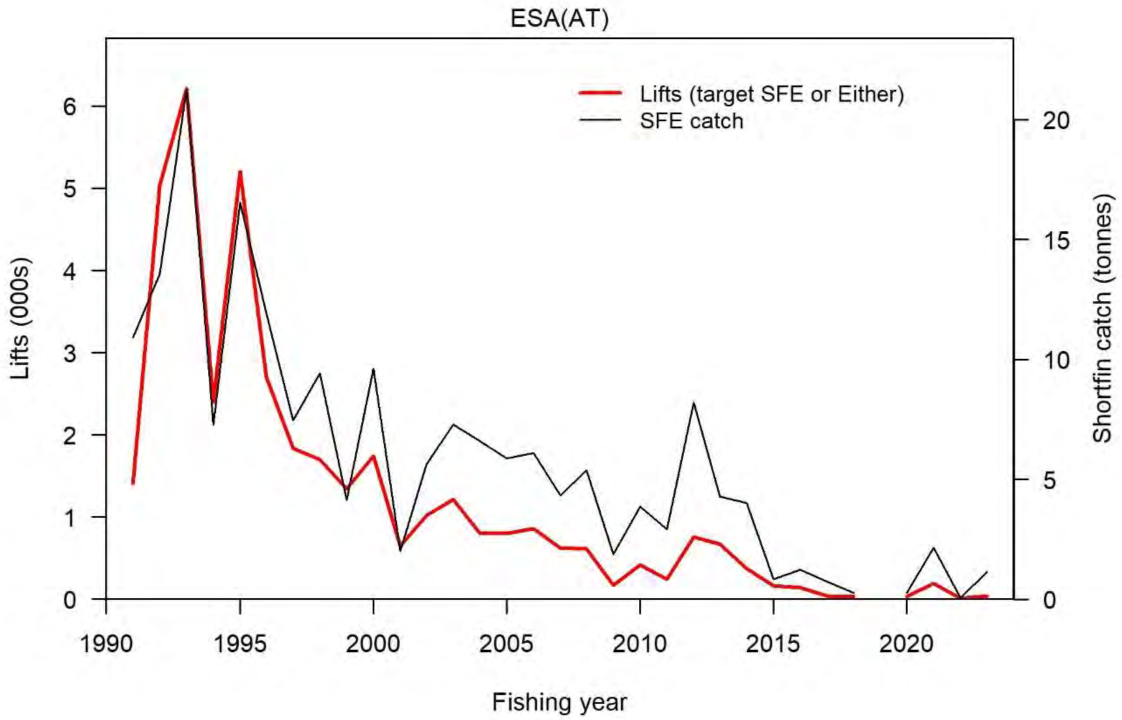

Figure D7: Total lifts and shortfin catch when target species was 'shortfin' or 'either' for the years 1990–91 to 2022–23 (ESA(AT)).

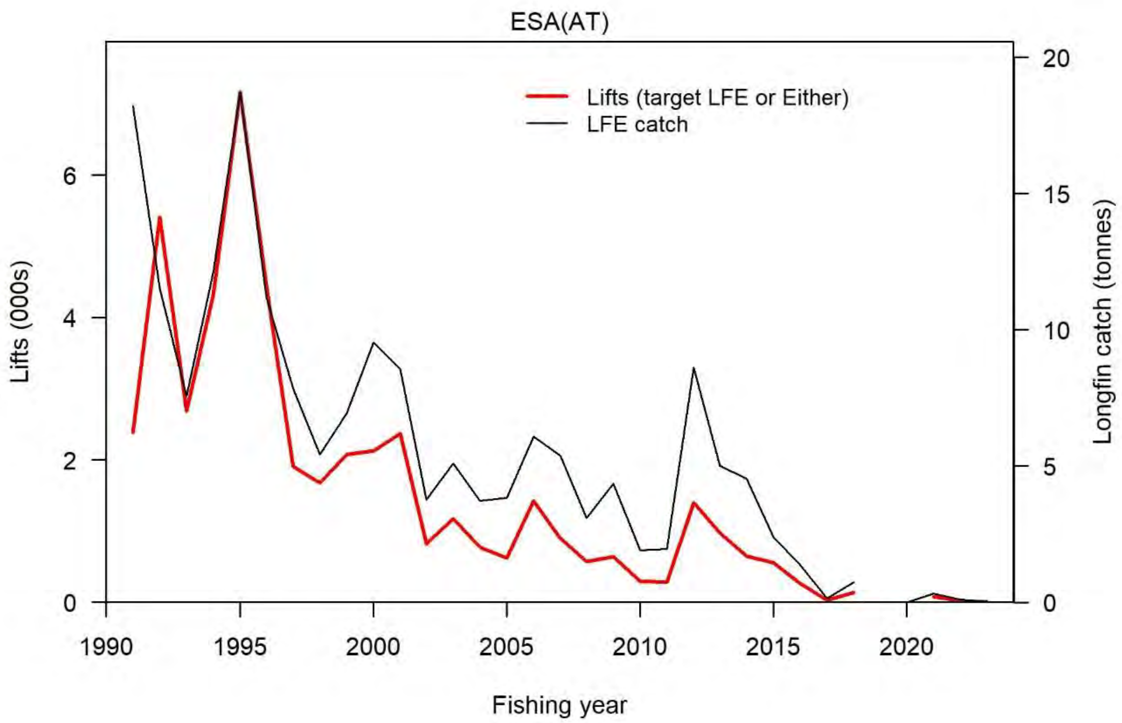

Figure D8: Total lifts and longfin catch when target species was 'longfin' or 'either' for the years 1990–91 to 2022–23 (ESA(AT)).

ESA AU (Waitaki)

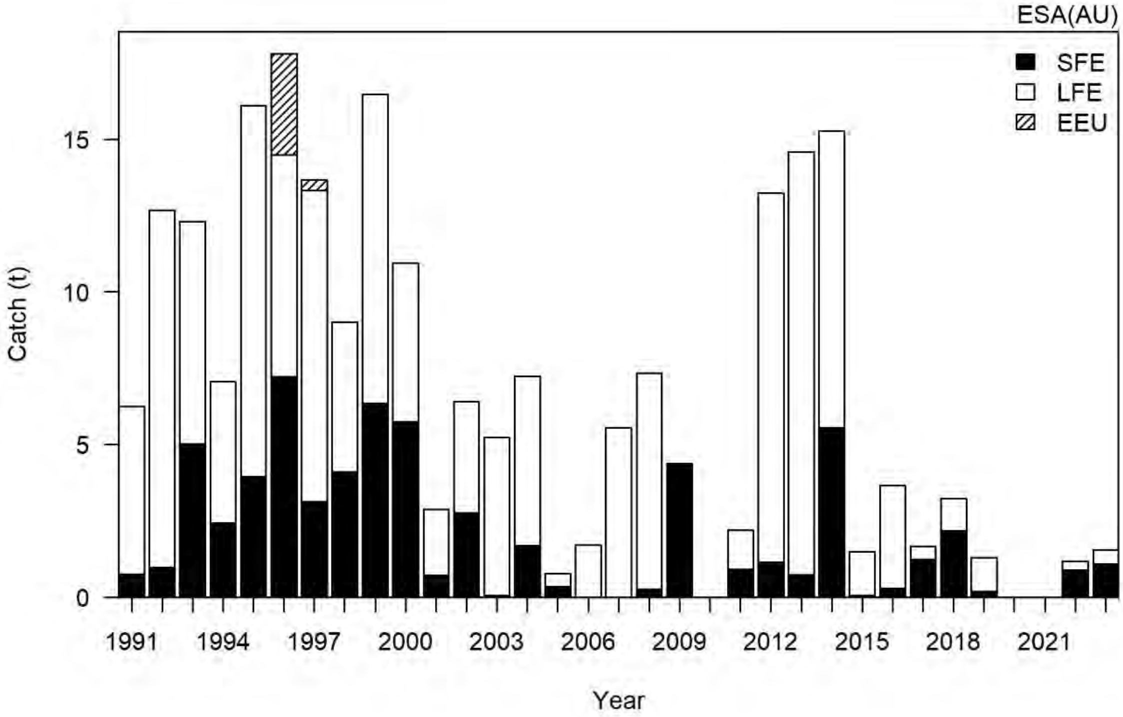

Figure E1: Total estimated commercial catch of shortfin (SFE), longfin (LFE), and unclassified eel catch (EEU) for the years 1990–91 to 2022–23 (ESA(AU)).

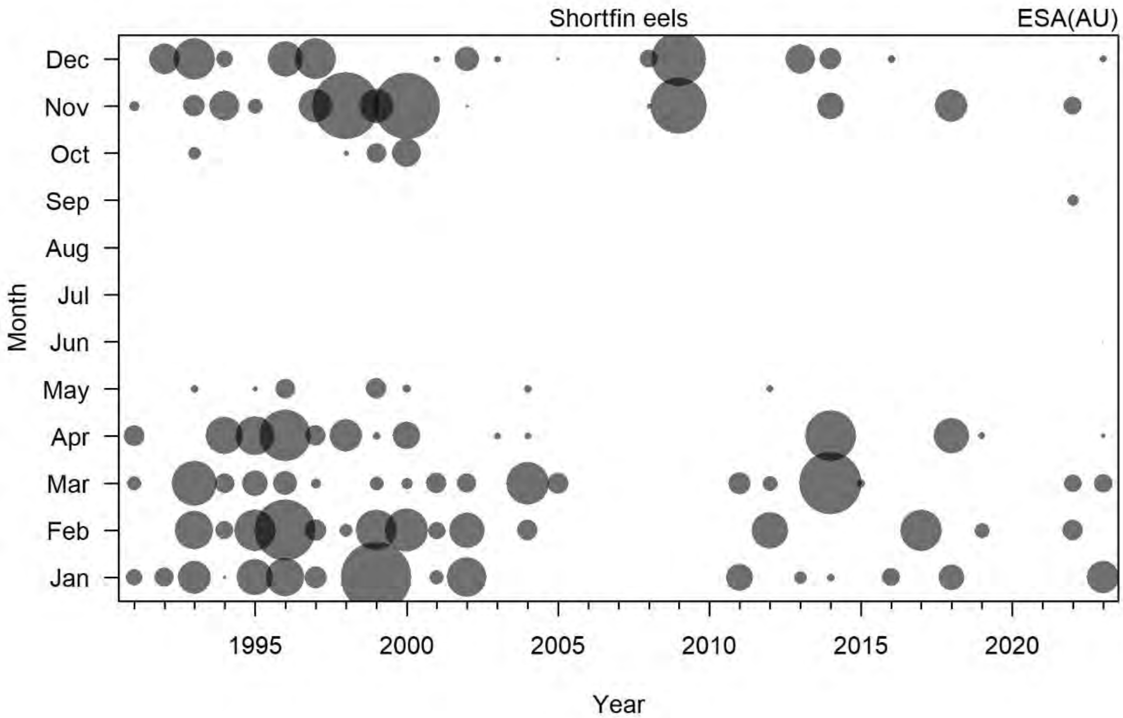

Figure E2: Shortfin eel catch by month for the years 1990–91 to 2022–23 (ESA(AU)).

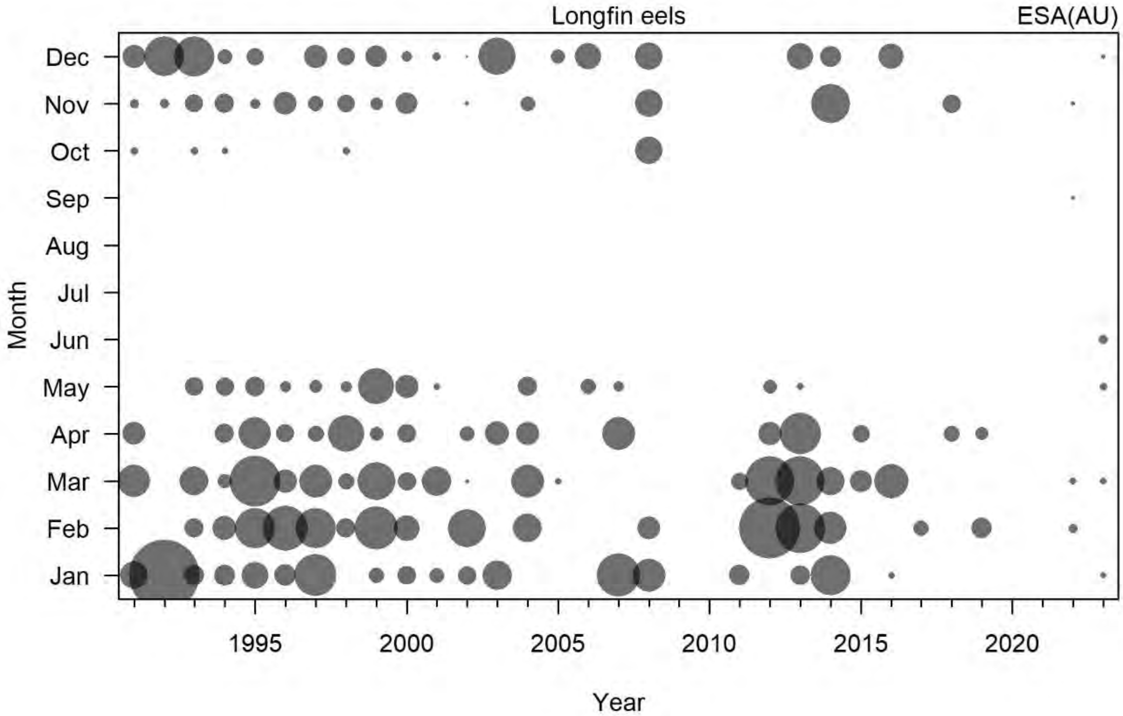

Figure E3: Longfin eel catch by month for the years 1990–-91 to 2022–23 (ESA(AU)).

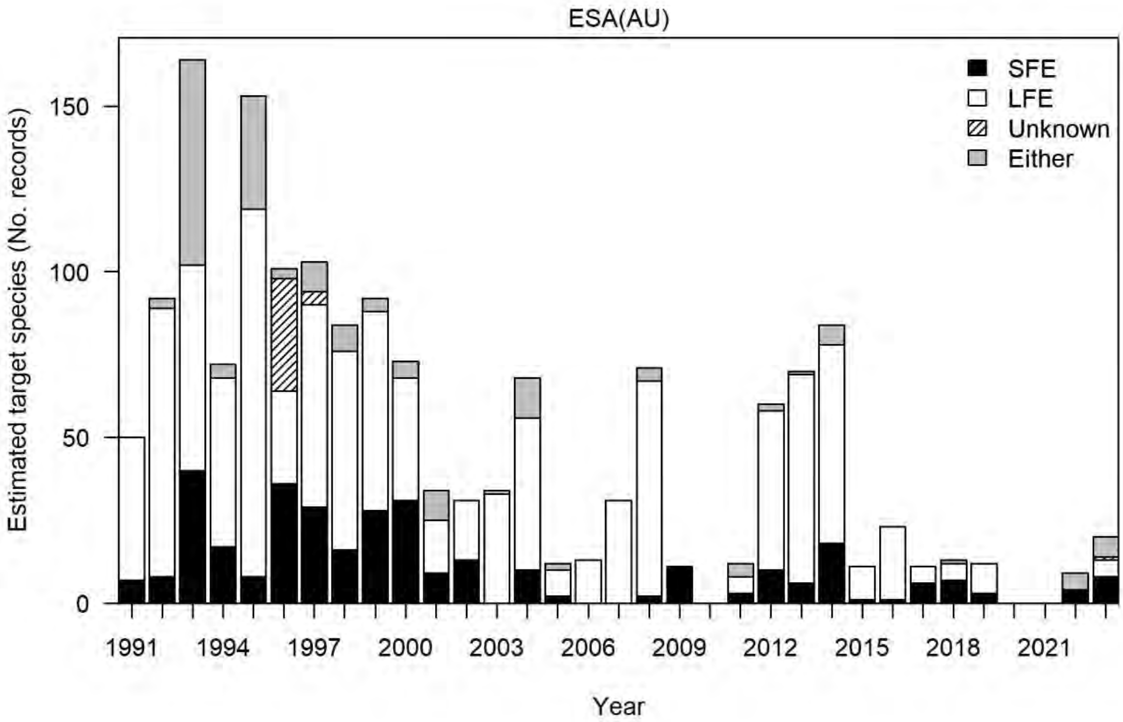

Figure E4: Reconstructed target species for the years 1990–91 to 2022–23 (ESA(AU)).

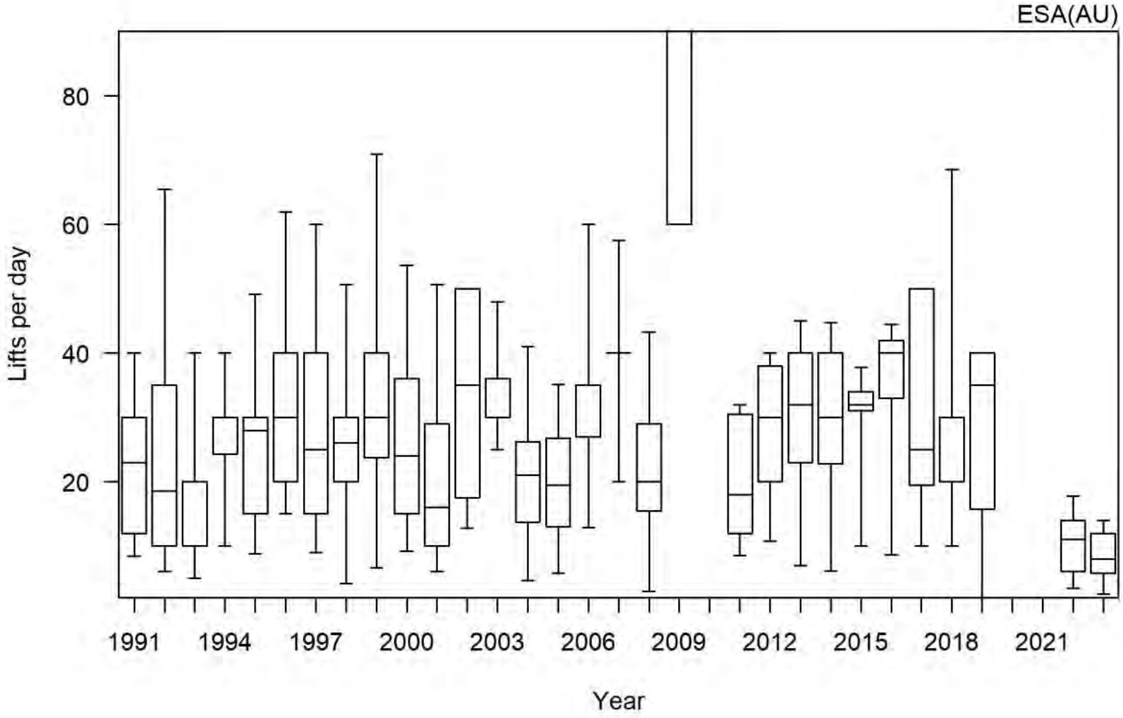

Figure E5: Total lifts per day for the years 1990–91 to 2022–23. The horizontal line is the median, the top and bottom of the box are the interquartiles (25th and 75th), and error bars are the 95th percentile range (ESA(AU)).

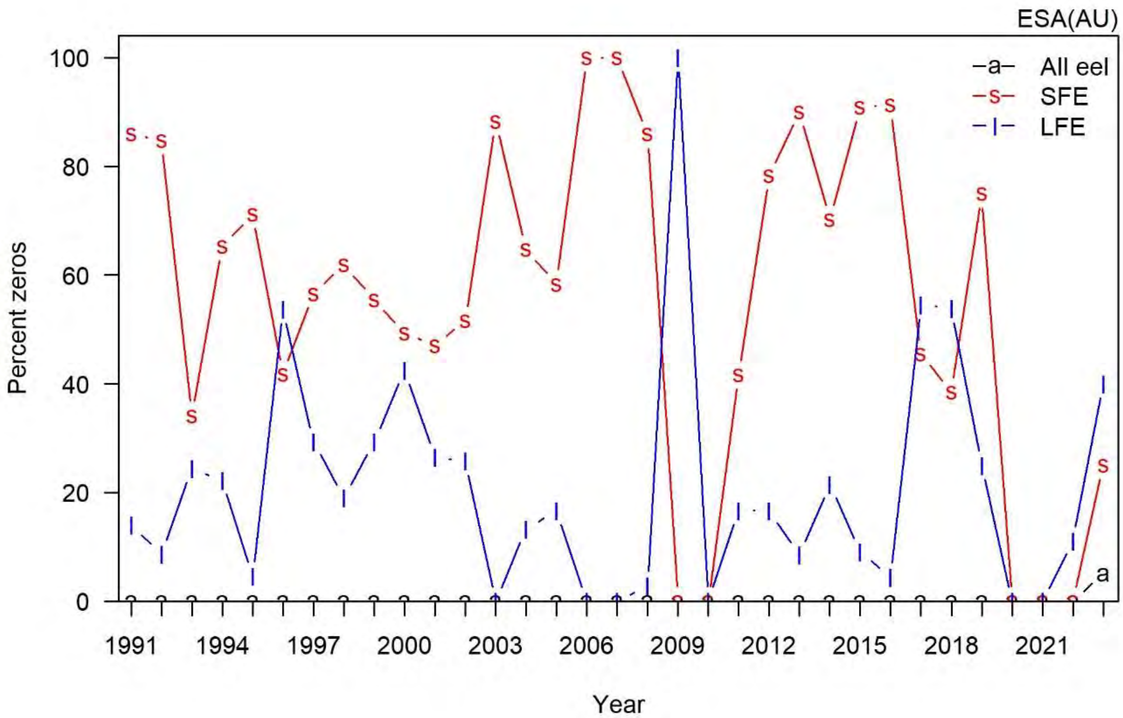

Figure E6: Proportion of valid zero records for all eels, shortfin (SFE), and longfin (LFE) catch for the years 1990–91 to 2022–23. Excludes zeros associated with reporting EEU (unclassified) (ESA(AU)).

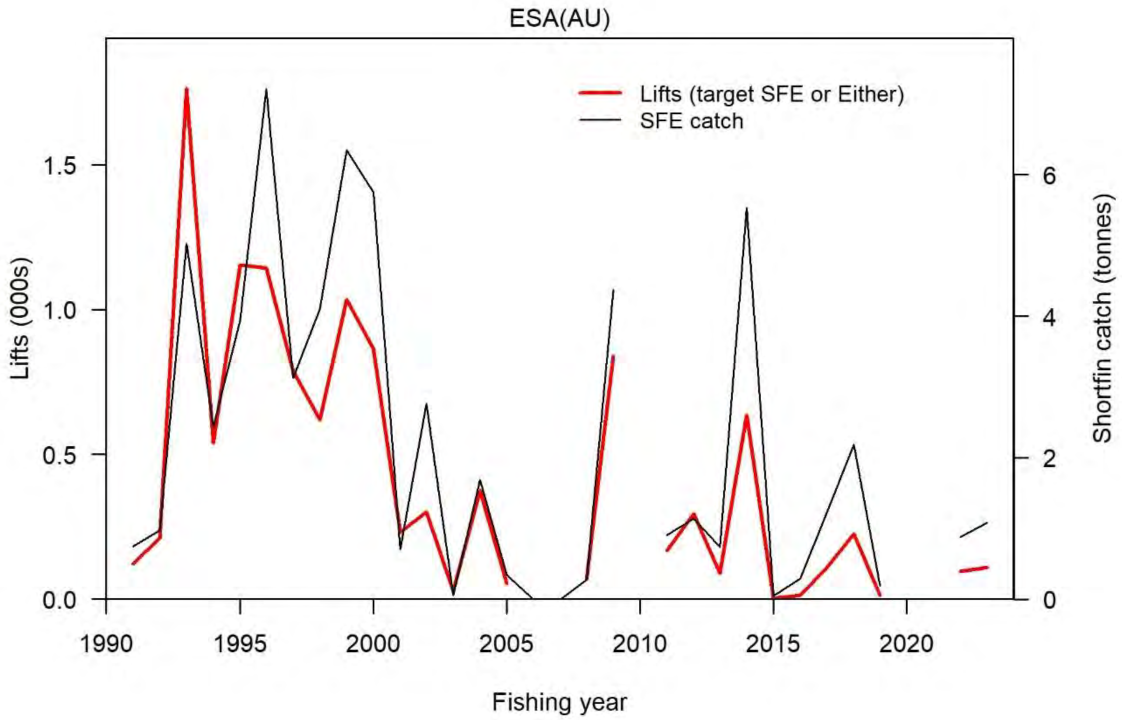

Figure E7: Total lifts and shortfin catch when target species was 'shortfin' or 'either' for the years 1990–91 to 2022–23 (ESA(AU)).

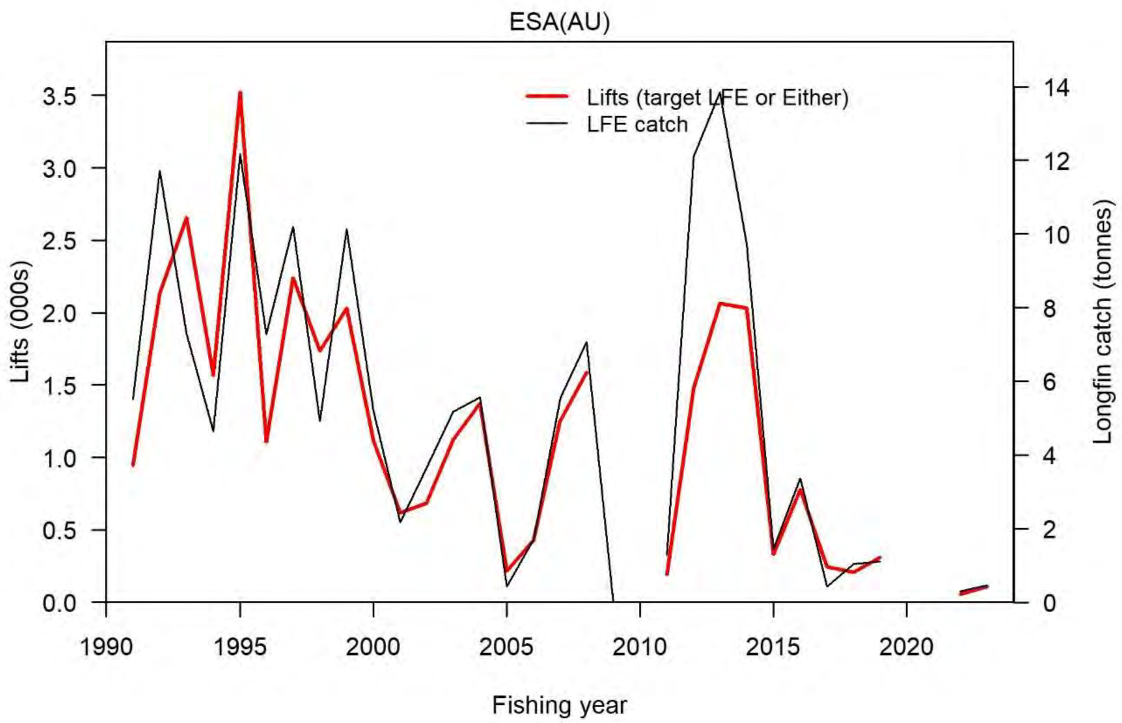

Figure E8: Total lifts and longfin catch when target species was 'longfin' or 'either' for the years 1990–91 to 2022–23 (ESA(AU)).

ESA AV (Otago)

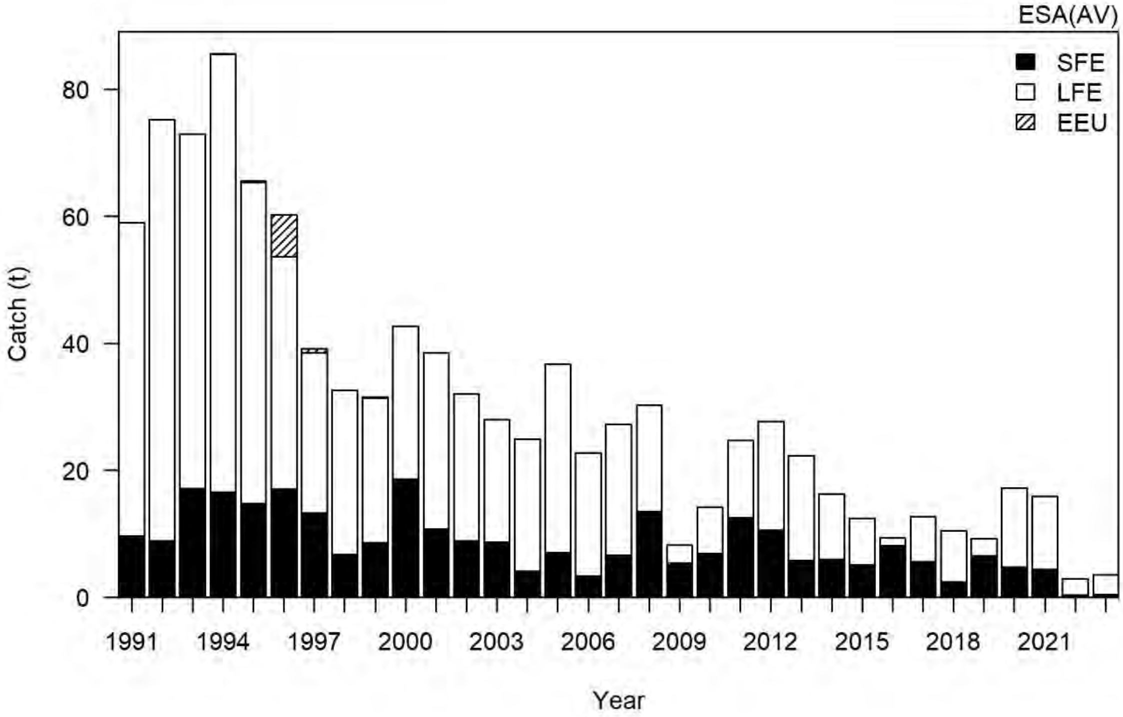

Figure F1: Total estimated commercial catch of shortfin (SFE), longfin (LFE), and unclassified eel catch (EEU) for the years 1990–91 to 2022–23 (ESA(AV)).

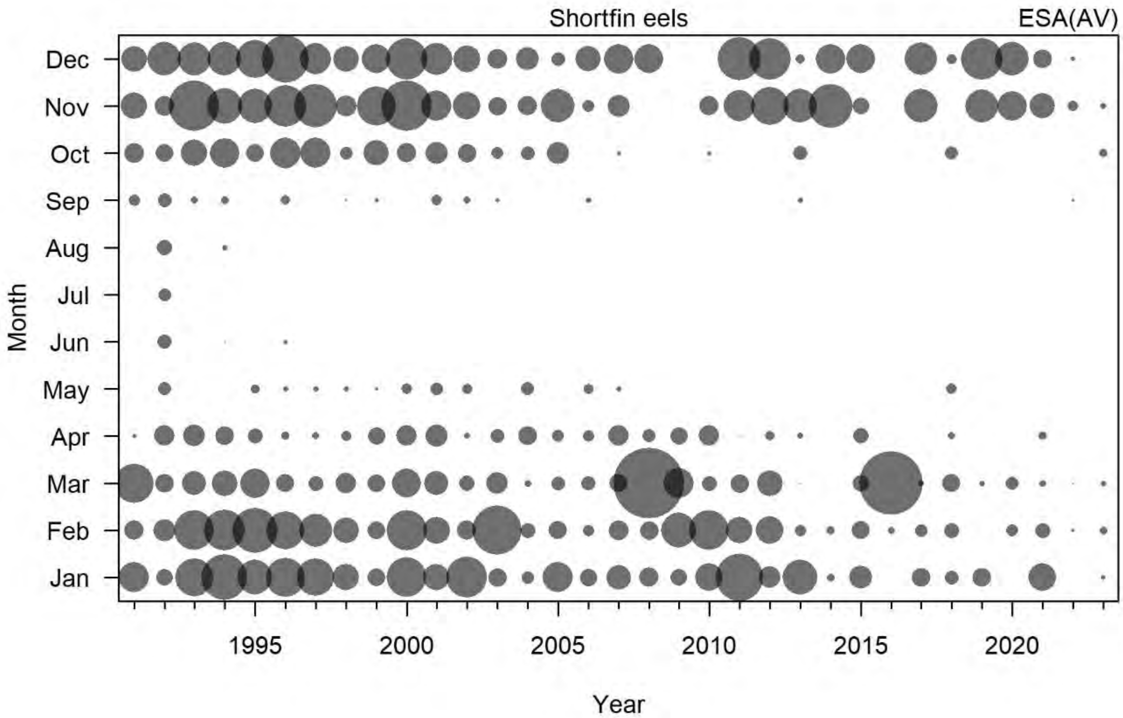

Figure F2: Shortfin eel catch by month for the years 1990–91 to 2022–23 (ESA(AV)).

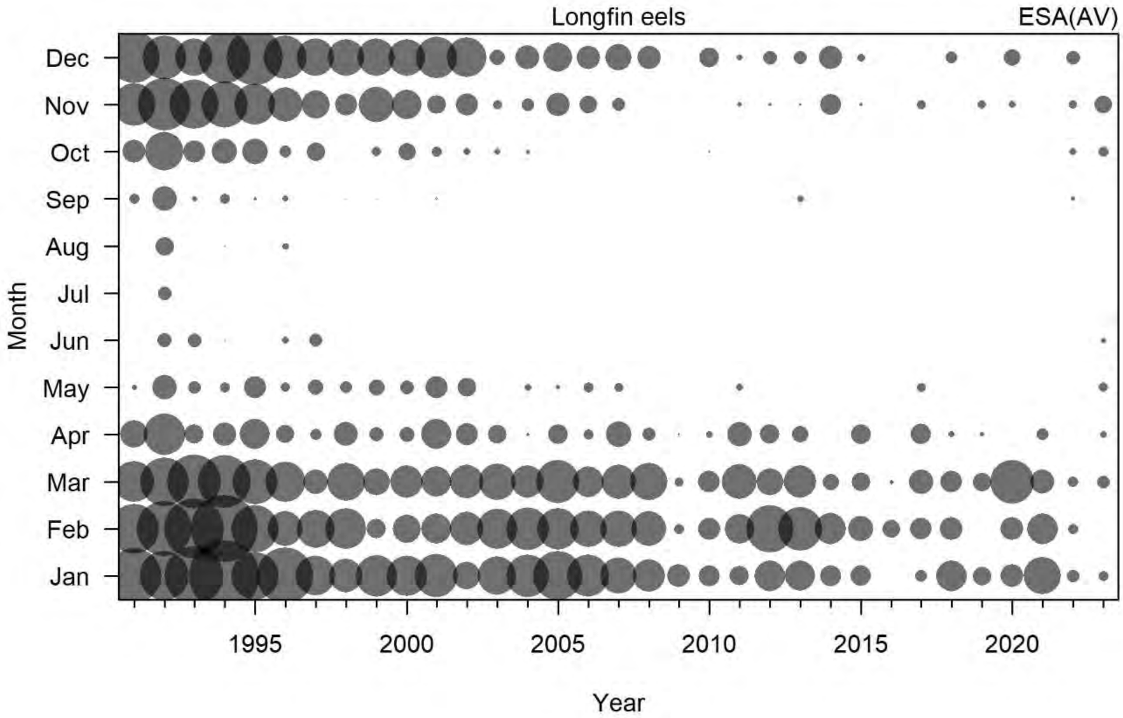

Figure F3: Longfin eel catch by month for the years 1990–-91 to 2022–23 (ESA(AV)).

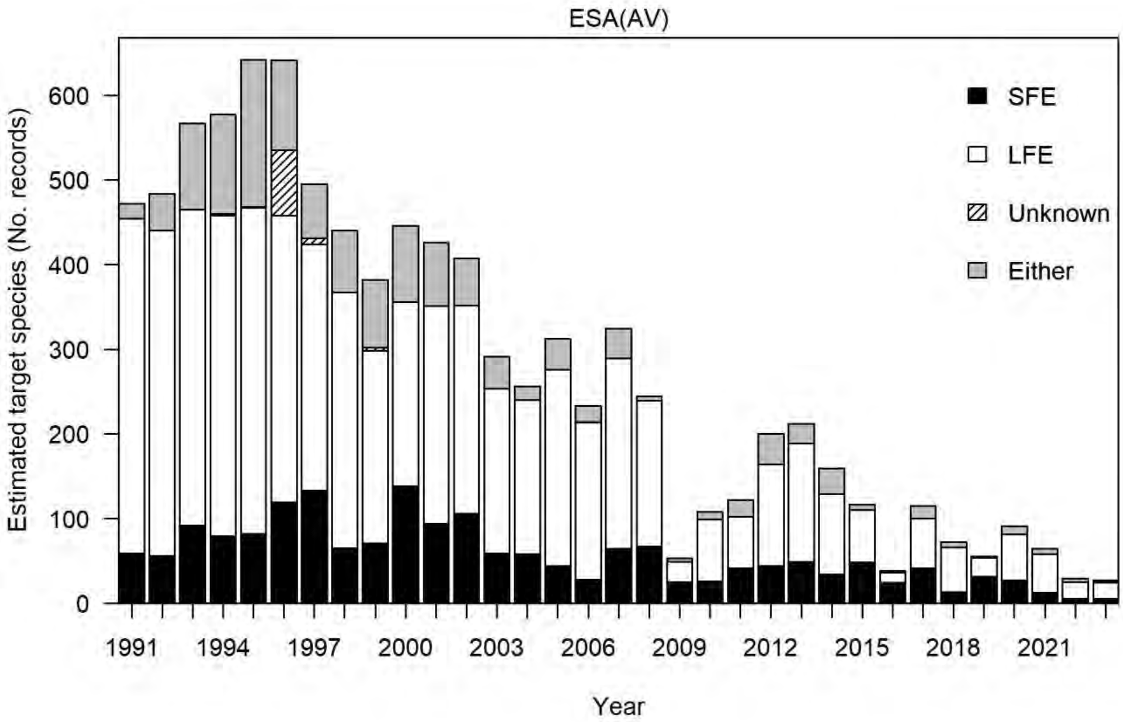

Figure F4: Reconstructed target species for the years 1990–91 to 2022–23 (ESA(AV)).

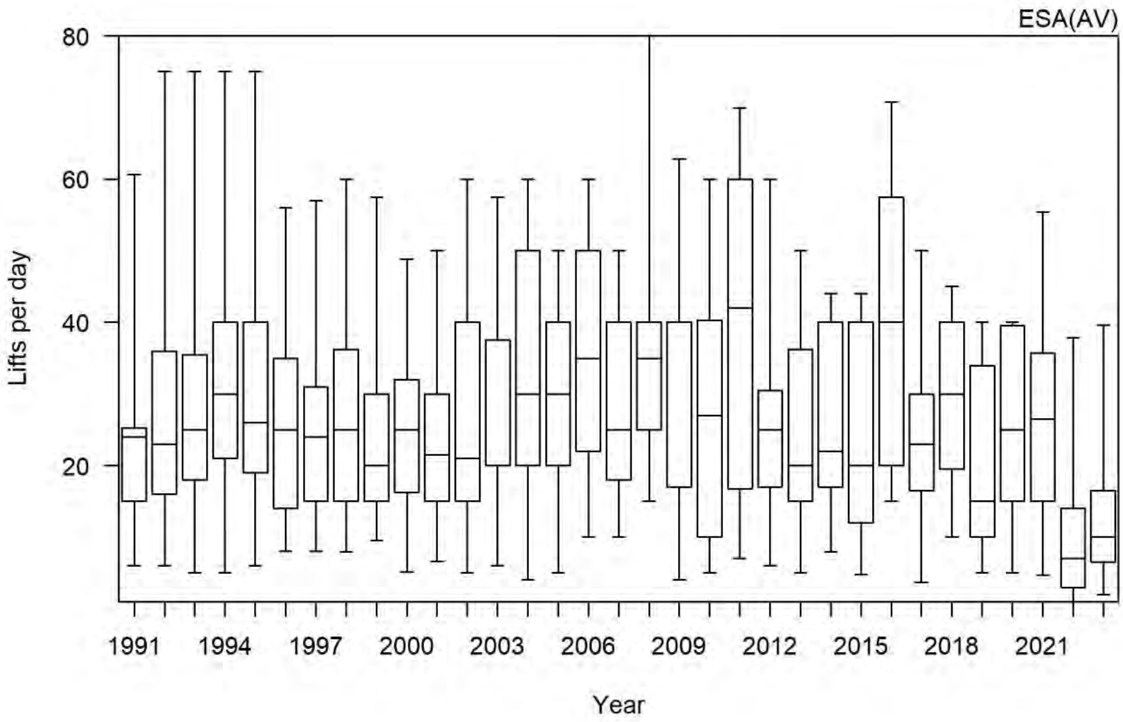

Figure F5: Total lifts per day for the years 1990–91 to 2022–23. The horizontal line is the median, the top and bottom of the box are the interquartiles (25th and 75th), and error bars are the 95th percentile range (ESA(AV)).

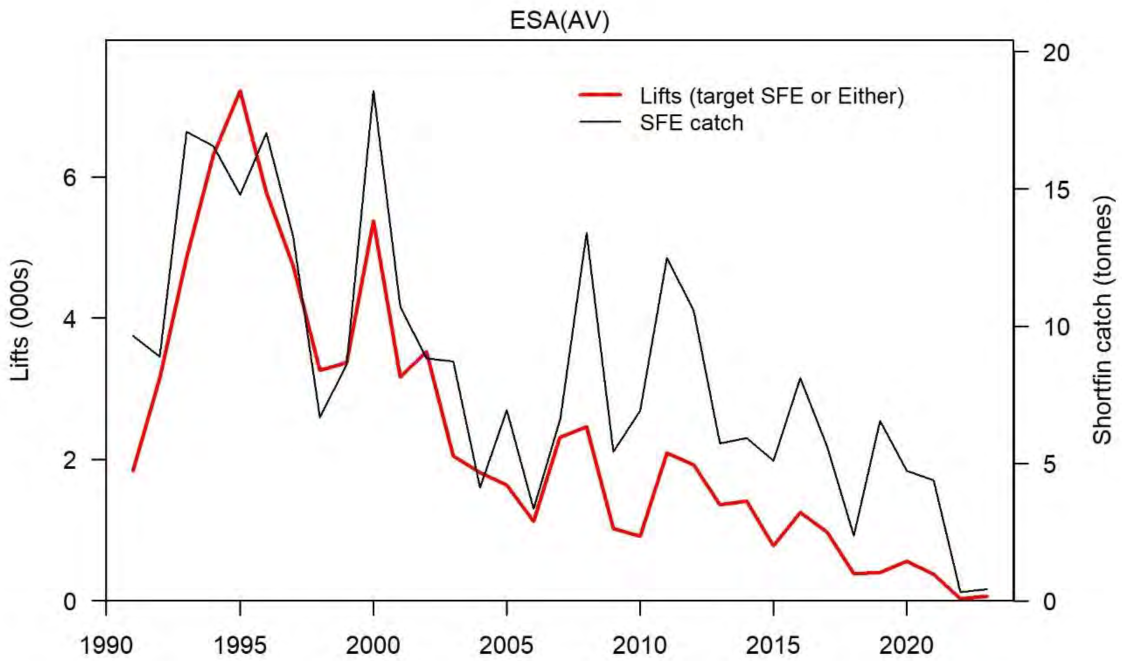

Figure F6: Total lifts and shortfin catch when target species was 'shortfin' or 'either' for the years 1990–91 to 2022–23 (ESA(AV)).

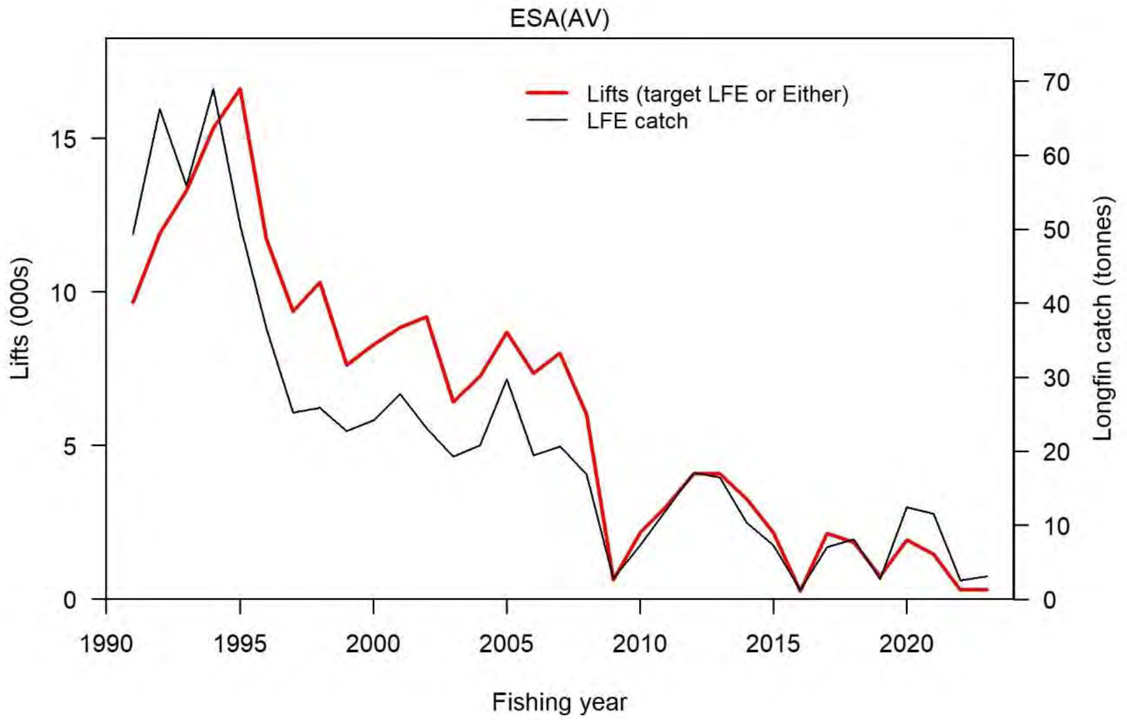

Figure F7: Total lifts and longfin catch when target species was 'longfin' or 'either' for the years 1990–91 to 2022–23 (ESA(AV)).

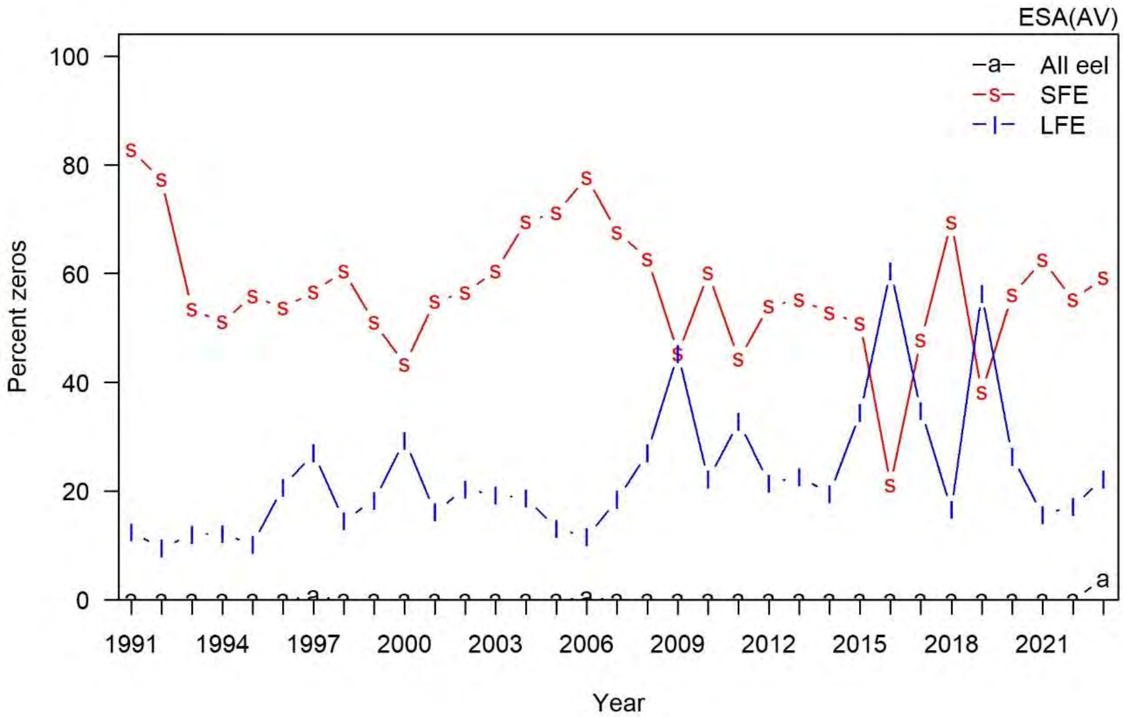

Figure F8: Proportion of valid zero records for all eels, shortfin (SFE), and longfin (LFE) catch for the years 1990–91 to 2022–23. Excludes zeros associated with reporting EEU (unclassified) (ESA(AV)).

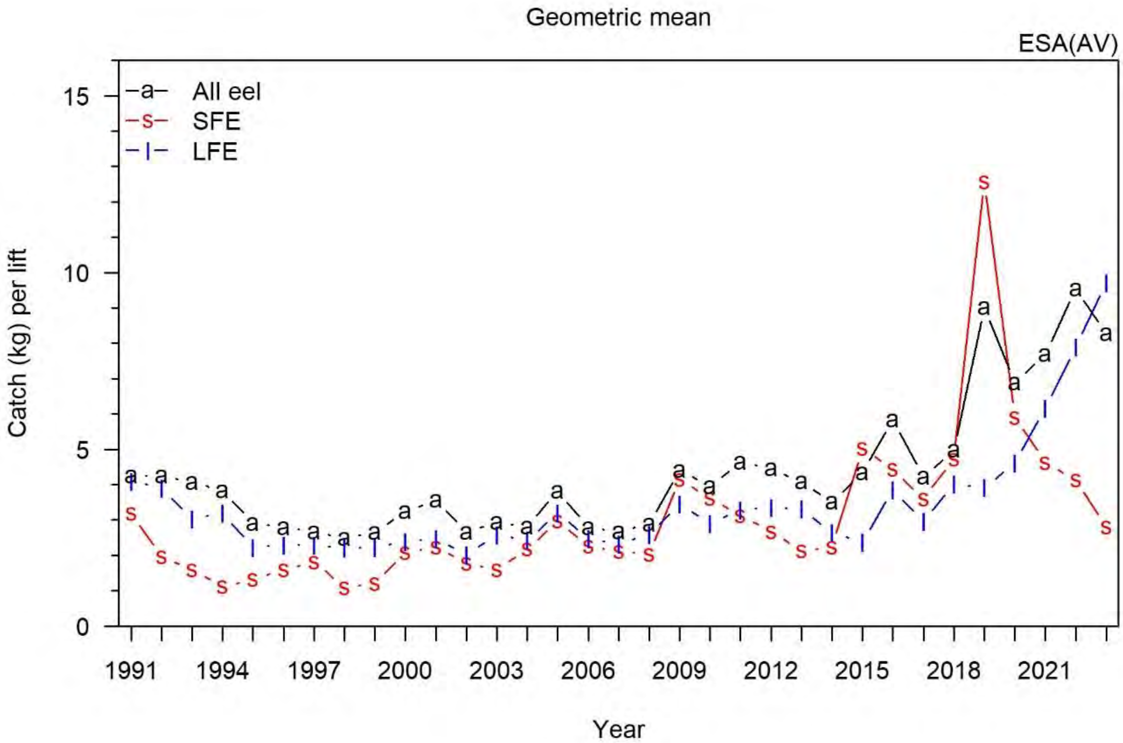

Figure F9: Unstandardised catch per lift (geometric mean of catch per lift) for all eels, shortfin (SFE), and longfin (LFE) for the years 1990–91 to 2022–23 (ESA(AV)).

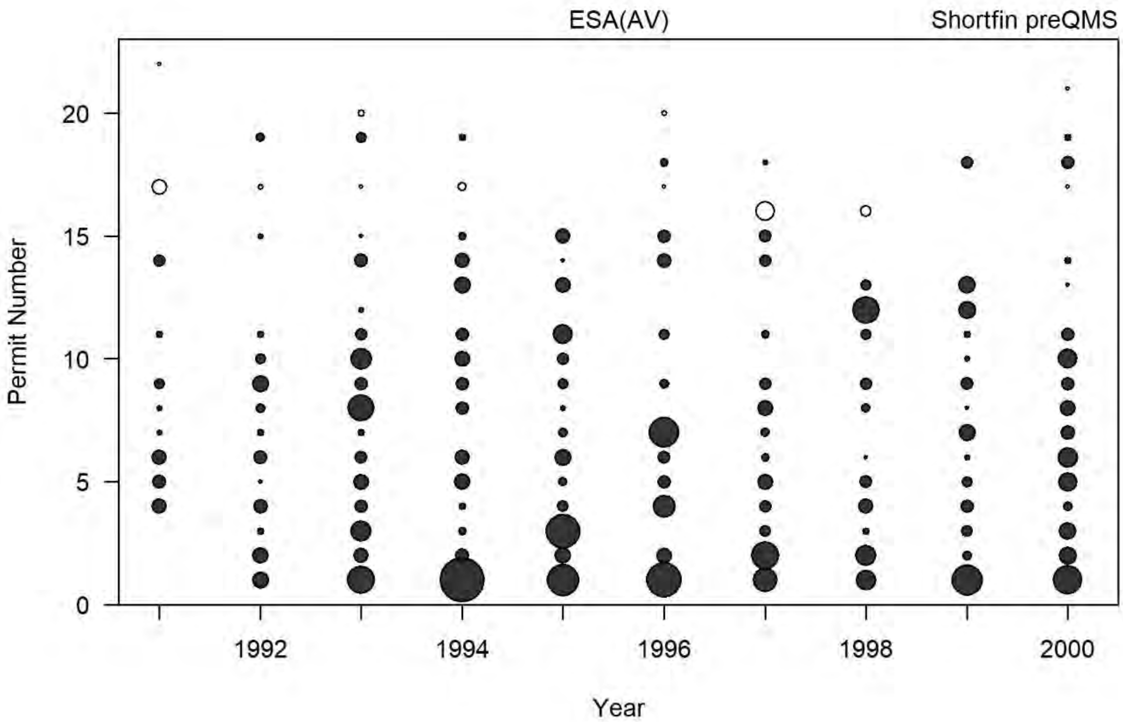

Figure F10: Relative shortfin catch from all fishers (all circles) for the years 1990–91 to 1999–2000 (pre-QMS), and for core fishers (dark shaded circles) included in the catch per unit effort analyses (ESA(AV)).

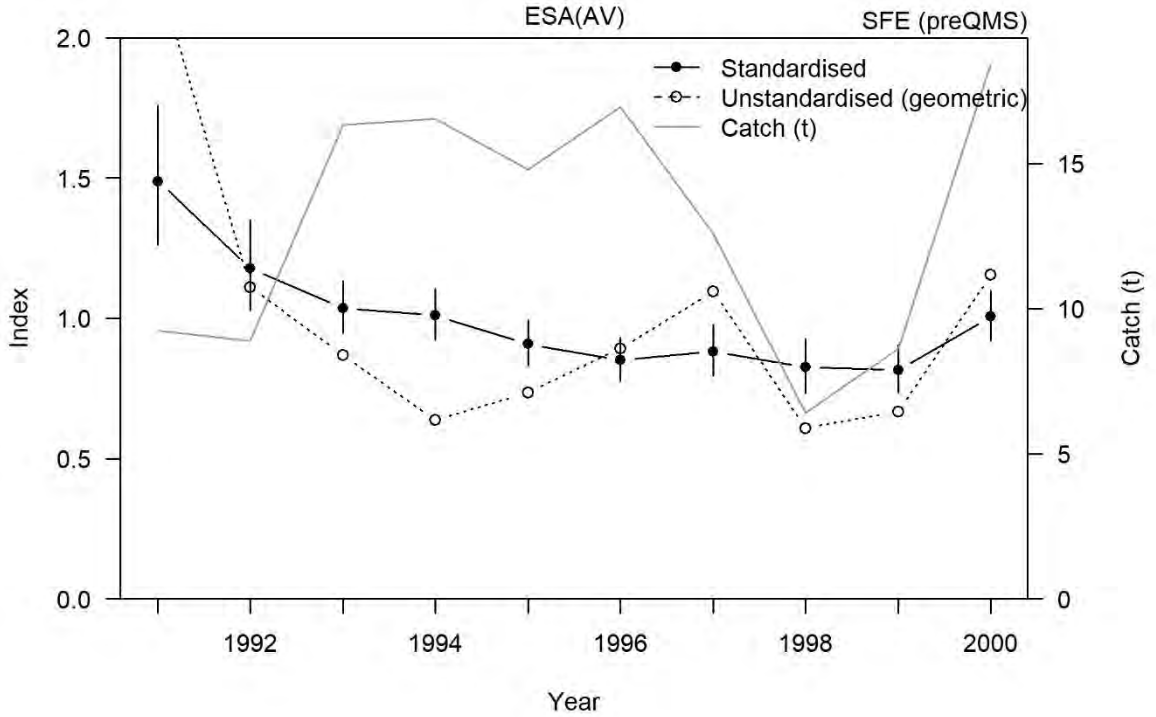

Figure F11: Indices of unstandardised (geometric mean of catch per lift) and standardised CPUE for shortfin (core fishers) pre-QMS for the years 1990–91 to 1999-2000 (ESA(AV)).

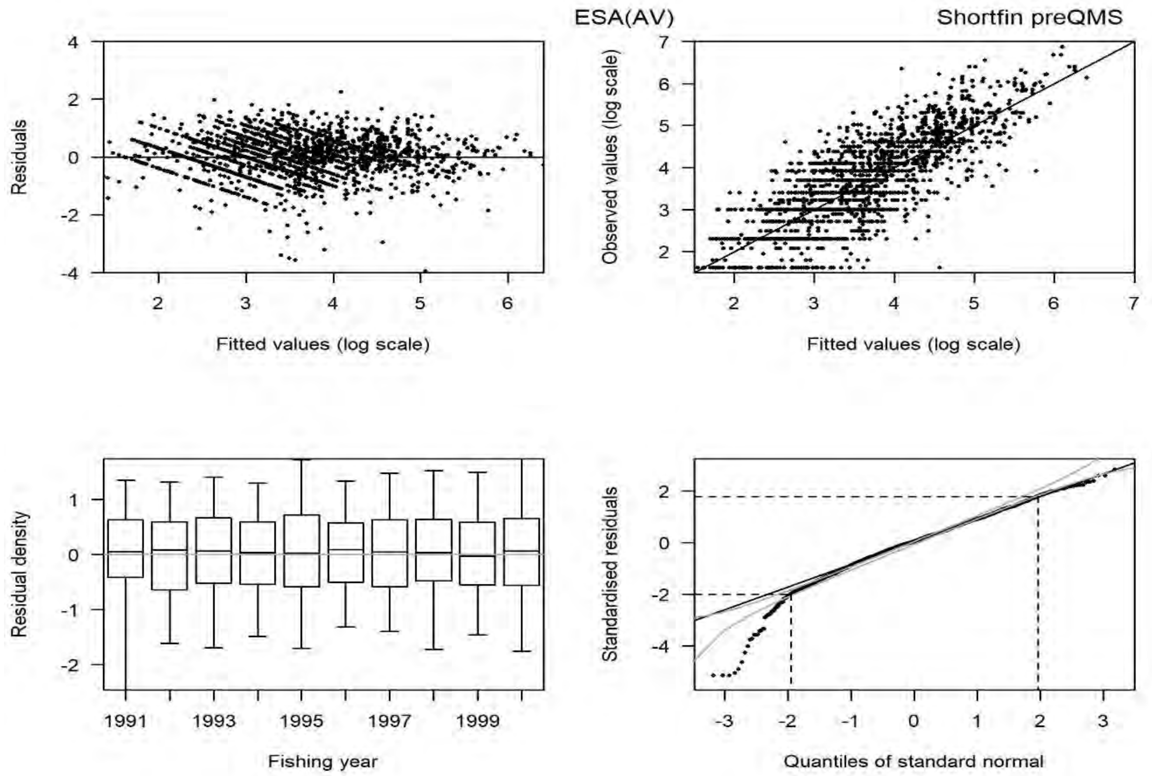

Figure F12: Residual diagnostic plots for the shortfin eel CPUE model for the years 1990–91 to 1999–2000 (pre-QMS). The grey lines on the quantile-quantile plot represent the 95% confidence envelopes of a standard normal distribution (ESA(AV)).

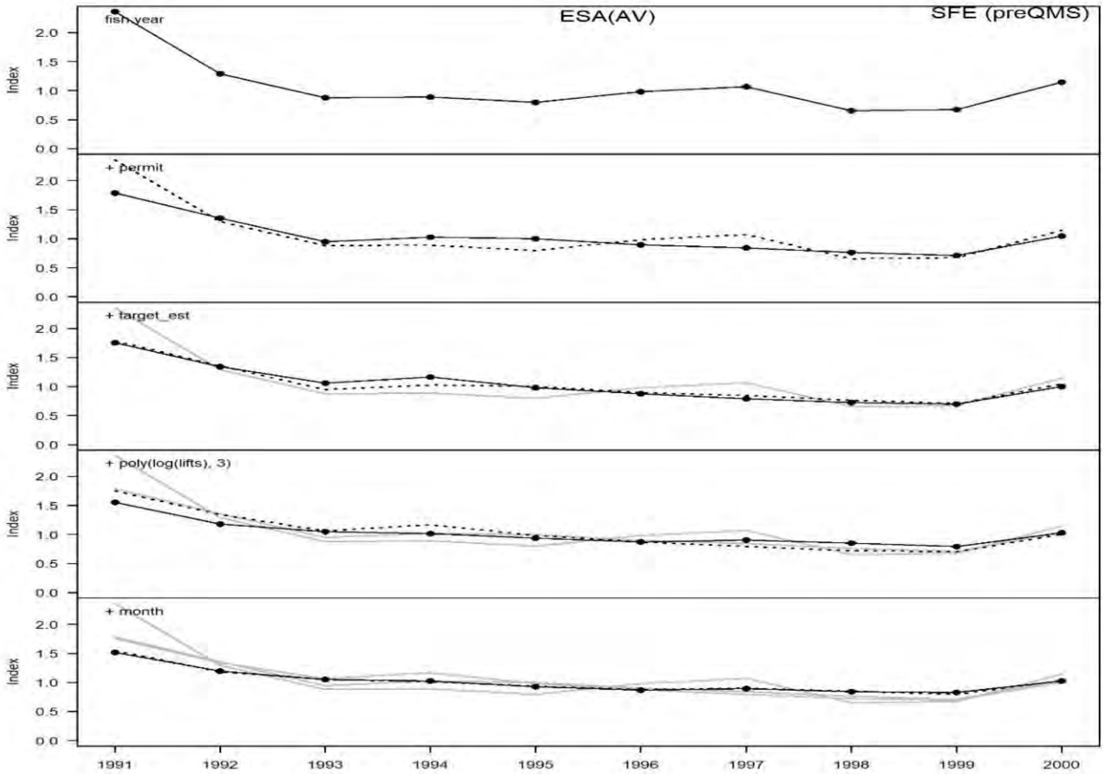

Figure F13: Step plot for the shortfin eel CPUE model for the years 1990–91 to 1999–2000 (pre-QMS). Each panel shows the standardised CPUE index as each explanatory variable is added to the model with the previous index shown by the dotted line and the grey lines for steps before that (ESA(AV)).

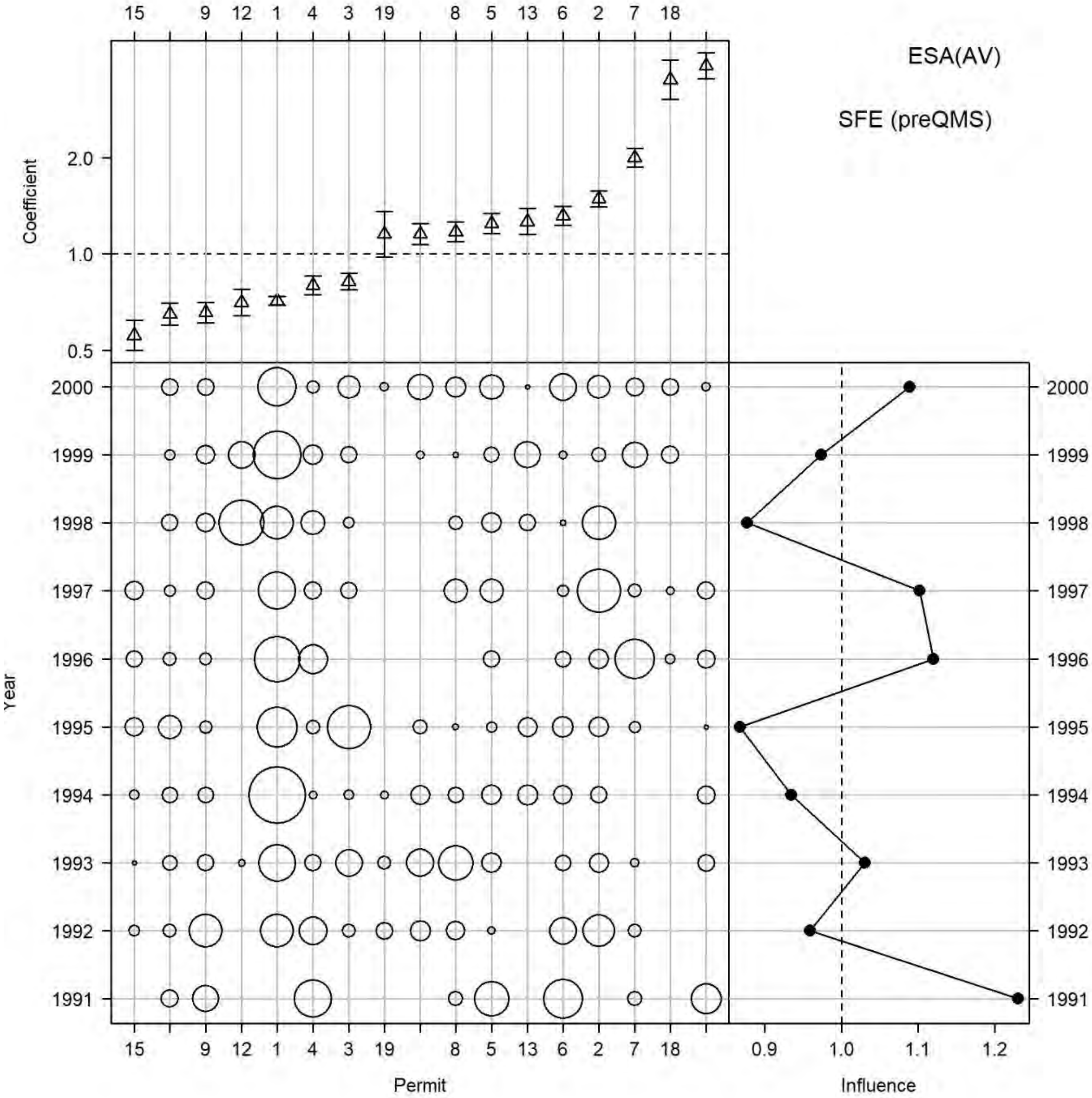

Figure F14: Influence of permit for the shortfin CPUE model for the years 1990–91 to 1999–2000 (pre-QMS) (ESA(AV)).

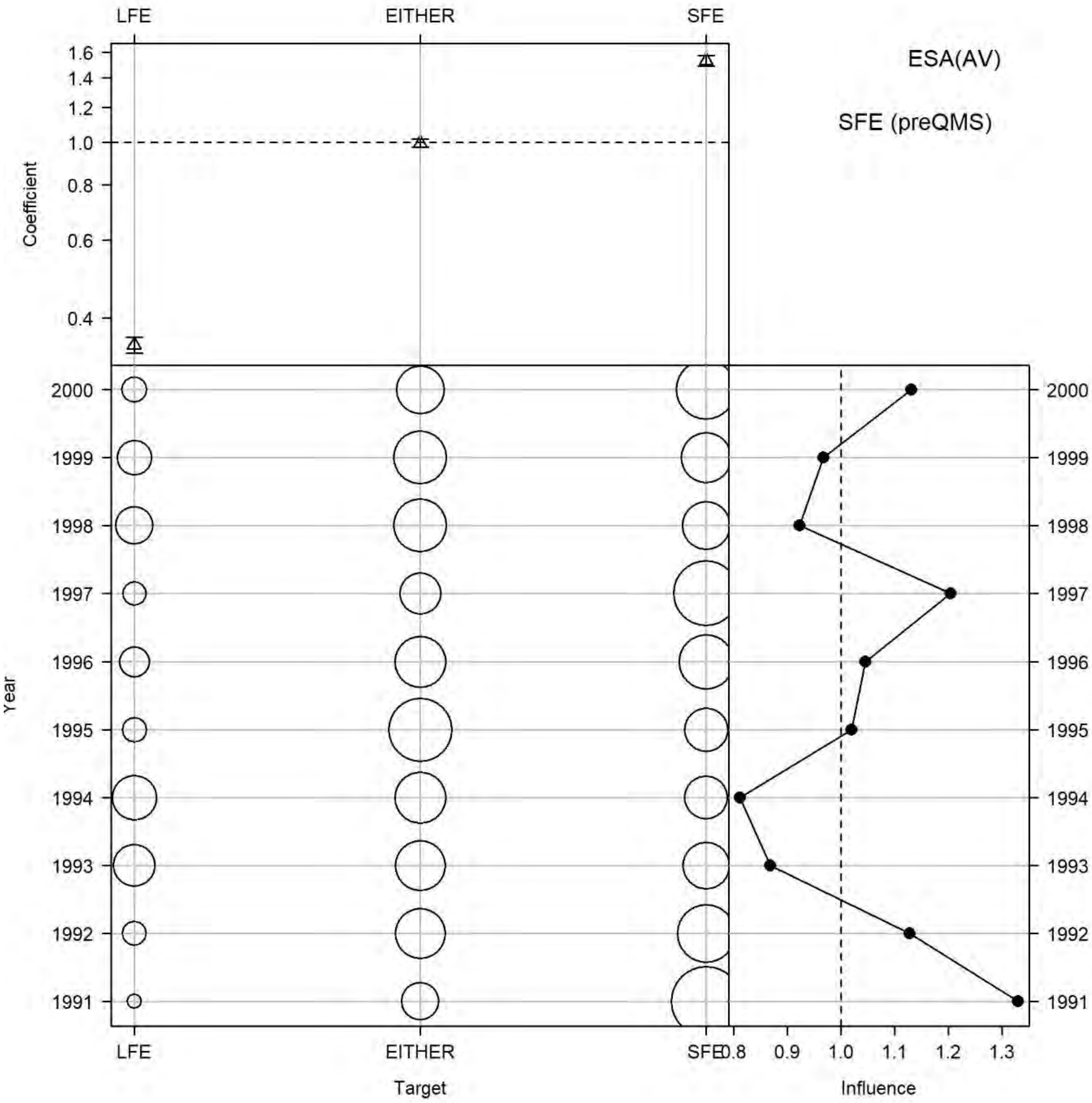

Figure F15: Influence of target for the shortfin CPUE model for the years 1990–91 to 1999–2000 (pre-QMS) (ESA(AV)).

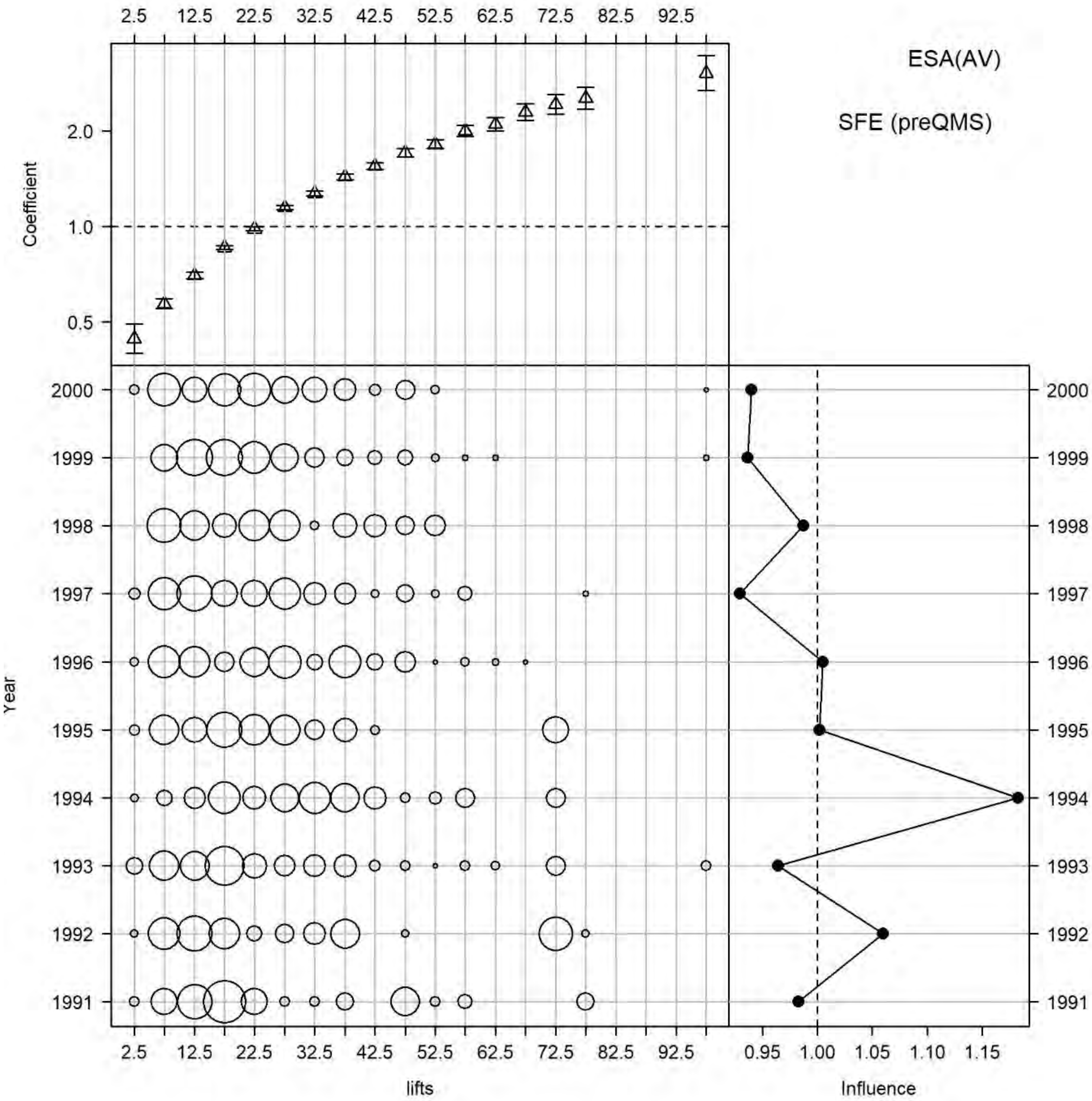

Figure F16: Influence of lifts for the shortfin CPUE model for the years 1990–91 to 1999–2000 (pre-QMS) (ESA(AV)).

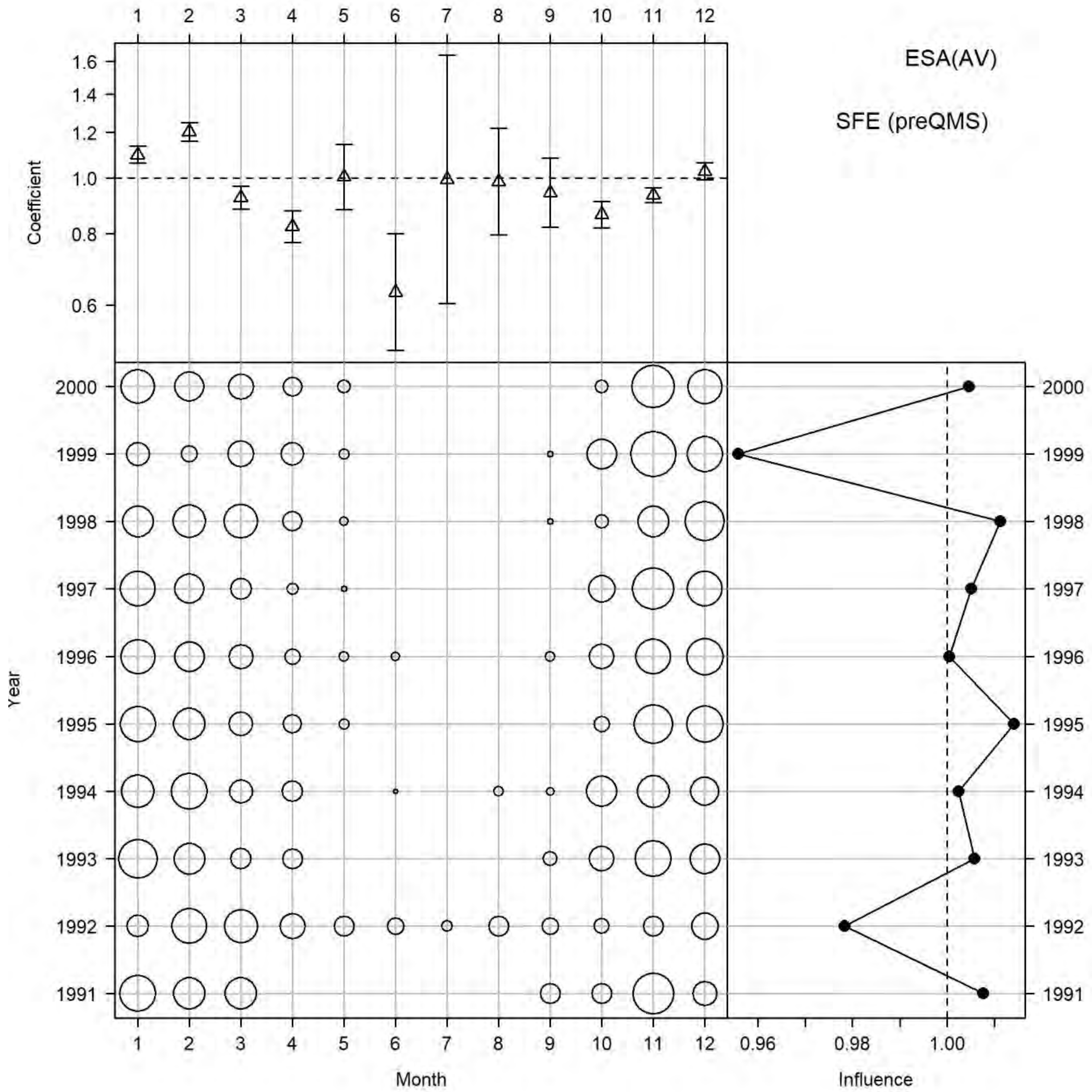

Figure F17: Influence of month for the shortfin CPUE model for the years 1990–91 to 1999–2000 (pre-QMS) (ESA(AV)).

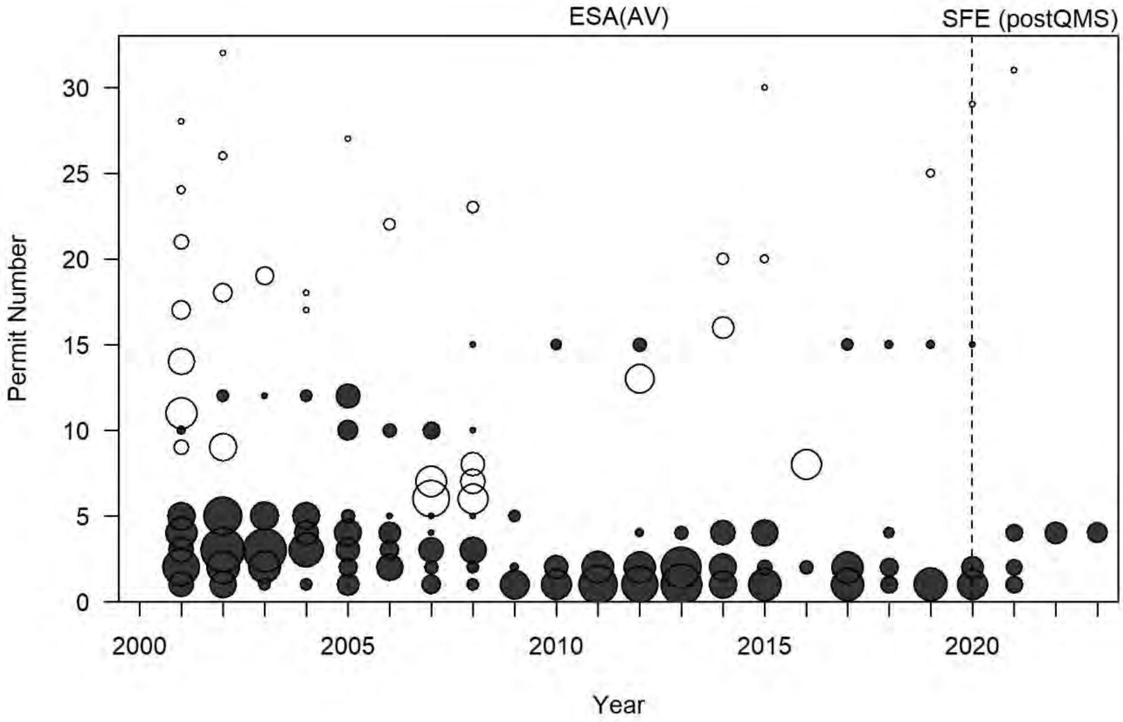

Figure F18: Relative shortfin catch from all fishers (all circles) for the years 2000–01 to 2022–23 (post-QMS), and for core fishers (dark shaded circles) included in the catch per unit effort analyses. Vertical dashed line represents introduction of electronic reporting in 2019–20 (ESA(AV)).

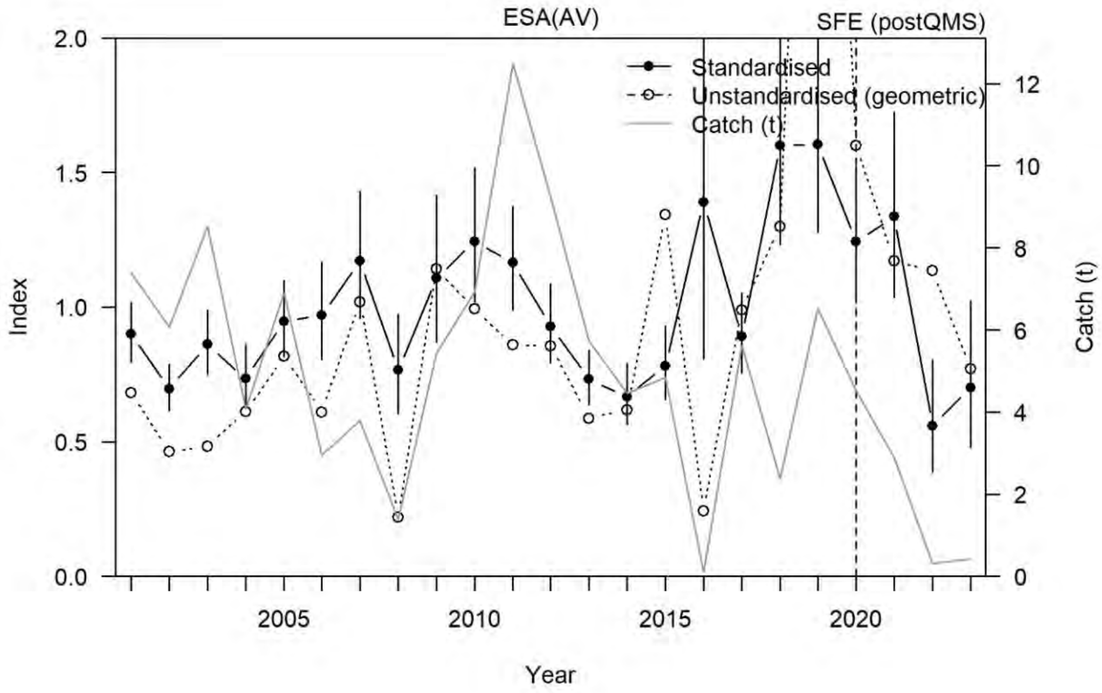

Figure F19: Indices of unstandardised (geometric mean of catch per lift) and standardised CPUE for shortfin (core fishers) post-QMS for the years 2000–01 to 2022–23. The catch by core fishers is also plotted. Vertical dashed line represents introduction of electronic reporting in 2019–20 (ESA(AV)).

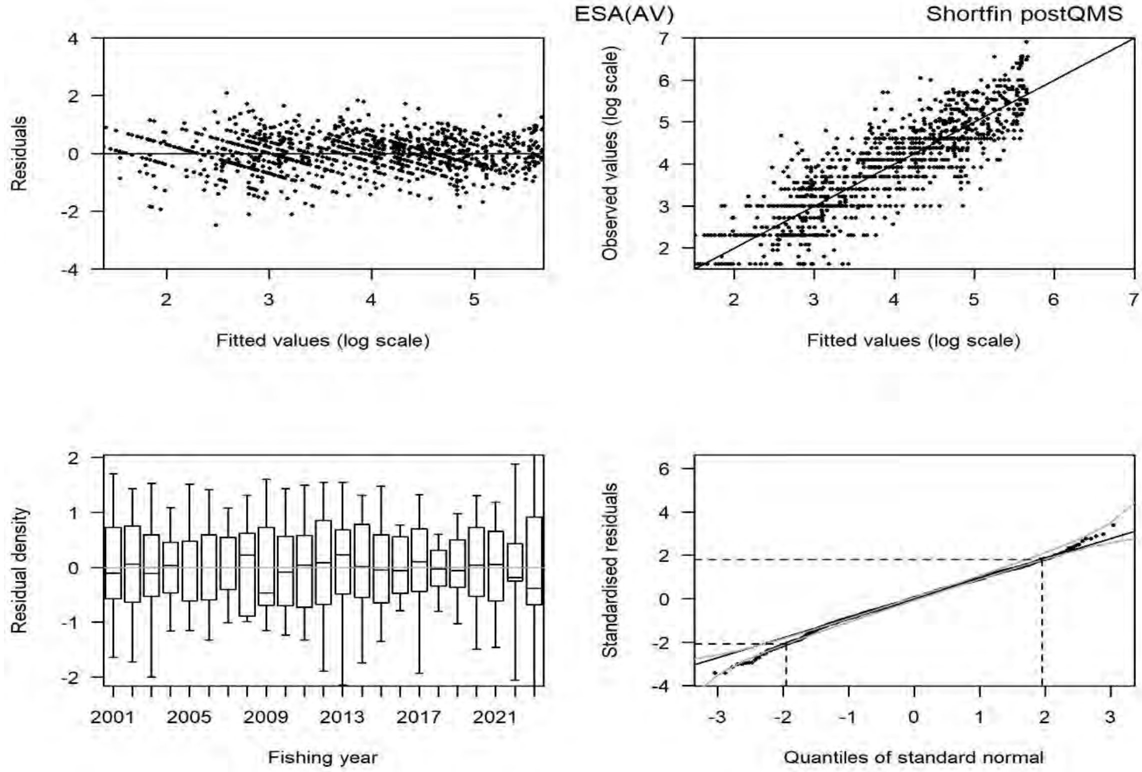

Figure F20: Residual diagnostic plots for the shortfin eel CPUE model for the years 2000–01 to 2022–23 (post-QMS). The grey lines on the quantile-quantile plot represent the 95% confidence envelopes of a standard normal distribution (ESA(AV)).

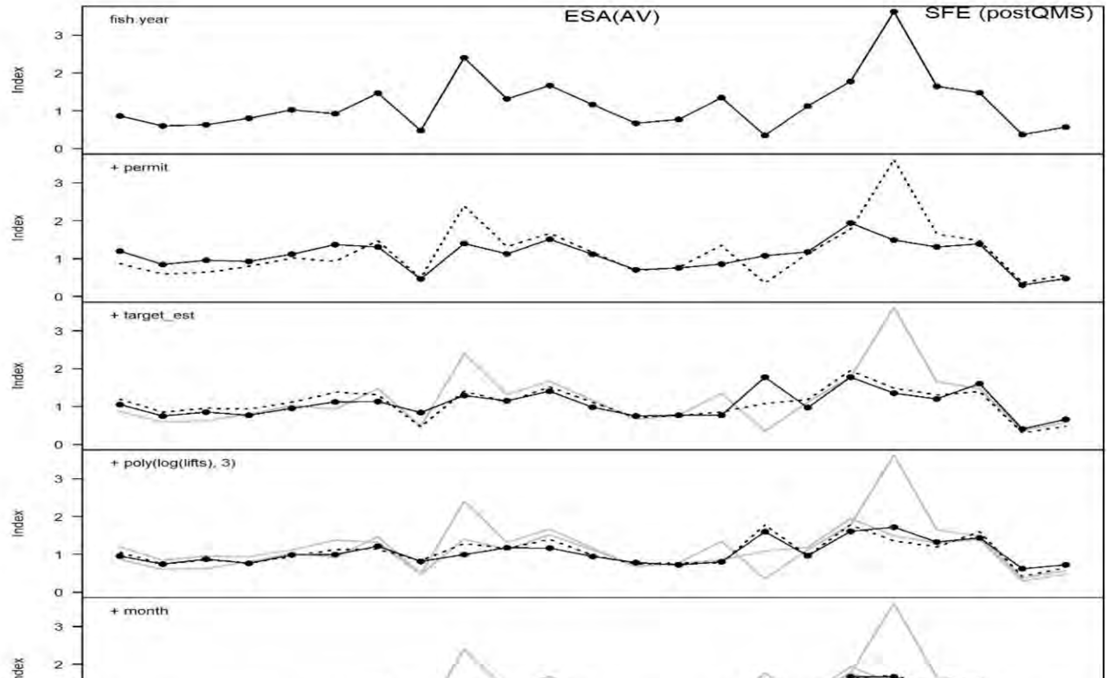

Figure F21: Step plot for the shortfin eel CPUE model for the years 2000–01 to 2022–23 (post-QMS). Each panel shows the standardised CPUE index as each explanatory variable is added to the model with the previous index shown by the dotted line and the grey lines for steps before that (ESA(AV)).

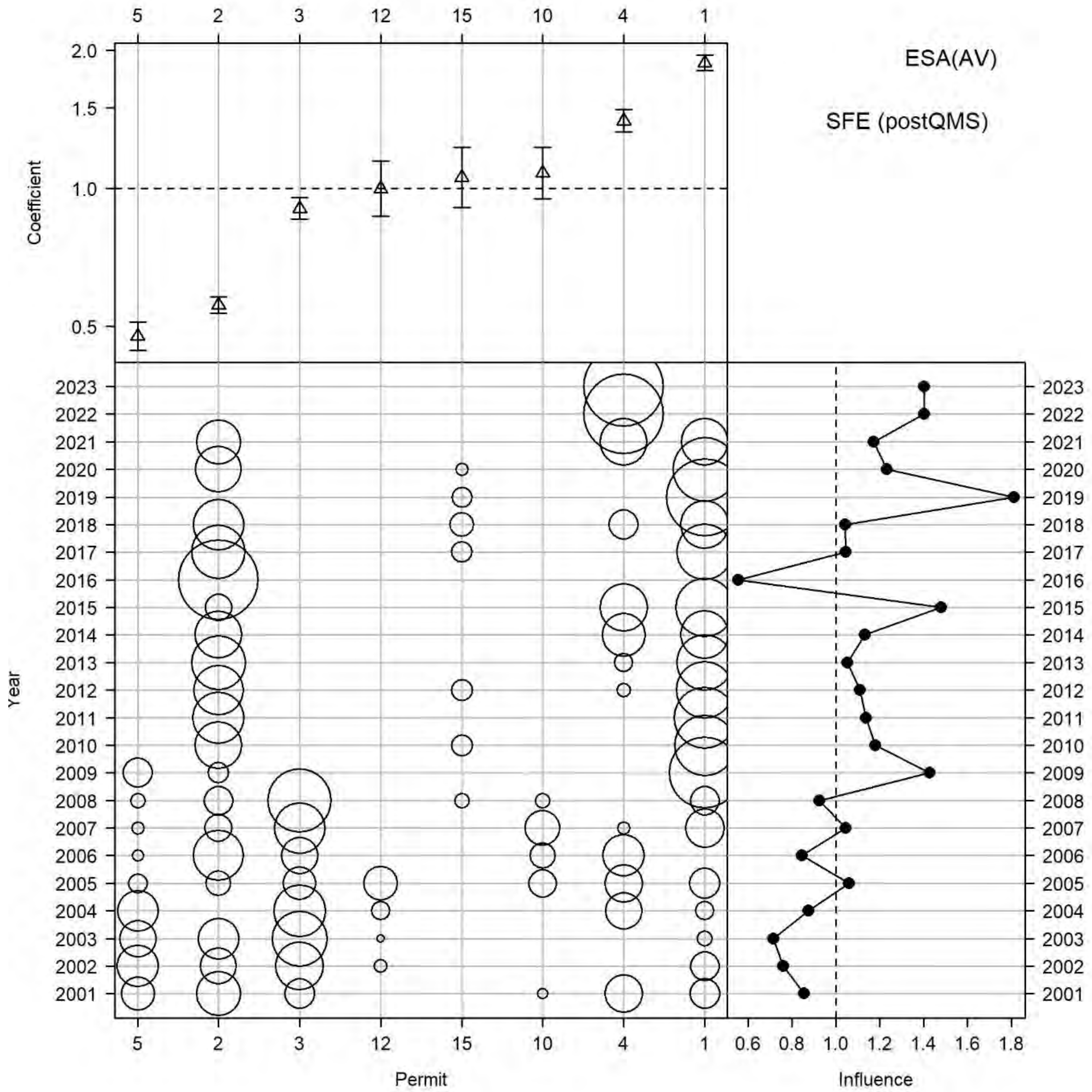

Figure F22: Influence of catcher for the shortfin CPUE model for the years 2000–01 to 2022–23 (post-QMS) (ESA(AV)).

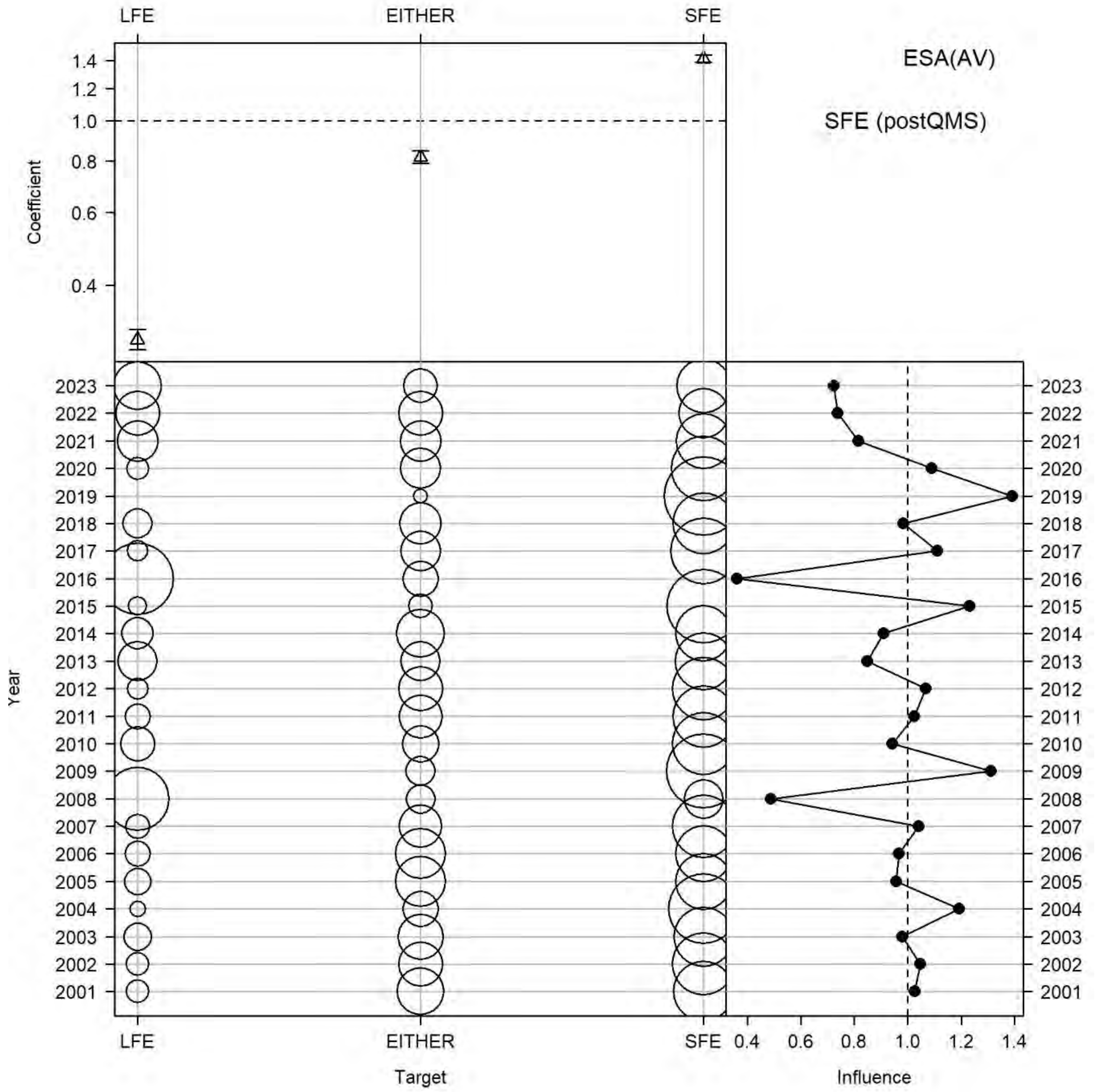

Figure F23: Influence of target for the shortfin CPUE model for the years 2000–01 to 2022–23 (post-QMS) (ESA(AV)).

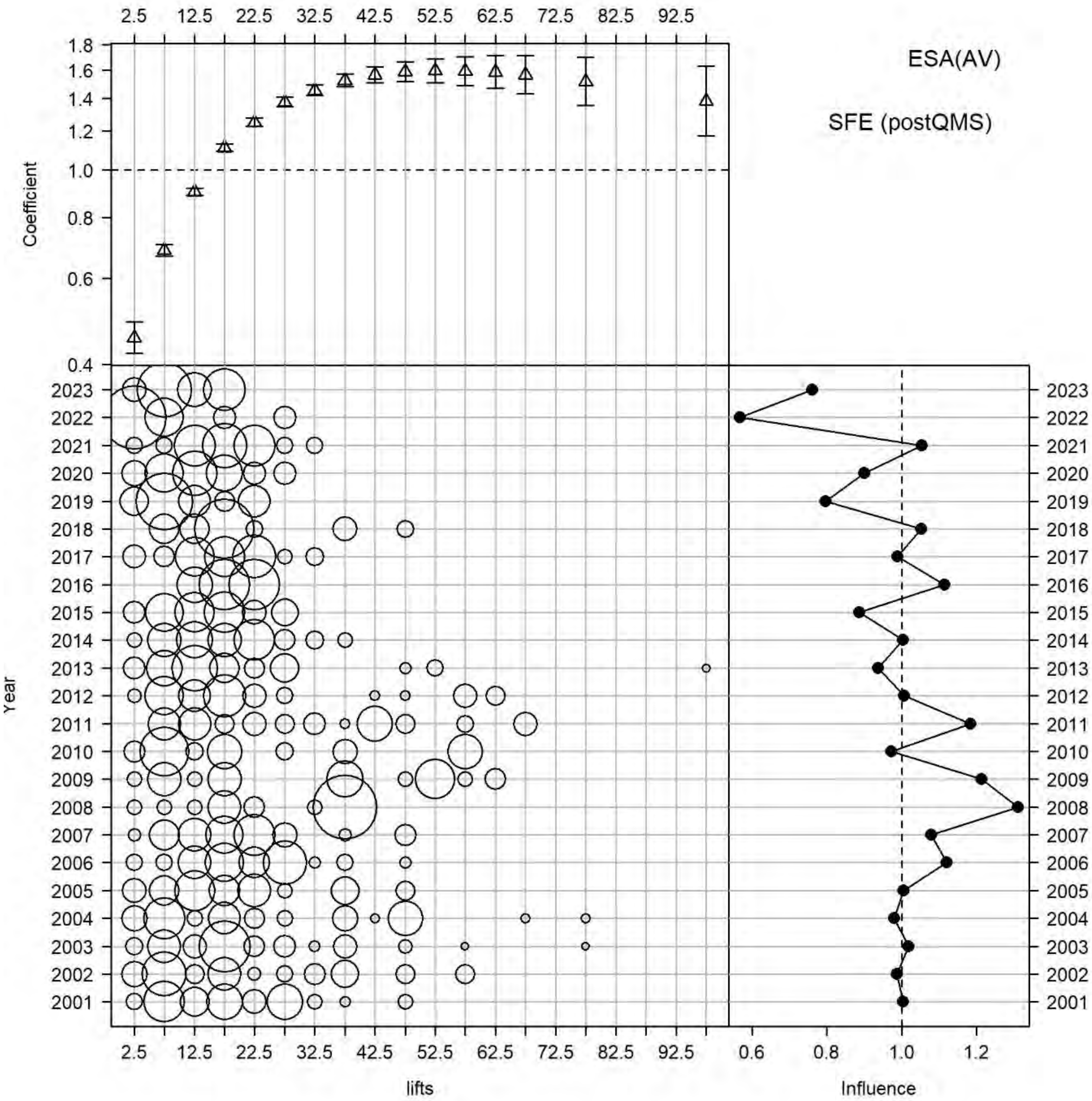

Figure F24: Influence of lifts for the shortfin CPUE model for the years 2000–01 to 2022–23 (post-QMS) (ESA(AV)).

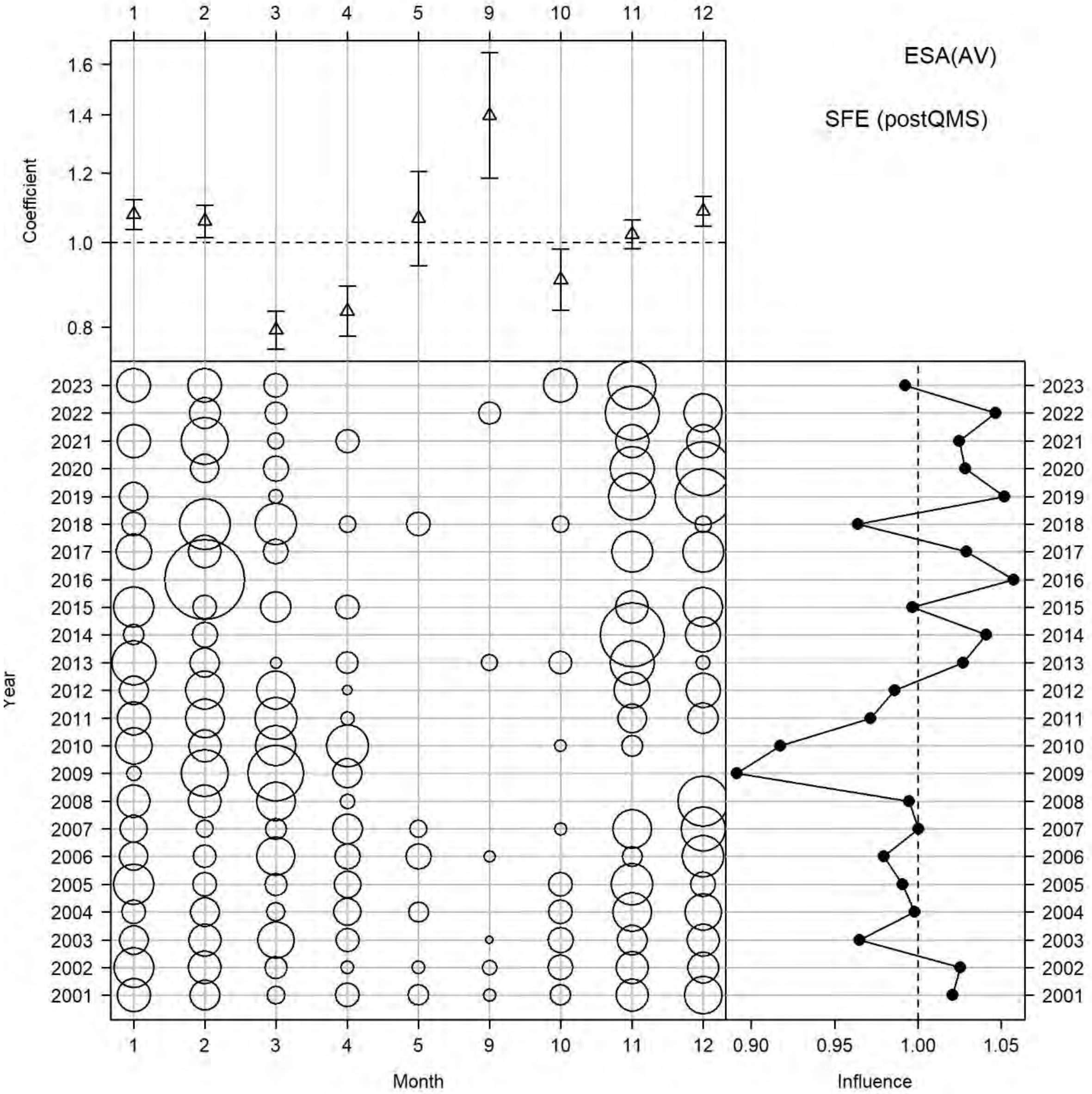

Figure F25: Influence of month for the shortfin CPUE model for the years 2000–01 to 2022–23 (post-QMS) (ESA(AV)).

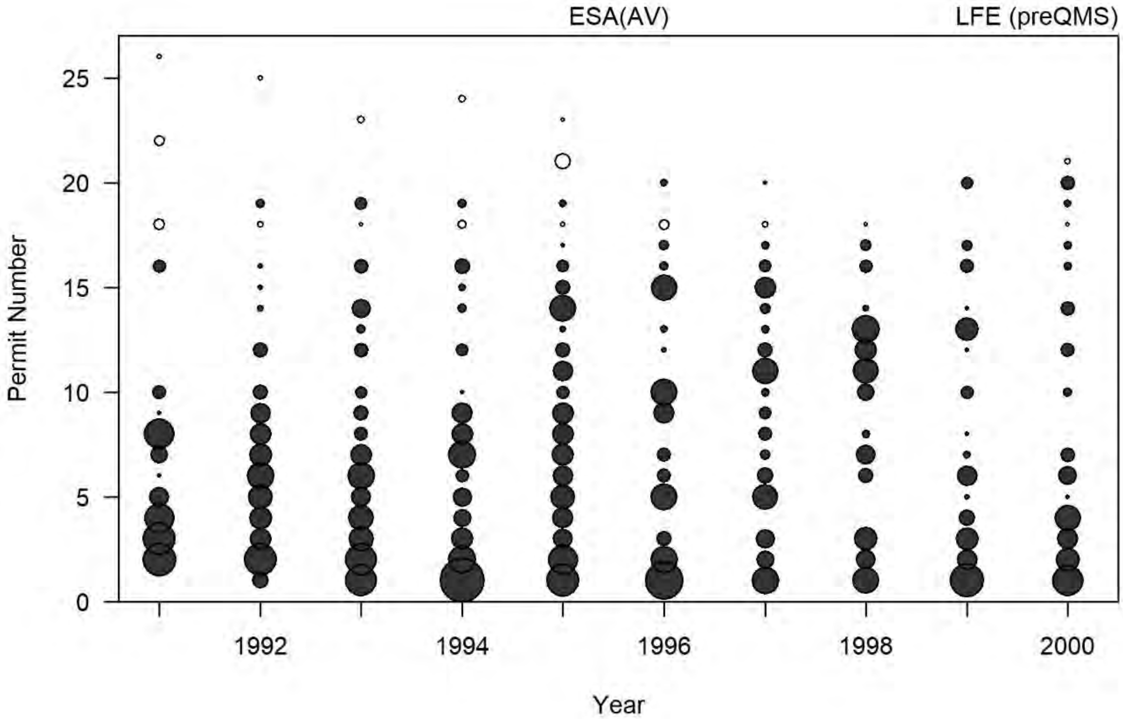

Figure F26: Relative longfin catch from all fishers (all circles) for the years 1990–91 to 1999–2000 (pre-QMS), and for core fishers (dark shaded circles) included in the catch per unit effort analyses (ESA(AV)).

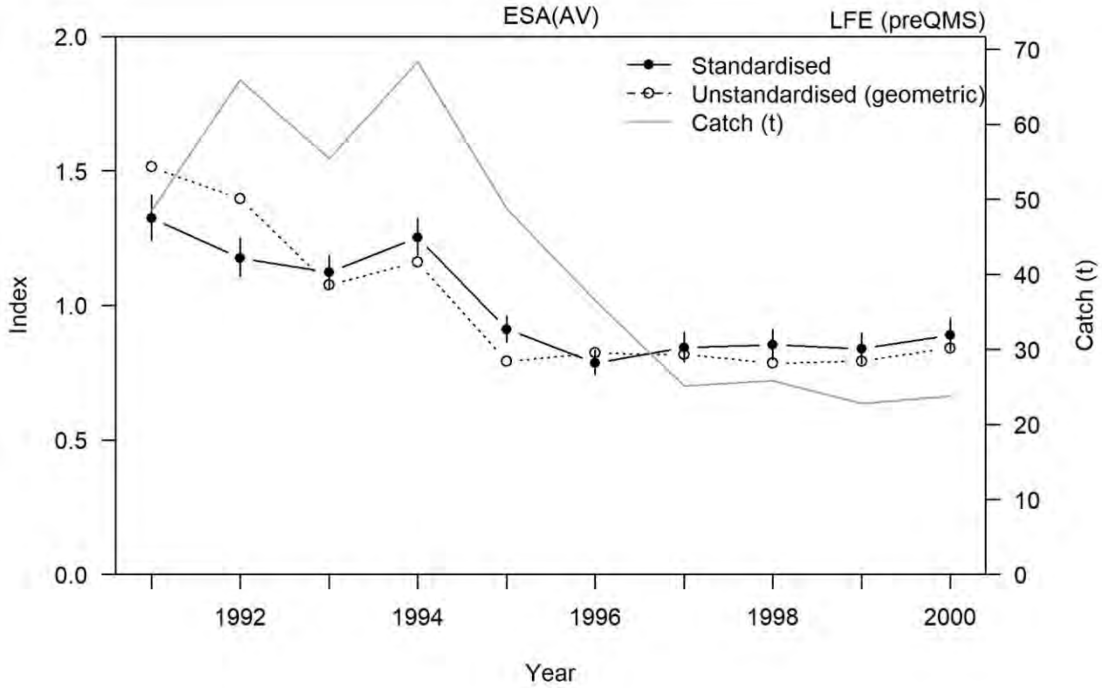

Figure F27: Indices of unstandardised (geometric mean of catch per lift) and standardised CPUE for longfin (core fishers) pre-QMS for the years 1990–91 to 1999–2000. The catch by core fishers is also plotted (ESA(AV)).

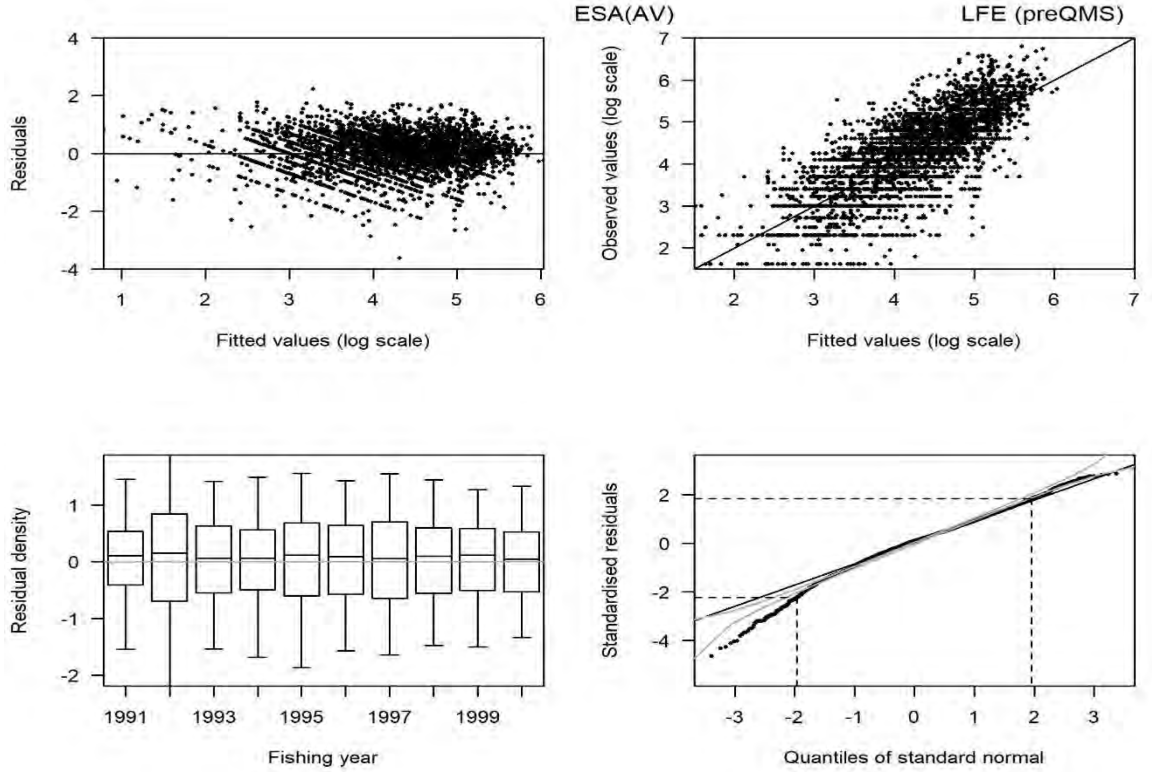

Figure F28: Residual diagnostic plots for the longfin eel CPUE model for the years 1990–91 to 1999–2000 (pre-QMS). The grey lines on the quantile-quantile plot represent the 95% confidence envelopes of a standard normal distribution (ESA(AV)).

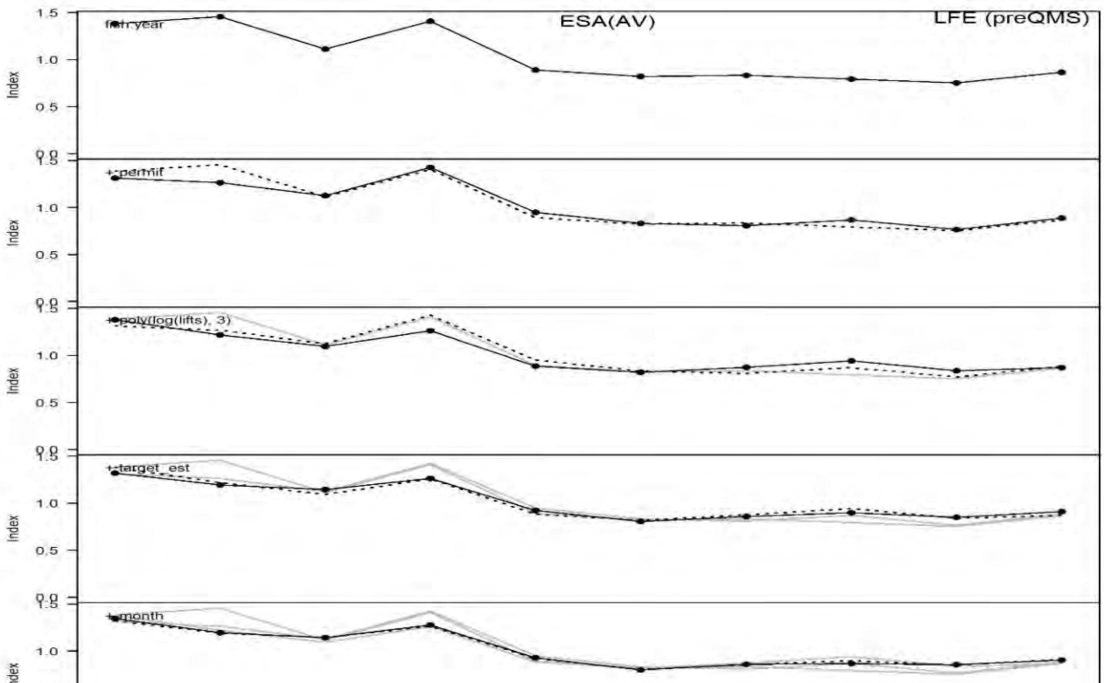

Figure F29: Step plot for the longfin eel CPUE model for the years 1990–91 to 1999–2000 (pre-QMS). Each panel shows the standardised CPUE index as each explanatory variable is added to the model with the previous index shown by the dotted line and the grey lines for steps before that (ESA(AV)).

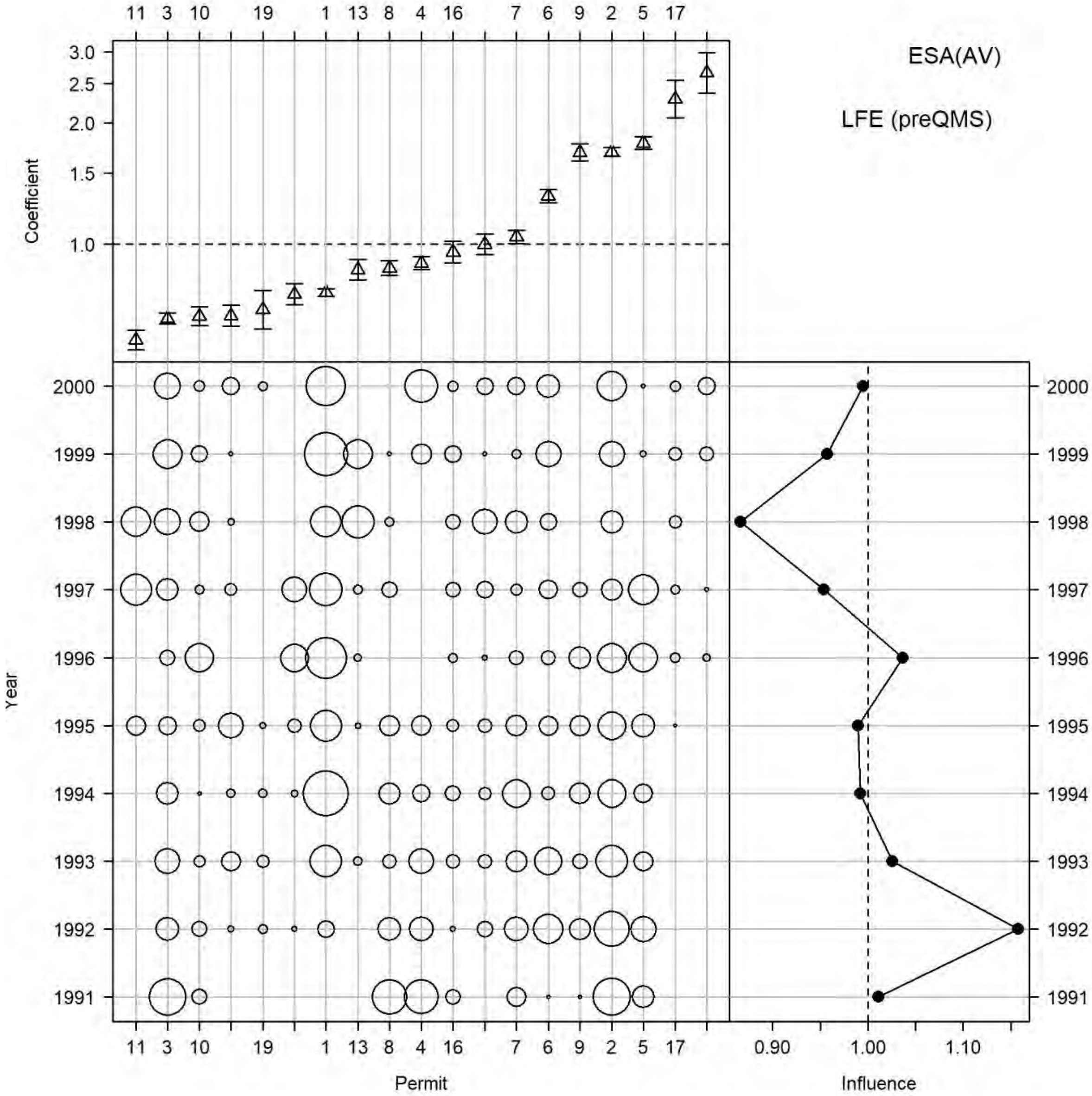

Figure F30: Influence of permit for the longfin CPUE model for the years 1990–91 to 1999–2000 (pre-QMS) (ESA(AV)).

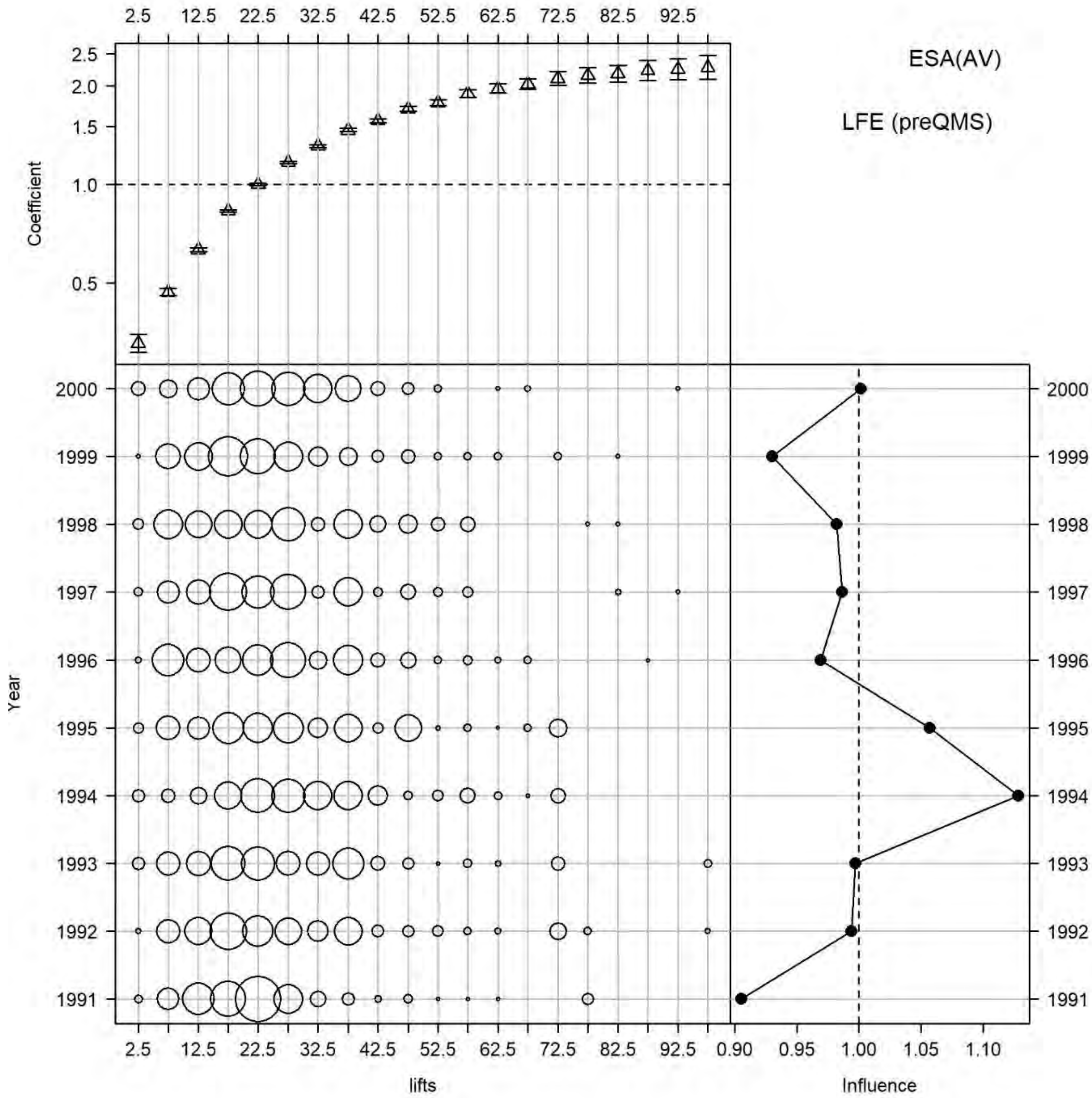

Figure F31: Influence of lifts for the longfin CPUE model for the years 1990–91 to 1999–2000 (pre-QMS) (ESA(AV)).

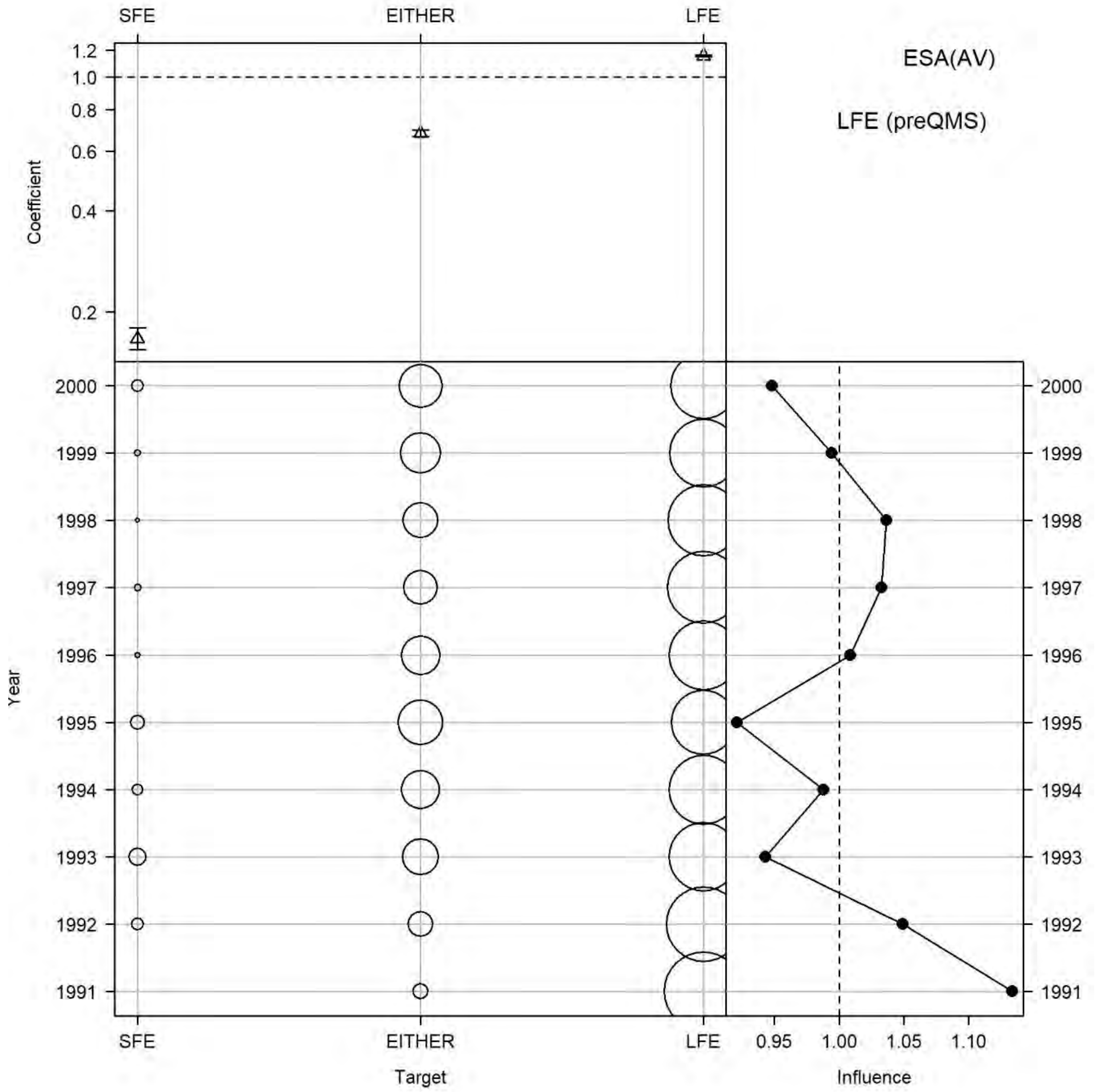

Figure F32: Influence of target for the longfin CPUE model for the years 1990–91 to 1999–2000 (pre-QMS) (ESA(AV)).

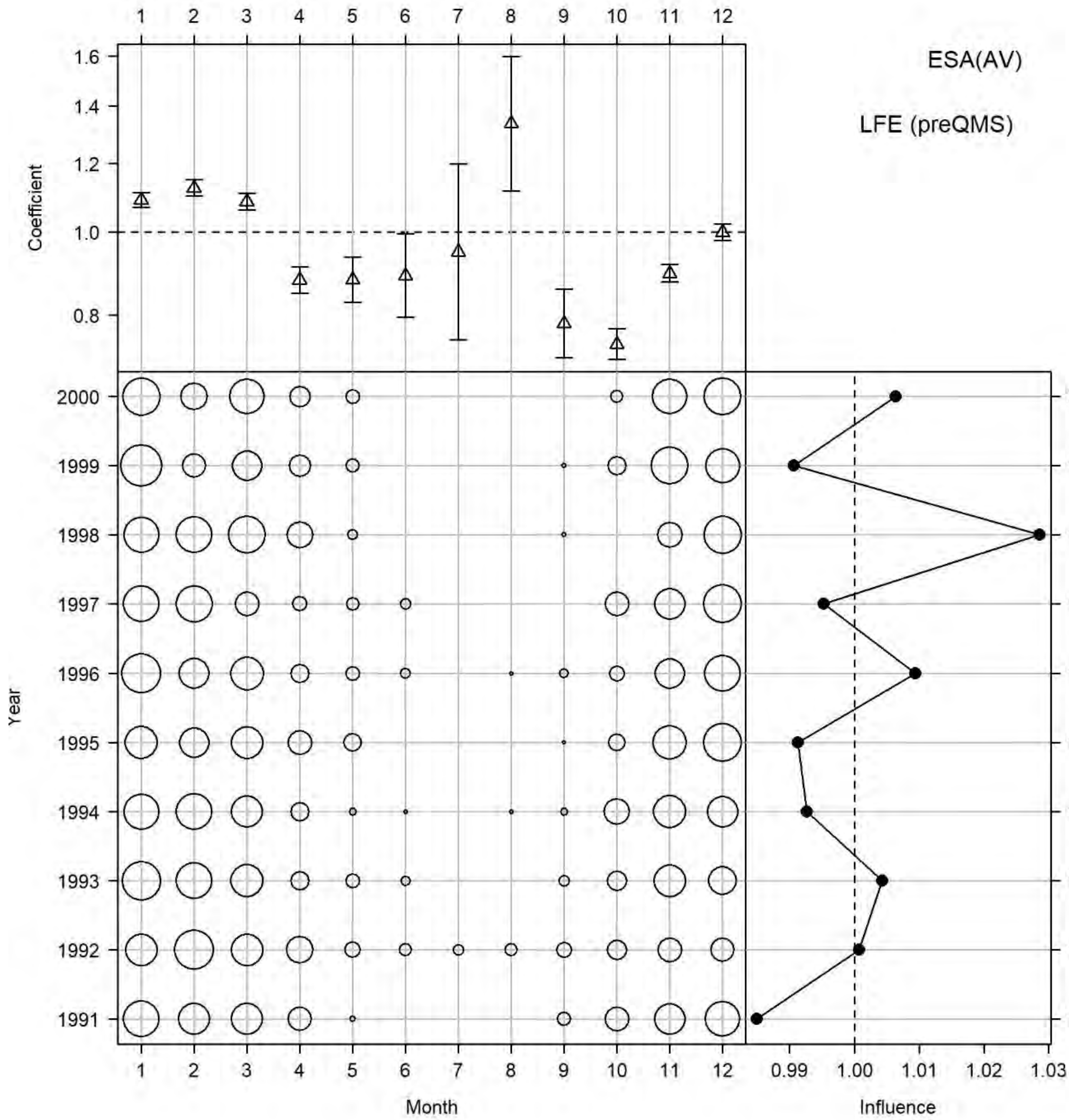

Figure F33: Influence of month for the longfin CPUE model for the years 1990–91 to 1999–2000 (pre-QMS) (ESA(AV)).

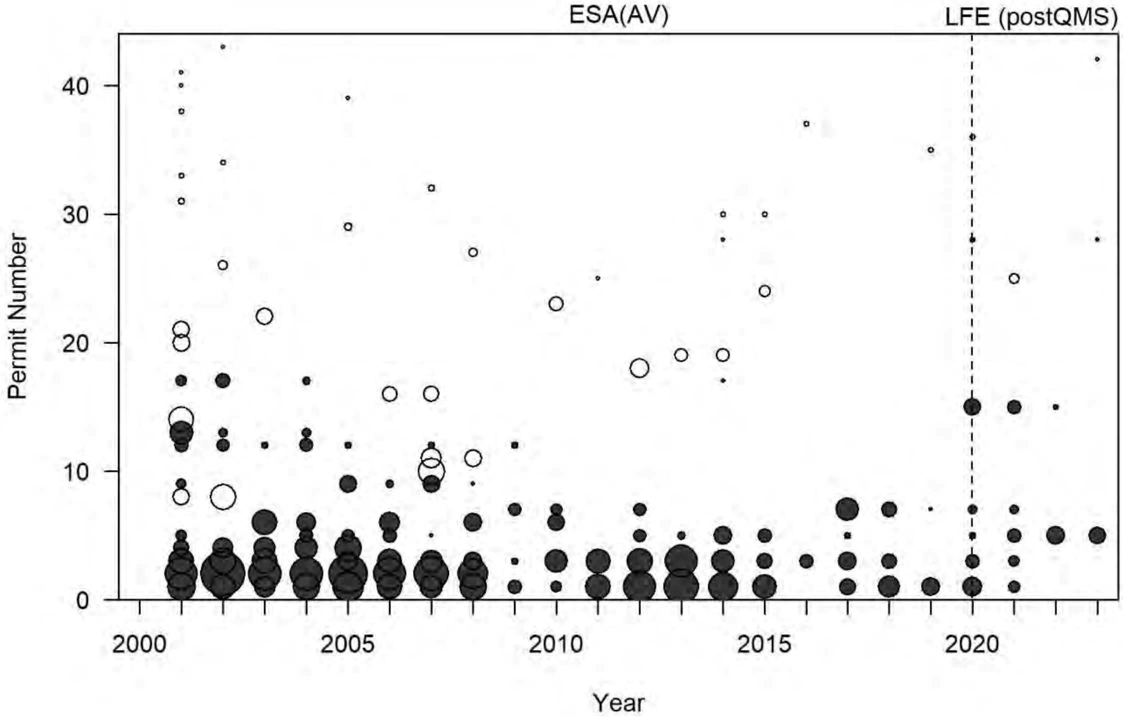

Figure F34: Relative longfin catch from all fishers (all circles) for the years 2000–01 to 2022–23 (post-QMS), and for core fishers (dark shaded circles) included in the catch per unit effort analyses. Vertical dashed line represents introduction of electronic reporting in 2019–20 (ESA(AV)).

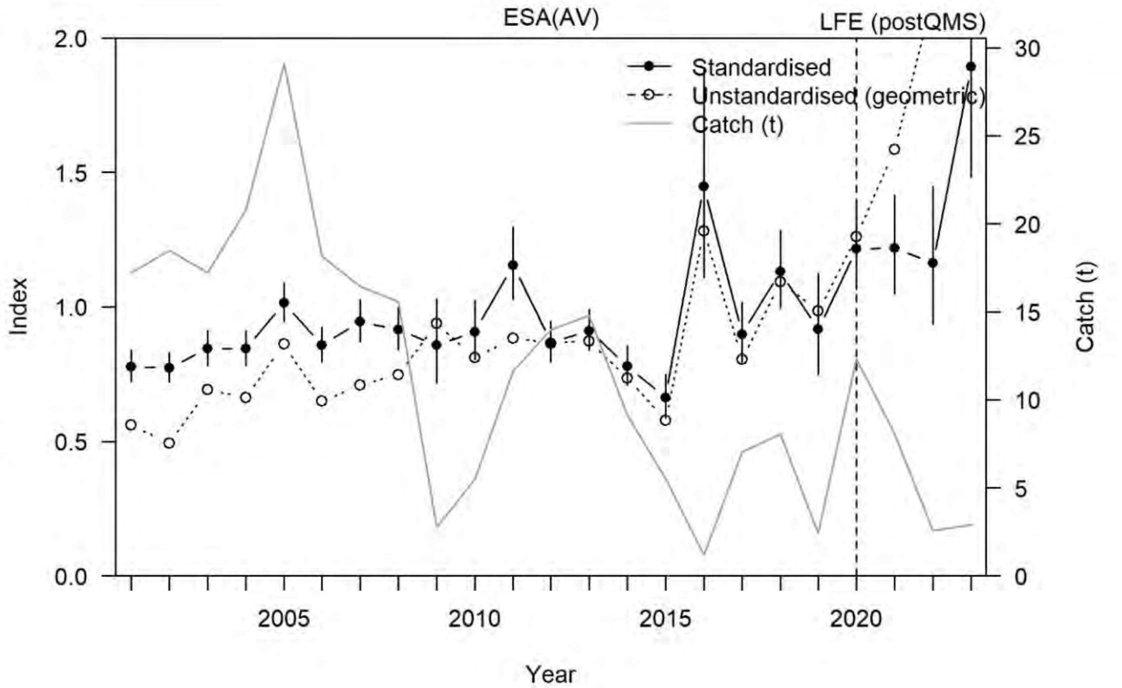

Figure F35: Indices of unstandardised (geometric mean of catch per lift) and standardised CPUE for longfin (core fishers) post-QMS for the years 2000–01 to 2022–23. The catch by core fishers is also plotted. Vertical dashed line represents introduction of electronic reporting in 2019–20 (ESA(AV)).

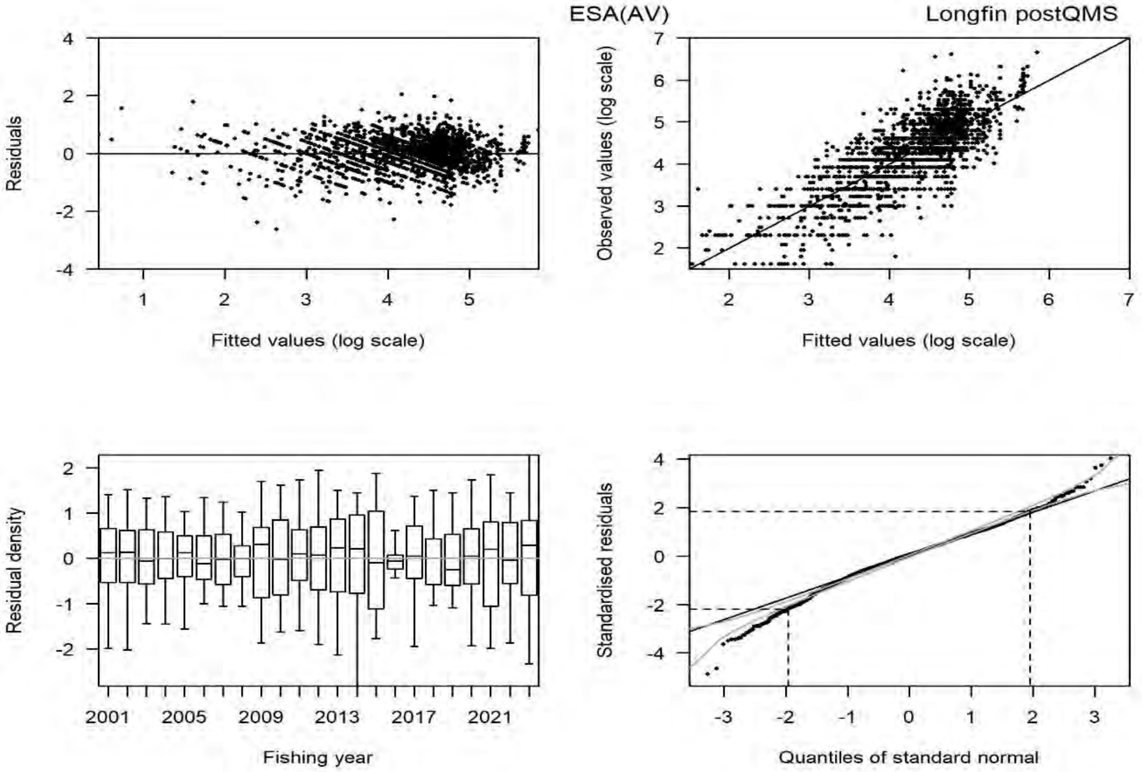

Figure F36: Residual diagnostic plots for the longfin eel CPUE model for the years 2000–01 to 2022–23 (post-QMS). The grey lines on the quantile-quantile plot represents the 95% confidence envelopes of a standard normal distribution (ESA(AV)).

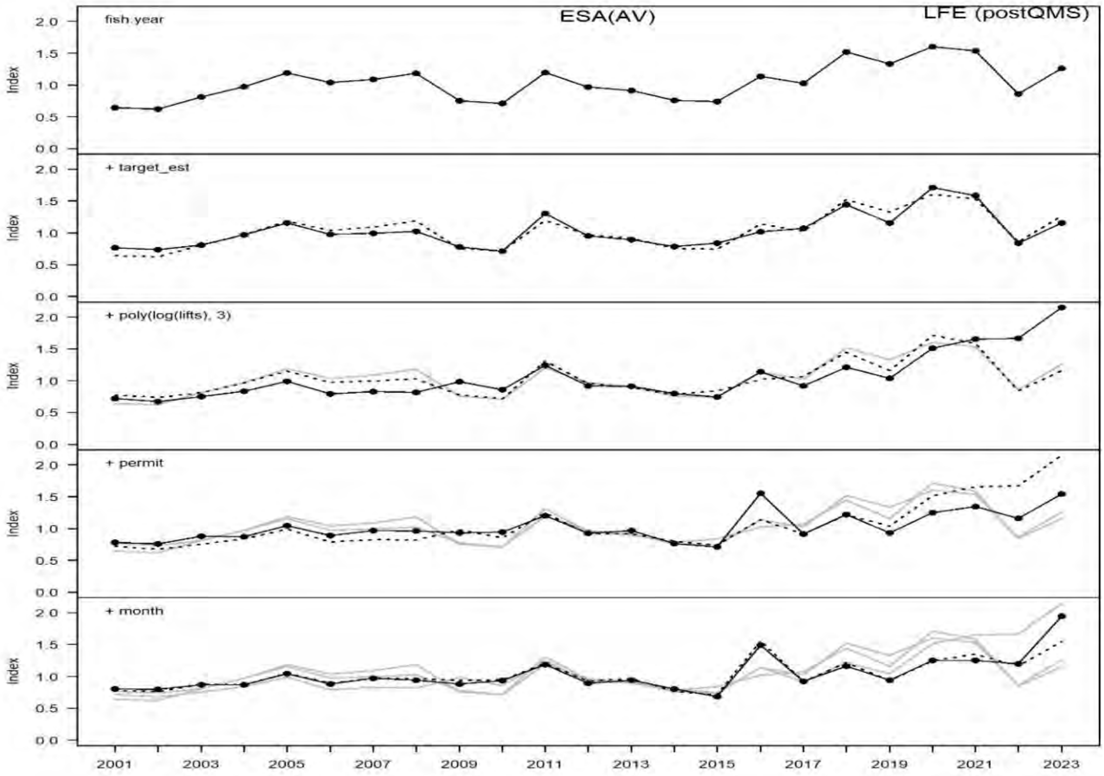

Figure F37: Step plot for the longfin eel CPUE model for the years 2000–01 to 2022–23 (post-QMS). Each panel shows the standardised CPUE index as each explanatory variable is added to the model with the previous index shown by the dotted line and the grey lines for steps before that (ESA(AV)).

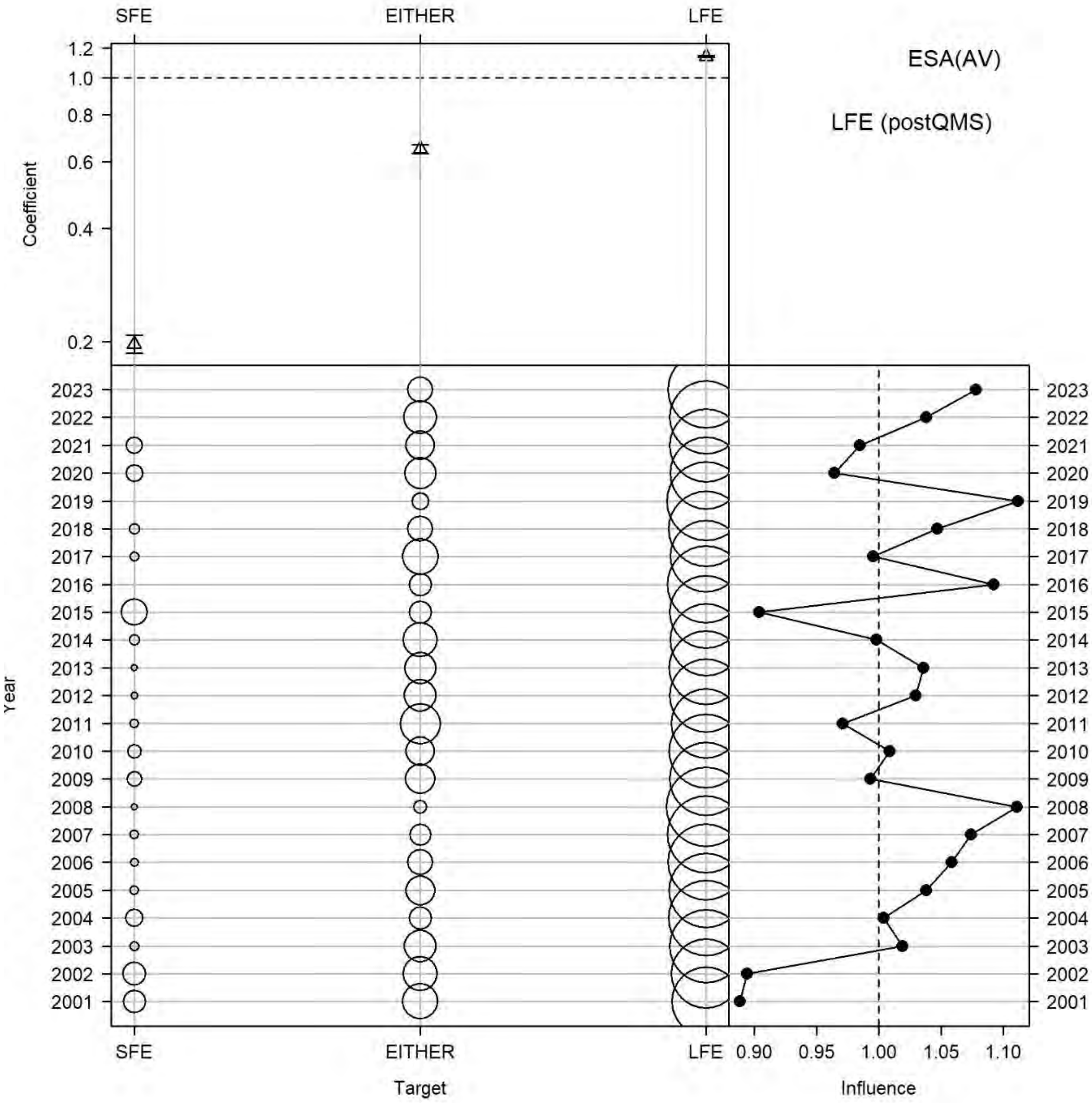

Figure F38: Influence of target for the longfin CPUE model for the years 2000–01 to 2022–23 (post-QMS) (ESA(AV)).

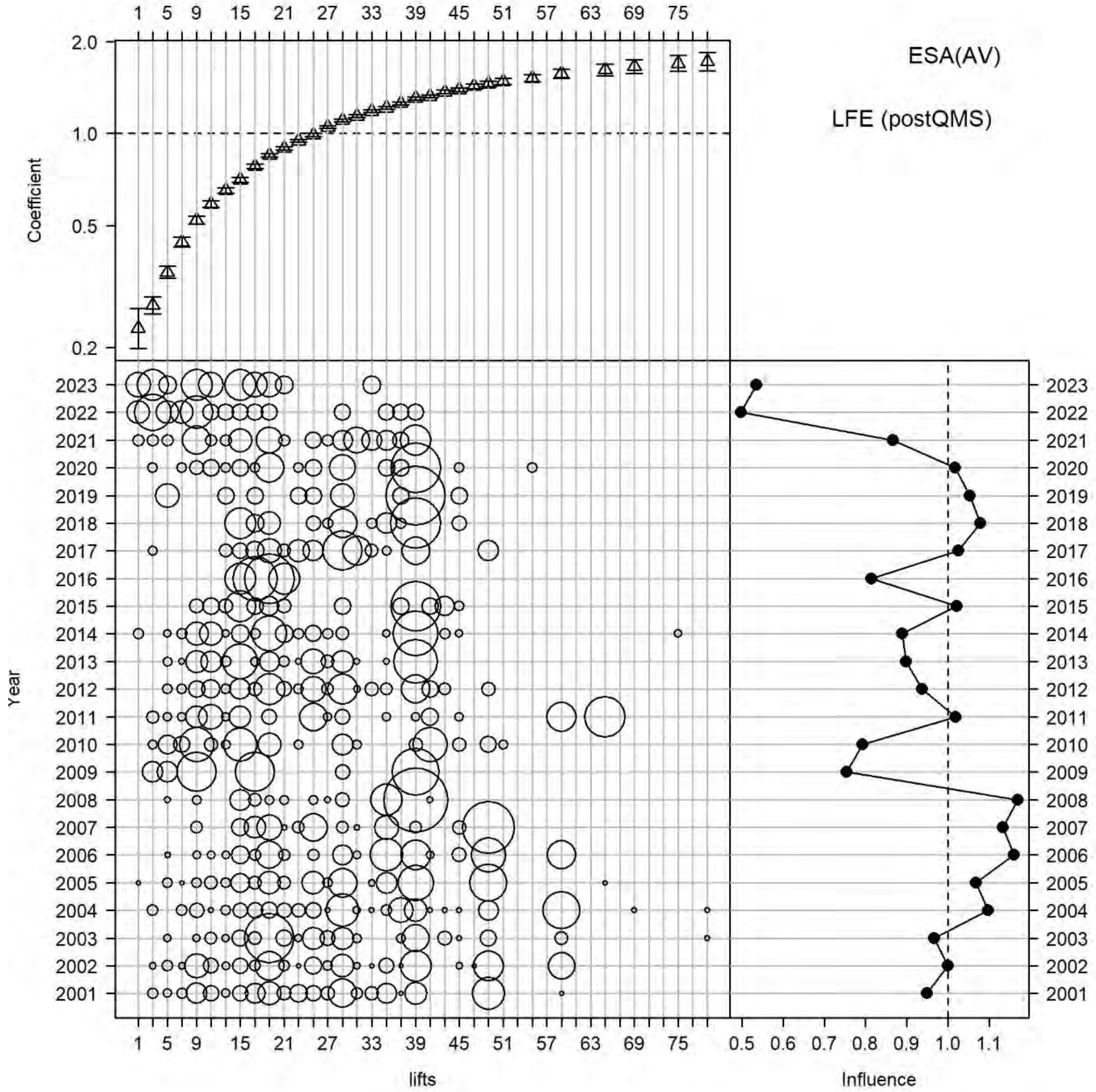

Figure F39: Influence of lifts for the longfin CPUE model for the years 2000–01 to 2022–23 (post-QMS) (ESA(AV)).

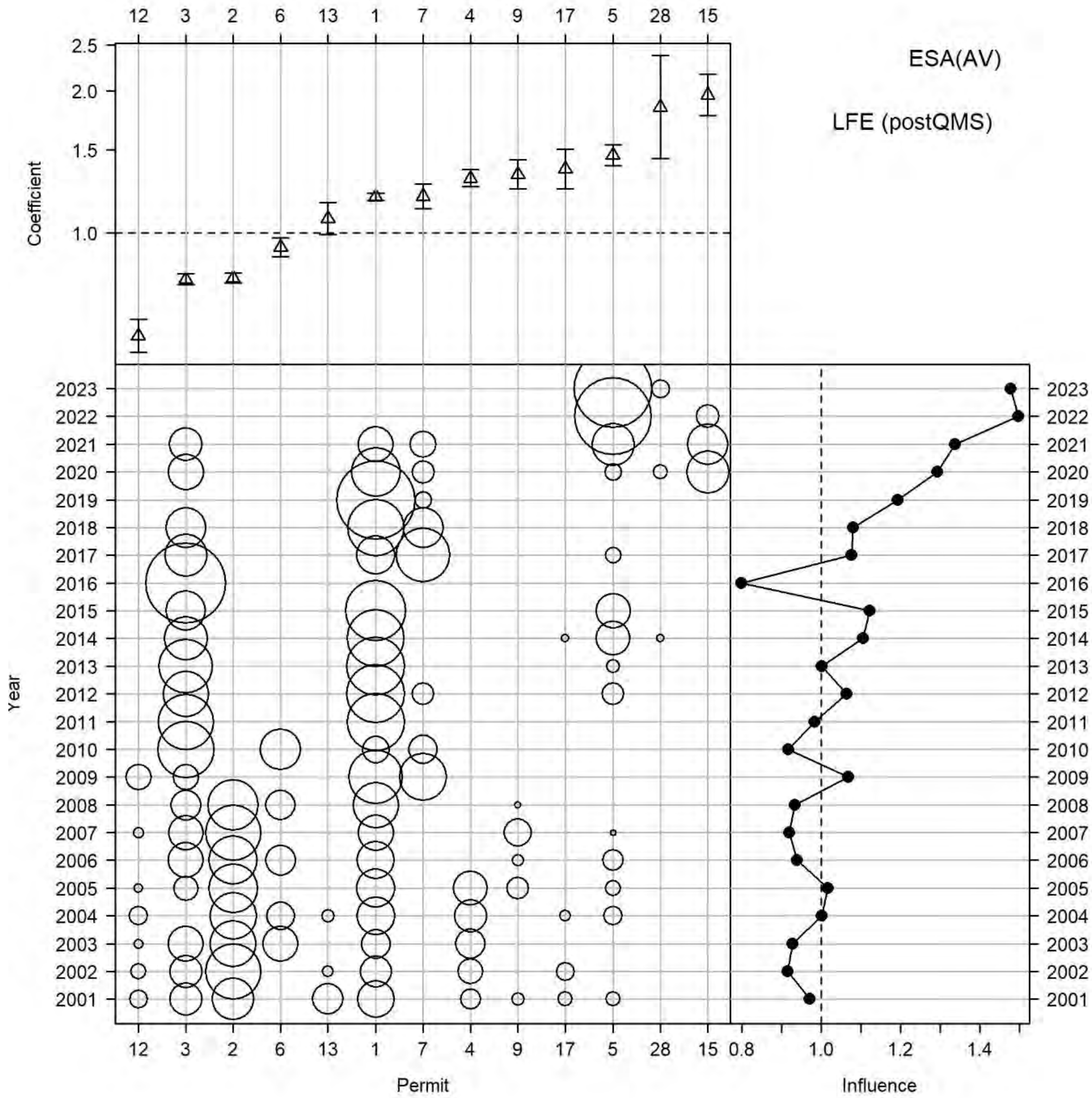

Figure F40: Influence of catcher for the longfin CPUE model for the years 2000–01 to 2022–23 (post-QMS) (ESA(AV)).

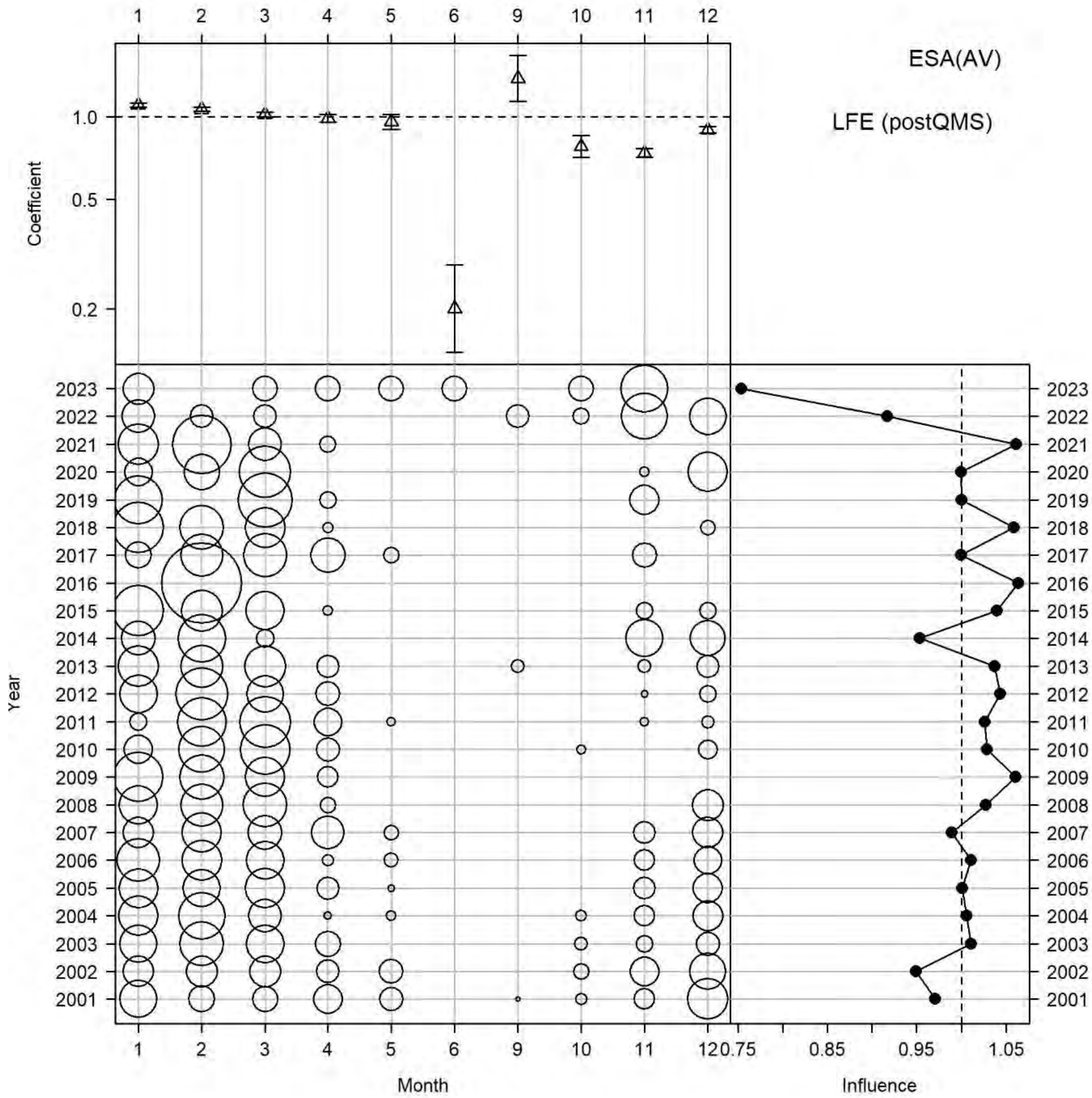

Figure F41: Influence of month for the longfin CPUE model for the years 2000–01 to 2022–23 (post-QMS) (ESA(AV)).

ESA AW (Southland)

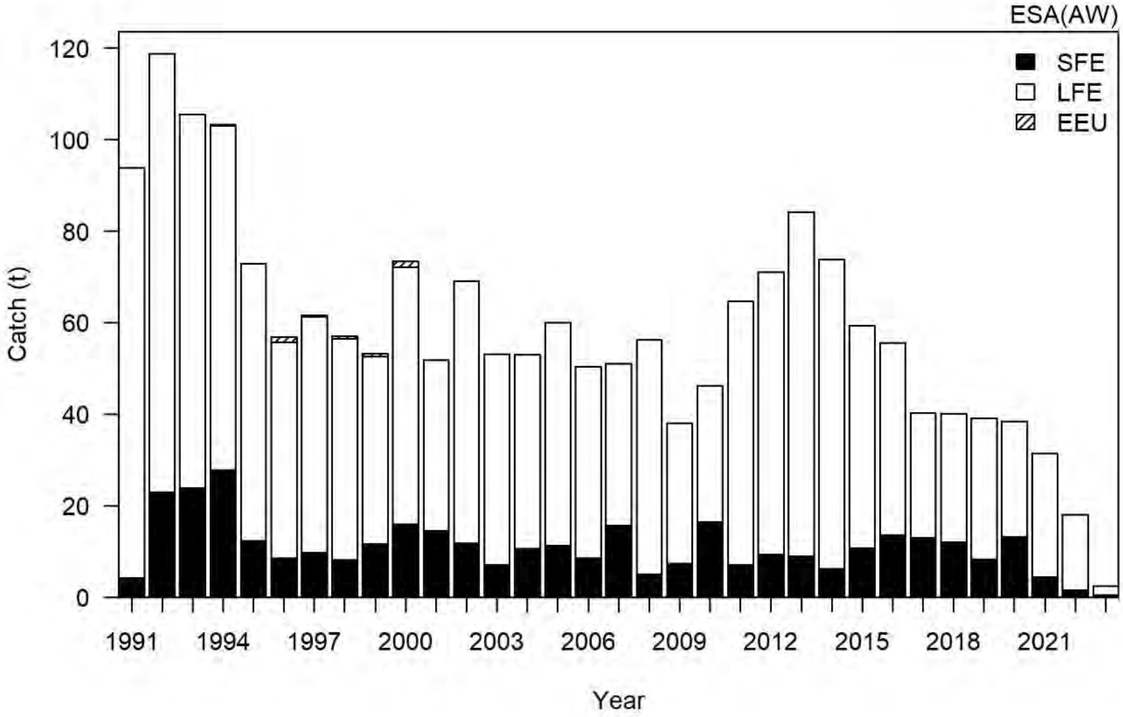

Figure G1: Total estimated commercial catch of shortfin (SFE), longfin (LFE), and unclassified eel catch (EEU) for the years 1990–91 to 2022–23 (ESA(AW)).

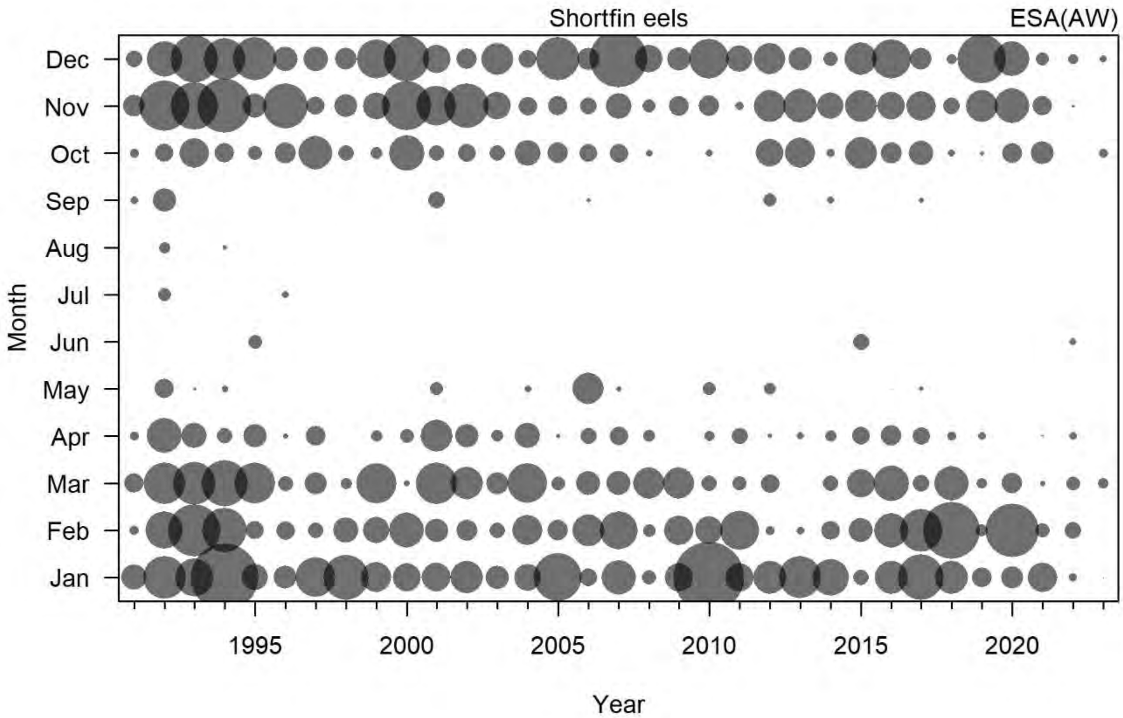

Figure G2: Shortfin eel catch by month for the years 1990–91 to 2022–23 (ESA(AW)).

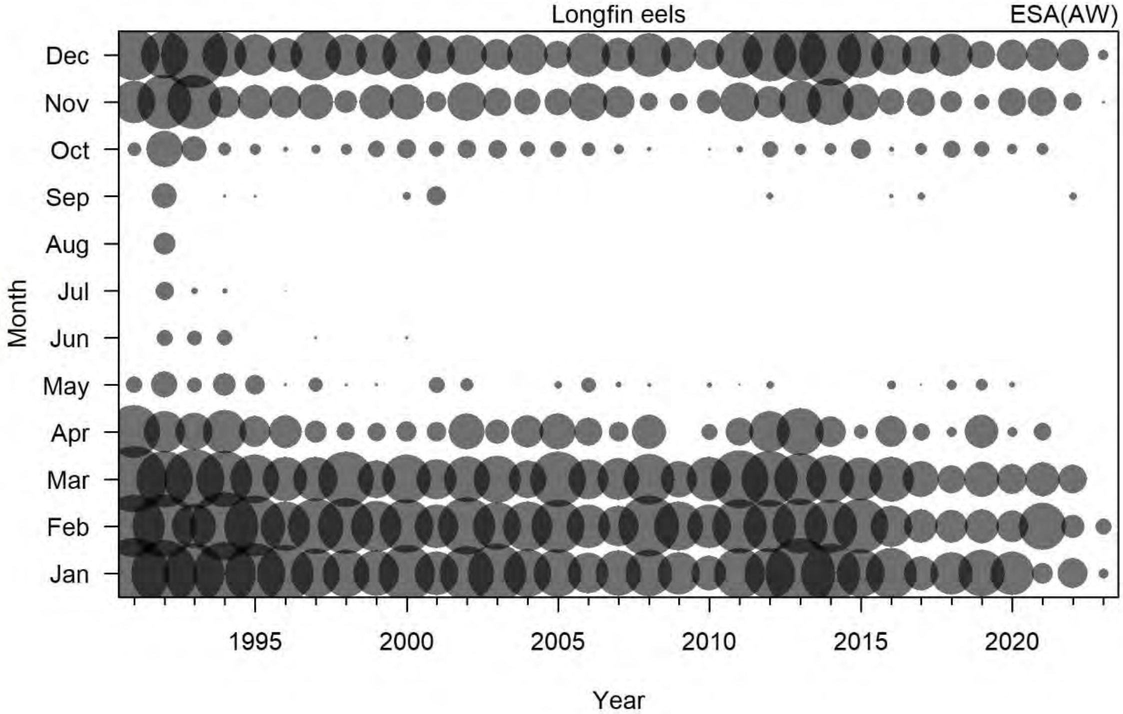

Figure G3: Longfin eel catch by month for the years 1990–-91 to 2022–23 (ESA(AW)).

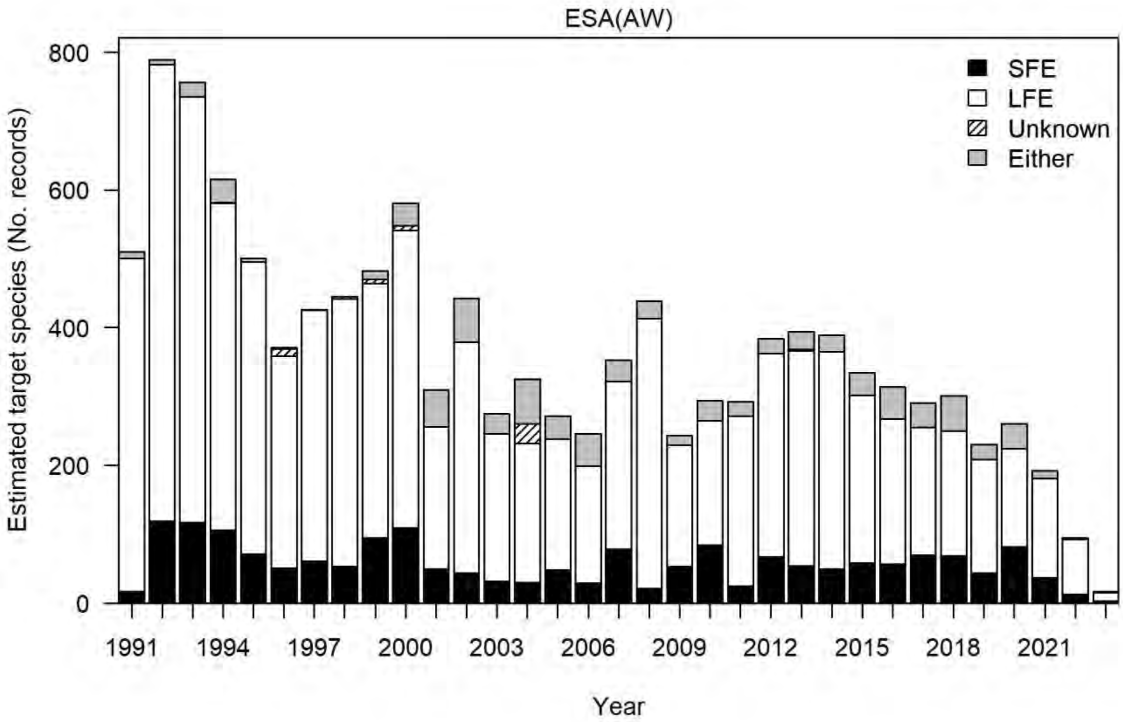

Figure G4: Reconstructed target species for the years 1990–91 to 2022–23 (ESA(AW)).

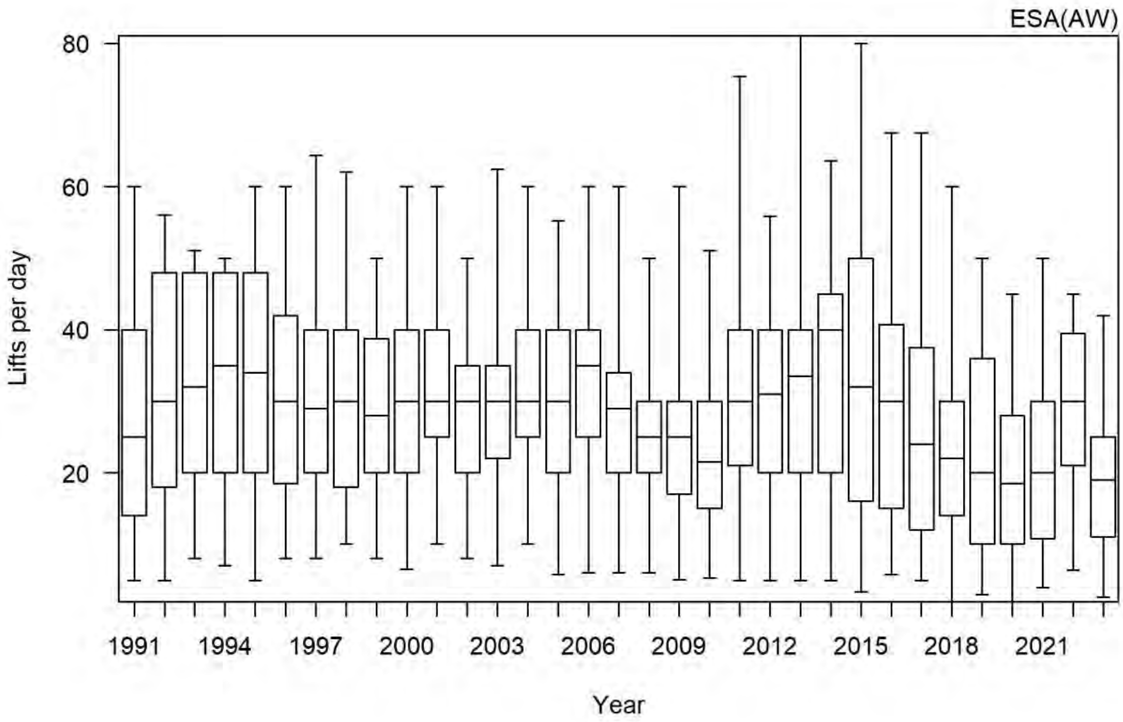

Figure G5: Total lifts per day for the years 1990–91 to 2022–23. The horizontal line is the median, the top and bottom of the box are the interquartiles (25th and 75th), and error bars are the 95th percentile range (ESA(AW)).

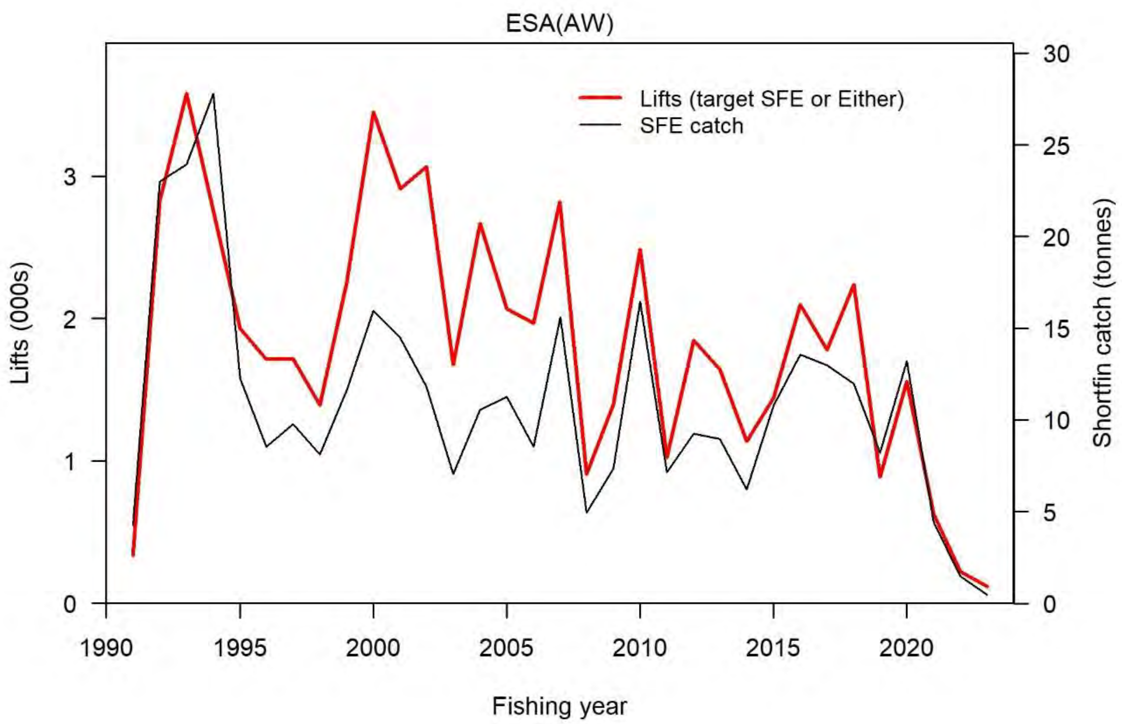

Figure G6: Total lifts and shortfin catch when target species was 'shortfin' or 'either' for the years 1990–91 to 2022–23 (ESA(AW)).

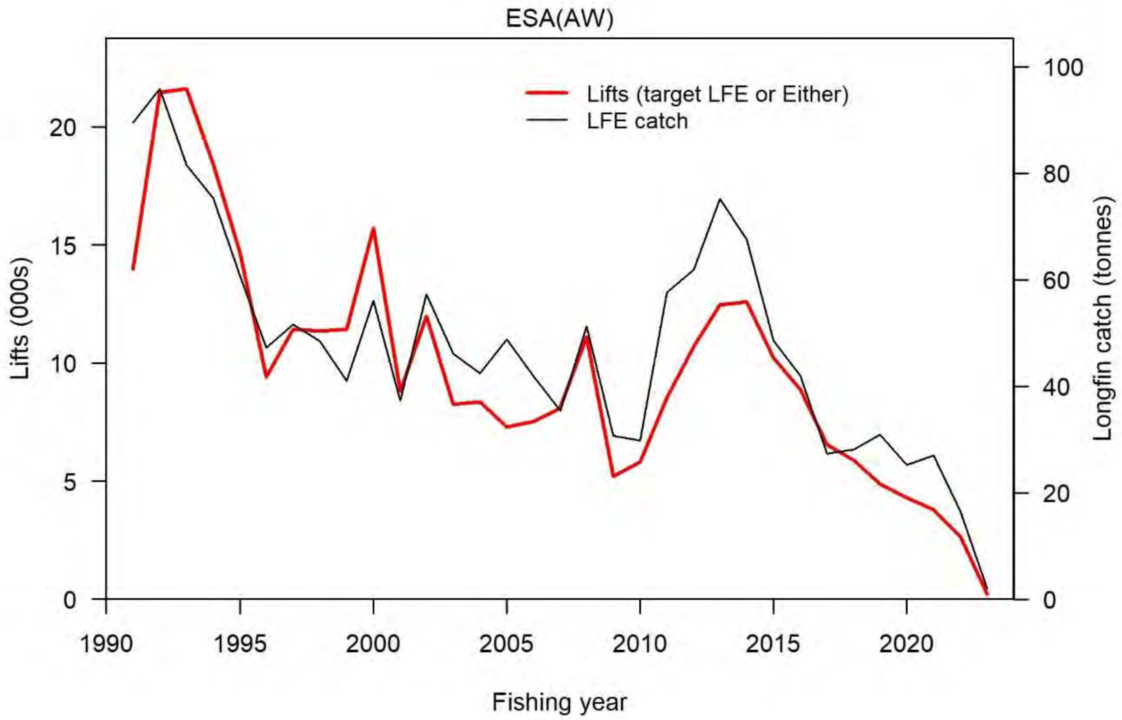

Figure G7: Total lifts and longfin catch when target species was 'longfin' or 'either' for the years 1990–91 to 2022–23 (ESA(AW)).

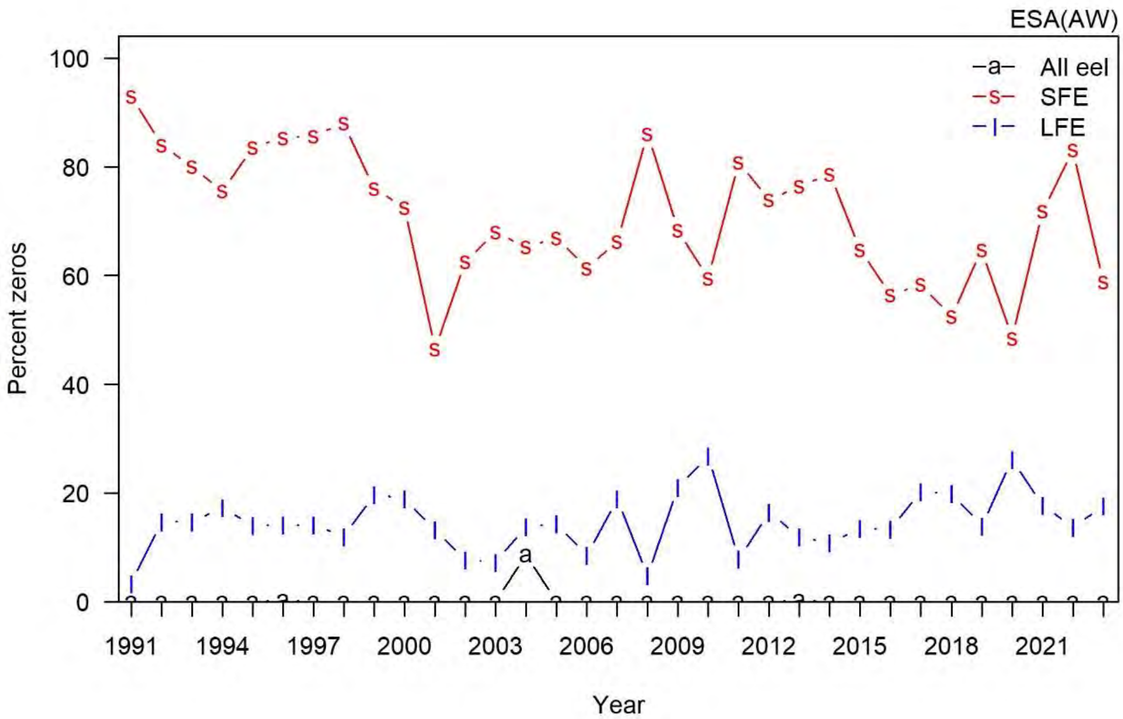

Figure G8: Proportion of valid zero records for all eels, shortfin (SFE), and longfin (LFE) catch for the years 1990–91 to 2022–23. Excludes zeros associated with reporting EEU (unclassified) (ESA(AW)).

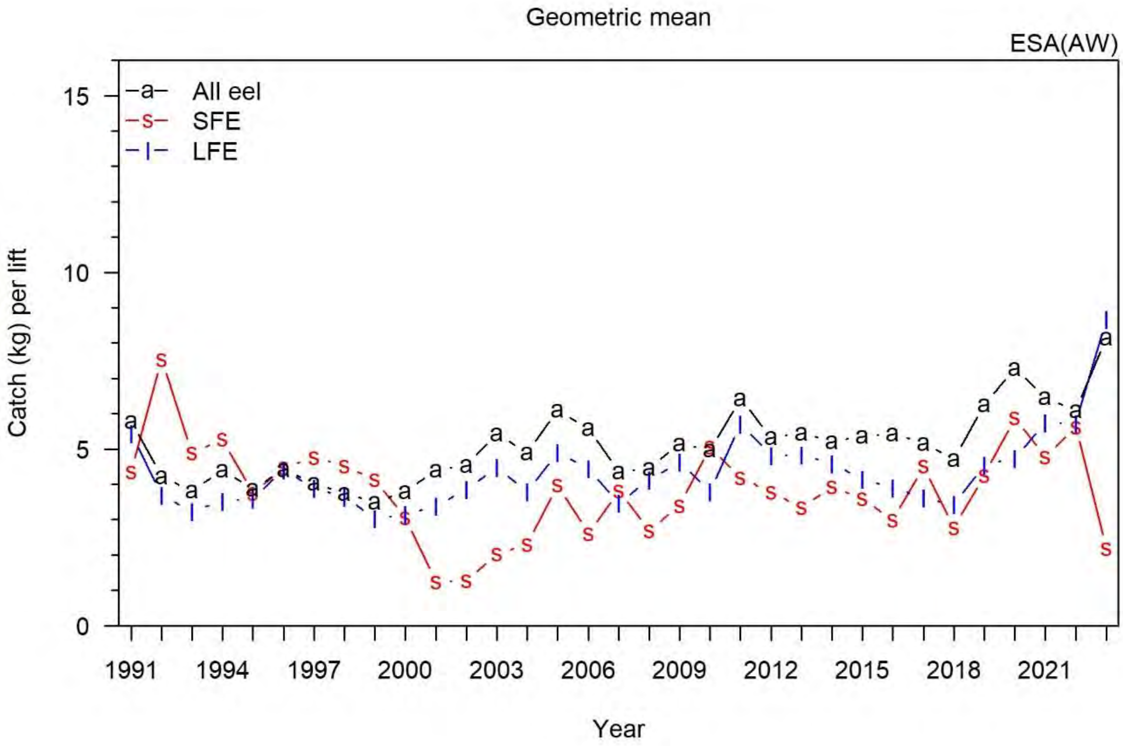

Figure G9: Unstandardised catch per lift (geometric mean of catch per lift) for all eels, shortfin (SFE), and longfin (LFE) for the years 1990–91 to 2022–23 (ESA(AW)).

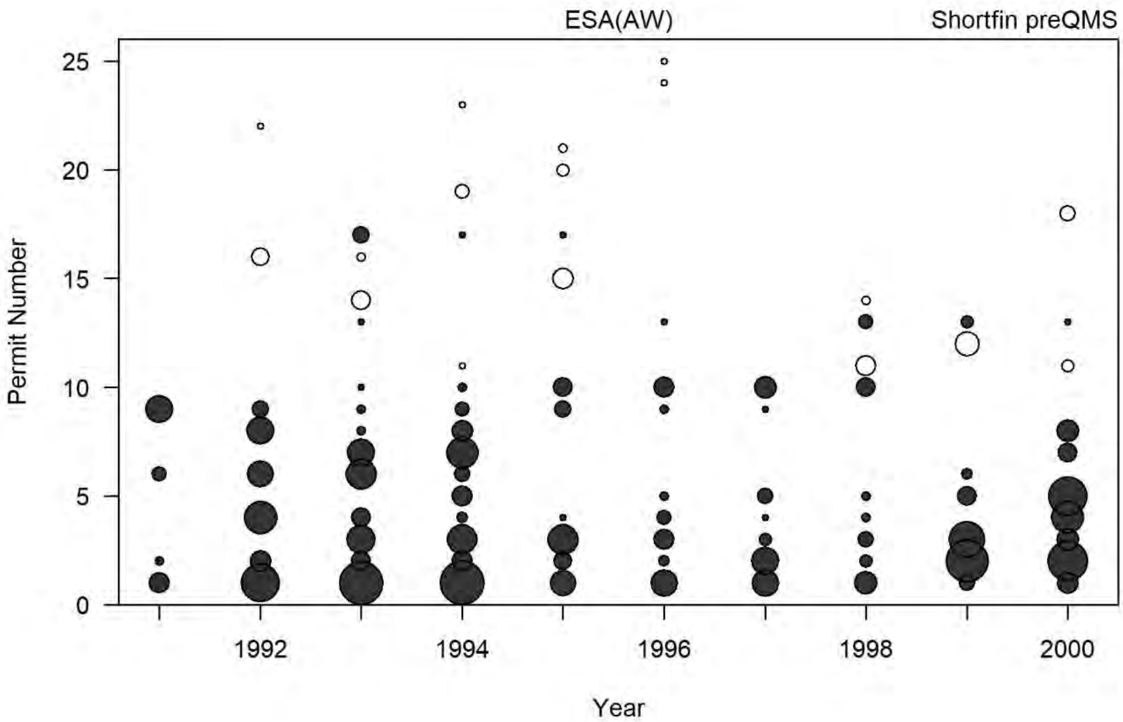

Figure G10: Relative shortfin catch from all fishers (all circles) for the years 1990–91 to 1999–2000 (pre-QMS), and for core fishers (dark shaded circles) included in the catch per unit effort analyses (ESA(AW)).

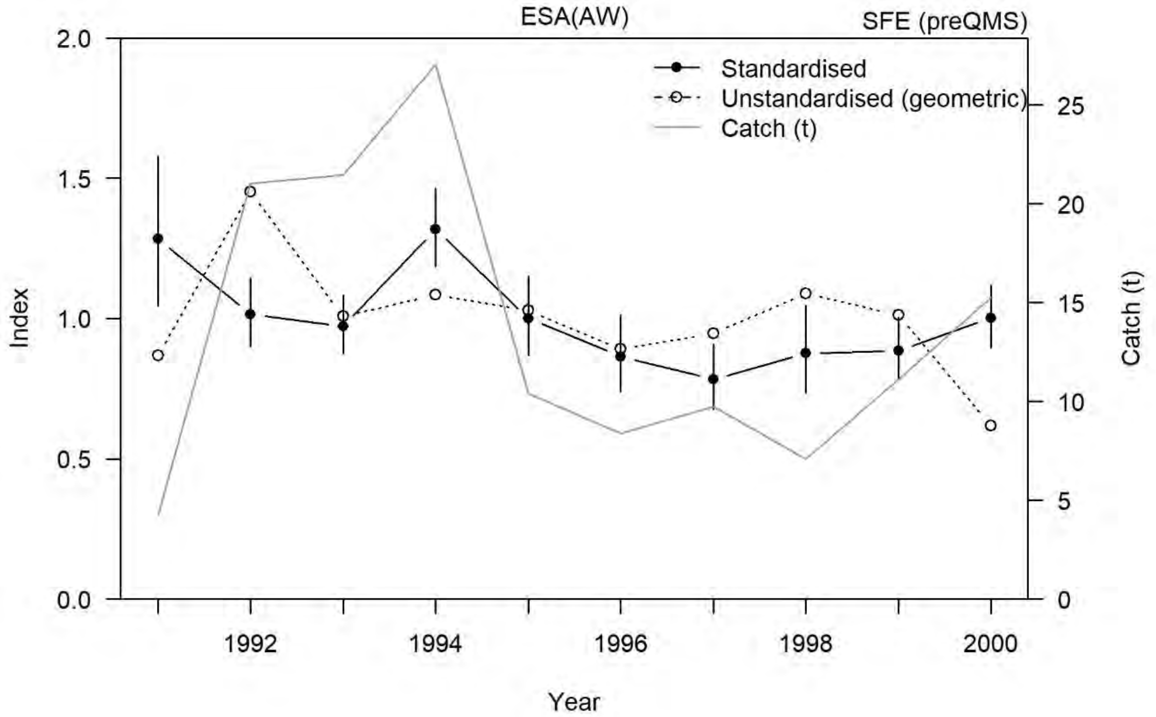

Figure G11: Indices of unstandardised (geometric mean of catch per lift) and standardised CPUE for shortfin (core fishers) pre-QMS for the years 1990–91 to 1999–2000 (ESA(AW)).

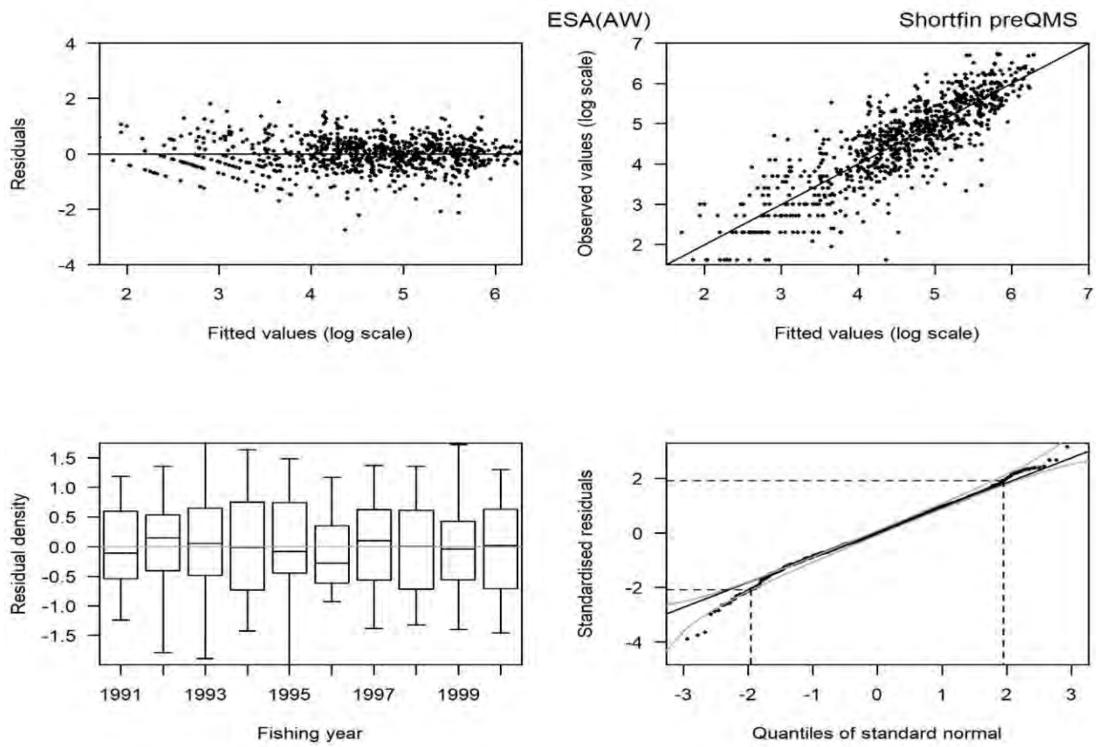

Figure G12: Residual diagnostic plots for the shortfin eel CPUE model for the years 1990–91 to 1999–2000 (pre-QMS). The grey lines on the quantile-quantile plot represent the 95% confidence envelopes of a standard normal distribution (ESA(AW)).

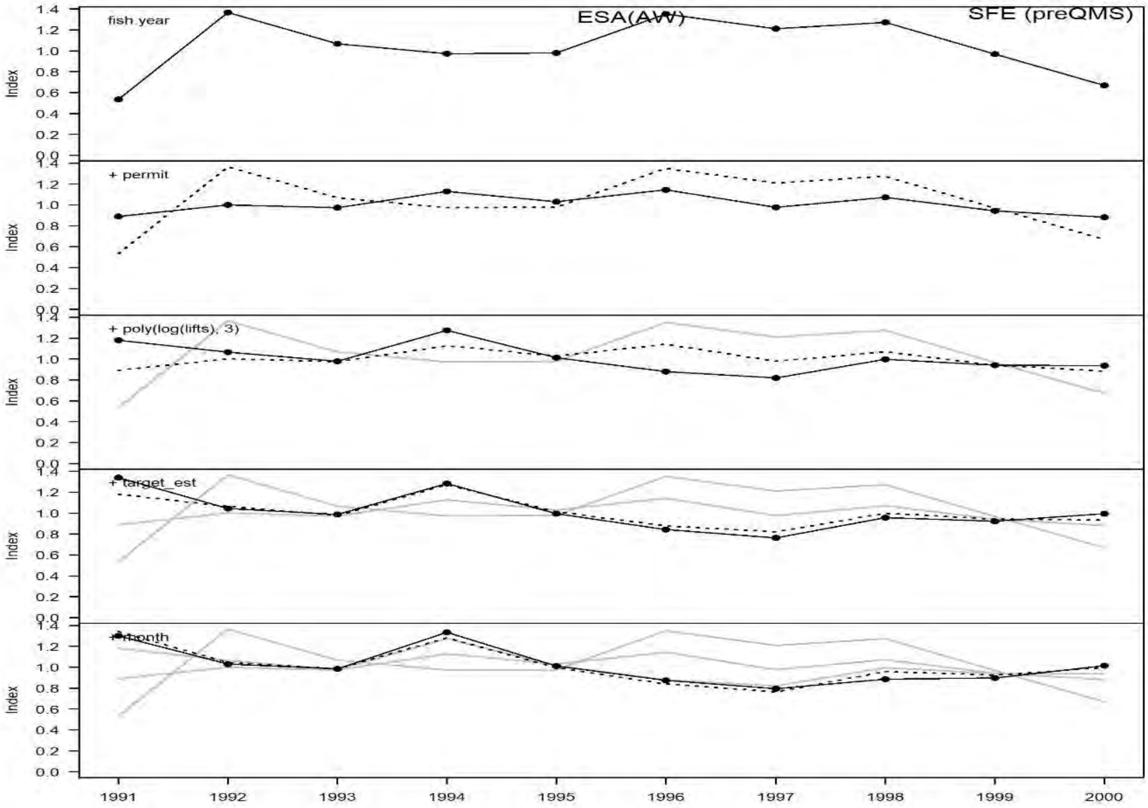

Figure G13: Step plot for the shortfin eel CPUE model for the years 1990–91 to 1999–2000 (pre-QMS). Each panel shows the standardised CPUE index as each explanatory variable is added to the model with the previous index shown by the dotted line and the grey lines for steps before that (ESA(AW)).

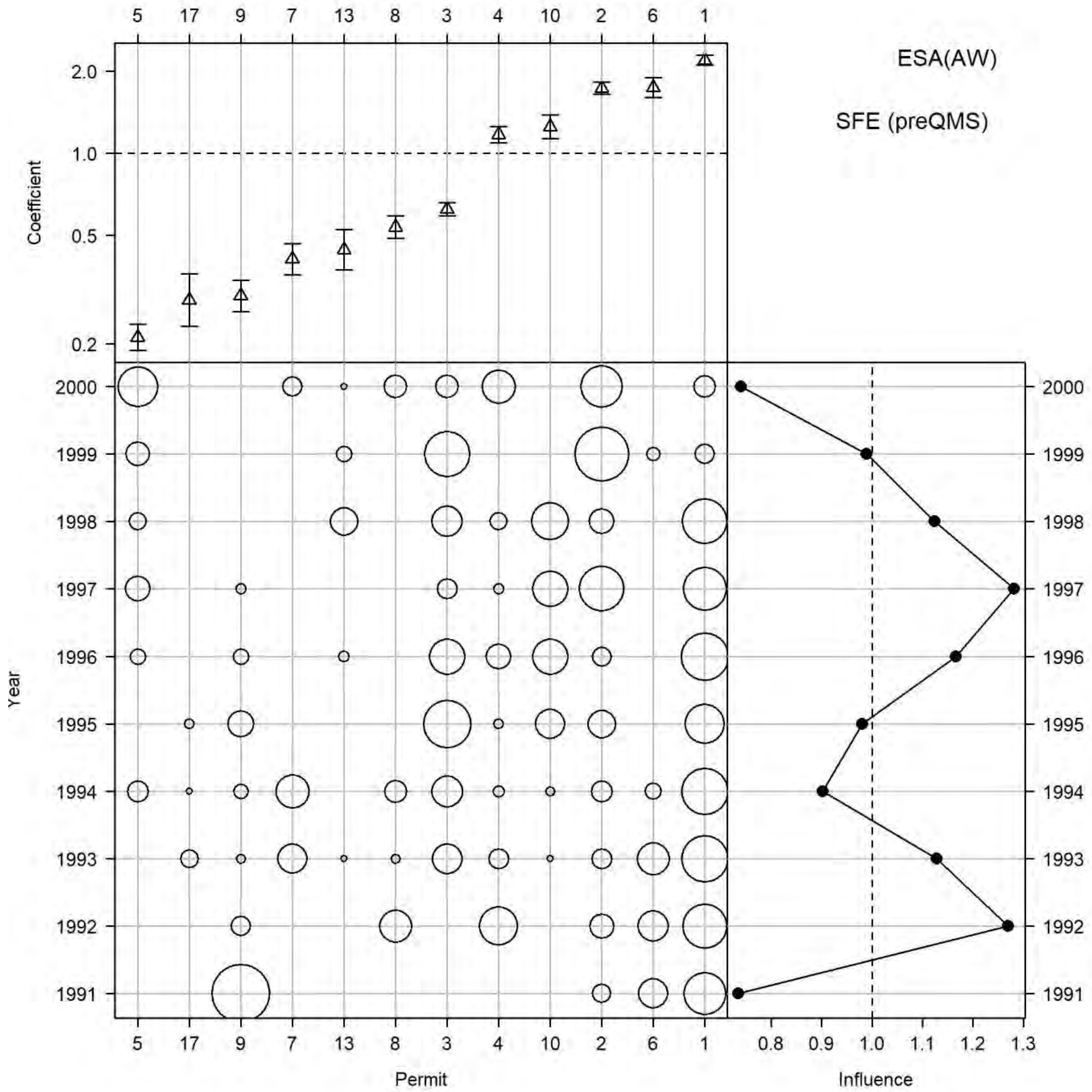

Figure G14: Influence of permit for the shortfin CPUE model for the years 1990–91 to 1999–2000 (pre-QMS) (ESA(AW)).

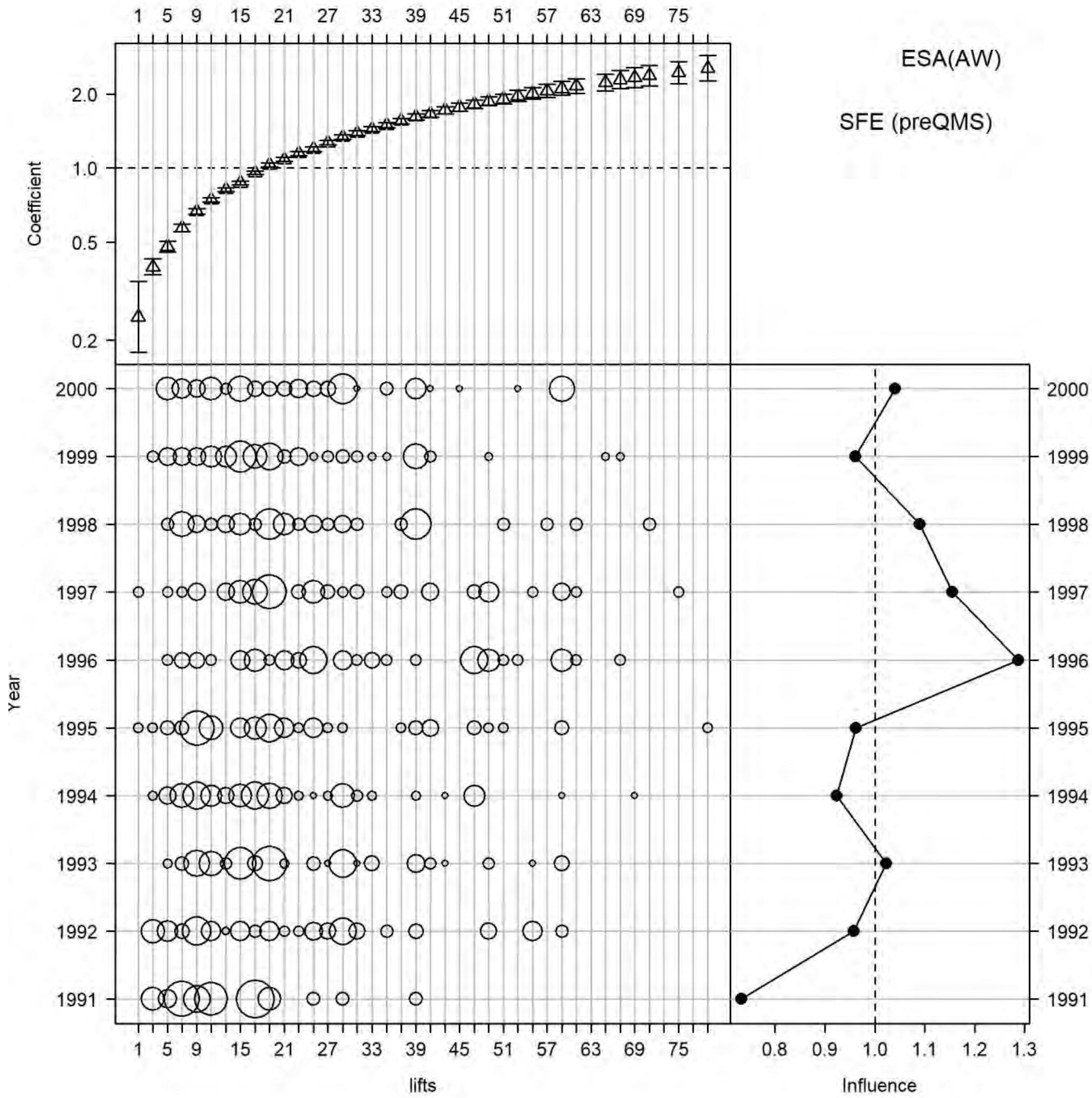

Figure G15: Influence of lifts for the shortfin CPUE model for the years 1990–91 to 1999–2000 (pre-QMS) (ESA(AW)).

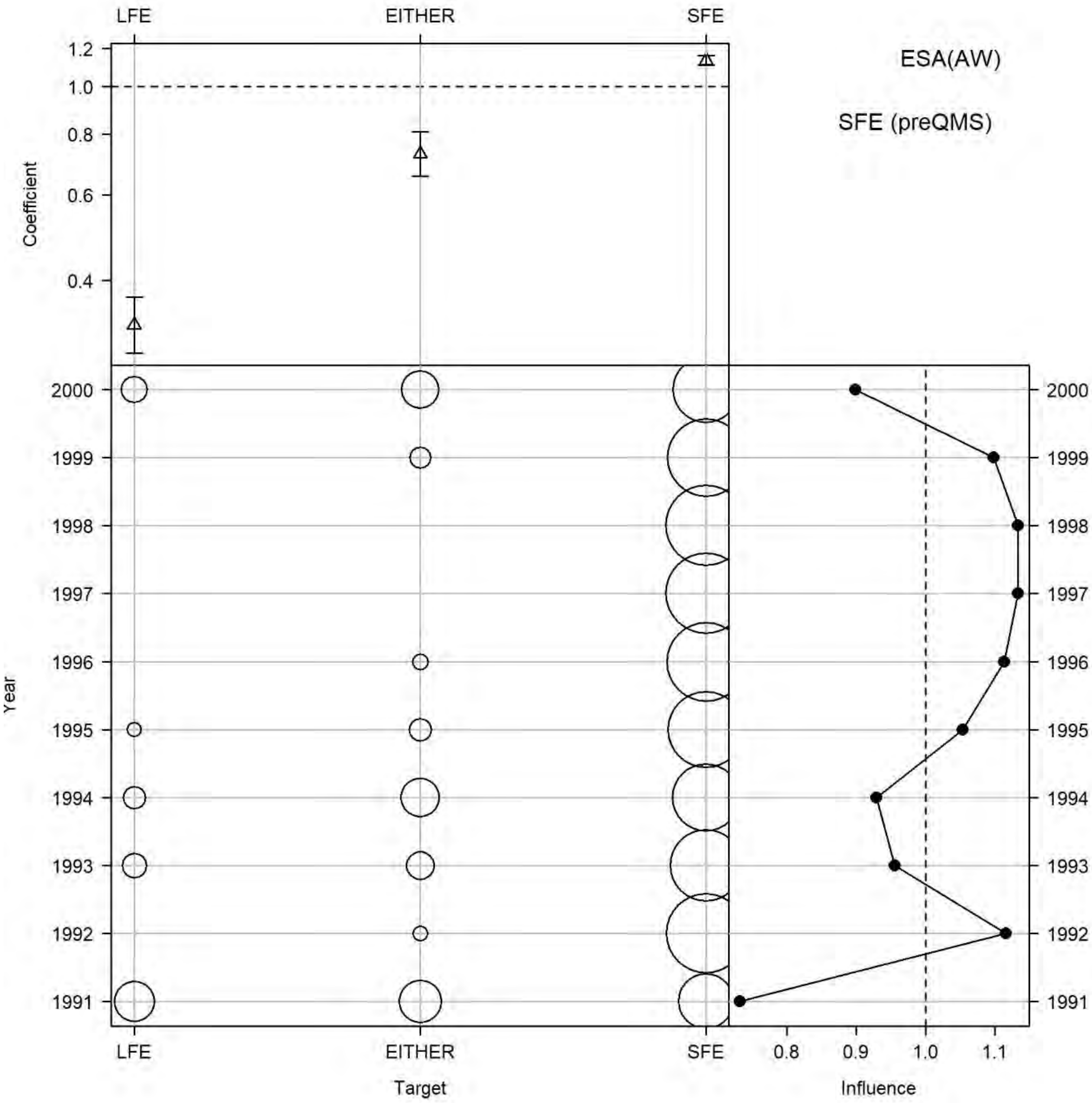

Figure G16: Influence of target for the shortfin CPUE model for the years 1990–91 to 1999–2000 (pre-QMS) (ESA(AW)).

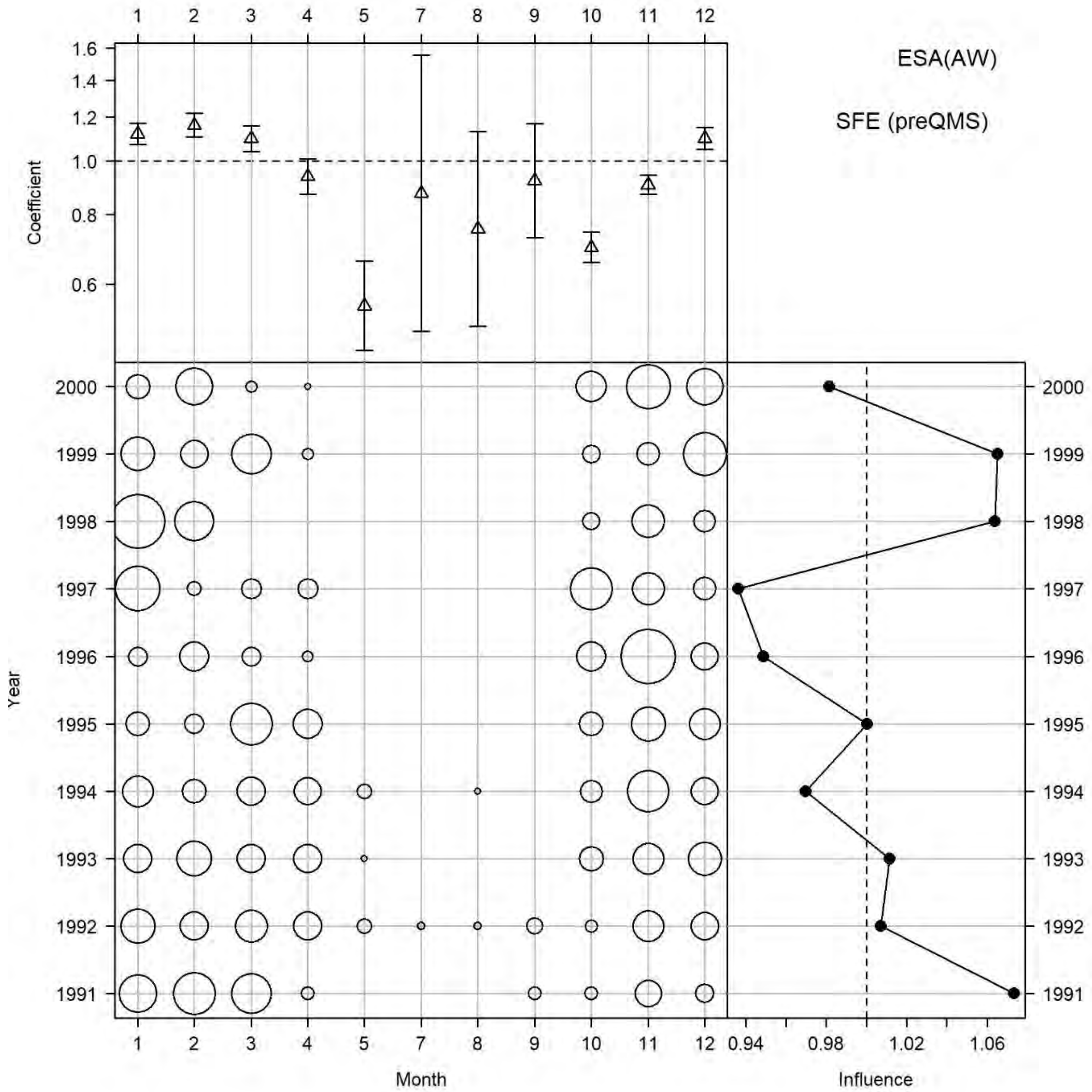

Figure G17: Influence of month for the shortfin CPUE model for the years 1990–91 to 1999–2000 (pre-QMS) (ESA(AW)).

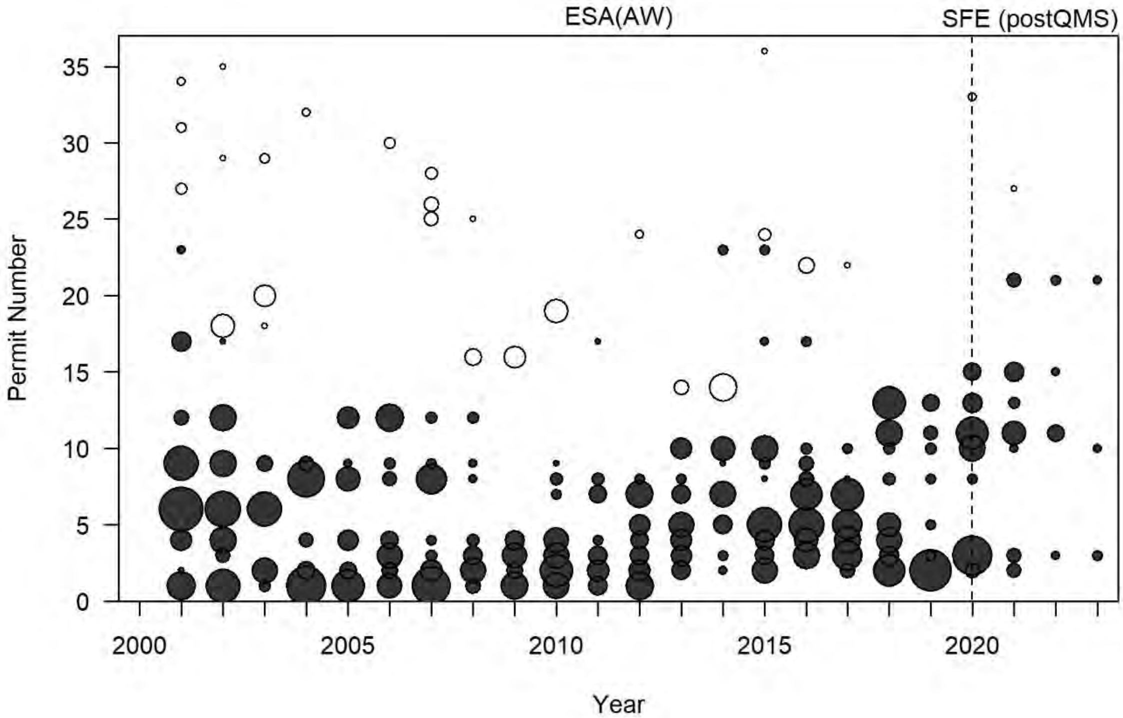

Figure G18: Relative shortfin catch from all fishers (all circles) for the years 2000–01 to 2022–23 (post-QMS), and for core fishers (dark shaded circles) included in the catch per unit effort analyses. Vertical dashed line represents introduction of electronic reporting in 2019–20 (ESA(AW)).

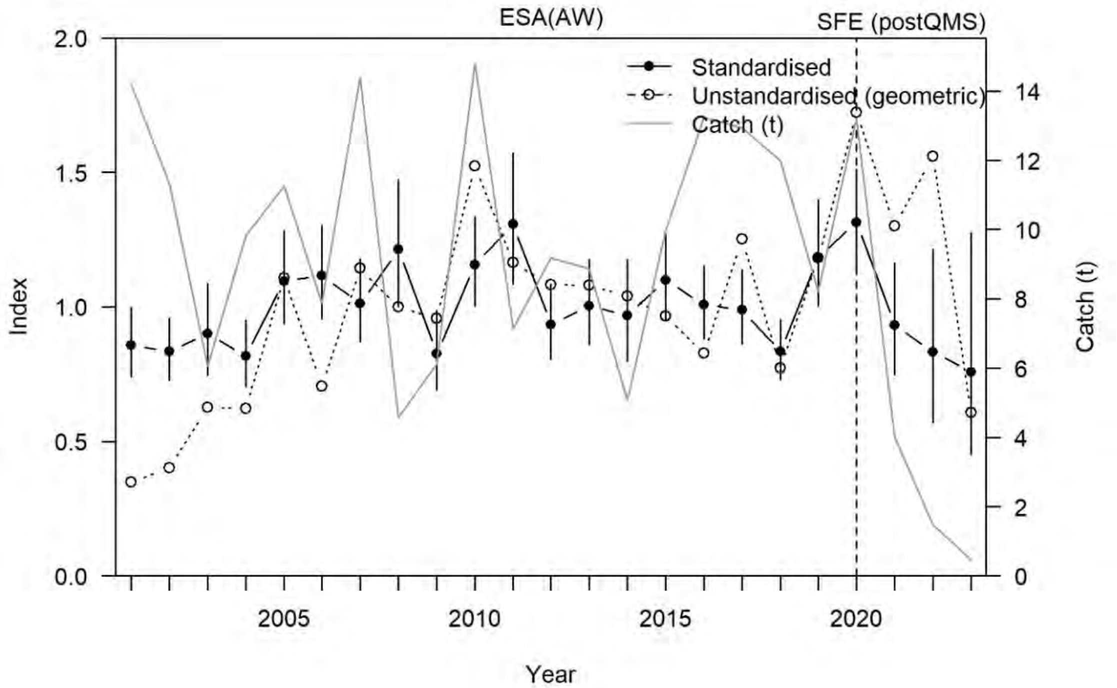

Figure G19: Indices of unstandardised (geometric mean of catch per lift) and standardised CPUE for shortfin (core fishers) post-QMS for the years 2000–01 to 2022–23. The catch by core fishers is also plotted. Vertical dashed line represents introduction of electronic reporting in 2019–20 (ESA(AW)).

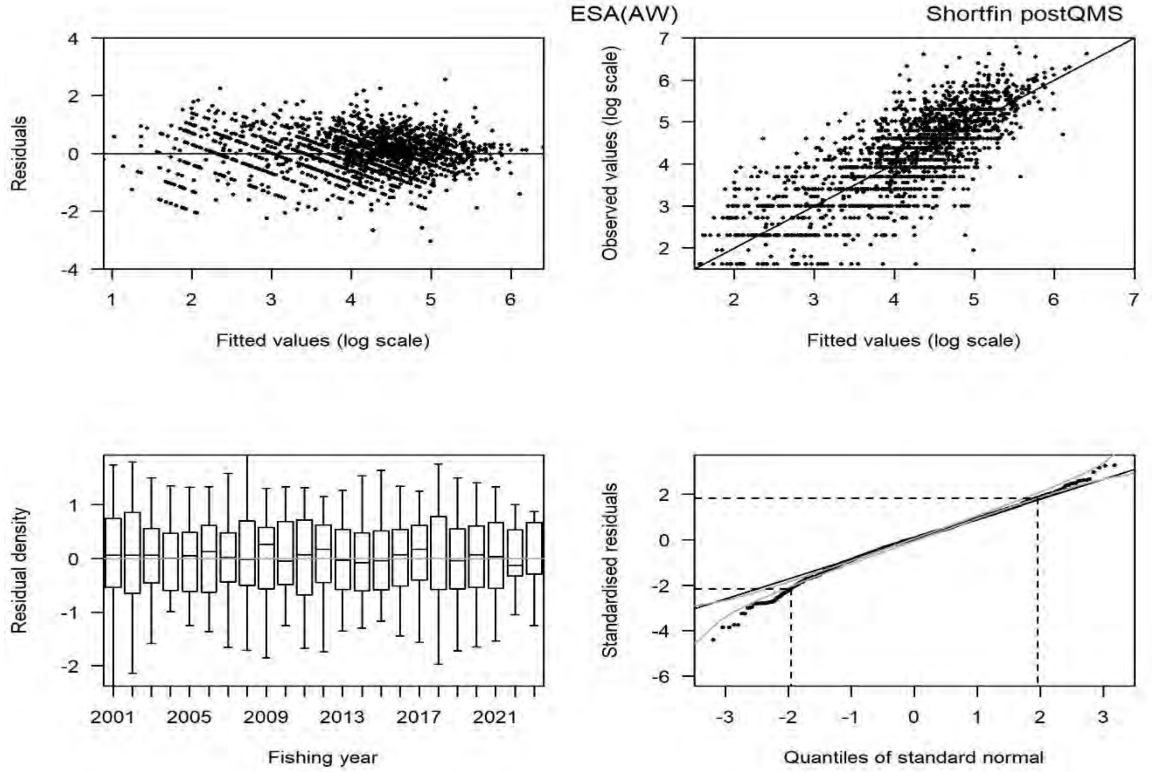

Figure G20: Residual diagnostic plots for the shortfin eel CPUE model for the years 2000–01 to 2022–23 (post-QMS). The grey lines on the quantile-quantile plot represent the 95% confidence envelopes of a standard normal distribution (ESA(AW)).

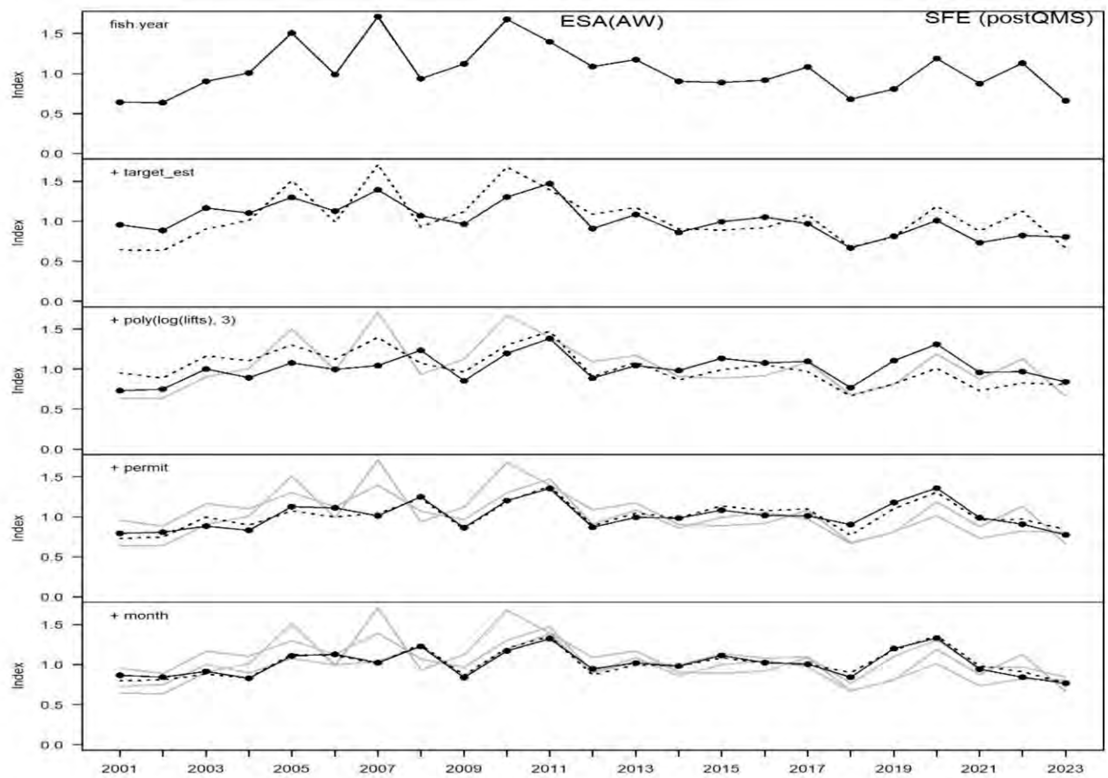

Figure G21: Step plot for the shortfin eel CPUE model for the years 2000–01 to 2022–23 (post-QMS). Each panel shows the standardised CPUE index as each explanatory variable is added to the model with the previous index shown by the dotted line and the grey lines for steps before that (ESA(AW)).

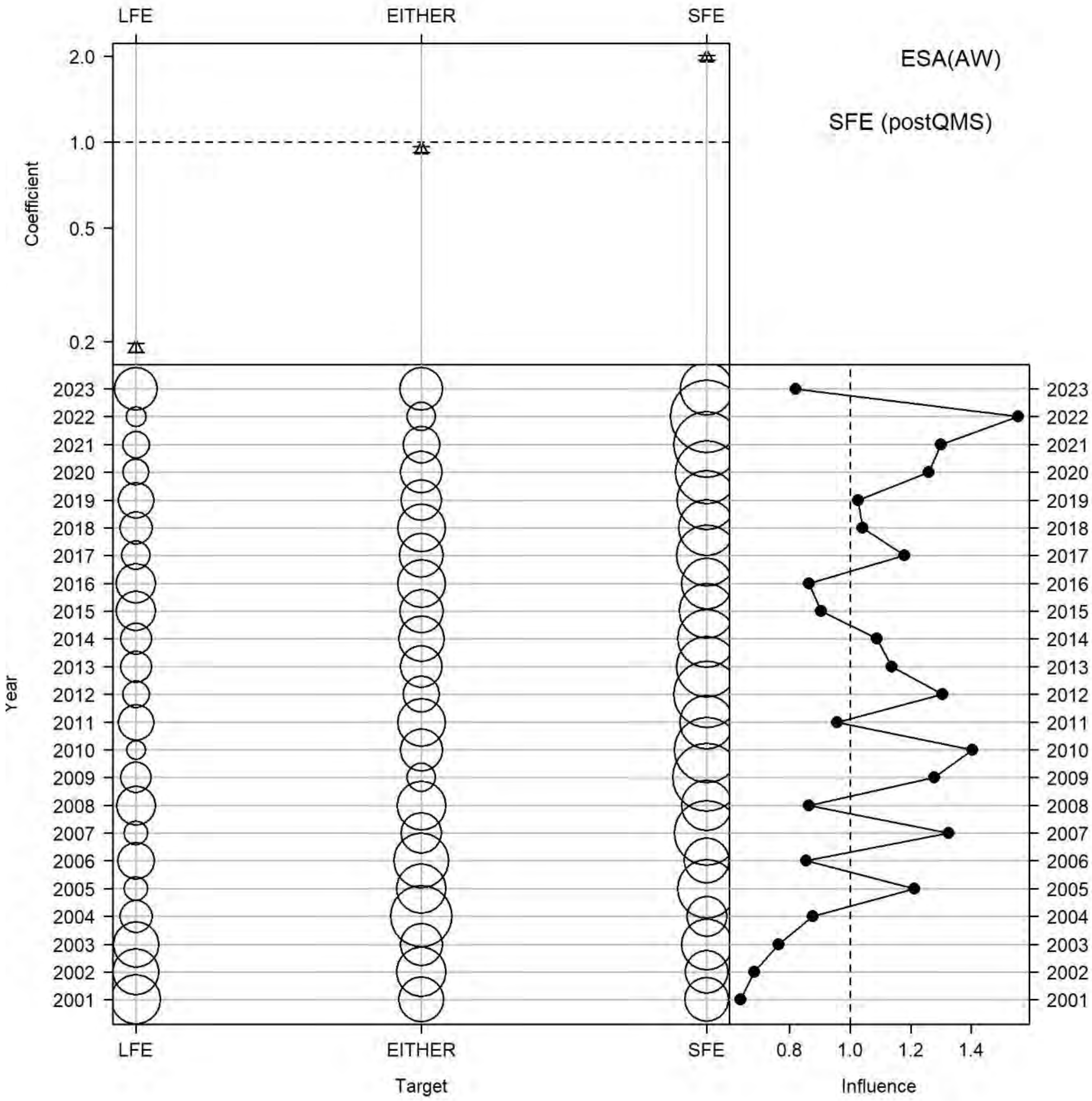

Figure G22: Influence of target for the shortfin CPUE model for the years 2000–01 to 2022–23 (post-QMS) (ESA(AW)).

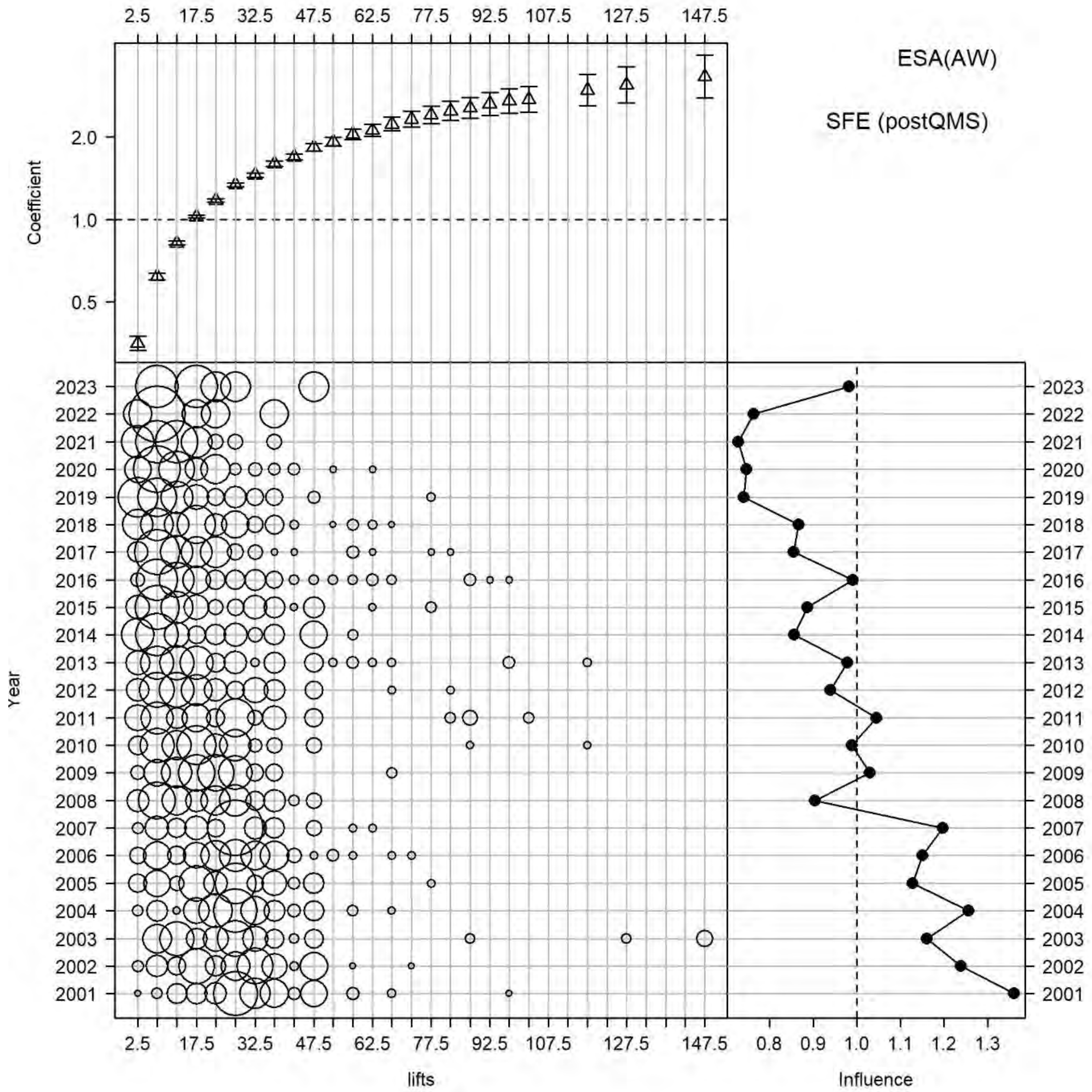

Figure G23: Influence of lifts for the shortfin CPUE model for the years 2000–01 to 2022–23 (post-QMS) (ESA(AW)).

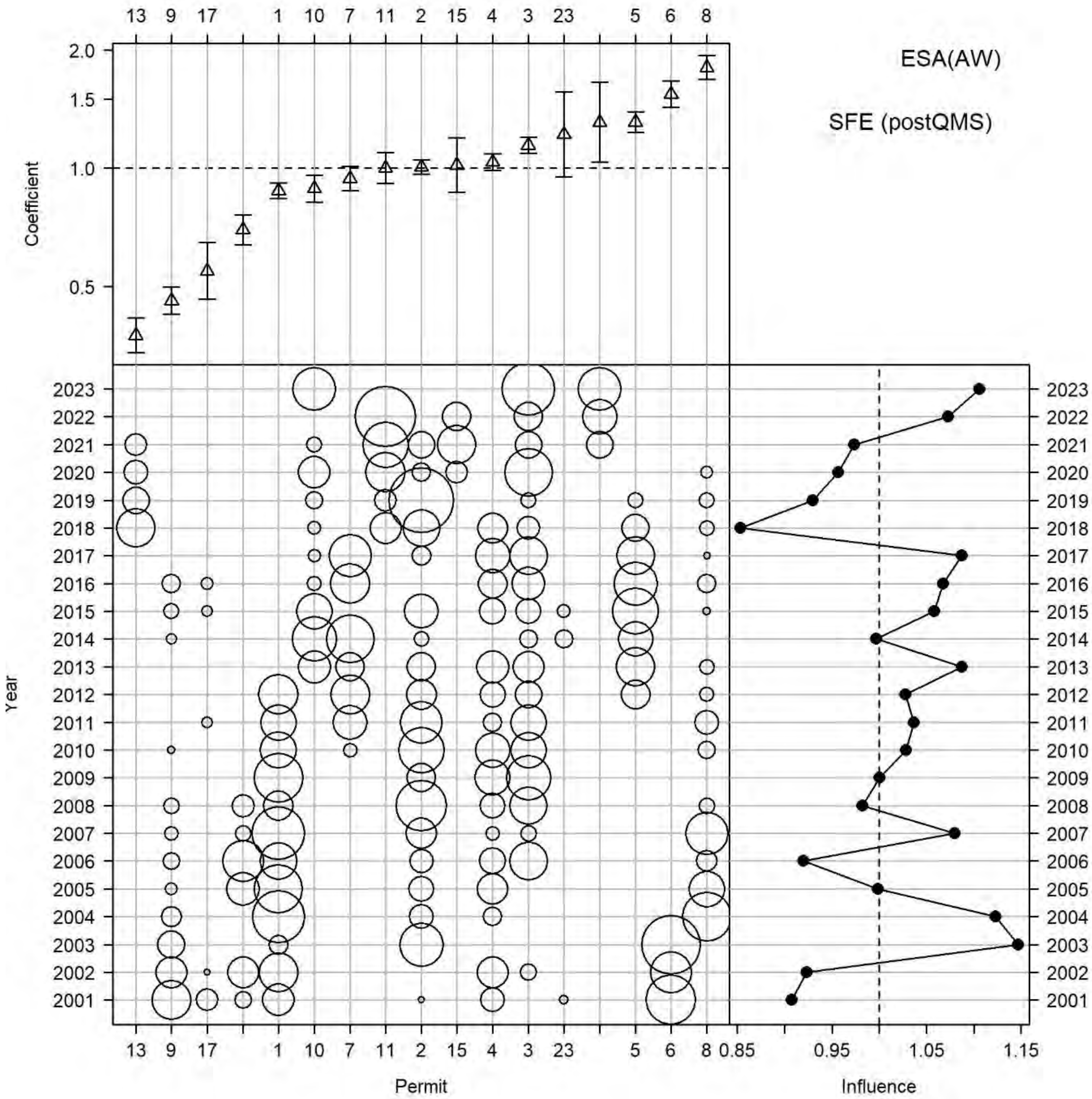

Figure G24: Influence of catcher for the shortfin CPUE model for the years 2000–01 to 2022–23 (post-QMS) (ESA(AW)).

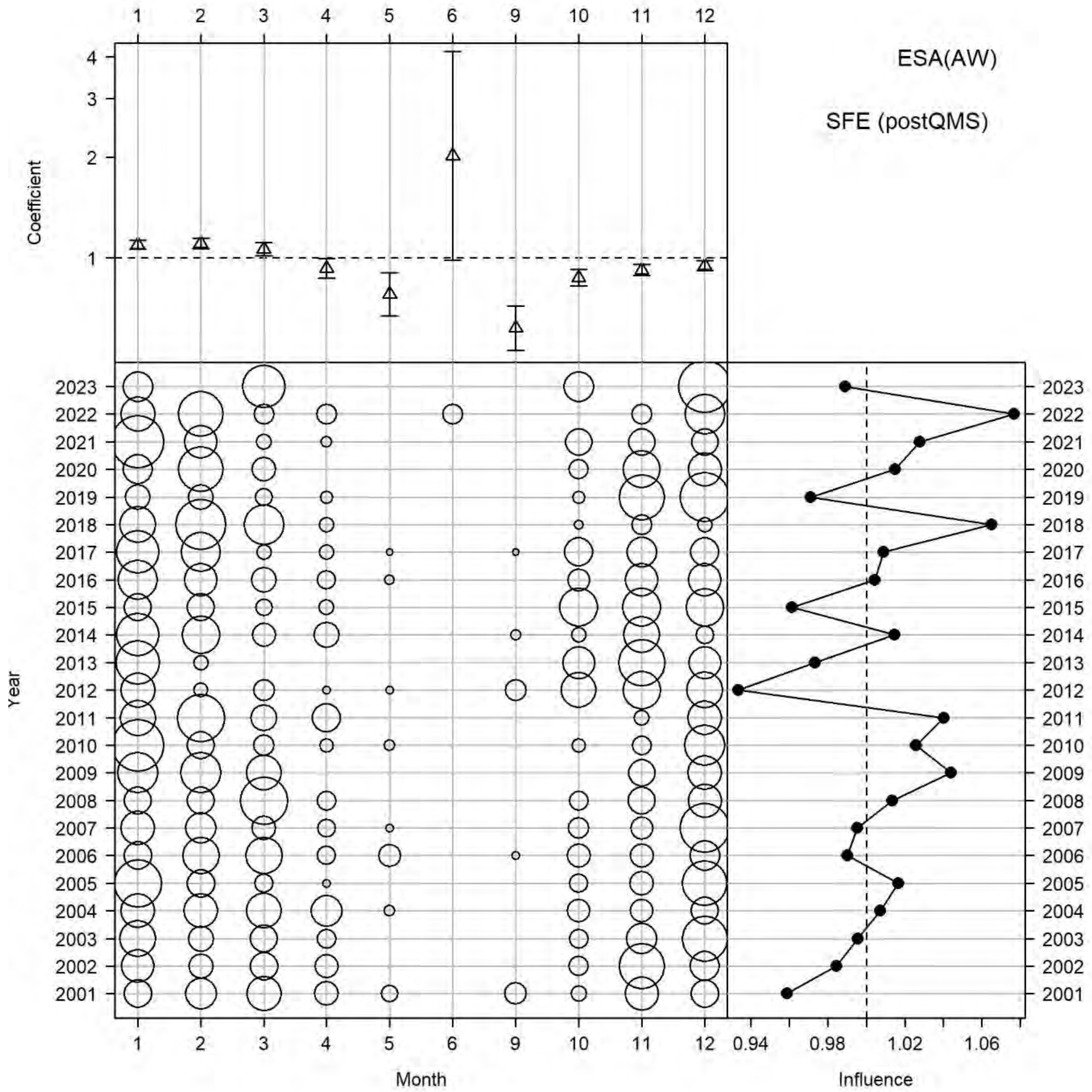

Figure G25: Influence of month for the shortfin CPUE model for the years 2000–01 to 2022–23 (post-QMS) (ESA(AW)).

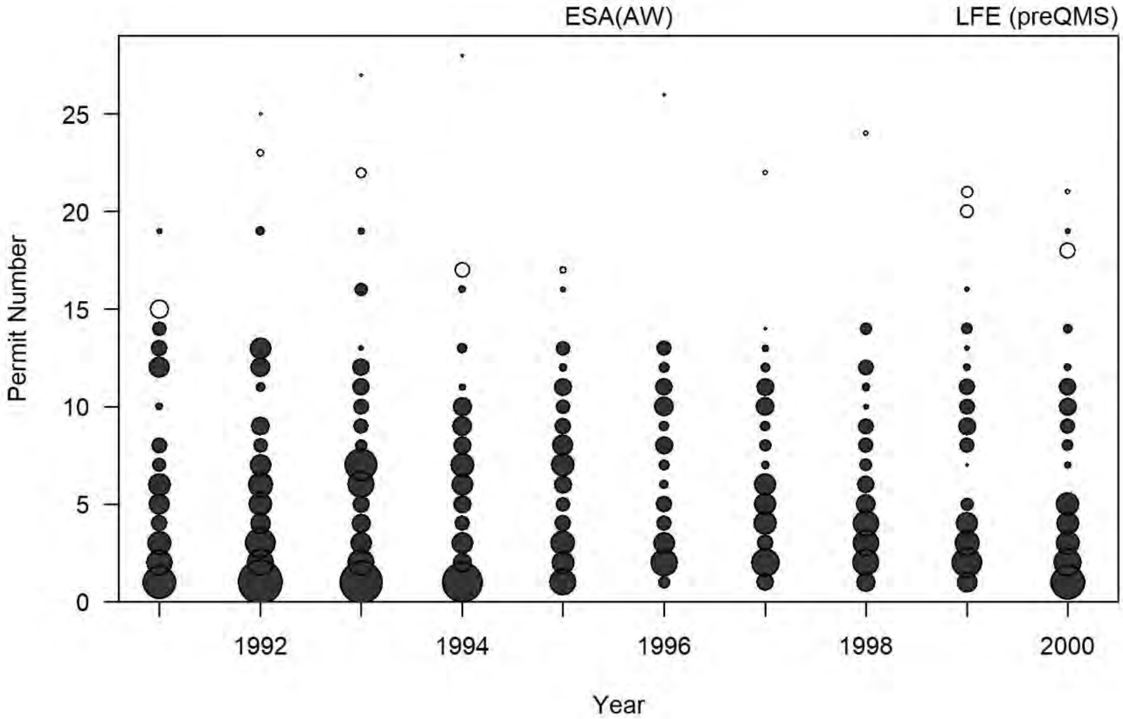

Figure G26: Relative longfin catch from all fishers (all circles) for the years 1990–91 to 1999–2000 (pre-QMS), and for core fishers (dark shaded circles) included in the catch per unit effort analyses (ESA(AW)).

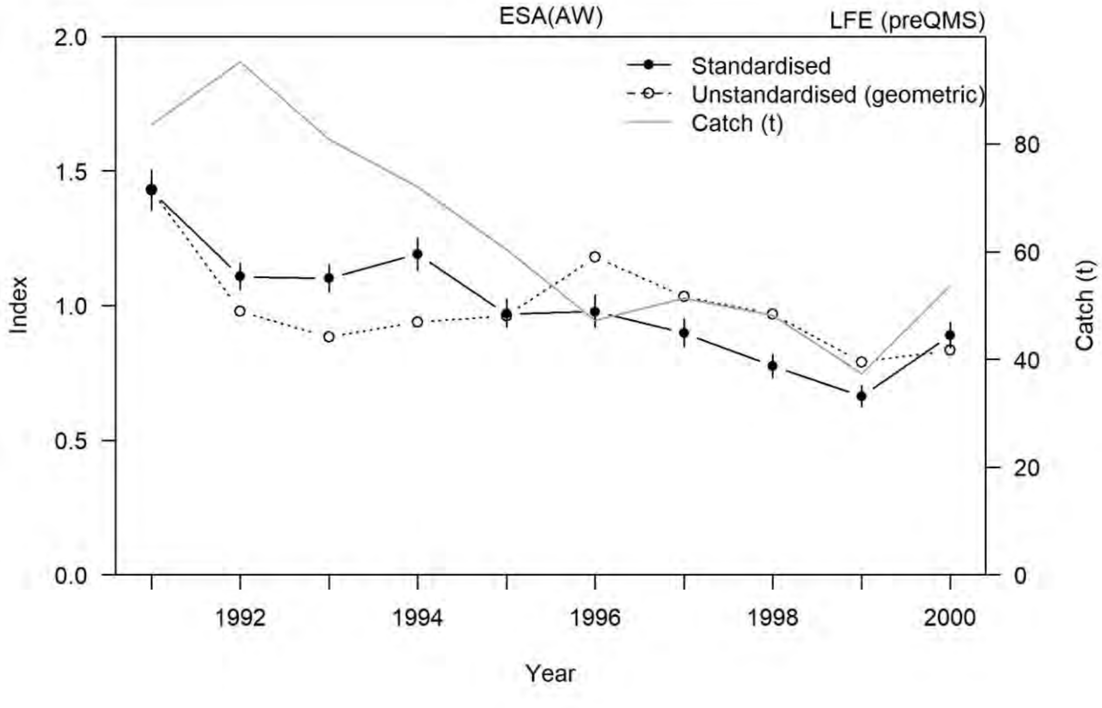

Figure G27: Indices of unstandardised (geometric mean of catch per lift) and standardised CPUE for longfin (core fishers) pre-QMS for the years 1990–91 to 1999–2000. The catch by core fishers is also plotted (ESA(AW)).

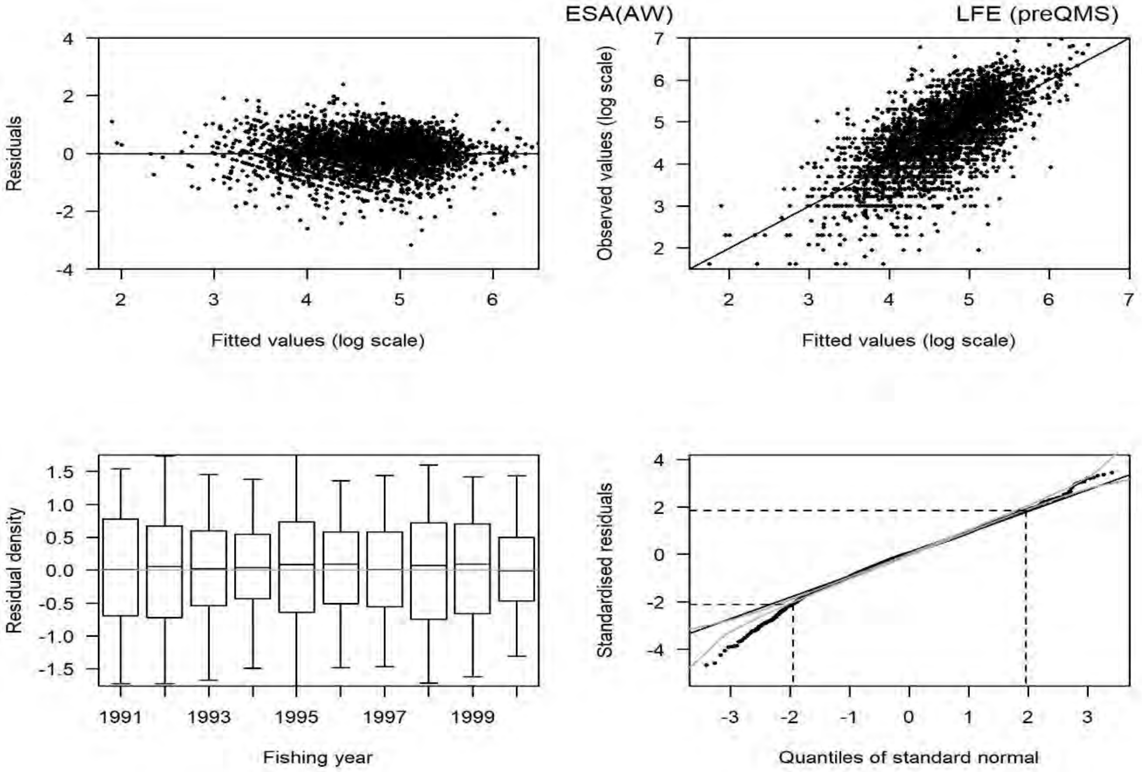

Figure G28: Residual diagnostic plots for the longfin eel CPUE model for the years 1990–91 to 1999–2000 (pre-QMS). The grey lines on the quantile-quantile plot represent the 95% confidence envelopes of a standard normal distribution (ESA(AW)).

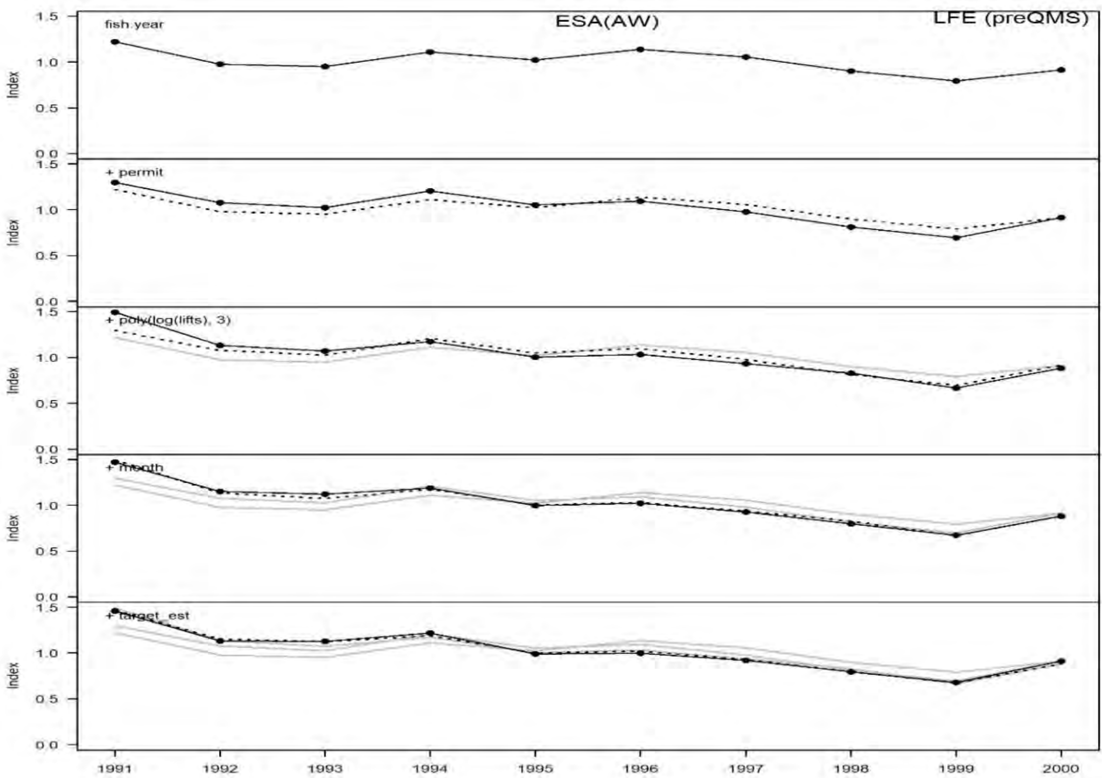

Figure G29: Step plot for the longfin eel CPUE model for the years 1990–91 to 1999–2000 (pre-QMS). Each panel shows the standardised CPUE index as each explanatory variable is added to the model with the previous index shown by the dotted line and the grey lines for steps before that (ESA(AW)).

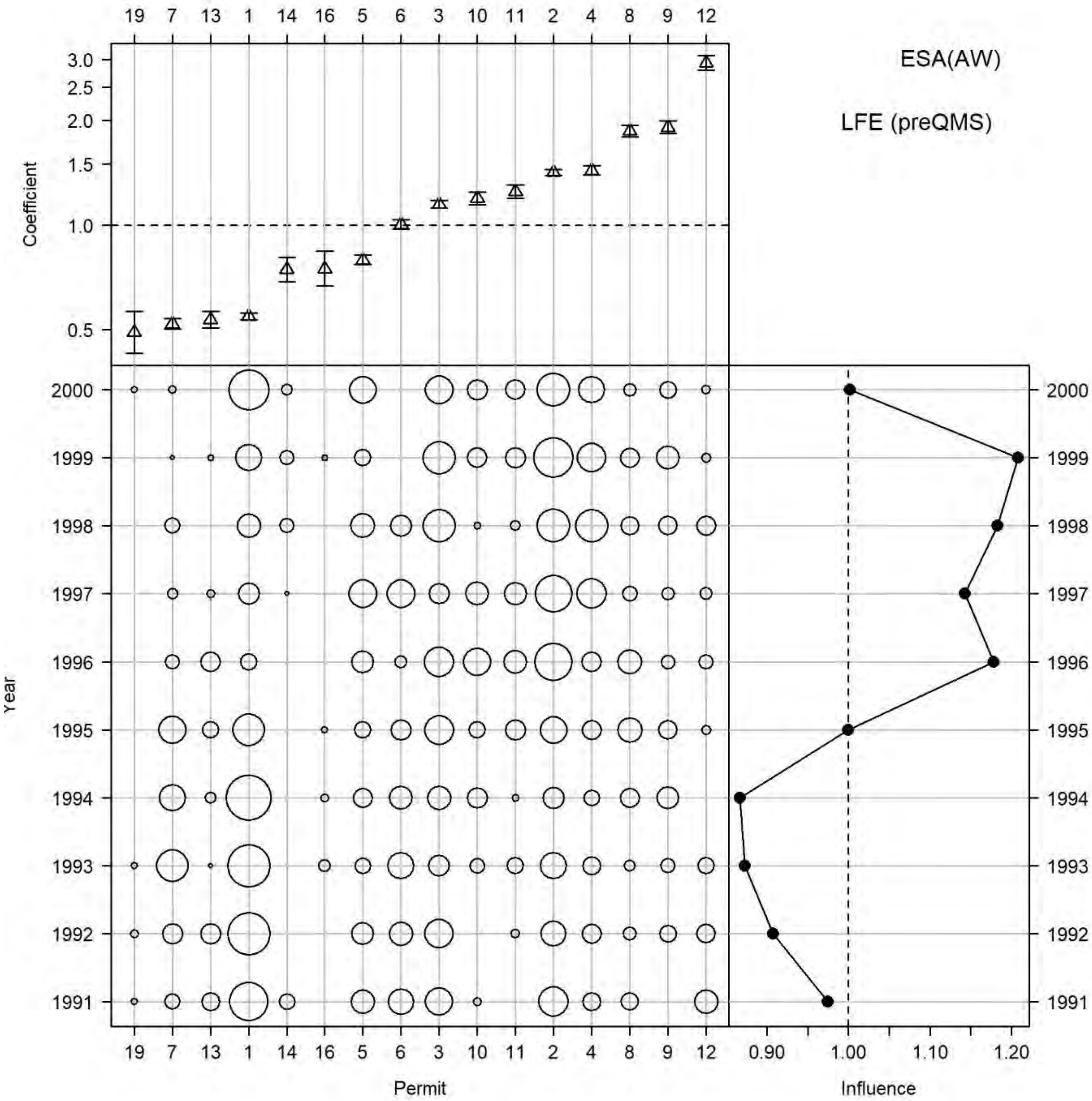

Figure G30: Influence of permit for the longfin CPUE model for the years 1990–91 to 1999–2000 (pre-QMS) (ESA(AW)).

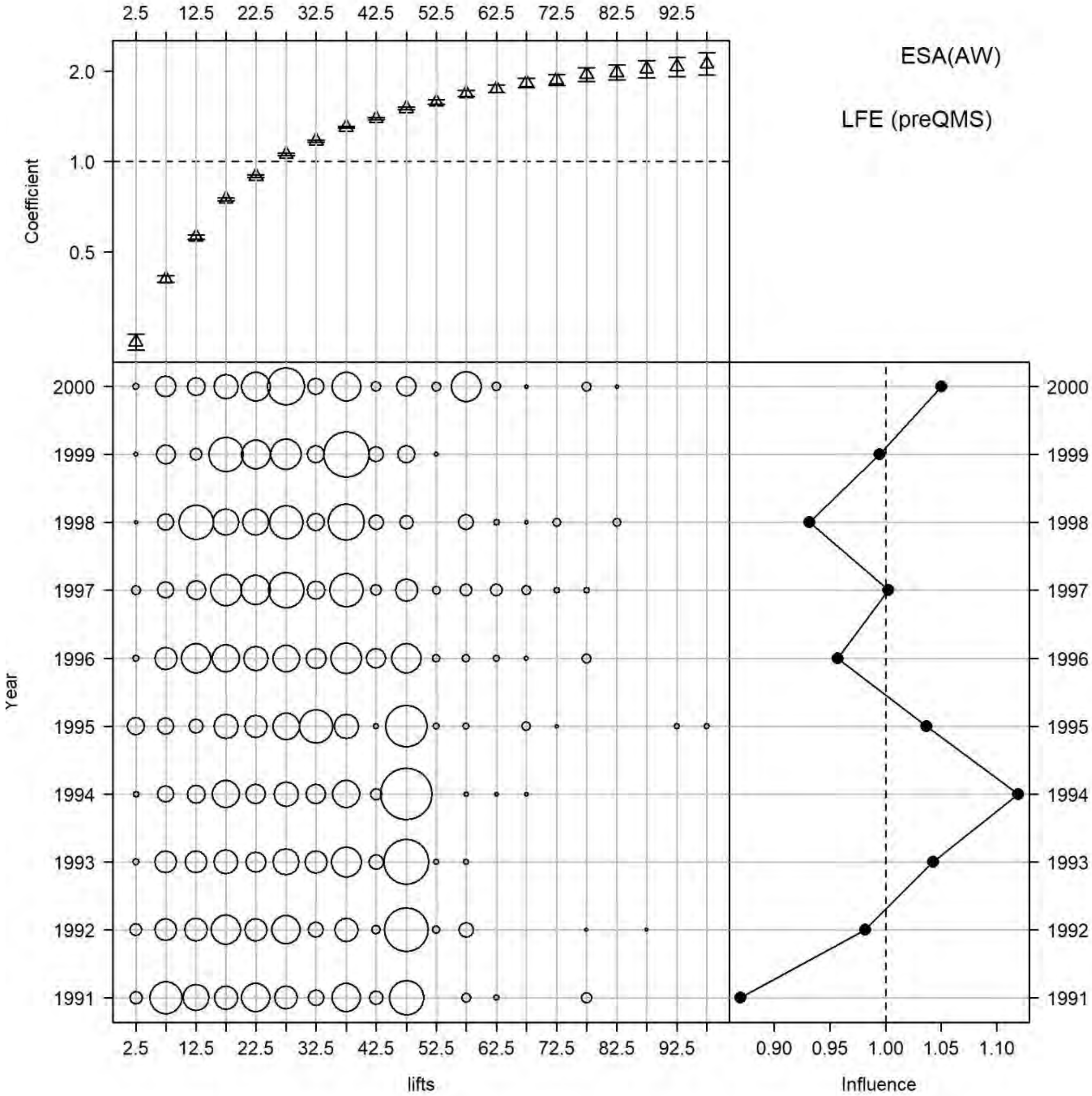

Figure G31: Influence of lifts for the longfin CPUE model for the years 1990–91 to 1999–2000 (pre-QMS) (ESA(AW)).

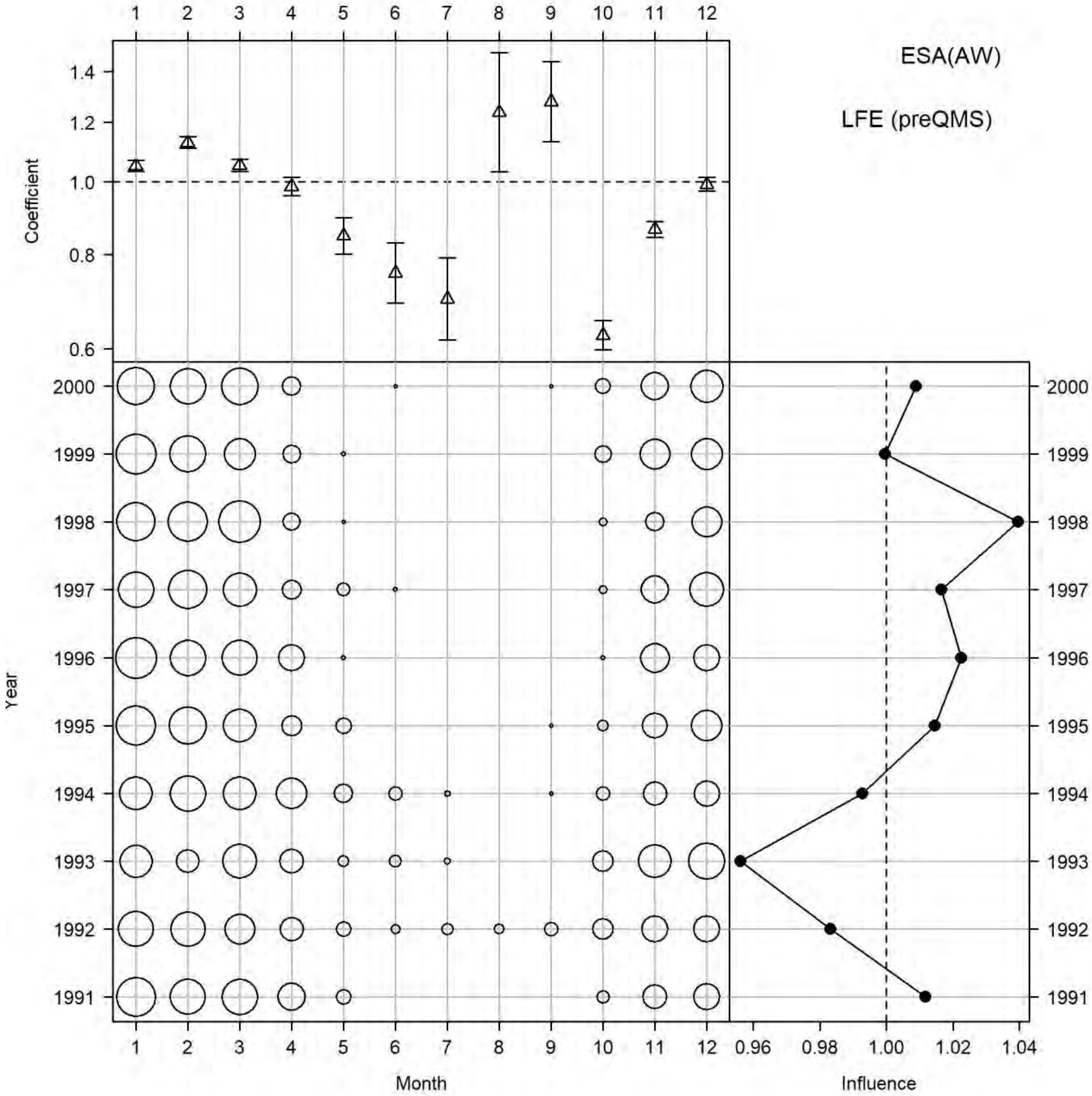

Figure G32: Influence of month for the longfin CPUE model for the years 1990–91 to 1999–2000 (pre-QMS) (ESA(AW)).

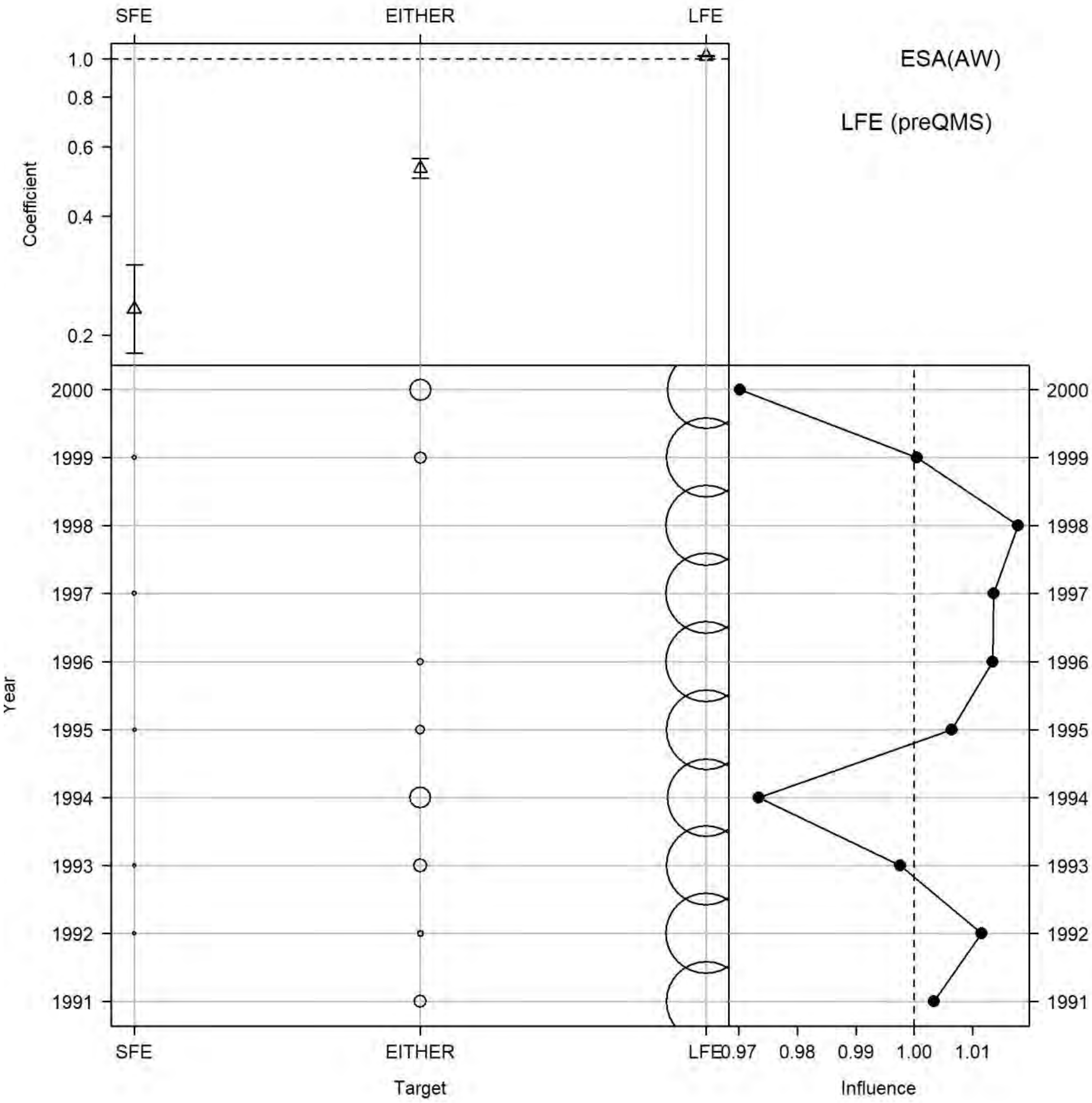

Figure G33: Influence of target for the longfin CPUE model for the years 1990–91 to 1999–2000 (pre-QMS) (ESA(AW)).

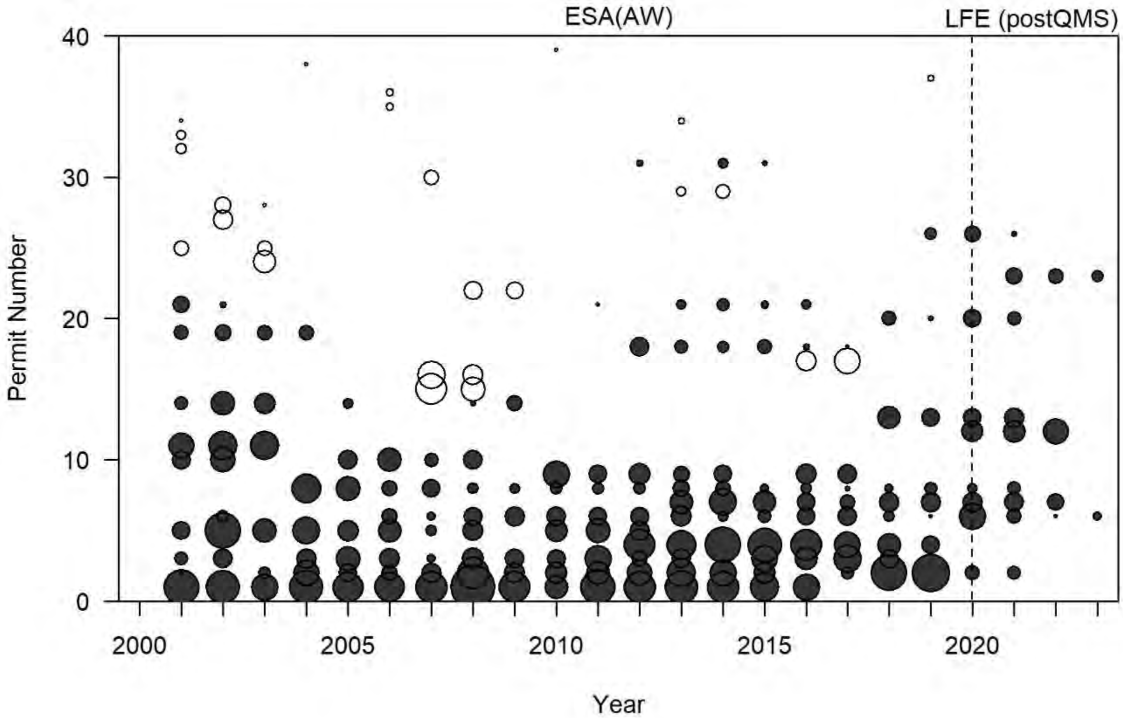

Figure G34: Relative longfin catch from all fishers (all circles) for the years 2000–01 to 2022–23 (post-QMS), and for core fishers (dark shaded circles) included in the catch per unit effort analyses. Vertical dashed line represents introduction of electronic reporting in 2019–20 (ESA(AW)).

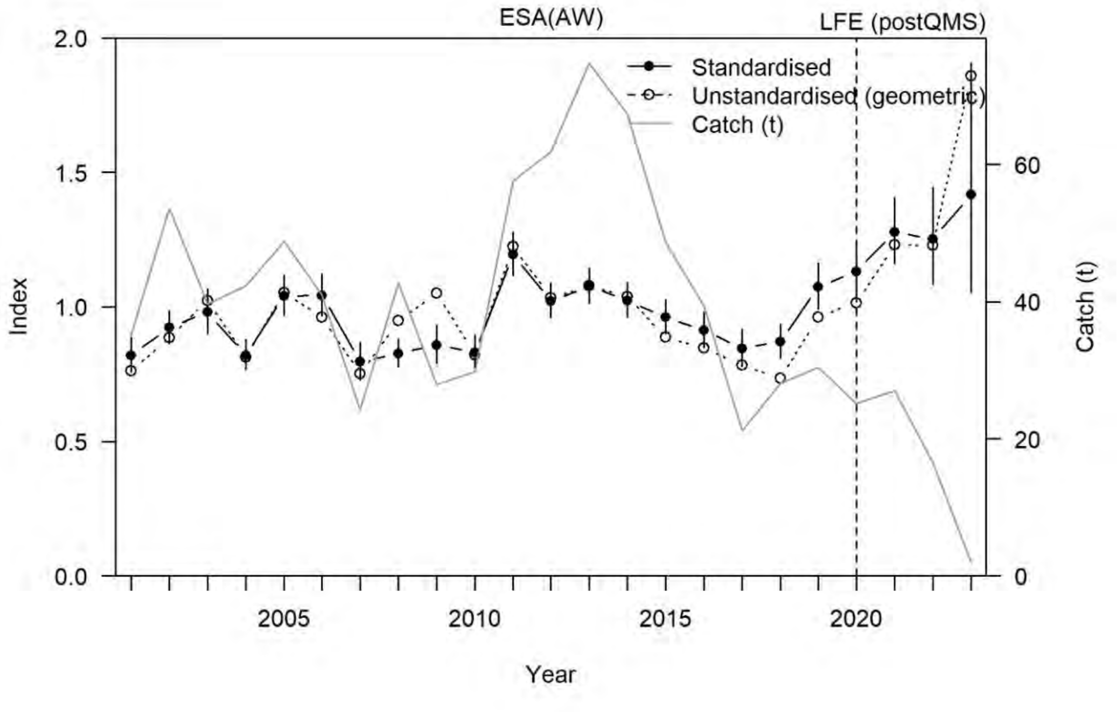

Figure G35: Indices of unstandardised (geometric mean of catch per lift) and standardised CPUE for longfin (core fishers) post-QMS for the years 2000–01 to 2022–23. The catch by core fishers is also plotted. Vertical dashed line represents introduction of electronic reporting in 2019–20 (ESA(AW)).

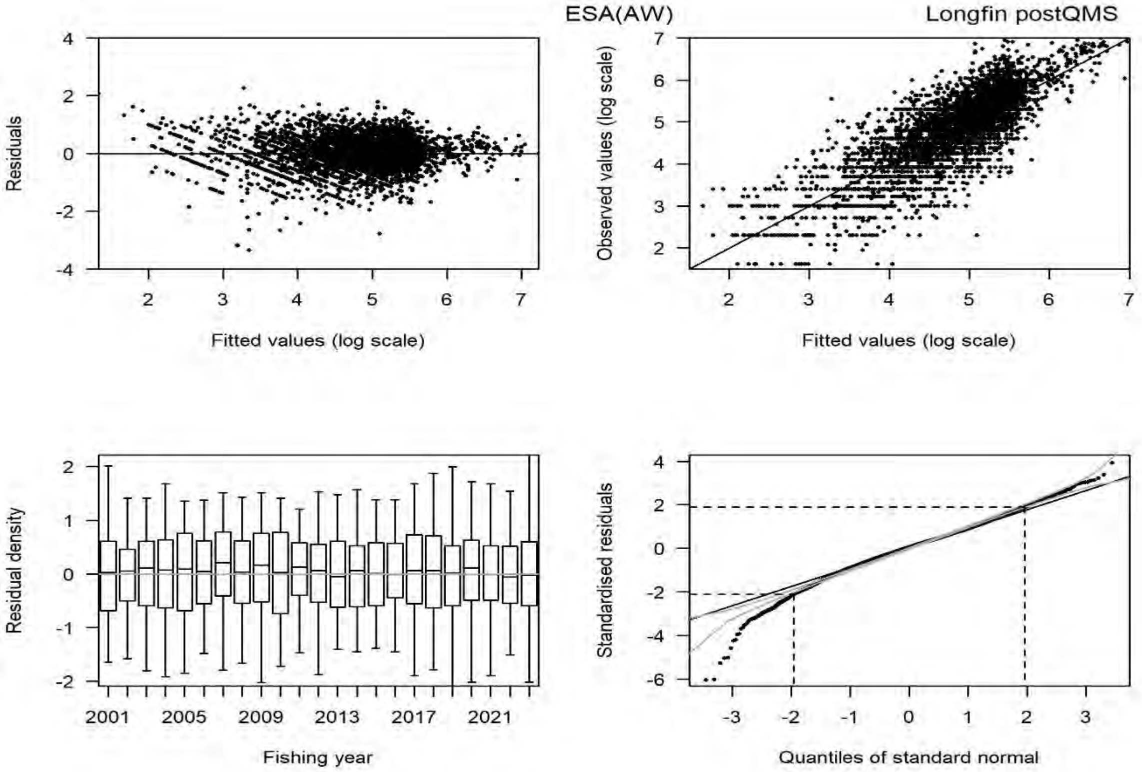

Figure G36: Residual diagnostic plots for the longfin eel CPUE model for the years 2000–01 to 2022–23 (post-QMS). The grey lines on the quantile-quantile plot represents the 95% confidence envelopes of a standard normal distribution (ESA(AW)).

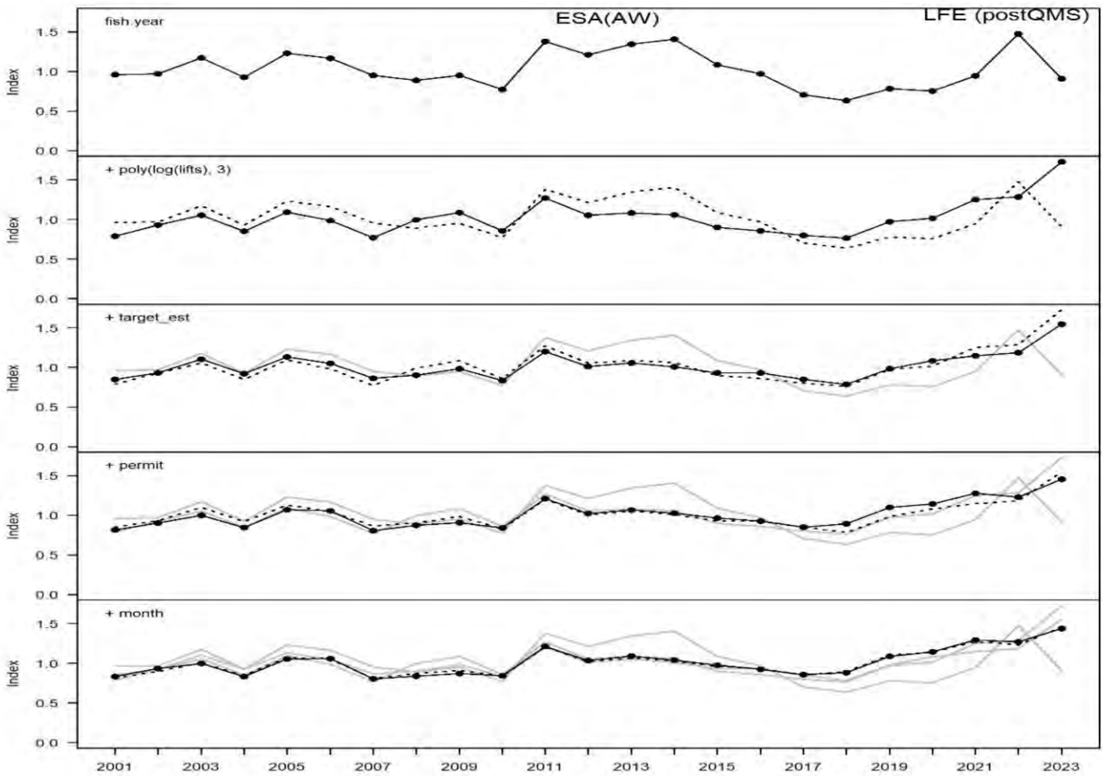

Figure G37: Step plot for the longfin eel CPUE model for the years 2000–01 to 2022–23 (post-QMS). Each panel shows the standardised CPUE index as each explanatory variable is added to the model with the previous index shown by the dotted line and the grey lines for steps before that (ESA(AW)).

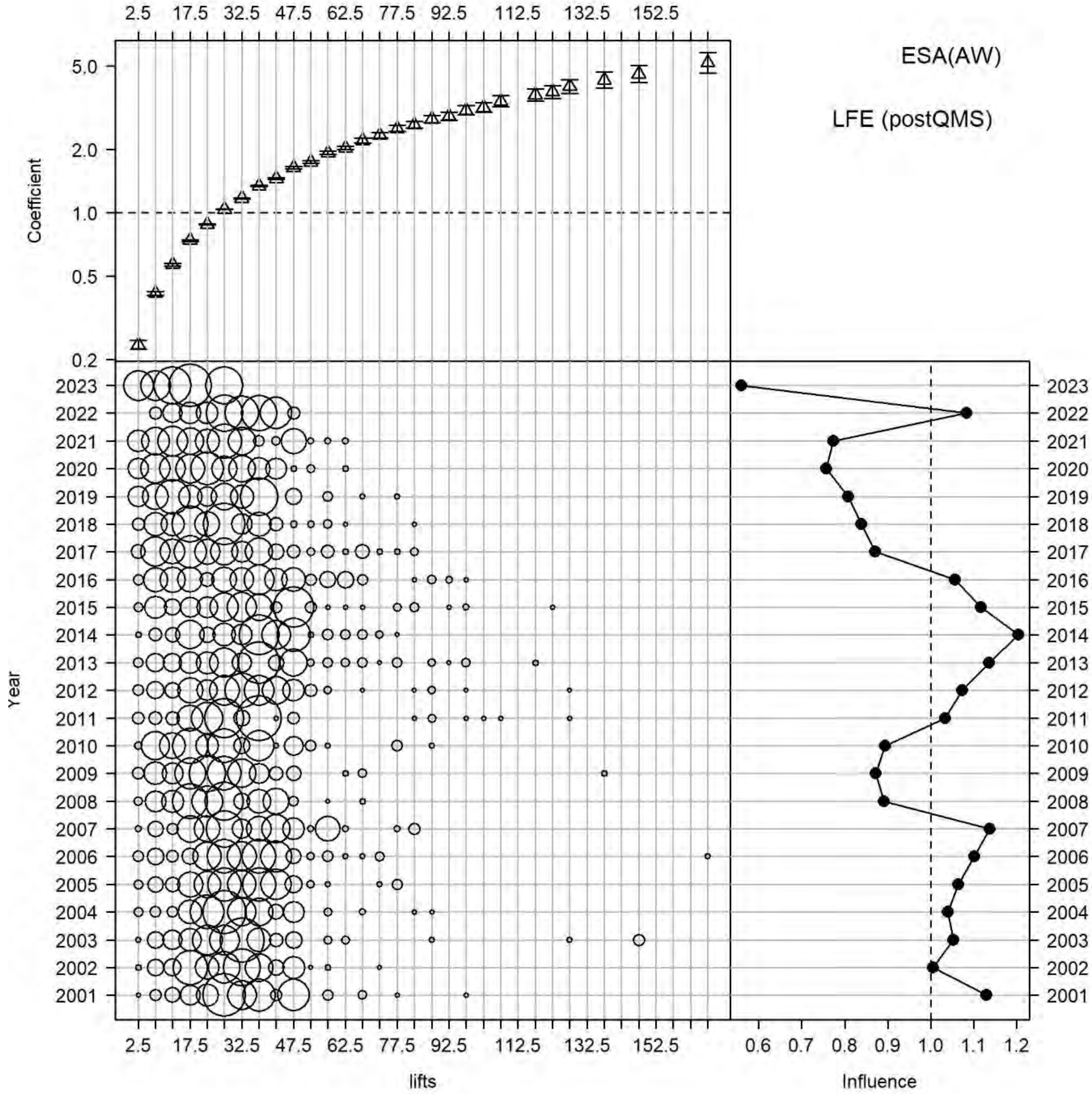

Figure G38: Influence of lifts for the longfin CPUE model for the years 2000–01 to 2022–23 (post-QMS) (ESA(AW)).

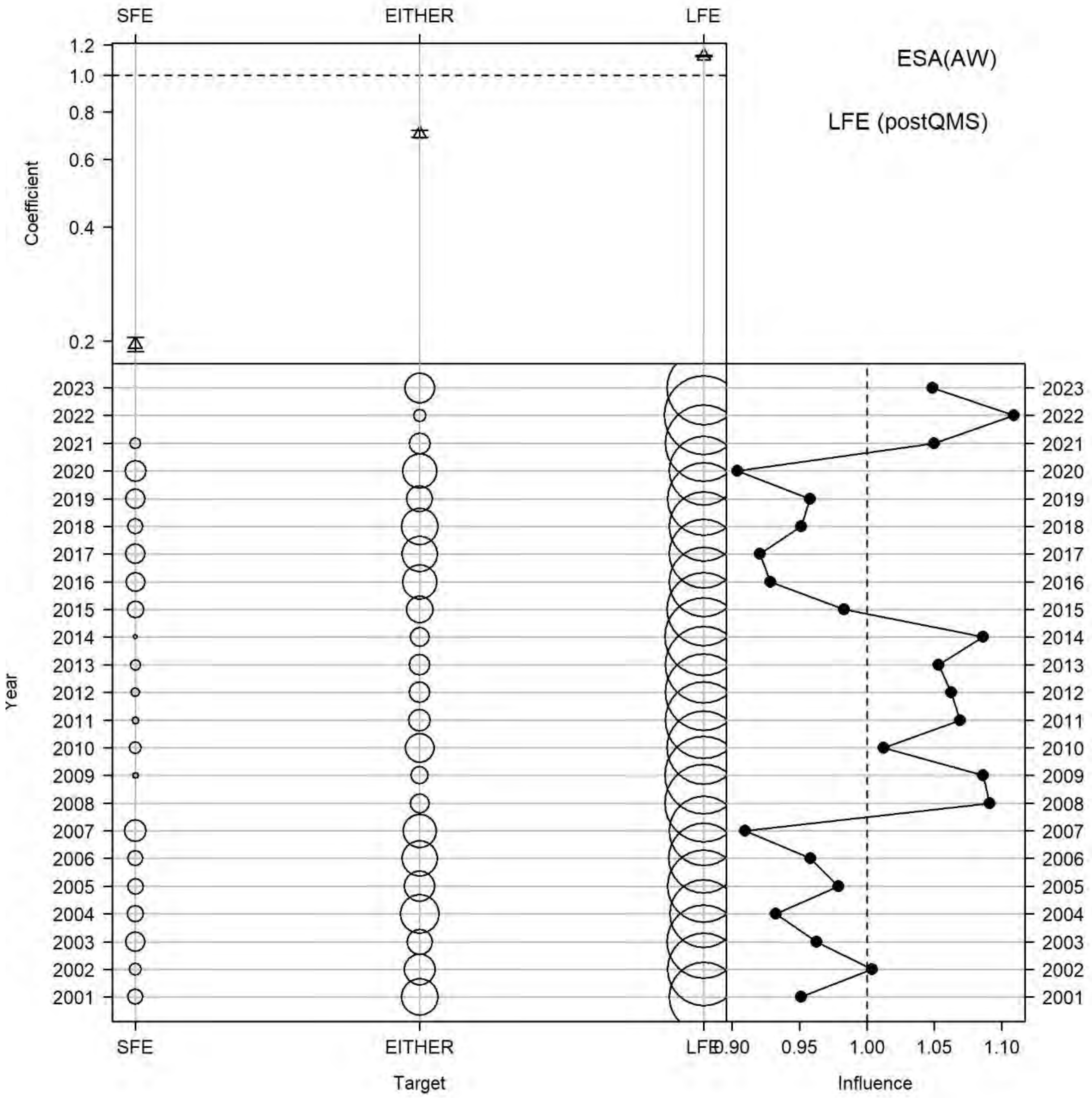

Figure G39: Influence of target for the longfin CPUE model for the years 2000–01 to 2022–23 (post-QMS) (ESA(AW)).

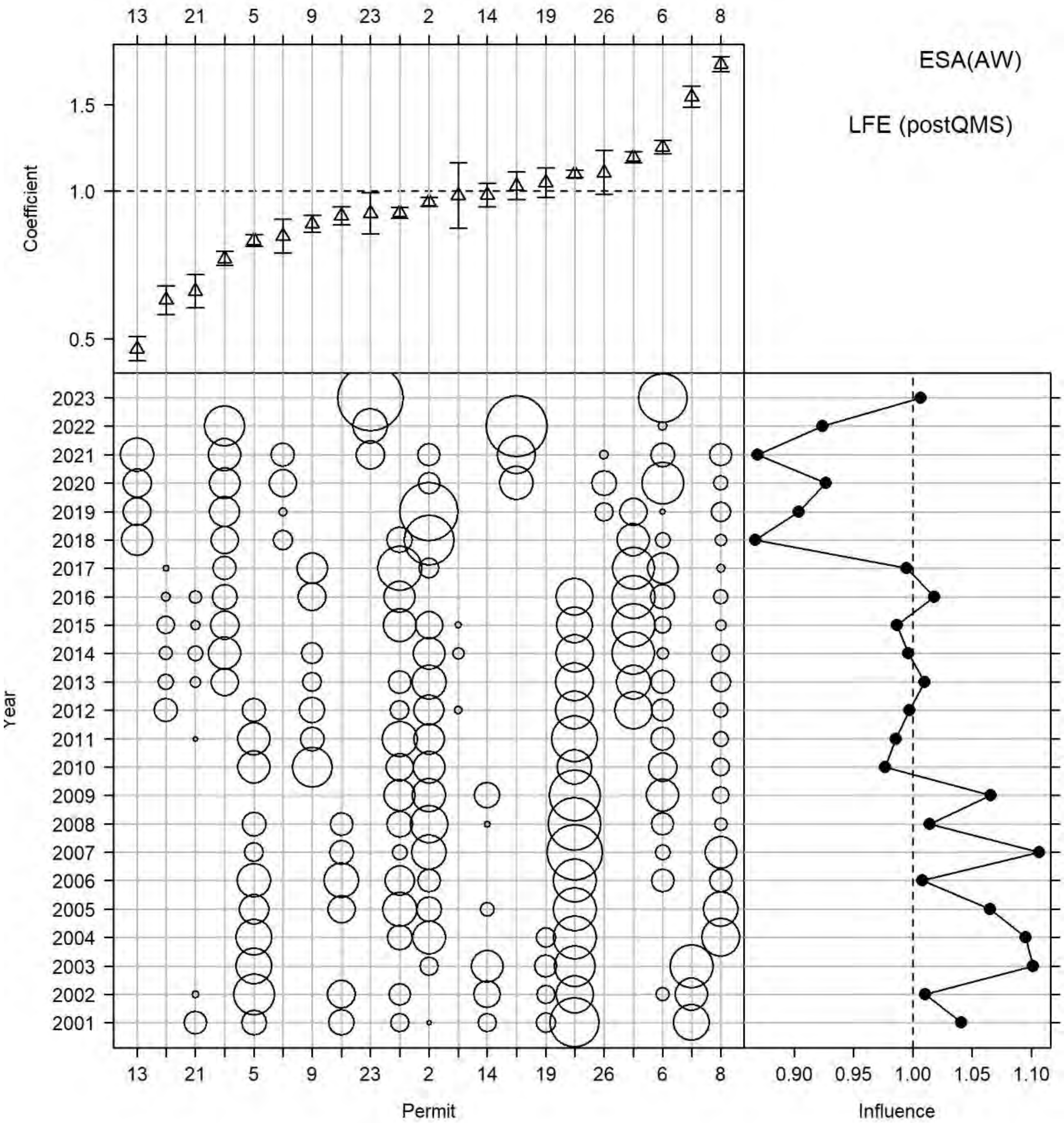

Figure G40: Influence of catcher for the longfin CPUE model for the years 2000–01 to 2022–23 (post-QMS) (ESA(AW)).

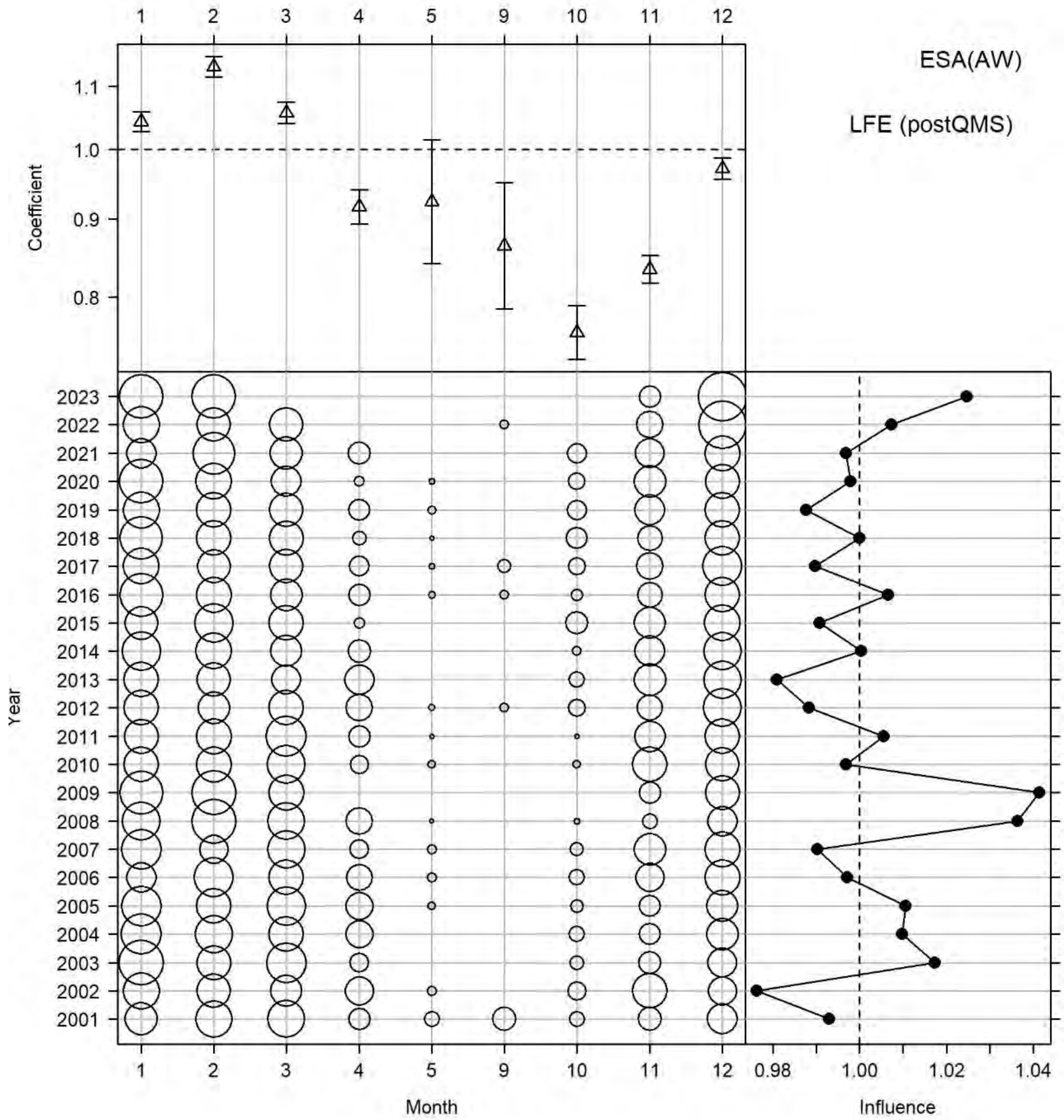

Figure G41: Influence of month for the longfin CPUE model for the years 2000–01 to 2022–23 (post-QMS) (ESA(AW)).

ESA AX (Westland)

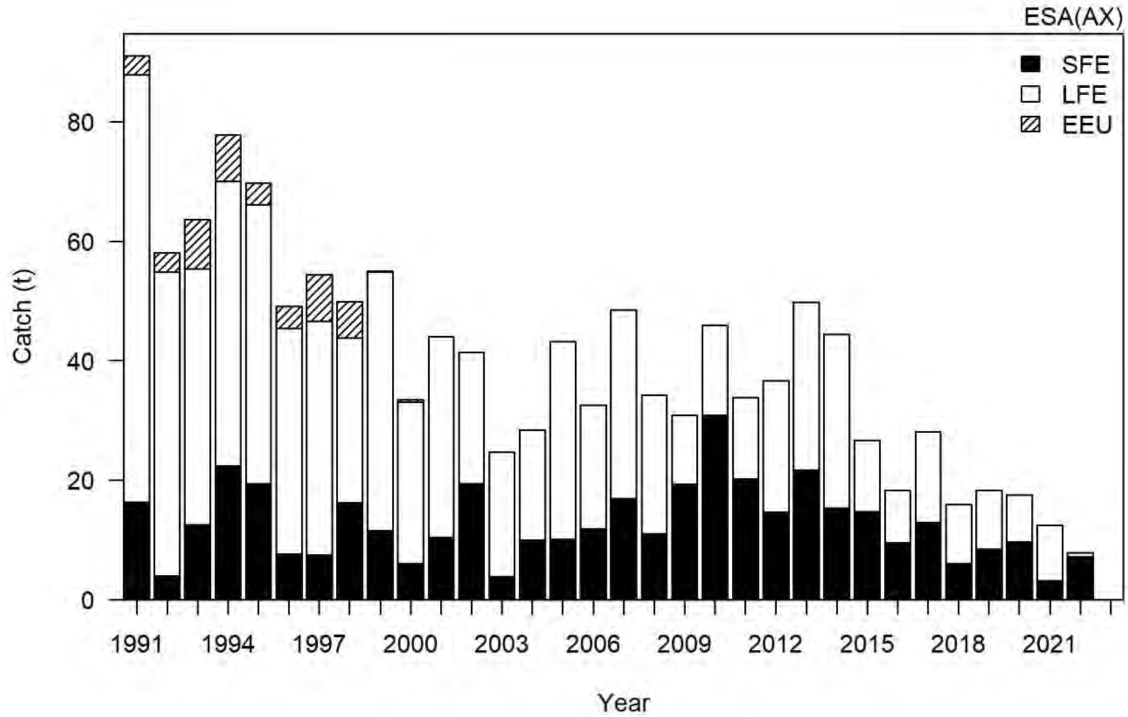

Figure H1: Total estimated commercial catch of shortfin (SFE), longfin (LFE), and unclassified eel catch (EEU) for the years 1990–91 to 2022–23 (ESA(AX)).

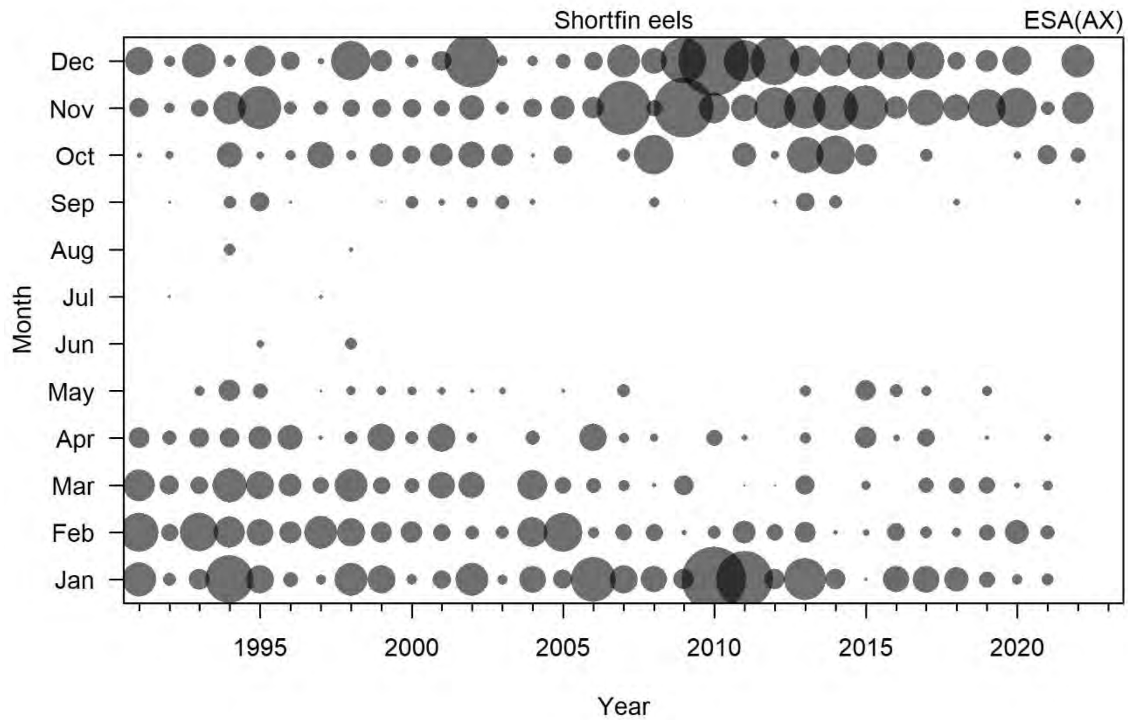

Figure H2: Shortfin eel catch by month for the years 1990–91 to 2022–23 (ESA(AX)).

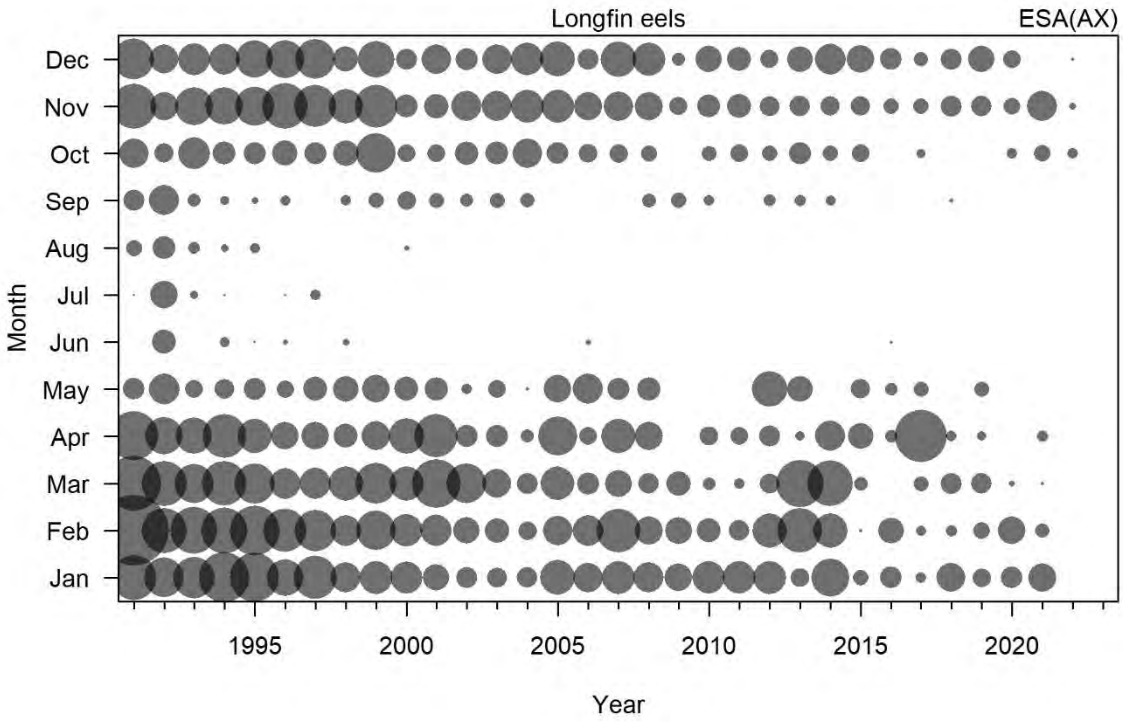

Figure H3: Longfin eel catch by month for the years 1990–-91 to 2022–23 (ESA(AX)).

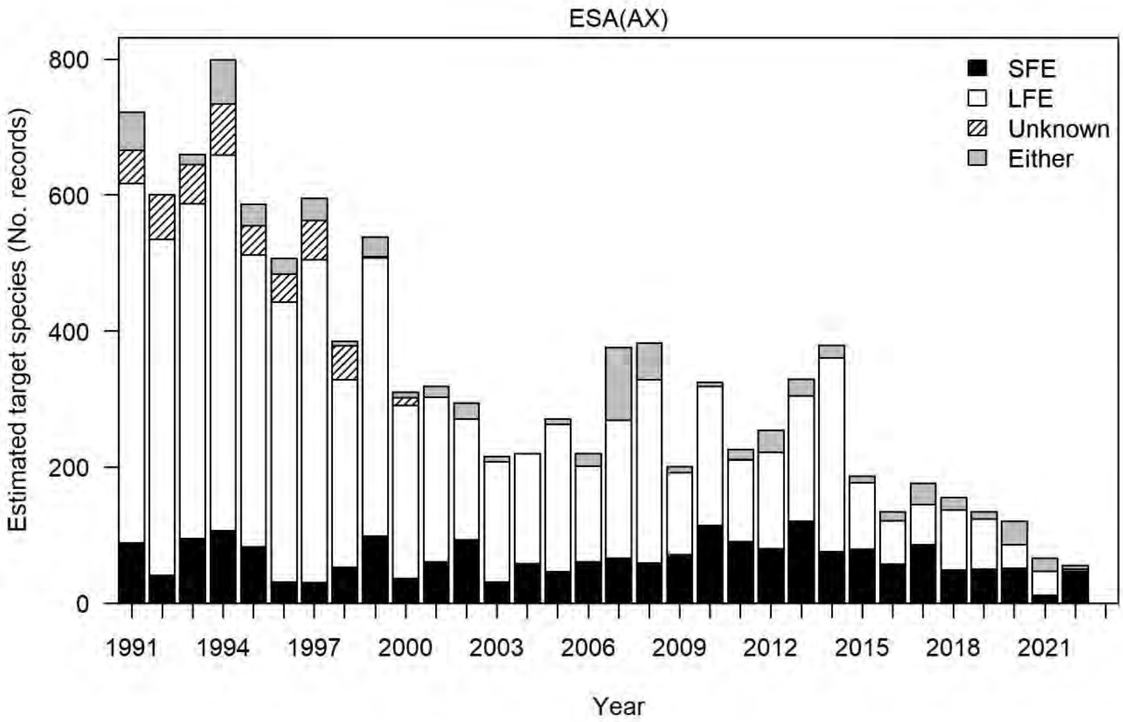

Figure H4: Reconstructed target species for the years 1990–91 to 2022–23 (ESA(AX)).

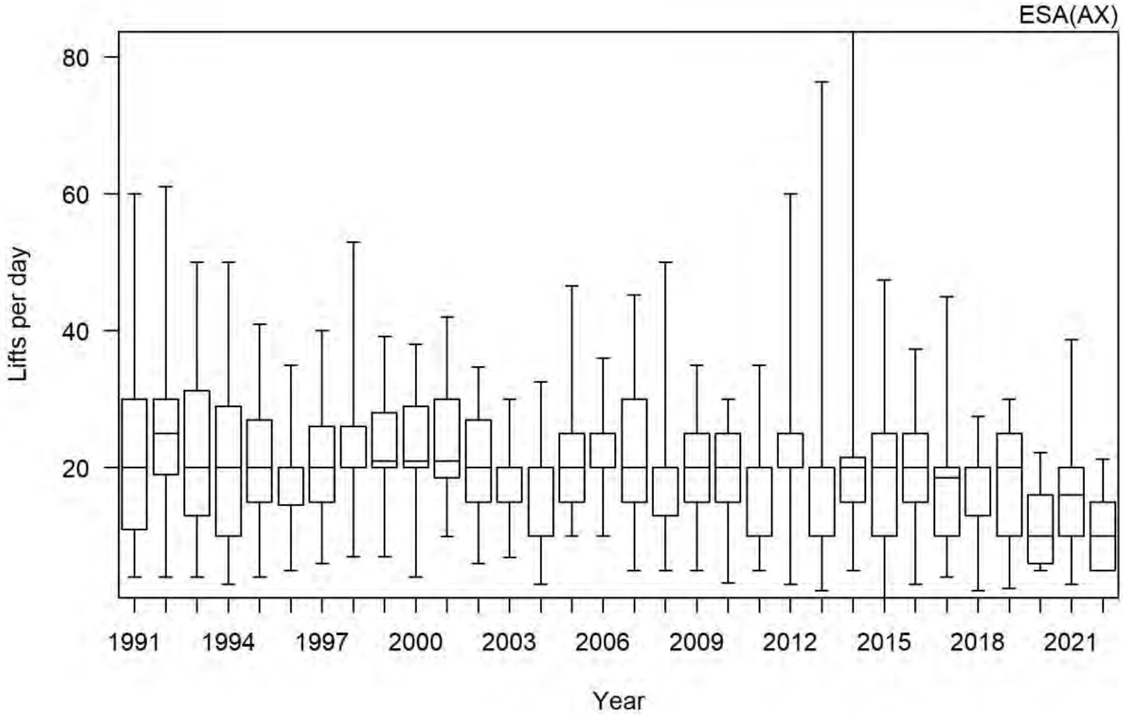

Figure H5: Total lifts per day for the years 1990–91 to 2022–23. The horizontal line is the median, the top and bottom of the box are the interquartiles (25th and 75th), and error bars are the 95th percentile range (ESA(AX)).

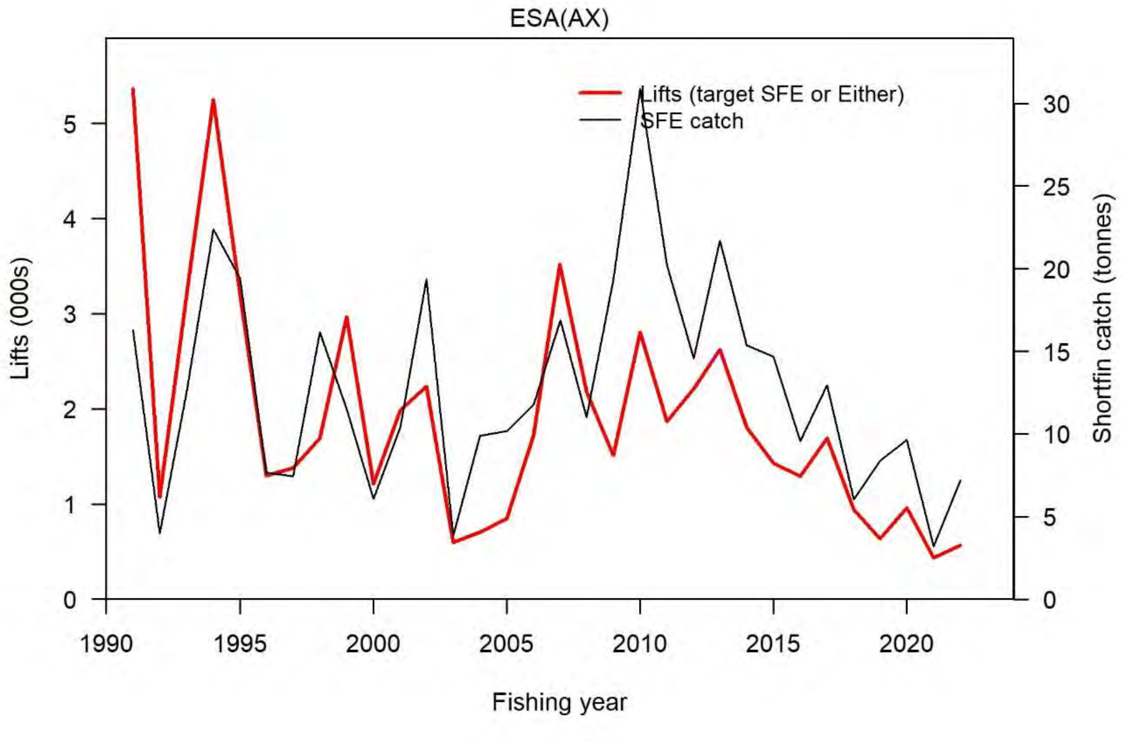

Figure H6: Total lifts and shortfin catch when target species was 'shortfin' or 'either' for the years 1990–91 to 2022–23 (ESA(AX)).

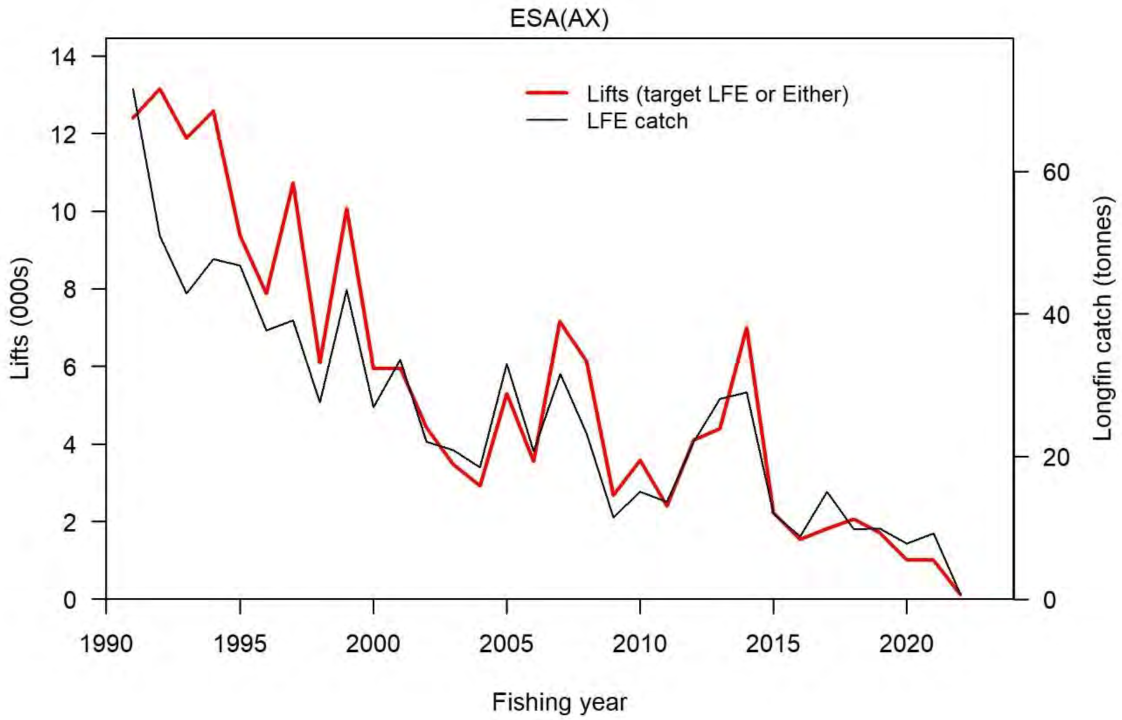

Figure H7: Total lifts and longfin catch when target species was 'longfin' or 'either' for the years 1990–91 to 2022–23 (ESA(AX)).

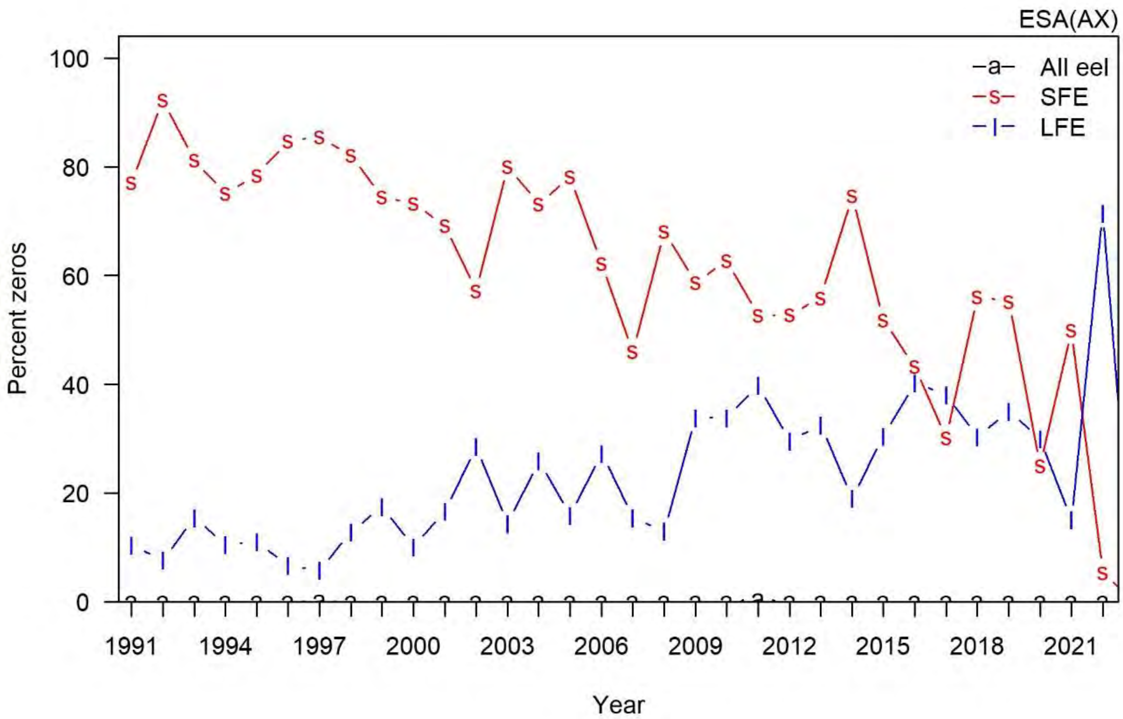

Figure H8: Proportion of valid zero records for all eels, shortfin (SFE), and longfin (LFE) catch for the years 1990–91 to 2022–23. Excludes zeros associated with reporting EEU (unclassified) (ESA(AX)).

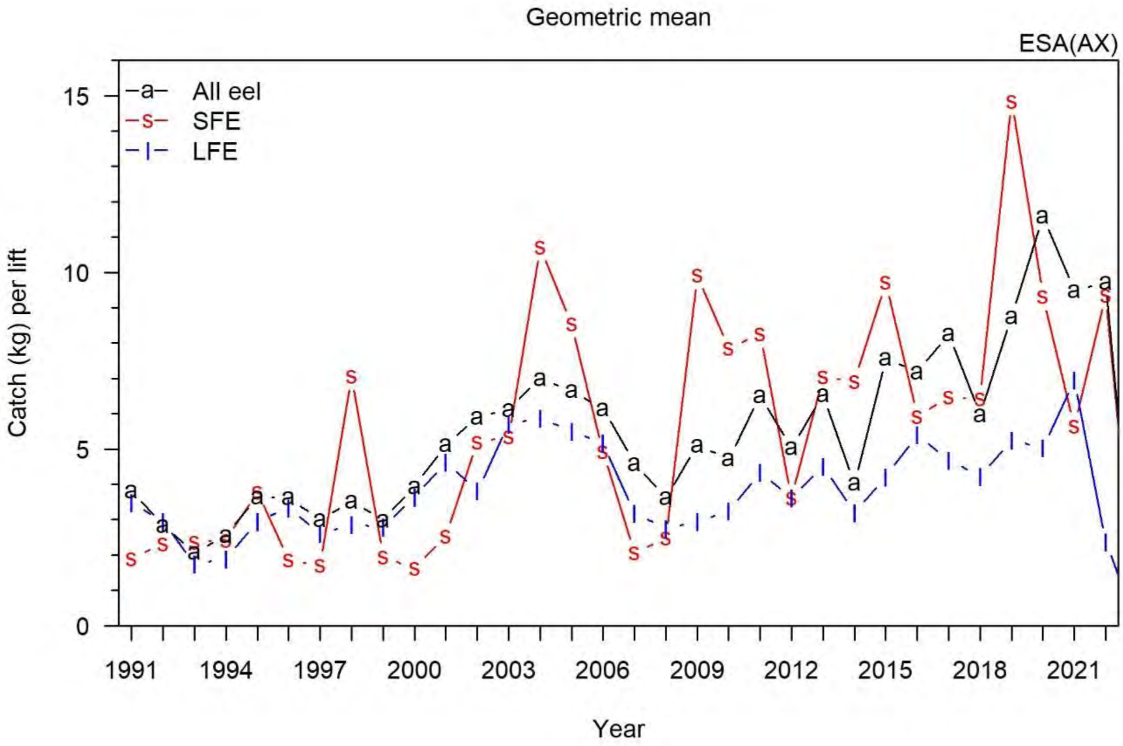

Figure H9: Unstandardised catch per lift (geometric mean of catch per lift) for all eels, shortfin (SFE), and longfin (LFE) for the years 1990–91 to 2022–23 (ESA(AX)).

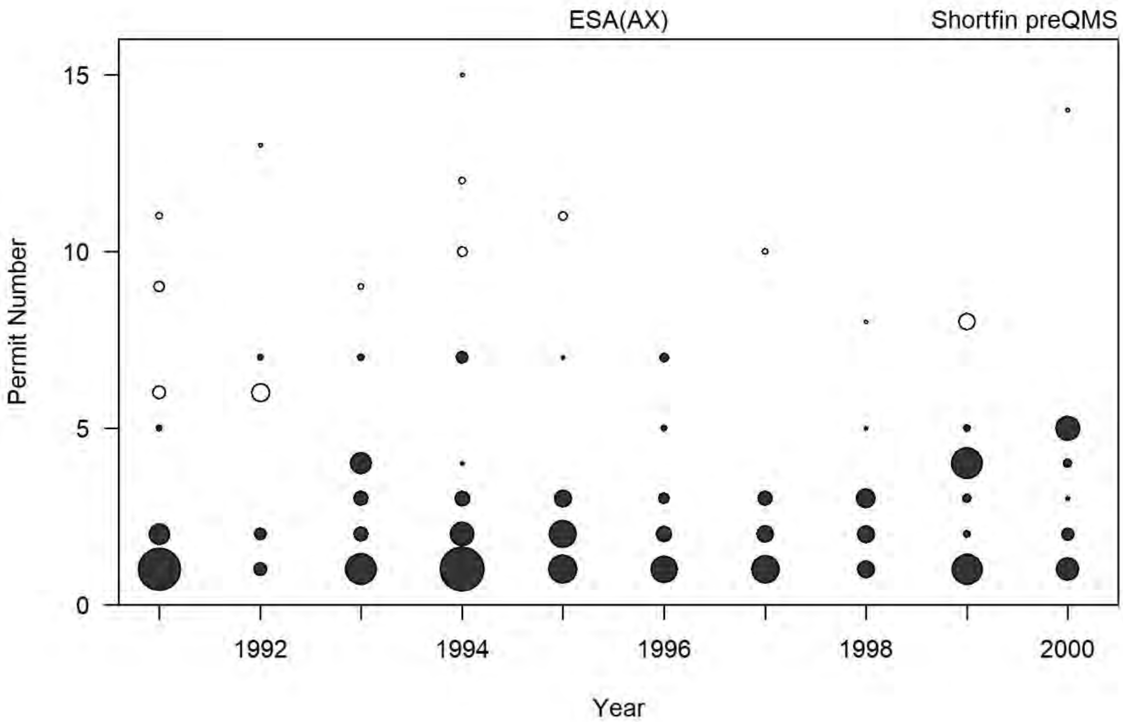

Figure H10: Relative shortfin catch from all fishers (all circles) for the years 1990–91 to 1999–2000 (pre-QMS), and for core fishers (dark shaded circles) included in the catch per unit effort analyses (ESA(AX)).

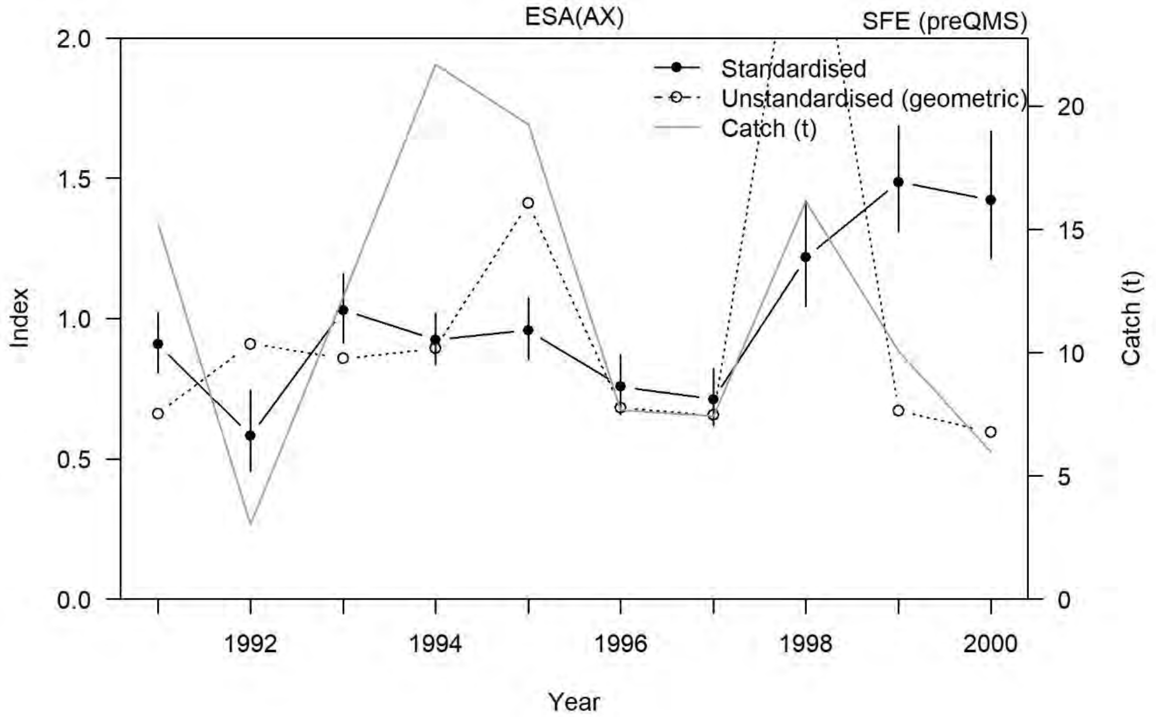

Figure H11: Indices of unstandardised (geometric mean of catch per lift) and standardised CPUE for shortfin (core fishers) pre-QMS for the years 1990–91 to 1999–2000 (ESA(AX)).

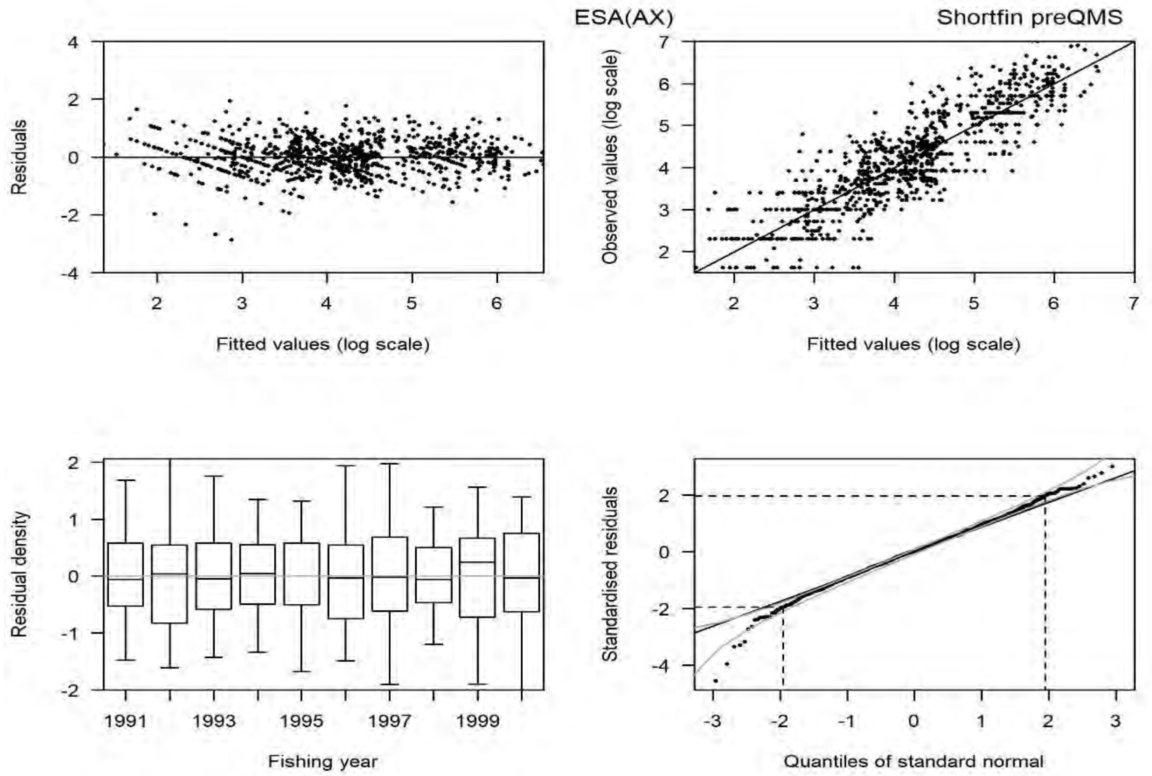

Figure H12: Residual diagnostic plots for the shortfin eel CPUE model for the years 1990–91 to 1999–2000 (pre-QMS). The grey lines on the quantile-quantile plot represent the 95% confidence envelopes of a standard normal distribution (ESA(AX)).

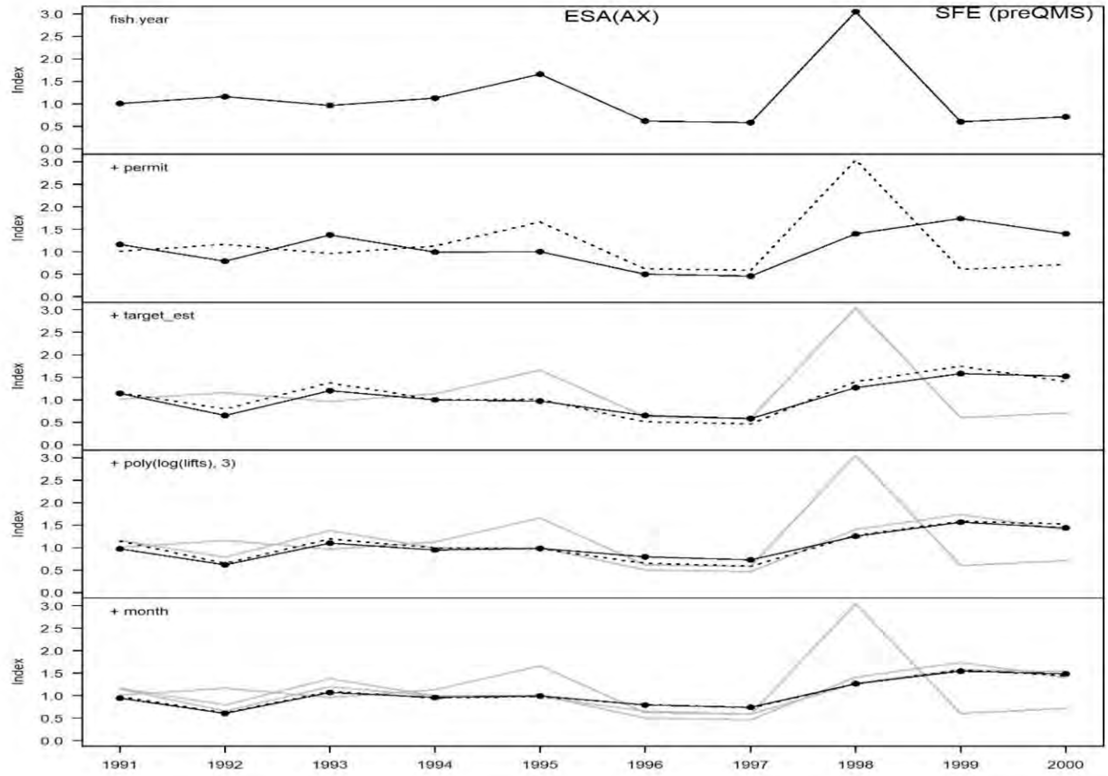

Figure H13: Step plot for the shortfin eel CPUE model for the years 1990–91 to 1999–2000 (pre-QMS). Each panel shows the standardised CPUE index as each explanatory variable is added to the model with the previous index shown by the dotted line and the grey lines for steps before that (ESA(AX)).

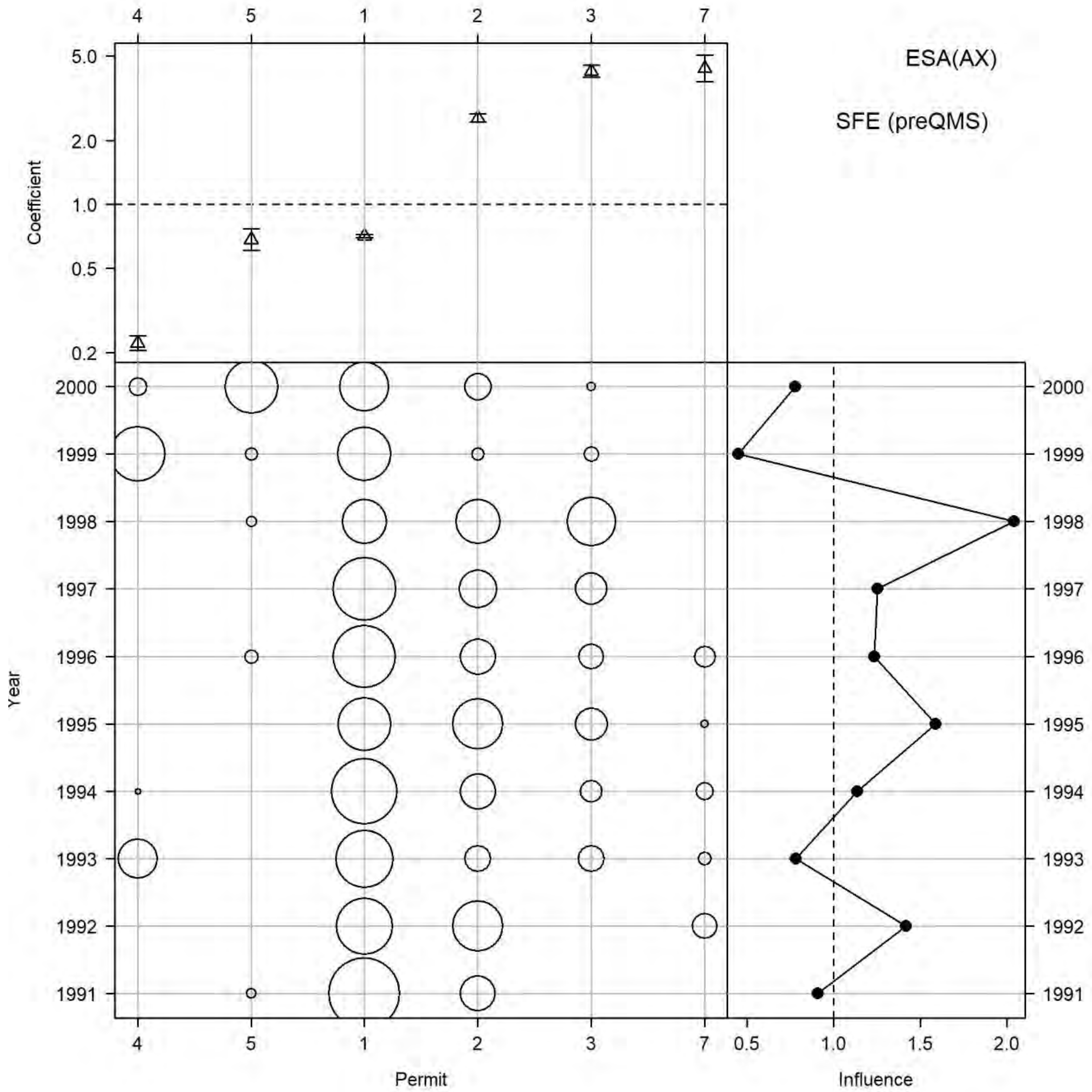

Figure H14: Influence of permit for the shortfin CPUE model for the years 1990–91 to 1999–2000 (pre-QMS) (ESA(AX)).

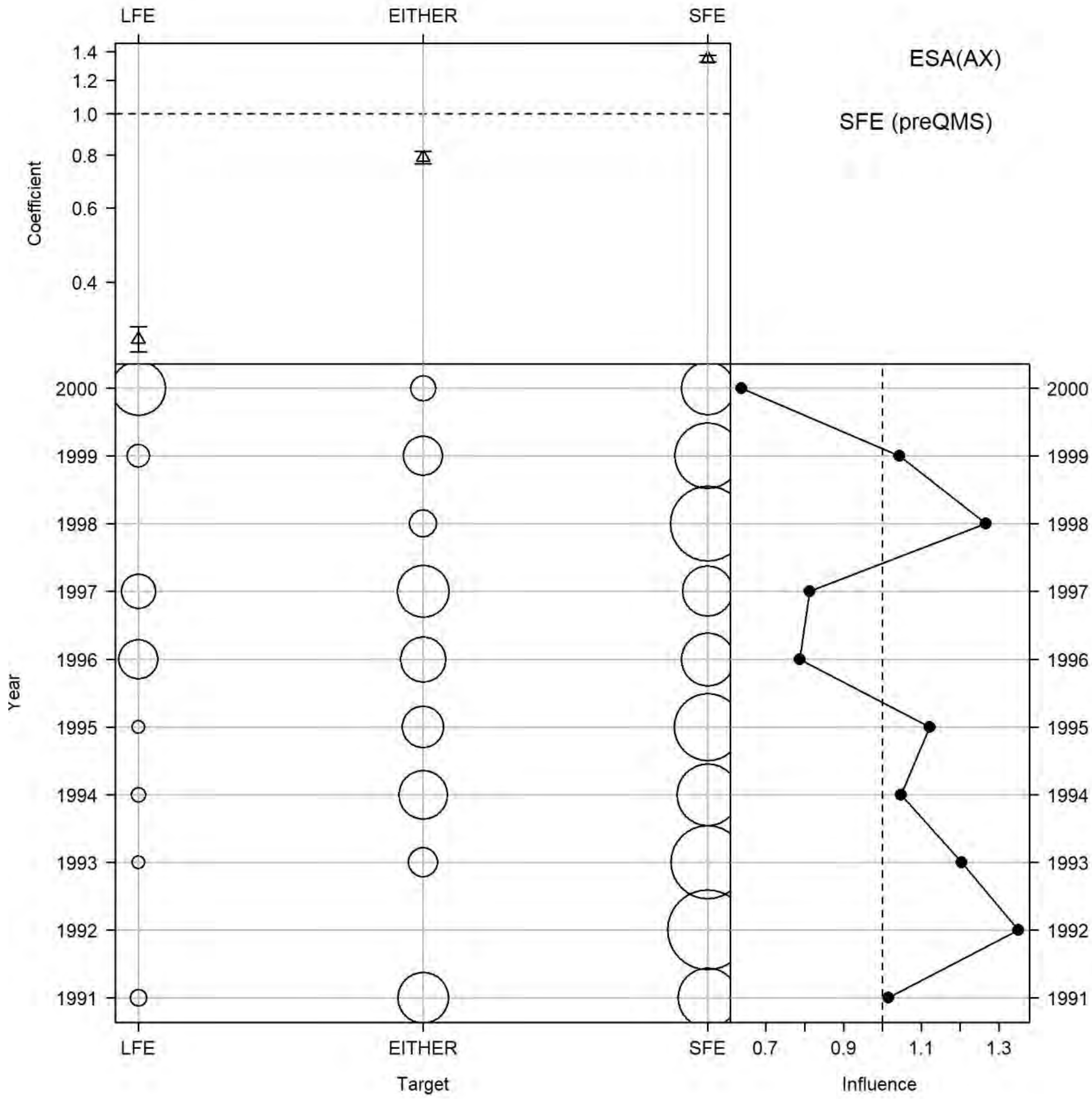

Figure H15: Influence of target for the shortfin CPUE model for the years 1990–91 to 1999–2000 (pre-QMS) (ESA(AX)).

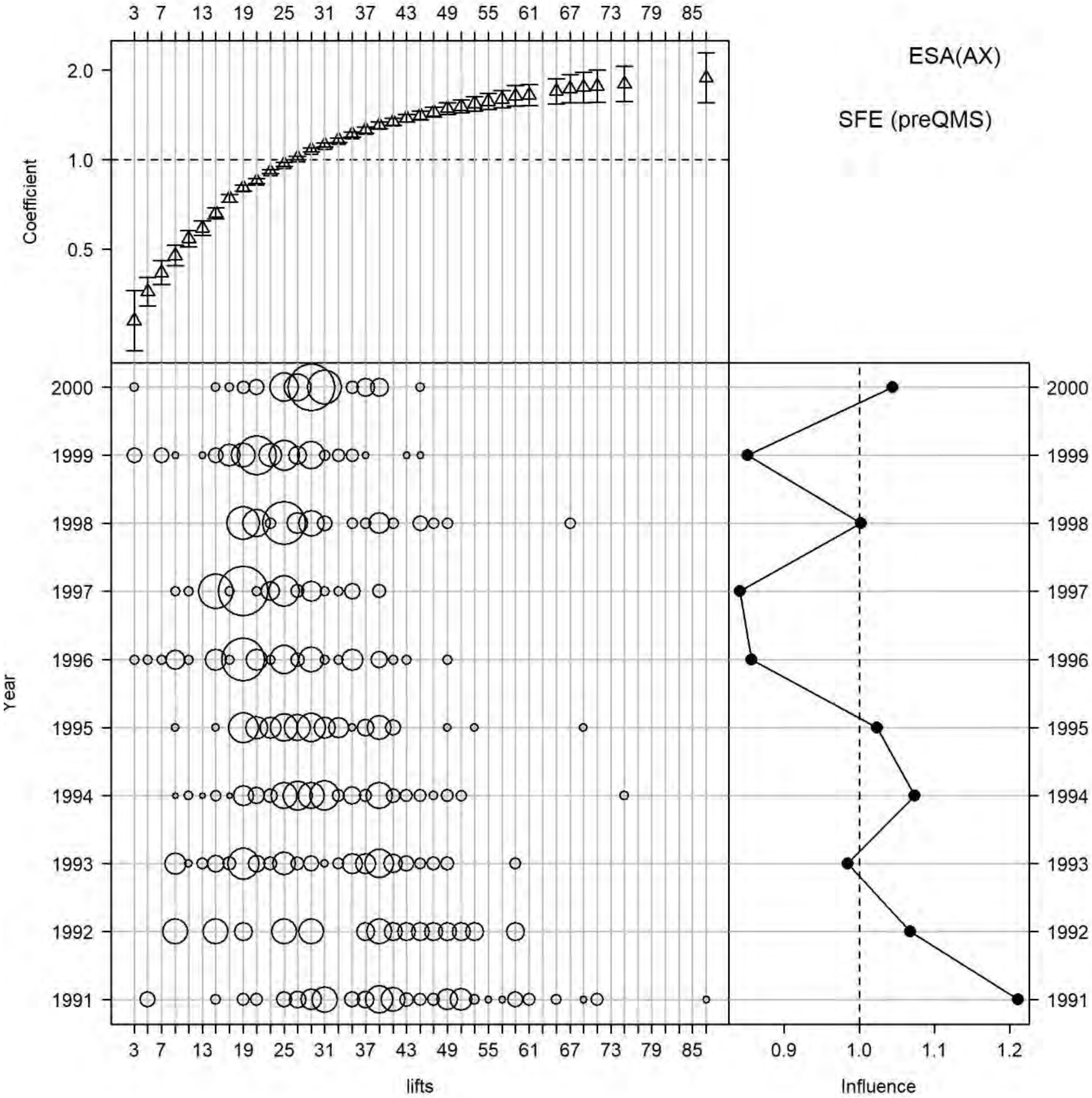

Figure H16: Influence of lifts for the shortfin CPUE model for the years 1990–91 to 1999–2000 (pre-QMS) (ESA(AX)).

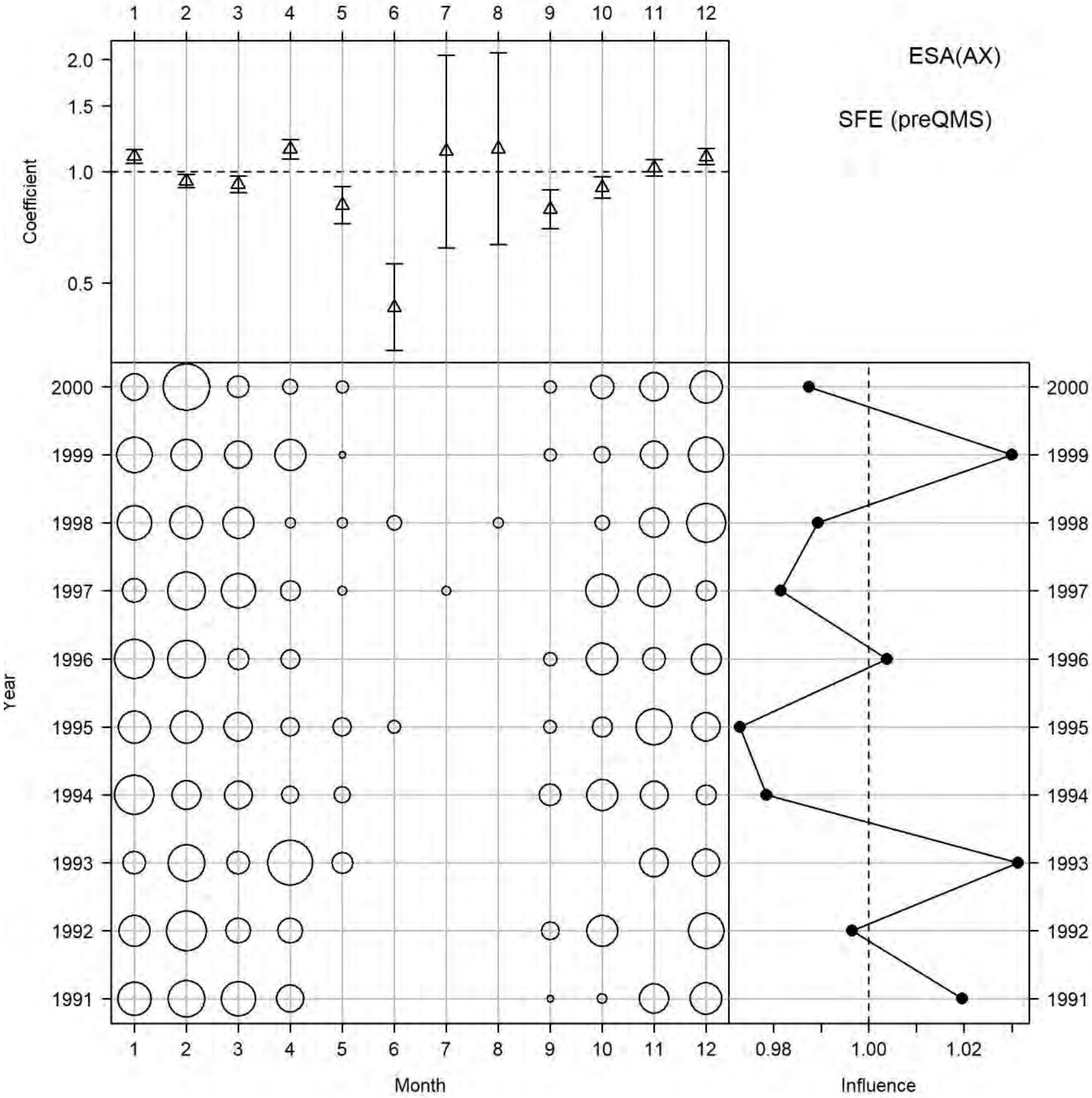

Figure H17: Influence of month for the shortfin CPUE model for the years 1990–91 to 1999–2000 (pre-QMS) (ESA(AX)).

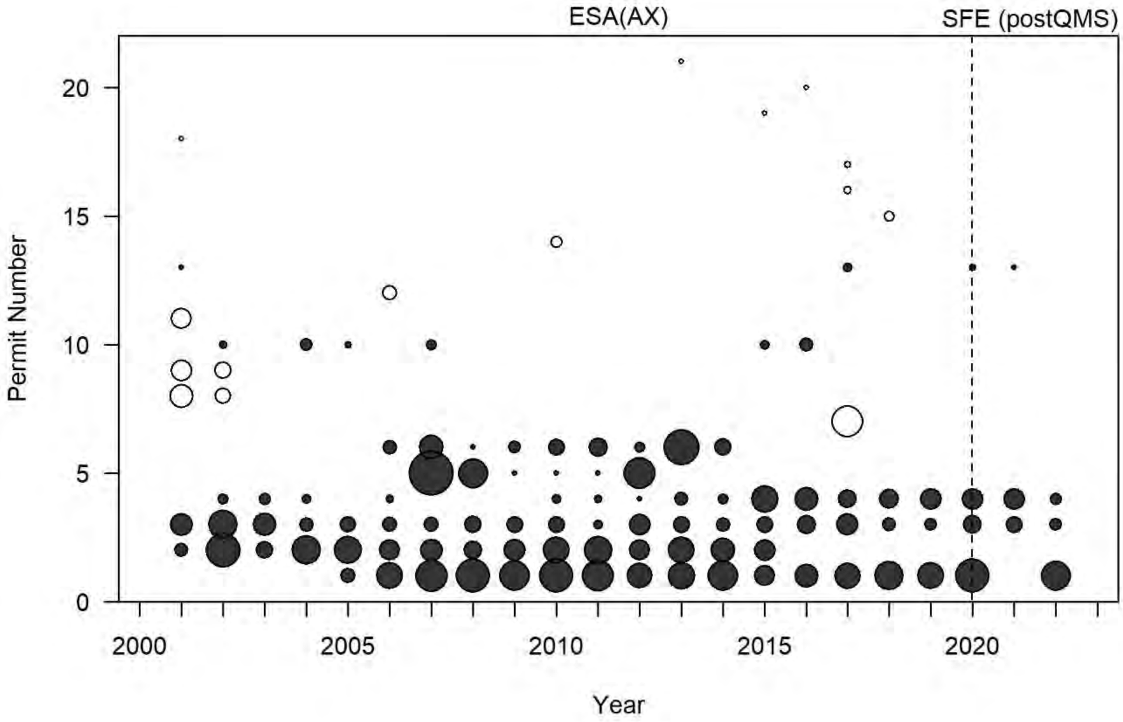

Figure H18: Relative shortfin catch from all fishers (all circles) for the years 2000–01 to 2022–23 (post-QMS), and for core fishers (dark shaded circles) included in the catch per unit effort analyses. Vertical dashed line represents introduction of electronic reporting in 2019–20 (ESA(AX)).

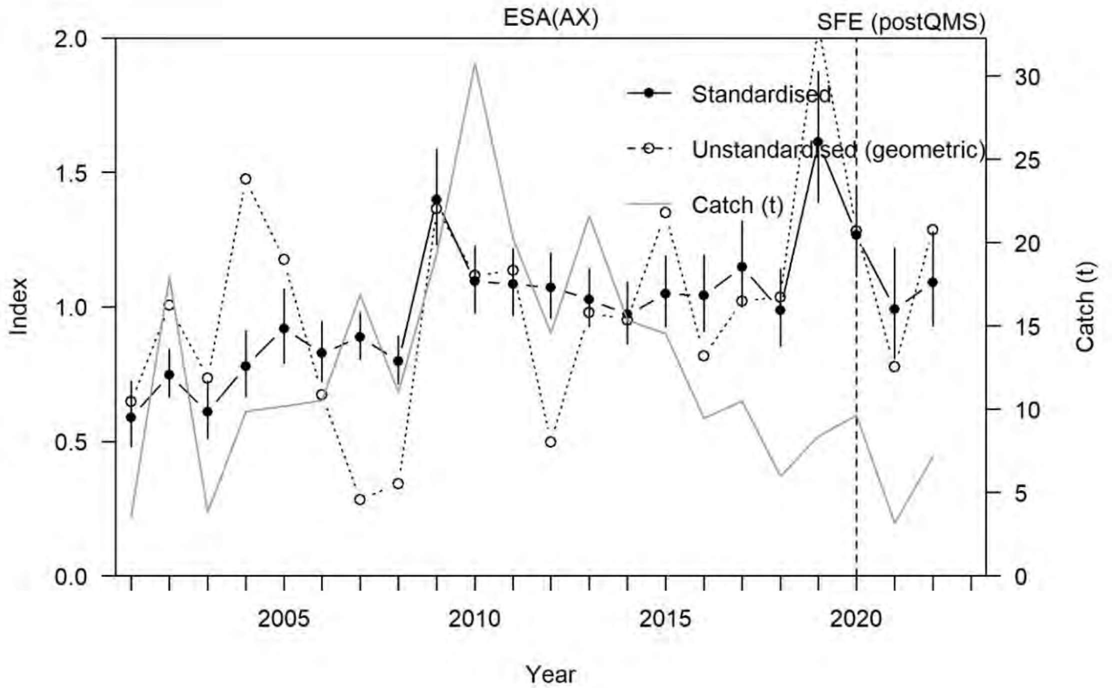

Figure H19: Indices of unstandardised (geometric mean of catch per lift) and standardised CPUE for shortfin (core fishers) post-QMS for the years 2000–01 to 2022–23. The catch by core fishers is also plotted. Vertical dashed line represents introduction of electronic reporting in 2019–20 (ESA(AX)).

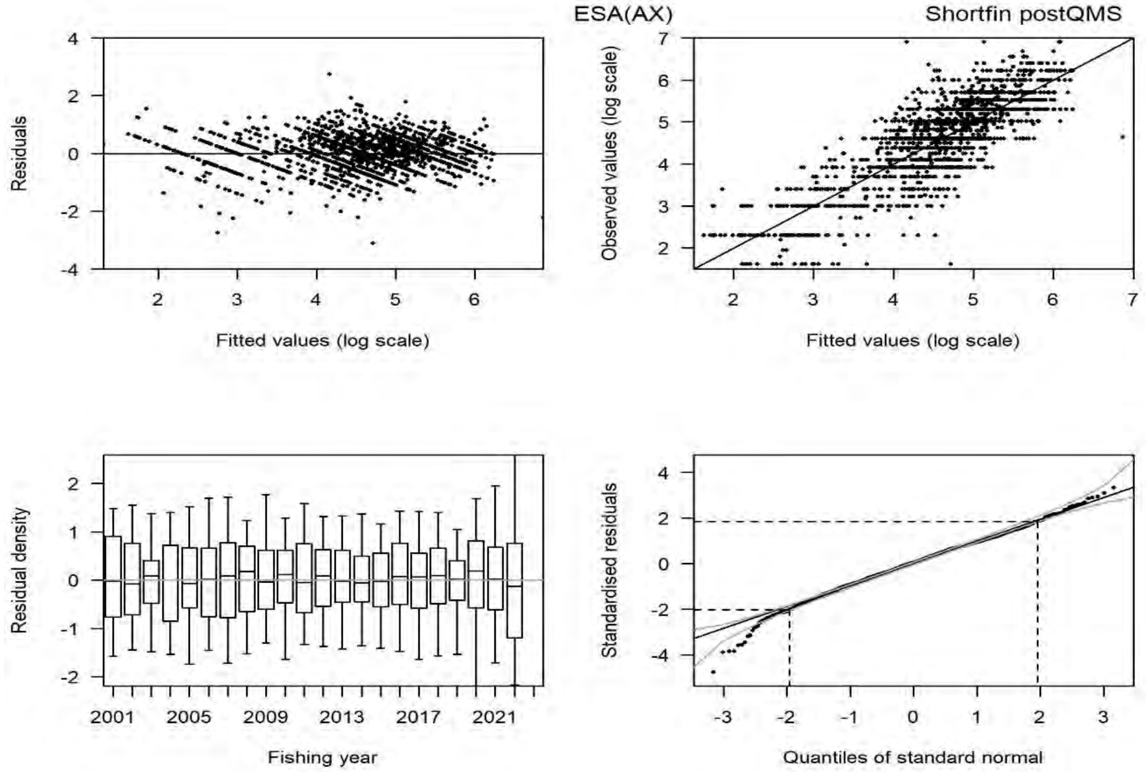

Figure H20: Residual diagnostic plots for the shortfin eel CPUE model for the years 2000–01 to 2022–23 (post-QMS). The grey lines on the quantile-quantile plot represent the 95% confidence envelopes of a standard normal distribution (ESA(AX)).

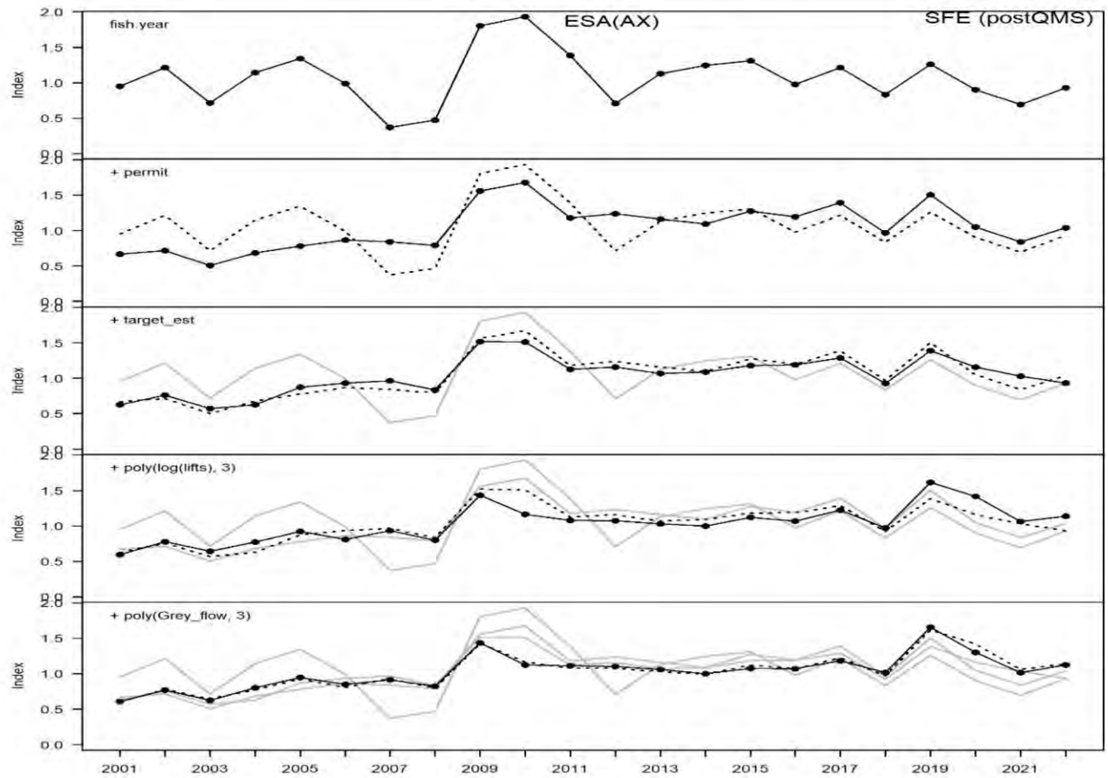

Figure H21: Step plot for the shortfin eel CPUE model for the years 2000–01 to 2022–23 (post-QMS). Each panel shows the standardised CPUE index as each explanatory variable is added to the model with the previous index shown by the dotted line and the grey lines for steps before that (ESA(AX)).

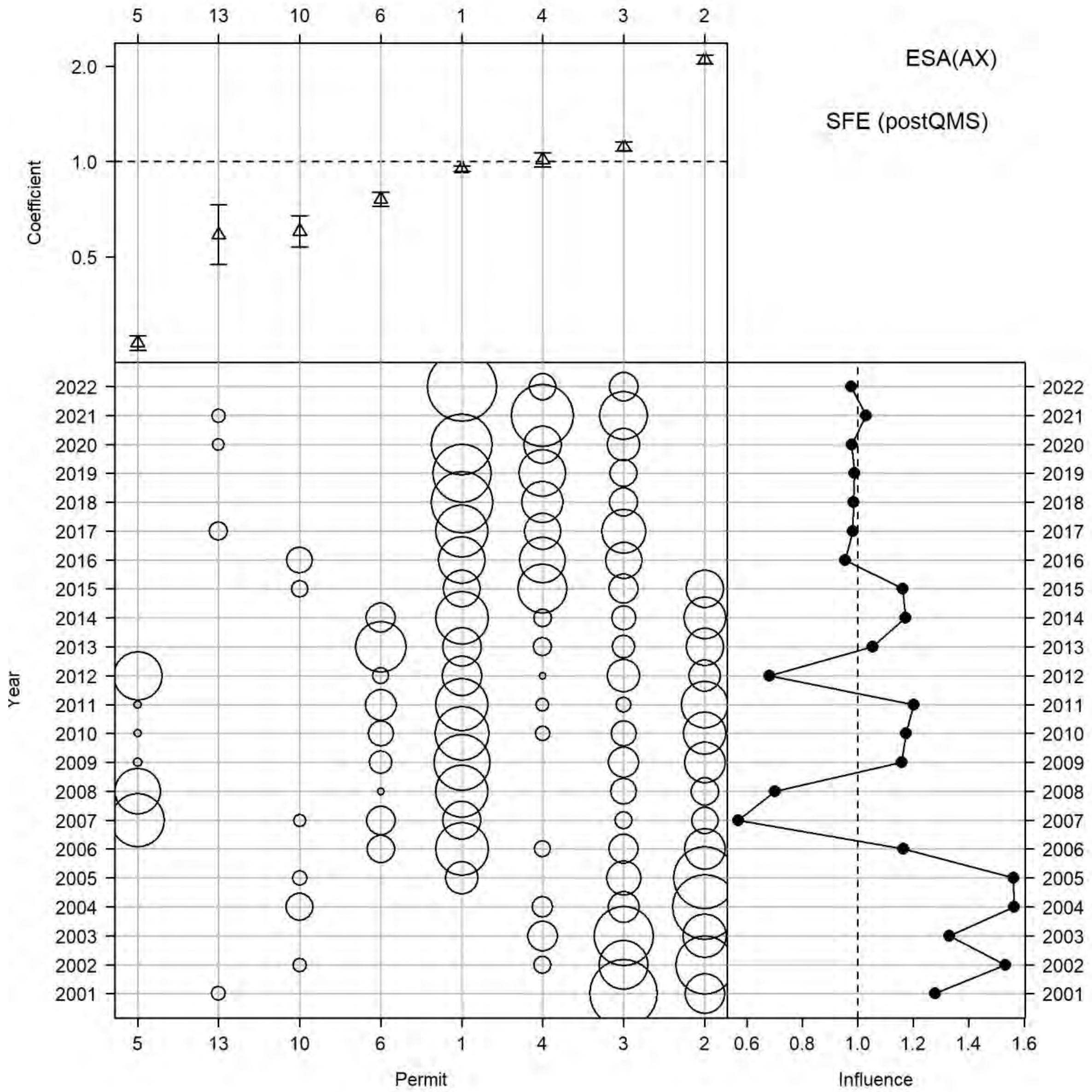

Figure H22: Influence of catcher for the shortfin CPUE model for the years 2000–01 to 2022–23 (post-QMS) (ESA(AX)).

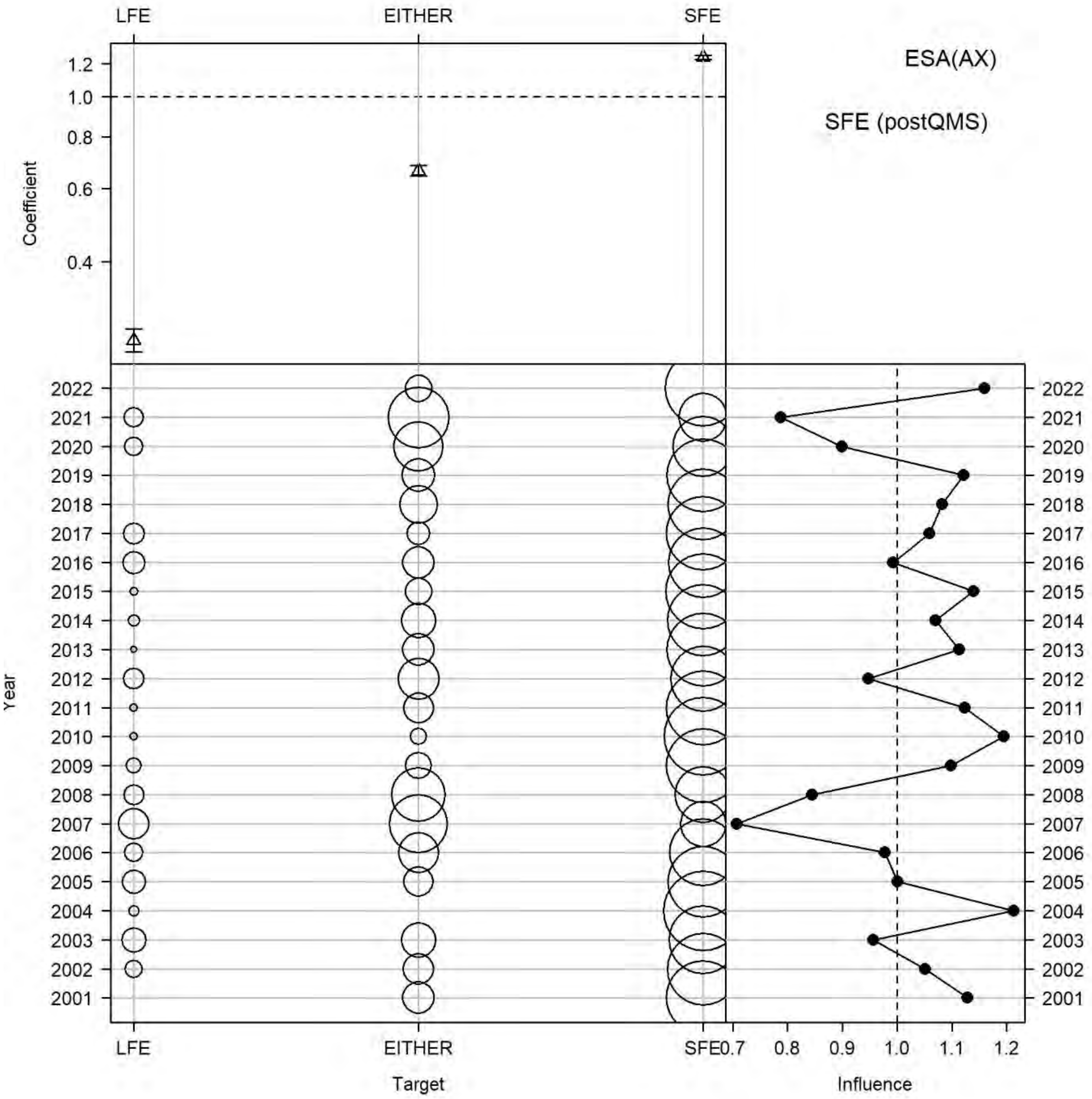

Figure H23: Influence of target for the shortfin CPUE model for the years 2000–01 to 2022–23 (post-QMS) (ESA(AX)).

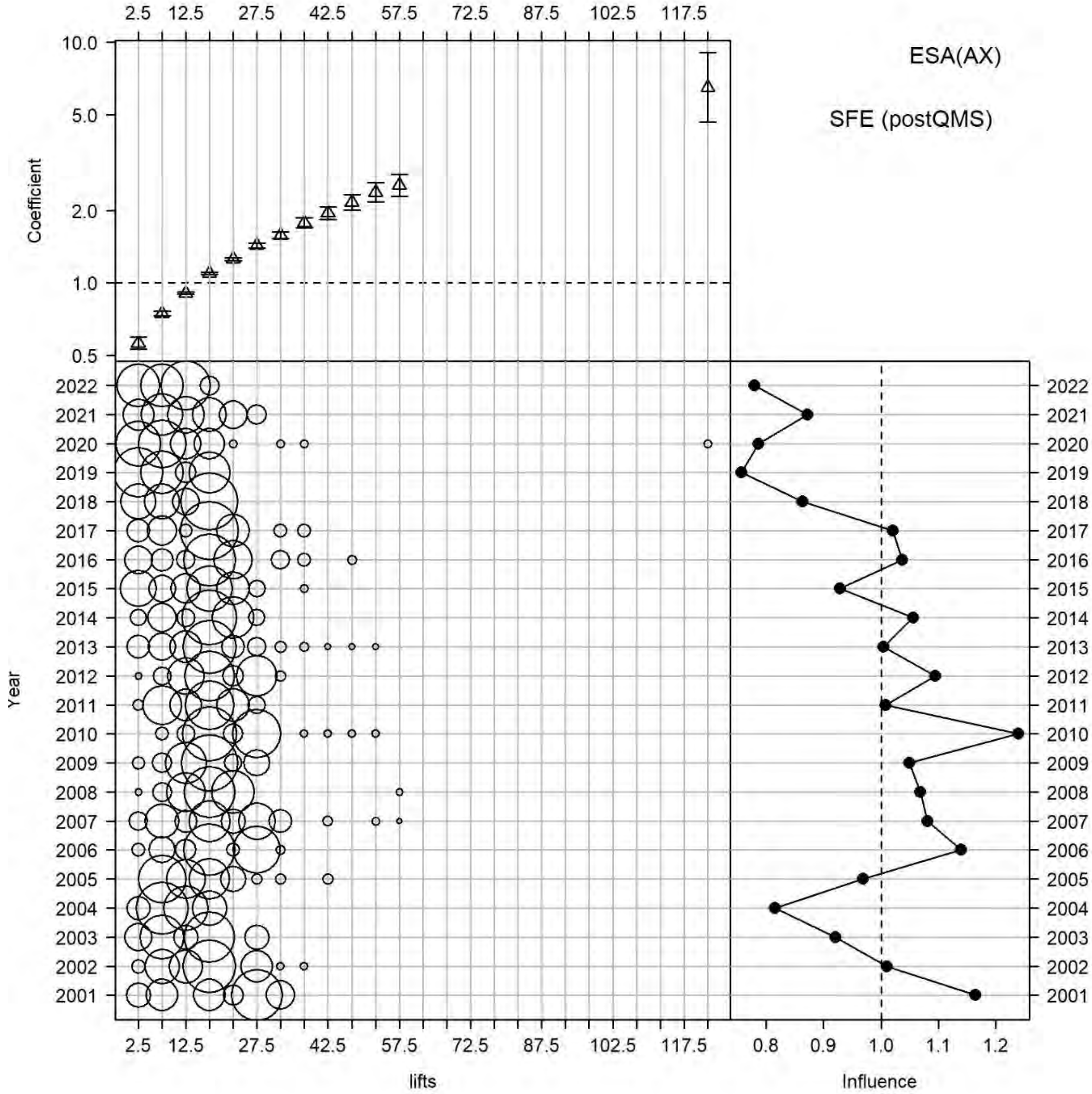

Figure H24: Influence of lifts for the shortfin CPUE model for the years 2000–01 to 2022–23 (post-QMS) (ESA(AX)).

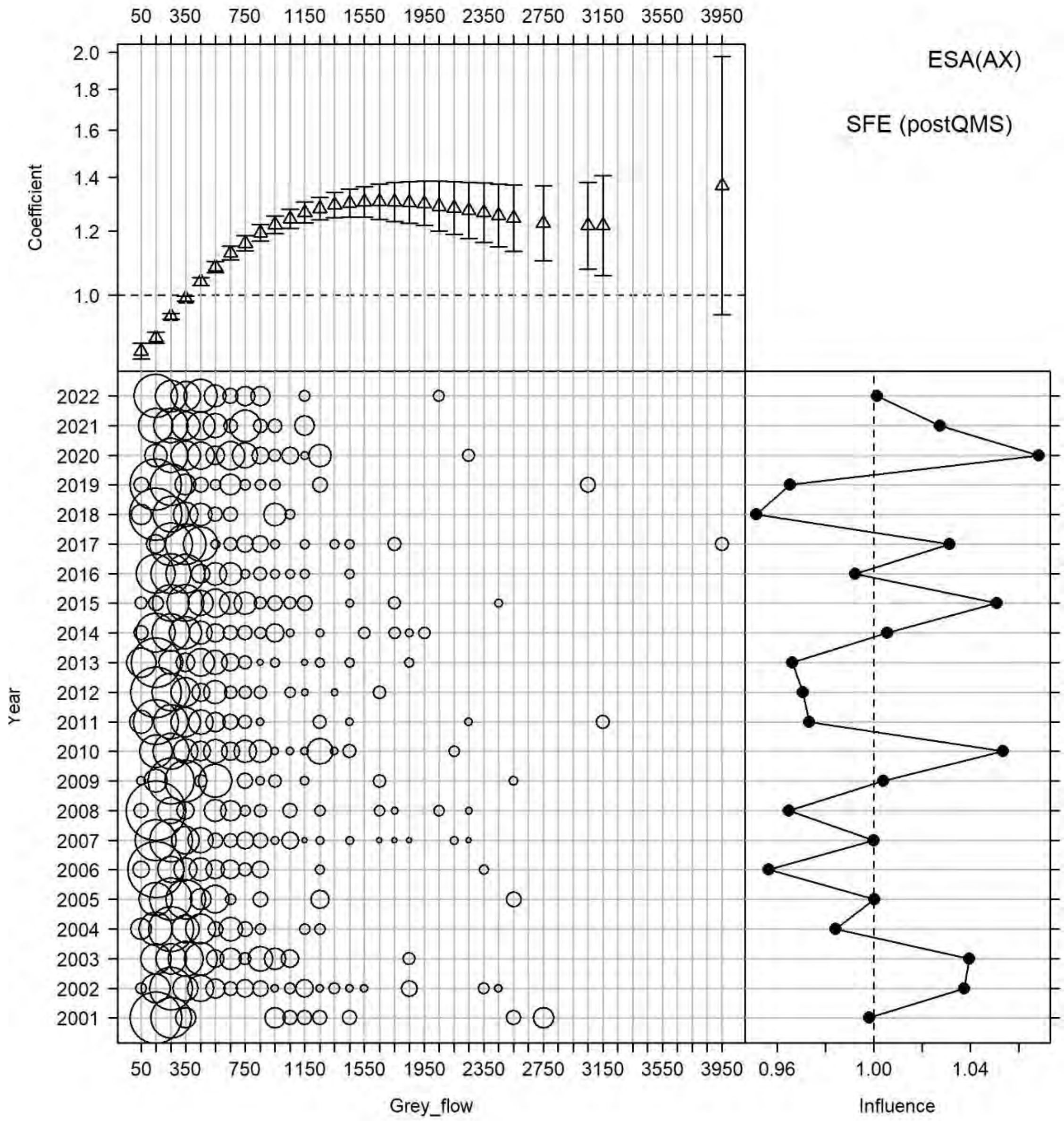

Figure H25: Influence of Grey River flow for the shortfin CPUE model for the years 2000–01 to 2022–23 (post-QMS) (ESA(AX)).

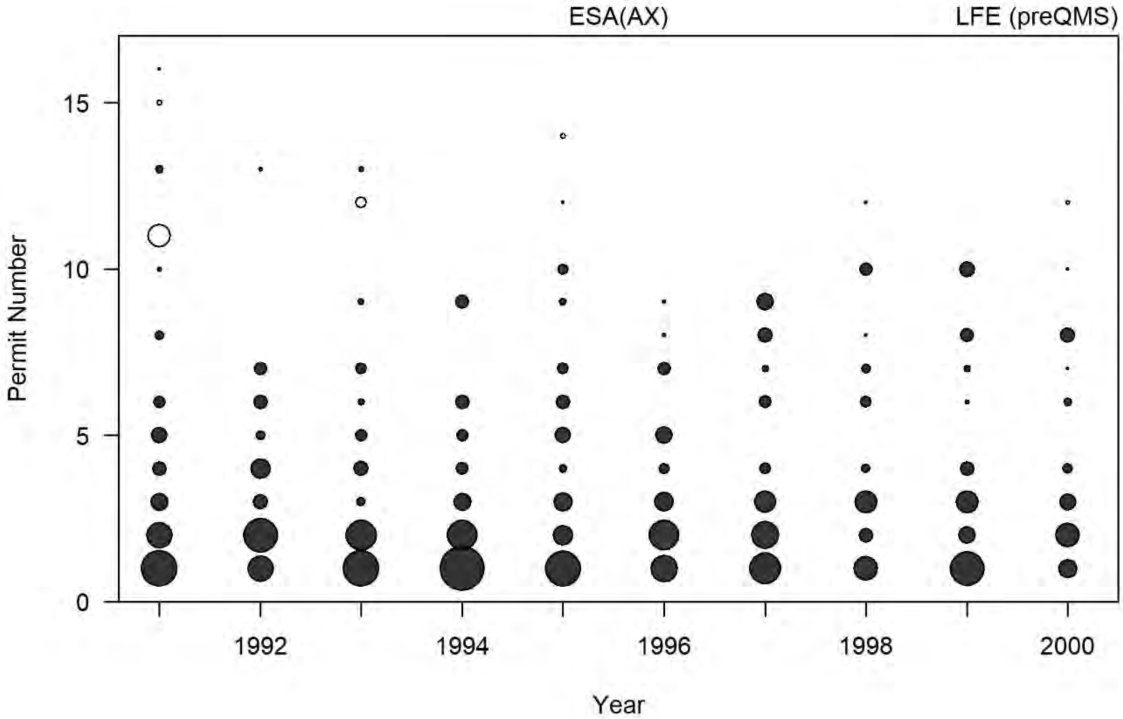

Figure H26: Relative longfin catch from all fishers (all circles) for the years 1990–91 to 1999–2000 (pre-QMS), and for core fishers (dark shaded circles) included in the catch per unit effort analyses (ESA(AX)).

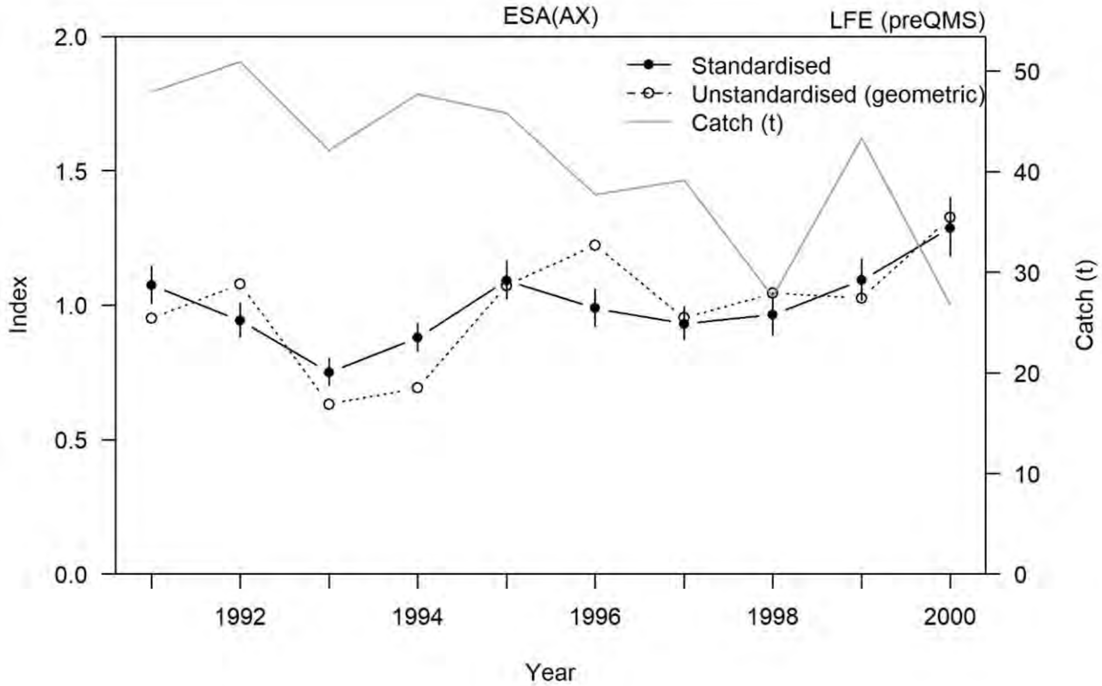

Figure H27: Indices of unstandardised (geometric mean of catch per lift) and standardised CPUE for longfin (core fishers) pre-QMS for the years 1990–91 to 1999–2000. The catch by core fishers is also plotted (ESA(AX)).

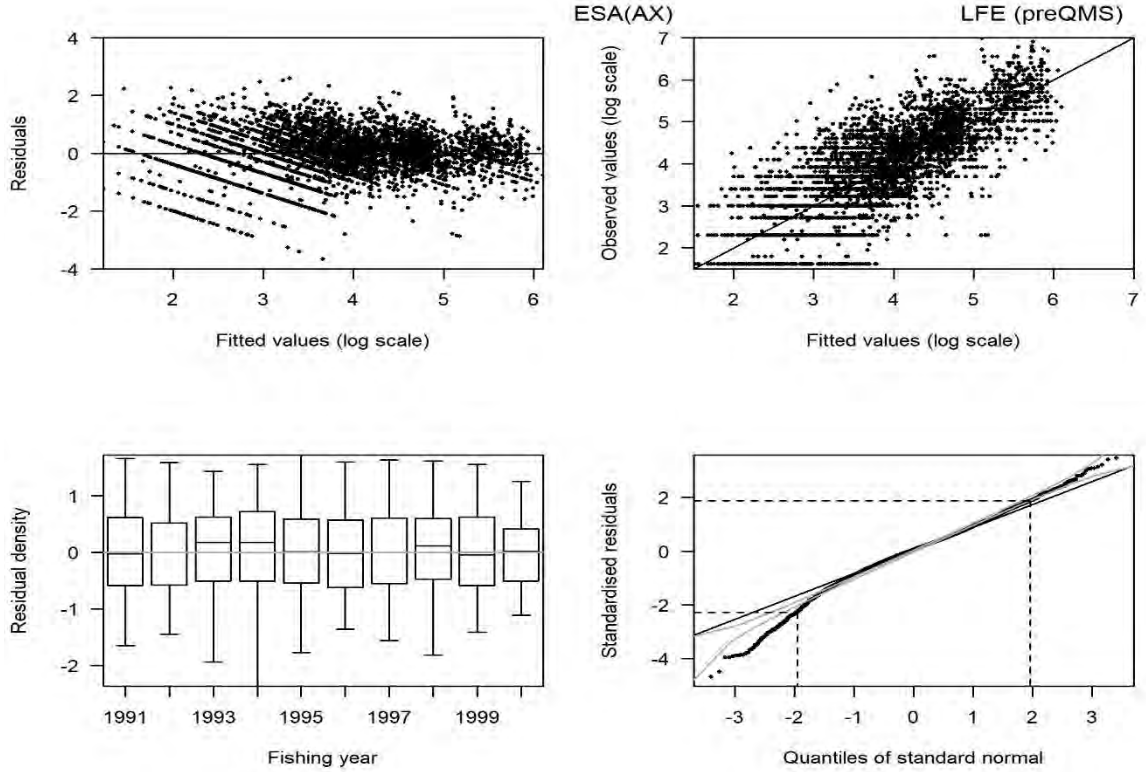

Figure H28: Residual diagnostic plots for the longfin eel CPUE model for the years 1990–91 to 1999–2000 (pre-QMS). The grey lines on the quantile-quantile plot represent the 95% confidence envelopes of a standard normal distribution (ESA(AX)).

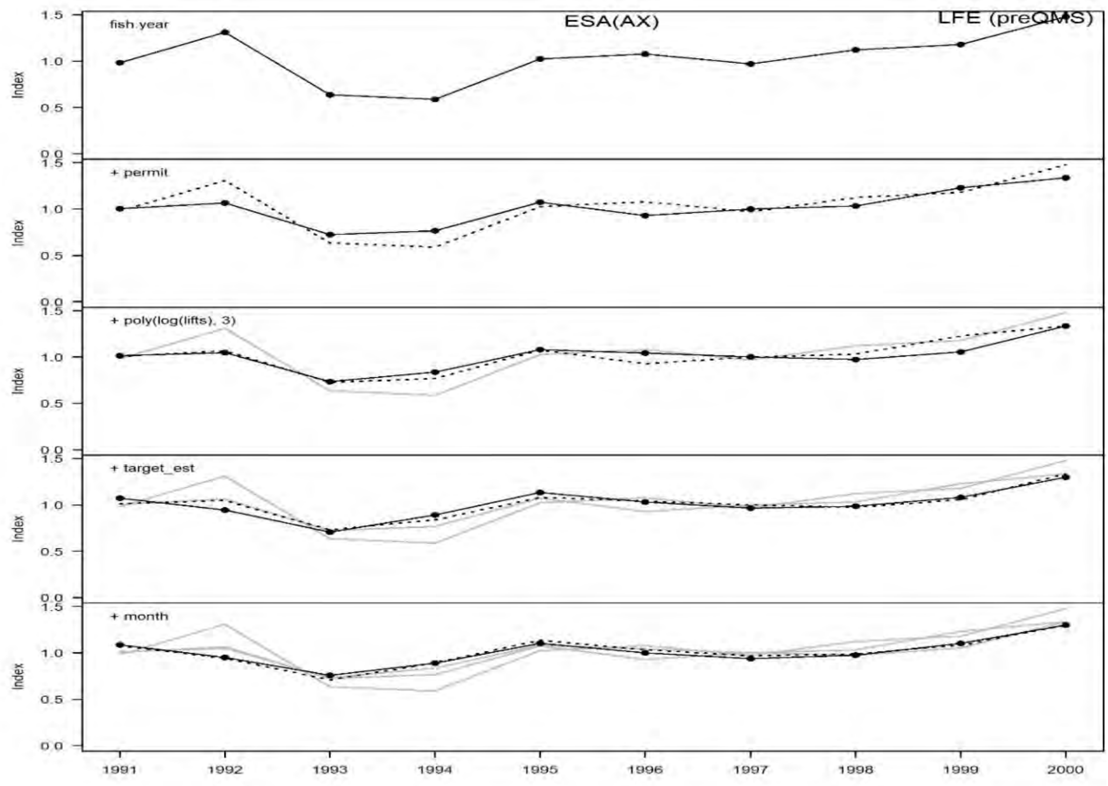

Figure H29: Step plot for the longfin eel CPUE model for the years 1990–91 to 1999–2000 (pre-QMS). Each panel shows the standardised CPUE index as each explanatory variable is added to the model with the previous index shown by the dotted line and the grey lines for steps before that (ESA(AX)).

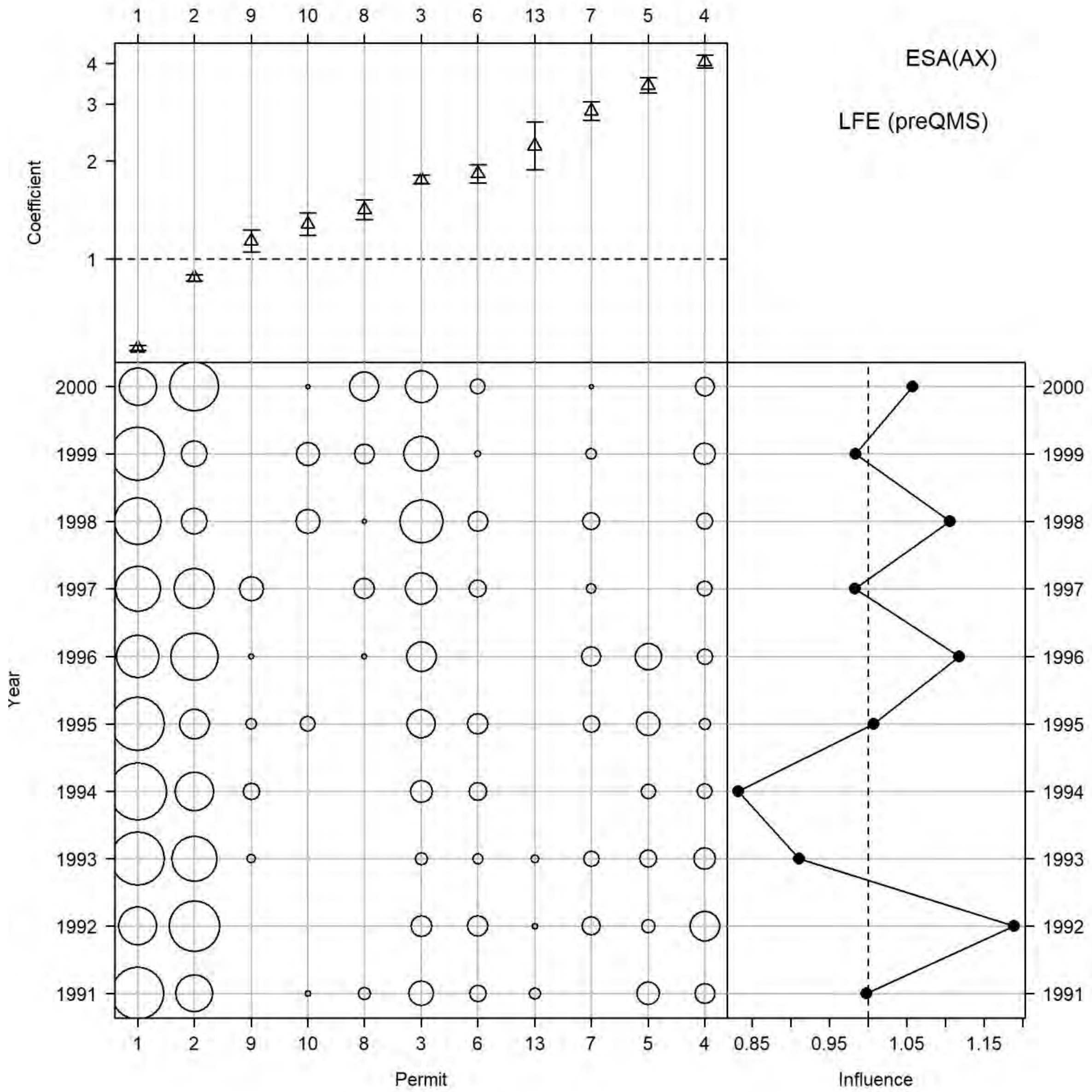

Figure H30: Influence of permit for the longfin CPUE model for the years 1990–91 to 1999–2000 (pre-QMS) (ESA(AX)).

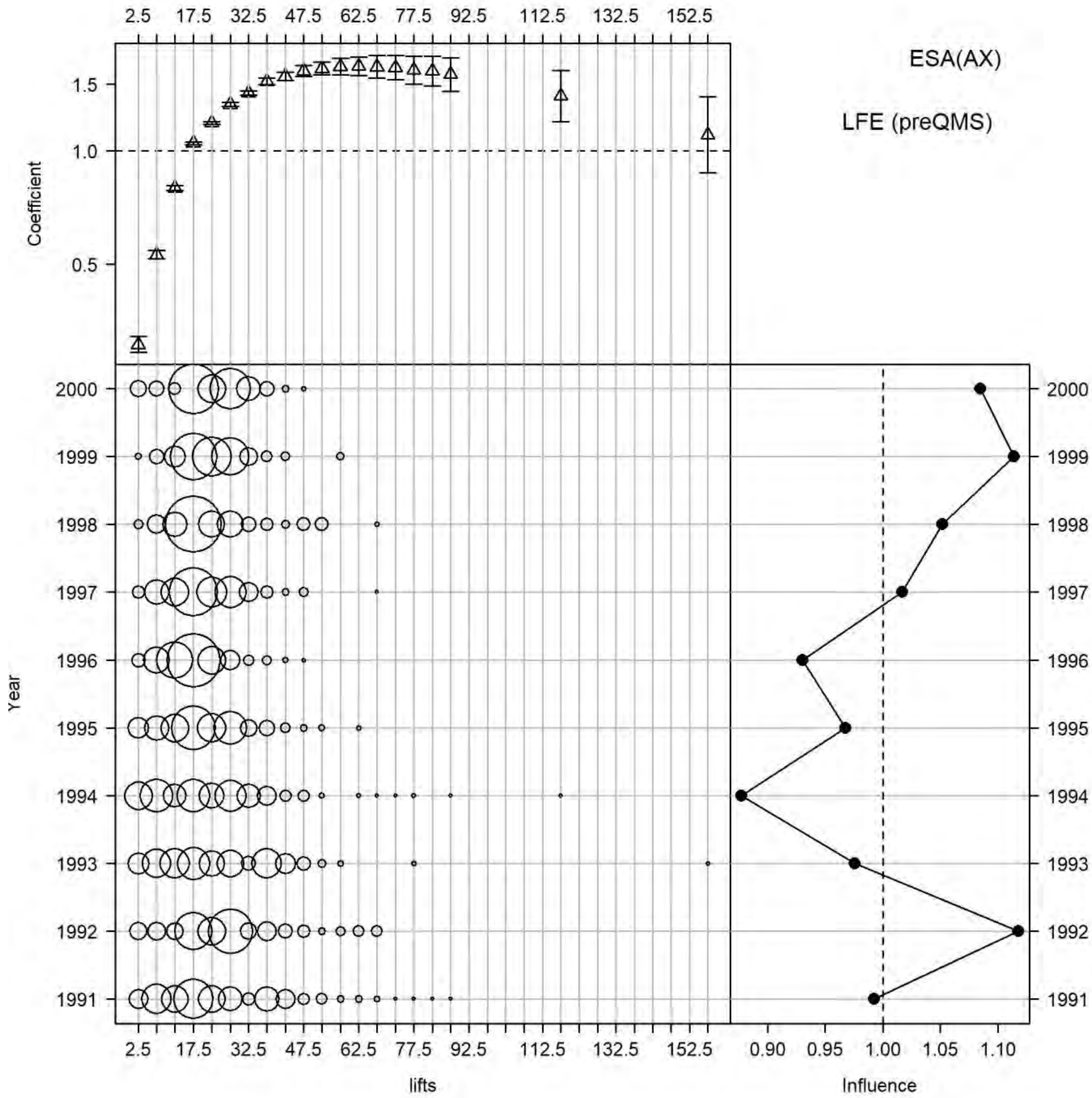

Figure H31: Influence of lifts for the longfin CPUE model for the years 1990–91 to 1999–2000 (pre-QMS) (ESA(AX)).

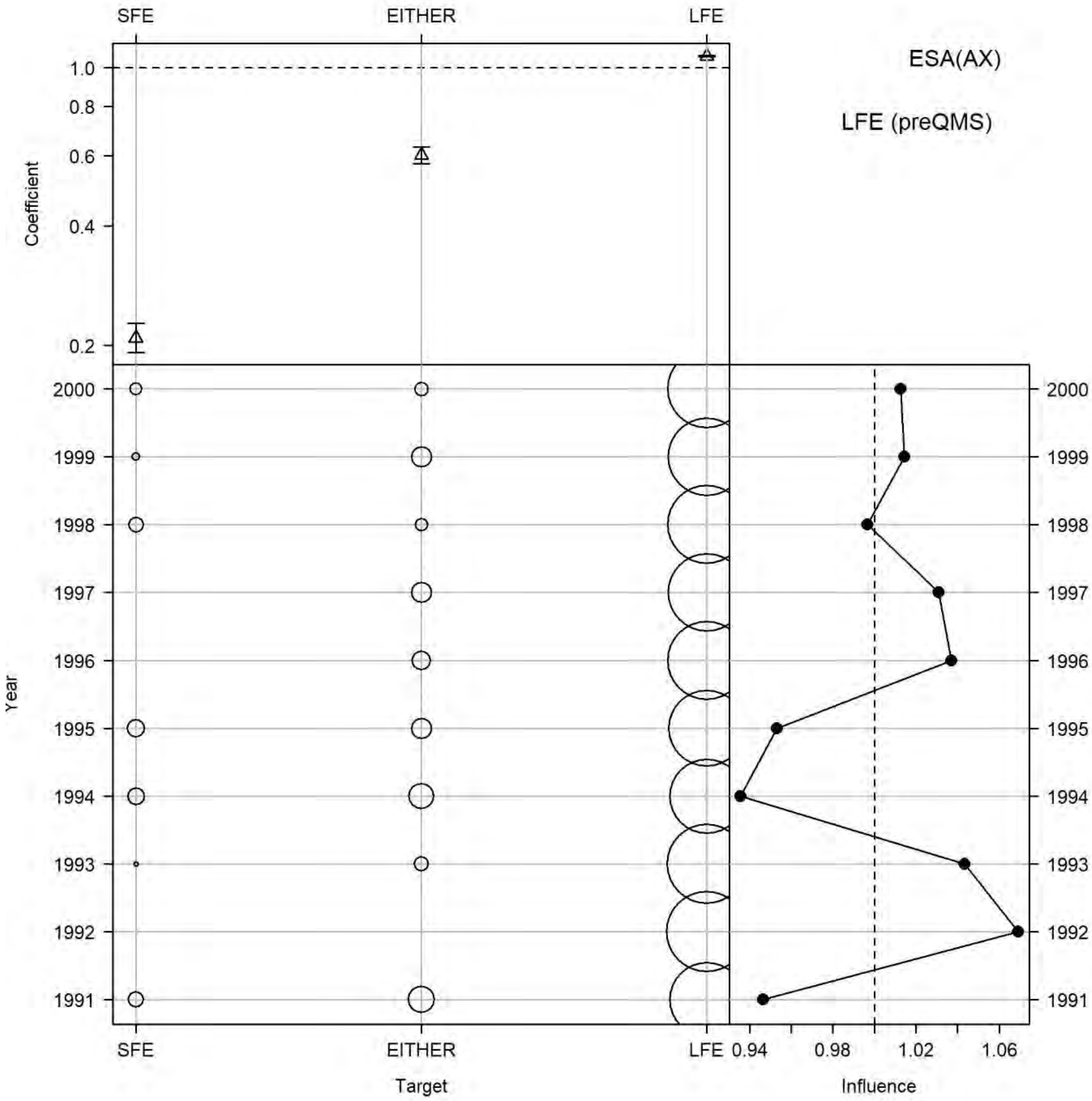

Figure H32: Influence of target for the longfin CPUE model for the years 1990–91 to 1999–2000 (pre-QMS) (ESA(AX)).

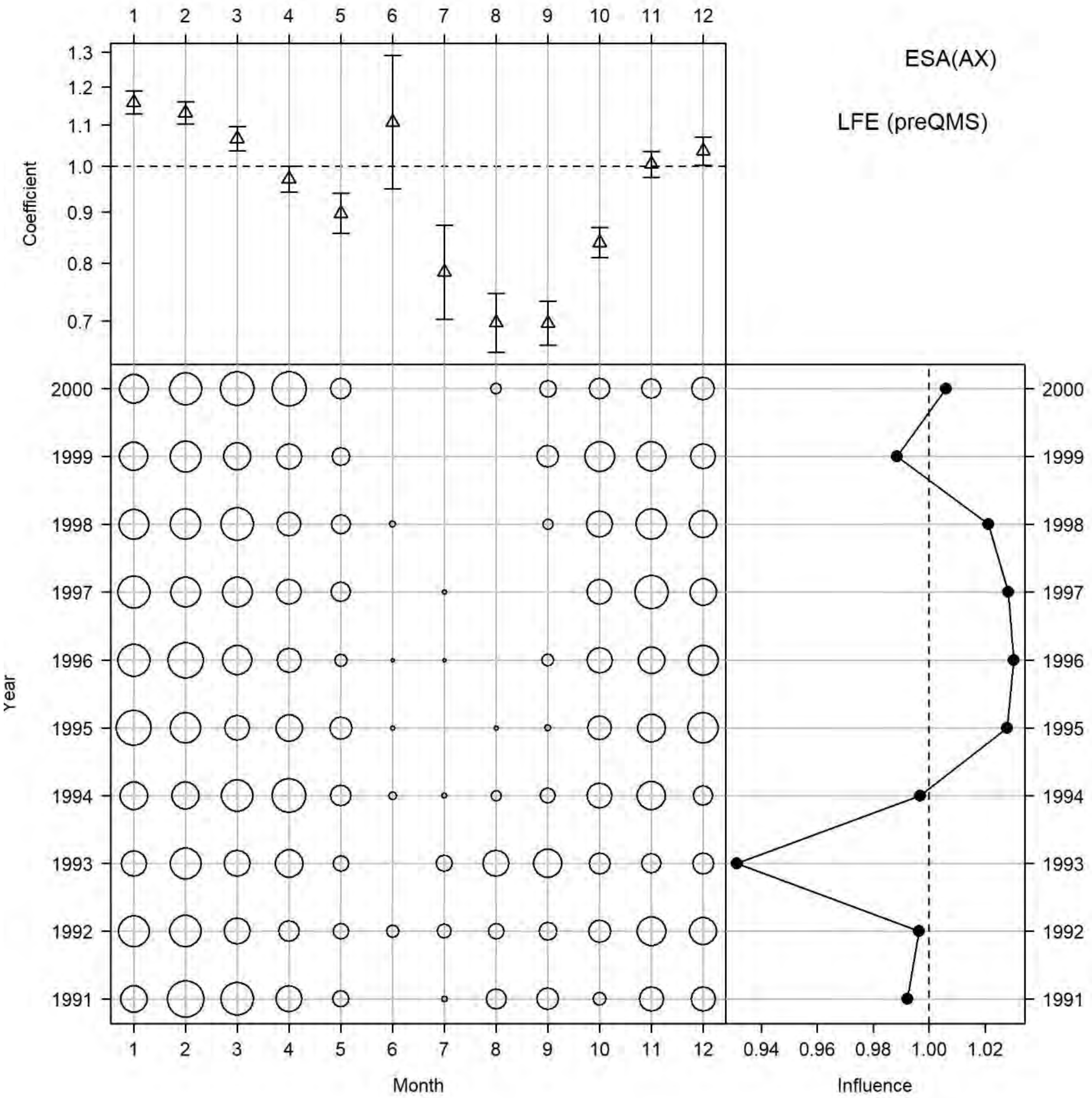

Figure H33: Influence of month for the longfin CPUE model for the years 1990–91 to 1999–2000 (pre-QMS) (ESA(AX)).

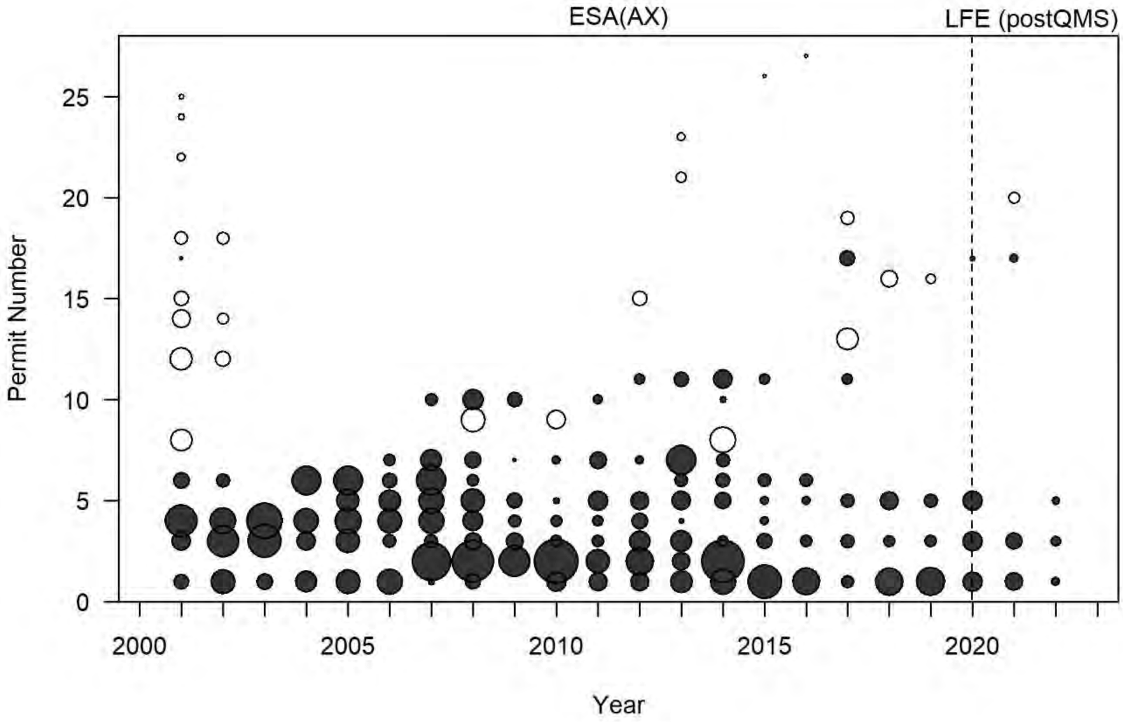

Figure H34: Relative longfin catch from all fishers (all circles) for the years 2000–01 to 2022–23 (post-QMS), and for core fishers (dark shaded circles) included in the catch per unit effort analyses. Vertical dashed line represents introduction of electronic reporting in 2019–20 (ESA(AX)).

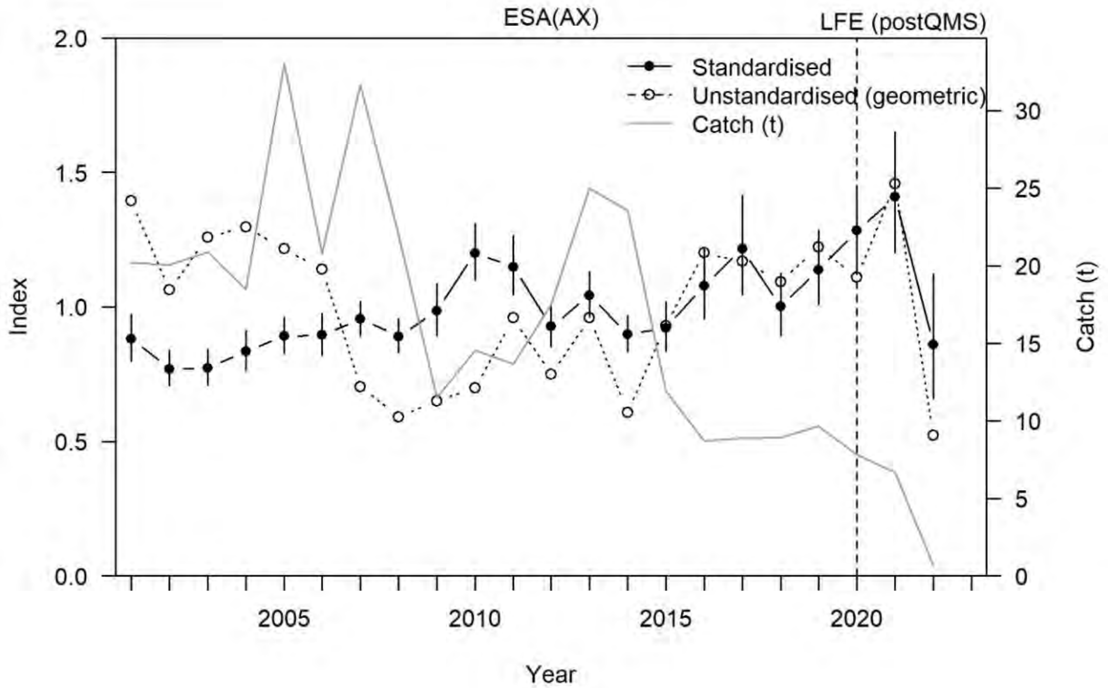

Figure H35: Indices of unstandardised (geometric mean of catch per lift) and standardised CPUE for longfin (core fishers) post-QMS for the years 2000–01 to 2022–23. The catch by core fishers is also plotted. Vertical dashed line represents introduction of electronic reporting in 2019–20 (ESA(AX)).

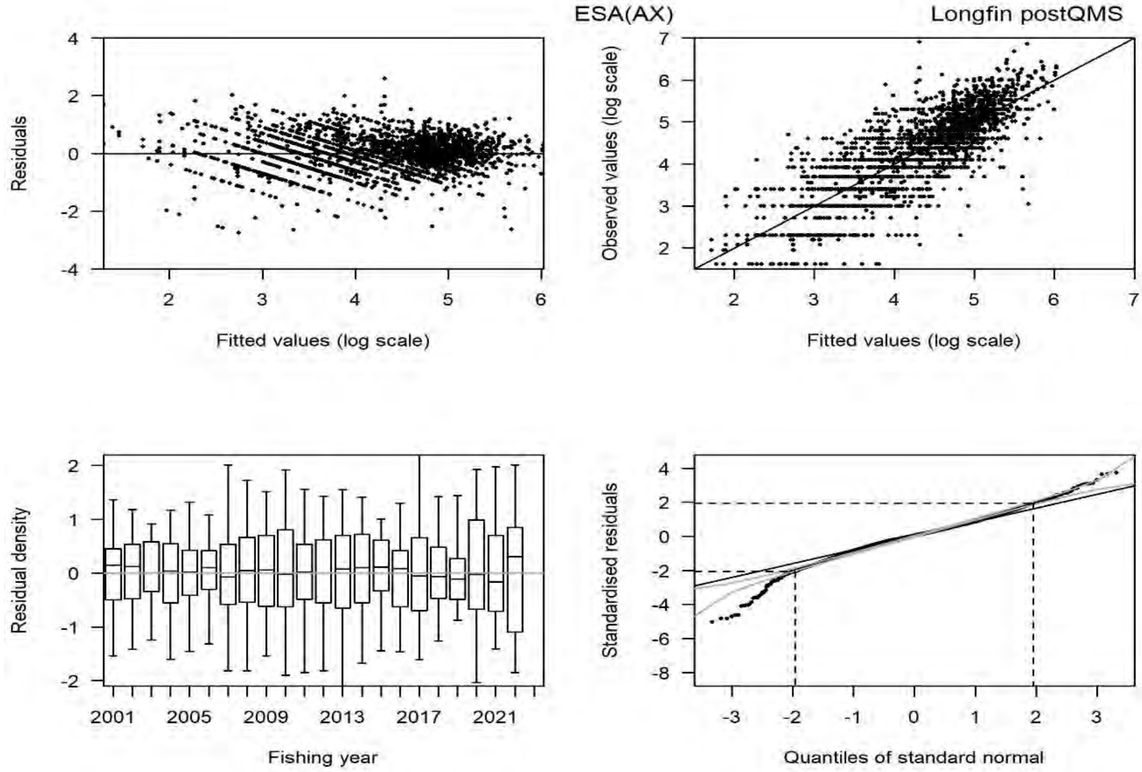

Figure H36: Residual diagnostic plots for the longfin eel CPUE model for the years 2000–01 to 2022–23 (post-QMS). The grey lines on the quantile-quantile plot represents the 95% confidence envelopes of a standard normal distribution (ESA(AX)).

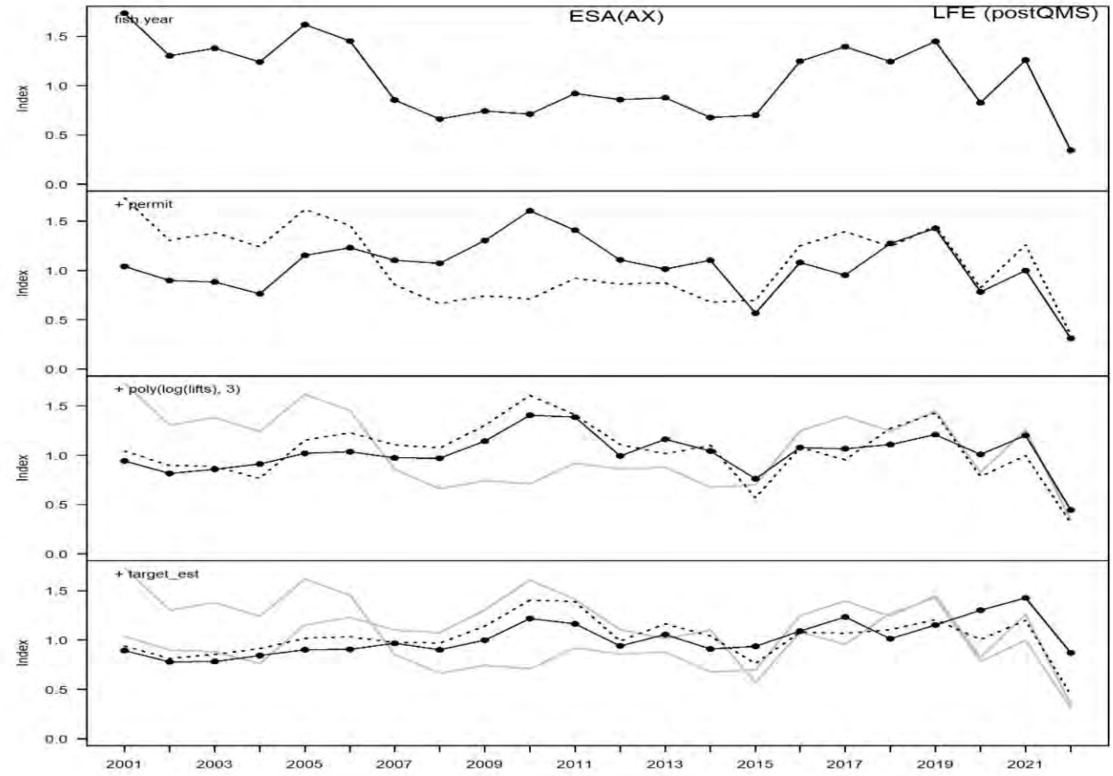

Figure H37: Step plot for the longfin eel CPUE model for the years 2000–01 to 2022–23 (post-QMS). Each panel shows the standardised CPUE index as each explanatory variable is added to the model with the previous index shown by the dotted line and the grey lines for steps before that (ESA(AX)).

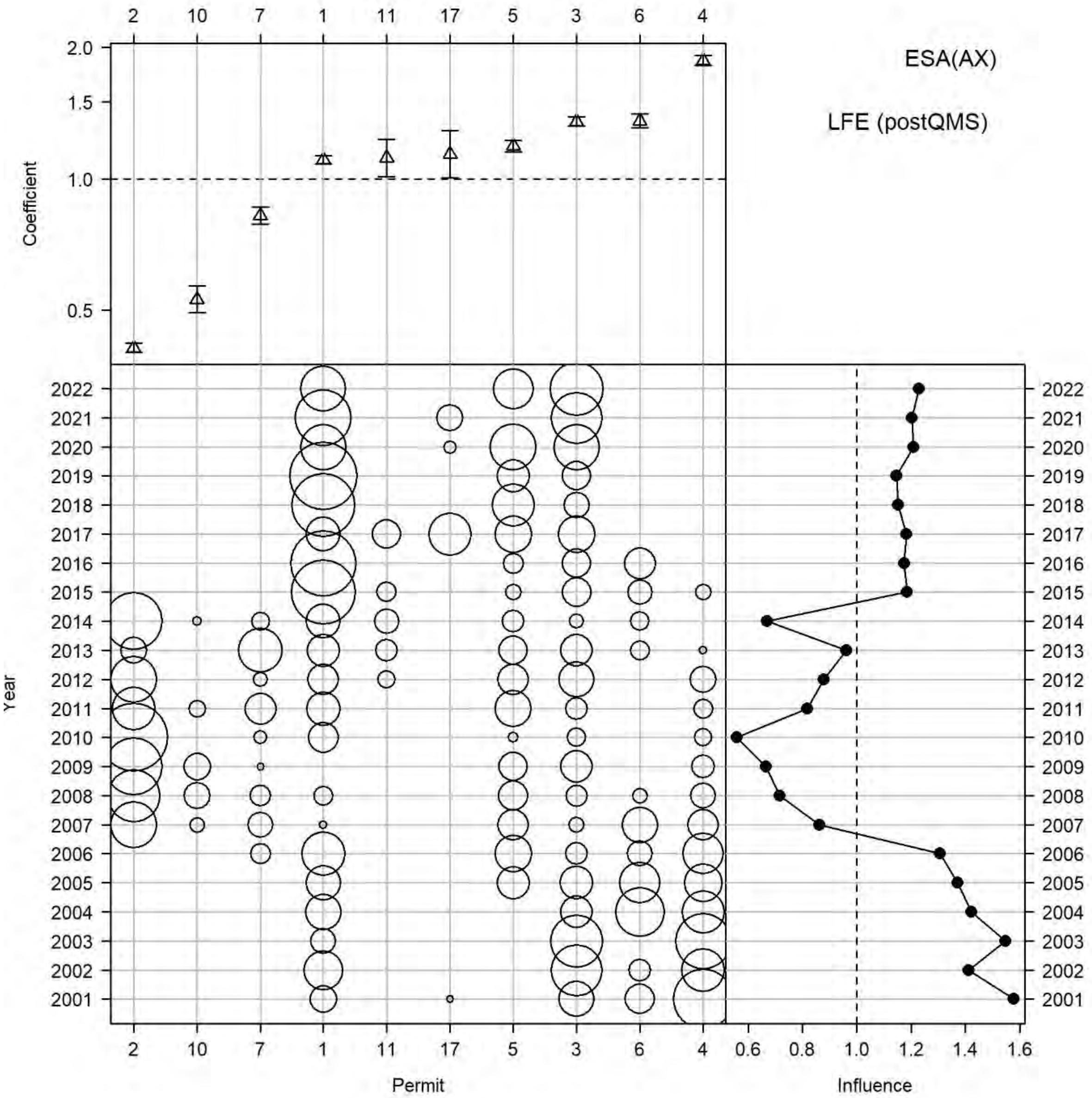

Figure H38: Influence of catcher for the longfin CPUE model for the years 2000–01 to 2022–23 (post-QMS) (ESA(AX)).

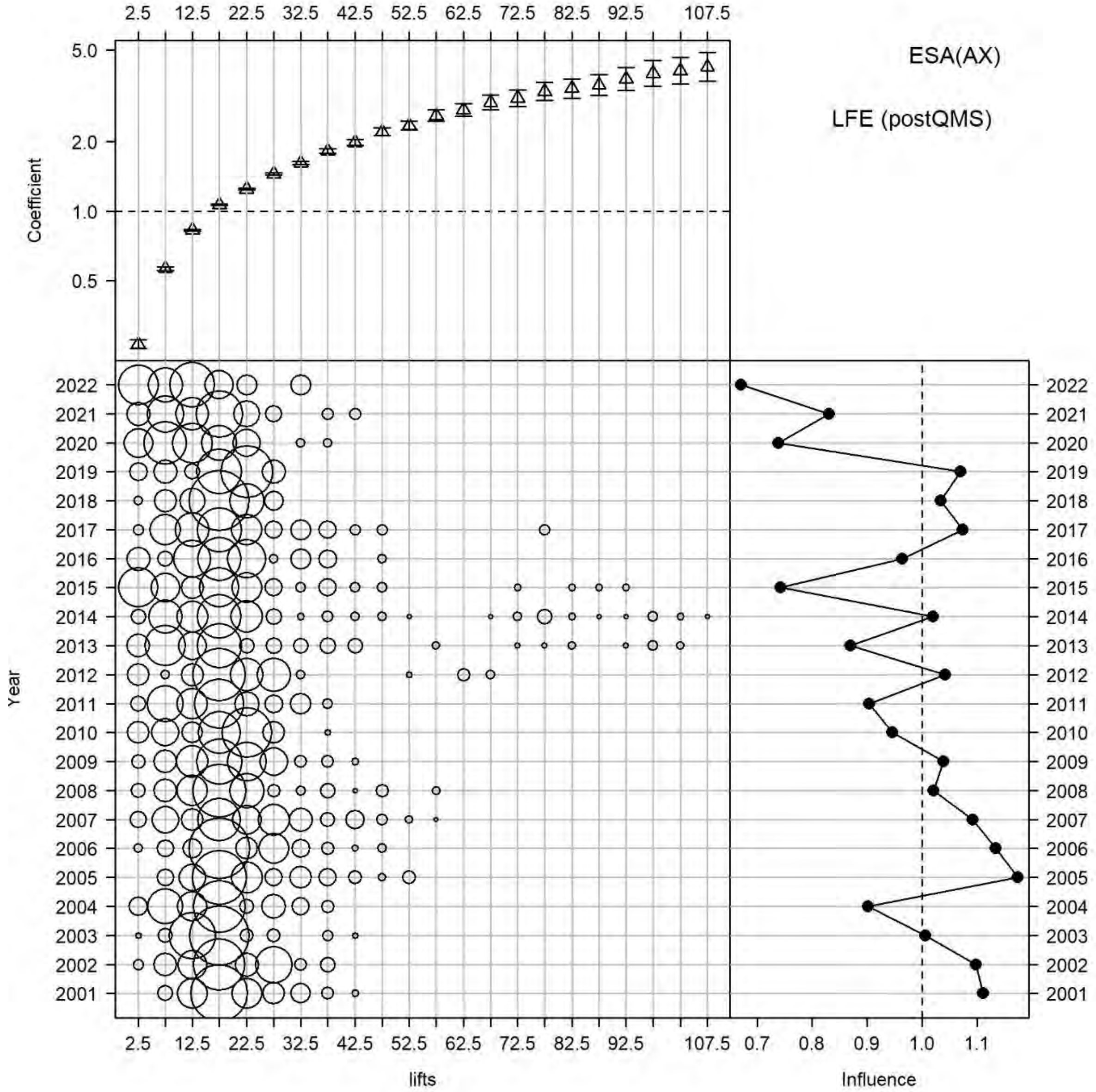

Figure H39: Influence of lifts for the longfin CPUE model for the years 2000–01 to 2022–23 (post-QMS) (ESA(AX)).

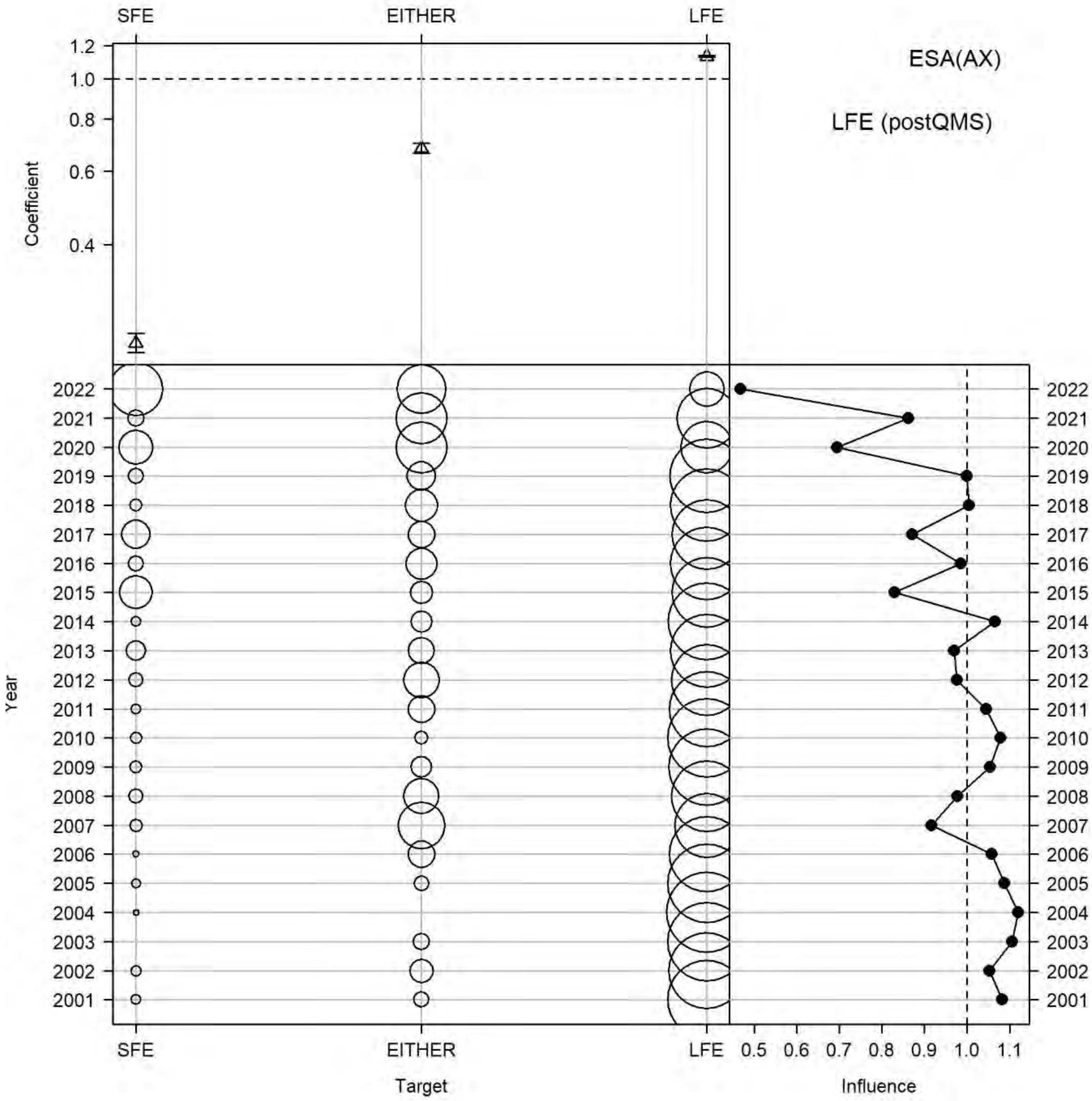

Figure H40: Influence of target for the longfin CPUE model for the years 2000–01 to 2022–23 (post-QMS) (ESA(AX)).

ESA AS (Te Waihora)

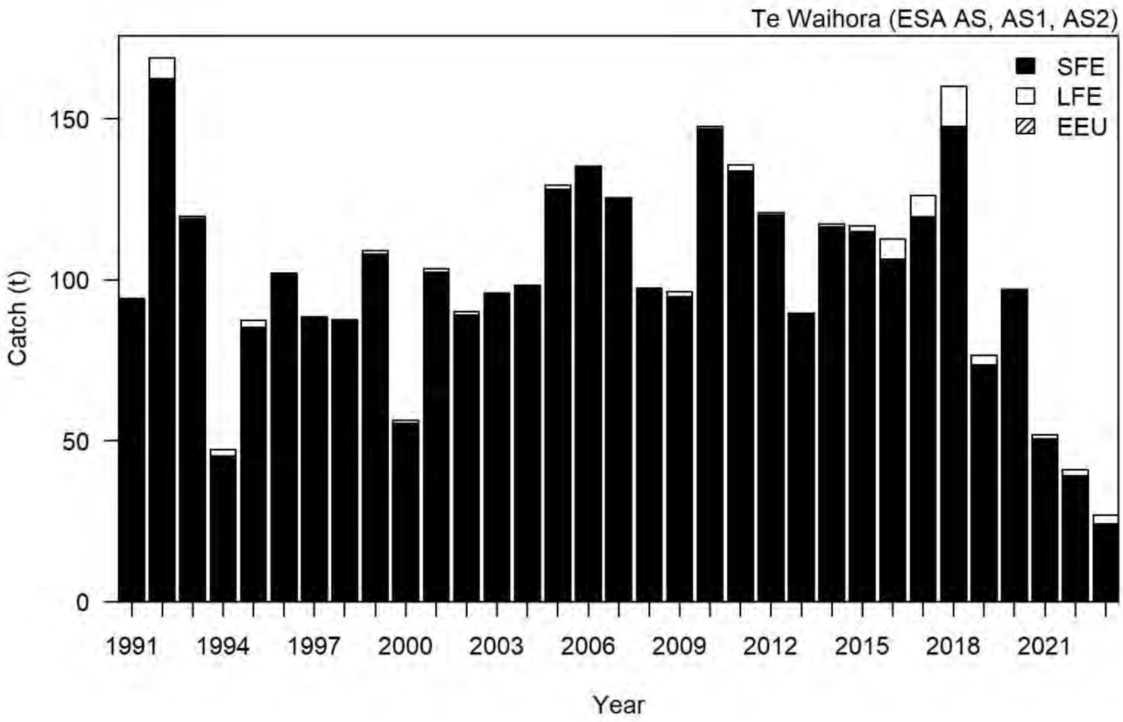

Figure I1: Total estimated commercial catch of shortfin (SFE), longfin (LFE), and unclassified eel catch (EEU) for the years 1990–91 to 2022–23 (Te Waihora (ESA AS, AS1, AS2)).

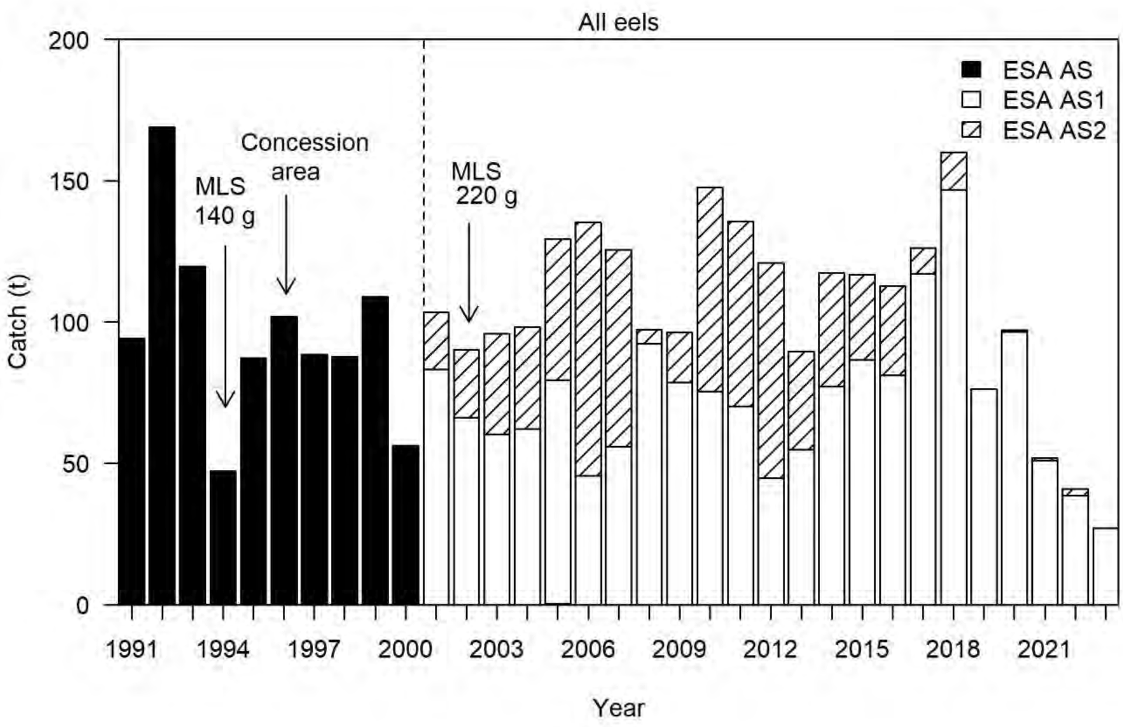

Figure I2: Total estimated commercial catch of all eels (shortfin and longfin combined) by eel statistical area for the years 1990–91 to 2022–23. Minimum legal size (MLS) of 140 g introduced in 1996 increasing by 10 g per year until it reached 220 g in 2002. The concession area was introduced in 1996, but ESA AS codes were not valid until 2001 (Te Waihora (ESA AS, AS1, AS2)).

Figure I3: Shortfin eel catch by month for the years 1990–91 to 2022–23 (Te Waihora (ESA AS, AS1, AS2)).

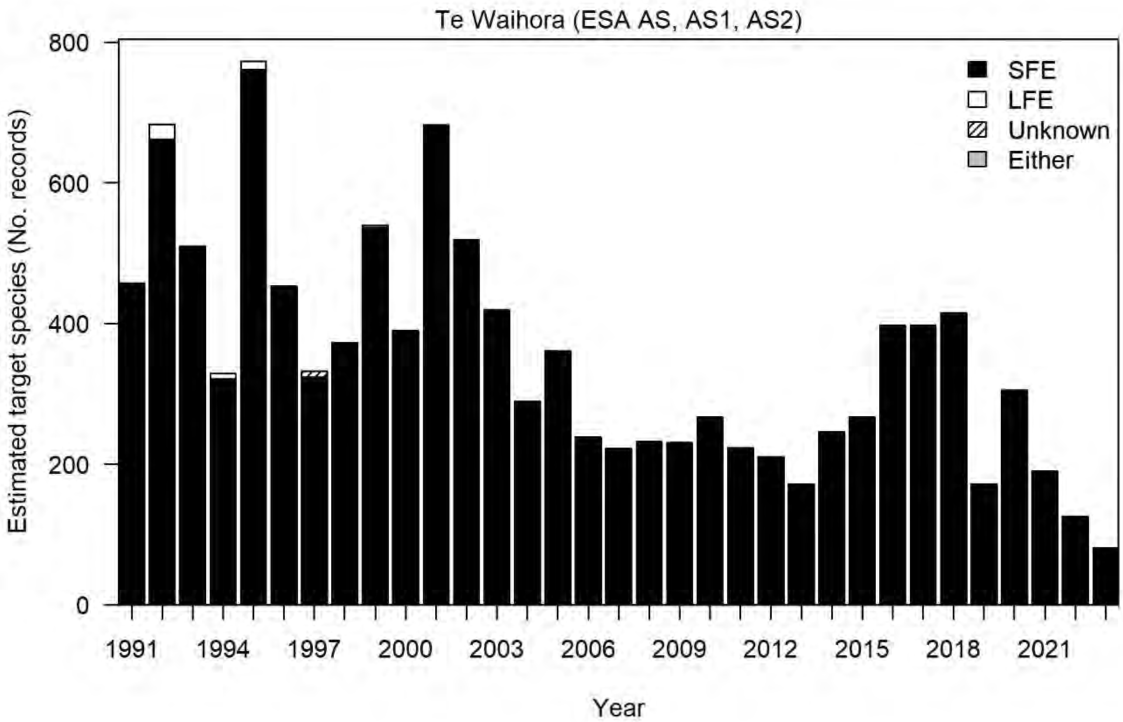

Figure I4: Reconstructed target species for the years 1990–91 to 2022–23 (Te Waihora (ESA AS, AS1, AS2)).

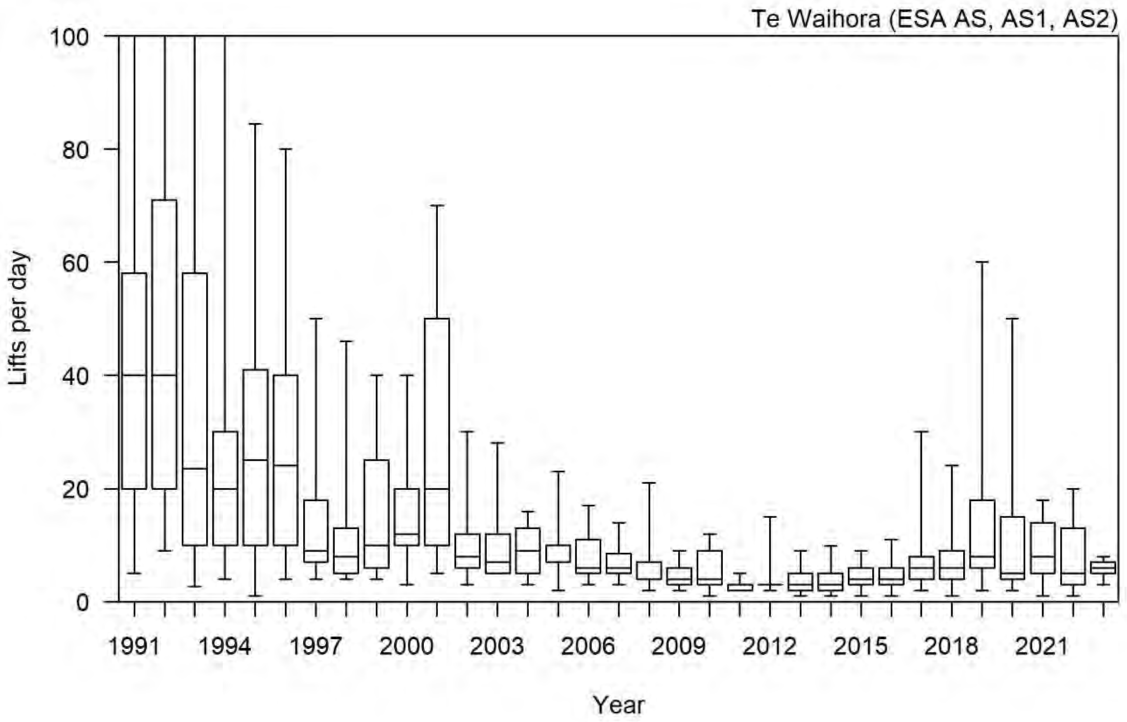

Figure I5: Total lifts per day for the years 1990–91 to 2022–23. The horizontal line is the median, the top and bottom of the box are the interquartiles (25th and 75th), and error bars are the 95th percentile range (Te Waihora (ESA AS, AS1, AS2)).

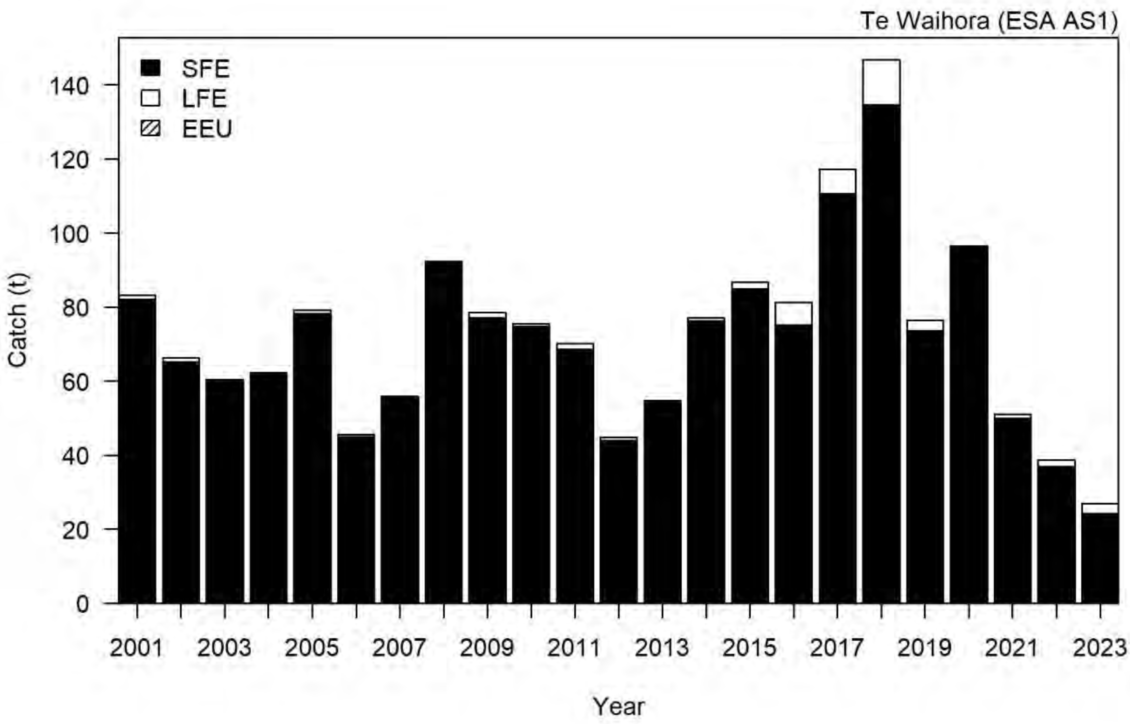

Figure I6: Total estimated commercial catch of shortfin (SFE)and longfin (LFE) from AS1 (lake) for the years 2000–01 to 2022–23 (Te Waihora (ESA AS1)).

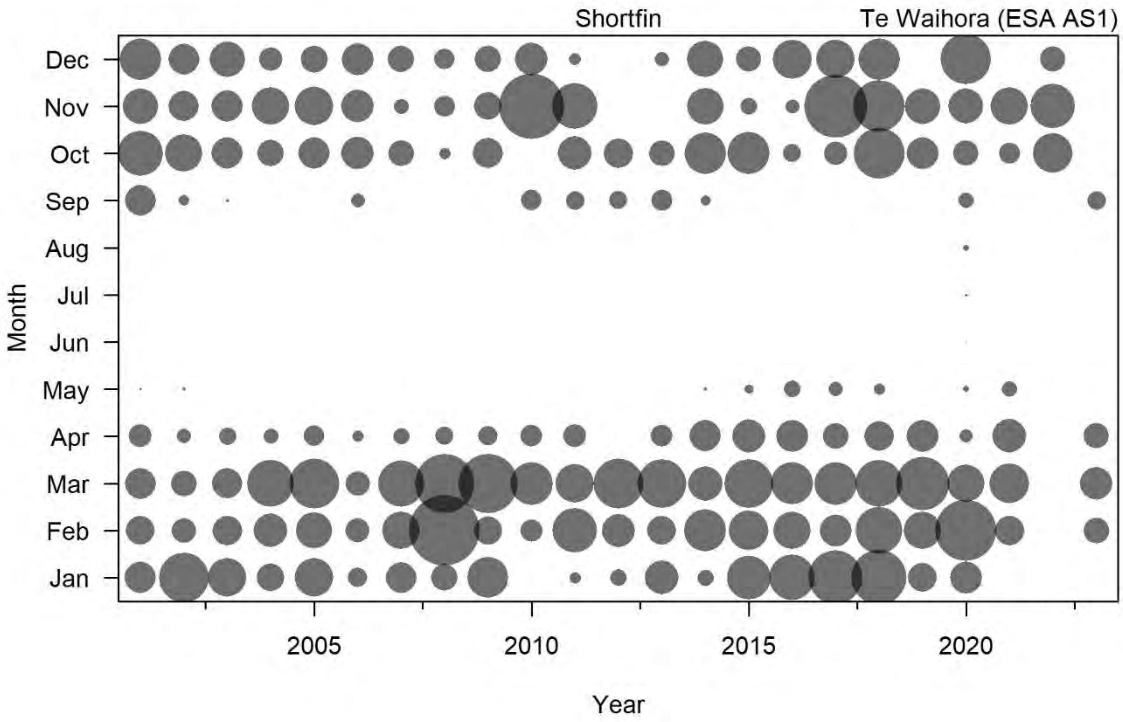

Figure I7: Shortfin eel catch by month for the years 2000–01 to 2022–23 (Te Waihora (ESA AS1)).

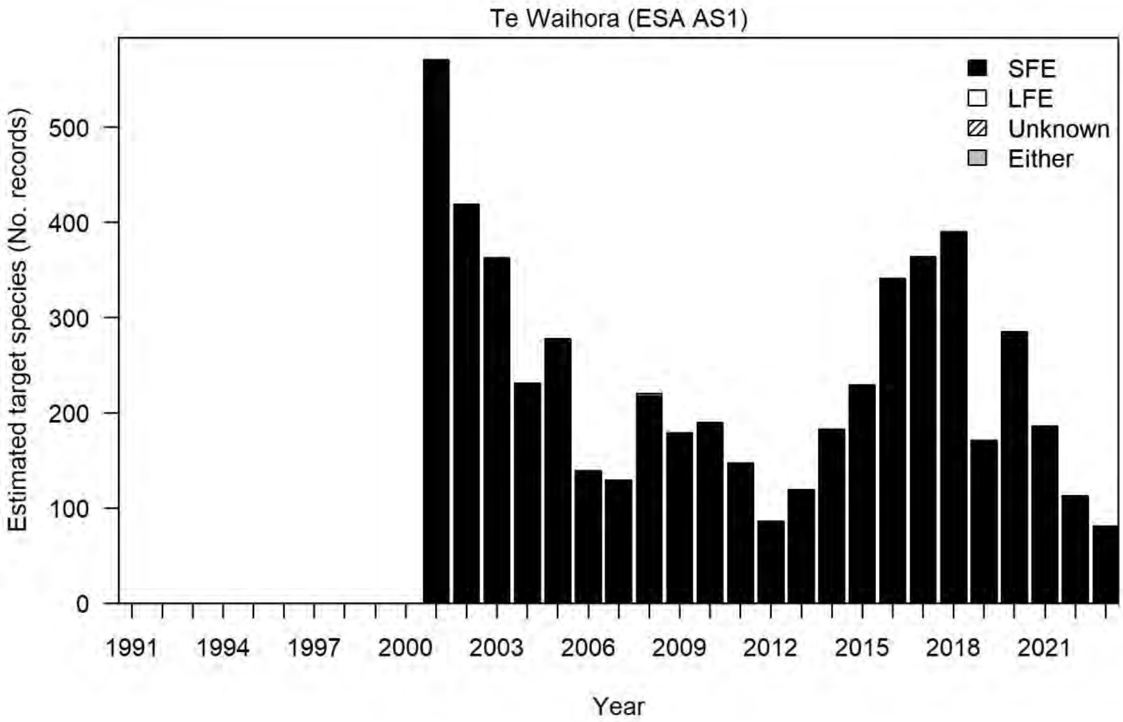

Figure I8: Reconstructed target species for the years 2000–01 to 2022–23 (Te Waihora (ESA AS1)).

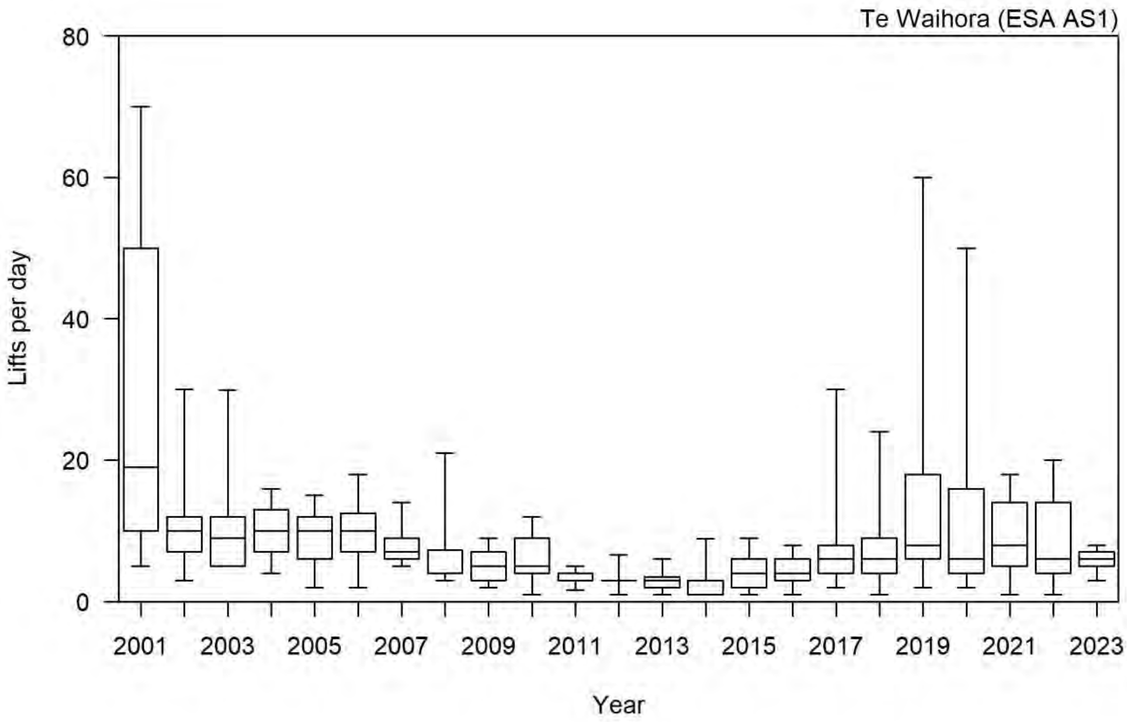

Figure I9: Total lifts per day for the years 2000–01 to 2022–23. The horizontal line is the median, the top and bottom of the box are the interquartiles (25th and 75th), and error bars are the 95th percentile range (Te Waihora (ESA AS1)).

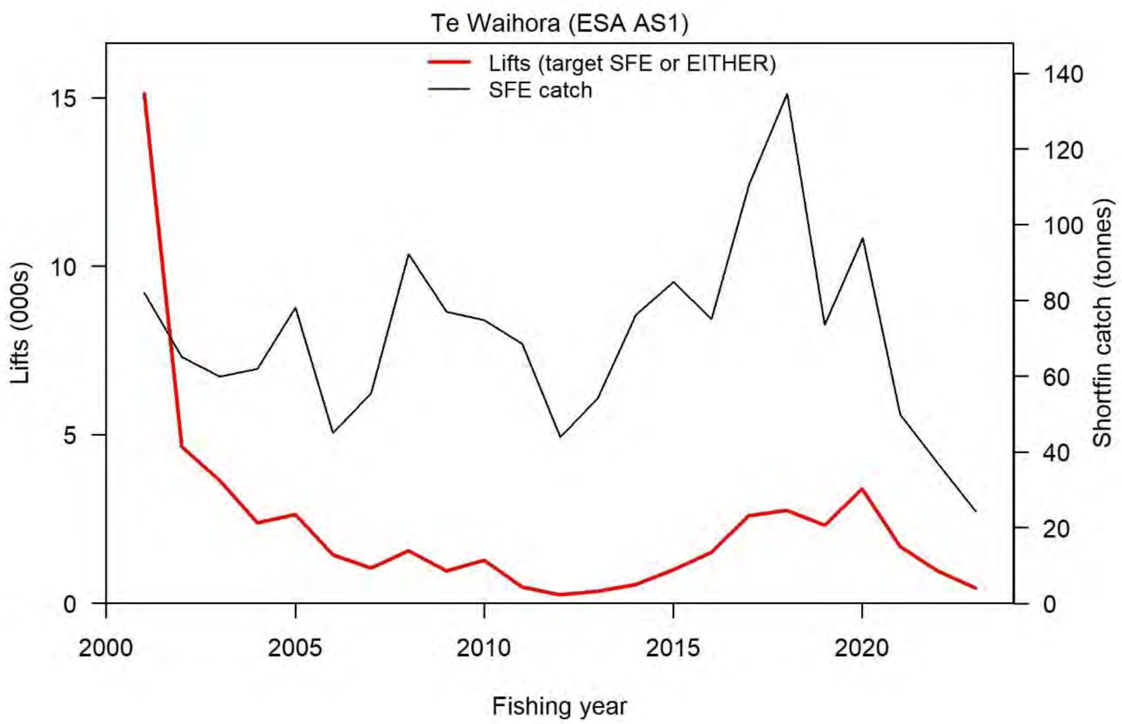

Figure I10: Total lifts and shortfin catch when target species was 'shortfin' or 'either' for the years 2000–01 to 2022–23 (Te Waihora (ESA AS1)).

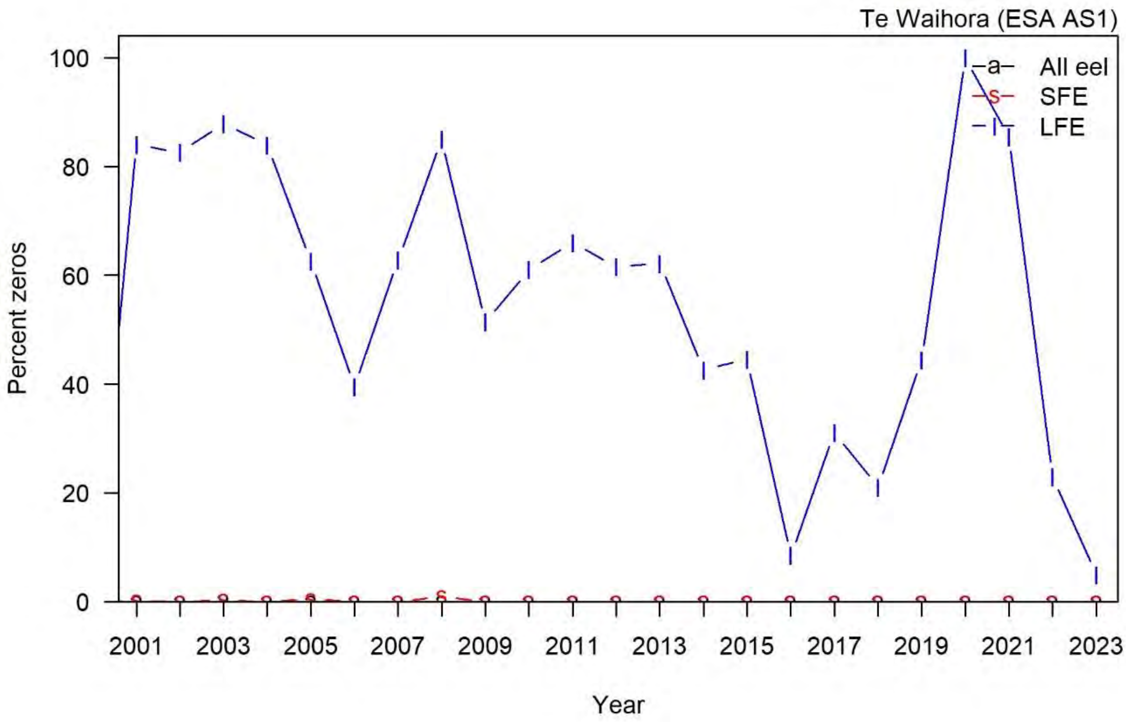

Figure I11: Proportion of zero records for all eel, shortfin (SFE), and longfin (LFE) catch for the years 2000–01 to 2022–23 (Te Waihora (ESA AS1)).

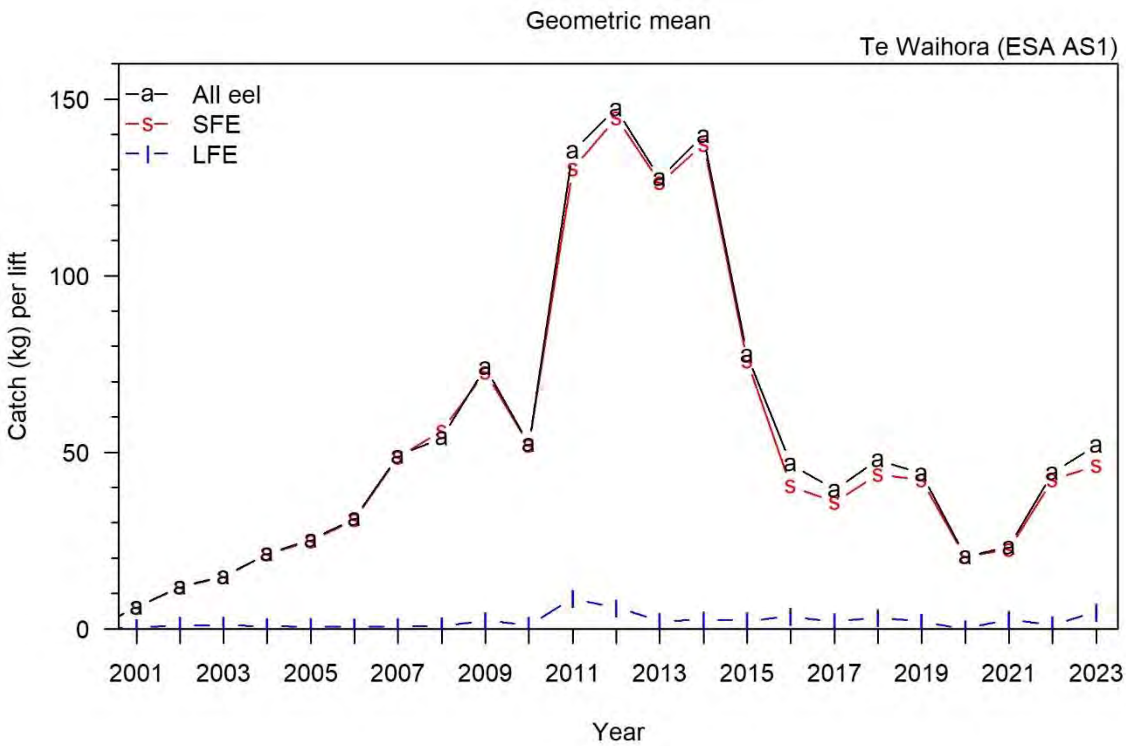

Figure I12: Unstandardised catch per lift (geometric mean of catch per lift) for shortfin eels for the years 2000–01 to 2022–23 (Te Waihora (ESA AS1)).

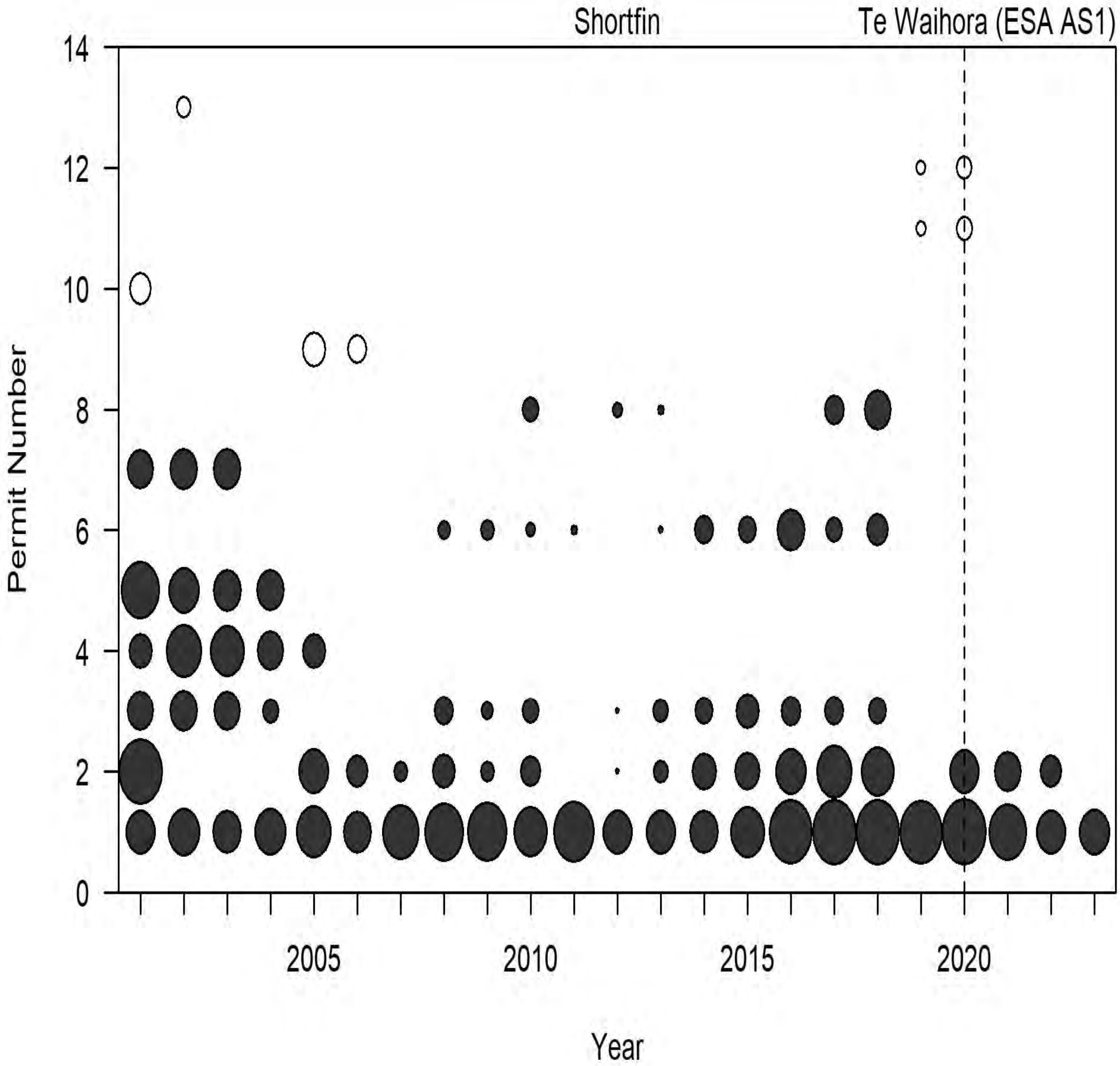

Figure I13: Relative catch of shortfin from all fishers (all circles) from AS1 (lake) for the years 2000–01 to 2022–23, and for core fishers (dark shaded circles) included in the catch per unit effort analyses (Te Waihora (ESA AS1)).

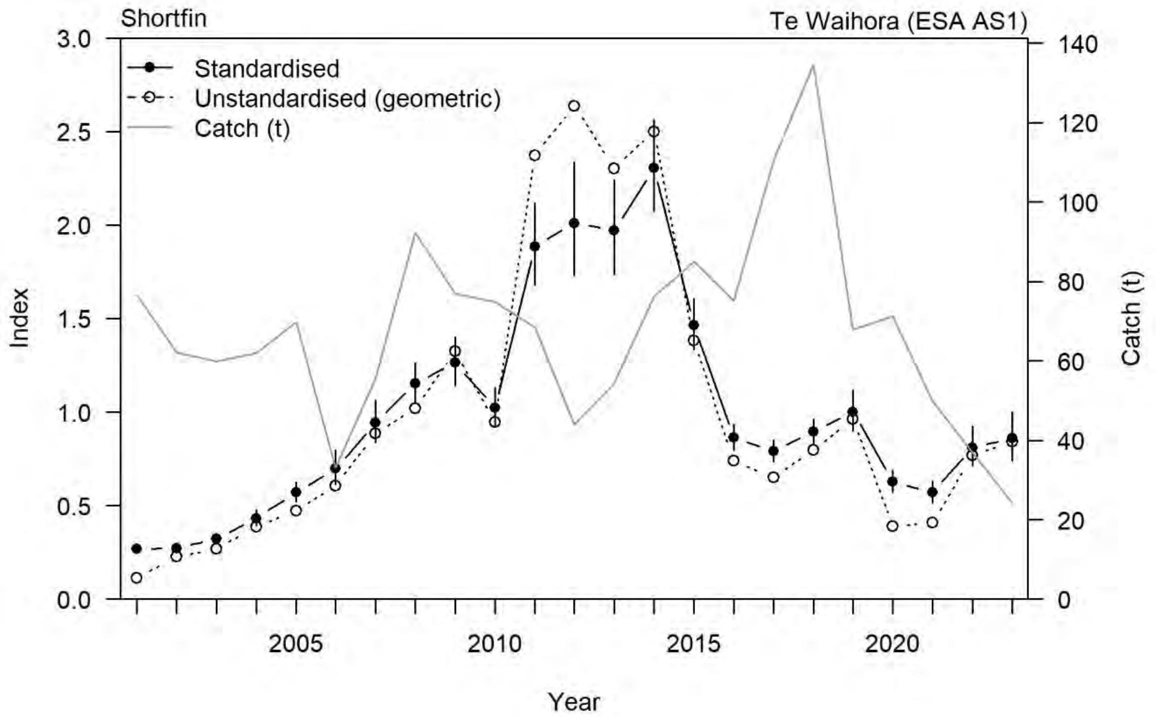

Figure I14: Indices of unstandardised catch per lift and standardised CPUE from AS1 (lake) for the core fishers shortfin CPUE model for the years 2000–01 to 2022–23. The catch by core fishers is also plotted (Te Waihora (ESA AS1)).

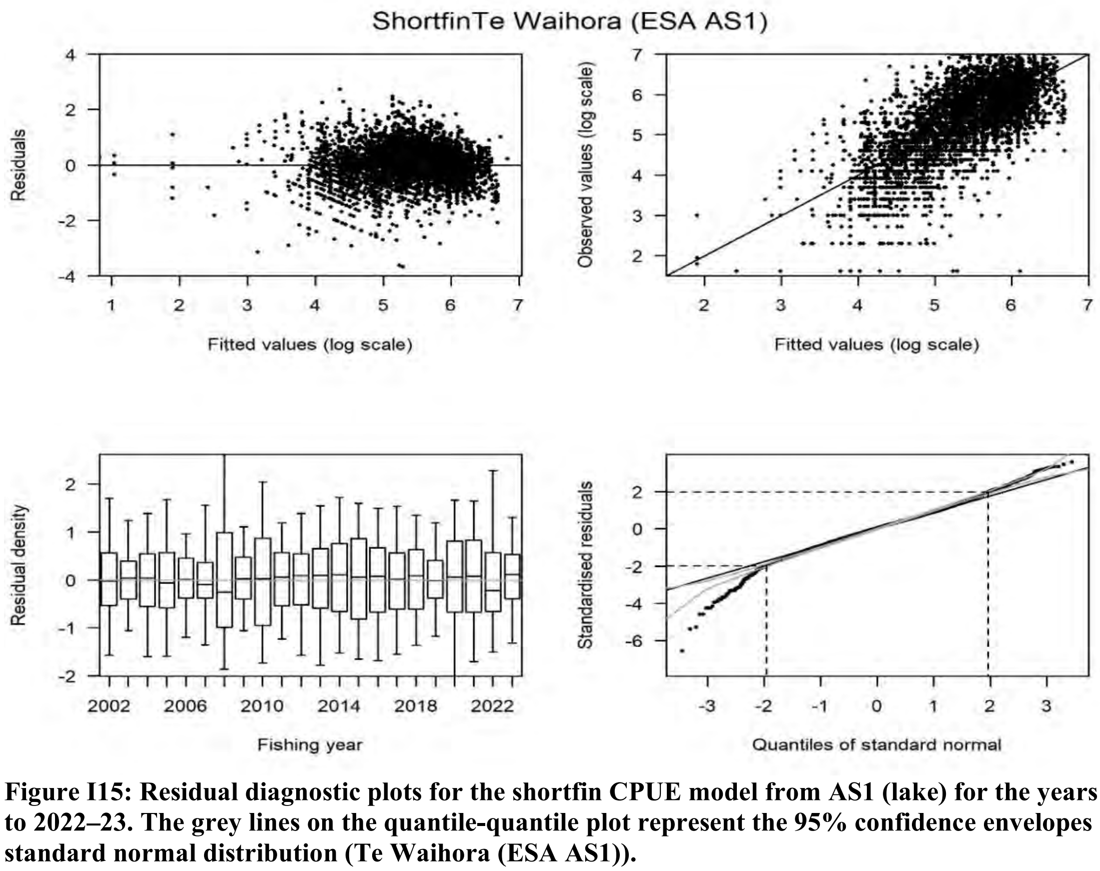

Figure I15: Residual diagnostic plots for the shortfin CPUE model from AS1 (lake) for the years 2000–01 to 2022–23. The grey lines on the quantile-quantile plot represent the 95% confidence envelopes of a standard normal distribution (Te Waihora (ESA AS1)).

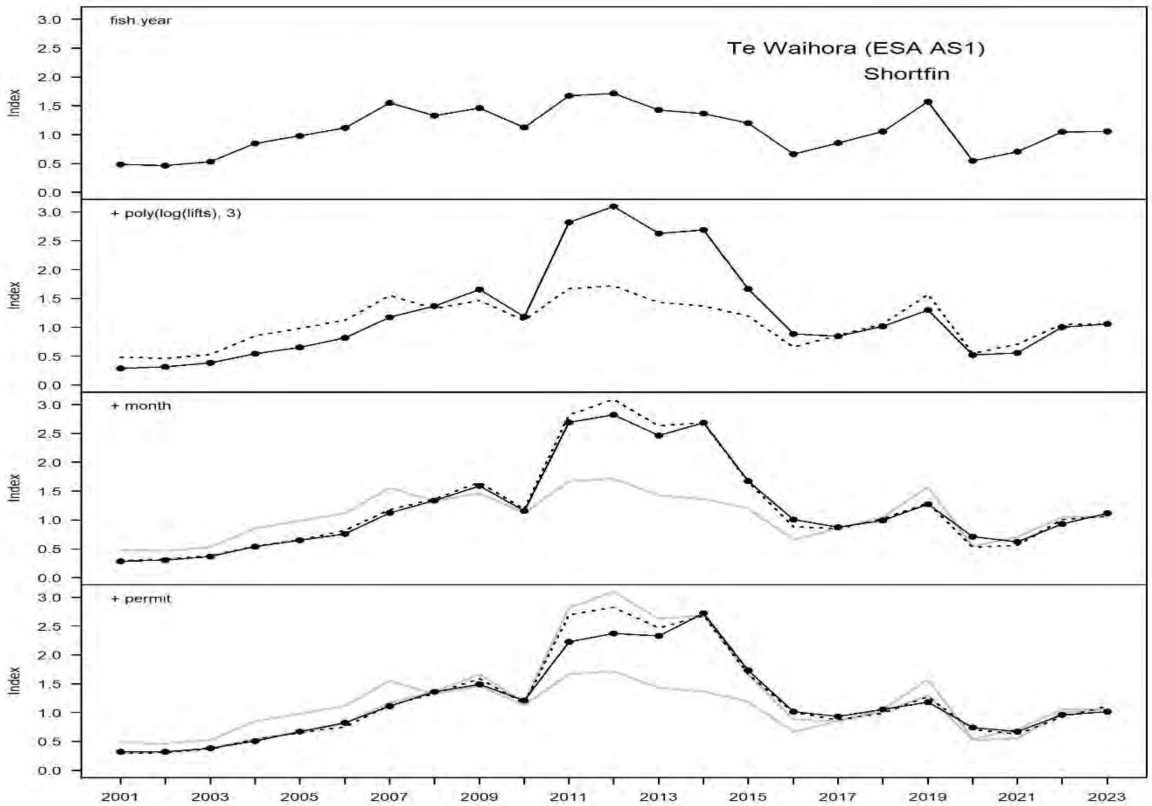

Figure I16: Step plot for the shortfin eel CPUE model from AS1 (lake) for the years 2000–01 to 2022–23. Each panel shows the standardised CPUE index as each explanatory variable is added to the model with the previous index shown by the dotted line and the grey lines for steps before that (Te Waihora (ESA AS1)).

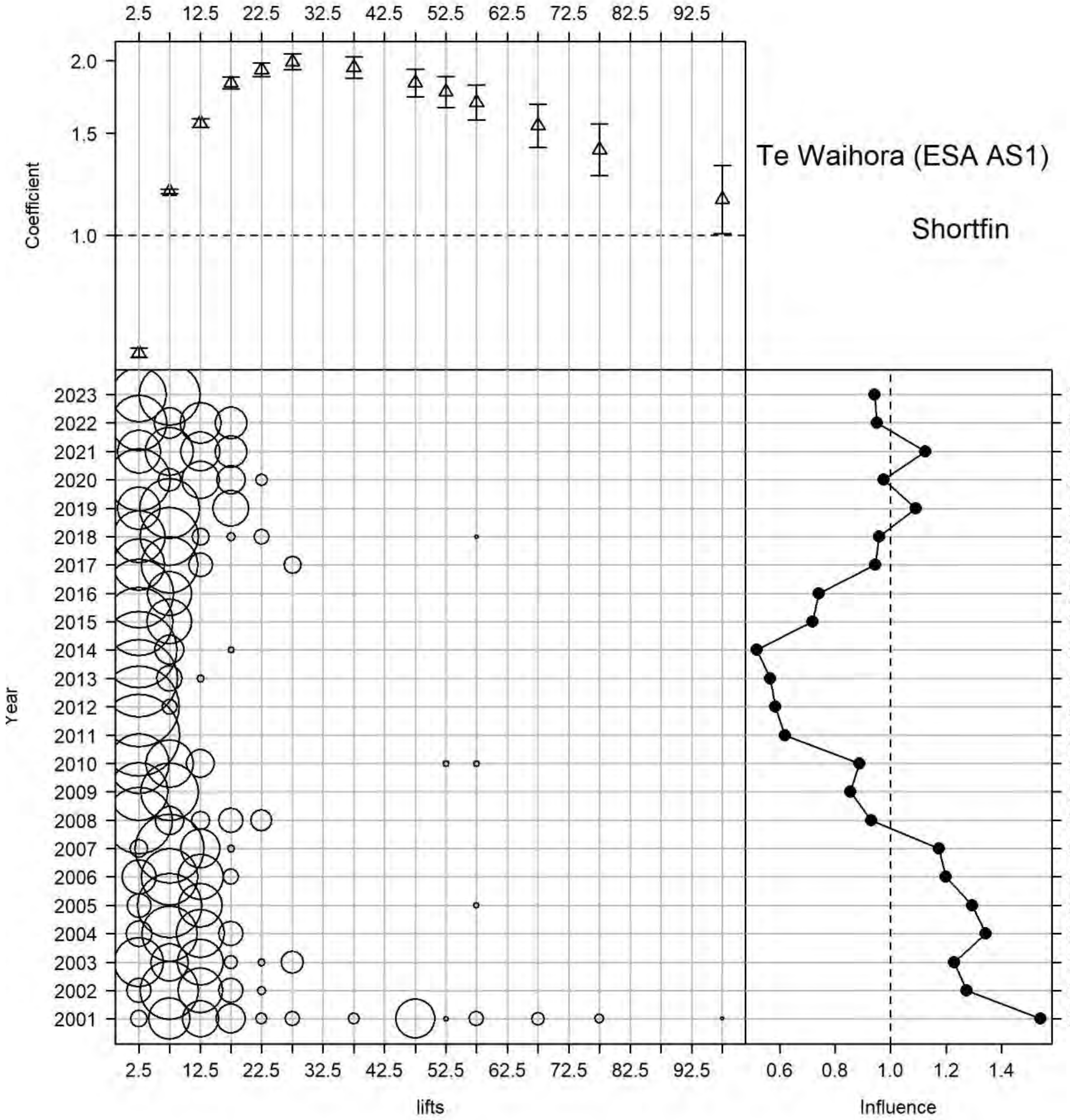

Figure I17: Influence of lifts for the shortfin CPUE model from AS1 (lake) for the years 2000–01 to 2022–23 (Te Waihora (ESA AS1)).

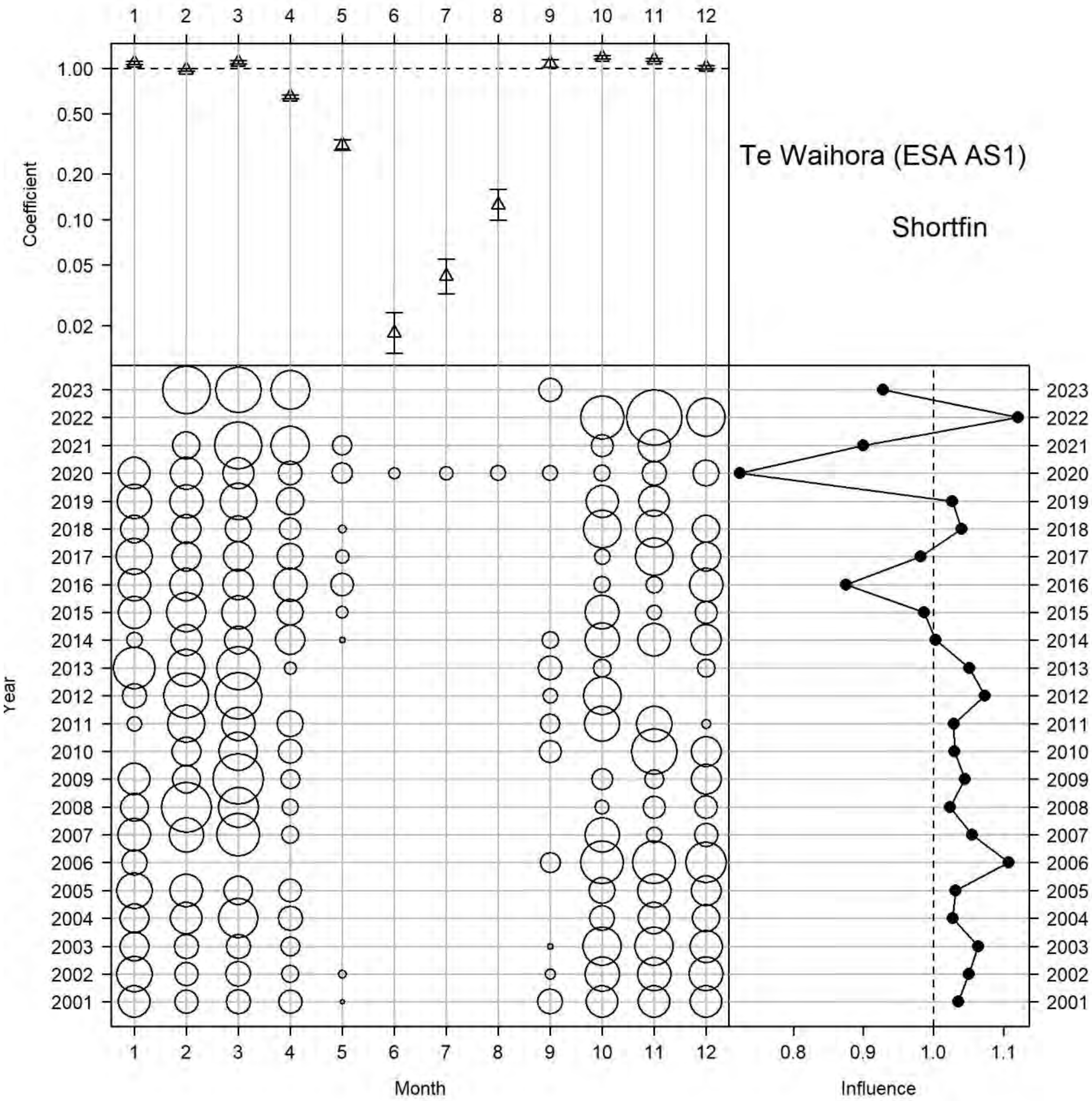

Figure I18: Influence of month for the shortfin CPUE model from AS1 (lake) for the years 2000–01 to 2022–23 (Te Waihora (ESA AS1)).

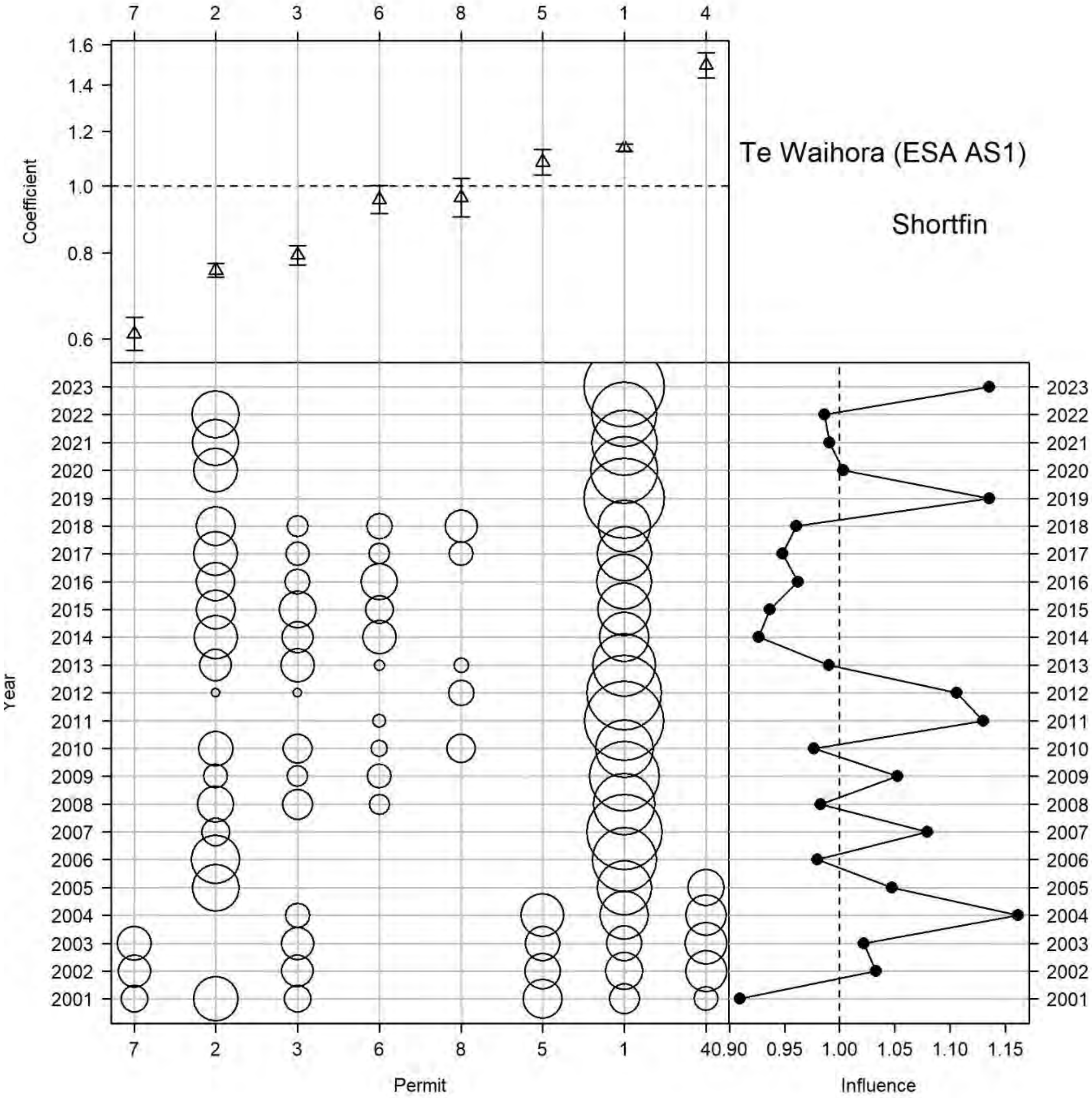

Figure I19: Influence of permit number for the shortfin CPUE model from AS1 (lake) for the years 2000–01 to 2022–23 (Te Waihora (ESA AS1)).