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Updated CPUE analyses for selected South Island inshore finfish stocks

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A total of 12 standardised CPUE analyses were updated (to 2012/13) for seven inshore fishstocks: ELE 3, ELE 5, ELE 7, GUR 3, GUR 7, TAR 7, and JDO 7. All of the CPUE analyses have been accepted by the Southern Inshore Stock Assessment Working Group and are utilised in stock monitoring. While comprehensive CPUE analyses were completed over the last 1–3 years; this study updates the CPUE indices with the inclusion of data up to 2012/13 (an additional 2–3 years depending on the analysis).

The CPUE analyses were all based on catch and effort data from the inshore trawl fisheries. The fisheries were defined based on fishing areas (defined by Statistical Area) and target species. The main fishing areas were west coast South Island (WCSI), east coast South Island (ECSI), Tasman Bay and Golden Bay (TBGB), Cook Strait (TBCS) and two specific fishstock areas (ELE 5 and JDO 7). The individual fisheries were either defined by a specific target species (flatfish, FLA) or group of target species (MIX).

The updated analyses were conducted independently of the previous analyses. For almost all CPUE analyses (except JDO 7), it was possible to closely approximate the original data sets. The resulting CPUE series were also similar for corresponding periods.

The current CPUE analyses used a standard set of algorithms that refined the previous approach used to standardise the CELR and TCER (and TCEPR) fishing effort data and the apportionment of the landed catch to the fishing effort records. Differences also existed in the level of data aggregation in the final CPUE data sets (trip versus effort strata). The resulting CPUE indices were largely insensitive to these changes in data configuration, indicating that the CPUE indices are relatively robust at least to minor changes in the data processing that may be introduced by individual analysts.

The recent trends in fishstock CPUE indices from each fishery are as follow:

- ELE 3 ECSI MIX Trawl. The CPUE indices steadily increased from 1989/90 to 1998/99 and then sharply increased in 1999/2000 and 2000/01. Over the subsequent years, the indices fluctuated about the higher (2000/01) level; CPUE was lower in 2004/05 and high again in 2007/08 and 2008/09. The CPUE indices from 2009/10 to 2012/13 were lower than the preceding peak in CPUE but were well above the average CPUE from the entire time series and substantially higher than the CPUE from the earlier period (prior to 1998/99).
- ELE 5 MIX Trawl. The CPUE indices generally increased from 1992/93 to reach a peak in 2007/08–2010/11. The indices for 2011/12–2012/13 are lower than the peak CPUE level but well above the average CPUE from the entire time series.
- ELE 7 WCSI MIX Trawl. The CPUE indices were variable over the time series with a very high index in 1999/2000 and low CPUE in 1997/98 and 2003/04. The CPUE indices were relatively stable in 2005/06–2010/11, sharply increased in 2011/12 and remained at the higher level in 2012/13.
- GUR 3 ECSI FLA Trawl. The indices fluctuated about a relatively low level during 1989/90–1998/99 and then increased steadily to reach a peak in 2009/10–2010/11. The most recent indices (2011/12 and 2012/13) fluctuated slightly below the peak CPUE level.
- GUR 3 ECSI Mix Trawl. The trend in CPUE indices was similar to the GUR 3 ECSI FLA Trawl indices. The recent CPUE indices (2011/12 and 2012/13) are considerably lower than the peak in the CPUE time series (2007/08–2009/10) but well above the average level for the entire time series.

- GUR 7 WCSI FLA Trawl. The CPUE indices fluctuated cyclically over the time series with peaks in CPUE during 1989/90–1992/93 and 2000/01–2003/04 and relatively low CPUE in 1994/95–1998/99 and 2006/07–2010/11. The CPUE indices increased steadily from 2009/10 to a relatively high level in 2012/13.
- GUR 7 WCSI Mix Trawl. The trend in the CPUE indices was broadly similar to the GUR 7 WCSI FLA Trawl fishery. The CPUE indices were high during 1990/91–1992/93 and 2000/01–2005/06 and relatively low during 1993/94–1999/2000 and 2008/09–2009/10. The CPUE indices increased steadily from 2009/10 to a relatively high level in 2012/13.
- GUR 7 TBGB FLA Trawl. The CPUE indices fluctuated over the time series with peaks in CPUE during 1989/90–1992/93 and 1999/00–2003/04 and relatively low CPUE in 1994/95–1998/99 and 2004/05–2007/08. The CPUE indices increased steadily from 2007/08 to a relatively high level in 2011/12 and declined slightly in 2012/13.
- GUR 7 TBCS Mix Trawl. The CPUE indices from the fishery were not considered to represent a reliable index of red gurnard stock abundance, especially for the latter period (from 2007/08) due to a considerable change in the spatial operation of the fishery.
- JDO 7 Trawl. The CPUE indices declined from 1989/90 to 1991/92, remained at a low level during 1991/92–1998/99 and then increased substantially during 1999/2000–2003/04. The CPUE indices declined in 2003/04 but still remained at a relatively high level during the subsequent years.
- TAR 7 WCSI Trawl. The CPUE indices have fluctuated over the time period; the indices increased from 1989/90 to 1997/98, decreased from 1997/98 to 2001/02, sharply increased in 2002/03 and then generally declined to 2010/11. The CPUE indices from 2011/12 and 2012/13 were slightly higher than the preceding years (2008/09–2010/11).
- TAR 7 TBCS Trawl. The TAR 7 CPUE indices from the TBCS fishery differ considerably from the WCSI fishery and the two areas may represent different stock units. For the TBCS fishery, the CPUE indices fluctuated considerably during 1989/90–2001/02 with very high CPUE indices for 1994/95 and relatively high CPUE in 2000/01–2001/02. Since 2002/03, the indices remained relatively stable.

The location based fishing effort data reported in the TCER format enables a more detailed analysis of fine-scale patterns in fishing effort, including fishing depth. Three simple metrics were derived to monitor the recent (2007/08 onwards) fishing patterns of the constituent fleet comprising each CPUE data set.

The spatial metrics do not reveal any concentration of fishing effort in core species-specific fishing areas from 2007/08 to 2012/13 for the following fisheries: ELE 5, GUR 3 FLA fishery, GUR 7 WCSI FLA fishery. However, the spatial metrics indicate a possible increase in the efficiency in a number of fisheries with more effort occurring at the more productive fishing locations, specifically GUR 7 WCSI MIX fishery, GUR 7 TBGB FLA fishery, TAR 7 WCSI fishery, ELE 7 fishery, and TAR 7 TBCS fishery. Conversely, there is a possible decrease in the efficiency for a number of other fisheries, specifically ELE 3, GUR 3 MIX fishery, GUR 7 TBCS MIX fishery, JDO 7 fishery. These observations are important in the consideration of the reliability and utility of the individual fishery specific CPUE indices for the monitoring of the respective fishstocks over recent years. However, further study is required to formulate reliable spatial indicators for monitoring fleet behaviour from location based CE data and to apply such analyses to quantify the reliability of the resulting CPUE indices.

1. INTRODUCTION

Trends in standardised CPUE are used to monitor a wide range of inshore finfish stocks. For these stocks, comprehensive CPUE analyses are typically conducted on 3–4 year cycles. However, for relatively short-lived finfish species, such as red gurnard, red cod, John dory and flatfish species, the time interval between individual analyses is probably not appropriate for the direct application of the CPUE indices to inform management advice. Stock indicators are required annually or biannually for a management regime to adequately respond to the variability in the abundance of these species.

For fishstocks with established CPUE indices, the author proposed that "rapid" updates of the existing CPUE analyses could be conducted in the intervening years between more comprehensive CPUE analyses. These "rapid CPUEs" would be undertaken annually or biannually based on the established analyses (data processing, model formulation, etc) and reported to an appropriate Fisheries Assessment Working Group (FAWWG) in an abbreviated format. A concise set of standard data summaries would also be included to identify whether or not there had been any large changes in the operation of the fishery since the last comprehensive analysis had been completed. It is envisaged that the more comprehensive CPUE analyses, and associated detailed fishery characterisations, would normally be updated every 4–5 years or more frequently in response to evidence of a substantial change in the operation of the fishery.

This report presents rapid CPUE updates for seven South Island inshore finfish stocks: ELE 3, ELE 5, ELE 7, GUR 3, GUR 7, TAR 7, and JDO 7. The report also provides detailed documentation of the generic data handling procedures developed to efficiently process the input CPUE data sets. The work was contracted by Southern Inshore Fisheries Management Company Limited.

2. METHODS

2.1 Candidate Fishstocks

For 2014, seven South Island inshore fishstocks were identified for an update of the existing CPUE analyses (Table 1). These fishstocks were selected on the basis that there were established CPUE analyses that had been previously reviewed and accepted by the SINS WG. The previous CPUE analyses had been conducted during the last 1–3 years and the current analyses extend the individual CPUE analyses to the 2012/13 fishing year (an additional 2–3 years depending on the analysis). For some of these fishstocks there are multiple CPUE indices, derived from multiple area and target fisheries, resulting in a total of 12 individual CPUE analyses from the seven fishstocks (Table 1).

The CPUE analyses were all based on catch and effort data from the inshore trawl fisheries. The fisheries were defined based on fishing areas (defined by Statistical Area) and target species. The main fishing areas were west coast South Island (WCSI), east coast South Island (ECSI), Tasman Bay and Golden Bay (TBGB), Cook Strait (TBCS) and two specific fishstock areas (ELE 5 and JDO 7). The individual fisheries were either defined by a specific target species (flatfish, FLA) or group of target species (MIX).

Table 1: Summary of the CPUE analyses selected for updating in the current project. The terminal year is the most recent year included in the previous CPUE analysis.

Fishstock	Fishery	Terminal year	Source document
ELE 3	ECSI MIX TRAWL	2010/11	Starr & Kendrick (2013)
ELE 5	ELE 5 MIX TRAWL	2010/11	Starr & Kendrick (2013)
ELE 7	WCSI MIX TRAWL	2010/11	Langley (2013)
GUR 3	ECSI FLA TRAWL	2010/11	Starr & Kendrick (2012)
GUR 3	ECSI MIX TRAWL	2010/11	Starr & Kendrick (2012)
GUR 7	WCSI FLA TRAWL	2009/10	Kendrick et al. (2011)
GUR 7	WCSI MIX TRAWL	2009/10	Kendrick et al. (2011)
GUR 7	TBGB FLA TRAWL	2009/10	Kendrick et al. (2011)
GUR 7	TBCS MIX TRAWL	2009/10	Kendrick et al. (2011)
JDO 7	JDO 7 TRAWL	2010/11	Dunn & Jones (2013)
TAR 7	WCSI TRAWL	2009/10	Kendrick et al. (2011)
TAR 7	TBCS TRAWL	2009/10	Kendrick et al. (2011)

2.2 Data processing

Catch and effort data from South Island inshore fishing operations were sourced from the Ministry for Primary Industries (Data extract 9205). The primary data set included all fishing effort and landings data from any fishing trip during the period 1/10/1989 to 30/9/2013 that either: a) landed ELE 3, ELE 5, ELE 7, GUR 3, GUR 7, TAR 7, JDO 2 or JDO 7 and/or b) targeted or caught ELE, GUR, JDO, STA, GSH, RCO, FLA (including individual species codes), TAR, BAR, WAR, JMA, and/or SPD within statistical areas 015–042, 701–706. The specified target species and statistical areas represented the broadest definition for the range of fisheries included in the suite of previous CPUE analyses.

For each fishstock and/or fishery, a separate data set was constructed from the primary data set. The individual data sets were based on the criteria applied to construct the data sets used in the previous CPUE analysis, although there were a number of refinements implemented in the current data processing routines.

A generic set of data processing algorithms was developed for this study. The algorithms are based on a similar "roll up" approach described by Starr (2007). The set of algorithms includes a number of key components: 1) the selection of the relevant fishery catch, effort and landing data, 2) the aggregation of the fishing effort data in a format that is consistent with the data recorded on Catch Effort Landing Returns (CELR) and 3) the allocation of the species landed catch amongst the relevant fishing effort records. A number of generalised data grooming protocols are also implemented in the data processing.

The initial data sets included all effort records from all fishing trips that included at least one fishing event within the defined fishery (target species, fishing method and statistical area) regardless of whether or not the main species of interest was caught (Step 1, Table 2).

For the fishstocks of interest, the CPUE analyses were based on bottom trawl catch and fishing effort only. Few of the qualifying fishing trips included multiple fishing methods and the species of interest are rarely caught during the other fishing activity. On that basis, fishing effort records from the other fishing activities (fishing method not equal BT) were excluded (Step 1, Table 2). Further, there were some fishing trips that reported bottom trawl fishing activity targeting species that were unlikely to have an associated catch of the species of interest (primarily targeting species that inhabit deeper water, such as hoki and orange roughy). These fishing effort records were also deleted from the initial data set (Step 1a, Table 2).

The Catch Effort Landing Return (CELR) form records fishing effort aggregated by fishing vessel, day, fishing method, statistical area and target species. The estimated weight of the five main species caught is also reported for the equivalent level of aggregation. In 2007/08, the Trawl Catch Effort Return (TCER) form was introduced for the reporting of trawl catch and effort data for most of the inshore fishing fleet, replacing the CELR for those vessels. The TCER form reports individual trawl activity (including location and trawl duration) and the catch of up to eight of the main species caught from the corresponding trawl.

The introduction of the TCER form in 2007/08 resulted in a change in the resolution and structure of the catch and effort data reported from the inshore trawl fisheries. There are concerns that the change in reporting could potentially introduce biases in the CPUE indices derived for the entire data period (1989/90 to 2012/13). Thus, attempts were made to reconfigure the TCER data at a lower level of resolution by aggregating the effort and estimated catch data in accordance with the CELR data format.

Initially, the TCER effort data (number of trawls and total fishing duration) were aggregated in accordance with the prescribed CELR data format (i.e. fishing vessel, day, fishing method, statistical area and target species). The statistical area fished was derived from the TCER data trawl start position. A comparison between the aggregated TCER records and the CELR records from the inshore ECSI and WCSI trawl fisheries revealed that, on average, consistently fewer trawls were included in the TCER aggregated records compared to the CELR records from the years immediately prior to the introduction of the TCER form (Figure 1 and Figure 2). Similarly, the duration of trawling from the aggregated TCER records was lower than from the CELR records (Figure 1 and Figure 2).

Aggregating the TCER records either by day and statistical area or day and target species also resulted in lower numbers of trawls and shorter fishing durations compared to the CELR data. The level of fishing effort reported in the CELR records was most closely approximated when the TCER data was aggregated by fishing day only (Figure 1 and Figure 2). This is consistent with the observation that most inshore trawl vessels tended to record only one CELR record for each day of fishing.

It appears that the CELR reporting format encouraged fishermen to generalise their fishing activity for the day with respect to both target species and statistical area. In contrast, the TCER form requires the fishermen to specify a target species for each trawl and the designated target species may vary in relation to the intended and/or realised catch composition (predominant species caught) of the individual trawl. The recording of statistical area on the CELR form is likely to be an indication of the main area fished during the day and it appears that fishermen were not closely monitoring the location of the individual trawls relative to the statistical area boundaries. The TCER form requires a specific location to be recorded and statistical area is derived based on that location. Thus, multiple statistical area records will be generated from the TCER data when daily trawl locations are recorded within multiple statistical areas.

There remain some discrepancies between the CELR and daily aggregated TCER data, most notably the longer aggregate fishing duration for the TCER data from the WCSI FLA target fishery (Figure 1). However, overall it appears that the daily aggregated TCER effort data provides the best approximation of the CELR data for the fisheries examined. Thus, the TCER effort data were converted to the daily aggregate format for the configuration of the CPUE data sets (Step 2, Table 2). These daily TCER records were assigned an individual target species and statistical area based on the most common target species and statistical area reported on the specific vessel fishing day.

The estimated catches from the TCER data were also aggregated by vessel fishing day. There are up to eight species reported by the TCER form per trawl and typically three trawls per day so that the estimated catches of up to 20–30 species may be reported for a day of fishing. By comparison, the estimated catches of only five species are reported in the CELR format. Therefore, the daily aggregate estimated catch of the species of interest (e.g. red gurnard) was only associated with the TCER daily

aggregate effort record if the catch of that species was ranked amongst the five largest species catches (by weight) for the vessel fishing day (Step 3, Table 2).

The aggregation routines applied to the TCER data were also applied to the limited amount of Trawl Catch Effort and Processing Return (TCEPR) data from the individual fisheries. The aggregated TCEPR data were then combined with the aggregated TCER data and then amalgamated with the CELR data to produce a combined, aggregated data set (Step 4, Table 2).

For the individual fishing trips selected in Step 1, the landed catch records of the species of interest were selected from the primary data set (Step 5, Table 2). The selection may include the landed catch from multiple Quota Management Areas to ensure that the landed catch encompasses the entire catch of the species for each fishing trip. For example, the analysis of GUR 7 CPUE from the TBGB FLA BT fishery included the landed catch of GUR 7 and GUR 2 for the qualifying fishing trips to account for the possibility of individual fishing trips operating in both QMAs.

For each fishing trip, the total landed catch of the species of interest was aggregated and a range of data grooming algorithms were implemented (Step 5, Table 2). These included comparing the aggregated estimated catches and landed catches for each trip and identifying outliers based on the ratio of the two catches. Large discrepancies were further examined by comparing the processed weight (multipled by the conversion factor) with the landed green weight. Erroneously large green weight catch records were usually due to double entry of an individual digit resulting in landed catches that were an order of magnitude larger than the processed catch weights. The correction of these erroneous landed catch records was automated by the data processing algorithm.

Once the landed catch data set was configured, the landed catch from individual trips was apportioned to the corresponding trip (aggregated) effort records following the approach of Starr (2007) (Step 6, Table 2). For trips with estimated catches (of the species of interest) associated with the effort records (in the aggregated data set), the landed catch was apportioned in proportion to the magnitude of the estimated catches. For trips with no estimated catch recorded (in the aggregated data set), the landed catch was apportioned relative to the number of fishing events (trawls) in each aggregated effort record. Fishing trips with no corresponding landed catch were assigned a zero catch for all aggregated effort records.

The resulting data set may include aggregated fishing effort records that do not meet the statistical area and target species selection criteria for the CPUE data set. These records occur for fishing trips that include fishing effort both inside and outside the spatial domain (based on statistical areas) of the defined fishery. The effort records that did not meet the selection criteria were deleted from the data set (Step 7, Table 2).

The continuity criteria (number of trips per year, number of years) used to determine the core fishing vessels in the original CPUE analysis were applied to the current data set (Step 8, Table 2). The data set was then screened to exclude a small number of anomalously large effort records (number of trawls and fishing duration) and anomalously large catch records (catches exceeding 1.5 times the 99.9% quantile of all catch records) (Step 9, Table 2).

The final CPUE data were aggregated at a level comparable to the CELR data (aggregated by vessel/trip/day/method/target species/stat area), termed ***effort strata*** (following the nomenclature of Starr 2007). Previous CPUE analyses have aggregated these data at the trip level (rather than fishing day); i.e. aggregated by vessel/trip/method/target species/stat area and data summarised in that format are termed ***trip strata*** data (following Starr 2007).

The approach described above differs in a number of aspects from the data processing described by Starr (2007). The current procedure attempts to more closely align the TCER (and TCEPR) data with the CELR data format by initially aggregating the effort data and estimated catch data by vessel fishing day (Steps 2–4, Table 2). The apportioning of the landed catch to the effort records is applied

to the aggregated effort data (Step 6, Table 2) rather than the individual effort records as in Starr (2007). Additional grooming routines have also been implemented in the current procedure.

Finally, Starr (2007) tends to "roll up" the data to generate final data sets in the *trip stratum* format. My preference is to aggregate the data at the *effort stratum* level as this approach produces records for each day of a fishing trip, thereby providing the highest resolution available for CELR format data.

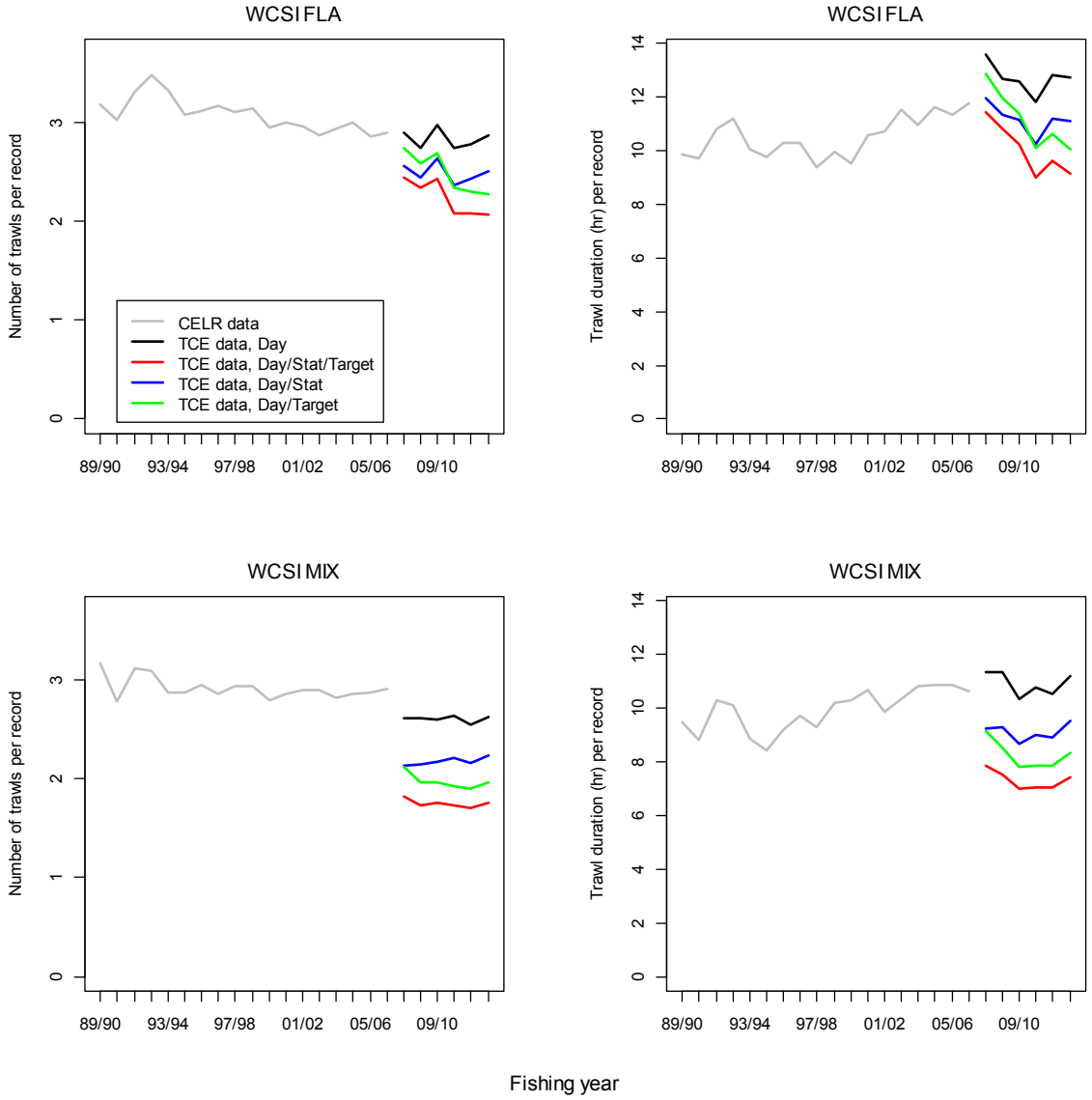

Figure 1: **A comparison of the annual average number of trawls (left) and fishing duration (right) for CELR records and TCE data records aggregated at various levels (day/stat/target, day/target, day/stat and day) from the WCSI target FLA (top) and MIX (bottom) trawl fisheries, 1989/90 to 2012/13.**

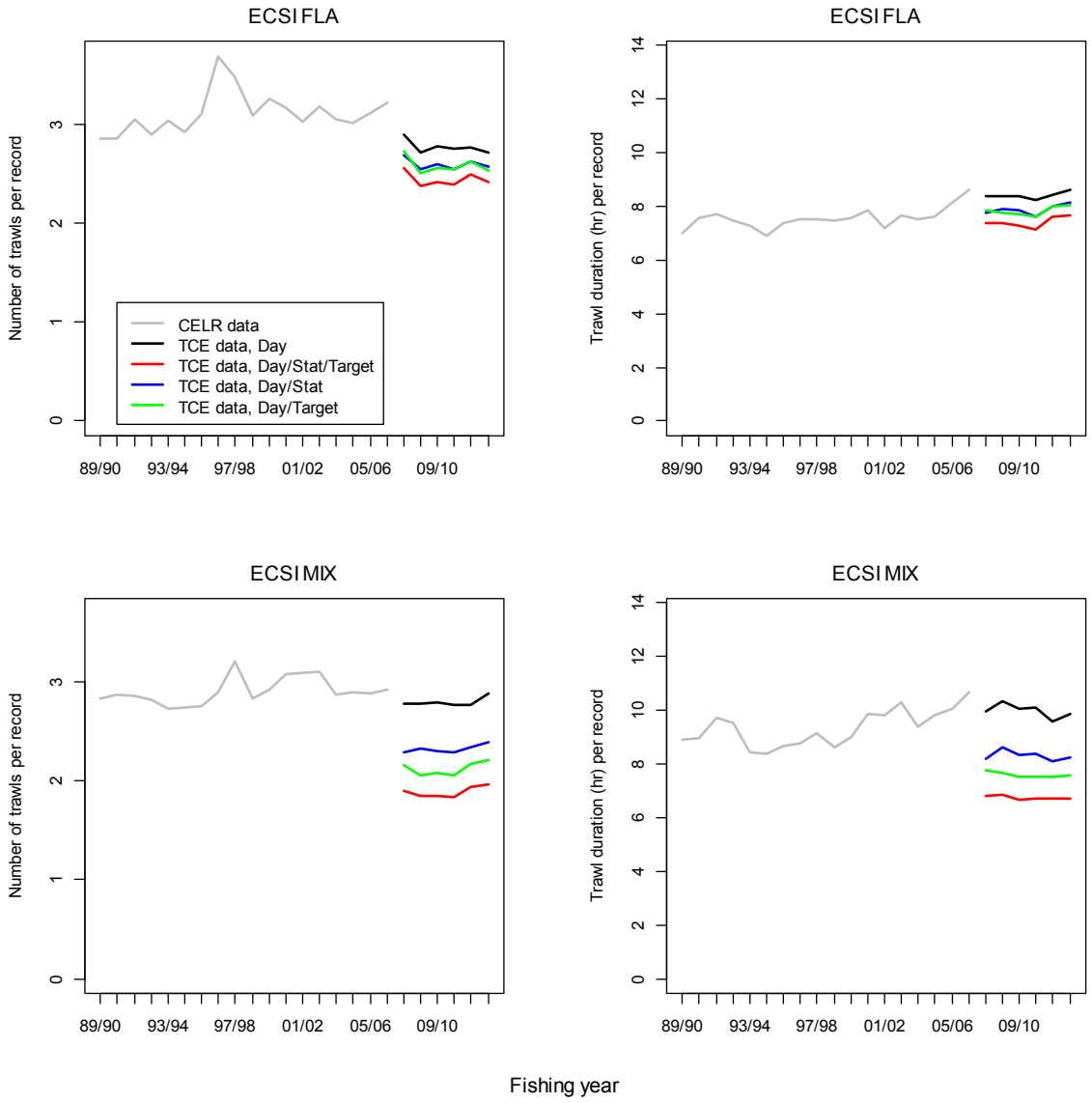

Figure 2: **A comparison of the annual average number of trawls (left) and fishing duration (right) for CELR records and TCE data records aggregated at various levels (day/stat/target, day/target, day/stat and day) from the ECSI target FLA (top) and MIX (bottom) trawl fisheries, 1989/90 to 2012/13.**

Table 2: Summary of the procedure applied to generate the CPUE data sets (see text for a detailed description of the procedure).

Step	Description	Criteria	Output
1.	Select all effort data from fishing trips that include any qualifying fishing effort based on criteria, this includes trips with no landed catch for the species.	Time period Statistical area Target species Fishing method = BT	*EffortData*
1a	Exclude effort data records from *EffortData* for which species of interest is unlikely to be caught. This prevents the situation of apportioning landed catch to anomalous target fishing activity.	Target species != "[NULL]", "ALB", "BCO", "BAS", "MOK", "LIN", HOK", "ORH", "SWA", "HAK", "SPD", "JMA", "BYX", "MIX", "RAT", "CDL", "SCA", "BOE", "SUR", "SSO", "RLA", "BAS", "RBY", "ALB", "ROC", "HPB", "CRA", "GSP","WAH", "SCM"	
2.	Aggregate TCE and TCEPR effort data (from *EffortData*) in a format equivalent to CELR. Aggregated at vessel/date/method strata.	Form type TCE or TCEPR	*TCEinCelrFormat*
3a.	Select CELR data from *EffortData* and assign estimated catch of species of interest (if recorded amongst top five species) otherwise assign zero (estimated) catch.	Form type CEL	*Celr*
3b.	For trips within *TCEinCelrFormat*, aggregate estimated catch of species of interest by vessel/date/method strata and determine rank of species in strata catch. Assign estimated catch of species of interest to the associated effort record if amongst top five (by estimated weight) otherwise assign zero (estimated) catch.	Estimated catch of all species reported from *TCEinCelrFormat* trips. Species of interest catch is amongst five main species reported for vessel fishing day.	*TCEinCelrFormat2*
4.	Merge records from CELR (*Celr*) and aggregated TCE and TCEPR data (*TCEinCelrFormat2*).		*CelrAll*
5a.	Select total landed catch per fishing trip from fishstock (or multiple fishstocks).	Fishstock or multiple fishstocks (when fishery operates adjacent QMA boundary). Destination type = "L"	*FishstockLanding*
5b.	Aggregate estimated catch of species of interest by fishing trip and merge with *FishstockLanding*. This step highlights any major discrepancies in the reported catches (estimated or landed).	Fishing trip included within *EffortData*	*CatchTrip*
5c	Error checking of landed catches. Errors in landed greenweight corrected using processed weights if appropriate.		

6.	For each fishing trip in *CelrAll*, apportion total landed catch per trip to the associated effort records (in *CelrAll*).		*ScaledCatchEffortAll*
6.1	Scaled-catch = estimated catch * sum(landed catch)/sum(estimated catch) from step 3 (*CatchTrip*).	Where aggregate estimated catch per trip is greater than zero.	
6.2	Scaled-catch = number of trawls (per strata) * sum(landed catch)/sum(number of trawls)	Where aggregate estimated catch per trip equals zero.	
7.	Apply final selection criteria to effort records in *ScaledCatchEffortAll*.	Statistical area Target species Fishing method	*ScaledCatchEffort2*
8.	Select effort records *ScaledCatchEffort2* for qualifying core vessels.	Core vessel definition, at least x years when at least y days or trips fished.	*ScaledCatchEffort3*
9	Apply range checks to individual records related to catch and key effort variables	Scaled species catch < X1 NumberTrawls < 10 FishingDuration < 20	*FinalData*

2.3 CPUE Analyses

For each fishery, the current effort strata data set was compared to the documented summary of the CPUE data set from the previous analysis (denoted *previous*) to ensure comparability in the aggregated annual catch and fishing effort (Table 3). The aggregated annual catch and fishing effort variables are equivalent for the effort strata and trip strata data sets, although the proportion of zero catch records is likely to differ between the two levels of stratification.

The summary data for the previous data set was obtained from the respective source documents. The two sets of summary data were compared for the time period of the previous CPUE series to ensure that the core vessel selection criteria were applied in an equivalent manner. The current data from the time period equivalent to the previous data set was termed the *comparative* data set. The full time series of the current data set was termed the *updated* data set (from 1989/90 to 2012/13) (Table 3).

The current CPUE models adopted a formulation equivalent to the previous CPUE models, in terms of explanatory variables and error structure. The models were typically repeated for the comparative and updated effort strata data sets. For models that were previously implemented using the trip strata data, the updated final data set was reformatted at the trip resolution and the CPUE analysis repeated (updated, trip strata) (Table 3).

Table 3: A description of the data sets included in the process of comparing summary data and CPUE indices from previous studies and the current study.

Dataset	Source	Data aggregation format	Terminal year
Previous	Relevant previous CPUE report	Depends on previous CPUE analysis: either effort strata or trip strata.	Depends on previous CPUE study.
Comparative	Current study	Effort strata	Equivalent to previous CPUE study.
Updated	Current study	Effort strata	2012/13
Updated, trip strata	Current study	Trip strata	2012/13

The formulation of the individual CPUE models is presented in the respective section of the Results (Sections 3.1–3.12). The range of variables included in the CPUE models is described in Table 4.

Table 4: Description of the variables included within the range of CPUE models.

Variable	Description	Data type
Catch	Species catch (kg)	Continuous
Bin	Presence/absence of catch of species	Binary
Fyear	Fishing year	Category
Target	Target species	Category
Month	Month	Category
Area	Statistical area	Category
Vessel key	Unique vessel identifier	Category
Num trawl	Number of trawls	Continuous
Duration	Duration (hours) of fishing	Continuous

To assist in the comparison of the various data sets and the interpretation of the CPUE results, the following summary plots are presented for each fishery.

a) Annual total landed species catch (green weight, t) included in the previous, comparative and updated CPUE data sets. The stratification (effort or trip) does not alter the total annual catches included in the data set.
b) Annual number of (core) vessels included in the previous, comparative and updated CPUE data sets.
c) Annual number of fishing trips included in the previous, comparative and updated CPUE data sets.
d) Annual number of fishing events (trawls) included in the previous, comparative and updated CPUE data sets.
e) Annual percentage of records with nil species catch included in the previous, comparative (effort strata), updated effort strata and updated trip strata CPUE data sets.
f) Updated normalised CPUE indices with 95% confidence intervals derived from the updated CPUE data set.
g) Standardised effort series derived from dividing annual catch (a) from the updated CPUE data set by the standardised CPUE indices (f).
h) Annual catch and TACC for fish stock (MPI 2013).
i) Annual basic and maximum deemed values for the fishstock (source: MPI website).
j) Trawl survey biomass estimates (t, total biomass) and 95% confidence interval from inshore trawl surveys within fishstock area (MPI 2013).
k) Annual proportion of total fishing effort (number of trawls) by CE form type included in the updated CPUE data set.
l) Annual proportion of CE records with an associated estimated species catch record by form type for fishing trips included within the updated CPUE data set.
m) Annual (median) rank of the species, by estimated catch weight, from CE records with an associated estimated species catch record by form type for fishing trips included within the updated CPUE data set.
n) Fishing depth (median, inter quartile range and 95% quantile interval) from CE effort records from fishing events included in the updated CPUE data set. Only data from 2007/08 onwards are presented as this represents the entire data set. The data set is limited to those fishing trips included within the final CPUE data set.
o) Proportion of the annual fishing effort (number of trawls) included within the 0.1 degree latitude/longitude cells that cumulatively accounted for the top X% (25%, 50%, 75% and

95%), ranked by catch, of the cumulative total estimated catch from 2007/08 to 2012/13. The data set is limited to those fishing trips included within the final CPUE data set.

p) Annual number of 0.1 degree latitude/longitude cells fished that cumulatively accounted for 25%, 50%, 75% and 95% of the annual estimated species catch. The data set is limited to those fishing trips included within the final CPUE data set.

For each CPUE analysis, a summary table is presented documenting the final CPUE data set (effort strata). The final CPUE indices are also tabulated with the associated 95% confidence interval.

3. RESULTS

The following sections present the results for the individual fishery CPUE updates. The notation for the specific fisheries is provided in Table 1.

3.1 ELE 3 ECSI MIX Trawl

The ELE 3 ECSI MIX Trawl fishery definition includes trawl fishing effort records targeting tarakihi, barracouta, elephantfish, red cod and/or stargazer off the east coast of the South Island. The previous CPUE analysis of Starr & Kendrick (2013) was based on data aggregated at the trip strata level (Table 5). The standardised CPUE analysis was limited to the data records with an associated catch of elephantfish (non zero catch records). The CPUE model formulation is presented in Table 5. The current CPUE analysis extended the previous analysis to include 2011/12 and 2012/13.

Table 5: A summary of the specific data selection criteria used to configure the ELE 3 ECSI Mix Trawl data set. The formulation of the CPUE model and model error structure is also presented.

Criteria	Range
Fishing year	1989/90 to 2012/13
Fishstock landed catch	ELE 3, ELE 5
Method	BT
Target species	RCO, STA, BAR, TAR, ELE
Statistical areas	018, 020, 022,024, 026
Max species catch	15 000 kg (effort strata)
Core fleet	≥ 10 trips ≥ 8 years
Data aggregation	Effort strata
CPUE model	log(catch) ~ fyear + poly(log(num trawl),3) + target + month + area + vessel_key
Model error structure	lognormal (zero catch records excluded)

A comparison of the previous and current data sets revealed comparable levels of annual catch and fishing effort (number of vessels, fishing trips and number of trawls) for the corresponding period (Figure 3 a–d and Table 6). The proportion of nil catch records was also comparable between the previous and current data sets (Figure 3e), although there is a higher proportion of nil catch records in the current data sets from 2000/01–2003/04. This may relate to the differences in the process applied to the assignment of the landed catch to the corresponding trip effort records.

For the corresponding period, the CPUE indices from the current models were very similar to the previous CPUE indices (Figure 4). There were a number of small differences between the CPUE indices: the indices for 2000/01–2003/04 from the current models were slightly higher than the previous analysis, while the index from the terminal year of the previous analysis (2010/11) was lower from the current models. The CPUE indices from the last three years have remained at or above the longer term average of the entire time-series (Figure 4 and Table 7).

Trawl survey biomass estimates for ELE 3 are highly variable and the individual indices are relatively imprecise. Nonetheless, the overall change in the magnitude of the trawl survey biomass estimates since the early 1990s is generally consistent with the magnitude of the increase in the CPUE indices (Figure 5).

Since 2007/08, there has been an increase in the depth fished by the defined fleet (Figure 6n). This coincided with a reduction of the proportion of the total fishing effort in the more productive spatial cells (0.1 lat/long cells); i.e. those spatial cells that accounted for the top 50% or 75% of the

cumulative elephantfish catch (for 2007/08–2012/13 years combined) (Figure 6o). There was also a reduction in the number of spatial cells accounting for 50% and 75% of the catch in each year (Figure 6p). These observations indicate a shift in the spatial distribution of fishing effort relative to the distribution of the elephantfish population (and/or a spatial shift in the distribution of elephantfish). These changes may not be adequately accounted for in the current CPUE analyses and should be examined in further detail during the next detailed CPUE analysis.

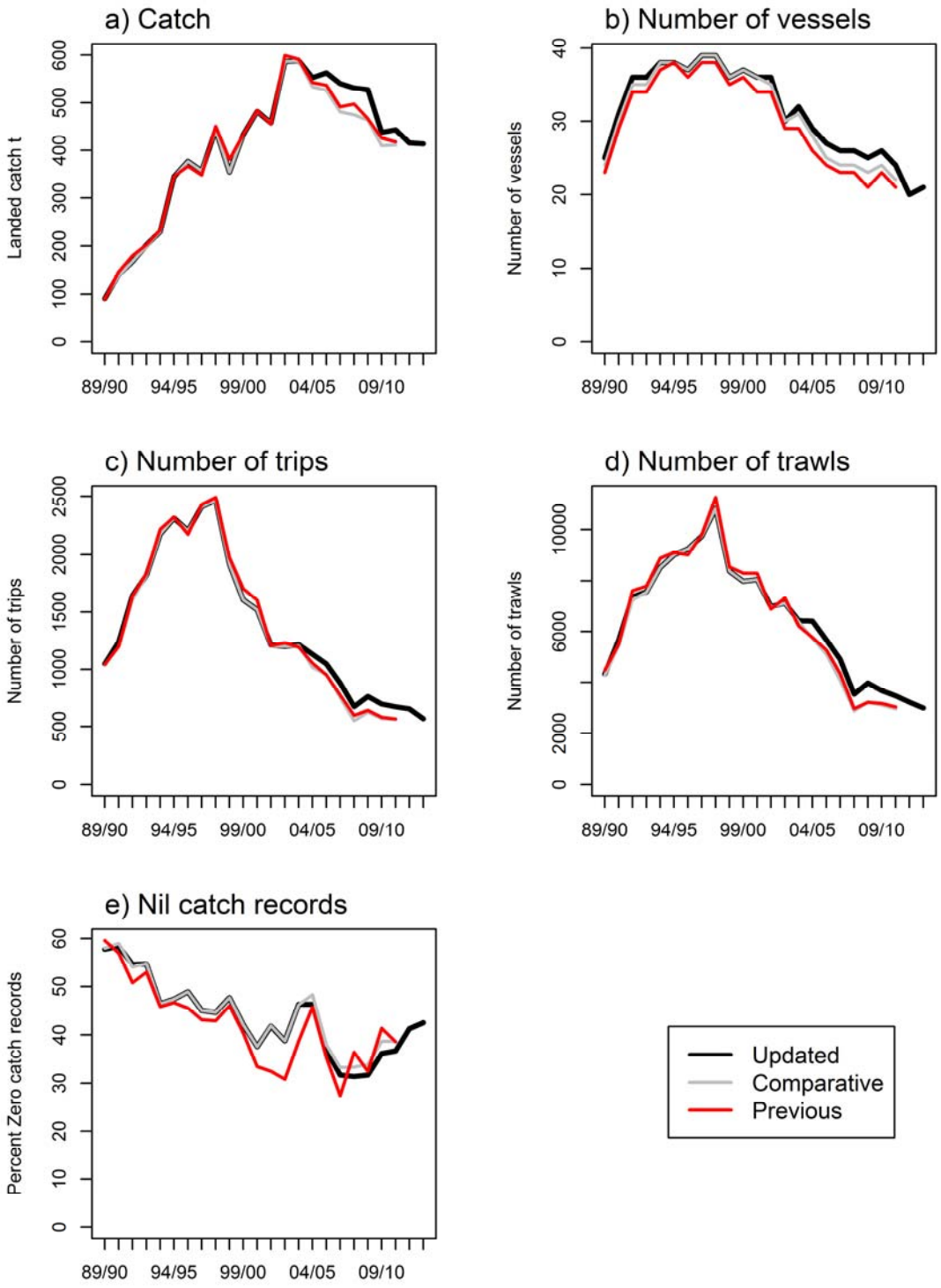

Figure 3: **Annual total landed species catch (green weight, t) (panel a), number of (core) vessels (panel b), number of fishing trips (panel c), number of fishing events (trawls) (panel d) and percentage of records with nil species catch (panel e) included in the previous, comparative and updated CPUE data sets for the ELE 3 ECSI MIX trawl fishery.**

Table 6: Summary of catch and effort (effort strata) included in the final data set (including zero species catch records) for the ELE 3 ECSI MIX trawl fishery.

Fishing year	No. of records	No. of vessel	No of trips	Catch (t)	No. of trawls	Fishing duration (hrs)	Percent zero catch
1989/90	1 593	25	1 046	90.8	4 323	14 769	57.8
1990/91	1 969	31	1 239	141.3	5 671	18 538	58.4
1991/92	2 666	36	1 643	168.3	7 367	26 628	54.6
1992/93	2 846	36	1 820	202.1	7 568	27 593	54.7
1993/94	3 122	38	2 177	229.7	8 530	28 287	46.4
1994/95	3 416	38	2 314	344.4	9 023	30 544	47.4
1995/96	3 440	37	2 205	376.6	9 257	30 049	48.9
1996/97	3 463	39	2 412	356.7	9 750	31 026	45.0
1997/98	3 649	39	2 466	442.9	10 825	32 238	44.6
1998/99	2 921	36	1 918	354.1	8 379	25 346	47.7
1999/00	2 670	37	1 606	432.6	7 981	24 720	42.1
2000/01	2 604	36	1 520	481.5	8 049	25 431	37.6
2001/02	2 215	36	1 211	457.4	6 993	22 423	41.8
2002/03	2 273	30	1 199	586.4	7 123	24 053	38.8
2003/04	2 235	32	1 215	587.8	6 437	21 597	46.3
2004/05	2 228	29	1 131	552.2	6 421	22 414	46.3
2005/06	2 009	27	1 046	562.4	5 671	20 264	36.9
2006/07	1 673	26	880	539.8	4 907	18 387	31.7
2007/08	1 325	26	674	530.6	3 540	13 109	31.4
2008/09	1 497	25	762	527.2	3 975	14 894	31.7
2009/10	1 363	26	697	437.6	3 680	13 681	36.2
2010/11	1 327	24	673	442.7	3 468	13 071	36.7
2011/12	1 212	20	655	415.6	3 219	11 274	41.3
2012/13	1 107	21	569	413.9	2 994	9 844	42.5

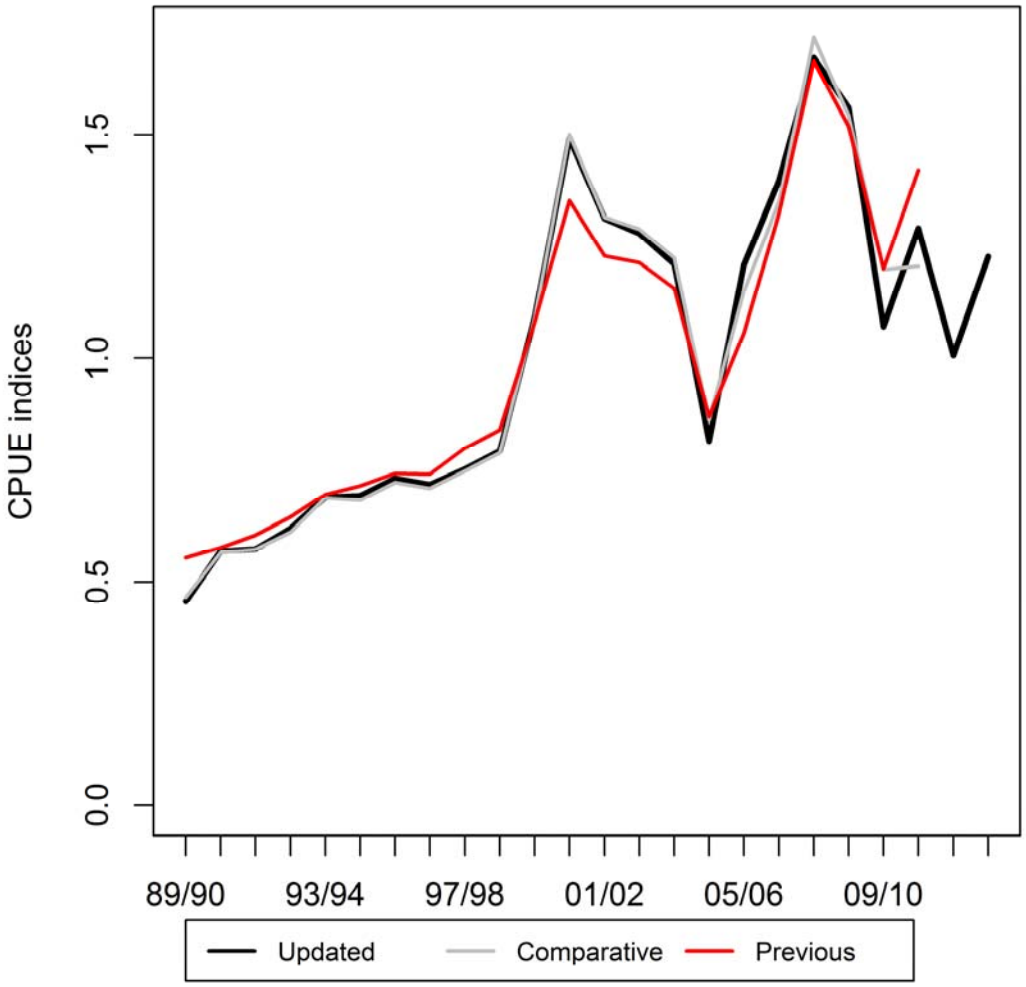

Figure 4: **Annual CPUE indices for the ELE 3 ECSI MIX trawl fishery from the previous, comparative and updated CPUE models. The indices are normalised to the average of the years included in the previous CPUE model.**

Table 7: Final CPUE model indices and lower and upper bounds of the 95% confidence interval for the ELE 3 ECSI MIX trawl fishery.

Fishing year	Index	LCI	UCI
1989/90	0.457	0.384	0.543
1990/91	0.568	0.478	0.675
1991/92	0.573	0.488	0.673
1992/93	0.619	0.528	0.726
1993/94	0.689	0.591	0.804
1994/95	0.692	0.594	0.806
1995/96	0.731	0.628	0.852
1996/97	0.718	0.617	0.835
1997/98	0.753	0.647	0.875
1998/99	0.794	0.679	0.928
1999/00	1.092	0.934	1.276
2000/01	1.491	1.276	1.743
2001/02	1.313	1.117	1.544
2002/03	1.280	1.091	1.502
2003/04	1.211	1.027	1.428
2004/05	0.816	0.692	0.963
2005/06	1.209	1.027	1.424
2006/07	1.398	1.183	1.652
2007/08	1.673	1.404	1.994
2008/09	1.561	1.315	1.852
2009/10	1.070	0.896	1.278
2010/11	1.291	1.081	1.543
2011/12	1.006	0.837	1.210
2012/13	1.227	1.016	1.483

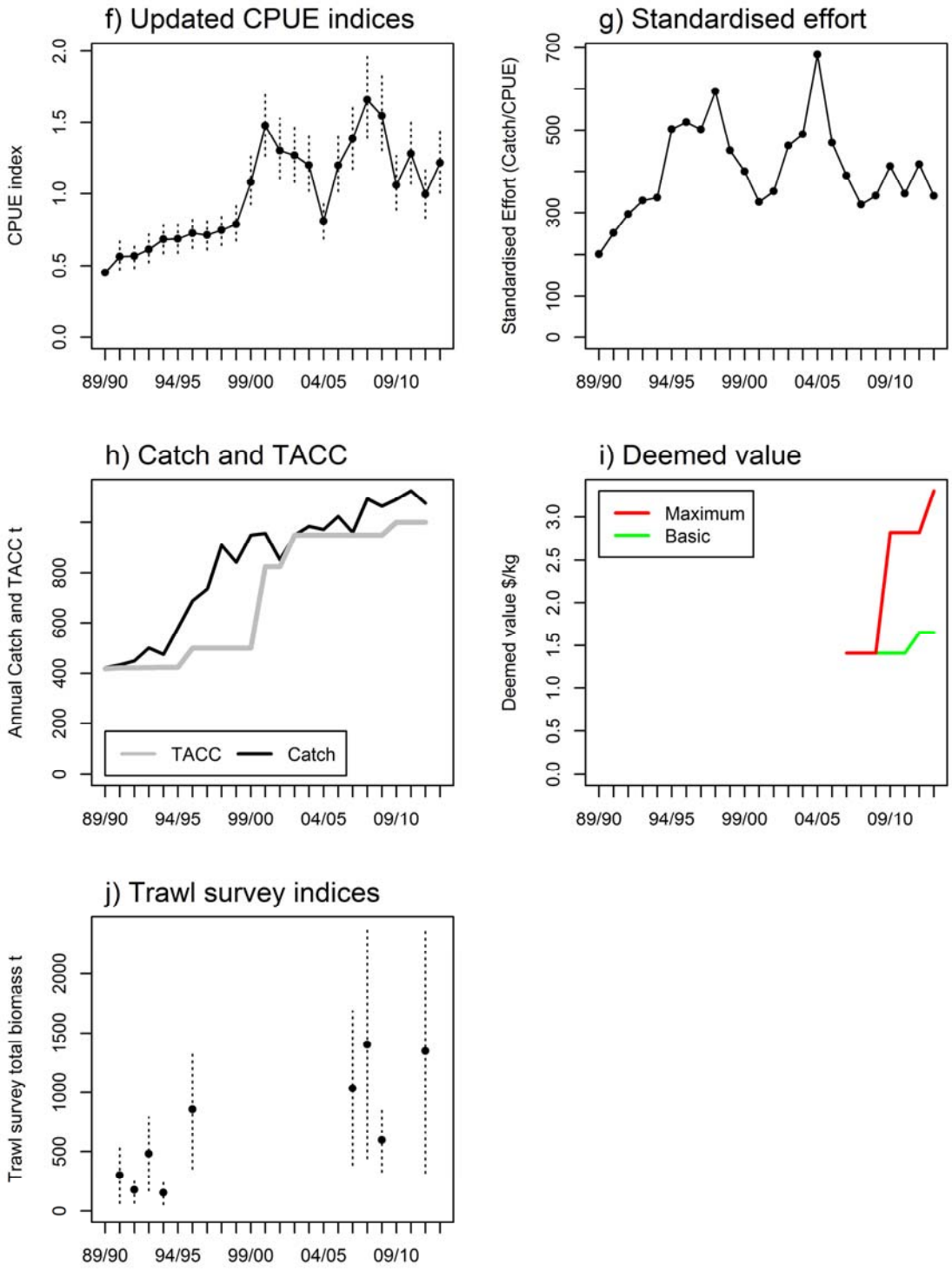

Figure 5: **A range of fishery indicators for the ELE 3 fishstock (see Section 2.3 for details): updated standardised CPUE indices with associated 95% confidence intervals (panel f), standardised fishing effort (annual CPUE catches divided by standardised CPUE indices) (panel g), total annual catches and TACC (panel h), annual deemed value penalties (panel i), and trawl survey total biomass estimates (and 95% confidence intervals) from the winter inshore ECSI trawl survey (panel j).**

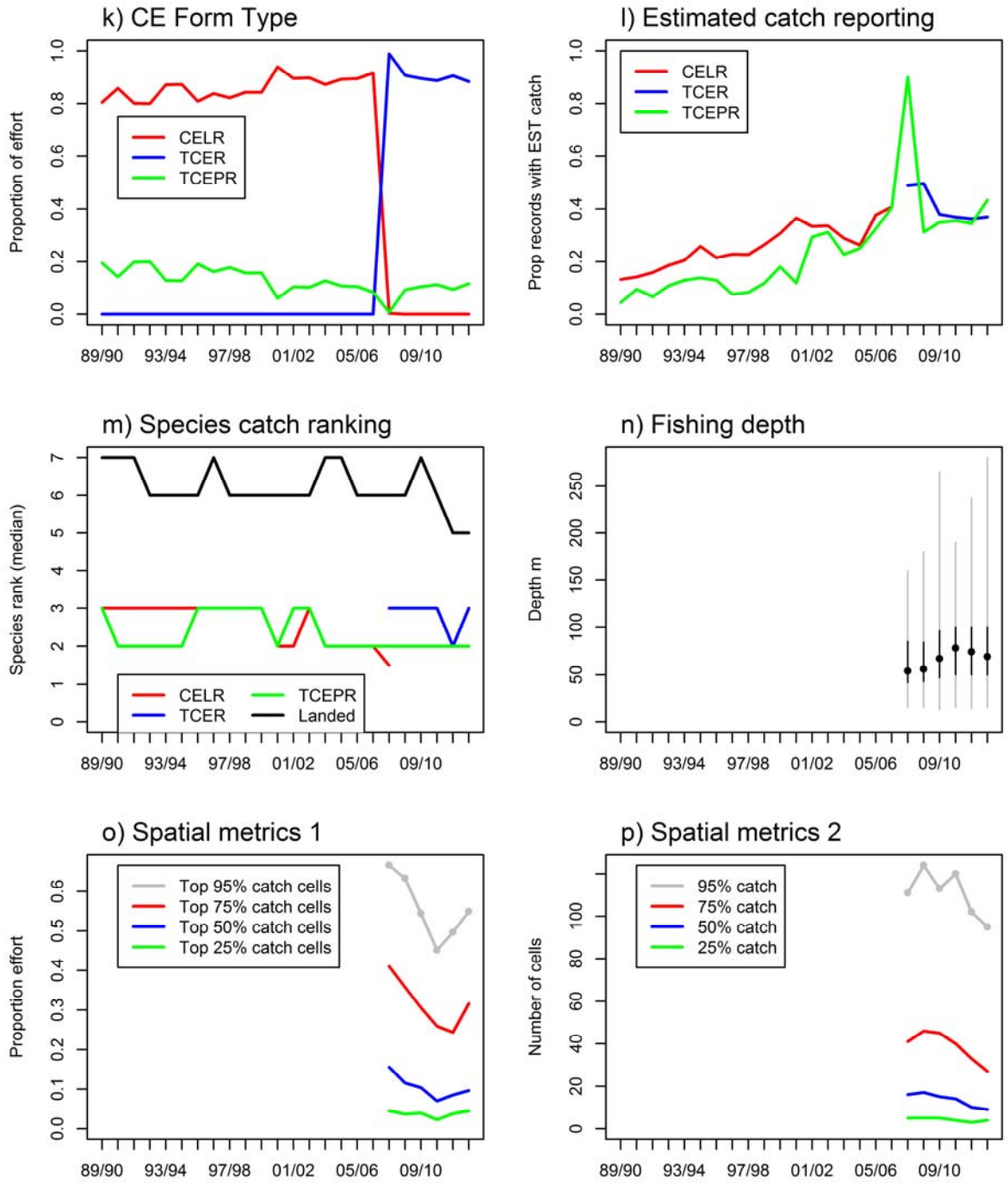

Figure 6: **A summary of the catch and effort data included in the ELE 3 ECSI MIX trawl fishery data set (see Section 2.3 for details): proportion of effort records by form type (panel k), proportion of effort records with an associated estimated catch of the species (panel l), median species rank from associated estimated catch records and landed catch records (panel m), fishing depth of effort records from TCER and TCEPR forms (median, quartile range and 95% interval) (panel n), and spatial metrics derived from TCER and TCEPR fishing records (panels o and p).**

3.2 ELE 5 MIX Trawl

The ELE 5 MIX Trawl fishery definition includes trawl fishing effort records targeting elephantfish, flatfish, barracouta, spiny dogfish, red cod and/or stargazer off the southern coast of the South Island. The previous CPUE analysis of Starr & Kendrick (2013) was conducted based on data aggregated at the trip strata level (Table 8). The standardised CPUE analysis was limited to the data records with an associated catch of elephantfish (non zero catch records). The CPUE model formulation is presented in Table 8. The current CPUE analysis extended the previous analysis to include 2011/12 and 2012/13.

Table 8: A summary of the specific data selection criteria used to configure the ELE 5 Mix Trawl data set. The formulation of the CPUE model and model error structure is also presented.

Criteria	Range
Fishing year	1989/90 to 2012/13
Fishstock landed catch	ELE 3, ELE 5 (ELE 5 > ELE 3 see notes below)
Method	BT
Target species	ELE, FLA, STA, BAR, SPD, RCO
Statistical areas	025, 026,027, 028, 029, 030 and ELE 5 landed catch greater than ELE 3 landed catch.
Max species catch	5000 kg (effort strata)
Core fleet	≥ 10 trips ≥ 6 years
Data aggregation	Effort strata
CPUE model	log(catch) ~ fyear + target + month + area
Model error structure	lognormal (zero catch records excluded)

The boundary between the ELE 3 and ELE 5 fishstocks is not well approximated by statistical area boundaries and the ELE 3/5 QMA boundary bisects statistical area 026. There are a relatively large number of fishing trips within 026 and the current protocol defines a qualifying ELE 5 fishing trip on the basis of ELE 5 landed catches exceeding ELE 3 catches. This protocol could be further refined by inclusion of data from other landed catch of other inshore finfish species that share a common QMA boundary (e.g. TAR 3/5, STA 3/5, SPD 3/5, and LIN 3/5). This would improve the classification of fishing trips with no ELE landed catch and would be important if the nil catch trips were included in the model data set (not currently the case). Further, the positional data available from the TCER data forms allows the recent fishing activity to be explicitly partitioned between the two QMAs.

A comparison of the previous and current data sets revealed comparable levels of annual catch and fishing effort (number of vessels, fishing trips and number of trawls) for the corresponding period (Figure 7a–d and Table 9). The proportion of nil catch records was also comparable between the previous and current data sets (Figure 7e).

For the corresponding period, the CPUE indices from the current model(s) were similar to the previous CPUE indices, although the magnitude of the increase in CPUE indices from the early 2000s was higher for the current analysis (Figure 8). There was also a higher level of inter-annual variability in the CPUE indices from the current analysis. These differences are likely to relate to differences in the approach of apportioning landed catch to the trip effort records, particularly for a species that may constitute a relatively small component of the overall catch from a trip.

The CPUE indices reveal a steady increase in catch rates during the late 1990s and early 2000s to reach a peak in 2008/09–2010/11 (Figure 8 and Table 10). The CPUE indices from the last two years (2011/12 and 2012/13) were lower than the average level of CPUE from the four preceding years

(2007/08–2010/11). Nonetheless, the two most recent indices are well above the longer term average level (Figure 8 and Table 10).

The annual trend in the CPUE indices is comparable to the trend in the total annual catch from ELE 5 (Figure 9h).

Since 2007/08, the overall depth distribution of the fishing effort from the defined fleet remained relatively stable (Figure 10n). There was also no substantive change in the proportion of the fishing effort that occurred within the more productive spatial cells; i.e. those 0.1 degree lat/long cells that account for the top 25% and 50% of the elephantfish catch (Figure 10o).

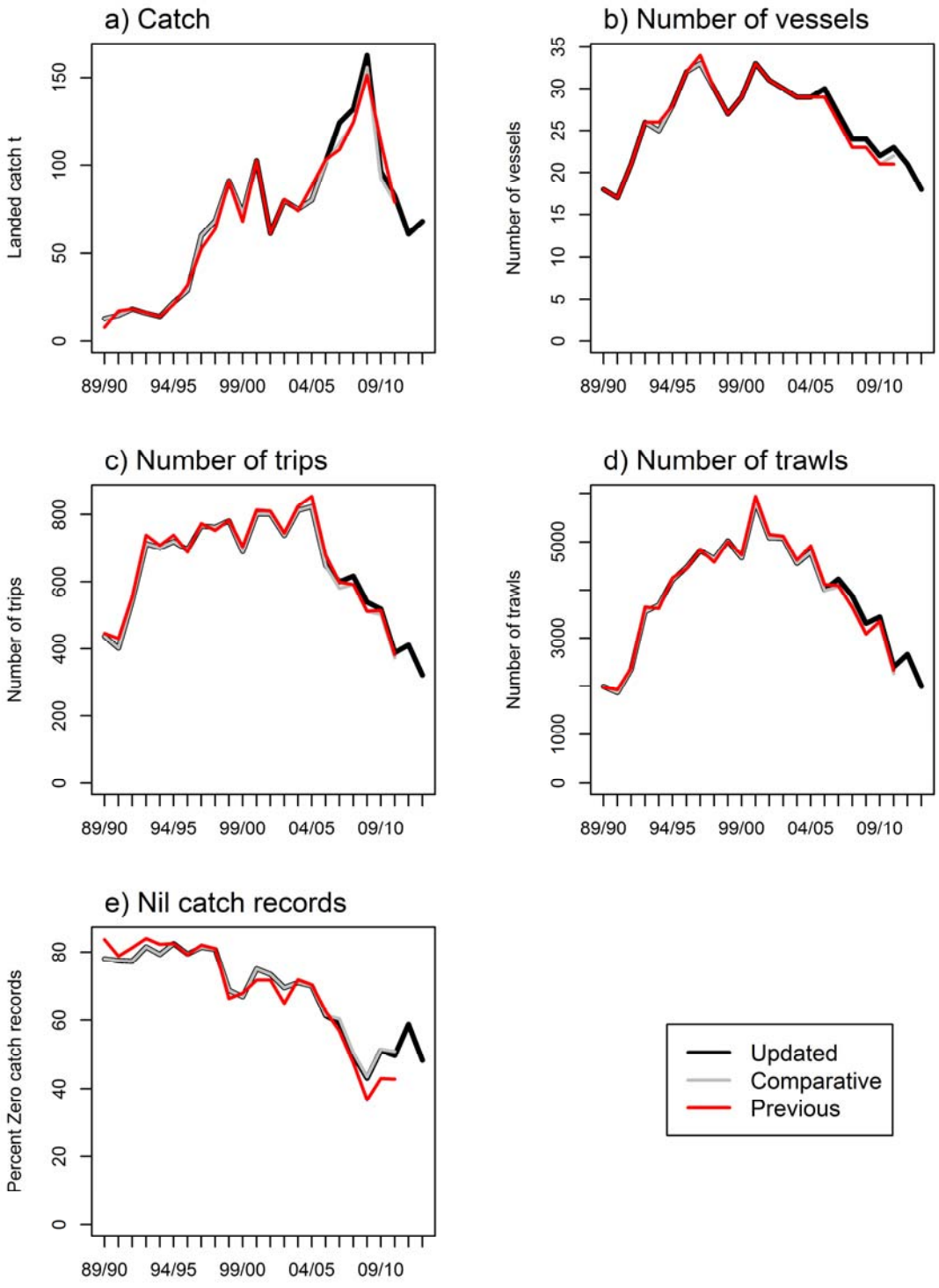

Figure 7: **Annual total landed species catch (green weight, t) (panel a), number of (core) vessels (panel b), number of fishing trips (panel c), number of fishing events (trawls) (panel d) and percentage of records with nil species catch (panel e) included in the previous, comparative and updated CPUE data sets for the ELE 5 MIX trawl fishery.**

Table 9: Summary of catch and effort (effort strata) included in the final data set (including zero species catch records) for the ELE 5 MIX trawl fishery.

Fishing year	No. of records	No. of vessel	No of trips	Catch (t)	No. of trawls	Fishing duration (hrs)	Percent zero catch
1989/90	738	18	437	12.9	1 995	4 936	78.0
1990/91	720	17	402	14.8	1 872	5 038	77.5
1991/92	863	21	543	18.4	2 349	5 951	77.3
1992/93	1 202	26	714	16.0	3 557	9 088	81.5
1993/94	1 189	25	702	14.1	3 692	8 862	79.3
1994/95	1 334	28	720	22.1	4 214	10 052	82.5
1995/96	1 400	32	696	29.1	4 477	10 994	79.4
1996/97	1 442	33	766	59.9	4 827	11 104	81.4
1997/98	1 381	30	762	68.3	4 658	10 291	80.8
1998/99	1 541	27	781	91.0	5 024	12 085	68.8
1999/00	1 470	29	691	72.5	4 681	12 338	66.9
2000/01	1 701	33	801	102.7	5 821	14 837	75.1
2001/02	1 616	31	801	61.2	5 083	12 548	73.5
2002/03	1 559	30	738	79.9	5 082	11 850	69.5
2003/04	1 449	29	812	75.0	4 560	11 363	71.0
2004/05	1 492	29	823	80.1	4 795	12 017	70.0
2005/06	1 247	30	649	102.1	4 011	10 999	61.3
2006/07	1 346	27	600	124.2	4 232	12 394	59.2
2007/08	1 312	24	617	132.1	3 880	11 059	49.8
2008/09	1 151	24	539	162.9	3 310	9 623	43.1
2009/10	1 167	22	519	96.4	3 445	10 098	51.3
2010/11	836	23	388	82.5	2 402	7 305	49.8
2011/12	928	21	411	60.8	2 666	8 278	58.8
2012/13	729	18	321	67.9	2 002	6 389	48.4

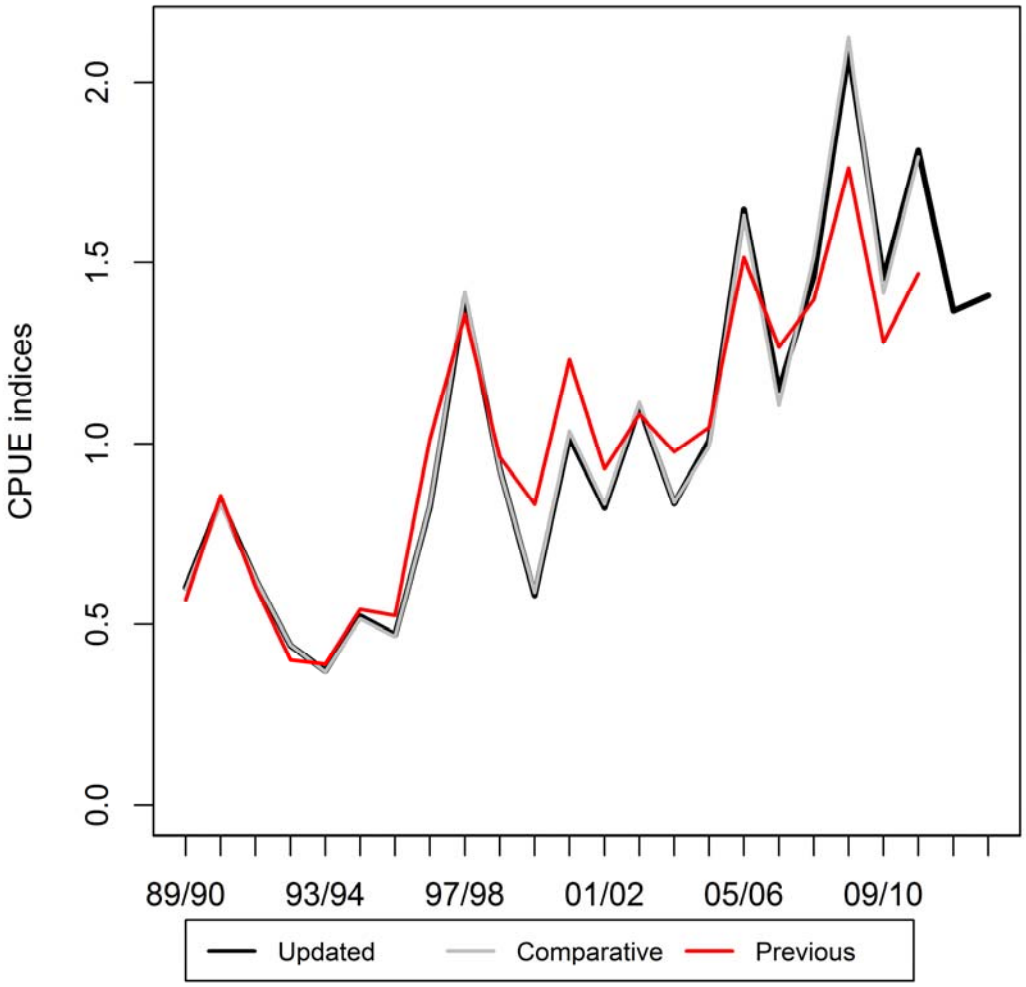

Figure 8: **Annual CPUE indices for the ELE 5 MIX trawl fishery from the previous, comparative and updated CPUE models. The indices are normalised to the average of the years included in the previous CPUE model.**

Table 10: Final CPUE model indices and lower and upper bounds of the 95% confidence interval for the ELE 5 MIX trawl fishery.

Fishing year	Index	LCI	UCI
1989/90	0.603	0.392	0.928
1990/91	0.840	0.546	1.292
1991/92	0.626	0.416	0.943
1992/93	0.441	0.296	0.657
1993/94	0.370	0.250	0.548
1994/95	0.523	0.352	0.776
1995/96	0.471	0.322	0.689
1996/97	0.824	0.560	1.213
1997/98	1.403	0.950	2.072
1998/99	0.929	0.653	1.322
1999/00	0.581	0.408	0.828
2000/01	1.020	0.712	1.461
2001/02	0.821	0.574	1.175
2002/03	1.104	0.775	1.572
2003/04	0.833	0.582	1.192
2004/05	1.008	0.707	1.438
2005/06	1.646	1.158	2.341
2006/07	1.149	0.812	1.626
2007/08	1.461	1.039	2.055
2008/09	2.081	1.480	2.926
2009/10	1.457	1.031	2.057
2010/11	1.809	1.263	2.590
2011/12	1.365	0.949	1.962
2012/13	1.408	0.977	2.028

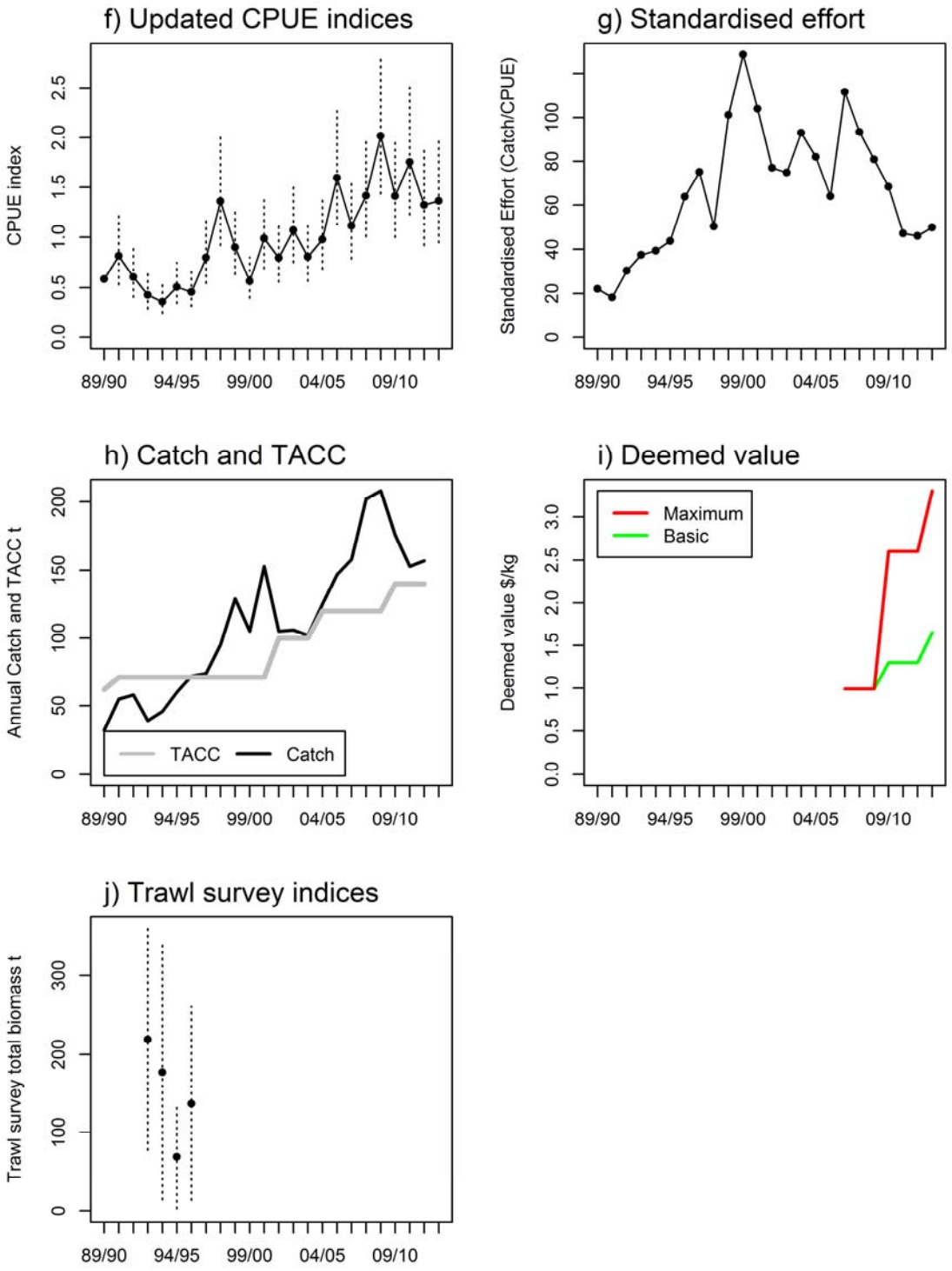

Figure 9: **A range of fishery indicators for the ELE 5 fishstock (see Section 2.3 for details): updated standardised CPUE indices with associated 95% confidence intervals (panel f), standardised fishing effort (annual CPUE catches divided by standardised CPUE indices) (panel g), total annual catches and TACC (panel h), annual deemed value penalties (panel i), and trawl survey total biomass estimates (and 95% confidence intervals) from the *Tangaroa* Southland trawl survey (panel j).**

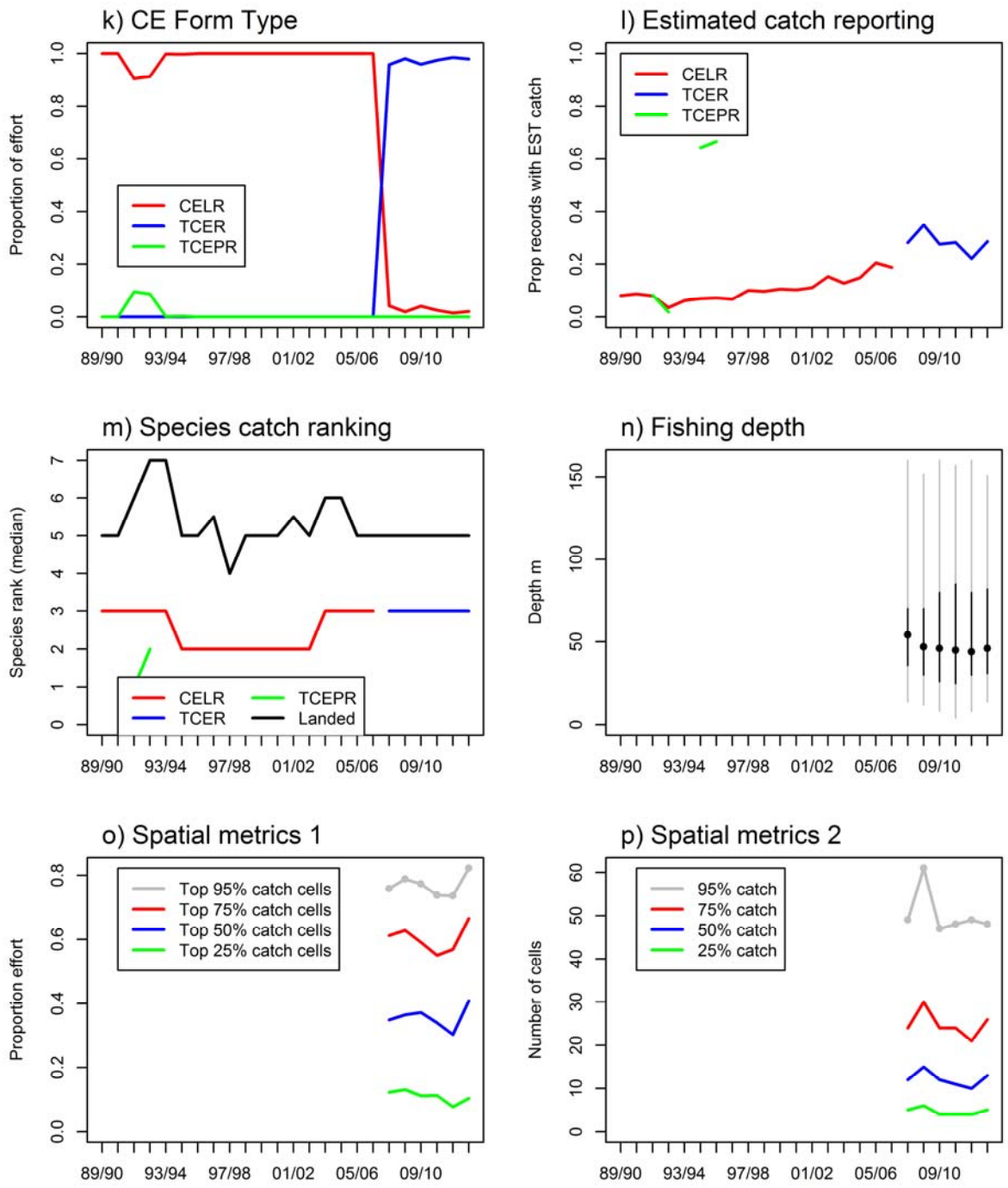

Figure 10: **A summary of the catch and effort included in the ELE 5 MIX trawl fishery data set (see Section 2.3 for details): proportion of effort records by form type (panel k), proportion of effort records with an associated estimated catch of the species (panel l), median species rank from associated estimated catch records and landed catch records (panel m), fishing depth of effort records from TCER and TCEPR forms (median, quartile range and 95% interval) (panel n), and spatial metrics derived from TCER and TCEPR fishing records (panels o and p).**

3.3 ELE 7 MIX Trawl

The ELE 7 MIX Trawl fishery definition includes trawl fishing effort records targeting elephantfish, red gurnard, red cod and/or flatfish off the west coast of the South Island. The previous CPUE analysis of Langley (2013) was based on data aggregated at the effort strata level (Table 11). The analysis derived a set of combined (delta-lognormal) CPUE indices from separate standardised CPUE analyses of the positive catch component and the probability of catching elephantfish (binomial component) (Table 11). The current CPUE analysis extended the previous analysis to include the 2011/12 and 2012/13 fishing years.

Table 11: A summary of the specific data selection criteria used to configure the ELE 7 Mix Trawl data set. The formulation of the CPUE model and model error structure is also presented.

Criteria	Range
Fishing year	1989/90 to 2012/13
Fishstock landed catch	ELE 7
Method	BT
Target species	ELE, FLA, GUR, RCO
Statistical areas	032, 033, 034, 035, 036
Max species catch	7000 kg (effort strata)
Core fleet	≥ 5 days ≥ 4 years
Data aggregation	Effort strata
Indices	Delta-lognormal
CPUE model 1	log(catch) ~ fyear + vessel_key + poly(duration,3) + month + area + target + poly(num trawl,3)
Model 1 error structure	lognormal (zero catch records excluded)
CPUE model 2	bin ~ fyear + vessel_key + poly(duration,3) + month + area + target + poly(num trawl,3)
Model 2 error structure	Binomial

A comparison of the previous and current data sets revealed comparable levels of annual catch and fishing effort (number of vessels, fishing trips and number of trawls) for the corresponding period (Figure 11a–d). The proportion of nil catch records was also comparable between the previous and current data sets (Figure 11e and Table 12).

For the corresponding period, the CPUE indices from the current model(s) were similar to the previous CPUE indices, although the magnitude of the variation in the CPUE indices differed between the two analyses (Figure 12). There was no obvious explanation for the difference in the CPUE indices derived from the two corresponding models (previous and comparative). However, it may relate to minor changes in the methodology applied to apportion the landed catches amongst the effort records.

The resulting CPUE indices fluctuated over the study period with a marked peak in CPUE in 1999/2000 and 2000/01 and low CPUE in 1997/98 and 2003/04. The CPUE indices remained stable during 2007/08–2009/10, increased in 2010/11, increased markedly in 2011/12 and remained at the higher level in 2012/13 (Figure 12 and Table 13). The two most recent indices are well above the longer term average level and close to the magnitude of the peak CPUE in 1999/2000 (Figure 12 and Table 13). Since 2006/07, annual catches were relatively high compared the earlier period and recent trawl survey indices have also been relatively high (Figure 13).

The CPUE indices from 2007/08–2012/13 are generally consistent with CPUE indices derived from a separate analysis of the catch and effort data from the individual TCER records from the inshore WCSI trawl fishery (Appendix 1).

Since 2007/08, the overall depth distribution of the fishing effort from the defined fleet remained relatively stable (Figure 14n). In 2012/13, there was an increase in the proportion of the fishing effort that occurred within the more productive spatial cells; i.e. those 0.1 degree lat/long cells that account for the top 50% and 75% of the elephantfish catch (Figure 14o) along with an increase in the number of cells fished to account for the top 50% and 75% of the annual catch. This may suggest the fishery is operating over a wider area and/or that the elephantfish population was more widely distributed in recent years.

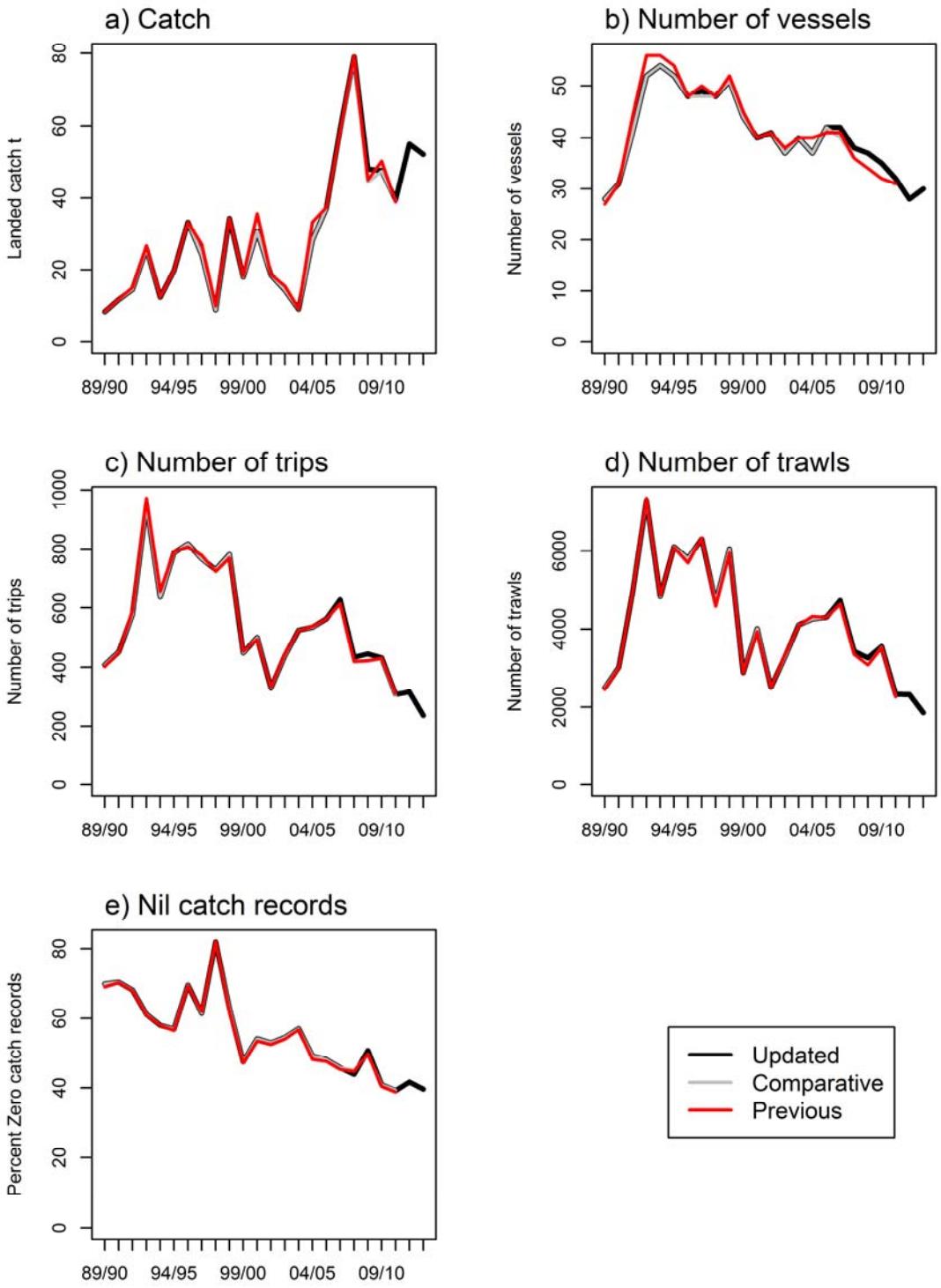

Figure 11: **Annual total landed species catch (green weight, t) (panel a), number of (core) vessels (panel b), number of fishing trips (panel c), number of fishing events (trawls) (panel d) and percentage of records with nil species catch (panel e) included in the previous, comparative and updated CPUE data sets for the ELE 7 MIX trawl fishery.**

Table 12: Summary of catch and effort (effort strata) included in the final data set (including zero species catch records) for the ELE 7 MIX trawl fishery.

Fishing year	No. of records	No. of vessel	No of trips	Catch (t)	No. of trawls	Fishing duration (hrs)	Percent zero catch
1989/90	897	28	408	8.4	2 497	8 057	69.9
1990/91	1 055	31	452	11.8	3 024	9 679	70.4
1991/92	1 562	41	579	14.6	4 911	15 670	68.1
1992/93	2 306	52	949	25.9	7 297	23 524	61.1
1993/94	1 616	54	637	12.4	4 827	15 631	58.0
1994/95	2 010	52	787	19.8	6 101	18 799	56.9
1995/96	1 928	48	817	33.3	5 802	17 817	69.5
1996/97	2 051	49	767	24.3	6 309	19 923	61.4
1997/98	1 596	48	729	8.9	4 677	14 238	82.0
1998/99	1 962	51	781	34.3	6 049	18 075	62.8
1999/00	1 019	44	449	18.0	2 882	9 128	47.5
2000/01	1 374	40	501	30.7	4 009	13 719	54.1
2001/02	875	41	330	18.6	2 508	8 601	52.9
2002/03	1 178	37	440	14.4	3 290	12 428	54.5
2003/04	1 467	40	525	9.1	4 106	15 165	57.0
2004/05	1 498	37	535	28.3	4 256	15 696	49.1
2005/06	1 587	42	563	37.2	4 295	15 604	48.1
2006/07	1 697	42	627	59.1	4 721	17 305	45.8
2007/08	1 293	38	434	79.1	3 433	15 164	43.9
2008/09	1 283	37	446	48.0	3 268	14 081	50.7
2009/10	1 268	35	432	47.6	3 561	14 390	40.9
2010/11	871	32	308	39.5	2 331	9 879	39.2
2011/12	900	28	316	55.0	2 329	10 062	41.7
2012/13	685	30	236	52.1	1 858	7 902	39.6

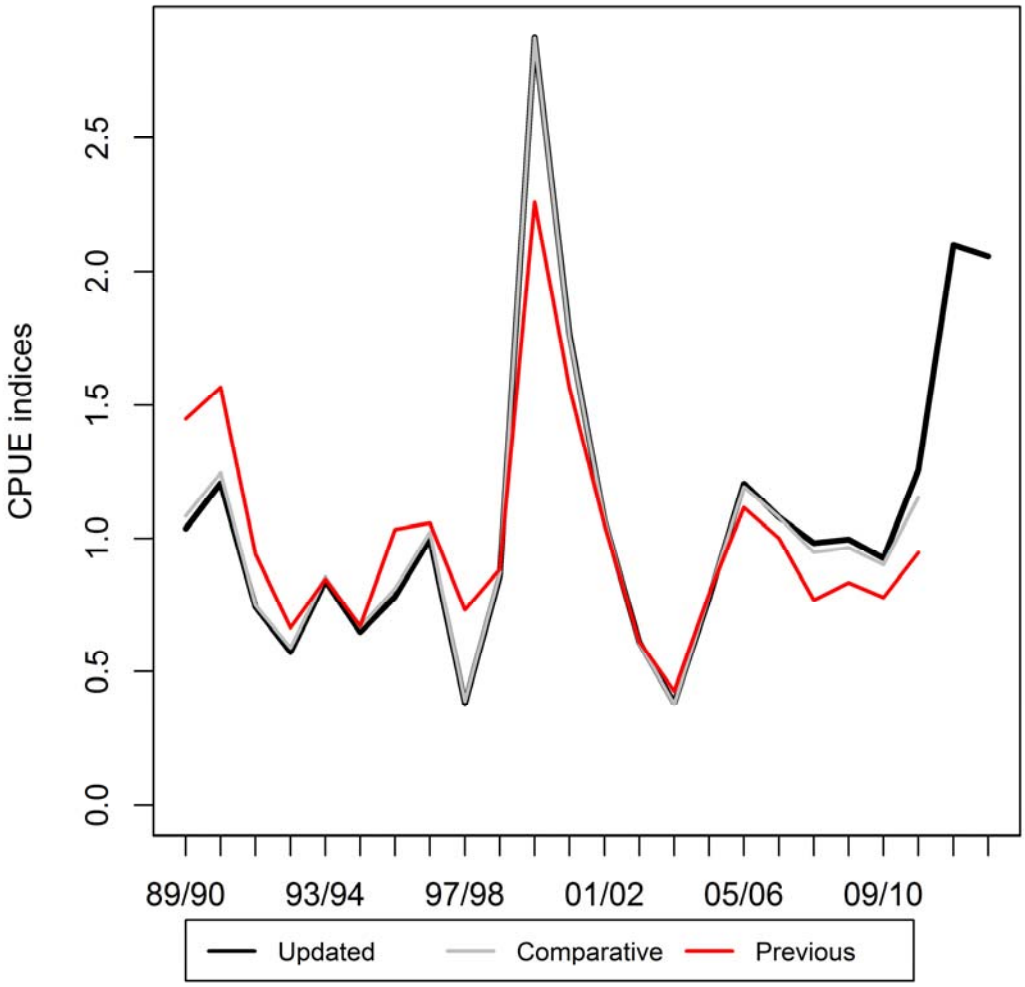

Figure 12: **Annual CPUE indices for the ELE 7 MIX trawl fishery from the previous, comparative and updated CPUE models. The indices are normalised to the average of the years included in the previous CPUE model.**

Table 13: Final CPUE model indices and lower and upper bounds of the 95% confidence interval.

Fishing year	Index	LCI	UCI
1989/90	1.037	0.770	1.370
1990/91	1.207	0.880	1.594
1991/92	0.745	0.551	0.997
1992/93	0.573	0.438	0.735
1993/94	0.843	0.638	1.060
1994/95	0.649	0.494	0.825
1995/96	0.783	0.598	1.029
1996/97	0.999	0.761	1.279
1997/98	0.381	0.278	0.532
1998/99	0.859	0.647	1.105
1999/00	2.876	2.196	3.750
2000/01	1.765	1.304	2.279
2001/02	1.066	0.789	1.408
2002/03	0.611	0.460	0.798
2003/04	0.383	0.290	0.511
2004/05	0.777	0.593	1.016
2005/06	1.205	0.907	1.565
2006/07	1.079	0.817	1.402
2007/08	0.983	0.730	1.278
2008/09	0.996	0.738	1.301
2009/10	0.926	0.693	1.202
2010/11	1.257	0.923	1.634
2011/12	2.099	1.587	2.769
2012/13	2.056	1.529	2.766

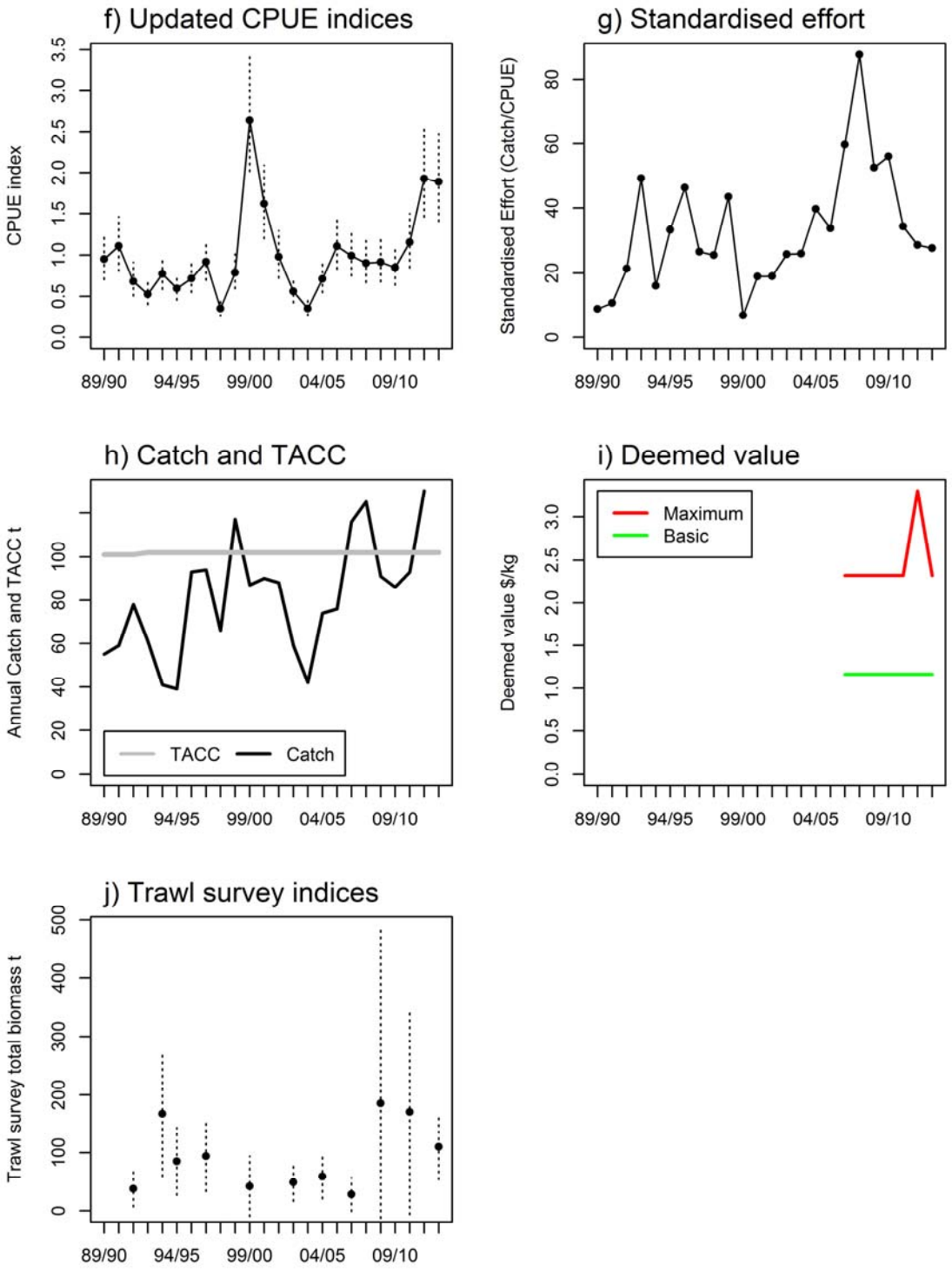

Figure 13: **A range of fishery indicators for the ELE 7 fishstock (see Section 2.3 for details): updated standardised CPUE indices with associated 95% confidence intervals (panel f), standardised fishing effort (annual CPUE catches divided by standardised CPUE indices) (panel g), total annual catches and TACC (panel h), annual deemed value penalties (panel i), and trawl survey total biomass estimates (and 95% confidence intervals) from the inshore WCSI trawl survey (panel j).**

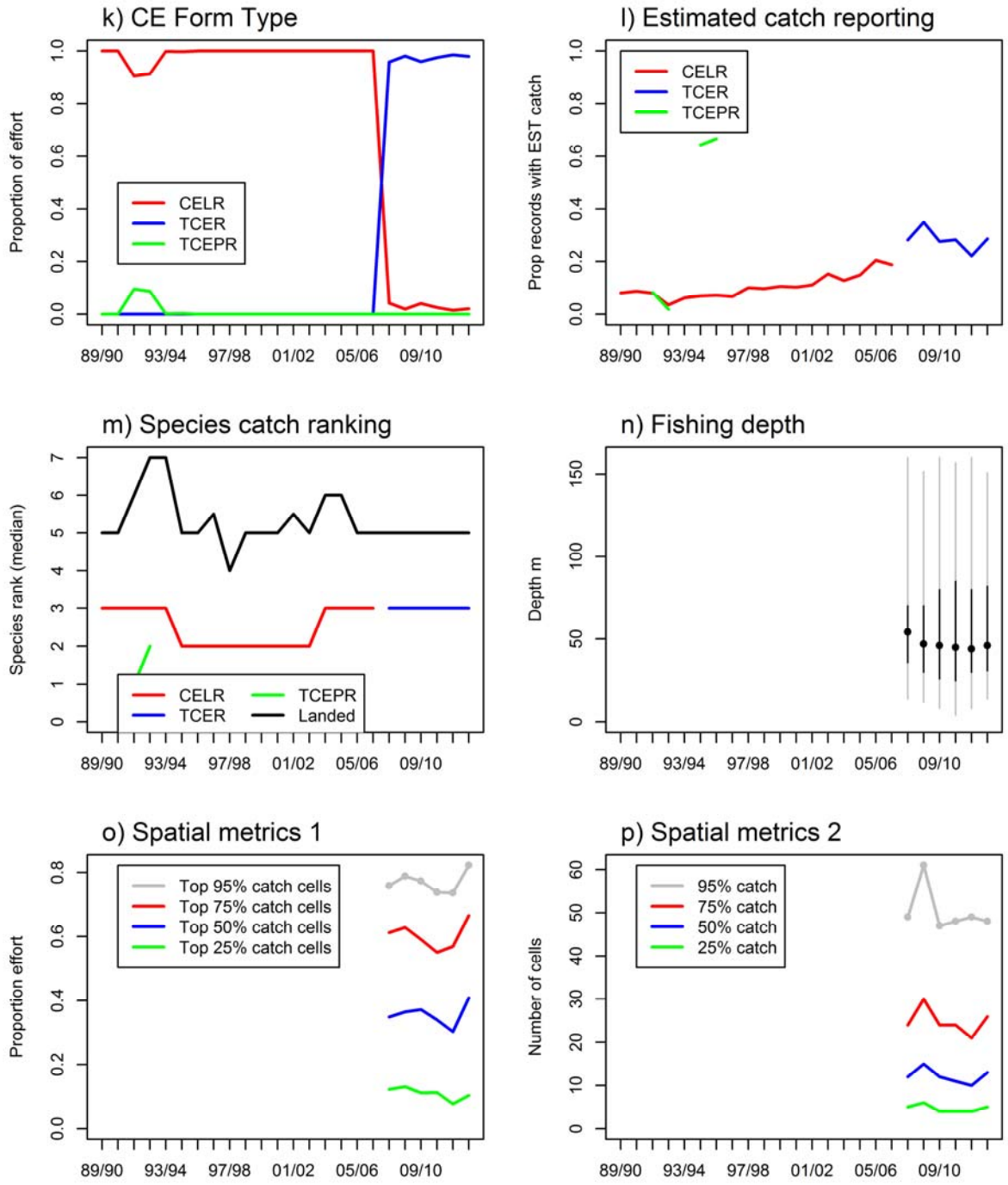

Figure 14: **A summary of the catch and effort included in the ELE 7 MIX trawl fishery data set (see Section 2.3 for details): proportion of effort records by form type (panel k), proportion of effort records with an associated estimated catch of the species (panel l), median species rank from associated estimated catch records and landed catch records (panel m), fishing depth of effort records from TCER and TCEPR forms (median, quartile range and 95% interval) (panel n), and spatial metrics derived from TCER and TCEPR fishing records (panels o and p).**

3.4 GUR 3 ECSI FLA Trawl

The GUR 3 ECSI FLA Trawl fishery definition includes trawl fishing effort records targeting flatfish off the east coast of the South Island. The previous CPUE analysis of Starr & Kendrick (2012) was based on data aggregated at the trip stratum level. The current CPUE analyses extended the trip strata analysis to include 2011/12 and 2012/13. CPUE indices were also derived using data aggregated at the effort stratum level for two time periods: a period equivalent to the original analysis (i.e., to 2010/11) and for the entire period (i.e., to 2012/13). The CPUE model formulation applied to the effort strata data was equivalent to the original model (for trip strata data) and is adopted as the final CPUE model (Table 14).

Table 14: A summary of the specific data selection criteria used to configure the GUR 3 ECSI FLA Trawl data set. The formulation of the CPUE model and model error structure is also presented.

Criteria	Range
Fishing year	1989/90 to 2012/13
Fishstock landed catch	GUR 3
Method	BT
Target species	FLA
Statistical areas	018, 020, 022,024, 026, 025, 030
Max species catch	2000 kg (effort strata)
Core fleet	≥ 10 trips ≥ 8 years
Data aggregation	Effort strata (and trip strata for comparative purposes)
CPUE model 1	log(catch) ~ fyear + vessel_key + poly(log(duration),3) + month + area
Model error structure	weibull (zero catch records excluded)

A comparison of the previous and current data sets revealed comparable levels of total annual catch and fishing effort (number of vessels, fishing trips and number of trawls) for the corresponding period (Figure 15a–d). The proportion of nil catch records was also comparable up to about 2007/08 (Figure 15e and Table 15). The difference in the latter period are probably due to differences in the two methods used for aggregating data.

The resulting CPUE indices were very similar for all model options (data aggregation and time period) (Figure 16). The CPUE indices derived from the effort strata CPUE model, for both the corresponding time period and the extended time period, were very similar to the CPUE indices from the previous trip strata analysis. For the corresponding period, the previous CPUE indices were also very similar to the updated trip strata indices. The recent trends were also very similar for the effort strata and trip strata indices (Figure 16).

The standardised CPUE indices increased steadily from a relatively low level in 1997/98–1999/2000 to reach a peak in 2007/08–2010/11 (Figure 16 and Table 16). The indices have fluctuated during the last few years (2011/12 and 2012/13) at a level slightly below the peak in the CPUE indices and well above the longer term average level. The magnitude of the increase in the CPUE indices over the entire time series (from 1989/90) is comparable to the change in the trawl survey biomass estimates over the same period (Figure 17j). Annual catches of red gurnard were at or above the TACC from 2004/05 to 2011/12 (Figure 17h).

Since 2007/08, there has been some minor variability in the depth fished between years, although there is no systematic trend (Figure 18n). There was no strong trend evident in the distribution of fishing effort (for the defined fishery) relative to the more productive spatial cells (0.1 lat/long cells);

i.e. those spatial cells that accounted for the top 25% or 50% of the cumulative red gurnard catch (for all years combined) (Figure 18o).

Similarly, the number of individual spatial cells that accounted for 25% of the annual red gurnard catch from the defined fishery was comparable over the recent period (from 2007/08). The number of cells accounting for 50% and 75% of the catch was more variable, increasing from 2007/08 to 2010/11 and then declining (Figure 18p). This is the inverse of the observed trend in fishing depth for the fishery (Figure 18n). These metrics do not indicate a strong shift in the recent pattern of fishing effort relative to red gurnard.

The overall trend in the CPUE indices from the GUR 3 FLA fishery is very similar to the indices derived for the GUR 3 MIX fishery (see Section 3.5).

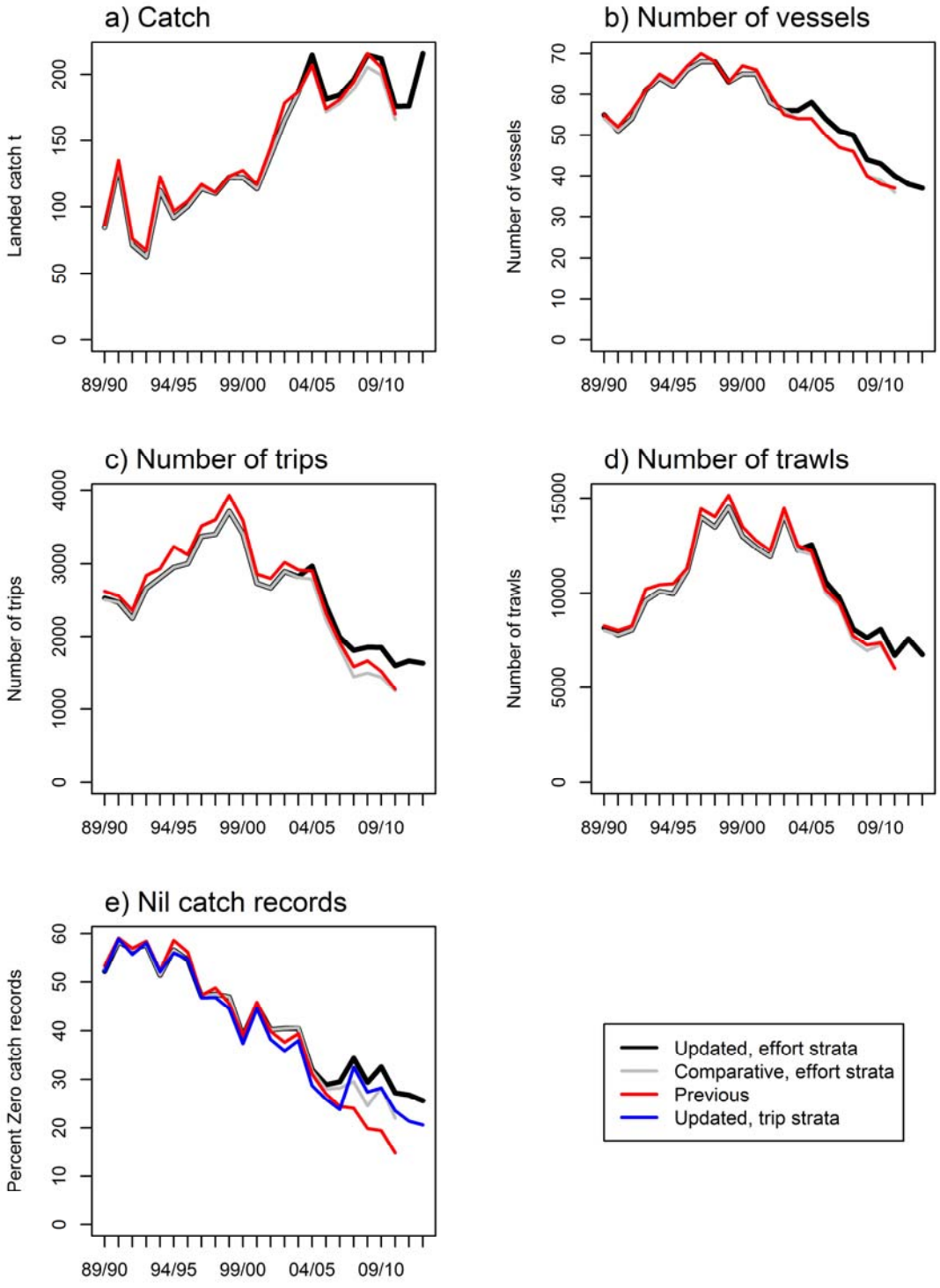

Figure 15: **Annual total landed species catch (green weight, t) (panel a), number of (core) vessels (panel b), number of fishing trips (panel c), number of fishing events (trawls) (panel d) and percentage of records with nil species catch (panel e) included in the previous, comparative and updated CPUE data sets for the GUR 3 ECSI FLA trawl fishery.**

Table 15: Summary of catch and effort (effort strata) included in the final data set (including zero species catch records) for the GUR 3 ECSI FLA trawl fishery.

Fishing year	No. of records	No. of vessel	No of trips	Catch (t)	No. of trawls	Fishing duration (hrs)	Percent zero catch
1989/90	2 896	55	2 529	84.3	8 171	20 024	52.2
1990/91	2 941	51	2 469	130.7	7 801	21 626	58.3
1991/92	2 864	54	2 249	71.4	8 060	21 810	56.7
1992/93	3 468	61	2 660	62.7	9 631	24 965	57.7
1993/94	3 497	64	2 807	112.4	10 106	24 984	51.4
1994/95	3 537	62	2 951	91.7	9 978	24 700	56.6
1995/96	3 727	66	3 001	100.4	11 203	27 955	54.6
1996/97	4 407	68	3 372	113.8	14 011	32 248	47.1
1997/98	4 380	68	3 402	110.1	13 497	31 846	47.5
1998/99	4 859	63	3 715	122.4	14 534	35 053	46.9
1999/00	4 418	65	3 406	122.1	13 015	32 442	38.9
2000/01	3 874	65	2 731	113.6	12 423	30 452	45.2
2001/02	3 845	58	2 666	138.9	11 956	27 669	40.2
2002/03	4 319	56	2 892	165.2	14 163	32 747	40.5
2003/04	3 860	56	2 823	186.5	12 295	29 243	40.5
2004/05	4 001	58	2 968	214.6	12 569	30 696	32.0
2005/06	3 364	54	2 424	181.3	10 606	27 579	28.9
2006/07	3 014	51	1 988	184.5	9 763	26 190	29.5
2007/08	2 770	50	1 809	196.1	8 104	21 682	34.4
2008/09	2 758	44	1 851	214.6	7 644	21 405	29.4
2009/10	2 898	43	1 849	211.9	8 102	22 743	32.6
2010/11	2 431	40	1 596	175.8	6 700	18 808	27.2
2011/12	2 673	38	1 663	176.0	7 581	22 046	26.8
2012/13	2 472	37	1 632	215.8	6 754	20 326	25.6

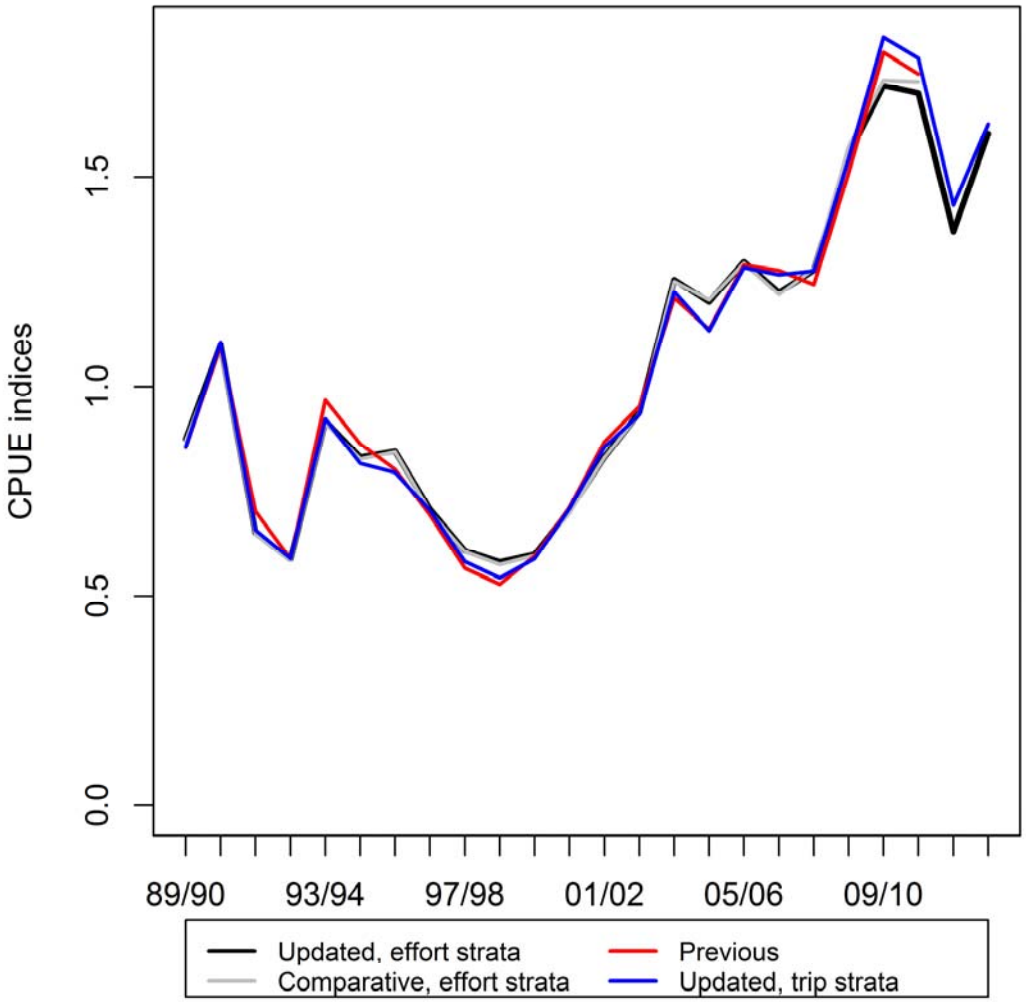

Figure 16: **Annual CPUE indices for the GUR 3 ECSI FLA trawl fishery from the previous, comparative and updated CPUE models. The indices are normalised to the average of the years included in the previous CPUE model.**

Table 16: Final CPUE model indices and lower and upper bounds of the 95% confidence interval for the GUR 3 ECSI FLA trawl fishery.

Fishing year	Index	LCI	UCI
1989/90	0.875	0.875	0.875
1990/91	1.099	1.006	1.200
1991/92	0.651	0.596	0.710
1992/93	0.588	0.540	0.640
1993/94	0.918	0.845	0.997
1994/95	0.831	0.764	0.904
1995/96	0.846	0.779	0.919
1996/97	0.706	0.653	0.762
1997/98	0.608	0.562	0.657
1998/99	0.581	0.538	0.627
1999/00	0.599	0.555	0.646
2000/01	0.703	0.649	0.761
2001/02	0.832	0.769	0.900
2002/03	0.939	0.869	1.015
2003/04	1.254	1.159	1.357
2004/05	1.201	1.111	1.297
2005/06	1.297	1.199	1.404
2006/07	1.224	1.129	1.326
2007/08	1.277	1.175	1.388
2008/09	1.553	1.431	1.686
2009/10	1.719	1.583	1.866
2010/11	1.701	1.564	1.849
2011/12	1.371	1.263	1.488
2012/13	1.603	1.475	1.743

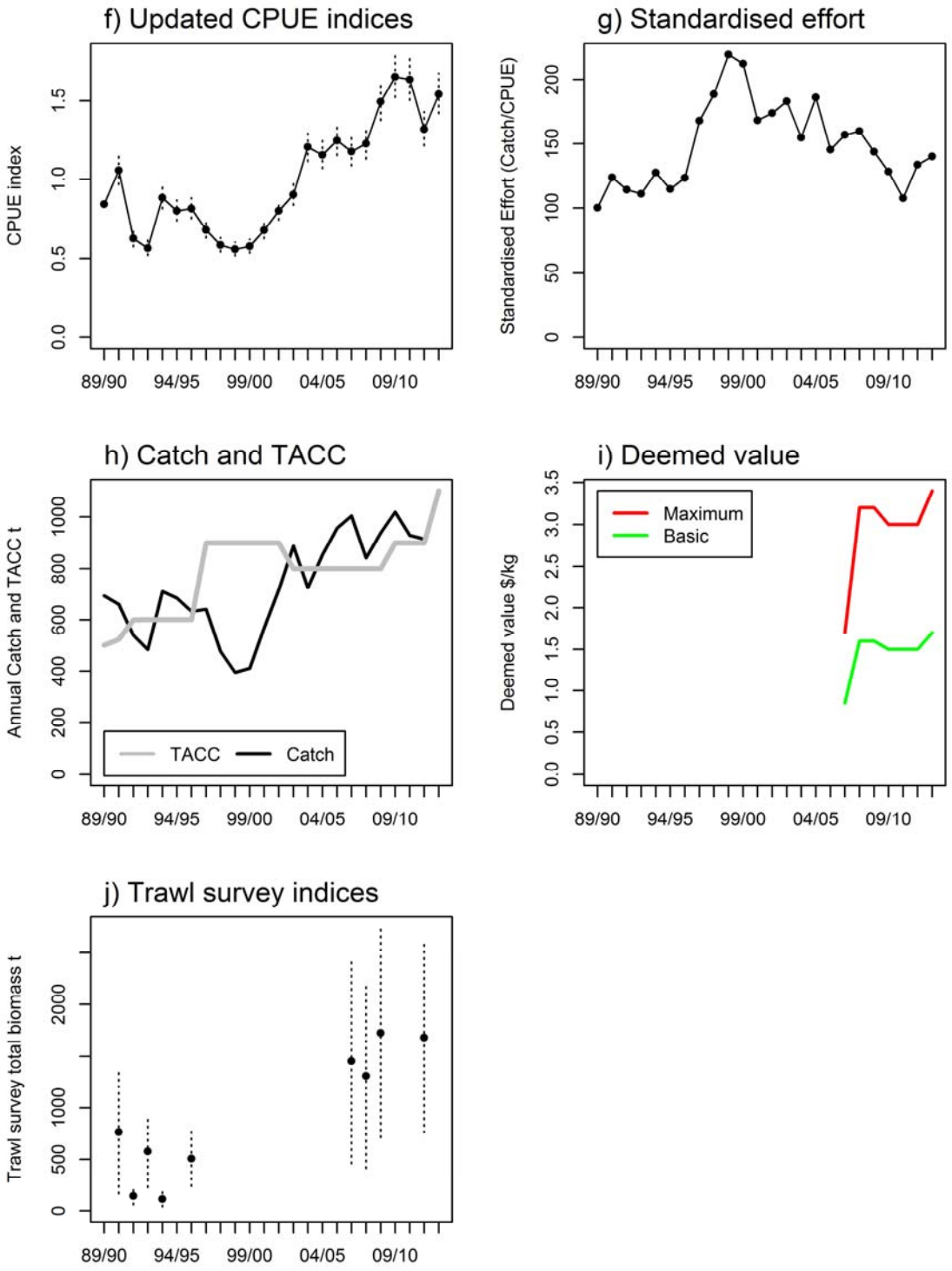

Figure 17: **A range of fishery indicators for the GUR 3 fishstock (see Section 2.3 for details): updated standardised CPUE indices with associated 95% confidence intervals (panel f), standardised fishing effort (annual CPUE catches divided by standardised CPUE indices) (panel g), total annual catches and TACC (panel h), annual deemed value penalties (panel i), and trawl survey total biomass estimates (and 95% confidence intervals) from the winter inshore ECSI trawl survey (panel j).**

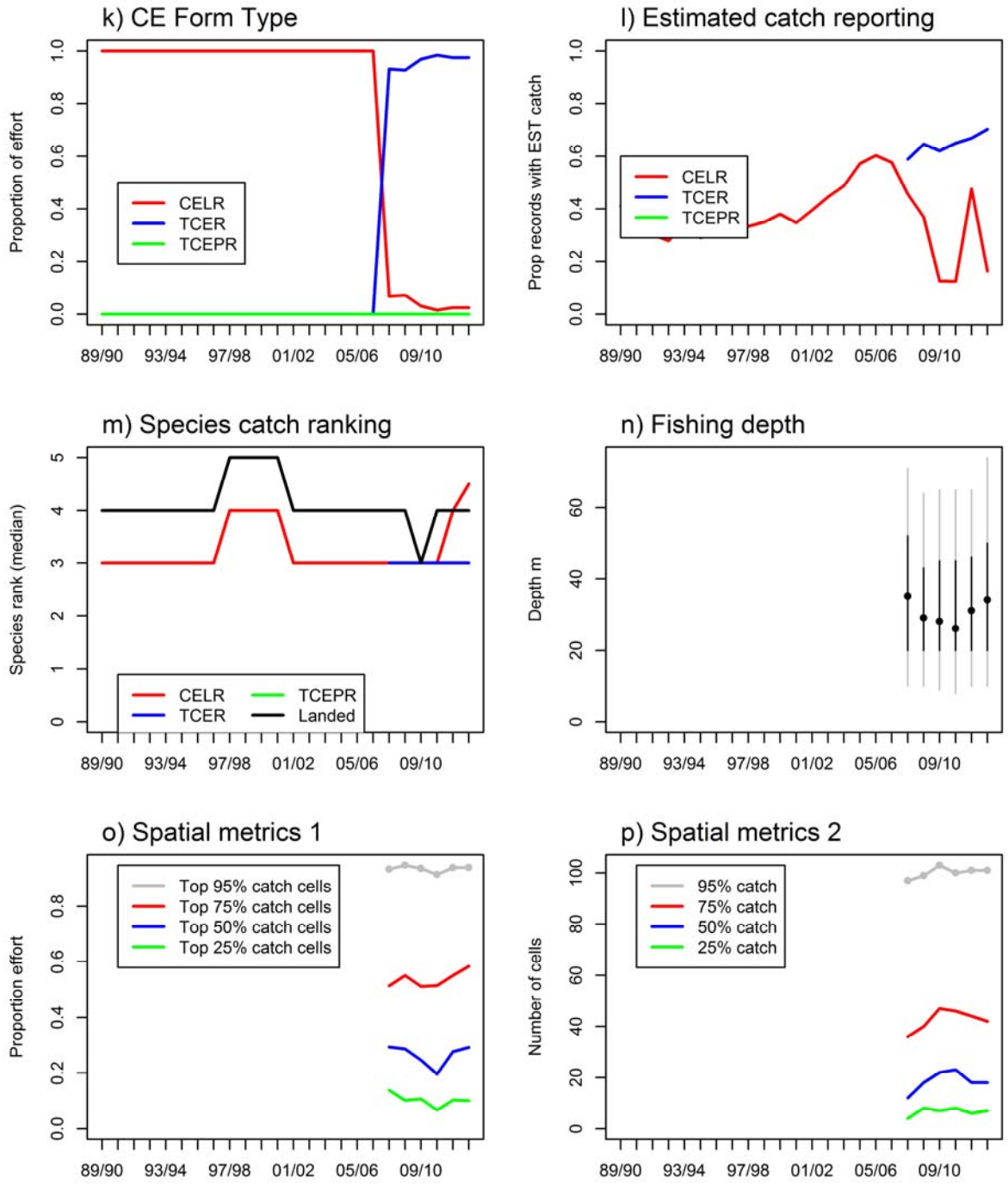

Figure 18: **A summary of the catch and effort included in the GUR 3 ECSI FLA trawl fishery data set (see Section 2.3 for details): proportion of effort records by form type (panel k), proportion of effort records with an associated estimated catch of the species (panel l), median species rank from associated estimated catch records and landed catch records (panel m), fishing depth of effort records from TCER and TCEPR forms (median, quartile range and 95% interval) (panel n), and spatial metrics derived from TCER and TCEPR fishing records (panels o and p).**

3.5 GUR 3 ECSI Mix Trawl

The GUR 3 ECSI MIX Trawl fishery definition includes trawl fishing effort records targeting tarakihi, barracouta, red gurnard, red cod and/or stargazer off the east coast of the South Island. The previous CPUE analysis of Starr & Kendrick (2012) was conducted based on data aggregated at the trip stratum level. The current CPUE analyses extended the trip strata analysis to include 2011/12 and 2012/13. CPUE indices were also derived using data aggregated at the effort strata level for two time periods: a period equivalent to the previous analysis (i.e., to 2010/11) and for the entire period (i.e., to 2012/13). The formulation of the CPUE model incorporating the effort stratum data set was equivalent to the previous CPUE model (for trip strata data) and was adopted as the final CPUE model (Table 17).

Table 17: A summary of the specific data selection criteria used to configure the GUR 3 ECSI Mix Trawl data set. The formulation of the CPUE model and model error structure is also presented.

Criteria	Range
Fishing year	1989/90 to 2012/13
Fishstock landed catch	GUR 3
Method	BT
Target species	RCO, STA, BAR, TAR, GUR
Statistical areas	018, 020, 022,024, 026, 025, 030
Max species catch	2000 kg (effort strata)
Core fleet	≥ 10 trips ≥ 8 years
Data aggregation	Effort strata (and trip strata for comparative purposes)
CPUE model 1	log(catch) ~ fyear + poly(log(duration),3) + target + vessel_key + area
Model error structure	weibull (zero catch records excluded)

A comparison of the previous and current data sets revealed comparable levels of total annual catch and fishing effort (number of vessels, fishing trips and number of trawls) for the corresponding period (Figure 19a–d and Table 18). The proportion of nil catch records was also comparable for the previous and the updated trip strata data sets (Figure 19e). There were a higher proportion of nil catch records in the effort strata data sets compared to the trip strata data sets. This is consistent with the higher resolution of the effort strata data; i.e. the occurrence of zero catch records is lower when the data are aggregated by trip rather than fishing day.

The resulting CPUE indices were very similar for all model options (data aggregation and time period) (Figure 20). The CPUE indices derived from the effort strata CPUE model, for both the corresponding time period and the extended time period, were very similar to the CPUE indices from the previous trip strata analysis. For the corresponding period, the previous CPUE indices were also very similar to the updated trip strata indices. The recent trends were also very similar for the effort strata and trip strata indices (Figure 20).

The standardised CPUE indices increased steadily from a relatively low level in 1997/98–1999/2000 to reach a peak in 2007/08–2009/10, declined in 2010/11 and 2011/12 and remained at a similar level in 2012/13. Over the last three years, the CPUE indices remained above the longer term average level (Figure 21f and Table 19). The magnitude of the increase in the CPUE indices over the entire time series (from 1989/90) is similar to the change in the trawl survey biomass estimates over the same period (Figure 21j). Annual catches of red gurnard were at or above the TACC from 2004/05 to 2011/12 (Figure 21h).

Since 2007/08, there was a general increase in the depth fished by the MIX trawl fleet (Figure 22n). This trend corresponded with a general decrease in the proportion of the total fishing effort (for the defined fishery) that occurred in the more productive spatial cells (0.1 lat/long cells); i.e. those spatial cells that accounted for the top 25% or 50% of the cumulative red gurnard catch (for all years combined) (Figure 22o). This may indicate a decline in the level of effective fishing effort with regard to red gurnard, although there was some reversal of this trend in the most recent year (2012/13).

The number of individual spatial cells that accounted for 25%, 50% and 75% of the annual red gurnard catch from the defined fishery was relatively stable over the recent period (from 2007/08) (Figure 22p), although the overall level of annual catch declined (Figure 19a).

The overall trend in the CPUE indices from the GUR 3 MIX fishery is similar to the indices derived for the GUR 3 FLA fishery (see Section 3.4), although the recent decline in CPUE from the MIX fishery was not evident for the FLA fishery. The difference between the recent indices may be partly explained by the apparent shift in MIX fishing effort from the more productive red gurnard spatial cells.

The SINS WG has adopted a composite CPUE index derived from the average of the MIX and FLA CPUE indices as an abundance index for GUR 3. The rationale for combining the two indices is that the two fisheries are spatially distinct and collectively the two indices cover the entire distribution of red gurnard. The trend in both sets of indices is generally comparable, providing some confidence that these series are likely to be tracking abundance.

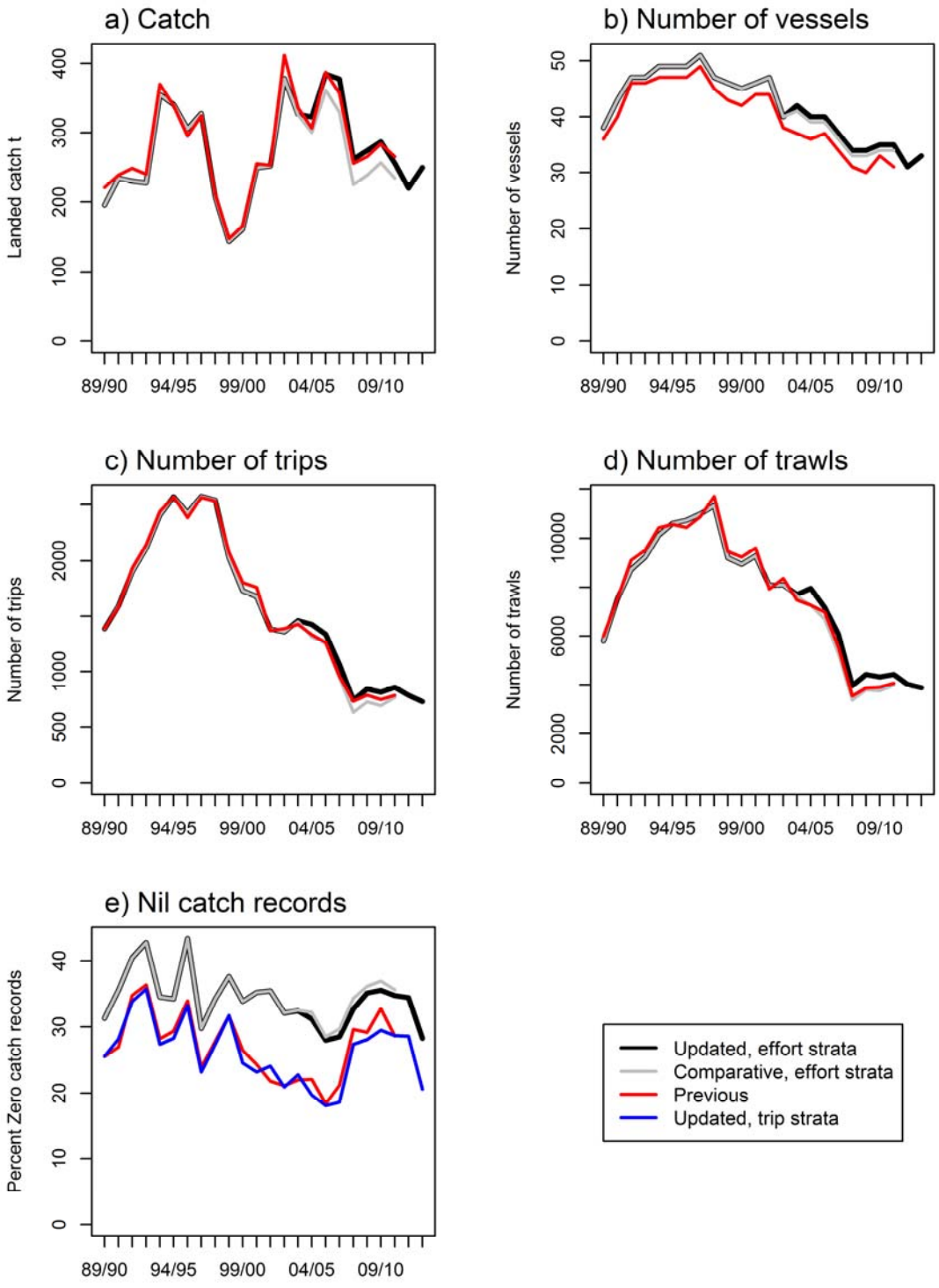

Figure 19: **Annual total landed species catch (green weight, t) (panel a), number of (core) vessels (panel b), number of fishing trips (panel c), number of fishing events (trawls) (panel d) and percentage of records with nil species catch (panel e) included in the previous, comparative and updated CPUE data sets for the GUR 3 ECSI MIX trawl fishery.**

Table 18: Summary of catch and effort (effort strata) included in the final data set (including zero species catch records) for the GUR 3 ECSI MIX trawl fishery.

Fishing year	No. of records	No. of vessel	No of trips	Catch (t)	No. of trawls	Fishing duration (hrs)	Percent zero catch
1989/90	2 169	38	1 387	195.5	5 800	19 913	31.3
1990/91	2 680	43	1 593	234.2	7 533	25 138	35.5
1991/92	3 176	47	1 902	229.8	8 740	31 304	40.5
1992/93	3 491	47	2 116	227.6	9 245	33 230	42.8
1993/94	3 701	49	2 410	355.1	10 136	32 703	34.5
1994/95	3 989	49	2 571	340.9	10 608	34 820	34.2
1995/96	3 988	49	2 425	305.4	10 735	34 298	43.4
1996/97	3 894	51	2 574	327.8	10 980	34 633	29.8
1997/98	3 836	47	2 540	207.2	11 330	33 717	34.2
1998/99	3 219	46	2 030	143.3	9 207	27 777	37.6
1999/00	3 013	45	1 730	160.9	8 949	27 828	33.8
2000/01	3 008	46	1 679	249.0	9 298	29 076	35.2
2001/02	2 604	47	1 385	251.7	8 072	25 411	35.4
2002/03	2 617	40	1 361	378.2	8 096	26 641	32.1
2003/04	2 702	42	1 460	326.6	7 706	25 591	32.4
2004/05	2 748	40	1 426	322.8	7 955	27 156	31.2
2005/06	2 515	40	1 337	384.5	7 179	24 832	28.0
2006/07	2 084	37	1 064	377.6	6 083	22 510	28.5
2007/08	1 473	34	743	261.7	3 966	14 313	32.7
2008/09	1 653	34	844	274.2	4 428	16 257	35.1
2009/10	1 621	35	814	286.8	4 323	15 801	35.5
2010/11	1 675	35	859	256.1	4 424	16 291	34.7
2011/12	1 528	31	787	219.8	4 020	14 240	34.4
2012/13	1 434	33	729	249.8	3 881	13 281	28.3

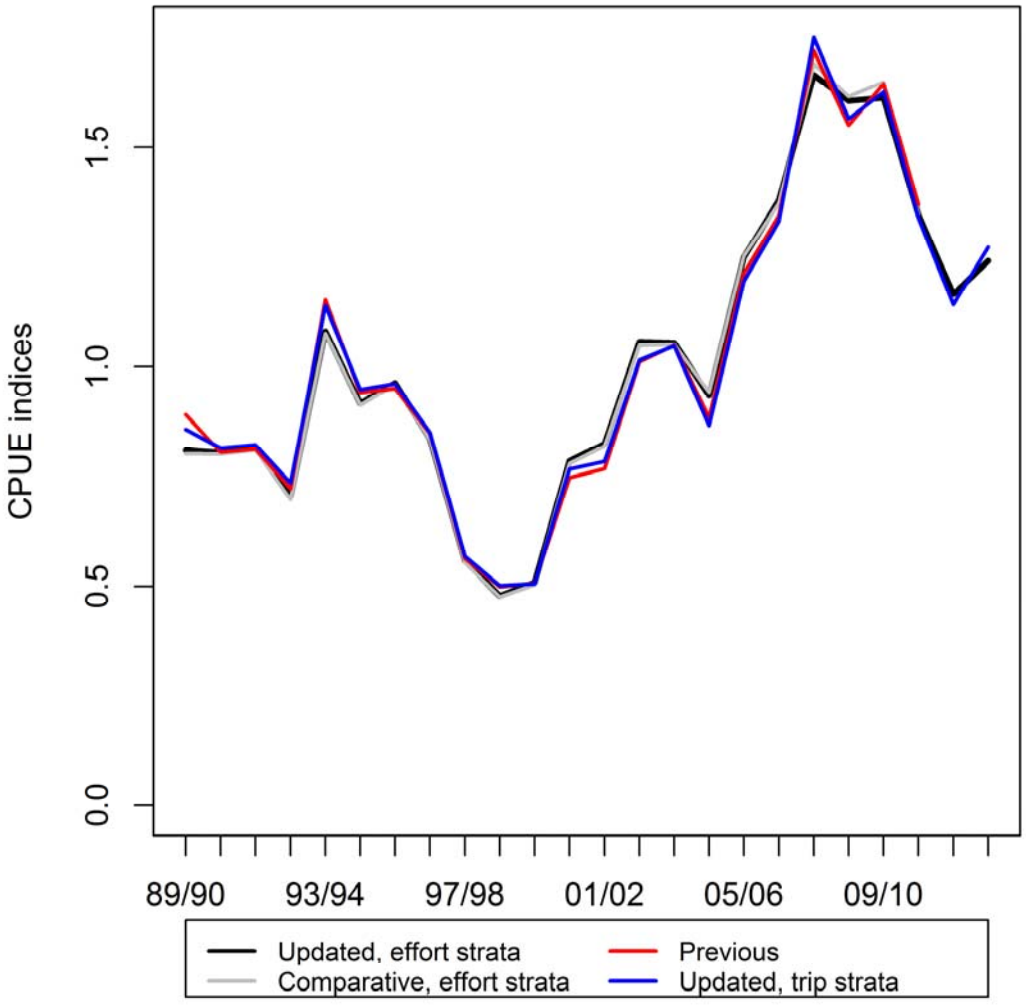

Figure 20: **Annual CPUE indices for the GUR 3 ECSI MIX trawl fishery from the previous, comparative and updated CPUE models. The indices are normalised to the average of the years included in the previous CPUE model.**

Table 19: Final CPUE model indices and lower and upper bounds of the 95% confidence interval.

Fishing year	Index	LCI	UCI
1989/90	0.810	0.743	0.884
1990/91	0.805	0.738	0.878
1991/92	0.817	0.750	0.890
1992/93	0.705	0.647	0.767
1993/94	1.080	0.995	1.173
1994/95	0.916	0.845	0.994
1995/96	0.964	0.887	1.047
1996/97	0.837	0.772	0.908
1997/98	0.557	0.513	0.605
1998/99	0.479	0.439	0.522
1999/00	0.509	0.467	0.554
2000/01	0.786	0.720	0.857
2001/02	0.825	0.754	0.902
2002/03	1.057	0.967	1.155
2003/04	1.054	0.964	1.152
2004/05	0.935	0.856	1.021
2005/06	1.250	1.144	1.366
2006/07	1.380	1.257	1.515
2007/08	1.666	1.502	1.849
2008/09	1.607	1.451	1.779
2009/10	1.614	1.457	1.787
2010/11	1.347	1.218	1.490
2011/12	1.164	1.050	1.292
2012/13	1.242	1.120	1.377

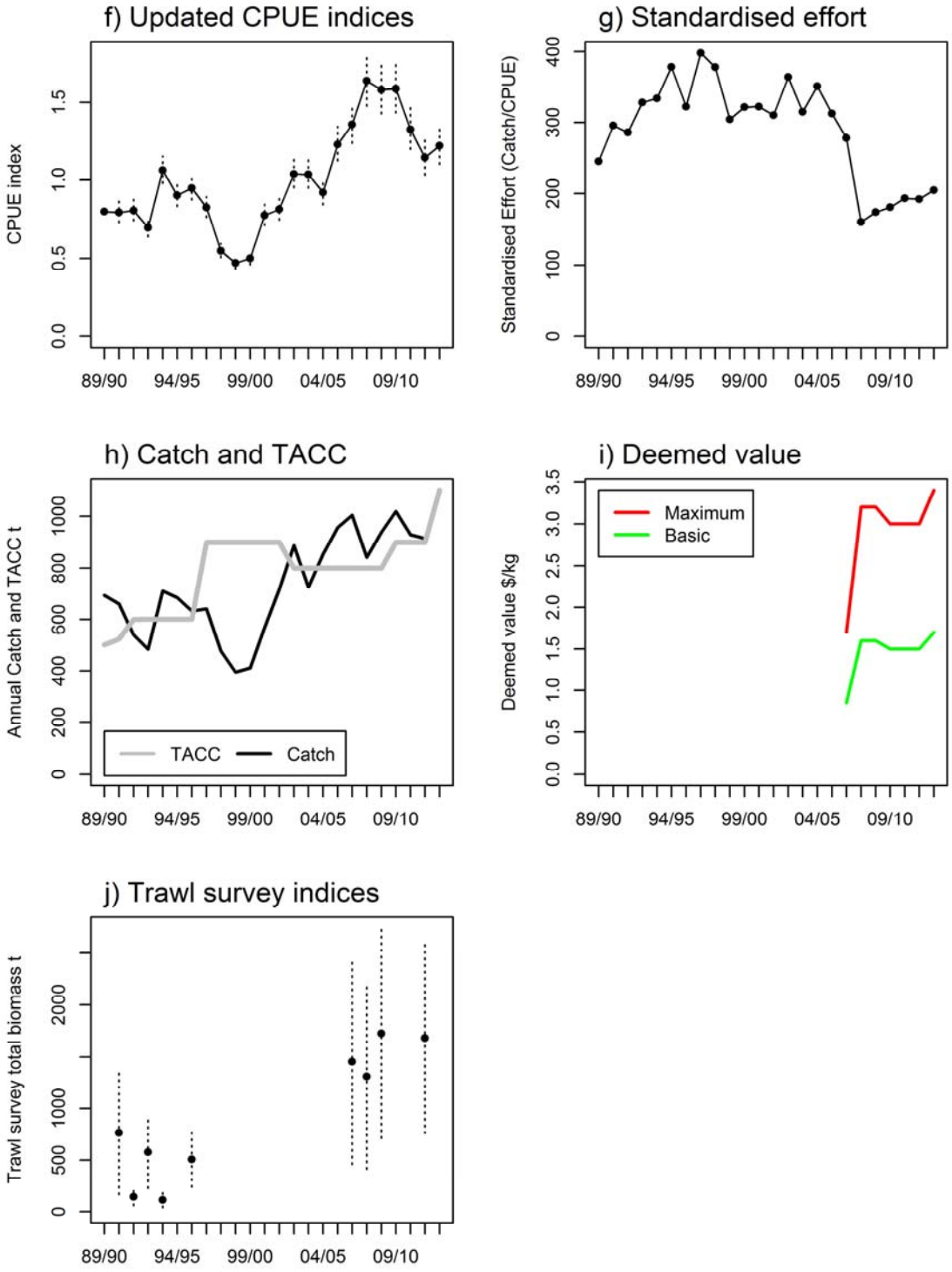

Figure 21: **A range of fishery indicators for the GUR 3 fishstock (see Section 2.3 for details): updated standardised CPUE indices with associated 95% confidence intervals (panel f), standardised fishing effort (annual CPUE catches divided by standardised CPUE indices) (panel g), total annual catches and TACC (panel h), annual deemed value penalties (panel i), and trawl survey total biomass estimates (and 95% confidence intervals) from the winter inshore ECSI trawl survey (panel j).**

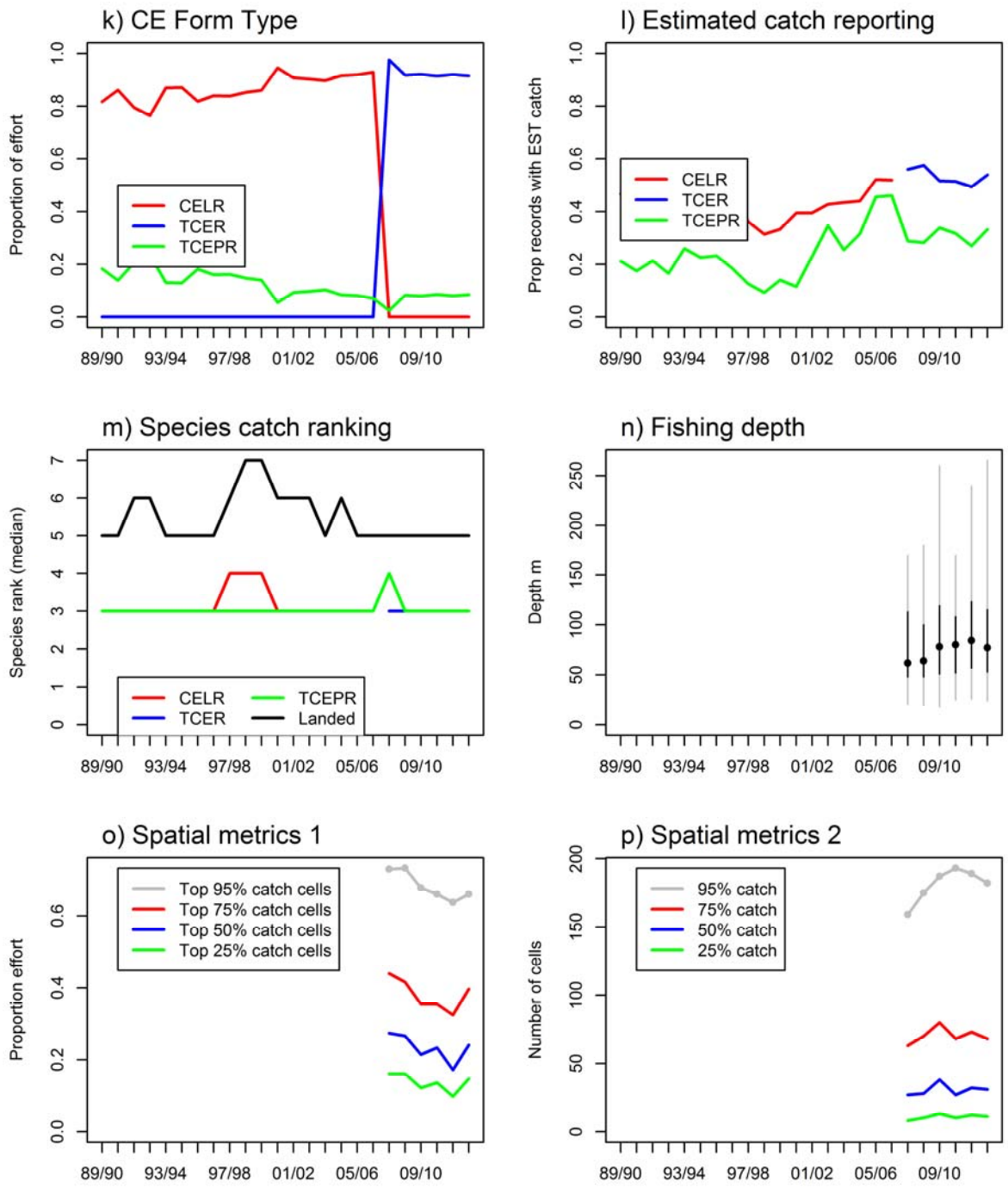

Figure 22: **A summary of the catch and effort included in the GUR 3 ECSI MIX trawl fishery data set (see Section 2.3 for details): proportion of effort records by form type (panel k), proportion of effort records with an associated estimated catch of the species (panel l), median species rank from associated estimated catch records and landed catch records (panel m), fishing depth of effort records from TCER and TCEPR forms (median, quartile range and 95% interval) (panel n), and spatial metrics derived from TCER and TCEPR fishing records (panels o and p).**

3.6 GUR 7 WCSI FLA Trawl

The GUR 7 WCSI FLA Trawl fishery definition includes trawl fishing effort records targeting flatfish off the west coast of the South Island. The previous CPUE analysis of Kendrick et al. (2011) was based on data aggregated at the trip stratum level. The current CPUE analyses extended the trip strata analysis by one year to include 2010/11–2012/13. CPUE indices were also derived using data aggregated at the effort strata level for two time periods: a period equivalent to the original analysis (to 2009/10) and for the entire period (to 2012/13). The formulation of the CPUE model applied to the effort stratum data was equivalent to the original model (for trip stratum data) (Table 20).

Table 20: A summary of the specific data selection criteria used to configure the GUR 7 WCSI FLA Trawl data set. The formulation of the CPUE model and model error structure is also presented.

Criteria	Range
Fishing year	1989/90 to 2012/13
Fishstock landed catch	GUR 7
Method	BT
Target species	FLA
Statistical areas	033, 034, 035, 036
Max species catch	2000 kg
Core fleet	≥ 5 trips ≥ 5 years
Data aggregation	Effort strata (and trip strata for comparative purposes)
CPUE model	log(catch) ~ fyear + vessel_key + poly(log(num trawls),3)
Model error structure	lognormal (zero catch records excluded)

A comparison of the previous and current data sets revealed comparable levels of total annual catch and fishing effort (number of vessels, fishing trips and number of trawls) for the corresponding period (Figure 23a–d and Table 21), with the exception of lower catches from the comparative data set in 2002/03–2004/05. The differences in annual catch are most likely attributable to differences in the grooming routines applied to the landed catch data. The proportion of nil catch records was also comparable for the previous and the updated trip strata data sets (Figure 23e). There was a higher proportion of nil catch records in the effort strata data sets compared to the trip strata data sets. This is consistent with the higher resolution of the effort strata data; i.e. the occurrence of zero catch records is lower when the data are aggregated by trip rather than fishing day.

The resulting CPUE indices were very similar for all model options (data aggregation and time period) (Figure 24). The CPUE indices derived from the effort strata CPUE model, for both the corresponding time period and the extended time period, were very similar to the CPUE indices from the previous trip strata analysis. For the corresponding period, the previous CPUE indices were also very similar to the updated trip strata indices. The recent trends were also very similar for the effort strata and trip strata indices (Figure 24).

The CPUE indices increased considerably from 2009/10 to 2012/13 (Figure 25a and Table 22). This recent increase in CPUE is consistent with the cyclical variability in CPUE observed over the entire data period with previous periods of higher CPUE in 1989/90–1991/92 and 2000/01–2003/04. The CPUE index for 2012/13 is above the average level for the entire period

Trawl survey indices indicate an increase in red gurnard abundance from the mid 2000s, although the survey indices do not exhibit the cyclical pattern of the CPUE indices (Figure 25j). The trawl survey indices are not directly comparable with the CPUE indices; the trawl survey biomass estimates

include both the west coast South Island and Tasman Bay/Golden Bay areas and include both pre-recruit and recruited fish (i.e. total biomass). A more thorough analysis of the trawl survey data is required to formulate trawl survey indices that are more directly comparable with the CPUE indices.

Since 2007/08, there has been some minor variability in the depth fished between years, although there is no systematic trend (Figure 26n). There was no strong trend evident in the distribution of fishing effort (for the defined fishery) relative to the more productive spatial cells (0.1 lat/long cells); i.e. those spatial cells that accounted for the top 25% or 50% of the cumulative red gurnard catch (for all years combined) (Figure 26o).

Similarly, the number of individual spatial cells that accounted for 25% and 50% of the annual red gurnard catch from the defined fishery was comparable over the recent period (from 2007/08) (Figure 26p). Collectively, these metrics do not indicate a strong shift in fishing effort relative to the distribution of red gurnard in recent years.

The overall trend in the CPUE indices from the GUR 7 WCSI FLA fishery is similar to the indices derived for the GUR 7 WCSI MIX fishery (see Section 3.7), although the variation in CPUE indices over the last 10 years is less pronounced in the MIX fishery.

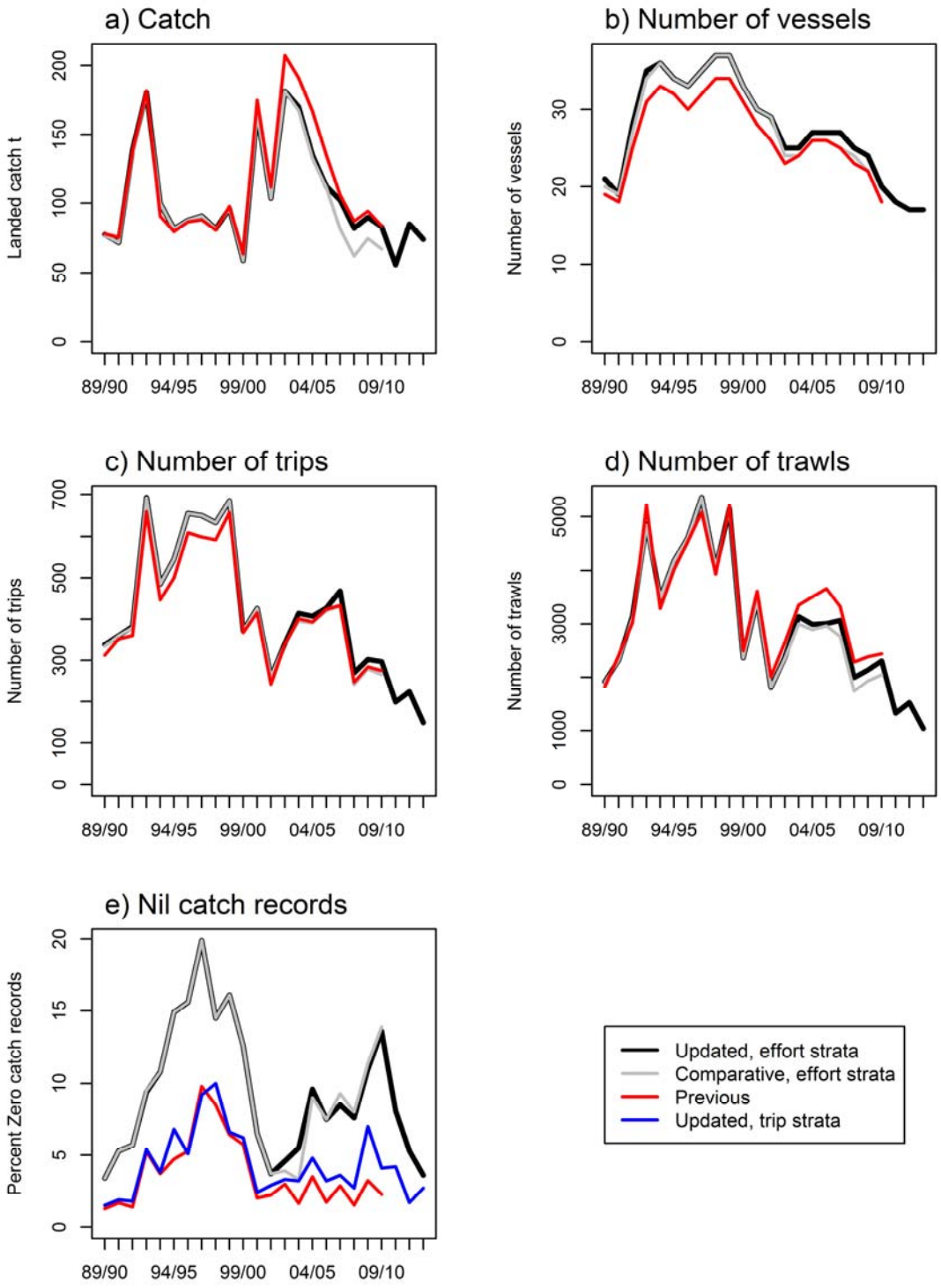

Figure 23: **Annual total landed species catch (green weight, t) (panel a), number of (core) vessels (panel b), number of fishing trips (panel c), number of fishing events (trawls) (panel d) and percentage of records with nil species catch (panel e) included in the previous, comparative and updated CPUE data sets for the GUR 7 WCSI FLA trawl fishery.**

Table 21: Summary of catch and effort (effort strata) included in the final data set (including zero species catch records) for the GUR 7 WCSI FLA trawl fishery.

Fishing year	No. of records	No. of vessel	No of trips	Catch (t)	No. of trawls	Fishing duration (hrs)	Percent zero catch
1989/90	681	21	338	77.4	1 917	6 471	3.4
1990/91	798	19	360	71.7	2 324	7 630	5.3
1991/92	985	28	382	138.7	3 148	10 056	5.7
1992/93	1 557	35	693	180.4	4 869	15 902	9.4
1993/94	1 160	36	485	99.9	3 489	11 360	10.8
1994/95	1 359	34	545	81.4	4 178	13 341	14.9
1995/96	1 541	33	655	87.6	4 620	14 848	15.6
1996/97	1 736	35	650	90.8	5 355	17 335	19.9
1997/98	1 385	37	633	81.4	4 053	12 838	14.5
1998/99	1 685	37	685	96.0	5 147	16 351	16.1
1999/00	841	33	372	58.8	2 365	8 020	12.6
2000/01	1 179	30	426	165.5	3 449	12 138	6.5
2001/02	648	29	259	103.6	1 809	6 533	3.7
2002/03	862	25	341	181.4	2 372	9 140	4.6
2003/04	1 115	25	414	170.0	3 137	11 441	5.5
2004/05	1 059	27	407	135.0	2 993	11 169	9.6
2005/06	1 140	27	427	112.3	3 009	11 186	7.5
2006/07	1 150	27	468	102.3	3 068	11 667	8.5
2007/08	772	25	270	81.8	1 995	8 771	7.6
2008/09	847	24	302	89.8	2 138	9 189	11.0
2009/10	844	20	297	83.0	2 307	9 640	13.6
2010/11	520	18	199	55.8	1 330	5 724	8.1
2011/12	608	17	224	84.9	1 524	6 774	5.3
2012/13	386	17	149	74.0	1 040	4 544	3.6

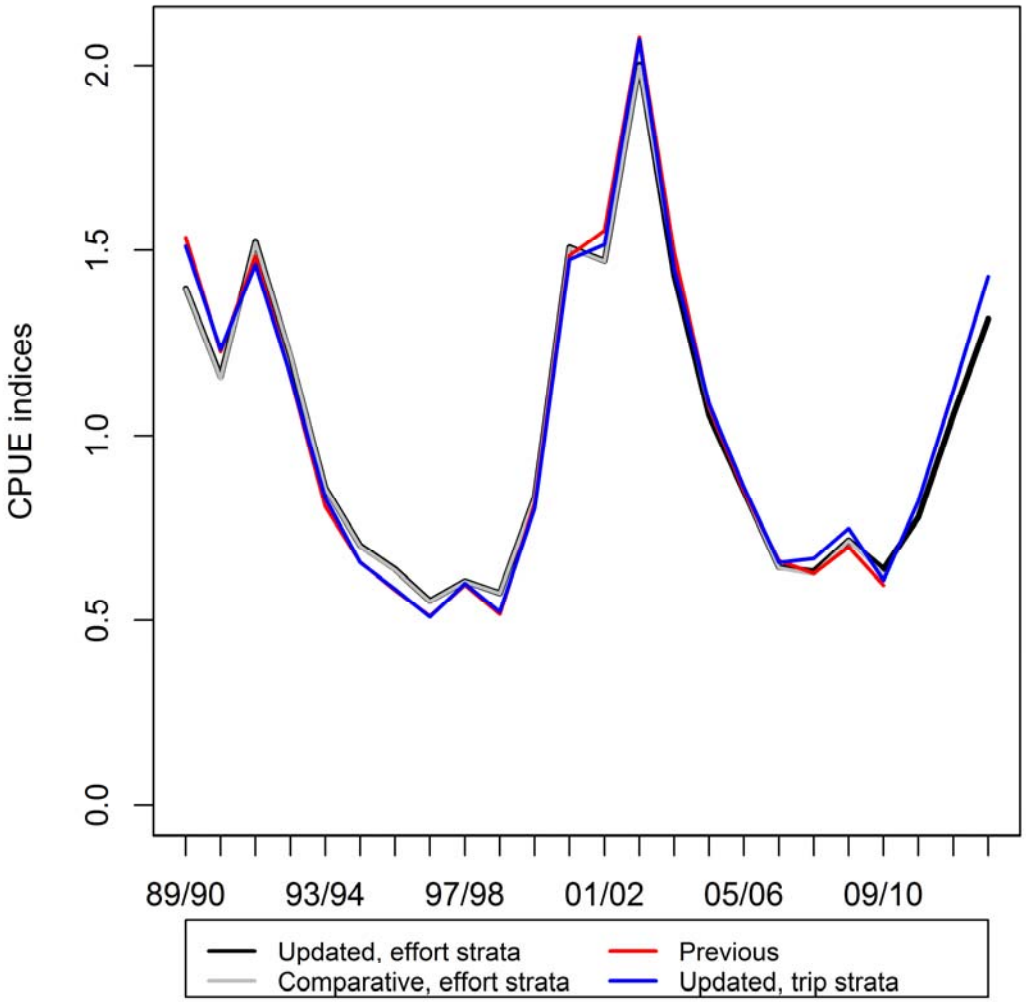

Figure 24: **Annual CPUE indices for the GUR 7 WCSI FLA trawl fishery from the previous, comparative and updated CPUE models. The indices are normalised to the average of the years included in the previous CPUE model.**

Table 22: Final CPUE model indices and lower and upper bounds of the 95% confidence interval for the GUR 7 WCSI FLA trawl fishery.

Fishing year	Index	LCI	UCI
1989/90	1.396	1.396	1.396
1990/91	1.158	1.066	1.259
1991/92	1.525	1.408	1.652
1992/93	1.211	1.124	1.304
1993/94	0.857	0.793	0.927
1994/95	0.702	0.650	0.758
1995/96	0.639	0.591	0.690
1996/97	0.553	0.512	0.597
1997/98	0.607	0.560	0.657
1998/99	0.574	0.531	0.620
1999/00	0.831	0.762	0.907
2000/01	1.509	1.392	1.635
2001/02	1.470	1.343	1.610
2002/03	2.003	1.838	2.183
2003/04	1.431	1.318	1.554
2004/05	1.055	0.970	1.147
2005/06	0.848	0.781	0.921
2006/07	0.643	0.592	0.698
2007/08	0.632	0.578	0.692
2008/09	0.717	0.656	0.783
2009/10	0.639	0.583	0.699
2010/11	0.778	0.704	0.860
2011/12	1.055	0.959	1.161
2012/13	1.313	1.181	1.461

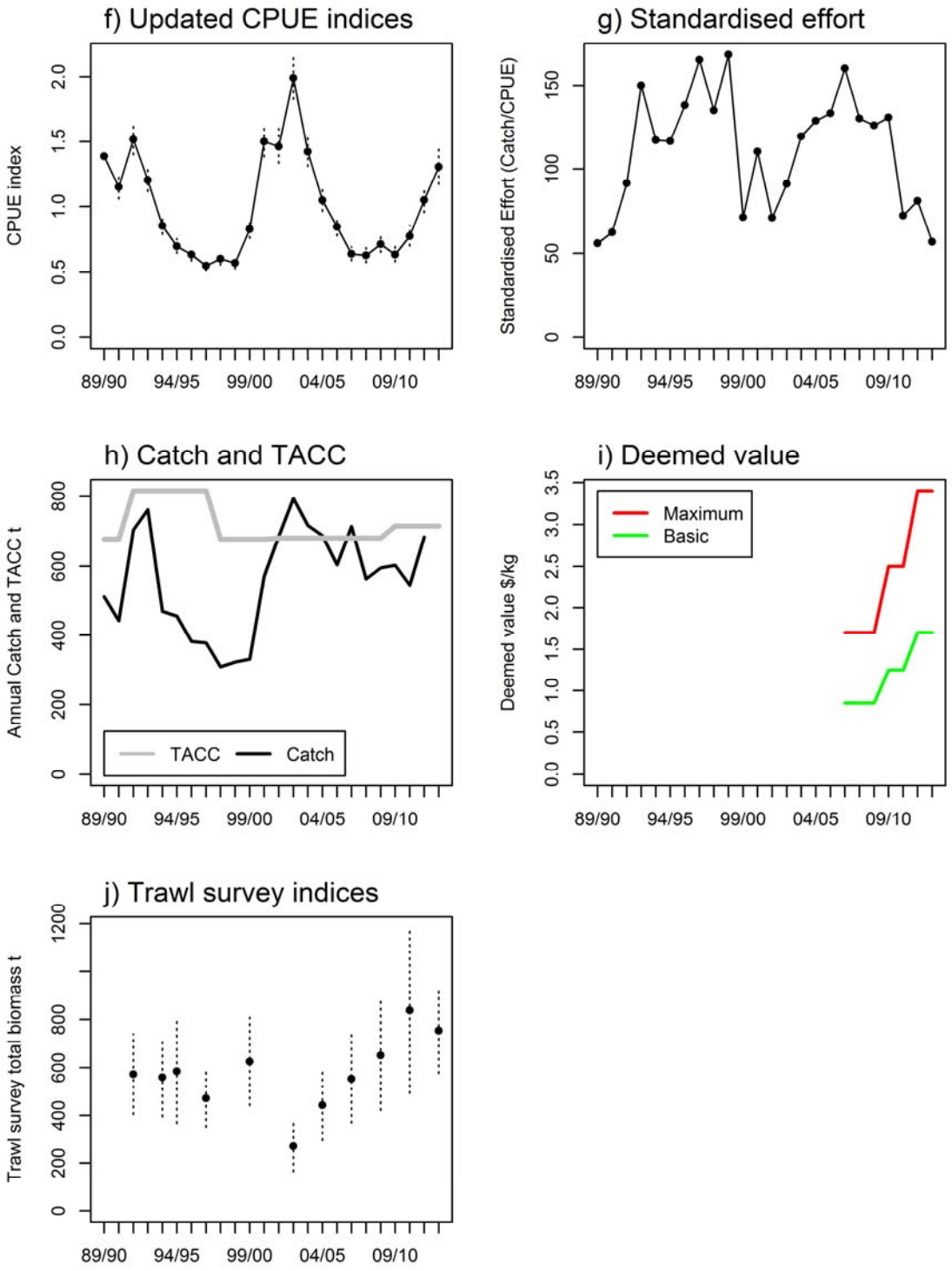

Figure 25: **A range of fishery indicators for the WCSI area of the GUR 7 fishstock (see Section 2.3 for details): updated standardised CPUE indices with associated 95% confidence intervals (panel f), standardised fishing effort (annual CPUE catches divided by standardised CPUE indices) (panel g), total annual catches and TACC (panel h), annual deemed value penalties (panel i), and trawl survey total biomass estimates (and 95% confidence intervals) from the inshore WCSI trawl survey (panel j).**

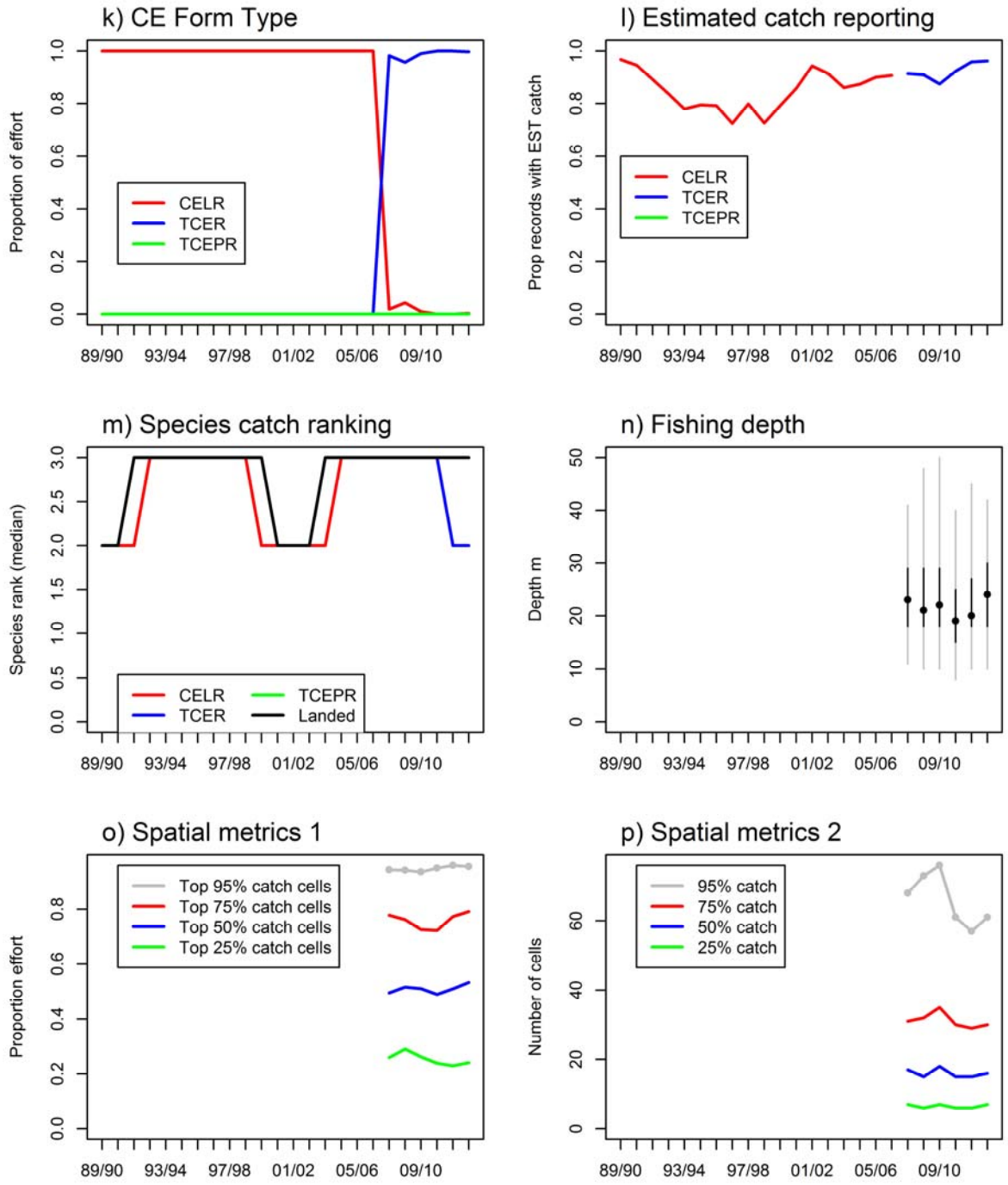

Figure 26: **A summary of the catch and effort included in the GUR 7 WCSI FLA trawl fishery data set (see Section 2.3 for details): proportion of effort records by form type (panel k), proportion of effort records with an associated estimated catch of the species (panel l), median species rank from associated estimated catch records and landed catch records (panel m), fishing depth of effort records from TCER and TCEPR forms (median, quartile range and 95% interval) (panel n), and spatial metrics derived from TCER and TCEPR fishing records (panels o and p).**

3.7 GUR 7 WCSI Mix Trawl

The GUR 7 WCSI MIX Trawl fishery definition includes trawl fishing effort records targeting tarakihi, barracouta, blue warehou, red cod and/or stargazer off the west coast of the South Island. The previous CPUE analysis of Kendrick et al. (2011) was based on data aggregated at the trip strata level. The current CPUE analyses extended the trip strata analysis to include 2010/11–2012/13. CPUE indices were also derived using data aggregated at the effort strata level for two time periods: a period equivalent to the original analysis (to 2009/10) and for the entire period (to 2012/13). The formulation of the CPUE model applied to the effort strata data was equivalent to the original model (for trip strata data) (Table 23).

Table 23: A summary of the specific data selection criteria used to configure the GUR 7 WCSI Mix Trawl data set. The formulation of the CPUE model and model error structure is also presented.

Criteria	Range
Fishing year	1989/90 to 2012/13
Fishstock landed catch	GUR 7
Method	BT
Target species	RCO, TAR, BAR, STA, WAR
Statistical areas	033, 034, 035, 036
Max species catch	2500 kg
Core fleet	≥ 5 trips ≥ 4 years
Data aggregation	Effort strata (and trip strata for comparative purposes)
CPUE model	log(catch) ~ fyear + poly(log(num trawls),3) + vessel_key + month + target + area
Model error structure	lognormal (zero catch records excluded)

A comparison of the previous and current data sets revealed comparable levels of total annual catch and fishing effort (number of vessels, fishing trips and number of trawls) for the corresponding period (Figure 27a–d). The proportion of nil catch records was also comparable for the previous and the updated trip strata data sets (Figure 27e). There was a higher proportion of nil catch records in the effort strata data sets compared to the trip strata data sets (Figure 27e and Table 24). This is consistent with the higher resolution of the effort strata data; i.e. the occurrence of zero catch records is lower when the data are aggregated by trip rather than fishing day.

The resulting CPUE indices were very similar for all model options (data aggregation and time period) (Figure 28). The CPUE indices derived from the effort strata CPUE model, for both the corresponding time period and the extended time period, were very similar to the CPUE indices from the previous trip strata analysis. For the corresponding period, the previous CPUE indices were also very similar to the updated trip strata indices. The recent trends were also very similar for the effort strata and trip strata indices (Figure 28).

The CPUE indices increased considerably from 2009/10 to 2012/13 (Figure 29a and Table 25). This recent increase in CPUE is consistent with the cyclical variability in CPUE observed over the entire data period; previous periods of high CPUE occurred in 1990/91–1991/92 and 2001/02–2004/05. The CPUE index for 2012/13 is above the average level for the entire period.

Trawl survey indices indicate an increase in red gurnard abundance from the mid 2000s, although the survey indices do not exhibit the cyclical pattern of the CPUE indices (Figure 29j). The trawl survey indices are not directly comparable with the CPUE indices; the trawl survey biomass estimates include both the west coast South Island and Tasman Bay/Golden Bay areas and include both pre-

recruit and recruited fish (i.e. total biomass). A more thorough analysis of the trawl survey data is required to formulate trawl survey indices that are more directly comparable with the CPUE indices.

Since 2007/08, the depth distribution fished by the defined fleet has remained relatively stable (Figure 30n). However, there was a steady increase in the proportion of fishing effort (for the defined fishery) that occurred in the more productive spatial cells (0.1 lat/long cells); i.e. the proportion of the annual fishing effort that occurred in those spatial cells that accounted for the top 25% or 50% of the cumulative red gurnard catch (for all years combined) increased over time (Figure 30o).

Conversely, there was a reduction, albeit relatively small, in the number of spatial cells fished to attain the top 25% and 50% of the total catch (by spatial cell) from the fleet (Figure 30p). The trends in these two spatial metrics may indicate that the catchability of red gurnard in the fishery increased over recent years due to changes in the distribution of fishing effort.

The overall trend in the CPUE indices from the GUR 7 WCSI MIX fishery is similar to the indices derived for the GUR 7 WCSI FLA fishery (see Section 3.6), although the variation in CPUE indices over the last 10 years is less pronounced in the MIX fishery.

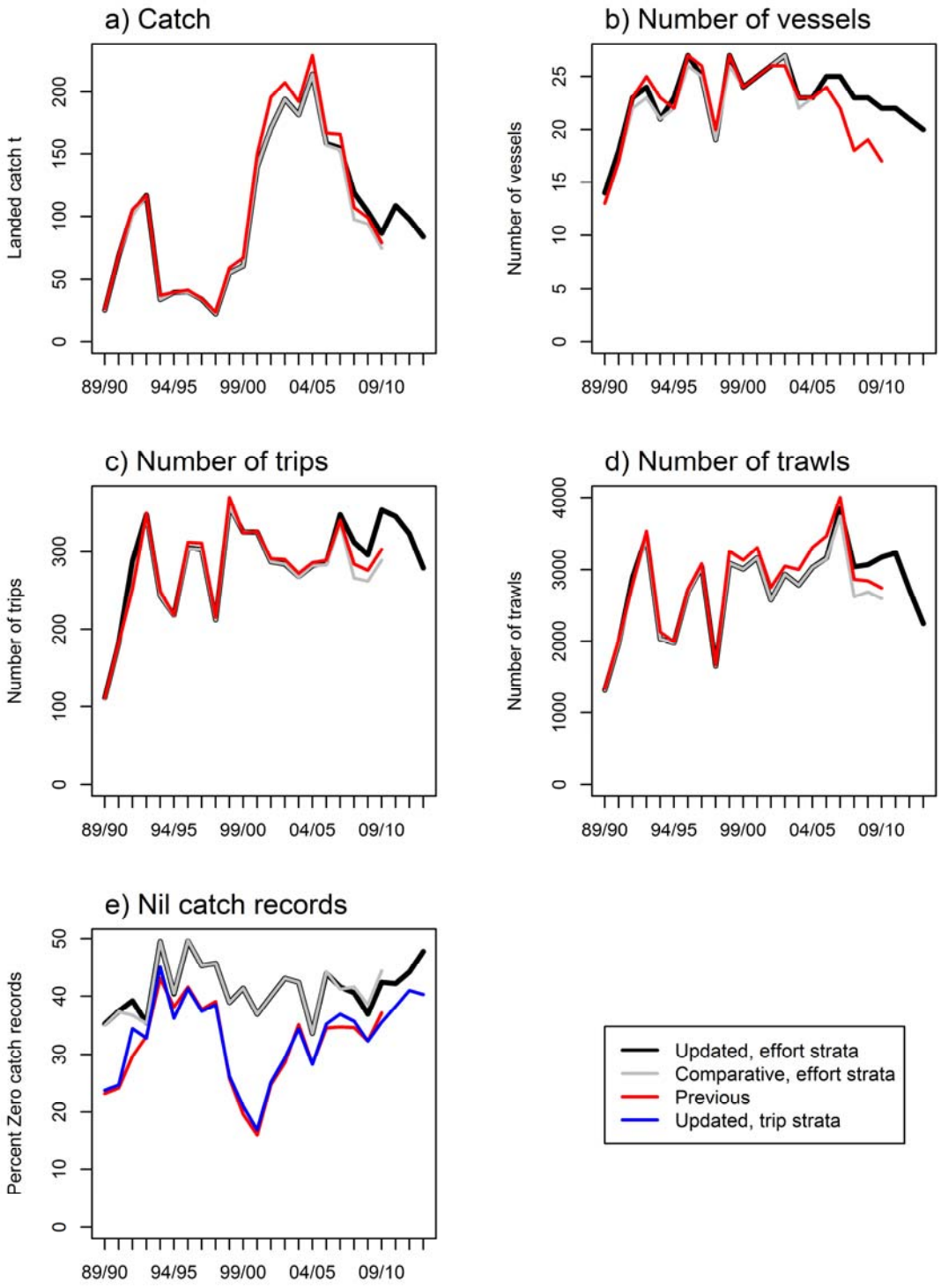

Figure 27: **Annual total landed species catch (green weight, t) (panel a), number of (core) vessels (panel b), number of fishing trips (panel c), number of fishing events (trawls) (panel d) and percentage of records with nil species catch (panel e) included in the previous, comparative and updated CPUE data sets for the GUR 7 WCSI MIX trawl fishery.**

Table 24: Summary of catch and effort (effort strata) included in the final data set (including zero species catch records) for the GUR 7 WCSI MIX trawl fishery.

Fishing year	No. of records	No. of vessel	No of trips	Catch (t)	No. of trawls	Fishing duration (hrs)	Percent zero catch
1989/90	506	14	111	25.6	1 314	4 554	35.2
1990/91	727	18	182	68.7	1 974	6 314	37.4
1991/92	1 015	23	288	103.3	2 891	10 374	39.2
1992/93	1 195	24	347	116.8	3 463	12 187	35.4
1993/94	745	21	243	34.0	2 031	6 632	49.5
1994/95	700	23	218	39.8	1 977	6 013	40.4
1995/96	954	27	305	40.3	2 690	8 501	49.6
1996/97	1 093	25	303	34.1	3 042	10 565	45.3
1997/98	621	19	212	22.5	1 652	5 738	45.7
1998/99	1 100	27	358	55.6	3 093	10 787	38.9
1999/00	1 084	24	325	61.0	3 008	11 027	41.4
2000/01	1 108	25	325	139.8	3 168	11 712	36.9
2001/02	901	26	287	171.0	2 579	8 509	40.0
2002/03	1 014	27	284	194.2	2 937	10 362	43.1
2003/04	1 007	23	268	181.7	2 787	10 636	42.4
2004/05	1 087	23	282	214.2	3 034	11 441	33.6
2005/06	1 112	25	286	158.4	3 165	11 862	44.0
2006/07	1 338	25	347	154.8	3 846	14 087	41.6
2007/08	1 171	23	312	118.9	3 041	13 104	40.6
2008/09	1 187	23	296	103.7	3 071	13 172	36.9
2009/10	1 218	22	353	86.4	3 177	12 667	42.4
2010/11	1 245	22	345	108.5	3 236	13 022	42.2
2011/12	1 067	21	323	97.8	2 724	11 203	44.2
2012/13	876	20	279	83.7	2 247	9 536	47.8

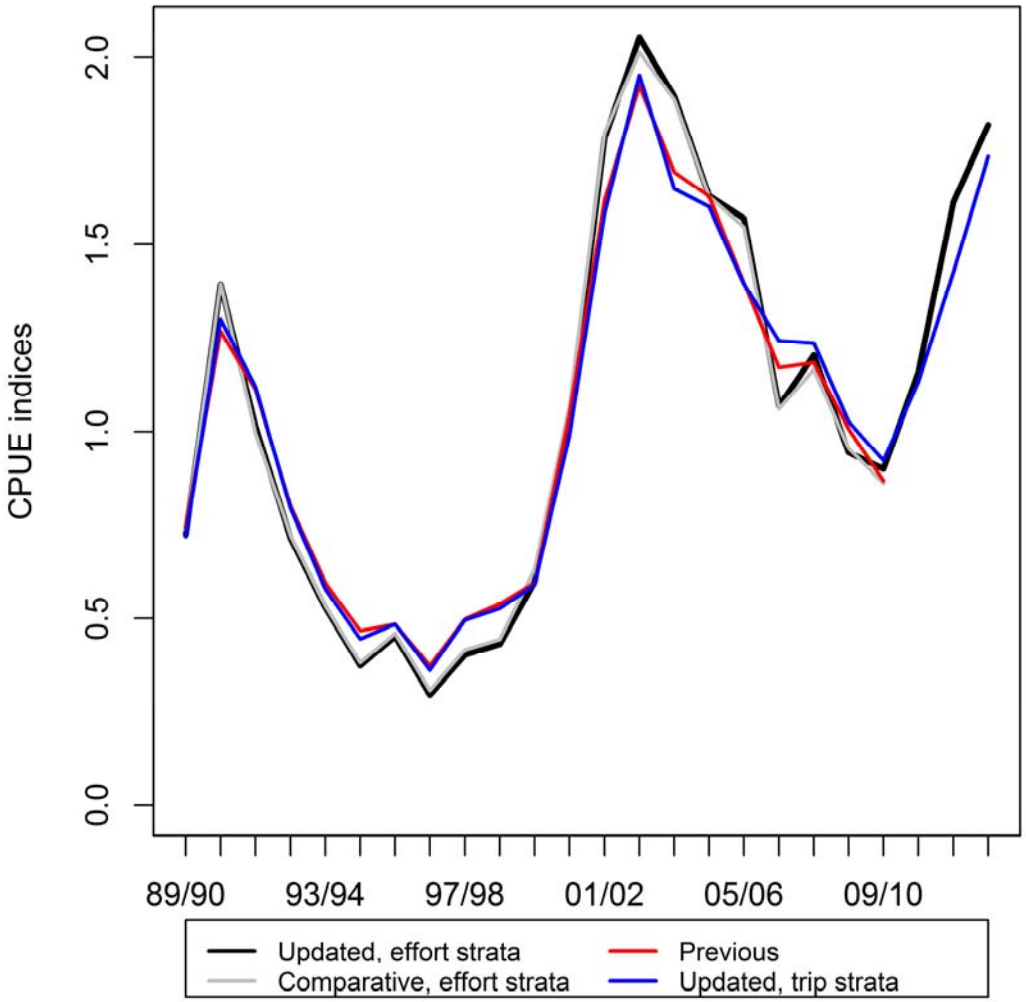

Figure 28: **Annual CPUE indices for the GUR 7 WCSI MIX trawl fishery from the previous, comparative and updated CPUE models. The indices are normalised to the average of the years included in the previous CPUE model.**

Table 25: Final CPUE model indices and lower and upper bounds of the 95% confidence interval for the GUR 7 WCSI MIX trawl fishery.

Fishing year	Index	LCI	UCI
1989/90	0.724	0.724	0.724
1990/91	1.392	1.128	1.718
1991/92	1.015	0.829	1.242
1992/93	0.714	0.586	0.870
1993/94	0.529	0.422	0.662
1994/95	0.372	0.297	0.467
1995/96	0.451	0.364	0.559
1996/97	0.295	0.240	0.364
1997/98	0.401	0.318	0.506
1998/99	0.430	0.350	0.529
1999/00	0.599	0.486	0.738
2000/01	1.034	0.842	1.270
2001/02	1.782	1.438	2.209
2002/03	2.052	1.657	2.542
2003/04	1.896	1.530	2.351
2004/05	1.629	1.322	2.007
2005/06	1.569	1.270	1.940
2006/07	1.068	0.870	1.310
2007/08	1.203	0.976	1.483
2008/09	0.944	0.768	1.160
2009/10	0.899	0.729	1.109
2010/11	1.158	0.939	1.429
2011/12	1.612	1.298	2.003
2012/13	1.819	1.449	2.284

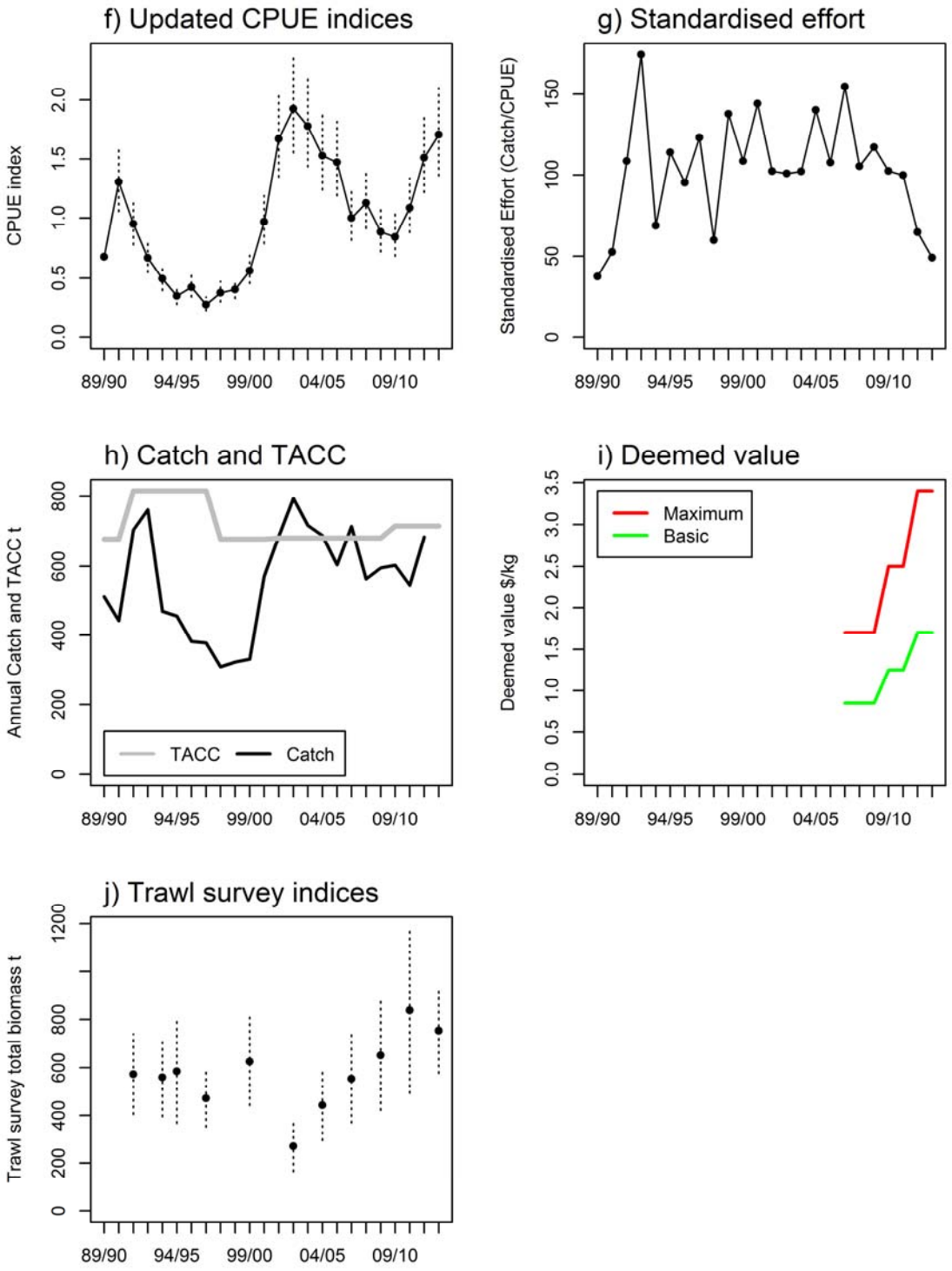

Figure 29: **A range of fishery indicators for the WCSI area of the GUR 7 fishstock (see Section 3.2 for details): updated standardised CPUE indices with associated 95% confidence intervals (panel f), standardised fishing effort (annual CPUE catches divided by standardised CPUE indices) (panel g), total annual catches and TACC (panel h), annual deemed value penalties (panel i), and trawl survey total biomass estimates (and 95% confidence intervals) from the inshore WCSI trawl survey (panel j).**

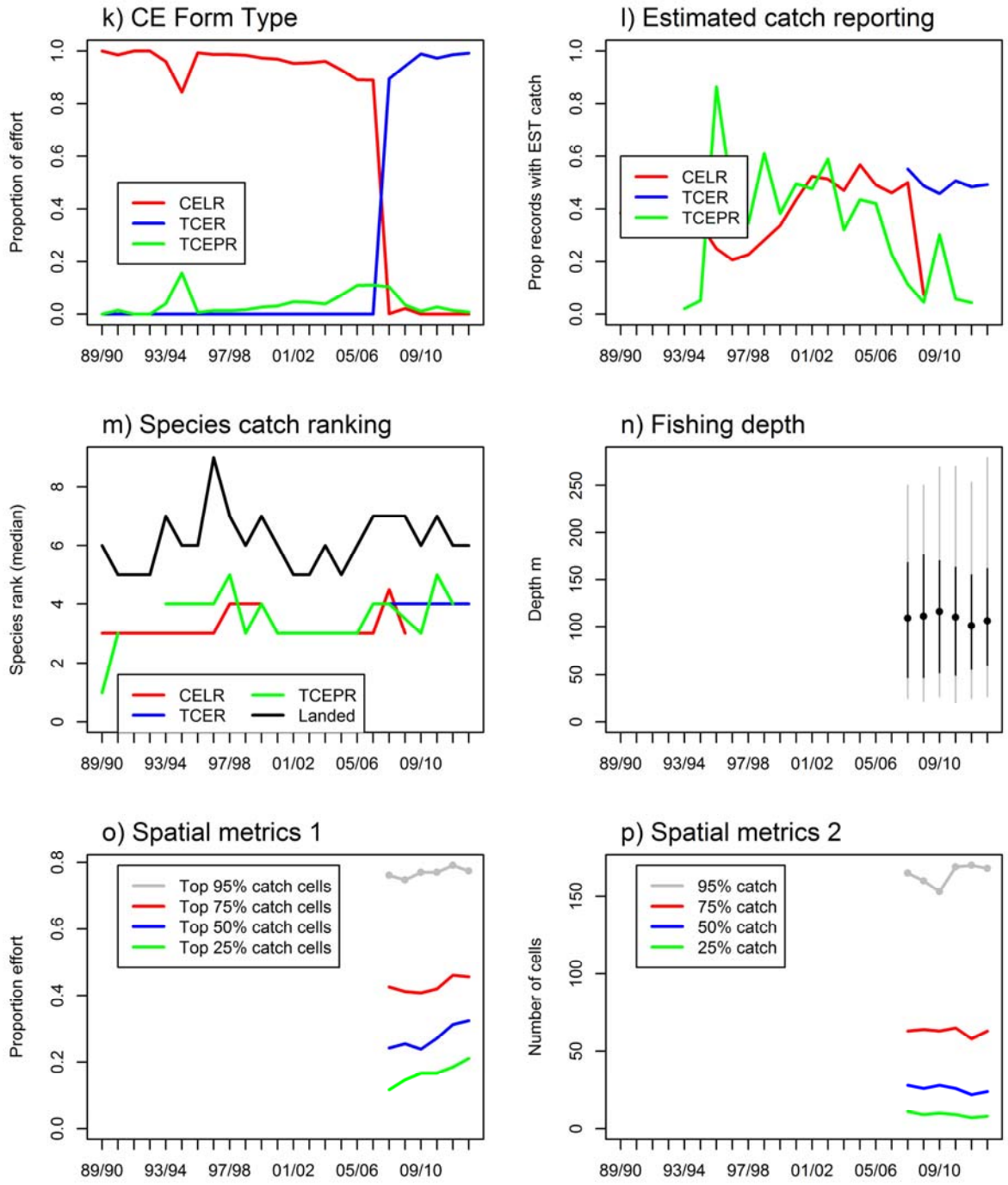

Figure 30: **A summary of the catch and effort included in the GUR 7 WCSI MIX trawl fishery data set (see Section 3.2 for details): proportion of effort records by form type (panel k), proportion of effort records with an associated estimated catch of the species (panel l), median species rank from associated estimated catch records and landed catch records (panel m), fishing depth of effort records from TCER and TCEPR forms (median, quartile range and 95% interval) (panel n), and spatial metrics derived from TCER and TCEPR fishing records (panels o and p).**

3.8 GUR 7 TBGB FLA Trawl

The GUR 7 TBGB Trawl fishery definition includes trawl fishing effort records targeting flatfish and red cod in Tasman Bay and Golden Bay. The previous CPUE analysis of Kendrick et al. (2011) was conducted based on data aggregated at the trip strata level. The current CPUE analyses extended the trip strata analysis to include 2010/11–2012/13. CPUE indices were also derived using data aggregated at the effort strata level for two time periods: a period equivalent to the original analysis (to 2009/10) and for the entire period (to 2012/13). The formulation of the CPUE model applied to the effort strata data was equivalent to the original model (for trip strata data) (Table 26).

Table 26: A summary of the specific data selection criteria used to configure the GUR 7 TBGB FLA Trawl data set. The formulation of the CPUE model and model error structure is also presented.

Criteria	Range
Fishing year	1989/90 to 2012/13
Fishstock landed catch	GUR 2, GUR 7, GUR 8
Method	BT
Target species	FLA, RCO
Statistical areas	038, 017
Max species catch	1000 kg
Core fleet	≥ 5 trips ≥ 5 years
Data aggregation	Effort strata (and trip strata for comparative purposes)
CPUE model	log(catch) ~ fyear + poly(log(duration),3) + vessel_key + area
Model error structure	lognormal (zero catch records excluded)

A comparison of the previous and current data sets revealed generally comparable levels of total annual catch and fishing effort (number of vessels, fishing trips and number of trawls) for the corresponding period (Figure 31a–d), although the current data sets included additional fishing effort in the earlier period (1989/90 to 1997/98). The proportion of nil catch records was also comparable for the previous and the updated trip strata data sets (Figure 31e). There was a higher proportion of nil catch records in the effort strata data sets compared to the trip strata data sets (Table 27). This is consistent with the higher resolution of the effort strata data; i.e. the occurrence of zero catch records is lower when the data are aggregated by trip rather than fishing day.

The resulting CPUE indices were very similar for all model options (data aggregation and time period) (Figure 32). The CPUE indices derived from the effort strata CPUE model, for both the corresponding time period and the extended time period, were very similar to the CPUE indices from the previous trip strata analysis. For the corresponding period, the previous CPUE indices were also very similar to the updated trip strata indices. The recent trends were also very similar for the effort strata and trip strata indices (Figure 32).

The CPUE indices declined during the early 1990s to a relatively low level during 1995/96–1998/99. The indices increased sharply in 1999/2000 and then remained relatively stable until 2007/2008. The CPUE indices increased considerably from 2009/10 to 2011/12 and declined slightly in 2012/13 (Figure 33a and Table 28). The recent indices include the two highest indices from the entire series and the indices from the three last years are well above the longer term average level.

Trawl survey indices indicate an increase in red gurnard abundance from the mid 2000s (Figure 33j) which is consistent with the trend in the CPUE indices, although there is some deviation between the two sets of indices during the preceding period. The trawl survey indices are not directly comparable

with the CPUE indices; the trawl survey biomass estimates include both the west coast South Island and Tasman Bay/Golden Bay areas and include both pre-recruit and recruited fish (i.e. total biomass). A more thorough analysis of the trawl survey data is required to formulate trawl survey indices that are more directly comparable with the CPUE indices.

Since 2007/08, the overall depth fished by the defined fleet tended to decrease (Figure 34n). There was also a steady increase in the proportion of fishing effort (for the defined fishery) that occurred in the more productive spatial cells (0.1 lat/long cells); i.e. the proportion of the annual fishing effort that occurred in those spatial cells that accounted for the top 25% and 50% of the cumulative red gurnard catch (for all years combined) increased over time (Figure 34o).

Conversely, there was a general decrease in the number of spatial cells fished to attain the top 25% and 50% of the total catch (by spatial cell) from the fleet (Figure 34p). The trends in these two spatial metrics may indicate that the catchability of red gurnard in the fishery increased over recent years due to changes in the distribution of fishing effort.

The overall trend in the CPUE indices from the GUR 7 TBGB FLA fishery is similar to the indices derived for the GUR 7 TBCS MIX fishery for the period 1989/90 to 2004/05 (see Section 3.9). The indices deviate in the more recent years with the indices from the MIX fishery more highly variable among years and not exhibiting the recent high CPUE (from 2010/11 to 2012/13).

The CPUE indices from the GUR 7 TBGB FLA fishery differ considerably from the two sets of CPUE indices from the GUR 7 WCSI fisheries (FLA and MIX) (see Sections 3.6 and 3.7).

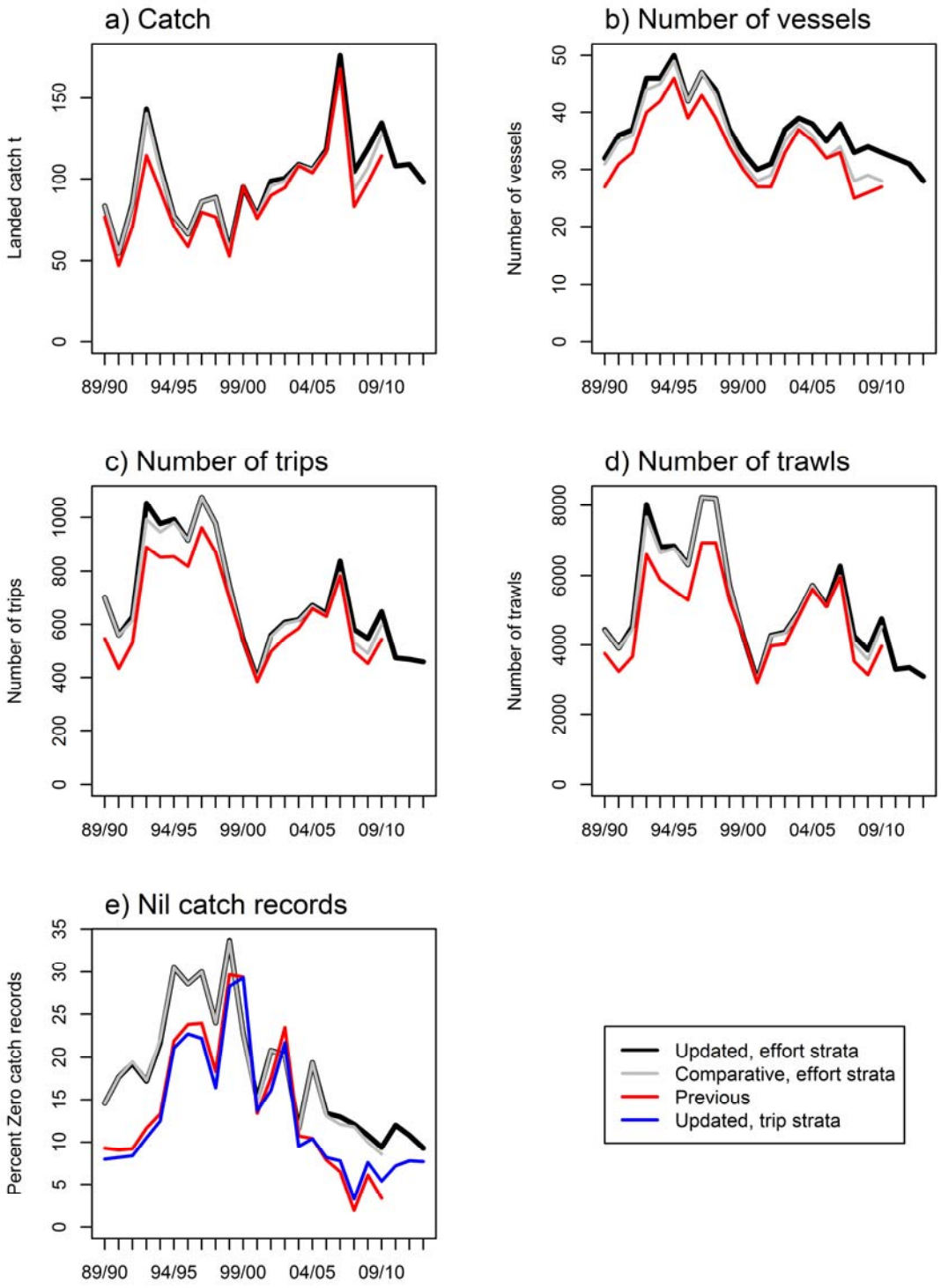

Figure 31: **Annual total landed species catch (green weight, t) (panel a), number of (core) vessels (panel b), number of fishing trips (panel c), number of fishing events (trawls) (panel d) and percentage of records with nil species catch (panel e) included in the previous, comparative and updated CPUE data sets for the GUR 7 TBGB FLA trawl fishery.**

Table 27: Summary of catch and effort (effort strata) included in the final data set (including zero species catch records) for the GUR 7 TBGB FLA trawl fishery.

Fishing year	No. of records	No. of vessel	No of trips	Catch (t)	No. of trawls	Fishing duration (hrs)	Percent zero catch
1989/90	1 325	32	701	83.4	4 440	9 547	14.6
1990/91	1 112	36	560	54.7	3 911	8 571	17.7
1991/92	1 387	37	629	85.2	4 537	10 955	19.3
1992/93	2 287	46	1 052	143.2	8 017	18 777	17.2
1993/94	2 087	46	977	107.7	6 822	15 380	21.7
1994/95	2 104	50	993	77.0	6 845	15 374	30.5
1995/96	2 050	42	916	66.1	6 312	14 990	28.6
1996/97	2 574	47	1 074	85.9	8 224	20 818	30.0
1997/98	2 628	44	977	88.8	8 197	21 728	24.0
1998/99	1 843	37	747	56.3	5 733	14 882	33.7
1999/00	1 298	33	543	95.2	4 255	10 593	22.8
2000/01	969	30	396	77.4	2 996	8 776	15.1
2001/02	1 425	31	560	98.6	4 281	12 969	20.8
2002/03	1 496	37	609	100.3	4 369	13 290	20.3
2003/04	1 664	39	618	109.1	4 947	15 499	11.6
2004/05	2 012	38	672	105.9	5 712	17 406	19.4
2005/06	1 854	35	642	118.3	5 141	16 334	13.4
2006/07	2 254	38	838	176.3	6 273	19 499	13.0
2007/08	1 589	33	581	104.6	4 257	12 903	12.1
2008/09	1 459	34	547	118.8	3 858	11 540	10.8
2009/10	1 737	33	648	134.6	4 757	13 483	9.4
2010/11	1 233	32	474	108.0	3 306	9 506	12.0
2011/12	1 210	31	469	109.1	3 353	9 273	10.8
2012/13	1 122	28	459	98.0	3 098	8 701	9.3

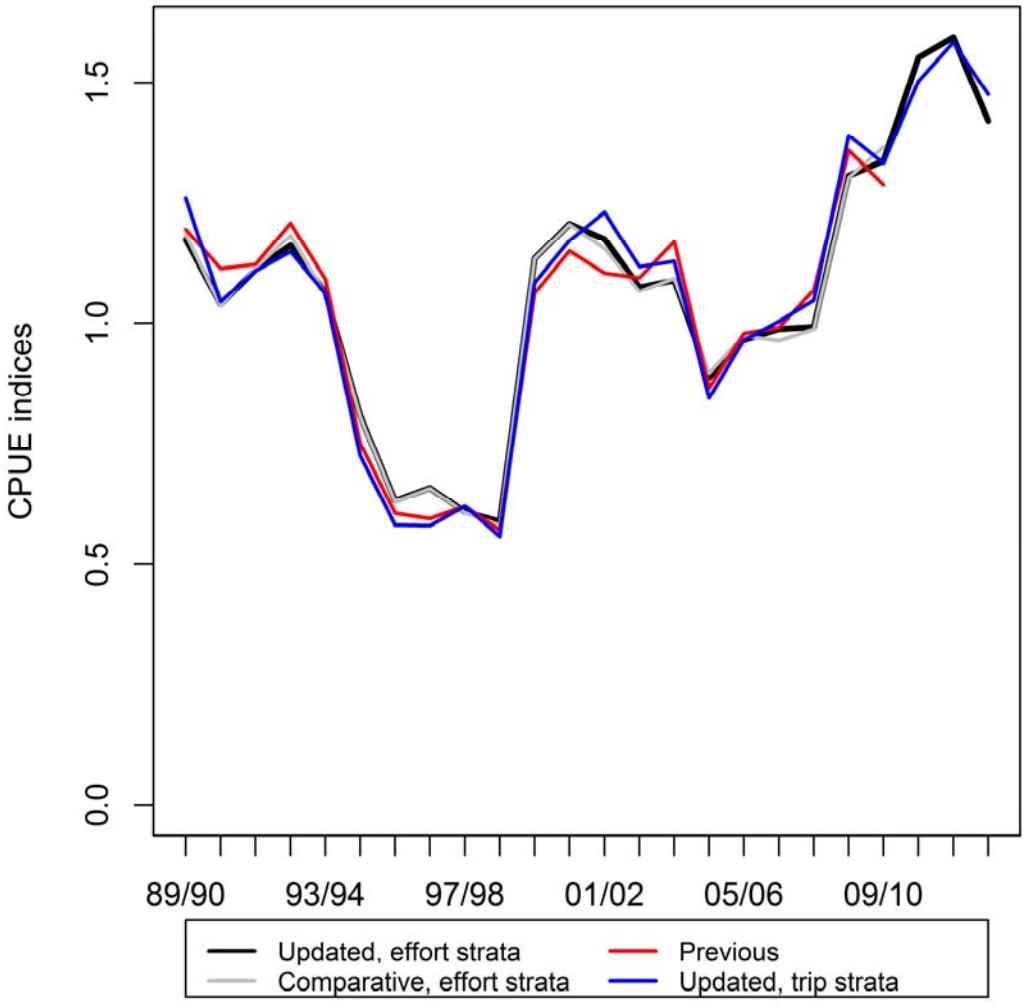

Figure 32: **Annual CPUE indices for the GUR 7 TBGB FLA trawl fishery from the previous, comparative and updated CPUE models. The indices are normalised to the average of the years included in the previous CPUE model.**

Table 28: Final CPUE model indices and lower and upper bounds of the 95% confidence interval for the GUR 7 TBGB FLA trawl fishery.

Fishing year	Index	LCI	UCI
1989/90	1.145	1.054	1.244
1990/91	1.012	0.932	1.100
1991/92	1.084	1.000	1.175
1992/93	1.134	1.054	1.219
1993/94	1.037	0.962	1.118
1994/95	0.789	0.731	0.852
1995/96	0.616	0.571	0.666
1996/97	0.642	0.596	0.692
1997/98	0.593	0.551	0.638
1998/99	0.574	0.530	0.623
1999/00	1.107	1.016	1.205
2000/01	1.177	1.077	1.287
2001/02	1.147	1.055	1.246
2002/03	1.048	0.965	1.138
2003/04	1.062	0.982	1.149
2004/05	0.866	0.801	0.936
2005/06	0.942	0.871	1.019
2006/07	0.964	0.894	1.040
2007/08	0.968	0.893	1.049
2008/09	1.274	1.174	1.383
2009/10	1.304	1.205	1.411
2010/11	1.513	1.391	1.647
2011/12	1.554	1.426	1.693
2012/13	1.385	1.270	1.511

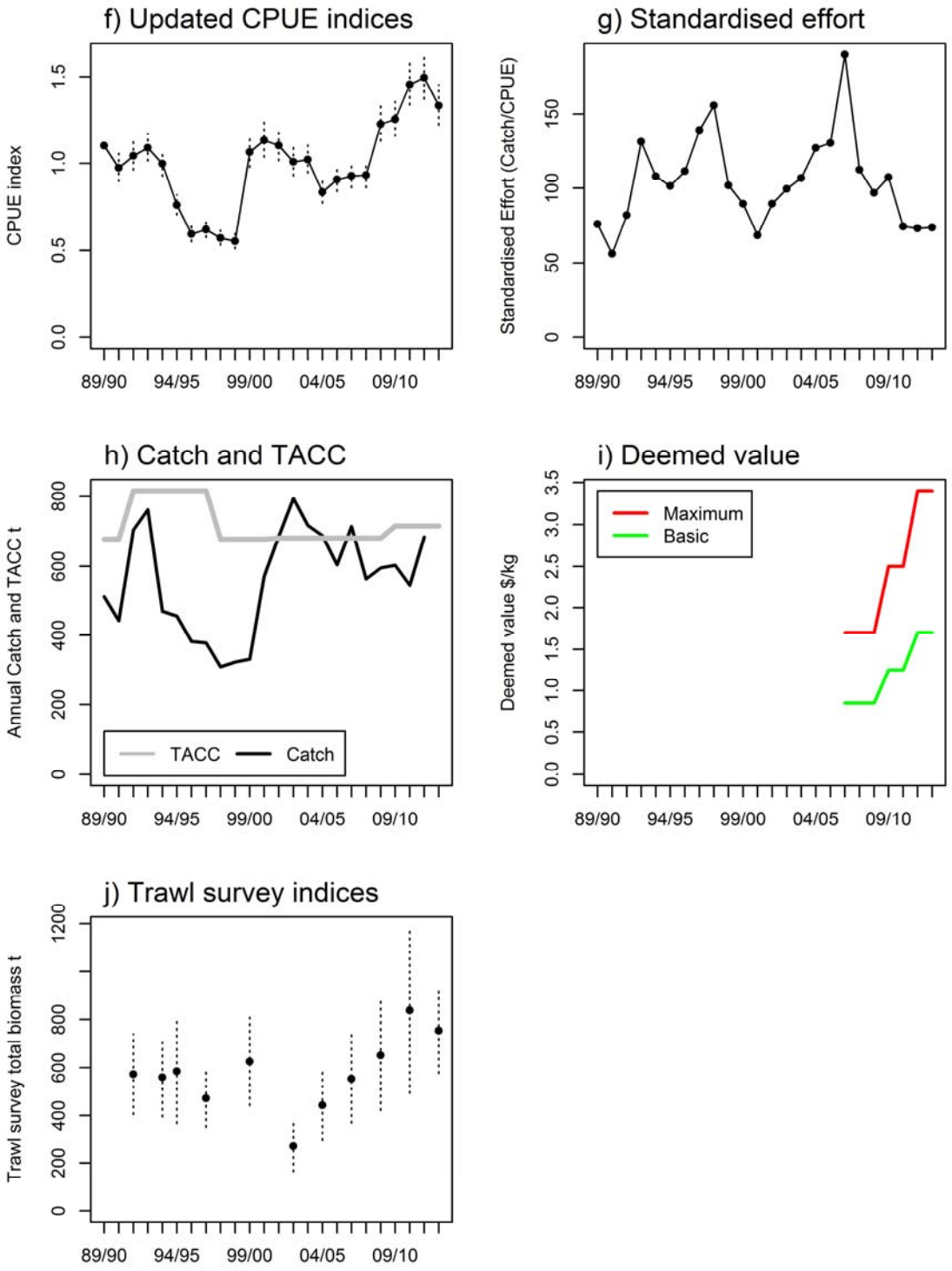

Figure 33: **A range of fishery indicators for the TBGB area of the GUR 7 fishstock (see Section 3.2 for details): updated standardised CPUE indices with associated 95% confidence intervals (panel f), standardised fishing effort (annual CPUE catches divided by standardised CPUE indices) (panel g), total annual catches and TACC (panel h), annual deemed value penalties (panel i), and trawl survey total biomass estimates (and 95% confidence intervals) from the inshore WCSI trawl survey (panel j).**

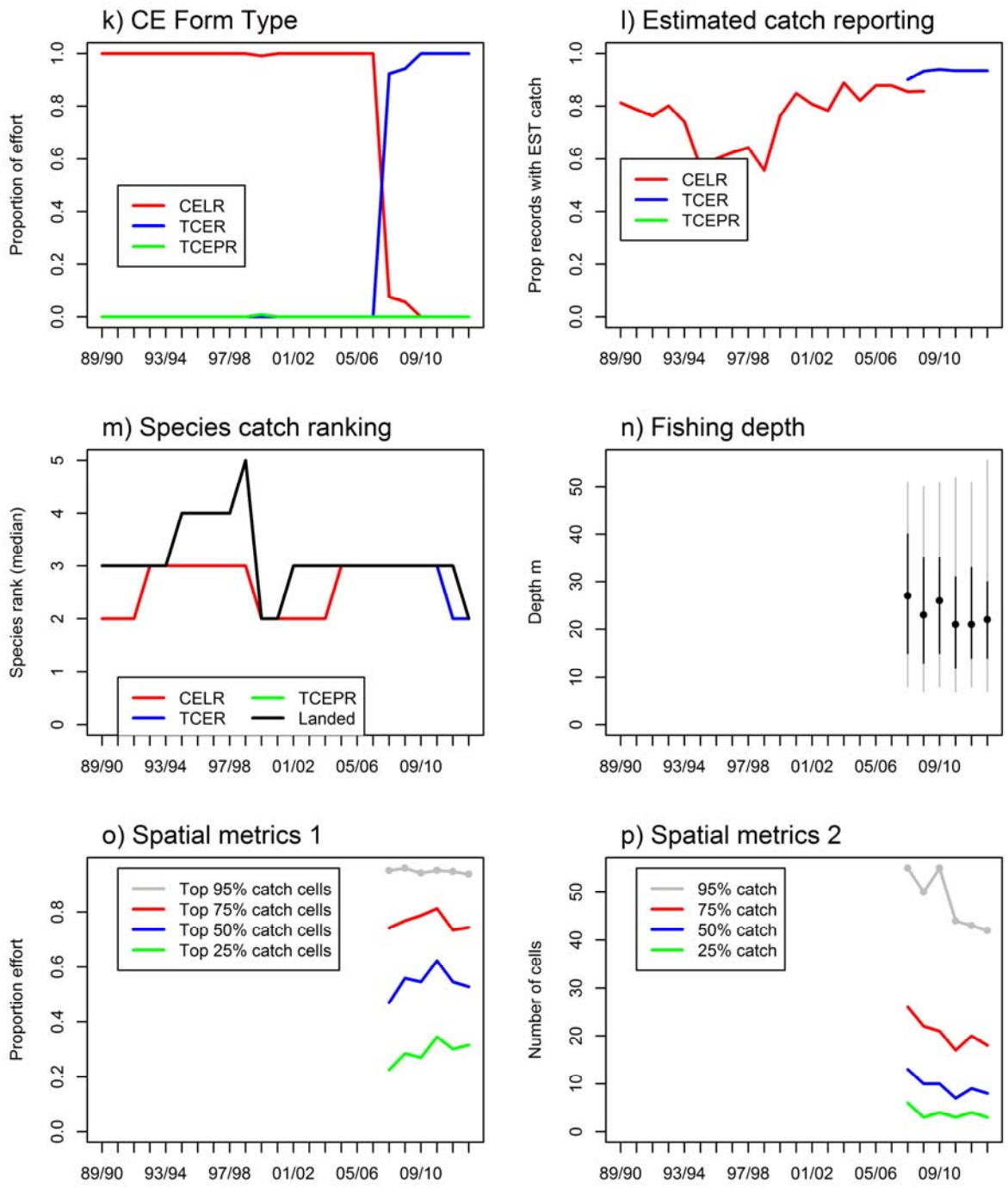

Figure 34: **A summary of the catch and effort included in the GUR 7 TBGB FLA trawl fishery data set (see Section 3.2 for details): proportion of effort records by form type (panel k), proportion of effort records with an associated estimated catch of the species (panel l), median species rank from associated estimated catch records and landed catch records (panel m), fishing depth of effort records from TCER and TCEPR forms (median, quartile range and 95% interval) (panel n), and spatial metrics derived from TCER and TCEPR fishing records (panels o and p).**

3.9 GUR 7 TBCS Mix Trawl

The TBCS fishery definition includes trawl fishing effort records targeting tarakihi, barracouta and blue warehou. The fishery primarily operates in the deeper water outside of the entrance to Tasman Bay and in the eastern approaches to Cook Strait (including Cloudy Bay and Clifford Bay). The previous CPUE analysis of Kendrick et al. (2011) was conducted based on data aggregated at the trip strata level. The current CPUE analyses extended the trip strata analysis to include 2010/11–2012/13. CPUE indices were also derived using data aggregated at the effort strata level for two time periods: a period equivalent to the original analysis (to 2009/10) and for the entire period (to 2012/13). The formulation of the CPUE model applied to the effort strata data was equivalent to the original model (for trip strata data) (Table 29).

Table 29: A summary of the specific data selection criteria used to configure the GUR 7 TBCS Mix Trawl data set. The formulation of the CPUE model and model error structure is also presented.

Criteria	Range
Fishing year	1989/90 to 2012/13
Fishstock landed catch	GUR 2, GUR 7, GUR 8
Method	BT
Target species	TAR, BAR, WAR
Statistical areas	038, 039, 017, 018
Max species catch	1500 kg
Core fleet	≥ 5 trips ≥ 5 years
Data aggregation	Effort strata (and trip strata for comparative purposes)
CPUE model	log(catch) ~ fyear + area + poly(log(duration),3) + vessel_key +target
Model error structure	lognormal (zero catch records excluded)

A comparison of the previous and current data sets revealed comparable levels of total annual catch and fishing effort (number of vessels, fishing trips and number of trawls) for the corresponding period (Figure 35a–d and Table 30), although the current data sets included less catch from 1991/92–1993/94. The proportion of nil catch records was also comparable for the previous and the updated trip strata data sets (Figure 35e). There was a higher proportion of nil catch records in the effort strata data sets compared to the trip strata data sets. This is consistent with the higher resolution of the effort strata data; i.e. the occurrence of zero catch records is lower when the data are aggregated by trip rather than fishing day.

The updated CPUE indices were similar to the previous indices (Figure 36), although the updated indices were lower for 1991/92–1993/94 which is consistent with the lower annual catch included in the updated CPUE data set during this period (Figure 35a). There was also some deviation between the previous and updated CPUE indices during the mid 2000s, although the underlying trends were comparable. The CPUE indices from the updated data sets were very similar for the three model options (data aggregation and time period combinations) (Figure 36).

For all model options, CPUE indices peaked during 2006/07–2009/10. The two updated CPUE analyses yielded indices that declined considerably from 2009/10 to 2012/13 and the final index was estimated to be well below the longer term average CPUE level (Figure 37a and Table 31). The precision of the CPUE indices from the last seven years is considerably lower than the other CPUE indices for the GUR 7 fishstock.

Trawl survey indices indicate an increase in red gurnard abundance from the mid 2000s and this trend is not consistent with the decline in the CPUE indices over the last four years (Figure 37j). The trawl survey indices are not directly comparable with the CPUE indices; the trawl survey biomass estimates include both the west coast South Island and Tasman Bay/Golden Bay areas and include both pre-recruit and recruited fish (i.e. total biomass). A more thorough analysis of the trawl survey data is required to formulate trawl survey indices that are more directly comparable with the CPUE indices.

Since 2008/09, the overall depth fished by the defined fleet remained relatively stable (Figure 38n). The spatial distribution of the fishery appears to have varied markedly from 2007/08 to 2012/13 with a decrease in the proportion of fishing effort (for the defined fishery) that occurred in the more productive spatial cells (0.1 lat/long cells); i.e. the proportion of the annual fishing effort that occurred in those spatial cells that accounted for the top 25% or 50% of the cumulative red gurnard catch (for all years combined) decreased over time (Figure 38o).

Conversely, there was a general decrease in the number of spatial cells fished to attain the top 50% and 75% of the total catch (by spatial cell) from the fleet (Figure 38p). The trends in these two spatial metrics may indicate that the catchability of red gurnard in the fishery decreased over the last six years due to changes in the distribution of fishing effort.

The overall trend in the CPUE indices from the GUR 7 TBCS MIX fishery is similar to the indices derived for the GUR 7 TBGB FLA fishery for the period 1989/90 to 2004/05 (see Section 3.8). The indices deviate in the more recent years with the indices from the MIX fishery more highly variable among years and declining sharply over the last four years (from 2009/10 to 2012/13). The TBCS MIX fishery account for a smaller proportion of the GUR 7 catch than the TBGB FLA fishery.

The trend in the CPUE indices from the GUR 7 TBCS MIX fishery also differs considerably from the two sets of CPUE indices from the GUR 7 WCSI fisheries (FLA and MIX) (see Sections 3.6 and 3.7).

Based on the recent trends in the spatial distribution of the fishery, the SINS WG discounted the utility of the TBCS CPUE index as an index of abundance for red gurnard (MPI 2014).

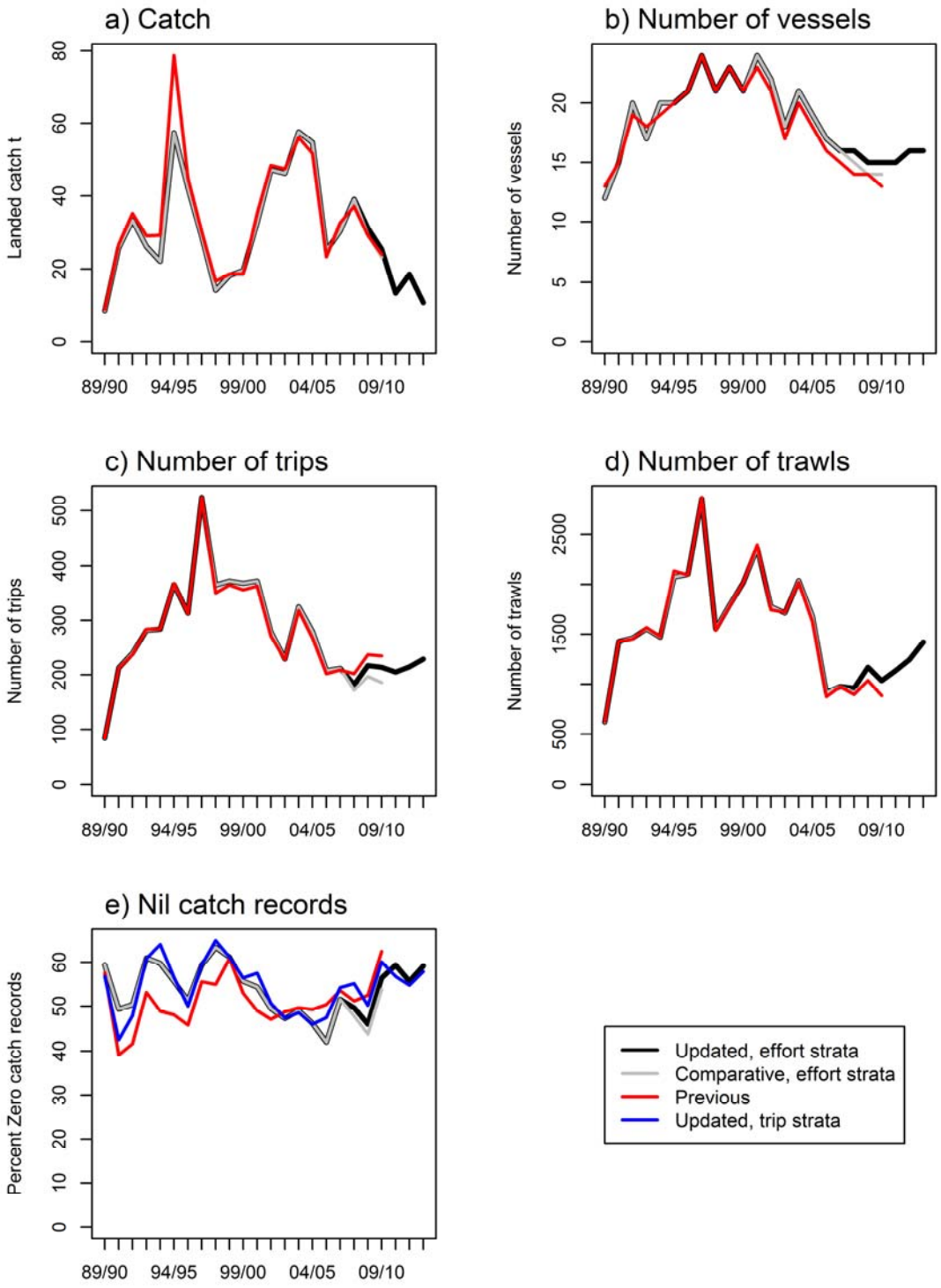

Figure 35: **Annual total landed species catch (green weight, t) (panel a), number of (core) vessels (panel b), number of fishing trips (panel c), number of fishing events (trawls) (panel d) and percentage of records with nil species catch (panel e) included in the previous, comparative and updated CPUE data sets for the GUR 7 TBCS MIX trawl fishery.**

Table 30: Summary of catch and effort (effort strata) included in the final data set (including zero species catch records) for the GUR 7 TBCS MIX trawl fishery.

Fishing year	No. of records	No. of vessel	No of trips	Catch (t)	No. of trawls	Fishing duration (hrs)	Percent zero catch
1989/90	212	12	84	8.6	619	1 904	59.4
1990/91	510	15	213	25.8	1 429	4 118	49.4
1991/92	536	20	240	33.2	1 463	4 595	50.4
1992/93	559	17	282	26.1	1 555	4 941	61.0
1993/94	517	20	284	22.1	1 471	3 906	59.8
1994/95	765	20	366	57.4	2 074	6 057	55.7
1995/96	744	21	313	42.2	2 101	6 253	51.3
1996/97	1 016	24	524	28.8	2 851	7 966	59.4
1997/98	628	21	365	14.2	1 553	4 363	63.4
1998/99	688	23	372	18.3	1 791	5 208	61.2
1999/00	736	21	368	19.6	2 018	5 735	55.7
2000/01	810	24	372	32.7	2 368	7 356	54.4
2001/02	656	22	279	47.2	1 776	5 745	49.5
2002/03	601	18	229	46.2	1 716	5 849	47.3
2003/04	789	21	325	57.6	2 038	7 016	49.0
2004/05	678	19	280	54.7	1 677	5 743	46.2
2005/06	386	17	208	25.0	915	3 053	42.0
2006/07	382	16	212	30.3	977	2 948	51.6
2007/08	378	16	182	39.1	961	3 036	49.7
2008/09	450	15	217	31.1	1 170	3 846	46.0
2009/10	393	15	214	25.4	1 036	3 404	56.5
2010/11	404	15	205	13.4	1 136	3 414	59.4
2011/12	436	16	215	18.6	1 245	3 907	55.7
2012/13	490	16	229	10.8	1 423	4 280	59.2

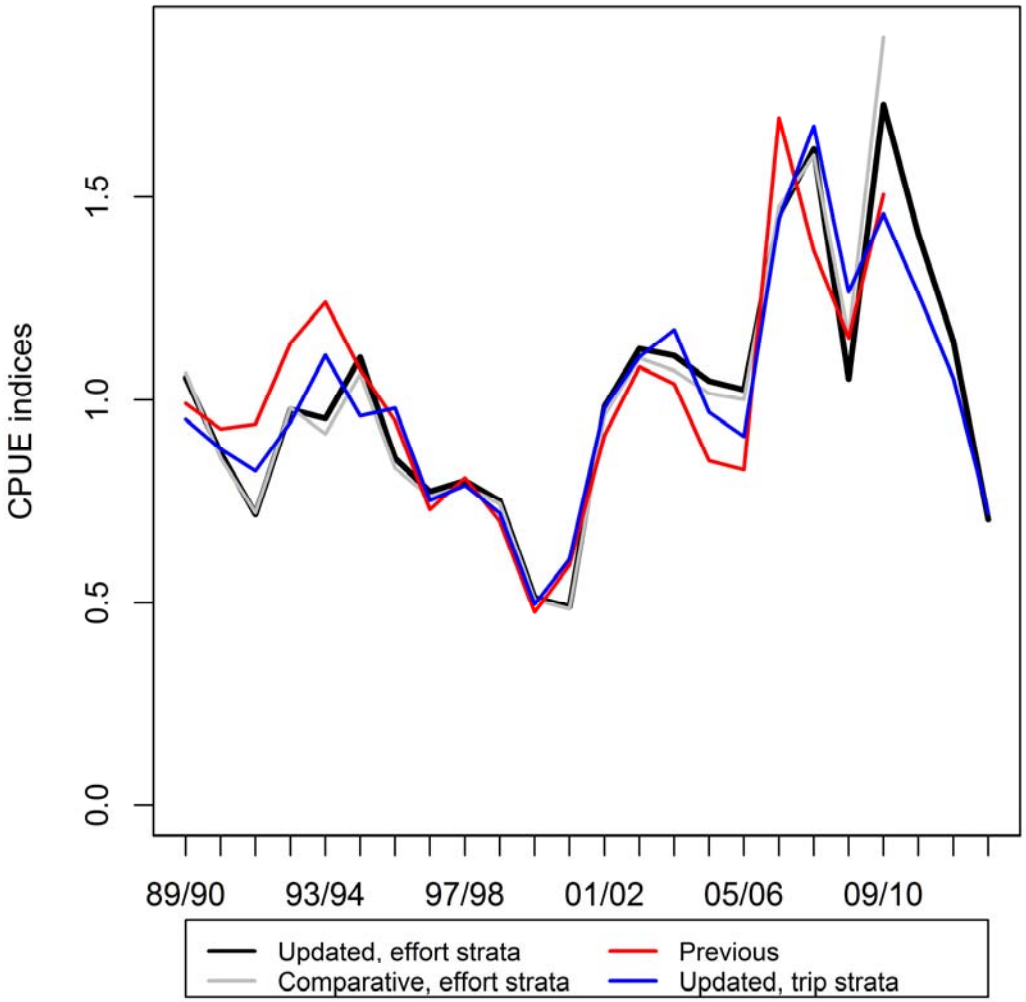

Figure 36: **Annual CPUE indices for the GUR 7 TBCS MIX trawl fishery from the previous, comparative and updated CPUE models. The indices are normalised to the average of the years included in the previous CPUE model.**

Table 31: Final CPUE model indices and lower and upper bounds of the 95% confidence interval for the GUR 7 TBCS MIX trawl fishery.

Fishing year	Index	LCI	UCI
1989/90	1.055	0.730	1.522
1990/91	0.869	0.602	1.255
1991/92	0.717	0.497	1.033
1992/93	0.977	0.673	1.419
1993/94	0.954	0.653	1.395
1994/95	1.104	0.771	1.582
1995/96	0.856	0.599	1.223
1996/97	0.773	0.544	1.100
1997/98	0.801	0.549	1.169
1998/99	0.750	0.518	1.085
1999/00	0.512	0.356	0.737
2000/01	0.489	0.341	0.702
2001/02	0.984	0.685	1.414
2002/03	1.126	0.782	1.621
2003/04	1.109	0.778	1.581
2004/05	1.047	0.731	1.498
2005/06	1.025	0.700	1.501
2006/07	1.456	0.983	2.156
2007/08	1.617	1.094	2.391
2008/09	1.051	0.715	1.546
2009/10	1.727	1.157	2.578
2010/11	1.409	0.941	2.110
2011/12	1.143	0.771	1.694
2012/13	0.704	0.475	1.045

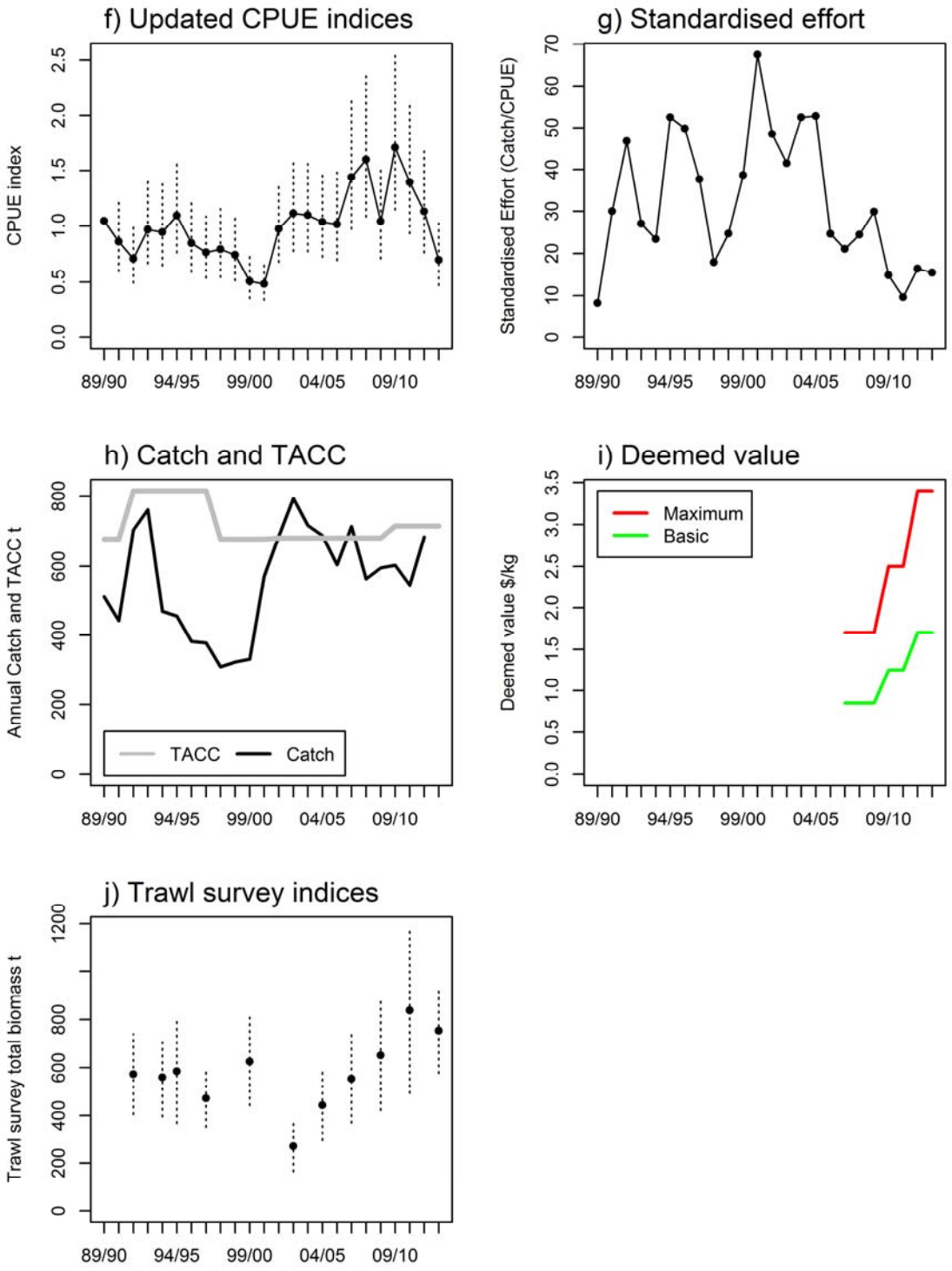

Figure 37: **A range of fishery indicators for the TBCS area of the GUR 7 fishstock (see Section 3.2 for details): updated standardised CPUE indices with associated 95% confidence intervals (panel f), standardised fishing effort (annual CPUE catches divided by standardised CPUE indices) (panel g), total annual catches and TACC (panel h), annual deemed value penalties (panel i), and trawl survey total biomass estimates (and 95% confidence intervals) from the inshore WCSI trawl survey (panel j).**

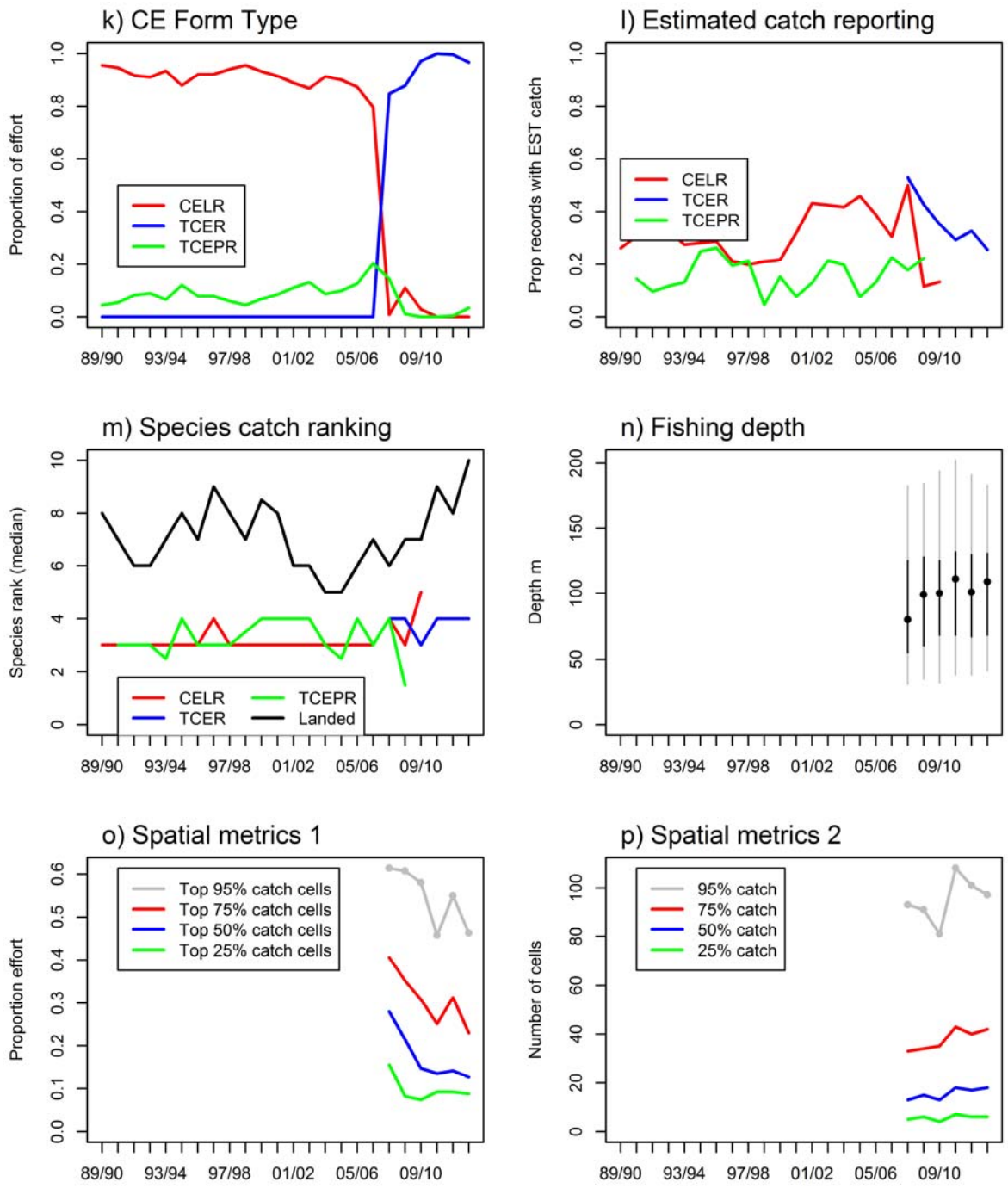

Figure 38: **A summary of the catch and effort included in the GUR 7 TBCS MIX trawl fishery data set (see Section 3.2 for details): proportion of effort records by form type (panel k), proportion of effort records with an associated estimated catch of the species (panel l), median species rank from associated estimated catch records and landed catch records (panel m), fishing depth of effort records from TCER and TCEPR forms (median, quartile range and 95% interval) (panel n), and spatial metrics derived from TCER and TCEPR fishing records (panels o and p).**

3.10 JDO 7 Trawl

The JDO 7 Trawl fishery definition includes inshore trawl fishing effort records targeting tarakihi, barracouta, red cod, flatfish, red gurnard, John dory and/or jack mackerel off the west coast of the South Island. The fishery spatial definition includes the WCSI (JDO 7), Tasman Bay/Golden Bay (JDO 7) and the western portion of JDO 2 (following Dunn & Jones 2013) (Table 32). The CPUE model formulation also followed Dunn & Jones (2013) incorporating indices from a positive catch CPUE model and a probability of catch (binomial) CPUE model to derive a delta-lognormal CPUE index (Table 32).

Table 32: A summary of the specific data selection criteria used to configure the JDO 7 Trawl data set. The formulation of the CPUE model and model error structure is also presented.

Criteria	Range
Fishing year	1989/90 to 2012/13
Fishstock landed catch	JDO 7, JDO 2, JDO 1
Method	BT
Target species	BAR, FLA, GUR, JDO, JMA, RCO, TAR
Statistical areas	033, 034, 035, 036, 037, 038, 039
Max species catch	500 kg (effort strata)
Core fleet	≥ 5 trips ≥ 5 years
Data aggregation	Effort strata
Indices	Delta-lognormal
CPUE model 1	log(catch) ~ fyear + vessel_key + poly(duration,3) + month + area + target + poly(num trawl,3)
Model 1 error structure	lognormal (zero catch records excluded)
CPUE model 2	bin ~ fyear + vessel_key + poly(duration,3) + month + area + target + poly(num trawl,3)
Model 2 error structure	Binomial

It was not possible to replicate the data set of Dunn & Jones (2013) by applying the specified data selection criteria and continuity rules. This resulted in a data set with slightly more catch but a much higher level of fishing effort (number of vessels and number of trawls) (Figure 39). A range of other continuity rules were investigated; however, it was not possible to approximate catch, effort, number of vessels and proportion of zero records. For example, to achieve the same magnitude of catch as included in the data set a larger number of fishing effort records were included.

An examination of the current data set revealed a much higher proportion of FLA target fishing records compared to the percentages included in table 26 of Dunn & Jones (2013). However, the ratios of the other target species were similar for both data sets. This indicates that the current data selection process included a much larger number of FLA target records. The exclusion of these records was not explained by the declaration of the individual FLA species codes (rather than combined FLA code). It is unclear why the large number of FLA catch and effort were excluded from the original analysis of Dunn & Jones (2013) (as target FLA was a specified component of the selection criteria).

It was decided to abandon further attempts to replicate the data set of Dunn & Jones (2013) although the original data selection criteria were applied to generate the data sets included in the current analysis (Table 32). The catch included in the current data set (Figure 39a and Table 33) represents 50–80% of the annual JDO 7 catch (Figure 41h).

The resulting CPUE indices from the delta-lognormal model were generally comparable to those of Dunn & Jones (2013) (Figure 40). The main difference was that the CPUE indices for 2000/01–2002/03 were higher in the current analysis, although the overall trend in the indices was similar. The current analysis also included the two initial years (1989/90 and 1990/91) that were excluded by Dunn & Jones (2013) due to the low level of catch included in the original data set.

The standardised CPUE series shows a similar trend to the trawl survey biomass index, with a large increase in biomass between the late 1990s and early 2000s, which has persisted to the present. The most recent indices (2011/12 and 2012/13) fluctuated at the higher level of the preceding decade, but are lower than the peak CPUE from 2001/02–2002/03 (Figure 40). The CPUE indices for the last two years are higher than the longer term average CPUE level (Table 34).

The CPUE indices are generally consistent with the trawl survey indices (Figure 41j), although the CPUE indices from 2008/09 and 2010/11 were lower than the corresponding relative trawl survey indices.

From 2009/10 to 2012/13, there was a slight increase in the median depth fished by the defined fleet (Figure 42n). This coincided with a decline in the proportion of the fishing effort occurring within the most productive fishing locations; there was a reduction in the proportion of the annual fishing effort that occurring in the 0.1 degree lat/long cells that accounted for the top 25% and 50% of the overall John dory catch from 2007/08 to 2012/13 (Figure 42o). There was also an increase in the number of cells that were fished to account for the top 50% and 75% of the annual catch (Figure 42p). These observations may indicate that the defined fishery has shifted from the more productive fishing locations for John dory and, consequently, the overall catchability of the fleet has declined.

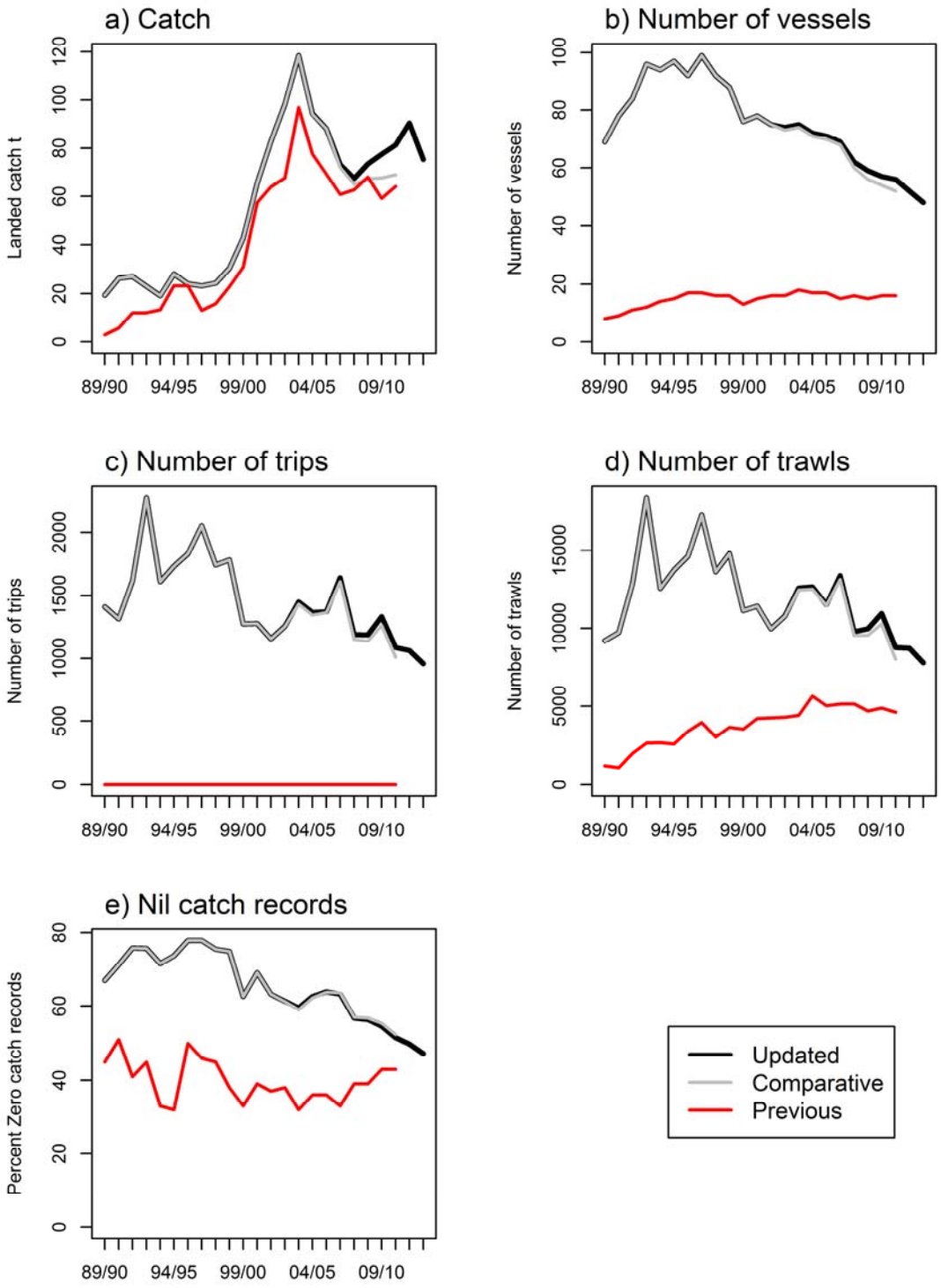

Figure 39: **Annual total landed species catch (green weight, t) (panel a), number of (core) vessels (panel b), number of fishing trips (panel c), number of fishing events (trawls) (panel d) and percentage of records with nil species catch (panel e) included in the previous, comparative and updated CPUE data sets for the JDO 7 Trawl fishery. The number of trips was not available for the previous data set.**

Table 33: Summary of catch and effort (effort strata) included in the final data set (including zero species catch records) for the JDO 7 Trawl fishery.

Fishing year	No. of records	No. of vessel	No of trips	Catch (t)	No. of trawls	Fishing duration (hrs)	Percent zero catch
1989/90	3 090	69	1 411	19.3	9 197	24 331	67.0
1990/91	3 267	78	1 315	26.4	9 723	27 469	71.3
1991/92	4 153	84	1 618	27.1	12 873	38 329	75.8
1992/93	5 687	96	2 275	23.1	18 354	54 447	75.7
1993/94	4 025	94	1 610	19.1	12 567	36 058	71.6
1994/95	4 429	97	1 735	28.1	13 743	39 248	73.7
1995/96	4 917	92	1 833	24.1	14 638	42 750	77.9
1996/97	5 649	99	2 053	23.2	17 241	52 136	77.9
1997/98	4 563	92	1 745	24.4	13 636	40 341	75.5
1998/99	4 942	88	1 784	30.5	14 798	45 314	74.9
1999/00	3 755	76	1 274	42.7	11 148	34 893	62.6
2000/01	3 870	78	1 278	65.4	11 429	39 159	69.1
2001/02	3 404	75	1 156	82.8	9 970	33 103	63.2
2002/03	3 725	74	1 256	98.2	10 796	37 242	61.3
2003/04	4 394	75	1 450	118.5	12 593	44 267	59.5
2004/05	4 483	72	1 367	94.3	12 652	43 826	62.6
2005/06	4 225	71	1 372	88.0	11 521	40 780	63.9
2006/07	4 829	69	1 642	73.2	13 384	46 374	63.3
2007/08	3 696	62	1 189	67.4	9 775	36 800	56.8
2008/09	3 819	59	1 187	73.5	9 965	37 614	56.4
2009/10	4 062	57	1 333	77.5	10 950	38 794	54.6
2010/11	3 269	56	1 086	81.3	8 770	31 788	51.5
2011/12	3 275	52	1 063	90.4	8 728	31 980	49.8
2012/13	2 889	48	957	75.3	7 779	28 533	47.2

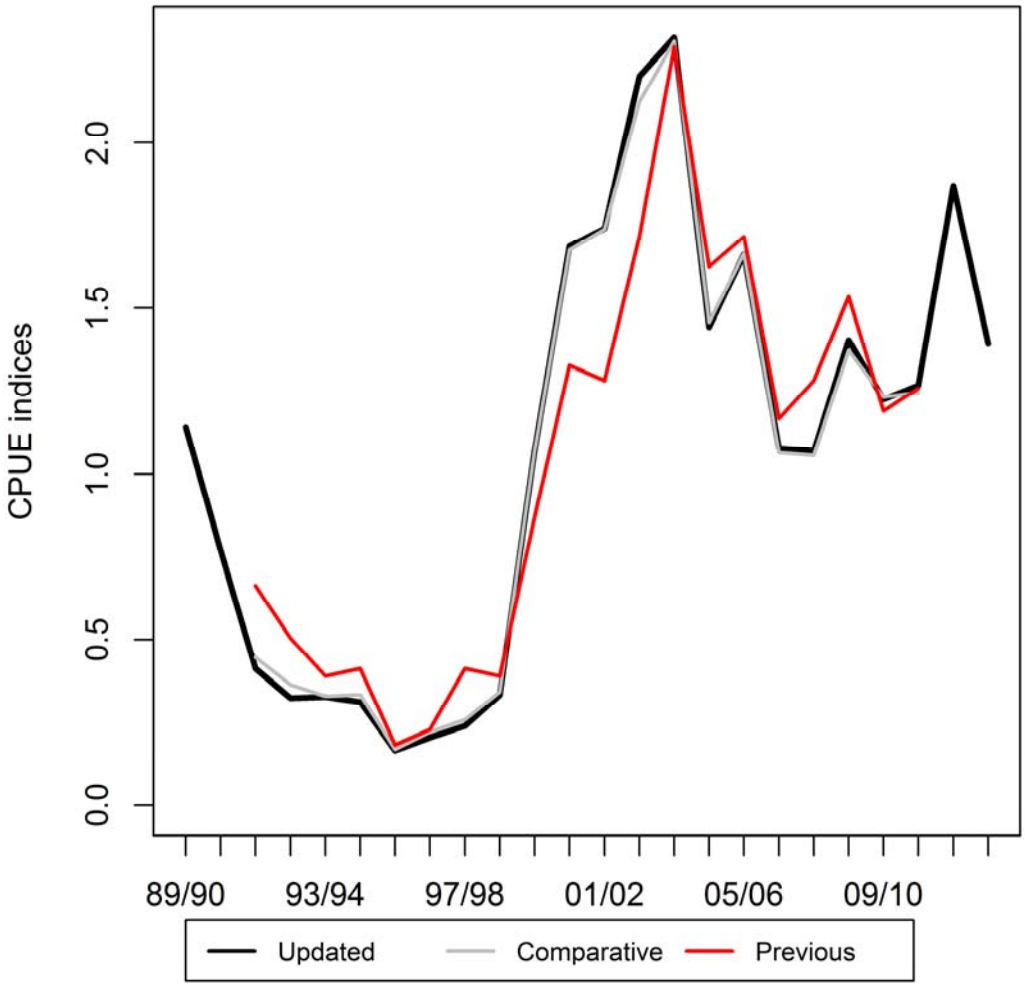

Figure 40: **Annual CPUE indices for the JDO 7 Trawl fishery from the previous, comparative and updated CPUE models. The indices are normalised to the average of the years included in the previous CPUE model.**

Table 34: Final CPUE model indices and lower and upper bounds of the 95% confidence interval for the JDO 7 Trawl fishery.

Fishing year	Index	LCI	UCI
1989/90	1.122	0.966	1.316
1990/91	0.756	0.652	0.881
1991/92	0.405	0.343	0.473
1992/93	0.317	0.275	0.365
1993/94	0.321	0.275	0.366
1994/95	0.306	0.260	0.357
1995/96	0.163	0.138	0.191
1996/97	0.201	0.171	0.231
1997/98	0.235	0.202	0.274
1998/99	0.327	0.280	0.386
1999/00	1.053	0.910	1.212
2000/01	1.658	1.415	1.908
2001/02	1.710	1.489	1.956
2002/03	2.162	1.884	2.458
2003/04	2.276	1.976	2.586
2004/05	1.417	1.236	1.613
2005/06	1.634	1.410	1.874
2006/07	1.060	0.913	1.223
2007/08	1.051	0.910	1.198
2008/09	1.378	1.213	1.577
2009/10	1.204	1.056	1.379
2010/11	1.245	1.082	1.416
2011/12	1.837	1.613	2.111
2012/13	1.368	1.178	1.559

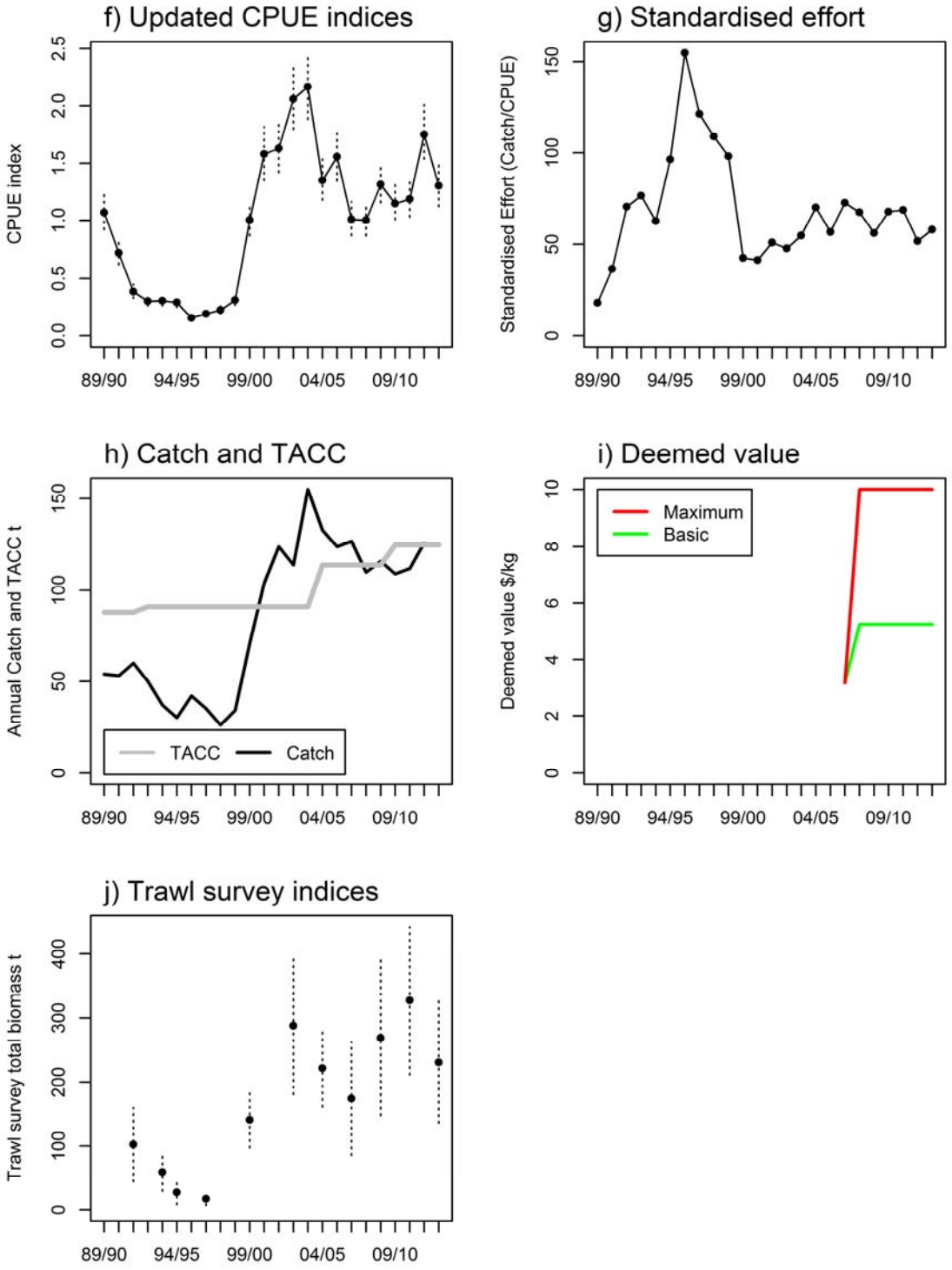

Figure 41: **A range of fishery indicators for the JDO 7 fishstock (see Section 3.2 for details): updated standardised CPUE indices with associated 95% confidence intervals (panel f), standardised fishing effort (annual CPUE catches divided by standardised CPUE indices) (panel g), total annual catches and TACC (panel h), annual deemed value penalties (panel i), and trawl survey total biomass estimates (and 95% confidence intervals) from the inshore WCSI trawl survey (panel j).**

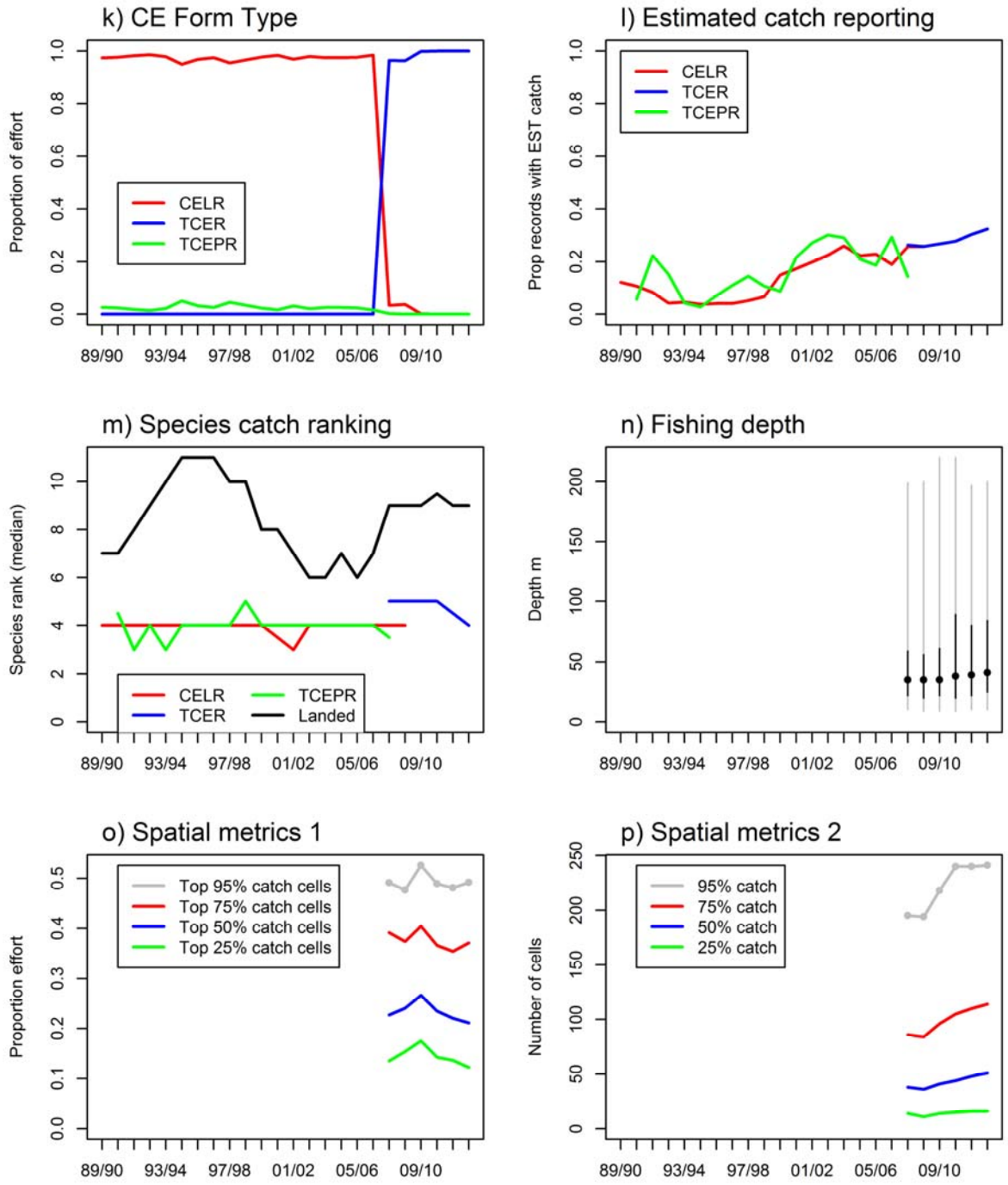

Figure 42: **A summary of the catch and effort included in the JDO 7 Trawl fishery data set (see Section 3.2 for details): proportion of effort records by form type (panel k), proportion of effort records with an associated estimated catch of the species (panel l), median species rank from associated estimated catch records and landed catch records (panel m), fishing depth of effort records from TCER and TCEPR forms (median, quartile range and 95% interval) (panel n), and spatial metrics derived from TCER and TCEPR fishing records (panels o and p).**

3.11 TAR 7 WCSI Trawl

The TAR 7 WCSI Trawl fishery definition includes trawl fishing effort records targeting tarakihi, barracouta, blue warehou, red cod and/or stargazer off the west coast of the South Island. The previous CPUE analysis of Kendrick et al. (2011) was conducted based on data aggregated at the trip strata level. The current CPUE analyses extended the trip strata analysis to include 2010/11–2012/13. CPUE indices were also derived using data aggregated at the effort strata level for two time periods: a period equivalent to the original analysis (to 2009/10) and for the entire period (to 2012/13). The formulation of the CPUE model applied to the effort strata data was equivalent to the original model (for trip strata data) (Table 35).

Table 35: A summary of the specific data selection criteria used to configure the TAR 7 WCSI Trawl data set. The formulation of the CPUE model and model error structure is also presented.

Criteria	Range
Fishing year	1989/90 to 2012/13
Fishstock landed catch	TAR 7, TAR 2, TAR 8
Method	BT
Target species	TAR, BAR, WAR, RCO, STA
Statistical areas	033, 034, 035, 036
Max species catch	5000 kg (effort strata)
Core fleet	≥ 5 trips ≥ 4 years
Data aggregation	Effort strata (and trip strata for comparative purposes)
CPUE model	log(catch) ~ fyear + poly(log(duration),3) + vessel_key +target+ poly(log(num trawls),3)
Model error structure	lognormal (zero catch records excluded)

A comparison of the previous and current data sets revealed comparable levels of total annual catch and fishing effort (number of vessels and fishing trips) for the corresponding period (Figure 43a–c), although the previous data set included additional tarakihi catch from 2003/04 to 2006/07. The annual number of trawls included in the previous data set was not reported in Kendrick & Bentley (2011). The proportion of nil catch records was also comparable for the previous and the updated trip strata data sets (Figure 43e and Table 36). There was a higher proportion of nil catch records in the effort strata data sets compared to the trip strata data sets. This is consistent with the higher resolution of the effort strata data; i.e. the occurrence of zero catch records is lower when the data are aggregated by trip rather than fishing day.

The updated trip strata CPUE indices were very similar to the previous (trip strata) indices, with the exception of the terminal year of the previous analysis (2009/10) (Figure 44). The effort strata CPUE indices differed slightly from the trip strata CPUE indices, although the trends in the CPUE indices were very similar. For the last three years, the CPUE indices from the trip strata and effort strata CPUE models were very similar (Figure 44).

The CPUE indices for 2011/12 and 2012/13 were higher than the indices from 2009/10 and 2010/11 (Figure 45a and Table 37). The most recent indices are lower than the peaks in CPUE during 1996/97–1998/99 and 2002/03–2005/06 and are slightly below the longer term average CPUE level.

The time series of TAR 7 trawl survey indices differ considerably from the WCSI CPUE indices (Figure 45j). The trawl survey biomass indices include variable proportions of pre-recruit fish (less than 25 cm F.L.) and are the amalgamation of biomass estimates for the two main trawl survey areas:

west coast South Island and Tasman Bay/Golden Bay. Further analysis of the trawl survey data is required to derive indices that are comparable to the spatial distribution of the WCSI trawl fishery.

The depth fished by the defined fleet decreased slightly from 2009/10 to 2011/12 (Figure 46n). The spatial distribution of the fishery appears to have changed markedly from 2007/08 to 2009/10 with an increase in the proportion of fishing effort (for the defined fishery) that occurred in the more productive spatial cells (0.1 lat/long cells); i.e. the proportion of the annual fishing effort that occurred in those spatial cells that accounted for the top 25% or 50% of the cumulative tarakihi catch (for all years combined) decreased over time (Figure 46o). This may indicate a higher degree of targeting of tarakihi by the trawl fishery in recent years and some of these trends may not be adequately accounted for by the inclusion of the target species variable in the CPUE model.

The CPUE indices from the TAR 7 WCSI fishery are markedly different from the TAR 7 TBCS CPUE indices (see Section 3.12). It is possible that these two areas represent different tarakihi stock units. The WCSI fishery accounts for a considerably higher proportion of the total catch from the TAR 7 fishstock.

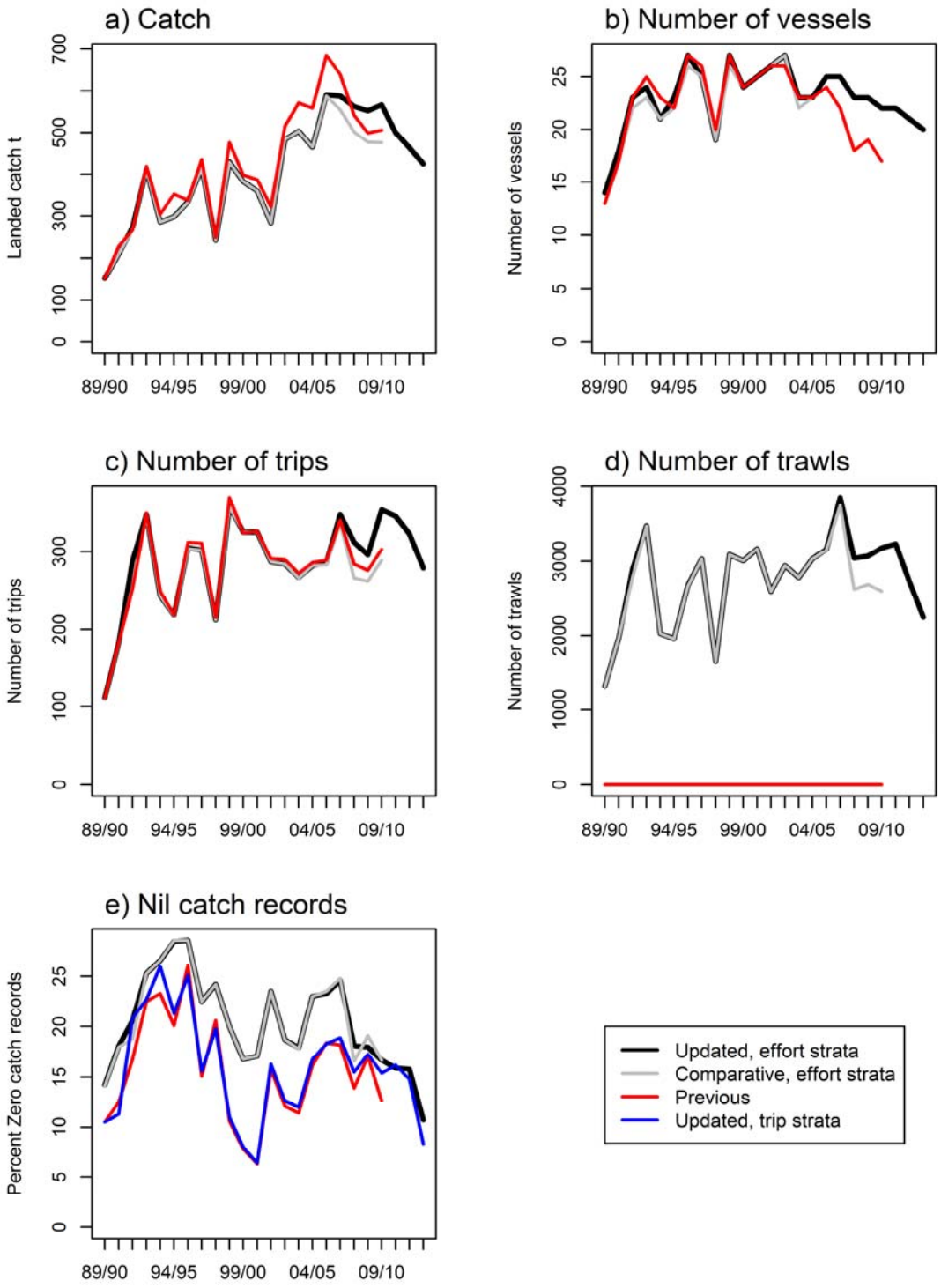

Figure 43: **Annual total landed species catch (green weight, t) (panel a), number of (core) vessels (panel b), number of fishing trips (panel c), number of fishing events (trawls) (panel d) and percentage of records with nil species catch (panel e) included in the previous, comparative and updated CPUE data sets for the TAR 7 WCSI Trawl fishery.**

Table 36: Summary of catch and effort (effort strata) included in the final data set (including zero species catch records) for the TAR 7 WCSI Trawl fishery.

Fishing year	No. of records	No. of vessel	No of trips	Catch (t)	No. of trawls	Fishing duration (hrs)	Percent zero catch
1989/90	506	14	111	152.0	1 314	4 554	14.2
1990/91	725	18	182	209.7	1 969	6 280	18.1
1991/92	1 015	23	288	272.3	2 891	10 374	20.6
1992/93	1 197	24	347	410.5	3 470	12 217	25.3
1993/94	744	21	243	285.4	2 027	6 616	26.6
1994/95	694	23	218	298.0	1 961	5 958	28.5
1995/96	951	27	305	333.8	2 680	8 467	28.6
1996/97	1 091	25	302	415.2	3 035	10 549	22.5
1997/98	621	19	212	242.1	1 652	5 738	24.2
1998/99	1 099	27	358	429.0	3 090	10 772	20.0
1999/00	1 084	24	325	382.1	3 008	11 027	16.8
2000/01	1 108	25	325	359.4	3 168	11 712	17.1
2001/02	905	26	287	283.5	2 595	8 569	23.5
2002/03	1 016	27	284	482.9	2 943	10 389	18.7
2003/04	1 006	23	267	503.3	2 783	10 618	17.9
2004/05	1 087	23	282	465.0	3 034	11 441	23.0
2005/06	1 111	25	286	589.8	3 161	11 849	23.3
2006/07	1 339	25	347	587.4	3 849	14 101	24.6
2007/08	1 171	23	312	562.4	3 041	13 104	18.1
2008/09	1 187	23	296	552.1	3 071	13 172	18.0
2009/10	1 218	22	353	566.3	3 177	12 667	16.7
2010/11	1 245	22	345	499.9	3 236	13 022	15.9
2011/12	1 069	21	323	463.6	2 729	11 231	15.8
2012/13	876	20	279	424.9	2 247	9 536	10.7

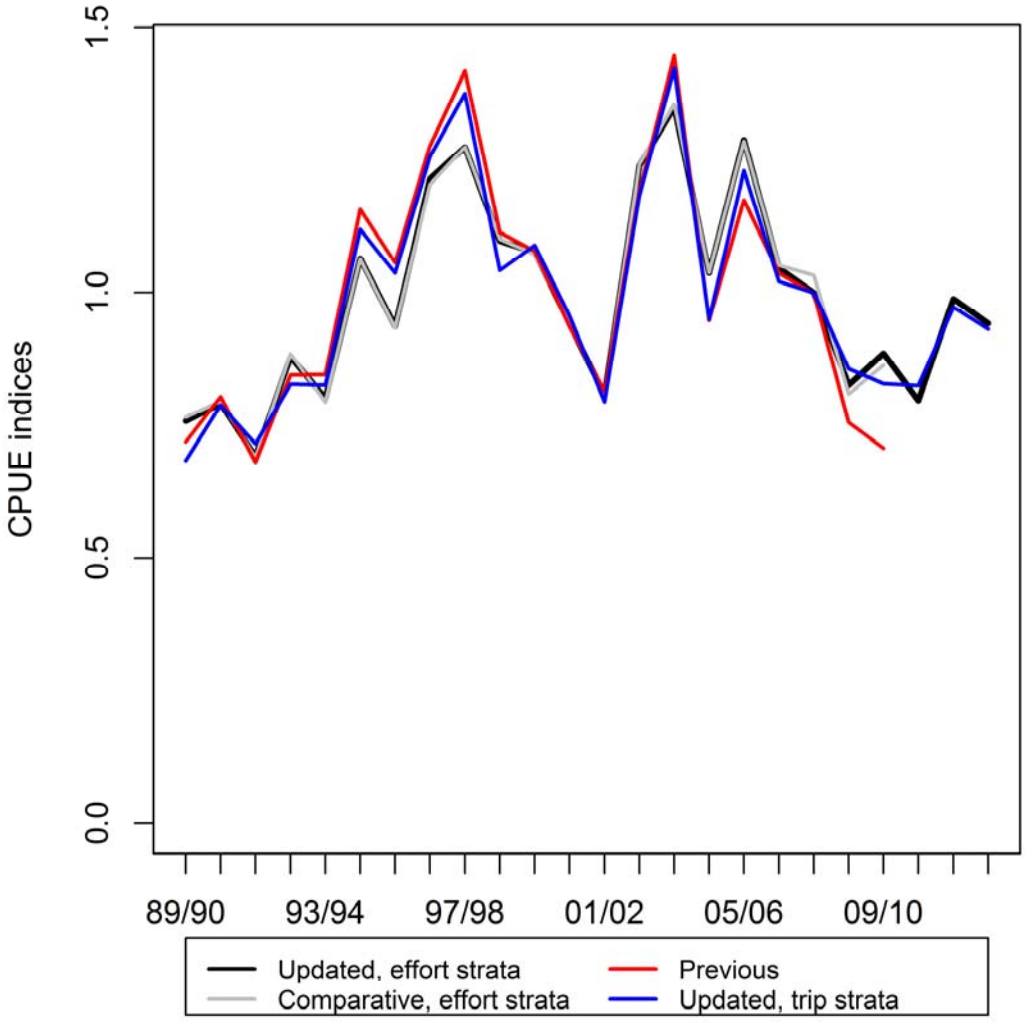

Figure 44: **Annual CPUE indices for the TAR 7 WCSI Trawl fishery from the previous, comparative and updated CPUE models. The indices are normalised to the average of the years included in the previous CPUE model.**

Table 37: Final CPUE model indices and lower and upper bounds of the 95% confidence interval for the TAR 7 WCSI Trawl fishery.

Fishing year	Index	LCI	UCI
1989/90	0.758	0.658	0.874
1990/91	0.791	0.686	0.912
1991/92	0.692	0.604	0.793
1992/93	0.878	0.767	1.006
1993/94	0.801	0.690	0.930
1994/95	1.065	0.911	1.245
1995/96	0.936	0.810	1.080
1996/97	1.214	1.054	1.397
1997/98	1.274	1.089	1.490
1998/99	1.098	0.954	1.263
1999/00	1.076	0.935	1.239
2000/01	0.941	0.818	1.082
2001/02	0.807	0.697	0.934
2002/03	1.239	1.074	1.429
2003/04	1.350	1.169	1.558
2004/05	1.037	0.898	1.197
2005/06	1.287	1.117	1.484
2006/07	1.046	0.910	1.202
2007/08	0.999	0.868	1.150
2008/09	0.826	0.717	0.950
2009/10	0.885	0.770	1.018
2010/11	0.797	0.692	0.917
2011/12	0.988	0.856	1.140
2012/13	0.941	0.812	1.090

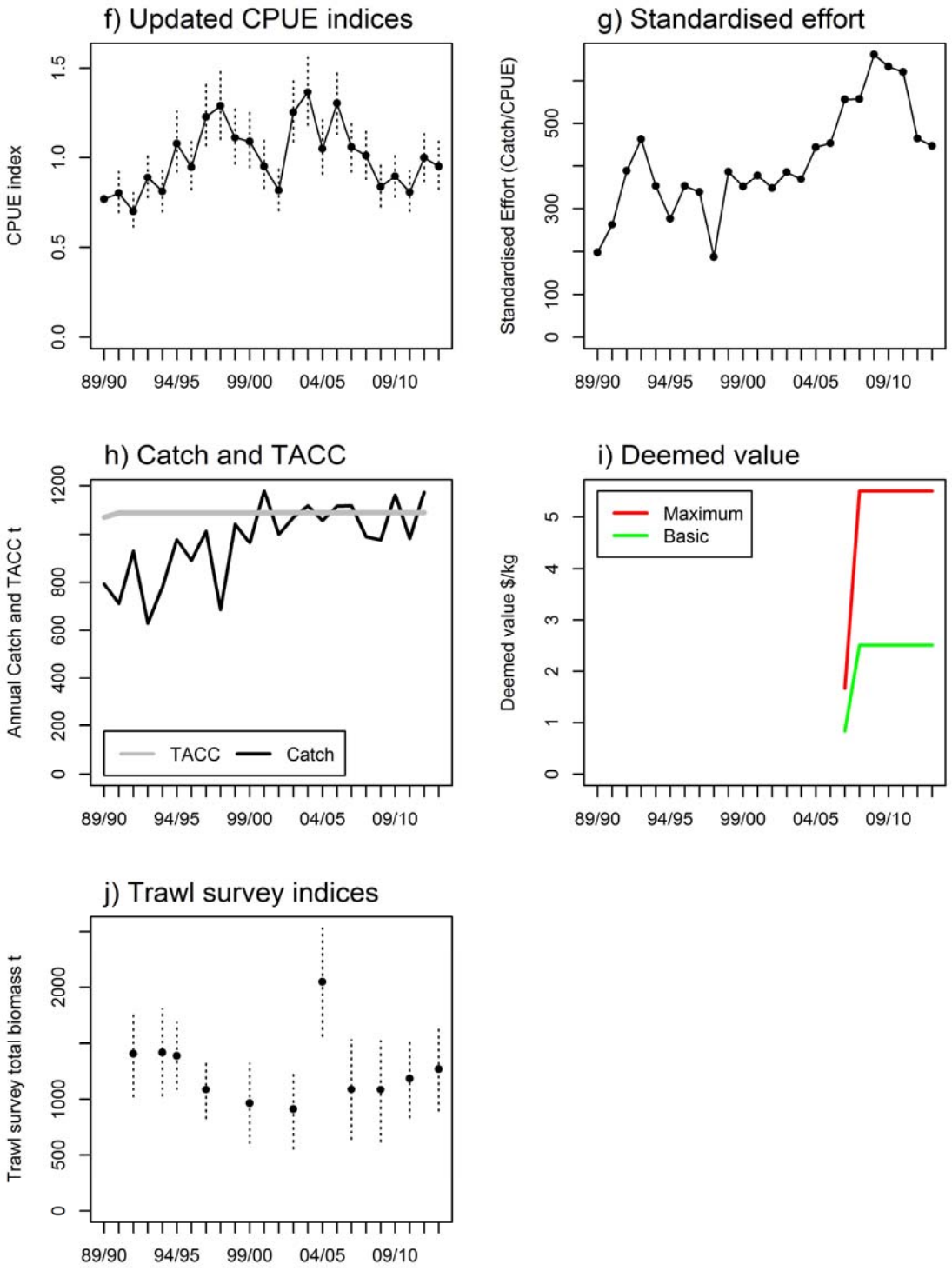

Figure 45: **A range of fishery indicators for the WCSI area of the TAR 7 fishstock (see Section 3.2 for details): updated standardised CPUE indices with associated 95% confidence intervals (panel f), standardised fishing effort (annual CPUE catches divided by standardised CPUE indices) (panel g), total annual catches and TACC (panel h), annual deemed value penalties (panel i), and trawl survey total biomass estimates (and 95% confidence intervals) from the inshore WCSI trawl survey (panel j).**

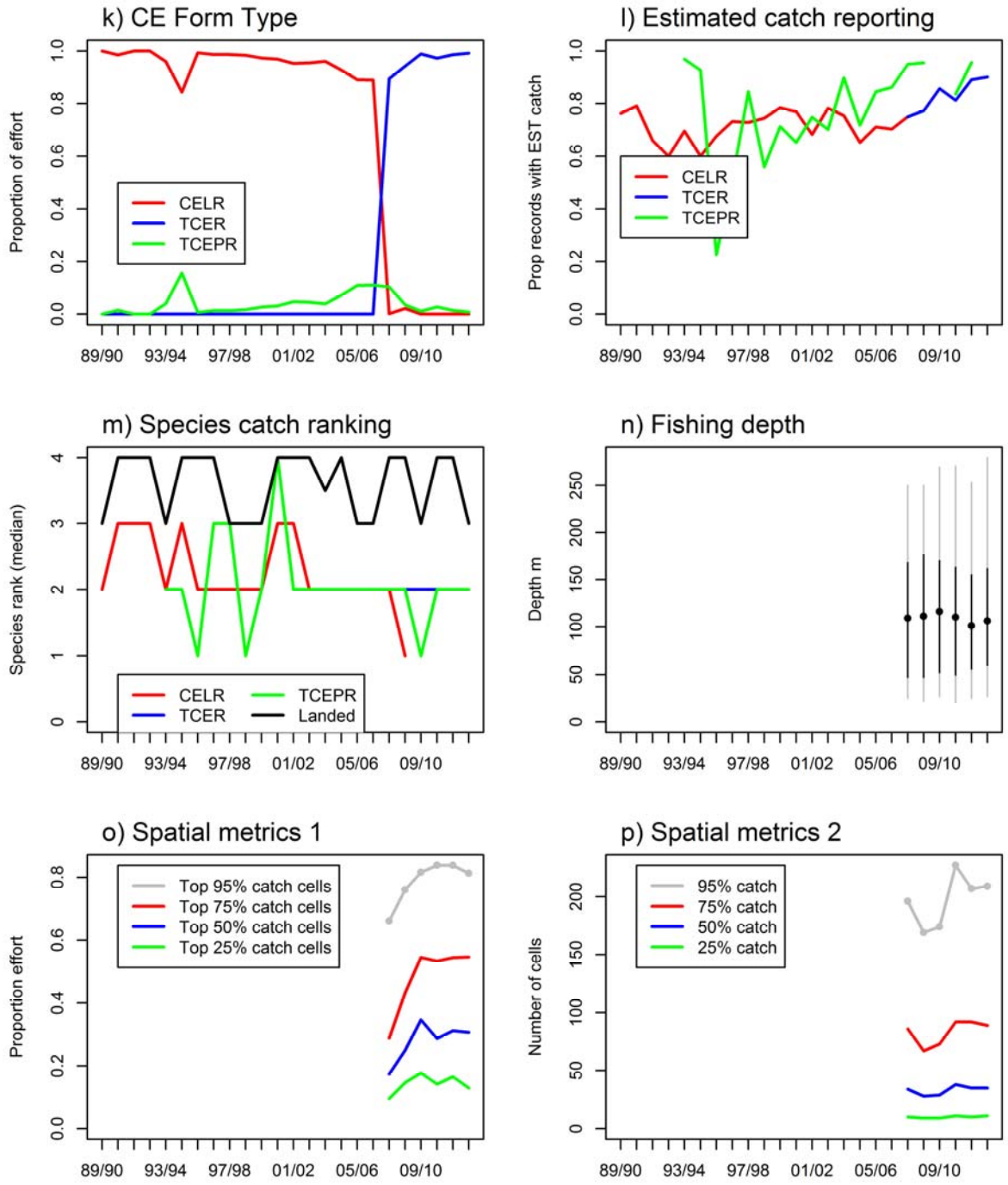

Figure 46: **A summary of the catch and effort included in the TAR 7 WCSI Trawl fishery data set (see Section 3.2 for details): proportion of effort records by form type (panel k), proportion of effort records with an associated estimated catch of the species (panel l), median species rank from associated estimated catch records and landed catch records (panel m), fishing depth of effort records from TCER and TCEPR forms (median, quartile range and 95% interval) (panel n), and spatial metrics derived from TCER and TCEPR fishing records (panels o and p).**

3.12 TAR 7 TBCS Trawl

The TAR 7 TBCS Trawl fishery definition includes trawl fishing effort records targeting tarakihi, barracouta and warehou. The fishery primarily operates in the deeper water outside of the entrance to Tasman Bay and in the eastern approaches to Cook Strait (including Cloudy Bay and Clifford Bay). The previous CPUE analysis of Kendrick et al. (2011) was conducted based on data aggregated at the trip strata level. The current CPUE analyses extended the trip strata analysis to include 2010/11–2012/13. CPUE indices were also derived using data aggregated at the effort strata level for two time periods: a period equivalent to the original analysis (to 2009/10) and for the entire period (to 2012/13). The formulation of the CPUE model applied to the effort strata data was equivalent to the original model (for trip strata data) (Table 38).

Table 38: A summary of the specific data selection criteria used to configure the TAR 7 TBCS Trawl data set. The formulation of the CPUE model and model error structure is also presented.

Criteria	Range
Fishing year	1989/90 to 2012/13
Fishstock landed catch	TAR 7, TAR 2, TAR 8, TAR 3
Method	BT
Target species	TAR, BAR, WAR
Statistical areas	038, 039, 017, 018
Max species catch	15 000 kg (effort strata)
Core fleet	≥ 5 trips ≥ 5 years
Data aggregation	Effort strata (and trip strata for comparative purposes)
CPUE model	log(catch) ~ fyear + vessel_key +target + poly(log(num trawls),3) + area + month + area:month
Model error structure	lognormal (zero catch records excluded)

A comparison of the previous and current data sets revealed comparable levels of total annual catch and fishing effort (number of vessels, fishing trips and number of trawls) for the corresponding period (Figure 47a–d), although the previous data set included additional tarakihi catch during the early 2000s. This difference is likely to be due to grooming of the landed catch data. The proportion of nil catch records was also comparable for the previous and the updated trip strata data sets (Figure 47e). There was a higher proportion of nil catch records in the effort strata data sets compared to the trip strata data sets (Table 39). This is consistent with the higher resolution of the effort strata data; i.e. the occurrence of zero catch records is lower when the data are aggregated by trip rather than fishing day.

The updated trip strata CPUE indices were very similar to the previous (trip strata) indices (Figure 48). The effort strata CPUE indices differed slightly from the trip strata CPUE indices, although the trends in the CPUE indices were very similar. For the last six years, the CPUE indices from the trip strata and effort strata CPUE models were very similar (Figure 48).

The CPUE indices for 2010/11–2012/13 are comparable to the indices from 2002/03–2009/10 (Figure 49a). The recent indices are considerably lower than the peaks in CPUE from 1994/95 and 2000/01–2001/02. These peaks in CPUE influence the longer term average CPUE level. Recent (2010/11–2012/13) CPUE indices are at or below the longer term average CPUE level (Table 40).

The time series of TAR 7 trawl survey indices differ considerably from the TBCS CPUE indices (Figure 49j). The trawl survey biomass indices include variable proportions of pre-recruit fish (less than 25 cm F.L.) and are the amalgamation of biomass estimates for the two main trawl survey areas:

west coast South Island and Tasman Bay/Golden Bay. Further analysis of the trawl survey data is required to derive indices that are comparable to the spatial distribution of the TBCS trawl fishery.

The depth fished by the defined fleet increased from 2007/08 to 2010/11 (Figure 50n). The spatial distribution of the fishery appears to have changed markedly from 2007/08 to 2009/10 with an increase in the proportion of fishing effort (for the defined fishery) that occurred in the more productive spatial cells (0.1 lat/long cells); i.e. the proportion of the annual fishing effort that occurred in those spatial cells that accounted for the top 25% or 50% of the cumulative tarakihi catch (for all years combined) increased over time (Figure 50o). This may indicate a higher degree of targeting of tarakihi by the trawl fishery in recent years and some of these trends may not be adequately accounted for by the inclusion of the target species and statistical area variables in the CPUE models.

The CPUE indices from the TAR 7 TBCS fishery are markedly different from the TAR 7 WCSI CPUE indices (see Section 3.11). It is possible that these two areas represent different tarakihi stock units. The WCSI fishery accounts for a considerably higher proportion of the total catch from the TAR 7 fishstock.

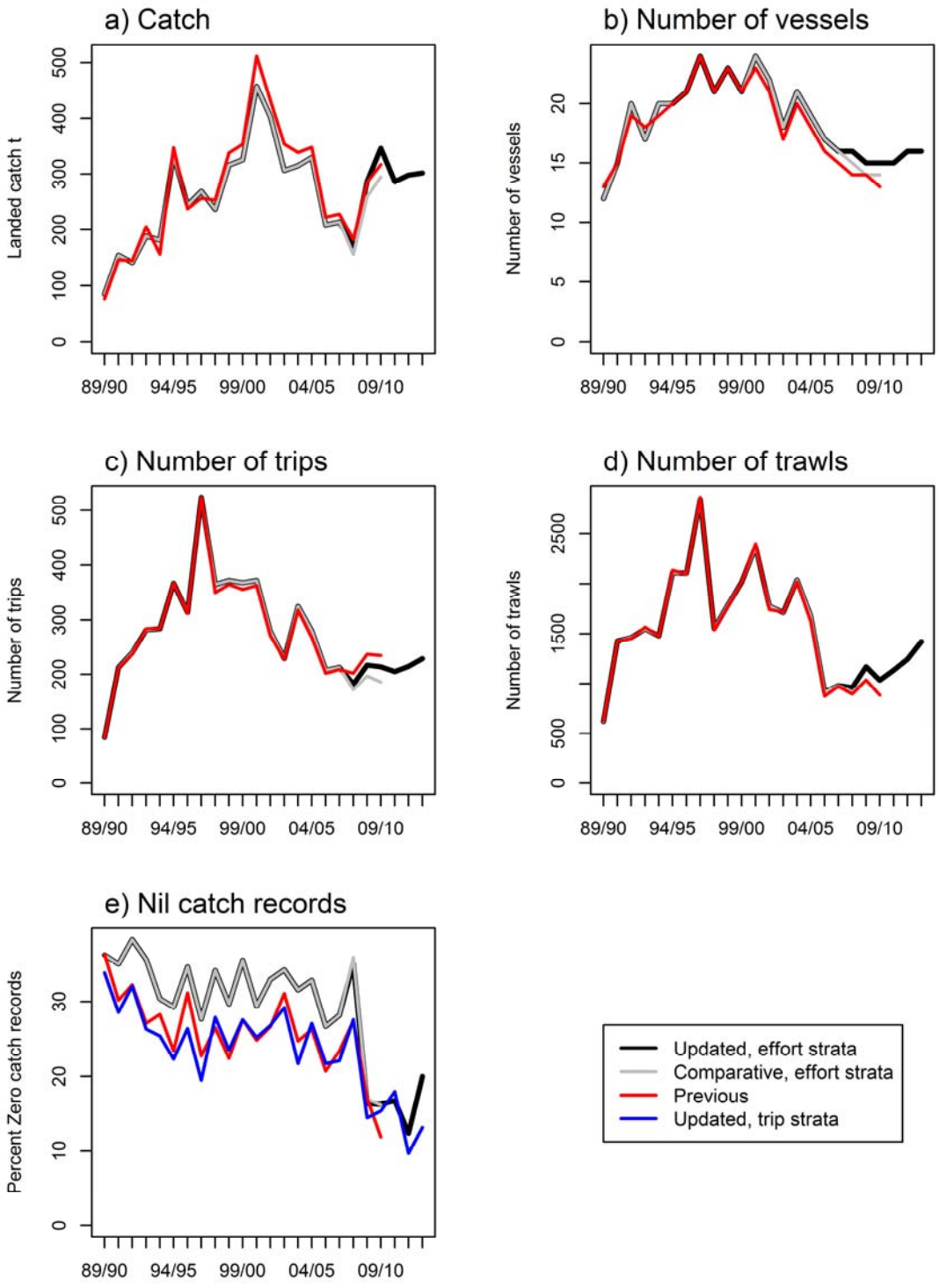

Figure 47: **Annual total landed species catch (green weight, t) (panel a), number of (core) vessels (panel b), number of fishing trips (panel c), number of fishing events (trawls) (panel d) and percentage of records with nil species catch (panel e) included in the previous, comparative and updated CPUE data sets for the TAR 7 TBCS Trawl fishery.**

Table 39: Summary of catch and effort (effort strata) included in the final data set (including zero species catch records) for the TAR 7 TBCS Trawl fishery.

Fishing year	No. of records	No. of vessel	No of trips	Catch (t)	No. of trawls	Fishing duration (hrs)	Percent zero catch
1989/90	212	12	84	84.9	619	1 904	36.3
1990/91	510	15	213	154.3	1 429	4 118	35.1
1991/92	536	20	240	140.9	1 463	4 595	38.4
1992/93	558	17	282	188.3	1 551	4 928	35.7
1993/94	519	20	284	181.5	1 479	3 927	30.4
1994/95	776	20	367	334.0	2 112	6 192	29.3
1995/96	746	21	314	244.4	2 105	6 279	34.7
1996/97	1 014	24	524	269.2	2 843	7 942	27.7
1997/98	628	21	365	236.7	1 553	4 363	34.2
1998/99	688	23	372	316.3	1 791	5 208	29.7
1999/00	736	21	368	325.5	2 018	5 735	35.6
2000/01	810	24	372	457.3	2 368	7 356	29.4
2001/02	657	22	279	403.2	1 780	5 761	33.0
2002/03	601	18	229	306.3	1 716	5 849	34.3
2003/04	789	21	325	315.1	2 038	7 016	31.6
2004/05	678	19	280	329.6	1 677	5 743	32.9
2005/06	386	17	208	208.8	915	3 053	26.7
2006/07	383	16	213	214.1	980	2 960	28.2
2007/08	378	16	182	168.8	961	3 036	35.2
2008/09	450	15	217	286.6	1 170	3 846	16.4
2009/10	393	15	214	346.4	1 036	3 404	16.3
2010/11	404	15	205	286.5	1 136	3 414	16.8
2011/12	436	16	215	298.2	1 245	3 907	12.4
2012/13	490	16	229	302.0	1 423	4 280	20.0

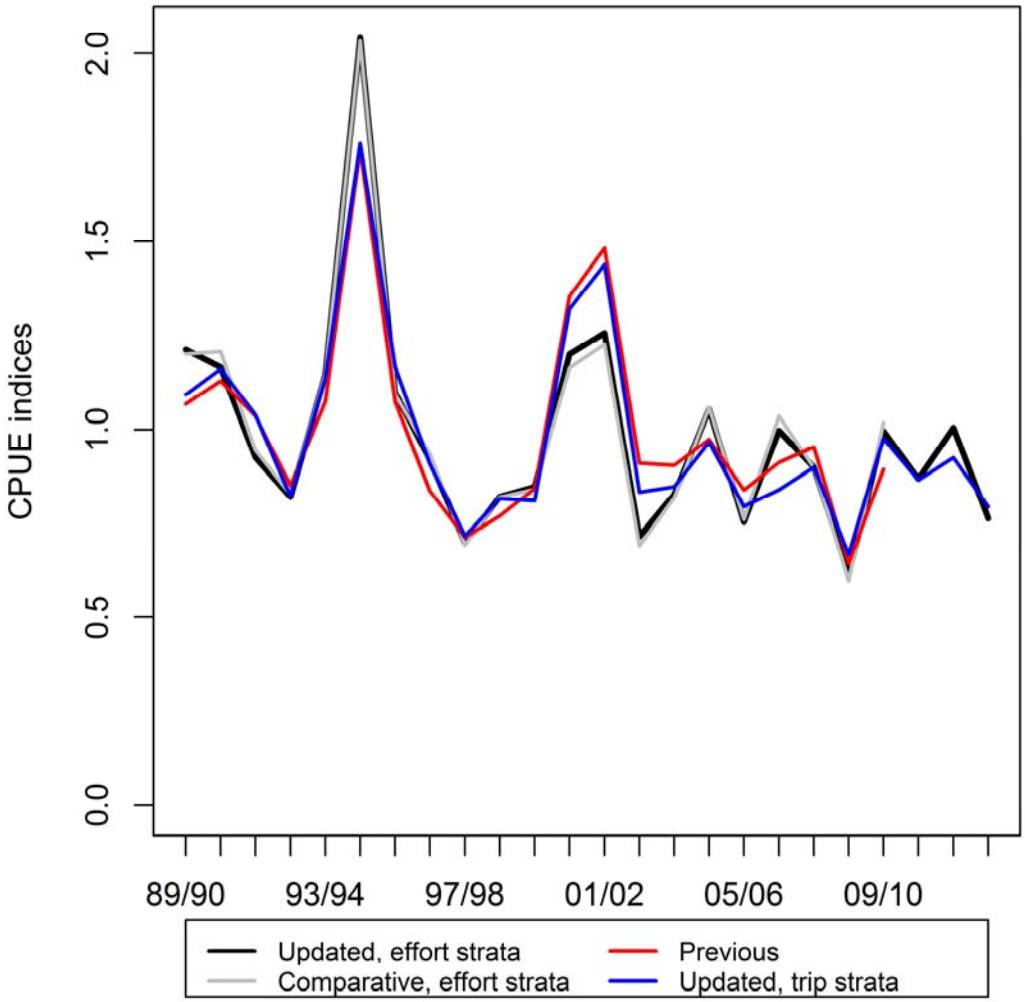

Figure 48: **Annual CPUE indices for the TAR 7 TBCS Trawl fishery from the previous, comparative and updated CPUE models. The indices are normalised to the average of the years included in the previous CPUE model.**

Table 40: Final CPUE model indices and lower and upper bounds of the 95% confidence interval for the TAR 7 TBCS Trawl fishery.

Fishing year	Index	LCI	UCI
1989/90	1.211	0.885	1.658
1990/91	1.165	0.851	1.595
1991/92	0.926	0.677	1.266
1992/93	0.819	0.601	1.117
1993/94	1.147	0.840	1.566
1994/95	2.041	1.513	2.754
1995/96	1.098	0.811	1.486
1996/97	0.920	0.687	1.231
1997/98	0.698	0.512	0.952
1998/99	0.820	0.605	1.111
1999/00	0.847	0.624	1.150
2000/01	1.199	0.888	1.619
2001/02	1.256	0.924	1.707
2002/03	0.714	0.523	0.975
2003/04	0.826	0.611	1.116
2004/05	1.054	0.775	1.433
2005/06	0.753	0.541	1.048
2006/07	0.997	0.715	1.391
2007/08	0.899	0.641	1.261
2008/09	0.613	0.445	0.845
2009/10	0.996	0.719	1.380
2010/11	0.868	0.629	1.199
2011/12	1.005	0.731	1.382
2012/13	0.762	0.555	1.047

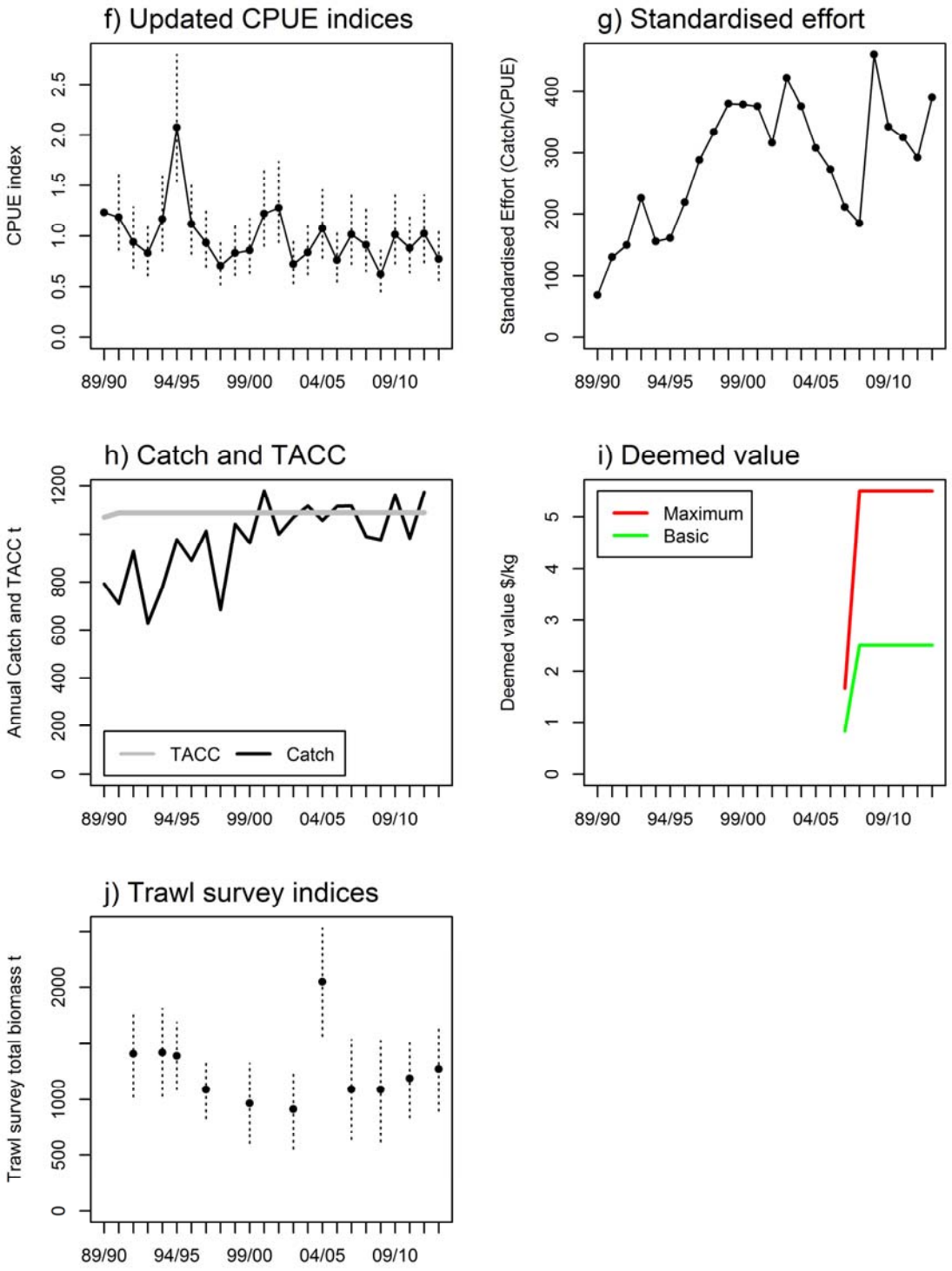

Figure 49: **A range of fishery indicators for the TBCS area of the TAR 7 fishstock (see Section 3.2 for details): updated standardised CPUE indices with associated 95% confidence intervals (panel f), standardised fishing effort (annual CPUE catches divided by standardised CPUE indices) (panel g), total annual catches and TACC (panel h), annual deemed value penalties (panel i), and trawl survey total biomass estimates (and 95% confidence intervals) from the inshore WCSI trawl survey (panel j).**

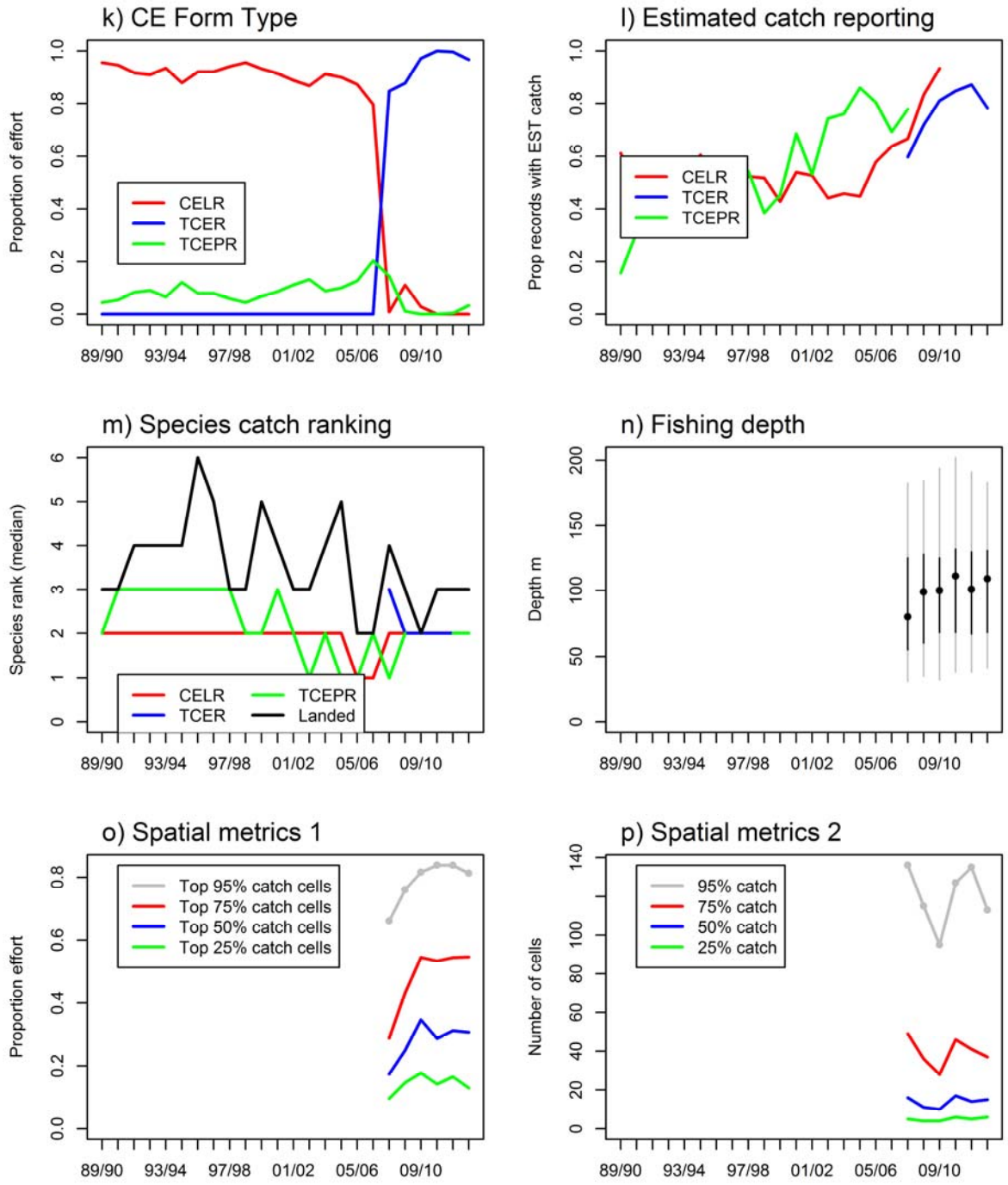

Figure 50: **A summary of the catch and effort included in the TAR 7 TBCS Trawl fishery data set (see Section 3.2 for details): proportion of effort records by form type (panel k), proportion of effort records with an associated estimated catch of the species (panel l), median species rank from associated estimated catch records and landed catch records (panel m), fishing depth of effort records from TCER and TCEPR forms (median, quartile range and 95% interval) (panel n), and spatial metrics derived from TCER and TCEPR fishing records (panels o and p).**

4. DISCUSSION

The current CPUE analyses used a standard set of algorithms that refined the previous approach used to standardise the CELR and TCE (and TCEPR) fishing effort data and the apportionment of the landed catch to the fishing effort records. Differences also existed in the level of data aggregation in the final CPUE data sets (trip versus effort strata). The resulting CPUE indices were largely insensitive to these changes in data configuration, indicating that the CPUE indices are relatively robust at least to minor changes in the data processing that may be introduced by individual analysts.

The location based fishing effort data reported in the TCE format enables a more detailed analysis of fine-scale patterns in fishing effort, including fishing depth. Three simple metrics were derived to monitor the recent (2007/08 onwards) fishing patterns of the constituent fleet comprising each CPUE data set.

The spatial metrics do not reveal any concentration of fishing effort in core species-specific fishing areas from 2007/08 to 2012/13 for the following fisheries: ELE 5, GUR 3 FLA fishery, GUR 7 WCSI FLA fishery. However, the spatial metrics indicate a possible increase in efficiency in a number of fisheries, with more effort targetted at productive fishing locations, specifically GUR 7 WCSI MIX fishery, GUR 7 TBGB FLA fishery, TAR 7 WCSI fishery, ELE 7 fishery, and TAR 7 TBCS fishery. Conversely, there is a possible decrease in the efficiency for a number of other fisheries, specifically the ELE 3 fishery, GUR 3 MIX fishery, GUR 7 TBCS MIX fishery, and JDO 7 fishery. These observations are important in the consideration of the reliability and utility of the individual fishery specific CPUE indices for the monitoring of the respective fishstocks over recent years. However, further study is required to formulate reliable spatial indicators for the monitoring fleet behaviour from location based catch and effort data and the application of such analyses to quantify the reliability of the resulting CPUE indices.

5. MANAGEMENT IMPLICATIONS

The SINS WG (26 March 2014) reviewed the methodology developed for amalgamating catch and effort data from CELR and TCER (and TCEPR) data formats and considered the methodology represented the current best practice for generating a composite CPUE data set. The approach is considered likely to minimise any potential sources of bias in the CPUE indices that might have resulted from the change in the catch and effort reporting following the introduction of the TCER form in 2007/08.

The SINS WG has also supported the proposed strategy of conducting routine updates of CPUE indices for monitoring selected inshore fishstocks in the manner outlined in this document. The approach would be limited to candidate fishstocks that have an established CPUE analysis accepted by the SINS WG. It is envisaged that the rapid CPUE updates would be conducted annually or biennially. A thorough fishery characterisation and detailed reanalysis of the CPUE data would be conducted every five years. It is envisaged that the approach would be most applicable to relatively short-lived species with relatively high recruitment variability and, consequently, considerable variation in stock abundance over the short-term (2–4 years). Such species include red gurnard, red cod and John dory. It may also be appropriate to update the CPUE indices for those fishstocks that have specific management issues that necessitate more regular monitoring of the stock, for example persistent over-catch of the TACC, concerns regarding discarding or declining trends in abundance.

For 2014, the CPUE indices presented in this document were accepted by the SINS WG and were incorporated in an update of the stock status for the specific fishstocks. For most of the fishstocks, the time series of CPUE indices have been used to develop proxies for target biomass, usually based on the average of the CPUE indices from a period when the stock was considered to be at a level that approximated the default target biomass level as defined by the Harvest Strategy Standard (MFish

2008). Recent CPUE indices are used to indicate the current status of the stock relative to the defined target biomass proxy. For the range of fishstocks, there is no direct linkage between the estimate of current stock status and a management response (i.e. TACC change). The development of such a decision rule would be best conducted in the framework of a Management Procedure Evaluation (MPE) analysis for the specific fishstocks.

The accumulating time-series of TCER data will enable the development of CPUE indices for inshore trawl fisheries from the detailed location-based catch and effort data, although currently there is a relatively short time-series of data available in the location based format (commencing 2007/08). For many of the inshore fishstocks included in this report, the analysis of CPUE data is likely to remain a primary component of the monitoring of the fishstock and CPUE-based stock status target and limit reference points have been defined for a number of these stocks. Thus, it will be necessary to routinely update the current CPUE analyses, based on the longer time-series of aggregated catch and effort data, to enable the stock to be referenced against the established benchmarks, at least in the medium term. The development of CPUE indices derived from the location based catch and effort data will complement the existing analyses and, over time, may become the primary CPUE index used for monitoring individual fishstocks.

6. ACKNOWLEDGMENTS

The project was funded by Southern Inshore Fisheries Management Company Limited. The project updated the previous analyses conducted by other researchers, most notably Paul Starr and Terese Kendrick (Trophia Ltd). Members of the SINS WG provided useful a review of the analyses, particularly the data aggregation methodology. Marc Griffiths provided valuable comments on an initial draft of the document.

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APPENDIX 1 ANALYSIS OF LOCATION BASED CATCH AND EFFORT DATA FOR ELE 7

The ELE 7 MIX Trawl CPUE indices increased considerably from 2010/11 to 2011/12 and remained at the higher level in 2012/13 (see Section 3.3). The reliability of the more recent CPUE indices was investigated through an examination of the detailed TCER catch and effort data from the fishery during 2007/08–2012/13.

The TCER data set was selected based on similar selection criteria applied to the configuration of the entire ELE 7 MIX Trawl data set, specifically fishing trips that included bottom trawls targeting either flatfish, elephantfish, red gurnard or red cod within statistical area 032–036 (3018 trips). The landed catch of elephantfish from the individual fishing trips were assigned to the individual trawls, primarily in proportion to the estimated catches of elephantfish reported for the individual trawl records. A total of 97.2% of the total landed catch of elephantfish from the qualifying fishing trips was allocated to the effort records in this manner (1382). The remainder of the landed catch was from fishing trips without estimated catch records of elephantfish. For these fishing trips, the elephantfish landed catch was apportioned equally between all the trawls conducted during the fishing trip (523 trips). There were a further 1113 qualifying fishing trips that did not land any elephantfish.

The TCER data set was further refined to include only vessels that conducted at least five trawls in at least five years during 2007/08–2012/13. The final data set was also restricted to fishing effort from trawls conducted in depths less than 100 m on the basis that elephantfish catches in the WCSI fishery are generally taken from trawls within the 15–60 m depth range. Effort records from outside of the initial target species and statistical area specifications were also excluded. The final data set included a total of 17 090 trawls from 1908 fishing trips (Table A1). There are a high proportion (60–70%) of effort records with no catch of elephantfish included within the data set.

Table A1: Summary of the ELE 7 catch and effort data included within the final TCER data set.

Fishing year	Records	Number vessels	Number trips	ELE catch (t)	Number trawls	Fishing duration	ELE zero catch (%)
2007/08	3 665	24	358	73.1	3 665	17 261	62.2
2008/09	3 287	27	365	50.1	3 287	15 413	71.6
2009/10	3 503	29	388	43.1	3 503	14 894	65.7
2010/11	2 275	28	287	40.3	2 275	10 134	68.9
2011/12	2 430	24	286	64.1	2 430	11 531	59.2
2012/13	1 930	26	224	50.7	1 930	8 646	67.2

The annual distribution of elephantfish catch and key effort variables were examined to determine whether there had been any substantial changes in the operation of the fishery that coincided with the large increase in CPUE in 2011/12. The distribution of elephantfish catch by target species changed considerably in 2011/12 with a substantial increase in the proportion of the elephantfish taken by the target red gurnard trawls, while there was a relatively small increase in the number of red gurnard target trawls (Figure A1).

Most of the elephantfish catch was taken during January–April (Figure A2). The seasonal distribution of fishing effort varied during 2007/08–2012/13 with lower levels of fishing effort in December–February during 2010/11–2012/13 (Figure A2).

The distribution of fishing effort tended to increase in the southern area of the fishery from 2009/10 to 2011/12 while fishing depth varied between years with a higher proportion of trawls occurring in deeper water in 2012/13 (Figure A3). There was no appreciable trend in trawl duration or trawl speed during the study period (Figure A3).

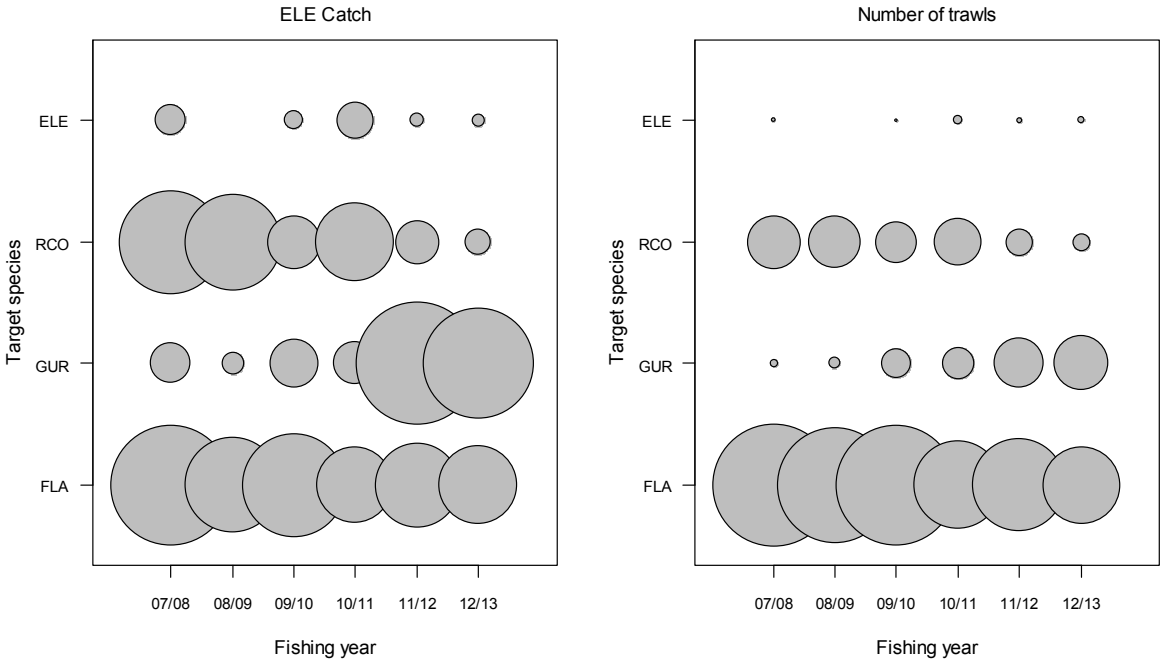

Figure A1: Annual elephantfish catch (left panel) and number of trawls (right panel) by target species for the final TCER data set. The area of the circle is proportional to the magnitude of the catch (maximum =39.5 t) and number of trawls (maximum = 3056).

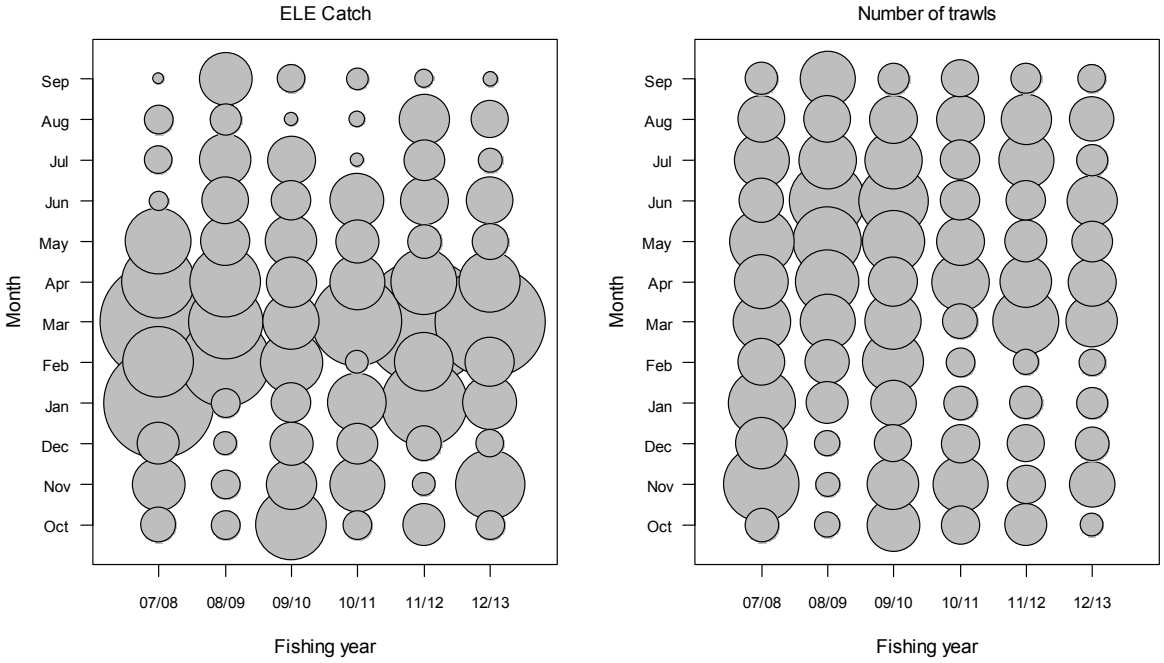

Figure A2: Annual elephantfish catch (left panel) and number of trawls (right panel) by month for the final TCER data set. The area of the circle is proportional to the magnitude of the catch (maximum =23.4 t) and number of trawls (maximum = 587).

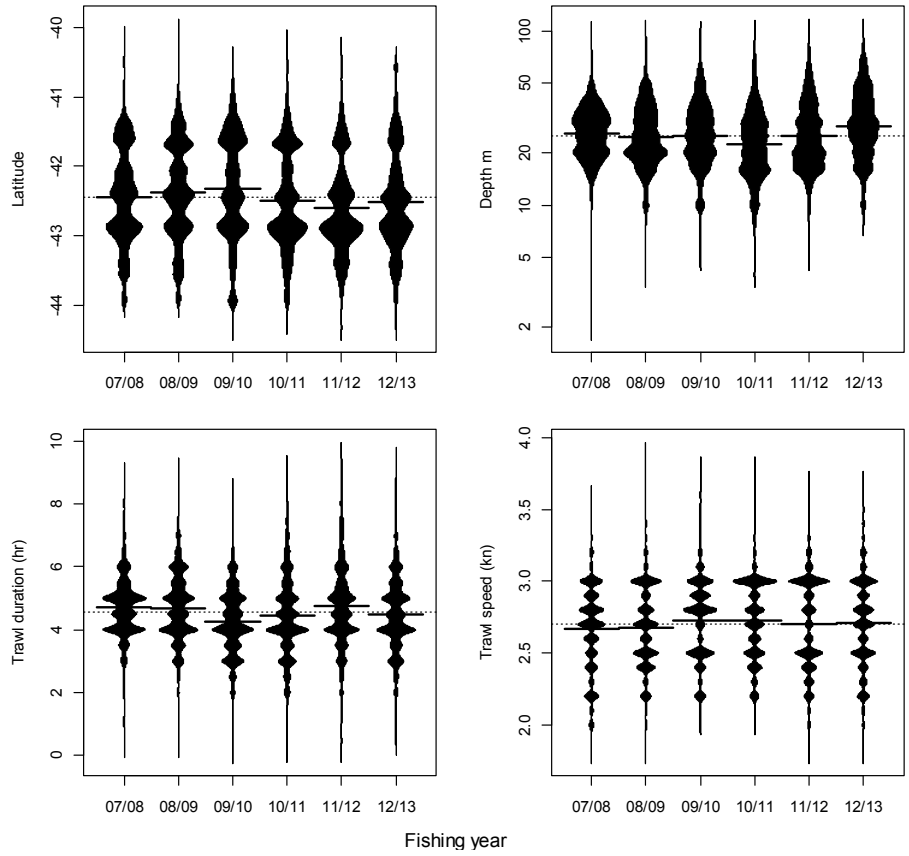

Figure A3: Beanplots of the annual distribution of selected variables from the final TCER data set. The solid horizontal line represents the mean value for the year, the dashed horizontal line represents the overall mean value.

The CPUE analysis included two components that determine the overall catch rate of elephantfish: the probability of catching elephantfish and the magnitude of the elephantfish catches. A high proportion of the qualifying trawls caught no elephantfish, although there was a slight increase in the annual proportion of trawls catching the species over the study period (Figure A4). There was also an increase in the magnitude of the positive elephantfish catch per trawl from 2008/09 to 2012/13 (Figure A4).

Separate CPUE models were formulated to predict the probability of catching elephantfish (binomial model) and the magnitude of the natural logarithm of elephantfish catches (lognormal model). The data set incorporated in the lognormal model was restricted to trawls with an associated catch of elephantfish. For both models, a range of potential explanatory variables were included; the categorical variables fishing year , month, vessel identifier and target species and the continuous variables fishing depth, time of day at start of trawl, trawl speed, trawl duration, and start latitude (to the nearest minute). The continuous variables were included in the model as third order polynomials. Fishing year was included in both models and the other potential explanatory variables were included using a step-wise AIC fitting procedure. For all model options, all potential explanatory variables were included within the final CPUE models.

Initial models included the categorical variable target species and the inclusion of this variable accounted for most of the difference between the unstandardized CPUE (geometric mean of non zero catches) and lognormal standardised CPUE indices (Figure A4). The standardised lognormal indices exhibited a smaller increase than the unstandardized CPUE.

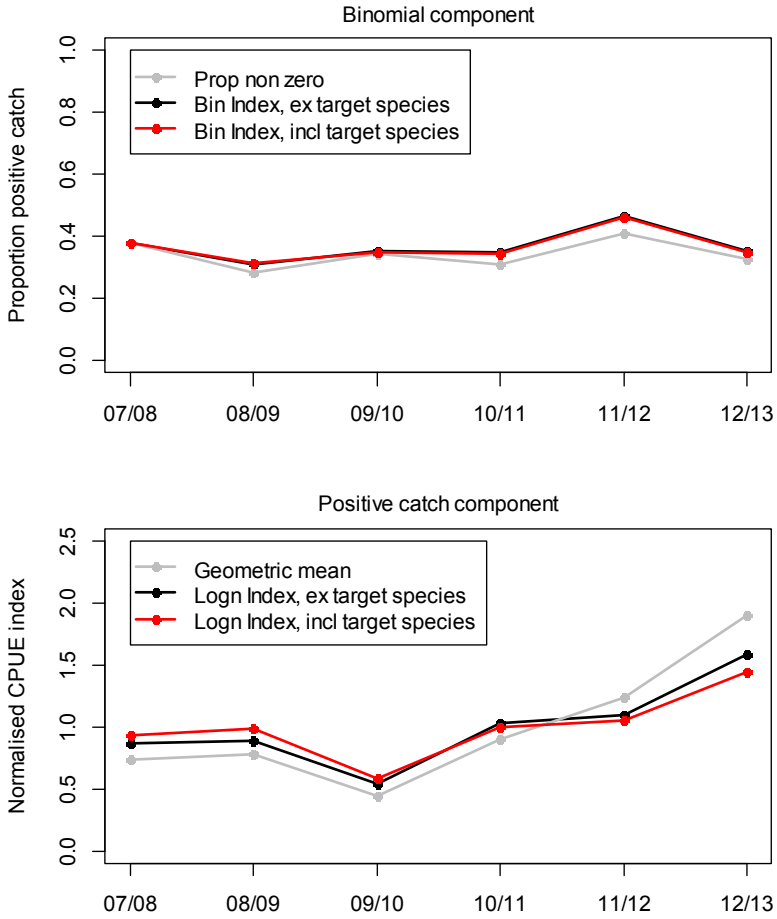

Figure A4: A comparison between the annual proportion of positive ELE catch records and the binomial CPUE indices (top panel) and the geometric mean of the positive catches (unstandardized CPUE) and the CPUE indices from the lognormal models that included and excluded target species as an explanatory variable (bottom panel).

The declared target species is likely to be aliased, to some extent, by fishing depth. The declaration of target species may be unreliable and is likely to vary amongst the fleet. This is evident when examining the influence of individual variables within the lognormal CPUE model. The annual indices from the base model (excluding target species) were comparable to indices derived from a simpler model that included only fishing year and fishing depth (Figure A5). The base indices were also approximated by a model option that included fishing year, target species and vessel.

A model that included fishing year and target species moderated the extent of the CPUE increase from 2009/10 to 2012/13 (Figure A5), suggesting a difference in the declaration of target species among vessels.

The final set of CPUE model options included binomial and lognormal models that either included or excluded target species. The indices from both the binomial and lognormal model were comparable to the models that included target species (Figure A4). The combined delta-lognormal CPUE indices were also similar for the two models and the two sets of delta-lognormal CPUE indices were comparable to the recent indices from ELE 7 MIX Trawl CPUE analysis (see Section 3.3) (Figure A6).

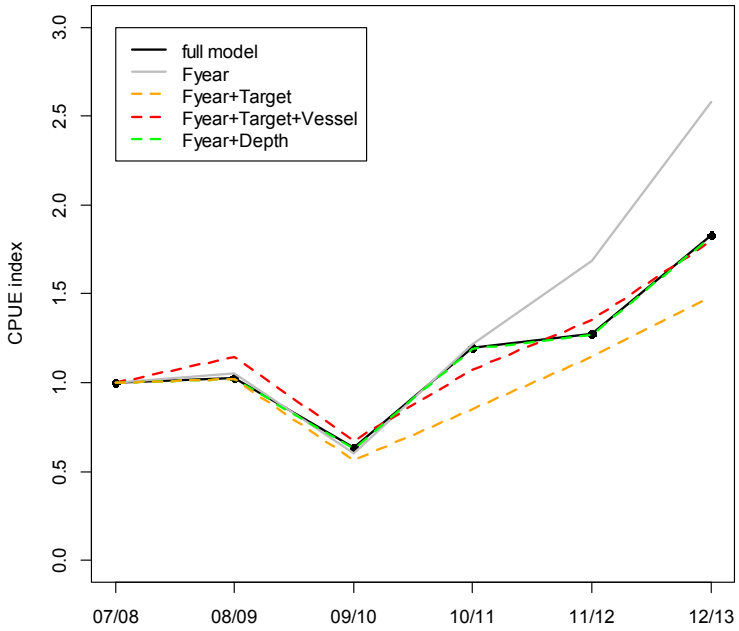

Figure A5: A comparison of the year effects derived from the full lognormal model (excluding target species) and lognormal models that included the fishing year variable and additional explanatory variables.

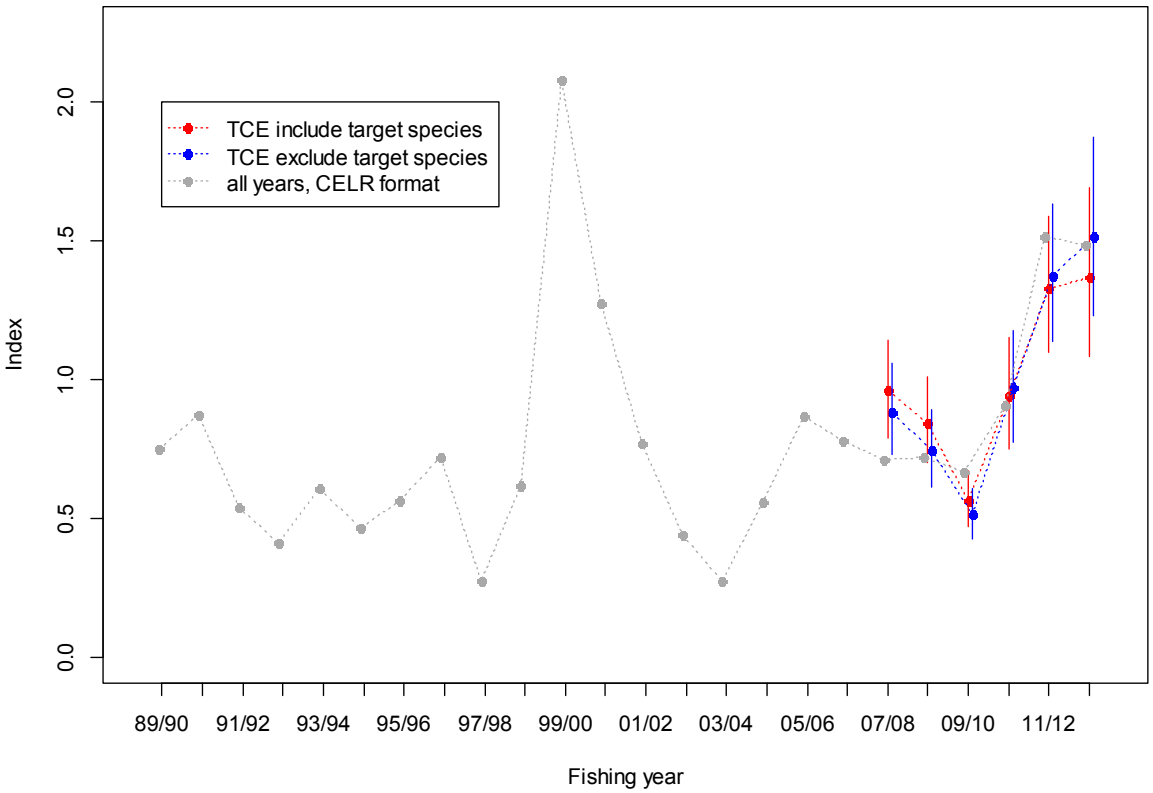

Figure A6: A comparison of the delta-lognormal CPUE indices the TCER models including and excluding target species. The indices are also compared with the full time series of CPUE indices derived from the combined data set (see Section 3.3).

The distribution of the fishing effort tended to shift southwards in 2010/11 and 2011/12 (Figure A3). There is potential that the shift in fishing effort may be influencing the (higher) CPUE indices from

the most recent years as unstandardised catch rates for elephantfish tend to be higher in the southern area of the fishery (within 44°–42.4°S).

For the TCER data set, there is a strong correlation between fishing depth and latitude. Most of the fishing effort in the main area of the fishery (latitude band 43.2°S to 42°S) tends to occur within the 15–30 m depth range, while fishing occurs at increasing depths further northward. Latitudinal changes in the operation of the fishery are therefore likely to be accounted for by the inclusion of both the latitude variable and the depth variable in the CPUE model.

Nonetheless, the sensitivity of the CPUE indices to the apparent shift in the spatial operation of the fishery was examined by partitioning the CPUE data set into two latitudinal bands: south of 42.5°S and north of 42.5°S and independently refitting a lognormal CPUE model (excluding target species) for each latitudinal band data set. In general, the annual indices derived from the CPUE models for the two latitudinal bands are generally consistent with the base model that includes the entire data set (Figure A7). This increases the confidence that the recent CPUE indices are not unduly biased by a change in the spatial operation of the fishery and/or a substantial shift in the distribution of elephantfish along the west coast.

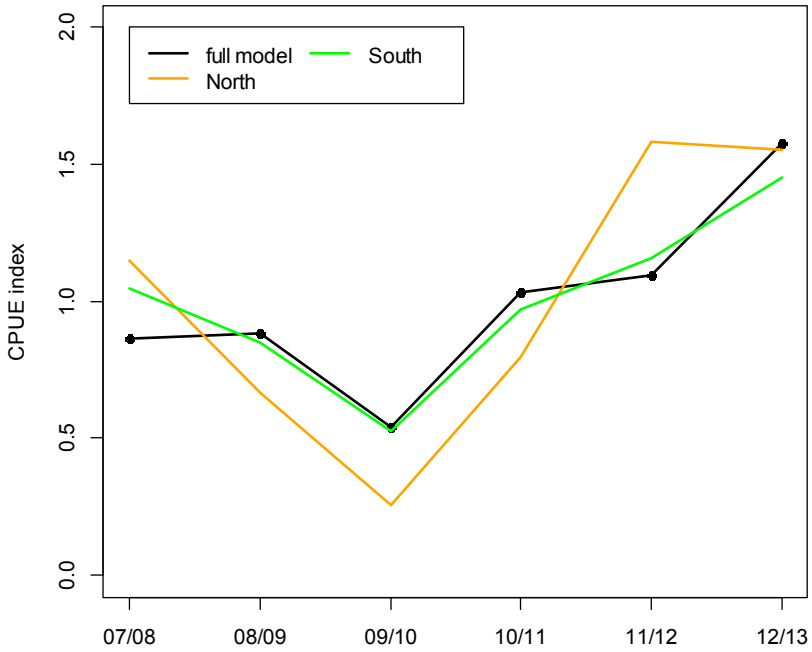

Figure A7: A comparison of the year effects derived from the base lognormal model (excluding target species) and separate lognormal models from data partitioned by latitudinal band (south of 42.5°S and north of 42.5°S).