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EXECUTIVE SUMMARY

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Standardised catch-per-unit-effort (CPUE) indices are presented for the silver warehou (*Seriolella punctata*) trawl fisheries for the west coast, sub-Antarctic, west Chatham Rise, and the east Chatham Rise of New Zealand.

CPUE indices from trawl fisheries are derived from catch and effort data from commercial logbooks such as Trawl Catch Effort Processing Returns (TCEPR) and Catch Effort Landings Returns (CELR). TCEPR contains estimated catch and effort data from each tow, but only the top five species caught are recorded. This may have an impact on estimates of CPUE for less frequent bycatch species, such as silver warehou. The daily processed catch summary is also recorded on the TCEPR. This contains information regarding the catch (of all quota species) that was caught and processed that day, but does not contain information regarding the individual tows. In this study, indices were derived using both TCEPR tow-by-tow and daily processed catch summaries, as well as the daily processed catch summaries combined with summarised daily data from the TCEPR tow-by-tow records. The indices are standardised for effects such as seasonal variation, differences in vessel characteristics, and fishing power. The CPUE indices were estimated using a lognormal generalised linear model.

The indices resulting from the TCEPR tow-by-tow data, daily processed catch summaries, or using information from both show similar trends and suggest the indices reflect abundance for all areas apart from the east Chatham Rise. It is recommended that the east Chatham Rise be excluded from the analysis or combined with the west Chatham Rise. Diagnostic analysis for all models suggested some departures from model assumptions, indicating that the model structure can be improved.

1. INTRODUCTION

Silver warehou (*Seriolella punctata*) are caught in coastal waters around mainland New Zealand and on the Chatham Rise, mainly in depths down to about 500 m (Anderson et al. 1998). Commercial fishing for silver warehou has developed since the 1970s. In recent years, most silver warehou has been taken as a bycatch of the hoki, squid, barracouta, and jack mackerel trawl fisheries, though some target fishing occurs (Schofield 1995).

Present management divides the fishery into four main stocks (Figure 1), or Fisheries Management Areas (FMA) (Schofield 1995): (a) North Island and the west coast of the South Island (SWA 1), (b) south east coast of the South Island (SWA 3), (c) sub-Antarctic, Southland and the east Chatham Rise (SWA 4). An administrative stock has been established for the Kermadec area (SWA 10), but no catch of silver warehou has been recorded from that area.

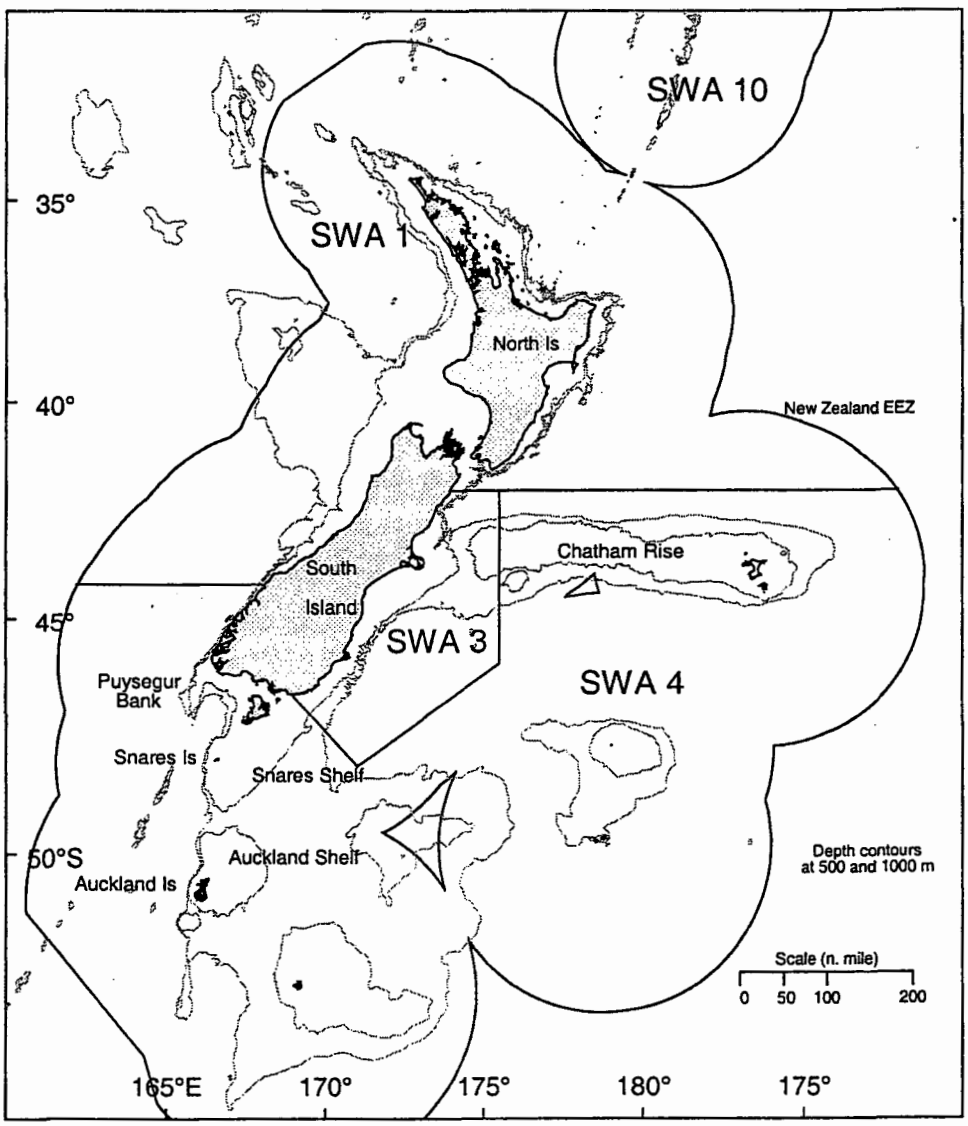

Figure 1: Silver warehou Fisheries Management Areas (FMA).

Previously, the analysis of CPUE of the west coast of the South Island SWA 1 fishery has not been considered useful for stock assessment as the fishery is primarily a bycatch of hoki target trawling (Langley 1992). In 1998, Knuckey et al. (Marine and Freshwater Resources Institute. Unpublished results) characterised the fishery using commercial catch and effort data, and carried out a feasibility

study of CPUE in SWA 3 and 4 (in particular, the Snares Shelf and Mernoo Bank area) using Trawl Catch Effort Processing Returns (TCEPR). The results from that study indicated that relative year effects obtained from the standardisation were variable and showed a flat trend. However, they did note that there were peaks in the indices from the 1993–94 and 1996–97 fishing years that may be related to high recruitment apparent in the commercial length frequency data from the fisheries. There was also some concern that a large proportion of the silver warehou catch was taken as bycatch, and only a small proportion of the catch was recorded on the commercial logbooks (see below for explanation).

CPUE indices are derived from catch and effort data from commercial logbooks such as TCEPR and Catch Effort Landings Returns (CELR). TCEPR contains estimated catch and effort data from each tow, but the CELR contains the estimated catch and effort data from each day. Both forms record only the top five species caught. This may have an impact on estimates of CPUE for bycatch species caught in smaller quantities, such as silver warehou. The daily processed catch summary is also recorded on the TCEPR form (for an example of a TCEPR form see Appendix 2). This contains information regarding the catch (of all quota species) that was caught and processed that day. The processed fish are weighed and a conversion factor (depending on processing type) allows the weight of the fish before processing (i.e., green weight) to be estimated. This should be more accurate than the estimated catch from the tow-by-tow component of the TCEPR form.

A CELR entry is a summary of a single day's fishing (which may comprise several sets or tows), with position given by statistical area. Longline and setnet landings are always recorded on CELR forms, but trawl vessels less than 28 m in length can use either CELR or TCEPR forms. Trawl vessels longer than 28 m use TCEPR forms.

This report updates the previous CPUE analyses that used the TCEPR tow-by-tow data, and compares resulting abundance indices with those derived from the daily processed catch summaries.

2. METHODS

2.1 The data and variables available for analysis

The data comprise commercial catch and effort data where silver warehou was targeted and/or caught in SWA 1, 3, and 4 for the 1989–90 to the 1998–99 fishing years. The data were extracted from the Ministry of Fisheries catch and effort database in August 2000.

The variables available for the analysis (including those derived) from TCEPR tow-by-tow records are described in Table 1, and the variables from the daily processing catch are described in Table 2. Most of the variables are self explanatory, but some require further definition. The *day/night* variable was introduced as a possible explanatory term to account for changes in the number of daylight hours at various longitudes and latitudes. The *start* time of each tow was grouped into a 4-level categorical variable with levels for within 1.5 hours of sunrise (dawn), and sunset (dusk), otherwise between sunrise and sunset (day) or between sunset and sunrise (night).

Some of the categorical variables including target species and processing type were summarised to simplify the analysis. For each area, target species were summarised into six levels: the four top target species caught (excluding silver warehou), silver warehou, and any remainder. Processing type was summarised into six levels: surimi, fillet, head and gut, ice, all others, and unknown.

Table 1: Description of variables available for the analysis from the tow-by-tow component of the TCEPR form. Variables in bold are categorical variables, those in italics are derived.

Variable	Description
Form number	Form number of the TCEPR form (lists the tows for that day and the daily processed catch)
Fishing year	Fishing year (1 October to 30 September)
Vessel number	Unique vessel identification number
Start date	Date at the start of the tow
Start time	Time at the start of the tow
Start longitude	Longitude in decimal degrees at the start of the tow
Start latitude	Latitude in decimal degrees at the start of the tow
End longitude	Longitude in decimal degrees at the end of the tow
End latitude	Latitude in decimal degrees at the end of the tow
Method	Gear type used
Start Stat	Statistical Area at the start of the tow
Wingspread	Wingspread in metres of the net at the start of the tow
Headline height	Headline height in metres of the net at the start of the tow
Bottom depth	Depth in metres of the bottom at the start of the tow
Groundrope depth	Depth in metres of the ground rope at the start of the tow
Target species	Species of fishes targeted
Total catch	Total catch in tonnes of target and bycatch species from the tow
Silver warehou catch	Catch in tonnes of silver warehou
Processing type	Processing method of the silver warehou catch
Vessel speed	Speed in knots of vessel during tow
Nationality	The registered nationality of the vessel at the time of the tow
Vessel length	The overall length of the vessel in metres at the time of the tow
Vessel draught	The registered draught of the vessel in metres at the time of the tow
Vessel breadth	The registered breadth of the vessel in metres at the time of the tow
Vessel tonnage	The gross tonnage in metric tonnes of the vessel at the time of the tow
Vessel power	Power in kilowatts of the vessel engine
Vessel year built	Year vessel built
Area	The fishery at the beginning of the tow
Tow duration	Duration of the tow in hours
Tow distance	The distance of the tow in nautical miles
SOI	Southern oscillation index
Moon phase	Moon phase
Sunrise	Time of sunrise
Sunset	Time of sunset
Net diff	Height of the net from the bottom
Day/night	Code for time of tow based on the sunrise and sunset time
Tow duration	Duration of tow in hours
Tow distance	Distance of the tow in nautical miles
CPUE	Catch (kg) per nautical mile

Table 2: Description of variables available for the analysis from the daily processed catch summary component of the TCEPR form. Variables in bold are categorical variables, those in italics are derived.

Variable	Description
Form number	Form number of the TCEPR form (lists the tows for that day and the daily processed catch)
Processing date	Date the fish were processed
Fishing year	Fishing year (1 October to 30 September)
Vessel key	Unique vessel identification number
Midday latitude	Latitude of vessel at midday
Midday longitude	Longitude of vessel at midday
Processing type	Processing method
Number of processed units	Number of processed units e.g. trays
Processed catch weight	Weight of processed catch (kg)
Conversion factor	Conversion factor that determines the green weight from the weight of the processed catch
Unprocessed catch	Weight of unprocessed catch (green weight)
Nationality	The registered nationality of the vessel at the time of the tow
Vessel length	The overall length of the vessel in metres at the time of the tow
Vessel draught	The registered draught of the vessel in metres at the time of the tow
Vessel breadth	The registered breadth of the vessel in metres at the time of the tow
Vessel tonnage	The gross tonnage in metric tonnes of the vessel at the time of the tow
Vessel power	Power in kilowatts of the vessel engine
Vessel year built	The year the vessel was built
SOI	Southern oscillation index
CPUE	Catch (kg) per day

2.2 Data checking and validation

Catch and effort data often contain a large number of errors, most in the form of missing data, invalid codes, or implausible values. Data for all areas were checked for such errors before the analysis (see Appendix 1 for a summary of the effects of such cleaning on the dataset). The process of checking, validating and cleaning the data is similar to that described by (Vignaux 1992) and (Dunn & Harley 1999) and is briefly described below.

Individual tow records and daily processed catch summary records were selected if they occurred within the area boundaries within the defined period. Tow records outside the defined areal boundaries or time period were not investigated or otherwise validated, and hence, were deleted.

All the variables for each record were checked for valid codes and values, and all variables were range checked. Variables with invalid codes or out of range values were visually compared with records from the same vessel on or around the time and date of the tow in question. Obvious transcription errors and recording errors were corrected, if possible. If no correction could be applied and the data were still considered highly improbable or had an invalid code, then the values were set to missing, otherwise no change was made.

The error-checked and corrected data sets provided the basis for fitting the standardised CPUE models.

2.3 Measurement of catch and effort

There are many measures of effort that could be used in CPUE analysis (Knuckey et al. unpublished analysis). However, any relationship between catch/effort and fish abundance is important in any CPUE analysis. Measures of effort should consider aspects of fisher behaviour and the spatial distribution of fish (Dunn et al. 2000).

The use of 'catch per tow' and 'catch per hour' as measures of CPUE were deemed unsuitable in the present study because there were significant changes in annual tow duration and vessel towing speed. Using these measures of effort where temporal change occurs can compromise the use of CPUE as an index of abundance (Knuckey et al. unpublished analysis). Consequently, tow distance (n. miles per tow) was the measure of effort used in the present study because it incorporated these temporal changes in tow time and speed. Tow distance was calculated as the tow duration (hours) × tow speed.

The daily processed catch forms do not include data on the total number of tows or their durations. The effort data from these logbooks could only be quantified as "per day".

As CELR forms do not contain tow-by-tow records, but only the number of tows, CPUE derived from these records could only be quantified as 'catch per average tow' or 'catch per day'. Fortunately, only 1.5% of the total silver warehou catch comes from vessels filling out these forms. Consequently, these data were omitted from the CPUE analyses

2.4 Descriptive analysis of TCEPR tow-by-tow data and daily processed catch summaries

Descriptive summaries of data recorded by the TCEPR tow-by-tow records and the daily processed catch summaries were compared. The records were checked to see if a TCEPR tow-by-tow record had an accompanying daily processed catch summary record and vice versa.

The estimated catch for a vessel on any day was derived by adding the TCEPR tow-by-tow catch data for that vessel for that day. This was compared to the processed catch for the day from the daily processed catch summary. The possibility that catch on one day was processed on the next was also investigated. The daily catch from TCEPR tow-by-tow records was calculated and compared to the daily processed catch for each vessel. If there was a greater amount from the calculated daily catch to that of the daily processed catch summary, and on the following day the opposite occurred, the individual TCEPR tow-by-tow records were investigated to establish the time the silver warehou catches occurred. If the large catch occurred late in the evening, this may suggest that processing occurred on the following day. However, there was no evidence that this occurred.

When fishers are catching fish in a certain area, it can be assumed they will continue to work that area until the catch rates are too low, or the boat is full or they have run out of quota. The median of the start longitudes and latitudes of the tow-by-tow data were compared to the midday longitudes and latitudes of the daily processed catch summary.

2.5 Calculating standardised CPUE indices from TCEPR tow-by-tow data

Estimates of relative year effects were obtained from a stepwise multiple regression method, where the data were modelled using a lognormal model similar to that of (Vignaux 1994). However, the binomial component of the model was not used as the number of tows targeting silver warehou but not catching any (zero tows) ranged from 11.7 to 14.7% by year for each area (Appendix 3), and were omitted from any further analysis.

A forward stepwise multiple regression-fitting algorithm was employed (Chambers & Hastie 1991; Venables & Ripley 1994). The algorithm generates a final regression model iteratively and was implemented using the simple intercept model as the base model starting point. The reduction in residual deviance is calculated for each single term added to the base model. The term that results in the greatest reduction in the residual deviance is added to the base model if this would result in a change of more than 0.5% (2% for the east Chatham Rise, due to the lack of available data). The algorithm then repeats this process, updating the base model, until no more terms can be added (Dunn & Harley 1999).

The stepwise algorithm also considered first order interactions terms. At each step, all first order interactions between variables selected up to that point were evaluated. As earlier, terms that resulted in a 0.5% reduction in residual deviance (2% for the east Chatham Rise) were added to the model, and terms less than 0.5% (2% for the east Chatham Rise) were deleted. As the primary interest in the model is an estimate of relative year effects, possible interactions with *fishing year* were not evaluated.

The model for each area was standardised for a year that had the most records. This reduces the standard error for all the remaining years (A. Dunn, NIWA, pers. comm.)

The fishing year was treated as a categorical value so that the regression coefficients of each year can vary independently. The relative year effects calculated from the regression coefficients represent the change in CPUE over time, all other effects having been taken into account. Therefore it represents a possible index of abundance.

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

Not all catch and effort data were used in the CPUE analysis. Data from outside the areas described and records which were likely to contain poor quality or incorrect data were removed. The reasons for any data removals and the number of records and the amount of silver warehou catch that were deleted are described in Appendix 3.

There was a need to incorporate vessel effects into the CPUE standardisation to allow for likely differences in fishing power between vessels. Because the standardisation requires a time series of data to determine changes in abundance, such vessel effects need to be distinguished from the year effects. Vessels that were not involved in the fishery for consecutive years, or participated for one or two consecutive years provide little information to the standardisations. (Knuckey et al. unpublished analysis) tried a variety of vessel selections: vessels with three or more consecutive years involvement in the fishery; vessels which captured the top 90% of silver warehou catches over the years; the top 75%; and the top 50%. Their results indicated that the standardised CPUE indices were not sensitive to the vessel selection method.

Eighty percent of the silver warehou catch over the period studied was taken by 77 (25%) vessels, and the rest of the vessels were usually involved in the fisheries for only one or two years, or had very low catches. Similar trials were also conducted here using vessels with three or more consecutive years in the fishery, and vessels which captured the top 80% of silver warehou catch over the years (for the effects of vessel selection see Appendix 3).

2.6 Calculating standardised CPUE indices from daily processed data

The method of vessel selection, and the analytical approach, were similar to that described above (i.e., the forward stepwise regression technique); however, 'catch per day' was used.

2.7 Calculating standardised CPUE indices using information from daily processed and TCEPR tow-by-tow data

The method of vessel selection, and the analytical approach, were similar to that described above (i.e., the forward stepwise regression technique). As in the analysis of daily processed data, CPUE was measured as 'catch per day'.

The median groundrope depth, bottom depth, wingspread, and headline heights for each vessel on each day were calculated from the TCEPR tow-by-tow records. This information was combined with the daily processed data and subsequently used in the analysis.

3. RESULTS

3.1 General aspects of the silver warehou fishery

As the Fishstock areas for silver warehou do not correspond exactly to the regions of the main fisheries, four main fisheries were investigated based on the distribution of commercial catches (Figure 2) and the amount caught (Table 3). These areas are: the west coast South Island (a subset of SWA 1) which is a clearly established separate fishery; sub-Antarctic (comprising the southern component of SWA 3 and sub-Antarctic region of SWA 4) which is a silver warehou target fishery; the west Chatham Rise (northern component of SWA 3 and part of SWA 4); and the east Chatham Rise (comprising part of SWA 4) which are clearly separate fisheries (Figure 2). The catch from the four areas is listed in Table 3. Approximately 23% (range 13–30% for each year) of the catch comes from the west coast area, 45% (range 37–58%) from the sub-Antarctic area, 26% (range 19.5–37%) from the west Chatham Rise, 3.5% (range 0.5–9%) from the east Chatham Rise, and 0.5% (range 0.1–1.5%) for the fishing outside these areas.

Silver warehou is taken mainly as by-catch (Table 4). A range of 64–97% (by year) of the silver warehou catch from the west coast area is caught while targeting hoki (Table 4), 1–52% from the east Chatham Rise while targeting hake, and 36–73% from the west Chatham Rise while targeting hoki. However, in the sub-Antarctic 29–72% of the silver warehou catch is taken as a target species.

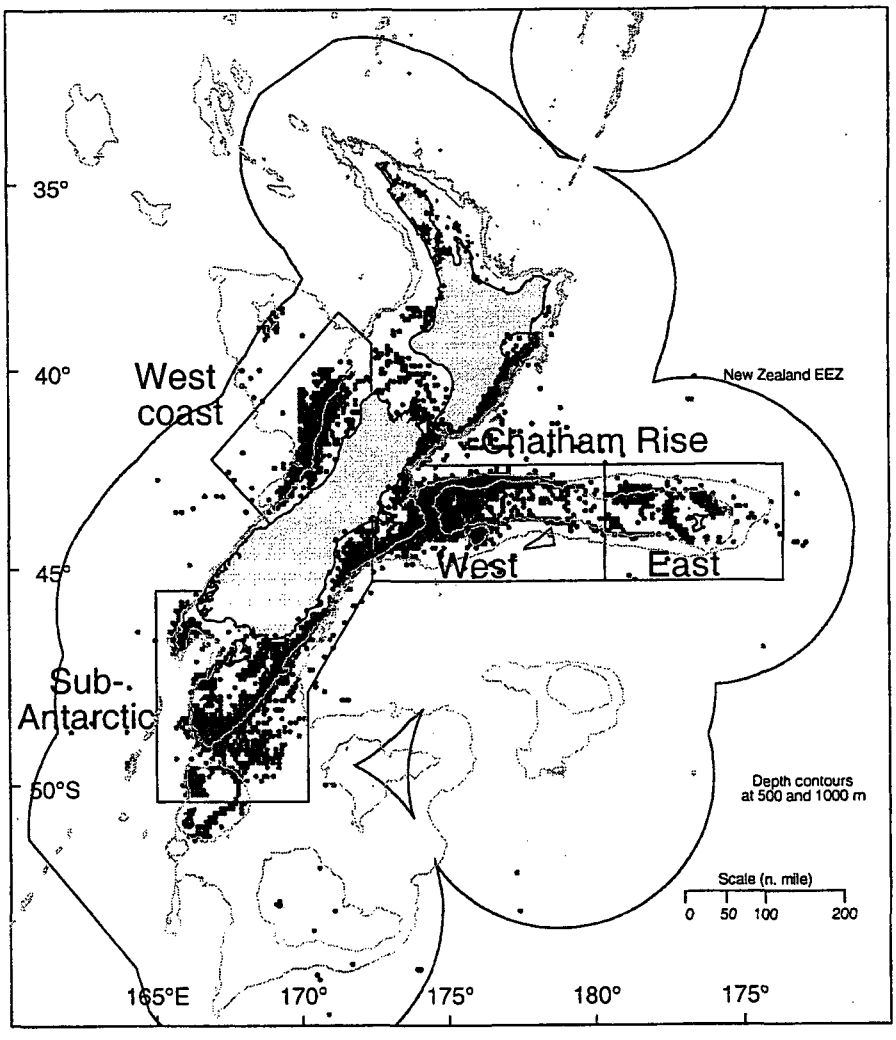

Figure 2: Locations of commercial tows where silver warehou was caught or targeted for all years combined and areas used in this report

Table 3: Catch (t) by each reporting form from each area from the 1989–90 to the 1998–99 fishing year. All values have been rounded to the nearest tonne, so "0" indicates landings less than 0.5 t and "-" indicates nil landings.

Reporting form	Area	Fishing year									
		1989–90	1990–91	1991–92	1992–93	1993–94	1994–95	1995–96	1996–97	1997–98	1998–99
TCEPR	East Chatham Rise	32	298	112	224	257	170	654	643	238	92
	West Chatham Rise	1 559	1 759	1 972	2 264	1 681	1 898	1 929	2 368	2 299	1 446
	sub-Antarctic	4 261	2 627	3 066	2 716	3 274	2 268	2 892	5 334	3 899	4 275
	West coast	1 919	1 699	1 081	809	2 289	1 686	1 780	2 482	2 620	1 411
	Remainder	18	9	21	19	64	24	93	50	74	30
CELR	East Chatham Rise	1	1	1	1	0	6	0	0	0	1
	West Chatham Rise	58	25	14	28	48	20	36	68	73	63
	sub-Antarctic	0	0	0	-	-	-	-	-	0	-
	West coast	3	17	38	32	29	34	25	21	39	39
	Remainder	11	39	35	54	67	115	64	63	47	28

Table 4: Percentage of silver warehou catch by the top 5 target species for each area using TCEPR tow-by-tow records. All values have been rounded to the nearest 1%, so "0" indicates landings less than 0.5% and "-" indicates nil landings. Note "1990" indicates the 1989–90 fishing year.

Area	Target species	Fishing year									
		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
West coast	Hoki	64	97	70	65	85	73	84	85	96	80
	Barracouta	14	1	11	23	12	17	12	2	0	2
	Jack mackerel	7	1	10	2	0	5	4	7	0	4
	Silver warehou	11	1	4	4	1	1	0	3	2	3
	Hake	0	-	1	2	1	2	1	1	2	5
	Other	3	0	4	4	0	2	0	1	0	7
sub-Antarctic	Silver warehou	69	57	70	72	57	60	53	24	29	29
	Squid	8	17	7	11	22	25	21	52	44	49
	Hoki	12	12	10	6	6	6	6	14	11	11
	Barracouta	6	10	7	6	5	3	5	6	4	1
	Red cod	0	0	2	2	4	5	6	4	6	1
	Other	5	4	4	3	6	2	9	2	7	9
East Chatham Rise	Silver warehou	30	89	21	68	58	3	47	6	4	1
	Hake	53	1	48	18	17	42	15	41	12	9
	Hoki	8	6	9	11	18	49	14	15	51	14
	Barracouta	6	3	12	3	6	6	21	6	19	57
	Squid	0	-	-	-	0	-	0	26	6	3
	Other	3	1	10	0	1	0	2	7	8	15
West Chatham Rise	Hoki	42	45	46	36	42	48	51	55	73	72
	Silver warehou	35	33	32	38	20	31	27	3	5	8
	Squid	12	7	10	6	18	7	13	20	12	13
	Barracouta	7	9	5	6	14	7	4	13	4	3
	Jack mackerel	0	1	0	7	1	2	1	5	2	0
	Other	5	5	7	7	5	6	5	4	4	4

3.2 Descriptive analyses of TCEPR tow-by-tow data and daily processed catch summaries

Fifty-four percent of the TCEPR tow-by-tow records which record silver warehou catch did not have an accompanying daily processing catch summary (Table 5). From each area, 51% of the west coast TCEPR tow-by-tow records did not have an accompanying daily processing catch summary, 56% for the sub-Antarctic, 59% east Chatham Rise, and 58% for the west Chatham Rise. Reasons for this are not clear.

Thirty-six percent of the daily processed summaries did not have an accompanying TCEPR tow-by-tow record (Table 5). Thirty five percent of the west coast and the sub-Antarctic daily processing catch summaries did not have an accompanying TCEPR tow-by-tow record, 38% east Chatham Rise and 37% for the west Chatham Rise. A possible reason is that silver warehou was not one of the top five species caught, and therefore not required to be recorded on the TCEPR tow-by-tow component. However, when the data were standardised for vessel effects in the calculation of the CPUE indices, the proportion of matching records increased (Appendix 3).

Table 5: Number of TCEPR tow-by-tow, daily processed catch and matching records for each area.

Area	Tow by tow records	Daily processed records	Matching records
West coast	26 705	20 442	13 187
sub-Antarctic	19 108	12 873	8 353
E. Chatham Rise	2 390	1 618	997
W. Chatham Rise	20 376	13 631	8 584
All areas combined	67 094	48 564	31 121

The estimated daily catch from TCEPR tow-by-tow records and the matching daily processed catch summaries are presented in Figure 3. About 37% of the daily catch from TCEPR tow-by-tow records is greater than daily processed catch. There were no clear reasons for the difference, but probably the TCEPR tow-by-tow catch was badly estimated, and/or there was a data processing error. About 59% of the daily TCEPR tow-by-tow catch is less than the daily processed catch. The most likely reason for this is that not all silver warehou catch was recorded on the TCEPR tow-by-tow forms, as it was not one of the top five species. About 4% of records have the same catch, probably because the catch was not estimated, but obtained from the daily processed catch.

Median longitudes and latitudes from the TCEPR tow-by-tow records and the midday longitudes and latitudes from the daily processed catch summaries are presented in Figure 4. About 94% of longitude and 97% of latitude differences lie within ± 0.5°, and 80% of the longitudes and 86% of the latitudes lie within ± 0.25° (15 n. miles). The extreme values were examined and it appeared that either there was an error in location data, or that the vessel was steaming. There does not appear to be any significant difference between the median start location from the TCEPR tow-by-tow data and the daily processed midday locations (t_{37058}=0.81, P-value=0.4 for the latitudes; t_{37053}=1.28, P-value=0.2 for the longitudes).

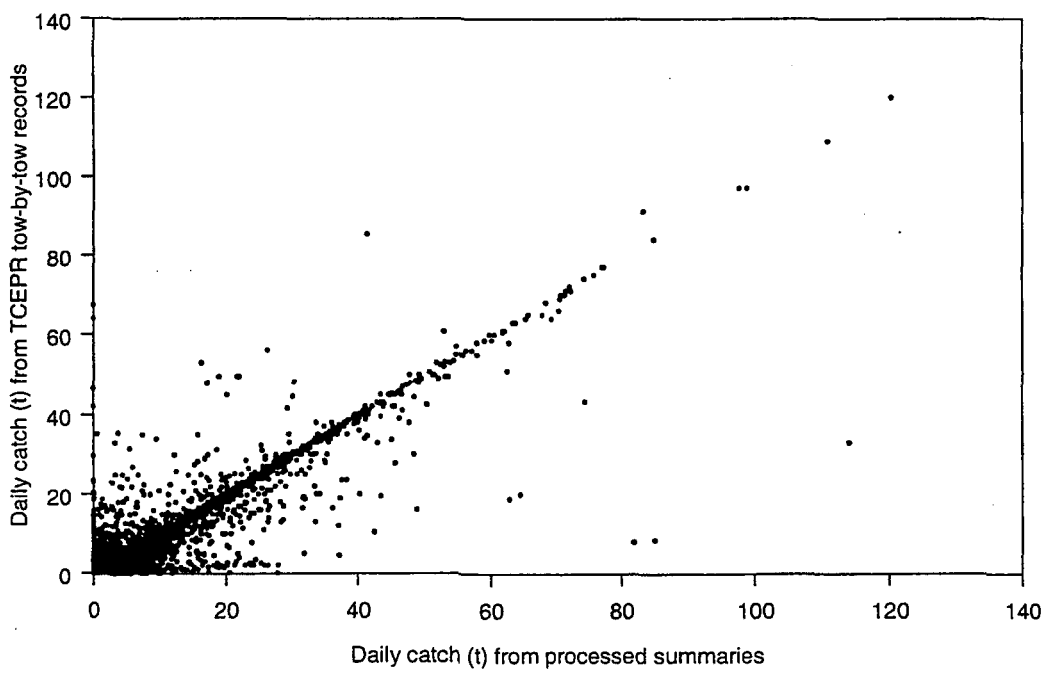

Figure 3: Estimated daily catch (t) from TCEPR tow-by-tow records and daily processed catch summaries for all areas and years combined.

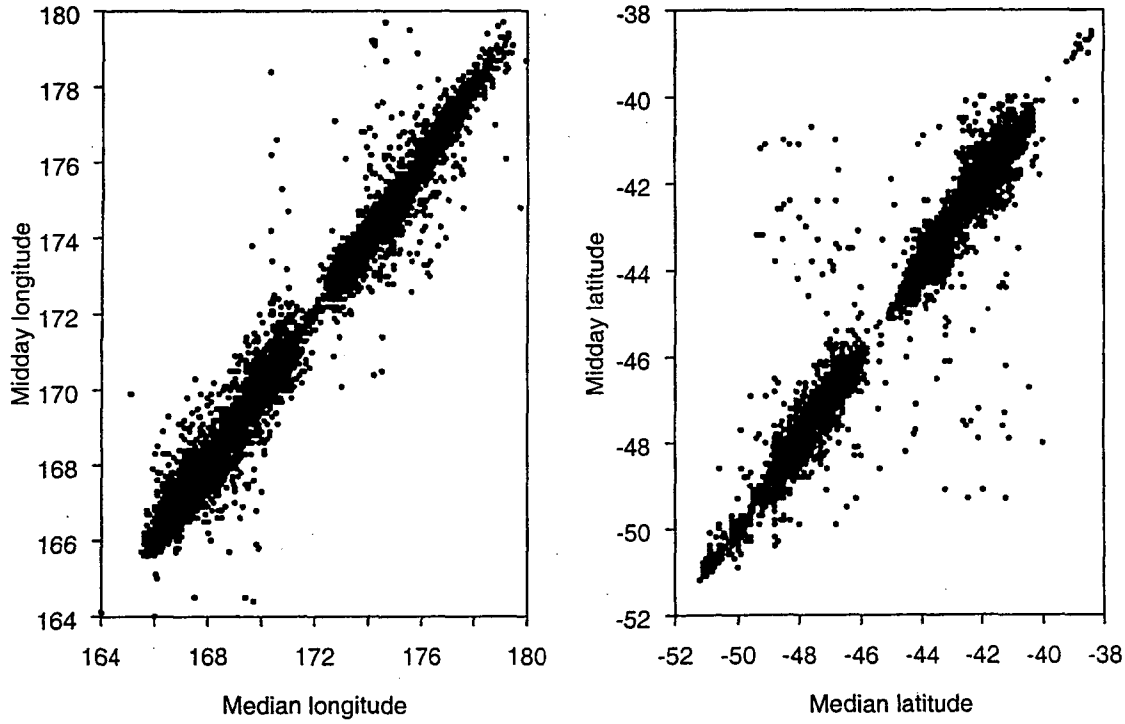

Figure 4: Median longitudes from TCEPR tow-by-tow data and the midday longitude from the daily processed catch summaries (left), and (right) median latitudes from TCEPR tow-by-tow data and the midday latitude from the daily processed summaries for all areas and years combined.

3.3 Estimated CPUE indices for the West coast

The variables selected by the stepwise regression, by order of selection, for the west coast TCEPR tow-by-tow data, the daily processed catch summary data, and the combined information are listed in Table 6, where vessels caught 80% of the total catch for all years, and Table 7 where vessels that fished for three or more consecutive years.

Using data from vessels that caught 80% of the total catch for all years, 12 variables were selected (which included 4 first order interaction terms) using the TCEPR tow-by-tow data. Seven variables (including 1 first order interaction term) were selected using the daily processed data, with a 34% reduction in residual deviance. Using the combined information from both the TCEPR tow-by-tow records and the daily processed records resulted in the selection of 10 variables (including 4 first order interaction terms) with a 36% reduction in residual deviance

Results were similar when using the data from vessels that fished for three or more years (Table 7). Twelve variables were selected for the TCEPR tow-by-tow data, giving a 21% reduction in residual deviance. This increased to 34% and 7 variables for the daily processed catch summaries, and 35% and 8 variables for the combined information.

The relative year indices and 95% confidence intervals are presented in Figure 5 (and are listed in Appendix 4). All models show a general decline in CPUE until 1993, followed by a general increase to 1998 and a decline in 1999. However, the levels of increase and decline differ somewhat between the models. There is a peak in the 1993–94 and the 1997–98 fishing years and a dip in the 1992–93 and the 1994–95 fishing years for all models. The 1990–91 indices are lower than the 1989–90 indices for the daily processed and combined information (Figure 5c–f), but higher for the TCEPR tow-by-tow data (Figure 5a, 5b).

The diagnostics show some departures from model assumptions (of normally distributed constant variance residual errors) for the models using the daily processed catch summary data and the combined information. The diagnostics analysis suggests the models using TCEPR tow-by-tow data are more acceptable (Figure 6–Figure 8).

Table 6: Variables selected by the stepwise multiple regression algorithm for the west coast where vessels caught 80% of the total catch for all years using TCEPR tow-by-tow data, daily processed catch summary data, and a combination of both by order of selection, with the reduction in residual deviance as a percent of the null deviance (r^2). Note: " 3 " implies third order polynomial.

TCEPR tow by tow		Daily processed		Combined information	
Variable	r^2	Variable	R^2	Variable	r^2
Bottom depth^3	5.2	Processing type	24.3	Processing type	21.8
Nationality	9.5	Midday latitude^3	27.9	Midday latitude^3	25.0
Month	11.3	Month	29.9	Year	27.3
Target species	12.8	Year	31.7	Year built	29.2
Start latitude^3	14.1	Nationality	32.3	Processing type:Year built	30.6
Year	15.5	Nationality:Month	33.2	Med. bottom depth^3	32.1
Month:Target species	16.6	Processing type:Nationality	33.9	Med. bottom depth^3:Year built	33.0
Length^3	17.3			Midday.Latitude^3:Year built	33.9
Processing type	17.8			SOI index^3	34.6
Processing type:Nationality	18.6			SOI index^3:Year built	35.7
Nationality:Month	19.1				
Nationality:Target species	19.7				

Table 7: Variables selected by the stepwise multiple regression algorithm for the west coast where vessels fished for three or more consecutive years using TCEPR tow-by-tow data, daily processed catch summary data, and a combination of both by order of selection, with the reduction in residual deviance as a percent of the null deviance (r^2). Note: " 3 " implies third order polynomial.

TCEPR tow by tow		Daily processed		Combined information	
Variable	r^2	Variable	r^2	Variable	r^2
Bottom depth^3	6.2	Processing type	24.3	Processing type	24.1
Nationality	10.0	Midday latitude^3	27.9	Midday latitude^3	27.2
Month	12.0	Month	29.9	Year	29.0
Year	13.2	Year	31.7	Year built	30.6
Target species	14.7	Nationality	32.3	Processing type:Year built	32.0
Start latitude^3	15.9	Nationality:Month	33.2	Med. bottom depth^3	33.4
Vessel length^3	16.9	Processing type:Nationality	33.9	Med. bottom depth^3: Year Built	34.4
Processing type	17.9			Midday latitude^3: Year built	35.2
Month:Target species	18.7				
Processing type:Nationality	19.4				
Nationality:Target species	19.9				
Nationality:Month	20.5				

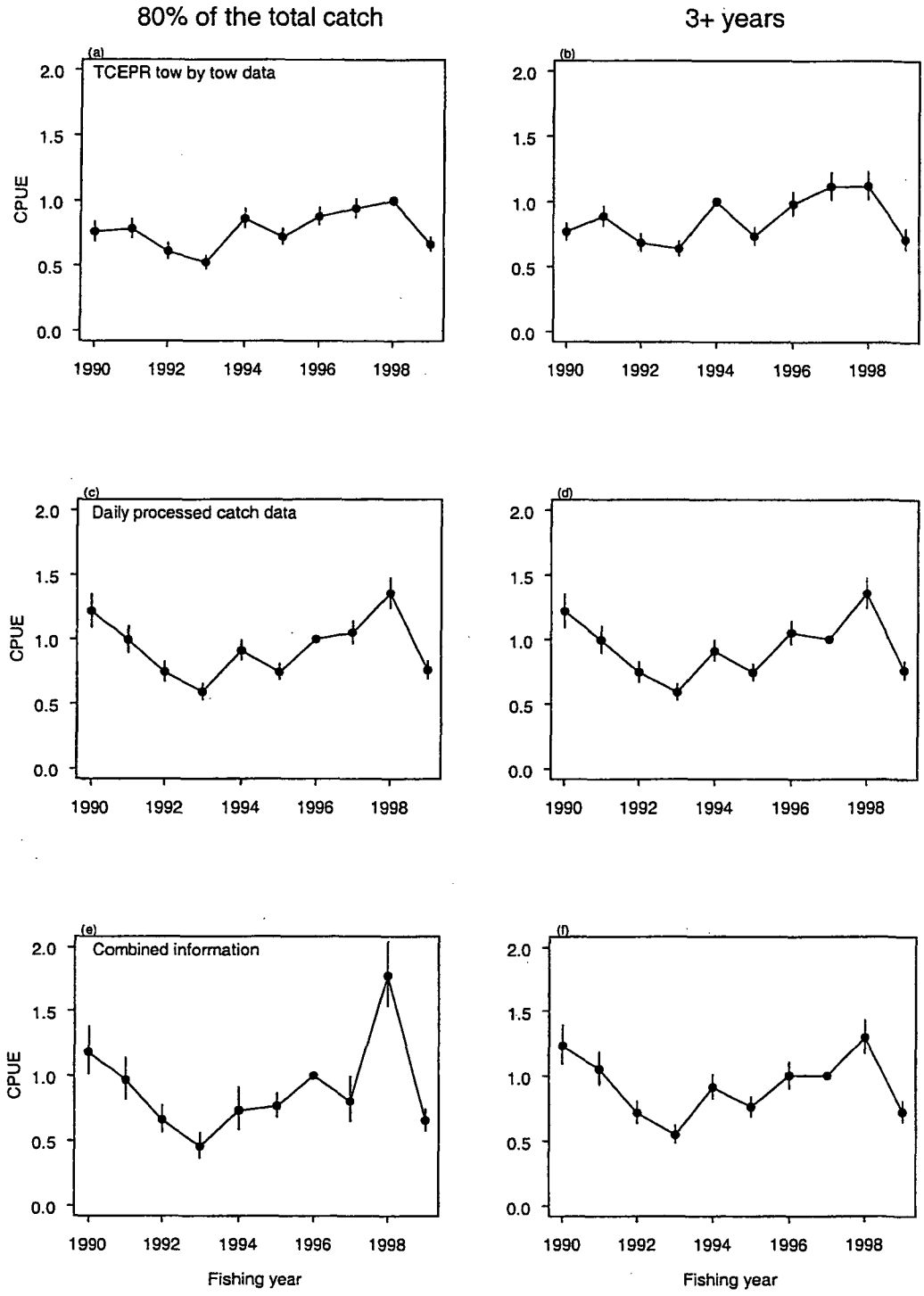

Figure 5: Lognormal CPUE indices with 95% confidence intervals for the west coast derived from TCEPR tow-by-tow data (a and b), daily processed catch data (c and d) and combined information from both (e and f). Figures on the left are from vessels that caught 80% or more of the catch from all years. Figures on the right are from vessels that fished for three or more consecutive years. Note "1990" indicates the "1989–90" fishing year.

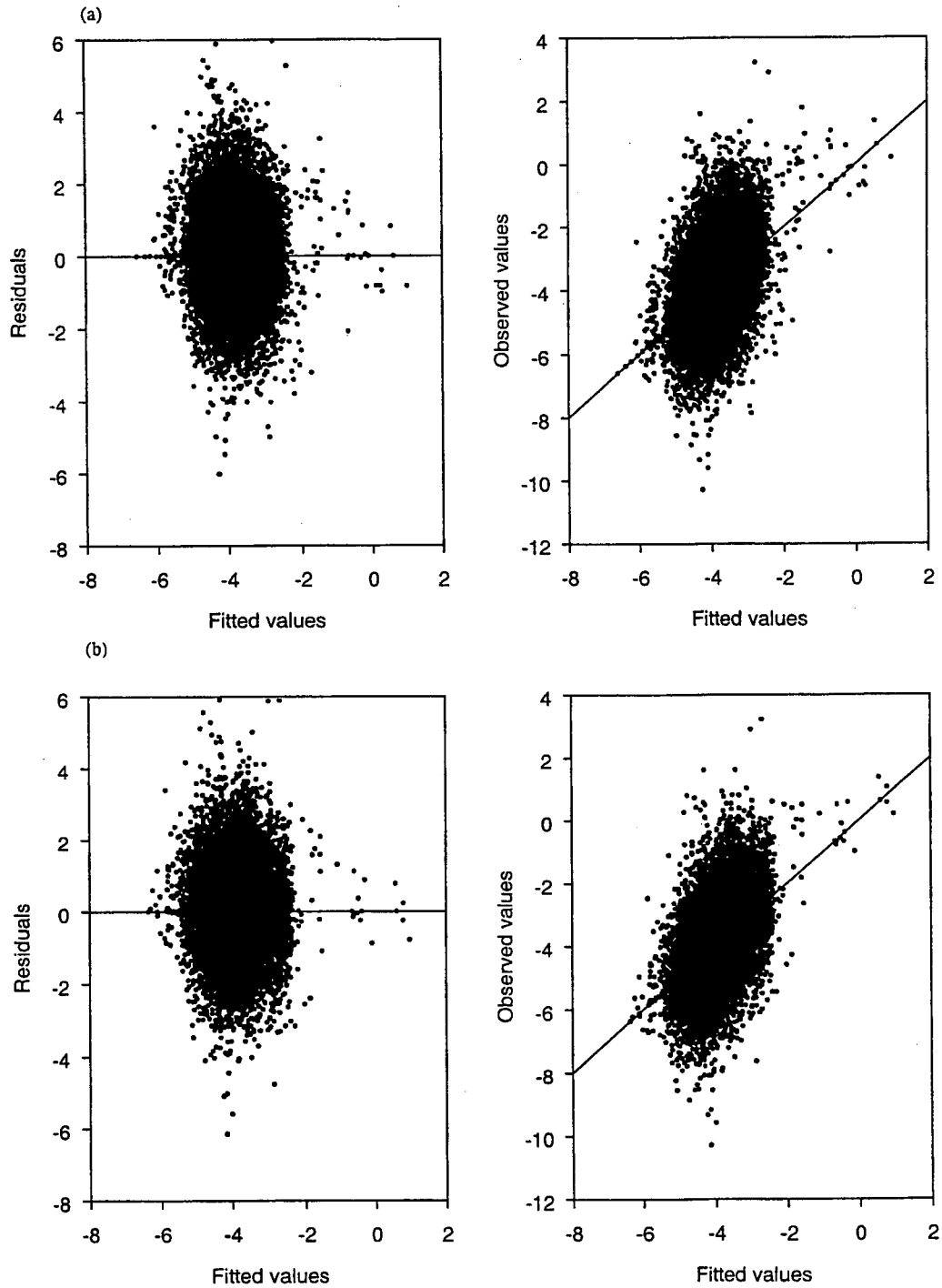

Figure 6: Diagnostic plots (log scale) of the lognormal model for the west coast TCEPR tow-by-tow data from (a) vessels that caught 80% of the total catch for all years for all years, (left) fitted values versus residuals, and (right) fitted values versus observed values, (b) vessels fishing three or more consecutive years, (left) fitted values versus residuals, and (right) fitted values versus observed values.

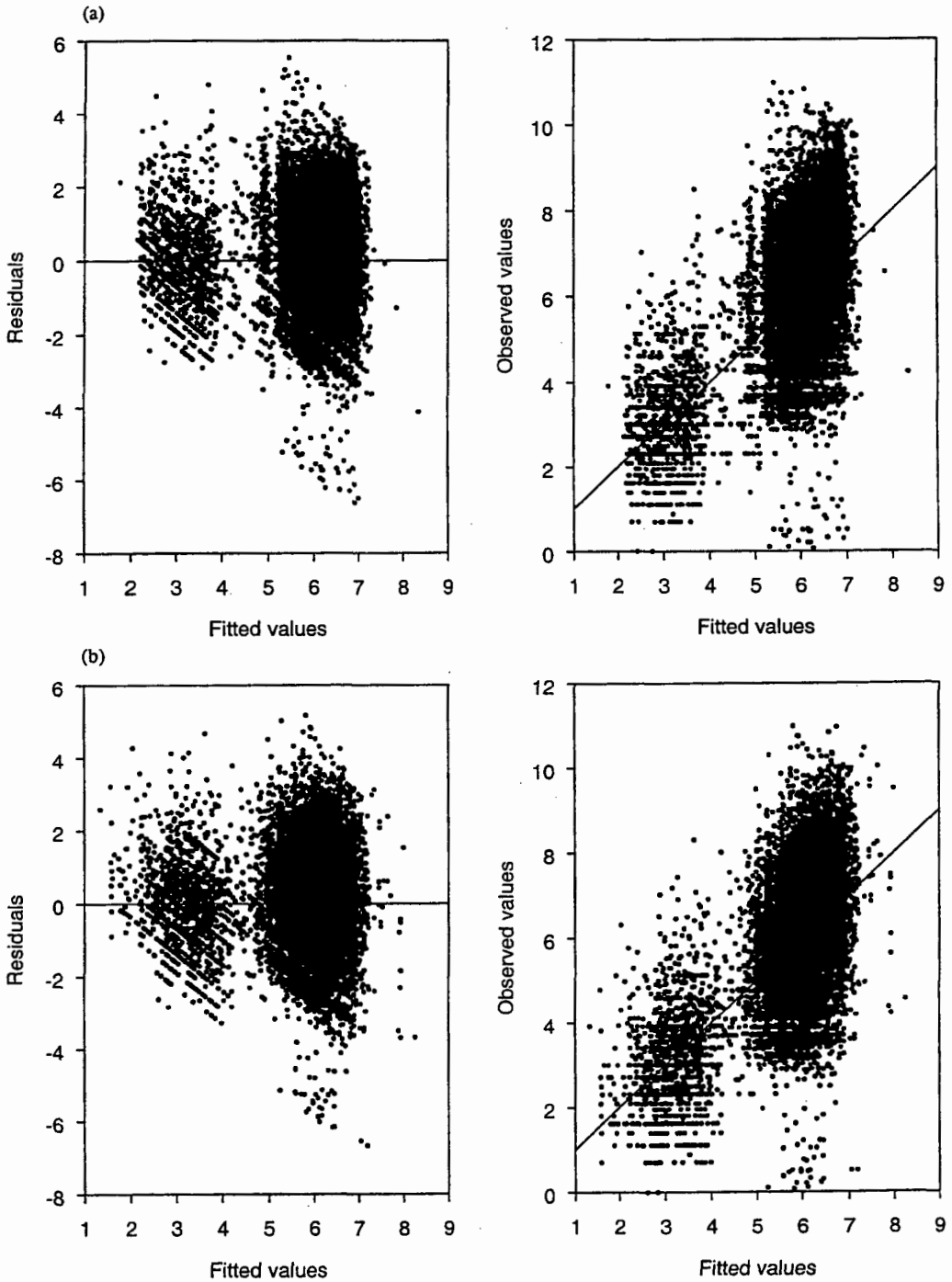

Figure 7: Diagnostic plots (log scale) of the lognormal model for the west coast daily processed catch summary data from (a) vessels that caught 80% of the total catch for all years for all years, (left) fitted values versus residuals, and (right) fitted values versus observed values, (b) vessels fishing three or more consecutive years, (left) fitted values versus residuals, and (right) fitted values versus observed values.

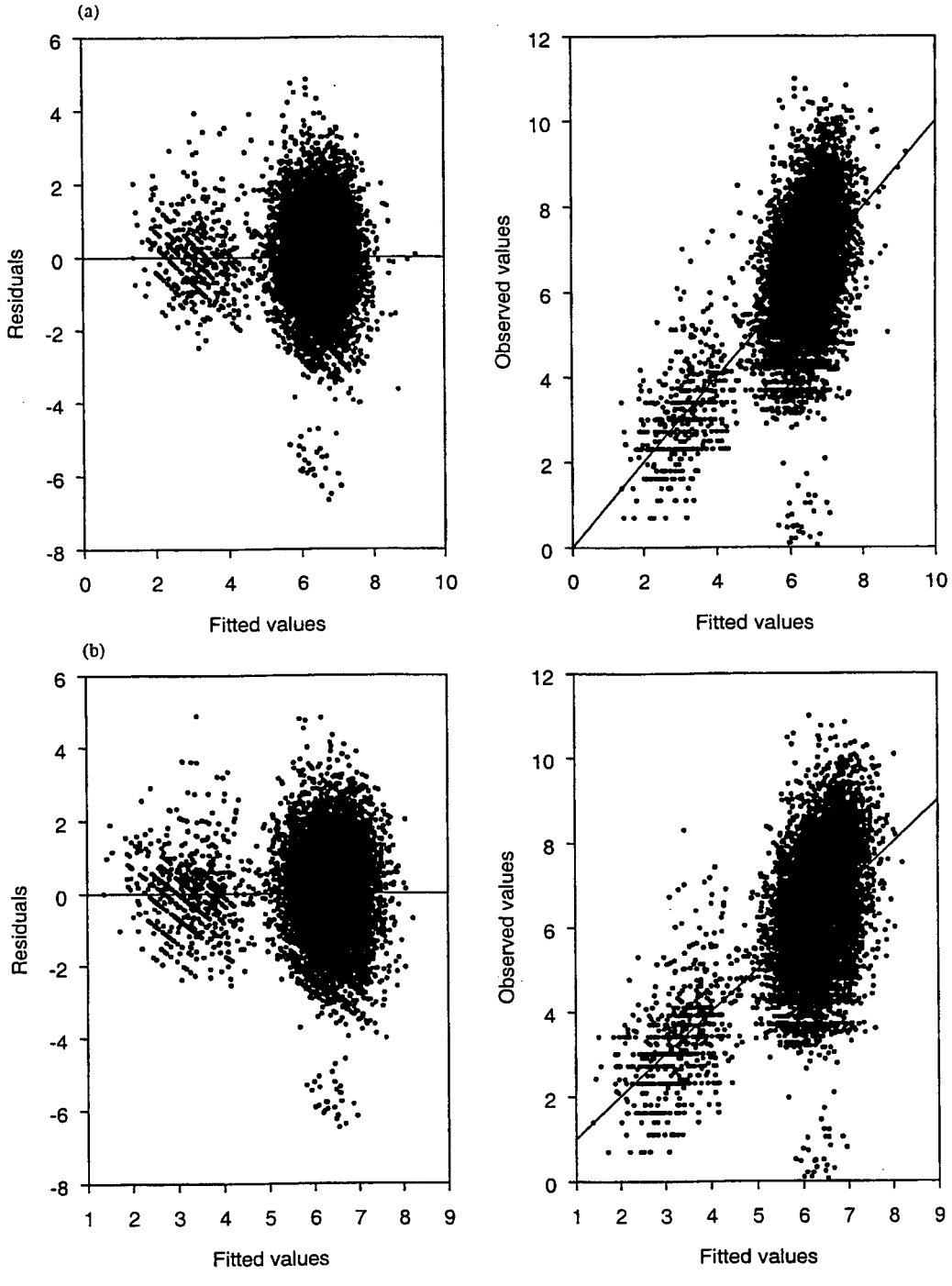

Figure 8: Diagnostic plots (log scale) of the lognormal model for the west coast combined TCEPR tow-by-tow and daily processed catch data from (a) vessels that catch 80% of the total catch for all years for all years, (left) fitted values versus residuals, and (right) fitted values versus observed values, (b) vessels fishing three or more consecutive years, (left) fitted values versus residuals, and (right) fitted values versus observed values.

3.4 Estimated CPUE indices for the sub-Antarctic

The variables selected by the stepwise regression, by order of selection, for the sub-Antarctic TCEPR tow-by-tow data, the daily processed catch summary data, and the combined information are listed in Table 8 where vessels caught 80% of the total catch for all years, and Table 9 where vessels that fished for three or more consecutive years.

Using data from vessels that caught 80% of the total catch for all years, 17 variables were selected (which included 9 first order interaction terms) using the TCEPR tow-by-tow data. Eleven variables (which included 6 first order interaction terms) were selected using the daily processed data, with a 42% reduction in residual deviance. Using the combined information from both the TCEPR tow-by-tow records and the daily processed records resulted in the selection of 11 variables (which included 6 first order interaction terms) with a 45% reduction in residual deviance (Table 8).

Results were similar when using the data from vessels that fished for three or more years (Table 9). Sixteen variables were selected for the TCEPR tow-by-tow data, which resulted in a 33% reduction in residual deviance. This increased to 46% and 12 variables for the daily processed catch summaries, and 45% and 11 variables for the combined information.

Year was not selected in any of the models when using daily processed or combined information data. This suggests there is little variability in the mean CPUE in any year.

The relative year indices and 95% confidence intervals are similar for each model and show no overall trend (Figure 9, Appendix 4). The main difference is the first year (1989–90) of the data series. The models from TCEPR tow-by-tow data show peaks, but are lower in other models. There is a peak in the 1993–94 fishing year and a dip in the 1995–96 fishing year for all models. There also appears to be a discrepancy with the 1990–91 fishing year index derived from the combined information and daily processed. There is an increase for the 1990–91 fishing year, but the tow-by-tow model shows a decrease for this year.

The diagnostics plots (Figures 10–12) show some departures from model assumptions (of normally distributed constant variance residual errors) for the models using the daily processed catch summary data and the combined information. The diagnostics analysis for the TCEPR tow-by-tow models suggests these models are more acceptable.

Table 8: Variables selected by the stepwise multiple regression algorithm for the sub-Antarctic where vessels caught 80% of the total catch for all years using TCEPR tow-by-tow data, daily processed catch summary data, and a combination of both by order of selection, with the reduction in residual deviance as a percent of the null deviance (r^2).

TCEPR tow by tow		Daily processed		Combined information	
Variable	r^2	Variable	r^2	Variable	r^2
Target species	12.6	Processing type	21.8	Processing type	25.2
Nationality	16.9	Month	27.4	Nationality	32.3
Nationality:Target species	19.6	Nationality	29.7	Month	33.9
Vessel draught^3	21.4	Nationality:Month	33.1	Nationality:Month	37.1
Groundrope depth^3	22.6	Vessel breadth^3	34.5	Vessel breadth^3	38.2
Nationality: Vessel draught^3	23.6	Vessel breadth^3: Month	36.6	Vessel breadth^3: Nationality	39.8
Year	24.7	Midday longitude^3	38.1	Midday longitude^3	41.0
Month	25.6	Midday longitude^3: Month	39.5	Midday longitude^3: Month	42.4
Nationality:Month	27.8	Vessel breadth^3: Nationality	40.3	Processing type: Nationality	43.5
Target species:Month	29.1	Midday longitude^3: Nationality	40.9	Vessel breadth^3: Month	44.3
Vessel draught^3:Month	30.1	Processing type: Nationality	41.5	Midday longitude^3:Nationality	45.1
Vessel draught^3:Target species	30.8				
Vessel tonnage^3	31.5				
Vessel tonnage^3:Nationality	32.7				
Start latitude^3	33.4				
Start latitude^3:Month	34.3				
Vessel tonnage^3:Month	34.9				

Table 9: Variables selected by the stepwise multiple regression algorithm for the sub-Antarctic where vessels fish for three or more consecutive years using TCEPR tow-by-tow data, daily processed catch summary data, and a combination of both by order of selection, with the reduction in residual deviance as a percent of the null deviance (r^2).

TCEPR tow by tow		Daily processed		Combined information	
Variable	r^2	Variable	r^2	Variable	r^2
Target species	12.5	Processing type	25.3	Processing type	25.3
Nationality	16.6	Nationality	32.1	Nationality	32.3
Nationality:Target species	19.3	Month	35.9	Month	33.9
Vessel tonnage^3	21.0	Nationality:Month	39.5	Nationality:Month	37.1
Vessel tonnage^3:Nationality	22.4	Vessel breadth^3	40.5	Vessel breadth^3	38.2
Processing type	23.7	Vessel breadth^3:Nationality	41.6	Vessel breadth^3:Nationality	39.8
Groundrope depth^3	24.8	Processing type:Nationality	42.6	Midday longitude^3	41.0
Month	25.6	Midday longitude^3	43.6	Midday longitude^3:Month	42.4
Nationality:Month	28.0	Midday longitude^3:Month	44.9	Processing type:Nationality	43.5
Month:Target species	29.1	Vessel breadth^3: Month	45.5	Vessel breadth^3: Month	44.3
Vessel tonnage^3:Month	30.1	Midday longitude^3:Nationality	46.1	Midday longitude^3: Nationality	45.1
Start longitude^3	30.8				
Start longitude^3:Month	31.5				
Start longitude^3:Nationality	32.3				
Year	32.8				
Processing type:Nationality	33.4				

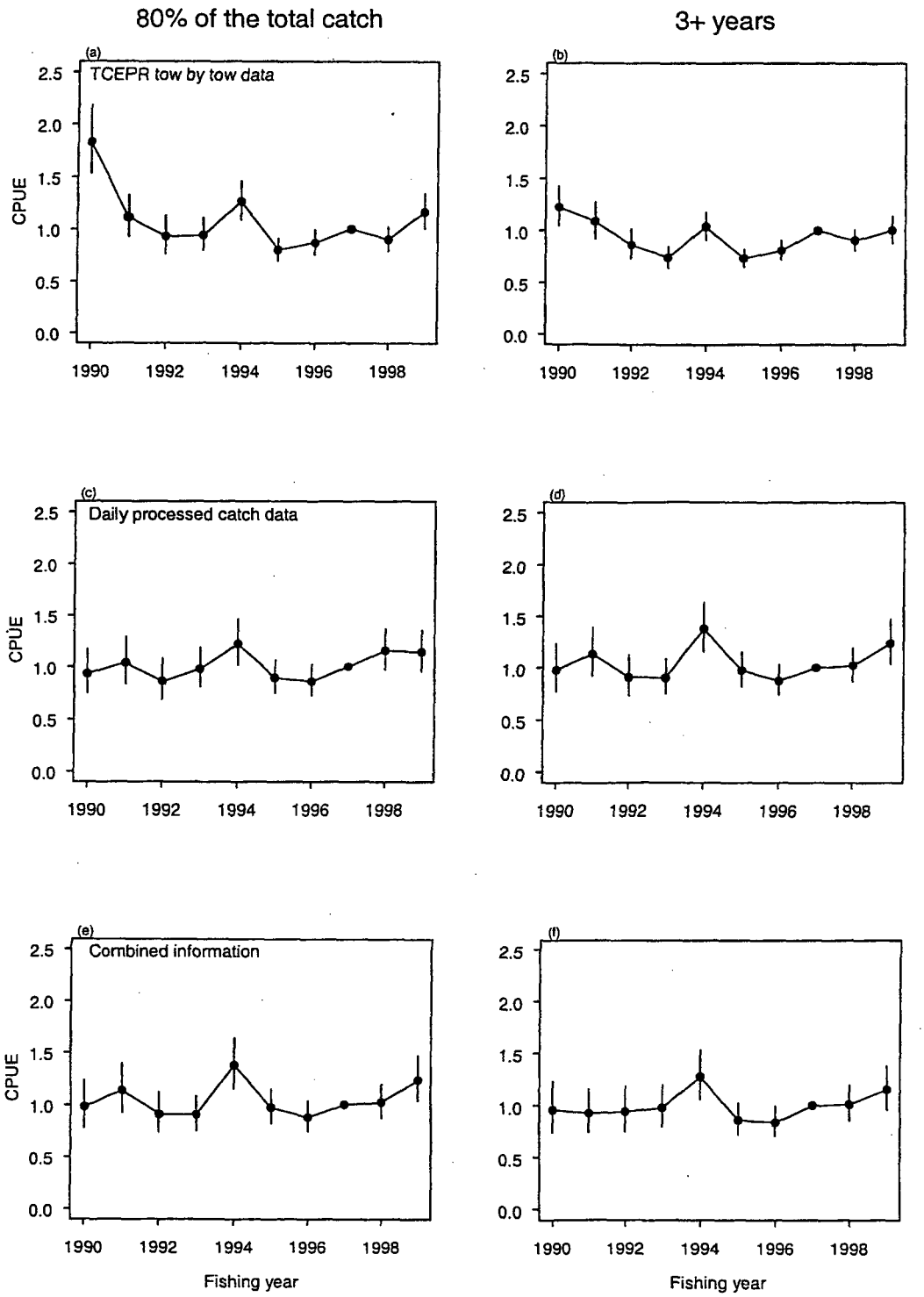

Figure 9: Lognormal CPUE indices with 95% confidence intervals for the sub-Antarctic derived from TCEPR tow-by-tow data (a and b), daily processed catch data (c and d) and combined information from both (e and f). Figures on the left are from vessels that caught 80% or more of the catch from all years. Figures on the right are from vessels that fished for three or more consecutive years. Note: "1990" indicates the "1989–90" fishing year.

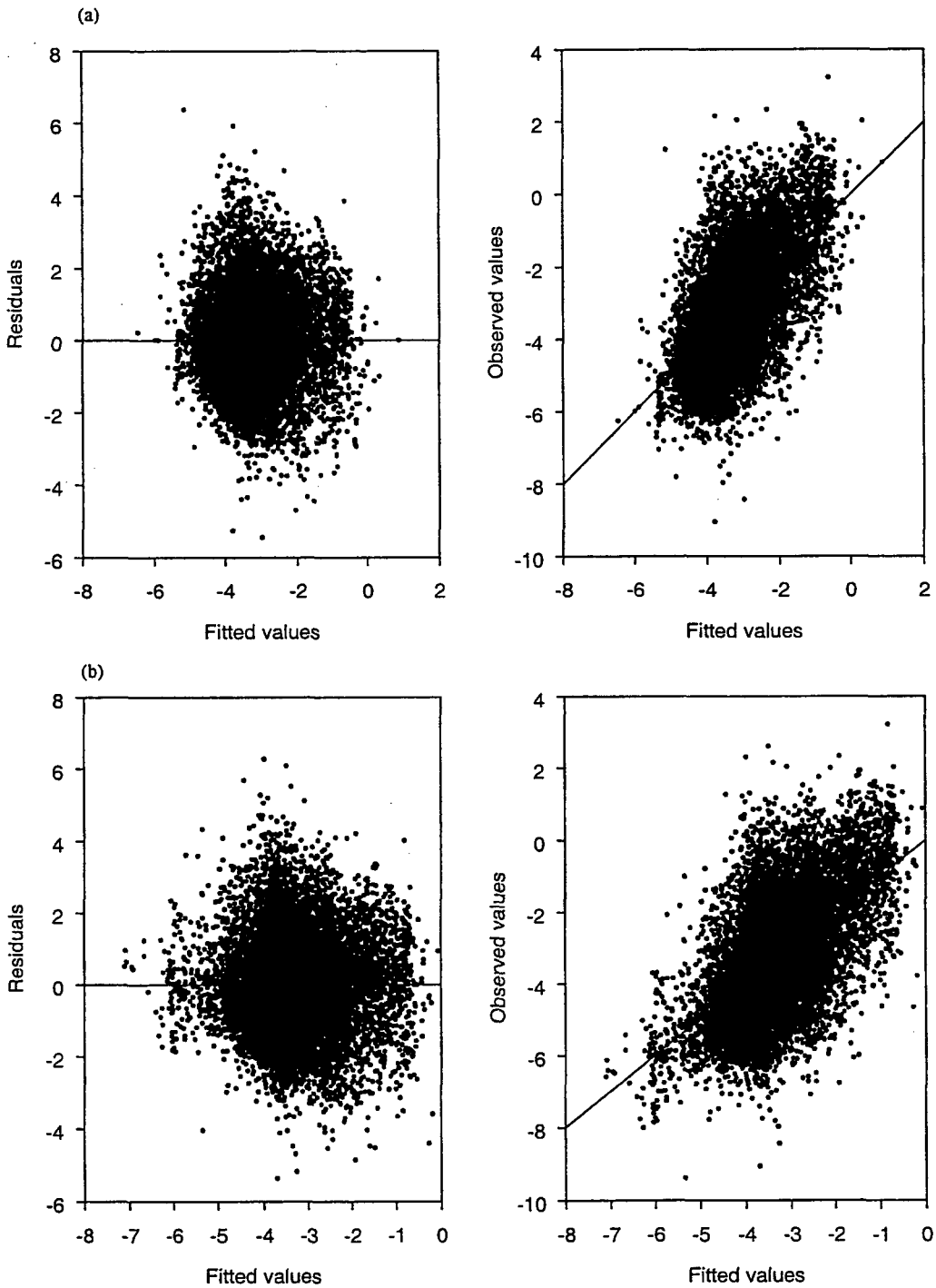

Figure 10: Diagnostic plots (log scale) of the lognormal model for the sub-Antarctic TCEPR tow-by-tow data from (a) vessels that caught 80% of the total catch for all years for all years, (left) fitted values versus residuals, and (right) fitted values versus observed values, (b) vessels fishing three or more consecutive years, (left) fitted values versus residuals, and (right) fitted values versus observed values.

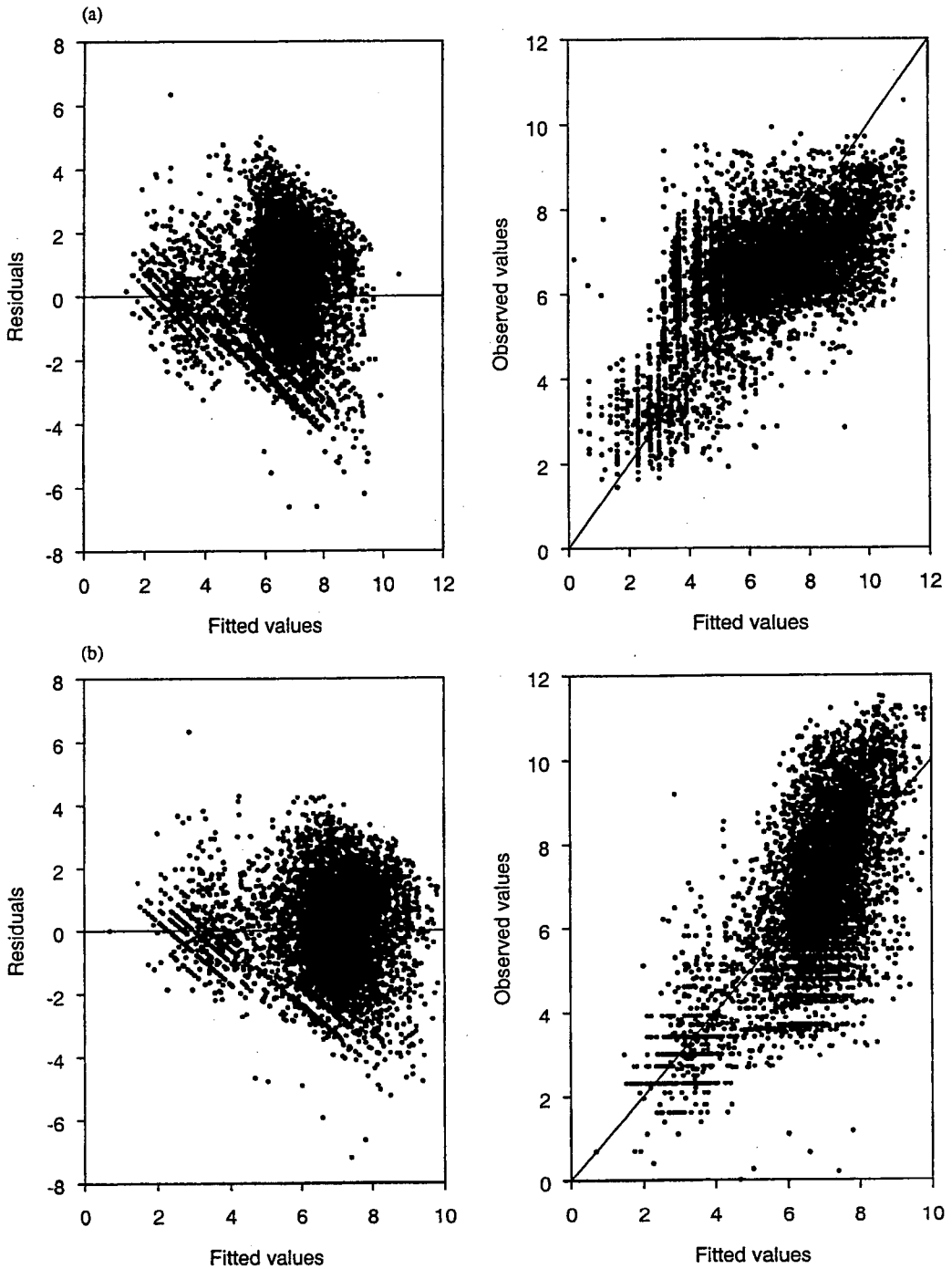

Figure 11: Diagnostic plots (log scale) of the lognormal model for the sub-Antarctic daily processed catch summary data from (a) vessels that caught 80% of the total catch for all years for all years, (left) fitted values versus residuals, and (right) fitted values versus observed values, (b) vessels fishing three or more consecutive years, (left) fitted values versus residuals, and (right) fitted values versus observed values.

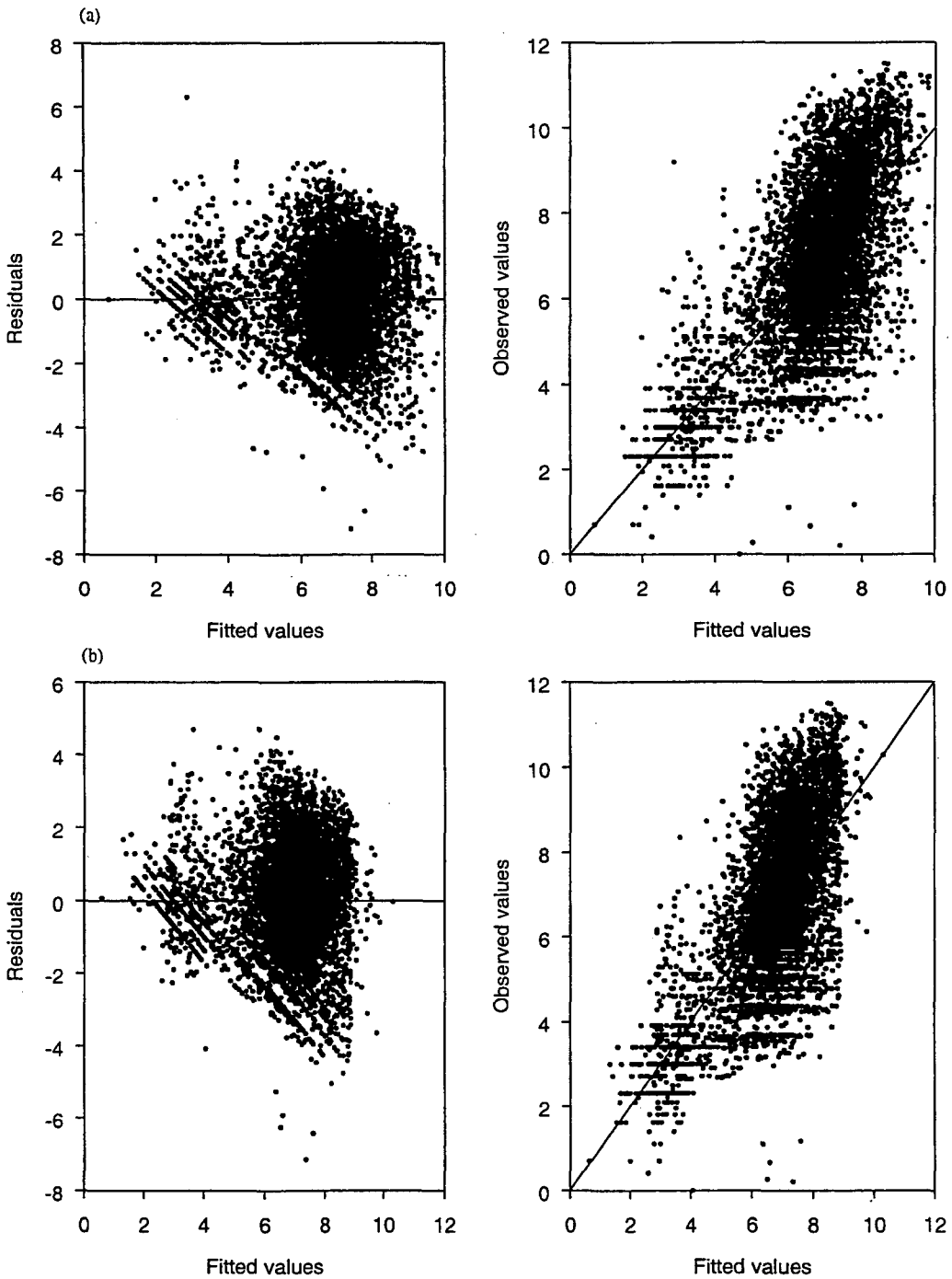

Figure 12: Diagnostic plots (log scale) of the lognormal model for the sub-Antarctic combined tow-by-tow and daily processed catch data from (a) vessels that catch 80% of the total catch for all years for all years, (left) fitted values versus residuals, and (right) fitted values versus observed values, (b) vessels fishing three or more consecutive years, (left) fitted values versus residuals, and (right) fitted values versus observed values.

3.5 Estimated CPUE indices for the west Chatham Rise

The variables selected by the stepwise regression, by order of selection, for the west Chatham Rise TCEPR tow-by-tow data, the daily processed catch summary data, and the combined information are listed in Table 10 where vessels caught 80% of the total catch for all years, and Table 11 where vessels that fished for three or more consecutive years.

Using data from vessels that caught 80% of the total catch for all years, 12 variables were selected (which included 5 first order interaction terms) using the TCEPR tow-by-tow data. Eleven variables (including 6 first order interaction terms) were selected using the daily processed data, with a 37% in the reduction in residual deviance. Using combined information from both the TCEPR tow-by-tow records and the daily processed records resulted in 13 variables (including 6 first order interaction terms) with a 30% reduction in residual deviance (Table 10).

Results were similar when using the data from vessels that fished for three or more years (Table 11). Seventeen variables were selected for the TCEPR tow-by-tow data, which resulted in a 35% reduction in residual deviance. This increased to 44% and 15 variables for the daily processed catch summaries, and 43% and 19 variables for the combined TCEPR tow-by-tow and daily processed catch summaries.

Year was not selected in any of the models when using daily processed or combined information data. This suggests there is little variability in the mean CPUE in any year.

The relative year indices and 95% confidence intervals are presented in Figure 13 (and are listed in Appendix 4). The indices show no overall upward or downward trend. There is a peak in the 1993–94 fishing year for all models, although indices derived from the TCEPR tow-by-tow data tend to be more pronounced and more variable. The peaks are more pronounced in the 1997–98 fishing year for all models apart from the combined information (Figure 13e & f).

The diagnostics plots (Figures 14–16) show some departures from model assumptions (of normally distributed constant variance residual errors) for the models using the daily processed catch summary data and the combined information. The diagnostics analysis for the TCEPR tow-by-tow models suggests these models are more acceptable (Figure 14).

Table 10: Variables selected by the stepwise multiple regression algorithm for the west Chatham Rise where vessels caught 80% of the total catch for all years using TCEPR tow-by-tow data, daily processed catch summary data, and combined information of both by order of selection, with the reduction in residual deviance as a percent of the null deviance (r^2).

TCEPR tow by tow		Daily processed		Combined information	
Variable	r^2	Variable	r^2	Variable	r^2
Target species	6.7	Processing type	13.2	Processing type	11.5
Month^3	12.2	Month	21.3	Midday latitude^3	16.5
Headline height^3	15.1	Nationality	25.6	Nationality	18.5
Month^3:Target species	17.5	Nationality:Month	29.1	Month	20.2
Start latitude^3	18.9	Midday latitude^3	30.4	Midday latitude^3:Nationality	21.5
Groundrope depth^3	20.3	Midday latitude^3:Month	31.7	Midday longitude^3	22.7
Target species: Groundrope depth^3	21.7	Midday longitude^3	32.6	Midday longitude^3:Month	24.0
Start latitude^3: Target species	22.6	Midday longitude^3:Month	34.6	Midday latitude^3: Midday longitude^3	25.3
Wingspread^3	23.4	Midday latitude^3: Midday longitude^3	35.8	Nationality:Month	26.4
Target species: Headline height^3	23.9	Processing type:Month	36.5	Midday longitude^3: Processing type	27.3
Start latitude^3 : Headline height^3	24.5	Midday latitude^3: Nationality	37.0	Vessel draught^3	27.8
Year	25.0			Vessel draught^3: Nationality	29.2
				Vessel tonnage^3	29.8

Table 11: Variables selected by the stepwise multiple regression algorithm for the west Chatham Rise where vessels fished for three or more consecutive years using TCEPR tow-by-tow data, daily processed catch summary data, and a combination of both by order of selection, with the reduction in residual deviance as a percent of the null deviance (r^2).

TCEPR tow by tow		Daily processed		Combined information	
Variable	r^2	Variable	r^2	Variable	r^2
Target species	8.5	Processing type	12.4	Processing type	12.8
Month	11.7	Nationality	23.1	Month	19.9
Target species:Month	16.8	Month	28.9	Nationality	23.2
Year	18.9	Nationality:Month	32.1	Nationality:Month	26.7
Headline height^3	20.3	Vessel breadth^3	34.7	Midday latitude^3	28.7
Headline height^3:Month	22.7	Vessel breadth^3:Nationality	36.1	Midday latitude^3:Month	30.2
Start latitude^3	23.9	Vessel breadth^3:Processing type	37.3	Med. groundrope depth^3	31.7
Start latitude^3:Month	26.3	Midday latitude^3	38.3	Med. groundrope depth^3: Month	33.1
Nationality	27.4	Vessel breadth^3:Month	39.2	Midday latitude^3: Nationality	34.2
Nationality:Month	29.5	Midday longitude^3	40.1	Processing type:Nationality	35.3
Headline height^3: Target species	30.4	Midday longitude^3:Month	41.5	Med. groundrope depth^3: Nationality	36.1
Start latitude^3:Nationality	31.3	Midday longitude^3: Nationality	42.3	Vessel draught^3	36.8
Target species:Nationality	32.0	Midday latitude^3:Month	42.8	Vessel draught^3:Month	37.8
Start latitude^3:Target species	32.5	Processing type:Nationality	43.3	Vessel draught^3:Nationality	38.7
Groundrope depth^3	33.0	Midday latitude^3: Nationality	43.9	Vessel draught^3: Processing type	39.3
Groundrope depth^3:Month	34.0			Midday longitude^3	39.8
Groundrope depth^3: Target species	34.6			Midday longitude^3:Month	41.3
				Midday latitude^3: Midday longitude^3	42.0
				Processing type:Month	42.5

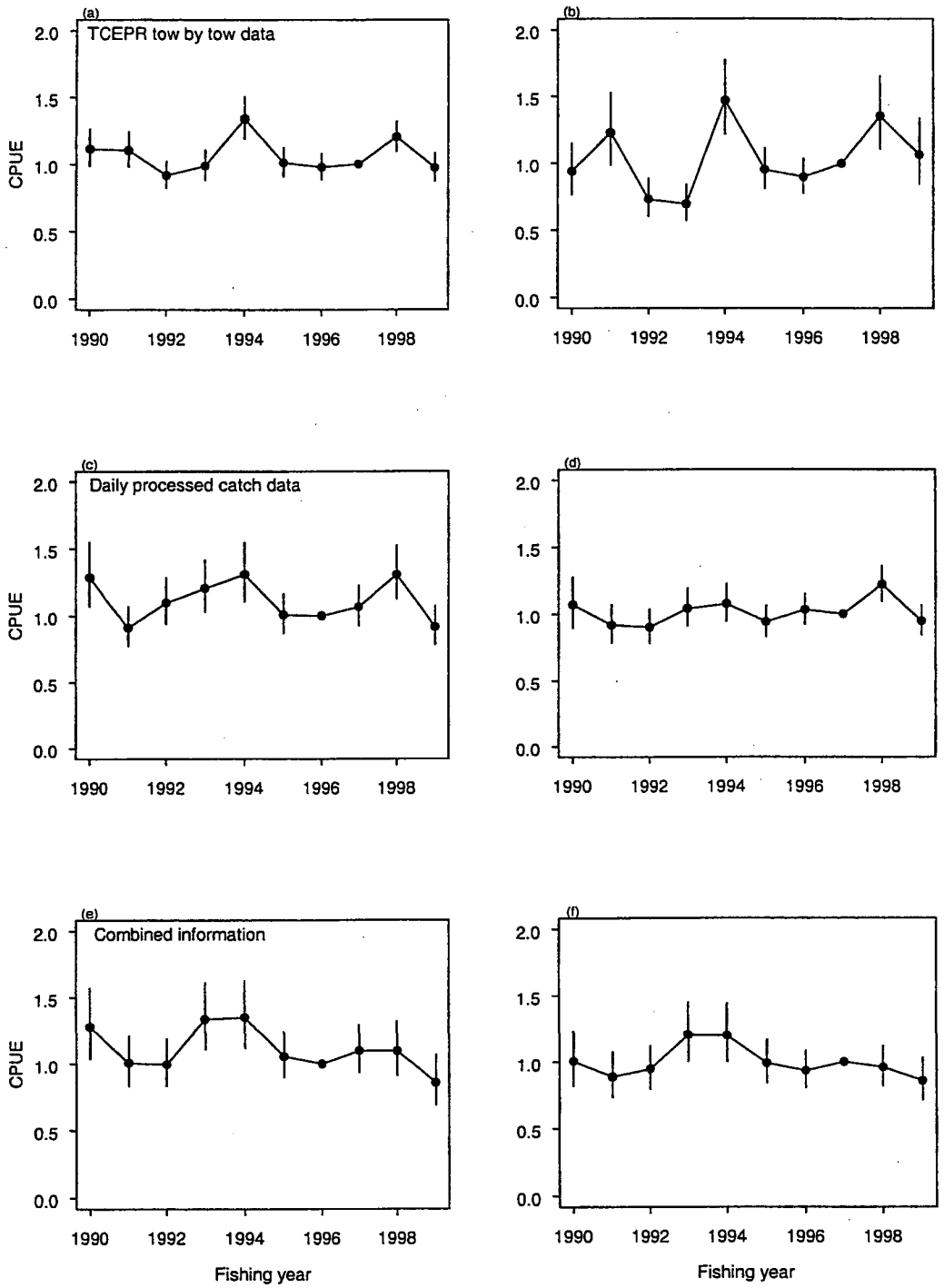

Figure 13: Lognormal CPUE indices with 95% confidence intervals for the west Chatham Rise derived from TCEPR tow-by-tow data (a and b), daily processed catch data (c and d) and combined information from both (e and f). Figures on the left are from vessels that caught 80% or more of the catch from all years. Figures on the right are from vessels that fished for three or more consecutive years. Note "1990" indicates the "1989–90" fishing year.

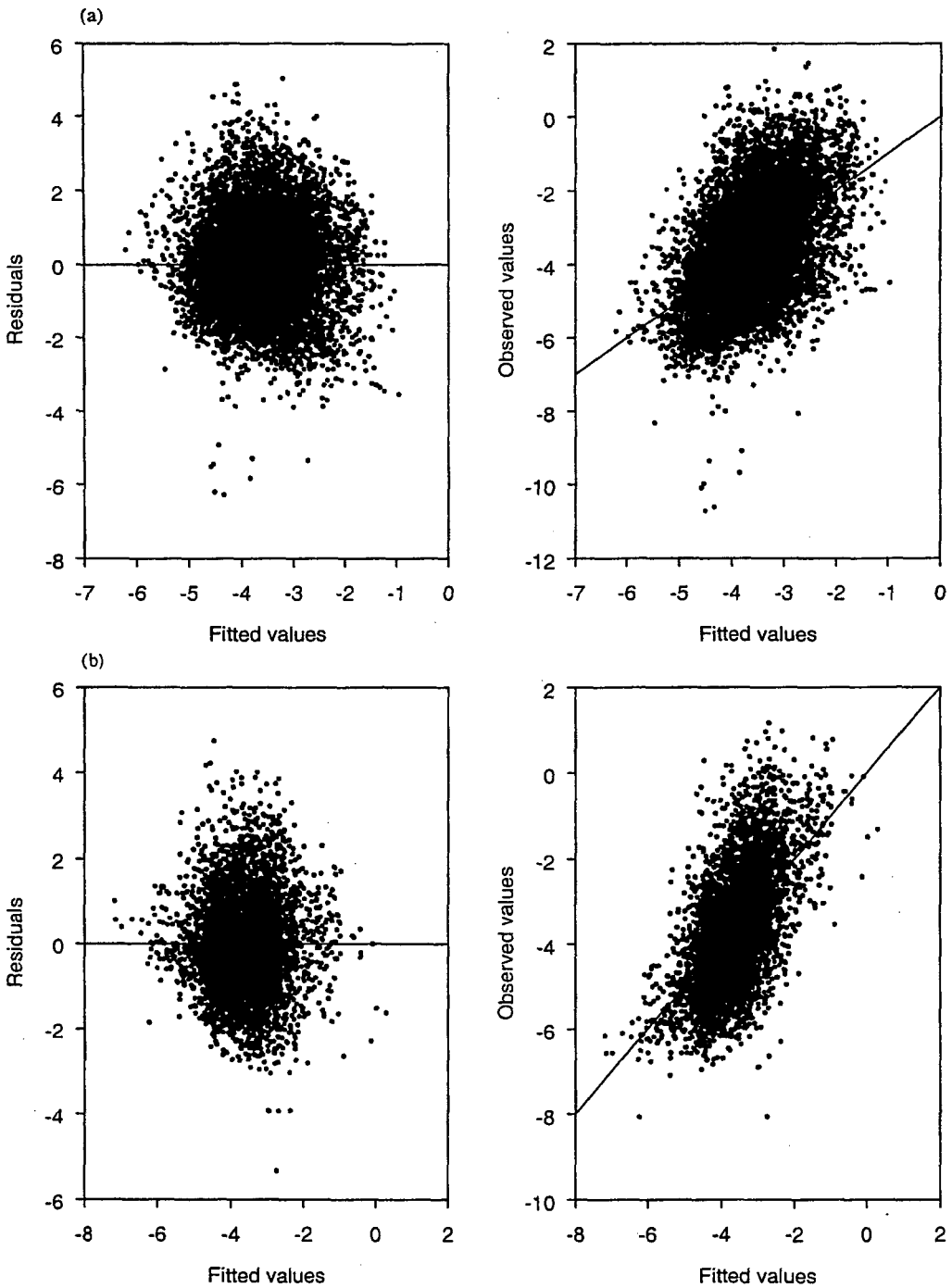

Figure 14: Diagnostic plots (log scale) of the lognormal model for the west Chatham Rise TCEPR tow-by-tow data from (a) vessels that catch 80% of the total catch for all years for all years, (left) fitted values versus residuals, and (right) fitted values versus observed values, (b) vessels fishing three or more consecutive years, (left) fitted values versus residuals, and (right) fitted values versus observed values.

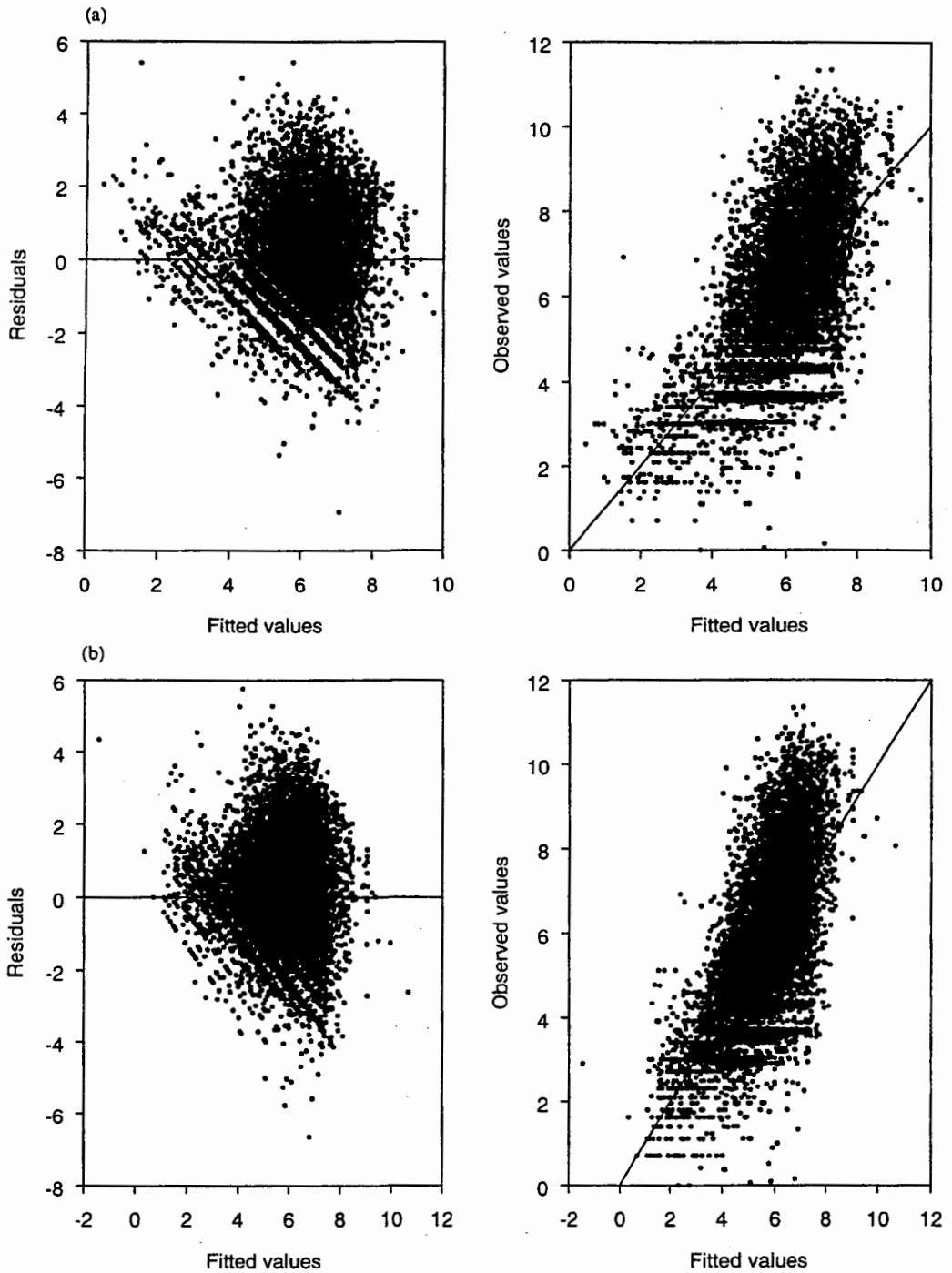

Figure 15: Diagnostic plots (log scale) of the lognormal model for the west Chatham Rise daily processed catch summary data from (a) vessels that catch 80% of the total catch for all years (left) fitted values versus residuals, and (right) fitted values versus observed values, (b) vessels fishing three or more consecutive years, (left) fitted values versus residuals, and (right) fitted values versus observed values.

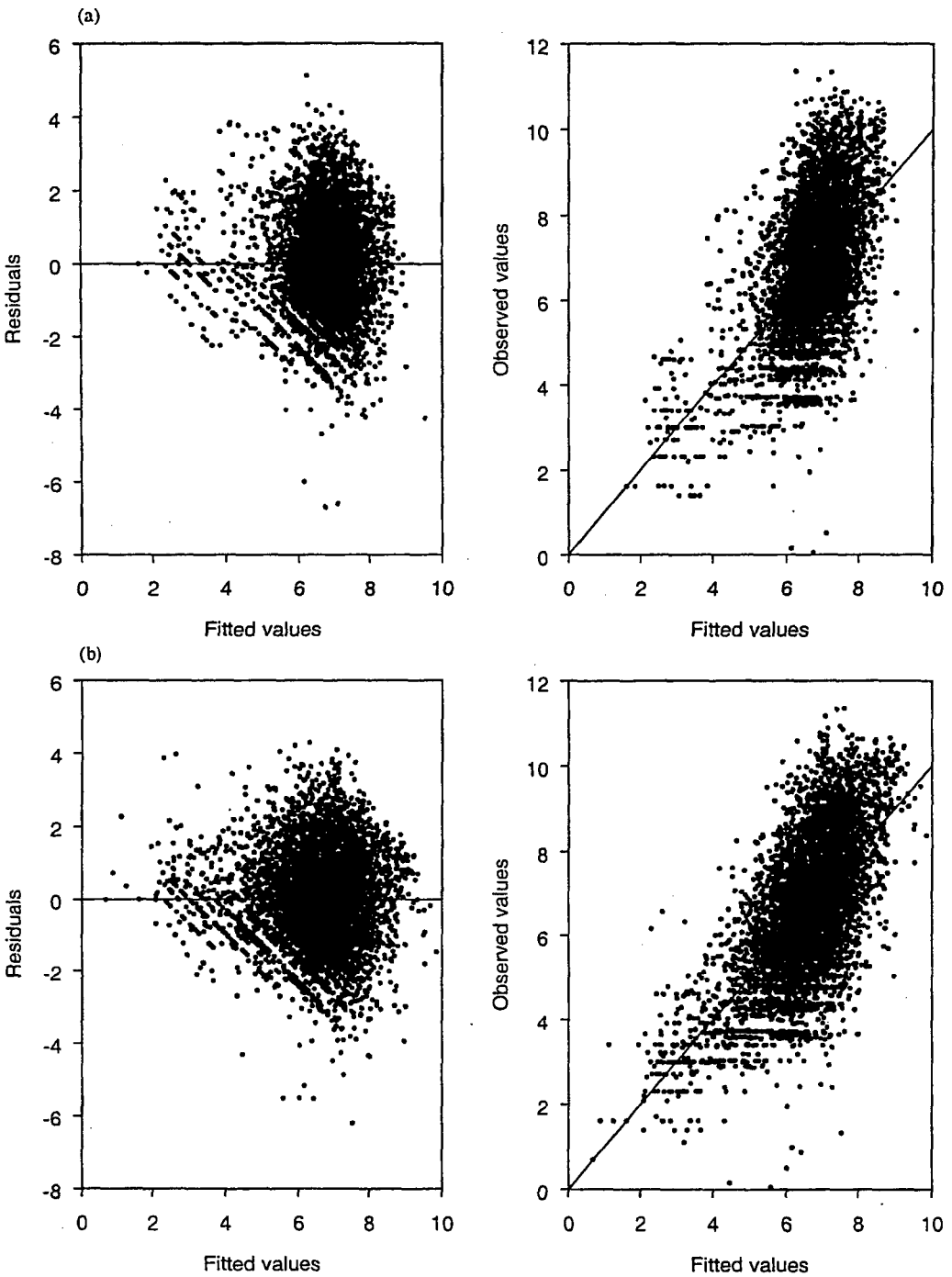

Figure 16: Diagnostic plots (log scale) of the lognormal model for the west Chatham Rise combined tow-by-tow and daily processed catch data from (a) vessels that catch 80% of the total catch for all years for all years, (left) fitted values versus residuals, and (right) fitted values versus observed values, (b) vessels fishing three or more consecutive years, (left) fitted values versus residuals, and (right) fitted values versus observed values.

3.6 Estimated CPUE indices for the east Chatham Rise

The variables selected by the stepwise regression, by order of selection, for the east Chatham Rise TCEPR tow-by-tow data, the daily processed catch summary data, and the combined information are listed in
Table 12 where vessels caught 80% of the total catch for all years, and Table 14 where vessels that fished for three or more consecutive years.

Using data from vessels that caught 80% of the total catch for all years, 5 variables were selected (which included 2 first order interaction terms) using the TCEPR tow-by-tow data. Seven variables (including 2 first order interaction terms) were selected using the daily processed data, with a 52% in the reduction in residual deviance. Using combined information from both the TCEPR tow-by-tow records and the daily processed records resulted in the selection of 8 variables (including 3 first order interaction terms) with a 58% reduction in residual deviance (Table 12).

Using data from vessels that fished three or more consecutive years, 10 variables were selected for the TCEPR tow-by-tow data, which resulted in a 58% reduction in residual deviance. This decreased to 42% and 5 variables for the daily processed catch summaries, but increased to 51% and 7 variables for the combined information. The greater reduction in residual deviance from the TCEPR tow-by-tow and the combined information is a result of reduction of variability in the data.

Year was not selected in any of the models when using TCEPR data. This suggests there is little variability in the mean CPUE in any year.

The relative year indices and 95% confidence intervals are presented in Figure 17 (and are listed in Appendix 4). There are no strong upward or downward trends. Even though the models seem different when using the three different types of data, similar features stand out, e.g., peaks are present for all models in the 1990–91 fishing year (even though the daily processed data is extremely noisy for this year), and there are declines from the 1996–97 to the 1998–99 fishing year.

The diagnostics plots (Figures 18–20) show some departures from model assumptions (of normally distributed constant variance residual errors) for the models using the daily processed catch summary data and the combined information. The diagnostics analysis for the TCEPR tow-by-tow models suggests these models are more acceptable (Figure 18).

The data available for the east Chatham Rise are very limited. There are only 2300 TCEPR tow-by-tow records, 1600 daily processed records, and some years with very little catch, e.g., 1989–90, 1998–99 (Table 3).

Table 12: Variables selected by the stepwise multiple regression algorithm for the east Chatham Rise where vessels caught 80% of the total catch for all years using TCEPR tow-by-tow data, daily processed catch summary data, and a combination of both by order of selection, with the reduction in residual deviance as a percent of the null deviance (r^2).

TCEPR tow by tow		Daily processed		Combined information	
Variable	r^2	Variable	r^2	Variable	r^2
Groundrope depth^3	37.4	Processing type	22.3	Med. groundrope depth^3	24.2
Month	45.3	Midday latitude^3	33.2	Processing type	36.7
Nationality	49.3	Year	36.8	Year	40.9
Nationality:Month^3	54.4	Month	39.3	Month	45.3
Nationality: Groundrope depth^3	56.4	Month:Midday latitude^3	45.0	Month: Med. groundrope depth^3	49.5
		Kilowatts^3	47.5	Midday Longitude^3	52.5
		Month:Kilowatts^3	52.4	Month: Midday Longitude^3	55.6
				Midday Longitude^3: Med. groundrope depth^3	57.6

Table 13: Variables selected by the stepwise multiple regression algorithm for the east Chatham Rise where vessels fish for three or more consecutive years using TCEPR tow-by-tow data, daily processed catch summary data, and a combination of both by order of selection, with the reduction in residual deviance as a percent of the null deviance (r^2).

TCEPR tow by tow		Daily processed		Combined information	
Variable	r^2	Variable	r^2	Variable	r^2
Bottom depth^3	33.6	Processing type	21.4	Med. groundrope depth^3	21.8
Headline height^3	39.2	Year	30.1	Processing type	33.4
Target species	41.7	Month	33.2	Med. headline height^3	38.2
Target species:Bottom depth^3	44.5	Vessel kilowatts^3	35.9	Year	41.7
Vessel tonnage^3	47.1	Month:Vessel kilowatts^3	42.3	Month	43.6
Nationality	48.9	Midday latitude^3		Month:Med. groundrope depth^3	48.3
Nationality:Vessel tonnage^3	51.4			Month:Med. headline height^3	50.7
Nationality: Headline height^3	53.9				
Vessel tonnage^3: Headline height^3	55.9				
Nationality: Target species	57.7				

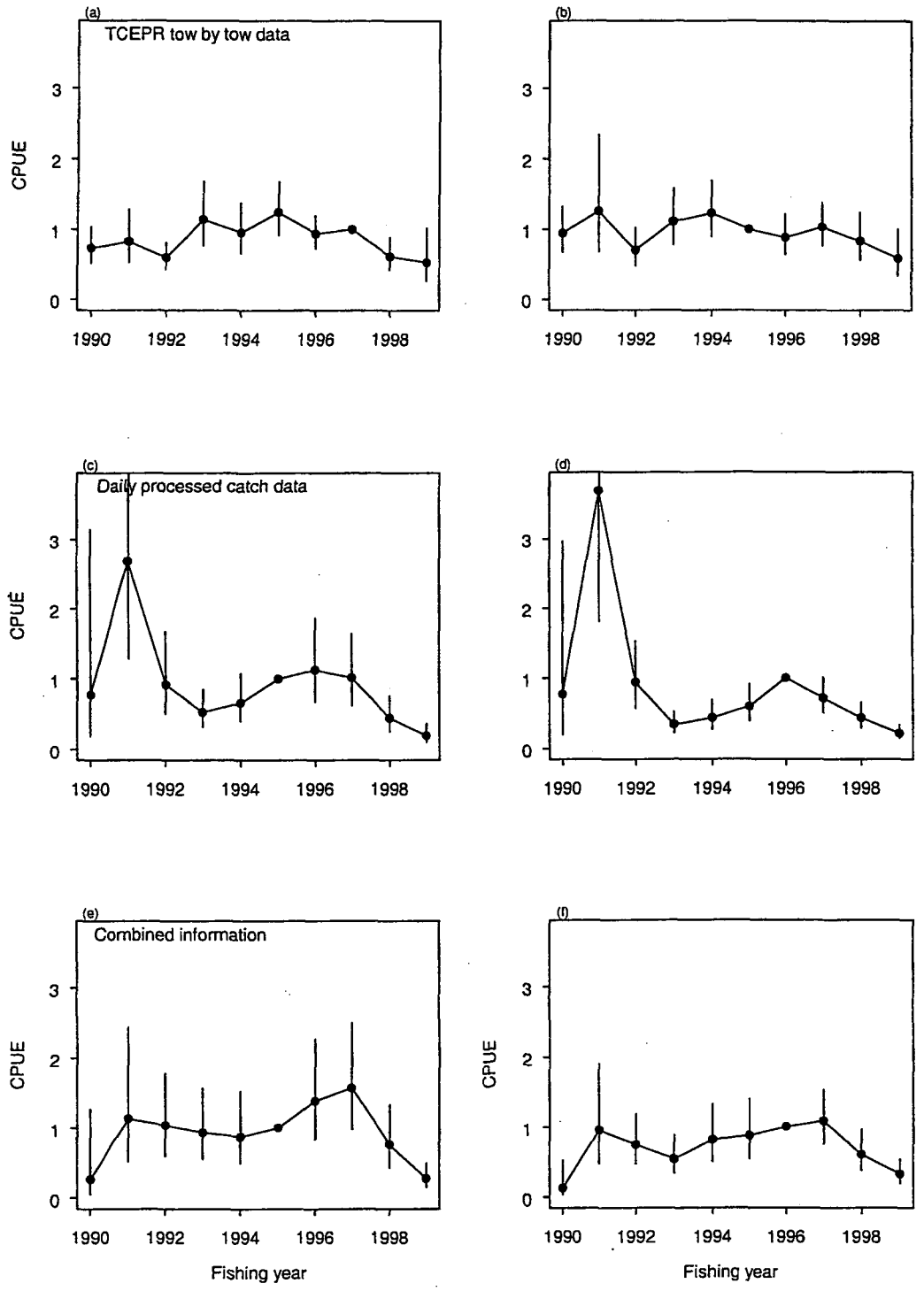

Figure 17: Lognormal CPUE indices with 95% confidence intervals for the east Chatham Rise derived from TCEPR tow-by-tow data (a and b), daily processed catch data (c and d) and combined information from both (e and f). Figures on the left are from vessels that caught 80% or more of the catch from all years. Figures on the right are from vessels that fished for three or more consecutive years. Note "1990" indicates the "1989–90" fishing year.

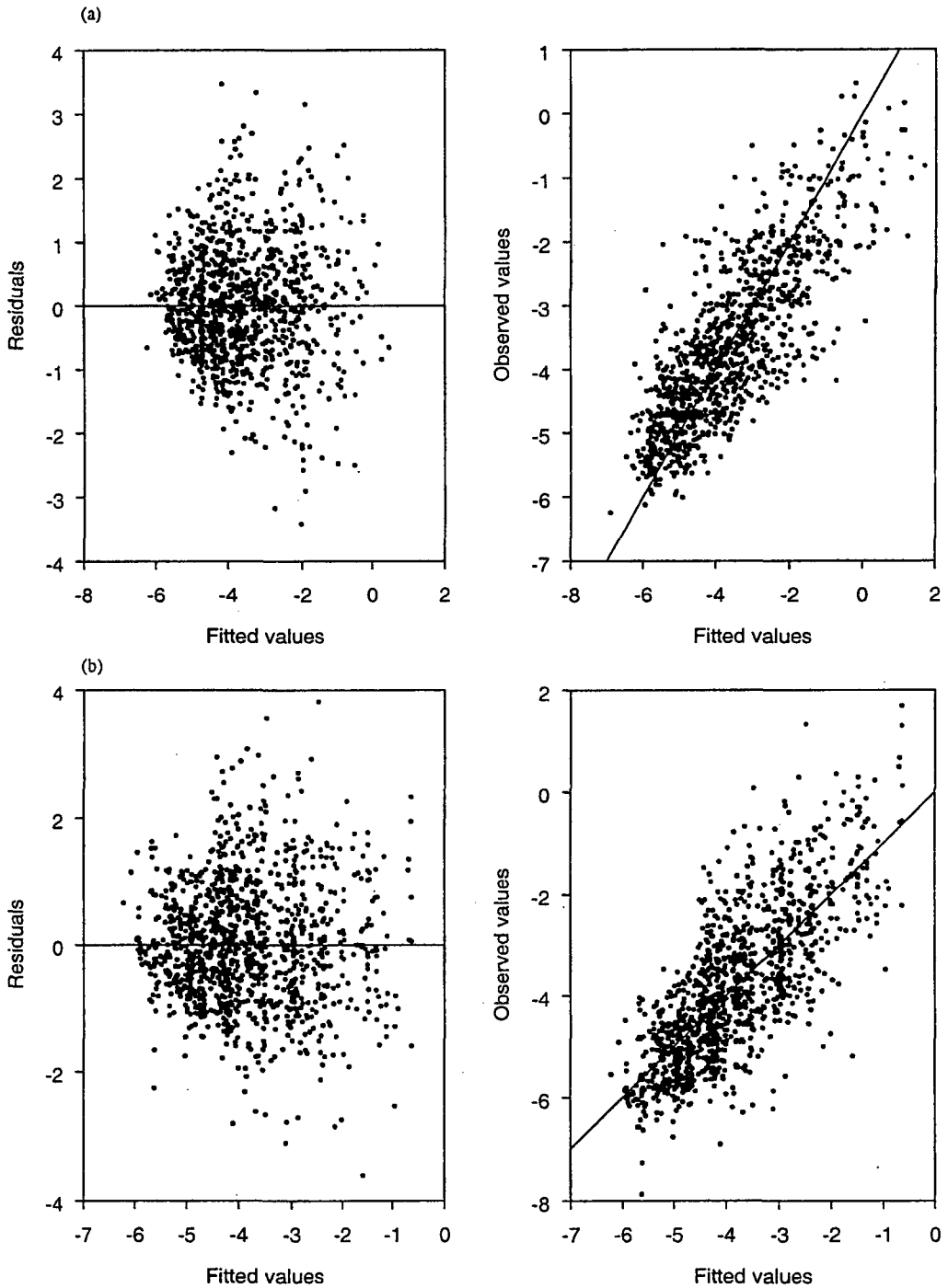

Figure 18: Diagnostic plots (log scale) of the lognormal model for the east Chatham Rise TCEPR tow-by-tow data from (a) vessels that catch 80% of the total catch for all years for all years, (left) fitted values versus residuals, and (right) fitted values versus observed values, (b) vessels fishing three or more consecutive years, (left) fitted values versus residuals, and (right) fitted values versus observed values.

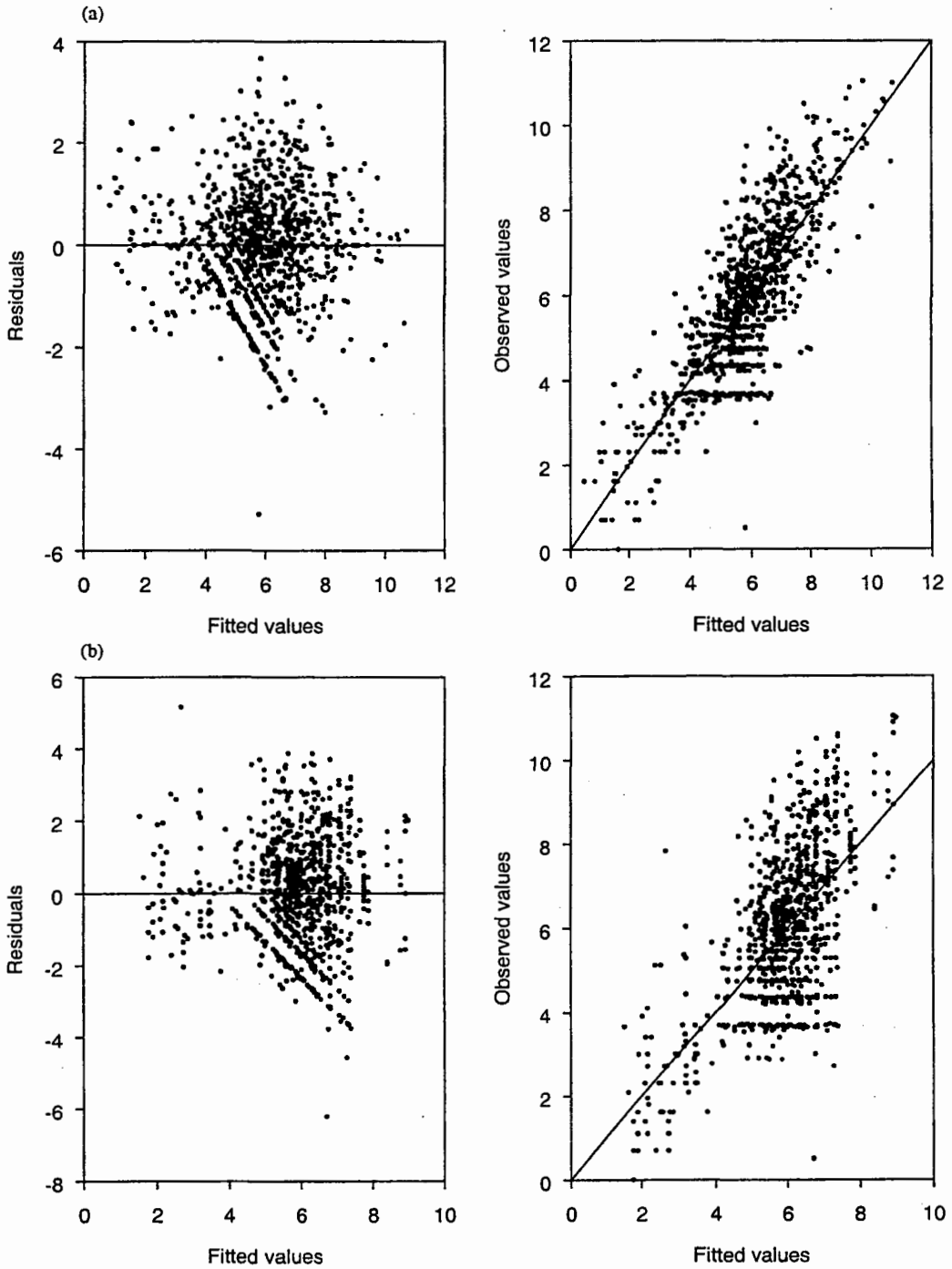

Figure 19: Diagnostic plots (log scale) of the lognormal model for the east Chatham Rise daily processed catch summary data from (a) vessels that fish for three or more consecutive years, (left) fitted values versus residuals, and (right) fitted values versus observed values, (b) vessels fishing three or more consecutive years, (left) fitted values versus residuals, and (right) fitted values versus observed values.

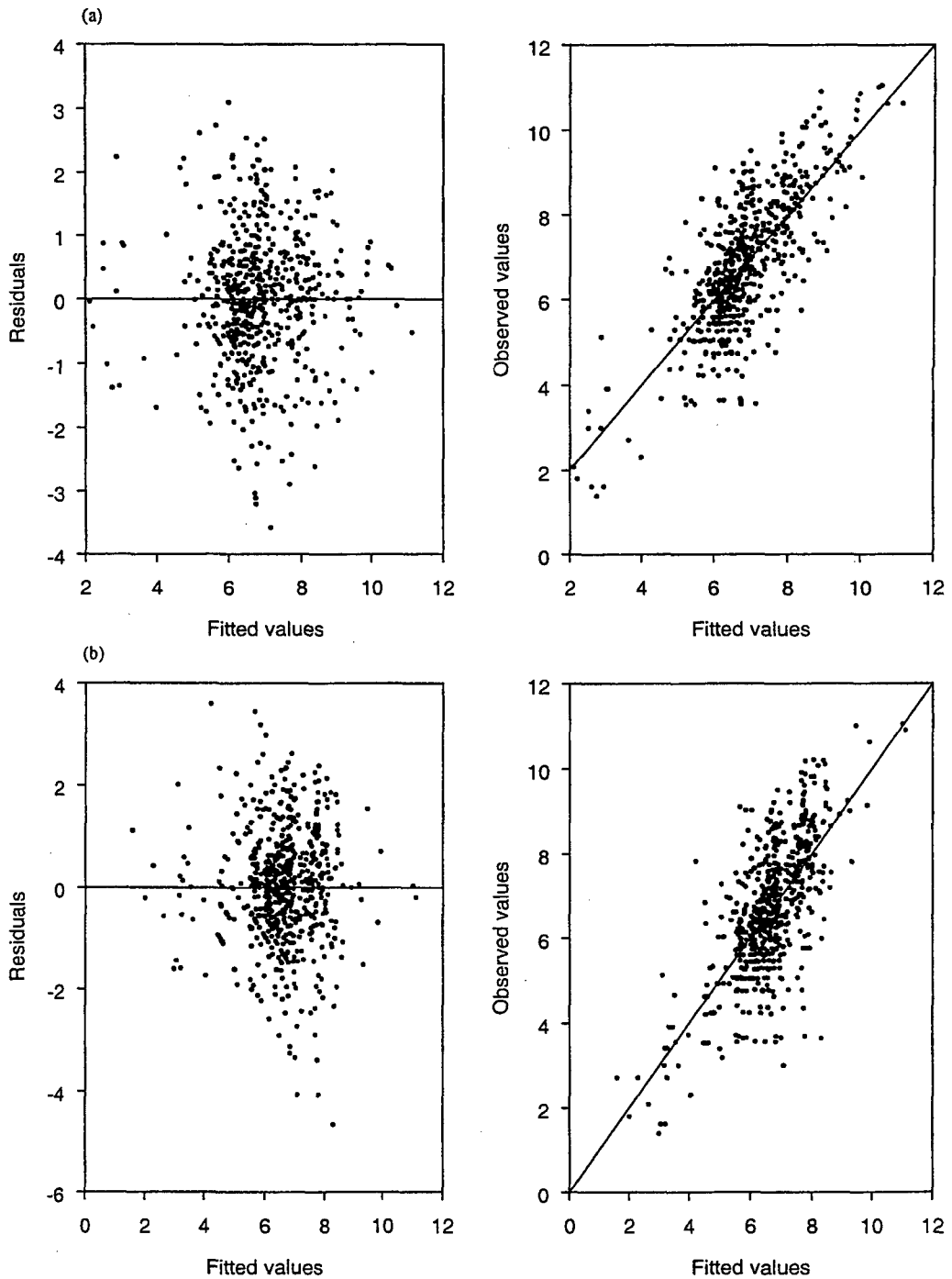

Figure 20: Diagnostic plots (log scale) of the lognormal model for the east Chatham Rise combined information from tow-by-tow and daily processed catch data forms (a) vessels that catch 80% of the total catch for all years for all years, (left) fitted values versus residuals, and (right) fitted values versus observed values, (b) vessels fishing three or more consecutive years, (left) fitted values versus residuals, and (right) fitted values versus observed values.

4. DISCUSSION

A CPUE analysis of the main silver warehou fisheries (Knuckey et al. unpublished analysis) showed that a large proportion of the silver warehou was taken as a bycatch, and only a small proportion of the total catch is likely to be captured be captured on the TCEPR tow-by-tow data. However, exclusion of silver warehou from the top five species on the TCEPR tow-by-tow records does not appear to be a problem as the catches from TCEPR tow-by-tow and daily processed catch summaries are similar (Appendix 3). Also the estimated catches from the TCEPR tow-by-tow records tend to match the daily processed catch summary. Most of the matching records are from vessels that did only one tow for a particular day, and it appears the catch was processed before the TCEPR tow-by-tow component was filled out.

Variables entering the models were similar for the different areas. Processing type appears to be an important factor for the models derived from the daily processed catch summary data for all areas, but not the tow-by-tow data. The preferred processing method is head and gut for target and non-target tows, and this appears to have the highest CPUE.

An important step in assessing the feasibility of CPUE as an index of abundance was to determine whether annual changes in CPUE are likely to reflect the abundance of silver warehou in the fishery. The presence of similar features in the relative year effects in the standardised CPUE models from the different fisheries increases confidence in the use of standardised CPUE as an indicator of abundance. Large proportions of the commercial catch contained 4 year old fish for the 1993–94 fishing year for the west coast, sub-Antarctic, and the Chatham Rise (Horn et al. 2001). This strong year class continues to dominate the catch in the two following years. These observations are consistent with CPUE models from the west coast, sub-Antarctic, and the west Chatham Rise. However, many of the differences between the models occur in the early years, when there is no biological information to compare with the indices.

Many of the variables selected by the stepwise regression were the same for each area. The models did not appear to be overly sensitive to the vessel sub-set used, thus increasing the confidence that CPUE reflects abundance.

Residual diagnostics provide a method for verifying model assumptions, and can provide some evidence that the estimated year effects are reliable. The diagnostics for the models using the TCEPR tow-by-tow data suggest the model is acceptable, but the diagnostic analyses for the models using the processed data suggest the fits may not be adequate and could be improved.

The different models for the west coast show similar trends and features, apart from the initial year. There is a lack of other abundance indices (e.g., acoustic surveys, trawl surveys) to compare with the CPUE results, but commercial catch-at-age data support the 1993–94 peak present in the CPUE indices from all models. One of the problems with the west coast fishery is that it is predominantly a hoki target fishery, and only 3–36% (by year) of the silver warehou catch is by target fishing. Langley (1992) noted that there may be problems with a variable silver warehou catch as vessels tend to concentrate effort to maintain high hoki catch rates which may influence the resulting CPUE indices. There is consistency between the different model results for the west coast, and the agreement with the biological data suggests that CPUE may be monitoring abundance in this fishery. As the west coast is predominantly a bycatch fishery, it is recommend using TCEPR tow-by-tow records from vessels that catch 80 % of the silver warehou catch because these should provide a better overall index of abundance and still include a relatively high proportion of the catch.

The sub-Antarctic models also show similar trends and features apart from the initial year. There is a lack of biological data for this year, but commercial catch-at-age data again support the 1993–94 peak present in the CPUE indices. Species other than silver warehou are targeted and this can be quite significant in some years. (Knuckey et al. unpublished analysis) noted similar features and trends in

CPUE between non-target and target hauls, however the CPUE differed in magnitude, and this may have an effect on the standardised CPUE in this area. We recommend using TCEPR tow-by-tow records from vessels that fished three or more consecutive years. These should provide a better overall index of abundance and still include a relatively high percentage of the catch.

The west Chatham Rise indices also show similar features and trends, apart from the initial year. The model that used TCEPR tow-by-tow data from vessels that fished three or more consecutive years showed a lot more variability in the indices. There were a high proportion of tows that did not target silver warehou. (Knuckey et al. unpublished analysis) noted that there were different results between target and non-target CPUEs. They suggested that this may be a result of fishing outside the main spatial or temporal boundaries of silver warehou stocks in this fishery. I recommend the use of TCEPR tow-by-tow records from vessels that caught 80% of the silver warehou catch because these should provide a better overall index of abundance and still include a relatively high percentage of the catch.

The east Chatham Rise should either be excluded from the analysis or combined with the west Chatham Rise as the data are minimal and the resulting CPUEs probably do not reflect abundance.

5. CONCLUSIONS AND RECOMMENDATIONS

- Silver warehou CPUE appears to represent abundance for the west coast, sub-Antarctic, and west Chatham Rise, as the different models show similar results, even using different data, and the indices reflect known biological features.
- It is recommended that the daily tow-by-tow indices are used because they have better residual analysis.
- It is recommended that the indices derived using data from vessels which caught 80 % of the silver warehou catch be used for the west coast and west Chatham Rise, and the indices derived using data from vessels that fished for three or more consecutive years be used for the sub-Antarctic. These should provide a better overall index of abundance and still include a relatively high percentage of the catch.
- The east Chatham Rise should be excluded from the analysis or combined with the west Chatham Rise, as the data are minimal and the indices probably do not reflect abundance.

6. ACKNOWLEDGMENTS

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8. APPENDIX 1

This summarises the effects of data grooming on the TCEPR tow-by-tow variables.

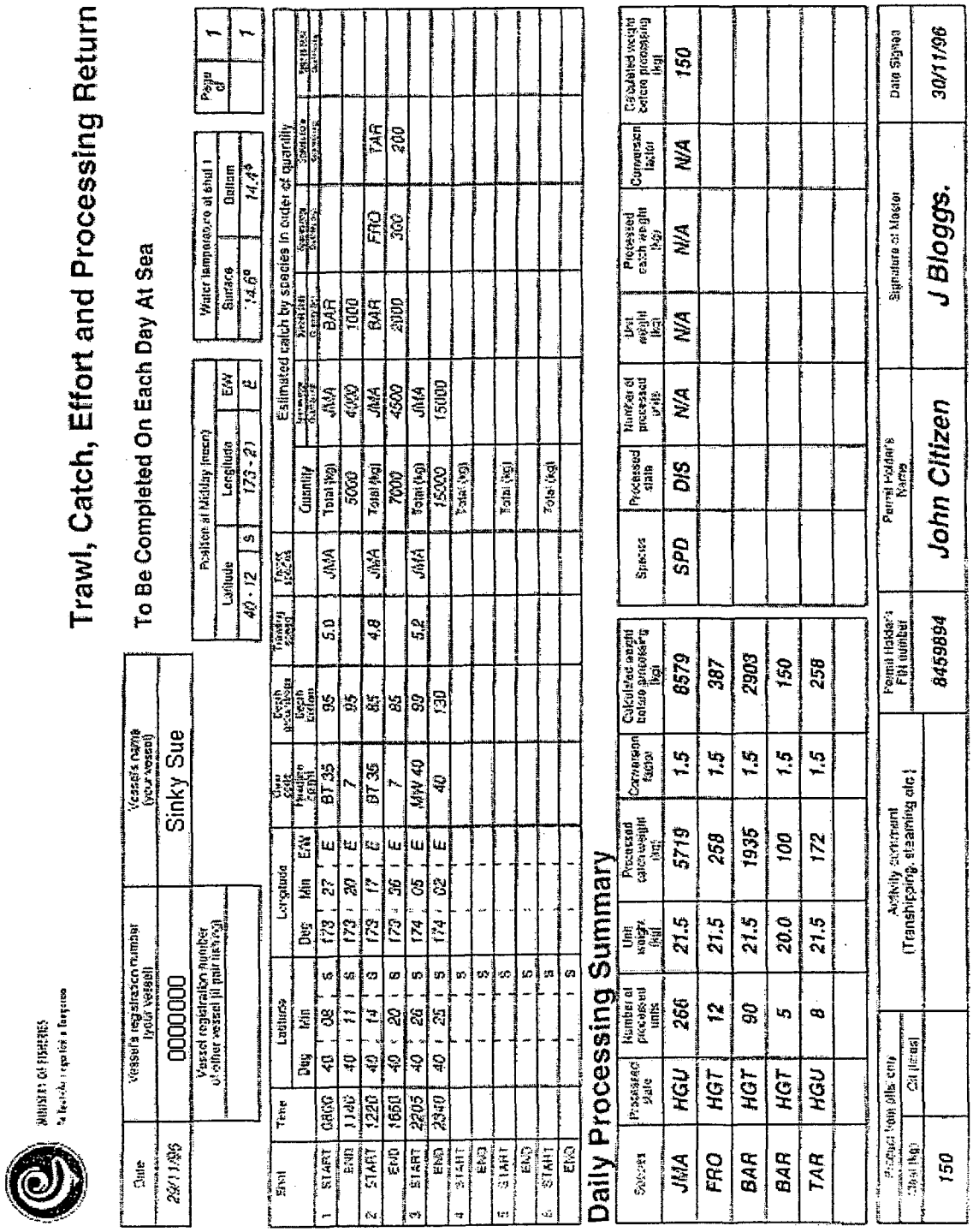
Table 1.1: Descriptive summary of the raw data for all tows and areas combined

Variable	Mean	Min.	25% Quartile	Median	75% Quartile	Max.	Missing data (n)
Start longitude	172.0	162.1	170.2	170.8	174.4	187.2	-
Start latitude	-43.5	-54.8	-44.6	-43.0	-41.8	-31.8	-
Wingspread	52.9	0.0	35.0	40.0	65.0	3 046.0	972
Headline height	21.1	0.1	4.0	6.0	40.0	3 535.0	246
Groundrope depth	370.5	2.0	265.0	386.0	470.0	5 757.0	199
Bottom depth	382.1	0.4	272.0	400.0	480.0	48 062.0	566
Speed	4.3	0.2	3.8	4.1	4.5	3 800.0	112
Total catch	9.2	0.0	2.1	5.0	10.5	240.0	313
SWA catch	1.0	0.0	0.1	0.3	0.8	140.0	21
Vessel length	65.1	4.5	51.9	64.0	82.1	118.0	21
Vessel draught	6.0	0.1	4.5	5.9	6.6	62.0	263
Vessel breadth	11.8	1.5	9.1	12.0	14.0	59.1	25
Vessel tonnage	1 514.1	0.2	349.2	1 048.0	2 576.9	5 460.0	239
Vessel power	2 259.4	0.0	1 566.6	2 237.1	2 909.4	8 100.0	137
Tow duration	4.4	0.0	2.9	4.0	5.4	23.9	-
Tow distance	16.0	0.0	11.2	18.5	21.8	15 580.0	112

Table 1.2: Descriptive summary of the groomed data for all tows and areas combined

Variable	Mean	Min.	25% Quartile	Median	75% Quartile	Max.	Missing data (n)
Start longitude	171.6	164.0	170.0	170.7	173.9	187.2	0
Start latitude	-43.9	-51.2	-45.1	-43.2	-42.1	-38.4	0
Wingspread	45.3	4.1	30.0	38.0	54.0	120.0	1 334
Headline height	22.2	2.5	4.0	6.0	45.0	120.0	6 742
Groundrope depth	380.5	100.0	280.0	400.0	479.0	1 000.0	1 089
Bottom depth	393.7	100.0	290.0	410.0	490.0	1 000.0	1 089
Speed	4.1	2.0	4.0	4.1	4.5	45.0	85
Total catch	9.2	0.0	2.5	5.5	11.2	100.0	189
SWA catch	1.1	0.0	0.1	0.3	1.0	80.0	15
Vessel length	69.1	20.0	56.0	66.5	86.1	118.0	313
Vessel draught	6.2	0.5	5.2	5.9	6.7	25.7	215
Vessel breadth	12.2	2.0	9.8	12.8	15.0	59.1	28
Vessel tonnage	1 639.6	42.2	363.9	1 594.0	2 577.1	5 460.0	184
Vessel power	2 443.1	179.0	1 716.0	2 353.0	2940.0	8 100.0	945
Tow duration	4.4	0.0	3.0	4.1	5.4	12.0	677
Tow distance	17.8	0.0	12.0	16.6	22.2	61.6	785

9. APPENDIX 2



Trawl, Catch, Effort and Processing Return

To Be Completed On Each Day At Sea

Date	Vessel's registration number (vessel)	Vessel's name (your vessel)
28/11/96	0000000	Sinky Sue

Vessel registration number (if other vessel in pair trawl)

Position at Midday (noon)					
Latitude		Longitude		E/W	
40 - 12	S	173 - 21		E	

Water temperature at shot 1	
Surface	Bottom
14.6°	14.4°

Page of: 1 / 1

Shot	Time	Latitude			Longitude			Gear code	Depth recorder		Depth (fathoms)	Towing speed	Estimated catch by species in order of quantity							
		Deg	Min		Deg	Min	E/W	Headline (cm)	Begin bottom	End bottom			Species	Quantity	Species code	Species	Species code	Species	Species code	Species
1 START	0800	40	08	S	173	27	E	BT 35	95		95	5.0	JMA	Total (kg)	JMA	BAR				
END	1040	40	11	S	173	20	E	7	95		95			5000		4000		1000		
2 START	1220	40	14	S	173	17	E	BT 35	85		85	4.8	JMA	Total (kg)	JMA	BAR	FRO	TAR		
END	1650	40	20	S	173	36	E	7	85		85			7000		4500	2000	500		
3 START	2205	40	26	S	174	05	E	MW 40	90		90	5.2	JMA	Total (kg)	JMA					
END	2340	40	25	S	174	02	E	40	130		130			15000		15000				
4 START				S										Total (kg)						
END				S																
5 START				S										Total (kg)						
END				S																
6 START				S										Total (kg)						
END				S																

Daily Processing Summary

Species	Processed state	Number of processed units	Unit weight (kg)	Processed catch weight (kg)	Conversion factor	Calculated weight before processing (kg)
JMA	HGU	266	21.5	5719	1.5	8579
FRO	HGT	12	21.5	258	1.5	387
BAR	HGT	90	21.5	1935	1.5	2903
BAR	HGT	5	20.0	100	1.5	150
TAR	HGU	8	21.5	172	1.5	258

Species	Processed state	Number of processed units	Unit weight (kg)	Processed catch weight (kg)	Conversion factor	Calculated weight before processing (kg)
SPD	DIS	N/A	N/A	N/A	N/A	150

Processed fish on this entry		Activity statement (Transhipping, steaming etc)	Permit Holder's Fish number	Permit Holder's Name	Signature or Master	Date Signed
Total (kg)	On board					
150			8459894	John Citizen	J Bloggs.	30/11/96

Figure 2.1: An example of a completed Trawl, Catch, Effort and Processing return (TCEPR) form (source: Ministry of Fisheries).

10. APPENDIX 3

Table 3. 1: Reduction of data from the initial TCEPR tow-by-tow and daily processed catch summary database by area to the final dataset used in the CPUE analysis. The criteria by which the data were selected are explained below.

		TCEPR tow-by-tow				Daily processed catch summaries			
Area	Criteria*	Records		Catch		Records		Catch	
		(No.)	(%)	(t)	(%)	(No.)	(%)	(t)	(%)
West coast	Raw data	26 705	100.0	18 264.3	100.0	20 442	100.0	20 367.3	100.0
	Zero tows	46	0.2						
	Method	157	0.6	67.5	0.4				
	Effort	390	1.5	421.9	2.3				
	80% vessel	7 949	29.8	3 510.3	19.2	5 738	28.1	3 887.5	19.1
	3+ years	10 981	41.1	7 026.4	38.5	4 078	20.0	16.5	16.5
	Missing values (80% catch)	863	3.2	784.9	4.3	32	0.2	1.2	0.0
	Missing values (3+ years)	11 574	56.7	601.1	3.3	25	0.1	0.8	0.0
	Final data set (80% catch)	17 300	64.8	13 480.1	75.8	14 671	71.8	16 478.6	80.9
	Final data set (3+ years)	14 369	53.8	10 148.0	57.1	16 338	79.9	17 015.2	83.5
sub-Antarctic	Raw data	19 108	100.0	34 931.2	100.0	12 873	100.0	34 005.5	100.0
	Zero tows	657	3.4						
	Method	0	0.0						
	Effort	210	1.1	320.2	0.9				
	80% vessel	6 951	36.4	6 719.7	19.2	5 727	44.5	6 476.2	19.0
	3+ years	2 969	15.5	2 907.7	8.3	2 468	19.2	2 809.5	8.3
	Missing values (80% catch)	1 764	9.2	5 215.1	14.9	11	0.1	0.3	0.0
	Missing values (3+ years)	3 439	18.0	6 574.6	18.8	33	0.3	1.0	0.0
	Final data set (80% catch)	9 526	49.9	22 675.7	64.9	7 133	55.4	27 527.8	81.0
	Final data set (3+ years)	11 830	61.9	25 132.0	72.0	10 370	80.6	31 193.7	91.7
East Chatham Rise	Raw data	2 390	100.0	2 719.7	100.0	1 618	100.0	2 651.7	100.0
	Zero tows	26	1.1						
	Method	0	0.0						
	Effort	32	1.3	22.4	0.8				
	80% vessel	978	40.9	534.9	19.7	740	45.7	522.8	19.7
	3+ years	757	31.7	782.1	28.8	583	36.0	800.3	30.2
	Missing values (80% catch)	140	5.9	256.6	9.4	2	0.1	0.1	0.0
	Missing values (3+ years)	216	9.0	263.6	9.7	3	0.2	0.1	0.0
	Final data set (80% catch)	1 391	58.2	1 673.9	61.6	876	54.1	2 128.8	80.3
	Final data set (3+ years)	1 246	52.1	1 928.1	70.9	1 032	63.8	1 851.3	69.8
West Chatham Rise	Raw data	20 376	100.0	19 176.0	100.0	13 631	100.0	19 963.3	100.0
	Zero tows	227	1.1						
	Method	0	0.0						
	Effort	32	0.2	22.4	0.1				
	80% vessel	8 493	41.7	4 518.0	23.6	5 410	39.7	3 917.9	19.6
	3+ years	14 580	71.6	11 545.2	60.2	1 503	11.0	1 648.8	8.3
	Missing values (80% catch)	1 091	5.4	1 355.0	7.1	6	0.0	2.7	0.0
	Missing values (3+ years)	514	2.5	718.7	3.8	16	0.1	3.1	0.0
	Final data set (80% catch)	10 787	52.9	13 302.2	69.4	8 214	60.3	16 042.7	80.4
	Final data set (3+ years)	5 277	25.9	6 911.2	36.0	12 111	88.9	18 311.3	91.7

*Criteria information

Raw Data	Catch and effort data from the groomed TCEPR tow-by-tow and daily processed catch summaries
Zero tows	All TCEPR tow-by-tow records removed that targeted silver warehou but did not catch any
Method	Vessels involved in pair trawl were removed
Effort	All TCEPR tow-by-tow records removed, as effort could not be determined, as the tow duration or tow speed missing or zero.
80% Catch	Vessels not involved in the top 80% of the catch removed
3+ Years	Vessels not involved in the fishery for 3 or more consecutive years
Missing values (80% Catch)	Missing values from vessels involved in the top 80% of the catch removed
Missing values (3+ years)	Missing values from vessels involved in the fishery for 3 or more consecutive years removed
Final data set (80% Catch)	Data used in the CPUE analysis where vessels caught the top 80 % of the catch
Final data set (3+ years)	Data used in the CPUE analysis where vessels were involved in the fishery for three or more consecutive years.

Table 3.2: The number of non-zero and zero tows which target silver warehou and the number of tows that target other species by area for all years combined from groomed TCEPR tow-by-tow records

Area	Target silver warehou			Non-target	Targeted (%)	Target zero tows (%)
	Non-zero tows	Zero tows	Total	Total		
West coast	231	35	266	25 847	1.0	13.2
sub-Antarctic	3 799	654	4 454	13 787	24.4	14.7
West Chatham Rise	1 630	227	1 857	18 519	9.1	12.22
East Chatham Rise	197	26	223	2 141	9.4	11.66

11. APPENDIX 4

Table 4. 1: Lognormal CPUE indices with 95% confidence intervals for the west coast where vessels catch 80% of the total catch for all years using TCEPR tow-by-tow data, daily processed catch summary data, and a combination of both.

	TCEPR tow-by-tow		Daily processed		Combined	
Year	Index	Confidence intervals	Index	Confidence intervals	Index	Confidence intervals
1989–90	0.76	0.69–0.84	1.22	1.09–1.35	1.18	1.01-1.38
1990–91	0.78	0.71–0.86	0.99	0.90–1.10	0.97	0.82-1.14
1991–92	0.61	0.55–0.68	0.74	0.67–0.83	0.66	0.57-0.77
1992–93	0.53	0.48–0.58	0.59	0.53–0.65	0.45	0.37-0.56
1993–94	0.86	0.79–0.94	0.91	0.84–0.99	0.73	0.59-0.91
1994–95	0.72	0.66–0.79	0.74	0.68–0.81	0.77	0.68-0.86
1995–96	0.88	0.81–0.95	1.00	na	1.00	na
1996–97	0.94	0.87–1.02	1.05	0.97–1.14	0.80	0.65-0.99
1997–98	1.00	na	1.36	1.24–1.48	1.77	1.53-2.04
1998-99	0.67	0.62–0.72	0.76	0.69–0.83	0.65	0.58-0.74

Table 4. 2: Lognormal CPUE indices with 95% confidence intervals for the west coast where vessels fish for three or more consecutive years using TCEPR tow-by-tow data, daily processed catch summary data, and a combination of both.

	TCEPR tow-by-tow		Daily processed		Combined	
Year	Index	Confidence intervals	Index	Confidence intervals	Index	Confidence intervals
1989–90	0.77	0.7-0.8	1.22	1.09-1.35	1.23	1.09–1.39
1990–91	0.89	0.8-1.0	0.99	0.90-1.10	1.05	0.93–1.18
1991–92	0.68	0.6-0.8	0.74	0.67-0.83	0.71	0.63–0.81
1992–93	0.64	0.6-0.7	0.59	0.53-0.65	0.54	0.48–0.62
1993–94	1.00	na	0.91	0.84-0.99	0.91	0.82–1.01
1994–95	0.74	0.7-0.8	0.74	0.68-0.81	0.76	0.69–0.84
1995–96	0.98	0.9-1.1	1.05	0.97-1.14	1.00	0.91–1.11
1996–97	1.12	1.0-1.2	1.00	na	1.00	na
1997–98	1.12	1.0-1.2	1.36	1.24-1.48	1.30	1.17–1.43
1998-99	0.71	0.6-0.8	0.76	0.69-0.83	0.72	0.64–0.81

Table 4. 3: Lognormal CPUE indices with 95% confidence intervals for the sub-Antarctic where vessels catch 80% of the total catch for all years using TCEPR tow-by-tow data, daily processed catch summary data, and a combination of both.

	TCEPR tow-by-tow		Daily processed		Combined	
Year	Index	Confidence intervals	Index	Confidence intervals	Index	Confidence intervals
1989–90	1.82	1.53–2.17	0.93	0.75–1.17	0.98	0.78–1.23
1990–91	1.12	0.93–1.34	1.04	0.83–1.29	1.14	0.93–1.39
1991–92	0.93	0.76–1.13	0.86	0.69–1.08	0.91	0.74–1.12
1992–93	0.95	0.80–1.12	0.98	0.81–1.18	0.90	0.75–1.08
1993–94	1.26	1.09–1.46	1.22	1.02–1.46	1.38	1.16–1.64
1994–95	0.80	0.70–0.92	0.89	0.75–1.06	0.97	0.82–1.15
1995–96	0.87	0.76–0.99	0.86	0.72–1.02	0.88	0.74–1.03
1996–97	1.00	na	1.00	na	1.00	na
1997–98	0.90	0.79–1.02	1.16	0.98–1.37	1.02	0.87–1.19
1998–99	1.16	1.01–1.34	1.14	0.96–1.36	1.23	1.04–1.47

Table 4.4: Lognormal CPUE indices with 95% confidence intervals for the sub–Antarctic where vessels fish for three or more consecutive years using TCEPR tow–by–tow data, daily processed catch summary data, and a combination of both.

	TCEPR tow–by–tow		Daily processed		Combined	
Year	Index	Confidence intervals	Index	Confidence intervals	Index	Confidence intervals
1989–90	1.22	1.05–1.42	0.67	0.56–0.81	0.98	0.78–1.23
1990–91	1.09	0.92–1.28	0.65	0.55–0.77	1.14	0.93–1.39
1991–92	0.86	0.73–1.01	0.67	0.56–0.80	0.91	0.74–1.12
1992–93	0.74	0.65–0.85	0.68	0.59–0.79	0.90	0.75–1.08
1993–94	1.04	0.92–1.18	0.94	0.81–1.09	1.38	1.16–1.64
1994–95	0.73	0.65–0.82	0.70	0.60–0.80	0.97	0.82–1.15
1995–96	0.81	0.72–0.91	0.70	0.61–0.80	0.88	0.74–1.03
1996–97	1.00	na	1.00	na	1.00	na
1997–98	0.91	0.81–1.01	0.99	0.87–1.12	1.02	0.87–1.19
1998–99	1.00	0.88–1.14	0.83	0.72–0.94	1.23	1.04–1.47

Table 4. 5: Lognormal CPUE indices with 95% confidence intervals for the east Chatham Rise where vessels catch 80% of the total catch for all years using TCEPR tow-by-tow data, daily processed catch summary data, and a combination of both.

	TCEPR tow-by-tow		Daily processed		Combined	
Year	Index	Confidence intervals	Index	Confidence intervals	Index	Confidence intervals
1989–90	0.73	0.52–1.04	0.77	0.19–3.14	0.26	0.05–1.27
1990–91	0.82	0.53–1.29	2.68	1.29–5.57	1.13	0.52–2.44
1991–92	0.59	0.43–0.81	0.92	0.50–1.68	1.03	0.60–1.78
1992–93	1.14	0.77–1.68	0.52	0.32–0.85	0.93	0.56–1.57
1993–94	0.95	0.66–1.37	0.66	0.40–1.08	0.87	0.50–1.52
1994–95	1.24	0.92–1.67	1.00	na	1.00	na
1995–96	0.94	0.74–1.20	1.13	0.68–1.87	1.38	0.84–2.28
1996–97	1.00	na	1.01	0.63–1.64	1.57	0.98–2.50
1997–98	0.61	0.42–0.89	0.44	0.26–0.76	0.76	0.43–1.33
1998-99	0.52	0.27–1.02	0.19	0.10–0.36	0.27	0.15–0.50

Table 4. 6: Lognormal CPUE indices with 95% confidence intervals for the east Chatham Rise where vessels fish for three or more consecutive years using TCEPR tow-by-tow data, daily processed catch summary data, and combined information of both.

	TCEPR tow-by-tow		Daily processed		Combined	
Year	Index	Confidence intervals	Index	Confidence intervals	Index	Confidence intervals
1989–90	1.00	0.71–1.39	0.77	0.20–2.96	0.12	0.03–0.52
1990–91	1.29	0.71–2.33	3.68	1.81–7.50	0.95	0.48–1.89
1991–92	0.72	0.50–1.05	0.94	0.57–1.53	0.75	0.47–1.18
1992–93	1.18	0.84–1.67	0.34	0.22–0.52	0.54	0.33–0.87
1993–94	1.24	0.91–1.68	0.44	0.28–0.68	0.82	0.50–1.32
1994–95	1.00	na	0.59	0.39–0.91	0.87	0.54–1.40
1995–96	1.01	0.74–1.37	1.00	na	1.00	na
1996–97	1.14	0.85–1.53	0.71	0.51–1.01	1.08	0.76–1.53
1997–98	1.03	0.71–1.49	0.43	0.29–0.65	0.60	0.38–0.96
1998-99	0.63	0.37–1.07	0.21	0.14–0.33	0.32	0.20–0.54

Table 4. 7: Lognormal CPUE indices with 95% confidence intervals for the west Chatham Rise where vessels catch 80% of the total catch for all years using TCEPR tow-by-tow data, daily processed catch summary data, and a combination of both

	TCEPR tow-by-tow		Daily processed		Combined	
Year	Index	Confidence intervals	Index	Confidence intervals	Index	Confidence intervals
1989–90	0.94	0.76–1.15	1.29	1.07–1.55	1.28	1.04–1.57
1990–91	1.23	0.99–1.53	0.91	0.77–1.07	1.01	0.83–1.21
1991–92	0.73	0.60–0.89	1.10	0.94–1.29	0.99	0.83–1.19
1992–93	0.70	0.57–0.84	1.21	1.03–1.42	1.34	1.11–1.61
1993–94	1.47	1.22–1.77	1.31	1.11–1.55	1.35	1.12–1.63
1994–95	0.95	0.81–1.11	1.01	0.87–1.17	1.06	0.90–1.24
1995–96	0.90	0.78–1.04	1.00	na	1.00	na
1996–97	1.00	na	1.07	0.93–1.23	1.10	0.93–1.29
1997–98	1.36	1.11–1.66	1.31	1.13–1.52	1.10	0.91–1.32
1998-99	1.07	0.85–1.34	0.92	0.78–1.07	0.86	0.69–1.07

Table 4. 8: Lognormal CPUE indices with 95% confidence intervals for the west Chatham Rise where vessels fish for three or more consecutive years using TCEPR tow-by-tow data, daily processed catch summary data, and a combination of both

	TCEPR tow-by-tow		Daily processed		Combined	
Year	Index	Confidence intervals	Index	Confidence intervals	Index	Confidence intervals
1989–90	0.94	0.76–1.15	1.07	0.90–1.28	1.00	0.82–1.23
1990–91	1.23	0.99–1.53	0.92	0.78–1.07	0.89	0.73–1.07
1991–92	0.73	0.60–0.89	0.90	0.78–1.04	0.95	0.80–1.12
1992–93	0.70	0.57–0.84	1.04	0.91–1.19	1.21	1.00–1.45
1993–94	1.47	1.22–1.77	1.08	0.95–1.23	1.20	1.00–1.44
1994–95	0.95	0.81–1.11	0.94	0.83–1.06	0.99	0.84–1.17
1995–96	0.90	0.78–1.04	1.03	0.92–1.15	0.93	0.80–1.08
1996–97	1.00	0.00–0.00	1.00		1.00	
1997–98	1.36	1.11–1.66	1.22	1.09–1.36	0.96	0.82–1.12
1998-99	1.07	0.85–1.34	0.95	0.84–1.07	0.86	0.71–1.03