New Zealand Fisheries Assessment Research Document 99/13

Trevally catch per unit effort in TRE 7

Malcolm P. Francis, Elizabeth Bradford, and Larry J. Paul

NIWA
PO Box 14 901
Wellington

March 1999

Ministry of Fisheries, Wellington

Trevally catch per unit effort in TRE 7

Malcolm P. Francis, Elizabeth Bradford, and Larry J. Paul
New Zealand Fisheries Assessment Research Document 99/13. 27 p.

1. Executive summary

The objective of this study was to investigate the use of standardised and unstandardised analyses of commercial catch and effort data as relative abundance indices for trevally in TRE 7. The results will be used in a population model to estimate biomass and sustainable yield. Three main sources of catch and effort data were analysed: MAF Fisheries manual data extracts for 1974–85; FSU data for 1983–89, and CELR/TCEPR data for 1989–97. The three data sources differed substantially in spatial resolution, target species definition, catch data type, catch data resolution, effort resolution, and treatment of zero catches. This made it impossible to carry out a single CPUE analysis for the fishery. Instead, we carried out analyses of raw and "pseudo-standardised" CPUE analyses for each of the three data series, and also a standardised CPUE analysis for the 1989–97 trevally and snapper target single trawl fisheries.

There have been major changes in the fishery during the last 24 years. Small pair trawlers dominated the fleet between 1974 and 1986, but then declined rapidly. Large pair trawlers were prominent in the fishery only for a relatively short period (1978–85). Single trawlers were the most consistent vessel class throughout the period, with relatively constant amounts of effort between 1980 and 1997. Fishing effort, catch, and CPUE all showed strong seasonal fluctuations throughout the 24 years, peaking in summer.

Raw and pseudo-standardised CPUE showed no long-term trends, either for individual fishing methods or for all methods combined. In the standardised CPUE analysis, one vessel characteristic (tonnage or breadth) entered the models first. Month was the second most important variable, reflecting the strong seasonal catch rate pattern. Fishing year and statistical area were the next most important variables. The standardised year indices for both the trevally and snapper target fisheries were essentially the same, and showed little contrast over the 8 years 1989–90 to 1996–97. There was no evidence from the analyses that trevally biomass has varied significantly since the early 1970s.

2. Introduction

The research reported in this document was part of a study conducted by NIWA for the Ministry of Fisheries under contract TRE9701. The objective of the study was:

To investigate the use of both standardised and unstandardised analyses of commercial catch and effort data as a relative abundance index for trevally in TRE 7.

The results from this study will be used, in conjunction with age structure information from the commercial catch and biological parameter estimates, to produce a population model that will be used to estimate biomass and sustainable yield in TRE 7. Results relevant to other objectives under contract TRE9701 will be reported elsewhere.

3. The TRE 7 fishery

Trevally (*Pseudocaranx dentex*) are caught around the North Island and off the northern coast of the South Island. The two main fishing regions are between East Cape and North Cape (TRE 1), and between Cape Egmont and North Cape (the northern half of TRE 7). The TRE 7 fishery has been the larger of the two since at least the early 1980s, with average landings of 1840 t (1983 to 1996–97) compared with 1270 t (Annala *et al.* 1998). A comparison for earlier years (*see* Figure 1A) is not valid because west coast catches were often landed into Auckland.

Trevally is a moderately valuable coastal fish species. At a port price of $1600 per tonne in 1993, the landed catch in that year had a primary value of $5.47 million (Parker 1994), and during the 1990s the traded value of TRE 7 quota was about $4000 per tonne (Quota Monitoring Reports, Ministry of Fisheries), giving a nominal value of $8 million to the holdings of TRE 7 quota, and perhaps $15 million to the total trevally quota.

Trevally are common northern inshore fish, and have almost certainly been caught in the commercial fishery since last century. Initially they were only a bycatch and of little value. They kept poorly under early handling and storage conditions, and until about 1940 most of the catch was dumped. From the early 1940s to the mid 1950s a few hundred tonnes were landed annually, much of it for sale as bait. Catches began rising in the mid 1950s (Figure 1A, Table 1) as the species acquired some value as food, although considerable quantities were still discarded. Reid (1969) described the North Island west coast trawl fishery for 1953–58, and recorded that the company-imposed "limits" on trevally were usually exceeded during a trip "so that seldom does all the trevally caught during a trip reach the markets". He also recorded that even when limits were not in force trawlers were reluctant to keep low-value trevally, in anticipation of catching more snapper and tarakihi, and would sometimes discard all trevally until the final day or two of the trip. Consequently, recorded landings seriously understate the true catches (and fishing mortality) until the late 1960s at least (James 1984, Gilbert 1988). During the 1970s (particularly 1975), problems with the fisheries statistics recording system led to an incomplete record of landings (Gilbert 1988).

The rapid rise of landings from TRE 7 (Figure 1A) from about 500 t in the early 1960s to over 2000 t in the early 1970s reflects both increased catches and an increase in the proportion of caught trevally that was landed. Reported landings from TRE 7 declined from a peak of nearly 3000 t in 1981 to under 2000 t a few years later, before the introduction of the TACC of 1800 t in 1986. Since 1986, TRE 7 landings have been close to the TACC, apart from a substantial and unexplained drop in 1991–92.

It is not easy to quantify the proportion of trevally caught in different TRE 7 sub-regions over time. Up to 1982, landings data were recorded by port of landing rather than area fished. Trawlers range widely along the west coast of the North Island, so port landings are only an approximate indication of the area fished. Also, the estimated catch records are incomplete in some years because of data reporting problems.

The distribution of estimated trevally catch by sub-region is shown in Figure 1B. Most of the catch has come from the northern region of TRE 7, but the Egmont and southern regions contributed significant landings between 1965 and 1982. Some of the increase in the southern region in 1966–68 reflects the effort of two large Nelson-based trawlers.

4. Methods

4.1 Data characteristics

Catch and effort data have been collected from the west coast trevally fishery for several decades. However, because of changes in the recording forms used by fishers, the data format has not been consistent over time. The three main time series of data are described below (*see* Table 2 for details).

4.1.1 Ministry of Agriculture and Fisheries (MAF) manual data extracts from 1974 to 1985

Data were extracted manually from MAF fishing returns by D. J. Gilbert and K. J. Sullivan for a study of snapper CPUE in the west coast North Island trawl fishery (Sullivan 1985, Vignaux 1993). They extracted trip by trip catch and effort data, and summarised them by month. Because of time constraints, and because the detailed data have not been computerised, we used only the data summaries in the present study. Data extracts for the 1976 calendar year were missing. The data contain no information on the geographical location of the fishing effort, but they do provide port of landing. Landings into the port of Onehunga were extracted, along with a few landings into Auckland by vessels known to be fishing on the west coast North Island, and a few landings into Kawhia and Raglan. Target species were not identified on the forms, so Gilbert and Sullivan extracted data for all trips for which the sum of the trevally and snapper catches exceeded the tarakihi catch. This was based on an assumption that trevally and snapper are generally caught in shallower water than tarakihi, and that the catch mix for a trip provides a good indication of whether the vessel was target fishing for snapper or trevally (D. J. Gilbert, NIWA, pers. comm.). Trips that caught no trevally would have been included in the monthly summaries if the snapper catch exceeded the tarakihi catch. The number of days fishing was not recorded on the forms, but the trip length (finish date – start date + 1) was.

4.1.2 Fisheries Statistics Unit (FSU) electronic data from 1983 to 1989

An electronic extract of data from the FSU database was obtained from the Ministry of Fisheries. Trevally catch rates peak in summer (*see* below), so only data for November–April were requested. Data were obtained for all statistical areas within TRE 7, but because most of the catch came from areas 41–47, only data from those areas were analysed further. Catches from areas 41–47 are roughly comparable with landings into Onehunga in the MAF manual data extracts.

The catch data provided by the Ministry consisted of the *landed* catch from the Landed Catch Form apportioned across the *estimated* catches in the Trawl Fishing Return. This is necessary because statistical area and effort information were provided only on the Trawl Fishing Return. As for the manual extracts, target species were not reported, so trevally targeting was assumed if the trevally and snapper catches combined exceeded the tarakihi catch. However for the FSU data, this was determined for each record of the data file, which was usually the catch from one day's fishing (and occasionally the catch for a single tow) rather than for the whole trip. Zero trevally catches would have been included if the snapper catch exceeded the tarakihi catch in an individual file record. The smallest unit of fishing effort was the number of days spent fishing.

4.1.3 Catch Effort Landing Return (CELR) and Trawl Catch and Effort Processing Return (TCEPR) electronic data from 1989 to 1997

Catch and effort data were extracted from the Ministry of Fisheries CATCHEFF database on 13 January 1998. The data came from the *estimated* catch portion (top panel) of CELR and TCEPR fishing returns. The CELR and TCEPR data formats were identical except that catches were reported mainly by *day* in the CELR data, and by *tow* in the TCEPR data. Between 1989 and 97, there was a shift from recording on CELRs to TCEPRs (Table 3). To ensure adequate coverage of the fishing effort in TRE 7, we combined the two data types into one series by aggregating the TCEPR tow-by-tow catches into daily catches. Some duplicate records were deleted from the CELR data.

CELR and TCEPR forms both have a declared target species. For unstandardised CPUE analyses, we included vessels targeting either snapper or trevally; for standardised CPUE we carried analysed trevally and snapper target fisheries separately. Days on which no trevally were caught were excluded from the CPUE analyses. The unit of fishing effort for the unstandardised analyses was the number of days spent fishing, and for the standardised analysis it was the number of tows.

4.2 CPUE analyses

The three data series described above differed substantially in spatial resolution (port of landing or statistical area), target species definition (assumed or declared), catch data type (landed, estimated, or apportioned), catch data resolution (trip, day or tow), effort resolution (trip days, days fished or tows), and treatment of zero catches (included or excluded) (*see* Table 2). This made it impossible to carry out a single CPUE analysis for the fishery. Instead, we carried out three different types of analyses: (1) separate raw CPUE analyses on each of the three data series; (2) separate "pseudo-standardised" CPUE analyses on each of the three data series; and (3) standardised CPUE analyses on the 1989 to 1997 trevally and snapper target fisheries using CELR/TCEPR data.

4.2.1 Raw and pseudo-standardised CPUE analyses, 1974 to 1997

For the MAF manual extracts, the trevally catches and fishing effort were aggregated by month. This meant that no information was available on the individual vessel CPUEs, so it was not possible to carry out a standardised analysis of the data. Trevally CPUE shows marked seasonal fluctuations, with a short peak in summer (*see* below), so we calculated raw CPUE (total catch divided by number of days fished) for the 4-month season December–March. Following Gilbert (1988), we classified vessels into one of three classes:

- Single trawlers (ST) 16–22.9 m long and 150–350 kW power
- Small pair trawlers (SPT) 18–22.9 m long
- Large pair trawlers (LPT) 23 m long and over

Some vessels did not fit into any of the three classes, and were omitted. Raw CPUE was calculated only for fishing seasons in which more than 100 days of effort were expended.

We also performed a "pseudo-standardised" analysis by treating the monthly aggregate CPUE values as replicate estimates of CPUE. Aggregate monthly CPUEs were $\log_{10}$ transformed to improve the normality of the data, and analysed with a generalised linear model (SAS procedure GLM) incorporating the fixed factors fishing year and vessel class, and also the interaction term between these two factors. The four monthly CPUE estimates for each

combination of fishing year and vessel class were treated as replicates. Each monthly CPUE value was weighted by the number of trip days in that month. Using this procedure, a month index could not be derived, but indexes for fishing year and vessel class were obtained. Because the model lacked true replication at the individual vessel level, the usual statistical tests of significance of each factor could not be performed (the significance of each factor should be tested against the variance among replicate vessel CPUEs, not the variance among the monthly aggregate CPUEs).

The above analyses were also applied to the FSU and CELR/TCEPR data series.

4.2.2 Standardised CPUE analysis, 1989–1997

Standardised CPUE analyses were conducted using the method described by Vignaux (1993, 1997). Separate analyses for the trevally and snapper target single trawl fisheries were performed using log (trevally catch per tow) as the dependent variable. Only days when trevally were caught were included. Fishing year, month, statistical area, and various vessel characteristics (defined in Table 4) were used as predictor variables. The analysis was restricted to statistical areas producing reasonable amounts of trevally catch; i.e., areas 40–42 and 45–47 for the trevally target analysis, and 41–42 and 45–47 for the snapper target analysis (see Results). The vessel characteristics were included as categorical variables. The break points were chosen to give roughly equal numbers of vessels in each category.

In the first iteration for each target fishery, log(CPUE) was regressed against each of the variables in turn to find the variable that explained the most variation (i.e., had the highest multiple regression coefficient, R^2). This variable was included in the model. At iteration 2, log(CPUE) was regressed against the new model plus each of the other variables in turn to find the next most significant variable. This process continued for six iterations, after which the increase in total model R^2 resulting from adding extra variables dropped to low levels (under 1%).

5. Results

5.1 Raw and pseudo-standardised CPUE analyses, 1974 to 1997

5.1.1 Effort and catch

Figure 2 shows the fishing effort expended by single trawlers, small pair trawlers, and large pair trawlers when targeting trevally in the selected parts of TRE 7 (i.e., vessels landing into Onehunga, or catches from areas 41–47). Fishing effort showed strong seasonal fluctuations, peaking in summer. However, this pattern is partly an artifact of the way in which target fishing was determined from the data (1974–89) or declared by fishers (1989–97); high summer catches of trevally (or snapper) are partly responsible for the high amount of effort defined as trevally target in summer.

There have been major changes in the amount of effort expended by the three vessel classes during the last 24 years. Small pair trawlers dominated the fleet between 1974 and 1986, but then declined rapidly to a level close to that of single trawlers. Large pair trawlers were prominent in the fishery only for a short period (1978–85). Single trawlers were the most consistent vessel class throughout the period, with relatively constant amounts of effort between 1980 and 1997.

The amount of effort recorded for single trawlers and small pair trawlers on the MAF manual extracts was generally close to the amount recorded in the FSU data between 1983 and early 1985, but the manual extracts were apparently missing some data in late 1985. For large pair trawlers, the FSU extracts were clearly incomplete, recording only half or less of the effort in the manual extracts. The missing effort may have been reported in FSU Deepwater Logbooks, which were not extracted in the present study.

The seasonal and annual patterns in trevally catches, and the correspondence between manual and FSU extracts, were essentially the same as those seen in the effort plots, except that the catch peaks were narrower and better defined than the effort peaks (Figure 3).

5.1.2 Catch per unit effort

Raw monthly CPUEs for the three data series and three vessel classes are plotted in Figure 4. For clarity, the CPUEs for the FSU data during the overlap period 1983–85 are not shown, but they were similar to the CPUEs for the manual extracts. CPUE was strongly seasonal, with catch rates usually peaking in December–March. Occasional very high or very low CPUEs for the FSU small pair trawl data, and the CELR/TCEPR large pair trawl data, resulted from little effort being expended in those months, and are regarded as unrepresentative of the fishery. Consequently, CPUE estimates based on low effort were omitted from the raw and pseudo-standardised analyses, as were fishing seasons that were represented by data for only one or two of the four months December–March. The periods used for the pseudo-standardised CPUE analyses for each data series are shown in Table 2.

Annual time series of raw CPUE showed no overall temporal changes (Table 5, Figure 5).

Time series of pseudo-standardised CPUE indices by vessel class, and for all vessel classes combined, are shown in Figures 6 and 7 respectively, and in Table 6. The combined vessel class indices in Figure 7 could be calculated only for fishing years for which data were available for all three vessel classes (manual extracts) or both vessel classes (FSU and CELR/TCEPR extracts). In the overlap period 1982–83 to 1984–85, there was no significant difference in CPUE between the manual extracts and the FSU data. Although each time series was relatively short, and subject to some inter-annual fluctuation, the overall pattern is one of stable CPUE from 1974 to 1997.

5.2 Standardised CPUE analysis, 1989–97

5.2.1 Effort and catch

A clear seasonal pattern was evident in the catch and effort data from both the trevally and snapper target fisheries extracted for the standardised CPUE analysis (Figures 8 and 9). From 1989 to 1997, single trawl was the main method catching trevally in TRE 7, with pair trawling being less important (Table 7).

Most of the trevally catch was taken in the trevally and snapper target fisheries (Table 8). Trevally was caught on more than 90% of the days when trevally was the declared target species, and on about 50% of the days when snapper and red gurnard were the target species. Trevally was caught only on about 10% of days when barracouta was the target species. Raw trevally catch rates were highest when trevally was the target species.

The trevally target fishery has obtained consistently high catches in statistical areas 40–42 and 45–47 (Table 9). Landings in areas 37–39 were relatively high in 1989–90 and 1990–91, but were low thereafter. Landings in areas 43 and 44 (Manukau and Kaipara Harbours respectively) were probably mis-coded because trawling is banned in those areas. The snapper target fishery has obtained consistently high catches of trevally in statistical areas 41–42, 45, and 47, with lower catches in area 46 (Table 10). CPUE analyses were restricted to these areas, but the inclusion of areas with smaller catches had little effect on the results.

5.2.2 Catch per unit effort

Predictor variables incorporated in the regression models for trevally and snapper target fisheries are shown in Tables 11 and 12. The more powerful boats seem better able to catch trevally (presumably because they could tow faster) and one vessel characteristic (tonnage or breadth) entered the models first. Month was the second most important variable, reflecting the strong seasonal catch rate pattern. Fishing year and statistical area were the next most important variables.

The standardised year indices for both the trevally and snapper target fisheries declined between 1989–90 and 1992–93, and then rose again (Figure 10, Tables 13 and 14). When the sizes of the 95% confidence limits are considered, the CPUE trends in the two target fisheries are essentially the same.

6. Discussion

Trawl catch rates of trevally are probably influenced by a number of variables that we did not consider in the present study. Vessels targeting trevally tow faster than vessels targeting snapper, which probably explains in part the higher CPUE in the trevally target fishery (compare Figures 8 and 9). Water clarity and temperature may affect catchability and possibly vertical and areal availability. Trevally school near the surface or on the seabed, but the factors affecting this variation in behaviour are unknown; prey availability could be important. Therefore CPUE may not directly measure stock abundance. Nevertheless, variation in clarity and temperature would be expected to be random, or perhaps follow a 3–7 year cycle driven by the El Niño–Southern Oscillation. In either event, such fluctuations would probably not obscure any long-term trends in stock abundance, if they existed. The lack of any clear trends over a 24-year period in the raw and pseudo-standardised indices suggests that stock size has not changed much. It is interesting to note that snapper CPUE from the west coast North Island stock showed a large decline in the late 1970s and early 1980s, followed by a recovery in recent years (Vignaux 1993). We are confident that similar trends in the trevally stock size would also have been detectable, despite the fact that the raw and pseudo-standardised analyses were based on three separate indices, each of which covered a short period.

The minimum trawl mesh size in the west coast North Island trawl fishery was increased from 100 mm to 125 mm during the summer of 1994–95 (October 1994 to March 1995), and then for the whole year from October 1995 onwards. There is no evidence that the change in mesh size had any effect on CPUE (*see* Figure 6).

There are other ways in which the CPUE data could be explored more fully, but they were beyond the scope of the present study. The FSU data contain information on daily catches and number of tows by vessel, and could be subjected to a standardised analysis similar to that

carried out on the CELR/TCEPR data, but using the definition of trevally targeting adopted for the FSU pseudo-standardised analysis (*see* Table 2). Alternatively, a single standardised analysis covering 1983–97 could be carried out by ignoring the target species declared by fishers filling out CELR/TCEPR forms, and defining their target trevally fishing in the same way that we defined the target trevally fishing for the FSU data. However, there were no apparent trends in the raw, pseudo-standardised, or standardised indices, and it seems unlikely that more refined analyses would alter that conclusion.

7. Acknowledgments

This work was done under Ministry of Fisheries contract TRE9701. We thank Brian Sanders for extracting the data from the CATCHEFF database, Jeremy McKenzie for advice, support, and project leadership, and Mark Morrison for comments on the manuscript.

8. References

Annala, J. H., Sullivan, K. J., O'Brien, C. J., & Iball, S. D. 1998: Report from the Fishery Assessment Plenary, May 1988: stock assessments and yield estimates. Ministry of Fisheries. 409 p. (Unpublished report held in NIWA library, Wellington.)

Gilbert, D. J. 1988: Trevally. *New Zealand Fisheries Assessment Research Document 88/29.* 28 p.

James, G. D. 1984: Trevally, *Caranx georgianus* Cuvier: age determination, population biology, and fisheries. *Fisheries Research Bulletin 25.* 51 p.

Parker, G. (Comp.) 1994: The New Zealand seafood industry economic review. New Zealand Fishing Industry Board, Wellington. 66 p.

Paul, L. J. 1977: The commercial fishery for snapper, *Chrysophrys auratus* (Forster), in the Auckland region, New Zealand, from 1900 to 1971. *Fisheries Research Bulletin 15.* 84 p.

Reid, B. 1969: The Auckland west coast trawl fishery 1953–1958. [*New Zealand Marine Department*] *Fisheries Technical Report 38.* 48 p.

Sullivan, K. J. 1985: Snapper. *In* Colman, J. A. *et al.* (Comps. and Eds.). Background papers for the 1985 Total Allowable Catch recommendations, pp.187–214. (Unpublished report held in NIWA library, Wellington.)

Vignaux, M. 1993: Catch per unit of effort (CPUE) analysis of the SNA 8 snapper fishery. *New Zealand Fisheries Assessment Research Document 93/2.* 12 p.

Vignaux, M. 1997: CPUE analyses for Fishstocks in the Adaptive Management Programme. *New Zealand Fisheries Assessment Research Document 97/24.* 68 p.

Table 1: Reported landings of trevally (t) in the two main Fishstocks, TRE 1 and TRE 7, and reported total New Zealand landings, 1931 to 1996–97

Year	TRE 1	TRE 7	N.Z. Total	Year	TRE 1	TRE 7	N.Z. Total	Year	TRE 1	TRE 7	N.Z. Total
1931	10		10	1954	484	78	720	1977	3 630	2 113	6 482
1932	6		6	1955	633	138	921	1978	3 531	2 322	6 526
1933	35		33	1956	575	130	858	1979	2 477	2 600	5 676
1934	32		30	1957	802	296	1 398	1980	1 405	2 493	4 324
1935	1		1	1958	884	343	1 462	1981	1 495	2 844	4 621
1936	<1		<1	1959	1 028	351	1 590	1982	2 039	2 497	4 780
1937	22		28	1960	1 203	595	2 018	1983	1 534	2 165	3 779
1938	57		72	1961	1 177	471	2 082	1984	1 798	1 707	3 841
1939	18		32	1962	1 450	543	2 504	1985	1 887	1 843	3 893
1940	12		42	1963	1 319	662	2 401	1986	1 431	1 830	3 425
1941	18		56	1964	1 283	534	2 361	1986-87	982	1 626	2 845
1942	90		146	1965	1 631	544	2 600	1987-88	1 111	1 752	3 131
1943	190		230	1966	1 583	1 080	3 100	1988-89	818	1 665	2 651
1944	407	3	422	1967	1 833	1 493	3 106	1989-90	1 240	1 589	3 122
1945	293	3	339	1968	1 399	1 515	3 474	1990-91	1 011	2 016	3 308
1946	256	3	340	1969	1 412	1 322	3 280	1991-92	1 169	1 367	2 733
1947	328	14	351	1970	1 978	1 682	4 241	1992-93	1 328	1 796	3 371
1948	456	8	473	1971	2 705	2 037	5 949	1993-94	1 162	2 231	3 624
1949	316	7	336	1972	2 544	2 226	5 992	1994-95	1 242	2 138	3 559
1950	433	15	498	1973	1 877	2 320	4 946	1995-96	1 175	2 019	3 415
1951	506	36	606	1974	2 200	2 024	5 133	1996-97	1 175	1 844	3 328
1952	330	31	445	1975	1 418	1 598	3 496				
1953	394	103	602	1976	2 368	1 894	5 680				

Notes:

1. Values to 1982 are based on ports of landing. Values 1983 to 1986 are based on FSU summaries of fishing area data, and values 1986–87 to 1996–97 on QMS summaries by QMA, both as reported in Annala *et al.* 1998.
2. Before 1970 at least, landings do not represent catches because of a high level of at-sea discards (see text).
3. The port landings of west coast (TRE 7) fish into Manukau rose in the early 1950s when the values for this port were first recorded separately from Auckland. However, an unknown quantity of west coast caught fish was still landed into Auckland in the 1960s and 1970s, resulting in catches from what subsequently became TRE 7 being recorded as northeast (TRE 1) fish. Auckland-based trawlers often fished both the east and west coasts. See Paul (1977) for information on this problem.

Table 2: Characteristics of data used for the analysis of catch per unit effort (CPUE) in TRE 7. FSU, Fisheries Statistics Unit; CELR, Catch Effort Landing Return; TCEPR, Trawl Catch and Effort Processing Return; ST, single trawl; SPT, small pair trawl; LPT, large pair trawl; TRE, trevally; SNA, snapper; TAR, tarakihi

Data type	Period covered by data	Time period analysed for CPUE	Spatial coverage of data	Target species definition	Catch data type	Catch data resolution	Treatment of zero catches	CPUE measure
Manual data extract	ST 1/77–12/85 SPT 1/74–12/85[1] LPT 1/76–3/85	ST 12/77–3/85 SPT 1/74–3/85[1] LPT 12/76–3/85	Onehunga landings[2]	TRE + SNA catch exceeded TAR catch[3]	Landed catch	Catch per method by month	Included if SNA > TAR[3]	Catch per day
FSU	ST 1/83–4/89 SPT 1/83–4/89 LPT 1/83–4/89	ST 1/83–3/89 SPT 1/83–3/87	Statistical areas 41–47	TRE + SNA catch exceeded TAR catch[4]	Landed catch apportioned across estim. catch	Catch per vessel by day[5]	Included if SNA > TAR[4]	Catch per day
CELR	All methods 10/89–9/97	ST 12/89–3/97 SPT 12/89–3/94	Statistical areas 41–47	TRE or SNA declared as target	Estimated catch	Catch per vessel by day	Excluded	Catch per day (or tow)
TCEPR	All methods 10/89–9/97	ST 12/89–3/97 SPT 12/89–3/94	Statistical areas 41–47	TRE or SNA declared as target	Estimated catch	Catch per vessel by tow	Excluded	Catch per tow (or day)

[1] 1976 data missing.
[2] Some vessels fishing in TRE 7 but landing into Auckland, and some vessels landing into Kawhia and Raglan, were also included.
[3] Based on the aggregate catch of each species from the whole trip.
[4] Based on an individual file record, which usually represented the catch from a day of fishing, but sometimes represented a single tow.
[5] Occasionally catches were recorded by tow rather than by day.

Table 3: Summary of estimated catches (t) of trevally by form type in TRE 7 from 1989–90 to 1996–97

Fishing year	CELR	TCEPR	Total
1989–90	1 035	238	1 273
1990–91	1 427	389	1 815
1991–92	850	388	1 238
1992–93	1 064	491	1 555
1993–94	1 289	691	1 981
1994–95	914	1 004	1 918
1995–96	512	1 305	1 817
1996–97	355	1 237	1 593

Table 4: Definitions of the variable categories used for the standardised CPUE regression analysis

Variable	Categories
Year	Fishing year
Month	Months
Area	Statistical areas
Year vessel built	Before 1971; 1971–1978; 1979 and after
Vessel breadth	≤ 5 m; > 5–6 m; > 6 m
Vessel draught	≤ 2.6 m; > 2.6–3 m; > 3 m
Vessel length	≤ 18 m; > 18–21 m; > 21 m
Vessel tonnage	≤ 60 t; > 60–90 t; > 90 t
Vessel power	≤ 180 kW; >180–320 kW; > 320 kW
Vessel crew size	≤ 3; 4; > 4

Table 5: **Raw CPUE (kg.day^{-1}) for December–March seasons, by vessel class. Only seasons with more than 100 days fishing effort are shown**

Year	Small pair trawl	Large pair trawl	Single trawl
1973–74	652		
1974–75	616		
1975–76			
1976–77	904		
1977–78	1 038		
1978–79	929	1 745	382
1979–80	710	1 145	
1980–81	693	1 296	1 191
1981–82	721	1 579	933
1982–83	1 071	1 774	1 069
1983–84	793	1 378	545
1984–85	1 112		815
1985–86	1 413		724
1986–87			467
1987–88			952
1988–89			830
1989–90			818
1990–91	1 241		888
1991–92	1 248		814
1992–93	986		702
1993–94	2 573		915
1994–95			911
1995–96			926
1996–97			658

Table 6: **Pseudo-standardised catch per unit effort indices and their standard errors for TRE 7 based on MAF manual data extracts, FSU data, and CELR/TCEPR data. Indices are provided for each vessel class separately, and for combined classes. ST, single trawl; SPT, small pair trawl; LPT, large pair trawl**

Fishing year	Log_{10} CPUE ± standard error																			
	Manual ST		Manual SPT		Manual LPT		FSU ST		FSU SPT		CELR/ TCEPR ST		CELR/ TCEPR SPT		Manual combined		FSU combined		CELR/TCEPR combined	
1973–74			2.72	0.11																
1974–75			2.77	0.07																
1975–76																				
1976–77			2.92	0.08	3.04	0.24														
1977–78	2.40	0.30	3.08	0.09	2.83	0.26									2.77	0.14				
1978–79	2.56	0.21	2.98	0.08	3.21	0.16									2.91	0.09				
1979–80	2.77	0.28	2.74	0.08	3.13	0.11									2.88	0.10				
1980–81	3.05	0.17	2.71	0.08	3.10	0.10									2.95	0.07				
1981–82	3.00	0.14	2.84	0.09	3.09	0.10									2.97	0.06				
1982–83	2.97	0.16	2.97	0.09	3.24	0.13	2.98	0.19	3.02	0.10					3.06	0.08	3.00	0.11		
1983–84	2.68	0.15	2.87	0.08	3.08	0.15	2.73	0.13	2.94	0.07					2.88	0.08	2.83	0.07		
1984–85	3.03	0.26	2.96	0.09	3.05	0.19	2.76	0.17	2.96	0.07					3.01	0.11	2.86	0.09		
1985–86							2.77	0.11	3.07	0.09							2.92	0.07		
1986–87							2.50	0.17	3.24	0.13							2.87	0.11		
1987–88							2.95	0.16												
1988–89							2.87	0.15												
1989–90											2.90	0.08	3.35	0.21					3.12	0.11
1990–91											2.95	0.08	3.18	0.09					3.06	0.06
1991–92											2.90	0.08	3.02	0.09					2.96	0.06
1992–93											2.79	0.09	2.93	0.12					2.86	0.07
1993–94											3.00	0.09	3.34	0.10					3.17	0.07
1994–95											2.90	0.10								
1995–96											2.92	0.08								
1996–97											2.76	0.10								

Table 7: **Summary of estimated catches (t) of trevally by main methods in TRE 7 from 1989–90 to 1996–97**

Fishing year	Pair trawl	Single trawl	Purse-seine	Set net	Other	Total
1989–90	418	784	7	58	6	1 273
1990–91	787	969	0	54	5	1 815
1991–92	283	847	0	93	15	1 238
1992–93	156	1 106	155	114	25	1 555
1993–94	476	1 325	70	85	24	1 981
1994–95	233	1 394	157	115	19	1 918
1995–96	491	1 176	22	97	30	1 817
1996–97	60	1 397	0	96	41	1 593

Table 8: **Summary of estimated catches (t) of trevally by main target species in TRE 7 from 1989–90 to 1996–97. BAR, barracouta; GUR, red gurnard; SNA, snapper; TRE, trevally**

Fishing year	BAR	GUR	SNA	TRE	Other	Total
1989–90	23	67	316	785	83	1 273
1990–91	46	69	244	1 402	54	1 815
1991–92	31	73	283	749	102	1 238
1992–93	54	50	461	887	104	1 555
1993–94	47	78	885	888	83	1 981
1994–95	53	48	360	1 260	198	1 918
1995–96	89	151	603	778	197	1 817
1996–97	72	153	402	780	186	1 593

Table 9: **Summary of estimated catches (t) of trevally in the trevally target single trawl fishery by statistical area in TRE 7 from 1989–90 to 1996–97. Statistical areas are included if at least 1 t of trevally was caught in at least one fishing year**

Fishing year	Statistical area														
	17	35	36	37	38	39	40	41	42	43	44	45	46	47	48
1989–90	3	0	13	69	10	60	4	119	10	0	0	89	25	60	0
1990–91	0	1	13	89	43	60	99	198	23	0	0	96	45	17	1
1991–92	3	0	0	6	8	13	115	58	16	0	0	186	41	55	0
1992–93	0	0	4	4	0	10	57	56	56	0	1	260	46	125	2
1993–94	19	0	4	0	0	3	69	39	51	2	1	169	41	202	0
1994–95	0	0	5	10	4	1	60	123	181	0	0	214	74	306	0
1995–96	0	0	24	2	0	3	24	84	65	0	0	57	50	195	0
1996–97	0	0	0	3	1	0	22	163	117	0	0	77	16	305	0

Table 10: **Summary of estimated catches (t) of trevally in the snapper target single trawl fishery by statistical area in TRE 7 from 1989–90 to 1996–97. Statistical areas are included if at least 1 t of trevally was caught in at least one fishing year**

Fishing year	Statistical area										
	17	37	38	39	40	41	42	45	46	47	48
1989–90	1	8	2	8	1	28	38	49	10	34	0
1990–91	0	1	0	22	5	29	40	43	5	4	0
1991–92	0	0	0	7	1	14	48	108	2	7	1
1992–93	0	1	0	2	0	54	119	148	6	23	0
1993–94	0	0	0	0	6	134	99	203	16	128	0
1994–95	0	0	0	6	0	21	53	88	16	87	0
1995–96	0	0	0	1	3	24	70	167	35	50	0
1996–97	0	0	0	0	18	45	35	165	13	76	0

Table 11: **Stepwise regression model used to estimate the CPUE index for tows catching trevally in the trevally target single trawl fishery in TRE 7 from 1989–90 to 1996–97. R^2 is the multiple regression coefficient. Variables are listed in descending order of inclusion in the model**

	R^2 values at iteration					
Variable	1	2	3	4	5	6
Vessel tonnage	0.1437					
Month	0.1171	0.2079				
Year	0.0304	0.1889	0.2510			
Area	0.0916	0.1785	0.2423	0.2685		
Year vessel built	0.0397	0.1598	0.2220	0.2532	0.2900	
Vessel breadth	0.1308	0.1600	0.2165	0.2404	0.2745	0.3010
Vessel draught	0.0318	0.1505	0.2165	0.2487	0.2744	0.2987
Vessel length	0.1317	0.1706	0.2229	0.2331	0.2685	0.2900
Vessel power	0.0443	0.1549	0.2170	0.2442	0.2778	0.3001
Vessel crew	0.1212	0.1779	0.2293	0.2497	0.2863	0.3030

Table 12: **Stepwise regression model used to estimate the CPUE index for tows catching trevally in the snapper target single trawl fishery in TRE 7 from 1989–90 to 1996–97. Variables are listed in descending order of inclusion in the model**

	R^2 values at iteration					
Variable	1	2	3	4	5	6
Vessel breadth	0.0698					
Month	0.0666	0.1311				
Area	0.0382	0.1105	0.1744			
Year	0.0215	0.0902	0.1551	0.1968		
Vessel power	0.0218	0.0699	0.1316	0.1793	0.2033	
Year vessel built	0.0021	0.0705	0.1312	0.1760	0.1988	0.2035
Vessel draught	0.0095	0.0848	0.1435	0.1769	0.1991	0.2117
Vessel length	0.0674	0.0698	0.1312	0.1744	0.1970	0.2035
Vessel tonnage	0.0698	0.0702	0.1330	0.1779	0.2002	0.2045
Vessel crew size	0.0261	0.0704	0.1318	0.1759	0.1988	0.2033

Table 13: Standardised CPUE index for tows catching trevally in the trevally target single trawl fishery in TRE 7 from 1989–90 to 1996–97. S.E., standard error

Fishing year	Index	S.E.
1989–90	1.0000	
1990–91	1.0593	0.1063
1991–92	0.6371	0.0682
1992–93	0.4083	0.0405
1993–94	0.5407	0.0563
1994–95	0.9296	0.1000
1995–96	0.5934	0.0601
1996–97	0.6368	0.0631

Table 14: Standardised CPUE index for tows catching trevally in the snapper target single trawl fishery in TRE 7 from 1989–90 to 1996–97. S.E., standard error

Fishing year	Index	S.E.
1989–90	1.0000	
1990–91	0.7333	0.1065
1991–92	0.5941	0.0753
1992–93	0.5497	0.0660
1993–94	0.6848	0.0821
1994–95	0.6537	0.0793
1995–96	0.8448	0.0993
1996–97	1.0294	0.1200

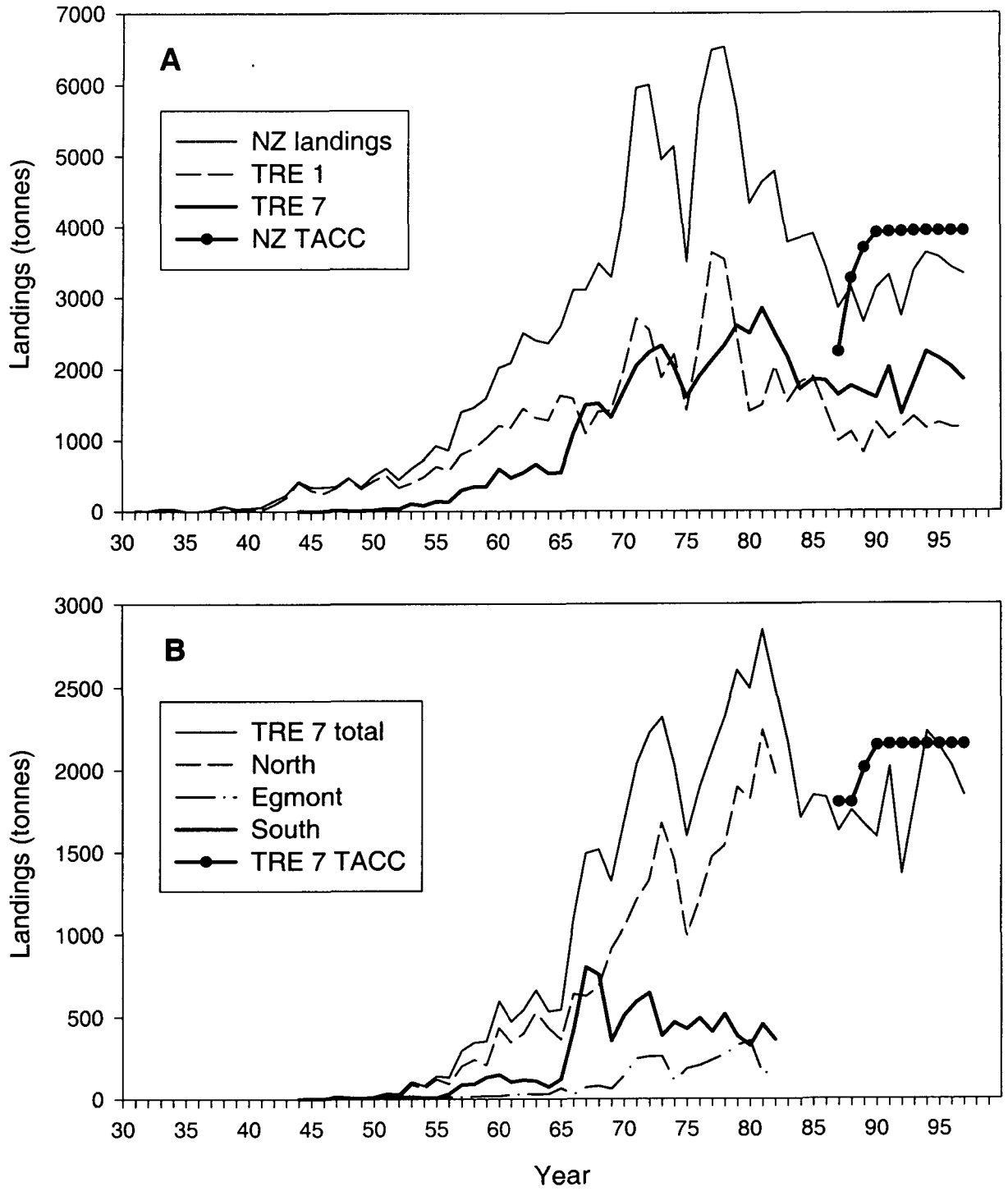

Figure 1: **A**. Annual trevally landings for New Zealand, TRE 1 and TRE 7, and the total New Zealand TACC. Data sources are given in Table 1. **B**. TRE 7 landings by sub-region, and TACC. North - ports from Hokianga to Kawhia to 1982, statistical areas 41 to 47 from 1983; Egmont - New Plymouth port, and area 40; South - ports from Wanganui to Greymouth, areas 33 to 39.

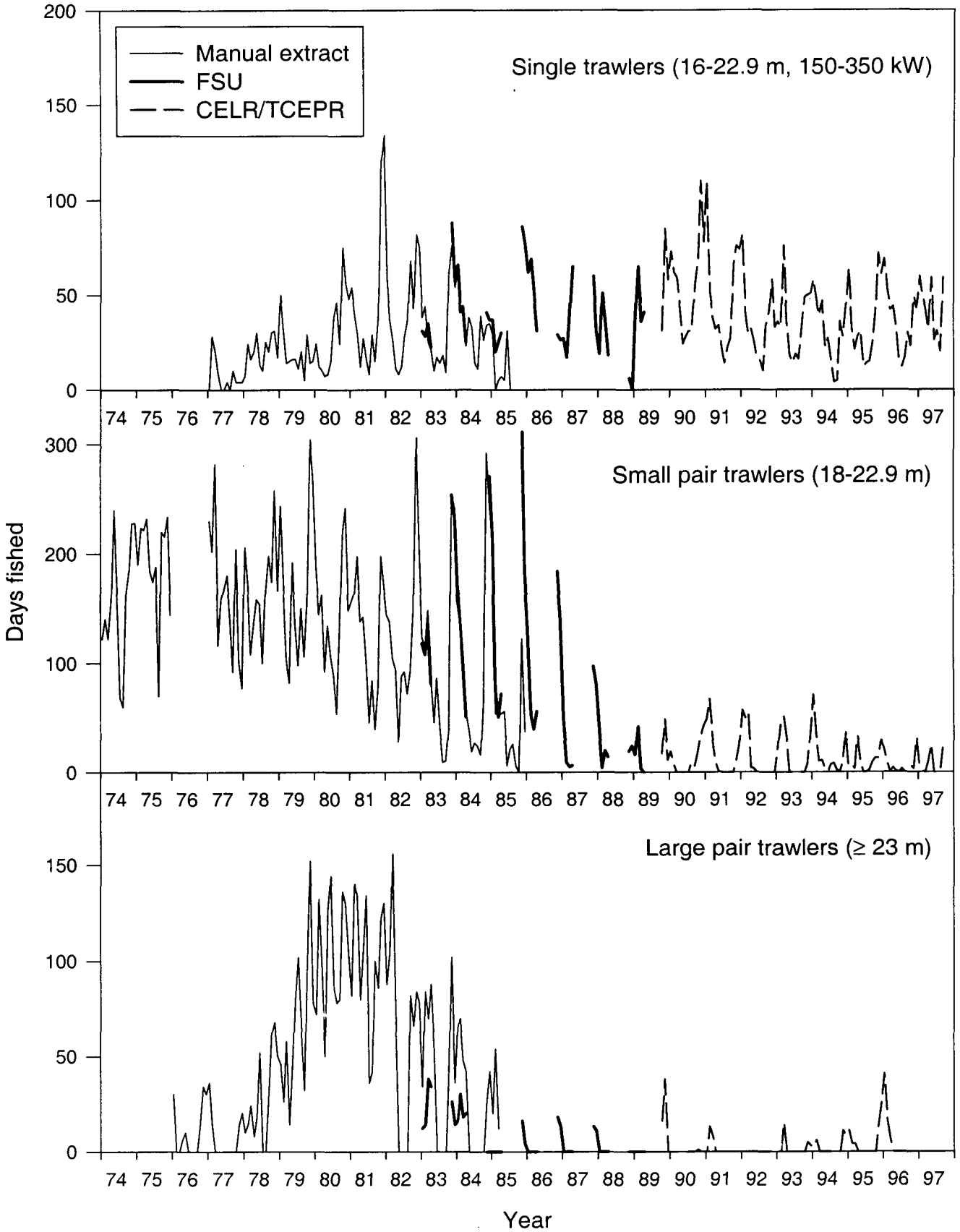

Figure 2: Fishing effort expended per month by three classes of trawlers target fishing for trevally in TRE 7 for the geographic areas described in Table 2. The unit of effort for MAF manual extracts was the number of trip days, and for FSU and CELR/TCEPR data it was number of days fished. Data for small pair trawlers in 1976 were missing. For FSU data, only data for November to April were extracted. Note the different vertical scales.

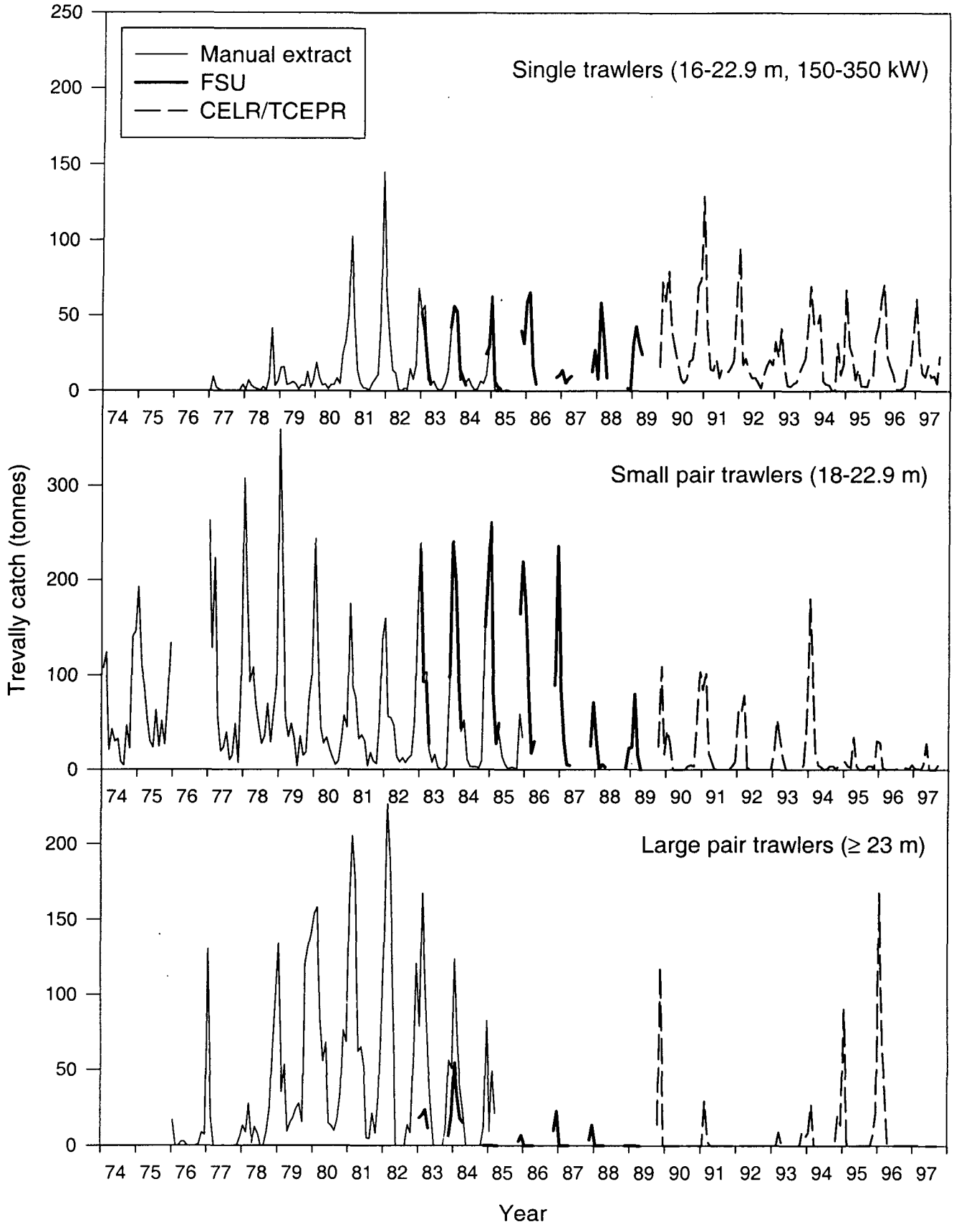

Figure 3: Trevally catches reported per month by three classes of trawlers "target fishing" for trevally in TRE 7 for the geographic areas described in Table 2. Data for small pair trawlers in 1976 were missing. For FSU data, only data for November to April were extracted. Note the different vertical scales.

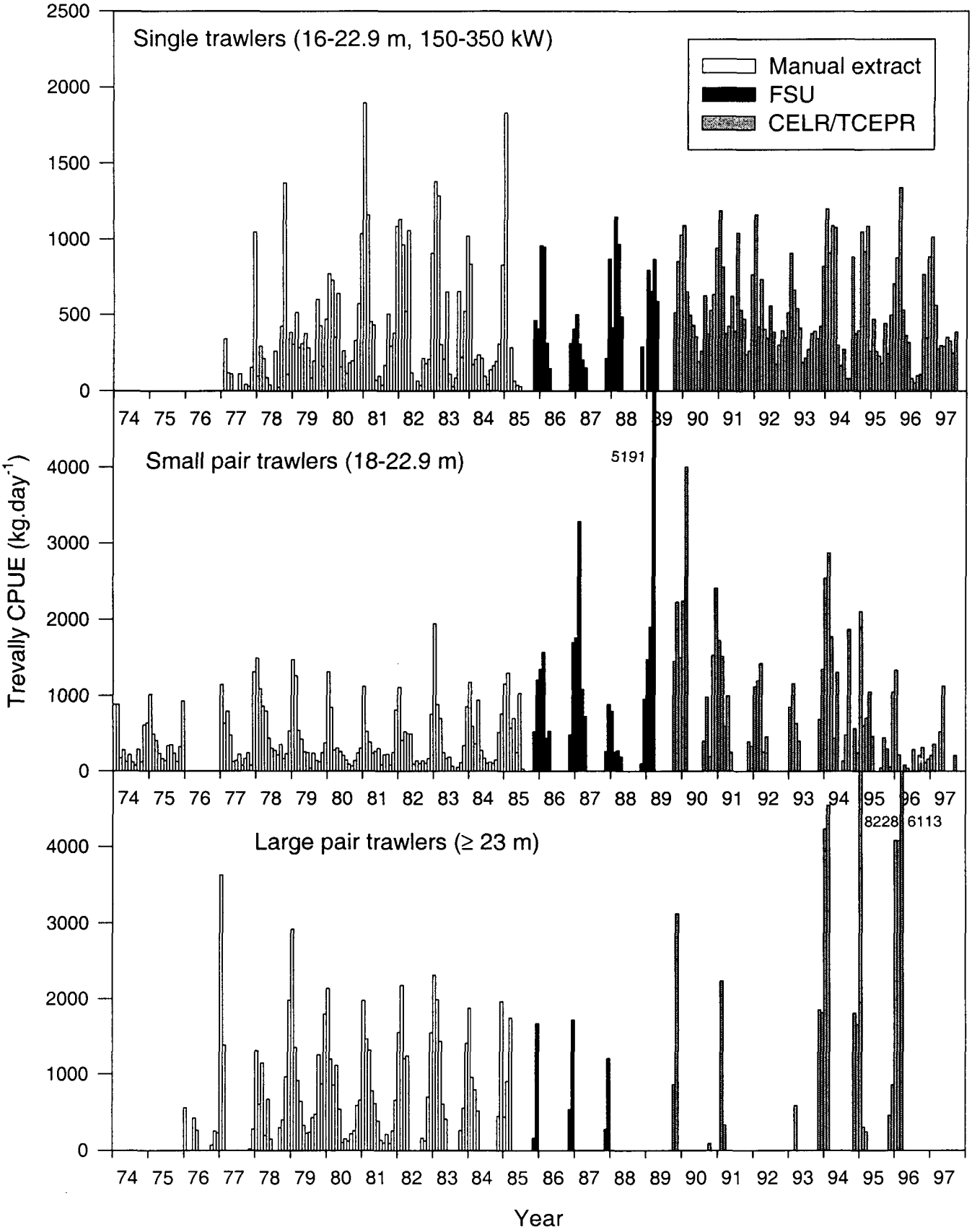

Figure 4: Trevally raw CPUE per month for three classes of trawlers "target fishing" for trevally in TRE 7 for the geographic areas described in Table 2. Data for small pair trawlers in 1976 were missing. For FSU data, only data for November to April were extracted. FSU data before November 1985 have been omitted for clarity. Note the different vertical scales.

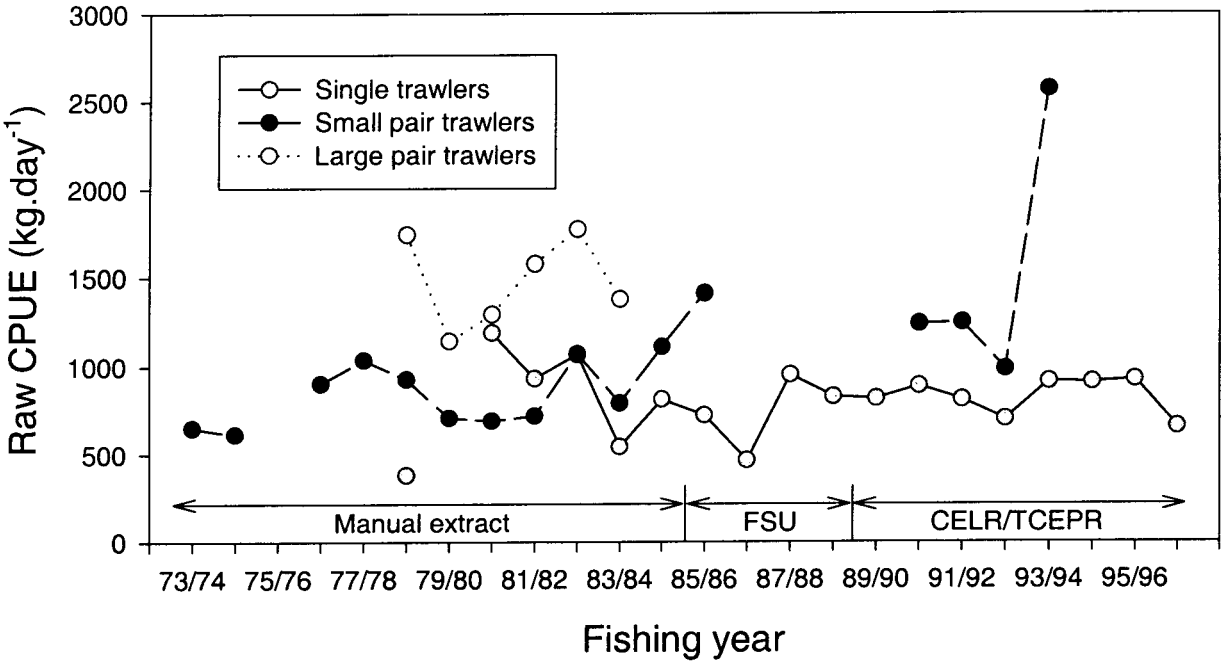

Figure 5: Raw December-March CPUE indices derived from three data series for three classes of trawlers. Only data points based on more than 100 days fishing effort are shown.

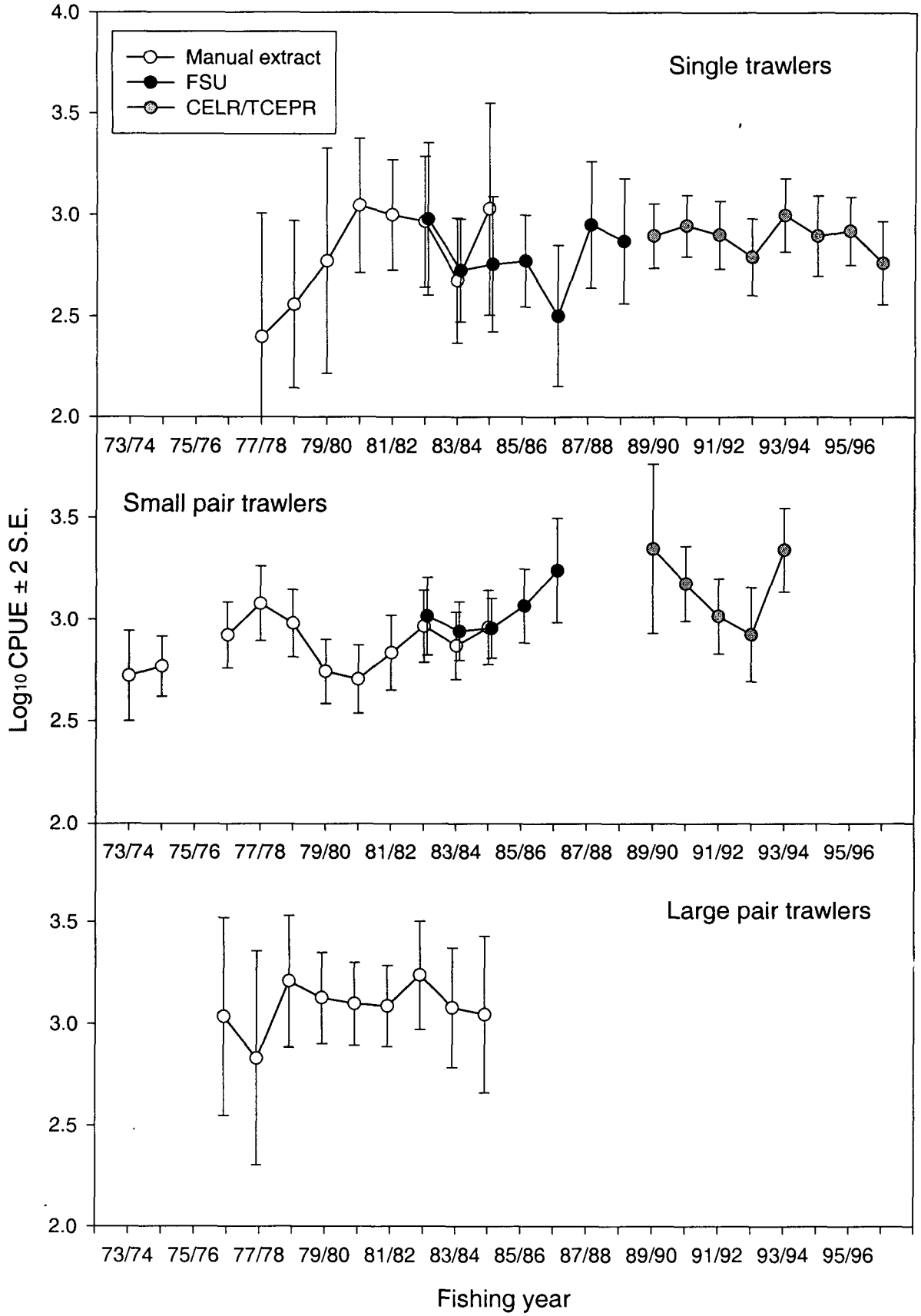

Figure 6: Pseudo-standardised CPUE indices (with 95% confidence limits) derived from three data series for three classes of trawlers.

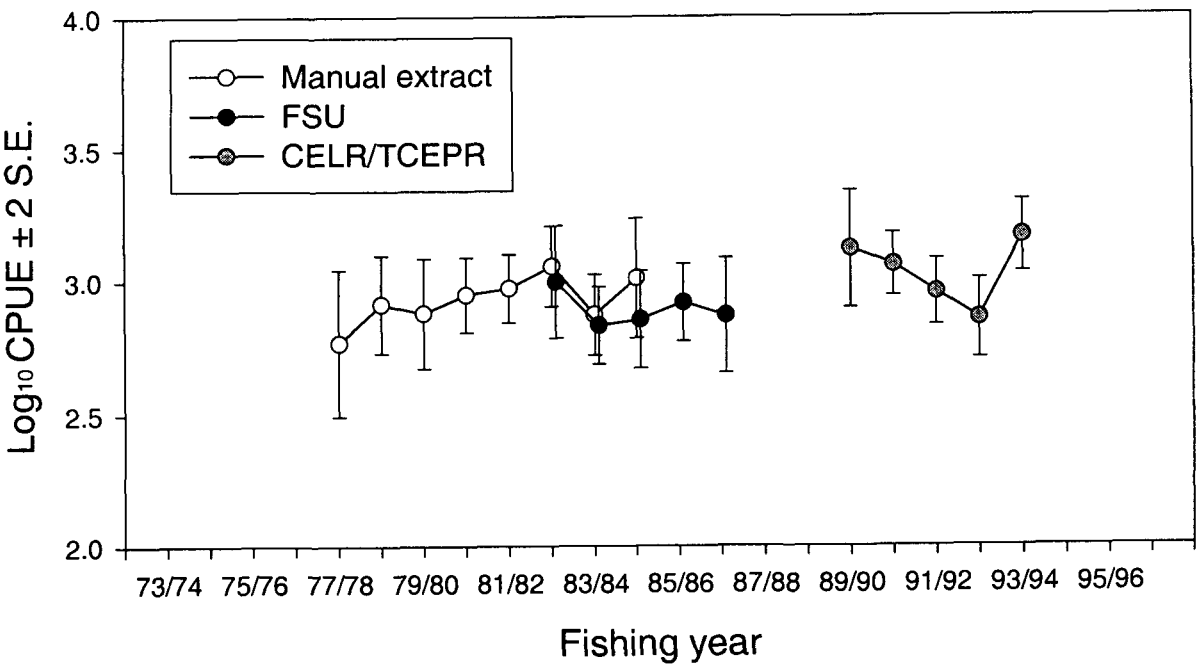

Figure 7: Pseudo-standardised CPUE indices (with 95% confidence limits) derived from three data series for all vessel classes combined.

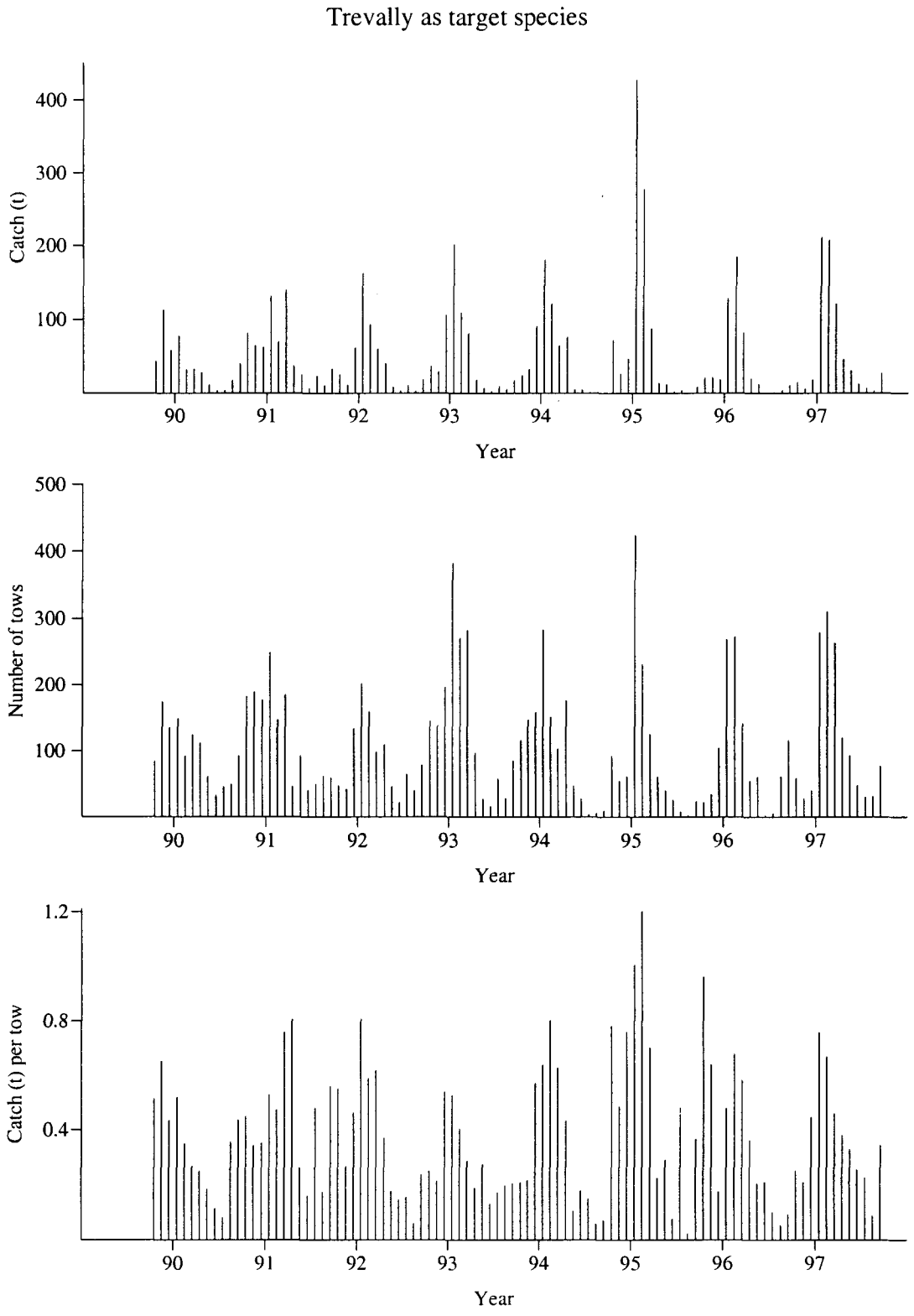

Figure 8: Trevally catch, number of tows and raw CPUE per month in the trevally target single trawl fishery (all vessels included).

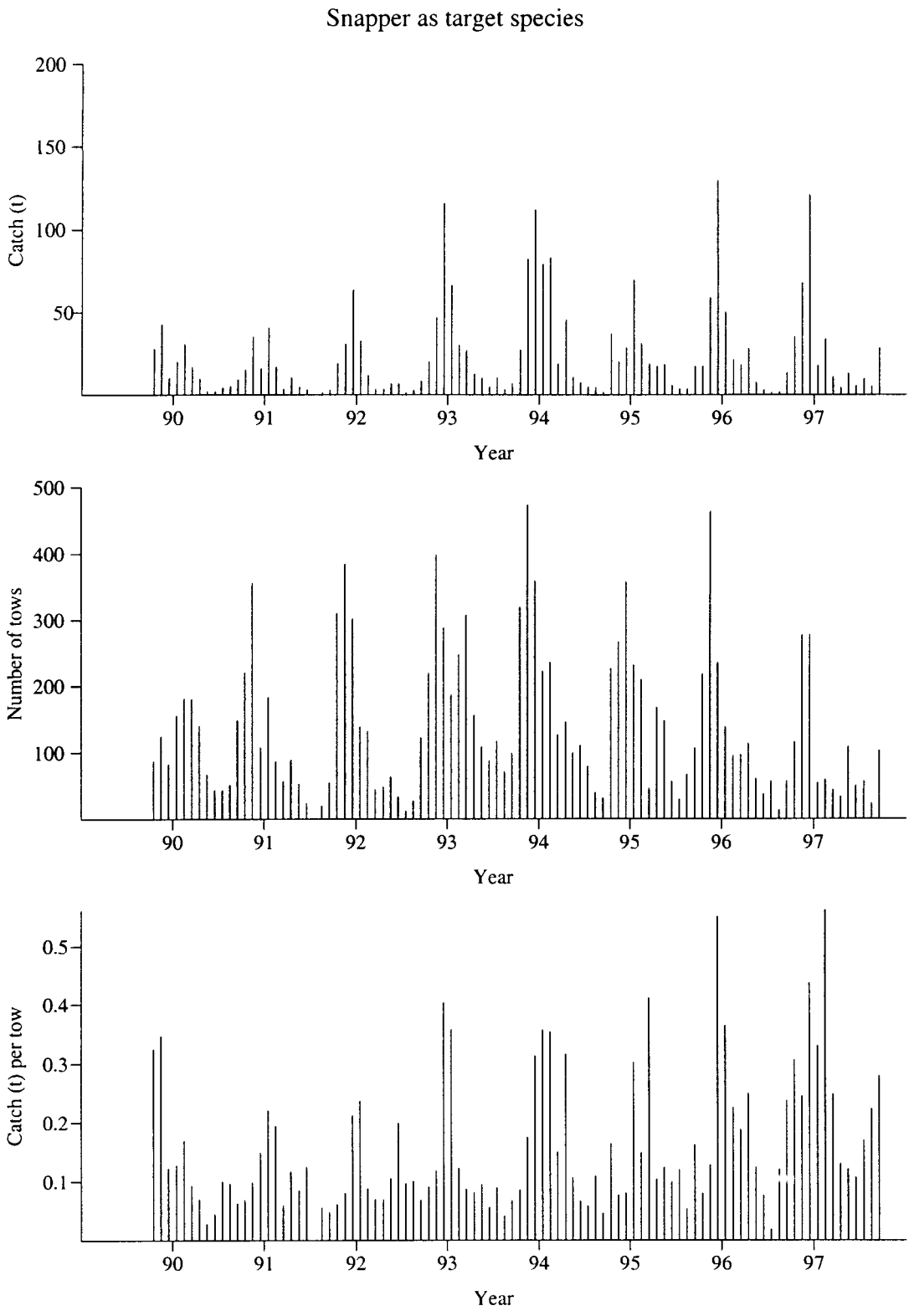

Figure 9: Trevally catch, number of tows and raw CPUE per month in the snapper target single trawl fishery (all vessels included).

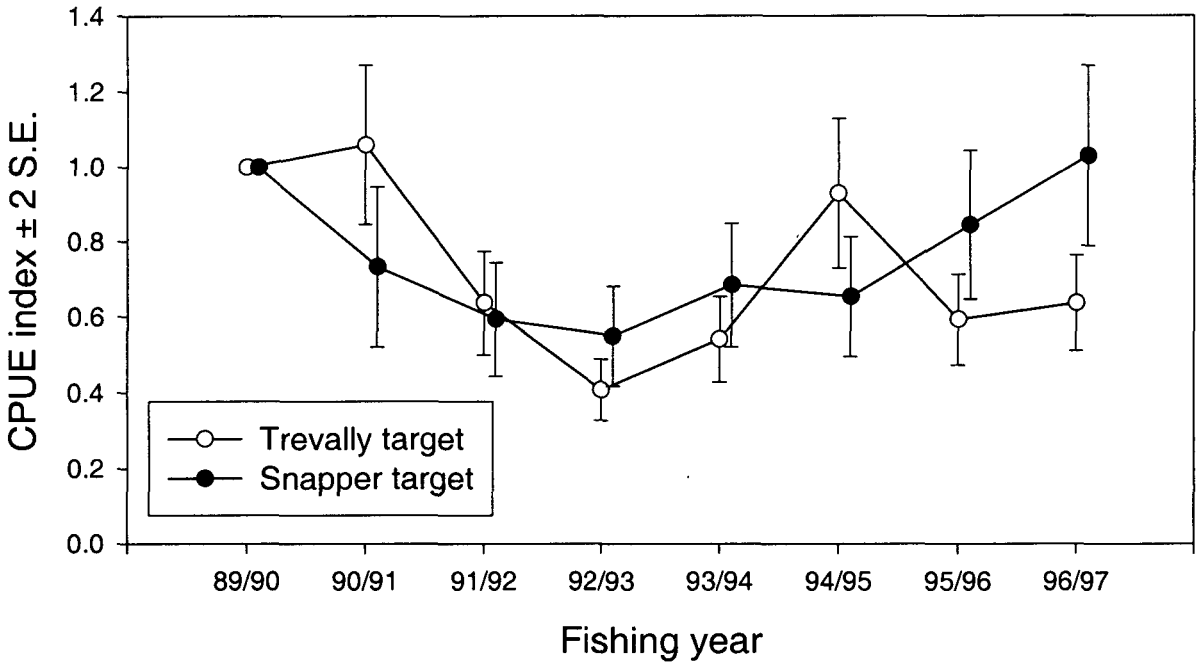

Figure 10: Standardised CPUE indices for trevally in the trevally and snapper target single trawl fisheries.