# Fishery characterisation and catch-per-unit-effort indices for snapper in SNA 8, 1989–90 to 2007–08

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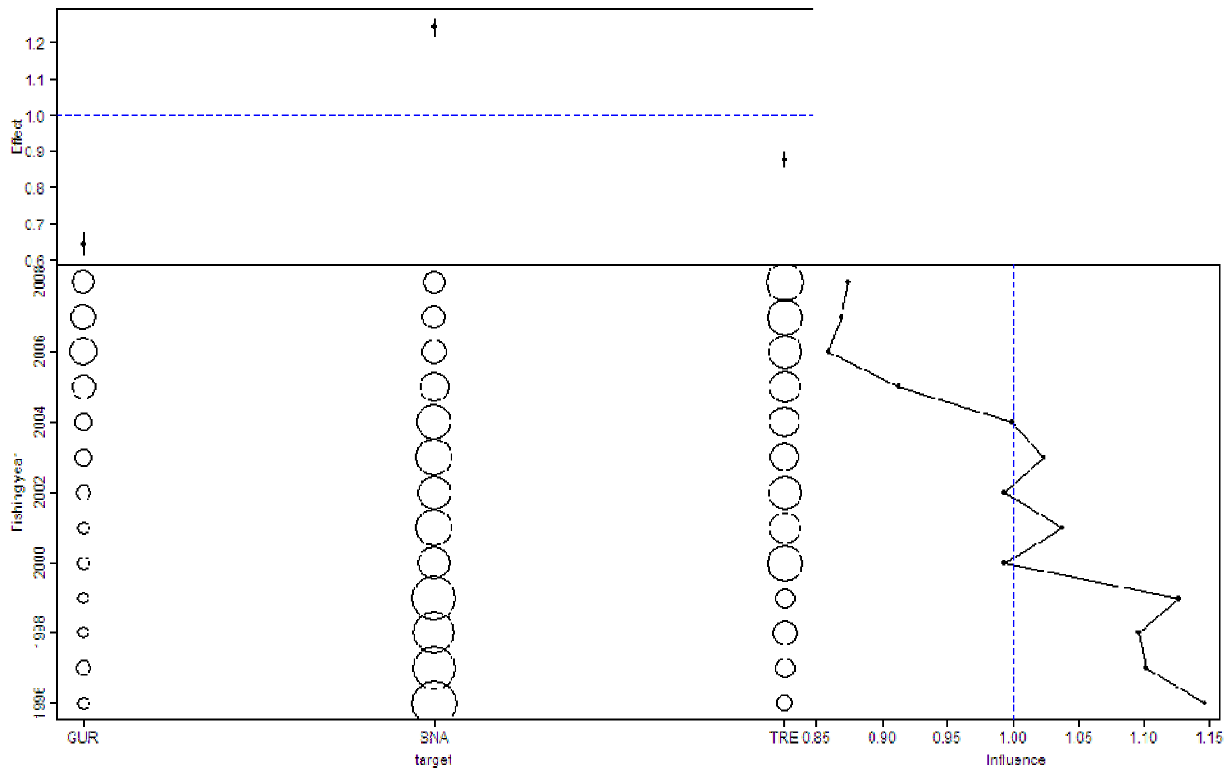


**Figure 31: Effect and influence of target in the SMST lognormal model. Top: relative effect by level of variable. Bottom-left: relative distribution of variable by fishing year. Bottom-right: influence of variable on unstandardised CPUE by fishing year.**

## APPENDIX D: INFLUENCE OF MODEL TERMS

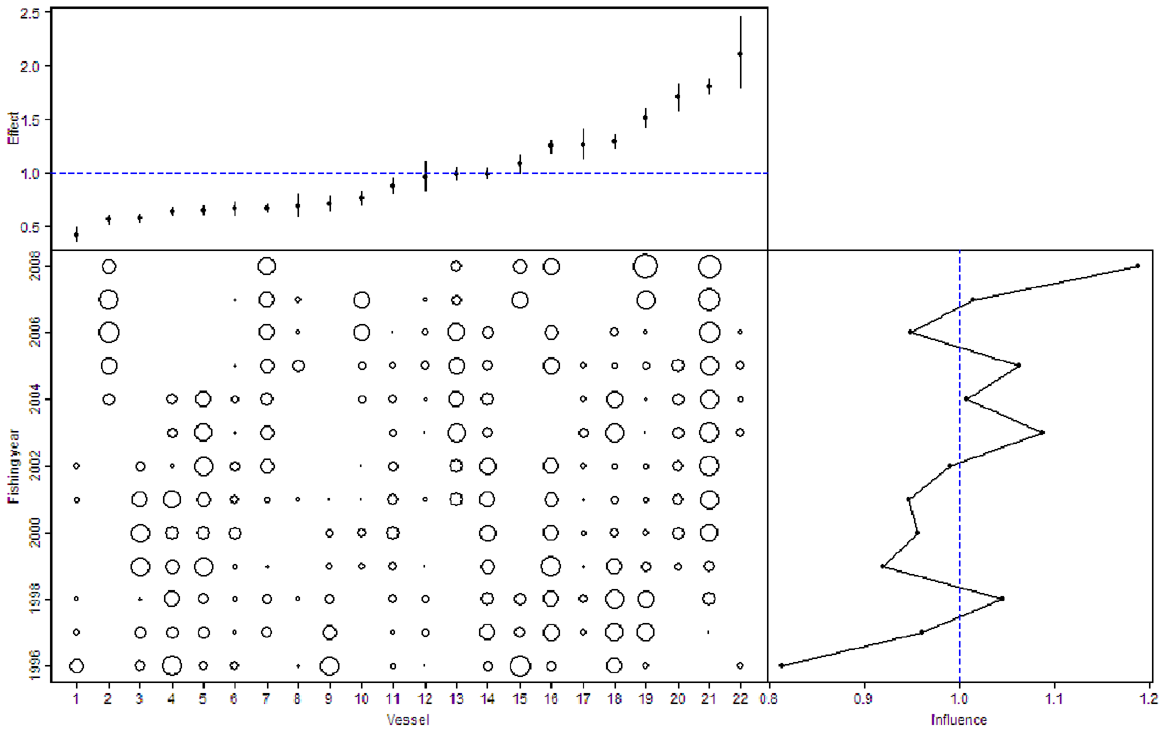


**Figure D1: Effect and influence of vessel in the SMST lognormal model. Top: relative effect by level of variable. Bottom-left: relative distribution of variable by fishing year. Bottom-right: influence of variable on unstandardised CPUE by fishing year.**

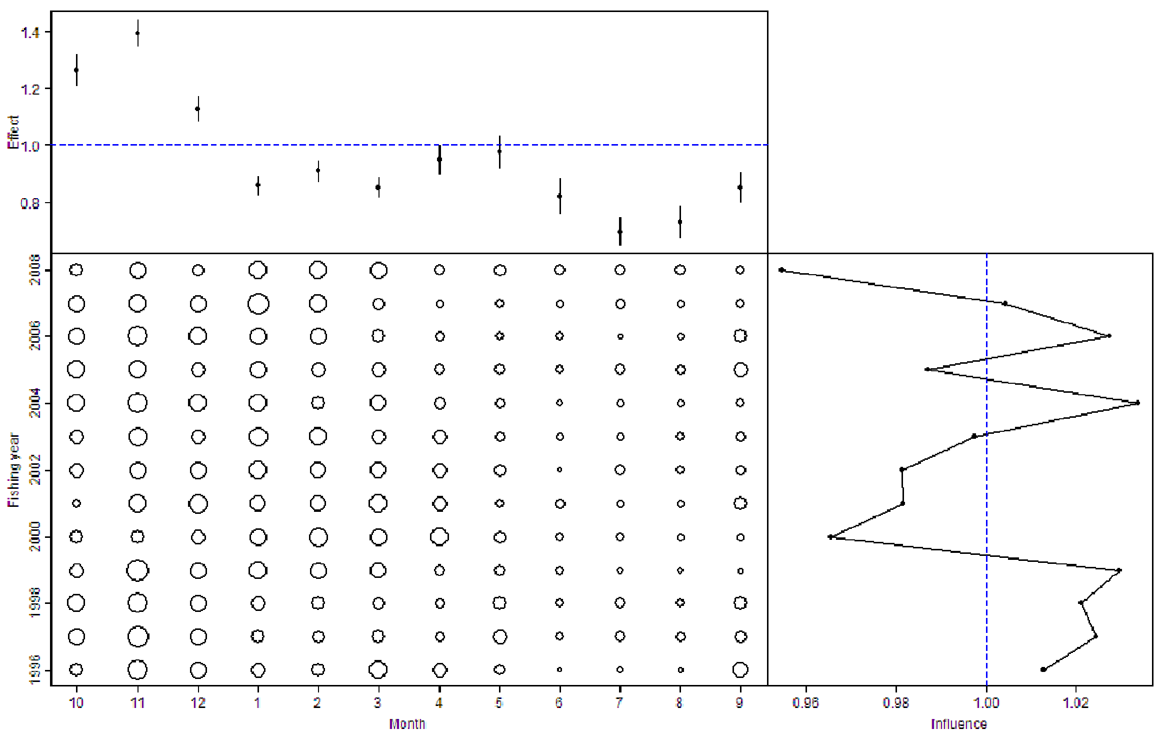


**Figure D2: Effect and influence of month in the SMST lognormal model. Top: relative effect by level of variable. Bottom-left: relative distribution of variable by fishing year. Bottom-right: influence of variable on unstandardised CPUE by fishing year.**



## EXECUTIVE SUMMARY

**Kendrick, T.H.; Bentley, N. (2010). Fishery characterisation and catch-per-unit-effort indices for snapper in SNA 8, 1989–90 to 2007–08.**

***New Zealand Fisheries Assessment Report 2010/42.***

This study was contracted as MFish project SNA2008/01 with the specific objective: To characterise the SNA 8 fishery and update the CPUE analyses for trawl fisheries in each area of SNA 8 using data up to the end of 2007–08.

The stock assessments for snapper rely mainly on absolute abundance estimates from tagging programmes. Absolute abundance of SNA 8 was last estimated in 2002 and the next mark-recapture study is scheduled for 2011. Standardised CPUE series, updated every three years, are used to provide crude indices of relative abundance in the periods between tagging programmes. The SNA 8 CPUE index was last updated to the end of the 2003–04 fishing year (MFish project SNA 2004-01) and indicated a declining trajectory to 2000–01 followed by a recovery in the subsequent three years.

The 2005 stock assessment indicated that current biomass (start of year 2004–05) was between 8% and 12% B0 and that biomass was predicted to slowly increase at the TACC level of 1500 t. However, from 1 October 2005 the TACC was reduced to 1300 t to ensure a faster rebuild of the stock. SNA 8 has been under TACC pressure since it entered the QMS and catch has exceeded the TACC in most years but has been reducing since 2004–05 in response to the most recent TACC reduction. Deemed values are high and in this mixed species fishery, where avoidance of bycatch is not always possible, declines in the catch of associated species, particularly trevally, is an indication that effort is being reduced.

Since 1989–90, bottom single trawl has been the dominant fishing method taking snapper in SNA 8, Most of the balance (11–39% annually) has been taken by bottom pair trawl, and consistent but small amounts by bottom longline and set net in each year. The bottom trawl catch of SNA 8 is mainly from target fishing with most of the balance taken as a bycatch of trevally tows. There has been a shift away from targeted snapper catch since 1997–98 with bycatch of gurnard also accounting for some of the increase in bycatch.

CPUE in this Fishstock is monitored in the single bottom trawl fishery using tow-by-tow data reported on TCEPR and, recently, on TCE forms. This necessarily yields a shortened time series but that is not inappropriate given that the purpose of the series is to monitor the rebuild of the stock. Improvements made in this study include using the Starr methodology to analyse CPUE using landed greenweight rather than estimated catch, an attempt to better define the fishery in which CPUE and encounter rates are monitored, a defensible selection of a core fleet, and further grooming to remove potential contamination by misreported catch and effort.

Large differences in trip-based SNA 8 nominal CPUE for 8 of the 22 core vessels when they fished SNA 8 only, or both SNA 8 and SNA 1, suggested that they may have been misreporting catch and effort data. As this could potentially negatively bias the trend in relative abundance, an additional CPUE standardisation was undertaken after removing the data for these vessels. The effect on the annual indices was to raise CPUE in some recent years and it is clear that the impact of misreporting on standardised CPUE can be marked and can mask much of the recent increase in CPUE.

An alternative approach adopted in this study was to remove all trips that landed both to SNA 8 and SNA 1 from the analysis dataset. This removed all potential contamination in a repeatable and non-subjective fashion without compromising the time series of data too severely and without markedly changing the core fleet selected. The annual indices from the final model suggest a continuation of the increase reported in 2005 to a level that is currently the highest for the series.

## 1. INTRODUCTION

### 1.1 The fishery

The snapper fishery is one of the largest and most valuable coastal fisheries in New Zealand, important to commercial, recreational, and customary fishers. Snapper has a long history of commercial exploitation, including significant removals by Japanese vessels from the late 1950s until 1977. By the mid 1980s some stocks showed signs of overfishing, and with the introduction of the Quota Management System in 1986 Total Allowable Commercial Catch (TACC) was set in all Fishstocks at levels intended to allow some stock rebuilding.

SNA 8 entered the QMS with a TACC of 1330 t which had increased by 1989–90 to 1594 t as a result of appeals. Changes to TACCs that took effect from 1 October 1992 resulted in a reduction for SNA 8 to 1500 t. Although the 2005 stock assessment indicated that biomass was predicted to slowly increase at the TACC level of 1500 t the TACC was further reduced from 1 October 2005 to 1300 t to ensure a faster rebuild of the stock. Catches have exceeded the TACC in most years, but have been reducing since 2004–05 in response to the most recent TACC reduction (Figure 1).

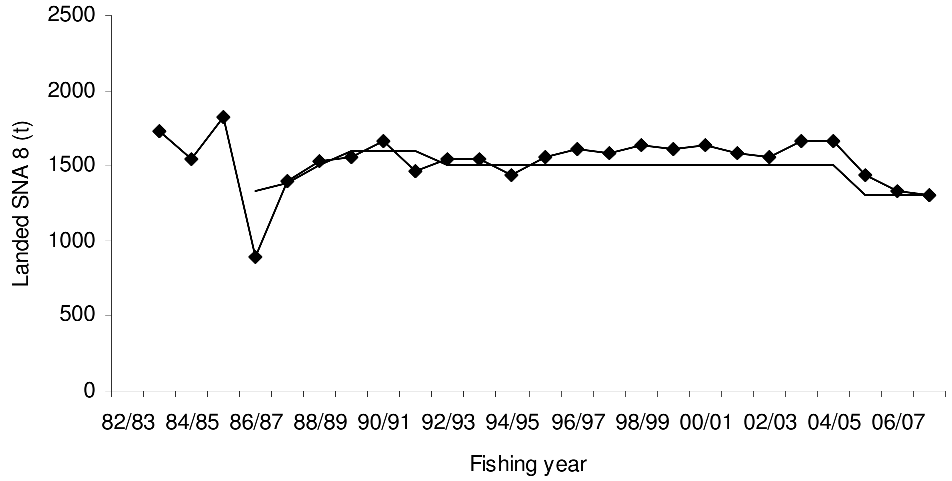


**Figure 1: Reported landings of snapper (t) in SNA 8 from 1983–84 to 2007–08 (•) and gazetted and actual TACCs (t) (solid line) for 1986–87 to 2007–08. QMS data from MFish 2009.**

Monitoring of SNA 8 for stock assessment relies mainly on the absolute abundance estimates from tagging programmes. Absolute abundance of SNA 8 was last estimated in 2002 and the next mark-recapture study is scheduled for 2011. Standardised CPUE series, updated every three years, are used to provide crude indices of relative abundance in the periods between tagging programmes. The SNA 8 CPUE index was last updated to the end of the 2003–04 fishing year (MFish project SNA 2004-01).

### 1.2 Previous work

Earlier attempts at monitoring SNA 8 include a time series of annual pair trawl CPUE indices (catch per day) derived by Vignaux (1993) for 1974–91 and a series of single bottom trawl CPUE indices that has been an input into all assessments to date. Davies et al. (1999) found that there were significant differences between pair and single trawl CPUE after 1989–90, and, due to the paucity of data for pair trawl and the possibility that that it contains duplicated effort data, the pair trawl series was not updated beyond 1990–91. In the 2004 assessment the pair trawl series was dropped entirely.



## APPENDIX C: MODEL FITS

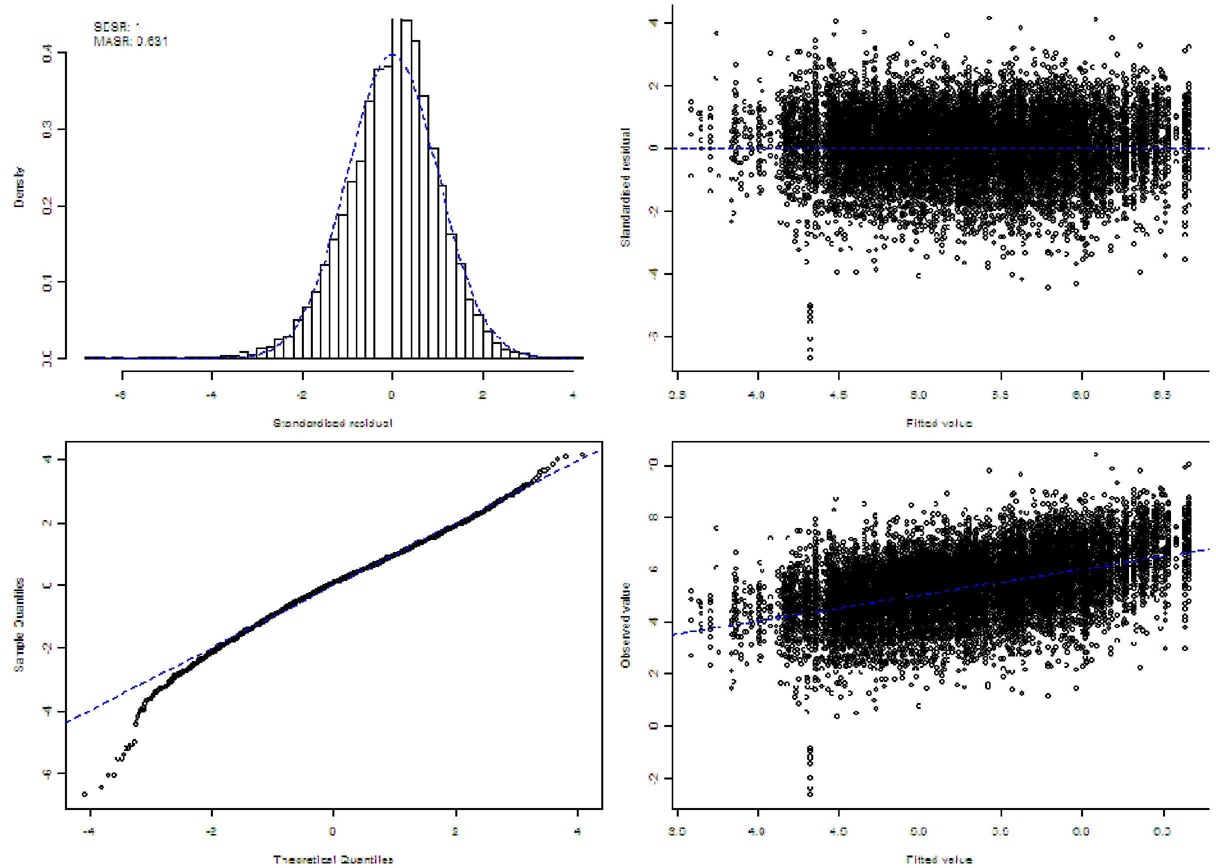


**Figure C1: Plots of the fit of the standardised CPUE model to successful catches of snapper in the SNA 8 (SMST) fishery. Upper left: histogram of the standardised residuals compared to a lognormal distribution (SDSR: standard deviation of standardised residuals. MASR: median of absolute standardised residuals); Upper right: Q-Q plot of the standardised residuals; Lower left: Standardised residuals plotted against the predicted model catch per trip; Lower right: Observed catch per record plotted against the predicted catch per record.**

**Table A3: Data summary for the SMST bottom trawl fishery. Core vessels selected as for V above, but after multi-stock (SNA8 & SNA 1) trips had been removed.**

| Fishing year | Trips | % zero strata | Vessels | Number of tows | Catch (t) | CPUE kg / tow |
|---|---|---|---|---|---|---|
| 95/96 | 119 | 31 | 15 | 933 | 233 | 250 |
| 96/97 | 248 | 18 | 17 | 2 201 | 701 | 318 |
| 97/98 | 236 | 16 | 17 | 2 518 | 648 | 257 |
| 98/99 | 177 | 12 | 16 | 2 100 | 462 | 220 |
| 99/00 | 204 | 12 | 15 | 2 398 | 565 | 236 |
| 00/01 | 210 | 19 | 18 | 2 446 | 586 | 240 |
| 01/02 | 223 | 12 | 14 | 2 103 | 715 | 340 |
| 02/03 | 197 | 16 | 16 | 1 921 | 791 | 412 |
| 03/04 | 230 | 19 | 17 | 2 601 | 974 | 374 |
| 04/05 | 213 | 20 | 16 | 2 365 | 772 | 326 |
| 05/06 | 140 | 21 | 12 | 1 407 | 584 | 415 |
| 06/07 | 128 | 25 | 10 | 1 408 | 684 | 486 |
| 07/08 | 159 | 11 | 8 | 1 799 | 723 | 402 |

## APPENDIX B: CPUE INDICES

**Table E1: Relative year effects and 95% confidence intervals for the CPUE models fitted to the V bottom trawl dataset for SNA 8.**

| Fishing year | Arithmetic mean(all vessels) | Arithmetic mean | Geometric mean | Lognormal standardisation | Binomial standardisation | Combined standardisation |
|---|---|---|---|---|---|---|
| 95/96 | 0.691 | 0.803 | 0.877 | 0.916 (0.849-0.988) | 0.716 | 0.719 (0.667-0.776) |
| 96/97 | 0.973 | 1.011 | 1.052 | 0.965 (0.920-1.012) | 0.908 (0.891-0.923) | 0.961 (0.916-1.008) |
| 97/98 | 0.907 | 0.838 | 0.972 | 0.822 (0.787-0.858) | 0.929 (0.916-0.941) | 0.837 (0.802-0.874) |
| 98/99 | 0.725 | 0.724 | 0.837 | 0.779 (0.743-0.817) | 0.933 (0.918-0.945) | 0.797 (0.759-0.835) |
| 99/00 | 0.781 | 0.744 | 0.783 | 0.846 (0.810-0.884) | 0.963 (0.955-0.970) | 0.894 (0.855-0.933) |
| 00/01 | 0.805 | 0.790 | 0.808 | 0.831 (0.794-0.869) | 0.921 (0.906-0.934) | 0.839 (0.802-0.878) |
| 01/02 | 1.093 | 1.112 | 1.086 | 1.114 (1.063-1.167) | 0.958 (0.948-0.966) | 1.169 (1.116-1.225) |
| 02/03 | 1.276 | 1.317 | 1.287 | 1.148 (1.093-1.207) | 0.927 (0.912-0.940) | 1.167 (1.111-1.226) |
| 03/04 | 1.191 | 1.199 | 1.103 | 1.049 (1.004-1.097) | 0.905 (0.886-0.920) | 1.041 (0.995-1.088) |
| 04/05 | 1.076 | 1.038 | 1.049 | 1.086 (1.036-1.138) | 0.929 (0.915-0.941) | 1.106 (1.056-1.159) |
| 05/06 | 1.302 | 1.215 | 1.145 | 1.354 (1.279-1.433) | 0.921 (0.903-0.935) | 1.366 (1.290-1.446) |
| 06/07 | 1.381 | 1.295 | 0.987 | 1.105 (1.045-1.168) | 0.912 (0.893-0.927) | 1.104 (1.044-1.167) |
| 07/08 | 1.122 | 1.205 | 1.154 | 1.152 (1.095-1.212) | 0.968 (0.960-0.974) | 1.222 (1.161-1.286) |



Single trawl catch and effort data are available from 1989–90 but there was a shift to more detailed reporting forms in 1994–95. To use the data prior to this year, a coarser unit of effort must be defined over the whole time series that limits the resolution of descriptive variables (Davies & McKenzie 2001). For the 2004 assessment, Davies et al. (2006) used a shorter time series of single trawl CPUE indices calculated using the detailed catch-effort data reported since 1994–95 on TCEPRs. The series showed an increasing trend that was modified downward slightly when the effort term was changed from catch per tow as used previously (Davies et al. 1999) to catch per nautical mile derived from "tow speed" and "tow duration".

Covariates in the general linear model included: a length/breadth/depth (LBD) parameter representing vessel-power; month; statistical area; and a categorical factor to indicate whether or not snapper was the target species. Zero catches were included in the GLM by the addition of 1 kg to all recorded catch estimates.

The shortened TCEPR series of CPUE for single trawl was updated to 2003–04 for the 2005 assessment (Davies et al. unpublished results). An attempt was made to model zero catches separately based on a binomial model but the effect of combining the binomial with the lognormal indices was slight and not considered to be useful. The Inshore Stock Assessment Working Group requested an updated analysis restricted to a core fleet of vessels. This data selection resulted in the construction of two datasets describing the catch and effort data for the top 20 and the top 12 catching vessels. The effect on the standardised CPUE series was marked, changing it from an increasing trajectory to one that was flat overall but which included a shallow decreasing trend from 1995–96 to 2000–01 followed by a general increase to 2003–04. There was virtually no difference between the year indices for the two series based on alternative core fleets and the WG adopted the series based on the top 12 vessels to include in the SNA 8 assessment model

The Inshore Stock Assessment Working Group recommended that in any subsequent update of these indices the LBD parameter should be replaced with a categorical vessel variable. It also flagged the continued exploration of including zero catch data in future analyses.

This study updates the shortened TCEPR series with an additional four years of data for a core fleet of vessels defined on the basis of participation rather than catch. The series includes data reported since 2008 on the new TCE form. Other improvements include using actual landed greenweight rather than estimated catch, and using a tighter definition of the fishery so that relevant but unsuccessful effort is more clearly defined and the modelling of the probability of capture more plausible. This study also investigates the likely effect of suspected misreporting of Fishstock.

## 2. DATA SOURCES AND METHODS

Fishers have been required to estimate the catch of only the top five species (eight species since introduction of the new TCE form in 2007–08) for a day's fishing on Catch Effort Landing Returns (CELRs) or in individual tows on Trawl Catch Effort and Processing Returns (TCEPRs) and TCEs, but often fewer species are reported. The estimated catch can therefore be an underestimate, especially for bycatch species. Only the landings values, reported on the bottom part of the CELR, or on Catch Landing Returns (CLRs) respectively, represent total catches. These values are available only at the end of the fishing trip, and are not directly linkable to individual fishing events or even to a single day's fishing. The linkage can be simulated by apportioning the landed catch to effort strata within the corresponding trip using procedures that were comprehensively described by Starr (2007).

Two datasets were prepared for this study: the fishery characterisation was done using landed greenweight of snapper as verified at the end of each fishing trip, linked to effort strata (unique combinations of trip, method, target species, and statistical area) using the method of Starr (2007). This methodology ensures that all unambiguous landed catch is included in the characterisation data set, not just the catch when estimated among the top five species. It also allows an elegant combining of data from multiple form types and rescales the catch to equal the QMR annual totals so that all tables and graphs represent the total commercial catch.

The CPUE standardisation was done on landed SNA 8 catches that were reported after 1995–96 in either TCEPR or TCE format. The CPUE dataset was prepared using a modification of the Starr methodology where landings were allocated to effort but no data amalgamation was done. The analysis was done on data in their original (tow-by-tow) resolution.

### 2.1.1 Sea surface temperatures

The oceanographic data included in the analysis are from a Pacific Ocean Hindcast data set derived from a model-based ocean analysis system (NOAA NCEP EMC CMB Pacific). These data are available for each month from January 1980 to December 2008 at a spatial resolution of one degree of latitude and 1.5 degrees of longitude.
(http://iridl.ldeo.columbia.edu/SOURCES/.IGOSS/.nmc/.Reyn_SmithOIv2/.monthly/.dataset_documentation.html).

Sea Surface Temperature (SST) was collated at statistical area/month resolution for the whole time series. A mean monthly temperature based on a ten year series (1989–99) was also calculated for each statistical area, and the anomaly from those measures of normality was calculated for each area and month. These anomalies are effectively the SSTs with the strong seasonal pattern (highly correlated with month) removed. A pattern of colder and warmer than usual years is apparent when those monthly anomalies are averaged over a fishing year. The pattern is consistent across statistical areas, though the temperature range is generally greater and the minimum temperatures cooler the further south the statistical area. For clarity and contrast, only one area is presented as an example (Figure 2). It is interesting to note that while El Nino events can generate an extreme water temperature response, the sign of that response relative to normal temperatures is not always predictable (Uddstrom & Oien 1999).

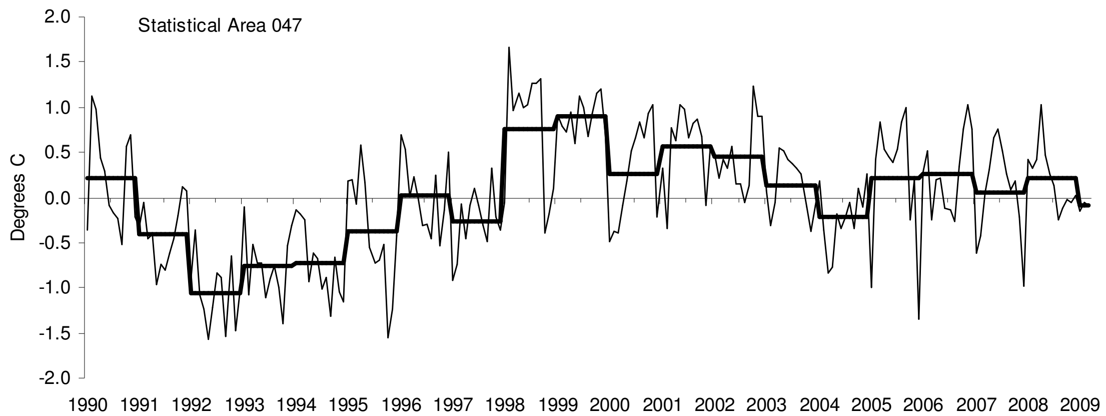


**Figure 2: Monthly sea surface temperature anomalies (light line) relative to a ten year (monthly) average, and the annual mean of those anomalies (bold line) for Statistical Area 047.**

## 2.2 Methods used for grooming and collation of MFish catch and effort data

Catch and effort data were obtained from the MFish data base "*warehou*" using a two-part extract. The first part identified candidate trips by searching for all landings to Fishstock SNA 8 **or** fishing events that fished using any trawl method (BT, MW, BPT, MPT) between 01 October 1989 and 01 October 2008 in any statistical area valid for SNA 8 but which did not target a deepwater species (ORH, OEO, SOE, SOR, SSO, BOE, WOE, CDL, BYX, HOK, SCI, SQU, HAK). Once trips that satisfied these criteria were identified, all effort and landing records associated with these trips were extracted. Landings, estimated catch, and associated effort were all groomed separately before merging and the resultant annual total landed and estimated catches are compared in Figure 3 and Table 1.



## APPENDIX A: DATA SUMMARIES

**Table A1: Data summary for the V bottom trawl fishery defined for standardised CPUE analysis for core vessels; (core vessels based on a minimum of 3 tows per year for at least 5 years); Number of trips, percentage of strata that recorded a zero catch of snapper, number of core vessels, total number of tows, landed weight of SNA 8 (tonnes), and the simple catch rate of SNA 8 across qualifying tows (kg/tow).**

| Fishing year | Trips | % zero strata | Vessels | Number of tows | Catch (t) | CPUE kg / tow |
|---|---|---|---|---|---|---|
| 95/96 | 142 | 28 | 15 | 1 128 | 270 | 239 |
| 96/97 | 282 | 19 | 17 | 2 506 | 756 | 302 |
| 97/98 | 306 | 15 | 17 | 3 044 | 761 | 250 |
| 98/99 | 207 | 12 | 16 | 2 360 | 510 | 216 |
| 99/00 | 249 | 11 | 15 | 2 853 | 634 | 222 |
| 00/01 | 251 | 18 | 19 | 2 756 | 650 | 236 |
| 01/02 | 262 | 12 | 16 | 2 321 | 770 | 332 |
| 02/03 | 236 | 17 | 16 | 2 212 | 869 | 393 |
| 03/04 | 261 | 19 | 17 | 2 792 | 999 | 358 |
| 04/05 | 257 | 19 | 16 | 2 660 | 824 | 310 |
| 05/06 | 191 | 21 | 13 | 1 786 | 647 | 362 |
| 06/07 | 193 | 22 | 11 | 1 953 | 755 | 387 |
| 07/08 | 203 | 12 | 8 | 2 117 | 761 | 359 |

**Table A2: Data summary for the SV bottom trawl fishery (core vessels selected as for V above, but with suspect vessels subsequently removed).**

| Fishing year | Trips | % zero strata | Vessels | Number of tows | Catch (t) | CPUE kg / tow |
|---|---|---|---|---|---|---|
| 95/96 | 110 | 33 | 11 | 838 | 176 | 210 |
| 96/97 | 215 | 18 | 12 | 1 810 | 531 | 293 |
| 97/98 | 235 | 14 | 12 | 2 252 | 525 | 233 |
| 98/99 | 153 | 12 | 12 | 1 494 | 350 | 234 |
| 99/00 | 184 | 9 | 10 | 1 887 | 456 | 242 |
| 00/01 | 179 | 13 | 13 | 1 754 | 455 | 259 |
| 01/02 | 199 | 11 | 11 | 1 623 | 560 | 345 |
| 02/03 | 182 | 13 | 12 | 1 646 | 698 | 424 |
| 03/04 | 188 | 18 | 12 | 2 052 | 831 | 405 |
| 04/05 | 132 | 21 | 10 | 1 280 | 512 | 400 |
| 05/06 | 89 | 24 | 8 | 730 | 378 | 518 |
| 06/07 | 97 | 28 | 6 | 1 048 | 614 | 586 |
| 07/08 | 114 | 11 | 4 | 1 302 | 578 | 444 |

## 5. ACKNOWLEDGMENTS

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**Table 1: TACC and landed catch totals (t) from the MFish catch and effort forms by fishing year compared with the total reported landings (t) to the QMS. Also shown are the catch totals (t) which remain after the dataset has been prepared for analysis by dropping trips which reported to more than one snapper fishstock and fished in a straddling statistical area or that used multiple and incompatible gear types. The estimated catch total is the sum from all trips with matching landing data.**

| Fishing year | TACC (t) | QMR reported catches (t) | Bottom of form (some edits) | Landed catch for analysis (t) | Estimated catch in dataset (t) | % analysis catch of landed catch | % analysis catch of QMR | % estimated catch of analysis |
|---|---|---|---|---|---|---|---|---|
| 89/90 | 1 594 | 1 550 | 1 233 | 1 216 | 1 449 | 99 | 78 | 119 |
| 90/91 | 1 594 | 1 658 | 1 612 | 1 531 | 1 502 | 95 | 92 | 98 |
| 91/92 | 1 594 | 1 464 | 1 473 | 1 398 | 1 329 | 95 | 95 | 95 |
| 92/93 | 1 500 | 1 543 | 1 478 | 1 380 | 1 325 | 93 | 89 | 96 |
| 93/94 | 1 500 | 1 542 | 1 525 | 1 431 | 1 366 | 94 | 93 | 95 |
| 94/95 | 1 500 | 1 434 | 1 365 | 1 292 | 1 251 | 95 | 90 | 97 |
| 95/96 | 1 500 | 1 558 | 1 377 | 1 285 | 1 343 | 93 | 82 | 104 |
| 96/97 | 1 500 | 1 613 | 1 571 | 1 479 | 1 324 | 94 | 92 | 90 |
| 97/98 | 1 500 | 1 589 | 1 555 | 1 464 | 1 342 | 94 | 92 | 92 |
| 98/99 | 1 500 | 1 636 | 1 600 | 1 532 | 1 482 | 96 | 94 | 97 |
| 99/00 | 1 500 | 1 604 | 1 609 | 1 564 | 1 510 | 97 | 98 | 97 |
| 00/01 | 1 500 | 1 630 | 1 605 | 1 553 | 1 460 | 97 | 95 | 94 |
| 01/02 | 1 500 | 1 577 | 1 486 | 1 446 | 1 448 | 97 | 92 | 100 |
| 02/03 | 1 500 | 1 558 | 1 530 | 1 486 | 1 469 | 97 | 95 | 99 |
| 03/04 | 1 500 | 1 667 | 1 666 | 1 586 | 1 565 | 95 | 95 | 99 |
| 04/05 | 1 500 | 1 663 | 1 663 | 1 588 | 1 563 | 95 | 96 | 98 |
| 05/06 | 1 300 | 1 434 | 1 472 | 1 335 | 1 284 | 91 | 93 | 96 |
| 06/07 | 1 300 | 1 327 | 1 318 | 1 244 | 1 207 | 94 | 94 | 97 |
| 07/08 | 1 300 | 1 304 | 1 294 | 1 226 | 1 227 | 95 | 94 | 100 |

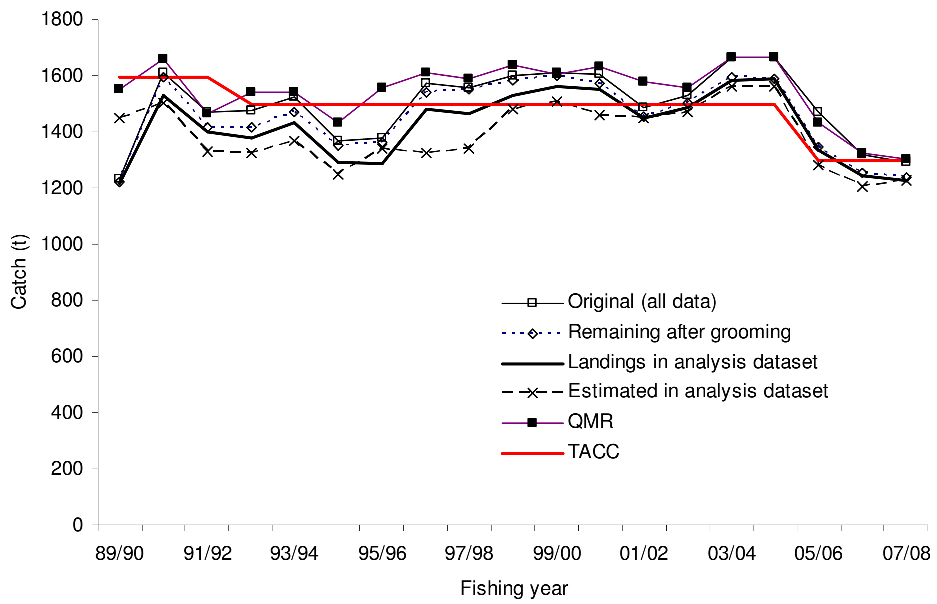


**Figure 3: Comparison of SNA 8 TACC and landed catch totals (t) from the MFish catch and effort forms by fishing year with the total reported landings (t) to the QMS. Values are given in Table 1.**

Outlier values in the landing data were identified by finding the trips with very high landings for snapper based on verified maximum values supplied by the Ministry of Fisheries data unit. The effort data for these trips were then used to calculate the trip CPUE and the associated estimated catch was also examined. Trips which had a ratio of landed to estimated catch which exceeded 4 and a CPUE which exceeded two times the 95th percentile of the trip CPUE distribution for the entire dataset were excluded from the analysis.

Most snapper were landed to destination code “L” (landed to a Licensed Fish Receiver in New Zealand), but there were some also some landings reported to destination code “R” meaning that they were retained on board, “Q” meaning they were held in a receptacle on land for subsequent landing, or “T” meaning they were transferred to another vessel (Table 2). These fish are not identifiable when subsequently landed and are therefore at risk of being double counted. Where these destination codes were reported, the entire trip was dropped with the loss of over 133 t of snapper from the analysis dataset.

Almost all SNA 8 are landed green (whole) with most of the balance being dressed or gutted (Table 3). The conversion factors used to back-calculate greenweight from landed (processed) weights for the three main processed states were collated by fishing year and found not to have changed since 1989–90 so that the wholeweights in the database could be used without further correction.

Occasional outlier values (input errors) in the effort data were identified by comparison with empirical distributions derived from the effort variable (duration or number of sets) and, where the values were in the extreme upper and lower tails of the distribution (a multiple of the 95th percentile value), they were replaced with the median value for the effort field for the affected vessel. Missing effort data were treated similarly. Missing values for statistical area, method, or target species within any trip were substituted with the predominant (most frequent) value for that field over all records for the trip. Trips with all fields missing for one of these descriptors were dropped entirely.

**Table 2: Total landed greenweight (t) of SNA 8 in the unedited file by the main destination codes and whether used or excluded from the analysis dataset. 0, less than 0.5 t.**

| | Used | | | | Not used | | |
|---|---|---|---|---|---|---|---|
| Fishing year | Landed to LFRR | Recreational catch | Disposed to crown | Eaten | Retained on board | Held on land | Transferred |
| 89/90 | 1 491 | - | 19 | - | 3 | - | 1 |
| 90/91 | 1 738 | - | 3 | - | 6 | - | 2 |
| 91/92 | 1 508 | - | 27 | - | 3 | - | 5 |
| 92/93 | 1 485 | - | 0 | 0 | 1 | - | 18 |
| 93/94 | 1 555 | - | - | 0 | 5 | - | 6 |
| 94/95 | 1 518 | - | - | 0 | 8 | - | - |
| 95/96 | 1 771 | - | 0 | 0 | - | - | 0 |
| 96/97 | 1 694 | - | 0 | 0 | - | - | 0 |
| 97/98 | 1 695 | - | - | 0 | 0 | - | 0 |
| 98/99 | 1 742 | - | - | 0 | 0 | - | - |
| 99/00 | 1 760 | - | 0 | 0 | - | - | - |
| 00/01 | 1 687 | - | 0 | 0 | 15 | - | - |
| 01/02 | 1 582 | 1 | - | 1 | 0 | 1 | - |
| 02/03 | 1 694 | 2 | - | 1 | 0 | 2 | - |
| 03/04 | 1 782 | 5 | - | 1 | 4 | 2 | 0 |
| 04/05 | 1 740 | 4 | - | 1 | 6 | 2 | - |
| 05/06 | 1 682 | 3 | - | 1 | 12 | 6 | 20 |
| 06/07 | 1 546 | 2 | - | 0 | 6 | 7 | 0 |
| 07/08 | 1 562 | 4 | - | 1 | 2 | 3 | - |



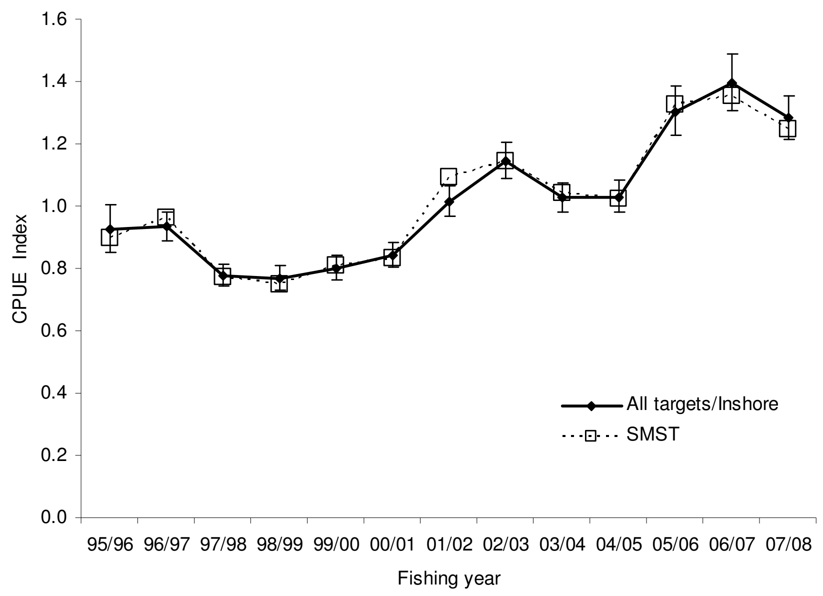


**Figure 30: Sensitivity of year effects from lognormal models to alternative SNA 8 BT fishery definitions; Inshore areas only with no selection of target species, SMST – top three target species only and offshore statistical areas not excluded.**

## 4. CONCLUSIONS

This study updates the monitoring of CPUE in SNA 8 to bring it into line with current best practice by using landed rather than estimated catch, by defining the fishery so that encounter rate can be defensibly monitored, and by applying the selection of the core fleet based on two variables that describe a vessels participation in the fishery rather than its catch of snapper. None of these improvements were expected to effect much change to the annual indices in this Fishstock, and any difference between this and the previous analysis is more likely a function of not including distance towed into the measurable variable but instead offering it to the model and it not being selected.

The most important explanatory variable was vessel and changes in the core fleet have served to lift observed CPUE: nevertheless, neither the lognormal nor the binomial models effected much change from the unstandardised series and this suggests some consistency in the way the fishery has operated.

The effect on CPUE of the systematic shift in reporting practice in this fishery during the mid 1990s from the daily CELR to the tow-by-tow TCEPR/TCE forms was not investigated. The potential bias described for other fisheries in this northern inshore trawl fishery has been avoided by using a shortened series based on tow-by-tow reporting only. This is appropriate for monitoring the recent rebuild of the stock and has advantages including the better identification of target species and of positive effort.

The series of CPUE indices suggests that abundance of snapper in SNA 8 is increasing but should continue to be treated with caution until the trend can be confirmed by mark-recapture work. The caution relates to likely hyperstability given that the fishery tends to target spawning aggregations near harbour mouths in spring.

Problems caused by misreporting of catch and effort have the potential to mask the rebuild of this fishery and require on-going monitoring and attention.

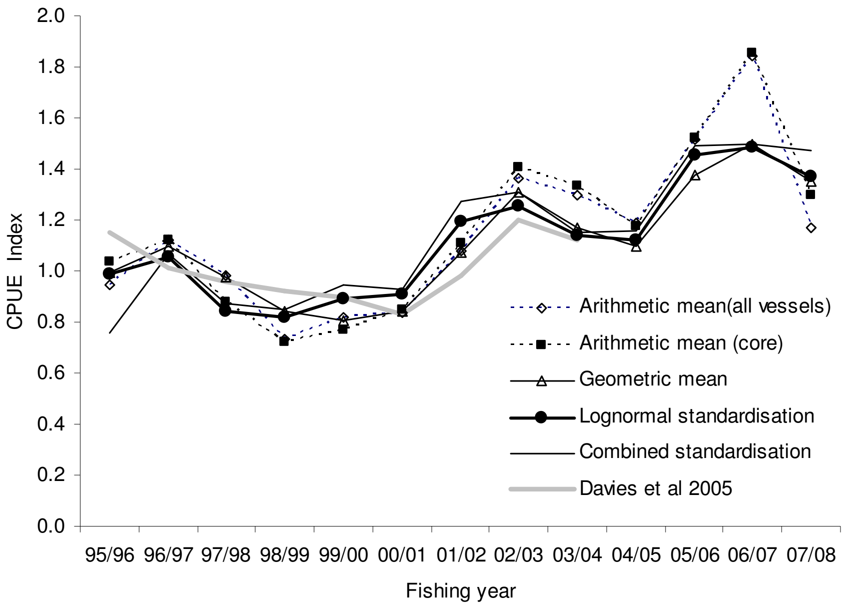


**Figure 28: Effect of core vessel selection, standardisation, and combining of annual lognormal and binomial annual indices. Unstandardised CPUE is based on kg/tow. Previous series from a similar model (Davies et al. 2005) are overlaid for comparison. All series have been rescaled to the geometric mean of the years in common (1995–96 to 2007–08).**

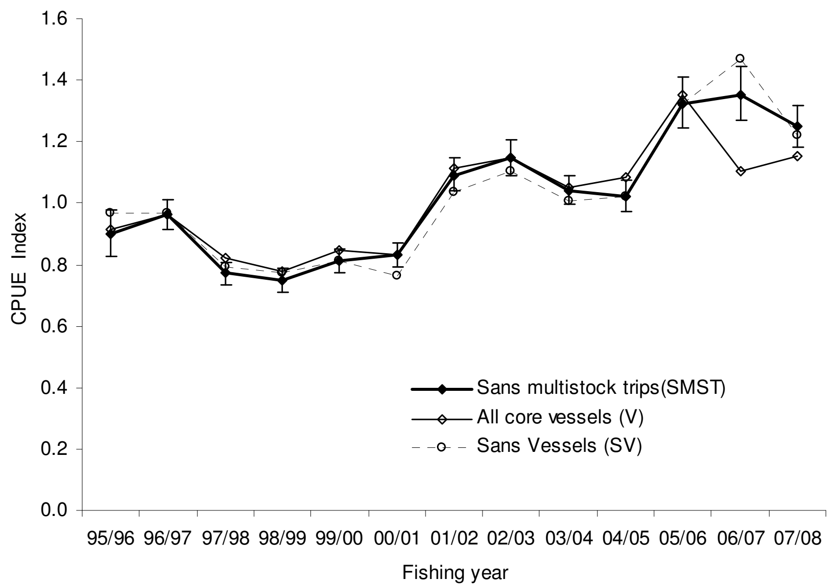


**Figure 29: Comparison of year effects from lognormal models of three datasets based on single bottom trawl in SNA 8; all core vessels (V) ; core fleet less suspect vessels (SV); core fleet less multi stock trips (SMST) ±2 s.e. All series are rescaled relative to their geometric mean.**



**Table 3: The median conversion factor in each fishing year by processed state (for states having at least 100 records); total landed greenweight (t) of SNA 8 in the unedited file by processed state. GRE, green; DRE, dressed; GUT, gutted; HGU, head and gutted. 0, less than 0.5 t.**

| Fishing | Conversion factor | | | | Landed SNA 8 (t) | | | |
|---|---|---|---|---|---|---|---|---|
| year | GRE | DRE | GUT | HGU | GRE | DRE | GUT | Other |
| 89/90 | 1.00 | | 1.10 | 1.50 | 1 511 | - | 1 | 2 |
| 90/91 | 1.00 | 1.80 | 1.10 | 1.50 | 1 738 | 1 | 2 | 0 |
| 91/92 | 1.00 | 1.80 | 1.10 | 1.50 | 1 531 | 3 | 1 | 0 |
| 92/93 | 1.00 | 1.80 | 1.10 | 1.50 | 1 488 | 2 | 0 | 0 |
| 93/94 | 1.00 | 1.80 | 1.10 | 1.50 | 1 549 | 4 | 1 | 2 |
| 94/95 | 1.00 | 1.80 | 1.10 | 1.50 | 1 502 | 6 | 7 | 2 |
| 95/96 | 1.00 | 1.80 | 1.10 | 1.50 | 1 766 | 4 | 1 | 1 |
| 96/97 | 1.00 | 1.80 | 1.10 | 1.50 | 1 691 | 2 | 1 | 1 |
| 97/98 | 1.00 | 1.80 | 1.10 | 1.50 | 1 693 | 3 | 1 | 0 |
| 98/99 | 1.00 | 1.80 | 1.10 | 1.50 | 1 743 | 2 | 0 | 0 |
| 99/00 | 1.00 | 1.80 | 1.10 | 1.50 | 1 747 | 11 | 2 | 1 |
| 00/01 | 1.00 | 1.80 | 1.10 | 1.50 | 1 666 | 22 | 0 | 0 |
| 01/02 | 1.00 | 1.80 | 1.10 | 1.50 | 1 560 | 24 | 0 | 0 |
| 02/03 | 1.00 | 1.80 | 1.10 | 1.50 | 1 694 | 2 | 0 | 0 |
| 03/04 | 1.00 | 1.80 | 1.10 | 1.50 | 1 759 | 32 | 0 | 0 |
| 04/05 | 1.00 | 1.80 | 1.10 | 1.50 | 1 722 | 22 | 1 | 0 |
| 05/06 | 1.00 | 1.80 | 1.10 | | 1 665 | 20 | 0 | 1 |
| 06/07 | 1.00 | 1.80 | 1.10 | | 1 539 | 10 | 0 | 0 |
| 07/08 | 1.00 | 1.80 | 1.10 | 1.50 | 1 553 | 12 | 3 | 0 |

The landed catch is allocated to effort by first summarising effort and estimated catch data for a fishing trip for every unique combination of fishing method, statistical area, and target species (referred to as a "trip-stratum"). This reduces both CELR and TCEPR format records to lower resolution "amalgamated" data, giving fewer records per trip, but retains the original method, area, and target species recorded by the skipper. The landed greenweight, declared at the end of the trip, is then allocated to the trip strata in proportion to the estimated catch. Where there were no estimated catches during the trip, the allocation is proportionate to the amount of effort. Trips landing to more than one fishstock of snapper from the straddling statistical areas (016, 017, 018, 019, 036, 037, 039, and 040), or that used multiple fishing methods with incompatible measures of effort, were entirely dropped.

The data available for each trip included estimated and landed catch of snapper, total hours fished, total number of tows/hooks, or length of net, fishing year, statistical area, target species, month of landing, and a unique vessel identifier. Data retained for the analyses might not represent an entire fishing trip, but just those portions of it that qualified, but the amount of landed catch assigned to the part of the trip that was kept would be proportional to the total landed catch for the trip.

This method of using allocated landings retained for analysis more than 91% of landed SNA 8 in each year. The estimated catch in the groomed dataset represented generally more than 90% of the allocated landings (Figure 3). The total landed greenweight available from the bottom of the form and obtained in the "*warehou*" database extract differs from the total QMR landings of snapper reported by MFish (2009) particularly in the first half of the time series due to the relatively poorer error checking routines for catch effort data in those years.

Alternative datasets delineated by form type and analysed at original resolution were also based on landed rather than estimated catch, but were allocated to effort at the resolution at which effort was recorded, not amalgamated to trip-stratum. The TCEPR series thus included some more detailed variables such as bottom depth and tow speed, which are only reported for tow-by-tow data. Landings were re-scaled in the dataset to equal the verified totals from Monthly Harvest Returns (MHR) or, before

October 2001, from Quota Management Returns (QMR). For the CPUE standardisation part of this study, records for which any field had been corrected or replaced during grooming were dropped.

## 2.3 Methods used for catch-per-unit-effort analysis

### 2.3.1 Defining fisheries

Fisheries are identified in a characterisation as likely candidates in which to monitor abundance based on a consideration of whether: 1) effort is effective with respect to the species of interest (accounts for a significant proportion of landed catch), 2) the gear type is suitable for sampling, 3) the selected target fisheries are equally effective with respect to the species of interest (similar depth, catch rates, encounter rates, and / or other evidence of association), and 4) there has been reasonable stability in the operation of the fishery (based on examination of the spatial and seasonal distribution of effort).

A clear definition of the fishery is of even greater importance if a meaningful analysis of success rate (probability of capture) is to be modelled separately to the catch rate in positive tows.

For SNA 8 the currently accepted series monitors CPUE in TCEPR single bottom trawl tows in the inshore statistical areas (039, 040, 041, 042, 045, 046, and 047), regardless of the species targeted. The restriction to inshore statistical areas is an attempt to exclude fishing effort targeted at deeper species

This definition may be appropriate if only the positive catches are analysed and the zero catches discarded (as is done for the lognormal model); however, it includes an unknown proportion of irrelevant effort in which zero catches will occur, and which is subject to changes over time with shifts in marketing and targeting initiatives for other species. In order to monitor any trend in the probability of capture (binomial model), a tighter or at least more consistent fishery definition is required. This study investigates an alternative fishery definition that is restricted to tows targeted at the main species with which catches of snapper are associated, regardless of the inshore/offshore statistical area boundaries.

### 2.3.2 Inclusion of zero catch information

When an appropriate fishery in which abundance might be monitored has been defined, then all effort in that fishery is considered relevant, and current practice in New Zealand fisheries is to model the encounter rate (probability of capture) in that fishery if there is an adequate proportion of unsuccessful effort records (usually considered to be at least 5% in each year).

This was done for this study because relevant but unsuccessful effort was considered to be adequately identified, and also because using data in tow-by-tow (TCEPR and TCE) resolution improves the utility of the approach as individual successful tows are identifiable (not subsumed into daily totals as they are in CELR format data) and more detailed tow-by-tow potential explanatory variables such as depth and tow speed are available to be offered to the models.

### 2.3.3 Landed greenweight versus estimated catch

The decision of whether to base the analysis of CPUE on 'estimated' or 'landed' catch depends firstly on whether CPUE is monitored in target fishing or in a bycatch/mixed target fishery, and secondly on whether data from both the main form types are to be combined for analysis. Where a species is not the target and not always among the top five species in the catch, the estimated catch is likely to be an underestimate, and zero catches are as likely to mean the species was caught, but was not among the top five species, as that it wasn't caught at all. This means that species other than target species can not usually be reliably monitored using estimated catch. When data in both CELR and TCEPR formats are to be used in a combined analysis, a coarser unit of effort must be defined over the whole time series that



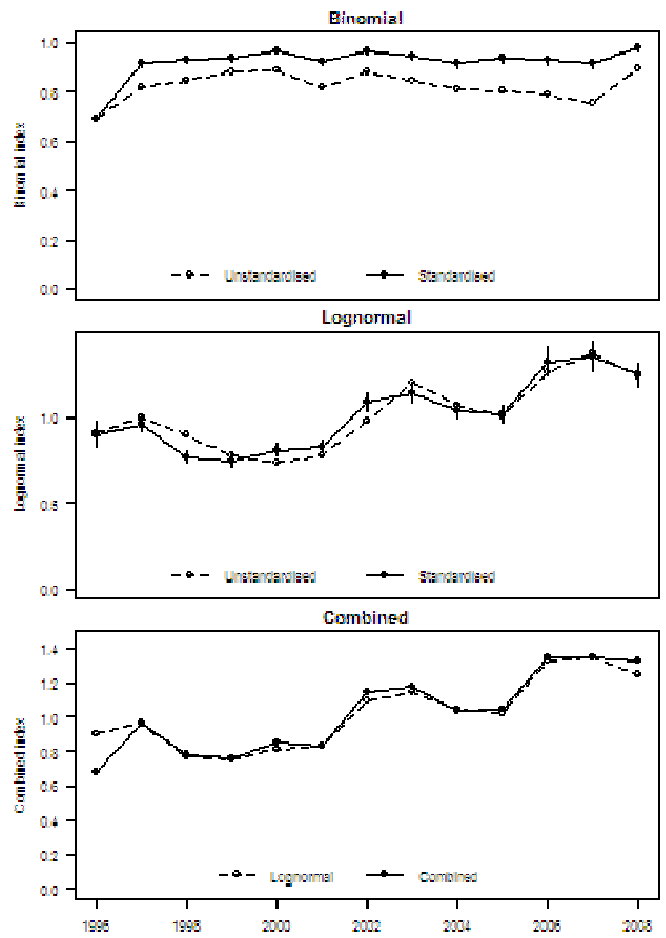


**Figure 27: Different standardised annual CPUE indices for the SNA 8 (SMST) fishery. Top: Binomial index representing probability of capture. Middle: Lognormal index representing magnitude of catch ±2 s.e. Bottom: Combined index representing expected catch per tow.**

### 3.2.9 Comparison with other models (sensitivities)

The annual indices from the SNA 8 (SMST) models are tabled in Appendix B and are compared (re-scaled) with the unstandardised indices (annual geometric means), and with arithmetic means for all data and for core fleet data only in Figure 28. The previous series presented for this Fishstock (Davies et al. 2005) is also overlaid in Figure 28 and the series re-scaled for valid comparison. There is reasonable agreement with the previous series over the years they have in common and the additional four years of data continue the increasing trend first described by that study. The main effective difference between the two analyses is that distance towed was offered to the model in this study but not accepted, whereas it had previously been subsumed into the dependent variable (kg/ km) on the left hand side of the model equation.

The sensitivity of the annual indices to alternative methods of grooming to eliminate misreported Fishstock is shown in Figure 29. Both methods (removing suspect vessels and removing multi-stock trips) raise the 2006–07 index substantially and the effect is still marked though not so dramatic in 2007–08. It is likely that SNA 8 catch reported as being SNA 1 is not the only form of misreporting and that removing multi-stock trips is not a complete answer, but it is a repeatable and non-subjective approach to quantifying behaviour that can potentially mask the rebuild of this Fishstock.

The effect of the alternative fishery definition used in this study (i.e., three main target species with no restriction to inshore statistical areas) on the annual indices is shown in Figure 30. The effect was almost indiscernible.

**and toward trevally and gurnard (Appendix D,**

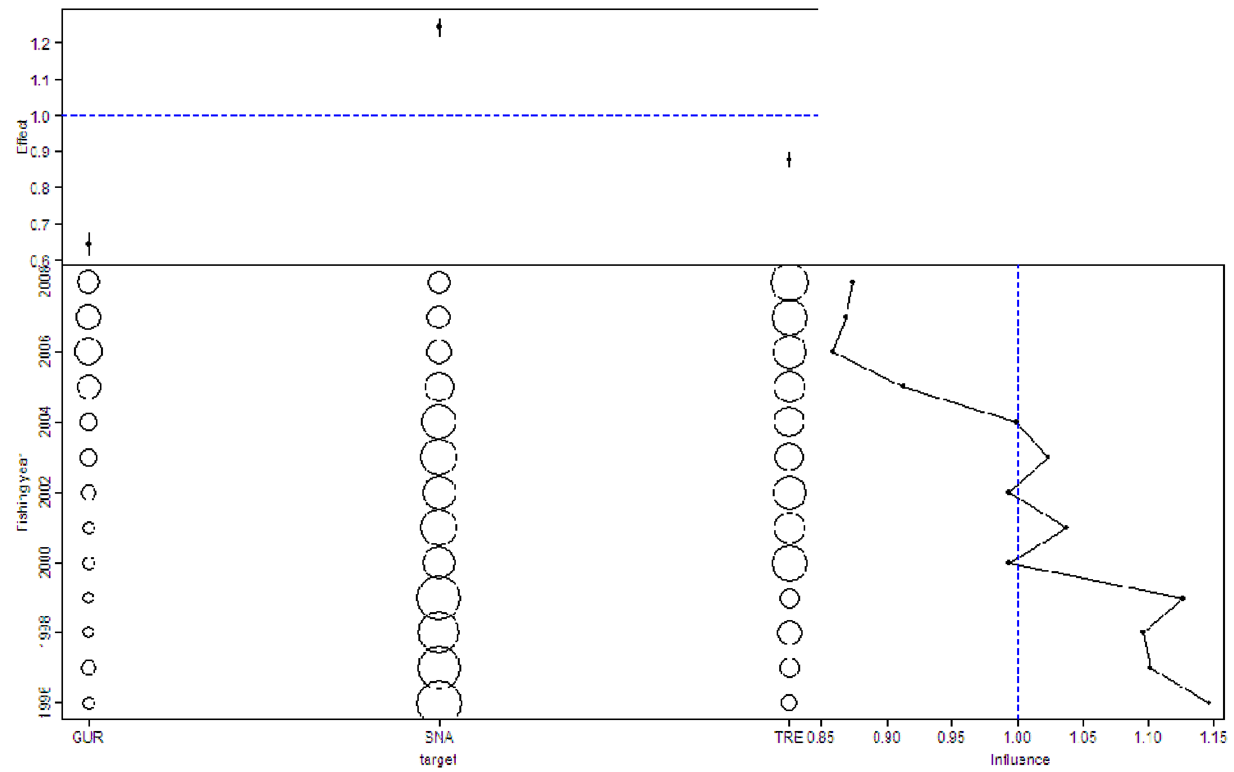


Figure 31).

### 3.2.8 Trends in model year effects

The year effects from the lognormal model of the SMST fishery describe an initial decline from 1989–90 to the lowest point in the series in 1998–99, followed by an increase that has been largely sustained over the subsequent 10 years except for a plateau or slight decline in the early to mid 2000s (Figure 27). There is very little effect of standardisation, indicating some consistency in the way this fishery has operated. The error bars around each point are small and the series is smooth with little interannual variance to mask the overall upward trend. Error bars are slightly larger in the most recent years, possibly reflecting the decreasing number of observations in the dataset as effort has declined in this fishery.

The binomial model of the probability of capture effected very little change to the unstandardised encounter rate so that when the coefficients from the binomial and lognormal models are combined there is consequently little additional change to the year effects (Figure 27).



limits the resolution of descriptive variables. The Starr (2007) methodology provides an elegant procedure for reducing data to a common trip-stratum resolution.

For SNA 8, the total estimated and allocated landed catches at trip stratum resolution are compared in Figure 4 and Figure 5. There is evidence of some over- and under-estimation, but generally snapper is a well reported (estimated) species despite this being a mixed target and bycatch fishery.

Although there may be little advantage in using allocated landed catch in this instance, it is nevertheless considered advisable as it represents the best attempt to address a potential bias in estimated catch towards the larger catches. The use of landed rather than estimated catch also allows much of the catch from straddling statistical areas to be identified by Fishstock and therefore included in the analysis.

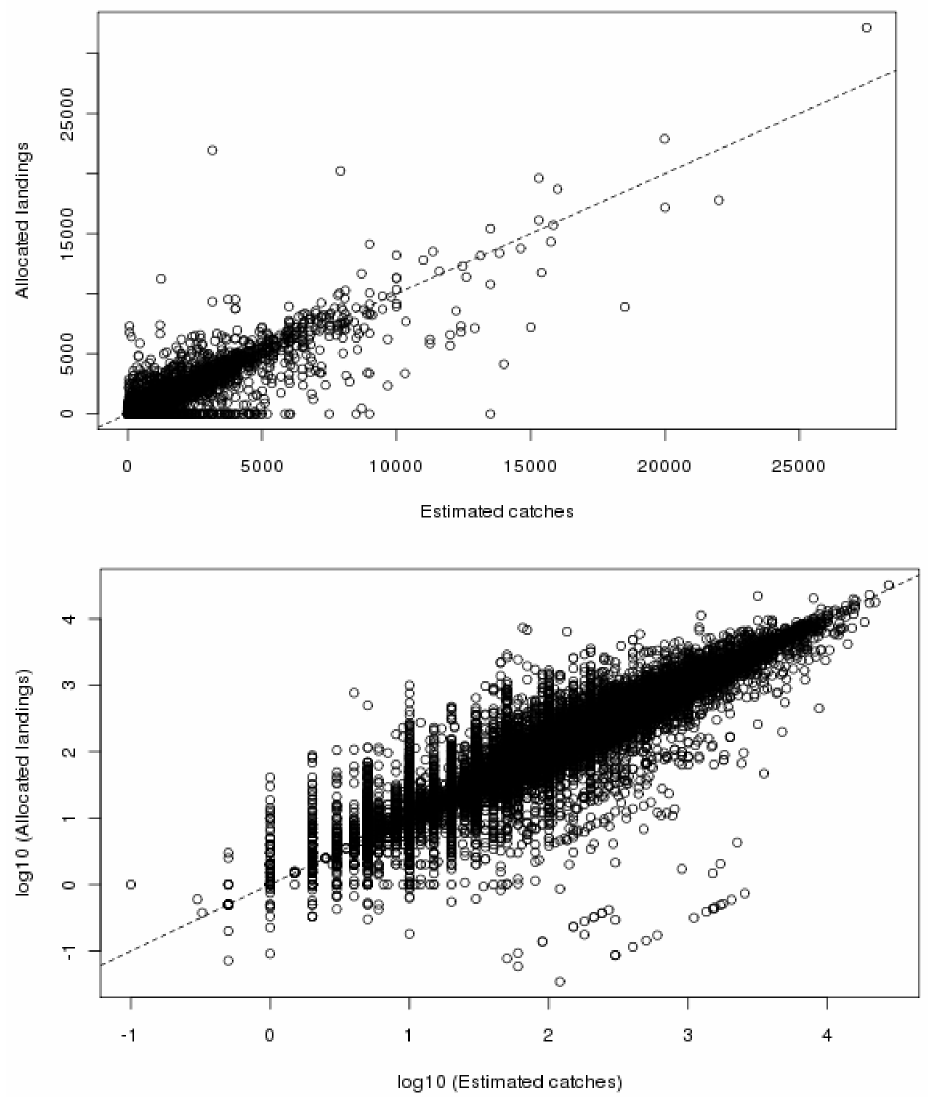


**Figure 4: Scatter plots of the landed greenweight (t) compared to the estimated catches (t) in the analysis dataset (at trip resolution). The lower plot uses log-scale axes to reduce the visual effect of large catches.**

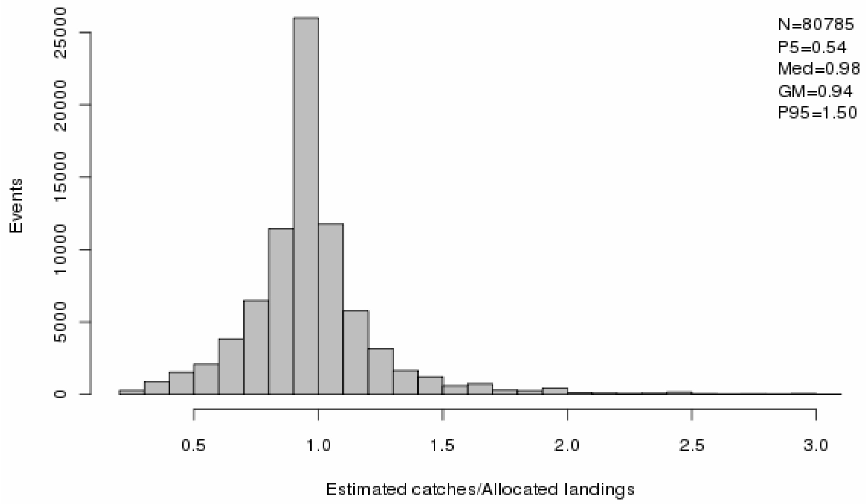


**Figure 5: Frequency of the ratio of estimated catches/landed greenweight in the analysis dataset (at trip resolution). This should centre tightly on 1.0 if the catch is well estimated.**

### 2.3.4 Combining form types

The currently accepted series for SNA 8 is based on data in the TCEPR/TCE formats only. The decision to use the shortened series based on TCEPR data was made for MFish project SNA2004/01 because it allowed a more informative measure of effort to be used (distance towed) based on tow speed and tow duration (Davies et al. 2006). The reported effect of using this more descriptive measure of effort was to lessen the degree of upward trend in the indices from 1995–96 (Davies et al. 2006).

One of the mechanisms that can produce overly optimistic CPUE trajectories from combined form type analyses, however, was described by Kendrick (2006) and is more likely the explanation of the effect noted above. In the mixed species northern inshore trawl fishery there was a systematic and almost total switch in the mid 1990s from reporting daily summaries of catch and effort (on CELRs) to tow-by-tow (TCEPR) reporting. The *target species* field can be used quite differently on these two forms, with the result that targeted CPUE for some species is greater when reported on TCEPRs than when reported on CELRs. As the proportion of data reported on TCEPRs increases, so too does the nominal catch rate.

The reason for the difference in target catch rates between form types is that fishers target a quota mix of species, and not all tows in a day's fishing will be optimised for the species recorded on a CELR as target. The catch rates for a targeted species can be lower in CELR data because the daily record includes this "other" less relevant effort whereas for TCEPRs a target species is recorded against every individual tow and describes it more accurately. The systematic switch therefore has the potential to bias CPUE, especially when it is monitored in targeted fishing. The effect is not standardised for by the model because the form type effect is confounded with, and subsumed into, the year effect yielding over-optimistic CPUE trajectories. In this study, distance was offered to the model (rather than forced) but did not prove to have significant explanatory power.

The approach taken here was to continue with the use of TCEPR/TCE format data only, even though that resulted in a shortened time series starting in 1995–96. This decision is considered appropriate because the purpose of the study is primarily for monitoring a rebuild of the stock rather than providing input into a stock assessment.



**the fishery of many of the poorer ones (Appendix D,**

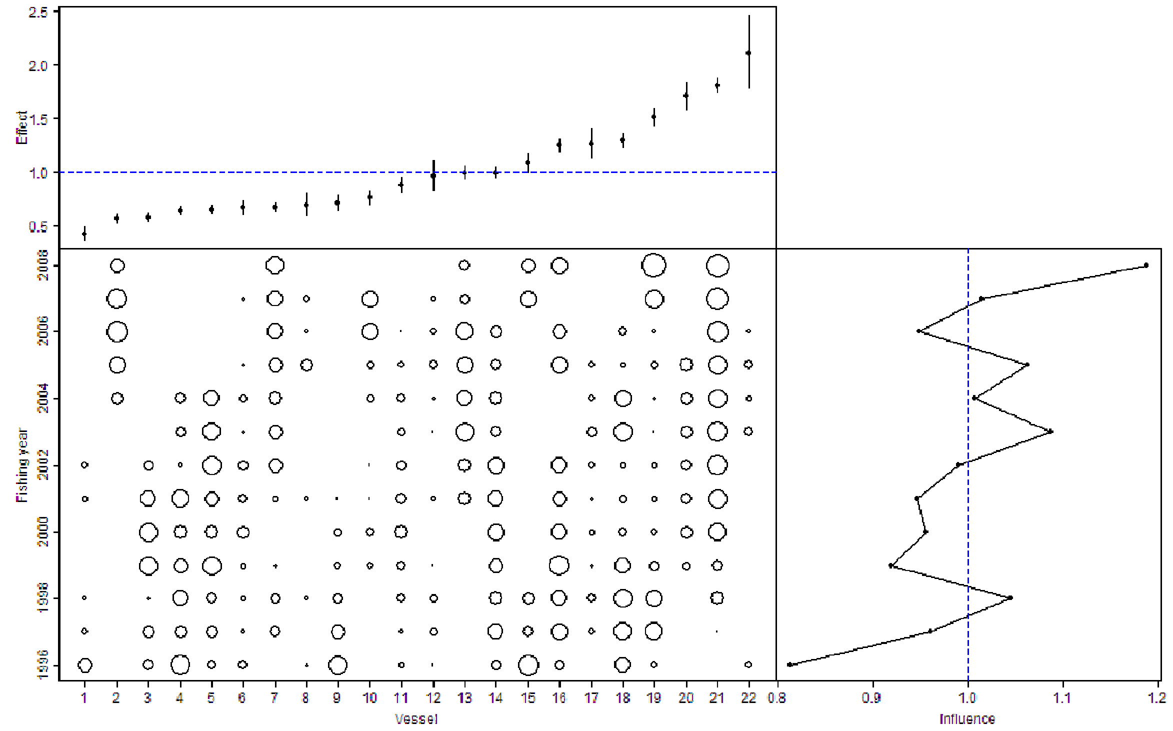


Figure D1).

**The seasonal pattern is one of highest predicted catches in October, November and December, and lowest in July. In most years the emphasis has been on summer fishing, but in those years for which effort was more evenly distributed across month the influence on CPUE was negative and that was particularly in 2000–01 and in the most recent two years (Appendix D,**

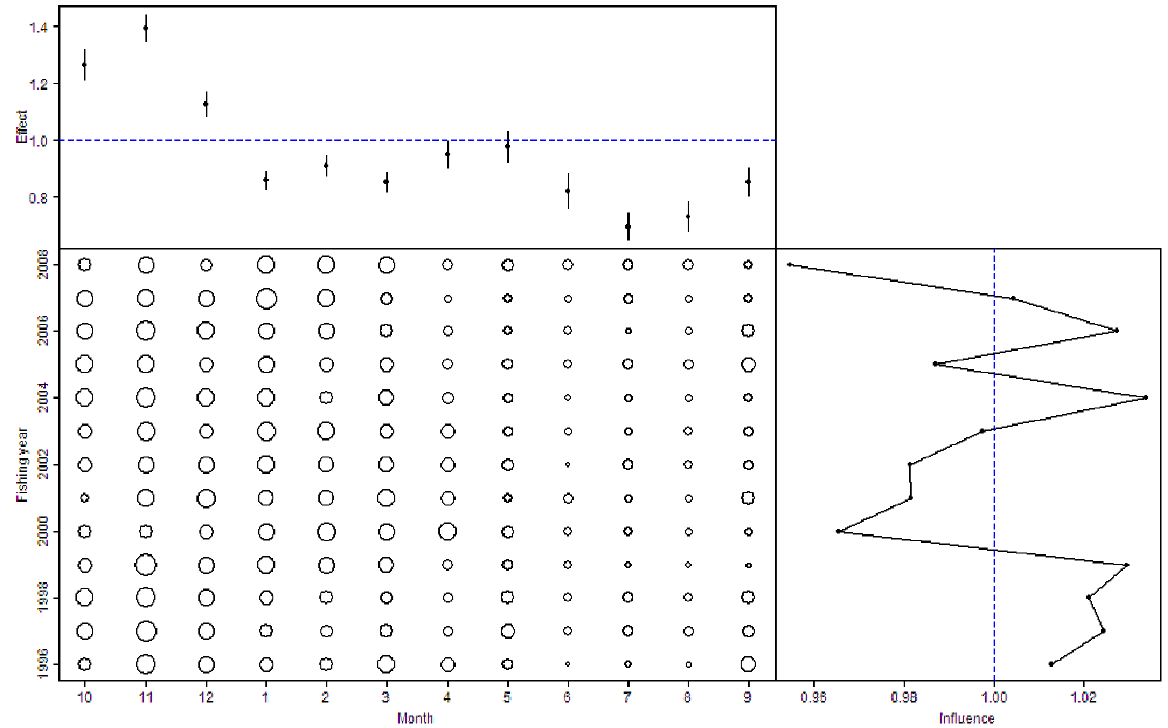


**Figure D2), perhaps indicating active avoidance of snapper. Similarly, the effect on observed CPUE of shifts in targeting behaviour has been strongly negative as effort has increasingly been directed away from snapper**

**Table 8: Summaries of final lognormal (upper panel) and binomial (lower panel) models for the SNA 8 (SMST) fishery based on the vessel selection criteria of at least three trips per year in at least five or more fishing years. Independent variables are listed in the order of acceptance to the model. AIC, Akaike Information Criterion; R2, proportion of deviance explained at each step and in the final model (bold); Final, Whether or not variable was included in final model; Fishing year was forced as the first variable.**

| Lognormal Term | DF | Deviance | AIC | R2 | Final |
|---|---|---|---|---|---|
| None | 0 | 31 182 | 69 534 | 0.0000 | |
| Fishing year | 13 | 30 414 | 69 016 | 0.0246 | * |
| Vessel ID | 34 | 25 546 | 65 267 | 0.1807 | * |
| Month | 45 | 24 301 | 64 203 | 0.2207 | * |
| Target species | 47 | 23 720 | 63 680 | **0.2393** | * |
| Statistical area (zone) | 52 | 23 443 | 63 435 | 0.2482 | |
| poly(bottom depth, 3) | 55 | 23 297 | 63 306 | 0.2529 | |
| poly(SST, 3) | 58 | 23 198 | 63 219 | 0.2560 | |
| poly(Annual Anomaly, 3) | 61 | 23 169 | 63 198 | 0.2570 | |
| poly(Tow speed, 3) | 64 | 23 148 | 63 184 | 0.2576 | |
| poly(log(Duration), 3) | 67 | 23 139 | 63 181 | 0.2579 | |

| Binomial erm | DF | Deviance | AIC | R2 | Final |
|---|---|---|---|---|---|
| None | 0 | 23 846 | 23 848 | 0.0000 | |
| Fishing year | 13 | 23 450 | 23 476 | 0.0166 | * |
| Target species | 15 | 22 303 | 22 333 | 0.0647 | * |
| Vessel ID | 36 | 21 388 | 21 460 | 0.1031 | * |
| Month | 47 | 20 920 | 21 014 | 0.1227 | * |
| Statistical area (zone) | 52 | 20 506 | 20 610 | 0.1401 | * |
| poly(Bottom depth 3) | 55 | 20 242 | 20 352 | 0.1511 | * |
| poly(log(Duration) 3) | 58 | 20 158 | 20 274 | 0.1547 | |
| poly(Tow speed 3) | 61 | 20 105 | 20 227 | 0.1569 | |
| poly(log(Distance) 3) | 64 | 20 069 | 20 197 | 0.1584 | |
| poly(SST 3) | 67 | 20 034 | 20 168 | 0.1599 | |
| poly(Annual Anomaly 3) | 70 | 20 027 | 20 167 | 0.1602 | |

### 3.2.7 Model fits

Diagnostic residual plots for the SMST lognormal model are presented in Appendix C, Figure C1. The fit of the data to the lognormal assumption is reasonable, though the standardised residuals display slight skewing and departure in the extreme ends of the distribution.

Influence plots (Jiang & Bentley 2008) for each predictor variable in each model are presented in Appendix D. They illustrate the combined effect of (a) the expected log catch for each level of the variable (model coefficients) and (b) the distribution of the levels of the variable in each year, and therefore describe the influence that the variable has on the unstandardised CPUE and which is accounted for by the standardisation.

**Differences in performance among vessels with respect to snapper catch are well defined and consistent as evidenced by reasonably tight error bars around each coefficient. Changes to the core fleet over the time series has tended to increase observed CPUE, due to the entry of better performing vessels and the loss from**



### 2.3.5 Core fleet definitions

The data sets used for the standardised CPUE analyses were further restricted to those vessels that participated with some consistency in the defined fishery. Core vessels were selected by specifying two variables: the number of trips that determined a qualifying year, and the number of qualifying years that each vessel participated in the fishery.

The core fleet was selected by choosing variable values that resulted in the fewest vessels while maintaining the largest catch of snapper. This selection process generally reduces the number of vessels in the dataset by about 70% while reducing the amount of landed snapper catch by about 20%. Note that the vessels thus selected are not necessarily the top vessels with respect to catching snapper.

### 2.3.6 Models

A lognormal linear model was fitted to successful landed catches of SNA 8, excluding zero catches. Catches were standardised for variance in the explanatory variables using a stepwise multiple regression procedure, selecting explanatory variables until the improvement in model $R^2$ was less than 0.01. The year effects were extracted as canonical coefficients (Francis 1999) so that confidence bounds could be calculated for each year.

The dependent variable for the lognormal models based on allocated landings was the log of landed weight of SNA 8 per record (a single tow). The explanatory variables offered to the model were: *fishing year* (always forced as the first variable), and *month* (of catch), *statistical area*, *target species*, *bottom depth*, *tow speed,* and a unique *vessel* identifier. The logs of the total *distance* and of *tow duration* were offered as alternative measures of effort to explain catch as a catch rate. Continuous effort variables were offered as third order polynomials. Environmental variables were also offered as third order polynomials and included sea surface temperature (*SST*) and *Annual SST Anomaly*.

Binomial models of the probability of capture were fitted to the entire dataset with a binary variable set to '1' for records which had associated SNA 8 catch and set to '0' for records with no catch as the dependent variable. This model was offered the same explanatory variables as the lognormal model. Combined indices were calculated for these fisheries based on methods discussed by Vignaux (1994), Stefansson (1996), and Fletcher et al. (2005).

### 2.3.7 Sub stock areas

Davies et al. (2006) reported no information that would alter the accepted stock boundaries of the west coast snapper stock (SNA 8), and believed that the results of their assessment supported the assumption of the SNA 8 population being a relatively discrete unit stock with boundaries that correspond with those of SNA 8 (Mana Island to North Cape).

Offshore areas were combined with adjacent inshore areas and referred to as zones in this study. A subset of the resultant zones in which the fishery has operated with some consistency were included in the CPUE standardisation. Previous analyses restricted the dataset to the inshore statistical areas but this was done to exclude irrelevant effort targeted at deepwater species. The distinction between the inshore and offshore statistical areas is not otherwise defensible and is not used here, though paucity of data precludes the offshore areas being offered to the standardised CPUE model as individual levels.

## 3. RESULTS

### 3.1 Characterisation of the SNA 8 fisheries

Since 1989–90, bottom single trawl has been the dominant fishing method taking snapper in SNA 8, varying between 55 and 82% of landed catch annually. Most of the balance (11–39% annually) has been taken by bottom pair trawl with consistent but small amounts by bottom longline and set net in each year. Danish seine has accounted for less than 2% of landings in most years, but its importance has been increasing in the most recent three years (Table 4, Figure 6).

**Table 4: Distribution of landed snapper in SNA 8, by method and fishing year, in tonnes and in percent of sub stock annual landings. Catches are raised to the annual QMR catch (Table 1)  0, less than 0.5 t. Percentages sum to 100 by year. BT, bottom trawl; BPT, bottom pair trawl; BLL, bottom longline; SN, set net; DS, Danish seine.**

SNA 8

| Fishing | Fishing method (t) | | | | | | Fishing method (%) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| year | BT | BPT | BLL | SN | DS | Other | BT | BPT | BLL | SN | DS | Other |
| 89/90 | 887 | 611 | 36 | 14 | 0 | 2 | 57 | 39 | 2 | 1 | 0 | 0 |
| 90/91 | 988 | 629 | 23 | 17 | 0 | 0 | 60 | 38 | 1 | 1 | 0 | 0 |
| 91/92 | 945 | 462 | 34 | 20 | 0 | 3 | 65 | 32 | 2 | 1 | 0 | 0 |
| 92/93 | 1173 | 272 | 42 | 54 | 0 | 2 | 76 | 18 | 3 | 4 | 0 | 0 |
| 93/94 | 981 | 472 | 50 | 36 | 2 | 1 | 64 | 31 | 3 | 2 | 0 | 0 |
| 94/95 | 789 | 501 | 64 | 51 | 20 | 8 | 55 | 35 | 4 | 4 | 1 | 1 |
| 95/96 | 921 | 508 | 62 | 44 | 10 | 13 | 59 | 33 | 4 | 3 | 1 | 1 |
| 96/97 | 1241 | 250 | 65 | 48 | 3 | 5 | 77 | 16 | 4 | 3 | 0 | 0 |
| 97/98 | 1299 | 209 | 33 | 44 | 1 | 2 | 82 | 13 | 2 | 3 | 0 | 0 |
| 98/99 | 1105 | 416 | 61 | 48 | 0 | 6 | 68 | 25 | 4 | 3 | 0 | 0 |
| 99/00 | 1044 | 450 | 84 | 24 | 0 | 2 | 65 | 28 | 5 | 1 | 0 | 0 |
| 00/01 | 951 | 489 | 158 | 28 | 1 | 3 | 58 | 30 | 10 | 2 | 0 | 0 |
| 01/02 | 1136 | 305 | 78 | 22 | 8 | 27 | 72 | 19 | 5 | 1 | 1 | 2 |
| 02/03 | 1166 | 269 | 88 | 26 | 4 | 5 | 75 | 17 | 6 | 2 | 0 | 0 |
| 03/04 | 1303 | 217 | 43 | 30 | 24 | 50 | 78 | 13 | 3 | 2 | 1 | 3 |
| 04/05 | 1041 | 525 | 13 | 47 | 5 | 33 | 63 | 32 | 1 | 3 | 0 | 2 |
| 05/06 | 950 | 395 | 15 | 28 | 26 | 21 | 66 | 28 | 1 | 2 | 2 | 1 |
| 06/07 | 1046 | 148 | 19 | 28 | 84 | 3 | 79 | 11 | 1 | 2 | 6 | 0 |
| 07/08 | 963 | 180 | 28 | 26 | 92 | 15 | 74 | 14 | 2 | 2 | 7 | 1 |



### 3.2.6 Model selection (SMST)

The final lognormal model selected for SNA 8 (SMST) is described in Table 8. *Fishing year* was forced as the first variable but explained less than 3% of the variance in catch. *Vessel ID* had the greatest explanatory power, entering the model second and explaining an additional 16 % of the variance in catch. *Month* was important and entered the model third, followed by *Target species.* The final model explained 24% of variance in catches.

There was no significant relation between catch and either of the additional measures of effort available for the trawl method (duration, or distance of the tow), indicating that either catches did not necessarily increase with longer tows (as might occur when suitable habitat is patchy) or that there was little contrast in those factors (as in consistent fishing practices). Neither sea surface temperature nor its annual anomaly were accepted into the model.

The effect on the annual indices as each variable entered the model is shown in Figure 26 and most of the movement away from the unstandardised CPUE index occurs in the final three years after Vessel ID entered the model. The effect of including month and then target species was to lift those points back to more closely resemble the unstandardised series so that overall the effect of standardisation was almost neutral.

The parameterisation of the binomial model was very similar except that statistical area and bottom depth also entered the model. The final model explained 15% of the variance in encounter rate (**Error! Reference source not found.**).

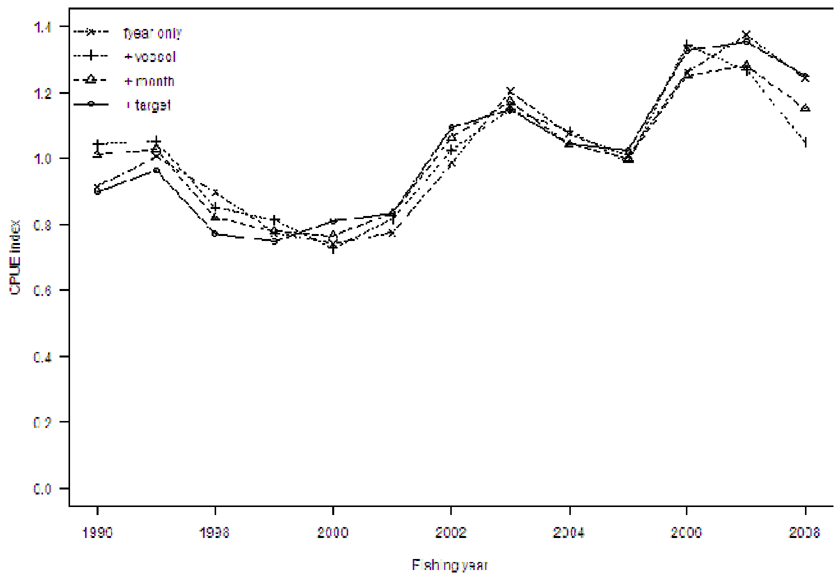


**Figure 26: Annual indices from the SNA 8 (SMST) lognormal model at each step in the variable selection process.**

### 3.2.5 Core vessel selection (SMST)

The core fleet was re-selected after removal of multi-stock trips using the definition of vessels that completed at least three qualifying trips per year (at least one bottom trawl tow targeted at snapper, trevally, or gurnard in Statistical Areas 039–042, 045–047) in at least five years. This reduced the amount of landed greenweight of snapper in the dataset by 1004 tonnes (from 9442 tonnes), and reduced the number of vessels from 60 to the same 22 identified in the V analysis (Figure 24). The selected core fleet of 22 vessels included 9 that had been present in the fishery for at least 10 years. The vessels selected therefore provided excellent coverage and overlap across years (Figure 25).

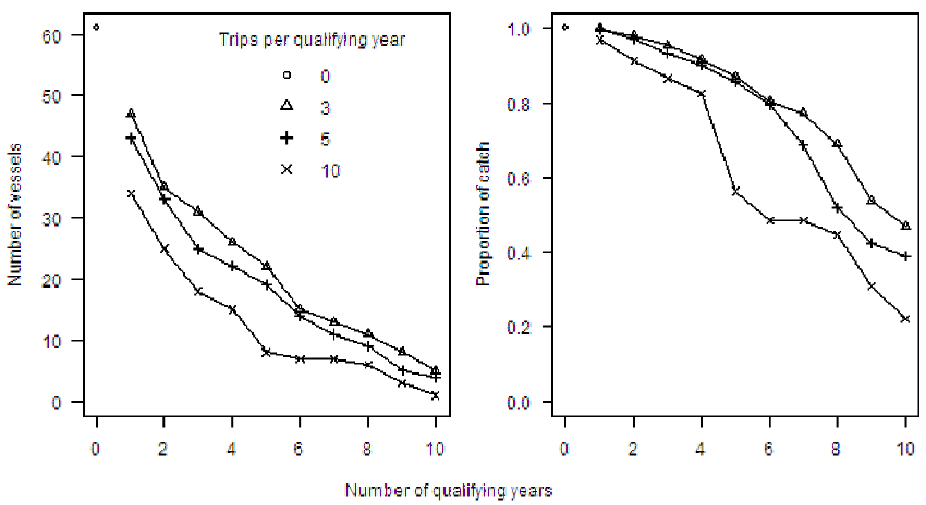


**Figure 24: The number of vessels [top] and the total landed SNA 8 [bottom] retained in the SNA 8 (SMST) dataset depending on the minimum number of qualifying years used to define core vessels. The number of qualifying years (minimum number of trips per year) for each series is indicated in the legend.**

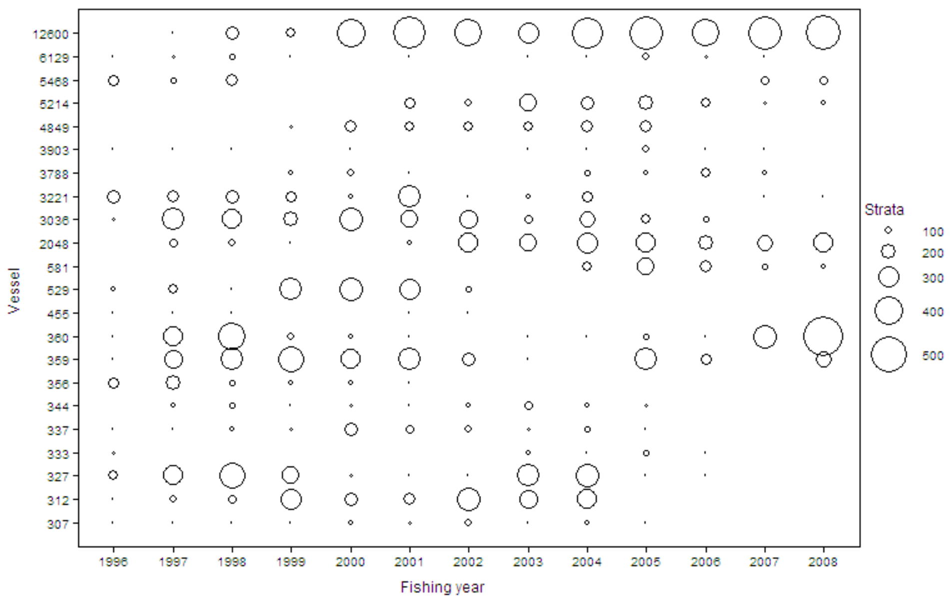


**Figure 25: The participation of selected core vessels (based on at least three trips per year in at least five years) for the SNA 8 (SMST) fishery; number of records for each vessel in each fishing year.**



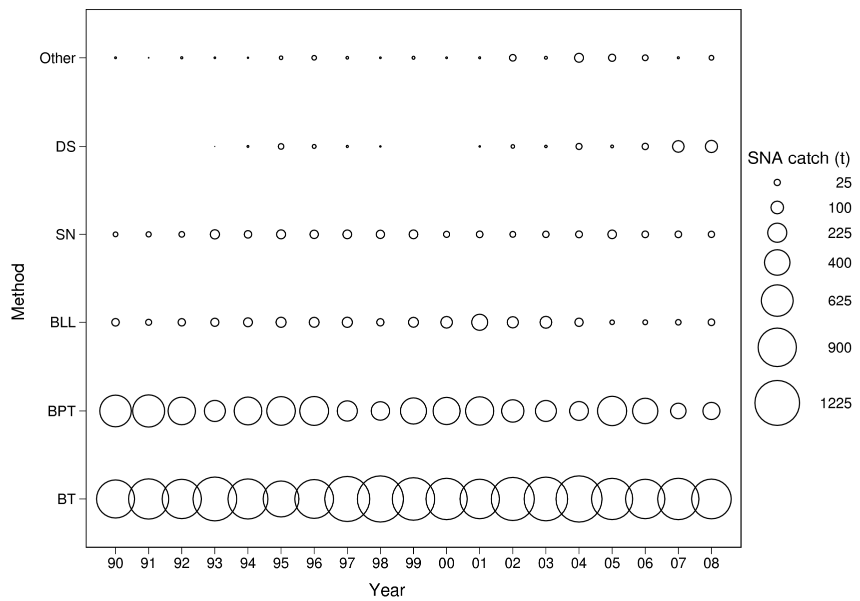


**Figure 6: Distribution of landed snapper by method and by fishing year for SNA 8. Values are given in Table 4.**

### 3.1.1 Characterisation of the bottom trawl fishery

The bottom trawl catch of SNA 8 is mainly from target fishing with most of the balance taken as a bycatch of trevally tows. Target catch accounted for higher proportions (64–75%) of landed SNA 8 in the first half of the time series than it did after 1997–98 (35–56%). In 2007–08 snapper as a bycatch of trevally exceeded targeted catch for the first time. Bycatch of tows targeted at gurnard has also accounted for some of the shift away from targeted catch, accounting for 11–23% of landed SNA 8 annually since 1997–98. Consistent but smaller amounts (less than 50 t annually) have been taken as bycatch of the tarakihi bottom trawl fishery, and in some years, similar amounts from the barracouta target fishery (Table 5, Figure 7).

The seasonality of the four most important target fisheries taking SNA 8 by bottom trawl is shown in Figure 8. Targeting of snapper has consistently been focused on the spring months from October to December, although catches occur throughout the year. Bycatch from trevally tows is greatest between November and March, coincident with the seasonal pattern of that target species. The bycatch from gurnard and barracouta tows has no strong seasonal pattern.

**Table 5: Distribution of bottom trawl caught snapper by target species (snapper, trevally, red gurnard tarakihi, barracouta, and other) and by fishing year for SNA 8, in tonnes and percent. Catches are scaled up to the annual QMR catch (Table 1). 0, less than 0.5 tonne. Percentages sum to 100 by year.**

SNA 8

| Fishing | Target species (t) | | | | | | Target species (%) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| year | SNA | TRE | GUR | TAR | BAR | Other | SNA | TRE | GUR | TAR | BAR | Other |
| 89/90 | 649 | 121 | 72 | 25 | 3 | 18 | 73 | 14 | 8 | 3 | 0 | 2 |
| 90/91 | 648 | 217 | 83 | 27 | 7 | 6 | 66 | 22 | 8 | 3 | 1 | 1 |
| 91/92 | 704 | 104 | 114 | 12 | 5 | 7 | 74 | 11 | 12 | 1 | 0 | 1 |
| 92/93 | 811 | 194 | 83 | 28 | 7 | 51 | 69 | 16 | 7 | 2 | 1 | 4 |
| 93/94 | 712 | 158 | 52 | 24 | 11 | 23 | 73 | 16 | 5 | 2 | 1 | 2 |
| 94/95 | 592 | 103 | 25 | 19 | 5 | 47 | 75 | 13 | 3 | 2 | 1 | 6 |
| 95/96 | 662 | 137 | 49 | 20 | 32 | 20 | 72 | 15 | 5 | 2 | 3 | 2 |
| 96/97 | 801 | 252 | 118 | 40 | 17 | 14 | 65 | 20 | 9 | 3 | 1 | 1 |
| 97/98 | 825 | 297 | 137 | 24 | 5 | 12 | 64 | 23 | 11 | 2 | 0 | 1 |
| 98/99 | 557 | 311 | 168 | 31 | 11 | 27 | 50 | 28 | 15 | 3 | 1 | 2 |
| 99/00 | 339 | 429 | 184 | 45 | 33 | 15 | 32 | 41 | 18 | 4 | 3 | 1 |
| 00/01 | 462 | 286 | 152 | 19 | 14 | 18 | 49 | 30 | 16 | 2 | 1 | 2 |
| 01/02 | 488 | 428 | 130 | 15 | 66 | 9 | 43 | 38 | 11 | 1 | 6 | 1 |
| 02/03 | 661 | 272 | 159 | 27 | 37 | 10 | 57 | 23 | 14 | 2 | 3 | 1 |
| 03/04 | 735 | 376 | 148 | 13 | 18 | 14 | 56 | 29 | 11 | 1 | 1 | 1 |
| 04/05 | 500 | 287 | 199 | 18 | 27 | 9 | 48 | 28 | 19 | 2 | 3 | 1 |
| 05/06 | 410 | 267 | 218 | 14 | 22 | 19 | 43 | 28 | 23 | 1 | 2 | 2 |
| 06/07 | 563 | 336 | 116 | 21 | 6 | 4 | 54 | 32 | 11 | 2 | 1 | 0 |
| 07/08 | 335 | 448 | 135 | 26 | 7 | 12 | 35 | 47 | 14 | 3 | 1 | 1 |

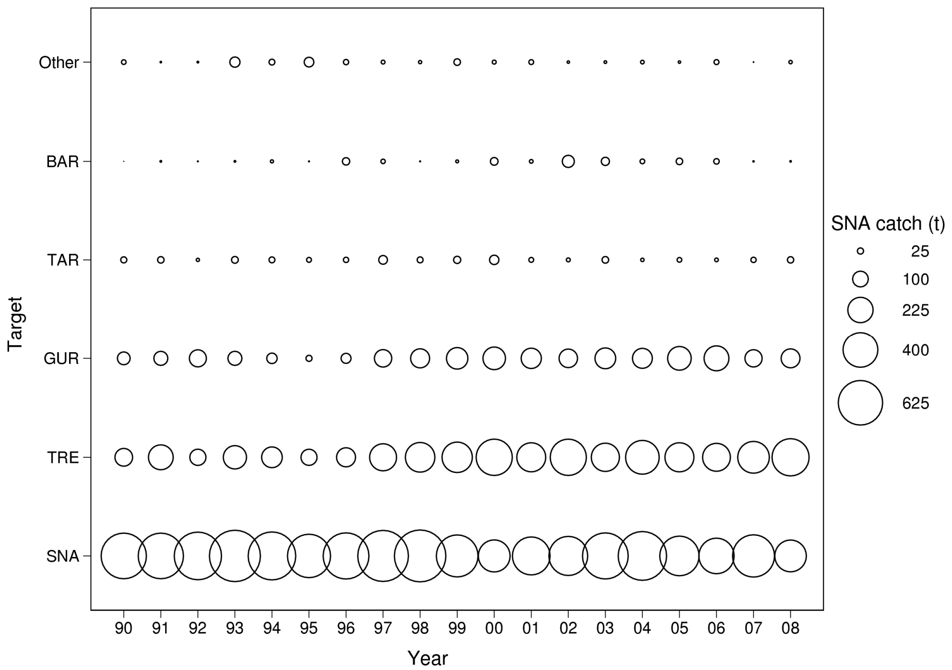


**Figure 7: Distribution of bottom trawl caught snapper, for SNA 8, by target species and fishing year. Circle areas are proportional to the catch totals by area, with the circle values given in Table 5.**



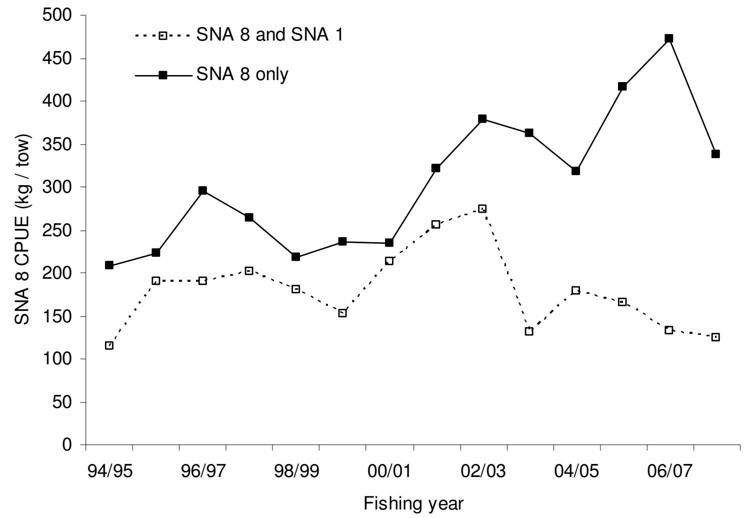


**Figure 22: Simple arithmetic annual CPUE (kg / tow) of SNA 8 for all qualifying vessels (used bottom trawl method in statistical areas valid for SNA 8 and targeted snapper, trevally, or gurnard and reported on TCEPR or TCE forms) for trips that landed to SNA 8 only compared with trips that landed to both SNA 8 and SNA 1 Fishstocks.**

### 3.2.4 Description of the defined fishery SNA 8 (SMST)

The defined SMST fishery is described by variable but generally declining effort in which almost all trips are successful with respect to snapper. The pattern of CPUE in successful tows has been one of increase since the late 1990s but shows a steep decrease in the most recent year (Figure 23). Because this fishery is reported on TCEPRs / TCEs there is no roll-up of effort or records to examine for trends that might confound the binomial analysis of encounter rate.

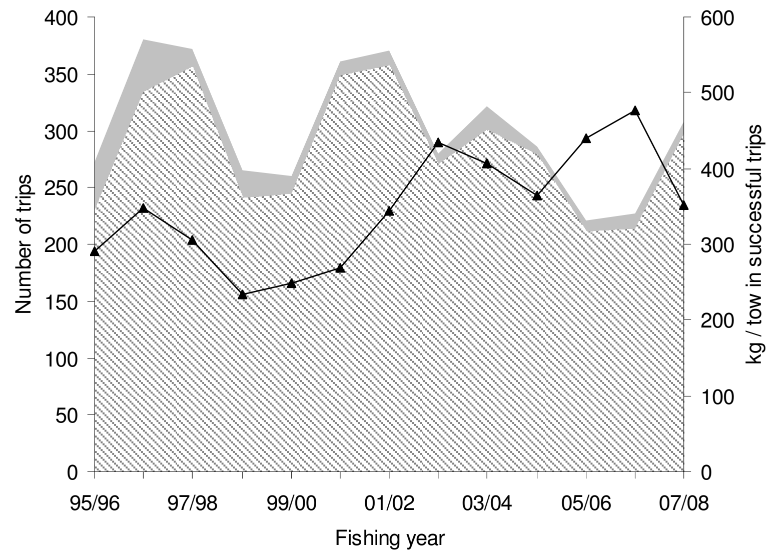


**Figure 23: Total effort (qualifying trips [dark grey]) and the proportion of those trips that landed snapper [light grey] by fishing year for the defined SNA 8 SMST fishery. Simple arithmetic catch rate (kg per positive tow [line]).**

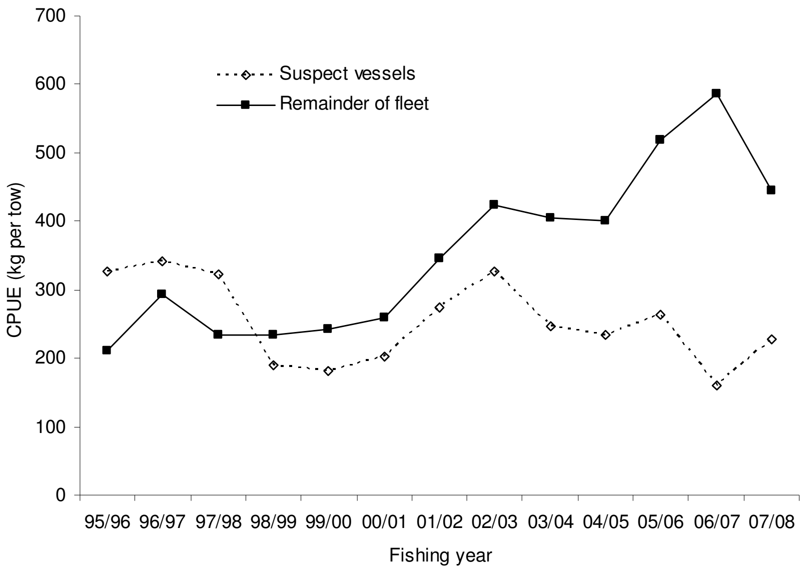


**Figure 21: Comparison of simple arithmetic CPUE (kg per tow) for vessels identified by MFish as "suspect", and for the remainder of core vessels. Neither analysis is described in detail in this report.**

### Suspect vessels removed (SV)

The removal of the eight suspect vessels from the core fleet further reduced the landed catch of SNA 8 in the dataset by 2518 t. An additional CPUE standardisation was undertaken and is not reported here in detail, but the annual indices are compared in Section 3.2.9. As expected, it yielded a more optimistic trajectory but the difference, though marked, was largely associated with a very few recent years, and the exclusion of all data for those vessels seemed unnecessarily harsh.

We were unable to exactly duplicate the selection of "suspect" vessels and it may have included an element of subjectiveness that was not easily quantifiable. A summary of the (SV) dataset is included in Appendix A.

### Multi-stock trips removed (SMST)

A more defensible approach is to identify trips that fished to both SNA 8 and SNA 1 and exclude those from the dataset before selection of the core fleet of vessels. There were also a few trips that fished to both SNA 8 and SNA 7, but those instances were sparse and the boundary between the two Fishstocks is some considerable distance south of the important statistical areas of SNA 8, so those trips were not considered to be part of the problem.

Multi-stock (SNA 8 & SNA 1) trips accounted for just 814 t of SNA 8 in the defined fishery and a simple analysis conducted using all vessels (before selection of a core fleet) suggests that they may have been used to misreport catch and effort throughout the time series, not just in the most resent few years (Figure 22).

Excluding multi-stock trips reduced the amount of landed catch of SNA 8 in the analysis dataset by 744 t, yet resulted in no change to the core fleet selected. It is a repeatable and non-subjective process that removes all potential for contamination by (this type of) misreporting, without severely compromising the time series of data available. That analysis is described below in detail and is the preferred series; referred to as the Sans Multi Stock Trips (SMST) fleet / dataset / analysis. A summary of the SMST dataset is included in Appendix A.



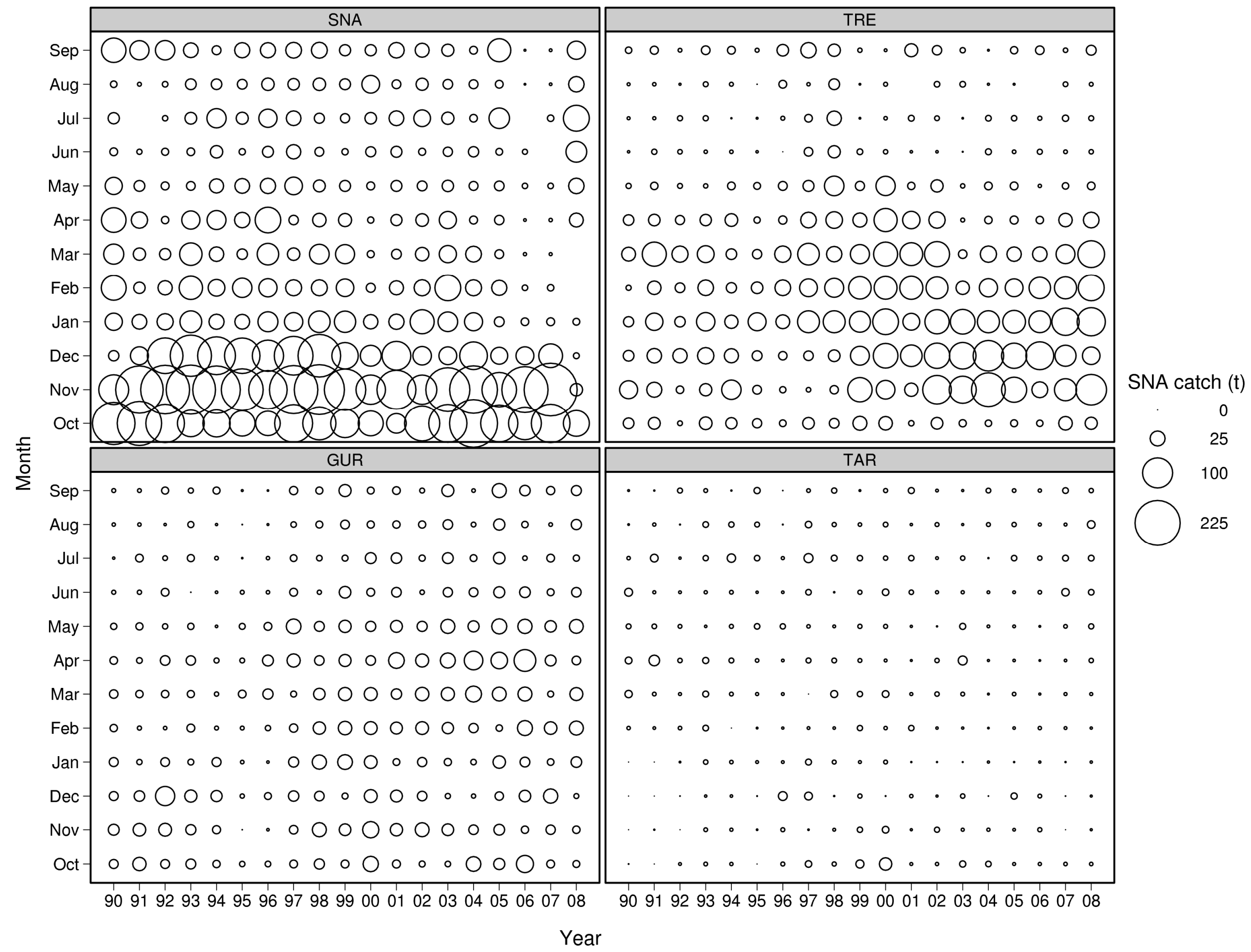


**Figure 8: Comparison of the seasonal distribution of bottom trawl snapper catches for the four main target fisheries in SNA 8, by fishing year. Circle areas are proportional to the catch totals for month and target species, summing to the annual totals given in Table 5.**

The spatial distributions of snapper catch for the four main target fisheries look similar with most of the catch of snapper coming from Statistical Area 045 regardless of target species: Area 042 is the next most important for both snapper and trevally target, with more sporadic annual catches from Areas 047 and 041. Most of the bycatch from gurnard tows comes from Statistical Area 041 in each year. Areas 043 and 044 are harbours that are protected from commercial trawling and are not included (Figure 9).

The depth distribution of tows targeted at snapper varies around 50 m bottom depth, as do positive tows (with respect to snapper) that were targeted at trevally. Positive tows targeted at gurnard were often shallower and tarakihi tows occurred much deeper, more typically centred around 100 m bottom depth (Figure 10). There is also a clear difference in tow speed reported on TCEPRs and TCEs for tows targeted at trevally versus snapper, with trevally tows faster on average in each year, although the difference falls within the interannual variance for each (Figure 11).

The shift in reporting practice that has already been described for the bottom trawl fishery is apparent as an abrupt change in 1995–96 (Table 6), from 64% of snapper catch reported on the daily CELR in the previous year to less than 35% in 1995–96. That proportion has continued to decline further rendering any analysis based solely on the CELR form type unrepresentative, and any analysis based on both form types as unnecessarily coarse.

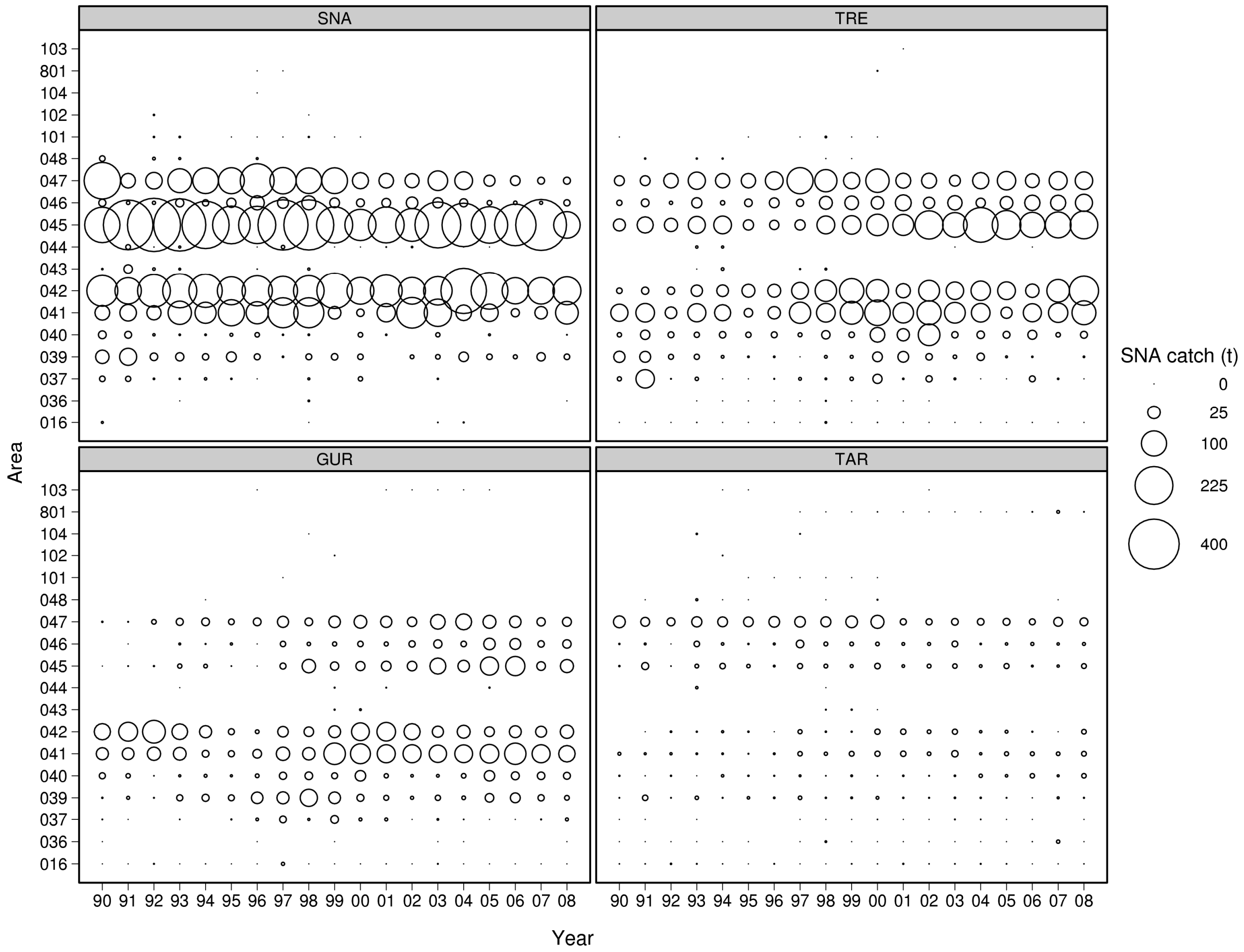


**Figure 9: Comparison of the areal distribution of bottom trawl snapper catches by fishing year. Circle areas are proportional to the catch totals by statistical area, summing to the annual totals given in Table 5.**

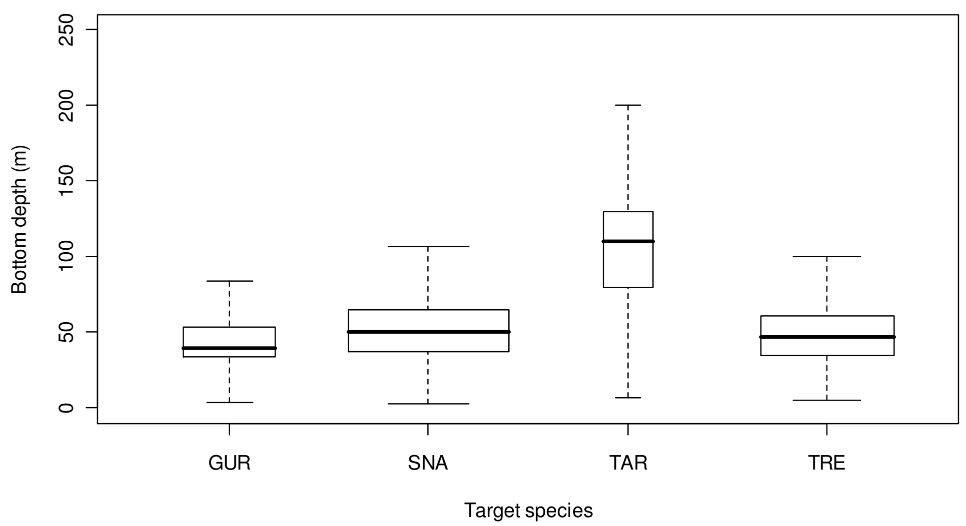


**Figure 10: Box plot distributions (median and interquartiles) of bottom depth from TCEPR or TCE records of the single bottom trawl method for the four main target species where a catch of snapper was reported (positive tows). All years and statistical areas combined. The width of the boxes is proportional to the number of records.**



effort that is targeted at deepwater species. In this study we used the alternative approach of defining effective effort as tows targeted at the main inshore target species. This is also somewhat arbitrary, but hopefully a little more consistent over time. The sensitivity of the lognormal model results to this change in the definition of the fishery was examined and found to be slight (See Section 3.2.9)

**SNA 8 _BT 1 - Previously accepted series**

Trips that landed SNA 8

Events that

- used bottom (single) trawl method
- reported on TCEPR tow-by-tow form
- started in 1995–96
- fished in inshore statistical areas 039, 040, 041, 042, 045, 046, 047
- included all target species; with Y/N categorical variable
- reported positive estimated catches

**SNA 8 _BT 2 – Changes made this study**

- Statistical Areas 039, 040, 041, 042, 045, 046, 047 including adjacent offshore areas
- Top three target species SNA, TRE, GUR only, so that zero catch effort is relevant.
- Allocated landed catch standardised, zero catches modelled separately, and combined model presented

This study used landed catch rather than estimated catch in the analysis, but because snapper is well reported (estimated) in the fishery defined above, this was not expected to significantly impact on the lognormal year effects for this Fishstock.

### 3.2.2 Core vessel selection (V)

The core fleet was defined on the basis of participation in the defined fishery, not on the basis of snapper catch as was done previously. The core fleet was defined as vessels that had completed at least three qualifying trips (included at least one bottom trawl tow targeted at snapper, trevally, or gurnard in Statistical Areas 039–042, 045–047) in at least five years. This reduced the amount of landed greenweight of snapper in the dataset by 1074 tonnes (from 10 256 tonnes), and reduced the number of vessels from 60 to 22 (Figure 24). The selected core fleet comprised almost twice as many vessels (22) as the previous analysis did (12), including 9 that had been present in the fishery for at least 10 years. However, the results of the previous study were found to be relatively insensitive to the inclusion of more (24) core vessels.

A standardised CPUE analysis based on this virgin (V) dataset was presented to a meeting of the Inshore Working Group and was described in an unpublished Research Progress Report for this project (SNA2008-03). It is considered to be flawed, however, because of the problem of "trucking" described below, and is not described in any detail in this report. Where comparisons are drawn to it, it is referred to as the virgin (V) fleet / dataset /analysis. A summary of the V dataset is included in Appendix A.

### 3.2.3 Grooming for potential misreporting

MFish advised that the potential for "trucking" of SNA 8 catch by vessels that transited (and fished in) SNA 1 was of concern, and that large differences in trip-based SNA 8 nominal CPUE for 8 of the 22 core vessels when they fished SNA 8 only, or both SNA 8 and SNA 1, suggested that they may have been misreporting catch and effort data. Unstandardised CPUE for the suspect vessels is compared to that for the remainder of the vessels in the core fleet in Figure 21 and the divergence can be seen to be particularly pronounced after 2002–03. As this could potentially negatively bias the trend in relative abundance an additional CPUE standardisation was requested after removing the data for these vessels.

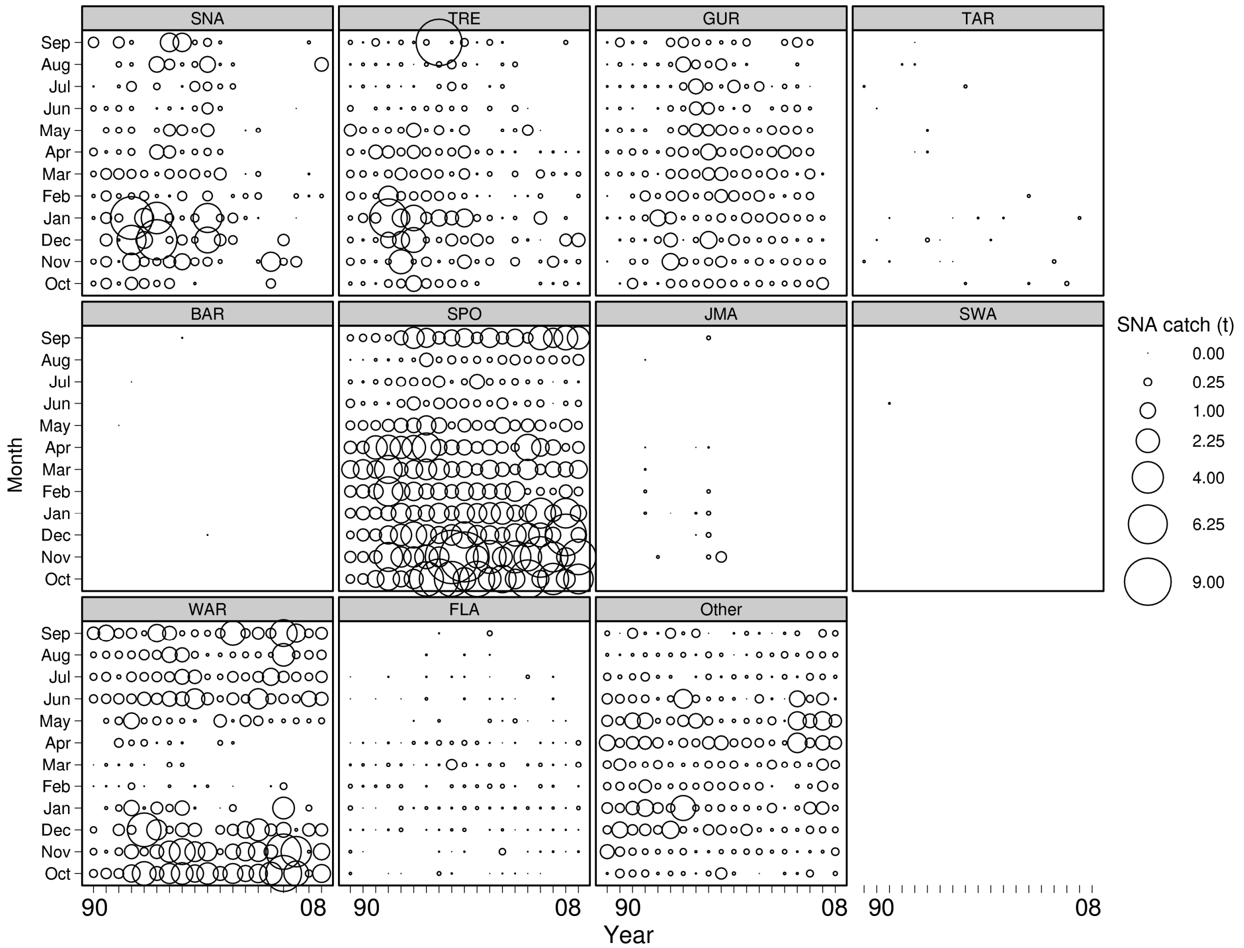


**Figure 20: SNA catch (t) by year, month, and target for method SN. Years are fishing years (e.g., 90 = 1 Oct 1989 to 30 Sep 1990).**

### 3.2 Standardised CPUE

#### 3.2.1 Fishery definitions for standardised CPUE analysis

The currently accepted CPUE series of abundance indices for SNA 8 is based on the single bottom trawl catch and effort data. The characterisation done for the present study confirms this data set and fishing method to be the most appropriate for monitoring the SNA 8 stock. Although there is also a long time series of bottom pair trawl data available, this contains few data and the time series is also compromised by a steep decline in effort (number of vessels) in the most recent couple of years that renders it less useful for monitoring the rebuild of the stock. The bottom longline and set net methods were not seriously considered as contenders for a standardised CPUE analysis due to the paucity and poor spatial and temporal representivity of the data.

#### SNA8_BT

SNA 8 has previously been monitored in single bottom trawl tows that fished in one of the inshore (coastal) statistical areas valid for SNA 8 and reported a positive catch of snapper. The fishery was not restricted to any particular targets. This is a reasonable way to define a fishery if only the positive catches are to be analysed, as in a lognormal model of catch rates in successful effort. Our concern was that the unsuccessful effort in such a fishery might vary with the availability or marketability of other species and not be consistent enough to give a meaningful signal of encounter (success) rate that could be modelled separately. The statistical area boundaries are somewhat arbitrary delineators of a fishery and in this study they were not used directly. Nevertheless they do serve to exclude a lot of irrelevant bottom trawl



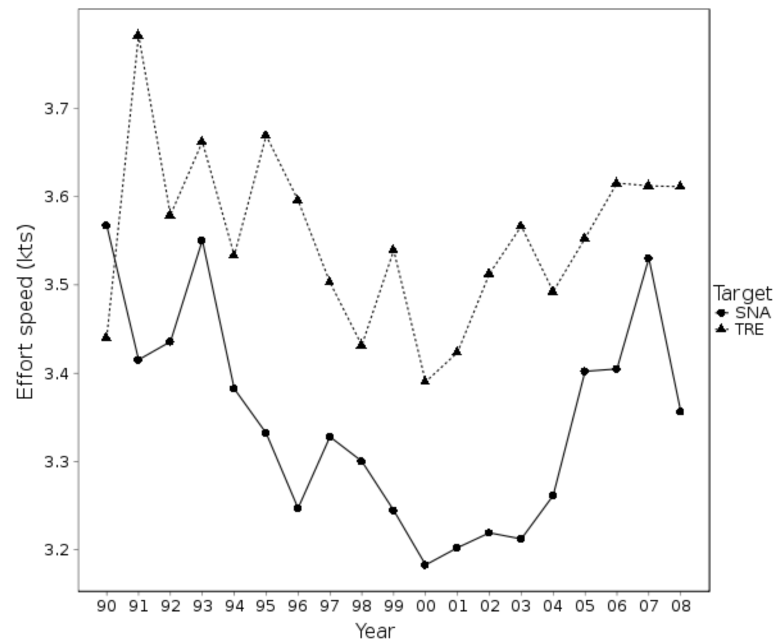


**Figure 11: Mean tow speed for positive bottom trawl tows targeted at trevally or at snapper and reported on TCEPR/TCEs by fishing year.**

**Table 6: Reporting practice in the SNA 8 bottom trawl fishery; bottom trawl-caught SNA 8 by landed weight (t) and percent reported on the daily form (CELR), the tow-by-tow form (TCEPR), and the new TCE tow-by-tow form by fishing year.**

| | SNA 8 Bottom trawl | | | | | |
|---|---|---|---|---|---|---|
| Fishing | Landed SNA 8 (t) | | | Landed SNA 8 (%) | | |
| year | TCEPR | CELR | TCE | TCEPR | CELR | TCE |
| 89/90 | 248 | 638 | 0 | 28 | 72 | 0 |
| 90/91 | 93 | 895 | 0 | 9 | 91 | 0 |
| 91/92 | 201 | 744 | 0 | 21 | 79 | 0 |
| 92/93 | 513 | 660 | 0 | 44 | 56 | 0 |
| 93/94 | 345 | 637 | 0 | 35 | 65 | 0 |
| 94/95 | 286 | 503 | 0 | 36 | 64 | 0 |
| 95/96 | 600 | 321 | 0 | 65 | 35 | 0 |
| 96/97 | 1033 | 209 | 0 | 83 | 17 | 0 |
| 97/98 | 1078 | 222 | 0 | 83 | 17 | 0 |
| 98/99 | 746 | 359 | 0 | 68 | 32 | 0 |
| 99/00 | 729 | 315 | 0 | 70 | 30 | 0 |
| 00/01 | 791 | 160 | 0 | 83 | 17 | 0 |
| 01/02 | 987 | 149 | 0 | 87 | 13 | 0 |
| 02/03 | 1016 | 150 | 0 | 87 | 13 | 0 |
| 03/04 | 1232 | 71 | 0 | 95 | 5 | 0 |
| 04/05 | 964 | 76 | 0 | 93 | 7 | 0 |
| 05/06 | 842 | 107 | 0 | 89 | 11 | 0 |
| 06/07 | 965 | 81 | 0 | 92 | 8 | 0 |
| 07/08 | 758 | 3 | 202 | 79 | 0 | 21 |

### 3.1.2 Characterisation of the bottom pair trawl fishery

The bottom pair trawl catch of SNA 8 is also mainly from target fishing with most of the balance taken as a bycatch of trevally tows. Targeting of snapper has generally accounted for a decreasing proportion of the landed catch, but there have been some dramatic shifts in targeting that has seen years when almost none was targeted (2003–04) and other years when almost none was taken as bycatch of trevally (1996–97). Bycatch of sets targeted at gurnard, tarakihi, and barracouta has accounted for small and sporadic amounts over the time series with barracouta sets being briefly important in the early part of the 2000s and catch from gurnard and tarakihi sets briefly higher in 2006–07 than at any time previously (Table 7, Figure 12).

Much of this pattern of shifting emphasis of target will be related to changes in the small fleet of vessels using this method. In the first half of the time series there were generally about a dozen vessels that participated in this fishery, but that number dropped by about half during the last half of the time series (Figure 13).

The seasonality of the four most important target fisheries taking SNA 8 by bottom pair trawl is shown in Figure 14. Targeting of snapper has consistently been focused on the winter/spring months from August to December, although catches occur throughout the year. Bycatch from trevally tows is greatest between November and March, coincident with the seasonal pattern of that target species. The bycatch from gurnard and barracouta tows has no strong seasonal pattern.

**Table 7: Distribution of bottom pair trawl caught snapper by target species (snapper, trevally, red gurnard tarakihi, barracouta and other) and by fishing year for SNA 8 in tonnes and percent. Catches are scaled up to the annual QMR catch (Table 1). 0, less than 0.5 tonne. Percentages sum to 100 by year.**

| | | | | | | | | | | | | SNA 8 bottom pair trawl |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Fishing | Target species (t) | | | | | | Target species (%) | | | | | |
| year | SNA | TRE | GUR | TAR | BAR | Other | SNA | TRE | GUR | TAR | BAR | Other |
| 89/90 | 502 | 109 | 0 | 0 | 0 | 0 | 82 | 18 | 0 | 0 | 0 | 0 |
| 90/91 | 327 | 295 | 0 | 1 | 0 | 6 | 52 | 47 | 0 | 0 | 0 | 1 |
| 91/92 | 305 | 152 | 1 | 3 | 0 | 0 | 66 | 33 | 0 | 1 | 0 | 0 |
| 92/93 | 165 | 105 | 1 | 0 | 0 | 0 | 61 | 39 | 0 | 0 | 0 | 0 |
| 93/94 | 431 | 31 | 9 | 0 | 1 | 0 | 91 | 7 | 2 | 0 | 0 | 0 |
| 94/95 | 468 | 20 | 8 | 0 | 0 | 5 | 94 | 4 | 2 | 0 | 0 | 1 |
| 95/96 | 413 | 51 | 21 | 0 | 2 | 20 | 81 | 10 | 4 | 0 | 0 | 4 |
| 96/97 | 231 | 0 | 19 | 0 | 0 | 0 | 92 | 0 | 8 | 0 | 0 | 0 |
| 97/98 | 188 | 7 | 15 | 0 | 0 | 0 | 90 | 3 | 7 | 0 | 0 | 0 |
| 98/99 | 379 | 31 | 5 | 0 | 0 | 0 | 91 | 7 | 1 | 0 | 0 | 0 |
| 99/00 | 290 | 116 | 6 | 9 | 23 | 7 | 64 | 26 | 1 | 2 | 5 | 2 |
| 00/01 | 216 | 212 | 0 | 13 | 38 | 11 | 44 | 43 | 0 | 3 | 8 | 2 |
| 01/02 | 53 | 251 | 0 | 0 | 0 | 2 | 17 | 82 | 0 | 0 | 0 | 1 |
| 02/03 | 73 | 179 | 5 | 5 | 0 | 8 | 27 | 66 | 2 | 2 | 0 | 3 |
| 03/04 | 1 | 211 | 4 | 1 | 0 | 0 | 0 | 97 | 2 | 0 | 0 | 0 |
| 04/05 | 284 | 241 | 0 | 0 | 0 | 0 | 54 | 46 | 0 | 0 | 0 | 0 |
| 05/06 | 268 | 121 | 4 | 1 | 0 | 0 | 68 | 31 | 1 | 0 | 0 | 0 |
| 06/07 | 71 | 41 | 18 | 18 | 0 | 0 | 48 | 28 | 12 | 12 | 0 | 0 |
| 07/08 | 24 | 141 | 0 | 15 | 0 | 0 | 13 | 78 | 0 | 8 | 0 | 0 |



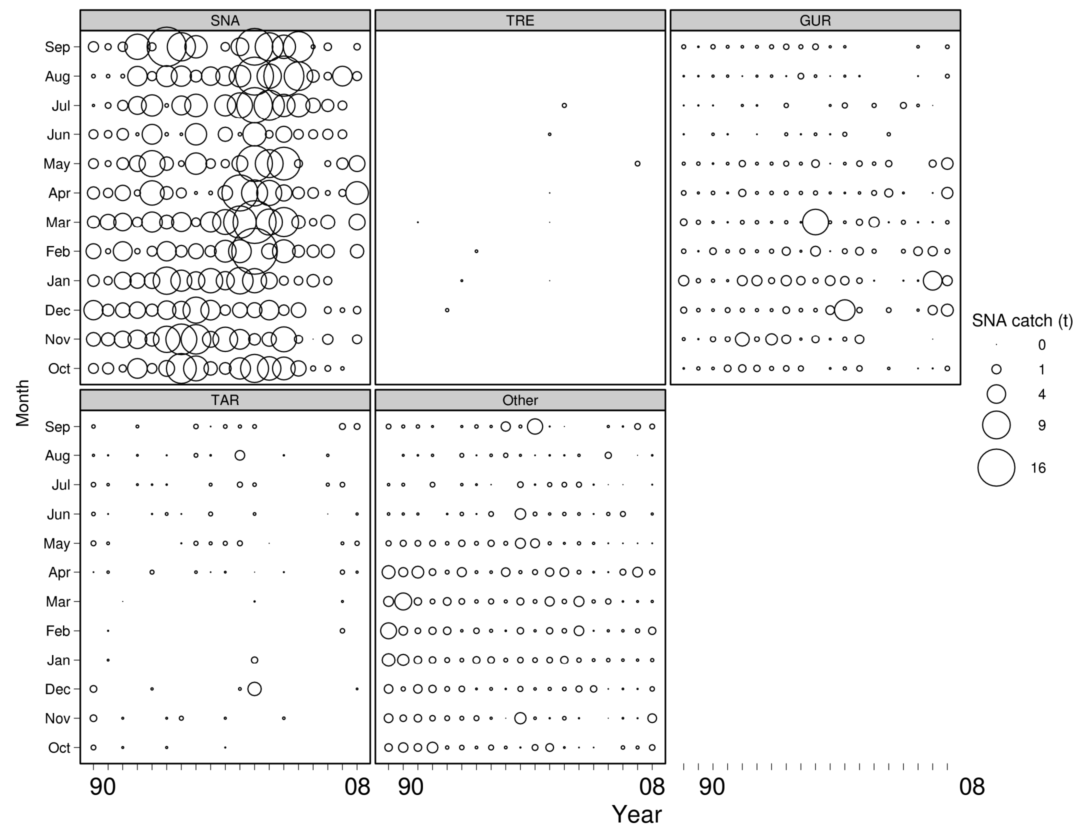


**Figure 18: SNA catch (t) by year, month, and target for method BLL. Years are fishing years (e.g., 90 = 1 Oct 1989 to 30 Sep 1990).**

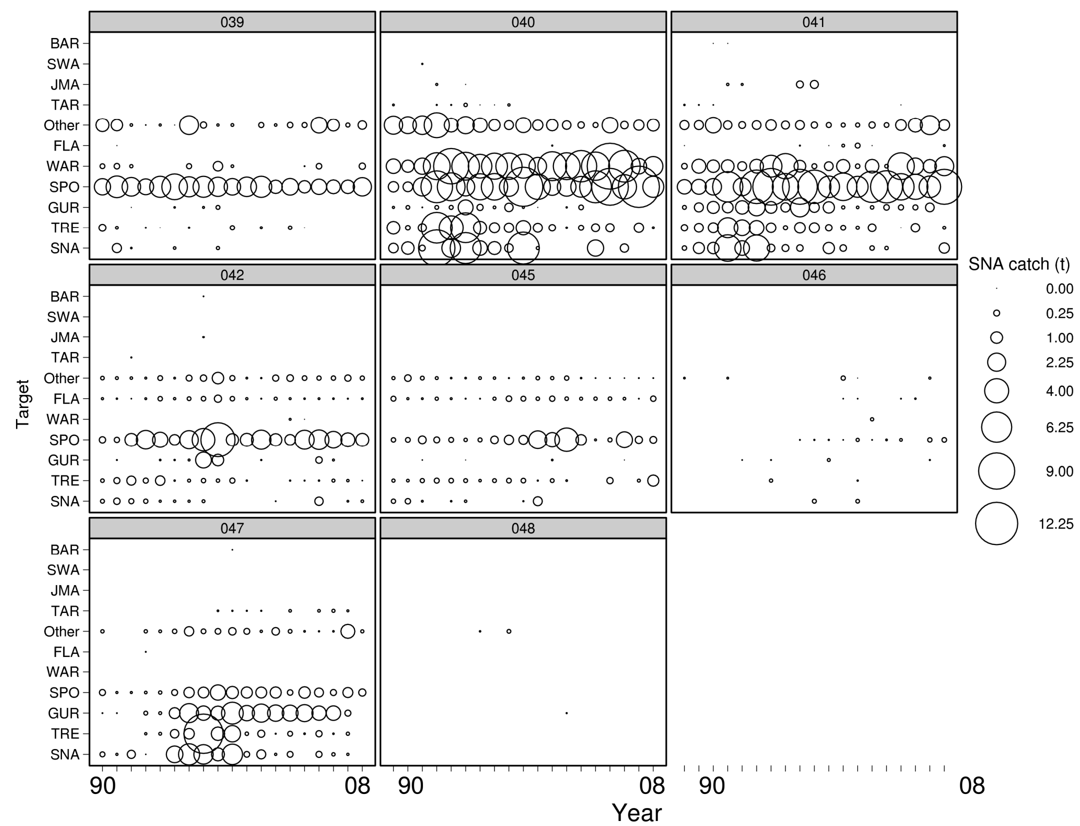


**Figure 19: SNA 8 catch (t) by year, target species, and statistical area (zone) for method SN. Years are fishing years (e.g., 90 = 1 Oct 1989 to 30 Sep 1990).**

### 3.1.3 Other SNA 8 fisheries

There are reasonably consistent time series of catch effort for both bottom longline and set net in SNA 8 that each take between 50 and 100 t of snapper per year (see Table 4).

Bottom longline is mostly targeted at snapper in Area 047 (Figure 17), and is less seasonal than either of the trawl methods (Figure 18). Catches peaked in 2000–01 and have decreased since then. Further south in Areas 040 and 041, snapper is almost as often a bycatch of sets targeted at gurnard, tarakihi, and a large number of other species (Figure 17) and is more focused on the summer months (Figure 18). There is no depth information available for this method.

SNA 8 taken by set net is mostly a bycatch of sets on rig and on warehou in Statistical Areas 040 and 041 (See Figure 20). The rig fishery is a summer fishery with lowest catches in May–August, and the warehou fishery catches snapper in the late winter through spring, with the lowest catches generally between January and May (See Figure 19). Some targeting of snapper by this method was done in Areas 040, 041, and 047 in the first half of the time series but there has been very little targeted catch this decade. There is no depth information available for this method.

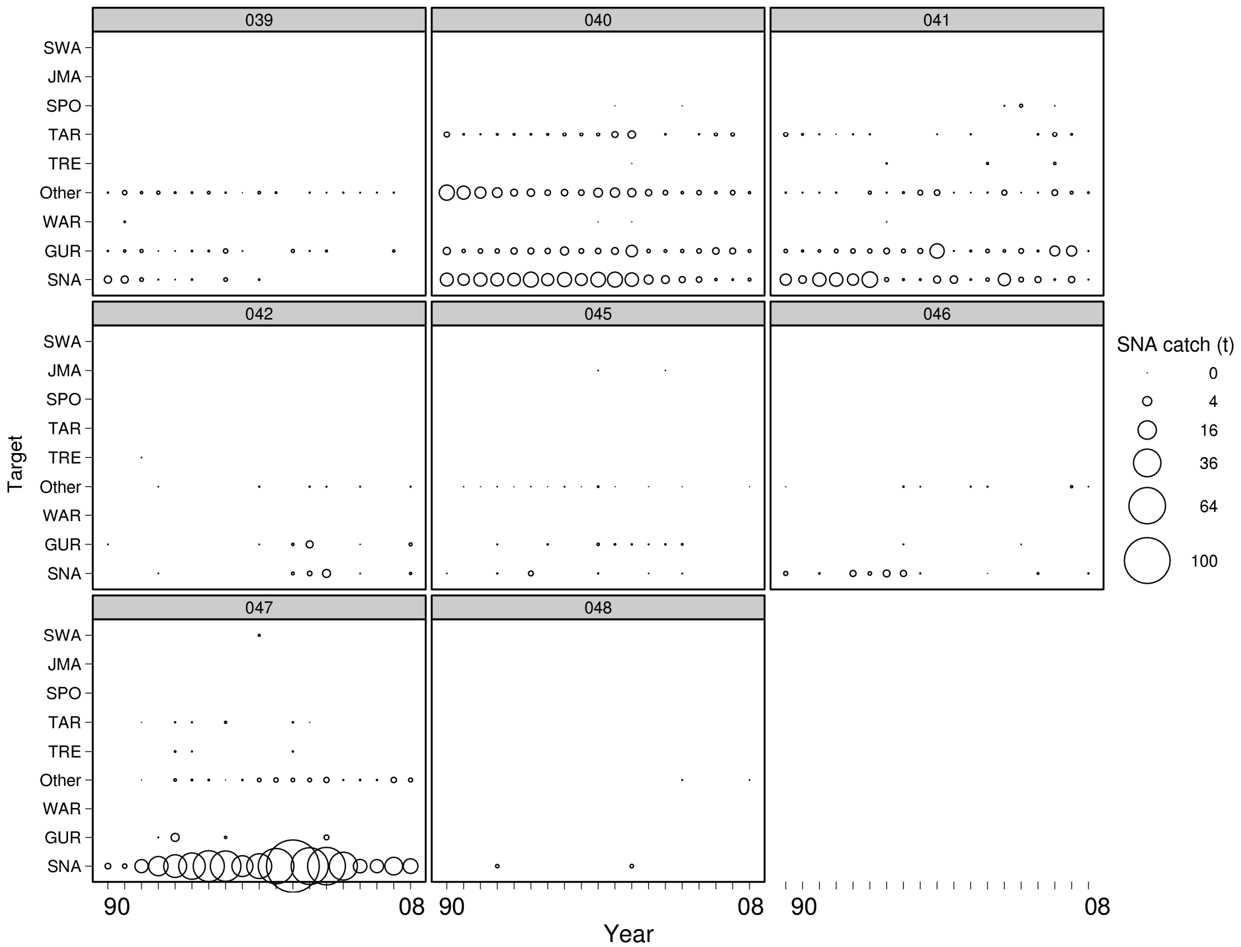


**Figure 17: SNA catch (t) by year, target and statistical area (zone) for method BLL. Years are fishing years (e.g., 90 = 1 Oct 1989 to 30 Sep 1990).**



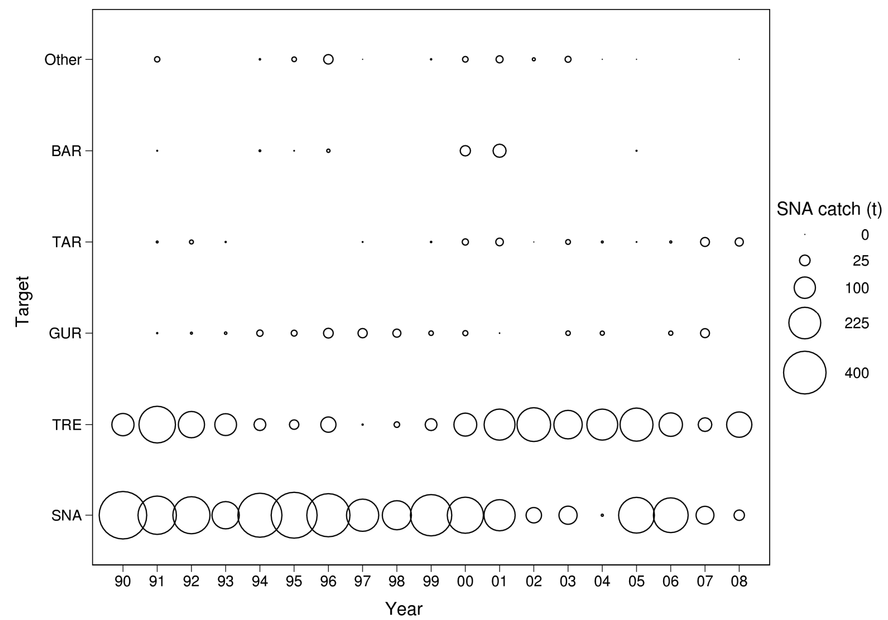


**Figure 12: Distribution of bottom pair trawl caught snapper, for SNA 8, by target species and fishing year. Circle areas are proportional to the catch totals by area, with the circle values given in Table 7.**

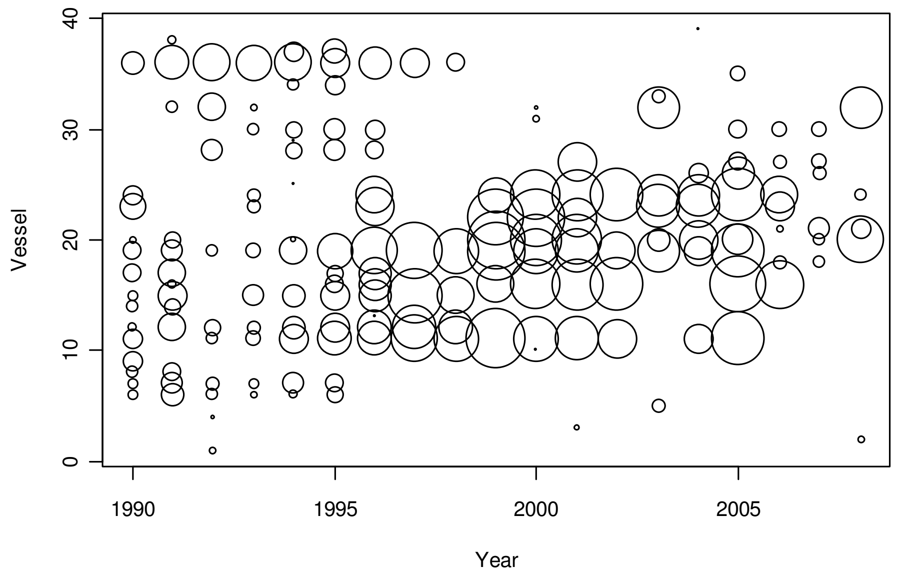


**Figure 13: Participation (sets) of all bottom pair trawl vessels in SNA 8 by fishing year. Area of circle is proportional to the number of records.**

The spatial distributions of snapper catch in the four main target fisheries look similar, with most catch of snapper coming from Statistical Areas 045 and 047 regardless of target species. Area 042 is the next most important for both snapper and trevally target, with more sporadic annual catches from Areas 046 and 041. Most of the bycatch from gurnard tows, however, comes from Statistical Area 041 in each year. Areas 043 and 044 are harbours that are protected from commercial trawling and are not included. Bycatch of trevally shots extended further south than target fishing, particularly during the early 1990s, into Areas 039 and 040 (Figure 15).

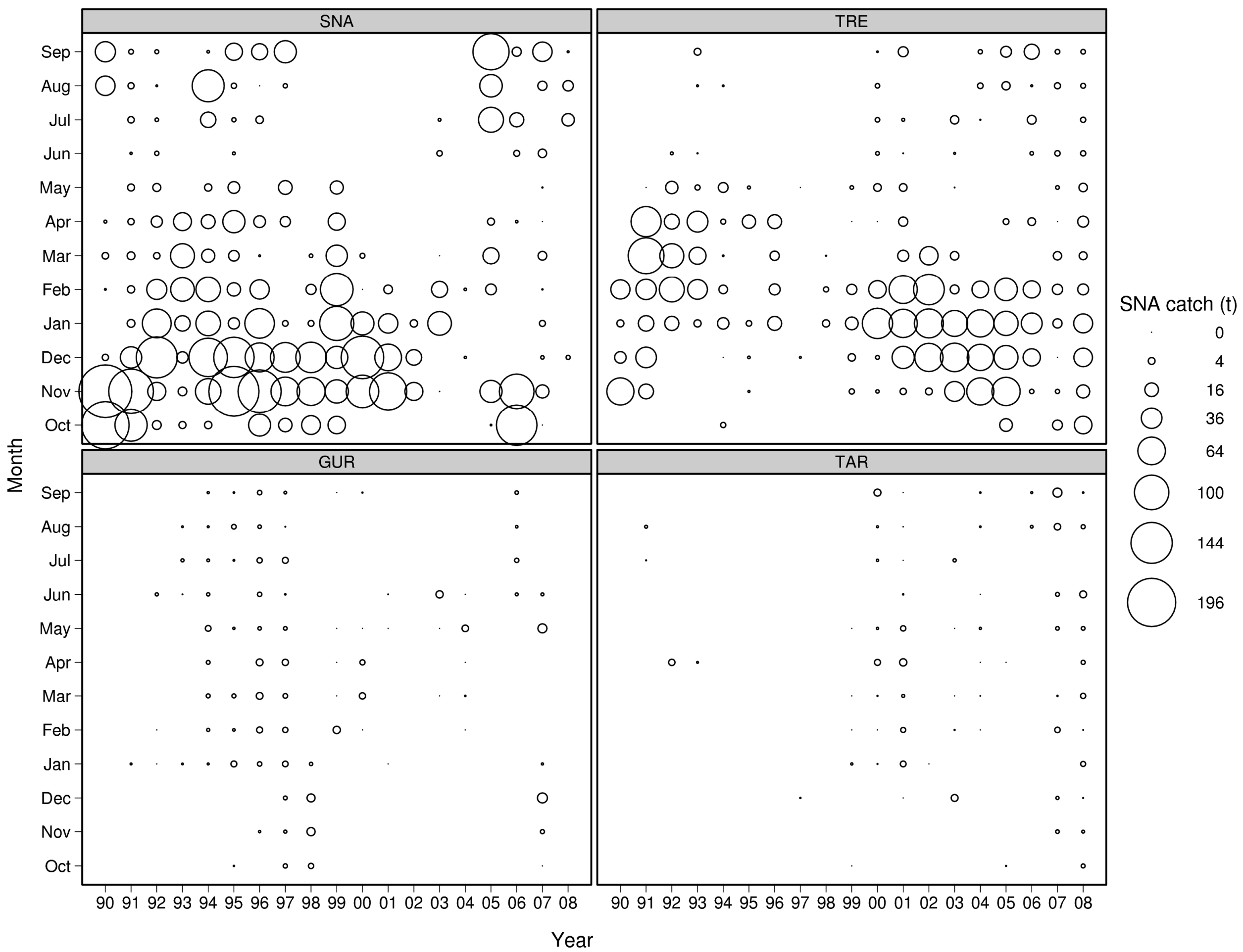


**Figure 14: Comparison of the seasonal distribution of bottom pair trawl snapper catches for the four main target fisheries in SNA 8, by fishing year. Circle areas are proportional to the catch totals by month, target species, summing to the annual totals given in Table 7.**

The depth distribution of shots targeted at snapper varies around 50 m bottom depth, as do positive tows (with respect to snapper) that were targeted at trevally. Positive shots targeted at gurnard are often shallower and tarakihi tows occurred much deeper, more typically centred around 100 m bottom depth (Figure 16).



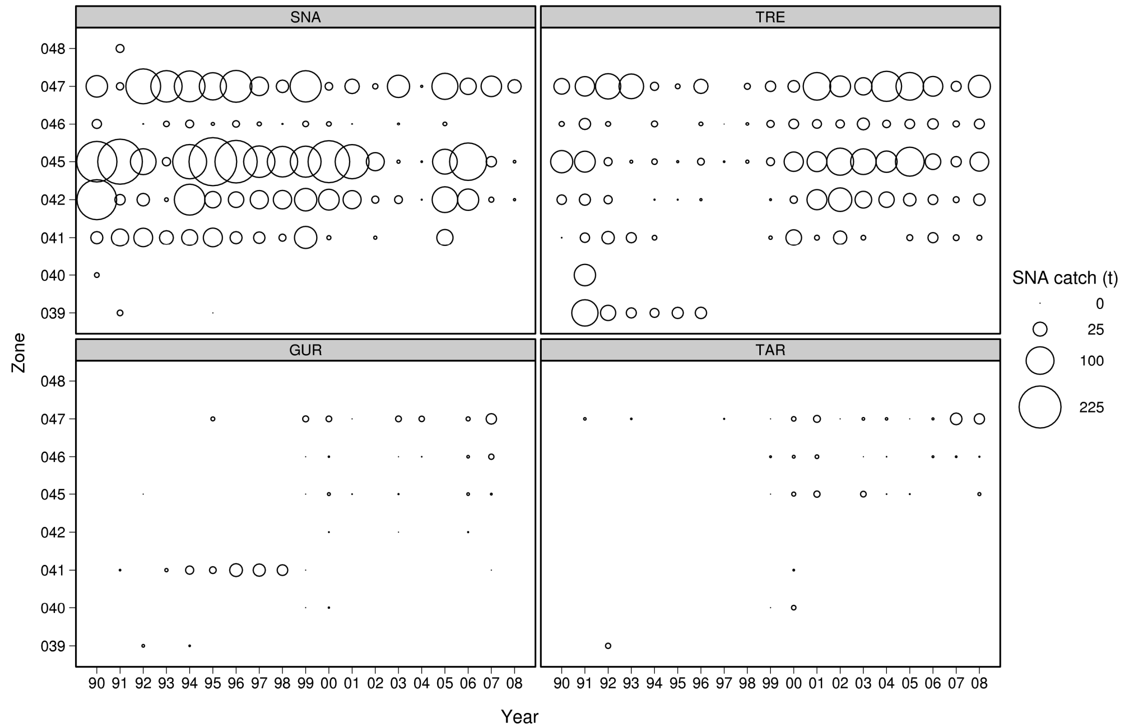


**Figure 15: Comparison of the spatial distributions of bottom pair trawl snapper catches by the main target species and fishing year. Circle areas are proportional to the catch totals by statistical area (zone), target, summing to the annual totals given in Table 7.**

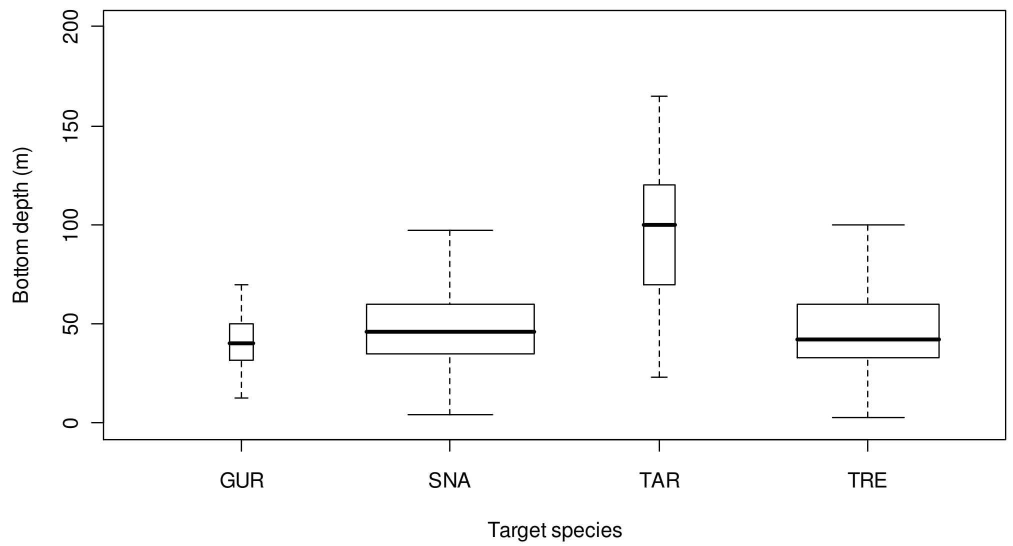


**Figure 16: Box plot distributions (median and interquartiles) of bottom depth from TCEPR or TCE records using the bottom pair trawl method for the main four target species where a catch of snapper was reported (positive tows). All years and statistical areas combined. The width of the boxes is proportionate to the number of records.**