Characterisation and catch per unit effort indices for the SNA 7 fishery

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EXECUTIVE SUMMARY

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Substantial quantities of snapper have been landed from Tasman Bay and Golden Bay since the Second World War. Landings peaked sharply at 2720 t in the late 1970s, as effort shifted from the declining scallop fishery and aerial surveys discovered surface spawning aggregations of snapper which were targeted by purse seiners. Following this pair and single trawl annual landings then declined substantially, and by the mid 1980s, only 200–300 tonnes of snapper were taken annually. The current TACC is 200 tonnes. Almost all of the commercial harvest from SNA 7 since 1989 has been taken in Tasman Bay and Golden Bay, and the available information suggests that the historical catch of SNA 7 was in these waters or nearby.

The most recent stock assessment of the SNA 7 fishery focussed on the snapper stock in Tasman Bay/Golden Bay, which was undertaken in 1999–00 (Harley & Gilbert 2000) and updated in 2000–01 (Gilbert & Phillips 2003). This stock assessment was externally reviewed and the Snapper Working Group concluded in 2006 (25 September 2006) that the model's biomass trajectory reached unrealistically high levels by 2010–11 (100–200% B_{msy}), and rejected the assessment. The Working Group suggested that an assessment should not be repeated for SNA 7 until a reliable index of abundance became available. This report provides relative indices of abundance which are based on single trawl catch effort data provided by single trawl fishers fishing in Tasman Bay and Golden Bay during the period 1 October 1989 to 30 September 2008. Other means of monitoring the fishery are also reviewed.

Snapper catches in Tasman Bay and Golden Bay are mainly taken by single trawlers, when targeting snapper, flatfish species, and to a lesser extent barracouta. Catch effort data from these fisheries were used to derive unstandardised and standardised indices of abundance. Standardised indices derived from individual target fisheries all fluctuate considerably from year to year, and their associated confidence intervals are relatively wide. The characterisation of the fishery suggested that each of the three single trawl fisheries could be interacting with different components of the SNA 7 stock, and that a combined fishery model may provide a more reliable descriptor of changes in abundance. The standardised combined fishery index given here is probably the most plausible descriptor of relative abundance that is currently available, given the level of precision achieved and suggested degree of interannual variability in abundance. Any of the indices provided here should be regarded with caution however, as they are based on relatively small scale fisheries) in terms of numbers of days fished per annum) and most of the data available have been reported on CELR forms, which only require reporting at a coarse spatial resolution. Despite this, there is no evidence of a rebuilding fishery as suggested in the 2000–01 SNA 7 stock assessment, in any of the standardised indices. The combined fishery index suggests that there has been little change in abundance over the past two decades. Any further interpretation of the utility of this index would benefit from the further collection of catch-at-age data, as abundance appears to fluctuate in response to highly variable levels of year class strength.

Alternative means of monitoring the SNA 7 fishery are also reviewed here: research trawl surveys, aerial surveys, tagging programmes, catch curves derived from catch sampling, and standardised commercial tows. None of these appear to offer a more viable and cost effective method of monitoring abundance. The most promising alternative monitoring method is for a pair of pair trawl vessels to conduct standardised tows and report detailed catch effort data for these tows. This approach would be reliant on the only pair of vessels consistently operating in the fishery, however, and there could be no certainty that these vessels would continue to participate in this fishery over the long term. Interviews with commercial fishers also suggest that there are several other variables which cannot be standardised, such as water clarity and tidal flow.

1. INTRODUCTION

A commercial fishery has existed in SNA 7 since at least the 1930s, with annual landings averaging around 550 t from the early 1950s to the early 1970s. Landings increased in the late 1970s as effort shifted from the declining Tasman Bay/ Golden Bay scallop dredge fishery, with many vessels fishing as pair trawlers. The annual harvest peaked sharply in 1978 at 2720 t, following the discovery of inshore spawning grounds by aerial spotter planes in Tasman Bay/Golden Bay. Landings subsequently declined substantially. The SNA 7 fishstock was introduced into the QMS in 1986–87 with a TACC set at 330 t. The commercial catch limit was then reduced further to 160 t in 1989–90, as concerns about the stock's status continued. The annual harvest from SNA 7 has gradually increased over the past 20 years, and the TACC was increased to 200 t in 1997–98.

An age structured assessment of the snapper stock in Tasman Bay/Golden Bay was undertaken in 1999–00 (Harley & Gilbert 2000) and updated in 2000–01 (Gilbert & Phillips 2003). This stock assessment was externally reviewed and the Snapper Working Group concluded in 2006 (25 September 2006) that the model's biomass trajectory reached unrealistically high levels by 2010–11 (100–200% B_{msy}), and rejected the assessment. The Working Group suggested that an assessment should not be repeated for SNA 7 until a reliable index of abundance was available.

This report provides a characterisation of the SNA 7 fishery, for the period 1 October 1989 to 30 September 2008, focussing primarily on the Tasman Bay/Golden Bay fishery considered in recent stock assessments. This characterisation is used to identify potential candidate fisheries that could provide data for standardised and unstandardised catch rate indices from which changes in relative abundance could be inferred. Catch rate indices are provided for three fisheries and their utility is compared with other means of monitoring the SNA 7 stock, which are also reviewed here.

Overall objective:

1. To determine the catch-at-age of snapper (*Pagrus auratus*) [this aspect was removed] and develop abundance trends for SNA 7.

Specific objectives:

1. To characterise the SNA 7 fishery and update the CPUE analyses for trawl fisheries in each area of SNA 7 using data up to the end of 2008–09.

2. To suggest alternative approaches for monitoring the SNA 7 stock based on all available information.

2. FISHERY CHARACTERISATION

2.1 Data sources

The data used to characterise the SNA 7 fishery were based on catch effort data for the period 1 October 1989 to 30 September 2009, provided by the Ministry of Fisheries. Catch effort data were requested for all trips where effort was targeted towards snapper in reporting areas corresponding to either SNA 7 or FMA 7, or where there was a reported landing weight for SNA 7.

All catch effort data submitted by SNA 7 fishers prior to the 2006–07 fishing year were recorded on either Catch Effort Landing Returns (CELRs) or Trawl Catch Effort and Processing Returns (TCEPRs) and associated Catch Landing Returns (CLRs) (Figure 1). The use of CELRs has declined substantially since late 2006–07 following the introduction of Lining Trip Catch Effort Returns (LTCERs), Netting Catch Effort Landing Returns (NCELRs), and Trawl Catch Effort Returns (TCERs).

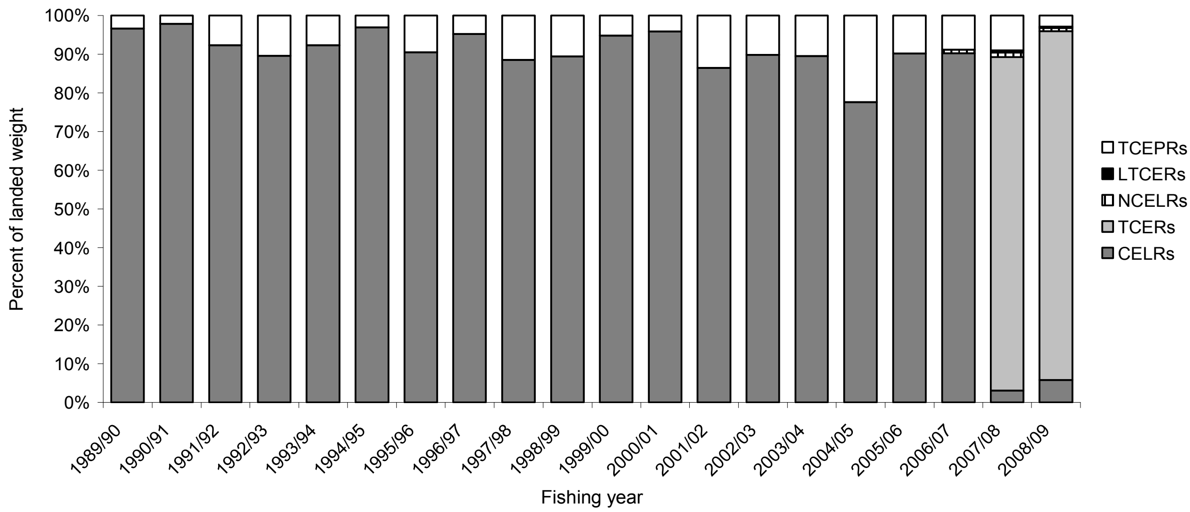

Figure 1: Proportion of SNA 7 catch reported by form type since 1 October 1989.

These data were groomed in two stages. Initially, selected fields for all records were groomed to characterise the fishery and identify specific target/method fisheries from which potentially informative standardized CPUE indices could be generated. Catch and effort data from this subset of fisheries were then groomed further. Two of these fisheries were bycatch fisheries (i.e. snapper caught when targeting other species) and in these cases data were also obtained for trips where fishing effort took place but snapper was not landed, as these events were not included in the original data extract. The methods used in both these data grooming processes were broadly similar to those described by Starr (2007).

Temporal and spatial data fields were initially examined and obvious errors were corrected or removed from the dataset if they were irresolvable. Catch and effort data were linked for each trip to ensure that only fishing events actually occurring within SNA 7 were included in the fishery characterisation. A proportion of the landed catch from SNA 7 was taken in statistical reporting areas which fall across Quota Management Area (QMA) boundaries, i.e. statistical reporting areas 036, 037, 039, and 040 overlap the boundary between SNA 7 and SNA 8 (Figure 2). Further, the majority of the SNA 7 catch was taken by trawlers, and these vessels often landed snapper from more than one QMA (mostly SNA 7 and SNA 8). Although there was usually a close correspondence between the statistical reporting areas recorded in effort fields and the QMA codes recorded in the landed section for each trip, this was not always the case. In a few instances all of the reported effort in the estimated section of a trip report was for areas in northern SNA 8, and/or in northern SNA 1 yet the landed weight was ascribed to SNA 7. In these cases it was assumed that landed catch weights had been miscoded as coming from SNA 7 when they were in fact from SNA 1 or SNA 8, and these trips were removed from the final data set. This assessment was also based on the species composition landed from these trips, and the recent spatial distribution of effort reported by each vessel.

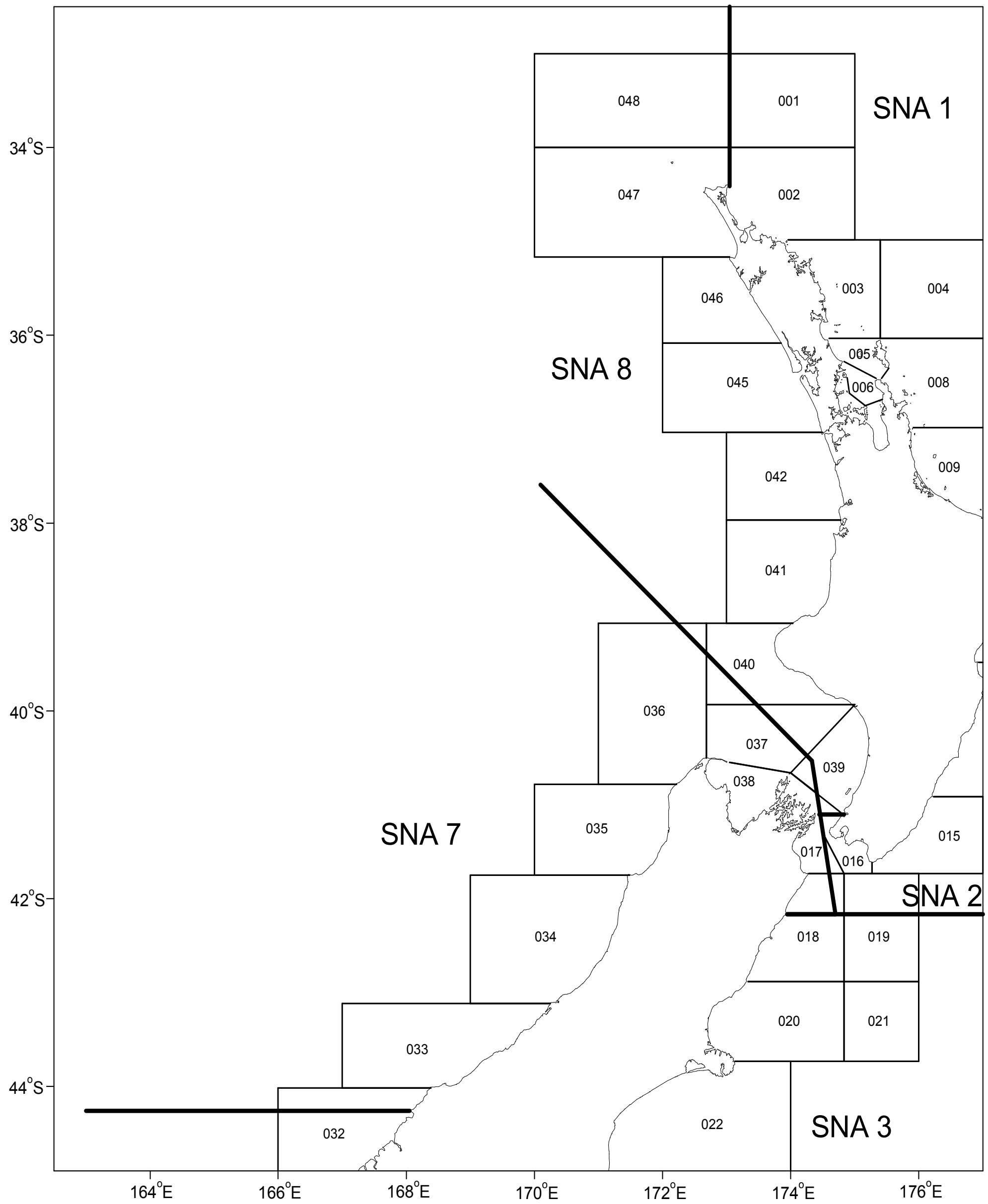

Figure 2: Quota management areas for snapper and statistical reporting areas including and adjoining SNA 7.

The linkage of effort and landed weight data for each trip was also used to identify extreme and potentially erroneous estimated catch and landed weight records. Estimated and landed snapper catch weights were summed for each trip and compared, to identify potential errors. Landed weights were also compared with values generated by combining unit weights, numbers of units and conversion factors, although many of these components were often deemed to be erroneous themselves (e.g. a unit number of 1 for a landing in excess of a tonne where the unit weight was 40 kg and the estimated catch weights were substantial). The assessment of the validity of landed weights was also informed by a chronological examination of each vessel's catch and effort history.

Raw and groomed catch weight data (both estimated and landed) for the entire fleet were summed by fishing year, and the result was compared with tonnages reported against on Quota Management Returns (QMRs) and Monthly Harvest Returns (MHRs) (Figure 3). It is assumed that QMRs and MHRs provide reasonably accurate estimates of the tonnage landed annually from SNA 7.

The grooming process resulted in a marked improvement in the relationship between annual tonnages obtained from QMR/MHR and catch effort data. Data grooming resulted in a substantial reduction in the total weight of snapper reported against the estimated part of the reporting returns, because many fishing events were identified which evidently took place outside of SNA 7, which are not relevant to the objectives of this study. There were often landed tonnages also reported for SNA 8 on these trips.

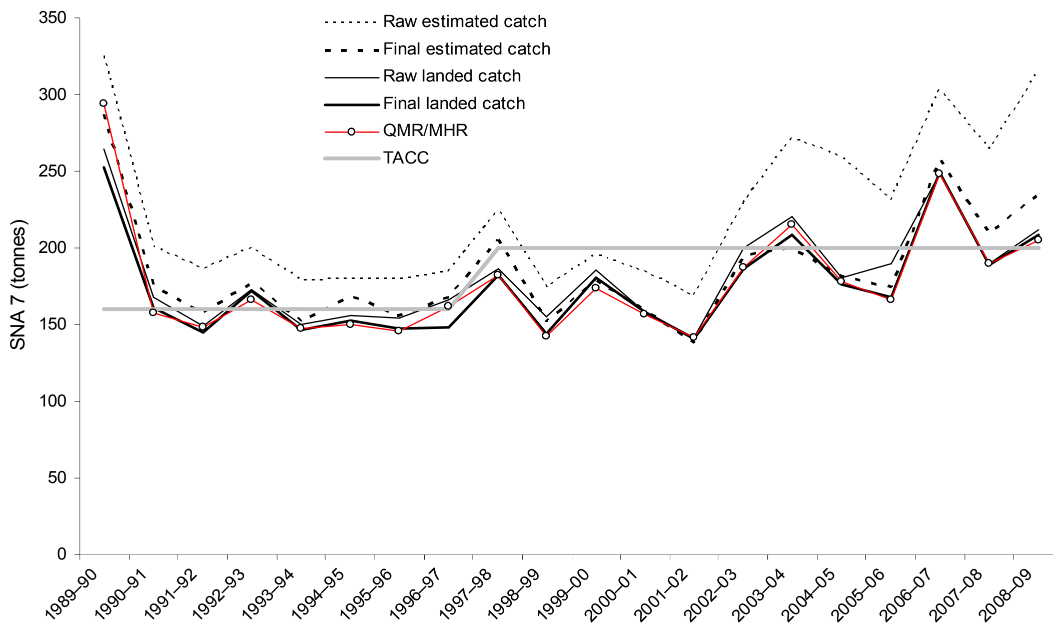

Figure 3: Comparison of annual total estimated and landed catch weights with tonnages reported on QMRs (Quota Management Returns – 1 October 1989 to 30 September 2001) and MHRs (Monthly Harvest Returns – 1 October 2001 to 30 September 2009). Annual tonnage totals are given for both the ungroomed (Raw) and groomed (Final) datasets.

A large proportion of the trips landing snapper from SNA 7 targeted a single species a single method in a single statistical reporting area. Multi method trips were relatively rare, but when a vessel fished in more than one statistical reporting area or targeted more than one species in a trip, it was necessary to apportion the landed snapper weight across these events. For most trips the landed catch was prorated between events based on the estimated catch, but when there was no snapper catch estimate for a trip, the landed catch was prorated between trip events based on the relative level of effort associated with each event. These prorated data were used to characterise the SNA 7 fishery in terms of the landed snapper catch by area, fishing method and target species.

Unsummarised catch effort data for SNA 7 are only available from late 1989 onwards, but substantial landings of snapper have been taken from this area since the late 1940s. Catch tonnage totals for the 1931 to 1990 calendar years and for fishing years between 1983–84 and 2008–09 are also presented here, as taken from the most recent Working Group Report (Ministry of Fisheries 2010).

Data on snapper landings from statistical reporting areas in SNA 7 were also extracted from the new_fsu (Fisheries Statistic Unit) database. Although landings data are available from the deep water factory trawl fleet since 1977–78, these vessels only accounted for a very small proportion of the annual tonnage landed, as reported in the most recent Working Group Report (Ministry of Fisheries 2010). Landings data are available from the bottom pair trawl fleet from January 1983 to 1987–88, which accounted for over 80% of the annual tonnage totals obtained from the FSU database. The new_fsu database documentation notes, however, that those species with the highest discrepancy between trawl catch tonnages obtained from the FSU database and published figures are for those fisheries with the highest pair trawl catches. This is because catches taken by a pair of vessels have not necessarily been reported in a consistent fashion. In some cases it appears that both skippers have independently reported the combined catch weight, whereas other skippers have only reported the tonnage actually landed by their own vessel. A comparison of FSU pair trawl landings data with catch statistics reported by King et al. (1987) suggests that the combined catch from both pair trawl vessels may have been recorded as the individual catch for the two vessels before 1988–89, but this is not known with any certainty. Consequently, there is no way of confidently apportioning annual landings from SNA 7 by fishing method before 1989–90, and no way whatsoever before 1982–83.

Almost all of the pair trawl catch taken since 1989 has been landed by a single pair of vessels, and these landings have been reported in a consistent manner (catch weight split evenly between the two vessels but both vessels reporting the number of hours the two vessels fished as a pair on that day). Some apparent discrepancies were resolved by grooming paired landings data with the help of these skippers, who were able to refer directly to their copies of their CELR logbooks.

2.2 Overview of the SNA 7 fishery

The single trawl fishery for snapper expanded rapidly after the Second World War, and for the next twenty five years annual landings fluctuated between 400 and 1600 tonnes (Figure 4). Short term peaks in landings over this period have been attributed to strong year classes entering the fishery, especially the 1960–61 cohort, which were vulnerable to the trawl fishery when they were between 3 and 8 years old (Mace & Sullivan 1980). Annual landings in the mid to late 1970s were consistently high, peaking at 2720 tonnes in 1978, with 1776 tonnes landed in the following year. These catches were the result of a substantial increase in fishing effort in Golden Bay and Tasman Bay, which occurred partially in response to aerial observations of large schools of snapper spawning midwater, in December 1977 (Mace & Sullivan 1980). Effort shifted from the declining Golden Bay/Tasman Bay scallop fishery to the snapper fishery at this time, with small vessels pairing up to tow nets supported with large buoys, which were used to target surface and midwater spawning aggregations. Three purse seine vessels and some larger single trawlers also briefly entered the fishery between 1978 and 1981. Landings then started to decline rapidly in the early 1980s. The fishery has since largely adopted single trawl methods, although a pair of pair trawlers has been in operation since the 1970s, which account for up to 40 tonnes of the annual catch. The following review is based on catch effort returns submitted since 1 October 1989, which is when the most commonly used CELR reporting system was introduced. Detailed catch effort data are not available before this date.

Landings since 1 October 1989 were allocated to regions of SNA 7 based on the statistical reporting areas recorded in the estimated section for each trip (Table 1). Most of the SNA 7 catch landed in any year was taken from the Golden Bay/Tasman Bay region (statistical reporting areas 037 and 038), but appreciable landings were also taken from the Marlborough Sounds (017 and 018) and West Coast (032 to 036, 039 and 040) regions. A small percentage of landings were not attributable to any region of SNA 7 because fishers used incorrect area codes in the estimated catch part of their form (usually area 7 which is probably 007 - in the Hauraki Gulf of the North Island where a far larger commercial fishery exists).

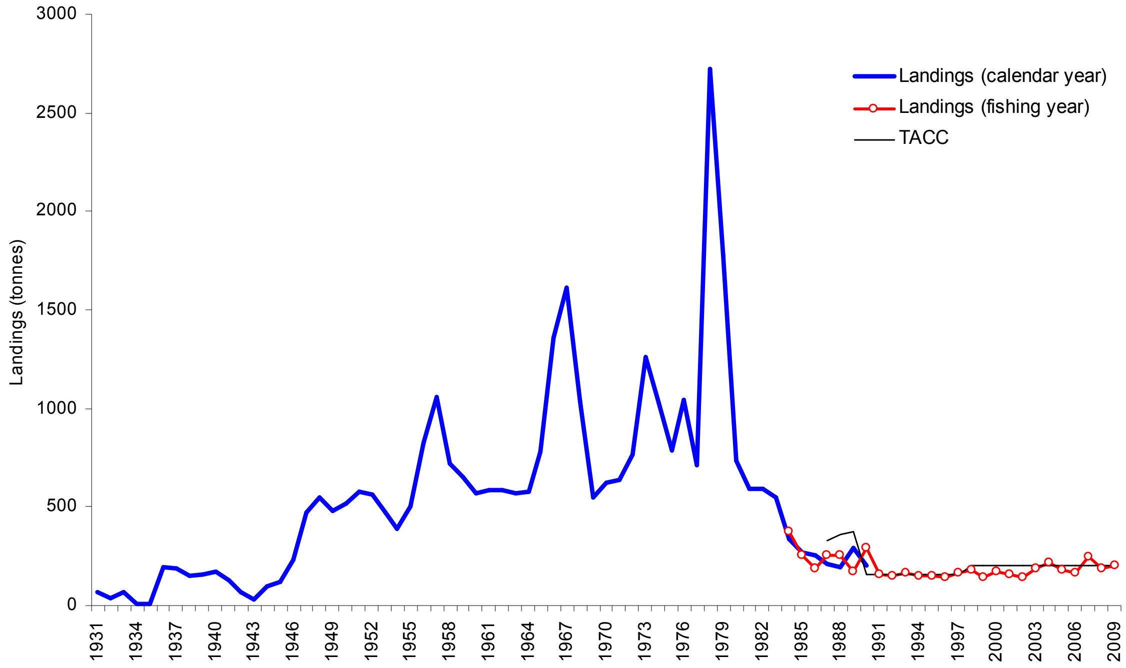

Figure 4: Commercial catch history for SNA 7 since 1931. Catch totals are plotted on the second calendar year of each fishing year.

Table 1: Tonnages and percentages of snapper landed in regions of SNA 7 by fishing year.

	SNA 7 region (t)				SNA 7 region (%)			
Fishing year	Golden Bay/ Tasman Bay	Marlb. Sounds	West Coast	SNA 7 unspec.	Golden Bay/ Tasman Bay	Marlb. Sounds	West Coast	SNA 7 unspec.
1989–90	206	24	21	2	81	9	8	1
1990–91	129	19	13	0	80	12	8	0
1991–92	118	10	15	2	81	7	11	1
1992–93	125	21	24	2	73	12	14	1
1993–94	122	6	20	0	82	4	13	0
1994–95	125	12	16	0	82	8	10	0
1995–96	106	10	27	5	72	7	18	3
1996–97	99	10	12	27	67	6	8	18
1997–98	139	15	12	11	79	8	7	6
1998–99	108	20	15	2	75	14	10	1
1999–00	110	39	22	10	61	22	12	5
2000–01	102	38	16	3	64	24	10	2
2001–02	95	9	36	0	68	6	26	0
2002–03	147	18	22	0	79	9	12	0
2003–04	136	30	42	1	65	14	20	0
2004–05	90	10	76	0	51	6	43	0
2005–06	124	6	37	0	74	4	22	0
2006–07	181	15	52	0	73	6	21	0
2007–08	143	10	35	1	76	5	19	1
2008–09	157	11	41	–	75	5	19	0

Most of the catch from SNA 7 since 1989 has been taken by single trawlers, followed by pair trawling, longlining, and to a much lesser extent, set netting and mid water trawling (Figure 5). Most of the catch taken by all of these methods has been caught in Golden Bay/Tasman Bay.

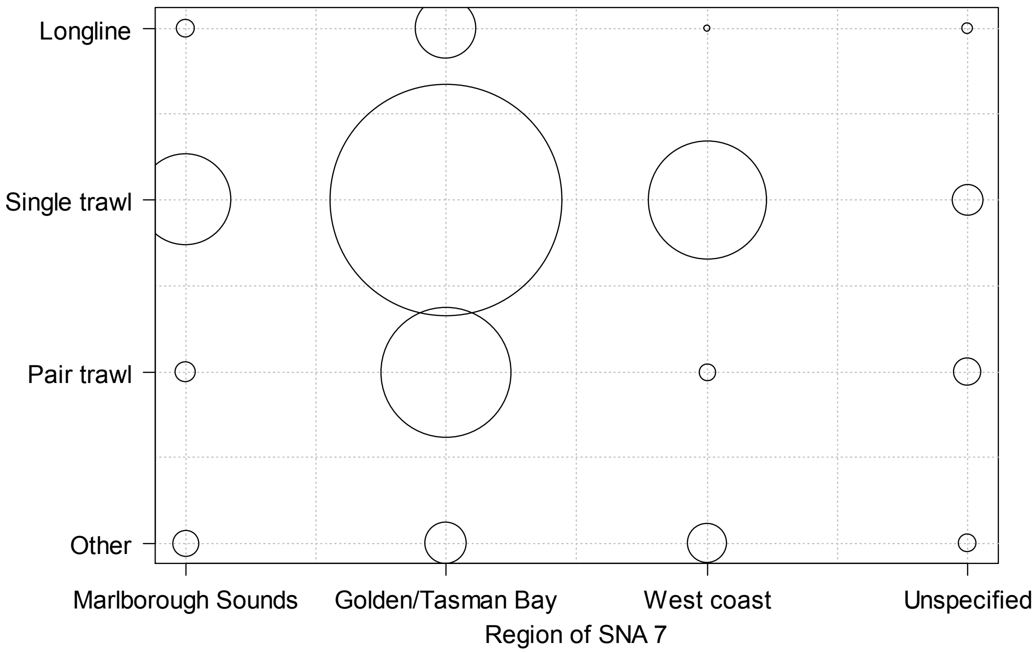

Figure 5: Comparison of relative landings of snapper by method and region. Circle areas are proportional to the total landed catch by each method in each region since 1 October 1989.

Although the relative contribution of catches from each region has fluctuated from year to year, landings from Golden Bay/Tasman Bay have on average accounted for 73% of the annual SNA 7 harvest (Table 1) and this characterisation will focus on the fishery in this region. The most recent stock assessments in 1999–00 (Harley & Gilbert 2000) and 2001–02 (Gilbert & Phillips 2003) also focused on assessing just the snapper stock in the Golden/Tasman Bay region of SNA 7, which they also defined as statistical reporting areas 037 and 038.

Most of the catch taken from Golden Bay/Tasman Bay has been taken by single (bottom) trawling. Up to 40 tonnes a year has also been taken from Golden Bay/Tasman Bay by a pair of 40′ pair trawlers, which have been operating in this area since the 1970s (see interview with Lex Bloomfield and Chris Weston in Appendix 2). Longline landings have been relatively insignificant since 1997–98, following the closure of the Marlborough Sounds to commercial line fishing, where snapper were targeted during the winter. The loss of the winter fishery undermined the viability of longlining for snapper and the main longline fisher subsequently changed to trawling (Appendix 2, Fisher 3).

Table 2: Tonnages and percentages of snapper landed in Golden Bay/Tasman Bay by method by fishing year.

Fishing year	Golden Bay/Tasman Bay (t) Bottom longline	Bottom pair trawl	Single trawl	Other	Golden Bay/Tasman Bay (%) Bottom longline	Bottom pair trawl	Single trawl	Other
1989–90	9	100	96	0	5	49	47	0
1990–91	14	23	89	3	11	18	69	2
1991–92	9	28	81	0	7	24	68	0
1992–93	11	25	87	2	9	20	70	1
1993–94	13	26	81	1	11	21	67	1
1994–95	15	26	81	2	12	21	65	2
1995–96	9	18	76	3	8	17	72	3
1996–97	14	16	65	5	14	16	65	5
1997–98	21	36	74	8	15	26	53	6
1998–99	1	22	80	5	1	20	74	4
1999–00	4	9	93	3	4	9	85	3
2000–01	2	25	74	1	2	24	72	1
2001–02	1	11	82	2	1	11	86	2
2002–03	1	35	108	3	0	24	74	2
2003–04	0	19	115	2	0	14	85	2
2004–05	0	24	65	1	0	26	72	1
2005–06	1	21	99	3	1	17	79	3
2006–07	1	31	147	2	0	17	81	1
2007–08	0	32	107	3	0	22	75	2
2008–09	0	40	108	10	0	26	68	6

2.3 The Golden Bay/Tasman Bay single trawl fishery

Since 1989 single trawlers have accounted for 47–86% of the snapper catch taken from Golden Bay/Tasman Bay and 37–58% of the catch taken from SNA 7 (Table 2). Almost all of this catch and effort was reported on CELRs between 1989–90 and 2006–07, but almost all fishers now report on TCERs (Figure 6).

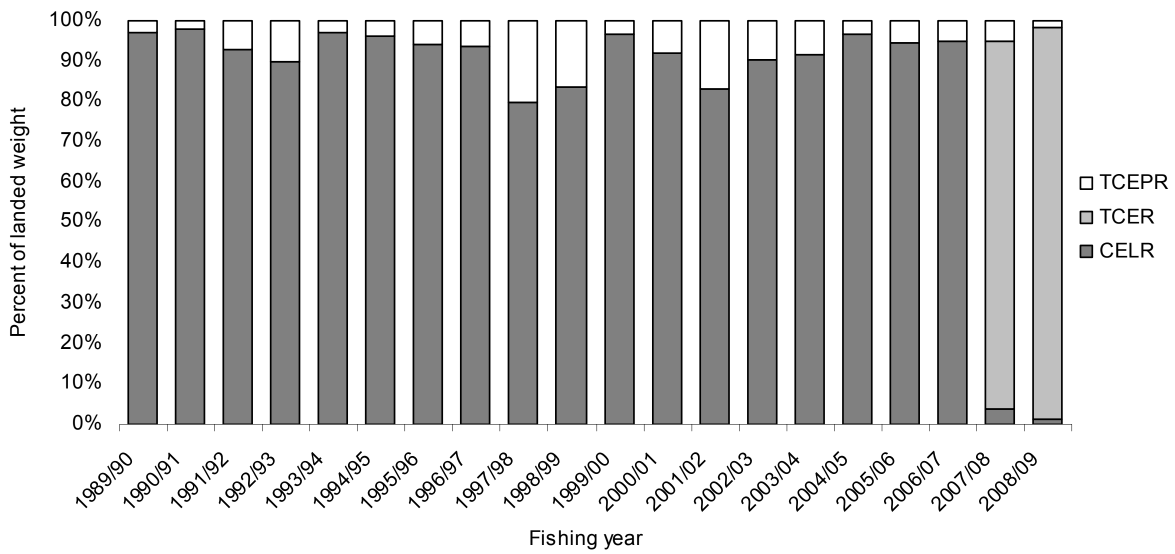

Figure 6: Proportion of snapper catch reported by single trawl vessels operating in Golden Bay/Tasman Bay by form type since 1 October 1989.

The spatial resolution of most of the available data is therefore limited to statistical reporting areas as fishers rarely reported exact fishing locations on CELR forms. On 1 October 1994, shallow coastal waters of statistical reporting area 038 were voluntarily closed to trawling (Appendix 3), and this may have led to changes in the spatial distribution of fishing effort which are not detectable at the coarse statistical reporting area level. Interviews with pair trawl skippers suggest that these closures led to a marked change in both the areas fished at certain times of the year, and the size of fish caught by this pair of vessels (see interview with Lex Bloomfield and Chris Weston, Appendix 2) and it is likely that these closures may have also influenced the spatial distribution of single trawl effort.

Between 74% and 96% of the snapper landed annually by single trawlers from statistical reporting areas 037 and 038 was caught when targeting snapper (SNA), flatfish (FLA), or barracouta (BAR) (Figure 7, Table 3). Up to 5 tonnes of the annual snapper catch was landed when targeting was attributed to one of the individual flatfish species codes (ESO – English sole, GFL – greenback flounder, LSO – lemon sole, SFL – sand flounder, or YBF – yellow belly flounder). The most commonly reported of these was SFL. The target species for these events was recoded to the generic flatfish code FLA. Small tonnages of snapper were also caught when targeting 28 other species, but most of this remaining catch was caught when targeting red gurnard (GUR), trevally (TRE) and red cod (RCO).

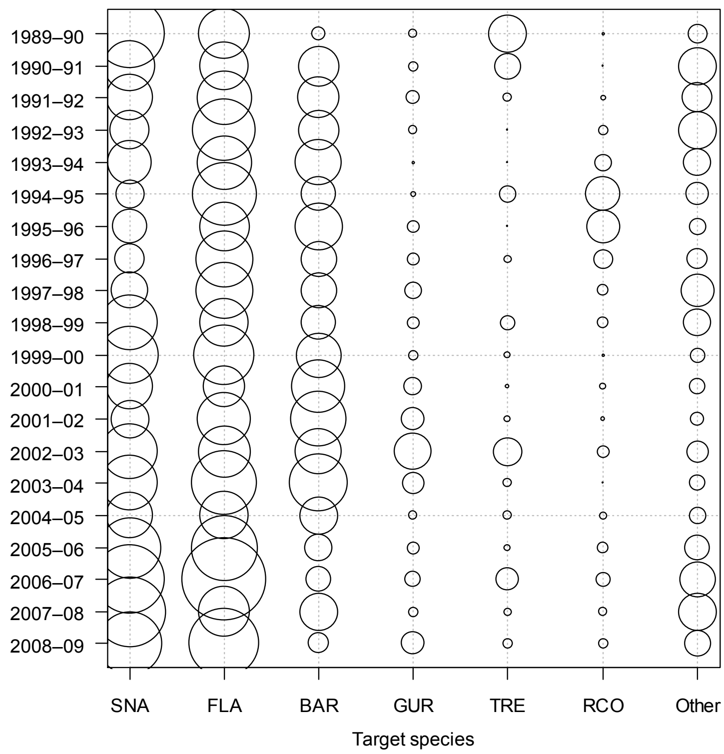

Figure 7: Single trawl catch by target species by fishing year. Circle areas are proportional to the tonnage of snapper caught by target species since 1 October 1989.

Table 3: Tonnages of snapper landed by single trawlers from statistical reporting areas 037 and 038 by target species by fishing year. Tonnages of 0 denote total landings of less than 0.5 t.

Fishing	Target species (t)							
year	SNA	FLA	BAR	GUR	TRE	RCO	Other	Top 3
1989–90	49	26	2	1	14	0	4	80%
1990–91	26	27	17	1	7	0	12	77%
1991–92	22	34	17	2	1	0	4	90%
1992–93	16	43	16	1	0	1	10	86%
1993–94	19	32	22	0	0	3	5	90%
1994–95	8	43	12	0	3	12	2	78%
1995–96	12	27	23	2	0	11	2	81%
1996–97	9	36	13	2	1	4	0	90%
1997–98	14	36	13	3	–	1	7	85%
1998–99	31	25	12	2	2	1	6	85%
1999–00	33	36	20	1	0	0	2	96%
2000–01	21	17	29	3	0	1	2	91%
2001–02	14	29	31	5	1	0	2	91%
2002–03	31	28	21	14	8	2	5	74%
2003–04	31	42	34	5	1	0	2	93%
2004–05	21	24	15	1	1	1	3	92%
2005–06	38	43	8	2	1	1	7	90%
2006–07	48	69	7	3	6	2	13	84%
2007–08	49	28	15	1	1	1	15	85%
2008–09	40	49	4	5	1	1	7	87%

Single trawlers targeting snapper, flatfish and barracouta in areas 037 and 038 therefore offer the best prospect of providing data for relative abundance indices for SNA 7 based on catch effort data, because of the number of fishing events taking place and the tonnages landed annually. The spatial and temporal dynamics of these target fisheries differ and they may interact with different components of the fish stock. The snapper target fishery is the most seasonal, with most of the catch taken between November and January (Figure 8). The length of the target season has increased in recent years, with an increase in the tonnage of targeted snapper landed over this time (Table 3).

Annual landings of snapper caught while targeting flatfish species have been relatively steady over the last twenty years (Table 3) with most catches landed over a broad season from October to May (Figure 8). Almost all of the snapper taken when targeting snapper and flatfish was taken in area 038, in depths of less than 60 m.

The bycatch of snapper landed from the single trawl barracouta target fishery has declined in recent years (Figure 7, Table 3). A large proportion of this catch has been taken in deeper waters in area 037, outside of the line between Farewell Spit and Stephens Island (Figure 8). Most of the snapper bycatch taken in deeper waters when targeting barracouta is caught in the spring (October and November) and Autumn (March to May). Summer bycatch of snapper from this fishery is usually taken in area 038.

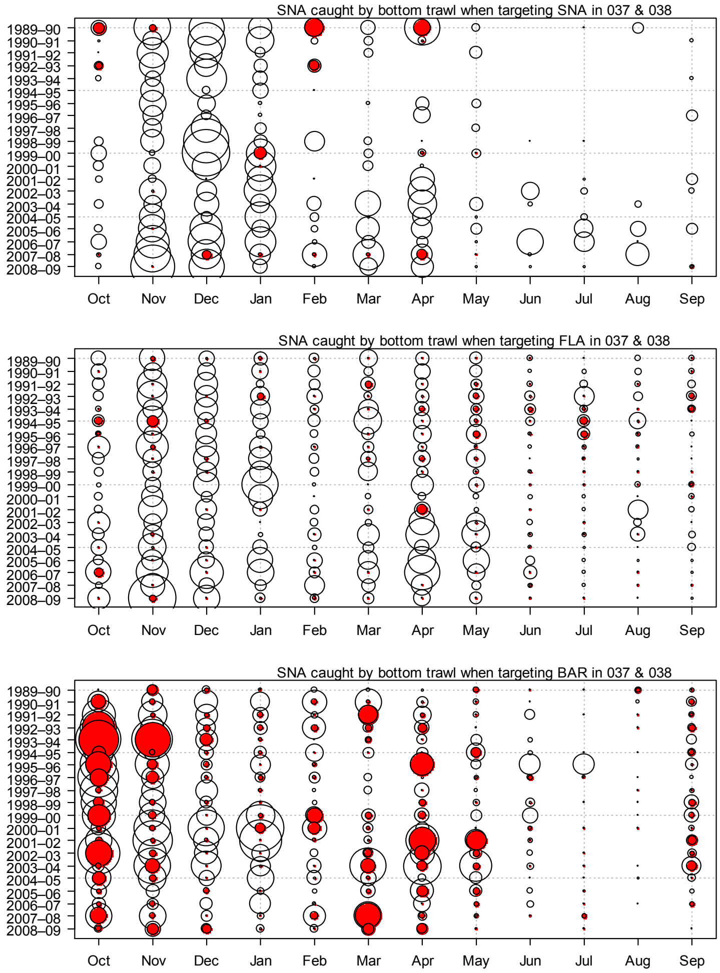

Figure 8: Monthly snapper catch taken by single trawlers targeting snapper (top panel, largest circle 20 t), flatfish (middle panel, largest circle 25 t), and barracouta (bottom panel, largest circle 10 t), by fishing year. Open circle areas are proportional to monthly tonnages of snapper landed from statistical reporting areas 037 and 038 combined and the area of shaded circles is proportional to the catch landed from area 038 only.

3. STANDARDISED CPUE INDICES FOR SNA 7

3.1 Standardisation methods

The characterisation identified three fisheries which could potentially provide informative indices of abundance for snapper in Golden Bay/Tasman Bay (statistical reporting areas 037 and 038). These were the trawl fisheries targeting snapper, flatfish and barracouta.

Snapper was caught on all but 17 of the 1414 days where snapper was targeted by single trawlers in Golden Bay/Tasman Bay. Data from the 17 zero catch days were dropped from this dataset because of their limited incidence and the need to model log transformed catch rates (catch per tow).

For the flatfish and barracouta target fisheries, the initial extract only included catch and effort for those events associated with landings of snapper, and additional effort data were sought for those events that did not result in catches of snapper. Catch effort data for tows undertaken by the flatfish and barracouta fisheries were modeled separately because of differences in the fishing gears used, and the areas and depths fished when targeting each species.

The high incidence of zero snapper catch fishing events in both the flatfish and barracouta fisheries necessitated the use of a delta-lognormal modeling approach. Generalised lognormal linear modeling was used to predict the catch rate for those events where snapper was caught, and a binomial model of all events was used to predict whether or not snapper were caught (positive catches were assigned a value of 1 and zero catch events a value of 0). Indices of abundance derived from the lognormal and binomial models were also combined into a unified index using the method descried by Vignaux (1994).

Catch effort data reported before 30 September 2006 were summarized by fishing day (on CELR forms) and by fishing event after this date (mostly on TCERs) and catch rates estimates derived from these two data sources may not be directly comparable. Kendrick (2009) found evidence of lower apparent catch rates associated with CELR data than those associated with shot-by-shot reporting systems such as TCEPRs (and presumably TCERs). These differences were attributed to the fact that fishers reporting on CELRs may combine multiple fishing events taking place on the same day, but only report a single target species for that day. Catch rates of the reported target species may therefore be negatively biased when other species are in fact targeted, reducing the aggregate catch rate for that day. The solution adopted to overcome this issue was to combine shot-by-shot catch and effort data by day for those vessels reporting by TCEPR and TCER. Regardless, only a single target species was reported on over 92% of these days (more than 98% of all days if CELR data is considered too). It is assumed that the summarizing of these TCEPR and TCER data by fishing day has made them directly comparable to catch effort data reported by the CELR system.

The grooming of catch effort data for the characterisation of the SNA 7 fishery focused primarily on the catch weight and fishing location fields, and there was little examination of information on the number of hours fished or the number of tows undertaken on each day. As there was no reliable means to determine the actual level of effort which took place on each day, records associated with implausibly low and high levels of effort were dropped from the combined fishery database, as recommended by Starr (2007). The discarded records accounted for 2.4% of the snapper catch and 2.2% of the days fished across all three fisheries (Figure 9).

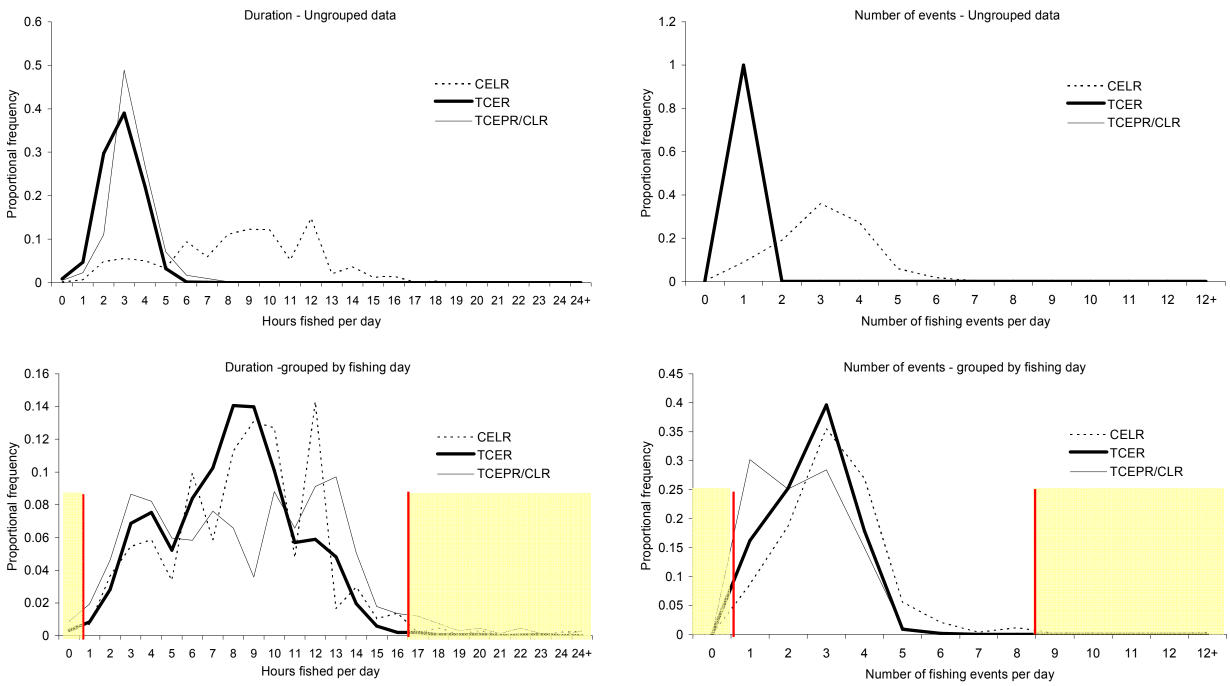

Figure 9. Comparison of effort metric distributions by form type, before and after records were grouped by fishing day.

The same predictor variables were offered to all catch rate standardisation models (Table 4). A forward stepwise procedure was used to select the predictor variable that explained most of the unexplained variance at each stage. Predictor variables were only accepted if they improved the R^2 statistic by at least 1%. The variable "fishing year" was forced in the first iteration of this stepwise procedure, because the purpose of these analyses was to produce annual indices of relative abundance, and catch rate predictions were therefore required for each year. The variable "fishing duration" was also forced in the binomial models as there was an increasing trend in the number of hours fished per day over the past two decades. But no effort variable was automatically selected in the stepwise procedure.

Commercial fishers who were interviewed as part of objective two suggested that water clarity could have a marked affect on catch rates (Appendix 2). Georgina Griffiths (NIWA Climate Scientist) suggested three potential proxy measurements of water clarity: two monthly indices of atmospheric pressure differential between two distant meteorological stations which provide a single unified descriptor of wind direction and strength (Trenberth M1 and Trenberth Z1 – see Trenberth 1976); and the cumulative rainfall measured at the Nelson Aero weather station during the week before the date fished.

Table 4 predictor variables used in catch rate standardisations. Continuous variable were offered as third order polynomials.

Variable	Type	Description
Fishing year	Categorical	Fishing year (forced)
Month	Categorical	Month of calendar year
Vessel	Categorical	Vessel (core vessels only)
Stat area	Categorical	037 or 038
Form type	Categorical	CELR, TCER, or TCEPR
Fishing duration	Continuous	Number of hours trawled per day (h)
Number of tows	Continuous	Number of tows per day (h)
SOI	Continuous	Monthly southern oscillation index
Trenberth M1 index	Continuous	South/north pressure differential index
Trenberth Z1 index	Continuous	West/east pressure differential index
Rainfall	Continuous	Rainfall over previous 7 days (mm)

3.2 Snapper CPUE indices for the snapper target fishery

Catch effort data were available for 1819 fishing events and collapsing these data into a total catch and effort per day format provided data on 1414 days when snapper were targeted and caught by trawlers in Golden Bay/Tasman Bay. The number of vessel days fished per fishing year where snapper were targeted by single trawlers ranged from 27 days in 1996–97 (9 tonnes landed) to 123 days in 2007–08 (49 tonnes).

Although numerous trawlers have participated in this fishery, most have only fished on a small number of days over a small number of years and further analyses were restricted to catch effort data provided by nine vessels which had fished for snapper on at least five days in at least four years. Although none of these vessels fished over the whole term assessed, their combined fishing histories overlapped to provide coverage by multiple vessels over the period assessed (Figure 10). Although there has been little change in the average catch per tow since 1989, the number of hours towed per day has gradually trended upwards during this period (Figure 11). There has been no consistent seasonal trend in unstandardised catch rates, although there can be a marked interannual variation in fishing success (Figure 12).

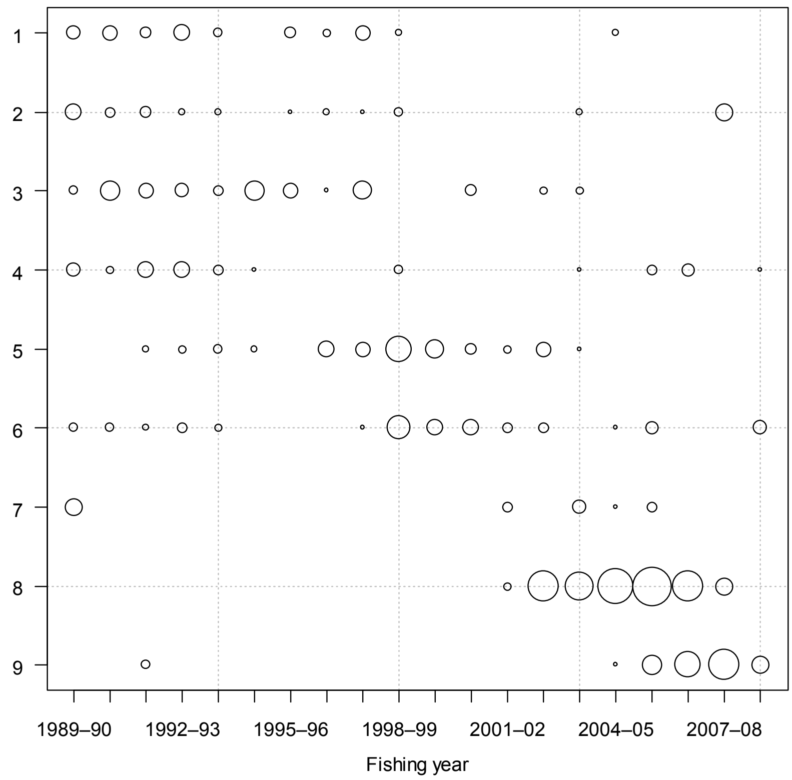

Figure 10: Number of days fished by single trawlers that targeted snapper on at least five days in at least four fishing years. The largest circle represents 63 days fished.

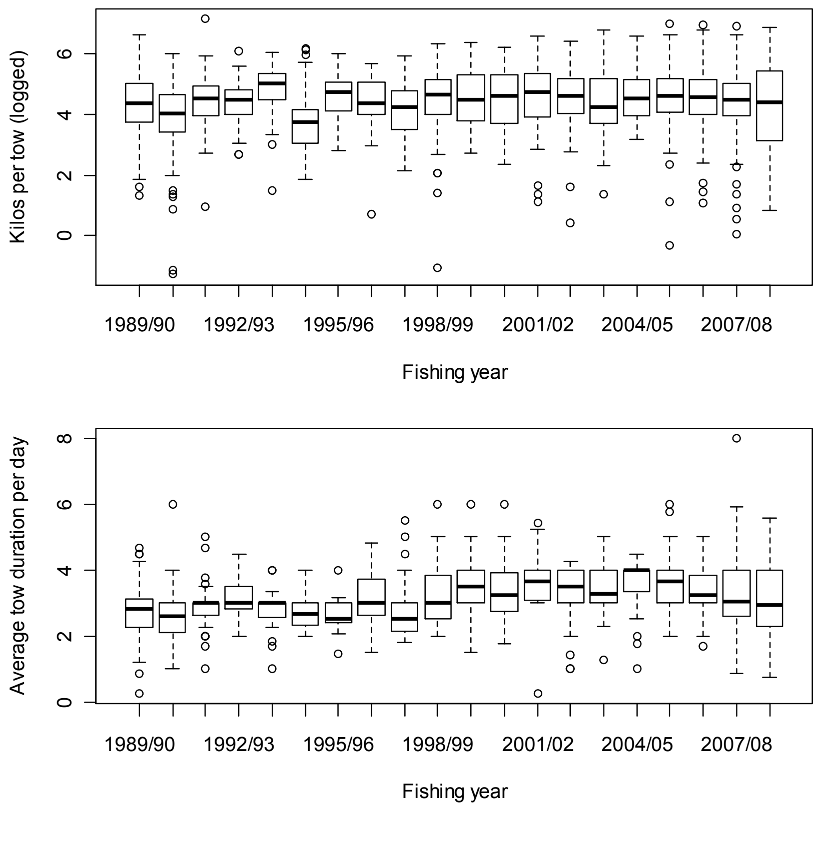

Figure 11: Annual distributions of snapper catch per tow (upper panel) and average tow durations per day, for the snapper target trawl fishery.

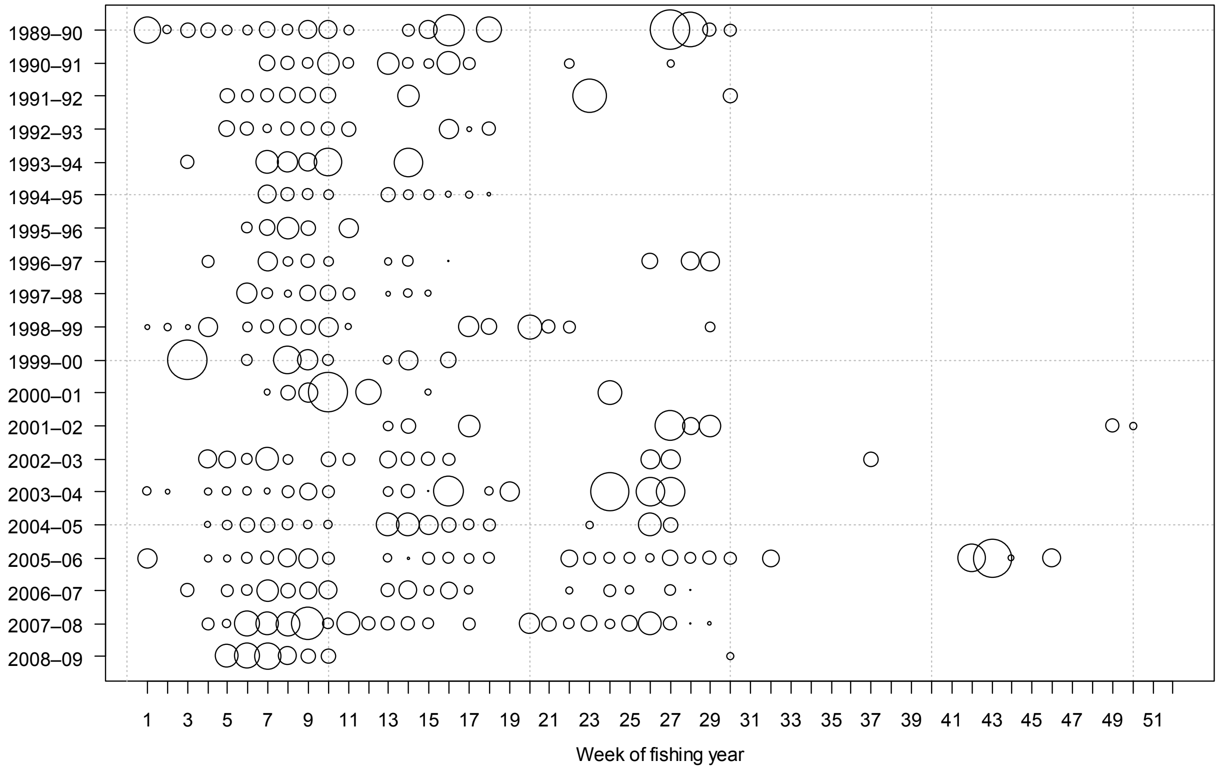

Figure 12: Average snapper catch rate (zero catch tows included) by week by fishing year, for the snapper target trawl fishery. The largest circle represents an average weekly catch rate of 249 kg/hr.

Daily catches were logged and modeled with a linear regression model which a normal error structure. The forced inclusion of the variable fishing duration forced the model to consider catch rates.

There were four unforced predictor variables which improved the R^2 statistic by at least 1%: Month, Vessel, number of fishing events per day and the Trenberth south/north pressure differential index (Table 5). Daily catches were higher when a greater number of tows took place, once the duration of those tows was taken into account (Figure 13). Catches were also higher on days in months when northerly winds were more common. Diagnostic plots for this model are given in Appendix 1a.

The trend seen in standardised catch rates since 1989 is broadly similar to that seen in the unstandardised catch rate index based on arithmetic and geometric means calculated for each fishing year (Figure 14). Dramatic fluctuations in the early to mid 1990s are possibly partially due to the voluntary closure of shallow inshore areas of Tasman Bay/Golden Bay on 1 October 1994, which may have led to significant changes in fishing practices. Catch rate indices have been more stable since the mid 1990s although a noticeable degree of interannual variability (and lack of precision) remains, possibly due in part to the limited amount of catch rate data available from the snapper target fishery.

Table 5: Order in which predictor variables were selected by a lognormal stepwise linear regression of snapper catch data for the Tasman Bay/Golden Bay snapper target fishery, and the improvement in the R^2 statistic which resulted from their inclusion at each step. The variable "Fishing year" was forced in the first iteration of the stepwise procedure. Variables accepted by the model are denoted with an * superscript.

						lognormal
Variable	1	2	3	4	5	n.s.
Fishing year*	0.059					
Events*		0.327				
Vessel*		0.089	0.375			
Month*		0.087	0.353	0.409		
Trenberth SN*		0.070	0.337	0.383	**0.420**	
Trenberth WE		0.060	0.330	0.377	0.417	0.428

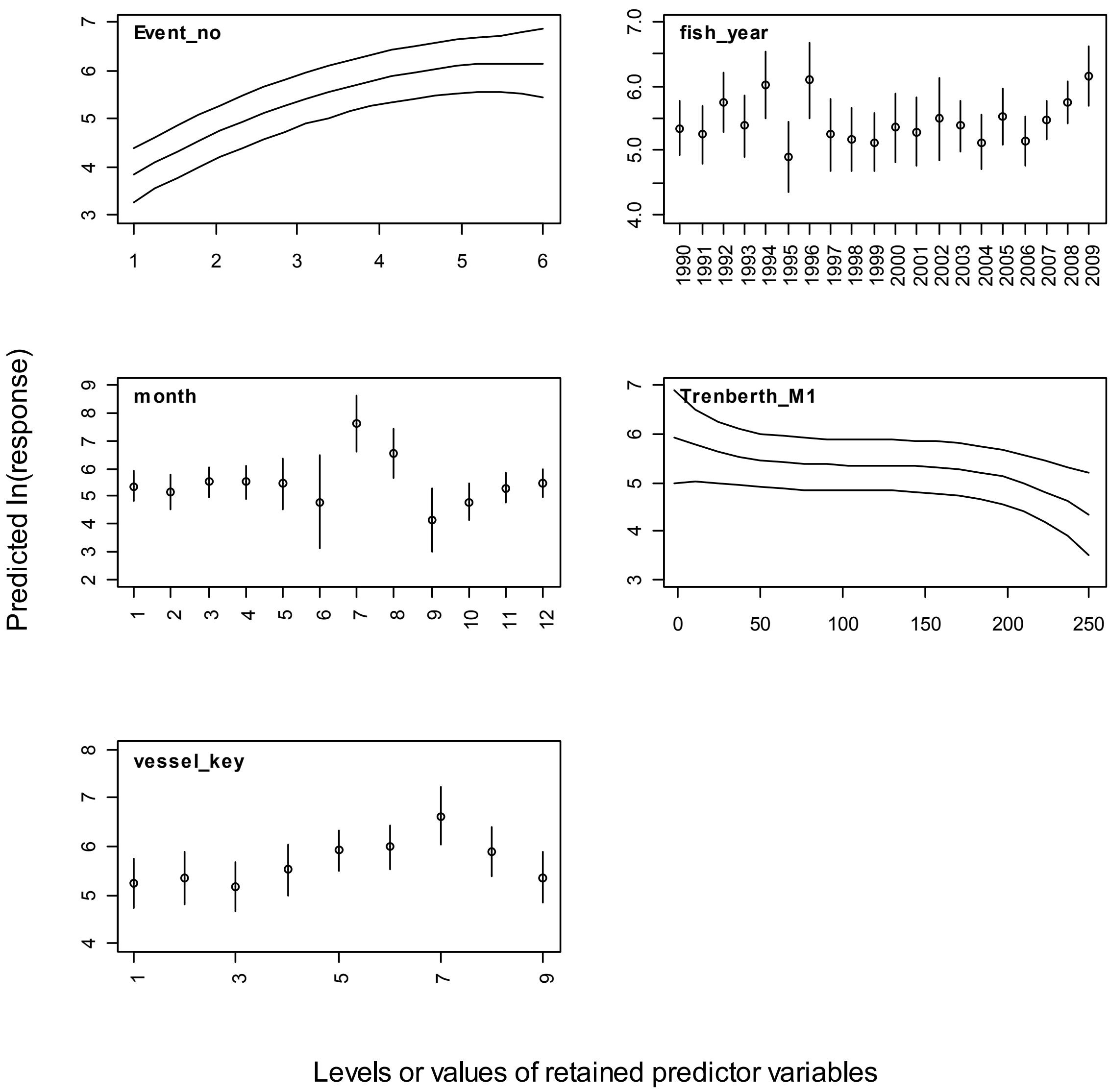

Figure 13: Predicted influence of variables selected by a lognormal linear regression of snapper catch rates for the snapper target trawl fishery in Tasman Bay/Golden Bay.

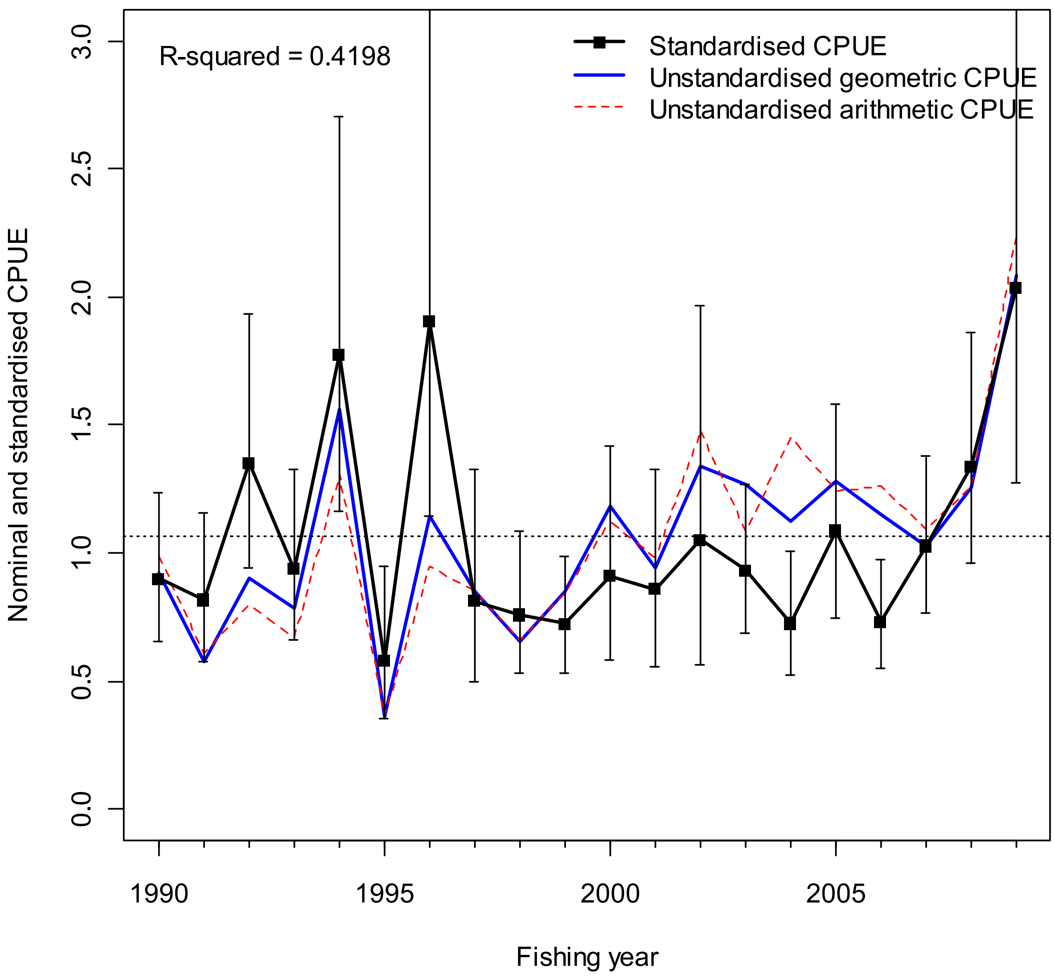

Figure 14: Standardised (lognormal) and unstandardised snapper catch rate indices based on catch effort data provided by a core set of vessels that targeted snapper on at least five days a year in at least four years between 1989–90 and 2008–09.

3.3 Snapper CPUE indices for the flatfish target fishery

Although data were available for 29 090 days where flatfish were targeted by single trawlers in Golden Bay/Tasman Bay, snapper were only caught on 16 475 of these days. Separate models were therefore used to model snapper catch rates on those days when bycatch of snapper was caught (lognormal regression), and the presence or absence of snapper in the catch on each day fished (binomial regression).

Although we identified 183 single trawl vessels that had targeted flatfish since 1989, data were only used from 29 vessels that had fished for flatfish on at least 10 days per year in at least five years (Figure 15). Although only a small number of these had fished throughout the last two decades, there was considerable overlap in vessel fishing histories over the period assessed. These core vessels fished on 17 561 days, and snapper were caught as a bycatch on 8273 of these. Although there has been little change in the average bycatch of snapper per tow since 1989, the number of hours towed per day has gradually trended upwards during this period (Figure 16). There has been no consistent seasonal trend in unstandardised catch rates, although there can be a marked interannual variation in fishing success (Figure 17).

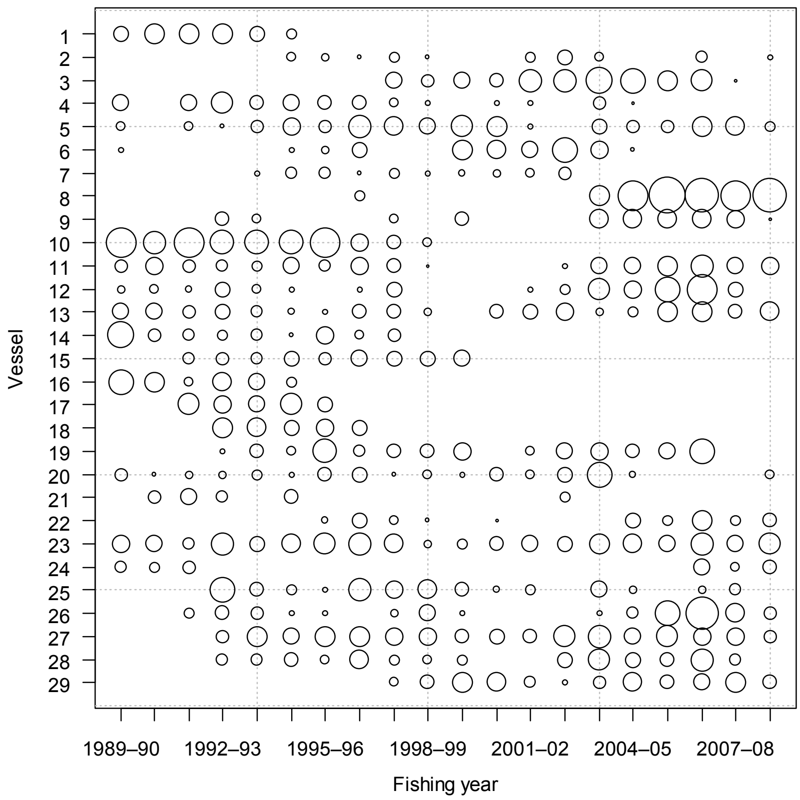

Figure 15: Number of days fished by single trawlers that targeted snapper on at least 10 days per year in at least five fishing years. The largest circle represents 128 days fished.

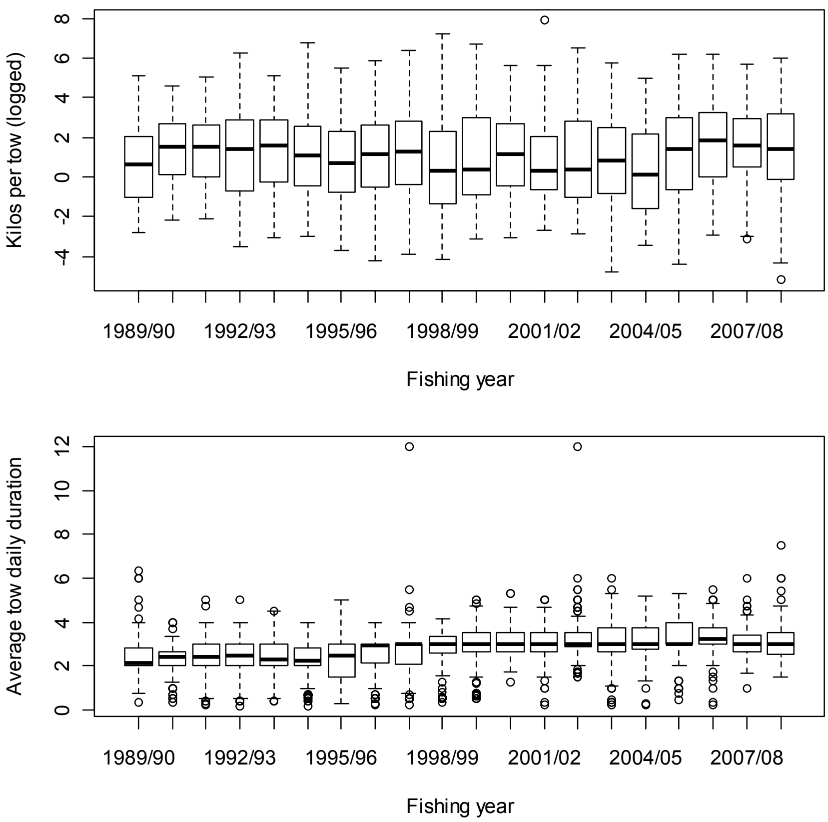

Figure 16: Annual distributions of snapper catch per tow (upper panel) and average tow durations per day, for the flatfish target trawl fishery.

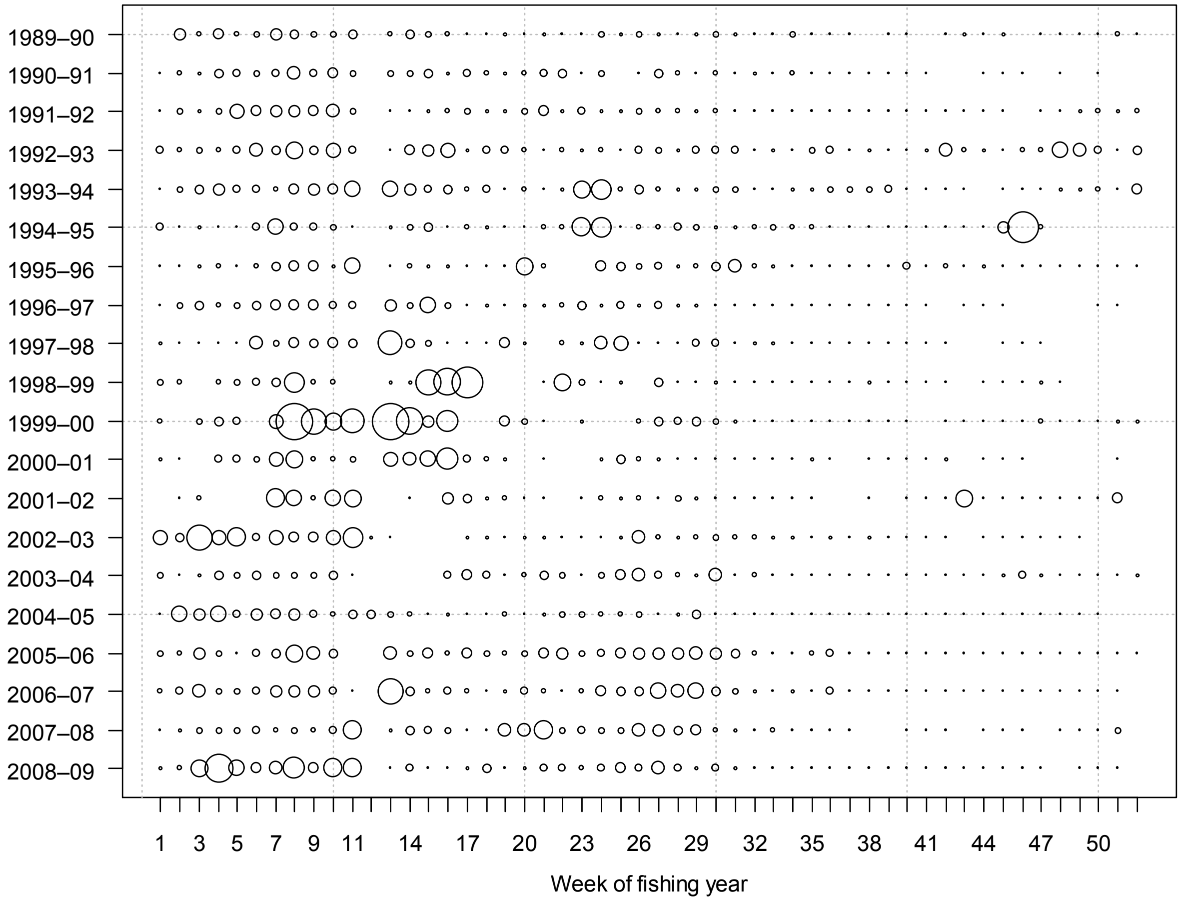

Figure 17: Average snapper catch rate (zero catch tows included) by week by fishing year (starting on the first of October), for the flatfish target trawl fishery. The largest circle represents an average weekly catch rate of 99 kg/hr.

Both standardisation models selected the variables "month" and "vessel" in the same order, following the forcing of the variable "fishing year" (Table 6). Snapper bycatch rates were highest in the spring and summer, but were highly variable between vessels (Figure 18). Daily snapper bycatch also increased with increased fishing duration. It was necessary to force an effort term ("duration") in the binomial model, as no measure of effort was selected by the model. The unstandardised geometric mean, lognormal and binomial catch rate indices all show bycatch rates declining in the late 1990s, followed by a gradual but fluctuating increase in recent years (Figures 19 and 20). Higher bycatch catch rates in the early 1990s may reflect fishing effort in shallower waters, which ceased after 1 October 1994 following a voluntary close of these areas to commercial fishing. Both the unstandardised and standardised indices fluctuate considerably from year to year, however, and although this may reflect localized changes in availability, the long term trend is more likely to reflect stock status. Diagnostic plots for these models are given in Appendices 1b and 1c.

Table 6: Order in which predictor variables were selected by lognormal and binomial stepwise linear regressions of snapper catch data for the Tasman Bay/Golden Bay flatfish target fishery, and the improvement in the R^2 statistic which resulted from their inclusion at each step. The variable "Fishing year" was forced in both models and "duration" was forced in the binomial model, in the first iteration of the stepwise procedure. Variables accepted by the model are denoted with an * superscript.

					lognormal
Variable	1	2	3	4	n.s.
Fishing year*	0.025				
Month*		0.249			
Vessel*		0.166	0.327		
Duration*		0.049	0.264	**0.345**	
SOI		0.041	0.254	0.330	0.348

				Binomial
Variable	1	2	3	n.s.
Fishing year & duration*	0.024			
Month*		0.108		
Vessel*		0.050	**0.127**	
Trenberth WE		0.028	0.109	0.128

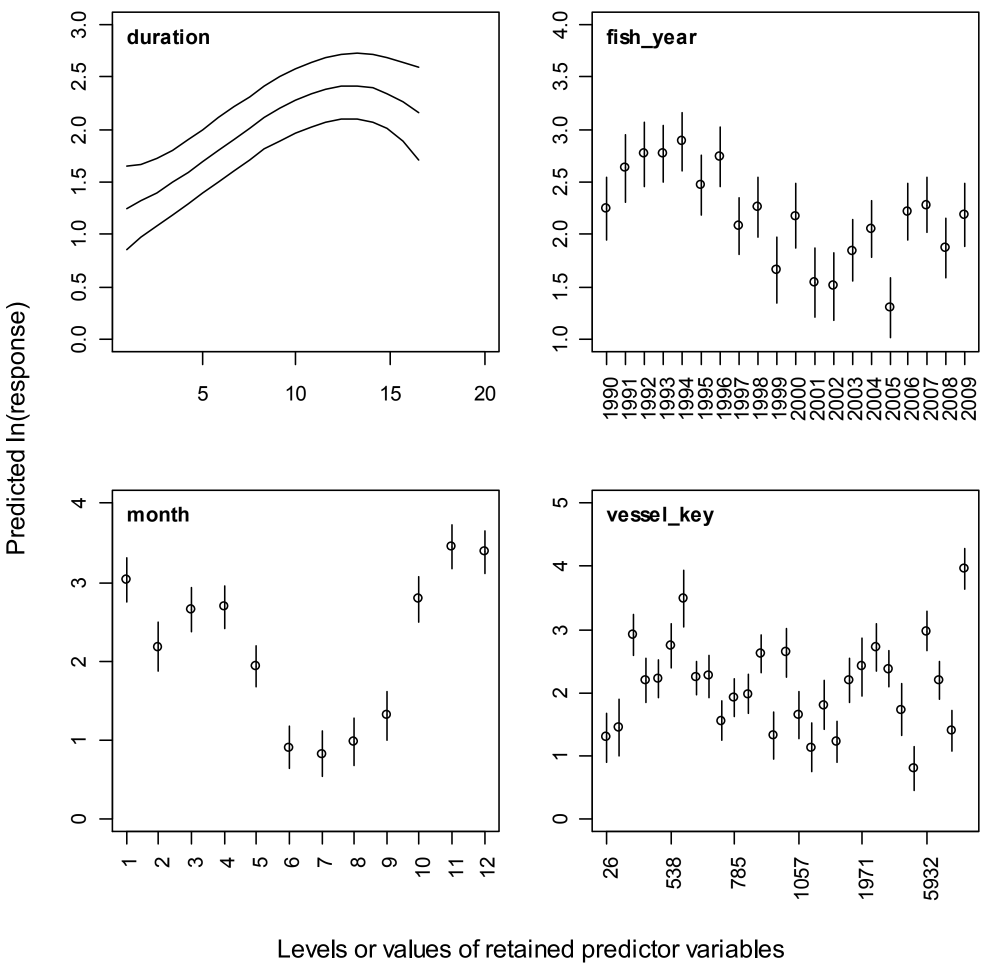

Figure 18: Predicted influence of variables selected by a lognormal linear regression of snapper catch rates for the flatfish target trawl fishery in Tasman Bay/Golden Bay.

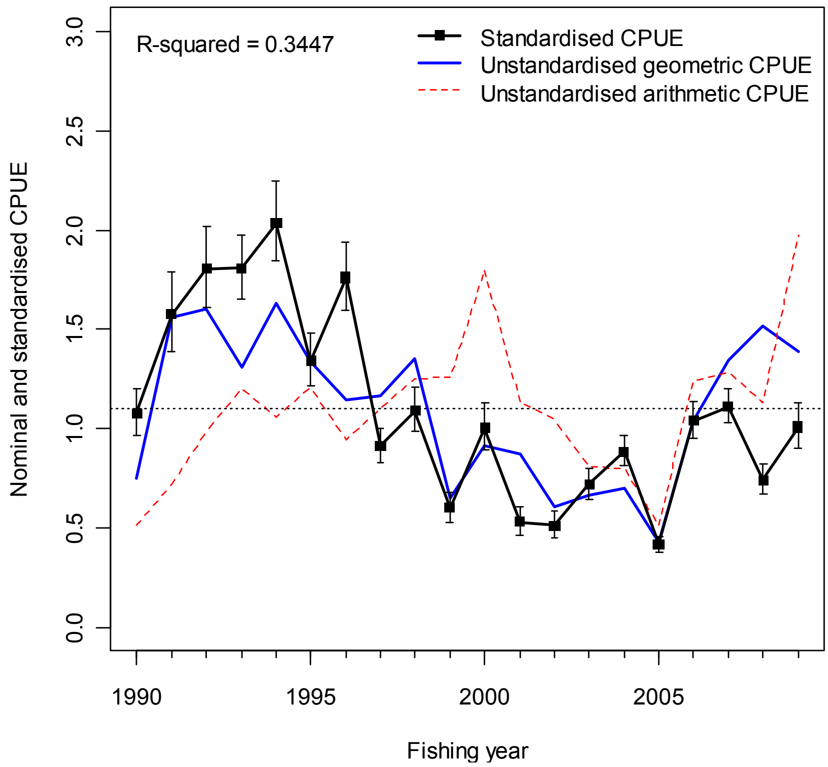

Figure 19: Standardised (lognormal) and unstandardised snapper catch rate indices based on catch effort data provided by a core set of vessels that targeted flatfish on at least 10 days a year in at least five years between 1989–90 and 2008–09.

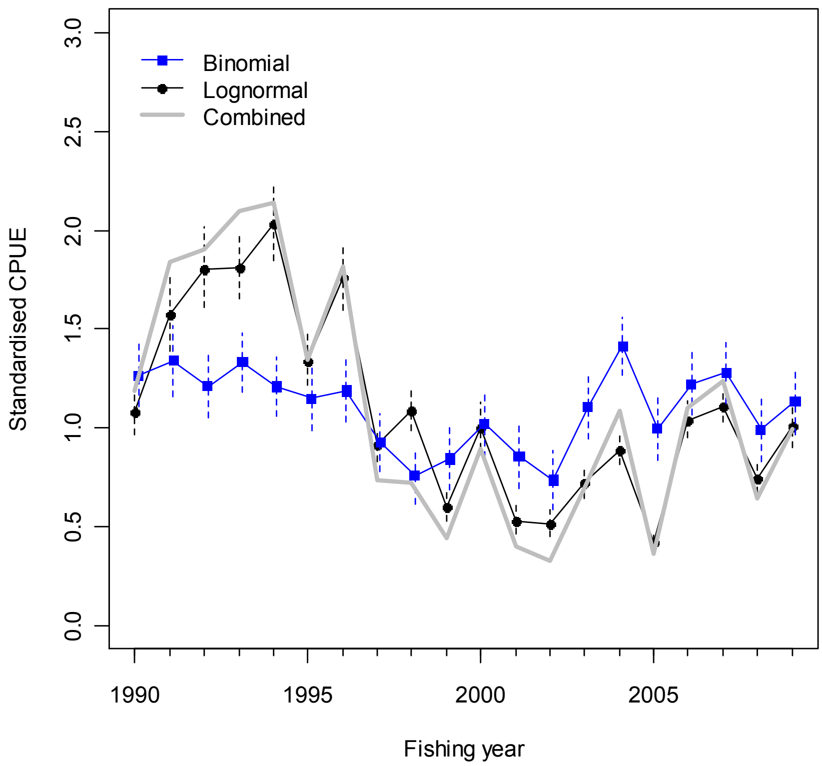

Figure 20: Standardised lognormal, binomial, and combined models based on snapper catch rate indices derived from catch effort data provided by a core set of vessels that targeted flatfish on at least 10 days a year in at least five years between 1989–90 and 2008–09.

3.4 Snapper CPUE indices for the barracouta target fishery

Of the 80 single trawlers that targeted barracouta in FMA 7, only 11 of these had caught snapper on at least 10 days per year in at least four fishing years (Figure 21). These vessels targeted barracouta on a total of 3958 days and caught snapper on 2392 of these. A linear binomial model was used to predict the presence or absence of snapper in each day's catch and a linear lognormal model was used to predict catch rates on days when snapper was caught. Although there has been little change in the average bycatch of snapper per tow since 1989, the number of hours towed per day has gradually trended upwards during this period (Figure 22), as seen in the flatfish target fishery (Figure 16). There has been no consistent seasonal trend in unstandardised catch rates, although there can be a marked interannual variation in fishing success (Figure 23).

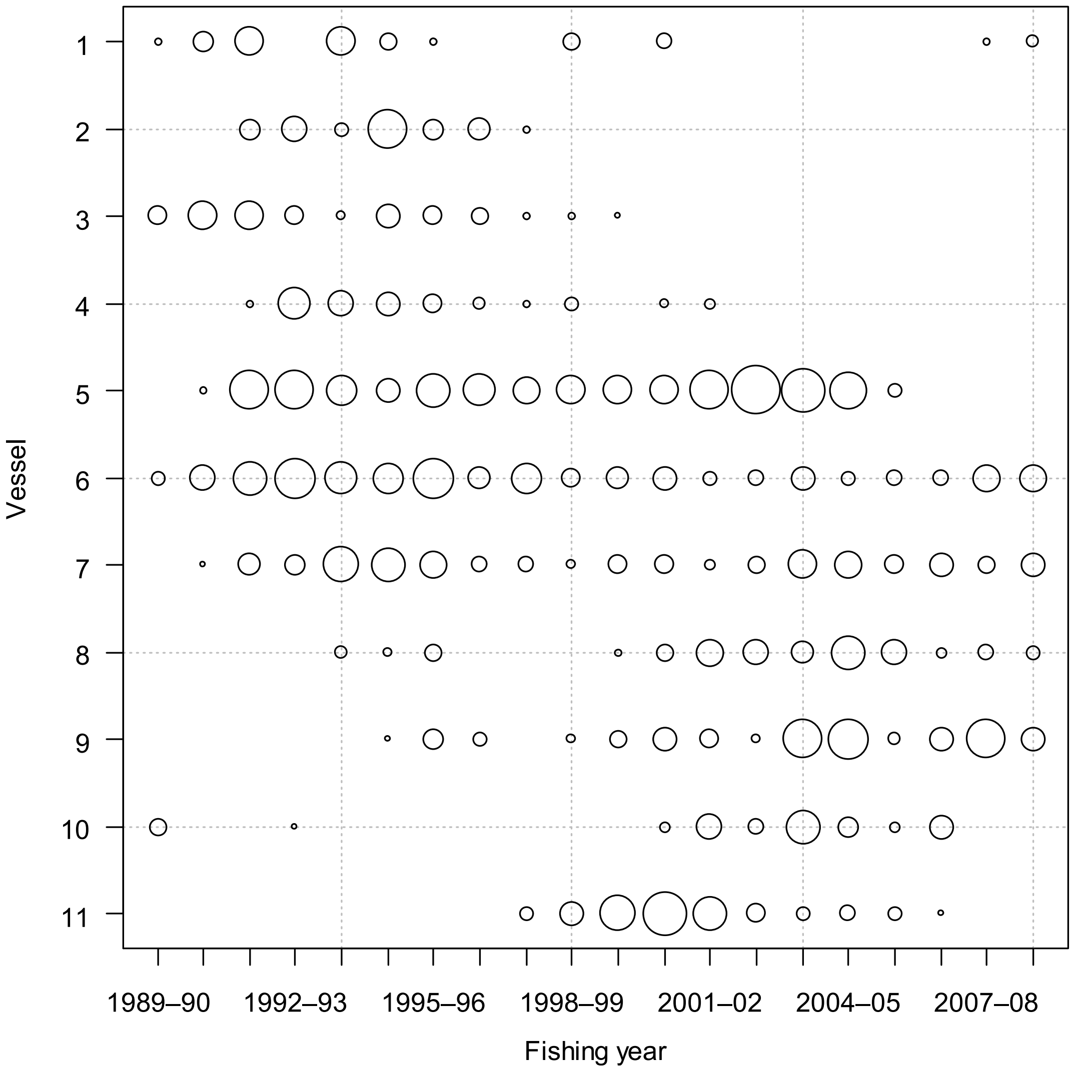

Figure 21: Number of days fished by single trawlers that targeted barracouta on at least 10 days per year in at least four fishing years. The largest circle represents 57 days fished.

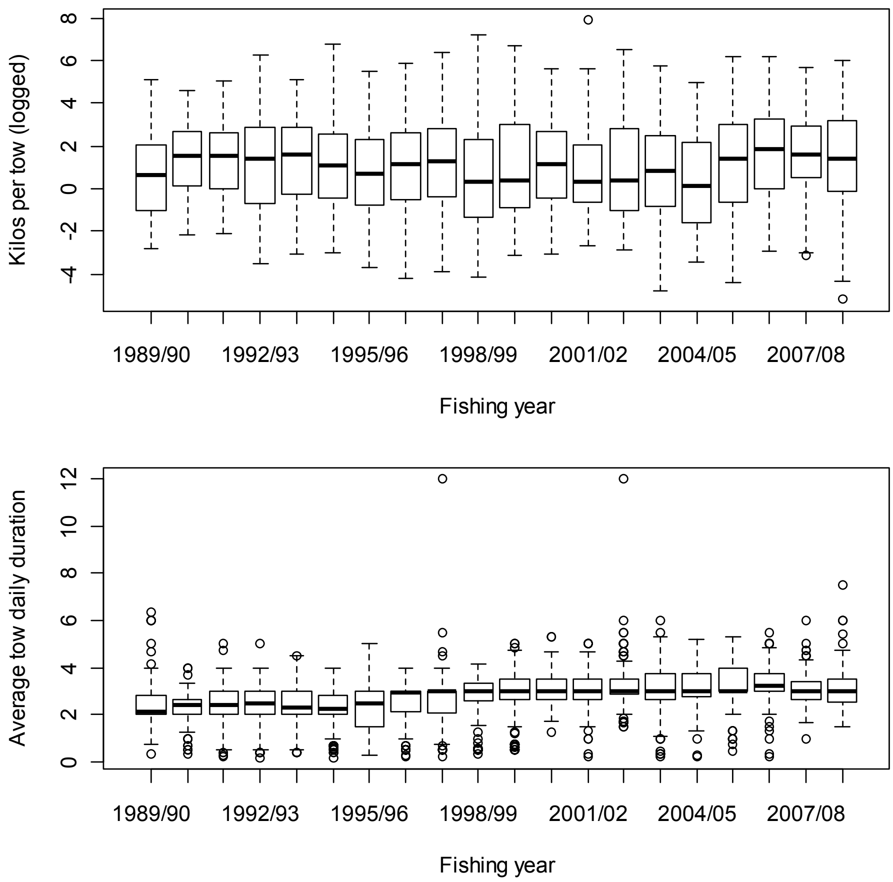

Figure 22: Annual distributions of snapper catch per tow (upper panel) and average tow durations per day, for the barracouta target trawl fishery.

The variable “fishing year” was forced in both models to provide and annual index, and it was necessary to force an effort term (“duration”) in the binomial model, as no measure of effort was selected by the model. The inclusion of the predictors “Month”, “Vessel” and “Duration” resulted in an improvement of at least 1% in the R^2 statistic for the lognormal model, and for the binomial model, only the variable “month” was selected (Table 7). The predicted bycatch of snapper was highest in autumn and spring (Figure 24), which is possibly attributable to areas/depths fished, as a substantial proportion of the snapper taken by this fishery, and the effort targeted towards barracouta, is often in statistical reporting area 038 in these months (Figure 8). The snapper bycatch was also higher on those days when a greater number of trawl tows took place. The standardisation of the log transformed bycatch data predicts lower snapper catch rates in the 1990s and higher rates since the 2003–04 fishing year than seen in unstandardised indices (Figure 25). There is relatively little trend in the binomial index (Figure 26).

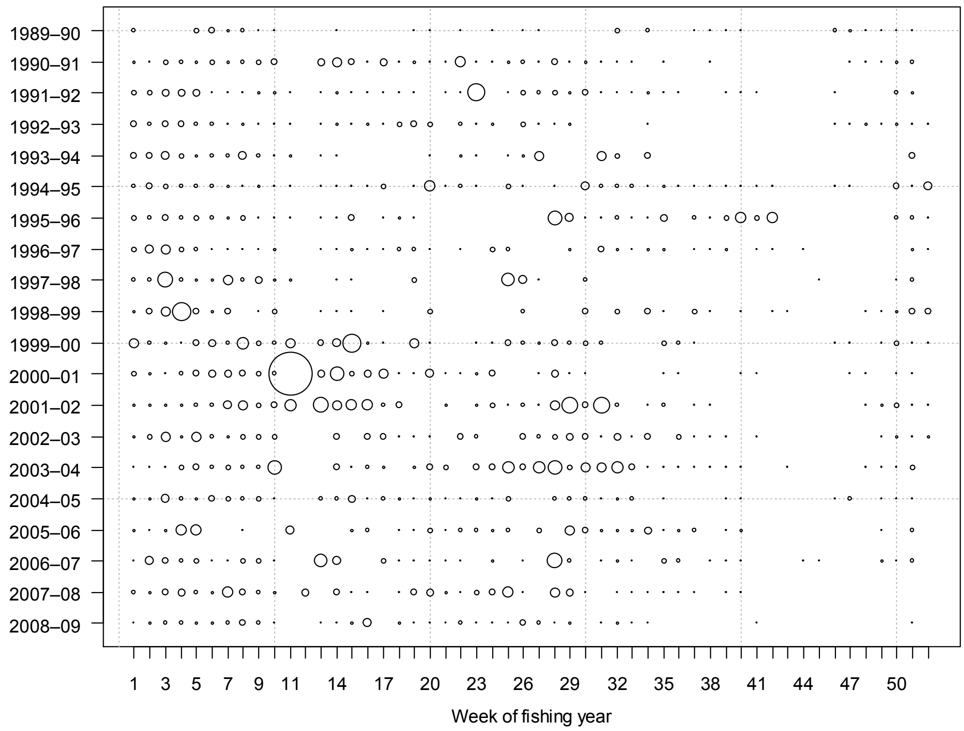

Figure 23: Average snapper catch rate (zero catch tows included) by week by fishing year (starting on the first of October), for the barracouta target trawl fishery. The largest circle represents an average weekly catch rate of 481 kg/hr.

Table 7: Order in which predictor variables were selected by lognormal and binomial stepwise linear regressions of snapper catch rate data for the Tasman Bay/Golden Bay barracouta target fishery, and the improvement in the R^2 statistic which resulted from their inclusion at each step. The variable "Fishing year" was forced in both models and "duration" was forced in the binomial model, in the first iteration of the stepwise procedure. Variables accepted by the model are denoted with an * superscript.

					lognormal
Variable	1	2	3	4	n.s.
Fishing year*	0.044				
Month*		0.164			
Vessel*		0.116	0.221		
Duration*		0.103	0.213	**0.270**	
SOI		0.067	0.176	0.230	0.278

			binomial
Variable	1	2	n.s.
Fishing year & duration*	0.031		
Month*		**0.070**	
Vessel		0.039	0.078

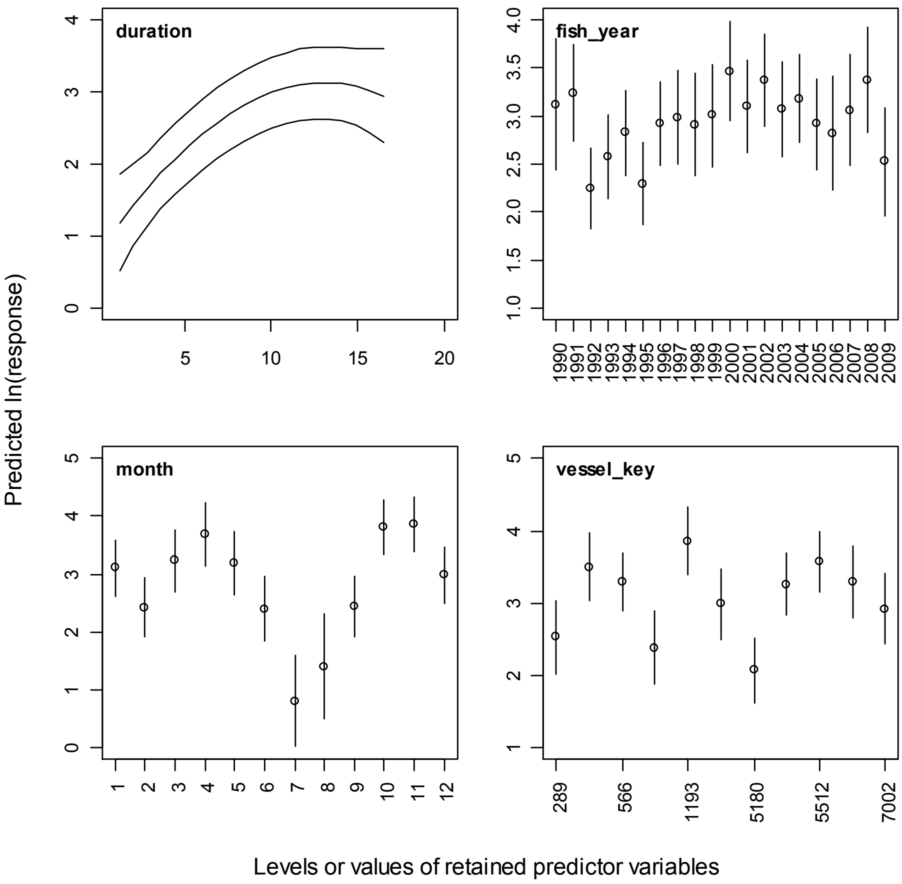

Figure 24: Predicted influence of variables selected by a lognormal linear regression of snapper catch rates for the barracouta target trawl fishery in Tasman Bay/Golden Bay.

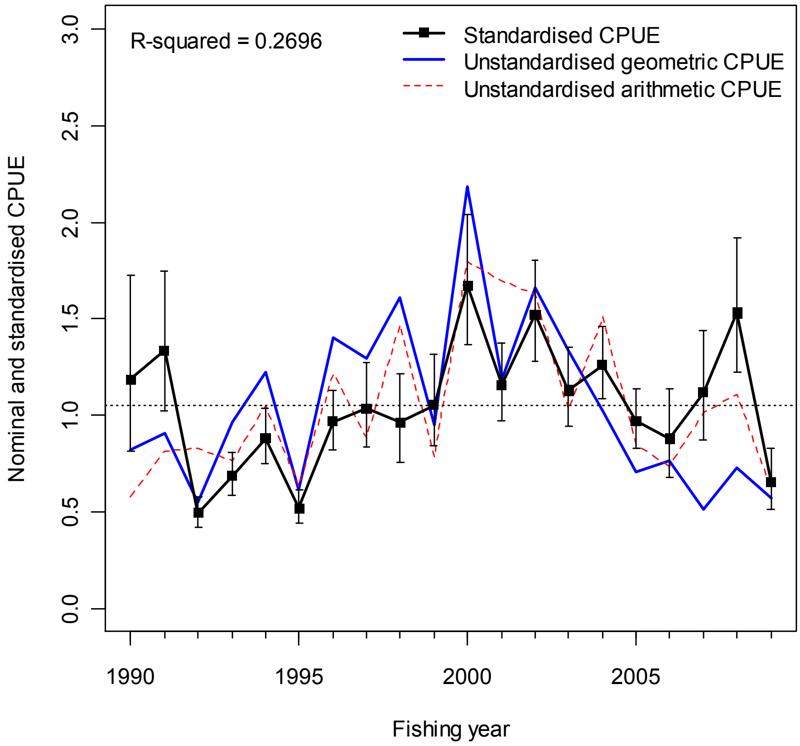

Figure 25: Standardised (lognormal) and unstandardised snapper catch rate indices based on catch effort data provided by a core set of vessels that targeted barracouta on at least 10 days per year in at least four years between 1989–90 and 2008–09.

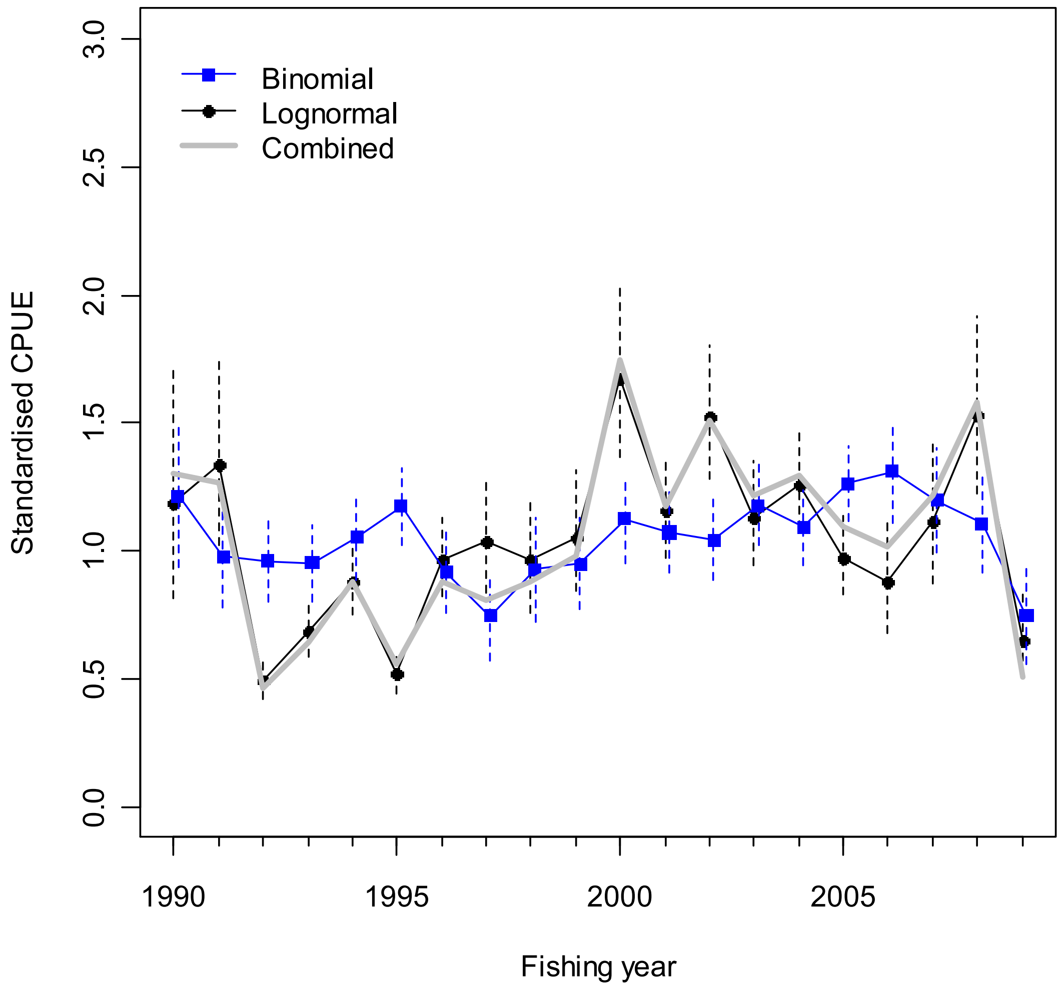

Figure 26: Standardised lognormal, binomial, and combined model based on snapper catch rate indices derived from catch effort data provided by a core set of vessels that targeted barracouta on at least 10 days per year in at least four years between 1989–90 and 2008–09.

3.5 A combined fishery standardised CPUE index

The snapper catch rate indices derived from the snapper, flatfish, and barracouta target trawl fisheries all fluctuate markedly from year to year, but these fluctuations do not coincide for any pair of fishery indices. Although the snapper target fishery should in theory provide the most informative indication of relative change in snapper abundance, the number of observations available for any fishing year is relatively low (16 to 96 days) and there is only limited overlap between the fishing histories of the few vessels that have participated in the fishery for any length of time. Differences between the flatfish and barracouta indices are perhaps not surprising given seasonal and spatial differences in the dynamics of these fleets, and in the fishing gears used.

Although indices derived for all three fisheries show a high degree of interannual variability, the general long term trend is broadly the same, with relatively little consistent change in catch rates over time. Results from the characterisation suggested that all three fisheries could potentially interact with different components of the wider stock, both spatially and temporally. Because of this, the Southern Inshore Working Group suggested that positive catch data (i.e. for those days where snapper was caught) from all three fisheries should be combined, and considered in a single lognormal model. A categorical variable, “Fishery”, was also offered to the model, as were the interaction terms

Fishery:Month and Fishery:Vessel, to allow for the fact that each fishery may interact with different components of the stock given the time of year and vessel used in a manner that was not detectable given the available explanatory variables.

The variables selected by the combined fishery model were similar to those selected by the individual fishery models (Table 8). Most of the variance in catch was explained by the month fished and by differences between vessels, as seen in individual fishery models. Fishery type also explained a significant proportion of the variance in catch, with catches on days when snapper was targeted being significantly higher than when flatfish were targeted, and in turn, barracouta (Figure 27). The inclusion of the Fishery:Month interaction term suggests that catch rates peaked in different months, depending on the target species. Increased daily fishing effort (hours fished) also resulted in increased catches, and this effort variable was selected by the model without the need to force its inclusion.

Table 8: Order in which predictor variables were selected by a lognormal stepwise linear regression of snapper catch data for the combined Tasman Bay/Golden Bay snapper, flatfish, and barracouta target fishery, and the improvement in the R^2 statistic which resulted from their inclusion at each step. The variable "Fishing year" was forced in the first iteration of the stepwise procedure. Variables accepted by the model are denoted with an * superscript.

							Lognormal
Variable	1	2	3	4	5	6	n.s.
Fishing year*	0.011						
Month*		0.255					
Vessel*		0.198	0.378				
Fishery*		0.176	0.336	0.393			
Duration*		0.044	0.273	0.366	0.412		
Fishery:Month*					0.404	**0.425**	
Fishery:Vessel					0.396	0.415	0.429

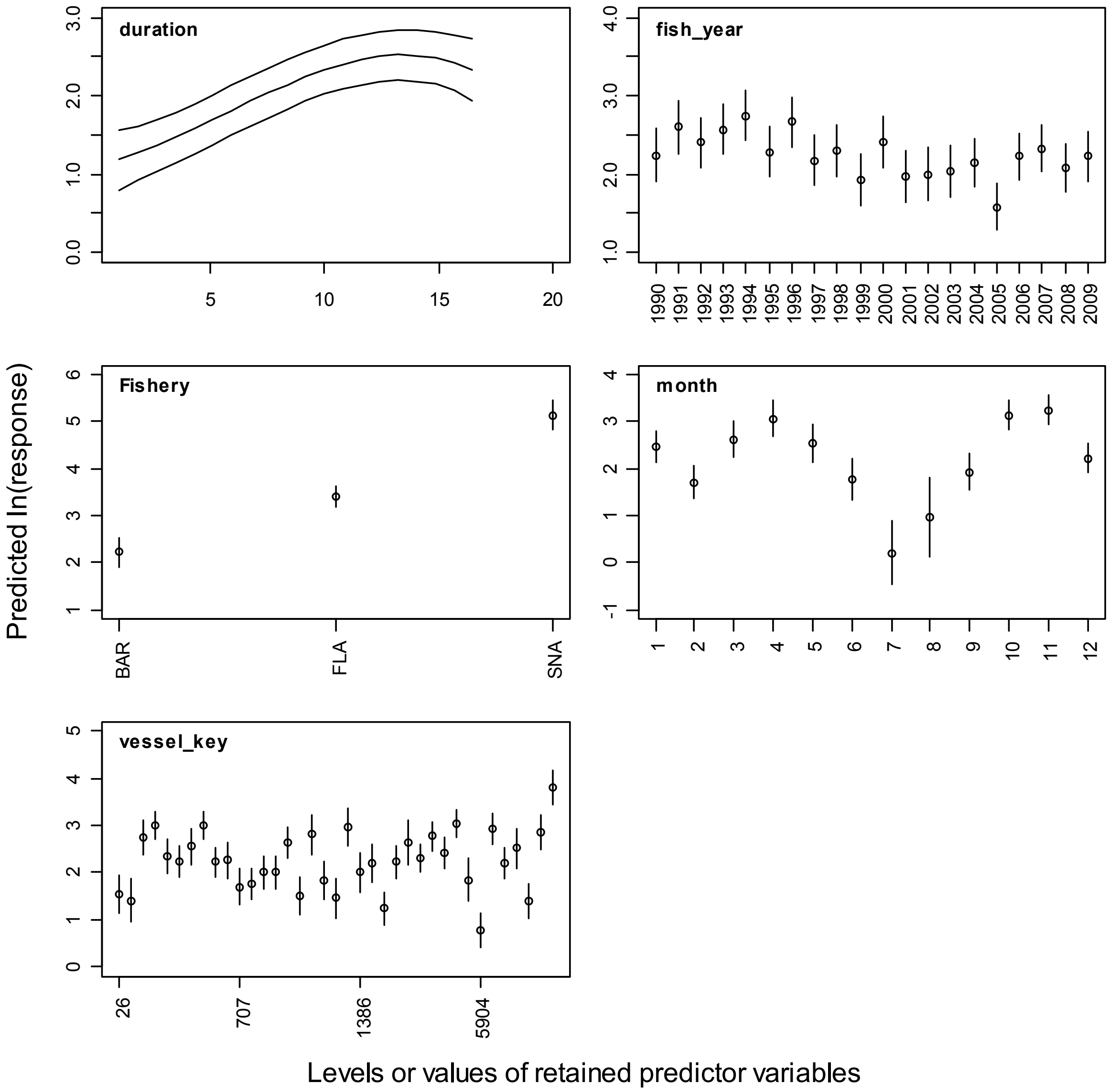

Figure 27: Predicted influence of variables selected by a lognormal linear regression of snapper catches taken by the combined snapper, flatfish, and barracouta target trawl fisheries in Tasman Bay/Golden Bay.

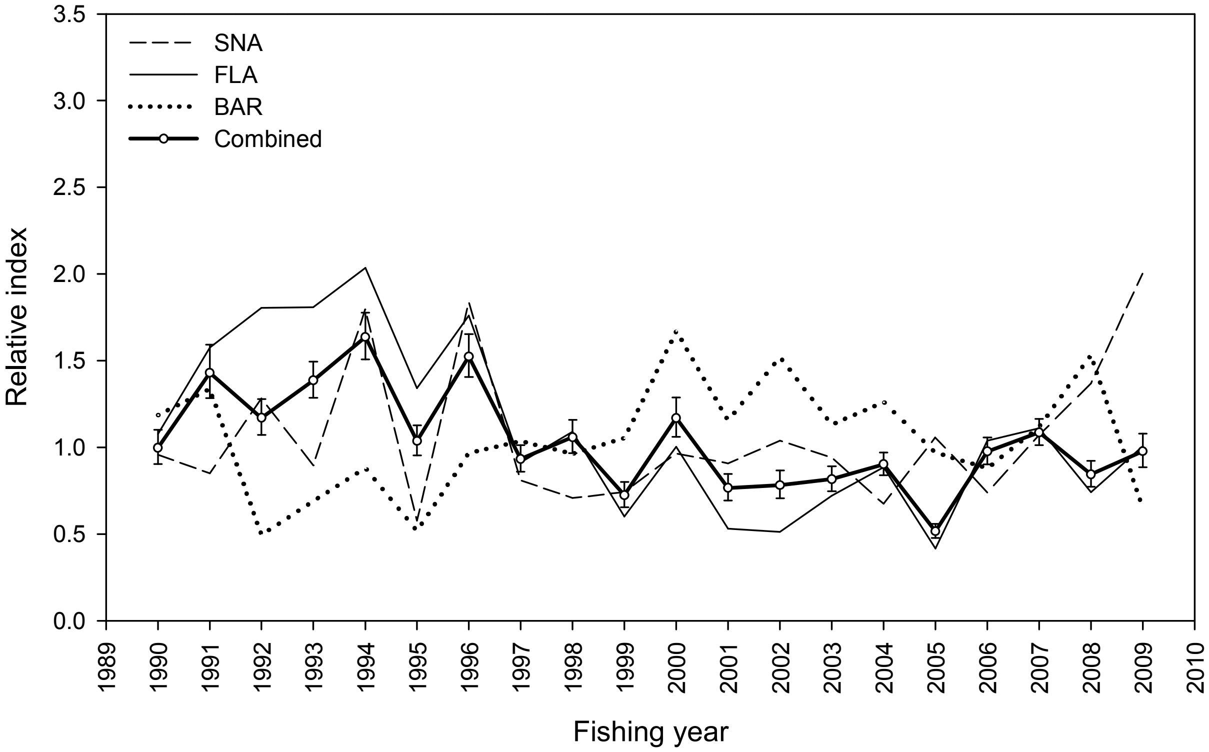

Figure 28: Comparison of standardised snapper catch indices derived from the snapper, flatfish, and barracouta target trawl fisheries and from all three fisheries combined. See Figures 14, 19 and 25 for confidence intervals associated with indices for the individual snapper, flatfish, and barracouta target fishery models.

The combined fishery index broadly resembles that of the flatfish target fishery index (Figure 28). This is because the majority of the data used in the combined fishery model are derived from the flatfish fishery (8272 days fished for FLA, 2392 days for BAR, and 832 days for SNA). Nonetheless, the combined fishery index probably provides the most reliable index of abundance currently available for SNA 7. This is because the model explicitly considers the manner in which differing fisheries may interact with different components of the Tasman Bay/Golden Bay snapper stock. The confidence intervals associated with the combined index are also tighter than those associated with the individual fishery indices, and there is less interannual variability in the combined index, which suggests that this index is more plausible.

4. ALTERNATIVE APPROACHES FOR MONITORING SNA 7

Although CPUE indices are commonly used to monitor fish stock abundance, there are alternative approaches which could be considered. Some of these approaches have been attempted in SNA 7 in the past; either directly or indirectly. Alternative monitoring approaches were identified from: a review of the available literature on the SNA 7 fishery, discussions with fisheries researchers, and formal interviews with commercial fishers who have a long association with the SNA 7 fishery.

Several of the commercial fishermen we approached worked for large fishing companies and were unwilling to be interviewed, but we were able to interview two pair trawl skippers (skippers of the only pair trawlers routinely operating in Golden Bay/Tasman Bay), two single trawl operators and an ex-longliner who now runs a single trawler (Appendix 2). These fishermen were asked to describe: their fishing history, the gear that they had used over that time, the dynamics of their catch and effort, and to discuss whether they thought some form of standardised industry tow monitoring programme could be informative, and what form that programme might take. These interviews were documented and then returned to interviewed fishers so that any errors could be detected and to ensure that they provided a true reflection of the information provided. Interviewed fishers have approved the release of these interviews.

4.1 Catch sampling and catch curves

Catch curves are commonly used to evaluate the rate at which a stock is being exploited, and a time series of these total mortality (Z) estimates can be used to monitor changes in the exploitation rate over time. This approach requires representative age frequency data which is usually obtained from catch sampling programmes. Catch-at-age data have been collected intermittently from SNA 7 since 1997–98 (1997–98, Blackwell et al. 2000a; 1998–99, Blackwell et al. 2000b; 1999–00, Blackwell & Gilbert 2001; 2000–01, Blackwell & Gilbert 2002; 2003–04, Blackwell & Gilbert 2005; 2006–07, Blackwell & Gilbert 2008).

The first four of the six years sampled were consecutive, and the progression of strong and weak year classes is clearly evident over this period (Figure 29). Although this suggests that the trawl fisheries can be used to monitor year class strength in an informative manner, the variability of these year class strengths appears to be too great to support a time series of catch curve estimates. This is because the infrequent presence of an atypically strong year class will have undue influence on the slope of any regression based estimator of Z as it progresses through the population. Any changes in the underlying exploitation rate of a population will therefore be misinterpreted because of year class strength variability.

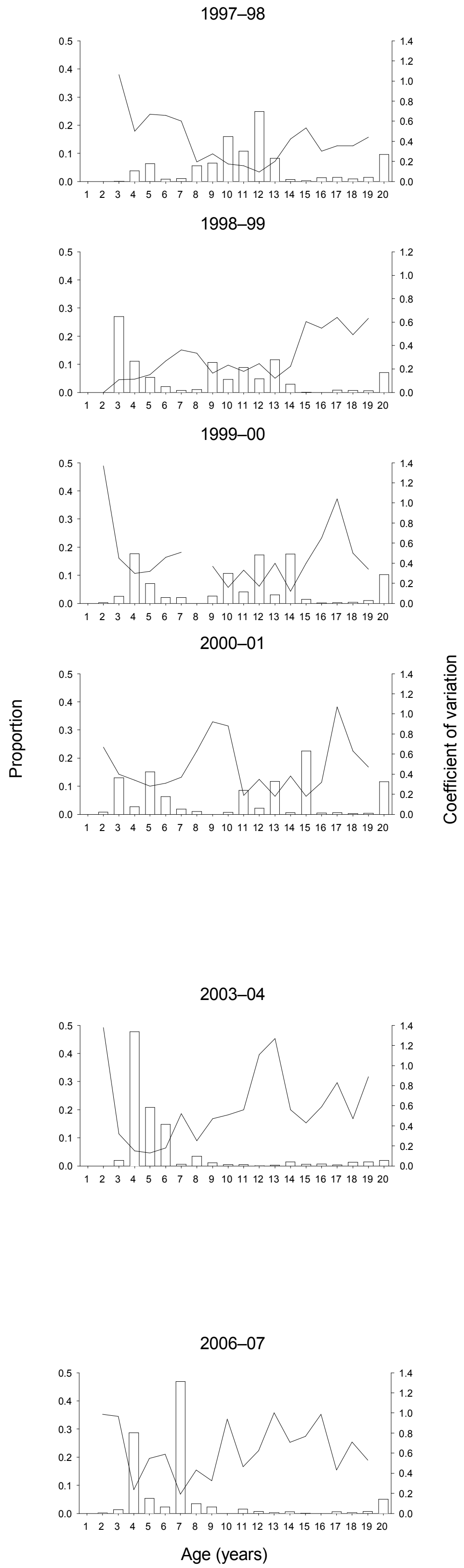

Figure 29: Time series of catch-at-age distributions for the SNA 7 trawl fishery in Golden Bay/Tasman Bay derived from catch sampling in commercial processing sheds.

4.2 Research trawl surveys

Standardised research trawl surveys have been conducted on the west coast of the South Island and in Tasman Bay/Golden Bay approximately every two years since 1990. In the most recent survey, in 2009, there were 15 trawl stations spread across three strata in Tasman Bay/Golden Bay, with a further 60 stations on the west coast of the South Island (Stevenson & Hanchet 2010). Snapper accounted for less than 1% of the catch taken during the entire survey, and were caught in only 13 of 75 tows. Standardised research trawl surveys in 1995 (Blackwell & Stevenson 1997) and 1996 (Stevenson 1996) were conducted solely within Tasman Bay/Golden Bay and targeted juvenile snapper. Only 12 snapper (no juveniles) were caught in the 1995 survey and 19 (13 juveniles) in 1996. These results suggest that a standardised research trawl survey approach is neither a viable nor cost effective means of monitoring snapper abundance.

The Challenger fishery stakeholder organisation has recently proposed an annual industry run trawl survey of Tasman Bay and Golden Bay, but the purpose of this will be primarily to monitor the abundance of flatfish, red gurnard and red cod (Adam Langley, Trophia Ltd., pers. comm.). A commercial trawler will fish with standardised flatfish trawl gear, and tows will be made at 30 stations. Some of these tows will be made in shallower depths than previously surveyed by the R.V. Kaharoa; potentially less than 10 m. It has been suggested that catch rates of juvenile snapper in these shallower waters could be informative.

4.3 Standardised commercial pair trawl fishing effort

Research trawl survey methods are standardised so that catch rates can be compared in space and time. Research surveys are expensive, however, because the value of the catch usually contributes little to the cost of the survey. Although regular trawl surveys offer a viable means of monitoring the abundance of more common species, such as red gurnard and red cod in Tasman Bay/Golden Bay, this is not the case for snapper because of the limited number of tows normally undertaken in this area and the low incidence of snapper caught.

In contrast, commercial fishing effort is often targeted at snapper, which is caught in a commercially cost effective manner. The number of fishing events directed annually towards snapper by a single commercial vessel often greatly exceeds that of any research trawl survey undertaken in Tasman Bay/Golden Bay to date. The methods used are not, however, necessarily standardized between tows because of the commercial imperative of maximizing catch rates (given the location fished and the prevailing conditions). The spatial and temporal distribution of commercial fishing effort is therefore intentionally non-random. Although analytical techniques such as Generalised Linear Modeling are routinely used to standardise and improve the comparability of reported catch rates over time, these standardisations are based on crude reported descriptors of effort, such as the aggregation of the locations of into statistical reporting areas.

The advantages of both of these approaches could be combined if one or more commercial fishing vessel used predetermined standardised methods when targeting snapper in a commercially viable manner. Greater consideration could be given to the resolution and nature of any catch effort data reported for these tows, to support any further standardisation of catch effort data by analytical methods. The location and direction of tows would be selected by the skipper of the vessel in the first year, and they would then be repeated in following years at the same time of year.

Commercial fishers were interviewed and asked if they thought this approach was viable, and if so, which method should be used (Appendix 2). The results of these interviews were equivocal. Although two pair trawl skippers were very supportive of the concept of standardised tows by pair trawling, three single trawl skippers expressed doubts about the value of standardised tows; by any method. Concerns were expressed about a variety of factors that affected catch rates which could not be controlled, such as water clarity, water temperature, tidal flow, onshore and offshore movements of snapper during the day and through the season, spatial variation on spawning aggregation location, and the fact that the timing of the snapper season was partially dependent on when the preceding scallop season finished.

These interviews suggested that regardless of any concerns about catchability, bottom pair trawling appeared to offer the most promising means of monitoring the fishery via standardised commercial tows. The pair trawl skippers suggested that they were already largely doing what was suggested, i.e., they fish with the same gear and vessels each year, typically at the same time of year and in the same areas.

We examined the catch effort data provided by these skippers since 1989, to determine whether these data could be used to derive an informative index of abundance. These vessels have targeted snapper in Golden Bay/Tasman Bay as paired trawlers in almost every year since 1989, but fishing by other pair trawlers has only been spasmodic. A detailed examination of the reporting history of these boats, and discussion with their skippers, has confirmed that they have recorded catch and effort in a consistent manner over the last two decades. The catch reported by each vessel was half of the combined catch, but both vessels recorded the number of hours towed as a pair. Some discrepancies were readily apparent and these were corrected, such as landing dates which were out by one day despite matching landed catch and effort totals for the trip. Other discrepancies were less intuitive, and these were discussed with the two skippers, who were able to refer to their CELR log books. For some trips, however, marked discrepancies in catch, effort and days fished remained, and these data were dropped from the data set.

All of the catch and effort reported by these vessels before 1 October 2007 was reported on the CELR system, and there is therefore no information available on the location (other than in area 038) and depth fished, or on key effort variables such as tow speed. Only unstandardised catch rate indices were therefore calculated, to assess the utility of this data source. The trend in pair trawl catch rates over the last two decades is markedly different from that seen in the single trawl snapper target fishery; showing a far greater degree of change over time (Figure 30). Pair trawl catch rates were highest in the early 1990s, before the closure of shallow inshore waters where pair trawling used to take place. One of the pair trawl skippers (Lex Bloomfield) has suggested that good catch rates were achieved in these areas before their closure, and that the shift out into deeper waters resulted in a decline in fishing success, partially because of the need to adapt to new fishing grounds. Catch rates have increased in recent years, and this may be due to the availability of a strong cohort of larger snapper from the 2000 year class, which may be more vulnerable to pair trawling than to single trawlers.

Another observation offered by Lex Bloomfield was that catch rates are often higher at the beginning of the fishing year, but pair trawling for snapper is often deferred because of a late scallop season. The timing of effort could therefore partially explain inter-annual fluctuations in catch rates. An examination of weekly catch rates during the first six months of the fishing year suggests that this is not the case, however, as there is no obvious seasonal pattern in catch per hour towed (Figure 31). Regardless of any seasonality in catch rates, a standardised tow programme should be restricted to a set time of year, which still has a reasonable prospect of yielding commercially viable catches.

Although the interviewed skippers expressed a willingness to participate in a long term standardised tow monitoring programme, there are several reasons why the utility of this approach is limited. Firstly, the long term viability of the approach is dependent on a single pair of vessels which have a considerable tonnage of snapper quota available to them, and any reliance on this method must assume that these vessels will continue to target snapper over the long term. Secondly, the degree of fluctuation seen in the catch rates by this single pair of vessels is far greater than that seen in single trawl CPUE indices, and this degree of change is unlikely to reflect actual changes in abundance. The skippers have suggested that they have already standardised their tows to some degree, and it is therefore likely that pair trawl catch rates could continue to suggest unrealistic levels of volatility in abundance. Finally, all commercial fishers agree that it is not possible to control for some circumstances that determine catch rates, such as water clarity, tidal current flow and the spatio-temporal distribution of snapper at different times of the day and season.

We conclude that a standardised tow monitoring approach is neither reliable nor cost effective in the long term.

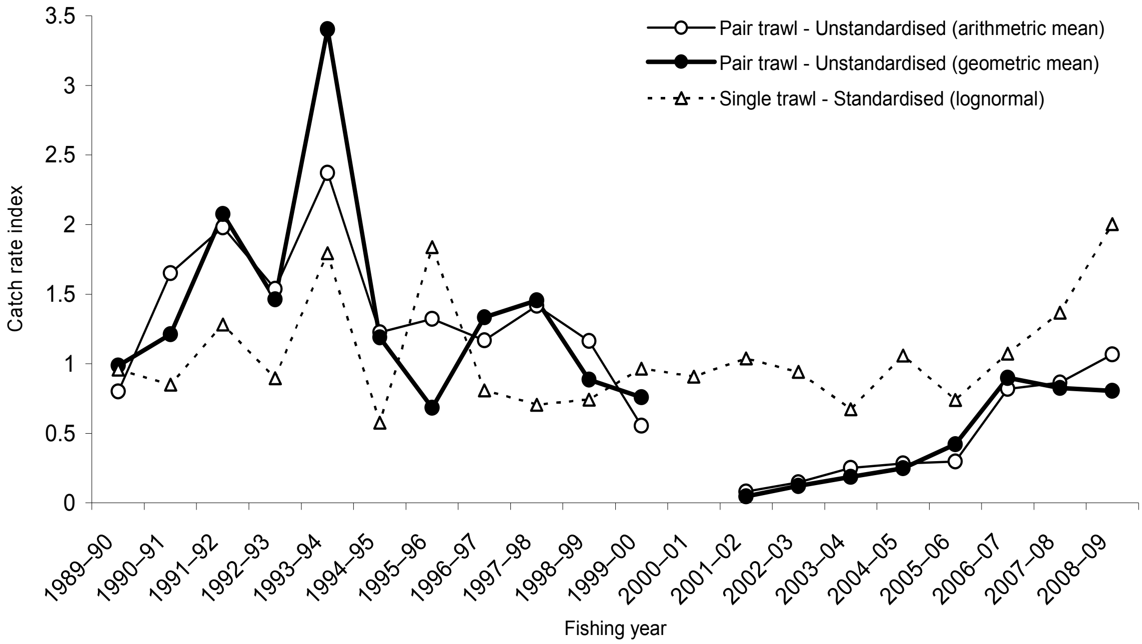

Figure 30: Comparison of unstandardised catch rate indices for the pair trawl snapper target fishery with a standardised index for the single trawl snapper target fishery.

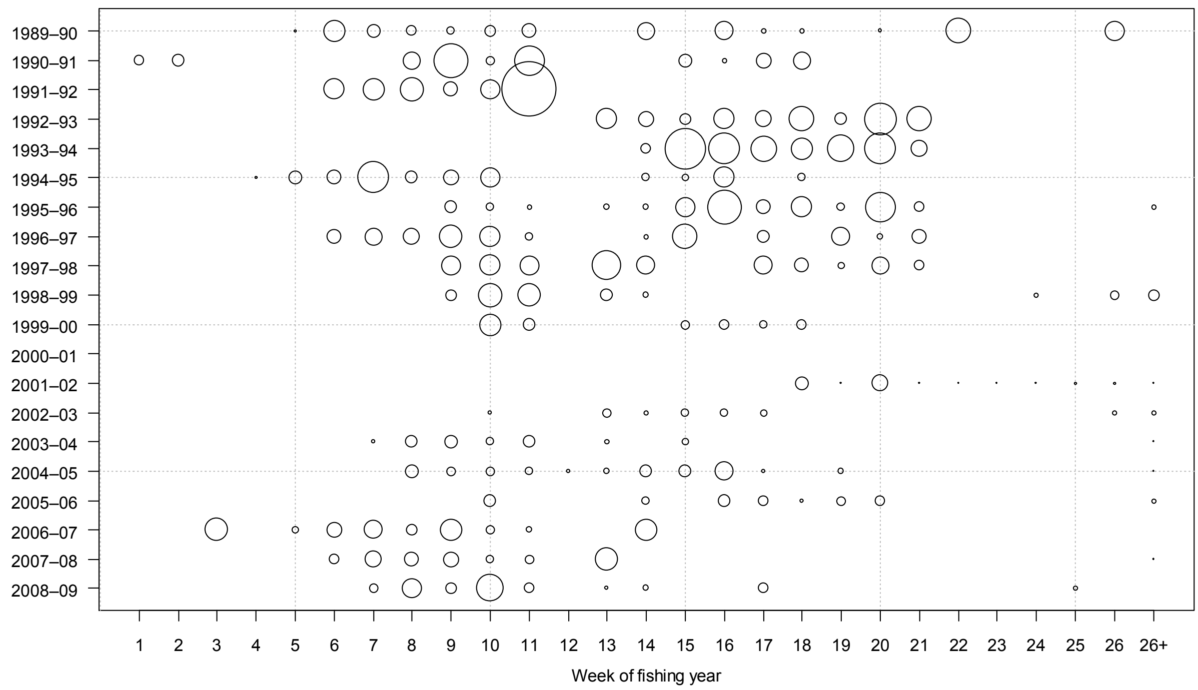

Figure 31: Weekly catch rates for the first six months of each fishing year (starting on 1st October) for a pair of pair trawlers operating in Tasman Bay/Golden Bay since 1989.

4.4 Aerial surveys

One of the interviewees suggested that aerial survey methods could be used to monitor the abundance of spawning aggregations between January and April. Aerial surveys in the late 1970s led to the discovery of large surface and midwater schools of spawning snapper, which resulted in a rapid expansion of the fishery followed by its decline.

This approach is unlikely to be informative given the current stock size, as sizable spawning aggregations no longer occur and only a small proportion of the stock would be visible from the air at any time.

4.5 Tagging programmes

Tagging programmes have been used to estimate the biomass of all but one of New Zealand's snapper stocks, including SNA 7 in 1987–88 (Kirk et al. 1988). The reliability of any tagging programme estimate is partially dependent on the amount of catch examined for marked fish, and the tonnage of snapper landed in 1987–88 is similar to that landed in recent times. Although the methods used in the 1987–88 tagging programme were much less sophisticated than those used in more recent programmes elsewhere, the biomass estimate provided is considered to be broadly indicative for that time (Jeremy McKenzie, NIWA, pers. comm.).

Any form of tagging programme is expensive, however, and this approach is only cost effective for fish stocks which support fisheries much larger than those found in SNA 7. Costs can be reduced by simultaneously tagging fish from two neighbouring fish stocks, and this was considered for 2001, when the most recent SNA 8 tagging programme took place. The additional cost of including the SNA 7 stock in this programme was thought to be in the order of $1M at the time, which was not considered cost effective given the value of the fishery.

Tagging programmes conducted in New Zealand usually use a Petersen estimator (Seber 1982), which provides a biomass estimate for a single period of time based on a single short term release period. This means that a series of tagging programmes would be required to monitor changes in abundance. Another alternative would be to use a Jolly-Seber method (Jolly 1965, Seber 1965) in which fish are tagged and recaptured (and rereleased) over a long period of time rather than during distinct events, from which a time series of exploitation rates is estimated. Either of these approaches would be prohibitively expensive which precludes the adoption of this approach.

5. CONCLUSIONS

- Most of the catch currently landed from the SNA 7 is taken in Tasman Bay/Golden Bay by single trawlers, with most of the remainder taken by a single pair of pair trawlers.
- The single trawl catch is mostly taken when targeting snapper, flatfish and barracouta.
- Standardised CPUE indices derived from these fisheries all fluctuate markedly from year to year, but fluctuations from any pair of fisheries do not coincide.
- These fluctuations and the low precision of annual catch rate estimates suggest that the utility of these CPUE indices is limited.
- Data from all three fisheries were combined and considered in a single lognormal model, and the resulting index appears to be the most plausible index of abundance currently available for the snapper stock in Tasman Bay/Golden Bay.
- There is no evidence of a rebuilding fishery as suggested in the 2000–01 SNA 7 stock assessment in any of the generated indices, and the combined fishery index suggests that there has been little change in abundance over the past two decades.

- Alternative means of monitoring the SNA 7 fishery have been considered (research trawl surveys, aerial surveys, tagging programmes, catch curves derived from catch sampling, and standardised commercial tows) but none of these appear to offer a more viable and cost effective monitoring method.

6. ACKNOWLEDGEMENTS

The authors wish to thank Murray Brown, Ivan Thompson, a single trawl skipper who wished to remain anonymous, and especially Lex Bloomfield and Chris Weston for the information and insights they provided during voluntary interviews. We also wish to thank David Fisher who provided data from the FSU database and helped with its interpretation, and Jeremy McKenzie for reviewing the draft manuscript. Useful suggestions were also made by the Southern Inshore Working Group, including the creation of a combined fishery lognormal standardised index. This study was funded by the Ministry of Fisheries under project SNA200902.

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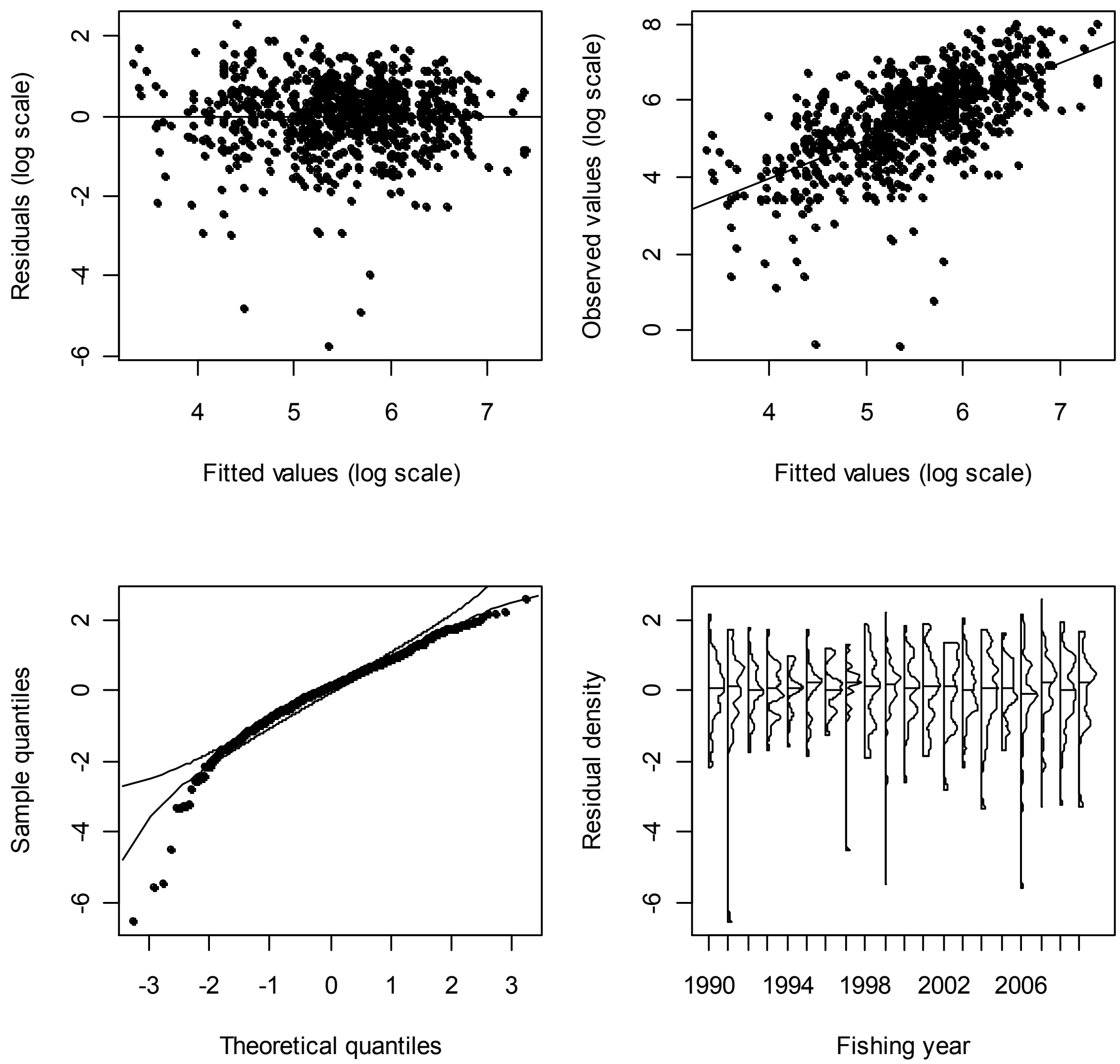
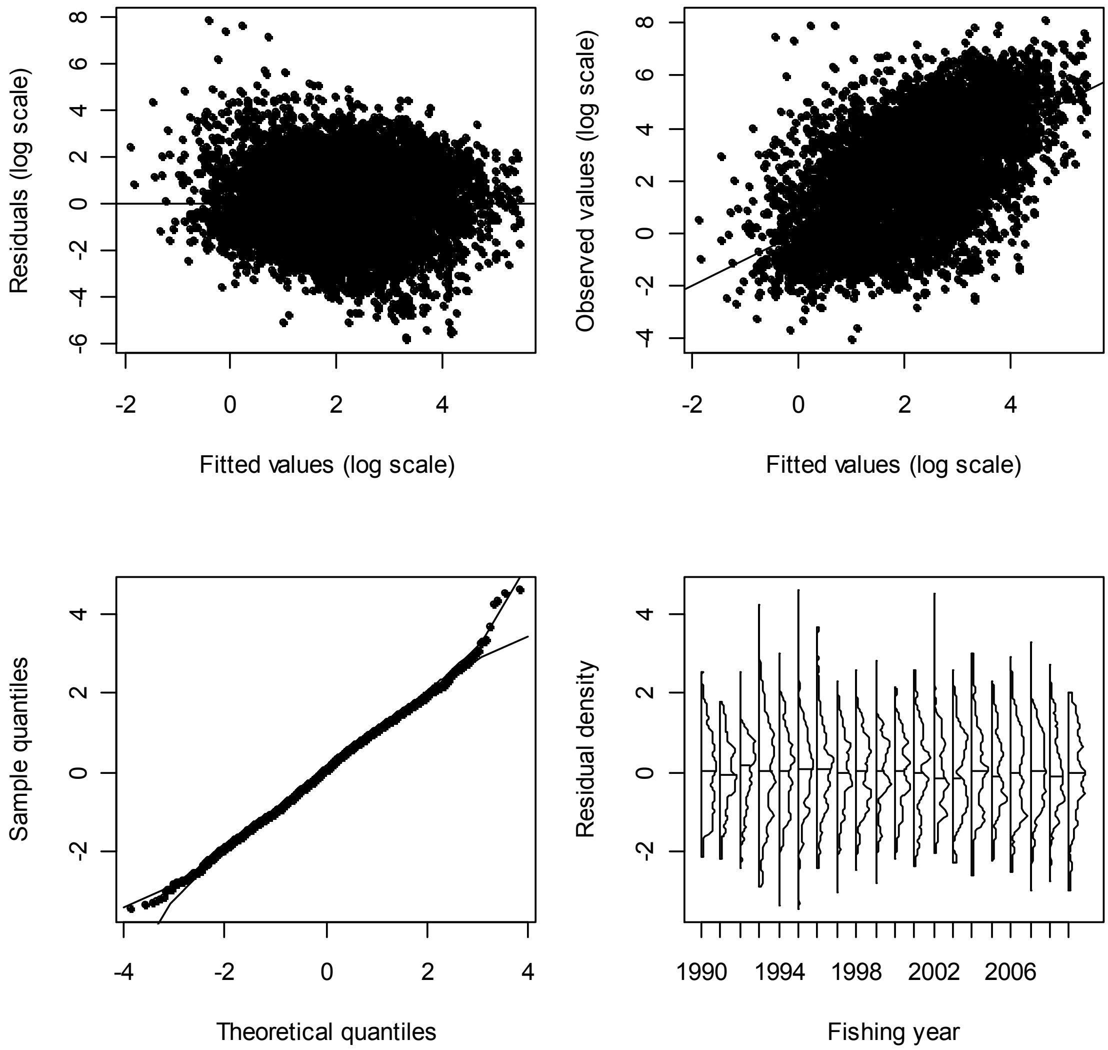
Appendix 1: Model diagnostics

Appendix 1a: Diagnostic plots for a lognormal model of the Golden Bay/Tasman Bay single trawl snapper target fishery.



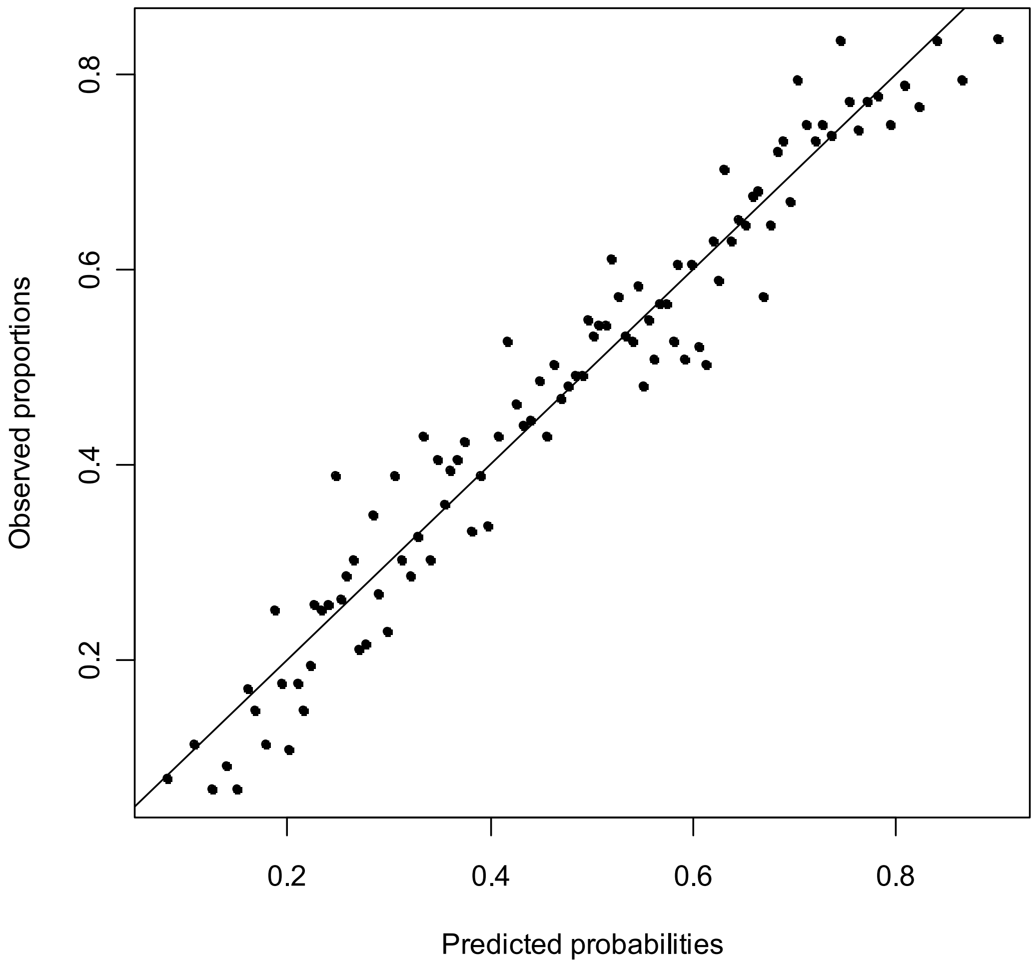
Appendix 1: Model diagnostics – continued

Appendix 1b: Diagnostic plots for a lognormal model of the Golden Bay/Tasman Bay single trawl flatfish target fishery.



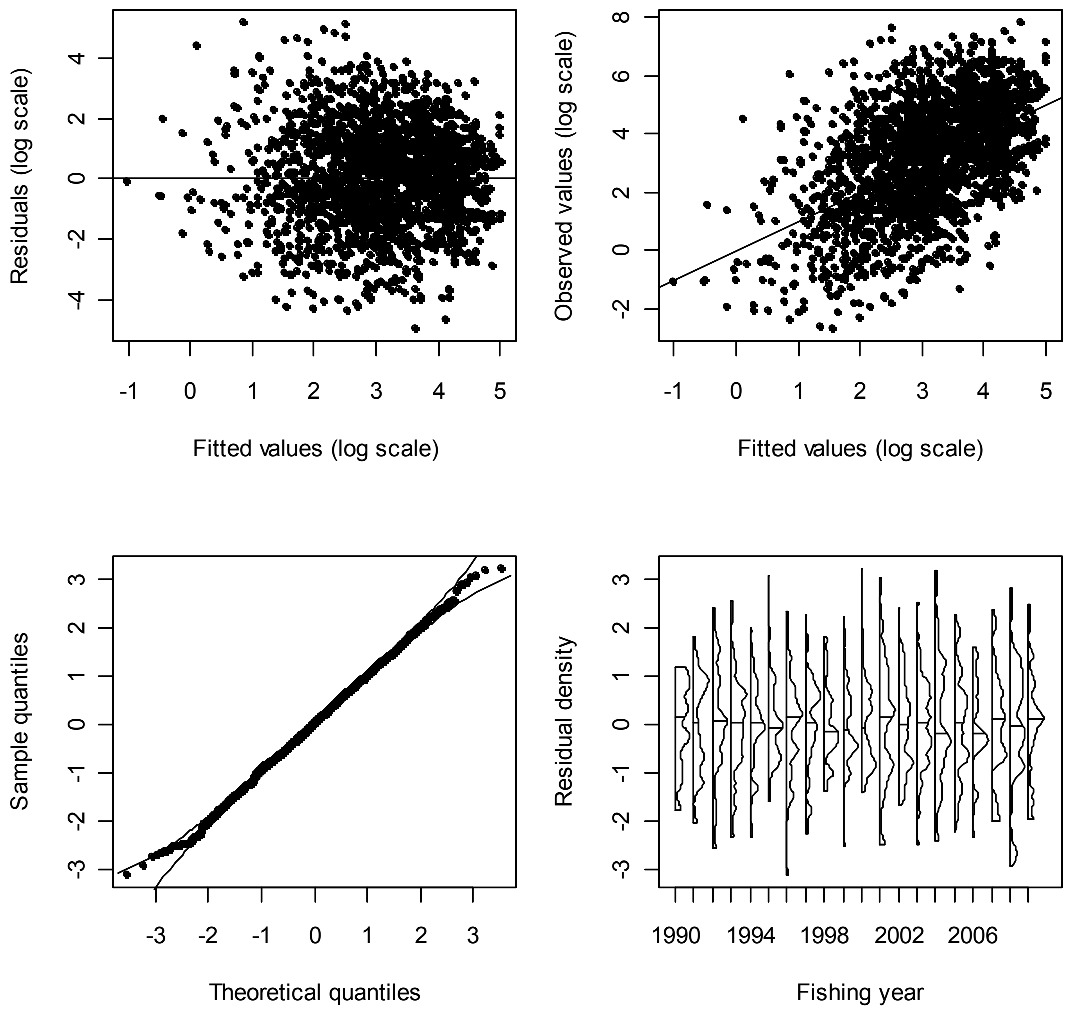
Appendix 1: Model diagnostics – continued

Appendix 1c: Diagnostic plots for a binomial model of the Golden Bay/Tasman Bay single trawl flatfish target fishery.



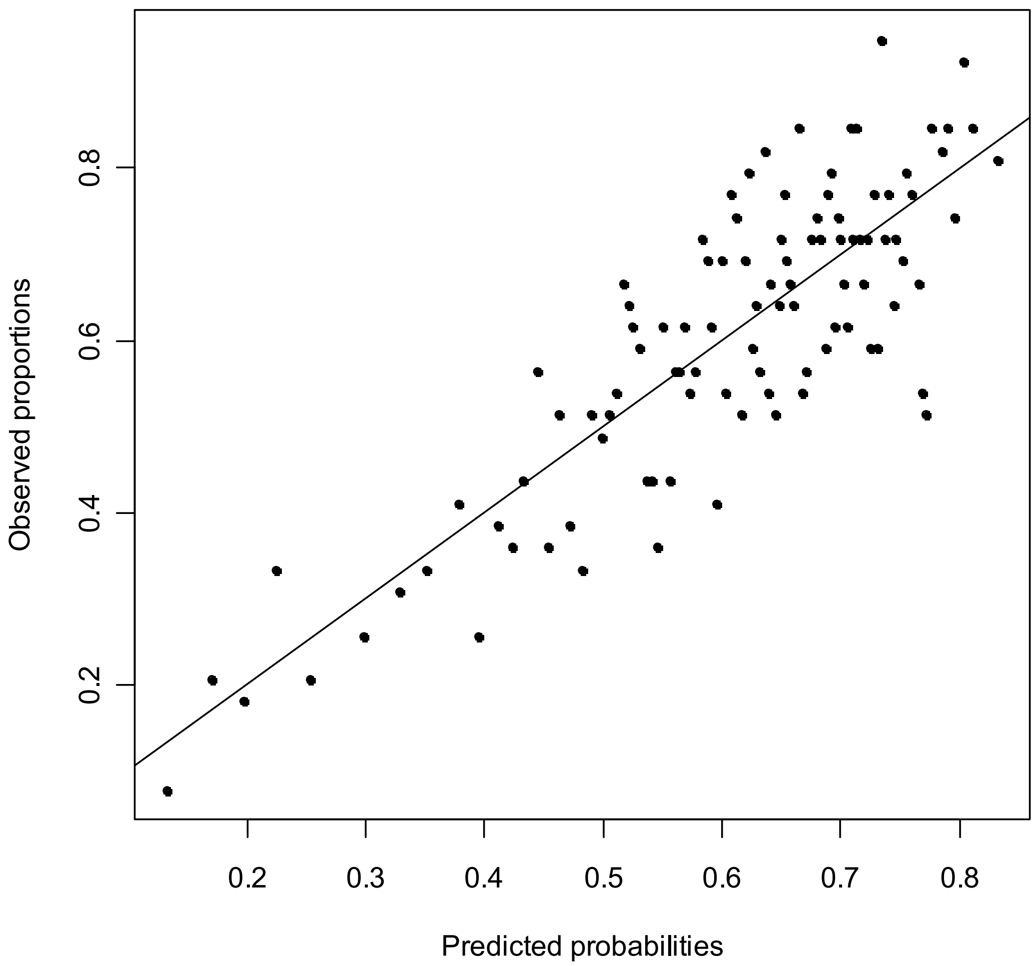
Appendix 1: Model diagnostics – continued

Appendix 1d: Diagnostic plots for a lognormal model of the Golden Bay/Tasman Bay single trawl barracouta target fishery.



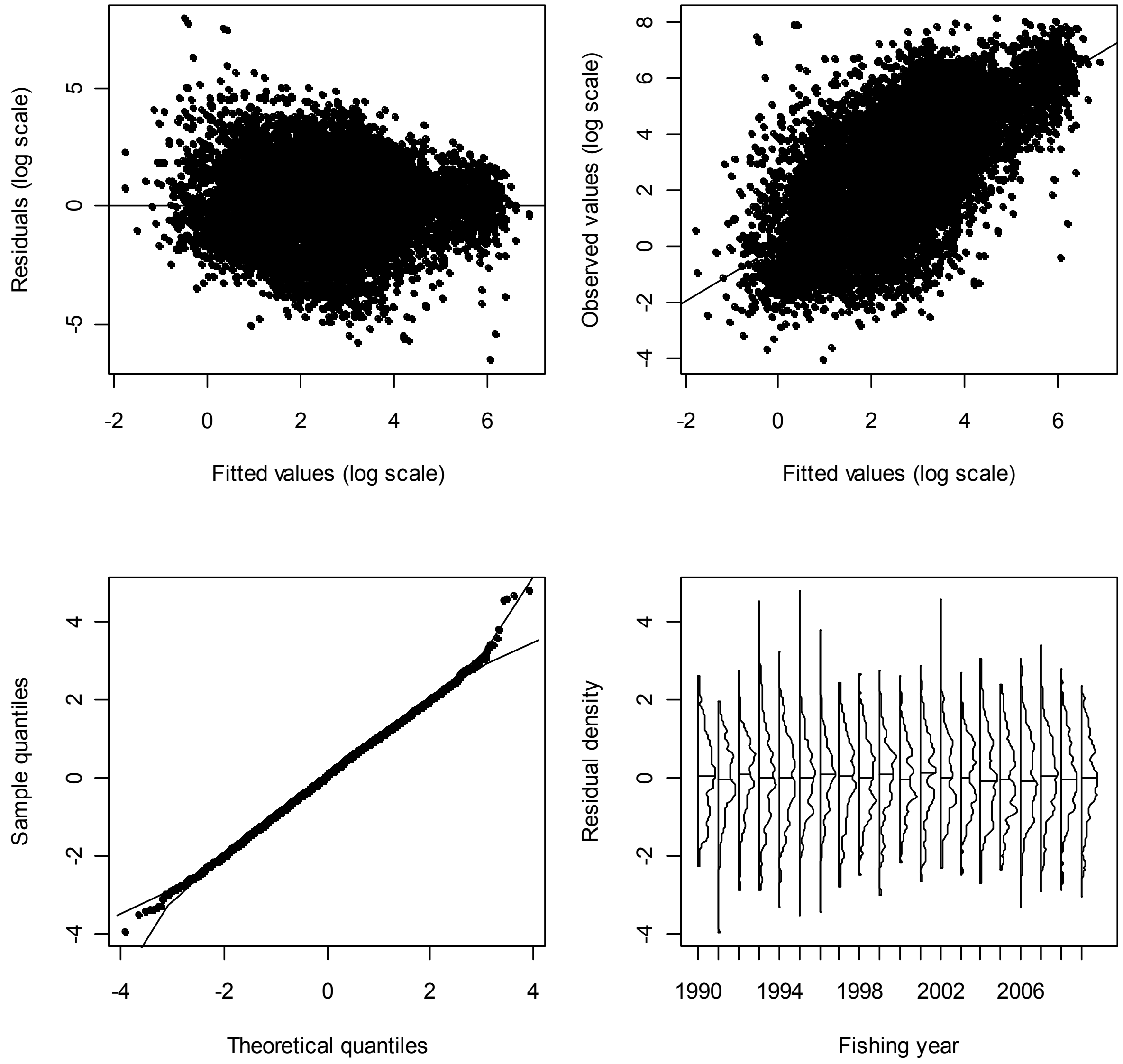
Appendix 1: Model diagnostics – continued

Appendix 1e: Diagnostic plots for a binomial model of the Golden Bay/Tasman Bay single trawl barracouta target fishery.



Appendix 1: Model diagnostics – continued

Appendix 1f: Diagnostic plots for a lognormal model of snapper catches from the combined Golden Bay/Tasman Bay single trawl snapper, flatfish, and barracouta target fisheries.



Appendix 2: Interviews with commercial fishermen

Lex Bloomfield (F.V. *Rongatea*)
Chris Weston (F.V. *Anna Marie*)

Fishing History
Lex began fishing in 1969 and has always fished FMA 7. He has mainly single trawled, pair trawled, and dredged. He did a bit of trolling for albacore tuna off the west coast of the South Island in the past, and has focused on pair trawling for snapper since 1970.

Chris began fishing in 1981 for rock lobster in Fiordland. In 1983 he began skippering a single trawler, fishing for oysters and scallops in FMA7. Now he fishes exclusively in FMA 7 with Lex. Skippers F.V. *Anna Marie*.

Both fishers were involved in a MAF survey in the late 1980s with Kim Drummond and Kevin Mulligan catching snapper in Tasman Bay and Golden Bay for an age validation project.

SNA7
Both Lex and Chris operate 40 ft vessels that are set up almost identically, i.e., same vessel length, engine type and nets (the net configuration, i.e., bridles, sweeps, etc are all the same). They are the only pair trawler operators in FMA 7 and catch about 40 tonnes of SNA each year. They used to catch up to 70 tonnes, but Sealord has purchased a parcel of SNA7 quota to cover their joint venture vessels operating in deeper water. These vessels catch snapper as bycatch.

Lex and Chris are the only operation that routinely targets snapper, as most operators (i.e., the single trawlers) don't have enough quota, and therefore it is just bycatch for them. These vessels may do the odd target tow.

Fishing Specifications
- They trawl at 3–3.5 knots whereas single trawlers typically operate at 2.8–3 knots. Lex and Chris believe the extra speed is critical for catching snapper. Also, the fishing gear on pair trawlers is lighter and less noisy than with single trawlers. They believe the engine noise tends to herd the fish towards the net rather than either side of the net as with the single trawl.

- They typically fish for 2–3 hours duration.

- They use a 5 inch codend, so this eliminates most of the small fish.

- They fish about 0.1 NM apart and use an 80 fathom ground rope with a spread of about 60 fathoms.

- Headline height is around 7 metres (and 12 metres wide).

- Gear is very light (11 mm sweeps, bridles and warps). Just want to touch the bottom so use the warps as the weight. Only put on weights in deeper water (over 25 m).

- Warp to depth ratio is 120 fathoms in 15–20 metres. This is double what a single trawler would use but they need to use this much as they want to get the sweeps and bridles down and they don't use weights.

The fishery

Used to only get a single size of fish in a tow (all 40 cm, or all 50 cm, or all 60 cm, etc), but from 2003–09 the fishery has been much more mixed (getting fish that are 25–30 cm through to large fish that are 70 cm+). Don't get small fish (25 cm and less because of 5 inch codend mesh, but got 1000s of them off Rabbit Island when doing the MAF survey. A lot of these fish were juveniles – up to 10 cm to 15 cm.

Catch Snapper generally over mud in 13–25 metres depth. Not associated with features.

Catches per tow are variable, ranging from 4 – 240 bins (each bin weighs about 25 kilos).

The areas fished vary each year, but only within the same general region. The areas they fish are restricted by exclusion zones and marine farms. The location of the Golden Bay fishery can vary from year to year but is always in the same general area (between late October and March/April). Lex used to fish on the outside of Farewell Spit in the 1970s, but hasn't since then as doesn't need to in order to catch quota, but used to get good fish in this area. The Tasman Bay fishery is also in the same general area each year.

They get very little bycatch as the gear is only lightly down (less than 1% bycatch) the odd mackerel, pilchards, John dory, etc., but nothing much.

Seasonality

The fishery is based on 2 periods:

1. The spawning fishery - starts around Labour weekend and runs until just prior to Christmas when the fish leave the area? Trawlers always did better than line fishers during this period as the fish are aggregated. However, in the last few years Lex and Chris have missed this period because they have still been fishing scallops owing to the poor scallop seasons of recent years.
2. A second run of fish occurs between late January and March/April. These fish are redder in colour and harder to catch. Traditionally the longliners did better on these fish as it is believed they are feeding fish and are not as aggregated. However, there have been no longliners for 4–5 years. Size composition is a mix of sizes as for the spawning fish. No obvious difference in size composition throughout the season.

They generally do day trips.

Last year took them 10 days to catch their quota (had one day of 8.5 tonnes, and another of 5 tonnes during mid-November). Lex said he hadn't seen fish like that since the 1970s (some years it has taken them up to 3 months to catch their fish).

Last year Tasman Bay had only big fish and they caught about ⅔ of their quota in this area. Golden Bay had a wider range of fish, including smaller fish (30 cm and up) and they caught about ⅓ of their quota here.

Lex and Chris' year:

September- October (Scallops)

November-April (Snapper) – like to have snapper caught by the end of January, but has taken up to May in some years

March/April-August (Oysters)

Is a standardised approach an option?

Both fishers thought that a standardised approach is an excellent idea and believe pair trawlers would be a good way to do it as they believe they are more constant than single trawlers. For example, door spread varies more on single trawlers than the spread on pair trawlers. They believe they are already doing largely what is being suggested, i.e., they fish the same gear and vessels each year, typically at the same time of year and in the same areas.

It was unclear whether the spawning fishery or the "feeding" fishery would be most appropriate to conduct the standardised approach on. The snapper are likely to be more aggregated during the spawning fishery? Both fisheries can be variable in terms of catch rate.

Lex was keen to see a juvenile (5 cm fish) survey considered. This would most likely take place in winter?

Suggested video footage, both on deck and attached to the net?

Conclusion

- They both were positive about better monitoring.
- Believe fishery hasn't changed significantly – although it has become easier over the last five years to catch fish and there has been a greater size range of fish. There has been no significant movement in fish distribution or in seasonal abundance.
- Believe 200 t restricts what you can determine with regards to effects on catch rates. The main factors effecting catch rates are vessel speed and vessel noise. Pair trawlers create noise that herds the fish towards the net.

Appendix 2 continued: Interviews with commercial fishermen

Name withheld

Fishing History (Longlining)

Fisher 3 began fishing in 1978 and has always fished FMA 7. He initially operated a 32 ft vessel built to fish the scallop fishery. He began fishing for Sealord, target longlining for snapper, using wooden reels and hand baiting the lines. With the advent of the iki market he moved to autobaiting and could set 1800 hooks per day. He would operate in Tasman and Golden Bays, and the Marlborough Sounds following the fish. The Tasman Bay fishery started at the beginning of November and would end in Jan-Feb. The Golden Bay fishery went from March-April. The Marlborough Sounds fishery was a winter fishery beginning at the end of April and continuing through to the end of August. This fishery was closed in the early 2000s which eliminated an important fishery. As a result he had to change to trawling as the lining was no longer viable.

Since 2002 he has trawled for mixed finfish, such as flatfish, red cod, and gurnard using a 34 ft vessel. Snapper is a bycatch of this fishery. He also target longlines for snapper between November and late Jan-early Feb. He catches 6–7 tonnes per year, with most of this being caught as trawl bycatch. His fishing operation is restricted to Tasman and Golden Bays. He typically longlines in 25–30 metres depth during the school season (out beyond the pair trawler). When he's trawling (March-August) he fishes in shallow (9–15 m) as catches are better and he doesn't catch as many carpet sharks, compared with the deeper sets.

Fishing Specifications

- He trawls at 3 kts using a 120 hp concrete hulled vessel.
- Headline height is around 2 metres.
- Warp to depth ratio is 120 metres warp in 9 metres depth.
- Uses a small 60 ft net that only weighs 21 kilos. The entire set up (i.e., sweeps and bridles and net) weighs about 50 kilos. The sweeps and bridles comprise of rope. The sweeps are 55 m and the bridles are 35 m for snapper. This net does not create a pressure wave so the "panic zone" is well down the net.
- He mentioned that his best catches are in shallow water (9–15 m) as the fish can't swim over the net.

The fishery

The main bycatch species in the line fishery are carpet shark and school shark. School shark appear to be on the increase which is positive, but carpet shark are a problem. This problem began in the 1990s when a larger vessel was given approval to dump fishing waste in Tasman Bay. This resulted in a large increase in carpet shark bycatch (e.g., it was not uncommon to set 1000 hooks and catch 800 carpet sharks).

The Tasman Bay fishery is clearly defined with vessels fishing the same area each year. In Golden Bay he has typically worked across the Bay from South to North. "It is easier to establish where the fish are located with longliners than with trawlers. Lining tracks movement better."

Catches were historically highly variable. In the longline fishery you could catch nothing through to 700 kg per 1800 hooks. Currently, you can catch nothing through to 250kg. Similarly, with trawling catches may range from nothing through to 10–12 boxes (each box is 25 kg). In some instances you may catch nothing in a tow, then follow the same line and get 10 boxes. Fisher 3 stated that this is a reflection of where the fish are rather than their abundance. There is definite lateral movement throughout the day (fish move up off the bottom by late morning) and water colour has an impact. Catches are not as good in clear water when trawling.

When lining he gets bigger fish (30–70 cm), whereas when trawling he gets smaller fish down to 25 cm. The fact that he is generally lining deeper water than he is trawling will be a factor.

He catches snapper generally over mud and not associated with features.

The areas where the fish occur are very consistent. The snapper are always in the same areas at the same time each year.

The fishery is recruitment driven with warm conditions being beneficial. The fish tend to school by size. Last year there were large numbers of fish that were about 20 cm. There were also large numbers of slightly smaller fish (10–15 cm), although less than the first group. This suggests that the future of the snapper fishery looks very positive.

Seasonality

The fishery is a spring/summer fishery that begins in early November each year and goes through to March.

Fisher 3's year:

September to October (set netting for rig)

November-February (longlines for Snapper)

March-August (trawls for mixed finfish, including snapper)

Is a standardised approach an option?

Fisher 3 believes that lining is not a good method to use if a standardised approach was adopted. There is very little lining undertaken these days and catch rates are highly variable. He felt pair trawling would be more appropriate as this is how most of the target-caught snapper are captured. Trawling is also highly variable though. However, he felt that neither method would be particularly useful at assessing abundance. Variability is too great due to numerous factors that could not be readily replicated annually e.g. lateral movement of snapper, water colour and clarity, water temperature, etc.

He considers that an aerial survey focused on identifying the schooling aggregations between November and January would be the most effective way of determining snapper abundance. This would give a better indication of abundance, as trawling catchability is highly variable.

Another option he suggested would be to ask past fishers who operated pair trawlers with windy buoys to conduct a survey. This would replicate the fishing operations of the late 1970s – early 1980s when maximum catches were taken.

Conclusion

- Snapper catch rates are highly variable and do not reflect abundance (i.e., poor catches do not necessarily mean low abundance. Sometimes the snapper are present, but not readily caught). For this reason a standardised survey will probably not address the issue of determining abundance.
- An aerial survey of spawning aggregations would be more useful but would require experienced "snapper spotters" as there is skill involved in identifying snapper schools from the air.

Appendix 2 continued: Interviews with commercial fishermen

Murray Brown (F.V. *Mako;* F.V. *Pursuit II*)

Fishing History
Murray began bottom trawling in 1967 out of Motueka and has mainly fished FMA 7. The first vessel he fished on was a 50 ft, 230 hp bottom trawler. He pair trawled from late 1979 to 1984, and has single trawled for mixed finfish since this period.

SNA 7
Murray has two vessels that both operate mainly outside Tasman and Golden Bays. His larger vessel is the 21 m F.V. *Mako* which was built in 1978. It targets hoki in Cook Strait during winter and then operates in FMA 7 for mixed finfish during the remainder of the year. The F.V. *Pursuit II* is his 16 m vessel, targeting mixed finfish. Both vessels target various species including, tarakihi, giant stargazer, barracouta.

The vessels catch about 25 tonnes of snapper between them each year, with most of this being bycatch of the mixed finfish fishery. They do not have enough quota to target the summer snapper fishery.

When he initially started fishing he did not catch a lot of snapper, but saw catches increase after moving to 18´´ mesh nets. This change enabled bigger nets to be towed at faster speeds, which meant snapper could be targeted during the summer.

Fishing Specifications
- They trawl at 3–3.3 knots.
- They typically fish for 3 hours duration.
- They use a 5 inch codend, so this eliminates most of the small fish.
- Warp to depth ratio is 2.75 – 3:1
- They fish with a 110 ft wing trawl with 9'' mesh wings. They also use a "scrapper net" (has a 2 m headline, which is only used on the west coast, South Island and catches very little snapper)

The fishery
Typically get a single size class of fish in a tow (all 40 cm, or all 50 cm, or all 60 cm). In summer they catch the smaller school fish (30 – 50 cm), but from April – June catch bigger fish (60 – 70 cm).

On the west coast, South Island they catch snapper generally over hard sand in 15–80 metres depth. Use to catch fish around D'urville Island associated with rougher ground.

Catches per tow are variable, ranging from 0–7 bins (each bin weighs about 25 kilos). Very occasionally catch 20–30 bins of snapper per tow.

Murray mentioned that snapper is currently more abundant than it has been for some time, but also pointed out that the species was not always abundant. For example, during the mid 1970s they operated out of Westport for some time as there were few fish around Tasman and Golden Bays.

Seasonality

The snapper "school" fishery is a spring summer fishery that begins in early November each year and goes through to March. Snapper is also caught as bycatch of the mixed finfish fishery during the rest of the year.

They generally do 6 –7 day trips.

Murray's year:

July–September: (fishes for hoki in the Cook Strait)

Sep–Jun: (mixed finfish, including snapper bycatch); March – May operates from the northern side of Farewell Spit to Karamea. January – February is a good time of the year to catch snapper on the seaward side of Farewell Spit.

Is a standardised approach an option?

Murray believes that a standardised approach is unlikely to provide a useful measure of snapper abundance or changes in snapper numbers. Catch rates are variable and there are just too many aspects that could affect survey results. For example, if the schooling aggregations were in a slightly different area of the Bay, or the fish aggregated at a slightly different time from one year to the next this could bias the results. He felt using a research vessel (like the R.V. *Kaharoa*) to survey schooling aggregations would be preferable to using a commercial vessel.

Conclusion

- Snapper are currently more abundant than they have been over recent years.
- Does not believe a standardised approach will provide a better estimate of snapper abundance.

Appendix 2 continued: Interviews with commercial fishermen

Ivan Thompson (F.V. *Cheryl Anne G*)

Fishing History
Ivan has been fishing for about 40 years. His fishing experience has involved both single trawling and dredging in the past, although now he focuses on trawling. He has fished FMA 7 for all of this period, and targets mixed finfish, such as flatfish, hoki, ling, stargazer, and tarakihi. His current vessel is the Cheryl Anne G, which is a 23 m, 150 tonne vessel built in 1974.

Ivan operates between Wanganui and Bruce Bay, as well as in Tasman and Golden Bays. He catches about 5 tonne of snapper per year which only equated to 4 tows last year. They do not have enough quota to target the summer snapper fishery. Increasing snapper abundance and lack of quota is a real problem within this fishery.

The vessel also targets Cook Strait hoki during winter.

They have noticed that catches of snapper have increased in southern areas. For example, when Ivan first began fishing snapper were seldom caught south of Karamea, but in recent years they have been catching them as far south as Bruce Bay. It is unclear why this is, although temperature and feed availability may be a factor?

Fishing Specifications
- They trawl at 2.8–3.2 kts.
- They fish with a 112 ft wing trawl
- The headline height is around 5 ftms (but Ivan believes you don't need a large headline as snapper are bottom feeders)

The fishery
Typically get a single size class of fish in a tow, but in the last four years the size range of snapper has increased (with fish ranging in size from 12 inches to over 70cm –"won't fit in a fish bin").

Catches of snapper (per tow) are variable, ranging from nil bins to a few bins (each bin weighs about 25 kgs). Currently, it is not uncommon to catch 30–40 bins.

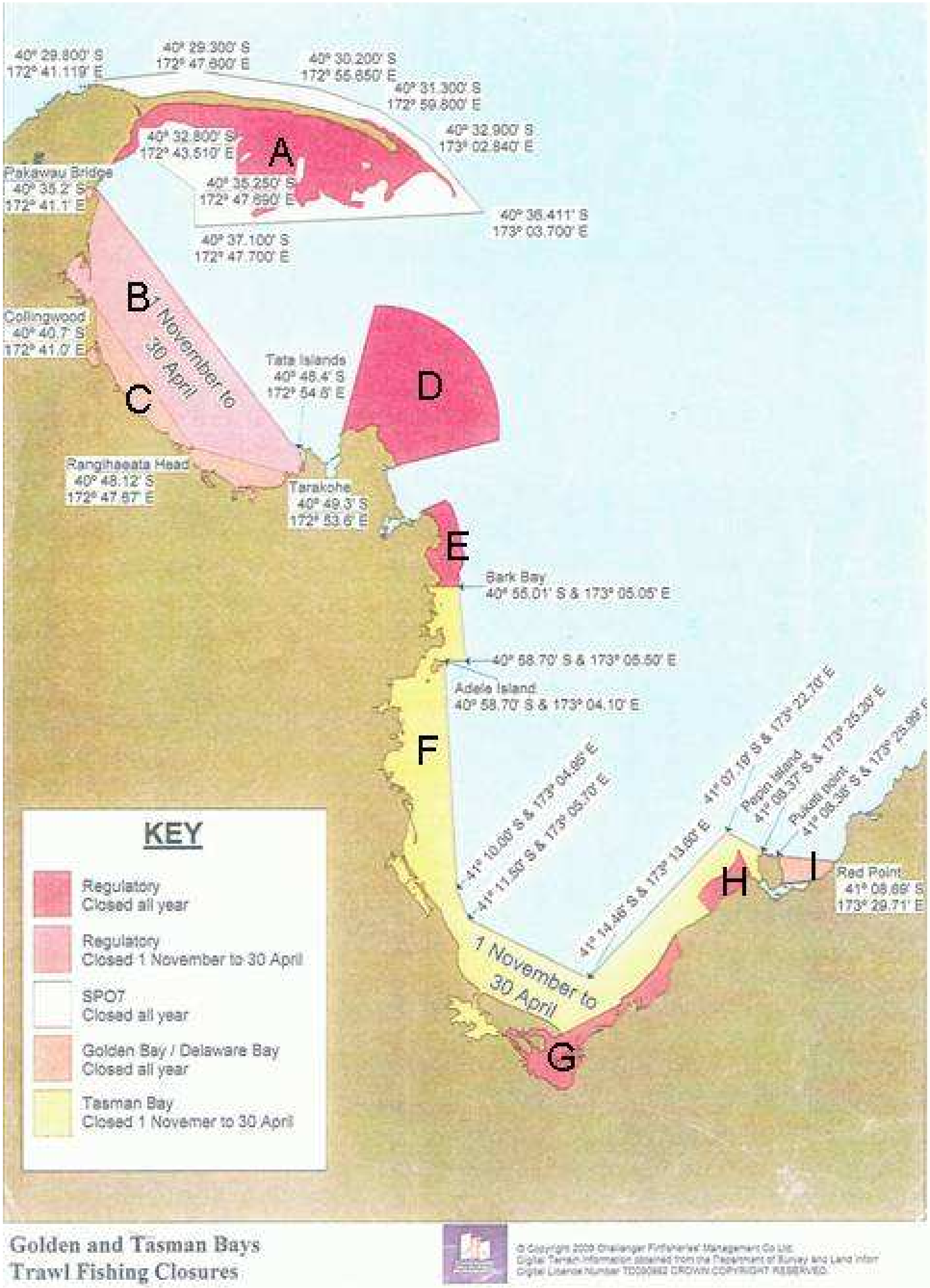
Ivan's year:

Jul–Aug: (Cook Strait hoki)
Sep–Jun: (mixed finfish, including snapper bycatch)

Is a standardised approach an option?
Ivan believes that a standardised approach is unlikely to provide a useful measure of snapper abundance or changes in snapper numbers. Catch rates are variable and there are many aspects that could affect survey results. For example, if the schooling aggregations were in a slightly different area of the Bay, or the fish aggregated at a slightly different time from one year to the next this could bias the results.

Conclusion
- Snapper are currently more abundant than they have been over recent years.
- Does not believe a standardised approach will provide a better estimate of snapper abundance.

Appendix 3: Areas of Golden Bay and Tasman Bay which are closed to trawling, seasonally and throughout the year.



Area	Title	Period closed	Introduction date
A	Inner Farewell Spit	All year	Unknown
B	Golden Bay regulatory trawl closure	1 November to 30 April	1 November 1989
C	Inner Golden Bay voluntary trawl closure	1 November to 30 April	1 October 1991
D	Separation Point trawl closure	All year	1 October 1980
E	Tonga Island Marine Reserve	All year	1 November 1993
F	Tasman Bay voluntary trawl closure	1 November to 30 April	1 October 1991
G	Nelson Boulder bank	All year	Unknown
H	Horoirangi Marine reserve	All year	26 January 2006
I	Delaware Bay Taipure	All year	Unknown