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Age composition of commercial snapper landings in SNA 2, for the 2007–08 fishing year

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EXECUTIVE SUMMARY

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This report fulfils the requirements of Objective 1 of Project SNA2007/03, "To estimate the year-class strengths of snapper, *Pagrus auratus*, in SNA 2." It presents the results of commercial catch-at-age for the SNA 2 fishstock for the 2007–08 fishing year, and compares relative year-class strengths with previous estimates.

The catch-at-age estimates for SNA 2 indicate that the fishery continues to be dominated by young fish, less than 11 years old. The 2003 year class (5 year olds) are numerically most abundant, while the 1999–2002 year classes (6–9 years) remain strong. The previously strong 1995 and 1996 year classes (12–13 years) remain present in the fishery. The most recent 2004 and 2005 year classes (3 and 4 year olds) appear comparatively weak, although these year classes may not be fully recruited into the fishery, and their influence may be underestimated due to the presence of the strong 2003 year class.

These patterns of catch-at-age are generally consistent with those from the SNA 1 fishery and with estimates of the SNA 2 fishstock in 2002–03 and 2004–05, and to a lesser degree 1999–2000. Earlier age frequencies in 1997–98 and 1998–99 appear inconsistent. The 2001 year class (7 year olds) now appears stronger than indicated by earlier estimates, possibly due to slower than expected recruitment into the fishery. The continuing dominance of these younger year classes is reflected in the reduction in mean fish size which declined from 1.5 kg in 1998–99, to 1.2 kg in 1999–2000, and has remained stable at 0.9 kg for the 2002–03, 2004–05, and 2007–08 fishing years.

In total, 55 samples were collected from the SNA 2 fishery in 2007–08, in four seasonal strata, providing an overall mean weighted c.v. for the catch-at-age estimates of 17% (target 30%) for ages 1–20 years.

The Northern Inshore Working Group (April 2009) suggested that SNA 2 landings from Napier may contain larger (and thus older) fish than those from Gisborne, and that disproportionate sampling from these areas could therefore profoundly influence and therefore bias overall SNA 2 catch-at-age estimates. Analysis of spatial structure in the SNA 2 fishery shows that most (66%) fishing occurred in northern SNA 2 (north of Mahia Peninsula) during 2007–08, while the catch in southern SNA 2 (south of Mahia Peninsula) was mainly taken in Hawke Bay (see Appendix 3). Initial data analysis suggests that spatial differences in length and age frequency may occur between these areas, but caution is suggested due to the low numbers of landings available from southern SNA 2. Of the 55 landings sampled, 39 (70%) related to fishing exclusively in northern SNA 2, but only seven landings (12%) fished exclusively in southern SNA 2. For the remaining 9 landings (16%), fishing occurred in both areas. Of these, 6 were landed into Napier, suggesting that port of landing may not be a useful stratification variable for location of fishing.

From the age frequency data, 5 year old snapper appear much more common in southern SNA 2 (Hawke Bay), while 6, 8 and 9 year old snapper were more common in northern SNA 2. These trends are less obvious in the raw unscaled length frequency data, although a higher proportion of larger fish appear more common in southern SNA 2. The data are unlikely to be representative of the true length frequencies of the catch, as no scaling has been carried out for catch weight. The apparent spatial trends in catch-at-age should be considered in subsequent catch sampling programmes in SNA 2.

1. INTRODUCTION

1.1 Overview

Snapper (*Pagrus auratus*), an inshore demersal species of the family Sparidae, commonly occurs in depths of 10–200 m throughout the northern and central areas of the New Zealand Exclusive Economic Zone (FMAs 1, 2, 7, 8, & 9). The number of juveniles that result from a spawning may vary widely, which results in strong or weak year-classes entering the stock (Smith & Francis 1991). Francis (1993) determined a positive correlation between year-class strength and sea surface temperature in the Hauraki Gulf (SNA 1 fishstock), and similar relationships have been shown for SNA 2, SNA 8, and the Tasman Bay/Golden Bay (SNA 7) fishstock (Davies & McKenzie 2001, Gilbert & Taylor 2001).

This report describes a catch sampling programme carried out on the SNA 2 fishstock during the 2007–08 fishing year. It extends the time series of catch-at-age estimates for this fishstock for fishing years 1991–92 (Ryan 1993), 1997–98 (Blackwell et al. 1999), 1998–99 (Blackwell et al. 2000), 1999–2000 (Blackwell & Gilbert 2001), 2002–03 (Blackwell & Gilbert 2005), and 2004–05 (Blackwell & Gilbert 2006). These catch-at-age data were used to develop an age-structured model for SNA 2 (Gilbert & Phillips 2003).

In April 2009, the Northern Inshore Working Group requested additional analysis to determine the existence of spatial patterns in length and age frequencies of catches in SNA 2. These data are included in the report as Appendix 4.

1.2 Description of the fisheries

Snapper are widespread throughout the inshore waters of northern New Zealand, with the highest densities occurring in waters less than 70 m deep. The SNA 2 (equivalent to QMA 2) fishstock extends southeast from Cape Runaway, south to the Clarence River. It includes the waters of Cook Strait and the lower south west coast of the North Island (Figure 1). Commercial snapper fishing is essentially confined to the shallow shelf areas of the northeast portion of QMA 2, which includes the East Coast and Hawke Bay (statistical areas 011–013) (Figure 2) Comparatively little snapper fishing occurs in the remaining areas of the south and west , where the continental shelf is relatively narrow (statistical areas 014–016).

The small commercial snapper fishery which existed in SNA 2 in the 1930s expanded during the 1960s and 1970s as a result of increased target trawl fishing (Kilner 1983). Landings reached 878 t in 1972, then declined to 160 t in 1982 and 1983, when a ban on pair trawling was imposed (Table 1). Snapper were included in the Quota Management System (QMS) in 1986. The SNA 2 TACC (130 t) was set below the 1985–86 catch level of 177 t to permit the stock to rebuild (Colman et al. 1985). Snapper landings frequently exceeded the TACC during the late 1980s and 1990s (by 80% in 1991–92) largely as a bycatch in the inshore trawl fisheries (Ryan 1993). The SNA 2 TACC was initially increased to 252 t in 1992–93 and further increased to 315 t in 2002–03 (Table 2).

The 2007–08 landings of 328 t are slightly higher than the revised TACC, but remain consistent with previous landings that have varied between 252 t (2001–02) and 391 t (1999–2000). Input controls, such as a ban on pair trawling in most of QMA 2 and closed areas (i.e., Wairoa Hard) remain in place (Ministry of Fisheries 2008).

During the 2007–08 fishing year, most snapper were taken by bottom trawling (Table 3), consistent with previous patterns in this fishery (Blackwell et al. 1999, Blackwell & Gilbert 2006) and occur throughout the year (Blackwell & Gilbert 2006). During 2007–08, 35% of the reported landings of 308 t were taken in the first quarter, 16% in the second quarter, 19% in the third quarter, and 30% in the fourth quarter, but these relative percentages vary among years (Blackwell & Gilbert 2006).

The snapper catch was essentially confined to the northern inshore areas of QMA 2 including statistical areas 011–014 (Figures 2 & 3). In statistical area 011 (eastern Bay of Plenty), 12% of the SNA 2 catch was taken mainly during autumn and winter (March-August). A further 30% of the catch was taken off the northern East Coast (statistical area 012), mainly in late winter-spring (August-October). Most (50%) of the SNA 2 catch was taken off the central East Coast and in Hawke Bay (statistical area 013), where landings occurred throughout the year.

Minor catch was reported from statistical areas 014–016 in the south of QMA 2 (Figures 2 &3), with 5% of catch from Castlepoint (statistical area 014), particularly during spring (October-December).

Since the 1992–93 TACC increase, target snapper fishing in SNA 2 has increased (A. Zame, Fish Processor, Gisborne, pers. comm. 2007). In 2007–08, target fishing only represented 16% of snapper landings (Figure 4). Snapper was taken as bycatch of the tarakihi and red gurnard fisheries (42% and 40% of total snapper landings, respectively; Figure 4). Landings were spread throughout the year in the tarakihi target fishery, but occurred mainly in late spring-summer (October-January) in the target red gurnard fishery. Snapper was a minor bycatch of trawling for gemfish, trevally, and barracouta throughout the year (Blackwell & Gilbert 2006). Snapper was also a minor bycatch of longlining for hapuku/bass and bluenose, line fishing for school shark, and set netting for rig and blue moki (Ryan 1993).

1.3 Previous research

Earlier reviews of the population structure of SNA 2 (Paul & Tarring 1980, Kilner 1983, Ryan 1993) indicated an increase in average size of snapper from north to south among the four main subareas of QMA 2 (eastern Bay of Plenty, East Cape, Hawke Bay, Castlepoint), and a general trend for older fish to occur in deeper waters. Year class strengths were variable during the 1960s and 1970s. The commercial fishery generally exploited older fish (5–10 years) during the late 1960s, with the oldest reported at 42 years (Paul & Tarring 1980). By the late 1970s, the fishery was generally exploiting younger fish (3–8 years) (Kilner 1983). Ryan (1993) found that the abundance of 4–7 year old fish had increased 2–4 fold between 1983–84 and 1991–92.

Ryan (1993) reviewed the use of CPUE as an index of relative abundance, but found that changes in CPUE were confounded by changes in fishing practices in the target tarakihi and gurnard fisheries during this period. The data were unable to monitor changes in relative abundance of snapper. Previous analysis of the SNA 2 fishery (Blackwell et al. 1999, Blackwell & Gilbert 2006) also found snapper fishing to be essentially restricted to the East Coast and in greater Hawke Bay, statistical areas 011–014 (Figure 2). Most (96%) snapper was taken by trawling, with other methods being Danish seining, longlining and set netting.

Recent estimates of catch-at-age (Blackwell et al. 2000, Blackwell & Gilbert 2001, 2006) found that the fishery was numerically dominated by fish less than 11 years of age, with several strong year classes. The youngest year classes present in the analysis of the 2002–03 and 2004–05 commercial fisheries (then 3 year old fish) were initially considered weak, but have subsequently proved to be stronger than expected. This is most likely due to slow recruitment by these fish into the commercial fishery (Blackwell & Gilbert 2006).

Estimates of current and reference biomass are unavailable for SNA 2. Estimates of the SNA 2 MSY and stock size in 2000–01 were 478 t and 90% of B_{MSY} respectively (Ministry of Fisheries 2008). These are based only on proportions–at-age data and should be treated with caution. The current (2007–08 fishing year) TAC is 450 t, of which the TACC is 315 t, and allowance for recreational fishers is 90 t, Maori customary fishing 14 t, and other 31 t (Ministry of Fisheries 2008).

Recruitment success for SNA 2 is positively related to air temperature (Gilbert & Taylor 2001). The 4-year series of proportions-at-age data were used to develop an assessment model for the 2001–02 fishing year (Gilbert & Phillips 2003). This model was projected to 2006 to derive estimates of uncertainty and calculate performance indicators using two total catch scenarios with TACCs of 317 t and 436 t. The projections gave a range for stock biomass in 2005–06 of 80–210% of B_{MSY}. No biomass indices are currently available for SNA 2, as these estimates were considered preliminary, but indicative of a continuing stock rebuild under the present TACC of 315 t (Sullivan et al. 2005).

2. METHODS

Separate substocks may occur in SNA 2 (Paul & Tarring 1980), but the catch-at-age data were treated as coming from a single stock in this analysis. Initial examination of spatial patterns in the fishery are reported in Appendix 4.

2.1 Stratification

The purpose of stratification is to increase the precision of the catch-at-age estimates. Sampling theory shows that this will be achieved if the strata are well chosen, i.e., if variability between strata is larger than that within strata (Cochran 1977). Estimation requires the sampling of landings to be random, but strict adherence to this is impractical. However, departure from strict randomness has less effect under a stratified sampling regime, if the strata are well chosen.

Earlier SNA 2 sampling (Blackwell & Gilbert 2001, 2005) used strata based on method, season, and mean vessel landings, but since the 2004–05 fishing year, the method of stratification was simplified to season alone. This was partly due to the decline in non-trawl snapper landings in SNA 2, and partly due to the increased volatility in the trawl fleet composition in QMA 2. An increase in annual variability of snapper landings of individual vessels after 2004–05 meant that strata based on snapper catch histories of individual vessels was no longer valid (Blackwell & Gilbert 2006). Snapper in SNA 2 is essentially a bycatch of inshore trawling in several target fisheries. Vessels commonly fish in several statistical areas and depth ranges during a trip (A. Zame, Fish Processor, Gisborne, Pers. Comm. 2007), which precludes stratification based on statistical areas, or depth ranges.

Previous sampling in this fishery has shown that the greatest variation occurred among seasons and suggested the use of additional stratification for method and mean landing was unnecessarily complicated (Blackwell & Gilbert 2006). The target number of landings to be sampled was based on the expected numbers of fish to be caught in each quarter (Table 4). The average quarterly catches by weight for 2004–05 to 2006–07 were divided by the estimated mean weight based on previous sampling (0.8 kg for spring, 1.4 kg for summer, 0.9 for autumn, and 0.7 kg for winter) to give expected catch numbers. As the data entry of fish returns was not complete for July–September 2006–07, landings for July–September were arbitrarily increased by 20% above the database value to compensate (based on the previous year's landings and the current TACC). As non-trawl methods accounted for only a small percentage of total landings, all vessels were combined in the quarterly strata. Sampling was randomly spread amongst the vessels in the quarter. This approximately minimises the variance of the estimated proportions at age and the mean weighted c.v. (MWCV).

2.2 Sampling

The planned stratification was revised during the sampling period, as more fish were trucked directly to Auckland for processing than in previous years and were thus unavailable for sampling in Napier and Gisborne. This meant that sampling was sub-optimal (Appendix 2), as there were fewer samples collected in the first quarter and second quarters, while slightly more landings were sampled in the third and fourth quarters, than were originally planned (Figure 5; Table 5). All landings available for sampling in 2007–08 were collected from trawl vessels. The actual catch for SNA 2 was 327 t.

2.3 Sampling procedure

A target random sample of at least 40 fish were collected from each landing where the landed weight was at least 80 kg, and a larger sample of at least 50 fish were collected from landings of over 100 kg. Samples were collected from a representative cross-section of the fishery to include both target fishing and bycatch (Blackwell et al. 1999). Fish were randomly selected from each sampled landing by sampling every fifth fish encountered throughout the landing, following standard procedures of Walsh et al. (2007).

The saggital otoliths were collected from each fish and the length (to the nearest centimetre below the fork length) was measured. As snapper show no differential growth between sexes (Paul 1976, Gilbert & Sullivan 1994), the sex was not determined during sampling. Sex of snapper was ignored in the determination of catch-at age (Blackwell & Gilbert 2006, Walsh et al. 2007). The otoliths were inventoried and stored in the otolith collection maintained by NIWA.

2.4 Ageing

As the numbers of otoliths collected from the 55 samples exceeded the nominal target of 800–1000 otoliths, random subsamples were selected for ageing, using a two-step algorithm (D.G. Gilbert, NIWA, pers. comm. 2006). The allocation of otoliths to each stratum was based on the ratio of the optimum to actual numbers of fish sampled, where the proportion of the current year's fishing in each quarter was estimated from the previous year's catch. The number, and the random selection of selected otoliths from each landing within these strata was determined from the product of two ratios: the ratio of the estimated total number of fish, to the number aged; and the ratio of the estimated number in all landings, to the estimated number in the sampled landings. Therefore the more fish there were in a landing the less was the weighting received by each one. The allocation of otoliths among strata was chosen to make the weightings as similar as possible. For large landings (1 t or greater), most or all of the collected otoliths were subsampled, up to a maximum of 55 otoliths per sample. For medium sized landings (100–1000 kg), 10–40 otoliths were selected, as detailed above. For smaller landings (80–100 kg), a minimum of four otoliths were subsampled from the landing.

Snapper otoliths were processed individually following the methods described by Davies & Walsh (1995). Each otolith was prepared by cutting dorsal-ventrally through the nucleus, then the cut surface was polished by wet grinding using 400 grit and 1200 grit diamond polishing wheels, and read under a binocular dissecting microscope at ×20–30 magnification.

Ages were defined from a nominal birthday (1 January). Age was recorded rounded down to one decimal place, based on the date of sampling, e.g., a 1989 year class fish would be aged 8.7 years if sampled in early October 1997, 8.9 years in December, and 9.4 years in May 1998. The sampled landings and these age data were stored on the Ministry of Fisheries (now Ministry for Primary Industries) *market* and *age* databases, respectively, maintained by NIWA.

Fish were then grouped into year classes consistent with the methods described by Davies & Walsh (1995). To do this, the decimalised ages of fish sampled from October to December were rounded up to the nearest whole integer (to their next January birthday) and those sampled from January to September were rounded down. The proportions at age, $\hat{p}_i$, were then calculated for each stratum and coefficients of variation for the proportion at age estimates, with a finite population correction, $\text{cv}\hat{}(\hat{p}_i)$, were calculated by bootstrapping, as described by Blackwell et al. (2000). The sampled landings and age data were stored on the Ministry of Fisheries (now Ministry for Primary Industries) *market* and *age* databases, respectively, maintained by NIWA.

3. RESULTS

3.1 Sample collections

Summaries of the sample sizes and otoliths collected for seasonal strata are given in Tables 4–5, and summaries of the otoliths aged are given in Table 6. The details of landing weight, number of fish measured, and the number of otoliths processed from each landing are given in Appendix 1.

A sample of 50 landings was planned (Table 4), with allocation of sample sizes based on previous data from the 2004–05 to 2006–07 fishing years. In total, 55 landings were achieved, but sampling was sub-optimal during spring and summer, as catch from some vessels was unavailable for sampling. These fish were landed in Napier or Gisborne, but processed in Auckland. The sampling schedule was revised to include this change in the second and subsequent quarters, with additional sampling completed in Auckland. Landings in the fourth quarter were also higher than expected (Tables 3–4), and additional sampling was completed to include this extra catch. The cumulative proportion of the number of snapper landings and those sampled in the SNA 2 stock from October 2007 to September 2008 are given in Appendix 2.

3.2 Age distributions

Catch-at-age compositions (using the random age frequency sampling approach) were derived for each seasonal stratum, and combined over all seasons to produce a 2007–08 fishing year summary. The numbers of fish aged, and the mean length and range of fish lengths for each stratum are given in Table 6.

The overall proportions at age, $\hat{p}_i$, and bootstrap estimated coefficients of variation, $\text{cv}\hat{}(\hat{p}_i)$ (Figure 6), and the proportion at age by stratum (Figure 7) are presented and used to compare differences in the age structure among seasons and to identify year class strengths. The analytical, and bootstrap estimates of c.v. by stratum are given in Appendix 1 (Table 1.2). The age-length matrices of actual numbers sampled and estimated proportions in the annual catch, and the mean weight-at-age estimates for each stratum are given in Appendix 1 (Tables 1.3 to 1.5). A time series comparison of the catch-at-age compositions is given in Appendix 3.

These data indicate that there were differences in both the proportions at age (Figure 7), and the mean weight-at-age among seasonal strata during 2007–08 (Appendix 1). The overall mean fish weight was 0.90 kg (Table 7), but this varied between 0.92 kg during summer, to 1.60 kg during winter.

The SNA 2 fishery continues to be strongly influenced by relatively young year classes (Figure 6). The 1999 to 2003 year classes (5–9 year old fish) together comprise 78% of the catch from the SNA 2 fishery in 2007–08 in terms of numbers of fish, with the most dominant 2003 year class (5 year old

fish) representing 33%.. An intermittent time series of previous catch-at-age estimates between 1997–98 and 2004–05 is given in Appendix 3.

3.3 Mean weight-at-age

The mean weight-at-age estimates (Table 7) were highest for winter (1.6 kg), where more 15–18 year old fish were caught. Little difference was apparent among the remaining seasonal strata (Appendix 1).

4. DISCUSSION

The SNA 2 fishery continues to be strongly influenced by relatively young year classes in 2007–08. No seasonal stratum contained the full range of age classes, and the mean weighted c.v. of each stratum was greater than the overall combined mean weighted c.v. (MWCV) estimate of 0.17. There were continuing major changes in the inshore trawl fisheries in QMA 2 during 2007–08. In previous years (Blackwell et al. 1999), the fishing patterns of the major vessels in the fleet were predictable and vessels could be reliably stratified by snapper catch history and fishing effort. Since 2004–05, fishing patterns have become more unpredictable, and the previous classification of vessels by effort and method strata is now invalid (Blackwell & Gilbert 2006).

Trawling remains the dominant fishing method in SNA 2, despite several major vessels having recently left the fishery. Fishing trips often extend across two or more statistical areas, so areal-based stratification is difficult. During 2007–08, the amount of fish processing undertaken in Napier and Gisborne declined. Instead, much of this fish was trucked immediately to Auckland, and processed on arrival, often very late at night, or during weekends. Initial attempts to sample these landings were not successful, and sampling was sub-optimal, with fewer samples collected during spring and summer. A revised sampling schedule which was implemented in the second quarter provided better coverage of the fishery, although more samples were collected in autumn and winter than originally planned.

As most snapper is taken as bycatch of other target fisheries, landings are unpredictable. Fishing effort in the fourth quarter was also higher than predicted from previous data, including some relatively large landings. Additional sampling was carried out in the fourth quarter to include this catch, giving a total of 55 landings sampled. The planned, but dynamically adjustable, sampling regime appears to be the optimum for sampling this fishstock. The over-sampling of otoliths and subsequent post-stratification by weight of landings provides the most flexibility in coping with within-season variation in this essentially bycatch trawl fishery.

The 2009 Inshore Working Group meeting queried the use of $n = 4$ as a minimum size for otolith selections from smaller samples. While the programme achieved a reasonable MWCV with this sample design, we acknowledge that this sample size was too small. It is recommended that a minimum of $n = 10$ otoliths be processed from samples in subsequent sampling programmes. Concerns were also raised about consistency in ageing methodology between years in SNA 2. Under the current otolith reading regime, each otolith is routinely read by two independent readers, who have been reading snapper otoliths since 1999–2000. A forced margin was implemented to anticipate *a priori* the otolith margin type (wide, line, or narrow) in the month in which the fish was sampled to provide guidance in determining age, particularly for year-round sample collections. Any discrepancies are resolved by re-reading the otolith and subsequent discussion and agreement, or by processing and reading of the second otolith from the fish concerned where necessary. The first two years of the catch-at-age series (1997–98 and 1998–99) involved other otolith readers and preparation methods, and did not implement a forced margin technique to age snapper. It is recommended that consideration be given to re-ageing these otoliths under the current ageing protocols. However, such work is outside of the scope of the current programme.

Strong year classes (1999, 2000, 2001, 2003 and 2003) dominated the SNA 2 commercial fishery in 2007–08. These correspond to strong year classes in the SNA 1 fishery, and relate to warm summer water temperatures with higher than average recruitment success (Walsh et al. 1998, 1999, 2000, 2001, 2002, 2003, NIWA unpublished data). This is reflected in the relatively low mean fish weight in SNA 2 which declined from 1.5 kg in 1998–99, to 1.2 kg in 1999–2000, and has subsequently remained at 0.9 kg (from 2002–03 to 2007–08), which shows the continuing influence of a high proportion of young year classes in the fishery in each year.

The data show clear modal progression from 1999–2000 onwards, but patterns for the first two years (1997–98 and 1998–99) appear inconsistent. The 2000 year class, which was initially considered weak, subsequently represented 23% of the 2004–05 fishery, suggesting that recruitment of this year class may have been delayed (Blackwell & Gilbert 2006). A similar trend was apparent from the 2004–05 analysis, where the 2001 year class was initially considered comparatively poor, or not fully recruited (Blackwell & Gilbert 2006), but in the 2007–08 analysis, this year class appears to be of similar strength to the 1999 to 2002 year classes. The previously dominant 1995 and 1996 year classes (now 12–13 years) which together represented 53% of the fishery in 1999–2000 are still present, but the influence of the previously strong 1989–91 year classes has declined due to the strength of recent recruitment .

Proportions at age and mean weights indicate some differences in age distributions between strata, consistent with previous analysis of this fishery (Blackwell & Gilbert 2005, 2006), and also apparent in the SNA 7 fishstock reviewed in 2006–07 (Blackwell & Gilbert 2008). Previously the SNA 2 bottom trawl fishery has tended to take more small fish during autumn and winter with increased numbers of large fish taken during spring and summer possibly representing fish moving into shallow inshore waters to spawn (Sullivan et al. 2005). As seen in 2004–05 (Blackwell & Gilbert 2005), sampling in 2007–08 suggested that more small fish were taken in spring. This may be related to cold spring temperatures, but high variability between sampling strata is common and appears to be due to spatial heterogeneity in the stock and variable targeting in the fishery.

The Northern Inshore Working Group (April 2009) noted that the inconsistencies in year class strength in the catch-at-age series could be due to disproportionate sampling of landings between Napier and Gisborne, if spatial variability in age frequency occurred between snapper caught from the northern and southern areas of SNA 2. Such an effect could also be due to differences in the interpretation of growth zones of otoliths sampled in the first two years, and during the remainder of the catch-at-age series.

Preliminary data analysis confirmed the existence of spatial heterogeneity in age frequency distributions between northern and southern strata in SNA 2, where larger fish appear to be more common in southern SNA 2 (Hawke Bay), while smaller fish appear to be more common in northern waters (see Appendix 4). Caution is advised in the interpretation of these data due to unequal sample sizes. The raw unscaled length frequency data are derived from the total aged sample and have not been properly adjusted for catch weights. They are provided for indicative purposes, and are unlikely to be representative of the true length frequencies of the catch. These apparent spatial patterns should be taken into consideration in the design of subsequent catch sampling programmes in SNA 2. Furthermore, with the introduction of revised catch and effort reporting forms in 2007–08, fishers now report the exact latitude and longitude of the tow positions of their catches, areal-based stratification of the SNA 2 fishery will now be more practical to implement in a sampling design than was previously possible.

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Table 1: Summary of reported landings (t) in SNA 2 by calendar year, 1961 to 1990. Source Ministry of Fisheries (2008).

Year	SNA 2	Year	SNA 2
1931	0	1961	589
1932	0	1962	604
1933	21	1963	636
1934	168	1964	667
1935	149	1965	605
1936	78	1966	744
1937	114	1967	856
1938	122	1968	765
1939	100	1969	837
1940	103	1970	804
1941	148	1971	861
1942	74	1972	878
1943	60	1973	798
1944	49	1974	716
1945	59	1975	732
1946	77	1976	732
1947	36	1977	374
1948	53	1978	454
1949	215	1979	662
1950	285	1980	636
1951	265	1981	283
1952	220	1982	160
1953	247	1983	160
1954	293	1984	227
1955	309	1985	208
1956	365	1986	255
1957	452	1987	122
1958	483	1988	165
1959	372	1989	227
1960	487	1990	429

Table 2: Reported landings (t) of snapper by Fishstock from 1983–84 to 2007–08 and gazetted and actual TACCs (t) for 1986–87 to 2007–08 (Source: Ministry of Fisheries 2008).

Fishstock		SNA 1		SNA 2		SNA 3		SNA 7		SNA 8		SNA 10		
QMAs		1		2		3,4,5,6		7		8,9		10		Total
	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC	Landings§	TACC
1983–84†	6 539	–	145	–	2	–	375	–	1 725	–	0	–	9153	–
1984–85†	6 898	–	163	–	2	–	255	–	1 546	–	0	–	9228	–
1985–86†	5 876	–	177	–	0	–	188	–	1 828	–	0	–	8653	–
1986–87‡	4 016	4 710	130	130	0	30	257	330	893	1 330	0	10	5314	6540
1987–88‡	5 061	5 098	152	137	1	30	256	363	1 401	1 383	0	10	6900	7021
1988–89‡	5 793	5 614	210	157	1	30	176	372	1 526	1 508	0	10	7706	7691
1989–90‡	5 826	5 981	364	157	< 1	30	294	160	1 550	1 594	0	10	8034	7932
1990–91‡	5 315	6 002	427	157	< 1	31	160	160	1 658	1594	0	10	7570	7944
1991–92‡	6 191	6 010	373	157	< 1	31	148	160	1 464	1 594	0	10	8176	7962
1992–93‡	5 423	4 904	316	252	2	32	165	160	1 543	1 500	0	10	7448	6858
1993–94‡	4 846	4 928	307	252	< 1	32	147	160	1 542	1 500	0	10	6842	6883
1994–95‡	4 831	4 938	307	252	< 1	32	150	160	1 434	1 500	0	10	6723	6893
1995–96‡	4 941	4 938	279	252	< 1	32	146	160	1 558	1 500	0	10	6924	6893
1996–97‡	5 049	4 938	352	252	< 1	32	162	160	1 613	1 500	0	10	7176	6893
1997–98‡	4 524	4 500	286	252	< 1	32	182	200	1 589	1 500	0	10	6583	6494
1998–99‡	4 411	4 500	283	252	3	32	142	200	1 636	1 500	0	10	6475	6494
1999–00‡	4 500	4 500	391	252	< 1	32	174	200	1 604	1 500	0	10	6669	6494
2000–01‡	4 347	4 500	360	252	< 1	32	156	200	1 630	1 500	0	10	6496	6494
2001–02‡	4 372	4 500	252	252	1	32	141	200	1 577	1 500	0	10	6342	6494
2002–03‡	4 484	4 500	334	315	<1	32	187	200	1 558	1 500	0	10	6563	6557
2003–04‡	4 466	4 500	339	315	<1	32	215	200	1 667	1 500	0	10	6686	6557
2004–05‡	4 641	4 500	399	315	<1	32	178	200	1 663	1 500	0	10	6881	6557
2005–06‡	4 539	4 500	389	315	<1	32	166	200	1 434	1 300	0	10	6527	6357
2006–07‡	4 424	4 500	329	315	<1	32	248	200	1 327	1 300	0	10	6328	6357
2007–08‡	4 547	4 500	328	315	<1	32	187	200	1 303	1 300	0	10	6366	6357

† FSU data. SNA 1 = stat areas 1–10; SNA 2 = stat areas 11–16; SNA 3 = stat areas 18–32; SNA 7 = stat areas 17, 33–36, 38; SNA 8 = stat areas 37, 39–48.
‡ QMS data.
§ Includes landings from unknown areas before 1986–87.

Table 3: Summary of estimated catch (t) by main method (BT, single bottom trawl; SN, set net; DS, Danish seine; Other, all other methods), and month, and reported landings (t) by month, in the SNA 2 fishery for the 2007–08 fishing year. Source: Ministry of Fisheries data extract January 2009. Note: the total landings for SNA 2 have been subsequently revised to 328 t (see Table 2).

Month	BT	SN	Other	Total (t) all methods	Percentage	Reported landings (t) (all methods)
Oct	37	<1	<1	38		35
Nov	36		1	36		38
Dec	33	<1	1	33		38
Total 1st quarter	106	0	2	107	35	
Jan	13	<1	<1	13		13
Feb	18	<1	<1	18		16
Mar	19	<1	<1	19		19
Total 2nd quarter	50	0	0	50	16	
Apr	19	<1	<1	19		18
May	25	<1	<1	26		26
Jun	14	<1	<1	15		17
Total 3rd quarter	58	0	0	60	19	
Jul	14	<1	1	15		17
Aug	29	<1	<1	29		20
Sep	47	<1	<1	47		56
Total 4th quarter	90	0	1	91	30	
Total fishing year	304	1	3	308	100	313

Table 4: Proportions of anticipated catch, by numbers, and by weight in SNA 2 for fishing years 2004–05 to 2006–07, by sampling stratum, and the initial and revised sampling allocation for the 2007–08 fishing year.

Stratum	Past proportion of catch in stratum by weight	Past proportion of catch in stratum by numbers of fish	Planned number of landings to sample	2007–08 proportion of catch in stratum by weight	Number of landings sampled
Spring	0.31	0.31	16	0.32	6
Summer	0.24	0.28	12	0.15	11
Autumn	0.23	0.26	13	0.18	21
Winter	0.21	0.15	9	0.27	17
Total	1,027,736 (kg)	1,021,602 (fish)	50	366.287 (kg)	55

Table 5: Summary of the catch (total numbers and weight of landings) and samples (number of landings and weight sampled, and number of fish sampled for otoliths) in seasonal strata for SNA 2 in the 2007–08 fishing year.

	Number of landings				Weight of landings (t)		
Stratum	Total	Sampled	% of total	No. of fish sampled	Total	Sampled	% of total
Spring	65	6	9.2	311	107.6	7.0	6.5
Summer	59	11	18.6	712	50.7	5.5	10.8
Autumn	56	21	37.5	1 140	59.1	16.7	28.2
Winter	59	17	28.8	1 356	90.9	15.0	16.5
Total	239	55	23.0	3 519	308.2	44.2	14.3

Table 6: Summary of snapper otolith samples aged, for fishing year 2007–08.

Stratum	Length range (cm)	Mean length (cm)	Number aged
SNA 2			
Spring	26–69	35.3	191
Summer	26–63	34.9	162
Autumn	26–74	35.0	290
Winter	25–66	33.5	263
Total	25–74	35.6	906

Table 7: Summary of estimates for fishing year 2007–08, by sampling stratum in SNA 2. Landings (t) of SNA 2 by quarter from QMR data.

Stratum	Spring Oct-Dec	Summer Jan-Mar	Autumn Apr-Jun	Winter Jul-Aug	Total
Landings sampled	6	11	21	17	55
Mean weight, $\hat{w}_j$ (kg)	1.0	0.9	0.9	1.6	0.9
Weight sampled landings, t_j (t)	7.0	5.5	16.7	15.0	44.2
Total landings, T_j (t)	107.3	50.7	59.1	90.9	308.2
Percent (%) of landings sampled (by weight (t))	6.5	10.8	28.25	16.5	14.3
Mean weighted *c.v.* of proportions at age (1–20+ y)	0.14	0.06	0.05	0.05	0.17
Number of landings N_j	65	59	56	59	239

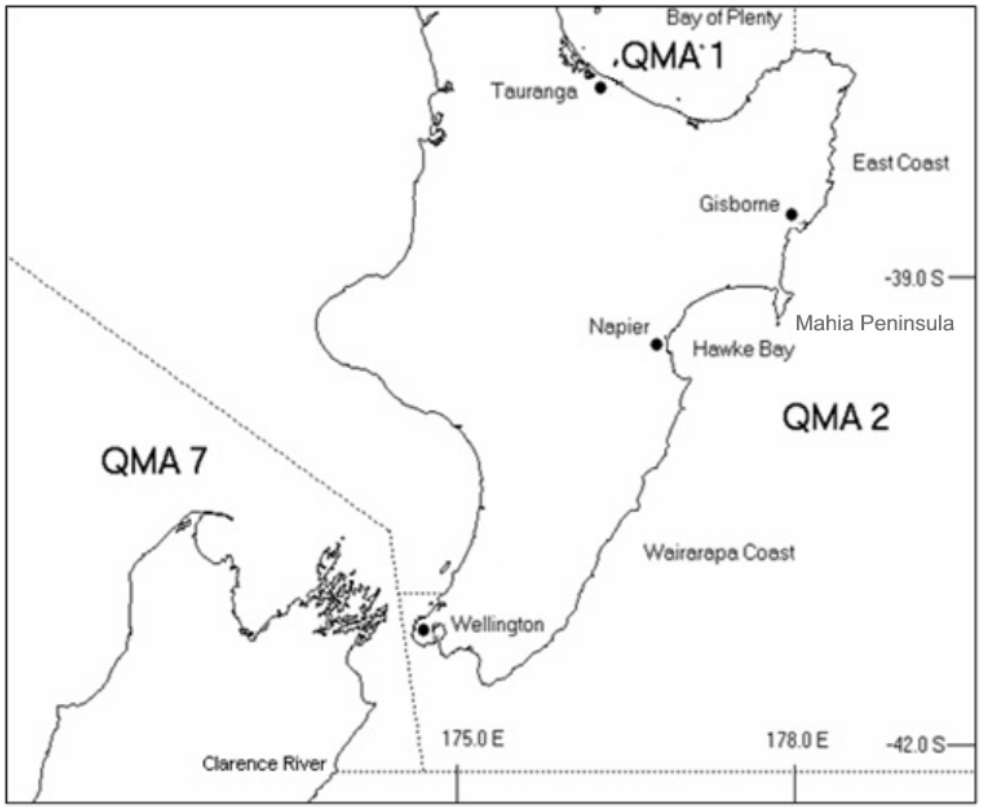


Figure 1: SNA 2 (equivalent to QMA 2) showing the main ports of landing in the fishery. Main snapper grounds are located on the east coast North Island, and in Hawke Bay.

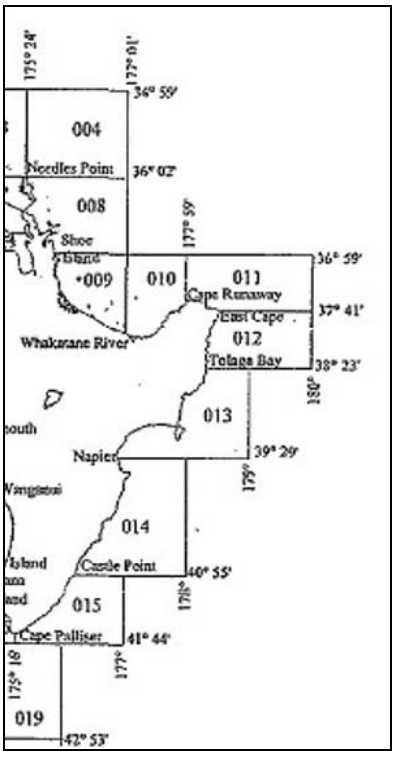


Figure 2: Statistical areas in the ECNI east coast North Island SNA 2 fishery. Not shown, statistical area 016 – Cook Strait.

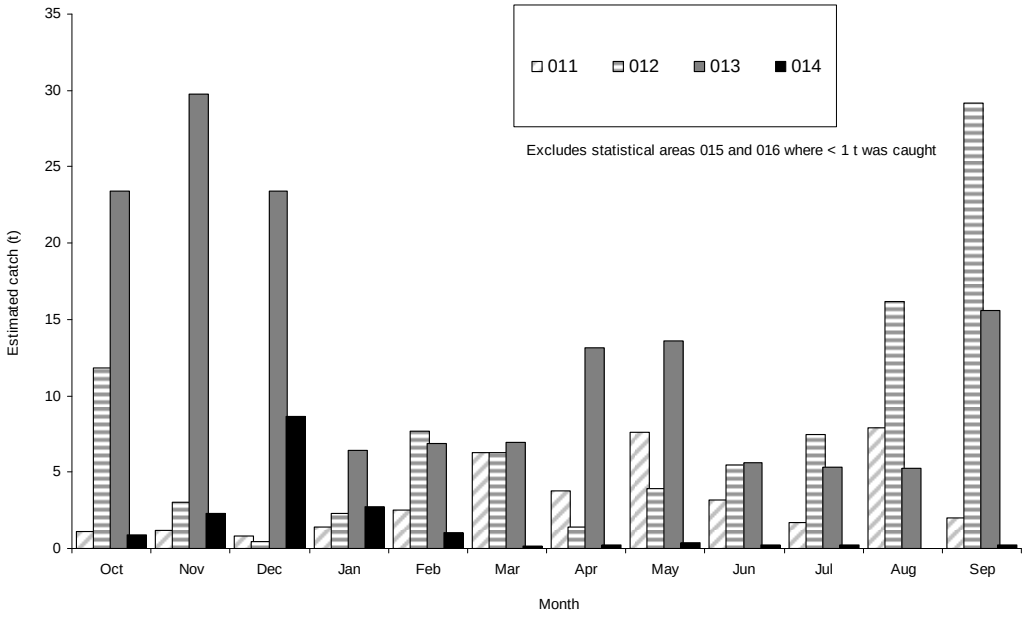


Figure 3: Estimated catch (t) by statistical area and month for all vessels during the 2007–08 fishing year. Source: Ministry of Fisheries data extract January 2009.

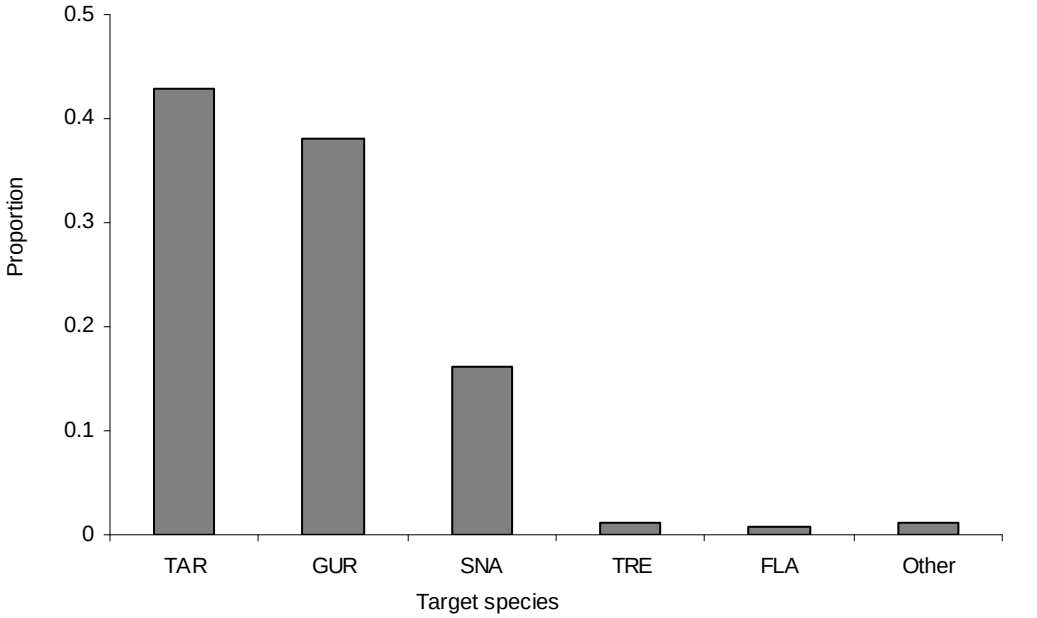


Figure 4: Proportion of estimated catch by target fishery for all vessels during the 2007–08 fishing year (total 308 t). Other, fisheries where less than 1 t was taken . Source: Ministry of Fisheries data extract January 2009.

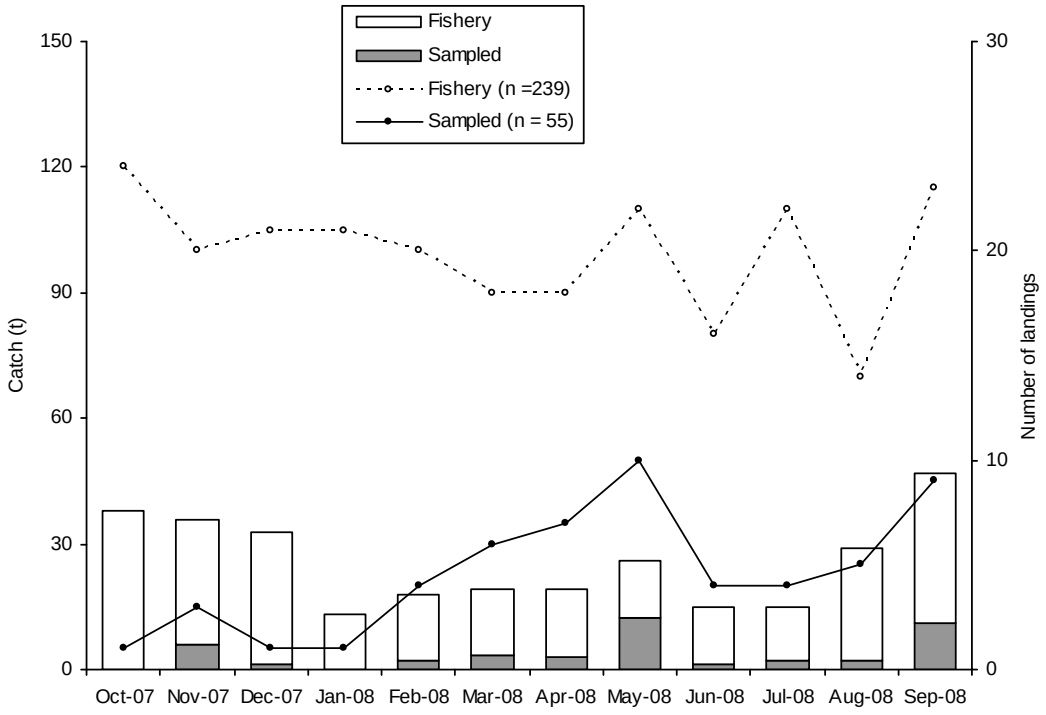


Figure 5: Summaries of fishing and sampling activity in SNA 2 during the 2007–08 fishing year. Histograms are of the total landed catch (t) by month for all vessels (white bars), overlaid by total catch (t) for all sampled vessels (light-grey bars). Also presented are the numbers of landings for all vessels in SNA 2 (dashed line), and the number of sampled vessels (solid line), by month. Source: Ministry of Fisheries data extract January 2009.

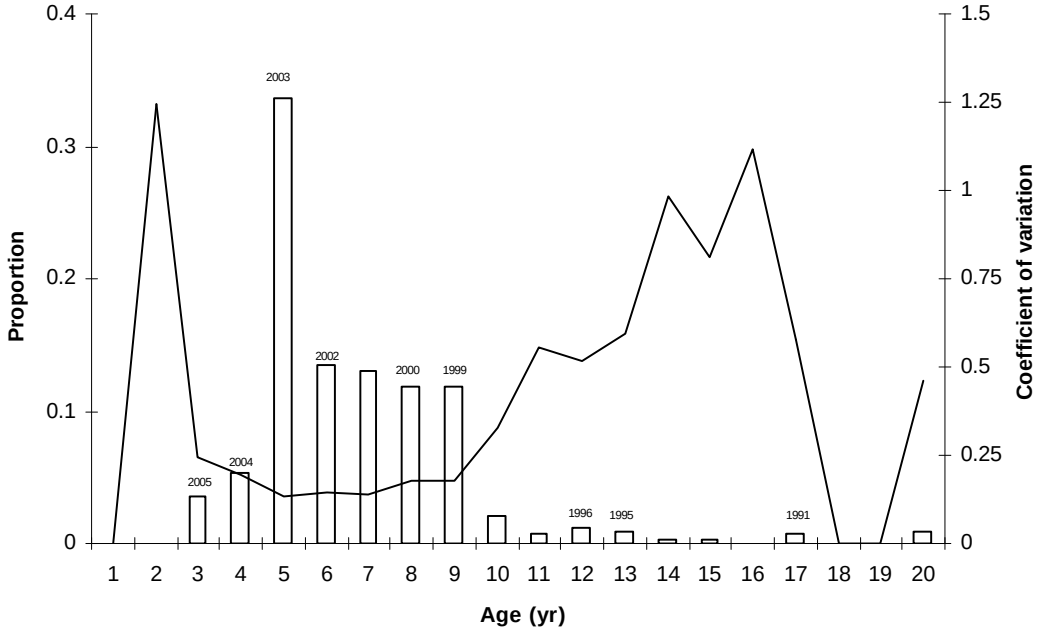


Figure 6: Proportion at age estimates (histogram) and bootstrap c.v.s (line) for SNA 2 landings, fishing year 2007–08.

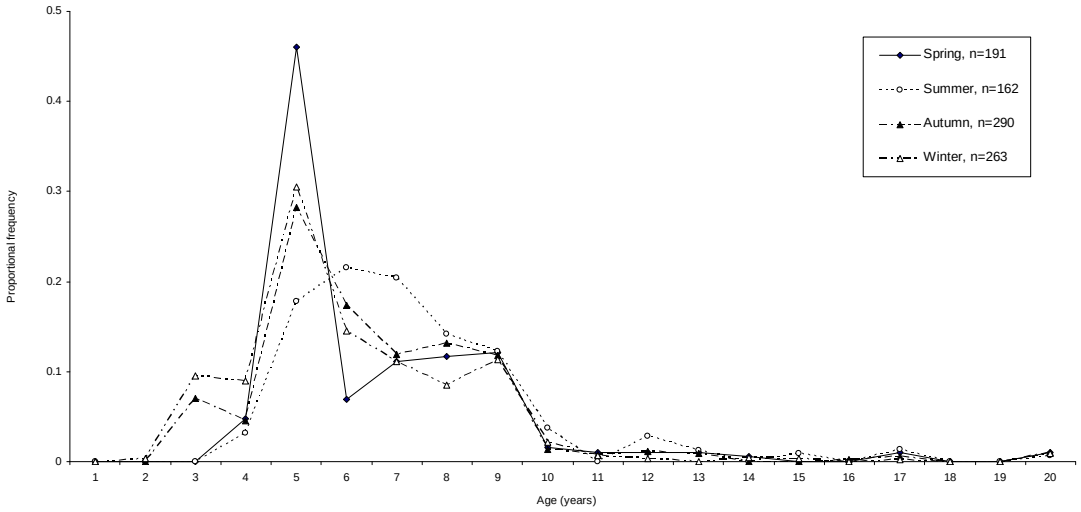


Figure 7: Proportion at age distributions determined from snapper landings sampled over four seasonal strata in SNA 2, 2007–08 (n, otolith sample size).

7. APPEDICES

Appendix 1: Details of the 2007–08 SNA 2 landings

Table 1.1: Details of sampled landings in SNA 2 during 2007–08, showing seasonal stratum, the sampled weight and total weight of SNA 2 landed, the location of fishing by statistical reporting area and by spatial stratum, the number of fish sampled and the number of otoliths processed.

Seasonal stratum	Sample number	Statistical areas fished	Spatial stratum	Landed weight of snapper	Weight of fish sampled	Number of of fish sampled	Number of otoliths processed
Spring	1	11–12	North	90	45	51	4
Spring	2	11	North	1 425	49	60	45
Spring	3	13	North	1 963	66	50	55
Spring	4	13–14	South	731	71	50	16
Spring	5	13	South	1 684	59	50	45
Spring	6	13–14	South	1 157	71	50	26
Total				7 049	360	311	191
Summer	7	11–13	Mixed	136	58	51	4
Summer	8	13	North	387	82	98	12
Summer	9	13	North	81	81	67	4
Summer	10	13	North	82	82	45	4
Summer	11	12–13	North	931	81	100	29
Summer	12	13	North	726	45	50	21
Summer	13	12	North	1 295	80	105	43
Summer	14	11–13	North	106	60	50	4
Summer	15	11–12	North	441	57	50	10
Summer	16	11–12	North	578	42	47	16
Summer	17	12–13	North	832	72	50	15
Total				5 595	739	713	162
Autumn	18	13	Mixed	250	107	49	4
Autumn	19	12–14	Mixed	140	75	50	4
Autumn	20	13–14	Mixed	1 129	90	50	12
Autumn	21	11–14	Mixed	698	54	51	13
Autumn	22	12–13	Mixed	323	75	50	5
Autumn	23	11–13	Mixed	484	68	50	7
Autumn	24	11	North	3 294	71	50	53
Autumn	25	11	North	2 442	43	50	50
Autumn	26	12–13	North	731	61	53	12
Autumn	27	11–12	North	443	78	63	7
Autumn	28	11–12	North	239	48	55	6
Autumn	29	13	North	436	51	49	8
Autumn	30	11–12	North	1 448	72	58	22
Autumn	31	13	North	811	70	81	18
Autumn	32	12–13	North	464	77	73	9
Autumn	33	13	North	693	45	51	15
Autumn	34	11–13	North	321	61	50	5
Autumn	35	13	North	200	65	50	4
Autumn	36	13–14	South	327	56	50	6
Autumn	37	13–14	South	700	98	50	7
Autumn	38	11–12	South	1 158	49	50	23
Total				16 731	1 409	1 133	290
Winter	39	11–13	Mixed	200	53	50	5
Winter	40	11–14	Mixed	484	44	50	12
Winter	41	11–13	North	572	53	78	13
Winter	42	12–13	North	1 160	81	78	23
Winter	43	13	North	174	81	126	4
Winter	44	12–13	North	243	80	120	6
Winter	45	12–13	North	388	78	81	6
Winter	46	11–13	North	485	85	136	11
Winter	47	12–13	North	823	79	100	15
Winter	48	12–13	North	1 806	80	99	32
Winter	49	12–13	North	1 032	80	88	16
Winter	50	13	North	337	79	75	4
Winter	51	12	North	1 034	44	50	20
Winter	52	12–13	North	2 755	67	66	44
Winter	53	12–13	North	1 951	50	65	38
Winter	54	13	South	866	81	50	8
Winter	55	13–14	South	673	111	44	6
Total				14 983	1 224	1 356	263

Table 1.2: Estimates of proportion at age with coefficients of variation (analytical and bootstrap estimates) by seasonal stratum and overall, for the 2007–08 SNA 2 landings.

P.j., proportion of fish in age class; c.v., coefficient of variation

									Random age frequency Trawl		
	Spring		Summer		Autumn		Winter				Spr-Win
Age (years)	*P.J.*	c.v. (an)	*P.J.*	c.v. (an)	*P.J.*	c.v. (an)	*P.J.*	c.v. (an)	*P.J.*	c.v. (an)	c.v. (bt)
1	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0.0033	0.9481	0.0008	0.9481	1.2446
3	0	0	0	0	0.0700	0.2868	0.0956	0.3234	0.0401	0.2254	0.2417
4	0.0475	0.2662	0.0319	0.3089	0.0458	0.1855	0.0899	0.1976	0.0554	0.1244	0.1927
5	0.4604	0.2476	0.1785	0.2908	0.2823	0.1455	0.3048	0.1134	0.3374	0.1315	0.1324
6	0.0688	0.3300	0.2150	0.2934	0.1736	0.1844	0.1456	0.2057	0.1345	0.1227	0.1444
7	0.1112	0.2788	0.2044	0.1489	0.1193	0.1735	0.1113	0.1432	0.1273	0.1080	0.1389
8	0.1173	0.3954	0.1413	0.1033	0.1310	0.1756	0.0853	0.2088	0.1161	0.1592	0.1762
9	0.1216	0.3439	0.1222	0.2986	0.1178	0.2606	0.1134	0.2048	0.1188	0.1574	0.1756
10	0.0156	0.6229	0.0378	0.4118	0.0140	0.5192	0.0216	0.5104	0.0201	0.2664	0.3299
11	0.0108	0.4689	0	0	0.0081	0.6444	0.0066	0.6552	0.0075	0.3292	0.5566
12	0.0105	0.9525	0.0281	0.7802	0.0112	0.6071	0.0033	1.0103	0.0115	0.4562	0.5169
13	0.0105	0.9525	0.0122	0.5498	0.0091	0.6335	0.0000	0.0000	0.0078	0.5164	0.5926
14	0.0057	0.8481	0	0	0	0	0.003993	0.943867	0.0031	0.6497	0.9812
15	0	0	0.0091	0.7305	0	0	0.003336	1.010272	0.0022	0.5935	0.8099
16	0	0	0	0	0.0018	1.0788	0	0	0.0004	1.0788	1.1186
17	0.0100	0.6608	0.0130	1.0315	0.0057	0.7517	0.0027	1.0623	0.0076	0.4455	0.5791
18	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0
20+	0.0100	0.7105	0.0064	0.8508	0.0103	0.6041	0.0094	0.6765	0.0094	0.3710	0.4606
n	191		162		290		263		906		

Table 1.3: Numbers of commercially caught snapper sampled by length and age for SNA 2 in 2007–08, aged to 01/01/2008.

Length												Age								No.
(cm)	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	20+	aged
25	1																			0	1
26		5		4	2	1														0	12
27		11	5	7	1															0	24
28		6	15	22	1															0	44
29		7	9	32	15	2	3													0	68
30		7	10	37	19	3	3	2												0	81
31		3	2	35	25	20	2	2												0	89
32		3	5	21	18	5	3	2												0	57
33			2	24	18	15	3	2	1											0	65
34		3		21	13	11	8	8		1	1									0	66
35			1	22	8	17	10	5	2											0	65
36			2	19	5	13	17	10												0	66
37			1	6	2	5	24	9												0	47
38				12		2	11	16												0	41
39				4		6	6	9	3	1										0	29
40					1	6	6	21	4		1									0	39
41				1		1	6	7	3	2	2	1								0	23
42						2	2	6	1	2										0	13
43						1	2	7	2		2									0	14
44						4	1	2	4			1				1				0	13
45						2	1	3	1		4	1		1						0	13
46											1	2	1	1		1			1	0	7
47						1		1				2				1				0	5
48								1		1						1				0	3
49						1							1							0	2
50						1		1						1						1	4
51								1								1				0	2
52												1								1	2
58									1											1	2
60																				1	1
63															1					1	2
65																1				0	1
66																				1	1
67																				1	1
69																				1	1
71																				1	1
74																				1	1
																				0	
Total	1	45	52	267	128	119	108	115	22	7	11	8	2	3	1	6			1	10	906

Table 1.4: Estimates of the proportion at length and age for commercially caught snapper in SNA 2 in 2007–08. Table sums to 1.

Length (cm)	Age (years)																			Number sampled
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25	0	0.0008215	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
26	0	0	0.0061637	0	0.0067571	0.0029477	0.0007584	0	0	0	0	0	0	0	0	0	0	0	0	0	12
27	0	0	0.0098641	0.0050561	0.0066589	0.0019228	0	0	0	0	0	0	0	0	0	0	0	0	0	0	24
28	0	0	0.0058091	0.0166058	0.0230723	0.0013034	0	0	0	0	0	0	0	0	0	0	0	0	0	0	44
29	0	0	0.0065162	0.0109199	0.0339128	0.0159816	0.0029947	0.0051489	0	0	0	0	0	0	0	0	0	0	0	0	68
30	0	0	0.0049845	0.0114194	0.0364914	0.020483	0.0027763	0.003768	0.0030196	0	0	0	0	0	0	0	0	0	0	0	81
31	0	0	0.0020913	0.0024683	0.0479302	0.0266224	0.0226304	0.0016298	0.0026812	0	0	0	0	0	0	0	0	0	0	0	89
32	0	0	0.0024877	0.0031462	0.0294376	0.0174184	0.005392	0.0035357	0.0028742	0	0	0	0	0	0	0	0	0	0	0	57
33	0	0	0	0.0021919	0.0347358	0.0194026	0.0127097	0.0027044	0.0025638	0.0010054	0	0	0	0	0	0	0	0	0	0	65
34	0	0	0.0022172	0	0.0347368	0.0129036	0.0091049	0.011112	0.012265	0	0.0008215	0.0019228	0	0	0	0	0	0	0	0	66
35	0	0	0	0.0007439	0.0271061	0.0074797	0.0175713	0.0112647	0.0053246	0.0037726	0	0	0	0	0	0	0	0	0	0	65
36	0	0	0	0.0015705	0.0257579	0.0043687	0.0139325	0.0201493	0.0084566	0	0	0	0	0	0	0	0	0	0	0	66
37	0	0	0	0.0013034	0.0086127	0.0018173	0.0034861	0.0248898	0.0070106	0	0	0	0	0	0	0	0	0	0	0	47
38	0	0	0	0	0.0165226	0	0.0015842	0.0098039	0.0172701	0	0	0	0	0	0	0	0	0	0	0	41
39	0	0	0	0	0.0049882	0	0.0104711	0.0060793	0.0102107	0.0027913	0.0020951	0	0	0	0	0	0	0	0	0	29
40	0	0	0	0	0	0.0018273	0.0065793	0.0062187	0.0173043	0.0025219	0	0.0012921	0	0	0	0	0	0	0	0	39
41	0	0	0	0	0.0006518	0	0.0018273	0.0057779	0.0065377	0.0035872	0.0014836	0.0015721	0.0007522	0	0	0	0	0	0	0	23
42	0	0	0	0	0	0	0.0035795	0.0013994	0.0057346	0.000648	0.0025542	0	0	0	0	0	0	0	0	0	13
43	0	0	0	0	0	0	0.0017521	0.0015179	0.0050936	0.0010311	0	0.0026346	0	0	0	0	0	0	0	0	14
44	0	0	0	0	0	0	0.0039127	0.0003594	0.0026151	0.0037262	0	0	0.0019228	0	0	0	0.0019228	0	0	0	13
45	0	0	0	0	0	0	0.003325	0.0007044	0.0049337	0.0005296	0	0.0034725	0.0009888	0	0.0003594	0	0	0	0	0	13
46	0	0	0	0	0	0	0	0	0	0	0	0.000648	0.0025004	0.0020951	0.0008399	0	0.000669	0	0	0.00052	7
47	0	0	0	0	0	0	0.0018498	0	0.0006518	0	0	0	0.0014262	0	0	0	0.0009945	0	0	0	5
48	0	0	0	0	0	0	0	0	0.0018273	0	0.00052	0	0	0	0	0	0.0009945	0	0	0	3
49	0	0	0	0	0	0	0.0004038	0	0	0	0	0	0	0.0010054	0	0	0	0	0	0	2
50	0	0	0	0	0	0	0.0006518	0	0.0017521	0	0	0	0	0	0.0010234	0	0	0	0	0.0010201	4
51	0	0	0	0	0	0	0	0	0.000619	0	0	0	0	0	0	0	0.0013034	0	0	0	2
52	0	0	0	0	0	0	0	0	0	0	0	0	0.0002089	0	0	0	0	0	0	0.0007657	2
53	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
54	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
55	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
56	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
57	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
58	0	0	0	0	0	0	0	0	0	0.0004956	0	0	0	0	0	0	0	0	0	0.0005776	2
59	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
60	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000669	1
61	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
62	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
63	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0004038	0	0	0	0.0002089	2
64	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
65	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0017521	0	0	0	1
66	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000669	1
67	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0018273	1
68	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
69	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0018498	1
70	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
71	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000619	1
72	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
73	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
74	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0006518	1
75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
																					906

Table 1.5: Estimated mean weight at age (kg) and c.v.s for snapper in SNA 2 in 2007–08. c.v., coefficient of variation (bootstrap estimates).

Age	Spring		Summer		Autumn		Winter	
(years)	Mean	c.v.	Mean	c.v.	Mean	c.v.	Mean	c.v.
1	–	–	–	–	–	–	–	–
2	–	–	–	–	–	–	–	–
3	–	–	–	–	–	–	0.36	1.00
4	0.52	0.10	–	–	0.50	0.13	0.52	0.09
5	0.77	0.10	0.51	0.16	0.70	0.15	0.56	0.05
6	0.74	0.15	0.58	0.07	0.68	0.09	0.67	0.07
7	1.12	0.14	0.66	0.06	0.73	0.06	0.72	0.05
8	1.01	0.11	0.81	0.07	0.87	0.13	0.99	0.09
9	1.51	0.18	1.02	0.06	1.06	0.08	1.06	0.07
10	1.05	0.49	1.17	0.12	1.28	0.06	1.24	0.07
11	1.36	0.60	1.52	0.12	1.75	0.23	1.26	0.25
12	1.24	0.82	–	–	1.59	0.38	1.05	0.67
13	1.85	0.76	1.53	0.49	1.74	0.27	1.85	1.04
14	1.97	1.04	1.88	0.39	1.87	0.41	–	–
15	–	–	–	–	–	–	2.35	1.06
16	–	–	2.46	0.63	–	–	1.97	1.09
17	2.92	0.74	–	–	4.74	1.00	–	–
18	–	–	2.15	0.81	2.63	1.02	1.97	0.97
19	–	–	–	–	–	–	–	–
20	–	–	–	–	–	–	–	–
			–	–	–	–	–	–
20+	5.98	0.56	2.87	0.64	5.50	0.40	2.67	0.60

APPENDIX 2: Cumulative proportion of the number of landings in the fishery, and the number of landings sampled.

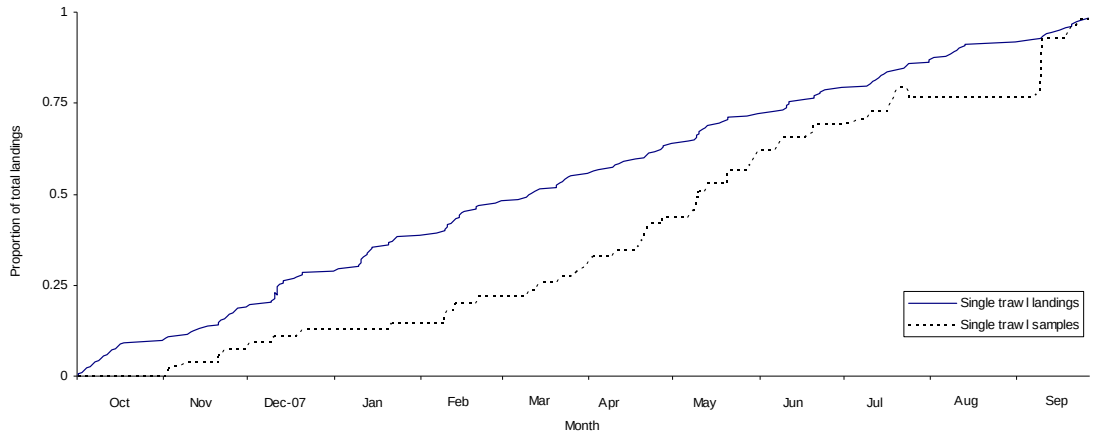
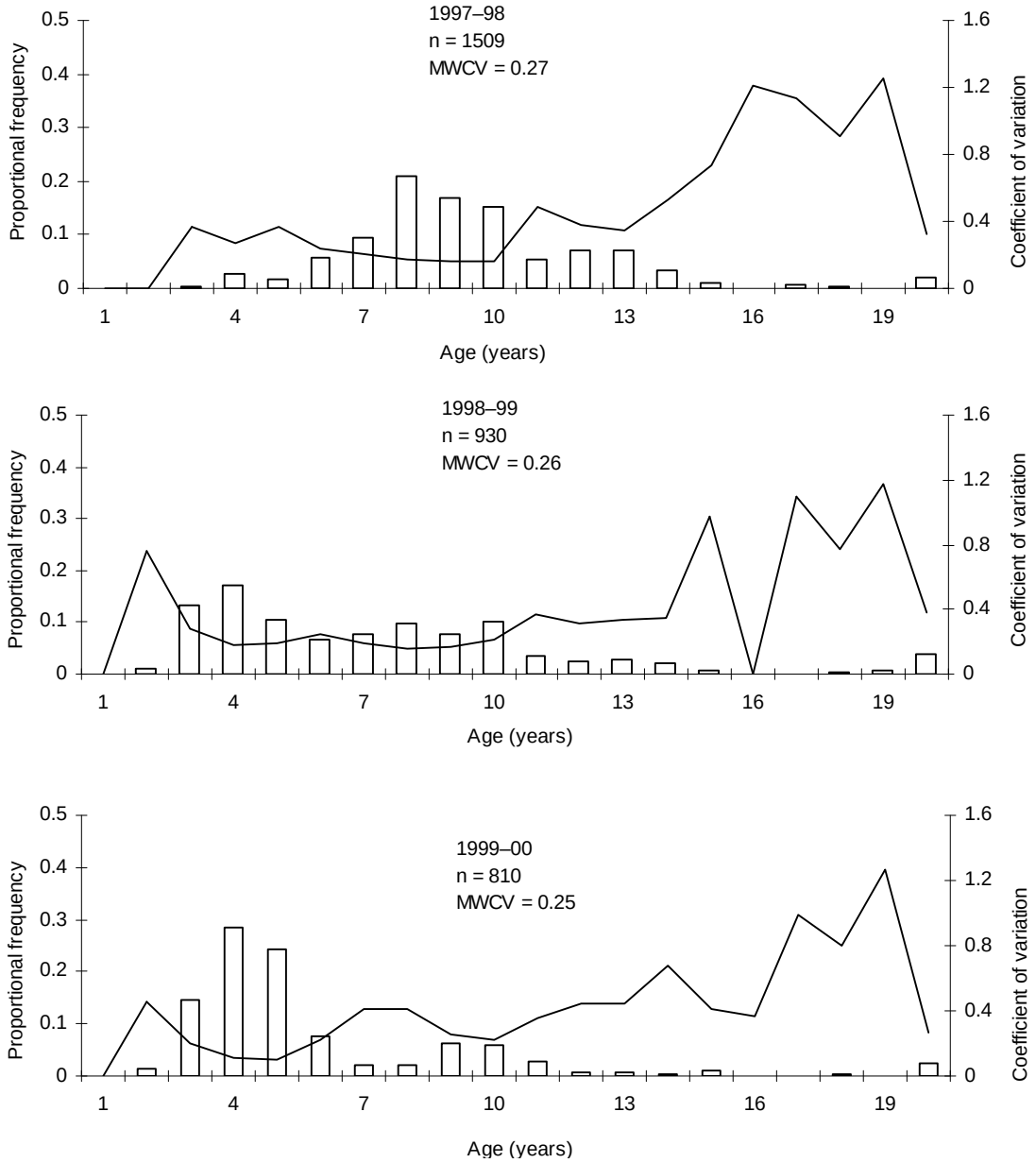


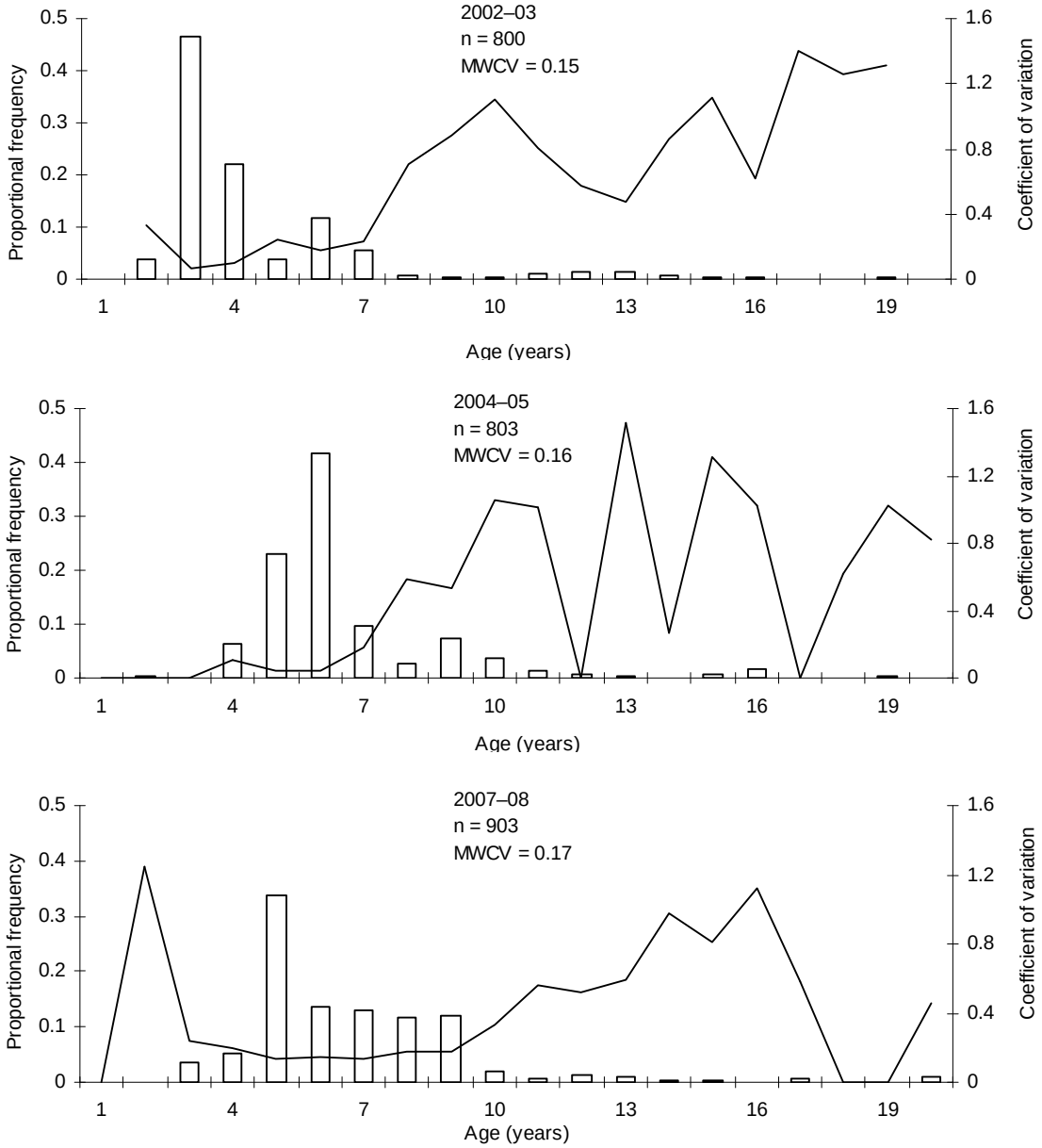
Figure 2.1: The cumulative proportion of the number of landings and samples of SNA 2 taken from the trawl fisheries in QMA 2 in 2007–08, by month.

Appendix 3: Comparisons with previous data

Figure 3.1: Comparison of the proportion-at-age distributions determined from snapper landings sampled from the SNA 2 fishery in 1997–98, 1998–99, 1999–2000, 2002–03, 2004–05, and 2006–07 (n, sample size).



Appendix Figure 3.1 continued: Comparison of the proportion-at-age distributions determined from snapper landings sampled from the SNA 2 fishery in 1997–98, 1998–99, 1999–2000, 2002–03, 2004–05, and 2006–07 (n, sample size).



Appendix 4: Spatial analysis of fishing in SNA 2

4.1 Introduction

Previous reports have described the age distribution of the SNA 2 catch in 1997–98, 1998–99, 1999–2000, 2002–03, 2004–05, and now 2007–08. The Northern Inshore Working Group meeting (April 2009) noted that strong year classes were able to be tracked from 1999–2000, but earlier age frequencies in 1997–98 and 1998–99 were inconsistent. Two possible reasons were discussed. Firstly, SNA 2 landings from Gisborne consistently contained smaller (and thus younger) fish than those from Napier. Disproportionate sampling of Napier and Gisborne landings could potentially bias the overall catch-at-age estimates. Secondly, otoliths collected in the first two years were aged by different personnel, whilst subsequent otolith samples have been aged by the same staff, and consistent procedures in age estimation have been followed.

The Working Group requested more information on sampling procedures and the SNA 2 fishery. This included the size and spatial distribution of SNA 2 catches, the size and spatial distribution of the catches sampled, the number of fish sampled from each catch, and the number of otoliths selected for ageing. Further information on the length and age frequency of catches by area was also requested.

4.2 Methods

Blackwell & Gilbert (2006) noted that the use of spatial strata in the analysis of the SNA 2 fishery was impractical, as most trips fished in several statistical reporting areas. The current boundaries of the statistical reporting areas in SNA 2 (011–016) are of limited usefulness in describing trends in catch. The main fishing grounds straddle the boundary between statistical areas 012 and 013, while the boundary between 013 and 014 bisects the main snapper fishery in Hawke Bay. Most vessels in the snapper fishery report their catch on the CELR (Catch Effort and Landing Report), which, prior to 2006–07 provided fishing location data only by statistical area. Subsequent catch data provide more detailed latitude and longitude information.

4.2.1 Spatial patterns in the fishery

The SNA 2 fishery was arbitrarily separated into northern, and southern regions at Mahia Peninsula (177.868^{o} S, -39.265^{o} E) (see Figure 4.1). Location of fishing details for 2007–08 were obtained from an extract of landed catch and estimated effort data (Extract 7572, November 2009). After error checking procedures were completed, these data were used to determine the estimated catch data by region, and to allocate sampled landings to regions.

4.2.2 Age and length frequency by region

The 55 samples collected in 2007–08 were allocated to a region based on tow positions, excluding all landings where fishing occurred in both regions of SNA 2. Length data are raw unscaled length frequencies, derived from the total sample of aged fish. The age frequency data were derived following standard catch-at-age RAF analysis procedures. The proportions at age, $\hat{p}_i$, and estimated coefficients of variation, $\mathrm{c\hat{v}}(\hat{p}_i)$ by spatial stratum, and overall are given in Table 4.4.

5.0 Results

5.1 Spatial patterns in SNA 2 catch

Most (199.4 t) of the total estimated SNA 2 catch of 301.5 t occurred in northern SNA 2, off the East Coast in statistical areas 011–013, representing 66% of the total catch). The remaining 102.2 t (33%) occurred in southern SNA 2. This was mainly taken in Hawke Bay (statistical areas 013 and 014), while the southern areas (statistical areas 015 and 016) were relatively unimportant (see Tables 4–5, Table 4.1).

A total of 55 landings were sampled in SNA 2 during 2007–08. Of these, 39 landings (70%) represented fishing conducted exclusively in northern SNA 2. The fish from northern SNA 2 was generally landed into either Gisborne or Tauranga, with only one landing reported from Napier. Only 7 sampled landings (12%) represented fishing exclusively from southern SNA 2, all of which were landed into Tauranga or Napier. A further 9 landings (16%) represented fishing that occurred in both northern and southern SNA 2. Of these, 6 were landed into Napier (Table 4.2).

5.2 Spatial patterns in length and age frequency distribution

The raw unscaled length frequency data are provided in Figure 4.2 As these data have not been scaled by catch weights, the frequencies are unlikely to be representative of the true length frequencies of the catch. These data are provided for indicative purposes only, and caution is advised in their interpretation. Trends are difficult to interpret due to unequal sample sizes, but landings from southern SNA 2 may be more variable than in northern SNA 2, with more larger and smaller snapper.

An additional catch-at-age analysis was completed on the 46 landings where fishing location could be classified to spatial stratum. The mean weighted c.v.s were 0.14 and 0.30 for northern and southern regions respectively (Table 4.3). Age frequency data suggest that 5 year old snapper appear much more common in southern SNA 2 (Hawke Bay), than in northern SNA 2, while older fish (particularly age classes 6, 8 and 9) were more common in northern SNA 2 (Figure 4.3).

5.3 Summary

This preliminary analysis supports the existence of spatial differences in age frequency distribution between the northern and southern areas of SNA 2 during 2007–08, but caution is advised in interpretation of these data due to the low sample sizes available from southern SNA 2. The snapper landed into Gisborne appears to be derived from fishing adjacent inshore snapper grounds off the East Coast, while snapper landings into Napier appear to be more spatially variable.

These data suggest that the southern region of SNA 2 may be slightly under-sampled by the seasonal stratification used for the analysis of the 2007–08 catch-at-age data. However, the apparent variability in location of fishing for the Napier landings suggests that the port of landing may not be a useful stratification variable in this fishery. These patterns should be taken into consideration in subsequent catch sampling programmes in SNA 2.

A tender for a snapper age determination protocol (project INS2012/01) has been let by the Ministry for Primary Industries in 2012–13. The findings of this report will document the latest methodology and expected best practise to ensure that consistency for ageing snapper in New Zealand is maintained over time, and that issues arising from ageing in past are unlikely to occur in the future.

Table 4.1: Number of fishing events and estimated catch (t) of snapper by region of SNA 2 for 2007–08 (Source: Ministry of Fisheries data extract November 2009).

Region	Number of fishing events	Estimated SNA 2 catch	Proportion by weight
Northern SNA 2	2 708	199	0.66
Southern SNA 2	1 582	102	0.34
Total	4 290	301	1

Table 4.2: Number of landings sampled in SNA 2 during 2007–08 by region of SNA 2.

Region	Number of samples	Estimated SNA 2 catch	Proportion by weight	Proportion by number
Northern SNA 2	39	35	0.79	0.71
Southern SNA 2	7	6	0.14	0.13
Mixed area SNA 2	9	3	0.07	0.16
Total	55	44	1	1

Table 4.3: Summary of estimates for fishing year 2007–08, by spatial stratum in SNA 2. Landings (t) of SNA 2 are estimated catches from MFish data extract November 2009.

Stratum	Northern SNA 2	Southern SNA 2	Total
Landings sampled	39	7	46
Mean weight, $\hat{w}_j$ (kg)	0.85	1.29	0.9
Weight sampled landings, t_j (t)	35.0	6.1	41.1
Total landings, T_j (t)	203.7	104.4	308.2
Percent (%) of landings sampled (by weight (t))	19.2	6.7	13.3
Mean weighted *c.v.* of proportions at age (1–20+ y)	0.14	0.30	0.22
Number of landings N_j	152	78	230

Table 4.4: Estimates of proportion at age with coefficients of variation (analytical and bootstrap estimates) by spatial stratum and overall, for 2007–08 SNA 2 landings, where location of fishing could be assigned to stratum.

P.j., proportion of fish in age class; c.v., coefficient of variation **.**

					Random age frequency Trawl		
Age	Northern SNA 2		Southern SNA2				Combined
(years	*P.J.*	c.v (an)	*P.J.*	c.v (an)	*P.J.*	c.v. (an)	c.v. (bt)
1	0	0	0	0	0	0	0
2	0.001396	0.985393	0	0	0.00104	0.98539	1.35981
3	0.046957	0.26493	0.093076	0.587954	0.05863	0.28446	0.34807
4	0.059213	0.15907	0.080928	0.326819	0.06471	0.15007	0.23547
5	0.278562	0.103925	0.512062	0.139104	0.33765	0.08337	0.10934
6	0.17907	0.113028	0.01472	0.542088	0.13748	0.11094	0.14672
7	0.127318	0.114526	0.141939	0.240917	0.13102	0.10617	0.14441
8	0.128349	0.10498	0.007405	0.791521	0.09774	0.10408	0.1397
9	0.122738	0.150446	0.064976	0.379042	0.10812	0.13999	0.17528
10	0.019129	0.327439	0.015823	0.629694	0.01829	0.29054	0.36364
11	0.007473	0.404424	0.007405	0.791521	0.00746	0.36229	0.54306
12	0.010021	0.451674	0	0	0.00749	0.45167	0.55391
13	0.004446	0.557119	0	0	0.00332	0.55712	0.73944
14	0.00268	0.702935	0	0	0.002	0.70293	1.06976
15	0.002766	0.650352	0	0	0.00207	0.65035	0.8501
16	0.000795	1.032081	0	0	0.00059	1.03208	1.38971
17	0.005385	0.537479	0.01682	0.761111	0.00828	0.47046	0.63575
18	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0
20+	0.003701	0.563547	0.044847	0.560558	0.01411	0.46408	0.52328
n	726		114			840	

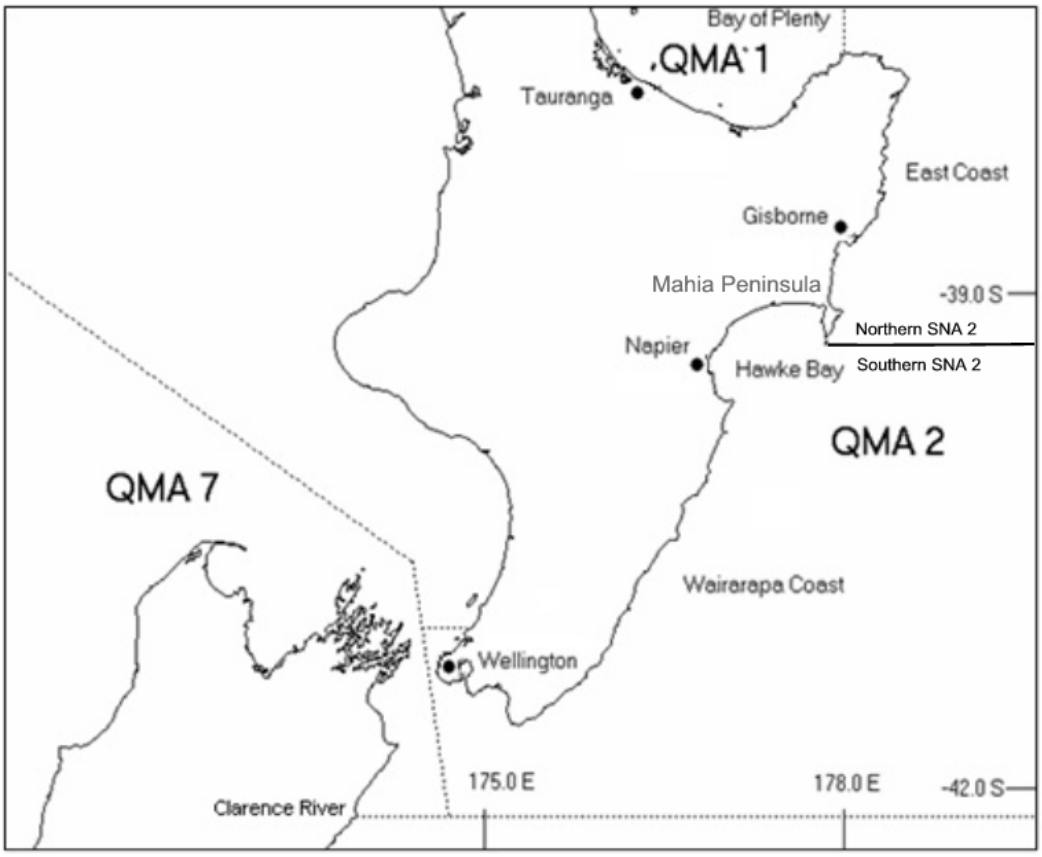


Figure 4.1: SNA 2 (equivalent to QMA 2) showing the main ports of landing in the fishery, and the two regions, northern SNA 2, and southern SNA 2 respectively, subdivided at Mahia Peninsula.

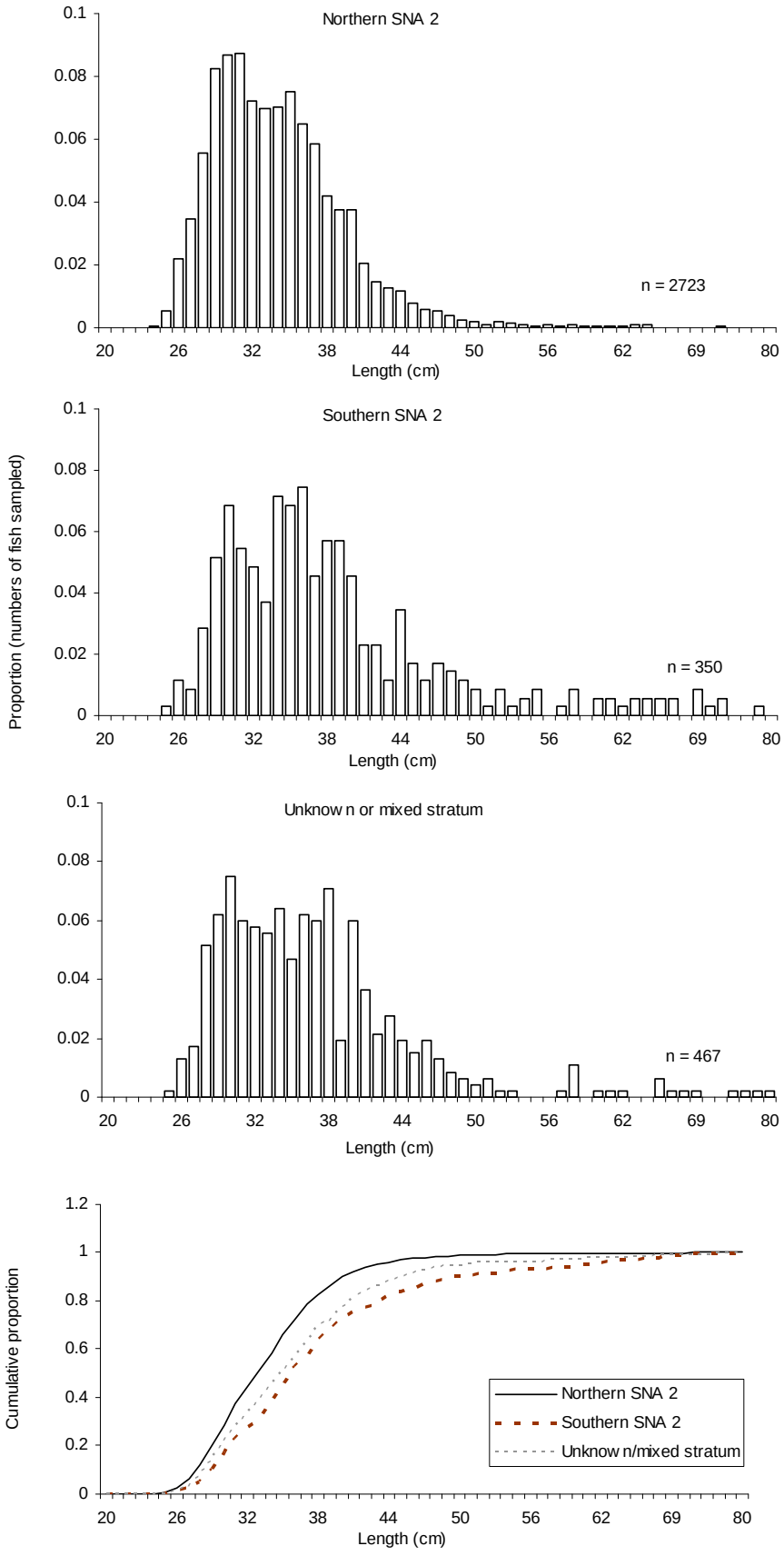


Figure 4.2: Proportions at length distributions derived from the combined raw unscaled SNA 2 2007–08 age data, and cumulative distributions (lower). (n, numbers of otoliths collected).

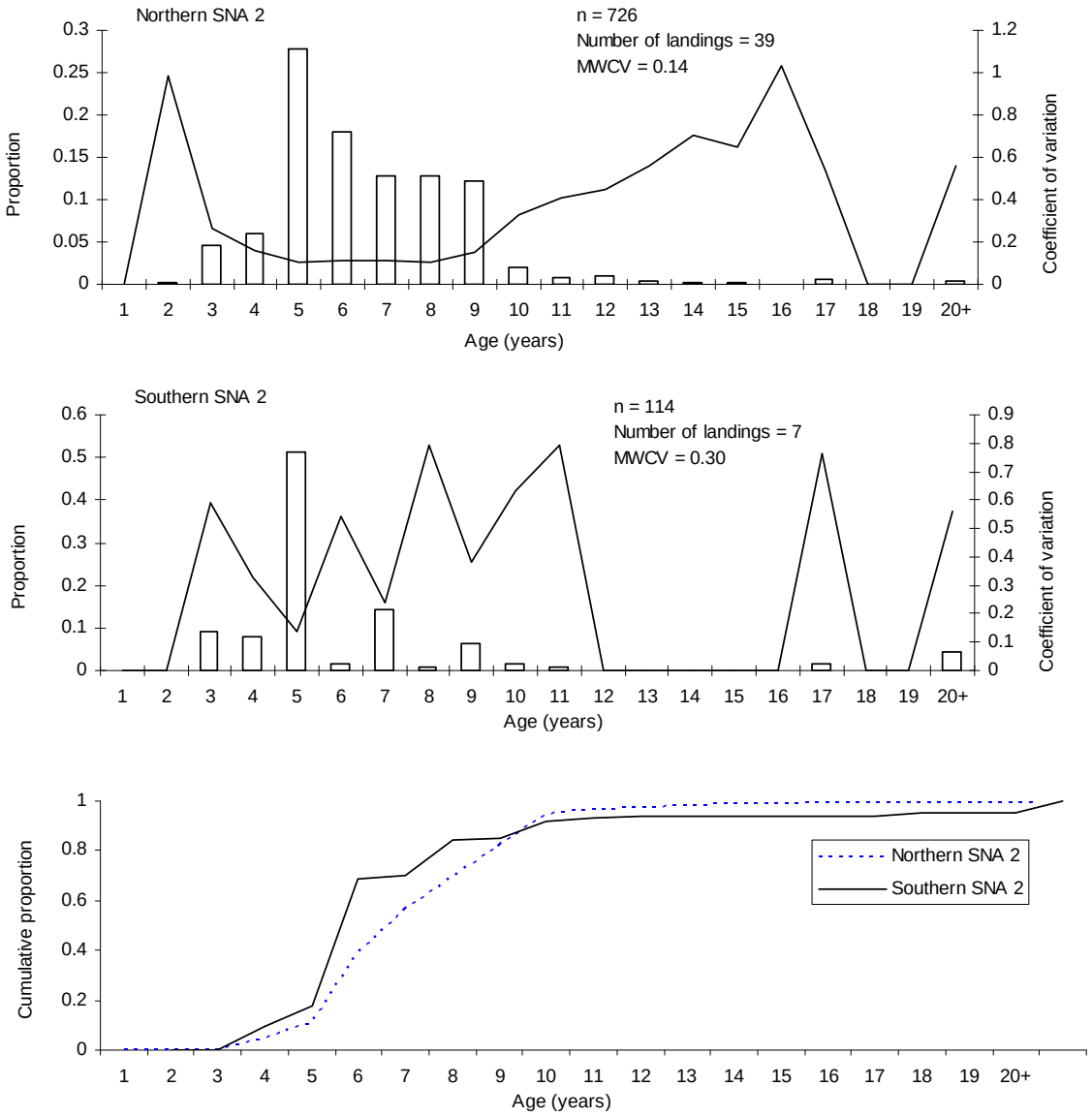


Figure 4.3: Proportion at age distributions, and cumulative distributions (lower) determined from snapper landings sampled by spatial strata in SNA 2, 2007–08. n, number of otoliths, MWCV, mean weighted *c.v.*