Length and age composition of commercial snapper landings in SNA 8, 2009–10

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EXECUTIVE SUMMARY

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This report presents the results of Objective 1 of the Ministry of Fisheries project "Estimation of snapper year class strength in SNA 8" (SNA2007/04C, Objective 1). The general objective was to determine the length frequency and age structure of commercial landings from SNA 8 market samples for use in stock assessment models.

The length frequency and age-length key sampling approach was employed during spring and summer 2009–10 to estimate catch-at-age for snapper for the main fishing methods in SNA 8. Length frequency samples were collected from the SNA 8 single trawl fishery, and age data were collected randomly in the form of a semi-fixed allocation age-length key, mainly to ensure fish in the large length intervals were well accounted for. Fifteen landings were sampled for length frequency from the single trawl fishery, with an age-length key collection of 525 otoliths, and although two landings and 31 otoliths had been sampled during March, outside the normal temporal strata, preliminary analysis showed that their inclusion did not bias the final results. No length frequency samples were obtained from the pair trawl fishery in 2009–10, largely due to a rationalisation of the Auckland based inshore trawl fleet in recent years, which resulted in fewer trawlers operating and a reduction in pair trawl landings in SNA 8.

Although relative year class strengths inferred in 2009–10 from the SNA 8 stock were generally similar to those estimates from recent years, the age distribution was dominated by the recent strong recruitment of the 2006 year class (4-year-olds), making up over one in every three (38%) snapper landed. This is possibly the second strongest year class to recruit in the past decade, and likely to be important for the short term sustainability and rebuilding of the fishery. The 2009–10 single trawl fishery was based largely on young fish, 87% below 9 years of age, characteristic of landings from the SNA 8 fishery for the past 21 years. At present, two of every three snapper landed are 5 years of age or less, the highest proportion for any New Zealand snapper stock. The combined total for fish over 10 years of age made up only 6% of the single trawl catch-at-age composition in 2009–10. These larger fish are either not as well represented in catch-at-age estimates because they now exceed the optimum selectivity of the single trawl method, or, more likely, they are of very low relative abundance in the fishery as a result of fishing mortality. Fish in the aggregate (over 19) age group continue to be rarely encountered in landings making up less than 1% of the catch by number, the lowest estimate for any New Zealand snapper stock. The newly recruited 2007 year class (3-year-olds), although not yet fully recruited to the fishery, appears to be of average strength, making up about 6% of the single trawl catch by number in 2009–10.

It is expected that the derived proportional length and age estimates presented here are adequate and representative descriptions of the temporal and spatial spread of single trawl catches from the SNA 8 fishery for 2009–10. Length and age compositions for the unstratified and stratified approaches were almost identical in their relative proportional estimates. Mean weighted coefficients of variation for the age compositions were 12% and 8% respectively (analytical estimate calculated across all age classes), so were well within the target of 20%.

1. INTRODUCTION

Staff of the National Institute of Water and Atmospheric Research (NIWA) and, formerly, MAF Fisheries have sampled the length and age compositions of snapper (*Pagrus auratus*) from commercial landings in port (market sampling) intermittently since 1963 (Davies et al. 1993). In the 1988–89 fishing year, a structured sampling programme was designed to establish a time series of length and age composition data for the main snapper fisheries in the east and west coast North Island stocks, SNA 1 and SNA 8, respectively. The time series of length and age information has been summarised in previous reports (Davies & Walsh 1995, Walsh et al. 1995, 1997, 1998, 1999, 2000, 2001, 2002, 2003, 2004, 2006a, 2006b, 2009a, 2009b, Walsh & Davies 2004, Walsh & Buckthought 2010). This report presents the results of market sampling from the SNA 8 stock between October 2009 and March 2010. Funding for this project, SNA2007/04C (Objective 1), was provided by the Ministry of Fisheries.

The specific objective of this project for 2009–10 was:

1. To carry out sampling and estimate the relative proportion at age and length of recruited snapper sampled from the commercial trawl catch in SNA 8 during spring and summer 2009–10. The target coefficient of variation (c.v.) for the catch-at-age will be 20% (mean weighted c.v. across all age classes).

2. METHODS

The SNA 8 stock encompasses almost all the west coast of New Zealand's North Island (Figure 1). Landings from the SNA 8 fishery were stratified by fishing method and quarter, e.g., single trawl – spring. The fishing method sampled was single trawl (BT) over the spring (September–November) and summer (December–February) quarters. Although the pair trawl (BPT) method had been sampled in previous years, in 2009–10, the relative effort was deemed insufficient to be considered useful for sampling purposes.

Details of the sampling design were described by Davies & Walsh (1995). Length frequency samples were collected from the SNA 8 single trawl fishery using a two-stage sampling procedure (West 1978). The random selection of landings and a random sample of bins within landings represent the first and second stages respectively, with a stipulation that each sampled landing comprises a minimum of 3 t of snapper. The sampling procedure was modified to account for the grading of fish according to length and quality by taking a stratified random sample of bins within a landing (Davies et al. 1993). All fish in bins making up the sample were measured to the nearest centimetre below the fork length. As snapper show no differential growth between sexes (Paul 1976), sex was not determined.

The age-length key method was used for collecting otoliths as described by Davies & Walsh (1995). In previous years the sample allocation for each length class interval for the age-length key was made according to the broadest proportion-at-length distribution of either the single trawl or pair trawl collection from the year before. However, as large snapper (i.e., those over 65 cm) were often poorly represented or absent in proportion-at-length distributions from SNA 8 collections in recent years, it was felt a proportional allocation age-length key design may under-represent fish in the large length class intervals and over-represent those in the mid-range. To determine whether a broadening of the age-length key collection had any real effect on resulting catch-at-age estimates, the sample collection in 2007–08 was altered to a semi-fixed allocation design, the same design implemented for sampling in 2009–10 (see Figure 2). This would ensure the right hand tail of the distribution, comprising the large and old snapper, was adequately sampled. A step-wise sample size of about six fish for length intervals greater than 45 cm, five fish over 51 cm, four fish over 58 cm, three fish over 65 cm, two fish over 70 cm, and one fish for all length classes 76 cm and above was specified for collection. To allow for annual variability in the abundance of fish in the 25–26 cm size range, a fixed sample size of about 10 otoliths was targeted for collection from each of these length intervals. It was thought that a broad, but slightly less dominant, mode (capped at 25 samples for the most common length intervals) based on the length distribution of the single trawl sample from 2008–09 that covered the mid-length class intervals of the age-length key collection would suitably describe the mid-range of cohorts currently present in the fishery. As in more recent years, otolith samples for fish over 75 cm were difficult to obtain because of their rarity in landings. The otolith sample size for the west coast collection (n = 525) was based on previous SNA 8 catch-at-age simulations using past length and age data that produce mean weighted coefficients of variation (MWCV) of below 20% for catch-at-age estimates.

A standardised procedure for reading otoliths was followed (Davies & Walsh 1995). Age was defined as the rounded whole year from a nominal birth date of 1 January.

The age-length key derived from the age data is assumed to be representative of the spring-summer period. The main assumption to be satisfied for an age-length key is that the sample was taken randomly with respect to age from within each length interval (Southward 1976).

Calculation of proportions at length and age, and variances from length frequency samples and age-length keys, followed that of Davies & Walsh (1995). For sample collections from the SNA 8 single trawl fishery in 2009–10, estimates of proportion at length and age were calculated according to two possible designs; unstratified and stratified. In the unstratified design, length and age data were pooled across temporal strata (spring and summer), thus treating the fishery as a single stratum. In the stratified design, estimates of proportion at age and length (and coefficient of variation) were calculated for each stratum, and then combined to calculate weighted mean estimates. The stratum estimates were combined and weighted according to the estimated number of fish landed in each stratum following Davies & Walsh (2003). Bootstrap variances have been determined for the unstratified combined spring and summer proportion-at-length and age estimates. The calculation of mean weight-at-age and variances followed Quinn II et al. (1983), with a length-weight relationship: w (g) = $0.04467\,l^{2.793}$ (cm) (Paul 1976). Proportions at age and mean weight-at-age (with analytical estimates of coefficient of variation, c.v.) were calculated for the range of age classes recruited, with the maximum age being an aggregate of all age classes over 19 years.

Snapper length and age data were stored on the Ministry of Fisheries *market* and *age* databases respectively, administered by NIWA.

3. RESULTS

3.1 Sample collections

Summaries of the length frequency sample sizes for method-season strata are given in Table 1, and summaries of the otolith sample collection in Table 2. However, because the fishing industry sub-contractor failed to achieve the target samples required during the sampling period (October 2009 – February 2010), despite sufficient landings being available, two further sample landings and 31 otoliths were collected during March to meet the shortfall. It was agreed by the Northern Inshore Working Group (meeting held December 2010) that these data be included as part of the summer stratum, as the preliminary analysis had shown that the inclusion did not bias the final results. Catch data from autumn 2009 to summer 2009–10 are provided in Table 1, displaying seasonal patterns in the fisheries. Single trawl was the dominant method, operating mainly over spring and summer. Although there may have been a broadening of the fishing season in SNA 8 in recent years, the greater proportion of the TACC (1300 t) in 2009–10 was still taken over spring and summer by single trawl, similar to the previous year. The catch from the pair trawl fishery has remained low, operating mainly over spring and summer, and landing considerably less snapper than a decade ago, reflective of the method being mainly used to target other species, e.g., trevally (*Pseudocaranx dentex*). Similarly, Danish seine, a method mainly used to target red gurnard (*Chelidonichthys kumu*) on the west coast, landed just over 60 t of snapper in the same period, most an incidental bycatch. The total percentage catch by the main methods in SNA 8 over the period of sampling (October 2009 to March 2010) was as follows: single trawl 79%, pair trawl 11%, Danish seine 6%. As has been the pattern in recent years the difference between the percentage of landings sampled and the percentage of the landed weight sampled was large, in part due to the minimum 3 t sampling requirement, resulting in large landings being sampled more frequently than small ones (Table 1). A marked shift from snapper to trevally targeting occurred in 2007–08 and this has continued into 2009–10. Before 2007–08, snapper was the target species in almost all spring samples. However, in 2009–10 trevally was the target for four of the six spring landings, despite snapper still making up a reasonable proportion of the overall catch. Over summer, trevally was the target species in all nine sampled landings. The summarised information in Table 1 is for all single trawl, pair trawl, and Danish seine landings containing snapper (target and bycatch) caught from SNA 8. The average sampled landing weight of snapper from single trawl catches in spring was about 14 t (range 6–27 t), while that for summer was about 8 t (range 3–13 t).

A total of 15 landings was sampled for length frequency from the single trawl fishery in 2009–10, meeting the required target, although two of the samples, as mentioned above, were collected in March. The cumulative proportion of the total number of landings and those sampled from the SNA 8 single trawl fishery from October 2009 to March 2010 shows that sampling effort was distributed in reasonable proportion to, and representative of, the landings from the fishery (Figure 3). A temporal comparison using the monthly catch of snapper and of that sampled (weight and number of landings) for the single trawl method (for all landings and for those over 3 t) from October 2009 to March 2010 is presented in Figures 4 and 5 to display patterns in the fishery and the representiveness of the sample collections. A similar summary depicting the number of otoliths subsampled from landings over the same period is given in Figure 6. The sampled catch accounted for 23% by weight and 7% by number of landings and is roughly proportional to the total single trawl catch in any given month during the sampling period. A spatial comparison for the same period using the proportional distribution of the estimated single trawl catch with that sampled for the statistical areas that make up SNA 8 is given in Figure 7. The largest part of the single trawl catch occurred in the northern half of SNA 8 between Ninety Mile Beach and North Taranaki Bight, with the greater proportion of the fishery and samples coming from those areas adjacent to the Kaipara Harbour and Ninety Mile Beach. A similar comparison depicting the single trawl catch by target species is given in Figure 8, with 65% of the landed snapper catch coming from trevally targeted tows, 21% where snapper was the target, and 10% for gurnard, far outweighing all other minor target species in SNA 8, most of which were exclusive to South Taranaki Bight. The proportionality of the sampled component to that of the fishery suggests that the sampled landings by and large are representative of the operation of the SNA 8 single trawl fleet as a whole.

3.2 Length and age distributions

For the SNA 8 single trawl fishery in 2009–10, catch-at-age compositions (using the length frequency and age-length key approach) were derived from the combined spring and summer length distributions, and used to identify year class strengths. Although otolith samples were collected from each sampled landing, they were not collected consistently across the entire spring or summer period. In combining the seasonal data, it is assumed that an age-length key collected from spring and/or summer can be applied to the combined spring and summer length data. Because the growth of snapper over 25 cm long is not great between spring and summer, this assumption is reasonable. This assumption has been accepted for other species with growth rates comparable to those of snapper (Westrheim & Ricker 1978).

Sample length and age distributions for the SNA 8 single trawl fishery in 2009–10 are presented as histograms and line graphs (Figures 9–12). The estimated proportions at length, age, and mean weight-at-age are tabulated in Appendices 1–3. The age-length key is presented in Appendix 4 and an age-at-length scatterplot for the full range of age classes present in the fishery is given in Appendix 5.

The estimated total number of fish caught in each season stratum was calculated from the reported total weight landed and the mean fish weight derived from stratum length compositions (Appendix 1). The estimated total number of fish caught for the spring-summer combined stratum may not correspond exactly to the sum of the individual season estimates because of differences in mean fish weight when spring and summer are treated separately.

3.3 Catch-at-length and catch-at-age

The unstratified and stratified length distributions of the single trawl catch in 2009–10, comprising mainly small to medium sized snapper, were almost identical, and characterised by a single mode at 32 cm, and a tail of the distribution extending to 60 cm (Figure 9). The mean lengths of snapper sampled from the fishery were 35.7 and 35.4 cm for the unstratified and stratified approaches respectively, and the analytical proportion-at-length MWCVs were 0.14 and 0.17.

The unstratified and stratified age distributions for the SNA 8 single trawl fishery in 2009–10 were also alike, and consisted largely of young fish between 3 and 8 years of age making up 87% of the number of snapper landed (Figure 10). The strong 2006 year class (4-year-olds), the most dominant in the fishery, made up almost 40% of the total, and combined with the second most dominant year class, 2005 (5-year-olds), the pair accounted for just under 60% of the landed catch. As a result, the proportion of most other age classes in the fishery is relatively low, especially those over 10 years of age, making up just 6% of the single trawl catch, with two-thirds of this total attributable to the 1999 and 1998 year classes (11- & 12-year-olds). The 1997, 1994, and 1992 year classes (13-, 16-, & 18-year-olds) were particularly weak, represented by only one fish each in the age-length key (see Appendix 4). Similarly, the aggregate (over 19) age group now makes up just 0.7% of the overall catch, reflecting the low number of fish of this age range available in the fishery despite a total of 41 fish over 19 years old in the otolith collection (see Appendix 5). The oldest fish sampled from the fishery in 2009–10 was 53 years.

The 2006 year class appears almost fully recruited as it contains few fish under 27 cm (see Appendix 4). The 2007 year class (3-year-olds) appears to be below average strength and is not yet fully recruited as it contains a proportion of fish under 27 cm. The mean age of snapper from the single trawl fishery was 5.8 and 5.7 years for the unstratified and stratified approaches respectively, and the catch-at-age analytical MWCVs were 0.12 and 0.08.

The spring and summer catch-at-length and catch-at-age samples for the single trawl fishery were relatively similar over both seasons, with spring samples containing a higher proportion of fish in the large length and old age ranges compared to summer samples which contained a slightly higher proportion of small young fish (Figures 11 & 12).

4. DISCUSSION

The relative year class strengths inferred in the length and age distributions sampled from the SNA 8 single trawl fishery in the 2009–10 are generally consistent with trends observed in recent years (Walsh et al. 2002, 2003, 2004, 2006a, 2006b, 2009a, 2009b, Walsh & Davies 2004, Walsh & Buckthought 2010). Although a slight broadening of the age distribution in SNA 8 is apparent in recent years (Walsh et al. 2006a, 2009a), indicative of a possible rebuild, population age dynamics of the fishery inferred from catch sampling suggest only moderate change has occurred since the introduction of the Quota Management System in 1986 (see Appendices 7–11).

Single trawl landings from the SNA 8 fishery in 2009–10 were dominated by young fish, 3 to 8 years of age, making up over 85% of the number of snapper landed, almost half of these solely attributable to the very strong 2006 year class (4-year-olds). As a result, the combined total proportion of older fish in the single trawl catch has remained low, not dissimilar to estimates seen in the fishery for the past 21 years, with fish over 10 years old now making up just 6% of the single trawl catch, half of this attributable to the previously dominant 1998 and 1996 year classes (12- and 14-year-olds). Some age classes below 20 years are now represented by only one individual in the age-length key, and the aggregate (over 19) age group accounts for less than 1% of the total single trawl catch, the lowest proportion for any New Zealand snapper stock (Appendix 6), despite efforts to ensure samples in the larger length intervals of the age-length key collection were more fully represented. In 2004–05, Walsh et al. (2006b) reported that the aggregate age group in SNA 8 was unlikely to increase substantially for at least another 10 years. The catch-at-age estimates for 2009–10 indicate very little change despite a TACC reduction from 1500 to 1300 t in 1 October 2005.

By the late 1980s, the SNA 8 fishery had become one of New Zealand's most exploited inshore fisheries, with landings based solely on small young fish, mostly between 3 and 6 years of age (see Appendices 7–9). Although a small remnant of large and old snapper from heydays of the fishery in the 1970s and early 1980s may have remained for some time, the vast majority of these fish have now been caught. Despite a slight broadening of the SNA 8 age structure in recent years (Walsh et al. 2006a, 2009a), catch samples from 1989–90 to the present day show the fishery is still based largely on small to moderate sized young individuals, where few fish are greater than 10 years of age (see Appendices 7–11). The catch-at-age time series sampled from the SNA 8 single trawl and pair trawl fisheries shows a declining trend in mean age occurred after the early 1970s (Appendices 7, 8, & 10) when larger and older snapper were more abundant. The fact that changes in estimates of mean length are less apparent than those for mean age indicate growth rates have increased in SNA 8 as the biomass decreased over time, where fish now attain a larger size for a given age than they did in the 1970s (Appendix 10). Obvious differences in mean length and mean age estimates between the two methods in the 1970s (Appendix 7) are likely due to selectivity and provide evidence that the pair trawl method is selective of larger and older fish (Appendix 7 & 8; Sullivan & Gilbert 1978, Davies et al. 2006). The length and age compositions from pair trawl and single trawl methods for the past 2 decades are generally similar, with both reflecting the current absence of larger older fish in the population, suggesting snapper are currently equally vulnerable to either method (Walsh et al. 2001, 2002, 2003, 2004, Walsh & Davies 2004). Although spatial and temporal variation in the length compositions within SNA 8 are known to occur (Reid 1969, Walsh et al. 2006a, 2006b), more often these reflect the location or season of the fishing operation, rather than any difference in selectivity between the pair and single trawl methods, typically more obvious in response to the availability of strong year classes (Davies et al. 2006). Either historically high fishing mortality has reduced the relative abundance of the large and old fish, as has been observed in previous years (Davies & Walsh 1995), or recent year classes have recruited into the fishery with above average strength to dominate age distributions, although this is noticeable only in a handful of years. However, as proportional catch-at-age data are not a direct index of absolute abundance, inferences from these data in respect to changes in stock size may not be totally reliable and should be interpreted with caution.

Two absolute stock biomass estimates derived from tagging programmes undertaken in 1990 and 2002 and comprehensive catch-at-age based models (Davies 1997, Davies et al. 2006) have all pointed to the SNA 8 stock being of a size well below a biomass that would achieve the maximum sustainable yield. For a long lived species such as snapper, the age structure of SNA 8 over the last 21 years has been consistent with that of a heavily exploited fishery, comprising only a few young age classes, often where only one or two dominate, and shows a distinct lack of accumulation of fish in the older age classes. Currently two of every three snapper landed in SNA 8 are 5 years or less, the highest estimate for any New Zealand snapper stock (see Appendix 6). The consistency seen in the long-term catch-at-age time series from SNA 8 implies that the biomass has been low for at least the past two decades, an inference consistent with the absolute abundance estimates from the previous 2 tagging programmes in 1990 and 2002 (Davies et al. 2006) (see Appendix 11).

In 2008–09, Walsh & Buckthought (2010) predicted the newly recruited 2006 year class (3-year-olds at that time) to be of above average strength, and now fully recruited as 4-year-olds in 2009–10, a comparison relative to other year classes has confirmed this to be one of the strongest year classes to recruit into SNA 8 fishery in the past decade. The 2006 year class dominated the SNA 8 fishery in 2009–10, accounting for more than one in every three fish landed, and although unlikely to be as dominant as the previously strong 1998 year class with a relative strength predicted to be almost twice that of the mean (Davies et al. 2006), the 2006 year class will most likely be important for the short term sustainability and rebuild of the SNA 8 stock.

The 2007 year class made up only 6% of the single trawl catch by number in 2009–10 and is yet to fully recruit to the SNA 8 fishery. It contains an appreciable proportion of fish in the smaller size classes, and is likely to be of average strength. Year classes that recruit at well above average strength as three year olds (i.e., more than 10% of the total age distribution) into the fishery (e.g., 1991, 1993, 1996, 1998, 2005, and 2006 year classes) strongly influence the shape of the length frequency distribution, either by broadening the distribution below 30 cm or appearing independently as a strong length mode dominating the 25–30 cm size classes (see Davies & Walsh 1995, Walsh et al. 1997, 2000, 2002, 2009b, Walsh & Buckthought 2010). This was not apparent for the 2007 year class in 2009–10.

As previously, length and age collections were made over the spring and summer seasons, a period when the greatest proportion of snapper is usually caught, estimated at about 60% of the TACC for 2009–10. This was a slight decrease from the previous year, 2008–09, when the landed catch over the same period was estimated to be close to 70%. Such changes can be directly attributed to the recent broadening of the fishing season in SNA 8 and rationalisation (and subsequent decline in the number of vessels) of the Auckland-based inshore trawl fleet in response to the TACC reduction (October 2005), as well as economic and market related factors (Walsh et al. 2009a). The recent trend for more of the SNA 8 catch to be taken as bycatch when targeting other west coast species (mainly trevally and gurnard) continued in 2009–10 with snapper being the principal target in 21% of fishing events (see Figure 8). Single trawl remains by far the most dominant fishing method in the SNA 8 fishery as it has been for over a decade, with landings of snapper from pair trawl, and more recently Danish seine, largely an incidental catch while targeting other species.

The SNA 8 sampling target of 15 single trawl landings in the spring and summer of 2009–10 was achieved, with samples coming from four different vessels fishing out of Onehunga. Six of a targeted eight samples occurred during the spring season (the main target period for snapper); a further two samples were collected in March just outside the normal temporal strata for sampling from SNA 8. Although the wider temporal spread in sampling was not ideal, sample collections are still likely to have been representative of the fishery's main temporal period. The average sampled landing weight over spring 2009–10 was about 14 t, a considerable increase on previous years, although the variance between landings appears high. The average landing sampled over summer was about 8 t, i.e., similar to recent years. As always, most of the sampled landings were from vessels operating mainly in an area off the Kaipara and Manukau Harbours, although considerable effort was also directed toward the Ninety Mile Beach area in the 2009–10 summer to target trevally. Ninety Mile Beach is renowned for catches of trevally, and was reflected in 65% of all single trawl tows in SNA 8 where snapper was caught, and trevally was the target species (source: TCEPR reports). Similar to previous findings, spring samples contained a higher proportion of fish in the larger length and older age ranges than summer samples. Walsh et al. (2006c) found that the similarity in the length distributions within a season is almost certainly related to the area that the vessels fished rather than a reflection of any seasonal or bycatch aspect of the fishery. Ninety Mile Beach is generally recognised for having smaller snapper than areas directly to the south, and the differences seen in the length samples for spring and summer in 2009–10 may in part reflect the spatial aspect of the sample collections or a combination of these factors. As is the norm for most vessels fishing SNA 8, landings were most often made up of individual long range fishing events that covered a number of sub-area strata on a single trip, therefore comprising catches of snapper from many parts of SNA 8, albeit largely north of New Plymouth. It is expected that the derived proportional length and age distributions from these landings are adequate and representative descriptions of the temporal and spatial spread of catches from the SNA 8 fishery for 2009–10, and are therefore comparable to those collections from past years over the 'school season', although snapper may have been more frequently used as the target species before the TACC reduction in October 2005.

The MWCV (analytical and bootstrap estimates) for the length and age distributions sampled from the SNA 8 single trawl fishery in 2009–10 ranged between 0.08 and 0.17, with all analytical estimates being below 0.20. Differences were apparent between the analytical and bootstrap variances of proportion-at-length and proportion-at-age estimates with the bootstrap variances being higher, particularly in the less abundant length and age classes respectively, i.e., small and large, young and old. The bootstrap solutions probably provide more accurate variance estimates (Davies et al. 2003). The level of precision in the catch-at-age estimates has been similar in recent years and reflects the rigorous sampling methodology and precise and accurate ageing currently in place.

5. CONCLUSIONS

1. The length and age distributions sampled from the SNA 8 single trawl fishery in 2009–10 were generally consistent with trends observed in recent years.

2. Single trawl landings from the SNA 8 fishery in 2009–10 were largely dominated by young fish aged 3 to 8 years from the 2002–2007 year classes, making up 87% of the number of snapper landed. Two of every three snapper landed are 5 years or less, the highest estimate for any New Zealand snapper stock.

3. Almost 40% of the total landed catch is attributable to the dominant 2006 year class (4-year-olds), possibly the second strongest year class to recruit into the fishery in the past decade and likely to be important for the short term sustainability and rebuild of the fishery.

4. Fish over 10 years of age made up only 6% of the single trawl catch-at-age composition in 2009–10. Older age classes may now be poorly represented in catch-at-age estimates for two main reasons: 1) a high proportion of fish in these cohorts now exceed the optimum selectivity of the single trawl method, and 2) lower relative abundance in the fishery as a result of fishing mortality.

5. The relative proportion of fish in the aggregate (over 19) age group is less than 1%, the lowest estimate for any New Zealand snapper stock.

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Table 1: Summary of the catch (total number and weight of landings) and samples (number of landings and weight sampled, and number of fish measured) in method–season strata for the SNA 8 snapper fisheries from autumn 2009 to summer 2009–10.*

		Number of landings			No. of fish	Weight of landings (t)		
Method	Season	Total	Sampled	% of total	measured	Total	Sampled	% of total
BPT	Autumn	20	0	0	0	39	0	0
	Winter	14	0	0	0	17	0	0
	Spring	18	0	0	0	37	0	0
	Summer	28	0	0	0	62	0	0
BT	Autumn	82	0	0	0	184	0	0
	Winter	72	0	0	0	112	0	0
	Spring	94	6	6.4	4 779	304	87	28.6
	Summer	162	9	5.6	6 713	418	69	16.5
DS	Autumn	17	0	0	0	25	0	0
	Winter	25	0	0	0	31	0	0
	Spring	23	0	0	0	27	0	0
	Summer	17	0	0	0	37	0	0

* BPT, pair trawl; BT, single trawl, DS, Danish seine.

Note: summaries for summer include the month of March (2010) which would normally lie outside the sampling period but has been included in order to capture the full complement of samples from the fishery in 2009–10 (see methods in report).

Table 2: Details of snapper otolith samples collected in 2009–10 from SNA 8.

Area	Fishing method †	Sampling period	Sample method ††	Length range (cm)	No. aged
SNA 8	BT	Spring, summer	SR	19–77	525

† BT, single trawl.

†† SR, stratified random sample.

Note: summaries for summer include the month of March (2010) which would normally lie outside the sampling period but has been included in order to capture the full complement of samples from the fishery in 2009–10 (see methods in report).

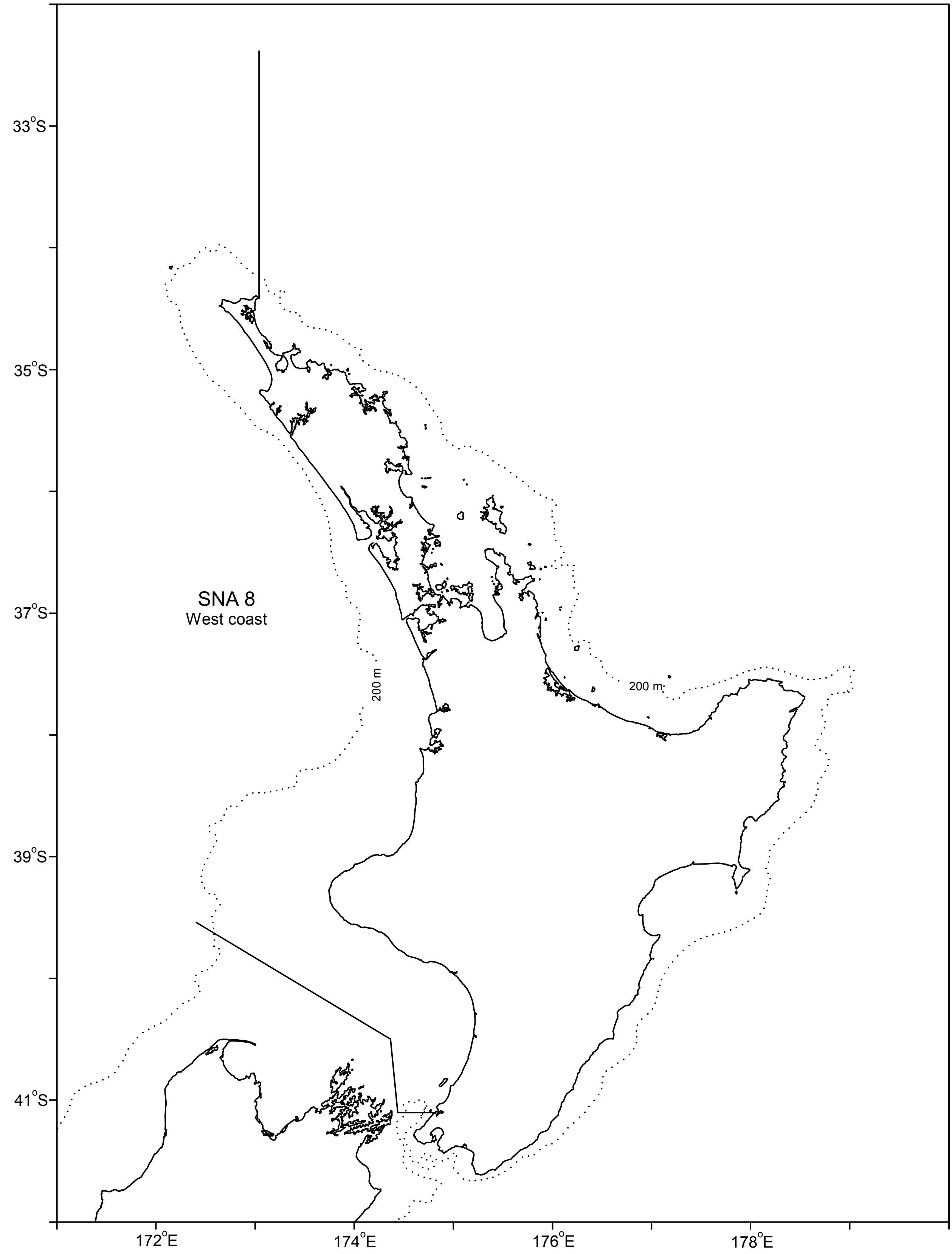


Figure 1: Quota management area for the west coast North Island snapper stock, SNA 8.

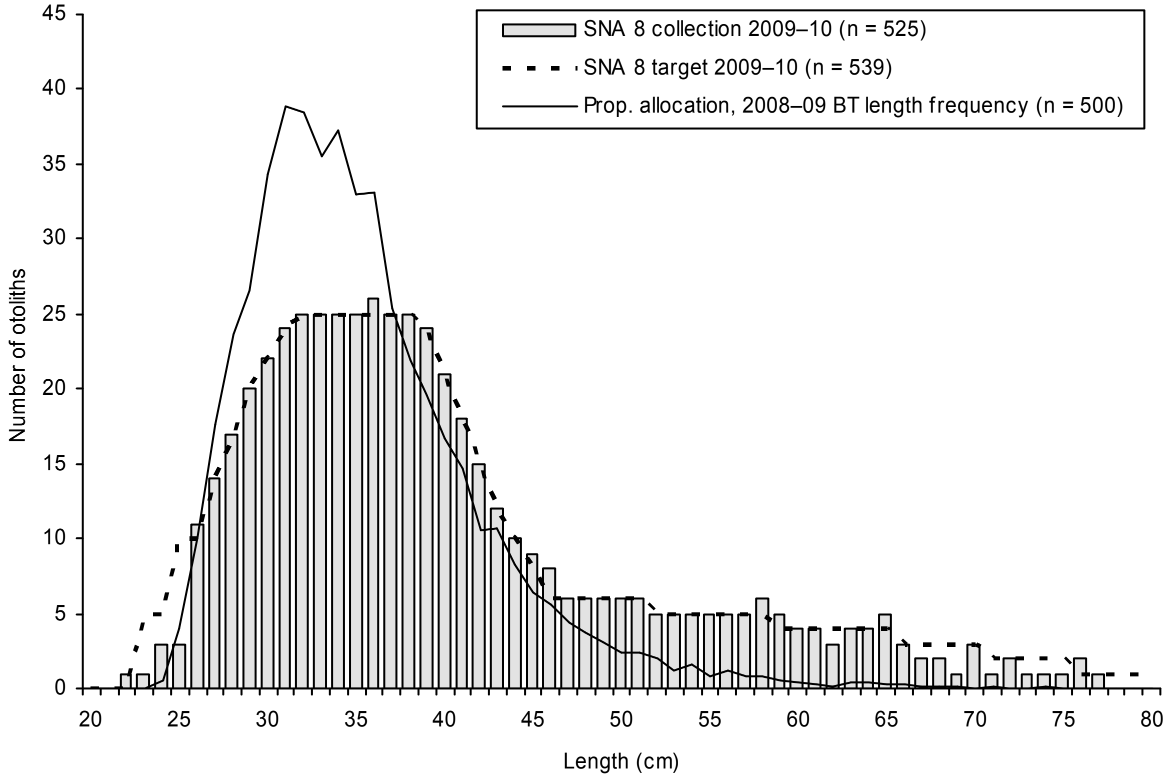


Figure 2: Length distributions of the target semi-fixed allocation otolith sample (dashed line) and the achieved otolith collection (histogram) from SNA 8 in 2009–10. For comparison, the proportional allocation otolith sample of 500 fish based on the single trawl length distribution from 2008–09 is also given (solid line).

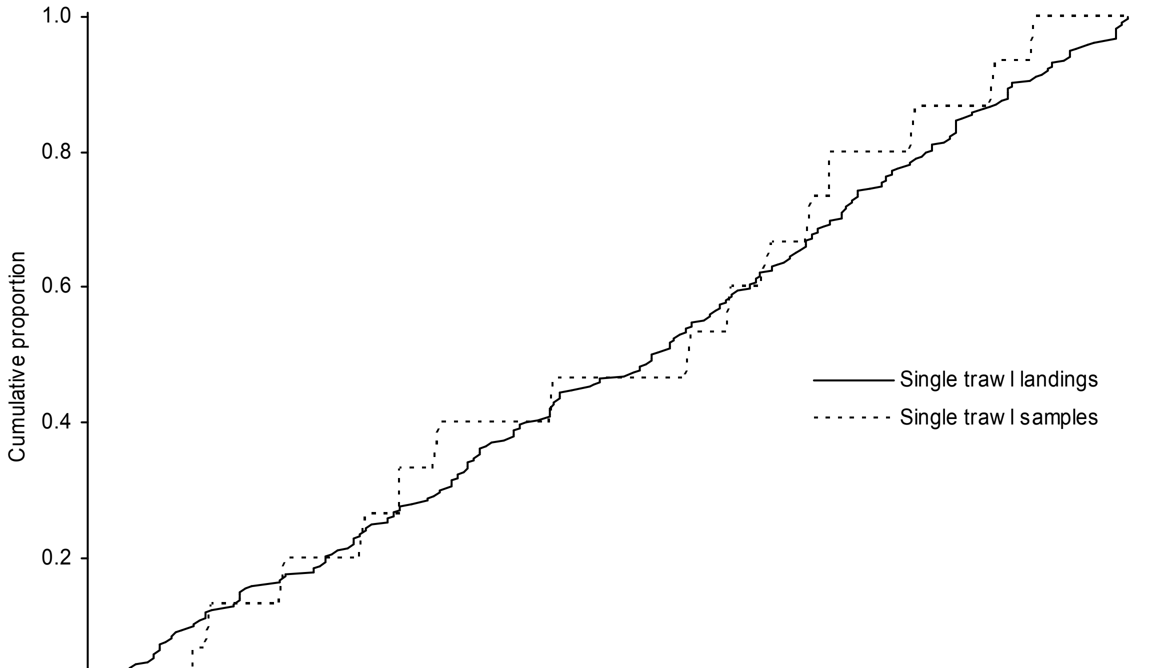


Figure 3: The cumulative proportion of the number of landings and samples taken from the SNA 8 single trawl fishery in 2009–10.

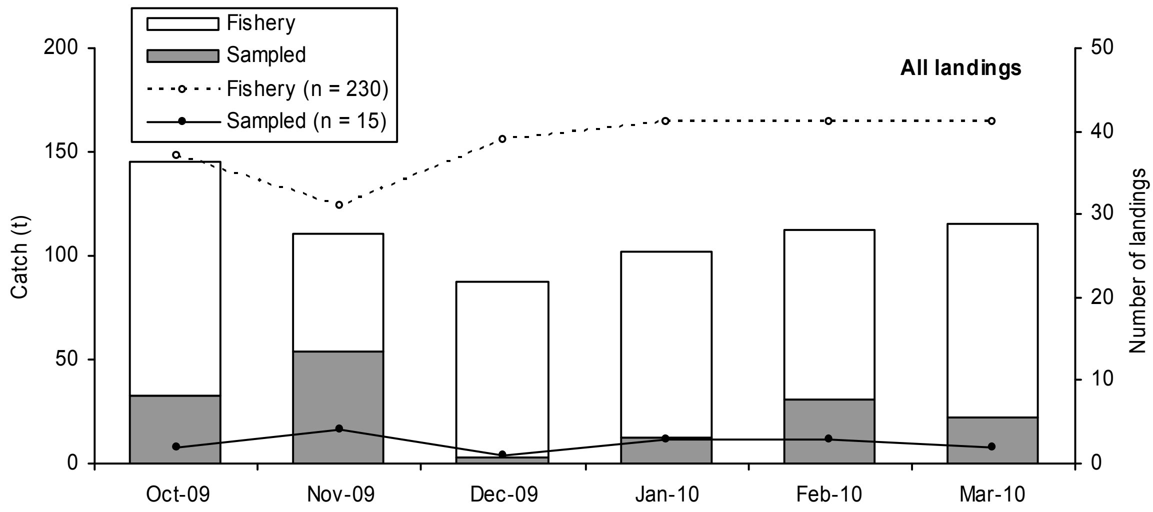


Figure 4: Comparison of the monthly distribution of landed weight (histograms) and numbers of landings (lines) of snapper in the SNA 8 single trawl fishery from October 2009 to March 2010 for all landings where snapper was caught. Included are corresponding estimates for all sampled landings to show representivity of collections.

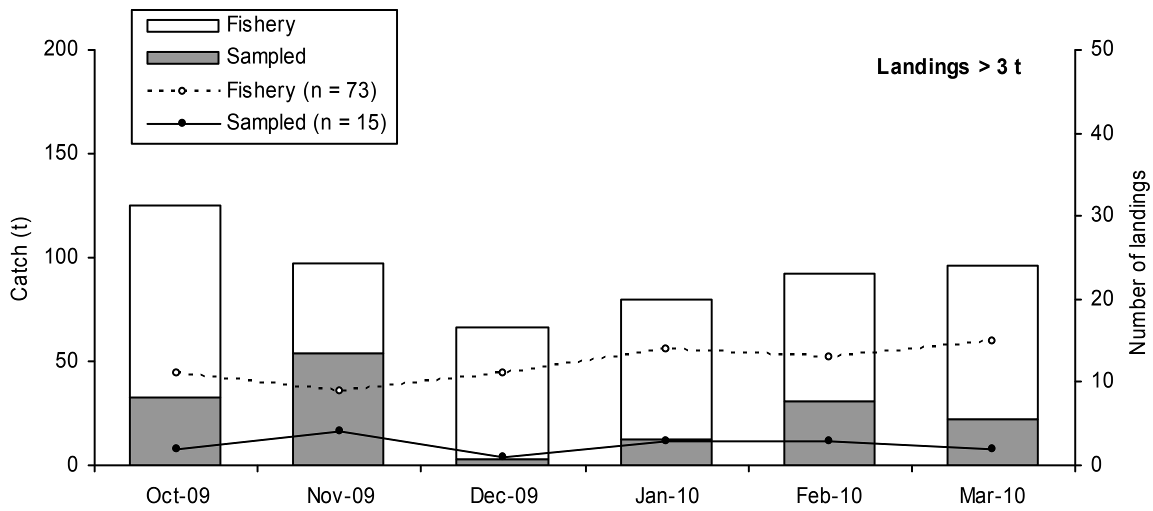


Figure 5: Comparison of the monthly distribution of landed weight (histograms) and numbers of landings (lines) of snapper in the SNA 8 single trawl fishery from October 2009 to March 2010 for all landings > 3 tonnes. Included are corresponding estimates for all sampled landings to show representivity of collections.

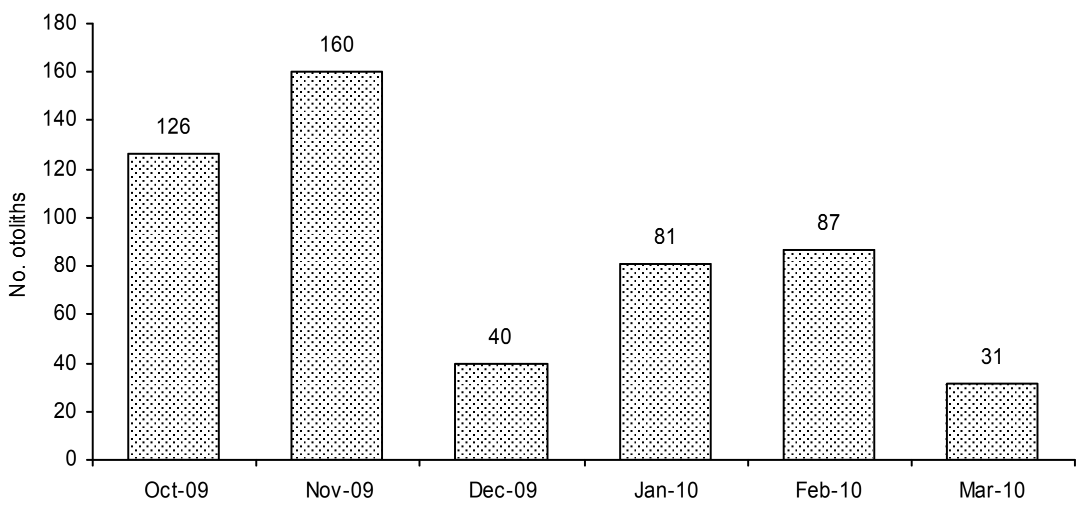


Figure 6: Summary of the monthly collection of otolith samples of snapper from the SNA 8 single trawl fishery from October 2009 to March 2010 to show representivity of collections in comparison with sampled landings.

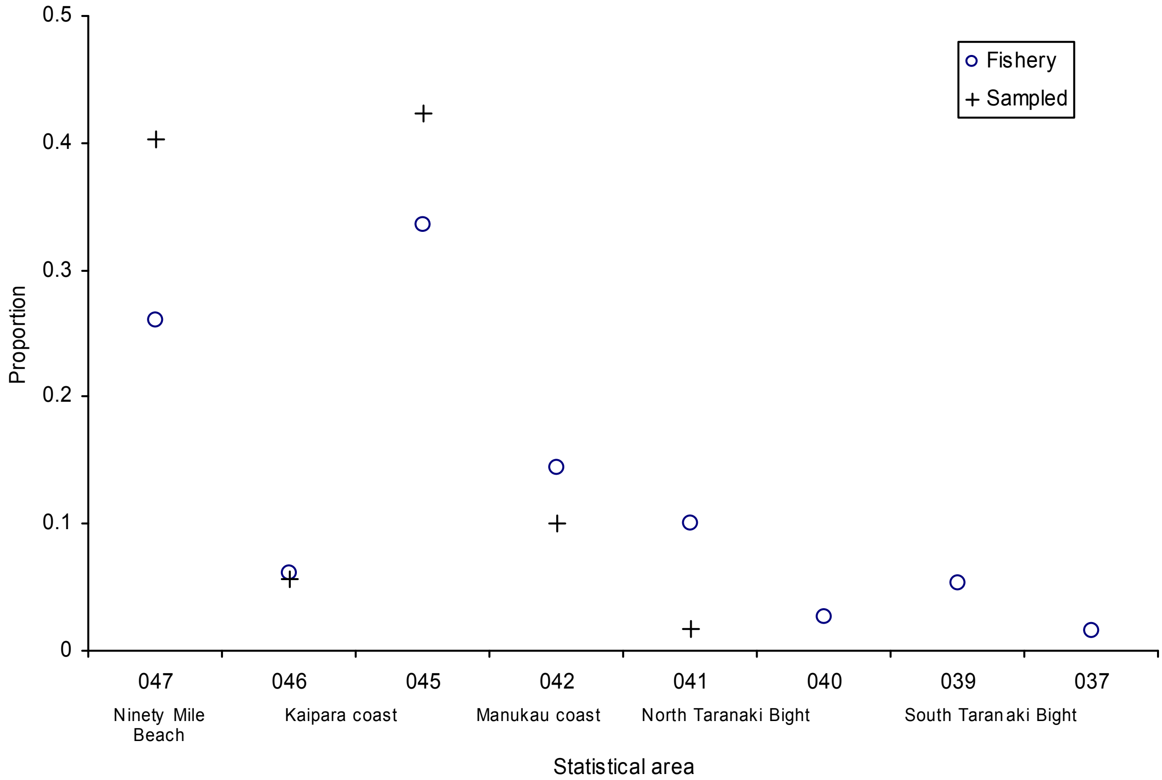


Figure 7: Comparison of the proportional distribution of the estimated single trawl catch and the sampled component by statistical area (with annotated spatial strata) over the sampling period for the SNA 8 stock in 2009–10.

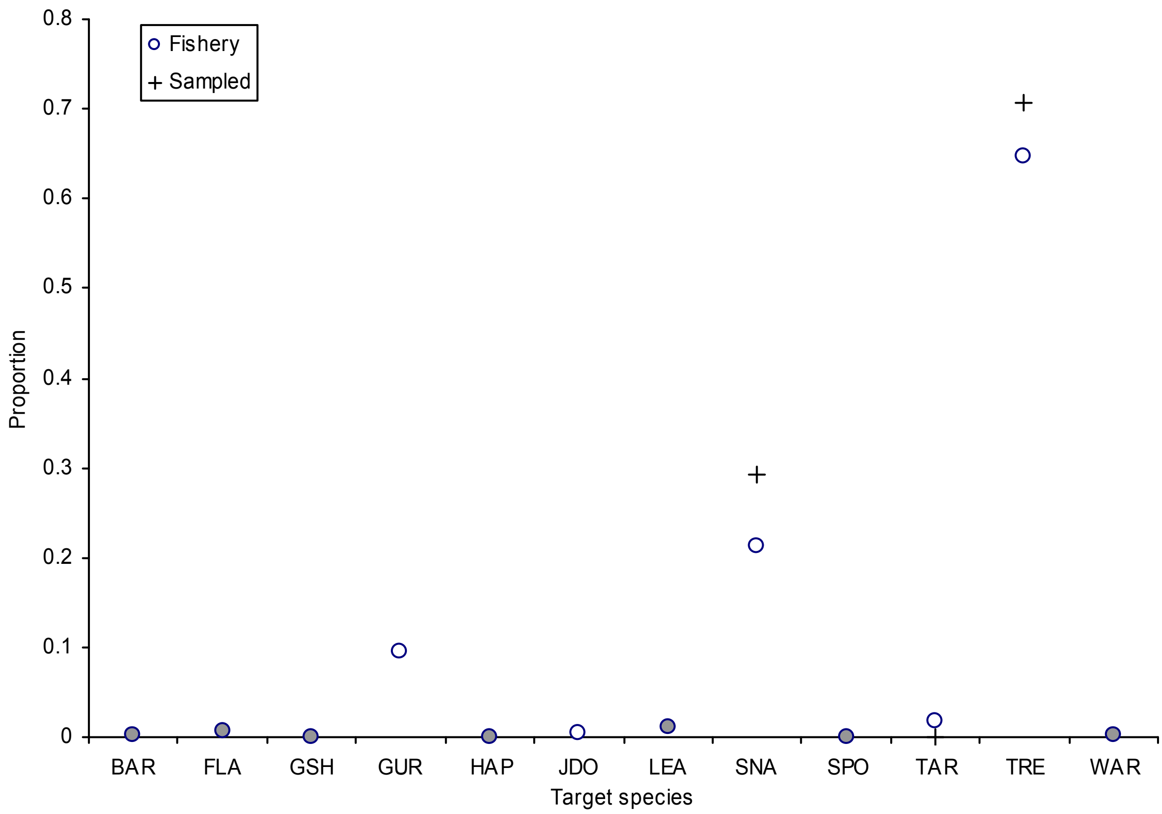


Figure 8: Comparison of the proportional distribution of the estimated single trawl catch and the sampled component by target species over the sampling period for the SNA 8 stock in 2009–10. Shaded circles designate target species almost exclusively used in the South Taranaki Bight (Statistical Areas 037, 039, 040).

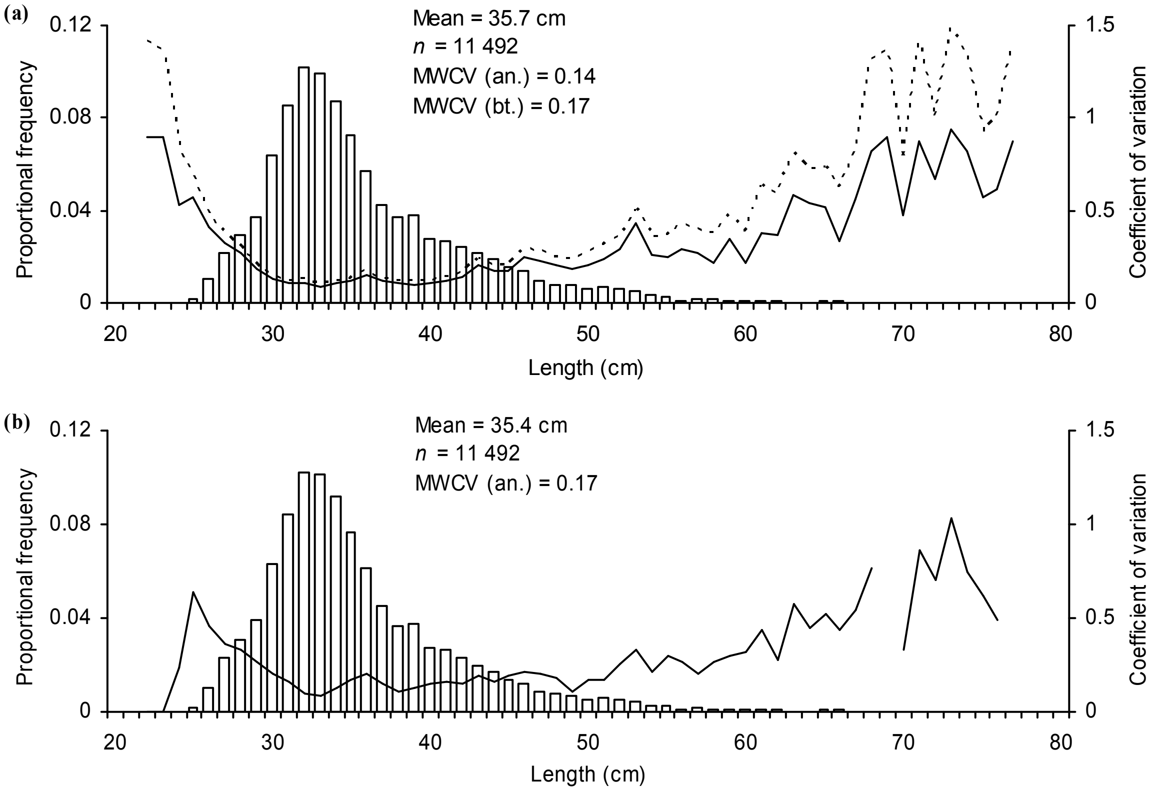


Figure 9: Unstratified (a) and stratified (b) proportion at length distributions (histograms) and analytical (solid line) and bootstrap (dashed line) c.v.s determined from snapper landings sampled from the SNA 8 single trawl fishery in 2009–10 (*n*, length sample size; MWCV, mean weighted c.v.).

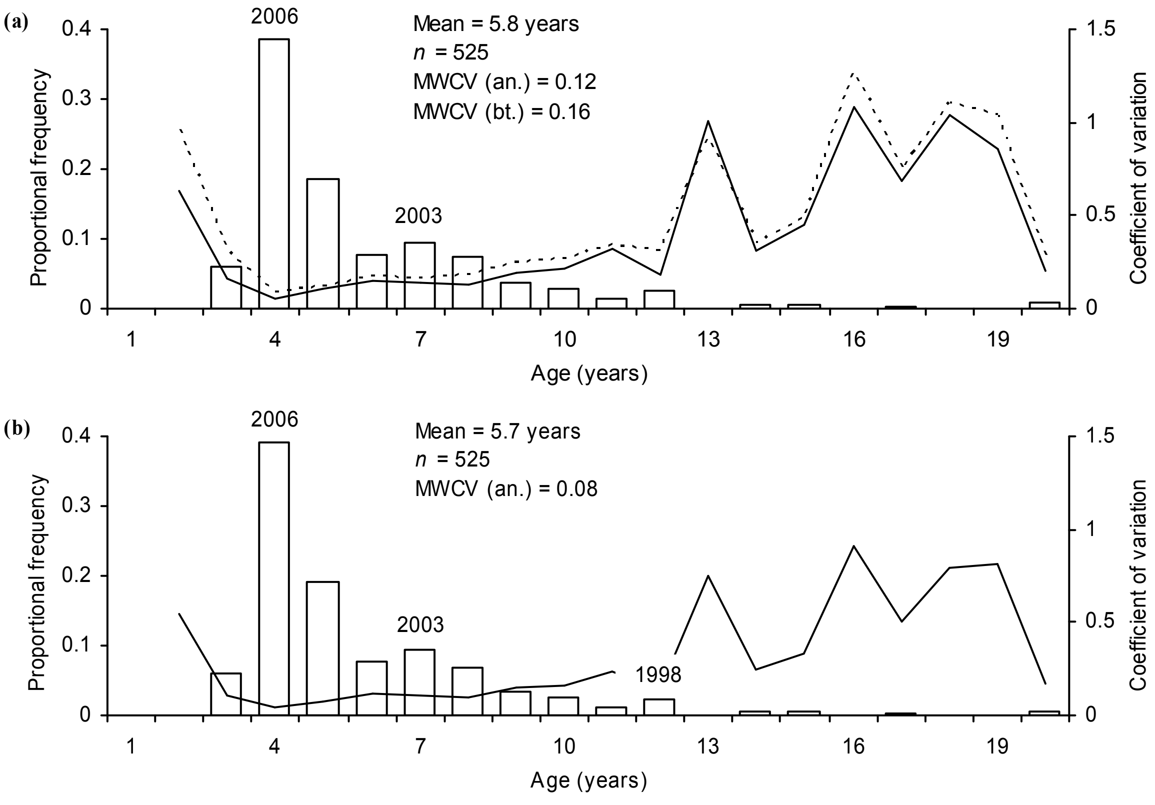


Figure 10: Unstratified (a) and stratified (b) proportions at age distribution (histograms) and analytical (solid line) and bootstrap (dashed line) c.v.s determined from snapper landings sampled from the SNA 8 single trawl fishery in 2009–10 using the age-length key approach (*n*, otolith sample size; MWCV, mean weighted c.v.).

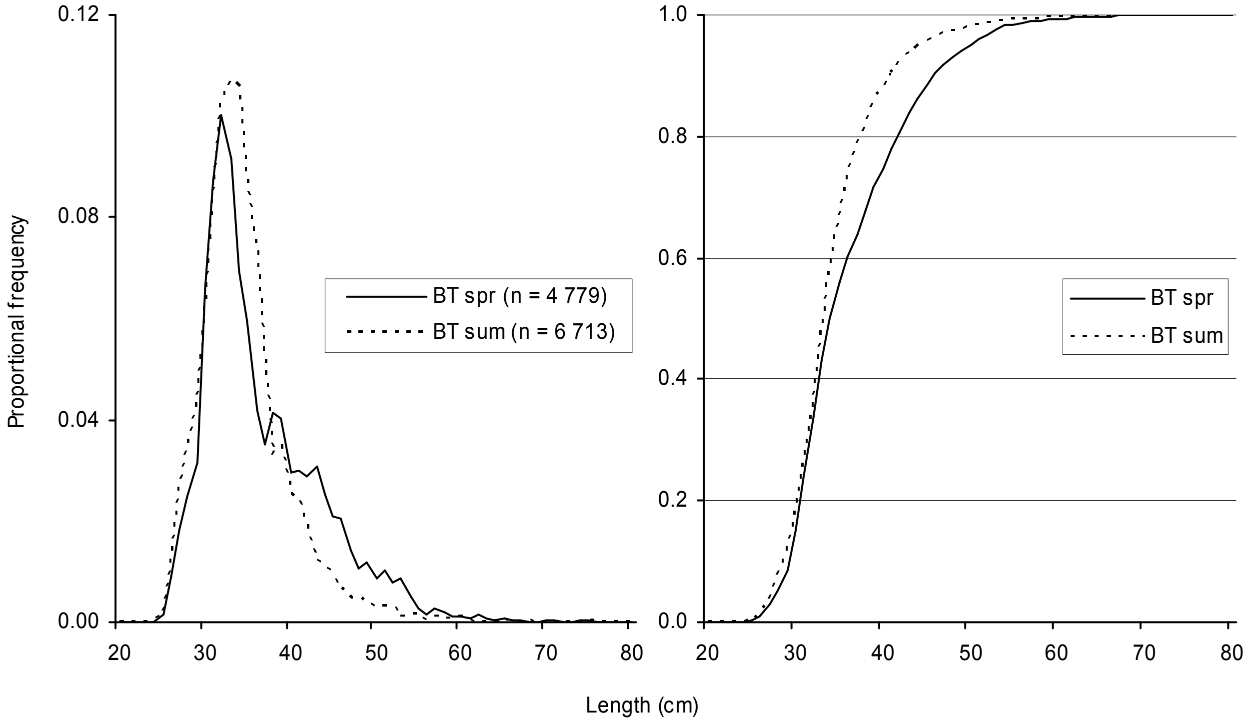


Figure 11: Comparison of the proportion and cumulative proportion at length distributions determined from snapper landings sampled over the spring and summer seasons from the SNA 8 single trawl fishery in 2009–10 (*n*, sample size).

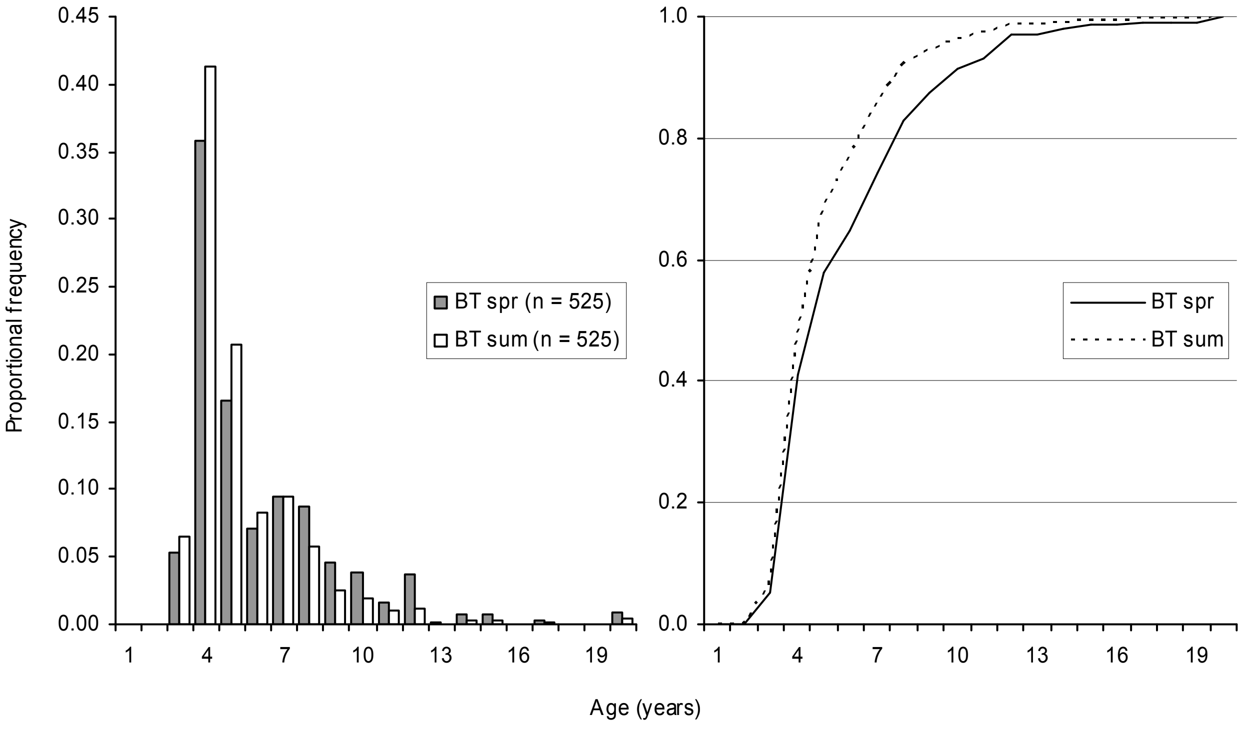


Figure 12: Comparison of the proportion and cumulative proportion at age distributions determined from snapper landings sampled over the spring and summer seasons from the SNA 8 single trawl fishery in 2009–10 (*n*, age-length key sample size).

Appendix 1: Estimates of proportion at length with c.v.s (analytical and bootstrap estimates) for snapper from the SNA 8 single trawl fishery in 2009–10.
Spr-sum estimates are based on a combined stratum, not the sum of spring and summer values.

P.i. = proportion of fish in length class. *Nt* = total number of fish caught.
c.v. = coefficient of variation. *n* = total number of fish sampled.

Length	Spring		Summer		Single trawl Spr-sum		
(cm)	*P.i.*	c.v. (an)	*P.i.*	c.v. (an)	*P.i.*	c.v. (an)	c.v. (bt)
20	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.00
21	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.00
22	0.0000	0.00	0.0001	0.89	0.0001	0.89	1.41
23	0.0000	0.00	0.0001	0.89	0.0001	0.89	1.36
24	0.0002	0.93	0.0003	0.66	0.0002	0.53	0.84
25	0.0016	0.74	0.0021	0.89	0.0019	0.58	0.69
26	0.0091	0.56	0.0115	0.61	0.0102	0.41	0.47
27	0.0180	0.44	0.0259	0.48	0.0219	0.32	0.38
28	0.0250	0.34	0.0344	0.40	0.0296	0.26	0.31
29	0.0317	0.19	0.0430	0.30	0.0372	0.18	0.21
30	0.0658	0.14	0.0613	0.25	0.0636	0.13	0.15
31	0.0871	0.12	0.0830	0.18	0.0851	0.10	0.12
32	0.1004	0.19	0.1028	0.12	0.1016	0.11	0.12
33	0.0916	0.11	0.1072	0.11	0.0992	0.08	0.10
34	0.0697	0.11	0.1059	0.12	0.0872	0.11	0.12
35	0.0596	0.10	0.0864	0.16	0.0726	0.11	0.13
36	0.0417	0.08	0.0726	0.21	0.0566	0.15	0.17
37	0.0351	0.10	0.0508	0.17	0.0427	0.12	0.13
38	0.0414	0.14	0.0332	0.15	0.0374	0.10	0.12
39	0.0403	0.14	0.0352	0.14	0.0378	0.10	0.12
40	0.0297	0.13	0.0254	0.18	0.0276	0.10	0.12
41	0.0299	0.13	0.0239	0.21	0.0270	0.12	0.14
42	0.0287	0.17	0.0191	0.19	0.0240	0.14	0.16
43	0.0309	0.18	0.0124	0.28	0.0219	0.20	0.24
44	0.0254	0.15	0.0113	0.28	0.0186	0.17	0.20
45	0.0211	0.13	0.0097	0.30	0.0155	0.17	0.21
46	0.0204	0.23	0.0069	0.34	0.0138	0.25	0.30
47	0.0142	0.20	0.0048	0.32	0.0097	0.22	0.28
48	0.0106	0.23	0.0053	0.20	0.0080	0.20	0.25
49	0.0120	0.14	0.0036	0.16	0.0079	0.18	0.24
50	0.0087	0.19	0.0032	0.23	0.0060	0.21	0.27
51	0.0103	0.19	0.0030	0.23	0.0068	0.24	0.31
52	0.0080	0.35	0.0036	0.32	0.0059	0.29	0.36
53	0.0086	0.40	0.0012	0.24	0.0050	0.43	0.51
54	0.0050	0.22	0.0015	0.40	0.0033	0.25	0.35
55	0.0029	0.25	0.0017	0.47	0.0023	0.25	0.37
56	0.0017	0.32	0.0005	0.41	0.0011	0.29	0.43
57	0.0029	0.27	0.0010	0.26	0.0020	0.27	0.40
58	0.0018	0.21	0.0008	0.36	0.0013	0.21	0.38
59	0.0013	0.50	0.0010	0.45	0.0011	0.34	0.48
60	0.0011	0.11	0.0012	0.46	0.0011	0.22	0.39
61	0.0006	0.52	0.0004	0.48	0.0005	0.37	0.64
62	0.0015	0.28	0.0002	0.88	0.0008	0.36	0.59
63	0.0006	0.59	0.0000	0.95	0.0003	0.59	0.81
64	0.0006	0.66	0.0002	0.89	0.0004	0.54	0.72
65	0.0007	0.63	0.0003	0.63	0.0005	0.52	0.73
66	0.0005	0.47	0.0004	0.50	0.0005	0.34	0.63
67	0.0005	0.71	0.0002	0.88	0.0003	0.56	0.82
68	0.0000	0.00	0.0002	0.81	0.0001	0.82	1.32
69	0.0000	0.00	0.0002	0.89	0.0001	0.89	1.37
70	0.0004	0.54	0.0002	0.89	0.0003	0.47	0.77
71	0.0002	0.86	0.0000	0.00	0.0001	0.88	1.41
72	0.0000	0.00	0.0001	0.70	0.0000	0.67	1.01
73	0.0000	0.00	0.0000	1.00	0.0000	0.94	1.49
74	0.0004	0.74	0.0000	0.00	0.0002	0.82	1.33
75	0.0003	0.74	0.0002	0.95	0.0003	0.58	0.93
76	0.0000	0.00	0.0004	0.56	0.0002	0.61	1.00
77	0.0000	0.00	0.0002	0.86	0.0001	0.88	1.41
78	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.00
79	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.00
80	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.00
Nt	266 615		436 826		686 653		
n	4 779		6 713		11 492		

Appendix 2: Estimates of proportion at age with c. v.s (analytical and bootstrap estimates) for snapper from the SNA 8 single trawl fishery in 2009–10.

P.j., proportion of fish in age class; c.v., coefficient of variation; otolith sample size = 525

							Single trawl
Age	Spring		Summer		Spr-sum		
(years)	*P.j.*	c.v. (an)	*P.j.*	c.v. (an)	*P.j.*	c.v. (an)	c.v. (bt)
1	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.00
2	0.0001	1.50	0.0004	0.60	0.0002	0.64	0.96
3	0.0532	0.17	0.0658	0.16	0.0593	0.16	0.31
4	0.3583	0.05	0.4124	0.06	0.3845	0.05	0.09
5	0.1657	0.11	0.2075	0.11	0.1860	0.11	0.12
6	0.0711	0.15	0.0828	0.16	0.0768	0.15	0.18
7	0.0943	0.13	0.0941	0.15	0.0942	0.14	0.16
8	0.0878	0.13	0.0571	0.14	0.0729	0.13	0.19
9	0.0460	0.20	0.0255	0.21	0.0361	0.20	0.24
10	0.0391	0.22	0.0191	0.23	0.0294	0.22	0.27
11	0.0163	0.32	0.0102	0.34	0.0134	0.32	0.34
12	0.0375	0.18	0.0124	0.19	0.0253	0.18	0.31
13	0.0020	1.01	0.0006	1.02	0.0013	1.01	0.92
14	0.0073	0.32	0.0028	0.33	0.0051	0.31	0.35
15	0.0080	0.47	0.0031	0.43	0.0056	0.45	0.48
16	0.0001	1.14	0.0001	1.24	0.0001	1.08	1.28
17	0.0032	0.68	0.0013	0.73	0.0023	0.69	0.75
18	0.0003	1.08	0.0002	1.07	0.0002	1.04	1.11
19	0.0001	1.14	0.0002	0.95	0.0002	0.85	1.04
>19	0.0096	0.24	0.0046	0.20	0.0072	0.20	0.28

Appendix 3: Estimated mean weight-at-age (kg) and c.v.s for snapper from the SNA 8 single trawl fishery in 2009–10.

c.v., coefficient of variation; otolith sample size = 525

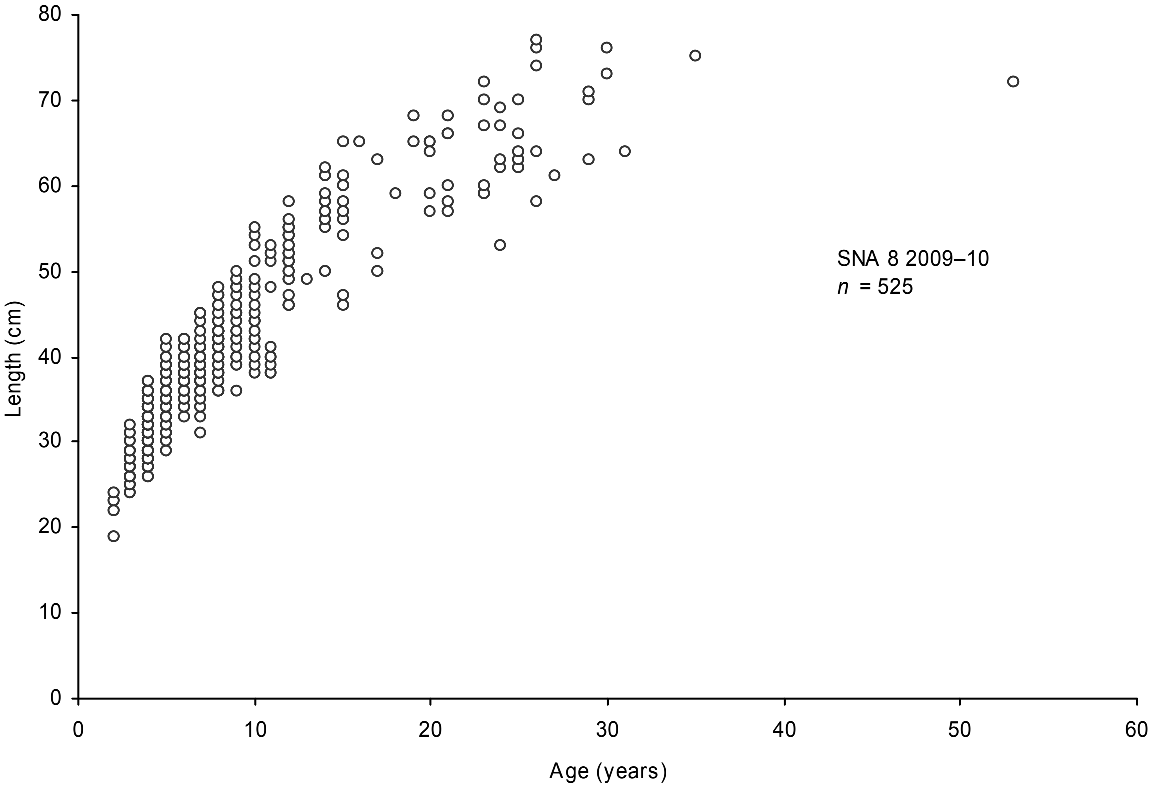
						Single trawl	
Age	Spring		Summer		Spr-sum		
(years)	Mean	c.v.	Mean	c.v.	Mean	c.v.	*n*
1	–	–	–	–	–	–	–
2	0.32	–	0.26	0.13	0.26	0.14	4
3	0.52	0.04	0.51	0.04	0.51	0.04	38
4	0.70	0.01	0.71	0.01	0.71	0.01	128
5	0.88	0.02	0.88	0.02	0.88	0.02	69
6	1.11	0.03	1.07	0.03	1.09	0.03	40
7	1.21	0.04	1.12	0.04	1.17	0.04	51
8	1.55	0.03	1.43	0.03	1.51	0.03	44
9	1.80	0.04	1.65	0.06	1.74	0.04	23
10	1.88	0.05	1.74	0.05	1.84	0.05	20
11	1.84	0.12	1.56	0.10	1.74	0.12	10
12	2.54	0.03	2.55	0.03	2.55	0.03	25
13	2.35	–	2.35	–	2.35	–	1
14	3.22	0.07	3.22	0.07	3.22	0.07	14
15	2.64	0.12	2.86	0.13	2.70	0.12	10
16	5.17	–	5.17	–	5.17	–	1
17	2.74	0.06	2.66	0.04	2.71	0.05	3
18	3.94	–	3.94	–	3.94	–	1
19	5.17	–	5.62	0.05	5.40	0.05	2
>19	4.50	0.07	5.18	0.06	4.71	0.06	41

Appendix 4: Age-length key derived from otolith samples collected from snapper fisheries in SNA 8 in 2009–10.

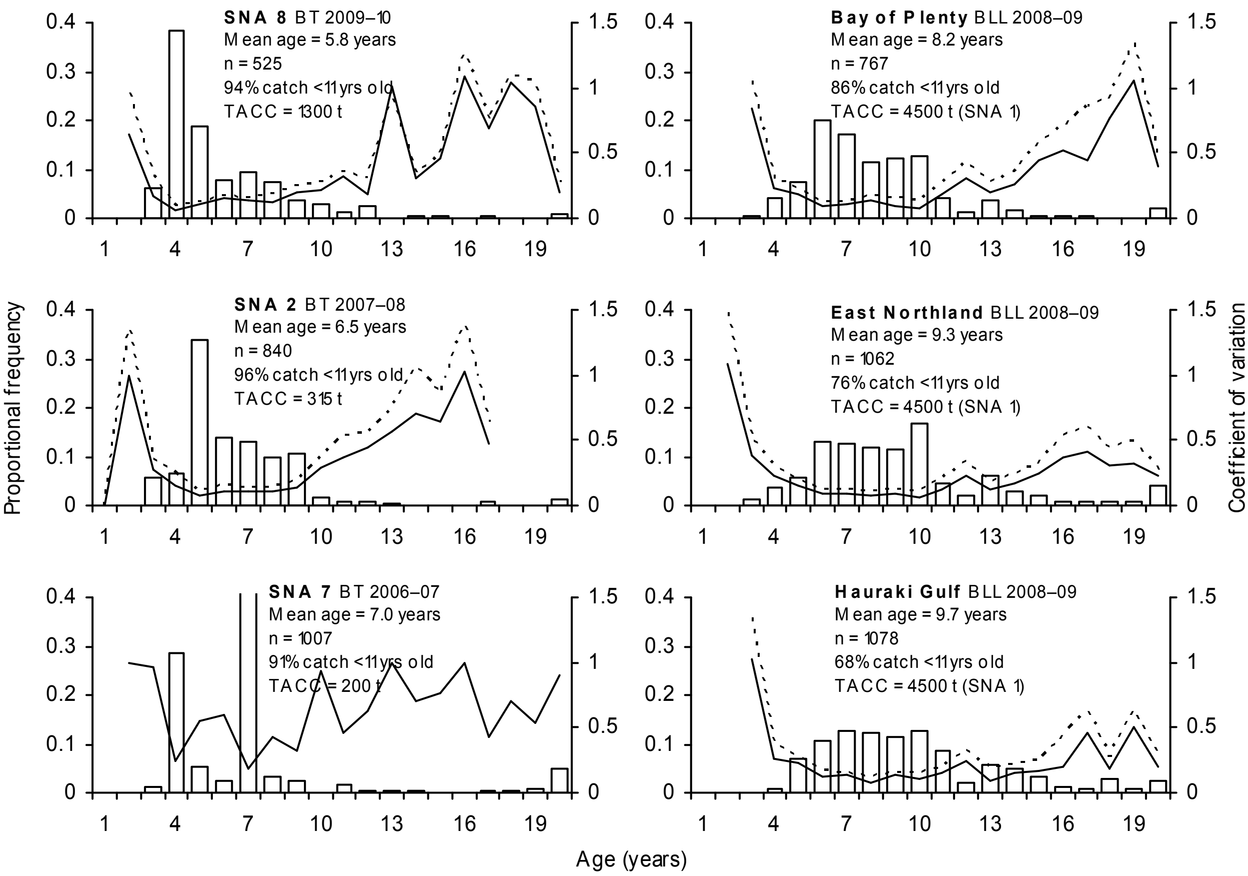
Estimates of proportion of age at length for snapper sampled from SNA 8, spring and summer 2009–10.
(Note: Aged to 01/01/2010)

Length (cm)	Age (years) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	>19	No. aged
19	0	1.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
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	1.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
23	0	1.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
24	0	0.33	0.67	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
25	0	0	1.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
26	0	0	0.82	0.18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11
27	0	0	0.64	0.36	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14
28	0	0	0.35	0.65	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17
29	0	0	0.20	0.70	0.10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20
30	0	0	0.09	0.82	0.09	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	22
31	0	0	0.08	0.67	0.21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	24
32	0	0	0.04	0.84	0.12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	25
33	0	0	0	0.64	0.28	0.04	0.04	0	0	0	0	0	0	0	0	0	0	0	0	0	25
34	0	0	0	0.48	0.32	0.08	0.12	0	0	0	0	0	0	0	0	0	0	0	0	0	25
35	0	0	0	0.16	0.60	0.16	0.08	0	0	0	0	0	0	0	0	0	0	0	0	0	25
36	0	0	0	0.27	0.31	0.15	0.12	0.12	0.04	0	0	0	0	0	0	0	0	0	0	0	26
37	0	0	0	0.08	0.24	0.36	0.28	0.04	0	0	0	0	0	0	0	0	0	0	0	0	25
38	0	0	0	0	0.12	0.28	0.32	0.16	0	0.04	0.08	0	0	0	0	0	0	0	0	0	25
39	0	0	0	0	0.25	0.21	0.29	0.08	0.08	0.04	0.04	0	0	0	0	0	0	0	0	0	24
40	0	0	0	0	0.10	0.14	0.29	0.24	0.10	0.05	0.10	0	0	0	0	0	0	0	0	0	21
41	0	0	0	0	0.06	0.11	0.39	0.28	0.06	0.06	0.06	0	0	0	0	0	0	0	0	0	18
42	0	0	0	0	0.07	0.20	0.07	0.40	0.13	0.13	0	0	0	0	0	0	0	0	0	0	15
43	0	0	0	0	0	0	0.08	0.67	0.17	0.08	0	0	0	0	0	0	0	0	0	0	12
44	0	0	0	0	0	0	0.10	0.40	0.10	0.40	0	0	0	0	0	0	0	0	0	0	10
45	0	0	0	0	0	0	0.33	0.11	0.44	0.11	0	0	0	0	0	0	0	0	0	0	9
46	0	0	0	0	0	0	0	0.25	0.13	0.13	0	0.38	0	0	0.13	0	0	0	0	0	8
47	0	0	0	0	0	0	0	0.33	0.17	0.17	0	0.17	0	0	0.17	0	0	0	0	0	6
48	0	0	0	0	0	0	0	0.17	0.50	0.17	0.17	0	0	0	0	0	0	0	0	0	6
49	0	0	0	0	0	0	0	0	0.33	0.17	0	0.33	0.17	0	0	0	0	0	0	0	6
50	0	0	0	0	0	0	0	0	0.17	0	0	0.33	0	0.33	0	0	0.17	0	0	0	6
51	0	0	0	0	0	0	0	0	0	0.17	0.17	0.67	0	0	0	0	0	0	0	0	6
52	0	0	0	0	0	0	0	0	0	0	0.20	0.60	0	0	0	0	0.20	0	0	0	5
53	0	0	0	0	0	0	0	0	0	0.20	0.20	0.40	0	0	0	0	0	0	0	0.20	5
54	0	0	0	0	0	0	0	0	0	0.20	0	0.60	0	0	0.20	0	0	0	0	0	5
55	0	0	0	0	0	0	0	0	0	0.20	0	0.60	0	0.20	0	0	0	0	0	0	5
56	0	0	0	0	0	0	0	0	0	0	0	0.20	0	0.60	0.20	0	0	0	0	0	5
57	0	0	0	0	0	0	0	0	0	0	0	0	0	0.40	0.20	0	0	0	0	0.40	5
58	0	0	0	0	0	0	0	0	0	0	0	0.17	0	0.33	0.17	0	0	0	0	0.33	6
59	0	0	0	0	0	0	0	0	0	0	0	0	0	0.20	0	0	0	0.20	0	0.60	5
60	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.50	0	0	0	0	0.50	4
61	0	0	0	0	0	0	0	0	0	0	0	0	0	0.50	0.25	0	0	0	0	0.25	4
62	0	0	0	0	0	0	0	0	0	0	0	0	0	0.33	0	0	0	0	0	0.67	3
63	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0	0	0.75	4
64	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.00	4
65	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.20	0.20	0	0	0.20	0.40	5
66	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.00	3
67	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.00	2
68	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.50	0.50	2
69	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.00	1
70	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.00	3
71	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.00	1
72	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.00	2
73	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.00	1
74	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.00	1
75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.00	1
76	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.00	2
77	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.00	1
78	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
79	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
80	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total																					525

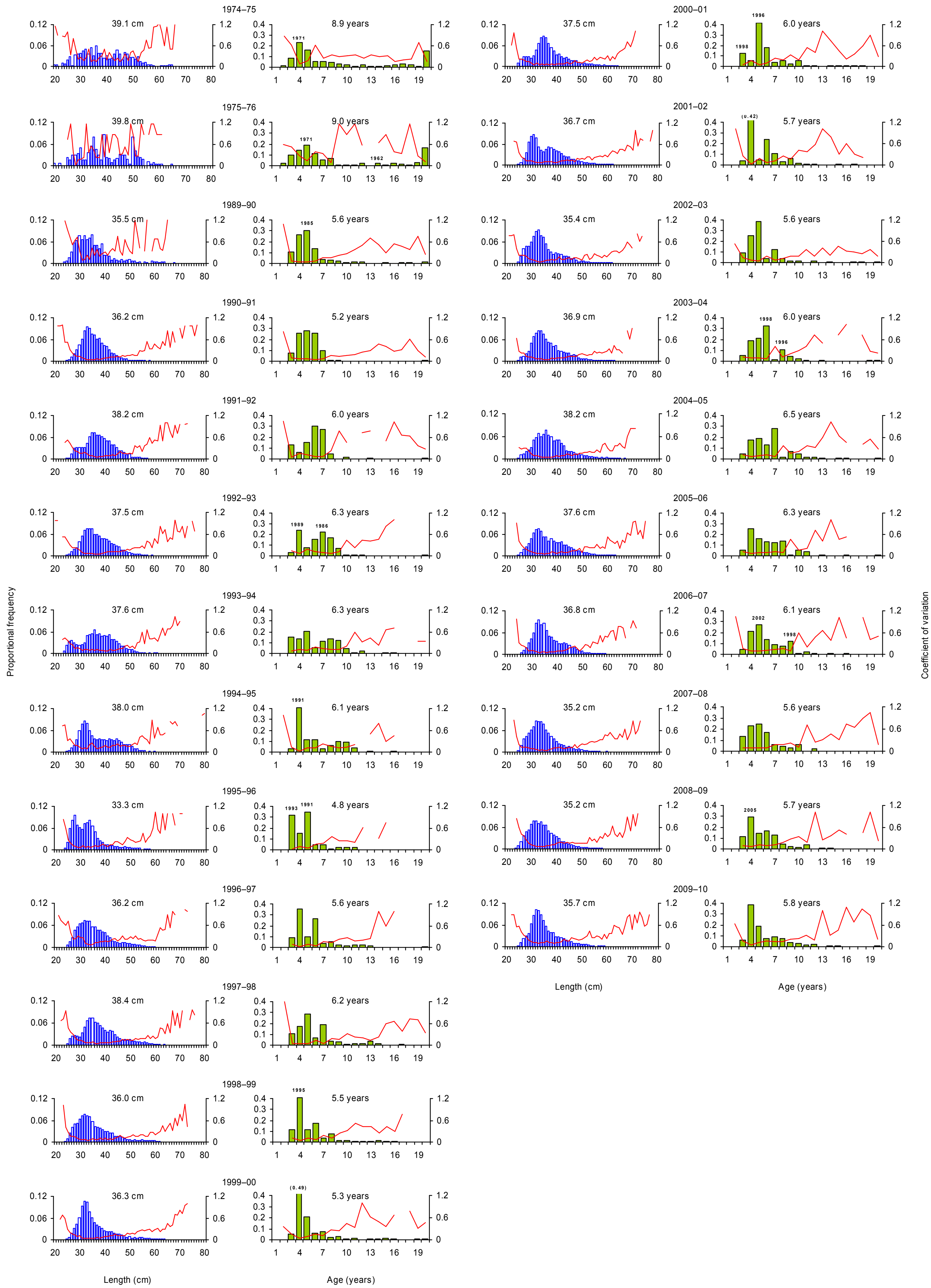
Appendix 5: Scatterplot of age-at-length data for snapper sampled from the SNA 8 single trawl fishery in 2009–10 (*n*, sample size).



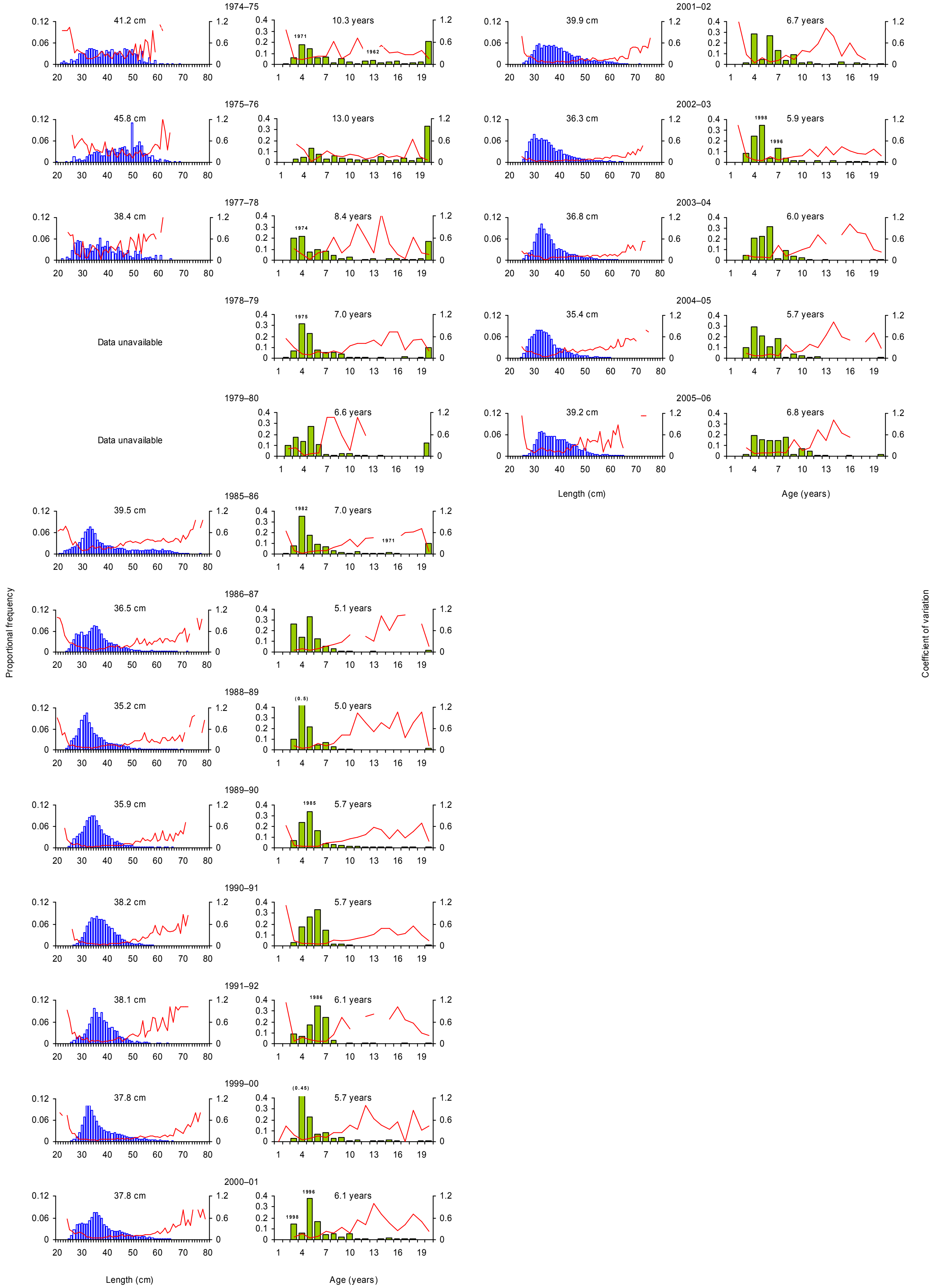
Appendix 6: Comparison of the 2009–10 SNA 8 catch-at-age estimate to that of other New Zealand snapper stocks; SNA 1 (East Northland, Hauraki Gulf, Bay of Plenty), SNA 2 (ECNI), SNA 7 (Tasman Bay/Golden Bay).



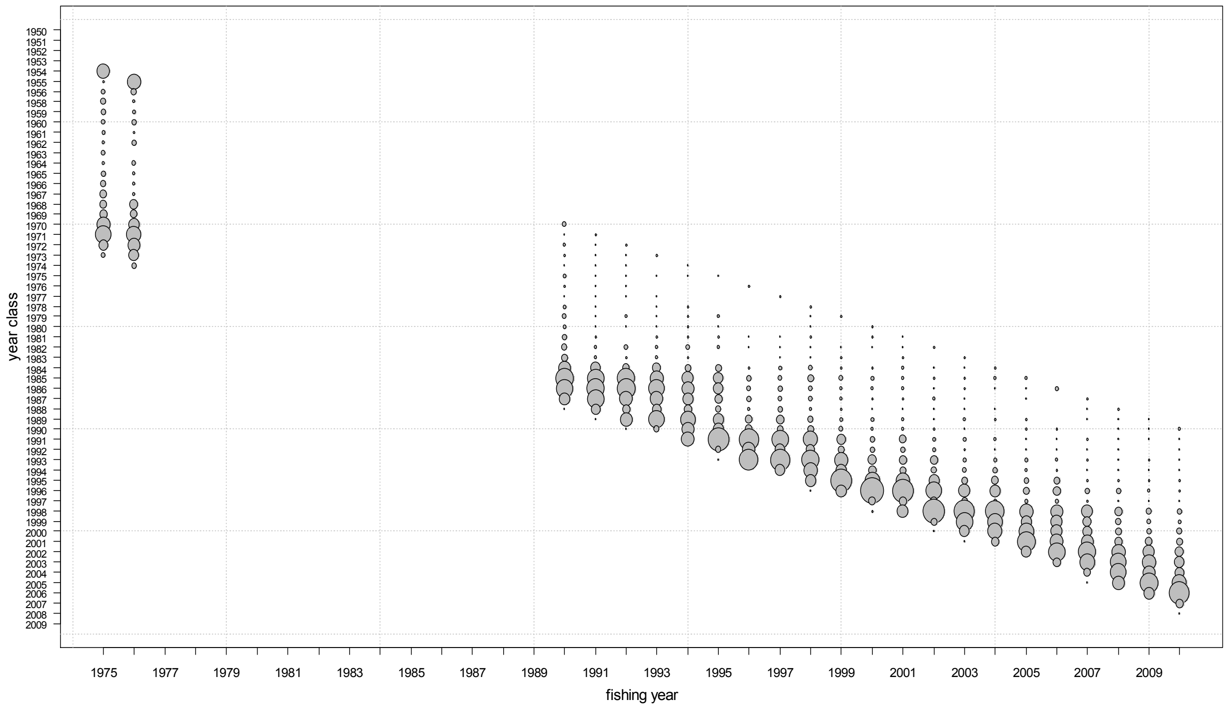
Appendix 7: Time series of proportion at length and age distributions and c.v.s for snapper from the SNA 8 single trawl fishery from 1974–75 to 1975–76 and 1989–90 to 2009–10. Data are from spring-summer and plots are annotated with estimates of mean length or age.



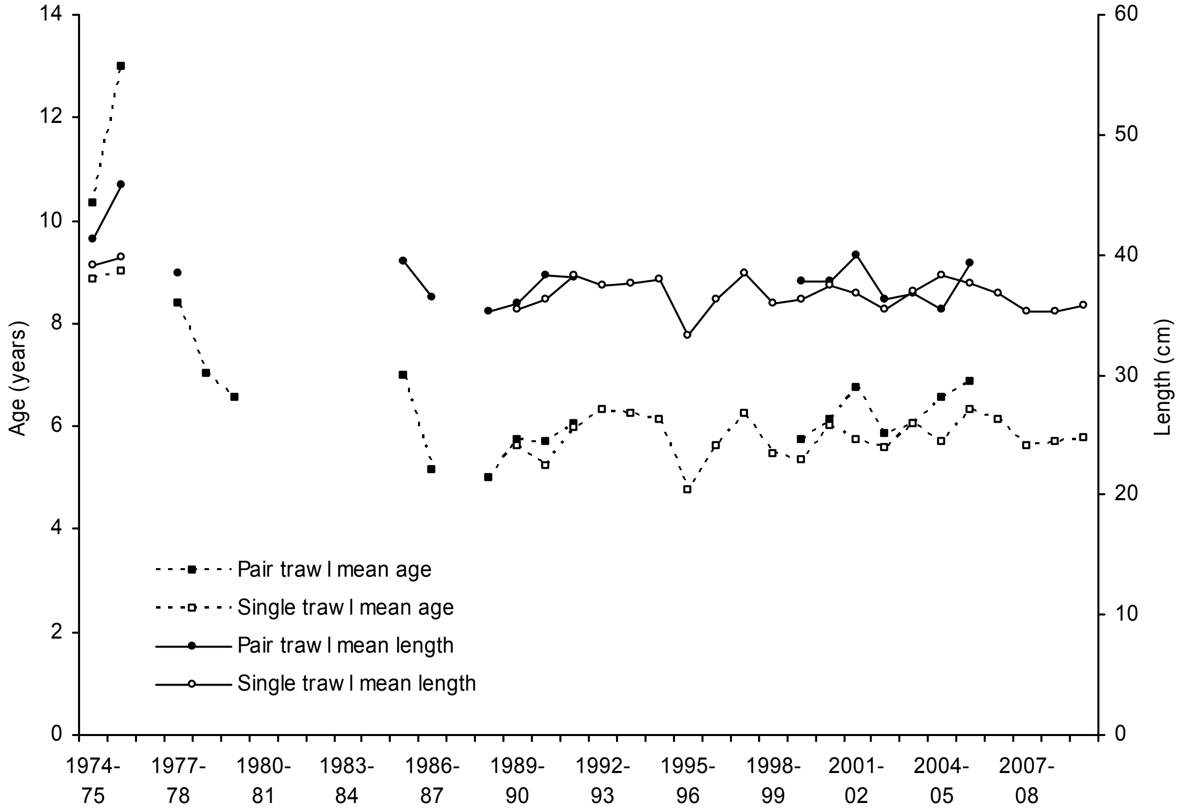
Appendix 8: Time series of proportion at length and age distributions and c.v.s for snapper from the SNA 8 pair trawl fishery from 1974–75 to 1979–80, 1985–86 to 1986–87, 1988–89 to 1991–92, and 2000–01 to 2005–06. Data are from spring-summer and plots are annotated with estimates of mean length or age.



Appendix 9: Age frequency distributions by year class and year from the SNA 8 single trawl spring-summer fishery from 1974–75 to 2009–10. Symbol area is proportional to the proportion-at-age.



Appendix 10: Time series of mean length and mean age estimates from the SNA 8 single trawl and pair trawl fisheries from 1974–75 to 2009–10.



Appendix 11: Relative proportions of snapper over 10 and 19 years of age in catch-at-age estimates from the SNA 8 single trawl and pair trawl fisheries from 1974–75 to 2009–10.