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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” (SNA2006/06). The general objective was to determine the length frequency and age structure of commercial landings from SNA 8 for use in stock assessment models by market sampling.

The length frequency and age-length key sampling approach was employed during spring and summer 2006–07 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 proportional allocation age-length key. A total sample size of 14 landings was sampled for length frequency from the single trawl fishery, with an age-length key collection of 475 otoliths. Unlike previous years, no length frequency samples were obtained from the pair trawl fishery in 2006–07, largely due to a rationalisation of the Auckland based inshore trawl fleet, which resulted in fewer trawlers operating, and the virtual cessation of pair trawling in SNA 8.

Year class strengths inferred in 2006–07 from the SNA 8 stock were generally similar to those from the previous year with the single trawl catch-at-age distribution dominated by fish from the 2003 to 1998 year classes (4- to 9-year-olds) making up about 90% of the catch. The 2003 and 2002 year classes (4- and 5-year-olds) are currently the most dominant making up just under half the number of fish landed. There is a low relative abundance of fish 12 years or older, and no appreciable growth in the right hand tail of the distribution. The previously dominant 1998, 1996, and 1995 year classes, may now not be as well represented in catch-at-age estimates because a high proportion of fish in these cohorts now exceed the optimum selectivity of the single trawl method or because their relative abundance is low because of past fishing mortality.

A mean weighted coefficient of variation (for analytical estimates) of below 20% across all age classes in the SNA 8 single trawl catch-at-age composition was achieved.

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, Walsh & Davies 2004). This report presents the results of market sampling from the SNA 8 stock between October 2006 and February 2007, thus continuing the time series. Funding for this project, SNA2006/06, was provided by the Ministry of Fisheries.

The specific objective of this project for 2006–07 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 2006–07. 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 only. In most recent years the pair trawl (BPT) method was also sampled. However, a rationalisation of the SNA 8 trawl fleet in 2006–07 resulted in a reduction in the number of vessels operating in the fishery, with the relative pair trawl effort being insufficient to be considered useful for sampling.

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. 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). The sample allocation for each length class interval was made according to the west coast pair trawl proportion-at-length distribution as estimated for the previous year. The west coast pair trawl length distribution was used (as opposed to that for the single trawl method) because it was broader and was thought to better represent the recruited population. 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. Similarly, a minimum sample size of at least one fish for size classes greater than 60 cm was specified to ensure the right hand limb of the catch length frequency was adequately represented. Otolith samples for fish greater than 70 cm were difficult to obtain because of their rarity in landings. The otolith sample size for the west coast collection (n = 475) 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, e.g., in 2006–07, the 1998 year class was 9 years old, whether sampled in December 2006 or February 2007.

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). Bootstrap variances have been determined for the 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. Catch data from autumn 2006 to summer 2006–07 are provided in Table 1, displaying seasonal patterns in the fisheries. Single trawl was the dominant method, operating mainly over spring and summer. Landings from the pair trawl fishery were much less frequent than in previous years and of considerably smaller average size, especially over spring and summer. As such, the relative catch by method for the SNA 8 stock over the sampling period (October 2006–February 2007) was considerably different from that in previous years, with single trawl making up 90% of the catch, while pair trawl accounted for only 6%, and other methods 4%. Considerable differences are apparent between the percentage of number of landings sampled and the percentage of weight of landings sampled in the west coast single trawl fishery (Table 1). Catches sampled from the single trawl fishery in spring were entirely from landings where snapper was the target species, while those from summer were almost exclusively from landings where trevally (*Pseudocaranx dentex*) was the target, although snapper still made up a reasonable proportion of the overall catch. The summarised information in Table 1 is for all single trawl and pair trawl landings containing snapper (target and bycatch) caught from SNA 8. The average sampled landing weight of snapper from single trawl catches in spring was around 27 t, while that for summer was only 6 t.

A total sample size of 15 landings was targeted from the single trawl fishery in 2006–07, with 14 landings being sampled for length frequency. Because of a rationalisation of the fishing fleet over the past two years, only limited pair trawl fishing was undertaken in 2006–07 and as such no catch sampling of this fishery was able to be undertaken. The cumulative proportion of the total number of landings and those sampled from the SNA 8 single trawl fishery from October 2006 to February 2007 is given in Appendix 1, showing the sampling effort was distributed reasonably uniformly in respect of landings over the sampling period.

Sampled landings from the single trawl fishery were entirely from the northern half of the SNA 8 stock, between Ninety Mile Beach and North Taranaki Bight, with the greater proportion of samples coming from those areas adjacent to the Kaipara and Manukau Harbours. This fishing pattern is similar to that seen in past years over the ‘school season’ in SNA 8.

3.2 Length and age distributions

For the SNA 8 single trawl fishery in 2006–07, a catch-at-age composition (using the length frequency and age-length key approach) was 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 2006–07 are presented as histograms and line graphs (Figures 2–5). The estimated proportions at length, age, and mean weight-at-age, are tabulated in Appendices 2–4. The age-length key is presented 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 2). 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 length distribution of the single trawl catch in 2006–07 was characterised by one main mode at 33 cm and a smaller mode at about 43 cm (Figure 2). The tail of the distribution extended to over 60 cm. The mean length of snapper sampled from the fishery was 36.8 cm, and the proportion-at-length analytical and bootstrap MWCVs were 0.10 and 0.13.

The age distribution for the SNA 8 single trawl fishery in 2006–07 was dominated by the 2002 year class (5-year-olds) making up over one-quarter (27%) of snapper landed, while the newly recruited, and the second most dominant, 2003 year class (4-year-olds) made up over 20% (Figure 3). Excluding the 1996 year class (11-year-olds), only those age classes between 4 and 9 years of age showed any appreciable strength in the fishery in 2006–07. The once strong 1996 and 1995 year classes (11- and 12-year-olds) combined now make up only 3% of fish by number in single trawl catches. Other than this, all age classes 10 years of age or older have a low proportion of fish. The aggregate (over 19) age class makes up less than 1% of the overall catch reflecting the low number of fish of this age range available in the fishery. Of the 12 fish over 19 years old, five were from either the 1986 and 1985 year classes (21- and 22-year-olds) that dominated landings in the early 1990s.

The 2002 year class may be of above average strength and is now fully recruited as it contains no fish under 29 cm (see Appendix 5). The 2003 year class (4-year-olds) appears to be of average strength and it too may be fully recruited with most fish measuring 28 cm or more. The mean age of snapper from the single trawl fishery was 6.1 years, and the catch-at-age analytical and bootstrap MWCVs were 0.12 and 0.14.

The spring and summer catch-at-length and catch-at-age samples for the single trawl fishery were fairly similar over both seasons, although spring samples contained a slightly higher proportion of fish in the mid length and age ranges compared to summer samples which comprised a higher proportion of small young fish (Figures 4 & 5).

4. DISCUSSION

The relative year class strengths inferred in the length and age distributions sampled from the SNA 8 single trawl fishery in the 2006–07 are generally consistent with trends observed in recent years (Walsh et al. 2001, 2002, 2003, 2004, 2006b, 2006a, Walsh & Davies 2004).

Single trawl landings from the SNA 8 fishery in 2006–07 were dominated by fish between 4 and 9 years of age with the 2003 and 2002 year classes (4- and 5-year-olds) making up just under half the number landed. Consequently, most other year classes, with the exception of the 1996 year class, appear to be of low to very low relative abundance. The relative proportion of fish 12 years or more is particularly low at 2%, indicating, as it has over recent years, that few older fish exist in the fishery. For the last two decades, the aggregate (over 19) age class accounted for less than 1% of the overall single trawl catch in SNA 8, the lowest proportion of any New Zealand snapper stock. Walsh et al. (2006b) reported that the aggregate (over 19) age class in SNA 8 was unlikely to increase substantially for at least another 10 years, and in 2006–07 was made up of only a handful of fish in the age-length key collection (see Appendix 5), almost half of these from the previously dominant 1986 and 1985 year classes (21- and 22-year-olds).

In 2005–06, Walsh et al. (2006a) reported an apparent broadening of the age distribution in SNA 8, compared to that seen a decade ago when the population model estimated a decreasing population size (Davies et al. 2006). Although some broadening of the age distribution appears to be continuing in 2006–07, the relative strengths of some previously dominant year classes (i.e., 1998, 1996, and 1995) that now occupy the mid age range, seem much less apparent. Davies et al. (2006) derived fishing method-specific selectivity estimates using the results of a SNA 8 tag-recapture programme undertaken in 2002–03. These three previously dominant year classes (with fish averaging about 50 cm in length or about 2.5 kg), are predicted to have around 50% selection probability by the single trawl method. For this reason, and because of past annual fishing mortalities impacting on cohorts over time, these once dominant year classes may now not be as well represented in the catch-at-age of this trawl based fishery as they used to. Catch-at-age estimates for the longline fishery (having selectivity at age roughly equal to one, i.e., for the SNA 1 fisheries) probably provide better estimates of population age structure than the trawl method, though this fishing method is not used extensively in SNA 8. Therefore, 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 are not totally reliable and should be treated with some care.

The 1998 year class has been estimated to be second strongest behind the 1985 year class, with a relative strength almost twice that of the mean (Davies et al. 2006), but now makes up 12% of the single trawl catch. Similarly, the previously dominant 1995 and 1996 year classes combined, now account for only 3%. In 2004–05, Walsh et al. (2006b) predicted that because of their relative sizes at age, the 1998, 1996, and 1995 year classes may contribute substantially in terms of their combined biomass, and will also be important in the future rebuilding of the SNA 8 stock. Overall, and although slowly, the SNA 8 fishery does appear to be broadening, differing from past years where singularly dominant young year classes (of average to above average strength) each contributed 30–40% by number to the landed catch.

Aside from the apparent effects of selectivity as described above, estimates of catch-at-age may also be influenced by spatial heterogeneity, where variability in catch-at-length and -age within the stock is known to exist (Walsh et al. 2006c). However, the collections in 2006–07 were largely based around samples taken from vessels operating in the main snapper fishing areas of SNA 8, off the Kaipara and Manukau Harbours, similar to most other years. Overall, it does appear obvious that few fish are able to be caught in the larger size and older age classes in SNA 8, unlike that seen in the late 1990s, or in other snapper fisheries (e.g., SNA 7) where similar fishing methods are used, and may primarily be because few fish of ages 10–20 years now exist in SNA 8. Support for this view may be drawn from recent MFish catch records (Ministry of Fisheries 2007) that show for the past decade, the

TACC has been over-caught on average each year by 6%, a combined surplus totalling almost 1000 t. This catch in excess of the TACC, may account for sustained high fishing mortality and contribute to a lack of appreciable growth in the right hand tail of the age distribution. West coast snapper are known to have some of the fastest growth rates of any New Zealand snapper stock (Davies et al. 2003), resulting in a high rate of stock productivity. This has allowed SNA 8 to sustain a high level of fishing mortality in recent years, but at the same time the levels of mortality may not have allowed the stock to grow significantly either.

Walsh et al. (2006b) used the previously dominant 1998 and 1996 year classes as a rough guide to predict adjacent year class strengths from data collected in 2004–05, predicting the 2001, 2000, and 1999 year classes were most likely of average to below average strength. Over 2005–06 and 2006–07, these three year classes have remained of similar relative strength, while the 2002 year class has become the most dominant in the single trawl fishery, although in 2005–06 it was predicted to be only of about average strength (Walsh et al. 2006b). Although the 2002 year class now appears the most dominant year class in the fishery at present, current relative year class strengths inferred here are from only the single trawl method, and as described above will be affected by the selectivity effects of this method, which has a bias in capturing a higher proportion of small fish compared to pair trawl. However, it does seem that the 2002 year class, and possibly the 2003 year class, may now be more important to the rebuilding of the SNA 8 fishery over the next few years than was first thought, especially as the other previously dominant year classes (1998, 1996, 1995) now appear to be of lower relative abundance.

The 2004 year class is not yet fully recruited to the fishery, as it still contains an appreciable proportion of fish in the smaller size classes, but appears to be of average strength. Those year classes that recruit at well above average strength as three year olds (i.e., more than 10%) into the fishery (e.g., 1996 and 1998 year classes in 1998–99 and 2000–01 respectively) most often appear in 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 Walsh et al. 2000, 2002). This is not apparent for the 2004 year class in 2006–07, and a comparison of a fully recruited 2004 year class (as 4 year olds) relative to other year classes in 2007–08 will further confirm this.

As always, length and age collections were made over the spring and summer seasons, a period when the greatest proportion of snapper is caught. However, over the past three years the Auckland based inshore trawl fleet has been rationalised considerably from that seen in previous years with fewer trawlers operating, and the virtual cessation of pair trawling in the SNA 8 fishery in 2006–07. Although the 14 sampled single trawl landings in 2006–07 came from only five vessels, the temporal and spatial spread of the catches were such that the derived proportional length and age estimates were expected to be representative of the fishery over spring and summer and therefore directly comparable to those collections in past years. However, only four landings were sampled in the spring (although each landing had a high average weight of about 27 t.), the season where the greatest tonnage of snapper was landed, compared to 10 landings in summer. The reason for the imbalance in the seasonal sample allocation was related to two main factors; one sampled landing was removed from the spring collection as it was found to be contaminated with samples from SNA 1, and secondly, some owner/operator fishers, aligned with particular companies, decided to fish their catch allocation only in the summer period (or later), largely due to other commitments, therefore making catches unavailable for sampling until mid to late summer. This deviation from what has been experienced in past years is a reflection in part to a change in the fishing method effort directed at the SNA 8 fishery, largely due to the downsizing of the trawl fleet for financial and economic reasons, changes in company and quota ownership, and of export and domestic markets, availability of ACE (Annual Catch Entitlement), fishing other stocks before fishing SNA 8, and fishing for a longer period so that less snapper and a greater bycatch for some species, e.g., red gurnard (*Chelidonichthys kumu*) and John dory (*Zeus faber*), is obtained per unit of effort, providing better financial returns (authors communications with industry managers and fishers).

Similar to that found the previous year, all spring sampled landings in 2006–07 were from vessels operating in an area off the Kaipara and Manukau Harbours (source: TCEPR reports) and generally contained a slightly higher proportion of fish in the mid-length and mid-age ranges compared to summer samples. Length summaries from single trawl vessels operating over summer contained a proportion of some catches from other areas such as Ninety Mile Beach and North Taranaki Bight where a high proportion of smaller fish are known to be more frequent (Reid 1969, Walsh et al. 2006), although the greatest effort was still from around the greater Kaipara and Manukau Harbour area. Spring landings comprised catches where snapper was the primary target, while summer landings were almost exclusively the bycatch of a trevally target fishery. Walsh et al. (2006c) found 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. However, as the areas fished were generally similar between the seasons, the minor differences seen in the length samples for spring and summer in 2006–07 may in part reflect a combination of all these factors.

The MWCV (analytical and bootstrap estimates) for the length and age distributions sampled from the SNA 8 single trawl fishery in 2006–07 ranged between 0.10 and 0.14, with all analytical estimates being well 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 2006–07 were generally consistent with trends observed in recent years.

2. The 2002 year class dominates the age distribution in the single trawl fishery in SNA 8 in 2006–07, and combined with the 2003 year class accounts for about half the number of landed snapper.

3. The previously dominant 1998, 1996, and 1995 year classes, may now not be as well represented in catch-at-age estimates for two main reasons: because a high proportion of fish in these cohorts now exceed the optimum selectivity of the single trawl method, and their lower relative abundance in the fishery because of past fishing mortality impacting on these cohorts over time.

4. Relative to most other age classes, those year classes over 11 years of age are of low to very low abundance, including the aggregate (over 19) age class.

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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 2006 to summer 2006–07.*

		Number of landings			No. of fish	Weight of landings (t)		
Method	Season	Total	Sampled	% of total	measured	Total	Sampled	% of total
BPT	Autumn	1	0	0	0	5	0	0
	Winter	14	0	0	0	30	0	0
	Spring	19	0	0	0	57	0	0
	Summer	15	0	0	0	31	0	0
BT	Autumn	104	0	0	0	140	0	0
	Winter	87	0	0	0	77	0	0
	Spring	87	4	4.6	3 070	559	106	19.0
	Summer	130	10	7.7	6 520	302	55	18.2

* BPT, pair trawl; BT, single trawl.

Table 2: Details of snapper otolith samples collected in 2006–07 from SNA 8.

Area	Fishing method †	Sampling period	Sample method ††	Length range (cm)	No. aged
SNA 8	BT	Spring, summer	SR	24–78	475

† BT, single trawl.
†† SR, stratified random sample.

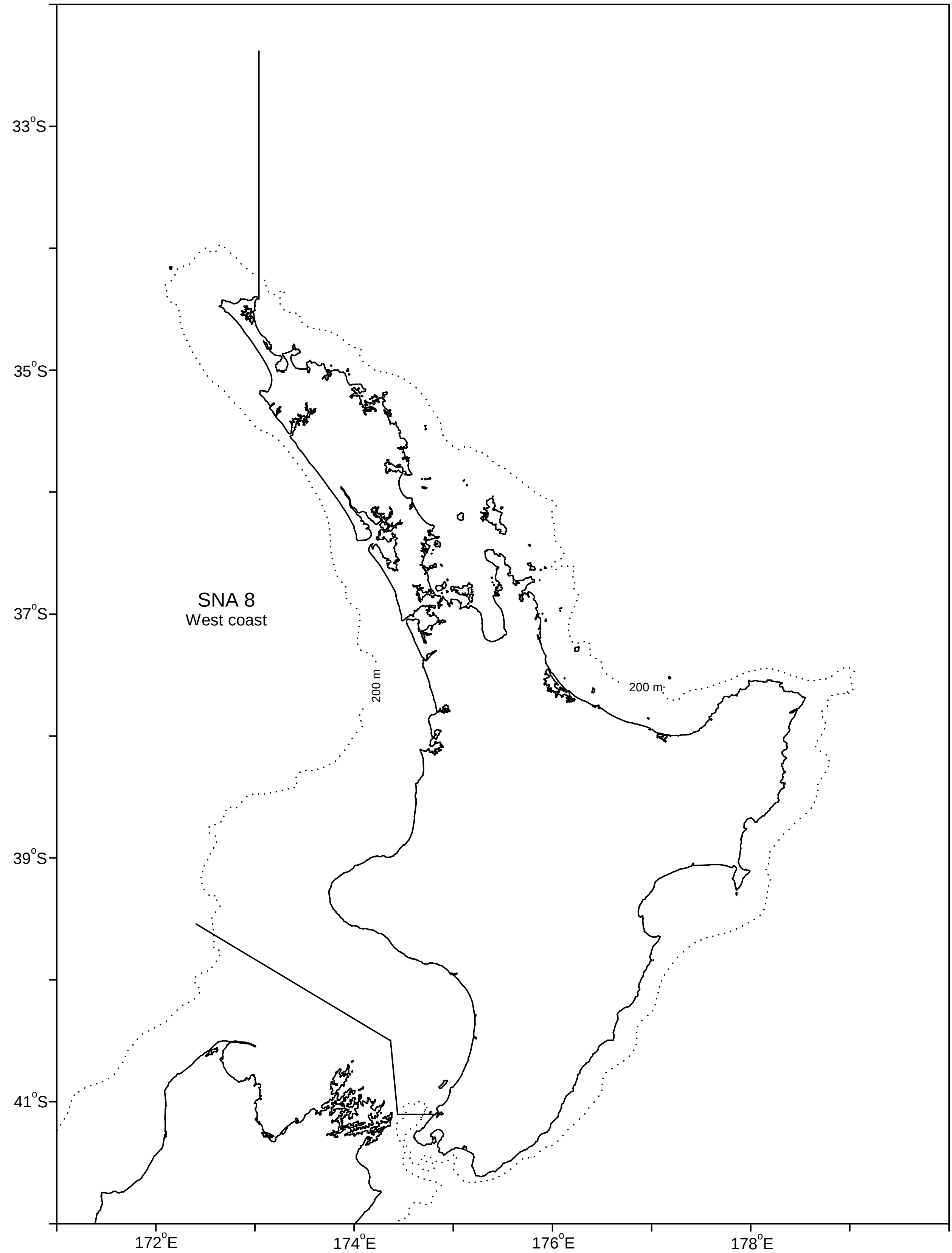


Figure 1: Quota management area for the west coast North Island snapper stock, SNA 8.

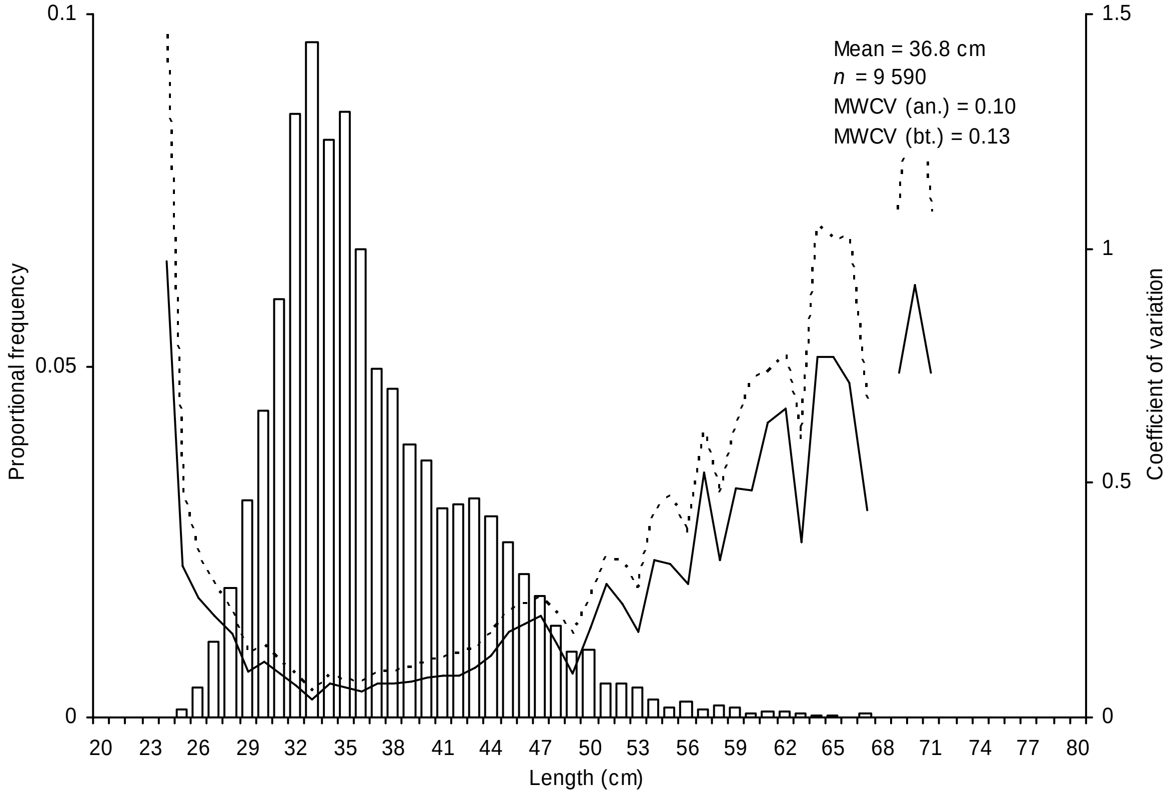


Figure 2: Proportion at length distribution (histogram) and analytical (solid line) and bootstrap (dashed line) c.v.s determined from snapper landings sampled from the SNA 8 single trawl fishery in 2006–07 (*n*, length sample size; MWCV, mean weighted c.v.).

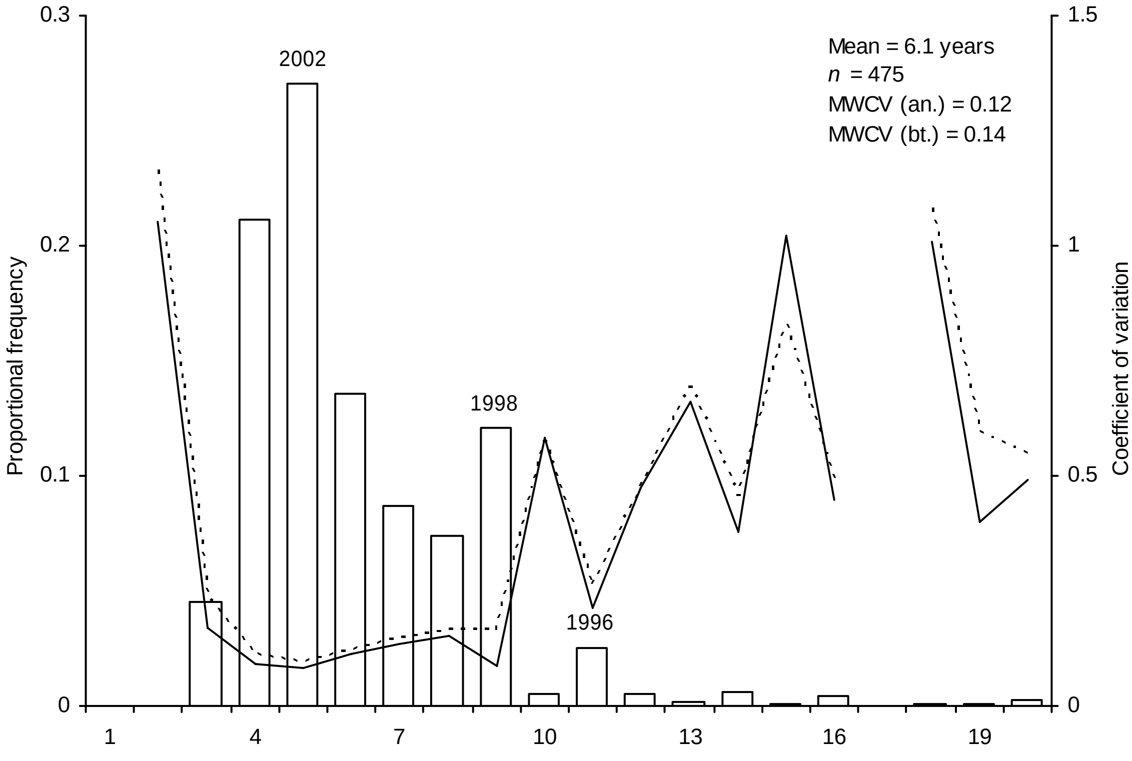


Figure 3: Proportion at age distribution (histogram) and analytical (solid line) and bootstrap (dashed line) c.v.s determined from snapper landings sampled from the SNA 8 single trawl fishery in 2006–07 using the age-length key approach (*n*, otolith sample size; MWCV, mean weighted c.v.).

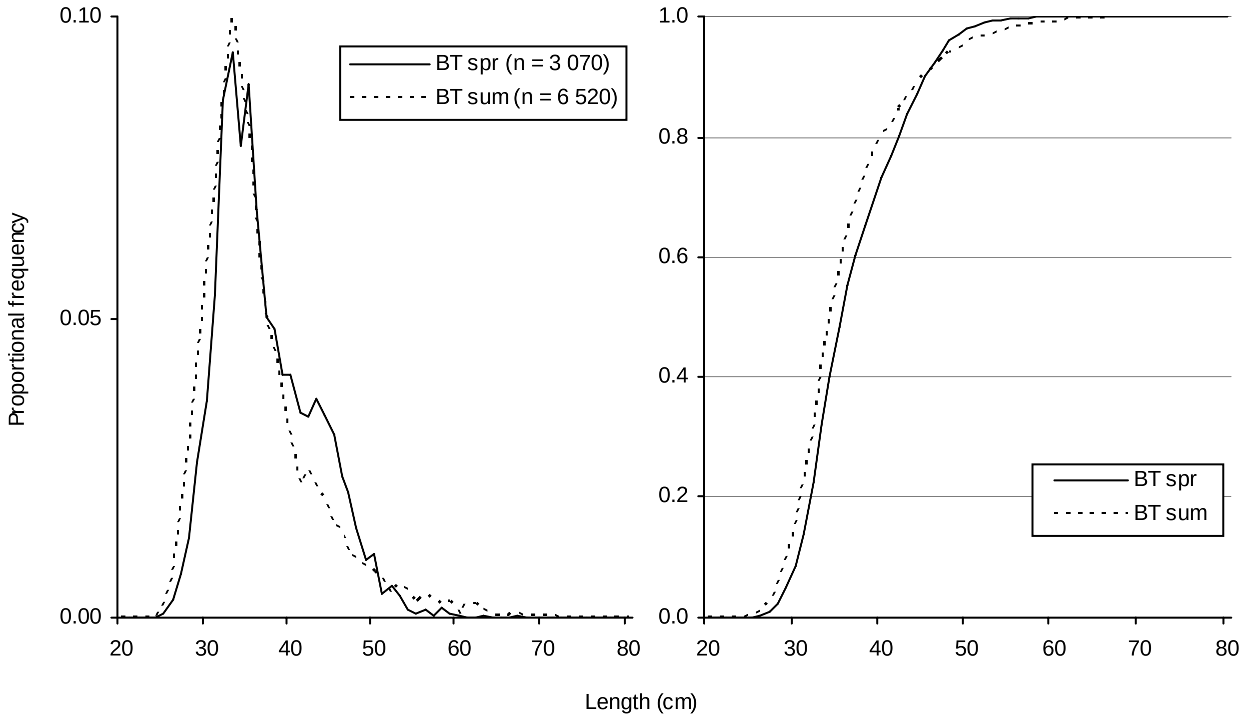


Figure 4: Comparison of the proportion and cumulative proportion at length distributions determined from snapper landings sampled over the spring and summer seasons from the SNA 8 single trawl fishery in 2006–07 (*n*, sample size).

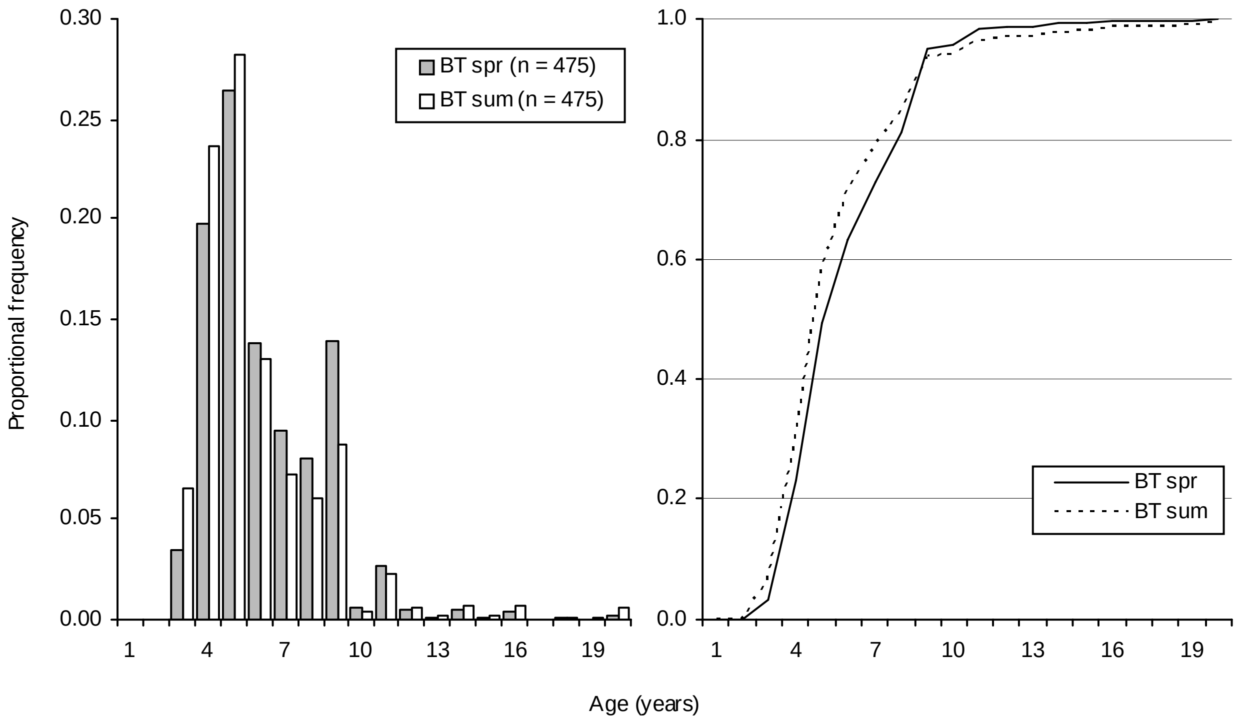
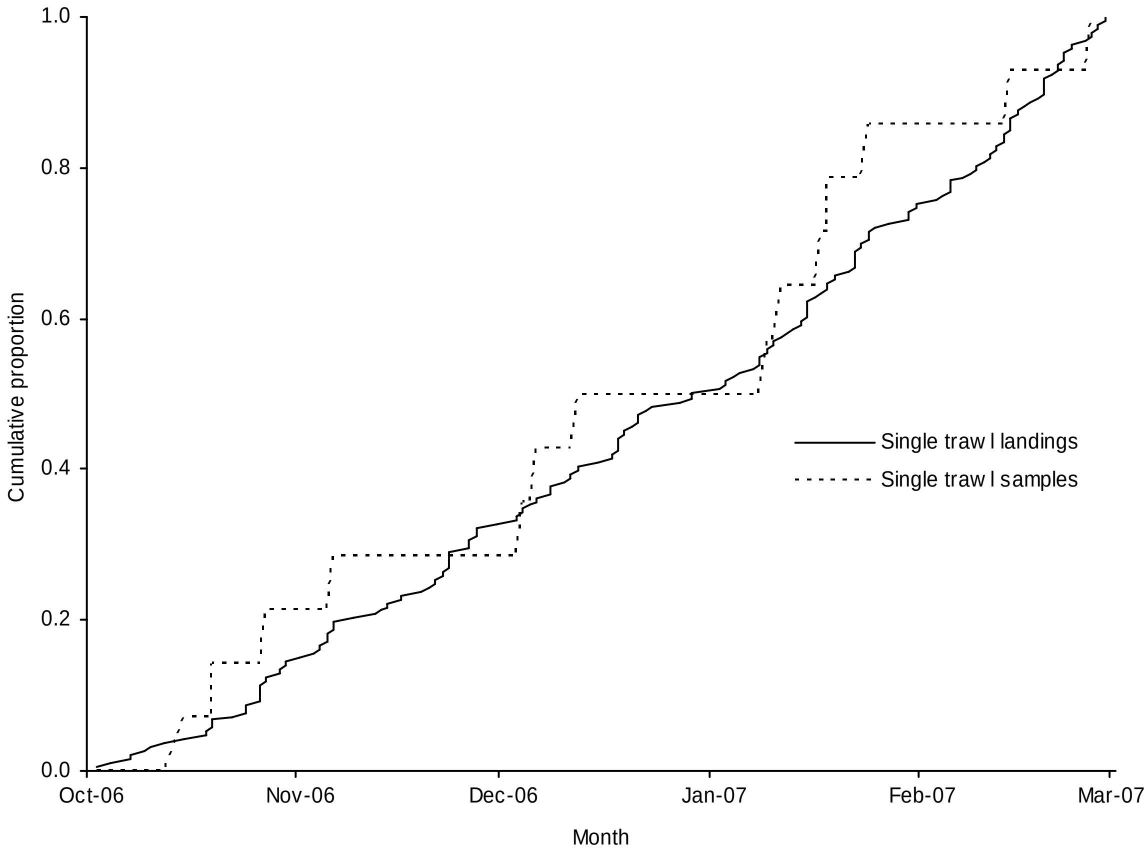


Figure 5: Comparison of the proportion and cumulative proportion at age distributions determined from snapper landings sampled over the spring and summer seasons from the SNA 8 single trawl fishery in 2006–07 (*n*, age-length key sample size).

Appendix 1: The cumulative proportion of the number of landings and samples taken from the SNA 8 single trawl fishery in 2006–07.



Appendix 2: Estimates of proportion at length with c.v.s (analytical and bootstrap estimates) for snapper from the SNA 8 single trawl fishery in 2006–07.
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.

	Single trawl						
Length	Spring		Summer		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	0.0000	0.00	0.0000	0.00	0.00
23	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.00
24	0.0000	0.00	0.0002	0.95	0.0001	0.97	1.46
25	0.0005	0.64	0.0018	0.27	0.0010	0.32	0.49
26	0.0028	0.30	0.0068	0.35	0.0042	0.25	0.34
27	0.0072	0.11	0.0175	0.33	0.0108	0.22	0.28
28	0.0131	0.12	0.0282	0.26	0.0184	0.18	0.23
29	0.0257	0.09	0.0408	0.15	0.0310	0.10	0.14
30	0.0359	0.16	0.0581	0.13	0.0437	0.12	0.15
31	0.0539	0.15	0.0699	0.11	0.0595	0.09	0.12
32	0.0862	0.10	0.0849	0.09	0.0858	0.07	0.09
33	0.0940	0.03	0.0996	0.09	0.0959	0.04	0.06
34	0.0784	0.11	0.0890	0.11	0.0821	0.07	0.09
35	0.0889	0.09	0.0810	0.08	0.0861	0.06	0.08
36	0.0679	0.07	0.0644	0.09	0.0667	0.05	0.08
37	0.0500	0.11	0.0490	0.10	0.0497	0.07	0.10
38	0.0483	0.11	0.0441	0.06	0.0468	0.07	0.10
39	0.0403	0.11	0.0361	0.10	0.0388	0.08	0.11
40	0.0403	0.11	0.0296	0.10	0.0366	0.09	0.12
41	0.0339	0.09	0.0220	0.08	0.0297	0.09	0.13
42	0.0335	0.10	0.0248	0.18	0.0304	0.09	0.13
43	0.0363	0.11	0.0213	0.26	0.0310	0.11	0.15
44	0.0337	0.16	0.0195	0.26	0.0287	0.13	0.18
45	0.0304	0.24	0.0151	0.19	0.0251	0.18	0.23
46	0.0233	0.29	0.0148	0.24	0.0203	0.20	0.24
47	0.0206	0.30	0.0109	0.33	0.0172	0.22	0.25
48	0.0148	0.22	0.0100	0.25	0.0131	0.16	0.22
49	0.0097	0.11	0.0087	0.22	0.0094	0.09	0.18
50	0.0107	0.26	0.0075	0.36	0.0096	0.19	0.26
51	0.0041	0.46	0.0066	0.29	0.0050	0.28	0.34
52	0.0052	0.38	0.0040	0.15	0.0048	0.24	0.33
53	0.0036	0.24	0.0055	0.24	0.0043	0.18	0.28
54	0.0014	0.31	0.0046	0.38	0.0026	0.34	0.44
55	0.0007	0.59	0.0024	0.22	0.0013	0.33	0.47
56	0.0014	0.31	0.0039	0.32	0.0023	0.29	0.39
57	0.0002	1.02	0.0030	0.37	0.0012	0.52	0.61
58	0.0015	0.51	0.0019	0.44	0.0017	0.33	0.47
59	0.0006	0.99	0.0028	0.42	0.0014	0.49	0.62
60	0.0004	0.90	0.0007	0.53	0.0005	0.48	0.72
61	0.0000	0.00	0.0027	0.43	0.0009	0.63	0.74
62	0.0000	0.00	0.0022	0.47	0.0008	0.66	0.77
63	0.0004	0.90	0.0012	0.21	0.0006	0.37	0.60
64	0.0000	0.00	0.0005	0.69	0.0002	0.77	1.05
65	0.0000	0.00	0.0005	0.69	0.0002	0.77	1.02
66	0.0000	0.00	0.0003	0.66	0.0001	0.72	1.03
67	0.0003	0.99	0.0009	0.29	0.0005	0.44	0.66
68	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.00
69	0.0000	0.00	0.0002	0.68	0.0001	0.73	1.08
70	0.0000	0.00	0.0004	0.78	0.0001	0.92	1.43
71	0.0000	0.00	0.0002	0.68	0.0001	0.73	1.08
72	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.00
73	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.00
74	0.0000	0.00	0.0001	0.92	0.0001	0.96	1.26
75	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.00
76	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.00
77	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.00
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	485 690		273 773		759114		
n	3 070		6 520		9 590		

Appendix 3: Estimates of proportion at age with c. v.s (analytical and bootstrap estimates) for snapper from the SNA 8 single trawl fishery in 2006–07.

P.j., proportion of fish in age class; c.v., coefficient of variation; otolith sample size = 475

	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	1.26	0.0002	1.04	0.0001	1.05	1.17
3	0.0343	0.19	0.0658	0.16	0.0453	0.17	0.23
4	0.1973	0.10	0.2364	0.09	0.2110	0.09	0.11
5	0.2650	0.08	0.2819	0.08	0.2709	0.08	0.10
6	0.1386	0.12	0.1306	0.12	0.1358	0.11	0.12
7	0.0948	0.13	0.0733	0.14	0.0873	0.13	0.15
8	0.0810	0.15	0.0614	0.16	0.0742	0.15	0.16
9	0.1388	0.09	0.0874	0.09	0.1208	0.09	0.16
10	0.0058	0.58	0.0037	0.58	0.0051	0.58	0.58
11	0.0264	0.23	0.0223	0.19	0.0250	0.21	0.26
12	0.0048	0.52	0.0059	0.43	0.0052	0.47	0.47
13	0.0010	0.75	0.0018	0.64	0.0013	0.66	0.70
14	0.0051	0.45	0.0072	0.37	0.0058	0.38	0.46
15	0.0007	1.11	0.0020	1.02	0.0012	1.02	0.83
16	0.0036	0.57	0.0066	0.37	0.0047	0.45	0.49
17	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.00
18	0.0007	1.04	0.0011	1.01	0.0008	1.01	1.08
19	0.0004	0.95	0.0012	0.36	0.0006	0.40	0.60
>19	0.0015	0.86	0.0059	0.34	0.0030	0.49	0.55

Appendix 4: Estimated mean weight-at-age (kg) and c.v.s for snapper from the SNA 8 single trawl fishery in 2006–07.

c.v., coefficient of variation; otolith sample size = 475

	Single trawl						
Age	Spring		Summer		Spr-sum		
(years)	Mean	c.v.	Mean	c.v.	Mean	c.v.	*n*
1	–	–	–	–	–	–	–
2	0.36	–	0.36	–	0.36	–	1
3	0.52	0.03	0.51	0.02	0.51	0.03	38
4	0.72	0.01	0.70	0.02	0.71	0.01	70
5	0.85	0.02	0.83	0.02	0.85	0.02	90
6	1.04	0.02	1.02	0.02	1.03	0.02	56
7	1.37	0.03	1.31	0.03	1.35	0.03	46
8	1.48	0.04	1.45	0.05	1.48	0.04	41
9	1.80	0.02	1.80	0.02	1.80	0.02	73
10	1.85	0.10	1.85	0.10	1.85	0.10	3
11	2.16	0.04	2.36	0.04	2.23	0.04	22
12	2.61	0.04	3.25	0.09	2.87	0.07	7
13	3.15	0.15	3.21	0.12	3.18	0.12	2
14	2.92	0.12	3.17	0.06	3.03	0.09	6
15	3.41	–	3.41	–	3.41	–	1
16	2.92	0.08	3.30	0.06	3.11	0.07	5
17	–	–	–	–	–	–	–
18	2.63	–	2.63	–	2.63	–	1
19	4.74	–	4.74	–	4.74	–	1
>19	3.48	0.19	4.27	0.10	4.02	0.14	12

Appendix 5: Age-length key derived from otolith samples collected from snapper fisheries in SNA 8 in 2006–07.

Estimates of proportion of age at length for snapper sampled from SNA 8, spring and summer 2006–07. (Note: Aged to 01/01/2007)

Length	Age (years)																				No.
(cm)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	>19	aged
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	1.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
25	0	0.11	0.67	0.22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9
26	0	0	1.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9
27	0	0	1.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9
28	0	0	0.36	0.64	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11
29	0	0	0.36	0.50	0.14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14
30	0	0	0.20	0.47	0.27	0.07	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15
31	0	0	0.05	0.47	0.47	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	19
32	0	0	0	0.58	0.38	0.04	0	0	0	0	0	0	0	0	0	0	0	0	0	0	24
33	0	0	0	0.52	0.48	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	25
34	0	0	0	0.26	0.59	0.11	0.04	0	0	0	0	0	0	0	0	0	0	0	0	0	27
35	0	0	0	0.13	0.43	0.35	0	0.09	0	0	0	0	0	0	0	0	0	0	0	0	23
36	0	0	0	0.04	0.42	0.42	0.08	0.04	0	0	0	0	0	0	0	0	0	0	0	0	26
37	0	0	0	0	0.39	0.30	0.26	0.04	0	0	0	0	0	0	0	0	0	0	0	0	23
38	0	0	0	0	0.13	0.58	0.21	0.08	0	0	0	0	0	0	0	0	0	0	0	0	24
39	0	0	0	0	0.18	0.32	0.23	0.23	0.05	0	0	0	0	0	0	0	0	0	0	0	22
40	0	0	0	0	0	0.15	0.40	0.20	0.25	0	0	0	0	0	0	0	0	0	0	0	20
41	0	0	0	0	0.06	0.06	0.18	0.24	0.29	0.06	0.12	0	0	0	0	0	0	0	0	0	17
42	0	0	0	0	0	0	0.16	0.42	0.42	0	0	0	0	0	0	0	0	0	0	0	19
43	0	0	0	0	0	0	0.26	0.21	0.53	0	0	0	0	0	0	0	0	0	0	0	19
44	0	0	0	0	0	0	0.31	0.13	0.56	0	0	0	0	0	0	0	0	0	0	0	16
45	0	0	0	0	0	0	0.17	0.08	0.75	0	0	0	0	0	0	0	0	0	0	0	12
46	0	0	0	0	0	0	0	0.18	0.55	0.09	0.18	0	0	0	0	0	0	0	0	0	11
47	0	0	0	0	0	0	0.09	0	0.64	0	0.18	0	0	0.09	0	0	0	0	0	0	11
48	0	0	0	0	0	0	0	0.11	0.33	0.11	0.44	0	0	0	0	0	0	0	0	0	9
49	0	0	0	0	0	0	0	0.13	0.50	0	0.25	0.13	0	0	0	0	0	0	0	0	8
50	0	0	0	0	0	0	0	0.29	0.29	0	0.14	0.14	0	0	0	0.14	0	0	0	0	7
51	0	0	0	0	0	0	0	0.17	0.17	0	0.17	0	0.17	0.17	0	0	0	0.17	0	0	6
52	0	0	0	0	0	0	0	0	0.50	0	0.33	0.17	0	0	0	0	0	0	0	0	6
53	0	0	0	0	0	0	0	0	0	0	0	0.33	0	0	0	0.33	0	0	0	0.33	3
54	0	0	0	0	0	0	0	0	0	0	0.80	0	0	0	0	0.20	0	0	0	0	5
55	0	0	0	0	0	0	0	0	0	0	0.50	0	0	0.50	0	0	0	0	0	0	4
56	0	0	0	0	0	0	0	0	0	0	0	0	0	0.50	0.50	0	0	0	0	0	2
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	0	0	0	1.00	0	0	0	0	0	0	1
59	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.00	0	0	0	0	2
60	0	0	0	0	0	0	0	0	0	0	0	0	1.00	0	0	0	0	0	0	0	1
61	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.00	1
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	0	0	1.00	0	1
64	0	0	0	0	0	0	0	0	0	0	0	1.00	0	0	0	0	0	0	0	0	1
65	0	0	0	0	0	0	0	0	0	0	0	1.00	0	0	0	0	0	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	0
67	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.00	1
68	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.00	1
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	1.00	0	0	0	0	0	0	0	0	1
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	1
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	1
77	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
78	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.00	1
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																					475