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EXECUTIVE SUMMARY

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New Zealand Fisheries Assessment Report 2006/54. **21 p.**

This report presents the results for Objective 1 of the Ministry of Fisheries project "Estimation of snapper year class strength in SNA 8" (SNA2005/03). 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 2005–06 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 and pair trawl fisheries, and age data were collected randomly in the form of a proportional allocation age-length key. Total sample sizes of 13 and 4 landings were sampled for length frequency from the single trawl and pair trawl fisheries respectively, with an age-length key collection of 533 otoliths.

Year class strengths inferred for the SNA 8 stock were generally similar to those from previous years. Both single trawl and pair trawl catch-at-age distributions in 2005–06 appear broader than for a number of years, dominated by five main year classes (1998 to 2002) of similar relative strengths. Combined, these year classes account for 80% of the catch by both methods. 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 and pair trawl methods. Most other year classes, especially those 12 years or older, are of low to very low abundance relative to other age classes.

The length and age distributions of the SNA 8 single trawl and pair trawl fisheries for 2005–06 were relatively similar to each other, with the pair trawl method having a slightly higher proportion of fish of moderate size and age and fewer small and young fish. Slight method-specific differences may reflect a combination of spatial heterogeneity in stock length composition and differences in method selectivity. Mean weighted coefficients of variation (for analytical estimates) of below 20% across all age classes in the SNA 8 catch-at-age compositions were 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, Walsh & Davies 2004). This report presents the results of market sampling from the SNA 8 stock between October 2005 and February 2006, thus continuing the time series. Funding for this project, SNA2005/03, was provided by the Ministry of Fisheries.

The specific objective of this project for 2005–06 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 2005–06. 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 methods sampled were single trawl (BT) and pair trawl (BPT) over the spring (September–November) and summer (December–February) quarters only.

Details of the sampling design were described by Davies & Walsh (1995). Length frequency samples were collected from the SNA 8 single trawl and pair trawl fisheries 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 single trawl proportion-at-length distribution as estimated for the previous year. The west coast single trawl length distribution was used (as opposed to that for the pair 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 9 otoliths was collected 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 = 533) 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 2005–06, the 1998 year class was 8 years old, whether sampled in December 2005 or February 2006.

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) $= 0.04467l^{2.793}$(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 2005 to summer 2005–06 are provided in Table 1, displaying seasonal patterns in the fisheries, with single trawl operating mainly over spring and summer and pair trawl mainly over spring. The relative catch by method for the SNA 8 stock over the sampling period (October 2005–February 2006) was similar to that of the previous year, with single trawl and pair trawl making up 65% and 28% of the catch respectively. 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 and pair trawl fisheries (Table 1). Catches sampled from the single trawl and pair trawl fisheries in spring were entirely from landings where snapper was the target species. Samples from summer were mainly from landings where trevally (*Pseudocaranx dentex*) was the main target species, although snapper still make up a large proportion of the overall catch. The summarised information in Table 1 is for all landings containing snapper (target and bycatch) caught from SNA 8.

A total sample size of 15 landings was targeted from the single trawl and pair trawl fisheries in 2005–06, with 13 and 4 landings being sampled for length frequency from each of the fisheries respectively. The cumulative proportion of the total number of landings and those sampled from the respective SNA 8 fisheries from October 2005 to February 2006 are given in Appendix 1.

3.2 Length and age distributions

For all fisheries sampled in 2005–06, catch-at-age compositions (using the length frequency and age-length key approach) were derived from the combined spring and summer length distributions, and were used to compare method strata and 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 fisheries in 2005–06 are presented as histograms and line graphs (Figures 2–7). 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 method-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 2005–06 was characterised by one main mode at 33 cm, and minor modes at about 38 and 43 cm (Figures 2 and 6). The tail of the distribution extended to over 65 cm. The mean length of snapper sampled from the fishery was 37.6 cm, and the proportion-at-length analytical and bootstrap MWCVs were 0.11 and 0.14. The pair trawl length distribution was relatively similar to that of single trawl, with a slightly higher proportion of moderate sized fish, and fewer small fish below about 33 cm (Figures 4 and 6). The main mode of the pair trawl length distribution was centred at 32 cm, with a number of minor modes evident in the larger size classes (37, 42, 46, 50 cm). The distribution had a tail extending to 65 cm and a mean length of 39.2 cm. The proportion-at-length analytical and bootstrap MWCVs were 0.20 and 0.26.

The age distribution for the single trawl fishery in 2005–06 was dominated by the 2002 year class (4-year-olds) making up 25% of snapper landed, while in the pair trawl fishery this year class accounted for about 20% (Figures 3, 5, & 7). Combined with year classes 2001 to 1998 (5- to 8-year-olds), each of similar relative strength in both fisheries, the total percentage of snapper landed increases to over 80% (Figures 3, 5, & 7). The once strong 1996 and 1995 year classes (10- and 11-year-olds) combined make up 9% and 12% of fish by number in single trawl and pair trawl catches respectively (Figures 3, 5, and 7). Many of the older age classes (i.e., those over 11 years of age) have a very low proportion of fish, while those 17–19 years old were absent. The aggregate (over 19) age class makes up 1% of the overall catch in either method, largely dominated by fish from the 1986 and 1985 year classes (20- and 21-year-olds). The 2002 year class appears to be of about average strength and is likely to be almost fully recruited as it contains few fish under 27 cm (see Appendix 5). The 2003 year class (3-year-olds) appears to be of below average strength. The mean age's of snapper from the single trawl and pair trawl fisheries were 6.3 and 6.8 years respectively, and the catch-at-age analytical and bootstrap MWCVs were 0.11 and 0.14, and 0.13 and 0.22.

4. DISCUSSION

The relative year class strengths inferred in the length and age distributions sampled from the SNA 8 single trawl and pair trawl fisheries in the 2005–06 are generally consistent with trends observed in recent years (Walsh et al. 2001, 2002, 2003, 2004, 2006a, Walsh & Davies 2004).

Unlike most recent years, where the west coast single trawl and pair trawl age distributions have been dominated by only one or two very strong year classes, the 2005–06 distributions comprised five main year classes (1998 to 2002) with similar relative strengths. Following on from the results in 2004–05, this apparent broadening of the age distribution could be compared to that seen over a decade ago in the early 1990s, a period when the SNA 8 population model estimated a decreasing population size (Davies et al. 2006). 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 are not reliable.

In 2005–06, these five year classes account for four in every five fish landed by both the single trawl and pair trawl methods in SNA 8. Consequently, most other year classes, with the exception of those from 1996 and 1995, appear to be of low to very low abundance, and those age classes 17–19 years are unrepresented in the age-length key. The relative proportion of fish 12 years old or more is particularly low at 3–4%, indicating, as it has in recent years, that few older fish exist in the fishery. The aggregate (over 19) age class now makes up 1% of the overall catch, a slight increase as a result of two previously very strong year classes (1985 and 1986) joining this group in the last two years. Because of the low numbers of older fish apparent in catches, the aggregate (over 19) age class is unlikely to increase substantially for at least another 9 years. The 1997 year class (9 year olds) continues to be very weak, as it has been over the last 6 years in catch-at-age summaries, currently made up of only a handful of fish in the age-length key collection (see Appendix 5).

Walsh et al. (2006a) used the 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. Should this be true, then it is likely the 2002 year class is also of average strength in 2005–06. The 1998 year class that dominated the SNA 8 fishery over the past 3–4 years is estimated to be second strongest (behind the 1985 year class) in the last 25 years, with a relative strength almost twice that of the mean (Davies et al. 2006), and now accounts for 14–20% of the catch, a lower estimate than was expected. The fishery in 2005–06 appears to be broadening due to the number of year classes of relatively even strength visibly dominating the early age classes of the single trawl and pair trawl age distributions, differing from most recent years where a singularly dominant year class often contributed 30–40% by number to the landed catch. However, two main factors that may affect catch-at-age estimates and are not readily apparent are the effects of method selectivity and the influence of spatial heterogeneity on the catch.

West coast snapper are known to have some of the fastest growth rates of any New Zealand snapper stock (Davies et al. 2003). The size range at age for some mid-range year classes, such as 1998, 1996, and 1995, has meant that although these year classes once dominated catches, their relative numbers in 2005–06 are such that a considerable proportion of fish from these cohorts are now not caught. Davies et al. (2006) derived method selectivity estimates, using the results of a SNA 8 tag-recapture programme undertaken in 2002–03, that predict fish around 50 cm (55 cm in pair trawl) in length were selected for only 50% of the time. For this reason, and because of past annual fishing mortalities impacting on the cohorts over time, previously dominant year classes such as 1998, 1996, and 1995 may now not represent the population age structure of this trawl based fishery as well as they used to. Longline catch-at-age estimates where selectivity at age is roughly equal to one (i.e., those from the SNA 1 fisheries) probably provide better estimates of population age structure; however, this fishing method is not used extensively in SNA 8.

Secondly, snapper sampled from commercial landings where vessels fished between the Kaipara Harbour and Waikato River entrance areas of SNA 8 have been found to be of a larger average size (Reid 1969, Walsh et al. 2006b) and greater average age than areas to the north or south (Walsh et al. 2006b). Current catch sampling practices by and large do not take into account the spatial differences within SNA 8, so annual catch-at-age estimates may not accurately reflect the true mortality and recruitment processes acting over the entire stock (Walsh et al. 2006b). In 2005–06, almost 40% of the otolith sample came from landings that fished in part or whole outside the Kaipara Harbour to Waikato River entrance area, and this is likely to have further influenced the catch-at-age results. The previously dominant 1998, 1996, and 1995 year classes, now, because of their relative sizes at age, may contribute substantially in terms of their combined biomass, and will therefore be important in the future rebuilding of the SNA 8 stock over the next few years.

The 2003 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 below 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 2003 year class in 2005–06, and a comparison of a fully recruited 2003 year class (as 4 year olds) relative to other year classes in 2006–07 will further confirm this.

Walsh et al. (2006a) 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. In 2005–06, all spring sampled landings (single trawl and pair trawl) were from the vessels operating in an area between the Kaipara Harbour and Waikato River entrance, concentrating effort in a region mainly around the Manukau Harbour (source: TCEPR reports). Although length summaries from single trawl vessels operating in summer contained vessels fishing other areas (such as North Taranaki and South Taranaki Bight) targeting mainly trevally, they too comprised catches mainly from around the Kaipara and Manukau regions, and were therefore similar to those samples from spring. Pair trawl summer length samples where trevally was the target species, were entirely from the North Taranaki Bight region, an area renowned for smaller fish (Reid 1969, Walsh et al. 2006b), and in 2005–06 were considerably smaller and narrower compared to the other season summaries. However, combined seasonal length summaries for the single trawl and pair trawl methods in 2005–06 were not considerably different, with the pair trawl method having a slightly higher proportion of moderate sized and fewer small fish. The pair trawl spring samples, although based on only two samples, were from landings having considerably more weight. These landings have influenced the final combined pair trawl length estimates, producing a noticeable broadening in the right hand tail of the distribution compared to most recent years, especially in the 40–55 cm size range. Single trawl and pair trawl sample length distributions in 2005–06 are generally more similar to those collected between 1999–2000 and 2003–04 (Walsh et al. 2001, 2002, 2003, 2004, Walsh & Davies 2004) where the selectivity characteristics of the methods were thought to be relatively similar. Differences are likely to become more apparent when fish from a strong year class grow to lengths that exceeded the optimum selectivity of the single trawl method yet remained vulnerable to pair trawl (Walsh et al. 2004), evident in SNA 8 catches from the 1970s when larger and older snapper were more abundant (Sullivan & Gilbert 1978). The slight method-specific differences seen here may reflect a combination of spatial heterogeneity in stock length composition as well as differences in method selectivity.

The sampling effort for each method was generally allocated proportionally between the seasons (see Appendix 1). However, for the west coast pair trawl fishery in 2005–06 only four landings (MWCV = 0.20) were sampled for length frequency compared to about 10–15 landings (MWCV = 0.06–0.13) in previous years, as specified in the design. The low number of pair trawl landings sampled was largely due to insufficient sampling effort. Pair trawl samples collected in 2000–01 were bootstrapped to determine optimum sample sizes using a length frequency and age-length key design. This showed that a collection of 10 to 15 landings (and 300 to 500 otoliths) should achieve catch-at-age MWCVs of between 0.12 and 0.17 (N. Davies, unpublished data). In practice, the resulting analytical MWCV is often less. Recent sampling of landings from the SNA 8 fishery has also shown that considerable spatial variation in length structure of snapper exists within the stock (Walsh et al. 2006b). The pair trawl fishery in particular, often used for catching trevally especially over summer in areas like North Taranaki Bight (where snapper would not normally be the target species but make up a considerable proportion of the landed catch), is thought to contribute to this variability. Although the MWCV for the pair trawl length distribution in 2005–06 meets the criteria of equal to or below 0.20, a sample size of only four landings (from a total of over 50 landings) is likely to be inadequate to describe the catch-at-length of the fishery. This level of under-sampling is likely to contribute some degree of bias in the final pair trawl catch-at-age estimate for 2005–06, and therefore may not be entirely representative of the fishery over spring and summer as in previous years.

The MWCV (analytical and bootstrap estimates) for the length and age distributions sampled from the SNA 8 fisheries in 2005–06 ranged between 0.11 and 0.26, and all analytical estimates were equal to or 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).

5. CONCLUSIONS

1. The length and age distributions sampled from the SNA 8 fisheries in 2005–06 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 2005–06, with the 1998–2001 year classes of relatively equal strength. All five of these year classes are of similar relative strength in the pair trawl fishery.

3. 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 exceeds the optimum selectivity of the single trawl and pair trawl methods.

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 2005 to summer 2005–06.*

		Number of landings			No. of fish	Weight of landings (t)		
Method	Season	Total	Sampled	% of total	measured	Total	Sampled	% of total
BPT	Autumn	5	0	0	0	20	0	0
	Winter	22	0	0	0	86	0	0
	Spring	36	2	5.6	1 163	360	53	14.7
	Summer	16	2	12.5	1 364	79	11	13.9
BT	Autumn	118	0	0	0	161	0	0
	Winter	87	0	0	0	121	0	0
	Spring	122	7	5.7	4 842	499	97	19.4
	Summer	120	6	5.0	4 299	302	53	17.5

* BPT, pair trawl; BT, single trawl.

Table 2: Details of snapper otolith samples collected in 2005–06 from SNA 8.

Area	Fishing method †	Sampling period	Sample method ††	Length range (cm)	No. aged
SNA 8	BPT, BT	Spring, summer	SR	24–77	533

† BPT, pair trawl; BT, single trawl.

†† SR, stratified random sample.

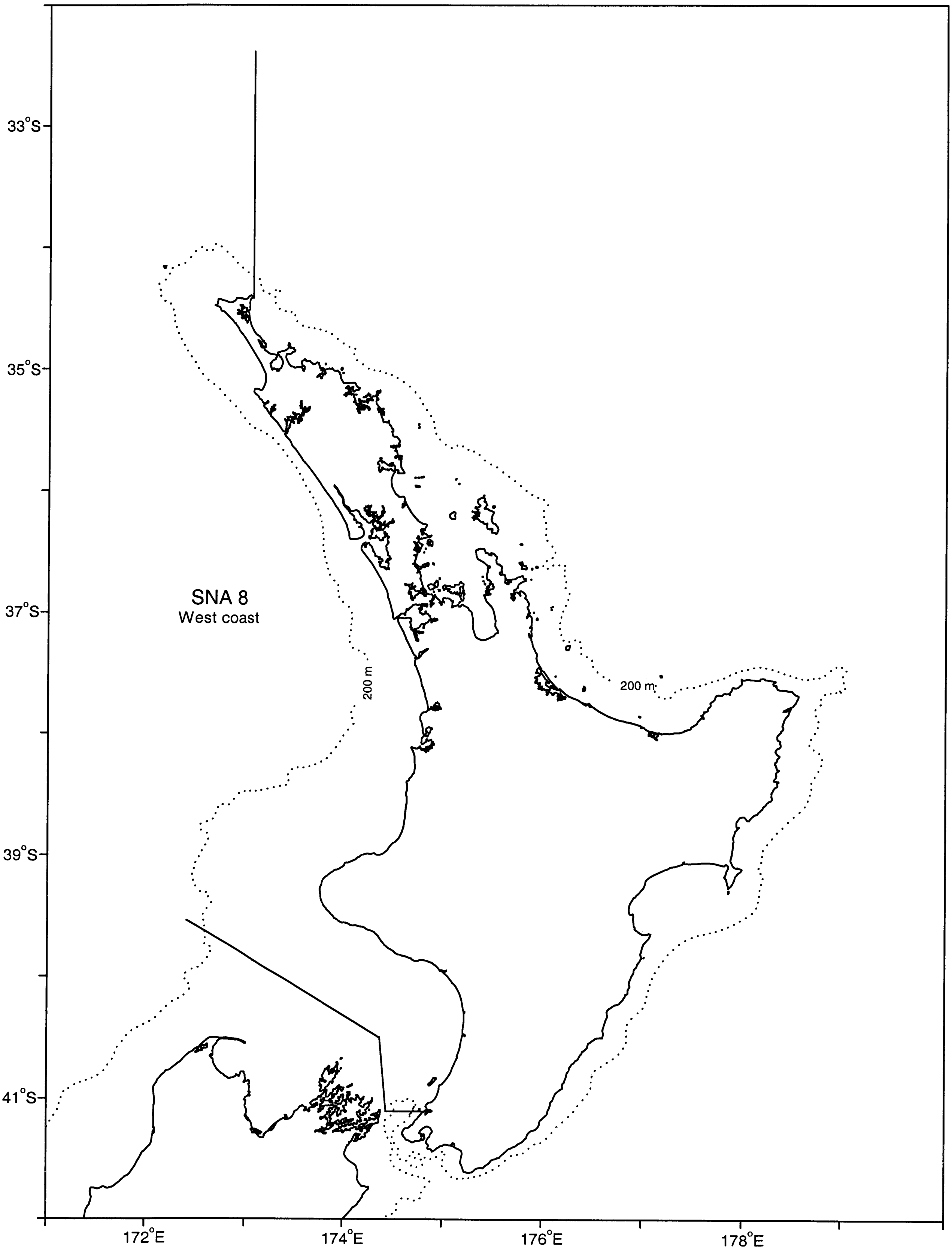


Figure 1: Quota management area for the west coast North Island snapper stock, SNA 8.

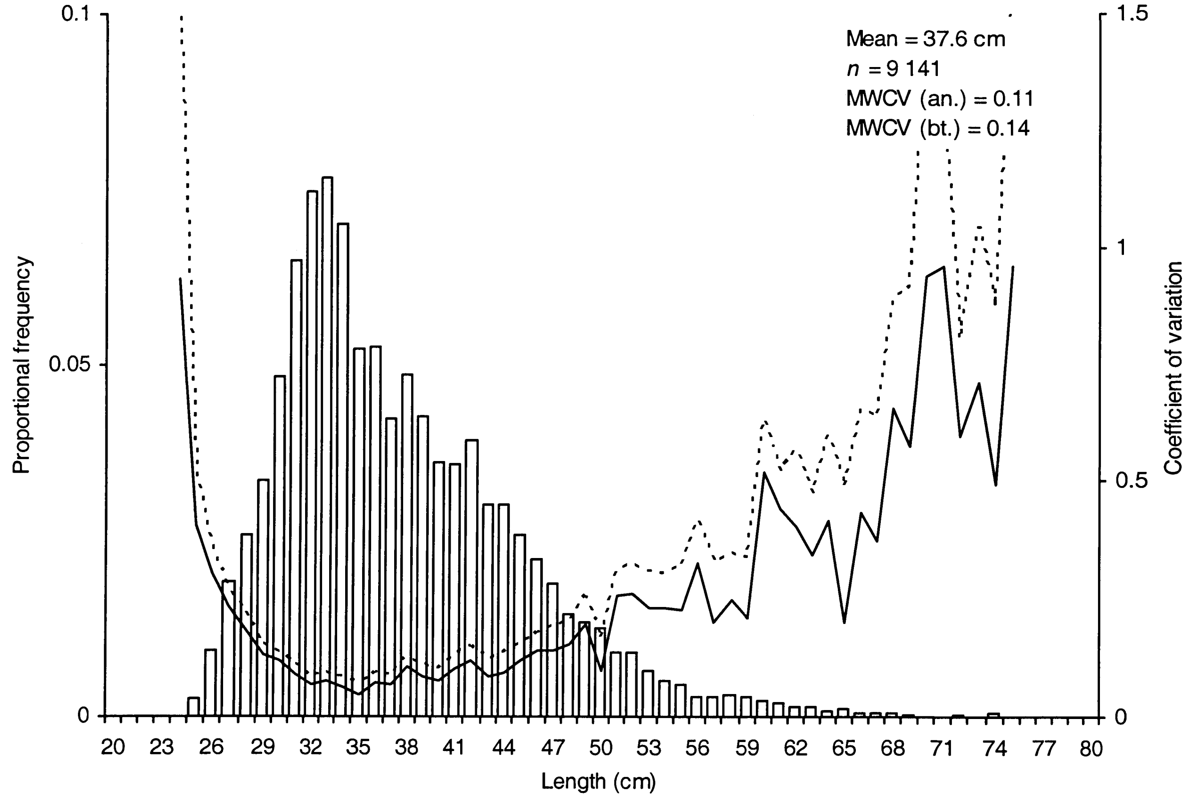


Figure 2: Proportion at length distribution (histogram) and analytical (solid line) and bootstrap (dashed line) c.v.s determined from snapper landings sampled from the SNA 8 single trawl fishery in 2005–06 (*n*, length sample size; MWCV, mean weighted c.v.).

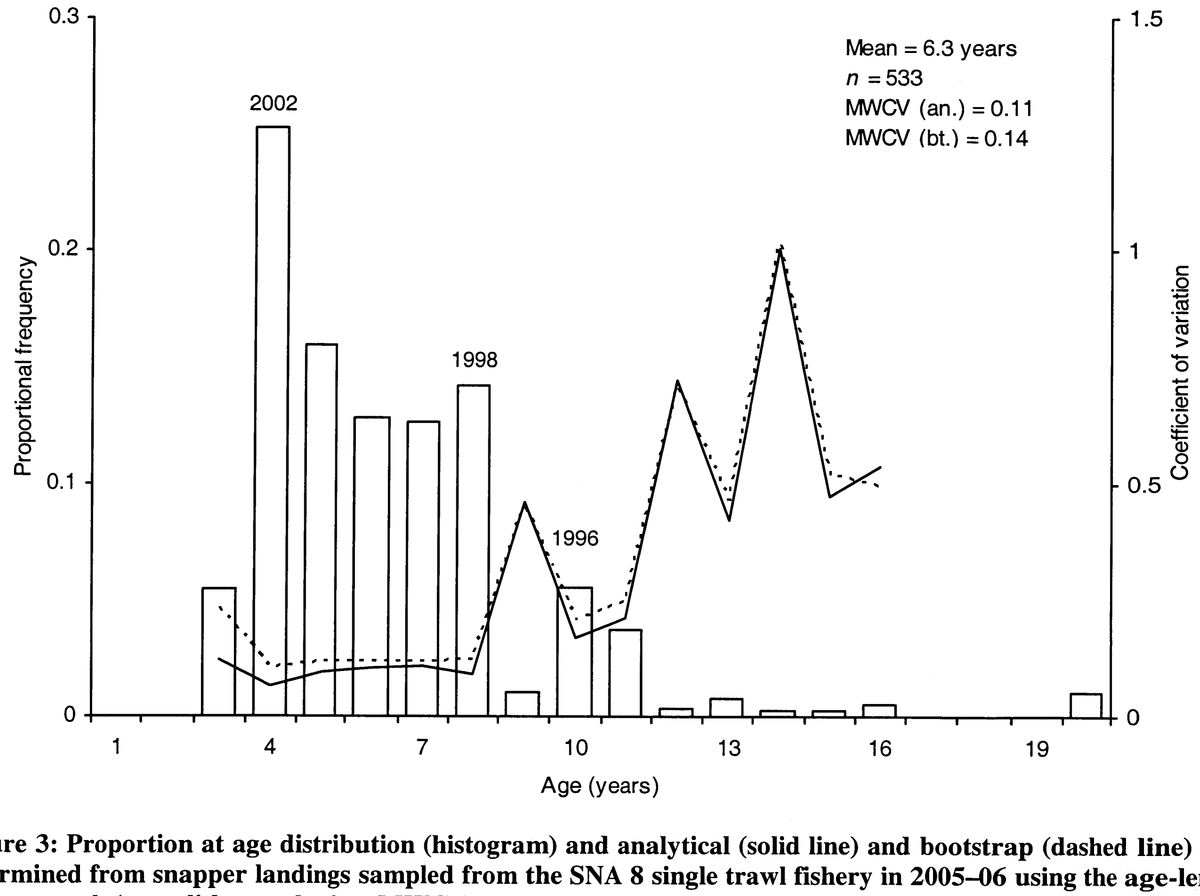


Figure 3: Proportion at age distribution (histogram) and analytical (solid line) and bootstrap (dashed line) c.v.s determined from snapper landings sampled from the SNA 8 single trawl fishery in 2005–06 using the age-length key approach (*n*, otolith sample size; MWCV, mean weighted c.v.).

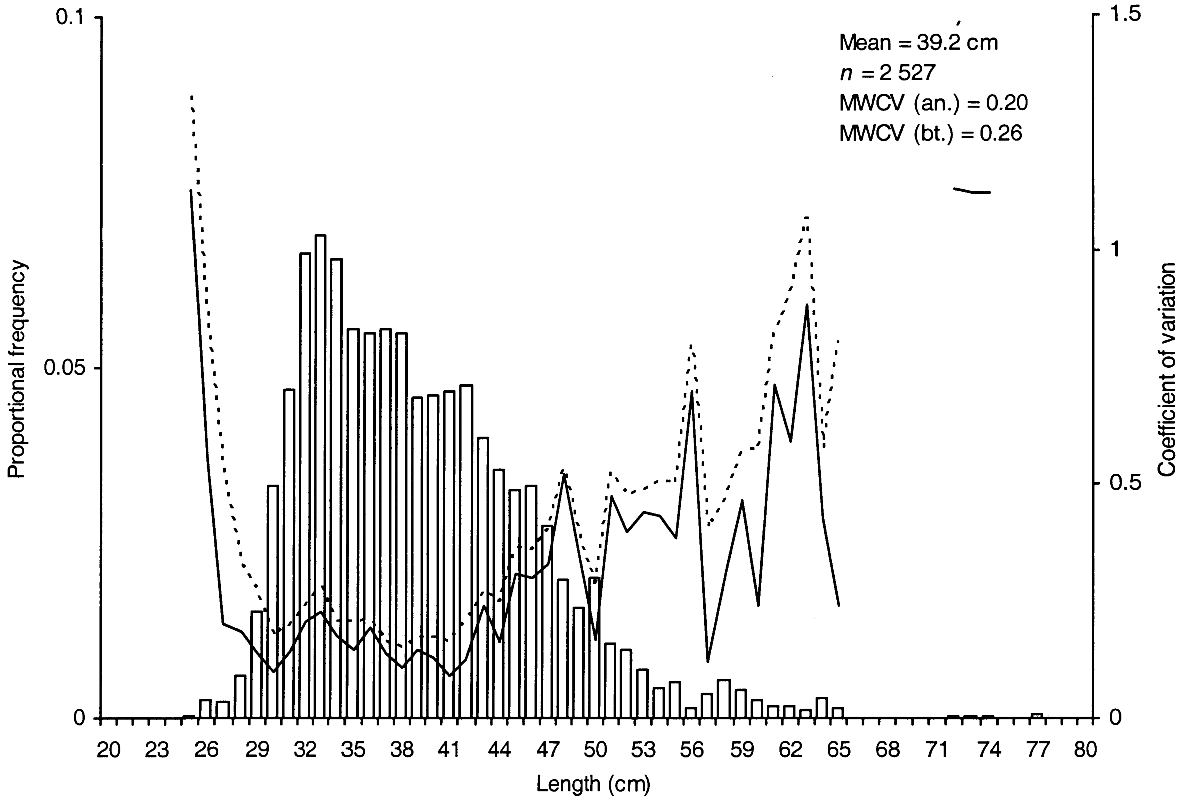


Figure 4: Proportion at length distribution (histogram) and analytical (solid line) and bootstrap (dashed line) c.v.s determined from snapper landings sampled from the SNA 8 pair trawl fishery in 2005–06 (*n*, length sample size; MWCV, mean weighted c.v.).

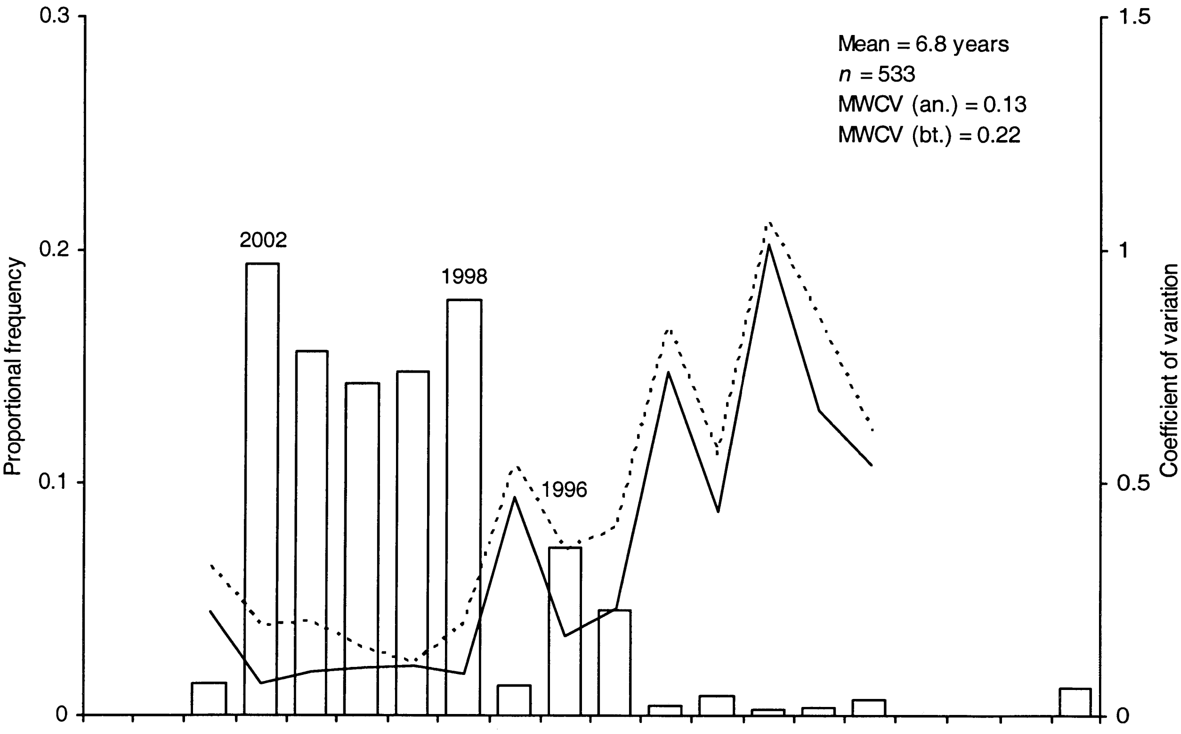


Figure 5: Proportion at age distribution (histogram) and analytical (solid line) and bootstrap (dashed line) c.v.s determined from snapper landings sampled from the SNA 8 pair trawl fishery in 2005–06 using the age-length key approach (*n*, otolith sample size; MWCV, mean weighted c.v.).

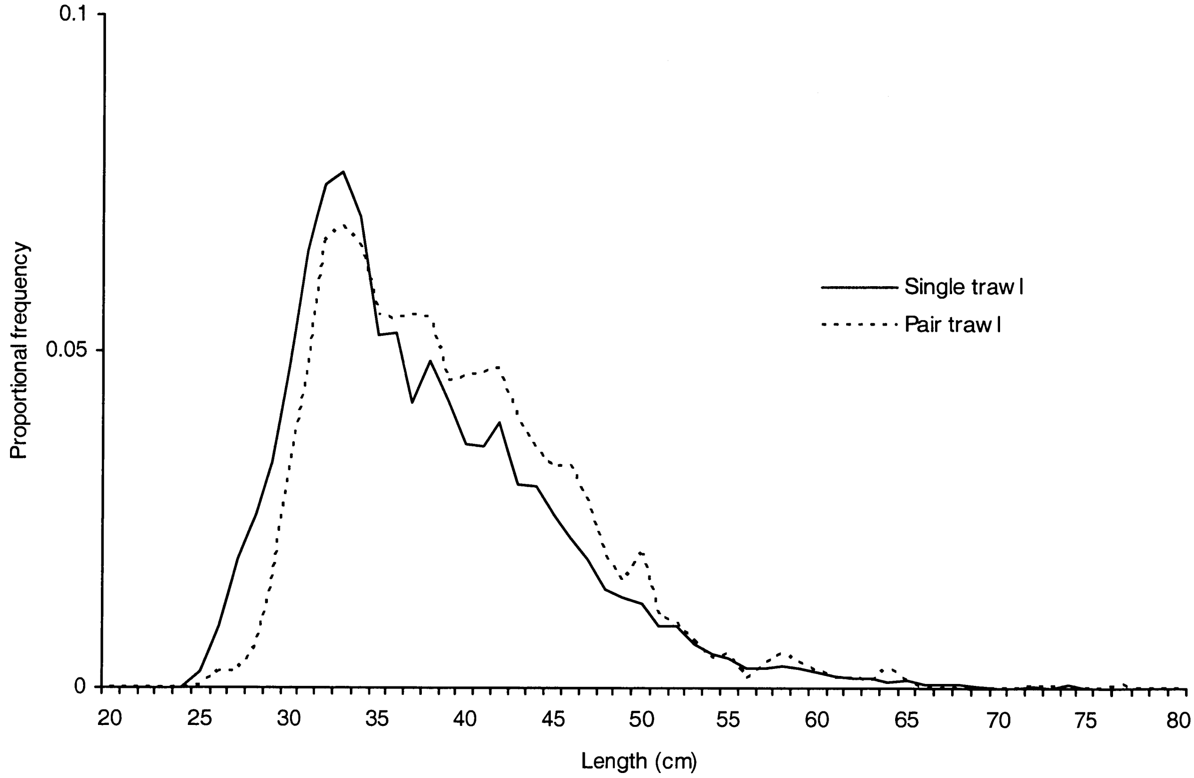


Figure 6: Proportion at length distributions determined from snapper landings sampled from the SNA 8 single trawl and pair trawl (solid and dashed lines respectively) fisheries in 2005–06.

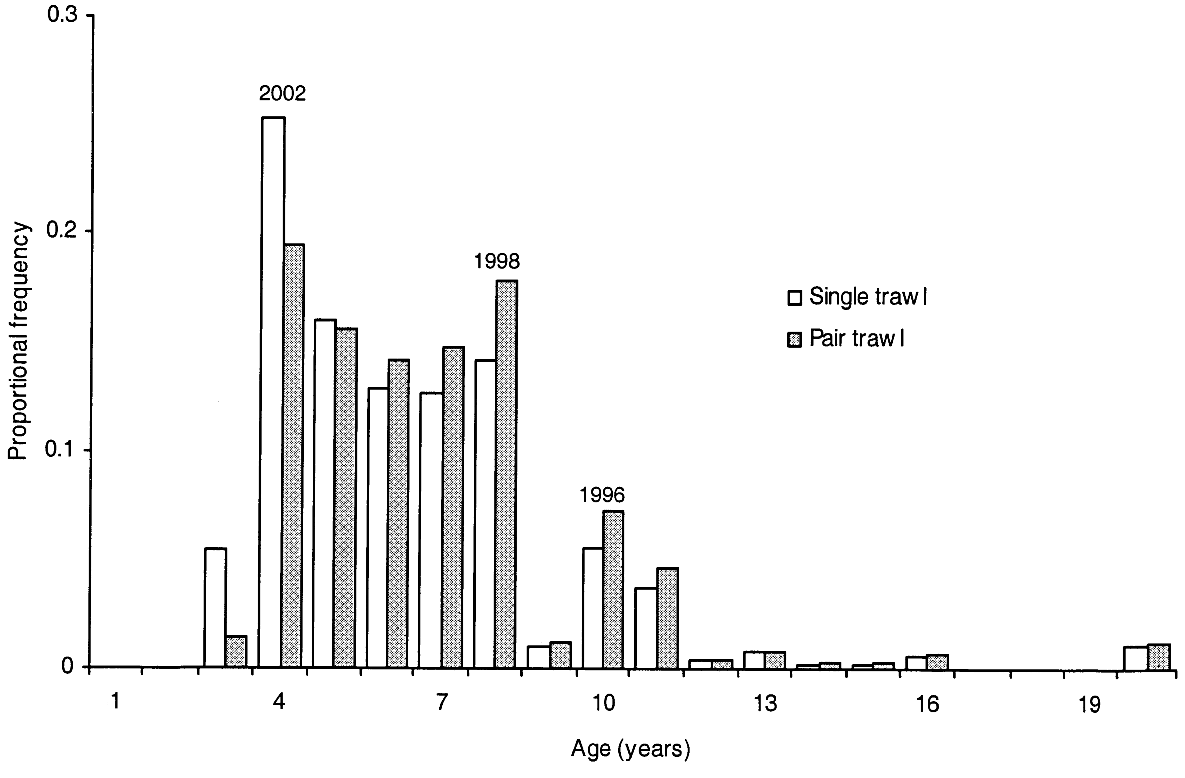
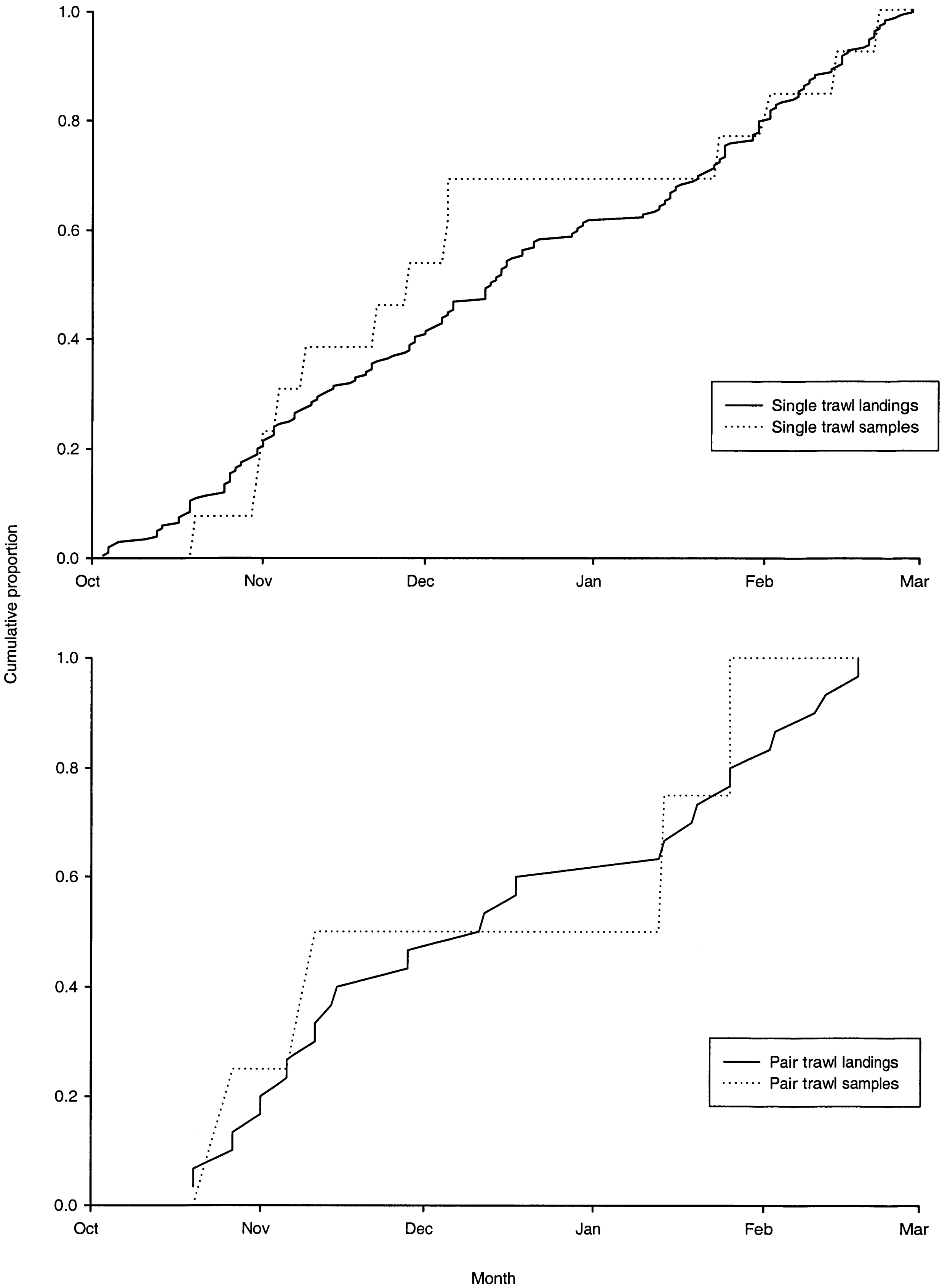


Figure 7: Proportion at age distributions determined from snapper landings sampled from the SNA 8 single trawl and pair trawl (unshaded and shaded histograms respectively) fisheries in 2005–06 using the age-length key approach.

Appendix 1: The cumulative proportion of the number of landings and samples taken from the SNA 8 single trawl and pair trawl fisheries in 2005–06.



Appendix 2: Estimates of proportion at length and c.v.s for the snapper fisheries in SNA 8 in 2005–06. 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.

Estimates of proportion at length with coefficients of variation (analytical and bootstrap estimates) for snapper from the SNA 8 single trawl fishery in 2005–06.

	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	0.0001	0.97	0.0000	0.00	0.0001	0.93	1.50
25	0.0037	0.34	0.0003	0.97	0.0025	0.41	0.52
26	0.0133	0.27	0.0024	0.63	0.0093	0.31	0.36
27	0.0237	0.24	0.0111	0.46	0.0191	0.24	0.27
28	0.0254	0.15	0.0260	0.45	0.0256	0.18	0.22
29	0.0347	0.13	0.0313	0.31	0.0335	0.13	0.16
30	0.0471	0.11	0.0505	0.27	0.0484	0.12	0.14
31	0.0672	0.09	0.0608	0.20	0.0649	0.09	0.11
32	0.0735	0.09	0.0766	0.11	0.0746	0.07	0.09
33	0.0724	0.10	0.0836	0.12	0.0765	0.08	0.09
34	0.0676	0.08	0.0739	0.10	0.0699	0.06	0.09
35	0.0490	0.03	0.0580	0.09	0.0523	0.05	0.07
36	0.0506	0.07	0.0562	0.16	0.0526	0.07	0.10
37	0.0386	0.06	0.0487	0.11	0.0423	0.07	0.09
38	0.0420	0.10	0.0600	0.17	0.0486	0.11	0.13
39	0.0370	0.08	0.0525	0.12	0.0426	0.09	0.11
40	0.0341	0.11	0.0393	0.10	0.0360	0.08	0.10
41	0.0334	0.10	0.0400	0.19	0.0358	0.10	0.13
42	0.0368	0.16	0.0434	0.20	0.0392	0.12	0.15
43	0.0310	0.10	0.0283	0.18	0.0300	0.09	0.12
44	0.0307	0.10	0.0285	0.21	0.0299	0.09	0.14
45	0.0268	0.15	0.0237	0.22	0.0257	0.12	0.15
46	0.0237	0.19	0.0200	0.23	0.0224	0.14	0.18
47	0.0221	0.15	0.0135	0.32	0.0189	0.14	0.19
48	0.0176	0.16	0.0096	0.21	0.0147	0.15	0.21
49	0.0170	0.20	0.0074	0.21	0.0135	0.20	0.26
50	0.0143	0.10	0.0092	0.20	0.0124	0.10	0.17
51	0.0095	0.36	0.0089	0.36	0.0093	0.26	0.31
52	0.0119	0.31	0.0047	0.22	0.0093	0.26	0.33
53	0.0087	0.22	0.0029	0.29	0.0066	0.23	0.31
54	0.0061	0.29	0.0034	0.23	0.0051	0.23	0.31
55	0.0055	0.26	0.0027	0.28	0.0045	0.23	0.32
56	0.0035	0.43	0.0021	0.37	0.0030	0.33	0.42
57	0.0031	0.30	0.0026	0.18	0.0029	0.20	0.33
58	0.0026	0.45	0.0040	0.13	0.0032	0.25	0.35
59	0.0026	0.36	0.0034	0.17	0.0029	0.21	0.34
60	0.0033	0.55	0.0006	0.71	0.0023	0.52	0.63
61	0.0023	0.61	0.0013	0.11	0.0019	0.44	0.52
62	0.0021	0.38	0.0005	0.76	0.0015	0.40	0.57
63	0.0013	0.54	0.0014	0.27	0.0014	0.34	0.47
64	0.0010	0.50	0.0006	0.80	0.0009	0.42	0.60
65	0.0010	0.26	0.0010	0.34	0.0010	0.20	0.49
66	0.0006	0.57	0.0005	0.71	0.0006	0.43	0.65
67	0.0008	0.41	0.0005	0.76	0.0007	0.37	0.64
68	0.0000	0.00	0.0016	0.44	0.0006	0.66	0.89
69	0.0003	0.92	0.0006	0.66	0.0004	0.57	0.92
70	0.0000	0.00	0.0002	0.97	0.0001	0.94	1.43
71	0.0000	0.00	0.0003	1.03	0.0001	0.96	1.29
72	0.0000	0.00	0.0008	0.62	0.0003	0.60	0.80
73	0.0001	1.00	0.0001	1.03	0.0001	0.71	1.04
74	0.0004	0.76	0.0006	0.66	0.0005	0.49	0.88
75	0.0000	0.00	0.0001	1.03	0.0000	0.96	1.54
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	398 184		252 444		649 944		
n	4 842		4 299		9 141		

Appendix 2 – continued:
Estimates of proportion at length with coefficients of variation (analytical and bootstrap estimates) for snapper from the SNA 8 pair trawl fishery in 2005–06.

	Pair 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	0.0000	0.00	0.0000	0.00	0.00
25	0.0000	0.00	0.0014	0.96	0.0003	1.13	1.33
26	0.0027	0.76	0.0015	0.02	0.0024	0.56	0.84
27	0.0026	0.20	0.0015	0.89	0.0024	0.20	0.53
28	0.0061	0.28	0.0059	0.02	0.0061	0.19	0.33
29	0.0148	0.17	0.0163	0.48	0.0151	0.14	0.27
30	0.0313	0.15	0.0395	0.06	0.0331	0.10	0.18
31	0.0409	0.19	0.0674	0.04	0.0468	0.14	0.20
32	0.0563	0.32	0.1023	0.16	0.0664	0.21	0.24
33	0.0534	0.27	0.1234	0.24	0.0688	0.23	0.28
34	0.0578	0.25	0.0927	0.25	0.0654	0.17	0.21
35	0.0468	0.10	0.0862	0.18	0.0554	0.14	0.20
36	0.0501	0.32	0.0718	0.02	0.0549	0.19	0.21
37	0.0506	0.21	0.0725	0.07	0.0554	0.14	0.16
38	0.0504	0.15	0.0710	0.09	0.0549	0.11	0.15
39	0.0454	0.21	0.0465	0.31	0.0456	0.15	0.17
40	0.0479	0.18	0.0397	0.18	0.0461	0.13	0.17
41	0.0515	0.04	0.0293	0.07	0.0466	0.09	0.16
42	0.0542	0.00	0.0228	0.24	0.0473	0.12	0.20
43	0.0455	0.30	0.0199	0.35	0.0399	0.24	0.28
44	0.0409	0.14	0.0156	0.63	0.0353	0.16	0.25
45	0.0394	0.36	0.0082	0.72	0.0326	0.31	0.36
46	0.0394	0.36	0.0104	0.76	0.0331	0.30	0.36
47	0.0344	0.35	0.0030	0.89	0.0275	0.33	0.40
48	0.0239	0.66	0.0045	0.89	0.0196	0.52	0.53
49	0.0184	0.44	0.0067	0.89	0.0158	0.34	0.39
50	0.0230	0.13	0.0089	0.89	0.0199	0.17	0.28
51	0.0132	0.57	0.0015	0.89	0.0107	0.47	0.53
52	0.0116	0.50	0.0030	0.89	0.0097	0.40	0.48
53	0.0074	0.63	0.0044	0.59	0.0068	0.44	0.49
54	0.0041	0.67	0.0052	0.63	0.0043	0.43	0.51
55	0.0058	0.50	0.0022	0.89	0.0050	0.38	0.50
56	0.0016	1.08	0.0015	0.02	0.0016	0.70	0.80
57	0.0034	0.10	0.0037	0.53	0.0035	0.12	0.41
58	0.0067	0.33	0.0007	0.89	0.0054	0.31	0.48
59	0.0041	0.67	0.0030	0.89	0.0039	0.47	0.57
60	0.0034	0.10	0.0000	0.00	0.0027	0.24	0.57
61	0.0016	1.08	0.0015	0.89	0.0016	0.71	0.82
62	0.0018	0.76	0.0007	0.89	0.0016	0.59	0.90
63	0.0016	1.08	0.0000	0.00	0.0012	0.88	1.07
64	0.0033	0.57	0.0014	0.96	0.0029	0.43	0.58
65	0.0017	0.10	0.0000	0.00	0.0013	0.24	0.80
66	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.00
67	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.00
68	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.00
69	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.00
70	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.00
71	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.00
72	0.0000	0.00	0.0007	0.96	0.0002	1.13	1.43
73	0.0000	0.00	0.0007	0.89	0.0002	1.12	1.64
74	0.0000	0.00	0.0007	0.89	0.0002	1.12	1.54
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	0.0008	1.08	0.0000	0.00	0.0006	0.88	1.29
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	249 712		72 433		321 722		
n	1 163		1 364		2 527		

Appendix 3: Estimates of proportion at age and c.v.s for the snapper fisheries in SNA 8 in 2005–06.
P.j., proportion of fish in age class; c.v., coefficient of variation; otolith sample size = 533

Estimates of proportion at age with coefficents of variation (analytical and bootstrap estimates) for snapper from the SNA 8 single trawl fishery in 2005–06.

Age	Single trawl						
	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	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.00
3	0.0631	0.11	0.0394	0.16	0.0544	0.12	0.23
4	0.2515	0.06	0.2556	0.06	0.2530	0.06	0.10
5	0.1530	0.10	0.1717	0.10	0.1599	0.10	0.11
6	0.1192	0.11	0.1455	0.10	0.1288	0.10	0.12
7	0.1197	0.11	0.1382	0.11	0.1265	0.11	0.12
8	0.1415	0.09	0.1426	0.09	0.1419	0.09	0.12
9	0.0110	0.47	0.0084	0.48	0.0100	0.46	0.45
10	0.0613	0.17	0.0439	0.17	0.0549	0.17	0.21
11	0.0424	0.21	0.0285	0.22	0.0373	0.21	0.25
12	0.0048	0.72	0.0020	0.74	0.0038	0.72	0.71
13	0.0090	0.43	0.0054	0.47	0.0077	0.42	0.47
14	0.0028	1.01	0.0012	1.02	0.0022	1.00	1.02
15	0.0022	0.48	0.0027	0.55	0.0024	0.47	0.52
16	0.0062	0.57	0.0044	0.54	0.0056	0.54	0.50
17	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.00
18	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.00
19	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.00
>19	0.0121	0.20	0.0082	0.23	0.0107	0.18	0.31

Estimates of proportion at age with coefficents of variation (analytical and bootstrap estimates) for snapper from the SNA 8 pair trawl fishery in 2005–06.

Age	Pair trawl						
	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	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.00
3	0.0138	0.26	0.0137	0.27	0.0137	0.23	0.32
4	0.1691	0.08	0.2820	0.07	0.1939	0.07	0.20
5	0.1355	0.10	0.2290	0.10	0.1560	0.10	0.20
6	0.1355	0.10	0.1668	0.11	0.1423	0.10	0.15
7	0.1503	0.11	0.1389	0.11	0.1478	0.11	0.11
8	0.2006	0.09	0.0988	0.12	0.1783	0.09	0.20
9	0.0145	0.48	0.0055	0.58	0.0125	0.47	0.54
10	0.0851	0.18	0.0272	0.21	0.0723	0.17	0.36
11	0.0528	0.24	0.0214	0.23	0.0459	0.23	0.40
12	0.0050	0.74	0.0016	0.81	0.0043	0.74	0.84
13	0.0098	0.45	0.0026	0.57	0.0082	0.44	0.56
14	0.0031	1.02	0.0011	1.05	0.0026	1.01	1.06
15	0.0038	0.69	0.0002	1.41	0.0031	0.65	0.85
16	0.0080	0.56	0.0033	0.61	0.0070	0.54	0.61
17	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.00
18	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.00
19	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.00
>19	0.0132	0.28	0.0077	0.37	0.0120	0.23	0.33

Appendix 4: Estimated mean weight-at-age (kg) and c.v.s for the single trawl and pair trawl fisheries in SNA 8 in 2005–06.

c.v., coefficient of variation; otolith sample size = 533

Age	Single trawl						Pair trawl						
	Spring		Summer		Spr-sum		Spring		Summer		Spr-sum		
(years)	Mean	c.v.	Mean	c.v.	Mean	c.v.	Mean	c.v.	Mean	c.v.	Mean	c.v.	*n*
1	–	–	–	–	–	–	–	–	–	–	–	–	–
2	–	–	–	–	–	–	–	–	–	–	–	–	–
3	0.46	0.02	0.49	0.02	0.47	0.02	0.49	0.03	0.49	0.04	0.49	0.03	40
4	0.69	0.01	0.70	0.01	0.69	0.01	0.72	0.01	0.73	0.01	0.72	0.01	107
5	0.86	0.02	0.87	0.02	0.87	0.02	0.90	0.02	0.87	0.02	0.89	0.02	79
6	1.10	0.02	1.11	0.02	1.10	0.02	1.14	0.02	1.07	0.02	1.12	0.02	73
7	1.28	0.03	1.26	0.03	1.28	0.03	1.34	0.03	1.17	0.03	1.30	0.03	71
8	1.64	0.02	1.56	0.02	1.61	0.02	1.65	0.02	1.45	0.03	1.63	0.02	77
9	2.02	0.11	1.78	0.13	1.95	0.12	1.99	0.10	1.59	0.17	1.95	0.11	5
10	2.23	0.03	2.12	0.04	2.20	0.03	2.18	0.03	2.10	0.06	2.17	0.03	27
11	2.57	0.04	2.55	0.05	2.56	0.04	2.48	0.05	2.78	0.06	2.51	0.05	20
12	2.52	0.06	2.51	0.06	2.52	0.06	2.51	0.06	2.48	0.06	2.51	0.06	2
13	3.16	0.06	3.17	0.07	3.16	0.06	3.20	0.08	3.08	0.06	3.19	0.07	6
14	2.35	0.01	2.35	0.01	2.35	0.01	2.35	0.01	2.35	0.01	2.35	0.01	1
15	4.35	0.06	4.26	0.06	4.31	0.06	4.17	0.07	3.76	0.01	4.16	0.07	2
16	3.33	0.05	3.54	0.05	3.39	0.05	3.45	0.05	3.41	0.07	3.44	0.05	4
17	–	–	–	–	–	–	–	–	–	–	–	–	–
18	–	–	–	–	–	–	–	–	–	–	–	–	–
19	–	–	–	–	–	–	–	–	–	–	–	–	–
>19	4.63	0.04	5.19	0.06	4.79	0.04	4.73	0.06	5.09	0.10	4.78	0.05	19

Appendix 5: Age-length key derived from otolith samples collected from snapper fisheries in SNA 8 in 2005–06.

Estimates of proportion of age at length for snapper sampled from SNA 8, spring and summer 2005–06.
(Note: Aged to 01/01/2006)

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	0	1.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
25	0	0	1.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9
26	0	0	0.89	0.11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9
27	0	0	0.83	0.17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12
28	0	0	0.69	0.31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13
29	0	0	0.23	0.77	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13
30	0	0	0.05	0.81	0.05	0.05	0.05	0	0	0	0	0	0	0	0	0	0	0	0	0	21
31	0	0	0	0.75	0.25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20
32	0	0	0	0.66	0.26	0.03	0.03	0.03	0	0	0	0	0	0	0	0	0	0	0	0	35
33	0	0	0	0.39	0.45	0.09	0.06	0	0	0	0	0	0	0	0	0	0	0	0	0	33
34	0	0	0	0.44	0.28	0.20	0.08	0	0	0	0	0	0	0	0	0	0	0	0	0	25
35	0	0	0	0.30	0.37	0.20	0.10	0.03	0	0	0	0	0	0	0	0	0	0	0	0	30
36	0	0	0	0.03	0.47	0.34	0.16	0	0	0	0	0	0	0	0	0	0	0	0	0	32
37	0	0	0	0	0.32	0.26	0.39	0.03	0	0	0	0	0	0	0	0	0	0	0	0	31
38	0	0	0	0	0.15	0.35	0.19	0.23	0.04	0.04	0	0	0	0	0	0	0	0	0	0	26
39	0	0	0	0	0	0.46	0.33	0.21	0	0	0	0	0	0	0	0	0	0	0	0	24
40	0	0	0	0	0	0.42	0.42	0.17	0	0	0	0	0	0	0	0	0	0	0	0	24
41	0	0	0	0	0.08	0.20	0.16	0.44	0	0.08	0.04	0	0	0	0	0	0	0	0	0	25
42	0	0	0	0	0	0.10	0.30	0.55	0.05	0	0	0	0	0	0	0	0	0	0	0	20
43	0	0	0	0	0	0.05	0.26	0.58	0	0.11	0	0	0	0	0	0	0	0	0	0	19
44	0	0	0	0	0	0	0.45	0.55	0	0	0	0	0	0	0	0	0	0	0	0	11
45	0	0	0	0	0	0	0.08	0.54	0	0.23	0.15	0	0	0	0	0	0	0	0	0	13
46	0	0	0	0	0	0	0.11	0.44	0	0.33	0.11	0	0	0	0	0	0	0	0	0	9
47	0	0	0	0	0	0	0	0.64	0.09	0.18	0.09	0	0	0	0	0	0	0	0	0	11
48	0	0	0	0	0	0	0	0	0.20	0.40	0.40	0	0	0	0	0	0	0	0	0	5
49	0	0	0	0	0	0	0	0.17	0	0.33	0.17	0.17	0	0.17	0	0	0	0	0	0	6
50	0	0	0	0	0	0	0	0	0	0.75	0.25	0	0	0	0	0	0	0	0	0	4
51	0	0	0	0	0	0	0	0	0	0.50	0.33	0	0.17	0	0	0	0	0	0	0	6
52	0	0	0	0	0	0	0	0.17	0.17	0.33	0	0.17	0.17	0	0	0	0	0	0	0	6
53	0	0	0	0	0	0	0	0	0	0.20	0.40	0	0.20	0	0	0.20	0	0	0	0	5
54	0	0	0	0	0	0	0	0	0	0	1.00	0	0	0	0	0	0	0	0	0	3
55	0	0	0	0	0	0	0	0	0	0	0.50	0	0	0	0	0.50	0	0	0	0	2
56	0	0	0	0	0	0	0	0	0	0.50	0	0	0.50	0	0	0	0	0	0	0	2
57	0	0	0	0	0	0	0	0	0	0	0.50	0	0	0	0	0	0	0	0	0.50	2
58	0	0	0	0	0	0	0	0	0	0	0	0	0.33	0	0.33	0.33	0	0	0	0	3
59	0	0	0	0	0	0	0	0	0	0	0.67	0	0	0	0	0.33	0	0	0	0	3
60	0	0	0	0	0	0	0	0	0	0	0	0	0.33	0	0	0	0	0	0	0.67	3
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	1.00	1
63	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.00	0	0	0	0	0	1
64	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.00	1
65	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.00	1
66	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.00	1
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	0	0
69	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
70	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.00	1
71	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.00	2
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	2
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	0	0
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																					533