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Tini a Tangaroa

Catch-at-age of snapper in SNA 7 in the 2019–20 fishing year

New Zealand Fisheries Assessment Report 2021/24

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A programme to estimate the age composition of snapper (SNA 7) caught by bottom trawl fisheries targeting snapper (SNA), flatfish (FLA), and red gurnard (GUR) was conducted during the 2019–20 fishing year. Sampling of landed catches was conducted weekly at Talley's Seafoods in Nelson and Motueka between October 2019 and March 2020. The target number of sampled landings was 30, and landings qualified for inclusion if they were at least 300 kg, the target species was SNA, GUR, or FLA and were taken from Statistical Areas 037 or 038.

A total of 30 landings were sampled from October 2019 through to early March 2020 with otoliths collected from a total of 1800 snapper. Data collected were entered into the Fisheries New Zealand *market* database and the otoliths stored at the National Institute of Water and Atmospheric Research for age determination. Five landings were excluded because they were outside the area or targeted the wrong species.

A subsample of 999 otoliths was selected for ageing from 1500 random age frequency samples from twenty-five qualifying SNA 7 landings. Bottom trawl landings were dominated by the 2015, 2011, and 2008 fishing year age classes (5, 9, and 12 year olds) and collectively accounted for over half (52%) of fish landed in 2019–20. These year classes are likely to be significant to the fishery for a number of years, although evidence of high inter-annual recruitment variability is also present. The mean weighted coefficient of variation for the SNA 7 age composition was 21%, just above the target of 20%.

1. INTRODUCTION

The purpose of this project was to estimate the relative year class strengths of snapper (*Chrysophrys auratus*, SNA) in the SNA 7 commercial catch by sampling landings at the major SNA 7 licensed fish receiver (LFR) during the 2019–20 fishing year. Sampling involved the collection of length and age composition samples and data from commercial landings before fish were sorted or processed. This provides relative catch-at-age information that may be combined with estimates of selectivity-at-age within an age-structured population model to estimate stock age composition and to determine year class strengths of cohorts recruited to the stock. Snapper stocks characteristically show large inter-annual variability in year class strength (Francis 1993, Walsh et al. 2011), therefore catch-at-age information is an important input into models used for their assessment.

SNA 7 currently supports a modest but important shared fishery in Tasman Bay and Golden Bay, with a Total Allowable Commercial Catch (TACC) allowance of 350 t and a non-commercial allowance of 270 t. Reported annual commercial landings from SNA 7 declined from 2720 t in the 1977-78 fishing year to 142 t in 1997–98 fishing year (please note that fishing years straddle calendar years, and a fishing year is denoted by the most recent part of the fishing year (i.e., 2018 denotes the 2017–18 fishing year). The TACC was set at 330 t when it was introduced into the Quota Management System (QMS) in 1986–87, but the TACC was reduced to 160 t in 1989–90 and then increased to 200 t in 1997–98. The fishery was unable to catch the 200 t TACC from 1997–98 to 2002–03 but has generally exceeded 200 t since 2010–11 (Fisheries New Zealand 2020). In 2016–17 the TACC was increased to 250 t, which was again consistently exceeded, with a further increase to the TACC to its current level (350 t) from 1 October 2020.

Stock assessments of SNA 7 in 2014 and 2018, based on an age-structured population model, concluded that biomass had increased rapidly since 2009 due to the recruitment of two strong year classes (Langley 2015, 2018). Following the 2014 assessment, the TACC for SNA 7 was increased to 250 t, and the non-commercial allowance was increased to 270 t. The year classes responsible for the increase in biomass within SNA 7 had been sampled only once for the 2014 assessment (i.e., in 2013–14, see Parker et al. 2015), but the result was confirmed on resampling in 2016–17 (see Parsons et al. 2018), and these data were subsequently used in the 2018 assessment. Furthermore, an update of the 2018 assessment in 2019 incorporated updated commercial Catch Per Unit Effort and trawl survey age structure information and resulted in a further increase of the TACC for SNA 7 to 350 t (Langley 2020). This 2019 assessment update recommended further sampling of the snapper age composition to better understand the relative strength of the dominant year classes (Langley 2020).

The objectives of the project, as described in the Fisheries New Zealand tender document, were:

1. To characterise the SNA 7 fishery.
2. To conduct representative sampling to determine the length and age structure of the commercial catch of snapper in SNA 7 during the 2019–20 fishing year. The target coefficient of variation (CV) for the catch-at-age is 20% (mean weighted CV across all age classes).

2. METHODS

2.1 Fishery characterisation

The spatial, temporal, and operational details of the SNA 7 fishery were summarised for the period 2015–2020 (2014–15 to 2019–20 fishing years). The characterisation was based on an extract from the Fisheries New Zealand catch and effort database and analysed using the National Institute of Water and Atmospheric Research's (NIWA's) Catch-at-length and -age analysis (CALA) program. Operational aspects such as fishery timing, gear type, target species, statistical area, and fine scale spatial distribution were summarised. This characterisation was conducted after all sampling had been conducted, and the design of the sampling conducted in 2019–20 was similar to that of the previous sampling programme (see below).

2.2 Catch-at-age sample design

The purpose of estimating the age composition of the SNA7 catch is to add to the previous age composition data that inform the stock assessment model. Therefore, it was important for the sampling design to be consistent with the previous sampling programmes and data generated for the purpose of age composition of the catch. The catch sampling design implemented for the 2019–20 fishing year was based on operational details from the fishery as characterised for the previous catch sampling programme (Parker et al. 2015, Parsons et al. 2018), but with the addition of tows targeting red gurnard (GUR, which has recently become an increasingly important target in SNA 7, see section 3.1) as well as snapper and flatfish (FLA). The operational details were:

- Bottom trawl only
- Statistical Areas 037 + 038
- Target species of SNA, FLA, or GUR
- Landings in October through to March
- Landed into Talley's (Nelson or Motueka)
- Minimum landing size of 300 kg.

Identification of the actual target species can be difficult to attain at the time of sampling. Therefore, the reported target species at the time of landing was ignored (i.e., a sample was obtained regardless of the target species that was communicated to the catch samplers).

The target of a 20% Mean Weighted Coefficient of Variation (MWCV) was the same as the most recent SNA 7 catch sampling programme in the 2016–17 fishing year. In that last programme, a MWCV of 19% was achieved with a sample size of 27 qualifying landing samples and 1000 otoliths aged (Parsons et al. 2018). Similar variation was anticipated for sampling conducted in the 2019–20 fishing year. As a result, a target sample size of 30 sampled landings was implemented.

The random age frequency approach was used, where 60 fish were selected at random from the catch for sampling, and subsequently otoliths selected for ageing in proportion to the relative weight of the landings (Davies & Walsh 2003). As such, more otoliths are collected than are aged.

The agreed catch sampling programme design was implemented from October 2019 to March 2020, with the intention that catch sampling should match the seasonal pattern in landings by sampling weekly instead of developing monthly targets based on the landing patterns from previous years. It was expected that minor adjustments in the number of samples and their timing would be needed to match the fishery operations in a given year.

All sampling was designed, conducted, and analysed following recommended practices documented in "Guidelines to the design, implementation and reporting of catch sampling" (Ministry of Fisheries 2008).

Fish were sampled using the following procedure:

1. Details for each trip were obtained from each processor to complete the landing record; i.e., the vessel, estimated landing weight (all fish), estimated landed weight of SNA, landing date, and statistical area of the capture of fish in a landing.

2. The sample was assigned a Fisheries New Zealand *market* database landing number. This is typically based on the calendar year, the code for the sampling programme, and a two-digit sample sequence.
3. Approximately 15 bins of fish were chosen from a landing. A sampler would then count through 300 fish from these 15 bins and be blindly prompted to select a fish for otolith extraction by another sampler. This sampling process was conducted according to a random sampling form which had 60 of 300 lines randomly highlighted. A unique random sampling form was used for each sampling event. If the 15 bins selected did not contain 300 fish, the samplers returned to the first bin and began recounting fish until they reached 300 (and as a result had also selected 60 fish).
4. Fork length (FL) (rounded down to the nearest cm), sex, and gonad stage (5 stage method, see Beentjes et al. 2012) were recorded, and both otoliths were removed with forceps, cleaned of adhering tissue, dried, and placed in otolith envelopes.
5. The landing number, species, fish number, date, length, sex, and sampler initials were recorded on the otolith envelope.
6. A landing record form was completed at the end of the sampling.

2.3 Quality assurance of sampling processes

All sampling events were conducted by two samplers, one measuring fish length and extracting otoliths and the other recording the relevant information. Catch sampling was conducted by trained science staff and at least one of the samplers at each event was highly experienced. Furthermore, a sampler with three decades experience in sampling made two mentoring visits to work with three of the SNA 7 sampling staff to ensure that sampling practice was consistent. In addition, comparisons of a full (300 fish) length frequency measurement distribution with the length frequency distribution of fish subsampled for otolith collection (60 fish) were conducted for all samplers that led SNA 7 sampling events (Appendix 1).

2.4 Snapper age determination

A standardised procedure for reading otoliths was followed, outlined in the age determination protocol for snapper (Walsh et al. 2014). Two readers aged SNA 7 otolith samples in 2019–20, with neither reader having any prior knowledge of the other's zone count, or of the fish length. For otoliths where both readers agreed on the zone count, the age was determined from this count. When readers disagreed, the otolith was re-examined to determine the likely source of disagreement, and a final count agreed upon. The forced margin method was implemented to anticipate the otolith margin type (wide, line, narrow) *a priori* based on the month in which the fish was sampled to provide guidance in determining age. To determine the 'fishing year age class' of fish using the forced margin, 'wide' readings are increased by 1 year (e.g., 3W is aged as a 4 year old) whereas 'line' and 'narrow' readings remain the same as the zone count (e.g., 4L or 4N are aged as a 4 year old), meaning that regardless of whether the fish was caught before or after the nominal birth date of 1 January, age remains the same throughout, unlike that which would be used for age groups/age classes or in growth rate estimation (see Walsh et al. 2014). Please note that due to the nominal birth date of 1 January as above, a specific year class is referred to by the year that 1 January is associated with for the year class in question.

Otolith reading precision was quantified by carrying out between-reader comparison tests after Campana et al. (1995), including those between each reader and the agreed age. The Index of Average Percentage Error, IAPE (Beamish & Fournier 1981), and MWCV (Chang 1982) were calculated for each test.

2.5 Snapper catch-at-age analysis

NIWA's catch-at-length and at-age analysis software tool CALA (catch-at-length and at-age, Francis & Bian (2011)) was used in the calculation of proportion-at-age and variance (bootstrap) estimates for the SNA 7 bottom trawl fishery from the random age frequency samples collected from each landing. Proportions-at-age across all landings within the sampling period were estimated from sample proportions, weighted by the estimated number of fish in each landing. Proportions-at-age were calculated for the range of fishing year age classes (herein referred to as ‘age classes’ encompassing October 2019 to March 2020) recruited, with the maximum age being an aggregate of all age classes over 29 years. Estimates of proportions of length-at-age were also calculated. All fish over 29 years were aggregated and assigned to an over 29 age group (although plots and appendices presented in this report are summarised to an over 19 age group).

3. RESULTS

3.1 Fishery characterisation

A fishery characterisation was not conducted prior to sampling because the SNA 7 fishery had been characterised twice in the recent past (Parker et al. 2015, Parsons et al. 2018), and the main components of the fishery that the sample design was based on were expected to be stable.

Since 2010–11, the SNA 7 fishery has landed annual catches ranging from 189 t (2015–16) to 263 t (2016–17 and 2017–18). Catches were mainly from bottom trawl, with 89% of snapper catch taken by this method in 2019–20 and an average of 88 % in the past six years (Figure 1). Bottom pair trawl landings comprised about 17% of the landings up to 2012 (Parker et al. 2015), but this method has not been used in recent years.

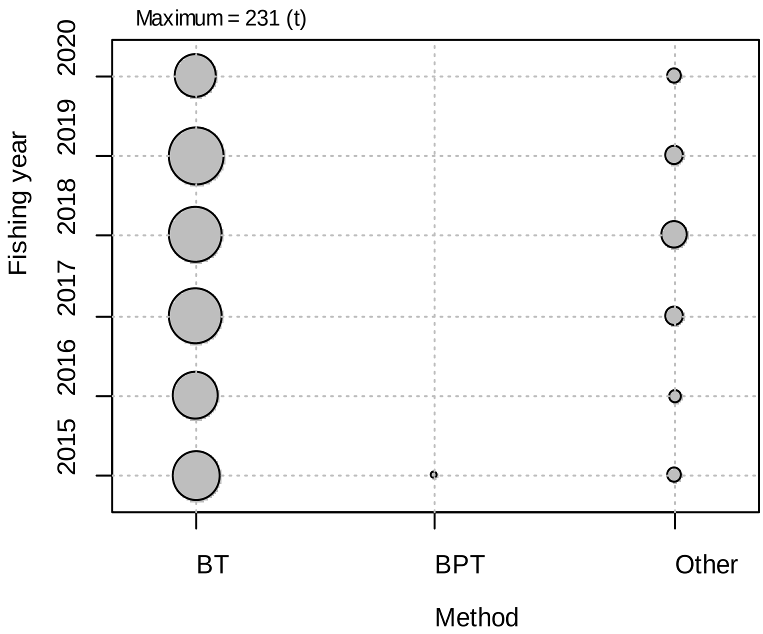

Figure 1: Snapper catch (t) by gear type from the SNA 7 fishery between 2015 and 2020 (2020 includes data up to March only). BT = bottom trawl, BPT = bottom pair trawl, and Other comprises principally longline and Danish seine.

On average over the past six years about 60% of the bottom trawl snapper catch was taken from Statistical Area 038 (Tasman Bay/Golden Bay), with smaller landings percentages from Statistical Areas 017 (about 6%), 035–037 (about 29%) and 039 (about 3%) (Figure 2 & Figure 3). Many trips straddled Statistical Areas 037 and 038. No major annual change in the spatial location of fishing effort or catch was observed.

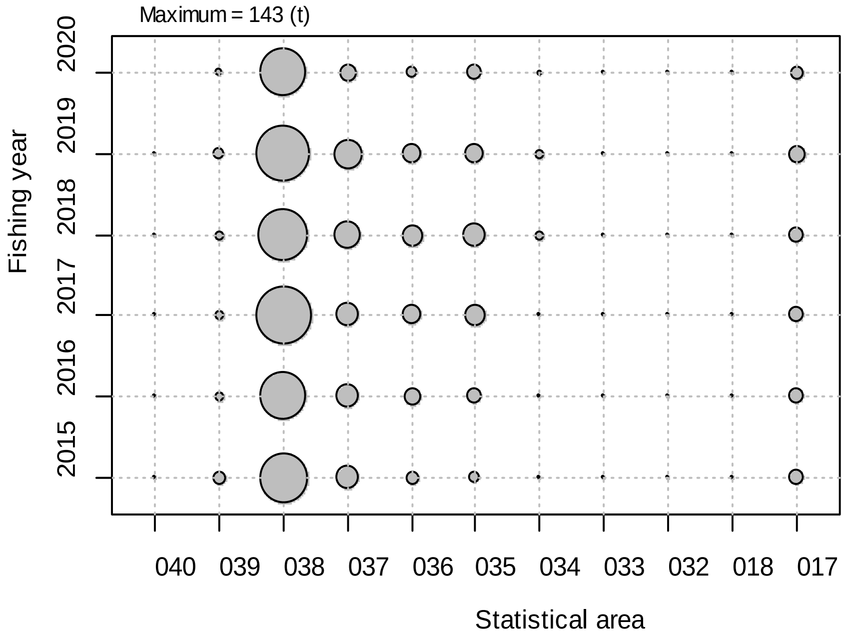

Figure 2: Snapper catch (t) by Statistical Area from the SNA 7 bottom trawl fishery between 2015 and 2020 (2020 includes data up to March only).

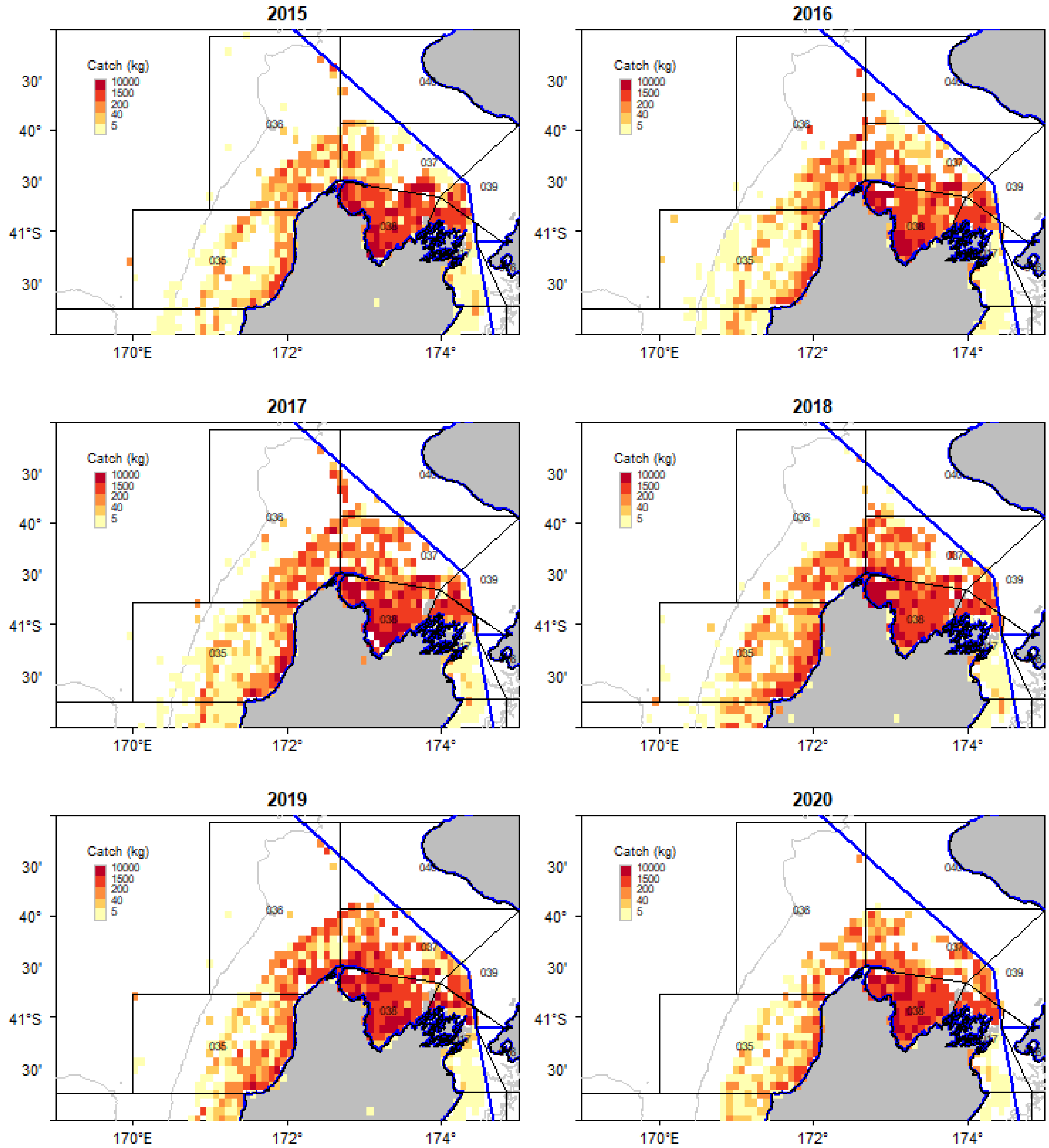

Figure 3: Spatial distribution of reported SNA 7 catch around the northern South Island, 2015–2020 (the 2020 plot includes data up to March only). Black lines delineate statistical areas and blue lines indicate boundaries of Quota Management Areas.

The majority of catch between 2015 and 2020 occurred in October to December, with significant catches continuing monthly through to April, and a diminishing trend for the remainder of the fishing year (Figure 4). An average of 72% of the bottom trawl landings from 2015 to 2019 occurred between October and March. The entire 2020 fishing year was not included in this characterisation due to the timing of the data extract. However, by the end of March 2020 bottom trawl alone had already caught 158 t of the 250 t total allowable commercial catch (63%) for SNA 7 (Figure 4).

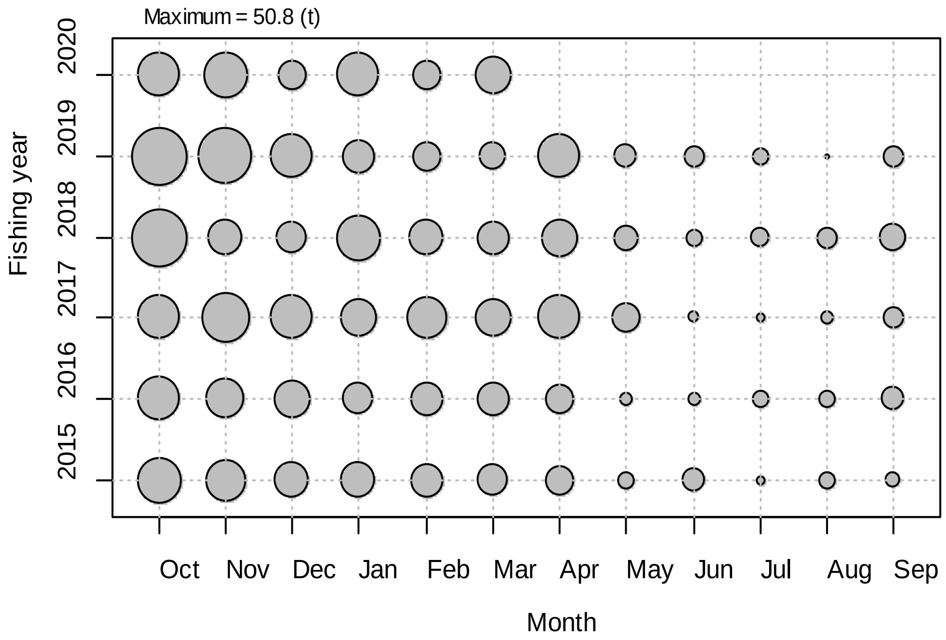

Figure 4: Monthly pattern of snapper catch (t) from the SNA 7 bottom trawl fishery between 2015 and 2020 (2020 includes data up to March only).

The majority of snapper landed by bottom trawl was taken while targeting FLA, SNA, and GUR, with the remainder from a range of other species (Figure 5). This pattern was consistent between 2015 and 2020 and similar to that reported by the previous two characterisations (see Parker et al. 2015 and Parsons et al. 2018). Although GUR developed as an important target prior to 2012 (see Parker et al. 2015), it was the most commonly recorded target in the 2019 and 2020 fishing years.

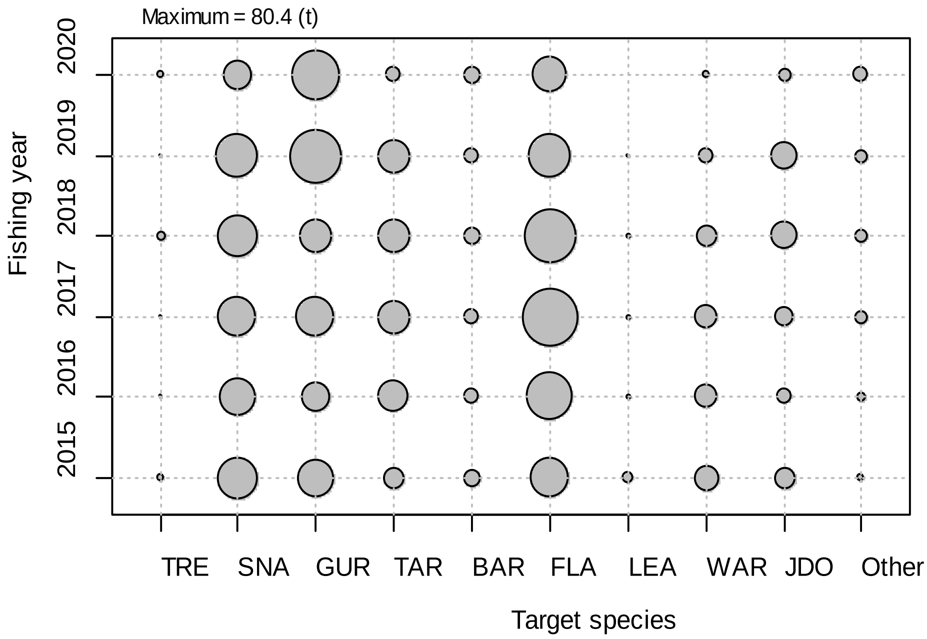

Figure 5: Target species associated with snapper catch (t) from the SNA 7 bottom trawl fishery between 2015 and 2020 (2020 includes data up to March only). Previously undefined species codes as follows: TRE = trevally, TAR = tarakihi, BAR = barracouta, LEA = leatherjacket, WAR = common warehou, JDO – John dory.

3.2 Sample representativeness

A total of 30 landings were sampled between October 2019 and March 2020. Five of these landings were subsequently excluded because some of the associated fishing effort (and snapper catch) occurred outside Statistical Areas 037 and 038 and targeted other species.

Overall the temporal pattern of landings sampled was similar to that of all landings but with some marginal over-sampling relative to catch in December and February, and consequently some under-sampling relative to catch in March (Figure 6). The approach of opportunistically sampling as landings became available matched temporal patterns in the fishery well as it did in the previous programme (Parsons et al. 2018) and better than the targeted approach implemented in the 2014–15 programme (Parker et al. 2015).

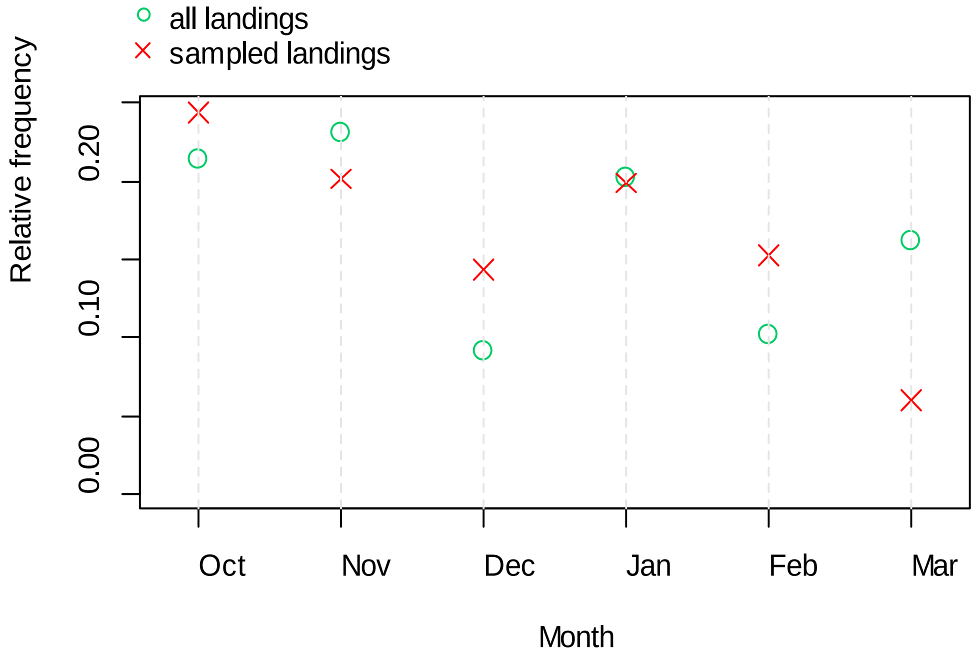

Figure 6: Relative proportions of landings sampled by the catch sampling programme compared with the relative frequency of landings of SNA 7 in the 2019–20 fishing year.

Spatially, sampled landings were constrained to Statistical Areas 037 and 038, as designated by the sampling design. Within these areas, the pattern of overall fishery catch compared with that of the sampled landings was similar (Figure 7).

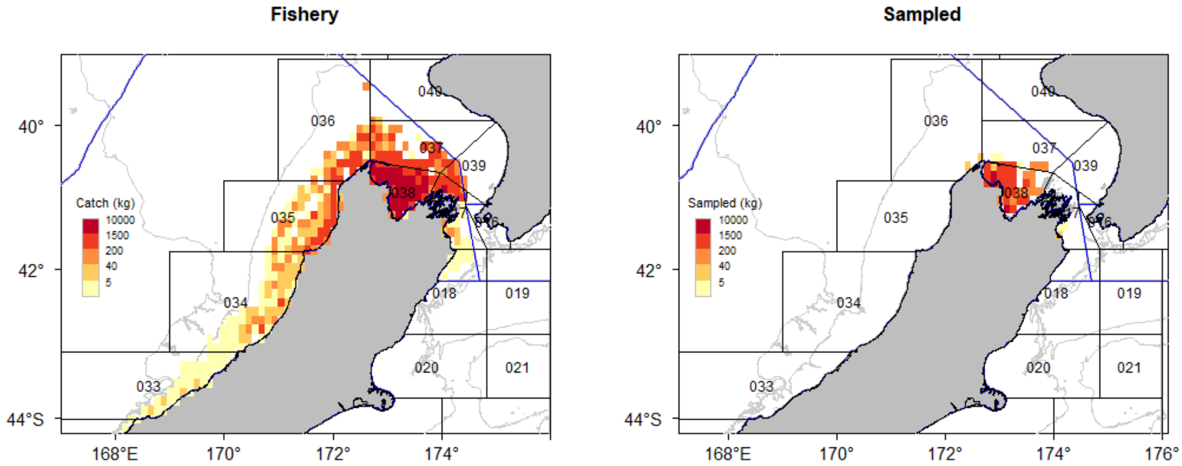

Figure 7: Spatial distribution of bottom trawl catch of snapper in 2020 (to March) for the whole SNA 7 fishery (left panel) compared with just the sampled landings (right panel). Black lines delineate Statistical Areas and blue lines indicate boundaries of Quota Management Areas.

3.3 Ageing SNA 7 otolith samples from 2019–20

A subsample of 1000 otoliths was randomly selected for ageing (with the number of otoliths within each landing based on weight of the landing) from the 1500 otoliths collected from twenty-five SNA 7 landings. The length distribution of the subsampled fish was representative of the larger random age frequency sample (Figure 8 & Figure 9).

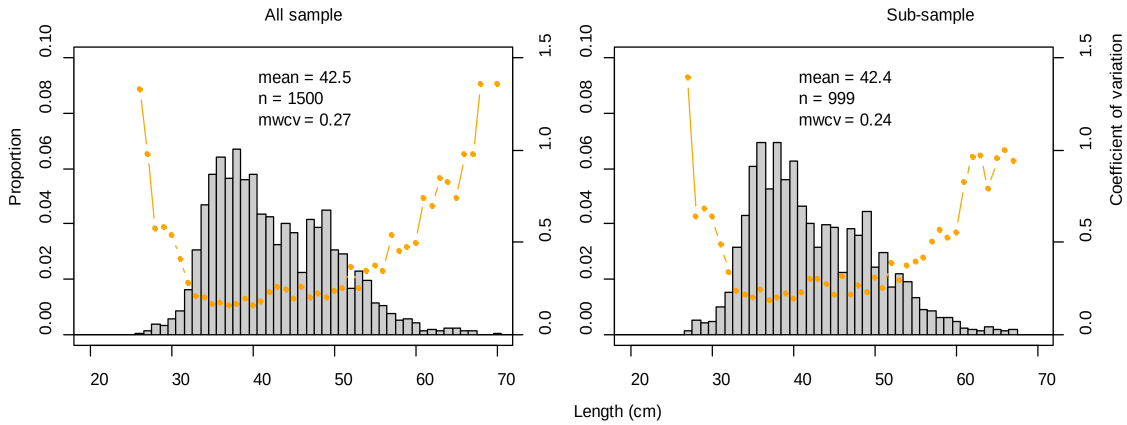

Figure 8: Proportion-at-length distributions (histograms) and CVs (lines) of the random age frequency sample (and subsample) determined from snapper landings sampled from the SNA 7 bottom trawl fishery in 2019–20 from October–March (n, sample size; MWCV, mean weighted CV).

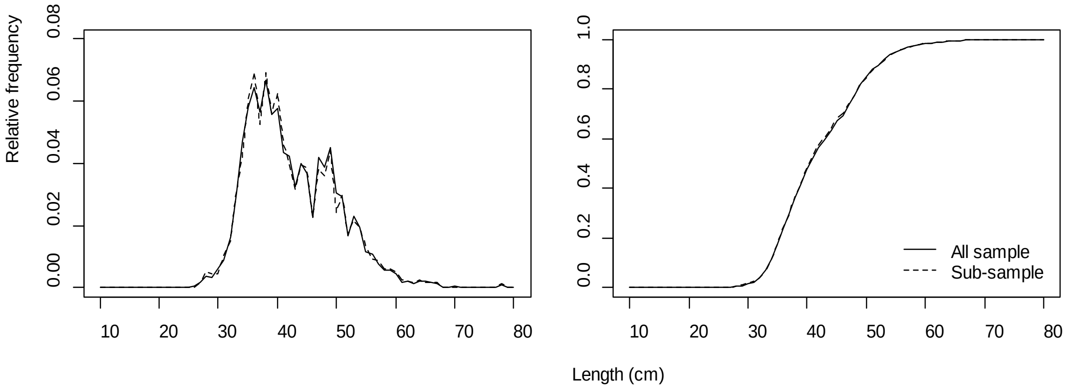

Figure 9: Comparison of the proportion- and cumulative proportion-at-length distributions of the random age frequency sample (solid line), and subsample (dashed line) determined from snapper landings sampled from the SNA 7 bottom trawl fishery in 2019–20 from October–March.

3.4 Reader comparison tests for SNA 7 readings

Of the total subsample of 1000 otoliths selected for ageing, 999 were successfully aged with one removed from the collection as a noticeable outlier due to an incorrect length measurement. Between-reader tests from reading these 999 otoliths showed a high level of consistency between readers (Figure 10). Overall there was a high level of agreement (90.5%) between the readers and only minor systematic differences (bias) in the first counts of snapper otoliths (Figure 10a–c). Between-reader CV and IAPE scores were equal to 1% or less (Figure 10c) and the analyses show that precision was high for almost all age classes (Figure 10d). Comparisons of age-bias plots for readers 1 and 2 with the agreed age show that overall agreement was high (100% and 90.5%) and precision was high, with CV and IAPE estimates equal to 1% or less (Figure 10e and f).

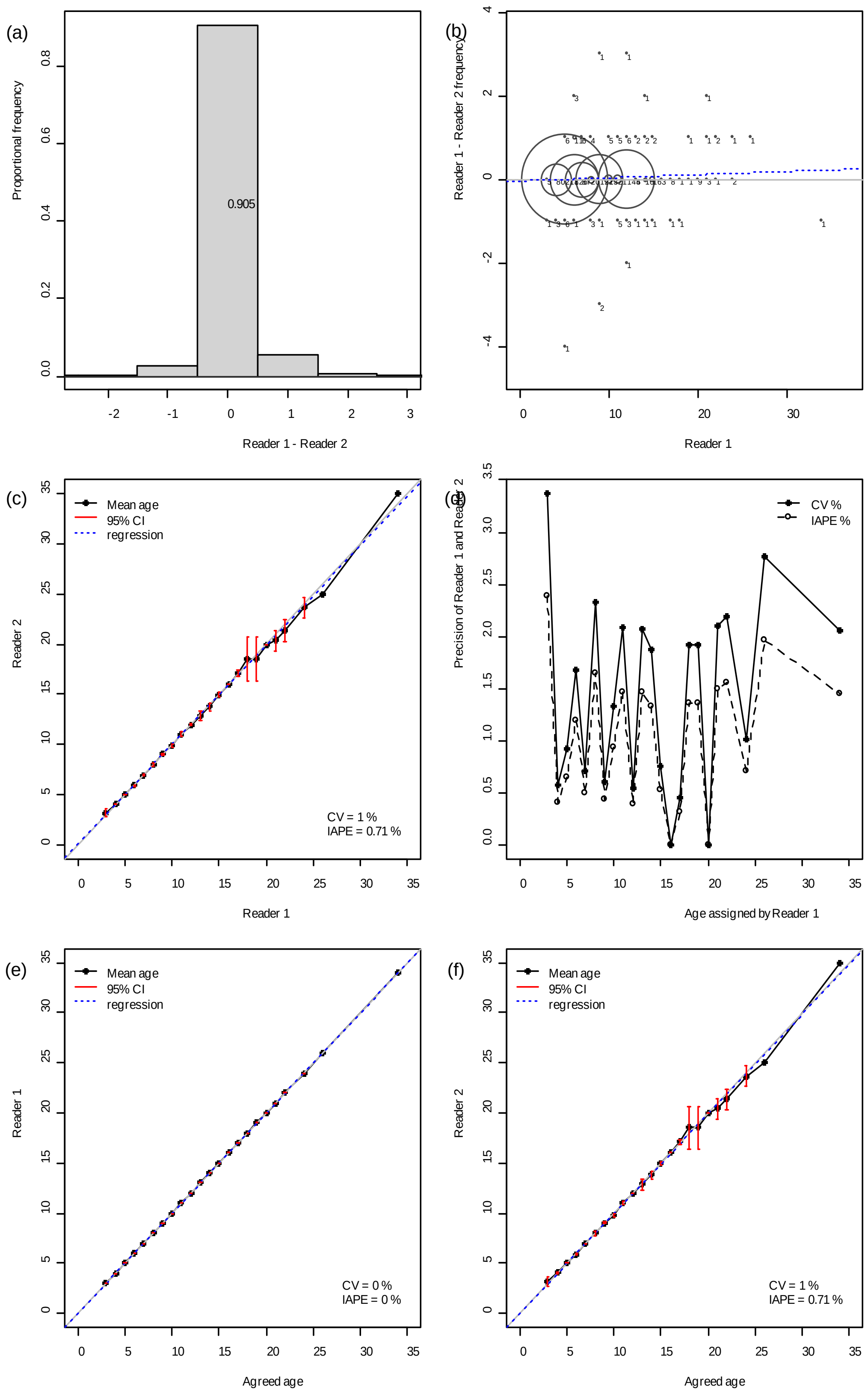

Figure 10: **Results of between-reader comparison tests (Reader 1 and 2) for SNA 7 otoliths collected in 2019–20 (n = 999): (a) histogram of differences between readings for the same otolith; (b) differences between readers for a given age assigned by Reader 1; (c) bias plot between readers; (d) CV and IAPE profiles (precision) relative to the age assigned by Reader 1; (e, f) bias plot between Reader 1 and Reader 2 and agreed age. The expected perfect agreement (solid line) and actual relationship (dashed line) between readers are overlaid on (b) and (c), and between reader 1 and 2 and the agreed age on (e) and (f).**

3.5 SNA 7 bottom trawl catch-at-age estimates

Catch-at-age compositions with bootstrapped variance estimates were derived for the October to March sampling period (Figure 11, Appendices 2 & 3). Cumulative proportion-at-age comparisons are also shown in Figure 12.

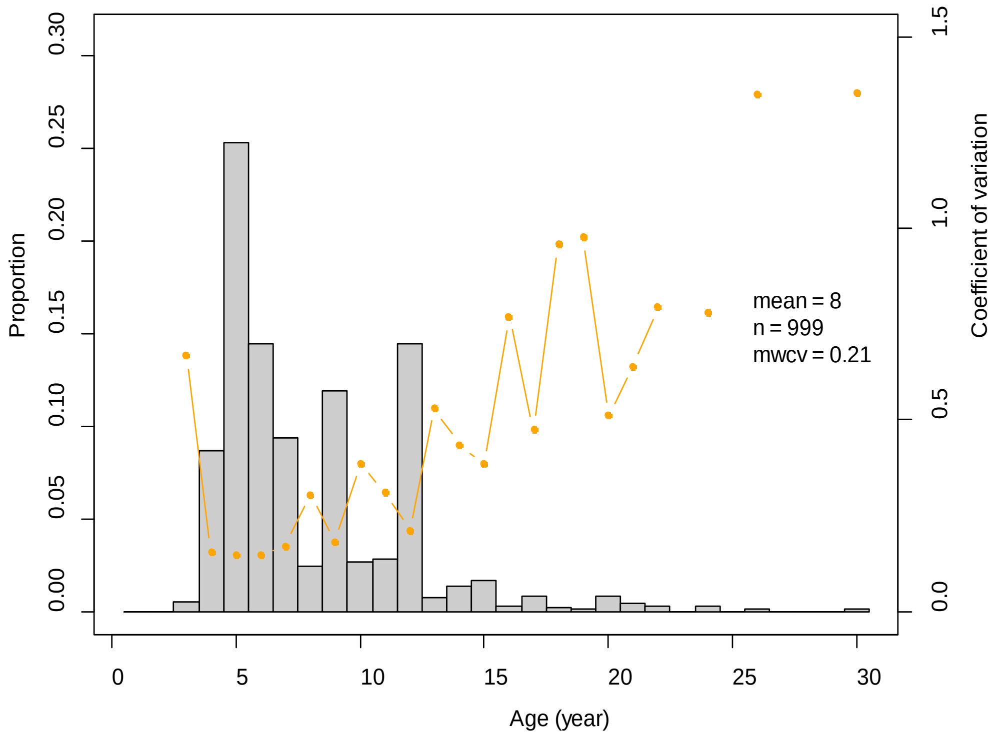

Figure 11: Proportion-at-age distributions (histogram) and CVs (line) determined from snapper landings sampled from the SNA 7 bottom trawl fishery in 2019–20 from October to March (n, sample size; MWCV, mean weighted CV).

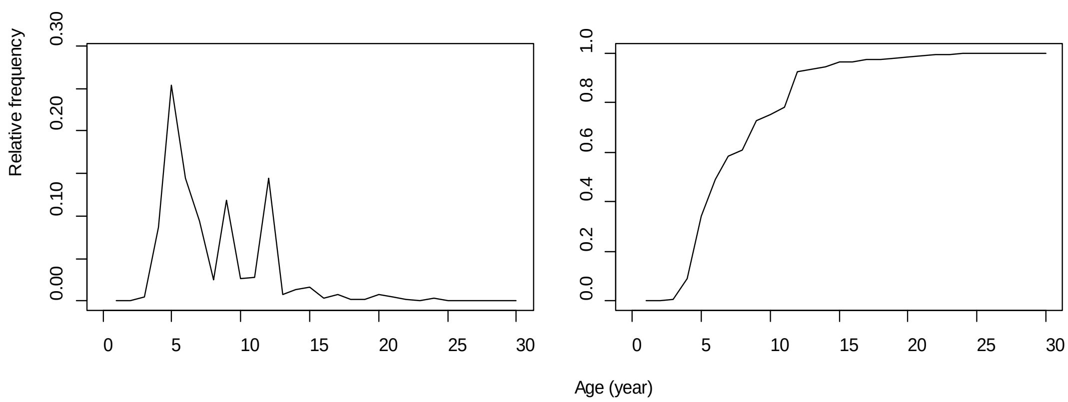

Figure 12: The proportion- and cumulative proportion-at-age distributions determined from snapper landings sampled from the SNA 7 bottom trawl fishery in 2019–20 from October to March.

The SNA 7 bottom trawl catch in 2019–20 consisted mainly of young to moderate aged fish, those 4 to 12 years of age collectively making up over 90% of the landed catch by number (Figure 11, see Appendix 3). The 2015 year class (5 year olds) was the most dominant, accounting for one-in-four snapper in SNA 7 landings in 2019–20 and is expected to be fully recruited to the fishery comprising individuals between 32 and 41 cm in length (Appendices 3 & 4). Other prominent year classes in the distribution were 2011 and 2008 (9 and 12 year olds) and to a lesser extent 2014 (6 year olds). With the exception of the moderate strength 2016 and 2013 years classes (4 and 7 year olds), most other year classes were based on relatively low numbers of fish and appear weak in comparison. The oldest fish sampled from the fishery in 2019–20 was 34 years old, with thirteen fish over 20 years of age in the subsample of 999 fish that were aged (Figure 11). The mean age of snapper in the SNA 7 fishery from October to March was 8.0 years and the MWCV was 21%, the precision indicative of relatively low between-landing variability.

Inspection of the time series of proportion-at-age distributions demonstrated a noticeable broadening in 2019–20 compared with that seen in recent years when the fishery comprised few contributing year classes and a distinct lack of accumulation of older aged fish compared with the age distributions of the late 1990s (Figure 13). With the presence of at least three age classes of above average strength in the 2019–20 age distribution, the SNA 7 bottom trawl fishery now contains more strong year classes and a higher mean age (about 8.0 years) than has been seen in almost two decades.

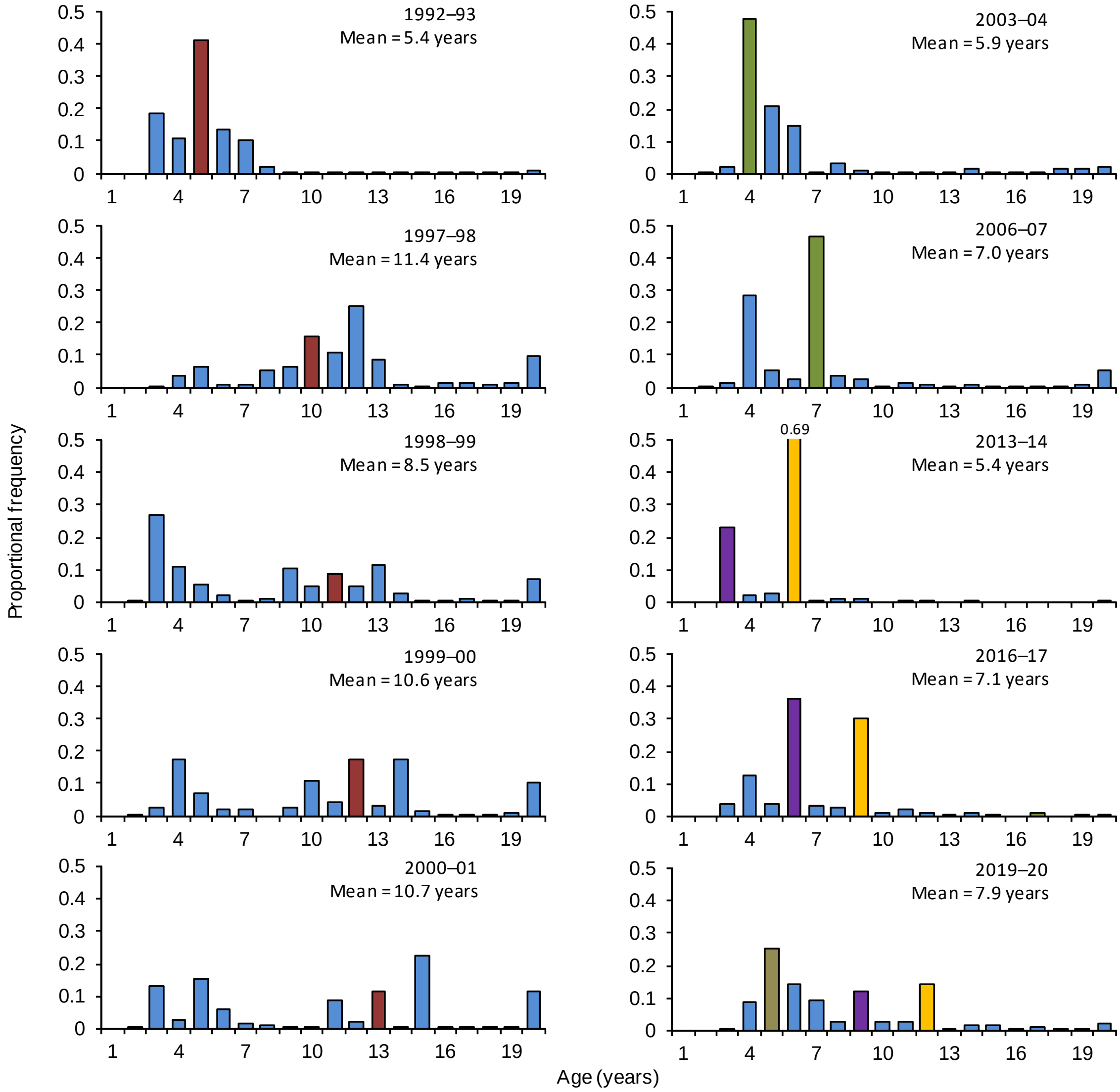

Figure 13: Intermittent time series of SNA 7 proportion-at-age distributions, 1992–93 (1993) to 2019–20 (2020). The 1988 year class is coloured maroon, 2000 year class green, 2008 year class yellow, 2011 year class purple, and the 2015 year class brown. Age distributions for all years contain an over 19 group. The 2013–14 (2014), 2016–17 (2017), and 2019–20 (2020) age distributions comprise sample data from only Statistical Areas 037 and 038, whereas previous age distributions may have sampled vessels that fished across all statistical areas of SNA 7.

4. DISCUSSION

The SNA 7 bottom trawl fishery targeting SNA, FLA, and GUR in Statistical Areas 037 and 038 was sampled for length and otoliths during the first half of the 2019–20 fishing year. A total of 30 landings were sampled, with 25 qualifying to represent the core SNA 7 fishery. A total of 1500 pairs of otoliths were collected from those qualifying landings, of which 999 were aged.

The patterns in the SNA 7 fishery (i.e., gear type, target species, monthly trends in catch) have been stable over the last few years and are similar to that presented in previous characterisations (Parker et al. 2015, Parsons et al. 2018). The most significant catch has been taken by bottom trawl in Statistical Area 038. It is likely that although a target species is usually recorded, the vessels are often fishing for a mix of species, in particular SNA, FLA, and GUR, but also John dory (JDO) and tarakihi (TAR).

Otolith reader comparison tests demonstrated a high level of agreement, indicating precise ageing. Furthermore, the MWCV of 0.21 was just above the target of 20%, indicating that the target of 30 landings and 1000 otoliths was 'sufficient' to describe the age composition of the fishery. However, with increasing numbers of significant year classes in the fishery, the MWCV is unlikely to improve without increasing the number of fish aged.

The SNA 7 age composition for 2019–20 was dominated by the 2015, 2011, and 2008 year classes (5, 9, and 12 year olds), which collectively accounted for over half (52%) of snapper landed by bottom trawl. The 2011 and 2008 year classes contributed a significant amount of weight to the total catch when sampling was conducted in 2013–14 and 2016–17 (Parker et al. 2015, Parsons et al. 2018). Despite their relative proportional decline in the 2019–20 age composition, individual mean lengths and weights for snapper occupying the 2011 and 2008 year classes continued to increase (approximating 47 and 51 cm and 2.1 and 2.6 kg respectively), due to the fast growth rate achievable in SNA 7—possibly the fastest of all snapper in New Zealand. Although the numbers of older age classes present in SNA 7 over the past decade have remained relatively low (Parker et al. 2015, Parsons et al. 2018), a consistent broadening in the proportions of young to moderate age classes has been apparent and confirms further improvement in the fishery as the stock continues to rebuild (Langley 2015, 2018, MacGibbon 2019).

Part of the age composition presented includes two landings (of 25 total qualifying landings), where a small amount of snapper catch (less than 5% of the total) was taken outside Statistical Areas 037 or 038, and one where catch included fishing effort where species other than SNA or FLA were targeted (specifically JDO) (Appendix 5). The effect of target species on age composition and the overall distributions is considered insignificant, with the same year classes dominating regardless of target species (Appendix 2).

The high inter-annual variability in year class strengths, characteristic of SNA 7, could be a feature resulting from the area being at the southern limit of the species distribution (Blackwell et al. 1999, 2000, Blackwell & Gilbert 2001, 2002, 2005, 2008, Walsh et al. 2012). However, other New Zealand snapper fisheries also exhibit this feature and recruitment in SNA 1 is known to be strongly positively correlated with sea surface temperature just after the time of spawning (Francis 1993). Although the recovery of biomass in SNA 7 (Langley 2015, 2018) over the past decade has largely been associated with the recruitment of two very strong years classes (i.e., 2008 and 2011), it is also important to note the potential for years of low recruitment and how this may change with environmental conditions. A relevant example of such variable recruitment in SNA 7 was recently observed in an investigation to estimate the catch-at-age of snapper from the 2019 *Kaharoa* west coast South Island trawl survey. A very strong recruiting 2018 year class (1+ age group) was present in the 10–20 m stratum of the Tasman Bay and Golden Bay region, the largest ever seen in a time series spanning almost three decades (MacGibbon 2019) and estimated to account for over half the snapper catch by number (Walsh et al. 2019). In contrast, the 2017 year class (2+ age group) that preceded the 2018 year class comprised no fish at all.

5. MANAGEMENT IMPLICATIONS

The bottom trawl catch of SNA 7 in 2019–20 was largely dominated by three year classes (2015, 2011, and 2008). This differs from the previous catch-at-age estimates in that there is another year class (2015) contributing significantly to the fishery and the age structure has continued to broaden with the 2008 year class persisting, now as 12 year old fish. The high level of inter-annual recruitment variability and the near absence of old fish in the catch (i.e., no strong age classes over 12) is reason for caution. Thus, it remains important to closely monitor the strength of new year classes entering the fishery and the persistence of existing year classes supporting the fishery into the future.

6. ACKNOWLEDGMENTS

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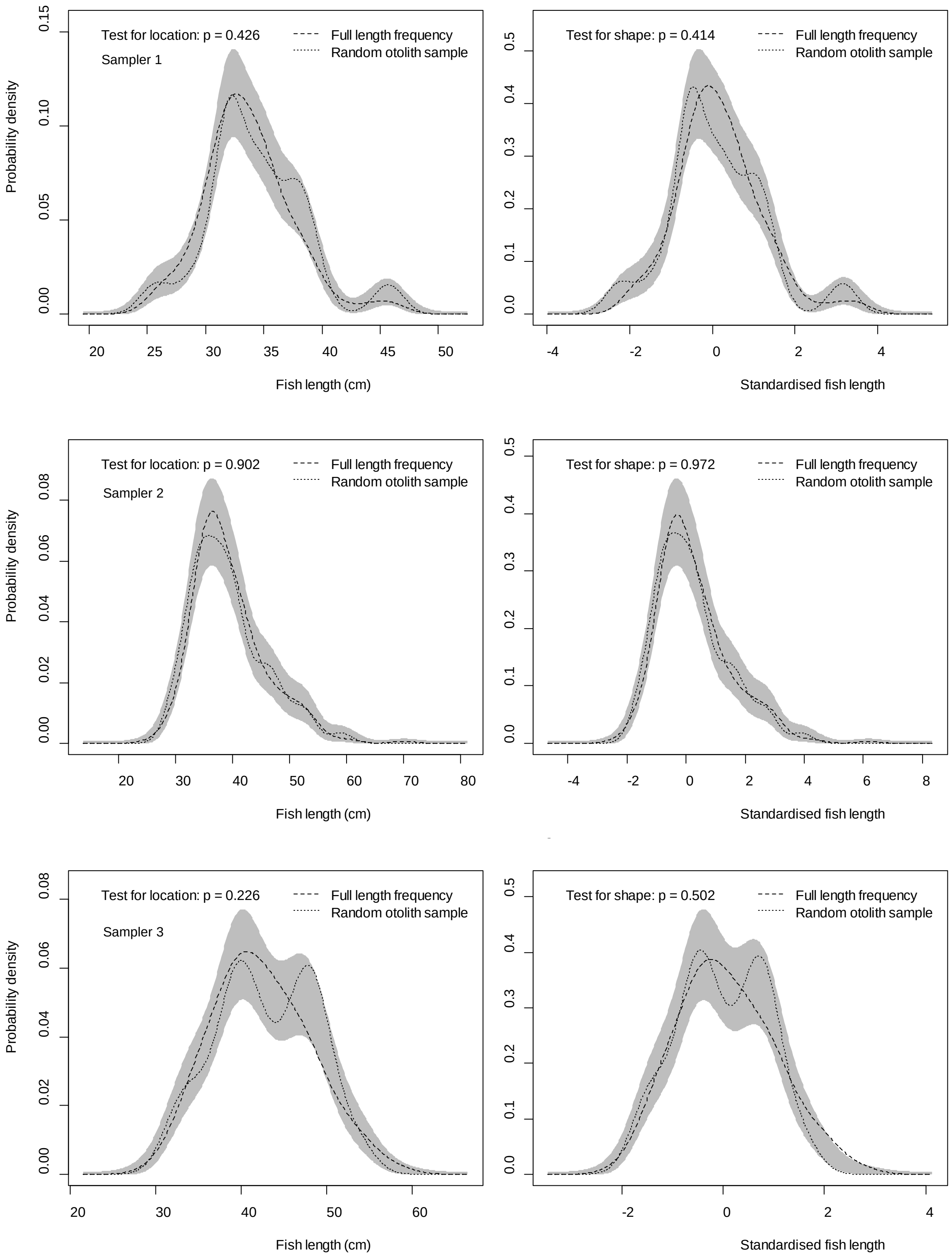
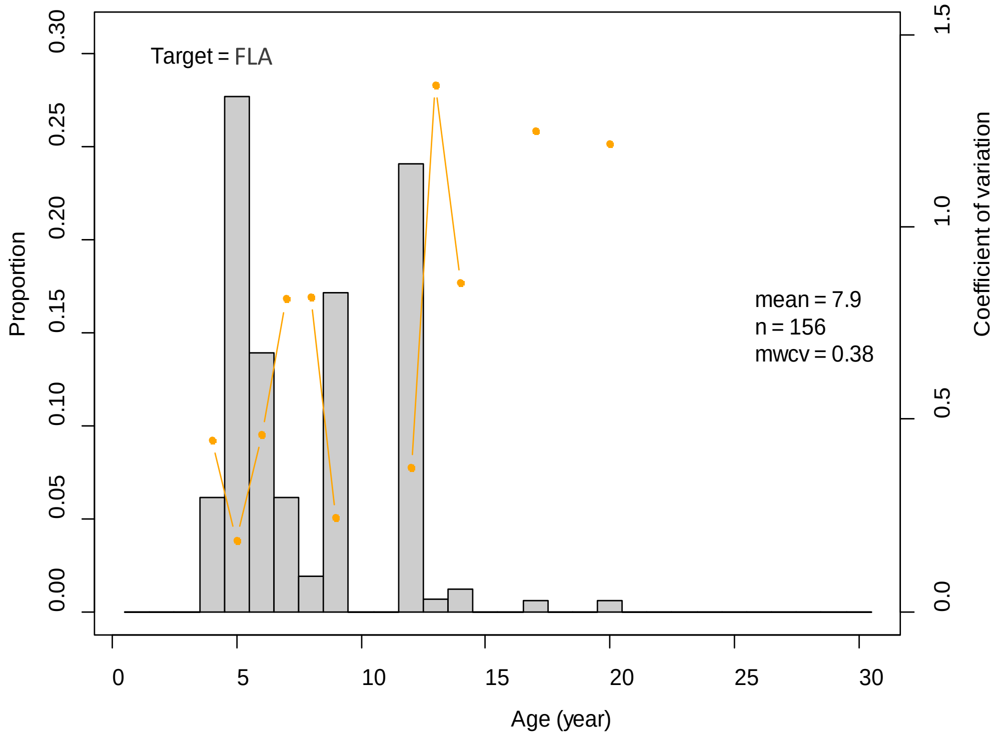
APPENDIX 1

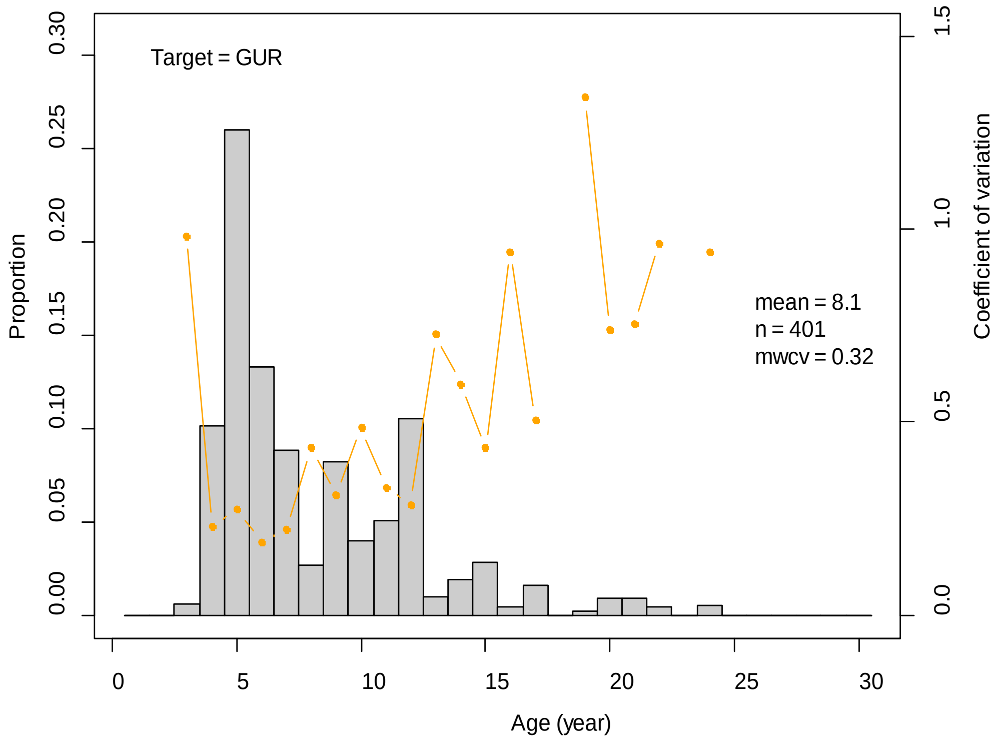
Kernel density estimate (KDE) probability density functions for samplers 1, 2, and 3 who had each measured a full length frequency of 300 fish to compare with the length distribution of a random sample of 60 fish identified for otolith extraction from within those 300 fish. Dashed and dotted lines represent the KDE probability density functions that approximate the random otolith sample and full length frequency, respectively. Grey bands represent one standard error either side of the null model of no difference between the KDEs for each method. Note that y and x-axis scales differ between plots. For greater detail on the KDE analysis method please see Langlois et al. (2015).

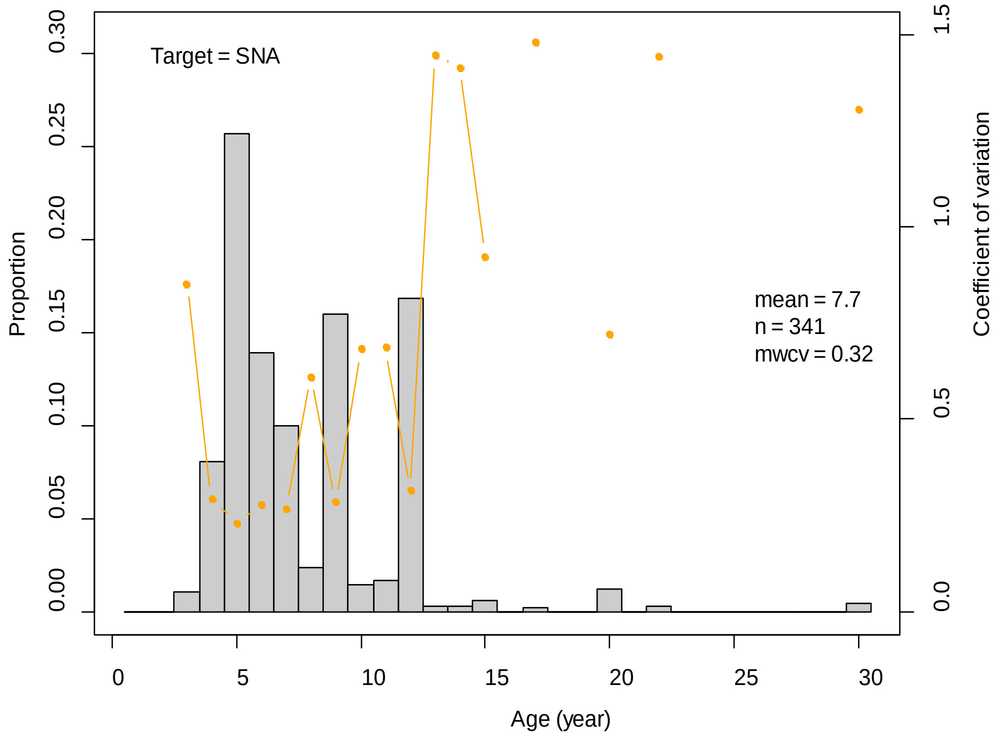


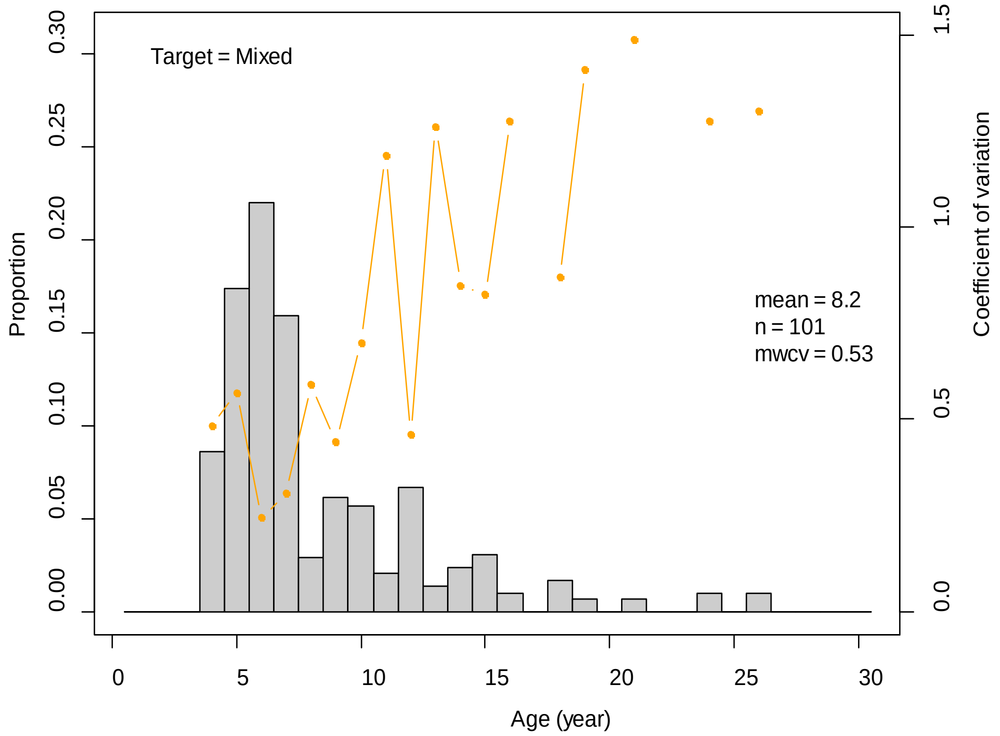
APPENDIX 2

Proportion-at-age distributions (histograms) and CVs (lines) separated by landings that targeted flat fish (FLA, sometimes listed as sand flounder or SFL) on effort reporting forms), red gurnard (GUR), snapper (SNA), and a mixture of species.






Target = SNA
mean = 7.7
n = 341
mwcv = 0.32
Proportion
Coefficient of variation
Age (year)


Target = Mixed
mean = 8.2
n = 101
mwcv = 0.53
Proportion
Coefficient of variation
Age (year)

APPENDIX 3

Estimated proportion-at-age and CVs for snapper sampled from the SNA 7 bottom trawl fishery, October–March 2019–20.

P.j., proportion of fish in age class; CV, coefficient of variation; *n*, otolith sample size

Age	October-March		
(years)	*P.j.*	CV	*n*
1	0.0000	0.000	–
2	0.0000	0.000	–
3	0.0054	0.668	6
4	0.0864	0.155	83
5	0.2533	0.149	231
6	0.1449	0.146	141
7	0.0938	0.172	93
8	0.0247	0.304	27
9	0.1189	0.181	125
10	0.0269	0.385	28
11	0.0283	0.313	31
12	0.1444	0.211	155
13	0.0075	0.531	8
14	0.0135	0.433	14
15	0.0165	0.385	19
16	0.0030	0.770	3
17	0.0084	0.476	9
18	0.0017	0.959	2
19	0.0016	0.978	2
20	0.0082	0.512	9
21	0.0045	0.641	5
22	0.0027	0.795	3
23	0.0000	0.000	–
24	0.0031	0.782	3
25	0.0000	0.000	–
26	0.0010	1.353	1
27	0.0000	0.000	–
28	0.0000	0.000	–
29	0.0000	0.000	–
>29	0.0012	1.355	1

APPENDIX 4

Estimates of proportion of length-at-age for snapper sampled from the Tasman Bay/Golden Bay subarea of SNA 7, October–March 2019–20. (Note: Aged to 01/01/20).

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	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27	0	0	0	0	1.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
28	0	0	0.60	0.40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
29	0	0	0.25	0.50	0.25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
30	0	0	0.20	0.80	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
31	0	0	0.11	0.67	0.22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9
32	0	0	0	0.80	0.13	0.07	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15
33	0	0	0	0.47	0.43	0.10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30
34	0	0	0	0.39	0.61	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	41
35	0	0	0	0.26	0.65	0.09	0	0	0	0	0	0	0	0	0	0	0	0	0	0	57
36	0	0	0	0.13	0.58	0.25	0.03	0	0	0	0	0	0	0	0	0	0	0	0	0	60
37	0	0	0	0.04	0.67	0.22	0.06	0	0	0	0	0	0	0	0	0	0	0	0	0	49
38	0	0	0	0.02	0.67	0.27	0.02	0.02	0	0.02	0	0	0	0	0	0	0	0	0	0	63
39	0	0	0	0.02	0.35	0.35	0.19	0.06	0.04	0	0	0	0	0	0	0	0	0	0	0	54
40	0	0	0	0	0.25	0.36	0.26	0.03	0.05	0.03	0.02	0	0	0	0	0	0	0	0	0	61
41	0	0	0	0	0.08	0.31	0.38	0.10	0.06	0.04	0	0.02	0	0	0	0	0	0	0	0	48
42	0	0	0	0	0	0.43	0.29	0.10	0.12	0.02	0.05	0	0	0	0	0	0	0	0	0	42
43	0	0	0	0	0.06	0.12	0.24	0.12	0.18	0.09	0.06	0.12	0	0	0	0	0	0	0	0	33
44	0	0	0	0	0	0.20	0.24	0.10	0.24	0.07	0.05	0.07	0	0	0.02	0	0	0	0	0	41
45	0	0	0	0	0	0.05	0.24	0.05	0.37	0.11	0.03	0.13	0	0.03	0	0	0	0	0	0	38
46	0	0	0	0	0	0	0.04	0.08	0.36	0.12	0.20	0.16	0.04	0	0	0	0	0	0	0	25
47	0	0	0	0	0	0.03	0.08	0	0.49	0.10	0.10	0.15	0.03	0	0.03	0	0	0	0	0	39
48	0	0	0	0	0	0	0	0	0.37	0.05	0.16	0.34	0.03	0.05	0	0	0	0	0	0	38
49	0	0	0	0	0	0	0	0	0.36	0.04	0.09	0.32	0.06	0.04	0.04	0	0	0	0	0.04	47
50	0	0	0	0	0	0	0	0	0.26	0.04	0.04	0.59	0	0.07	0	0	0	0	0	0	27
51	0	0	0	0	0	0	0	0	0.16	0	0.06	0.55	0.03	0.10	0	0.03	0.03	0	0	0.03	31
52	0	0	0	0	0	0	0	0	0.11	0	0.05	0.58	0	0.11	0.05	0.05	0	0	0	0.05	19
53	0	0	0	0	0	0	0	0	0.35	0	0	0.52	0	0.04	0	0	0	0	0	0.09	23
54	0	0	0	0	0	0	0	0	0.05	0	0	0.68	0.05	0	0.14	0	0.05	0	0	0.05	22
55	0	0	0	0	0	0	0	0	0	0	0	0.67	0	0	0.20	0.07	0.07	0	0	0	15
56	0	0	0	0	0	0	0	0	0	0	0	0.70	0	0	0.10	0	0.10	0	0.10	0	10
57	0	0	0	0	0	0	0	0	0	0	0	0.60	0	0.10	0.20	0	0	0	0	0.10	10
58	0	0	0	0	0	0	0	0	0	0	0	0.57	0	0	0.14	0	0	0	0	0.29	7
59	0	0	0	0	0	0	0	0	0	0	0	0.57	0	0	0	0	0.14	0.14	0	0.14	7
60	0	0	0	0	0	0	0	0	0	0	0	0.33	0	0	0.17	0	0.17	0.17	0	0.17	6
61	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.33	0	0	0.67	3
62	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.50	0	0	0	0	0.50	2
63	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.50	0	0	0.50	2
64	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.33	0	0.33	0	0	0.33	3
65	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.00	2
66	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.50	0	0	0	0	0.50	2
67	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.50	0.50	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	0	0
71	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
72	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
73	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
74	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
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	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																					999

APPENDIX 5

Sampled landings that were used for SNA 7 age composition under project SNA201902. Note that target species is that recorded in the logbook, not that reported at the time of sampling. Note that SFL (sand flounder) is a specific species included within the FLA species group.

Sample number	Date sampled	Target species	Landing weight (kg)	Sample weight (kg)	Statistical area	Number of otoliths
20191450	17/10/2019	GUR	498.0	110.5	038	60
20191451	22/10/2019	GUR	1213.0	140.0	038	60
20191452	24/10/2019	SFL	1454.5	138.0	038	60
20191453	30/10/2019	SFL	1498.5	109.0	038	60
20191458	13/11/2019	SNA	1181.0	150.5	038	60
20191459	19/11/2019	SNA	375.0	135.0	038	60
20191460	21/11/2019	GUR	546.5	88.0	038	60
20191461	26/11/2019	GUR, FLA	709.0	92.0	037, 038, 036*	60
20191462	27/11/2019	FLA, SNA, JDO*	1032.5	99.5	038	60
20191463	03/12/2019	GUR	836.0	100.0	37, 038	60
20191464	10/12/2019	GUR	745.5	77.5	038	60
20191466	12/12/2019	SNA	425.5	76.5	038	60
20191467	18/12/2019	SFL	733.0	85.5	038	60
20201450	13/01/2020	GUR, SFL	537.5	146.5	038, 017*	60
20201451	16/01/2020	GUR	665.5	107.5	038	60
20201452	28/01/2020	GUR	682.0	106.5	038	60
20201453	22/01/2020	SNA	884.0	108.5	038	60
20201454	31/01/2020	SNA	1025.5	113.5	038	60
20201455	10/02/2020	GUR	360.0	94.0	038	60
20201456	11/02/2020	GUR	681.0	124.5	038	60
20201457	17/02/2020	GUR	591.0	113.0	038	60
20201458	20/02/2020	GUR, FLA	690.0	107.5	038	60
20201459	26/02/2020	GUR	579.0	103.5	038	60
20201460	03/03/2020	GUR	472.5	117.5	038	60
20201461	13/03/2020	SNA	668.5	108.5	038	60

* denotes the acceptance of a landing that lists additional targets or areas, but where specific fishing events concerned accounted for under 5% of the total estimated catch weight of snapper.