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Age composition of the commercial red gurnard (*Chelidonichthys kumu*) catch in GUR 1 in fishery year 2009–2010

New Zealand Fisheries Assessment Report 2012/31

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EXECUTIVE SUMMARY

McKenzie, J., Armiger, H.; Sutton, C.; Smith, M.; Walsh, C.; Parker, S. (2012). Age composition of the commercial red gurnard (*Chelidonichthys kumu*) catch in quota management area GUR 1 in fishery year 2009–2010.

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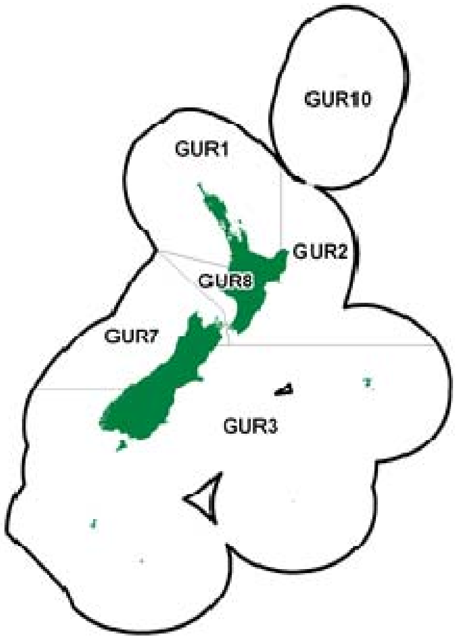
Catch sampling for age using the random age sampling approach was undertaken in three GUR 1 substocks (west coast North Island; East Northland/Hauraki Gulf; Bay of Plenty) during the 2009–10 fishing year. Sampling achieved good spatial and temporal coverage of the bottom trawl fishery in all three GUR 1 substocks. Budget limitations meant that only 1600 otoliths of the 2159 collected could be aged. Despite the reduced age sample, the target mean weighted coefficient of variation (0.30) was achieved for the west coast North Island and East Northland/Hauraki Gulf substocks (0.27; 0.23), and only marginally exceeded for the Bay of Plenty substock (0.33). Sampling designs to achieve lower mean weighted coefficients of variation were simulated using the catch-at-age data.

Gurnard ageing protocols were reviewed as part of this study and a protocol involving single readings from two independent readers, with subsequent conferring, was adopted for ageing. This approach is recommended for future gurnard ageing studies.

Comparison of the results from this study with those from programmes conducted in the early 2000s showed similar age compositions, suggesting that there has been little discernible change in total mortality on either coast of GUR 1 during the last decade. A comparison of the East Northland/Hauraki Gulf age composition with that from the Hauraki Gulf bottom trawl fishery in 1968–69 indicates a broader age structure exists now than in the late 1960s, the implication being that total mortality is unlikely to be greater now than in the 1960s.

1. INTRODUCTION



Red gurnard (*Chelidonichthys kumu*) is a demersal finfish species widely distributed within the shallow coastal waters of the New Zealand fishery zone. It is a major bycatch of most northern New Zealand inshore trawl fisheries.

There is no current stock assessment for GUR 1. A standardised catch per unit effort (CPUE) analysis by Kendrick (2009) shows different abundance patterns for the west coast North Island, East Northland/Hauraki Gulf and Bay of Plenty substocks. These results suggest that GUR 1 might be composed of three relatively distinct substocks. Strong cyclic trends in abundance are evident in Ministry of Fisheries catch and effort data from the three GUR 1 substocks over the last 20 years.

Catch sampling was last conducted during the 2002–03, 2003–04 and 2004–05 fishing years (Horn et al. 2006). Catches were dominated by strong year classes of 2–4 year old fish and there was no apparent year class progression evident in the three year time series. This earlier catch sampling programme did not, however, achieve acceptable temporal coverage of the respective fisheries.

The purpose of this project was to develop a catch sampling strategy for GUR 1 for the 2009–10 fishing year, determine the age composition of the GUR 1 catch, and use these data to determine an optimal sample size for future GUR 1 catch sampling projects.

The specific objectives of contract GUR2008/01 were:

1. Characterise the GUR 1 fishery and design a catch sampling programme to sample GUR 1 catches taken by the single bottom trawl method.

2. To conduct representative sampling and determine the length, sex, and age composition of the single bottom trawl catch of red gurnard (*Chelidonichthys kumu*) in GUR 1 during the 2009/10 fishing year. The target coefficient of variation (c.v.) for the catch-at-age being 30 % (mean weighted c.v. across all age classes) combined across sexes.

3. To explore the times series of catch sampling data, in particular, for any significant changes in the length and age composition of commercial catches.

4. To develop a cost effective catch-at-age sampling strategy for GUR 1.

1.1 Stock area

GUR 1 encompasses the west and east coasts of the northern North Island of New Zealand (Figure 1). For assessment purposes GUR 1 is divided into three spatial substocks: west coast North Island (WCNI); East Northland/Hauraki Gulf (ENHG); Bay of Plenty (BPLE) (Figure 1).

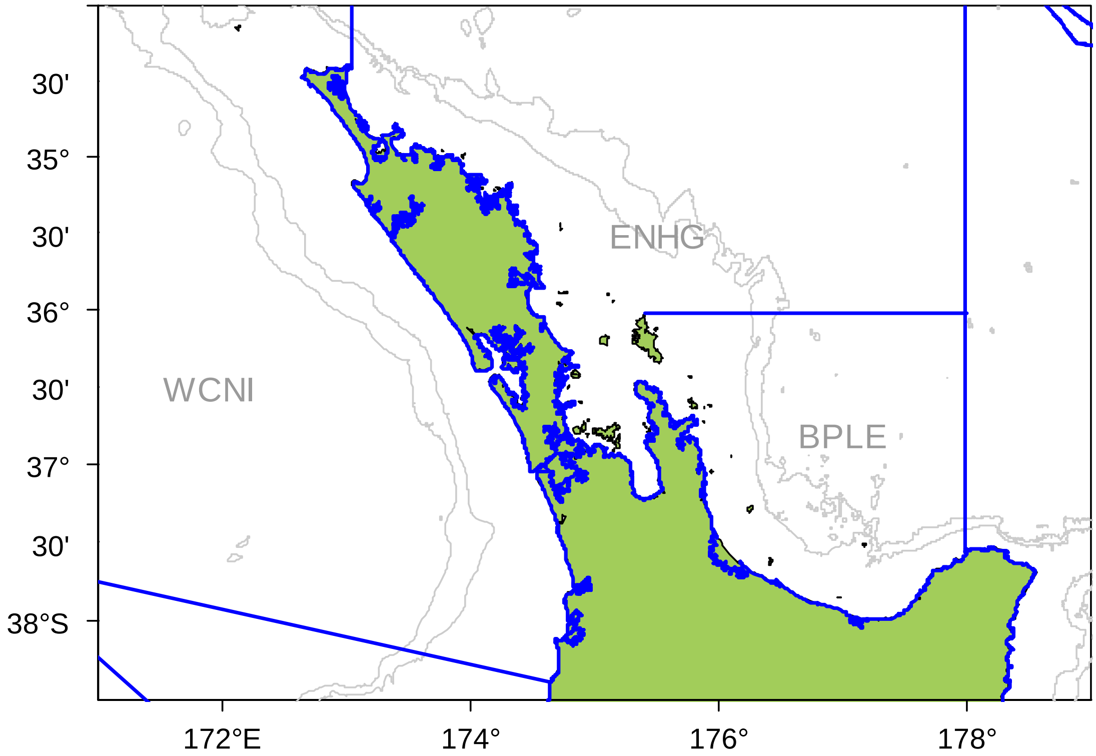


Figure 1: Location of substocks within the GUR 1 fishery management area. The 200 m and 500 m depth contours are shown as grey lines.

1.2 Commercial fisheries

The current Total Allowable Commercial Catch (TACC) for red gurnard is almost 5000 t, of which GUR 1 is allocated 2287 t, only half which is caught in most years (Ministry of Fisheries 2011b).

1.3 Recreational fisheries

The most recent estimate of recreational harvest from GUR 1 was 127 t in 2005 (Hartill et al. 2007).

1.4 Maori customary fisheries

No quantitative information on the level of customary non-commercial fishing is available.

1.5 Illegal and misreported catch

No quantitative information on the level of illegal red gurnard catch is available.

1.6 Other sources of mortality

No information is available.

2. COMMERCIAL FISHERY CHARACTERISATION

2.1 Historical catches

The total catch of GUR 1 has been relatively stable since 1985, moderately fluctuating around 1300 t, i.e., well below the TACC (Figure 2).

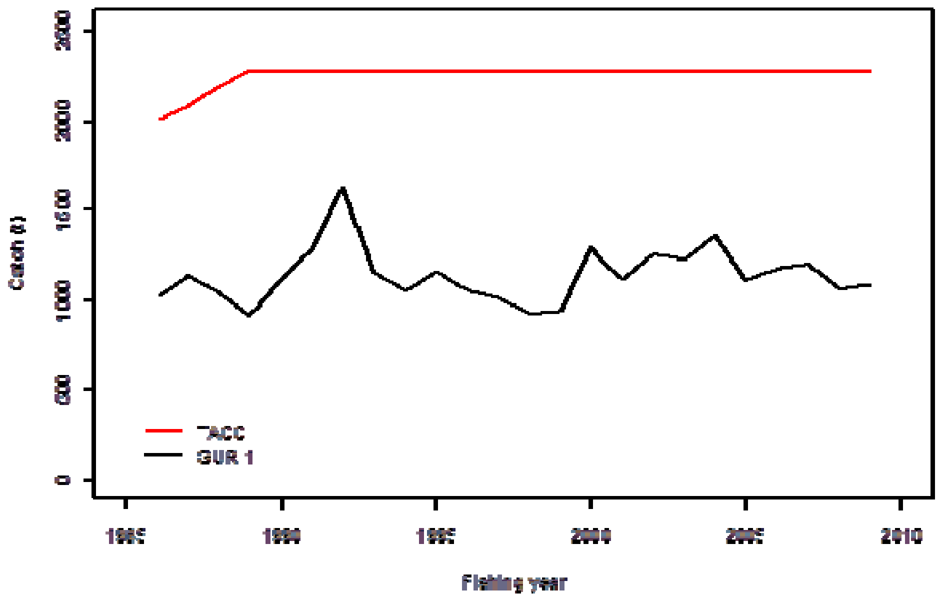


Figure 2: Total commercial catch (Quota Management Report (QMR)/Monthly Harvest Return (MHR)) and Total Allowable Commercial Catch of GUR 1 (1986–87 to 2009–10).

2.2 Catch by substock

A large proportion of the annual GUR 1 catch is taken from the west coast North Island and catches from the East Northland/Hauraki Gulf and Bay of Plenty substocks have been roughly equivalent since 2003–04 (Figure 3).

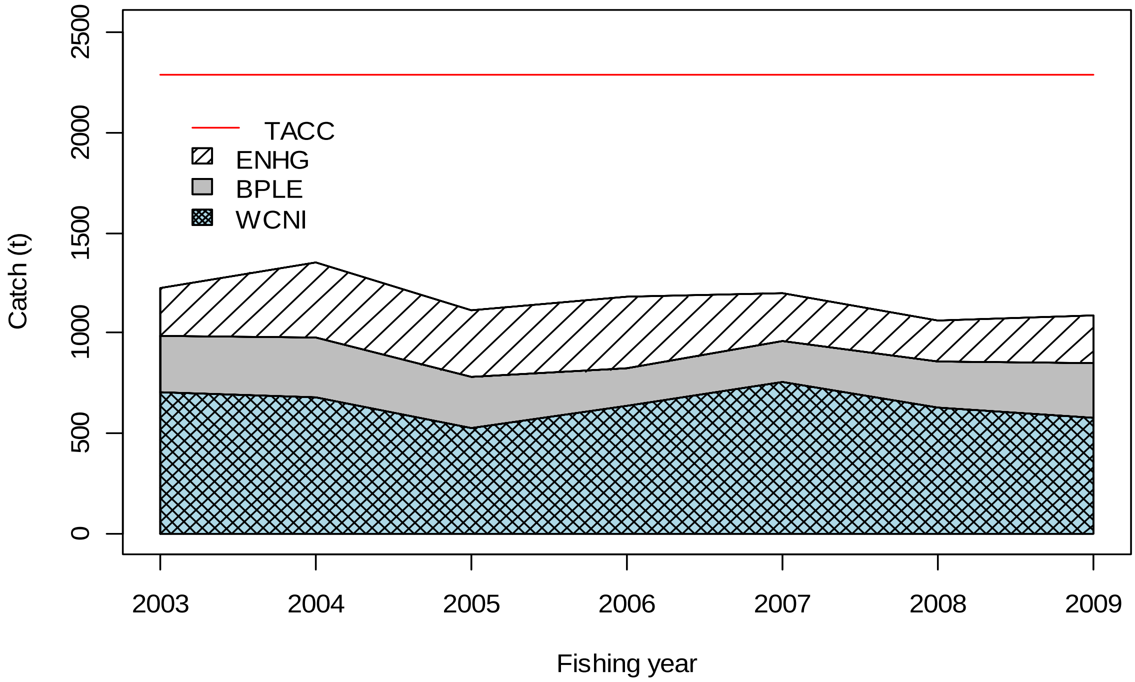


Figure 3: Annual GUR 1 catch by substock (WCNI, west coast North Island; ENHG, East Northland/Hauraki Gulf; BPLE, Bay of Plenty).

2.3 Main fishing methods

Danish seine, bottom trawl and longline are the main methods used for targeting gurnard in the East Northland/Hauraki Gulf substock (Figure 4; Appendix 1). The importance of bottom trawl has diminished over the recent period of the fishery and the three methods are now of roughly equivalent importance.

Danish seine is the most important fishing method for red gurnard in the Bay of Plenty, followed closely by bottom trawl (Figure 4; Appendix 1).

Bottom trawl catches have been declining on the west coast whereas Danish seine has come into prominence in recent years (Figure 4; Appendix 1).

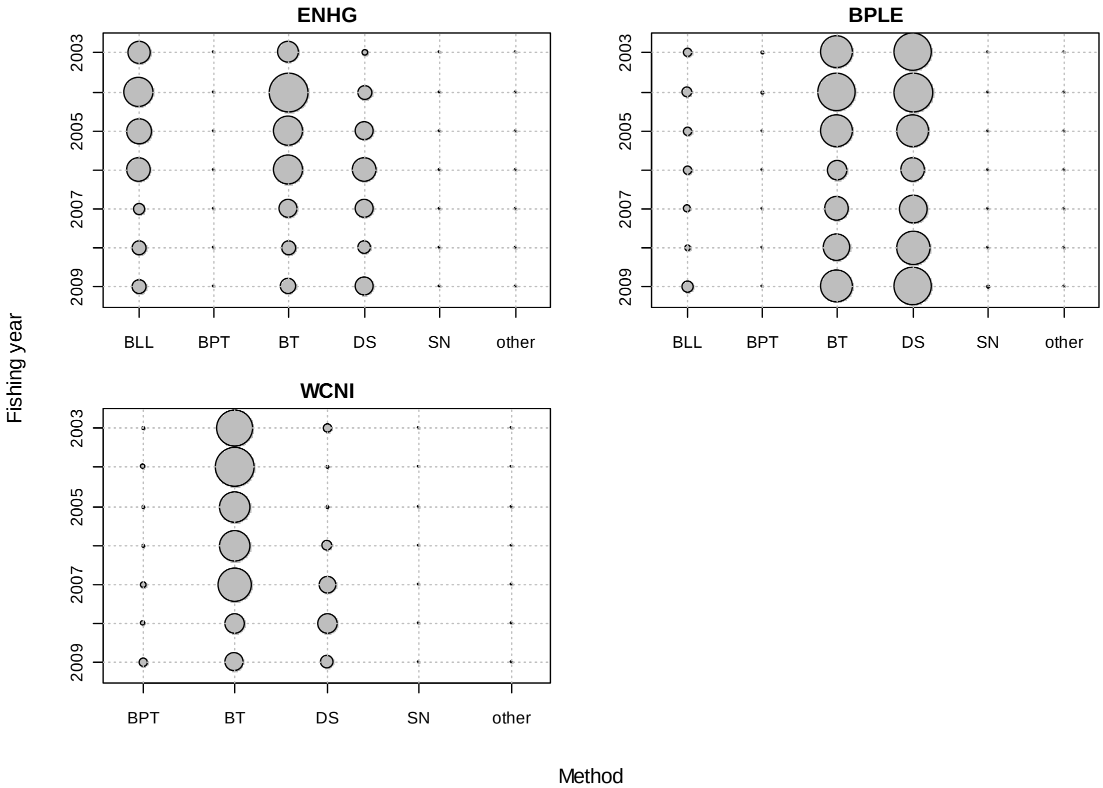


Figure 4: Relative annual GUR 1 catch by area and method (BPT, bottom pair trawl; BT, bottom trawl; DS, Danish seine; SN, setnet). Symbol area is proportional to the landed weight.

2.3.1 (Bottom) longline (BLL)

The spatial distribution of GUR 1 longline catches in the 2009–10 fishing year shows areas of higher catch in Rangaunu Bay (002), Bream Bay (003, 005) and the western Bay of Plenty (008) (Figure 5). These spatial patterns in longline catch are likely to have been relatively consistent through time as indicated by the coarser information available on catch by statistical area (Figure 6).

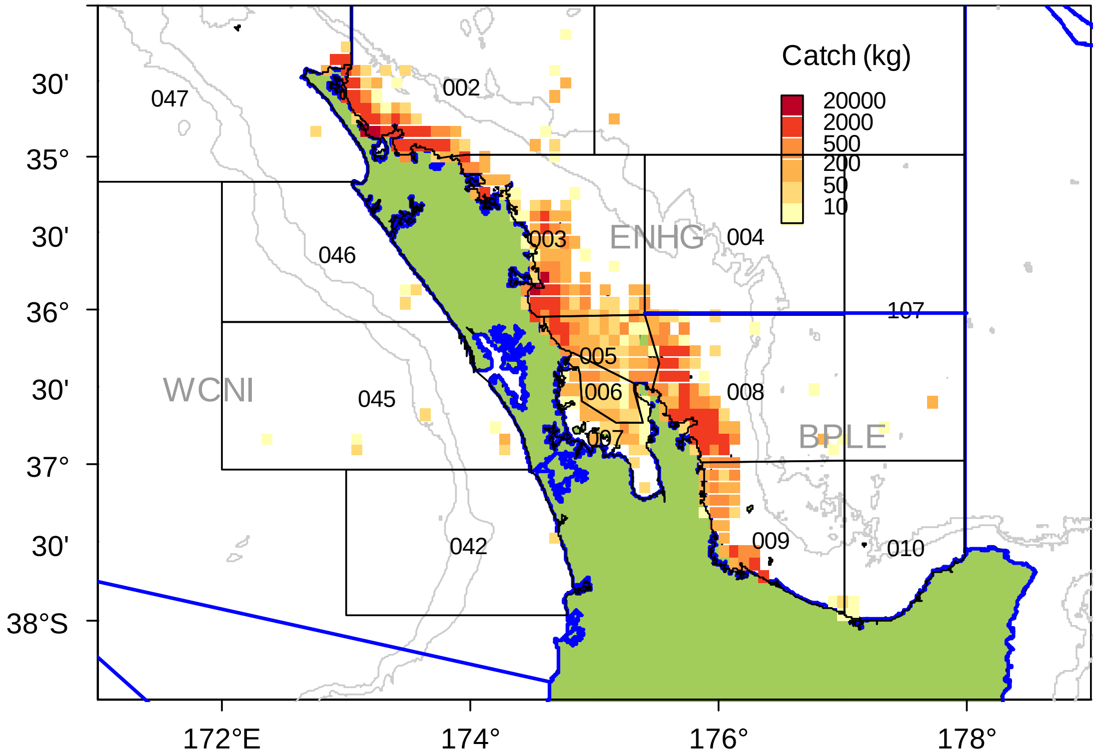


Figure 5: Spatial distribution of the GUR 1 bottom longline catch in the 2009–10 fishing year.

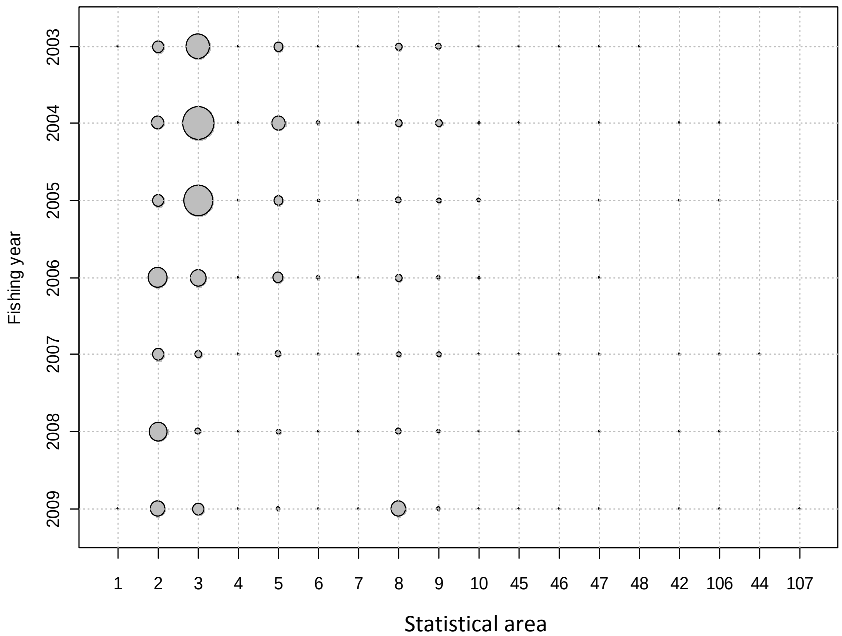


Figure 6: Relative annual GUR 1 bottom longline catch by statistical reporting area. Symbol area is proportional to the landed weight.

Gurnard is principally taken by longline in East Northland and the Bay of Plenty as a by-catch of the snapper target fisheries (Figure 7).

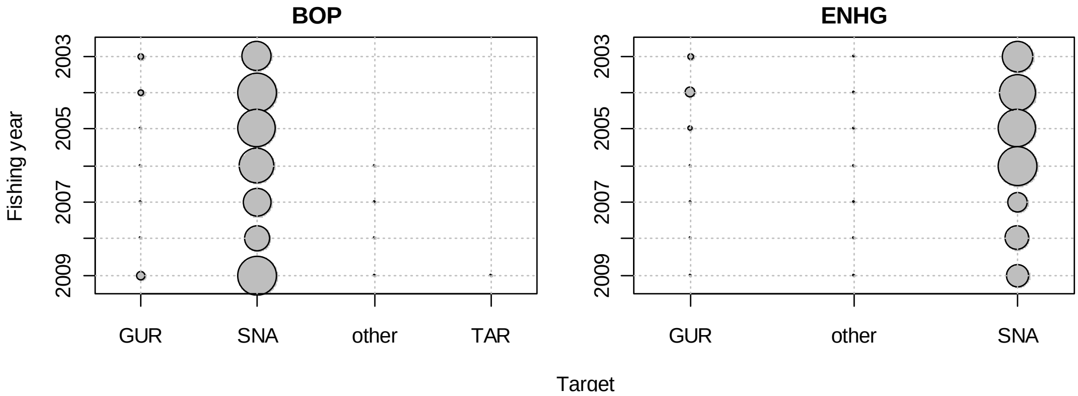


Figure 7: Relative annual GUR 1 bottom longline catch by target species. Symbol area is proportional to the landed weight.

Seasonal patterns seen in both of these GUR 1 substocks are therefore more likely to reflect activity of the target snapper longline fishery than gurnard temporal abundance (Figure 8).

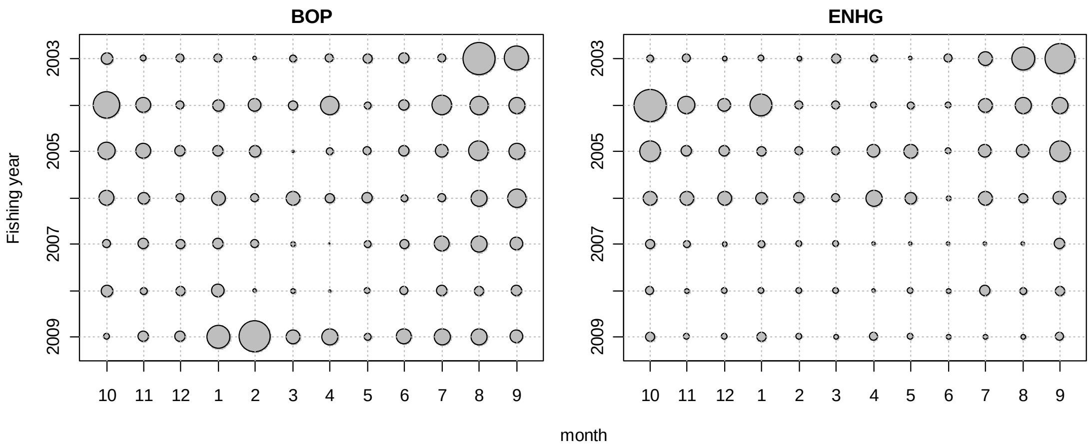


Figure 8: Seasonal pattern in relative monthly GUR 1 longline catches.

2.3.2 Danish seine (DS)

The majority of the Danish seine GUR 1 catch was taken from statistical areas 047 (west coast North Island) and 009 (Bay of Plenty) (Figure 9).

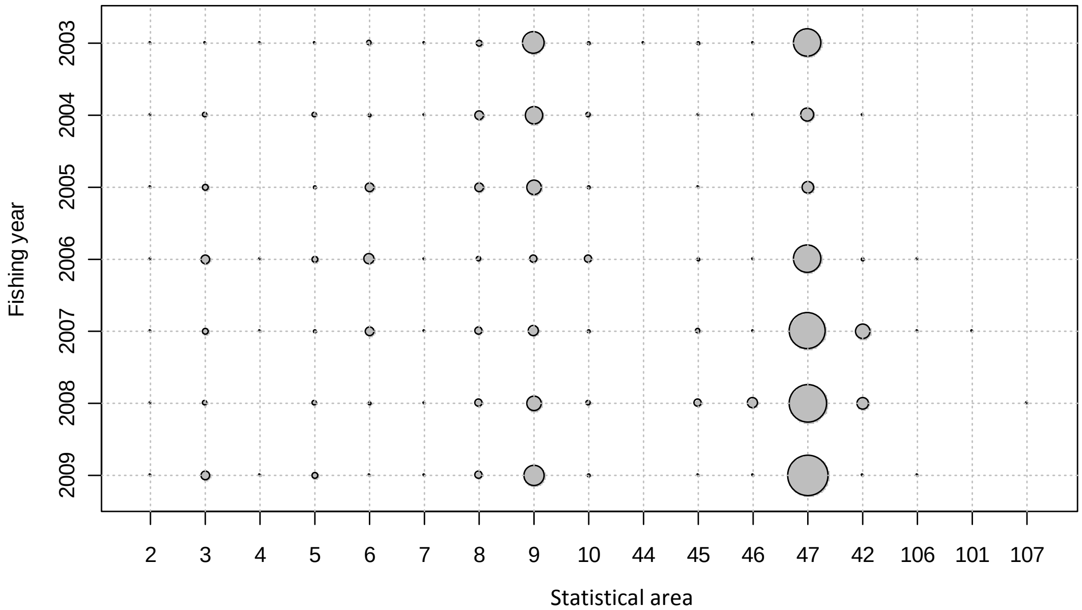


Figure 9: Relative annual GUR 1 Danish seine catch by statistical reporting area. Symbol area is proportional to the landed weight.

West Coast North Island gurnard are targeted using Danish seine (Figure 10). A significant proportion of the Danish seine gurnard catch from East Northland/Hauraki Gulf and Bay of Plenty substocks is taken as by-catch of snapper targeting (Figure 10).

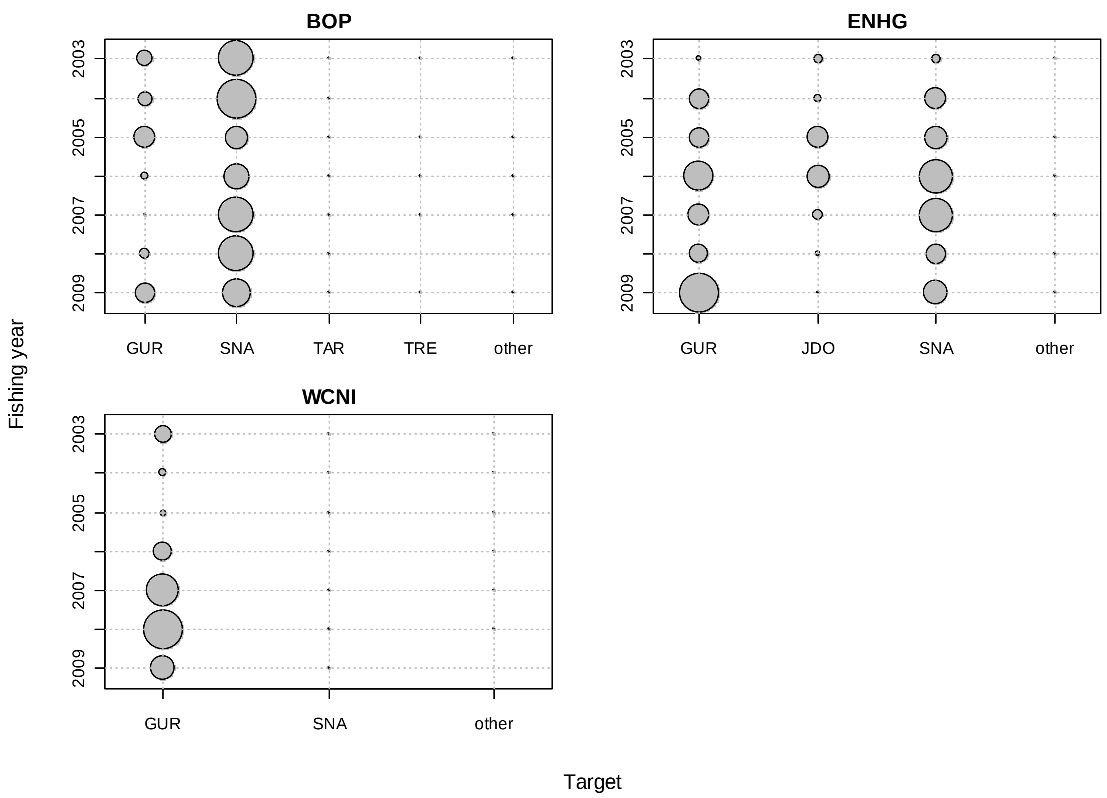


Figure 10: Relative annual GUR 1 Danish seine catch by target species. Symbol area is proportional to the landed weight.

Danish seine catches of gurnard in the Hauraki Gulf and Bay of Plenty were lower in winter (Figure 11).

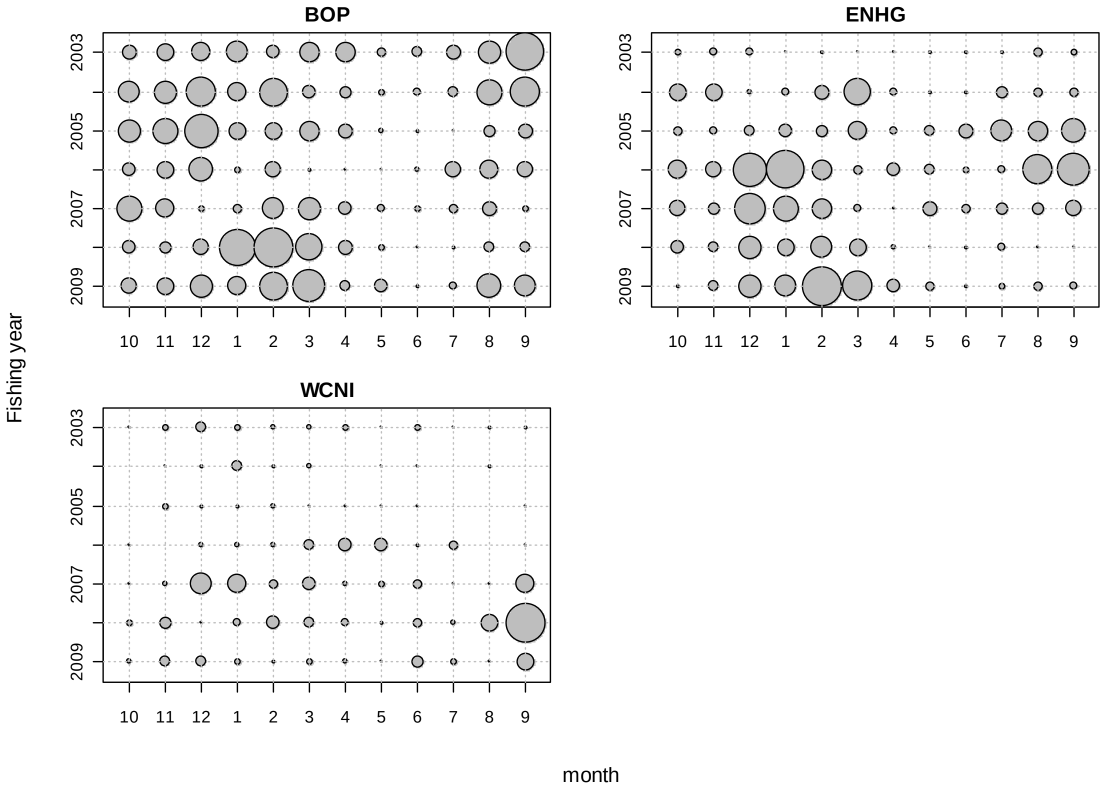


Figure 11: Seasonal pattern in relative monthly GUR 1 Danish seine catches.

2.3.3 Bottom Trawl (BT)

The spatial distribution of GUR 1 bottom trawl catches in the 2009–10 fishing year shows that the entire west coast of the North Island is important for this substock (Figure 12). On the east coast, gurnard are taken by bottom trawl over the northern Hauraki Gulf and eastern Bay of Plenty areas (Figure 12).

These spatial patterns in bottom trawl catches are likely to have been relatively consistent through time as indicated by the coarser information available on catch by statistical area (Figure 13).

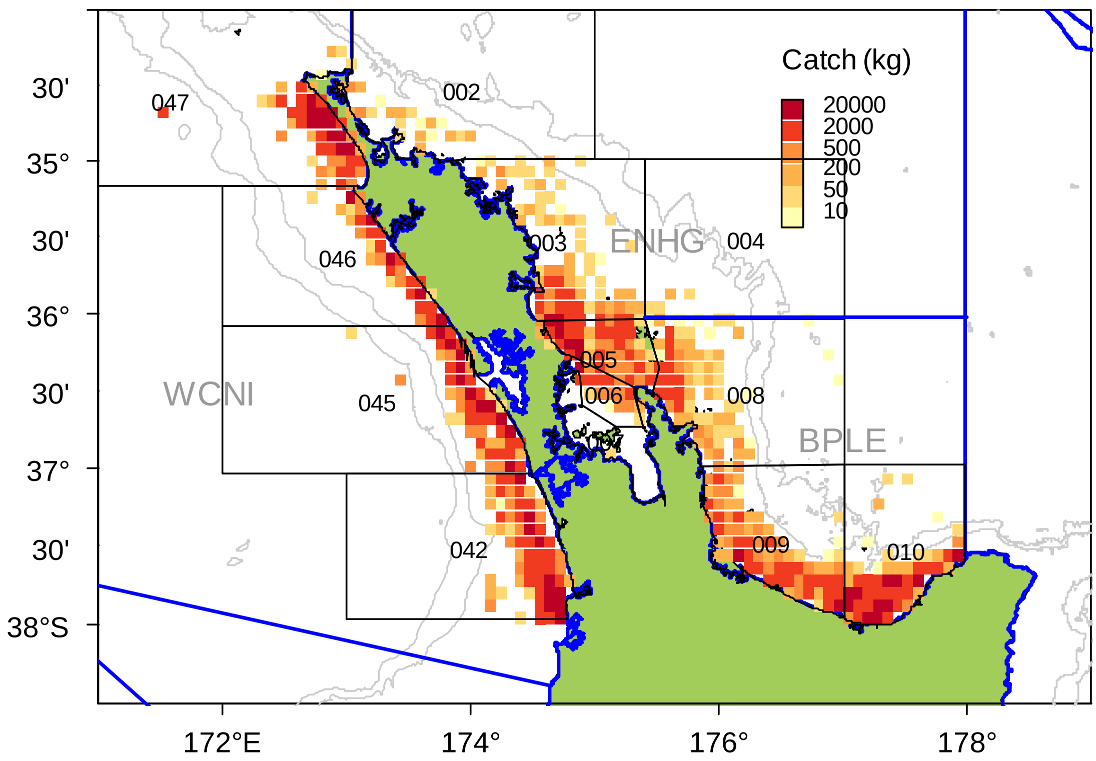


Figure 12: **Spatial distribution of the GUR 1 bottom trawl catch in the 2009–10 fishing year.**

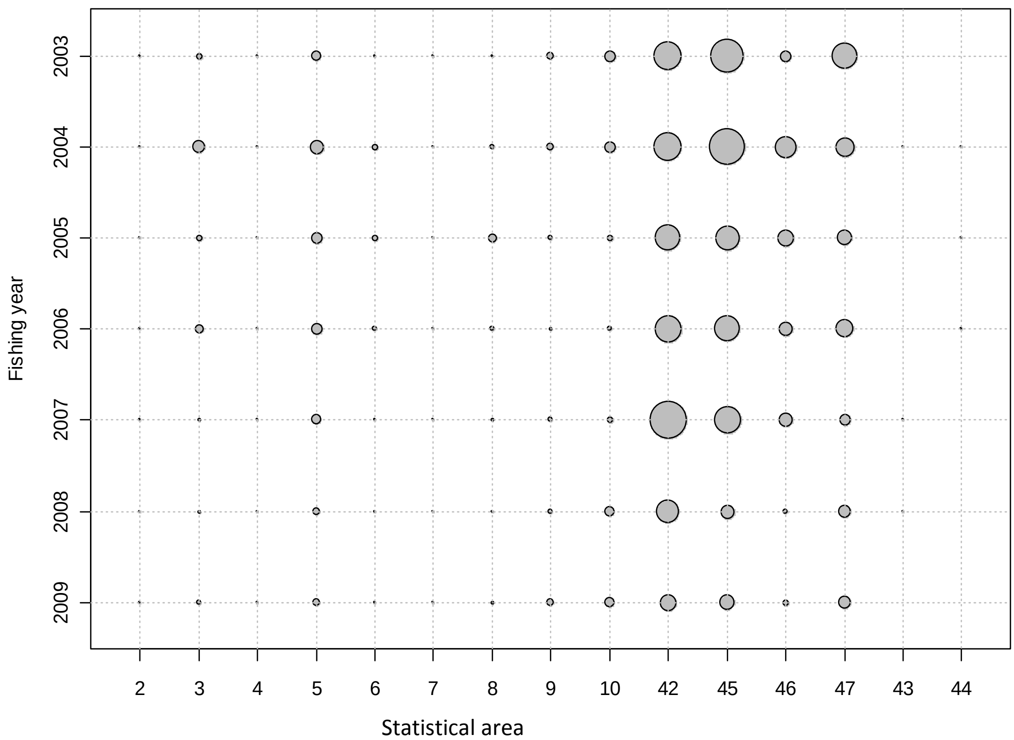


Figure 13: **Relative annual GUR 1 bottom trawl catch by statistical reporting area. Symbol area is proportional to the landed weight.**

Gurnard are predominantly taken as bycatch to trevally targeting in the bottom trawl fishery on the west coast North Island and Bay of Plenty substocks, and John dory and snapper targeting in the East Northland/Hauraki Gulf substock (Figure 14). There was a higher proportion of gurnard targeting in the early 2000's than toward the end of the decade in all GUR 1 subareas; the reasons for this are unclear (Figure 14).

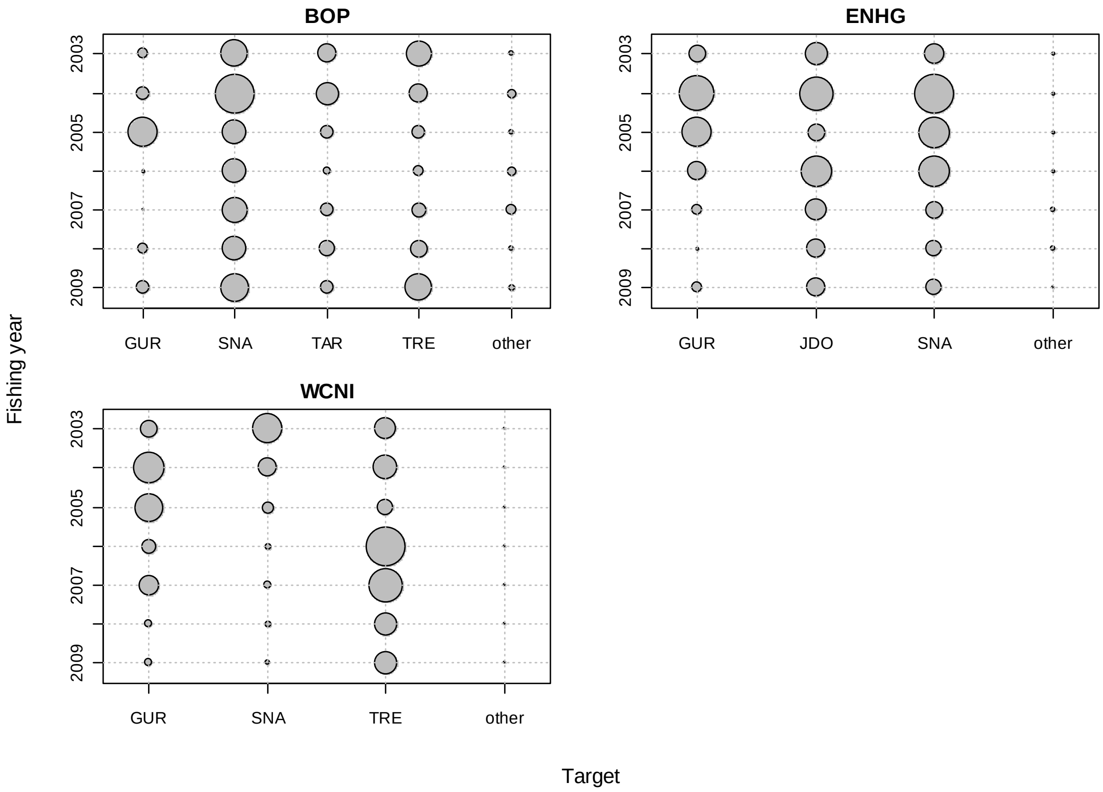


Figure 14: Relative annual GUR 1 bottom trawl catch by target species. Symbol area is proportional to the landed weight.

Lower gurnard catches were recorded by the West Coast North Island bottom trawl fishery during winter, a pattern also evident in the East Northland/Hauraki Gulf substock (Figure 15). Gurnard catches in the Bay of Plenty seem to be relatively consistent throughout the year (Figure 15).

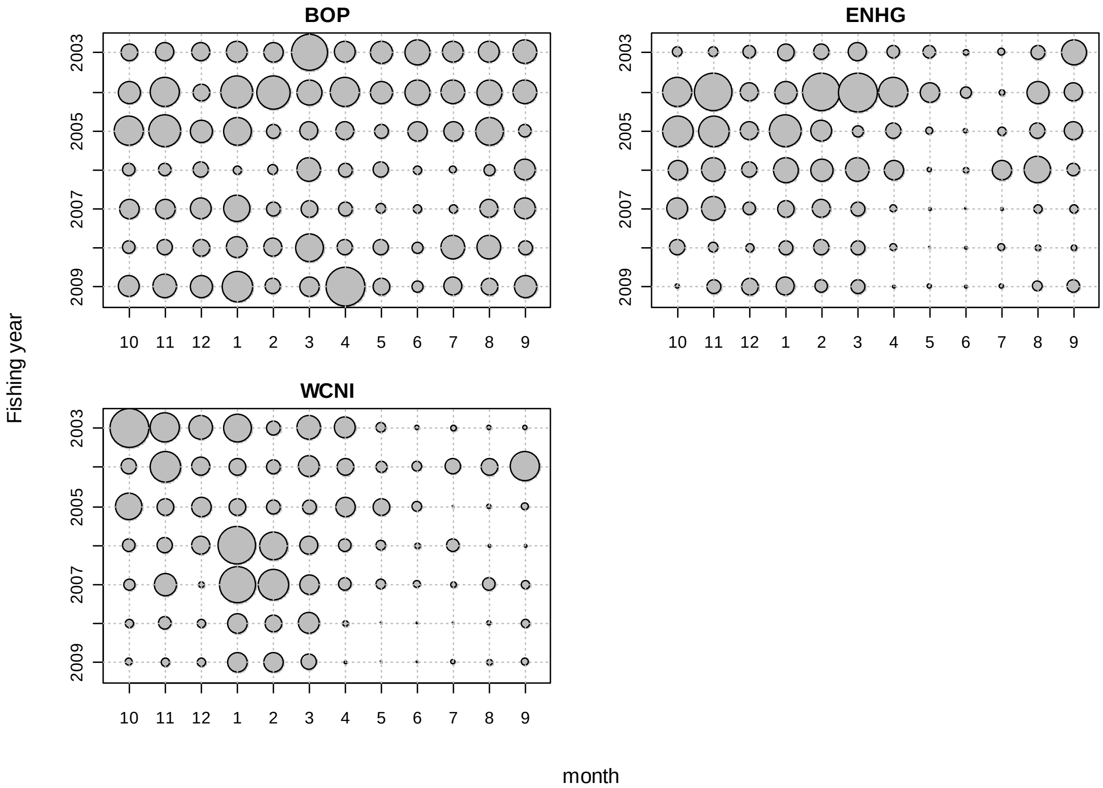


Figure 15: Seasonal pattern in relative monthly GUR 1 bottom trawl catches.

3. METHODS

3.1 Sampling design

The purpose of the catch sampling programme was to describe the age composition of the annual catch of red gurnard taken by bottom trawl fisheries operating in each of the three GUR 1 sub-areas in 2009–10 (Figure 1).

Sampling programmes were designed and implemented according to Ministry protocols (Ministry of Fisheries 2011a). Suitable landings were identified by coordination between samplers and processing shed managers.

3.1.1 Minimum sampled landing size

Approximately 90% of gurnard landings from the west coast over the five fishing years prior to 2009–10 were greater than 700 kg (vertical line Figure 16). Based on these data a minimum landing size of 700 kg was established for west coast North Island gurnard catch sampling.

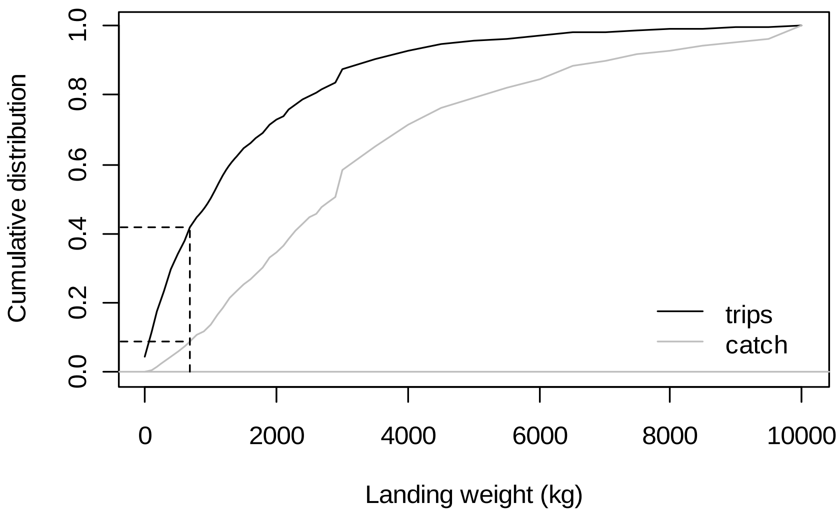


Figure 16: West coast North Island bottom trawl cumulative proportion of catch and number of trips by size of landing (kg) category (data from 2003–2009).

Approximately 70% of landings from East Northland/Hauraki Gulf and 60% from the Bay of Plenty were greater than 200 kg (vertical lines Figure 17 and Figure 18). Based on these data a minimum landing size of 200 kg was established for east coast gurnard catch sampling. Logistically it is not practical to sample gurnard landings less than 200 kg.

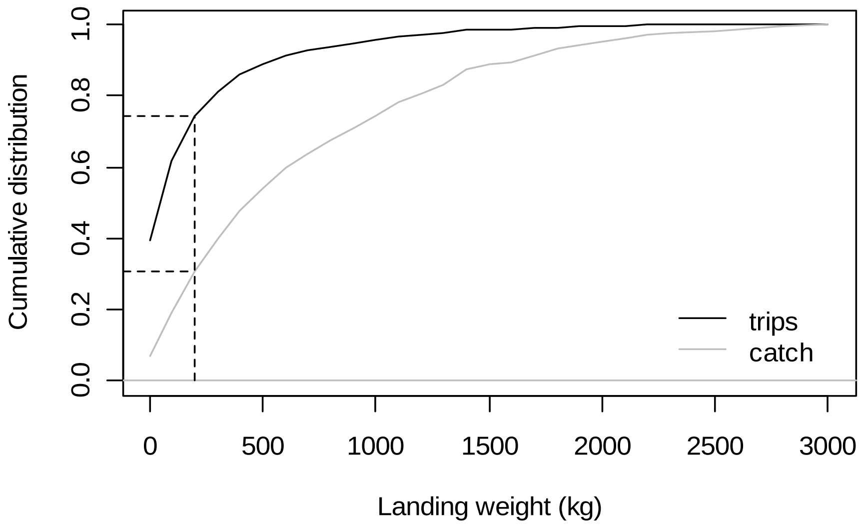


Figure 17: East Northland/Hauraki Gulf bottom trawl cumulative proportion of catch and number of trips by size of landing (kg) category (data from 2003–2009).

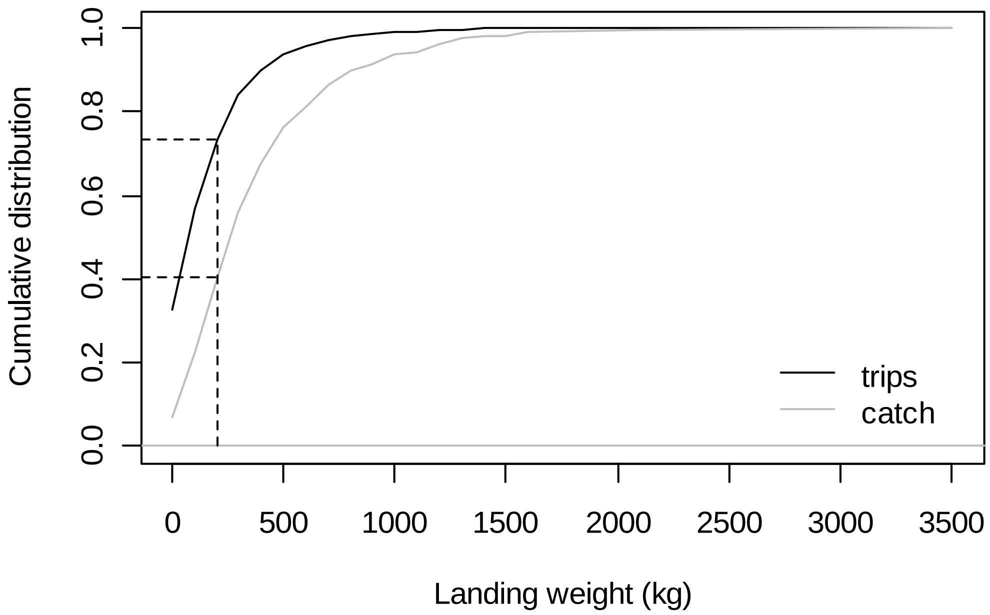


Figure 18: Bay of Plenty bottom trawl: cumulative proportion of catch and number of trips by size of landing (kg) category (data from 2003- 2009).

3.1.2 Sampling methods

Direct age sampling (Davies et al. 2003) was used to sample the GUR 1 bottom trawl fishery in 2009–10.

The number of landings to be sampled in each sub-area was based on established sampling programmes for northern snapper fisheries (Walsh et al. 2011), and was subsequently endorsed by the Northern Inshore working group (i.e., West coast North Island 16; East Northland/Hauraki Gulf 20; Bay of Plenty 20). Samples were allocated throughout the year proportional to the recent seasonal patterns observed for each fishery (Figure 15).

Sampling excluded any trips where a catch was from more than one substock. Fifty fish were processed for each sample using a random age frequency strategy (otoliths collected from all sampled fish).

Criteria for sample selection of landing.

1. Landing sampled must be from a single vessel for a single trip using only bottom trawl.
2. Landing weight of gurnard catch must be over minimum substock limit.
3. Sample frequency in accordance with monthly sampling schedule.
4. Each sample is comprised of 50 fish if landing weight is greater than 1000 kg, and at least 20 fish if between 200 and 1000 kg.

Catch sampling took place in fish processor sheds located in Tauranga and Auckland, covering the main GUR 1 receiving companies. West coast North Island and East Northland/Hauraki Gulf catches were sampled at Auckland sheds by NIWA. Bay of Plenty catches were sampled under contract by the main Tauranga based fishing company.

3.2 Otolith preparation and reading

In February 2010, NIWA held an ageing workshop on red gurnard, attended by NIWA staff that prepared and aged the otoliths from this catch sampling programme. The following methods were agreed upon:

1. Otoliths were prepared following NIWA's ageing protocols for red gurnard (Sutton 2011) using the bake and embed method for whole otoliths. Otoliths were baked, embedded in a resin block, then sectioned through the primordium using a high speed Gemmasta GS6D® revolving saw. The resulting surface was polished and viewed with a stereomicroscope.
2. Otoliths were examined using reflected light under a stereomicroscope at a magnification of 100×. With transmitted light, the wide opaque zone appears light and the narrow hyaline zone appears dark.
3. Two elected core red gurnard expert readers (Colin Sutton and Matt Smith) counted annuli for all otoliths without reference to fish length.
4. The forced margin method was used to assign age for samples taken in months throughout the year (see below).
5. A subsequent rereading of otoliths with discrepant age estimates was carried out by the two readers and a third adjudicating reader (Cameron Walsh) jointly with conferring to determine a final agreed age.

The forced margin method is described in the NIWA red gurnard ageing protocol document (Sutton 2011), and also defined in the glossary of the Ministry guidelines for New Zealand fish ageing protocols (Ministry of Fisheries 2011a) as follows: **Forced Margin /Fixed Margin** – Otolith margin description (Line, Narrow, Medium, Wide) is determined according to the margin type anticipated for the season/month in which the fish was sampled. The otolith is then interpreted and age determined based on the forced margin. The forced margin method is usually used in situations where fish are sampled throughout the year and otolith readers have difficulty correctly interpreting otolith margins.

In the case of red gurnard the wide margin was used for otoliths collected in October–November and were assigned W (wide). The resulting age of a fish recorded as 6W, for example, is 7 years. Otoliths collected from December–January were interpreted as L (Line), or N (Narrow) if collected between February and September. Hence 7L and 7N were assigned an age of 7 years. The nominal birthday of red gurnard is taken as 1 January. However for the purpose of the analysis which is based on the 2009–10 fishing year (October – September), fish collected prior to 1 January 2010 were assigned the age they would be at the end of the fishing year, i.e. advanced in age by one year. This was necessary in order to preserve the temporal continuity of each year class relative to the 2009–10 fishing year. These fishing year age classes are herein referred to as "age classes" within the body of this document.

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 mean coefficient of variation (c.v.), were calculated for each test.

3.3 Catch at age estimation

Estimated scaled numbers-at-age were calculated using NIWA Catch-at-length and age software in R (NIWA 2011, R Development Core Team 2011). Age data were scaled in the same way as length data, i.e., by landed weights of red gurnard from the sampled vessels, and by commercial catch from the sampling strata. Scaled age-frequency distributions of the GUR 1 substock bottom trawl fisheries for 2009–10 were estimated for male and female red gurnard respectively, and for both sexes combined. The mean weighted coefficients of variation (MWCV) were estimated using a bootstrapping routine with 1000 bootstraps.

3.4 Growth parameter estimates

A von Bertalanffy growth model was fitted to red gurnard age-at-length data from each substock fishery, for each sex, using the model:

$$L_t = L_\infty (1 - \exp^{-K[t - t0]})$$

Where L_t was the length (cm) at age t, L_∞ the asymptotic mean maximum length, K was a constant (growth rate coefficient), and t_0 was the hypothetical age (years) that a fish has zero length.

The data fitted in the growth model were decimalised ages as of the date of collection, relative to an assumed January 1 "birthdate", not fishing year age classes as described in 3.2 above.

3.5 Mortality estimates

Total mortality (Z) was estimated from catch-curve analysis using the Chapman-Robson estimator (CR, Robson & Chapman 1961). The CR method has been shown to be less biased than the simple regression catch curve analysis (Dunn et al. 1999). Catch curve analysis assumes that the catch of fully recruited age classes declines exponentially with age and that the slope is equivalent to equilibrium total mortality experienced by the population, the sum of natural and fishing mortality, $Z = (M + F)$. Implicit in this calculation are the assumptions that recruitment and mortality are constant, that all fully recruited fish are equally vulnerable to capture, and that there are no age estimation errors.

We used the method of Dunn et al. (1999) to estimate the variance (95% confidence intervals) for age at full recruitment of 2 and 3 years for both sexes combined. Estimates of total mortality, Z, were calculated for age at full recruitment (a_{rec}) using the maximum-likelihood estimator:

$$\hat{Z} = \log_e \left(\frac{1 + \bar{a} - a_{\text{rec}}}{\bar{a} - a_{\text{rec}}} \right)$$

where $\bar{a} = \left(\sum_a^{\text{rec}} a f_a \right) \Big/ \left(\sum_a^{\text{rec}} f_a \right)$ is the mean age of recruited fish in the combined sex age frequency, and $\sum_a^{\text{rec}}$ denotes summation across all recruited ages.

3.6 Historical length and age distributions

Red gurnard data from previous catch sampling programmes and bottom trawl surveys were summarised from relevant technical reports for comparison with data generated in the present study.

3.7 Catch Sampling Design Optimisation

Data collected during this project are useful in estimating the sample size needed to achieve a desired level of precision in future red gurnard catch sampling programmes. The optimal sample size, both in numbers of landings sampled, and in the numbers of otoliths aged per sampled landing, depend on the number of age classes present and the variation in the age composition of the catch among the sampled landings within each stratum. Sample size optimisations were undertaken on the three spatial strata defining GUR 1: west coast North Island, East Northland/Hauraki Gulf and Bay of Plenty. The simulations were conducted using a bootstrap routine used to optimise catch sampling of snapper (Davies et al. 2003). The optimal sample size is the minimum number of samples required to achieve a particular level of precision (MWCV); typically a target of less than 0.30 in New Zealand catch sampling programmes. However, the target MWCV for simulations should ideally be less than 0.30 as the realized MWCV will depend on the catch sampled, which may vary substantially among years.

Also, the lower the MWCV, the more power to observe structure within the GUR 1 catch, such as temporal, spatial, or operations (e.g. gear type) differences in catch composition. The simulation study carried out here provides estimates of MWCVs for various combinations of numbers-of-landings-sampled and numbers-of-otoliths-sampled per landing.

4. RESULTS

4.1 Catch sampling summary

The target of 16 landings for the west coast North Island bottom trawl fishery was achieved, but part of one landing was subsequently found to have come from outside the substock, and was therefore omitted from the collection. There were initially 16 sampled landings from the East Northland/Hauraki Gulf subarea. However, two of these were subsequently rejected as they were contaminated with samples from outside the substock. All 16 landings sampled from the Bay of Plenty substock were retained for analysis. Targets of 20 landings for the two east coast substocks were therefore not achieved.

A total of 2159 otoliths were sampled (Table 1). As indicated to the Northern Inshore working group in 2009 when the catch sampling design was reviewed and subsequently expanded, there were insufficient resources to age all the collected otoliths. As a result, a smaller set of otoliths were subsequently aged, drawn at random from the larger set (Table 1). The selection process resulted in a greater number of otoliths being aged from the larger landings. Otoliths from sampled landings subsequently found to be invalid upon receipt of Ministry of Fisheries catch and effort data were removed from the west coast North Island and East Northland/Hauraki Gulf substock analyses (Table 1).

Table 1: Summary of the number of red gurnard otoliths collected and aged from GUR 1 substock collections in 2009–10.

Area	Collected	Aged	Used in analysis
WCNI	830	650	594
ENHG	829	552	529
BPLE	500	480	477
Total	2 159	1 682	1 600

4.1.1 Representativeness

The temporal spread of samples reflects the temporal distribution of landings in each of the three GUR 1 substocks (Figure 19). The level of sampling in the East Northland/Hauraki Gulf and west coast North Island substocks adequately matched the monthly catch patterns in the fishery, but sampling was less than ideal for the Bay of Plenty (Figure 19).

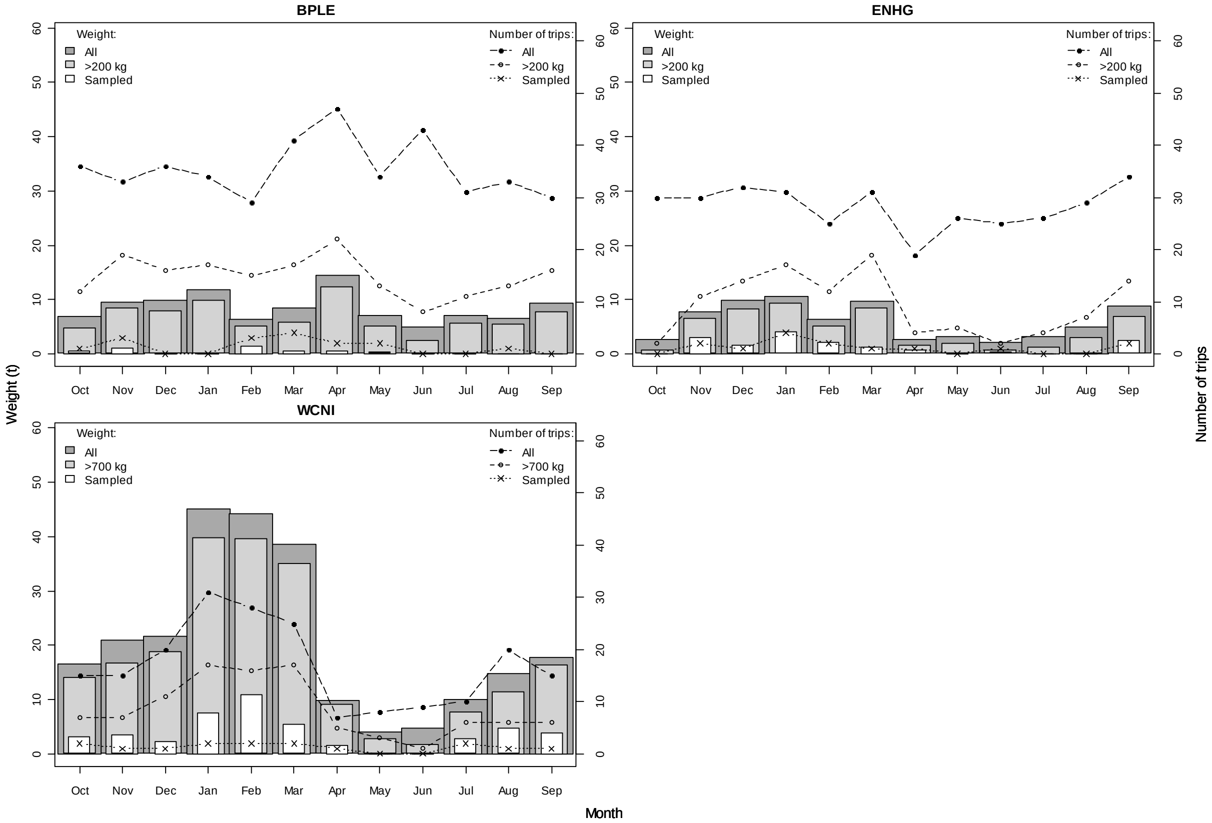


Figure 19: A comparison of the monthly catches and number of landings in the GUR 1 substock bottom trawl fisheries to those sampled in 2009–10.

Spatial representativeness of sampled landings in each sub-area in 2009–10 was adequate. (Figure 20; Figure 21).

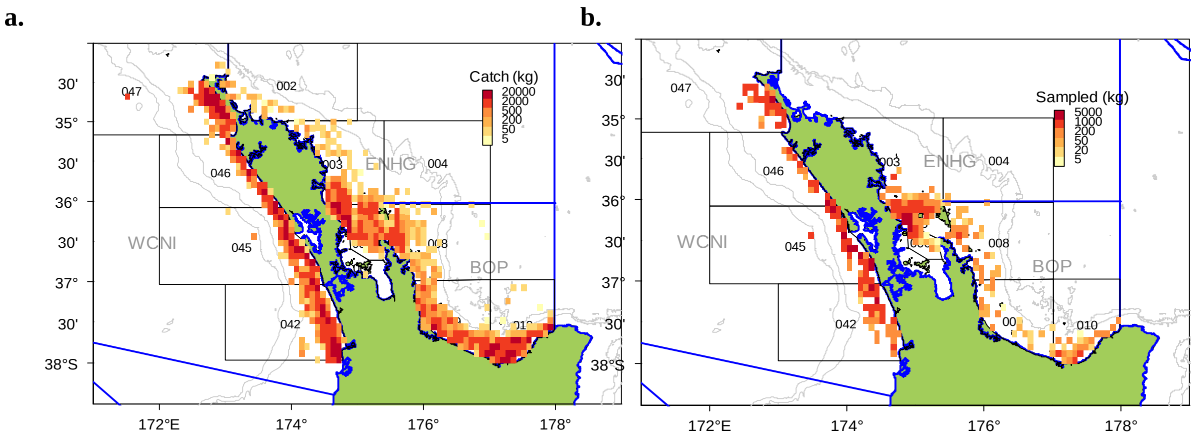


Figure 20: Spatial distribution of GUR 1 bottom trawl fishery in 2009–10 (a) and of sampled landings (b).

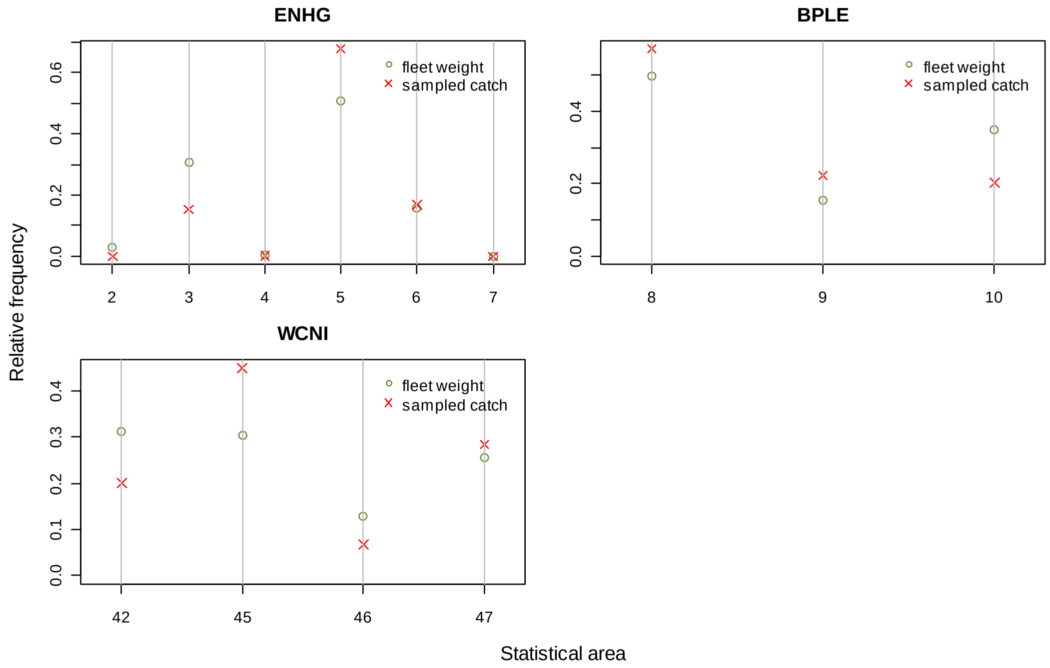


Figure 21: Proportional representativeness of the GUR 1 bottom trawl catches to the sampled component by statistical reporting area in 2009–10.

Catch sampling reflected the targeting proportions of gurnard catches from the west coast North Island and Bay of Plenty substocks (Figure 22). Sampling in the East Northland/ Hauraki Gulf substock under-represented gurnard targeting and over represented snapper targeting (Figure 22).

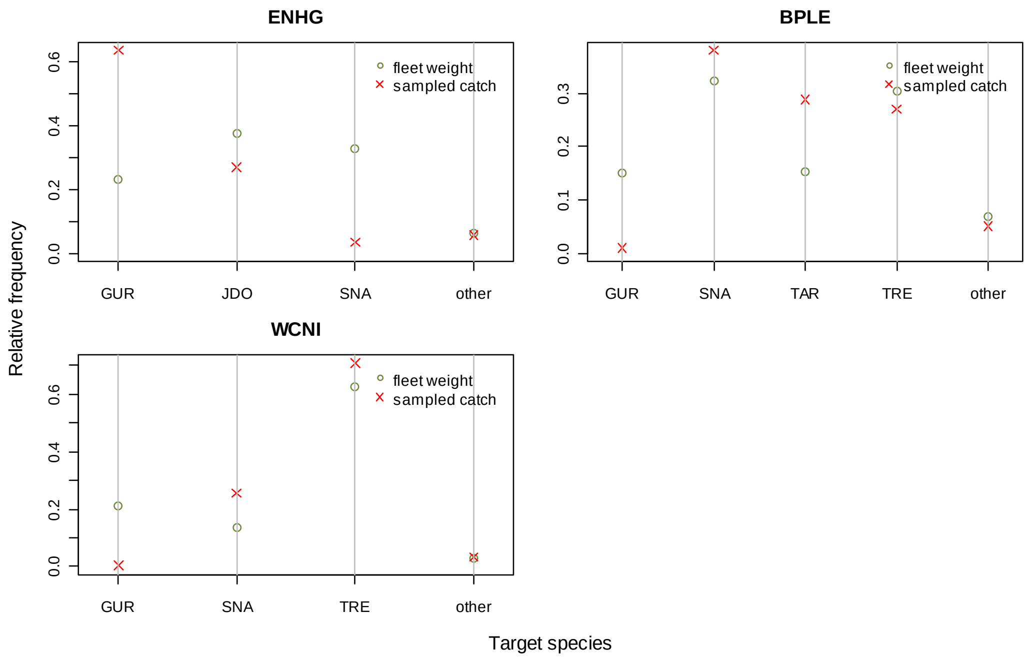


Figure 22: Proportional representativeness of the GUR 1 bottom trawl catches to the sampled component by target species in 2009–10.

The depth distribution of sampled catch was very similar to the depth distribution of all bottom trawl red gurnard catches in the East Northland/Hauraki Gulf and west coast North Island substocks (Figure 23). Sampling in the Bay of Plenty over-represented the middle depth range of the gurnard fishery in 2009–10 (Figure 23).

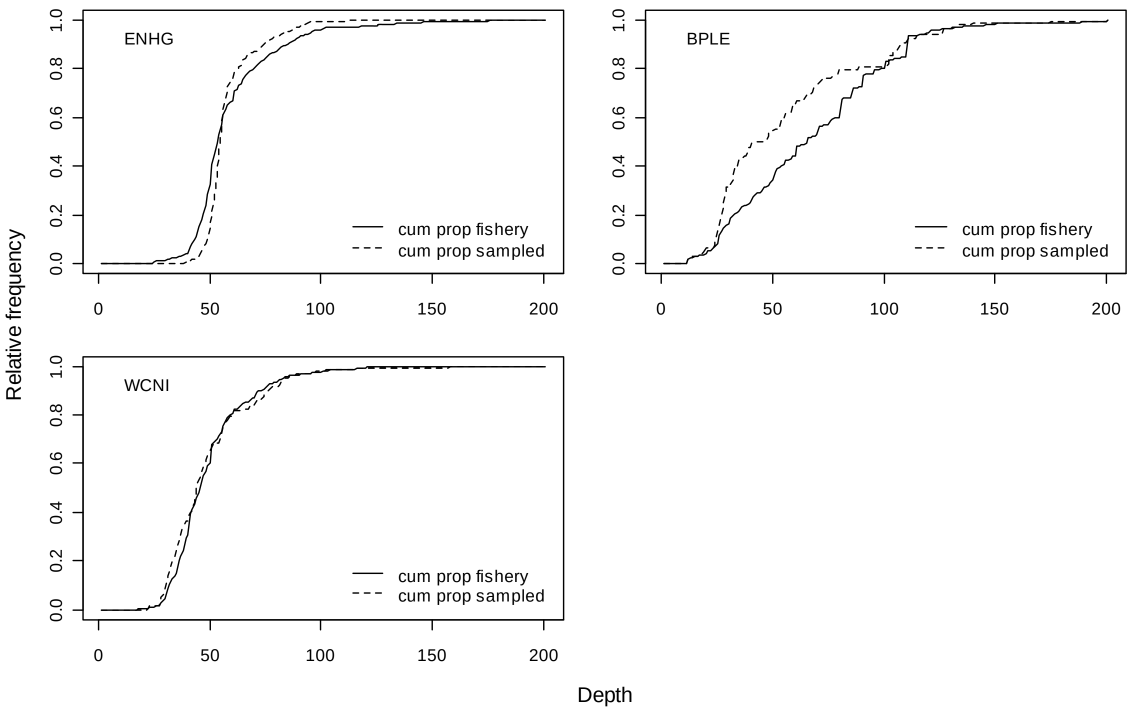


Figure 23: A comparison of the depth distribution of GUR 1 bottom trawl catches in 2009–10 for all tows to that of sampled landings.

4.2 Length composition of the catch

Bottom trawl catches comprised disproportionately more female than male red gurnard, a pattern consistent across the three GUR 1 substocks (Figure 24). The length distribution of males was also consistently smaller than females for all three substock fisheries (Figure 24). Differences in length composition between the three substocks were also evident (Figure 25).

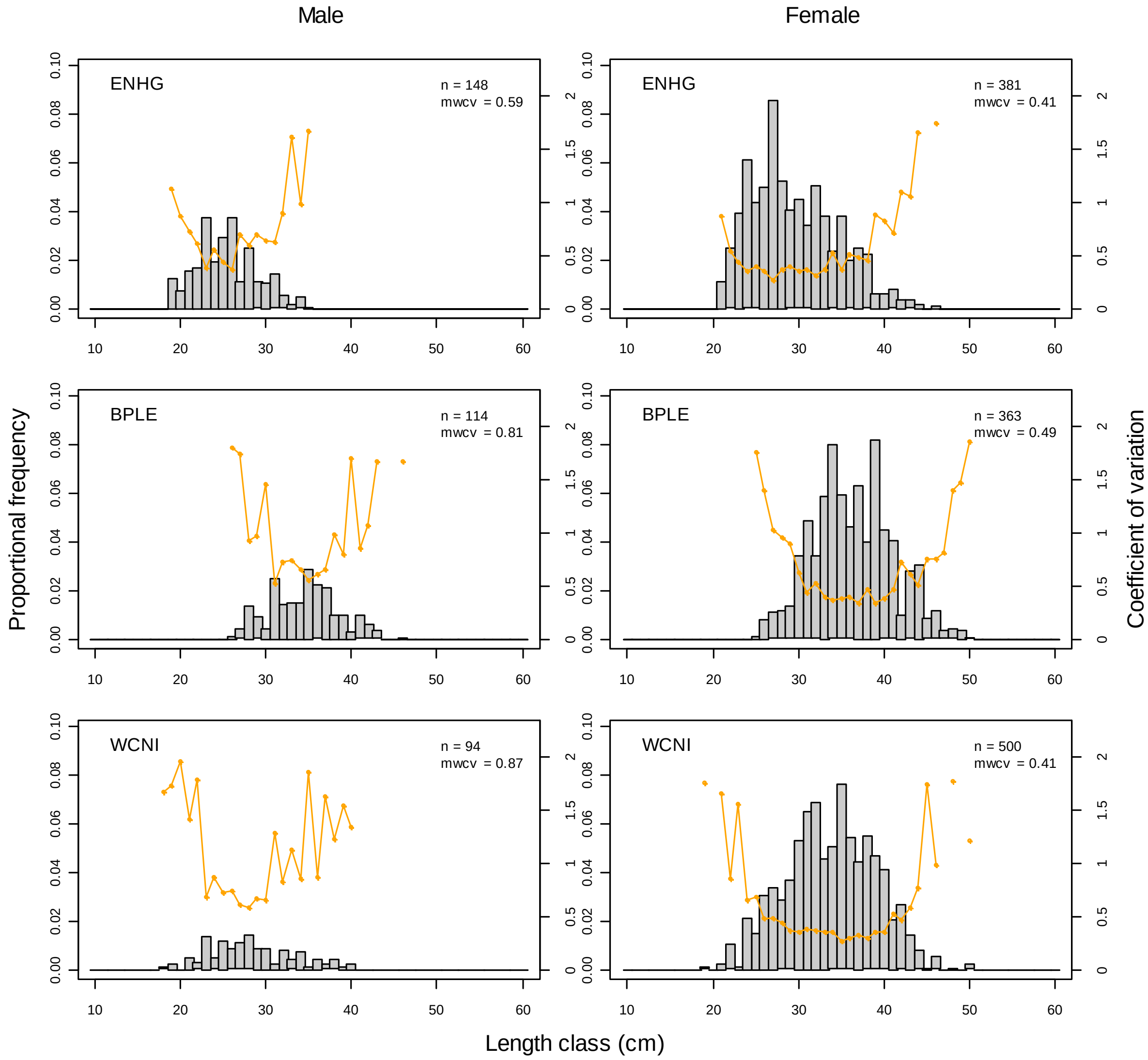


Figure 24: **Bottom trawl length frequency distributions by sex for each of the three GUR 1 substocks in 2009–10. Line indicates the c.v. for each length class.**

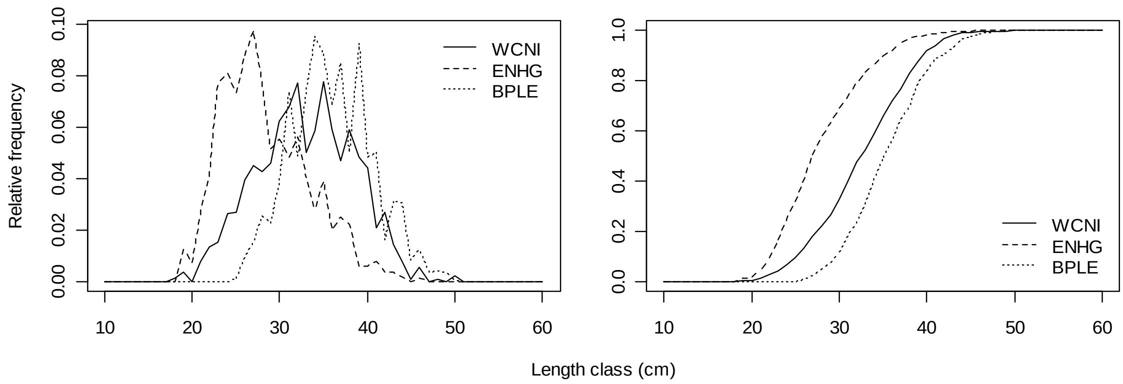


Figure 25: **Substock comparison of bottom trawl total proportional sample length compositions in 2009–10.**

4.2.1 Age determination

Age readings were consistent between readers, with an average percent error (APE) of 9.38 and a MWCV of 13.27% (Figure 26 a. and b.). The second reader tended to underestimate age compared to the first reader, especially for ages between 5 and 10 years (Figure 26 b, c). The between reader discrepancies were resolved through a conferring process and a final agreed age was determined. The initial readings of Reader 2 were more reflective of the final agreed age readings than Reader 1 (Figure 26 e. f.). Protocols for annulus readings have been updated to avoid future discrepancies of this type.

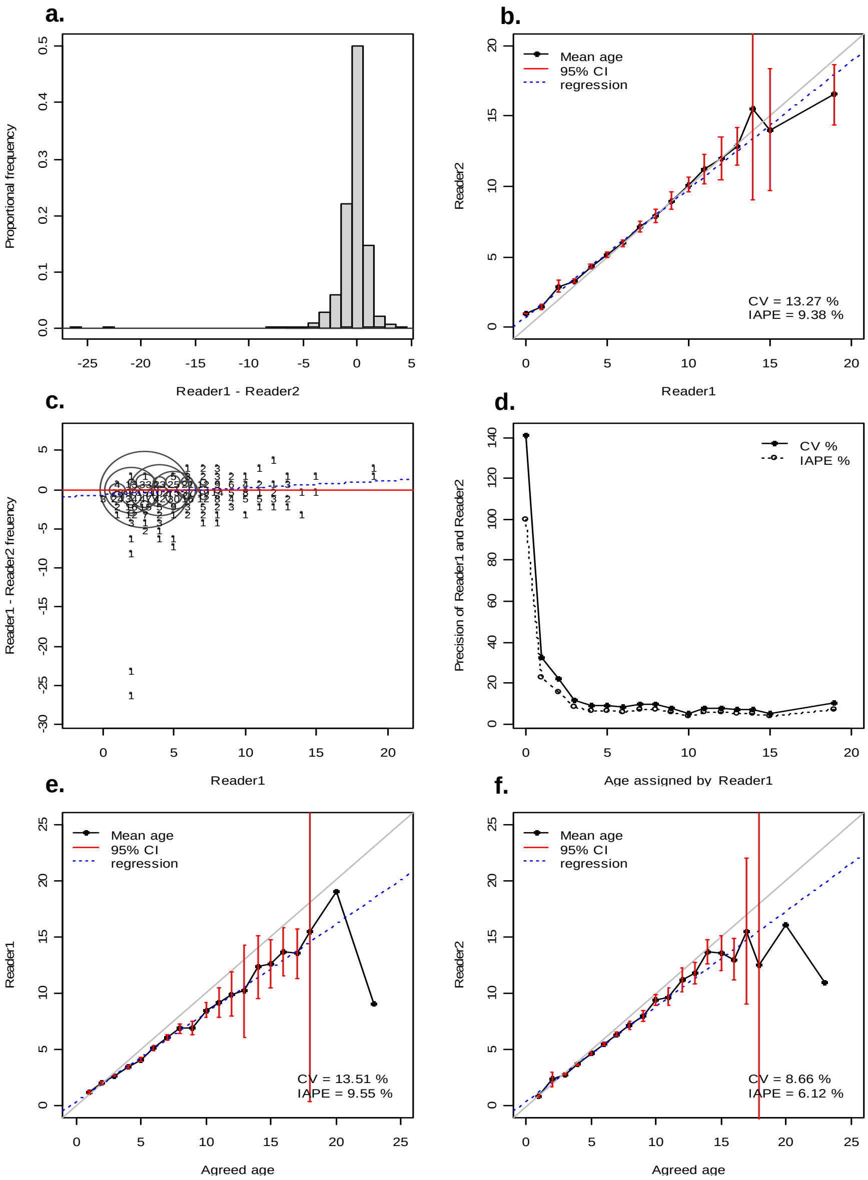


Figure 26: Age reader comparison plots. (a) histogram of age differences between two readers. (b) Plot of the c.v. and the average percent error (APE) for each age as assigned by the first reader. Red lines show perfect agreement. (c. and d.) difference between reader 1 and reader 2 as a function of the age assigned by reader 1. (e. and f.) plots of the c.v. and the average percent error (APE) for the initial readings of each reader relative to the final agreed age. Red lines show perfect agreement.

4.3 Age composition of the catch

The GUR 1 bottom trawl fishery in 2009–10 comprised fish predominately aged between 1 and 9 years of age in all three substocks, with fish 20 years or old being an extremely rare component of the catch (Figure 27; Appendix 3). The age range for males was marginally younger than females in that there were relatively fewer males older than 9 years in the catches (Figure 27; Appendix 3). It is likely this was due to spatial differences in the distribution of males and females relative to the operation of the bottom trawl fishery rather than sex related differential mortality at the population level, but neither hypothesis can be discounted.

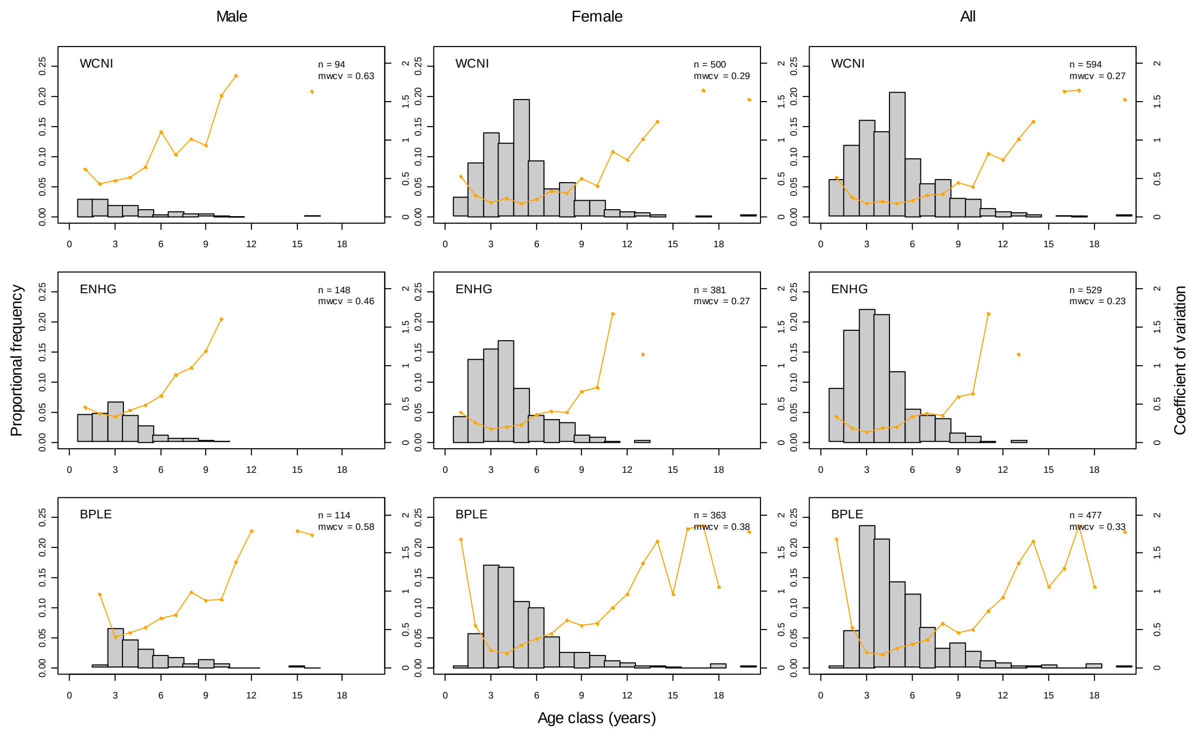


Figure 27: Proportional age frequency distributions for the GUR 1 substock bottom trawl fisheries in 2009–10, segregated by sex. Line indicates the c.v. for each age class.

The age compositions of the west coast North Island and Bay of Plenty substocks were similar in that they both had a broader range of age classes than the East Northland/Hauraki Gulf substock (Figure 28).

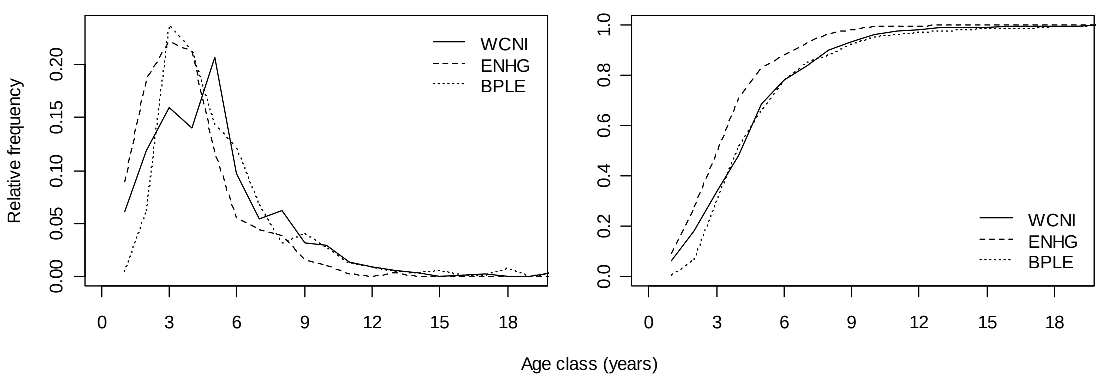


Figure 28: Substock comparison of bottom trawl total proportional sample age compositions in 2009–10.

4.4 Life history parameter estimates

4.4.1 Total Mortality estimates

Chapman-Robson estimates of total mortality (*Z*) depend on the age of full recruitment to the fishery (Robson & Chapman 1961). This age is usually estimated from the scaled age composition as the age class with the peak abundance, or one year after that age. The total mortality estimates derived from the west coast North Island and Bay of Plenty substock bottom trawl data as expected were similar (Table 2). The East Northland/Hauraki Gulf total mortality estimates were consistently higher due to the lack of older age classes in the data (Table 2). The selectivity characteristics of bottom trawl will influence the slope of the catch curve, for example, mortality will be overestimated if the method is less selective of older fish. The mortality estimates in Table 2 should not be assumed to be unbiased.

Table 2: GUR 1 total mortality estimates (Chapman and Robson) derived from bottom trawl catch-at-age using various assumed full recruitment ages with bootstrap MWCVs in brackets.

	Age of full recruitment		
Area	2	3	4
WCNI	0.27 (0.09)	0.32 (0.09)	0.37 (0.11)
ENHG	0.39 (0.07)	0.47 (0.08)	0.54 (0.12)
BPLE	0.27 (0.10)	0.34 (0.12)	0.37 (0.11)

4.4.2 Growth estimates

Growth curves (von Bertalanffy) fitted to the sampled age data suggest that red gurnard growth rates were similar for the west coast North Island and East Northland/Hauraki Gulf substocks, but fastest in the Bay of Plenty (Figure 29). Differences in the growth of males to females are evident in all three substocks, with females growing faster than males and to a larger size (Figure 29). Although the patterns seen in the growth data are informative, these results should not be assumed to be unbiased estimates of population growth, nor should differences seen between the three substocks be considered significant for the following reasons: the selectivity characteristics of bottom trawl are unlikely to be uniform for smaller fish and the sample sizes are particularly low for the very young and old age classes.

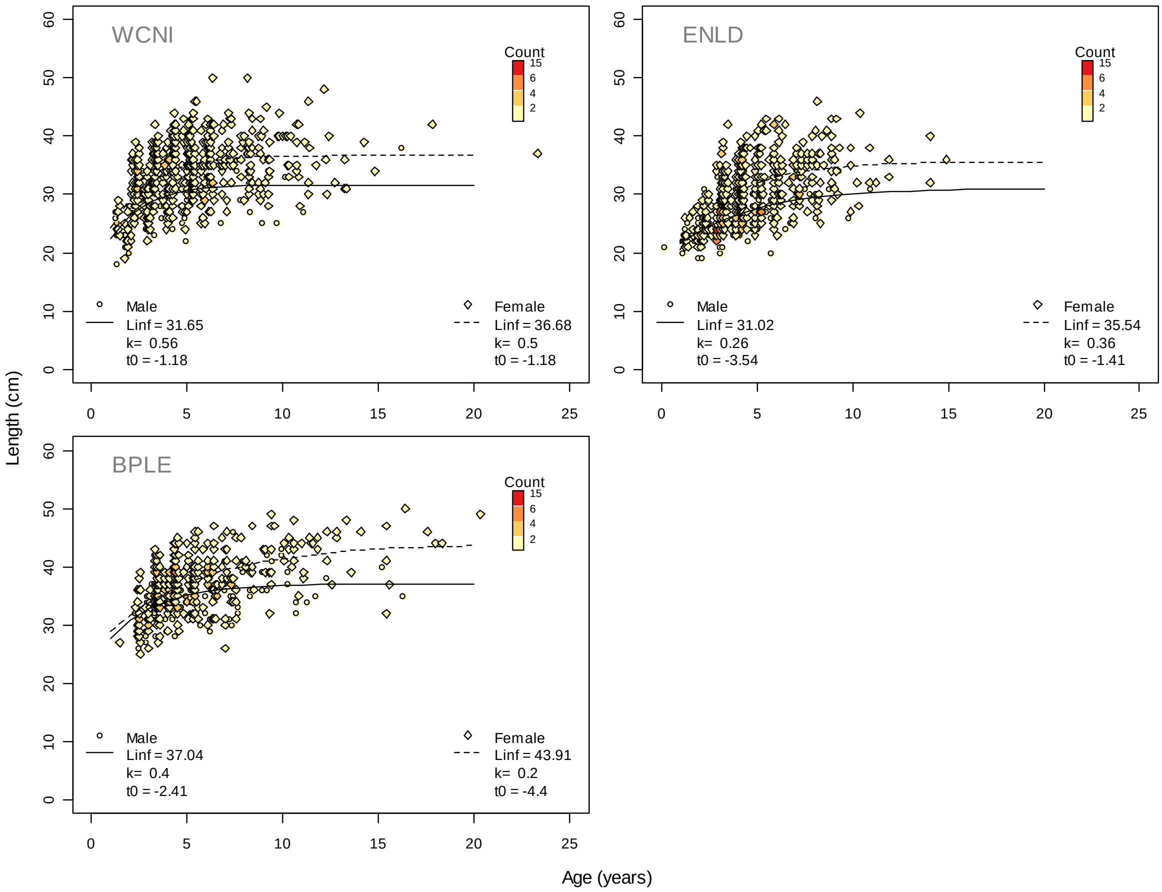


Figure 29: Length-at-age observations for male and female red gurnard (points) and the von Bertalanffy growth model fits (lines) for fish aged from the GUR 1 substock bottom trawl fisheries in 2009–10. Data are decimalised age at date of collection relative to an assumed January 1 "birthdate".

4.5 Comparison with length and age compositions from previous studies

Previous published work describing the age composition of GUR 1 bottom trawl catches is limited to Elder (1976) for the Hauraki Gulf substock (1968–69) and Horn et al. (2006) for the East Northland/Hauraki Gulf (2002–03, 2003–04 and 2004–05) and west coast North Island substocks (2003–04, 2004–05).

The red gurnard age composition for bottom trawl catches from the Hauraki Gulf in 1968–69 is similar to recent catches for the wider east coast (not including the Bay of Plenty) (Figure 30). At face value, the total mortality as indicated by the age composition was lower in 2009–10 than in 1968–69 as indicated by the broader range of age classes in the more recent bottom trawl catches. However, the broader age composition may be due to the wider East Northland coverage in the recent sampling. Despite these caveats it is reasonable to conclude that fishing pressure in East Northland/Hauraki Gulf was no greater in the 2000s than during the late 1960s.

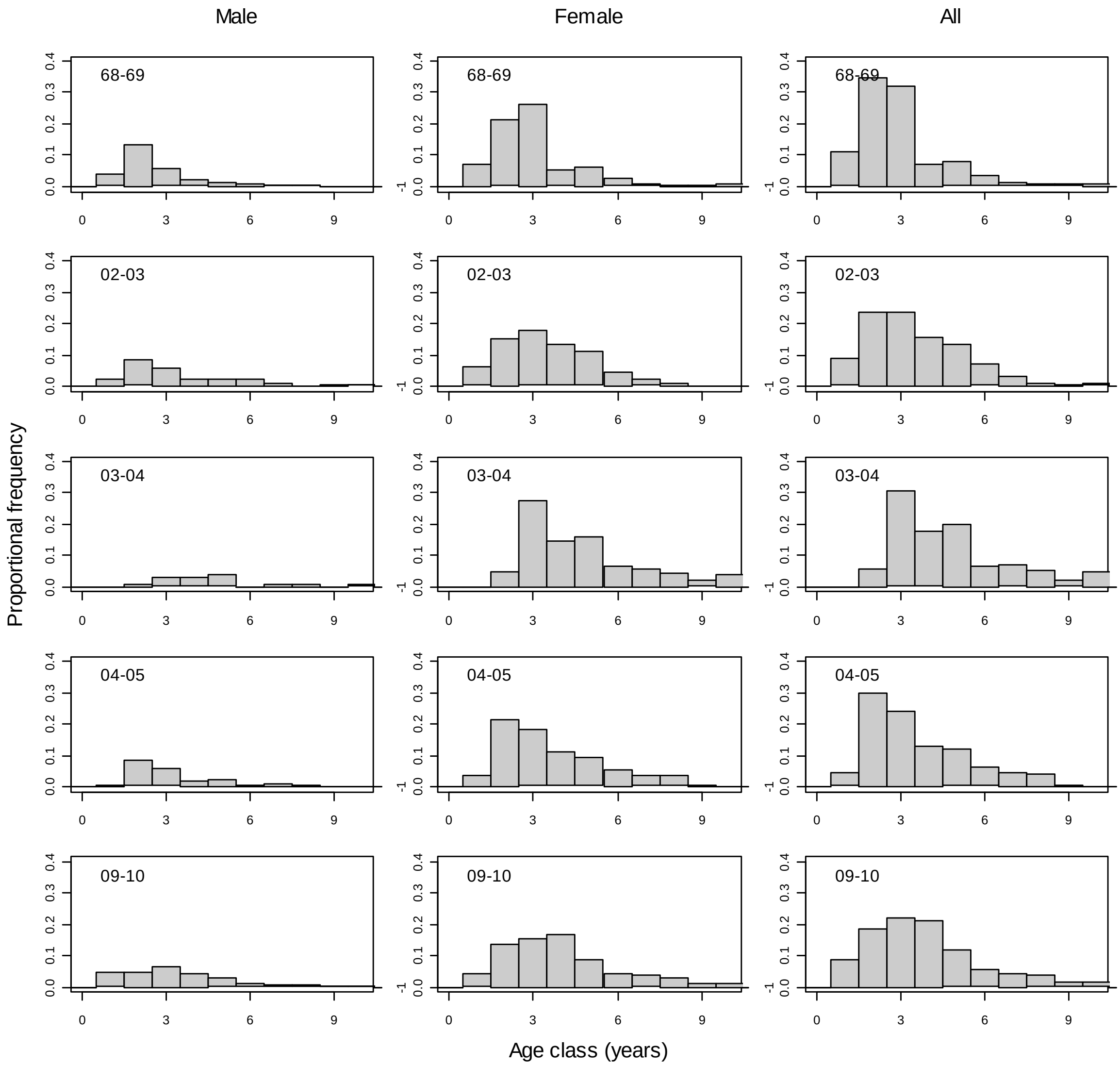


Figure 30: Age distributions for red gurnard from the East Northland/Hauraki Gulf bottom trawl catches. Data from Elder (1976), Horn et al. (2006) and the current study. The 10 year age class is an aggregate of all age classes over 9 years.

The recent time series of age distributions from the west coast North Island bottom trawl fishery were broadly similar to those for the two east coast substocks, but with higher proportions of fish older than 9 years, (Figure 31). Comparison of west coast age composition from this study with those from 2003–04 and 2004–05 suggest that there has been no systematic change in total mortality over the recent decade in the west coast fishery (Figure 31).

The lack of any discernible progression of strong and weak cohorts in recent data series (Figure 30 and Figure 31) is likely to be due to poor spatial and temporal coverage in the Horn series and a lack of consistency in ageing. By and large, the current programme has better represented the GUR 1 fishery than the previous studies, with superior ageing protocols developed and used in the analyses.

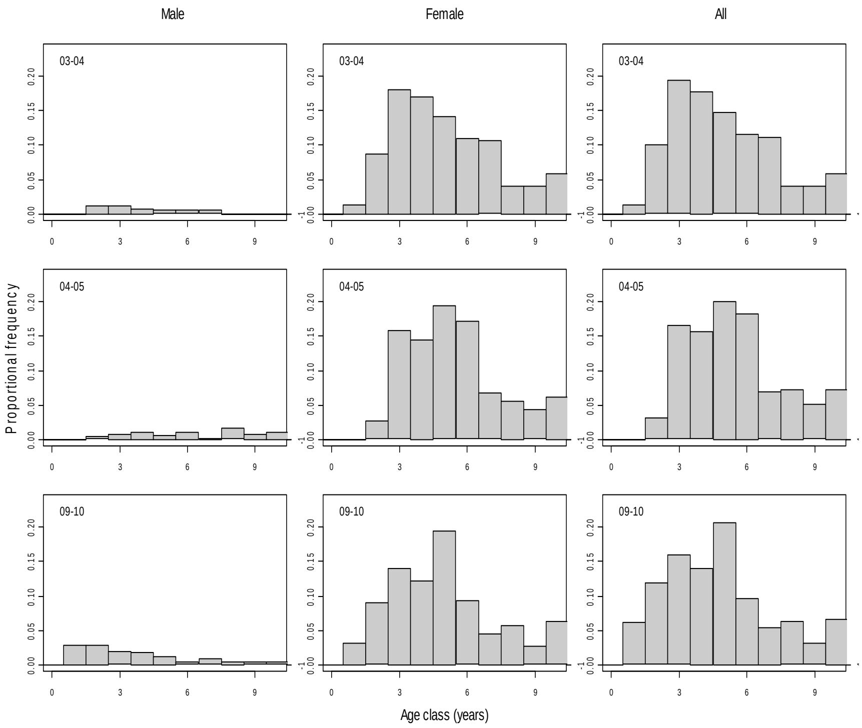


Figure 31: Age distributions of west coast North Island red gurnard bottom trawl catches. Data from Horn et al. (2006) and current study. The 10 year age class is an aggregate of all age classes over 9 years.

5. RECOMMENDATIONS FOR FUTURE CATCH SAMPLING PROGRAMMES

The Ministry of Fisheries specified target MWCV (0.30 for both sexes combined) for the GUR 1 catch-at-age sampling project in 2009–10 was achieved for the west coast North Island and East Northland/Hauraki Gulf substocks (0.23; Appendix 3) and marginally exceeded for the Bay of Plenty substock (0.33; Appendix 3).

Although the west coast North Island and Bay of Plenty substocks had a similar age range, only the west coast North Island substock achieved the desired precision with approximately 600 otolith samples. A sample size of fewer than 500 otoliths was inadequate to achieve the Bay of Plenty catch-at-age composition desired precision (Appendix 3).

In our opinion an overall target MWCV of 0.30 is not ideal for red gurnard given that it is important to stratify the analysis by sex. We recommend future gurnard catch sampling projects are designed with an overall precision target of at least 0.25.

The bootstrap simulation analysis, using the 2009–10 catch sampling data, indicated that for the west coast North Island bottom trawl fishery a MWCV in the order of 0.25 could be achieved by collecting 600–700 otolith samples from 10 to 15 landings (Table 3). Sampling simulations for the East Northland/Hauraki Gulf substock suggested only 400–500 otoliths from 10 to 20 landings are required to achieve the same MWCV (0.25), while that for the Bay of Plenty, 600–800 otoliths from 15 to 20 landings are required (Table 3). The simulation results assume that future samples will have the same variance structure as the 2009–10 collections; if variance increases larger numbers of landings and samples would be required to achieve the predicted MWCVs.

Table 3: Bootstrapped MWCVs based on landings sampled and otoliths collected from the GUR 1 bottom trawl fishery 2009-10 using the random age sampling approach. The shaded area indicates the recommended number of landings and otoliths per landing to sample from the fishery.

West coast North Island

	Average number of otoliths per landing									
Landings	10	20	30	40	50	60	70	80	90	100
10	0.45	0.36	0.32	0.30	0.28	0.27	0.26	0.26	0.25	0.25
15	0.36	0.29	0.26	0.24	0.23	0.22	0.21	0.21	0.21	0.21
20	0.31	0.25	0.22	0.21	0.20	0.19	0.19	0.18	0.18	0.18
25	0.28	0.22	0.20	0.18	0.17	0.17	0.16	0.16	0.16	0.16
30	0.26	0.21	0.18	0.17	0.16	0.16	0.15	0.15	0.15	0.14

East Northland/Hauraki Gulf

	Average number of otoliths per landing									
Landings	10	20	30	40	50	60	70	80	90	100
10	0.39	0.31	0.27	0.25	0.25	0.23	0.23	0.23	0.22	0.22
15	0.32	0.25	0.23	0.21	0.20	0.19	0.19	0.19	0.18	0.18
20	0.28	0.22	0.20	0.18	0.18	0.17	0.17	0.16	0.16	0.16
25	0.25	0.20	0.18	0.16	0.16	0.15	0.15	0.15	0.14	0.14
30	0.23	0.18	0.16	0.15	0.15	0.14	0.14	0.13	0.13	0.13

Bay of Plenty

	Average number of otoliths per landing									
Landings	10	20	30	40	50	60	70	80	90	100
10	0.47	0.40	0.37	0.35	0.34	0.33	0.33	0.32	0.31	0.31
15	0.38	0.32	0.30	0.28	0.27	0.26	0.26	0.26	0.25	0.25
20	0.33	0.28	0.25	0.24	0.24	0.23	0.23	0.22	0.22	0.22
25	0.29	0.24	0.23	0.22	0.21	0.20	0.20	0.20	0.20	0.19
30	0.27	0.23	0.20	0.20	0.19	0.19	0.19	0.18	0.18	0.18

6. ACKNOWLEDGMENTS

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7. REFERENCES

Beamish, R. J., and D. A. Fournier. 1981. A method for comparing the precision of a set of age determinations. *Canadian Journal of Fisheries and Aquatic Sciences 38: 982-983*

Campana, S.E.; Annand, M.C.; McMillan, J.I. (1995). Graphical and statistical methods for determining the consistency of age determinations. *Transactions of the American Fisheries Society 124:* 131–138.

Davies, N.M.; Hartill, B.; Walsh, C. (2003). A review of methods used to estimate snapper catch-at-age and growth in SNA 1 and SNA 8. *New Zealand Fisheries Assessment Report 2003/10.* 63 p.

Dunn, A.; Francis, R.I.C.C.; Doonan, I.J. (1999). The sensitivity of some catch curve estimators of mortality to stochastic noise, error, and selectivity. New Zealand Fisheries Assessment Research Document 99/15. 23 p. (Unpublished report held by NIWA library, Wellington).

Elder, R.D. (1976). Studies on age and growth, reproduction and population dynamics of red gurnard, *Chelidonichthys kumu* (Lesson and Garnot), in the Hauraki Gulf, New Zealand. *Fisheries Research Bulletin No: 12*. 62 p.

Hartill, B.; Bian, R.; Armiger, H.; Vaughan, M.; Rush, N. (2007). Recreational marine harvest estimates of snapper, kahawai, and kingfish in QMA 1 in 2004–05. *New Zealand Fisheries Assessment Report 2007/26.* 44 p.

Horn, P.L.; McMillan, P.J.; Manning, M.J.; Sutton, C.P. (2006). Commercial catch sampling for length and age of John Dory in JDO 1, grey Mullet in GMU 1, red gurnard in GUR 1 and GUR 2, gemfish in SKI 2, and alfonsino in BYX 3, in the 2004-05 fishing year. Final Research Report for project INS2003-01. Unpublished report held by the Ministry for Primary Industries, Wellington. 42 p.

Kendrick, T.H. (2009). Fishery characterisation and catch-per-unit-effort indices for three substocks of red gurnard in GUR 1; 1989–90 to 2004–05. *New Zealand Fisheries Assessment Report 2009/10. 79 p.*

Ministry of Fisheries (2011a). Age determination workshop. Ministry of Fisheries, Wellington. (Unpublished report held by Ministry for Primary Industries, Wellington).

Ministry of Fisheries (2011b). Red Gurnard (GUR), pp. 793–817. *In:* Report from the Fisheries Assessment Plenary, May 2010: stock assessments and yield estimates. Ministry of Fisheries, Wellington.

NIWA (2011). Catch and Length at Age (CALA) software. NIWA, Wellington. (Unpublished report held by NIWA library, Wellington).

R Development Core Team (2011). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna. http://www.R-project.org.

Robson, D.S.; Chapman, D.G. (1961). Catch curves and mortality rates. *Transactions of the American Fisheries Society. 90*:181–189.

Sutton, C.P. (2011). Manual for age determination of red gurnard, *Chelidonichthys kumu*. Otolith preparation and interpretation. Unpublished document held by NIWA, Wellington. 22 p.

Walsh, C.; McKenzie, J.; Buckthought, D.; Armiger, H.; Ferguson, H.; Smith, M.; Spong, K.; Miller, A. (2011). Age composition of commercial snapper landings in SNA 1, 2009–10. *New Zealand Fisheries Assessment Report 2011/54*. 55 p.

8. APPENDICES

Appendix 1: Annual GUR 1 catch (t) by area and method (BLL, bottom longline; BPT, bottom pair trawl; BT, bottom trawl; DS, Danish seine; SN, setnet).

West coast North Island						Method
Fishing year		BPT	BT	DS	SN	Other
2003–04		49	485	125	34	13
2004–05		78	510	58	30	2
2005–06		52	405	51	20	1
2006–07		56	418	139	21	1
2007–08		80	433	224	15	2
2008–09		67	273	273	11	3
2009–10		128	256	175	12	3

ENHG						Method
Fishing year	BLL	BPT	BT	DS	SN	Other
2003–04	98	8	96	31	3	0
2004–05	126	12	168	63	2	0
2005–06	113	6	128	80	3	0
2006–07	109	6	129	109	4	0
2007–08	55	8	84	83	3	0
2008–09	65	5	68	60	2	0
2009–10	63	8	73	83	3	0

BPLE						Method
Fishing year	BLL	BPT	BT	DS	SN	Other
2003–04	30	13	108	125	4	1
2004–05	37	11	124	128	4	0
2005–06	31	2	106	109	5	0
2006–07	31	1	68	81	6	1
2007–08	26	1	82	93	8	0
2008–09	22	1	90	112	8	0
2009–10	38	2	105	124	11	0

Appendix 2: Length composition and MWCVs for bottom trawl sampled catches by substock.

a. East Northland/Hauraki Gulf

Length (cm)	Male	Female	Total	Male_cv	Female_cv	Total_cv
15	0	0	0	0.00	0.00	0.00
16	0	0	0	0.00	0.00	0.00
17	0	0	0	0.00	0.00	0.00
18	0	0	0	0.00	0.00	0.00
19	0.0127347	0	0.0127347	1.12	0.00	1.12
20	0.0074803	0	0.0074803	0.87	0.00	0.87
21	0.0158052	0.0112934	0.0270986	0.73	0.87	0.54
22	0.0169122	0.0247068	0.041619	0.62	0.54	0.41
23	0.0377033	0.0395194	0.0772226	0.39	0.44	0.28
24	0.0195914	0.0610228	0.0806142	0.56	0.35	0.27
25	0.0296378	0.0436263	0.0732641	0.44	0.40	0.32
26	0.037626	0.0500294	0.0876554	0.37	0.35	0.25
27	0.0114167	0.0859156	0.0973322	0.70	0.26	0.24
28	0.0251987	0.052476	0.0776747	0.59	0.37	0.28
29	0.0109565	0.0405728	0.0515293	0.69	0.40	0.34
30	0.0106636	0.0446605	0.0553241	0.65	0.36	0.31
31	0.0142884	0.0341637	0.0484521	0.63	0.36	0.30
32	0.0053365	0.05071	0.0560465	0.89	0.31	0.28
33	0.0019376	0.0383224	0.0402599	1.61	0.37	0.36
34	0.0049331	0.0235166	0.0284496	0.99	0.52	0.45
35	0.000767	0.0383945	0.0391616	1.66	0.37	0.37
36	0	0.0198611	0.0198611	0.00	0.51	0.51
37	0	0.0250006	0.0250006	0.00	0.48	0.48
38	0	0.0221898	0.0221898	0.00	0.45	0.45
39	0	0.0062662	0.0062662	0.00	0.88	0.88
40	0	0.0062103	0.0062103	0.00	0.83	0.83
41	0	0.007842	0.007842	0.00	0.71	0.71
42	0	0.0037452	0.0037452	0.00	1.09	1.09
43	0	0.0036564	0.0036564	0.00	1.05	1.05
44	0	0.0018649	0.0018649	0.00	1.66	1.66
45	0	0	0	0.00	0.00	0.00
46	0	0.0014447	0.0014447	0.00	1.73	1.73
47	0	0	0	0.00	0.00	0.00
48	0	0	0	0.00	0.00	0.00
49	0	0	0	0.00	0.00	0.00
50	0	0	0	0.00	0.00	0.00
MWCV				0.59	0.41	0.36

b. Bay of Plenty

Length (cm)	Male	Female	Total	Male_cv	Female_cv	Total_cv
15	0	0	0	0.00	0.00	0.00
16	0	0	0	0.00	0.00	0.00
17	0	0	0	0.00	0.00	0.00
18	0	0	0	0.00	0.00	0.00
19	0	0	0	0.00	0.00	0.00
20	0	0	0	0.00	0.00	0.00
21	0	0	0	0.00	0.00	0.00
22	0	0	0	0.00	0.00	0.00
23	0	0	0	0.00	0.00	0.00
24	0	0	0	0.00	0.00	0.00
25	0	0.0014402	0.0014402	0.00	1.76	1.76
26	0.0014402	0.0083338	0.009774	1.80	1.39	1.17
27	0.0041669	0.0111159	0.0152827	1.75	1.03	0.85
28	0.0138425	0.011879	0.0257215	0.93	0.95	0.78
29	0.0093096	0.0136454	0.022955	0.98	0.91	0.72
30	0.0044093	0.034273	0.0386823	1.46	0.62	0.59
31	0.0250538	0.0485562	0.0736101	0.52	0.44	0.35
32	0.0144973	0.0343338	0.0488311	0.72	0.52	0.42
33	0.0153055	0.0590695	0.0743751	0.74	0.39	0.38
34	0.0150729	0.0799079	0.0949808	0.66	0.37	0.31
35	0.0288681	0.0593838	0.0882519	0.55	0.39	0.31
36	0.0221995	0.0460539	0.0682534	0.61	0.40	0.31
37	0.0214817	0.0633359	0.0848176	0.65	0.35	0.29
38	0.0101547	0.0400389	0.0501936	0.98	0.48	0.40
39	0.0101765	0.0821462	0.0923227	0.80	0.34	0.32
40	0.0034299	0.0448248	0.0482548	1.70	0.39	0.38
41	0.0097063	0.0404589	0.0501652	0.85	0.47	0.45
42	0.0062106	0.0102637	0.0164743	1.07	0.73	0.68
43	0.0035231	0.0281112	0.0316343	1.66	0.61	0.58
44	0	0.0306848	0.0306848	0.00	0.52	0.52
45	0	0.0085696	0.0085696	0.00	0.75	0.75
46	0.0008486	0.0117225	0.012571	1.67	0.75	0.71
47	0	0.0035292	0.0035292	0.00	0.81	0.81
48	0	0.0042785	0.0042785	0.00	1.40	1.40
49	0	0.0038881	0.0038881	0.00	1.47	1.47
50	0	0.0004582	0.0004582	0.00	1.86	1.86
			MWCV	0.78	0.48	0.43

c. West coast North Island

Length (cm)	Male	Female	Total	Male_cv	Female_cv	Total_cv
15	0	0	0	0.00	0.00	0.00
16	0	0	0	0.00	0.00	0.00
17	0	0	0	0.00	0.00	0.00
18	0.0013112	0	0.0013112	1.67	0.00	1.67
19	0.0026116	0.001308	0.0039196	1.73	1.76	1.25
20	0.0001275	0	0.0001275	1.96	0.00	1.96
21	0.0052231	0.0026116	0.0078347	1.41	1.65	1.26
22	0.0031529	0.0104059	0.0135588	1.79	0.86	0.85
23	0.0140725	0.0014387	0.0155111	0.69	1.56	0.68
24	0.0050048	0.0215041	0.0265089	0.87	0.65	0.55
25	0.0119522	0.0152117	0.0271639	0.73	0.69	0.55
26	0.0085251	0.0308257	0.0393508	0.74	0.49	0.42
27	0.0111424	0.033959	0.0451014	0.62	0.49	0.38
28	0.0142103	0.0285583	0.0427686	0.58	0.44	0.38
29	0.0091233	0.0368064	0.0459296	0.67	0.38	0.33
30	0.0089317	0.0533718	0.0623035	0.66	0.36	0.31
31	0.002565	0.0653383	0.0679032	1.28	0.38	0.37
32	0.0082666	0.0689111	0.0771777	0.83	0.37	0.36
33	0.0044376	0.0458644	0.050302	1.13	0.35	0.33
34	0.0076637	0.0506254	0.0582891	0.86	0.36	0.35
35	0.001443	0.0761941	0.0776371	1.85	0.28	0.27
36	0.0045742	0.0543472	0.0589214	0.87	0.30	0.28
37	0.0024077	0.0445803	0.046988	1.62	0.33	0.32
38	0.0043673	0.0547816	0.0591489	1.23	0.30	0.30
39	0.001443	0.0469386	0.0483817	1.54	0.36	0.35
40	0.0027494	0.0411851	0.0439345	1.35	0.37	0.35
41	0	0.0208212	0.0208212	0.00	0.53	0.53
42	0	0.0267412	0.0267412	0.00	0.47	0.47
43	0	0.0146558	0.0146558	0.00	0.59	0.59
44	0	0.0081002	0.0081002	0.00	0.78	0.78
45	0	0.0009132	0.0009132	0.00	1.74	1.74
46	0	0.005494	0.005494	0.00	0.99	0.99
47	0	0	0	0.00	0.00	0.00
48	0	0.0009132	0.0009132	0.00	1.77	1.77
49	0	0	0	0.00	0.00	0.00
50	0	0.0022879	0.0022879	0.00	1.22	1.22
			MWCV	0.88	0.41	0.40

Appendix 3: Age composition and MWCVs for bottom trawl sampled catches by substock.

a. East Northland/Hauraki Gulf

Age	Male	Female	Total	Male_cv	Female_cv	Total_cv
1	0.0460697	0.043209	0.0892787	0.46	0.40	0.33
2	0.0482496	0.138513	0.186762	0.38	0.25	0.19
3	0.0668823	0.154815	0.221698	0.34	0.18	0.13
4	0.0442435	0.168825	0.213068	0.42	0.21	0.19
5	0.0282596	0.0898378	0.118097	0.49	0.24	0.20
6	0.0113	0.0440977	0.0553977	0.61	0.36	0.34
7	0.0062536	0.0382881	0.0445417	0.88	0.40	0.38
8	0.0068564	0.0320551	0.0389115	0.98	0.39	0.36
9	0.0033419	0.0127973	0.0161391	1.20	0.66	0.59
10	0.0015324	0.0088926	0.0104249	1.62	0.72	0.64
11	0	0.0022111	0.0022111	0.00	1.68	1.68
12	0	0	0	0.00	0.00	0.00
13	0	0.0034699	0.0034699	0.00	1.15	1.15
14	0	0	0	0.00	0.00	0.00
15	0	0	0	0.00	0.00	0.00
16	0	0	0	0.00	0.00	0.00
17	0	0	0	0.00	0.00	0.00
18	0	0	0	0.00	0.00	0.00
19	0	0	0	0.00	0.00	0.00
20+	0	0	0	0.00	0.00	0.00
MWCV				0.46	0.28	0.23

b. Bay of Plenty

Age	Male	Female	Total	Male_cv	Female_cv	Total_cv
1	0	0.0041177	0.0041177	0.00	1.68	1.68
2	0.0046447	0.0579664	0.0626111	0.96	0.56	0.52
3	0.0656356	0.171609	0.237245	0.40	0.23	0.21
4	0.0467461	0.166972	0.213718	0.46	0.19	0.18
5	0.0317389	0.11149	0.143229	0.53	0.30	0.26
6	0.0211668	0.101049	0.122216	0.65	0.38	0.31
7	0.0169308	0.0513377	0.0682685	0.69	0.45	0.37
8	0.0063882	0.0257463	0.0321345	1.00	0.63	0.59
9	0.0142581	0.0266673	0.0409254	0.88	0.56	0.47
10	0.0070094	0.0205091	0.0275186	0.90	0.59	0.50
11	0.0007497	0.0115342	0.012284	1.38	0.79	0.75
12	0.0004582	0.0087095	0.0091676	1.79	0.97	0.92
13	0	0.0042785	0.0042785	0.00	1.37	1.37
14	0	0.0035231	0.0035231	0.00	1.66	1.66
15	0.0034299	0.0024591	0.005889	1.79	0.97	1.06
16	0.0005403	0.0004582	0.0009985	1.74	1.82	1.30
17	0	0.0008486	0.0008486	0.00	1.86	1.86
18	0	0.0075968	0.0075968	0.00	1.05	1.05
19	0	0	0	0.00	0.00	0.00
20+	0	0.0034299	0.0034299	0.00	1.78	1.78
			MWCV	0.59	0.38	0.33

c. West coast

Age	Male	Female	Total	Male_cv	Female_cv	Total_cv
1	0.0293321	0.0318242	0.0611563	0.62	0.53	0.51
2	0.0289388	0.0898592	0.118798	0.43	0.29	0.26
3	0.0192857	0.140361	0.159646	0.48	0.18	0.18
4	0.0185122	0.122281	0.140793	0.51	0.24	0.20
5	0.0124608	0.194344	0.206804	0.64	0.18	0.17
6	0.0039863	0.0929476	0.0969339	1.12	0.23	0.21
7	0.0087062	0.0458053	0.0545115	0.81	0.34	0.29
8	0.0052938	0.0575213	0.0628151	1.01	0.31	0.30
9	0.0045136	0.0269903	0.0315039	0.93	0.50	0.44
10	0.0024077	0.0268098	0.0292176	1.59	0.41	0.39
11	0.0004944	0.0126387	0.0131331	1.84	0.86	0.82
12	0	0.0090613	0.0090613	0.00	0.74	0.74
13	0	0.0058947	0.0058947	0.00	1.02	1.02
14	0	0.0033333	0.0033333	0.00	1.24	1.24
15	0	0	0	0.00	0.00	0.00
16	0.0013747	0	0.0013747	1.64	0.00	1.64
17	0	0.0020299	0.0020299	0.00	1.65	1.65
18	0	0	0	0.00	0.00	0.00
19	0	0	0	0.00	0.00	0.00
20+	0	0.0029926	0.0029926	0.00	1.52	1.52
			MWCV	0.63	0.29	0.27