Length and age composition of commercial trevally landings in TRE 1, 2008–09

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New Zealand Fisheries Assessment Report 2012/04
January 2012

Published by Ministry of Fisheries
Wellington
2012

ISSN 1175-1584 (print)
ISSN 1179-5352 (online)

Walsh, C.; McKenzie, J.M.; Ó Maolagáin, C.; Buckthought, D.; James, G.D. (2012).
Length and age composition of commercial trevally landings in TRE 1, 2008–09.
New Zealand Fisheries Assessment Report 2012/04.42p.

This series continues the informal
New Zealand Fisheries Assessment Research Document series
which ceased at the end of 1999.

EXECUTIVE SUMMARY

Walsh, C.; McKenzie, J.M.; Ó Maolagáin, C.; Buckthought, D.; James, G.D. (2012). Length and age composition of commercial trevally landings in TRE 1, 2008–09.

New Zealand Fisheries Assessment Report 2012/04. **42p.**

This report presents the results of Objective 2 of the Ministry of Fisheries project "Estimation of year class strength in TRE 1" (PEL2008/03). The general objective was to determine the length frequency and age structure of commercial landings of trevally from TRE 1 (by market sampling), for use in stock assessment models.

The length frequency and age-length key sampling approach was employed during the 2008–09 fishing year to estimate catch-at-age for trevally for the main fishing methods in TRE 1. Length frequency samples were collected from the TRE 1 single trawl and purse-seine fisheries, and otoliths were collected randomly to form a fixed allocation age-length key. A total of 13 and 3 landings (targets of 20 and 8) were sampled for length frequency from the TRE 1 single trawl and purse-seine fisheries respectively, with an age-length key collection of 694 otoliths.

The length and age distributions sampled from the TRE 1 purse-seine fishery in 2008–09 showed some of the largest proportions of old trevally sampled in recent years, the aggregate (over 19) age group making up almost 20% of total annual catch by number. Length and age compositions of the TRE 1 single trawl fishery contained a high proportion of small young fish, those 3 to 5 years (2006 to 2004 year classes) being the most dominant, collectively making up 47% of the trevally landed by this method. By and large, there were relatively low numbers of old fish present in the single trawl landings.

For the second consecutive year, spatial differences in length and age structure of single trawl landings were examined in TRE 1, with independent sample collections made from the East Northland and Bay of Plenty subareas. Although length distributions for the respective subareas were not considerably different in 2008–09, the age compositions showed spatially heterogeneous patterns with year class strength varying between subareas. These differences (also evident in purse-seine subarea catch-at-age estimates), included East Northland landings being composed of more young fish and considerably fewer old fish in the aggregate age group than landings from the Bay of Plenty.

Spatial heterogeneity was investigated within subareas for the second (in the Bay of Plenty) and third (in East Northland) consecutive years, revealing sufficient continuity in year class strength between years to conclude that spatial heterogeneity in catch-at-age exists within the TRE 1 stock. Sample estimates from the Bay of Plenty fishery were by far the most obvious, with strong and weak year classes apparent in consecutive year collections, reflective of comprehensive sampling, consistency in the fishery operation over the same spatial scale, and the rigorous and accurate ageing approach in place, and further emphasising that trevally movement between subareas is relatively limited.

Precision on catch-at-age compositions varied considerably between methods, stock, and subarea summaries for TRE 1, with mean weighted coefficient of variation (MWCV) estimates ranging from 0.16 to 0.28, although sample sizes, and spatial and temporal representativeness between the sampled component and the fishery were often poor, especially for purse-seine sample collections.

Mean weight-at-age estimates for most of the recruited age classes in the single trawl and purse-seine collections from the TRE 1 stock were generally well below the predicted values based on published parameters. Trevally from purse-seine samples were most often of a greater weight- and length-at-age than those captured by trawl, and samples from East Northland, comprising the fastest growing

individuals in TRE 1 collections for 2008–09, were almost consistently larger than the respective Bay of Plenty samples. Should spatial and/or temporal variation in growth exist within the TRE 1 stock and subarea strata, then it is unlikely that the predicted estimate will be a suitable description of the stock.

1. INTRODUCTION

Trevally (*Pseudocaranx dentex*) is one of New Zealand's most important commercial inshore fish species. Almost 40% of the national Total Allowable Commercial Catch (TACC) of 3932 t is apportioned to TRE 1 (1506 t) encompassing the northeast coast of the North Island (Figure 1). In most recent years the greatest proportion of the TRE 1 catch has been taken by the single trawl and purse-seine methods, mainly from the Bay of Plenty and East Northland subareas. Most trevally is caught as the target species, but it can also be a bycatch when targeting other species, usually snapper (*Pagrus auratus*), in trawl fisheries.

Catch sampling of the TRE 1 commercial landings for length and age compositions took place intermittently from 1972 to 1978 (James 1984, unpublished data) and was resumed in the 1997–98 fishing year (Walsh et al. 1999) as part of a new stock monitoring programme initiated by the Ministry of Fisheries. Annual sampling from the main fishing methods continued in the TRE 1 fisheries until 2002–03 and the data summarised in a series of subsequent reports (Walsh et al. 2000, Langley 2001, 2002, 2003, 2004) and in two reviews by Langley (unpublished results) and Walsh & McKenzie (2009). The programme was reinstated in 2005–06 (Langley 2009) with sampling conducted on the TRE 1 purse-seine fishery and continued to 2007–08 (Walsh et al. 2010a, 2010b) with additional collections being directed to the TRE 1 single trawl fisheries, with a secondary aim to investigate patterns of spatial heterogeneity within the stock. A summary of the various method and subarea strata that have been sampled from TRE 1 since 1997–98 is presented in Table 1.

This report presents the results of market sampling from the TRE 1 stock for both the single trawl and purse-seine fisheries between October 2008 and September 2009 and thus continues the time series. Funding for this project, PEL2008/03, was provided by the Ministry of Fisheries.

The specific objective of this project for 2008–09 was:

1. To conduct representative sampling and determine the length and age composition of commercial catches in TRE 1 during the 2008/2009 fishing year. The target coefficient of variation (c.v.) for the catch-at-age will be 30% (mean weighted c.v. across all age classes), including demonstrating that sampling was representative of the fishery.

2. METHODS

2.1 Sample collection

Landings were stratified by subarea and sample collections made from the main commercial methods that operate in TRE 1: single trawl and purse-seine. There was no seasonal stratification imposed on the sampling other than it be conducted over the main "peak" period when trevally is landed by these methods. The stratification of the single trawl landings by subarea was most often done by communication with the skipper during the fishing trip and before sampling to confirm the area fished. If vessels fished in more than one subarea during the trip, cooperative skippers would mark the bins (as stratification of ponds within the hold was not viable) indicating a catch relating to a particular subarea stratum. The strata sample collections were confirmed some months after sampling based on data received from the Ministry of Fisheries catch and effort returns.

As part of the trevally catch sampling review, Walsh & McKenzie (2009) undertook an optimisation analysis for various catch sampling designs. The optimisation results for the length frequency and age-length key approach indicated that a mean weighted coefficient of variation (MWCV) of 0.20 for TRE 1 single trawl catch-at-age estimates could be achieved by sampling about 20 landings and through the application of a 900 otolith age-length key. A MWCV of 0.20 could be achieved for TRE 1 purse-seine if a similar size age-length key was applied to length data from 10 sampled landings, however, in the past decade the greatest number of purse-seine landings in the fishery is typically less than this, so a MWCV of 0.20 would most likely be unachievable. For reasons of cost, it was not proposed to target a MWCV of 0.20 in each subarea–method stratum. Instead the goal of the programme in 2008–09 would be to achieve a MWCV of at least 0.20 (for each method) in the TRE 1 stock after stratum amalgamation using the target sample sizes (length frequency samples and age-length key) outlined above and in Table 2.

Length frequency samples were collected sporadically from the TRE 1 fishery and are considered representative of the period January–May 2009 for single trawl and of September* 2009 for purse-seine The TRE 1 purse-seine fishery is typically concentrated around periods when more valuable species such as skipjack tuna are absent, usually around spring–summer and winter. Single trawl landings in TRE 1 are often a bycatch of other targeted species, although some targeting does occur typically during summer. In 2006–07, it was proposed that spatial differences in the length composition over the TRE 1 stock be investigated for the single trawl and purse-seine fisheries with subarea stratification based on the stock boundaries used for snapper for East Northland and the Bay of Plenty (see Walsh et al. (2010a)). The sampling regime for TRE 1 specified that all purse-seine landings that targeted trevally were to be selected for sampling, and that single trawl landings were to be of a minimum catch weight of at least 1 t for the East Northland subarea and 2 t for the Bay of Plenty subarea.

A two-stage sampling procedure was used to obtain length frequencies (West 1978). A random selection of landings and a random sample of bins within landings represent the first and second stages respectively. All fish in sampled bins were measured to the nearest centimetre below the fork length. As trevally show no differential growth between sexes (James 1984), sex was not determined. The sampling design used for snapper (Davies & Walsh 1995) was adopted for trevally. Sampling of purse-seine catches as described by Walsh et al. (1999) was slightly modified in that each hold (from a total of four) was treated as a separate stratum. A random sample of two bins of trevally was collected from the top, middle, and bottom of each hold as the fish were unloaded.

2.2 Otolith collection and ageing

Otoliths were generally collected as a subsample of all landings sampled for length frequency to create age-length keys (refer Davies & Walsh 1995). Samples taken from TRE 1 single trawl and purse-seine landings encompassed the period January–September. The purpose of the keys was to convert catch length frequency information to age frequency. It was assumed that age was distributed randomly within each sampled centimetre length class (Southward 1976). A fixed allocation sample for each length class was determined from the proportion of fish in each length class in single trawl length frequency samples in TRE 1 from 1999–2000. This resulted in about 450 otolith samples targeted for collection from each subarea, East Northland and Bay of Plenty. The overall target otolith allocation for TRE 1 would therefore sum to about 900 otolith samples, the optimised target sample outlined above (see Table 2). To ensure spatial and temporal representativeness in the sample collections, a target of about 30–40 otoliths was collected from all landings sampled for length frequency (single trawl and purse-seine) within a subarea until the target sample sizes for each length class within the age-length key were achieved. Those size classes that were uncommon in landings (i.e., very small or large fish) were often targeted for otoliths when available to samplers in order to fulfil the age-length key requirements as best as possible.

* Although landings occurred in December and January, samples were only taken in September (refer discussion).

All otoliths were prepared using the thin section technique as described by Stevens & Kalish (1998) and Tracey & Horn (1999) and a standardised procedure for reading otoliths was followed (Walsh et al. 1999). However, Walsh & McKenzie (2009) determined that inconsistencies observed in the relative year class strengths of trevally catch-at-age data from previous collections were most likely to be a result of ageing error caused by two main factors: the misinterpretation of growth zones in difficult otolith sections, and the inaccurate determination of the margin relative to the sample collection and birth dates. A revised trevally ageing protocol developed in 2006–07 adopted a more rigorous approach than in previous years to improve reader accuracy and increase the level of between-reader agreements, and this protocol was followed for 2008–09. In summary, this modified protocol focused mainly on a few main facets: the interpretation and location of the first annulus; forcing an expected margin on the reader relative to the otolith collection date; and allowing the readers access to a variety of otolith images from previous collections in the hope of improving reader accuracy and precision, especially in preparations that are not easily interpreted. Three readers read the entire set independently to determine an unbiased reading estimate. Where agreement was reached, it was deemed to be the final agreed reading. If no agreement was attained, then the otolith was reviewed again by all three readers together (via remote log-ons and teleconference technology) to reach agreement, or discarded from the set as unreadable (if it was of an age less than 20 years, as samples over 19 years were combined into an aggregate age group for the analysis). It was envisaged that discarding a few unreadable otoliths from the age-length key should have minimal effect on the sample collections and is likely to improve the precision in estimates of catch-at-age.

2.3 Data analysis

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

The calculation of proportions at length and age, and variances from length frequency samples and age-length keys, followed Davies & Walsh (1995). For sample collections from the TRE 1 single trawl and purse-seine fisheries, estimates of proportion at length and age for the respective methods were calculated according to two possible designs: unstratified and stratified. In the unstratified design, length and age data were pooled across both spatial strata (East Northland and Bay of Plenty subareas), thus treating the fishery as a single stratum. In the stratified design, estimates of proportion at age and length (and coefficient of variation) were calculated for each stratum separately, and then combined to calculate weighted mean estimates. The stratum estimates were combined and weighted according to the estimated number of fish landed in each stratum following Davies & Walsh (2003).

The calculation of mean weight-at-age and variances followed Quinn II et al. (1983), with a length-weight relationship: w (g) = 0.016 $l^{3.064}$ (cm) (James 1984). Proportions at age, mean weight-at-age, and mean length-at-age (with analytical estimates of coefficient of variation, c.v.) were calculated for the range of age classes recruited, with the maximum age being an aggregate of all age classes over 19 years. Weight-at-age estimates are compared with reference curves from the published length-weight relationship (James 1984) and von Bertalanffy growth parameters for TRE 1 (Walsh et al. 1999) as follows:

$$w_j = 0.016(L_\infty(1 - e^{-K(j-j_0)}))^{3.064}$$

where w_j is the predicted weight (g) at age j.

3. RESULTS

3.1 Sample collections

Summaries of the length frequency sample sizes for each method–subarea stratum taken within TRE 1 in 2008–09 are given in Table 3 and summaries of the otolith sample collections in Table 4.

The weight of the annual trevally catch and percentage catch by method for the TRE 1 stock by subarea strata for 2008–09 is shown in Figure 2. Most of the 2008–09 TRE 1 catch of 855 t was taken from the Bay of Plenty (53%) and East Northland (41%) subareas, while the Hauraki Gulf subarea accounted for only 6% (Figure 2). Although single trawl was the dominant method for catching trevally over the previous two years, accounting for about two-thirds (65–67%) of the TRE 1 landed catch, in 2008–09 this had decreased to about half (48%), with a decline of almost 150 t. In the same year, the catch by purse-seine had increased substantially to almost three times that landed in the previous two years, accounting for 39% of the TRE 1 catch. Despite the recent increase by purse-seine, the overall tonnage landed from the TRE 1 fishery remains relatively unchanged. Following the trend seen in 2006–07 and 2007–08, just under half (about 44%) of the TRE 1 stock TACC remained uncaught in 2008–09 (Ministry of Fisheries 2010).

The average single trawl landing size and the numbers of landings in each subarea stratum, for all landings and for those greater than 1 t, is illustrated in Figure 3 to depict landing size and availability of single trawl landings for sampling (generally the main method catching trevally), with the Bay of Plenty subarea comprising by far the greatest number of large landings in TRE 1 in 2008–09. The monthly catch of trevally and of that sampled (weight and number of landings) for the single trawl (all landings and those greater than 1 t) and purse-seine (all landings) methods is presented in Figures 4 to 6 to display the seasonal patterns in the fisheries and the representativeness of the sample collections. Although trevally may be caught year-round, most of the single trawl catch was over the spring and summer months, and the purse-seine catch was almost exclusively taken in November, December, and September. Comparisons of the proportional distribution of the estimated single trawl and purse-seine catch of trevally with the sampled component, by statistical area and by target species, are shown in Figures 7 and 8. By far the greatest proportion of trevally caught by single trawl in 2008–09 was from vessels targeting trevally in the eastern Bay of Plenty, principally statistical areas 009 and 010. Surface schools of trevally targeted by purse-seine were captured over both the East Northland (statistical areas 002 and 003) and Bay of Plenty (statistical areas 008 and 009) subareas, the largest proportion from the Far North (statistical area 002).

Thirteen landings of a total target of 20 (see Tables 2 and 3) were sampled from the TRE 1 single trawl fishery: four landings from the East Northland subarea and nine from the Bay of Plenty subarea. The average weight of the sampled landings from TRE 1 single trawl fishery was 6.0 t, with trevally the target species in 11 landings and snapper the target in the other 2. As trevally was generally the main target in sampled single trawl landings, the average sampled landing size was quite large compared to that of the fishery (around 0.6 t), which summarises information for all single trawl landings containing trevally (target and bycatch) caught from TRE 1 (see Table 3). The largest sampled landings of trevally in 2008–09 were from vessels targeting trevally in the eastern Bay of Plenty, predominantly from statistical area 010.

There were eight substantial purse-seine landings (compared to only two to three in the previous two years), in the TRE 1 fishery in 2008–09 (see Table 3); seven where trevally was the target species, and one where kahawai (*Arripis trutta*) was targeted, ranging in size from 8 to 115 t (average 41.8 t). Despite the sizeable number of purse-seine landings, only three were sampled, two from East Northland and one other from the Bay of Plenty, and all in September. The average weight of the sampled landings from the fishery was 45.3 t, with trevally the target species in all three landings.

3.2 TRE 1 length and age distributions

For the TRE 1 fisheries in 2008–09, catch age compositions (using the length frequency and age-length key approach) were derived from the combined length distributions of subarea strata, and used to identify year class strengths. Otolith collections may not have been consistent across the entire sampling period, especially from landings sampled toward the end of the season when the age-length key collection was nearly complete or when specific subarea collections were difficult to obtain. This is unlikely to bias the age characterisations because the growth of recruited trevally (i.e., those over 25 cm long) would have been relatively low over the period when length frequency collections were made. This assumption has been accepted for other species with growth rates comparable to those of trevally (Westrheim & Ricker 1978, Davies & Walsh 1995).

Sample length and age distributions for the TRE 1 single trawl and purse-seine fisheries in 2008–09 are presented as histograms and line graphs (Figures 9–18). Scatterplots of age-length data collected from TRE 1 subareas for 2008–09 are given in Figures 19–20. Mean weight-at-age estimates for the East Northland and Bay of Plenty subarea-method strata of TRE 1 are presented in Figure 21 and mean length-at-age estimates in Figure 22. The estimated proportions at length, age, mean weight-at-age, and mean length-at-age, are tabulated in Appendices 1–4. The age-length keys for the TRE 1 stock and subarea strata are presented in Appendix 5. Length distributions of otolith sample collections as a comparison to that targeted for TRE 1 subarea strata are presented in Appendix 6. A time series of consecutive year sample length and age distributions for the TRE 1 subarea (East Northland, three years; Bay of Plenty, two years) single trawl fisheries are presented in Appendices 7 and 8. A discontinuous time series of length and age compositions from the main trevally fisheries in TRE 1 from 1997–98 to 2008–09 is given in Appendix 9.

The estimated total number of fish caught in each stock and subarea method stratum was calculated from the reported total weight landed and the mean fish weight derived from stratum length compositions (see Appendix 1).

3.3 TRE 1 single trawl catch-at-length and catch-at-age (unstratified and stratified)

The unstratified and stratified length distributions of the TRE 1 single trawl catch in 2008–09, comprising mainly small to medium sized trevally, were almost identical, and characterised by one main mode centred at 34 cm, and a tail of the distribution extending to 50 cm (Figure 9). The mean lengths of trevally sampled from the fishery were 36.5 and 36.6 cm for the unstratified and stratified approaches respectively, and the proportion-at-length MWCVs were 0.22 and 0.21. The moderate MWCV estimates are probably a reflection of sufficient landings sampled from the fishery (13) given the level of homogeneity between them.

The age distributions (unstratified and stratified) for the TRE 1 single trawl fishery in 2008–09 were relatively similar and consisted largely of young fish between 3 and 11 years of age, those 3 to 5 years (2006 to 2004 year classes) being the most dominant, and collectively making up 47% of trevally landed (Figure 10). Most of the older age classes contain relatively low numbers of fish, only those from the 1995 and 1994 year classes (14- & 15-year-olds) and the aggregate (over 19) age group showed any notable presence, albeit with only moderate representation, none of which individually exceed more than 4% of the catch. In the age-length key collection for TRE 1, a high proportion of samples (14%) made up the aggregate (over 19) age group, with good representation in all age classes older than this up to and over 30 years of age (see Appendix 5, Figures 19–20). Only those age classes over three years of age are likely to be fully recruited to the fishery as they no longer contain a noticeable proportion of fish in the 27–30 cm length interval (see age-length key, Appendix 5). The mean ages of trevally sampled from the fishery were 6.8 and 7.2 years for the unstratified and stratified approaches respectively, and the proportion-at-age MWCVs were 0.16 and 0.18.

3.4 TRE 1 purse-seine catch-at-length and catch-at-age (unstratified and stratified)

The unstratified and stratified length distributions of the TRE 1 purse-seine catch in 2008–09 were almost identical, being largely comprised of fish between 40 and 48 cm and with a peak at 44 cm (Figure 11). The mean lengths of trevally sampled from the fishery were the same at 42.9 cm for both the unstratified and stratified approaches, and the proportion-at-length MWCVs were 0.21 and 0.22. Although only three landings were sampled for length frequency from the purse-seine fishery, the MWCV estimates were relatively low and are probably reflecting the homogeneity in length structure between the samples.

Like the length distributions above, the age distributions (unstratified and stratified) for the TRE 1 purse-seine fishery in 2008–09 were almost identical as well. The distributions were very broad and largely made up of fish from year classes of similar relative strengths, the noticeable exceptions being the dominant 1998 year class (11-year-olds) and the aggregate (over 19 years) age group, the latter accounting for a particularly high proportion (about 18–19%) of purse-seine catch (Figure 12). The mean ages of trevally sampled from the fishery were high at 12.7 and 12.3 years for the unstratified and stratified approaches respectively, and the proportion-at-age MWCVs were low at 0.20 and 0.21.

3.5 TRE 1 subarea/method catch-at-length and catch-at-age

The length distributions for the TRE 1 subarea method collections were relatively dissimilar, with the single trawl dataset comprising fish over a greater size range and with proportionally smaller fish to those sampled from the purse-seine fishery (Figures 13, 15 and 17). For single trawl landings, East Northland samples comprised proportionally more large fish (i.e., over 45 cm) compared to those from the Bay of Plenty, although there appeared to be considerable similarity for small to medium sized fish in closely aligned modes (Figures 13 and 17). In contrast, the East Northland and Bay of Plenty subarea purse-seine length distributions were narrow, based largely on medium sized fish 39 to 47 cm, with more than one mode present, and minimal difference in length structure between the subarea collections (Figures 15 and 17). The mean lengths of trevally sampled from the East Northland and Bay of Plenty single trawl fisheries were 37.0 and 36.5 cm respectively (mean weights of 1.0 kg) and the proportion-at-length MWCVs were 0.34 and 0.25. The mean lengths sampled from the East Northland and Bay of Plenty purse-seine fisheries were 43.0 and 42.9 cm (mean weights of 1.6 kg), and the MWCV (for East Northland) was 0.34. No MWCV was calculated for the Bay of Plenty purse-seine length distribution as only one landing was sampled from this subarea fishery (see Table 3).

The age distributions for the East Northland and Bay of Plenty single trawl fisheries were largely made up of young fish below 12 years of age, and differed considerably from that of the respective subarea purse-seine catch-at-age estimates which were generally broader, contained a reasonable proportion of middle and old aged fish, and therefore a smaller proportion of young fish (Figures 14, 16 and 18). Similarly, between subarea differences in year class strengths were also apparent for both single trawl and purse-seine proportion-at-age summaries (Figures 14, 16 and 18). The 2006 year class (3-year-olds) dominated landings in the East Northland single trawl fishery in 2008–09 accounting for almost one in every three fish landed (Figures 14 and 18). With the exception of the 2007 and 1998 year classes (2- and 11-year-olds), most other year classes contained relatively low numbers of fish, although the aggregate (over 19 years) age group accounted for 4% of the catch. Bay of Plenty single trawl catch-at-age estimates were slightly broader comprising a greater number of fish in the mid-age range, although almost half (47%) the landed catch was based on the 2006 to 2004 year classes alone (3- to 5-year-olds) (Figures 14 and 18). The 1999 and 1998 year classes (10- & 11-year-olds) appeared to be of above average strength in the Bay of Plenty and combined accounted for 12% of the landed catch by number, with the aggregate (over 19 years) age group making up 4%. East Northland purse-seine landings were dominated by the 1998 year classes (11-year-olds) and had a reasonable proportion (11%) of fish in the aggregate age group, while Bay of Plenty purse-seine landings were also broad, but dominated by old fish, with almost one in three fish being at least 20 years old (Figures 16 and 18). Estimates of mean age for the East Northland and Bay of Plenty single trawl fisheries were moderate at 6.1 and 7.5 years respectively with MWCVs of 0.22 and 0.21, depicting relatively good levels of precision. Estimates of mean age for the respective purse-seine fisheries were high at 11.3 and 14.2 years with MWCVs of 0.28 and 0.25.

Scatterplots of age-length data and generated von Bertalanffy growth curves for 2008–09 otolith collections from TRE 1 showed that considerable growth variability exists between subareas, with those individuals from the East Northland single trawl fishery having the greatest variability in length about age and attaining a larger size than elsewhere (Figures 19 and 20; Table 5). Despite a broad age range, otolith samples taken from the respective subarea purse-seine fisheries comprised few small or large individuals (Figures 19 and 20).

3.6 TRE 1 mean weight-at-age and mean length-at-age estimates

Observed and predicted mean weight-at-age estimates are given for the TRE 1 subarea method fisheries, with predicted values based on published parameters (Figure 21). The mean weight-at-age estimates for some of the young age classes (2- to 5-year-olds) lie on or above the predicted weight-at-age curve because of the minimum legal size (MLS) restriction of 25 cm in commercial catches, and also because fish of this age range may not yet be fully recruited to the fishery. The absence of smaller fish of a partially recruited age class would positively bias the observed mean for that age class (Davies et al. 2003).

In 2008–09, the observed mean weight estimates from the East Northland subarea method (single trawl and purse-seine) fisheries were typically higher for a given age than estimates derived for the respective Bay of Plenty subarea method fisheries, and generally well below the predicted estimates for TRE 1 (Figure 21). Estimates from the purse-seine fisheries were different from single trawl, being generally highest for the most common age classes in the respective subarea fisheries. Those estimates for some of the older age classes (i.e., 18 years and older) for the East Northland subarea method fisheries did not fit well with the predicted values, sitting well above the line.

Observed mean length-at-age estimates in the TRE 1 subarea method fisheries closely resemble those patterns seen in mean weight-at-age estimates (Figure 22).

4. DISCUSSION

This is the tenth report to summarise the length and age compositions of trevally landings from the main fishing methods operating in TRE 1 and/or TRE 7 since 1997–98. In a review of the trevally catch sampling data collected between 1997–98 and 2002–03 from both stocks, Walsh & McKenzie (2009) found that due to inconsistencies in year class strengths, trends in the progression of weak and strong year classes in TRE 1 and TRE 7 catches were difficult to determine. This conclusion is borne out by recent TRE 1 and TRE 7 stock assessments, in which the models also found it difficult to fit to the time series of catch-at-age observations (McKenzie 2007, 2008). Walsh & McKenzie (2009) determined that the 'smoothing' in trevally catch-at-age estimates was a direct result of ageing error, where the misinterpretation of growth zones in difficult otolith sections, and the inaccurate determination of the margin relative to the sample collection and birth dates, were the main contributing factors. A new ageing protocol was implemented in 2006–07 which adopted a more rigorous approach with the aim of improving reader accuracy and increasing the level of between-reader agreements. However, trevally otoliths can be inherently difficult to age, and as such, some level of ageing error is always likely to be present in catch-at-age results.

In 2008–09, and similar to previous years, there continued to be difficulty in obtaining length and age sample collections from the East Northland single trawl fishery with a total of four landings sampled from a target of ten. Walsh et al. (2009) documented a downsizing and rationalisation of the inshore trawl fleet in northern New Zealand in recent years, largely for financial and economic reasons, resulting in fewer trawl vessels available to obtain samples from. The few that do operate, regularly fish between the TRE 1 and TRE 7 stocks on the same fishing trip, thereby rendering the catch useless for sample selection. In 2006–07, liaison with cooperative fishers enabled samples to be collected from within a stock (when the vessel fished in both TRE 1 and TRE 7) only when the fisher agreed to mark the sample bins directly after capture. Initially this proved unworkable as later inspection of the catch length distributions revealed that the two samples comprised trevally of the same length structure, obviously reflecting no separation by the fisher as requested (Walsh et al. 2010a). By 2007–08 further progress with the fisher had successfully enabled marked bins of trevally caught from East Northland to be tracked to the fishing company which were then set aside for sampling. Despite this success, another major TRE 1 and TRE 7 processor refused to undertake sample collections from its single trawl vessels operating in the East Northland subarea and denied the researcher access to its processing operation in order to conduct sampling themselves. As a result, single trawl sample collections presented here from the East Northland fishery are solely based on landings from one single trawl vessel, and for the Bay of Plenty fishery, based on landings from only two vessels, the latter collection successfully undertaken by this processor under contract.

In 2006–07, Walsh et al. (2010a) postulated that inadequate sample sizes from trevally catch sampling may adversely affect results, warning that in order to fully determine if spatial variability in length and age exists for trevally, future sampling would require full industry cooperation to improve on current results. The cooperation of the fishing industry (company managers and fishermen) in such a project as this is pivotal, with resulting estimates being as true a reflection of the fishery catch as can be expected with the least amount of bias (i.e., spatial, temporal, size/age selective). Although some level of cooperation was forthcoming for this specific project (i.e., Bay of Plenty single trawl and purse seine samples sampled under subcontract to the fishing industry), the refusal to undertake sample collections or provide access to landings from the East Northland single trawl fishery resulted in sample targets not being met for this fishery.

The results determined for length and age collections in TRE 1 in 2008–09 show that variability in trevally catch-at-length and catch-at-age estimates exists between the method fisheries, similar to findings in previous years (Walsh et al. 1999, 2000, Langley 2001, Walsh & McKenzie 2009, Walsh et al. 2010a, Walsh et al. 2010b). Similar to the previous year, the unstratified and stratified length compositions of the single trawl catch were almost identical, albeit spread over a slightly broader length range and largely dominated by small to medium sized trevally, markedly different from that of the purse-seine catch, reflecting method–specific differences in selectivity. The TRE 1 length distribution in 2008–09 was made up of two closely aligned modes centred at 34 and 38 cm respectively, the first indicative of recent strong recruitment into the fishery, the second the remainder of the main mode in the fishery from the previous two years. Although similar to that seen in 2006–07 and 2007–08, the single trawl length distributions for 2008–09 were not as broad as those from sample collections made in the late 1990s (Walsh et al. 1999, 2000, Langley 2001), the current collections being largely made up of fish less than 46 cm (2.0 kg), with the average size in the TRE 1 fishery about 37 cm (about 1.0 kg). The purse-seine catch was characterised by a narrow distribution comprising possibly more than one mode, and largely based on moderate sized individuals, reflecting selection of surface schools of similar sized fish with little variation, analogous to findings by James (1984), and generally similar to that seen in past years. Walsh & McKenzie (2009) found the length compositions of purse-seine landings generally varied little between years, although current sample estimates, like that in 2007–08, comprised more large trevally (average size 42.9 cm, about 1.6 kg) than purse-seine collections a decade ago, and closely resembled purse-seine samples from the late 1970s (James 1984).

As in past years, the differences seen in TRE 1 length compositions in 2008–09 between the single trawl and purse-seine methods were also apparent in the catch-at-age compositions, with single trawl catches predominantly made up of young trevally, 11 years of age or less, and a low relative abundance of old fish compared to collections from past years. Purse-seine catch-at-age estimates although broad, comprised fewer young fish, a moderate number in the mid-age range, and a high proportion (about 19%) in the aggregate (over 19) age group, twice that of collections a decade ago. High proportions of fish in the aggregate (over 19) age group have been seen only in purse-seine sample collections from the late 1970s (James 1984), when the TRE 1 biomass was large and in the fishing down phase. As the purse-seine method is highly selective, sampling from the single trawl fishery is likely to be more representative of the recruited population, capturing a wider range of sizes and ages, and therefore having better stock monitoring utility (Walsh & McKenzie 2009). Despite selectivity issues relating to very small (Walsh et al. 2000) and large (fast swimming) trevally, Walsh et al. (2010a) speculated that the recent differences seen in the TRE 1 single trawl length and age distributions compared to collections a decade or more ago, may actually reflect a change in the trevally population length and age structure within the stock, now predominantly comprised of small and young fish.

Within a method, minimal differences were observed between the unstratified and stratified age compositions for the TRE 1 single trawl and purse-seine fisheries. In the unstratified design data are pooled across spatial strata, thus treating the fishery as a single stratum, whereas in the stratified design proportions of length and age are calculated for each stratum and the strata are then weighted according to the estimated number of fish landed. As the total tonnage (and the estimated number of trevally) landed by single trawl in the respective subarea strata in 2008–09 was far greater for the Bay of Plenty subarea (about four times by number) than for East Northland, results for both the stratified length and age compositions for the TRE 1 single trawl fishery more closely resemble the single stratum estimates derived for the Bay of Plenty subarea. That the unstratified and stratified length distributions for the TRE 1 single trawl fishery were almost identical, and similar to the length composition of the Bay of Plenty subarea catch, directly reflects the larger landings (both by weight and number of fish) sampled from this subarea, compared to those samples taken from East Northland. Similarly, the total tonnage landed by purse-seine in the respective subarea strata in 2008–09 was far greater for the East Northland subarea (almost twice as much), and the results for both the stratified length and age compositions more closely resemble the single stratum estimates derived for East Northland purse-seine fishery, although not as clearly for the older age classes.

As reasonably adequate sample collections for length and age were made from the single trawl subarea fisheries that make up TRE 1 in 2008–09, spatial and temporal age/length comparisons were able to be made for the second and third consecutive years in the Bay of Plenty and East Northland subareas respectively. Length distributions from the East Northland and Bay of Plenty single trawl catch were relatively similar, although the East Northland fishery had a slightly higher proportion of large fish, sampled from only four landings. Catch-at-age estimates for the respective fisheries showed some similarity over the general age range, with both fisheries largely based on young fish of 11 years or less, East Northland with a higher proportion of very young fish compared to the Bay of

Plenty. Heterogeneity in age structure was present in comparisons in catch-at-age estimates between the subarea fisheries, where the relative dominance in particular age classes occurs more for one subarea than the other (see Figures 14 and 18, Appendices 7 and 8). The recent TRE 1 catch sampling series, which also includes a revision of ageing protocols, has largely explained the inconsistencies in year class strengths seen in previous TRE 1 catch-at-age collections a decade ago. Despite considerable variability in the length compositions over the past three years for the East Northland single trawl fishery (likely to be related to spatial differences between statistical areas 002 and 003 collections) and two years for the Bay of Plenty single trawl fishery, there is sufficient continuity in year class strength from one year to the next specific to each subarea to conclude that spatial heterogeneity in age is a persistent feature within TRE 1 (see Appendices 7 and 8). The consistency of strong and weak age classes was most apparent in the Bay of Plenty single trawl fishery clearly seen in the consecutive year collections.

The spatial heterogeneity seen in the recent sample series is consistent with what is known from tagging studies in that trevally movement between areas is limited with most fish (88%) captured within 30 nautical miles of release sites (James 1980), and the vast majority of fish probably reside within the same spatial strata from year to year indicative of low levels of stock and subarea mixing (Walsh et al. 2010b). The continuation of a trawl-based sampling programme with some regularity should continue to provide better information on the mortality and recruitment variation of the TRE 1 stock required for stock assessments, as long as spatially specific sample collections can be maintained and industry participation and cooperation is forthcoming.

Similarly, the re-reading of previous otolith collections from the TRE 1 single trawl fishery (i.e. 1997–98, 1998–99, 1999–2000), where spatially discrete collections have been made from East Northland and the Bay of Plenty subareas may significantly increase the effectiveness of catch-at-age data in future stock assessments, particularly since ageing protocols have been revised and consistent spatial heterogeneous patterns in age have been determined for TRE 1.

For the first time, spatial comparisons in both length and age were able to be made from the TRE 1 purse-seine fisheries in 2008–09, despite only one and two landings being sampled from the Bay of Plenty and East Northland subareas respectively. As described above for single trawl, heterogeneity in purse-seine catch-at-age estimates was apparent, similarly reflecting the variability in relative year class strength present in the underlying subarea age-length key collections, mainly orientated around larger and older fish.

A few speculative correlations could be made between relative year class strengths in catch-at-age estimates for the TRE 1 and SNA 1 stocks for 2008–09, most noticeably for the 1998 and 1999 year classes, but these may just be coincidental, as the selectivity differences between the fishing methods and species, and the relative exploitation status of the respective populations is likely to have significance.

An acceptable level of precision in the TRE 1 proportion at length and age sample estimates was achieved with MWCVs ranging from 0.16 to 0.22, reflective of a reasonable level of homogeneity between sample estimates and the sizeable number of length and age samples in the collections. Subarea single trawl length distributions comprised higher MWCVs ranging from 0.21 to 0.34, the higher estimates indicative of spatial heterogeneous patterns in trevally length structure within the East Northland subarea fishery, similar to that found in snapper (Davies & Walsh 2003). Temporal and spatial representativeness in sample collections for the single trawl fishery are likely to provide adequate descriptions of the sub-area fisheries, although an increase in the sampled number of landings from East Northland would probably increase precision in estimates, and Bay of Plenty samples could be better selected spatially in proportion to the fishery operation. Moderate MWCV estimates were achieved for the TRE 1 purse-seine length and age distributions, ranging from 0.20 to

0.22, also reflective of a level of homogeneity between samples, and the size of the sample collections relative to that of the fishery. Despite only three landings being sampled from the purse-seine fishery (from a total of eight) the sample estimates presented here may appear to be adequate, although spatial and temporal representativeness between the sampled component and the fishery were relatively poor. Purse-seine subarea MWCVs were higher than the combined TRE 1 stock estimates, ranging from 0.25 to 0.34, and are probably indicative of the lower sample sizes in subarea length and age collections.

The oldest trevally sampled from the TRE 1 fishery in 2008–09 was 38 years old, and samples aged by James (1984) from collections undertaken in the 1970s determined maximum age estimates of 46 years.

Overall mean weight-at-age estimates for most of the recruited age classes in the single trawl and purse-seine collections from the TRE 1 subarea fisheries were generally well below the predicted values based on published parameters, the exception being some of the very young trevally captured by purse-seine in the East Northland subarea. Similar to previous years, trevally caught by purse-seine, were most often of a greater mean weight-at-age than those captured by trawl. Walsh and McKenzie (2009) found growth estimates for the TRE 1 fishery to vary inter-annually, with collections made in 1997–98 and 2000–01 containing a higher number of fast growing large individuals than other years, often from catches in the Far North. A visual comparison of subarea samples from 2007–08 (Walsh et al. 2010b) determined that few noticeable growth rate differences existed between the East Northland and Bay of Plenty single trawl fishery, with good correlation in mean weight-at-age (and mean length-at-age) estimates for many of the common age classes, and only older East Northland trevally (18- and 19-year-olds) attaining a size above or close to the predicted values. However, the current samples from 2008–09 showed that East Northland mean weight- and length-at-age estimates for both the purse-seine and single trawl fisheries were almost consistently higher than the respective Bay of Plenty method estimates. Of more significance, the samples comprising the fastest growing individuals (i.e., those over 50 cm (see Figure 19)), came solely from East Northland single trawl collections from statistical area 002, similar to findings in 1997–98 and 2000–01, and as above, only 18- to 20-year-olds attained a size above or close to the predicted values, based on the published length-weight relationship (James 1984) and von Bertalanffy growth parameters (Walsh et al. 1999) for TRE 1. Spatial and temporal variability between observed and predicted mean weight-at-age estimates have also been found in snapper and are thought to be due to difference in regional exploitation levels, recruitment rates, and annual variation in water temperature (Davies et al. 2003, Walsh et al. 2006a, 2006b, 2006c). Should spatial and/or temporal variation in growth exist within the TRE 1 stock and subarea strata, then it is likely that the predicted estimate presented here is not a suitable description of the stock. Similarly, should only the single trawl method (as opposed to purse-seine) capture the faster growing trevally in the East Northland subarea, then the use of a subarea specific age-length key to describe catch-at-age across both methods may be invalid for the East Northland fishery as it may bias estimates. Langley (unpublished results) proposed that as the single trawl and purse-seine fisheries operate on different components of the TRE 1 population (demersel compared to pelagic), any future monitoring of the TRE 1 stock should include the collection of a method specific age-length key to fully determine age specific selectivity differences.

5. ACKNOWLEDGMENTS

We thank Dave Fisher, Christopher Dick, Colin Sutton, and the stock monitoring team for their prompt and efficient handling and storage of data; Jason Morris (Ministry of Fisheries) for the provision of data from the catch effort return system; Steve Parker for reviewing this report and providing some helpful comments. Funding for this project, PEL2008/03, was provided by the

Ministry of Fisheries.

Thanks to Sean Walker and Mark Hartstone and crew for all their help in coordinating trevally samples from the East Northland subarea. Thanks to Moana Pacific Ltd, especially Boo Rowley, and Gypsy Rameka (Seafood Processors Ltd) for their cooperation in enabling NIWA staff to sample catches. Thanks also to Geoff Plowman and Fay Anderson (Sanford Ltd, Tauranga) for collecting length and age samples from the Bay of Plenty purse-seine and single trawl fisheries.

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Table 1: TRE 1 catch sampling summary from 1997–98 to 2008–09 (Note: all collections made using the length frequency and age-length key sampling approach, and all ageing undertaken by NIWA).

TRE 1

Catch sampling report	Research provider	Fishing year	Fishing method	No. of landings sampled for LF	Season††	Comments*	Otolith sample size	Otolith prep.†	Season††
Walsh et al. (1999)	NIWA	1997–98	Purse-seine	7	Spr–Sum, Win	5 BPLE, 2 ENLD			
			Single trawl	12	Sum–Aut	3 BPLE, 4 HAGU, 4 ENLD, 1 Mixed	387	B&E	Sum–Aut
Walsh et al. (2000)	NIWA	1998–99	Purse-seine	9	Spr–Sum, Win	5 BPLE, 4 ENLD	30	TS	Win
			Single trawl	12	Sum–Win	8 BPLE, 3 ENLD, 1 Mixed	280	TS	Sum–Win
Langley (2001)	Sanford Ltd	1999–2000	Purse-seine	7	Spr–Sum	4 BPLE, 3 ENLD			
			Single trawl	22	Spr–Win	18 BPLE, 4 Mixed	572	TS	Aut–Win
Langley (2002)	Sanford Ltd	2000–01	Purse-seine	7	Spr–Sum, Win	5 BPLE, 2 ENLD	745	TS	Spr–Sum, Win
Langley (2003)	Sanford Ltd	2001–02	Purse-seine	8	Spr–Sum, Win	7 BPLE, 1 ENLD	360	TS	Sum,Win
Langley (2004)	Sanford Ltd	2002–03	Purse-seine	8	Spr–Sum	2 BPLE, 6 ENLD	554	TS	Spr–Sum
Langley (2009)	GANZL	2005–06	Purse-seine	5	Spr, Aut, Win	2 BPLE, 3 ENLD	257	TS	Spr, Aut, Win
Walsh et al. (2010a)	NIWA	2006–07	Purse-seine	2	Spr, Sum	2 ENLD			
			Single trawl	5	Aut, Win	4 ENLD, 1 Mixed	338	TS	Aut, Win
Walsh et al. (2010b)	NIWA	2007–08	Purse-seine	2	Sum	2 BPLE	73	TS	Sum
			Single trawl	15	Spr–Aut	10 BPLE, 5 ENLD	499	TS	Spr–Aut
This report	NIWA	2008–09	Purse-seine	3	Win	1 BPLE, 2 ENLD	135	TS	Win
			Single trawl	13	Sum–Aut	9 BPLE, 4 ENLD	559	TS	Sum–Aut

* BPLE = Bay of Plenty; ENLD = East Northland; HAGU = Hauraki Gulf.
† B&E = Bake and embed; TS = Thin section.
†† Spr (Oct–Nov), Sum (Dec–Feb), Aut (Mar–May), Win (Jun–Sep).
NIWA, National Institute of Water and Atmospheric Research; GANZL, Golder Associates (NZ) Ltd.

Table 2: Level of sampling proposed to describe the TRE 1 subarea method fisheries in 2008–09.

	Subarea	Method	Number of landings sampled	Number of otoliths in age-length-key
TRE 1	East Northland	Single trawl	10	450
		Purse-seine	*1–10	
	Bay of Plenty	Single trawl	10	450
		Purse-seine	*1–10	

* Although the total number of TRE 1 purse-seine landings is 10, the number to be sampled in each stratum cannot not be specified *a priori*.

Table 3: Summary of the catch (total number and weight of landings) and samples (number of landings and weight sampled, and number of fish measured) in method–subarea strata for the TRE 1 purse-seine and single trawl fisheries for the 2008–09 fishing year.^

		Number of landings			No. of fish	Weight of landings (t)		
Method*	Area**	Total	Sampled	% of total	measured	Total	Sampled	% of total
PS	ENLD	4	2	50.0	639	214	85	39.7
	BPLE	4	1	25.0	338	121	51	42.1
	TRE 1	8	3	37.5	977	335	136	40.6
BT	ENLD	314	4	1.3	1 505	74	11	14.9
	HAGU	204	0	0.0	0	38	0	0.0
	BPLE	137	9	6.6	3 726	297	66	22.2
	TRE 1†	541	13	2.4	5 231	409	77	18.8

* PS, purse-seine; BT, single trawl.

† The TRE 1 single trawl total number of landings does not equal combined subareas total as a vessel may fish over more than one subarea per trip.

** ENLD, East Northland; HAGU, Hauraki Gulf; BPLE, Bay of Plenty.

Table 4: Details of trevally otolith samples collected in 2008–09 from TRE 1 subareas for age-length key collections.

Method*	Area**	Sampling period	Sample method †	Length range (cm)	No. aged
PS/BT	ENLD	31 Mar 09–25 Sep 09	SR	26–68	346
PS/BT	BPLE	13 Jan 09–14 Sep 09	SR	25–50	348
PS/BT	TRE 1	13 Jan 09–25 Sep 09	SR	25–68	694

* PS, purse-seine; BT, single trawl.

** ENLD, East Northland; BPLE, Bay of Plenty.

† Stratified random sample.

Table 5: Von Bertalanffy parameters calculated from trevally otolith data collected from the TRE 1 subareas in 2008–09.

Fishing year	L_{inf}	k	t_o	n
East Northland	54.5	0.085	-8.80	346
Bay of Plenty	46.6	0.136	-4.92	348

L_{inf} = length-at-age infinity; k = Brody's growth coefficient; t_o = hypothetical age at zero length.

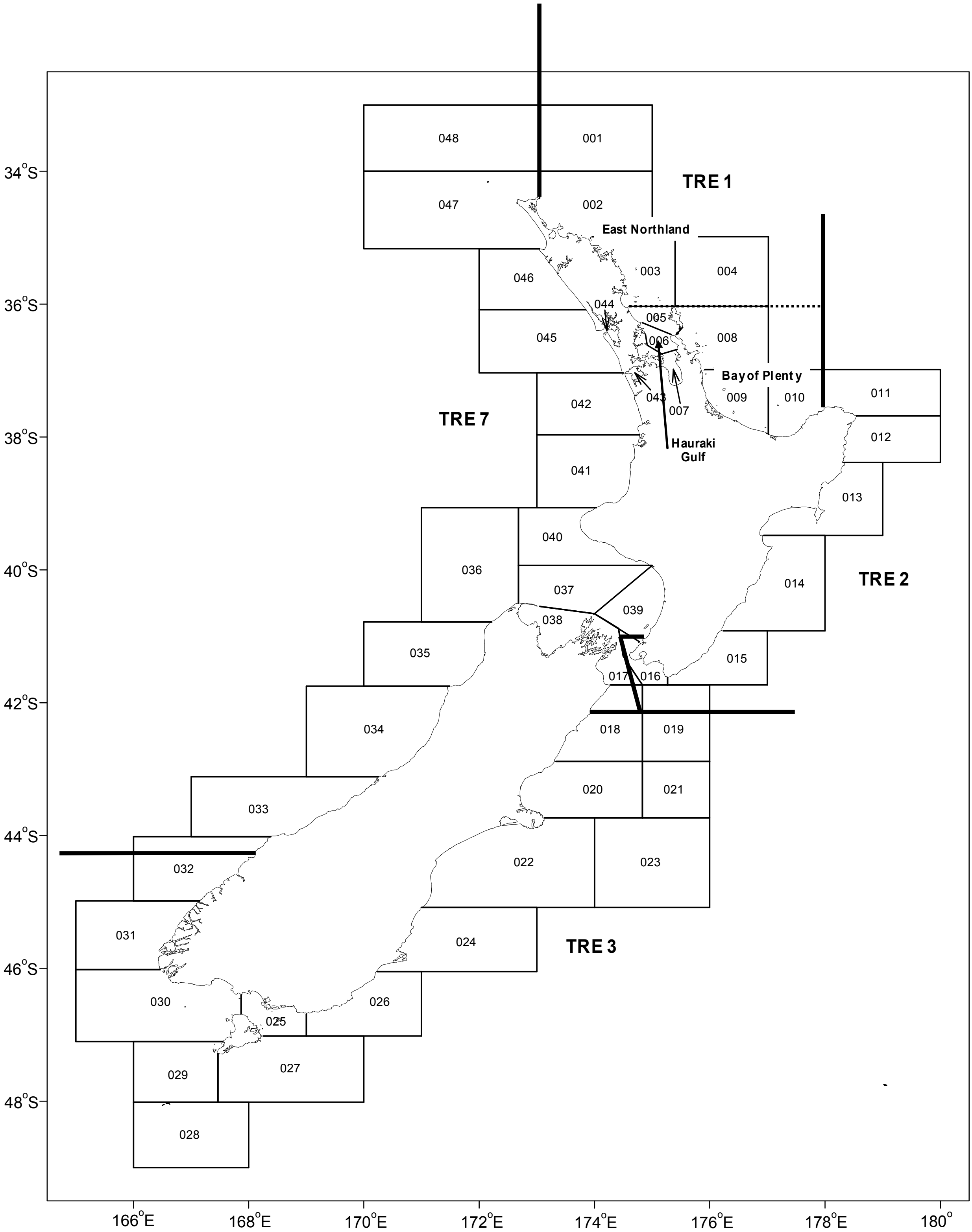


Figure 1: Trevally quota management areas, statistical areas, and locations referred to in the text. Dashed lines represent the boundaries separating the subareas that make up the TRE 1 stock.

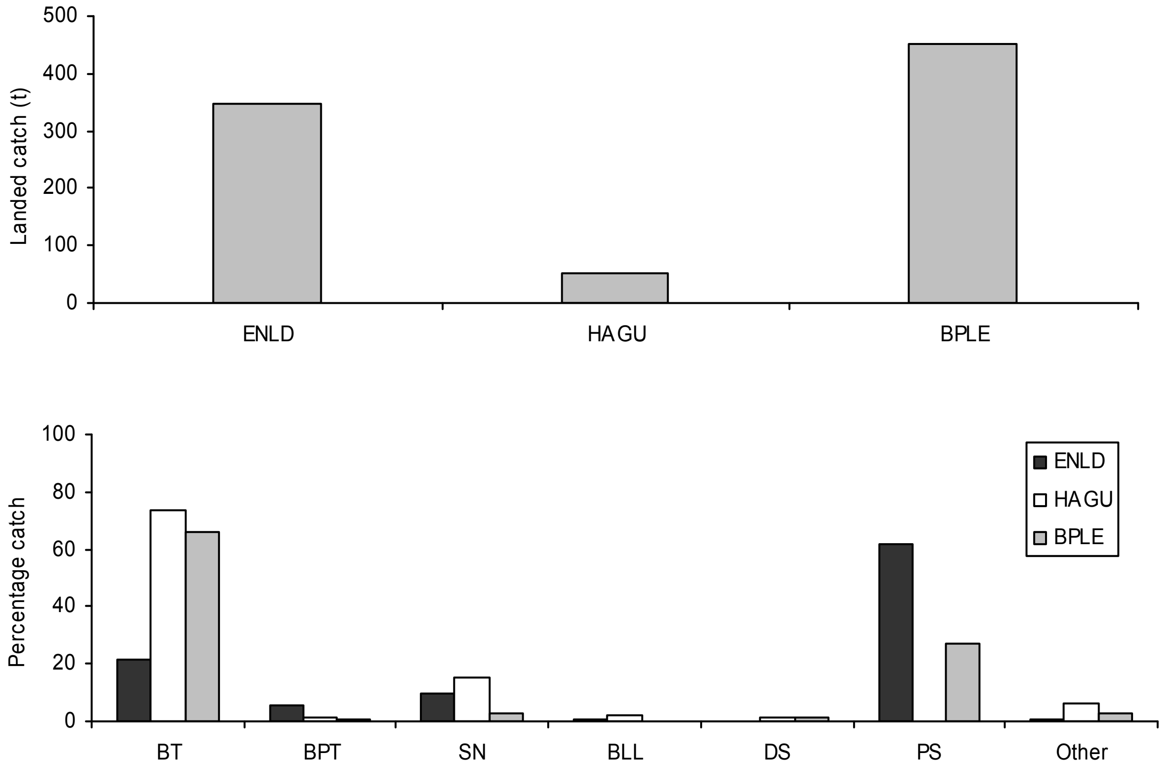


Figure 2: The landed catch (t) and percentage catch by method of trevally for the subareas of TRE 1 in 2008–09 (ENLD, East Northland; HAGU, Hauraki Gulf; BPLE, Bay of Plenty; BT, single trawl; BPT, pair trawl; SN, set net; BLL, bottom longline; DS, Danish seine; PS, purse-seine).

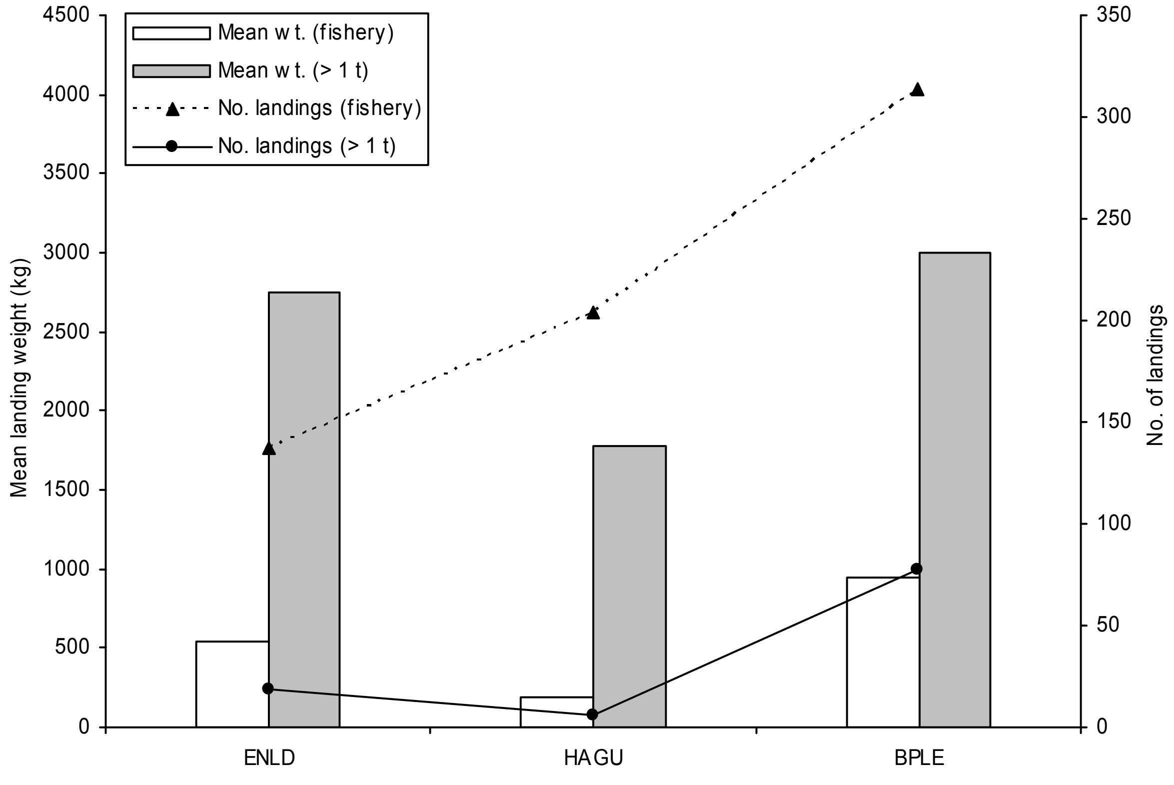


Figure 3: Mean single trawl landing size and number of landings of trevally for all landings in the fishery and for those landings > 1 tonne in 2008–09 (ENLD, East Northland; HAGU, Hauraki Gulf; BPLE, Bay of Plenty).

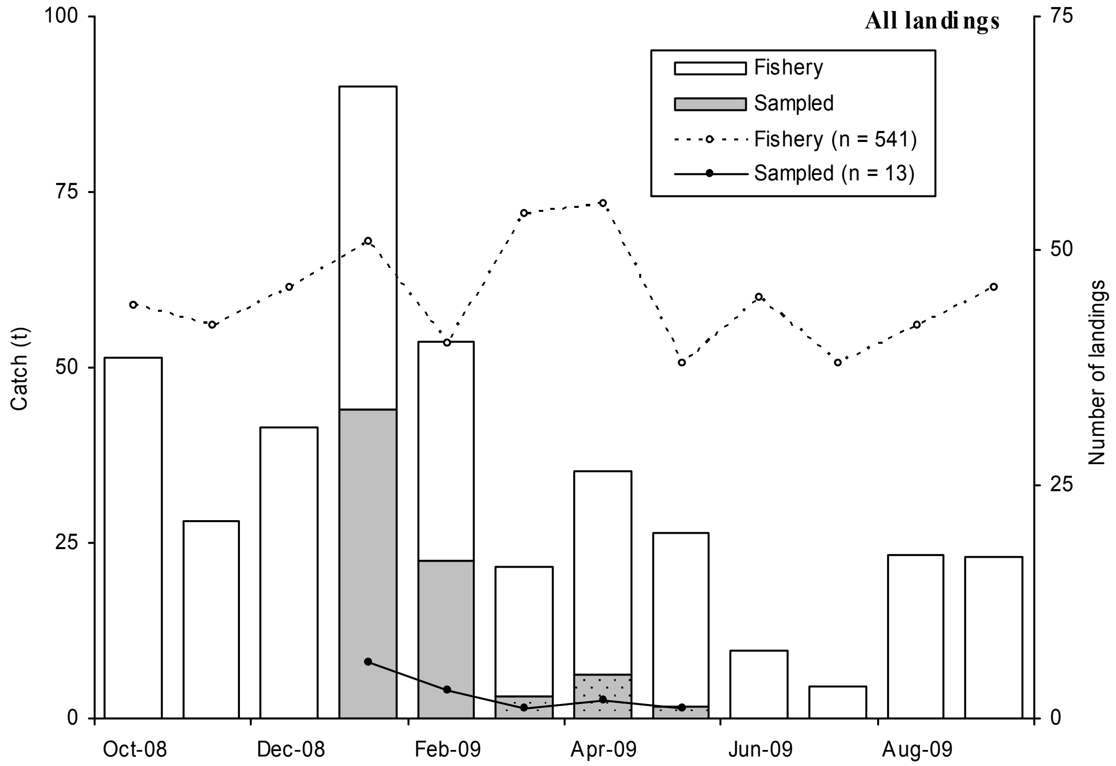


Figure 4: Comparison of the monthly distribution of landed weight (white bars) and numbers of landings (dashed line) of trevally in the TRE 1 single trawl fishery for all landings where trevally was caught. Included are corresponding estimates for all sampled landings (grey (Bay of Plenty) and speckled (East Northland) bars and solid line) to show representivity of collections. Note: bars and lines are overlaid.

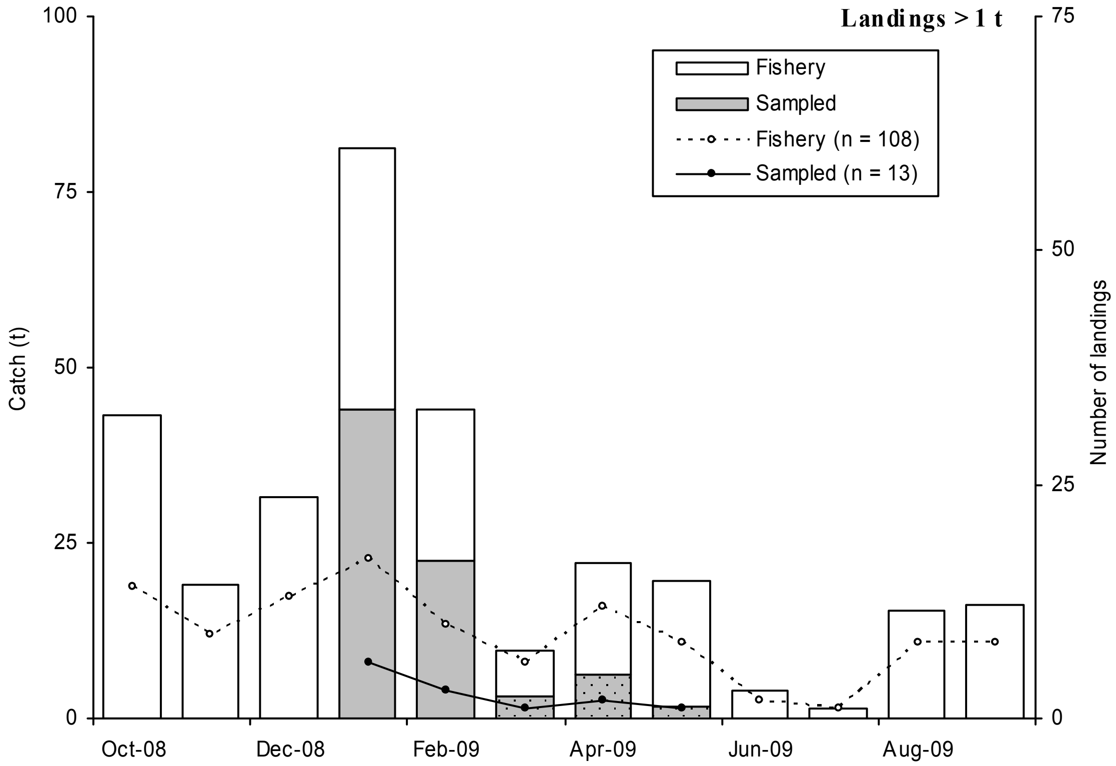


Figure 5: Comparison of the monthly distribution of landed weight (white bars) and numbers of landings (dashed line) of trevally in the TRE 1 single trawl fishery for all landings > 1 tonne. Included are corresponding estimates for all sampled landings (grey (Bay of Plenty) and speckled (East Northland) and solid line) to show representivity of collections. Note: bars and lines are overlaid.

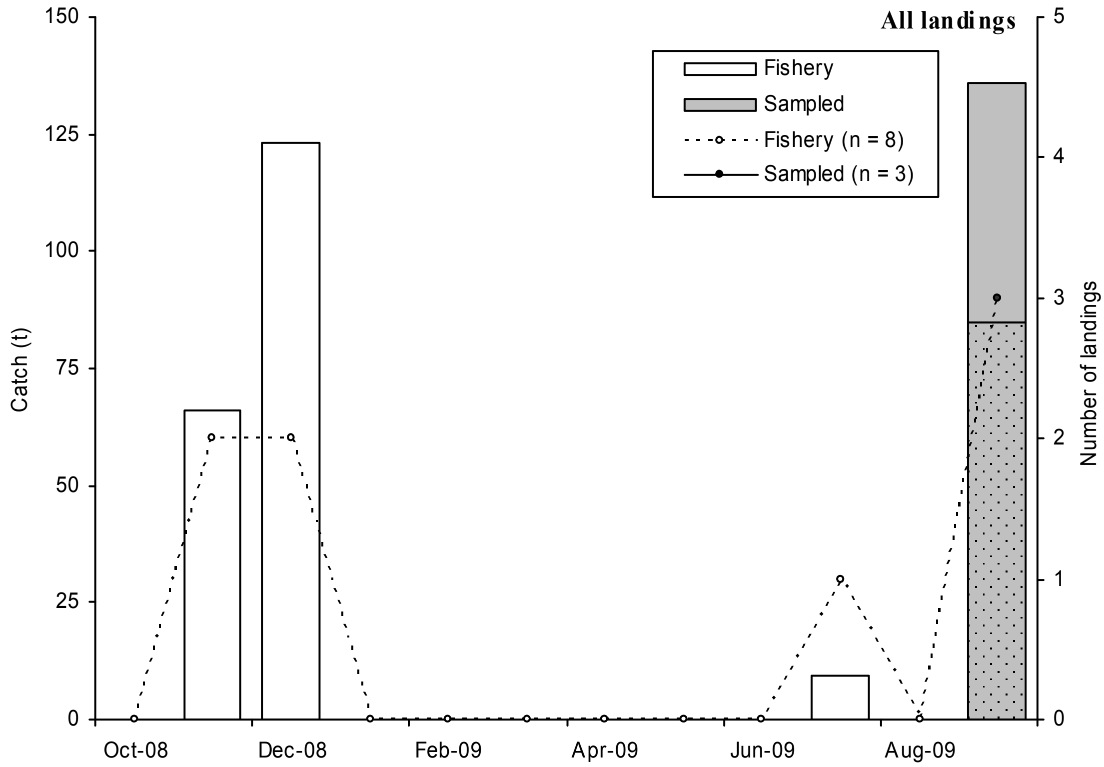


Figure 6: Comparison of the monthly distribution of landed weight (white bars) and numbers of landings (dashed line) of trevally in the TRE 1 purse-seine fishery for all landings where trevally was caught. Included are corresponding estimates for all sampled landings (grey (Bay of Plenty) and speckled (East Northland) bars and solid line) to show representivity of collections. Note: bars and lines are overlaid.

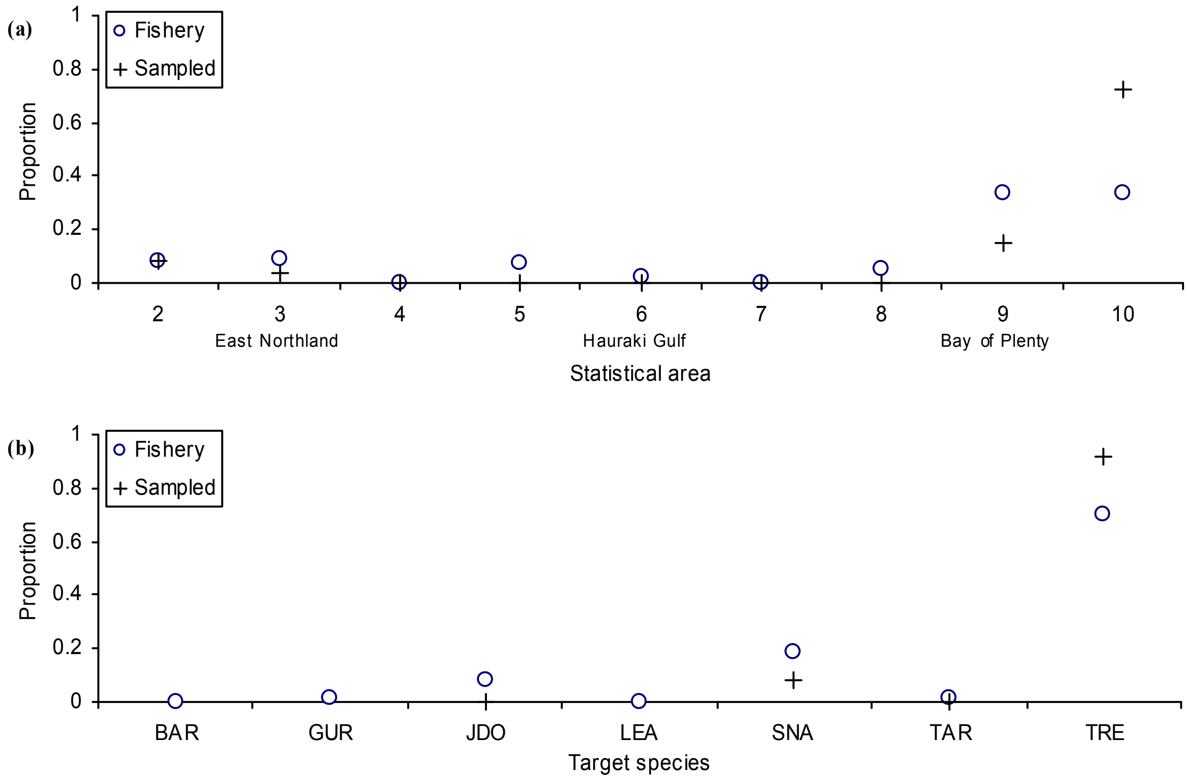


Figure 7: Comparison of the proportional distribution of the estimated single trawl catch and the sampled component by (a) statistical area (with annotated spatial subarea strata) and (b) target species over the sampling period for the TRE 1 stock in 2008–09.

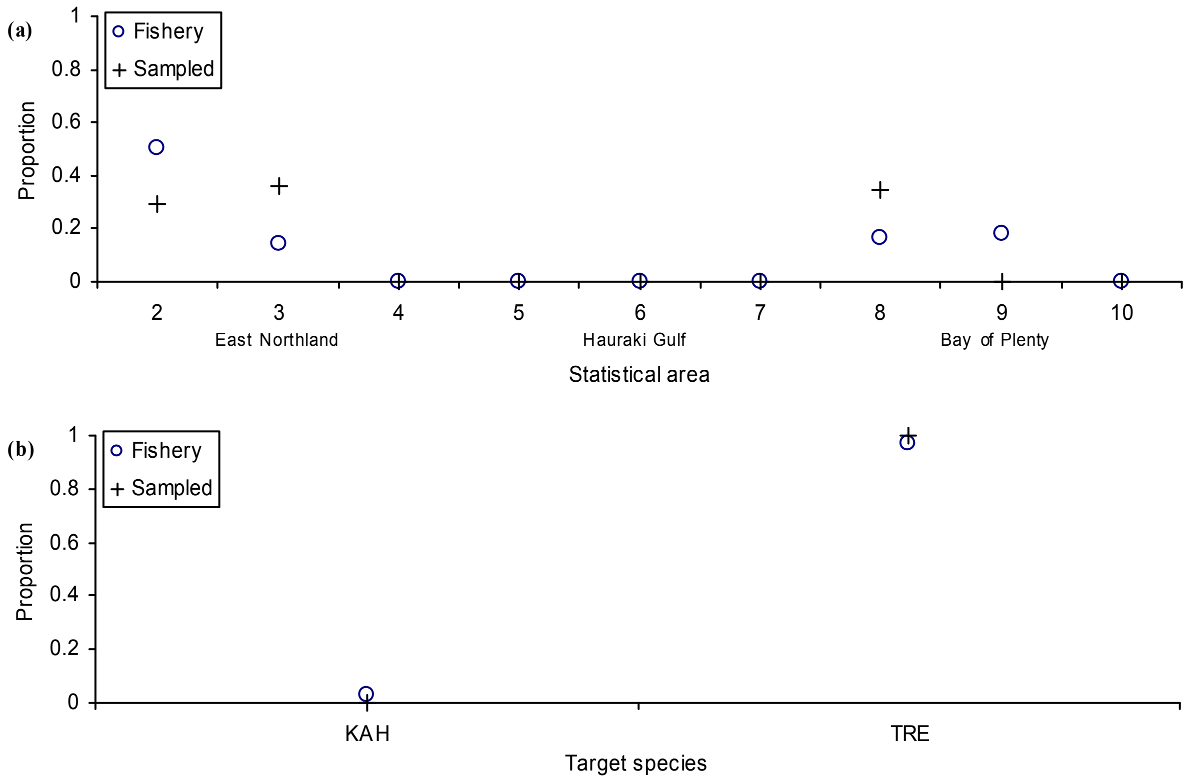


Figure 8: Comparison of the proportional distribution of the estimated purse-seine catch and the sampled component by (a) statistical area (with annotated spatial subarea strata) and (b) target species over the sampling period for the TRE 1 stock in 2008–09.

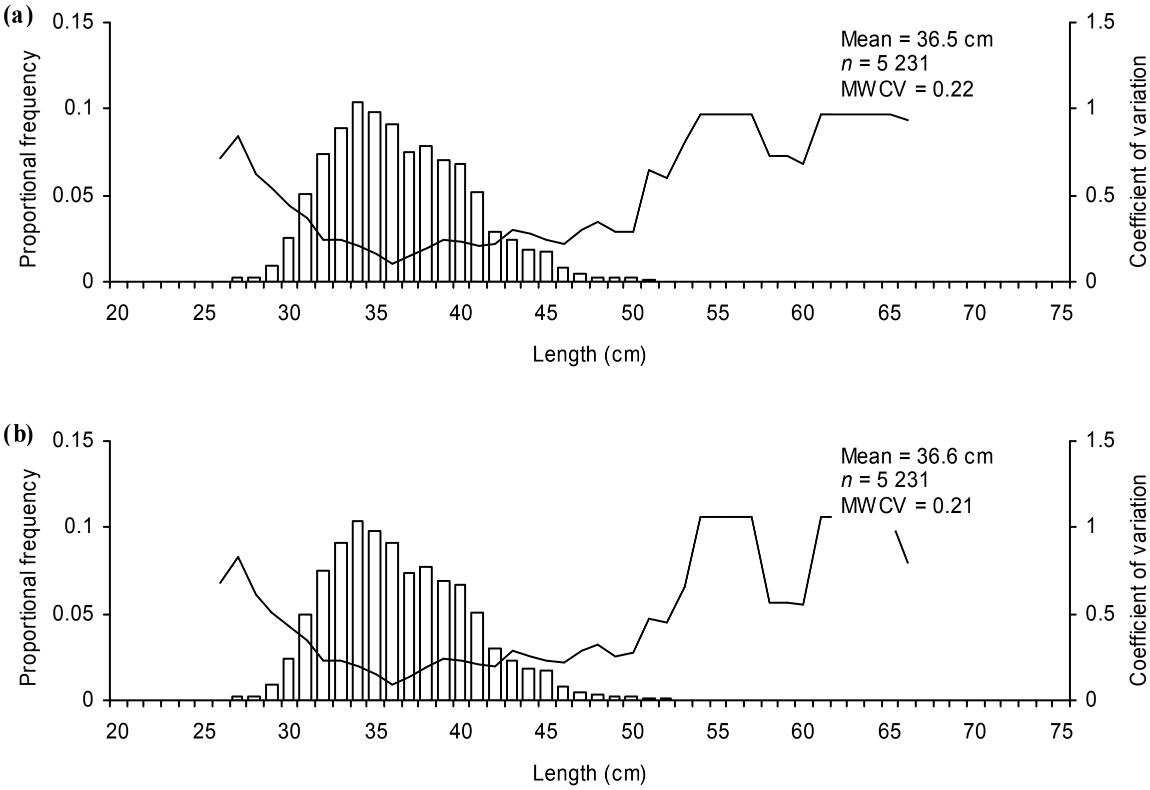


Figure 9: Unstratified (a) and stratified (b) proportion at length distributions (histogram) and analytical (solid line) c.v.s determined from trevally landings sampled from the TRE 1 single trawl fishery in 2008–09 (*n,* length sample size; MWCV, mean weighted c.v.).

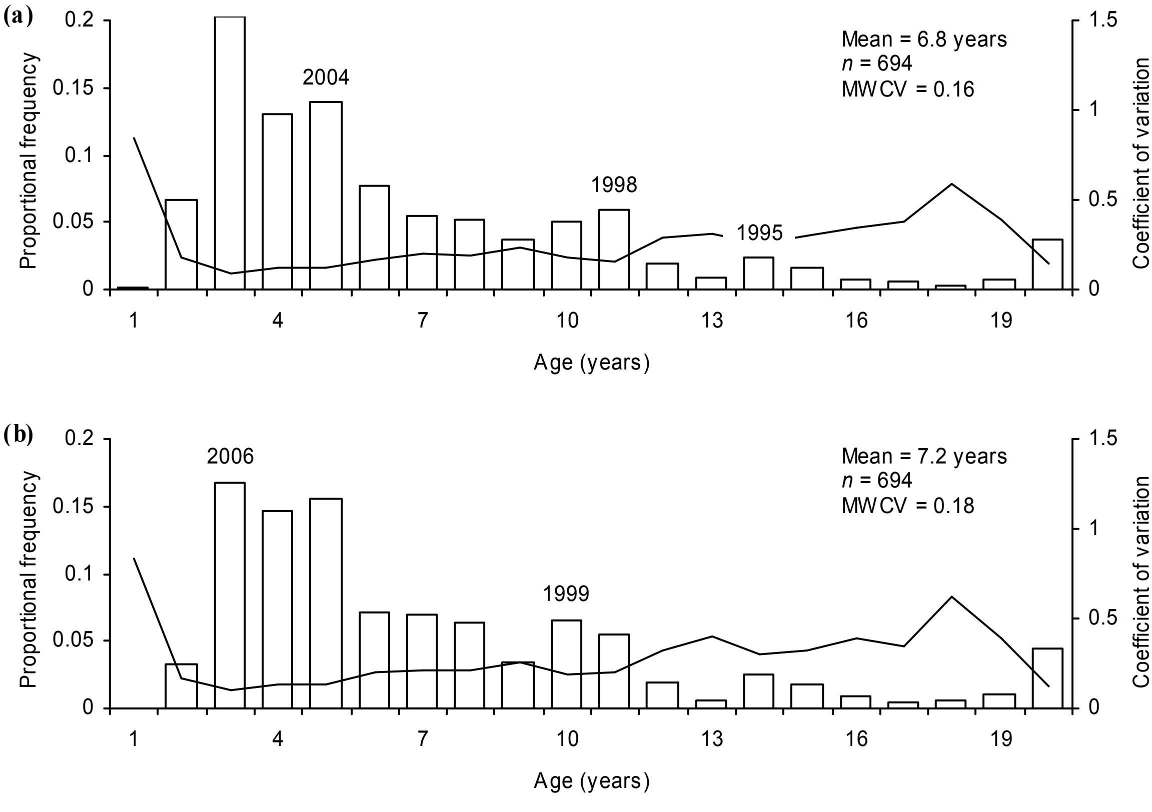


Figure 10: Unstratified (a) and stratified (b) proportion at age distributions (histogram) and analytical (solid line) c.v.s determined from trevally landings sampled from the TRE 1 single trawl fishery in 2008–09 (*n,* otolith sample size; MWCV, mean weighted c.v.).

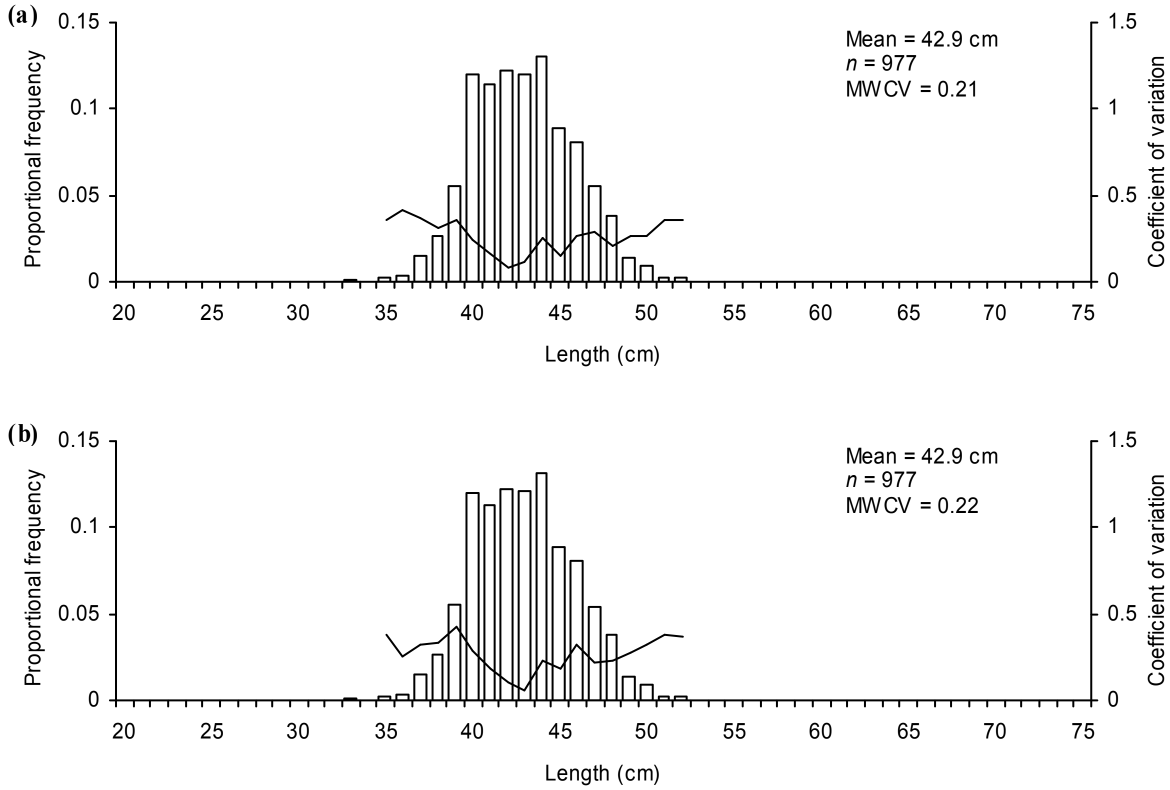


Figure 11: Unstratified (a) and stratified (b) proportion at length distributions (histogram) and analytical (solid line) c.v.s determined from trevally landings sampled from the TRE 1 purse-seine fishery in 2008–09 (*n,* length sample size; MWCV, mean weighted c.v.).

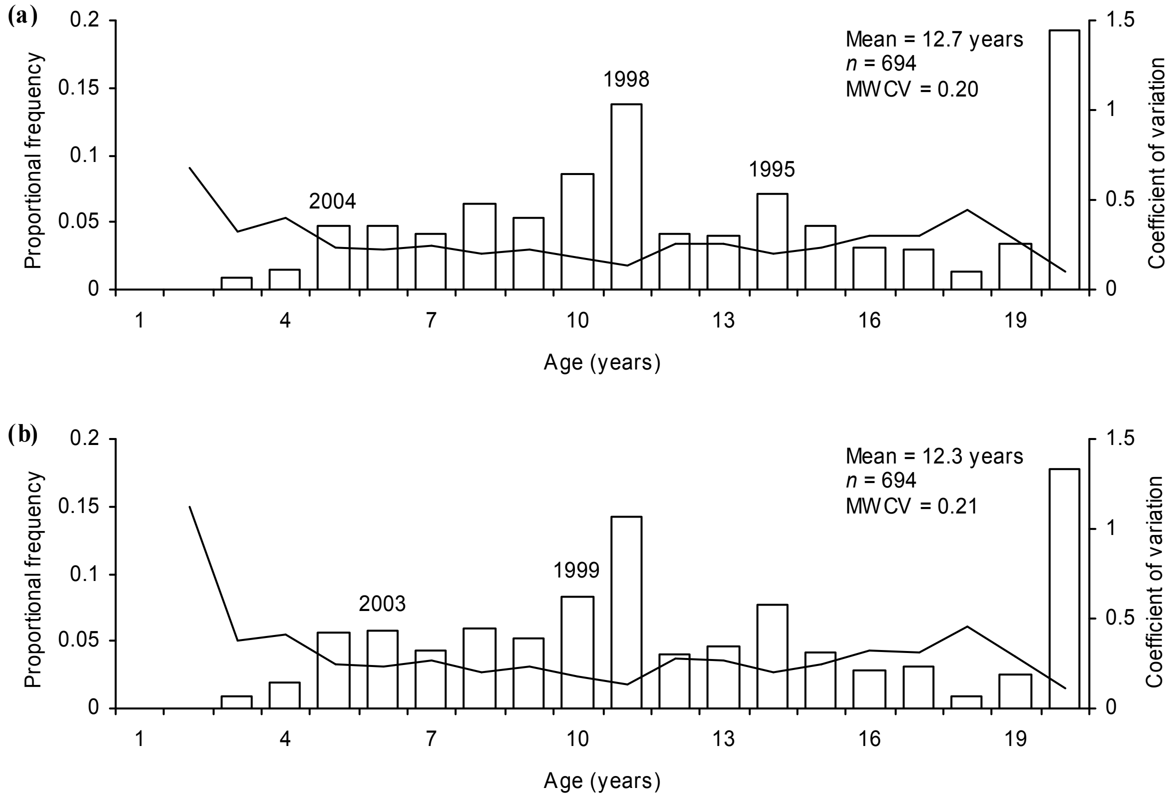
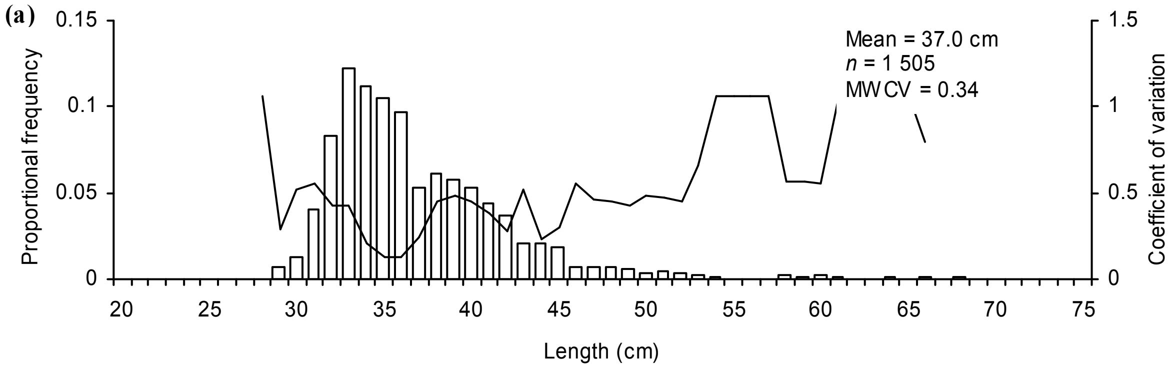


Figure 12: Unstratified (a) and stratified (b) proportion at age distributions (histogram) and analytical (solid line) c.v.s determined from trevally landings sampled from the TRE 1 purse-seine fishery in 2008–09 (*n,* otolith sample size; MWCV, mean weighted c.v.).



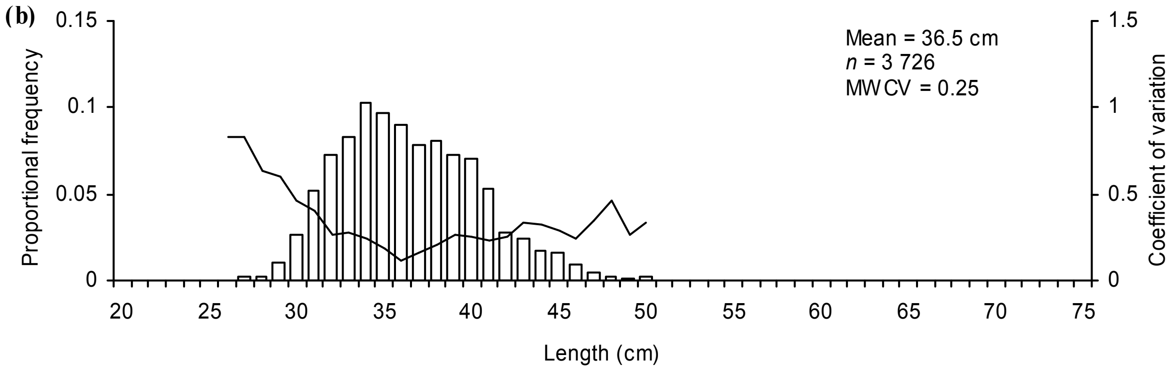
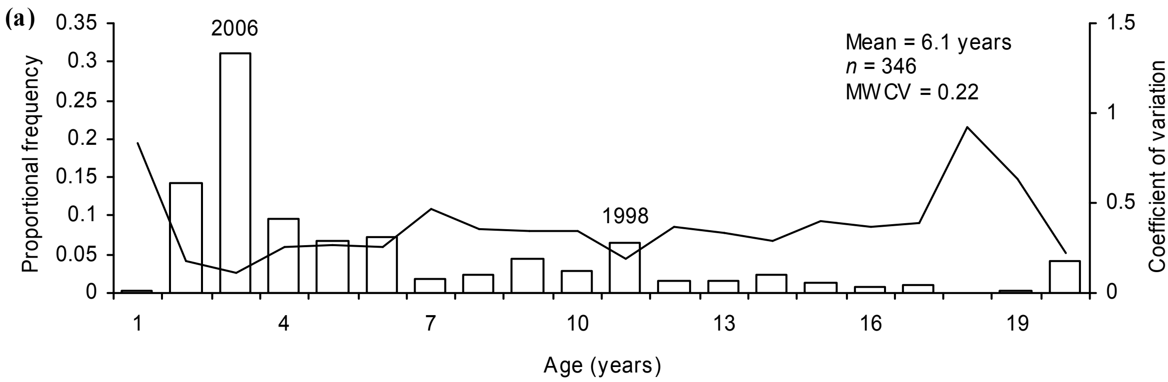


Figure 13: Proportion at length distributions (histogram) and analytical (solid line) c.v.s determined from trevally landings sampled from the (a) East Northland and (b) Bay of Plenty single trawl fisheries in 2008–09 (n, length sample size; MWCV, mean weighted c.v.).



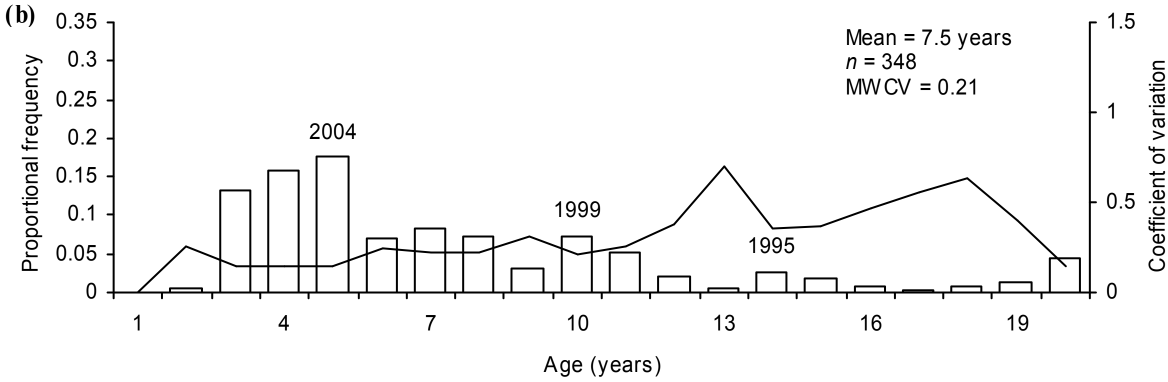
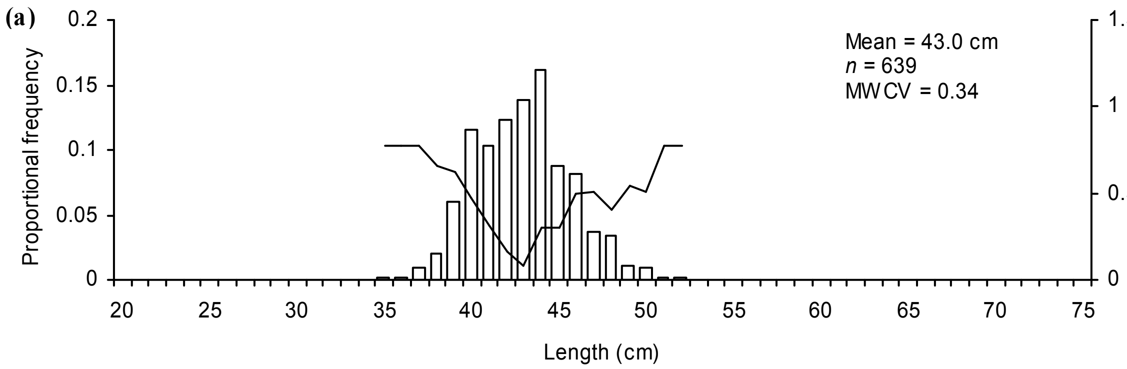


Figure 14: Proportion at age distributions (histogram) and analytical (solid line) c.v.s determined from trevally landings sampled from the (a) East Northland and (b) Bay of Plenty single trawl fisheries in 2008–09 (*n*, length sample size; MWCV, mean weighted c.v.).



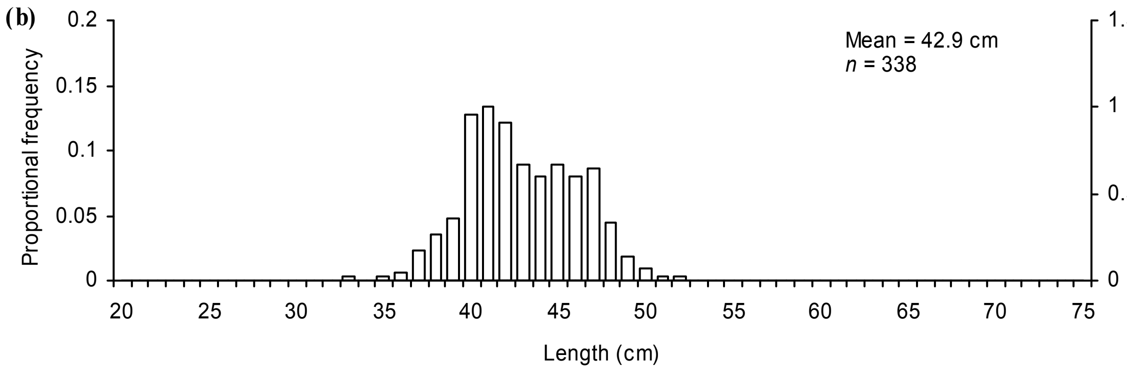
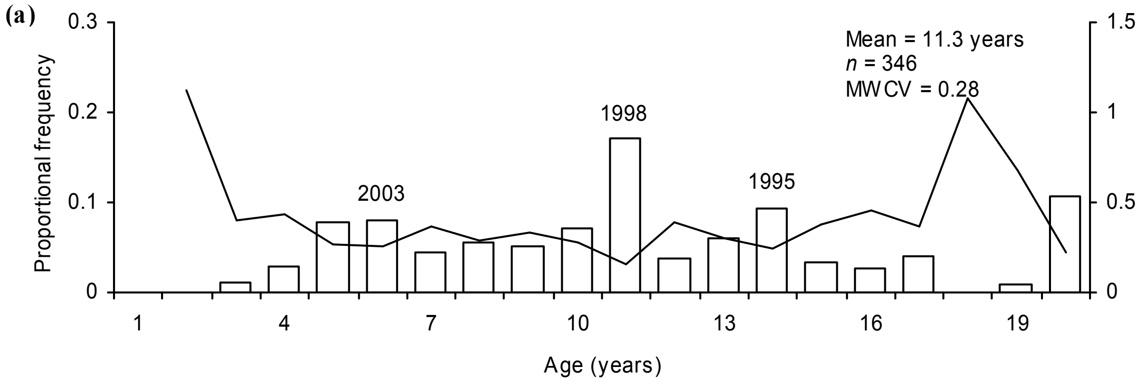


Figure 15: Proportion at length distributions (histogram) and analytical (solid line) c.v.s determined from trevally landings sampled from the (a) East Northland and (b) Bay of Plenty purse-seine fisheries in 2008–09 (n, length sample size; MWCV, mean weighted c.v.).



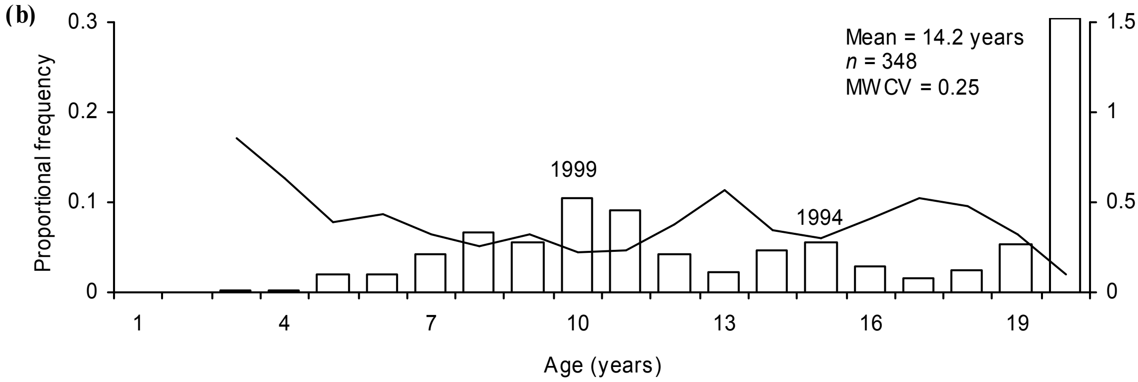


Figure 16: Proportion at age distributions (histogram) and analytical (solid line) c.v.s determined from trevally landings sampled from the (a) East Northland and (b) Bay of Plenty purse-seine fisheries in 2008–09 (*n*, length sample size; MWCV, mean weighted c.v.).

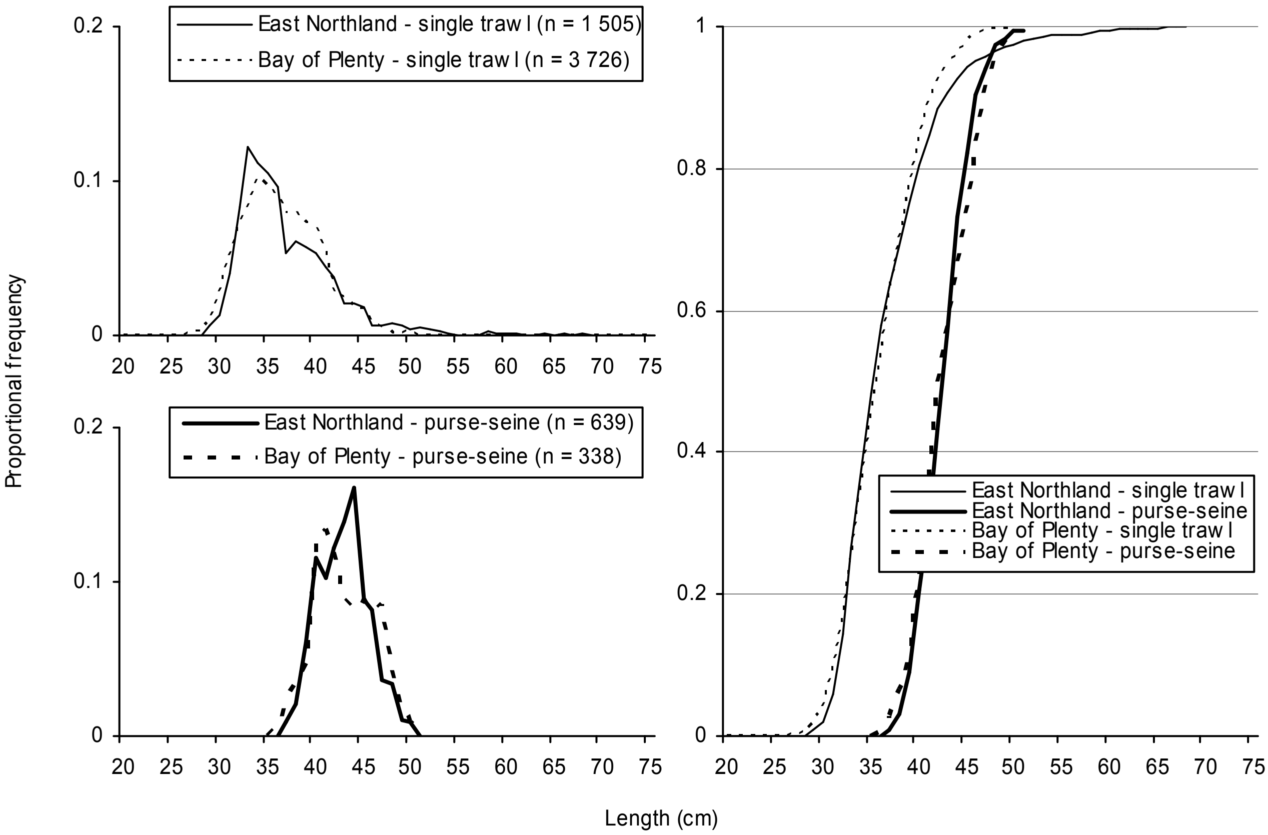


Figure 17: Comparison of the proportion and cumulative proportion at length distributions determined from trevally landings sampled from the East Northland and Bay of Plenty method fisheries of TRE 1 in 2008–09 (*n*, length sample size).

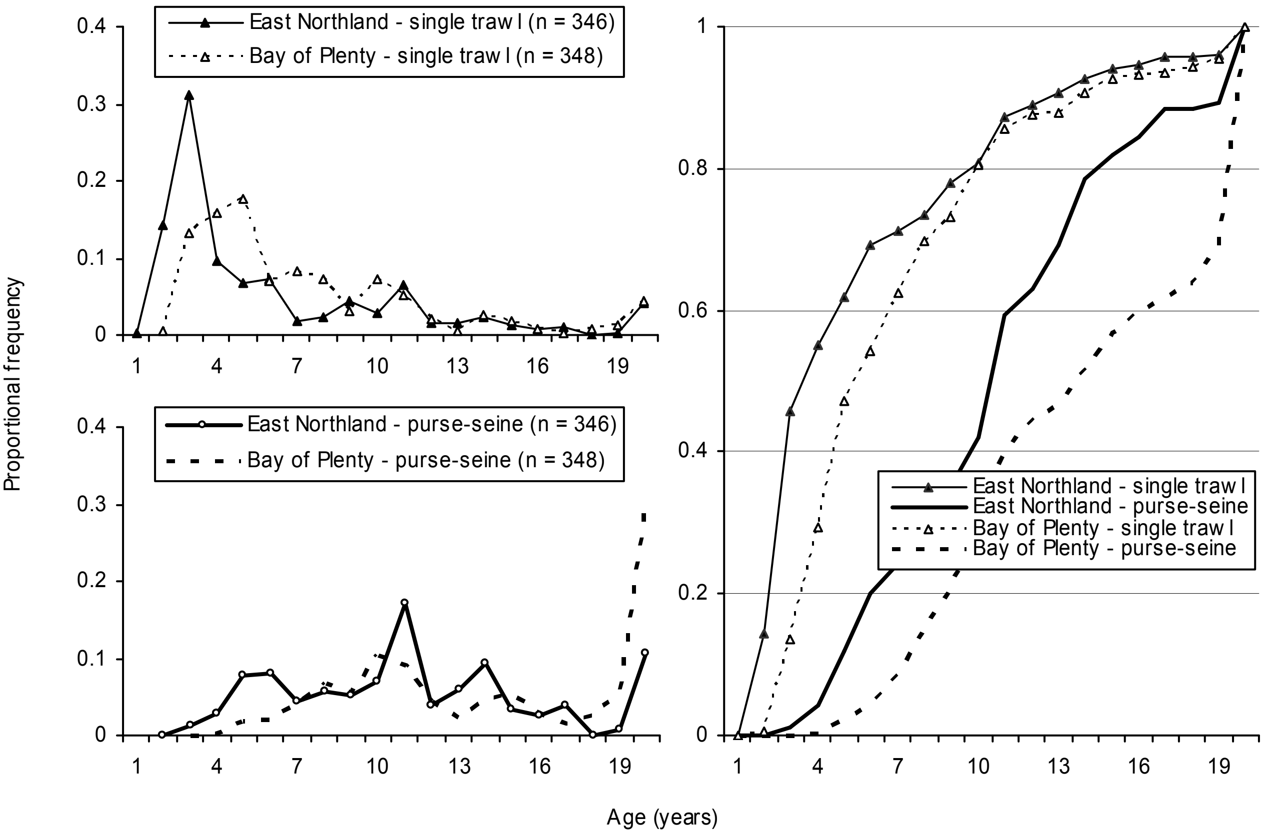


Figure 18: Comparison of the proportion and cumulative proportion at age distributions determined from trevally landings sampled from the East Northland and Bay of Plenty method fisheries of TRE 1 in 2008–09 (*n*, otolith sample size).

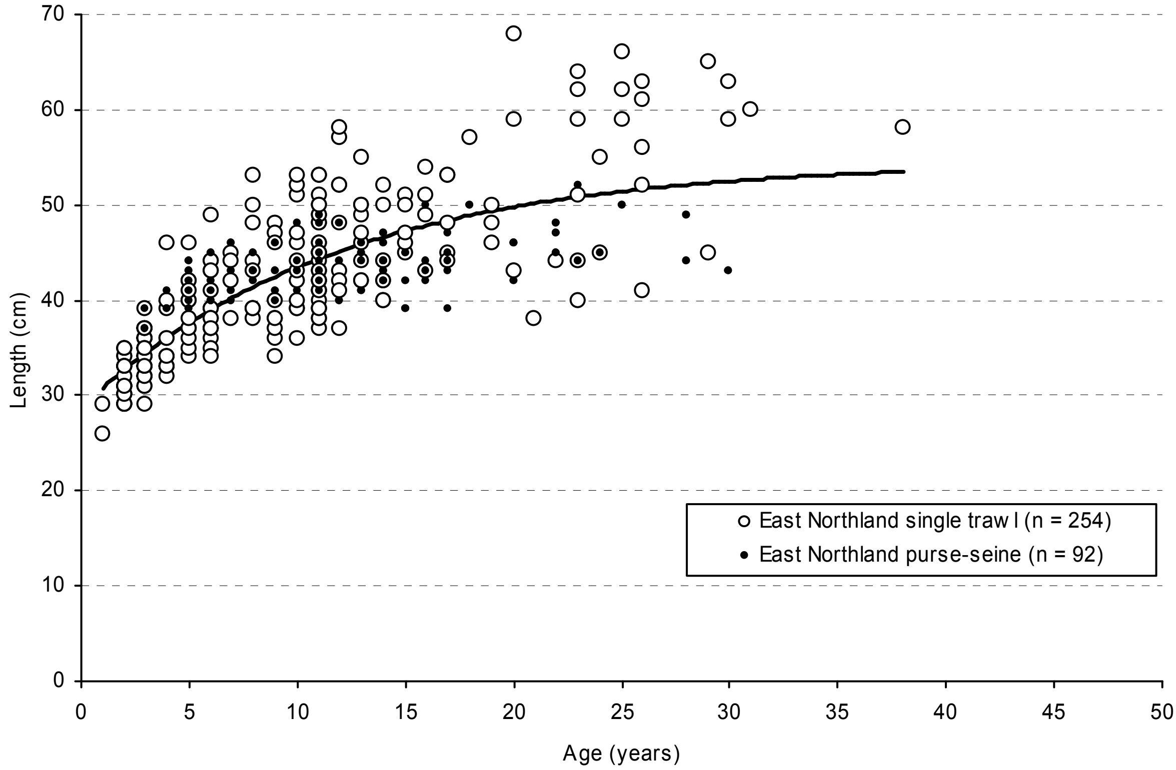


Figure 19: von Bertalanffy growth curve and scatterplot of age-length data for trevally sampled from the East Northland method fisheries in 2008–09 (Note: *n*, sample size).

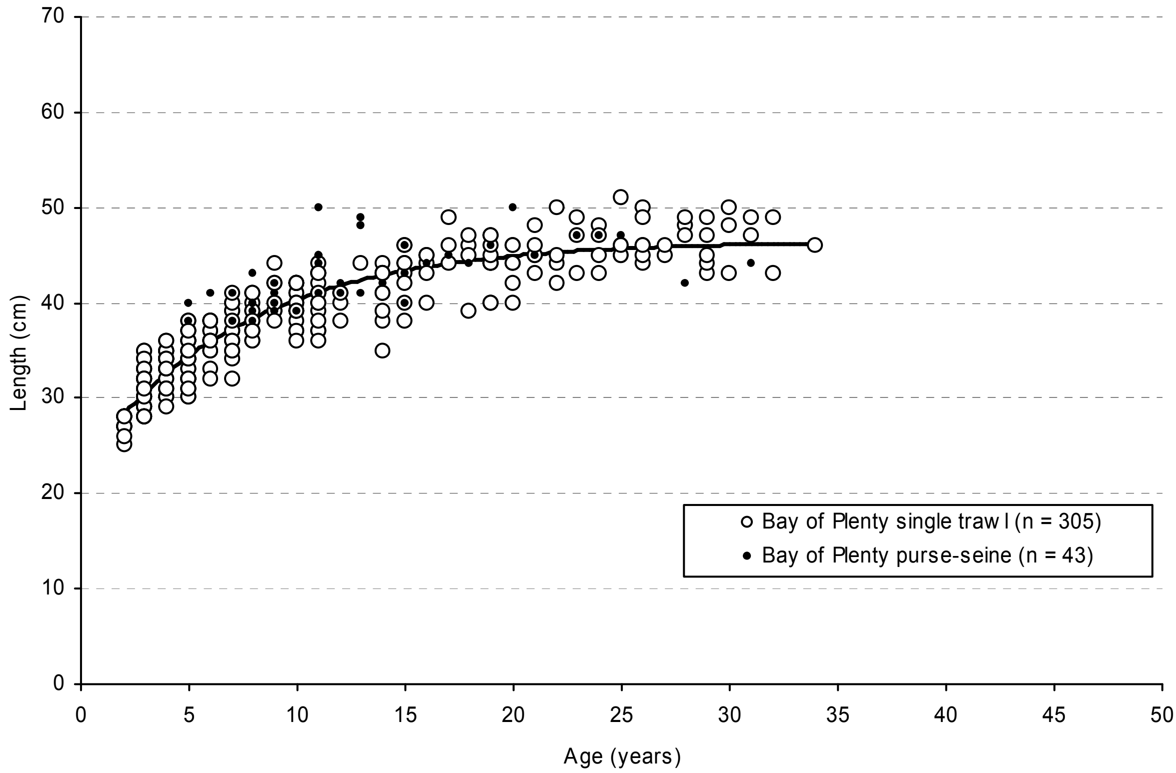


Figure 20: von Bertalanffy growth curve and scatterplot of age-length data for trevally sampled from the Bay of Plenty method fisheries in 2008–09 (Note: *n*, sample size).

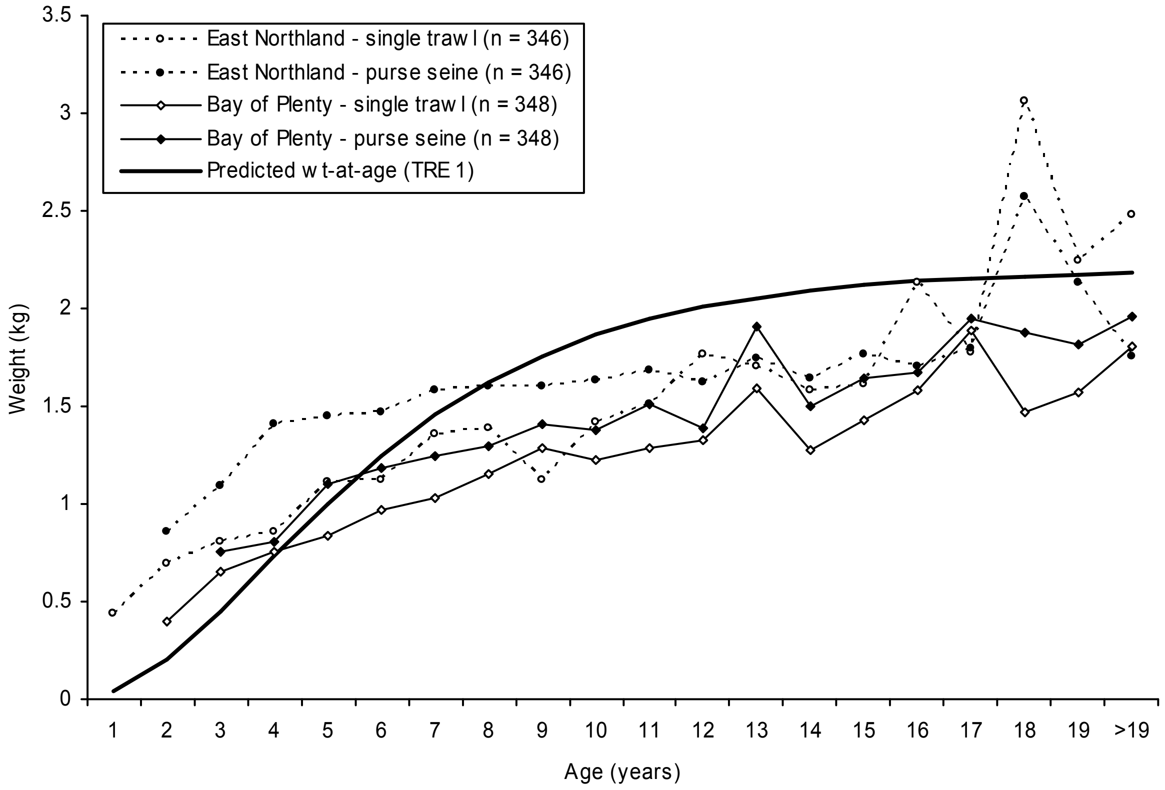


Figure 21: Observed and predicted mean weight-at-age estimates from trevally landings sampled from the East Northland and Bay of Plenty method fisheries of TRE 1 in 2008–09 (*n*, sample size). Note: Predicted estimates are based on published growth (Walsh et al. 1999) and length-weight (James 1984) parameters.

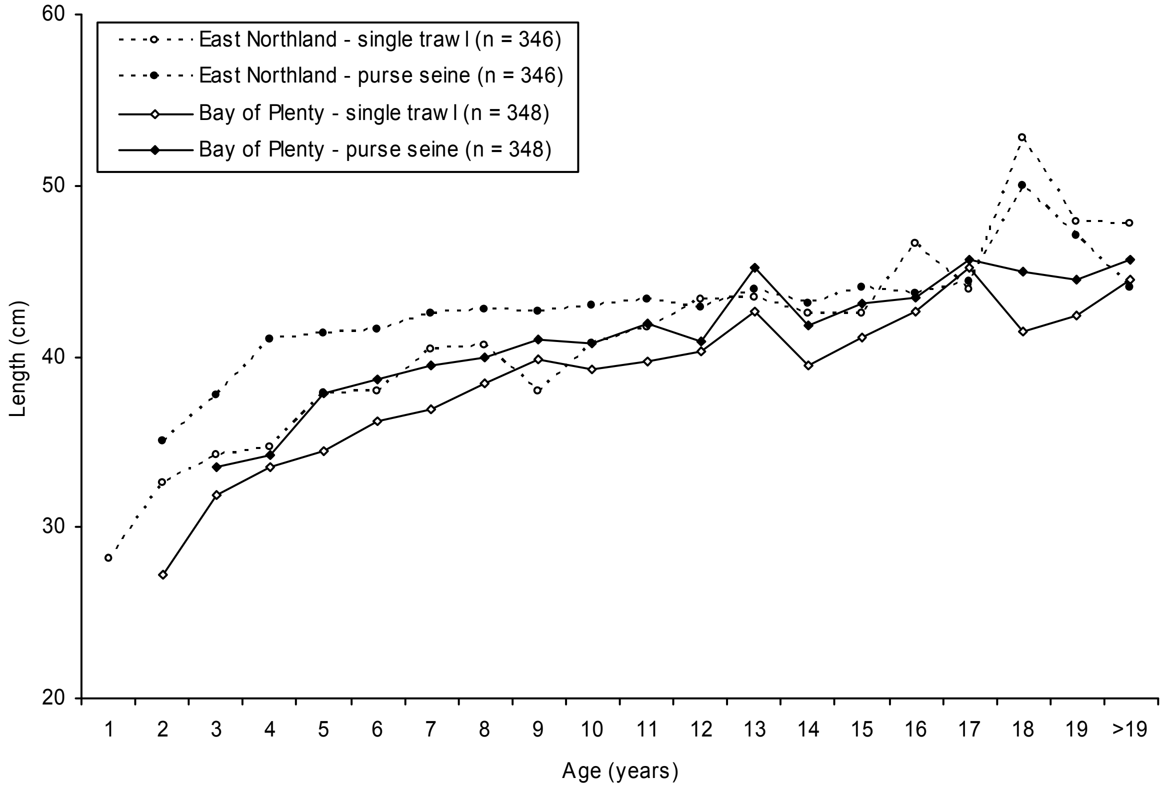


Figure 22: Observed mean length-at-age estimates from trevally landings sampled from the East Northland and Bay of Plenty method fisheries of TRE 1 in 2008–09 (*n*, sample size).

Appendix 1: Estimates of the proportion at length of trevally from the TRE 1 single trawl and purse-seine fisheries in 2008–09. The proportion at length for each subarea is also presented (Area codes: ENLD, East Northland; BPLE, Bay of Plenty).

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

Length	Single trawl						Purse-seine					
	TRE 1		ENLD		BPLE		TRE 1		ENLD		BPLE	
(cm)	*P.i.*	c.v.	*P.i.*	c.v.	*P.i.*	c.v.	*P.i.*	*c.v.*	*P.i.*	*c.v.*	*P.i.*	*c.v.*
20	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	–
21	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	–
22	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	–
23	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	–
24	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	–
25	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	–
26	0.0003	0.71	0.0004	1.06	0.0003	0.84	0.0000	0.00	0.0000	0.00	0.0000	–
27	0.0021	0.85	0.0000	0.00	0.0024	0.84	0.0000	0.00	0.0000	0.00	0.0000	–
28	0.0025	0.63	0.0004	1.06	0.0028	0.63	0.0000	0.00	0.0000	0.00	0.0000	–
29	0.0098	0.54	0.0069	0.29	0.0102	0.59	0.0000	0.00	0.0000	0.00	0.0000	–
30	0.0249	0.44	0.0125	0.52	0.0269	0.47	0.0000	0.00	0.0000	0.00	0.0000	–
31	0.0504	0.36	0.0400	0.55	0.0520	0.40	0.0000	0.00	0.0000	0.00	0.0000	–
32	0.0742	0.24	0.0833	0.43	0.0728	0.27	0.0000	0.00	0.0000	0.00	0.0000	–
33	0.0883	0.24	0.1221	0.42	0.0830	0.28	0.0011	0.71	0.0000	0.00	0.0030	–
34	0.1034	0.21	0.1115	0.20	0.1021	0.24	0.0000	0.00	0.0000	0.00	0.0000	–
35	0.0977	0.16	0.1055	0.13	0.0965	0.18	0.0021	0.36	0.0016	0.78	0.0030	–
36	0.0912	0.10	0.0966	0.13	0.0903	0.12	0.0032	0.41	0.0016	0.78	0.0059	–
37	0.0752	0.15	0.0527	0.24	0.0787	0.16	0.0149	0.36	0.0096	0.78	0.0237	–
38	0.0780	0.19	0.0613	0.45	0.0806	0.21	0.0263	0.31	0.0207	0.66	0.0355	–
39	0.0705	0.24	0.0574	0.49	0.0725	0.27	0.0556	0.36	0.0606	0.62	0.0473	–
40	0.0682	0.23	0.0532	0.45	0.0706	0.26	0.1201	0.24	0.1158	0.47	0.1272	–
41	0.0518	0.21	0.0441	0.38	0.0530	0.24	0.1141	0.17	0.1027	0.32	0.1331	–
42	0.0291	0.21	0.0373	0.28	0.0278	0.25	0.1221	0.08	0.1226	0.16	0.1213	–
43	0.0237	0.30	0.0203	0.52	0.0242	0.34	0.1201	0.12	0.1390	0.08	0.0888	–
44	0.0180	0.28	0.0205	0.23	0.0176	0.33	0.1307	0.25	0.1614	0.29	0.0799	–
45	0.0170	0.25	0.0185	0.29	0.0167	0.28	0.0886	0.16	0.0884	0.29	0.0888	–
46	0.0086	0.22	0.0069	0.56	0.0089	0.24	0.0810	0.26	0.0817	0.50	0.0799	–
47	0.0048	0.30	0.0067	0.47	0.0046	0.35	0.0554	0.29	0.0370	0.50	0.0858	–
48	0.0026	0.35	0.0075	0.45	0.0019	0.46	0.0379	0.21	0.0340	0.41	0.0444	–
49	0.0021	0.28	0.0063	0.43	0.0014	0.26	0.0134	0.27	0.0108	0.54	0.0178	–
50	0.0024	0.29	0.0035	0.49	0.0023	0.34	0.0091	0.27	0.0093	0.50	0.0089	–
51	0.0007	0.64	0.0049	0.48	0.0000	0.00	0.0021	0.36	0.0016	0.78	0.0030	–
52	0.0005	0.60	0.0040	0.45	0.0000	0.00	0.0021	0.35	0.0015	0.77	0.0030	–
53	0.0003	0.81	0.0024	0.66	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	–
54	0.0002	0.96	0.0012	1.06	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	–
55	0.0001	0.96	0.0004	1.06	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	–
56	0.0001	0.96	0.0004	1.06	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	–
57	0.0001	0.96	0.0004	1.06	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	–
58	0.0004	0.73	0.0028	0.56	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	–
59	0.0002	0.73	0.0014	0.56	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	–
60	0.0002	0.68	0.0018	0.55	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	–
61	0.0001	0.96	0.0008	1.06	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	–
62	0.0001	0.96	0.0004	1.06	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	–
63	0.0001	0.96	0.0004	1.06	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	–
64	0.0001	0.96	0.0008	1.06	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	–
65	0.0001	0.96	0.0004	1.06	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	–
66	0.0001	0.94	0.0010	0.80	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	–
67	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	–
68	0.0001	0.94	0.0010	0.80	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	–
69	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	–
70	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	–
71	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	–
72	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	–
73	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	–
74	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	–
75	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	–
Nt	399 029		72 733		292 629		204 708		130 982		73 731	
n	5 231		1 505		3 726		977		639		338	

Appendix 2: Estimates of proportion at age of trevally from the TRE 1 single trawl and purse-seine fisheries in 2008–09. The proportion at age for each subarea is also presented (Area codes: ENLD, East Northland; BPLE, Bay of Plenty).
P.j. = proportion of fish in age class; c.v. = coefficient of variation; *n* = number of fish aged.

	Single trawl						Purse-seine					
Age	TRE 1		ENLD		BPLE		TRE 1		ENLD		BPLE	
(years)	*P.j.*	c.v.	*P.j.*	c.v.	*P.j.*	c.v.	*P.j.*	c.v.	*P.j.*	c.v.	*P.j.*	c.v.
1	0.0008	0.85	0.0014	0.83	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00
2	0.0664	0.18	0.1435	0.18	0.0043	0.25	0.0004	0.68	0.0004	1.12	0.0000	0.00
3	0.2036	0.09	0.3116	0.11	0.1314	0.15	0.0083	0.32	0.0122	0.40	0.0013	0.86
4	0.1305	0.13	0.0951	0.26	0.1594	0.14	0.0146	0.40	0.0286	0.43	0.0028	0.63
5	0.1394	0.13	0.0684	0.26	0.1767	0.14	0.0471	0.23	0.0784	0.27	0.0190	0.39
6	0.0774	0.17	0.0733	0.26	0.0701	0.25	0.0477	0.22	0.0800	0.26	0.0197	0.43
7	0.0542	0.20	0.0173	0.46	0.0830	0.22	0.0416	0.25	0.0443	0.37	0.0418	0.33
8	0.0521	0.19	0.0232	0.36	0.0735	0.22	0.0635	0.20	0.0560	0.29	0.0666	0.26
9	0.0368	0.23	0.0444	0.35	0.0323	0.31	0.0532	0.22	0.0511	0.33	0.0551	0.32
10	0.0508	0.18	0.0294	0.34	0.0732	0.21	0.0861	0.17	0.0705	0.28	0.1036	0.22
11	0.0590	0.16	0.0661	0.19	0.0513	0.25	0.1374	0.13	0.1706	0.16	0.0916	0.24
12	0.0192	0.29	0.0167	0.37	0.0204	0.38	0.0416	0.26	0.0389	0.39	0.0431	0.38
13	0.0092	0.32	0.0151	0.33	0.0042	0.70	0.0406	0.26	0.0604	0.30	0.0221	0.56
14	0.0242	0.25	0.0221	0.29	0.0266	0.35	0.0705	0.20	0.0935	0.24	0.0471	0.34
15	0.0163	0.30	0.0123	0.40	0.0188	0.37	0.0479	0.23	0.0333	0.37	0.0547	0.31
16	0.0071	0.34	0.0076	0.37	0.0083	0.47	0.0310	0.30	0.0266	0.45	0.0295	0.41
17	0.0061	0.38	0.0098	0.39	0.0026	0.56	0.0294	0.29	0.0394	0.36	0.0164	0.53
18	0.0035	0.59	0.0005	0.92	0.0071	0.64	0.0131	0.44	0.0008	1.08	0.0248	0.48
19	0.0069	0.39	0.0014	0.63	0.0117	0.40	0.0339	0.28	0.0088	0.68	0.0539	0.32
>19	0.0366	0.14	0.0403	0.22	0.0451	0.14	0.1920	0.10	0.1063	0.22	0.3039	0.10
n	694		346		348		694		346		348	

Appendix 3: Estimates of mean weight-at-age (kg) of trevally from the TRE 1 single trawl and purse-seine fisheries in 2008–09. The mean weight-at-age for each subarea is also presented (Area codes: ENLD, East Northland; BPLE, Bay of Plenty).

	Single trawl						Purse-seine					
Age	TRE 1		ENLD		BPLE		TRE 1		ENLD		BPLE	
(years)	Mean	c.v.	Mean	c.v.	Mean	c.v.	Mean	c.v.	Mean	c.v.	Mean	c.v.
1	0.46	0.08	0.44	0.11	–	–	–	–	–	–	–	–
2	0.66	0.03	0.70	0.03	0.40	0.02	0.79	0.06	0.86	–	–	–
3	0.76	0.02	0.81	0.02	0.66	0.02	1.05	0.04	1.09	0.04	0.75	0.06
4	0.80	0.02	0.86	0.05	0.76	0.02	1.37	0.08	1.41	0.08	0.81	0.07
5	0.90	0.03	1.11	0.06	0.83	0.03	1.39	0.03	1.45	0.04	1.11	0.05
6	1.05	0.03	1.13	0.05	0.97	0.04	1.43	0.03	1.47	0.04	1.18	0.07
7	1.07	0.04	1.35	0.07	1.03	0.04	1.43	0.04	1.58	0.05	1.25	0.03
8	1.20	0.03	1.39	0.07	1.16	0.03	1.45	0.03	1.60	0.04	1.29	0.03
9	1.20	0.04	1.13	0.07	1.29	0.03	1.52	0.04	1.61	0.07	1.41	0.03
10	1.26	0.03	1.42	0.10	1.23	0.03	1.50	0.03	1.64	0.05	1.37	0.02
11	1.36	0.03	1.51	0.05	1.29	0.05	1.65	0.02	1.68	0.03	1.51	0.03
12	1.37	0.05	1.77	0.16	1.33	0.04	1.54	0.04	1.62	0.06	1.39	0.02
13	1.63	0.05	1.70	0.06	1.59	0.09	1.77	0.04	1.75	0.04	1.91	0.12
14	1.37	0.06	1.58	0.05	1.27	0.07	1.61	0.03	1.64	0.03	1.50	0.03
15	1.42	0.05	1.61	0.11	1.43	0.06	1.69	0.04	1.77	0.06	1.64	0.05
16	1.67	0.07	2.13	0.11	1.58	0.07	1.70	0.03	1.70	0.04	1.68	0.05
17	1.67	0.09	1.77	0.11	1.88	0.04	1.85	0.04	1.80	0.04	1.94	0.05
18	1.56	0.14	3.06	0.19	1.47	0.13	1.88	0.06	2.57	–	1.88	0.06
19	1.61	0.08	2.25	0.05	1.57	0.07	1.84	0.05	2.13	0.05	1.82	0.05
>19	1.84	0.05	2.48	0.12	1.81	0.03	1.87	0.02	1.75	0.03	1.96	0.02

Appendix 4: Estimates of mean length-at-age (cm) of trevally from the TRE 1 single trawl and purse-seine fisheries in 2008–09. The mean length-at-age for each subarea is also presented (Area codes: ENLD, East Northland; BPLE, Bay of Plenty).

	Single trawl						Purse-seine					
Age	TRE 1		ENLD		BPLE		TRE 1		ENLD		BPLE	
(years)	Mean	c.v.	Mean	c.v.	Mean	c.v.	Mean	c.v.	Mean	c.v.	Mean	c.v.
1	28.4	0.027	28.1	0.037	–	–	–	–	–	–	–	–
2	32.0	0.010	32.6	0.008	27.3	0.005	34.0	0.020	35.0	–	–	–
3	33.5	0.006	34.2	0.005	31.9	0.007	37.3	0.014	37.8	0.014	33.5	0.018
4	34.0	0.007	34.7	0.016	33.5	0.007	40.5	0.025	40.9	0.025	34.3	0.023
5	35.3	0.009	37.8	0.019	34.5	0.009	40.8	0.011	41.4	0.012	37.9	0.018
6	37.1	0.010	38.0	0.018	36.2	0.013	41.1	0.011	41.5	0.012	38.7	0.023
7	37.4	0.013	40.4	0.024	37.0	0.012	41.2	0.012	42.5	0.018	39.5	0.011
8	38.9	0.009	40.6	0.022	38.4	0.009	41.3	0.010	42.7	0.013	39.9	0.009
9	38.9	0.014	37.9	0.024	39.8	0.010	42.0	0.014	42.6	0.023	41.0	0.010
10	39.5	0.009	40.8	0.033	39.2	0.009	41.8	0.009	43.0	0.015	40.7	0.006
11	40.4	0.010	41.7	0.015	39.7	0.015	43.1	0.007	43.4	0.009	41.9	0.010
12	40.5	0.015	43.3	0.047	40.3	0.014	42.2	0.014	42.8	0.020	40.9	0.006
13	42.9	0.015	43.5	0.020	42.6	0.029	44.1	0.014	43.9	0.015	45.2	0.040
14	40.5	0.020	42.5	0.016	39.5	0.026	42.8	0.008	43.1	0.011	41.9	0.010
15	41.0	0.017	42.6	0.034	41.1	0.021	43.5	0.013	44.0	0.022	43.0	0.016
16	43.2	0.021	46.6	0.036	42.6	0.025	43.6	0.011	43.6	0.013	43.4	0.018
17	43.2	0.032	43.9	0.037	45.1	0.012	44.8	0.012	44.4	0.015	45.6	0.015
18	42.2	0.045	52.7	0.062	41.5	0.040	45.0	0.020	50.0	–	45.0	0.022
19	42.7	0.025	47.8	0.017	42.4	0.023	44.7	0.017	47.0	0.016	44.5	0.019
>19	44.3	0.015	47.7	0.041	44.4	0.009	45.0	0.005	44.0	0.011	45.6	0.006

Appendix 5: Age-length key derived from otolith samples collected from trevally fisheries in TRE 1 in 2008–09.

Estimates of proportion of age at length for trevally sampled from all TRE 1 subareas combined, 2008–09. (Note: Aged to 01/01/2009)

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	1.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
26	0.50	0.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
27	0	1.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
28	0	0.55	0.45	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11
29	0	0.33	0.53	0.07	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15
30	0	0.25	0.50	0.13	0.13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16
31	0	0.37	0.32	0.16	0.16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	19
32	0	0.04	0.56	0.11	0.22	0.04	0.04	0	0	0	0	0	0	0	0	0	0	0	0	0	27
33	0	0.19	0.38	0.34	0.06	0.03	0	0	0	0	0	0	0	0	0	0	0	0	0	0	32
34	0	0.06	0.21	0.42	0.21	0.03	0.03	0	0.03	0	0	0	0	0	0	0	0	0	0	0	33
35	0	0.09	0.31	0.16	0.25	0.09	0.06	0	0	0	0	0	0	0.03	0	0	0	0	0	0	32
36	0	0	0.23	0.13	0.19	0.16	0.10	0.06	0.03	0.06	0.03	0	0	0	0	0	0	0	0	0	31
37	0	0	0.24	0	0.21	0.15	0.12	0.09	0.03	0.06	0.09	0.03	0	0	0	0	0	0	0	0	34
38	0	0	0	0	0.14	0.21	0.11	0.14	0.11	0.04	0.11	0.04	0	0.04	0.04	0	0	0	0	0.04	28
39	0	0	0.05	0.08	0.03	0.08	0.05	0.16	0.08	0.22	0.11	0	0	0.03	0.05	0	0.03	0.03	0	0	37
40	0	0	0	0.03	0.11	0.05	0.08	0.13	0.11	0.13	0.08	0.05	0	0.05	0.05	0.03	0	0	0.05	0.05	38
41	0	0	0	0.03	0.06	0.09	0.09	0.06	0.06	0.09	0.23	0.14	0.09	0.06	0	0	0	0	0	0.03	35
42	0	0	0	0	0.08	0.03	0.03	0.03	0.08	0.19	0.14	0.05	0.05	0.14	0.05	0.03	0	0	0	0.11	37
43	0	0	0	0	0.03	0.05	0.03	0.13	0.03	0.08	0.18	0.03	0	0.10	0.05	0.08	0.03	0	0	0.21	39
44	0	0	0	0	0.02	0.04	0.02	0.02	0.02	0.04	0.09	0.02	0.07	0.15	0.04	0.07	0.07	0.02	0.07	0.24	46
45	0	0	0	0	0	0.03	0.03	0.03	0	0	0.23	0	0.03	0	0.06	0.06	0.09	0.03	0.03	0.40	35
46	0	0	0	0.03	0.03	0	0.03	0	0.06	0.03	0.09	0	0.06	0.03	0.13	0	0.03	0.03	0.09	0.34	32
47	0	0	0	0	0	0	0	0	0.06	0.06	0	0	0.06	0.06	0.06	0	0.06	0.06	0.11	0.50	18
48	0	0	0	0	0	0	0	0.06	0.06	0.06	0.24	0.12	0.06	0	0	0	0.06	0	0.06	0.29	17
49	0	0	0	0	0	0.06	0	0	0	0	0.25	0	0.13	0	0	0.06	0.06	0	0	0.44	16
50	0	0	0	0	0	0	0	0.06	0	0	0.19	0	0.13	0.06	0.06	0.06	0	0.06	0.06	0.31	16
51	0	0	0	0	0	0	0	0	0	0.17	0.17	0	0	0	0.17	0.17	0	0	0	0.33	6
52	0	0	0	0	0	0	0	0	0	0.14	0	0.29	0	0.14	0	0	0	0	0	0.43	7
53	0	0	0	0	0	0	0	0.17	0	0.17	0.33	0	0	0	0	0	0.33	0	0	0	6
54	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.00	0	0	0	0	1
55	0	0	0	0	0	0	0	0	0	0	0	0	0.50	0	0	0	0	0	0	0.50	2
56	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.00	1
57	0	0	0	0	0	0	0	0	0	0	0	0.50	0	0	0	0	0	0.50	0	0	2
58	0	0	0	0	0	0	0	0	0	0	0	0.50	0	0	0	0	0	0	0	0.50	2
59	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.00	4
60	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.00	1
61	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.00	1
62	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.00	2
63	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.00	2
64	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.00	1
65	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.00	1
66	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.00	1
67	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
68	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.00	1
69	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	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
Total																					694

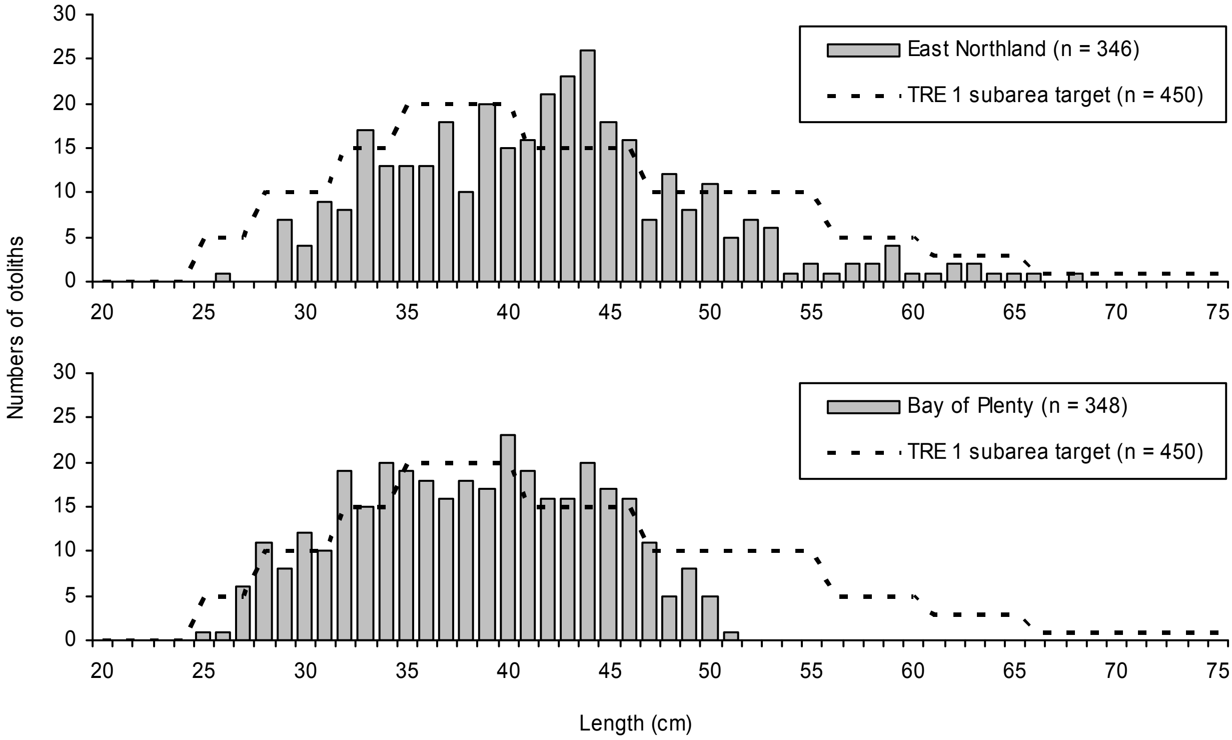
Appendix 5 – continued:
Estimates of proportion of age at length for trevally sampled from the East Northland subarea of TRE 1, 2008–09.
(Note: Aged to 01/01/2009)

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	1.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29	0.14	0.71	0.14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7
30	0	1.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
31	0	0.78	0.22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9
32	0	0.13	0.75	0.13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8
33	0	0.35	0.41	0.24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17
34	0	0.15	0.38	0.23	0.08	0.08	0	0	0.08	0	0	0	0	0	0	0	0	0	0	0	13
35	0	0.23	0.62	0	0.08	0.08	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13
36	0	0	0.54	0.15	0.08	0.08	0	0	0.08	0.08	0	0	0	0	0	0	0	0	0	0	13
37	0	0	0.44	0	0.22	0.17	0	0	0.06	0	0.06	0.06	0	0	0	0	0	0	0	0	18
38	0	0	0	0	0.10	0.20	0.10	0.10	0.20	0	0.20	0	0	0	0	0	0	0	0	0.10	10
39	0	0	0.10	0.15	0.05	0.15	0	0.15	0	0.10	0.15	0	0	0	0.10	0	0.05	0	0	0	20
40	0	0	0	0.07	0.20	0.13	0.07	0	0.13	0.07	0.07	0.07	0	0.13	0	0	0	0	0	0.07	15
41	0	0	0	0.06	0.13	0.13	0.06	0	0.06	0.06	0.25	0.06	0.13	0	0	0	0	0	0	0.06	16
42	0	0	0	0	0.14	0.05	0.05	0.05	0	0.05	0.19	0.05	0.10	0.19	0.05	0.05	0	0	0	0.05	21
43	0	0	0	0	0.04	0.09	0.04	0.17	0.04	0.13	0.17	0.04	0	0.04	0	0.09	0.04	0	0	0.09	23
44	0	0	0	0	0.04	0.08	0.04	0.04	0	0.08	0.08	0.04	0.08	0.23	0	0.04	0.08	0	0	0.19	26
45	0	0	0	0	0	0.06	0.06	0.06	0	0	0.33	0	0.06	0	0.11	0	0.11	0	0	0.22	18
46	0	0	0	0	0.06	0	0.06	0	0.13	0.06	0.19	0	0.13	0.06	0.06	0	0	0	0.06	0.13	16
47	0	0	0	0	0	0	0	0	0.14	0.14	0	0	0.14	0.14	0.14	0	0.14	0	0	0.14	7
48	0	0	0	0	0	0	0	0.08	0.08	0.08	0.33	0.17	0	0	0	0	0.08	0	0.08	0.08	12
49	0	0	0	0	0	0.13	0	0	0	0	0.50	0	0.13	0	0	0.13	0	0	0	0.13	8
50	0	0	0	0	0	0	0	0.09	0	0	0.18	0	0.18	0.09	0.09	0.09	0	0.09	0.09	0.09	11
51	0	0	0	0	0	0	0	0	0	0.20	0.20	0	0	0	0.20	0.20	0	0	0	0.20	5
52	0	0	0	0	0	0	0	0	0	0.14	0	0.29	0	0.14	0	0	0	0	0	0.43	7
53	0	0	0	0	0	0	0	0.17	0	0.17	0.33	0	0	0	0	0	0.33	0	0	0	6
54	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.00	0	0	0	0	1
55	0	0	0	0	0	0	0	0	0	0	0	0	0.50	0	0	0	0	0	0	0.50	2
56	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.00	1
57	0	0	0	0	0	0	0	0	0	0	0	0.50	0	0	0	0	0	0.50	0	0	2
58	0	0	0	0	0	0	0	0	0	0	0	0.50	0	0	0	0	0	0	0	0.50	2
59	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.00	4
60	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.00	1
61	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.00	1
62	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.00	2
63	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.00	2
64	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.00	1
65	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.00	1
66	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.00	1
67	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
68	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.00	1
69	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	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
Total																					346

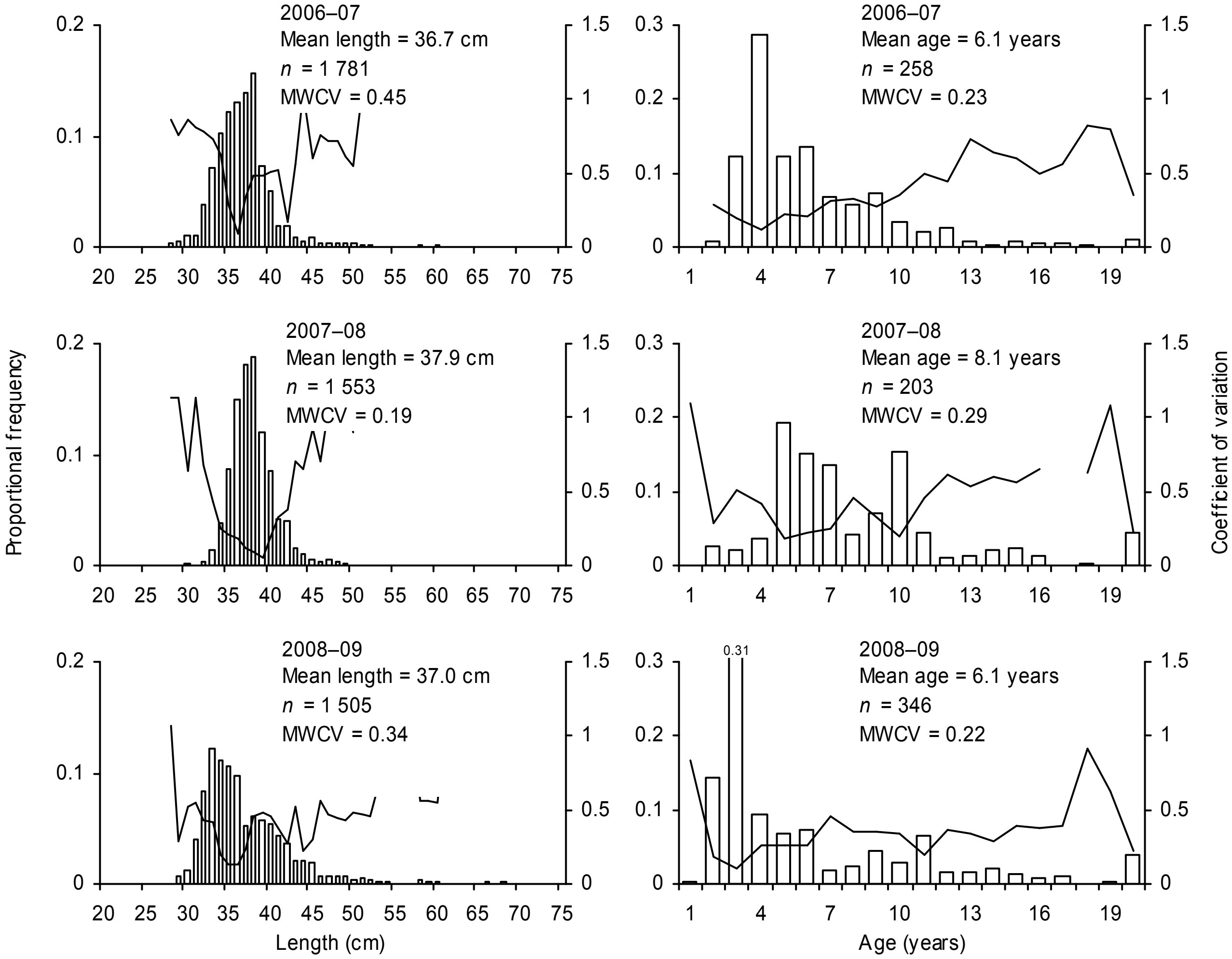
Appendix 5 – continued:
Estimates of proportion of age at length for trevally sampled from the Bay of Plenty subarea of TRE 1, 2008–09.
(Note: Aged to 01/01/2009)

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	1.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
26	0	1.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
27	0	1.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
28	0	0.55	0.45	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11
29	0	0	0.88	0.13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8
30	0	0	0.67	0.17	0.17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12
31	0	0	0.40	0.30	0.30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10
32	0	0	0.47	0.11	0.32	0.05	0.05	0	0	0	0	0	0	0	0	0	0	0	0	0	19
33	0	0	0.33	0.47	0.13	0.07	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15
34	0	0	0.10	0.55	0.30	0	0.05	0	0	0	0	0	0	0	0	0	0	0	0	0	20
35	0	0	0.11	0.26	0.37	0.11	0.11	0	0	0	0	0	0	0.05	0	0	0	0	0	0	19
36	0	0	0	0.11	0.28	0.22	0.17	0.11	0	0.06	0.06	0	0	0	0	0	0	0	0	0	18
37	0	0	0	0	0.19	0.13	0.25	0.19	0	0.13	0.13	0	0	0	0	0	0	0	0	0	16
38	0	0	0	0	0.17	0.22	0.11	0.17	0.06	0.06	0.06	0.06	0	0.06	0.06	0	0	0	0	0	18
39	0	0	0	0	0	0	0.12	0.18	0.18	0.35	0.06	0	0	0.06	0	0	0	0.06	0	0	17
40	0	0	0	0	0.04	0	0.09	0.22	0.09	0.17	0.09	0.04	0	0	0.09	0.04	0	0	0.09	0.04	23
41	0	0	0	0	0	0.05	0.11	0.11	0.05	0.11	0.21	0.21	0.05	0.11	0	0	0	0	0	0	19
42	0	0	0	0	0	0	0	0	0.19	0.38	0.06	0.06	0	0.06	0.06	0	0	0	0	0.19	16
43	0	0	0	0	0	0	0	0.06	0	0	0.19	0	0	0.19	0.13	0.06	0	0	0	0.38	16
44	0	0	0	0	0	0	0	0	0.05	0	0.10	0	0.05	0.05	0.10	0.10	0.05	0.05	0.15	0.30	20
45	0	0	0	0	0	0	0	0	0	0	0.12	0	0	0	0	0.12	0.06	0.06	0.06	0.59	17
46	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.19	0	0.06	0.06	0.13	0.56	16
47	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.09	0.18	0.73	11
48	0	0	0	0	0	0	0	0	0	0	0	0	0.20	0	0	0	0	0	0	0.80	5
49	0	0	0	0	0	0	0	0	0	0	0	0	0.13	0	0	0	0.13	0	0	0.75	8
50	0	0	0	0	0	0	0	0	0	0	0.20	0	0	0	0	0	0	0	0	0.80	5
51	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.00	1
52	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
53	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
54	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
55	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
56	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
57	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
58	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
59	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
60	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
61	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
62	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
63	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
64	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
65	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
66	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
67	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
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
Total																					348

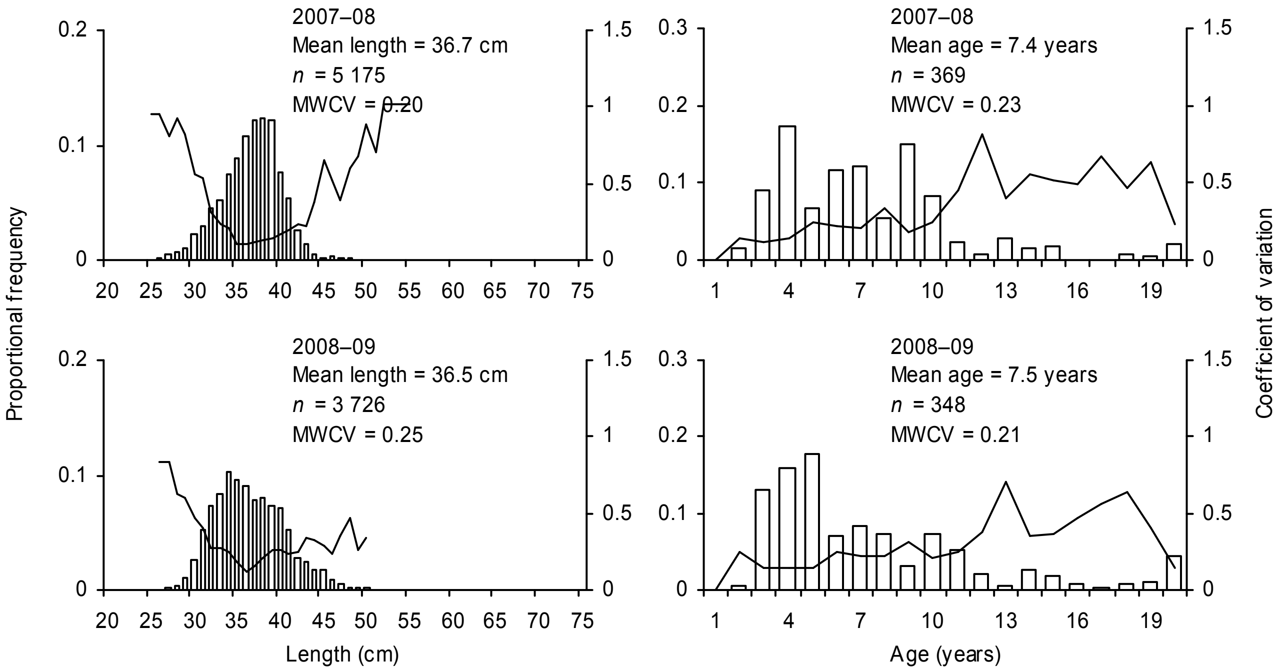
Appendix 6: Length distributions of the target fixed allocation otolith samples (dashed lines) and the achieved otolith collections (histograms) for the subarea strata of the TRE 1 stock in 2008–09.



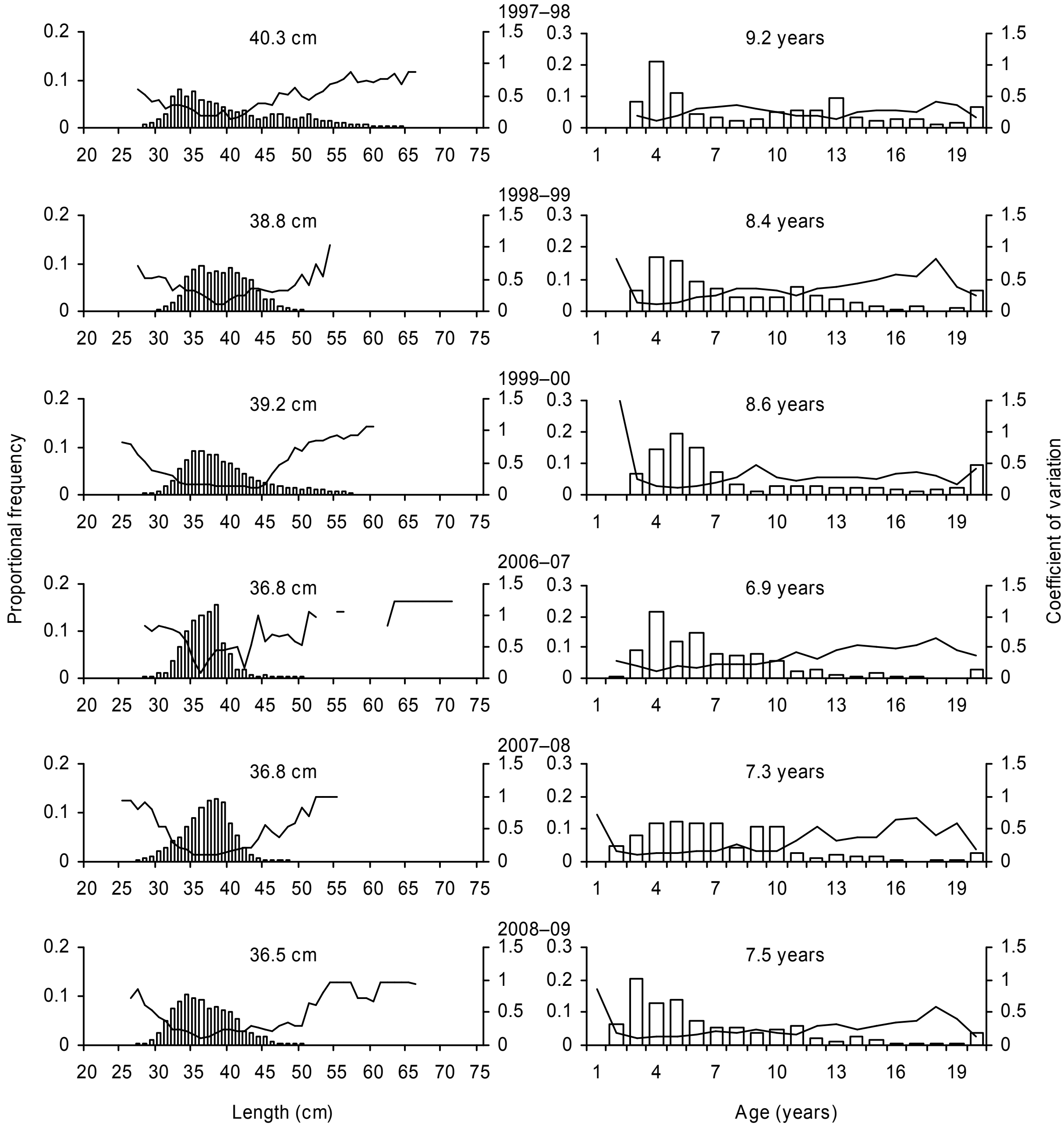
Appendix 7: Time series of proportion at length distributions (histogram) and analytical (solid line) c.v.s determined from trevally landings sampled from the East Northland single trawl fishery in 2006–07, 2007–08, and 2008–09 (n, length sample size; MWCV, mean weighted c.v.).



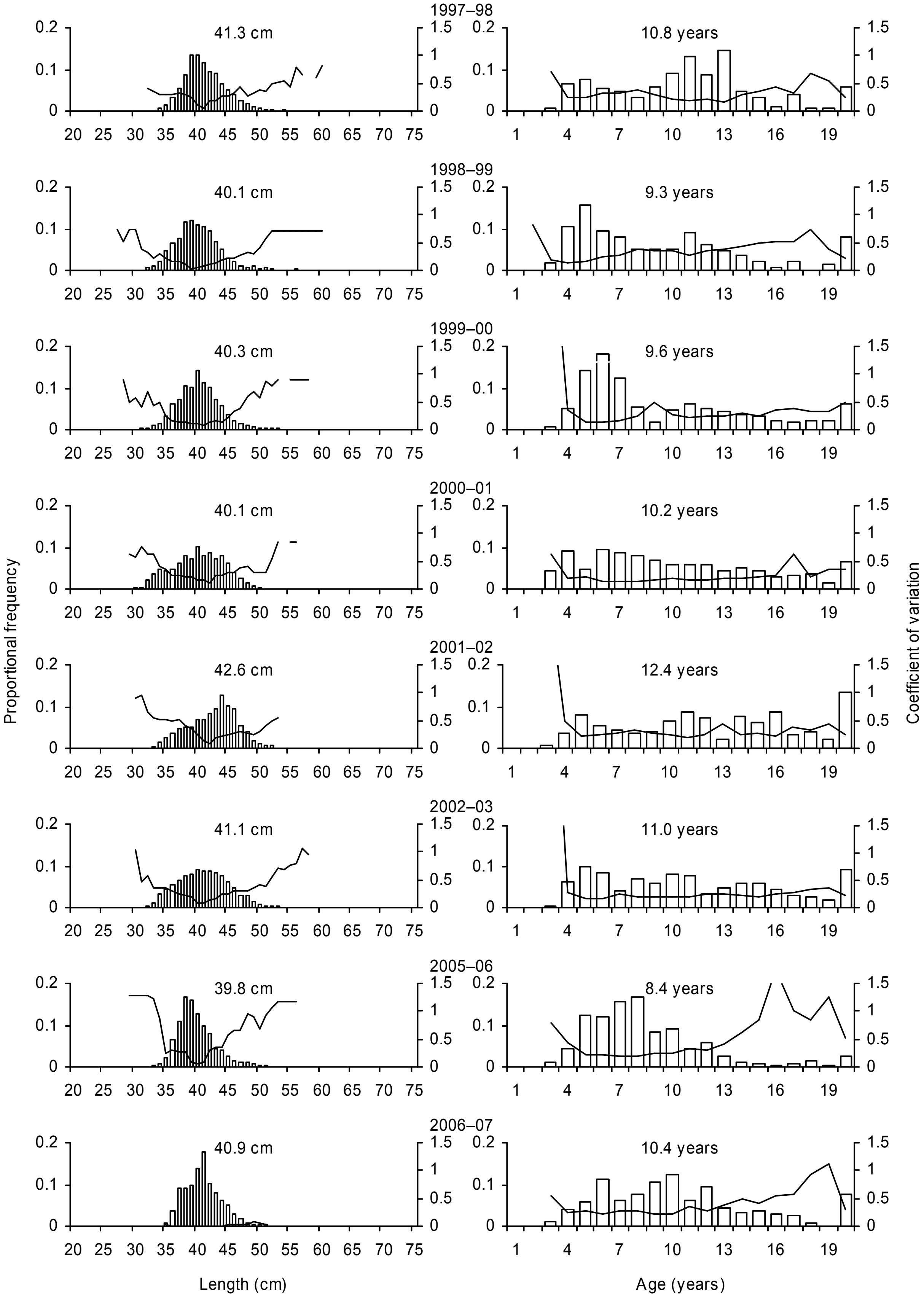
Appendix 8: Time series of proportion at length distributions (histogram) and analytical (solid line) c.v.s determined from trevally landings sampled from the Bay of Plenty single trawl fishery in 2007–08 and 2008–09 (n, length sample size; MWCV, mean weighted c.v.).



Appendix 9: A discontinuous time series of proportion at length and age distributions and c.v.s for trevally from the TRE 1 single trawl fishery from 1997–98 to 2008–09. Average length and age are also given. Note: all figures depict unstratified estimates (see results section).



Appendix 9 – continued: A discontinuous time series of proportion at length and age distributions and c.v.s for trevally from the TRE 1 purse seine fishery from 1997–98 to 2006–07. Average length and age are also given. Note: all figures depict unstratified estimates (see results section).



Appendix 9 – continued: A discontinuous time series of proportion at length and age distributions and c.v.s for trevally from the TRE 1 purse seine fishery from 2007–08 to 2008–09. Average length and age are also given. Note: all figures depict unstratified proportions (see results section).