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Length and age composition of trevally in TRE 1 (2017–18 & 2019–20) and TRE 2 (2019–20)

New Zealand Fisheries Assessment Report 2022/12

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TABLE OF CONTENTS

EXECUTIVE SUMMARY

Parsons, D.M.[1]; Bian, R.; Walsh, C.; McKenzie, J.; Armiger, Taylor, R.; Spong, K.; Buckthought, D.; Ó Maolagáin, C. (2022). Length and age composition of trevally in TRE 1 (2017–18 & 2019–20) and TRE 2 (2019–20).

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This report presents the results of the Ministry for Primary Industries project "TRE 1 catch-at-age" (TRE2017-01). The overall objective was to determine the length and age structure of the commercial catch of trevally in TRE 1 (by land-based sampling), for use in stock assessment models.

While it was initially intended to apply a Random Age Frequency sampling approach in TRE 1 to better accommodate year-round sampling of the main bottom trawl method, the subsequent need to also sample the Modular Harvest System (MHS) fishing method necessitated some adaptation of the sampling design to keep the cost within the budgeted range. This was achieved by incorporating a length frequency and age-length key approach to cover the MHS method in each of the two TRE 1 sub-stocks: East Northland/Hauraki Gulf (ENHG) and Bay of Plenty (BPLE). Sampling took place during two years, 2017–18 and 2019–20. In the second year the TRE 2 bottom trawl fishery was also sampled for the first time.

Overall, 74 landings were sampled, 29 (9 bottom trawl and 20 MHS) in 2017–18 and 45 (31 bottom trawl and 14 MHS) in and 2019–20. A total of 14 460 fish were measured during both years of sampling, with 2913 otolith samples aged (1120 from ENHG, 1200 from BPLE, and 593 from TRE 2) representing the most comprehensive catch sampling description of the TRE 1 (and TRE 2) fishery to date.

The ENHG MHS fishery in 2017–18 was dominated by young (two and three year-old) fish between 30 and 40 cm in length with a high mean weighted coefficient of variation (MWCV) for age (0.34). Alternatively, the MHS fishery from ENHG in 2019–20 had a much higher proportion of 10–20 year-old fish, that were between 40–50 cm in length. The ENHG bottom trawl fishery (only included in this second year of sampling) was characterised by a high proportion of young (three to five year-old) fish and a length composition dominated by fish between 30–40 cm in size. In 2019–20 the MWCVs for age were 0.34 for bottom trawl and 0.32 for MHS. Both the BPLE bottom trawl and MHS fisheries in 2017–18 had length distributions centred on a mean length of about 40 cm. However, the MHS age composition had a relatively high proportion of fish greater than 10 years old compared with bottom trawl. The MWCVs for age in the BPLE were 0.25 for MHS and 0.28 for bottom trawl. The BPLE bottom trawl and MHS fisheries in 2019–20 had very similar length and age compositions, with age dominated by fish less than 10 years in age. The TRE 2 bottom trawl fishery in 2019–20 was dominated by small and young fish (mostly three and four year-olds) with a high MWCV for age of 0.35. Given the differences in length and age composition between the two fishing methods described above, there is potentially some evidence that the bottom trawl fishing method has a higher selectivity for smaller trevally relative to MHS.

Overall, the 2019–20 age compositions of trevally in both the ENHG and BPLE bottom trawl fisheries had the highest proportion of trevally 15 years or older for the entire time series. In the BPLE this continues a trend of consistent broadening of the bottom trawl age composition.

Despite improvements in otolith reading incorporated into the present study the level of precision achieved was only marginally acceptable. Although reductions in sample size to accommodate the sampling of a second fishing method would have undoubtedly been influential, the broadening age distributions would have also contributed to this result. A sampling optimisation assessment using the results from the present study is therefore recommended before the next TRE 1 and TRE 2 sampling programme is initiated.

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1. INTRODUCTION

Trevally (*Pseudocaranx dentex*) occur in coastal waters around the North Island and northern South Island to depths of 200 m, with highest densities occurring around the northern half of the North Island (Francis 2012). Trevally exhibit both semi-pelagic and coastal-demersal behaviour characteristics, which are likely a response to breeding and feeding cycles. As a result, there are distinct seasonal fluctuations in the spatial availability of trevally to commercial fishing.

Trevally is one of New Zealand's most important commercial inshore fish species. TRE 1 is the second largest of the trevally Quota Management Areas (QMAs), constituting ca. 40 % of the national trevally Total Allowable Commercial Catch (TACC) (i.e., 1507 t of 3933 t in the 2019–20 fishing year). TRE 1 encompasses the northeast coast of the North Island (Figure 1). Since 2010–11, the annual TRE 1 catch has generally been caught or has been close to the 1507 t TACC. Trevally catch in TRE 1 was dominated by the bottom trawl and purse seine methods for the last 10 years or more, although from 2015–16, the Modular Harvest System method (MHS) was introduced. Subsequently the proportion of the fishery associated with purse seine decreased as the proportion associated with MHS increased. Most trevally is caught as the target species, but it is also taken as a bycatch when targeting other species, usually snapper (*Chrysophrys auratus*) in the trawl fisheries. The recreational catch of trevally in TRE 1 was assessed in 2018 using the aerial-access and panel survey methods, which estimated the catch to be 125 t and 145 t, respectively (Hartill et al. 2019, Wynne-Jones et al. 2019). Patterns seen in the time series of catch-at-age data from TRE 1 suggest that the Bay of Plenty (BPLE) and East Northland Hauraki Gulf (ENHG) regions of TRE 1 are likely to constitute two biological sub-stocks (McKenzie et al 2016). The most recent stock assessment plenary document (Fisheries New Zealand 2021) does not provide a stock status for TRE 1, but a preliminary assessment for the BPLE was conducted (McKenzie et al. 2016) utilising standardised Catch Per Unit Effort (CPUE) indices, bottom trawl catch-at-age, and catch history. Both TRE 1 sub-stocks are currently being reassessed utilising the catch-at-age data from the present project. Relative abundance, as indicated by the CPUE indices, has increased since the early to mid-1990s for both the BPLE and ENHG sub-stocks.

The TRE 2 fishery is much smaller than the TRE 1 fishery, with a TACC of 241 t in 2019–20. This TACC has generally been fully caught since the early 1990s. The TRE 2 fishery is dominated by a single method, bottom trawl. The most recent stock assessment plenary document (Fisheries New Zealand 2021) does not provide a stock status for TRE 2, and, furthermore, CPUE analysis suggested that factors other than abundance are likely to be influencing CPUE (Schofield et al. 2018). In terms of stock structure, correspondence of fluctuations in CPUE between TRE 2 and the BPLE sub-stock in TRE 1 suggest that TRE 2 is likely part of the TRE 1 sub-stock in the BPLE (Fisheries New Zealand 2021). As such, the Northern Inshore Working Group (NINSWG) suggested that TRE 2 assessments be conducted in conjunction with TRE 1. In response to this, TRE 2 catch sampling was included as an addition for the second year of catch sampling in this present project.

Land-based catch sampling of the TRE 1 commercial landings for length and age composition 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 instigated by the Ministry of Fisheries. Annual sampling from the main fishing methods continued in the TRE 1 fisheries until 2002–03 and the data are summarised in a series of subsequent reports (Walsh et al. 2000, Langley 2001, 2002, 2003, 2004) and in reviews by Langley (unpublished) and Walsh & McKenzie (2009). The programme was reinstated in 2005–06 (Langley 2009) and continued to 2008–09 (Walsh et al. 2010a, 2010b, 2012a), with sampling conducted on the TRE 1 purse seine fishery with additional collections being directed to the TRE 1 bottom trawl fisheries. The last time the TRE 1 fishery was sampled was in 2012–13 (Walsh et al. 2014a). Catch sampling of TRE 2 commercial landings has not previously been conducted.

The existing catch-at-age monitoring strategy for TRE 1 is to conduct sampling at a frequency of two consecutive years in every five. In 2015 the NINSWG recommended dropping purse seine catch-at-age sampling due to high inter-annual age variability in the time series (Marc Griffiths, Fisheries New Zealand, pers. comm.). The present report presents the results of catch sampling from the TRE 1 stock for the bottom trawl and Modular Harvest System fishing methods in the 2017–18 and 2019–20 fishing years. In addition, for the first time, catch sampling results for the TRE 2 stock are presented, specifically for the bottom trawl fishery in the 2019–20 fishing year. This report fulfils the final reporting requirements of Fisheries New Zealand project TRE201701.

1.1 Overall Objective

To determine the length and age structure of the commercial catch of trevally in TRE 1.

1.2 Specific Research Objectives

1. To characterise the TRE 1 fishery by analysing existing commercial catch and effort data to the end of 2015/16 fishing year.
2. To conduct representative sampling to determine the length, sex and age composition of the commercial catch of trevally (*Pseudocaranx dentex*) in TRE 1 during the 2017/18 fishing year. The target coefficient of variation (CV) for the catch-at-age is 30 % (mean weighted CV across all age classes) combined across sexes.
3. To conduct representative sampling to determine the length, sex and age composition of the commercial catch of trevally (*Pseudocaranx dentex*) in TRE 1 during the 2019/20 fishing year. The target coefficient of variation (CV) for the catch-at-age is 30 % (mean weighted CV across all age classes) combined across sexes.
4. To explore the times series of catch sampling data for any significant changes in the length and age composition of commercial catches.
5. To characterise the TRE 2 fishery by analysing commercial catch and effort data to the end of the 2017/18 fishing year
6. To conduct representative sampling to determine the length, sex and age composition of the commercial catch of trevally (*Pseudocaranx dentex*) in TRE 2 during the 2019/20 fishing year. The target coefficient of variation (CV) for the catch-at-age is 30 % (mean weighted CV across all age classes) combined across sexes.

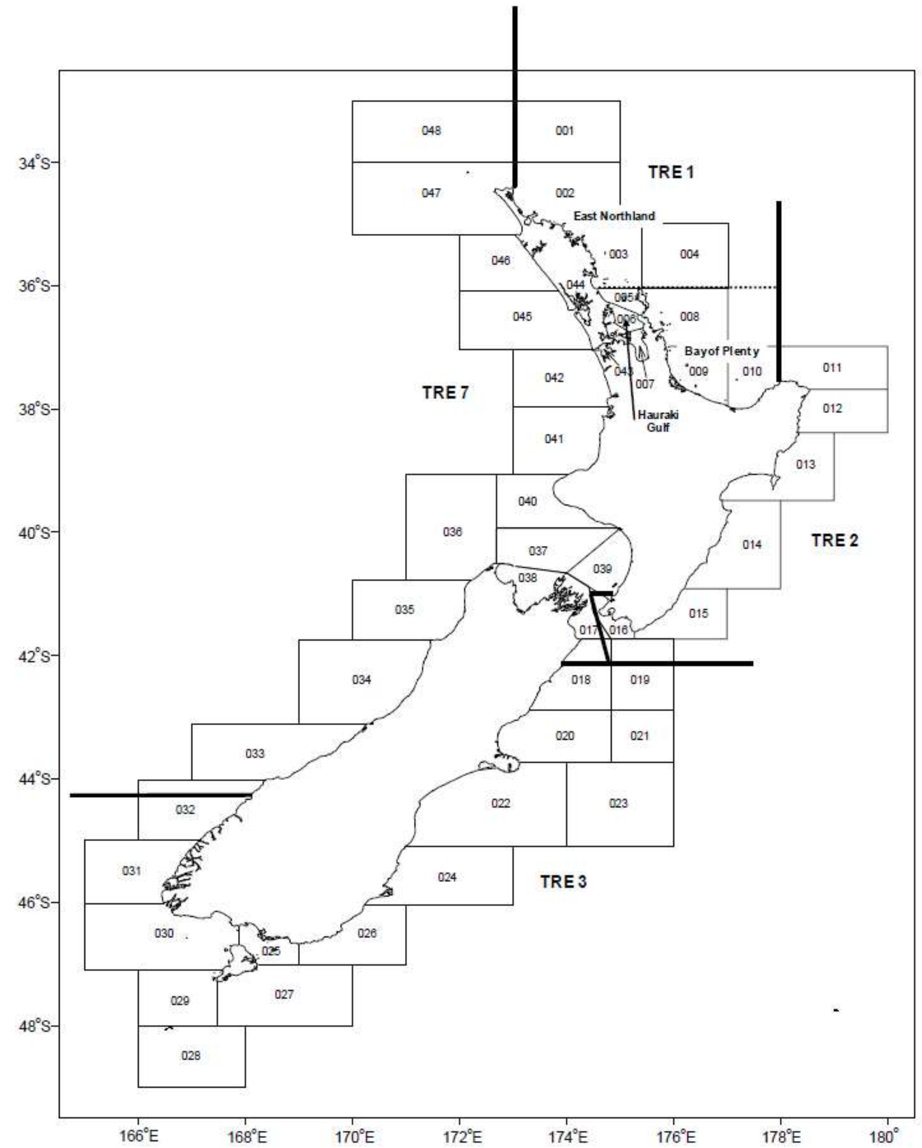

Figure 1: Trevally quota management areas, statistical areas, and locations referred to in the text. Dashed lines represent the boundaries separating the sub-stocks that make up the TRE 1 stock.

2. METHODS

2.1 Fishery characterisation and sampling design

Two fishery characterisations are generally conducted as part of catch-at-age projects. The first is conducted prior to the commencement of sampling and describes fishery patterns (e.g., TRE catch by fishing year, fishing method, statistical area, month, and target species), as well as assessing the proposed sampling design by considering an appropriate minimum landing weight for samples, and the availability of landings by sampling location (Licenced Fish Receiver (LFR)). The second characterisation is conducted after sampling has been completed. It provides the most up to date description of fishery patterns and also provides an opportunity to compare the patterns of the entire fishery with that of the samples collected (i.e., a description of sampling representativeness in terms of the number and weight of landings spatially, throughout the depth range of the fishery, and across the months of the sampling programme).

To achieve these characterisations, commercial catch and effort data were extracted from the Fisheries New Zealand catch effort database (October 2011 to September 2016 for the sampling design characterisation and October 2012 to September 2019 for the final characterisation). These extracts included all reported effort data and associated catch weights (for all species including trevally) from all trips landing trevally from TRE 1 and 2. Estimates of trevally catch per fishing event were linked to their associated effort variables by fishing event (such as fishing location, fishing method, target species, tow speed). Individual fishing events were then linked to landed catch weights for each trip, to prorate the landed weight for each species across events, given event-based catch weight estimates. The link between the event-based estimated effort and trip-based landed catch weight tables was a common trip number field (trip_key). Thus, the catch weight from individual fishing events could be assigned across sub-stocks and stocks. This data set was then used to produce plots of trevally catch by fishing method, month, target species, and statistical area.

2.2 Sampling the TRE 1 and TRE 2 fisheries

The two spatial strata considered for sampling in the first year of sampling (2017–18) were the ENHG and BPLE sub-stocks (Figure 1), which is in line with the most recent TRE 1 catch sampling project (Walsh et al. 2014a) and the understanding of biological stocks as described by McKenzie et al. (2016). In the second year of sampling (2019–20) TRE 2 (Figure 1) was added as a third spatial stratum. In terms of the method of sampling employed, a length frequency and age-length key (LF + ALK) approach has been employed in TRE 1 since 1997–98. However, the NINSWG suggested that a Random Age Frequency (RAF) approach be adopted in TRE 1 for future catch-at-age projects (Walsh et al. 2014a). It was our intention that such an RAF approach would be used for all sampling in the present project; however, due to the emergence of an additional fishing method after the sampling design had already been set, both RAF and LF + ALK approaches were eventually employed. This allowed for multiple area-method strata to be sampled without increasing the total number of samples collected. The specific strata that each of these sampling approaches were applied to are detailed in section 3.1. No formal seasonal strata were included in the sampling design, but sampled landings were intentionally spread across the year to match patterns in the fishery for the specific area-method stratum being sampled.

The RAF approach to sampling requires randomly selecting a small number of fish (typically 30–60) from a sampled landing for subsequent ageing using otoliths (Davies et al. 2003). The total number of otoliths collected from a fishery using the RAF approach is usually higher than that required under the LF + ALK approach for the same target precision (Davies et al. 2003). RAF sampling optimisations for TRE 1 and 7 (Walsh & McKenzie 2009) suggested that an RAF collection based on 15 landings and 600 otoliths per stratum would achieve a coefficient of variation (CV) of 0.3 or lower. RAF is primarily used when samples are to be collected over a protracted period of time (e.g., one year) such that fish growth during the sampling period is likely to introduce bias (Davies et al. 2003). Here, the LF + ALK approach was used for samples collected over a year, which may have introduced a negligible bias. As stated above, this did, however, allow us to accommodate additional fishing methods into the sampling design.

When implementing an RAF approach, the main challenge with collecting a small number of fish (about 60) from a trawl landing of several thousand fish (i.e., 1–6 tonnes) is in ensuring that the fish sample is 'random', i.e., representative of the age composition of the landing. The sampling process relied on the fact that most New Zealand trawl trevally catches are packed into standard 35 kg fish bins at some stage during the catch unloading process. Samplers were instructed to collect a quasi-random sample of 12 × 35 kg bins of trevally from throughout the total unloaded catch. To achieve a random sample of 60 fish from the selected bins a specially designed random selection form was used. This form identified a unique sequence of random draws from 300 fish sequentially withdrawn from the bins so the sampler could not anticipate which fish were to be selected for otolith removal. Two people were required to undertake the random sampling process: one to draw the fish sequentially from the 12 bins, and the other to track the form and alert the sampler when a fish was to be retained (i.e., the sampler did not know immediately prior to selecting the fish if it was to be retained). Each of the 60 fish selected were measured to the nearest centimetre below the fork length. Both sagittal otoliths were removed, cleaned and dried, and placed into an Eppendorf tube within an individual envelope. In 2017–18 all 300 fish in each RAF sample were measured as well, but in 2019–20 only the 60 fish that had otoliths removed were measured. Landings that were sampled using the LF + ALK approach followed an identical procedure, except all 300 fish were measured (and 60 random otoliths were collected from those 300 fish). Although the recording of sex was part of the specific objectives for this project it was not recorded and is not reported on here. Sex has not been recorded for previous trevally catch-at-age programmes because there is no evidence of growth differences between the sexes (James 1984).

In 2017–18, sampling was coordinated by Trident Systems Ltd (hereafter referred to as Trident). Trident identified the landings to sample and trained the fish factory staff who conducted the sampling. NIWA was responsible for quality assurance, which consisted of mentoring visits to oversee fish selection and otolith removal. The number of mentoring visits each sampler received was based on their level of catch sampling experience. In 2019–20 NIWA staff or sub-contractors identified landings to sample and conducted all sampling. Training and quality assurance visits were conducted by NIWA, generally by the head sampler who has more than 30 years catch sampling experience. The number of mentoring visits a sampler received was again based on their level of catch sampling experience. Because RAF sampling conducted in 2019–20 only measured the 60 fish selected for otolith removal, a comparison of the length frequency of these 60 fish, relative to the length frequency of the 300 fish they were selected from, was conducted at least once for each sampler. A Kernel Density Estimation (KDE) non-parametric test (Anderson & Titterington 1994) was used to compare the shape and location of these two length frequency distributions. If the fish selection conducted by a sampler failed this test, they received guidance about the fish selection process and repeated the test until it was passed.

2.3 Otolith selection and aging

RAF sampling conducted as described above intentionally collected more otoliths than the target 600 to be aged, i.e., 60 otoliths from each of 15 landings within a stratum would result in about 900 otoliths being collected. Where two fishing methods were sampled within an area, an LF + ALK sampling approach was used to describe the age composition of the second method. The reason being to minimise the number of age samples that needed to be aged overall because the primary method RAF sample otoliths could be used to build the ALK to apply to the second method length sample. Some additional otoliths still needed to be collected and aged from the second-method sampled landings, to describe less frequent size categories (i.e., smaller and larger fish).

All trevally 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 documented in an age determination protocol for trevally (Walsh et al. 2014b). In a review of trevally catch sampling, Walsh & McKenzie (2009) determined that inconsistencies observed in the relative year class strengths of trevally catch-at-age data from collections prior to 2006–07 were most likely 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 more rigorous approach to ageing trevally was adopted in 2006–07 to improve reader accuracy and increase the level of between-reader agreements (now documented in a trevally age determination protocol by Walsh et al. (2014b)), and this approach was followed for the present report.

In summary, this approach focused on a few main aspects: 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. The forced margin method was implemented to anticipate the otolith margin type (wide, line, narrow) *a priori* in the month in which the fish was sampled to provide guidance in determining age; this was found to be essential for ageing trevally sampled throughout the fishing year (October to September). To determine the 'fishing year age class' of fish using the forced margin, 'wide' readings are increased by 1 year (e.g., 3W is aged as a 4 year old) and 'line' and 'narrow' readings remain the same as the zone count (e.g., 4L or 4N are aged as a 4 year old), meaning that regardless of whether the fish was caught before or after the nominal birth date of 1 January, age remains the same throughout, unlike that which would be used for age groups/age classes or in growth rate estimation (see Walsh et al. 2014b). As a result, there has been considerable improvement in reader accuracy and precision in recent years (Walsh et al. 2010a, 2010b, 2012a, 2012b, 2014a, 2014c).

As part of the development of the age determination protocol for trevally, a reference collection of otoliths numbering approximately 500 preparations was compiled and documented from previously prepared archived samples (Walsh et al. 2014a). Reference collections are used to ensure consistent ageing between readers and across time. To assess reader competency before ageing of sampled trevally otoliths took place, each of the two selected readers aged a subsample of 50 reference otolith preparations with an aim of achieving a pass mark score for Index of Average Percentage Error, IAPE (Beamish & Fournier 1981), and a mean CV (Chang 1982) of 2.50% and 3.54%, respectively (see Walsh et al. 2014b). Once reader competency was established, both readers read the entire TRE 1 or TRE 2 otolith collection from 2017–18 or 2019–20 independently to determine an unbiased reading estimate. Counts that agreed were accepted as the final reading. If counts disagreed, then the otolith was reviewed again by both readers with an experienced third reader present to reach agreement, or discarded if deemed to be unreadable; but only if it was of an age less than 30 years, because samples over 29 years were combined into an aggregate age group for the analysis. It was envisaged that discarding a few unreadable otoliths should have minimal effect on the sample collections and was likely to improve the precision in estimates of catch-at-age. 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, with IAPE and CV calculated for each test.

2.4 Catch-at-age analysis

Scaled numbers-at-age were derived for each area by fishing method using the NIWA program Catch-at-length-and-age (CALA, Francis & Bian 2011). Age data were scaled by landed weights of trevally from the sampled vessels, and by the annual commercial catch from the sampled area. The mean-weighted coefficients of variation (MWCV) were estimated using a bootstrapping routine (500 bootstraps). For fishing methods sampled by the LF + ALK approach, estimates of proportion-at-length and -age are combined to calculate weighted mean estimates. CALA scales up the numbers of fish in the samples to numbers of fish in landings and finally the numbers of fish in each area, based on the weights of both samples and landings. Bootstrap variances were determined for area proportion-at-length and proportion-at-age.

Proportions-at-age were calculated for the range of fishing year age classes (herein referred to as ‘age classes’). The maximum age was a plus group, being an aggregate of all age classes over 29 years, which were assigned an age of 30.

Trevally length and age data are stored on the Fisheries New Zealand *market* and *age* databases respectively, administered by NIWA.

3. RESULTS

3.1 Fishery characterisation

The pattern of trevally catch in the TRE 1 QMA was similar between sub-stocks (i.e., ENHG vs. BPLE), although BPLE trevally catch was greater (Figure 2). Purse seine has been the dominant method in both areas since 2012–13, although a more prominent decline in purse seine landings in BPLE has been observed since 2016–17. Bottom trawl has generally landed the second largest amount of trevally in TRE 1; however, since the MHS method was introduced in 2015–16 it has caught comparable amounts to bottom trawl in some years. TRE 2 catches are smaller than in TRE 1 and are dominated by bottom trawl.

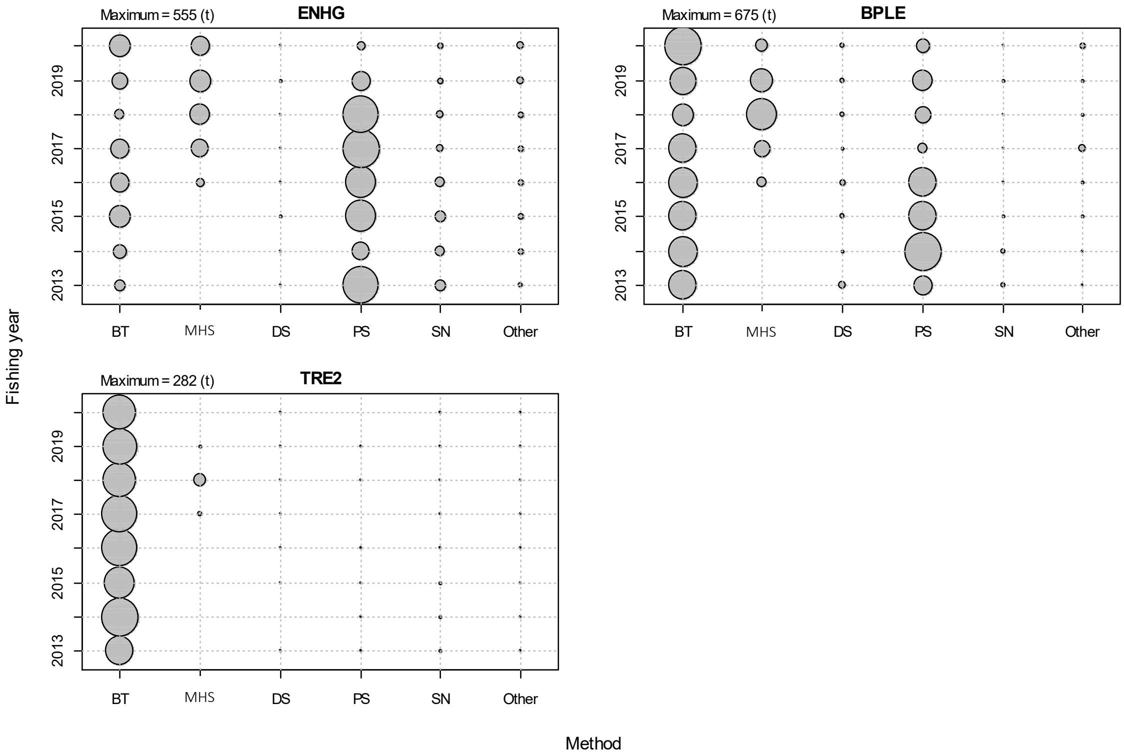

Figure 2: Relative annual trevally catch (t) by method for TRE 1 (by sub-stock) and TRE 2 from 2012–13 to 2020–21 (BT, bottom trawl; PS, purse seine; SN, set net; MHS, modular harvest system). Scales differ between sub-stocks.

The bottom trawl catch of trevally is predominantly taken in Statistical Areas 008–010 (BPLE), although reasonable amounts are also taken in Statistical Areas 012–014 (TRE 2) as well as Statistical Area 002 and to some extent Statistical Area 005 (both ENHG) (Figure 3). MHS first appeared as a fishing method in 2015–16, with the catch of trevally predominantly taken in Statistical Areas 008–010 (BPLE) and Statistical Area 002 (ENHG) (Figure 4).

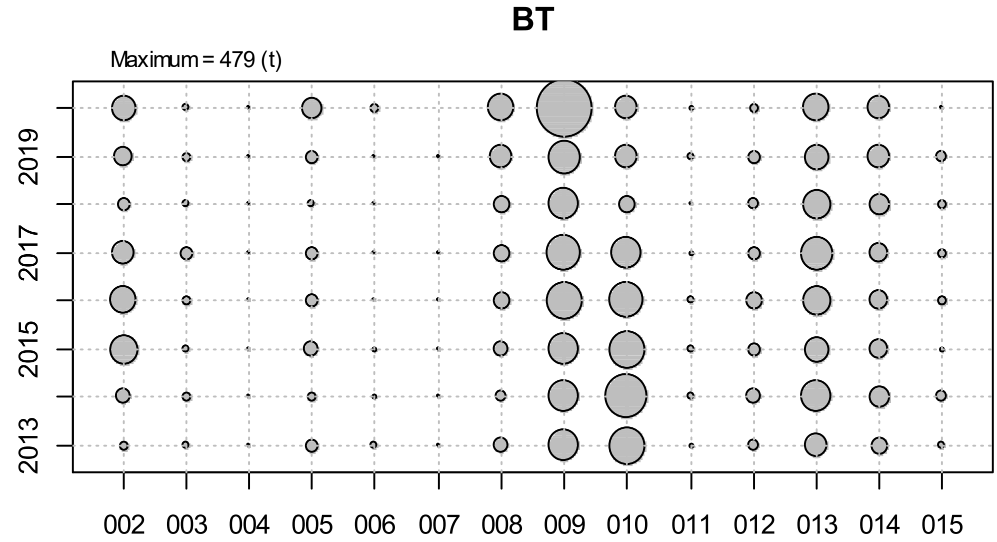

Figure 3: Relative annual bottom trawl trevally catch (t) by statistical reporting area within the TRE 1 and TRE 2 QMAs, from 2012–13 to 2020–21.

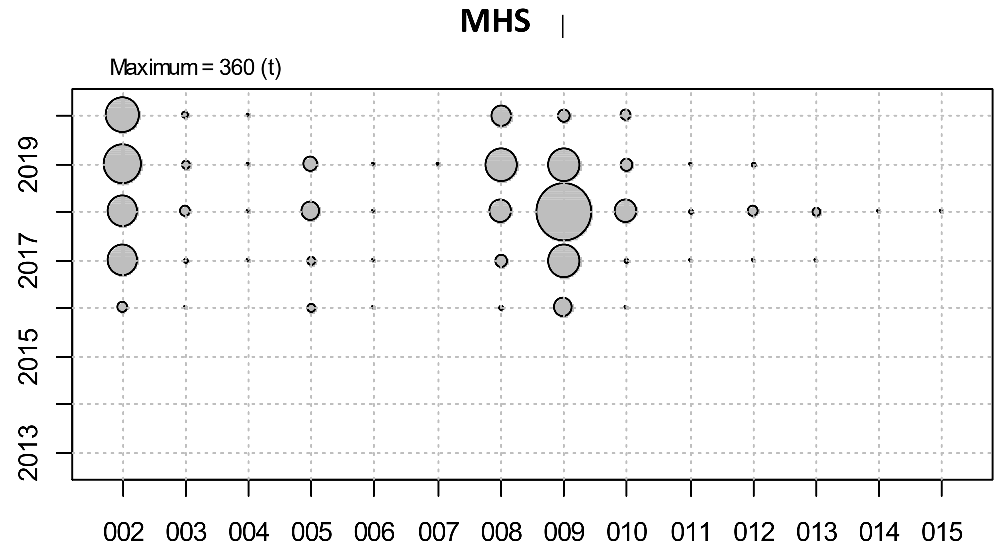

Figure 4: Relative annual modular harvest system trevally catch (t) by statistical reporting area within the TRE 1 and TRE 2 QMAs, from 2012–13 to 2020–21.

In ENHG and BPLE the bottom trawl catch of trevally during the early part of the characterisation period was predominantly during summer and early autumn, although this pattern was less consistent in ENHG (Figure 5). In the most recent year (2019–20), however, bottom trawl catch has become more year-round. Bottom trawl catch of trevally in TRE 2 is more evenly spread throughout the year, with a slight peak in summer and a reduction of catch in winter. Trevally catch by MHS has no consistent temporal pattern in ENHG, BPLE, or TRE 2 (Figure 6).

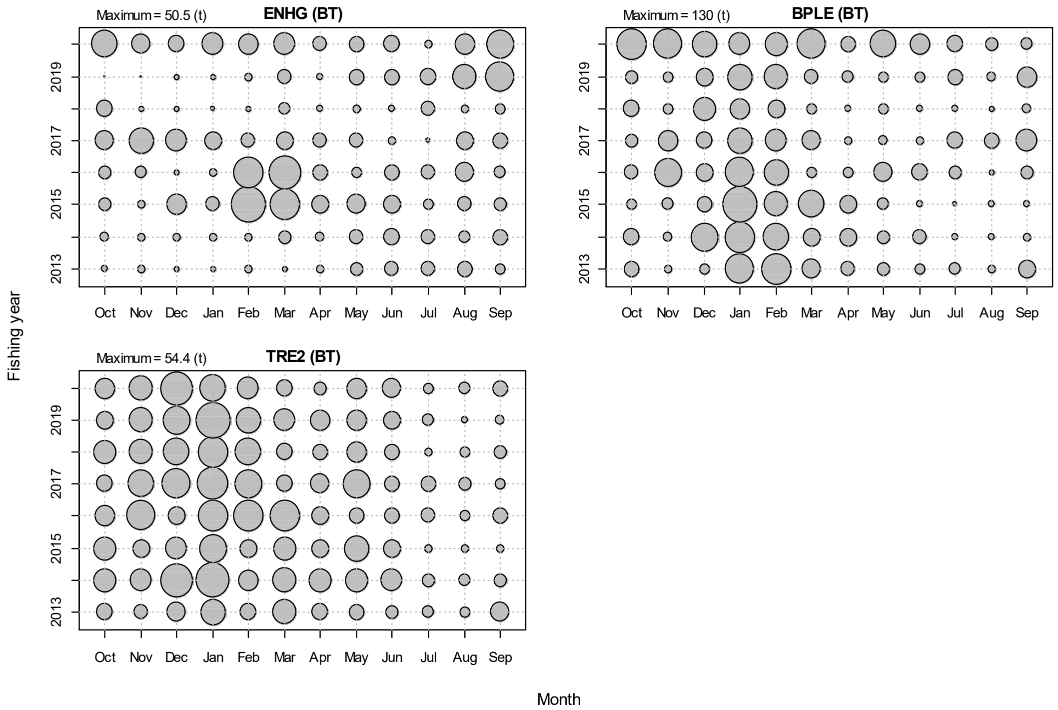

Figure 5: Relative annual bottom trawl trevally catch (t) by month for TRE 1 (by sub-stock) and TRE 2 from 2012–13 to 2020–21. Scales differ between areas.

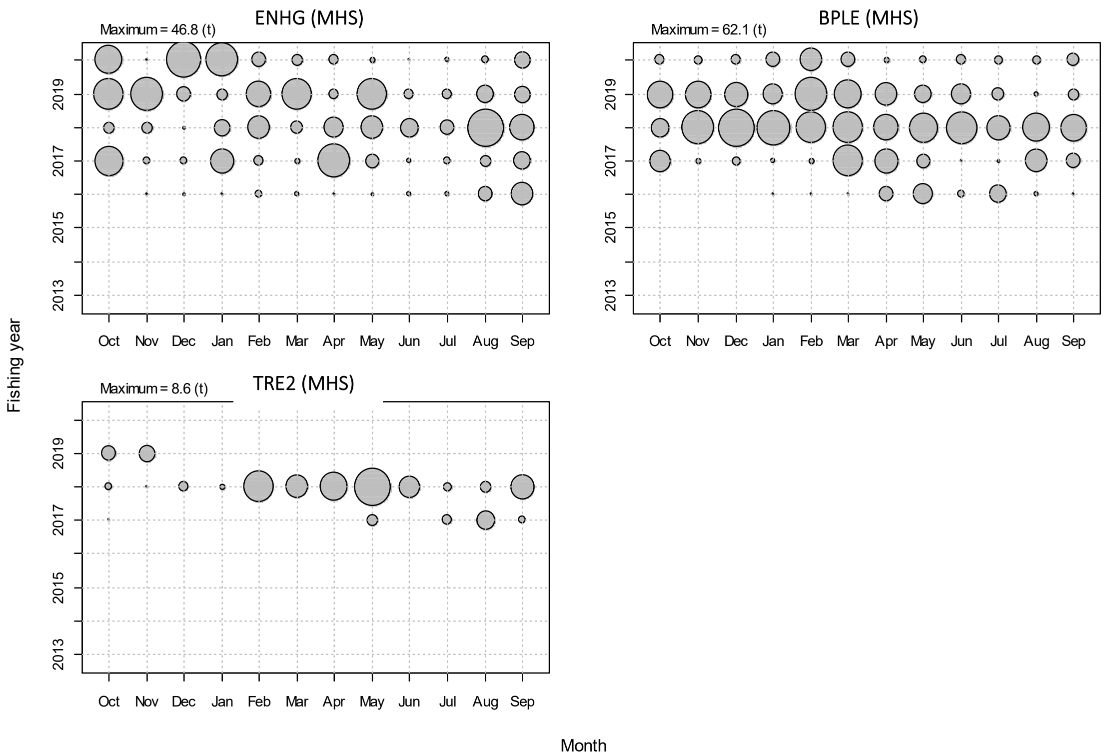

Figure 6: Relative annual modular harvest system trevally catch (t) by month for TRE 1 (by sub-stock) and TRE 2 from 2012–13 to 2020–21. Scales differ between areas.

The predominant target of bottom trawl trevally catch in ENHG and BPLE was trevally, with snapper as a secondary target (Figure 7). In TRE 2 the predominant target of bottom trawl trevally catch was red gurnard (*Chelidonichthys kumu)*, followed by tarakihi (*Nemadactylus macropterus*). Snapper and trevally targets made up a small proportion of the bottom trawl catch of trevally in TRE 2. The predominant target of the MHS catch of trevally in ENHG and BPLE was trevally and to a lesser extent snapper (Figure 8). In TRE 2 the predominant target of the MHS catch of trevally was tarakihi, with red gurnard and snapper as secondary targets.

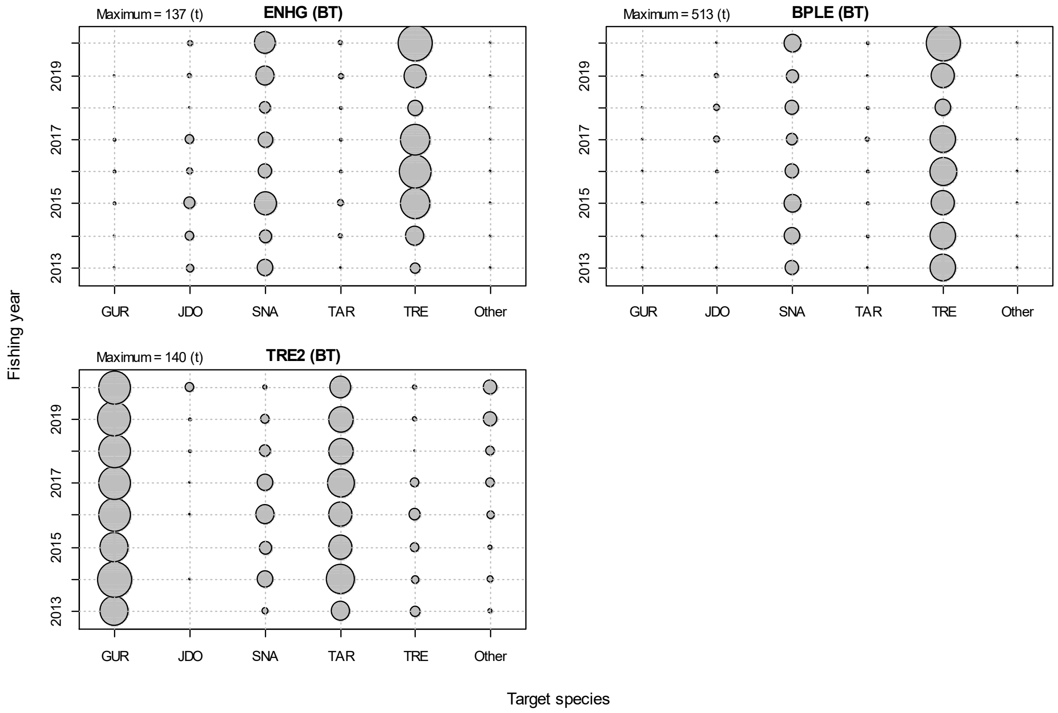

Figure 7: Relative annual bottom trawl trevally catch (t) by target species for TRE 1 (by sub-stock) and TRE 2 from 2012–13 to 2020–21 (TRE, trevally; SNA, snapper; JDO, John dory (*Zeus faber*); TAR, tarakihi; GUR, red gurnard). Scales differ between areas.

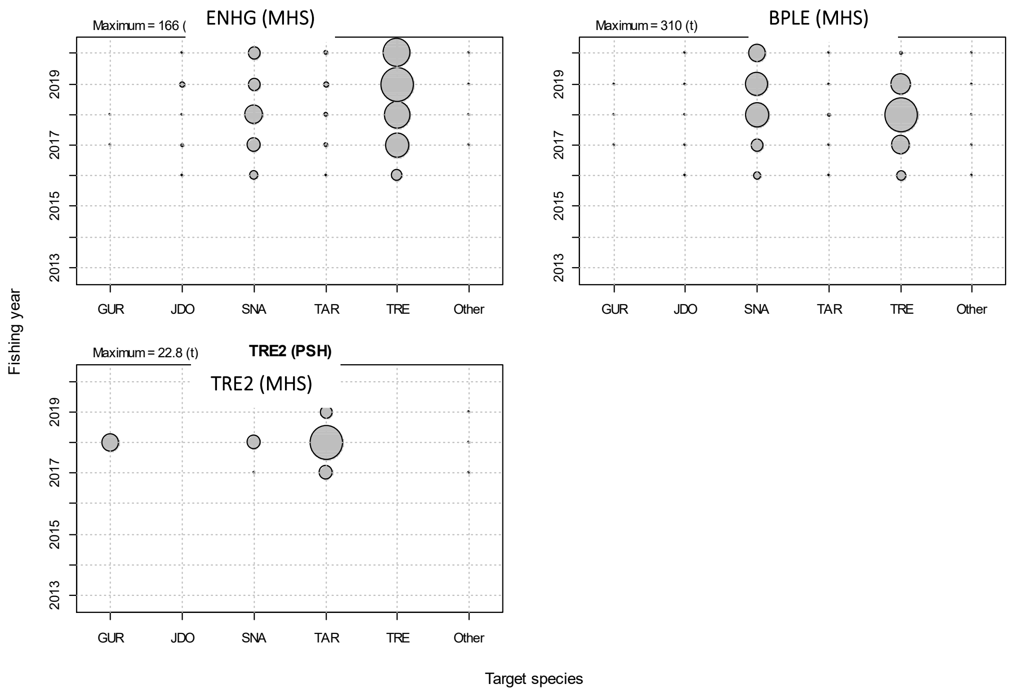

Figure 8: Relative annual modular harvest system trevally catch (t) by target species for TRE 1 (by sub-stock) and TRE 2 from 2012–13 to 2020–21 (TRE, trevally; SNA, snapper; JDO, John dory; TAR, tarakihi; GUR, red gurnard). Scales differ between area.

3.2 Sample collections

The initial sampling design for the 2017–18 fishing year allowed for 15 landings to be sampled in each of the ENHG and BPLE sub-stocks (TRE 2 sampling was added to the project as a variation after the first year of sampling and is discussed below). The intention was for each of these 30 total landings to sample the bottom trawl fishing method. This was because, at the time of the sampling design characterisation (i.e., up to and including the 2015–16 fishing year), TRE 1 landings were dominated by bottom trawl and purse seine (with sampling of the latter not recommended by the NINSWG) (Figure 2). However, as sampling began in the 2017–18 fishing year, it quickly became apparent that MHS had appeared as an important fishing method, which would need to be considered in the sampling design. As a result, for sampling in 2017–18, all 15 ENHG samples were transferred to the MHS method (with a minimum landing weight of 400 kg), while in the BPLE a mixture of bottom trawl and MHS was sampled (both with minimum landing weights of 1000 kg). Because bottom trawl was expected to be the dominant method in the BPLE it was decided that 10 of the available 15 landings would be targeted to bottom trawl and analysed as a RAF, and the remaining five landings would be targeted to MHS and analysed as a LF + ALK (see section 2.2 above).

Mentoring visits for quality assurance purposes were conducted for 10 of the 29 sampled landings in the 2017–18 sampling year. Sampling was generally of a high standard with the size distribution of the 60 fish with otoliths removed generally matching the overall size distribution of the 300 fish measured. Although two of these mentoring sessions identified some non-conformities in sample selection process (mostly relating to missing or broken otoliths), these issues were adequately addressed and are unlikely to be a significant source of variability or bias.

The second year of sampling was originally intended to be conducted in 2018–19 but was postponed by Fisheries New Zealand until 2019–20. To accommodate this postponement, the TRE 1 fishery was re-characterised to include the 2017–18 fishing year. A substantial number of ENHG bottom trawl landings were found to have taken place in 2017–18, so the 2019–20 sampling design was modified to include bottom trawl. As such, in 2019–20, MHS was determined to be the dominant method in ENHG with 10 landings targeted (RAF approach), and five bottom trawl (LF + ALK approach) landings were also targeted for sampling (both ENHG fishing methods had a minimum landing weight of 400 kg). Sampling in the BPLE in 2019–20 was conducted as it was in 2017–18 (10 bottom trawl and five MHS landings targeted with minimum landing weights of 1000 kg for each method). In 2019–20 TRE 2 was also included as an additional sampling stratum. TRE 2 catches are dominated by bottom trawl (Figure 2), and, as such, 15 bottom trawl landings were targeted (RAF approach and with a minimum landing weight of 400 kg). Table 1 outlines the number of landings targeted and the number of landings sampled.

More than 40 training or mentoring visits or length frequency checks for quality assurance were conducted for the 13 samplers that conducted trevally sampling in the in 2019–20 sampling year. Sampling was generally of a high standard. All samplers passed length frequency checks to determine that the size distribution of the 60 fish with otoliths removed matched that of the 300 fish measured.

Table 1: Sampling achieved for TRE 1 and TRE 2 and the percentage of the total fishery for that stratum (% weight and % number of landings) represented by sampling. BT = bottom trawl, MHS = Modular Harvest System, RAF = Random Age Frequency, LF + ALK = Length Frequency + Age-Length Key, BPLE = Bay of Plenty sub-stock, ENHG = East Northland Hauraki Gulf sub-stock.

			No. of landings				No. of	Weight of landings (t)		
Fishing method	Area	Sampling approach	Total landings	Sampling target	Landings sampled	% of total	fish measured	Total	Sampled	% of total
Sampling in 2017–18										
BT	BPLE	RAF	156	10	9	5.77	2 792	234	41	17.34
MHS	BPLE	LF + ALK	121	5	6	4.96	1 835	449	27	6.12
BT	ENHG	None	106	0	0	0.00	0	46	0	0.00
MHS	ENHG	RAF	153	15	14	9.15	4 421	167	29	17.56
Sampling in 2019–20										
BT	BPLE	RAF	285	10	10	3.51	602	670	47	7.06
MHS	BPLE	LF + ALK	56	5	5	8.93	1 543	85	24	28.50
BT	ENHG	LF + ALK	181	5	6	3.31	1 827	197	10	5.25
MHS	ENHG	RAF	80	10	9	11.25	540	143	71	49.74
BT	TRE 2	RAF	717	15	15	2.09	900	221	19	8.60

3.3 Sample representativeness

Sampling in 2017–18

The temporal coverage of sampling was well aligned with the temporal spread of landings and the weight of trevally catch overall for the ENHG MHS fishery, except for August and September, when sampling was under-represented (Figure 9). For the MHS method in the BPLE, the number and weight of landings for the fishery overall was reasonably evenly spread throughout the year, except for low catches and numbers of landings in October and September. The temporal spread of the BPLE MHS sampled landings was satisfactory, although because only six landings were sampled, sampling was patchy compared with that of the fishery (Figure 9). The BPLE bottom trawl fishery was highly seasonal with most of the catches occurring in summer, which is when all the sampling occurred (Figure 9).

For bottom trawl in the BPLE, most of the landings and the catch by weight occurred in summer for the fishery overall. This is also when all the samples for bottom trawl in the BPLE were obtained during 2017–18.

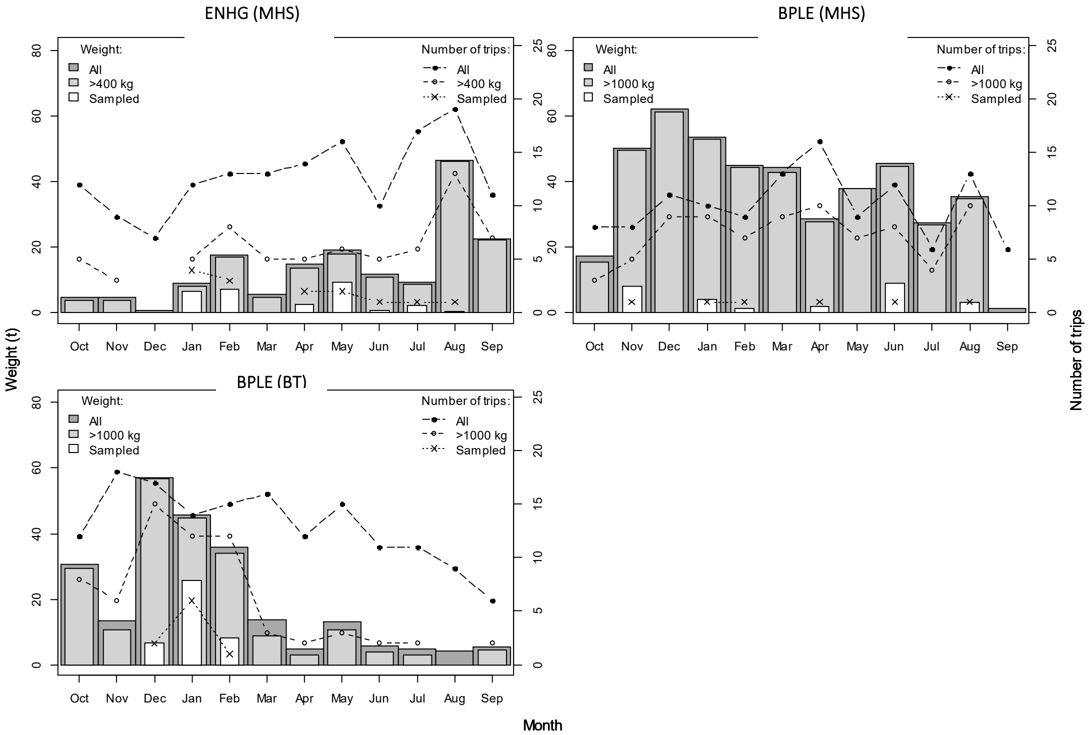

Figure 9: Comparison of the monthly distributions of landed weight and number of landings of trevally in the TRE 1 sub-stocks by fishing method for all landings where trevally was caught in 2017–18. Also provided are monthly weight and number of landings to qualifying trips, and the weight and number of landings sampled. Note: bars and lines are overlaid.

The sampling performance relative to the cumulative proportion of the total number and catch weight of bottom trawl landings throughout the sampling period was reasonably good for all methods, although the BPLE bottom trawl fishery was under sampled in October and November, and over-sampled in summer (Figures 10 and 11).

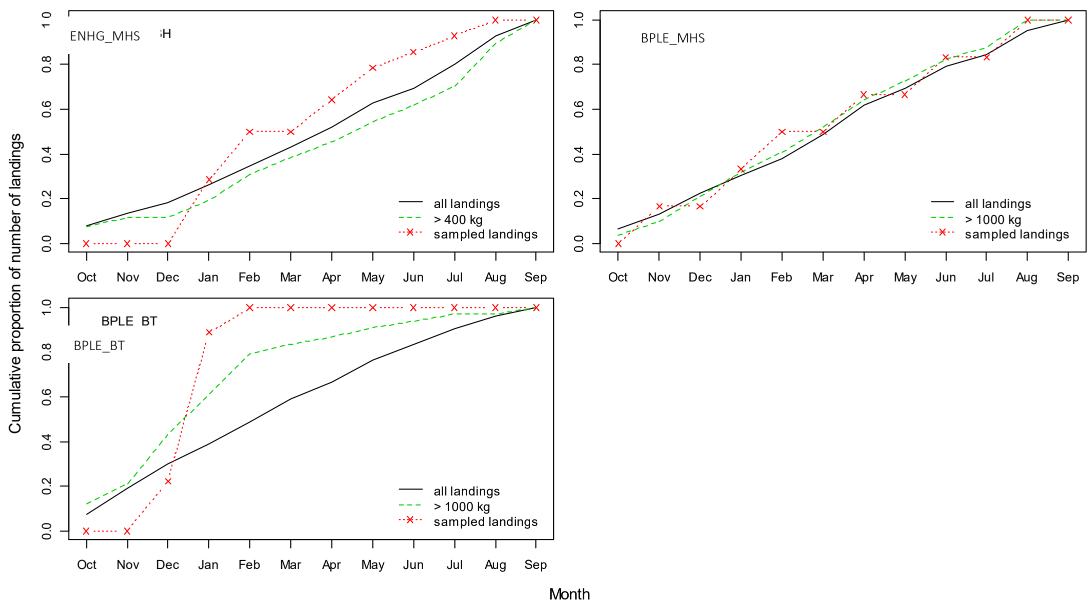

Figure 10: Comparison of the cumulative proportion of the number of landings with samples taken from TRE 1 by sub-stock and fishing method in 2017–18. Sub-stocks: ENHG, East Northland/Hauraki Gulf; BPLE, Bay of Plenty. Fishing methods: BT, bottom trawl; MHS, modular harvest system.

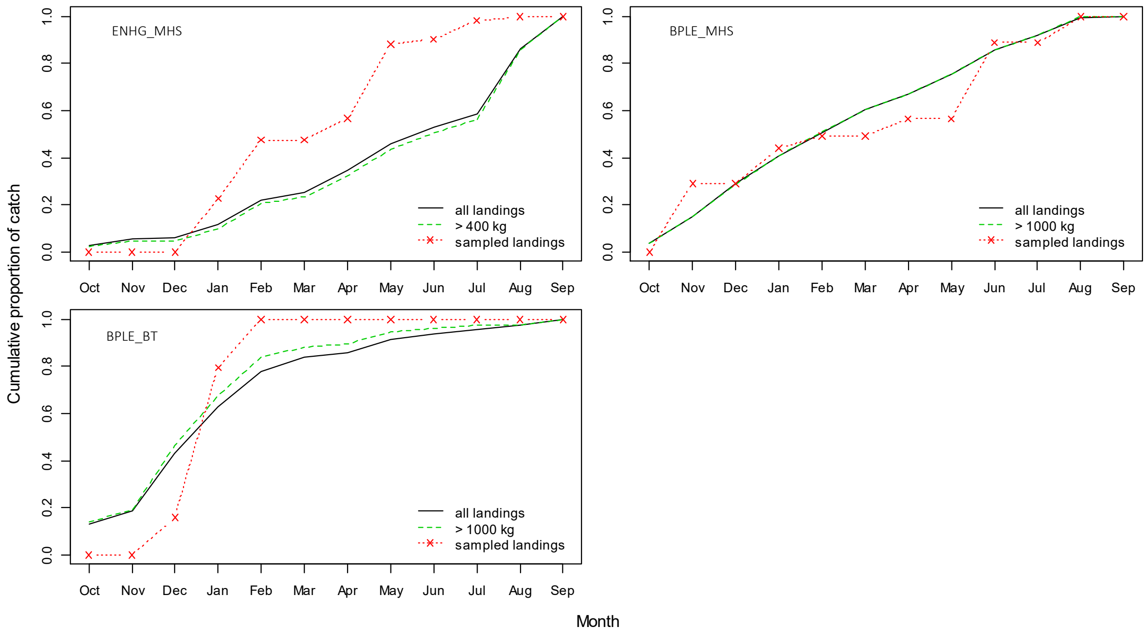

Figure 11: Comparison of the cumulative proportion of the catch weight of landings with samples taken from TRE 1 by sub-stock fishing and method in 2017–18. Sub-stocks: ENHG, East Northland/Hauraki Gulf; BPLE, Bay of Plenty. Fishing methods: BT, bottom trawl; MHS, modular harvest system.

MHS catch of trevally in 2017–18 was widely distributed throughout TRE 1, with the highest catches off Pārengarenga Harbour and Rangaunu Harbour in east Northland, in the northwestern Hauraki Gulf within Statistical Area 005, along the eastern Coromandel Peninsula, and off Ōhiwa Harbour in the BPLE. Sampled MHS landings largely caught trevally from these same areas (Figure 12). Bottom trawl catch of trevally was also distributed throughout TRE 1, with the highest catches throughout the BPLE and lower catches off the northern tip of the Coromandel Peninsula, in the northwestern Hauraki Gulf, and off Pārengarenga Harbour and Rangaunu Harbour in east Northland. Sampled bottom trawl landings caught trevally from throughout the BPLE (Figure 12). No sampled bottom trawl landings had fished in ENHG because this sub-stock was not a sampling stratum in 2017–18.

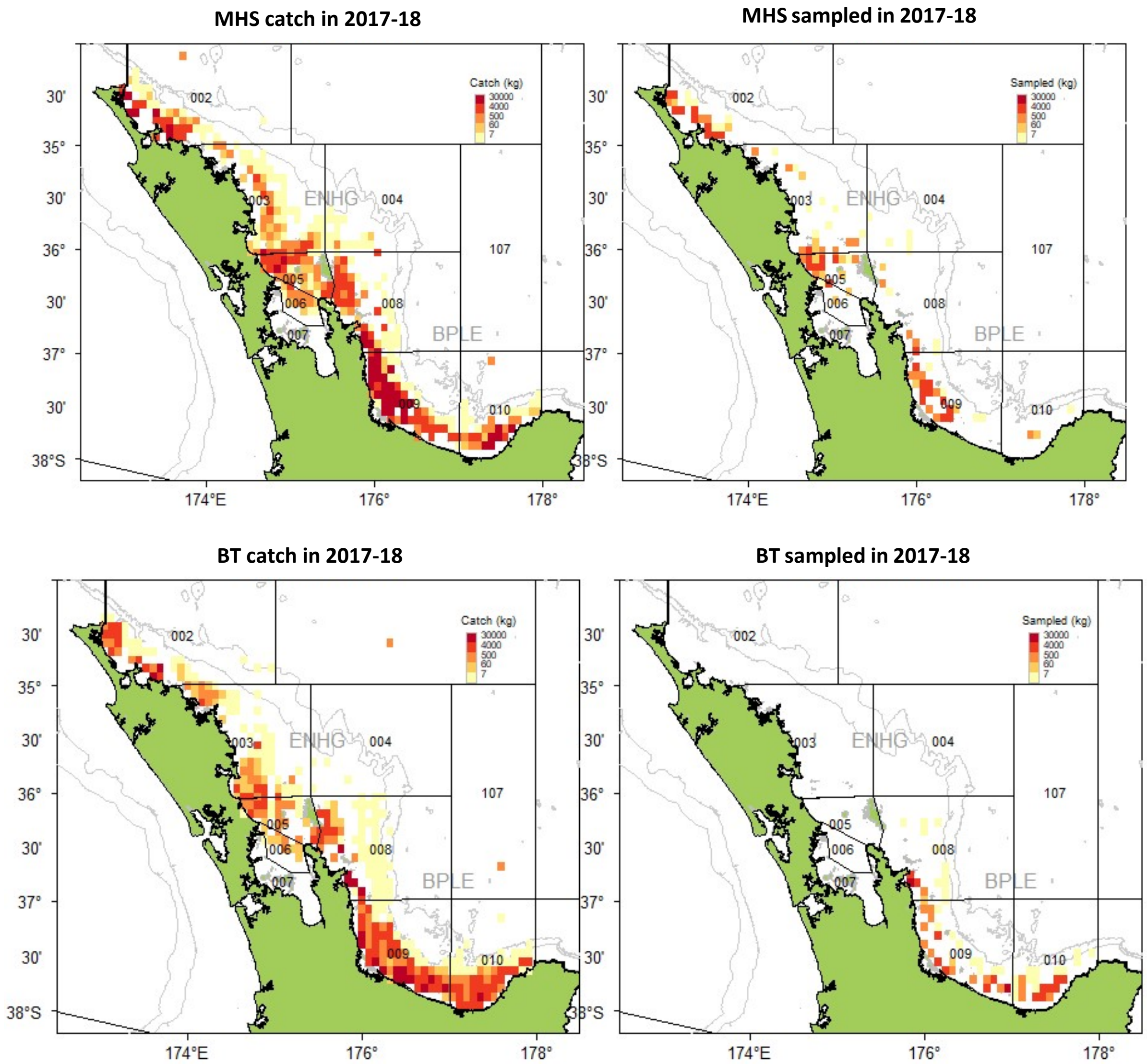

Figure 12: Comparison of the spatial distribution of TRE 1 trevally catch (left) and the sampled component (right) for the MHS (upper panel) and bottom trawl (lower panel) fishing methods in 2017–18. Note that bottom trawl was not sampled in the ENHG sub-stock in 2017–18. ENHG, East Northland/Hauraki Gulf; BPLE, Bay of Plenty. Fishing methods: BT, bottom trawl; MHS, modular harvest system.

By statistical area, the relative frequency of sampled trevally landings compared with that of the overall trevally fishery was well aligned, although bottom trawl in Statistical Area 008 was over-sampled relative to the fishery (Figure 13).

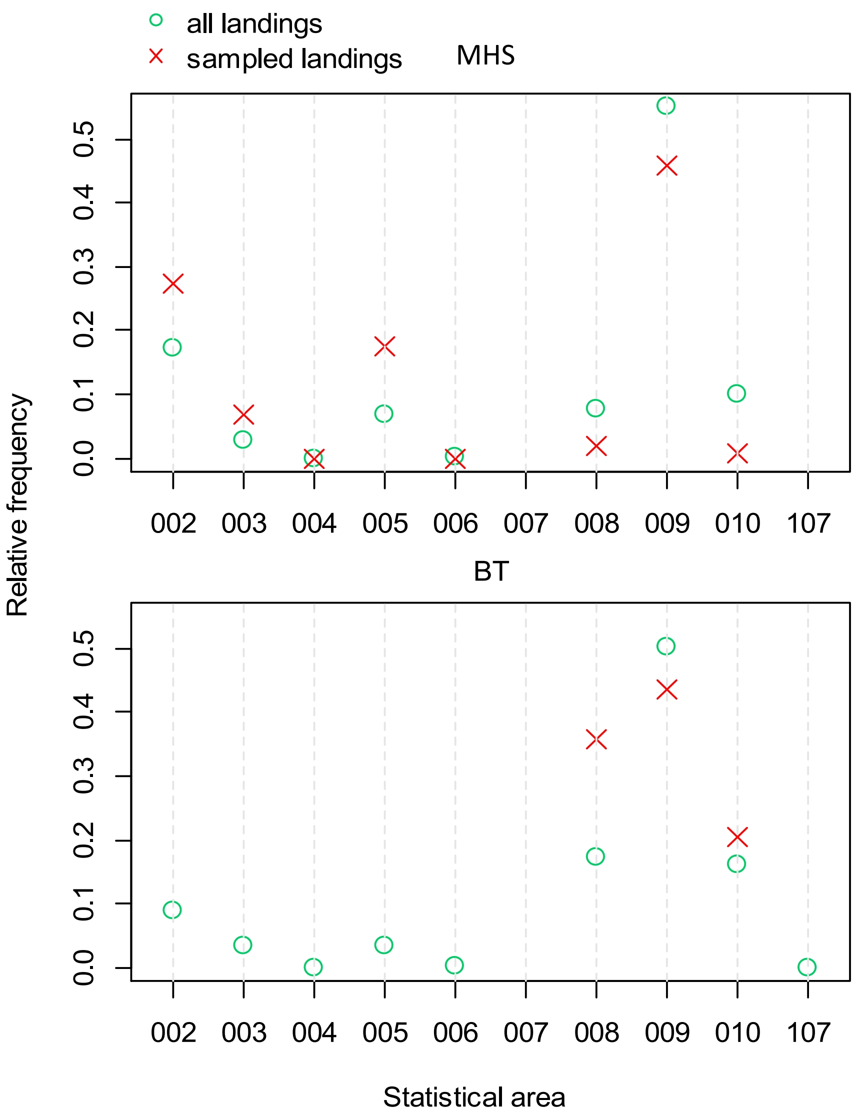

Figure 13: Comparison of the relative frequency of trevally catch (MHS upper panel, bottom trawl lower panel) compared with the sampled component by statistical area for TRE 1 in 2017–18.

By target species, the relative frequency of sampled trevally landings compared with that of the overall trevally fishery was well aligned, although bottom trawl in the BPLE over-sampled snapper target and under-sampled TRE target relative to the fishery (Figure 14).

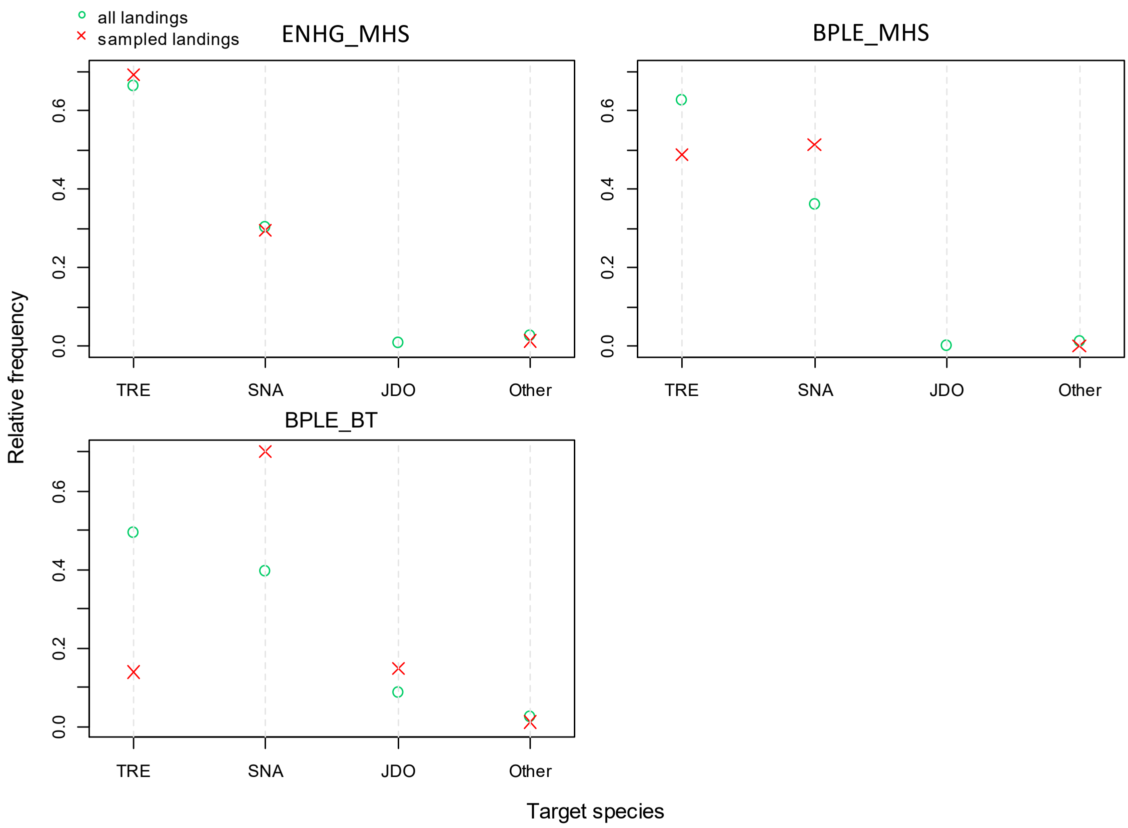

Figure 14: Comparison of the relative frequency of trevally catch compared with the sampled component by target species across the areas and fishing methods sampled within TRE 1 in 2017–18. ENHG, East Northland/Hauraki Gulf; BPLE, Bay of Plenty. Fishing methods: BT, bottom trawl; MHS, modular harvest system.

The depth distribution of sampled trevally catch was generally well aligned (but more variable) relative to that of the whole fishery for all fishing methods and areas sampled in 2017–18 (Figures 15 and 16).

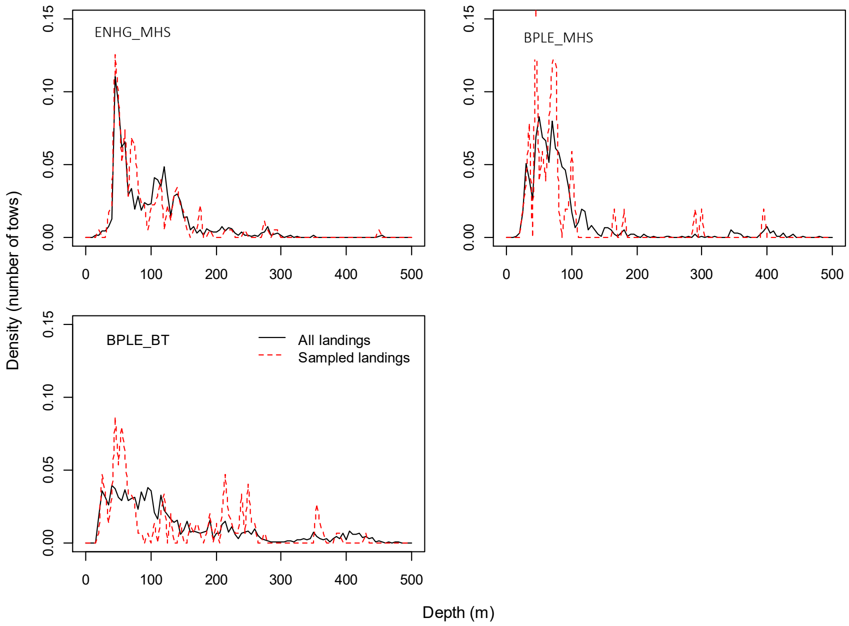

Figure 15: Comparison of the proportional distribution of the estimated bottom trawl trevally catch and the sampled component by number of tows over the sampling period for the TRE 1 bottom trawl and MHS sub-stock fisheries in 2017–18. Depth scale differs between sub-stocks. ENHG, East Northland/Hauraki Gulf; BPLE, Bay of Plenty. Fishing methods: BT, bottom trawl; MHS, modular harvest system.

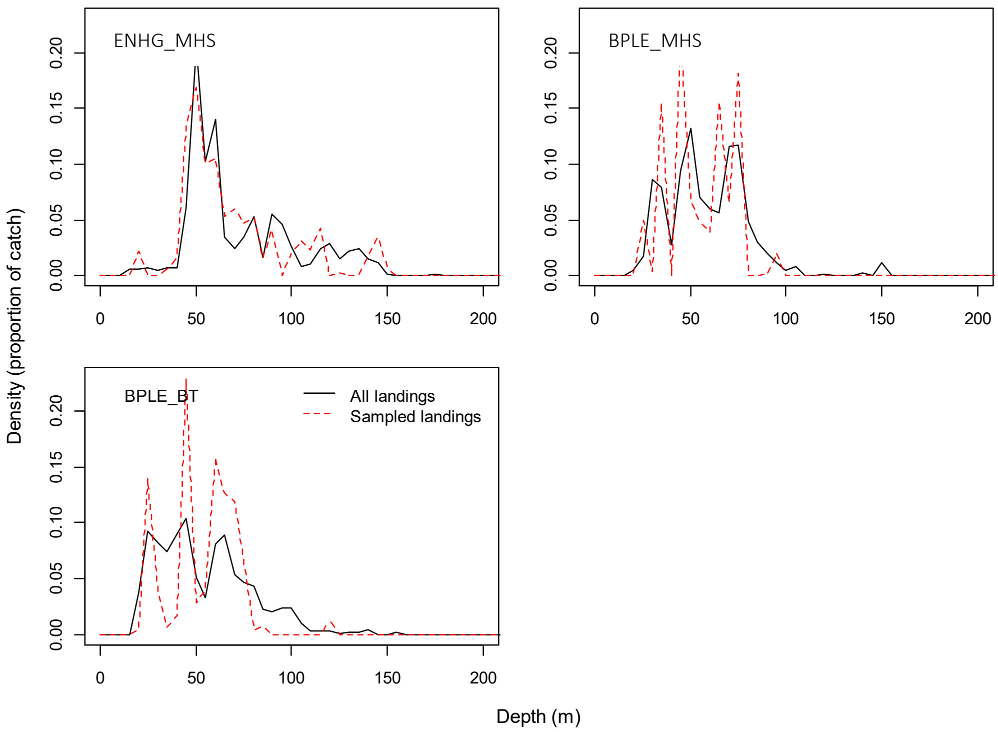

Figure 16: Comparison of the proportional distribution of the estimated bottom trawl trevally catch and the sampled component by catch over the sampling period for the TRE 1 bottom trawl and MHS sub-stock fisheries in 2017–18. Depth scale differs between sub-stock. ENHG, East Northland/Hauraki Gulf; BPLE, Bay of Plenty. Fishing methods: BT, bottom trawl; MHS, modular harvest system.

Sampling in 2019–20

For the primary fishing method that was sampled in each TRE 1 sub-stock (MHS in ENHG and bottom trawl in BPLE) as well as TRE 2 bottom trawl, the temporal coverage of sampling was reasonably well aligned with the temporal spread of landings and the weight of trevally catch overall (although BPLE bottom trawl was under-sampled in May) (Figure 17). Because only six MHS landings were sampled in the BPLE and five bottom trawl landings in ENHG during 2019–20, the temporal spread of these samples was patchy compared with that of the fishery.

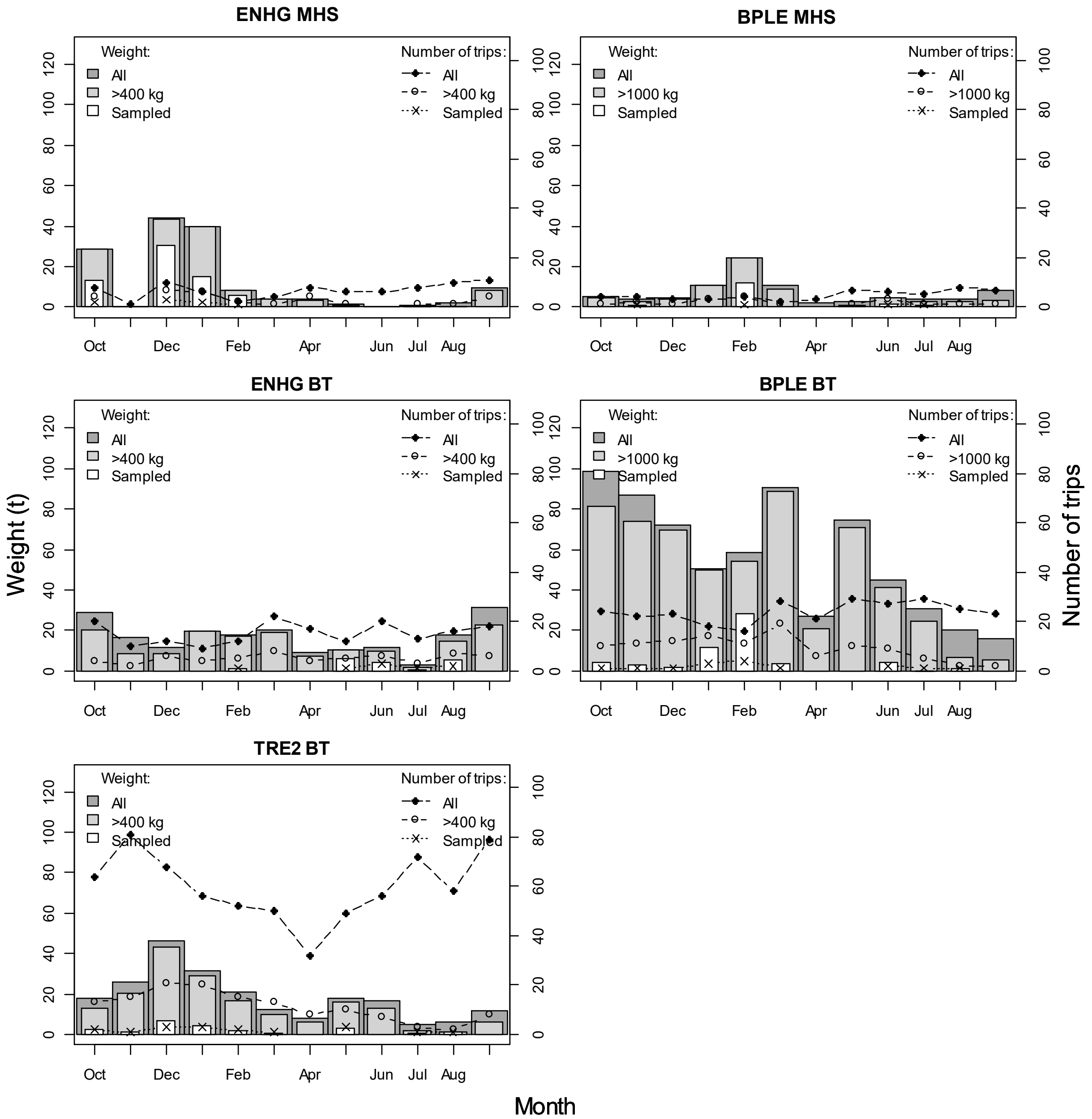

Figure 17: Comparison of the monthly distributions of landed weight and number of landings of trevally in the TRE 1 sub-stocks and TRE 2 by fishing method for all landings where trevally was caught in 2019–20. Also provided are monthly weight and number of landings to qualifying trips, and the weight and number of landings sampled. Note: bars and lines are overlaid.

The sampling performance relative to the cumulative proportion of the total number and catch weight of landings throughout the sampling period was reasonably good for most fishing methods and sub-stocks (Figures 18 and 19). There were some fishing methods and sub-stocks, however, where under- or over-sampling occurred during parts of the year. For ENHG MHS over-sampling relative to the number of landings occurred between November and February, but sampling performance matched the fishery well in terms of catch weight. For ENHG bottom trawl under-sampling occurred from October until May for both the number of landings and catch weight. For BPLE MHS under-sampling occurred between October and January in terms of catch weight, but not the number of landings.

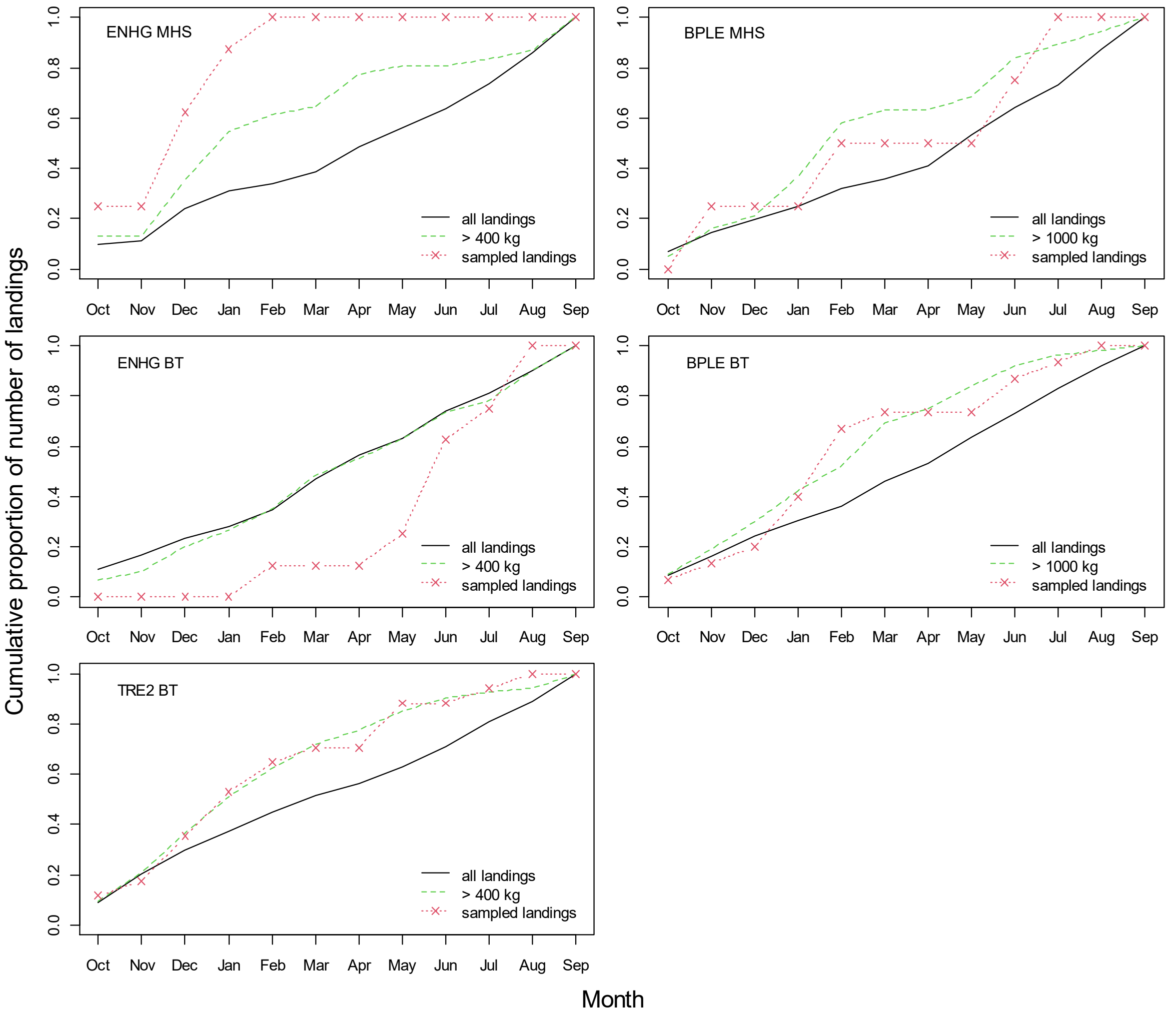

Figure 18: Comparison of the cumulative proportion of the number of landings with samples taken from TRE 1 and TRE 2 by sub-stock and fishing method in 2019–20. Sub-stocks: ENHG, East Northland/Hauraki Gulf; BPLE, Bay of Plenty. Fishing methods: BT, bottom trawl; MHS, modular harvest system.

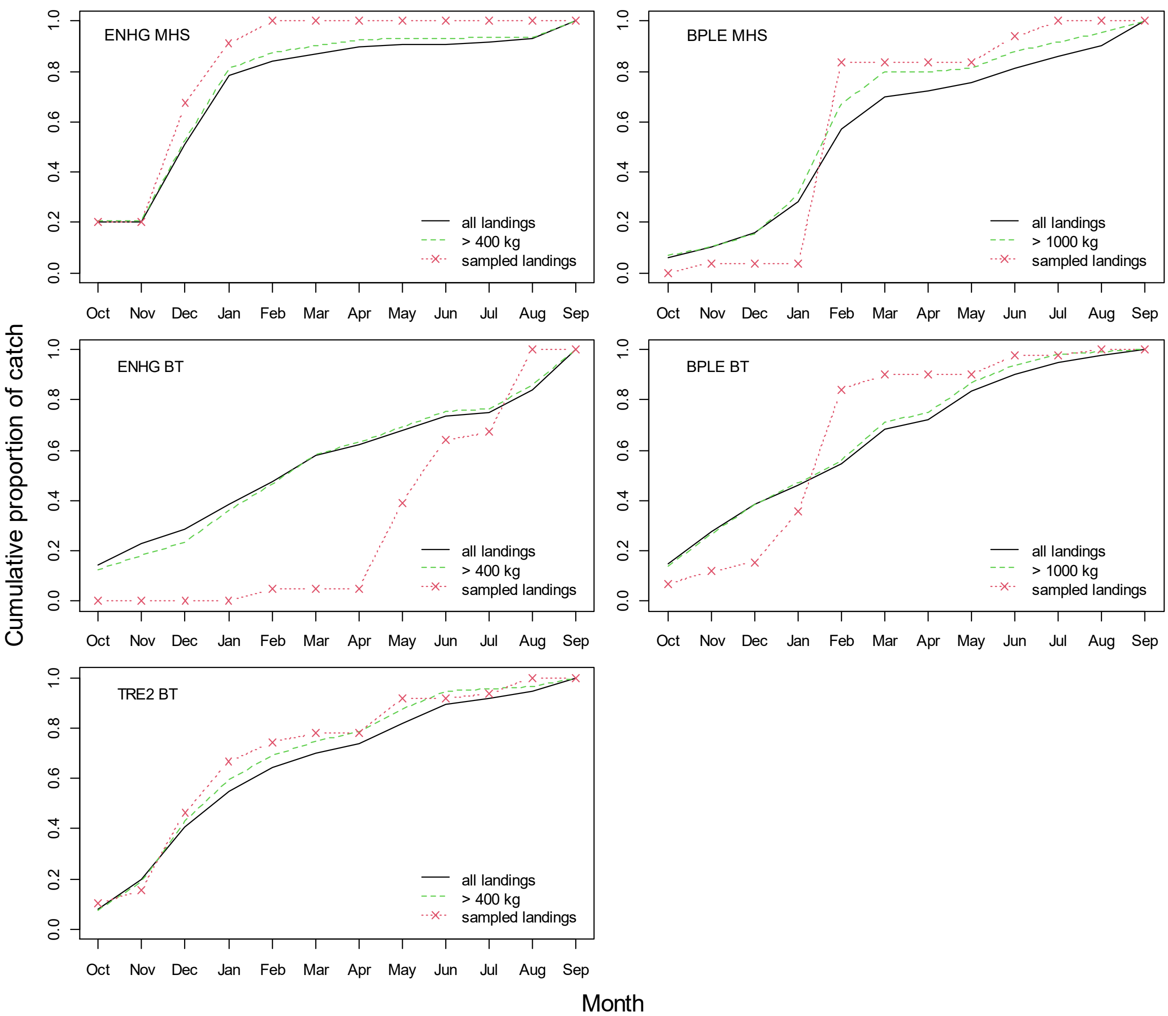

Figure 19: Comparison of the cumulative proportion of the catch weight of landings with samples taken from TRE 1 and TRE 2 by sub-stock and fishing method in 2019–20. Sub-stocks: ENHG, East Northland/Hauraki Gulf; BPLE, Bay of Plenty. Fishing methods: BT, bottom trawl; MHS, modular harvest system.

MHS catch of trevally in 2019–20 was widely distributed throughout TRE 1, with the highest catches off Pārengarenga Harbour and in the southern part of Statistical Area 003 in east Northland, to the east of Colville Channel in Statistical Area 008, and all throughout the BPLE. Sampled MHS landings largely caught trevally from these same areas, although trevally catch in the southern part of Statistical Area 003 in east Northland was under sampled (Figure 20). Bottom trawl catch of trevally was distributed throughout TRE 1 and TRE 2, with the exception of the northern part of Statistical Area 003, the inner Hauraki Gulf, and Statistical Area 015. Sampled bottom trawl landings caught trevally from these same areas, although Statistical Area 002 in east Northland and Statistical Area 011 in TRE 2 appeared to be under-sampled (Figure 20).

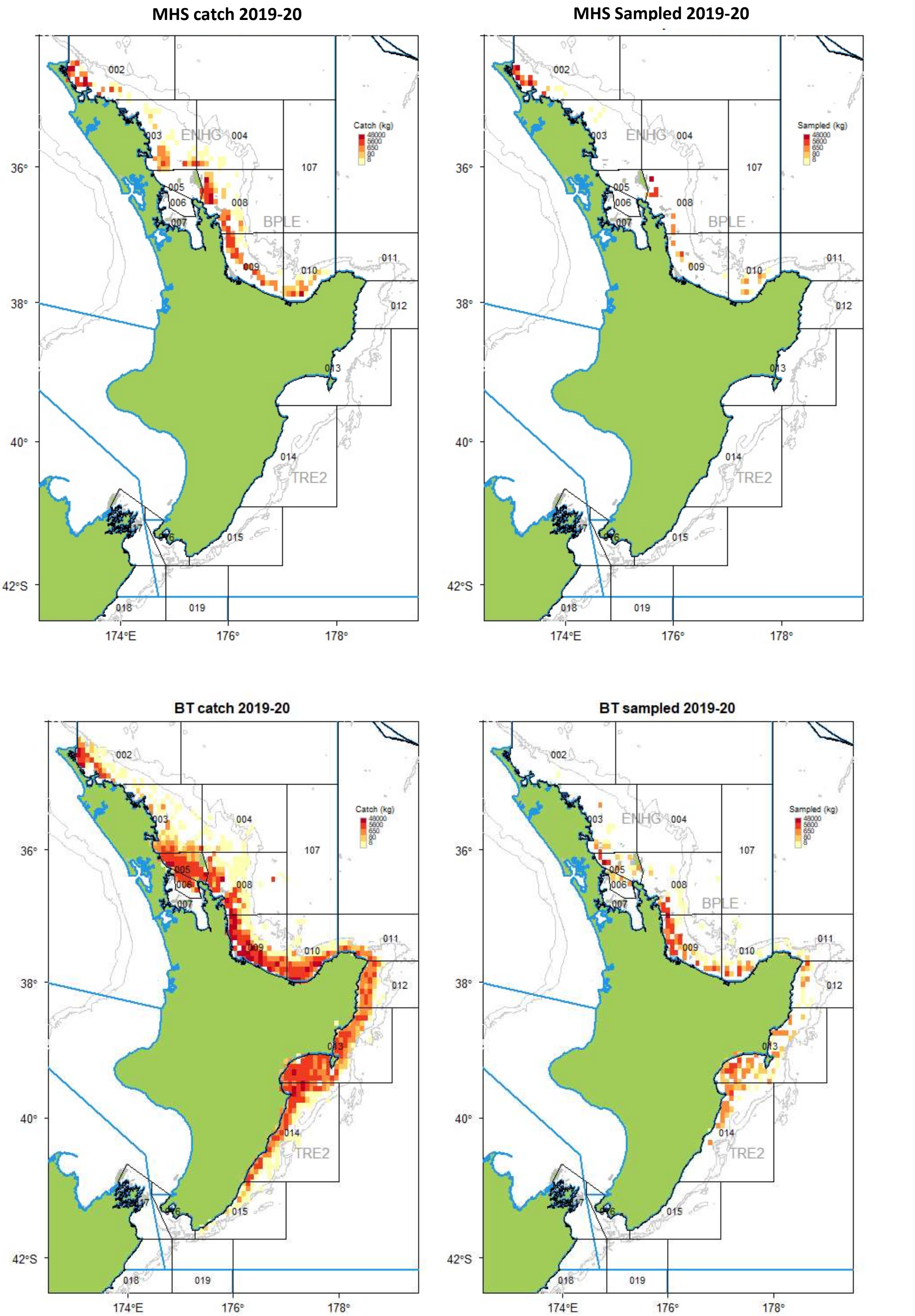

Figure 20: Comparison of the spatial distribution of TRE 1 and TRE 2 trevally catch (left) and the sampled component (right) for the MHS (upper panel) and bottom trawl (lower panel) fishing methods in 2019–20. Note that MHS wasn't sampled in the TRE 2 area in 2019–20. ENHG, East Northland/Hauraki Gulf; BPLE, Bay of Plenty. Fishing methods: BT, bottom trawl; MHS, modular harvest system.

By statistical area, the relative frequency of sampled trevally landings compared with that of the overall trevally fishery was well aligned for both the MHS and bottom trawl methods (Figure 21).

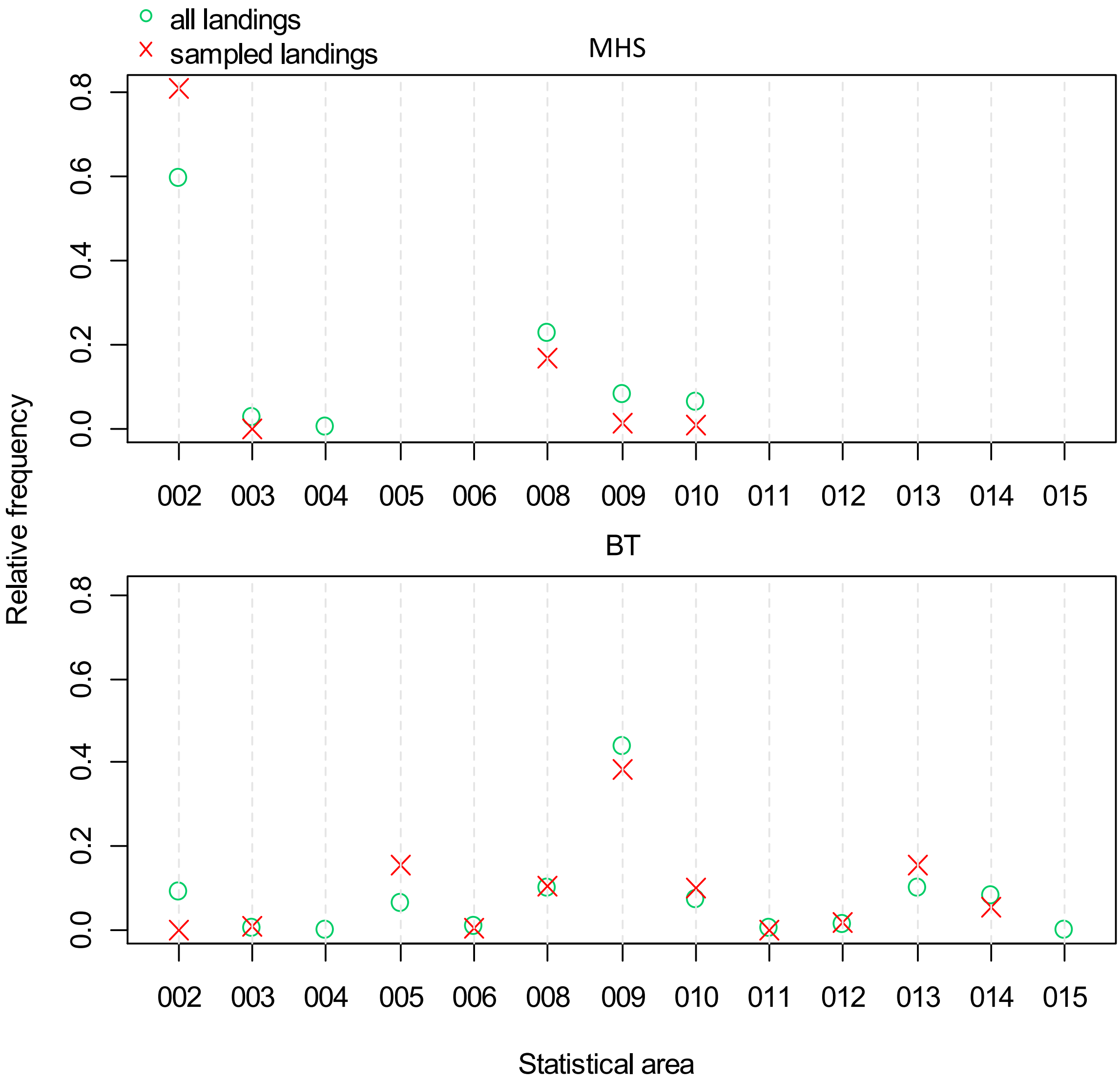

Figure 21: Comparison of the relative frequency of trevally catch (MHS upper panel, bottom trawl lower panel) compared to the sampled component by statistical area for TRE 1 and TRE 2 in 2019–20.

By target species, the relative frequency of sampled trevally landings compared with that of the overall trevally fishery was also well aligned (Figure 22).

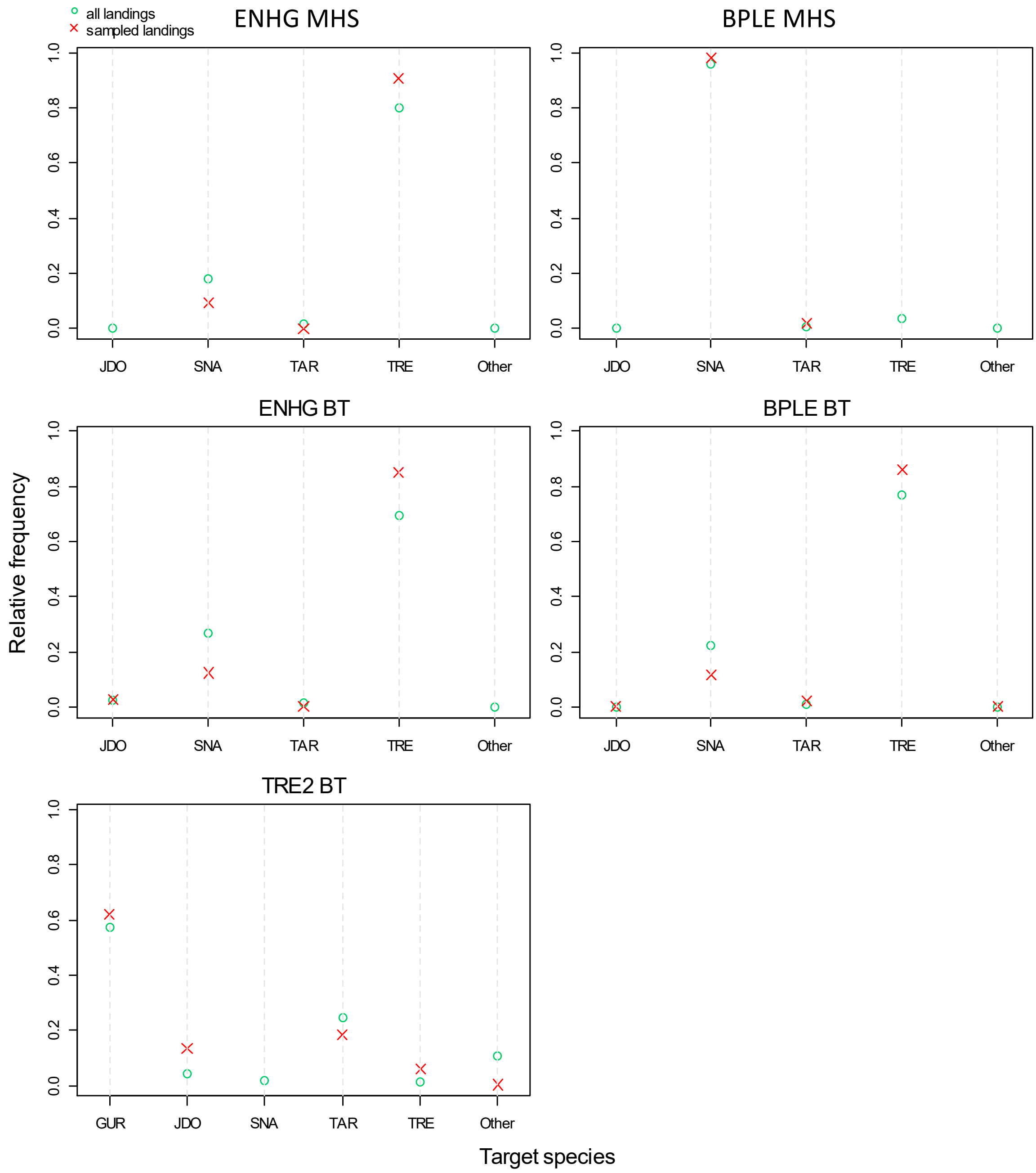

Figure 22: Comparison of the relative frequency of trevally catch compared with the sampled component by target species across the areas and fishing methods sampled within TRE 1 and TRE 2 in 2019–20. ENHG, East Northland/Hauraki Gulf; BPLE, Bay of Plenty. Fishing methods: BT, bottom trawl; MHS, modular harvest system.

The depth distribution of sampled trevally catch was generally well aligned (but more variable) relative to that of the whole fishery for all fishing methods and areas sampled in 2019–20 (Figures 23 and 24).

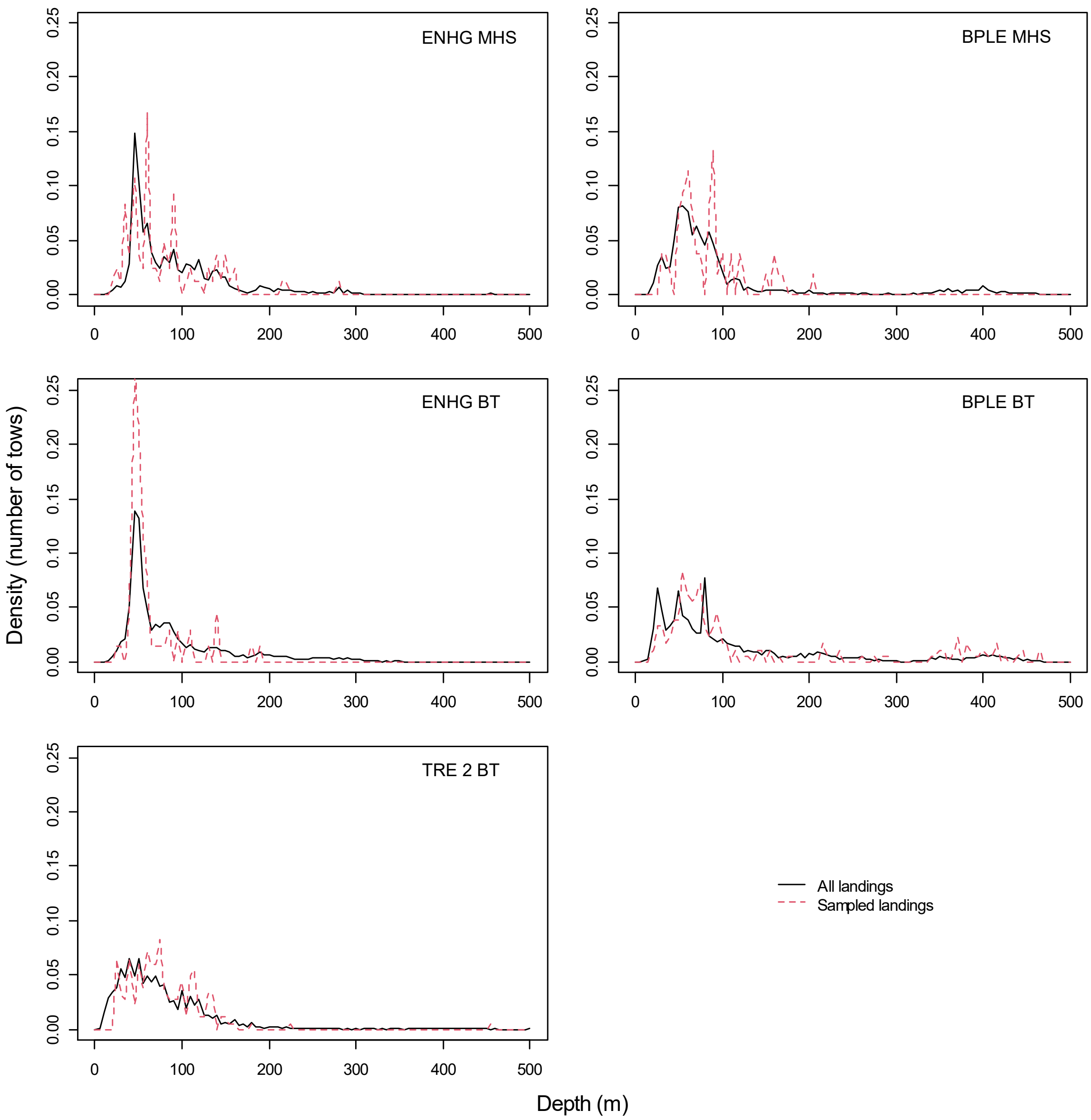

Figure 23: Comparison of the proportional distribution of the estimated bottom trawl trevally catch and the sampled component by number of tows over the sampling period for the TRE 1 and TRE 2 bottom trawl and MHS sub-stock fisheries in 2019–20. Depth scale differs between sub-stocks. ENHG, East Northland/Hauraki Gulf; BPLE, Bay of Plenty. Fishing methods: BT, bottom trawl; MHS, modular harvest system.

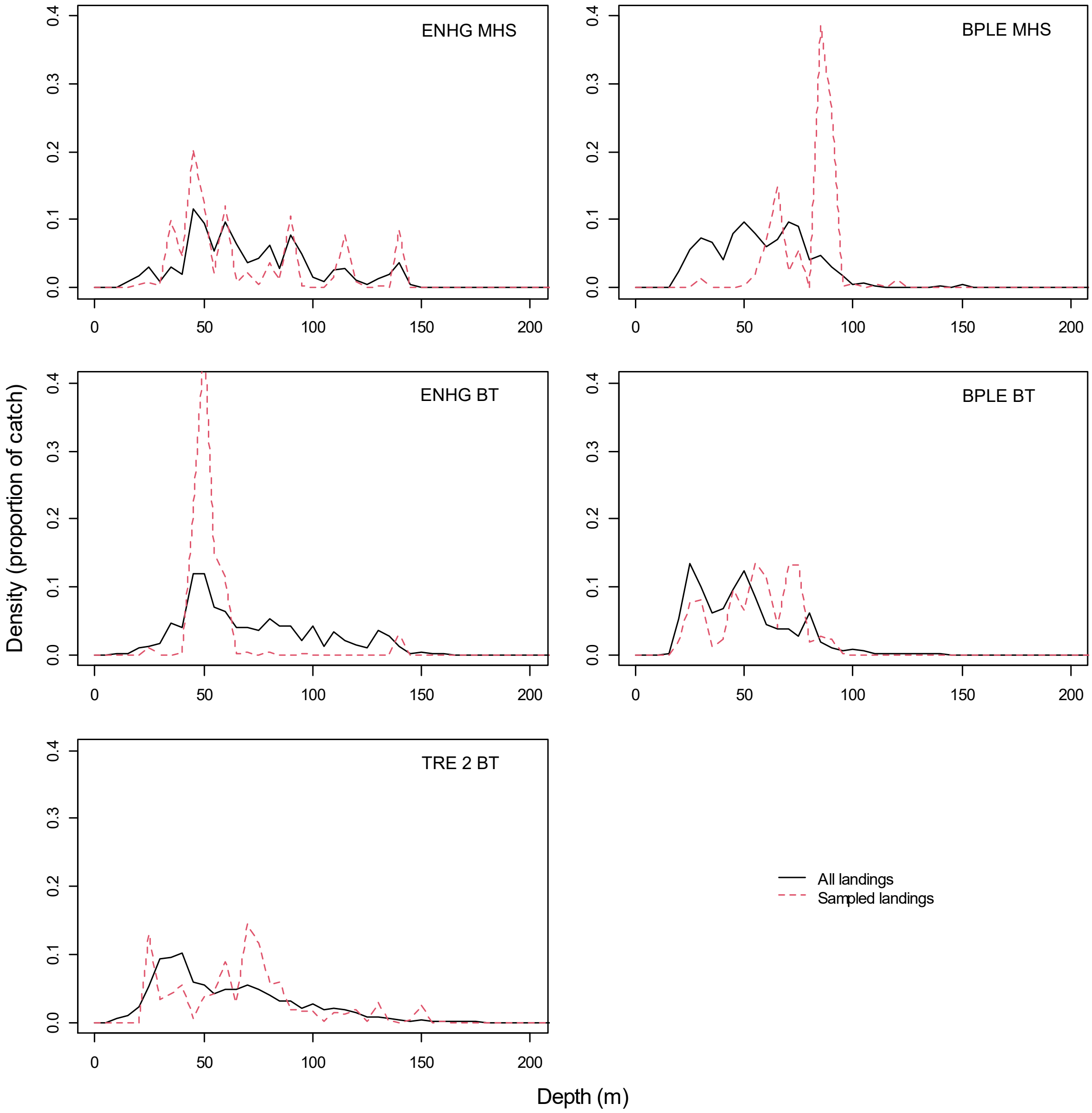

Figure 24: Comparison of the proportional distribution of the estimated bottom trawl trevally catch and the sampled component by catch weight over the sampling period for the TRE 1 and TRE 2 bottom trawl and MHS sub-stock fisheries in 2019–20. Depth scale differs between sub-stocks. ENHG, East Northland/Hauraki Gulf; BPLE, Bay of Plenty. Fishing methods: BT, bottom trawl; MHS, modular harvest system.

3.4 Otolith reading

Reader comparison tests for reference readings

To assess reader competency in ageing trevally otoliths in 2017–18 and 2019–20, each of the two selected readers aged a subsample of 50 reference otolith preparations with the aim of achieving a score for Index of Average Percentage Error, IAPE (Beamish & Fournier 1981), and mean coefficient of variation (CV) (Chang 1982), of below 2.50% and 3.54%, respectively (Walsh et al. 2014b). Both readers achieved CV and IAPE scores below the targets in their first attempt (Table 2).

Table 2: **Reader comparison scores determined from ageing 50 randomly selected trevally reference otolith samples ranging in age from 3 to 56 years. IAPE = Index of Average Percentage Error, CV = coefficient of variation.**

	IAPE	CV	Agreed age	Pass/Fail
Target	2.50%	3.54%	–	–
Reader 1	1.07%	1.52%	81%	Pass (1st attempt)
Reader 2	1.98%	2.80%	71%	Pass (1st attempt)

Reader comparison tests for TRE 1 and TRE 2 readings in 2017–18 and 2019–20

Between reader comparison tests are conducted on the actual otolith sets used for catch-at-age analysis to provide an understanding of reader bias, precision, and consistency relative to the agreed age and to assess how these factors varied across trevally age classes. Overall, more than 4000 otolith pair samples were collected from the TRE 1 and TRE 2 stocks in 2017–18 and 2019–20 (from RAF and LF + ALK sampling methods) with 2913 aged successfully by both readers. The same readers (referred to as readers 1 and 2) read all otolith collections. Between-reader tests, based on graphical comparisons, are given in Figures 25–29 and depict a good level of consistency between readers with the exception of the ENHG in 2017–18 (Figure 25).

The overall percentage agreement between readers was 55% for ENHG and 69% for the BPLE in 2017–18 and 64% for ENHG, 72% for BPLE, and 71% for TRE 2 in 2019–20. There were noticeable systematic differences (bias) in first counts of trevally otoliths between the readers for some sets. The negative weighting of the histogram, the relative clustering of plotted points about the zero line, and the slight deviation from the one-to-one line on the age-bias plots for ENHG in 2017–18 (Figure 25, top left and right and middle left panels) indicate that reader 1, at times, overestimated young fish (i.e., below 5 years) and often underestimated moderate to old aged fish. The between-reader CVs ranged from 2.23 to 5.87% and IAPE ranged from 1.57 to 4.15% (Figures 25–29, middle left panel). Furthermore, profiles show that precision varied across age classes in all stock collections, being highest for ENHG in 2017–18 and lowest for BPLE in 2019–20 (Figures 25 and 28, middle right panel), the latter mainly due to overestimated age for very young trevally. Age-bias plots for both readers indicated that the agreed age more closely matched reader 2, who showed a high level of precision and consistency in estimating age with CV and IAPE estimates less than 1.00% (Figures 25–29, bottom right panel). For reader 1, precision was lower, with CVs and IAPEs more closely aligned to the between-reader estimates (Figures 25–29, middle left panel), ranging from 1.96 to 5.66% (CV) and 1.39 to 4.00% (IAPE) (Figures 25–29, bottom right panel).

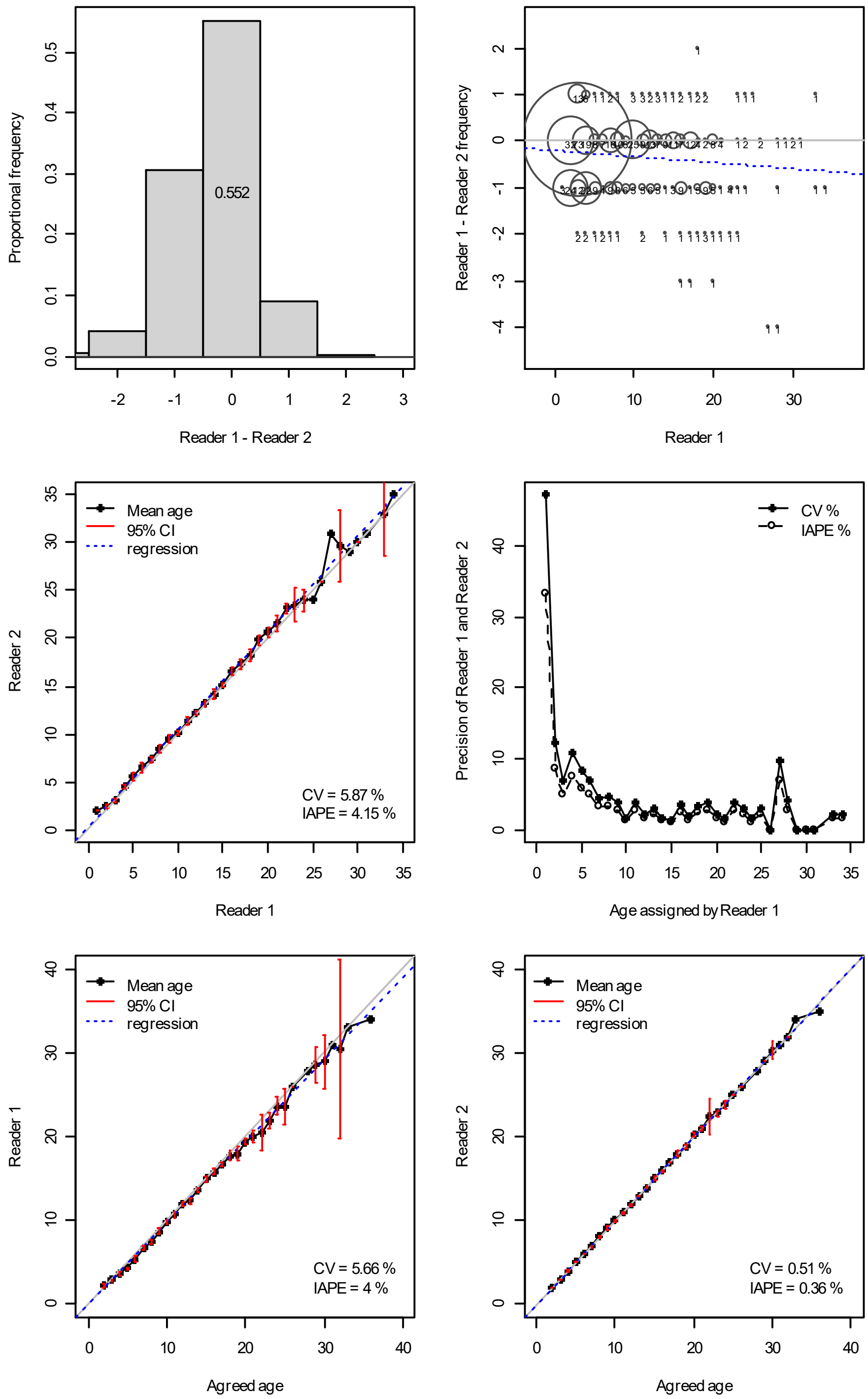

Figure 25: Results of between-reader comparison test (reader 1 and 2) for TRE 1 otoliths collected from ENHG in 2017–18 (*n* = 529). Panels described as follows: (Top left) histogram of differences between readings for the same otolith; (Top right) differences between readers for a given age assigned by reader 1; (Middle left) bias plot between readers; (Middle right) CV and IAPE profiles (precision) relative to the age assigned by reader 1; (Bottom left) bias plot between reader 1 and agreed age; (Bottom right) bias plot between reader 2 and agreed age. The expected one-to-one (solid line) and actual relationship (dashed line) between readers are overlaid on (Top right) and (Middle left), and between reader 1 and 2 and the agreed age on (Bottom left) and (Bottom right).

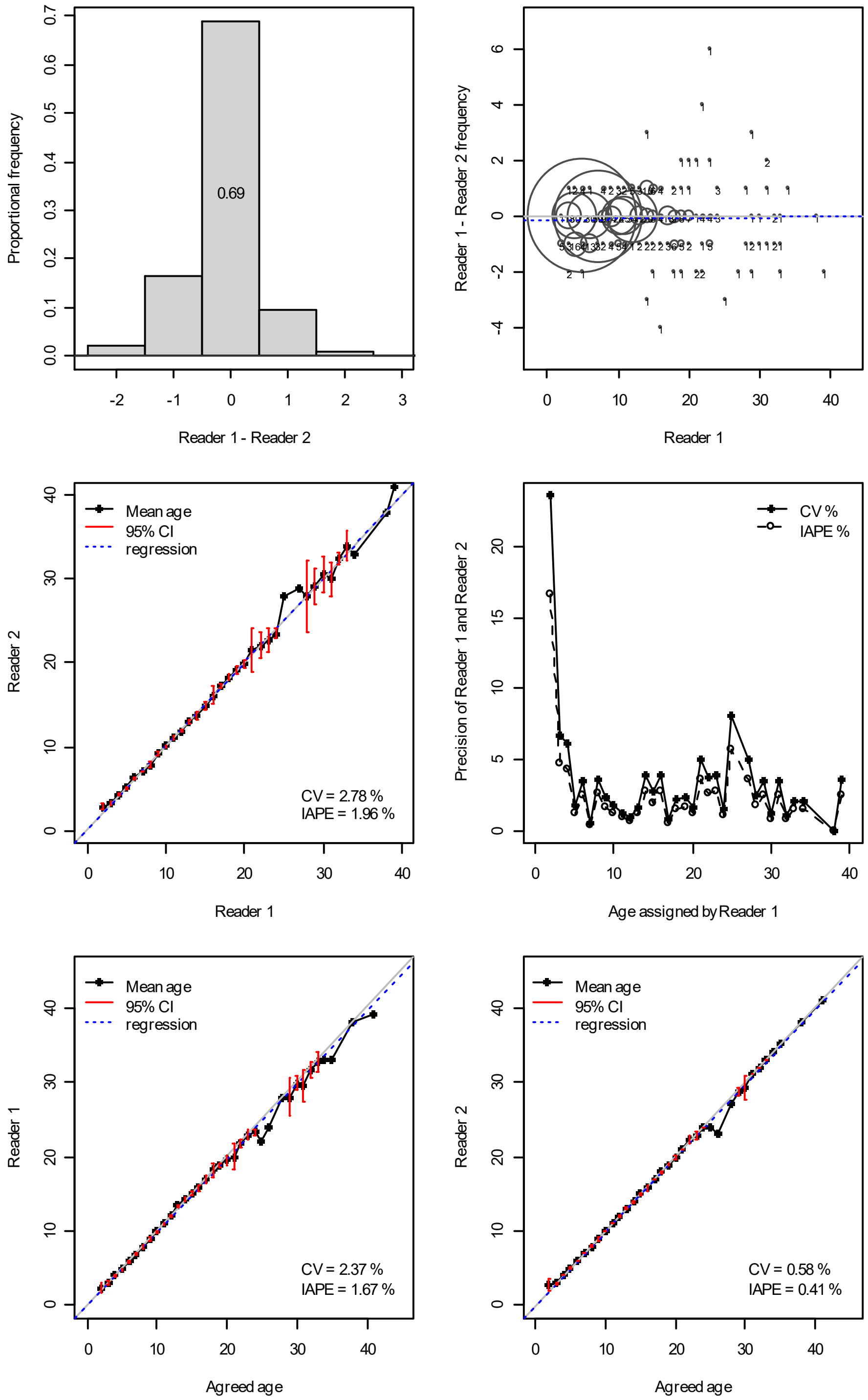

Figure 26: Results of between-reader comparison test (reader 1 and 2) for TRE 1 otoliths collected from BPLE in 2017–18 (*n* = 587). Refer to Figure 25 for an explanation of each panel.

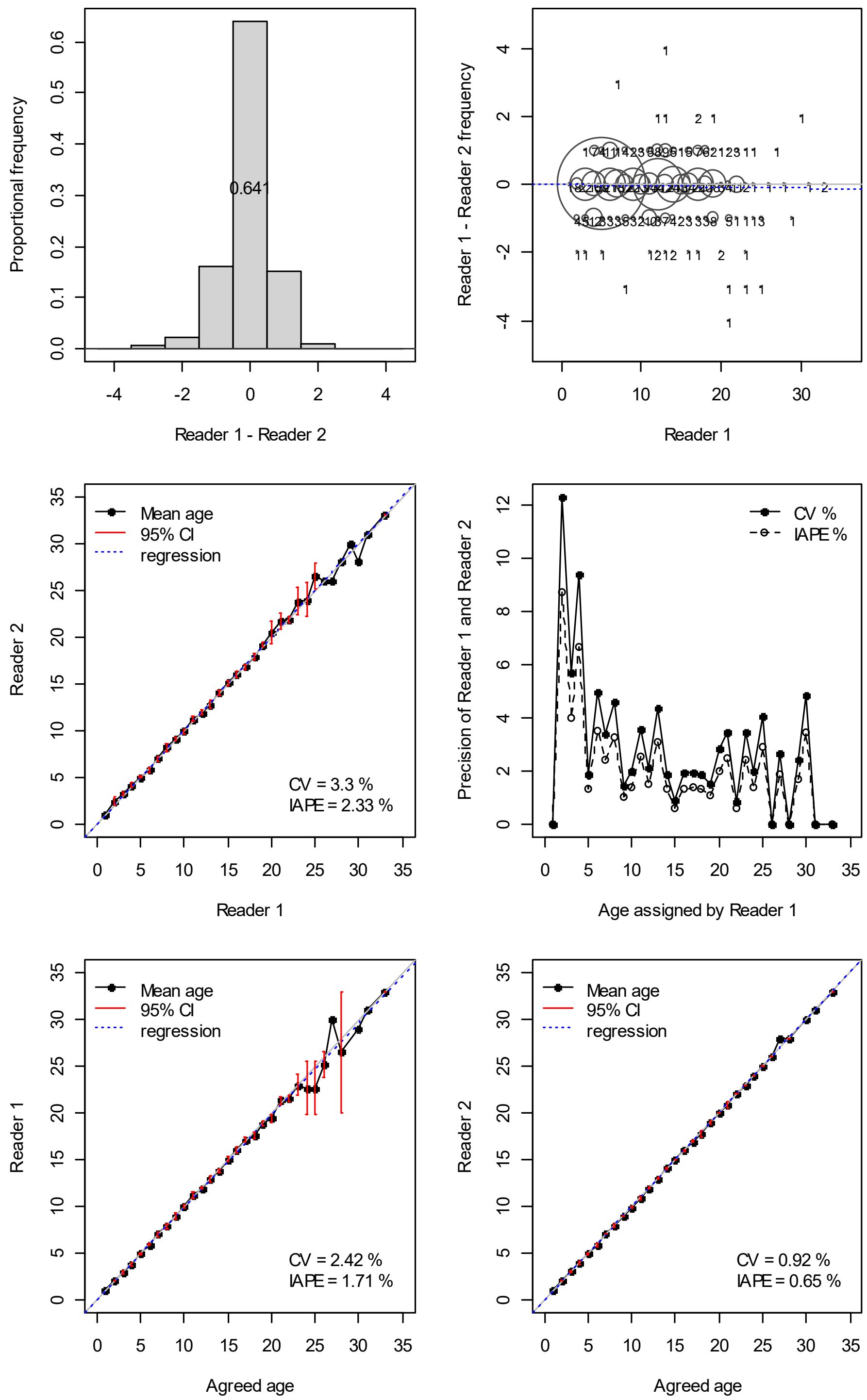

Figure 27: Results of between-reader comparison test (reader 1 and 2) for TRE 1 otoliths collected from ENHG in 2019–20 (*n* = 591). Refer to Figure 25 for an explanation of each panel.

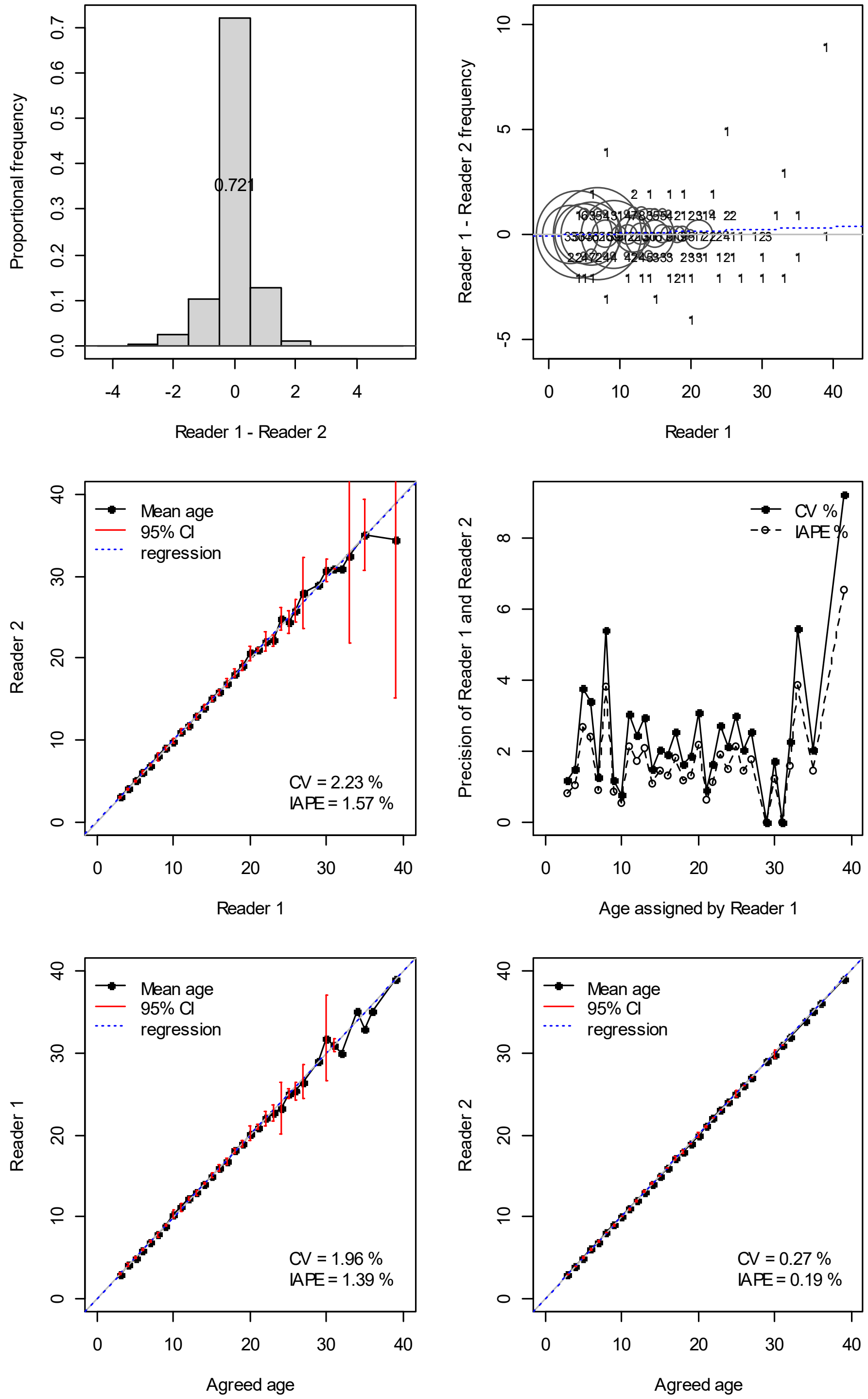

Figure 28: Results of between-reader comparison test (reader 1 and 2) for TRE 1 otoliths collected from BPLE in 2019–20 (*n* = 613). Refer to Figure 25 for an explanation of each panel.

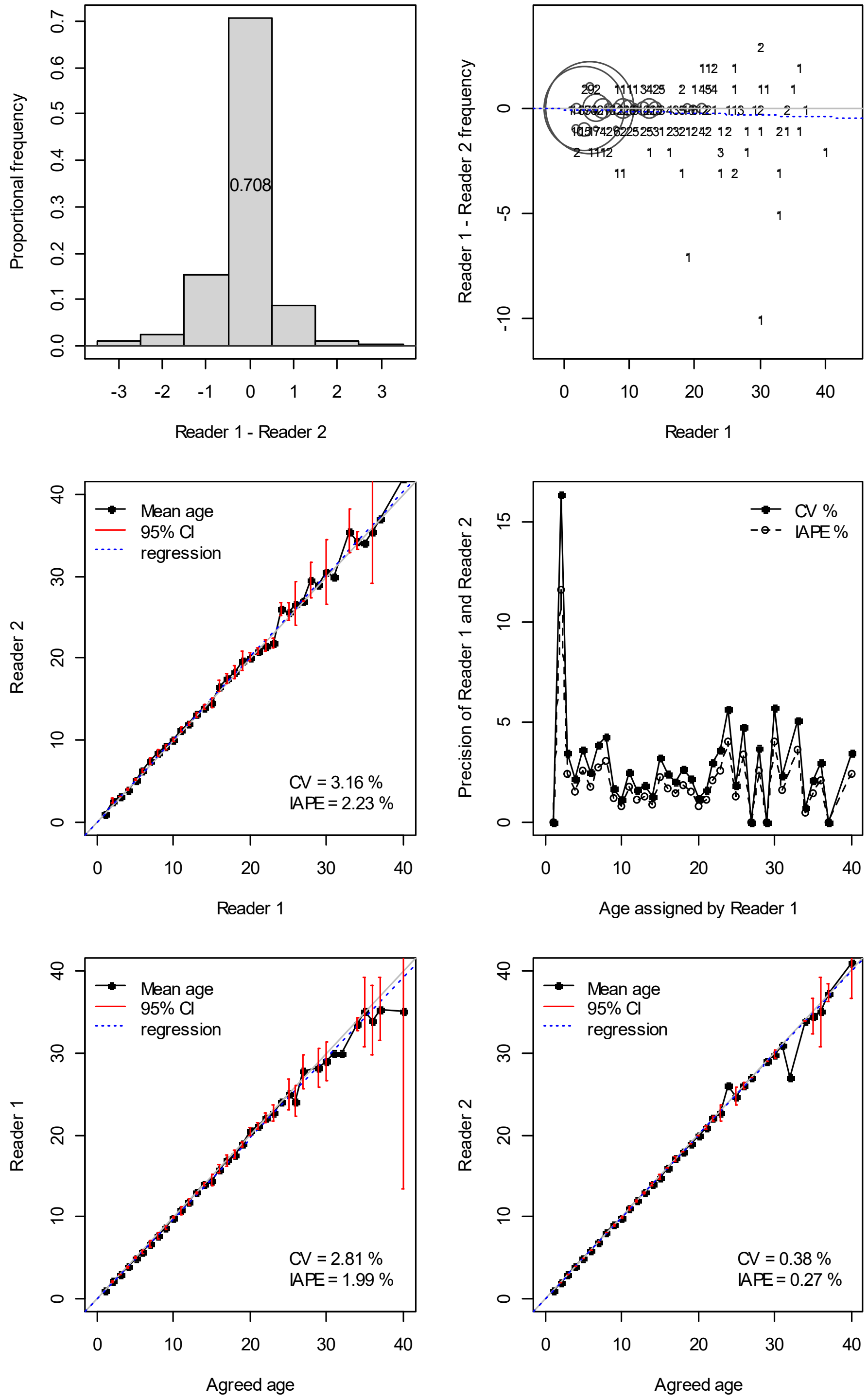

Figure 29: Results of between-reader comparison test (reader 1 and 2) for TRE 2 otoliths collected in 2019–20 (*n* = 593). Refer to Figure 25 for an explanation of each panel.

3.5 Catch-at-length and -age

Catch-at-length and -age in 2017–18

The length and age distributions for the three area-method fisheries sampled in 2017–18 revealed different length and age compositions (Figure 30, Appendices 1 and 2). In ENHG, the length composition (of fish sampled from the MHS fishery) was bimodal, centred around a mean length of

38.5 cm, with a substantial proportion of fish between 30 and 40 cm in length, and very few fish greater than 50 cm in length. As such, the age composition included a substantial proportion of young (two and three year-old) fish. The MWCV was high (0.34), indicative of high between-landing variability. In the BPLE both fishing methods sampled showed unimodal length distributions centred on a mean length of about 40 cm. However, the bottom trawl age composition had proportionately more five and seven year-old fish, with a higher proportion of fish less than 40 cm relative to the MHS fishery from the same area (Figure 30). As such, the MHS method in the BPLE had a relatively high proportion of fish greater than 10 years old, including a reasonable proportion of fish in the 30+ year age group. The MWCVs for age in the BPLE were lower than in ENHG, being 0.25 for MHS and 0.28 for bottom trawl.

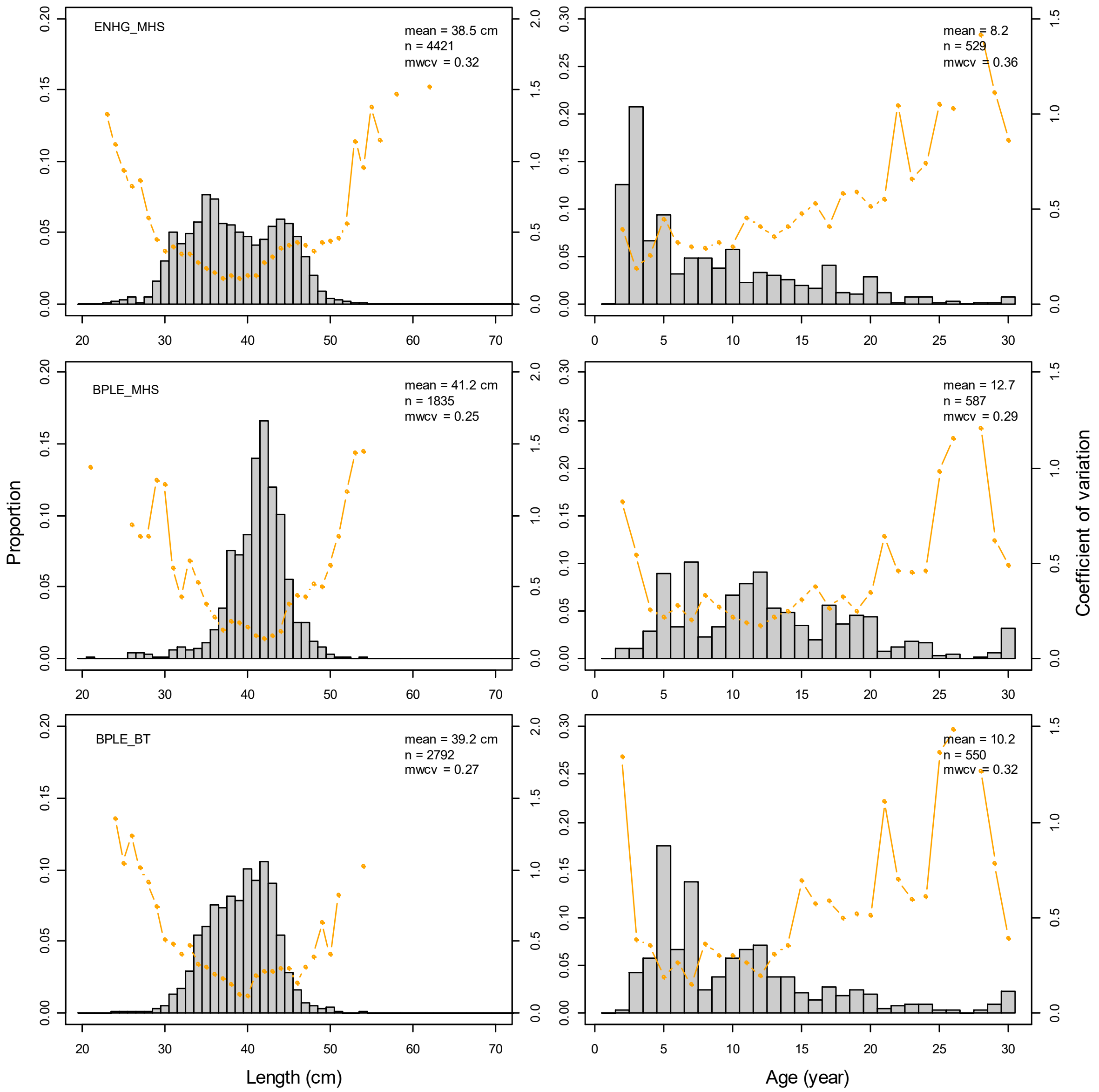

Figure 30: Proportion-at-length and -age distributions (histograms) and bootstrap CVs (lines) determined from trevally landings sampled from the TRE 1 bottom trawl and MHS fisheries in 2017–18 using the LF + ALK (BPLE MHS) and RAF (ENHG MHS and BPLE bottom trawl) approaches. n, sample size; MWCV, mean weighted CV; ENHG, East Northland Hauraki Gulf; BPLE, Bay of Plenty; MHS, modular harvest system.

Catch-at-length and -age in 2019–20

Sampling conducted in 2019–20 in the ENHG sub-stock included the addition of the bottom trawl fishery, which was characterised by a high proportion of young (three to five year old) fish and a length composition centred on a mean of 39 cm and dominated by fish between 30–40 cm in size (Figure 31, Appendices 1 and 2). In contrast, the MHS fishery from ENHG had a much higher proportion of 10–20 year-old fish, a mean length of 44 cm, and a size composition that included a substantial proportion of fish between 40–50 cm in length (Figure 31). The size compositions of both ENHG fisheries in 2019–20 exhibited tails that included larger fish, extending beyond 50 cm in size. The MWCVs for age were comparable to ENHG sampling in 2017–18, being 0.34 for bottom trawl and 0.32 for MHS.

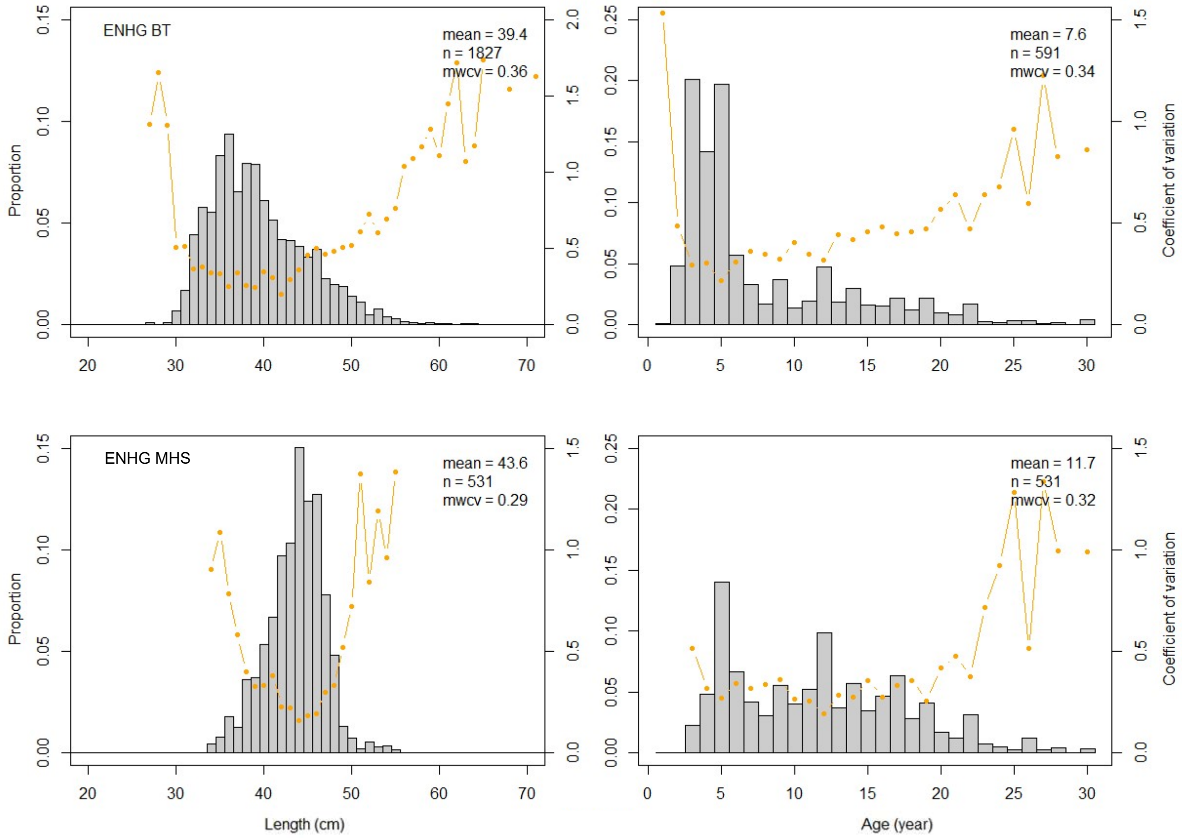

Figure 31: Proportion-at-length and -age distributions (histograms) and bootstrap CVs (lines) determined from trevally landings sampled from the ENHG sub-stock bottom trawl and MHS fisheries in 2019–20 using the LF + ALK (bottom trawl) and RAF (MHS) approaches. n, sample size; MWCV, mean weighted CV; ENHG, East Northland Hauraki Gulf; MHS, modular harvest system.

Both BPLE 2019–20 sampled fisheries showed very similar length and age compositions (Figure 32, Appendices 1 and 2) (this was not the case in 2017–18; Figure 30). Both length compositions were centred on a mean of about 40 cm, with nearly the entire length distribution for both methods between 30 and 50 cm. Age compositions were dominated by fish less than 10 years in age for both fisheries, with the MHS method being composed of a slightly higher proportion of these younger fish.

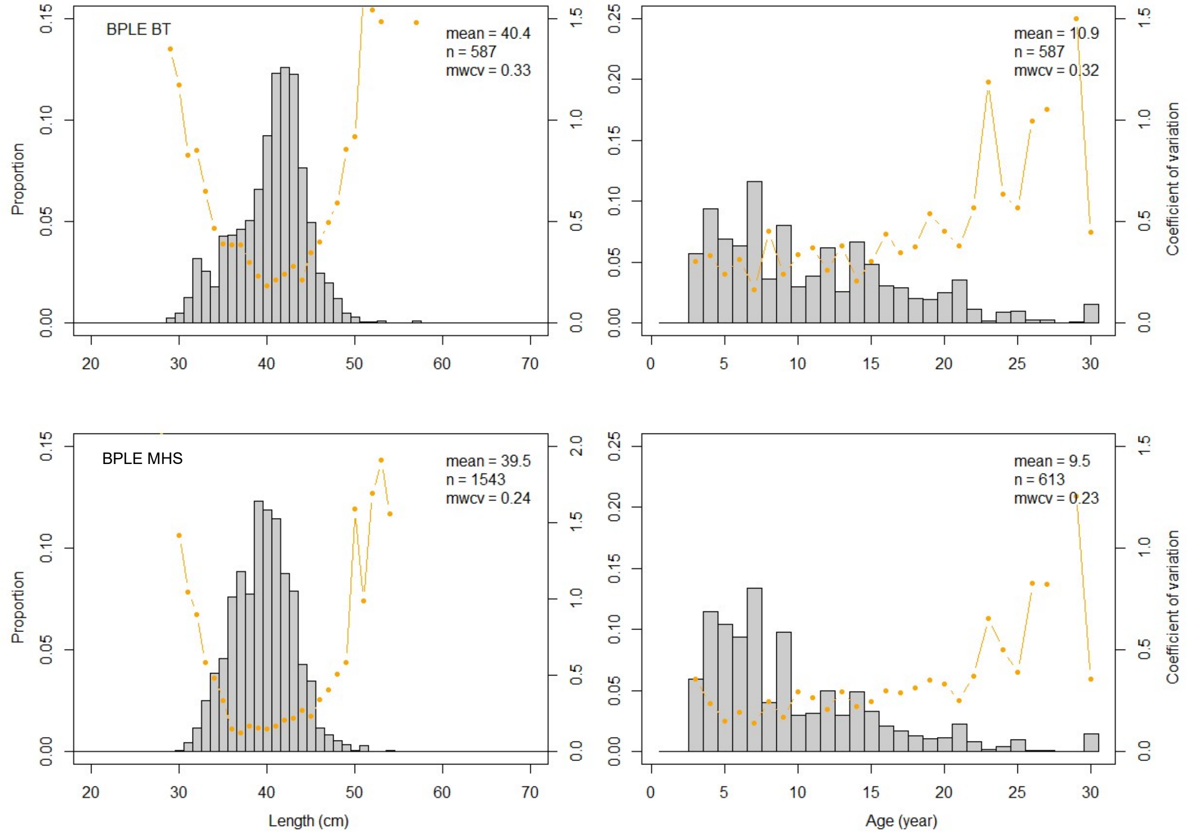

Figure 32: Proportion-at-length and -age distributions (histograms) and bootstrap CVs (lines) determined from trevally landings sampled from the BPLE sub-stock bottom trawl and MHS fisheries in 2019–20 using the LF + ALK (MHS) and RAF (bottom trawl) approaches. n, sample size; MWCV, mean weighted CV; BPLE, Bay of Plenty; MHS, modular harvest system.

The length composition of trevally in TRE 2 was bimodal and had the smallest mean length (37 cm) of all area-method strata sampled (Figure 33, Appendices 1 and 2). This included a substantial proportion of fish around 30 cm, and very few fish greater than 50 cm in size. The age composition was dominated by three and four year-old fish, although there was a reasonable proportion of fish in the 30+ age group (Figure 33). The MWCV was reasonably high at 0.35.

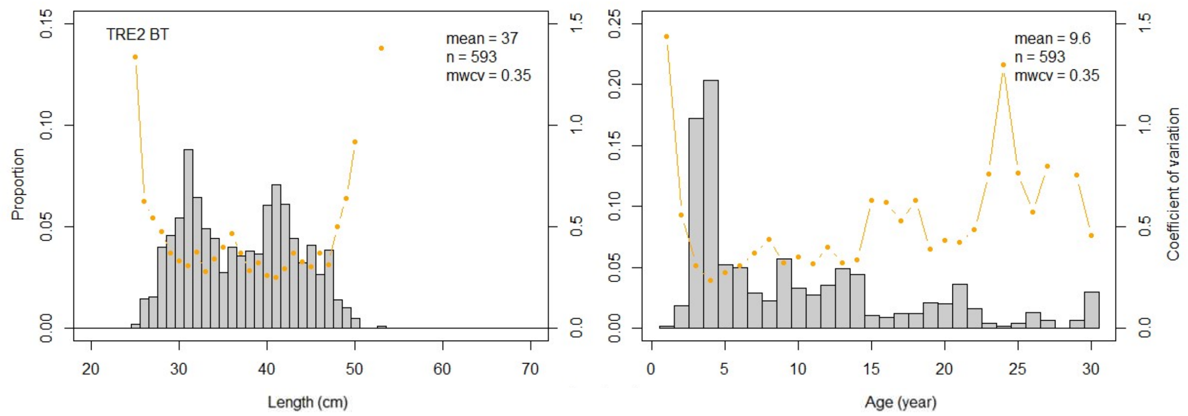

Figure 33: Proportion-at-length and -age distributions (histograms) and bootstrap CVs (lines) determined from trevally landings sampled from the TRE 2 bottom trawl fishery in 2019–20 using the RAF approach. n, sample size; MWCV, mean weighted CV.

3.6 TRE 1 sub-stock-method length and age distribution time series comparisons

Although a time series of length and age information from catch sampling in the TRE 1 fishery spans the period 1997–98 to 2019–20, investigation into patterns of spatial heterogeneity within the stock for the ENHG and BPLE sub-stocks only began in 2006–07 (Walsh et al. 2010a). A five year non-sequential time series for the ENHG (2006–07, 2007–08, 2008–09, 2012–13, and 2019–20) and BPLE (2007–08, 2008–09, 2012–13, 2017–18, and 2019–20) sub-stock fisheries is presented in Figures 34 and 35 for bottom trawl.

ENHG bottom trawl time series

The length and age distributions sampled from bottom trawl landings from the ENHG sub-stock between 2006–07 and 2019–20, although variable, consistently comprised a high proportion of small and young trevally, with fish 10 years and younger accounting for 75–91% of the catch (Figure 34). In 2019–20, however, the proportion of the age composition in the right-hand limb had increased, with trevally 15 years and older making up 14% of the total catch, the highest recorded in the time series. Time series mean length ranged between 36.7 and 40.0 cm and mean age between 6.1 and 8.1 years. Some continuity of year class progression over successive years was evident, although sample sizes for both length and age collections in the 2006–07 and 2007–08 fishing years were well below targets and likely explain some of the variability apparent in length and age structure comparisons. Furthermore, observation of year class progression was likely hindered by the seven-year gap between sampling events in 2012–13 and 2019–20. A RAF sampling design was introduced for ENHG trevally in 2019–20 with all previous collections sampled using the LF + ALK approach.

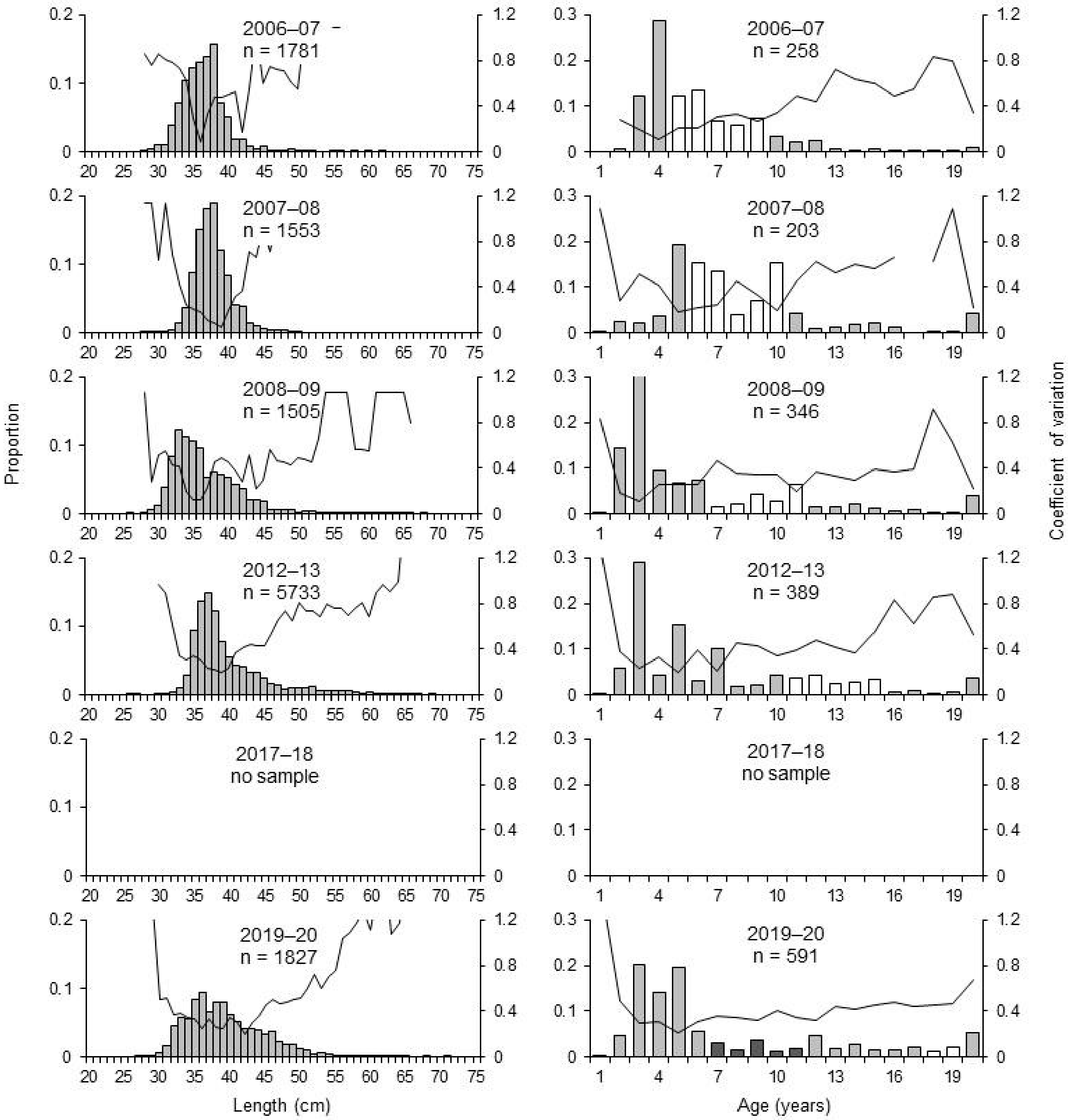

Figure 34: Recent time series of proportion-at-length and -age distributions (histograms) and CVs (lines) determined from trevally landings sampled from the ENHG sub-stock bottom trawl fishery (n, sample size). Sampling conducted in the ENHG sub-stock during 2017–18 was for the MHS method and is not represented on this plot of the bottom trawl fishery. White bars in the age distribution represent the 1998 to 2002 year classes and dark bars the 2009 to 2013 year classes.

BPLE bottom trawl time series

Sampled bottom trawl length and age distributions from the BPLE have continued to broaden between 2007–08 and 2019–20, with estimates of mean length increasing from 36.7 to 40.4 cm and mean age increasing from 7.4 to 10.5 years (Figure 35). Despite some variability in length and age structure between years, there is good continuity in year class strength evident in the progression of many year classes over successive years, with sample sizes for both length and age collections over the five fishing years being the most comprehensive in TRE 1, despite no sampling being undertaken in 2006–07. A substantial increase in the proportion of the age composition in the right-hand limb was evident in 2017–18 and 2019–20. Trevally 15 years and older made up 19–25% of the total catch, the highest recorded in the time series. A RAF sampling design was introduced for BPLE trevally in 2017–18, with all previous collections sampled using the LF + ALK approach.

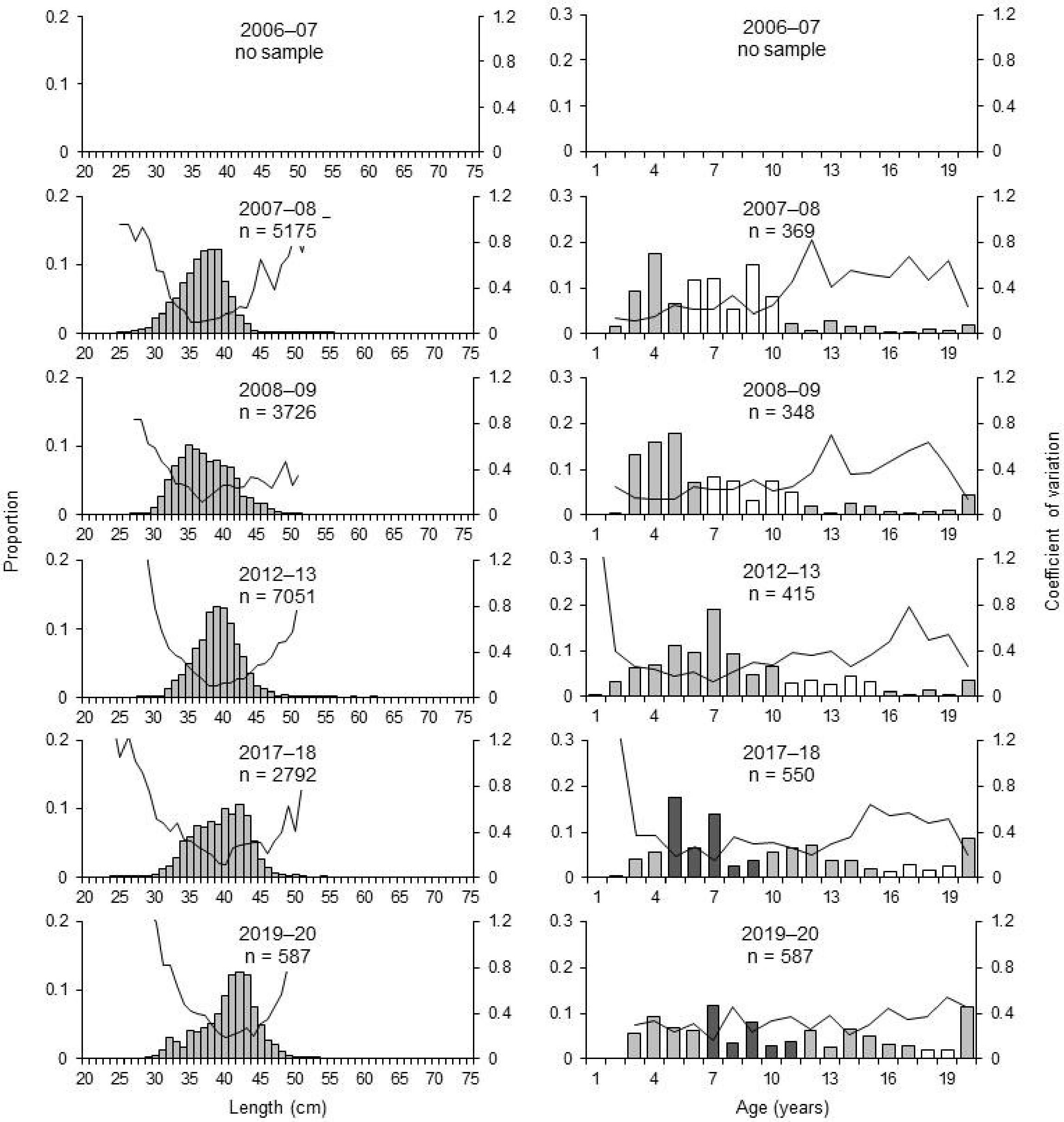

Figure 35: Recent time series of proportion-at-length and -age distributions (histograms) and CVs (lines) determined from trevally landings sampled from the BPLE sub-stock bottom trawl fishery (n, sample size). White bars in the age distribution represent the 1998 to 2002 year classes and dark bars the 2009 to 2013 year classes.

4. DISCUSSION

This is the twelfth TRE 1 age and length sampling report since 1997–98, and the first to describe the length and age composition of trevally from TRE 2. Although purse seine has been part of the TRE 1 catch-at-age time series for many years, it was not included in the current project (i.e., 2017–18 and 2019–20 sampling) due to high inter-annual age variability in the time series for this fishing method. In addition to this change, the intention was to transition all sampling to an RAF approach focused on the bottom trawl fishing method. However, the recent introduction of the MHS fishing method in 2015–16 necessitated changes to our sampling approach after sampling had begun. These changes were achieved without additional sampling events by incorporating an LF + ALK sampling approach to cover a secondary method in each of the two TRE 1 sub-stocks, ENHG and the BPLE. It should be noted that utilising an LF + ALK sampling approach over a full year of sampling has the potential to introduce bias because fish will continue to grow during the sampling period. This bias, however, is likely to be small because samples were collected randomly throughout the year which should account for changes in the distribution of length on age and, also, the growth of recruited fish is likely to be minimal over such a period (Westrheim & Ricker 1978, Davies & Walsh 1995).

In total 74 landings were sampled, 29 in 2017–18 and 45 in 2019–20 when sampling of TRE 2 was included. This compares well with the overall sampling target of 75 landings, with the one targeted landing not sampled being an ENHG MHS landing in 2017–18. In total, 14 460 fish were measured during both years of sampling, with 2913 otoliths samples aged (1120 from ENHG, 1200 from BPLE, and 593 from TRE 2) representing the most comprehensive catch sampling description of the TRE 1 (and TRE 2) fishery to date.

The overall pattern of trevally catch in TRE 1 has been dominated by both the bottom trawl and purse seine fishing methods since at least 2008–09 (Walsh et al. 2014a). This pattern changed with the introduction of MHS in 2015–16, and purse seine landings have likely declined as a result. Further to this, although the bottom trawl catch of trevally in TRE 1 has increasingly become more year-round, MHS catch is temporally less predictable. In TRE 2, landings have been almost entirely dominated by bottom trawl over recent years, with seasonal catches lower in winter.

For the representativeness of the catch-at-age samples collected relative to the fishery, it is important to note that to accommodate the sampling of a second fishing method the number of landings sampled in some area-method strata was sometimes small (as few as five landings sampled). As such, sampling representativeness relative to an entire fishery operating across a 12-month period will understandably have some departures. Given this, the sampling of trevally landings was still generally well aligned with the fishery in terms of temporal patterns in the weight and number of landings sampled, as well as the distribution of samples compared to whole fishery spatial, depth and target species distributions.

Because sampling in the present programme was conducted across two years, two TRE 1 sub-stocks (as well as TRE 2 in the second year of sampling only) and two fishing methods, various comparisons of length and age compositions can be made. Although sampling of trevally from ENHG MHS revealed a bimodal length distribution and an age distribution dominated by young fish in 2017–18, a bimodal length distribution was not present in 2019–20, and the age distribution had significantly broadened by this time. This could potentially be explained by the progression of year classes (some of the dominant year classes had indeed moved two years between the two sampling events as expected). However, it should be noted that the bottom trawl length and age compositions from ENHG in 2019–20 (bottom trawl was not sampled in ENHG in 2017–18) contained significantly more, smaller and younger fish relative to that of MHS in 2019–20. Interestingly, the pattern of relative year class strength was similar between the two fishing methods (for ages greater than 10), but bottom trawl contained proportionately more three to five year-old fish than MHS. It is difficult to tell if these differences are due to different selectivities between the two fishing methods as opposed to the contribution of the relatively small number of landings that were sampled.

Comparison of the two fishing methods in the BPLE provides some further insight. In 2017–18 the length and age composition of trevally caught by MHS in the BPLE had a similar pattern of year classes but contained more larger and older fish than bottom trawl. This is consistent with the comparison of MHS and bottom trawl in ENHG in 2019–20. However, comparison of the two methods in the BPLE in 2019–20 revealed very similar length and age compositions. As such, although there is some indication that bottom trawl may have a higher selectivity for smaller trevally, it is difficult to confirm whether this is due to selectivity differences or variation likely resulting from the small number of landings sampled.

Comparison of relative patterns in year class strength between sub-stocks can provide some insight about stock separation. Indeed Walsh et al. (2014a) noted that spatial heterogeneity in age within TRE 1 indicated the presence of more than one biological stock, but also noted some consistency in the pattern of relative year class strengths between the two sub-stocks sampled (i.e., ENHG and BPLE). Furthermore, tagging conducted by James (1980) observed that most trevally recaptures were within 30 nautical miles, suggesting relatively low levels of stock and sub-stock mixing. In the present study, some consistency was also noted in the relative year class strength pattern between the ENHG and BPLE sub-stocks. For example, strong year classes for 9, 12, and 14 year-old fish were evident in both sub-stocks in 2019–20, whereas many of the other year classes did not match up. Following on from the observation of similar patterns in CPUE between the BPLE and TRE 2 (Fisheries New Zealand 2021), sampling in 2019–20 provided a valuable first opportunity to assess patterns in relative year class strength between these two areas. Although some strong year classes were consistent between the two sub-stocks (notably 4, 9, and 21 year-old fish), many others did not match up. Indeed, the length and age composition of trevally in TRE 2 was notably different compared with the BPLE, with a bimodal length distribution present in TRE 2 and a much higher proportion of three and four year-old fish.

The age composition of trevally in ENHG has been dominated by young fish since the start of the time series in 2006–07. Sampling in 2019–20 revealed a broadening age composition, with significantly more older trevally present. Indeed, in 2019–20 trevally of 15 years or older were at the highest proportion ever for the ENHG time series. Observation of year class progression was difficult due to the seven-year gap between sampling events in 2012–13 and 2019–20. In the BPLE the time series trend of consistent broadening of the age composition and increasing mean age continued in 2017–18 and 2019–20. As for ENHG, the proportion of trevally of 15 years or older was the highest it had ever been in the BPLE in 2019–20. Although year class progression between 2012–13 and 2017–18 was not apparent, there was strong year class progression in the time series between 2017–18 and 2019–20.

The introduction of a revised trevally ageing protocol (Walsh et al. 2014b) for sampling conducted in 2012–13 is likely to have led to an improvement in reader competency. Trevally are inherently difficult to age and therefore some level of ageing error is always likely to be present in catch-at-age results, particularly when ageing older fish. For the present study there was, however, a good level of consistency between readers, although reader consistency was lower for ENHG in 2017–18. Despite these improvements and general reader consistency, the level of precision achieved was only marginally acceptable, with MWCVs ranging between 0.23 and 0.36, and only two of the eight area-method strata below the target MVCV of 0.30. These MWCVs were similar to those achieved for bottom trawl in 2012–13 (MWCVs of 0.32 and 0.25 for ENHG and BPLE respectively) (Walsh et al. 2014a). The reduction in the number of landings sampled within each area-method stratum to accommodate the inclusion of MHS sampling is likely to have contributed to the high MWCVs achieved. In addition, the broader age distributions and greater mean age compared with that of previous sampling would have also contributed. We recommend an assessment of the results of the present sampling programme should be used to optimise sample size targets before the next TRE 1 and/or TRE 2 catch sampling programme is initiated. Further, the next TRE 1 (and TRE 2) catch-at-age sampling programme should be initiated within three years to enable the progression of year classes to be observed, and any sudden changes in year class strength should be monitored reasonably frequently.

5. ACKNOWLEDGEMENTS

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Appendix 1: Proportion-at-age and -length for the various area-method fisheries in TRE 1 and TRE 2 in 2017–18 and 2019–20

MHS = Modular Harvest System; BT = bottom trawl; CV = coefficient of variation; *P.j.* = proportion of fish in an age or length class; mvcv = mean-weighted coefficient of variation; n = number of fish or otoliths pairs sampled

East Northland Hauraki Gulf proportion-at-age

	2017–18				2019–20			
	MHS		BT		MHS		BT	
	P.j.	CV	*P.j.*	CV	*P.j.*	CV	*P.j.*	CV
Age								
1	0.0000	0.00			0.0000	0.00	0.0006	1.53
2	0.1248	0.39			0.0000	0.00	0.0479	0.49
3	0.2078	0.19			0.0224	0.52	0.2012	0.29
4	0.0663	0.25			0.0478	0.32	0.1421	0.30
5	0.0938	0.45			0.1400	0.27	0.1969	0.22
6	0.0319	0.32			0.0665	0.34	0.0566	0.31
7	0.0486	0.30			0.0416	0.32	0.0326	0.36
8	0.0478	0.30			0.0308	0.34	0.0172	0.35
9	0.0377	0.32			0.0555	0.36	0.0370	0.32
10	0.0566	0.30			0.0399	0.26	0.0136	0.40
11	0.0233	0.46			0.0525	0.25	0.0192	0.35
12	0.0339	0.41			0.0989	0.19	0.0475	0.32
13	0.0299	0.35			0.0371	0.28	0.0184	0.44
14	0.0254	0.41			0.0573	0.28	0.0294	0.42
15	0.0202	0.47			0.0349	0.36	0.0163	0.46
16	0.0160	0.53			0.0468	0.28	0.0157	0.48
17	0.0401	0.41			0.0632	0.33	0.0215	0.45
18	0.0124	0.59			0.0280	0.36	0.0118	0.46
19	0.0105	0.59			0.0407	0.26	0.0214	0.47
20	0.0282	0.51			0.0166	0.42	0.0097	0.56
21	0.0126	0.55			0.0118	0.48	0.0078	0.64
22	0.0020	1.04			0.0313	0.38	0.0170	0.47
23	0.0078	0.65			0.0072	0.72	0.0026	0.64
24	0.0076	0.74			0.0048	0.92	0.0018	0.68
25	0.0019	1.05			0.0025	1.28	0.0032	0.96
26	0.0028	1.03			0.0124	0.51	0.0036	0.60
27	0.0000	0.00			0.0025	1.34	0.0006	1.22
28	0.0008	1.41			0.0039	1.00	0.0021	0.83
29	0.0020	1.11			0.0000	0.00	0.0000	0.00
30+	0.0074	0.86			0.0033	0.99	0.0043	0.86
n	529		Not sampled		531		591	
mwcv	0.3606				0.3204		0.3418	

Appendix 1 continued: Bay of Plenty proportion at age

	2017–18				2019–20			
	MHS		BT		MHS		BT	
	P.j.	CV	*P.j.*	CV	*P.j.*	CV	*P.j.*	CV
Age								
1	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00
2	0.0101	0.83	0.0020	1.34	0.0000	0.00	0.0000	0.00
3	0.0104	0.55	0.0416	0.38	0.0593	0.36	0.0572	0.30
4	0.0289	0.26	0.0570	0.35	0.1148	0.24	0.0937	0.33
5	0.0884	0.21	0.1751	0.19	0.1038	0.15	0.0692	0.24
6	0.0331	0.28	0.0661	0.26	0.0940	0.19	0.0635	0.31
7	0.1014	0.20	0.1375	0.15	0.1336	0.14	0.1161	0.17
8	0.0226	0.33	0.0245	0.36	0.0401	0.25	0.0360	0.45
9	0.0323	0.27	0.0378	0.30	0.0976	0.17	0.0803	0.24
10	0.0669	0.22	0.0575	0.30	0.0294	0.29	0.0299	0.34
11	0.0777	0.19	0.0656	0.26	0.0310	0.26	0.0385	0.37
12	0.0907	0.17	0.0712	0.19	0.0499	0.21	0.0620	0.26
13	0.0528	0.22	0.0371	0.31	0.0296	0.29	0.0258	0.38
14	0.0489	0.25	0.0371	0.35	0.0486	0.22	0.0663	0.21
15	0.0348	0.31	0.0210	0.69	0.0327	0.25	0.0484	0.30
16	0.0187	0.38	0.0131	0.58	0.0210	0.30	0.0304	0.44
17	0.0558	0.27	0.0275	0.59	0.0168	0.29	0.0293	0.35
18	0.0365	0.32	0.0171	0.50	0.0129	0.31	0.0205	0.38
19	0.0448	0.25	0.0241	0.52	0.0105	0.35	0.0194	0.54
20	0.0440	0.35	0.0200	0.51	0.0115	0.33	0.0252	0.45
21	0.0071	0.64	0.0037	1.11	0.0222	0.25	0.0353	0.38
22	0.0122	0.46	0.0069	0.70	0.0084	0.37	0.0113	0.57
23	0.0175	0.45	0.0089	0.60	0.0020	0.66	0.0017	1.19
24	0.0167	0.46	0.0092	0.61	0.0039	0.50	0.0090	0.63
25	0.0022	0.98	0.0021	1.36	0.0096	0.39	0.0094	0.57
26	0.0050	1.16	0.0028	1.48	0.0011	0.82	0.0028	0.99
27	0.0000	0.00	0.0000	0.00	0.0008	0.82	0.0026	1.05
28	0.0020	1.21	0.0033	1.27	0.0000	0.00	0.0000	0.00
29	0.0059	0.62	0.0083	0.78	0.0004	1.26	0.0010	1.50
30+	0.0310	0.49	0.0222	0.39	0.0144	0.36	0.0153	0.45
n	587		550		613		587	
mwcv	0.2856		0.3182		0.2292		0.3185	

Appendix 1 continued: TRE 2 proportion at age

	2019–20	
	BT	
	P.j.	CV
Age		
1	0.0015	1.44
2	0.0187	0.56
3	0.1723	0.31
4	0.2036	0.24
5	0.0524	0.27
6	0.0499	0.31
7	0.0291	0.37
8	0.0226	0.44
9	0.0569	0.32
10	0.0333	0.35
11	0.0271	0.32
12	0.0353	0.40
13	0.0492	0.32
14	0.0439	0.34
15	0.0106	0.63
16	0.0091	0.62
17	0.0124	0.53
18	0.0122	0.63
19	0.0209	0.39
20	0.0203	0.43
21	0.0362	0.42
22	0.0159	0.48
23	0.0044	0.76
24	0.0019	1.30
25	0.0045	0.76
26	0.0132	0.57
27	0.0063	0.80
28	0.0000	0.00
29	0.0066	0.75
30+	0.0297	0.45
n	593	
mwcv	0.3530	

Appendix 1 continued: East Northland Hauraki Gulf proportion at length

	2017–18				2019–20			
	MHS		BT		MHS		BT	
	P.j.	CV	*P.j.*	CV	*P.j.*	CV	*P.j.*	CV
Length								
20	0.0000	0.00			0.0000	0.00	0.0000	0.00
21	0.0000	0.00			0.0000	0.00	0.0000	0.00
22	0.0000	0.00			0.0000	0.00	0.0000	0.00
23	0.0011	1.33			0.0000	0.00	0.0000	0.00
24	0.0022	1.12			0.0000	0.00	0.0000	0.00
25	0.0025	0.94			0.0000	0.00	0.0000	0.00
26	0.0050	0.82			0.0000	0.00	0.0000	0.00
27	0.0010	0.87			0.0000	0.00	0.0011	1.31
28	0.0050	0.60			0.0000	0.00	0.0002	1.65
29	0.0164	0.45			0.0000	0.00	0.0009	1.31
30	0.0298	0.38			0.0000	0.00	0.0067	0.51
31	0.0503	0.40			0.0000	0.00	0.0167	0.51
32	0.0419	0.35			0.0000	0.00	0.0444	0.37
33	0.0494	0.35			0.0000	0.00	0.0578	0.38
34	0.0577	0.29			0.0046	0.90	0.0555	0.34
35	0.0764	0.25			0.0076	1.09	0.0832	0.33
36	0.0732	0.22			0.0180	0.78	0.0935	0.25
37	0.0568	0.18			0.0125	0.58	0.0653	0.34
38	0.0555	0.20			0.0359	0.40	0.0794	0.26
39	0.0508	0.18			0.0371	0.33	0.0788	0.24
40	0.0469	0.20			0.0535	0.33	0.0611	0.34
41	0.0411	0.20			0.0669	0.38	0.0513	0.31
42	0.0455	0.29			0.0971	0.23	0.0417	0.20
43	0.0545	0.33			0.1034	0.22	0.0414	0.30
44	0.0591	0.39			0.1501	0.16	0.0385	0.36
45	0.0560	0.41			0.1241	0.18	0.0333	0.46
46	0.0476	0.43			0.1275	0.19	0.0372	0.50
47	0.0331	0.41			0.0779	0.30	0.0227	0.46
48	0.0201	0.38			0.0482	0.33	0.0198	0.48
49	0.0089	0.44			0.0129	0.52	0.0190	0.51
50	0.0037	0.44			0.0072	0.72	0.0138	0.52
51	0.0028	0.46			0.0021	1.37	0.0111	0.61
52	0.0022	0.56			0.0052	0.84	0.0049	0.72
53	0.0012	1.14			0.0031	1.19	0.0075	0.60
54	0.0014	0.96			0.0036	0.96	0.0038	0.69
55	0.0003	1.38			0.0016	1.38	0.0029	0.76
56	0.0001	1.15			0.0000	0.00	0.0016	1.04
57	0.0000	0.00			0.0000	0.00	0.0009	1.09
58	0.0003	1.47			0.0000	0.00	0.0004	1.17
59	0.0000	0.00			0.0000	0.00	0.0009	1.28
60	0.0000	0.00			0.0000	0.00	0.0005	1.11
61	0.0000	0.00			0.0000	0.00	0.0004	1.45
62	0.0001	1.52			0.0000	0.00	0.0002	1.72
63	0.0000	0.00			0.0000	0.00	0.0008	1.07
64	0.0000	0.00			0.0000	0.00	0.0005	1.17
65	0.0000	0.00			0.0000	0.00	0.0002	1.73
66	0.0000	0.00			0.0000	0.00	0.0000	0.00
67	0.0000	0.00			0.0000	0.00	0.0000	0.00
68	0.0000	0.00			0.0000	0.00	0.0002	1.54
69	0.0000	0.00			0.0000	0.00	0.0000	0.00
70	0.0000	0.00			0.0000	0.00	0.0000	0.00
n	4 421		Not sampled		531		1 827	
mwcv	0.3164				0.2889		0.3597	

Appendix 1 continued: Bay of Plenty proportion at length

	2017–18				2019–20			
	MHS		BT		MHS		BT	
	P.j.	CV	*P.j.*	CV	*P.j.*	CV	*P.j.*	CV
Length								
20	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00
21	0.0010	1.34	0.0000	0.00	0.0000	0.00	0.0000	0.00
22	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00
23	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00
24	0.0000	0.00	0.0005	1.36	0.0000	0.00	0.0000	0.00
25	0.0000	0.00	0.0006	1.05	0.0000	0.00	0.0000	0.00
26	0.0041	0.93	0.0007	1.24	0.0000	0.00	0.0000	0.00
27	0.0043	0.85	0.0009	1.01	0.0000	0.00	0.0000	0.00
28	0.0033	0.86	0.0011	0.92	0.0001	2.09	0.0000	0.00
29	0.0006	1.25	0.0024	0.74	0.0000	0.00	0.0025	1.35
30	0.0012	1.22	0.0053	0.51	0.0007	1.42	0.0049	1.17
31	0.0057	0.63	0.0134	0.48	0.0042	1.05	0.0124	0.83
32	0.0083	0.44	0.0168	0.41	0.0117	0.90	0.0315	0.85
33	0.0061	0.68	0.0290	0.47	0.0252	0.58	0.0257	0.65
34	0.0070	0.53	0.0544	0.34	0.0383	0.48	0.0180	0.47
35	0.0112	0.38	0.0600	0.32	0.0457	0.33	0.0427	0.39
36	0.0198	0.29	0.0752	0.27	0.0758	0.15	0.0432	0.39
37	0.0348	0.20	0.0736	0.24	0.0884	0.12	0.0461	0.38
38	0.0759	0.26	0.0814	0.20	0.0775	0.17	0.0506	0.30
39	0.0727	0.25	0.0785	0.12	0.1230	0.16	0.0658	0.23
40	0.0863	0.23	0.1011	0.12	0.1184	0.15	0.0923	0.18
41	0.1400	0.16	0.0921	0.26	0.1141	0.17	0.1229	0.21
42	0.1665	0.14	0.1054	0.29	0.0873	0.21	0.1259	0.24
43	0.1200	0.16	0.0900	0.29	0.0786	0.22	0.1223	0.28
44	0.1003	0.19	0.0538	0.31	0.0429	0.27	0.0766	0.21
45	0.0553	0.39	0.0282	0.31	0.0348	0.23	0.0493	0.35
46	0.0254	0.44	0.0159	0.21	0.0115	0.34	0.0245	0.40
47	0.0248	0.44	0.0072	0.32	0.0084	0.41	0.0198	0.49
48	0.0122	0.53	0.0045	0.40	0.0054	0.50	0.0121	0.59
49	0.0078	0.50	0.0026	0.63	0.0035	0.59	0.0047	0.85
50	0.0031	0.65	0.0041	0.41	0.0005	1.59	0.0031	0.92
51	0.0010	0.86	0.0008	0.82	0.0032	0.99	0.0006	1.60
52	0.0005	1.16	0.0000	0.00	0.0002	1.69	0.0006	1.54
53	0.0003	1.44	0.0000	0.00	0.0002	1.90	0.0009	1.48
54	0.0004	1.45	0.0007	1.03	0.0003	1.56	0.0000	0.00
55	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00
56	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00
57	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0009	1.48
58	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00
59	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00
60	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00
61	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00
62	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00
63	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00
64	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00
65	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00
66	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00
67	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00
68	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00
69	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00
70	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00
n	1 835		2 792		1 543		587	
mwcv	0.2485		0.2677		0.2375		0.3324	

Appendix 1 continued: TRE 2 proportion at length

	2019–20	
	BT	
	P.j.	CV
Length		
20	0.0000	0.00
21	0.0000	0.00
22	0.0000	0.00
23	0.0000	0.00
24	0.0000	0.00
25	0.0021	0.00
26	0.0145	0.00
27	0.0152	0.00
28	0.0397	0.00
29	0.0459	0.00
30	0.0545	0.00
31	0.0881	0.00
32	0.0643	0.00
33	0.0492	0.00
34	0.0443	0.90
35	0.0275	1.09
36	0.0399	0.78
37	0.0354	0.58
38	0.0378	0.40
39	0.0367	0.33
40	0.0606	0.33
41	0.0705	0.38
42	0.0613	0.23
43	0.0443	0.22
44	0.0323	0.16
45	0.0409	0.18
46	0.0266	0.19
47	0.0385	0.30
48	0.0139	0.33
49	0.0101	0.52
50	0.0048	0.72
51	0.0000	1.37
52	0.0000	0.84
53	0.0012	1.19
54	0.0000	0.96
55	0.0000	1.38
56	0.0000	0.00
57	0.0000	0.00
58	0.0000	0.00
59	0.0000	0.00
60	0.0000	0.00
61	0.0000	0.00
62	0.0000	0.00
63	0.0000	0.00
64	0.0000	0.00
65	0.0000	0.00
66	0.0000	0.00
67	0.0000	0.00
68	0.0000	0.00
69	0.0000	0.00
70	0.0000	0.00
n	593	
mwcv	0.3516	

Appendix 2: Age-length keys derived from otolith samples collected from trevally fisheries 2017–18 and 2019–20

East Northland Hauraki Gulf bottom trawl in 2017–18

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	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
25	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1
26	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2
27	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1
28	0.00	0.50	0.30	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
29	0.00	0.00	0.60	0.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5
30	0.00	0.00	0.67	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6
31	0.00	0.00	0.78	0.00	0.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9
32	0.00	0.00	0.11	0.11	0.67	0.00	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9
33	0.00	0.00	0.17	0.22	0.44	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	18
34	0.00	0.00	0.07	0.10	0.55	0.10	0.10	0.00	0.03	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	29
35	0.00	0.00	0.08	0.14	0.39	0.08	0.22	0.00	0.06	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	36
36	0.00	0.00	0.03	0.08	0.25	0.18	0.30	0.08	0.00	0.05	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	40
37	0.00	0.00	0.00	0.22	0.10	0.10	0.32	0.00	0.10	0.05	0.02	0.07	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	41
38	0.00	0.00	0.00	0.10	0.27	0.07	0.22	0.07	0.02	0.07	0.05	0.02	0.07	0.02	0.00	0.00	0.00	0.00	0.00	0.00	41
39	0.00	0.00	0.00	0.03	0.30	0.09	0.18	0.09	0.09	0.03	0.09	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	33
40	0.00	0.00	0.00	0.05	0.10	0.10	0.20	0.02	0.05	0.08	0.15	0.10	0.02	0.07	0.02	0.02	0.00	0.00	0.00	0.03	60
41	0.00	0.00	0.00	0.00	0.06	0.02	0.18	0.00	0.02	0.10	0.12	0.10	0.04	0.06	0.10	0.00	0.08	0.02	0.08	0.04	51
42	0.00	0.00	0.00	0.00	0.02	0.00	0.04	0.02	0.02	0.17	0.11	0.15	0.09	0.09	0.02	0.06	0.08	0.04	0.06	0.04	53
43	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.04	0.05	0.04	0.05	0.15	0.09	0.05	0.04	0.05	0.07	0.05	0.07	0.22	55
44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.03	0.11	0.14	0.11	0.06	0.06	0.00	0.06	0.11	0.06	0.23	35
45	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.09	0.00	0.18	0.09	0.09	0.45	11
46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.05	0.00	0.05	0.05	0.11	0.05	0.11	0.53	19
47	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.13	0.00	0.75	8
48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	11
49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.75	4
50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	7
51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1
52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1
53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
54	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
57	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
59	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
61	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
66	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
69	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
Total																					587

Appendix 2 continued: East Northland Hauraki Gulf bottom trawl in 2019–20

Length	Age (years)																				No.
(cm)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	>19	Aged
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
26	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1
27	0.25	0.00	0.50	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
28	0.50	0.00	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2
29	0.25	0.50	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
30	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1
31	0.00	0.33	0.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6
32	0.00	0.43	0.57	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7
33	0.00	0.14	0.86	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7
34	0.00	0.14	0.29	0.43	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7
35	0.00	0.00	0.43	0.29	0.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7
36	0.00	0.00	0.25	0.17	0.25	0.08	0.17	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12
37	0.00	0.00	0.29	0.43	0.00	0.14	0.00	0.00	0.00	0.00	0.00	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7
38	0.00	0.00	0.20	0.35	0.30	0.05	0.00	0.05	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	20
39	0.00	0.00	0.05	0.14	0.62	0.10	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	21
40	0.00	0.00	0.00	0.10	0.41	0.14	0.03	0.03	0.03	0.03	0.03	0.10	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.03	29
41	0.00	0.00	0.03	0.06	0.53	0.15	0.06	0.03	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.03	0.03	0.03	34
42	0.00	0.00	0.00	0.02	0.25	0.10	0.08	0.12	0.00	0.00	0.12	0.12	0.06	0.04	0.04	0.00	0.00	0.00	0.02	0.06	52
43	0.00	0.00	0.00	0.02	0.09	0.07	0.07	0.05	0.09	0.07	0.04	0.05	0.09	0.11	0.05	0.04	0.00	0.00	0.04	0.11	55
44	0.00	0.00	0.00	0.01	0.05	0.04	0.10	0.06	0.06	0.09	0.12	0.14	0.04	0.03	0.03	0.04	0.05	0.01	0.01	0.10	77
45	0.00	0.00	0.00	0.00	0.00	0.05	0.02	0.00	0.13	0.05	0.05	0.18	0.02	0.10	0.07	0.05	0.08	0.08	0.05	0.08	61
46	0.00	0.00	0.00	0.00	0.00	0.03	0.02	0.00	0.03	0.08	0.05	0.14	0.06	0.11	0.03	0.12	0.12	0.05	0.06	0.12	66
47	0.00	0.00	0.00	0.02	0.00	0.00	0.02	0.00	0.07	0.02	0.02	0.10	0.07	0.07	0.10	0.07	0.20	0.07	0.02	0.12	41
48	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.04	0.00	0.07	0.04	0.04	0.07	0.00	0.11	0.15	0.04	0.19	0.22	27
49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.14	0.14	0.00	0.00	0.14	0.43	7
50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.00	0.14	0.00	0.00	0.00	0.00	0.14	0.57	7
51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.25	0.00	0.00	0.25	0.00	0.00	0.00	4
52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.20	0.20	0.00	0.00	0.20	0.20	0.00	5
53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.13	0.00	0.13	0.13	0.00	0.00	0.00	0.25	0.25	8
54	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.00	0.00	0.33	0.00	0.17	0.33	0.00	0.00	6
55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.25	0.50	0.00	4
56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1
57	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.50	2
58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1
59	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1
60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1
61	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0
62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1
63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1
64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1
65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1
66	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
69	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
Total																					591

Appendix 2 continued: Bay of Plenty MHS in 2019–20

Length	Age (years)																				No.
(cm)		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	>19	Aged
20		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
21		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
22		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
23		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
24		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
25		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
26		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
27		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
28		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
29		0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1
30		0.00	0.00	0.67	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3
31		0.00	0.00	0.43	0.57	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7
32		0.00	0.00	0.30	0.35	0.10	0.20	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	20
33		0.00	0.00	0.11	0.63	0.05	0.16	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	19
34		0.00	0.00	0.32	0.16	0.05	0.32	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	19
35		0.00	0.00	0.27	0.27	0.14	0.14	0.09	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	22
36		0.00	0.00	0.13	0.25	0.08	0.17	0.13	0.08	0.08	0.00	0.00	0.00	0.00	0.04	0.04	0.00	0.00	0.00	0.00	0.00	24
37		0.00	0.00	0.16	0.20	0.20	0.16	0.08	0.00	0.16	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	25
38		0.00	0.00	0.03	0.14	0.17	0.10	0.24	0.10	0.10	0.03	0.03	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	29
39		0.00	0.00	0.00	0.11	0.25	0.06	0.25	0.03	0.11	0.08	0.03	0.00	0.06	0.03	0.00	0.00	0.00	0.00	0.00	0.00	36
40		0.00	0.00	0.00	0.09	0.11	0.13	0.13	0.06	0.20	0.00	0.04	0.13	0.04	0.00	0.02	0.02	0.02	0.00	0.00	0.02	54
41		0.00	0.00	0.00	0.01	0.07	0.07	0.19	0.06	0.12	0.07	0.07	0.07	0.03	0.07	0.04	0.03	0.01	0.00	0.00	0.07	69
42		0.00	0.00	0.00	0.00	0.01	0.04	0.14	0.04	0.13	0.06	0.06	0.04	0.06	0.17	0.06	0.04	0.01	0.06	0.01	0.06	70
43		0.00	0.00	0.00	0.00	0.03	0.00	0.07	0.03	0.04	0.01	0.04	0.13	0.09	0.12	0.12	0.04	0.03	0.01	0.06	0.16	68
44		0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.04	0.00	0.04	0.12	0.06	0.16	0.08	0.04	0.10	0.04	0.04	0.24	50
45		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.06	0.06	0.03	0.00	0.03	0.12	0.06	0.09	0.09	0.06	0.38	34
46		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.05	0.00	0.05	0.05	0.10	0.10	0.00	0.60	20
47		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.05	0.00	0.10	0.00	0.15	0.05	0.05	0.10	0.45	20
48		0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.00	0.00	0.08	0.08	0.00	0.62	13
49		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.67	3
50		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	3
51		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1
52		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1
53		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1
54		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0
55		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0
56		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0
57		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1
58		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
59		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
60		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
61		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
62		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
63		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
64		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
65		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
66		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
67		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
68		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
69		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
70		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
Total																						613