Fisheries New Zealand
Tini a Tangaroa

Trawl surveys of the Hauraki Gulf and Bay of Plenty in 2020 and 2021 to estimate the abundance of juvenile snapper

New Zealand Fisheries Assessment Report 2022/10

D.M. Parsons,
R. Bian

ISSN 1179-5352 (online)
ISBN 978-1-99-102667-5 (online)

April 2022

Te Kāwanatanga o Aotearoa
New Zealand Government

Disclaimer

Requests for further copies should be directed to:

Fisheries Science Editor
Fisheries New Zealand
Ministry for Primary Industries
PO Box 2526
Wellington 6140
NEW ZEALAND

Email: Fisheries-Science.Editor@mpi.govt.nz
Telephone: 0800 00 83 33

This publication is also available on the Ministry for Primary Industries websites at:
http://www.mpi.govt.nz/news-and-resources/publications
http://fs.fish.govt.nz go to Document library/Research reports

Please cite this report as:

Parsons, D.M.; Bian, R. (2022). Trawl surveys of the Hauraki Gulf and Bay of Plenty in 2020 and 2021 to estimate the abundance of juvenile snapper. *New Zealand Fisheries Assessment Report 2022/10.* 134 p.

TABLE OF CONTENTS

EXECUTIVE SUMMARY

Parsons, D.M.[1]; Bian, R.[1] (2022). Trawl surveys of the Hauraki Gulf and Bay of Plenty in 2020 and 2021 to estimate the abundance of juvenile snapper.

New Zealand Fisheries Assessment Report 2022/10. **134 p.**

This report presents the results of inshore trawl surveys of the Hauraki Gulf (2020) and Bay of Plenty (2021) using the R.V. *Kaharoa*. Hauraki Gulf and Bay of Plenty surveys were conducted the year before (2019 and 2020, respectively), but prior to this, surveys had not been conducted for 19 (Hauraki Gulf) and 20 (Bay of Plenty) years.

The recent surveys took place between 17 November and 5 December 2020 (Hauraki Gulf) and 1 to 14 February 2021 (Bay of Plenty) and used a stratified two-phase design targeted at pre-recruit snapper. A total of 36 phase one and 7 phase two stations were completed for the Hauraki Gulf, and 40 phase one and 10 phase two stations were successfully completed in the Bay of Plenty. Phase two stations were conducted to reduce the coefficient of variation (CV) for recruit snapper in the Hauraki Gulf and pre-recruit snapper in the Bay of Plenty. In the Bay of Plenty, 14 additional extended phase two stations were also conducted to reduce the CV for John dory, trevally, and tarakihi.

In the Hauraki Gulf, the estimated year class strength (YCS) of 1+ and 2+ snapper (the 2019 and 2018 year classes) was 8.0 (CV = 16.6%) and 5.8 (CV = 14.4%) million fish, respectively. These estimates were both well above the average YCS estimates for the entire Hauraki Gulf survey series (average YCS is 3.9 and 3.6 million for 1+ and 2+ snapper, respectively), but well below the YCS predictions based on a previously established temperature-recruitment relationship. Estimates of the 2018 YCS from the two recent *Kaharoa* surveys were consistent (5.4 million as 1+ fish in 2019 and 5.8 million as 2+ fish 2020). In the Bay of Plenty, the estimated YCS of 1+ and 2+ snapper (the 2020 and 2019 year classes) was 1.37 (CV = 38.5%) and 0.94 (CV = 18.0%) million fish, respectively. Again, both these estimates were well above average for the entire Bay of Plenty survey series (average YCS is 0.44 and 0.54 million for 1+ and 2+ snapper, respectively). The spatial distribution of snapper (especially pre-recruit snapper) in the Bay of Plenty in 2021 was restricted to the eastern bay, as it was in 2020. If this pattern represents a recent constriction of recruit habitats for snapper in the Bay of Plenty, it should be investigated. However, the influence of water clarity on snapper catch rates is potentially influential and should be investigated across the survey series.

The Hauraki Gulf and Bay of Plenty trawl surveys series may also provide potential to monitor the relative abundance of recruited snapper and other fish species. In the Hauraki Gulf, the estimated total snapper biomass was 23 876 t (CV = 17.0%), whereas in the Bay of Plenty it was 3506 t (CV = 17.7%), representing increases of 16% and 24%, respectively, since the year before. Other species that the Hauraki Gulf and Bay of Plenty surveys may have some potential to monitor include: red gurnard (Hauraki Gulf: 196 t, CV = 21.5%; Bay of Plenty: 118 t, CV = 10.7%); John dory (Hauraki Gulf: 159 t, CV = 30.5%; Bay of Plenty: 95 t, CV = 27.0%); leatherjacket (Hauraki Gulf: 223 t, CV = 21.2%; Bay of Plenty: 88 t, CV = 16.1%); and trevally (Hauraki Gulf: 73 t, CV = 59.3%; Bay of Plenty: 35 t, CV = 20.0%). For the Hauraki Gulf, the biomass of red gurnard increased, whereas John dory, trevally, and leatherjacket decreased relative to the survey estimates from the year before. In the Bay of Plenty, John dory increased and red gurnard, trevally, and leatherjacket decreased relative to the year before.

[1] National Institute of Water and Atmospheric Research (NIWA), New Zealand.

1. INTRODUCTION

The northern inshore trawl survey series were initiated in the early 1980s to monitor the status of snapper (SNA, *Chrysophrys auratus*), with secondary target species of John dory (JDO, *Zeus faber*) and red gurnard (GUR, *Chelidonichtys kumu*). These trawl surveys were conducted from the R.V. *Kaharoa* across separate SNA 1 sub-stocks in east Northland, the Hauraki Gulf, and the Bay of Plenty. Although only two east Northland surveys were conducted due to large areas of untrawlable ground (Drury & Hartill 1994, Drury & McKenzie 1992a), six surveys were conducted in the Bay of Plenty (Drury & Hartill 1993, Drury & McKenzie 1992b, Morrison 1997, Morrison & Parkinson 2000), and twelve were conducted in the Hauraki Gulf (Drury & McKenzie 1992c, Langley 1994a, Langley 1994b, Langley 1994c, Morrison & Francis 1999, Morrison et al. 2001a).

In the Hauraki Gulf, the target of the survey was shifted in the mid-1980s to focus on juvenile (1+) snapper. Various other changes in target occurred to the other surveys as well, with snapper eventually being dropped as a target from the Bay of Plenty survey in 1999, and with deeper strata added to better target tarakihi (NMP, *Nemadactylus macropterus*) (, Morrison & Parkinson 2000, Morrison et al. 2001a, Morrison et al. 2001b, Morrison et al. 2013). The focus on juvenile snapper in the Hauraki Gulf was because SNA 1 recruitment has high inter-annual variation, which influences the yield available to commercial and recreational fisheries and could be effectively monitored by a trawl survey that estimated the abundance of recruiting year classes. The extensive survey series in the Hauraki Gulf proved capable of monitoring year-class strength for 1+ pre-recruit snapper. This time series was also used to establish a strong relationship between snapper recruitment strength and sea surface temperature (SST) (Francis 1993, Francis et al. 1995).

These northern trawl survey series were discontinued after 2000 (Hauraki Gulf) and after 1999 (Bay of Plenty). At this time, it was decided that snapper year class strength information could be more cost-effectively gathered by sampling commercial fish sheds for proportions-at-age in the catch. Although commercial catch sampling can provide a wider spatial-temporal coverage than trawl surveys, it has a critical disadvantage in that only fishery-recruited cohorts can be monitored. The advantage of estimating year class strength from a trawl survey is that it provides advanced information about weak or strong year classes that are yet to recruit to the fishery, which informs model projections. With the next SNA 1 assessment scheduled for 2021–22, SNA 1 pre-recruit surveys in the Hauraki Gulf and Bay of Plenty were re-initiated in 2019 and 2020, respectively. These surveys were timed to provide the most up to date information about the strength of year classes that will recruit to the SNA 1 fishery to assist with predicting SNA 1 yield out to 2025. The surveys conducted in 2019 and 2020 were successful in that they were able to estimate the year class strength of 1+ and 2+ snapper with a reasonable level of precision, and also demonstrated potential to monitor the relative abundance of recruited year classes of a range of species, including snapper.

This report details the results of the second of the re-initiated Hauraki Gulf and Bay of Plenty surveys, conducted in 2020 and 2021 respectively, and is timed to further strengthen the estimates of year class strength going into the SNA 1 assessment. This report fulfils the final reporting requirements of Fisheries New Zealand project INT2020–02.

1.1 Overall Objective

To determine the relative abundance of 1+ and 2+ pre-recruit snapper in the Hauraki Gulf and Bay of Plenty sub-stock regions of SNA 1.

1.2 Specific objectives

1. To design an updated R.V. *Kaharoa* Hauraki Gulf and Bay of Plenty trawl survey focused on estimating the abundance of 1+ and 2+ snapper over trawlable habitat in under 100 m depths

for the purpose of estimating relative annual abundance (year class strength). The target CV for the estimate of biomass of SNA <25 cm is 20%.

2. To determine the relative abundance and distribution of 1+ and 2+ snapper in the Hauraki Gulf spring-summer (October to November) period and the Bay of Plenty summer (January to February) period during the 2020–21 fishing year, by carrying out R.V. *Kaharoa* trawl surveys over the depth range 10 to 100 m. The target CV for the estimate of biomass of SNA <25 cm is 20%.
3. To collect the necessary data and determine the length frequency, length-weight relationship, and reproductive condition of snapper, and other Quota Management System (QMS) species.
4. To collect otoliths from snapper from Hauraki Gulf and Bay of Plenty.
5. To collect the data to determine the catch weight of all species caught and the length frequencies and spawning condition of all other QMS species.
6. To identify benthic macro-invertebrates collected during the trawl survey.

2. METHODS

2.1 Survey areas and design

Two separate two-phase stratified random trawl surveys (Francis 1984) were conducted. Survey areas and stratification were based on those used in the 2019 (Hauraki Gulf) and 2020 (Bay of Plenty) surveys. This stratification was evaluated relative to spatial patterns in the catch rates of all snapper and under 25 cm (fork length, FL) snapper from the 2019 (KAH1907) and 2020 (KAH2001) surveys.

For the Hauraki Gulf, no changes to stratification were made. The final stratification had eleven strata that encompassed 5004 km^2, depths of 10–75 m, and an area that included all the inner Hauraki Gulf and the outer gulf, from Bream Bay in the northwest to the Mercury Islands in the southeast (Table 1, Figure 1). For the Bay of Plenty, a component polygon of stratum 5187 had higher catch rates than the rest of that stratum in 2020. That polygon was merged with stratum 4085 for 2021. The resulting new strata were denoted as 518M and 408M. The final stratification had nine strata that encompassed 3989 km^2, depths of 10–100 m, and an area that stretched from the Mercury Islands in the northwest to Cape Runaway in the east (Table 1, Figure 1). As done for the historical surveys conducted in these areas, untrawlable ground was not included in the survey areas.

Station allocation for the surveys was determined using NIWA's R function *allocate* (see appendix 2 of Francis & Fu (2012)) using the catch rate data for pre-recruit (under 25 cm) snapper from the KAH1901 survey for the Hauraki Gulf and from the KAH2001 for the Bay of Plenty. Specifying a minimum of three stations per stratum, the phase one allocation was calculated to achieve a target coefficient of variation (CV) of 20%. A separate *allocate* analysis using data for all snapper from the same surveys (i.e., KAH1901 survey for the Hauraki Gulf and KAH2001 for the Bay of Plenty) was also conducted to ensure that the station allocation designed for pre-recruit snapper would serve as an effective design for all snapper. The final allocation for both surveys is presented in Table 1. Overall, 36 phase one stations were planned for the Hauraki Gulf and 40 for the Bay of Plenty.

Station positions were randomly generated using NIWA's custom software 'RandomStation'. The stations were required to be a minimum of 1.852 km (1 nautical mile, n. mile) apart. Non-trawlable ground was already excluded from the survey strata and was therefore also excluded from the station allocation.

2.2 Vessel, gear, and trawling procedure

R.V. *Kaharoa* is a 28-m stern trawler with a beam of 8.2 m, displacement of 302 t, engine power of 522 kW, and is capable of trawling to depths of 500 m. To be consistent with the historic trawl surveys, both the Hauraki Gulf and Bay of Plenty surveys used the high opening bottom trawl (HOBT) net, with cut away lower wings and a nominal 40-mm codend (Morrison et al. 2013). Depending on depth, the net should achieve doorspreads of 70–90 m and headline heights of 5–6 m (Morrison et al. 2013).

Procedures followed those recommended by Stevenson & Hanchet (1999). All tows were undertaken in the daylight (between 0530 and 1700 hours NZST). For each tow, the vessel steamed to the station position and, if necessary, the bottom was checked with the echosounder to determine whether it was suitable for bottom trawling. Once the station was considered trawlable, the gear was shot away so that the midpoint of the tow would coincide as closely as possible with the generated position. The direction of the tow was influenced by a combination of factors, including weather conditions, tides, bottom contours, and the location of the next tow.

If the station was found to be in an area of untrawlable ground or if another vessel was at the station, an area within 5 km of the station was searched for a replacement tow path. If the search was unsuccessful, the station was abandoned and the next alternative station within the stratum was chosen from the random station list. Standard tows were 0.7 n. mile with a minimum valid tow length of 0.5 n. mile (i.e., tows were hauled early if large amounts of fish were observed going into the net). As such, standard tows were about 14 minutes in duration at a speed over the ground of 3.0–3.5 knots. The tow was deemed to have started when the net monitor indicated that the net was on the bottom and performing correctly and was completed when hauling began. A warp length of 200 m was used for most tows in less than 50 m depth. At depths between 50 and 75 m, a warp length of 250 m was used and for tows in depths greater than 75 m, a warp length of 275 m was used.

Headline height and doorspread were recorded from a Marport net monitor and Scanmar sensors, respectively. The surface and bottom temperatures and salinity at each station were recorded by a calibrated Seabird Microcat Conductivity Temperature Depth (CTD) unit that was attached to the headline of the trawl. Surface temperatures were taken at a depth of 5 m below the surface. Bottom temperatures were taken at about 5 m above the sea floor. In addition to water temperature and salinity, water clarity (secchi depth), wind direction and speed, sea condition and colour, and swell height and direction were recorded for each trawl station. Acoustic data were also recorded during and between tows using the Simrad ES60 echosounder and hull-mounted 38 kHz transducer.

2.3 Catch and biological sampling

The catch from each tow was sorted into species on deck and weighed on electronic motion-compensating Marel scales to the nearest 0.1 kg. Organisms were identified to species, where possible. Crustaceans, shellfish, and other invertebrate species not readily identified were frozen for later identification on shore. Unidentified specimens were placed in sealed plastic bags with a label noting the trip code and station number.

Length, to the nearest whole centimetre (cm) below the measured length, and sex (where possible) were recorded for all species managed under the Quota Management System (QMS) and a selection of non-QMS species. Either the whole catch or a randomly selected subsample of up to 100 fish per tow were measured. For snapper, John dory, red gurnard, tarakihi, and some other important species, more detailed biological examinations were carried out on a sub-sample of up to 20 fish per tow. This included individual fish weight (grams), length to the nearest millimetre, sex, and gonad stage (using the middle depths gonad stage definitions given in Appendix 1). Otoliths were collected from the (up to) 20 snapper that were biologically sampled at each station. As each voyage progressed, length frequency plots for snapper were used to identify length classes where additional otoliths were required (the aim was to obtain 10 snapper otoliths per centimetre length class and for these otoliths to be representative of the spatial strata for each survey).

2.4 Otolith preparation and aging

About 700 snapper otoliths were selected for ageing from each survey. For most one-centimetre length classes, all otoliths collected were aged, but for the most common length classes (i.e., 20–35 cm), a sub-set of 20 otolith pairs per length class were randomly selected.

For the selected set of about 700 otolith pairs from each survey, preparation followed the break and burn technique (Chugunova 1963) and a standardised procedure for reading otoliths was followed, outlined in the age determination protocol for snapper (Walsh et al. 2014). Two readers were used, with each reader having no prior knowledge of the other's zone count obtained or of the fish length. For otoliths where both readers agreed on the zone count, the age was determined from this count. When readers disagreed, the otolith was re-examined by both readers together to determine the likely source of disagreement and a final count agreed upon. The forced margin method was implemented to anticipate the otolith margin type (wide, line, narrow) *a priori* based on the month in which the fish was sampled to provide guidance in determining age. The theoretical birth date for ageing snapper is 1 January following (Paul 1976), and, to be consistent with past trawl survey snapper ageing, otoliths were aged as age groups (i.e., 0+, 1+, etc.) from the collection date (November 2020 for the Hauraki Gulf and February 2021 for the Bay of Plenty). The resulting final ages were then used to form an Age Length Key (ALK) using NIWA's catch-at-length and -age analysis software tool CALA (Francis & Bian 2011).

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

2.5 Historical survey time series

Data from the previous surveys of the Hauraki Gulf (13 surveys, 1984–2019) and Bay of Plenty (7 surveys, 1983–2020) were obtained from the Fisheries New Zealand *trawl* database. Data from these previous surveys were analysed as described by Parsons et al. (2021), with some important exceptions. The entire analysis process for the previous surveys is outlined below.

In a small number of instances, the data from previous surveys contained some errors that were dealt with as follows.

1. Where length data were recorded but catch weight data were absent, a calculated catch weight using appropriate length-weight coefficients for that species was used (Appendix 2), by scaling up to the total weight caught using the percent sampled data for that species and station.
2. Where percent sampled was absent, the appropriate length-weight coefficients for that species (Appendix 2) and the available catch weight data were used to calculate percent sampled for that species and station.
3. Where the sum of the number of male and female fish measured was greater than the sum of all that was listed for that species, it was assumed that the sum of the number of male and female fish was the correct value.
4. Where there were multiple percent sampled values listed for a species at a station, it was assumed that separate sub-catches should have been denoted, and so, retrospectively, sub-catches were applied.

Although Parsons et al. (2021) re-stratified the previous survey data, this was not done for the present report. This important change follows the advice of the Inshore Working Group, which had noted that re-stratifying survey stations could violate the assumptions of random station allocation. As such, the stratum areas used throughout both the Hauraki Gulf and Bay of Plenty time series were investigated. Subsets of the original survey strata could be selected for each survey in the series, with the total area of these subsets being virtually identical to the survey areas of the Hauraki Gulf and Bay of Plenty surveys in 2020 and 2021, respectively. These subsets of original historical survey strata were then used

for the subsequent analysis of each historical survey. While conducting this assessment of the historical survey strata, also it was noticed that the distribution of stations from the KAH8716 survey had very poor coverage of the Hauraki Gulf survey area. As a result, this survey was not included in the Hauraki Gulf time series.

Age data for snapper used from these historical surveys were the same data as used by Parsons et al. (2021). Briefly, these age data were obtained from the ALKs published in the survey reports (where available) and from Fisheries New Zealand *age* database. For the Hauraki Gulf, reports with ALKs were available for the seven surveys conducted after 1990. For the five Hauraki Gulf surveys conducted in the 1980s (KAH8716 had already been removed), the age data from the database were first inspected. Because the Hauraki Gulf survey is conducted just prior to the theoretical birth date for ageing snapper (1 January), otolith readers sometimes record fish ages as being one year older than they actually are. In these instances (identified when the age data for a survey contained no fish in the 0+ age cohort), one year from all ages was subtracted before utilising these age data. CALA was then used to calculate ALKs for all the Hauraki Gulf surveys from the 1980s. For one survey (KAH8517), the ALK produced was anomalous, with the length classes for some ages not matching the other ALKs. Further, the ALK produced for this survey had considerable overlap for the young age cohorts (i.e., 1+ and 2+ fish). For this survey, modal analysis of the scaled length frequency distributions was conducted to estimate the number of fish at age. This involved specifying a lower and upper size limit for the 1+ cohort, and then calculating the number of fish within this size range from the scaled length frequency distribution. Because only the 1+ cohort was clearly defined and largely separate from other cohorts, this modal analysis was conducted only for the 1+ cohort. For the Bay of Plenty, reports with ALKs were available for three of the five surveys conducted in the 1990s (KAH9004, KAH9202, KAH9601) and for the 2000 survey (KAH2001). For the remaining three Bay of Plenty surveys (KAH8303, KAH8506, KAH9902), otoliths were collected, but not aged. For these surveys, modal analysis was performed to estimate the number of fish in the 1+ cohort only.

2.6 Data analysis

Biomasses and their associated CVs were estimated by the area-swept method (Francis 1981, Francis 1984) using the SurvCalc Program (Francis & Fu 2012). Biomass estimates were also re-calculated for all the historic survey data series. Only tows for which the gear performance was satisfactory (code 1 or 2) were incorporated into the scaled length frequency distributions, biomass estimates, and relative abundance estimates.

The following assumptions were made for calculating biomass estimates with the SurvCalc Program.

1. The area swept during each tow equalled the distance between the doors multiplied by the distance towed.
2. Vulnerability was 1.0. This assumes that all fish in the area swept were caught and there was no escapement.
3. Vertical availability was 1.0. This assumes that all fish in the water column were below the headline height and available to the net.
4. Areal availability was 1.0. This assumes that the fish stock being sampled was entirely within the survey area at the time of the survey.
5. Non-trawlable ground was excluded from the survey area.

It is unlikely that all these assumptions are correct, but they have been applied consistently to the entire trawl survey time series for both the Hauraki Gulf and the Bay of Plenty. Given that the assumptions are likely to be violated, the biomass estimates generated should be treated as relative indices of abundance.

Length frequencies were scaled by the percentage of catch sampled, area swept, and stratum area using CALA (Francis & Bian 2011). The geometric mean functional relationship was used to calculate length-weight coefficients for species where sufficient length-weight data were collected. For other species,

and often for the historic surveys where length-weight data were not as commonly recorded, coefficients were chosen from the *rdb* database and other published data sources (Appendix 2).

Sex ratios were calculated using scaled population numbers and are expressed as the ratio of males to females. Recruited lengths (see Table 5) were determined from either minimum legal sizes, the size at which 50% of fish mature, or minimum lengths of fish considered desirable for sale.

Relative recruitment indices of the number of 1+ (2019 year class for the Hauraki Gulf, 2020 for the Bay of Plenty) and 2+ (2018 year class for the Hauraki Gulf, 2019 for the Bay of Plenty) snapper were generated by either: (1) combining the final ALKs with the scaled length frequency distribution for the matching survey; or (2) conducting modal analysis of the scaled length frequency distribution for just the 1+ cohort for the historical surveys without useable age data. The process of estimating relative recruitment indices from the number of snapper was intended to be similar to that of Francis et al. (1995), Morrison & Francis (1999), and Morrison et al. (2001a), all of whom used the historical R.V. *Kaharoa* survey dataset to estimate the year class strength (YCS) of snapper, but only for the 1+ cohort and just in the Hauraki Gulf. In addition, Francis et al. (1995), Morrison & Francis (1999), and Morrison et al. (2001a) also related these estimates to February–June SST measured at the Leigh Marine Laboratory. So that the relative recruitment estimates could be plotted in a way that was comparable to, and could extend, those of Francis et al. (1995), Morrison & Francis (1999), and Morrison et al. (2001a), similar adjustments were made, as follows.

1. From about 1988, alterations to the HOBT net (increases in the weight of the groundrope and flotation on the headline) resulted in reduced escapement of 1+ fish underneath the groundrope. Francis et al. (1995) compensated for this by multiplying the 1+ YCS estimates (in millions) from the first four Hauraki Gulf surveys by a correction factor of 1.822. The same correction factor was applied to our estimates of the number of 1+ and 2+ snapper prior to 1988 from the Hauraki Gulf and Bay of Plenty.
2. Francis et al. (1995) divided the number of 1+ snapper in the Hauraki Gulf by 1 000 000. This convention was continued for 1+ and 2+ fish in the Hauraki Gulf, but, for the Bay of Plenty, the number of 1+ and 2+ snapper was divided by 10 000 (the number of recruiting fish was sometimes less than 100 000 in the Bay of Plenty).
3. Recruitment data are usually log-normally distributed, so Francis et al. (1995) $\log_e$ transformed YCS estimates. To ensure the relative recruitment estimates could be plotted in a way that was comparable with that of Francis et al. (1995), the same $\log_e$ transformation was conducted on the estimates of the number of 1+ and 2+ snapper for both the Hauraki Gulf and the Bay of Plenty.
4. Francis et al. (1995) normalised YCS estimates to produce an index by dividing by the mean value. For 1+ snapper in the Hauraki Gulf, the long-term predicted mean $\log_e$ YCS value was 1.2 (Francis et al. 1995). Therefore, for comparability with Francis et al. (1995), the Hauraki Gulf 1+ estimates and CVs were divided by 1.2, but all the other YCS indices were divided by their own means (1.18 for 2+ snapper in the Hauraki Gulf, and 0.99 and 1.56 for 1+ and 2+ snapper in the Bay of Plenty, respectively).
5. For the Hauraki Gulf, Francis et al. (1995) used February–June SST measured at the Leigh Marine Laboratory to generate a temperature-recruitment relationship (a predicted 1+ recruitment index). This relationship was then subsequently updated by Morrison & Francis (1999), using data from the KAH9720 survey. This was the last time the relationship was updated because estimates of 1+ recruitment from the KAH0012 survey were much lower than expected. The Morrison & Francis (1999) relationship ($\log_e(YCS) = -16.99 + 0.9942$ SST) to Leigh Marine Laboratory SST data (the February–June monthly average for 1982 to 2019) (Shears & Bowen 2017) was applied to generate an updated predicted 1+ snapper index for the Hauraki Gulf. In the Bay of Plenty, no temperature-recruitment relationship has ever been developed because the relationship is weak.

3. RESULTS

3.1 Survey timing

For the Hauraki Gulf survey (KAH2006), R.V. *Kaharoa* departed Wellington on 17 November 2020 and arrived in Auckland on 20 November to load science crew, ice, and bins and then commenced trawling that day. Thirty-six phase one stations were completed by 25 November. Seven phase two stations were completed on 1 December, before returning to Auckland that evening. *Kaharoa* departed Auckland on 2 December and returned to Wellington and demobilised on 5 December. All 36 phase one stations and seven phase two stations, in stratum 2229 (five stations) and stratum 1219 (two stations), were completed (Table 1). As the CV for pre-recruit snapper was already acceptable, these phase two stations were selected to improve the CV for recruited snapper. One additional tow (station 4) was not used for biomass estimation because it was a foul tow (poor gear performance due to the net becoming fast).

For the Bay of Plenty survey (KAH2101), R.V. *Kaharoa* departed Wellington on 19 January 2021 and conducted a scampi survey before arriving in Tauranga on the evening of 31 January. Science crew, ice, and bins were loaded on 1 February and trawling commenced that day. Forty phase one stations were completed by 7 February (Table 1). Phase two then commenced immediately. Ten phase two stations, selected to improve the CV for pre-recruit snapper (7 stations in stratum 1096, 2 in stratum 6085, and 1 in stratum 2096), were complete by 9 February, with *Kaharoa* returning to Tauranga that evening. Because the survey had completed its objectives earlier than expected with acceptable CVs for pre-recruit and recruit snapper, discussion with Fisheries New Zealand led to the inclusion of an extended phase two. After unloading fish on 10 February, repair work and bad weather delayed departure until the evening of 11 February. Fourteen extended phase two stations were then completed over 12–13 February across stratum 2096 (five stations), stratum 708S (five stations), and stratum 6085 (four stations). This extended phase two was designed to improve the CV of John dory, trevally (*Pseudocaranx georgianus*), and tarakihi. *Kaharoa* returned to Tauranga on 14 February to unload fish and science staff. Results presented for the 2021 Bay of Plenty survey included these extended phase two stations only for John dory, trevally, and tarakihi. Three additional tows (station numbers 11, 14, and 21) were not used for biomass estimation because they were foul tows (poor gear performance due to the net becoming fast).

Because the proportion of phase two stations conducted in a survey can introduce bias to the survey biomass estimates (Francis 1984), both the Hauraki Gulf and Bay of Plenty trawl survey time series were assessed for any trend in the proportion of phase two stations (Appendix 3). The proportion of phase two stations decreased, although non-significantly, since 1985 in the Hauraki Gulf (linear regression $p > 0.05$, $r^2 = 0.25$) and since 1983 in the Bay of Plenty (linear regression $p > 0.05$, $r^2 = 0.41$). It should also be noted that some of the historical surveys did not record which phase each survey station was a part of and, as such, these surveys have not been included in Appendix 3.

The survey areas, with stratum boundaries and station positions, are shown in Figure 1 and individual station data are given in Appendix 4.

A summary of gear and tow parameters by depth is shown in Table 2. Doorspreads ranged from 65.9 to 81.2 m in the Hauraki Gulf and from 67.6 to 85.4 m in the Bay of Plenty; headline height varied between 4.7 and 5.9 m in the Hauraki Gulf and was 5.0–6.5 m in the Bay of Plenty (Table 2, Appendix 4). Measurements of headline height and doorspread, coupled with observations that the doors and trawl gear were polishing well, indicated that the gear was operating correctly. Overall, the density distributions of doorspread and headline height in 2020 and 2021 were similar to those of previous surveys for the Hauraki Gulf and Bay of Plenty (Appendix 5). It should be noted, however, that the depth range of these surveys has varied throughout the time series, that in some of the earlier surveys headline height was missing, and in some of the other surveys data used for both doorspread and headline height were estimated not measured.

3.2 Catch composition

Totals of about 26.5 and 10.4 t of fish and invertebrates were caught from the 43 and 64 valid biomass tows from the Hauraki Gulf (average 617 kg per tow) and Bay of Plenty (average 163 kg per tow) surveys, respectively. Of the fish catch, 8 chondrichthyan and 19 teleost species were recorded on the Hauraki Gulf survey, and 9 chondrichthyan and 33 teleost species were recorded on the Bay of Plenty survey. Species codes, common names, scientific names, and catch weights of all species identified during the survey are given in Appendix 6. Benthic and pelagic macro-invertebrate species are listed in Appendix 7. Appendix 6 and 7 include extended phase two stations for the 2021 Bay of Plenty survey in their summaries; however, most of the plots and tables described below only include extended phase two stations for the three species for which this phase was designed (John dory, trevally, and tarakihi).

The most abundant species by weight for both surveys was snapper, with 23.9 t (90% of the total catch) caught on the Hauraki Gulf survey and 8.5 t (80% of the total catch) caught on the Bay of Plenty survey. For the Hauraki Gulf survey, the next most abundant species was the yellowtail jack mackerel *Trachurus novaezelandiae* at 1.4 t (5.2% of the total catch). Other commonly caught species from the Hauraki Gulf survey included porcupine fish (*Allomycterus jaculiferus*), eagle ray (*Myliobatis tenuicaudatus*), short-tailed black ray (*Dasyatis brevicaudata*), red gurnard (*Chelidonichthys kumu*) John dory (*Zeus faber*), and leatherjacket (*Meuschenia scaber*) (all less than 200 kg per species). Similar species were commonly caught in the Bay of Plenty survey but accounted for a slightly higher percentage of the overall catch compared with the Hauraki Gulf.

Forty-four and sixteen species (or species groups) of benthic and pelagic macro-invertebrates were identified during the Hauraki Gulf and Bay of Plenty surveys, respectively (Appendix 7). The number of invertebrate species does not necessarily reflect biodiversity in the survey area because the gear is not designed to collect benthic macro-invertebrates. In addition, stations were intentionally positioned over soft or flat ground (i.e., trawlable ground), which would strongly influence the incidence of some species groups.

3.3 Catch rates and species distribution

Catch rates for the most commonly caught QMS species are shown in Figure 2. Catch rate maps for the Bay of Plenty only include extended phase 2 stations for John dory (Figure 2g), tarakihi (Figure 2m), and trevally (Figure 2u). The number of stations a species was caught at is therefore either out of 50, if not including extended phase two, or out of 64, if including extended phase two. Some of the species plotted here were not abundant in the 2020 Hauraki Gulf or 2021 Bay of Plenty surveys (e.g., kahawai (*Arripis trutta*), frostfish (*Lepidopus caudatus*), kingfish (*Seriola lalandi*), tarakihi, and rig (*Mustelus lenticulatus*)), but have been included due to their occasional higher abundance historically. Mean catch rates for the most abundant QMS species by stratum for the 2020 Hauraki Gulf and 2021 Bay of Plenty surveys are given in Table 3. Catch rate maps for these species for the entire historical survey series (both Hauraki Gulf and Bay of Plenty) are presented in Figure 3 and discussed in section 3.6.

In the Hauraki Gulf, snapper were caught at all 43 stations and at depths of between 11 and 54 m (Appendix 6). Catch rates of pre-recruit snapper (under 25 cm FL) were consistently high inside the line between Cape Rodney and Cape Colville (Figure 2n). The highest catch rates were achieved in the inner gulf, whereas low catch rates or zero catches occurred in the outer gulf. In the Bay of Plenty, snapper were caught at 48 of 50 stations (excluding extended phase two stations) and between 14 and 96 m deep (Appendix 6). Pre-recruit snapper catch rates were lower than in the gulf and largely constrained to the inner eastern Bay of Plenty, between the Rangitaiki River mouth in the west and Te Kaha in the east (Figure 2o). Very low catch rates or zero catches were recorded from nearly all other stations in the Bay of Plenty.

The pattern of catch rates for recruited snapper (25 cm FL and larger) in the Hauraki Gulf was similar to that of pre-recruit snapper, in that they were consistently high throughout the inner gulf and very low in the outer gulf (Figure 2p). The highest catch rates were between Kawau Island and Tiritiri Matangi

Island. Recruit-sized snapper were caught at every station in the Hauraki Gulf survey. In the Bay of Plenty, catch rates of recruited snapper were high in the same area of the inner eastern bay where pre-recruit snapper were most abundant (i.e., between the Rangitaiki River mouth and Te Kaha) (Figure 2q). There were a few stations with high catches in the western bay around Tauranga Harbour, but catches were low in deeper water. Recruit-sized snapper were caught at all except two stations.

Moderate gurnard catch rates were encountered at most stations throughout the Hauraki Gulf (gurnard were caught at all Hauraki Gulf stations and between 11 and 54 m deep) (Figure 2d). In the Bay of Plenty, the highest gurnard catch rates were encountered in the eastern bay, between the Whakatane River and Te Kaha (gurnard were caught at 44 of 50 stations and between 14 and 96 m deep) (Figure 2e).

John dory were caught at more than half of the stations in the Hauraki Gulf (28 of 43 stations between 17 and 54 m deep), with catch rates highest in the mid-gulf, following an arc between the islands off Coromandel, across the north of Waiheke Island, and past Tiritiri Matangi Island into Kawau Bay (Figure 2f). Lower catch rates of John dory were achieved at most other sites throughout the gulf. In the Bay of Plenty, moderate John dory catch rates were achieved throughout the bay except close to the coast, between Whale Island and the Hawai River mouth, where no John dory were caught. More than half of the stations in the Bay caught John dory (43 of 64 stations between 19 and 96 m deep) (Figure 2g).

Yellowtail jack mackerel were caught at most stations in the Hauraki Gulf (39 of 43 stations between 11 and 54 m deep), with catch rates generally high in the inner gulf and lower or non-existent in the outer gulf (Figure 2h). In the Bay of Plenty, yellowtail jack mackerel were caught at about half of the stations (26 of 50 stations between 16 and 86 m deep), with the largest catches between Opotiki and the Hawai River mouth (Figure 2i). At nearly all other sites in the Bay of Plenty, catches of yellowtail jack mackerel were low to non-existent.

Leatherjacket were caught at 18 stations in the Hauraki Gulf between 17 and 54 m deep (Appendix 6). Leatherjacket were almost exclusively constrained to the outer gulf (outside a line between Cape Rodney and Cape Colville) (Figure 2k). South of this line, leatherjacket catches were consistently moderate. In the Bay of Plenty, leatherjacket were caught at 25 of 50 stations between 16 and 93 m deep (Appendix 6). Catches were constrained to the western bay, between the Rangitaiki River mouth and Mercury Bay (Figure 2l). At all sites further east, catches of leatherjacket were low to non-existent.

Trevally were caught at less than half of the stations in the Hauraki Gulf (18 of 43 stations between 10 and 54 m deep); catch rates were relatively low and catches were mostly from shallow water (both inner and outer gulf), although many stations did not catch any trevally (Figure 2t). In the Bay of Plenty, trevally were caught at 37 of 64 (including extended phase two) stations between 14 and 68 m deep (Appendix 6). Trevally were consistently caught at most shallow inner stations throughout the entire bay (Figure 2u). Deeper outer stations (greater than 70 m) mostly had zero catches.

Rig catch rates in the Hauraki Gulf were low (Figure 2r). Rig were caught at only 14 of 43 stations, generally those located in the shallow areas of the inner gulf (Firth of Thames and Kawau Bay). In the Bay of Plenty, rig catches were infrequent (6 of 50 stations between 16 and 32 m deep), but catches did occur in the shallow inner bay, mostly between Opotiki and Te Kaha, but with one reasonable catch off Tairua (Figure 2s).

Kahawai catch rates were low throughout the Hauraki Gulf and Bay of Plenty, being recorded at only 6 out 43 and 5 out 50 stations, respectively (Figures 2a and 2b). Kahawai have been included here due to their historically higher catch rates (see section 3.6).

Frostfish, kingfish, and tarakihi were also included because of their historical importance and only for the Bay of Plenty. Frostfish were not caught in 2020 or 2021 (Figure 2c), and kingfish and tarakihi were caught at only a few stations in the Bay of Plenty (9 and 4 of 50 stations, respectively). Kingfish were

caught at stations to the east of Maketu and inshore (Figure 2j). Tarakihi were caught between Opotiki and Hawai Bay and near the Mercury Islands (Figure 2m).

3.4 Biomass estimation

References to 'biomass' are to relative abundance estimates unless otherwise stated.

Biomass estimates for QMS species caught in all surveys in the Hauraki Gulf and Bay of Plenty trawl survey series are given in Table 4. Estimated biomass and CVs for the most common QMS species for the 2020 Hauraki Gulf survey were: snapper 23 876 t (17%); yellowtail jack mackerel 1662 t (31%); leatherjacket 223 t (21%); John dory 159 t (31%); gurnard 196 t (7%); trevally 73 t (59%); rig 24 t (29%); and kahawai 5 t (50%). Estimated biomass and CVs for the most common QMS species for the 2021 Bay of Plenty survey were: snapper 3506 t (18%); yellowtail jack mackerel 43 t (39%); gurnard 118 t (11%); leatherjacket 88 t (16%); kahawai 4 t (50%); John dory 95 t (21%); trevally 35 t (20%); rig 11 t (60%); frostfish 0 t (0%); kingfish 18 t (34%); and tarakihi 24 t (50%)

Biomass estimates based on length-at-recruitment for the most common QMS species are given in Table 5. For the 2020 Hauraki Gulf survey, John dory, leatherjacket, snapper, and trevally all had estimates of recruited biomass that represented a high percentage of the total biomass (at least 80%). Alternatively, yellowtail jack mackerel and rig had low percentages of recruited biomass. For the 2021 Bay of Plenty survey, kahawai, gurnard, John dory, leatherjacket, tarakihi, snapper, and trevally all had estimates of recruited biomass that represented a high percentage of the total biomass (at least 70%).

The biomass estimates and CVs for the most common QMS species for both the 2020 Hauraki Gulf and 2021 Bay of Plenty surveys are given by stratum in Table 6 and are discussed below.

For snapper in the Hauraki Gulf, mid-gulf strata made large contributions to the overall snapper biomass (e.g., 1219, 1268, 1887, and 2229), although the large outer gulf strata (COLV and LITB) also made sizeable biomass contributions (1568 and 4163 t, respectively) (Table 6). In the Bay of Plenty, estimated snapper biomass was dominated by the eastern strata (e.g., 1096, 408M, and 6085) and the inner stratum around Tauranga Harbour (stratum 2096) (Table 6).

Most of the gurnard biomass in the Hauraki Gulf was associated with three of the outermost strata LITB, 1219, and COLV (Table 6). Although the highest catches of gurnard in the Bay of Plenty were in the east of the survey area, the estimated biomass of gurnard was spread across all strata. Strata with larger areas, however, often contributed more to the overall biomass estimate (e.g., 4085, 6085, 708N, 708S) (Table 6).

Although mid-Hauraki Gulf strata made large contributions to the overall John dory biomass (e.g., 1219, 1268, and 2229), the large outer strata also made sizeable biomass contributions (LITB and COLV) (Table 6). In the Bay of Plenty, the estimated biomass of John dory was dominated by the larger and deeper strata (e.g., 6085, 708N, and 708S) (Table 6).

For yellowtail jack mackerel in the Hauraki Gulf, some inner strata (1268 and 1887) made large contributions to the overall biomass estimate through high catch rates, and some mid and outer gulf strata (1219, 2229, COLV, and LITB) also made sizeable biomass contributions due to their large size (Table 6). In the Bay of Plenty, strata that dominated the biomass estimate included 1096, 408M, 6085, and 708S (Table 6).

Leatherjacket biomass was dominated by the outer Hauraki Gulf strata in 2020 (strata 1219, 1449, LITB, and COLV) (Table 6). In the Bay of Plenty the western strata (518M, 5287, 708N, 708S) were the most important for biomass estimates of leatherjacket (Table 6).

Trevally biomass in the Hauraki Gulf was dominated by two strata (2229 and LITB) (Table 6). In the Bay of Plenty, one of the shallowest strata (2096) and an eastern stratum (408M) dominated trevally biomass (Table 6).

The strata that contributed most to rig biomass in the Hauraki Gulf were spread throughout the gulf (1219, 1887, 2229, and COLV) (Table 6). In the Bay of Plenty two of the eastern strata dominated the estimated biomass for rig (408M and 1096) (Table 6).

Only three strata contributed to kahawai biomass estimates in the Hauraki Gulf (1887, 2229, and 9292) (Table 6). In the Bay of Plenty the vast majority of kahawai biomass was associated with stratum 408M, in the eastern part of the Bay of Plenty survey area (Table 6).

The majority of the estimated biomass of tarakihi in the Bay of Plenty was associated with one stratum, 6085 (Table 6).

The majority of the estimated biomass of kingfish in the Bay of Plenty was associated with two strata, 1096 and 6085 (Table 6).

Trends in biomass for selected species are shown in Figure 4 and are discussed in section 3.6.

3.5 Length frequency and biological data

The numbers of length frequency and biological samples taken during the survey are given in Table 7. Comparative population scaled length frequency distributions for the most common QMS species are shown in Figures 5a–5h and 6a–6k. Length frequency distributions are presented in alphabetical order by species code. Species codes are defined in Appendix 6.

Using measurements from the 2020 Hauraki Gulf and 2021 Bay of Plenty surveys, length-weight coefficients (by area) were determined for gurnard, John dory, yellowtail jack mackerel, snapper, leatherjacket, and trevally (Appendix 2).

In the Hauraki Gulf, 944 pairs of snapper otoliths were collected and 698 of these pairs were prepared and aged. The between-reader CV and IAPE for the Hauraki Gulf otolith set were 1.75 and 1.23%, respectively. In the Bay of Plenty, 892 pairs of snapper otoliths were collected and 700 of these pairs were prepared and aged. The between-reader CV and IAPE for the Bay of Plenty otolith set were 5.40 and 3.82%, respectively. The age-length keys derived from these otolith readings can be found in Appendix 8.

Details of maturity stages for gurnard, John dory, tarakihi, snapper, and trevally are given in Table 8 and discussed in section 3.6; the gonad stages are defined in Appendix 1.

3.6 Recruited percentage, sex ratios, and reproductive stage for the recent surveys and trends in distribution, biomass, and size composition for the most common QMS species

3.6.1 Snapper

The highest catches of both pre-recruit and recruit snapper in 2020 were predominantly from the inner to mid Hauraki Gulf, which has been the trend throughout the survey series (Figures 2n, 2p, 3f, 3g). Overall, snapper biomass in the gulf was variable, with a slight overall positive slope until the 2000 survey (7682.5 t), before increasing to 20 617.7 t in 2019 and then to 23 875.5 t in 2020 (Table 4 and Figure 4a). In 2020, a high proportion of the biomass estimate (19 503 t or 82%) was recruited fish (25 cm and larger) (Table 5). The male to female sex ratio in 2020 was 1.09 to 1. Previous surveys, where snapper were sexed, have also had a slightly male-biased sex ratio (Figure 5f). Most snapper caught on the 2020 survey were between 6 and 40 cm, with one distinct size mode between 6 and 11 cm (likely

0+ fish), and another merged age class mode between 14 and 40 cm (Figure 5f). Although the appearance of juvenile size modes varies between years according to the YCS of specific cohorts (see section 3.7), the size range of snapper in 2020 was broadly similar to that of previous surveys, but some of the surveys prior to 1990 had a higher proportion of fish 40 cm and larger (Figure 5f). There was little gonad development in snapper under 20 cm. Larger males were predominantly ripening or ripe, but ranged between resting and running ripe. Larger females were predominantly ripening but ranged between resting and spent (Table 8).

The spatial pattern of catches of snapper in the Bay of Plenty in 2021 was similar to that of the 2020 survey. Snapper were predominantly from the inshore and eastern parts of the survey area, with a few large catches in the western Bay of Plenty near Tauranga Harbour (Figures 2o, 2q, 3r, 3s). This differs from previous surveys, where snapper were caught throughout the inner parts of the entire survey area (Figures 3r and 3s). Overall, snapper biomass has increased, with some oscillation, throughout the survey series, with a large increase to 2824 t in 2020, and then a further increase to 3506 t in 2021 (Table 4, Figure 4b). In 2021, 3291 t (94%) of the Bay of Plenty snapper biomass was recruited fish (25 cm and larger) (Table 5). The male to female sex ratio in 2021 was 1.09 to 1. Conversely, the two previous Bay of Plenty surveys where a large number of snapper were sexed had slightly female-biased sex ratios (Figure 6i). The majority of snapper caught in 2021 were between 6 and 40 cm length, with one distinct size mode between 6 and 13 cm (likely 1+ fish) (Figure 6i). This size range was broadly similar to that of previous surveys; but see section 3.7 for more specific detail about variation in snapper YCS in the Bay of Plenty. There was little gonad development in snapper under 20 cm. Larger males and females were predominantly resting, but ranged between resting and spent (Table 8).

3.6.2 Red gurnard

The overall Hauraki Gulf gurnard biomass in 2020 was 196 t, which was increase from previous survey in 2019 (162 t) (Table 4). Gurnard biomass in the Hauraki Gulf was much higher previously (e.g., 571 t in 1988), but biomass levels fluctuated between surveys (Figure 4a). In 2020, 96 t (49%) of the Hauraki Gulf gurnard biomass was recruited fish (30 cm and larger) (Table 5). The male to female sex ratio in 2020 was 0.60 to 1. Most historical surveys have also produced a female dominated sex ratio (Figure 5b). The length of gurnard caught in 2020 was largely between 10 and 40 cm, with a mixed age mode between 17 and 40 cm (Figure 5b). The overall size range was generally similar to that of previous surveys (Figure 5b). Gurnard had a range of gonad stages, with the majority of males resting or ripening and the majority of females resting to ripe (Table 8).

Apart from an anomalously low gurnard biomass estimate in 1985, gurnard biomass has declined throughout the Bay of Plenty survey series (Figure 4b). The overall gurnard biomass estimate in 2021 was 118 t, the lowest in the series except for the 1985 estimate (Table 4). In 2021, 85 t (72%) of the Bay of Plenty gurnard biomass was recruited fish (30 cm and larger) (Table 5) and the male to female sex ratio was 0.64 to 1. As in the Hauraki Gulf, gurnard have often had a female biased sex ratio (Figure 6c). The length of gurnard caught in 2021 was mostly between 15 and 45 cm, which is generally similar to that of previous surveys (Figure 6c). Gurnard had a range of gonad stages, with the majority of males and females resting or ripening, although a number of females were also spent (Table 8).

3.6.3 John dory

The highest catches of John dory in 2020 were predominantly from the mid Hauraki Gulf, which has been the trend throughout the survey series (Figures 2f and 3c). John dory biomass has oscillated around a mean of about 245 t since 1988. The 2020 survey had a slightly lower biomass (159 t) relative to the 2019 survey (188 t) (Table 4). In 2020, nearly all (156 t or 98 %) of the Hauraki Gulf John dory biomass was recruited fish (25 cm and larger) (Table 5). The male to female sex ratio in 2020 was 0.48 to 1. Previous surveys also had female-dominated sex ratios (Figure 5c). The length of John dory caught in 2020 was largely between 17 and 55 cm and without distinct size modes (Figure 5c), which was broadly similar to that of previous surveys (Figure 5c). The majority of mature John dory were resting or ripening (Table 8).

Catches of John dory in 2021 occurred throughout the Bay of Plenty survey area, which is consistent with the historical distribution (Figures 2g and 3m). John dory biomass increased throughout the survey series until the early 1990s, before steadily decreasing (Figure 4b). The overall John dory biomass estimate in 2021 (95 t) was slightly higher than in 2020 (84 t) (Table 4). In 2021, 92 t (97%) of the Bay of Plenty John dory biomass was recruited fish (25 cm and larger) (Table 5). The male to female sex ratio in 2021 was 1.29 to 1. Although the 2020 Bay of Plenty survey also had a male-biased sex ratio, previous surveys have had a more even sex ratio (Figure 6d). The length of John dory caught in 2021 was between 19 and 50 cm, without distinct size modes, which is generally similar to that of previous surveys (Figure 6d). The majority of both males and females were resting, ripening, or ripe (Table 8).

3.6.4 Yellowtail jack mackerel

Catches of yellowtail jack mackerel in 2020 were predominantly from the inner Hauraki Gulf, which has been the pattern throughout the survey series (Figures 2h and 3d). Yellowtail jack mackerel biomass has fluctuated, often with high associated CV, throughout the survey series (Figure 4a). In 2020, yellowtail jack mackerel biomass had decreased to 1662 t, from a series high of 2131 t in 2019 (Table 4) and little of the biomass (129 t or 8%) was recruited fish (25 cm and larger) (Table 5). Too few yellowtail jack mackerel were sexed on the Hauraki Gulf survey in 2020 or previous years to make any inference about trends in sex ratio (Figure 5d). The length frequency distribution of yellowtail jack mackerel from previous surveys has sometimes contained multiple modes, but in 2020 there was one mode with fish mainly between 7 and 25 cm (Figure 5d). The gonad stage of yellowtail jack mackerel caught on the 2020 Hauraki Gulf survey was not examined.

Highest catches of yellowtail jack mackerel in 2021 predominantly occurred in the eastern part of the Bay of Plenty survey area, which is consistent with the historical distribution (Figures 2i and 3n). Yellowtail jack mackerel biomass has remained relatively stable throughout the Bay of Plenty survey series, apart from an anomalously high estimate in 1996 (Table 4). The overall yellowtail jack mackerel biomass estimate in 2021 was 43 t, a decrease from 214 t in 2020 (Table 4). In 2020, only 2.9 t (6.8 %) of the Bay of Plenty yellowtail jack mackerel biomass was recruited fish (25 cm and larger) (Table 5). Yellowtail jack mackerel are typically not sexed, therefore the male to female sex ratio is unknown. The majority of yellowtail jack mackerel caught in 2021 were less than 10 cm in length (Figure 6e). The gonad stage of yellowtail jack mackerel caught on the 2021 Bay of Plenty survey was not examined.

3.6.5 Leatherjacket

Highest catches of leatherjacket in 2020 were predominantly from the outer Hauraki Gulf, which has been the pattern throughout the survey series (Figures 2k and 3e). Leatherjacket biomass has varied throughout the survey series with high CVs (Figure 4a). In 2020, the overall estimated biomass of leatherjacket in the Hauraki Gulf was 223 t, down from 338 t in 2019 (Table 4). In 2020, nearly all (222 t or 99.4 %) of the Hauraki Gulf leatherjacket biomass was recruited fish (19 cm and larger) (Table 5). The male to female sex ratio in 2020 was 1.14 to 1. No previous surveys have sexed enough leatherjacket to make any inferences about sex ratio. The length of leatherjacket caught in 2020 was largely between 15 and 30 cm and was broadly similar to that of previous surveys, although some surveys in the 1980s had a higher proportion of smaller (10–20 cm) leatherjacket (Figure 5e). The majority of male and female leatherjacket were resting or ripening, although some females were ripe.

Catches of leatherjacket have largely occurred in the western part of the Bay of Plenty survey area throughout the time series (Figures 2l and 3p). Leatherjacket biomass increased to a peak in 1992 (255 t), before a decline in the later 1990s (Figure 4b). The overall leatherjacket biomass estimate in 2021 was 88 t, down from 149 t in 2020 (Table 4). In 2021, 86 t (98%) of the Bay of Plenty leatherjacket biomass was recruited fish (19 cm and larger) (Table 5). The male to female sex ratio in 2021 was 1.04 to 1. In 2020, leatherjacket had a slightly female biased sex ratio, but trends are unknown because leatherjacket were not sexed on surveys prior to this (Figure 6g). The length of leatherjacket caught in 2021 was generally between 15 and 30 cm, a size range similar to that caught on previous surveys (Figure 6g). The gonad stage of leatherjacket caught on the 2020 Bay of Plenty survey was not examined.

3.6.6 Trevally

Catches of trevally in 2020 were from shallow areas (both inner and outer Hauraki Gulf), which is reasonably consistent with the time series considering the generally low overall catches (Figures 2t and 3i). Trevally biomass was low in the 1990s but had increased to 107 t in 2019, before a decrease to 73 t in 2020 (Figure 4a, Table 4). Nearly all of the 2020 biomass (72 t or 98%) was recruited fish (25 cm and larger) (Table 5). The male to female sex ratio in 2020 was 0.69 to 1. The 2019 survey also had a female-biased sex ratio, but too few fish were sexed prior to this to determine trends (Figure 5h). The length of trevally caught in 2020 was mainly between 12 and 40 cm (Figure 5h). The size range of trevally from previous surveys has been variable, with sizes ranging between 5 and 60 cm, depending on the particular survey (Figure 5h). It should be noted that the number of trevally measured on surveys has generally been low, which makes the identification of size modes difficult. There was no gonad development in trevally under 20 cm, whereas for larger male and female fish, the gonad stage was ranged from resting to running ripe (Table 8).

Catches of trevally in 2021 were from throughout the Bay of Plenty survey area, although somewhat lower offshore and in the west (Figure 2u). This spatial pattern is reasonably consistent with the survey time series (Figure 3u). Apart from a very low initial biomass estimate in 1983 (6 t) and a very high biomass estimate in 1999 (267 t), trevally biomass has been relatively stable (Figure 4b). The estimated biomass in 2021 (34 t) was the second lowest estimate in the series. Nearly all estimated biomass (34 t or 97%) was recruited fish (25 cm and larger) (Table 5). The male to female sex ratio in 2021 was 0.97 to 1. Only two other Bay of Plenty surveys sexed trevally, and they had a very slightly female-biased sex ratio (Figure 6k). The length of trevally caught in 2021 was mostly between 15 and 45 cm, although a small mode of fish of about 5 cm were also caught (Figure 6k), broadly similar to patterns of previous surveys (Figure 6k). Male trevally were predominantly ripening to running ripe, and female trevally were predominantly ripening (Table 8).

3.6.7 Rig

The highest catches of rig in 2020 were predominantly from the inner Hauraki Gulf, which is consistent throughout the survey series (Figures 2r and 3h). Rig biomass generally increased to a peak in 1988 (106 t), before declining to a low in 2000 (4 t) (Table 4). Only 4 t (17 %) of the 2020 biomass was recruited fish (90 cm and larger) (Table 5). Too few rig were sexed in 2020 to make inferences about sex ratio, but previous surveys have generally had a male-dominated sex ratio (Figure 5). The length of rig caught in 2020 was mainly between 50 and 80 cm (Figure 5g) and was broadly similar to that of previous surveys, although relatively few rig have been measured in most surveys (Figure 5g). The gonad stage of rig caught on the 2020 Hauraki Gulf survey was not examined.

Catches of rig in the Bay of Plenty in 2021 predominantly occurred in the eastern parts of the survey area (Figures 2s and 3t). This is broadly consistent with the historical distribution (Figures 2 and 3). Rig biomass has generally increased throughout the survey series (with some variation), although the estimated biomass in 2021 (11 t) was lower than in 2020, which was a high point in the survey series (Figure 4b). In 2021, 4 t (34%) of the Bay of Plenty rig biomass was recruited fish (90 cm and larger) (Table 5). Bay of Plenty surveys have caught few rig and provide little insight into trends in the sex ratio of rig (Figure 6j). The length of rig caught in 2021 was mostly between 60 and 100 cm and without distinct size modes, which is generally similar to previous surveys, although few rig were measured (Figure 6j). The gonad stage of rig caught on the 2021 Bay of Plenty survey was not examined.

3.6.8 Kahawai

Catches of kahawai in the Hauraki Gulf have been low throughout the time series (Figures 2a and 3a). The estimated biomass of kahawai in the Hauraki Gulf has also generally been low throughout the time series, except for some higher estimates in the 1980s and early 1990s (Figure 4a). In 2020, 3.3 t (63%) of the biomass was recruited fish (40 cm and larger) (Table 5). Not enough kahawai were caught to make inferences about sex ratio (Figure 5a). Only 17 fish were caught in 2020, but the majority of fish were between 20 and 25 cm, ranging between 12 and 50 cm. This range was similar to that of previous

surveys (Figure 5a). The gonad stage of kahawai caught on the 2020 Hauraki Gulf survey was not examined due to low catches (which is also the same for previous surveys).

Catches of kahawai in the Bay of Plenty have also been low throughout the time series (Figures 2b and 3j). Biomass has been relatively consistent at about 50 t throughout the time series, but dropped to 4 t in 2021 from a peak of 95 t in 2020. It should be noted that nearly all surveys had high CVs because of low sample size (Table 4, Figure 4b). In 2021, 3.8 t (93%) of the kahawai biomass in the Bay of Plenty was recruited fish (40 cm and larger) (Table 5). Trends in sex ratio are unknown because low sample sizes meant sex was either not determined or ratios could not be estimated for kahawai in most surveys. Kahawai caught in 2021 were between 20 and 50 cm, which was similar to the size range in previous Bay of Plenty surveys (Figure 6a). There was no gonad development in kahawai under 30 cm, but for larger fish there was a range of gonad stages with the majority of males running ripe, and the only mature female sampled was ripening (Table 8).

3.6.9 Tarakihi

The removal of the deeper strata from both surveys likely contributed to the low catches of tarakihi in the 2020 Hauraki Gulf or 2021 Bay of Plenty surveys; they were previously more frequently caught, particularly in the Bay of Plenty. Because of this, tarakihi are only discussed in detail for the Bay of Plenty.

The majority of stations where tarakihi were caught in the 2021 Bay of Plenty survey were in the eastern part of the survey area, whereas historically, catches have come from throughout the survey area (Figures 2m and 3q). Tarakihi biomass has remained relatively low throughout the Bay of Plenty survey series apart from a high biomass estimate in 1992 (99 t) (Figure 4b). The overall tarakihi biomass estimate in 2021 (24 t) was much higher than the series low of 2.7 t in 2020, but the 2021 estimate had a high associated CV because of a low number of non-zero stations (Table 4). In 2021, nearly all the tarakihi biomass (24.2 t or 99.5 %) was recruited fish (25 cm and larger) (Table 5). The tarakihi caught on the 2021 survey were between 20 and 40 cm (Figure 6h). This is broadly similar with the size distribution of tarakihi from previous surveys (Figure 6h). All the tarakihi sampled were mature, with the majority of both males and females resting (Table 8).

3.6.10 Kingfish

Kingfish were seldom caught on either the 2020 Hauraki Gulf or 2021 Bay of Plenty surveys, but have been more frequently caught in previous Bay of Plenty surveys. Detailed results are presented here just for the Bay of Plenty.

Kingfish were caught at stations mainly in the eastern part of the survey area in 2020, but, in previous surveys, kingfish have occurred throughout the inner strata (Figures 2j and 3o). The 2021 biomass estimate of 18 t was higher than the survey series low observed in 2020 (6 t); the highest biomass (51 t) was in 1992 (Table 4). In 2021, all kingfish were released alive; no length, sex, or reproductive information were collected.

3.6.11 Frostfish

Frostfish were seldom caught on either the 2020 Hauraki Gulf or 2021 Bay of Plenty surveys, but they have been more frequently caught in previous Bay of Plenty surveys; detailed results were presented for frostfish by Parsons et al. (2021). During the 2021 Bay of Plenty survey, frostfish were only caught at two stations, which were both part of the extended phase two portion of the survey.

3.7 Estimation of snapper year class strength

Proportion-at-age distributions for snapper caught on the 2020 Hauraki Gulf and 2021 Bay of Plenty surveys are presented in Figure 7. Strong age classes observed in the previous surveys (Parsons et al. 2021) had advanced one year in the proportion-at-age distributions produced here as expected (e.g., 4 and 10 year olds for the Hauraki Gulf in 2019 and 1 and 5 year olds for the Bay of Plenty in 2020).

Although the relative strength of year classes is difficult to interpret from proportion-at-age distributions alone, a strong 2019 year class was evident in both the Hauraki Gulf and Bay of Plenty (1+ fish during the 2020 Hauraki Gulf survey and as 2+ fish in the 2021 Bay of Plenty survey).

For the Hauraki Gulf in 2020, the estimated YCS of 1+ and 2+ snapper (the 2019 and 2018 year classes) was 8.0 (CV = 16.6%) and 5.8 (CV = 14.4%) million fish, respectively (Table 9). These estimates were well above the average YCS estimates for the entire Hauraki Gulf survey series (average YCS is 3.9 and 3.6 million for 1+ and 2+ snapper, respectively). The two recent estimates of the 2018 YCS were both similar (5.4 million as 1+ fish in 2019 and 5.8 million as 2+ fish 2020). The raw numbers of the estimated abundance of 1+ and 2+ snapper in the Hauraki Gulf were also used to recalculate the YCS index for 1+ snapper (see section 2.6). The YCS index values estimated by the 2020 Hauraki Gulf survey were well below the YCS predictions based on the mean February-June Leigh SST temperature relationship (Figure 8a).

For the Bay of Plenty in 2021, the estimated YCS of 1+ and 2+ snapper (the 2020 and 2019 year classes) was 1.374 (CV = 38.5%) and 0.945 (CV = 18.0%) million fish, respectively (Table 9). These estimates were well above the average YCS estimates for the entire Bay of Plenty survey series (average YCS is 0.440 and 0.542 million for 1+ and 2+ snapper, respectively). The two recent estimates of 2019 YCS were similar (0.926 million as 1+ fish in 2020 and 0.925 million as 2+ fish 2021). As per the conclusions of Parsons et al. (2021), there does not appear to be a strong relationship between SST and YCS in the Bay of Plenty (1+ r^2 = 0.29, 2+ r^2 = 0.16) (Figure 8b). It should be noted that though the CV of 1+ snapper ended up being high, the CV for < 25 cm snapper during the survey was acceptable (i.e., less than 20%).

4. CONCLUSIONS

The 2020 Hauraki Gulf and 2021 Bay of Plenty surveys were the 14th and 8th surveys in these series (although the 1987 Hauraki Gulf survey has not been included in the analyses presented here). Estimates of YCS for pre-recruit snapper were produced with acceptable levels of variation, except for 1+ snapper in the Bay of Plenty with a CV of 38.5%. For both the Hauraki Gulf and Bay of Plenty surveys, the 1+ and 2+ year classes observed in 2020 and 2021 were well above average strength and likely represent reasonably strong year classes that will recruit to the Hauraki Gulf and Bay of Plenty fisheries over the next three to five years. In the 2021 Bay of Plenty survey, the spatial distribution of pre-recruit snapper was again constrained to the eastern Bay of Plenty as it was in 2020. This is a more restricted distribution than in surveys prior to 2020 and may suggest that the value of the eastern Bay of Plenty to snapper recruitment has increased, or alternatively other areas have decreased in importance. An alternative hypothesis is that the locations with high snapper catch rates across both of the Hauraki Gulf and Bay of Plenty surveys since 2019 (i.e., the inner gulf and the eastern Bay of Plenty) were also often locations of low water clarity (D. Parsons pers. obs). Water visibility may influence snapper catchability in addition to any underlying patterns in abundance. A more thorough investigation of the influence of water clarity on snapper catch rates throughout the survey time series should therefore be conducted.

In the Hauraki Gulf, a strong snapper temperature-recruitment relationship was established (Francis et al. 1995). However, in 1999, the Hauraki Gulf survey estimate of 1+ snapper abundance was well below the estimate predicted by this temperature-recruitment relationship (Morrison et al. 2001a). The 1999 year class nevertheless did eventually turn out to be a very strong year class that dominated the Hauraki Gulf fishery for a number of years (Walsh et al. 2011). During the 2020 Hauraki Gulf survey, the 2018 year class was also predicted by the temperature-recruitment relationship to be very strong. Both the 2019 and 2020 Hauraki Gulf surveys have estimated this year class as above average, but not anywhere near as strong as that predicted by the temperature relationship. Further, in 2020, the 2019 year class, also predicted by the temperature-recruitment relationship to be very strong, was again only estimated to be above average. The strength of the 2018 and 2019 year classes will ultimately be verified when they recruit to the fishery in three to five years, but these recent results raise questions about the

predictive power of the temperature-recruitment relationship (Francis et al. 1995). Others have also found that environment-recruitment relationships often fail when the relationships are updated (Myers 1998).

In 2019, a beam trawl survey of the Hauraki Gulf was conducted to also provide a biomass estimate of the 2019 year class (10.7 million 0+ fish) (Morrison et al. 2019). The beam trawl used by Morrison et al. (2019) was small and would therefore be a less impactful survey method, but verification that this method produces valid biomass estimates of snapper YCS is required. Direct comparison of the beam trawl estimate with that of the 2019 year class observed from the *Kaharoa* in 2020 (and described in this report) is not possible. However, with time, trends from both surveys could be compared and, if synchronous, would give greater confidence in beam trawl estimates of predicted YCS. An additional 2018 beam trawl survey conducted in the Hauraki Gulf might also be useful for YCS verification (Mark Morrison, NIWA as part of Ministry of Business Innovation and Employment "Bottlenecks" Progamme, unpublished data).

The recommencement of the northern trawl survey series also provides potential to monitor, with reasonable precision, the relative abundance of snapper biomass overall (i.e., including recruited snapper) and associated species. In 2020 and 2021, snapper biomass increased relative to the surveys conducted the previous year for both the Hauraki Gulf (16%) and the Bay of Plenty (24%) surveys. The relative abundance of red gurnard, John dory, leatherjacket, and trevally are also potentially well monitored by these surveys, although the CV for trevally in the Hauraki Gulf was high at 59% and the large biomass change for trevally in the Bay of Plenty was implausibly high (see below). In the Hauraki Gulf, the biomass of red gurnard increased by 22% relative to the 2019 survey, and the biomass of John dory, leatherjacket, and trevally decreased (by 15, 34, and 32%, respectively). In the Bay of Plenty, the biomass of John dory increased by 13% relative to the 2020 survey, and the biomass of red gurnard, leatherjacket, and trevally decreased (by 35, 41, and 53% respectively).

5. ACKNOWLEDGEMENTS

This project was funded by Fisheries New Zealand under project INT2020-02. We thank the skipper of the R.V. *Kaharoa* Lindsay Copland and his crew for their hard work during the trawl survey. Thanks to: Derrick Parkinson, Louis Olsen, Bruce Hartill, Yoann Ladroit, Dan MacGibbon, Oliver Evans, Rikki Taylor, Ann Parkinson, Brent Wood, and Adele Dutilloy (all NIWA) for their efforts during the survey; Brent Wood, Jade Maggs, and Jeremy Yeoman (NIWA) for database assistance; Helena Armiger (NIWA), Cameron Walsh (Stock Monitoring Services), and Matt Smith (NIWA) for ageing otoliths; Sadie Mills, Michelle Kelly, Mike Page (all NIWA), and others who assisted with invertebrate identification; and Yoann Ladroit (NIWA) for assistance with acoustics. We are very appreciative for logistical support provided by Sanford Ltd (Tessa van Ginkel, Lindsay Gudsell, Dave Falconer, and Julian Clarke) and project and technical advice provided by NIWA colleagues Emma Jones, Jim Drury, Bruce Hartill, and Ian Tuck. We are extremely grateful for overall project oversight and review from Jennifer Devine and Richard O'Driscoll (NIWA).

6. REFERENCES

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

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

Chang, W.Y.B. (1982). A statistical method for evaluating the reproducibility of age determination. *Canadian Journal of Fisheries and Aquatic Sciences 39*: 1208–1210.

Chugunova, N.I. (1963). Age and growth studies in fish: a systematic guide for ichthyologists. Published for the National Science Foundation, Washington D. C. and the Department of the Interior by the Israel Program for Scientific Translations. 119 p.

Drury, J.; Hartill, B. (1993). Summary findings from the 1992 R.V. Kaharoa trawl survey of the Bay of Plenty (KAH9202). Northern Fisheries Region Internal Report No. 16. 56 p. (Draft report held by NIWA library Wellington.)

Drury, J.; Hartill, B. (1994). Summary findings from the 1993 R.V. Kaharoa trawl survey of East Northland (KAH9302). MAF Fisheries North Internal Report No. 19. 72 p. (Draft report held by NIWA library Wellington.)

Drury, J.; McKenzie, J.M. (1992a). Summary findings from the 1990 R.V. Kaharoa trawl survey of Northland (KAH9017). MAF Fisheries North Internal Report No. 7. 69 p. (Draft report held by NIWA library, Wellington.)

Drury, J.; McKenzie, J.M. (1992b). Summary findings from the 1990 R.V. Kaharoa trawl survey of the Bay of Plenty (KAH9004). Northern Fisheries Region Internal Report No. 5. 56 p. (Draft report held by NIWA library Wellington.)

Drury, J.; McKenzie, J.M. (1992c). Summary findings from the 1990 R.V. Kaharoa trawl survey of the Hauraki Gulf (KAH9016). MAF Fisheries North Internal Report No. 6. 23 p. (Draft report held by NIWA library Wellington.)

Francis, M.P. (1979). A biological basis for the management of New Zealand moki (*Latridopsis ciliaris*) and smoothhound (*Mustelus lenticulatus*) fisheries. Unpublished MSc thesis, University of Canterbury.

Francis, M.P. (1993). Does water temperature determine year class strength in New Zealand snapper (*Pagrus auratus*, Sparidae)? *Fisheries Oceanography 2*: 65–72.

Francis, M.P.; Langley, A.D.; Gilbert, D.J. (1995). Snapper recruitment in the Hauraki Gulf. New Zealand Fisheries Assessment Research Document 95/17. (Unpublished report held by NIWA library, Wellington.) 27 p.

Francis, R.I.C.C. (1981). Stratified random trawl surveys of deep-water demersal stocks around New Zealand. *Fisheries Research Division Occasional Publication No. 32*. 28 p.

Francis, R.I.C.C. (1984). An adaptive strategy for stratified random trawl surveys. *New Zealand Journal of Marine and Freshwater Research 18*: 59–71.

Francis, R.I.C.C.; Bian, R. (2011). Catch-at-length and -age User Manual. National Institute of Water & Atmospheric Research Ltd. (Unpublished report held by NIWA library, Wellington.) 83 p.

Francis, R.I.C.C.; Fu, D. (2012). SurvCalc User Manual v1.2-2011-09-28. *NIWA Technical Report 134*. 54 p.

Hartill, B.W.; Walsh, C. (2005). Characterisation of the kahawai fisheries of New Zealand and review of biological knowledge. (Final Research Report for Ministry of Fisheries Project KAH2004/01 held by Fisheries New Zealand.) 160 p.

Horn, P.L. (2013). Age determination of frostfish (*Lepidopus caudatus*) off west coast South Island. *New Zealand Fisheries Assessment Report 2013/2*1. 24 p.

Langley, A.D. (1994a). Trawl survey of snapper and associated species in the Hauraki Gulf, November 1992 (KAH9212). MAF Fisheries North Internal Report No. 20. (Draft report held by NIWA library, Wellington.)

Langley, A.D. (1994b). Trawl survey of snapper and associated species in the Hauraki Gulf, November 1993 (KAH9311). MAF Fisheries North Internal Report No. 21. (Draft report held by NIWA library, Wellington.)

Langley, A.D. (1994c). Trawl survey of snapper and associated species in the Hauraki Gulf, October-December 1994 (KAH9411). New Zealand Fisheries Data Report No. 61. (Draft report held by NIWA library, Wellington.)

Morrison, M.A. (1997). Trawl survey of snapper and associated species off the Bay of Plenty, North Island, November 1996 (KAH9615). *NIWA Technical Report 33*. 44 p.

Morrison, M.A.; Bian, R.; Jones, E.G.; McKenzie, J.; Parsons, D.; Shankar, U. (2013). The relative abundance of red gurnard john dory, tarakihi and other inshore species around northern New Zealand – the potential for a new "northern hotspot" trawl survey series. *New Zealand Fisheries Assessment Report 2013/8*. 130 p.

Morrison, M.A.; Francis, M.P. (1999). Trawl survey of snapper and associated species in the Hauraki Gulf, October-November 1997 (KAH9720). *NIWA Technical Report 58*. 33 p.

Morrison, M.A.; Francis, M.P.; Parkinson, D. (2001a). Trawl survey of snapper and associated species in the Hauraki Gulf, October 2000 (KAH0012). Final Research Report for Ministry of Fisheries Research Project INT2001/02. (Draft report held by NIWA library, Wellington.)

Morrison, M.A.; McKenzie, J.; Bian, R. (2019). Pre-recruit (0+) snapper (*Chrysophrys auratus*) beam trawl and beach seine surveys of East Northland and the Hauraki Gulf (SNA 1). *New Zealand Fisheries Assessment Report 2019/72*. 50 p.

Morrison, M.A.; Parkinson, D. (2000). Inshore trawl survey of the Bay of Plenty, North Island, February 1999 (KAH9902). *NIWA Technical Report 89*. 27 p.

Morrison, M.A.; Stevenson, M.; Hanchet, S. (2001b). Review of Bay of Plenty trawl survey time series (1983–99). *NIWA Technical Report 107*. 55 p.

Myers, R.A. (1998). When do environment–recruitment correlations work? *Reviews in Fish Biology and Fisheries 8*: 285–305.

Parsons, D.M.; Bian, R.; Parkinson, D.; MacGibbon, D.J. (2021). Trawl surveys of the Hauraki Gulf and Bay of Plenty in 2019 and 2020 to estimate the abundance of juvenile snapper. *New Zealand Fisheries Assessment Report 2021/08*. 127 p.

Paul, L.J. (1976). A study on age, growth, and population structure of the snapper, *Chrysophrys auratus* (Forster), in the Hauraki Gulf, New Zealand. *Fisheries Research Bulletin No. 13*. 62 p.

Shears, N.T.; Bowen, M.M. (2017). Half a century of coastal temperature records reveal complex warming trends in western boundary currents. *Scientific Reports 7*: 14527.

Stevenson, M.L.; Hanchet, S.M. (1999). Trawl survey design and data analysis procedures for inshore fisheries research. *NIWA Technical Report 53*. 20 p.

Visconti, V.; Trip, E.D.L.; Griffiths, M.H.; Clements, K.D. (2018). Life history traits of the leatherjacket *Meuschenia scaber*, a long-lived monacanthid. *Journal of Fish Biology 92*: 470–486.

Walsh, C.; Horn, P.; McKenzie, J.; Ó Maolagáin, C.; Buckthought, D.; Sutton, C.; Armiger, H. (2014). Age determination protocol for snapper (*Pagrus auratus*). *New Zealand Fisheries Assessment Report 2014/51*. 33 p.

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

Walsh, C.; McKenzie, J.; McGreggor, G.; Poortenar, C.; Hartill, B.; Smith, M. (2003). Information available for the management of New Zealand kingfish (*Seriola lalandi lalandi*) stocks. *New Zealand Fisheries Assessment Report 2003/25*. 57 p.

7. TABLES AND FIGURES

Table 1: Stratum depth ranges, survey area, number of stations suggested by *allocate*, as well as the number of valid phase one stations completed, the number of valid phase two biomass stations successfully completed, and station density. Non-trawlable area was excluded from survey strata so is not listed. Note that in the Bay of Plenty survey, 14 extended phase two stations were conducted. Foul tows not included.

Hauraki Gulf

Stratum	Depth (m)	Area (km^2)	No. of stations suggested by *allocate*	No. of valid phase one stations completed	No. of valid phase two stations completed	No. of valid extended phase two stations completed	Station density (km^2 per station)
1149	10–25	64.13	3	3	0	0	21.38
1219	25–50	882.86	3	3	2	0	176.57
1268	25–45	310.18	3	3	0	0	103.39
1284	10–25	72.76	3	3	0	0	24.25
1386	10–25	67.39	3	3	0	0	22.46
1449	10–50	267.61	3	3	0	0	89.20
1887	10–25	268.48	4	4	0	0	67.12
2229	25–45	556.60	3	3	5	0	69.58
9292	10–25	66.22	3	3	0	0	22.07
COLV	15–75	843.66	3	3	0	0	281.22
LITB	45–75	1 570.70	5	5	0	0	314.14
Total		4 970.59		36	7		108.31

Bay of Plenty

Stratum	Depth (m)	Area (km^2)	No. of stations suggested by *allocate*	No. of valid phase one stations completed	No. of valid phase two stations completed	No. of valid extended phase two stations completed	Station density (km^2 per station)
1096	10–25	296.17	5	5	7	0	24.68
2096	10–25	133.30	3	3	1	5	14.81
32NH	10–25	25.51	3	3	0	0	8.50
408M	25–50	512.78	9	9	0	0	56.98
518M	25–50	201.53	3	3	0	0	67.18
5287	25–50	393.26	3	3	0	0	131.09
6085	50–100	734.85	3	3	2	4	81.65
708N	50–100	834.53	8	8	0	0	104.32
708S	50–100	856.88	3	3	0	5	107.11
Total		3 988.81		40	10	14	66.26

Table 2: Gear parameters for valid biomass stations by depth range (n, number of stations; s.d., standard deviation). Extended phase two stations included for the Bay of Plenty survey.

Hauraki Gulf		*n*	Mean	s.d.	Range
All stations		43			
	Headline height (m)		5.3	0.3	4.7–5.9
	Doorspread (m)		75.1	3.7	65.9–81.2
	Distance (n. mile)		0.6	0.08	0.50–0.75
	Warp:depth ratio		8.1	4.7	3.7–20.0
0–25 m		16			
	Headline height (m)		5.3	0.3	4.8–5.9
	Doorspread (m)		72.2	2.6	68.8–76.8
	Distance (n. mile)		0.6	0.08	0.51–0.71
	Warp:depth ratio		13.1	3.9	8.0–20.0
25–50 m		24			
	Headline height (m)		5.2	0.3	4.7–5.8
	Doorspread (m)		76.6	3.3	65.9–81.2
	Distance (n. mile)		0.6	0.08	0.50–0.75
	Warp:depth ratio		5.3	1.3	4.0–8.0
50–75 m		3			
	Headline height (m)		5.7	0.3	5.4–5.9
	Doorspread (m)		78.9	1.2	77.6–79.9
	Distance (n. mile)		0.7	0.01	0.69–0.70
	Warp:depth ratio		3.9	0.2	3.7–4.0
Bay of Plenty					
All stations		64			
	Headline height (m)		5.7	0.4	5.0–6.5
	Doorspread (m)		76.5	4.7	67.6–85.4
	Distance (n. mile)		0.7	0.06	0.50–0.77
	Warp:depth ratio		6.9	3.6	2.9–15.4
0–25 m		22			
	Headline height (m)		5.9	0.3	5.2–6.5
	Doorspread (m)		72	2.66	67.6–77.7
	Distance (n. mile)		0.7	0.08	0.50–0.71
	Warp:depth ratio		11.3	1.7	8.3–15.4
25–50 m		17			
	Headline height (m)		5.7	0.3	5.2–6.3
	Doorspread (m)		76.5	2.3	71.3–80.1
	Distance (n. mile)		0.7	0.05	0.51–0.71
	Warp:depth ratio		5.6	1.5	4.1–8.7
50–75 m		17			
	Headline height (m)		5.5	0.4	5.0–6.2
	Doorspread (m)		82.1	2.2	76.4–85.4
	Distance (n. mile)		0.7	0.02	0.69–0.77
	Warp:depth ratio		4.1	0.3	3.7–4.6
75–100 m		8			
	Headline height (m)		5.6	0.5	5.0–6.2
	Doorspread (m)		77.5	4.2	71.0–84.2
	Distance (n. mile)		0.7	0.01	0.69–0.70
	Warp:depth ratio		3.2	0.2	2.9–3.4

Table 3: Mean catch rates (kg km^{-2}) by stratum for the most common QMS species in order of catch abundance for the 2020 Hauraki Gulf and 2021 Bay of Plenty surveys. Some species, denoted by a *, are included due to high historical abundance. Species codes are given in Appendix 6. Bay of Plenty catch rates incorporate extended phase two stations for only John dory, trevally, and tarakihi.

Hauraki Gulf

	Species code							
Stratum	SNA	JMN	JDO	LEA	GUR	TRE	SPO*	ATT*
1149	4 885	759	83	0	28	40	6	0
1219	3 968	171	30	59	59	4	6	0
1268	6 387	509	36	0	27	13	4	0
1284	8 361	29	3	6	50	15	34	0
1386	8 227	823	32	0	40	26	7	2
1449	187	33	18	121	43	0	0	0
1887	12 663	964	0	0	14	0	24	5
2229	13 119	394	45	3	42	24	7	4
9292	6 524	6	6	0	9	34	4	27
COLV	1 859	606	30	32	52	3	4	0
LITB	2 650	158	37	69	29	26	0	0

Bay of Plenty

	Species code										
Stratum	SNA	JMN	GUR	LEA	TRE	ATT*	JDO	SPO*	FRO*	KIN*	NMP*
1096	2 908	32	38	7	21	5	2	15	0	29	0
2096	5 894	0	5	17	79	0	14	0	0	4	0
32NH	340	2	11	151	14	0	3	8	0	0	0
408M	1 498	19	49	0	17	5	9	11	0	3	3
518M	262	1	11	76	17	0	15	0	0	14	0
5287	158	0	19	84	0	0	17	0	0	0	0
6085	991	13	30	5	7	0	22	0	0	6	25
708N	149	1	18	17	0	0	15	0	0	0	5
708S	134	15	39	15	0	0	57	0	0	0	0

Table 4: Relative biomass estimates (t) and CVs by trip for each of the Hauraki Gulf and Bay of Plenty surveys for QMS species. Species codes are given in Appendix 6. KAH2101 biomass estimates incorporate extended phase two stations for only John dory, trevally, and tarakihi. (Continued on next 3 pages)

	KAH8421		KAH8517		KAH8613		KAH8810		KAH8917		KAH9016		KAH9212	
Species code	Biomass	CV	Biomass	CV	Biomass	CV	Biomass	CV	Biomass	CV	Biomass	CV	Biomass	CV
ATT	0.1	100.0	14.0	52.1	90.6	84.9	25.9	84.6	10.1	79.6	4.2	37.8	2.7	58.3
BAR	15.8	100.0	0.0	0.0	0.0	0.0	9.6	51.7	97.4	63.4	34.7	100.0	237.0	46.3
EMA	0.0	0.0	0.1	100.0	2.7	67.1	9.6	80.3	4.1	30.8	0.6	37.8	3.1	37.5
GUR	460.3	15.7	35.6	55.3	269.8	30.3	571.2	20.7	76.7	35.2	103.3	17.8	288.6	8.3
JDO	147.5	16.2	135.2	13.1	110.2	18.2	391.2	38.8	209.2	20.1	196.2	17.8	176.4	35.2
JMA	65.9	55.4	0.0	0.0	71.0	48.9	0.0	0.0	40.5	62.3	0.0	0.0	0.0	0.0
JMD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
JMM	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
JMN	43.6	36.8	160.6	32.4	908.6	49.5	1 137.0	33.7	898.2	34.0	854.5	24.2	619.3	27.8
LEA	244.6	44.7	244.4	61.0	326.4	37.6	152.4	35.1	220.1	23.8	228.5	22.2	166.7	31.1
NMP	19.4	67.2	0.0	0.0	0.0	0.0	1.0	100.0	0.0	0.0	31.4	99.3	27.5	91.6
PAR	0.0	0.0	0.0	0.0	0.0	0.0	1.3	51.2	0.0	0.0	2.6	43.4	1.6	61.3
PIL	0.0	0.0	0.0	0.0	0.4	100.0	4.3	69.4	0.0	100.0	0.5	94.2	22.8	90.0
RSK	33.3	96.6	0.0	0.0	20.9	72.3	77.9	34.2	1.9	100.0	0.0	0.0	0.0	0.0
SCH	0.0	0.0	0.3	100.0	9.2	100.0	30.4	56.9	4.9	92.4	0.0	0.0	2.1	89.4
SFL	21.2	83.0	0.4	100.0	2.0	61.4	67.8	45.5	4.6	33.6	1.1	69.6	52.3	19.8
SNA	3 606.4	27.1	1 867.4	22.4	2 396.2	22.5	4 171.1	21.8	6 826.9	18.1	6 940.3	17.5	2 585.3	13.3
SPO	45.1	34.2	11.1	75.2	84.1	45.4	106.4	22.3	58.9	61.9	77.2	73.1	39.0	22.3
SPZ	0.0	0.0	0.0	0.0	6.5	57.5	59.4	46.6	12.3	33.2	2.0	59.4	34.7	24.7
SSK	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TRE	66.6	82.5	58.8	45.0	31.5	46.5	10.8	52.8	97.0	69.6	29.1	57.7	4.7	65.2
YBF	0.0	0.0	0.2	100.0	1.4	51.7	14.5	35.2	2.3	40.1	0.6	61.6	18.3	27.1
YEM	0.0	0.0	0.0	0.0	21.7	99.5	7.3	96.0	1.1	36.0	3.4	45.6	8.4	81.6

Table 4— Hauraki Gulf continued.

Hauraki Gulf

Species code	KAH9311		KAH9411		KAH9720		KAH0012		KAH1907		KAH2006	
	Biomass	CV	Biomass	CV	Biomass	CV	Biomass	CV	Biomass	CV	Biomass	CV
ATT	16.5	54.0	28.9	91.2	1.3	74.2	4.1	55.6	6.9	27.9	5.2	50.4
BAR	18.2	34.2	62.0	35.9	147.2	41.2	143.4	64.7	0.9	70.7	9.4	90.4
EMA	136.8	39.4	2.4	41.3	6.9	41.1	4.6	66.7	2.3	64.6	7.1	52.1
GUR	138.9	15.7	208.8	21.4	212.1	15.3	24.4	46.1	161.7	28.3	196.4	7.4
JDO	328.7	26.7	231.4	12.4	292.5	20.0	191.3	28.5	188.3	14.7	159.3	30.5
JMA	0.0	0.0	20.5	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
JMD	0.0	0.0	2 227.7	58.4	34.3	71.2	6.3	100.0	0.0	0.0	0.1	100.0
JMM	0.0	0.0	0.0	0.0	0.0	0.0	0.8	100.0	0.0	0.0	0.0	0.0
JMN	1 804.5	13.7	1 476.2	18.6	841.0	21.0	757.2	17.5	2130.6	29.1	1661.8	31.4
LEA	456.2	27.2	238.1	19.4	477.1	21.5	116.5	37.1	337.5	30.0	222.9	21.2
NMP	30.8	65.0	75.0	95.1	35.1	47.8	679.8	96.9	11.9	41.6	29.6	92.0
PAR	3.3	41.9	2.9	56.8	0.4	70.7	0.9	100.0	0.2	100.0	0.0	0.0
PIL	135.3	83.4	153.5	99.4	19.3	98.6	4.1	51.0	0.8	68.2	0.0	0.0
RSK	25.1	34.8	0.3	100.0	0.0	0.0	0.0	0.0	27.2	61.7	0.0	0.0
SCH	4.4	72.2	2.4	69.7	5.7	77.7	0.5	100.0	39.9	67.6	6.1	87.4
SFL	106.5	21.1	176.4	19.4	4.5	45.7	0.1	100.0	0.6	40.8	0.4	70.2
SNA	6 468.6	13.6	3 458.9	10.0	5 779.8	18.1	7 682.5	27.7	20 617.7	13.6	23 875.5	17.0
SPO	22.8	30.6	34.2	35.4	28.2	27.4	3.9	55.0	28.9	24.8	24.2	29.3
SPZ	13.7	23.0	17.5	21.1	22.5	32.7	1.1	70.9	2.6	64.3	4.6	56.9
SSK	0.0	0.0	232.4	27.9	181.9	49.8	0.0	0.0	0.0	0.0	0.0	0.0
TRE	12.0	60.8	9.9	76.5	5.9	73.6	21.9	56.1	107.1	34.7	72.8	59.3
YBF	3.9	48.9	20.8	49.0	0.0	0.0	0.1	100.0	0.0	0.0	0.0	0.0
YEM	0.3	90.7	6.8	98.7	1.5	100.0	0.1	100.0	0.0	0.0	0.1	100.0

Table 4— Bay of Plenty.

Species	KAH8303		KAH8506		KAH9004		KAH9202		KAH9601		KAH9902		KAH2001		KAH2101	
code	Biomass	CV	Biomass	CV	Biomass	CV	Biomass	CV	Biomass	CV	Biomass	CV	Biomass	CV	Biomass	CV
ATT	23.7	45.6	78.8	40.4	69.4	49.6	39.6	56.9	21.3	58.5	46.7	25.6	94.8	88.1	4.1	49.5
BCO	2.8	70.2	0.0	0.0	1.3	92.6	1.6	70.3	0.7	64.2	0.0	0.0	0.0	0.0	0.0	0.0
BRI	1.3	39.7	0.0	0.0	0.2	59.4	0.4	67.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FRO	7.5	60.3	0.0	0.0	24.5	47.5	7.5	56.7	20.4	70.3	62.5	35.9	18.6	55.7	0.0	0.0
GSH	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GUR	356.0	22.6	32.6	16.1	403.9	11.5	259.9	9.5	307.5	14.6	326.3	14.8	181.3	14.6	117.8	10.7
HOK	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
JDO	109.3	24.3	92.2	15.0	127.8	17.2	225.8	12.2	174.7	48.0	153.3	14.8	84.2	23.3	95.3	20.7
JMA	115.8	79.4	58.3	44.5	51.8	60.5	107.0	29.6	3.0	96.0	0.0	0.0	0.0	0.0	0.0	0.0
JMD	1.1	79.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.1	35.7	2.6	28.4	12.2	37.5
JMM	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0
JMN	460.3	37.2	280.5	89.0	19.5	60.5	0.0	0.0	973.4	63.7	233.5	40.0	214.4	47.5	42.5	39.3
KIN	10.9	36.6	35.8	67.7	20.3	58.1	51.4	36.6	12.6	40.2	18.4	50.8	6.0	71.9	18.1	34.4
LDO	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LEA	61.2	29.9	45.1	38.9	128.4	16.4	255.4	27.6	118.5	21.4	84.5	18.6	148.7	55.7	87.7	16.1
LIN	1.3	59.1	0.0	0.0	0.0	0.0	0.0	0.0	4.3	100.0	0.0	0.0	0.0	0.0	0.0	0.0
LSO	8.0	42.5	0.0	0.0	1.1	31.9	0.1	84.7	2.2	47.5	2.6	28.3	1.6	48.4	0.0	0.0
NMP	6.2	46.3	3.1	54.9	13.0	66.0	98.7	33.8	16.1	86.3	11.2	68.3	2.7	54.2	24.3	50.3
RBT	0.0	0.0	0.0	0.0	0.0	0.0	0.2	100.0	0.2	100.0	0.0	0.0	0.0	0.0	0.0	0.0
RCO	2.8	61.8	0.0	0.0	0.6	71.4	0.0	0.0	5.1	100.0	16.6	66.7	0.0	0.0	0.0	0.0
RSK	47.4	34.2	0.0	0.0	0.0	0.0	0.0	0.0	52.7	38.7	48.0	35.1	8.5	74.8	0.8	100.0
SCH	0.0	0.0	0.0	0.0	21.4	67.1	0.9	71.5	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0
SFL	6.0	34.2	0.0	0.0	13.7	48.2	1.7	37.7	7.8	27.4	6.8	63.9	0.3	100.0	0.0	0.0
SKI	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	100.0	0.0	0.0
SNA	117.8	21.8	458.5	13.0	1 454.3	13.2	1 109.9	10.0	934.5	14.1	1 594.9	18.1	2 823.9	8.9	3 506.3	17.7
SPE	0.6	76.8	0.0	0.0	0.2	100.0	1.5	59.6	2.6	90.9	3.5	67.3	0.0	0.0	0.0	0.0

Species	KAH8303		KAH8506		KAH9004		KAH9202		KAH9601		KAH9902		KAH2001		KAH2101	
code	Biomass	CV	Biomass	CV	Biomass	CV	Biomass	CV	Biomass	CV	Biomass	CV	Biomass	CV	Biomass	CV
SPO	2.3	100.0	2.8	82.2	24.7	37.9	12.9	39.2	9.2	73.8	26.9	84.4	35.9	24.9	10.6	60.2
SPZ	3.0	33.8	0.0	100.0	9.0	17.0	4.3	26.1	8.1	20.2	1.0	55.7	2.9	62.2	1.9	45.2
SQU	23.1	50.2	0.0	0.0	0.4	72.0	5.0	51.9	2.6	35.9	0.9	56.0	1.7	100.0	2.7	53.8
SSK	0.0	0.0	0.0	0.0	75.0	47.7	0.0	0.0	0.0	0.0	8.2	84.3	0.0	0.0	0.0	0.0
STA	1.1	100.0	0.0	0.0	0.8	73.6	5.4	50.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TRE	5.8	51.1	79.6	19.9	89.7	42.5	64.9	41.1	40.0	25.4	267.1	26.1	73.5	18.2	34.5	20.0
WAR	8.0	93.4	0.0	0.0	0.0	0.0	7.6	80.7	0.1	80.1	0.0	0.0	0.1	100.0	0.0	0.0

Table 5: Estimates of recruited biomass (fish length ≥ recruited length) for the most common QMS species (in alphabetical order by species code) for the 2020 Hauraki Gulf and 2021 Bay of Plenty surveys. Some species, denoted by a *, are included due to high historical abundance. Species codes are given in Appendix 6. The recruited biomass of kingfish in the Bay of Plenty is listed as NA because length data were not collected. Bay of Plenty biomass estimates incorporate extended phase two stations for only John dory, trevally, and tarakihi.

Hauraki Gulf

Species code	Recruited length (cm)	Biomass (t)	CV %	% of overall biomass ≥ recruited length
ATT*	40	3.3	71.0	62.8
GUR	30	96.2	12.4	49.0
JDO	25	156.4	31.3	98.2
JMN	25	129.1	49.6	7.8
LEA	19	221.5	21.2	99.4
SNA	25	19 502.9	20.1	81.7
SPO*	90	4.1	100.0	17.1
TRE	25	71.6	60.1	98.4

Bay of Plenty

Species code	Recruited length (cm)	Biomass (t)	CV %	% of overall biomass ≥ recruited length
ATT*	40	3.8	51.6	92.5
FRO*	90	0.0	0.0	0.0
GUR	30	85.1	10.4	72.2
JDO	25	92.1	21.6	96.6
JMN	25	2.9	93.8	6.8
KIN*	90	NA	NA	NA
LEA	19	85.5	16.6	97.5
NMP*	25	24.2	50.2	99.5
SNA	25	3 291.1	18.5	93.9
SPO*	90	3.6	72.4	34.1
TRE	25	33.5	20.8	97.0

Table 6: Estimated biomass (t) and CV (%) by stratum for the most common QMS species for both the 2020 Hauraki Gulf and 2021 Bay of Plenty surveys. Some species, denoted by a *, are included due to high historical abundance. Species codes are given in Appendix 6. Bay of Plenty biomass estimates incorporate extended phase two stations for only John dory, trevally, and tarakihi.

Hauraki Gulf

								Species code		
Stratum	SNA all	SNA pre–recruit	SNA recruit	JMN	LEA	JDO	GUR	TRE	SPO*	ATT*
1149	313 (55)	93 (46)	220 (61)	49 (43)	0 (0)	5 (74)	2 (38)	3 (92)	0 (100)	0 (0)
1219	3 503 (36)	757 (38)	2 746 (36)	151 (56)	52 (55)	27 (10)	52 (12)	3 (100)	5 (61)	0 (0)
1268	1 981 (12)	417 (6)	1 564 (14)	158 (51)	0 (0)	11 (53)	8 (5)	4 (53)	1 (100)	0 (0)
1284	608 (16)	138 (11)	470 (18)	2 (38)	0 (100)	0 (100)	4 (78)	1 (87)	2 (68)	0 (0)
1386	554 (13)	124 (4)	431 (16)	55 (38)	0 (0)	2 (56)	3 (58)	2 (100)	0 (90)	0 (100)
1449	50 (40)	16 (56)	34 (39)	9 (100)	32 (6)	5 (59)	12 (6)	0 (0)	0 (0)	0 (0)
1887	3 400 (24)	382 (13)	3 018 (26)	259 (41)	0 (0)	0 (0)	4 (24)	0 (100)	6 (35)	1 (100)
2229	7 302 (50)	705 (11)	6 597 (55)	219 (36)	2 (65)	25 (41)	23 (26)	14 (87)	4 (100)	2 (71)
9292	432 (16)	113 (26)	319 (13)	0 (16)	0 (0)	0 (100)	1 (24)	2 (52)	0 (100)	2 (100)
COLV	1 568 (58)	405 (48)	1 163 (64)	511 (91)	27 (61)	26 (9)	44 (13)	3 (100)	4 (100)	0 (0)
LITB	4163 (9)	1 222 (21)	2 941 (12)	248 (62)	109 (31)	58 (80)	45 (21)	42 (99)	0 (0)	0 (0)
Total	23 875 (17)	4 373 (10)	19 503 (20)	1 662 (31)	223 (21)	159 (30)	196 (7)	73 (59)	24 (29)	5 (50)

Bay of Plenty

												Species code	
Stratum	SNA	SNA pre–recruit	SNA recruit	JMN	GUR	LEA	ATT*	JDO	TRE	SPO*	FRO*	KIN*	NMP*
1096	861 (14)	67 (29)	794 (14)	9 (96)	11 (31)	2 (100)	1 (65)	1 (86)	6 (22)	4 (54)	0 (0)	9 (52)	0 (0)
2096	786 (57)	22 (95)	764 (56)	0 (100)	1 (58)	2 (85)	0 (0)	2 (37)	10 (49)	0 (0)	0 (0)	1 (100)	0 (0)
32NH	9 (57)	0 (55)	9 (57)	0 (69)	0 (51)	4 (94)	0 (0)	0 (100)	0 (48)	0 (100)	0 (0)	0 (0)	0 (0)
408M	768 (21)	57 (30)	711 (22)	9 (47)	25 (22)	0 (100)	3 (68)	5 (33)	9 (28)	6 (100)	0 (0)	2 (100)	1 (100)
518M	53 (46)	9 (50)	44 (49)	0 (50)	2 (61)	15 (13)	0 (0)	3 (57)	3 (50)	0 (0)	0 (0)	3 (100)	0 (0)
5287	62 (52)	0 (0)	62 (52)	0 (100)	7 (64)	33 (6)	0 (0)	7 (39)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
6085	729 (52)	49 (42)	680 (57)	9 (73)	22 (18)	4 (55)	0 (0)	16 (19)	5 (66)	0 (0)	0 (0)	5 (61)	19 (62)
708N	125 (40)	6 (51)	119 (40)	1 (61)	15 (29)	14 (45)	0 (0)	12 (31)	0 (0)	0 (0)	0 (0)	0 (0)	4 (84)
708S	114 (15)	6 (74)	108 (20)	13 (90)	34 (23)	13 (86)	0 (0)	49 (38)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Total	3 506 (18)	215 (18)	3 291 (19)	43 (39)	118 (11)	88 (16)	4 (49)	95 (21)	35 (20)	11 (60)	0 (0)	18 (34)	24 (50)

Table 7: Number of biological and length frequency records. Measurement methods; 1, fork length; 2, total length; 5, pelvic length. Biological data includes one or more of the following: fish weight, gonad/maturity stage, otoliths. Species codes are given in Appendix 6. Bay of Plenty table includes extended phase two stations for all species. (Continued on next page)

Hauraki Gulf

		Length frequency data		Biological data		
Species	Measurement method	No. of samples	No. of fish	No. of samples	No. of fish	No. of otoliths
ATT	1	6	17	2	12	
BAR	1	3	3			
BWH	2	1	1			
EMA	1	6	14			
FRO	1	1	1			
GUR	1	43	639	43	623	
HHS	2	3	7			
JDO	2	28	93	28	93	
JMN	1	38	3 310	8	844	
KIN	1	1	2	1	2	
LEA	2	18	434	18	250	
NMP	1	2	6	2	6	
SCH	2	2	2			
SFL	2	2	4			
SNA	1	43	7 151	43	972	944
SPO	2	14	20			
SPZ	2	3	4			
THR	2	1	1			
TRE	1	17	107	17	107	
YEM	1	1	3			

Bay of Plenty

		Length frequency data		Biological data		
Species	Measurement method	No. of samples	No. of fish	No. of samples	No. of fish	No. of otoliths
ATT	1	6	12	6	12	
BAR	1	2	2			
BOA	1	3	53	1	1	
EMA	1	2	2			
FRO	1	2	7			
GUR	1	55	501	55	422	
JDO	2	43	147	43	147	
JGU	1	1	2			
JMD	1	19	551			
JMN	1	29	1 024	7	124	
LEA	2	33	524	26	347	
MOK	1	1	3			
NMP	1	6	45	6	45	
POR	1	1	10			
RSK	5	2	4			
SNA	1	63	5 373	63	1 267	892
SPO	2	6	12	1	2	
TRE	1	35	129	34	114	
YBF	2	2	2			

Table 8: Number of individual fish at each reproductive stage for fish staged on the 2020 Hauraki Gulf and 2021 Bay of Plenty surveys (small fish of undetermined sex were not included). Gonad stages are defined in Appendix 1. Bay of Plenty table includes extended phase two stations for all species. (Continued on next page)

Hauraki Gulf

	Male gonad stages							Female gonad stages							
Length (cm)	1	2	3	4	5	6	7	1	2	3	4	5	6	7	Total
Gurnard															
11–20	7	7	2					3	2	2					23
21–30	15	70	48	5			1	10	46	107	22	3	4	3	334
31–40		8	5				1		5	90	28	4	11	6	158
41–50										4	2	1			7
Total	22	85	55	5	0	0	2	13	53	203	52	8	15	9	522
John dory															
0–10	1														1
11–20									2						2
21–30	6	6	3					1	7						23
31–40		2	6						1	14					23
41–50		1								33	3				37
51–60										7					7
Total	7	9	9	0	0	0	0	1	10	54	3	0	0	0	93
Leatherjacket															
11–20	4	1	2					1		1					9
21–30	6	93	20						12	82	22	2	1		238
31–40			1						1	1					3
Total	10	94	23	0	0	0	0	1	13	84	22	2	1	0	250
Tarakihi															
31–40		1													1
41–50									5						5
Total	0	1	0	0	0	0	0	0	5	0	0	0	0	0	6
Snapper															
11–20	63	11						48	18	3					143
21–30	4	26	142	67	8			2	50	151	33	2			485
31–40			55	38	11				5	44	14	4		1	172
41–50			4	6	7					5	5	3			30
51–60			3	8	2						4	4	1		22
61–70			1	2	2										5
71–80				1						1					2
81–90			1												1
Total	67	37	206	122	30	0	0	50	73	204	56	13	1	1	860
Trevally															
11–20	12							6							18
21–30			9	1	1			1	3	5					20
31–40		2	6	4	15				3	28	1				59
41–50			1							2	1				4
Total	12	2	16	5	16	0	0	7	6	35	2	0	0	0	101

Bay of Plenty

	Male gonad stages							Female gonad stages							
Length (cm)	1	2	3	4	5	6	7	1	2	3	4	5	6	7	Total
Kahawai															
21–30	2							4							6
31–40															0
41–50		1			2	1				1					5
51–60					1										1
Total	2	1	0	0	3	1	0	4	0	1	0	0	0	0	12
Gurnard															
11–20	1	1													2
21–30	11	70	27	1	2	1	4	7	16	16	11		4	30	200
31–40		13	9	1	2		2		14	81	18	5	7	42	194
41–50										19	3		1		23
Total	12	84	36	2	4	1	6	7	30	116	32	5	12	72	419
John dory															
21–30	8	16	2					10	23						59
31–40		14	20	10					8	3	4	1		1	61
41–50				1						9	14	1		1	26
51–60											1				1
Total	8	30	22	11	0	0	0	10	31	12	19	2	0	2	147
Tarakihi															
21–30		2							1						3
31–40		10	3	1	4				20	2					40
Total	0	12	3	1	4	0	0	0	21	2	0	0	0	0	43
Snapper															
0–10	1								1						2
11–20	60							46							106
21–30	50	75	18	29	34	10	8	72	101	39	20	2	2	3	463
31–40	1	102	8	38	38	13	33		123	48	27		4	53	488
41–50		6	2	7	11		9		13	12	5		3	39	107
51–60			1		2		1		1	2	1			9	17
61–70		1		1										5	7
71–80													1	1	2
Total	112	184	29	75	85	23	51	118	239	101	53	2	10	110	1 192
Trevally															
21–30		3	2	1	1					3					10
31–40		2	6	6	18	1			2	29		1			65
41–50			2	2	2					13				2	21
51–60											1				1
Total	0	5	10	9	21	1	0	0	2	45	1	1	0	2	97

Table 9: Estimated number and CV (%) of 1+ and 2+ snapper for the Hauraki Gulf and Bay of Plenty survey series. Numbers estimated for historic surveys were calculated using either a combination of scaled length frequency distributions and age length keys of those historic surveys or, if age data were not available or were unreliable, a modal analysis of just the 1+ cohort (indicated by an *). – = not estimable.

Hauraki Gulf

Trip code	No. 1+ SNA	CV (%)	No. 2+ SNA	CV (%)
KAH8421	703 098	40	1 018 116	24
KAH8517	2 450 453*	16	–	–
KAH8613	2 704 737	17	2 177 629	15
KAH8810	1 833 352	15	2 590 168	14
KAH8917	3 945 077	20	1 298 830	16
KAH9016	9 981 150	16	5 768 755	07
KAH9212	3 470 219	16	1 825 219	10
KAH9311	1 245 062	16	5 404 236	09
KAH9411	1 429 884	18	1 422 187	12
KAH9720	5 241 233	14	4 433 344	07
KAH0012	3 985 095	19	3 710 258	21
KAH1907	5 364 819	21	7 317 125	11
KAH2006	7 982 358	17	5 760 733	14

Bay of Plenty

Trip code	No. 1+ SNA	CV (%)	No. 2+ SNA	CV (%)
KAH8303	202 947*	50	–	–
KAH8506	19 526*	36	–	–
KAH9004	306 620	22	611 740	18
KAH9202	313 654	26	287 898	19
KAH9601	326 964	24	411 390	19
KAH9902	44 595	52	–	–
KAH2001	926 233	25	453 003	23
KAH2101	1 374 195	38	945 089	18

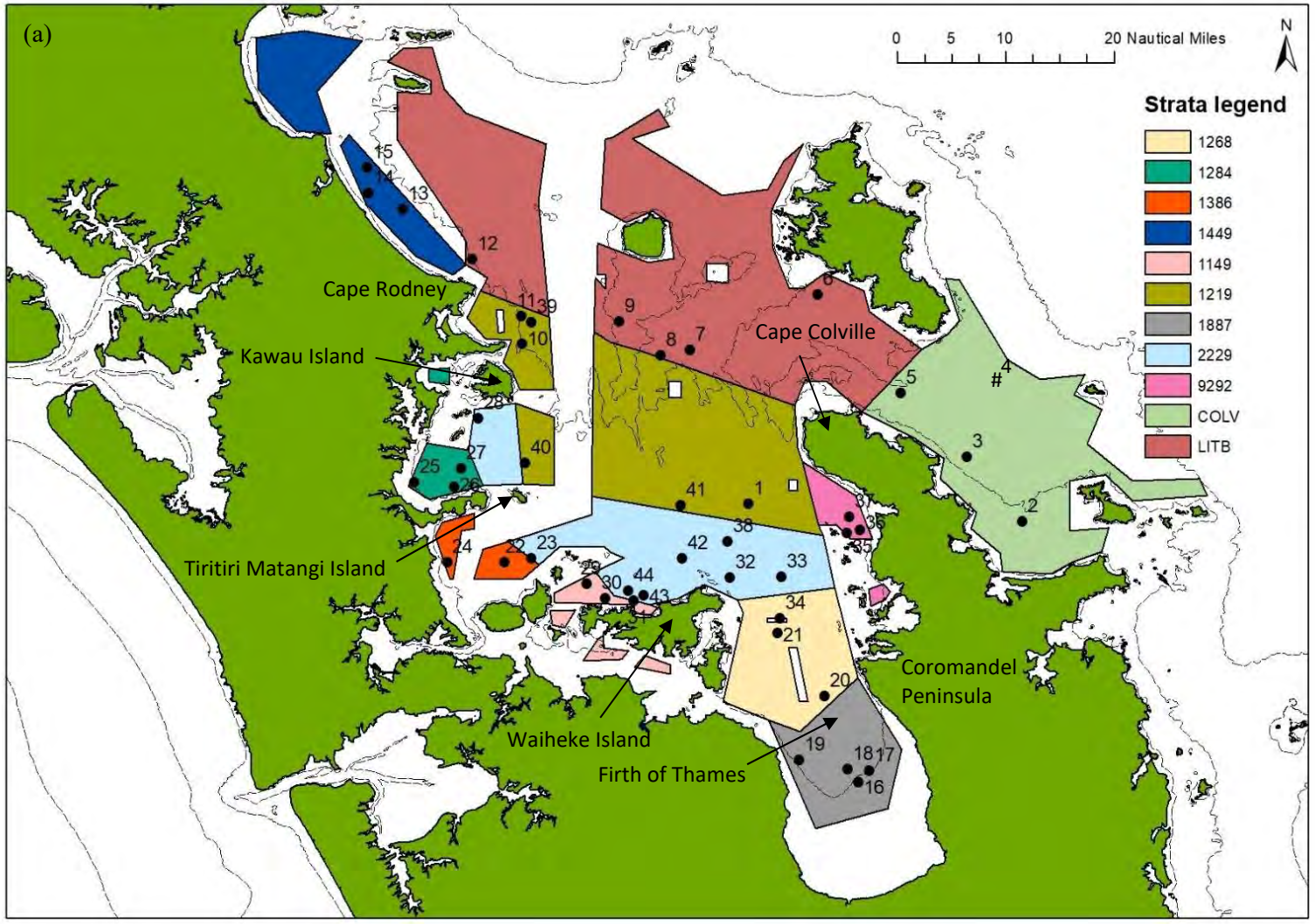


Figure 1: **Survey area showing stratum boundaries and names (legend) for the Hauraki Gulf (a) and Bay of Plenty (b) surveys, with valid station positions (filled circles) and station numbers. Foul shots indicated by a #. Dashed lines represent the 10, 50, and 100 m depth contours. White areas were not within the survey areas (they were either outside the survey area or excluded due to foul ground). (Continued on next page)**

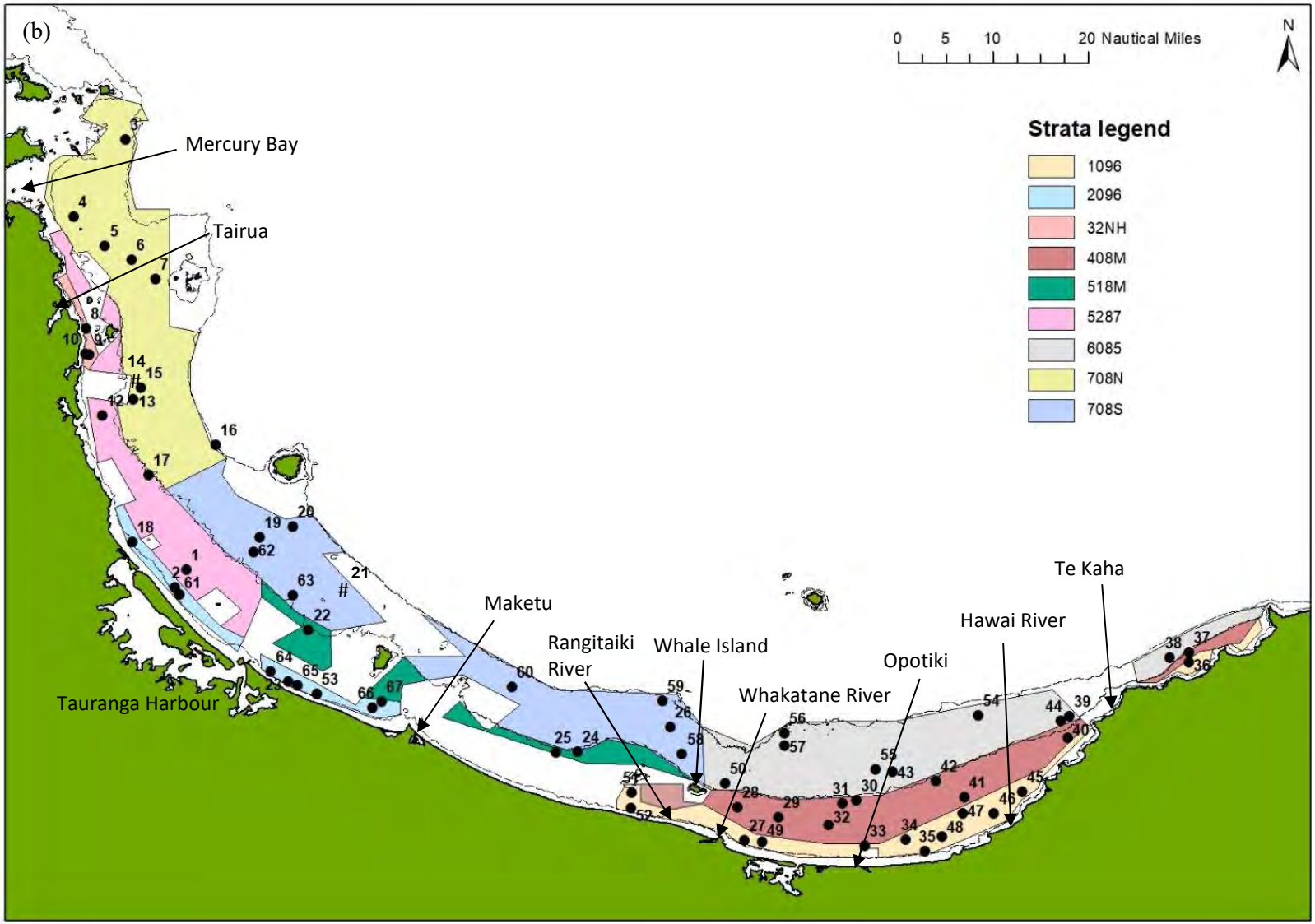
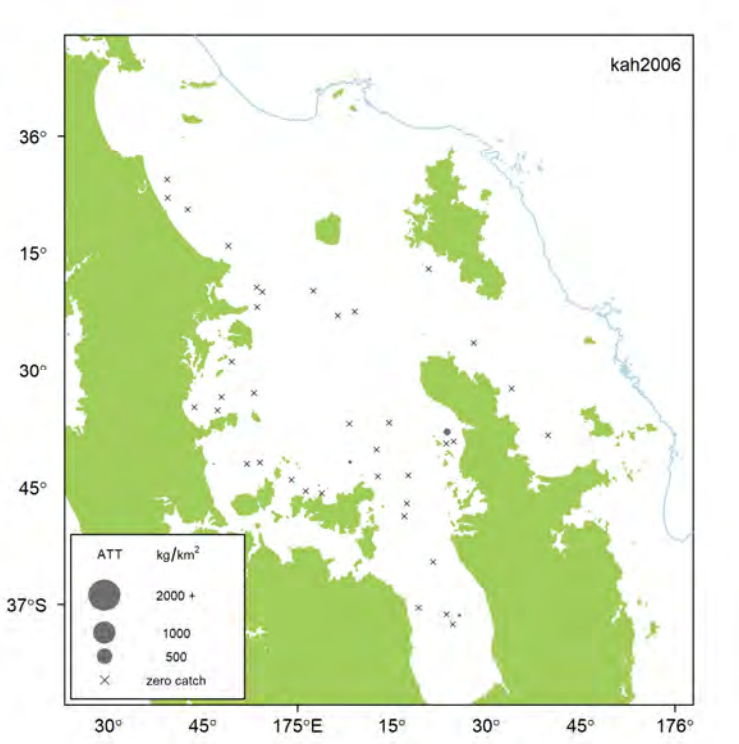
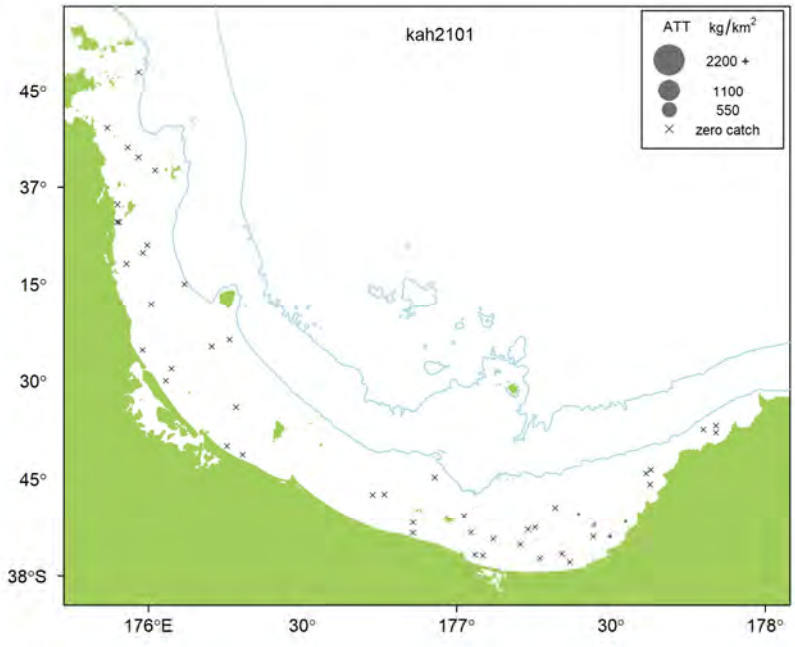


Figure 1: continued.

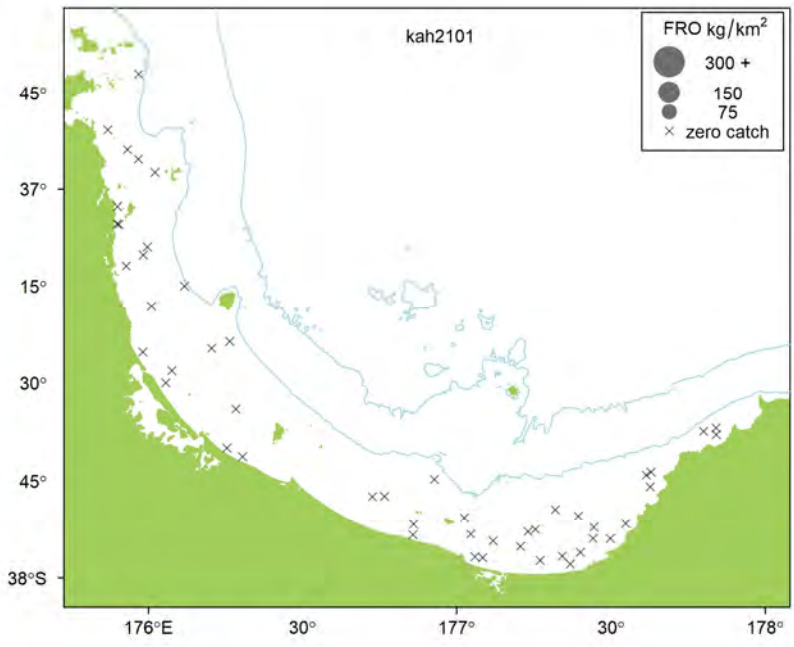


a: Kahawai (ATT)*, Hauraki Gulf

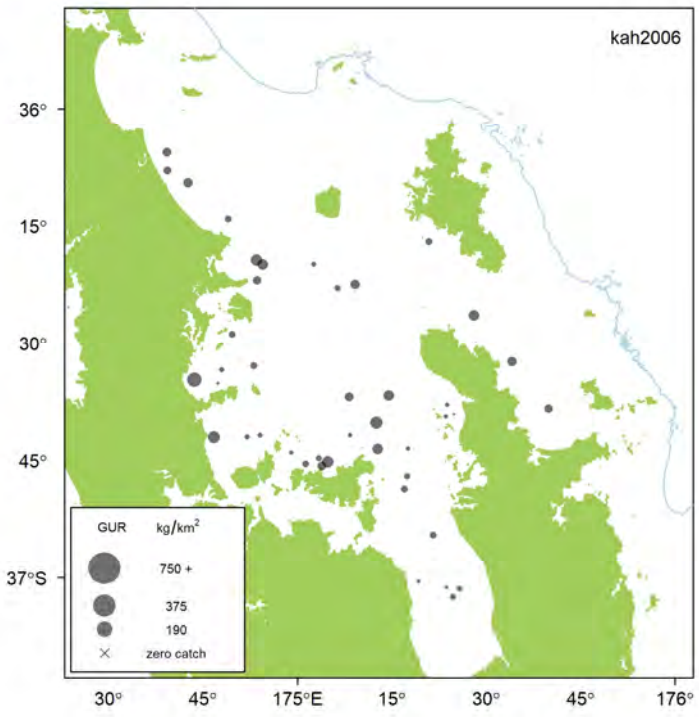
Figure 2: The spatial distribution of catch (kg km^{-2}) for the most common QMS species (in alphabetical order by species code) from the 2020 Hauraki Gulf and 2021 Bay of Plenty surveys. Some species are included due to high historical abundance; denoted by a *. N.B. Catch rate scale varies between species. For consistency within a species, however, catch rates are scaled to the largest catch in the full historic time series (see Figure 3) for that species in either the Hauraki Gulf or Bay of Plenty surveys. Bay of Plenty catch rate maps include extended phase two stations for only John dory, trevally, and tarakihi.



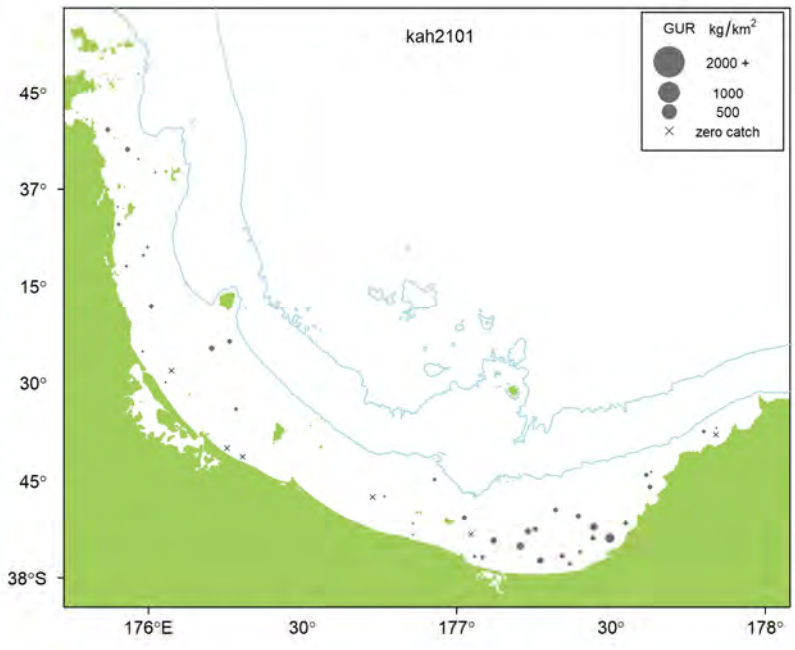
b: Kahawai (ATT)*, Bay of Plenty.



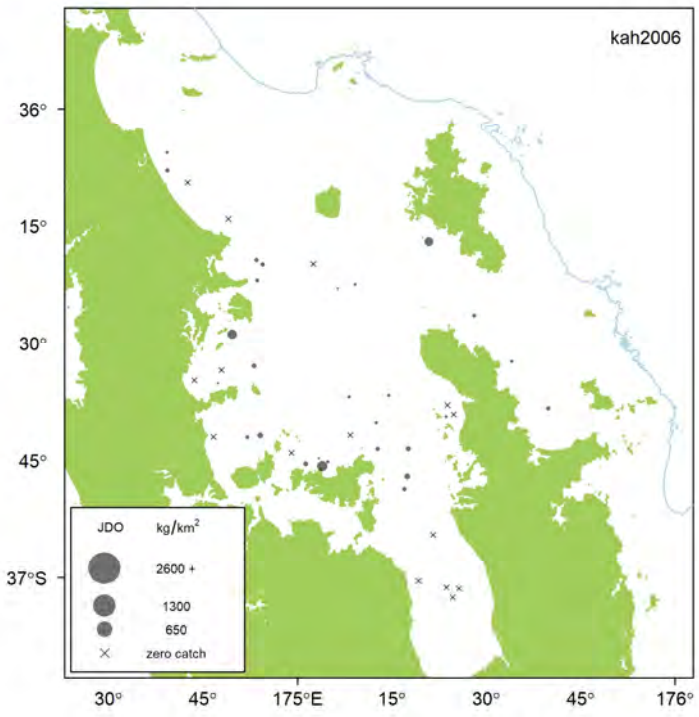
c: Frostfish (FRO)*, Bay of Plenty.



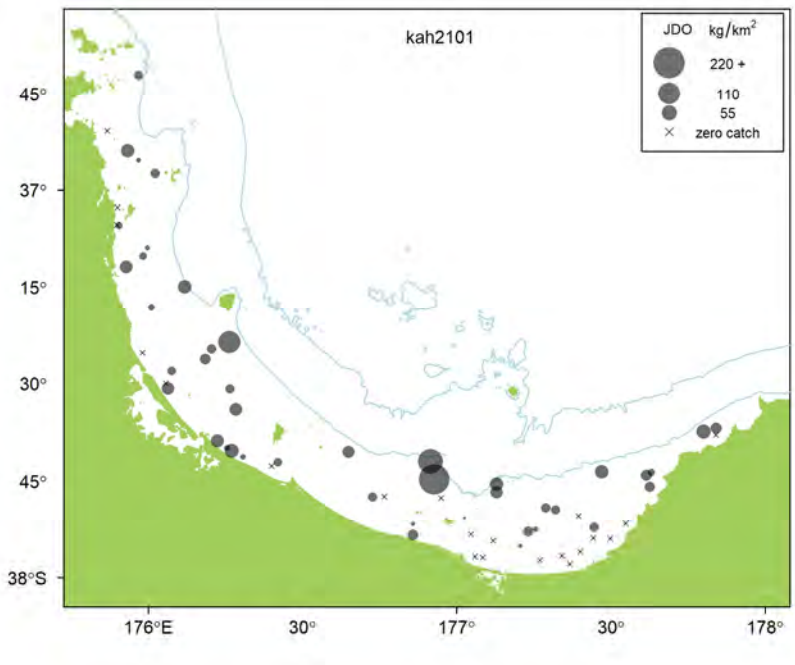
d: Red gurnard (GUR), Hauraki Gulf.



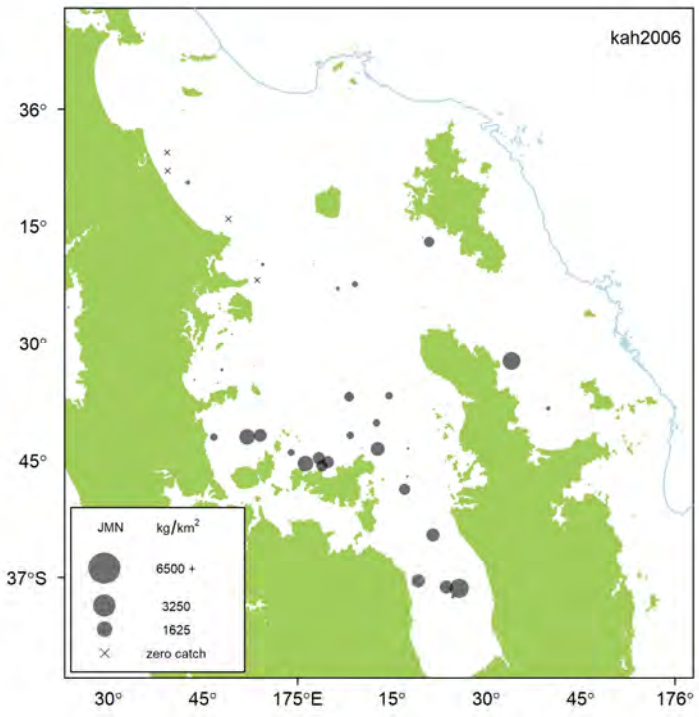
e: Red gurnard (GUR), Bay of Plenty.



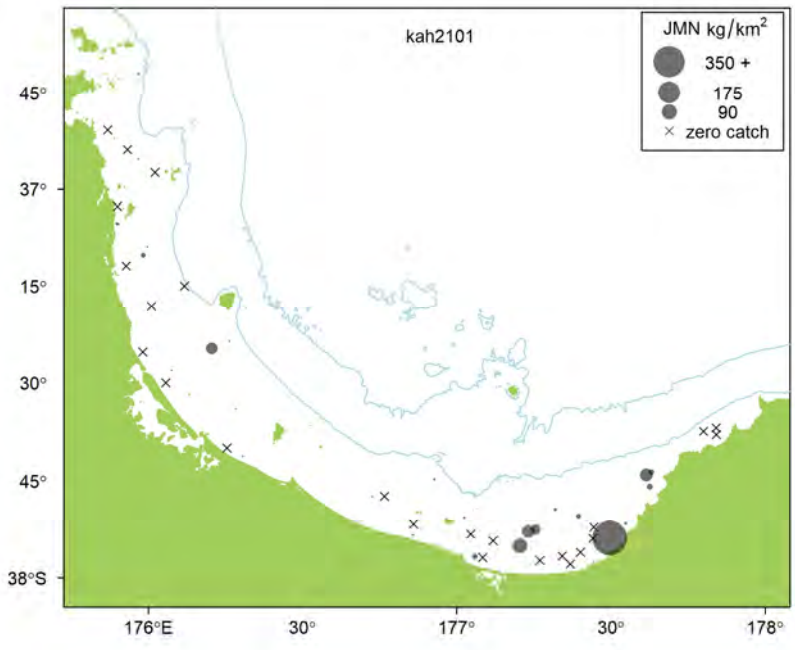
f: John dory (JDO), Hauraki Gulf.



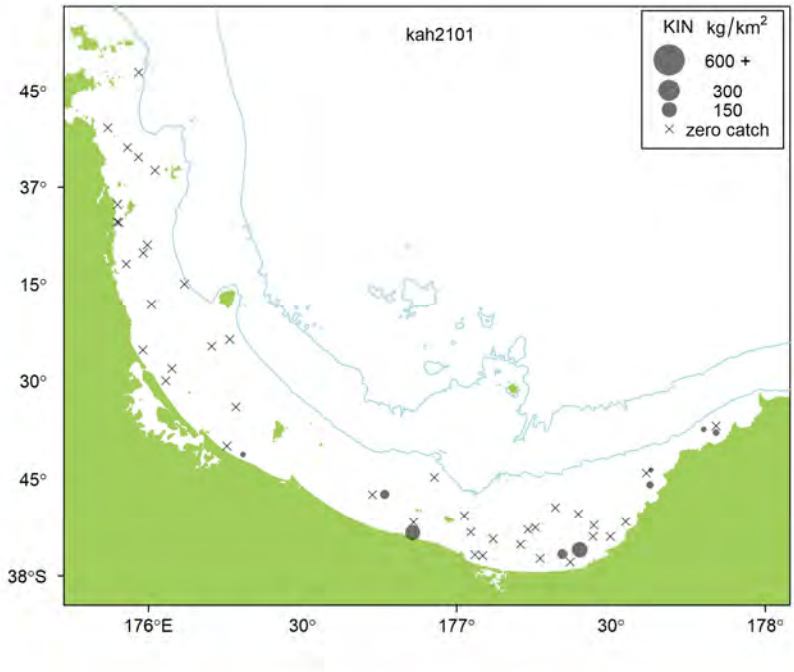
g: John dory (JDO), Bay of Plenty.



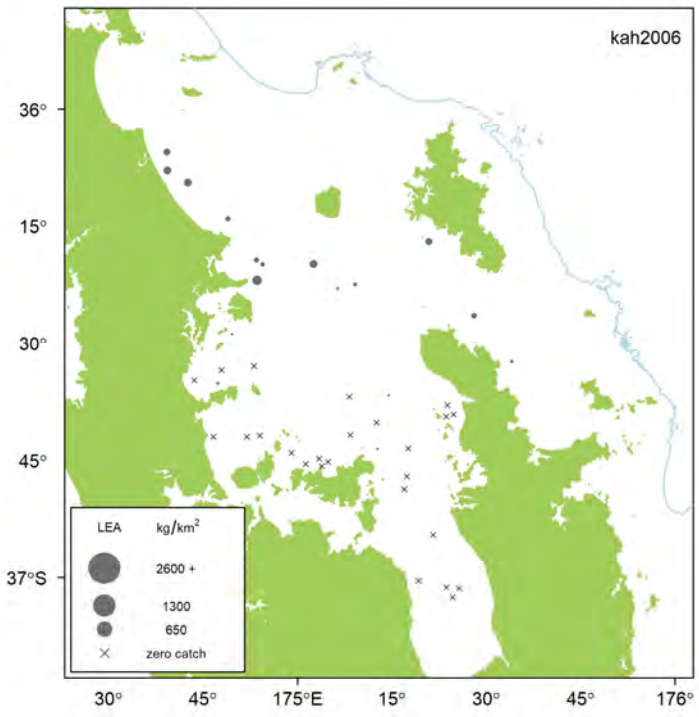
h: Yellowtail jack mackerel (JMN), Hauraki Gulf.



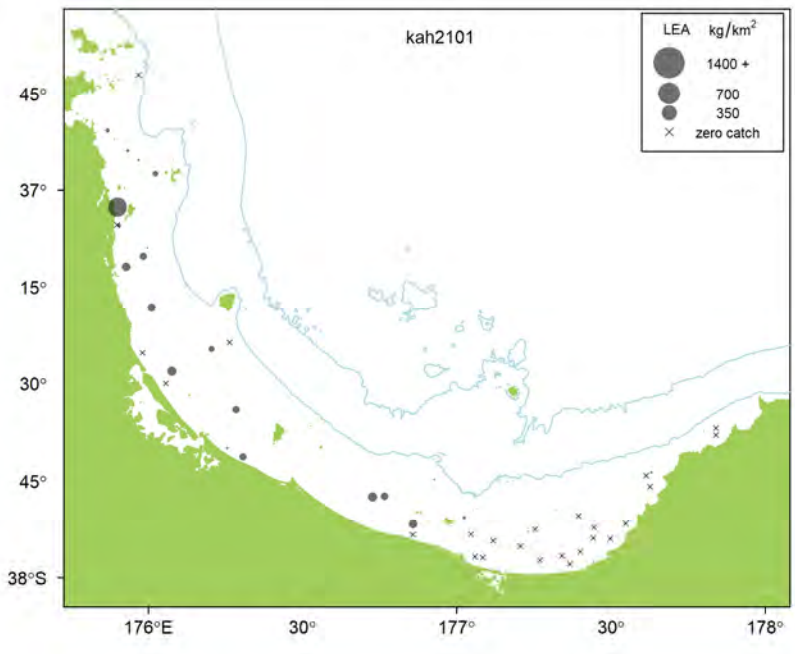
i: Yellowtail jack mackerel (JMN), Bay of Plenty. Note bubble size scale different than time series plot (Figure 3n).



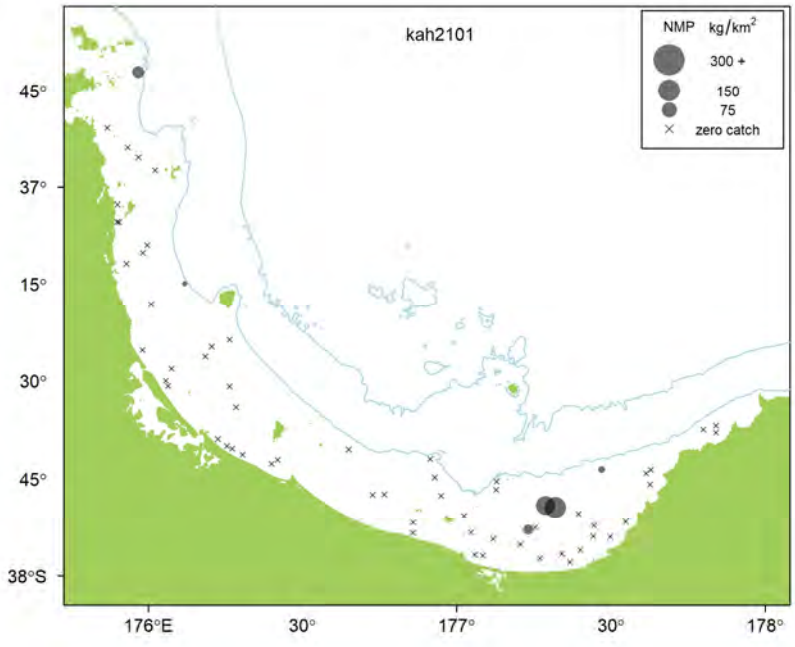
j: Kingfish (KIN)*, Bay of Plenty.



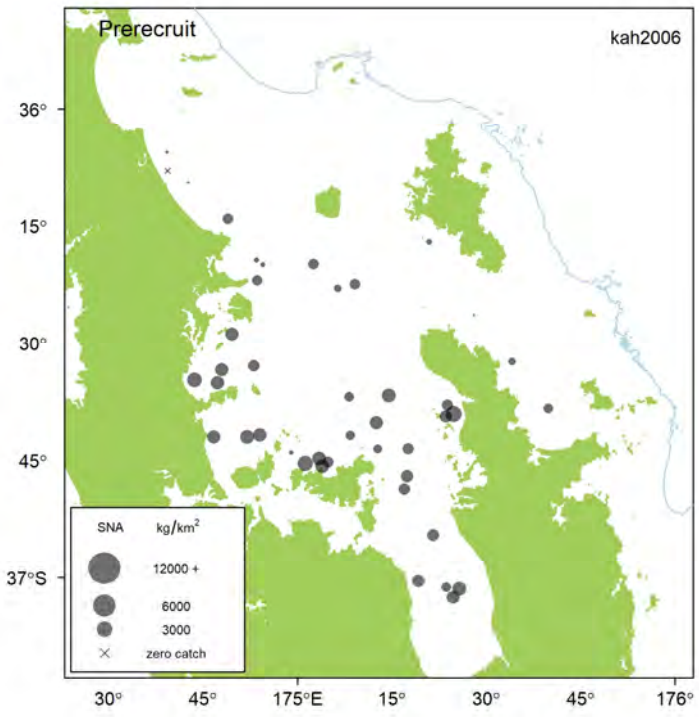
k: Leatherjacket (LEA), Hauraki Gulf.



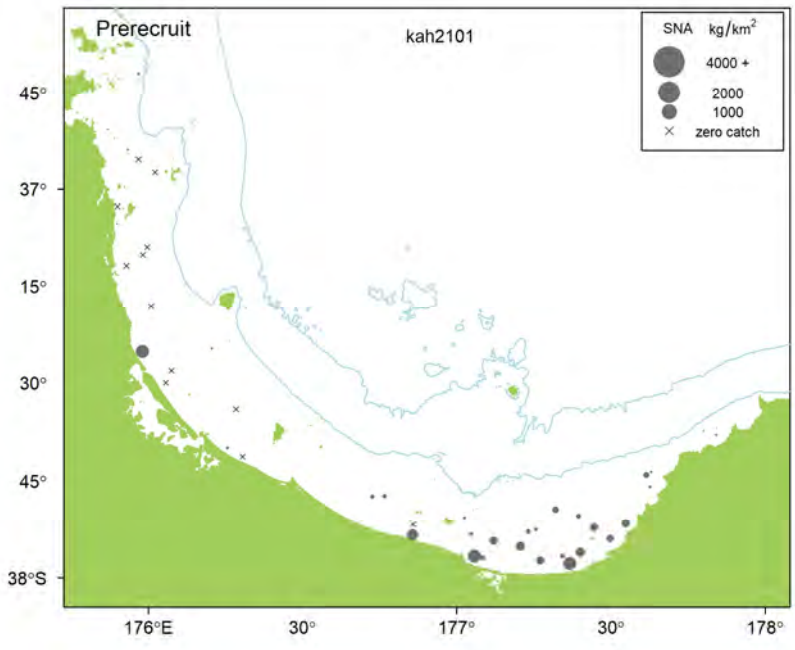
l: Leatherjacket (LEA), Bay of Plenty.



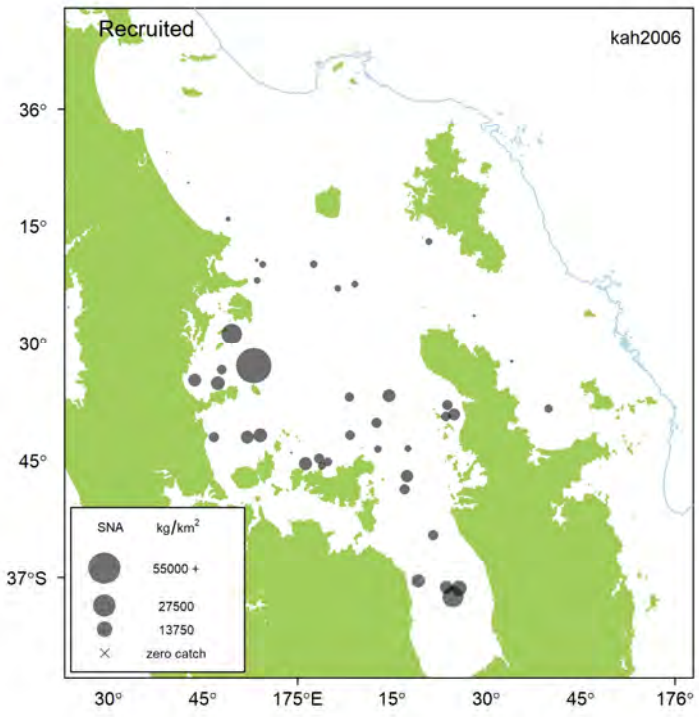
m: Tarakihi (NMP)*, Bay of Plenty.



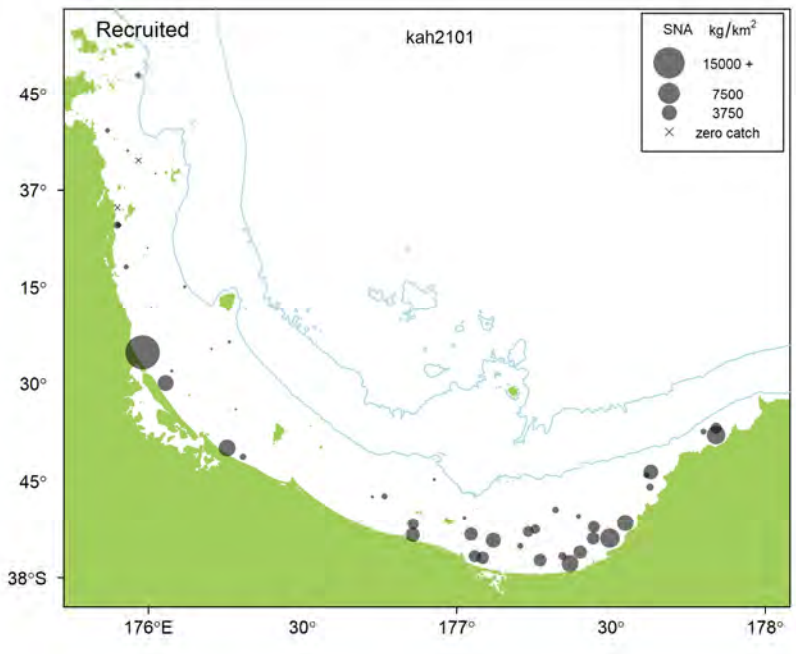
n: Pre–recruit snapper (SNA; <25 cm FL), Hauraki Gulf.



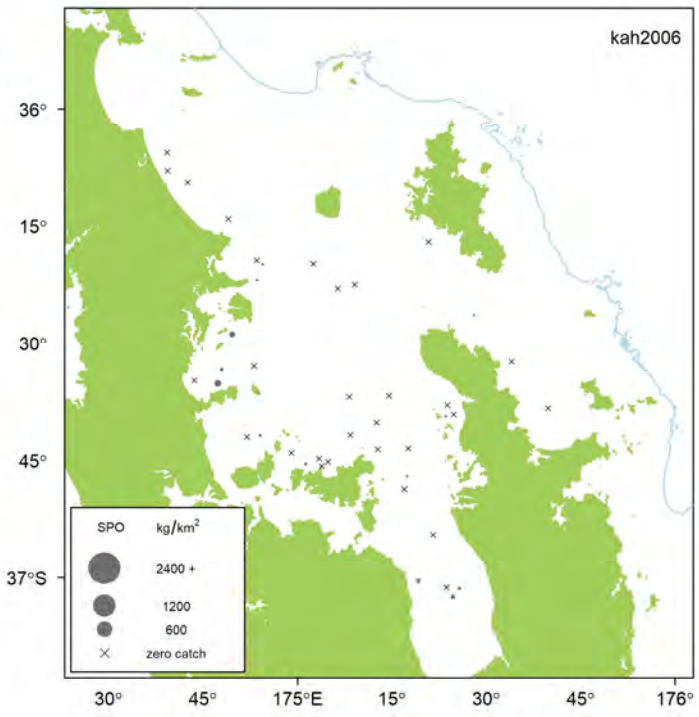
o: Pre–recruit snapper (SNA; <25 cm FL), Bay of Plenty.



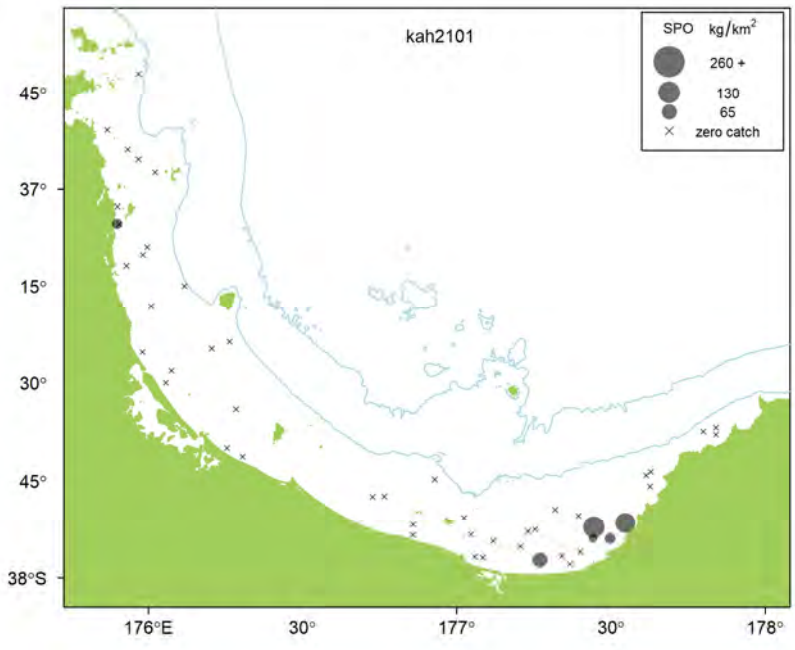
p: Recruited snapper (SNA; 25 cm and larger), Hauraki Gulf.



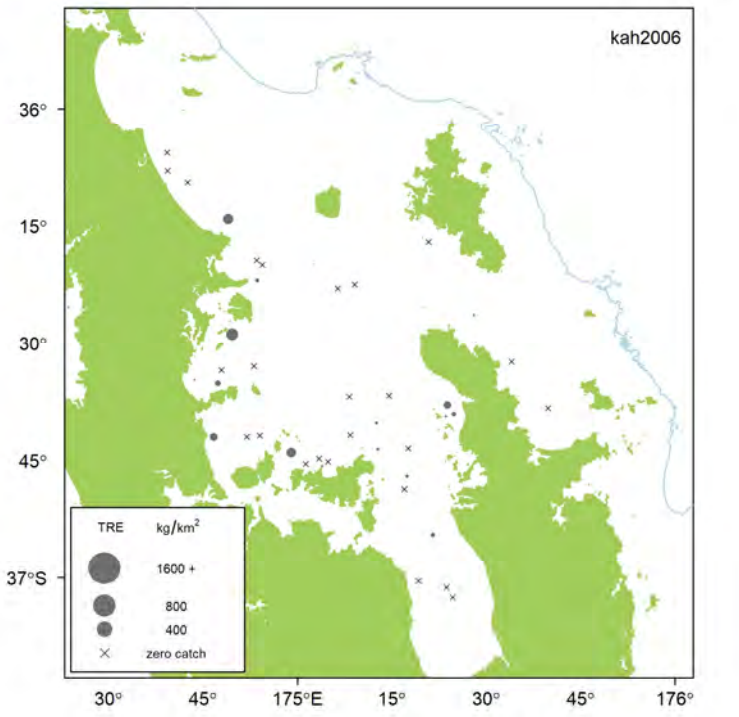
q: Recruited snapper (SNA; 25 cm FL and larger), Bay of Plenty.



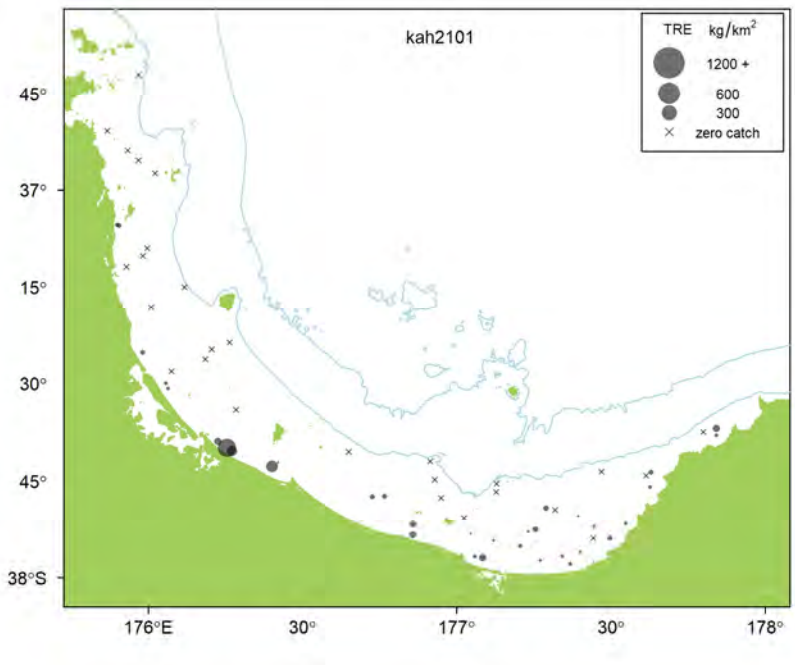
r: Rig (SPO)*, Hauraki Gulf.



s: Rig (SPO)*, Bay of Plenty.



t: Trevally (TRE), Hauraki Gulf.



u: Trevally (TRE), Bay of Plenty.

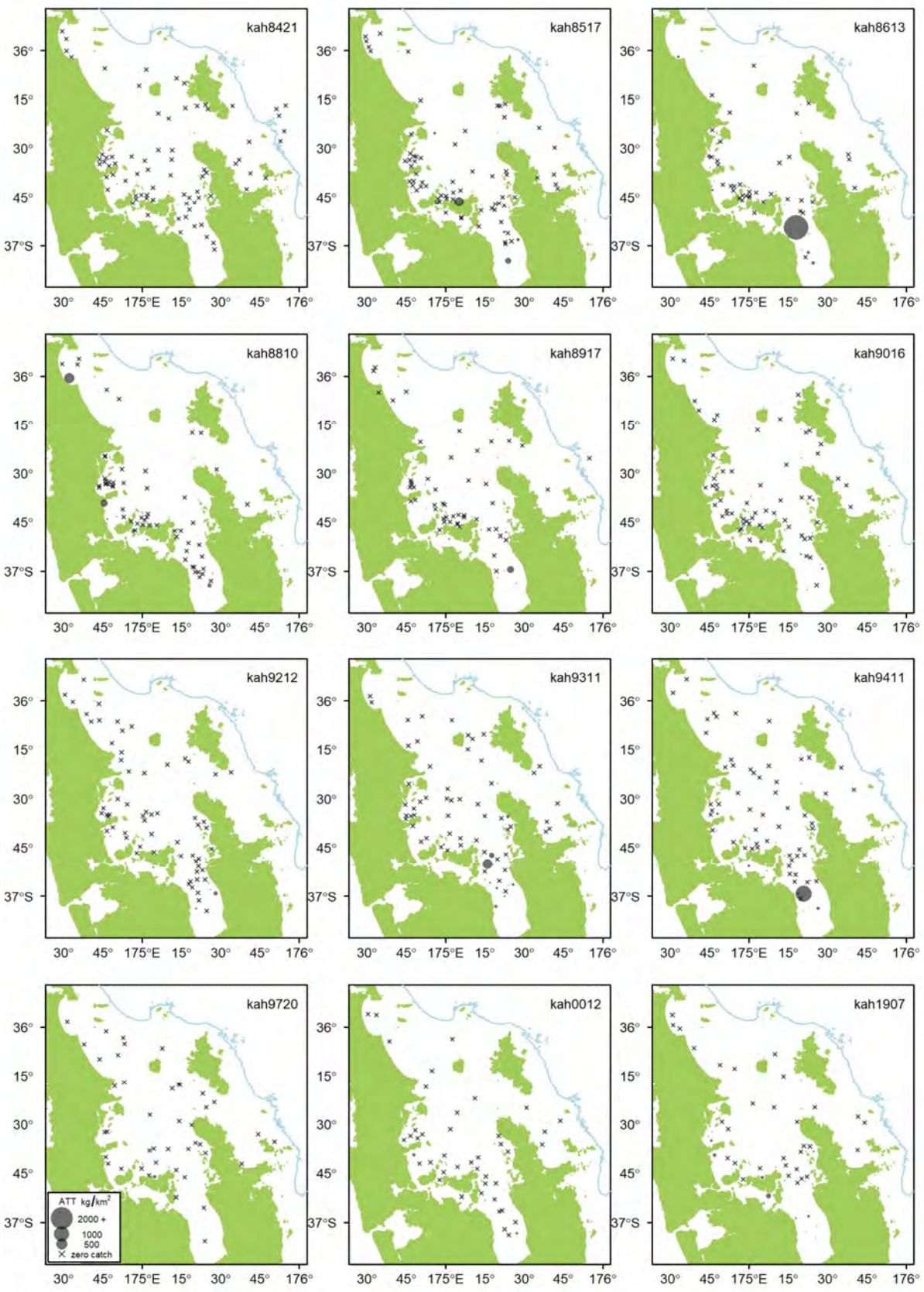
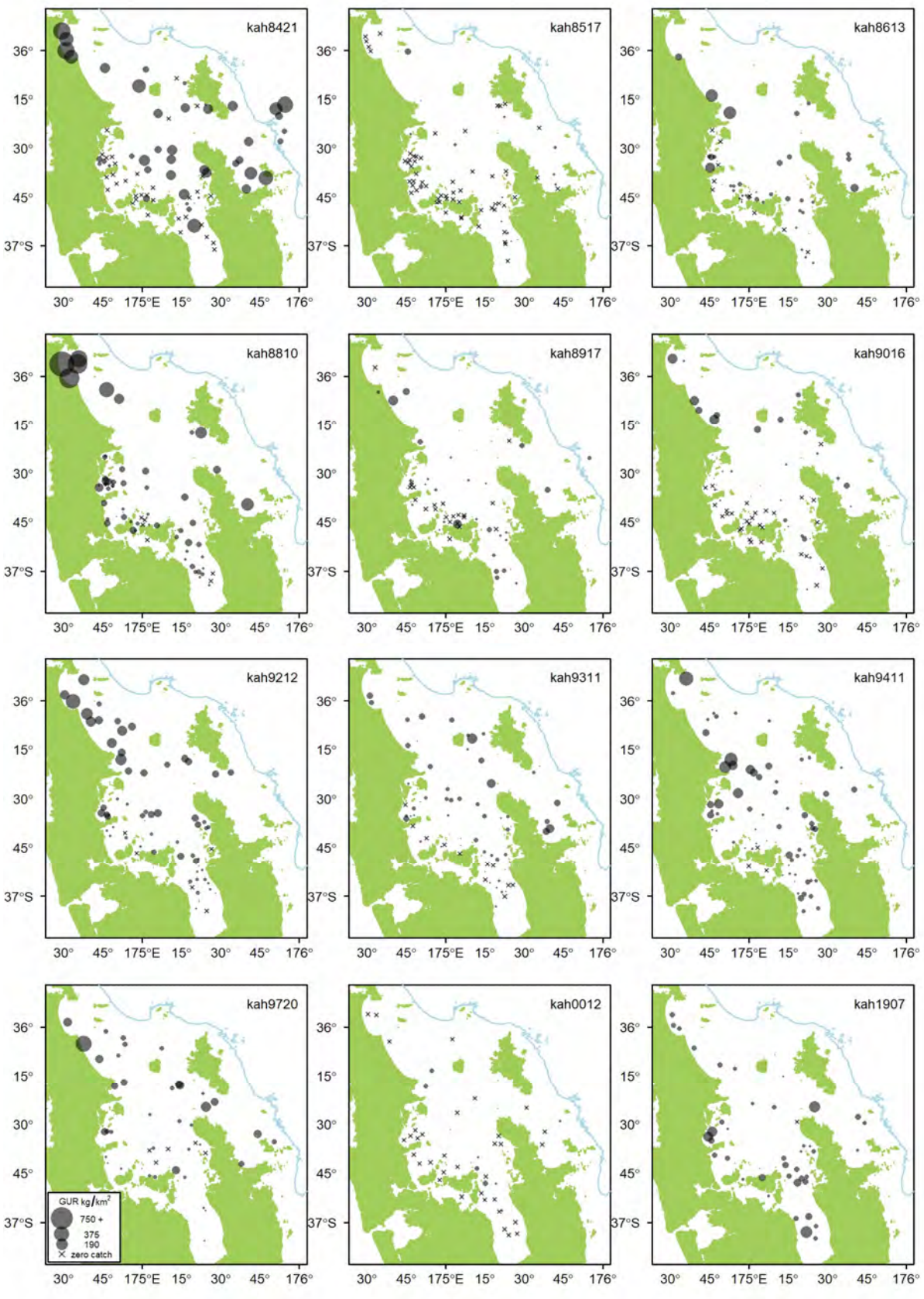
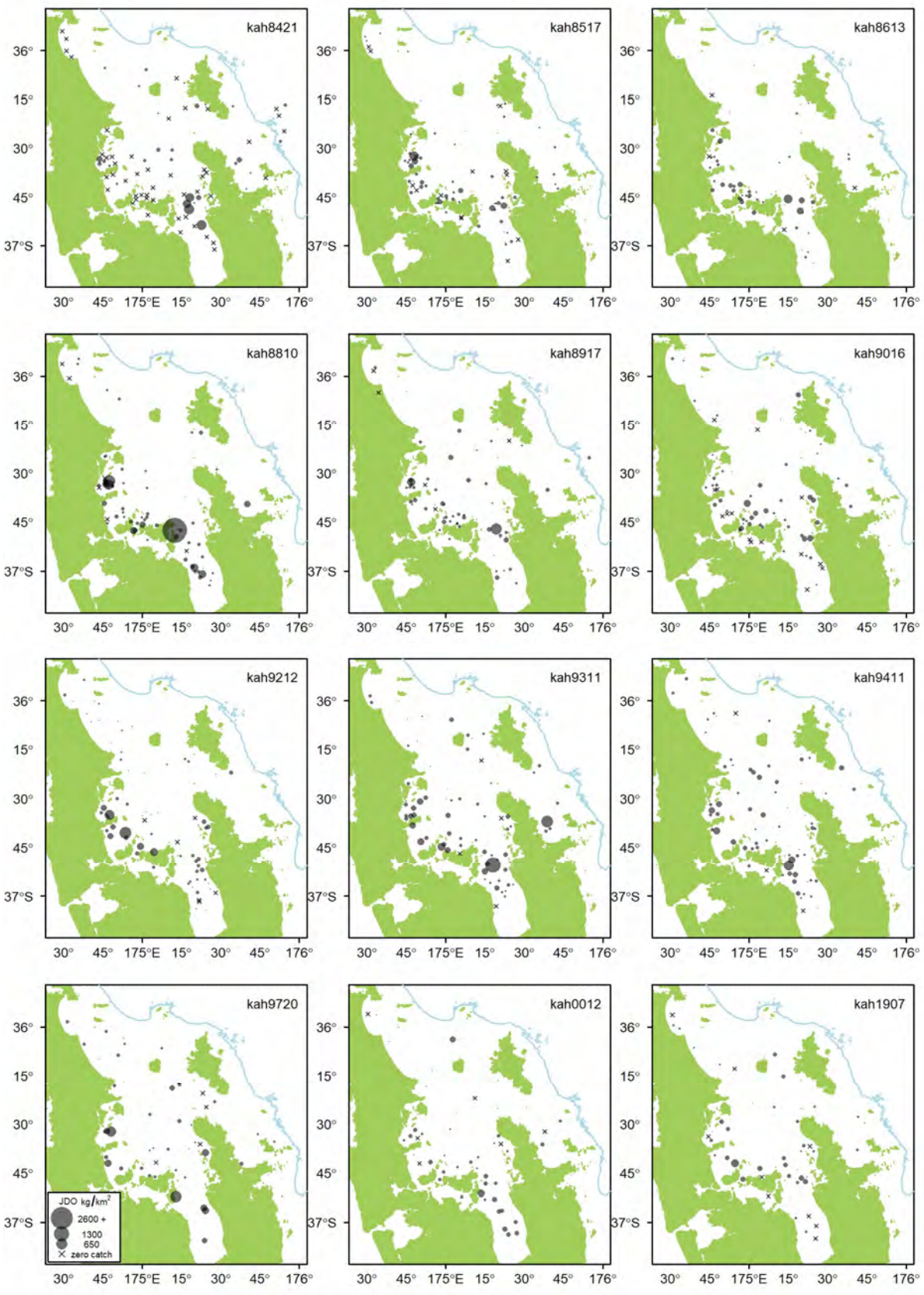


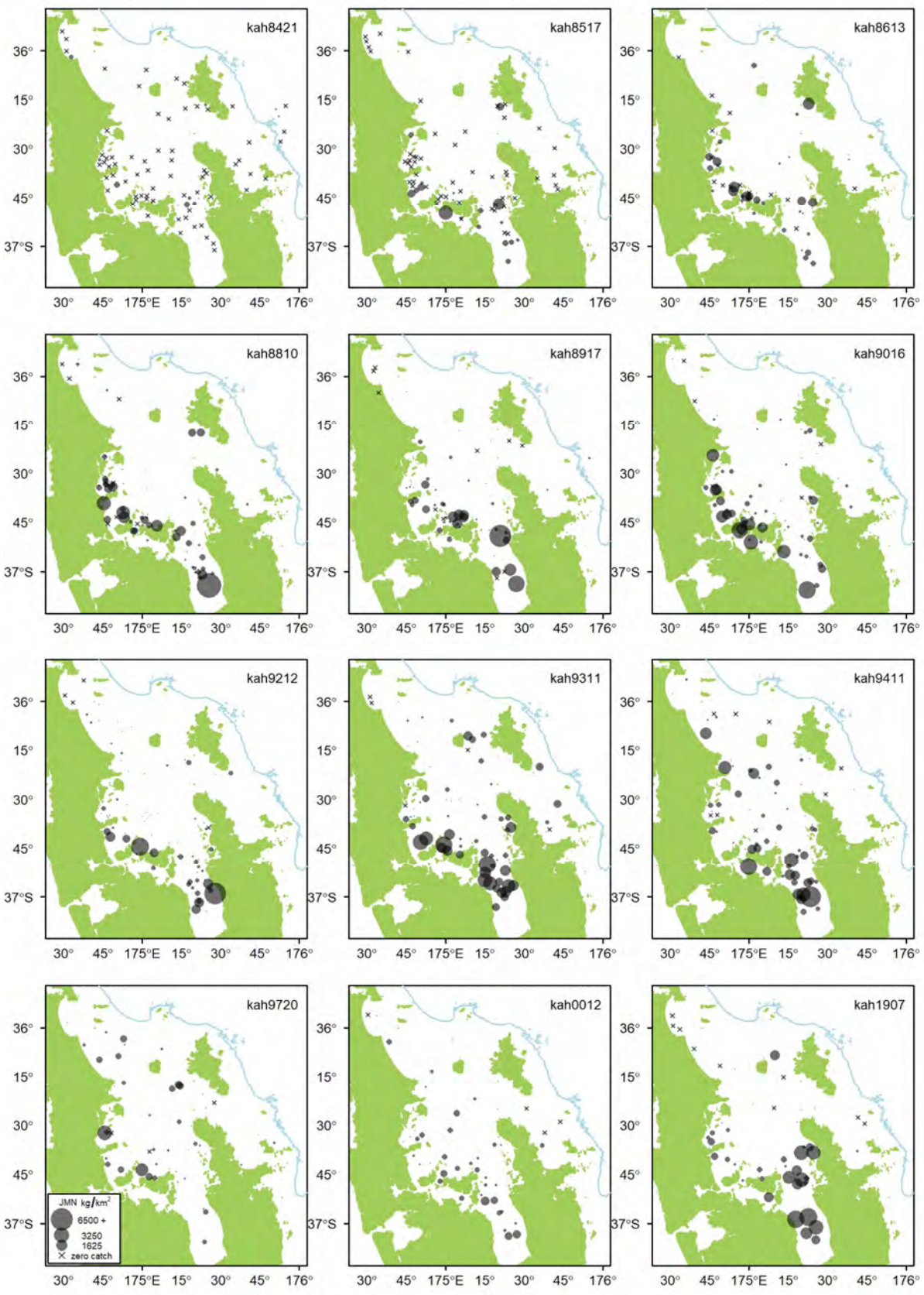
Figure 3: The spatial distribution of catch (kg km^{-2}) for the most common QMS species for the historical survey series in Hauraki Gulf and Bay of Plenty. N.B. Catch rate scale varies between species. a: Kahawai (ATT), Hauraki Gulf.



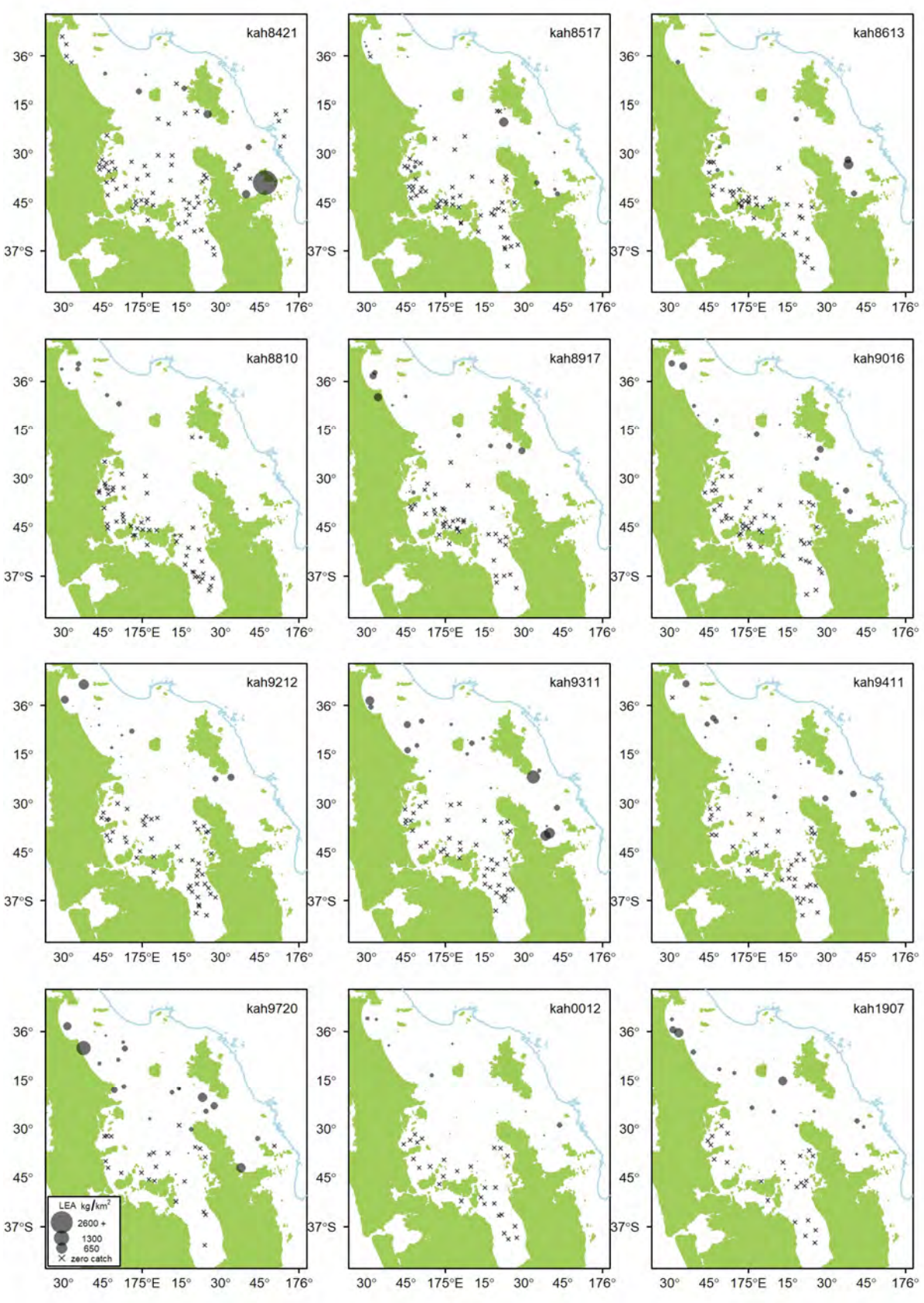
b: Red gurnard (GUR), Hauraki Gulf.



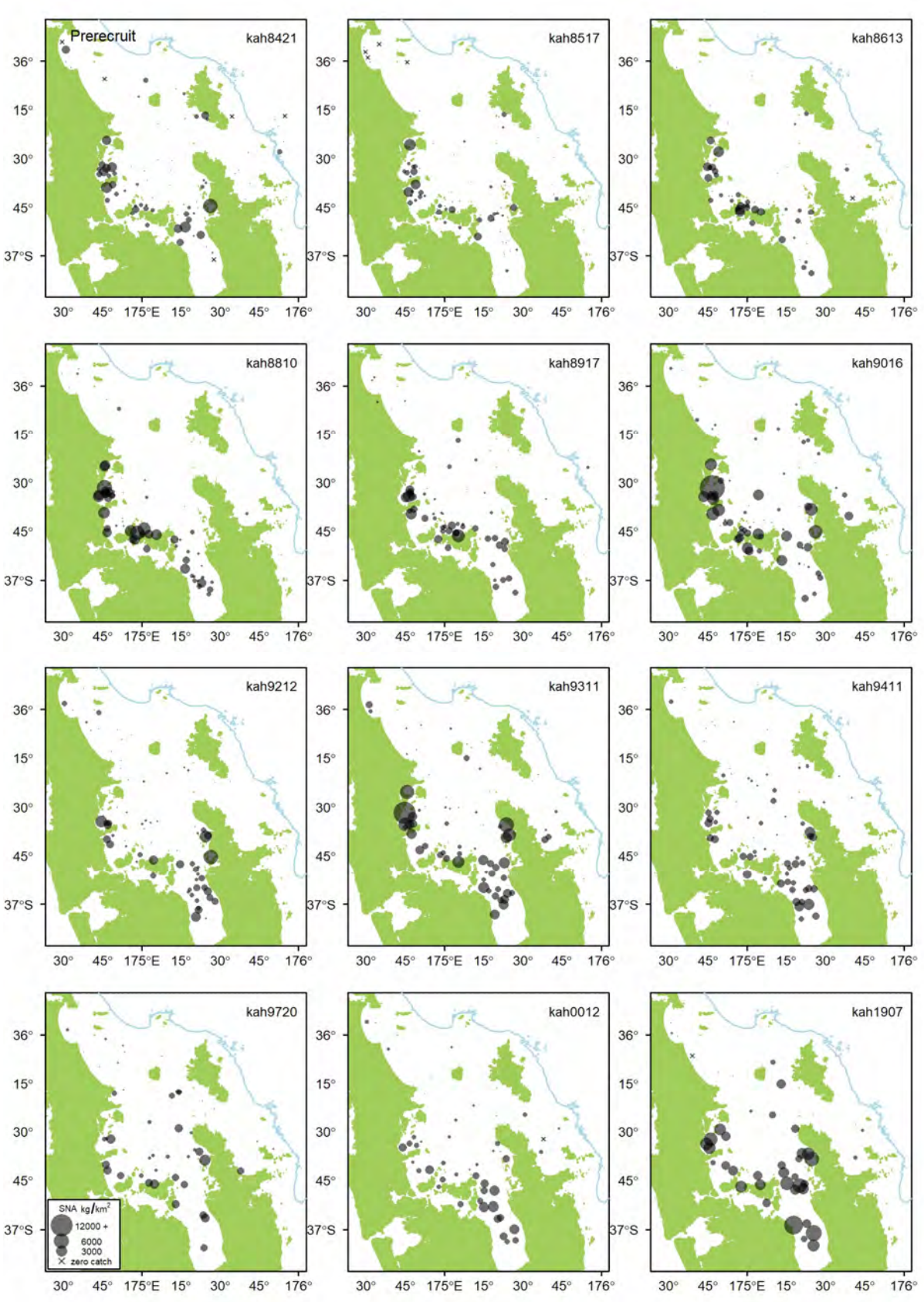
c: John dory (JDO), Hauraki Gulf.



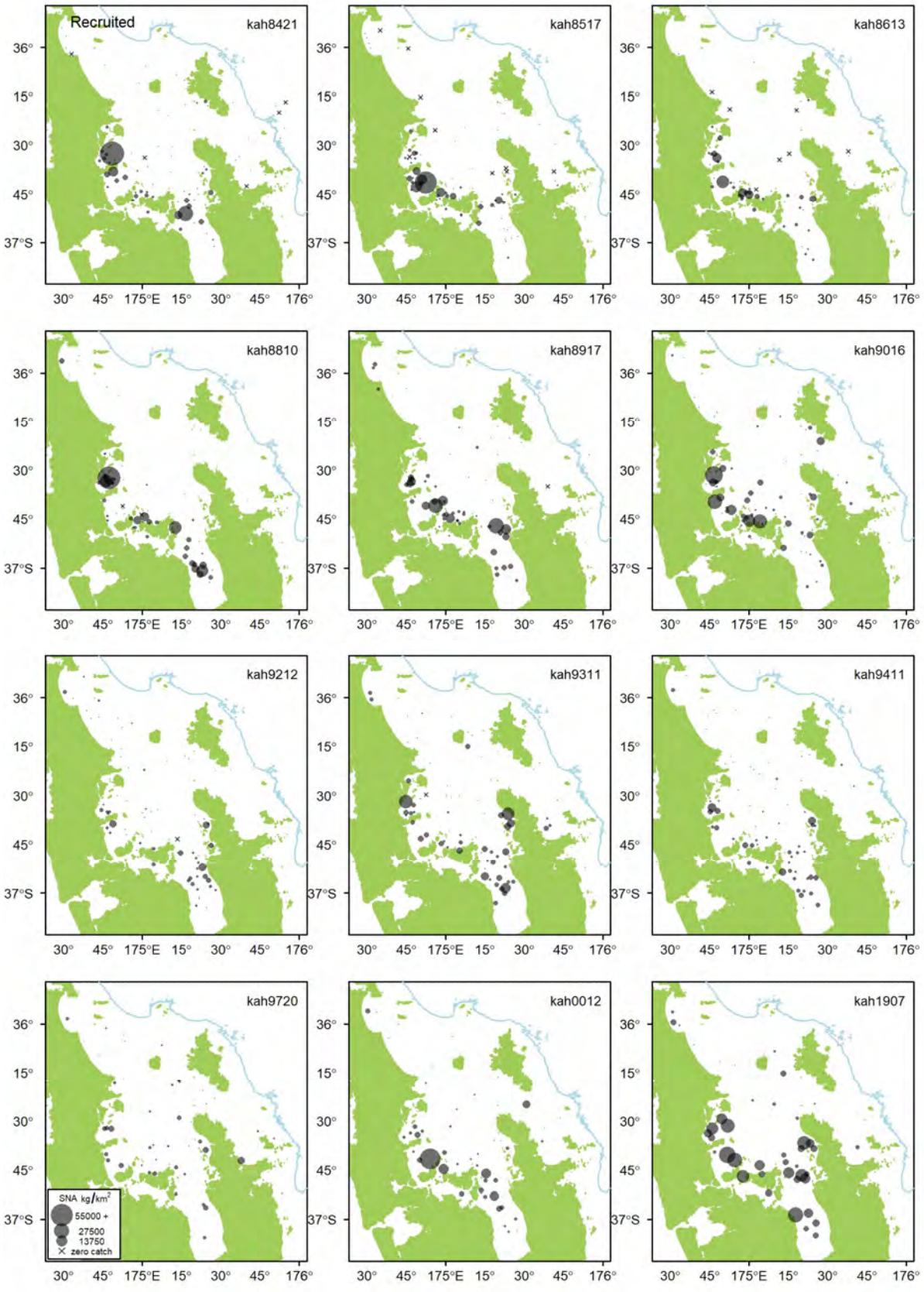
d: Yellowtail jack mackerel (JMN), Hauraki Gulf.



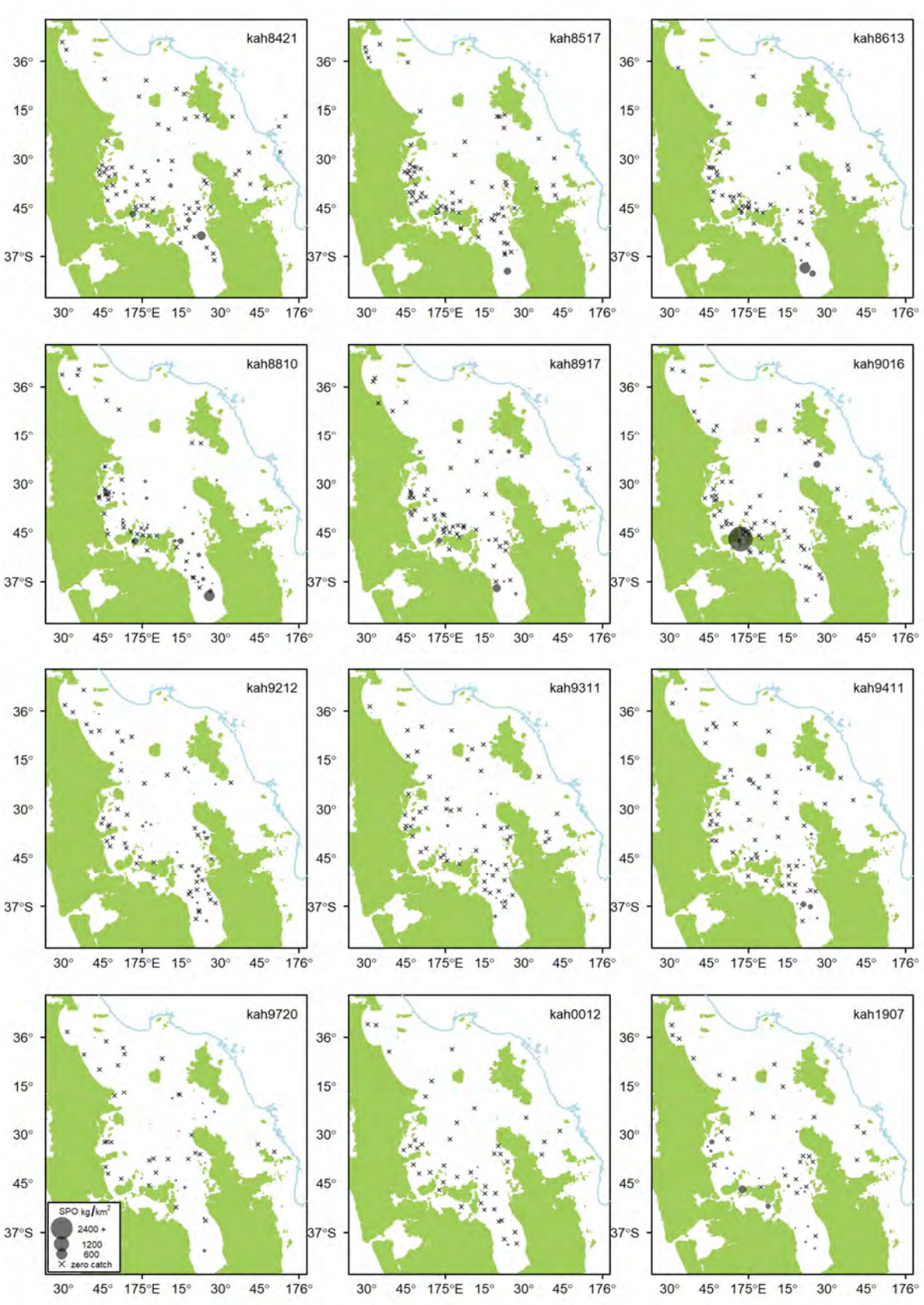
e: Leatherjacket (LEA), Hauraki Gulf.



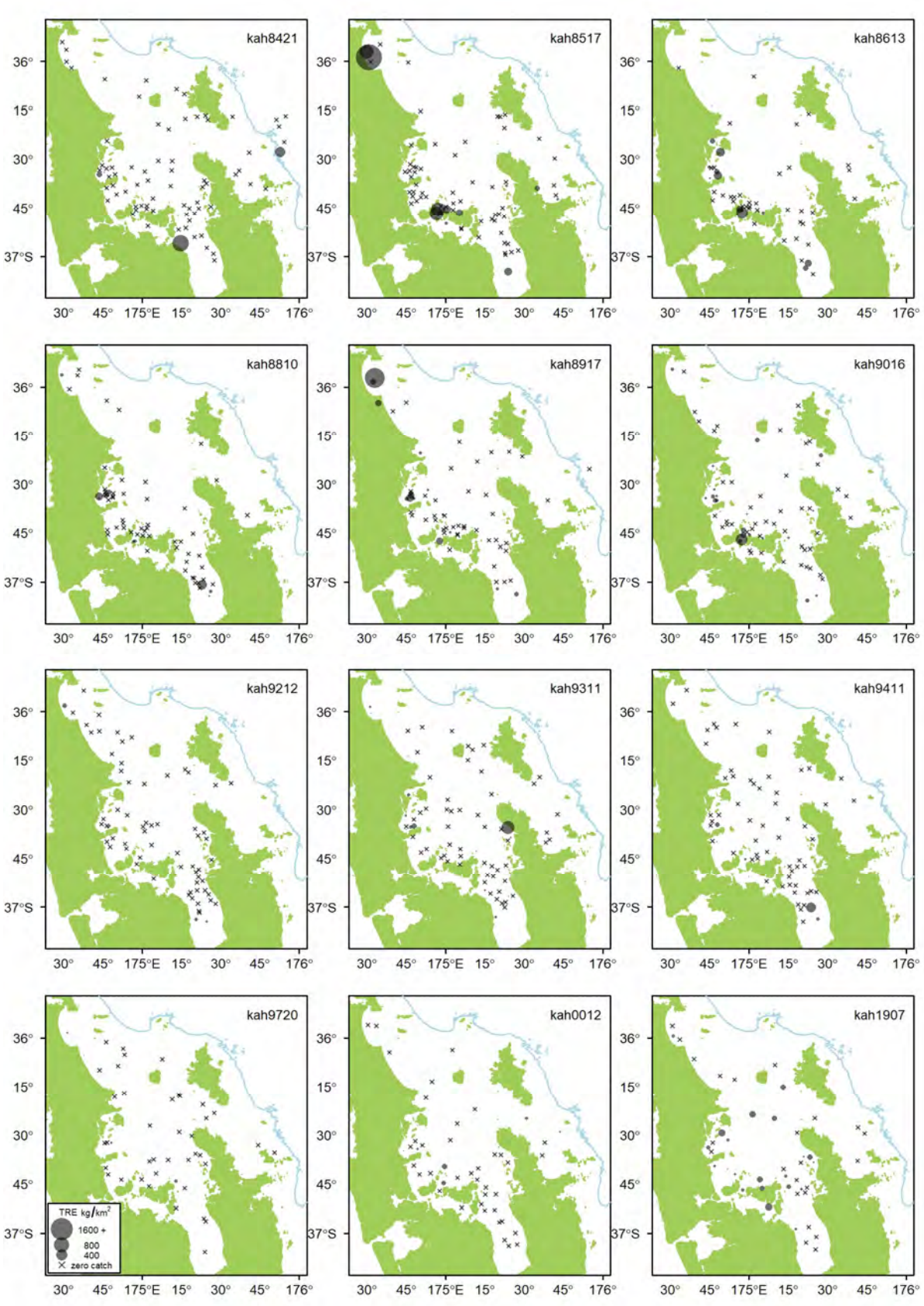
f: Pre-recruit snapper (SNA), Hauraki Gulf.



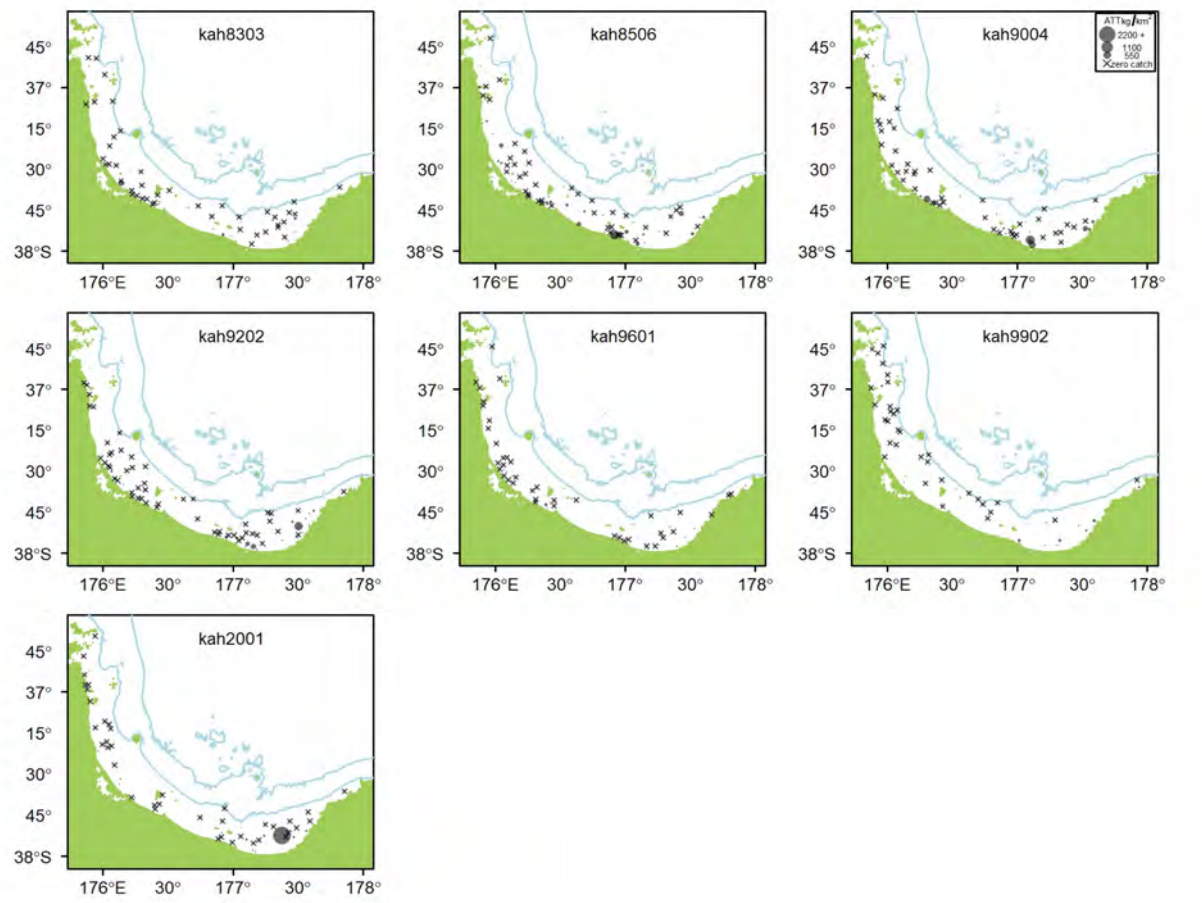
g: Recruited snapper (SNA), Hauraki Gulf.



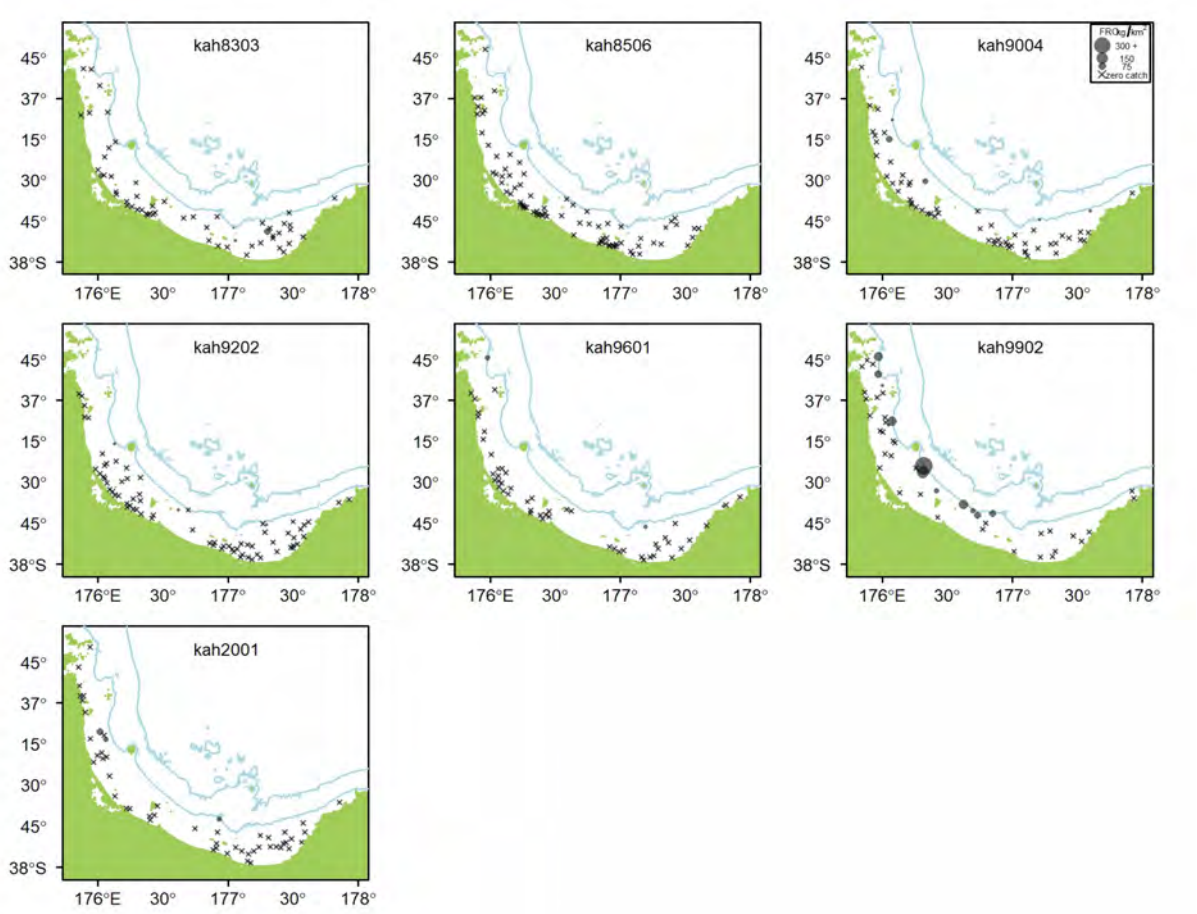
h: Rig (SPO), Hauraki Gulf.



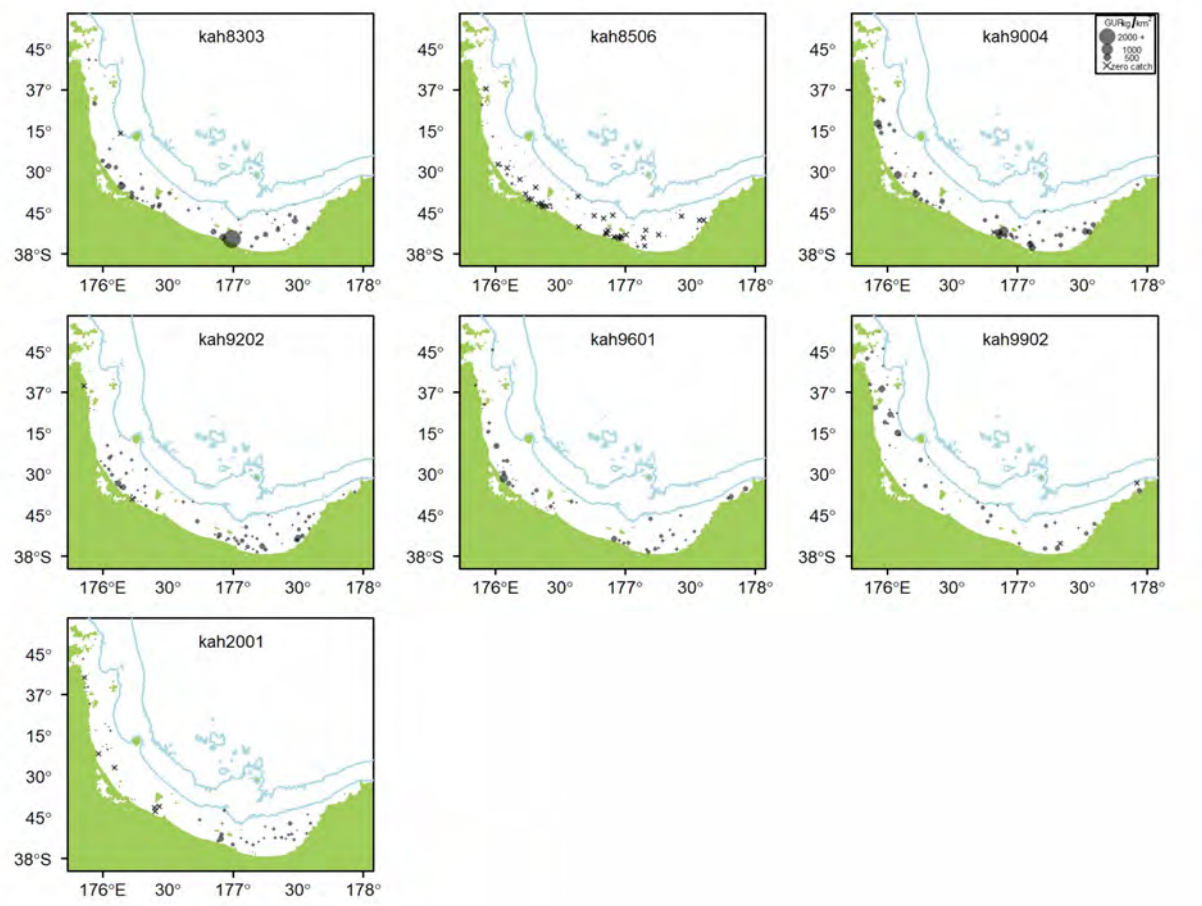
i: Trevally (TRE), Hauraki Gulf.



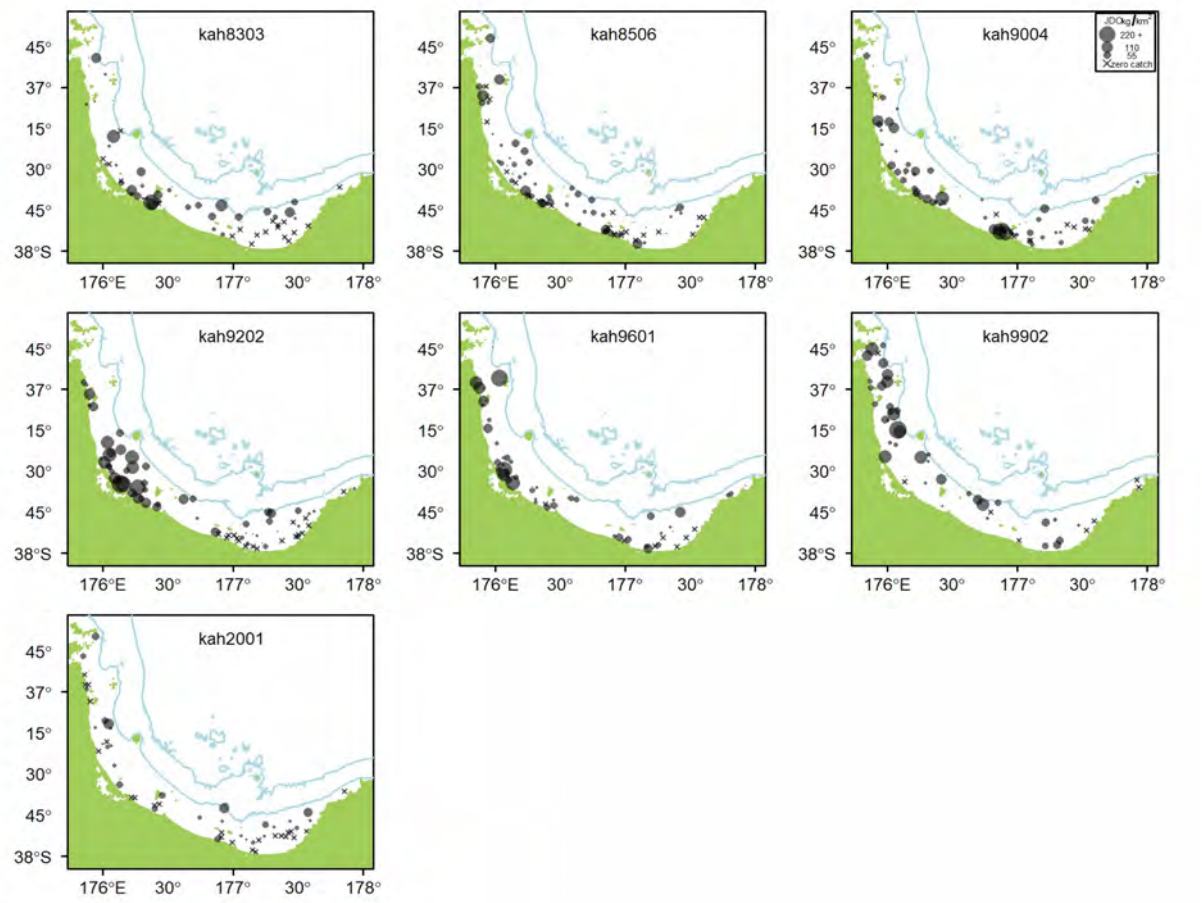
j: Kahawai (ATT), Bay of Plenty.



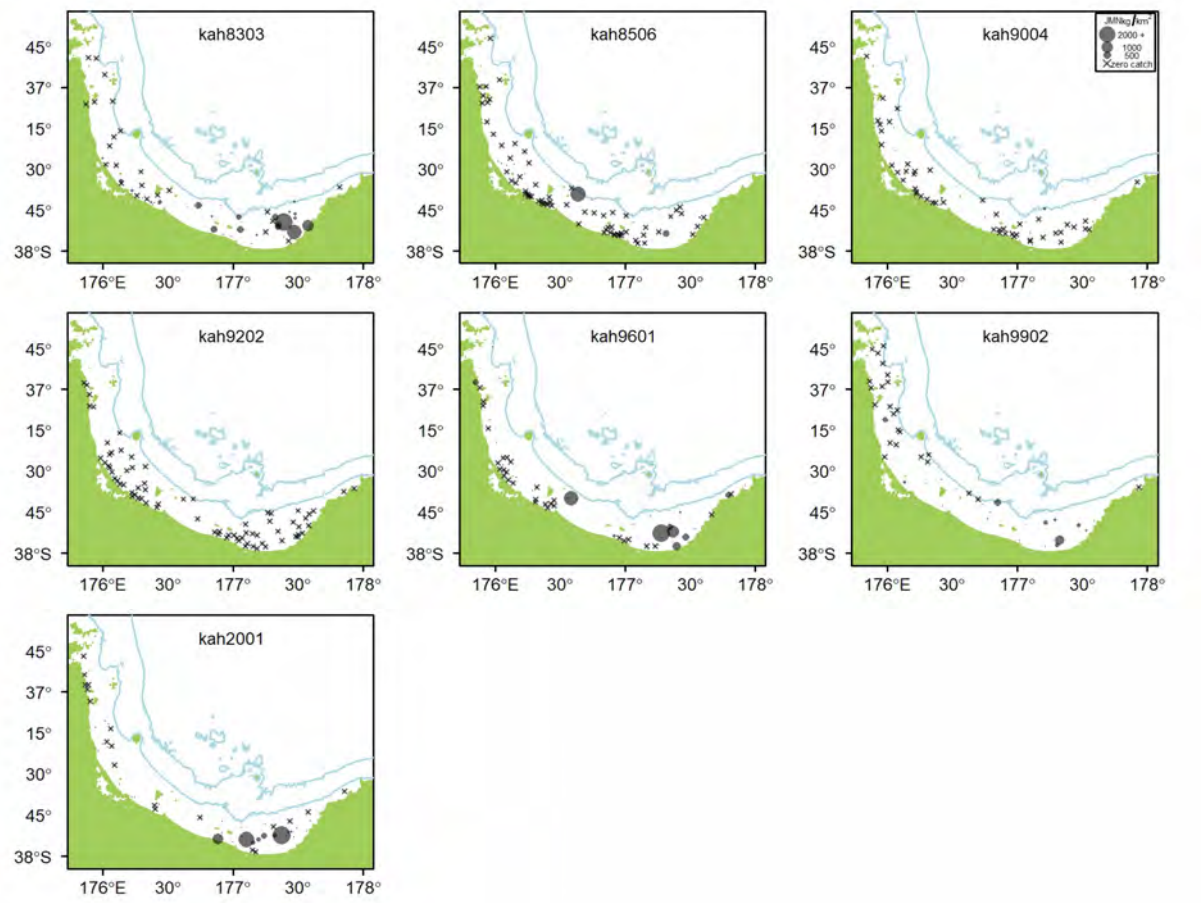
k: Frostfish (FRO), Bay of Plenty.



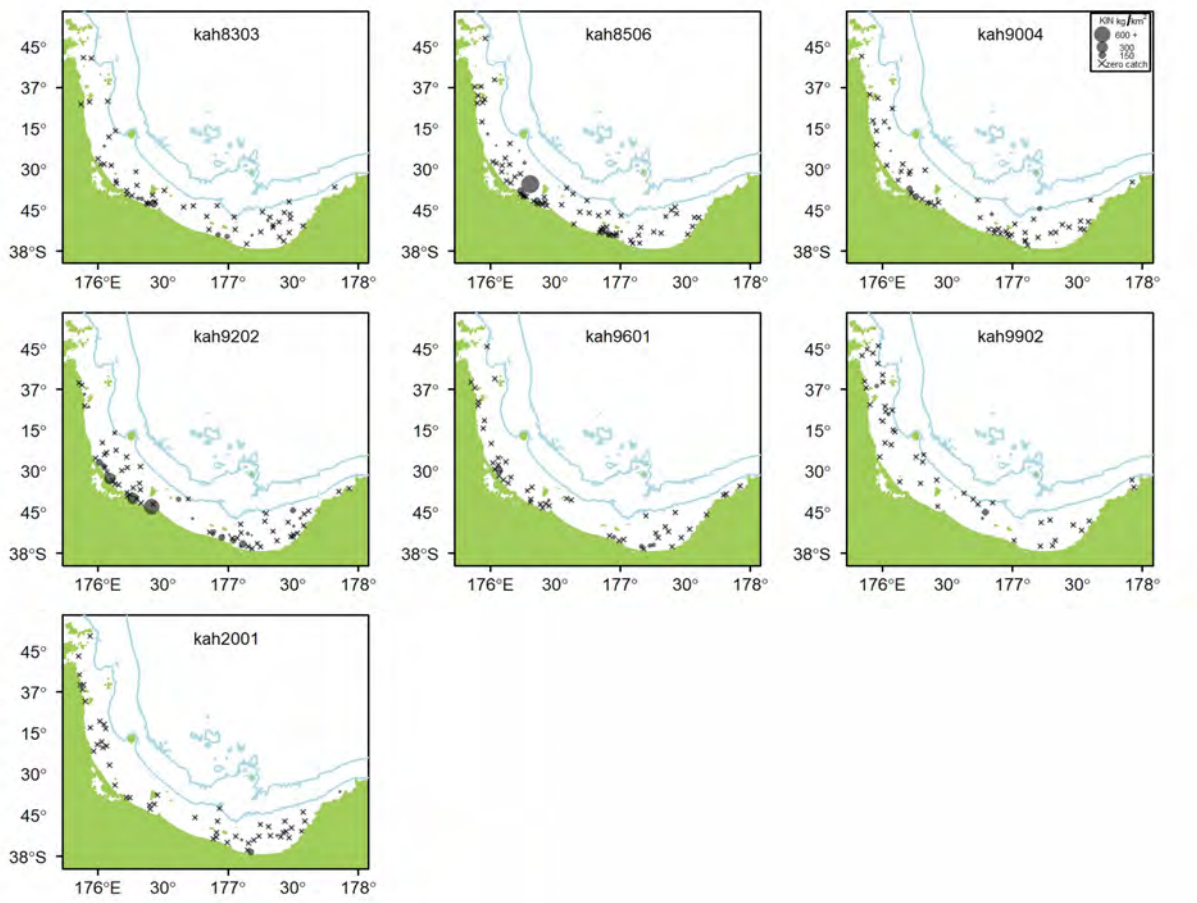
l: Red gurnard (GUR), Bay of Plenty.



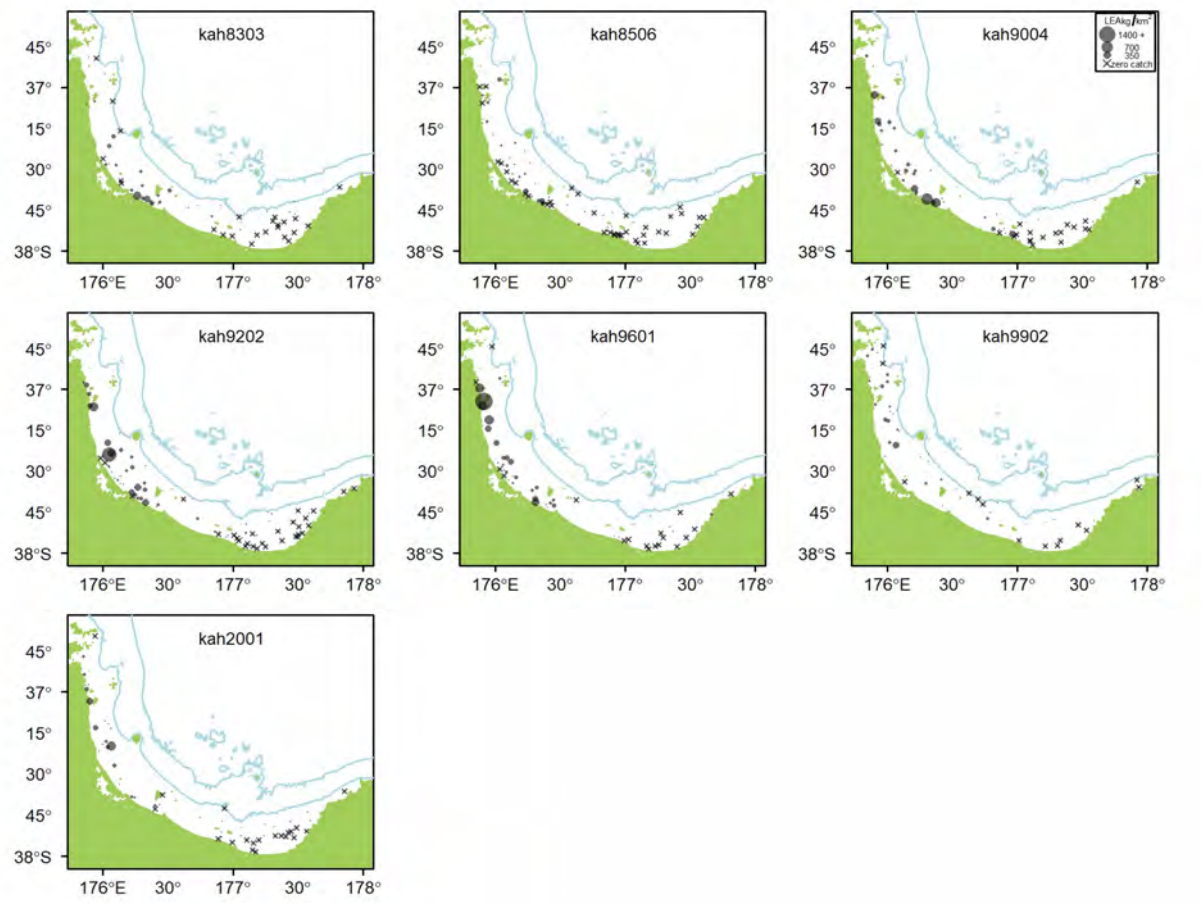
m: John dory (JDO), Bay of Plenty.



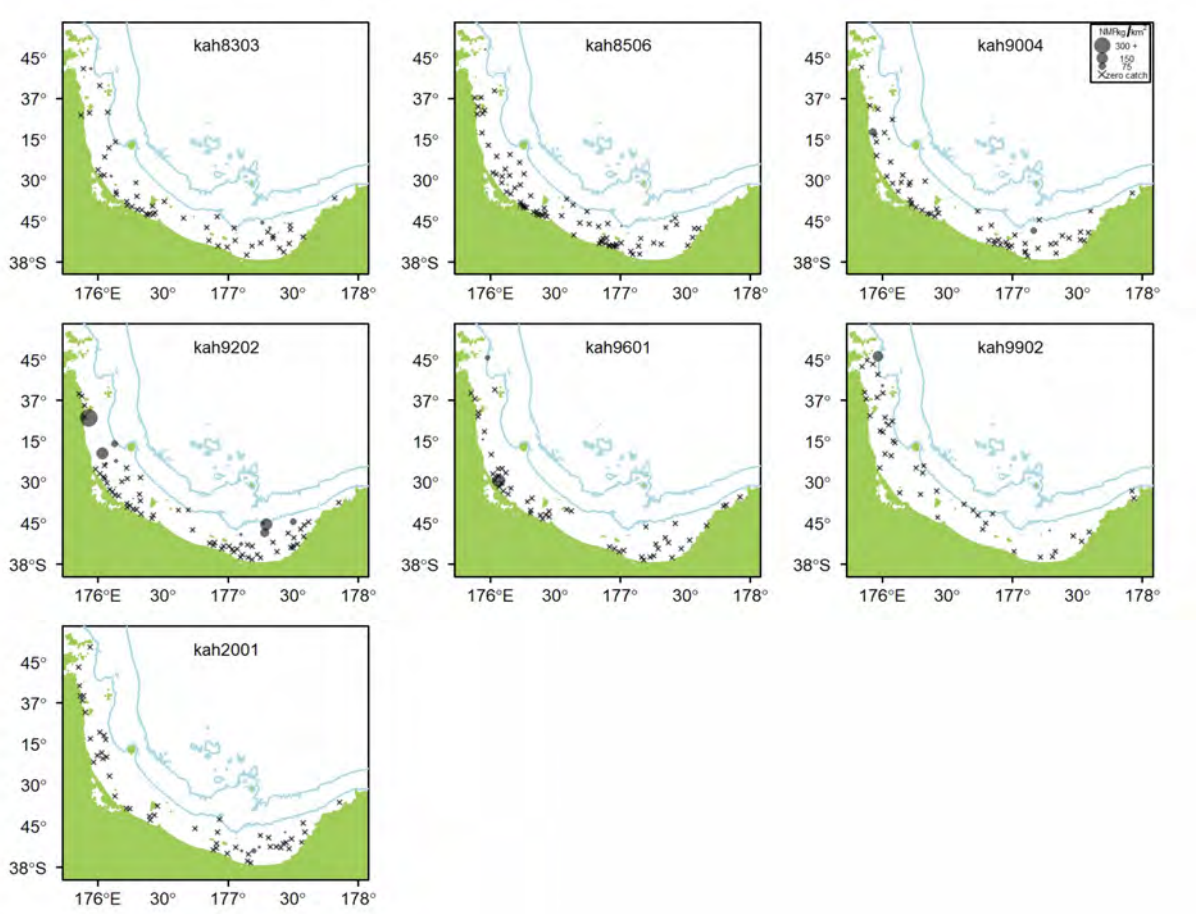
n: Yellowtail jack mackerel (JMN), Bay of Plenty.



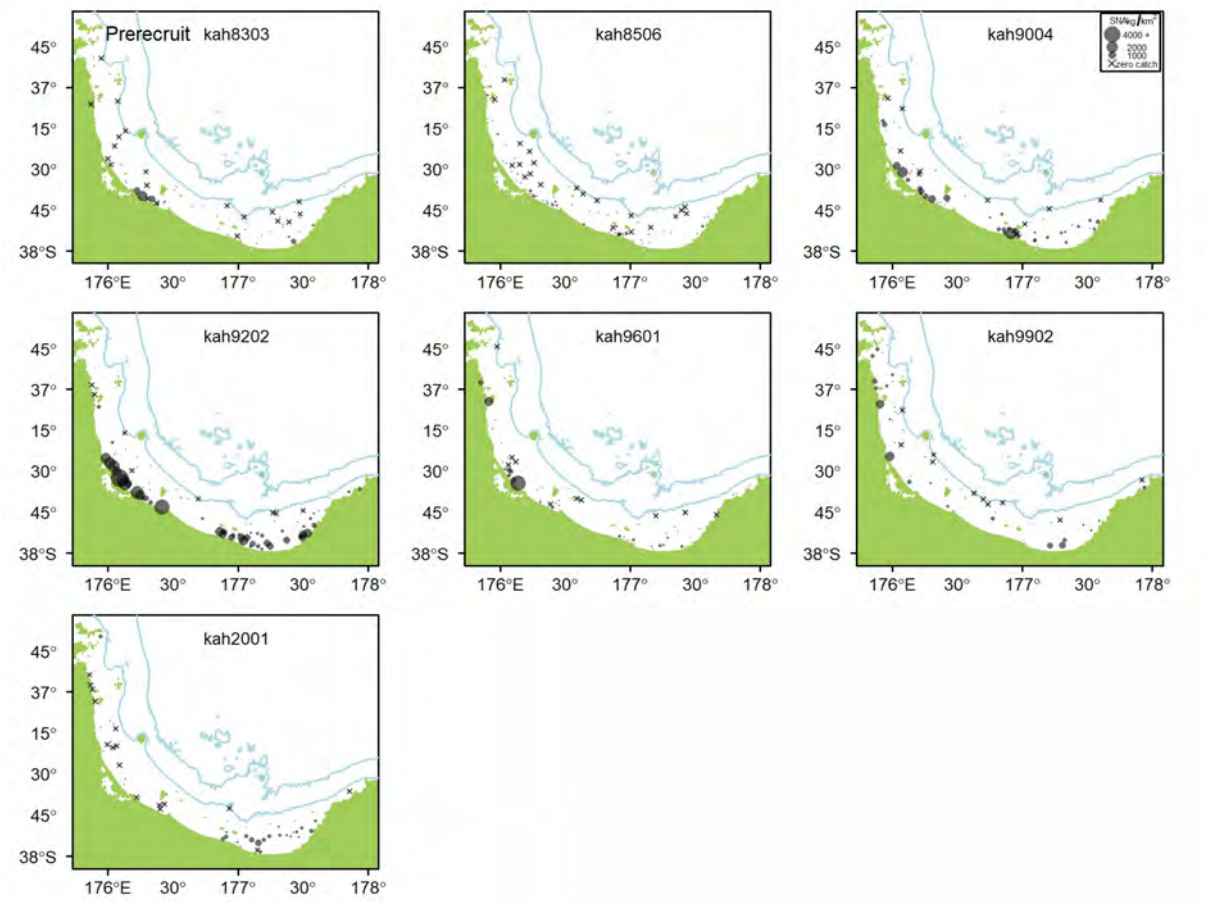
o: Kingfish (KIN), Bay of Plenty.



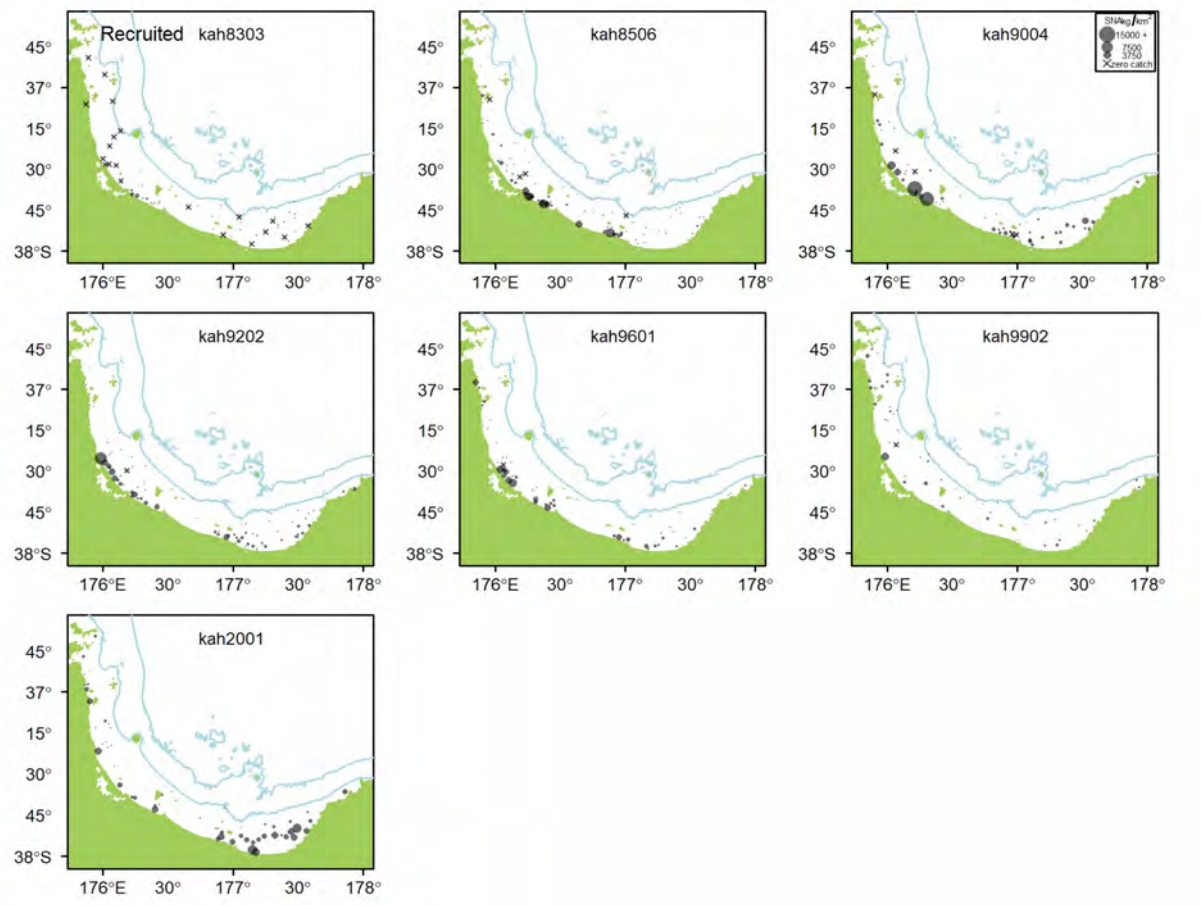
p: Leatherjacket (LEA), Bay of Plenty.



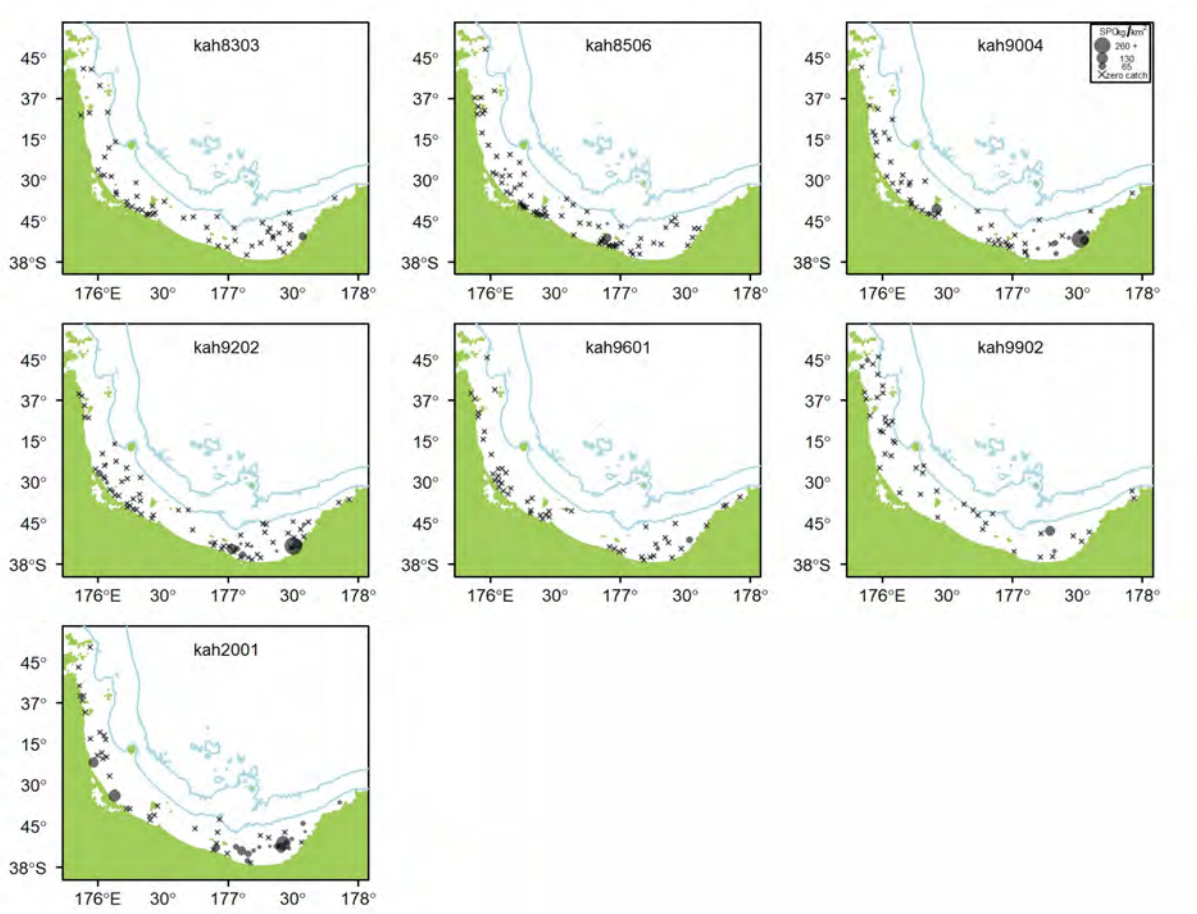
q: Tarakihi (NMP), Bay of Plenty.



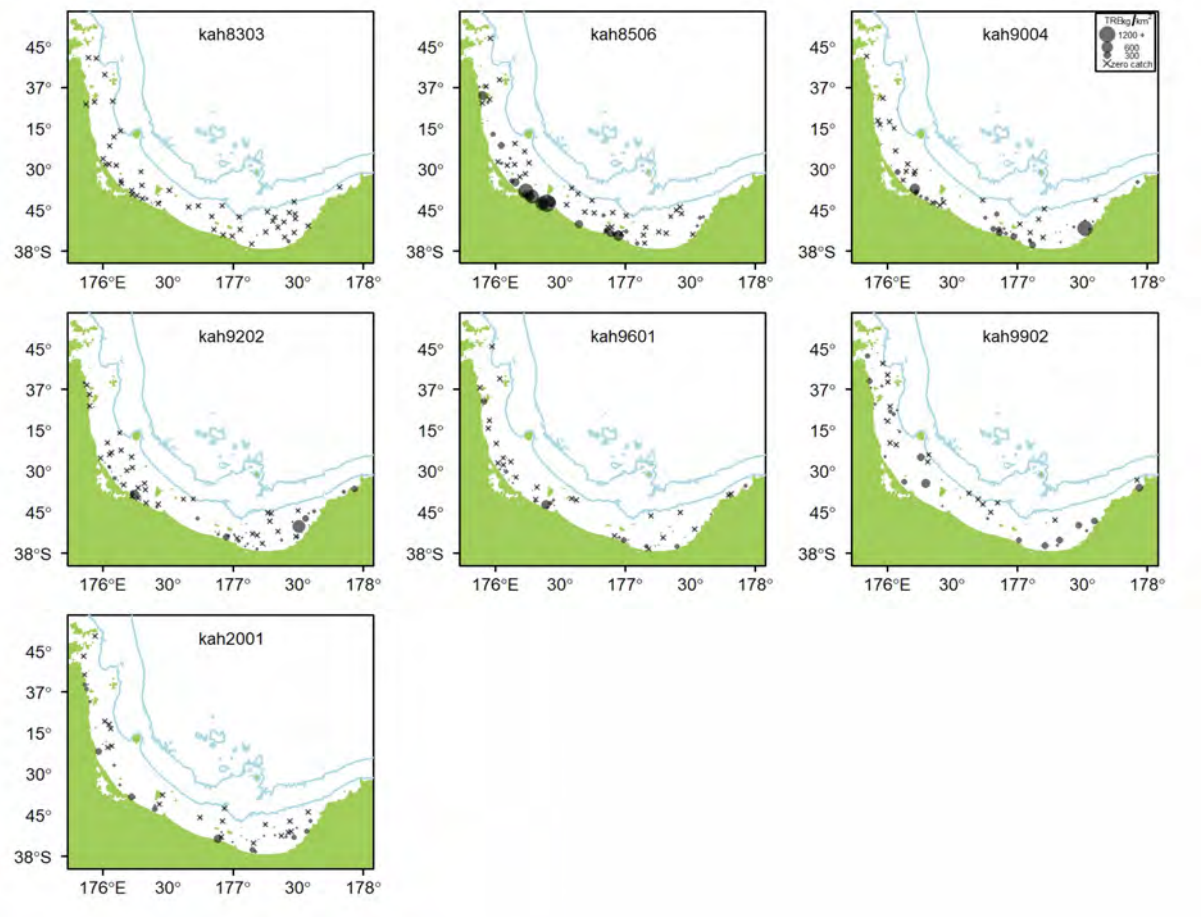
r: Pre-recruit snapper (SNA), Bay of Plenty.



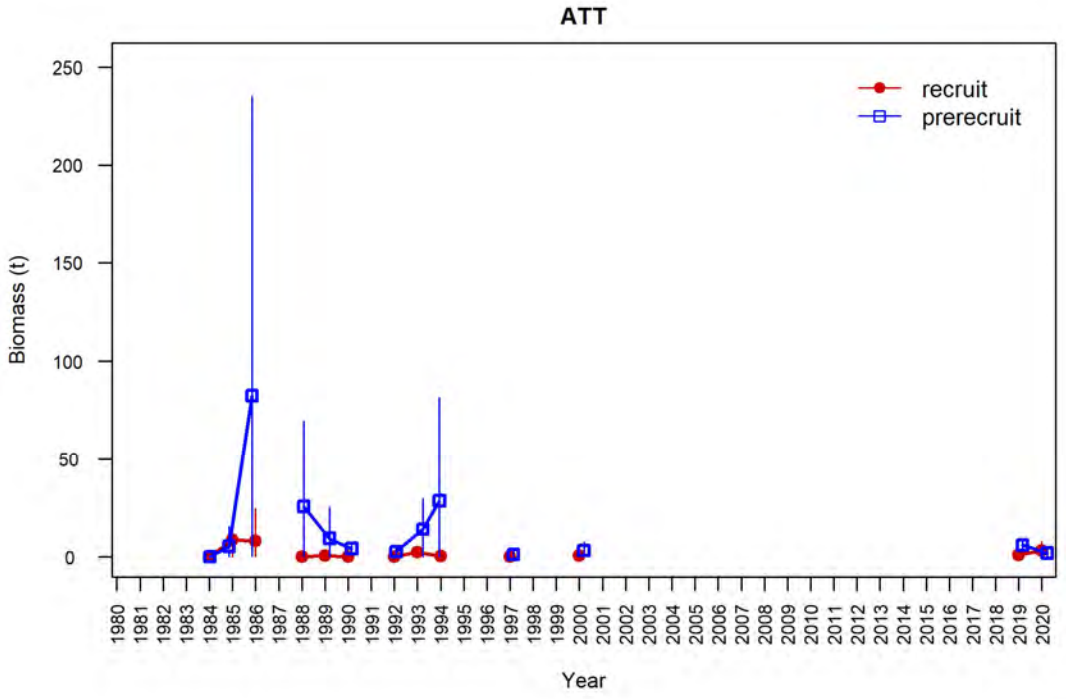
s: Recruited snapper (SNA), Bay of Plenty.

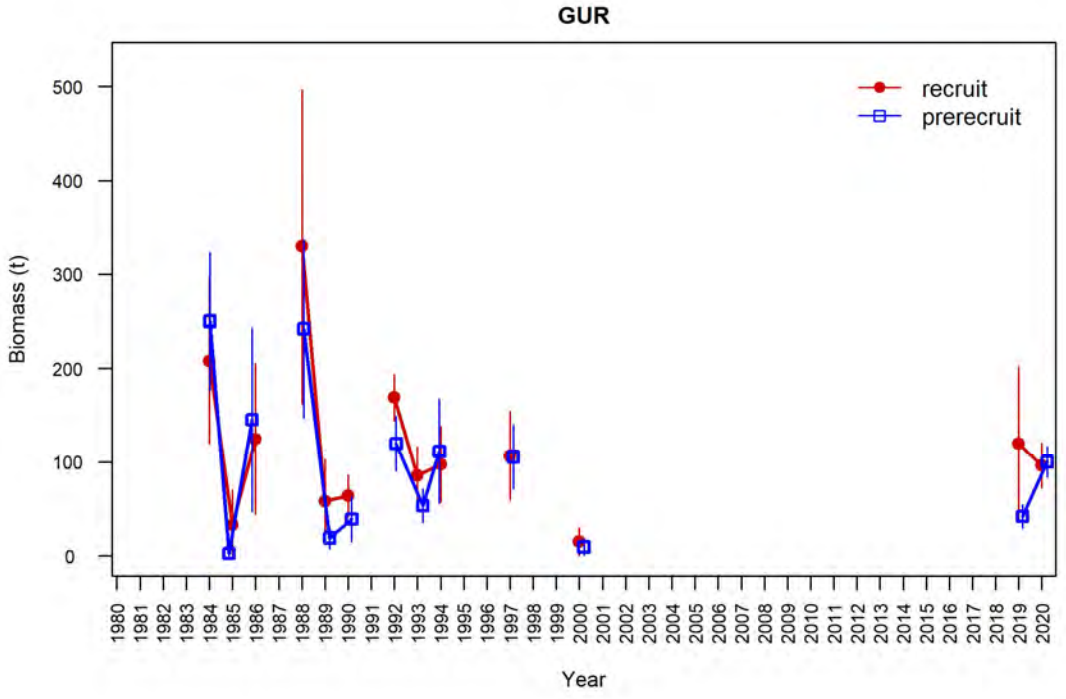


t: Rig (SPO), Bay of Plenty.



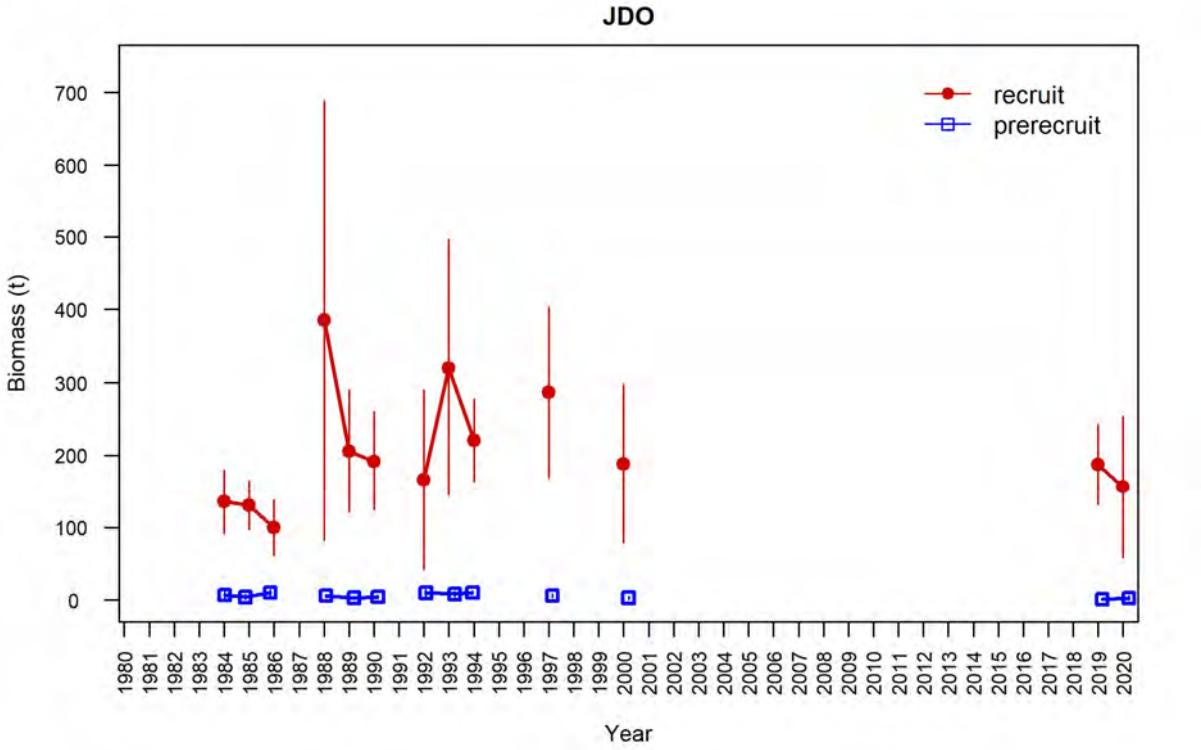
u: Trevally (TRE), Bay of Plenty.





a: Hauraki Gulf.

Figure 4: Biomass trends with 95% confidence intervals for pre-recruit (solid blue line with squares) and recruited (solid red line with circles) fish for the most common QMS species (all sexes combined) for all Hauraki Gulf (a) and Bay of Plenty (b) surveys. For some species (JMN, LEA, and TRE in the Hauraki Gulf and FRO, JMN, KIN, and LEA in the Bay of Plenty) only overall biomass is presented (solid black line) as historic length measurements were not available. Bay of Plenty biomass estimates in 2021 include extended phase two stations for only John dory, trevally, and tarakihi. Recruited lengths, see Table 5.



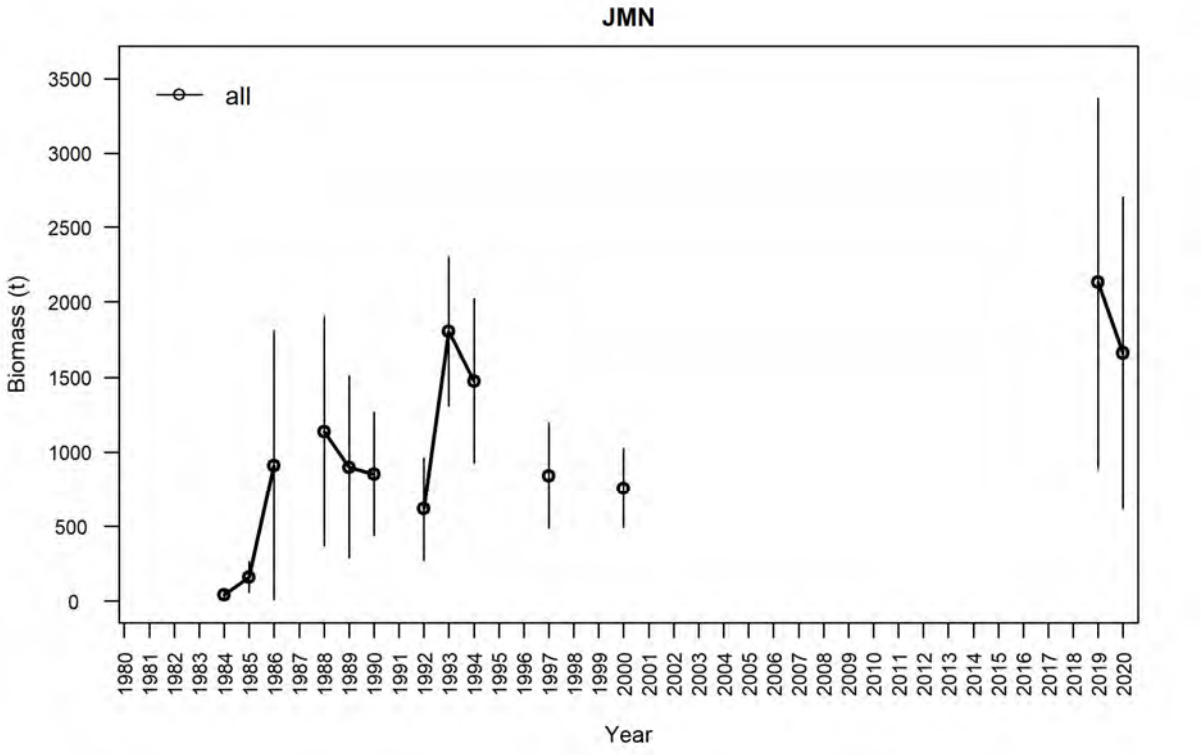


Figure 4a: Hauraki Gulf—continued.

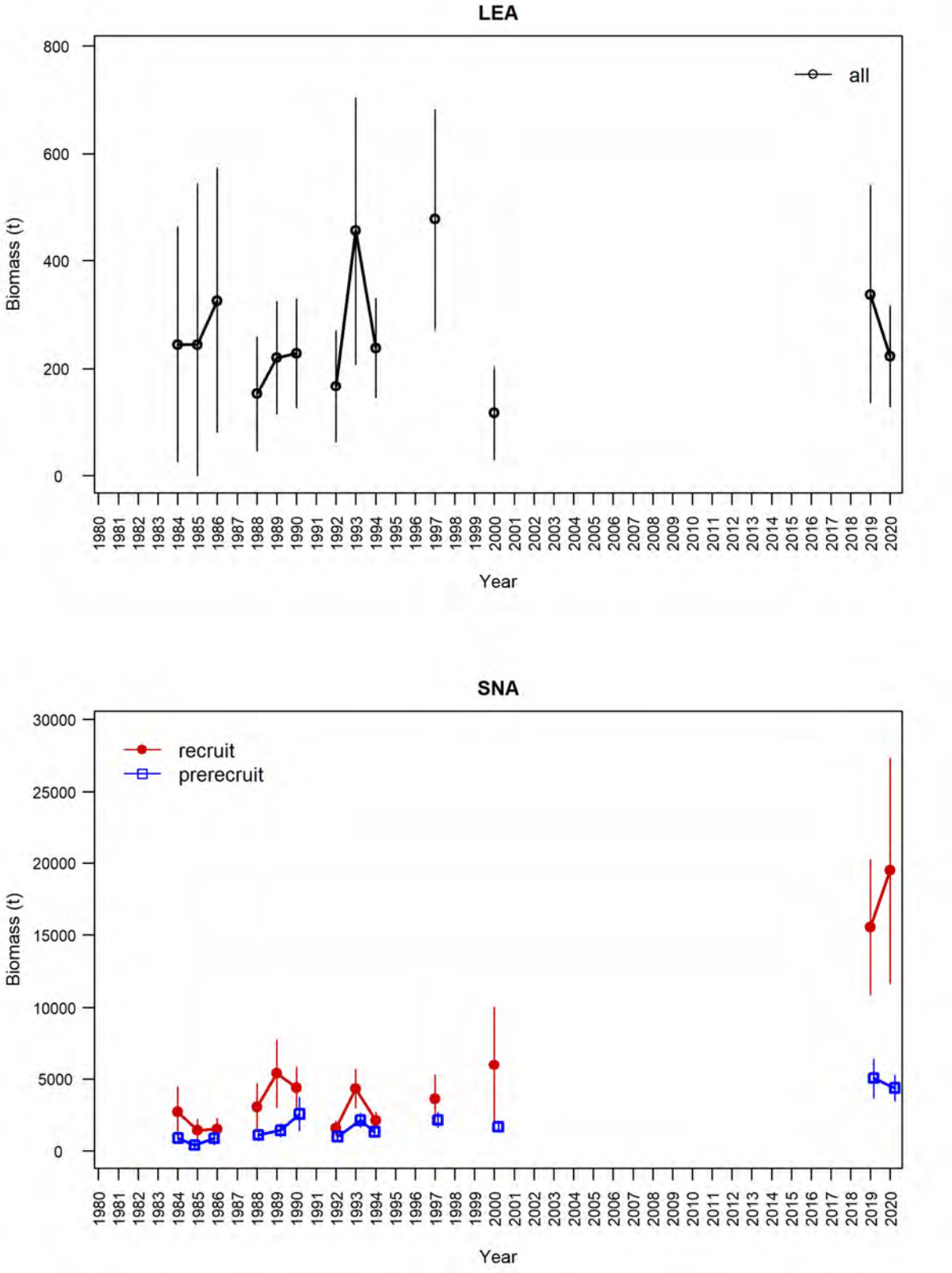
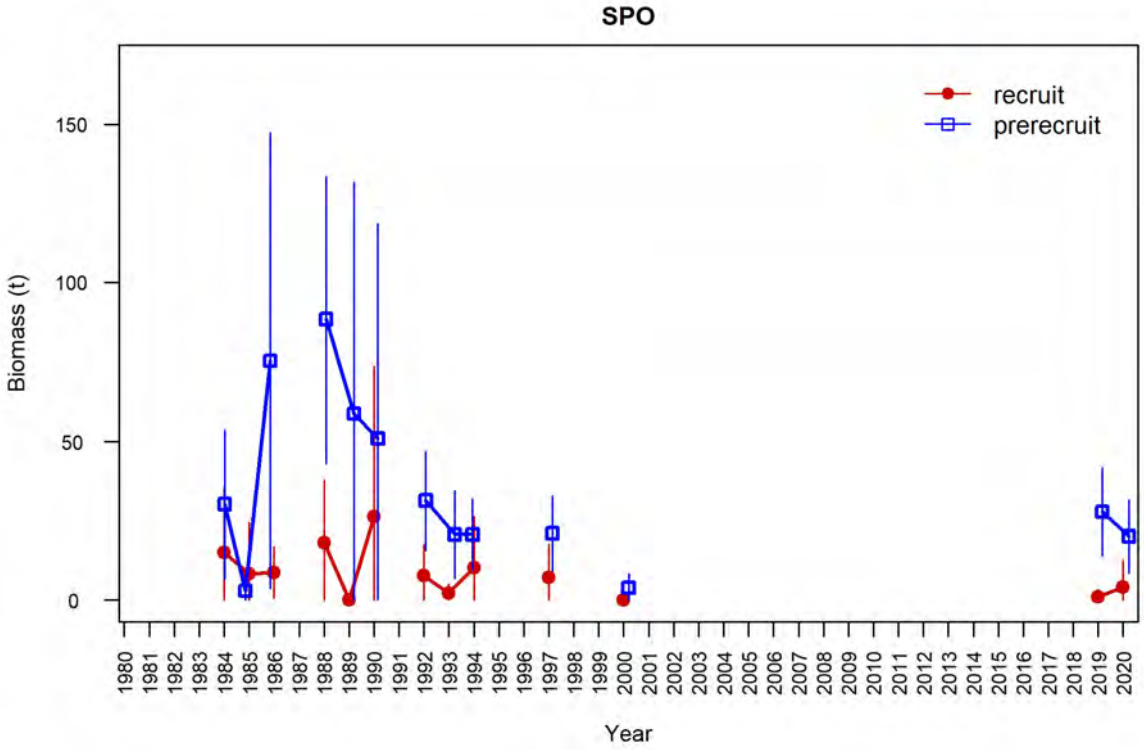


Figure 4a: Hauraki Gulf—continued.



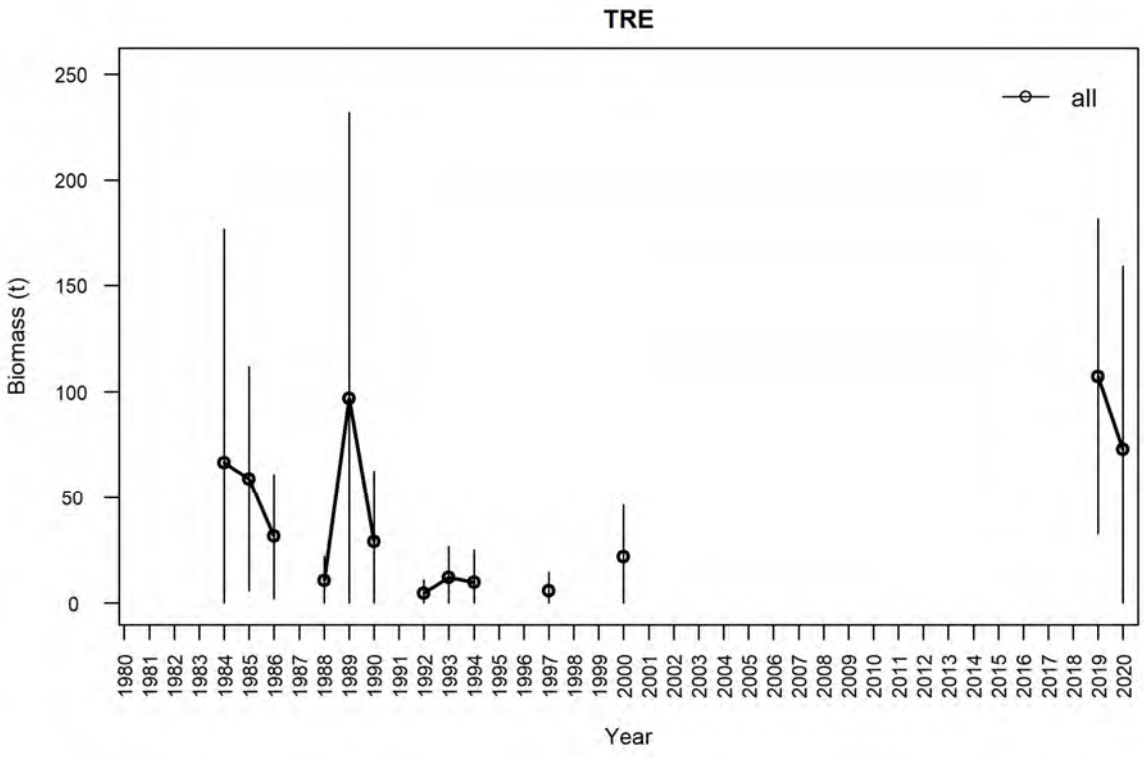


Figure 4a: Hauraki Gulf—continued.

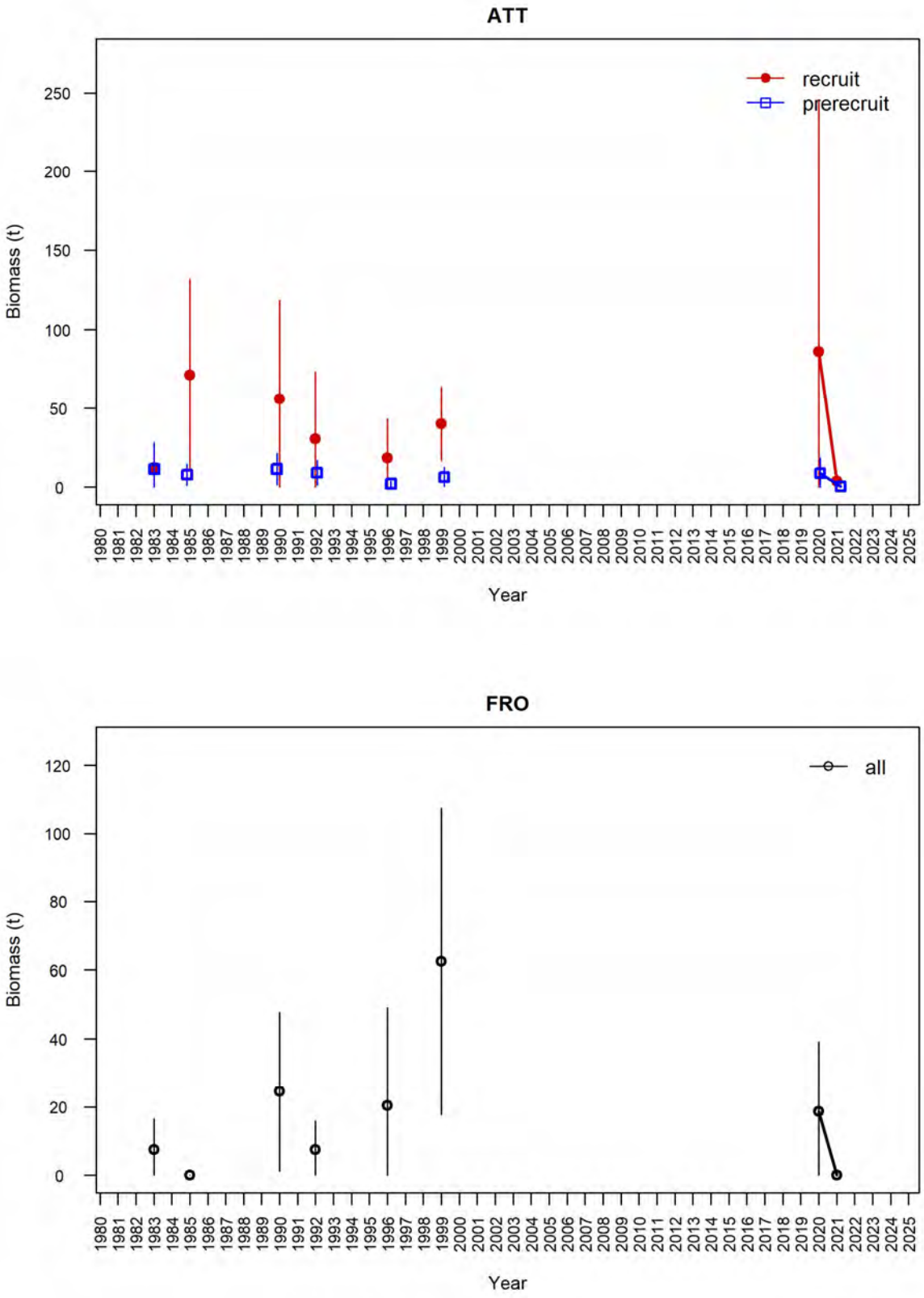


Figure 4b: Bay of Plenty.

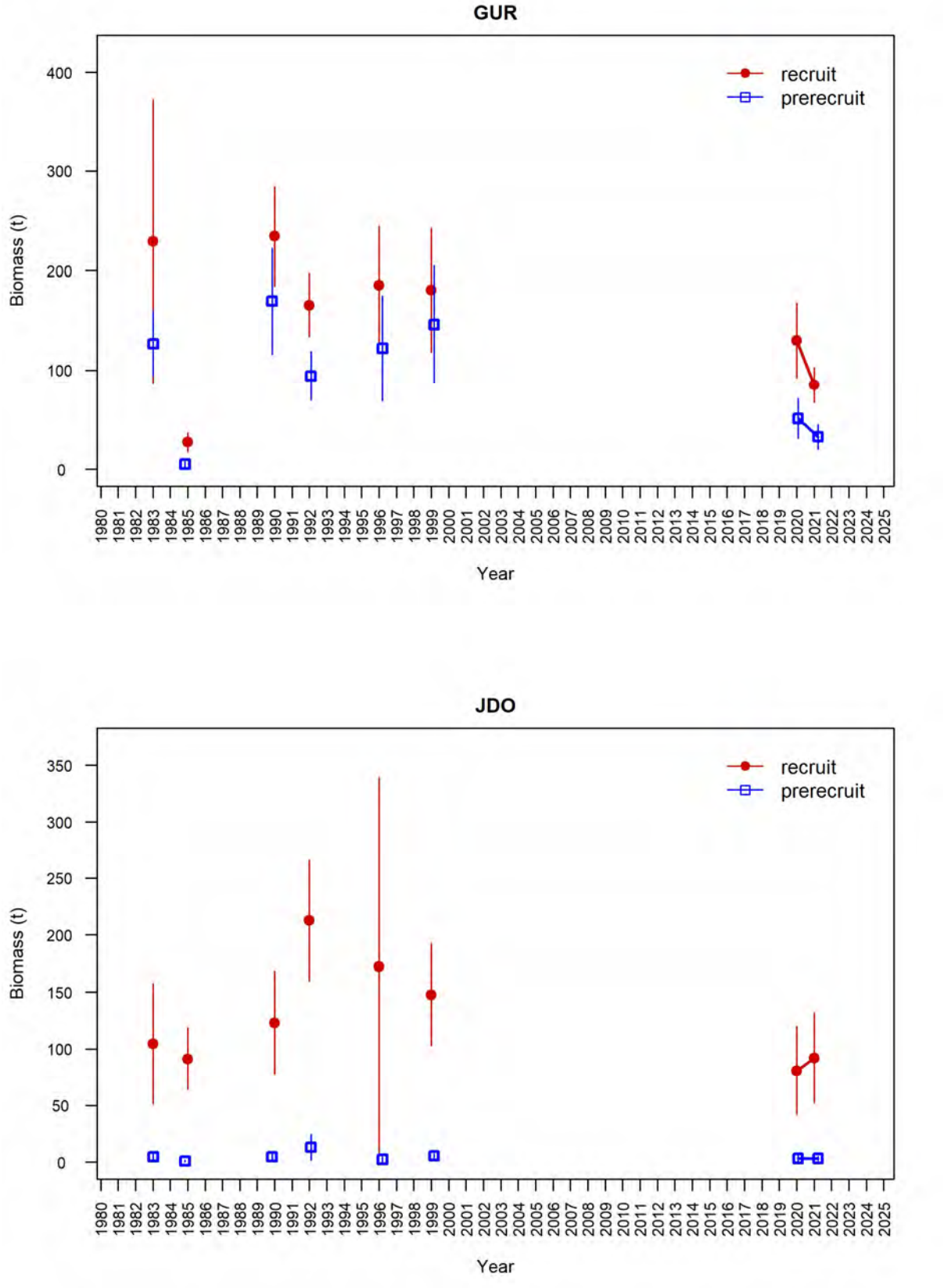
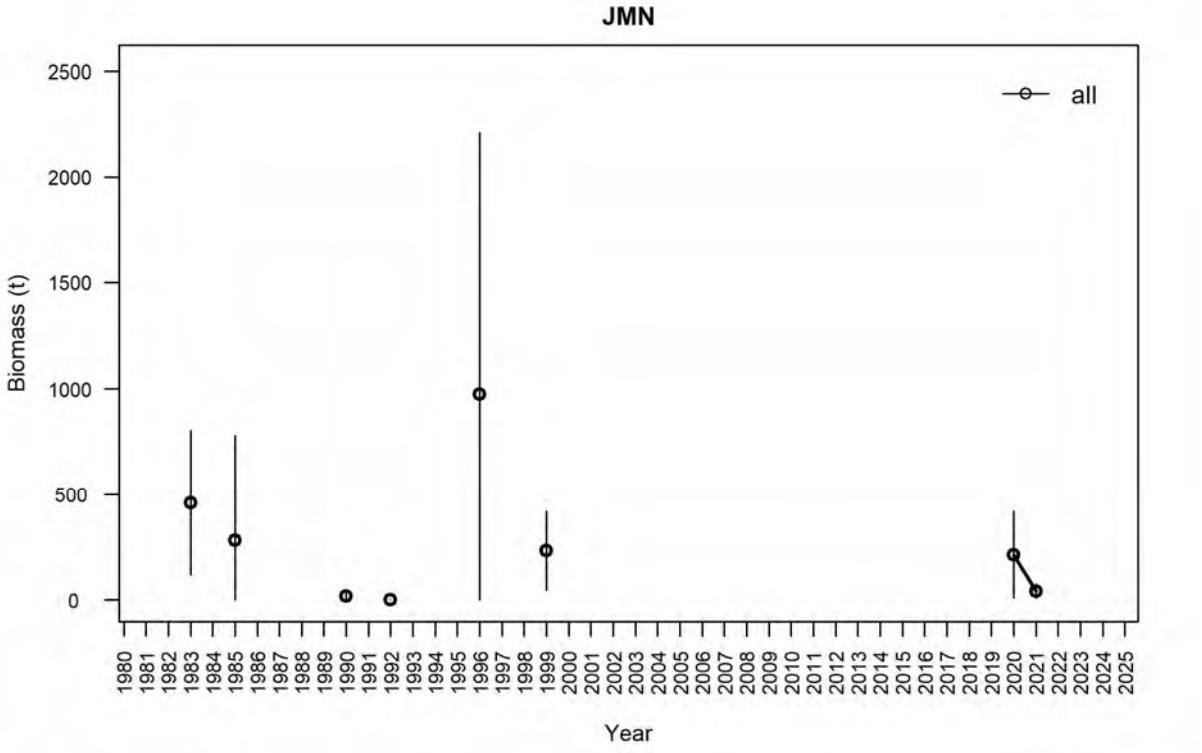


Figure 4b: Bay of Plenty—continued.



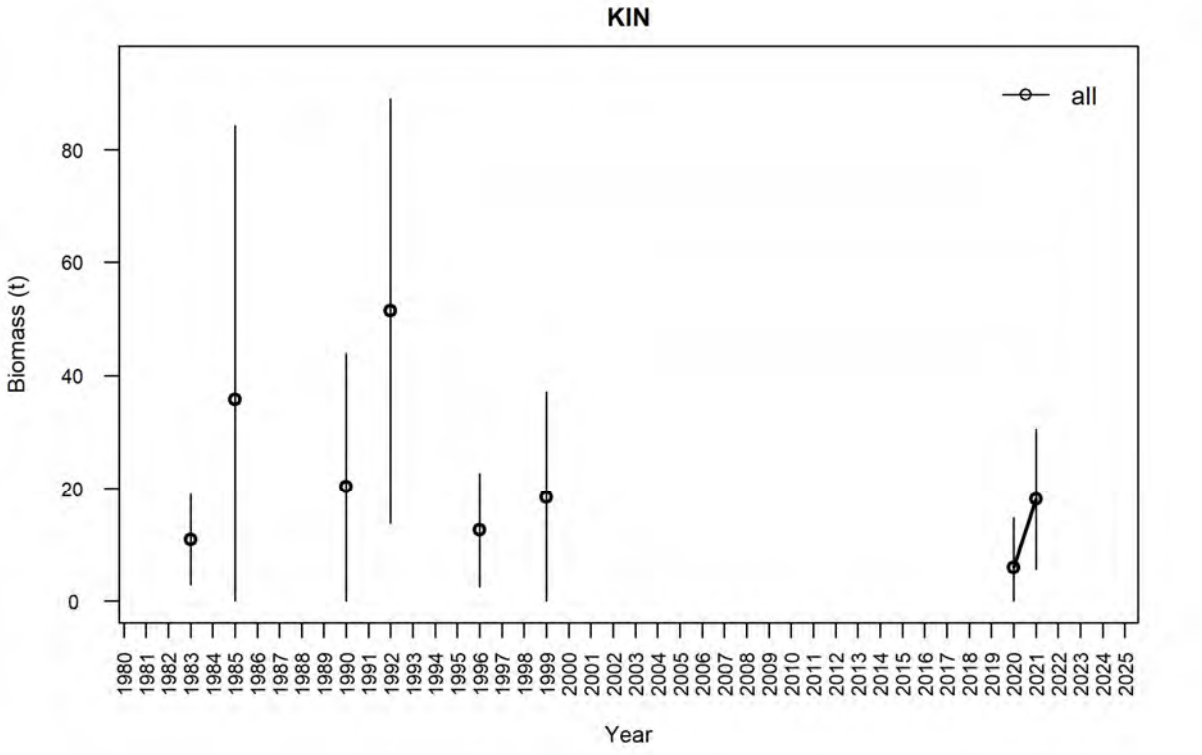


Figure 4b: Bay of Plenty—continued.

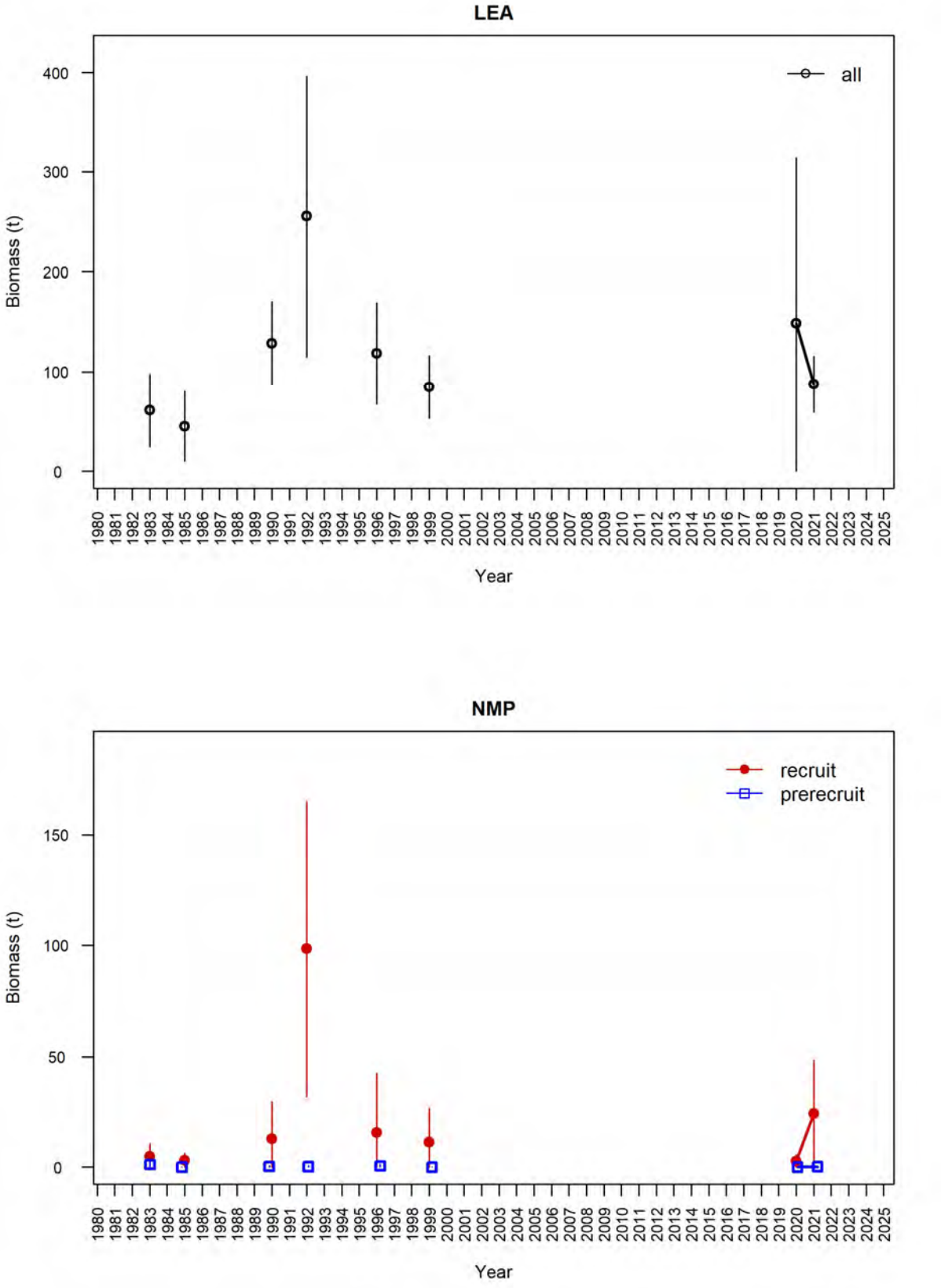


Figure 4b: Bay of Plenty—continued.

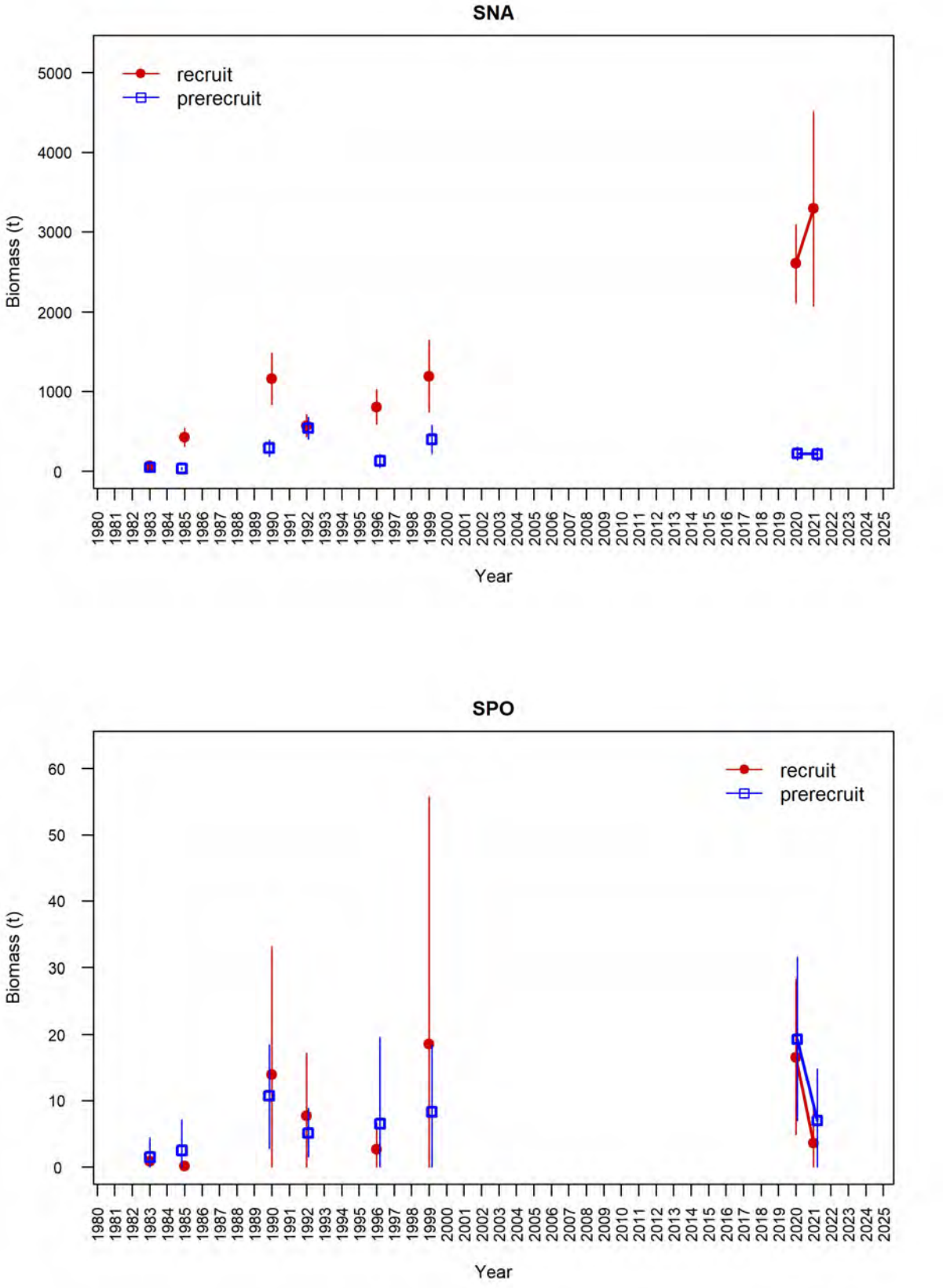


Figure 4b: Bay of Plenty—continued.

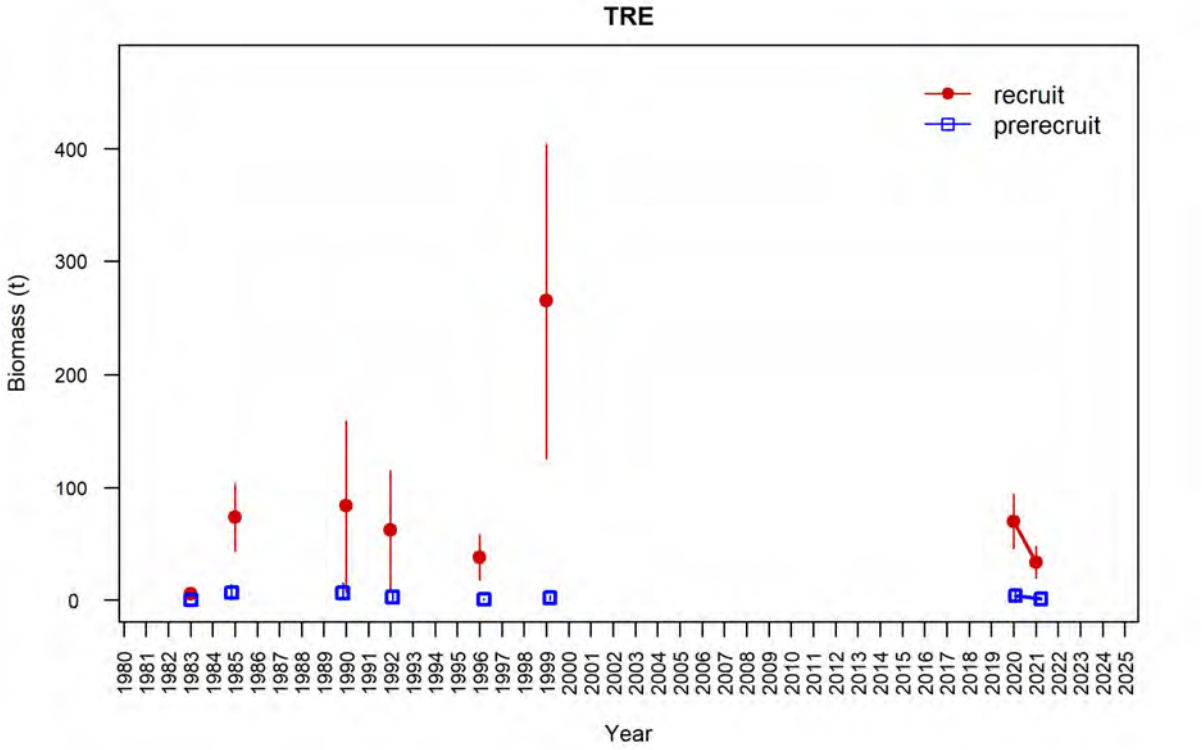
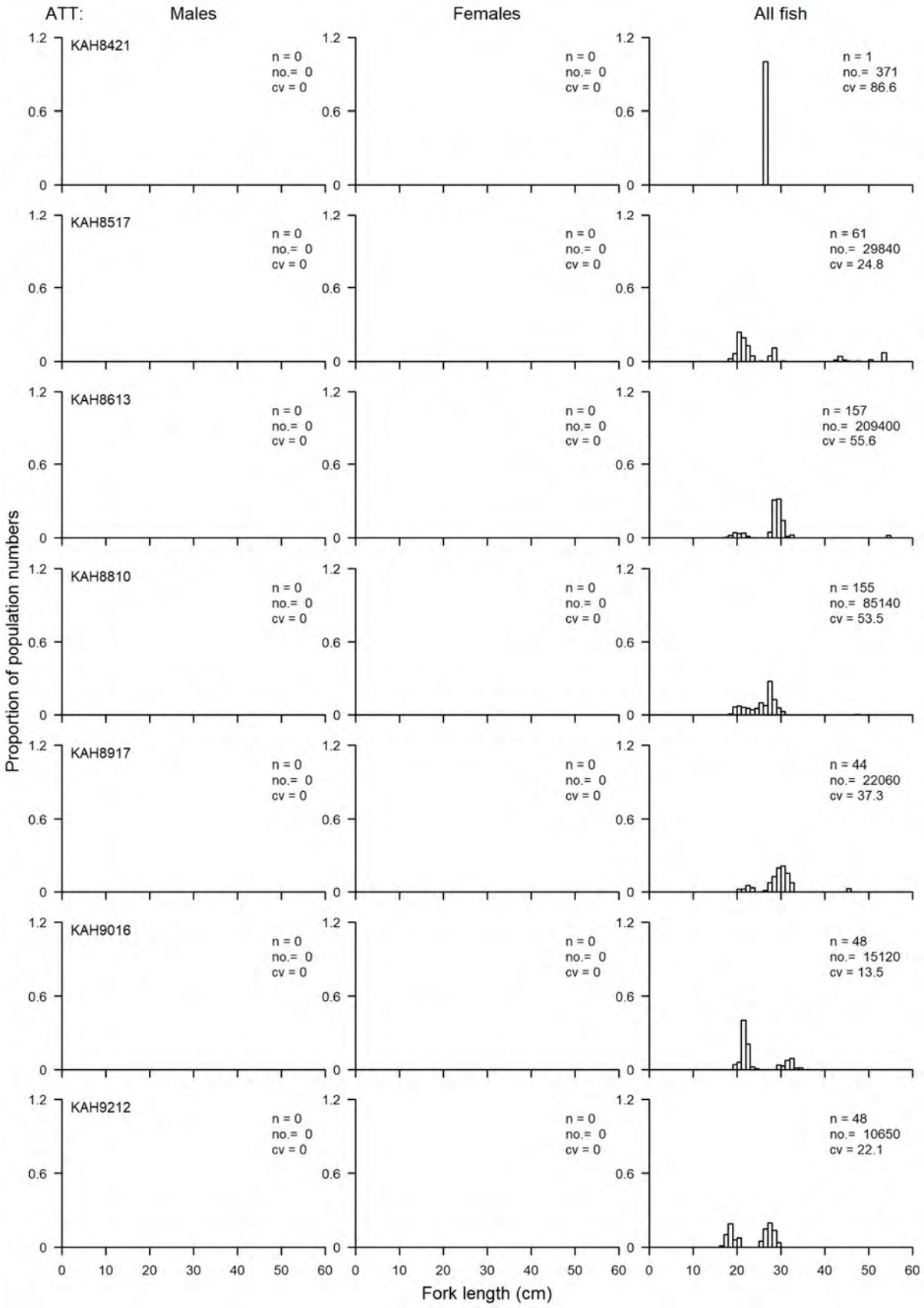


Figure 4b: Bay of Plenty—continued.



a) Kahawai.

Figure 5: Comparative scaled length frequency distributions for the most common QMS species in the Hauraki Gulf. n = number of fish measured, no. = scaled population number, cv = coefficient of variation. * = scaled population number inaccurate due to limited length sampling for that species and survey. 'All fish' includes any unsexed fish.

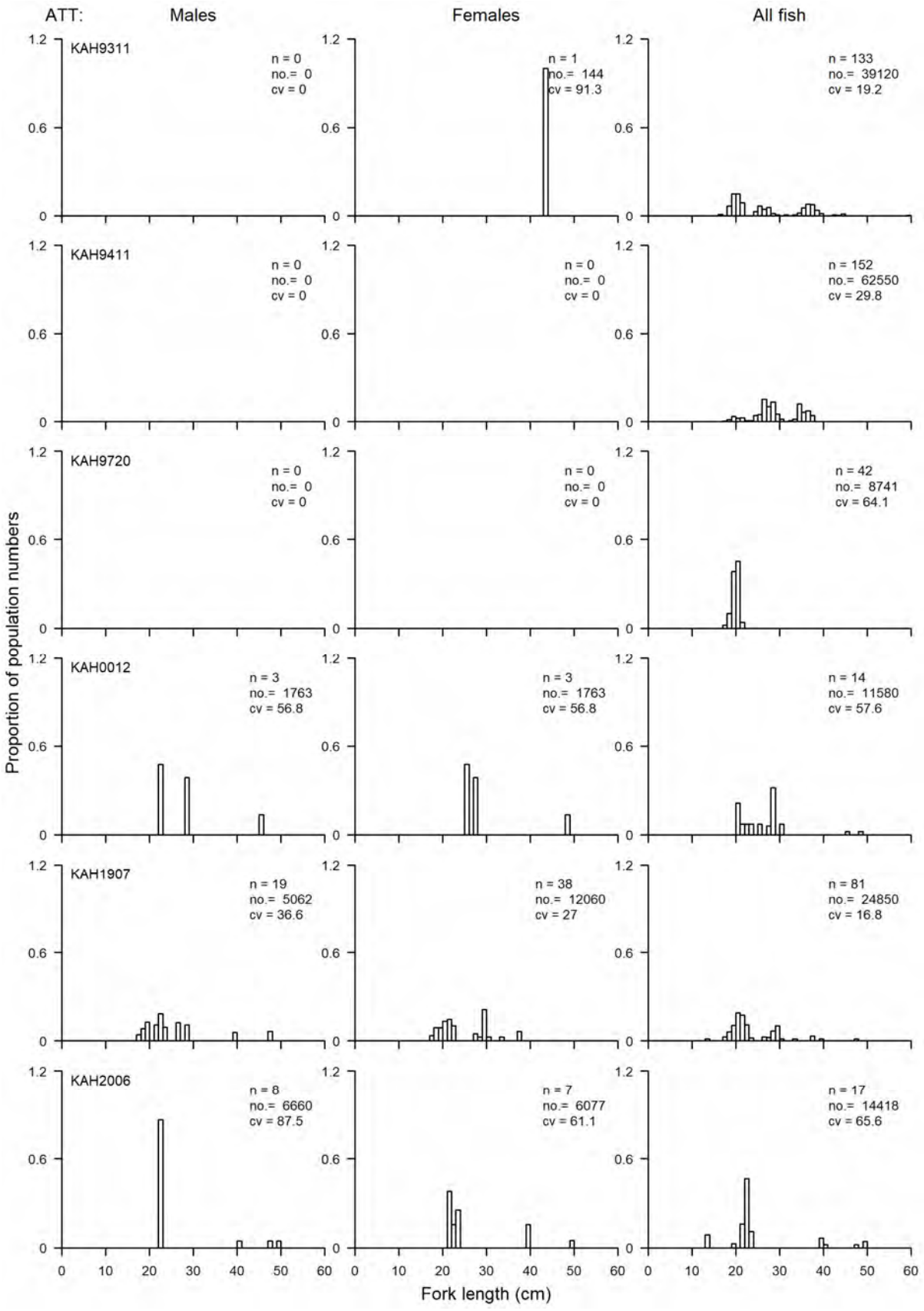


Figure 5a: – Kahawai continued.

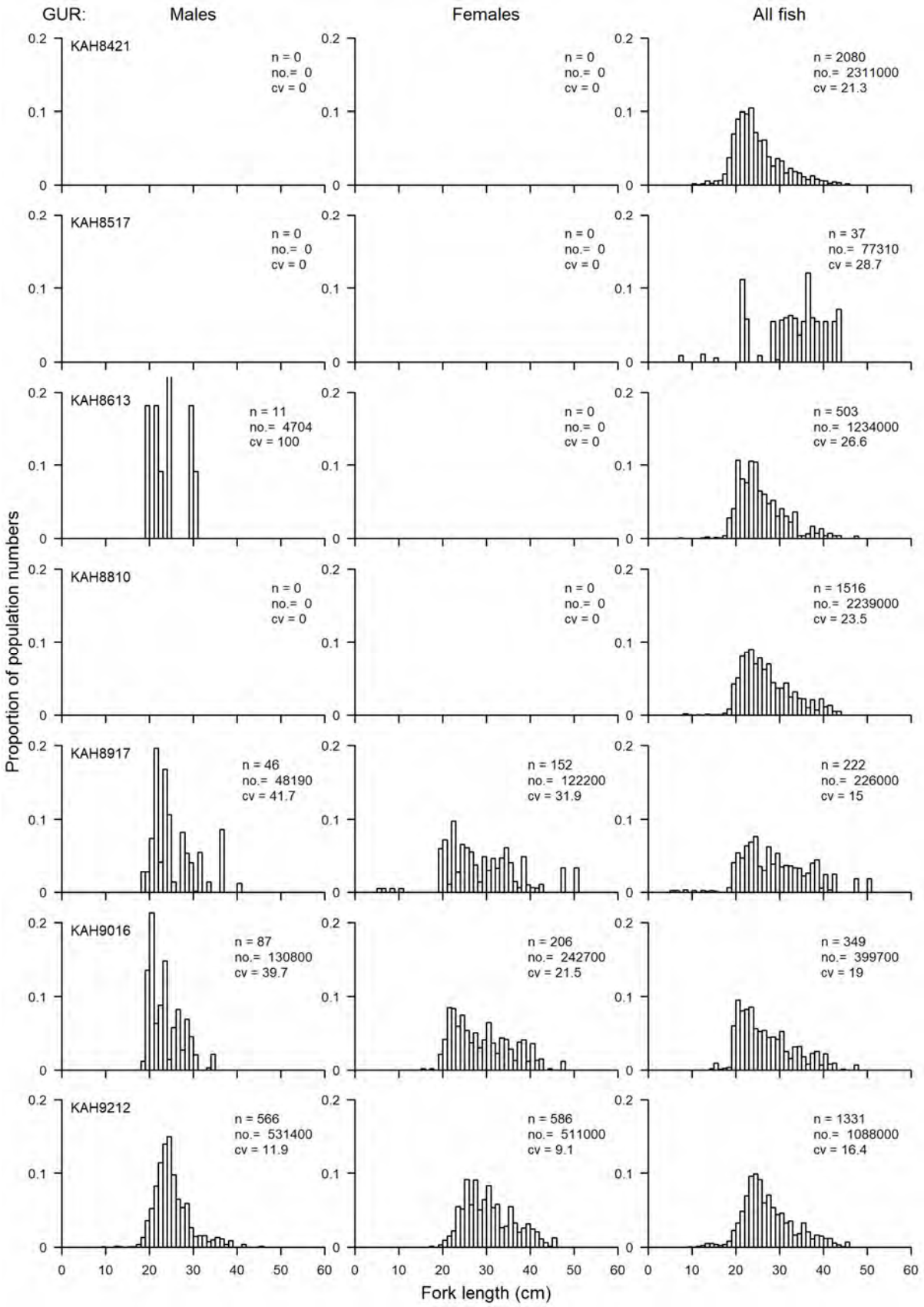


Figure 5b: Red gurnard.

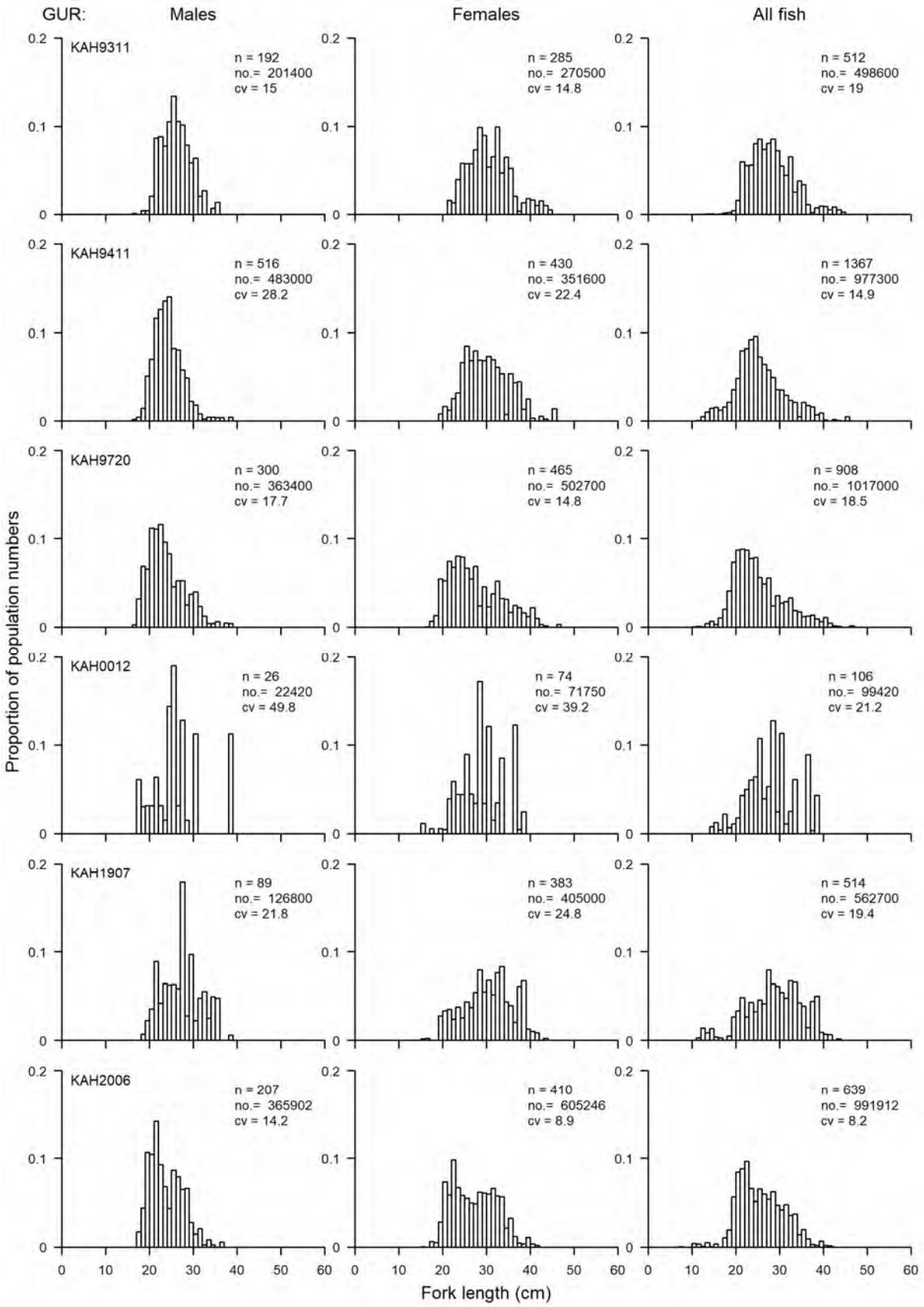


Figure 5b: – Red gurnard continued.

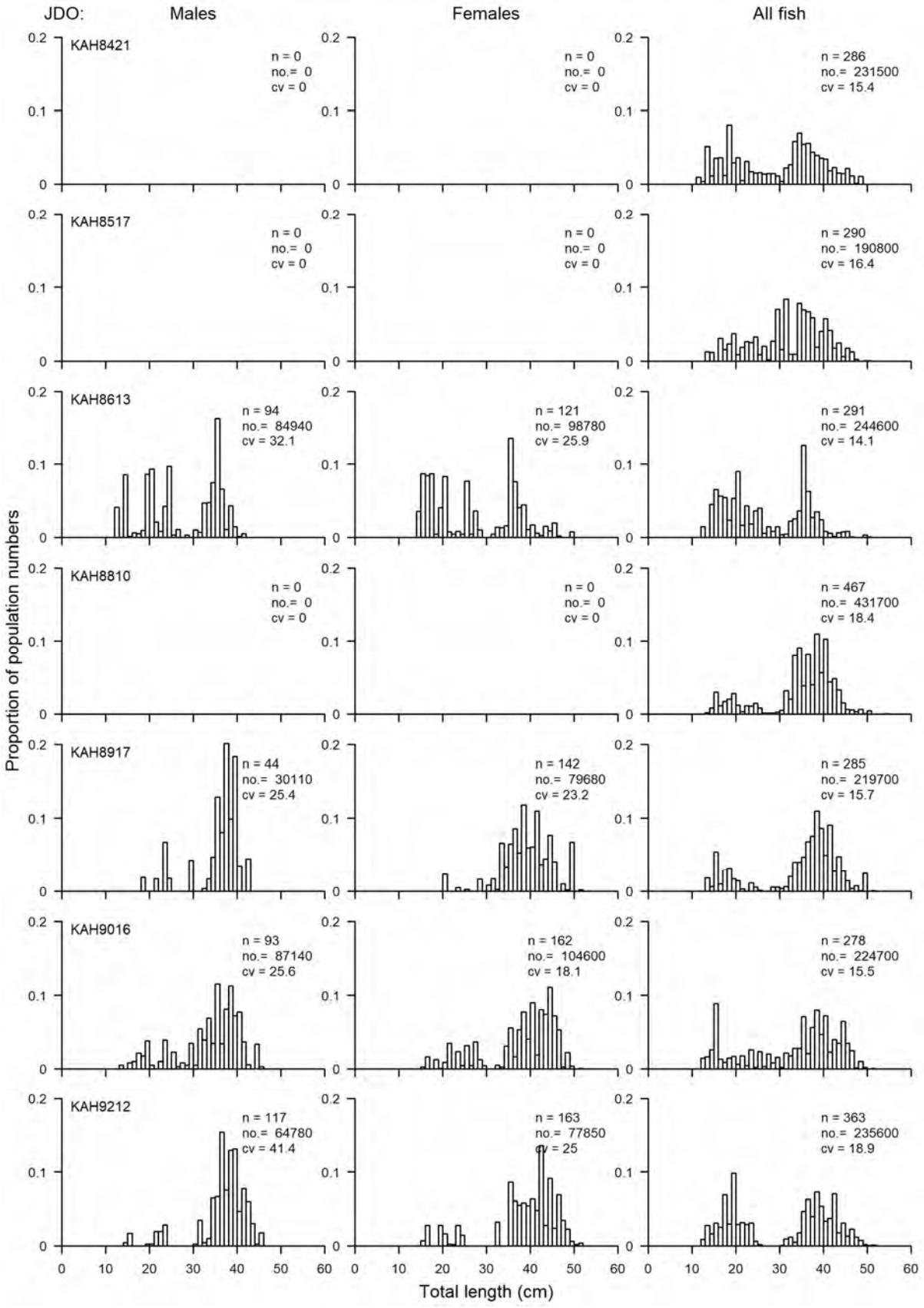


Figure 5c: John dory.

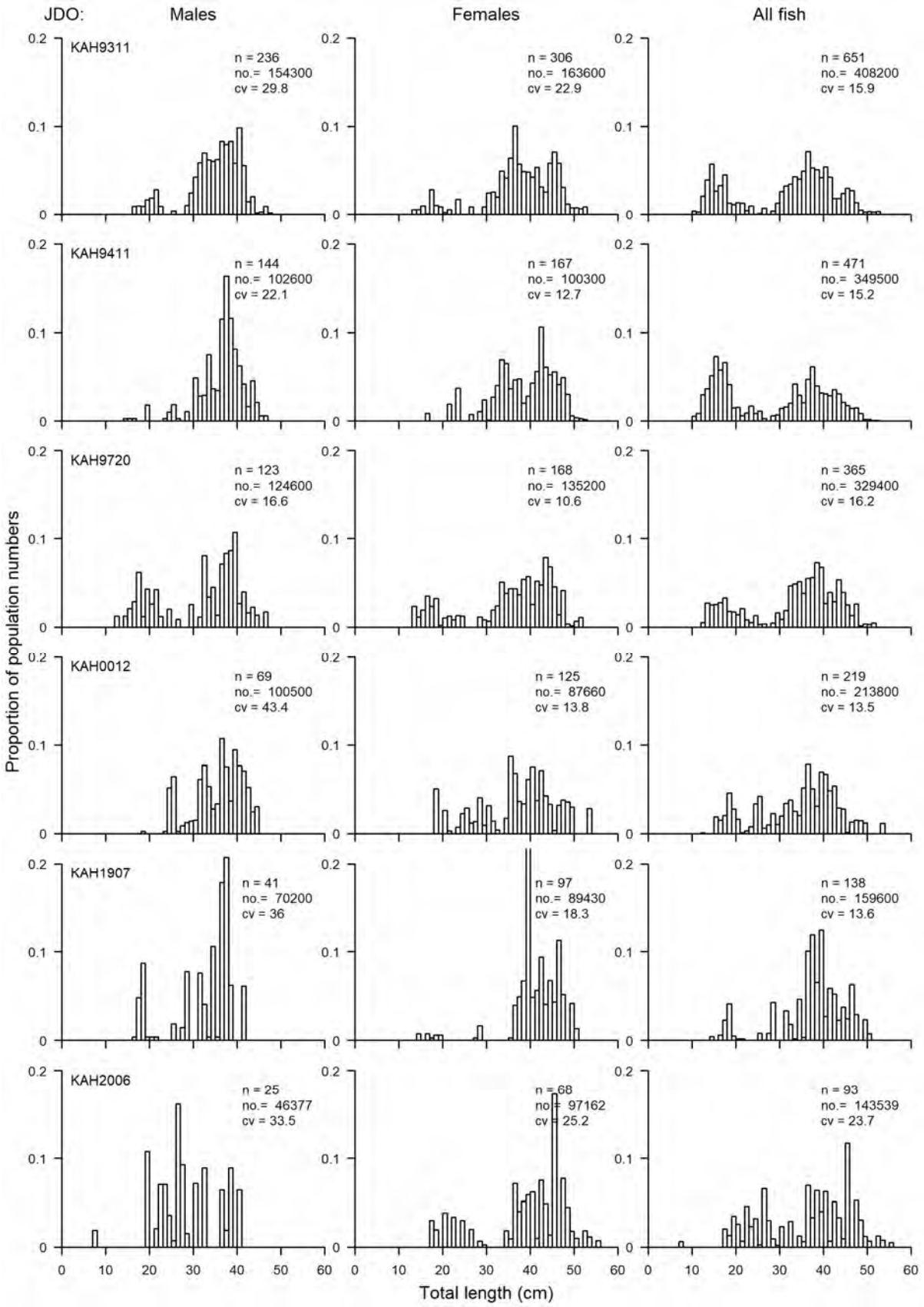


Figure 5c: – John dory continued.

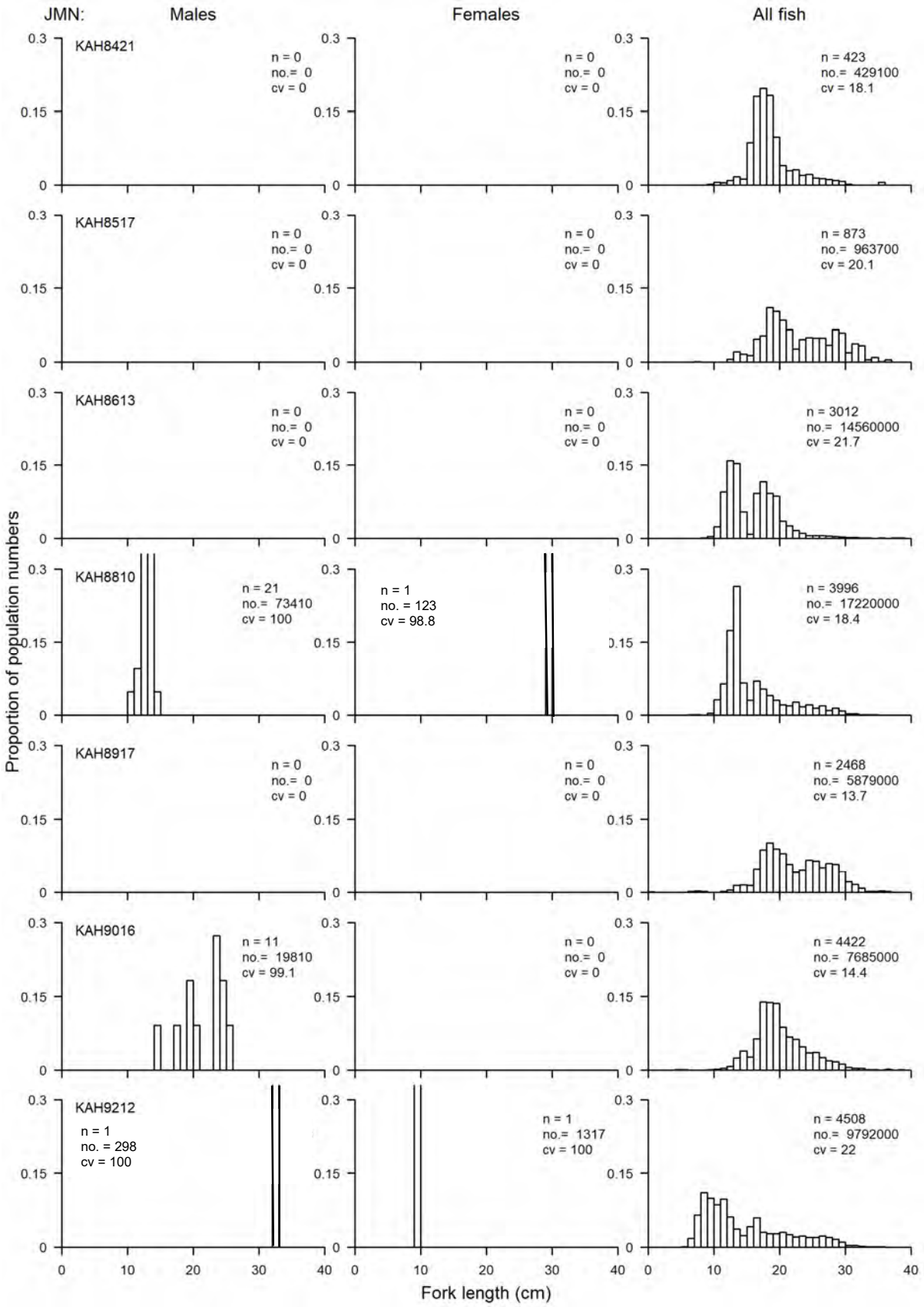


Figure 5d: Yellowtail jack mackerel.

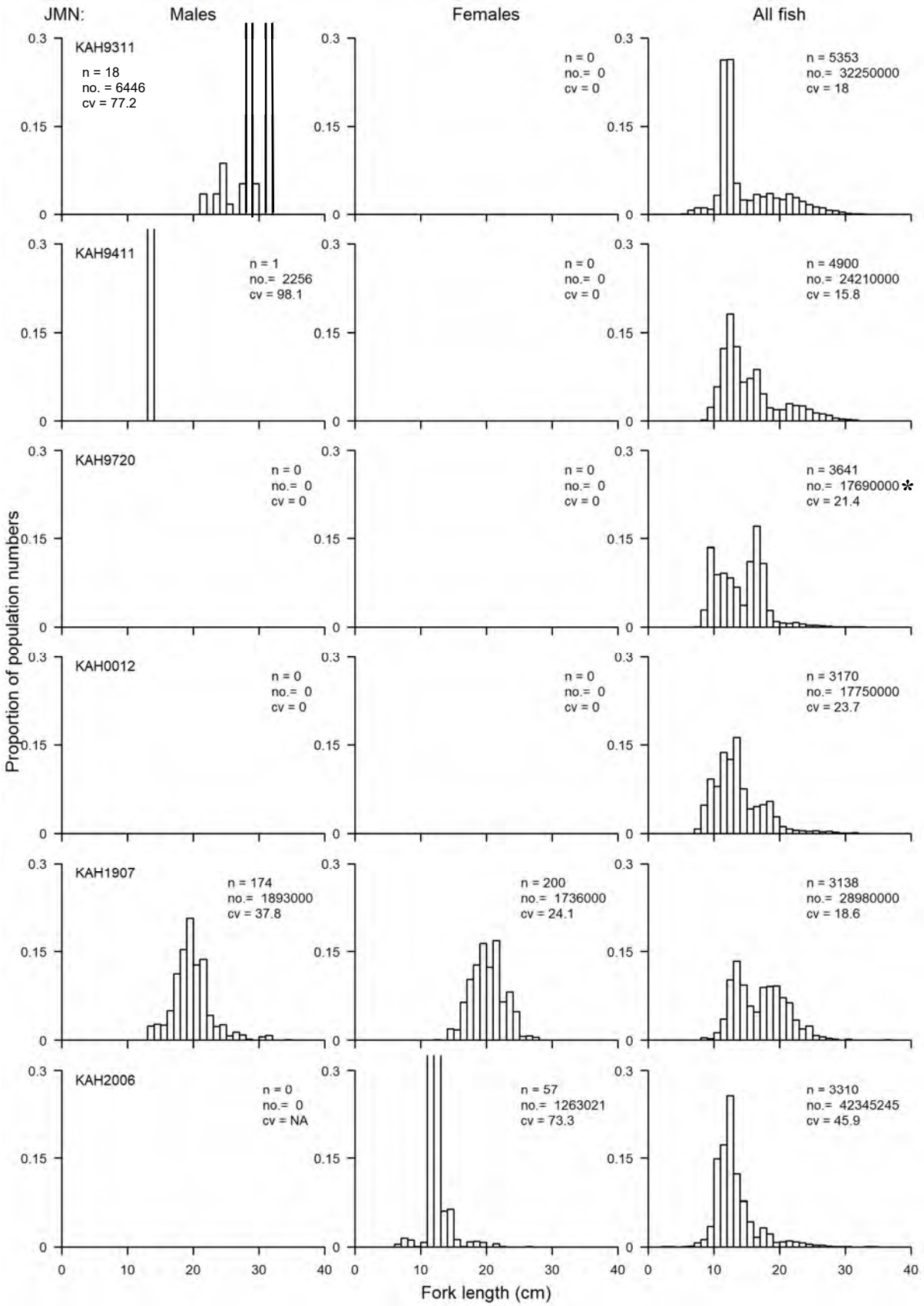


Figure 5d: – Yellowtail jack mackerel continued. * scaled population number inaccurate due to limited length sampling for the 1997 survey.

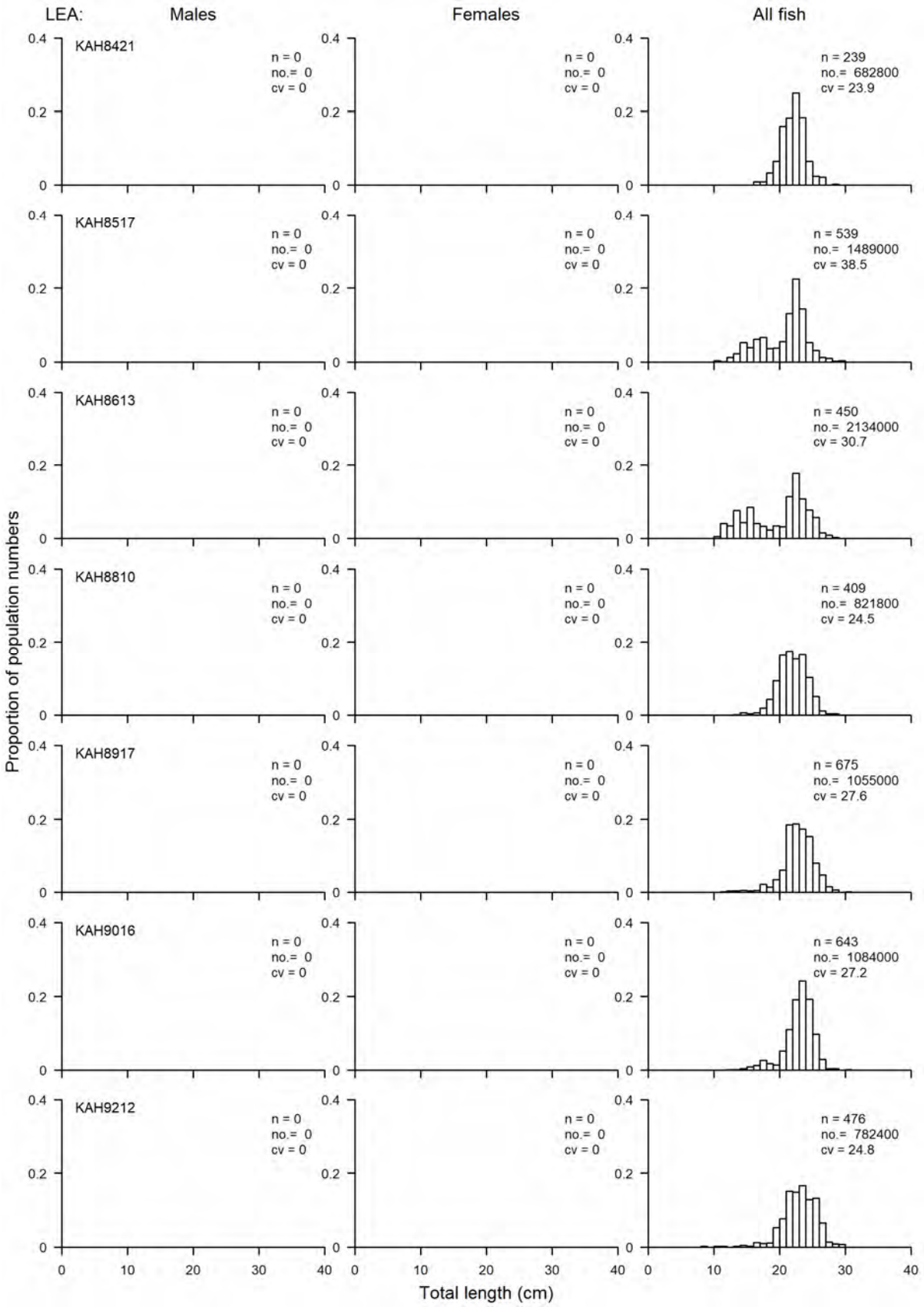


Figure 5e: Leatherjacket.

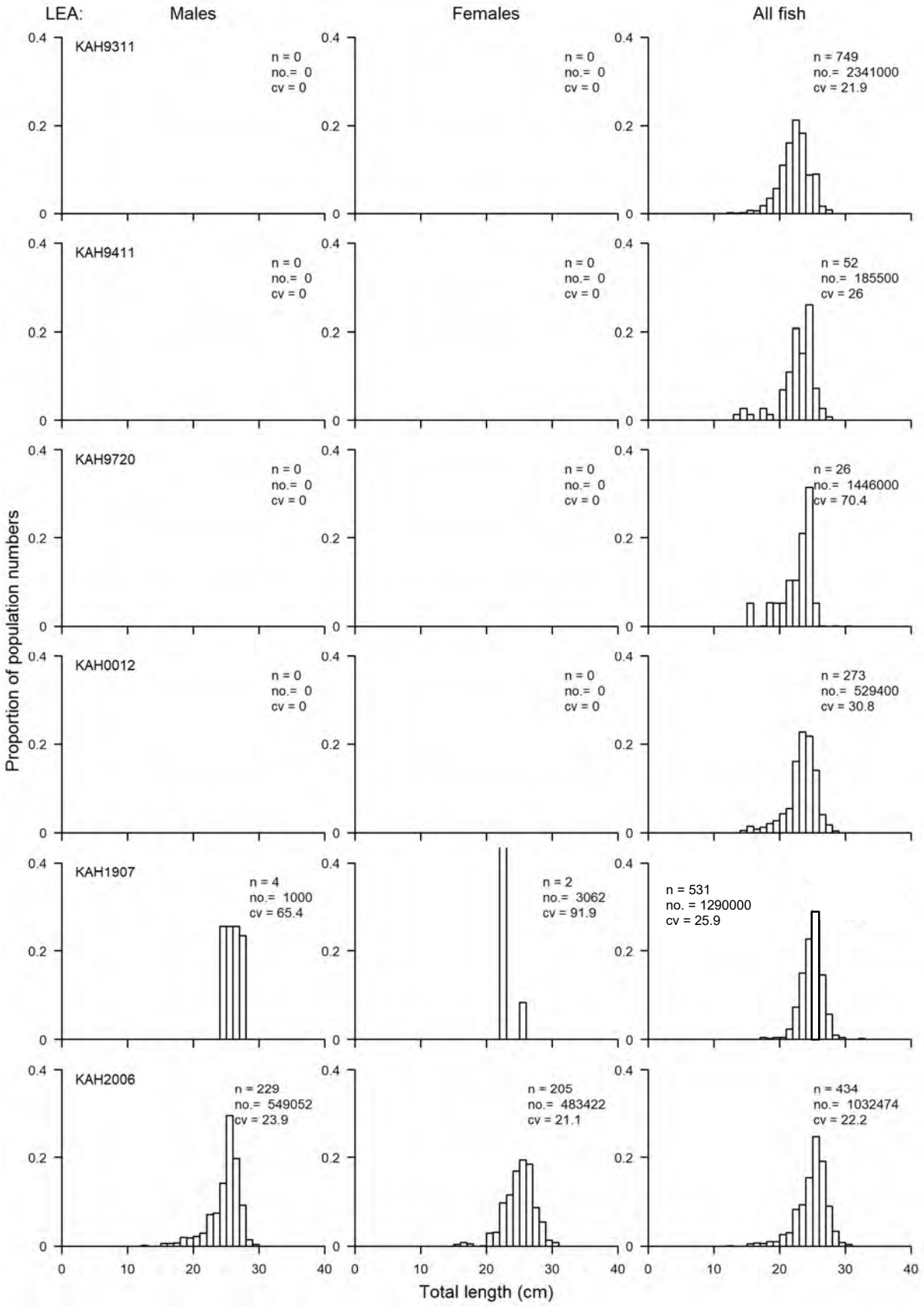


Figure 5e: – Leatherjacket continued.

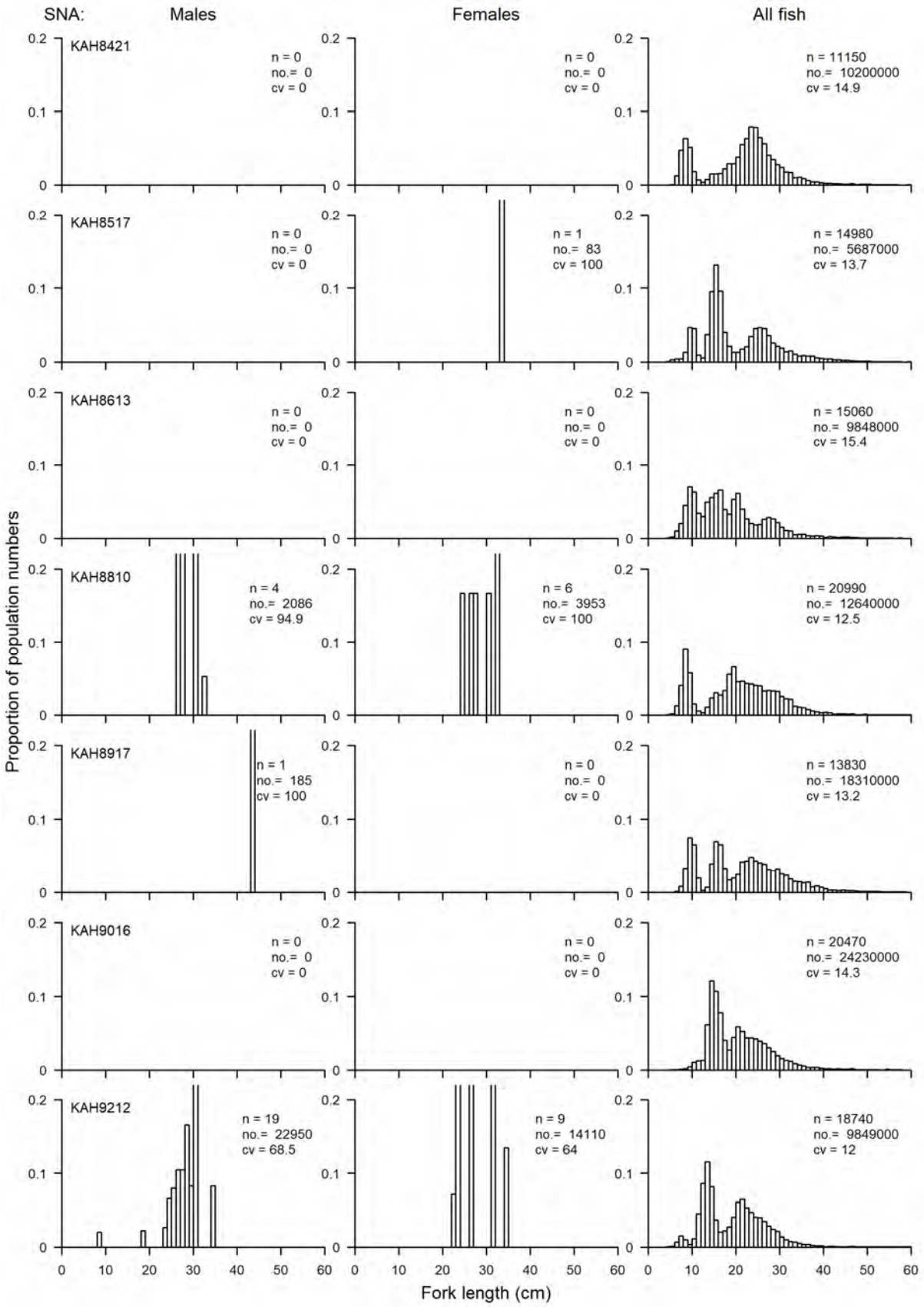


Figure 5f: Snapper.

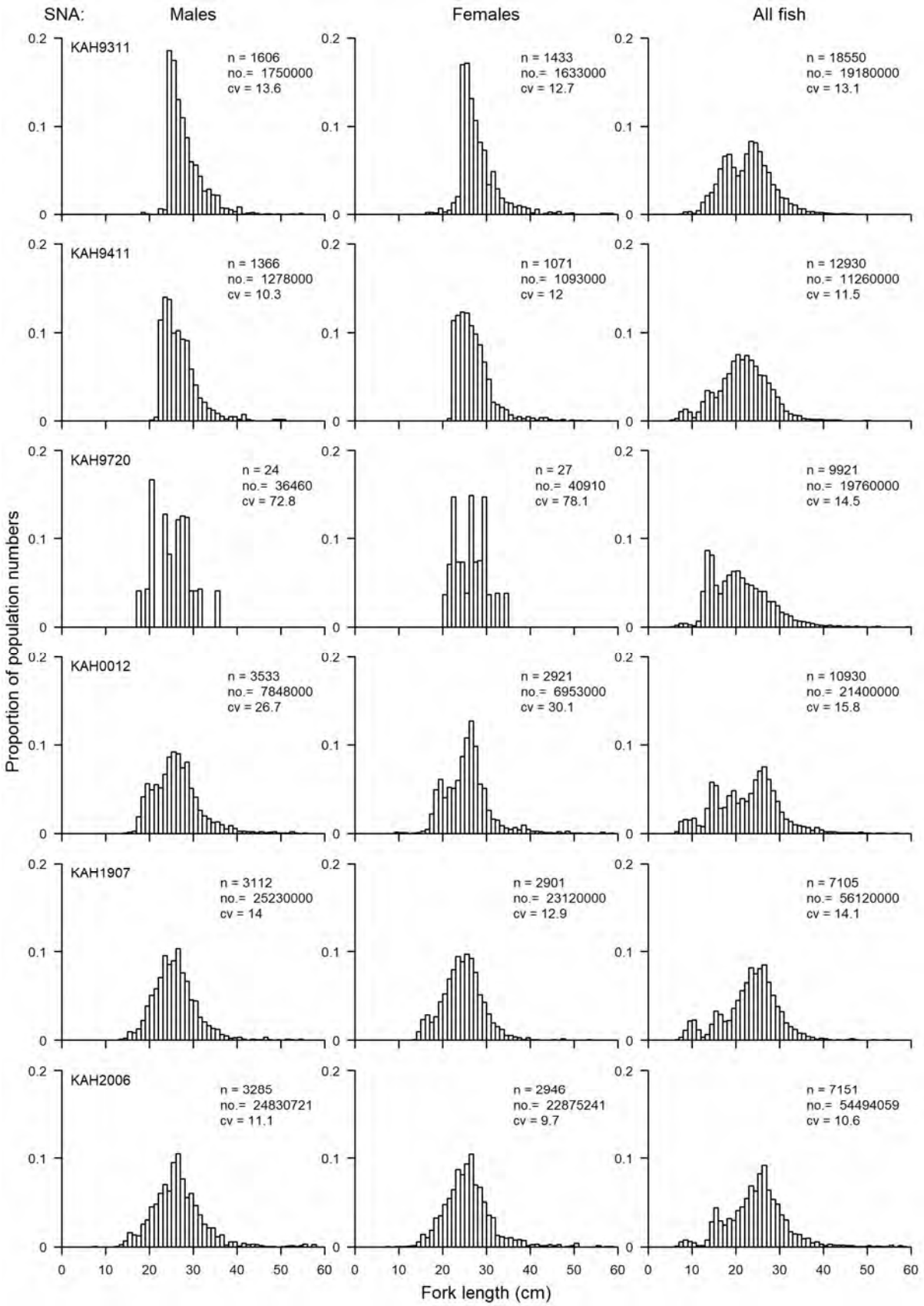


Figure 5f: – Snapper continued.

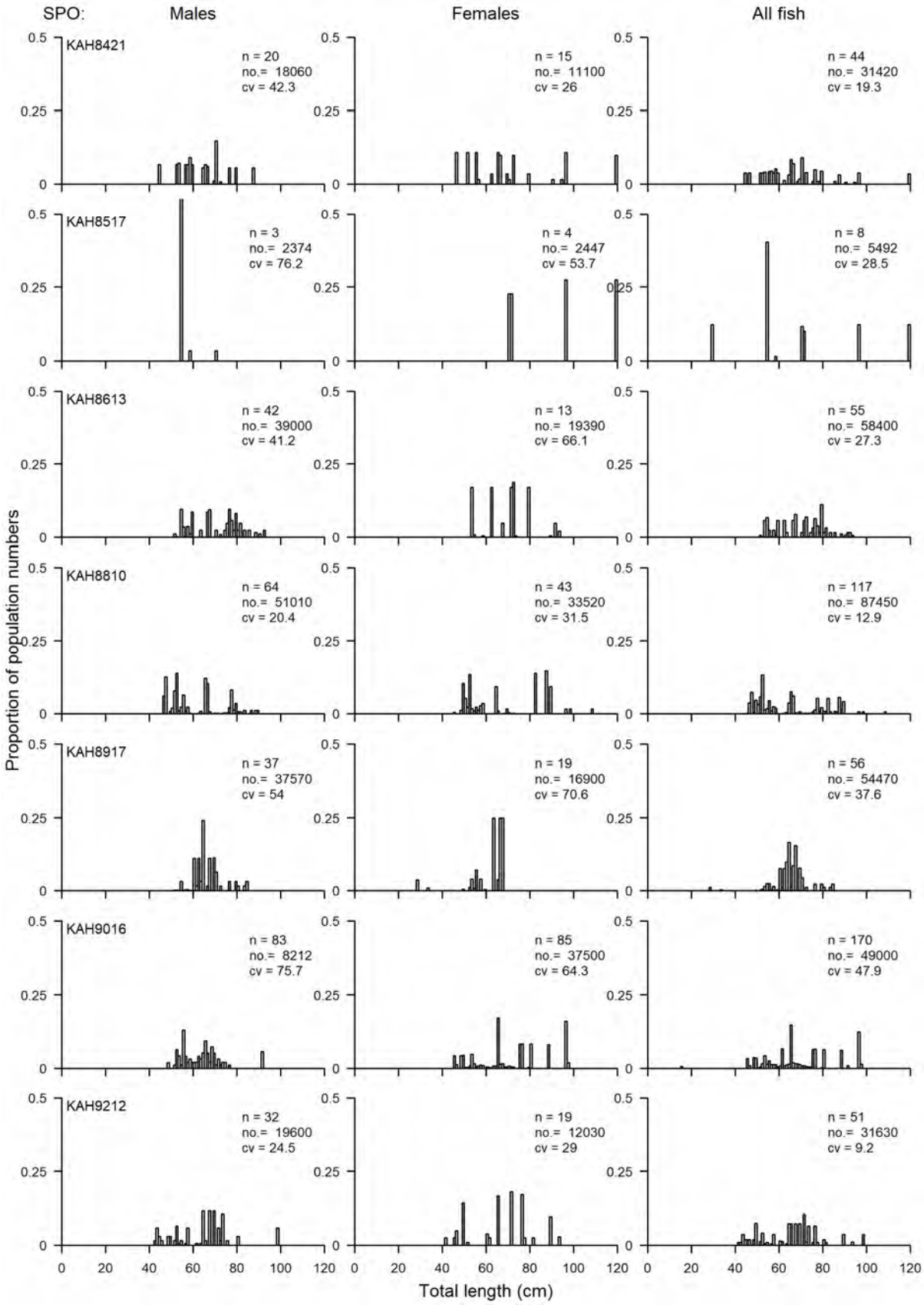


Figure 5g: Rig.

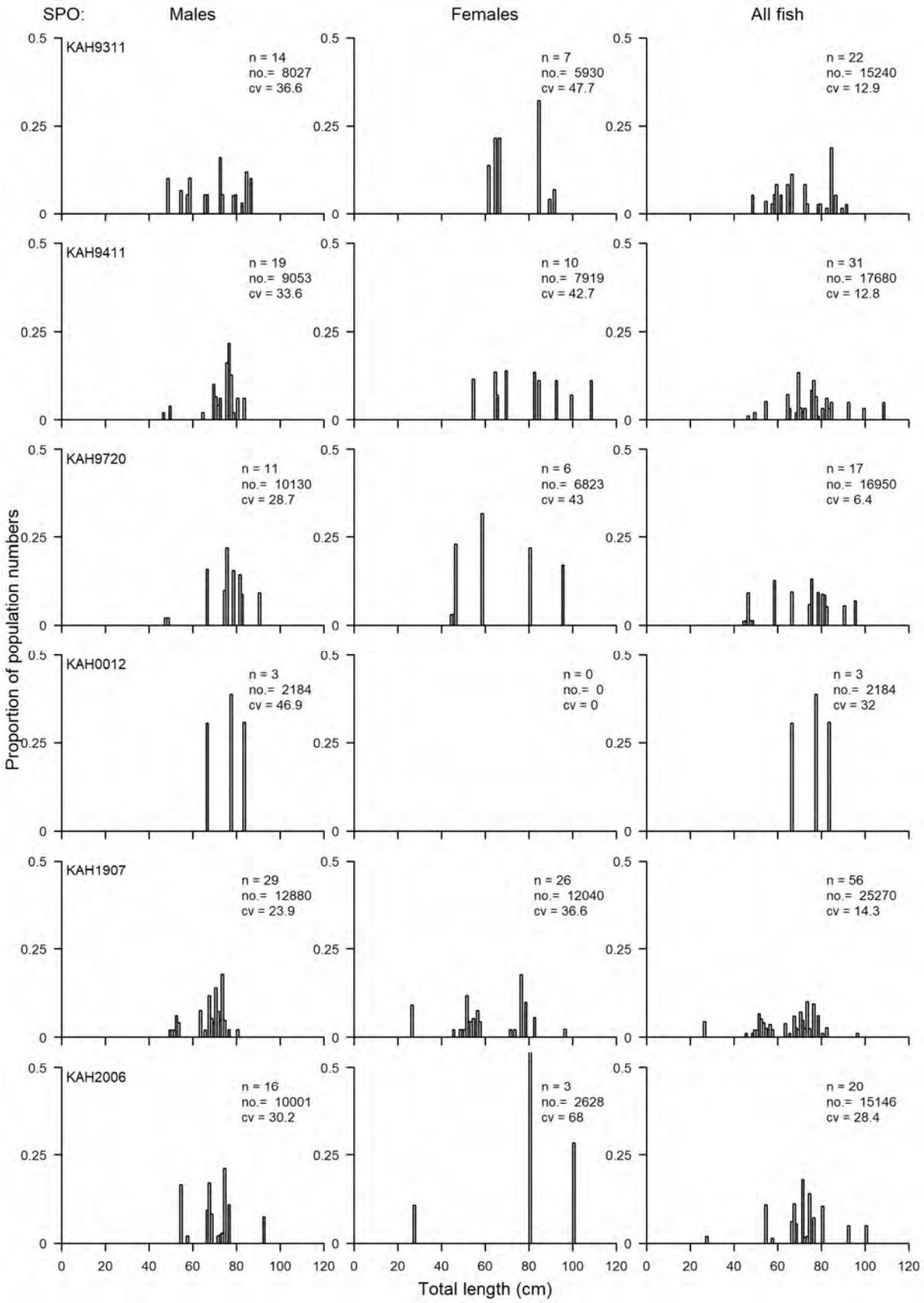


Figure 5g: – Rig continued.

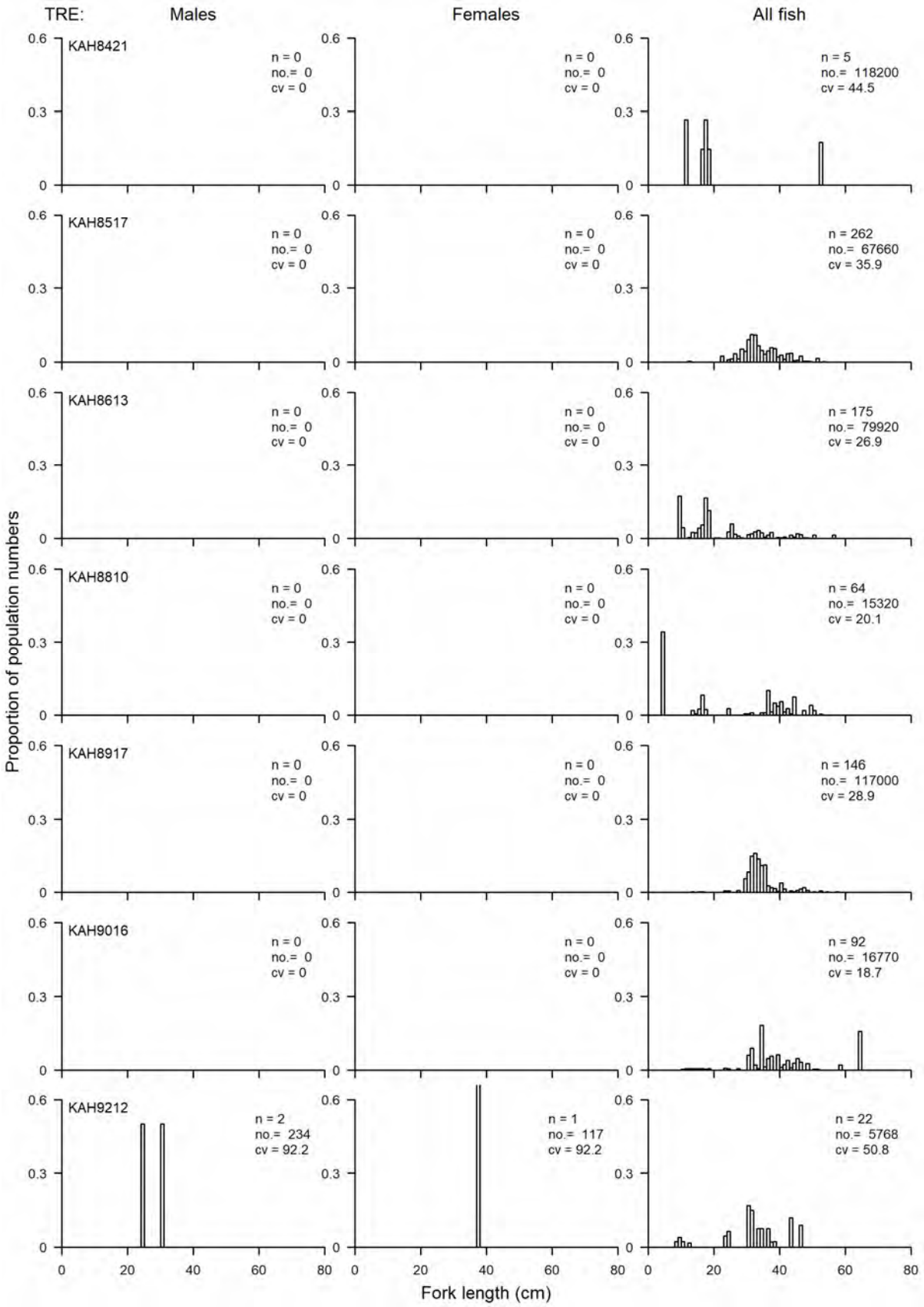


Figure 5h: Trevally.

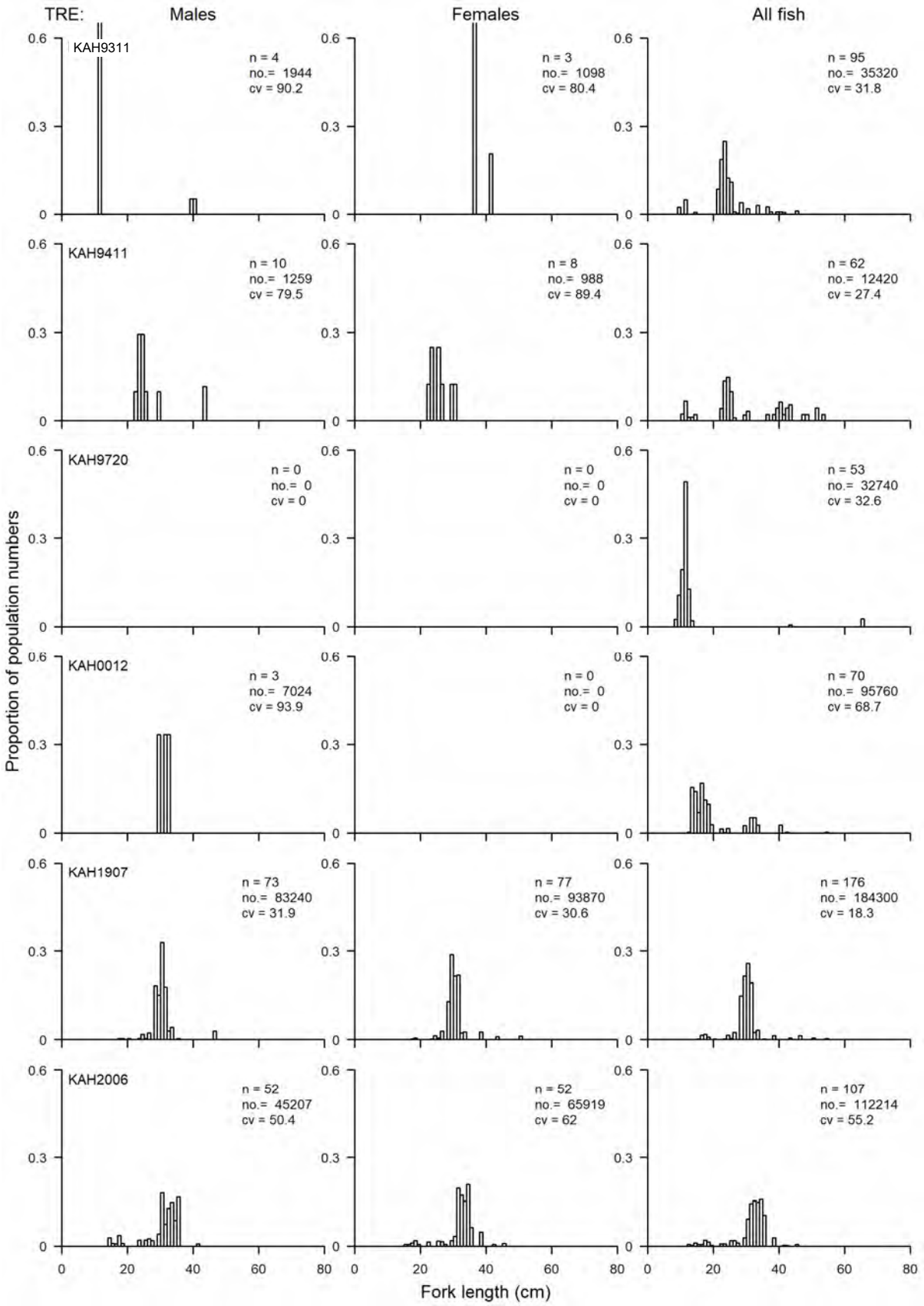
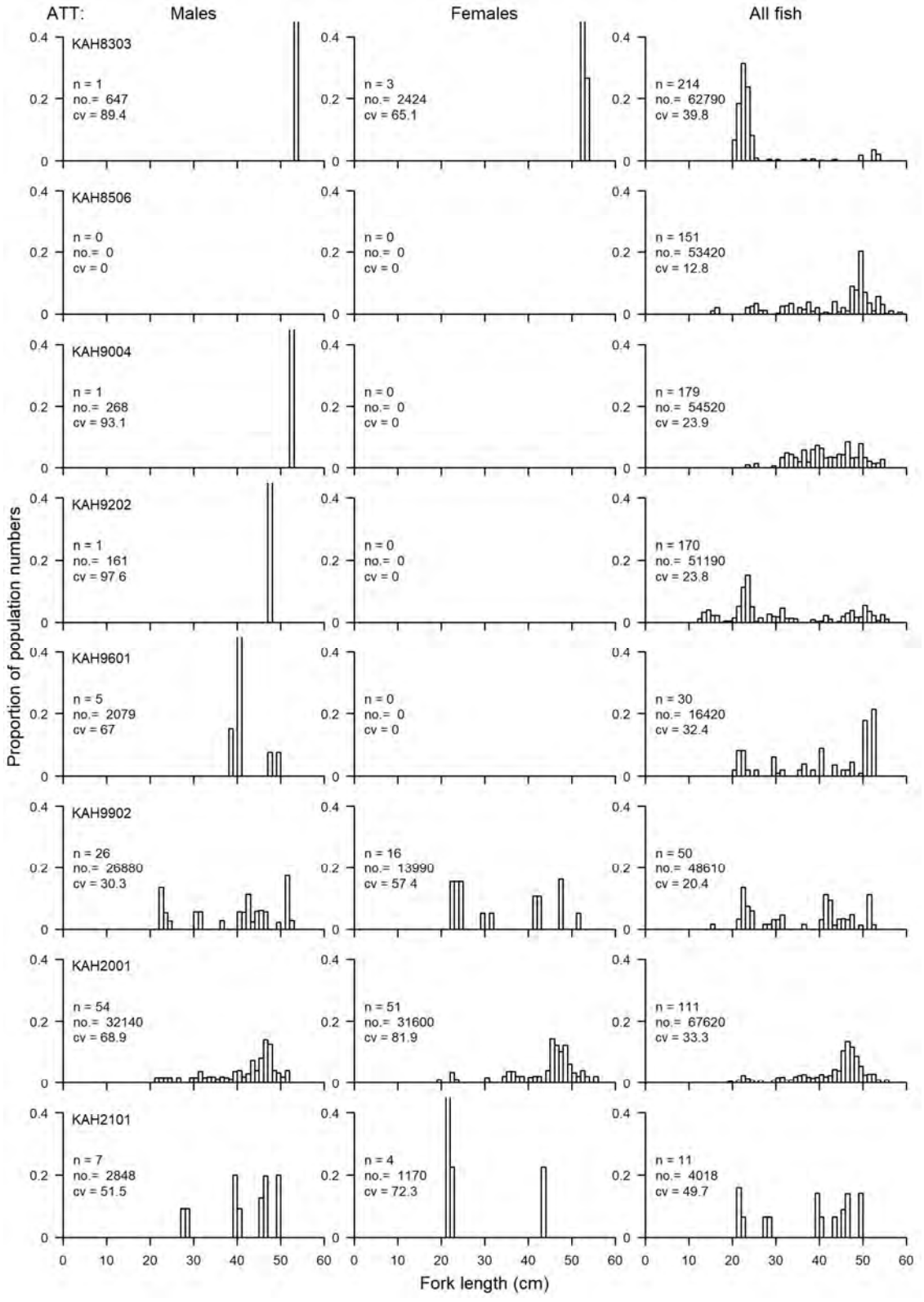


Figure 5h: – Trevally continued.



a) Kahawai.

Figure 6: Comparative scaled length frequency distributions for the most common QMS species in the Bay of Plenty. n = number of fish measured, no. = scaled population number, CV = coefficient of variation. KAH2101 length frequency distribution only includes extended phase two stations for John dory, trevally, and tarakihi. * = scaled population number inaccurate due to limited length sampling for that species and survey. 'All fish' includes any unsexed fish.

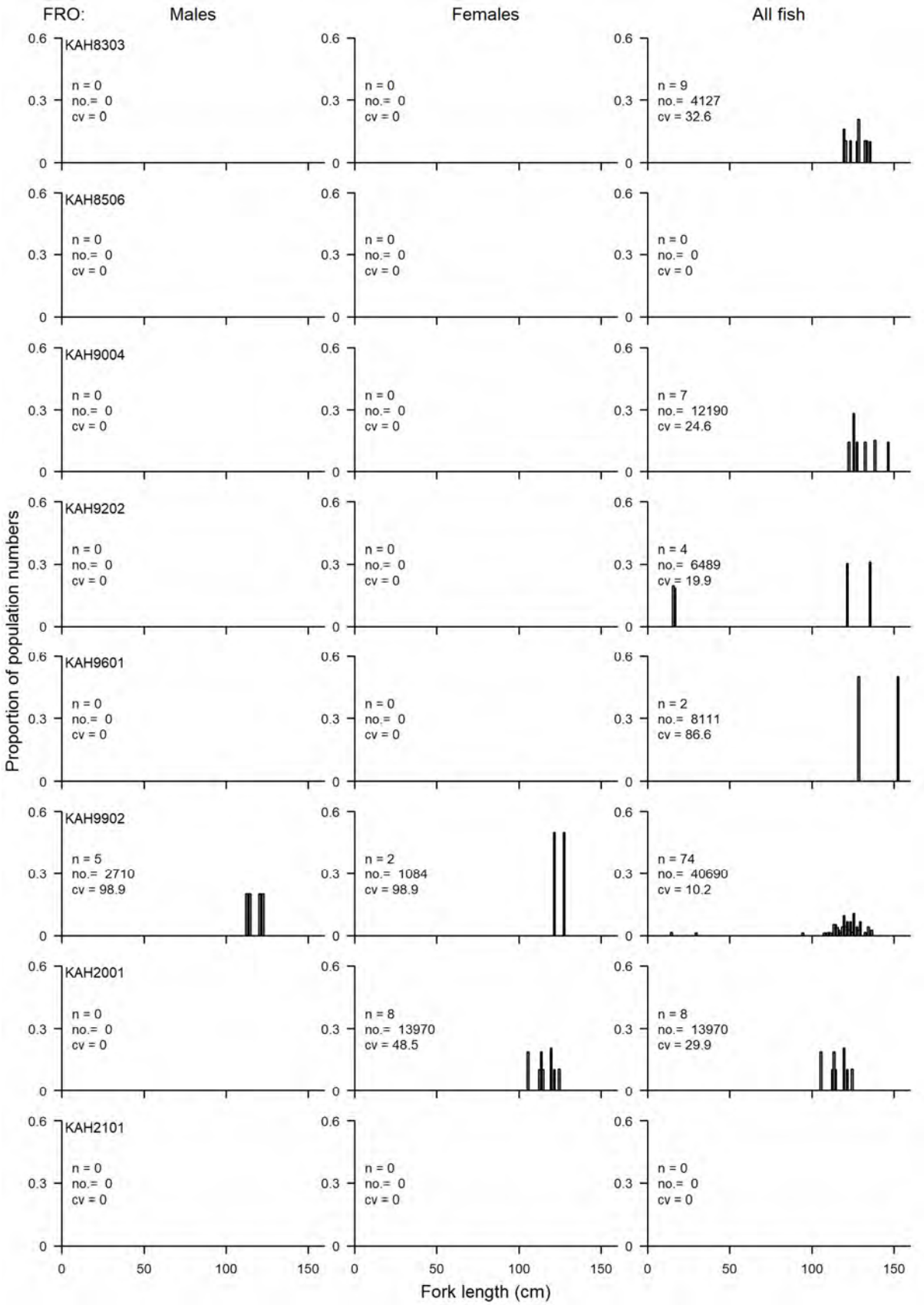


Figure 6b: Frostfish. Note that no frostfish were caught during the phase one or two component of the 2021 survey.

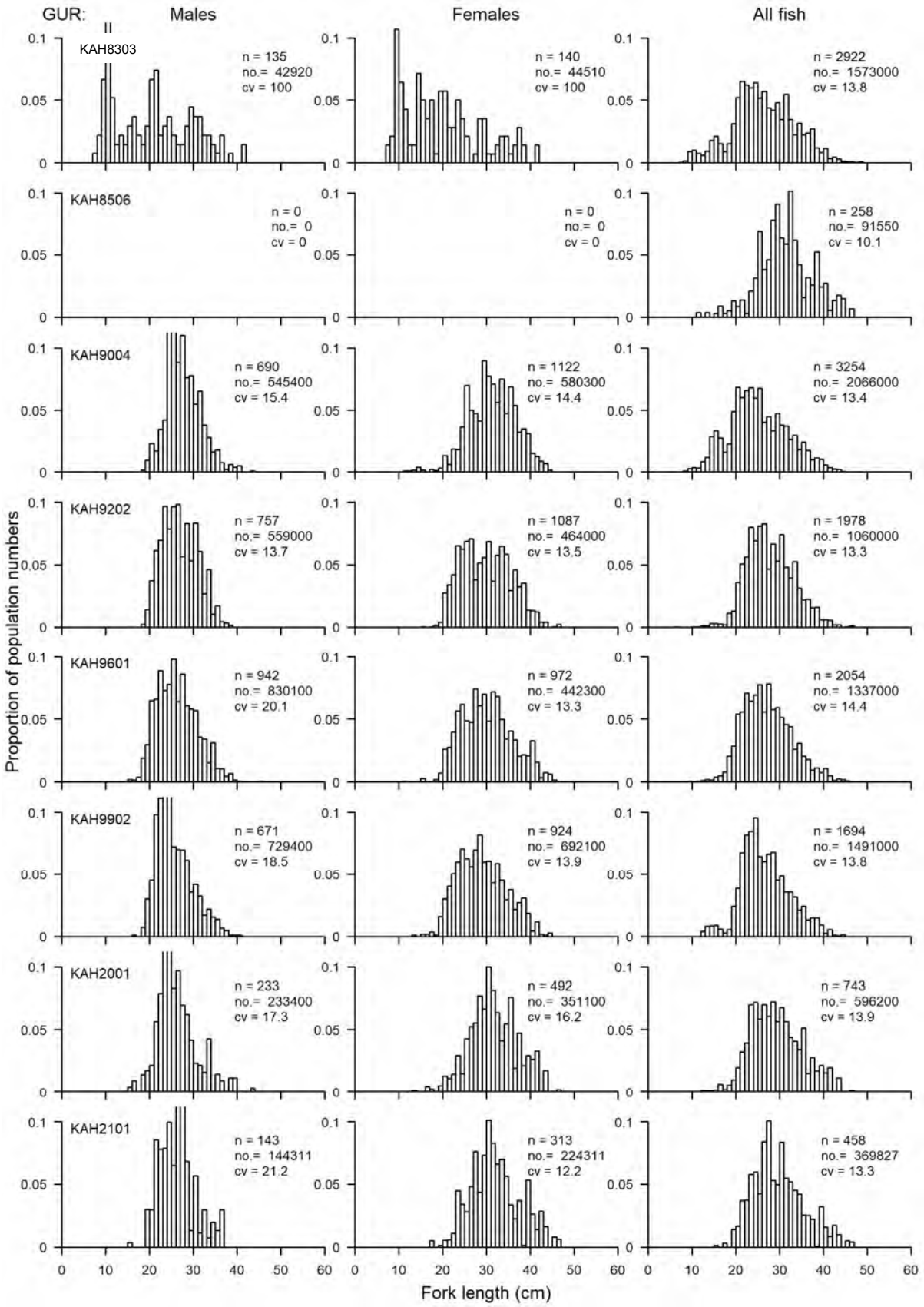


Figure 6c: Red gurnard.

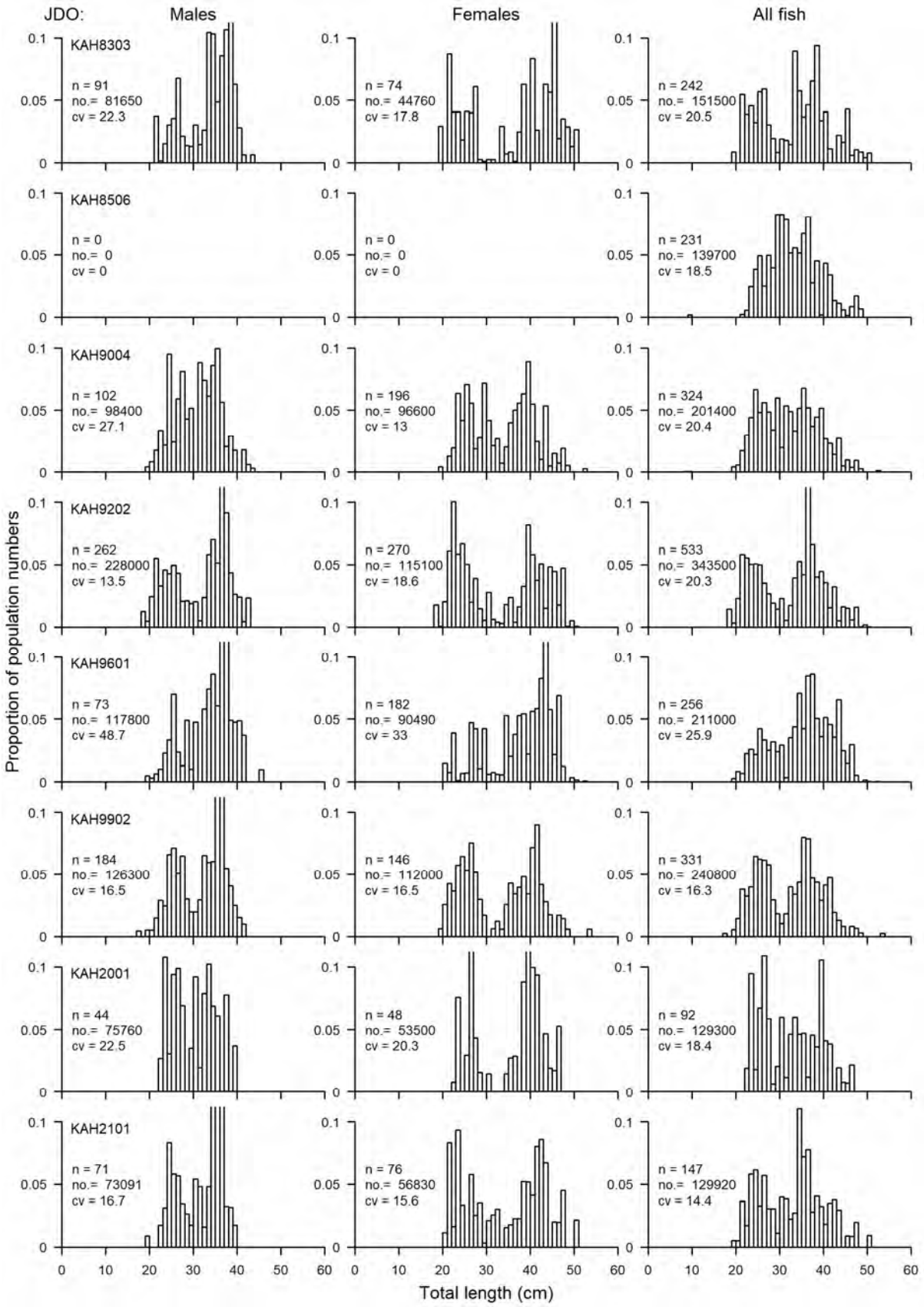


Figure 6d: John dory.

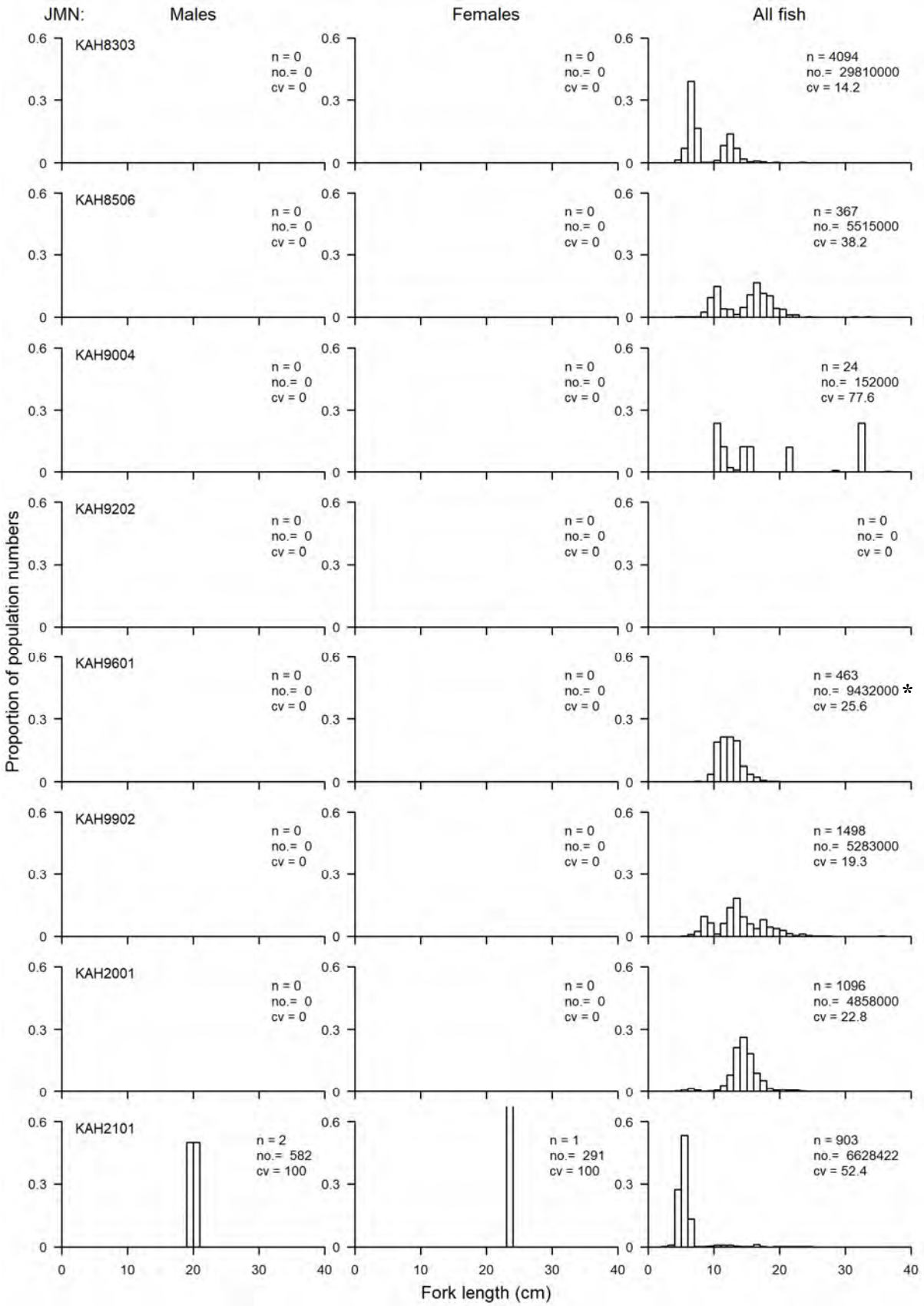


Figure 6e: Yellowtail jack mackerel. * = scaled population number inaccurate due to limited length sampling for the 1996 survey.

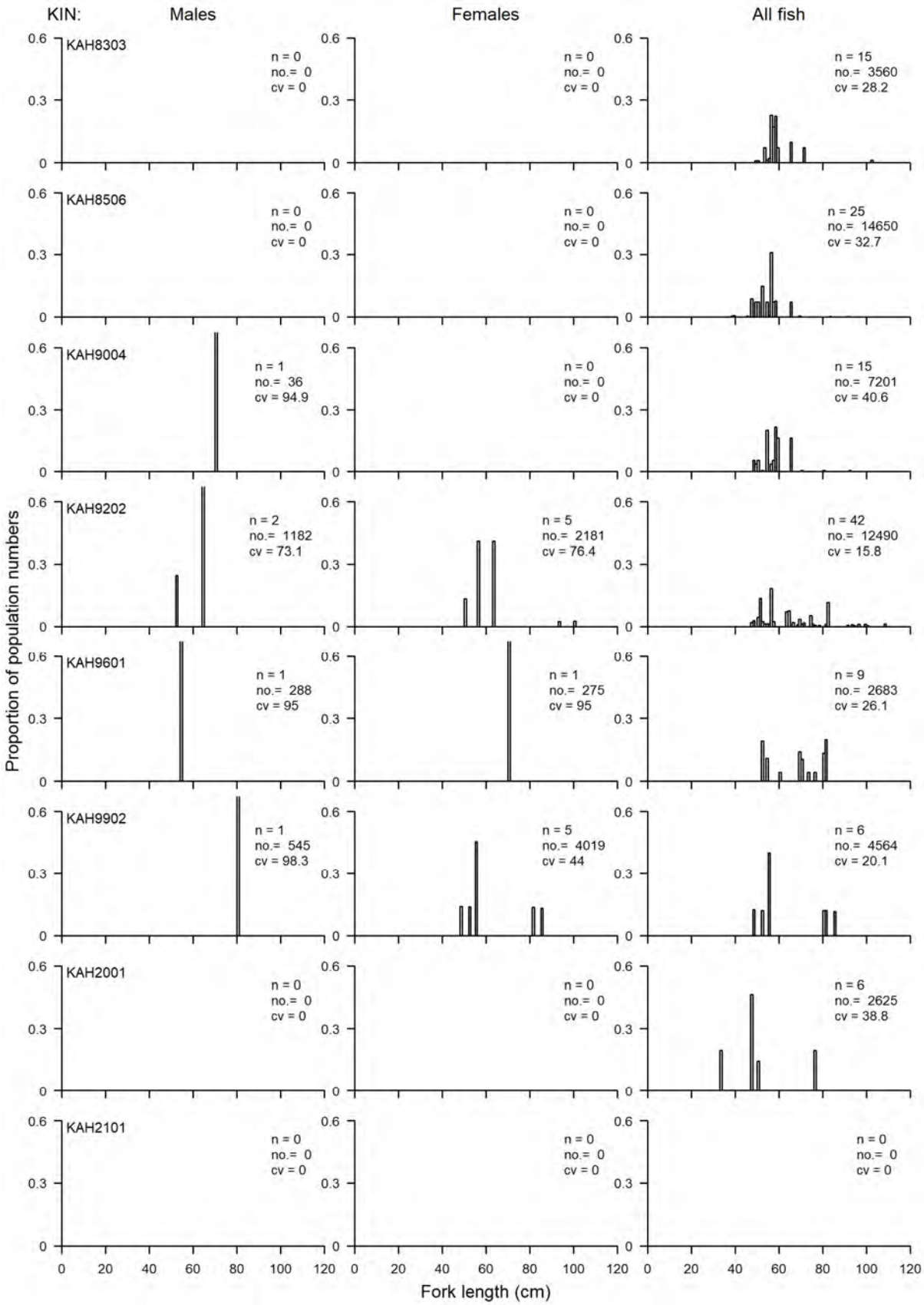


Figure 6f: Kingfish. Note that all kingfish were released alive on the 2021 survey, so no kingfish were measured.

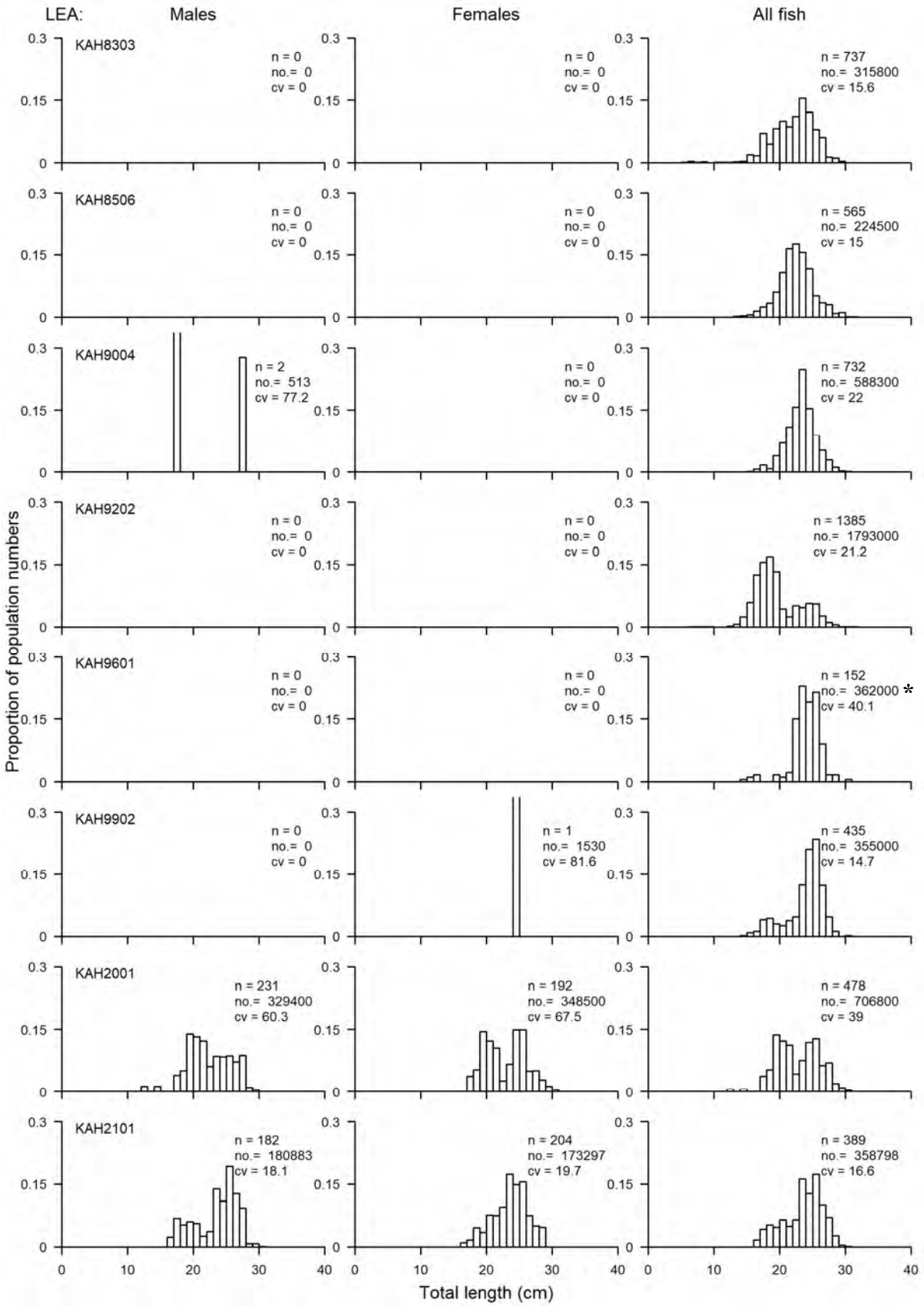


Figure 6g: Leatherjacket. * = scaled population number inaccurate due to limited length sampling for the 1996 survey.

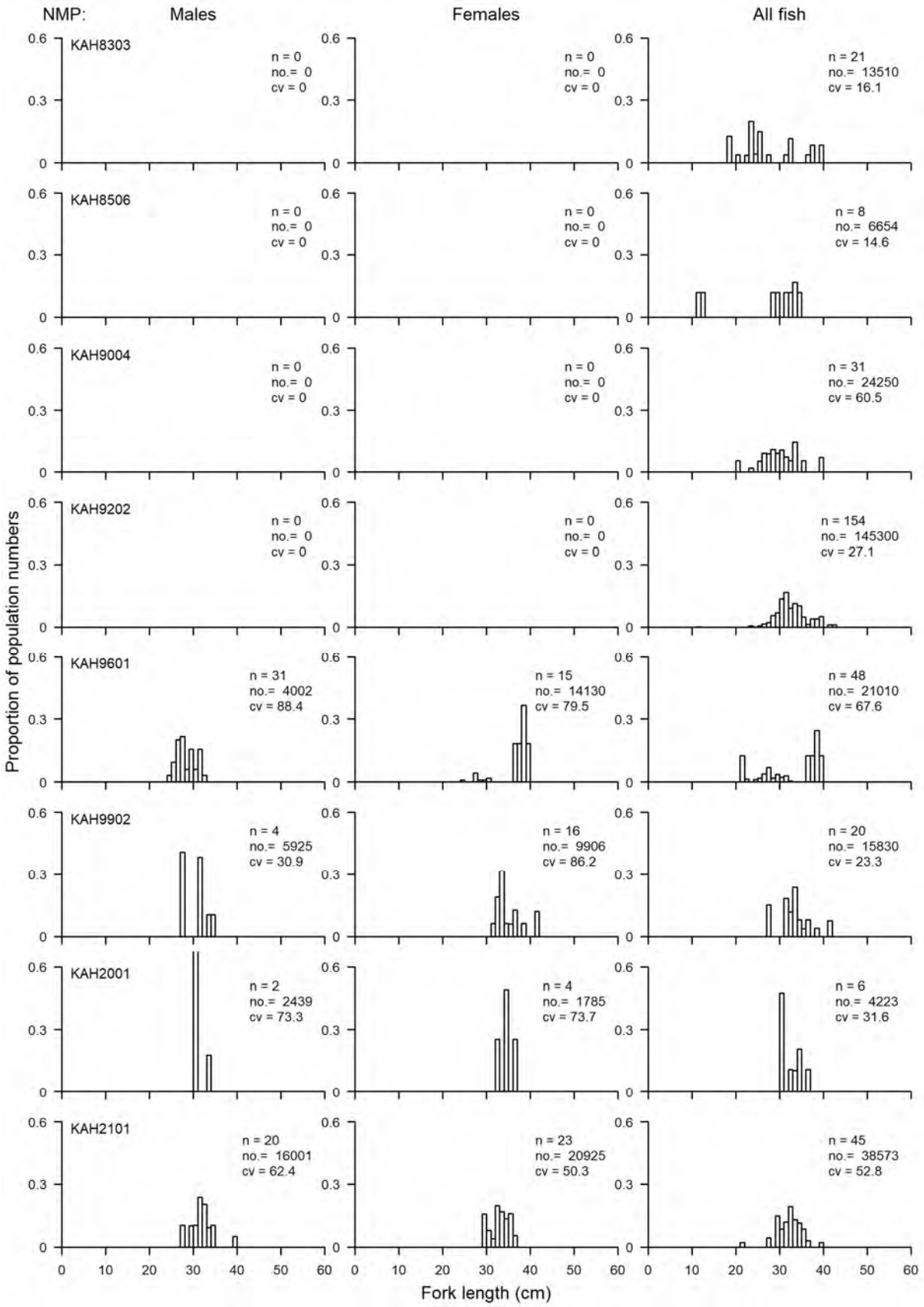


Figure 6h: Tarakihi.

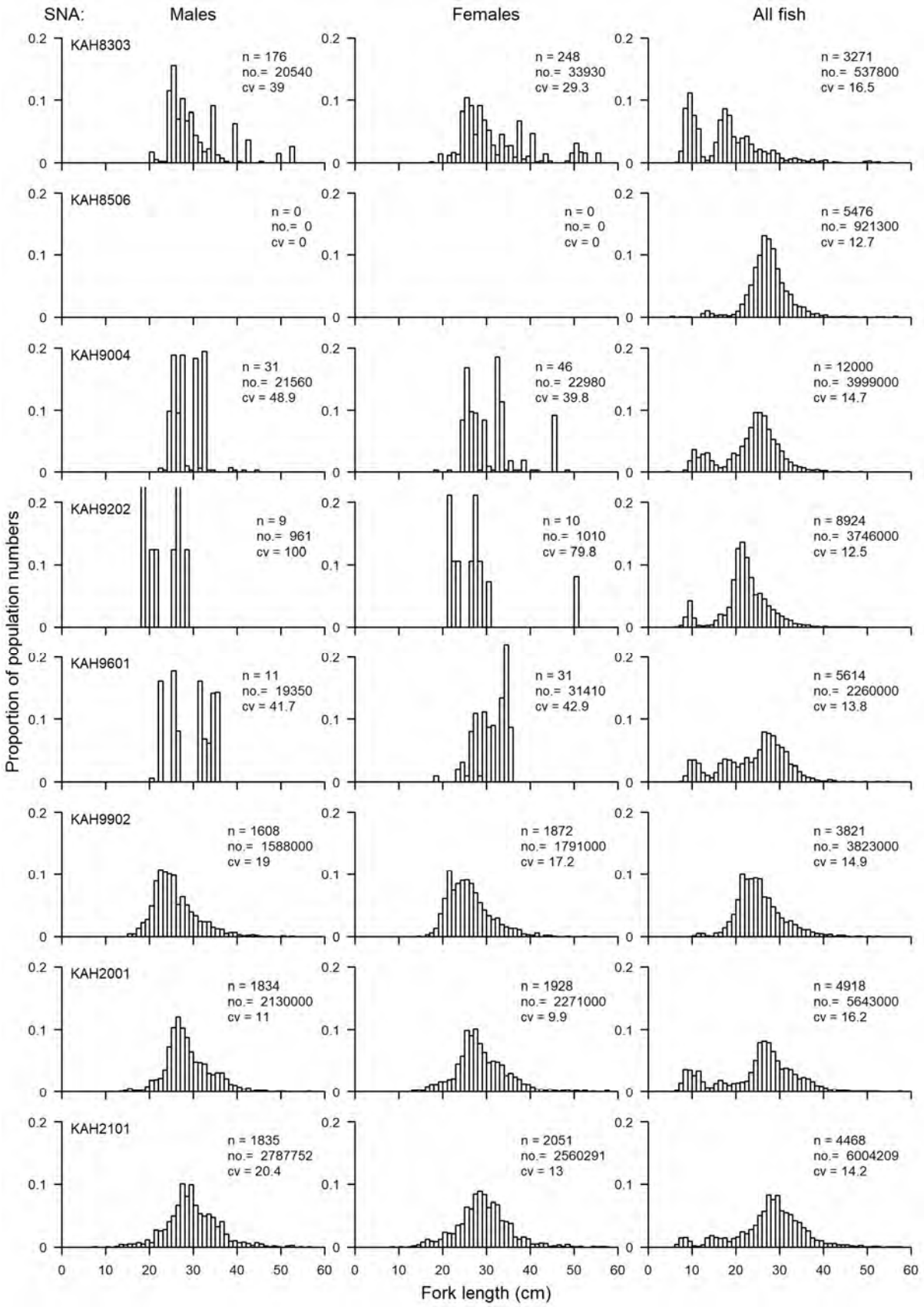


Figure 6i: Snapper.

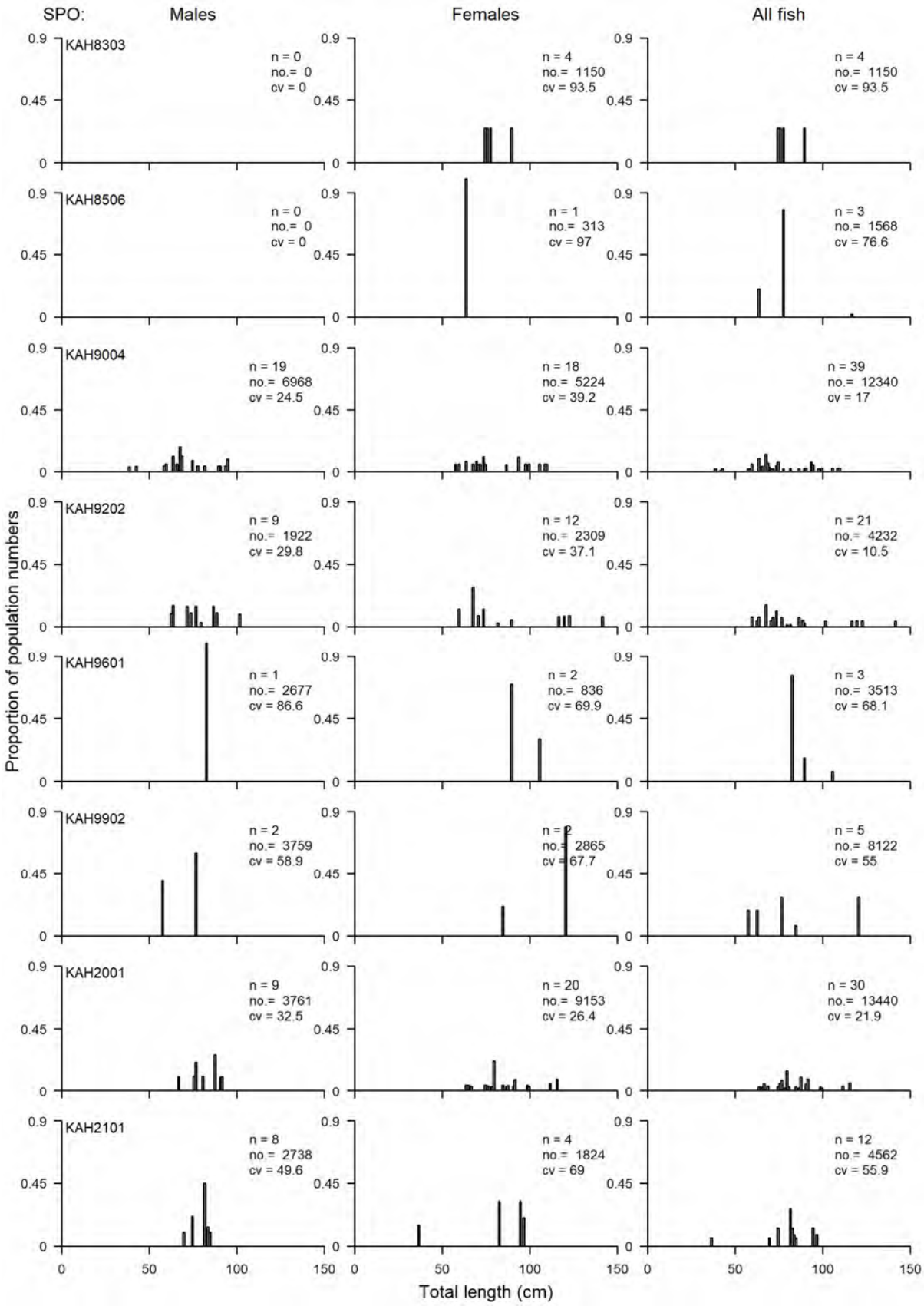


Figure 6j: Rig.

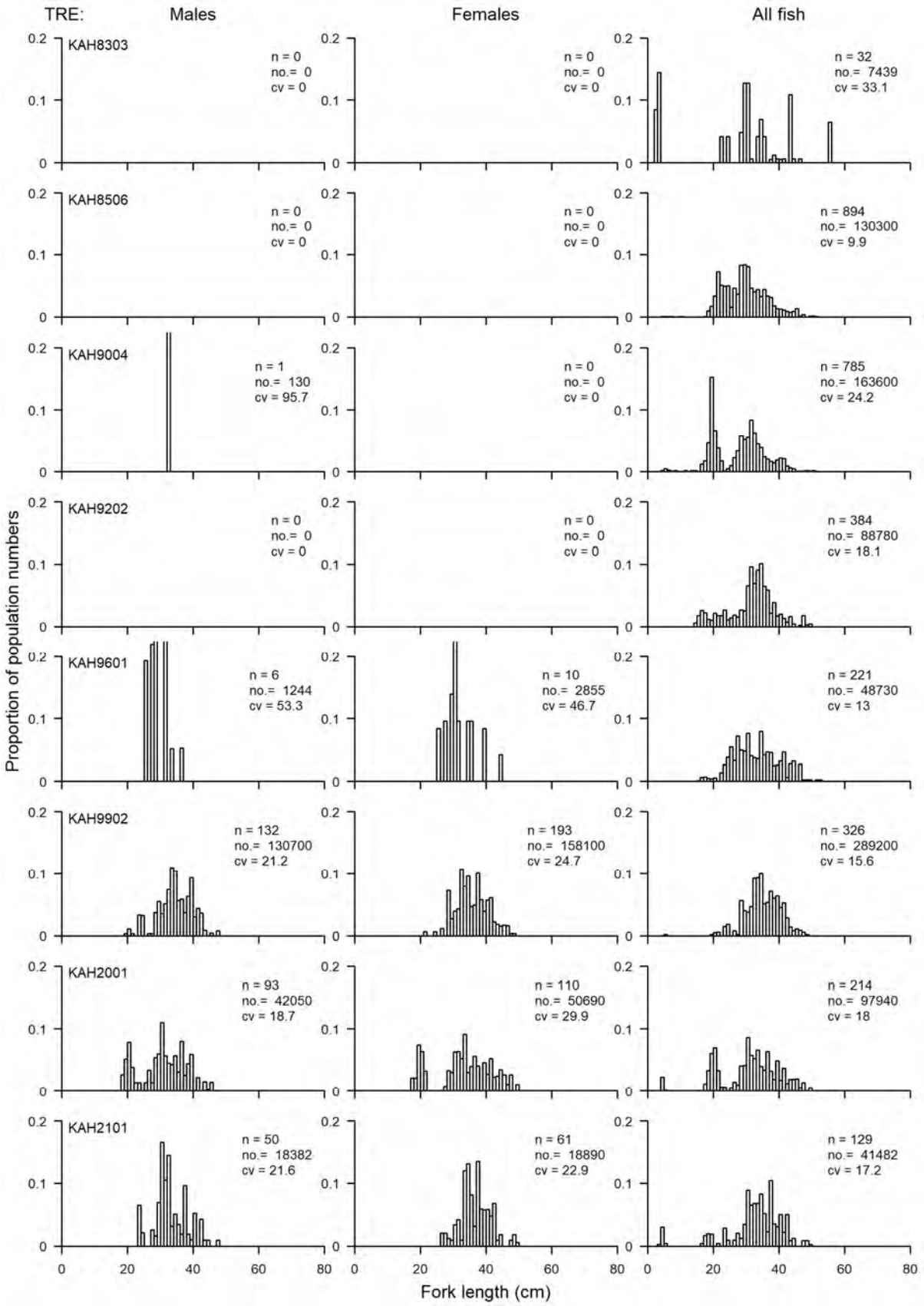


Figure 6k: Trevally.

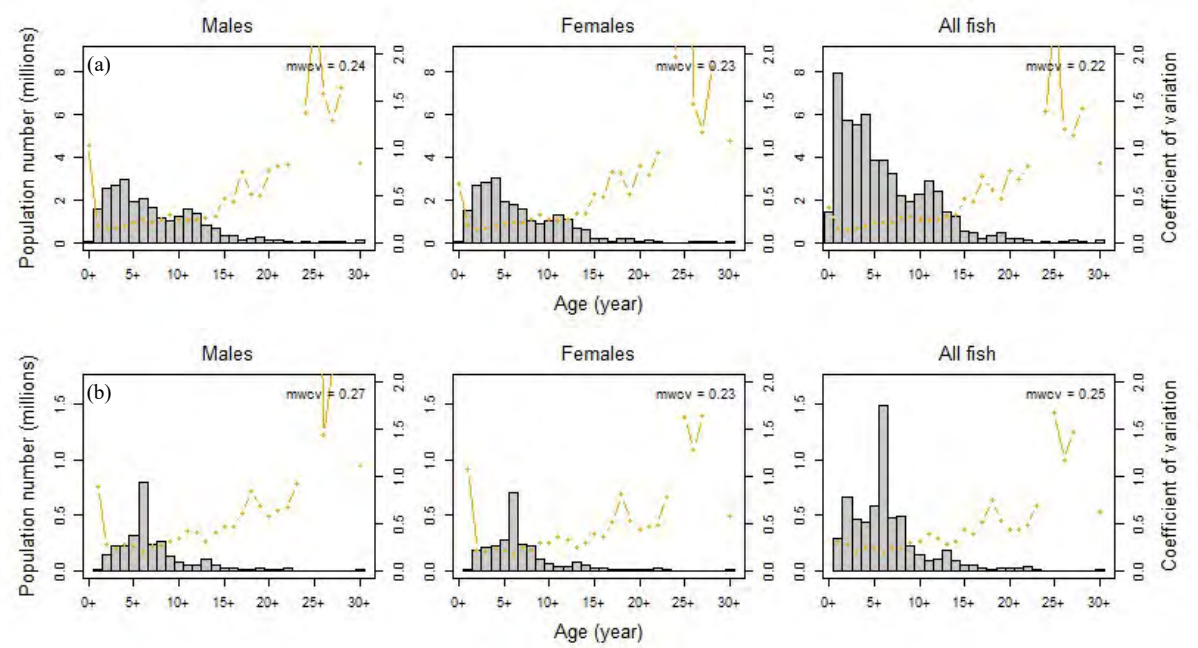


Figure 7: Proportion-at-age distributions (histogram) and CVs (line) determined from snapper caught on the (a) 2020 Hauraki Gulf and (b) 2021 Bay of Plenty surveys (mwcv = mean weighted coefficient of variation).

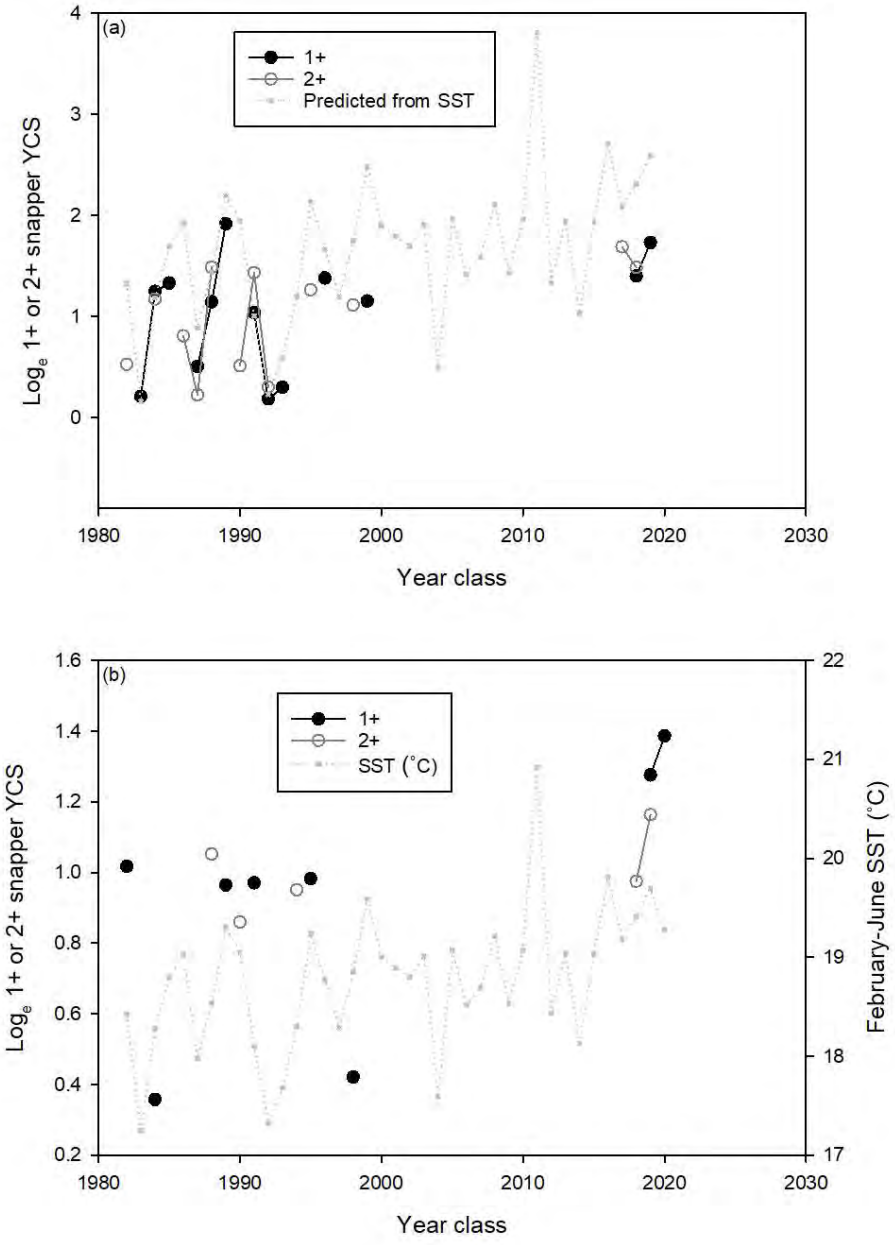


Figure 8: **Trawl survey estimates of 1+ and 2+ snapper year class strength (YCS) for the (a) Hauraki Gulf and (b) Bay of Plenty. For the Hauraki Gulf, a time series of predicted YCS based on Leigh sea surface temperature (SST) is also presented. For the Bay of Plenty, the average February-June Leigh SST is presented on a second axis.**

Appendix 1: Description of gonad staging for teleosts (middle depths method (MD)).

Research gonad stage		Males	Females
1	Immature	Testes small and translucent, threadlike or narrow membranes.	Ovaries small and translucent. No developing oocytes.
2	Resting	Testes thin and flabby; white or transparent.	Ovaries are developed, but no developing eggs are visible.
3	Ripening	Testes firm and well developed, but no milt is present.	Ovaries contain visible developing eggs, but no hyaline eggs present.
4	Ripe	Testes large, well developed; milt is present and flows when testis is cut, but not when body is squeezed.	Some or all eggs are hyaline, but eggs are not extruded when body is squeezed.
5	Running-ripe	Testis is large, well formed; milt flows easily under pressure on the body.	Eggs flow freely from the ovary when it is cut or the body is pressed.
6	Partially spent	Testis somewhat flabby and may be slightly bloodshot, but milt still flows freely under pressure on the body.	Ovary partially deflated, often bloodshot. Some hyaline and ovulated eggs present and flowing from a cut ovary or when the body is squeezed.
7	Spent	Testis is flabby and bloodshot. No milt in most of testis, but there may be some remaining near the lumen. Milt not easily expressed even when present.	Ovary bloodshot; ovary wall may appear thick and white. Some residual ovulated eggs may still remain, but will not flow when body is squeezed.

Appendix 2: Length-weight relationship parameters used to scale length frequencies and calculate length class biomass estimates.

Note that $W = aL^b$, where W is weight (g), and L is length (cm). *rdb* refers to Fisheries New Zealand research database for length-weight parameters; n = sample size. Species codes are given in Appendix 6. All units are in g and cm.

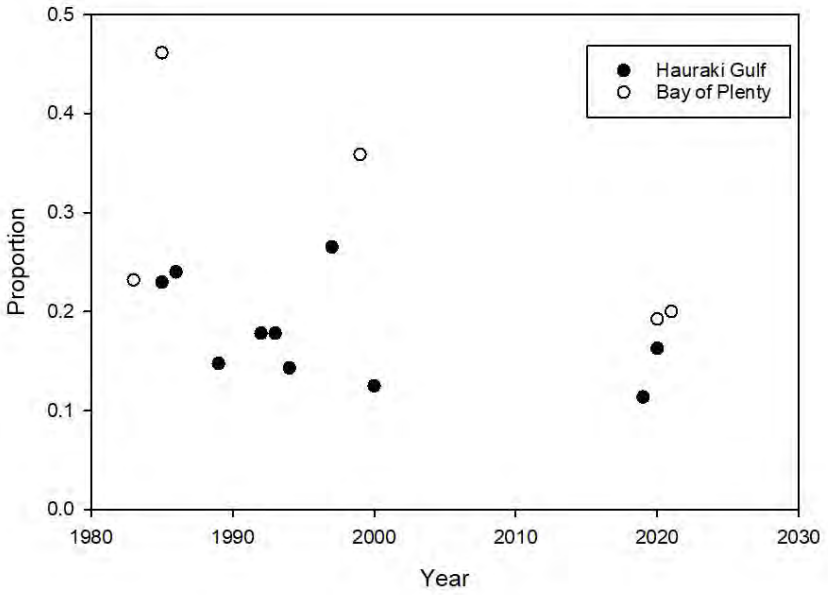
Hauraki Gulf

Species	*a*	*b*	n	Min length (cm)	Max length (cm)	Surveys parameters applied to	Data source	Area of source data
ATT	0.0236	2.8900	2 091	5.0	60.0	All surveys	Hartill & Walsh (2005)	KAH 1 & 3
GUR	0.0085	3.0451	520	11.0	42.5	KAH2006	KAH2006	Hauraki Gulf
GUR	0.0114	2.9622	418	12.5	44.5	KAH1907	KAH1907	Hauraki Gulf
GUR	0.0099	2.9924	106	15.9	39.2	KAH0012	*rdb*, KAH0012	Hauraki Gulf
GUR	0.0075	3.1032	505	11.0	47.0	All surveys prior to KAH0012	*rdb*, KAH9720	Hauraki Gulf
JDO	0.0006	3.9423	90	19.7	56.1	kah2006	KAH2006	Hauraki Gulf
JDO	0.0026	3.5431	138	15.5	51.4	KAH1907	KAH1907	Hauraki Gulf
JDO	0.0021	3.5814	227	13.5	54.6	KAH0012	*rdb*, KAH0012	Hauraki Gulf
JDO	0.0024	3.5461	352	13.0	52.0	All surveys prior to KAH0012	*rdb*, KAH9720	Hauraki Gulf
JMN	0.0275	2.7324	167	11.0	30.4	KAH2006	KAH2006	Hauraki Gulf
JMN	0.0200	2.8204	376	12.6	35.7	All surveys prior to KAH2006	KAH1907	Hauraki Gulf
LEA	0.0304	2.7357	242	16.0	31.2	kah2006	KAH2006	Hauraki Gulf
LEA	0.0216	2.9035	659	c. 60.0	c. 330.0	All surveys prior to KAH2006	Visconti et al. (2018)	Hauraki Gulf
SNA	0.0361	2.8474	916	7.5	76.1	KAH2006	KAH2006	Hauraki Gulf
SNA	0.0409	2.8084	972	7.1	82.6	KAH1907	KAH1907	Hauraki Gulf
SNA	0.0412	2.8117	1 817	7.4	57.3	KAH0012	*rdb*, KAH0012	Hauraki Gulf
SNA	0.0341	2.8744	871	9.0	76.0	All surveys prior to KAH0012	*rdb*, KAH9720	Hauraki Gulf
SPO	0.0005	3.4660	–	–	–	All surveys	Francis (1979)	SPO 3
TRE	0.0129	3.1012	104	13.8	46.5	KAH2006	KAH2006	Hauraki Gulf
TRE	0.0201	2.9837	125	16.2	55.5	All surveys prior to KAH2006	*rdb*, KAH9720	Hauraki Gulf

Bay of Plenty

Species	*a*	*b*	n	Min length (cm)	Max length (cm)	Surveys parameters applied to	Data source	Area of source data
ATT	0.0236	2.8900	2 091	5.0	60.0	All surveys	Hartill & Walsh (2005)	KAH 1 & 3
FRO	0.0004	3.1550	965	10.0	164.0	All surveys	Horn (2013)	WCSI
GUR	0.0063	3.1452	415	16.7	47.5	KAH2101	KAH2101	BPLE
GUR	0.0043	3.2514	517	14.0	47.0	KAH2001	KAH2001	BPLE
GUR	0.0038	3.2771	1 184	13.4	48.3	All surveys prior to KAH2001	*rdb*, KAH9902	BPLE
JDO	0.0063	3.2785	143	20.8	51.0	KAH2101	KAH2101	BPLE
JDO	0.0066	3.2455	352	18.4	54.3	All surveys prior to KAH2101	*rdb*, KAH9902	BPLE
JMN	0.0325	2.6963	121	8.0	35.3	KAH2101	KAH2101	BPLE
JMN	0.0200	2.8204	376	12.6	35.7	All surveys prior to KAH2101	KAH1907	HAGU
KIN	0.0365	2.7620	489	34.0	159.0	All surveys	Walsh et al. (2003)	KIN 1
LEA	0.0612	2.5980	333	17.5	30.7	KAH2101	KAH2101	BPLE
LEA	0.0216	2.9035	659	c. 6	c. 33	All surveys prior to KAH2101	Visconti et al. (2018)	Hauraki Gulf
NMP	0.0098	3.1666	155	19.2	48.0	All surveys	*rdb*, KAH9902	BPLE
SNA	0.0355	2.8515	1 246	7.5	76.0	KAH2101	KAH2101	BPLE
SNA	0.0449	2.7970	1 063	7.5	58.8	KAH2001	KAH2001	BPLE
SNA	0.0445	2.7809	1 222	12.4	62.0	All surveys prior to KAH2001	*rdb*, KAH9902	BPLE
SPO	0.0005	3.4660	–	–	–	All surveys	Francis (1979)	SPO 3
TRE	0.0291	2.8861	180	5.4	48.8	All surveys	KAH2001	BPLE

Appendix 3: Proportion of phase two stations included in the Hauraki Gulf and Bay of Plenty survey time series. Note that these data were not recorded for some surveys and those data are therefore not included here.



Appendix 4: Station details

'#' = not suitable for biomass calculation.

Hauraki Gulf

				Start of tow		End of tow		Gear depth (m)		Distance trawled	Headline height	Doorspread	Surface temp	Bottom temp	Warp length
Station	Stratum	Date	Time	° ' S	° ' E	° ' S	° ' E	Min.	Max.	(n.mile)	(m)	(m)	˚C	˚C	(m)
1	1219	20/11/2020	1601	36 36.74	175 14.55	36 36.45	175 15.24	41	42	0.62	5.2	78.4	19.2	16.8	200
2	COLV	21/11/2020	531	36 38.36	175 39.86	36 37.82	175 39.27	43	46	0.71	5.5	78.7	17.4	15.4	200
3	COLV	21/11/2020	700	36 32.36	175 34.70	36 31.94	175 33.36	49	51	0.70	5.7	79.1	17.0	15.8	200
4#	COLV	21/11/2020	841	36 25.87	175 38.44	36 26.13	175 38.66	64	68	0.31	4.7	69.3	17.9	15.2	250
5	COLV	21/11/2020	1015	36 26.46	175 28.60	36 25.96	175 27.45	54	54	0.70	5.9	77.6	18.2	15.7	200
6	LITB	21/11/2020	1158	36 17.40	175 20.91	36 17.20	175 20.40	45	48	0.70	5.3	79.2	18.4	16.1	200
7	LITB	21/11/2020	1347	36 22.47	175 09.15	36 23.70	175 08.72	50	51	0.69	4.9	75.5	18.6	15.3	200
8	LITB	21/11/2020	1509	36 22.96	175 06.43	36 22.39	175 05.93	51	51	0.69	5.4	79.9	18.8	15.4	200
9	LITB	22/11/2020	526	36 19.86	175 02.57	36 20.41	175 03.90	47	47	0.69	5.3	78.6	18.6	15.5	200
10	1219	22/11/2020	659	36 21.91	174 53.60	36 21.22	174 53.50	48	48	0.69	5.0	77.8	18.7	15.1	200
11	1219	22/11/2020	813	36 19.38	174 53.53	36 18.70	174 53.11	48	49	0.75	4.9	76.9	18.7	15.0	200
12	LITB	22/11/2020	929	36 14.11	174 49.00	36 13.49	174 49.32	50	52	0.67	5.0	77.4	18.6	15.0	200
13	1449	22/11/2020	1124	36 09.47	174 42.59	36 08.82	174 42.93	46	49	0.70	5.1	77.0	18.5	15.0	200
14	1449	22/11/2020	1225	36 07.96	174 39.37	36 07.26	174 39.17	32	34	0.71	5.5	74.4	18.2	16.7	200
15	1449	22/11/2020	1313	36 05.61	174 39.30	36 04.93	174 39.44	45	47	0.68	5.2	76.8	18.2	15.1	200
16	1887	23/11/2020	533	37 02.49	175 24.72	37 02.00	175 24.52	10	11	0.51	5.7	75.4	18.3	18.3	200
17	1887	23/11/2020	730	37 01.38	175 25.70	37 00.85	175 25.52	10	11	0.54	5.1	75.4	18.5	18.2	200
18	1887	23/11/2020	908	37 01.24	175 23.69	37 00.73	175 23.48	13	15	0.53	5.0	70.4	18.6	18.0	200
19	1887	23/11/2020	1121	37 00.41	175 19.25	36 59.89	175 18.99	14	15	0.55	4.8	71.8	18.5	18.0	200
20	1268	23/11/2020	1256	36 54.46	175 21.56	36 54.60	175 21.90	27	28	0.54	5.8	65.9	18.5	16.3	200
21	1268	23/11/2020	1407	36 48.65	175 17.20	36 48.12	175 16.44	37	39	0.70	5.4	76.0	18.5	16.0	200
22	1386	26/11/2020	1318	36 42.10	174 52.00	36 41.61	174 52.46	23	24	0.54	5.3	69.9	18.6	18.4	200
23	1386	26/11/2020	1454	36 41.79	174 54.50	36 42.29	174 53.58	25	25	0.62	5.3	69.8	18.6	17.4	200

Station	Stratum	Date	Time	Start of tow ° ' S	Start of tow ° ' E	End of tow ° ' S	End of tow ° ' E	Gear depth (m) Min.	Gear depth (m) Max.	Distance trawled (n.mile)	Headline height (m)	Doorspread (m)	Surface temp ˚C	Bottom temp ˚C	Warp length (m)
24	1386	26/11/2020	1625	36 42.10	174 46.68	36 42.56	174 46.79	14	14	0.55	5.1	69.8	18.8	18.5	200
25	1284	27/11/2020	542	36 34.75	174 43.66	36 34.29	174 43.99	11	12	0.53	5.2	73.2	19.0	18.7	200
26	1284	27/11/2020	654	36 35.16	174 47.33	36 34.66	174 47.62	16	18	0.55	5.2	74.4	18.6	17.9	200
27	1284	27/11/2020	817	36 33.45	174 47.96	36 32.93	174 48.16	20	21	0.54	5.4	75.5	18.9	17.4	200
28	2229	27/11/2020	932	36 28.84	174 49.59	36 28.32	174 49.93	26	27	0.58	5.2	78.4	19.0	16.4	200
29	1149	27/11/2020	1320	36 44.10	174 59.60	36 43.67	174 59.66	17	18	0.58	5.4	68.8	18.6	17.8	200
30	1149	27/11/2020	1414	36 45.43	175 01.33	36 45.57	175 02.21	21	22	0.71	5.2	71.3	18.3	16.0	200
31	1149	27/11/2020	1546	36 45.71	175 03.90	36 46.20	175 04.44	21	24	0.53	5.1	76.8	18.2	16.0	200
32	2229	28/11/2020	552	36 43.56	175 12.79	36 43.15	175 13.15	39	41	0.50	4.7	79.8	18.0	16.3	200
33	2229	28/11/2020	701	36 43.47	175 17.61	36 42.79	175 17.81	39	41	0.72	5.1	78.6	18.3	16.4	200
34	1268	28/11/2020	832	36 47.30	175 17.42	36 46.48	175 17.96	33	35	0.69	5.3	78.6	18.1	16.6	200
35	9292	28/11/2020	1002	36 39.40	175 23.63	36 38.71	175 23.40	18	21	0.71	5.6	71.5	18.3	18.1	200
36	9292	28/11/2020	1137	36 39.14	175 24.86	36 38.43	175 24.79	13	13	0.71	5.9	69.3	18.3	18.3	200
37	9292	28/11/2020	1301	36 37.95	175 23.85	36 37.27	175 23.59	16	17	0.71	5.2	72.4	18.5	18.3	200
38	2229	28/11/2020	1512	36 40.17	175 12.59	36 39.83	175 13.60	39	40	0.50	5.5	77.4	18.5	15.8	200
39	1219	29/11/2020	527	36 19.96	174 54.50	36 20.64	174 54.76	50	50	0.71	5.2	79.1	18.3	15.0	200
40	2229	29/11/2020	721	36 32.94	174 53.90	36 33.45	174 53.31	34	35	0.53	5.2	70.7	18.4	15.8	200
41	1219	1/12/2020	946	36 36.89	175 08.26	36 36.49	175 08.67	44	45	0.51	5.1	81.2	18.0	15.6	200
42	2229	1/12/2020	1125	36 41.77	175 08.41	36 41.14	175 08.78	35	37	0.69	5.5	73.3	17.5	15.7	200
43	2229	1/12/2020	1256	36 45.18	175 04.85	36 44.84	175 05.33	25	27	0.51	5.2	74.9	17.7	16.5	200
44	2229	1/12/2020	1357	36 44.75	175 03.45	36 44.31	175 04.14	25	27	0.70	4.8	73.0	17.7	16.3	200

Bay of Plenty

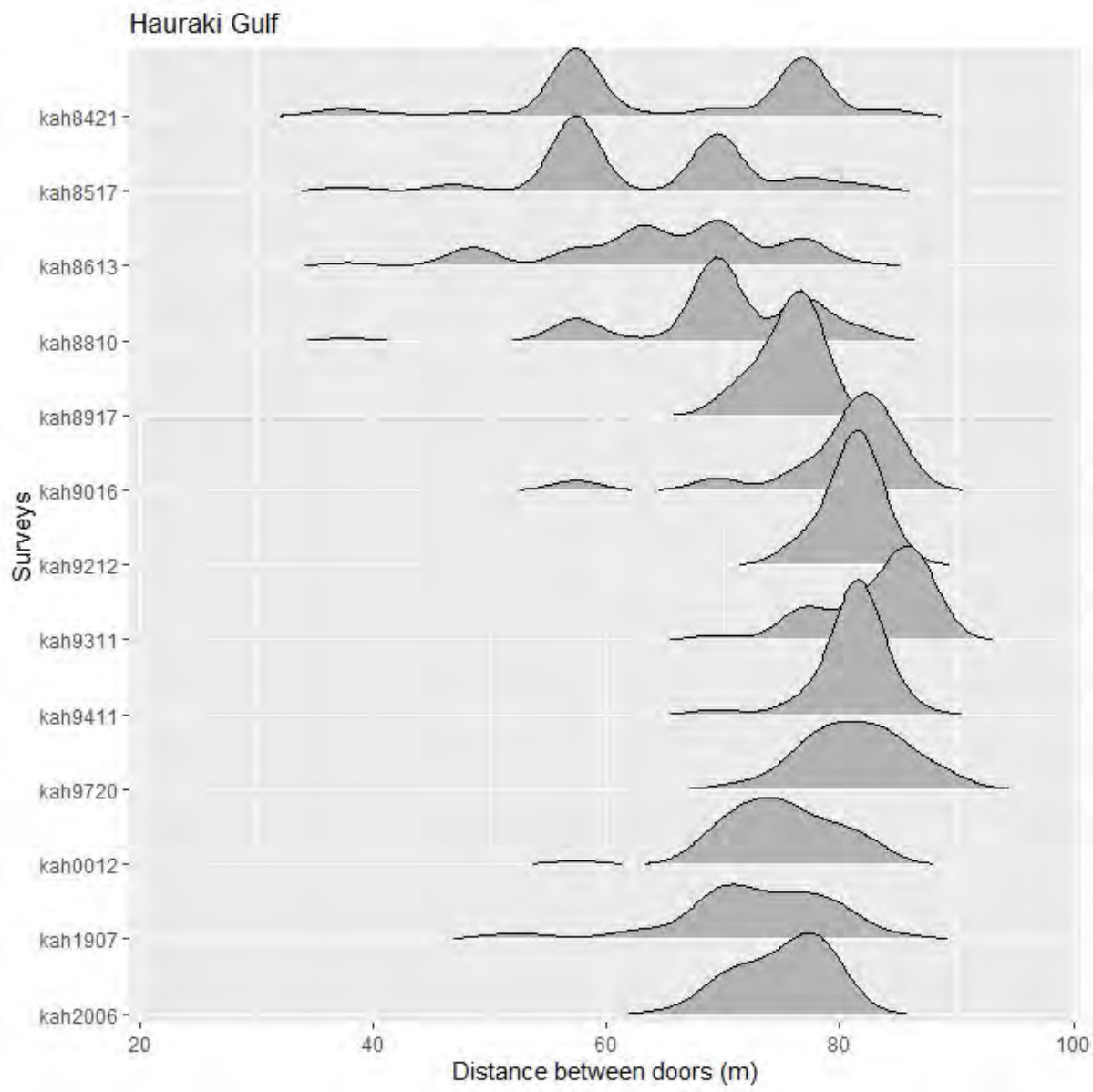
Station	Stratum	Date	Time	Start of tow ° ' S	Start of tow ° ' E	End of tow ° ' S	End of tow ° ' E	Gear depth (m) Min.	Gear depth (m) Max.	Distance trawled (n.mile)	Headline height (m)	Doorspread (m)	Surface temp ˚C	Bottom temp ˚C	Warp length (m)
1	5287	1/02/2021	1431	37 28.11	176 04.55	37 27.53	176 04.50	25	26	0.70	5.6	73.9	19.5	19.3	200
2	2096	1/02/2021	1601	37 29.98	176 03.40	37 29.37	176 02.95	17	18	0.70	6.0	69.5	19.7	19.6	200
3	708N	2/02/2021	616	36 42.70	175 58.11	36 42.69	175 57.69	84	86	0.70	5.2	76.4	20.6	19.2	275
4	708N	2/02/2021	800	36 50.82	175 52.70	36 51.50	175 52.33	61	61	0.71	5.1	82.1	20.5	18.0	250
5	708N	2/02/2021	927	36 53.88	175 55.97	36 54.55	175 56.27	73	74	0.71	5.0	81.6	NA	NA	275
6	708N	2/02/2021	1109	36 55.38	175 58.80	36 55.93	175 58.65	73	74	0.71	5.3	78.7	NA	NA	275
7	708N	2/02/2021	1215	36 57.44	176 01.34	36 56.80	176 00.98	63	67	0.70	5.7	82.2	NA	NA	250
8	32NH	2/02/2021	1409	37 02.65	175 53.99	37 01.97	175 53.88	14	15	0.68	6.5	70.7	NA	NA	200
9	32NH	2/02/2021	1536	37 05.39	175 54.29	37 04.73	175 54.55	20	21	0.69	6.0	69.6	NA	NA	200
10	32NH	3/02/2021	541	37 05.34	175 53.92	37 06.50	175 53.94	14	15	0.71	5.7	77.2	NA	NA	200
11#	5287	3/02/2021	645	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	200
12	5287	3/02/2021	740	37 11.85	175 55.72	37 11.15	175 55.79	37	39	0.70	5.4	77.5	NA	NA	200
13	708N	3/02/2021	840	37 10.15	175 59.00	37 09.45	175 59.30	54	56	0.70	5.2	83.3	NA	NA	250
14#	708N	3/02/2021	931	37 09.78	176 00.30	NA	NA	66	67	NA	5.0	79.8	NA	NA	250
15	708N	3/02/2021	1119	37 08.91	175 59.81	37 08.14	175 59.78	63	67	0.77	5.0	82.2	NA	NA	250
16	708N	3/02/2021	1317	37 14.97	176 07.70	37 14.34	176 06.71	92	93	0.69	5.0	84.2	NA	NA	275
17	5287	3/02/2021	1445	37 18.15	176 00.59	37 17.56	176 00.13	45	49	0.69	5.6	77.8	NA	NA	200
18	2096	4/02/2021	535	37 25.24	175 58.90	37 25.69	175 59.25	13	13	0.52	5.7	70.5	NA	NA	200
19	708S	4/02/2021	730	37 24.69	176 12.33	37 24.16	176 11.74	62	64	0.70	5.1	82.4	NA	NA	250
20	708S	4/02/2021	845	37 23.61	176 15.82	37 23.18	176 15.12	82	82	0.70	5.3	81.1	NA	NA	275
21#	708S	4/02/2021	1115	37 31.92	176 22.16	37 31.29	176 22.10	69	72	0.63	5.6	87.4	NA	NA	250
22	518M	5/02/2021	541	37 34.50	176 17.50	37 33.57	176 16.41	46	48	0.69	5.7	74.1	20.2	18.2	200
23	2096	5/02/2021	712	37 39.95	176 15.34	37 39.49	176 14.68	17	19	0.69	5.9	70.7	20.5	20.1	200
24	518M	5/02/2021	1119	37 47.40	176 45.94	37 47.42	176 45.50	44	45	0.70	6.0	71.3	20.0	18.8	200
25	518M	5/02/2021	1305	37 47.46	176 43.63	37 47.16	176 42.82	44	45	0.70	6.2	75.0	20.1	18.6	200

Station	Stratum	Date	Time	Start of tow ° ' S	Start of tow ° ' E	End of tow ° ' S	End of tow ° ' E	Gear depth (m) Min.	Gear depth (m) Max.	Distance trawled (n.mile)	Headline height (m)	Doorspread (m)	Surface temp ˚C	Bottom temp ˚C	Warp length (m)
26	708S	5/02/2021	1520	37 44.79	176 55.68	37 44.46	176 54.90	81	82	0.69	6.0	73.7	20.1	16.6	275
27	1096	6/02/2021	537	37 56.73	177 03.54	37 56.39	177 03.70	16	18	0.50	5.9	72.0	20.1	20.1	200
28	408M	6/02/2021	639	37 53.26	177 02.78	37 53.62	177 03.24	34	34	0.51	5.6	78.0	20.6	20.5	200
29	408M	6/02/2021	737	37 54.27	177 07.11	37 54.33	177 07.99	37	38	0.69	5.8	78.9	20.6	19.7	200
30	408M	6/02/2021	902	37 52.50	177 15.31	37 52.49	177 14.41	46	47	0.71	5.8	76.9	20.2	19.1	200
31	408M	6/02/2021	1018	37 52.85	177 13.89	37 52.87	177 13.00	45	47	0.70	5.7	77.0	20.3	19.0	200
32	408M	6/02/2021	1158	37 55.14	177 12.40	37 55.12	177 13.29	35	36	0.70	5.9	76.8	20.3	19.1	200
33	1096	6/02/2021	1314	37 57.30	177 16.22	37 57.28	177 17.12	24	25	0.70	5.4	74.4	20.1	19.3	200
34	1096	6/02/2021	1436	37 56.63	177 20.55	37 56.20	177 21.25	22	23	0.69	5.8	70.9	19.6	19.6	200
35	1096	6/02/2021	1547	37 57.86	177 22.60	37 57.66	177 22.91	16	16	0.69	5.9	67.6	19.4	19.3	200
36	1096	7/02/2021	538	37 37.89	177 50.47	37 37.49	177 51.20	21	24	0.70	6.0	70.8	20.4	20.3	200
37	408M	7/02/2021	702	37 36.83	177 50.46	37 37.24	177 49.73	38	42	0.70	6.0	77.7	20.6	19.8	200
38	6085	7/02/2021	808	37 37.39	177 48.40	37 37.82	177 47.34	66	70	0.70	6.2	76.4	20.6	18.5	250
39	6085	7/02/2021	942	37 43.65	177 37.81	37 44.30	177 37.60	55	56	0.70	5.9	84.3	20.3	19.5	250
40	408M	7/02/2021	1123	37 45.92	177 37.62	37 46.37	177 36.94	39	39	0.70	5.5	77.0	20.4	19.8	200
41	408M	7/02/2021	1304	37 52.20	177 26.73	37 52.67	177 26.50	30	31	0.71	6.0	79.1	20.2	19.0	200
42	408M	7/02/2021	1431	37 50.44	177 23.69	37 50.88	177 22.98	47	47	0.71	6.3	80.1	21.0	18.9	200
43	6085	7/02/2021	1545	37 49.47	177 19.19	37 49.93	177 18.52	62	63	0.70	5.8	85.4	20.3	18.7	250
44	6085	8/02/2021	537	37 44.13	177 36.90	37 44.40	177 36.80	55	55	0.70	5.3	83.5	20.7	19.8	250
45	1096	8/02/2021	712	37 51.61	177 32.87	37 51.96	177 32.40	18	19	0.51	5.2	75.6	19.8	19.2	200
46	1096	8/02/2021	817	37 53.93	177 29.87	37 54.32	177 29.13	19	19	0.70	5.3	74.9	19.5	19.1	200
47	1096	8/02/2021	947	37 53.90	177 26.54	37 54.10	177 25.68	23	24	0.70	5.2	75.1	20.2	19.4	200
48	1096	8/02/2021	1115	37 56.30	177 24.40	37 56.21	177 23.44	20	20	0.50	5.7	73.1	19.6	19.1	200
49	1096	8/02/2021	1343	37 56.88	177 05.40	37 56.56	177 04.24	20	22	0.70	5.8	72.6	20.3	19.9	200
50	6085	8/02/2021	1508	37 50.73	177 01.48	37 50.42	177 00.67	60	62	0.71	5.5	82.9	20.3	18.9	250
51	1096	9/02/2021	647	37 51.73	176 51.58	37 51.92	176 50.71	18	20	0.71	5.9	72.2	20.5	20.0	200

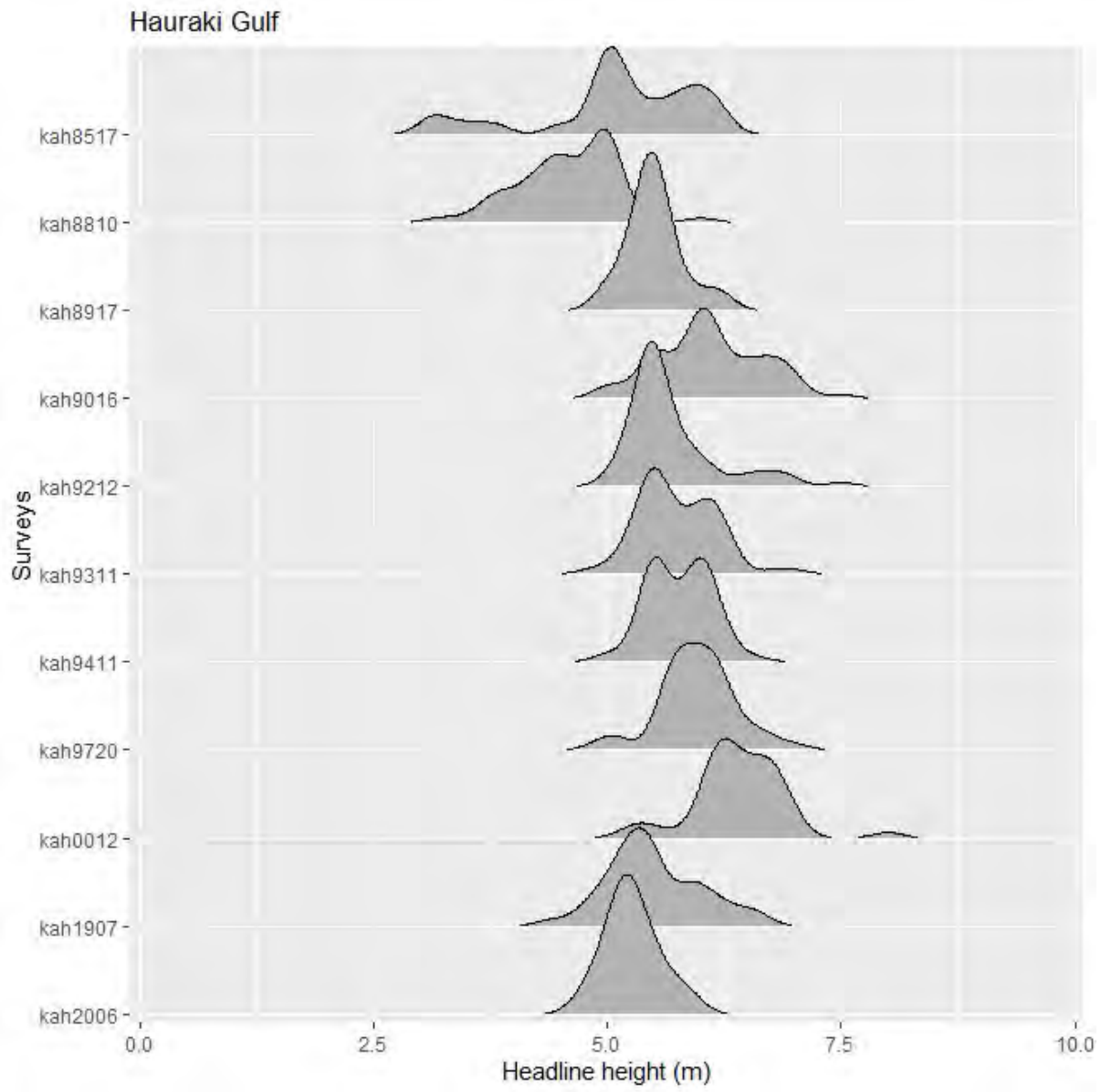
Station	Stratum	Date	Time	Start of tow ° ' S	Start of tow ° ' E	End of tow ° ' S	End of tow ° ' E	Gear depth (m) Min.	Gear depth (m) Max.	Distance trawled (n.mile)	Headline height (m)	Doorspread (m)	Surface temp ˚C	Bottom temp ˚C	Warp length (m)
52	1096	9/02/2021	810	37 53.35	176 51.49	37 53.17	176 50.89	19	19	0.50	5.9	74.9	20.5	20.1	200
53	2096	9/02/2021	1211	37 41.28	176 18.36	37 41.78	176 18.97	17	20	0.69	5.9	77.7	20.8	20.6	200
54	6085	12/02/2021	548	37 43.58	177 28.22	37 43.80	177 27.37	90	90	0.70	6.2	71.0	21.2	15.4	275
55	6085	12/02/2021	753	37 49.21	177 17.39	37 49.13	177 18.27	65	66	0.69	5.4	85.1	20.8	18.5	250
56	6085	12/02/2021	947	37 45.45	177 07.75	37 45.63	177 08.60	84	85	0.69	6.1	77.8	20.6	17.3	275
57	6085	12/02/2021	1046	37 46.72	177 07.71	37 46.86	177 08.57	73	74	0.69	6.0	80.5	20.6	18.2	275
58	708S	12/02/2021	1231	37 47.65	176 56.95	37 47.27	176 56.20	61	62	0.70	5.6	81.8	20.7	15.4	250
59	708S	12/02/2021	1400	37 41.96	176 54.89	37 42.42	176 55.57	94	96	0.70	5.6	76.3	20.5	15.5	275
60	708S	12/02/2021	1626	37 40.50	176 38.98	37 40.97	176 39.63	80	81	0.69	5.1	79.7	20.3	15.8	275
61	2096	13/02/2021	532	37 30.77	176 03.82	37 31.37	176 04.28	17	18	0.70	6.1	70.2	20.5	20.0	200
62	708S	13/02/2021	707	37 26.23	176 11.70	37 26.87	176 11.42	54	54	0.69	6.2	81.1	20.8	18.0	250
63	708S	13/02/2021	818	37 30.85	176 15.83	37 31.49	176 16.20	54	54	0.70	5.7	81.4	20.6	18.4	250
64	2096	13/02/2021	1001	37 38.86	176 13.51	37 38.44	176 12.88	19	20	0.65	5.9	71.7	20.6	19.3	200
65	2096	13/02/2021	1146	37 40.38	176 16.30	37 40.73	176 17.70	16	20	0.70	6.0	69.9	20.5	19.3	200
66	2096	13/02/2021	1319	37 42.71	176 24.20	37 43.11	176 24.75	16	17	0.70	5.9	68.8	20.2	19.6	200
67	2096	13/02/2021	1420	37 42.11	176 25.21	37 42.31	176 26.60	21	22	0.70	5.8	72.1	20.4	19.6	200

Appendix 5: Density distribution of doorspread and headline height for the Hauraki Gulf and Bay of Plenty survey series. Note headline height was not available for some surveys and both headline height and doorspread were estimated for some surveys.

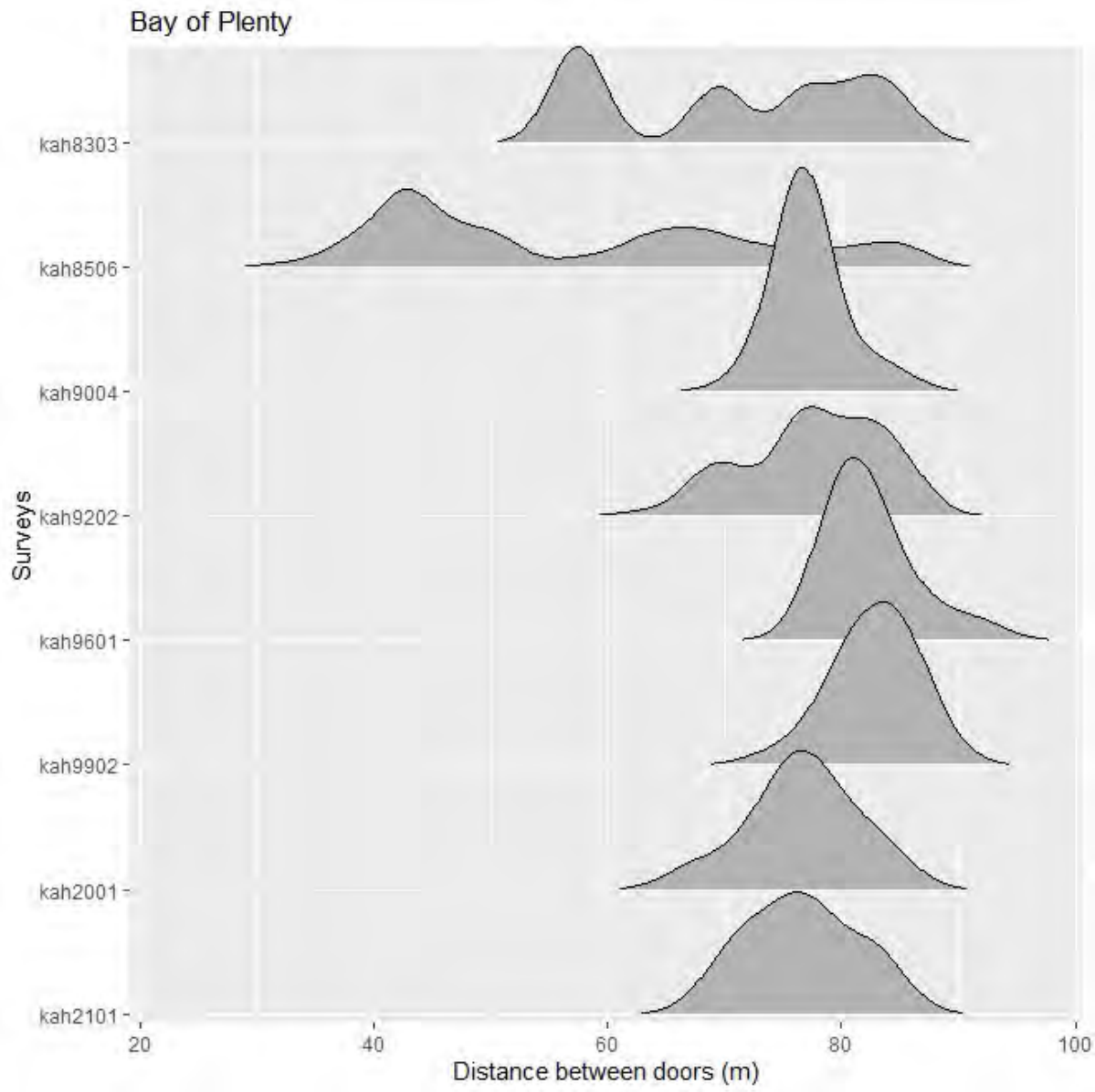
(a) Hauraki Gulf doorspread.



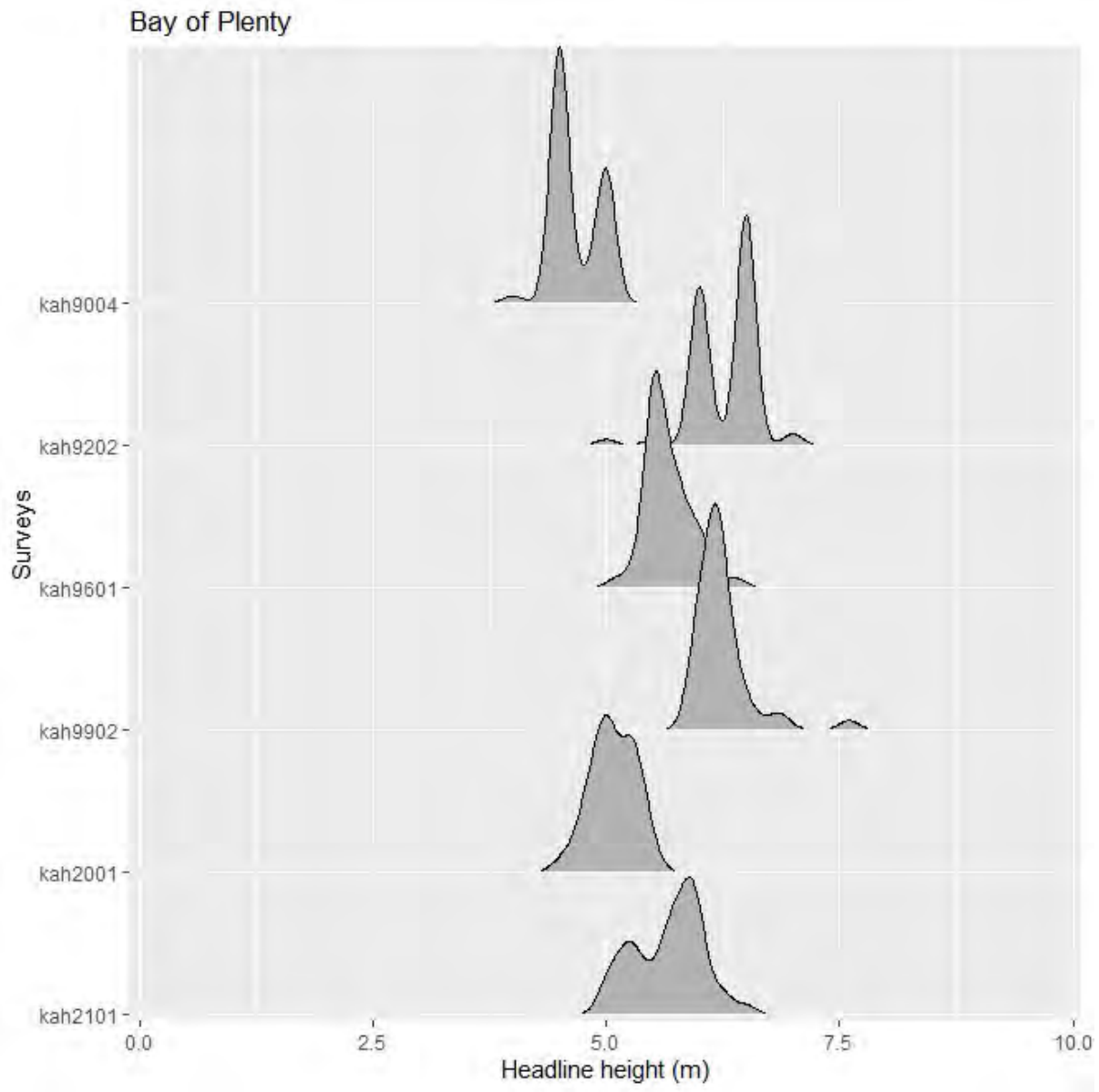
(b) Hauraki Gulf headline height.



(c) Bay of Plenty doorspread.



(d) Bay of Plenty headline height.



Appendix 6: Catch summary for the Hauraki Gulf and Bay of Plenty surveys in order by catch weight. Extended phase two stations have been included for the Bay of Plenty survey. * = less than 0.1% of the total catch for that survey.

Hauraki Gulf

Species code	Common name	Scientific name	Catch weight (kg)	% of total catch	No. of stations	% occurrence	Min. depth (m)	Max depth (m)
SNA	Snapper	*Chrysophrys auratus*	23 941.4	89.9	43	97.7	11	54
JMN	Yellowtail jack mackerel	*Trachurus novaezelandiae*	1 390.1	5.2	39	88.6	11	54
POP	Porcupine fish	*Allomycterus jaculiferus*	191.5	0.7	13	29.5	32	51
EGR	Eagle ray	*Myliobatis tenuicaudatus*	188.2	0.7	15	34.1	11	50
BRA	Short-tailed black ray	*Dasyatis brevicaudata*	160.3	0.6	9	20.5	11	50
GUR	Gurnard	*Chelidonichthys kumu*	136.8	0.5	43	97.7	11	54
JDO	John dory	*Zeus faber*	117.9	0.4	28	63.6	17	54
LEA	Leatherjacket	*Meuschenia scaber*	113.5	0.4	18	40.9	17	54
HHS	Hammerhead shark	*Sphyrna zygaena*	63.5	0.2	4	9.1	11	15
TRE	Trevally	*Pseudocaranx georgianus*	62.5	0.2	18	40.9	11	54
BWH	Bronze whaler shark	*Carcharhinus brachyurus*	40.0	0.2	1	2.3	11	11
ECK	Ecklonia	*Ecklonia*	39.3	0.1	8	18.2	14	41
CRM	Airy finger sponge	*Callyspongia cf ramosa*	33.7	0.1	21	47.7	11	54
SPO	Rig	*Mustelus lenticulatus*	29.7	0.1	14	31.8	11	54
KIN	Kingfish	*Seriola lalandi*	22.3	0.1	3	6.8	41	51
THR	Thresher shark	*Alopias vulpinus*	20.0	0.1	1	2.3	11	11
WOD	Wood	Wood	15.3	0.1	4	9.1	41	45
ATT	Kahawai	*Arripis trutta*	12.2	*	6	13.6	11	37
ERA	Electric ray	*Torpedo fairchildi*	9.7	*	1	2.3	48	48
NMP	Tarakihi	*Nemadactylus macropterus*	9.2	*	2	4.5	50	51
ECN	Echinoid (sea urchin)		5.9	*	1	2.3	18	18
SPZ	Spotted stargazer	*Genyagnus monopterygius*	5.7	*	3	6.8	15	27
ONG	Sponges	Porifera	4.7	*	11	25.0	17	54
NOS	NZ southern arrow squid	*Nototodarus sloanii*	4.7	*	9	20.5	17	54

Species code	Common name	Scientific name	Catch weight (kg)	% of total catch	No. of stations	% occurrence	Min. depth (m)	Max depth (m)
BAR	Barracouta	*Thyrsites atun*	3.8	*	5	11.4	23	50
EMA	Blue mackerel	*Scomber australasicus*	3.5	*	7	15.9	18	51
SCH	School shark	*Galeorhinus galeus*	2.6	*	2	4.5	15	51
SBL	Fanworms	Sabellidae	2.6	*	6	13.6	11	40
FRO	Frostfish	*Lepidopus caudatus*	2.3	*	1	2.3	54	54
APC	Astropecten spp.	*Astropecten* spp.	1.7	*	7	15.9	18	48
PHC	Packhorse rock lobster	*Jasus verreauxi*	1.6	*	1	2.3	48	48
ASC	Sea squirt	Ascidiacea	1.5	*	3	6.8	17	40
CCM	Eleven-arm seastar	*Coscinasterias muricata*	1.4	*	3	6.8	11	38
ANZ	Knobbly sandpaper sponge	*Ecionemia novaezelandiae*	1.4	*	2	4.5	44	50
SEO	Seaweed		0.9	*	3	6.8	12	51
ECH	Echinoderms	Echinodermata	0.9	*	1	2.3	15	15
SLT	Orange fat finger sponge	*Stelletta* spp.	0.5	*	1	2.3	50	50
SFL	Sand flounder	*Rhombosolea plebeia*	0.4	*	2	4.5	11	14
STY	Spotty	*Notolabrus celidotus*	0.4	*	1	2.3	14	14
YEM	Yellow-eyed mullet	*Aldrichetta forsteri*	0.4	*	1	2.3	14	14
RMU	Red mullet	*Upeneichthys lineatus*	0.4	*	2	4.5	17	48
COE	Coelenterata	Coelenterata	0.2	*	1	2.3	48	48
SOC	Soft coral	Alcyonacea	0.2	*	1	2.3	46	46
BRN	Barnacle	Cirripedia	0.2	*	1	2.3	41	41
COZ	Bryozoan	Bryozoa	0.1	*	1	2.3	54	54
SIA	Stony corals	Scleractinia	0.1	*	1	2.3	47	47
JMD	Greenback jack mackerel	*Trachurus declivis*	0.1	*	1	2.3	46	46
NUD	Nudibranchs	Nudibranchia	0.1	*	1	2.3	40	40

Bay of Plenty

Species code	Common name	Scientific name	Catch weight (kg)	% of total catch	No. of stations	% occurrence	Min. depth (m)	Max depth (m)
SNA	Snapper	*Chrysophrys auratus*	8 539.3	80.3	63	94.0	14	96
EGR	Eagle ray	*Myliobatis tenuicaudatus*	584.3	5.5	30	44.8	14	69
POP	Porcupine fish	*Allomycterus jaculiferus*	282.8	2.7	36	53.7	16	93
ECK	Ecklonia	Ecklonia	212.0	2.0	6	9.0	19	22
GUR	Gurnard	*Chelidonichthys kumu*	159.8	1.5	56	83.6	14	96
LEA	Leatherjacket	*Meuschenia scaber*	158.0	1.5	35	52.2	16	93
TRE	Trevally	*Pseudocaranx georgianus*	117.5	1.1	38	56.7	14	68
JDO	John dory	*Zeus faber*	110.9	1.0	43	64.2	19	96
JMN	Yellowtail jack mackerel	*Trachurus novaezelandiae*	71.5	0.7	36	53.7	16	86
BOA	Sowfish	*Paristiopterus labiosus*	61.3	0.6	4	6.0	20	47
KIN	Kingfish	*Seriola lalandi*	40.4	0.4	10	14.9	21	69
SPO	Rig	*Mustelus lenticulatus*	32.1	0.3	7	10.4	16	32
NMP	Tarakihi	*Nemadactylus macropterus*	31.4	0.3	6	9.0	47	93
HHS	Hammerhead shark	*Sphyrna zygaena*	29.9	0.3	11	16.4	14	48
WOD	Wood	Wood	23.8	0.2	6	9.0	20	62
BRA	Short-tailed black ray	*Dasyatis brevicaudata*	19.8	0.2	3	4.5	23	96
POR	Porae	*Nemadactylus douglasii*	19.3	0.2	1	1.5	23	23
ERA	Electric ray	*Torpedo fairchildi*	15.7	0.1	5	7.5	21	83
WRA	Longtailed stingray	*Dasyatis thetidis*	14.3	0.1	1	1.5	16	16
JMD	Greenback jack mackerel	*Trachurus declivis*	12.0	0.1	21	31.3	16	96
BSQ	Broad squid	*Sepioteuthis australis*	11.3	0.1	13	19.4	16	86
FRO	Frostfish	*Lepidopus caudatus*	10.2	0.1	2	3.0	82	92
ATT	Kahawai	*Arripis trutta*	10.2	0.1	6	9.0	20	49
MOK	Moki	*Latridopsis ciliaris*	7.2	0.1	1	1.5	23	23
RSK	Rough skate	*Zearaja nasuta*	6.3	0.1	2	3.0	92	93
SPZ	Spotted stargazer	*Genyagnus monopterygius*	6.1	0.1	6	9.0	14	35
THR	Thresher shark	*Alopias vulpinus*	6.0	0.1	1	1.5	26	26
SNI	Snipefish	*Macroramphosus scolopax*	5.9	0.1	5	7.5	65	96

Species code	Common name	Scientific name	Catch weight (kg)	% of total catch	No. of stations	% occurrence	Min. depth (m)	Max depth (m)
OCT	Octopus	*Pinnoctopus cordiformis*	4.5	*	3	4.5	47	86
SQU	Arrow squid	*Nototodarus sloanii & N. gouldi*	4.3	*	14	20.9	45	96
STT	Starry toado	*Arothron firmamentum*	3.6	*	3	4.5	27	55
ONG	Sponges	Porifera	3.3	*	7	10.4	23	66
PYR	*Pyrosoma atlanticum*	*Pyrosoma atlanticum*	3.3	*	4	6.0	19	92
CRS	Airy finger sponge	*Callyspongia ramosa*	2.5	*	12	17.9	19	96
OCP	Octopod		2.1	*	2	3.0	37	74
SEO	Seaweed		1.6	*	2	3.0	23	40
WIT	Witch	*Arnoglossus scapha*	1.5	*	5	7.5	47	93
CAR	Carpet shark	*Cephaloscyllium isabellum*	1.2	*	2	3.0	55	83
GAS	Gastropods	Gastropoda	1.1	*	3	4.5	38	64
YBF	Yellowbelly flounder	*Rhombosolea leporina*	1.0	*	2	3.0	21	48
ANC	Anchovy	*Engraulis australis*	0.7	*	1	1.5	48	48
CON	Conger eel	*Conger* spp.	0.6	*	1	1.5	65	65
MOL	Molluscs		0.6	*	3	4.5	47	65
CEP	Red bandfish	*Cepola haastii*	0.5	*	5	7.5	65	93
JGU	Spotted gurnard	*Pterygotrigla picta*	0.5	*	1	1.5	93	93
CCM	Eleven-arm seastar	*Coscinasterias muricata*	0.5	*	2	3.0	62	63
LSO	Lemon sole	*Pelotretis flavilatus*	0.3	*	1	1.5	68	68
SCA	Scallop	*Pecten novaezelandiae*	0.3	*	1	1.5	21	21
EMA	Blue mackerel	*Scomber australasicus*	0.2	*	2	3.0	74	86
BAR	Barracouta	*Thyrsites atun*	0.2	*	2	3.0	86	93
APC	Astropecten spp.	*Astropecten* spp.	0.2	*	2	3.0	47	65
LFB	Longfinned boarfish	*Zanclistius elevatus*	0.2	*	1	1.5	83	83
SCG	Scaly gurnard	*Lepidotrigla brachyoptera*	0.2	*	2	3.0	83	86
STY	Spotty	*Notolabrus celidotus*	0.2	*	1	1.5	20	20
PHA	Brown seaweed	Phaeophyta	0.1	*	1	1.5	55	55
NUD	Nudibranchs	Nudibranchia	0.1	*	1	1.5	93	93

Species code	Common name	Scientific name	Catch weight (kg)	% of total catch	No. of stations	% occurrence	Min. depth (m)	Max depth (m)
SLR	Slender roughy	*Optivus elongatus*	0.1	*	1	1.5	65	65
BRC	Northern bastard cod	*Pseudophycis breviuscula*	0.1	*	1	1.5	83	83
GON	*Gonorynchus forsteri & G. Greyi*	*Gonorynchus forsteri & G. greyi*	0.1	*	1	1.5	45	45
RUB	Rubbish other than fish		0.1	*	1	1.5	47	47
PDL	Penis worms	Priapulida	0.1	*	1	1.5	22	22

Appendix 7: Benthic and pelagic macro-invertebrates taken as bycatch during the Hauraki Gulf and Bay of Plenty surveys.

Hauraki Gulf

Species code	Common name	Scientific name	No. of stations
CRM	Airy finger sponge	*Callyspongia cf ramosa*	21
APC	Astropecten spp.	*Astropecten* spp.	7
SBL	Fanworms	Sabellidae	6
CCM	Eleven-arm seastar	*Coscinasterias muricata*	3
ANZ	Knobbly sandpaper sponge	*Ecionemia novaezelandiae*	2
ECN	Echinoid (sea urchin)		1
ASC	Sea squirt	Ascidiacea	1
COZ	Bryozoan	Bryozoa	1
BRN	Barnacle	Cirripedia	1
ECH	Echinoderms	Echinodermata	1
PHC	Packhorse rock lobster	*Jasus verreauxi*	1
NUD	Nudibranchs	Nudibranchia	1
SIA	Stony corals	Scleractinia	1
SLT	Orange fat finger sponge	*Stelletta* spp.	1
COZ	Bryozoan	*Orthoscuticella innominata*	1
COZ	Bryozoan	*Cornuticella trapezoidea*	1
COZ	Bryozoan	*Crisularia cuspidata*	1
COZ	Bryozoan	*Otionellina squamosa*	1
COZ	Bryozoan	*Hippothoa watersi*	1
COZ	Bryozoan	*Schizosmittina cinctipora*	1
COZ	Bryozoan	*Galeopsis porcellanicus*	1
COZ	Bryozoan	*Galeopsis polyporus*	1
COZ	Bryozoan	*Bicrisia edwardsiana*	1
COZ	Bryozoan	*Tubulipora* n. sp.	1
COZ	Bryozoan	*Disporella novaehollandiae*	1
COZ	Bryozoan	*Disporella pristis*	1
COZ	Bryozoan	*Telopora* n. sp.	1
COZ	Bryozoan	*Favosipora candida*	1
ONG	Porifera	*Chondropsis kirkii*	1
ONG	Porifera	*Ciocalypta polymastia*	1
COZ	Bryozoan	*Celleporaria agglutinans*	1
COZ	Bryozoan	*Tubulipora* n. sp.	1
CRB	Crab	*Metadromia wilsoni*	1
ONG	Sponges	*Aaptos globosa*	1
ONG	Sponges	*Tetrapocillon novaezealandiae*	1
ONG	Sponges	*Ciocalypta* cf. *penicillus*	1
ONG	Sponges	*Axinella* cf. n. sp. 1	1
ANT	Anemones	cf. *Alcyonium*	1
ONG	Sponges	*Euryspongia* n. sp. 2	1
ASC	Sea squirts	*Aplidium siphonum*	1
ONG	Sponges	*Myxilla (Ectyomyxilla) kerguelensis*	1
ASC	Sea squirts	Aplousobranchia indet.	1
ASC	Sea squirts	Aplousobranchia	1
ONG	Sponges	*Petrosia (Petrosia) australis*	1

Bay of Plenty

Species code	Common name	Scientific name	No. of stations
CRS	Airy finger sponge	*Callyspongia ramosa*	12
ONG	Sponges	Porifera	3
PYR	Pyrosoma atlanticum	*Pyrosoma atlanticum*	4
OCT	Octopus	*Pinnoctopus cordiformis*	3
GAS	Gastropods	*Xenophora neozelanica*	3
OCP	Octopod		2
CCM	Eleven-arm seastar	*Coscinasterias muricata*	2
APC	Astropecten spp.	*Astropecten* spp.	2
SCA	Scallop	*Pecten novaezelandiae*	1
PDL	Penis worms	Priapulida	1
NUD	Nudibranchs	Nudibranchia	1
ASC	Sea squirts	*Molgula mortenseni*	1
ONG	Sponges	Ircinidae	1
ONG	Sponges	*Ciocalypta n. sp. 2*	1
ONG	Sponges	*Latrunculia (Biannulata) procumbens*	1
ONG	Sponges	*Iophon minor*	1

Appendix 8: Estimates of proportion of length-at-age for snapper sampled from (a) the 2020 Hauraki Gulf and (b) the 2021 Bay of Plenty surveys.

(a) Hauraki Gulf

Length (cm)	Age (years)																	No. aged
	0+	1+	2+	3+	4+	5+	6+	7+	8+	9+	10+	11+	12+	13+	14+	15+	>15+	
7	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	3
8	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	14
9	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	15
10	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	21
11	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	14
12	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	9
13	0.40	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	5
14	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	19
15	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	27
16	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	34
17	0.00	0.96	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	23
18	0.00	0.75	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	20
19	0.00	0.35	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	20
20	0.00	0.13	0.81	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	31
21	0.00	0.04	0.71	0.21	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	28
22	0.00	0.04	0.36	0.32	0.24	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	25
23	0.00	0.00	0.08	0.48	0.24	0.12	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	25
24	0.00	0.00	0.04	0.48	0.24	0.16	0.00	0.04	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	25
25	0.00	0.00	0.00	0.16	0.28	0.20	0.08	0.16	0.04	0.04	0.04	0.00	0.00	0.00	0.00	0.00	0.00	25
26	0.00	0.00	0.00	0.08	0.28	0.12	0.28	0.16	0.00	0.04	0.00	0.00	0.04	0.00	0.00	0.00	0.00	25
27	0.00	0.00	0.00	0.00	0.20	0.20	0.16	0.00	0.08	0.08	0.04	0.16	0.08	0.00	0.00	0.00	0.00	25
28	0.00	0.00	0.00	0.00	0.08	0.04	0.12	0.04	0.12	0.12	0.16	0.12	0.16	0.00	0.04	0.00	0.00	25
29	0.00	0.00	0.00	0.00	0.04	0.12	0.08	0.20	0.16	0.04	0.04	0.08	0.08	0.04	0.08	0.04	0.00	25
30	0.00	0.00	0.00	0.00	0.04	0.04	0.08	0.20	0.08	0.04	0.08	0.08	0.08	0.16	0.00	0.04	0.08	25
31	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.16	0.04	0.08	0.20	0.16	0.08	0.16	0.08	0.00	0.00	25
32	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.04	0.13	0.04	0.13	0.17	0.04	0.08	0.21	0.00	0.08	24

Length (cm)	Age (years)																	No. aged
	0+	1+	2+	3+	4+	5+	6+	7+	8+	9+	10+	11+	12+	13+	14+	15+	>15+	
33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.05	0.14	0.24	0.19	0.05	0.10	0.00	0.10	21
34	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.06	0.13	0.13	0.13	0.06	0.06	0.13	0.06	0.19	16
35	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.08	0.00	0.08	0.08	0.15	0.08	0.00	0.15	0.31	13
36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.00	0.00	0.11	0.33	0.33	0.00	0.11	0.00	0.00	9
37	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.08	0.08	0.00	0.00	0.00	0.17	0.00	0.08	0.08	0.42	12
38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.20	0.00	0.00	0.40	0.00	0.00	0.20	5
39	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	0.00	0.00	0.60	5
40	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	0.50	0.00	0.00	0.25	4
41	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	0.33	0.33	0.00	0.00	3
42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.50	2
43	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	0.25	0.00	0.50	4
44	0.00	0.00	0.00	0.00	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	4
45	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.20	0.20	0.00	0.40	5
46	0.00	0.00	0.00	0.00	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
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	1.00	4
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	1.00	1
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	1.00	2
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	1.00	2
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	0.20	0.00	0.80	5
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	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	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	1.00	2
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	0.50	0.50	2
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	1.00	4
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	1.00	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	1.00	4
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	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	1.00	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	1.00	0

Length (cm)	Age (years)																No. aged
	0+	1+	2+	3+	4+	5+	6+	7+	8+	9+	10+	11+	12+	13+	14+	15+	>15+	
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	1.00	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	1.00	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	1.00	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	1.00	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	1.00	4
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	1.00	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	1.00	1
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	1.00	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	1.00	0
71	0.00	0.00	0.00	0.00	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
72	0.00	0.00	0.00	0.00	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
73	0.00	0.00	0.00	0.00	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
74	0.00	0.00	0.00	0.00	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
75	0.00	0.00	0.00	0.00	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
76	0.00	0.00	0.00	0.00	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
77	0.00	0.00	0.00	0.00	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
78	0.00	0.00	0.00	0.00	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
79	0.00	0.00	0.00	0.00	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
80	0.00	0.00	0.00	0.00	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
Total																		698

(b) Bay of Plenty

Length (cm)	Age (years)																	No. aged
	0+	1+	2+	3+	4+	5+	6+	7+	8+	9+	10+	11+	12+	13+	14+	15+	>15+	
7	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	5
8	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	14
9	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	13
10	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	13
11	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	9
12	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	2
13	0.00	0.25	0.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4
14	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	14
15	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	11
16	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	11
17	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	11
18	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	17
19	0.00	0.00	0.88	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	25
20	0.00	0.00	0.64	0.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	11
21	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	15
22	0.00	0.00	0.07	0.93	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	14
23	0.00	0.00	0.16	0.68	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	19
24	0.00	0.00	0.08	0.48	0.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	25
25	0.00	0.00	0.04	0.39	0.48	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	23
26	0.00	0.00	0.00	0.04	0.52	0.39	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	23
27	0.00	0.00	0.00	0.00	0.13	0.39	0.43	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	23
28	0.00	0.00	0.00	0.00	0.09	0.35	0.52	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	23
29	0.00	0.00	0.00	0.00	0.00	0.09	0.65	0.17	0.04	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	23
30	0.00	0.00	0.00	0.00	0.00	0.13	0.61	0.04	0.17	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	23
31	0.00	0.00	0.00	0.00	0.00	0.04	0.52	0.17	0.09	0.13	0.00	0.00	0.00	0.00	0.04	0.00	0.00	23
32	0.00	0.00	0.00	0.00	0.00	0.09	0.35	0.35	0.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	23

Length (cm)	Age (years)																	No. aged
	0+	1+	2+	3+	4+	5+	6+	7+	8+	9+	10+	11+	12+	13+	14+	15+	>15+	
33	0.00	0.00	0.00	0.00	0.00	0.00	0.30	0.22	0.26	0.09	0.04	0.04	0.04	0.00	0.00	0.00	0.00	23
34	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.09	0.22	0.22	0.04	0.04	0.04	0.09	0.04	0.04	0.00	23
35	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.13	0.17	0.04	0.22	0.13	0.00	0.17	0.00	0.00	0.04	23
36	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.13	0.22	0.04	0.13	0.04	0.09	0.26	0.00	0.04	0.00	23
37	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.05	0.32	0.11	0.11	0.05	0.16	0.05	0.05	0.00	0.00	19
38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.15	0.15	0.00	0.15	0.23	0.15	0.08	0.00	13
39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.05	0.14	0.05	0.10	0.10	0.19	0.10	0.19	21
40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.06	0.11	0.11	0.11	0.17	0.11	0.28	18
41	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.08	0.00	0.08	0.15	0.08	0.15	0.38	13
42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.09	0.00	0.00	0.00	0.36	0.09	0.00	0.36	11
43	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	0.11	0.26	0.00	0.53	19
44	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	0.00	0.33	0.50	6
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	0.10	0.00	0.10	0.80	10
46	0.00	0.00	0.00	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	0.80	10
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	0.09	0.00	0.00	0.91	11
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	0.33	0.00	0.00	0.67	3
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	0.27	0.00	0.73	11
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	1.00	2
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	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	1.00	3
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	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	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	1.00	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	1.00	2
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	1.00	3
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	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	1.00	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	1.00	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	1.00	2

Length (cm)	Age (years)																	No. aged
	0+	1+	2+	3+	4+	5+	6+	7+	8+	9+	10+	11+	12+	13+	14+	15+	>15+	
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	1.00	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	1.00	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	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	1.00	2
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	1.00	2
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	1.00	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	1.00	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	1.00	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	1.00	1
71	0.00	0.00	0.00	0.00	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
72	0.00	0.00	0.00	0.00	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
73	0.00	0.00	0.00	0.00	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
74	0.00	0.00	0.00	0.00	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
75	0.00	0.00	0.00	0.00	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
76	0.00	0.00	0.00	0.00	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
Total																		700