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Inshore trawl survey of the west coast South Island and Tasman and Golden Bays, March-April 2017 (KAH1703)

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EXECUTIVE SUMMARY

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This report presents the results of the thirteenth inshore trawl survey along the west coast of the South Island, from Farewell Spit to the Haast River mouth, and within Tasman and Golden Bays at depths from 20 to 400 m using RV *Kaharoa*.

The survey took place from 24 March to 17 April 2017 and used a stratified two-phase design optimised for giant stargazer, red cod, red gurnard, spiny dogfish, and tarakihi. Snapper were added as a target species in 2017 and two new strata were added to better sample them: stratum 20 covered depths of 10 to 20 m in Tasman Bay, whilst stratum 21 covered depths of 10–20 m in Golden Bay. A total of 69 phase 1 stations were successfully completed. Five phase two stations were completed in stratum 19 to improve the coefficient of variation (CV) for spiny dogfish. Trends in relative biomass estimates, catch distributions for the target species, and population length frequencies for the major species are presented.

The biomass estimates for the target species were: giant stargazer, 1674 t; red gurnard, 1708 t; red cod, 1247 t; snapper, 674 t; spiny dogfish, 3255 t; and tarakihi, 1857 t. The snapper biomass estimate which includes the new strata was 719 t. The additional inshore stations (and strata) included a higher proportion of snapper under 30 cm, suggesting that they may be useful for estimating the biomass of pre-recruits. Target CVs of 20% were met for giant stargazer (14%), red gurnard (12%) and tarakihi (18%). The target CV for red cod of 25% was met (21%) and the target CV of 30% was met for snapper (17%). The CV for spiny dogfish (22%) was slightly higher than the target (20%). Other commercial species with CVs less than 20% were john dory, jack mackerel (*T. novaezelandiae*), leatherjacket, lemon sole, gemfish, and school shark.

The John dory estimate was the second highest in the series. The biomass of 1+ fish (i.e. pre-recruits) in 2017 was the highest for the entire series, suggesting good future recruitment for the fishery. The biomass estimates for red gurnard and tarakihi were the second highest for any survey in the series. The biomass estimate for spiny dogfish was the lowest for any survey in the series, whilst the red cod biomass estimates was the fourth lowest of the time series. The biomass estimate for giant stargazer was in the midrange of estimates for the series.

1. INTRODUCTION

This report presents results from the thirteenth stratified random trawl survey using RV *Kaharoa* at depths of 20–400 m off the west coast of the South Island, and in Tasman and Golden Bays. Other surveys have taken place in 1992, 1994, 1995, 1997, 2000, 2003, 2005, 2007, 2009, 2011, 2013 and 2015. The survey design was optimised to estimate the relative biomass of giant stargazer (*Kathetostoma giganteum*), red cod (*Pseudophycis bachus*), red gurnard (*Chelidonichthys kumu*), snapper (*Pagrus auratus*), spiny dogfish (*Squalus acanthias*), and tarakihi (*Nemadactylus macropterus*). The results of earlier surveys in this series were reported by Drummond & Stevenson (1995a, 1995b, 1996), Stevenson (1998, 2002, 2004, 2006, 2007a, 2012), Stevenson & Hanchet (2010), MacGibbon & Stevenson (2013) and Stevenson & MacGibbon (2015). The first four surveys in the series were reviewed by Stevenson & Hanchet (2000). Additional analyses of the non-target species were completed to determine for which species relative abundance trends and size comparison information should be provided in each survey report (Stevenson 2007b).

The principal objective of the surveys was to develop a time series of relative biomass indices for giant stargazer, red cod, red gurnard, spiny dogfish, and tarakihi for the inshore waters off the west coast of the South Island and in Tasman and Golden Bays. Changes in the relative biomass and length frequency distributions over time should reflect changes in the absolute biomass and size distributions of the fish populations.

Snapper was included as a target species for this survey as the first of two pilots to determine the feasibility of adding them as a regular target species for future surveys. The second pilot is scheduled for 2019. The station optimization for existing core strata included snapper in the inputs and the new strata had modelling done on commercial data to establish the number of stations required. The final number was based on logistics as the simulation modelling suggested that a higher number of tows would be needed than was feasible.

This report details the 2017 trawl survey design and methods and provides relative biomass estimates for commercially important species managed under the Quota Management System (QMS) and non-QMS species. The trawl survey time series of relative biomass estimates for key inshore species provide information used for stock assessment and fisheries management advice.

This report fulfils the final reporting requirement of Ministry for Primary Industries project INT2016-01

1.1 Programme objective

To determine the relative abundance and distribution of inshore finfish species off the west coast of the South Island, and Tasman Bay and Golden Bay; focusing on red cod (*Pseudophycis bachus*), red gurnard (*Chelidonichthys kumu*), giant stargazer (*Kathetostoma giganteum*), tarakihi (*Nemadactylus macropterus*), spiny dogfish (*Squalus acanthias*), and john dory (*Zeus faber*).

Specific objectives

1. To determine the relative abundance and distribution of inshore finfish species off the west coast of the South Island, and Tasman Bay and Golden Bay; focusing on red cod, red gurnard, giant stargazer, tarakihi, spiny dogfish, and john dory from Farewell Spit to the Haast River mouth and within Tasman Bay and Golden Bay by carrying out a trawl survey. The target coefficients of variation (CV) of the biomass estimates of these species were as follows: red cod (20–25%), red gurnard (20%), giant stargazer (20%), tarakihi (20%), snapper (30%), and spiny dogfish (20%). No target CV was set for john dory.

2. To collect the data and determine the length frequency, length-weight relationship and reproductive condition of red cod, red gurnard, giant stargazer, tarakihi, spiny dogfish, and john dory.
3. To collect otoliths from red cod, red gurnard, giant stargazer, and tarakihi.
4. To collect the data to determine the length frequencies for all other Quota Management System (QMS) species.
5. To complete experimental trawl stations for snapper in Tasman/Golden Bays.
6. To identify benthic macro-invertebrates collected during the trawl survey.
7. To present biomass trends and size composition information for all QMS species for which the survey reliably monitors relative abundance trends.

2. METHODS

2.1 Survey area and design

The survey was a two-phase stratified random survey after Francis (1984). The survey area covered depths of 20–200 m off the west coast of the South Island from Cape Farewell to Karamea; 25–400 m from Karamea to Cape Foulwind; 20–400 m from Cape Foulwind to the Haast River mouth; and 10–70 m within Tasman and Golden Bays inside a line drawn between Farewell Spit and Stephens Island (Figure 1a–b). The maximum depth on the west coast north of Karamea was limited to 200 m because of historically low catch rates in the 200–400 m range.

The survey area of 25 595 km^2, including untrawlable ground, was divided into 18 strata by area and depth (Table 1, Figure 1a–b). Strata were identical to those used in previous surveys in the time series (the core strata) but with the addition of two new strata in the 10–20 m depth range in Tasman and Golden Bays. The trawlable ground within the survey area represented 84% of the total survey area.

Phase 1 station allocation was optimised using the R (R Core Team 2012) function *allocate* (Francis 2006) to achieve the target CVs. The *allocate* function uses stratum area and catch rate data from previous trawl surveys in the time series to simulate optimal station allocation. Simulations were run for each target species separately. Based on the simulation results, the survey plan was to carry out 63 phase 1 stations which would give a CV of 25% for red cod and 20% for all other target species. An allocation of 8 stations for the new snapper strata based on analyses of commercial catch and effort data presented to the Southern Inshore Species Working Group on 15 October 2015 by Adam Langley (Trophia Ltd), gave a total of 71 planned phase 1 stations.

Station positions were randomly generated using NIWA's custom software 'RandomStation'. The stations were required to be a minimum of 5.6 km (3 nautical miles) apart. Non-trawlable ground was identified before the voyage from data collected during previous trawl surveys in the area and that ground was excluded from the station allocation program.

2.2 Vessel, gear, and trawling procedure

RV *Kaharoa* is a 28 m stern trawler with a beam of 8.2 m, displacement of 302 t, engine power of 522 kW, capable of trawling to depths of 500 m. The two-panel trawl net used during the survey was designed and constructed in 1991 specifically for South Island inshore trawl surveys and is based on an 'Alfredo' design. The net was fitted with a 60 mm (inside measurement) knotless codend. Details of the net design were given by Beentjes & Stevenson (2008). Gear specifications were the same as for previous surveys (Drummond & Stevenson 1996).

Procedures followed those recommended by Stevenson & Hanchet (1999). All tows were undertaken in daylight, and four to six tows a day were planned. For each tow the vessel steamed to the station position and, if necessary, the bottom was checked with the echosounder to determine trawlability. 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 position generated by RandomStation. 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, but was usually in the direction of the next station.

If the station was found to be in an area of foul ground or the depth was out of the stratum range, 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 one hour duration at a speed over the ground of 3 knots and the distance covered was measured by GPS. The tow was deemed to have started when the net monitor indicated that the net was on the bottom, and was completed when hauling began. A warp length of 200 m was used for all tows less than 70 m depth. At greater depths, the warp to depth ratio decreased linearly to about 2.4:1 at 400 m.

2.3 Water temperatures

The surface and bottom temperatures at each station were recorded by a calibrated Seabird Microcat CTD unit. 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 because the CTD rests on the net just behind the headline.

2.4 Catch and biological sampling

The catch from each tow was sorted into species on deck and weighed on 100 kg electronic motion-compensating Seaway scales to the nearest 0.1 kg. Finfish, squid, and scampi were identified to species where possible. Crustaceans, shellfish, and other invertebrate species not readily identified were frozen for later identification. Unidentified specimens were placed in sealed plastic bags with a label noting the trip code and station number.

Length, to the nearest whole centimetre below the actual length, and sex (where possible) were recorded for all species managed under the QMS, either for the whole catch or a randomly selected subsample of up to 200 fish per tow.

2.5 Data analysis

Biomass estimates and population scaled length-frequency distributions and their associated CVs were estimated by the area-swept method (Francis 1981, 1989) using the SurvCalc Program (Francis & Fu 2012). All data were entered into the Ministry for Primary Industries' *trawl* database.

The following assumptions were made for calculating biomass estimates with the SurvCalc Programme:

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 fishstock being sampled was entirely within the survey area at the time of the survey.
5. Within the survey area, fish were evenly distributed over both trawlable and non-trawlable ground.

All these assumptions are unlikely to be correct, but were adopted for all the trawl survey time series of relative biomass (Stevenson & Hanchet 1999).

In the core strata, 68 stations from phases one and two were used for biomass estimation where gear performance was satisfactory (gear performance of 1 or 2). For snapper, biomass estimates are reported separately for the core strata and for all strata including the additional strata 20 and 21. Where strata 20 and 21 are included for snapper the total number of stations is 69 (phase 1 stations only from the core strata, plus six stations from strata 20 and 21). Biomass estimates for all other species do not include data from strata 20 and 21.

Length frequencies were scaled by the percentage of catch sampled, area swept, and stratum area. The geometric mean functional relationship was used to calculate the length-weight coefficients for species where sufficient length-weight data were collected on the 2017 survey. For other species, coefficients were chosen from the *rdb* database. Coefficients were chosen from *rdb* based on whether there were coefficients for a given species from previous surveys in this time series, or on the best match between the size range of the fish used to calculate the coefficients in *rdb* and the sample size range from this survey (Appendix 1).

Sex ratios were calculated using scaled population numbers and are expressed as the ratio of males to females.

3. RESULTS

3.1 Timetable and personnel

RV *Kaharoa* departed Nelson on 25 March and began trawling in Tasman Bay. Twenty-two phase 1 stations in Tasman and Golden Bays were successfully completed by 2 April after which fish was offloaded to Talley's Nelson. Fishing recommenced on the west coast of the South Island on 3 April and continued until 6 April when the vessel docked in Westport to unload fish and exchange one scientific staff member. Fishing resumed on 8 April and finished on the west coast on 16 April when all phase 1 stations were completed. Fishing resumed in Tasman Bay and five phase two stations were completed in stratum 19 to improve the precision of the spiny dogfish biomass estimate. RV *Kaharoa* docked in Nelson on 19 April to discharge fish and drop off one scientific staff member. The vessel docked in Wellington on 20 April for demobilization.

Dan MacGibbon was voyage leader and was responsible for final database editing. The skipper was Lindsay Copland. The project manager was Dan MacGibbon.

A total of 63 core phase 1 stations were completed with 5 phase two stations in stratum 19 to improve the CV for spiny dogfish. A minimum of 3 stations were completed in all the core strata. Whilst 4 stations were completed in stratum 20, only 2 stations could be fitted in stratum 21 (lack of space) for a total of 74 successful stations completed for the entire survey. An additional three stations were not used for biomass estimates because of poor gear performance.

The survey area, with stratum boundaries and station positions, is shown in Figures 1a and 1b and individual station data are given in Appendix 2.

A summary of gear and tow parameters by depth are shown in Table 2. Doorspread varied from 70.1 to 93.3 m and headline height varied between 4.0 and 4.9 m (Table 2, Appendix 2). Measurements of headline height and doorspread, together with bottom contact sensor output and observations that the doors and trawl gear were polishing well, indicated that the gear was in general operating correctly. Overall, gear

parameters were similar to those of previous surveys, indicating consistency between surveys (Stevenson & Hanchet 2000).

3.2 Catch composition

A total of about 34.5 t of fish and invertebrates were caught from the 74 valid biomass tows at an average of 466.7 kg per tow. Amongst the fish catch, 13 elasmobranch, and 37 teleost species were recorded. Species codes, common names, scientific names, and catch weights of all species identified during the survey are given in Appendix 3. Invertebrate species identified from the catch are given in Appendix 4.

The most abundant species by weight was barracouta with 5.5 t caught (16.4% of the total catch). The top four species - barracouta (*Thyrsites atun*), spiny dogfish, red gurnard, and snapper - made up 44% of the total. The target species giant stargazer, red cod, red gurnard, spiny dogfish and tarakihi made up 38% of the catch. Barracouta, arrow squid (*Nototodarus sloanii* & *N. gouldi*), witch (*Arnoglossus scapha*), school shark (*Galeorhinus galeus*) and carpet shark (*Cephaloscyllium isabellum*) each occurred in over 80% of the tows.

Forty-nine species or species groups of invertebrates were identified during the survey or from retained specimens (Appendix 4). The numbers of invertebrate species does not necessarily reflect biodiversity in the survey area because the gear is not designed to collect benthic macroinvertebrates. In addition, station location strongly influences the incidence of some groups (e.g., some bryozoans prefer hard substrate, so if no trawl station fell on such substrate then this group may not be represented in the catch).

3.3 Catch rates and species distribution

Distribution by stratum and catch rates for the target species are shown in Figures 2a–2e. Catch rates are given in kilograms per square kilometre.

Giant stargazer catch rates were highest in the 100–200 m strata (Figure 2a), south of Cape Foulwind. Catches in the Tasman and Golden Bay region were low.

Red cod catch rates were highest in the 30–100 m strata on the west coast (Figure 2b), followed by 100–200 m strata. Catch rates in Tasman and Golden Bays and in the 200–400 m strata on the west coast were low in comparison.

Red gurnard catch rates were highest in the 30–100 m strata on the west coast and in Tasman and Golden Bay (Figure 2c). Catch rates in the 100–200 and 200–400 m strata were low to non-existent.

The highest catch rates for spiny dogfish were from the 30–100 m strata on the west coast (Figure 2d), with the exception of one unusually large catch in stratum 19 (outer Tasman Bay). Catch rates were lower in the 100–200 m strata, and lowest in the 200–400 m strata.

Highest catch rates for tarakihi were in the south of the west coast area between Greymouth and Haast in the 200–400 m strata (Figure 2e). Catch rates were very low in the north of the west coast compared to the previous survey.

Mean catch rates by stratum for the 20 most abundant commercially important species are given in Table 3.

3.4 Biomass estimation

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

Biomass estimates for species managed under the QMS caught in all surveys in the series are given in Table 4. Estimated biomass and coefficients of variation for the target species in 2017 were: giant stargazer, 1674 t (14%); red gurnard, 1708 t (12%); red cod, 1247 t (21%); snapper (core strata), 674 t (20%); snapper (all strata), 791 t (17%); spiny dogfish, 3255 t (22%); tarakihi, 1857 t (18%); and John Dory (12%) (Table 4). Target CVs were 20% for giant stargazer, tarakihi, red gurnard, and spiny dogfish whilst the target CV for red cod was 20–25%. These values were chosen during the initial planning for the series because it was felt they would provide information accurate enough to detect trends in relative abundance for the target species. There is no target CV for John dory.

Recruited lengths and biomass estimates for the following species are given in Table 5: barracouta, blue warehou (*Seriolella brama*), giant stargazer, hoki, john dory, ling (*Genypterus blacodes)*, red cod, red gurnard, rig (*Mustelus lenticulatus*), sand flounder (*Rhombosolea plebeia*), snapper, school shark, silver warehou (*Seriolella punctata*), and tarakihi. Estimates of total recruited biomass for giant stargazer, red cod, red gurnard, snapper and tarakihi were 93%, 34%, 79%, 99.7% and 78% of the totals, respectively. Recruited lengths were determined following discussions with the commercial fishing industry and reflect the minimum lengths considered desirable for sale to the public; they are often the minimum legal sizes previously set for fishery management (but not all species have minimum legal sizes).

Biomass estimates by year class (where they were discernible from the length frequency distributions) for barracouta, blue warehou (*Seriolella brama*), hake (Merluccius australis), hoki (*Macruronus novaezelandiae*), jack mackerel (*Trachurus novaezelandiae*), red cod, red gurnard, school shark, silver warehou, snapper and tarakihi are given in Table 6. For red cod, the 1+ cohort made up only 7% of the total biomass whereas in previous surveys the 1+ year class usually made up more than 60% of the total biomass. For red gurnard, the 1+ cohort made up 17% of the total biomass and for tarakihi the 1+ and 2+ cohorts made up 1% and 6% of the total respectively.

The biomass estimates and CVs for the 20 most abundant commercially important species are given by stratum in Table 7.

Trends in biomass for selected species are shown in Figure 3 and discussed in Section 3.7.

3.5 Length frequency and biological data

Length frequency distributions for other species are given for the 2017 survey only if the species is commercially important and more than 100 fish were measured. The numbers of length frequency and biological samples taken during the survey are given in Table 8. Comparative population scaled length frequency distributions for the target species and for the eight other species monitored by the survey are shown in Figures 5a–n. Length frequency distributions are presented in alphabetical order by common name. Scaled length frequency distributions from this survey for other commercial species where more than 100 fish were measured are shown in Figure 6 in alphabetical order by common name.

Length-weight coefficients were determined for carpet shark, giant stargazer, red cod, red gurnard, rig, rough skate (*Zearaja nasuta*), school shark, snapper, spiny dogfish and tarakihi from data collected on this survey (Appendix 1**).**

Ageing material collected included 330 pairs of otoliths from giant stargazer, 477 from red cod, 460 from red gurnard, and 431 from tarakihi (Table 8).

Details of gonad stages for giant stargazer, red cod, red gurnard, and tarakihi are given in Table 9a and maturity stage details for spiny dogfish are given in Table 9b and are discussed in Section 3.7.

3.6 Trends in target species

3.6.1 Giant stargazer

Giant stargazer were caught at 51 stations with the highest catch rates south of Cape Foulwind at depths of 100–200 m and at all depths south of Greymouth (strata 8, 12, 13, 14 and 15) (Figure 2a, Table 3). The biomass was fairly constant for the first four surveys but declined in 2000 and again in 2003 to a low of 834 t. The biomass has steadily increased since then with the highest estimate (2118 t) in 2013, and the second highest estimate in the series (1983 t) from the 2015 survey. The biomass estimate for 2017 declined to 1674 t which is nearer the average for the series (1546 t) (Table 4, Figure 3). Most of the biomass was from the west coast South Island region, with Tasman and Golden Bays contributing little of the total biomass (Figure 4). Eighty-six percent of the biomass was south of Cape Foulwind, and 74% was from the 100–200 m depth range (Table 7). Biomass of adult fish (over 45 cm) was 1552 t and juveniles were about 7% of the total (Table 5, Figure 5, Figure 7). Figure 8 shows that males make up slightly more of the juvenile biomass than females do, and females make up slightly more of the adult biomass than do males. Adult and juvenile indices track each other fairly closely.

There were more fish under 45 cm caught on the 2017 survey than in 2015 but still fewer than the previous three surveys (2009, 2011 and 2013) (Figure 5d). Few fish larger than 40 cm occur in the Tasman and Golden Bay region (Figure 5d). No obvious year class modes were apparent in the length frequency distribution. The sex ratio (male:female) was 1.21:1 overall (Figure 5d), very similar to 2015 survey (1.27:1). All females shorter than 50 cm were immature or had resting gonads, but above this size, most had maturing gonads. Most males under 40 cm were immature or resting, and most males over 40 cm were maturing (Table 9a). The survey takes place in autumn; the spawning period of giant stargazer is believed to be in winter.

3.6.2 Red cod

Red cod were caught at 54 stations, with the highest catch rates in strata 5 and 15 (Figure 2b, Table 3). Total biomass estimates were fairly stable for the first four surveys varying from 2546 t to 3370 t. There was a sharp decline in 2000 to 414 t but the biomass gradually recovered to 2782 t in 2009. The biomass estimate of 1247 t from the 2017 survey was a 26% increase from 2015 and matched the estimate from 2013 (the fourth lowest estimate in the time series) but is still less than half that of 2009 (Table 4, Figure 3). The increase in the biomass came almost entirely from the west coast with little change in the biomass from the Tasman and Golden Bay region (Figure 4).

Population numbers increased by over 35% from 2015 after dropping around 50% from 2013 to 2015. Numbers are still lower than 2013 because of the lower numbers of 1+ fish. Higher numbers of older fish resulted in the biomass being the same as in 2013 (Figure 5h). The continued low numbers of 1+ fish (25–40 cm) from this survey may be significant for the commercial fishery in 2017–18 given the dependence on recruitment (Beentjes 2000). The biomass from stratum 1 increased from the low levels in 2013 (3 t) and 2015 (no catch) but are still not as high as in 2011 (579 t). The estimated biomass in Tasman and Golden Bays totalled 30 t. Eighty-six percent of the total biomass was from five strata (1, 5, 11, 12 and 15) and 96% was from depths less than 200 m (Table 7). Adult biomass (over 50 cm) was 423 t, about 34% of the total (Table 5, Figures 6, and 8). In most years juvenile males have been more abundant than juvenile females and adults of both sexes (Figure 8). Adult males have historically contributed the least to total biomass. Adult and juvenile indices previously tracked each other fairly closely. There were good numbers of fish in the 10–20 cm range (0+ fish), but fewer than were caught during 2015 (Figure 5h). The sex ratio was 1.19:1 overall (Figure 5h). Almost all red cod examined had immature or resting gonads but a few larger fish were ripening or running ripe (Table 9a). Since red

cod spawn from late winter to spring (Ministry of Fisheries 2009), fish with maturing or ripe gonads were not expected during the survey.

3.6.3 Red gurnard

Red gurnard were caught at all stations in Tasman and Golden Bays, and all stations in depths less than 100 m along the west coast (Figure 2c). The highest catch rates were in strata 11, 14 and 19 (Table 3). The biomass estimates were consistent from 1992–2000 but showed a sharp decline in 2003. There was a steady increase over the last five surveys and the estimate for 2017 (1708 t) was the second highest in the time series and only slightly lower than the high from the 2015 survey (1776 t) (Table 4, Figure 3). A significant proportion of the biomass has always occurred in the Tasman and Golden Bay region, although for the last four surveys markedly more was from the west coast South Island (Figure 4).

The length frequency distribution was similar to 2013 and 2015 with large numbers of fish greater than 30 cm (Figure 5i). As in all previous surveys, there were relatively more smaller fish from the Tasman and Golden Bay region, and relatively more bigger fish from the west coast. The estimates of recruited and adult biomass (30 cm or greater) was 1352 t (79% of the total biomass) with 950 t of that (56%) occurring on the west coast (Table 5, Figure 7). Juvenile males contribute more to the biomass than do juvenile females but adult biomass is generally even between the sexes (Figure 8). Adult and juvenile indices track each other fairly closely. Almost all (i.e., 98%) the red gurnard biomass was in depths less than 100 m and no gurnard were caught deeper than 200 m (Table 7). The overall sex ratio was 1.06:1 (Figure 5i). Most red gurnard longer than 30 cm and a few smaller fish (particularly males) had developing or mature gonads (Table 9a). Red gurnard have a long spawning period and ripe individuals can be found in the Hauraki Gulf throughout the year (Ministry of Fisheries 2009).

3.6.4 Snapper

Large numbers of 1+ snapper (around 14–19 cm) were caught on the 2009 survey (Figure 6) (Stevenson & Hanchet 2010) and this appeared to indicate a strong year class of fish spawned over the summer of 2007–08. In each survey since 2013, this year class has been dominant in the length frequency. Biomass estimates for snapper from the core strata was 674 t and combined with the new strata was 791 t (Table 4). For the core strata this is the second highest estimate in the time series, down slightly from the time series high in 2015. It should be noted, however, that the core survey area probably does not adequately cover the geographic distribution of snapper.

The highest catch rates were in the two Golden Bay strata (17 and 21). Phase two stations were not included in the biomass estimates because snapper are known to begin moving out of the bays at this time of year. A comparison of the length frequency distributions from stratum 19 between fish caught during phase 1 and phase 2 shows more small fish and fewer large fish taken on the phase 2 stations compared to phase 1 stations, despite a similar geographic spread of stations across the stratum between phases (Appendix 5).

For 2017, the length frequency distributions show a main mode around 46–53 cm and another strong secondary mode at 36–46 cm, but there is some overlap (Figure 5l). In addition, there are two weaker modes at 15–20 cm and 21–28 cm. Most snapper (i.e., 94%) were immature or resting Table 9a). Since snapper spawn in summer maturing or ripe fish were not expected during the survey.

3.6.5 Spiny dogfish

Spiny dogfish were caught at 57 stations with the highest catch rates in strata 19, 12 and 7 (Table 3, Figure 2d). The biomass estimates were relatively stable from 1992 to 2007 but there was a sharp

increase in 2009 to 10 270 t although this was mainly due to a single large catch and so the associated CV was high (Table 4, Figure 3). The 2011 biomass was similar to the rest of the time series, decreasing to 6154 t, the 2013 estimate was the highest in the time series at 15 086 t, but the biomass for 2015 decreased to 7613 t and even further in 2017 to 3255 t, the lowest estimate in the series. The decrease has come entirely from the west coast strata; there was a slight increase in the biomass from Tasman and Golden Bays between 2015 and 2017 (Figure 4). The associated CV for the 2017 biomass estimate is 22%.

There was a decrease in the proportion of fish between 45 and 70 cm and overall the numbers decreased to less than half those seen in 2015 (Figure 5m). Adult fish made up over 61% of the total biomass (Table 5, Figure 7). Juvenile males have historically made up the smallest portion of the total biomass (Figure 8). Adult and juvenile indices track each other fairly closely through the time series. Over 99% of the biomass was at depths less than 200 m (Table 7). The sex ratio was 1.22:1 overall (Figure 5m). Maturity stages for spiny dogfish are shown in Table 9b. For males overall most are mature (approximately 72%) and for females overall, most were mature (approximately 60%). Forty-one percent of all females contained pups compared to over half in 2015. All males less than 40 cm and all females less than 50 cm were immature, whilst only one male greater than 60 cm and two females greater than 70 cm were immature.

3.6.6 Tarakihi

Tarakihi were caught at 53 stations with the highest catch rates in strata 12, 13 and 15 (Table 3, Figure 2e). The biomass estimates show a gradually declining trend until 2003 with a sharp increase in 2005 and a subsequent drop in the next five surveys to levels similar to those seen from 1997 to 2003 (Table 4, Figure 3). For the 2017 survey, the biomass estimate was the second highest of the series at 1857 t, representing an increase of over 75% from 2015. The majority of the biomass has always been from the west coast region, with little from Tasman and Golden Bays. Almost 87% of the biomass estimate was recruited fish (25 cm or over) while the adult biomass (over 31 cm) was 79% of the total (Table 5). The juvenile biomass decreased as a proportion of the total since the 2011 survey and has been at a relatively similar level in the last three surveys (Figure 7). Adult females have historically contributed the majority of the total biomass, followed by adult males (Figure 8).

The length frequency data shows large numbers of fish between 16 and 20 cm compared to 2015 and similar to the 2013 survey. There are also more fish between 23 and 27 cm compared to 2013 and 2015 (Figure 5n). There were distinct modes at 10–14 cm (0+ fish), 15–22 cm (1+ fish) and at about 23–27 cm (2+ fish). Previous reports included a biomass estimate for 2+ fish. However, it is not reported here because for 2017 the size difference in the 2+ modes from Tasman and Golden Bays and the west coast meant that including the larger 2+ fish from the Bays would have captured many 3+ fish from the west coast. The majority of fish under 25 cm were from Tasman and Golden Bays (Figure 5n). The majority of fish over 25 cm were from the west coast. Of the total tarakihi biomass, over 89% was on the west coast (1657 t), and over 73% (1359 t) of the total was at depths between 100 and 200 m (Table 7). The sex ratio for the estimated population was 0.83:1 (Figure 5n). There was little reproductive development in tarakihi under 30 cm, but for bigger fish the full range of gonad stages was recorded, although the majority were still resting or starting to mature (Table 9a). Almost all (i.e., 98%) males greater than 30 cm were running ripe or spent, whilst over 65% of the adult females were maturing but only 2% were running ripe or spent.

3.6.7 Trends in other species

Barracouta

Barracouta were caught at 62 stations and represented 16% of the total catch (Appendix 3). The highest catch rates were in stratum 14 (Table 3). The biomass has varied almost 3-fold during the series but

does not show a consistent trend (Table 4, Figure 3). The majority of the biomass has always come from the west coast region, with little from Tasman and Golden Bays (Figure 4). The 2017 estimate of 4153 t was above average for the series. In most years that had a strong 0+ mode, a large proportion of these fish were from the Tasman and Golden Bay region (Figure 6a). In 2013 however, this mode was almost entirely made up of fish from the west coast. Also, there were usually distinct modes centred at about 45 and 55 cm in most years, both of which were all but absent in 2013 and were again weak in 2015. For 2017, the mode at 45 cm appears much stronger but the 55 cm mode remains weak.

Blue warehou

Blue warehou were caught at 36 stations, with the highest catch rates in strata 14 and 15 (Table 3). The biomass estimate for 2017 (626 t) was the second highest of the series estimates (Table 4, Figure 3). The majority of the biomass has always been from the west coast region (Figure 4) and for 2017 the majority of the biomass was south of Greymouth (Table 7). There was a strong mode in the length frequency distribution for 2017 at 10–20 cm (0+ fish). While not as strong as that seen in 2009 or 2013, it is stronger than that for 2011 and 2015 (Figure 5b). Stevenson & Hanchet (2000) noted that because of the poor precision in the biomass estimates the surveys are probably not suitable for monitoring adult or pre-recruit blue warehou. However, Stevenson (2007b) suggested that the survey may be able to provide information on year class strengths, but ageing of the commercial catch would be required to show if this is the case.

Gemfish

Gemfish were caught at 25 stations, more than in any previous survey (Appendix 3, Table 8). The biomass estimate of 545 t was the second highest in the series but overall the indices do not show any particular trend (Table 4, Figure 3). No gemfish have ever been caught in the Tasman and Golden Bay region (Figure 4). The length frequency distributions occasionally showed apparently strong year classes (Figure 5c). For 2017, three distinct length modes were apparent: 17–22 cm (0+ fish), 26–40 cm (1+ fish), and 41–55 cm (2+ fish).

Hake

Hake were taken in small quantities from 29 stations (Table 8) and almost all fish were under 50 cm (Figure 6). The biomass estimate of 261 t was higher than the previous five surveys, but the biomass estimates have varied widely throughout the time series (Figure 3, Table 4).

Hoki

Hoki were taken from 18 stations, all on the west coast south of Cape Foulwind (Tables 3 and 8). The length frequency distribution for hoki showed a strong mode at 21–31 cm (0+ fish) and a much weaker mode at around 37–44 cm (1+) (Figure 6). In 2011, for the first time in the time series, the strongest mode was for 1+ fish, but for the last three surveys the strongest mode has reverted to being 0+ fish. The biomass estimate of 539 t was the third lowest in the series.

Jack mackerel (*Trachurus declivis*)

T. declivis were caught at 35 stations (Appendix 3). The biomass estimate of 58 t was the second lowest in the series and only slightly greater than the low of 43 t in 2015. (Figure 3, Table 4). Most of the biomass was from the west coast. There was one distinct mode in the length frequency plot at 11–18 cm (Figure 5e) mostly taken from Tasman Bay.

John dory

John dory were caught at 46 stations, with the highest catch rates in the Tasman and Golden Bay strata (Appendix 3, Table 3). The biomass estimate of 431 t was the second highest in the time series (Table

4, Figure 3), down slightly from the time series high in 2015. In some years, more biomass was from the Tasman and Golden Bay region, but in most years more has been from the west coast (Figure 4), mostly north of Cape Foulwind (Table 7). In 2017, only 38% of biomass was from the Tasman and Golden Bay region. The length frequency distribution showed a mode at 21–32 cm (1+ fish), which was stronger than the 1+ mode from any previous survey in the series (Figure 5f). Most of the smaller fish were from the Tasman and Golden Bay region, which is typical of most years (Figure 5f).

Ling

Ling were caught at 29 stations, with the highest catch rates in stratum 16 (Appendix 3, Table 3). The biomass estimate of 150 t was the second lowest from the time series. This reverses a relatively steady increase since 2000 (Table 4, Figure 3). As in all other surveys, the vast majority of the biomass in 2017 was from the west coast region, with little from Tasman and Golden Bays (Figure 4). The scaled length frequency distribution for 2011 showed a strong mode at 36–48 cm for both sexes, but this mode has been weaker but still apparent in each survey since then (Figure 5g). There were no other significant modes in the 2017 length frequency distribution and the low numbers of fish greater than 70 cm would account for the very low biomass estimate for 2017.

Rig

Rig were caught at 48 stations, with the highest catch rates in strata 5, 14 and 17 (Appendix 3, Table 3). The estimated biomass of 506 t was the second highest for any survey in the series, down slightly from the time series high in 2015 (Table 4, Figure 3). Biomass from the Tasman and Golden Bay regions accounted for about 28% of the total in 2017 (Figure 4). The length frequency distributions for 2017 did not show any particularly strong modes (Figure 5j). In the survey series, there were often few females measured greater than about 80 cm, compared with relatively abundant males up to about 100 cm, which may indicate that the survey does not sample adult female rig well.

School shark

School shark were caught at 65 stations, with the highest catch rates in strata 7 and 17 (Appendix 3, Table 3). The estimated biomass of 933 t was the highest since 2011 (Table 4, Figure 3). Most of the biomass was from the west coast (Figure 4). The length frequency distribution for 2017 showed three modes at around 32–40, 43–53 and 54–65 cm for both sexes, similar to 2015 (Figure 5k). There were fewer large school shark caught in the Tasman and Golden Bay region compared to the west coast (Figure 5k).

4. CONCLUSIONS

The 2017 (13th) survey successfully extended the March-April RV *Kaharoa* time series for the west coast of the South Island and Tasman and Golden Bays. The 2017 results show that the series continues to monitor well the target species and adults and/or pre-recruits and juveniles of several other species. The biomass estimates for red gurnard and john dory were the second highest in the series, whilst those for giant stargazer, red cod and tarakihi were within the range of previous surveys, and that for spiny dogfish was the lowest in the series. The high numbers of 1+ fish seen in the length frequency for john dory indicates the increase in abundance, apparent since 2000, should continue for at least another two years.

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Table 1: Stratum depth ranges, survey area, non-trawlable area, number of successful Phase 1 and Phase 2 biomass stations and station density.

Stratum	Depth (m)	Area (km^2)	Non-trawlable area (km^2)	No. of phase 1 Stations	No. of phase 2 stations	Station density (km^2 per station)
1	20–100	1 343	102	4	0	336
2	100–200	4 302	300	5	0	860
5	25–100	1 224	0	3	0	408
6	100–200	3 233	238	3	0	1 078
7	25–100	927	0	3	0	309
8	100–200	2 354	214	4	0	589
9	200–400	1 877	1 456	3	0	626
11	25–100	1 438	63	5	0	288
12	100–200	2 054	501	5	0	411
13	200–400	1 101	466	3	0	367
14	25–100	851	36	3	0	284
15	100–200	881	373	3	0	294
16	200–400	319	35	3	0	106
17	20–33	307	27	3	0	102
18	20–42	947	30	7	0	135
19	20–70	2 436	193	6	5	221
20	10–20	217	0	4	0	54
21	10–20	165	0	2	0	83
Total		25 976	4 034	69	5	351

Table 2: Gear parameters for biomass stations by depth range (*n*, number of stations; s.d., standard deviation).

	n	Mean	s.d.	Range
All stations	74			
Headline height (m)		4.8	0.13	4.3–5.0
Doorspread (m)		79.1	8.75	67.7–99.7
Distance (n. miles)		2.0	3.14	1.99–3.14
Warp:depth ratio		4.7	2.94	2.43–14.81
Tasman/Golden Bays				
10–20 m	6			
Headline height (m)		4.7	0.26	4.3–4.9
Doorspread (m)		68.0	0.16	67.7–68.2
Distance (n. miles)		2.9	0.28	2.28–3.03
Warp:depth ratio		13.0	1.04	11.76–14.81
20–70 m	21			
Headline height (m)		4.8	0.12	4.6–5.0
Doorspread (m)		73.3	0.83	72.3–75.5
Distance (n. miles)		2.8	0.32	1.99–3.11
Warp:depth ratio		5.5	1.74	3.05–9.52
10–70 m	27			
Headline height (m)		4.8	0.17	4.3–5.0
Doorspread (m)		72.1	2.38	67.7–75.5
Distance (n. miles)		2.8	0.31	1.99–3.11
Warp:depth ratio		7.1	3.55	3.05–14.81
West coast				
20–400 m	47			
Headline height (m)		4.8	0.10	4.5–5.0
Doorspread (m)		83.1	8.59	71.4–99.7
Distance (n. miles)		3.0	0.08	2.75–3.14
Warp:depth ratio		3.3	0.96	2.43–6.78
20–100 m	18			
Headline height (m)		4.8	0.13	4.5–5.0
Doorspread (m)		73.9	2.30	71.4–79
Distance (n. miles)		3.0	0.06	2.91–3.14
Warp:depth ratio		4.1	1.11	2.81–6.78
100–200 m	20			
Headline height (m)		4.8	0.06	4.8–5.0
Doorspread (m)		86.1	3.65	75.8–91.1
Distance (n. miles)		3.0	0.09	2.8–3.14
Warp:depth ratio		2.8	0.05	2.68–2.88
200–400 m	9			
Headline height (m)		4.8	0.09	4.6–4.9
Doorspread (m)		94.7	4.07	88.0–99.7
Distance (n. miles)		3.0	0.08	2.9–3.1
Warp:depth ratio		2.6	0.10	2.43–2.69

Table 3: Mean catch rates (kg km^{-2}) by stratum for the 20 most abundant commercially important species in order of catch abundance. Species codes are given in Appendix 3.

	Species code									
Stratum	BAR	SPD	GUR	SNA	NMP	GIZ	RCO	WAR	SPO	SCH
1	54	75	69	10	28	1	74	7	11	39
2	112	82	3	8	83	4	2	0	4	33
5	8	88	27	4	1	0	238	0	42	32
6	144	123	5	0	46	52	12	0	0	44
7	168	282	190	2	10	31	42	6	14	161
8	32	42	3	0	30	144	4	0	2	20
9	1	0	0	0	13	5	0	0	0	7
11	245	146	266	0	14	17	133	27	15	27
12	112	313	1	0	226	243	151	2	14	91
13	26	27	0	0	174	187	34	0	0	7
14	2 225	180	264	0	15	153	5	234	237	14
15	136	98	0	0	359	253	205	344	18	15
16	0	0	0	0	2	57	24	0	0	15
17	24	16	165	489	55	5	12	5	47	56
18	149	28	184	169	69	0	21	13	31	13
19	48	321	219	141	49	3	2	30	40	23
20	N/A	N/A	N/A	241	N/A	N/A	N/A	N/A	N/A	N/A
21	N/A	N/A	N/A	397	N/A	N/A	N/A	N/A	N/A	N/A

	Species code									
Stratum	HOK	RSO	GSH	JDO	FRO	JMN	SFL	LIN	LEA	RSK
1	0	0	20	31	0	22	0	2	0	38
2	0	4	27	30	14	0	0	0	0	5
5	0	0	0	0	0	1	0	14	0	29
6	0	14	147	19	10	0	0	0	0	0
7	18	0	0	17	4	5	1	1	0	58
8	0	9	17	4	47	0	0	8	0	0
9	15	32	1	0	1	0	0	2	0	7
11	2	3	0	5	0	6	0	12	0	5
12	197	110	23	0	84	1	0	10	0	9
13	7	140	8	0	105	0	0	5	0	3
14	0	0	0	0	0	0	0	8	0	11
15	17	10	22	0	15	0	0	2	0	0
16	195	22	112	0	19	0	0	165	0	0
17	0	0	0	47	0	43	63	0	34	0
18	0	0	0	55	0	42	73	0	53	6
19	0	0	0	40	0	23	9	0	45	22

N/A, Not applicable

Table 4: Relative biomass estimates (t) and CVs by trip from the entire survey area for species managed under the QMS. Species codes are given in Appendix 3.

Species	KAH9204		KAH9404		KAH9504		KAH9701		KAH0004		KAH0304		KAH0503		KAH0704		KAH0904	
code	Biomass	CV	Biomass	CV	Biomass	CV	Biomass	CV	Biomass	CV	Biomass	CV	Biomass	CV	Biomass	CV	Biomass	CV
BAR	2 420	15	5 228	16	4 474	13	2 993	19	1 787	11	4 485	20	2 763	13	2 582	14	3 512	17
ELE	21	42	167	33	84	35	94	33	42	63	48	34	59	33	28	53	185	83
ESO	68	33	68	16	38	31	45	29	16	32	21	57	27	45	39	71	75	32
FRO	24	33	27	23	89	31	259	32	316	16	494	22	423	45	529	39	835	35
GIZ	1 450	14	1 358	17	1 556	16	1 450	15	1 023	12	834	15	1 458	19	1 630	13	1 952	19
GSH	380	17	722	14	767	24	1 591	21	2 259	8.8	544	15	832	22	2 215	21	900	17
GUR	564	16	551	14	577	19	470	13	625	14	270	20	442	17	553	17	651	18
HAK	390	25	99	31	5 197	27	1 019	46	15	36	55	47	1 673	30	359	35	212	56
HOK	404	16	826	49	3 611	21	1 100	25	103	50	233	22	701	55	772	52	1 302	46
JDO	101	29	73	27	27	36	17	31	141	16	288	19	222	14	174	26	269	23
JMD	90	24	97	26	106	20	162	19	168	33	87	21	118	22	62	23	79	23
JMN	258	57	68	23	57	29	363	27	194	46	126	49	98	21	214	62	399	24
LEA	185	30	230	23	153	34	231	34	236	50	254	18	139	20	252	40	323	27
LIN	280	19	261	20	373	16	151	30	95	46	150	33	274	37	180	27	291	37
LSO	86	19	77	25	124	21	68	21	59	19	2	44	21	42	119	46	62	16
NMP	1 351	13	1 403	13	1 417	10	1 087	12	964	19	912	20	2 050	12	1 189	21	1 088	22
NSD	130	19	159	21	89	28	164	46	256	18	111	27	180	22	134	29	189	28
RCO	2 690	13	3 370	18	3 077	15	2 546	23	414	26	906	24	2 610	18	1 638	19	2 782	25
RSK	171	25	198	22	250	22	185	31	186	23	43	34	58	30	256	23	114	22
RSO	130	19	68	29	21	55	704	83	120	30	137	23	474	49	101	19	143	29
SCH	975	21	1 176	40	1 201	35	1 432	25	896	13	655	18	774	14	816	20	1 085	16
SFL	98	30	203	23	132	28	106	28	62	22	10	33	62	25	67	47	170	32
SNA	71	32	15	56	22	47	115	48	21	59	10	93	10	70	56	70	81	58
SPD	3 856	15	7 093	7.1	8 370	10	5 275	13	4 777	13	4 446	15	6 175	12	6 291	14	10 270	19
SPE	233	21	425	18	667	23	338	14	302	22	76	25	150	20	163	19	336	20
SPO	286	14	378	10	487	10	308	18	333	18	144	22	153	19	383	33	274	26
SQU	2 765	18	1 195	9.2	3 467	14	966	13	523	11	2 255	12	889	9.3	1 228	9	402	16
SSK	330	18	336	18	315	20	302	26	140	29	91	79	80	30	55	44	67	61
SWA	267	37	64	35	39	19	204	20	99	34	69	27	72	28	165	20	80	24
WAR	123	40	80	22	113	29	842	31	272	37	191	66	116	40	286	50	175	27

Table 4—continued (SNA biomass does not include phase 2 stations).

Species	KAH1104		KAH1304		KAH1503		KAH1703	
code	Biomass	CV	Biomass	CV	Biomass	CV	Biomass	CV
BAR	4 958	21	3 423	16	2 662	21	4 153	30
ELE	169	53	110	26	72	45	92	65
ESO	26	42	25	26	92	40	119	20
FRO	251	29	424	24	341	34	518	23
GIZ	1 620	16	2 118	9	1 984	11	1 674	14
GSH	2 348	23	981	23	1 211	55	772	37
GUR	837	21	754	12	1 776	16	1 708	12
HAK	44	36	36	41	81	37	217	61
HOK	1 527	61	1 545	43	2 129	36	539	62
JDO	327	18	231	21	487	16	431	12
JMD	217	37	106	43	43	40	58	23
JMN	95	39	56	35	399	38	156	19
LEA	111	20	231	19	239	30	170	15
LIN	234	43	405	44	472	53	150	18
LSO	62	16	43	37	90	22	85	16
NMP	1 331	15	1 272	22	1 060	17	1 857	18
NSD	368	29	211	26	259	22	180	25
RCO	2 055	28	1 247	38	989	45	1 247	21
RSK	261	21	243	24	150	20	270	21
RSO	101	34	113	28	186	17	545	28
SCH	1 099	14	912	12	788	17	933	15
SFL	71	23	48	52	84	33	112	21
SNA (core strata)	66	31	277	56	837	32	674	20
SNA (+ 10-20 m)							791	17
SPD	6 154	14	15 086	57	7 613	21	3 255	22
SPE	548	39	161	20	191	21	153	31
SPO	264	20	278	20	622	27	506	33
SQU	153	14	308	14	419	21	280	16
SSK	180	34	188	29	342	25	62	37
SWA	69	32	68	28	109	32	86	22
WAR	263	27	248	22	222	36	646	51

Table 5: Estimates of recruited biomass (fish length ≥ recruited length) and adult biomass (fish length ≥ 50% maturity length).

Species	Recruited length (cm)	Tasman and Golden Bays		West coast		Total survey area		50% maturity length (cm)	Total survey area	
		Biomass	CV %	Biomass	CV %	Biomass	CV %		Biomass	CV %
Barracouta	50	47	23	3 678	34	3 725	33			
Blue warehou	45	68	77	531	61	599	54			
Giant stargazer	30	6	53	1 656	14	1 662	14	45	1 552	14
Hoki	65	0	0	44	90	44	90			
John dory	25	160	14	266	17	426	12			
Ling	65	0	0	83	20	83	20			
Red cod	40	11	32	822	23	833	22	50	423	22
Red gurnard	30	436	15	916	16	1 352	12	30	1 352	12
Rig	90	34	31	89	38	123	29			
Sand flounder	25	68	23	1	100	69	23			
Snapper (core strata)	25							25	674	20
(all strata)	25	733	18	57	40	789	17	25	789	17
Spiny dogfish								58	1 239	42
								72	752	28
School shark	90	19	59	425	31	444	30			
Silver warehou	25	1	89	11	52	12	48			
Tarakihi	25	48	40	1 615	20	1 664	19	31	1 459	20

Table 6: Biomass estimates (t) by year class estimated from length frequency distributions.

Species	Year class	Length range (cm)	Biomass	CV (%)
Barracouta	0 +	>17	2.2	35.1
	1 +	17–27	34.7	40.4
	2 +	28–36	2.7	35.5
	3 +	37–52	401.2	31.2
Blue warehou	0 +	>22	27.5	38.6
Hake	0 +	>19	8.6	61.0
	1 +	19–27	124.2	74.5
	2 +	28–41	73.4	54.1
Hoki	0 +	>33	426.3	73.5
Jack mackerel	0 +	>28	99.2	20.7
T. novaezelandiae	1 +	28–38	57.1	34.3
Red cod	0 +	>23	20.9	32.0
	1 +	23–33	245.1	33.1
Red gurnard	0 +	>18	1.3	25.9
	1 +	18–27	241.2	30.9
School shark	0 +	>44	26.3	41.2
	1 +	44–54	69.4	19.1
Silver warehou	0 +	>26	74.1	23.0
Snapper	2 +	15–19	0.4	68.4
	3 +	20–27	3.4	72.5
Tarakihi	0 +	9–15	3.6	44.8
	1 +	16–20	76.0	28.4

Table 7: Estimated biomass (t) (and % CV) by stratum for the 20 most abundant commercially important species in order of catch abundance. Species codes are given in Appendix 3. –, no data, + less than 0.5 t.

	Species code									
Stratum	BAR	SPD	GUR	SNA	NMP	GIZ	RCO	WAR	SPO	SCH
1	73	100	93	13	37	1	100	9	15	53
	(90)	(36)	(52)	(78)	(58)	(84)	(100)	(100)	(49)	(82)
2	482	352	14	36	358	19	9	–	17	142
	(95)	(27)	(61)	(54)	(67)	(58)	(100)	(0)	(64)	(28)
5	10	108	34	5	1	–	292	+	51	39
	(74)	(21)	(23)	(100)	(100)	(0)	(10)	(100)	(52)	(40)
6	465	398	17	–	150	168	40	–	–	142
	(43)	(70)	(46)	(0)	(36)	(71)	(89)	(0)	(0)	(72)
7	156	261	176	2	9	28	38	6	13	150
	(35)	(40)	(41)	(100)	(100)	(100)	(14)	(84)	(46)	(25)
8	76	99	7	–	71	338	8	–	4	46
	(42)	(33)	(100)	(0)	(55)	(34)	(58)	(0)	(100)	(20)
9	2	–	–	–	25	10	–	–	–	13
	(100)	(0)	(0)	(0)	(58)	(52)	(0)	(0)	(0)	(100)
11	352	209	382	–	20	24	191	38	21	38
	(52)	(51)	(30)	(0)	(98)	(62)	(94)	(91)	(41)	(40)
12	229	643	2	–	464	499	310	4	28	188
	(48)	(20)	(100)	(0)	(30)	(14)	(30)	(100)	(61)	(31)
13	29	30	–	–	192	206	37	–	–	7
	(78)	(52)	(0)	(0)	(40)	(32)	(50)	(0)	(0)	(50)
14	1894	153	225	–	13	130	5	199	202	12
	(59)	(83)	(25)	(0)	(70)	(56)	(100)	(100)	(80)	(91)
15	120	87	–	–	316	223	180	303	16	14
	(46)	(90)	(0)	(0)	(43)	(48)	(63)	(83)	(100)	(41)
16	–	–	–	–	0.5	18	8	–	–	5
	(0)	(0)	(0)	(0)	(51)	(34)	(51)	(0)	(0)	(67)
17	8	5	51	150	17	2	4	2	14	17
	(38)	(34)	(12)	(29)	(99)	(91)	(34)	(54)	(72)	(56)
18	141	26	174	160	66	+	20	12	30	12
	(46)	(74)	(23)	(40)	(55)	(18)	(42)	(53)	(35)	(38)
19	116	783	533	342	119	7	6	73	96	56
	(34)	(77)	(26)	(26)	(42)	(52)	(27)	(72)	(15)	(33)

Table 7– continued

Stratum	Species code: HOK	RSO	GSH	JDO	FRO	JMN	SFL	LIN	LEA	RSK
1	–	–	26	41	+	30	–	2	–	50
	(0)	(0)	(77)	(16)	(58)	(61)	(0)	(63)	(0)	(36)
2	0	17	117	131	61	–	–	1	–	21
	(0)	(100)	(76)	(33)	(66)	(0)	(0)	(100)	(0)	(46)
5	–	–	–	1	+	2	–	17	–	35
	(0)	(0)	(0)	(100)	(100)	(26)	(0)	(63)	(0)	(46)
6	–	45	476	60	34	–	–	1	–	–
	(0)	(86)	(56)	(14)	(79)	(0)	(0)	(100)	(0)	(0)
7	17	–	–	15	3	5	1	1	–	54
	(100)	(0)	(0)	(50)	(100)	(54)	(100)	(100)	(0)	(85)
8	1	22	40	10	111	–	–	19	–	–
	(100)	(49)	(52)	(43)	(41)	(0)	(0)	(60)	(0)	(0)
9	29	61	3	–	2	–	–	5	–	13
	(62)	(29)	(61)	(0)	(100)	(0)	(0)	(100)	(0)	(75)
11	3	4	–	7	–	9	–	17	–	8
	(62)	(100)	(0)	(92)	(0)	(77)	(0)	(65)	(0)	(100)
12	404	227	47	–	173	2	–	20	–	19
	(82)	(34)	(54)	(0)	(28)	(100)	(0)	(58)	(0)	(53)
13	8	154	9	–	115	–	–	6	–	3
	(89)	(81)	(54)	(0)	(76)	(0)	(0)	(100)	(0)	(100)
14	–	–	–	–	–	–	–	7	–	9
	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(100)	(0)	(71)
15	15	8	19	0	13	–	–	2	–	–
	(53)	(53)	(92)	(0)	(91)	(0)	(0)	(85)	(0)	(0)
16	62	7	36	–	6	–	–	53	–	–
	(73)	(46)	(45)	(0)	(47)	(0)	(0)	(20)	(0)	(0)
17	–	–	–	14	–	13	19	–	11	–
	(0)	(0)	(0)	(34)	(0)	(58)	(29)	(0)	(89)	(0)
18	–	–	–	52	–	39	70	–	50	6
	(0)	(0)	(0)	(31)	(0)	(29)	(20)	(0)	(31)	(81)
19	–	–	–	98	–	57	22	+	109	52
	(0)	(0)	(0)	(16)	(0)	(30)	(80)	(67)	(17)	(19)

Table 8: Number of biological and length frequency records. Measurement methods; 1, fork length; 2, total length; 5, pelvic length; G, chimaera length. †, data includes one or more of the following: fish length, fish weight, gonad/maturity stage, otoliths. Species codes are given in Appendix 3.

		Length frequency data		Biological data (†)		
Species code	Measurement method	No. of samples	No. of fish	No. of samples	No. of fish	No. of otoliths
ATT	1	6	144			
BAR	1	60	2 790			
BCO	2	19	488			
BRI	2	5	29			
CAR	2	12	48	13	49	
ELE	1	5	24			
EMA	1	2	63			
ESO	2	17	393			
FRO	1	22	543			
GIZ	2	51	747	47	416	330
GSH	G	22	466			
GUR	1	53	4 360	48	804	460
HAK	2	25	441			
HAP	2	2	2			
HOK	2	17	1 019			
JDO	2	45	658	41	437	
JMD	1	30	540			
JMN	1	33	1 543			
KIN	1	4	4			
LEA	2	20	1 306			
LIN	2	28	220			
LSO	2	47	787	1	31	
MOK	1	1	1			
NMP	1	53	2 608	48	731	431
NSD	2	15	70			
RBT	1	6	165			
RCO	2	53	1 949	49	716	477
RSK	5	35	194	30	149	
RSO	1	25	751			
SCH	2	65	741	60	494	
SFL	2	21	1 312			
SNA	1	32	1 153	28	391	
SPD	2	57	2 205	52	785	
SPE	2	33	983			
SPO	2	47	603	43	432	
SSK	5	11	19	11	19	
SWA	1	36	962			
THR	2	2	2	2	2	

Table 8—continued.

		Length frequency data		Biological data (†)		
Species code	Measurement method	No. of samples	No. of fish	No. of samples	No. of Fish	No. of otoliths
TRE	1	1	1			
WAR	1	34	911	2	131	
YBF	2	9	157	1	43	
YEM	1	6	220			

Table 9: Numbers of the five target species sampled at each reproductive stage (small fish of undetermined sex were not included). –; no data.

a) Teleosts

	Male gonad stages					Female gonad stages					
Length (cm)	1	2	3	4	5	1	2	3	4	5	Total
Giant stargazer											
<20	17	–	–	–	–	11	–	–	–	–	28
21–30	4	–	–	–	–	10	–	–	–	–	14
31–40	15	3	2	–	–	13	–	–	–	–	33
41–50	12	42	38	3	–	11	–	–	–	–	106
51–60	4	44	24	2	1	18	19	1	–	–	113
61–70	1	3	4	–	–	12	92	–	–	1	113
>70	–	–	–	–	–	–	4	–	–	–	4
Total	53	92	68	5	1	75	115	1	0	1	411
Red cod											
11–20	37	–	–	–	–	60	–	–	–	–	97
21–30	82	2	–	–	–	66	–	–	–	–	150
31–40	72	3	1	–	–	133	–	–	–	–	209
41–50	73	9	13	2	–	55	3	–	–	–	155
51–60	12	3	7	2	–	57	6	4	2	–	93
>60	–	–	–	–	–	3	1	1	–	–	5
Total	276	17	21	4	0	374	10	5	2	0	709
Red gurnard											
<21	28	–	–	–	–	18	–	–	–	–	46
21–30	74	26	24	9	3	115	7	–	–	1	259
31–40	11	15	43	63	34	53	108	17	4	11	359
>40	–	1	3	10	8	5	82	18	6	7	140
Total	113	42	70	82	45	191	197	35	10	19	804
Snapper											
21–30	11	–	–	–	–	5	–	–	–	–	16
31–40	43	2	–	–	–	28	2	–	–	–	75
41–50	92	–	1	–	3	99	4	–	–	–	199
51–60	15	–	–	–	1	23	2	–	–	2	43
61–70	4	–	1	–	1	5	1	–	–	–	12
>70	3	–	–	–	–	1	–	–	–	–	4
Total	168	2	2	0	5	161	9	0	0	2	349
Tarakihi											
<11	–	–	–	–	–	1	–	–	–	–	1
11–20	71	16	1	–	–	78	1	–	–	–	167
21–30	57	5	2	1	6	74	3	–	–	–	148
31–40	15	1	1	45	47	69	126	15	–	4	323
>40	–	–	–	5	9	3	63	8	2	1	91
Total	143	22	4	51	62	225	193	23	2	5	730

Gonad stages used were: 1, immature or resting; 2, maturing (oocytes visible in females, thickening gonad but no milt expressible in males); 3, mature (hyaline oocytes in females, milt expressible in males); 4, running ripe (eggs and milt free flowing); 5, spent (gonads flacid and bloodshot)

Table 9—continued.

b) Elasmobranchs

Spiny dogfish

	Male maturity stages			Female maturity stages						
	1	2	3	1	2	3	4	5	6	Total
Length (cm)										
<31	2	–	–	1	–	–	–	–	–	3
31–40	35	–	–	29	–	–	–	–	–	64
41–50	47	–	–	40	–	–	–	–	–	87
51–60	7	18	61	8	35	1	–	–	–	130
61–70	–	4	218	–	35	19	7	39	1	323
71–80	–	–	11	–	2	14	23	92	1	143
>80	–	–	–	–	–	2	3	22	–	27
Total	91	22	290	78	72	36	33	153	2	777

Maturity stages used were:

Males
1. Immature (Claspers shorter than the pelvic fins)
2. Maturing (Claspers at least as long as the pelvic fins but soft)
3. Mature (Claspers longer than the pelvic fins and hard and firm)

Females
1. Immature (No eggs visible in the ovary larger than about 2 mm in diameter)
2. Maturing (Ovary contains eggs greater than 2 mm in diameter but no yolk apparent)
3. Mature (Yolked eggs in the ovary, uterus small and firm)
4. Ripe ('Candle' of eggs in the uterus, no embryos visible)
5. Running Ripe (Embryos visible in the uterus)
6. Spent (No embryos in the ovary, ovary flabby and may be bloodshot. Yolked eggs may be present in the ovary)

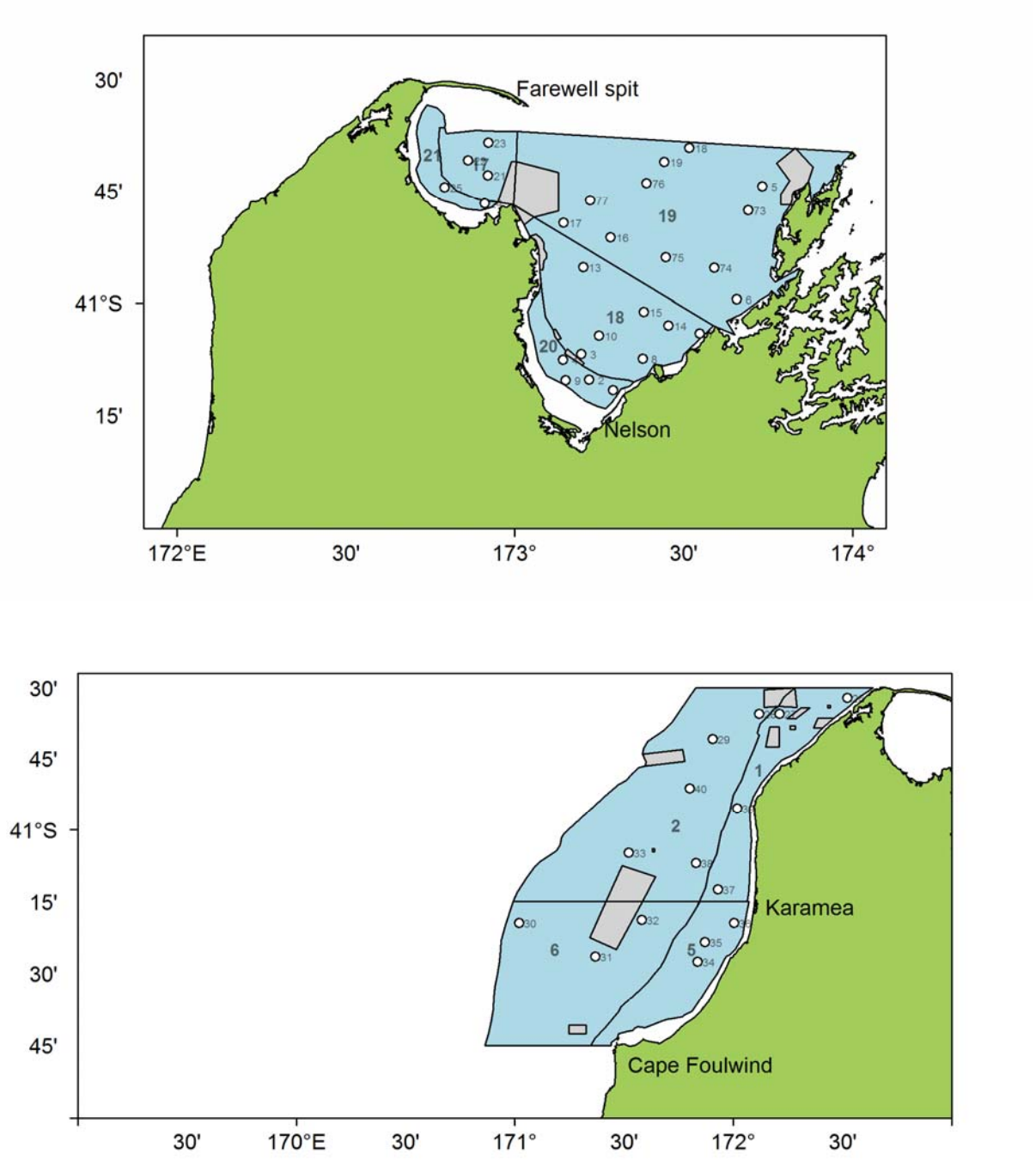


Figure 1a: Survey area showing stratum boundaries and numbers (bold type) for Tasman and Golden Bays (top) and the west coast north of Cape Foulwind (bottom), with station positions (white circles) and station numbers.

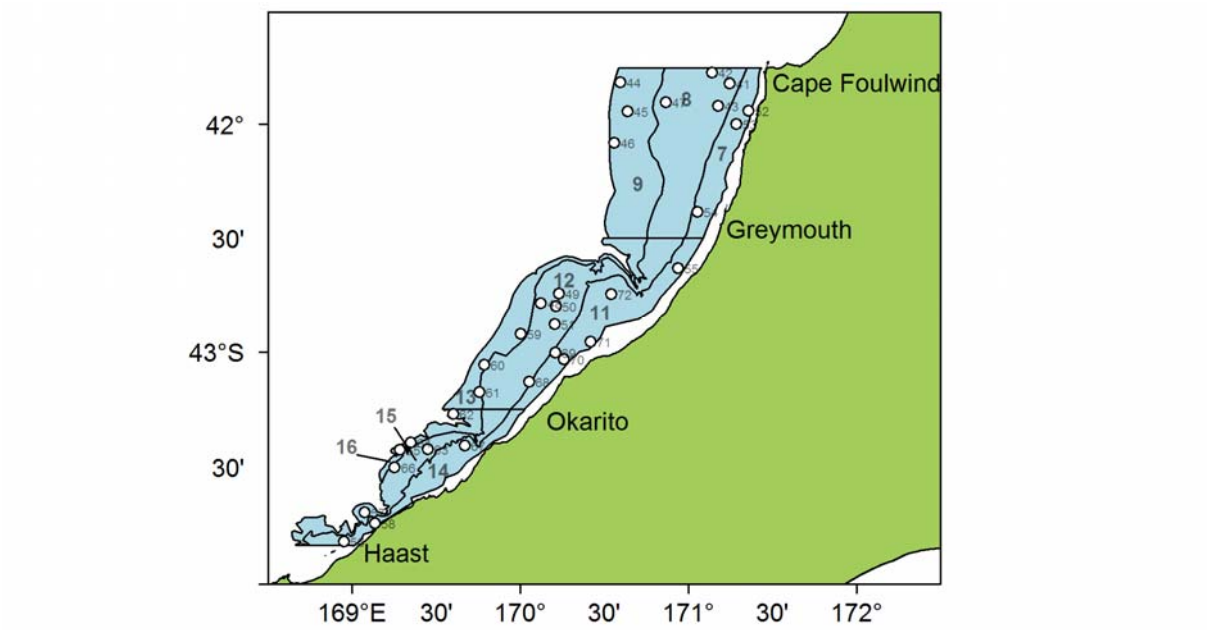


Figure 1b: Strata boundaries and numbers (bold type) south of Cape Foulwind with station positions (white circles) and station numbers.

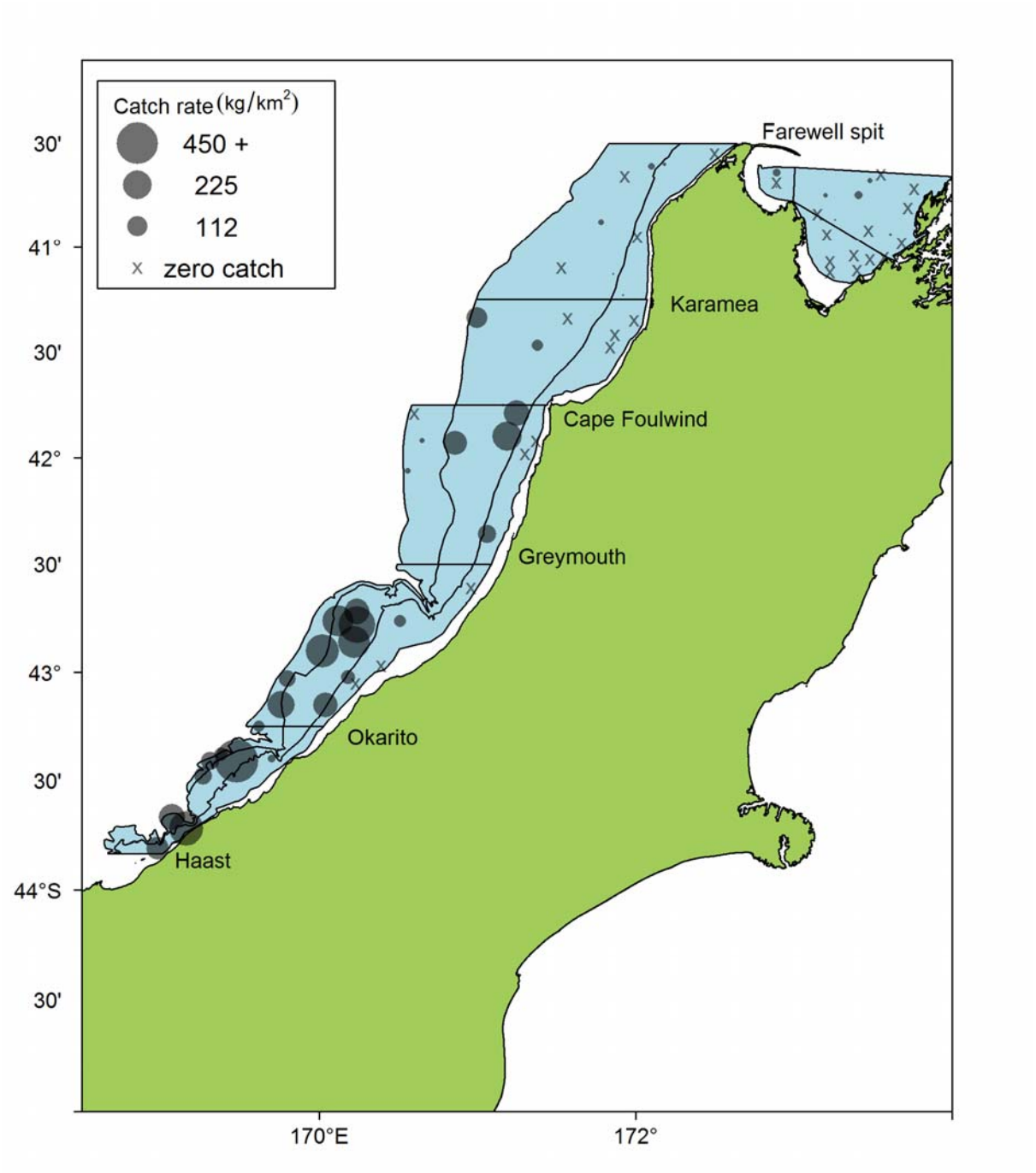
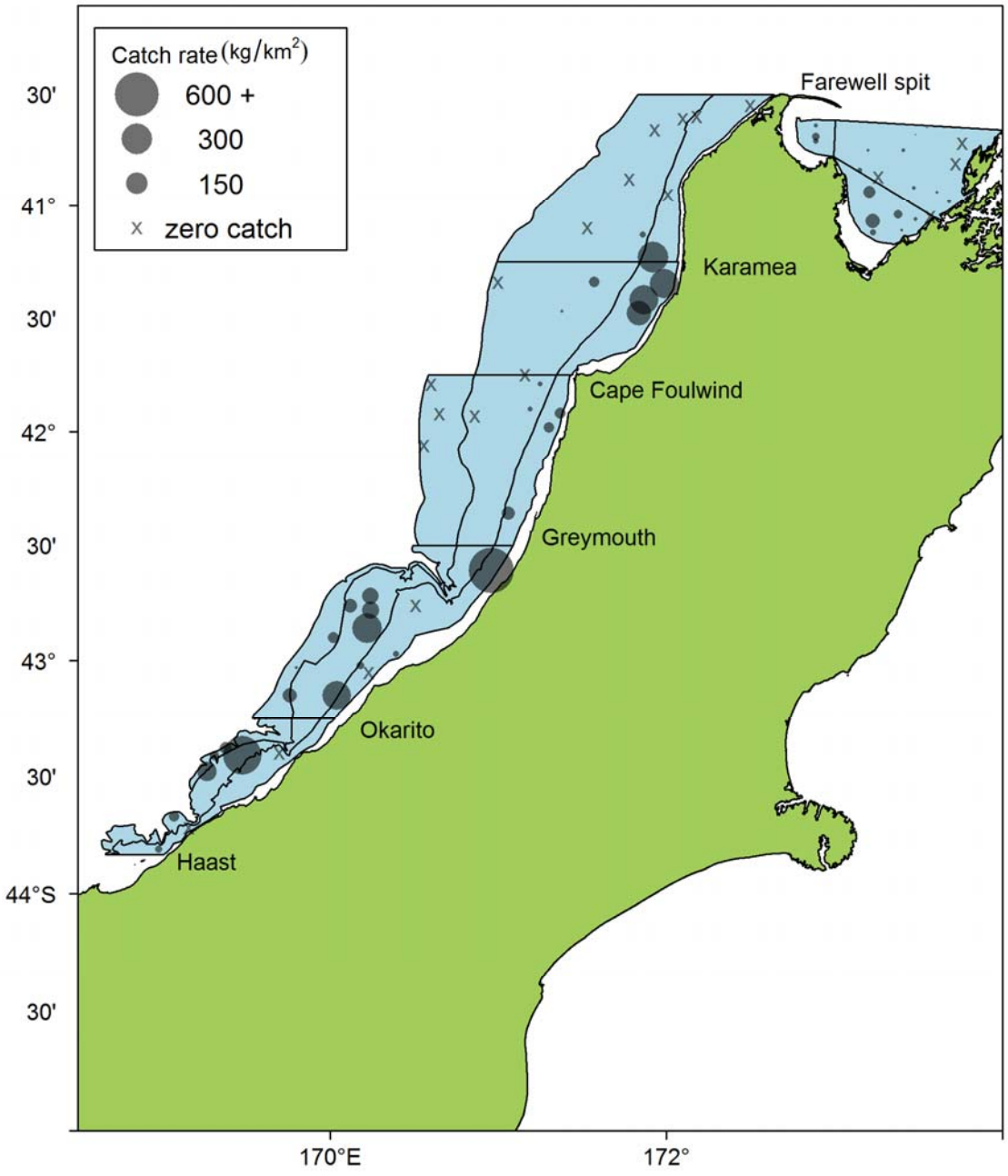
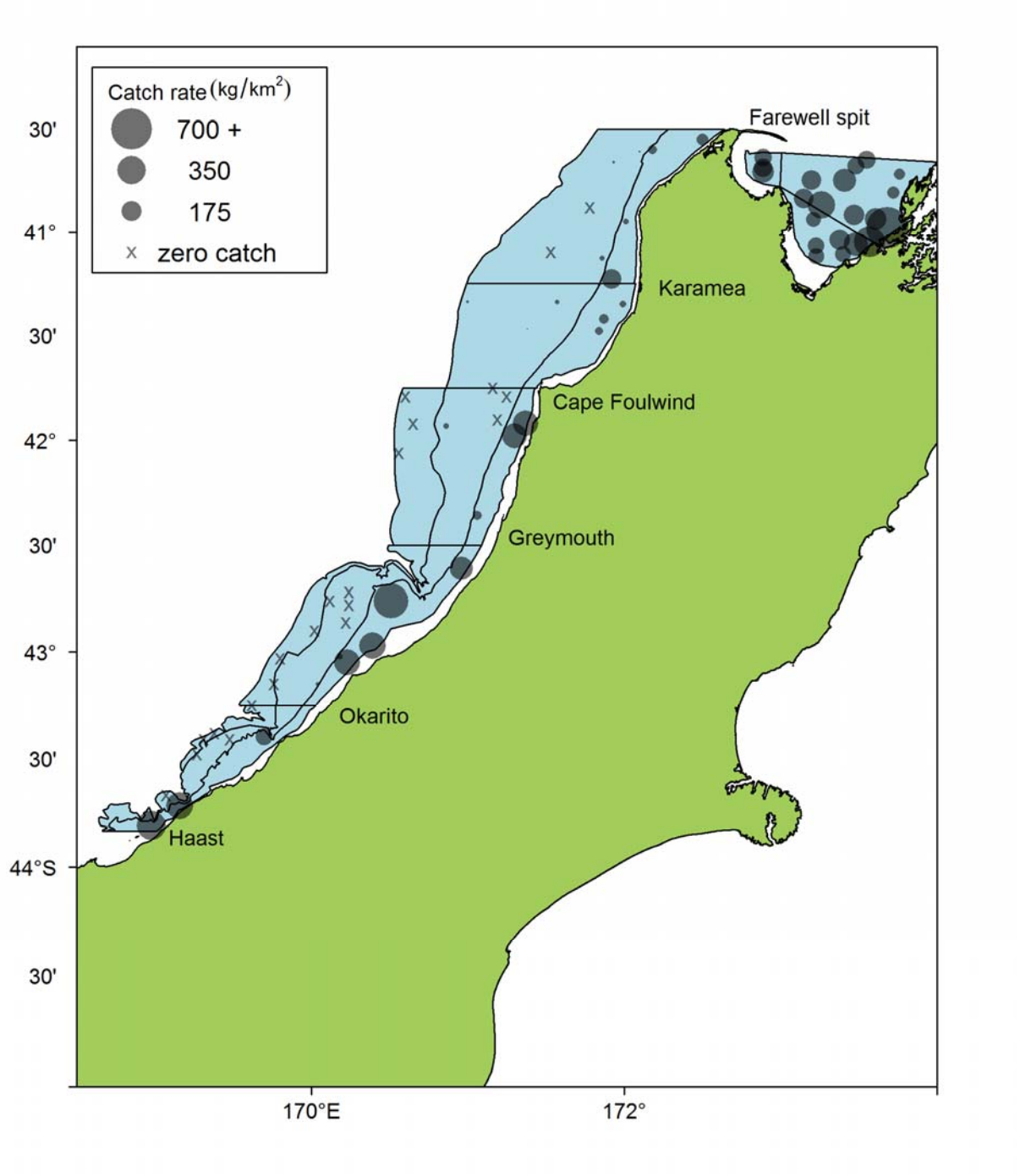


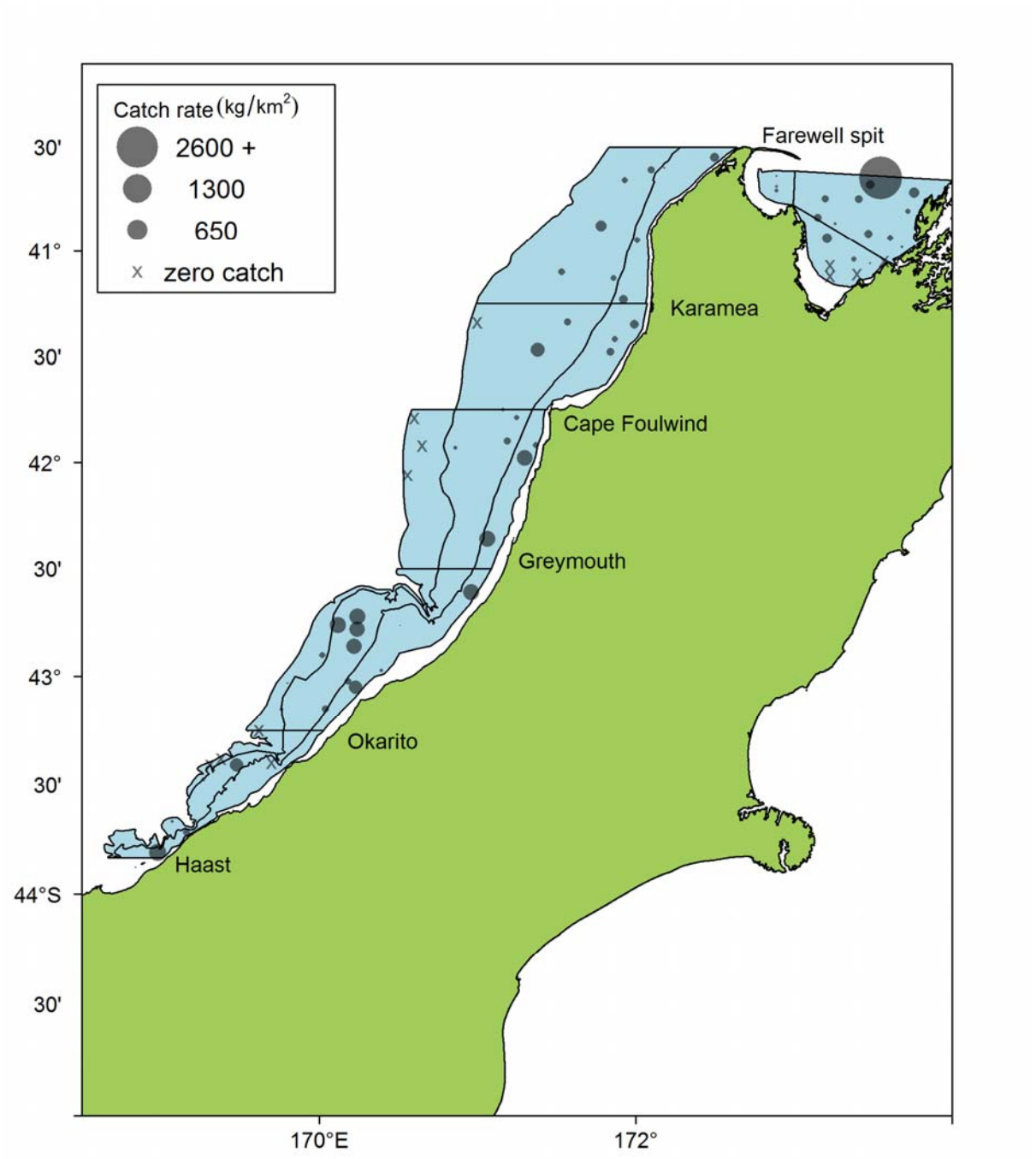
Figure 2: Catch rates (kg km^{-2}) and distribution for the target species in alphabetical order by common name.
a: Giant stargazer (maximum catch rate = 490 kg km^{-2}).



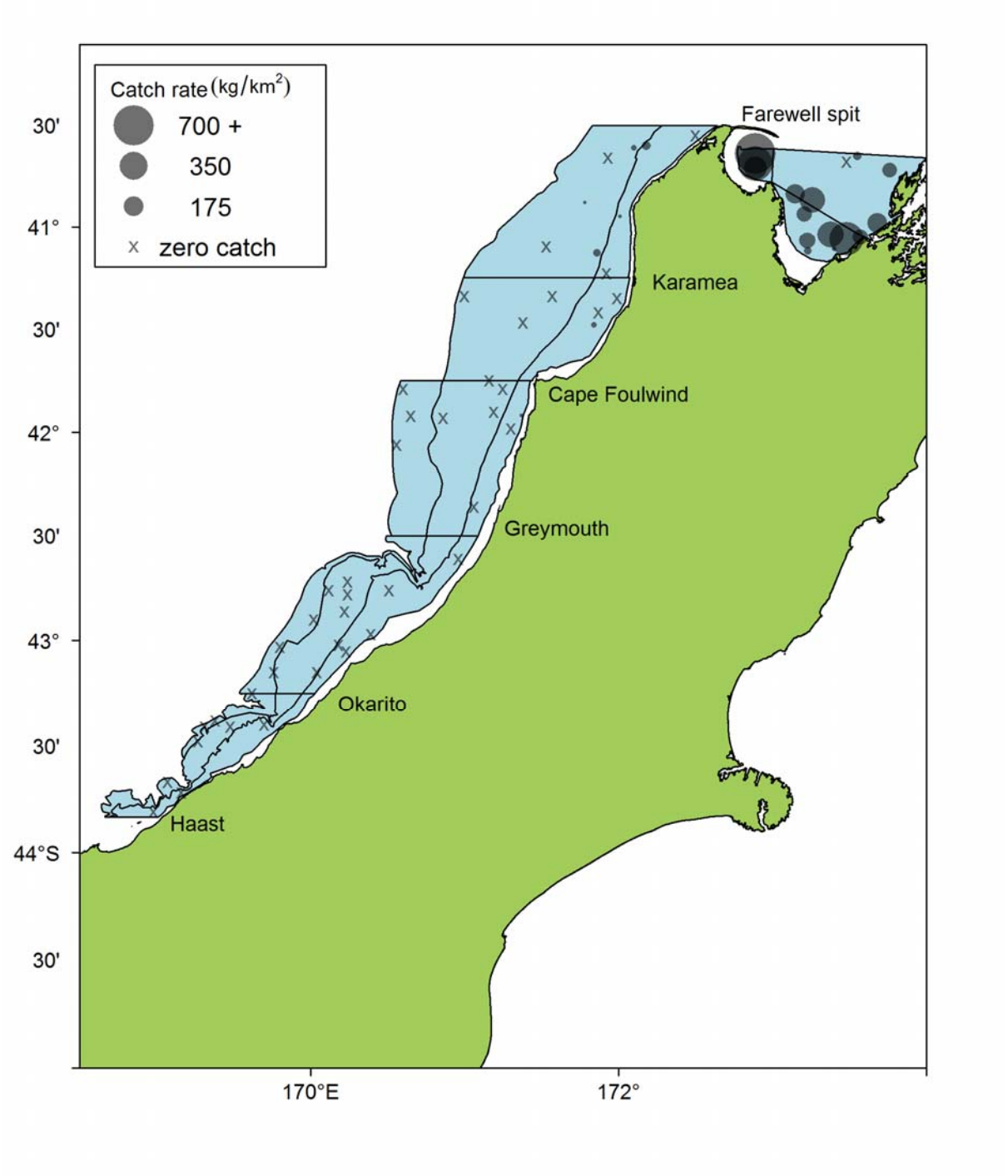
b: Red cod (maximum catch rate = 633 kg km^{-2}).



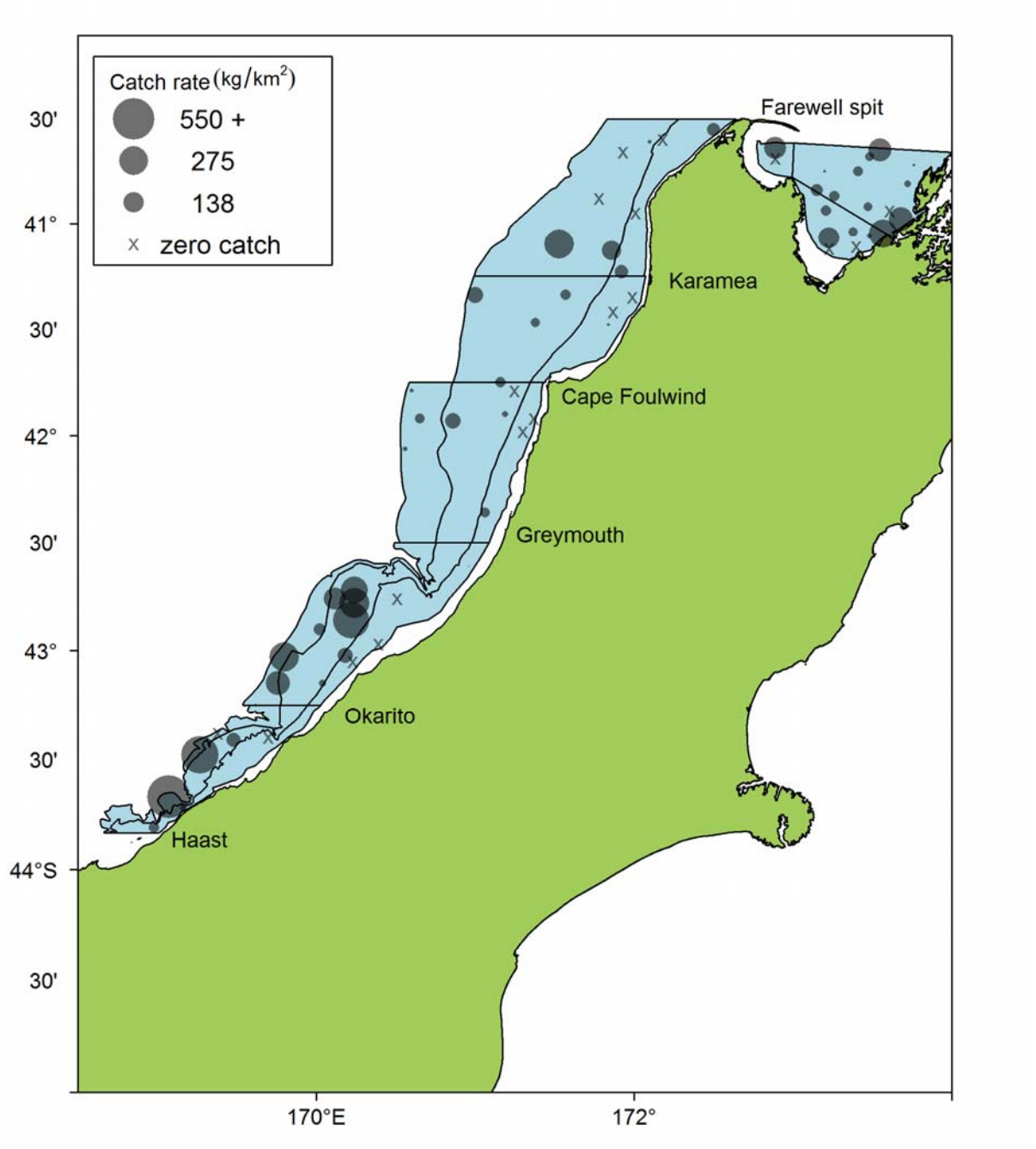
c: Red gurnard (maximum catch rate = 735 kg km^{-2}).



d: Spiny dogfish (maximum catch rate = 2 794 kg km^{-2}).



e. Snapper (maximum catch rate = 718 kg km$^{-2)}$.



f: Tarakihi (maximum catch rate = 573 kg km^{-2}).

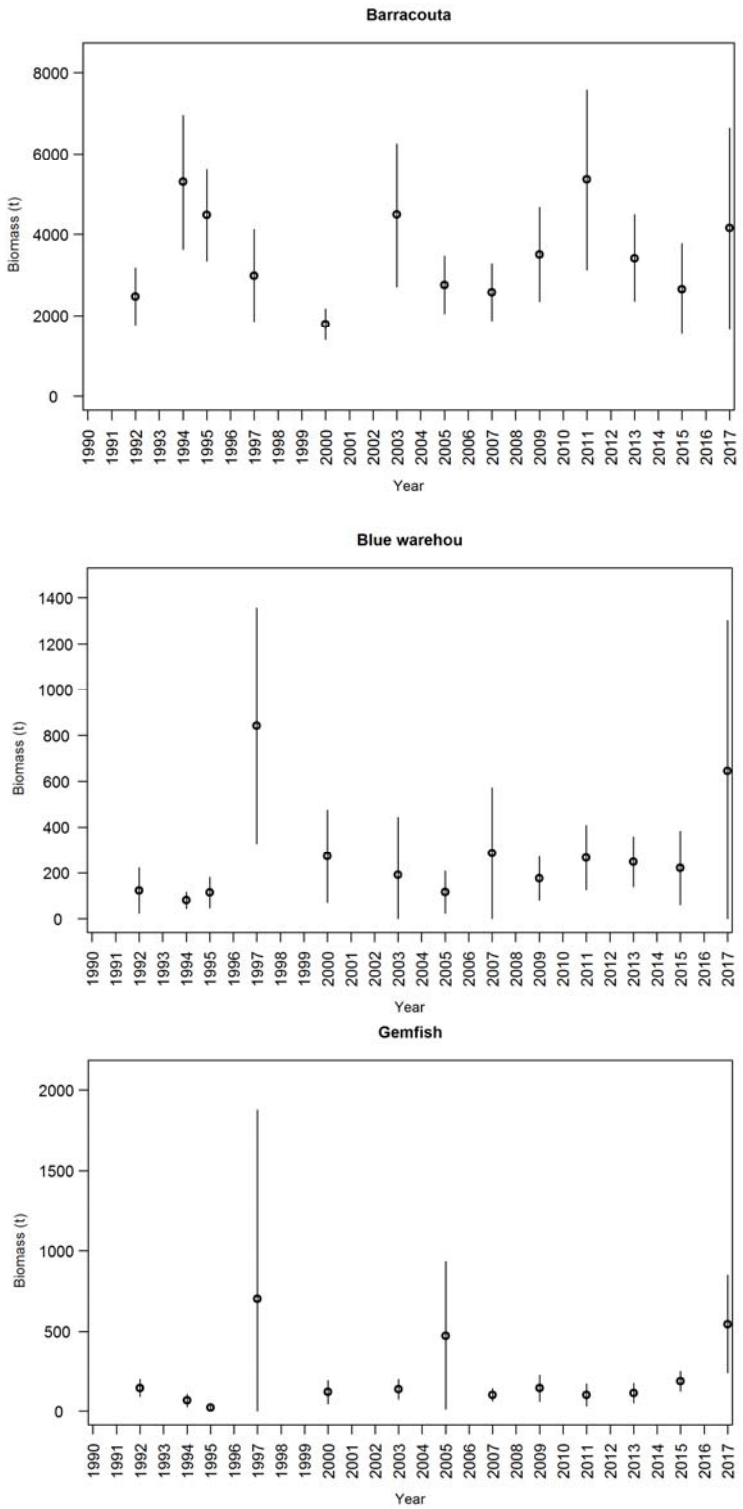


Figure 3: Trends in total biomass from the core strata for the target species and other species reliably monitored by the survey time series. Arranged in alphabetical order by common name. Error bars are +/- two standard deviations.

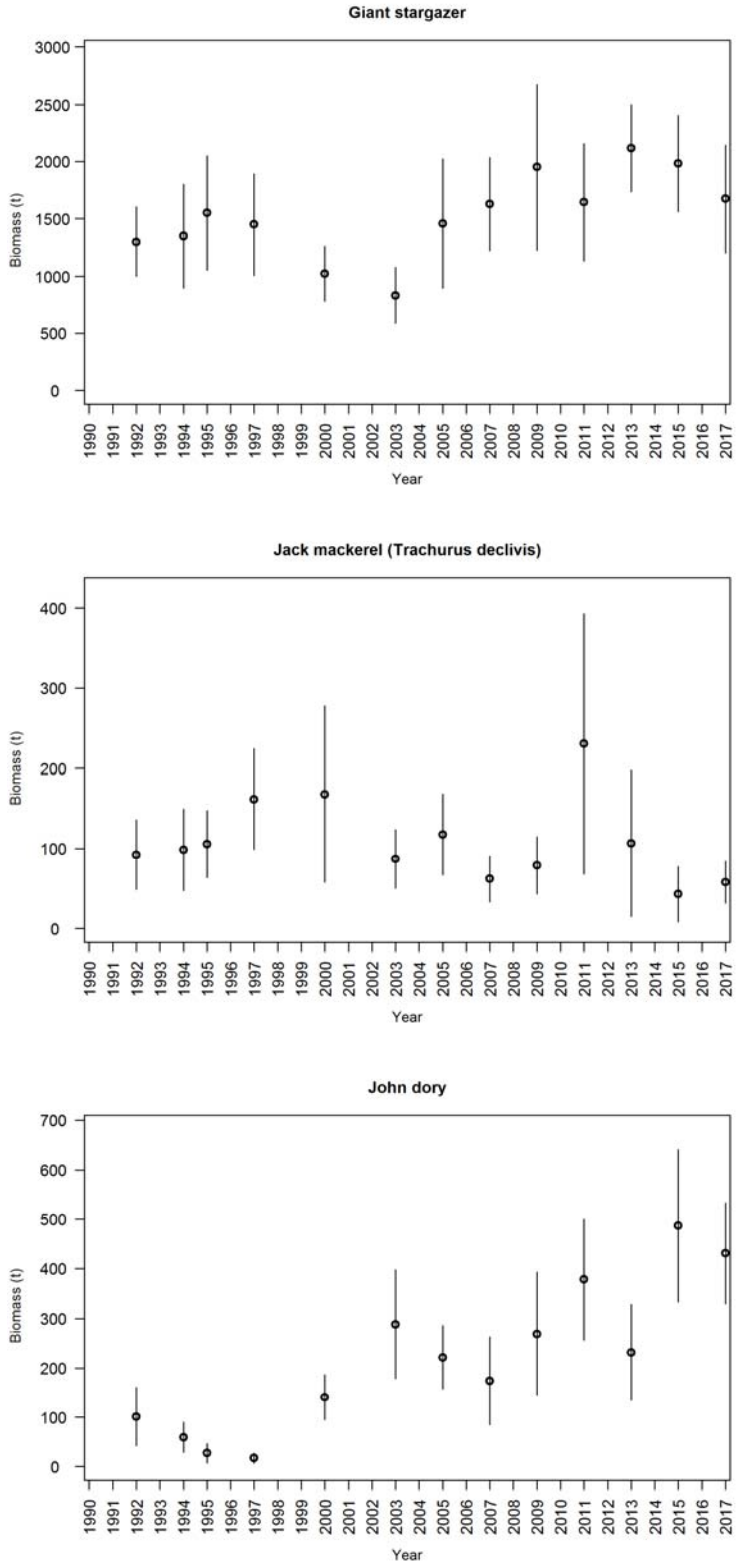


Figure 3—continued.

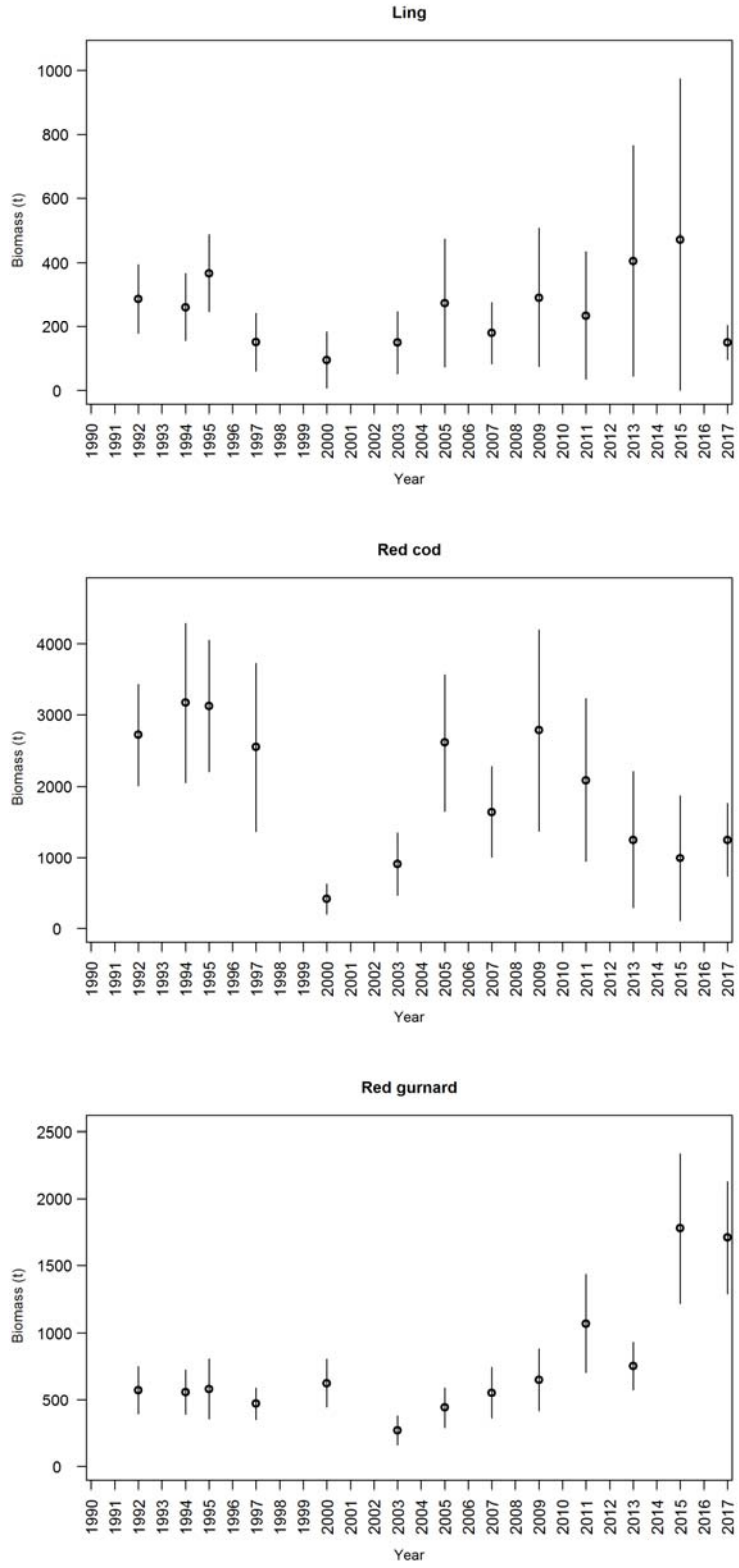


Figure 3—continued.

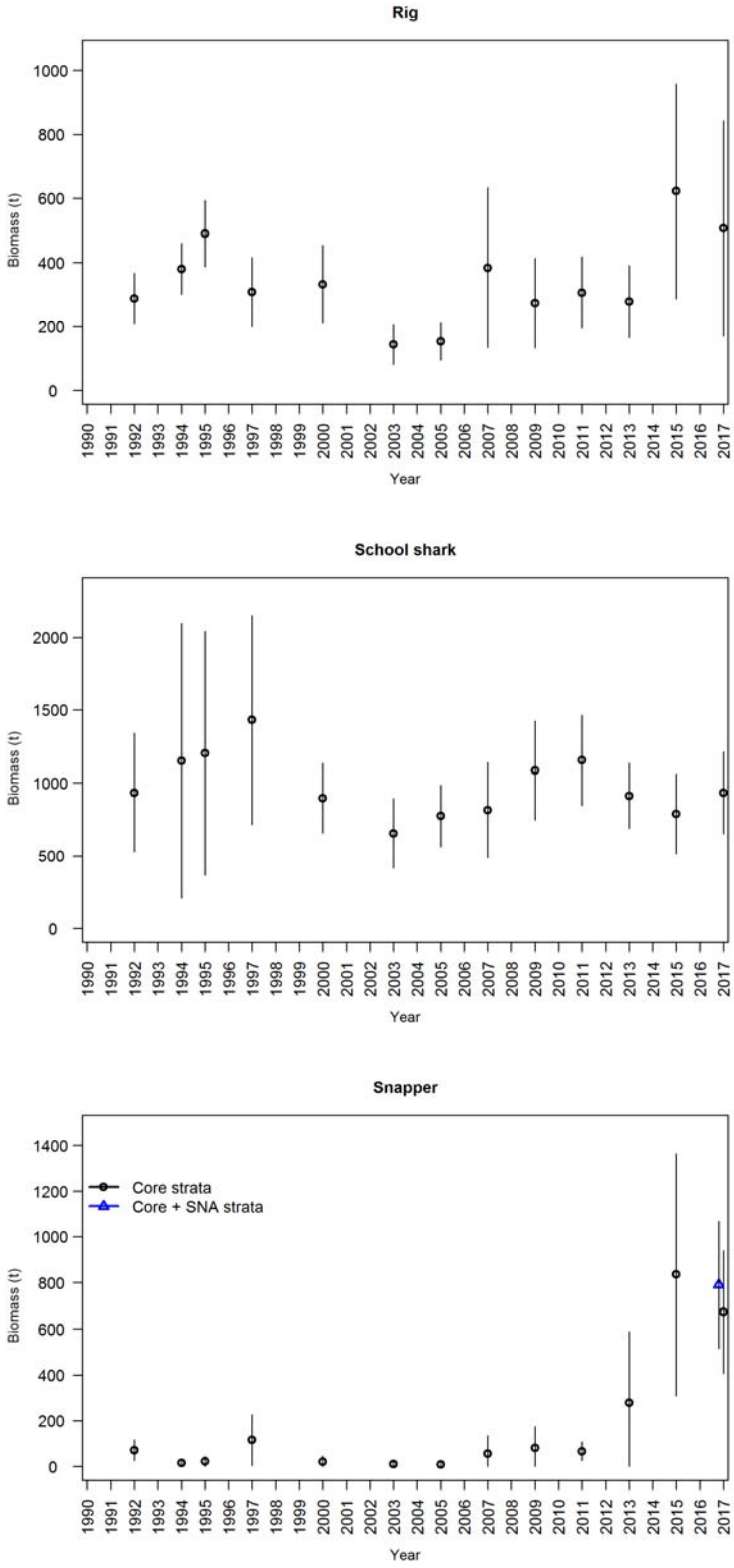


Figure 3—continued.

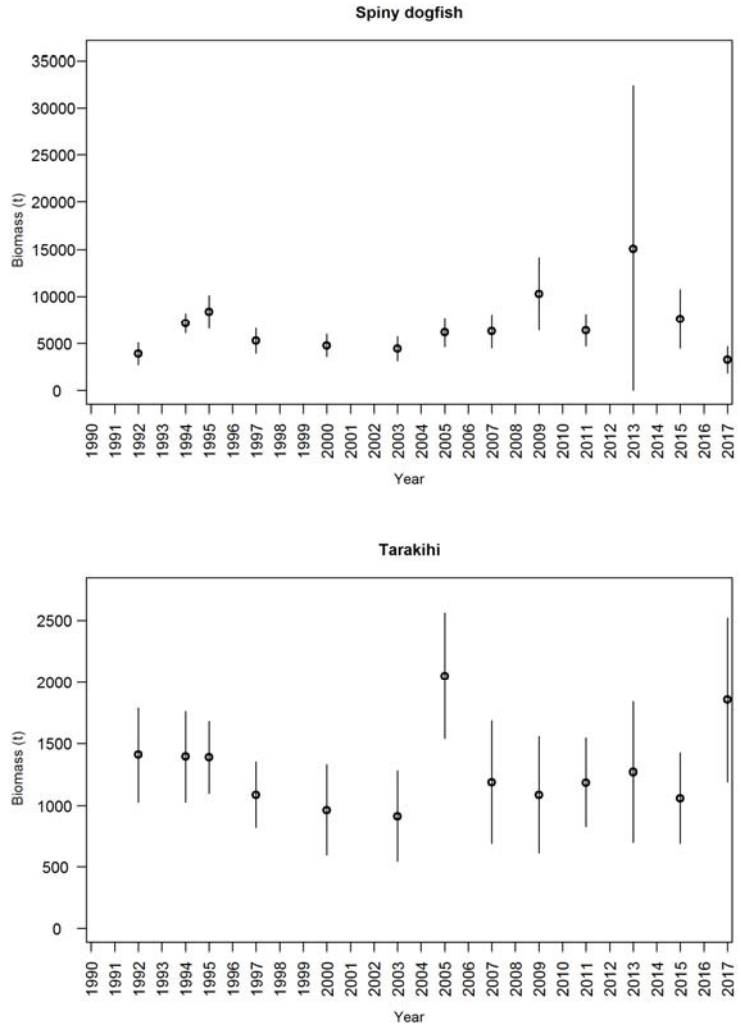


Figure 3—continued.

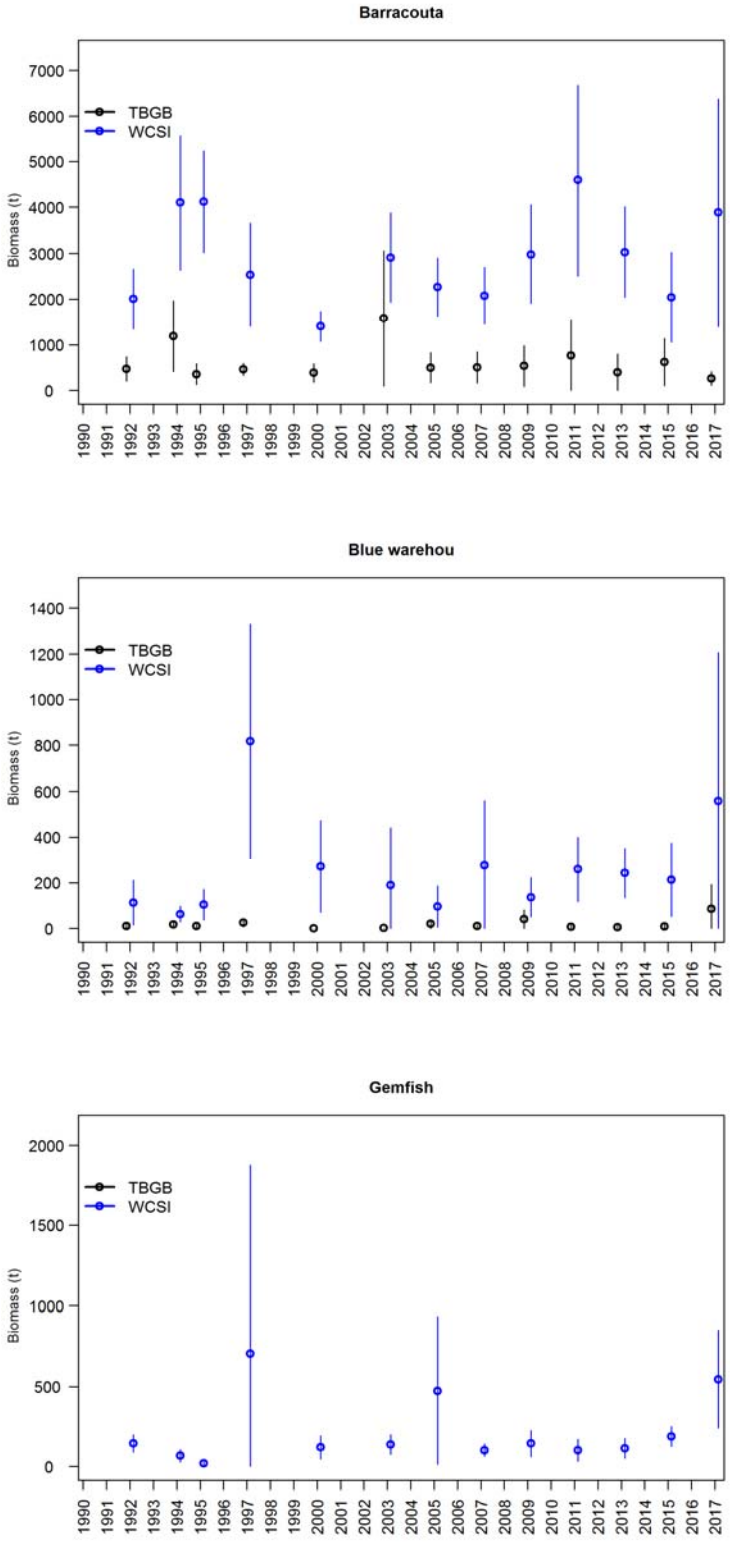


Figure 4: Trends in total biomass for the target species and other species for which the survey time series is likely to be monitoring adult or pre-recruit abundance, separated by Tasman and Golden Bays (TBGB), and the west coast South Island (WCSI). Arranged in alphabetical order by common name. Error bars are +/- two standard deviations.

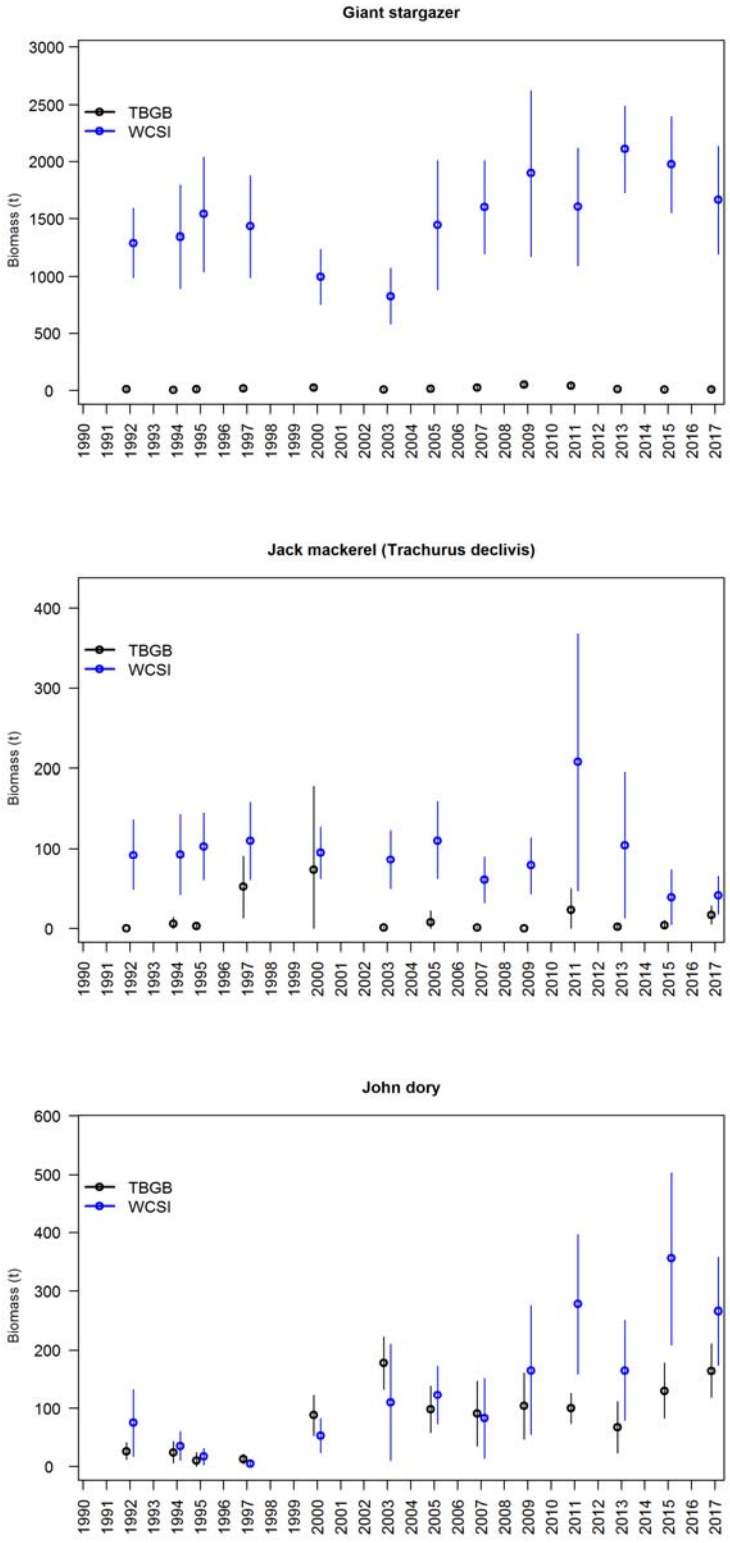


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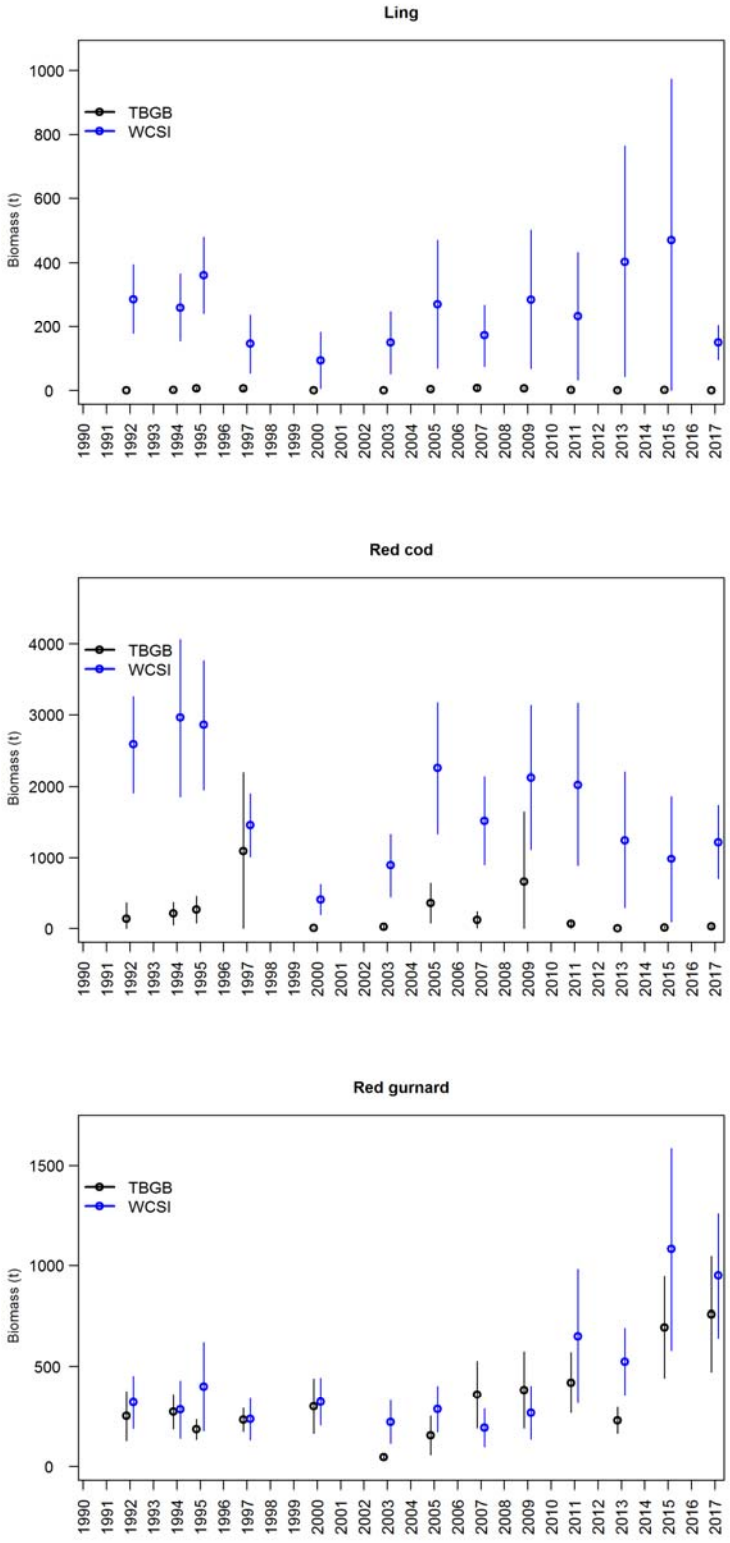


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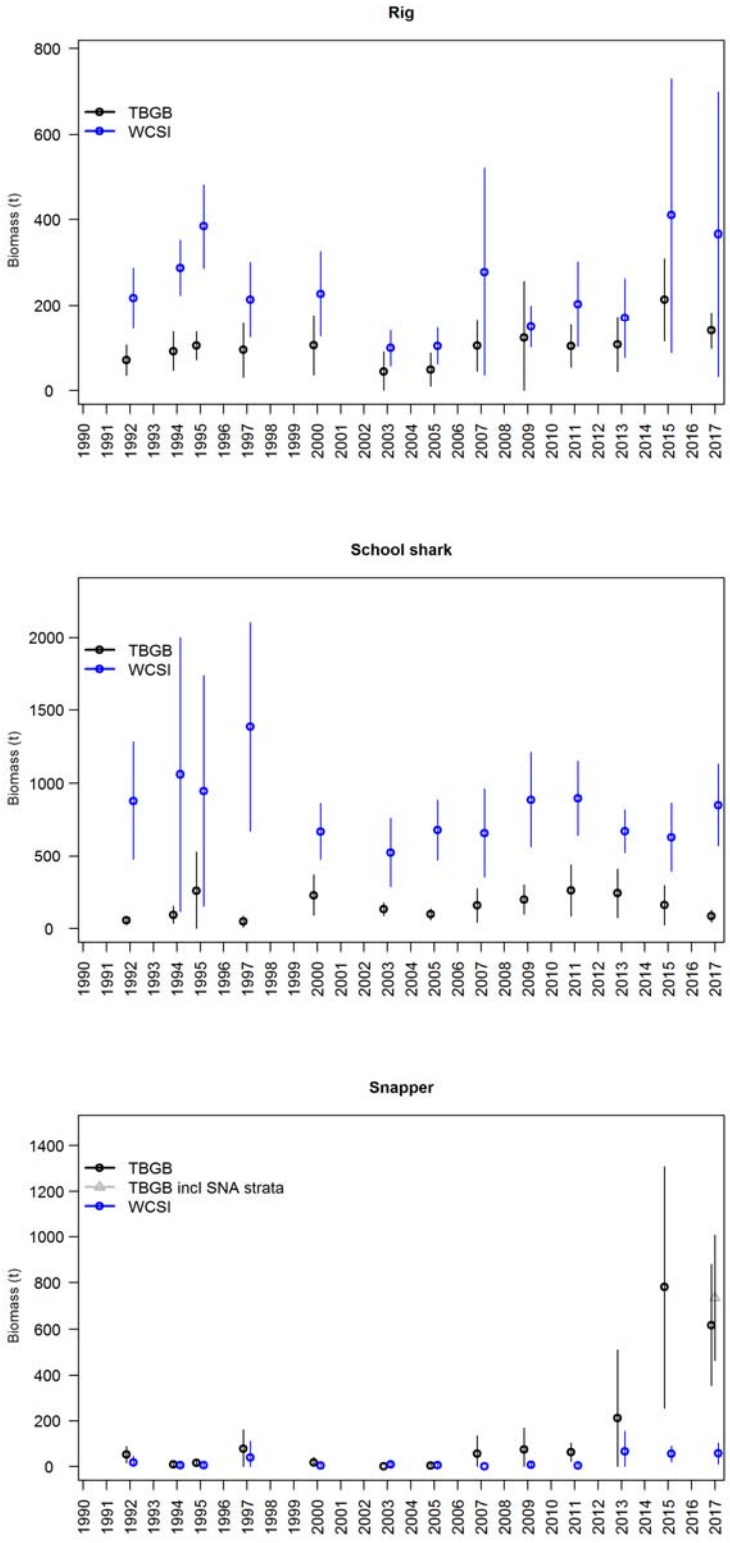


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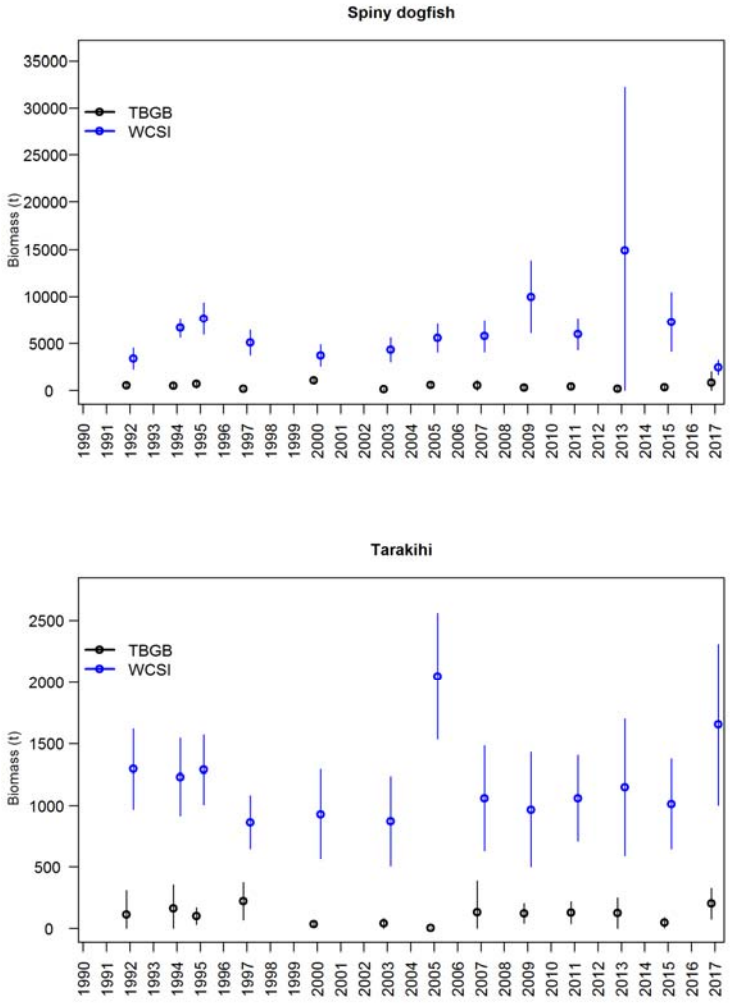


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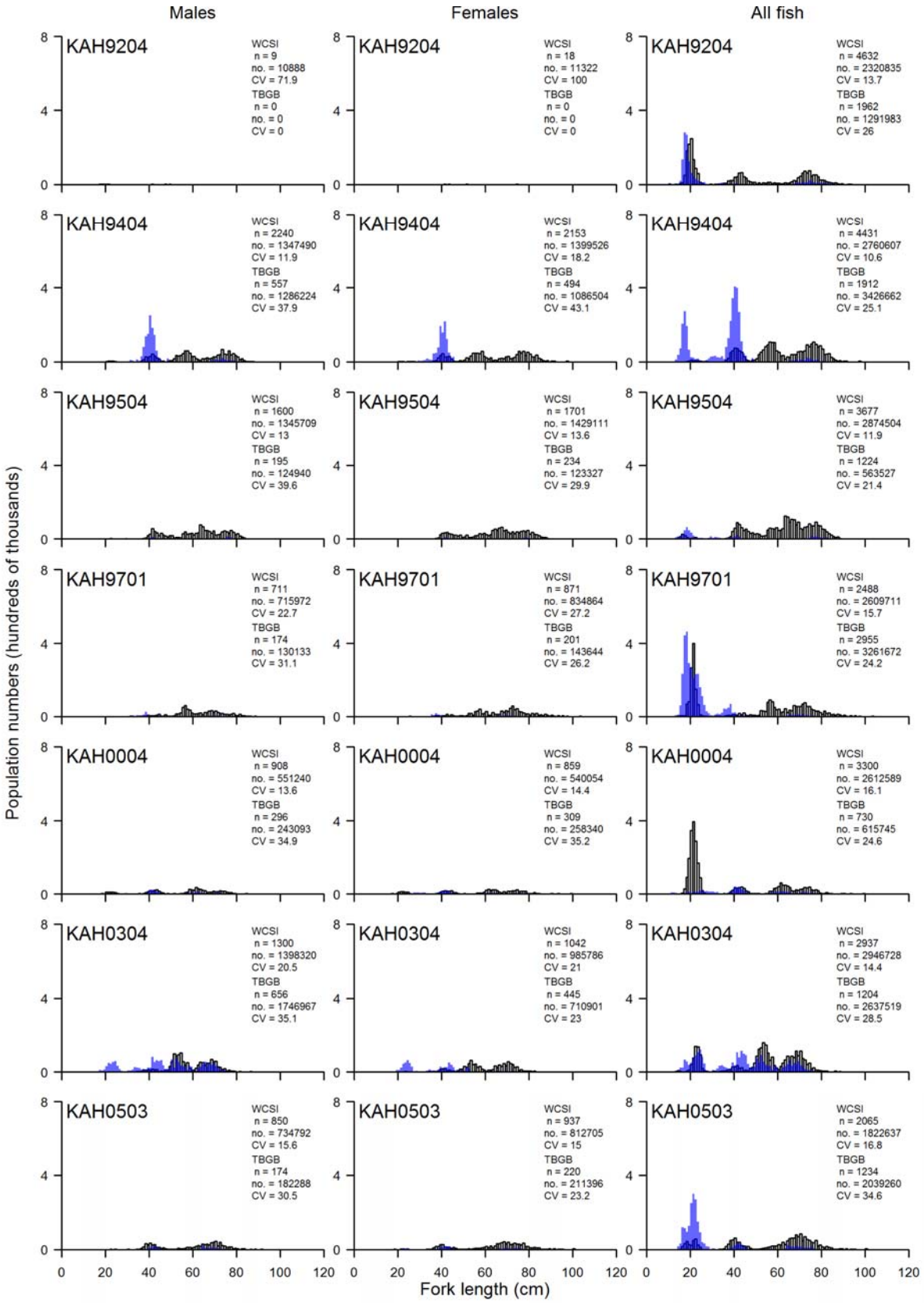


Figure 5: Comparative scaled length frequencies with Tasman and Golden Bays (TBGB) and west coast South Island (WCSI) plotted separately for the target species and those species where the surveys are monitoring adult or pre-recruit abundance. n = number of fish measured, no. = scaled population number, CV = coefficient of variation. 'All fish' includes any unsexed fish. Blue bars = Tasman and Golden Bays, black bars = west coast South Island. a) Barracouta.

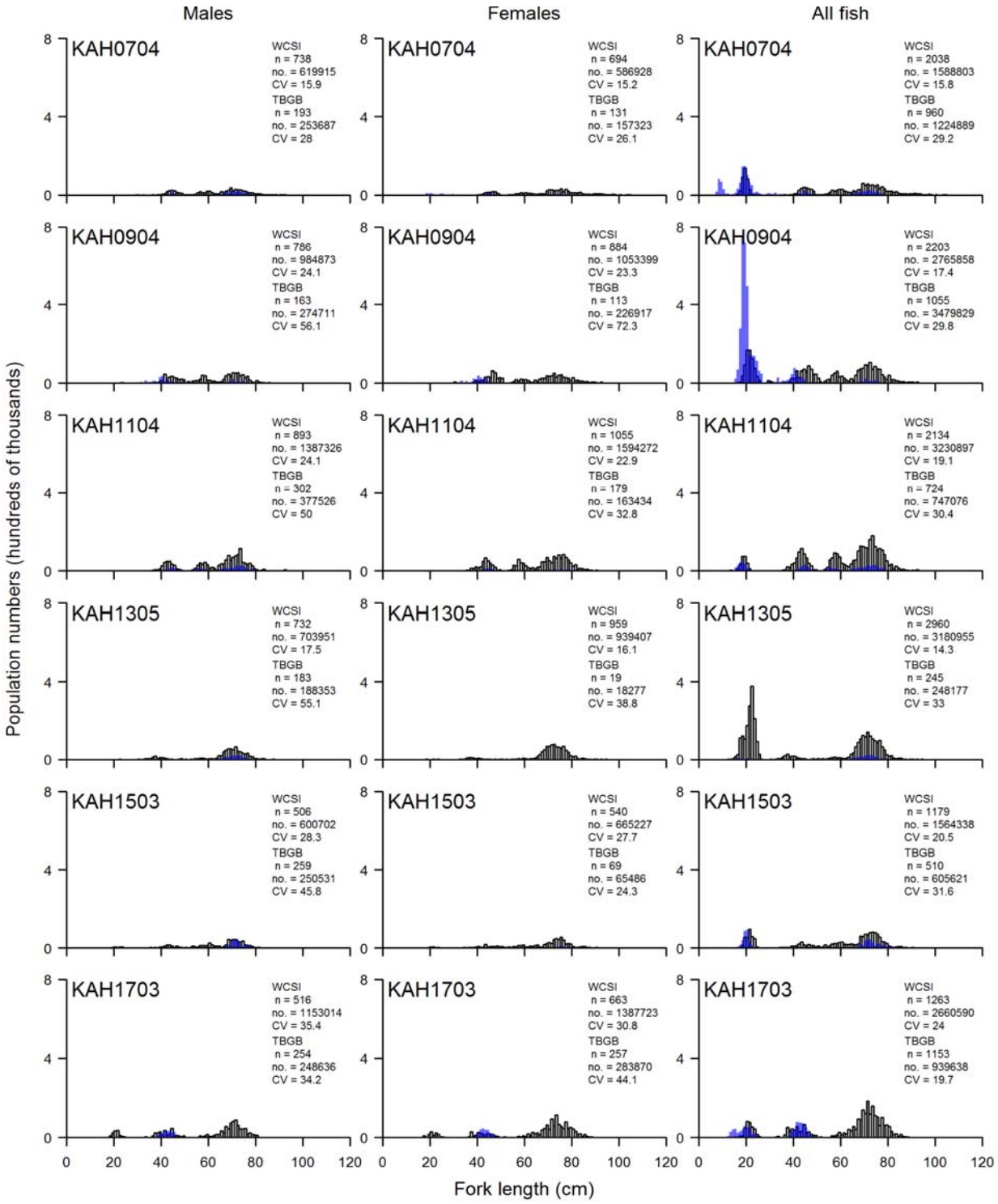


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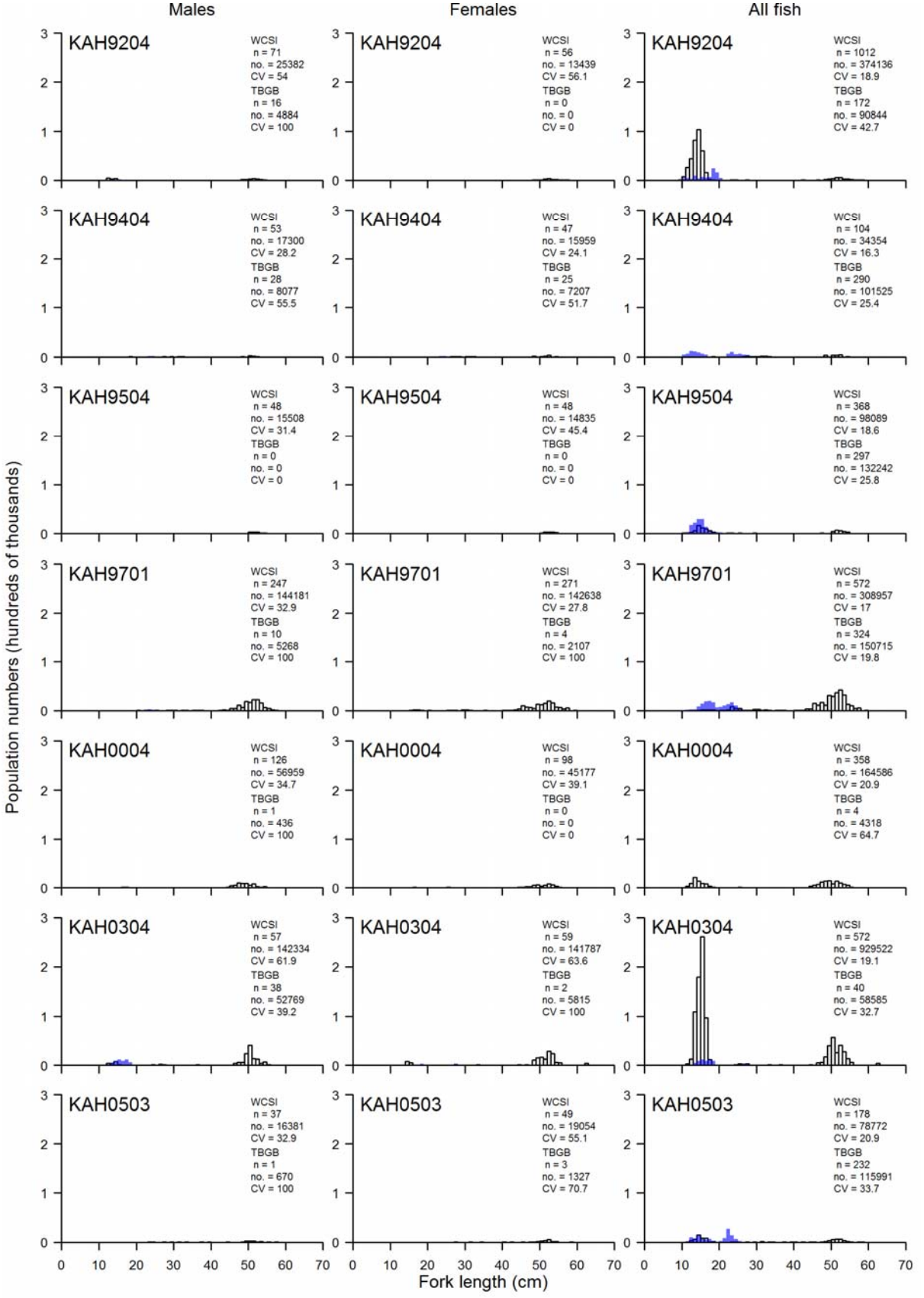


Figure 5b: Blue warehou.

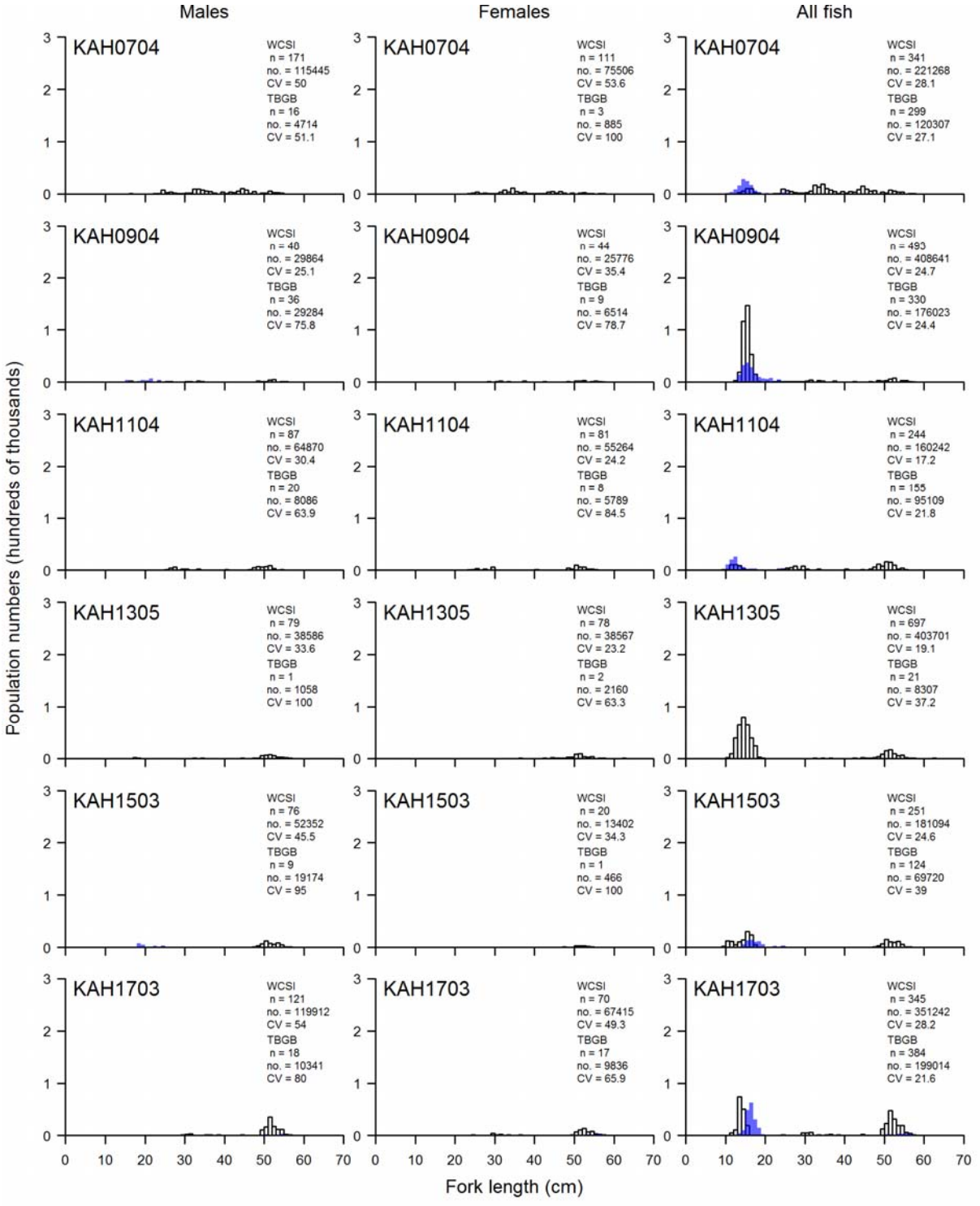


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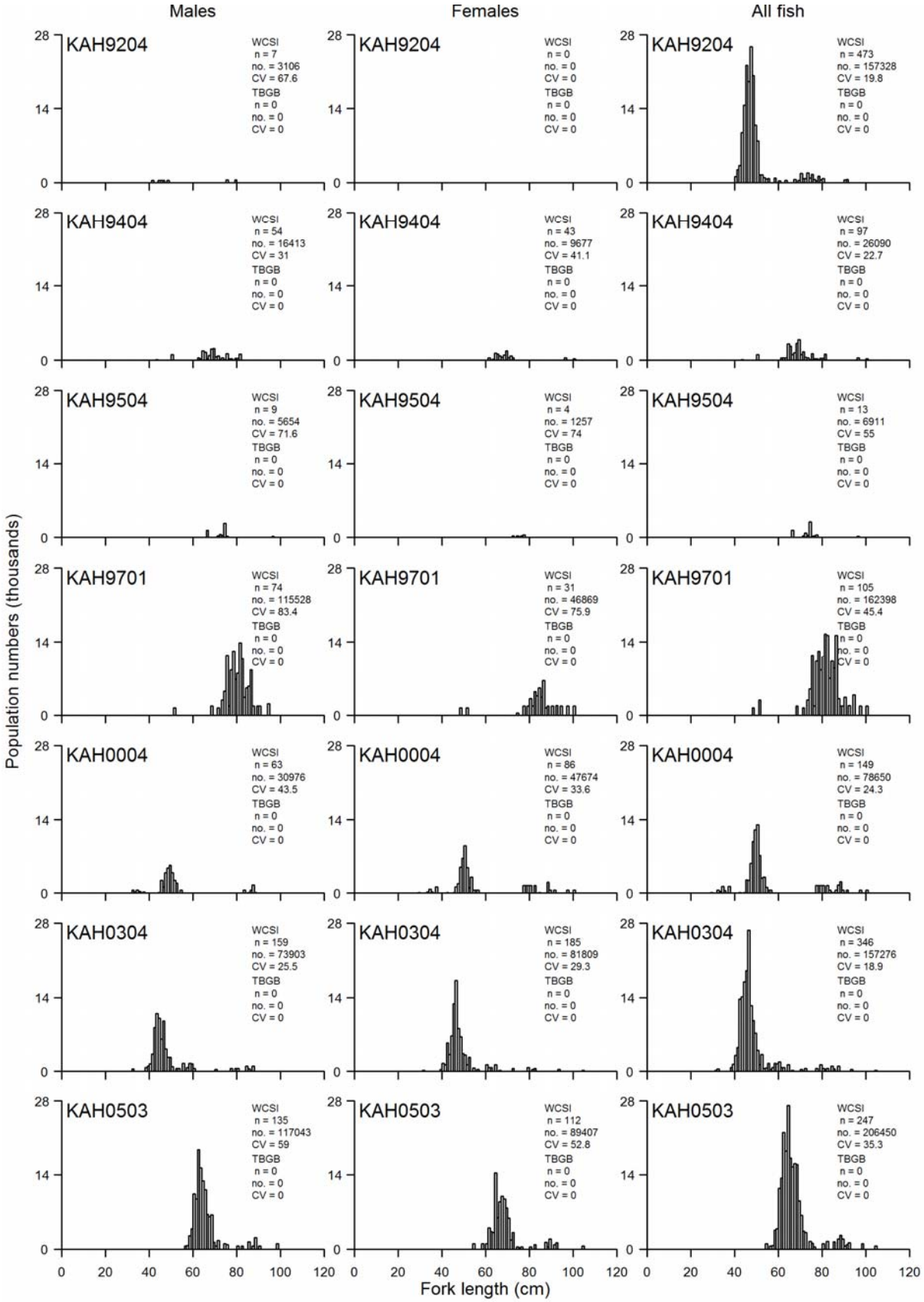


Figure 5c: Gemfish (100% of fish from the west coast).

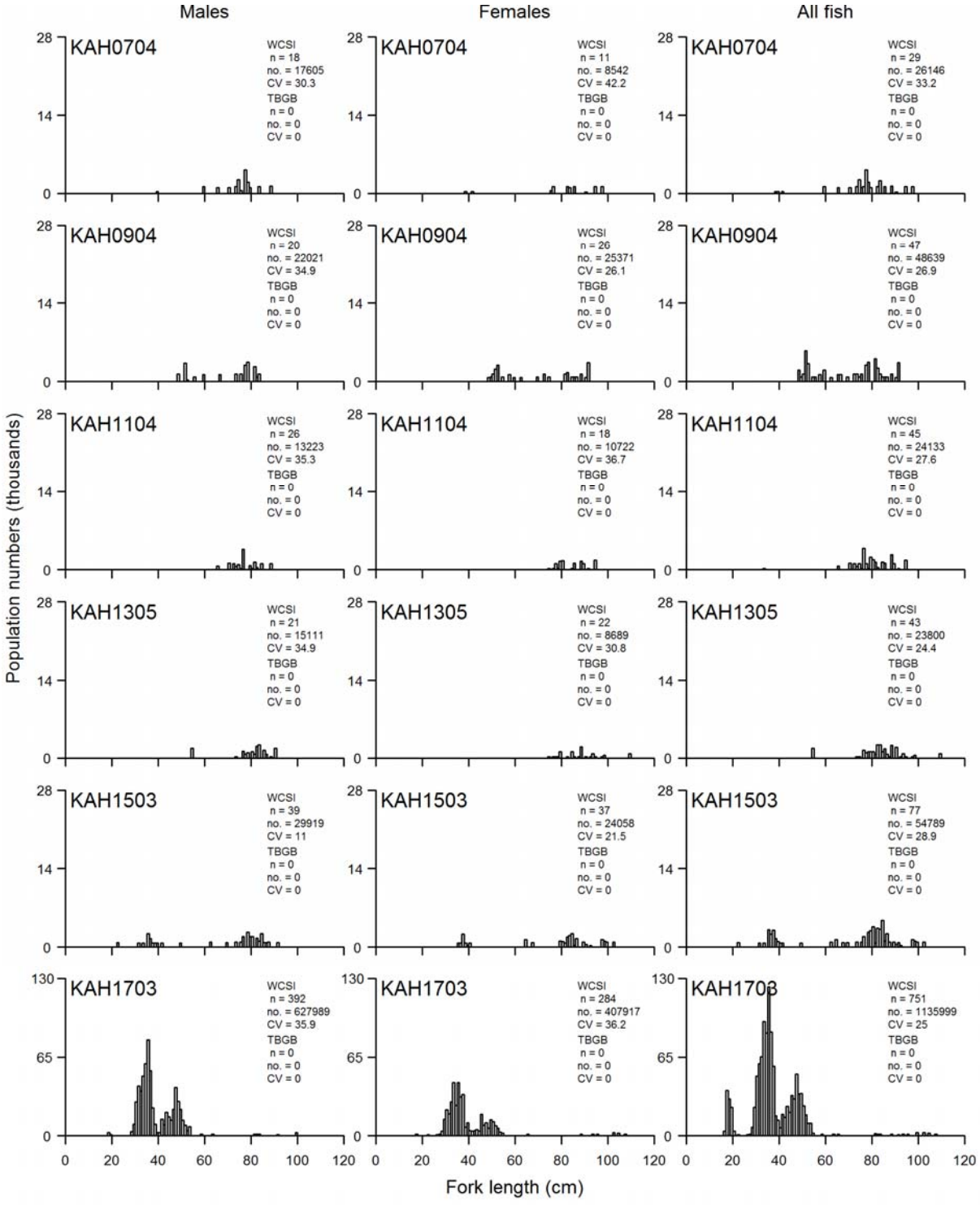


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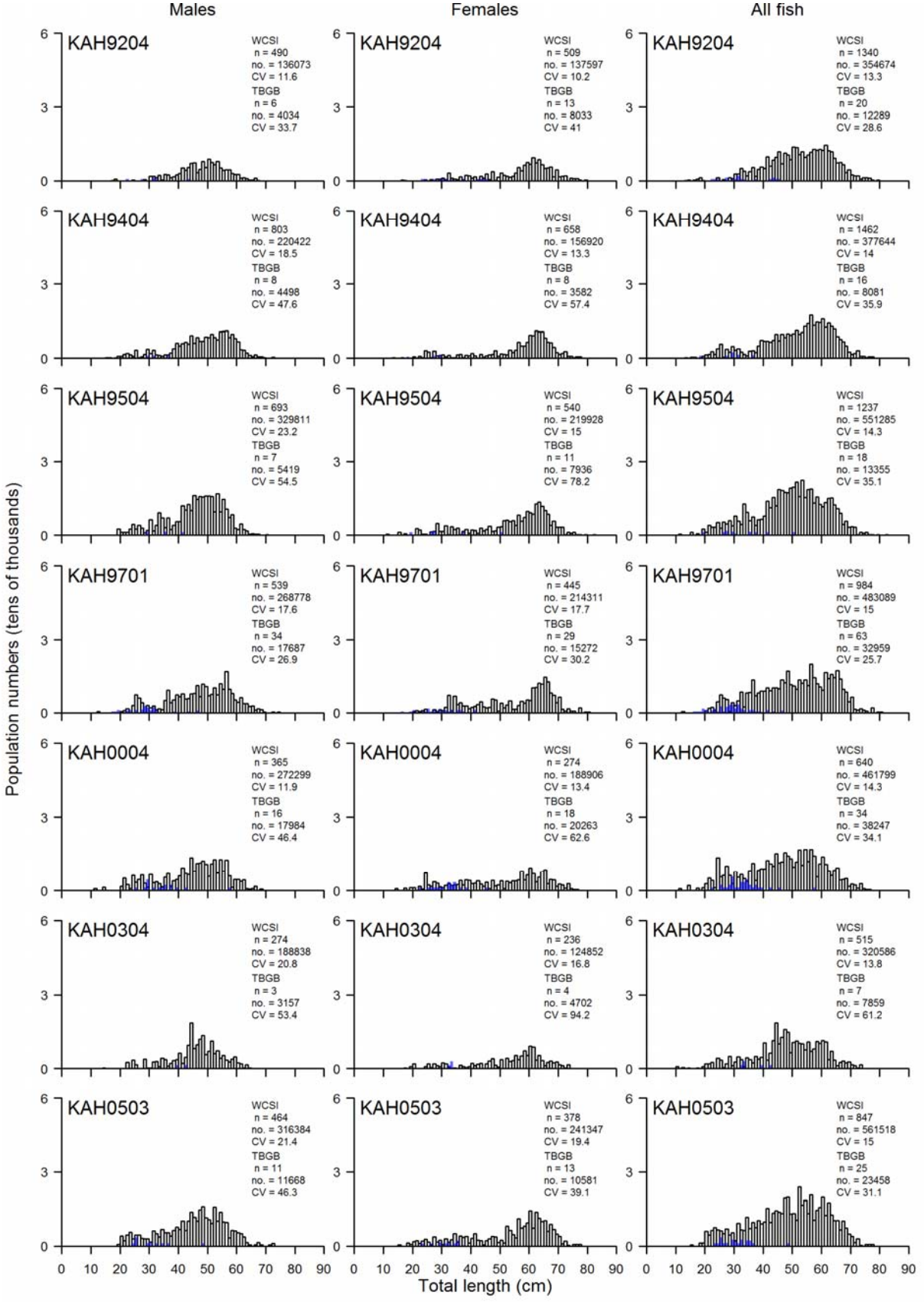


Figure 5d: Giant stargazer.

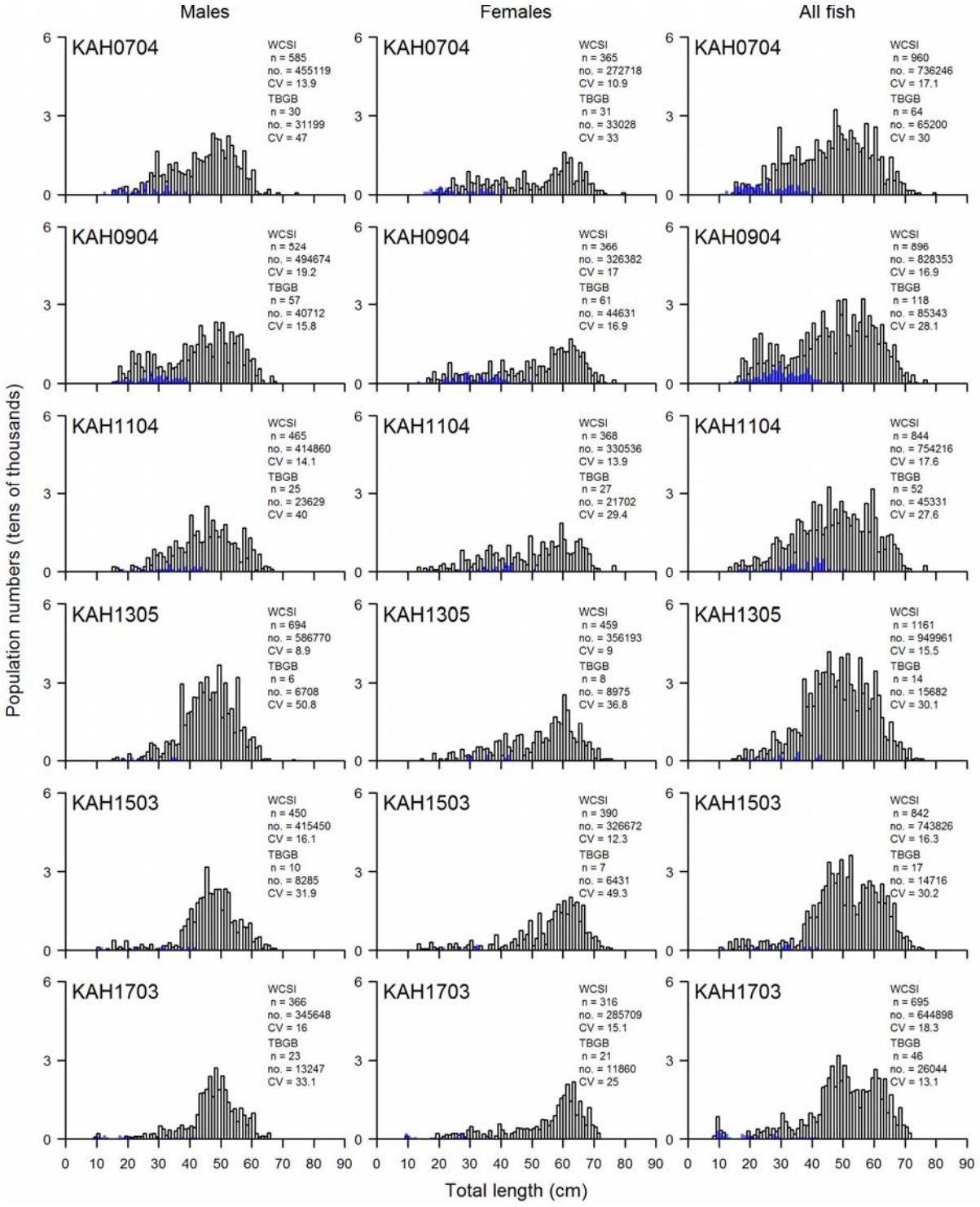


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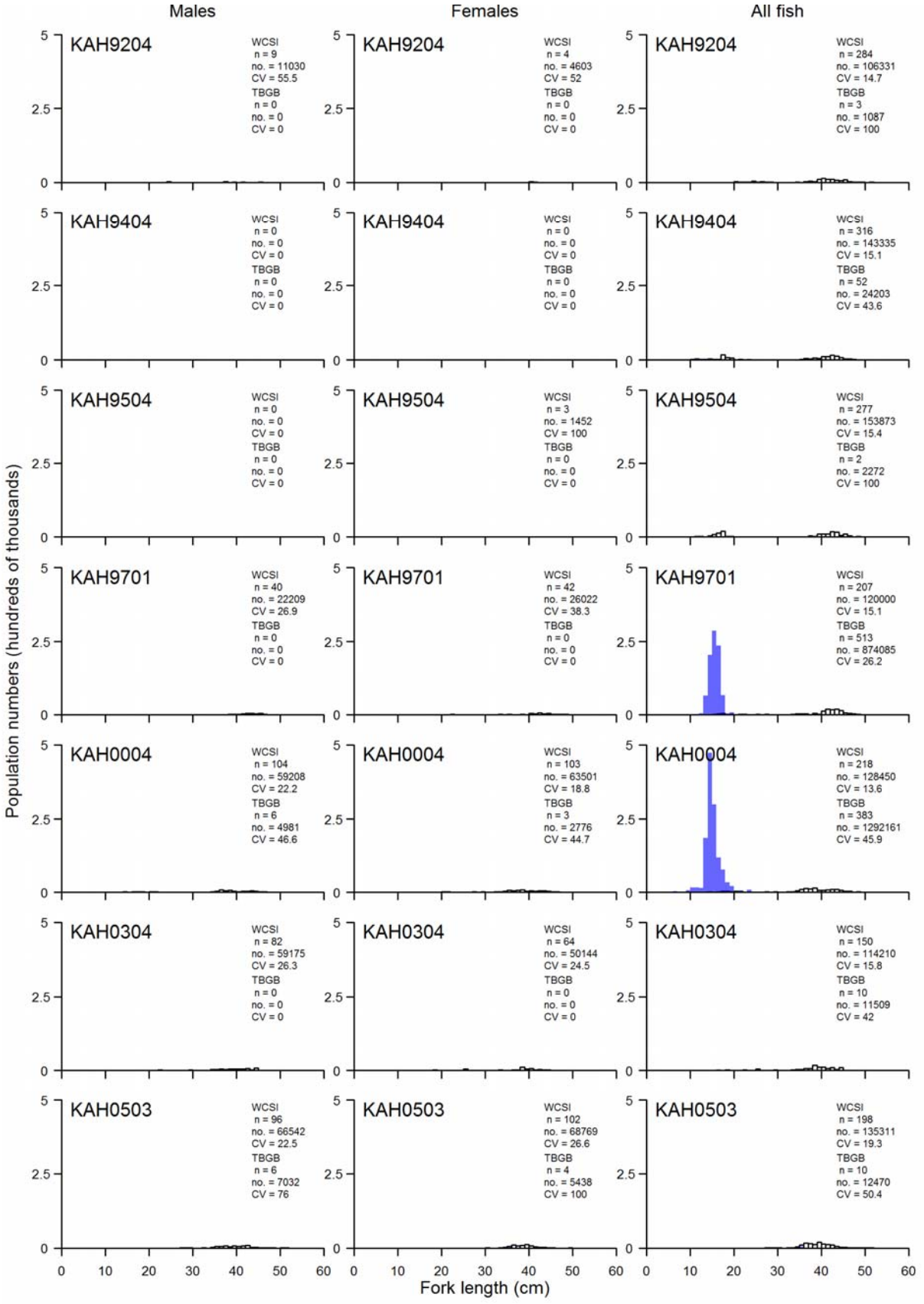


Figure 5e: Jack mackerel (*Trachurus declivis*).

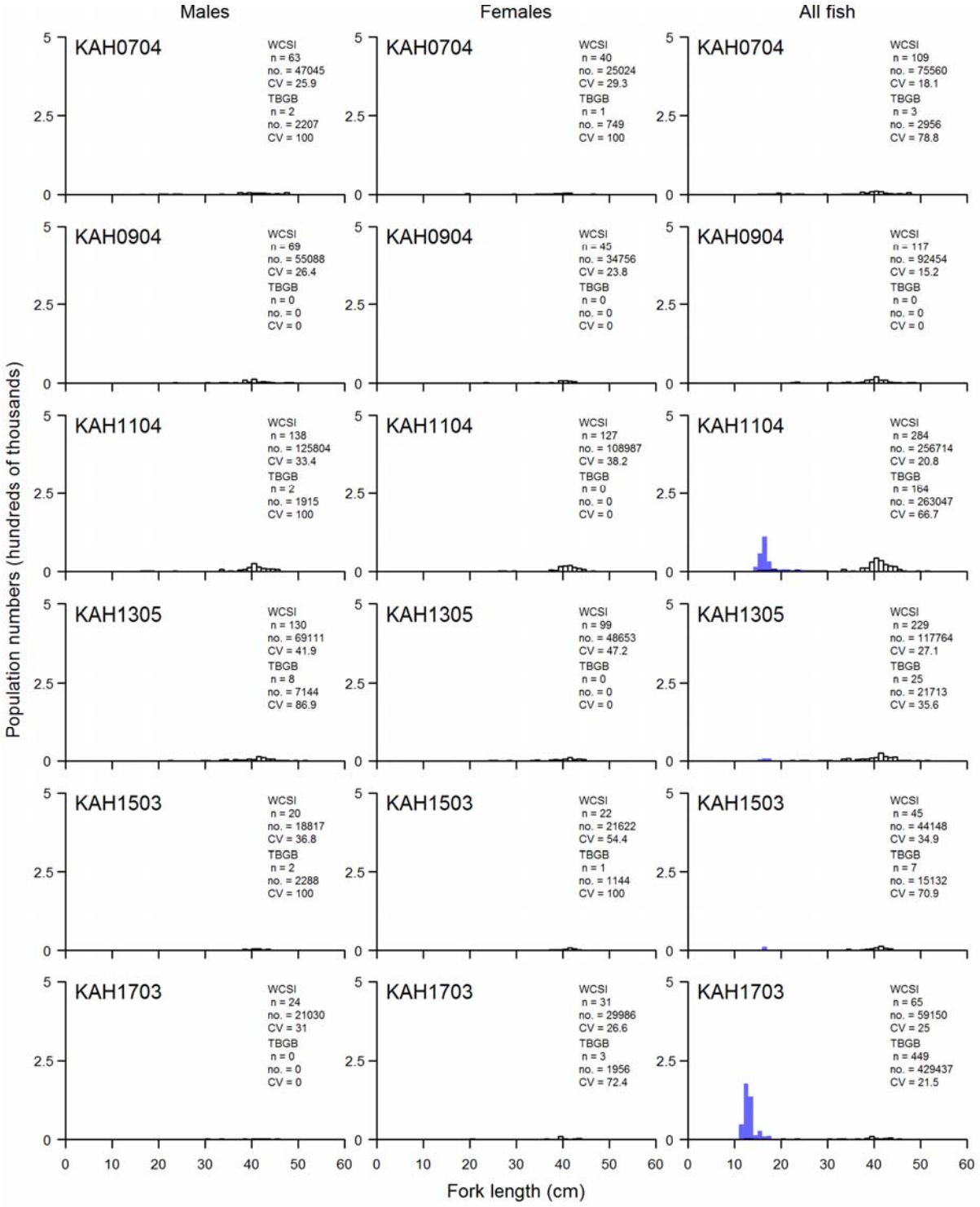


Figure 5e—continued.

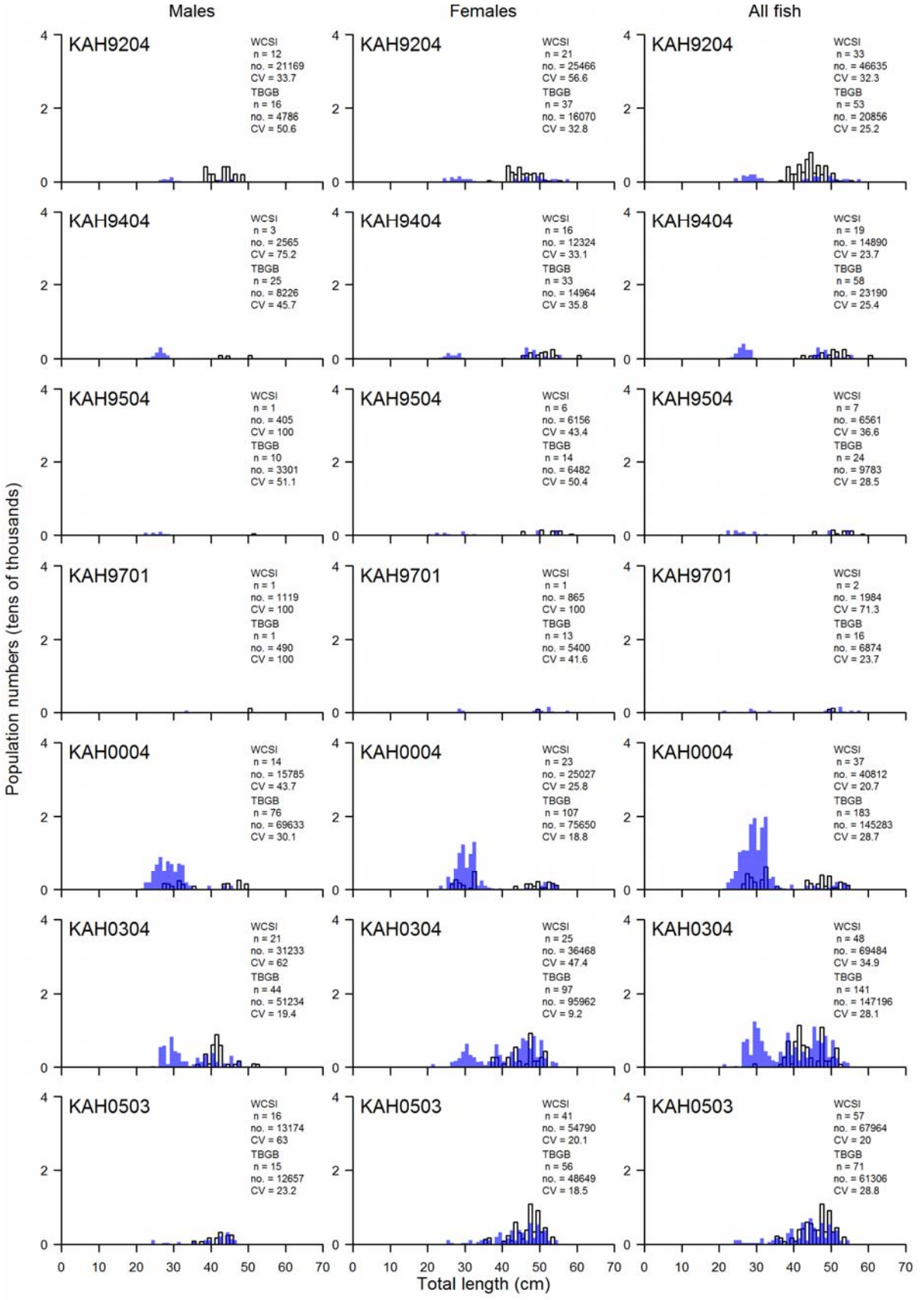


Figure 5f: John dory.

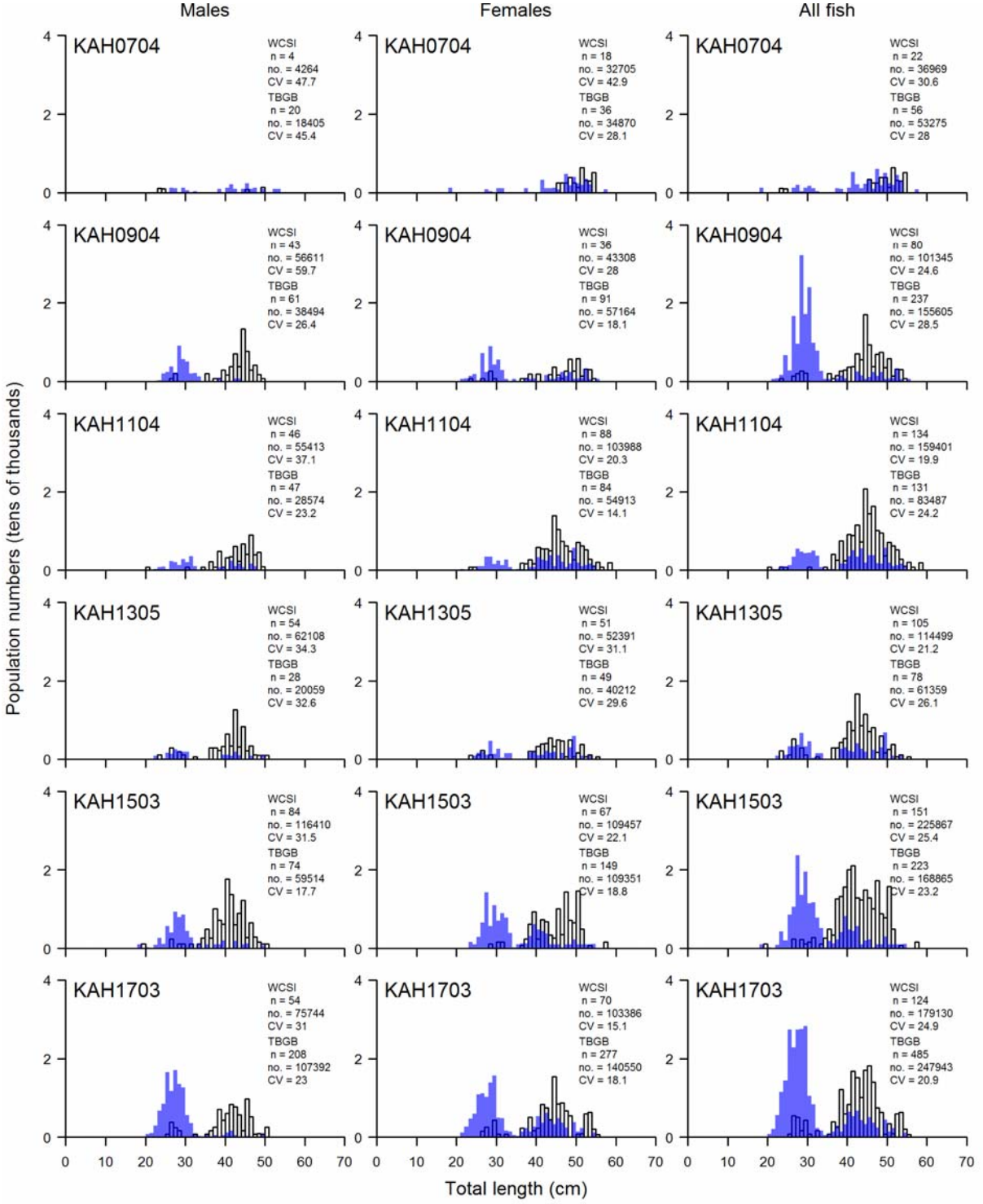


Figure 5f—continued.

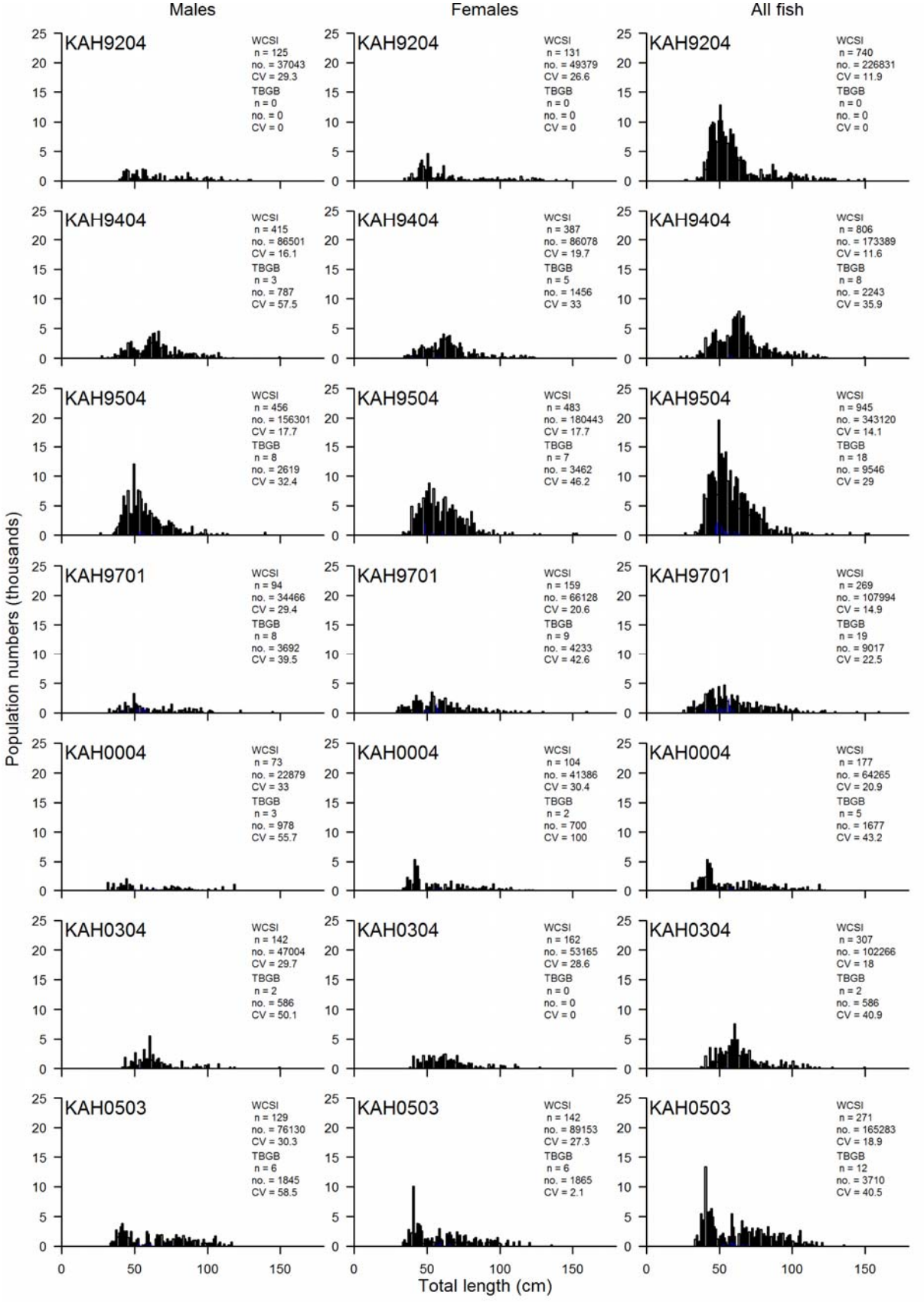


Figure 5g: Ling.

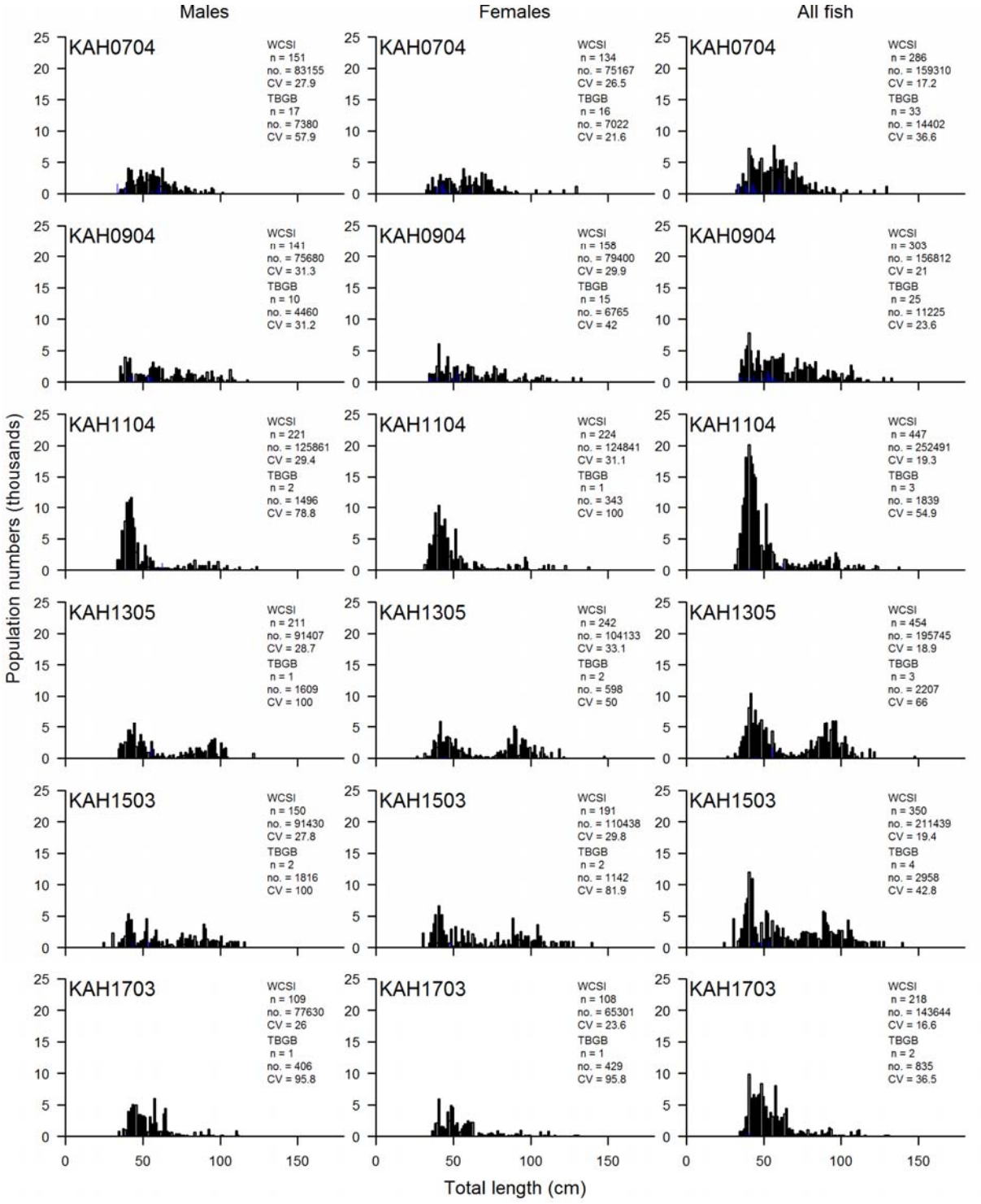


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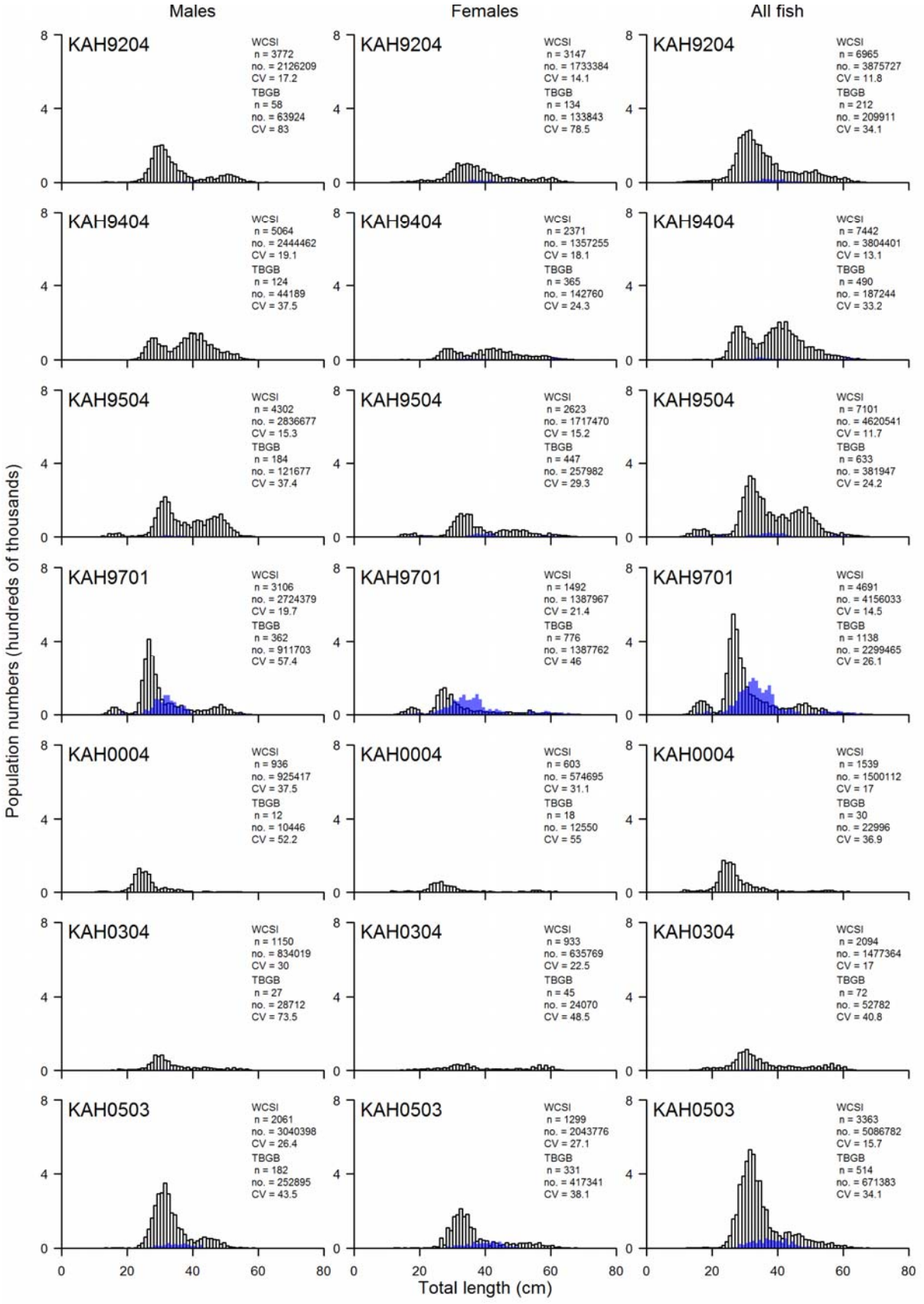


Figure 5h: Red cod.

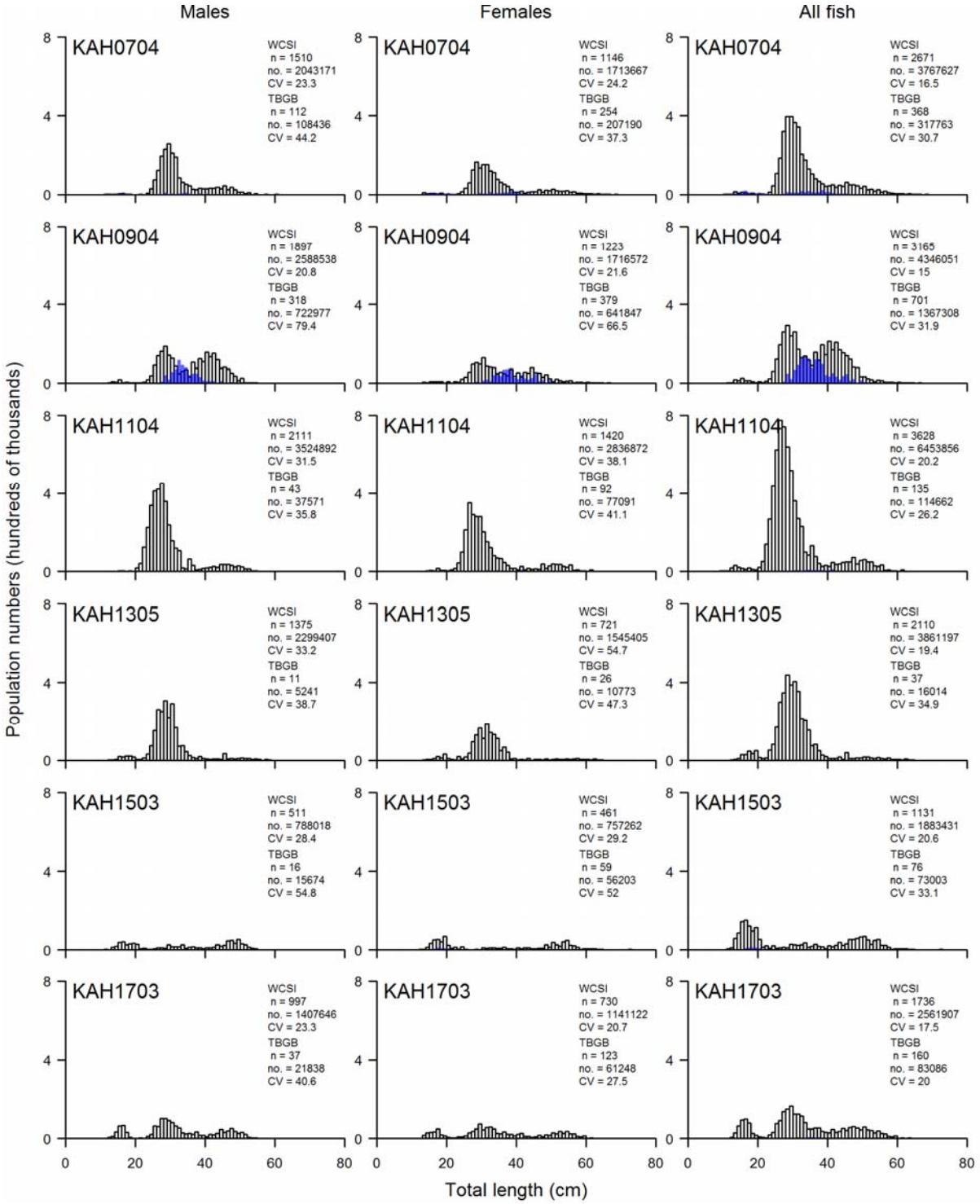


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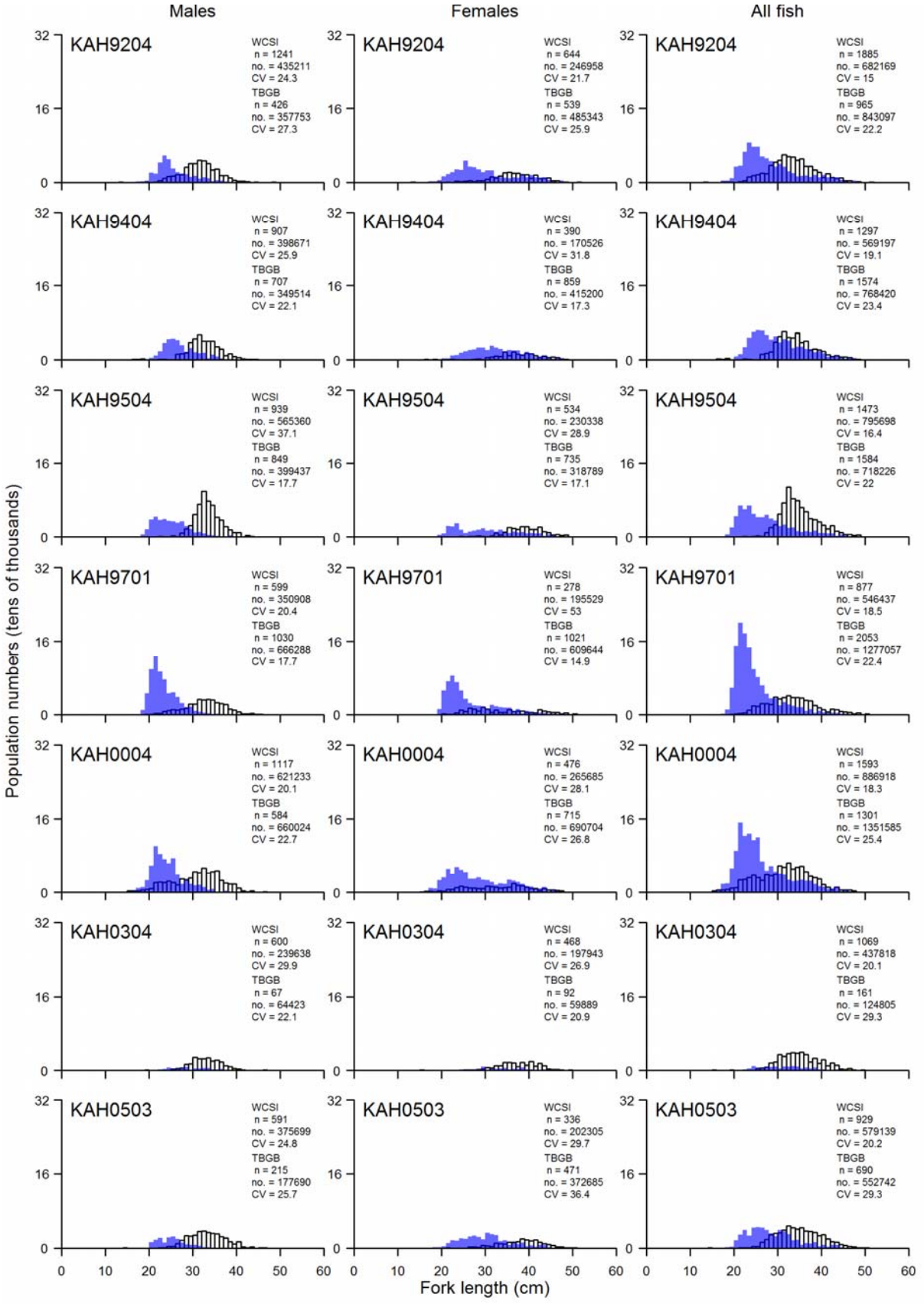


Figure 5i: Red gurnard.

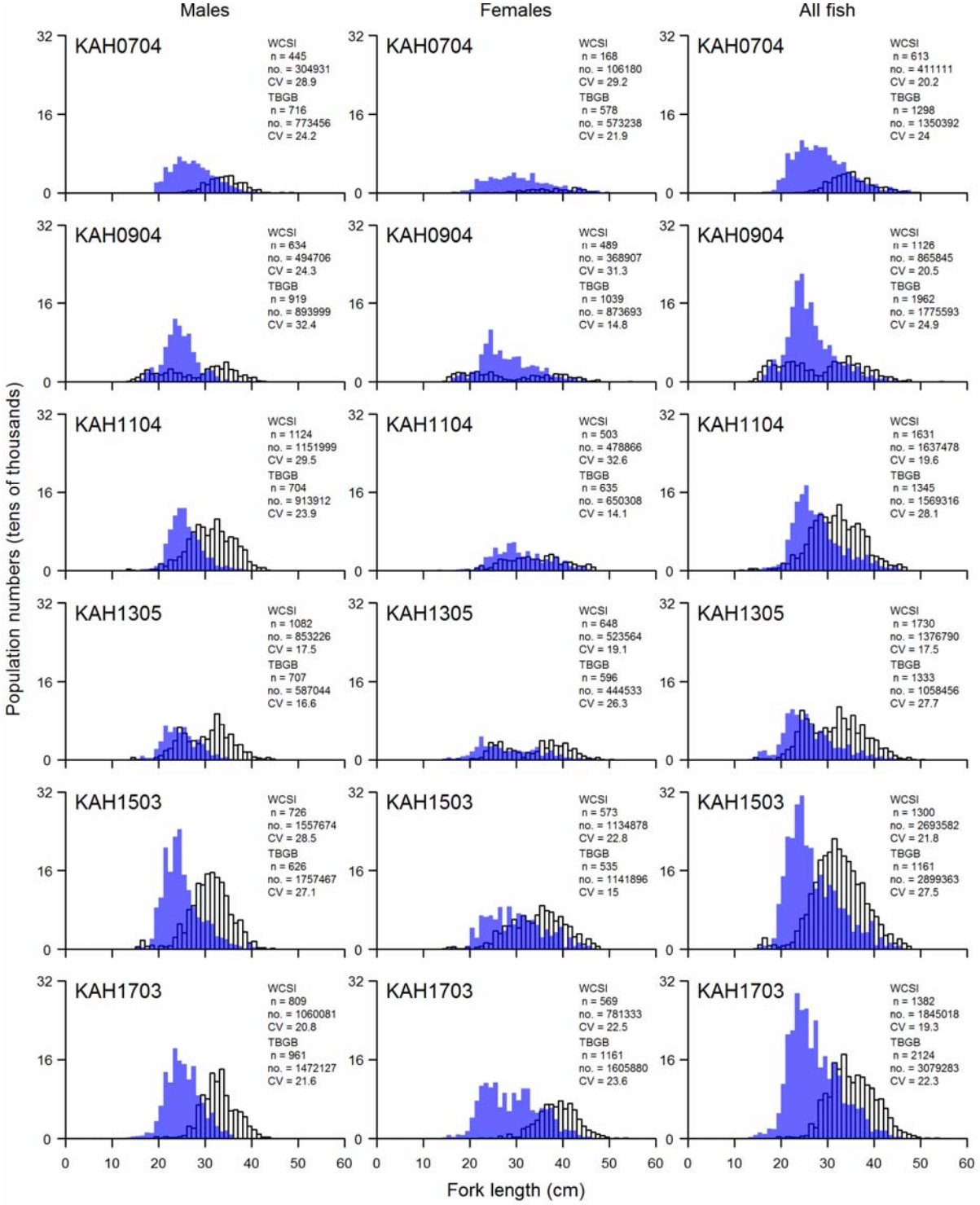


Figure 5i—continued.

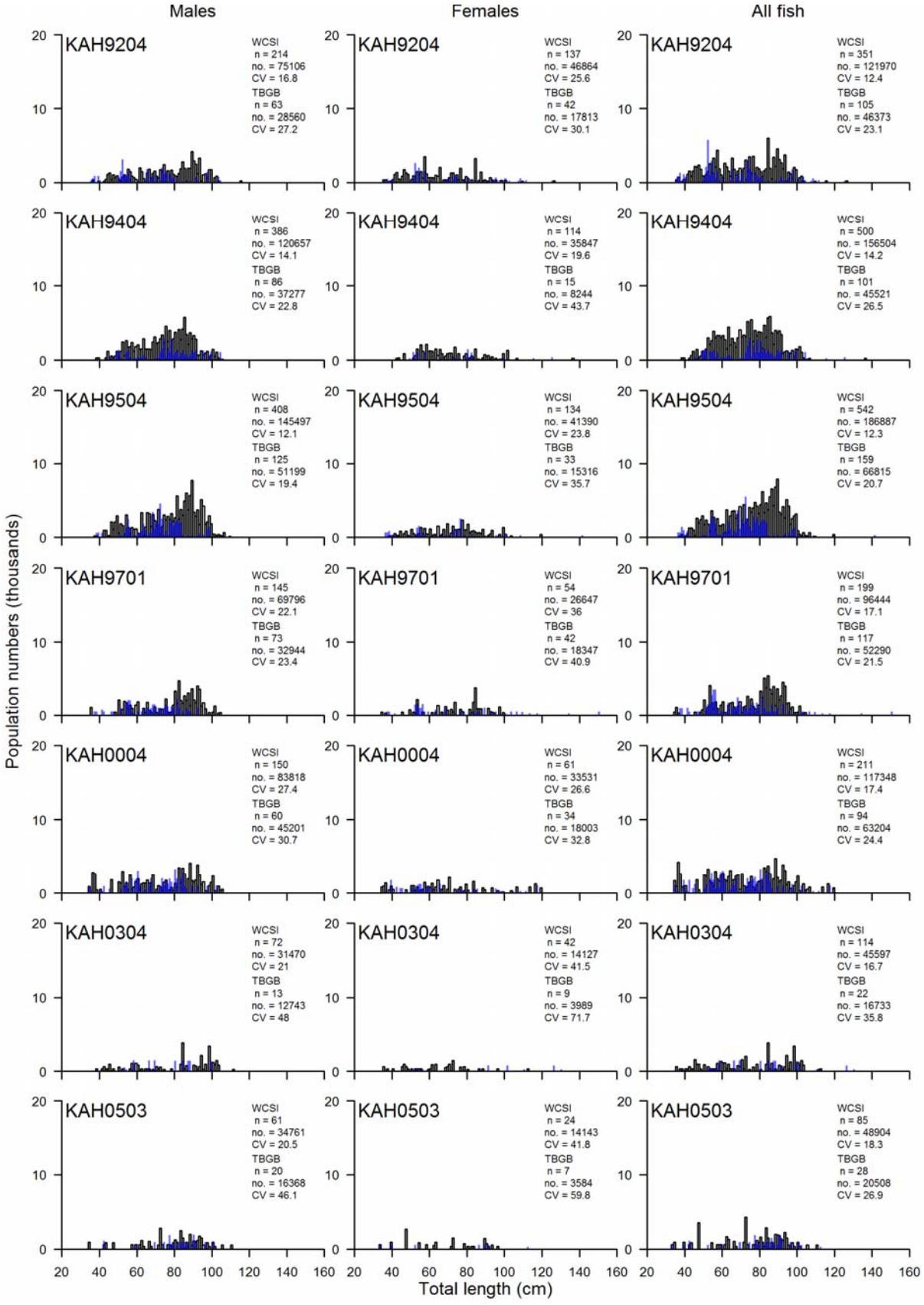


Figure 5j: Rig.

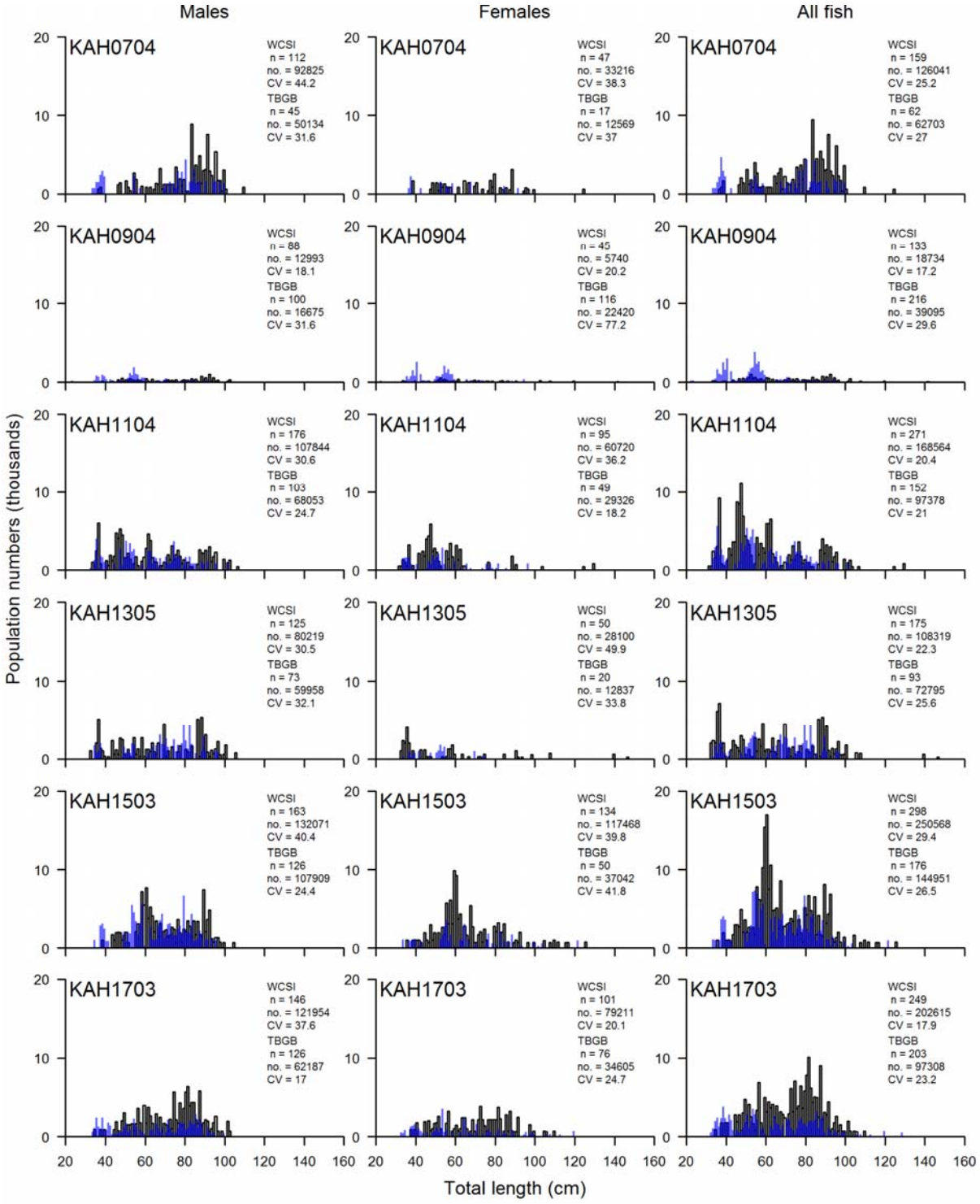


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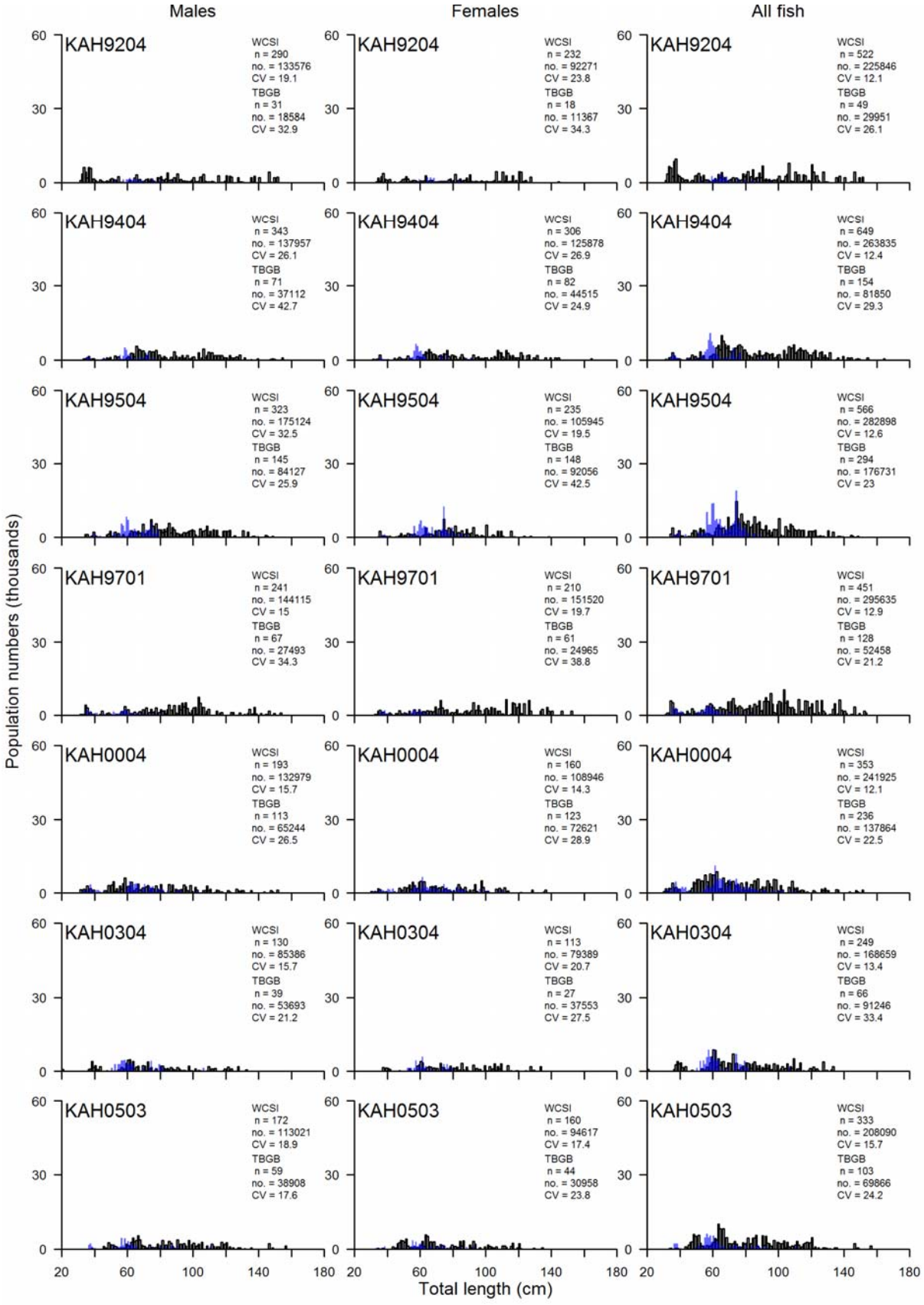


Figure 5k: School shark.

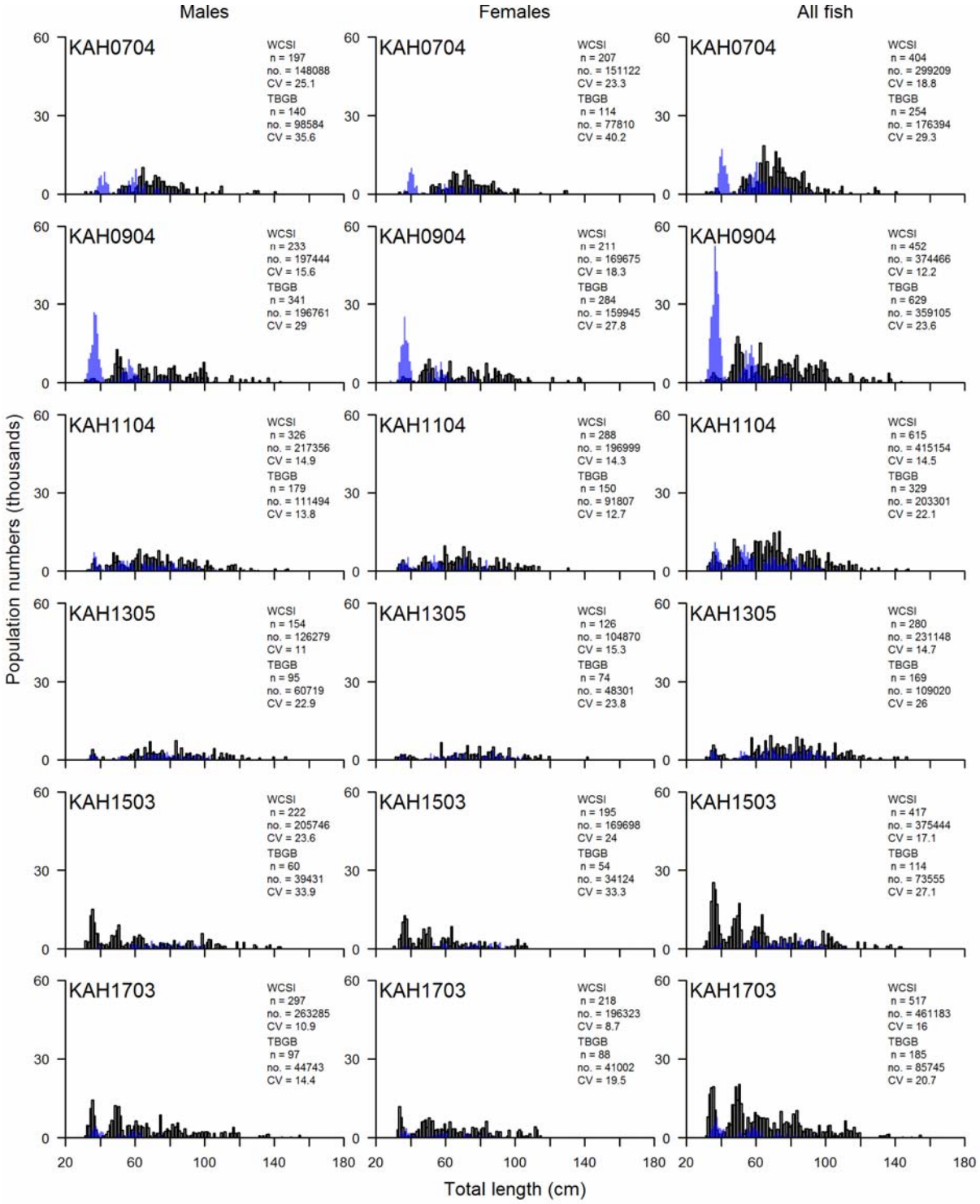


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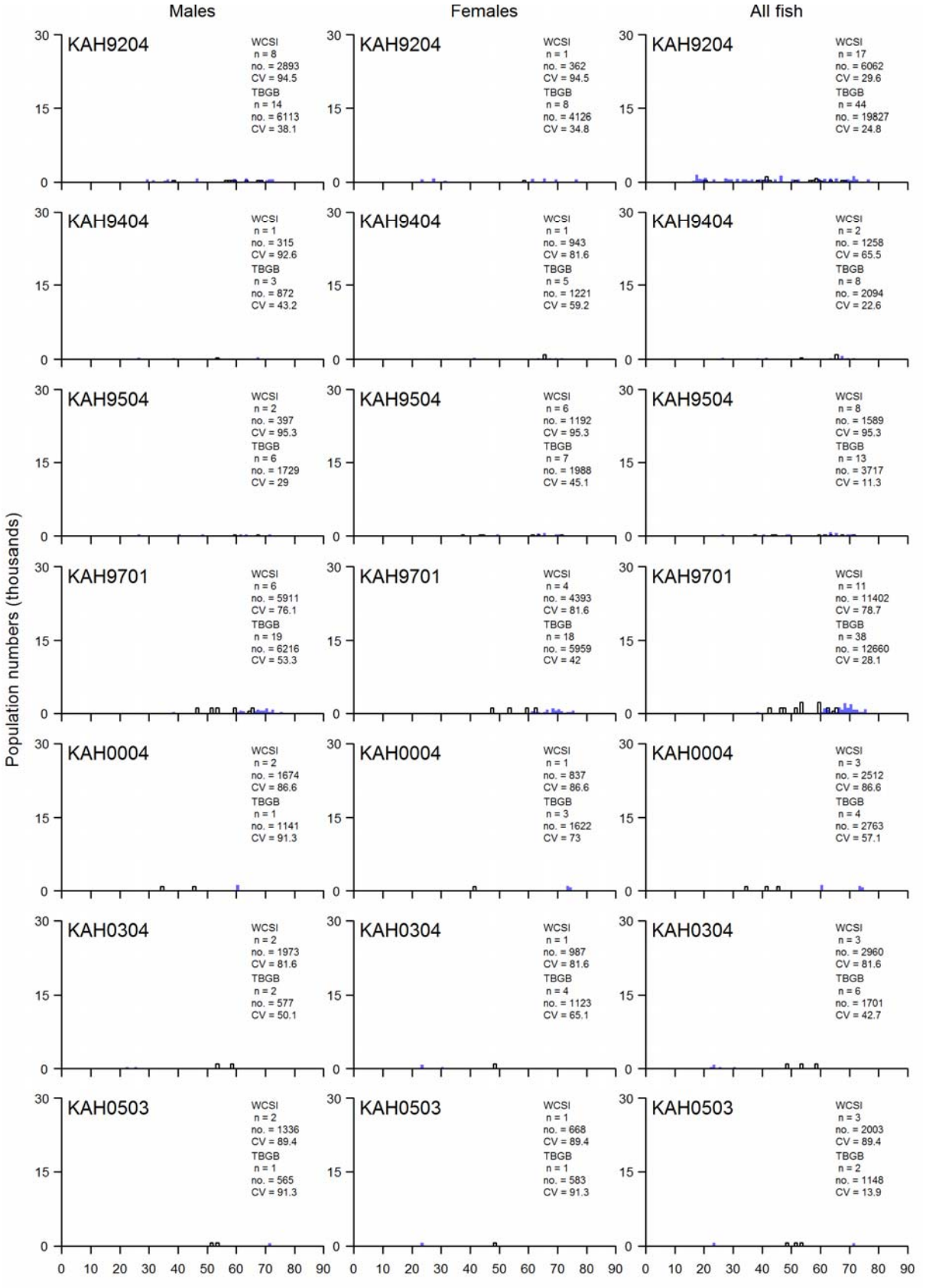


Figure 5l: Snapper

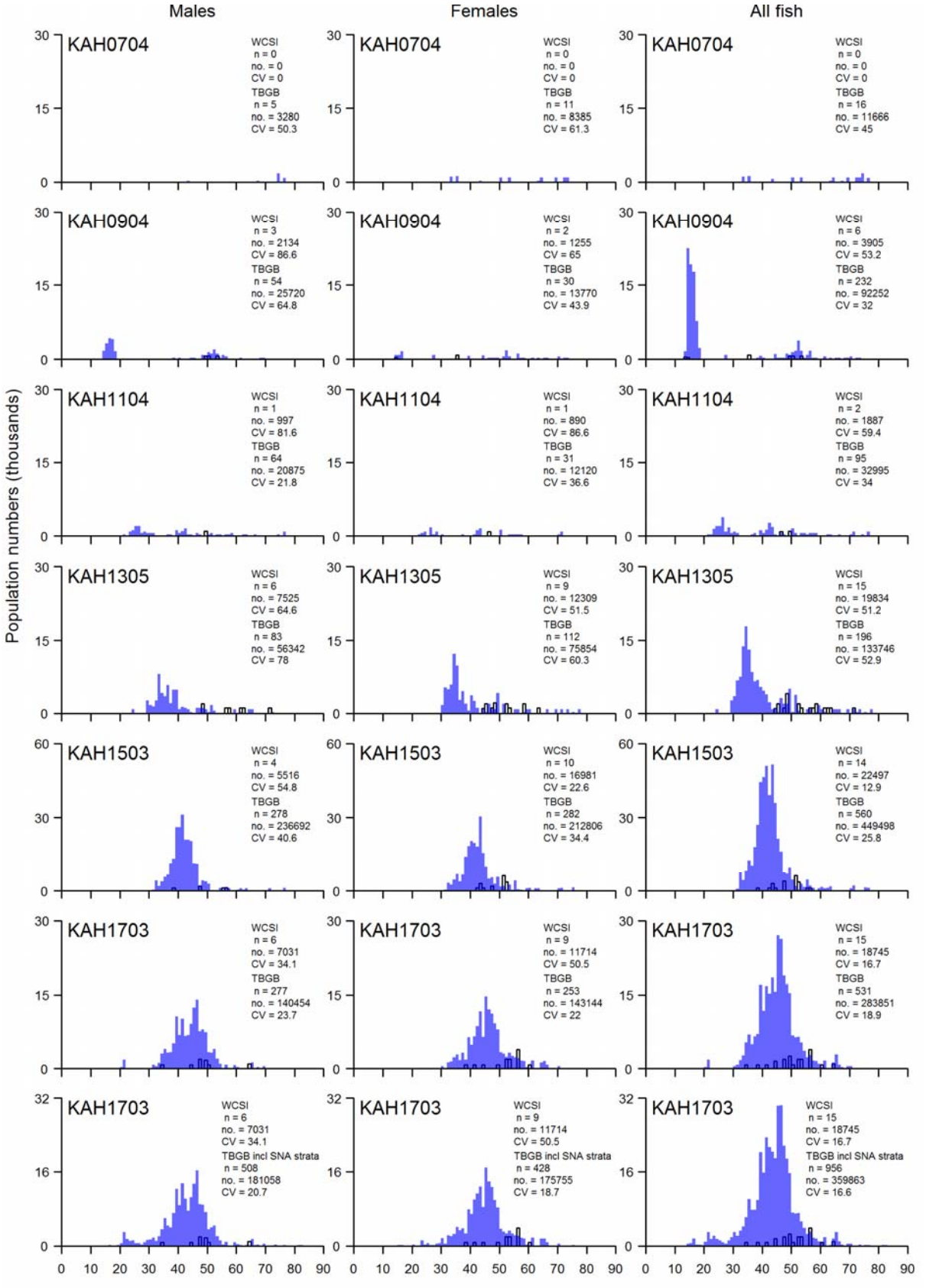


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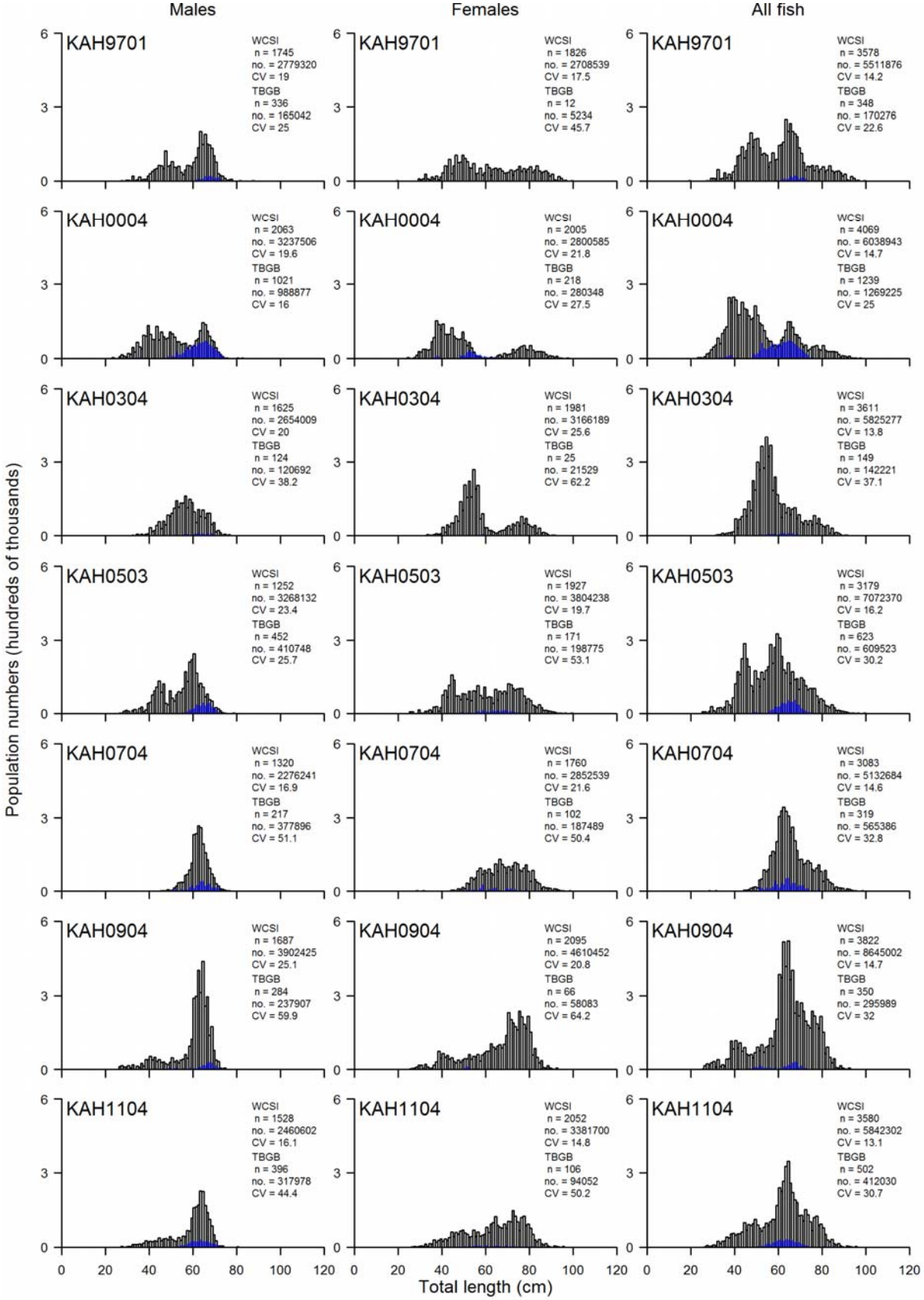


Figure 5m: Spiny dogfish. NB: no spiny dogfish were measured before 1997.

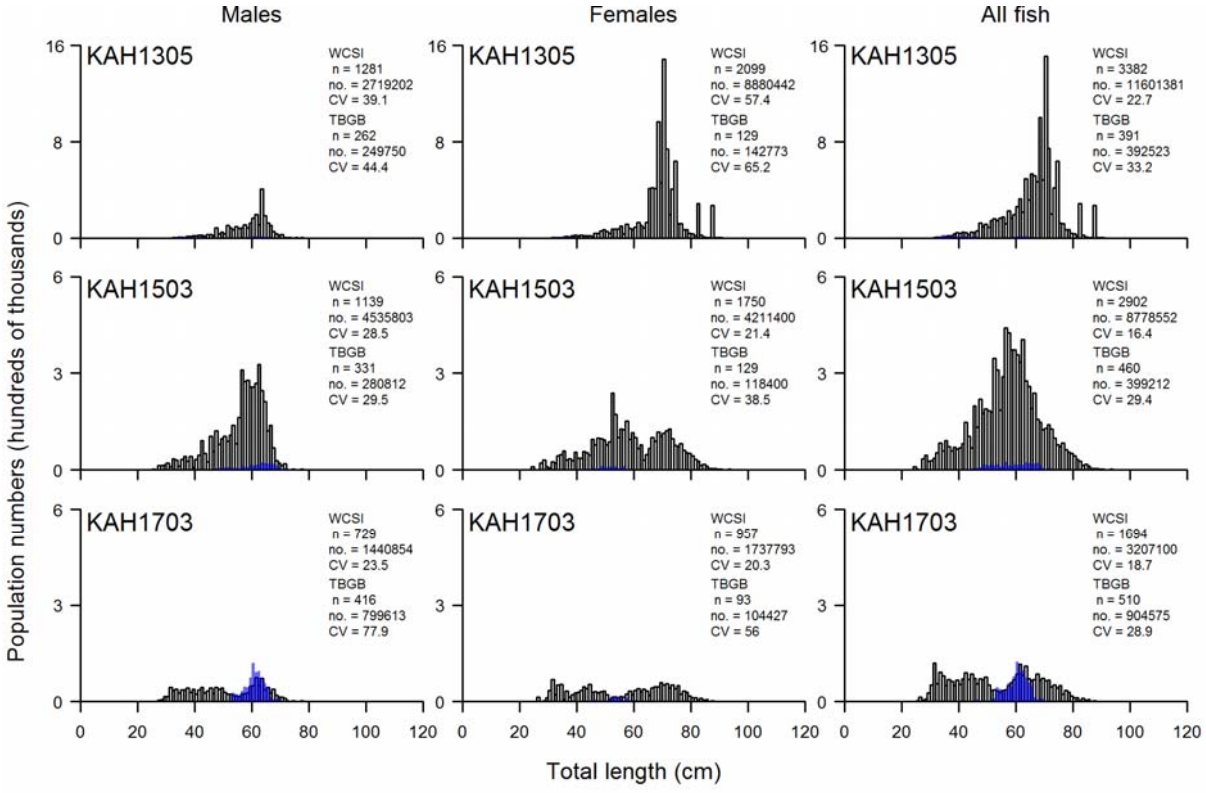


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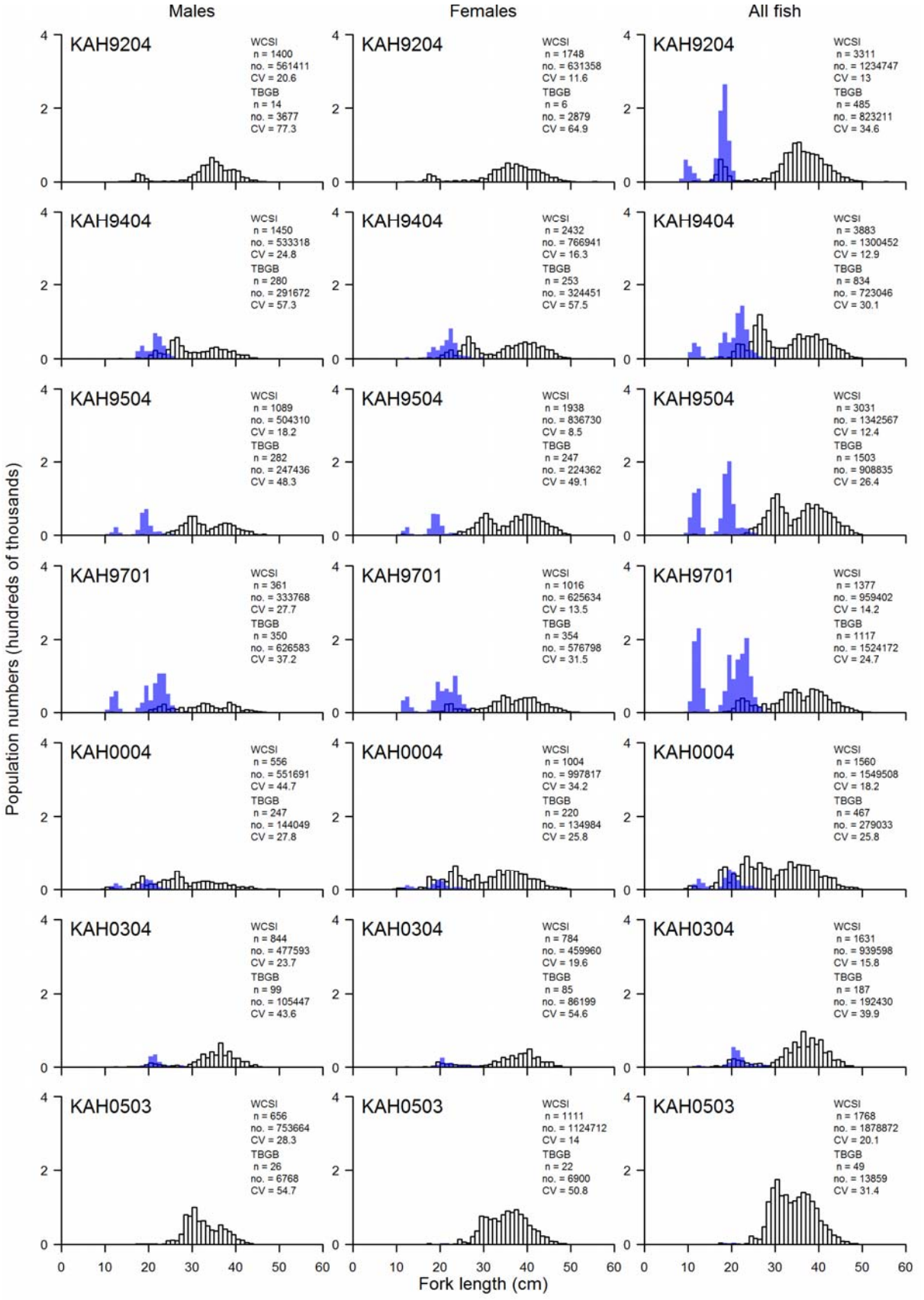


Figure 5n: Tarakihi.

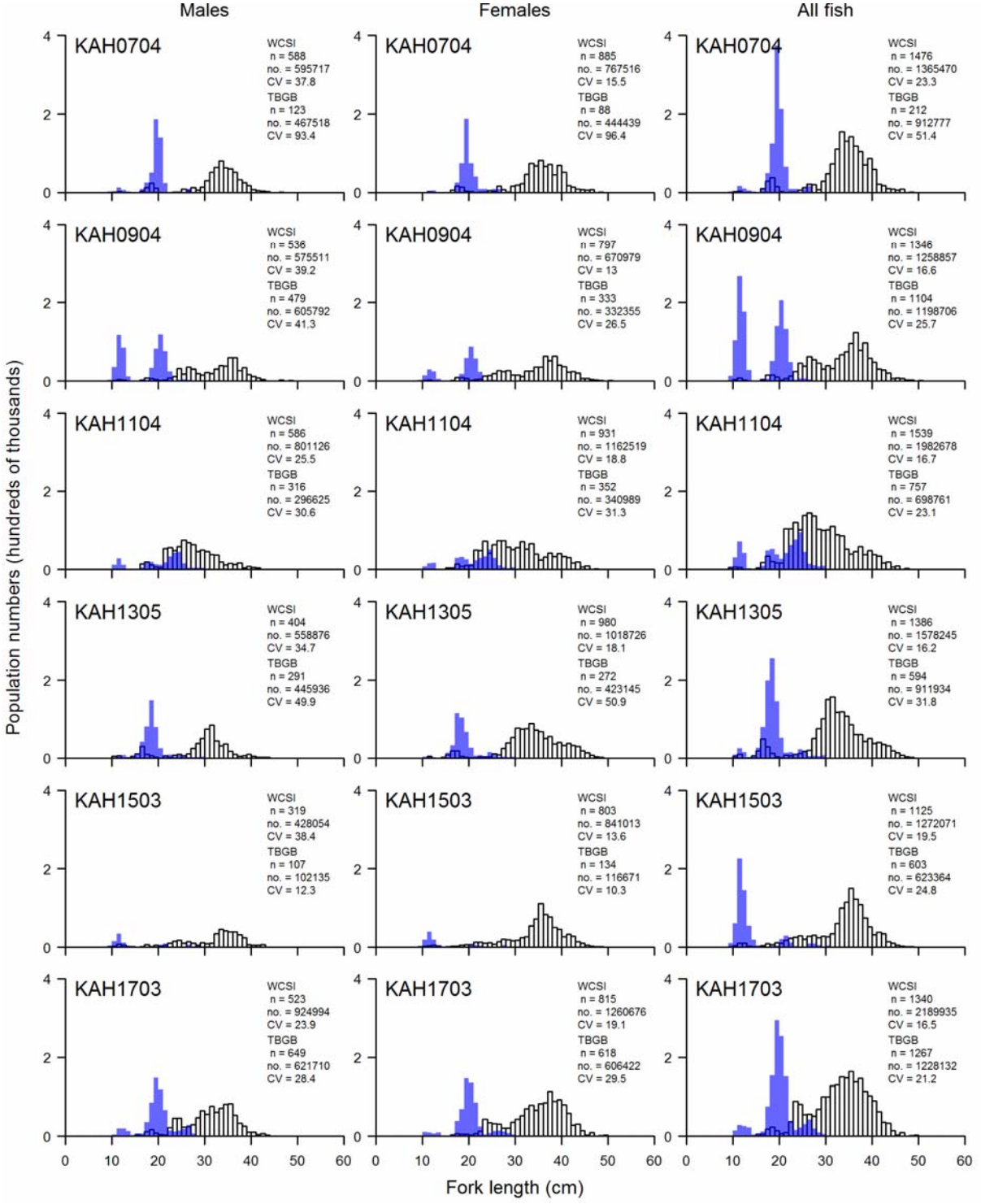
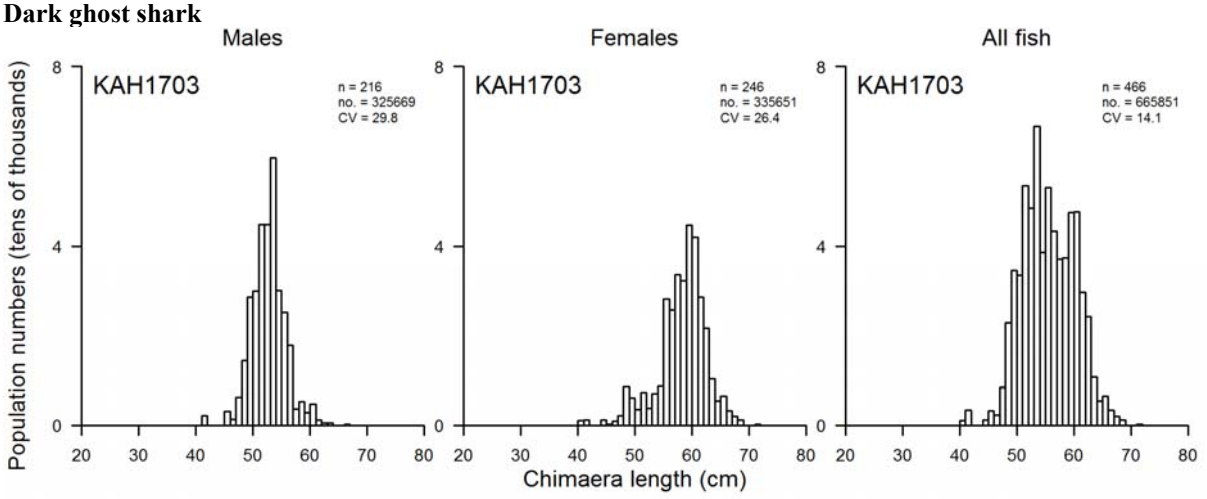
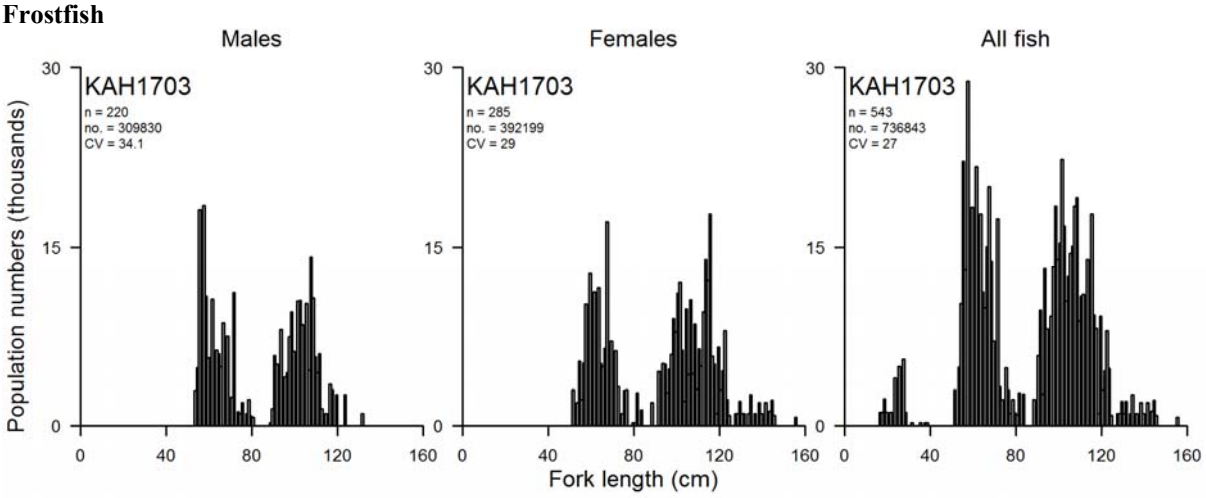


Figure 5n—continued.

Dark ghost shark



Frostfish



Hake

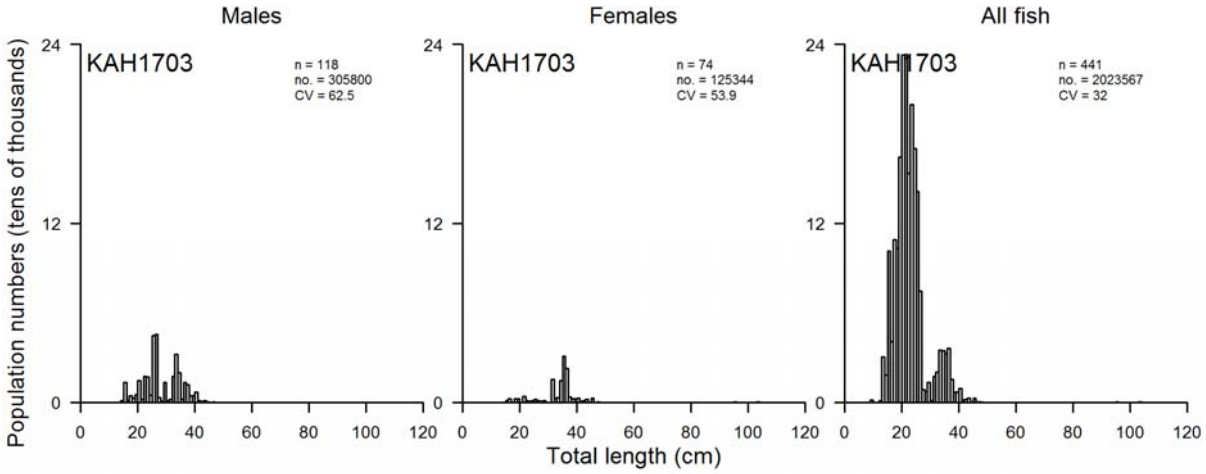
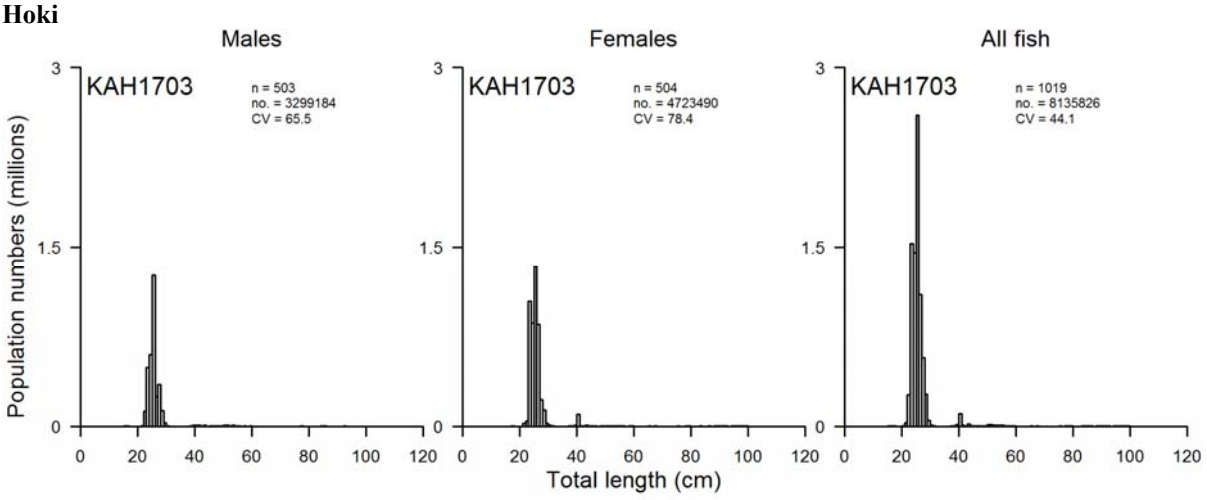
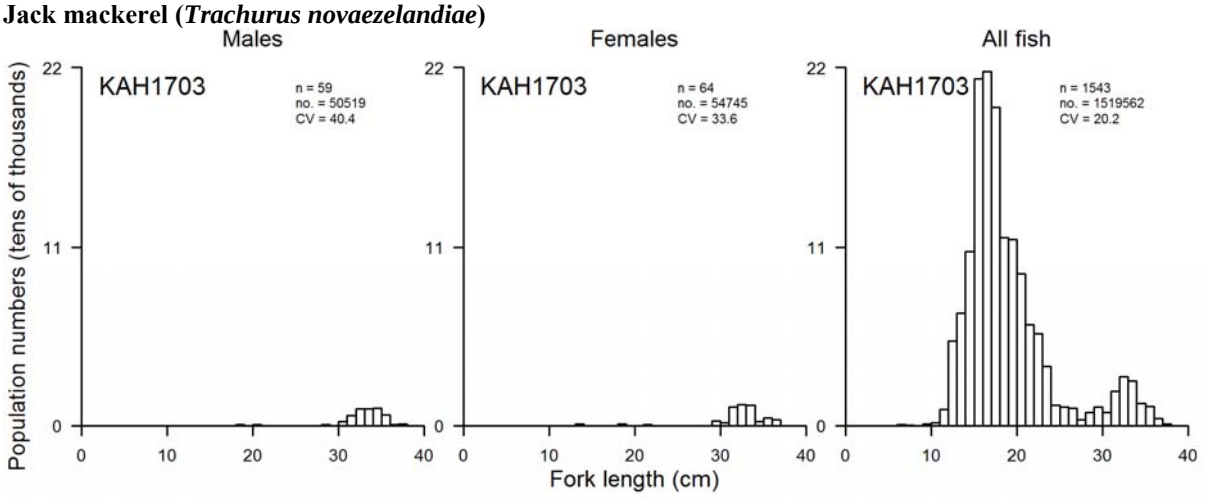


Figure 6: Scaled length frequency distributions for the other commercial species where more than 100 fish were measured. n = number of fish measured, no. = scaled population number, CV = coefficient of variation.

Hoki



Jack mackerel (*Trachurus novaezelandiae*)



Kahawai

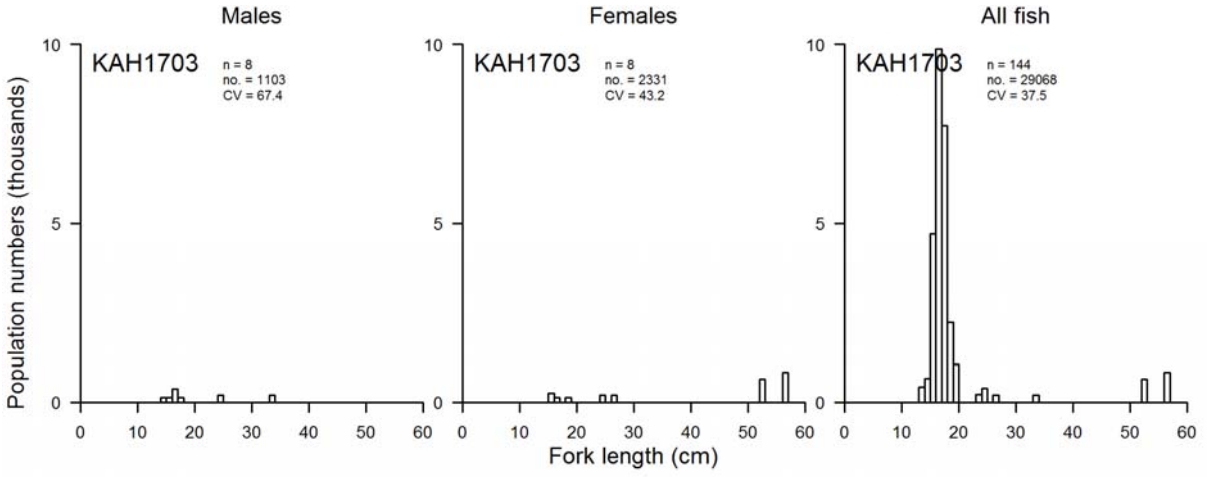
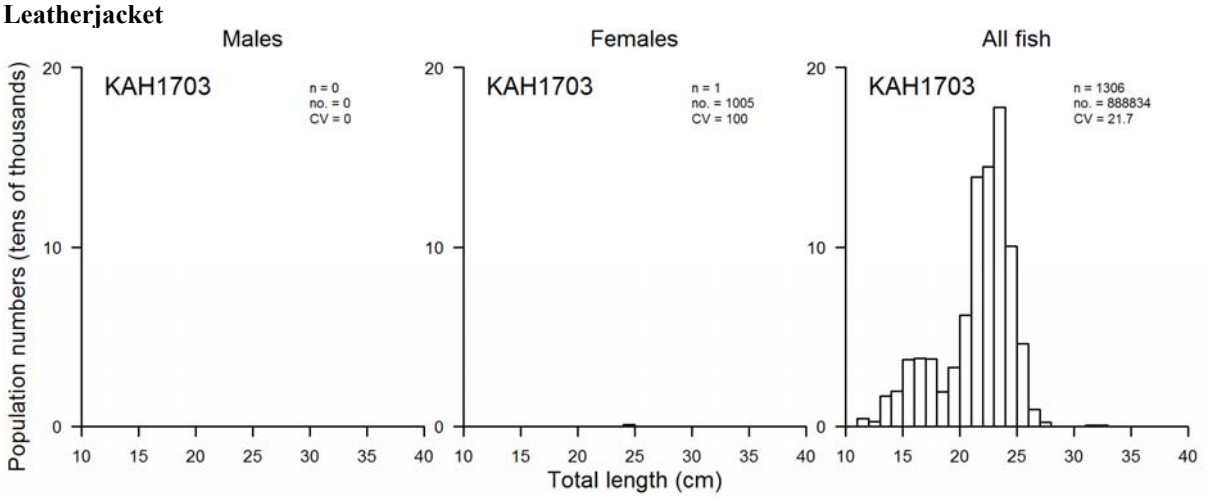
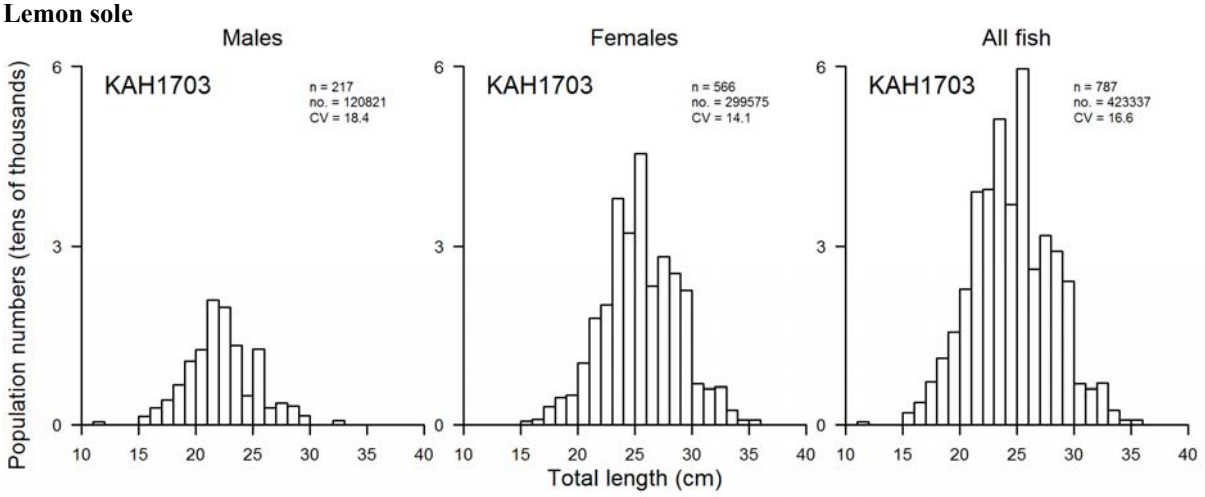


Figure 6—continued.

Leatherjacket



Lemon sole



New Zealand sole

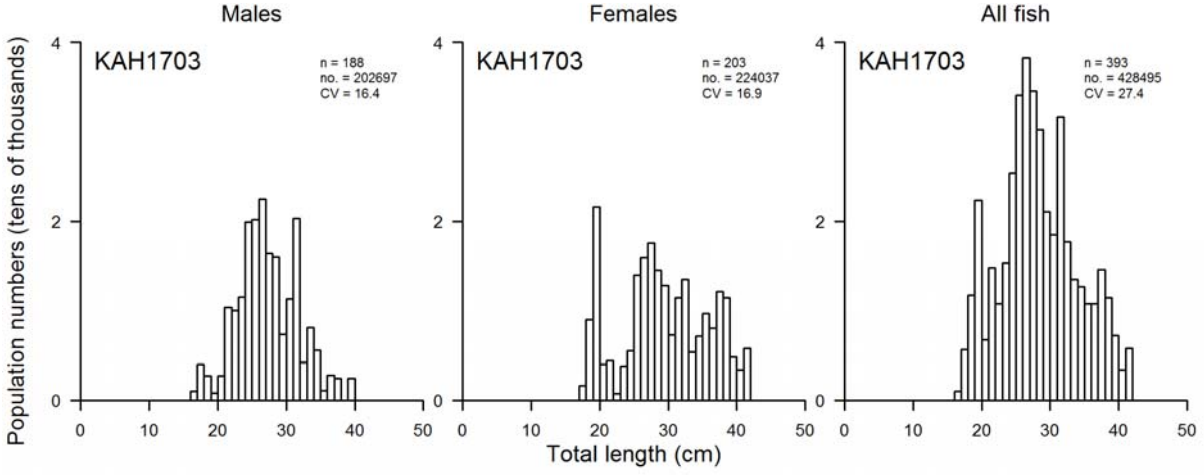
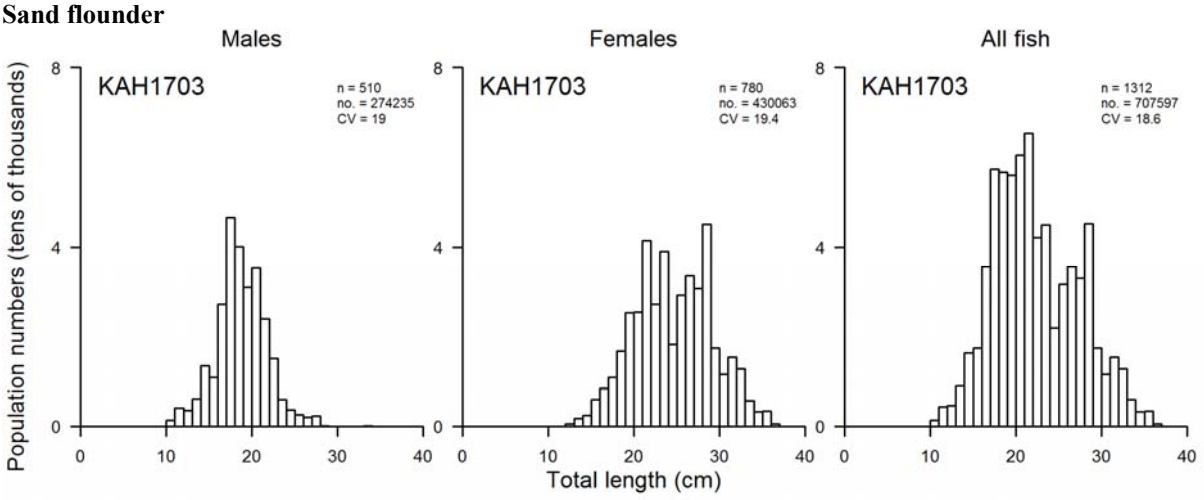
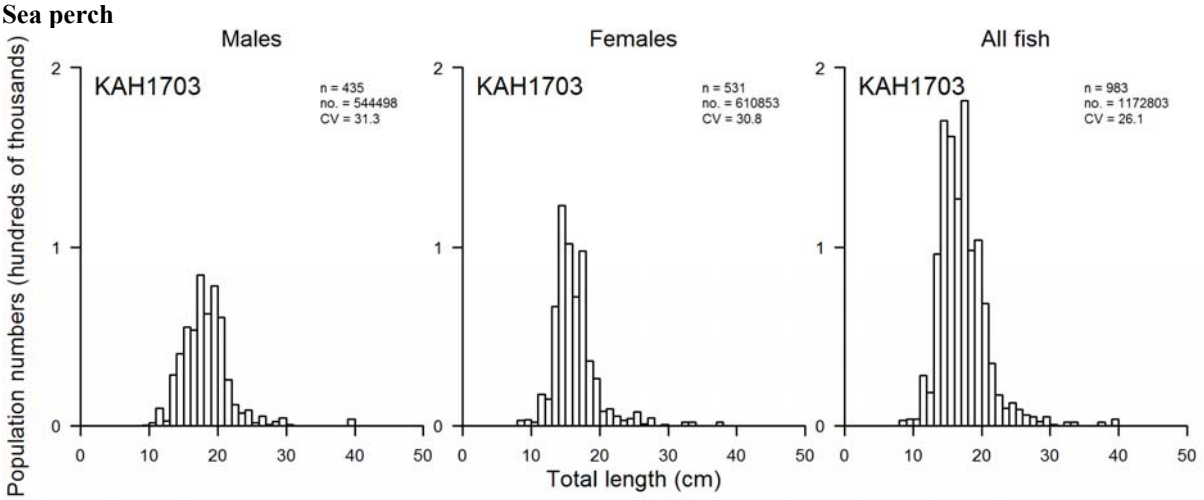


Figure 6—continued.

Sand flounder



Sea perch



Silver warehou

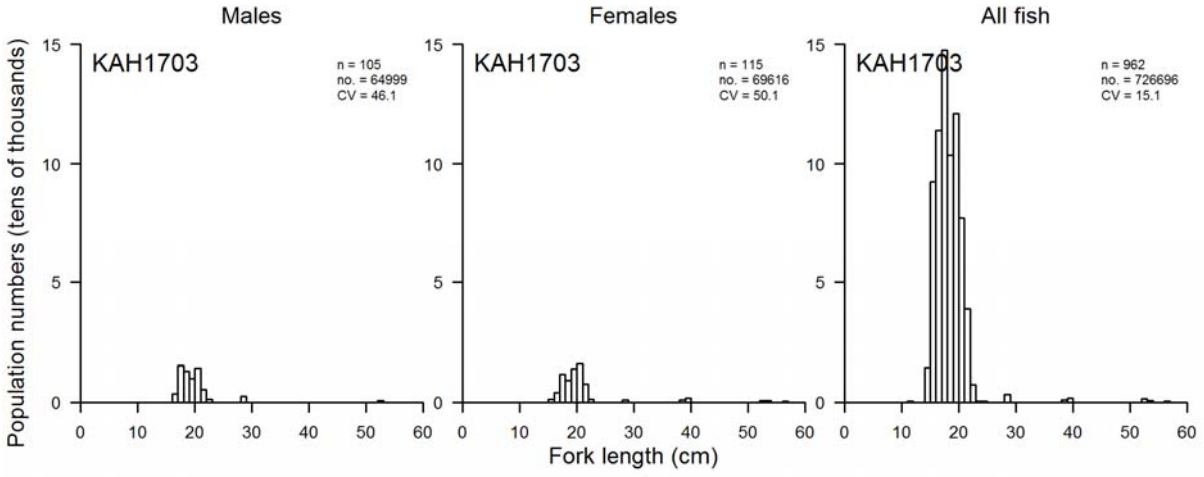
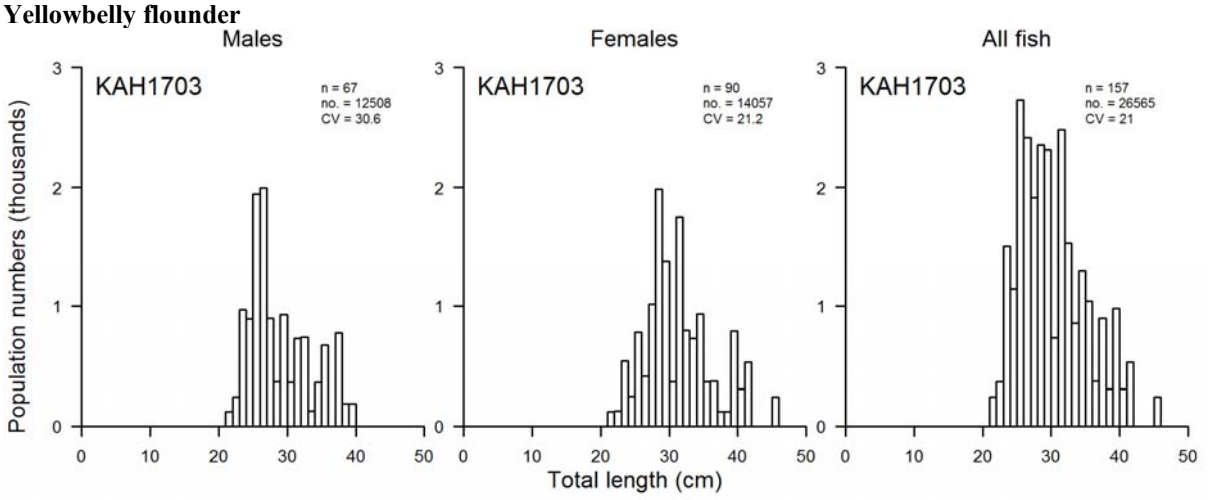


Figure 6—continued.

Yellowbelly flounder



Yellow-eyed mullet

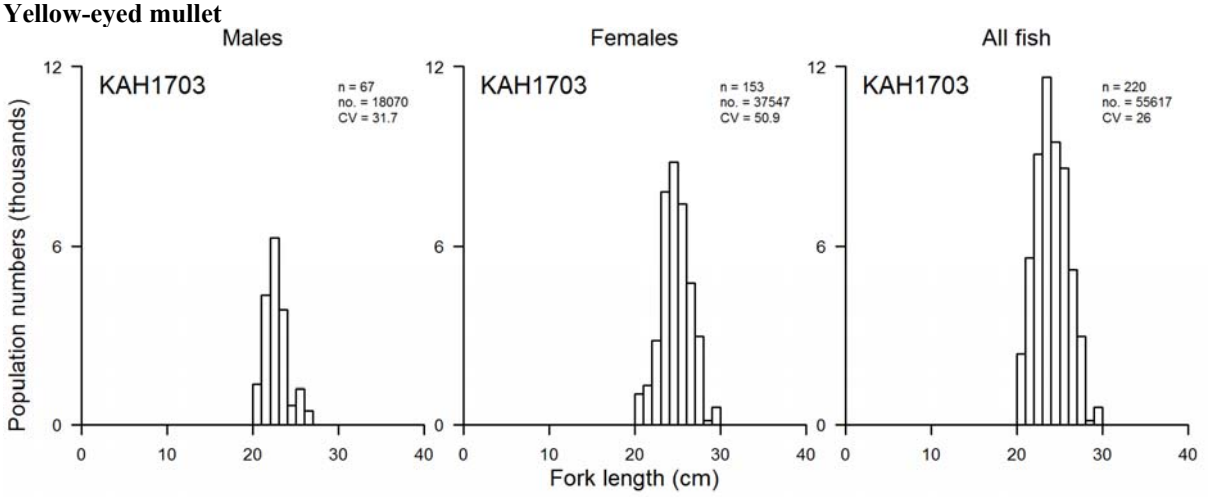


Figure 6—continued.

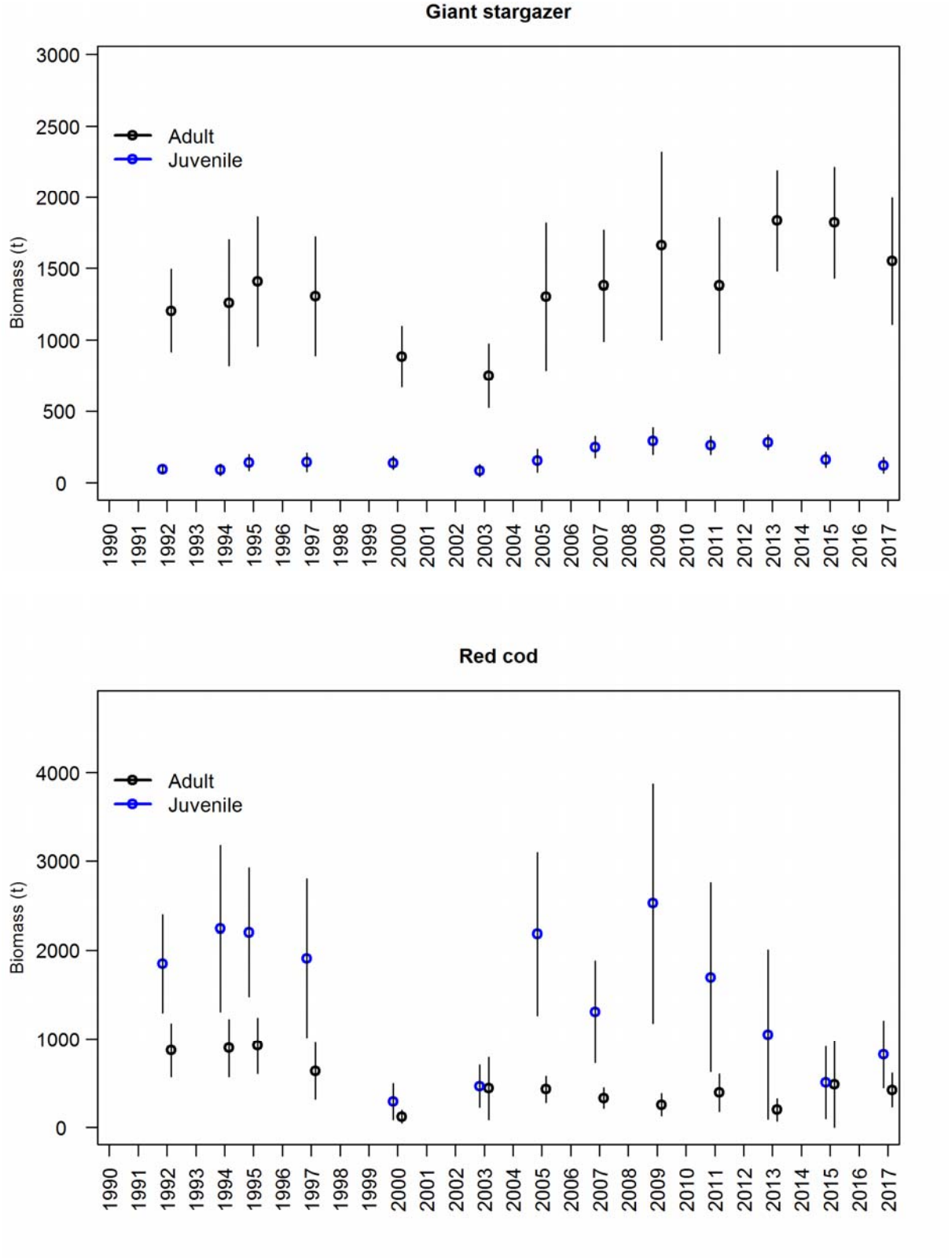


Figure 7: Biomass trends with 95% confidence intervals for juveniles (dashed blue lines) and adults (solid black lines) for the target species (all sexes combined) from all surveys in the series. For 50% maturity lengths, see Table 5.

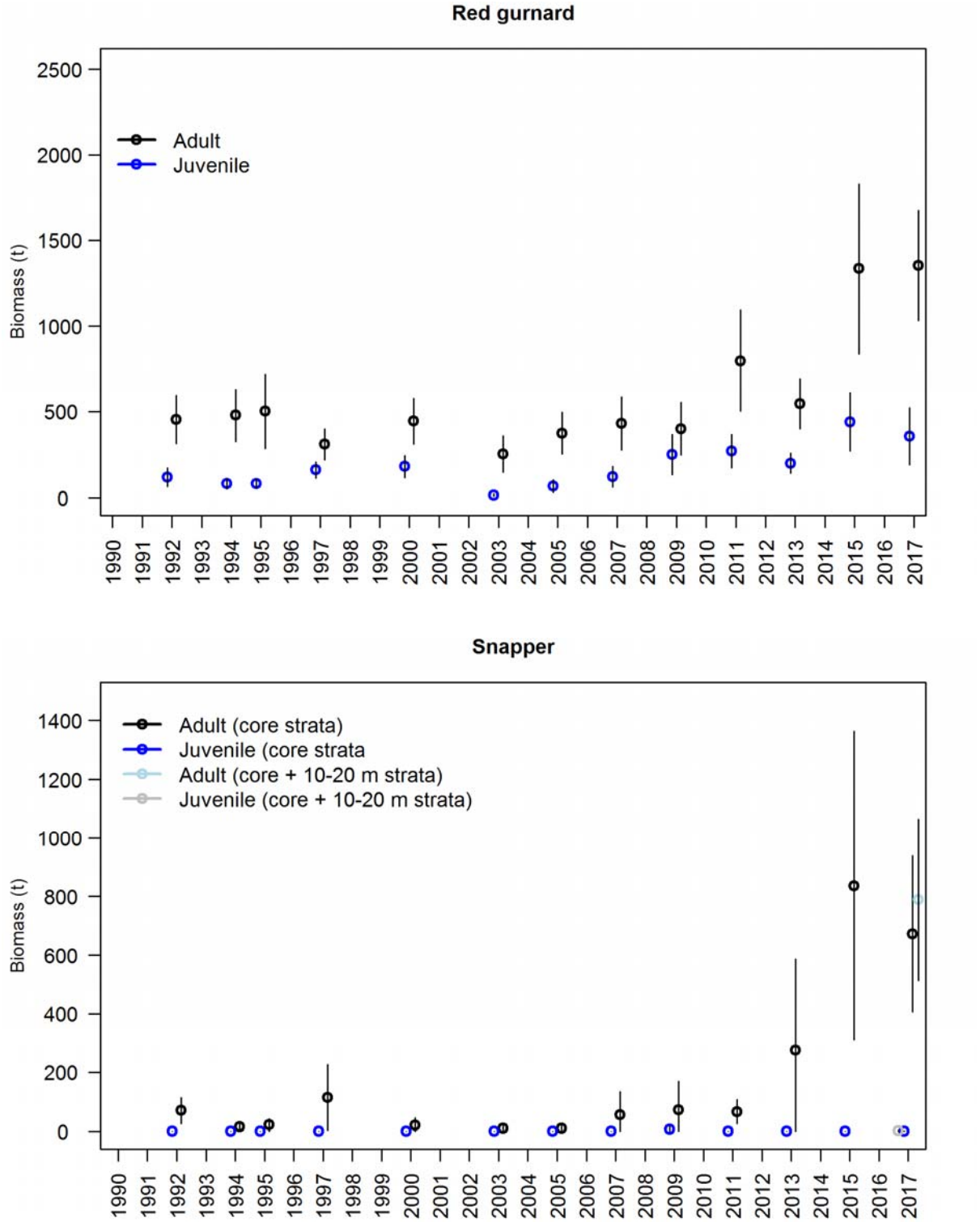


Figure 7—continued.

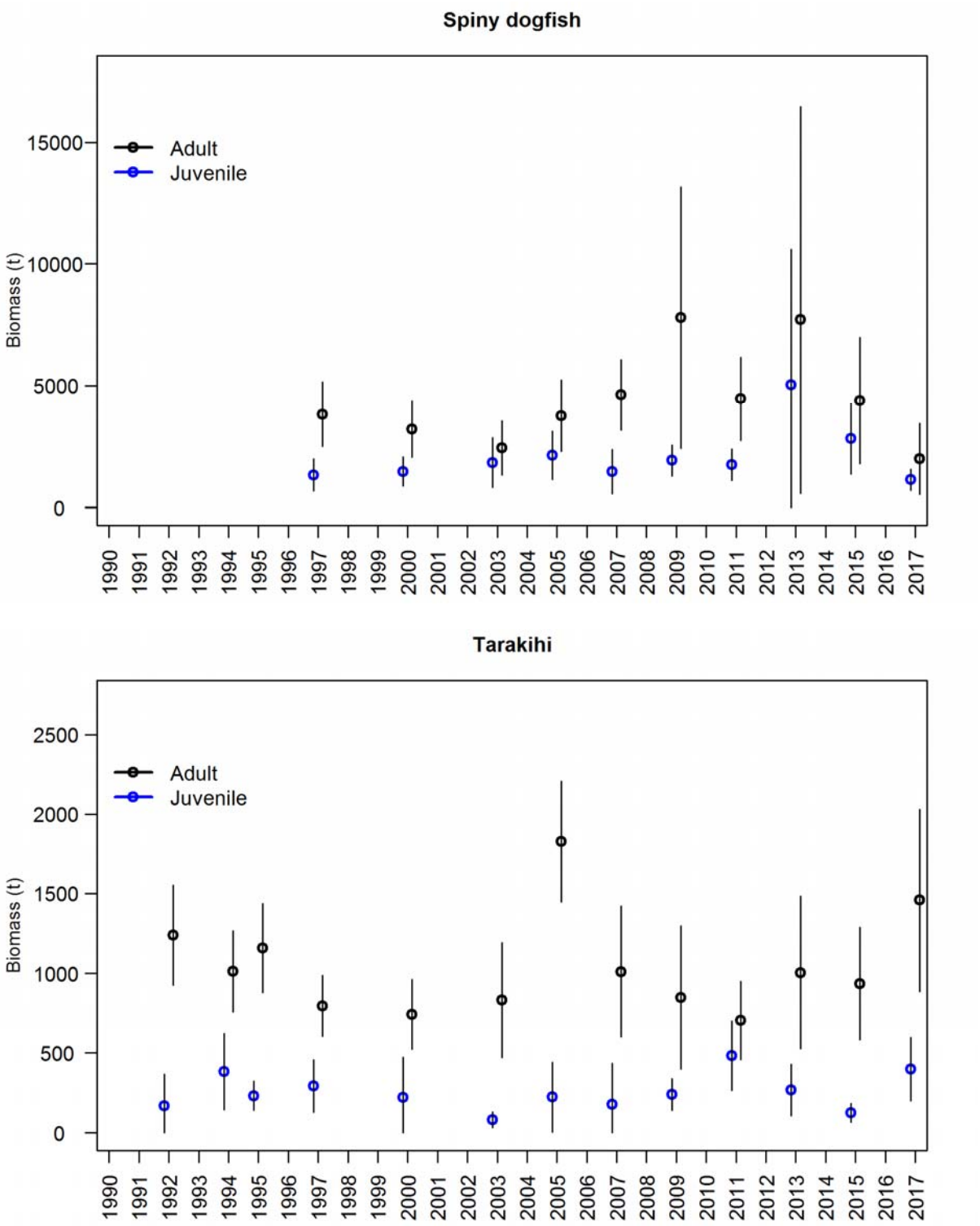


Figure 7—continued.

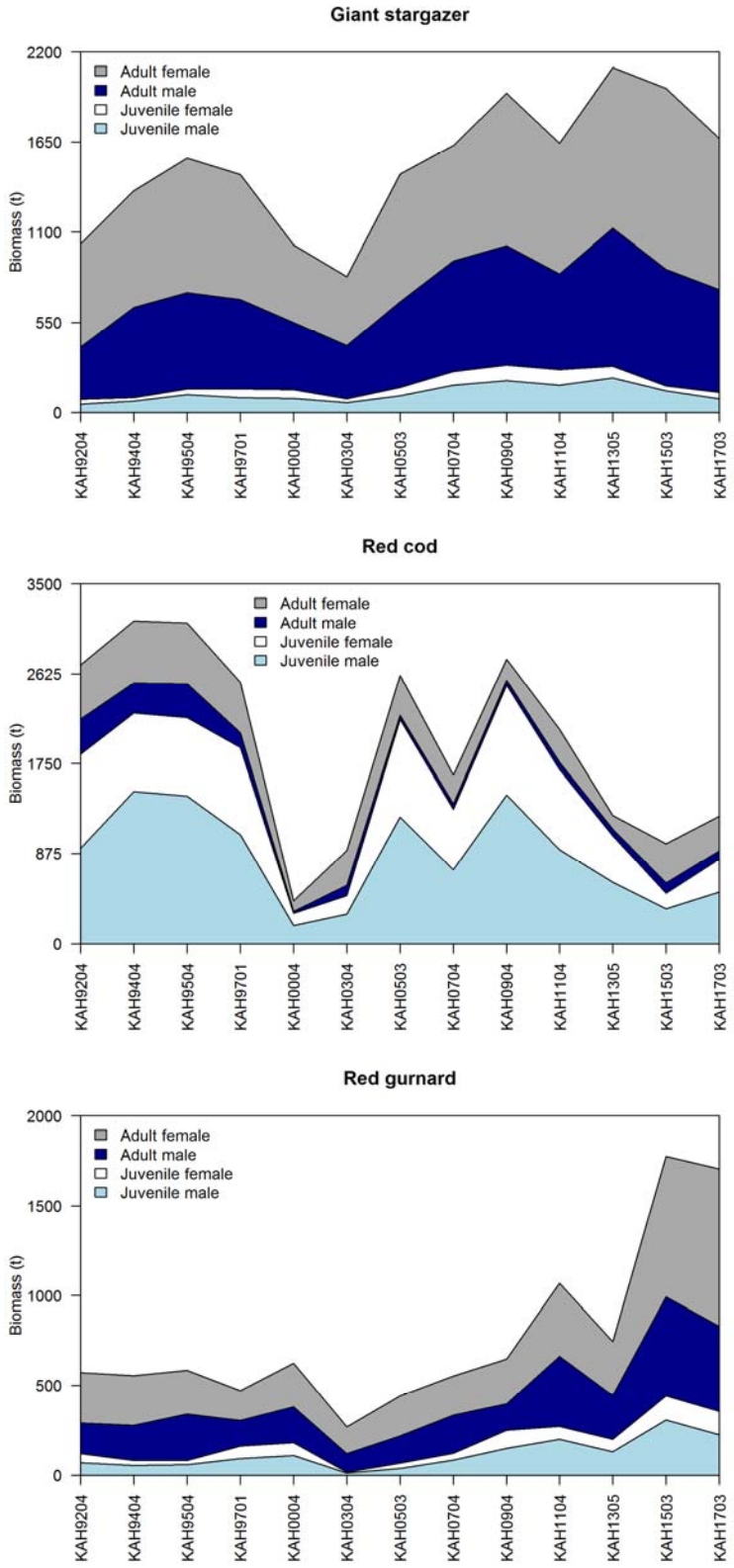


Figure 8: Biomass trends for juveniles and adults by sex for the target species for all surveys in the series. For 50% maturity lengths, see Table 5.

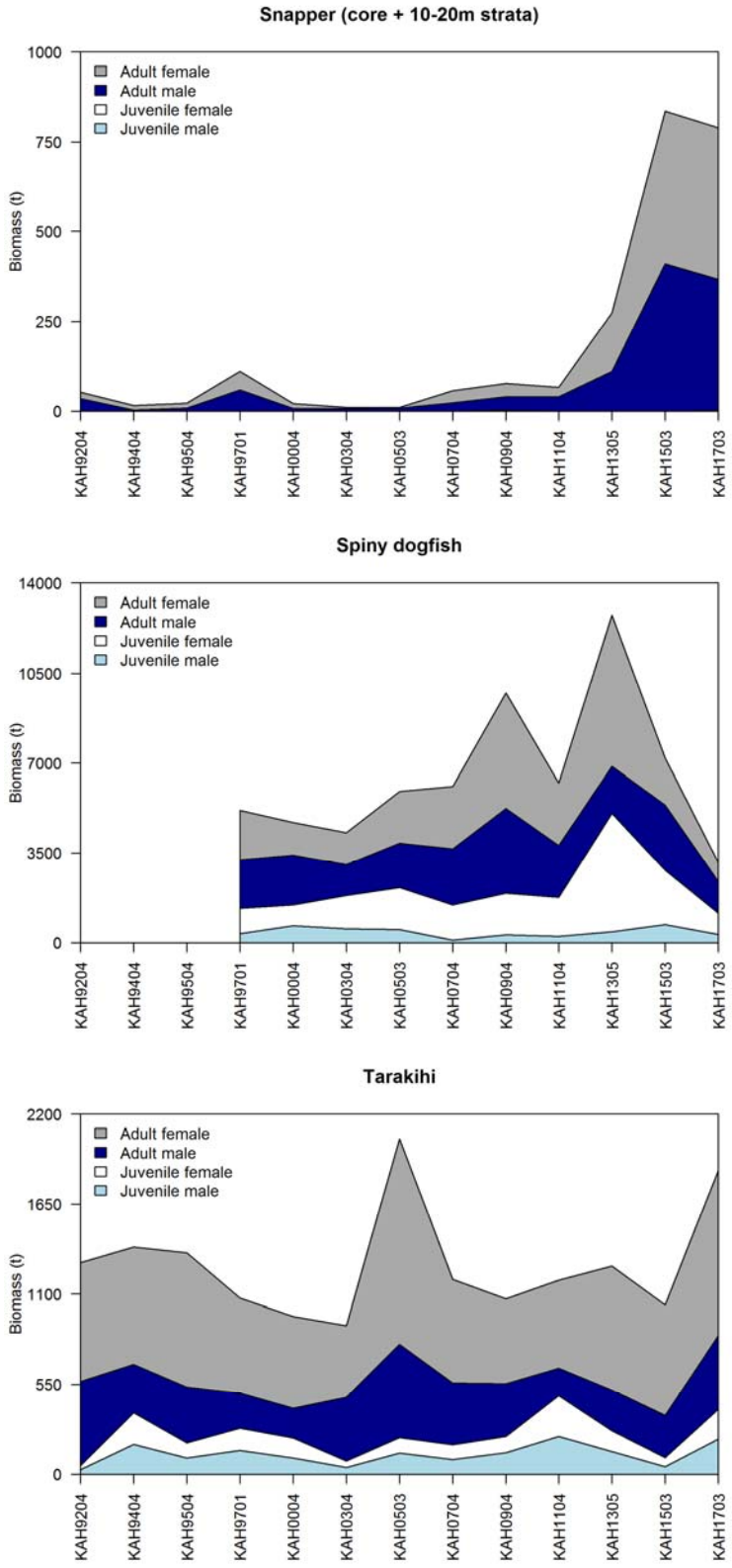


Figure 8—continued.

Appendix 1: Length-weight relationship parameters used to scale length frequencies and calculate length class biomass estimates. (Ministry for Primary Industries *rdb* database; n, sample size.)

				Length range (cm)		
Species	*a*	*b*	n	Min	Max	Data source
Barracouta	0.0056	2.9766	408	13.2	91.4	*rdb*, KAH1305
Blue warehou	0.0144	3.1050	338	27.4	69.6	*rdb*, KAH9604
Carpet shark	0.0018	3.3628	48	29.3	86.5	KAH1703
Dark ghost shark	0.0015	3.3611	332	21.1	67.9	*rdb*, KAH9704
Frostfish	0.0004	3.1629	450	10.4	153	*rdb*, KAH0004
Gemfish	0.0017	3.3419	391	32	107	*rdb*, KAH9602
Giant stargazer	0.0195	2.9670	804	13.2	54.1	KAH1703
Hake	0.0049	3.1072	260	10.7	45.2	*rdb*, KAH1104
Hoki	0.0046	2.8840	525	22	110	*rdb*, SHI8301
Jack mackerel						
(*Trachurus declivis*)	0.0165	2.9300	200	15	53	*rdb*, COR9001
(*T. novaezelandiae*)	0.0163	2.9230	200	15	40	*rdb*, COR9001
John dory	0.0253	2.9033	436	19.7	56.5	KAH1703
Kahawai	0.0236	2.8900	170	5	60	*rdb*, Unpublished data
Leather jacket	0.0088	3.2110	–	–	–	*rdb*, IKA8003
Lemon sole	0.0080	3.1278	524	14.6	41.2	*rdb*, KAH9809
Ling	0.0016	3.2477	232	27	122	KAH1305
New Zealand sole	0.0049	3.2151	114	20	48	*rdb*, KAH0304
Red cod	0.0113	2.9331	710	13.2	70.3	KAH1703
Red gurnard	0.0065	3.1349	804	13.2	54.1	KAH1703
Rig	0.0040	3.0065	430	33.6	129	KAH1703
Sand flounder	0.0207	2.8768	282	13.5	44.5	*rdb*, KAH9809
School shark	0.0031	3.0963	494	32.3	155	KAH1703
Sea perch	0.0262	2.9210	210	7	42	KAH9618
Silver warehou	0.0058	3.3279	146	15.8	43.2	TAN0502
Snapper	0.0389	2.8460	358	15.8	83.2	KAH1703
Spiny dogfish	0.0024	3.1165	784	28.6	89.8	KAH1703
Tarakihi	0.0143	3.0677	728	10.9	50	KAH1703

Appendix 2: Summary of station data.

			Start of tow			End of tow		Gear depth (m)		Distance trawled	Headline	Doorspread	Surface temp	Bottom temp	warp_lgth
Station	Stratum	Date	Time	° ' S	° ' E	° ' S	° ' E	Min.	Max.	(n. miles)	height (m)	(m)	(°C)	(°C)	
1	20	25-Mar-17	759	41 12.47	173 15.90	41 10.70	173 18.98	15	19	2.91	4.9	68	18.9	17.6	200
2	20	25-Mar-17	1038	41 11.21	173 14.65	41 09.16	173 11.75	15	16	2.99	4.3	68	8.9	18.3	200
3	18	25-Mar-17	1328	41 07.29	173 13.66	41 06.31	173 10.01	20	22	2.91	4.7	73	18.2	17.6	200
4	20	25-Mar-17	1538	41 06.19	173 07.70	41 08.92	173 09.47	14	16	3.03	4.9	68	18.7	14.3	200
5	19	26-Mar-17	718	40 43.46	173 45.54	40 45.28	173 42.54	64	67	2.91	5	73	17.2	16.2	200
6	19	26-Mar-17	1000	40 58.63	173 40.96	41 00.39	173 37.99	39	41	2.85	4.7	73	17.7	16.4	200
7	18	26-Mar-17	1529	41 03.09	173 34.32	41 05.10	173 31.34	25	30	3.01	4.7	73	18	16.7	200
8	18	27-Mar-17	714	41 06.50	173 24.07	41 08.38	173 21.40	25	28	2.75	4.6	73	18.5	17	200
9	20	27-Mar-17	924	41 11.19	173 10.64	41 09.43	173 07.42	13	14	2.99	4.8	68	18.7	18.4	200
10	18	27-Mar-17	1134	41 04.06	173 13.61	41 04.62	173 16.33	32	33	2.12	5	73	18.2	17.6	200
11 #	18	27-Mar-17	1345	41 02.46	173 16.31	41 01.06	173 15.90	35	36	1.43	4.8	73	18.2	16.1	200
12 #	18	27-Mar-17	1537	40 58.34	173 11.09	40 59.38	173 11.34	29	30	1.05	4.8	73	17.9	16.4	200
13	18	27-Mar-17	1649	40 56.19	173 12.47	40 54.25	173 11.86	33	35	1.99	4.7	73	18	16.3	200
14	18	28-Mar-17	729	41 03.83	173 28.90	41 02.17	173 25.72	32	38	2.91	4.8	73	17.9	16.2	200
15	18	28-Mar-17	927	41 02.46	173 22.83	40 59.95	173 23.13	38	41	2.52	4.8	73	18.3	16	200
16	19	28-Mar-17	1322	40 52.42	173 15.82	40 50.06	173 18.22	40	42	2.97	4.9	73	17.8	16.2	200
17	19	28-Mar-17	1539	40 50.43	173 09.12	40 48.18	173 08.21	36	36	2.35	4.8	73	17.6	15.9	200
18	19	29-Mar-17	723	40 39.17	173 33.06	40 39.18	173 29.01	56	57	3.07	5	73	16.9	15.4	200
19	19	29-Mar-17	945	40 41.05	173 28.54	40 41.09	173 24.65	50	55	2.95	5	73	16.7	15.5	200
20 #	17	29-Mar-17	1313	40 43.21	172 57.86	40 43.02	172 56.67	30	31	0.92	4.8	73	18	16.9	200
21	17	29-Mar-17	1430	40 42.33	172 53.36	40 43.44	172 57.11	27	28	3.05	4.9	73	18.2	16.8	200
22	17	29-Mar-17	1617	40 41.33	172 53.28	40 40.37	172 50.11	24	26	2.58	4.8	73	18.1	16.9	200
23	17	30-Mar-17	831	40 38.45	172 53.38	40 38.55	172 57.21	28	32	2.9	4.6	73	18	17.1	200
24	21	2-Apr-17	1502	40 46.63	172 56.14	40 46.80	172 53.13	15	17	2.28	4.4	67.7	18.2	17.3	200
25	21	2-Apr-17	1635	40 45.31	172 49.12	40 43.70	172 45.90	15	17	2.92	4.6	68.2	18.1	17.4	200
26	1	3-Apr-17	632	40 33.02	172 29.73	40 31.37	172 33.04	63	67	3	4.9	75	16.1	14.4	200
27	1	3-Apr-17	1013	40 36.05	172 10.79	40 35.14	172 14.53	83	93	2.98	4.9	79	18.3	14.4	250
28	2	3-Apr-17	1250	40 36.64	172 05.95	40 34.54	172 08.44	115	116	2.82	4.8	86.2	18.3	14.1	325
29	2	3-Apr-17	1527	40 39.83	171 56.03	40 41.85	171 52.85	137	139	3.14	4.9	90.4	18.4	14	390
30	6	4-Apr-17	634	41 20.67	171 00.07	41 18.29	171 02.36	185	188	2.93	4.9	90.6	18	13.7	500
31	6	4-Apr-17	1015	41 27.90	171 22.51	41 25.00	171 21.82	138	140	2.94	4.8	88.9	18.2	13.1	390

Appendix 2—*continued*

Station	Stratum	Date	Start of tow			End of tow		Gear depth (m)		Distance trawled	Headline	Doorspread	Surface temp	Bottom temp	warp_lgth
			Time	° ' S	° ' E	° ' S	° ' E	Min.	Max.	(n. miles)	height (m)	(m)	(°C)	(°C)	
32	6	4-Apr-17	1246	41 20.21	171 34.14	41 17.46	171 35.60	127	129	2.96	4.8	84.8	18.1	13.1	355
33	2	4-Apr-17	1520	41 06.19	171 31.84	41 03.36	171 30.71	136	147	2.95	4.8	86.6	18.3	13.8	400
34	5	5-Apr-17	633	41 29.03	171 50.60	41 26.07	171 49.87	38	44	3.01	4.5	76.7	17.3	15.1	200
35	5	5-Apr-17	815	41 24.99	171 52.28	41 21.93	171 52.22	41	48	3.06	4.8	74.1	17.2	14.9	200
36	5	5-Apr-17	1012	41 20.87	171 59.38	41 18.16	172 01.11	36	38	3	4.8	74.1	17.4	15.7	200
37	1	5-Apr-17	1223	41 13.81	171 54.98	41 11.14	171 56.57	74	77	2.92	4.5	71.5	16.9	14.8	230
38	2	5-Apr-17	1431	41 07.83	171 51.34	41 06.03	171 48.20	102	113	2.97	4.8	81.1	17.5	13.2	310
39	1	6-Apr-17	805	40 56.91	172 00.57	40 54.07	172 01.77	86	87	2.98	4.8	78.3	17.5	15.2	250
40	2	6-Apr-17	1245	40 52.54	171 46.92	40 50.01	171 49.13	130	131	3.03	4.9	88	18.2	13.9	370
41	8	8-Apr-17	1031	41 47.69	171 15.07	41 50.73	171 14.28	129	135	3.09	4.9	86.3	16.8	13.2	360
42	8	8-Apr-17	1312	41 45.14	171 09.55	41 47.39	171 07.44	149	152	2.75	4.9	91	16.8	13.2	420
43	8	8-Apr-17	1524	41 53.75	171 11.38	41 56.59	171 09.70	132	134	3.1	4.9	87.4	16.9	13.4	370
44	9	9-Apr-17	646	41 47.30	170 35.73	41 50.42	170 35.69	386	394	3.12	4.7	98.7	17.8	11.4	950
45	9	9-Apr-17	909	41 55.17	170 38.89	41 58.10	170 37.67	299	308	3.06	4.8	97.5	17.8	12.7	770
46	9	9-Apr-17	1125	42 03.43	170 33.51	42 06.47	170 33.55	378	384	3.04	4.6	99.7	17.9	11.4	930
47	8	9-Apr-17	1448	41 55.63	170 51.75	41 52.63	170 52.07	179	181	3	4.8	91.1	18.1	13	500
48	12	10-Apr-17	640	42 45.79	170 07.22	42 48.70	170 07.63	163	164	2.92	4.8	85.5	17.8	13.4	450
49	12	10-Apr-17	904	42 43.16	170 14.17	42 46.08	170 13.32	141	143	2.98	4.9	84.5	17.1	13.5	390
50	12	10-Apr-17	1134	42 47.01	170 14.20	42 49.07	170 11.27	138	149	2.97	4.8	83.7	16.8	13.5	410
51	12	10-Apr-17	1405	42 51.56	170 13.41	42 54.04	170 11.27	134	135	2.93	4.8	84.2	16.6	13.4	370
52	7	11-Apr-17	641	41 54.94	171 22.13	41 57.77	171 20.73	38	39	3.01	4.8	73	16.9	16.2	200
53	7	11-Apr-17	827	41 58.55	171 17.88	42 01.42	171 16.43	53	54	3.06	4.9	73.3	16.9	16.2	200
54	7	11-Apr-17	1156	42 21.68	171 03.67	42 24.57	171 02.67	74	75	2.98	4.7	72.1	16.4	14.9	210
55	11	11-Apr-17	1428	42 36.76	170 57.47	42 39.26	170 55.08	53	56	3.05	4.8	73.8	16.4	15.5	200
56	14	12-Apr-17	718	43 48.52	168 59.08	43 49.56	168 55.07	39	45	3.07	4.8	71.6	16	16.1	200
57	15	12-Apr-17	1129	43 40.01	169 04.33	43 43.05	169 04.53	112	134	3.04	5	85.9	16.5	13.5	350
58	14	12-Apr-17	1354	43 43.31	169 09.89	43 45.26	169 06.47	29	54	3.14	5	71.6	15.9	16.2	200
59	13	13-Apr-17	653	42 54.04	170 01.08	42 56.61	169 59.18	227	236	2.92	4.8	88	17.5	13.1	620
60	13	13-Apr-17	927	43 02.05	169 48.02	43 04.73	169 46.16	214	225	3	4.8	90.9	17.8	13.2	590
61	13	13-Apr-17	1128	43 08.99	169 45.40	43 12.00	169 45.46	200	201	3.01	4.8	90.4	17.8	13.2	540
62	16	13-Apr-17	1354	43 14.94	169 37.16	43 17.35	169 34.92	303	315	2.91	4.9	95.1	17.8	13	780

Appendix 3: Catch summary in order by weight. * = less than 0.5%.

Species code	Common name	Scientific name	Catch (kg)	% of total catch	No. of Stations	% Occurrence	Depth Min.	Depth Max.
BAR	Barracouta	*Thyrsites atun*	5 541.3	16	62	83.8	13	308
SPD	Spiny dogfish	*Squalus acanthias*	3 988.6	11.5	57	77	16	227
GUR	Red gurnard	*Chelidonichthys kumu*	3 151.1	9.1	53	71.6	13	188
SNA	Snapper	*Pagrus auratus*	2 279.1	6.6	33	44.6	13	130
NMP	Tarakihi	*Nemadactylus macropterus*	2 189.5	6.3	53	71.6	13	394
GIZ	Giant stargazer	*Kathetostoma giganteum*	1 949.1	5.6	51	68.9	15	384
RCO	Red cod	*Pseudophycis bachus*	1 588.3	4.6	54	73	13	334
WAR	Blue warehou	*Seriolella brama*	1 196.1	3.5	36	48.6	13	136
SPO	Rig	*Mustelus lenticulatus*	1 043.1	3	48	64.9	13	163
SCH	School shark	*Galeorhinus galeus*	1 033	3	65	87.8	13	384
HOK	Hoki	*Macruronus novaezelandiae*	834.8	2.4	18	24.3	53	394
CAR	Carpet shark	*Cephaloscyllium isabellum*	663	1.9	62	83.8	15	384
RSO	Gemfish	*Rexea solandri*	616.7	1.8	25	33.8	89	394
GSH	Dark ghost shark	*Hydrolagus novaezealandiae*	607.4	1.8	22	29.7	74	394
JDO	John dory	*Zeus faber*	580.5	1.7	46	62.2	15	188
FRO	Frostfish	*Lepidopus caudatus*	548.8	1.6	25	33.8	41	394
JMN	Yellowtail jack mackerel	*Trachurus novaezelandiae*	425.4	1.2	40	54.1	13	105
SFL	Sand flounder	*Rhombosolea plebeia*	407.6	1.2	22	29.7	13	48
LIN	Ling	*Genypterus blacodes*	364.9	1.1	29	39.2	16	394
LEA	Leatherjacket	*Meuschenia scaber*	358	1	20	27	17	65
RSK	Rough skate	*Zearaja nasuta*	354.6	1	35	47.3	22	394
HAK	Hake	*Merluccius australis*	324.4	0.9	29	39.2	26	334
SDO	Silver dory	*Cyttus novaezealandiae*	281	0.8	27	36.5	56	394
WIT	Witch	*Arnoglossus scapha*	261.4	0.8	65	87.8	13	394
SQU	Arrow squid	*Nototodarus sloanii & N. gouldi*	251.1	0.7	65	87.8	15	394
CBI	Two saddle rattail	*Coelorinchus biclinozonalis*	249.3	0.7	23	31.1	36	394
SCG	Scaly gurnard	*Lepidotrigla brachyoptera*	227.7	0.7	54	73	29	308
CUC	Cucumber fish	*Paraulopus nigripinnis*	196	0.6	22	29.7	57	394
SPE	Sea perch	*Helicolenus* spp.	176.5	0.5	34	45.9	26	394
LSO	Lemon sole	*Pelotretis flavilatus*	175.2	0.5	50	67.6	13	326
ERA	Electric ray	*Torpedo fairchildi*	167.8	0.5	17	23	15	74
BCO	Blue cod	*Parapercis colias*	154.4	0.4	19	25.7	26	57
SWA	Silver warehou	*Seriolella punctata*	153.4	0.4	37	50	26	315
ESO	N.Z. sole	*Peltorhamphus novaezeelandiae*	138.8	0.4	18	24.3	13	74
POP	Porcupine fish	*Allomycterus jaculiferus*	137.9	0.4	14	18.9	30	188
ELE	Elephant fish	*Callorhinchus milii*	129.6	0.4	5	6.8	30	89
NSD	Northern spiny dogfish	*Squalus griffini*	126.7	0.4	15	20.3	74	394
GLB	Globefish	*Contusus richei*	122.3	0.4	6	8.1	30	48
GLM	Green-lipped mussel	*Perna canaliculus*	113.2	0.3	9	12.2	13	65
RHY	Common roughy	*Paratrachichthys trailli*	88.5	0.3	2	2.7	227	315
JMD	Greenback jack mackerel	*Trachurus declivis*	79.6	0.2	35	47.3	16	180
SSK	Smooth skate	*Dipturus innominatus*	71.2	0.2	11	14.9	63	394
WOD	Wood	Wood	69.7	0.2	12	16.2	15	137
BRA	Short-tailed black ray	*Dasyatis brevicaudata*	66.6	0.2	4	5.4	17	33
KIN	Kingfish	*Seriola lalandi*	65.2	0.2	10	13.5	17	136
CON	Conger eel	*Conger* spp.	63.4	0.2	14	18.9	30	130
CDO	Capro dory	*Capromimus abbreviatus*	60.6	0.2	19	25.7	89	394
EGR	Eagle ray	*Myliobatis tenuicaudatus*	55.1	0.2	11	14.9	13	48
CBO	Bollon's rattail	*Coelorinchus bollonsi*	53.9	0.2	2	2.7	326	334
YBF	Yellowbelly flounder	*Rhombosolea leporina*	53.7	0.2	9	12.2	13	32
ASC	Sea squirt	Ascidiacea	53.3	0.2	13	17.6	13	48

Appendix 3–continued.

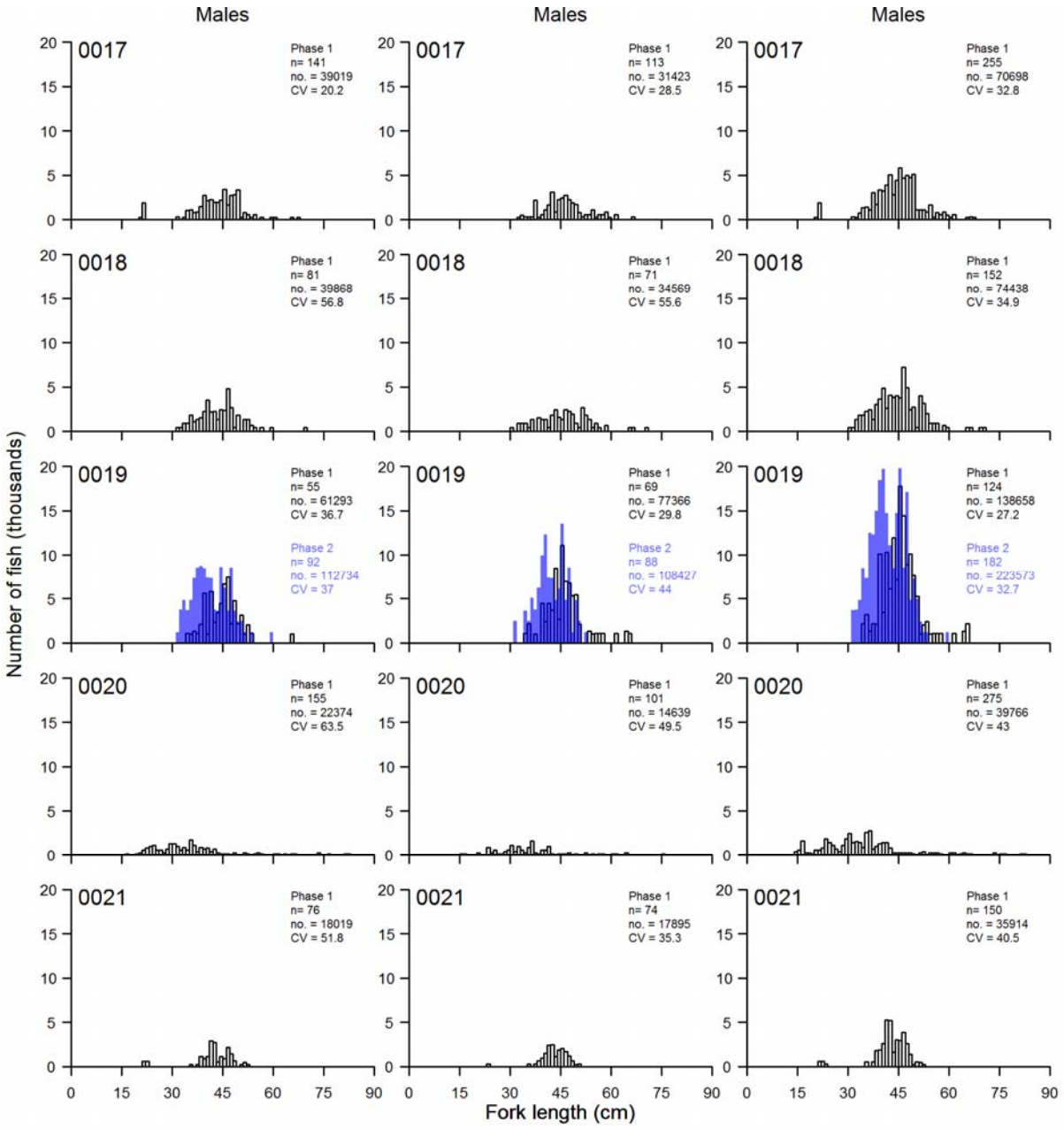
Species code	Common name	Scientific name	Catch (kg)	% of total catch	No. of Stations	% Occurrence	Depth Min.	Depth Max.
ONG	Sponges	Porifera (Phylum)	52.4	0.2	14	18.9	13	137
STY	Spotty	*Notolabrus celidotus*	46.2	0.1	16	21.6	13	38
YEM	Yellow-eyed mullet	*Aldrichetta forsteri*	39.1	0.1	10	13.5	13	33
DIR	Pagurid	*Diacanthurus rubricatus*	36.8	0.1	19	25.7	13	334
HEX	Sixgill shark	*Hexanchus griseus*	34.9	0.1	2	2.7	200	334

Appendix 4: Benthic macro-invertebrates taken as bycatch during the survey.

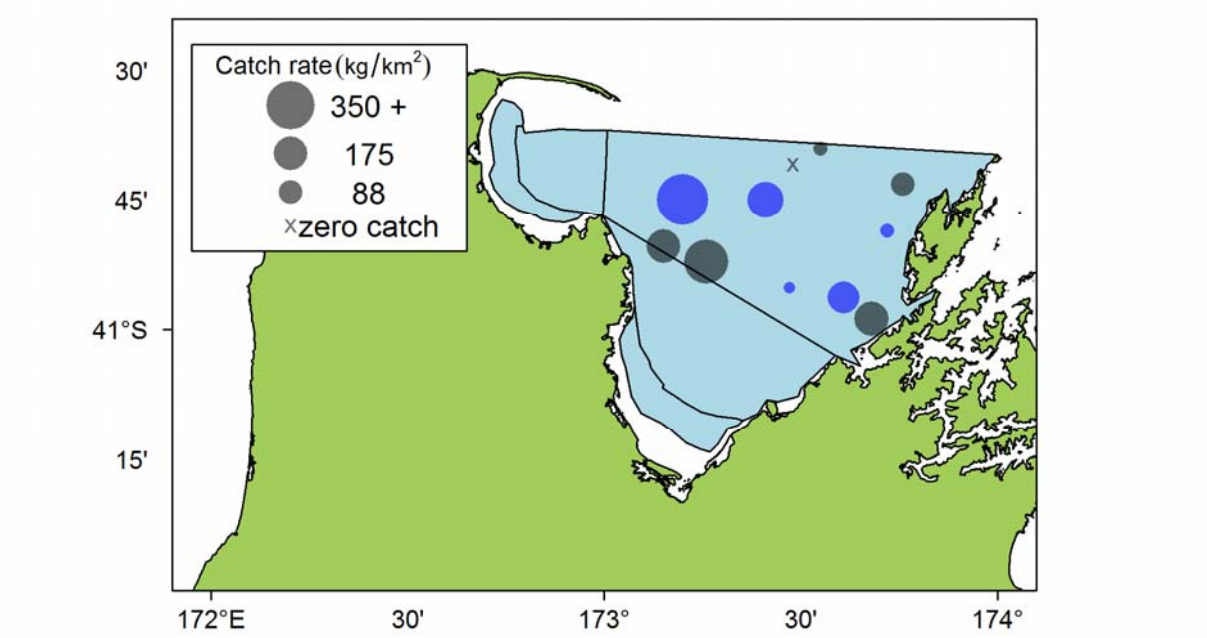
Species code	Taxon	Common_name	Scientific_name	No. of Stations
ANN	Annelida	Segmented worms	Annelida	2
BRN	Arthropoda: Cirripedia	Barnacle	Cirripedia (Class)	1
DIR	Arthropoda: Decapoda	Pagurid	*Diacanthurus rubricatus*	19
PRK	Arthropoda: Decapoda	Prawn killer	*Ibacus alticrenatus*	14
CRA	Arthropoda: Decapoda	Rock lobster	*Jasus edwardsii*	1
SCI	Arthropoda: Decapoda	Scampi	*Metanephrops challengeri*	2
CRB	Arthropoda: Decapoda	Crab	NA	1
NMA	Arthropoda: Decapoda	*Notopandalus magnoculus*	*Notopandalus magnoculus*	1
ZSQ	Arthropoda: Malacostraca	Stomatopod	*Squilla* spp.	1
ASC	Ascidiacea	Sea squirt	NA	13
COZ	Bryozoa	Bryozoan	NA	2
HVE	Bryozoa: Gymnolaemata	Cornflakes coral	*Hippomenella vellicata*	1
ACS	Cnidaria: Anthozoa	Deepsea anemone	Actinostolidae	1
HDR	Cnidaria: Anthozoa	Hydroid	NA	2
NEE	Cnidaria: Hydrozoa	Nemertesia elongata	*Nemertesia elongata*	1
CCM	Echinodermata: Asteroidea	Eleven-arm seastar	*Coscinasterias muricata*	2
CDY	Echinodermata: Asteroidea	Cosmasterias dyscrita	*Cosmasterias dyscrita*	15
PRE	Echinodermata: Asteroidea	Cushion starfish	*Patiriella regularis*	6
PNE	Echinodermata: Asteroidea	*Proserpinaster neozelanicus*	*Proserpinaster neozelanicus*	14
PSI	Echinodermata: Asteroidea	Geometric star	*Psilaster acuminatus*	2
URO	Echinodermata: Echinoidea	Sea urchin other	NA	1
SPT	Echinodermata: Echinoidea	Heart urchin	*Spatangus multispinus*	7
HTH	Echinodermata: Holothuroidea	Sea cucumber	NA	6
SCC	Echinodermata: Holothuroidea	Sea cucumber	*Stichopus mollis*	12
OMA	Echinodermata: Ophiuroidea	Red snakestar	*Ophiopsammus maculata*	2
OYS	Mollusca: Bivalvia	Oysters dredge	*Ostrea chilensis*	4
SCA	Mollusca: Bivalvia	Scallop	*Pecten novaezelandiae*	2
OCP	Mollusca: Cephalopoda	Octopod	NA	1
OCO	Mollusca: Cephalopoda	Octopus spp.	*Octopus* spp.	1
OCT	Mollusca: Cephalopoda	Octopus	*Pinnoctopus cordiformis*	12
ATA	Mollusca: Gastropoda	Alcithoe arabica	*Alcithoe arabica*	1
ALL	Mollusca: Gastropoda	Alcithoe larochei	*Alcithoe larochei*	16
ASH	Mollusca: Gastropoda	Circular saw shell	*Astraea heliotropium*	1
KWH	Mollusca: Gastropoda	Knobbed whelk	*Austrofucus glans*	1
CTS	Mollusca: Gastropoda	Spenglers trumpet	*Cabestana spengleri*	1
CSS	Mollusca: Gastropoda	Maurea	*Calliostoma selectum*	3
SWK	Mollusca: Gastropoda	Speckled whelk	*Cominella adspersa*	1
FMA	Mollusca: Gastropoda	*Fusitriton magellanicus*	*Fusitriton magellanicus*	8
GAS	Mollusca: Gastropoda	Gastropods	NA	4
NUD	Mollusca: Gastropoda	Nudibranchia	NA	1
WHE	Mollusca: Gastropoda	Whelks	NA	1
SIW	Mollusca: Gastropoda	Siphon whelk	*Penion cuvieranus* & *P. sulcatus*	1
LOF	Mollusca: Gastropoda	Large ostrich foot	*Struthiolaria papulosa*	2

Appendix 4—continued.

Species	Taxon	Common_name	Scientific_name	No. of Stations
ONG	Porifera	Sponges	NA	14
CRM	Porifera: Demospongiae	Airy finger sponge	*Callyspongia* cf. *ramosa*	17
CIC	Porifera: Demospongiae	Orange frond sponge	*Crella incrustans*	1
GVE	Porifera: Demospongiae	Ostrich egg sponge	*Geodia vestigifera*	1
IRC	Porifera: Demospongiae	Grey sponge	*Ircinia* spp.	1
SUA	Porifera: Demospongiae	Fleshy club sponge	*Suberites affinis*	1



Appendix 5: Scaled length frequency distributions for snapper caught in Tasman and Golden Bays, showing phase 1 and phase 2 fish separately. Blue bars = phase 2, clear bars = phase 1.



Appendix 5 continued: Catch rates of snapper caught in stratum 19 showing phase 1 (black circles) and phase 2 (blue circles) separately.