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Inshore trawl survey of the west coast South Island and Tasman and Golden Bays, March-April 2013 (KAH1305)

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EXECUTIVE SUMMARY

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This report gives the results of the eleventh 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 in March-April 2013 and used a two-phase design optimised for giant stargazer, red cod, red gurnard, spiny dogfish, and tarakihi. A total of 65 phase one and 14 phase two stations were successfully completed. Trends in relative biomass estimates, catch distribution for the target species, and population length frequencies for the major species are presented.

The biomass estimates for the target species were giant stargazer, 2118 t; red gurnard, 754 t; red cod, 1247 t; spiny dogfish, 15 086 t; and tarakihi, 1272 t. Target coefficients of variation (CVs) were met for giant stargazer (9%) and red gurnard (12%), and slightly exceeded for tarakihi (22%). The CV for red cod (38%) was higher than the target (20–25%). One very large catch of spiny dogfish (approximately 15 t) meant that the CV (57%) was substantially higher than the target.

The biomass estimate for giant stargazer (2118 t) was the highest for any survey in the series. The biomass estimate for spiny dogfish was also the highest in the time series but also had a very high CV, due to one large catch. The red cod biomass estimate was much lower than for the last survey (2087 t, 2011) but was much higher than the lows of the 2000 (414 t) and 2003 (906 t) surveys. The biomass estimate for red gurnard was the second highest in the time series. For tarakihi, the biomass estimate was slightly higher than the 2011 survey estimate.

Other commercial species with CVs less than 20% were arrow squid, barracouta, leather jacket, school shark, and sea perch.

1. INTRODUCTION

This report presents results from the eleventh stratified random trawl survey using RV *Kaharoa* at depths of 20–400 m off the west coast of the South Island, and Tasman and Golden Bays. Other surveys have taken place in 1992, 1994, 1995, 1997, 2000, 2003, 2005, 2007, 2009, and 2011. The survey design was optimised to estimate the relative biomass of giant stargazer (*Kathetostoma giganteum*), red cod (*Pseudophycis bachus*), red gurnard (*Chelidonichthys kumu*), 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), and Stevenson & Hanchet (2010). The first four surveys in the series were reviewed by Stevenson & Hanchet (2000).

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 of the west coast of the South Island and 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.

This report details the 2013 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 in part the requirements of Ministry for Primary Industries contract INT2012-01.

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 (*Chelidonychtys kumu*), giant stargazer (*Katetostoma giganteum*), tarakihi (*Nemadactylus macropterus*), spiny dogfigh (*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, and spiny dogfish (20%). No formal 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 gurnard, giant stargazer, and tarakihi, and spines from spiny dogfish.
4. To collect the data to determine the length frequencies from all other Quota Management System (QMS) species.
5. To tag viable smooth and rough skates, school shark, and rig.

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.

1.2 Timetable and personnel

RV *Kaharoa* departed Wellington on 24 March and berthed in Nelson on 25 March to offload some equipment, pick up three additional science staff, and take on ice and fish bins. Trawling began on the afternoon of 25 March but was cut short when substantial damage was done to the trawl after catching a large tree. The vessel returned to Nelson and the trawl was sent to Motueka Nets Ltd for repair while the survey continued using the spare trawl. The repaired trawl was picked up on 29 March. A total of 36 successful stations were completed before the vessel berthed at Westport on the evening of 3 April to unload fish and exchange two scientific team members. Bad weather on 4 April delayed departure until 5 April when the vessel recommenced fishing. Phase one was completed on the morning of 11 April. Phase two began in the afternoon of the same day and was completed on 14 April. The vessel berthed at Nelson on the morning of 15 April to unload fish and drop off scientific staff based in Nelson and left that afternoon for Wellington where it arrived on 16 April.

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

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 20–70 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 16 strata by area and depth (Table 1, Figure 1a–b). Strata were identical to those used in previous surveys in the time series. 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* to achieve the target CVs. The *allocate* function uses stratum area and catch rate data from previous *Kaharoa* trawl surveys to simulate optimal station allocation. Simulations were run for each target species separately. Results suggested that red gurnard and red cod required the most effort to achieve the target predicted CVs, with a total of 65 stations required. The 2011 survey achieved 65 phase one stations but suffered from an unusual number of days lost to bad weather. As the same number of days was available, the 2013 survey had the same target number of phase one stations.

Before the survey began, sufficient trawl stations to cover both first and second phase stations were randomly generated for each stratum by the computer programme 'Rand_stn v2.1' (Vignaux 1994). 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. The distribution of non-trawlable ground is given in Table 1 and shown in Figures 1a and 1b.

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 depth sounder. 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 station position. The direction of the tow was influenced by a combination of factors including weather conditions, tides, bottom contours, and the location of the next tow but was usually in the direction of the next tow.

If the station was found to be in an area of foul 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 at 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 temperature calibrated Seabird CTD unit. Surface temperatures were taken at a depth of 5 m below the surface and bottom temperatures when the net settled on the bottom. 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.

Individual fish weights and/or reproductive state were collected for the target species, as well as barracouta (*Thyrsites atun*), blue cod (*Parapercis colias*), ling (*Genypterus blacodes*), rig (*Mustelus lenticulatus*), rough skate (*Zearaja nasutus*), smooth skate (*Dipturus innominatus*), and school shark (*Galeorhinus galeus*). Individual fish weights were taken to enable length-weight relationships to be calculated for scaling length frequency data and calculation of abundance for length intervals.

Samples were selected non-randomly from the random length frequency sample to ensure a wide range was obtained for each species.

Up to 20 otoliths per station were collected for the target finfish species (no otoliths were collected for John dory) and up to 20 posterior dorsal spines from spiny dogfish. Otoliths for tarakihi and red gurnard were placed in 0.5 ml vials to reduce breakage. Posterior dorsal spines collected from spiny dogfish were stored in 70% ethanol in 5 ml vials.

2.5 Data analysis

Biomass estimates and 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.

None of these assumptions are likely to be correct, but may be used for the purpose of obtaining an index of relative biomass (Stevenson & Hanchet 1999).

All stations where the gear performance was excellent or satisfactory, codes 1 or 2, (79 stations) were used for biomass estimation.

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 this survey. For other species, coefficients were chosen from the *trawl* database and a selection made on the basis of whether coefficients were available from previous surveys in the series or on the best match between the size range of the fish used to calculate the coefficients 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.

2.6 Elasmobranch tagging

As soon as the net was brought on board, whenever possible, lively rig, school shark, rough skate, and smooth skate were separated from the catch, placed in an aerated tank of seawater, and tagged with Hallprint dart tags. Length, weight, and sex were recorded for each tagged fish. Maturity stage was recorded for male elasmobranchs as this can easily be done externally without causing harm. This is not possible for females.

3. RESULTS AND DISCUSSION

Biomass estimates and CVs by stratum and catch rates by stratum are given for the 20 most abundant commercially important species. Trends in adult and/or pre-recruit abundance and comparative length frequency distributions are presented for the target species and for those species considered to be reliably monitored by the surveys (Stevenson 2007b). Length frequency distributions for other species are given for the 2013 survey only if the species is commercially important and more than 100 fish were measured. In addition, snapper (*Pagrus auratus)* is included for this survey to test the hypothesis of a strong year class of 14–19 cm fish caught in the 2009 survey. Catch rate figures are only given for the target species.

3.1 Survey area, design, and gear performance

Sixty-five phase one and 14 phase two stations were successfully completed. Station density ranged from one station per 102 km^2 in stratum 17 to one station per 808 km^2 in stratum 6, with an average density of one station per 324 km^2 (Table 1). At least three stations were completed in all 16 strata and all project and survey objectives were met, aside from target CVs not being achieved for red cod, spiny dogfish, and tarakihi. 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 67.2 to 93.4 m and headline height varied between 4.0 and 5.6 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. After switching trawls due to the damage caused by catching a large submerged tree on station one, five successful tows were completed before it was noticed that six of twenty-two floats were missing from the trawl. Six floats were added to the trawl after this. While the headline height was slightly lower for these tows compared with the rest of the survey, the values were within ranges seen on past surveys in the time series and it was not deemed necessary to repeat these stations and they were kept as valid biomass tows. 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 56 t of fish and invertebrates were caught from the 79 valid biomass tows at an average of 703.8 kg per tow. Amongst the fish catch, 14 elasmobranch, and 68 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 spiny dogfish with 24 t caught (43% of the total catch). The top four species, spiny dogfish, barracouta, red cod, and giant stargazer made up 65% of the total. The target species giant stargazer, red cod, red gurnard, spiny dogfish and tarakihi made up 60% of the catch. Carpet shark (*Cephaloscyllium isabellum*) and spiny dogfish occurred in over 80% of the tows.

Twenty-one 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 indicate reduced 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).

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 to the north and south of Greymouth (Figure 2c). Catch rates were also reasonable in Tasman and Golden Bay. 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 100–200 m strata on the west coast (Figure 2d). Although a single catch dominated off Greymouth, the 100–200 m strata had the highest catch rates. Catch rates were lower in the 30–100 m strata, and lowest in the 200–400 m strata.

Highest catch rates for tarakihi were in the north of the west coast area in the 100–200 m strata (Figure 2e). Catch rates were also high in the south of the survey area between Greymouth and Haast.

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

3.4 Biomass estimation

Unless otherwise stated, all references to 'biomass' mean '*relative* biomass'.

Biomass estimates for species managed under the QMS caught in all surveys in the series are given in Table 4 and shown in Figure 3–4. Estimated biomass and coefficients of variation for the target species were giant stargazer, 2118 t (9%); red gurnard, 754 t (12%); red cod, 1247 t (38%); spiny dogfish, 15 086 t (57%); and tarakihi, 1272 t (22%) (Table 4).

Recruit biomass estimates for the following species are given in Table 5: Barracouta, blue warehou (*Seriolella brama*), giant stargazer, hoki, John dory (*Zeus faber*), ling, red cod, red gurnard, rig, sand flounder (*Rhombosolea plebeia*), school shark, silver warehou (*Seriolella punctata*), and tarakihi. As a proportion of total biomass, recruited biomass for giant stargazer, red cod, red gurnard, and tarakihi were 99%, 26%, 72%, and 91% respectively.

Biomass estimates by year class (where they were discernible from the length frequency distributions) for barracouta, blue warehou, hake, hoki, jack mackerel (*Trachurus novaezelandiae*), red cod, red gurnard, school shark, silver warehou, and tarakihi are given in Table 6. For red cod, the 1+ cohort made up about 64% of the total biomass. For red gurnard, the 1+ cohort made up 20% of the total biomass and for tarakihi the 1+ and 2+ cohorts made up 8% and 5% 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 3.6.

3.5 Length frequency and biological data

The numbers of length frequency and biological samples taken during the survey are given in Table 8. Comparative scaled length frequency distributions for the target species and for the eight other species monitored by the survey are shown in Figures 5a–m for the total survey area combined, and Figure 6a–m with separated indices for i) Tasman and Golden Bays, and ii) west coast South Island. Length frequencies 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 7 in alphabetical order by common name.

Length-weight coefficients were determined for giant stargazer, red cod, red gurnard, spiny dogfish, tarakihi, rig, rough skate, school shark, barracouta, and ling from data collected on this survey (Appendix 1). Individual length and weight data for ling and barracouta were collected on this survey in order to obtain length-weight coefficients specific to the region.

Ageing material collected included 463 pairs of otoliths from giant stargazer, 481 from red gurnard, and 558 from tarakihi. Spines were collected from 775 spiny dogfish (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.

3.6 Trends in target species

3.6.1 Giant stargazer

Giant stargazer were caught at 52 stations with the highest catch rates south of Cape Foulwind at depths of 100–200 m (strata 8, 12, 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 second highest estimate in the series (1952 t) in 2009 and the highest estimate being from the latest survey (2118 t) (Table 4, Figure 3). The majority 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-seven percent of the biomass was south of Cape Foulwind, and 81% was from the 100–200 m depth range (Table 7). Biomass of adult fish (over 45 cm) was 1834 t and juveniles were about 15% of the total (Table 5, Figure 6, Figure 8). Figure 9 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 females. Adult and juvenile indices track each other fairly closely.

There were slightly fewer fish under 45 cm caught on the 2013 survey than in 2009 and 2011 (Figure 5d). Few fish grow larger than 40 cm in the Tasman and Golden Bay region (Figure 6d). No obvious year class modes were apparent in the length frequency distribution. The sex ratio (male:female) was 1.63:1 overall (Figure 5d), an increase on the 2011 survey (1.24:1). All females under 50 cm total length 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). While the survey takes place in autumn, the spawning period of giant stargazer is winter.

3.6.2 Red cod

Red cod were caught at 51 stations, with the highest catch rates in strata 11, 12 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 2013 survey was the third lowest in the series, down from 2087 t in 2011 (the fifth lowest estimate in the time series) (Table 4, Figure 3). While the

biomass from the west coast decreased, the decline in red cod biomass was most marked from the Tasman and Golden Bay region, particularly between 2009 and 2011 (Figure 4).

Population numbers also declined by around 40% from 2011 to 2013, with fewer fish over 20 cm (Figure 5h). The most marked decrease was from stratum 1 with 579 t in 2011, down to just 3 t in 2013. The decrease in biomass seen in Tasman and Golden Bays between 2009 and 2011 appears to have continued, with no red cod caught in Tasman Bay, and an estimate of 8 t from Golden Bay in 2013. Eighty-six percent of the total biomass was south of Greymouth and 91% was from depths less than 200 m (Table 7). Adult biomass (over 51 cm) was 199 t, only 20% of the total (Table 5, Figure 6, Figure 8). In most years juvenile males have been more abundant than juvenile females, and adults of both sexes (Figure 9). Adult males have historically contributed the least to total biomass. Adult and juvenile indices track each other fairly closely. Very few fish in the 10–20 cm range (0+ fish) were caught which is consistent with previous surveys except for 1995 and 1997 (Figure 5h). The sex ratio was 1.48:1 overall (Figure 5h). Almost all red cod examined had immature or resting gonads but some larger fish were ripening or spent (Table 9a). No running ripe fish of either sex were observed. 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 at all but one station at depths less than 100 m along the west coast (Figure 2c). The highest catch rates were in strata 7, 11, 17 and 18 (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 four surveys and the estimate for 2013 (754 t) was the second highest in the time series, behind the 2011 estimate of 837 t (Table 4, Figure 3). A significant proportion of the biomass was from the Tasman and Golden Bay region, although for the last two surveys more was from the west coast South Island (Figure 4).

The length frequency distribution was similar in 2013 to 2011 although there is possibly a reasonably strong year class of pre-recruit fish in 2013 with a mode visible at 15–20 cm (Figure 5i). This mode appears to come from the Tasman and Golden Bay region (Figure 6i). Overall, there were larger numbers of smaller fish from the Tasman and Golden Bay region, and larger numbers of bigger fish from the west coast. The recruited and adult biomass estimates (30 cm or over) was 547 t (73% of the total) with 522 t (69 %) occurring on the west coast (Table 5, Figure 8). Juvenile males contribute more to the biomass than do juvenile females but adult biomass is fairly even between the sexes (Figure 9). Adult and juvenile indices track each other fairly closely. Ninety-six percent of the red gurnard biomass was at depths less than 100 m and no gurnard were caught deeper than 200 m (Table 7). The overall sex ratio was 1.49:1 (Figure 5i). Most red gurnard longer than 30 cm and a few smaller fish 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). Red gurnard spawning from the west coast may be similar.

3.6.4 Spiny dogfish

Spiny dogfish were caught at 66 stations with the highest catch rates in strata 8, 12 and 15 (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 (Table 4, Figure 3). The 2011 biomass was more similar to the rest of the time series, decreasing to 6402 t, but the 2013 estimate was the highest in the time series at 15 086 t. This was the result of one particularly large catch of approximately 15 t in stratum 8, which also covers a relatively large area. The associated CV for the 2013 biomass estimate is predictably high (57%).Very little of the total biomass was from the Tasman and Golden Bay region (Figure 4).

There was a decrease in the proportion of fish greater than 70 cm but overall the numbers have increased (Figure 5l), due in part to the large catch in stratum 8. Adult fish made up about 51% of the total biomass (Table 5, Figure 8). Juvenile males have historically made up only a minority of the total biomass (Figure 9). Adult and juvenile indices track each other fairly closely through the time series. The sharp increase in biomass in 2013 appears to have come mainly from females. Over 98% of the biomass was at depths less than 200 m (Table 7). The sex ratio of 0.33:1 was the lowest recorded since 1997, when spiny dogfish were first measured in this time series (Figure 5l).

3.6.5 Tarakihi

Tarakihi were caught at 61 stations with the highest catch rates in strata 2, 12 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 last four surveys to levels similar to that seen for the first few years of the survey (Table 4, Figure 3). The majority of the biomass was always from the west coast region, with little from Tasman and Golden Bays. Over 90% of the biomass estimate was recruited fish (25 cm or over) while the adult biomass (over 31 cm) was 79% 1004 t (Table 5). The juvenile biomass decreased as a proportion of the total since the 2011 survey and is now similar to previous years (Figure 8). Adult females have historically contributed the majority of the total biomass, followed by adult males (Figure 9).

The length frequency data shows fewer fish between 20 and 30 cm compared with 2011 (Figure 5m). There were distinct modes at 10–14 cm (0+ fish), and at about 16–21 cm (1+ fish), similar to that seen in 2000 and 2011. The majority of fish under 25 cm were from Tasman and Golden Bays (Figure 6m). The majority of fish over 20 cm were from the west coast. Of the total tarakihi biomass (1272 t), over 90% was on the west coast (1148 t), and over 80% (1028 t) of the total was at depths between 100 and 200 m (Table 7). The sex ratio for the estimated population was 0.70:1 (Figure 5m), similar to 2011. There was little reproductive development in tarakihi under 30 cm FL, but for bigger fish the full range of gonad stages was recorded, although the majority were still resting or starting to mature (Table 9a). The range of developmental stages observed is consistent with tarakihi spawning in summer and autumn.

3.6.6 Trends in other species

Barracouta

Barracouta were caught at 64 stations and represented 10% of the total catch (Appendix 3). The highest catch rates were in strata 11 and 14 (Table 3). The biomass varied almost 3-fold during the series but does not show a consistent trend (Table 4, Figure 3). The majority of the biomass came from the west coast region, with little from Tasman and Golden Bays (Figure 4). The 2013 estimate of 3423 t was down from the previous survey. In most years there was a strong mode of 0+ fish that was absent in the 2011 survey. This mode was strong again in 2013 (Figure 5a). 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 around 45 and 55 cm in most years, both of which were absent in 2013.

Blue warehou

Blue warehou were caught at 32 stations with the highest catch rates in strata 14 and 15 (Table 3). The biomass estimate for 2013 was slightly lower than that for 2011 and is in the mid-range of the series estimates (Table 4, Figure 3). The majority of the biomass was always from the west coast region (Figure 4). There was a strong mode in the length frequency distribution for 2013 at 10–20 cm (0+ fish). While not as strong as that seen in 2009, it is stronger than that for 2011(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 only caught in low numbers at 13 stations (Appendix 3, Table 8). The biomass estimates from the series do not show a predictable trend (Table 4, Figure 3). No gemfish were ever caught in the Tasman and Golden Bay region (Figure 4). The length frequency distributions occasionally showed apparently strong year classes (Figure 5c). There were no strong year classes observed in the last four surveys.

Hake

Hake were taken in low numbers from 18 stations (Table 8) and almost all fish were under 50 cm (Figure 9). The biomass estimate of 36 t was the third lowest in the series but the biomass estimates varied widely through the series (Figure 3, Table 4).

Hoki

Hoki were taken from 24 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 22–35 cm (0+ fish) and a much weaker mode at around 36–44 cm (1+) (Figure 8). In 2011 the strongest mode was for 1+ fish for the first time in the time series, but in 2013 the stronger mode had reverted to 0+ fish again.

Jack mackerel (*Trachurus declivis*)

T. declivis was caught on 32 stations (Appendix 3). The biomass estimate was down from 2011, which was the highest in the series, and is now more similar to values seen from 1992–97 and 2003–09 (Figure 3 Table 4). Most of the biomass was from the west coast. There were no obvious modes in the length frequency plot (Figure 5e).

John dory

John dory were caught at 28 stations with the highest catch rates in strata 1 and 18 (Appendix 3, Table 3). The biomass estimate of 232 t was down from 2011 which was the highest in the time series, but is still well above the values seen from 1992–97, the period after which the biomass started to increase (Table 4, Figure 3). In some years, more biomass was from the Tasman and Golden Bay region, and in others more was from the west coast (Figure 4). Around one-third of the biomass in 2013 was from the Tasman and Golden Bay region. The length frequency distribution showed a mode at 23–33 cm (1+ fish), and was stronger than the 1+ mode from 2011, but not as strong as that from 2009 (Figure 5f). In most years, most of the smaller fish were from the Tasman and Golden Bay region, but not in 2013 (Figure 6f). The strong 1+ year class from 2009, which was fully recruited into the fishery and probably accounted for the record biomass from 2011, was probably helping to maintain the biomass at higher levels than was seen from 1992–97, but the small 1+ year class from 2011 meant that the biomass has decreased.

Ling

Ling were caught at 35 stations with the highest catch rates in strata 12, 13 and 16 (Appendix 3, Table 3). The biomass estimate of 405 t was the highest in the time series, although there does not appear to be a continuous trend over the series (Table 4, Figure 3). As in all other surveys, the vast majority of the biomass in 2013 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 was weaker in 2013 (Figure 5g). There were more fish from 70–110 cm than were seen in any other survey, which would account for the higher biomass estimate for 2013.

Rig

Rig were caught at 36 stations, with the highest catch rates in strata 7 and 18 (Appendix 3, Table 3). The estimated biomass of 278 t was slightly lower than for 2011 and in the mid-range for the series (Table 4, Figure 3). Biomass from the Tasman and Golden Bay regions accounted for just over a third of the total in 2013 (Figure 4). The length frequency distributions for 2013 showed a strong mode at 30–40 cm and 40–60 for males, but these were weaker for females (Figure 5j). There were two larger modes for males, from around 60–80 and 80–100 cm. In 2013 as in other years, there was a lack of two larger modes in the female length frequency that were present in the male length frequency, which may indicate that the survey does not sample adult female rig well.

School shark

School shark were caught at 60 stations with the highest catch rates in strata 12 and 18 (Appendix 3, Table 3). The estimated biomass of 912 t was slightly lower than the 2011 estimate (1155 t) but was still above the time series low of 655 t in 2003, which suggests that the biomass appears to be steadily increasing (Table 4, Figure 3). Most of the biomass was from the west coast (Figure 4). The length frequency distribution for 2013showed a mode at around 33–42 cm for both sexes but not as strong as seen in either 2009 or 2011 (Figure 5k). There were no obvious size differences between the Tasman and Golden Bay region and the west coast (Figure 6k).

Snapper

A large number of 1+ snapper (around 14–19 cm) were caught on the 2009 survey (Figure 7) (Stevenson & Hanchet 2010) and this appeared to indicate a strong year class of fish spawned over the summer of 2007–08. To test this hypothesis, snapper were again examined from the 2011 survey and it was deemed that this was not such a strong year class after few of these fish (now 3+, 21–32 cm) were caught compared with 2009 (Stevenson 2012) (Note the large difference in the y-axis scales for 2011 compared with 2009 and 2013 in Figure 7). In 2013 however, a large number of 5+ fish (around 35–42 cm) were caught, suggesting that it was, after all, a strong year class. This survey series is not optimised for snapper and it appears that by chance this year class was missed in the 2011 survey and that it was indeed a strong year class.

3.7 Tagging

358 school elasmobranchs were tagged and released during the 2013 survey (Table 8). Of these, 177 school shark (94 males, 83 females, 54–147 cm), 55 were rig (42 males, 13 females, 52–147 cm), 106 were rough skate (38 males, 68 females, 26–62 cm), and 20 were smooth skate (10 males, 10 females, 35–105 cm).

A total of 2247 elasmobranchs have been tagged and released since the beginning of the time series, (Table 10). Of these, 71 have been returned (Table 11). Release positions of tagged elasmobranchs are shown in Figure 10 and are the same as the hauling positions of the stations on which they were caught. Note that release positions are often for several individuals of a given species at one site. Recapture positions are shown in Figure 11.

1651 school shark have been tagged since the beginning of the time series with the largest number coming from the 2011 survey (233 individuals). To date, 69 school shark tags have been returned, with more returns coming from those tagged on the 2009 survey than any other. The majority of the recaptured sharks have been taken on the west coast of the South Island and Golden and Tasman Bays, suggesting that movement for most individuals is fairly limited. However, some recaptures have also occurred in Cook Strait, North Taranaki Bight, North Cape, and off the Canterbury and Otago coasts, indicating that at least some individuals can travel reasonable distances. Further, some have

also been recaptured in Australian waters on both the northern and southern coasts of Tasmania, and in the Great Australian Bight. It is believed that there is regular interchange of school sharks between Australian and New Zealand populations (Hurst et al. 1999, Francis 2010) although the exact nature and extent is not currently known.

Tagging of rig began in 2007 and since then 160 individuals have been tagged and released with more having come from the 2013 survey than any other (55 individuals). To date there has been one returned rig tag, tagged in 2011. Unfortunately the location of the recapture was not supplied with the return.

Rough skate tagging began on the 2003 survey and since then 364 individuals have been tagged and released with the majority coming from the 2011 and 2013 surveys (116 and 106 tags respectively). To date two rough skate tags have been returned, one of which was recaptured on the west coast of the South Island near Haast, the other was not returned with locality data more specific than the west coast of the South Island.

Smooth skate tagging also began on the 2003 survey with a total of 72 individuals tagged and released. More have been tagged and released on the 2013 survey than any other (20 individuals). To date, no smooth skate tags have been returned.

4 CONCLUSIONS

The 2013 (11^{th}) survey successfully extended the March-April RV *Kaharoa* time series for the west coast of the South Island and Tasman and Golden Bays. The 2013 results show that the series continues to monitor the target species and adults and/or pre-recruits and juveniles of several other species. The biomass estimate of giant stargazer was the highest in the series, whilst those for red cod, red gurnard, and tarakihi were within the range of previous surveys. The biomass for spiny dogfish was also the highest in the time series but this was the result of one particularly large catch and had a correspondingly high CV

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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	4	478
5	25–100	1 224	0	3	0	408
6	100–200	3 233	238	4	0	808
7	25–100	927	0	4	0	232
8	100–200	2 354	214	4	5	262
9	200–400	1 877	1 456	3	0	626
11	25–100	1 438	63	8	4	120
12	100–200	2 054	501	5	1	342
13	200–400	1 101	466	3	0	367
14	25–100	851	36	4	0	213
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	3	0	316
19	20–70	2 436	193	6	0	406
Total		25 594	4 034	65	14	324

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	79			
Headline height (m)		4.9	0.28	4.0–5.6
Doorspread (m)		80.0	7.70	67.2–93.4
Distance (n. miles)		3.0	0.26	1.51–3.14
Warp:depth ratio		3.7	1.44	2.47–8.51
Tasman/Golden Bays				
20–70 m	12			
Headline height (m)		4.7	0.59	4.0–5.4
Doorspread (m)		72.9	2.30	67.2–75.4
Distance (n. miles)		2.9	0.28	2.0–3.1
Warp:depth ratio		5.3	1.75	3.2–8.5
West coast				
20–400 m	67			
Headline height (m)		4.9	0.18	4.6–5.6
Doorspread (m)		81.3	7.63	68.0–93.4
Distance (n. miles)		3.0	0.26	1.51–3.14
Warp:depth ratio		3.4	1.16	2.47–7.55
20–100 m	27			
Headline height (m)		5.0	0.23	4.8–5.6
Doorspread (m)		73.3	3.37	68.0–85.6
Distance (n. miles)		3.0	0.06	2.91–3.13
Warp:depth ratio		4.4	1.37	2.81–7.55
100–200 m	31			
Headline height (m)		4.9	0.10	4.7–5.1
Doorspread (m)		85.3	3.30	75.6–92.7
Distance (n. miles)		2.9	0.37	1.51–3.14
Warp:depth ratio		2.8	0.06	2.66–2.96
200–400 m	9			
Headline height (m)		4.8	0.11	4.6–4.9
Doorspread (m)		91.6	1.87	88.2–93.4
Distance (n. miles)		3.0	0.11	1.51–3.14
Warp:depth ratio		2.6	0.09	2.47–2.71

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. –, less than 0.5 kg.km^{-2}.

	Species Code									
Stratum	SPD	BAR	RCO	GIZ	HOK	NMP	GUR	GSH	SCH	LIN
1	82	97	3	3	–	–	9	96	42	1
2	87	64	–	1	–	102	1	89	15	–
5	153	18	53	–	–	–	37	–	15	–
6	233	95	–	79	–	49	4	38	43	–
7	39	195	50	16	–	–	265	8	7	–
8	3971	245	22	175	9	36	3	64	36	1
9	–	14	–	2	23	18	–	–	5	–
11	254	286	436	72	5	23	118	–	6	27
12	1366	251	84	372	645	129	1	30	109	92
13	157	9	54	115	66	23	–	18	37	76
14	57	471	7	149	1	26	29	–	14	14
15	764	196	228	315	41	90	–	80	8	1
16	51	5	31	36	119	18	–	71	–	224
17	156	–	8	–	–	7	82	–	30	1
18	–	275	–	–	–	35	66	–	106	–
19	60	54	–	4	–	36	59	4	54	1

	FRO	WAR	SPO	SNA	SQU	RSK	ELE	LEA	JDO	SSK
1	4	1	8	–	8	35	–	–	41	–
2	1	–	1	1	11	3	–	–	17	8
5	–	9	15	32	–	21	6	–	–	3
6	5	–	–	6	11	1	–	–	7	17
7	–	12	38	–	2	18	25	–	2	7
8	5	1	2	1	15	8	–	–	4	9
9	–	–	–	–	22	9	–	–	–	–
11	1	46	22	–	8	31	51	–	–	–
12	140	1	20	–	21	4	–	–	–	13
13	57	4	4	–	12	1	–	–	2	27
14	–	60	19	–	8	15	2	–	–	–
15	35	106	3	–	29	2	–	–	–	4
16	12	–	5	–	17	–	–	–	–	16
17	–	1	12	103	–	–	–	48	7	4
18	–	–	41	167	1	12	–	88	32	–
19	–	2	27	9	11	8	2	55	14	–

Table 4: Relative biomass estimates (t) and CVs by trip from the entire survey area for species managed under the QMS.

	KAH9204		KAH9404		KAH9504		KAH9701		KAH0004		KAH0304	
Species	Biomass	CV%	Biomass	CV%	Biomass	CV%	Biomass	CV%	Biomass	CV%	Biomass	CV%
Arrow squid	2 960	18	1 199	9	3 450	14	966	13	523	11	2 255	12
Barracouta	2 478	14	5 298	15	4 480	12	2 993	19	1 787	11	4 485	20
Blue warehou	123	40	80	22	115	29	842	31	272	37	191	66
Dark ghost shark	375	20	722	14	767	23	1 591	21	2 259	9	544	15
Elephant fish	21	41	167	32	85	35	94	33	42	63	48	34
Frostfish	25	32	27	23	89	31	259	32	316	16	494	22
Gemfish	145	18	68	29	21	55	704	83	120	30	137	23
Giant stargazer	1 302	11	1 350	16	1 551	16	1 450	15	1 023	12	834	15
Hake	391	25	99	30	5 244	27	1 019	46	15	36	55	47
Hoki	405	17	826	49	3 616	21	1 100	25	103	50	233	22
Jack mackerel												
Trachurus declivis	92	23	99	25	106	19	162	19	168	33	87	21
T. novaezelandiae	281	58	69	22	57	29	363	27	194	46	126	49
John dory	102	29	59	25	27	36	17	31	141	16	288	19
Leather jacket	203	29	230	23	153	34	231	34	236	50	254	18
Lemon sole	88	18	77	25	126	21	68	21	59	19	2	44
Ling	286	18	261	20	367	16	151	30	95	46	150	33
New Zealand sole	68	32	68	16	39	30	45	29	16	32	21	57
Northern spiny dogfish	146	19	159	20	86	28	164	46	256	18	111	27
Red cod	2 719	13	3 169	17	3 123	14	2 546	23	414	26	906	24
Red gurnard	572	15	559	15	584	19	470	13	625	14	270	20
Rig	288	13	380	10	490	10	308	18	333	18	144	22
Rough skate	173	27	196	22	251	22	185	31	186	23	43	34
Sand flounder	100	31	203	23	132	27	106	28	62	22	10	33
School shark	933	21	1 151	41	1 204	34	1 432	25	896	13	655	18
Sea perch	242	22	426	17	667	22	338	14	302	22	76	25
Silver warehou	292	37	66	34	38	19	204	20	99	34	69	27
Smooth skate	339	18	341	18	315	20	302	26	140	29	91	79
Spiny dogfish	3 919	15	7 145	7	8 370	10	5 275	13	4 777	13	4 446	15
Tarakihi	1 409	13	1 394	13	1 389	10	1 087	12	964	19	912	20

Table 4 – continued.

	KAH0503		KAH0704		KAH0904		KAH1104		KAH1305	
Species	Biomass	CV%	Biomass	CV%	Biomass	CV%	Biomass	CV%	Biomass	CV%
Arrow squid	889	9	1 228	9	402	16	158	13	308	14
Barracouta	2 763	13	2 582	14	3 512	17	5 361	20	3 423	16
Blue warehou	116	40	286	50	175	27	267	26	248	22
Dark ghost shark	832	22	2 215	21	900	17	2 363	22	981	23
Elephant fish	59	33	28	53	185	83	170	53	110	26
Frostfish	423	45	529	39	835	35	251	28	424	24
Gemfish	474	49	101	19	143	29	101	34	113	28
Giant stargazer	1 458	19	1 630	13	1 952	19	1 645	15	2 118	9
Hake	1 673	30	359	35	212	56	44	36	36	41
Hoki	701	55	772	52	1 302	46	1 527	61	1 545	43
Jack mackerel										
Trachurus declivis	118	22	62	23	79	23	230	35	106	43
T. novaezelandiae	98	21	214	62	399	24	193	44	56	35
John dory	222	14	174	26	269	23	378	16	231	21
Leather jacket	139	20	252	40	323	27	190	24	231	19
Lemon sole	21	42	119	46	62	16	83	14	43	37
Ling	274	37	180	27	291	37	235	42	405	44
New Zealand sole	27	45	39	71	75	32	27	40	25	26
Northern spiny dogfish	180	22	134	29	189	28	368	29	211	26
Red cod	2 610	18	1 638	19	2 782	25	2 087	27	1 247	38
Red gurnard	442	17	553	17	651	18	1 070	17	754	12
Rig	153	19	383	33	274	26	307	18	278	20
Rough skate	58	30	256	23	114	22	347	22	243	24
Sand flounder	62	25	67	47	170	32	102	22	48	52
School shark	774	14	816	20	1 085	16	1 155	13	912	12
Sea perch	150	20	163	19	336	20	558	38	161	20
Silver warehou	72	28	165	20	80	24	69	31	68	28
Smooth skate	80	30	55	44	67	61	185	33	188	29
Spiny dogfish	6 175	12	6 291	14	10 270	19	6 402	13	15 086	57
Tarakihi	2 050	12	1 189	21	1 088	22	1 188	15	1 272	22

Table 5: Recruited biomass estimates and target species adult biomass estimates (t). –, less than 0.5 t.

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	391	51	2 899	17	3 290	16			
Blue warehou	45	4	100	213	25	217	25			
Giant stargazer	30	9	35	2 096	9	2 105	9	45	1 834	10
Hoki	65	–	–	11	37	11	37			
John dory	25	67	33	164	26	231	21			
Ling	65	–	–	352	51	352	51			
Red cod	40	–	100	324	27	324	27	50	199	32
Red gurnard	30	118	17	428	16	547	13	30	547	13
Rig	90	19	48	74	33	93	28			
Sand flounder	25	31	61	–	100	31	60			
Spiny dogfish								Males 58	1 825	34
								Females 72	5 897	64
School shark	90	115	49	397	16	512	17			
Silver warehou	25	–	–	12	40	12	40			
Tarakihi	25	23	44	1 131	24	1 154	24	31	1 004	24

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

Species	Year class	Length range (cm)	Biomass	CV (%)
Barracouta	0 +	<15	<0.1	64
	1 +	15–25	83.6	25.5
	2 +	26–36	7.6	27
	3 +	37–52	46.5	29.4
Blue warehou	0 +	<21	27.1	36.5
	1 +	22–31	1.1	90.3
	2 +	32–42	2.9	74.7
Hake	0 +	<19	0.6	39.7
	1 +	19–28	18	41.5
	2 +	29–42	9.7	75.5
Hoki	0 +	15–30	1185.9	46.8
	1 +	31–44	329	34.8
Jack mackerel				
Trachurus novaezelandiae	1 +	13–20	34.8	50.1
Red cod	0 +	<20	11.5	23.9
	1 +	21–35	801.4	50.4
Red gurnard	0 +	<17	1.1	59.7
	1 +	17–27	148.6	18.4
School shark	0 +	<44	7.8	25.1
	1 +	44–54	9.4	31.4
Silver warehou	1 +	13–23	55.6	33.3
Tarakihi	0 +	10–14	2.2	31.2
	1 +	15–21	101.7	49.9
	2 +	22–28	66.6	27.1

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	SPD	BAR	RCO	GIZ	HOK	NMP	GUR	GSH	SCH	LIN
1	110	131	4	4	–	+	12	129	56	1
	(54)	(56)	(82)	(67)	(0)	(66)	(27)	(100)	(24)	(50)
2	373	276	0.5	6	–	440	5	384	65	0.5
	(32)	(65)	(100)	(86)	(0)	(59)	(56)	(38)	(46)	(100)
5	187	22	64	–	–	–	45	–	18	+
	(75)	(65)	(36)	(0)	(0)	(0)	(51)	(0)	(71)	(100)
6	754	306	1	257	–	159	13	124	138	1
	(55)	(78)	(100)	(45)	(0)	(49)	(60)	(65)	(23)	(100)
7	36	181	47	14	–	–	245	8	7	–
	(41)	(70)	(58)	(100)	(0)	(0)	(25)	(100)	(43)	(0)
8	9350	577	51	412	22	84	7	151	84	4
	(91)	(36)	(33)	(12)	(96)	(37)	(92)	(37)	(36)	(44)
9	–	26	–	5	44	34	–	+	10	–
	(0)	(100)	(0)	(96)	59)	(63)	(0)	(100)	(100)	(0)
11	366	411	626	103	7	33	169	–	8	39
	(19)	(41)	(74)	(43)	(80)	(49)	(26)	(0)	(32)	(54)
12	2805	516	173	764	1325	266	2	62	224	189
	(47)	(27)	(32)	(14)	(50)	(9)	(100)	(44)	(17)	(82)
13	173	10	59	126	73	25	–	20	41	84
	(60)	(59)	(42)	(45)	(75)	(27)	(0)	(62)	(62)	(100)
14	48	401	6	127	0.5	22	25	–	12	12
	(57)	(50)	(72)	(23)	(100)	(67)	(84)	(0)	(82)	(39)
15	675	173	202	278	36	79	–	70	7	1
	(60)	(19)	(50)	(18)	(56)	(30)	(0)	(40)	(13)	(71)
16	16	2	10	11	38	6	–	23	–	71
	(50)	(54)	(59)	(39)	(36)	(58)	(0)	(54)	(0)	(39)
17	48	–	2	–	–	2	25	–	9	+
	(72)	(100)	(68)	(0)	(0)	(71)	(20)	(0)	(40)	(52)
18	–	260	+	–	–	33	62	–	100	–
	(0)	(69)	(100)	(0)	(0)	(61)	(9)	(0)	(54)	(0)
19	145	133	1	10	–	89	143	10	132	1
	(50)	(67)	(88)	(32)	(0)	(66)	(22)	(100)	(48)	(100)

Table 7–continued.

	Species code									
Stratum	FRO	WAR	SPO	SNA	SQU	RSK	ELE	LEA	JDO	SSK
1	5	1	10	–	11	47	–	–	56	–
	(100)	(100)	(50)	(0)	(75)	(100)	(0)	(0)	(21)	(0)
2	4	–	3	5	47	13	–	–	73	36
	(74)	(0)	(100)	(68)	(29)	(54)	(0)	(0)	(47)	(69)
5	–	11	18	39	0.5	26	7	–	–	4
	(0)	(59)	(52)	(100)	(100)	(57)	(51)	(0)	(0)	(100)
6	16	–	–	21	36	4	–	–	22	55
	(70)	(0)	(0)	(100)	(73)	(100)	(0)	(0)	(100)	(59)
7	+	11	36	–	2	16	23	–	2	6
	(100)	(67)	(68)	(0)	(39)	(75)	(10)	(0)	(100)	(100)
8	12	2	6	2	35	18	–	–	10	20
	(42)	(100)	(73)	(100)	(26)	(56)	(0)	(0)	(46)	(63)
9	–	–	–	–	41	18	–	–	–	0.5
	(0)	(0)	(0)	(0)	(13)	(50)	(0)	(0)	(0)	(100)
11	1	67	31	–	12	45	74	–	–	0.5
	(97)	(34)	(50)	(0)	(51)	(40)	(38)	(0)	(0)	(100)
12	288	2	40	–	43	7	–	–	–	26
	(31)	(100)	(74)	(0)	(22)	(72)	(0)	(0)	(0)	(57)
13	63	4	4	–	14	2	–	–	2	29
	(65)	(100)	(100)	(0)	(50)	(100)	(0)	(0)	(100)	(100)
14	–	51	16	–	7	13	2	–	–	–
	(0)	(86)	(100)	(0)	(80)	(78)	(100)	(0)	(0)	(0)
15	31	94	3	–	26	2	–	–	–	4
	(27)	(21)	(100)	(0)	(13)	(100)	(0)	(0)	(0)	(50)
16	4	–	2	–	6	–	–	–	–	5
	(58)	(0)	(100)	(0)	(45)	(0)	(0)	(0)	(0)	(53)
17	–	+	4	32	+	+	+	15	2	1
	(0)	(31)	(39)	(59)	(50)	(100)	(100)	(92)	(48)	(100)
18	–	–	39	158	1	12	–	83	30	–
	(0)	(0)	(67)	(93)	(100)	(39)	(0)	(39)	(56)	(0)
19	–	5	65	22	28	20	4	134	35	–
	(0)	(79)	(28)	(71)	(80)	(47)	(100)	(21)	(41)	(0)

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 stage, otoliths, spines.

		Length frequency data		Biological data (†)			
Species code	Measurement method	No. of samples	No. of fish	No. of samples	No. of fish	No. of otoliths or spines	No. of tagged fish
BAR	1	59	3 205	21	410		
BCO	2	12	112	11	110		
BRI	2	6	19				
ELE	1	15	94				
ESO	2	13	311				
FRO	1	19	540				
GIZ	2	50	1 175	43	506	463	
GSH	G	35	946				
GUR	1	44	3 063	39	559	481	
HAK	2	13	392				
HAP	2	5	7				
HOK	2	20	1 561				
JDO	2	27	183	22	159		
JMD	1	18	254				
JMM	1	6	8				
JMN	1	16	759				
KAH	1	3	4				
KIN	1	2	2				
LEA	2	11	937				
LIN	2	32	457	26	232		
LSO	2	30	414				
NMP	1	60	1 980	51	728	558	
NSD	2	17	126				
RCO	2	49	2 147	44	740		
RSK	5	41	206	41	206		106
RSO	1	13	43				
SAM	1	1	2				
SCH	2	60	449	60	449		177
SEV	2	1	1				
SFL	2	7	267				
SNA	1	12	211				
SPD	2	65	3 773	51	936	775	
SPE	2	43	1 457				
SPO	2	36	268	35	237		55
SSK	5	24	52	24	52		20
SWA	1	34	704				
TRE	1	2	2				
TUR	2	1	1				
WAR	1	31	718				
YEM	1	1	1				

Table 9: Numbers of the four 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											
11–20	4	–	–	–	–	3	–	–	–	–	7
21–30	17	–	–	–	–	10	–	–	–	–	27
31–40	26	9	4	–	–	19	–	–	–	–	58
41–50	19	53	30	1	20	25	–	–	–	–	148
51–60	6	24	24	2	15	24	33	1	1	2	132
61–70	1	2	4	1	4	8	78	5	1	7	111
>70	–	–	–	–	–	–	9	1	–	1	11
Total	73	88	62	4	39	89	120	7	2	10	494
Red cod											
11–20	15	–	–	–	–	17	–	–	–	–	32
21–30	207	5	3	–	–	91	1	–	–	–	307
31–40	87	11	12	–	–	89	1	–	–	–	200
41–50	30	8	5	–	1	37	–	–	–	–	81
51–60	12	9	13	–	4	52	3	–	–	–	93
>60	–	–	–	–	–	9	3	1	–	1	14
Total	351	33	33	–	5	295	8	1	–	1	727
Red gurnard											
<21	9	3	–	–	–	7	–	–	–	–	19
21–30	34	70	10	6	4	43	5	–	–	–	172
31–40	5	20	39	45	15	31	71	18	2	15	261
>40	–	–	6	3	2	2	47	8	5	7	80
Total	48	93	55	54	21	83	123	26	7	22	532
Tarakihi											
11–20	117	–	–	–	–	101	–	–	–	–	218
21–30	35	3	–	–	13	56	4	–	–	–	111
31–40	11	7	6	14	24	88	143	7	4	4	308
>40	–	–	–	3	11	1	62	5	3	4	89
Total	163	10	6	17	48	246	209	12	7	8	726

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 ctd.

b) Elasmobranchs

	Male gonad stages			Female gonad stages						
Length (cm)	1	2	3	1	2	3	4	5	6	Total
Spiny dogfish										
<=40	22	–	–	26	–	–	–	–	–	48
41–50	58	1	–	51	–	–	–	–	–	110
51–60	4	27	43	30	28	–	–	–	–	132
61–70	–	–	186	–	25	37	10	84	19	361
71–80	–	–	11	1	2	10	15	152	10	201
>80	–	–	–	–	1	1	5	27	2	36
Total	84	28	240	108	56	48	30	263	31	888

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)
2. Maturing (Non-yolked eggs visible in the ovary);
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 (Uterus flabby and may be bloodshot. Yolked eggs may be present in the ovary)

Table 10: Number of tagged and released elasmobranchs by species for each survey.

Trip	RSK	SCH	SPO	SSK	Total
KAH9204	–	195	–	–	195
KAH9404	–	131	–	–	131
KAH9504	–	209	–	–	209
KAH9701	–	158	–	–	158
KAH0004	–	–	–	–	0
KAH0304	21	144	–	9	174
KAH0503	25	141	–	16	182
KAH0704	56	112	31	7	206
KAH0904	40	151	29	3	223
KAH1104	116	233	45	17	411
KAH1305	106	177	55	20	358
Total	364	1651	160	72	2247

Table 11: Number of returns from tagged and released elasmobranchs by species for each survey.

Trip	RSK	SCH	SPO	SSK	Total
KAH9204	–	–	–	–	0
KAH9404	–	–	–	–	0
KAH9504	–	4	–	–	4
KAH9701	–	2	–	–	2
KAH0004	–	–	–	–	0
KAH0304	–	1	–	–	1
KAH0503	1	13	–	–	14
KAH0704	–	12	–	–	11
KAH0904	–	25	–	–	24
KAH1104	1	9	–	–	0
KAH1305	–	3	–	–	0
Total	2	69	0	0	71

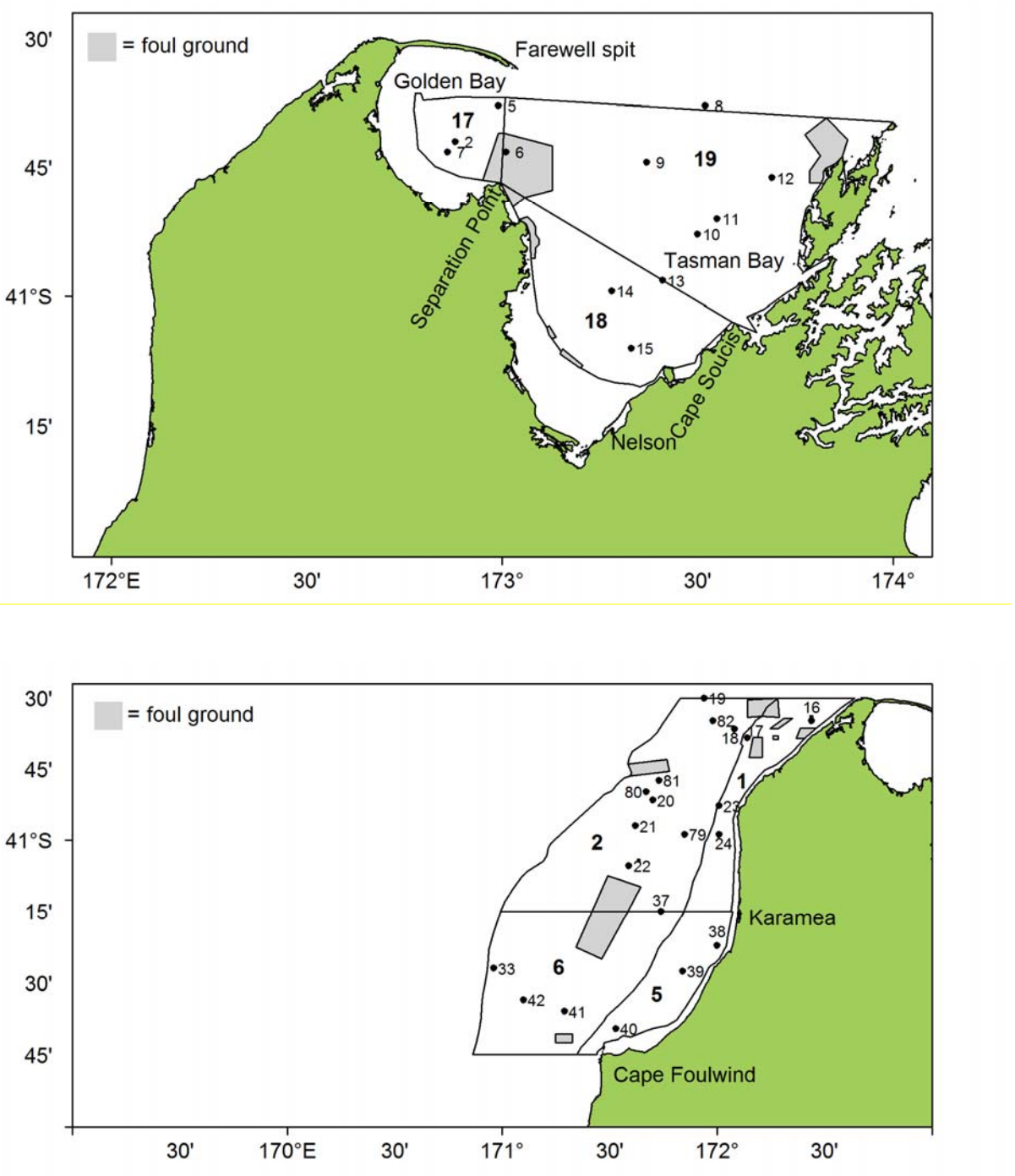


Figure 1a: Survey area showing stratum boundaries and numbers (bold type) for Tasman and Golden Bays (top) and the west coast north of Cape Foulwind (bottom) with station positions and numbers.

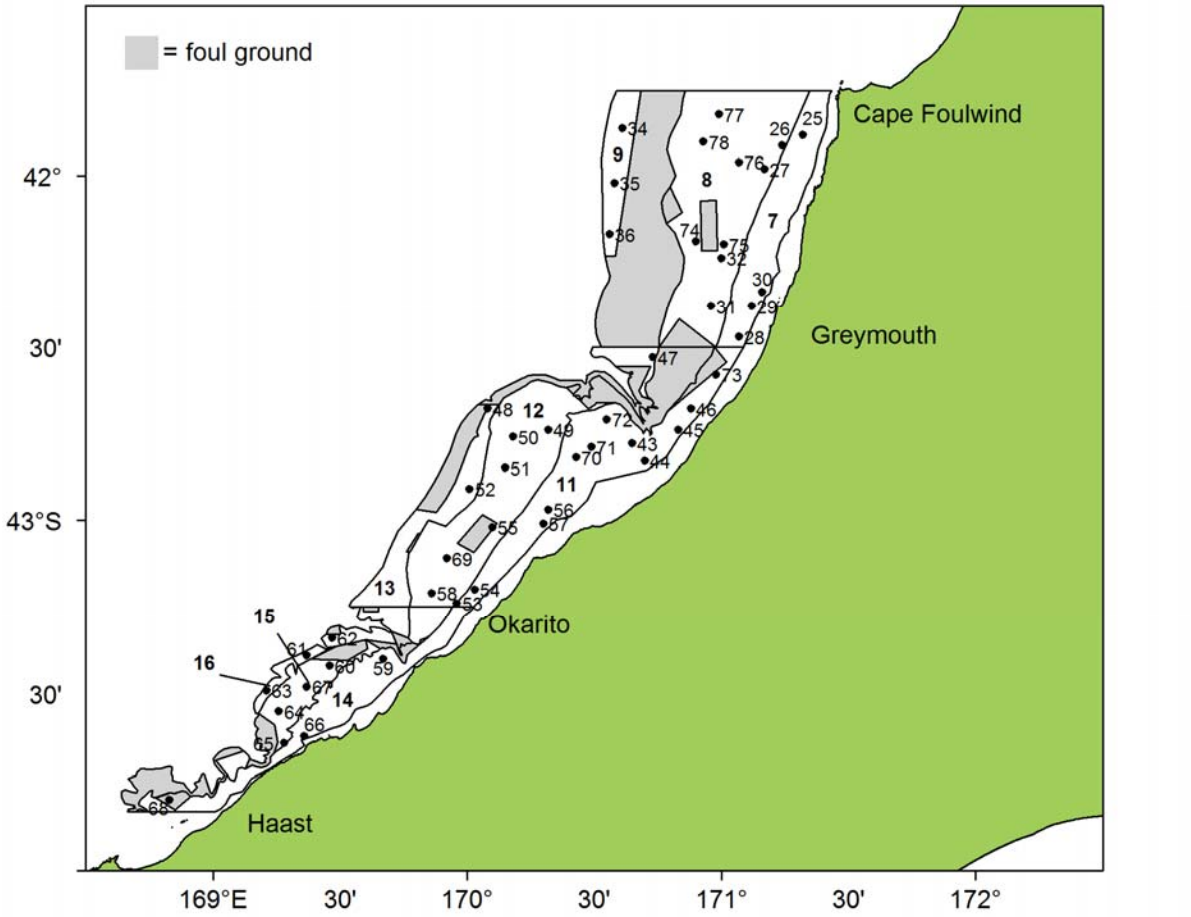


Figure 1b: Stratum boundaries and numbers (bold type) south of Cape Foulwind with station positions and numbers.

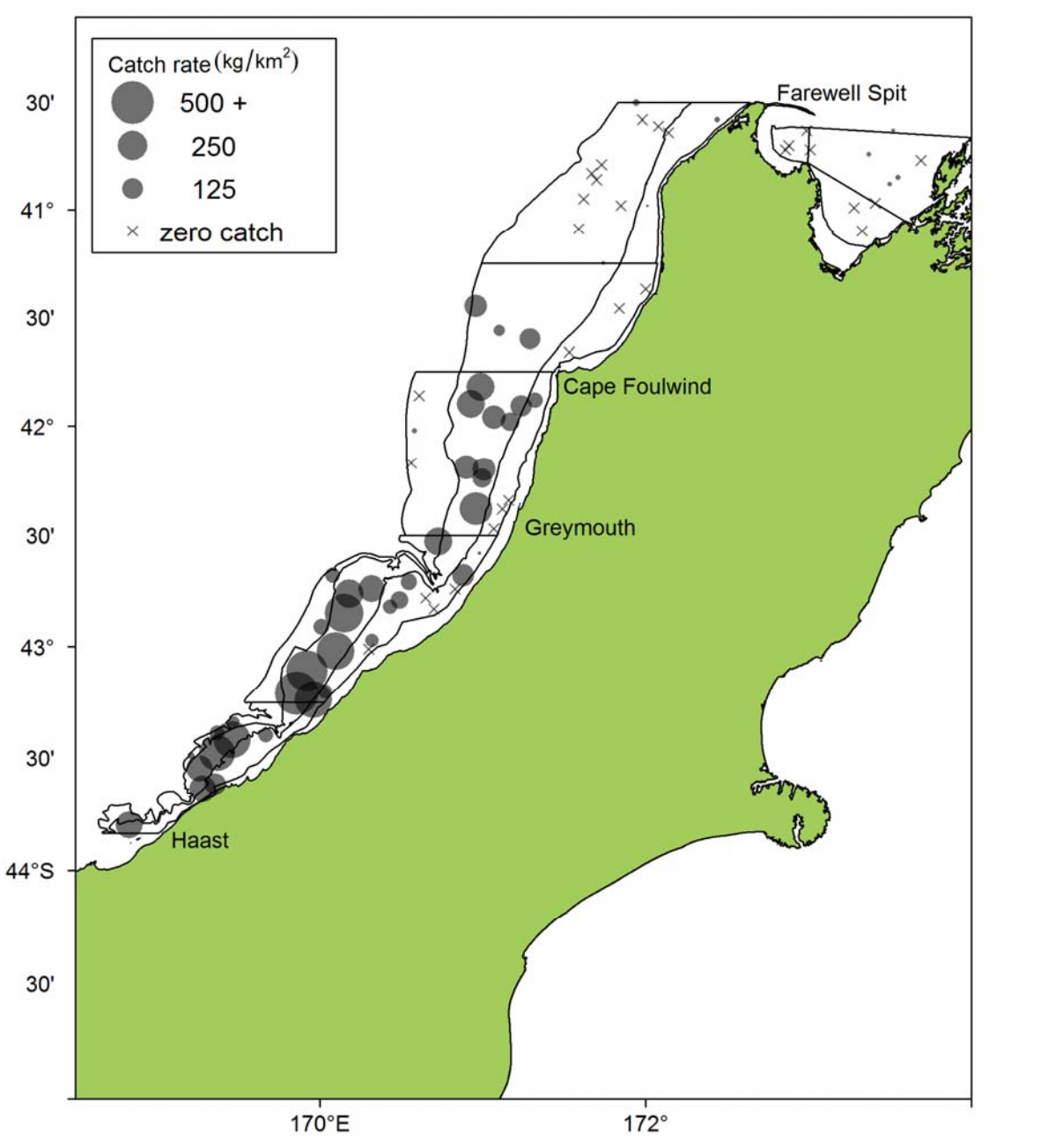


Figure 2: Catch rates (kg.km^{-2}) and distribution for the target species in alphabetical order by common name.

a: Giant stargazer (maximum catch rate = 523 kg.km^{-2}.

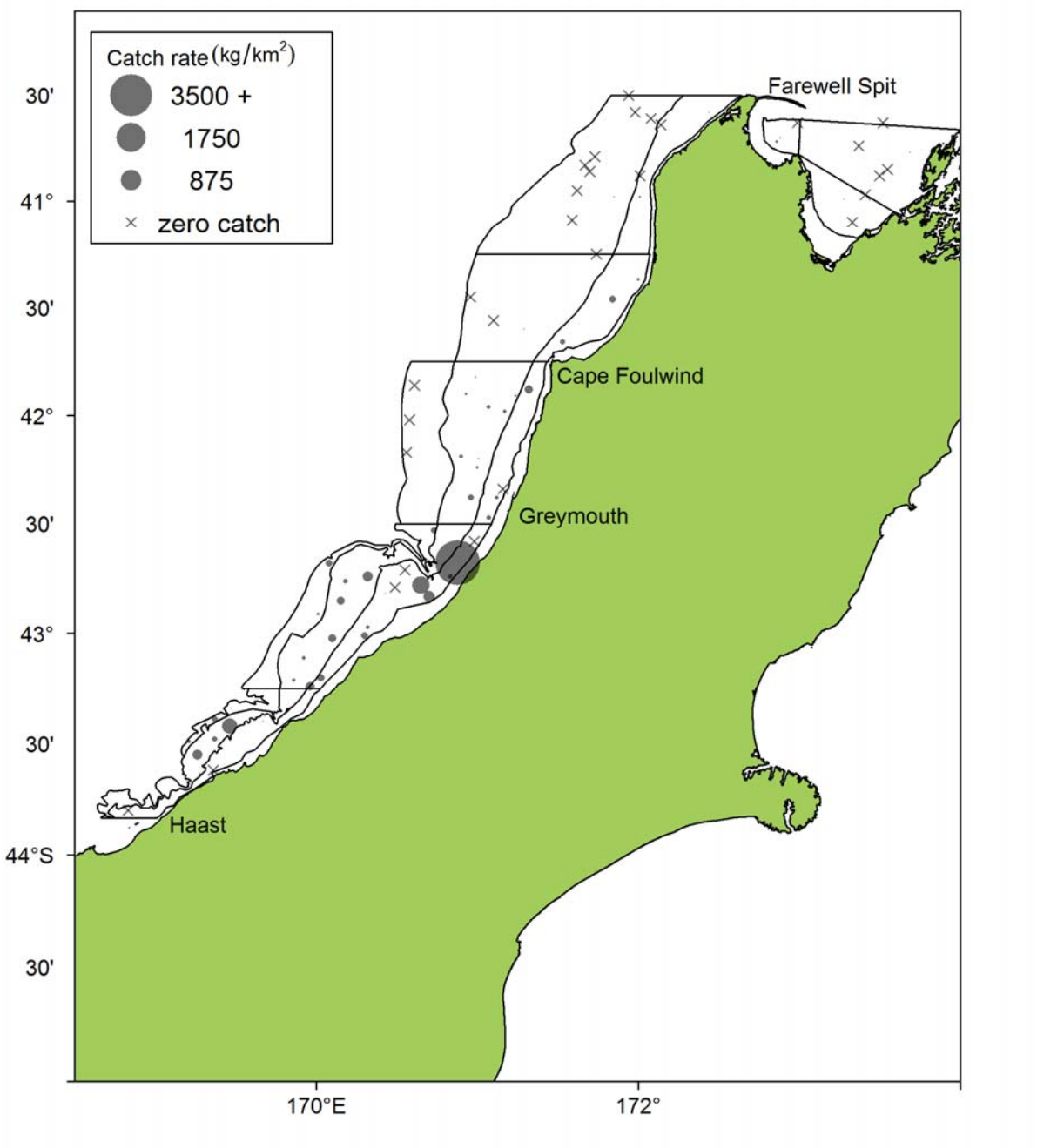


Figure 2 ctd.

b: Red cod. (maximum catch rate = 3905 kg.km^{-2}.

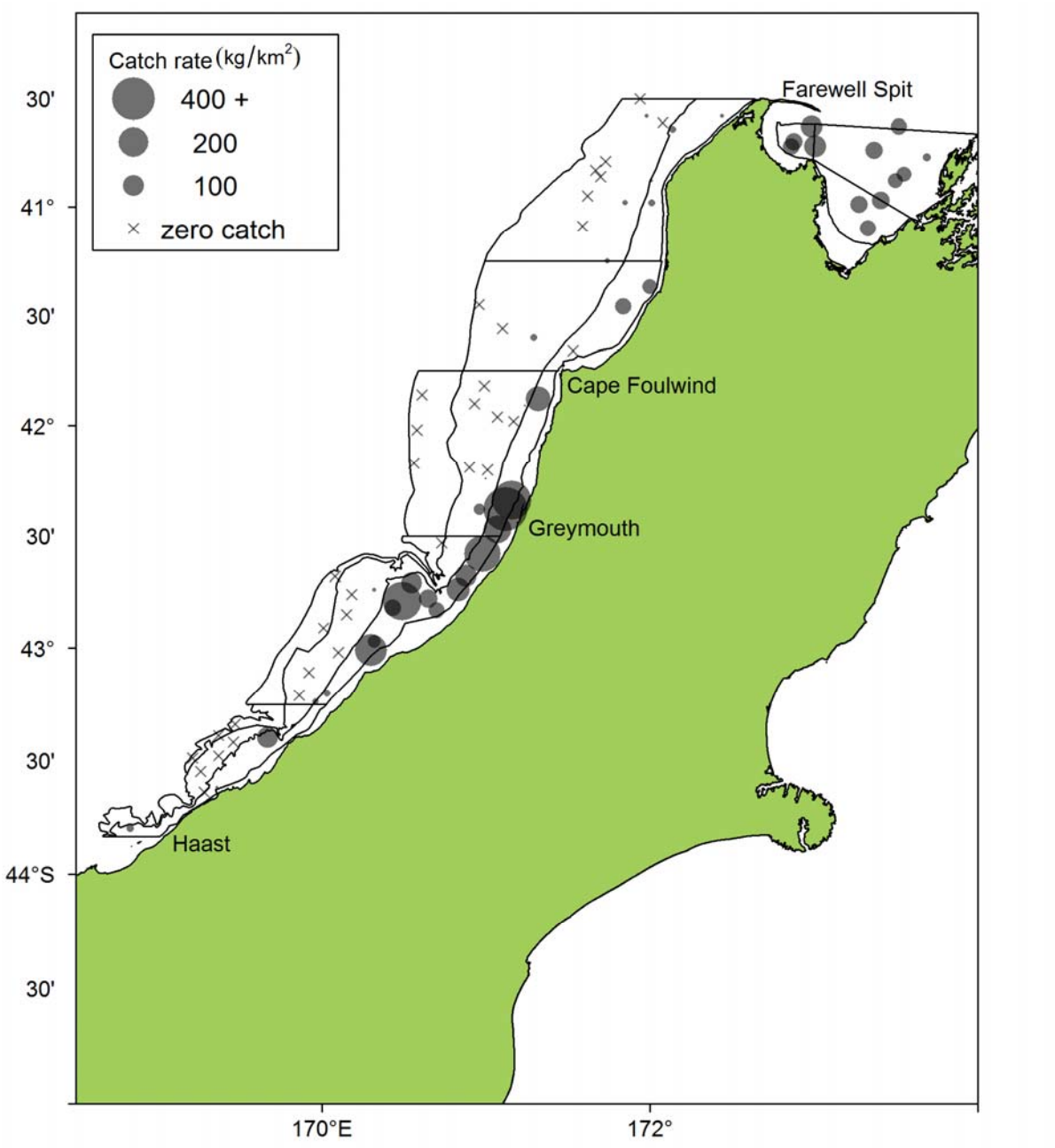


Figure 2 ctd.

c: Red gurnard (maximum catch rate = 420 kg.km^{-2}).

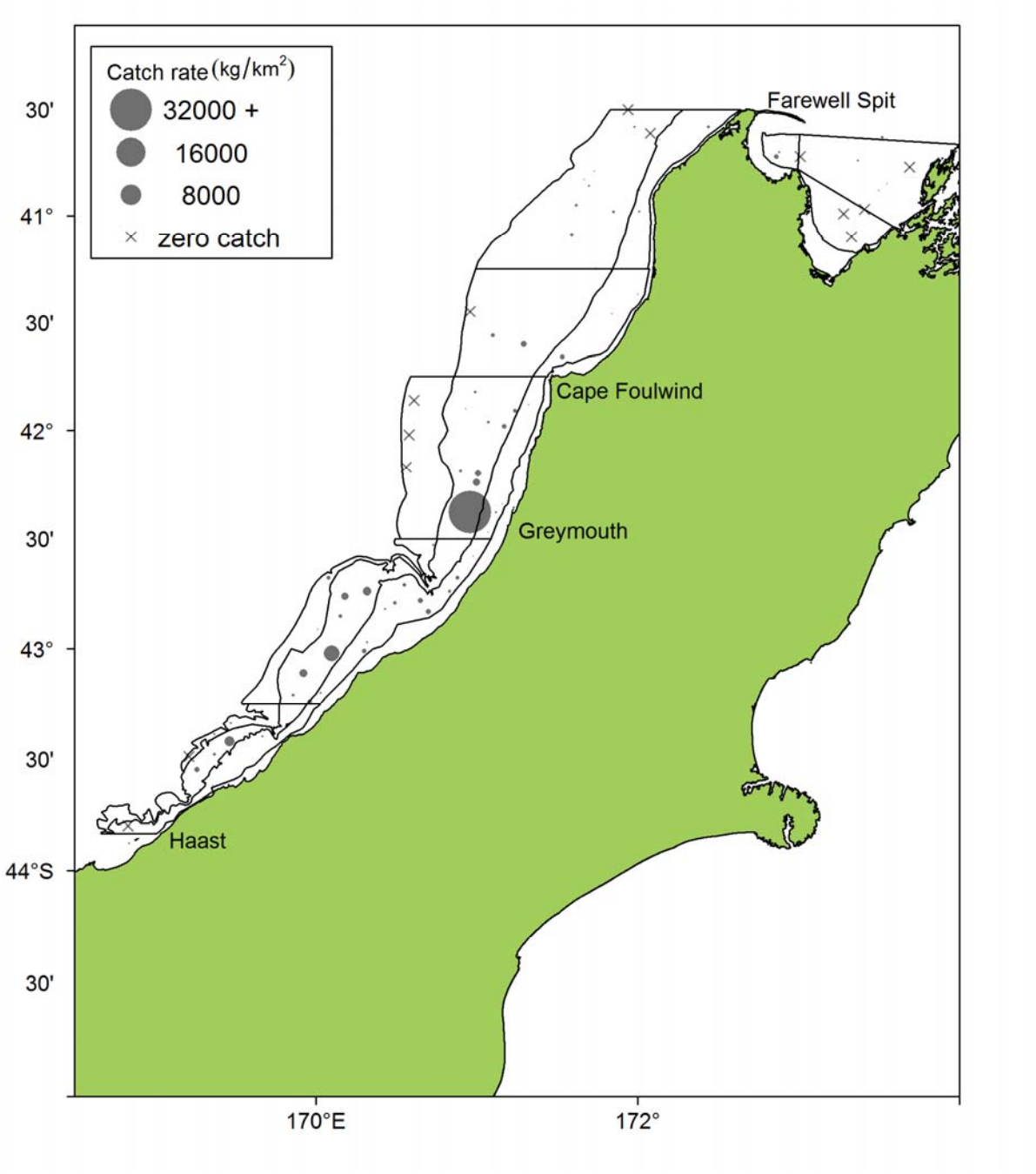


Figure 2 ctd.

d: Spiny dogfish (maximum catch rate = 32 956 kg.km^{-2}).

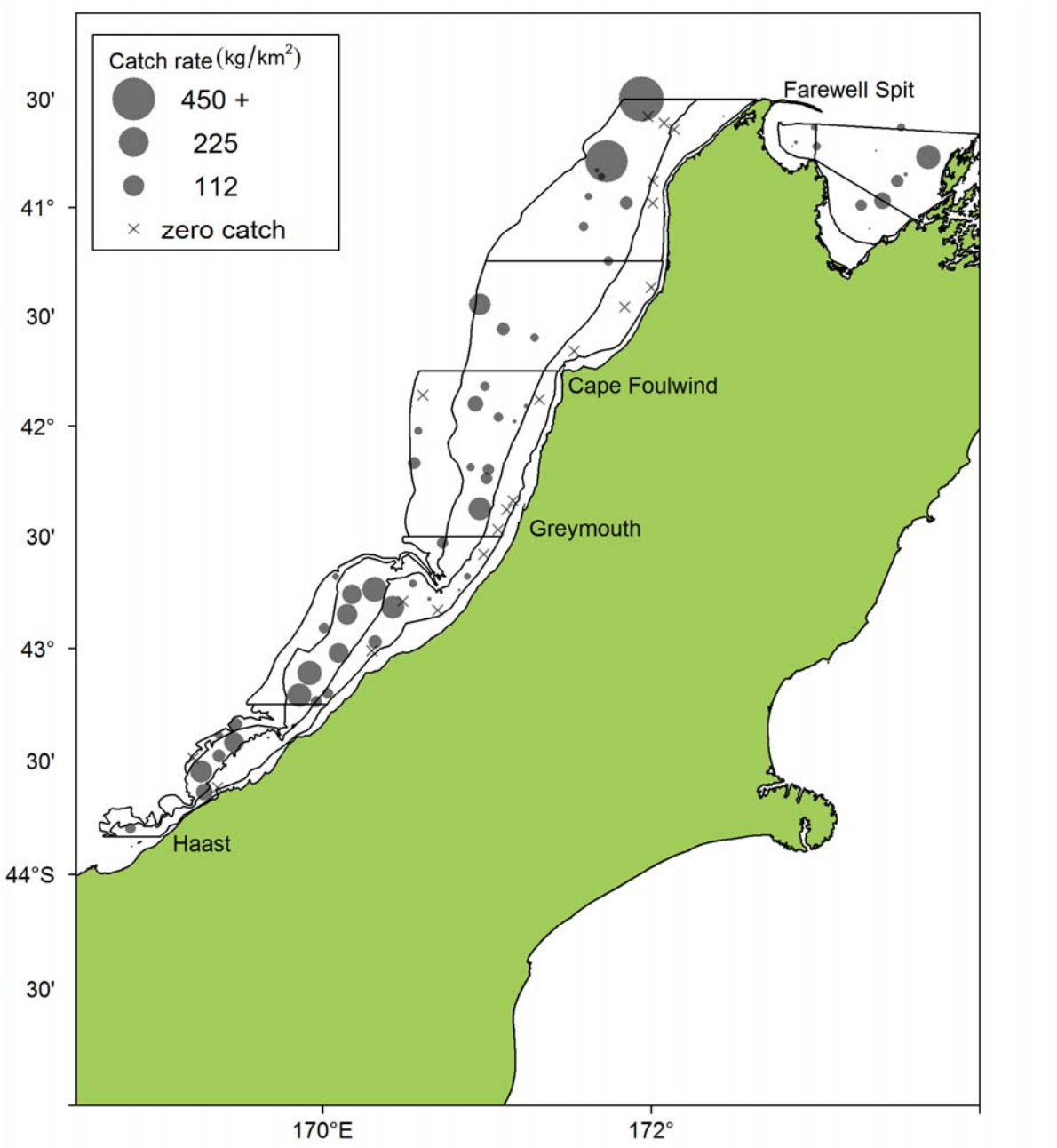


Figure 2 ctd.

e: Tarakihi (maximum catch rate = 489 kg.km^{-2}).

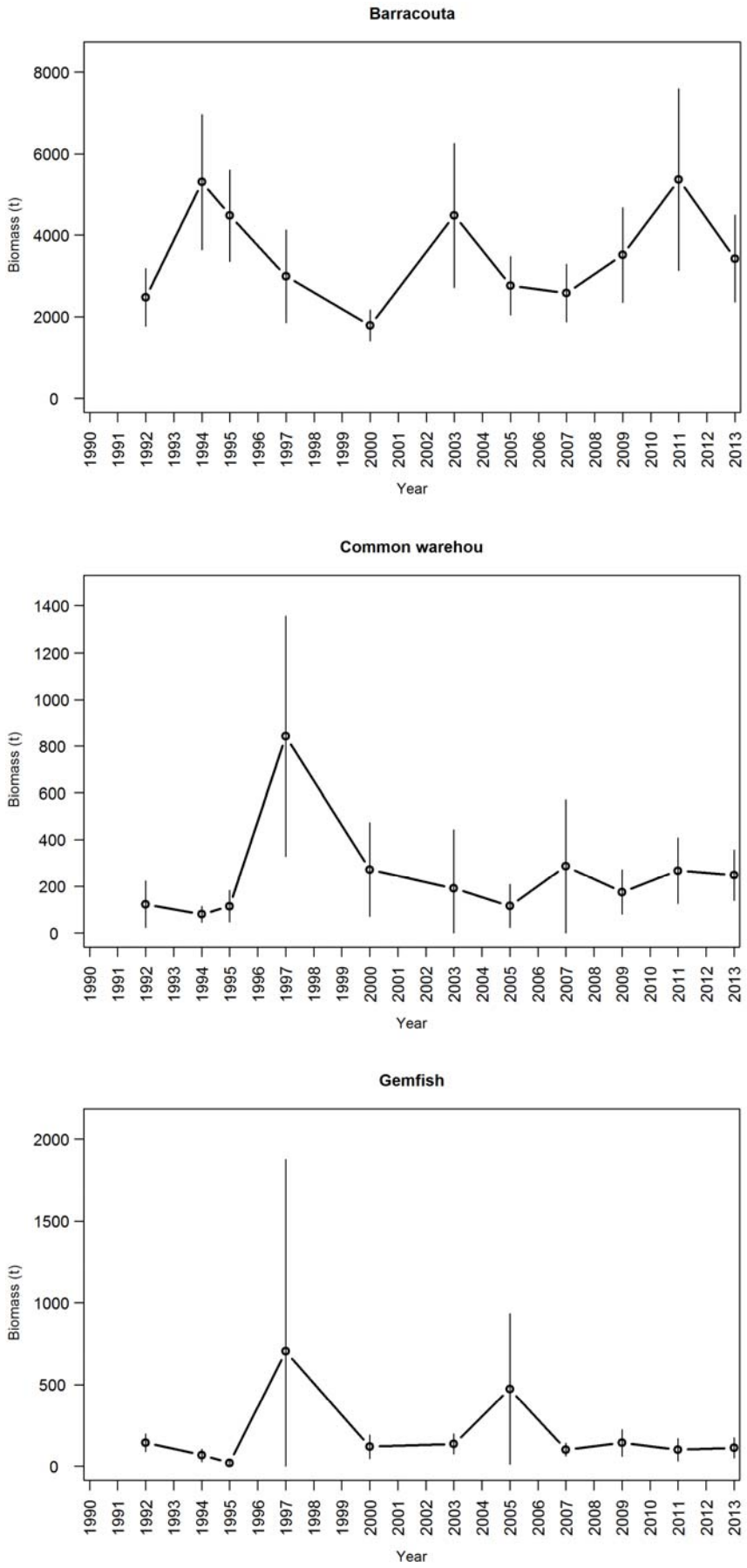


Figure 3: Trends in total biomass for the target species and other species reliably monitored by the survey time series.

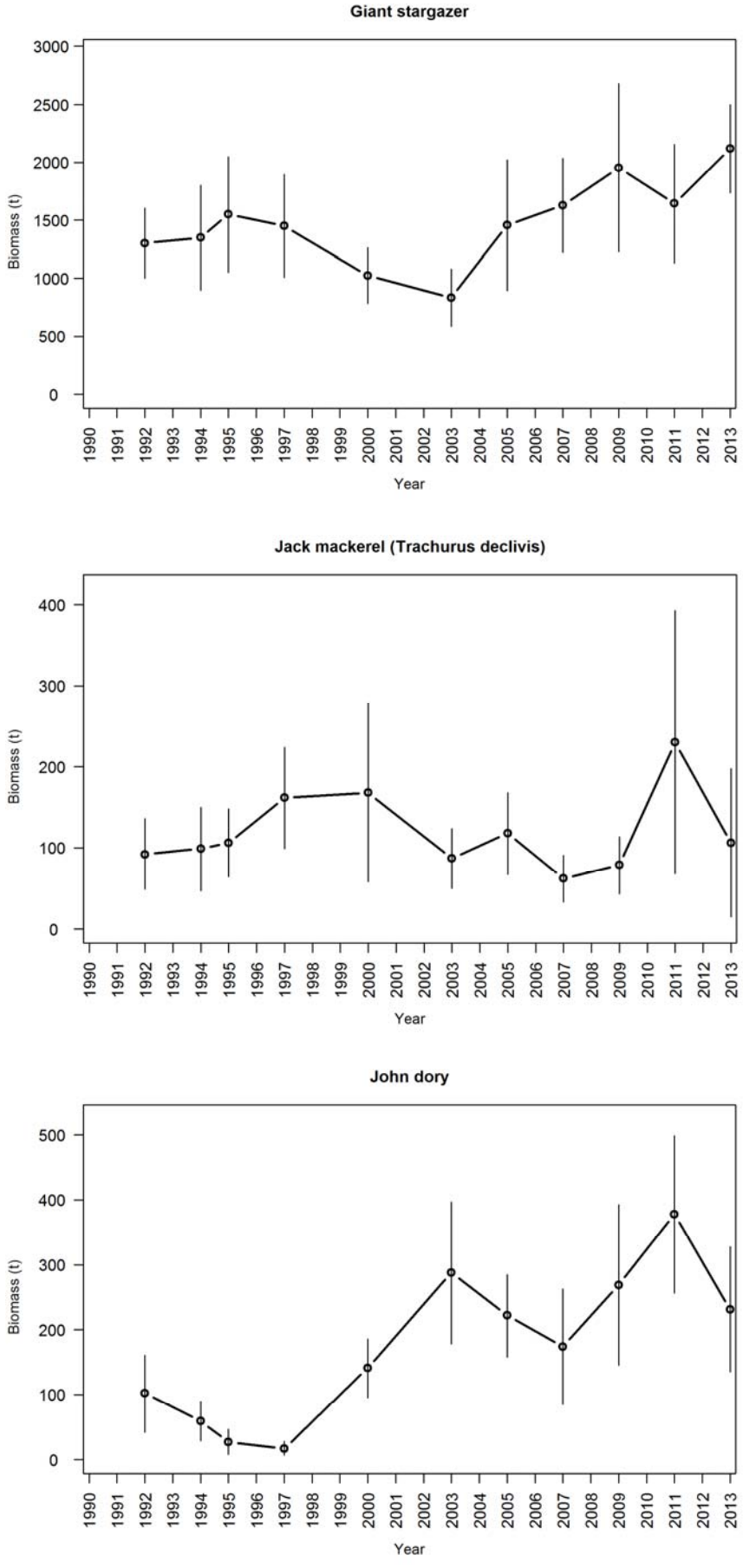
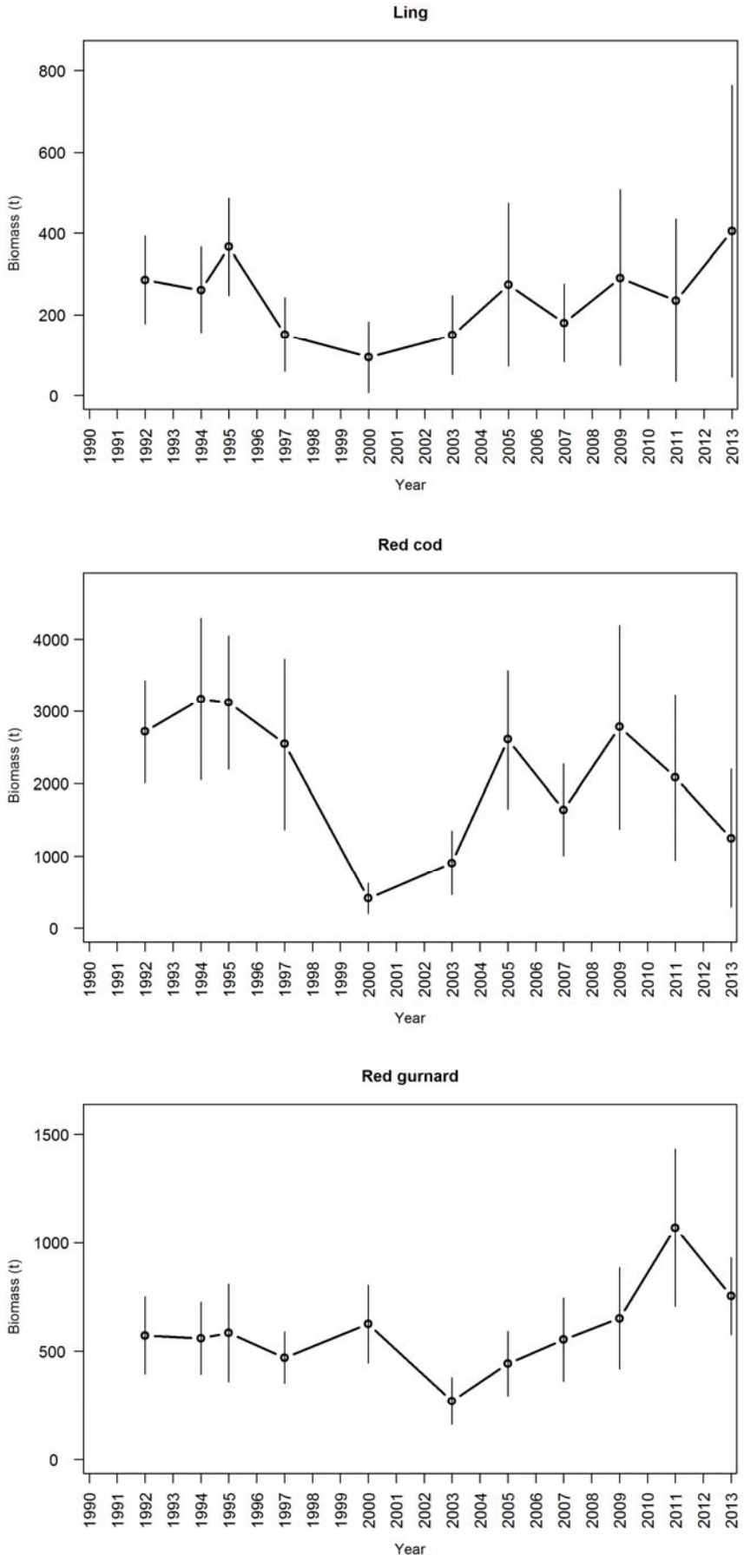


Figure 3—continued.



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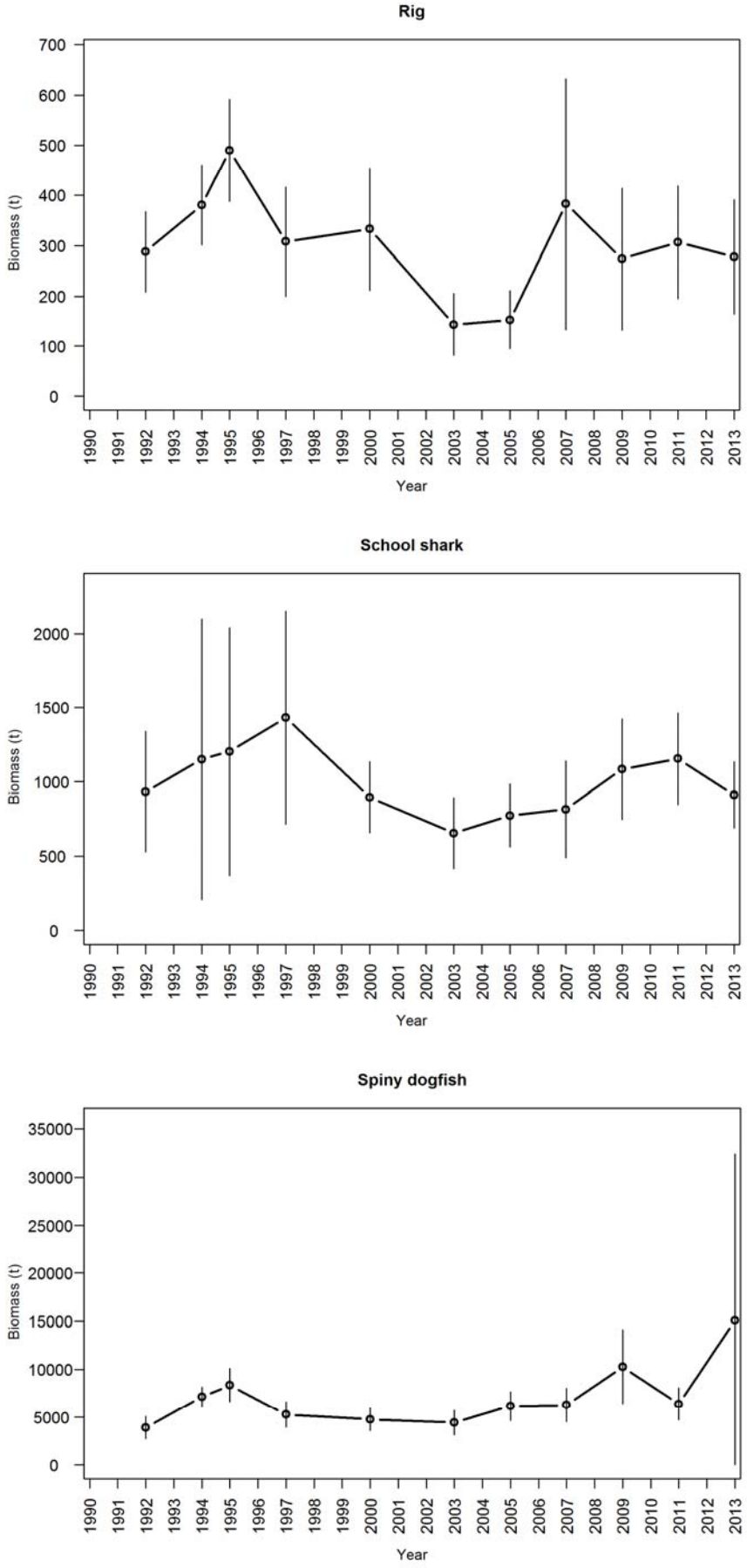

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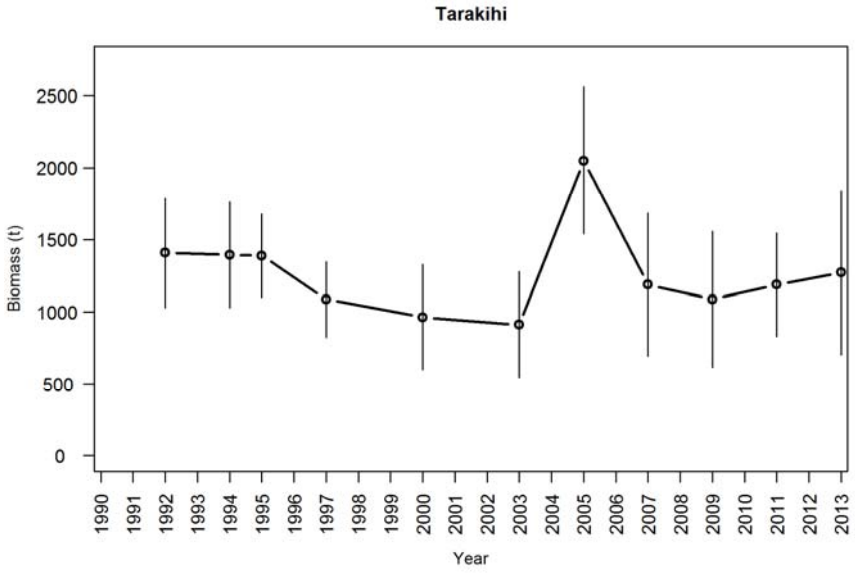

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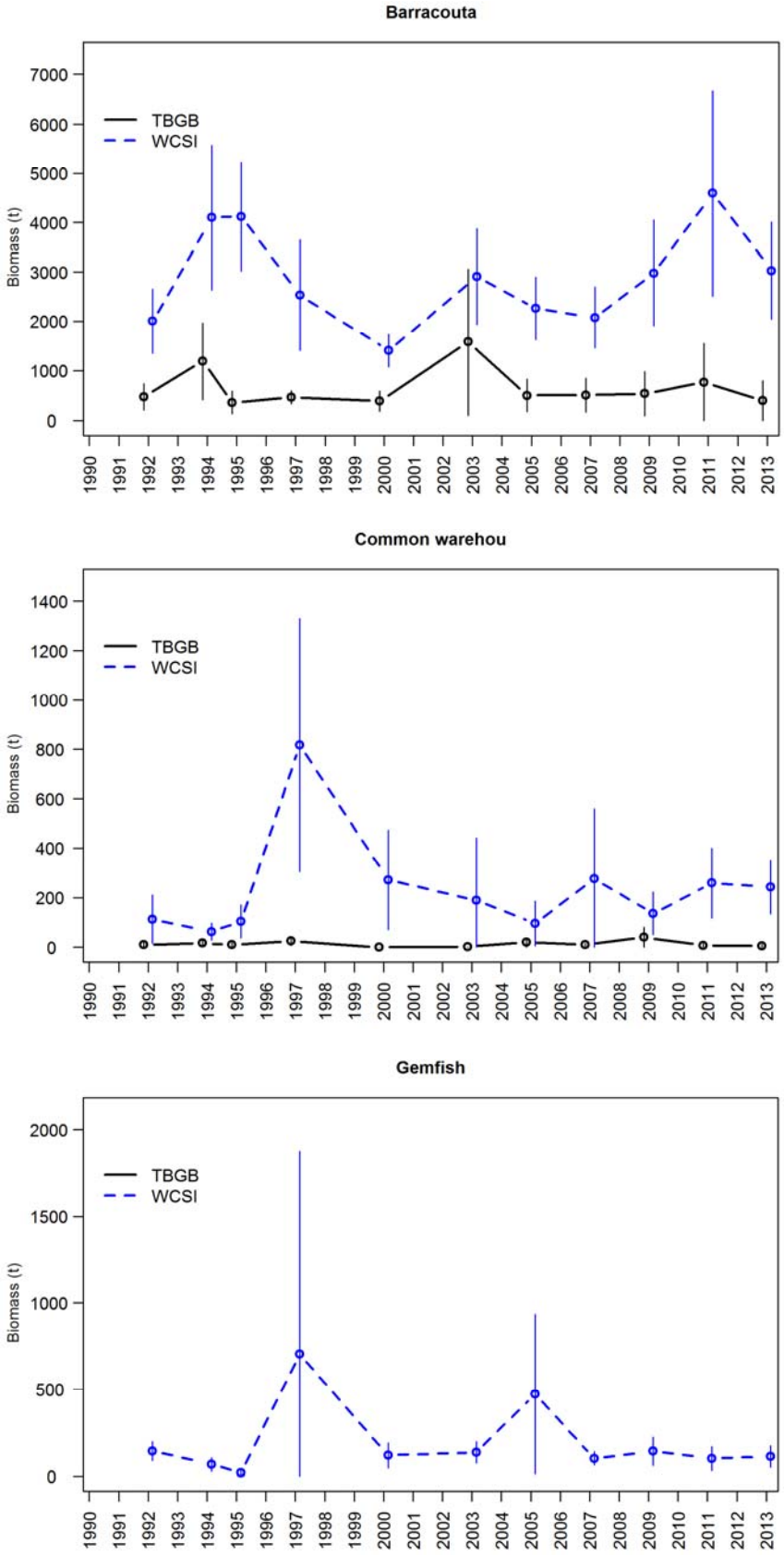


Figure 4: Trends in total biomass for the target species and other species for which the survey time series is likely to be monitoring adult or pre-recruit abundance, separated into Tasman and Golden Bays (TBGB), and the west coast South Island (WCSI).

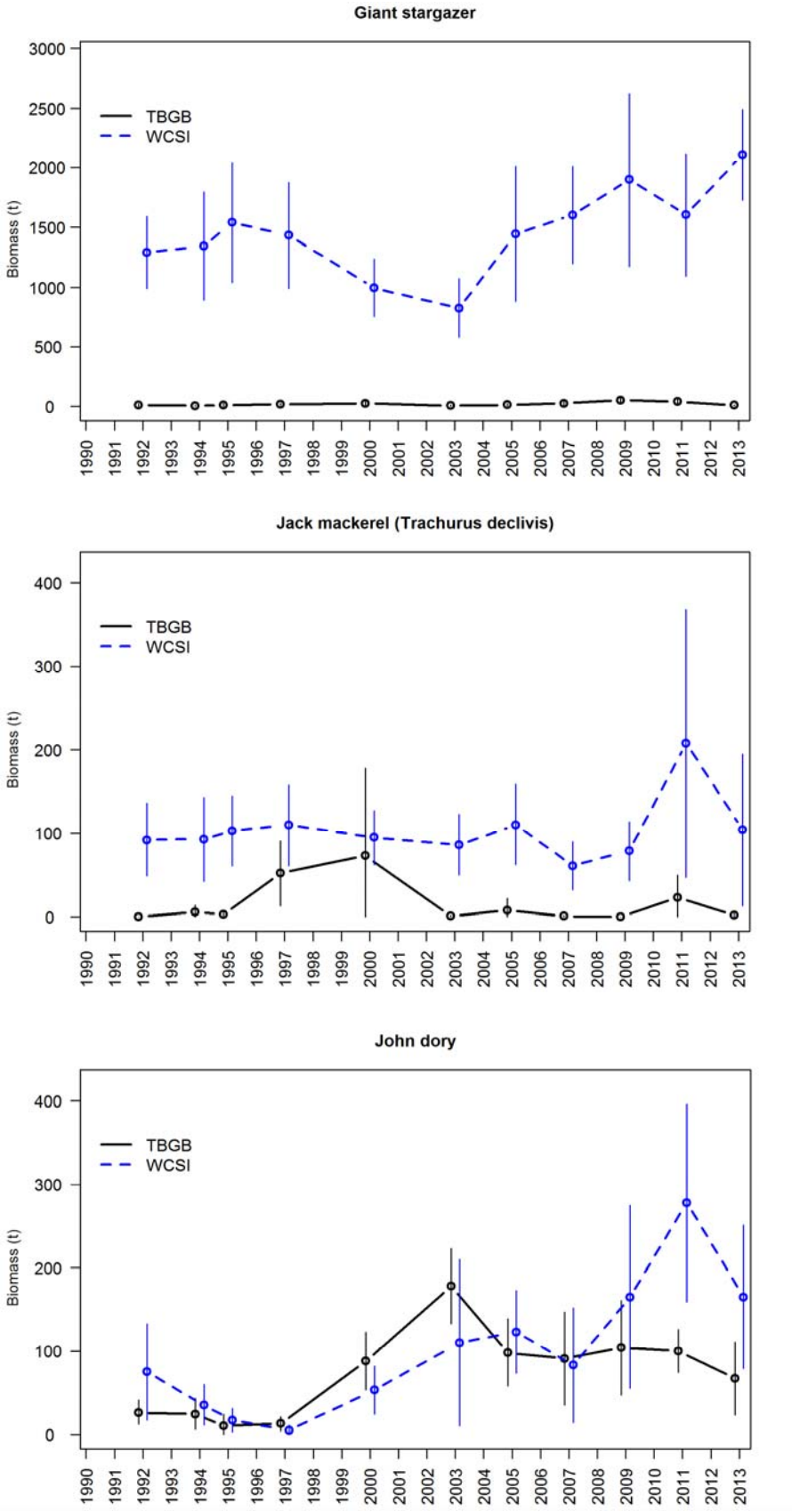
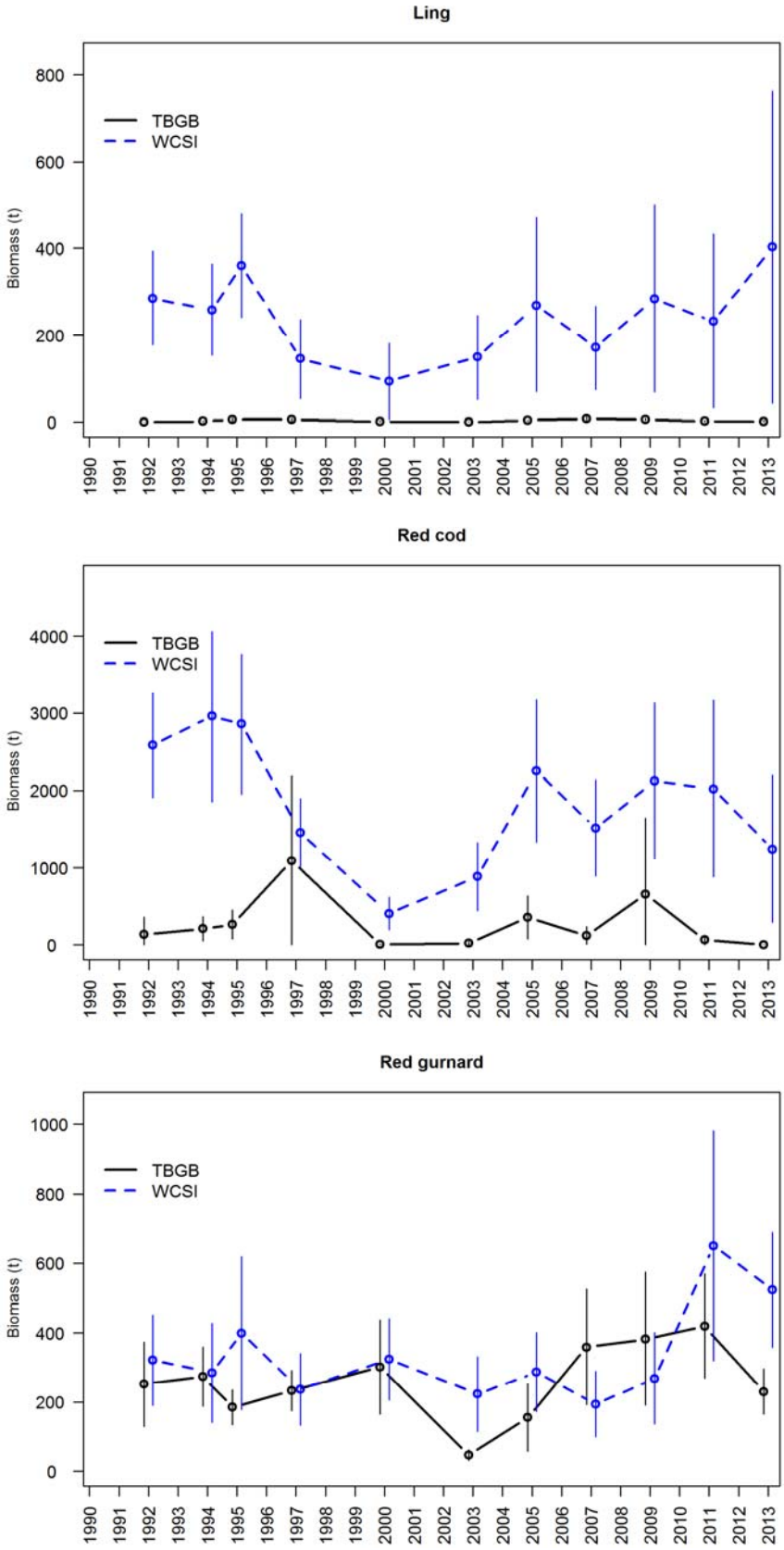


Figure 4—continued



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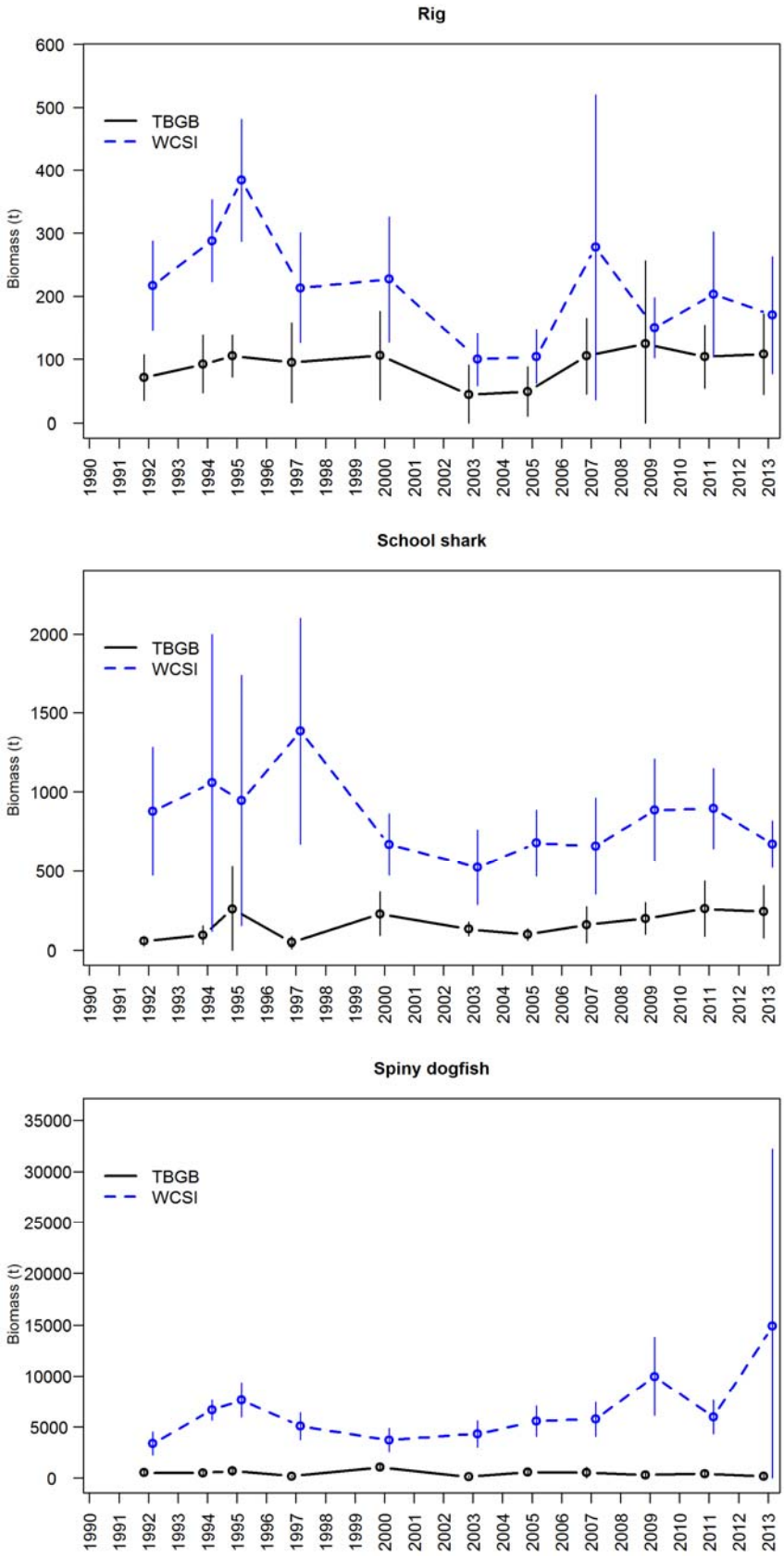

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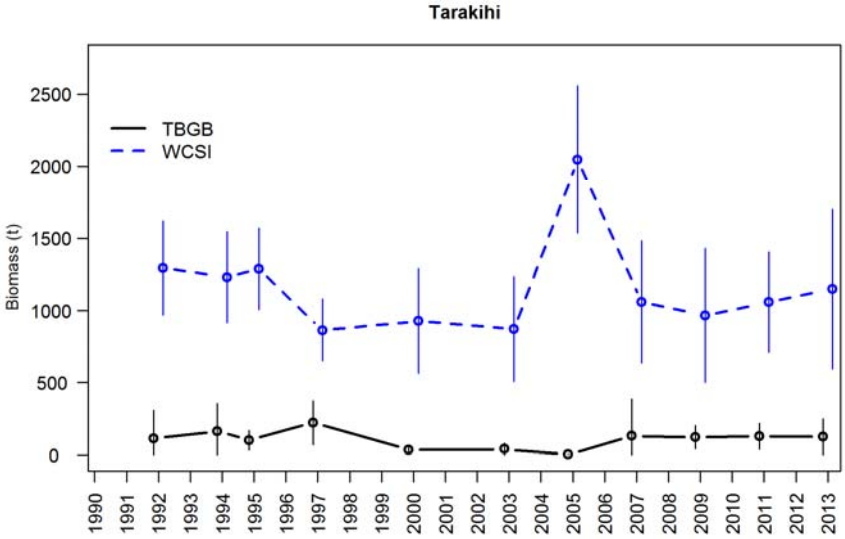

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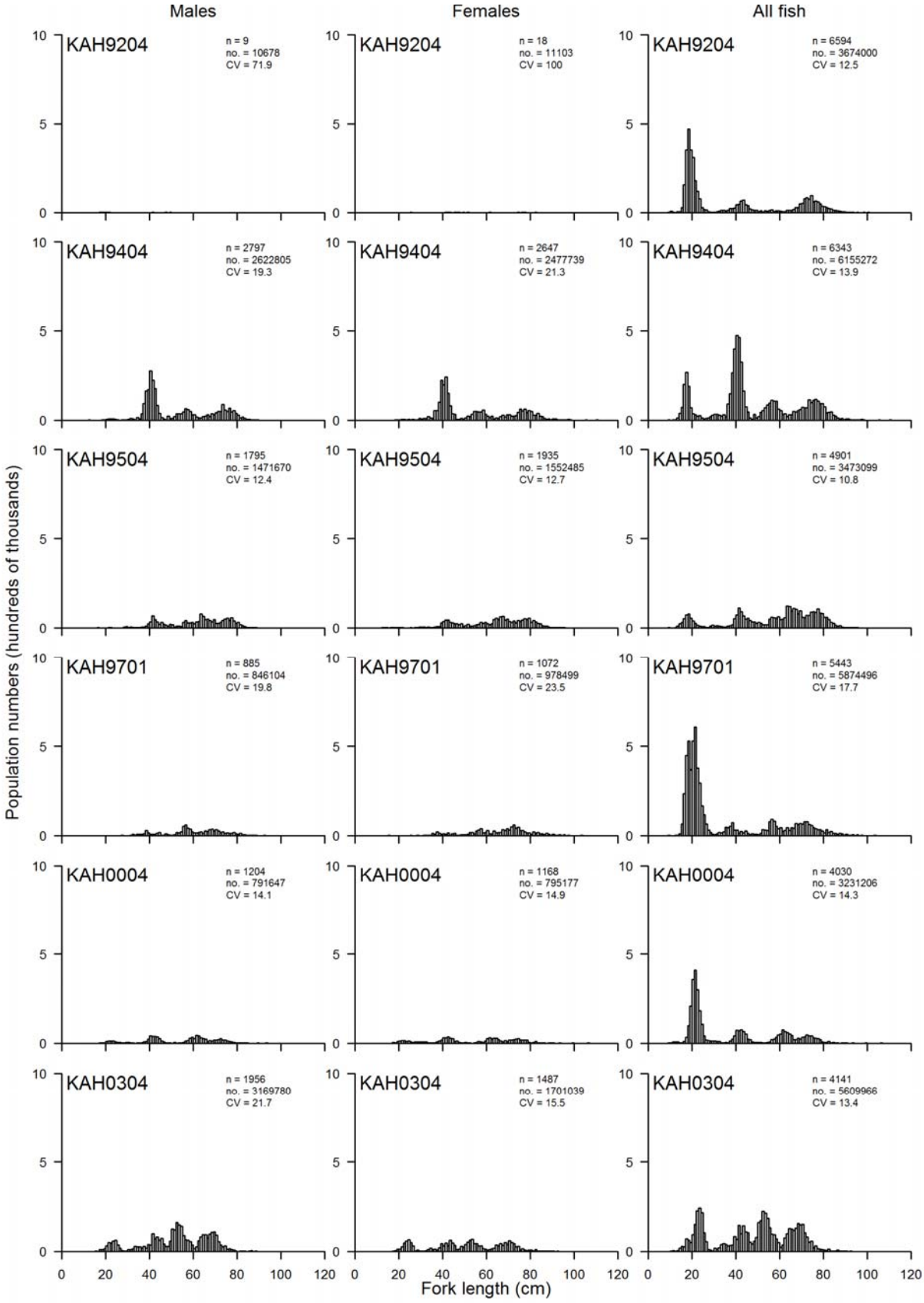
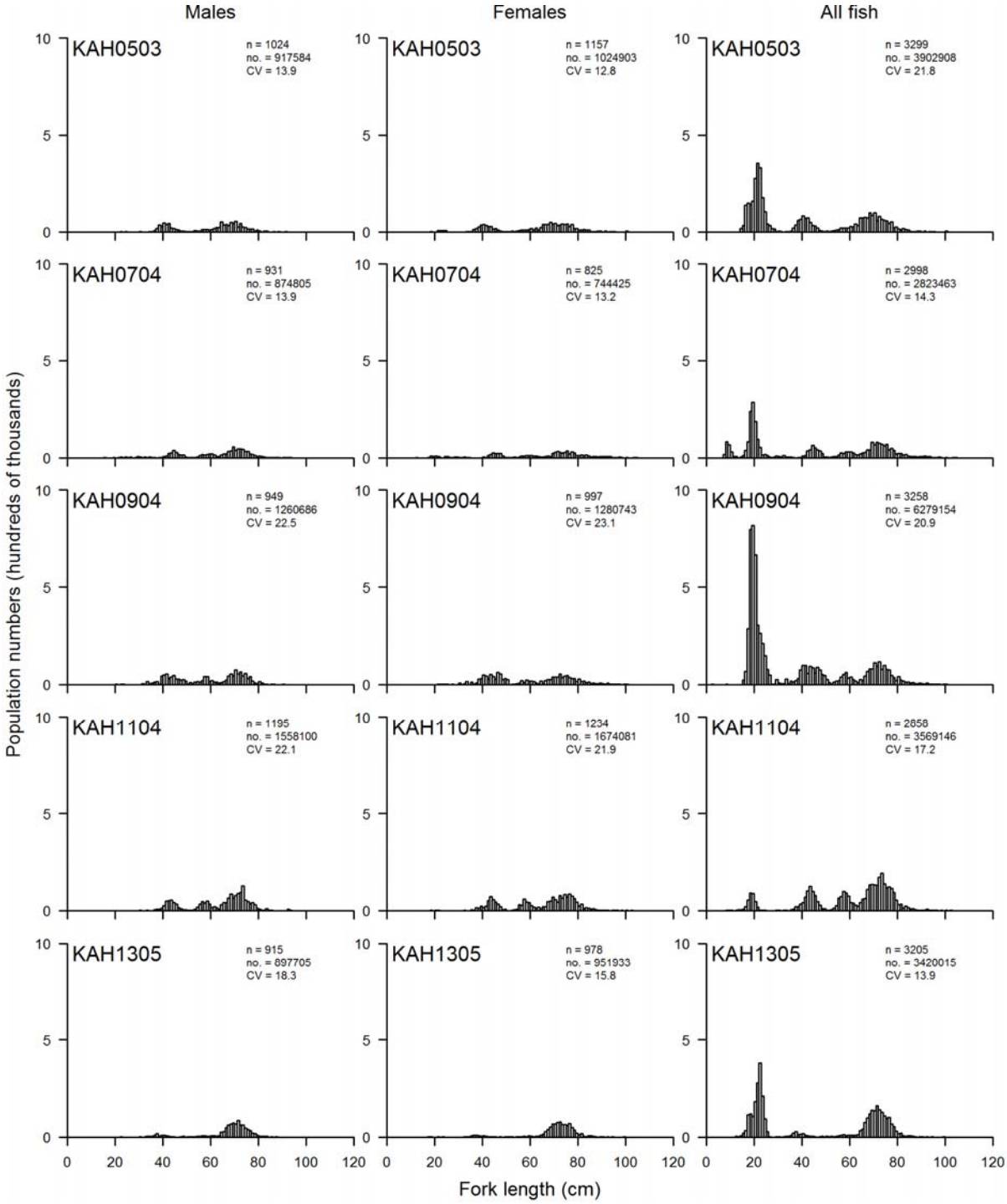


Figure 5: Comparative scaled length frequencies for the target species and those species where the surveys are monitoring adult or pre-recruit abundance. n = number of fish measured, no. = scaled population number, CV = coefficient of variation. 'All fish' includes any unsexed fish.

a) Barracouta



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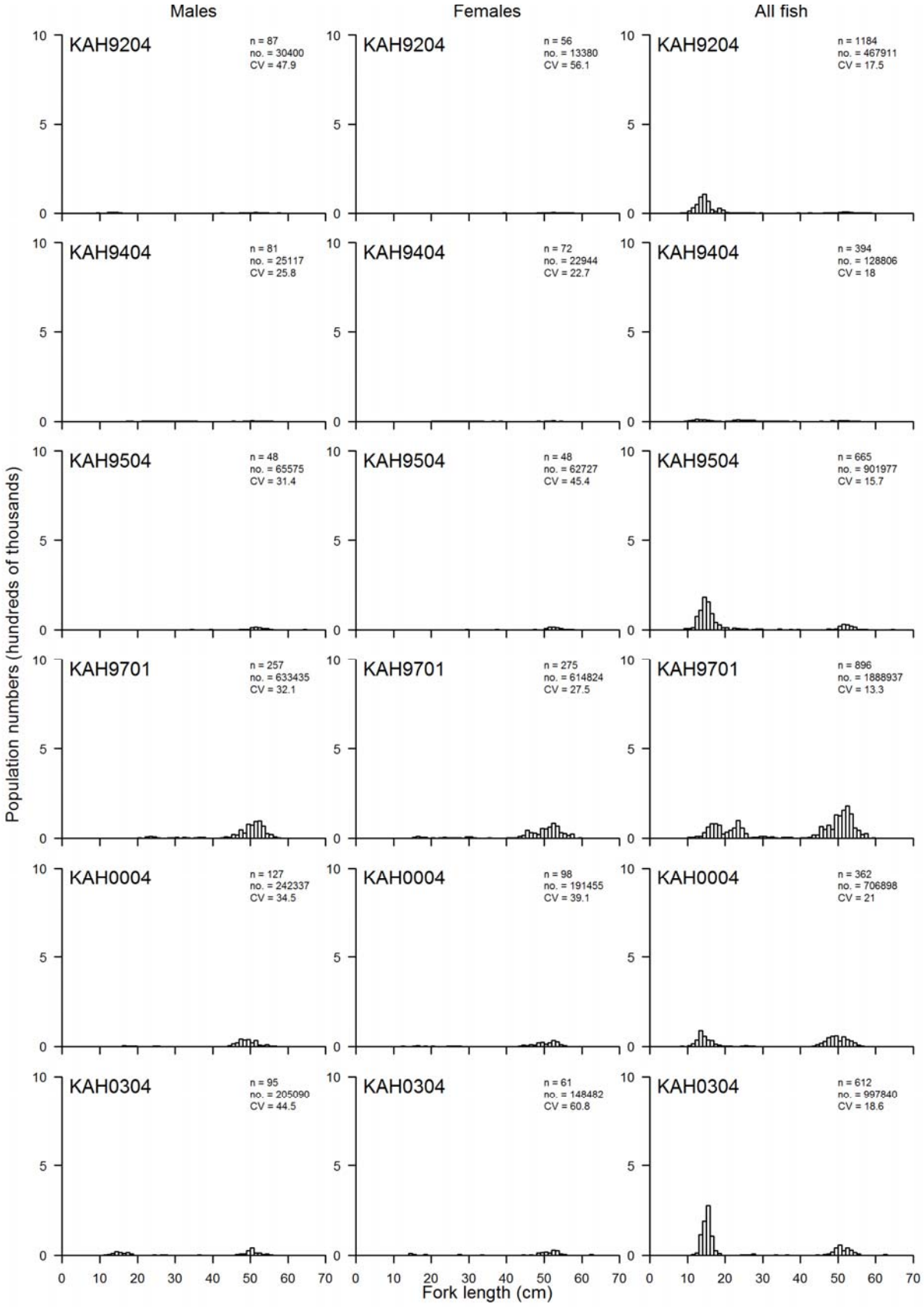


Figure 5 ctd. b: Blue warehou

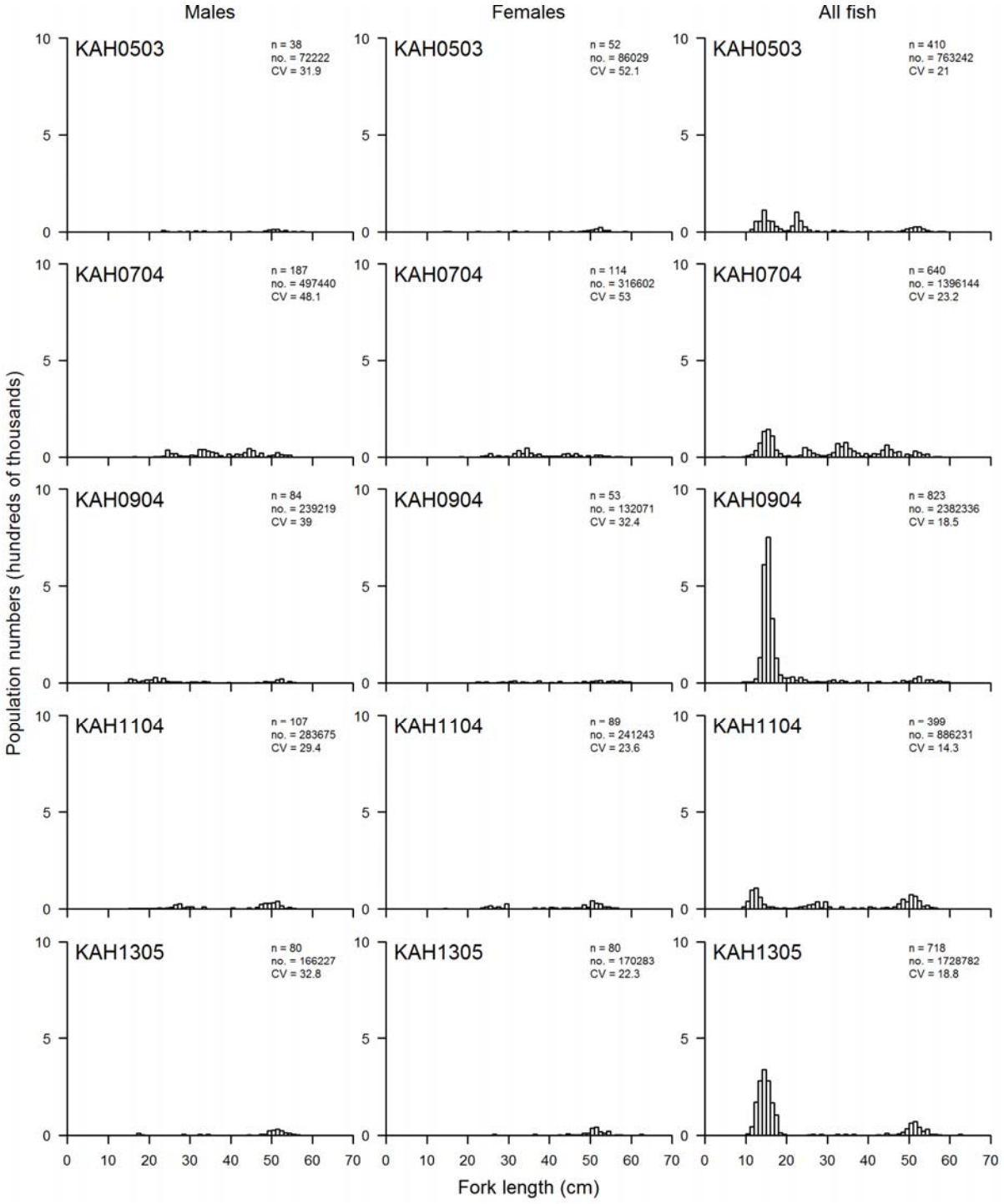


Figure 5 ctd.
b: Blue warehou

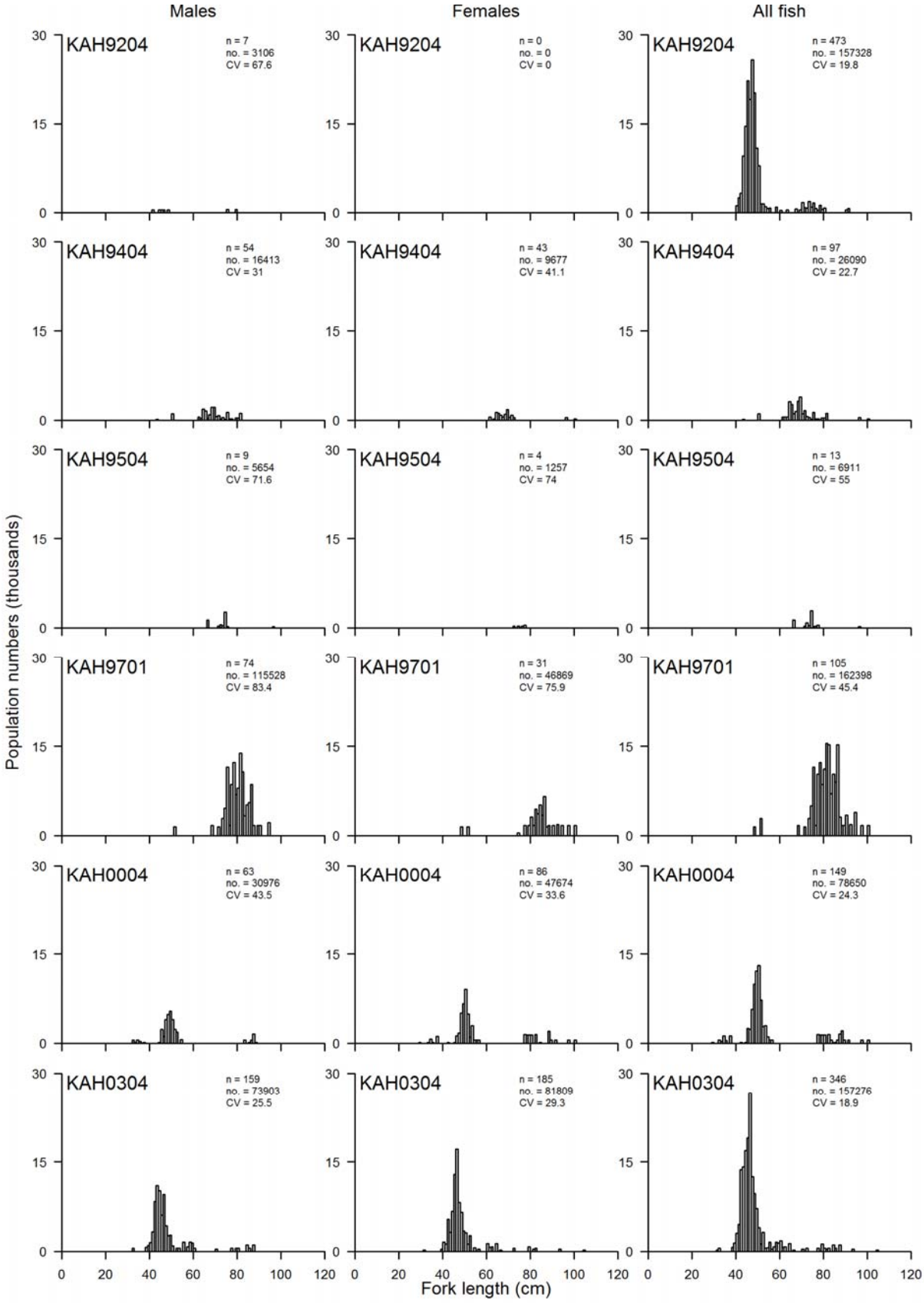


Figure 5 ctd.
c: Gemfish (100% of fish from the west coast).

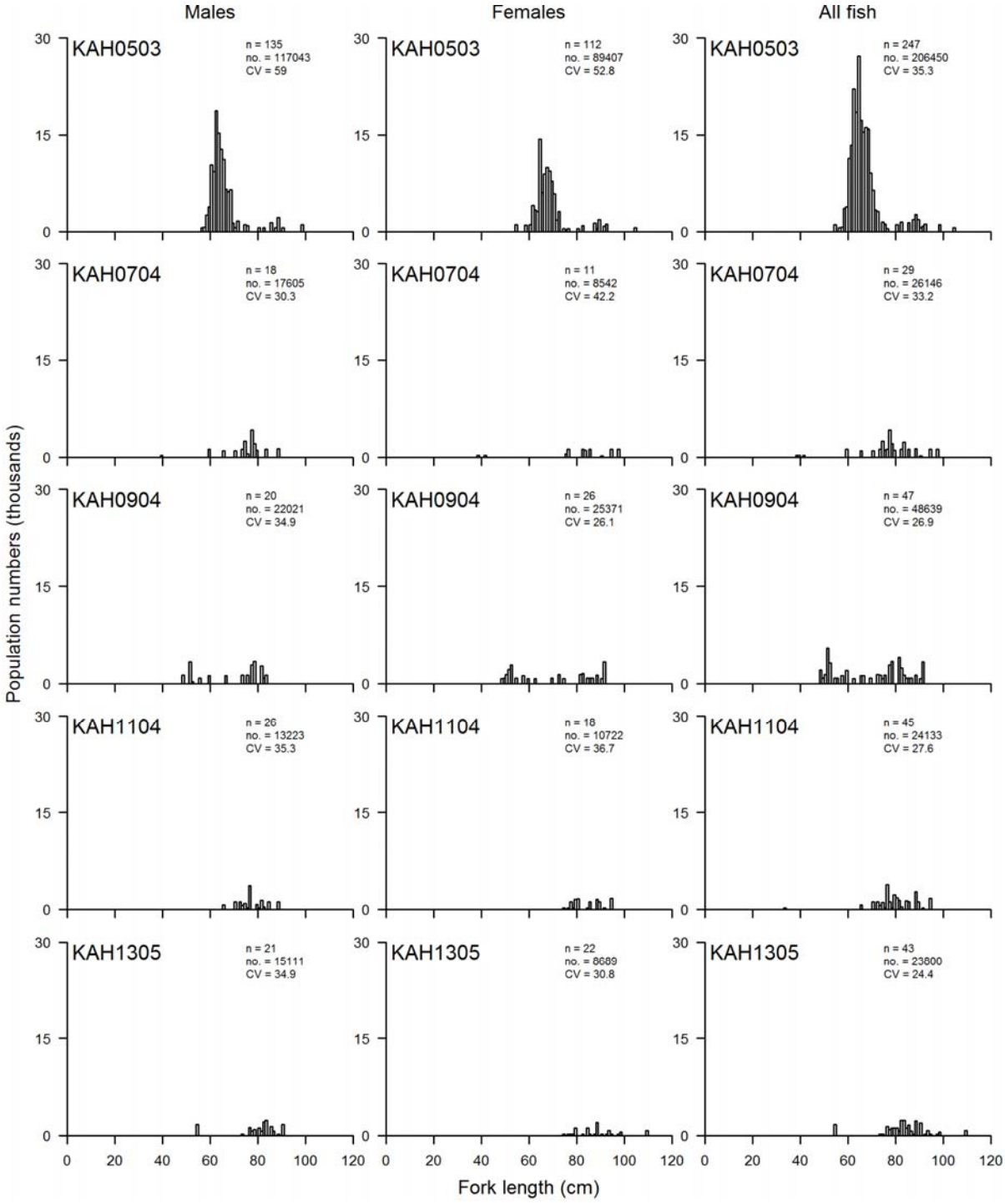


Figure 5 ctd.
c: Gemfish (100% of fish from the west coast).

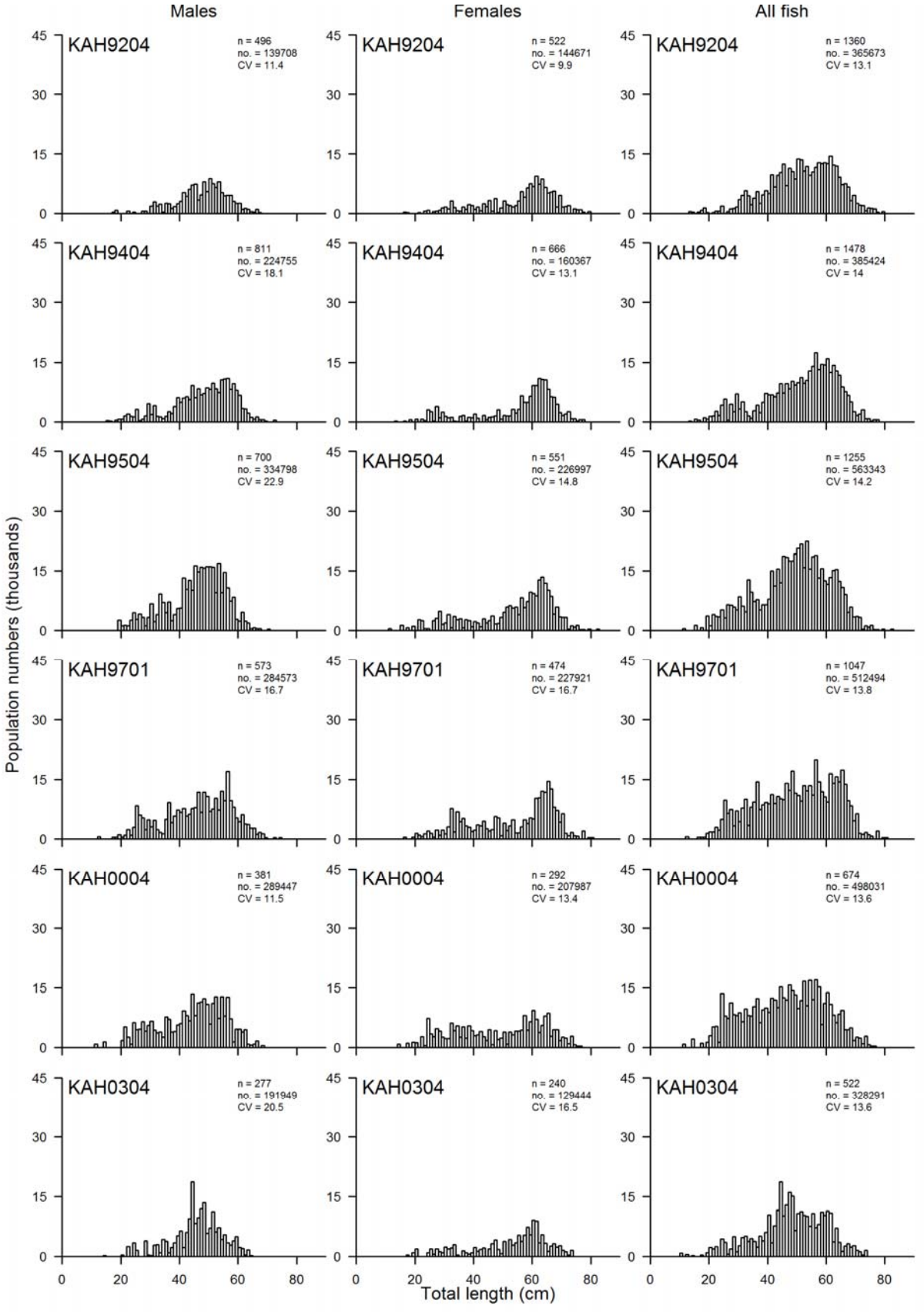
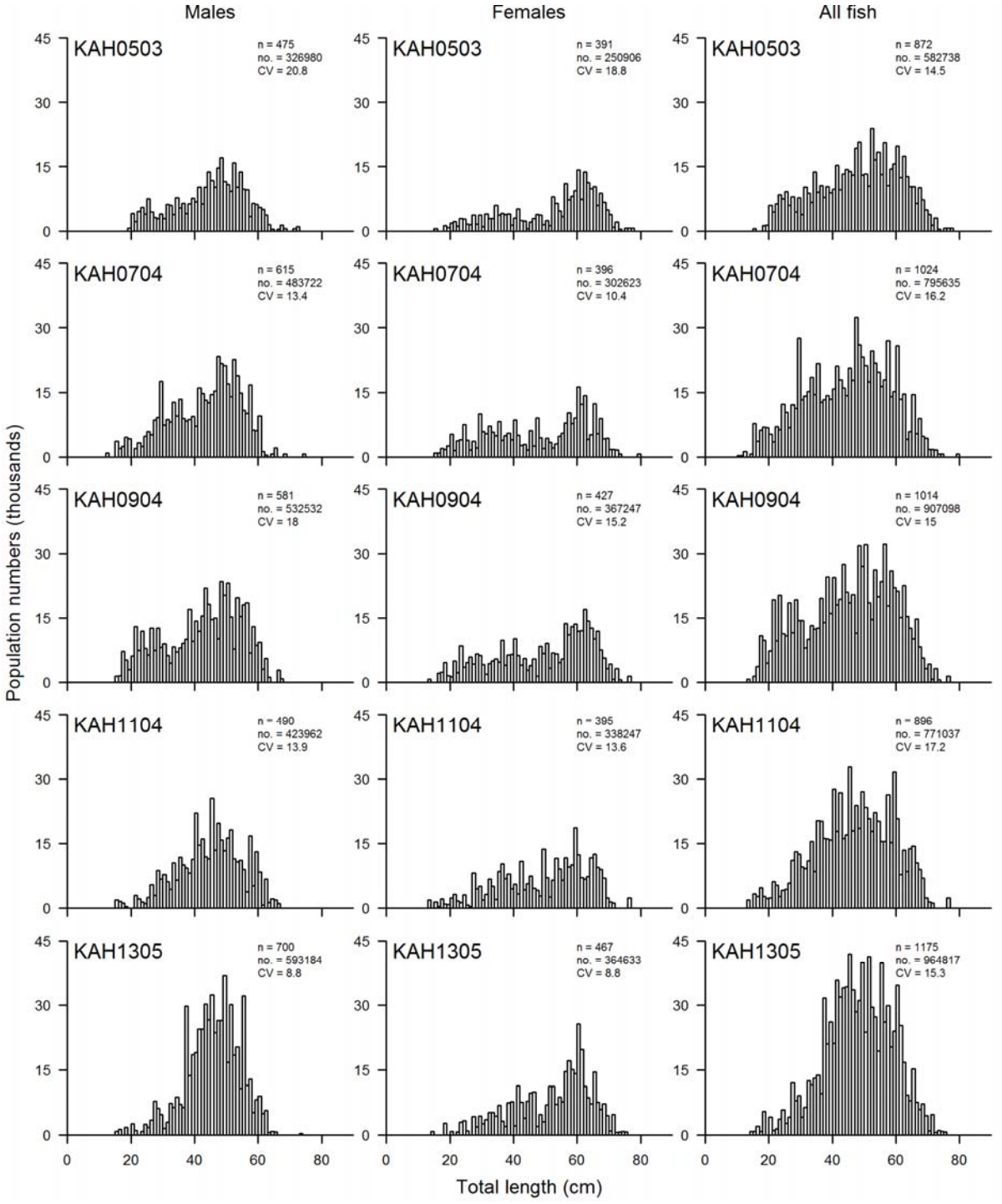


Figure 5 ctd. d: Giant stargazer.



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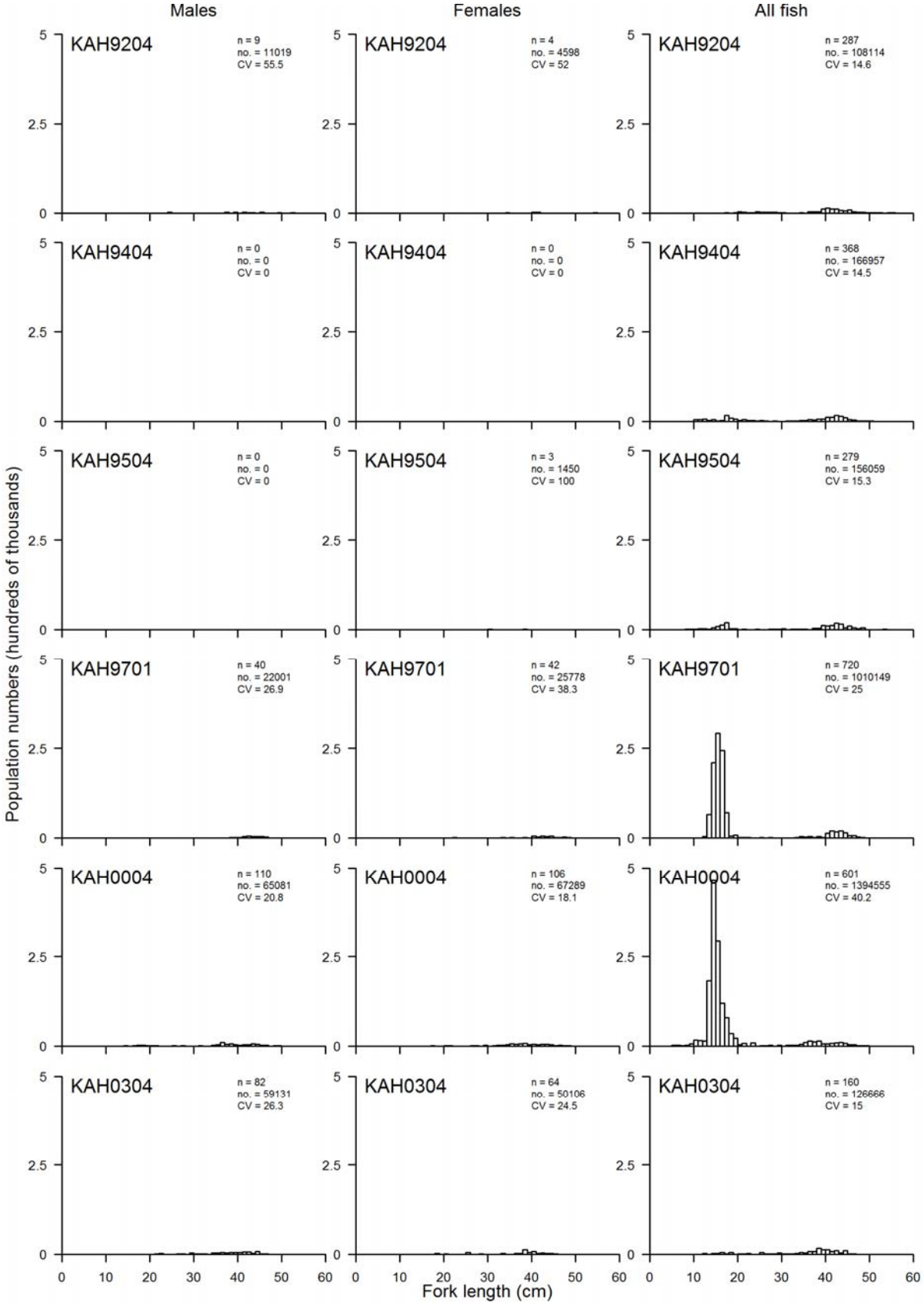
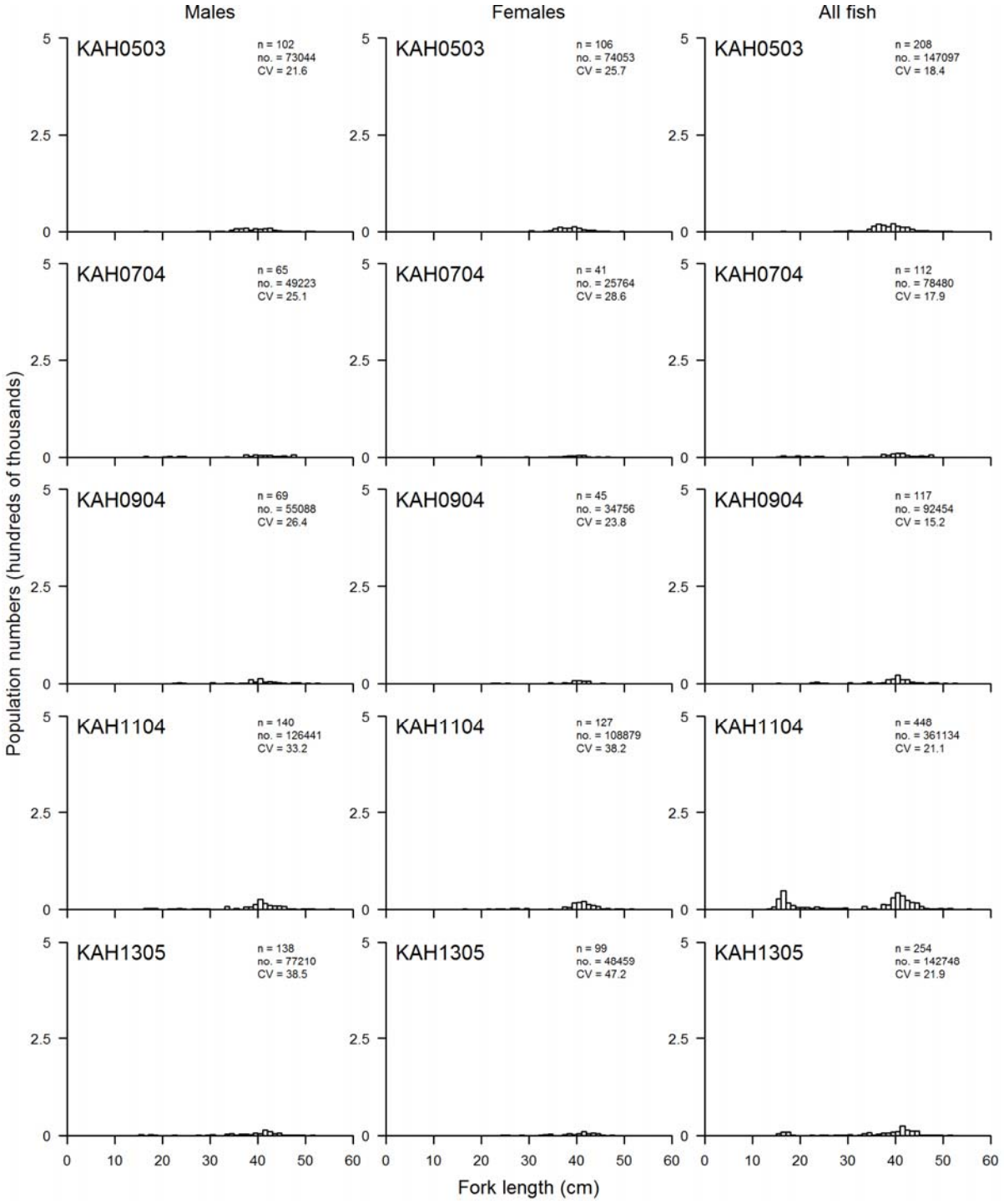


Figure 5 ctd. e: Jack mackerel (*Trachurus declivis*).



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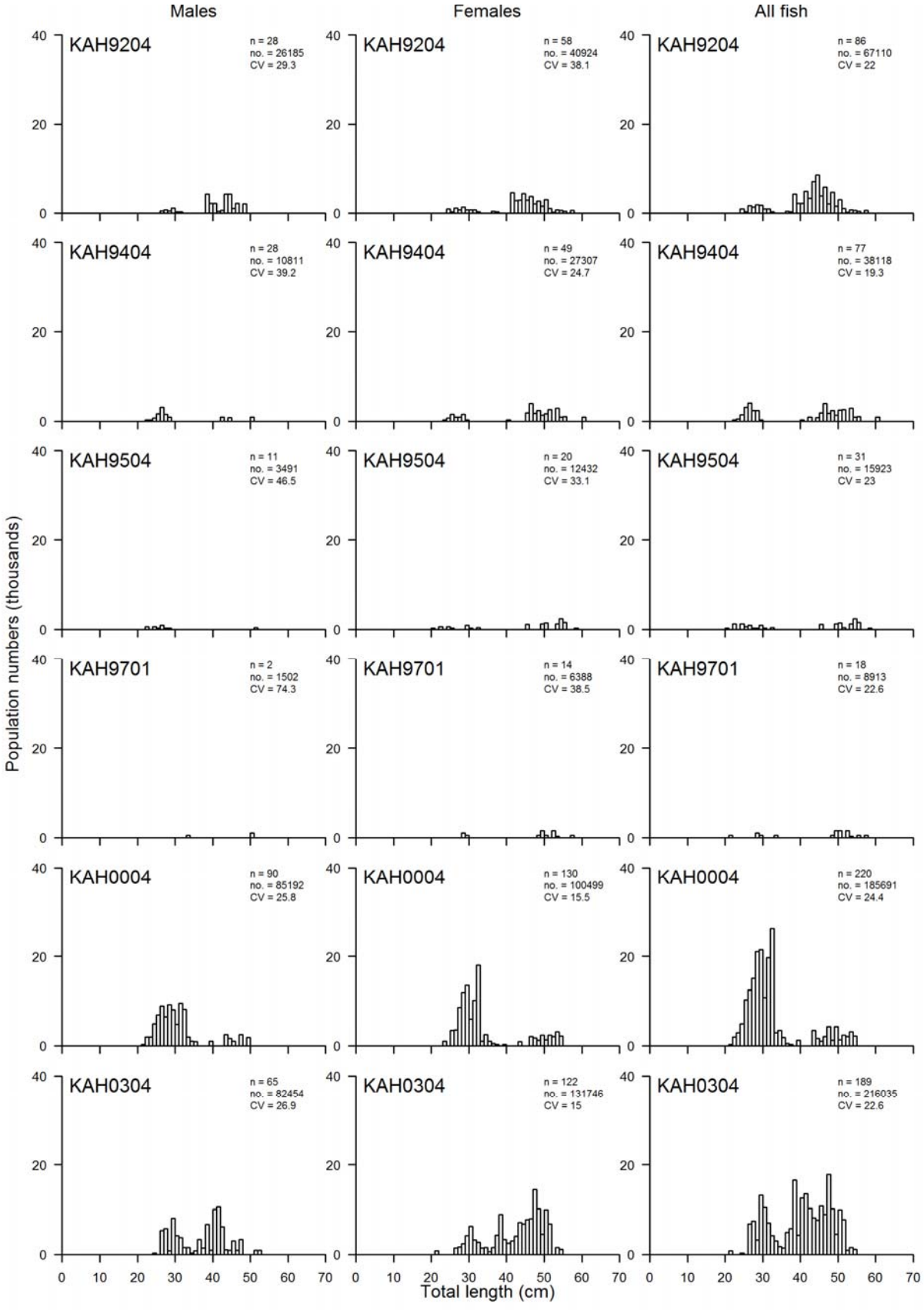
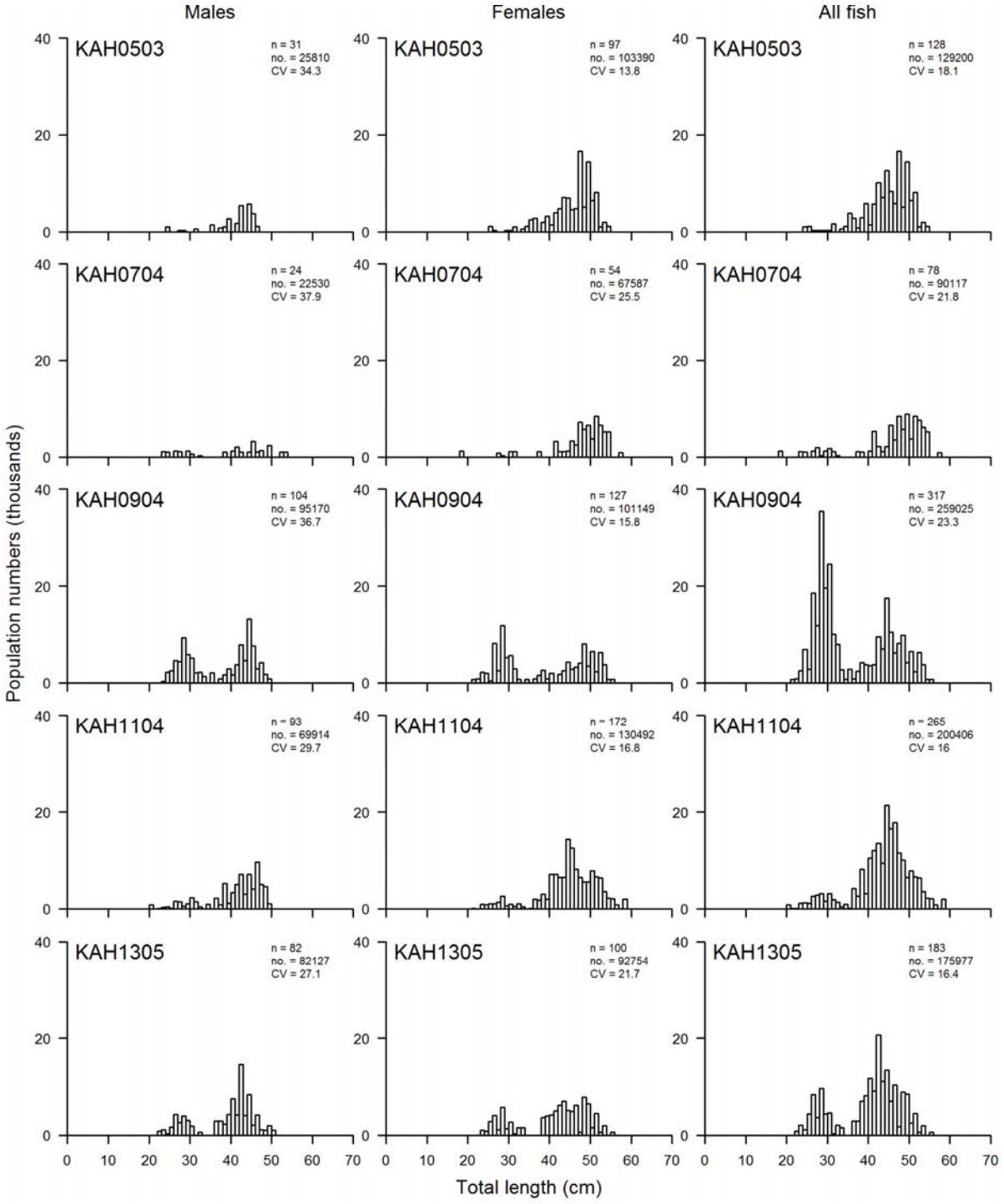


Figure 5f: John dory.



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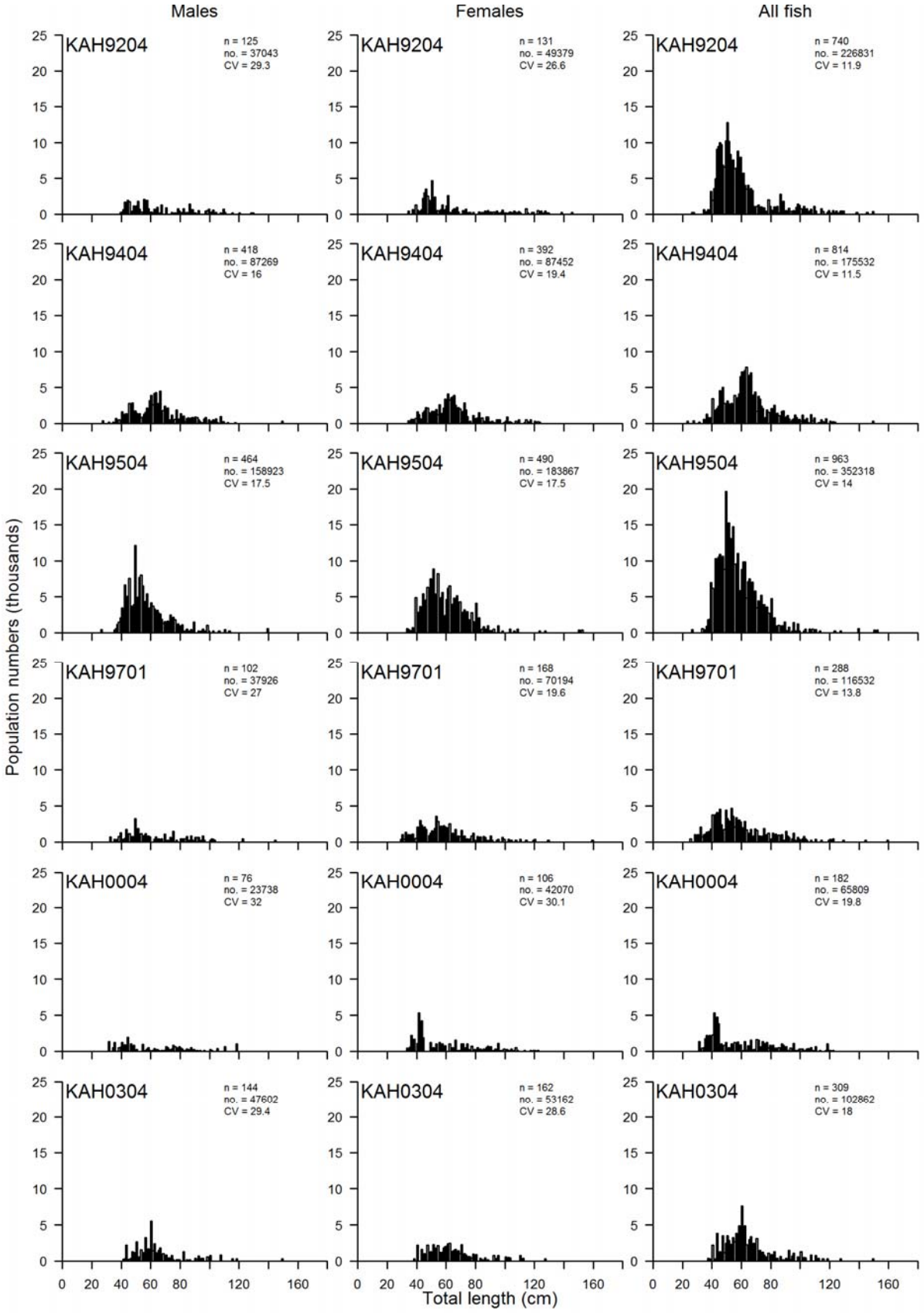
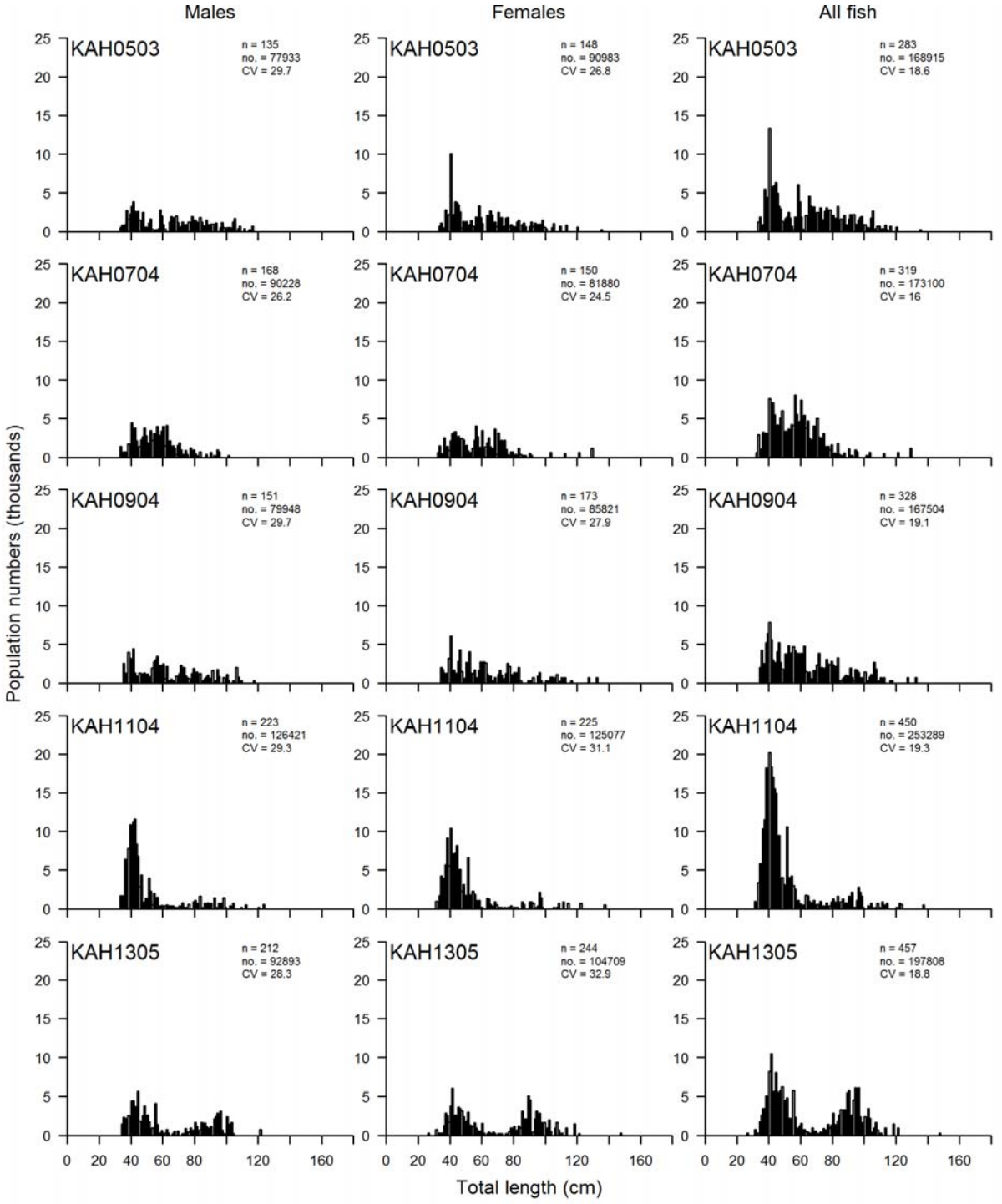


Figure 5g: Ling.



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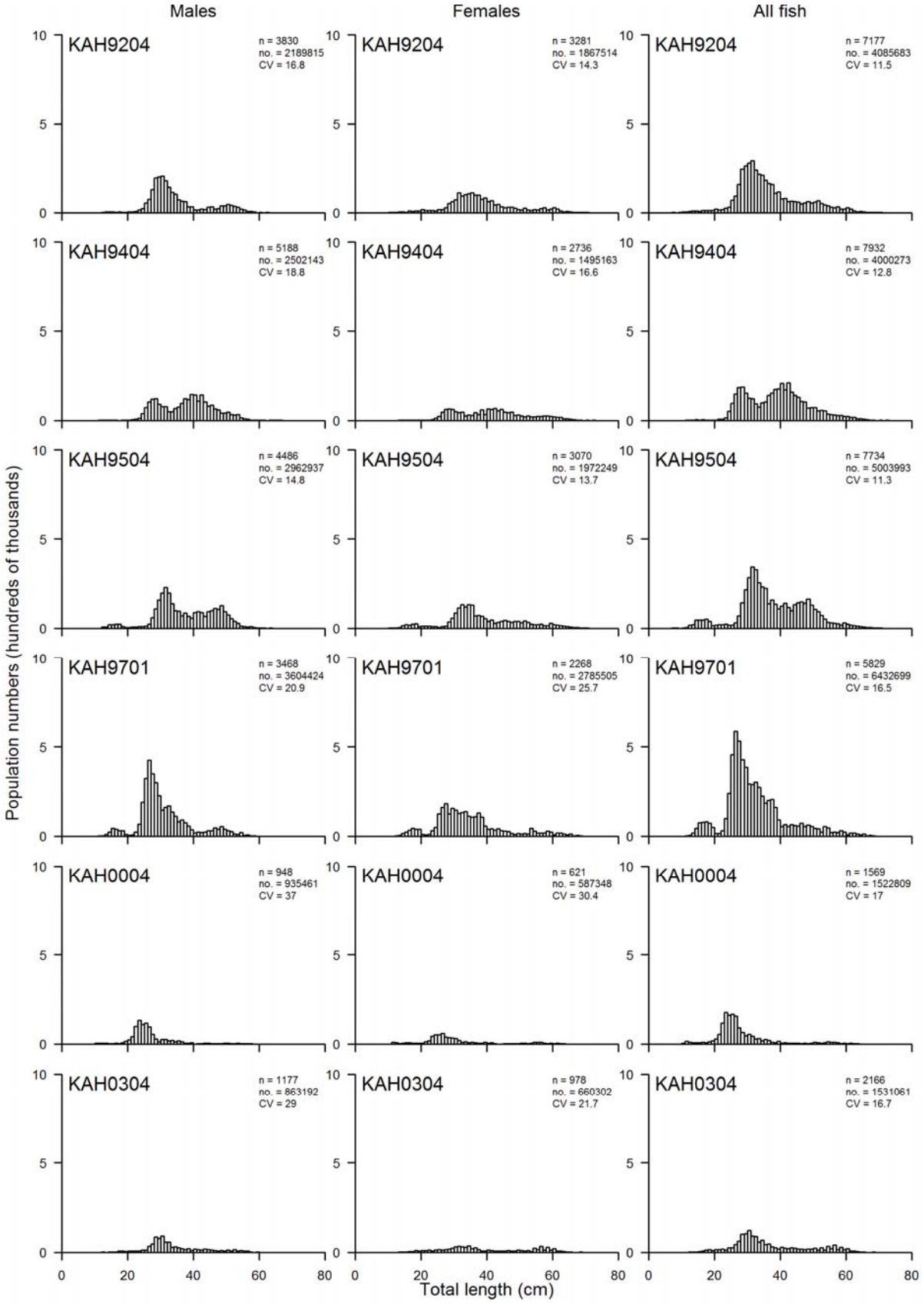
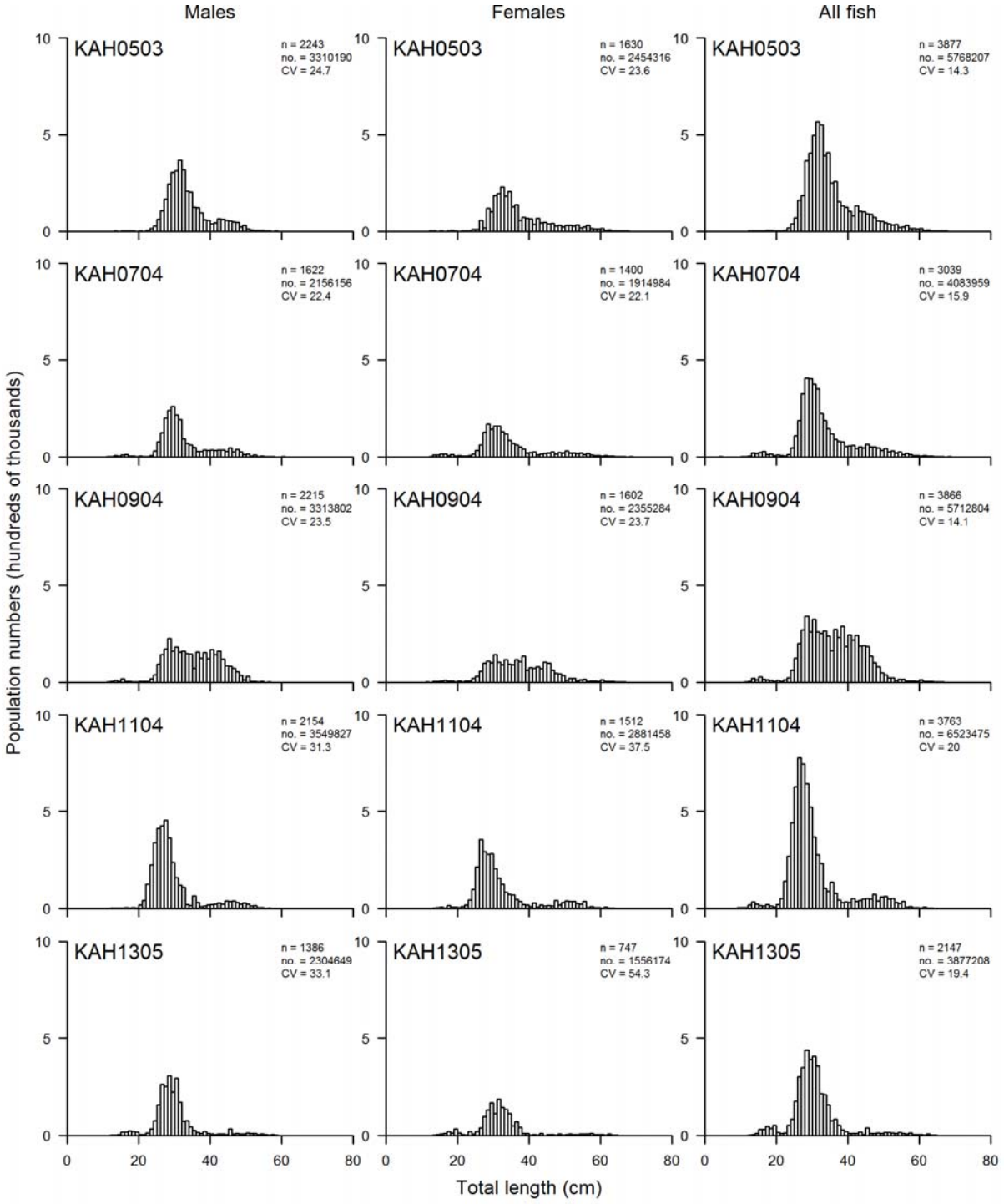


Figure 5h: Red cod.



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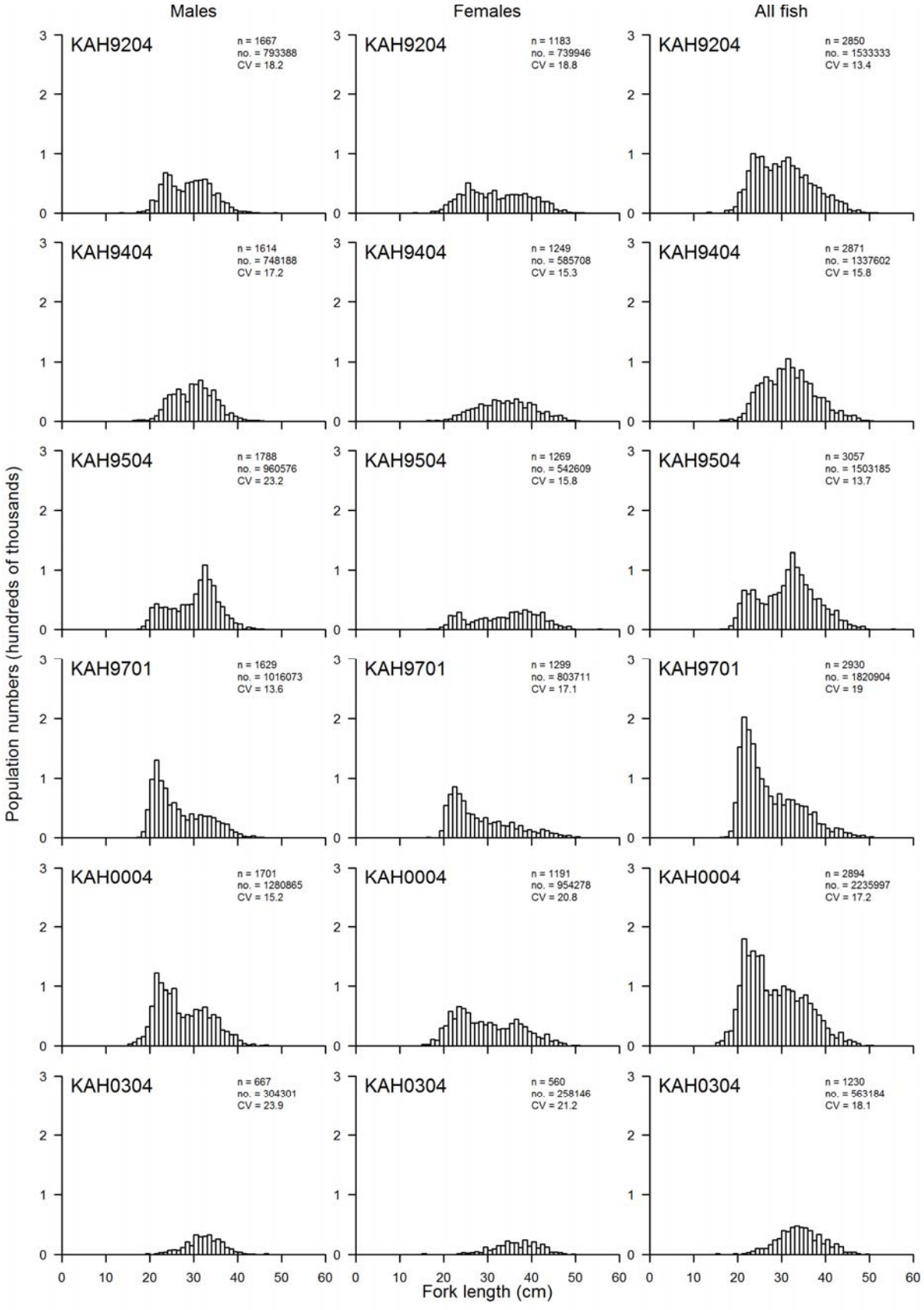


Figure 5i: Red gurnard.

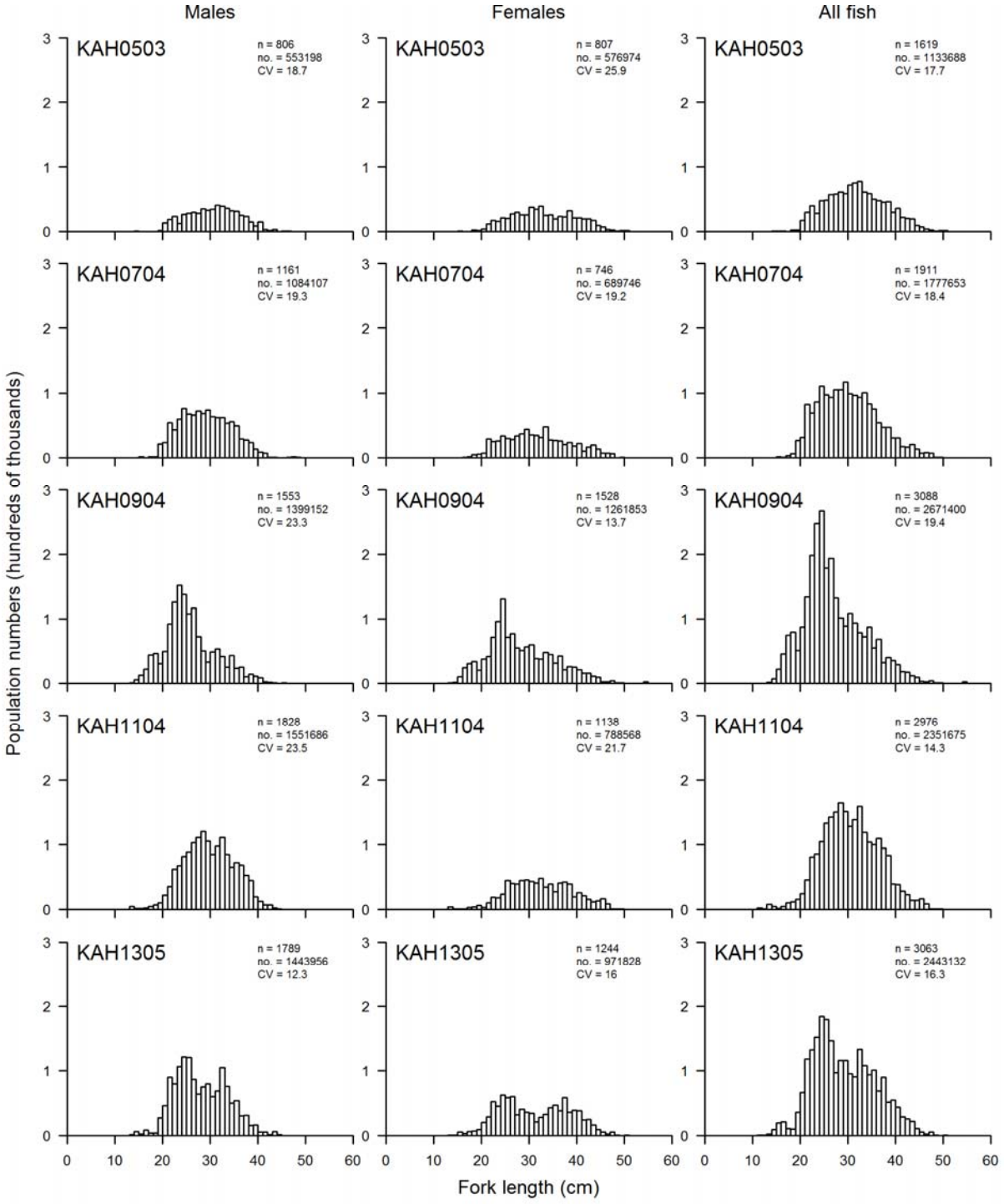


Figure 5i—continued.

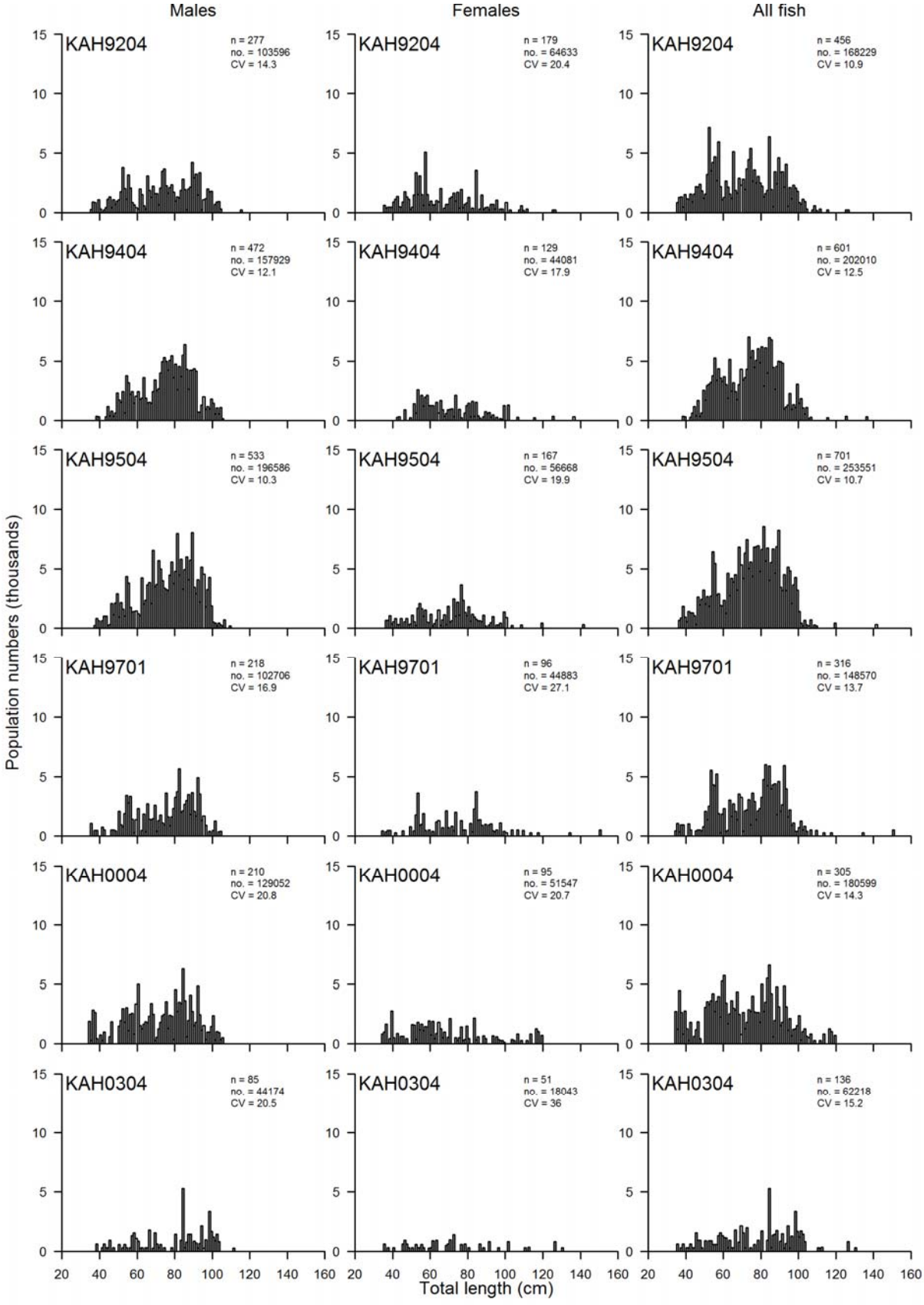
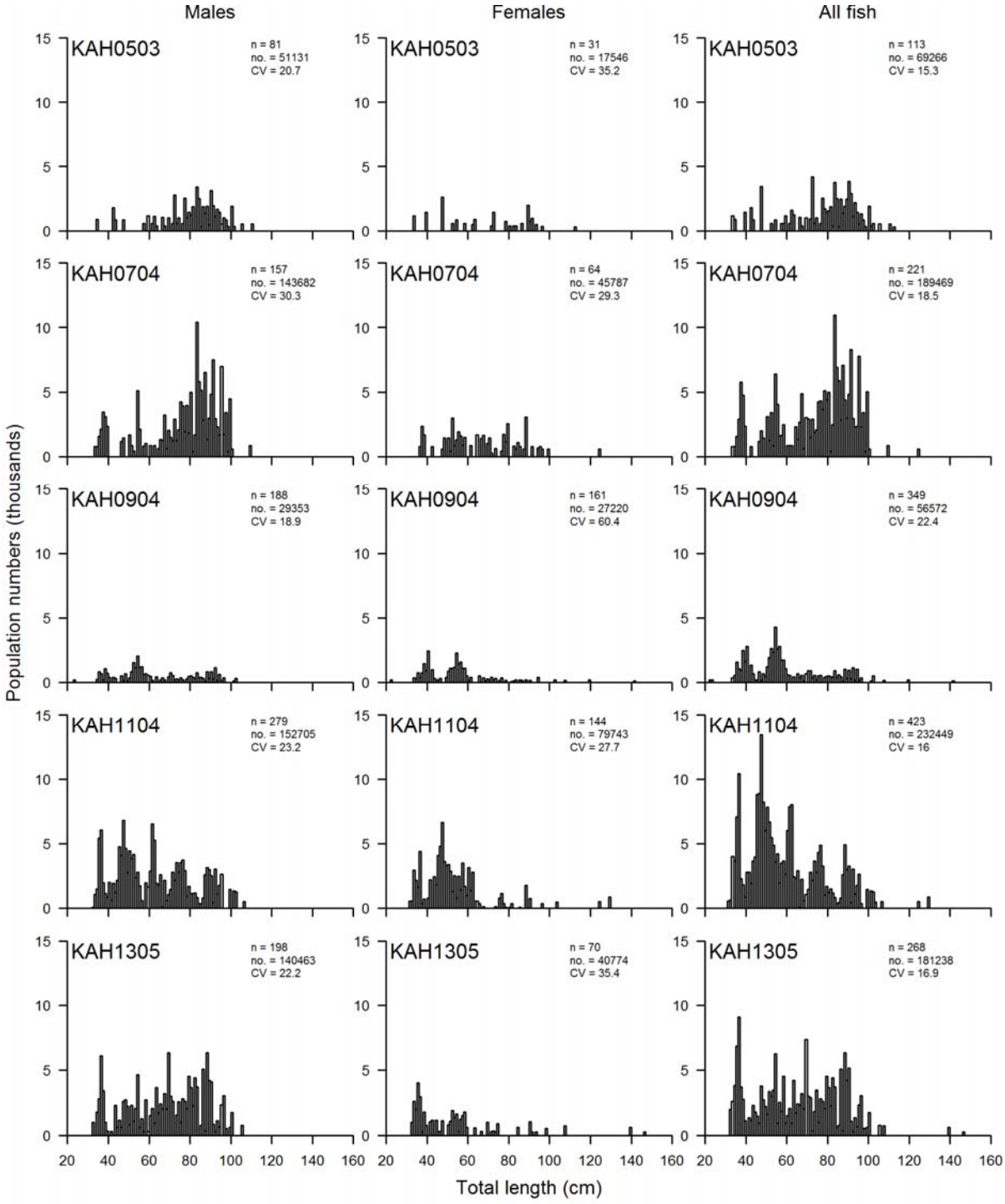


Figure 5j: Rig.



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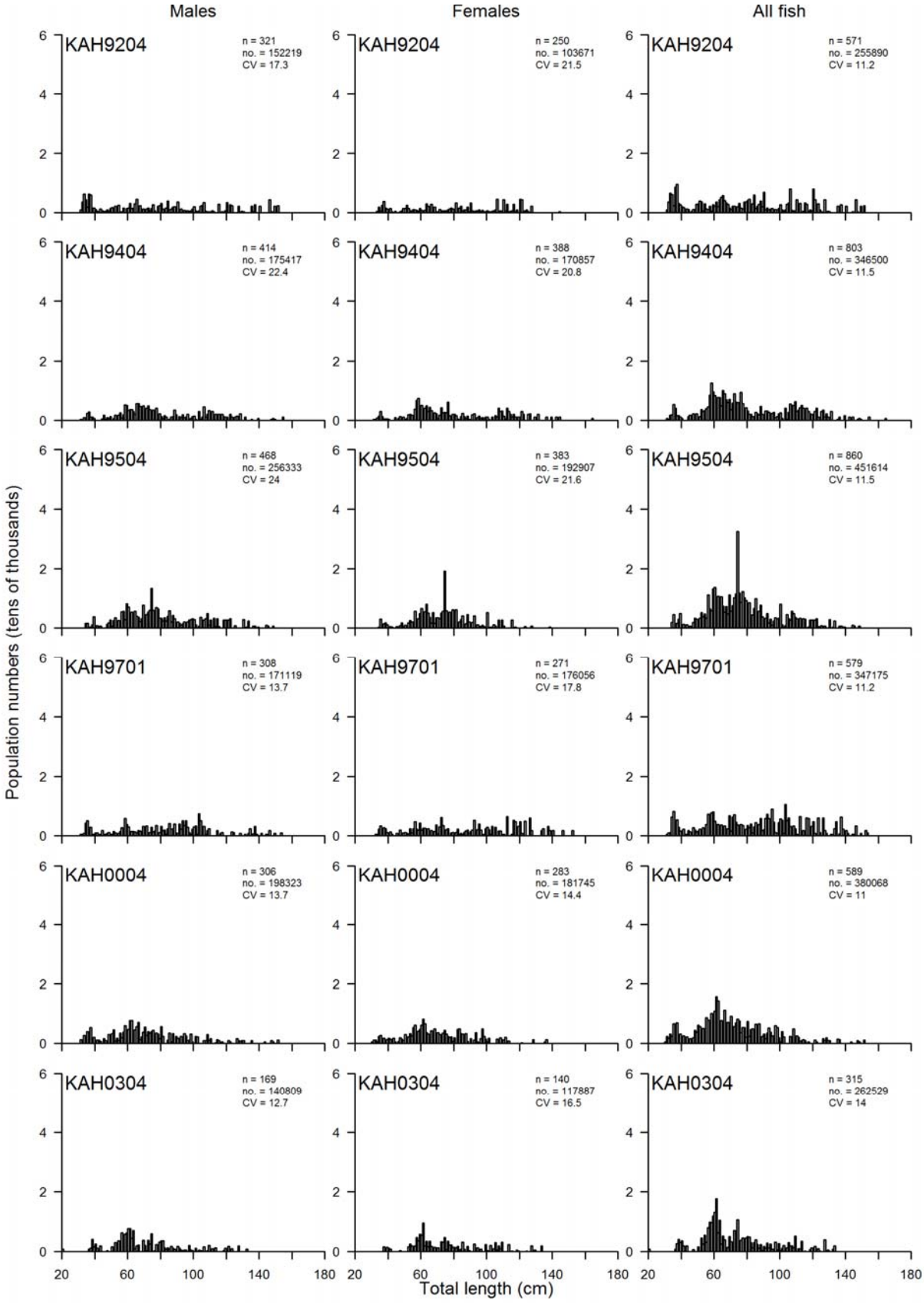
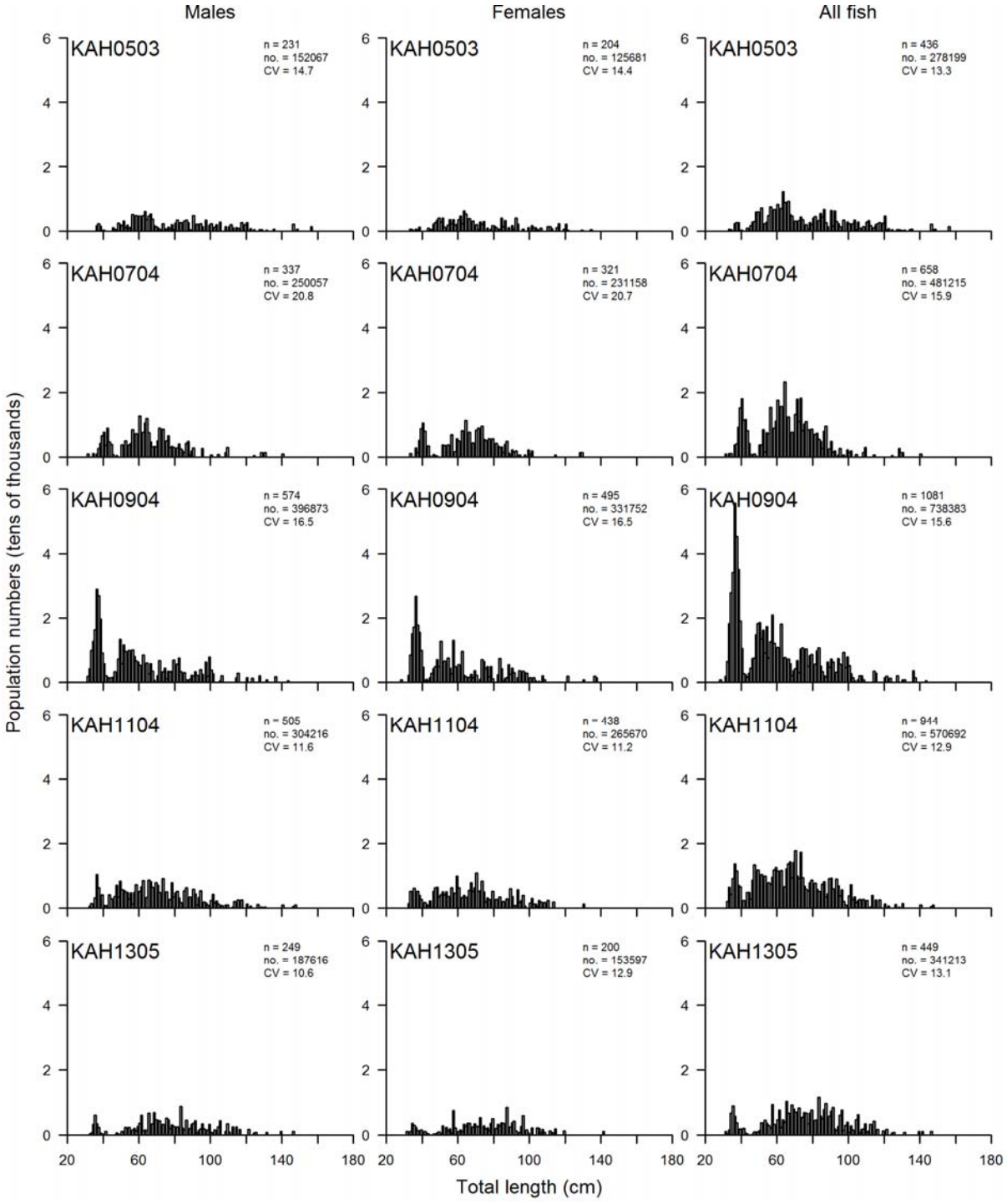


Figure 5k: School shark.



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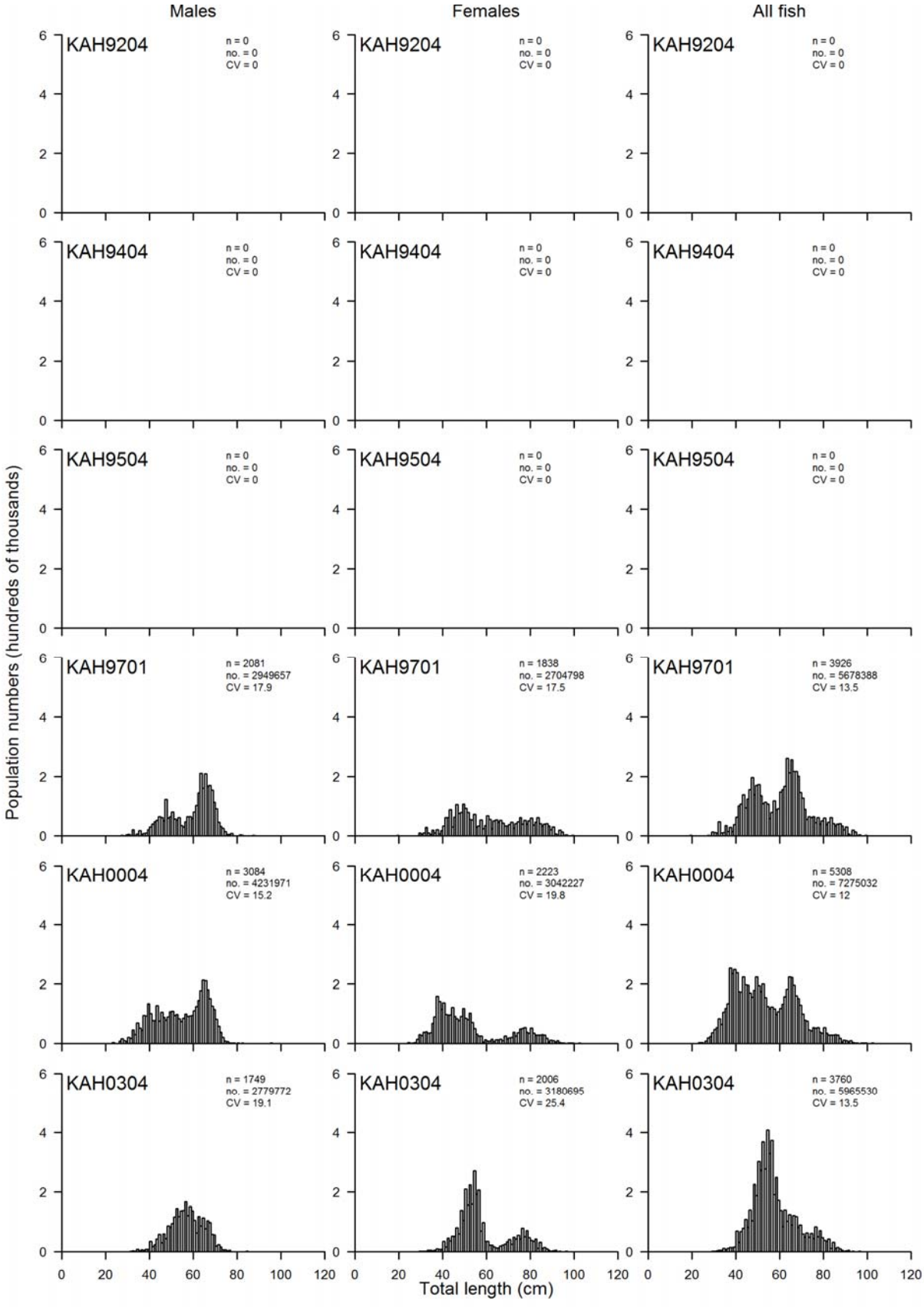


Figure 5l: Spiny dogfish.

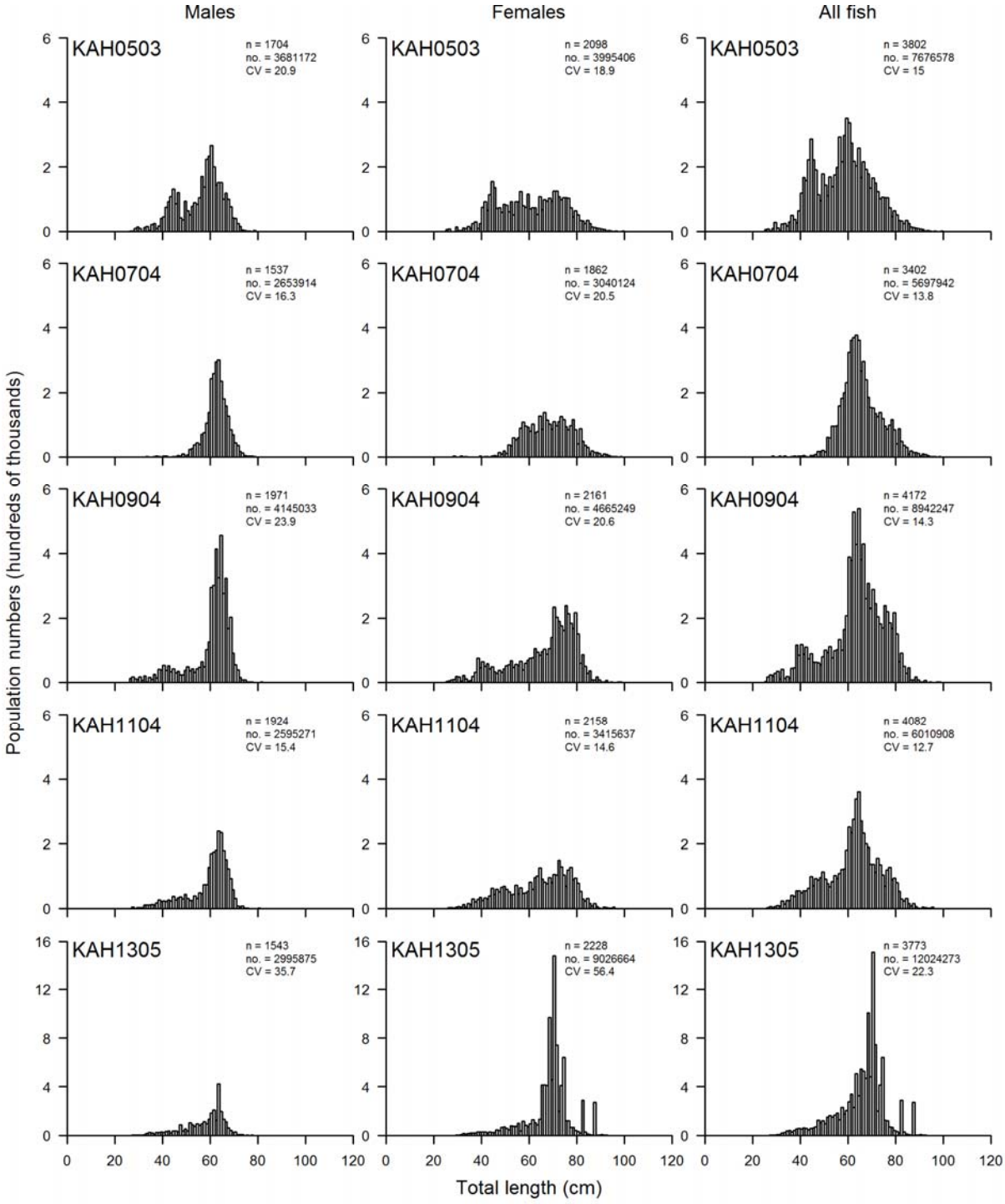


Figure 5l continued.

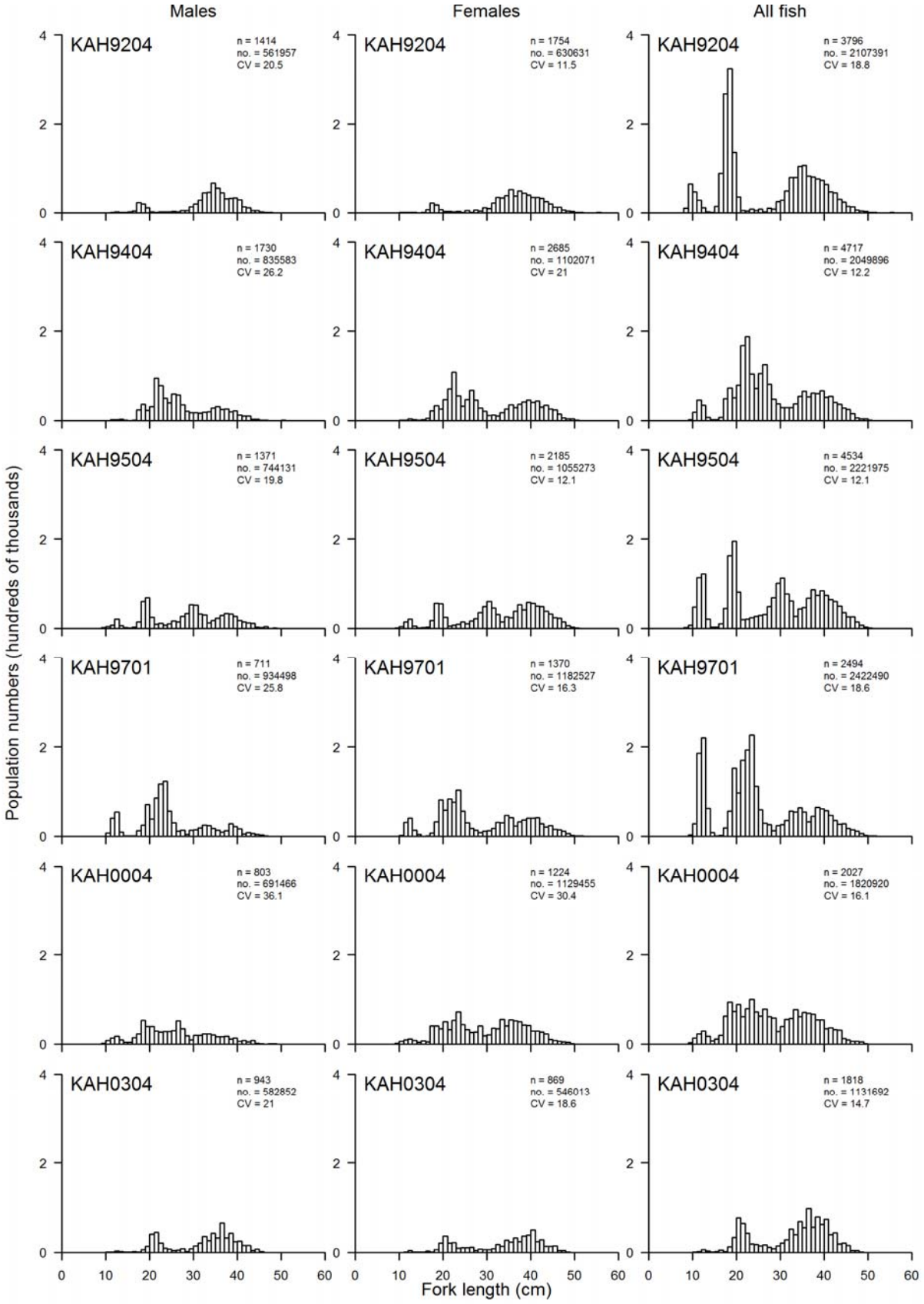


Figure 5m: Tarakihi.

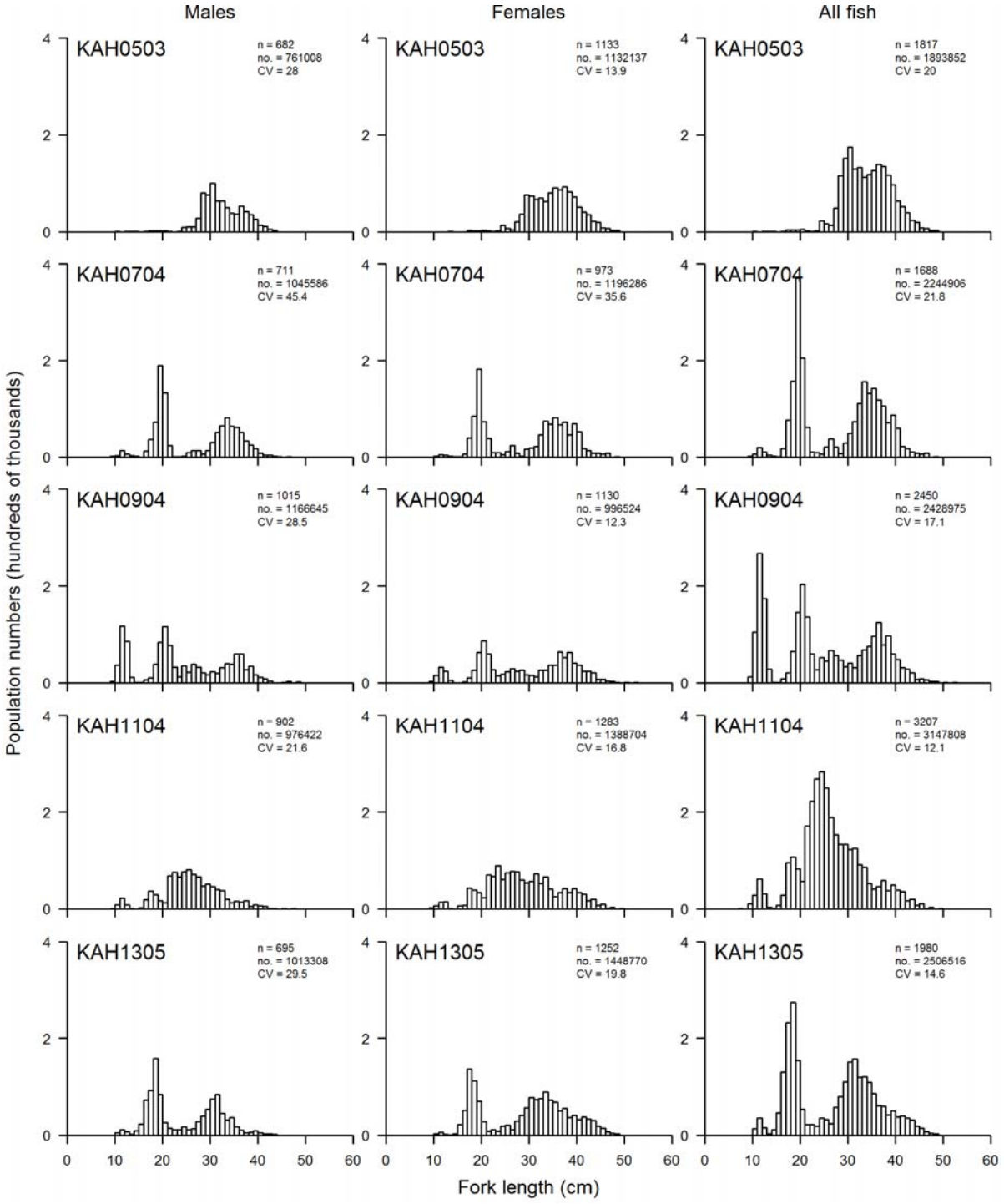


Figure 5m—continued.

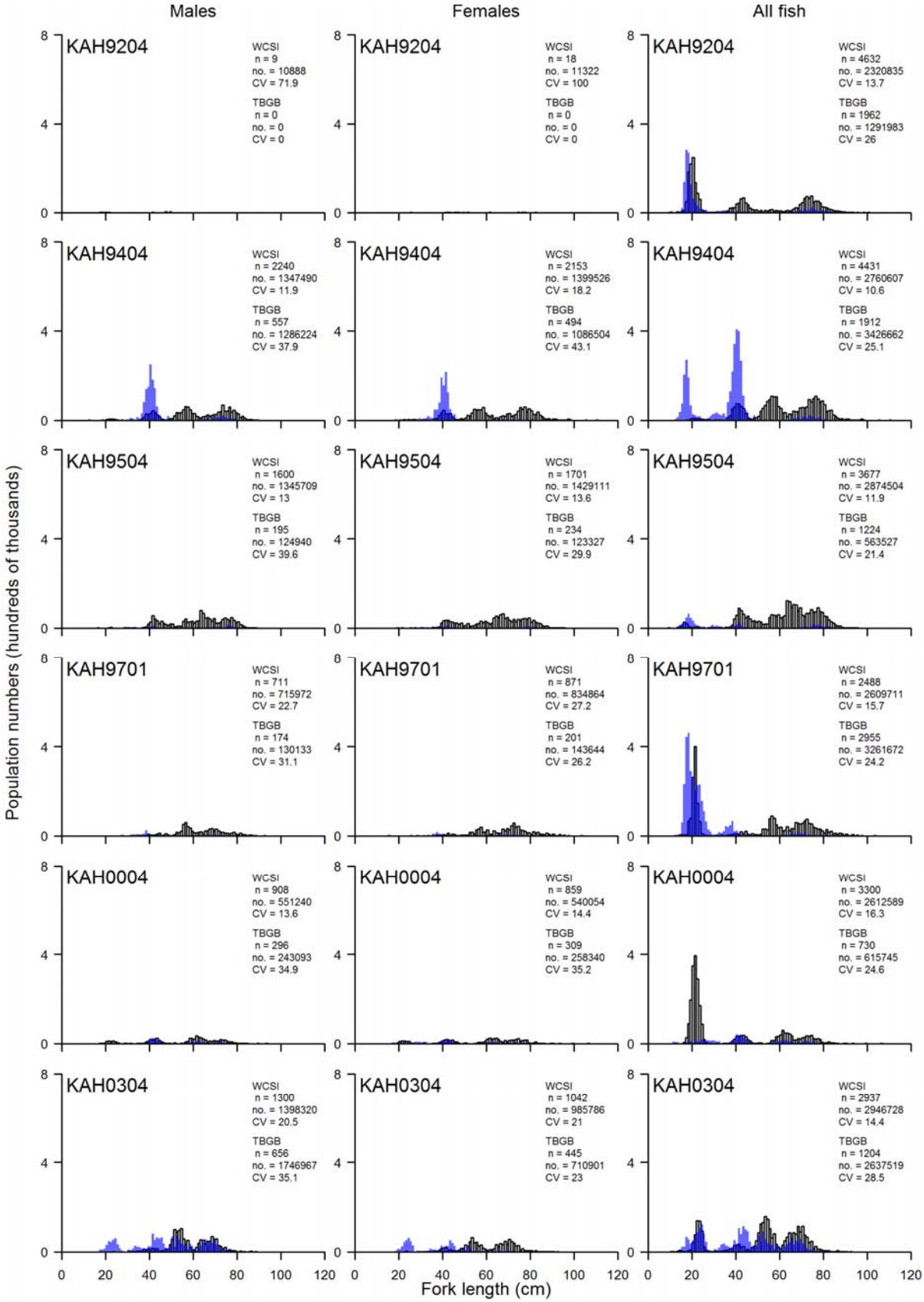


Figure 6: Comparative scaled length frequencies with Tasman and Golden Bays and west coast South Island plotted separately for the target species and those species where the surveys are monitoring adult or pre-recruit abundance. n = number of fish measured, no. = scaled population number, CV = coefficient of variation. 'All fish' includes any unsexed fish. Blue bars = Tasman and Golden Bays, black bars = west coast South Island. a) Barracouta

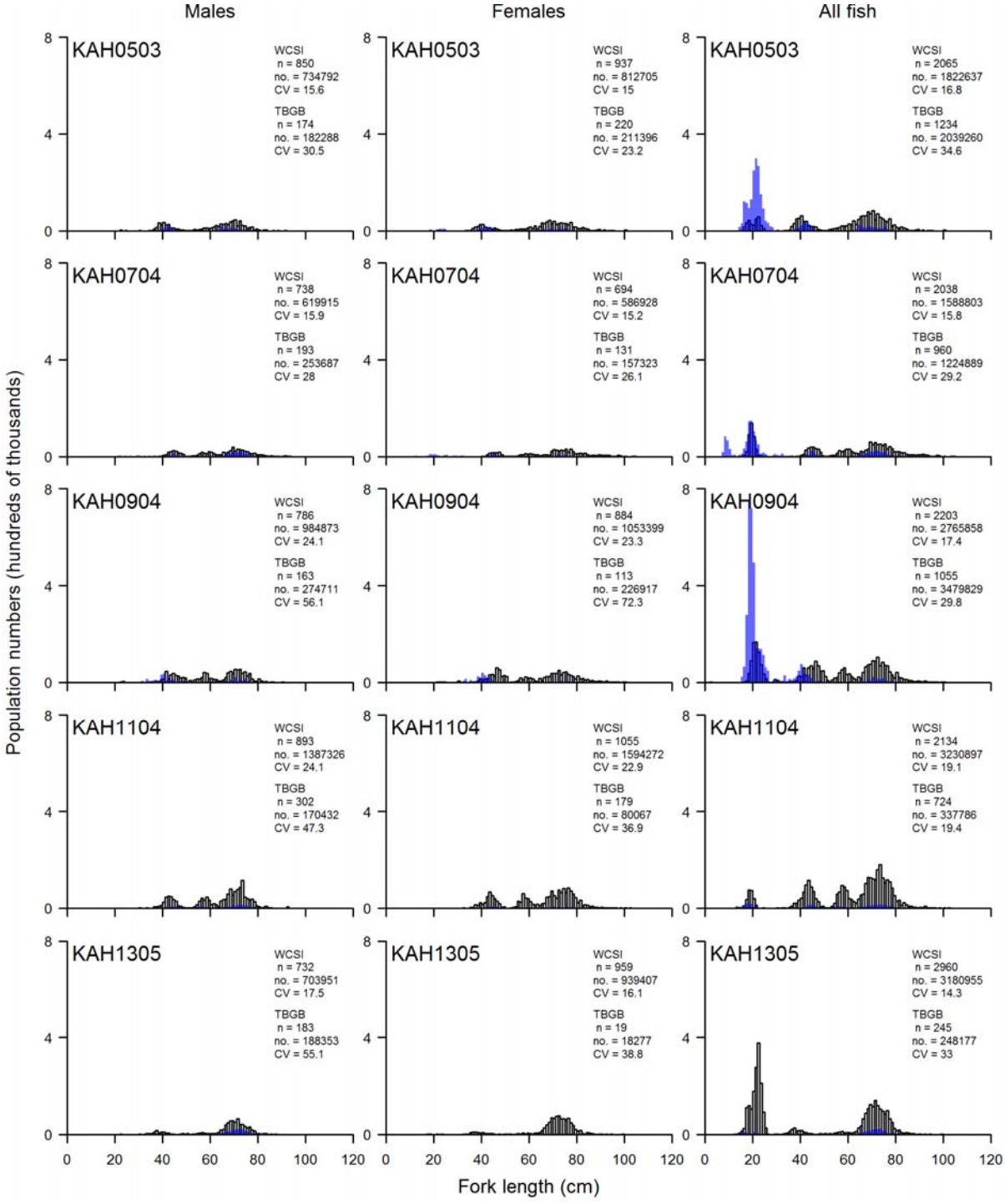


Figure 6a—continued.

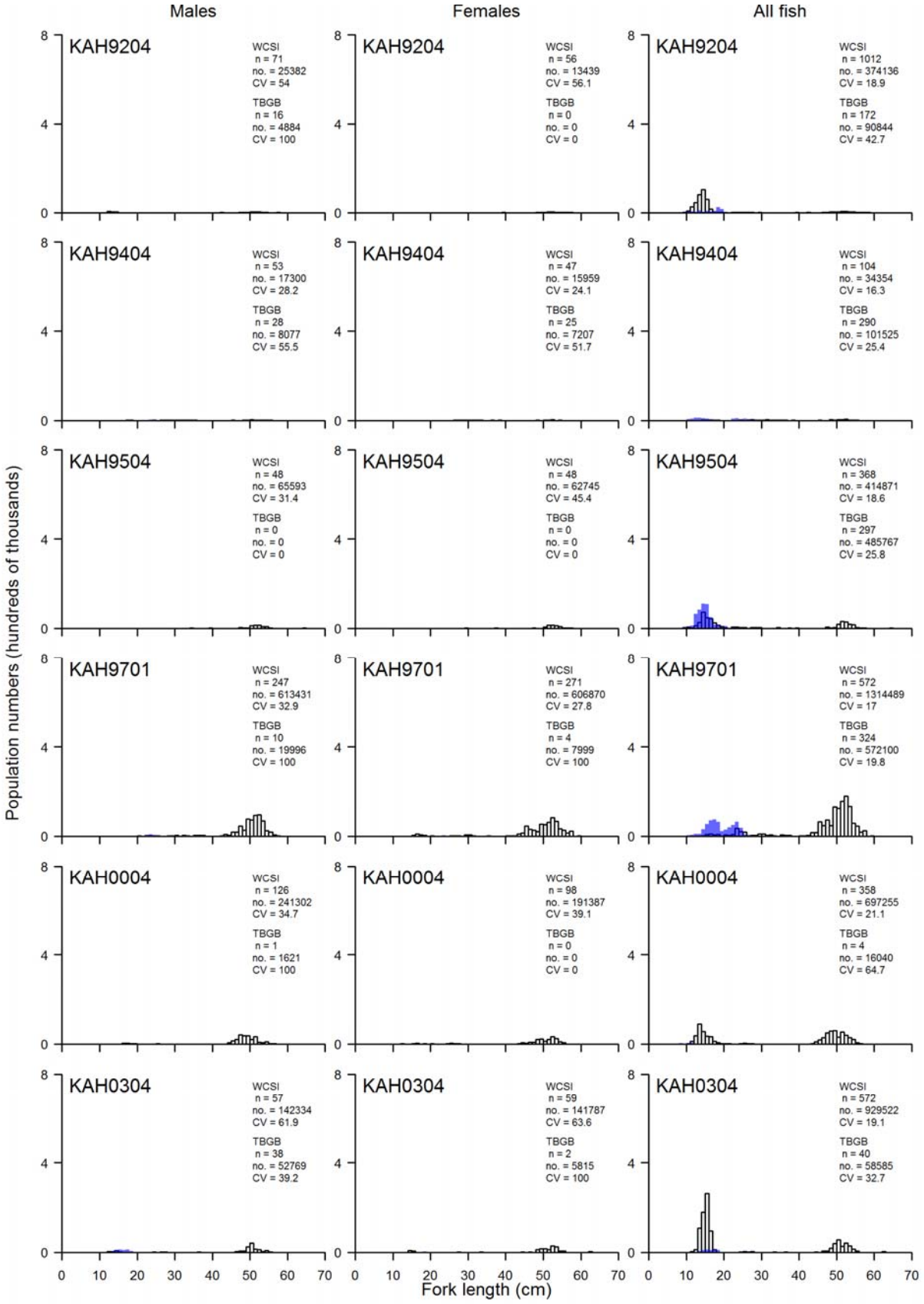


Figure 6b: Blue warehou

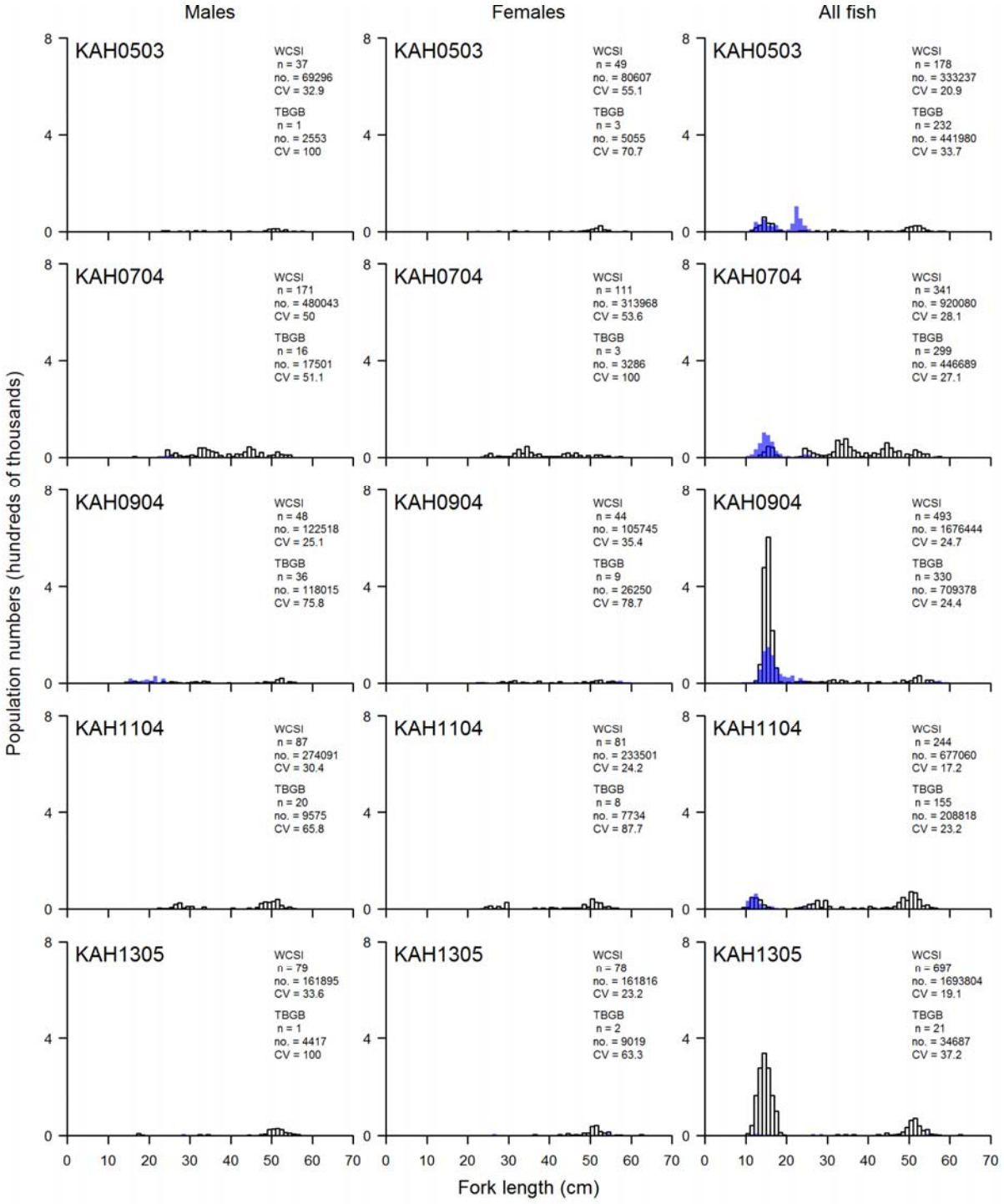


Figure 6b—continued.

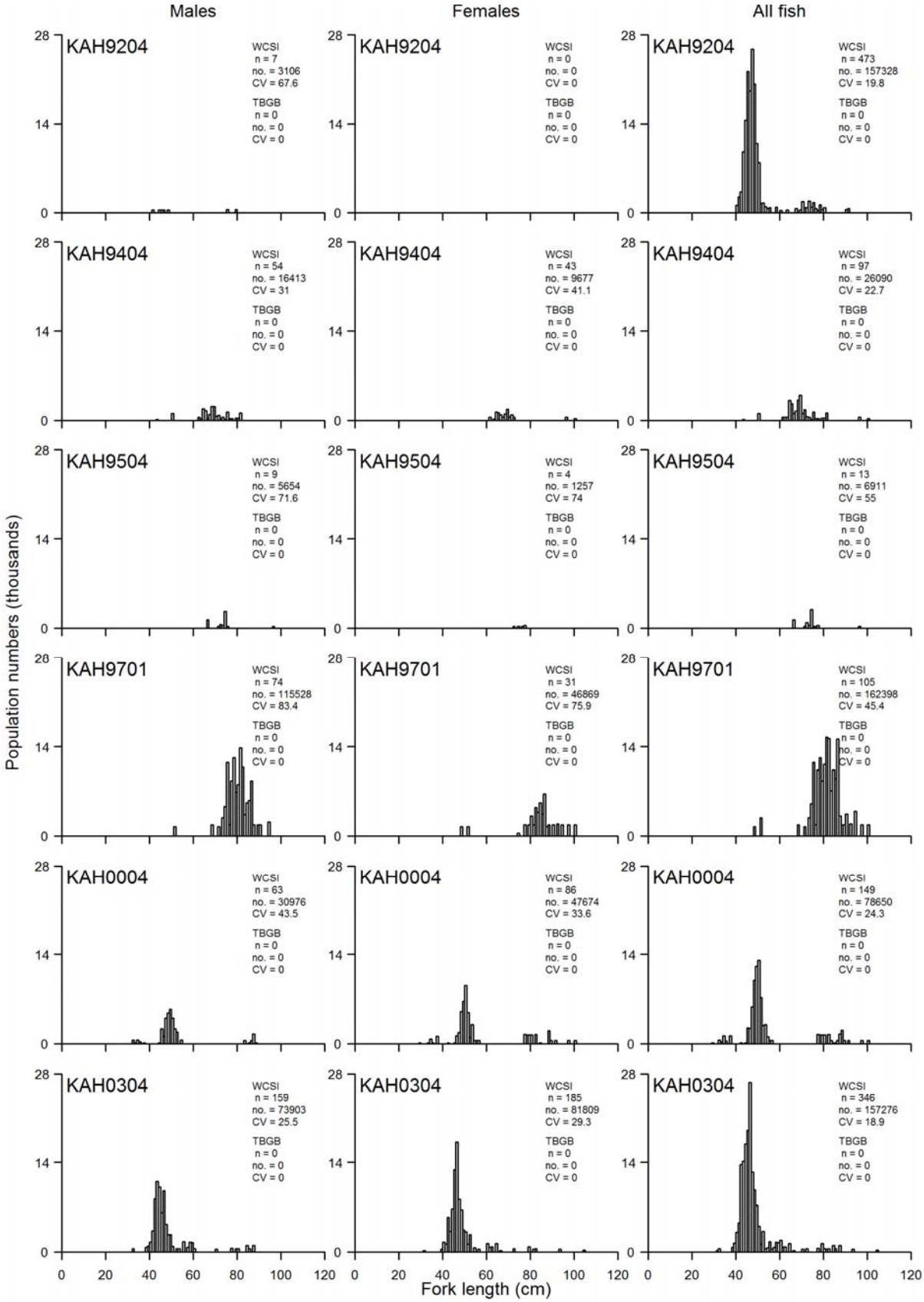


Figure 6c: Gemfish (100% of fish from the west coast).

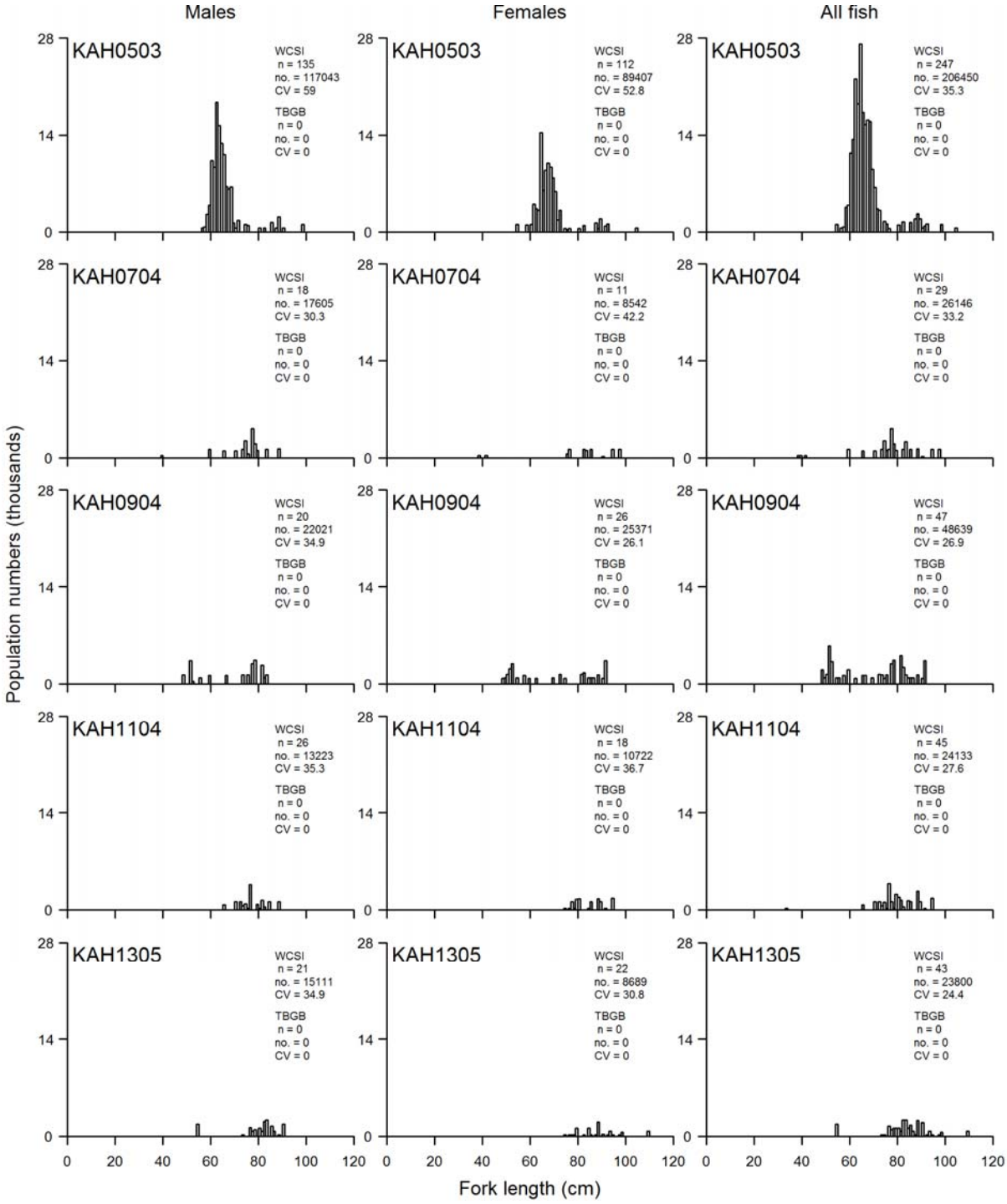


Figure 6c—continued.

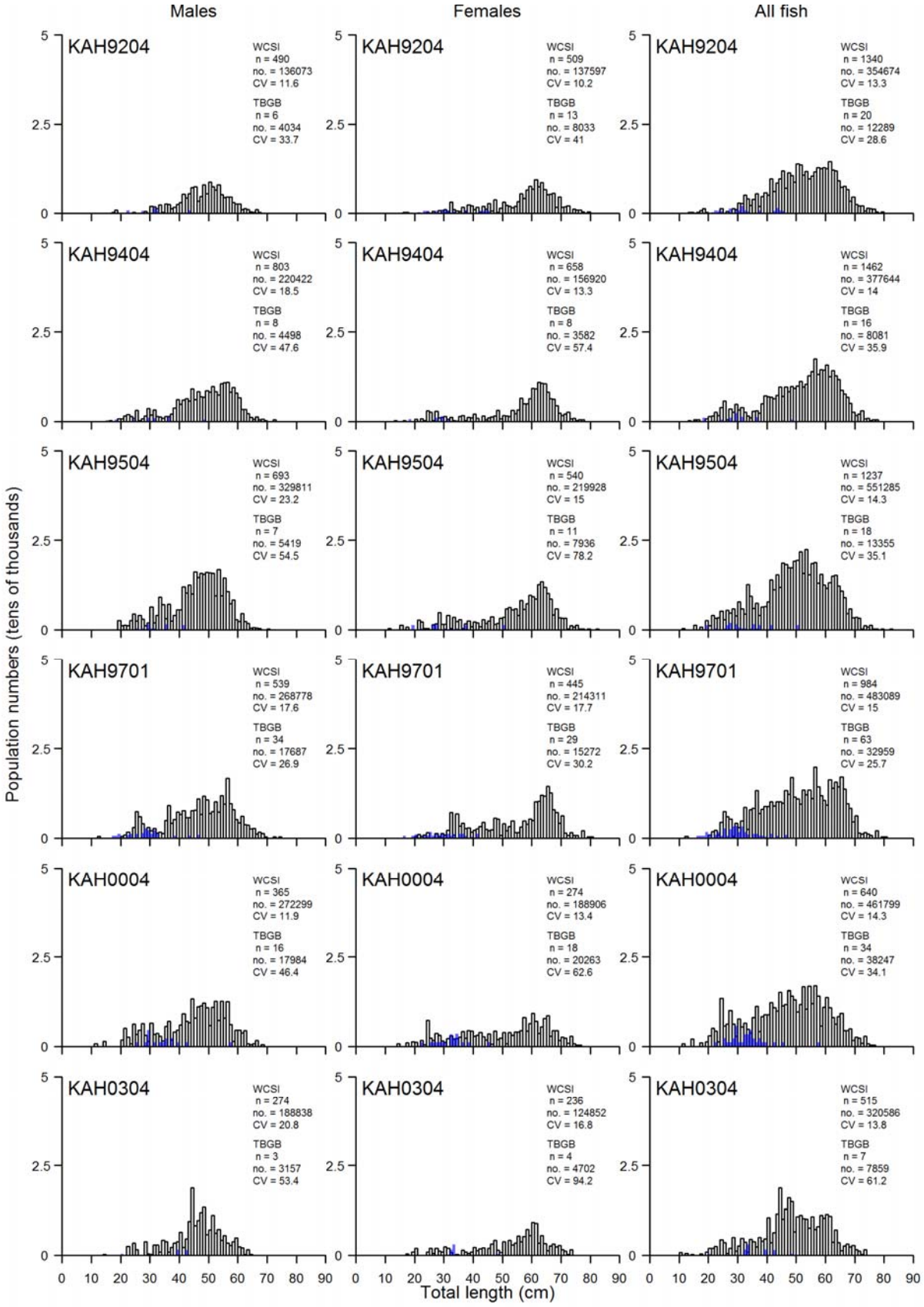


Figure 6d: Giant stargazer.

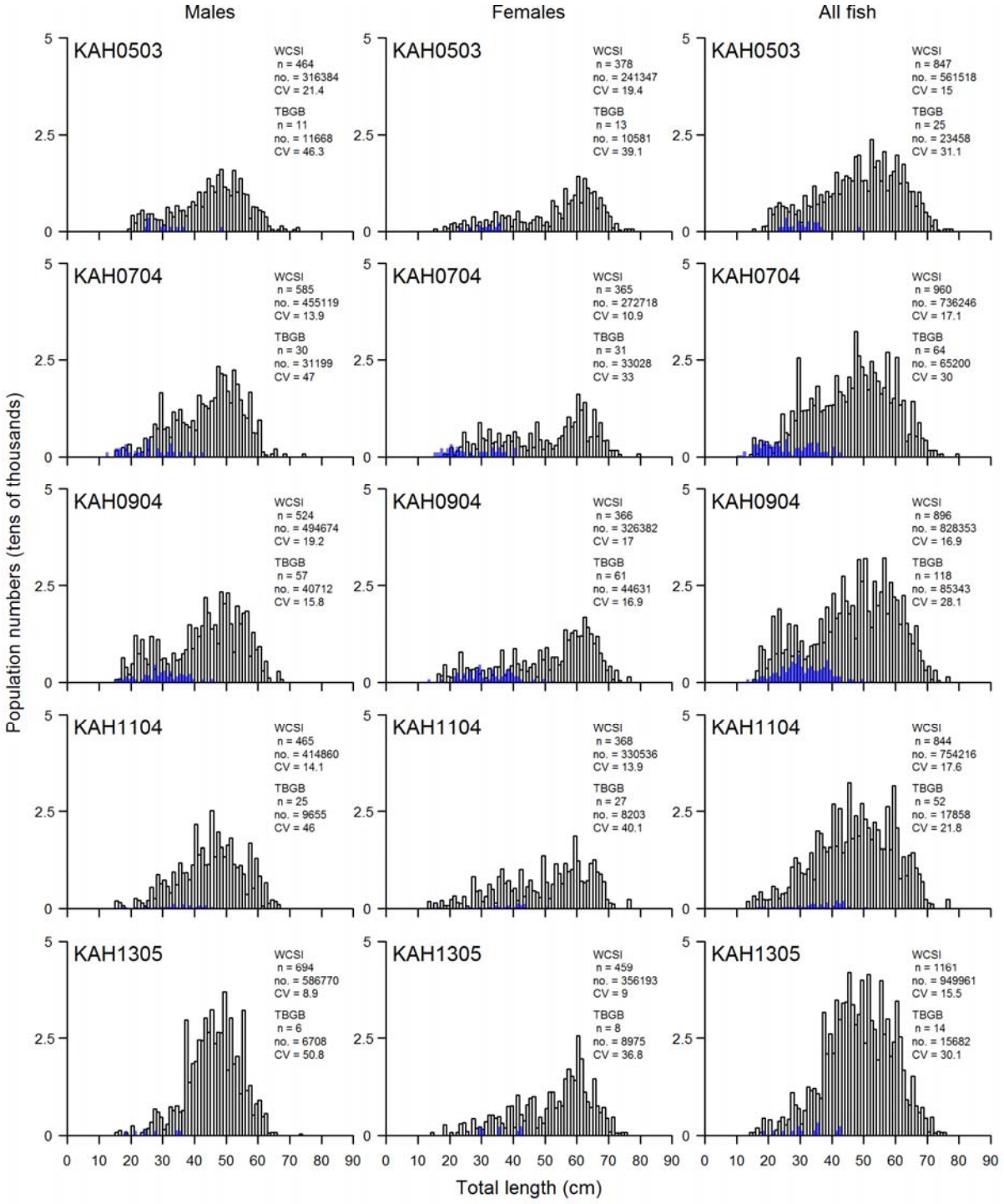


Figure 6d continued.

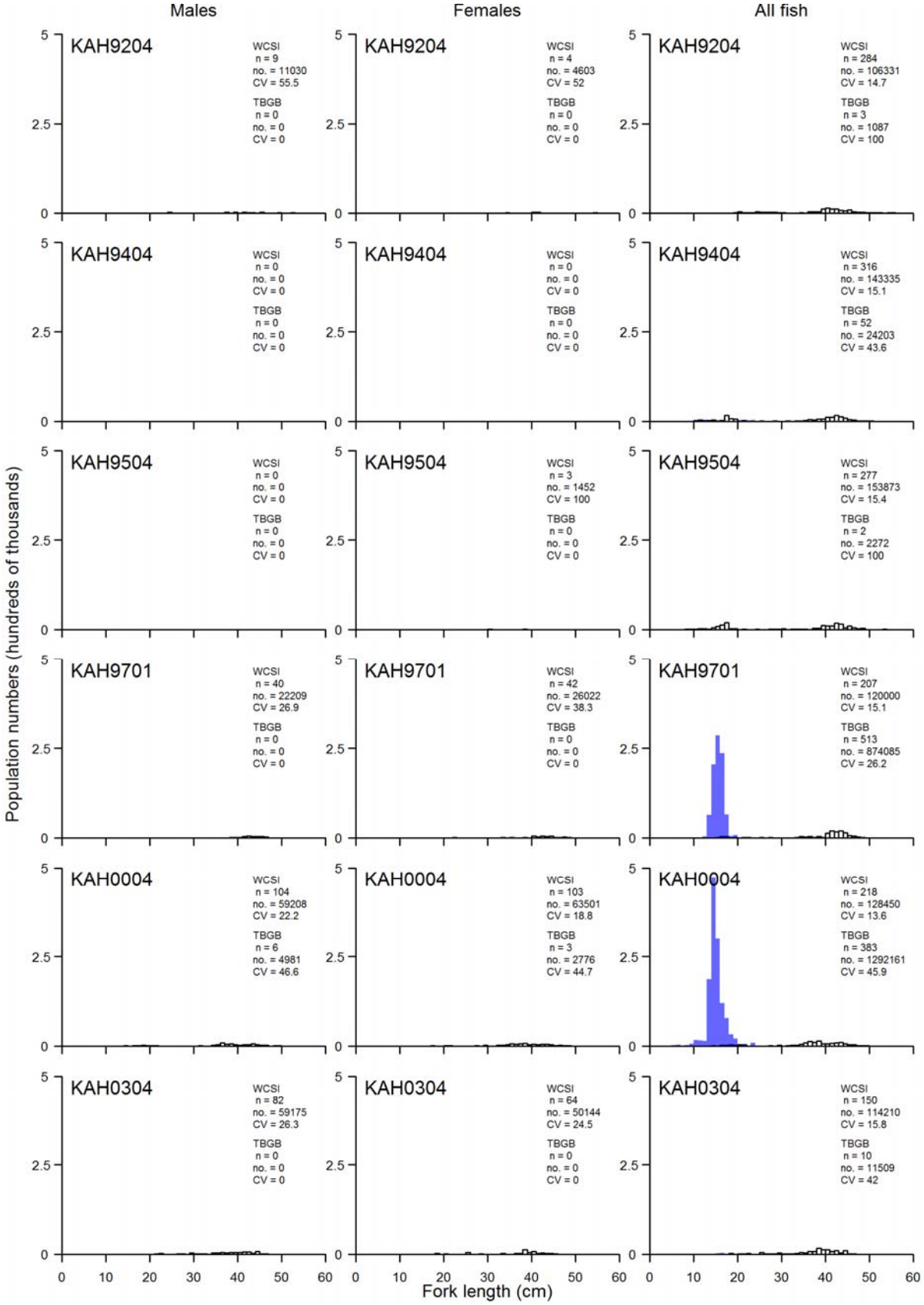


Figure 6e: Jack mackerel (*Trachurus declivis*).

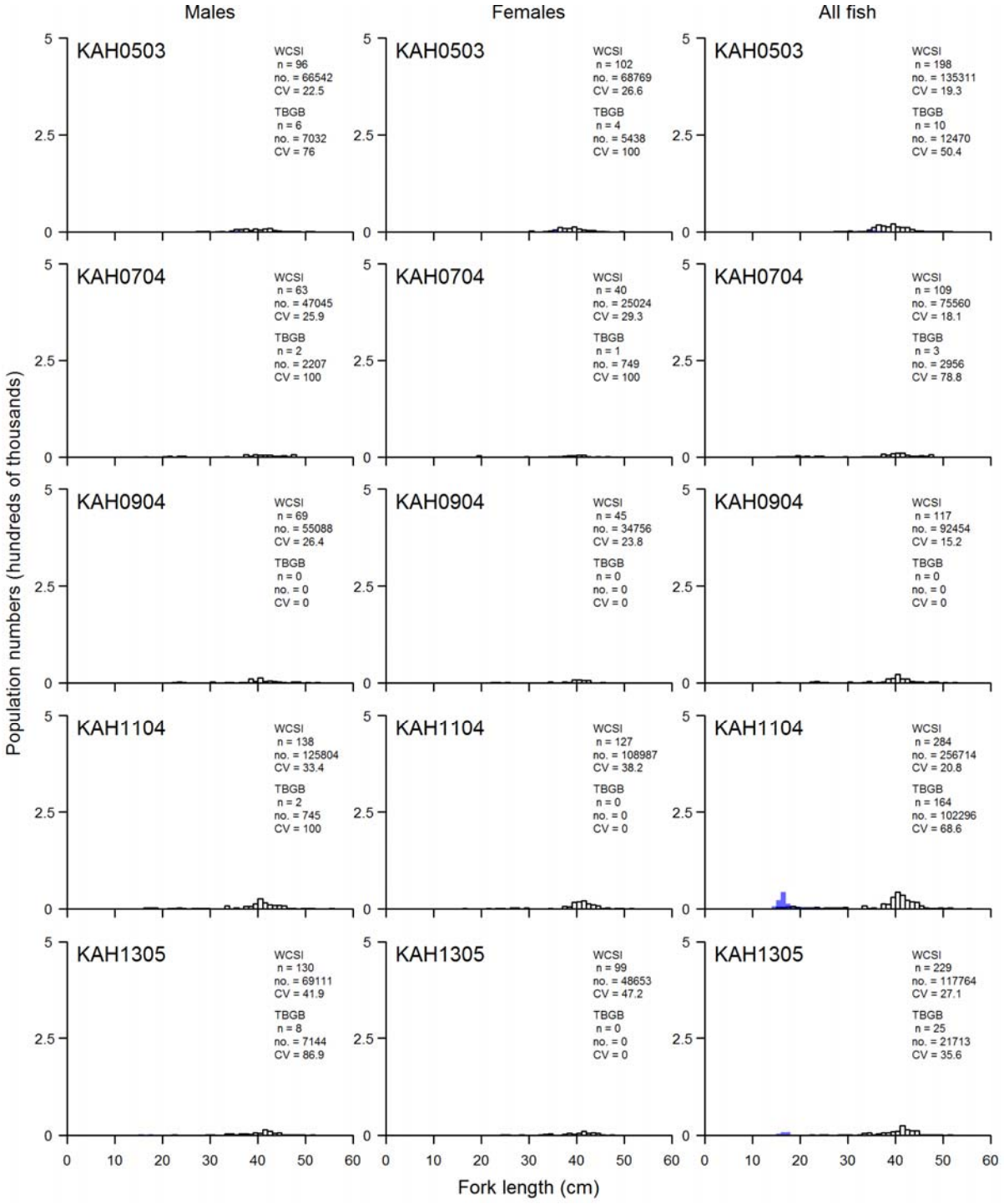


Figure 6e continued.

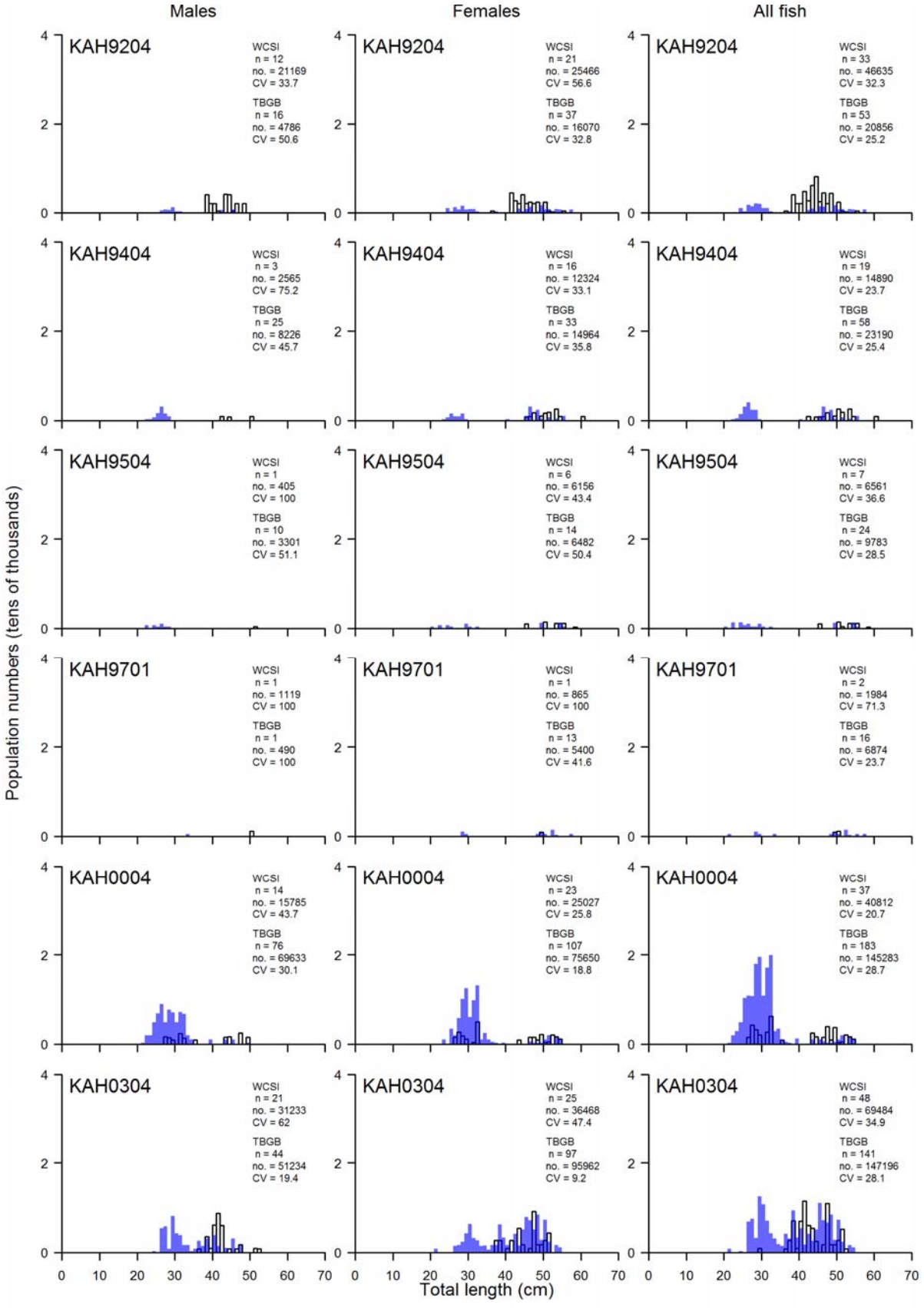
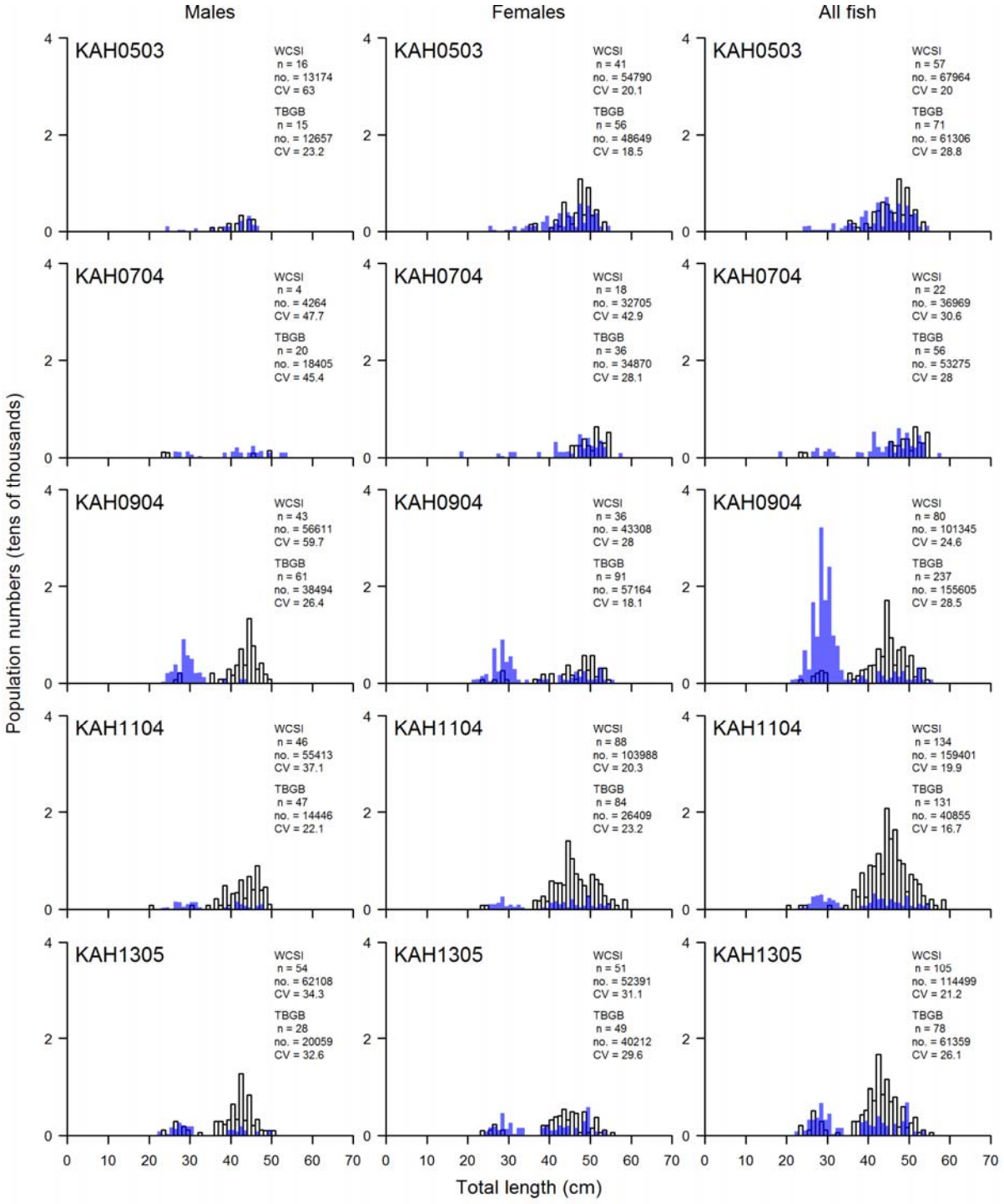


Figure 6f: John dory.



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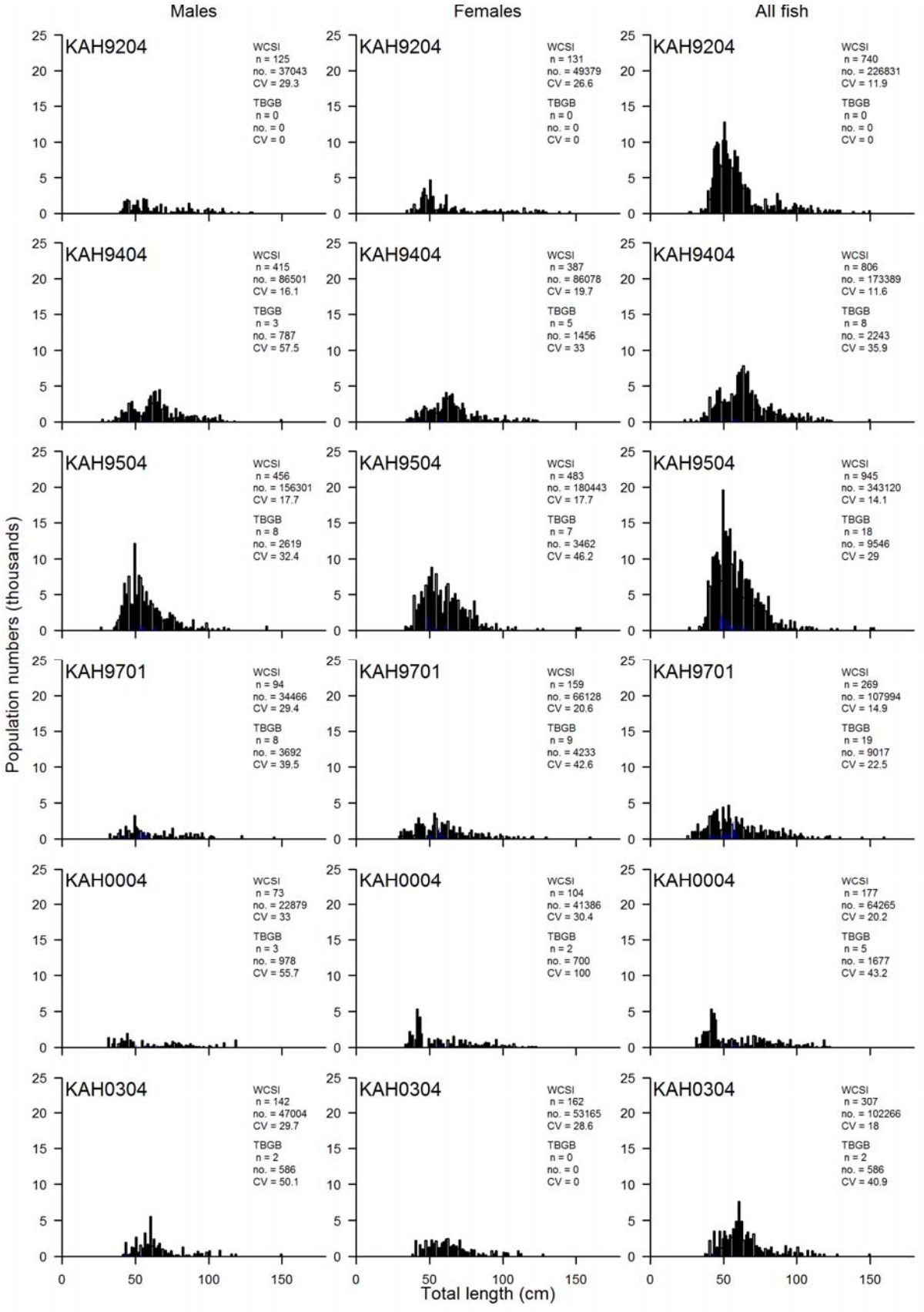
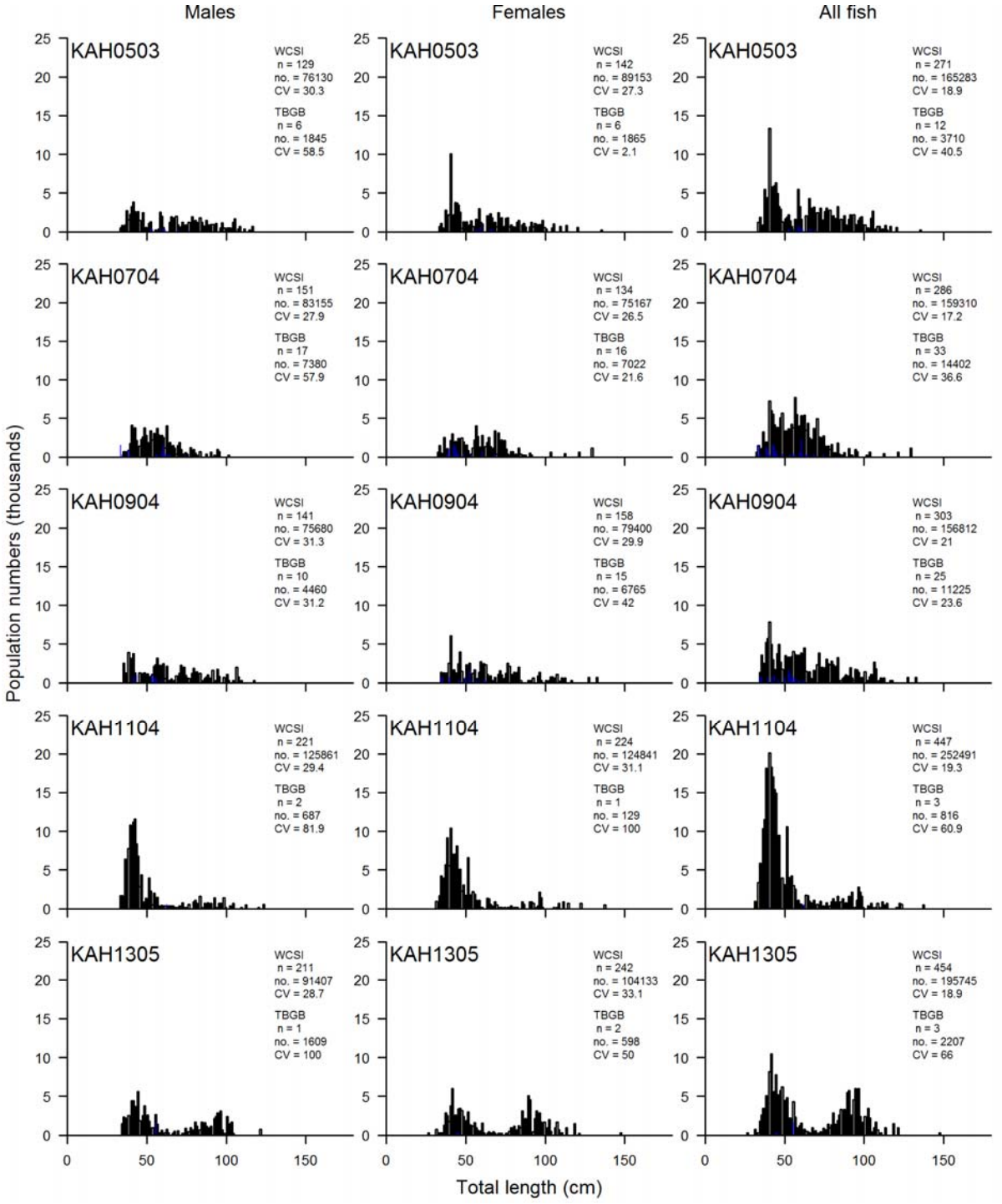


Figure 6g: Ling.



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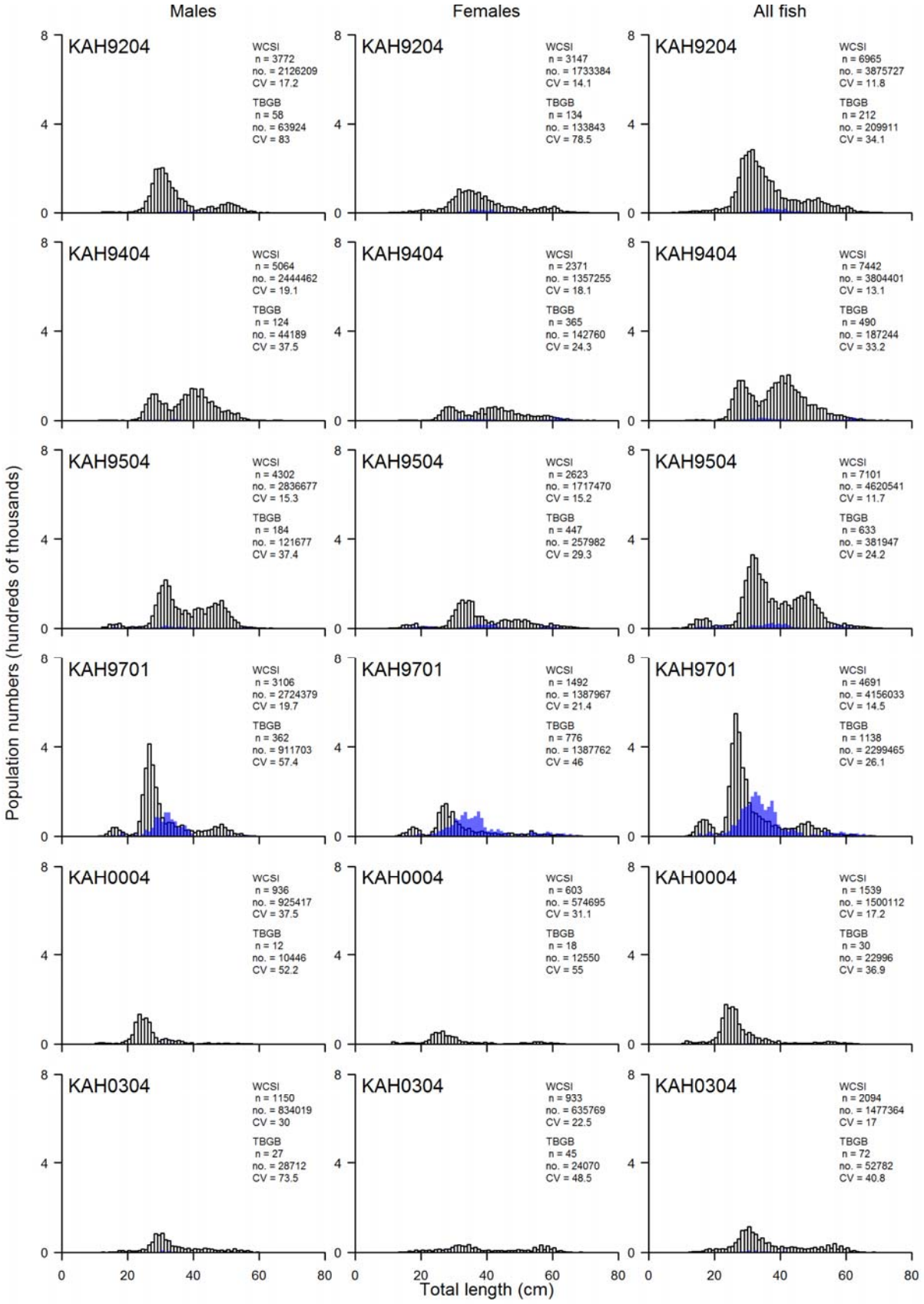
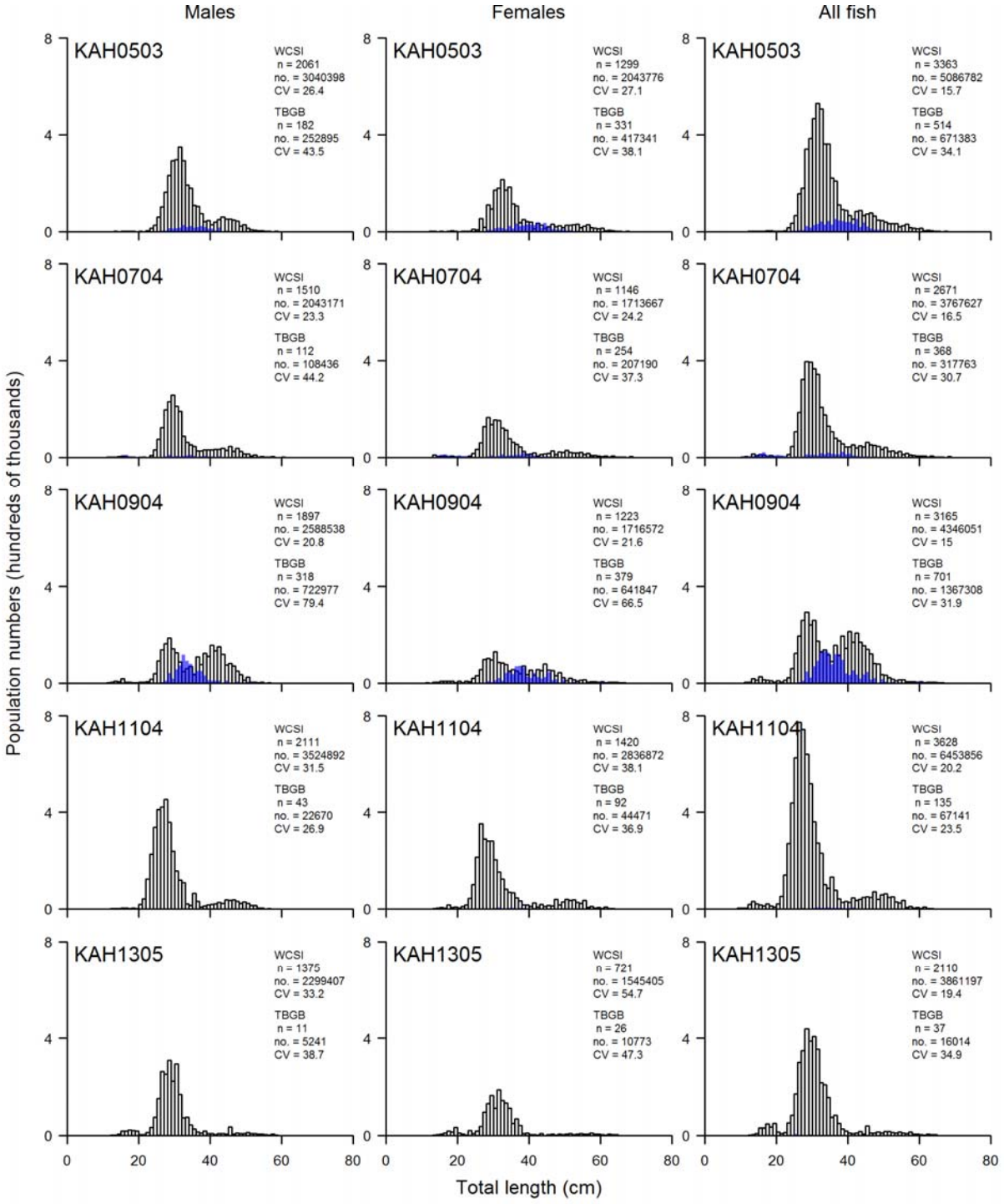


Figure 6h: Red cod.



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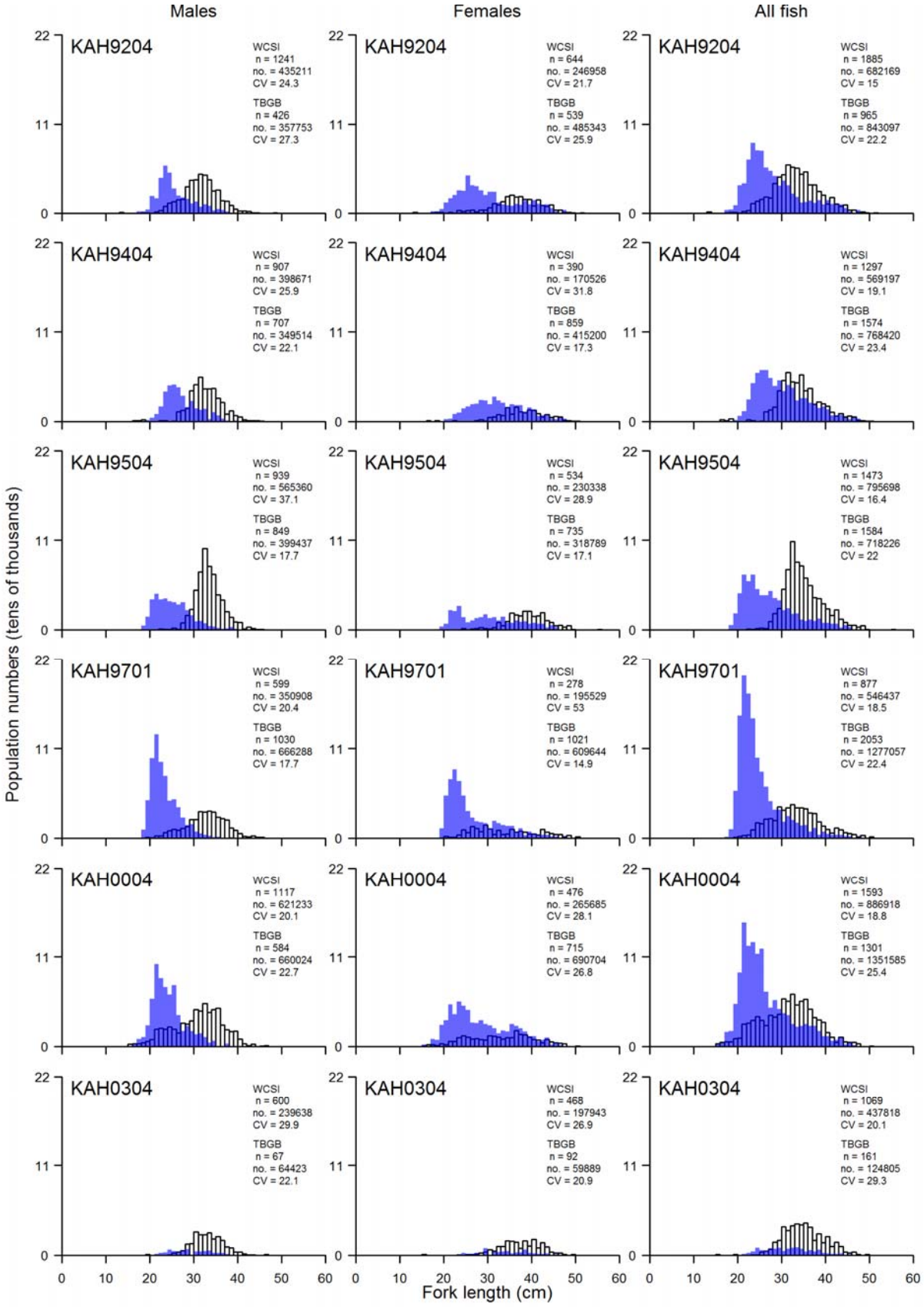


Figure 6i: Red gurnard.

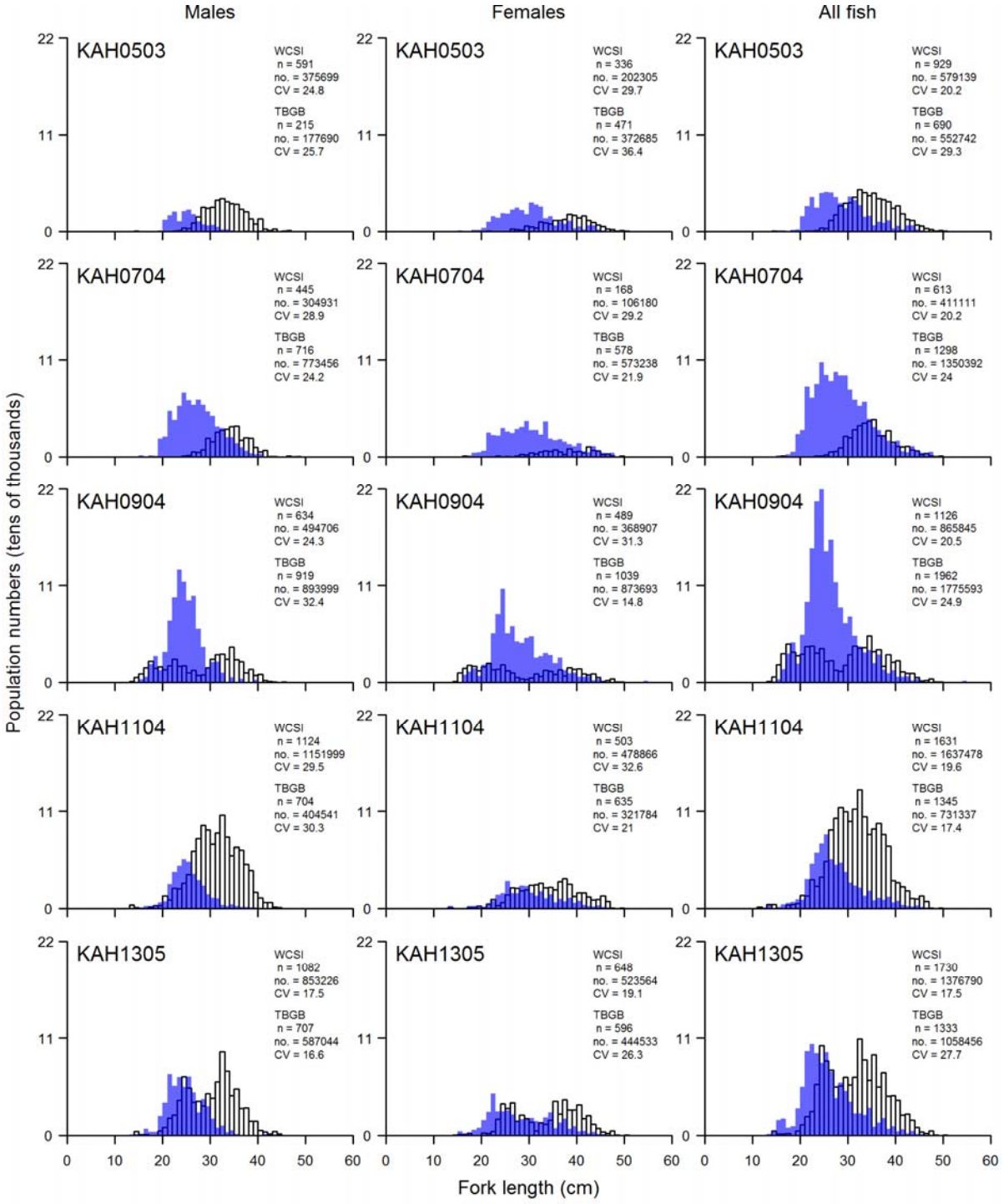


Figure 6i—continued.

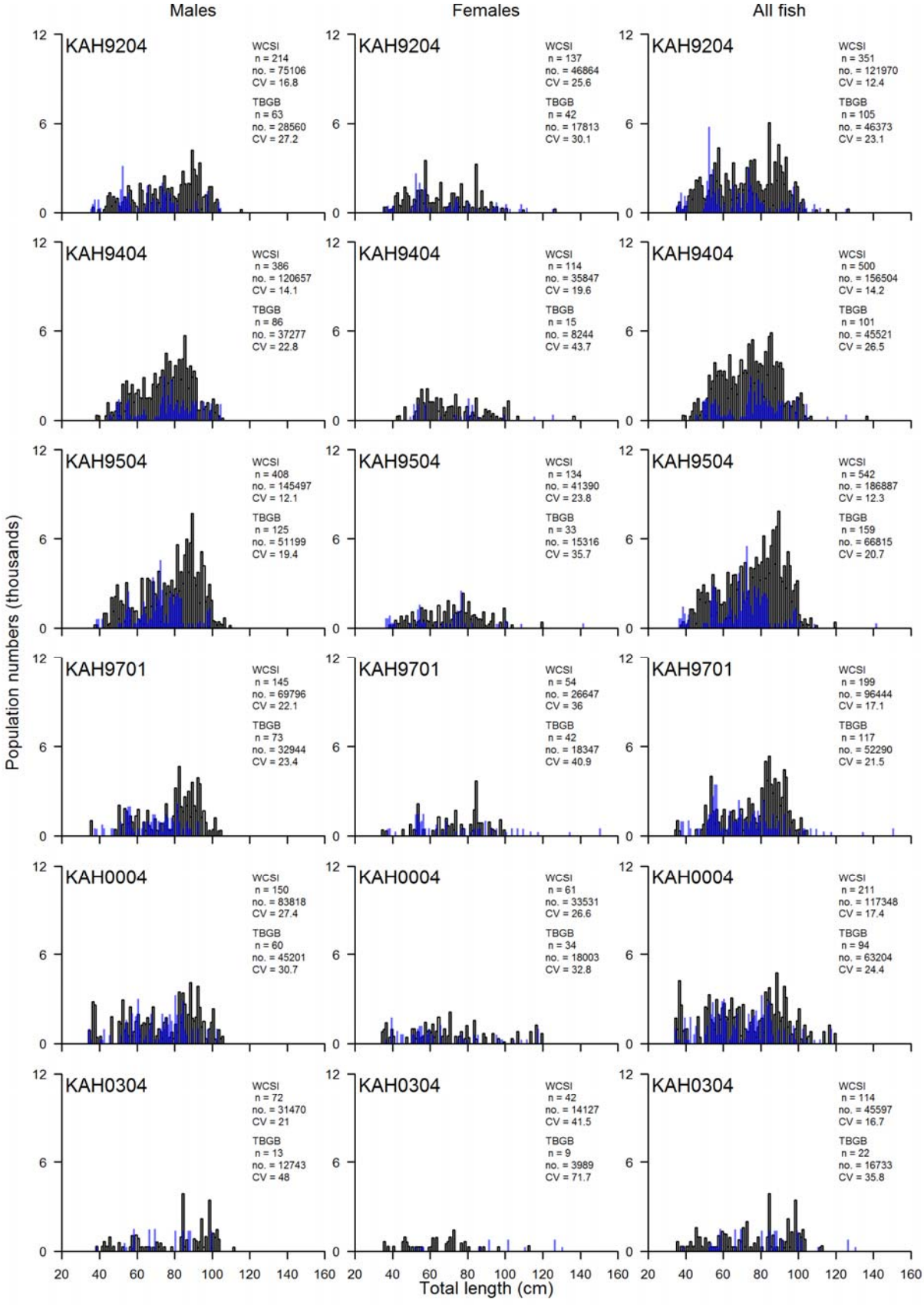
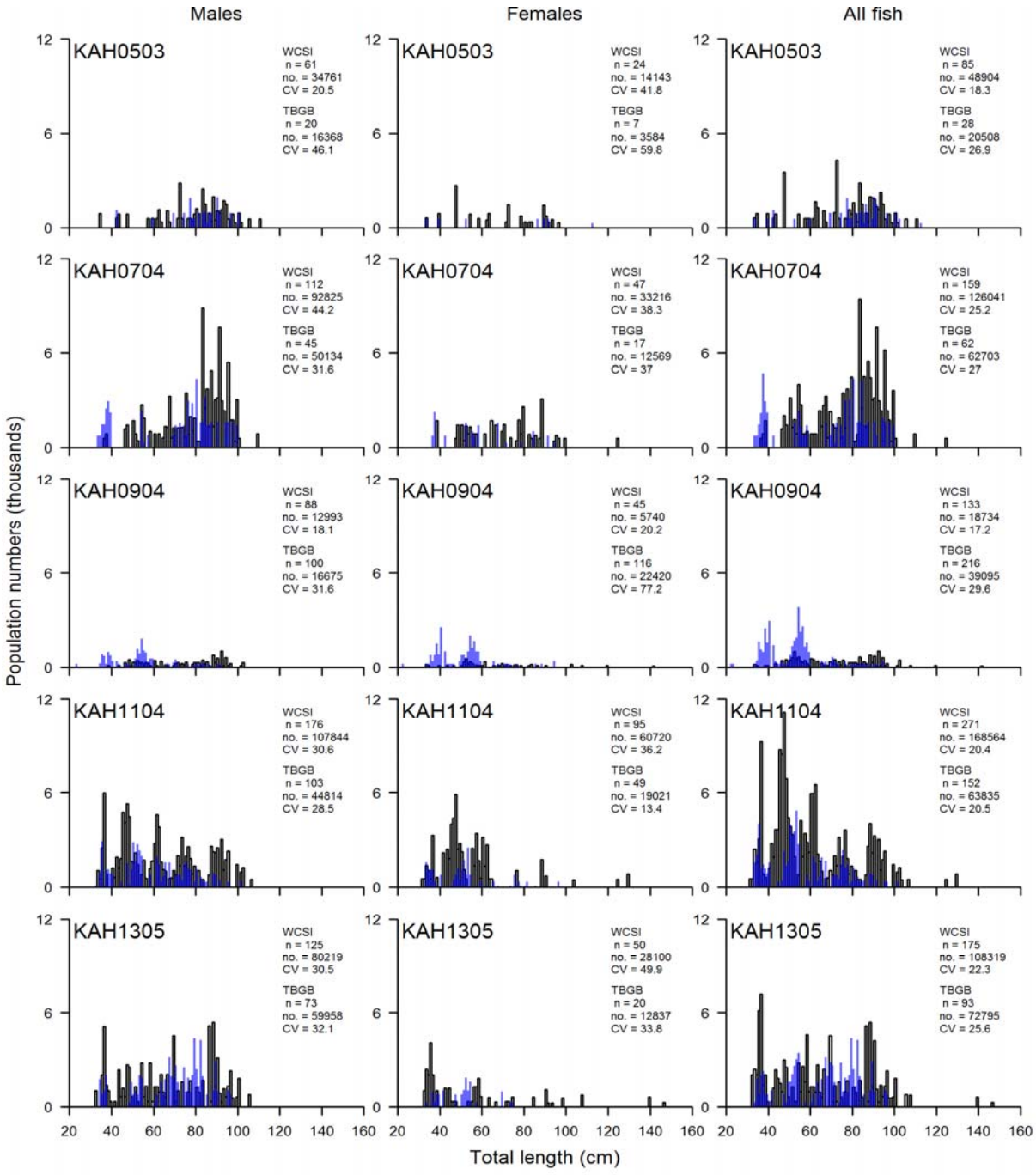


Figure 6j: Rig.



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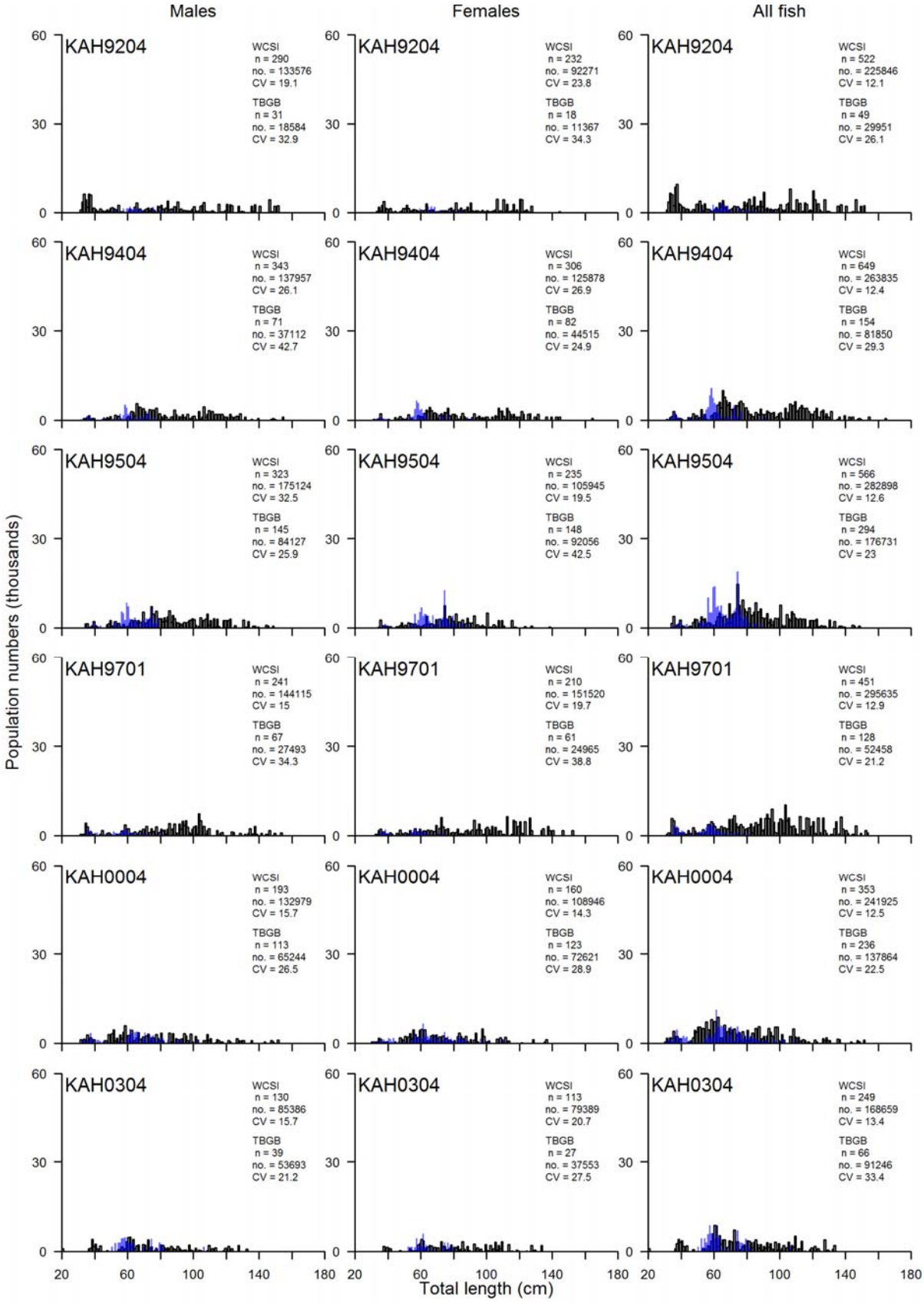
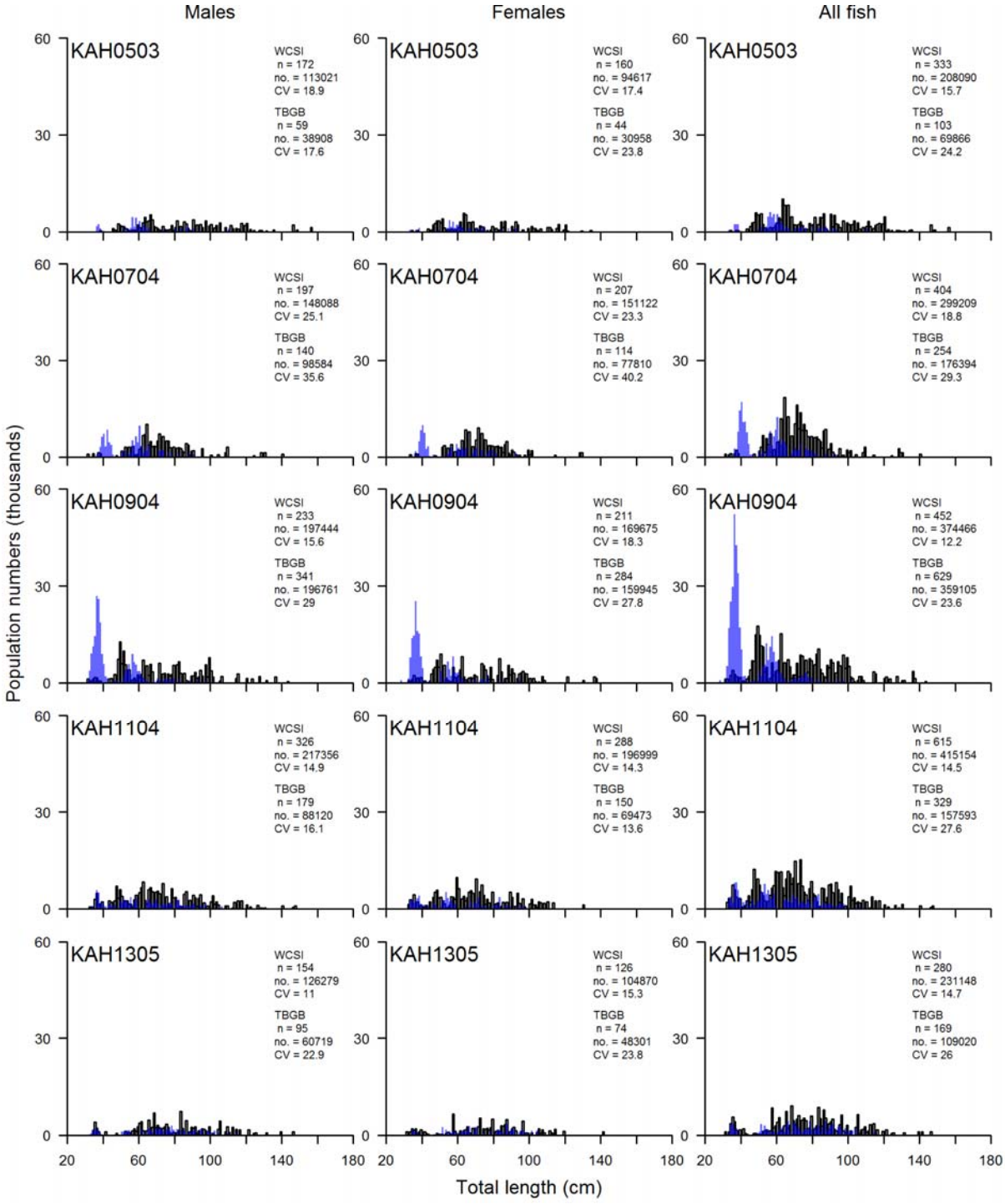


Figure 6k: School shark.



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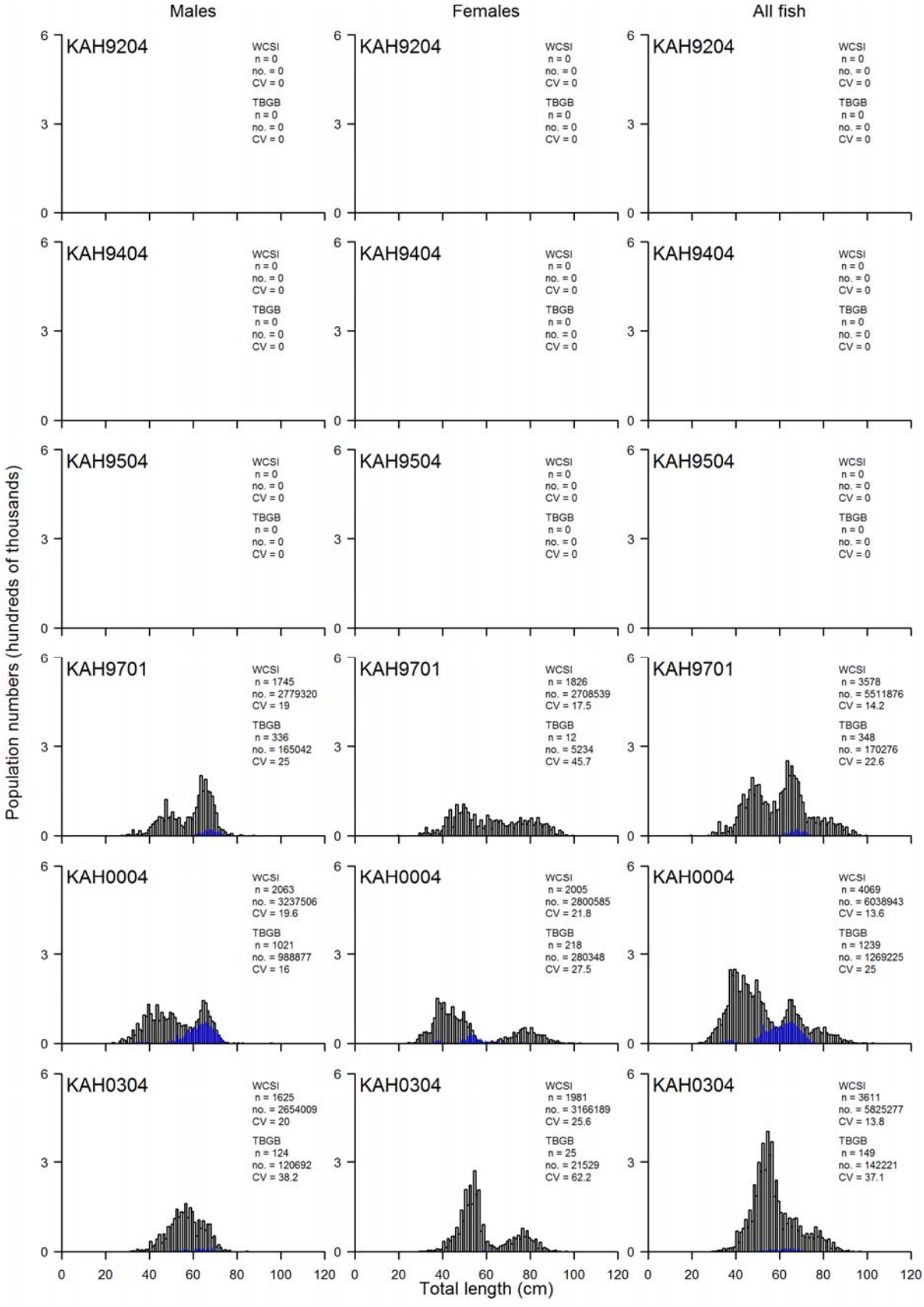
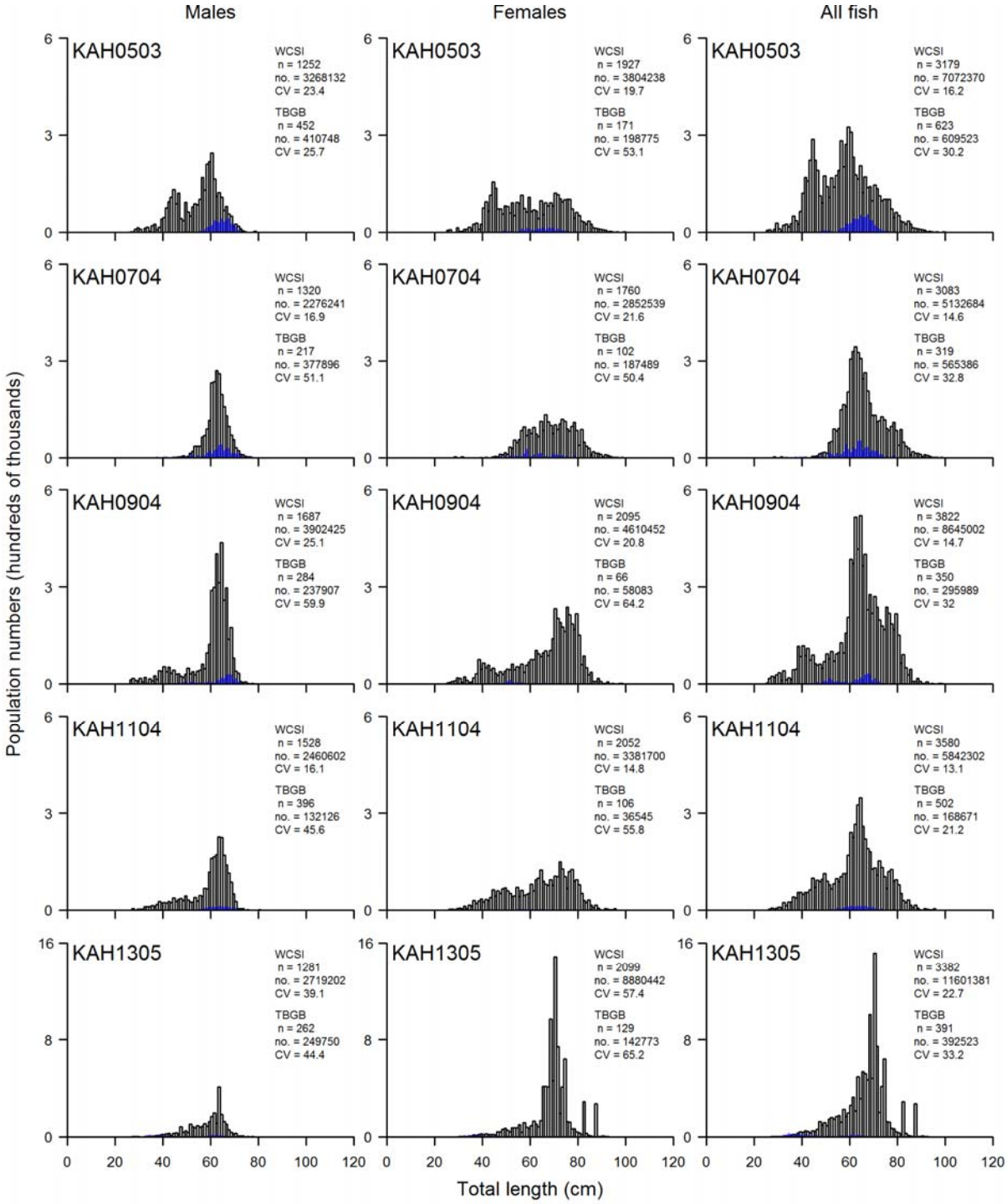


Figure 6l: Spiny dogfish.



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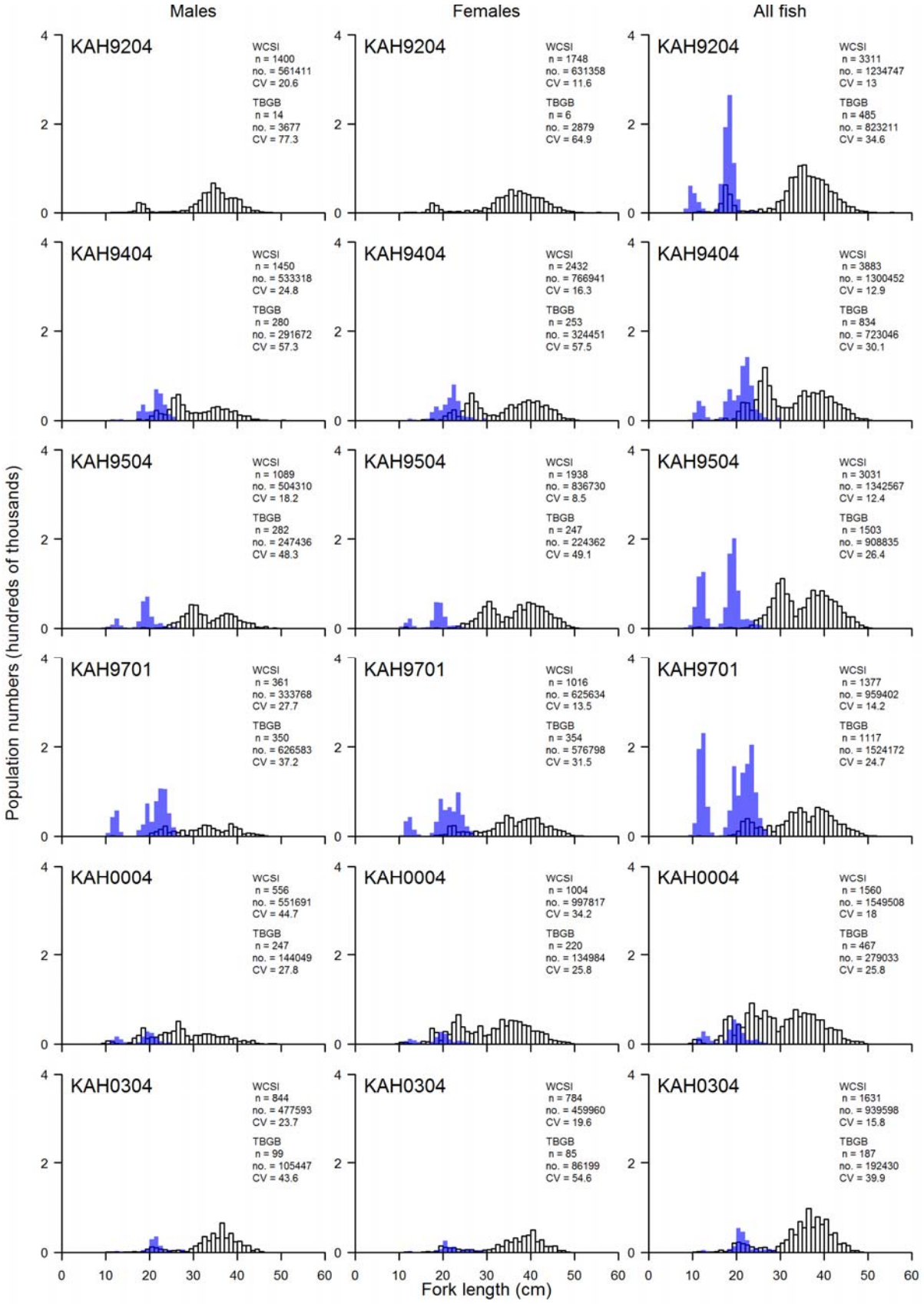


Figure 6m: Tarakihi.

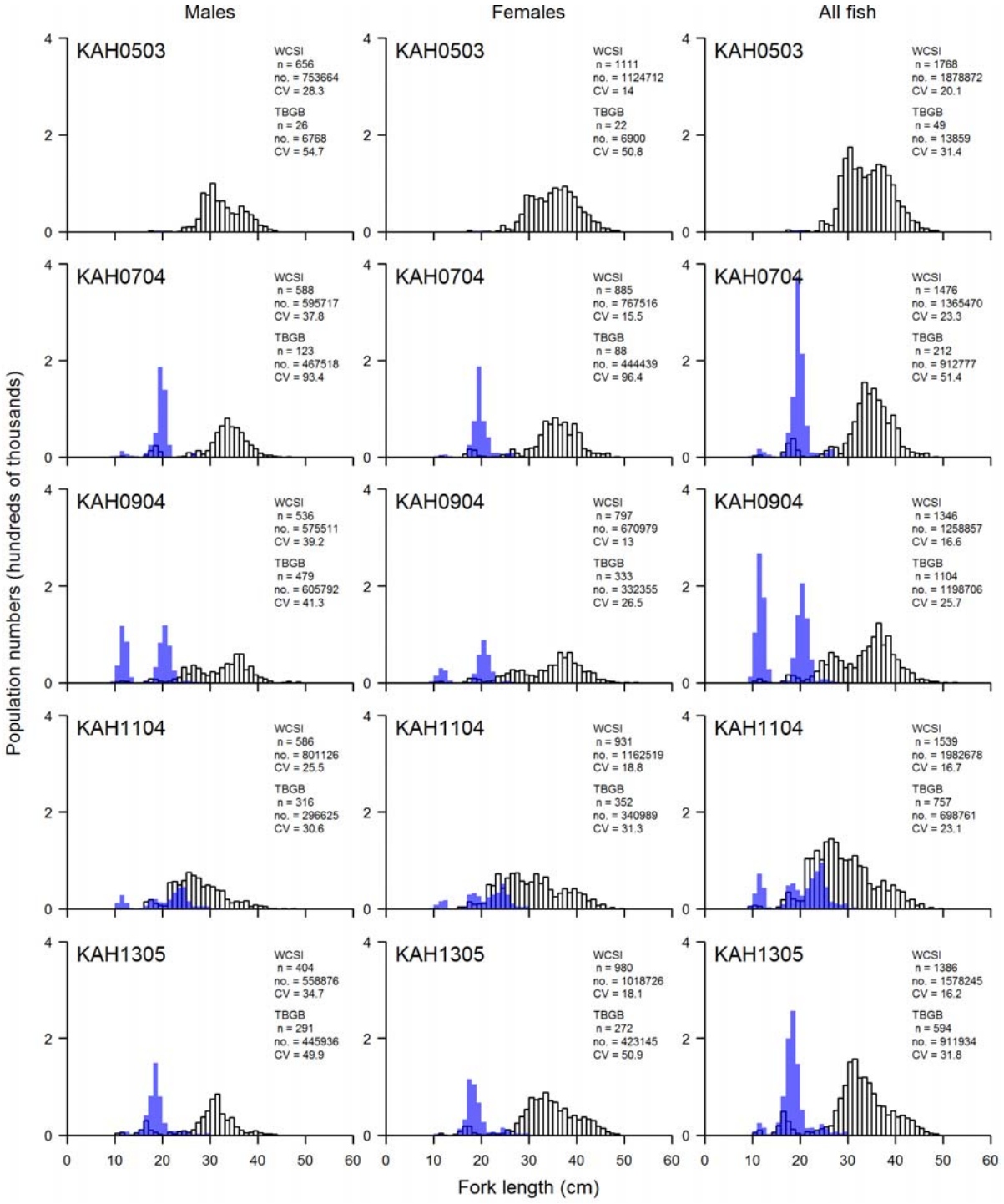
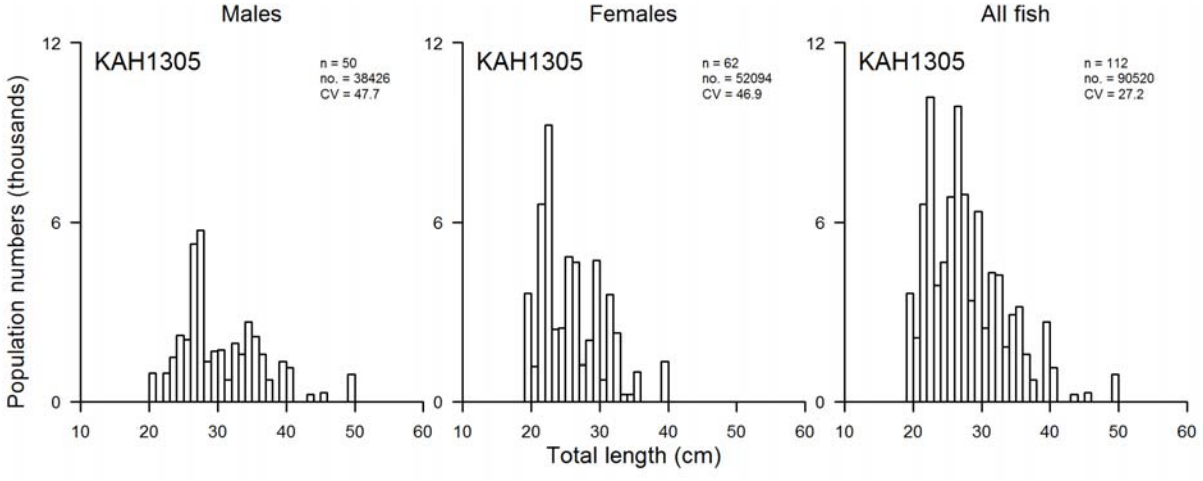
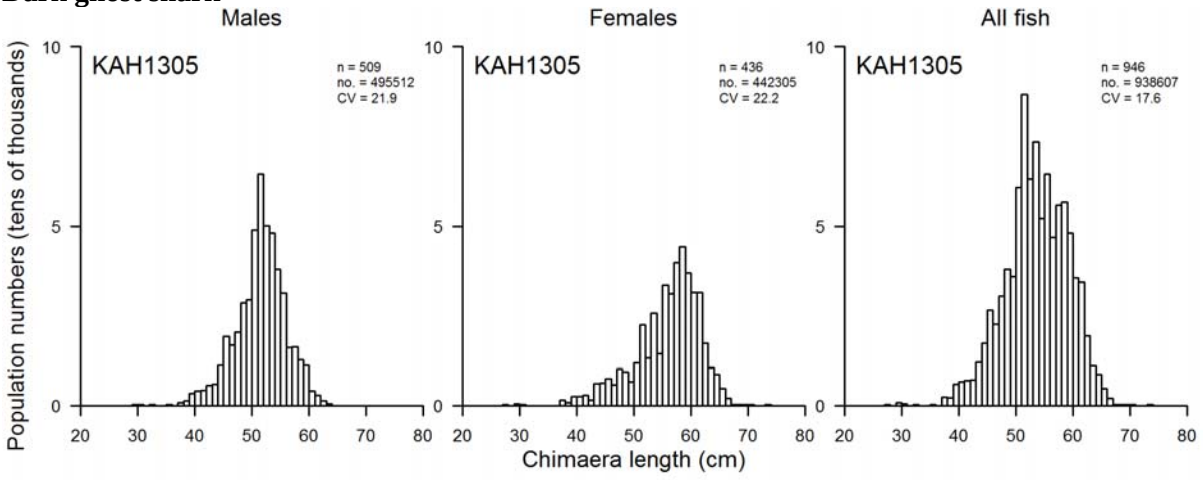


Figure 6m—continued.

Blue cod



Dark ghost shark



Frostfish

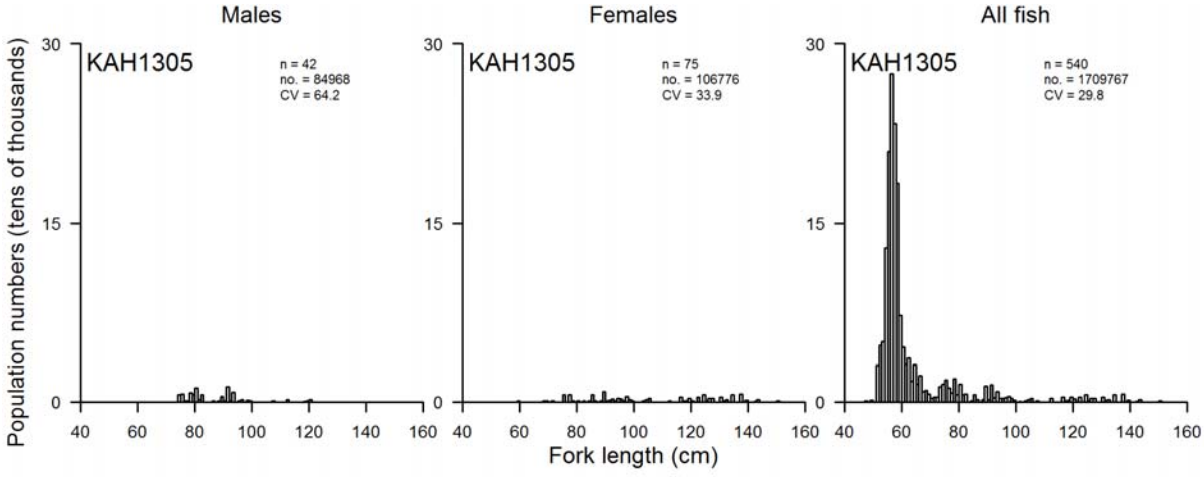
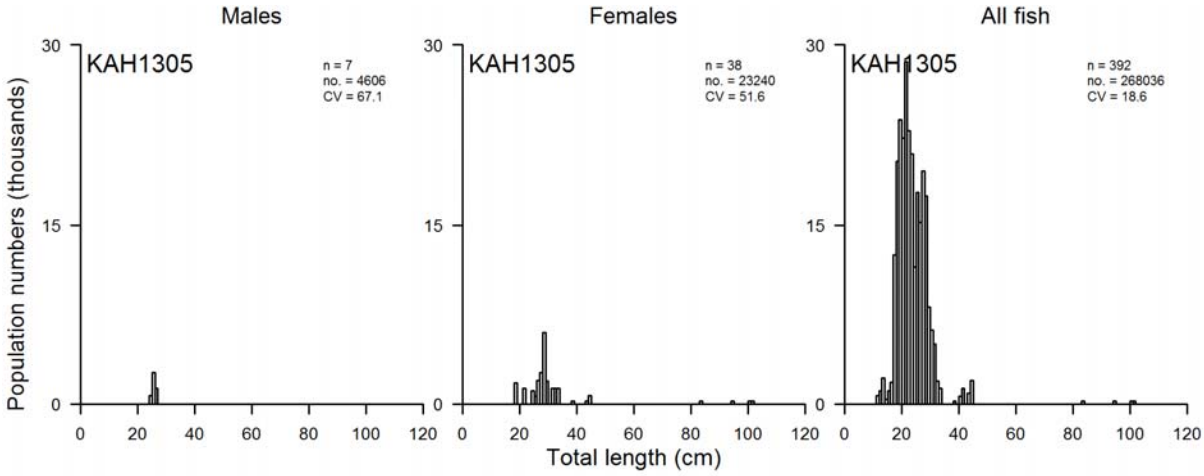
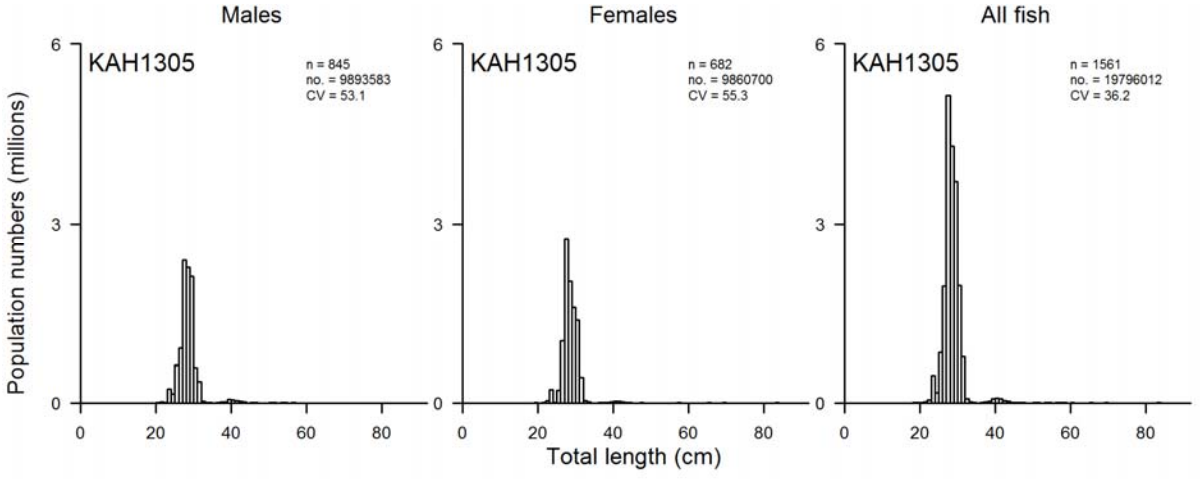


Figure 7: Scaled length frequency distributions for the other commercial species where more than 100 fish were measured. n = number of fish measured, no. = scaled population number, CV = coefficient of variation.

Hake



Hoki



Jack mackerel (*Trachurus novaezelandiae*)

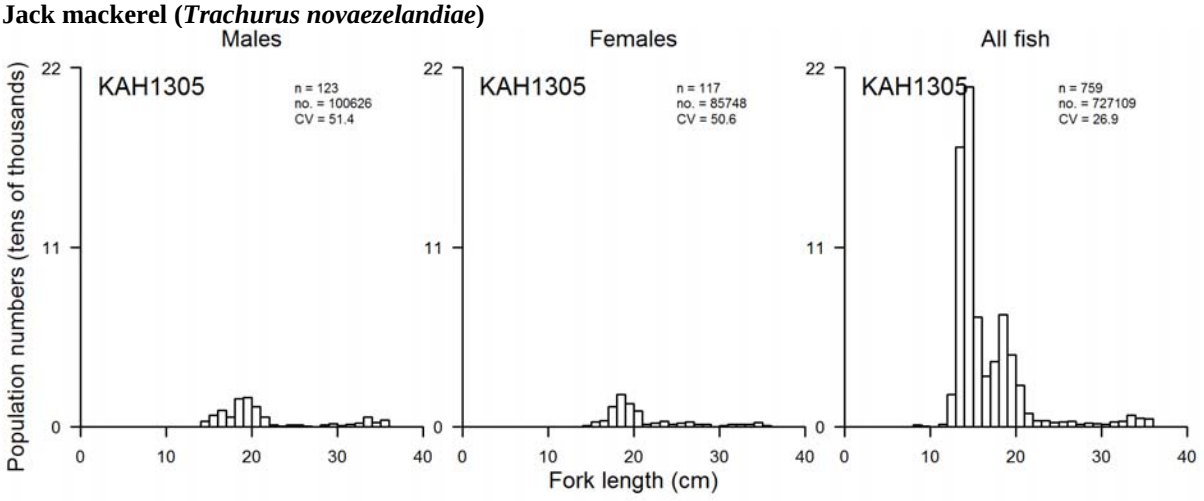
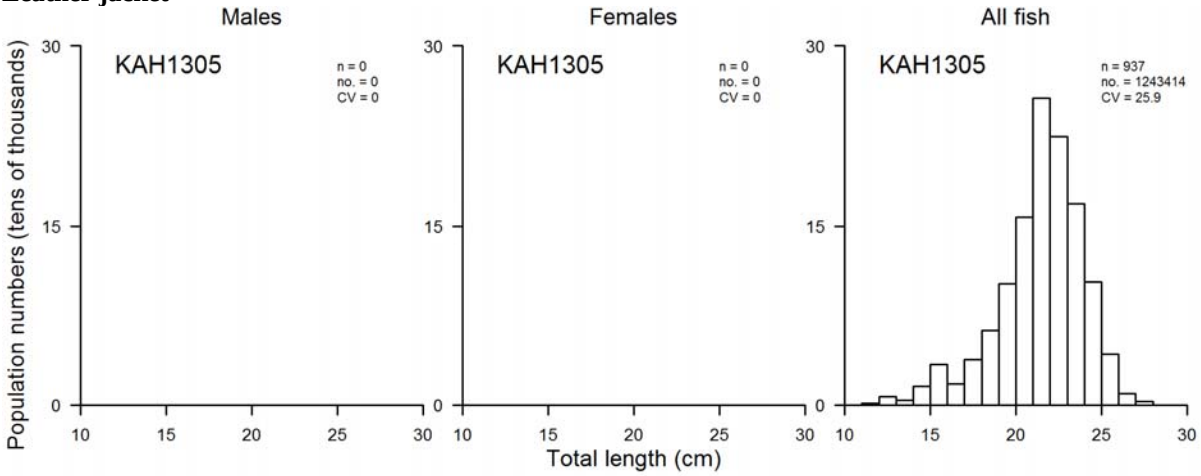
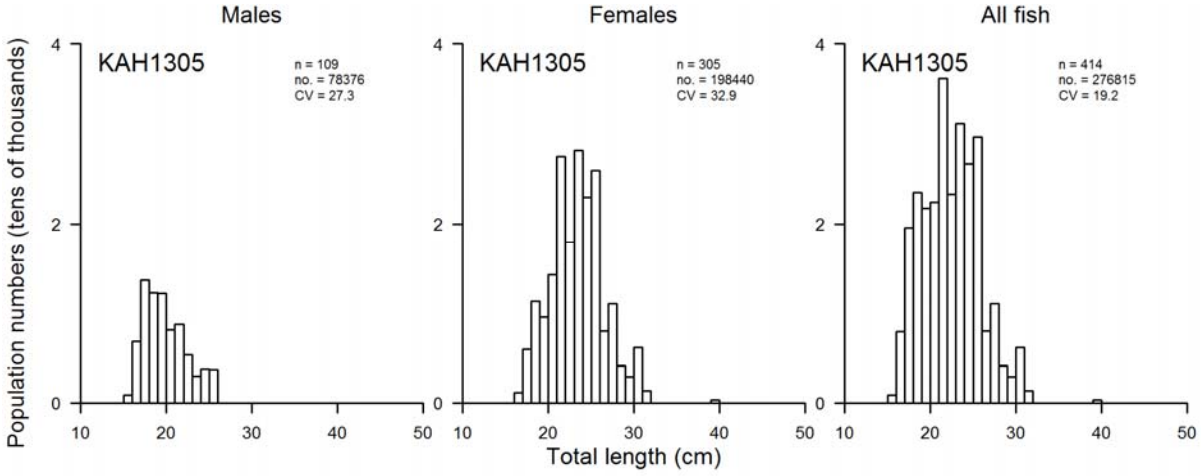


Figure 7—continued.

Leather jacket



Lemon sole



New Zealand sole

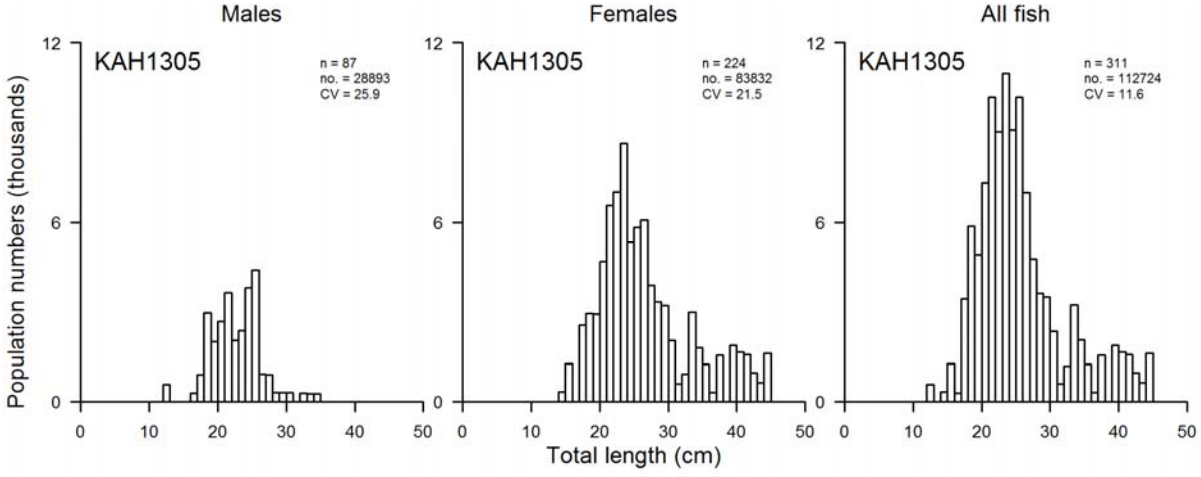
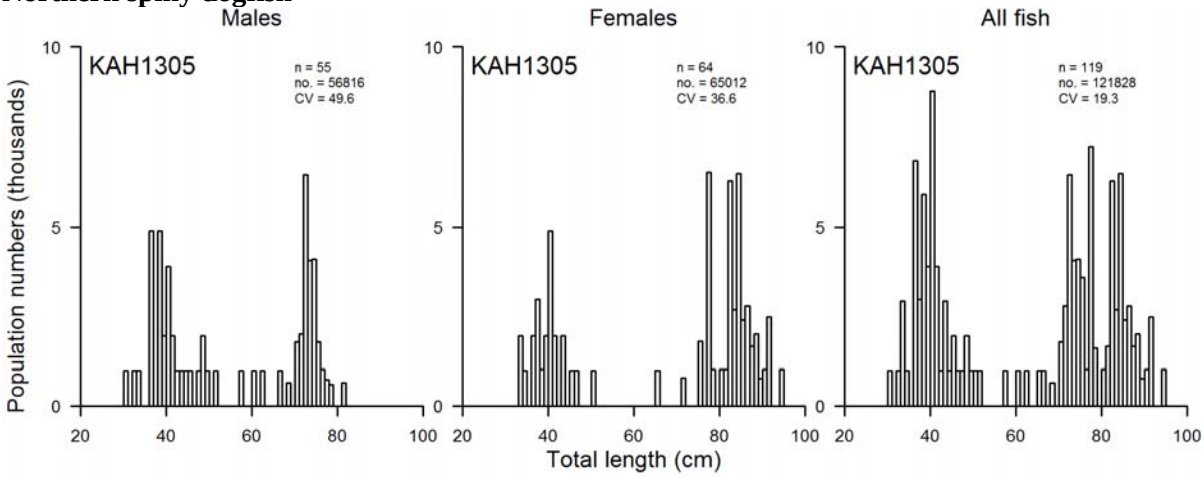
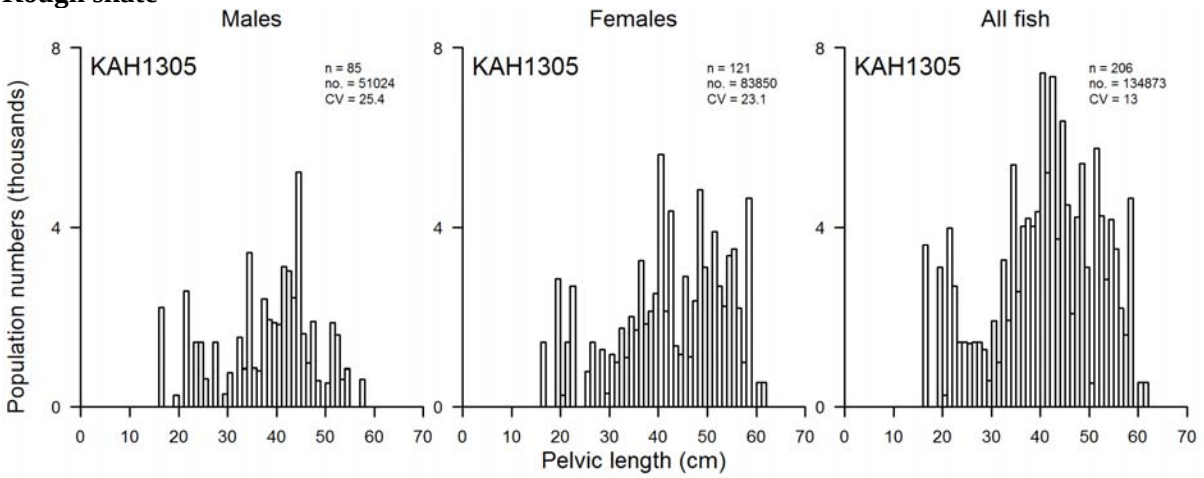


Figure 7—continued.

Northern spiny dogfish



Rough skate



Sand flounder

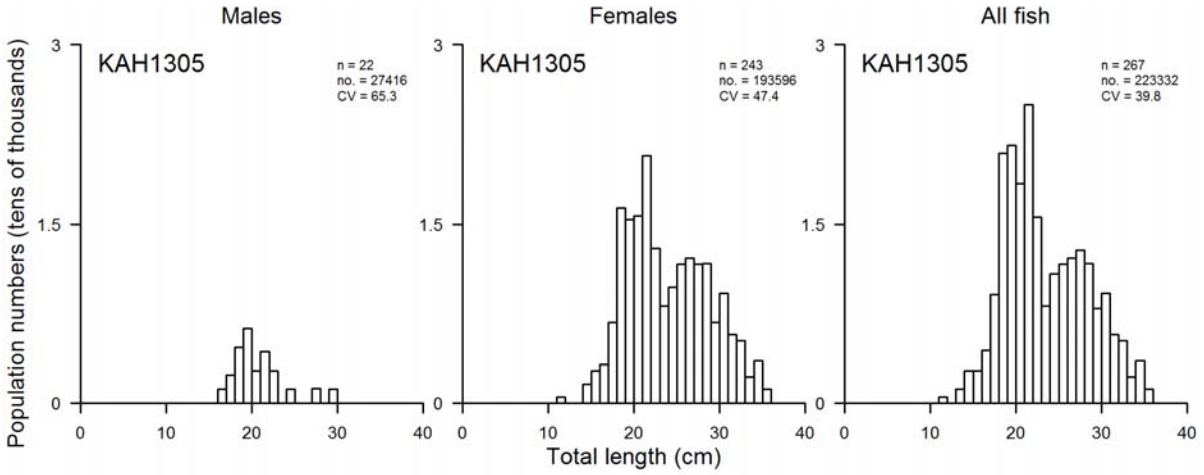
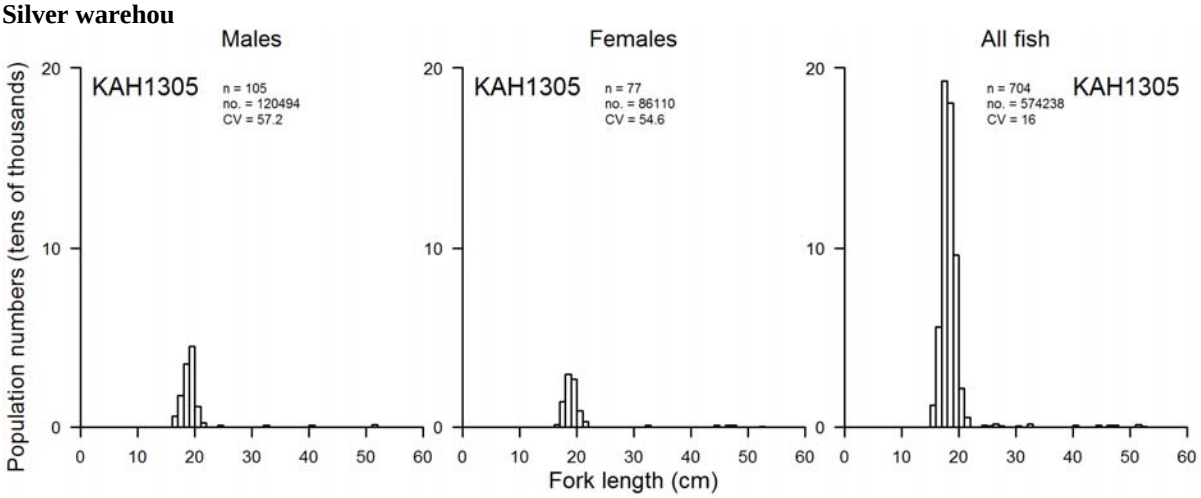


Figure 7—continued.

Silver warehou



Snapper

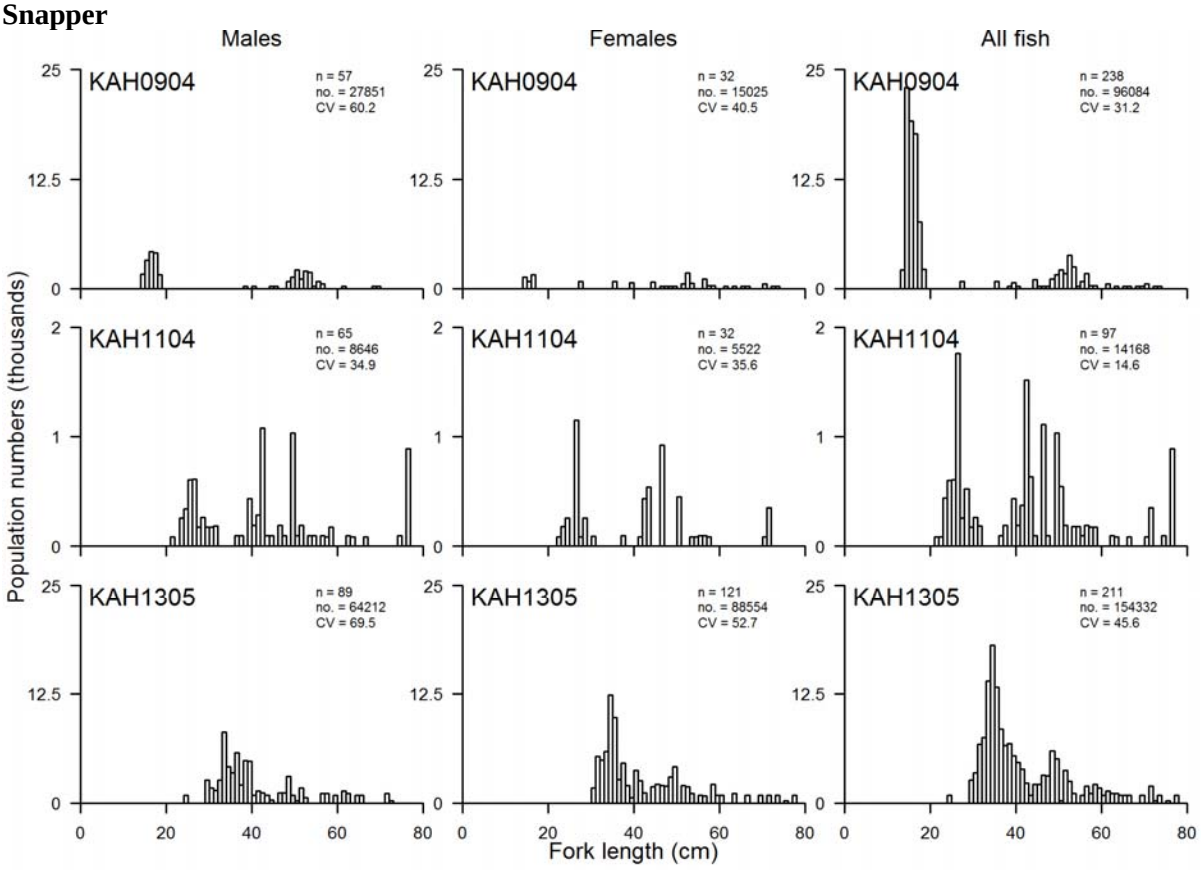


Figure 7—continued.

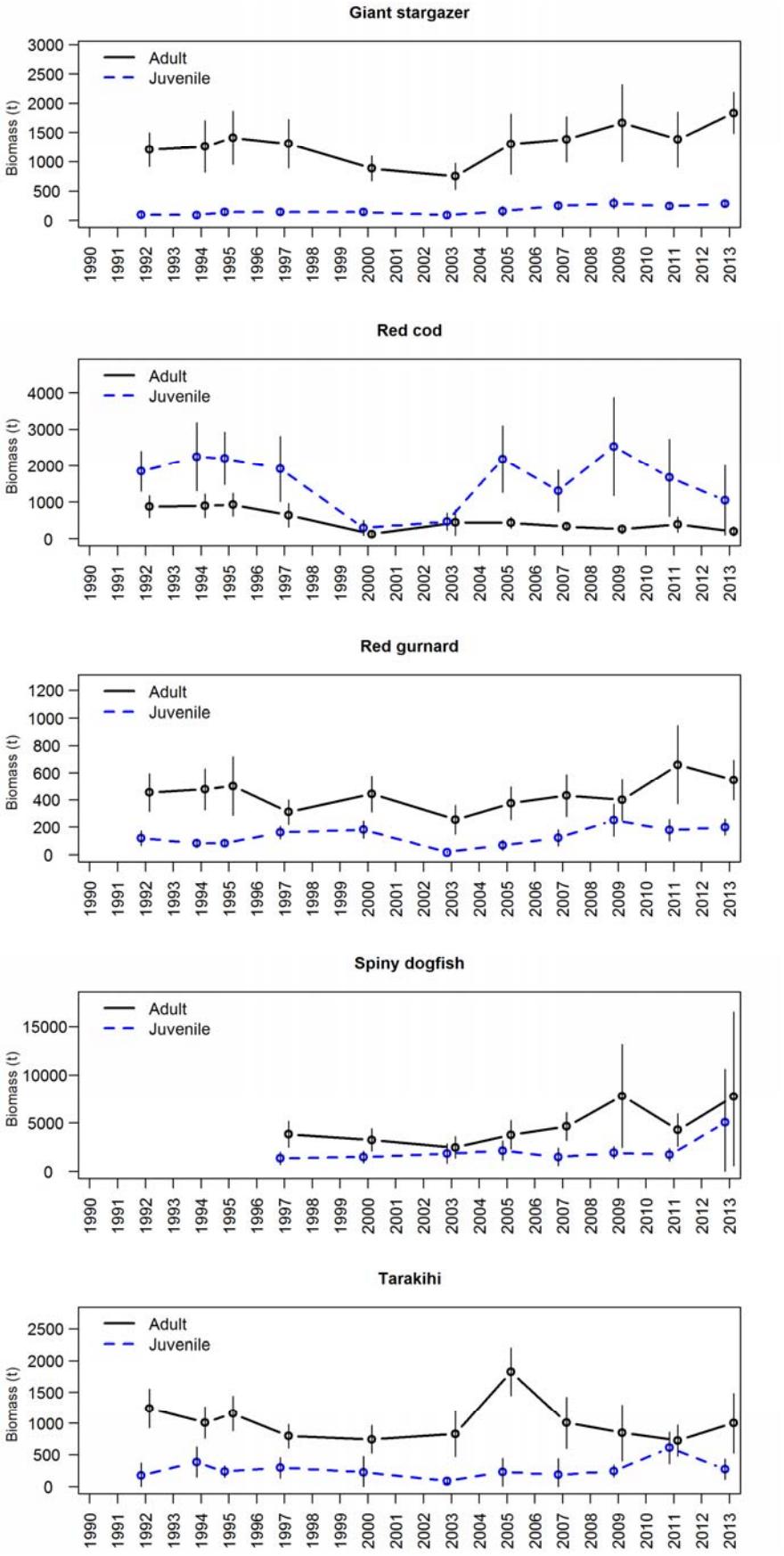


Figure 8: Biomass trends with 95% confidence intervals for juveniles (dashed blue lines) and adults (solid black lines) for the target species (all sexes combined) from all surveys in the series. For 50% maturity lengths, see Table 5.

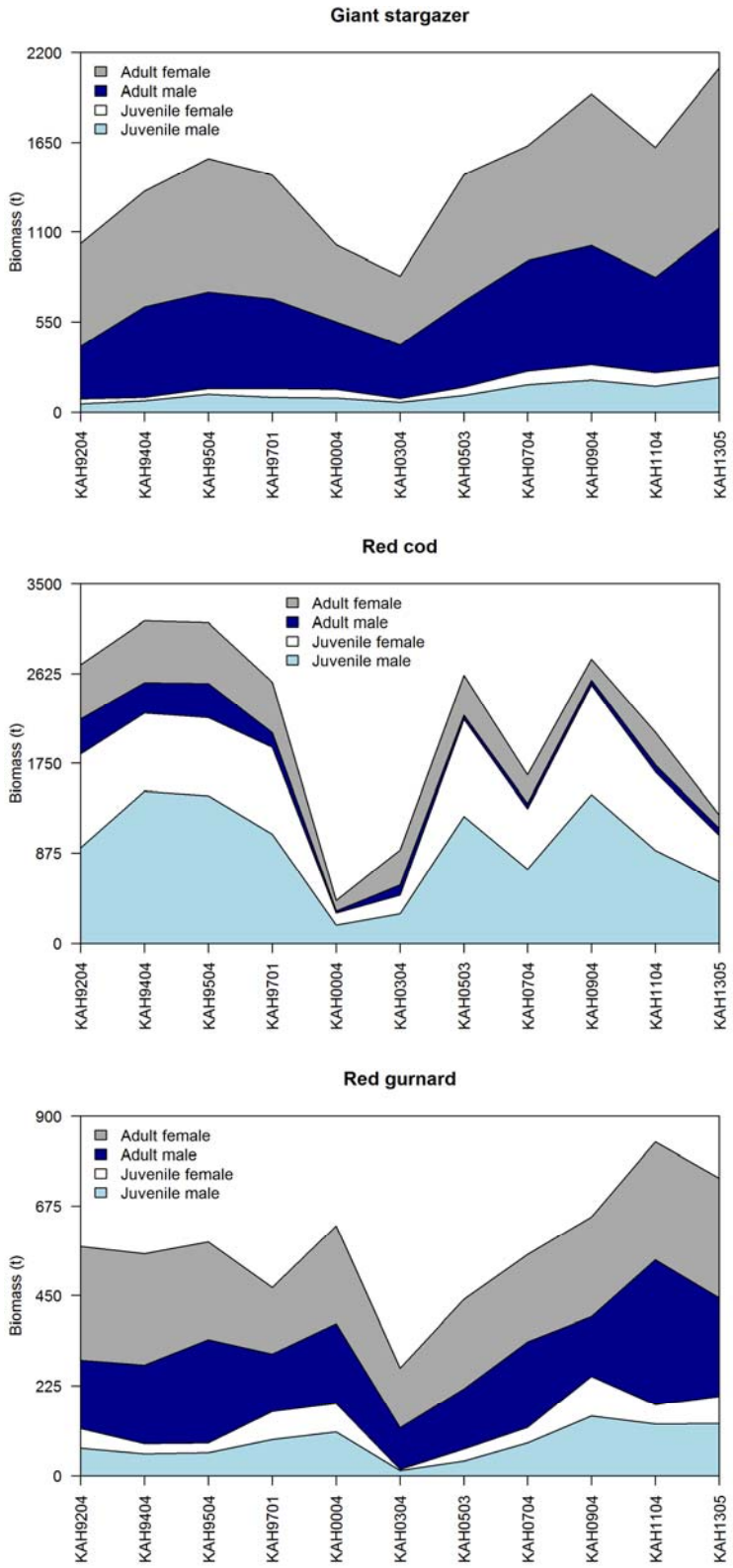


Figure 9: Biomass trends for juveniles and adults by sex for the target species for all surveys in the series. For 50% maturity lengths, see Table 5.

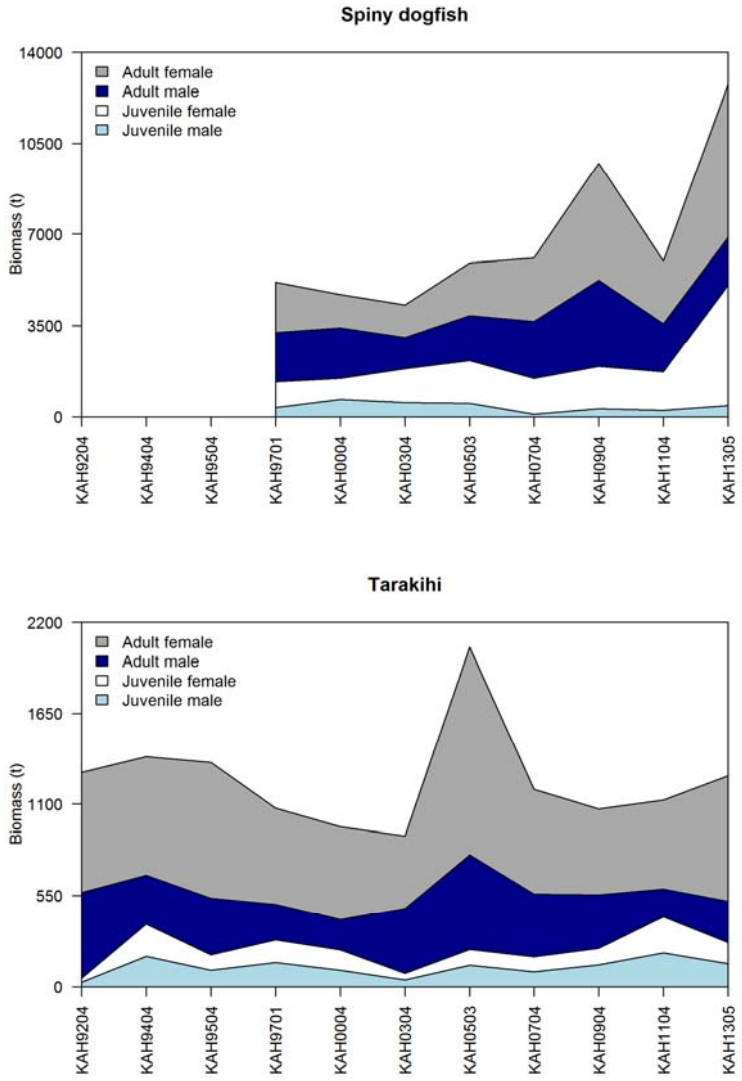


Figure 9 continued.

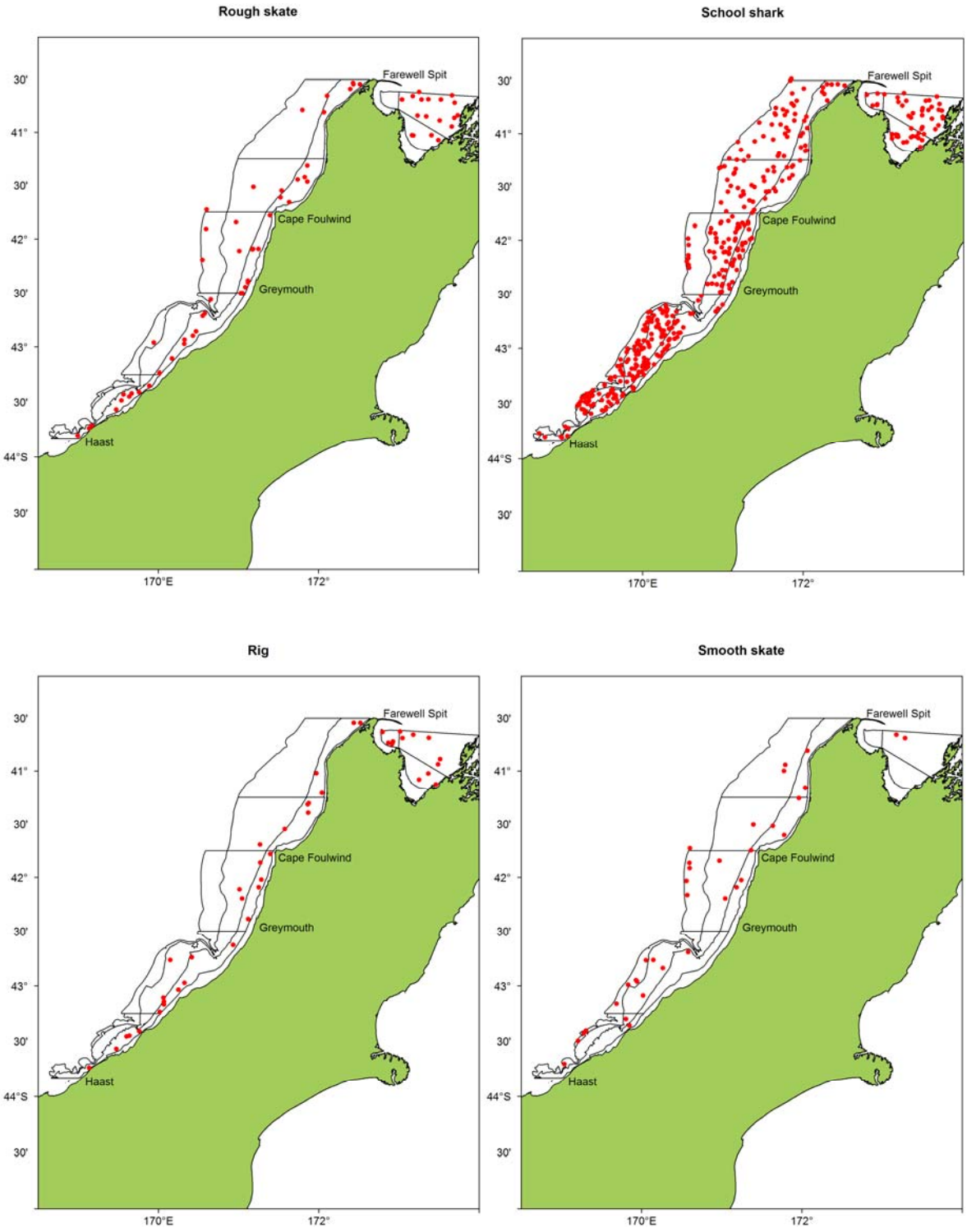


Figure 10: Release positions of tagged elasmobranchs by species for all surveys in the time series. Note that release positions often include more than one individual of a species.

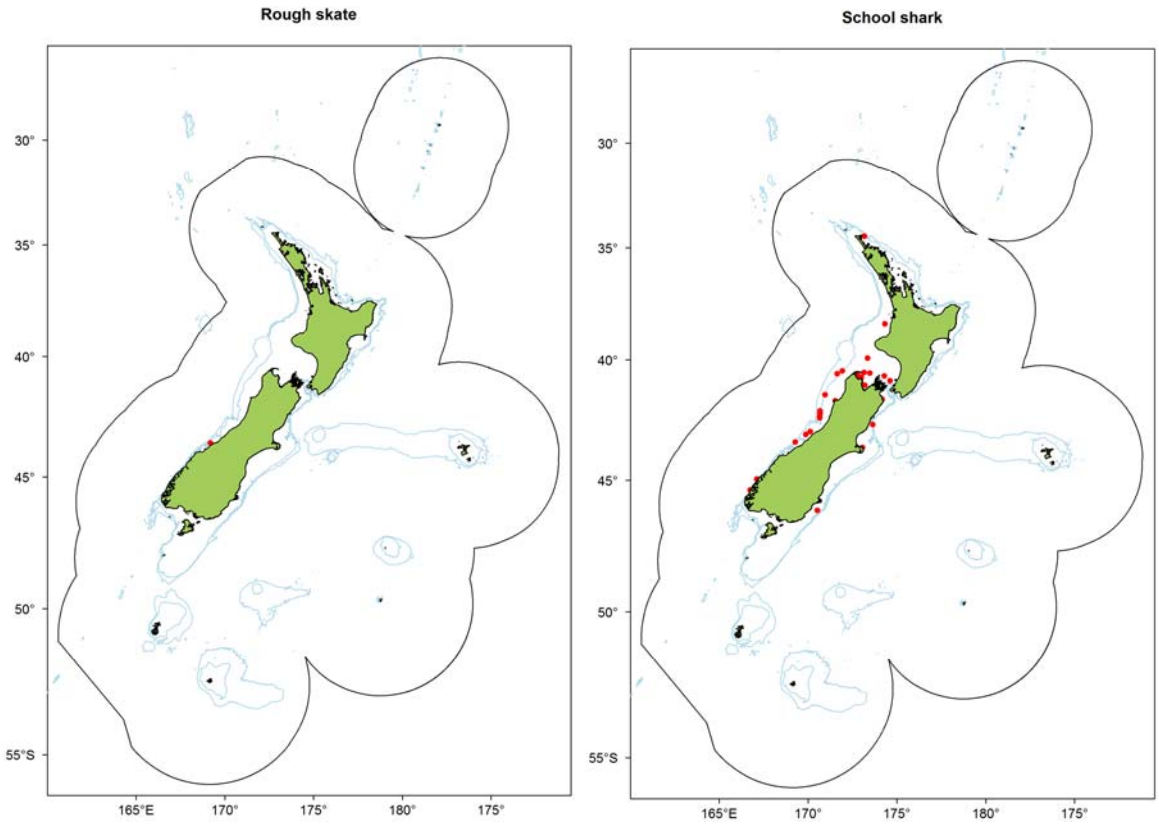


Figure 11: Positions of returned elasmobranch tags (NB: to date, no tags have been returned for smooth skate, and no location data provided by fishers for rig).

Appendix 1: Length-weight relationship parameters used to scale length frequencies and calculate length class biomass estimates. (DB, Ministry for Primary Industries *trawl* database; –, no data; n, sample size.)

$W = aL^b$ where W is weight (g) and L is length (cm);

Species	*a*	*b*	n	Length range (cm) Min.	Max.	Data source
Barracouta	0.0056	2.977	408	13.2	91.4	This survey
Blue cod	0.0089	3.129	109	20	50.1	This survey
Blue warehou	0.0144	3.105	338	27.4	69.6	DB, TAN9604
Carpet shark	0.0069	3.007	532	24.5	99.4	DB, KAH0904
Dark ghost shark	0.0015	3.361	332	21.2	67.9	DB, KAH9704
Elephantfish	0.0049	3.165	378	13.4	91	DB, KAH9618
Frostfish	0.0004	3.163	450	10.4	153	DB, KAH0004
Gemfish	0.0017	3.342	391	32	107	DB, KAH9304, KAH9602
Giant stargazer	0.0069	3.222	506	15.2	75.5	This survey
Hake	0.0049	3.107	260	10.7	45.2	DB, KAH1104
Hapuku	0.0078	3.140	307	49	108	DB, TAN9301
Hoki	0.0046	2.884	525	22	110	DB, SHI8301
Jack mackerel						
(*Trachurus declivis*)	0.0165	2.930	200	15	53	DB, COR9001
(*T. novaezelandiae*)	0.0163	2.923	200	15	40	DB, COR9001
John dory	0.0195	2.975	159	23.7	56.9	This survey
Leatherjacket	0.0088	3.211				DB, IKA8003
Lemon sole	0.0080	3.128	524	14.6	41.2	DB, KAH9809
Ling	0.0016	3.248	232	27	122	This survey
New Zealand sole	0.0049	3.215	114	20	48	DB, KAH0304
Northern spiny dogfish	0.0034	3.078	207	43	90.3	DB, combined surveys
Red cod	0.0108	2.956	740	14.2	65.4	This survey
Red gurnard	0.0064	3.136	559	14.6	51.7	This survey
Rig	0.0045	2.982	237	33.1	147	This survey
Rough skate	0.0257	2.945	206	17	62	This survey
Sand flounder	0.0207	2.877	282	13.5	44.5	DB, KAH9809
School shark	0.0027	3.129	448	32.8	147	This survey
Sea perch	0.0262	2.921	210	7	42	DB, KAH9618
Silver dory	0.0191	2.965	506	13.2	27.5	DB, KAH0904
Silver warehou	0.0048	3.380	262	16.6	57.8	DB, TAN502
Smooth skate	0.0254	2.928	52	21.2	105	This survey
Snapper	0.0447	2.793	780	8	71	DB, Paul, FRD Bull. 13
Spiny dogfish	0.0017	3.202	936	28.1	92.2	This survey
Tarakihi	0.0163	3.035	727	11.2	49.1	This survey
Two-saddle rattail	0.0015	3.310	605	18	55.8	DB, KAH0904

Appendix 2: Summary of station data.

Station		Stratum	Date	Time	Start of tow ° ' S	Start of tow ° ' E	End of tow ° ' S	End of tow ° ' E	Gear depth (m) Min.	Gear depth (m) Max.	Distance trawled (n. miles)	Headline height (m)	Doorspread (m)	Surface temp (°C)	Bottom temp (°C)	Warp length
1	#	18	25-Mar-13	1552	41 03.02	173 10.77	42 13.13	171 00.84	27	27	0.14	5.0		19.3	18.2	200
2		17	26-Mar-13	620	40 42.25	172 52.83	41 29.41	170 56.30	26	28	2.86	4.1	74.5	19.1	17.5	200
3	#	17	26-Mar-13	820	40 37.62	172 47.37	41 54.47	170 36.35	25	28	1.36	4.0	74.5	18.3	17.9	200
4	#	17	26-Mar-13	1007	40 38.29	172 53.47	42 04.05	170 34.61	31	32		4.0	74.5	19.1	17.5	200
5		19	26-Mar-13	1137	40 37.75	172 59.25	42 13.00	170 32.71	35	35	2.04	4.1	75.0	19.0	17.4	200
6		17	26-Mar-13	1314	40 42.90	173 00.75	41 17.68	171 42.93	30	33	3.01	4.0	71.3	19.1	17.9	200
7		17	26-Mar-13	1502	40 42.91	172 51.81	41 24.84	171 58.53	23	24	3.02	4.0	67.2	19.3	17.8	200
8		19	27-Mar-13	609	40 37.60	173 31.22	41 30.33	171 48.39	56	60	3.02	4.2	75.4	18.7	15.0	200
9		19	27-Mar-13	841	40 44.58	173 22.46	41 38.48	171 35.09	49	53	2.89	5.1	72.2	18.8	16.3	200
10		19	27-Mar-13	1103	40 52.94	173 29.94	41 33.47	171 19.89	51	52	3.02	5.4	74.4	18.8	16.6	200
11		19	27-Mar-13	1236	40 51.14	173 33.20	41 35.64	171 03.26	51	54	3.06	5.4	75.0	19.2	16.8	200
12		19	27-Mar-13	1423	40 46.08	173 41.50	42 47.22	170 42.68	62	63	3.02	5.3	71.4	19.3	17.0	200
13		18	28-Mar-13	617	40 58.22	173 24.83	42 49.34	170 45.85	41	42	2.95	5.2	73.2	19.2	16.8	200
14		18	28-Mar-13	819	40 59.56	173 16.59	42 42.50	170 52.44	38	38	3.08	5.0	72.8	19.3	16.8	200
15		18	28-Mar-13	1002	41 06.17	173 19.87	42 38.67	170 55.82	24	32	2.97	5.0	72.4	19.3	17.4	200
16		1	29-Mar-13	624	40 34.66	172 26.41	42 29.79	170 40.94	55	65	3.03	5.3	75.4	17.2	14.4	200
17		1	29-Mar-13	941	40 38.53	172 08.53	42 43.53	170 02.79	92	93	2.99	5.0	75.4	18.7	13.9	265
18		2	29-Mar-13	1145	40 36.46	172 04.78	42 47.27	170 18.38	122	124	3.08	4.8	79.4	18.8	13.8	340
19		2	29-Mar-13	1415	40 29.80	171 56.13	42 48.93	170 10.30	180	188	3.08	4.8	87.2	19.3	13.8	490
20		2	30-Mar-13	618	40 51.32	171 41.96	42 53.62	170 08.33	142	143	3.05	4.8	83.0	19.1	13.7	400
21		2	30-Mar-13	804	40 56.72	171 37.18	42 56.96	169 58.86	139	142	2.97	4.7	89.2	18.7	13.6	386
22		2	30-Mar-13	1002	41 05.20	171 35.12	43 12.28	169 59.99	131	133	3.05	4.9	86.1	18.8	13.5	370
23		2	30-Mar-13	1430	40 52.54	172 00.59	43 09.95	170 04.59	96	98	2.91	4.9	76.9	18.3	13.7	370
24		1	30-Mar-13	1608	40 58.91	172 00.48	42 58.84	170 07.70	80	80	3.00	4.8	75.3	17.9	13.9	235
25		7	31-Mar-13	624	41 53.09	171 19.26	43 00.15	170 16.49	56	64	2.99	4.9	70.7	17.2	14.9	200
26		8	31-Mar-13	827	41 54.85	171 14.12	43 02.77	170 15.07	104	104	3.01	4.8	82.2	17.7	13.4	308
27		8	31-Mar-13	1011	41 58.75	171 10.13	43 15.26	169 49.71	119	125	2.99	4.9	84.8	17.6	13.3	353
28		7	1-Apr-13	638	42 28.20	171 04.12	43 26.08	169 37.29	31	33	3.12	5.4	71.8	17.3	17.1	200
29		7	1-Apr-13	830	42 23.01	171 07.21	43 26.89	169 24.05	29	30	3.13	5.6	71.6	17.3	17.0	200
30		7	1-Apr-13	1013	42 20.63	171 09.42	43 23.23	169 25.96	26	27	3.08	5.6	71.6	17.2	17.2	200
31		8	1-Apr-13	1306	42 22.61	170 57.30	43 19.47	169 31.51	134	134	2.94	4.8	83.8	17.7	13.1	380

Appendix 2—*continued*

			Start of tow			End of tow		Gear depth (m)		Distance trawled	Headline	Doorspread	Surface temp	Bottom temp	Warp length
Station	Stratum	Date	Time	° ' S	° ' E	° ' S	° ' E	Min.	Max.	(n. miles)	height (m)	(m)	(°C)	(°C)	
32	17	6-Apr-11	639	42 14.56	170 59.81	40 37.54	172 53.10	133	133	1.62	4.8	85.9	18.2	13.2	380
33	17	6-Apr-11	811	41 26.75	170 57.72	40 37.74	172 55.16	193	195	2.86	4.8	87.7	19.1	12.9	525
34	17	6-Apr-11	1003	41 51.47	170 36.56	40 40.51	172 53.95	370	383	3.00	4.6	92.6	19.1	11.9	930
35	19	6-Apr-11	1145	42 00.92	170 34.88	40 37.38	173 03.28	350	351	3.13	4.7	92.6	19.1	11.9	870
36	19	6-Apr-11	1331	42 10.06	170 33.72	40 38.09	173 14.54	372	372	3.03	4.7	92.6	19.1	11.9	920
37	19	6-Apr-11	1521	41 14.98	171 44.58	40 41.53	173 30.38	114	116	2.97	4.8	85.6	18.3	13.4	330
38	19	6-Apr-11	1714	41 22.12	172 00.19	40 44.26	173 40.89	30	35	2.99	4.8	74.7	17.7	16.6	200
39	19	7-Apr-11	648	41 27.62	171 50.19	40 46.25	173 40.36	37	40	3.02	4.8	75.1	17.4	16.0	200
40	19	7-Apr-11	851	41 39.73	171 31.52	40 45.34	173 41.33	48	54	2.94	5.0	76.0	16.2	13.8	200
41	19	7-Apr-11	1040	41 35.88	171 17.47	40 46.38	173 40.80	138	142	3.01	4.9	87.8	17.4	13.0	390
42	19	7-Apr-11	1241	41 33.46	171 06.06	40 47.11	173 40.46	155	161	3.02	4.9	89.5	18.3	13.1	445
43	19	7-Apr-11	1355	42 46.50	170 38.78	40 45.27	173 41.30	42	47	2.95	5.0	70.5	16.1	14.9	200
44	5	8-Apr-11	1335	42 49.90	170 41.90	41 36.89	171 31.66	28	31	2.95	4.8	68.0	16.1	15.4	200
45	5	8-Apr-11	1525	42 44.54	170 49.54	41 32.70	171 39.58	41	41	2.94	4.8	68.8	16.2	15.3	200
46	9	9-Apr-11	657	42 40.92	170 52.95	42 09.86	170 34.29	54	59	3.08	4.8	85.6	16.4	14.3	200
47	9	9-Apr-11	947	42 31.70	170 43.94	42 00.89	170 34.98	239	241	2.92	4.8	92.6			640
48	9	9-Apr-11	1252	42 40.96	170 04.95	41 43.63	170 36.37	271	283	3.02	4.9	93.4	18.4	12.8	730
49	6	9-Apr-11	1610	42 44.29	170 19.46	41 44.48	170 55.75	118	118	3.08	4.8	81.4	16.5	13.5	330
50	6	10-Apr-11	652	42 45.89	170 10.95	41 38.71	171 22.63	150	153	3.07	4.9	85.9	18.1	13.3	425
51	8	10-Apr-11	910	42 50.76	170 09.22	41 50.44	171 14.80	154	156	2.93	5.0	85.2	17.7	13.3	435
52	7	10-Apr-11	1116	42 54.34	170 00.82	42 01.63	171 14.61	230	235	2.98	4.9	88.2	17.2	13.2	630
53	7	10-Apr-11	1308	43 14.57	169 57.41	42 05.55	171 11.09	90	92	2.96	5.0	70.5	16.4	14.3	
54	8	10-Apr-11	1617	43 12.28	170 01.99	41 50.73	170 58.32	61	62	3.00	4.9	72.9	15.6	14.7	200
55	8	11-Apr-11	644	43 01.43	170 05.87	42 03.94	170 59.29	130	130	2.91	4.8	75.6	16.4	13.4	360
56	8	11-Apr-11	838	42 57.90	170 19.21	42 11.81	171 02.64	53	55	3.00	4.9	73.3	16.3	15.1	200
57	7	11-Apr-11	1100	43 00.52	170 17.82	42 23.18	171 07.18	35	39	3.01	4.9	70.8	16.0	15.4	200
58	7	11-Apr-11	1301	43 12.63	169 51.61	42 30.17	171 03.07	164	165	2.97	4.9	86.2	16.6	13.3	450
59	11	11-Apr-11	1502	43 24.04	169 40.35	42 39.70	170 54.89	47	53	3.01	5.1	73.0	16.5	15.2	200
60	11	11-Apr-11	1713	43 25.18	169 27.68	42 46.20	170 41.00	118	122	3.14	5.1	84.6	16.8	13.7	335
61	11	12-Apr-11	639	43 23.56	169 22.17	42 51.51	170 28.33	245	272	2.77	4.8	88.9	16.5	13.2	675
62	11	12-Apr-11	831	43 20.64	169 27.92	42 58.78	170 24.27	297	301	2.86	4.8	90.6	17.4	12.8	760

Appendix 2—*continued*

Station	Stratum	Date	Start of tow Time	Start of tow ° ' S	Start of tow ° ' E	End of tow ° ' S	End of tow ° ' E	Gear depth (m) Min.	Gear depth (m) Max.	Distance trawled (n. miles)	Headline height (m)	Doorspread (m)	Surface temp (°C)	Bottom temp (°C)	Warp length
63	16	10-Apr-13	629	43 29.19	169 12.64	43 31.58	169 10.01	298	303	3.05	4.9	92.6	16.6	12.9	770
64	15	10-Apr-13	839	43 33.09	169 15.36	43 35.71	169 13.35	128	132	2.99	4.8	82.2	16.4	13.7	360
65	14	10-Apr-13	1051	43 38.60	169 16.58	43 36.13	169 19.07	96	96	3.05	4.8	73.4	16.5	14.7	270
66	14	10-Apr-13	1241	43 37.28	169 21.47	43 35.16	169 24.58	48	55	3.09	4.9	70.3	15.9	15.6	200
67	15	10-Apr-13	1534	43 28.96	169 22.22	43 30.12	169 20.87	116	119	1.51	4.8	82.2	17.5	13.8	340
68	14	11-Apr-13	633	43 47.90	168 49.79	43 49.90	168 46.71	60	64	2.98	4.8	71.3	16.6	14.8	200
69	12	11-Apr-13	1608	43 06.83	169 55.31	43 09.35	169 52.98	164	168	3.03	4.9	88.4	18	13.4	460
70	11	12-Apr-13	643	42 49.12	170 25.63	42 46.58	170 27.64	61	65	2.93	5.0	74.5	16.7	15.7	200
71	11	12-Apr-13	849	42 47.13	170 29.38	42 45.19	170 32.57	49	51	3.04	5.0	74.5	16.4	15.8	200
72	11	12-Apr-13	1035	42 42.63	170 32.76	42 42.77	170 36.87	60	62	3.02	5.0	71.7	16.2	15.4	200
73	11	12-Apr-13	1400	42 35.07	170 58.87	42 32.98	171 01.98	30	57	3.10	5.0	74.5	16.9	16.3	200
74	8	13-Apr-13	634	42 11.46	170 54.15	42 08.67	170 55.42	183	184	2.94	4.7	92.7	17	13.1	510
75	8	13-Apr-13	842	42 11.78	171 00.37	42 09.04	171 01.88	139	140	2.95	5.0	88.1	17.3	13.3	385
76	8	13-Apr-13	1122	41 57.84	171 04.01	41 55.27	171 05.98	156	159	2.95	4.9	85.6	17.5	13.1	435
77	8	13-Apr-13	1342	41 49.50	170 59.14	41 46.75	171 00.64	165	169	2.96	4.9	85.6	17.6	13	460
78	8	13-Apr-13	1558	41 53.91	170 55.68	41 56.68	170 54.12	173	177	3.00	4.9	85.6	17.6	13	485
79	2	14-Apr-13	631	40 58.72	171 51.09	40 55.96	171 52.95	117	118	3.09	5.0	83.2	17.7	14.1	335
80	2	14-Apr-13	915	40 49.73	171 39.99	40 46.74	171 40.46	155	157	3.01	5.0	89.3	18.6	13.9	435
81	2	14-Apr-13	1106	40 47.45	171 43.74	40 44.62	171 45.19	150	153	3.03	5.0	84.8	18.7	13.9	410
82	2	14-Apr-13	1453	40 34.58	171 58.63	40 32.05	172 00.93	141	142	3.07	5.0	86.5	18.4	14.2	400

Not used for biomass estimates

Appendix 3: Catch summary in alphabetical order by species code. * = less than 0.5%.

Species code	Common name	Scientific name	Catch (kg)	% of total catch	No. of stations	Depth (m) Min	Depth (m) Max
ALL	*Alcithoe larochei*	*Alcithoe larochei*	0.1	*	1	159	159
ANC	Anchovy	*Engraulis australis*	0.2	*	2	31	39
API	Alert pigfish	*Alertichthys blacki*	0.5	*	1	230	230
ASC	Sea squirt	Ascidiacea	14.6	*	4	28	42
BAR	Barracouta	*Thyrsites atun*	5 670.8	10.2	64	26	370
BCO	Blue cod	*Parapercis colias*	43.4	*	12	28	93
BER	Numbfish	*Typhlonarke spp.*	2.5	*	1	303	303
BRI	Brill	*Colistium guntheri*	11	*	6	26	42
BRN	Barnacle	Cirripedia (Class)	0.3	*	1	351	351
BRZ	Brown stargazer	*Xenocephalus armatus*	0.2	*	1	60	60
BSQ	Broad squid	*Sepioteuthis australis*	0.4	*	3	24	33
BTA	Smooth deepsea skate	*Brochiraja asperula*	0.7	*	1	301	301
BTS	Prickly deepsea skate	*Brochiraja spinifera*	2.2	*	1	370	370
CAR	Carpet shark	*Cephaloscyllium isabellum*	955.9	1.7	67	24	372
CAS	Oblique banded rattail	*Coelorinchus aspercephalus*	1.5	*	1	301	301
CBI	Two saddle rattail	*Coelorinchus biclinozonalis*	772.5	1.4	35	31	351
CBO	Bollons's rattail	*Coelorinchus bollonsi*	12.6	*	1	303	303
CCX	Small banded rattail	*Coelorinchus parvifasciatus*	4.4	*	2	272	301
CDO	Capro dory	*Capromimus abbreviatus*	139.8	*	29	51	372
CDY	*Cosmasterias dyscrita*	*Cosmasterias dyscrita*	5.3	*	6	24	60
COL	Oliver's rattail	*Coelorinchus oliverianus*	3.8	*	3	272	303
CON	Conger eel	*Conger spp.*	61.7	*	10	24	62
COZ	Bryozoan	Bryozoa (Phylum)	0.9	*	2	42	51
CUC	Cucumber fish	*Paraulopus nigripinnis*	193.5	*	31	42	372
DMG	*Dipsacaster magnificus*	*Dipsacaster magnificus*	0.4	*	1	351	351
EGC	Egg case		0.7	*	2	26	57
EGR	Eagle ray	*Myliobatis tenuicaudatus*	45	*	3	32	35
ELE	Elephant fish	*Callorhinchus milii*	307.8	0.6	15	26	64
EMA	Blue mackerel	*Scomber australasicus*	0.1	*	1	28	28
ERA	Electric ray	*Torpedo fairchildi*	103.5	*	8	24	59
ESO	N.Z. sole	*Peltorhamphus novaezeelandiae*	59.7	*	14	24	64
FHD	Deepsea flathead	*Hoplichthys haswelli*	11.1	*	2	301	303
FLL	Fragments shell		48.4	*	7	28	60
FMA	*Fusitriton magellanicus*	*Fusitriton magellanicus*	0.3	*	1	35	35
FRO	Frostfish	*Lepidopus caudatus*	572.2	1.0	29	55	303
GAS	Gastropods	*Gastropoda*	3.2	*	7	42	303
GIZ	Giant stargazer	*Kathetostoma giganteum*	3 140.6	5.7	52	48	372
GLB	Globefish	*Contusus richei*	168.4	*	8	26	57
GLM	Green-lipped mussel	*Perna canaliculus*	16	*	2	32	55
GLS	Glass sponges	Hexactinellida (Class)	0.8	*	1	28	28
GRC	Grenadier cod	*Tripterophycis gilchristi*	0.1	*	1	351	351
GSH	Ghost shark	*Hydrolagus novaezealandiae*	1 201.5	2.2	37	53	351
GUR	Gurnard	*Chelidonichthys kumu*	1455	2.6	46	24	142
HAK	Hake	*Merluccius australis*	109.5	*	18	30	303
HAP	Hapuku	*Polyprion oxygeneios*	42.2	*	5	114	183
HDR	Hydroid corals		1.5	*	1	35	35
HOK	Hoki	*Macruronus novaezelandiae*	2 122.5	3.8	24	55	372
JAV	Javelin fish	*Lepidorhynchus denticulatus*	17.7	*	6	272	372
JDO	John dory	*Zeus faber*	244.6	*	28	24	239

Appendix 3 – continued.

Species code	Common name	Scientific name	Catch (kg)	% of total catch	No. of stations	Depth (m) Min	Depth (m) Max
JFI	Jellyfish		13.8	*	9	26	96
JGU	Spotted gurnard	*Pterygotrigla picta*	1	*	2	193	351
JMD	Greenback jack mackerel	*Trachurus declivis*	212.1	*	24	40	183
JMM	Slender jack mackerel	*Trachurus murphyi*	11.5	*	6	48	156
JMN	Yellowtail jack mackerel	*Trachurus novaezelandiae*	91.1	*	19	24	143
KAH	Kahawai	*Arripis trutta, A. xylabion*	11.1	*	4	39	62
KIN	Kingfish	*Seriola lalandi*	17.7	*	2	32	62
LEA	Leatherjacket	*Meuschenia scaber*	291.9	0.5	11	28	62
LIN	Ling	*Genypterus blacodes*	876	1.6	35	24	303
LSO	Lemon sole	*Pelotretis flavilatus*	70.6	*	32	24	156
NMP	Tarakihi	*Nemadactylus macropterus*	1 594.3	2.9	61	24	372
NOS	Arrow squid	*Nototodarus gouldi, N. sloanii*	397.5	0.7	61	24	372
NSD	Northern spiny dogfish	*Squalus griffini*	216.4	*	21	114	372
NUD	Nudibranchia	Nudibranchia (Order)	0.4	*	1	35	35
OCT	Octopus	*Pinnoctopus cordiformis*	34.1	*	11	26	193
ONG	Sponges	Porifera (Phylum)	46.3	*	12	24	142
OPE	Orange perch	*Lepidoperca aurantia*	5.3	*	2	230	372
OYS	Dredge oyster	*Ostrea chilensis*	1.4	*	2	32	42
PAD	Paddle crab	*Ovalipes catharus*	0.2	*	2	26	35
PAG	Pagurid	Paguroidea	0.2	*	2	55	239
PAT	*Patiriella spp.*	*Patiriella spp.*	0.1	*	1	48	48
PCO	Ahuru	*Auchenoceros punctatus*	6.9	*	14	26	142
PIG	Pigfish	*Congiopodus leucopaecilus*	0.3	*	2	122	132
PNE	*Proserpinaster neozelanicus*	*Proserpinaster neozelanicus*	0.3	*	3	114	142
POL	Polychaete	Polychaeta	0.3	*	1	24	24
POP	Porcupine fish	*Allomycterus jaculiferus*	102.3	*	10	38	155
PRK	Prawn killer	*Ibacus alticrenatus*	4	*	19	114	281
PYR	*Pyrosoma atlanticum*	*Pyrosoma atlanticum*	8.6	*	10	38	372
RBT	Redbait	*Emmelichthys nitidus*	0.3	*	3	118	301
RCO	Red cod	*Pseudophycis bachus*	3 351.6	6.0	51	24	303
RMU	Red mullet	*Upeneichthys lineatus*	0.4	*	1	28	28
RSK	Rough skate	*Zearaja nasuta*	388.5	0.7	42	28	372
RSO	Gemfish	*Rexea solandri*	212.3	*	13	140	372
SAL	Salps		1.8	*	1	351	351
SAM	Quinnat salmon	*Oncorhynchus tshawytscha*	4.6	*	1	31	31
SAZ	Sand stargazer	*Crapatalus novaezelandiae*	0.1	*	1	26	26
SCA	Scallop	*Pecten novaezelandiae*	4.2	*	5	24	42
SCC	Sea cucumber	*Stichopus mollis*	1.4	*	6	28	188
SCG	Scaly gurnard	*Lepidotrigla brachyoptera*	573.6	1.0	58	35	281
SCH	School shark	*Galeorhinus galeus*	1 076.9	1.9	60	24	372
SCI	Scampi	*Metanephrops challengeri*	0.6	*	3	272	303
SDO	Silver dory	*Cyttus novaezealandiae*	1658	3.0	32	42	372
SDR	Spiny seadragon	*Solegnathus spinosissimus*	0.6	*	4	60	164
SEQ	Sepiolid squid	Sepiolidae	0.1	*	1	370	370
SEV	Broadnose sevengill shark	*Notorynchus cepedianus*	18.8	*	1	230	230
SFL	Sand flounder	*Rhombosolea plebeia*	162.6	*	8	24	57
SNA	Snapper	*Pagrus auratus*	398.6	0.7	13	24	183
SPD	Spiny dogfish	*Squalus acanthias*	24 010.8	43.2	66	24	301
SPE	Sea perch	*Helicolenus spp.*	240	*	48	33	372

Appendix 3 – continued.

Species code	Common name	Scientific name	Catch (kg)	% of total catch	No. of stations	Depth (m) Min	Depth (m) Max
SPM	Broad sprat	*Sprattus muelleri*	3.1	*	11	26	65
SPO	Rig	*Mustelus lenticulatus*	434.6	0.8	36	24	281
SPR	Sprats	*Sprattus antipodum, S. muelleri*	0.6	*	1	39	39
SPS	Speckled sole	*Peltorhamphus latus*	0.1	*	1	33	33
SPZ	Spotted stargazer	*Genyagnus monopterygius*	1.2	*	1	24	24
SSH	Slender smooth-hound	*Gollum attenuatus*	46.8	*	3	351	372
SSI	Silverside	*Argentina elongata*	11.9	*	32	42	303
SSK	Smooth skate	*Dipturus innominatus*	240.4	*	24	28	351
STP	Solitary bowl coral	*Stephanocyathus platypus*	4.6	*	7	104	159
STY	Spotty	*Notolabrus celidotus*	3.1	*	4	24	38
SWA	Silver warehou	*Seriolella punctata*	91.7	*	46	26	372
TOD	Dark toadfish	*Neophrynichthys latus*	2.1	*	12	42	370
TOP	Pale toadfish	*Ambophthalmos angustus*	0.2	*	2	116	132
TRE	Trevally	*Pseudocaranx georgianus*	5	*	2	35	93
TUR	Turbot	*Colistium nudipinnis*	2.5	*	1	31	31
UNI	Unidentified		0.1	*	1	301	301
WAR	Common warehou	*Seriolella brama*	502.8	0.9	32	24	239
WIT	Witch	*Arnoglossus scapha*	291.6	0.5	63	24	372
WOD	Wood		261.2	0.5	15	26	301
YBO	Yellow boarfish	*Pentaceros decacanthus*	0.9	*	2	370	372
YEM	Yellow-eyed mullet	*Aldrichetta forsteri*	0.2	*	1	32	32

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

Taxon	No. of stations
Porifera	
Hexactinellida (Class)	1
Demospongiae	3
Bryozoa	2
Cnidaria: Anthozoa	
Stephanocyathus platypus	7
Crustacea: Palinura	
Ibacus alticrenatus	19
Crustacea: Decapoda	
Metanephrops challengeri	3
Crustacea: Paguridae	
Diacanthurus rubricatus	2
Crustacea: Anomura	2
Ovalipes catharus	
Arthropoda:	1
Cirripedia	
Echinoidea: Asteroidea	
Patiriella spp.	1
Proserpinaster neozelanicus	3
Cosmasterias dyscrita	6
Dipsacaster magnificus	1
Echinoidea: Holothuroidea	6
Stichopus mollis	
Annelida: Oligochaeta	
Stibarobdella benhami	1
Mollusca: Gastropoda	
Fusitriton magellanicus	1
Alcithoe ostenfeldi	5
Austrofusus glans	1
Mollusca: Bivalvia	
Pecten novaezelandiae	5
Perna canaliculus	2
Ostrea chilensis	2

Appendix 4—continued.

Tunicata:	
Ascidiacea	4
Leptoclinides novaezelandiae	1
Tunicata: Thaliacea	
Pyrosoma atlanticum	10