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Inshore trawl survey of Canterbury Bight and Pegasus Bay April–June 2016, (KAH1605)

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A bottom trawl survey of the east coast South Island (ECSI) in 10–400 m depths was carried out using R.V. *Kaharoa* (KAH1605) in April–June 2016. The core (30–400 m) survey was the eleventh in the winter ECSI inshore time series (1991–94, 1996, 2007–2009, 2012, 2014, and 2016). Four strata in 10–30 m (shallow strata), previously surveyed in 2007, 2012, and 2014, were surveyed again in 2016 to monitor elephantfish and red gurnard over their full depth range.

The stratified random trawl survey had a two-phase design optimised for dark ghost shark, giant stargazer, red cod, sea perch, spiny dogfish, and tarakihi in 30–400 m; and elephantfish and red gurnard in 10–400 m. A total of 92 successful stations (79 phase 1 and 13 phase 2) was completed from 17 core strata, with 18 further successful stations from the four shallow 10 to 30 m strata (all phase 1). Two additional core stations were included for spiny dogfish estimates of biomass and scaled length frequency only; these stations had large catches comprised mainly of spiny dogfish in which weight of the spiny dogfish catch was estimated satisfactorily, but not that of other species. Relative abundance estimates and coefficients of variation (CV) for the target species in the core strata were: dark ghost shark 15 271 t (25%); elephantfish 6812 t (68%); giant stargazer 565 t (17%); red cod 2268 t (54%); red gurnard 941 t (30%); sea perch 3032 t (29%); spiny dogfish 26 063 t (41%); and tarakihi 1462 t (31%). Biomass estimates and CVs for elephantfish and red gurnard in the core plus shallow strata were 7299 t (63%) and 2420 t (15%), respectively, with the shallow strata accounting for 7% of the biomass of elephantfish and 61% of the biomass of red gurnard.

Dorsal spines were collected for elephantfish (389), and otoliths for red gurnard (531), tarakihi (505), sea perch (504), giant stargazer (468) and red cod (512).

Data are presented on catch rates, biomass, spatial distribution, and length frequencies for the eight target and eight non-target QMS species. An analysis of mean rankings of species across all surveys in the time-series showed evidence of increased catchability in 2014. When only the eight target species were included, all surveys fall within the 95% confidence intervals and hence no survey can be regarded as having extreme catchability.

1. INTRODUCTION

1.1 The 2016 east coast South Island inshore trawl survey

This report describes the results of the 2016 east coast South Island (ECSI) bottom trawl survey in 10–400 m from late April to early June using R.V. *Kaharoa* (KAH1605). The survey was the eleventh in the winter ECSI time series in 30–400 m. Previous surveys were carried out in 1991–1994, 1996, 2007, 2008, 2009, 2012, and 2014 (Beentjes & Wass 1994, Beentjes 1995a, 1995b, 1998a, 1998b, Beentjes & Stevenson 2008, 2009, Beentjes et al. 2010, Beentjes et al. 2013, 2015). For the 2012 survey, red gurnard (*Chelidonichthys kumu*) and elephantfish (*Callorhinchus milii*) were officially added to the list of target species, bringing the total to eight (existing target species were: dark ghost shark, *Hydrolagus novaezelandiae;* giant stargazer, *Kathetostoma giganteum*; red cod, *Pseudophycis bachus*; sea perch, *Helicolenus percoides*; spiny dogfish, *Squalus acanthius*; and tarakihi, *Nemadactylus macropterus*).

1.2 Background to east coast South Island inshore trawl surveys

The main target species for the first five ECSI winter trawl surveys (1991 to 1994, and 1996) was red cod (pre-recruited and recruited), although other commercial species were also of interest (giant stargazer, barracouta, spiny dogfish, tarakihi, sea perch, ling, elephantfish, rig, dark ghost shark, and red gurnard). The winter time series up to 1996 was reviewed by Beentjes & Stevenson (2000). After 1996 the winter time series was discontinued because it was considered that red gurnard and elephantfish were not being adequately monitored and that these species would be more appropriately surveyed in summer, and in shallower depths. Consequently the winter survey was replaced by a summer time series (five consecutive surveys from 1996 to 2000). The summer trawl surveys used a finer codend mesh (28 mm compared to 60 mm in winter), the minimum depth range was reduced from 30 m to 10 m, and the target species were elephantfish, red gurnard, giant stargazer, pre-recruit red cod, and juvenile rig (later dropped as a target). The summer time series was reviewed by Beentjes & Stevenson (2001).

The summer time series was discontinued after the fifth in the time series (2000) because of the extreme fluctuations in catchability between surveys (Francis et al. 2001). Of the four surveys examined, three were deemed to have "extreme catchability". The biomass estimates for the target species were therefore not providing reliable abundance indices, some of which at the time, were incorporated in the 'Decision Rules' for Adaptive Management Species such as giant stargazer (STA 3), elephantfish (ELE 3), and red gurnard (GUR 3) (Ministry of Fisheries 2006). With the discontinuation of both the winter and summer surveys, in 1996 and 2000 respectively, there was no means of effectively monitoring many of the commercial ECSI inshore fish stocks. Further, since 1996, several new species were introduced into the QMS (e.g., skates, dark ghost shark, sea perch, and spiny dogfish). ECSI surveys also provided a useful comparison with Chatham Rise and sub-Antarctic middle depth trawl surveys because many of the species found on the ECSI tend to be smaller than elsewhere, indicating that this may be an important nursery ground (Beentjes et al. 2004).

A Ministry for Primary Industries workshop, held in May 2005 (SITS-REV-2012-07) to discuss ways of monitoring inshore species, concluded that a winter survey time series would provide reliable information on long-term trends in abundance for a number of inshore species. The 2007 survey marked the reinstatement of the winter survey time series, eleven years after the time series was discontinued. Following reinstatement, the 2007 to 2009 surveys retained the 30–400 m depth range and stratification (Figure 1), but also included four additional strata in 10–30 m. There were, however, no target species specified, nor additional days added to the survey to accommodate the extra stations in the 10–30 m shallow strata. Consequently, the allocated stations in 10–30 m strata were not always completed due to time and resource constraints, and because they were outside the 30–400 m core strata used in the historical winter time series, priority was low. In 2012, the ECSI survey range was formally expanded to include four strata in the 10–30 m depth range, primarily to monitor elephantfish and red gurnard, but also shallow dwelling target species.

Following reinstatement of the winter surveys in 2007, the intention was to carry out three consecutive surveys from 2007 to 2009, and then move to biennial surveys. The three year gap between 2009 and 2012 was to align the ECSI survey with the west coast South Island survey so that they run in alternate years. There have now been six surveys since the time series was reinstated (2007, 2008, 2009, 2012, 2014, and 2016).

1.3 Objectives

This report fulfils the final reporting requirement for Objectives 1–5 of Ministry for Primary Industries (MPI) Research Project INT2015/01.

Overall objective

To determine the relative abundance and distribution of southern inshore finfish species off the east coast of the South Island; focusing on red cod (*Pseudophycis bachus*), stargazer (*Kathetostoma giganteum*), sea perch (*Helicolenus percoides*), tarakihi (*Nemadactylus macropterus*), spiny dogfish (*Squalus acanthius*), elephantfish (*Callorhinchus milii*), red gurnard (*Chelidonichthys kumu*) and dark ghost shark (*Hydrolagus novaezelandiae*).

Specific objectives

1. To determine the relative abundance and distribution of dark ghost shark, elephantfish, red cod, red gurnard, spiny dogfish, giant stargazer, sea perch, and tarakihi, off the east coast of the South Island from the Waiau River to Shag Point by carrying out a trawl survey over the depth range 10 to 400 m. The target coefficients of variation (CVs) of the biomass estimates for these species are as follows: red cod (20–25%), sea perch (20%), giant stargazer (20%), tarakihi (20–30%), spiny dogfish (20%) elephantfish (20–30%), red gurnard (20%) and dark ghost shark (20–30%).
2. To collect the necessary data and determine the length frequency, length-weight relationship, and reproductive condition of red cod, giant stargazer, sea perch, tarakihi, spiny dogfish, elephantfish, red gurnard and dark ghost shark.
3. To collect otoliths from giant stargazer, sea perch, red gurnard, red cod, and tarakihi; and spines from elephantfish.
4. To collect the data to determine the length frequencies and catch weight of all other Quota Management System (QMS) species.
5. To identify benthic macro-invertebrates collected during the trawl survey.

2. METHODS

2.1 Survey area

Core strata (30–400 m)

The 2016 survey (KAH1605) in the 30–400 m depth range (‘core strata’) covered the same area as the previous winter surveys, extending from the Waiau River in the north to Shag Point in the south. The core strata survey area of 23 339 km^2, including untrawlable foul ground (2018 km^2), was divided into 17 strata, identical to those used in the 1994 and subsequent winter surveys (Figure 1, Table 1). Nine strata were used in the first three winter surveys (1991, 1992, and 1993), and these were subdivided into 17 strata in 1994 to reduce CVs for the target species red cod, as well as the other important commercial species. These strata subdivisions were made across depth (i.e., perpendicular to the coastline) and there were no changes to strata depth ranges or of the total survey area (see strata boundaries in Beentjes 1998a).

Shallow strata (10–30 m)

The 2016 survey in the 10–30 m depth range covered the same area as 2012 and 2014 surveys, and were also identical to the four ancillary strata surveyed (or part thereof) from 2007 to 2009 (Figure 1, Table 1). The shallow strata survey area was 3579 km^2, including untrawlable foul ground (236 km^2).

Core plus shallow strata (10–400 m)

The combined area that included all 21 strata in the 10–400 m depth range is referred to as the 'core plus shallow strata', an area of 26 918 km^2, including untrawlable foul ground (2244 km^2).

2.2 Survey design

Consistent with previous winter surveys, a two-phase random stratified station survey design was used (Francis 1984). To determine the theoretical number of stations required in each of the 21 strata to achieve the specified coefficient of variation (CV) for each of the eight target species, simulations using NIWA's Optimal Station Allocation Programme (*Allocate*) were carried out using catch rates for the eight target species from the last five winter surveys (2007, 2008, 2009, 2012, and 2014). Simulations were carried out for the eight target species, using the minimum and maximum of the CV range, and requiring a minimum of three stations per stratum for the seventeen 30 to 400 m strata (Table 2). For elephantfish and red gurnard, the same approach was used to optimise allocation in the 10–30 m strata, using strata catch rates from 2007, 2012 and 2014. The sum of the stratum maximum for each target species indicated that 125 stations were theoretically required to achieve the lower target CV range (Table 2). The number of stations that were likely to be completed within the survey timeframe, based on average tows per day from previous surveys, was about 125 and hence the phase 1 target was 100 stations, leaving 25 stations for phase 2 (i.e., an allocation of 80% phase 1). To achieve this number, the maximum across each stratum (excluding red cod where CVs are usually very high), was pro-rated down to 100 stations to achieve the number of phase 1 stations for the survey (Table 2).

Sufficient trawl stations to cover both first and second phase stations were generated for each stratum using the NIWA random station generator program (*Rand_stn* v1.00-2014-07-21), with the constraint that stations were at least 3 n. miles apart. Phase 2 stations were allocated using the NIWA program *SurvCalc* (Francis & Fu 2012). The program calculates the phase 1 station catch rate variance for each species in each stratum and outputs a table of estimated gains for each species by stratum (algorithm from Francis 1984). It also outputs an optimal station allocation across species and strata, and projected CVs based on any given allocation scenario. Hence, *SurvCalc* allows for phase 2 optimisation of more than one species. The final phase 2 allocation was adjusted according to factors such as time available, steaming distance, achieved CV for each target species, and species priority. Core strata species priority, in order of decreasing importance, was tarakihi, sea perch, dark ghost shark, and spiny dogfish. Giant stargazer is the only target species that does not usually require phase 2 allocation, whereas acceptable CVs for red cod are virtually unobtainable without considerably more effort than is practical – neither were included in the priority list. For elephantfish and red gurnard, phase 2 stations were allocated based on catch rates in the core plus shallow strata (10–400 m).

2.3 Vessel and gear

The vessel and trawl gear specifications were the same as for all previous ECSI winter surveys. R.V. *Kaharoa* is a 28 m stern trawler with a beam of 8.2 m, displacement of 302 t, engine power of 522 kW, and capable of trawling to depths of about 500 m. The two-panel bottom trawl net was constructed in 1991, specifically for the South Island trawl surveys; there are two nets (A and B), complete with ground rope and flotation. The nets fish hard down and achieve a headline height of about 4–5 m. Rectangular 'V' trawl doors fitted with Scanmar sensors were used and these achieve a doorspread of 80 m on average. For both the shallow (10–30 m) and core strata (30–400 m) depth ranges, 60 mm (knotless) codend mesh, standard for winter surveys, was used. A bottom contact sensor was deployed on the ground rope, and a net sonde monitor (Furuno CN22) attached to the headline to measure headline height. A Seabird Microcat CTD (conductivity, temperature, depth) data logger was also attached to the headline to record depth (by measuring pressure), water temperature, and salinity on all tows. All trawl gear was overhauled and specifications checked before the 2016 survey. Gear specifications were documented in Beentjes et al. (2013).

2.4 Timetable and survey plan

Following mobilisation, the R.V. *Kaharoa* departed Wellington on 24 April 2016 and arrived and began fishing in Pegasus Bay on 25 April in stratum 7 north east of Banks Peninsula. All phase 1 tows (10–400 m) north of and around Banks Peninsula were completed before heading generally southward to complete tows in the southern part of the ECSI survey area (Figure 2). This is the standard survey plan followed for ECSI surveys. The 10 to 30 m strata were surveyed along with the 30 to 400 m strata in the most efficient manner to reduce steaming time and to survey shallow strata when weather was too rough to survey the deeper strata. Saleable fish was initially landed into Lyttelton, but catches from south of Banks Peninsula were landed into Timaru. The first leg was completed on 15 May when the vessel discharged fish at Timaru and there was a change of scientific staff. The last tow was on 4 June, and after discharging the catch into Timaru the vessel steamed to Wellington, arriving on 6 June for demobilisation. Eight days fishing were lost to bad weather, and three days were required to deal with unloading fish and gear damage during the survey.

2.5 Trawling procedure

Trawling procedures followed those documented by Stevenson & Hanchet (1999) and as well as the protocols from previous surveys in the time series. All tows were carried out in daylight (shooting and hauling) between 0730 and 1700 hours NZST. Tows were standardised at 1 hour long at a speed of 3.0 knots resulting in a tow length of about 3 n. miles. For some areas, large catches of dogfish and barracouta made tows unmanageable and the standard towing time was reduced, but with a minimum acceptable tow length of 1.5 n. miles. Potentially large catches were indicated by fish moving under the net monitor and changes in the doorspread. Timing began when the net reached the bottom and settled, as indicated by the net monitor, and finished when hauling began. Standardised optimal warp/depth ratio for different depths was strictly adhered to. Tow direction was generally along depth contours and/or towards the nearest random station position, but was also dependent on wind direction and bathymetry. Some tow paths, particularly those on the slope in 200–400 m, were surveyed before towing to ensure that they were acceptable, both in depth and trawlable bathymetry. When untrawlable ground was encountered, an area within a 2 n. mile radius of the station was searched for suitable ground. If no suitable ground was found within that radius, the next alternative random station was selected. Doorspread (Scanmar monitor*)* and headline height (net monitor) data were transmitted remotely to the ship and were monitored continuously during the tow. Both parameters were recorded manually at 10–15 minute intervals, and averaged over the tow.

At the end of the tow, immediately after the gear came on deck, the ground contact sensor and CTD data files were downloaded. Bottom and surface water temperatures were taken from the CTD output data with surface temperatures at a depth of 5 m and bottom temperatures about 5 m above the sea floor where the CTD is attached to the net just behind the headline.

2.6 Catch and biological sampling

The catch from each tow was sorted by species, boxed, and weighed on motion-compensated 100 kg Seaway scales to the nearest 0.1 kg. Length, to the nearest centimetre below actual length, and sex were recorded for all QMS and selected non-QMS species, either for the whole catch or, for larger catches, on a subsample of about 100 randomly selected fish. All data were captured electronically from scales or digitised measuring boards that connect to the *Trawl Coordinator Access Database* in real time allowing live error checking.

For each tow, biological information was obtained from a sample of up to 20 fish (sub-sampled from the random length frequency sample) for each target species, during which the following records or samples were taken: sex, length to the nearest centimetre below actual length; individual fish weight to the nearest 5 g (using motion-compensated 5 kg Seaway scales); sagittal otoliths from all five target finfish and dorsal spines from elephantfish; and gonad stages (Appendix 1). Individual weights were also recorded for some non-target QMS species to provide current length-weight relationships.

Otoliths were stored clean and dry in small paper envelopes and elephantfish spines were placed into zip-lock plastic bags and frozen. All specimens were labelled with the survey trip code, station number, species, fish number, length, and sex.

The otolith collection method before the 2014 survey involved removing at least five otoliths or spines per centimetre size class per sex, endeavouring to spread the collection across the entire survey area. In 2014 and again in 2016 this procedure was modified as follows. From each tow (if sufficient numbers were available) 10 otoliths or spines were collected. These 10 fish were randomly selected, but to ensure that the full size range was sampled, otoliths and spines were sometimes collected from the very small and very large fish, out of the random length frequency sample. This approach resulted in many more otoliths and spines being collected on the survey than from previous surveys, but aimed to avoid any possible spatial bias resulting from filling the bulk of the length bins in the early part of the survey.

Macro-invertebrates that could not be clearly identified on deck, were retained and preserved for later identification at Greta Point.

2.7 Data storage

All catch, biological, and length frequency data were entered into the MPI *trawl* research database after the survey was completed. Data from fish for which otoliths were removed or elephantfish for which dorsal spines were removed, were entered into the MPI *age* research database, and the otoliths and spines were stored at NIWA, Greta Point. After identification of invertebrates (at sea), data were entered into the *trawl* database The parameters used in *SurvCalc* for estimating biomass and length frequency from the 2016 and earlier surveys, were archived under the project INT2015-01.

2.8 Analysis of data

Relative biomass and coefficients of variation were estimated by the area-swept method described by Francis (1981, 1989) using *SurvCalc* (Francis & Fu 2012). All tows for which the gear performance was satisfactory (code 1 or 2) were used for biomass estimation. Biomass estimates assume that: the area swept on each tow equals the distance between the doors multiplied by the distance towed; all fish within the area swept are caught and there is no escapement; all fish in the water column are below the headline height and available to the net; there are no target species outside the survey area; and fish distribution over foul ground is the same as that over trawlable ground.

The combined biomass and length frequency analysis option in *SurvCalc* was used for deriving scaled length frequency distributions and biomass estimates. All length frequencies were scaled by the percentage of catch sampled, area swept, and stratum area.

For the eight target species (dark ghost shark (GSH), elephantfish (ELE), giant stargazer (GIZ), red cod (RCO), red gurnard (GUR), sea perch (SPE), spiny dogfish (SPD), and tarakihi (NMP)), estimates of total biomass, pre-recruited, recruited, and immature and mature biomass were calculated and compared to previous surveys in the ECSI time-series. Total biomass estimates are also presented for eight key non target QMS species: barracouta (BAR), lemon sole (LSO), ling (LIN), rough skate (RSK), school shark (SCH), smooth skate (SSK), rig (SPO), and silver warehou (SWA); as recommended by Beentjes & MacGibbon (2013). For spiny dogfish there is a discrepancy between the sum of recruited and pre-recruited biomass when compared with total biomass for the total survey area. This is because of a large catch (4450 kg) of spiny dogfish in stratum three (station 57), where it was not possible to safely haul the trawl on board and take a representative sample for length frequencies. The weight of this catch had to be estimated by eye. *SurvCalc* cannot calculate scaled population length frequencies for any stratum where less than 30 % of the total catch for that stratum had at least a sample taken from it for length frequencies. The catch from station 57 comprised 90% of the total catch from stratum 3 and so scaled population length frequencies could not be calculated. As recruited and pre-recruited biomass are length-based sub-populations, their estimates can only be calculated for strata where scaled population frequencies can also be calculated. For the same reason, juvenile and adult biomass could not be calculated for stratum three, and hence there is a discrepancy between the sum of juvenile and adult spiny dogfish biomass when compared with total biomass for the total survey area

Separate analyses of total biomass were carried out for the core strata (30–400 m) and core plus the shallow strata (10–400 m). These are plotted on the same figures to show the contribution of biomass made by the 10 to 30 m shallow strata. For the core strata (30–400 m), time series of total, pre-recruited, and recruited biomass for the target species are tabulated and plotted by survey to show temporal trends. Size at recruitment to the fishery were presumed to be: ELE, 50 cm; GUR, 30 cm; GSH, 55 cm; RCO, 40 cm; STA, 30 cm; SPD, 50 cm; SPE, 20 cm; TAR, 25 cm.

Time series biomass equal to and above length-at-50% maturity, and below length-at-50% maturity were also tabulated and plotted for target species. Length-at-50%-maturity estimates were taken from Hurst et al. (2000) for all target species except sea perch, where it was estimated from the cumulative length frequencies of all the mature stages from the 2008 survey. Hurst et al. (2000) averaged the size at maturity between males and females for the teleosts because they were similar, but for the elasmobranchs, where it varied more than 10 cm between sexes, values are provided for both males and females. Hence we estimated teleost 50% maturity biomass for GUR, RCO, GIZ, and NMP for males and females combined, but for males and females separately for GSH and SPD, and ELE. The cut-off lengths used were: GUR, 22 cm; RCO, 51 cm; GIZ, 45 cm; NMP, 31 cm; SPE, 26 cm; GSH males 52 cm, females 62 cm; SPD males 58 cm, females 72 cm; ELE males 51, females 70 cm:

Catch rates (kg km^{-2}) for the target and key QMS species were tabulated by stratum and plotted on the survey strata map for each tow to show areas of relative density throughout the survey area. For the core strata (30–400 m), the percent occurrence (i.e., the proportion of tows with non-zero catch) of each target species was tabulated for each survey. Similarly, the catch of each target species as a percent of the catch of all species from each survey was tabulated.

Scaled length frequency distributions are plotted for the target species and key non-target QMS species, and also by depth range for the target species. Length-weight coefficients for 2016 were determined for all eight target species and also for rig, rough skate, school shark, and smooth skate. Coefficients were determined by regressing natural log weight against natural log length ($W=aL^b$). These length-weight coefficients were used to scale length frequencies, and potentially to calculate recruited and pre-recruited biomass. For other species, the most appropriate length-weight coefficients in the *trawl* database were used.

Biomass estimates and length frequency distributions for ECSI winter surveys in 1991 to 1994 in this report and in the review of the time series (Beentjes & Stevenson 2000) may differ from those in the original survey reports (Beentjes & Wass 1994, Beentjes 1995a, 1995b, 1998b) because doorspread was not measured on those surveys and was assumed to be 79 m for all tows. The biomass estimates from these surveys were later recalculated using the relationship between doorspread (measured using Scanmar) and depth determined by Drummond & Stevenson (1996). Scanmar was subsequently used from the 1996 surveys onward where doorspread was measured directly.

2.9 Survey representativeness

Representativeness refers to the survey catchability and whether the biomass estimate from a range of species was within an acceptable range (representative) or was extreme (non-representative). This approach was derived from the work by Francis et al. (2001) who examined data from 17 trawl survey time series including the ECSI winter survey time series from 1991 to 1996. The method involves ranking species in order of increasing biomass index, and then averaging across species to obtain a mean rank for each year. This analysis was updated for the ECSI winter surveys including the five surveys from 2007 to 2014 (Beentjes et al. 2015). Species included in the ranking calculations were the eight target species and 10 other species that are most commonly caught on these surveys (barracouta, carpet shark, New Zealand sole, lemon sole, pigfish, scaly gurnard, school shark, rig, blue warehou, and witch flounder). This analysis was updated by including the 2016 survey results. In addition, the analysis was run with the target species only.

3. RESULTS

3.1 Trawling details

A total of 97 tows were carried out in the core strata (30–400 m). Two tows (stations 5 and 108) had unsatisfactory gear performance, one tow (station 58) had a distance towed of less than 1.5 n. mile, and two tows (stations 23 and 57) had very larges catches comprised mainly of spiny dogfish in which weight of the spiny dogfish catch was estimated satisfactorily, but not that of other species. The remaining 92 stations were used in length frequency and biomass estimation for all species. Estimates for spiny dogfish also included tows 23 and 57 (Table 1, Appendix 2). All planned phase-one tows in core strata were completed (N = 79). The survey covered the same total area as the previous winter surveys with at least three successful stations completed in each of the 17 strata (Table 1). Station density ranged from one station per 57 km^2 in stratum 8 to one station per 791 km^2 in stratum 6, with an overall average density of one station per 220 km^2 (Table 1). Of the total survey area, 9% was defined as foul ground and untrawlable. Station positions and tow numbers are plotted in Figure 2, and individual station data tabulated in Appendix 2.

In the shallow strata (10–30 m), 19 tows were carried out, and all but one (station 80) had satisfactory gear performance. The 18 successful tows were used in length frequency and biomass estimation (Table 1, Appendix 2). All planned phase 1 tows in shallow strata were completed (N = 18). Of the total survey area in the shallow strata, 6% was defined as foul ground and untrawlable. Station positions and tow numbers are shown in Figure 2 and individual station data in Appendix 2.

Only 13 of the planned 25 phase 2 tows were achieved, due mainly to eight days of bad weather. All phase 2 tows were allocated to three core strata to reduce CVs for target species (Table 1, Appendix 2).

Monitoring of headline height and doorspread, observations that the doors and trawl gear were polishing well, and information from the ground contact sensors, indicated that the gear was fishing hard down and efficiently throughout the survey. For the core strata (30–400 m), means for doorspread, headline height, distance towed, and warp to depth ratio were 77.5 m, 4.8 m, 2.8 n. miles, and 3.2:1, respectively (Appendix 3). For the shallow strata (10–30 m), means for doorspread, headline height, distance towed, and warp to depth ratio were 73.2 m, 4.8 m, 2.8 n. miles, and 10.9:1, respectively (Appendix 3). Net-A was used on all tows before station 6, and Net-B in subsequent tows after damage was sustained to Net-A when the gear became ‘fast’ on station 5.

Surface and bottom temperatures for each station are shown in Appendix 2. Problems with the CTD resulted in missing temperatures on five stations.

3.2 Catch composition

Core strata (30–400 m)

The total catch from the core strata (30–400 m) was 148.1 t from the 92 biomass tows, and 157.5 t including the tows 23 and 57 (hereafter referred to as the spiny dogfish tows). Catches from the 92 tows were highly variable, ranging from 120 kg to 13 635 kg per tow, with an average of 1610 kg. Vertebrate fish species caught included 13 chondrichthyans, and 67 teleosts (Appendix 4). There were also many invertebrate species caught. Catch weights, percent catch, occurrence, and depth range of all species identified during the survey are given in Appendix 4. The catches were dominated by dark ghost shark (32 t), barracouta (26 t), spiny dogfish (19 t), elephant fish (18 t), and sea perch (7 t), representing 22%, 17%, 13%, 12% and 5% respectively, of the total catch. These five species, and the next five most abundant species (NZ southern arrow squid, two saddle rattail, crested bellows fish, red cod, and tarakihi) made up 84% of the total catch (Appendix 4). The percentage of the catch represented by the eight target species was as follows: dark ghost shark 22%; elephantfish 12%, giant stargazer 1%; red cod 3%; red gurnard 1%, sea perch 5%; spiny dogfish 13%; and tarakihi 2%, making a combined total of 58%. Spiny dogfish was caught in 98% and barracouta in 91% of tows. Other non-target species commonly caught included arrow squid (92% of tows), witch (91% of tows), and carpet shark (85% of tows) (Appendix 4).

Shallow strata (10–30 m)

The total catch in 10–30 m depth range was 18.4 t from the 18 biomass tows. Catches were highly variable, ranging from 106 to 3805 kg per tow, with an average of 1021 kg. Vertebrate fish species caught included eight chondrichthyans and 34 teleosts (Appendix 4). Catch weights, percent catch, occurrence, and depth range of all species identified during the survey are given in Appendix 4. The shallow catches were dominated by barracouta (6.9 t), leatherjacket (3.2 t), red gurnard (2.7 t), spiny dogfish (2.3 t), and elephantfish (0.9 t), representing 37%, 18%, 15%, 13% and 5%, respectively, of the total catch. These five species, and the next five most abundant species (rough skate, carpet shark, red cod, rig, and octopus) made up 95% of the total shallow catch (Appendix 4). The percent of the shallow catch represented by the eight target species was as follows: dark ghost shark 0%; elephantfish 5.2%, giant stargazer 0%; red cod 0.8%; red gurnard 14.7%, sea perch 0%; spiny dogfish 12.6%; tarakihi 0.7%, making a combined total of 34.0% (Appendix 4).

3.3 Biomass estimates

Core strata (30–400 m)

Biomass estimates and CVs for the target species and the eight key non target QMS species in the core strata (30–400 m) are given in Table 3 (Panel A). Of the target species, spiny dogfish had by far the largest total biomass at 26 063 t (CV = 41%), followed by dark ghost shark (15 271 t, CV = 25%), elephantfish (6812 t, CV = 68%), sea perch (3032 t, CV = 29%), red cod (2268 t, CV = 54%), tarakihi (1462 t, CV = 31%), red gurnard (941 t, CV = 30%), and giant stargazer (565 t, CV = 17%). The CVs were within or very close to the range specified in the project objectives for dark ghost shark, giant stargazer, and tarakihi (see Section 1.5 Objectives). However, the CVs were 29% higher than the target for red cod, 21% higher for spiny dogfish, and 9% higher for sea perch. There were no target CVs specified for red gurnard and elephantfish in the core strata.

The breakdown of biomass for target species by sex showed strongly unbalanced sex ratios for spiny dogfish where the biomass was 77% male, and elephantfish biomass was 87% male. For the other target species biomass by sex was within the range of 41 to 61% male (Table 3, panel A).

Of the eight key QMS species, barracouta had the largest biomass at 19 708 t and a CV of 27% (Table 3, panel A). Other species with substantial biomass included rough skate (1142 t, CV = 30%), and smooth skate (663 t, CV = 17%).

Recruited biomass estimates and CVs for the target species and the eight key QMS species are shown in Table 3. For the core strata target species the percentage of total biomass that was recruited fish was spiny dogfish 69%, dark ghost shark 46%, tarakihi 77%, sea perch 96%, red cod 74%, and giant stargazer 96%.

Core plus shallow strata (10–400 m)

Biomass estimates and CVs in the core plus shallow strata (10–400 m) for elephantfish and red gurnard, as well as target species and key QMS species that were caught in less than 30 m are given in Table 3 (panel B). Of the target species, spiny dogfish had by far the largest total biomass at 27 300 t (CV = 39%), followed by elephantfish (7299 t, CV = 63%), red gurnard (2420 t, CV = 15%), and red cod (2360 t, CV = 52%). The red gurnard CV was less than the target of 20%, but elephant fish was 33% higher than the target of 30%. There were no target CVs specified for the other six target species in the core plus shallow strata.

The breakdown of biomass for target species by sex in the core plus shallow strata showed that males comprised 83% of the total elephantfish biomass, similar to the sex ratio in the core strata (Table 3, panels A and B). For red gurnard the proportion of males was closer to parity at 43% male, but is was less than in the core strata where it was 61%. Red cod biomass was 59% male and spiny dogfish 76% male, both almost the same as in the core strata.

Of the five key QMS species caught in the core plus shallow strata, barracouta had the largest biomass of all species at 23 007 t and a CV of 24% (Table 3, panel B). The only other species with substantial biomass was rough skate (1576 t, CV = 22%).

Recruited biomass estimates and CVs for the target species and the key QMS species in the core plus shallow strata are shown in Table 3 (panel B). For elephantfish the percentage of total biomass that was recruited fish was 98% compared to 99% for the core strata. Similarly, for red gurnard it was 87% compared with 93% for the core strata. For spiny dogfish and red cod the recruited biomass proportions were almost the same as in the core strata at 67% and 75%, respectively.

3.4 Strata catch rates, biomass, and distribution

For the eight target and eight key QMS species catch rates by stratum are given in Table 4, and catch rates by station are plotted in Figures 3 and 4. Biomass by stratum is given in Table 5. Strata with the highest catch rates were not always the same as those with the highest biomass because biomass was scaled by the area of the stratum.

Dark ghost shark was predominantly caught in waters deeper than 100 m throughout the survey area. They occurred in 40% of core tows, with the shallowest catch in 70 m and the deepest in 385 m (Appendix 4). Highest catch rates and biomass estimates were in 100 to 400 m in strata 10 and 15 (Figure 3, Tables 4 and 5).

Elephantfish was caught between 14 and 139 m, in 31% of core tows and 83% of shallow tows (Appendix 4). Highest catch rates and biomass estimates were in core stratum 1, and shallow strata 19 and 20 (Figure 3, Tables 4 and 5)

Giant stargazer was predominantly caught in waters deeper than about 50 m throughout the survey area. They occurred in 78% of core tows, with the shallowest catch in 42 m and the deepest in 385 m (Appendix 4). Highest catch rates were in stratum 8, and the highest biomass estimates in stratum 3 (Figure 3, Tables 4 and 5).

Red cod was caught between 14 and 365 m in 66% of core tows and 50% of shallow tows (Appendix 4). Highest catch rates and biomass estimates were in core strata 11 and 15, and shallow strata 18 and 20 (Figure 3, Tables 4 and 5).

Red gurnard was caught between 13 and 139 m, in 61% of core tows and 100% of shallow tows (Appendix 4). Highest catch rates and biomass estimates were in core strata 4 and 7, and shallow strata 20 and 21 (Figure 3, Tables 4 and 5)

Sea perch was caught between 31 and 385 m, predominantly in 100 to 200 m and was caught in 72% of core tows (Appendix 4). The highest catch rates and biomass estimates were in 100 to 200 m stratum 8 (Figure 3, Tables 4 and 5).

Spiny dogfish was caught in all depth ranges throughout the survey area between 13 and 385 m in 98% of core tows and 100% or shallow tows (Appendix 4). The highest catch rates and biomass estimates were in core strata 3, 7, and 15 (Figure 3, Tables 4 and 5).

Tarakihi was caught between 31 and 347 m, but predominantly in 50 to 100 m with the exception of one large catch from a tow in stratum 8 (100–200 m), throughout the survey area. They were caught in 70% of core tows (Appendix 4). The highest catch rates were in stratum 8, and the highest biomass estimates in strata 4 and 8 (Figure 3, Tables 4 and 5).

3.5 Biological and length frequency data

Details of length frequency and biological data recorded for each species are given in Table 6. Just over 40 000 length frequency and nearly 9 000 biological records were taken from 48 species. This included otoliths from 468 giant stargazer, 512 red cod, 531 red gurnard, 504 sea perch, and 505 tarakihi. Dorsal spines were collected from 389 elephantfish.

Scaled length frequency distributions for dark ghost shark, giant stargazer, red cod, sea perch, spiny dogfish, and tarakihi are plotted from core strata (30–400 m) as well as for the depth ranges 10–30 m (where appropriate), 30–100 m, 100–200 m, and 200–400 m (Figure 5). For elephantfish and red gurnard, distributions are shown for the core plus shallow (10–400 m) and also for the four depth ranges. For the key QMS species, scaled length frequency distributions in the core strata (30–400 m) and the 10 to 30 m depth range are plotted in Figure 6. The length-weight coefficients used to scale the length frequency data are shown in Appendix 5.

Dark ghost shark – The length frequency distribution for dark ghost shark males shows two modes at about 40 and 50 cm for males, and 40 and 60 cm for females (Figure 5). The largest fish (over 60 cm) were mostly females. The bulk of the males and females were pre-recruited fish (under 55 cm). For both sexes the larger modes were mainly caught in 100–200 m, whereas the smaller modes were mainly caught in the deeper 200 to 400 m depth range, although the size distribution was wide. Dark ghost shark in the 200 to 400 m depth, comprised virtually all pre-recruited fish. The overall scaled numbers sex ratio in the core strata (30–400 m) was 57% male (Figure 5).

Elephantfish – The length frequency distributions for elephantfish showed a strong juvenile male mode centred at about 60 cm, with indications of small 1+ mode at about 25 cm. Females, in contrast, do not show any clear or strong modes, with the possible exception of a 1+ mode at about 25 cm (Figure 5). The female length distribution had a wider right hand tail indicating that the largest fish were mostly females. For males the strong 60 cm mode was largely restricted to 30–100 m and the smaller 25 cm 1+ mode was found exclusively in the shallower 10–30 m depth range. Similarly, larger females were caught deeper and the 1+ mode only in the shallower 10–30 m strata. The overall scaled population sex ratios were heavily skewed towards male, at 84% male in core plus shallow (10–400 m) and 90% in the core strata (30–400 m).

Giant stargazer – The length frequency distributions for giant stargazer males and females had no clear modes, and based on previous ageing (Sutton 1999) were comprised of multiple cohorts, with the possible exception of juvenile modes for both sexes centred at about 18 cm (Figure 5). The female length distribution had a wider right hand tail indicating that the largest fish were mostly females. For both sexes the length distributions were generally similar in 30 to 100 m, 100 to 200 m, and possibly 200 to 400 m although numbers are low in the latter depth range. Giant stargazer were more than twice as common in 30 to 100 m than 100 to 200 m, with less than 2% of the population found in 200–400 m. The overall scaled numbers sex ratio in core strata (30–400 m) was 50% male.

Red cod – The length frequency distributions for all red cod (of which 7% were unsexed) showed well-defined modes at about 10–25 cm (0+) and 30–45 cm (1+), with the larger less defined mode comprising fish of 2+, 3+, and 4+ cohorts (Figure 5). These modes were also evident for the male and female distributions, although the latter modes were slightly larger as females grow faster (Horn 1996, Beentjes 2000). The bulk of the red cod were in 100 to 200 m with the small 0+ fish absent in 200–400 m depth range, and the larger 1 + and older fish uncommon in the shallow 30–100 m depths. Less than 2% of the red cod population was in the shallow 10–30 m depths, although the full size range appears to be represented. The overall scaled numbers sex ratio was 61% male in both the core strata (30–400 m) and core plus shallow strata (10–400 m).

Red gurnard – The length frequency distributions for red gurnard male and female had two clear modes centred at about 25 cm and 35 cm (combined sexes), but neither mode represents a single cohort and based on ageing, the distribution comprised ages from about 1 to 13 years (Sutton 1997) (Figure 5). The smaller mode, however, was likely to be mainly 1+ and 2+ fish. Female length distribution had a wider right hand tail indicating that the largest fish were mostly females. Red gurnard were caught mainly in 10 to 100 m with the smaller 25 cm mode more prominent and females more abundant in the shallow 10 to 30 m depth range. The overall scaled numbers sex ratio was 51% male in core plus shallow (10–400 m), and 70% male in the core strata (30–400 m).

Sea perch – The length frequency distribution for sea perch was unimodal with peaks at about 25 cm for males and females, with little difference between sexes (Figure 5). Although found from 30 to 400 m they were most common in 100–200 m and least common in 200–400 m, with no separation of size by depth. The overall scaled numbers sex ratio in 30–400 m was 48% male.

Spiny dogfish – The length frequency distributions for spiny dogfish showed a clear mode at about 65 cm for males in 10–400 m, and smaller modes at about 30 cm for both sexes, more apparent in the shallow 10–30 m depths (Figure 5). Spiny dogfish were caught in all depth ranges, including the shallow 10 to 30 m, but the bulk of fish were in 30–100 m, with the smaller fish in shallow (10–30 m) and the larger fish deeper than 100 m. The overall scaled numbers sex ratio was 69% male in the core strata (30–400 m) and 67% in the core plus shallow strata (10–400 m).

Tarakihi –The length frequency distribution for tarakihi (of which 9% were unsexed) showed modes at about 12 cm, 18 cm, and possibly 27 cm for both sexes. The largest fish are females, and there were few fish over 35 cm (Figure 5). The smallest modes are likely to be 0+ and 1+ fish. Tarakihi were caught in 30 to 400 m, but the bulk were caught in 30–100 m, with less than 0.5% of the tarakihi in deeper than 200 m. The two smallest modes were largely confined to less than 100 m. The overall scaled numbers sex ratio in the core strata (30–400 m) was 52% male.

Gonad stages

Details of the gonad stages for the target species are given in Table 7. Giant stargazer were mostly resting/immature, although 13% of males were classified as ripening. Red cod and tarakihi were predominantly immature/resting. Sea perch females were predominantly immature/resting, whereas males displayed all five stages, but mainly the maturing stage. Red gurnard in the core strata (30–400 m) were predominantly immature/resting, but there were reasonable numbers of fish that were maturing, running ripe, and spent indicating some spawning activity was occurring. Red gurnard gonad stages were similar in the shallow strata (10–30 m), but with less spawning activity. Dark ghost shark showed all gonad stages and about half of males and females were mature, with 5% of females in the mature and gravid spawning condition. Spiny dogfish showed a mix of stages with all stages present for both sexes except female spent. Eighty five percent of the spiny dogfish males were mature, and over one third of the females were classified as pregnant (i.e., with large yolked eggs in the ovary). In contrast, most male and female elephantfish in the core strata (30–400 m) were maturing or mature, whereas in the shallow strata (10–30 m) immature and maturing were the predominant gonad stages for both sexes.

4. DISCUSSION

4.1 2016 survey

The 2016 survey was successful in meeting all the project objectives and the CVs were within the specified range in core strata (30–400 m) for dark ghost shark, tarakihi, giant stargazer, within 9% of the target for sea perch, but over 20% higher for spiny dogfish and red cod (Table 3). For red cod the CV was 29% above the upper target limit of 25%. It has historically been difficult to achieve low CVs for red cod, even during the early surveys when it was the only target species. This is because red cod tends to form aggregations of cohorts and catches are often highly variable among tows which are characterised by many zero-catch tows and the occasional very large catch; this was also the case in 2016 (see Figure 3). The red cod CV of 54% in 2016 was 13% higher than the average of 41% from the ten surveys. Further, in years of high red cod abundance (or recruitment) low CVs become even more difficult to achieve, as in 2012 when a very strong 1+ cohort dominated the red cod catch and the CV was 79%. The spiny dogfish CV of 41% is 18% higher than the ten year average before 2016, a result of two particularly large catches in strata 3 and 7 (see Figure 3).

The CV for red gurnard of 15% in core plus shallow strata (10–400 m) was less than the target of 20%, and for elephantfish the CV of 63% was more than twice the upper limit of the target range of 30%. The high elephantfish CV was mainly a result of the very large catch from a single tow in stratum 1 (see Figure 3).

4.2 Time series trends in biomass, distribution, and size

Implicit in our interpretation of trends in biomass, geographic distribution, and length distribution is that we have no information on these variables over the 11 year interval between the 1996 and 2007 surveys.

In the discussion below, unless explicitly stated, we refer to the core strata (30–400 m).

4.2.1 Target species

Dark ghost shark

Total biomass in the core strata increased 16-fold between 1992 and 2016 (Table 8, Figure 7). Dark ghost shark on the Chatham Rise show a general similar trend of increasing biomass since 1995 (Stevens et al. 2015), whereas biomass from the Sub-Antarctic surveys has fluctuated without trend (Bagley et al. In prep). All surveys had a large component of pre-recruit biomass ranging from 30–61% (Table 9, Figure 8) – in 2016 the pre-recruit biomass was relatively high at 54% of total biomass. The juvenile and adult biomass (based on length-at-50% maturity) of both sexes have generally increased proportionately over the time series and juvenile biomass comprised about half of the total biomass. In 2016 the juvenile biomass was 49% of total biomass. (Table 10, Figure 9).

Dark ghost shark was present in 27–57% of core strata tows (40% in 2014), with a general trend of increasing occurrence (Table 11) and comprised 2–21% of the total catch on the surveys, with a clear increasing trend, peaking in 2016 at 21% of the catch (Table 11). Distribution over the time series was similar and was confined to the continental slope and edge mainly in the Canterbury Bight, although the larger biomass from 2007 to 2016 is commensurate with a slightly expanded distribution throughout the survey area in this depth range and into Pegasus Bay (Figure 10).

The size distributions in each of the last nine surveys (1993–2016) were similar and generally bimodal (Figure 11). The 2012, 2014 and 2016 length frequency distributions were distinct from previous years with relatively large numbers of adults or mature fish. The distributions differ from those of the Chatham Rise and Southland/Sub-Antarctic surveys (O'Driscoll & Bagley 2001, Livingston et al. 2002, Stevens et al. 2015, Bagley et al. In prep) in that ECSI has a large component of juvenile fish, suggesting that this area is an important nursery ground for dark ghost shark.

Elephantfish

Total biomass in the core strata increased markedly in 1996 and although it has fluctuated since then it has remained high with the post-1994 average of 1032 t up to and including 2014 about three-fold greater than that of the early 1990s (Table 8, Figure 7). The 2016 biomass was more than six-fold greater than this average but the CV around the estimate was 68%, very high compared to previous surveys. The proportion of pre-recruited biomass in the core strata varied greatly among surveys ranging from 50% in 2007 to only 1% in 2016, the latter value reflecting the high numbers of large fish present in 2016 (Table 9, Figure 8). Similarly, the proportion of juvenile biomass (based on the length-at-50% maturity) in 2016 was the lowest of all surveys at 6% compared to 28% in 2014 (Table 10, Figure 9).

Elephantfish were present in 30–35 % of core strata tows up to 1996, and then increased from 37 to 47% in the following five surveys before declining in 2016 to 31%. Elephantfish have consistently made up 1–2% of the total catch on all surveys up to 2014, with a large increase to 12% in 2016 largely driven by the high numbers of mature large fish and the exceptionally large catch from a single tow in stratum 1 (Table 11, Figure 10). The distribution of elephantfish hot spots varies over the time series, but overall this species was consistently well represented from 10 to 100 m over the entire survey area. (Figure 10).

The size distributions of elephantfish were inconsistent among the eleven core strata surveys but generally characterised by a wide right hand tail of 3+ and older fish (up to about 10 years) based on the ageing of Francis (1997), and the occasional poorly represented 1+ and 2+ cohort modes (Figure 11).

The additional elephantfish biomass captured in the 10–30 m depth range accounted for 44%, 64%, 41% and 7% of the biomass in the core plus shallow strata (10–400 m) for 2007, 2012, 2014 and 2016 respectively, indicating the importance of shallow strata for elephantfish biomass (Table 8, Figure 7). The low value of 7% in 2016 indicates that elephantfish distribution was deeper overall than in the three previous core plus shallow surveys. Further, the inclusion of the 10–30 m depth range has significantly changed the shape of the length frequency distributions with the appearance of 1+ and 2+ cohorts, otherwise poorly represented in the core strata, particularly in 2007 and 2012 (Figures 5 and 11). Correspondingly, the proportion of pre-recruit biomass in the core plus shallow strata was also greater than that of the core strata alone (i.e., 64% compared to 50% in 2007, 15% to 5% in 2012, 27% to 18% in 2014, and 2% to 1% in 2016), indicating that younger fish are more common in shallow water (Table 9, Figures 11 and 12).

The time series of elephant fish length frequency distributions in the core plus shallow strata included only the 2007, 2012, 2014 and 2016 surveys showing clearly the juvenile 1+ and 2+ cohorts although in 2014 and 2016 the 1+ year cohort was not as dominant as in the two previous surveys and in 2016 the 3+ and older fish were dominant (Figure 13). For the four core plus shallow strata surveys the juvenile biomass (based on the length-at-50% maturity) varies from about one third to three quarters of the total biomass in the first three surveys, to 9% in 2016 (Table 10, Figure 14).

Giant stargazer

Giant stargazer biomass showed peaks in 2007 and 2014, but no trend over the time series (Table 8, Figure 7). Pre-recruited biomass was a small but consistent component of the total biomass estimate on all surveys (range 2–5% of total biomass) and in 2016 it was 4% (Table 9, Figure 8). The juvenile to adult biomass ratio (based on length-at-50% maturity) was relatively constant over the time series at about 1 to 1 (Table 10, Figure 9), and in 2016 biomass was 48% juvenile.

Giant stargazer were present in 70–92% of core strata tows (77% in 2016) and consistently made up 1% of the total catch on the surveys, with no trend (Table 11). The distribution of giant stargazer hotspots varied, but overall this species was consistently well represented over the entire survey area, most commonly from 30 m to about 200 m (Figure 10).

The size distributions of giant stargazer in each of the eleven surveys were similar and generally had one large mode comprising multiple age classes and in some years a small juvenile mode (Figure 11). Giant stargazer on the ECSI sampled during these surveys, overall are smaller than those from the Chatham Rise, Southland, and WCSI inshore surveys (Bagley & Hurst 1996, Stevenson & Hanchet 2000, Livingston et al. 2002, MacGibbon & Stevenson 2013, Stevens et al. 2015), suggesting that this area may be an important nursery ground for juvenile giant stargazer.

Red cod

Red cod biomass from 2007 to 2009 was stable, but was low relative to the period between 1991 and 1996 before a more than six-fold increase in 2012, followed by a decline of the same magnitude in 2014, with a biomass estimate similar to 2014 in 2016. (Table 8, Figure 7). The relatively high biomass in 1994 and the low biomass in 2007–09 are consistent with the magnitude of commercial landings in RCO 3, a fishery in which cyclical fluctuating catches are characteristic (Beentjes & Renwick 2001). The large biomass in 2012 was predominantly contributed by 1+ year fish and appears to have resulted in commercial catches hard up against the TACC in 2012–13 and 2013–14, indicating that catches were constrained (Ministry for Primary Industries 2016). The proportion of pre-recruit biomass in the core strata varied greatly among surveys ranging from 7% of the total biomass in 2008 to 59% in 2012, and in 2016 it was 26% (Table 9, Figure 8). The proportion of juvenile biomass (based on the length-at-50% maturity) also varied greatly among surveys from 27% to 80% and in 2016 it was 58% (Table 10, Figure 9).

Red cod was present in 63–89 % of core strata tows with indications of a declining trend of occurrence over the time series (Table 11). Red cod made up 2–28% of the total catch from the survey core strata, with the lowest proportions from 2007 to 2008, and 2014 to 2016 (Table 11). The distribution of red cod hot spots varied, but overall this species was consistently well represented over the entire survey area, most commonly from 30 m to about 300 m, but was also found in waters shallower than 30 m and in 2014 the tow with the highest catch was in 10 to 30 m (Figure 10).

The size distributions of red cod in each of the eleven surveys were similar and generally characterised by a 0+ mode (10–20 cm), 1+ mode (30–40 cm), and a less defined right hand tail comprised predominantly of 2+ and 3+ fish (Figure 11). The 1996 to 2009 surveys showed poor recruitment of 1+ fish compared to earlier surveys, whereas the 1+ cohort was the largest of all eleven surveys in 2012 and was only average in 2014 and 2016. Red cod on the ECSI, sampled during these surveys, were generally smaller than those from Southland (Bagley & Hurst 1996), suggesting that this area may be an important nursery ground for juvenile red cod.

The additional red cod biomass captured in the 10–30 m depth range accounted for only 4%, 2% and 4% of the biomass in the core plus shallow strata (10–400 m) for 2007, 2012 and 2016 respectively, but in 2014 it was 44% indicating the sporadic importance of shallow strata for red cod (Table 8, Figure 7). The addition of the 10–30 m depth range had little effect on the shape of the length frequency distributions in 2007, 2012, and 2016, but in in 2014 the largest fish were in 10–30 m (Figures 5 and 11).

Red gurnard

In the 1990s, red gurnard biomass averaged 422 t in the core strata, increasing more than three-fold to 1453 t in 2007 (Table 8, Figure 7). From 2007 to 2014 biomass had an upward trend followed by a substantial decline in 2016 when biomass more than halved. The proportion of pre-recruit biomass in the core strata varied greatly among surveys, but was generally low, 2–20%, and in 2016 was 7% (Table 9, Figure 8). Similarly, the proportion of juvenile biomass (based on the length-at-50% maturity) was close to zero for all surveys (Table 10, Figure 9).

Red gurnard was present in 24–61% of core strata tows (61% in 2016) with an increasing trend from 1993 onward, although red gurnard made up only 1–2% of the total catch on the surveys, with no trend (Table 11). The distribution of red gurnard hot spots varied, but overall this species was consistently well represented over the entire survey area from 10 to 100 m, but was most abundant in the shallow 10 to 30 m strata (Figure 10).

The size distributions of red gurnard were more consistent over the last four core strata surveys as the biomass increased. Over this period, based on the ageing analyses of Sutton (1997), they were characterised by a single mode representing multiple age classes ranging from 1+ to about 15+ years (Figure 11).

The additional red gurnard biomass captured in the 10–30 m depth range accounted for 29%, 52%, 36% and 61% of the biomass in the core plus shallow strata (10–400 m) for 2007, 2012, 2014 and 2016 respectively, indicating the importance of shallow strata for red gurnard biomass (Table 8, Figure 7). This also indicates that red gurnard distribution above and below 30 m is highly variable among years. The addition of the 10–30 m depth range had no significant effect on the shape of the length frequency distributions in 2007 and 2014, but in 2012 and 2016 there were 1+ cohorts in 10–30 m, poorly represented in the core strata (Figures 5 and 11). The time series length frequency distributions in the core plus shallow strata (10–400) included only the 2007, 2012, 2014 and 2016 surveys, and had similar distributions with indications of a 1+ mode distinct from the older aged cohorts (Figure 13). The proportion of pre-recruit biomass in the core plus shallow strata was greater than that of the core strata and was higher by 4% in 2007, 10% in 2012, and 6% in 2016, indicating that smaller red gurnard are more abundant in the shallow, particularly in 2012. However, in 2014 the pre-recruited proportion was 2% higher in the core strata (Table 9, Figure 12). For all four core plus shallow strata surveys, virtually all biomass was adult fish (based on the length-at-50% maturity) (Table 10, Figure 14).

Sea perch

Sea perch biomass shows no trend over the time series although the 2016 biomass was the highest of the time series and was 40% higher than 2014 (Table 8, Figure 7). Pre-recruit biomass was a small and reasonably constant component of the total biomass estimate on all surveys (3–8% of total biomass) and in 2016 it was 4% (Table 9, Figure 8). The juvenile to adult biomass ratio (based on length-at-50% maturity) was relatively constant over the time series at 23–36% juvenile, and in 2016 it was 23% juvenile (Table 10, Figure 9).

Sea perch were present in 58–82% of tows and constituted 2–6% of the total catch on the surveys, with no trends in either variable (see Table 11). In 2016 it was present in 66% of tows and comprised 5% of the catch. The distribution of sea perch hot spots varied, but overall this species was consistently well represented over the entire survey area, most commonly from about 70 to 300 m (see Figure 10).

The size distributions of sea perch on each of the eleven surveys were similar and generally unimodal with a right hand tail reflecting the large number of age classes (Paul & Francis 2002) (Figure 11). Sea perch from the ECSI sampled on these surveys were generally smaller than those from the Chatham Rise and Southland surveys (Bagley & Hurst 1996, Livingston et al. 2002). This suggests that this area may be an important nursery ground for juvenile sea perch and/or that sea perch tend to be larger at greater depths (Beentjes et al. 2007). The ECSI survey does not extend to the full depth range of sea perch which are found as deep as 800 m.

Spiny dogfish

Spiny dogfish biomass in the core strata increased markedly in 1996 and has fluctuated over the last six surveys with indications of a declining trend, although the magnitude of the CVs indicate that this may not be significant (Table 8, Figure 7). Spiny dogfish in both the Chatham Rise and Sub-Antarctic also showed marked increases in biomass around 1996, which has largely been sustained over time (Stevens et al. 2015, Bagley et al. In prep). Pre-recruited biomass was a small component of the total biomass estimate in the 1992 to 1994 surveys at 1–3% of total biomass, but since 1996 it ranged from 7 to 28%, and in 2016 it was the highest at 12% (Table 9, Figure 8). This is also reflected in the biomass of juvenile spiny dogfish (based on the length-at-50% maturity) which increased markedly from about 14% of total biomass before 1996, to between 32 and 57% in the last seven surveys, and in 2016 it was 32% juvenile (Table 10, Figure 9).

Spiny dogfish were consistently the most commonly caught species on the ECSI trawl survey and occurred in 96–100% of tows and comprised 18–46% of the total catch on the surveys (Table 11). In 2014 spiny dogfish comprised only 18% of the total catch, the lowest proportion in the time series. Of the target species spiny dogfish has consistently the largest biomass on these eleven surveys, although in some years biomass of barracouta has been higher (Table 8). The distribution of spiny dogfish hotspots varied, but overall this species was consistently well represented over the entire survey area, most commonly from 30 m to about 350 m, although in 2014 catch rates were uncharacteristically low south of Banks Peninsula (Figure 10).

The size distributions of spiny dogfish in the 1992 to 1994 surveys were similar and generally bimodal for males, but less defined for females which are less numerous than males throughout the time series (Figure 11). From 1996 onwards, smaller fish were more abundant, particularly in the last four surveys. The large increase in biomass observed post-1996 is in part a result of the change in the population size composition. Spiny dogfish on the ECSI sampled on these surveys were considerably smaller than those from the Chatham Rise, Southland, and the sub-Antarctic surveys (Bagley & Hurst 1996, O'Driscoll & Bagley 2001, Livingston et al. 2002, Stevens et al. 2015, Bagley et al. In prep), suggesting that this area may be an important nursery ground for juvenile spiny dogfish and there may be movement in and out of the ECSI survey area.

The additional spiny dogfish biomass captured in the 10–30 m depth range accounted for 5%, 8%, 10% and 5% of the biomass in the core plus shallow strata (10–400 m) for 2007, 2012, 2014 and 2016 respectively, indicating that it is useful to monitor the shallow strata for spiny dogfish biomass (Table 8, Figure 7). Further, the addition of the 10–30 m depth range may be important for monitoring the small fish (Figures 5 and 11).

Tarakihi

Tarakihi biomass peaked in 1993 due to a single large catch off Timaru resulting in a high CV of 55%. Overall, however, there is no trend in the time series, although the 2016 biomass was the second lowest of the time series, (Table 8, Figure 7). Pre-recruit biomass was a major but variable component of tarakihi total biomass estimates on all surveys ranging from 18% to 60% of total biomass, and in 2016 it was 23% (Table 9, Figure 8). Similarly, juvenile biomass (based on length-at-50% maturity) was also a large component of total biomass, but the proportion was relatively constant over the time series between 60% and 80%, and in 2016 it was relatively high at 75% (Table 10, Figure 9).

Tarakihi were present in 52–71% of tows and made up 1–5% of the total catch on the surveys, with no trends in either variable (Table 11). In 2016 it was present in 69% of tows and comprised 2% of the catch. The distribution of tarakihi hotspots varied, but overall this species was consistently well represented over the entire survey area, most commonly from 30 to about 150 m (Figure 10).

The size distributions of tarakihi in each of the eleven surveys were similar and were multi-modal, with smaller modes representing individual cohorts (Figure 11). In 2012 and 2016, the 0+, 1+, 2+, and possibly 3+ cohorts were particularly evident (Beentjes et al. 2012), but were less defined in 2014. Tarakihi on the ECSI, overall, were generally smaller than those from the west coast South Island (Stevenson & Hanchet 2000) and the east coast North Island (Parker & Fu 2011), supporting the findings that this area is an important nursery ground for juvenile tarakihi (Beentjes et al. 2012, McKenzie et al. in prep).

4.2.2 Key non-target QMS species

Time series of biomass estimates for the eight key non-target QMS species (barracouta, lemon sole, ling, rough skate, smooth skate, school shark, rig, and silver warehou) are presented in Figure 15. Time series plots of catch rate distributions and scaled length frequency distributions for these species up to and including 2012 were presented and discussed by Beentjes & MacGibbon (2013). Barracouta in the core strata show a strong trend of increasing biomass from 1996 to 2014 before a 57% decline in 2016. In 2014 the biomass of barracouta was the highest of any species, and also the highest recorded biomass of the eleven surveys for any species.

4.3 Survey representativeness

The representativeness analysis showing the mean species ranking for each of the ECSI eleven winter trawl surveys in core strata is shown in Figures 16 and 17. When all 18 species are included, the mean ranking of the 2014 survey is outside the 95% confidence intervals, so by the definition of Francis et al. (2001) this survey had extreme catchability. Of the non-target species, all but two showed an increase in biomass from 2012 to 2014. However, when only the eight target species are included, all surveys fall within the 95% confidence intervals and hence, by definition, no survey can be regarded as extreme. The Francis et al. (2001) method assumes that species' abundances are uncorrelated and that particularly high (or low) estimates across a range of species in a given survey is due to a change to the trawl catchability. However, in this survey series there appears to be a trend of increasing abundance for most inshore species, which will result in a higher ranking overall in recent surveys. Hence, it is possible that the 2014 survey may not be extreme, but instead reflect general increased abundance of inshore species.

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Table 1: Stratum depth ranges, survey area, non-trawlable area, number of successful phase 1 and phase 2 stations (gear performance of 1 or 2) and station density for the 2016 ECSI trawl survey. Strata 1–17 are the core strata and strata 18–21 the shallow strata. Two additional stations in strata 3 and 7 (Stations 57 and 23 respectively) were successful for spiny dogfish, but not other species.

					No. stations		Station density
Stratum	Depth (m)	Area (km^2)	Description	Foul ground (km^2)	Phase 1	Phase 2	(km^2 per station)
1	30–100	984	Shag Point	202	4	4	123.0
2	30–100	1 242	Oamaru	0	3		414.1
3	30–100	3 023	Timaru	0	4	4	377.9
4	30–100	2 703	Rakaia	0	10		270.3
5	30–100	2 485	Banks Pen.	0	10		248.5
6	30–100	2 373	Pegasus	208	3		791.1
7	30–100	2 089	Conway	871	5		417.8
8	100–200	628	Shag Point	17	6	5	57.1
9	100–200	1 163	Oamaru	0	6		193.9
10	100–200	1 191	Timaru	0	5		238.3
11	100–200	1 468	Banks Pen.	0	5		293.6
12	100–200	764	Pegasus	132	3		254.8
13	100–200	999	Conway	406	3		333.0
14	200–400	322	Oamaru Crack	17	3		107.4
15	200–400	430	Timaru	0	3		143.4
16	200–400	751	Banks Pen.	0	3		250.5
17	200–400	724	Conway	165	3		241.5
Sub total		**23 339**		**2 018**	**79**	**13**	**222.3**
18	10–30	1 276	Pegasus	0	6		212.6
19	10–30	986	Rakaia	0	6		164.9
20	10–30	797	Timaru	0	3		265.7
21	10–30	520	Oamaru	226	3		173.2
Sub total		**3 579**		**226**	**18**		**198.8**
Total		**26 918**		**2 244**	**97**	**13**	244.7

Table 2: Simulated number of stations required to achieve the lower range target coefficients of variation (CV) for each species for the 2016 winter survey. For SPE, STA, SPD, and GUR there was no range and the CV was 20%. Right hand columns show the maximum stations of any species (excluding red cod), and the phase 1 allocation prorated down to 100 stations. Species codes are given in Appendix 4.

		Number of stations required to achieve lower target CV									
Depth (m)	Stratum	GSH (20)	RCO (20)	SPE (20)	SPD (20)	GIZ (20)	NMP (20)	ELE (20)	GUR (20)	Stations required. Max. (excl. RCO)	Phase 1 stations (pro-rated
30–100	1	3	4	3	3	3	5	4	3	5	4
30–100	2	3	5	3	3	3	3	3	3	3	3
30–100	3	3	5	4	7	3	8	3	5	8	6
30–100	4	3	3	3	11	3	16	4	7	16	10
30–100	5	3	3	3	15	3	5	3	3	15	10
30–100	6	3	3	3	3	3	3	3	3	3	3
30–100	7	3	5	3	5	3	4	4	8	8	6
100–200	8	3	3	8	3	3	3	3	3	8	6
100–200	9	7	19	3	3	3	3	3	3	7	6
100–200	10	4	4	6	3	3	3	3	3	6	5
100–200	11	6	20	4	3	3	3	3	3	6	5
100–200	12	3	3	3	3	3	3	3	3	3	3
100–200	13	3	3	3	3	3	4	3	3	4	3
200–400	14	3	8	3	3	3	3	3	3	3	3
200–400	15	3	3	3	3	3	3	3	3	3	3
200–400	16	3	3	3	3	3	3	3	3	3	3
200–400	17	3	3	3	3	3	3	3	3	3	3
10–30	18	–	–	–	–	–	–	7	3	7	6
10–30	19	–	–	–	–	–	–	8	3	8	6
10–30	20	–	–	–	–	–	–	3	3	3	3
10–30	21	–	–	–	–	–	–	3	3	3	3
	Total	59	97	61	77	51	75	75	74	125	100

Table 3: Catch and estimated biomass for the target species (in bold) and the key QMS species in 30–400 m (A), and for elephantfish, red gurnard and selected species in 10–400 m (B). (2016 winter survey).

A (30–400 m)		Males		Females		All fish		Recruited		
Common name	Catch (kg)	Biomass (t)	CV	Biomass (t)	CV	Biomass (t)	CV	Size (cm)	Biomass (t)	CV
Dark ghost shark	32 291	8 004	28	7 262	23	15 271	25	55	6 988	24
Elephantfish	17 902	5 924	75	887	56	6 812	68	50	6 750	68
Giant stargazer	978	232	19	332	18	565	17	30	543	18
Red cod	3 997	1 374	57	878	52	2 268	54	30	1 670	61
Red gurnard	1 253	575	34	366	30	941	30	40	877	30
Sea perch	7 508	1 562	26	1 464	34	3 032	29	20	2 923	30
Spiny dogfish	32 274	15 248	52	4 452	26	26 063	41	50	17 971	50
Tarakihi	3 230	723	35	716	28	1 462	31	25	1 121	33
Barracouta	25 682	12 145	40	7 493	14	19 708	27	50	18 487	29
Lemon sole	204	14	19	62	17	91	15	25	74	16
Ling	1 326	152	57	337	49	489	48	65	338	52
Rig	216	92	51	89	32	181	39	90	38	35
Rough skate	1 664	633	33	509	28	1 142	30	40	1 048	28
School shark	497	206	24	163	23	369	21	90	102	24
Silver warehou	841	191	70	133	70	428	53	25	323	70
Smooth skate	1 264	416	18	246	31	663	17	40	640	17

B (10–400 m)		Males		Females		All fish		Recruited		
Common name	Catch (kg)	Biomass (t)	CV	Biomass (t)	CV	Biomass (t)	CV	Size (cm)	Biomass (t)	CV
Elephantfish	18 861	6 068	73	1 231	41	7 299	63	50	7 132	64
Red cod	4 137	1 377	56	967	48	2 360	52	30	1 760	58
Red gurnard	3 948	1 052	20	1 368	13	2 420	15	40	2 114	15
Barracouta	32 563	12 914	37	8 512	14	23 007	24	50	20 261	27
Rig	353	125	38	130	25	255	29	90	38	35
Rough skate	2 486	825	26	751	20	1 576	22	40	1 459	21
School shark	518	211	23	168	22	379	21	90	102	24
Silver warehou	841	191	70	133	70	428	53	25	323	70

Table 4: Catch rates (kg.km^{-2}) by stratum for the target species (A) and key QMS species (B). Strata 1–17, core strata 30–400 m; strata 18–21, shallow strata 10–30 m. Species codes are given in Appendix 4.

A (Target species)

	Target species catch rates (kg.km^{-2})							
Stratum	GSH	ELE	GIZ	RCO	GUR	SPE	SPD	NMP
1	0	5 002	11	4	52	477	79	247
2	0	0	26	4	18	342	791	7
3	0	1	37	41	81	57	2 105	58
4	5	241	28	9	112	34	132	148
5	0	408	28	4	10	11	374	38
6	0	19	7	0	2	1	202	46
7	0	68	33	12	129	2	5 281	11
8	412	41	64	16	2	1 442	106	485
9	807	2	38	133	5	124	182	0
10	6 017	4	22	200	1	330	108	18
11	112	0	15	822	6	95	342	6
12	367	0	6	0	4	2	374	1
13	547	0	20	3	0	199	412	47
14	5 035	0	21	121	0	2	394	0
15	6 604	0	6	904	0	0	7 553	2
16	803	0	13	39	0	2	486	0
17	1 155	0	4	7	0	73	684	30
18	0	91	0	39	386	0	510	0
19	0	183	0	0	174	0	403	3
20	0	198	0	48	526	0	166	2
21	0	64	0	9	763	0	107	115

Table 4 – *continued*

B (Key QMS species)

Stratum	Key QMS species catch rates (kg.km^{-2})							
	BAR	LSO	LIN	SPO	RSK	SCH	SWA	SSK
1	280	13	164	9	17	8	0	7
2	936	2	5	0	141	11	0	0
3	2 838	5	2	13	42	23	2	39
4	730	2	0	4	50	25	7	39
5	1 071	3	0	11	167	13	13	26
6	126	2	0	0	28	5	1	37
7	389	8	0	43	54	24	5	0
8	616	21	25	0	53	6	24	81
9	698	0	3	0	8	6	8	92
10	779	0	7	4	5	50	187	18
11	623	0	3	0	2	26	8	13
12	634	2	0	0	51	13	2	18
13	371	6	0	0	4	0	1	35
14	119	4	45	0	0	0	64	11
15	2	0	422	0	0	0	46	0
16	12	3	51	0	0	0	77	32
17	0	0	64	0	3	0	0	9
18	244	0	0	40	82	1	0	0
19	1 288	0	0	8	97	7	0	0
20	255	0	0	14	192	1	0	0
21	2 906	6	0	5	156	0	0	39

Table 5: Estimated biomass (t) and coefficient of variation (CV %) by stratum for the target species in core strata 30–400 m (A) and shallow strata 10–30 m (B), and for the key QMS species in core strata 30–400 m (C) and shallow strata 10–30 m (D). Species codes are given in Appendix 4.

A (Target species in core strata 30–400 m)

		Target species biomass and CV							
Stratum		GSH	ELE	GIZ	RCO	GUR	SPE	SPD	NMP
1	Biomass	0	4 923	11	4	51	470	78	243
	CV	0	90	38	60	35	66	30	47
2	Biomass	0	0	32	6	22	425	983	9
	CV	0	0	91	50	68	100	83	70
3	Biomass	0	3	113	124	245	174	6 362	176
	CV	0	77	44	73	62	50	90	62
4	Biomass	13	651	75	24	304	93	358	400
	CV	55	92	27	81	63	71	26	69
5	Biomass	0	1 015	69	10	24	28	928	95
	CV	0	95	44	82	20	66	40	49
6	Biomass	0	45	16	0	5	1	479	110
	CV	0	65	100	0	65	100	79	94
7	Biomass	0	142	70	26	269	4	11 032	23
	CV	0	92	90	43	54	60	78	77
8	Biomass	259	26	40	10	1	906	67	304
	CV	42	70	25	58	53	72	37	98
9	Biomass	939	2	44	154	6	144	212	0
	CV	48	100	33	76	31	63	40	0
10	Biomass	7 169	5	26	238	2	394	128	21
	CV	36	63	42	51	50	48	18	71
11	Biomass	164	0	23	1 207	9	139	502	9
	CV	73	0	64	98	63	61	39	72
12	Biomass	280	0	4	0	3	2	286	1
	CV	99	0	20	100	50	44	52	50
13	Biomass	547	0	20	3	0	199	412	47
	CV	77	0	45	89	0	51	28	75
14	Biomass	1 622	0	7	39	0	1	127	0
	CV	55	0	13	78	0	100	32	0
15	Biomass	2 840	0	3	389	0	0	3 249	1
	CV	88	0	100	66	0	0	65	100
16	Biomass	603	0	10	29	0	1	366	0
	CV	62	0	52	100	0	22	42	0
17	Biomass	837	0	3	5	0	53	495	22
	CV	25	0	100	74	0	99	31	98
Total	Biomass	15 271	6 812	565	2 268	941	3 032	26 063	1 462
	CV	25	68	17	54	30	29	41	31

Table 5 – *continued*

B (Target species in shallow strata 10–30 m)

Stratum		Target species biomass and CV							
		GSH	ELE	GIZ	RCO	GUR	SPE	SPD	NMP
18	Biomass	0	116	0	49	493	0	651	0
	CV	0	57	0	20	19	0	57	0
19	Biomass	0	181	0	0	172	0	398	3
	CV	0	65	0	0	21	0	63	93
20	Biomass	0	158	0	38	419	0	132	2
	CV	0	84	0	94	34	0	88	100
21	Biomass	0	33	0	5	396	0	55	60
	CV	0	46	0	100	30	0	71	95
		0	487	0	92	1 480	0	1 236	64
Total	Biomass	0	39	0	40	14	0	37	88
	CV	0	116	0	49	493	0	651	0

C (Key QMS species in core strata 30–400 m)

Stratum		Key QMS species biomass and CV							
		BAR	LSO	LIN	SPO	RSK	SCH	SWA	SSK
1	Biomass	276	13	162	9	17	8	0	7
	CV	33	36	92	42	28	35	53	100
2	Biomass	1 163	3	6	0	175	14	0	0
	CV	56	100	100	0	82	38	0	0
3	Biomass	8 578	15	7	39	126	70	6	117
	CV	58	48	62	79	57	76	50	58
4	Biomass	1 973	6	1	11	135	67	18	106
	CV	40	81	63	100	46	32	66	37
5	Biomass	2 662	7	1	28	414	31	32	64
	CV	51	53	72	89	72	41	56	54
6	Biomass	298	5	0	0	67	11	2	88
	CV	47	39	0	0	18	50	69	43
7	Biomass	813	17	0	89	114	50	12	0
	CV	35	39	0	64	36	55	80	0
8	Biomass	387	13	16	0	33	4	15	51
	CV	36	23	34	0	44	75	44	52
9	Biomass	812	0	3	0	9	7	10	108
	CV	24	0	30	0	63	72	45	42
10	Biomass	928	0	9	5	5	59	222	21
	CV	23	0	58	64	62	30	98	28
11	Biomass	915	1	4	0	2	38	12	19
	CV	26	56	62	0	100	100	30	85
12	Biomass	484	2	0	0	39	10	1	14
	CV	69	95	0	0	33	86	51	100
13	Biomass	371	6	0	0	4	0	1	35
	CV	30	33	0	0	100	0	52	23
14	Biomass	38	1	14	0	0	0	21	4
	CV	53	100	40	0	0	0	51	100

Table 5 – *continued*

Stratum		Key QMS species biomass and CV							
		BAR	LSO	LIN	SPO	RSK	SCH	SWA	SSK
15	Biomass	1	0	181	0	0	0	20	0
	CV	100	0	98	0	0	0	92	0
16	Biomass	9	2	38	0	0	0	58	24
	CV	100	88	51	0	0	0	99	52
17	Biomass	0	0	47	0	2	0	0	7
	CV	0	0	40	0	51	0	100	78
Total	Biomass	19 708	91	489	181	1142	369	428	663
	CV	27	15	48	39	30	21	53	17

D (Key QMS species in shallow strata 10–30 m)

Stratum		Key QMS species biomass and CV							
		BAR	LSO	LIN	SPO	RSK	SCH	SWA	SSK
18	Biomass	312	0	0	51	105	2	0	0
	CV	35	51	0	36	11	90	100	0
19	Biomass	1 274	0	0	8	96	7	0	0
	CV	79	100	0	26	20	91	0	0
20	Biomass	203	0	0	11	153	1	0	0
	CV	30	0	100	56	26	46	0	0
21	Biomass	1 510	3	0	2	81	0	0	20
	CV	75	61	100	82	45	100	0	100
		3 299	3	0	74	434	10	0	20
Total	Biomass	46	52	71	27	13	64	100	100
	CV	312	0	0	51	105	2	0	0

Table 6: Number of length frequency and biological records. Measurement methods: 1, fork length; 2, total length; 4, mantle length; 5, pelvic length; B, carapace length; G, total length excluding tail filament. + Data include one or more of the following: fish length, fish weight, gonad stage, otoliths, and spines. Species codes are defined in Appendix 4.

		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
ATT	1	3	15	0	0	0
BAR	1	95	8 591	0	0	0
BCO	2	23	302	1	1	0
BRI	2	5	14	0	0	0
BYS	1	1	1	0	0	0
CAR	2	1	8	0	0	0
ELE	1	45	1 268	45	475	389
ESO	2	12	229	0	0	0
GFL	2	4	25	0	0	0
GIZ	2	71	825	71	669	468
GSH	G	36	2 717	35	639	0
GUR	2	74	2 921	74	826	531
HAP	2	35	161	17	62	0
HOK	2	7	261	1	30	0
JAV	2	2	214	0	0	0
JDO	2	2	3	0	0	0
JMD	1	19	77	0	0	0
JMM	1	5	17	0	0	0
JMN	1	1	1	0	0	0
KIN	1	14	26	1	1	0
LDO	2	3	51	0	0	0
LEA	2	12	1 109	0	0	0
LIN	2	41	432	18	180	0
LSO	2	42	640	0	0	0
MOK	1	7	13	1	3	0
NMP	1	70	2 886	70	880	505
NOS	4	40	1 259	0	0	0
OPE	1	1	2	0	0	0
RCO	2	67	1 770	68	736	512
RSK	5	68	772	64	520	0
RSO	1	19	502	1	1	0
SBW	1	1	91	0	0	0
SCG	1	1	11	0	0	0
SCH	2	48	265	45	214	0
SFL	2	14	178	0	0	0
SPD	2	108	6 777	108	2166	0
SPE	2	59	3 440	59	873	504
SPO	2	32	327	27	215	0
SSI	1	3	176	0	0	0
SSK	5	50	207	49	177	0
SWA	1	48	1 329	0	0	0
THR	2	1	2	1	2	0

Table 6 – *continued*

		Length frequency data		Biological data+		
Species code	Measurement method	No. of samples	No. of fish	No. of samples	No. of fish	No. of otoliths or spines
TRU	1	1	1	1	1	0
TUR	2	2	2	0	0	0
WAR	1	14	234	0	0	0
WWA	1	4	27	0	0	0
YBF	2	2	13	0	0	0
YCO	2	1	2	0	0	0
Totals	0	1 214	40 194	757	8 671	2 909

Table 7: Gonad stages of target species in 30–400 m, and for elephantfish and red gurnard in 10 to 30 m. See Appendix 1 for gonad stage definitions. NA, not applicable.

Species	Sex	No. of fish	% Gonad stage					
			1	2	3	4	5	
30–400 m								
Giant stargazer	Males	327	65	18	13	2	1	
	Females	326	91	7	2	0	0	
Red cod	Males	327	89	8	3	<1	0	
	Females	283	87	13	0	0	0	
Red gurnard	Males	261	32	43	16	2	6	
	Females	170	19	60	13	1	7	
Sea perch	Males	442	22	43	29	4	1	
	Females	397	52	36	4	1	7	
Tarakihi	Males	386	92	5	<1	0	3	
	Females	374	89	11	0	0	0	
			% Gonad state					
			1	2	3	4		
Dark ghost shark	Males	261	45	17	38	NA		
	Females	420	22	16	56	5		
			% Gonad state					
			1	2	3	4	5	6
Elephantfish	Males	146	5	17	78	NA	NA	NA
	Females	88	15	56	30	0	NA	NA
Spiny dogfish	Males	1 121	11	4	85	NA	NA	NA
	Females	543	33	22	5	3	37	0
			% Gonad state					
10–30 m			1	2	3	4	5	6
Elephantfish	Males	77	82	13	5	NA	NA	NA
	Females	160	48	48	4	0	NA	NA
			% Gonad state					
			1	2	3	4	5	
Red gurnard	Males	115	67	29	3	1	1	
	Females	248	54	39	3	0	4	

Table 8: Estimated biomass (t) and coefficient of variation (CV) for the target species (in bold) and key non-target QMS species for all ECSI winter surveys in the core strata (30–400 m) (A), and core plus shallow strata (10 to 400 m) in 2007, 2012, 2014, and 2016 for species found in less than 30 m (B). Biomass estimates for 1991 were adjusted to allow for non-sampled strata (7 and 9 equivalent to current strata 13, 16 and 17). * Rough and smooth skates were not separated in 1991 (combined biomass 1993 t, CV 25%). Species in order of common name. NA, not applicable.

A (Core strata, 30–400 m). Target species

Survey	GSH		ELE		GIZ		RCO		GUR		SPE		SPD		NMP	
	Biom. (t)	CV	Biom. (t)	CV	Biom. (t)	CV	Biom. (t)	CV	Biom. (t)	CV	Biom. (t)	CV	Biom. (t)	CV	Biom. (t)	CV
1991	962	42	300	40	672	17	3 760	33	763	33	1 716	30	12 873	22	1 712	33
1992	934	44	176	32	669	16	4 527	40	142	30	1 934	28	10 787	26	932	26
1993	2 911	42	481	33	609	14	5 601	30	576	31	2 948	32	13 949	17	3 805	55
1994	2 702	25	164	32	439	17	5 637	35	123	34	2 342	29	14 530	10	1 219	31
1996	3 176	23	858	30	466	11	4 619	30	505	27	1 671	26	35 169	15	1 656	24
2007	4 483	25	1 034	32	755	18	1 486	25	1 453	35	1 954	22	35 386	27	2 589	24
2008	3 763	20	1 404	35	606	14	1 824	49	1 309	34	1 944	23	28 476	22	1 863	29
2009	4 329	24	596	23	475	14	1 871	40	1 725	30	1 444	25	25 311	31	1 519	36
2012	10 704	29	1 351	39	643	16	11 821	79	1 680	28	1 964	26	35 546	31	1 661	25
2014	13 137	26	951	34	790	14	2 096	39	2 063	25	2 168	25	19 949	31	2 380	23
2016	15 271	25	6 812	68	565	17	2 268	54	941	30	3 032	29	26 063	41	1 462	31

A (Core strata, 30–400 m). Non-target QMS species

Survey	BAR		LSO		LIN		SPO		RSK		SCH		SWA		SSK	
	Biom. (t)	CV	Biom. (t)	CV	Biom. (t)	CV	Biom. (t)	CV	Biom. (t)	CV	Biom. (t)	CV	Biom. (t)	CV	Biom. (t)	CV
1991	8 354	29	92	27	1 009	35	175	30	NA	NA	100	30	30	21	NA	NA
1992	11 672	23	57	18	525	17	66	18	224	24	104	21	32	22	609	18
1993	18 197	22	121	19	651	27	67	30	340	21	369	42	256	44	670	24
1994	6 965	34	77	21	488	19	54	29	517	20	155	36	35	28	306	25
1996	16 848	19	49	33	488	21	63	37	177	20	202	18	231	32	385	24
2007	21 132	17	74	26	283	27	134	37	878	22	538	22	445	44	709	20
2008	25 544	16	116	25	351	22	280	23	858	19	411	20	319	32	554	18
2009	33 360	16	55	27	262	19	125	26	1 029	30	254	18	446	42	736	23
2012	34 325	17	65	18	265	21	171	62	1 133	20	292	20	434	46	1 025	35

Table 8 – *continued*

Survey	BAR Biom. (t)	BAR CV	LSO Biom. (t)	LSO CV	LIN Biom. (t)	LIN CV	SPO Biom. (t)	SPO CV	RSK Biom. (t)	RSK CV	SCH Biom. (t)	SCH CV	SWA Biom. (t)	SWA CV	SSK Biom. (t)	SSK CV
2014	46 563	19	107	27	230	21	194	48	1 153	38	529	36	626	83	637	20
2016	19 708	27	91	15	489	48	181	39	1 142	30	369	21	428	53	663	17

B (Core plus shallow strata, 10–400 m). Target species

Survey	ELE Biom. (t)	ELE CV	RCO Biom. (t)	RCO CV	GUR Biom. (t)	GUR CV	SPD Biom. (t)	SPD CV
2007	1 859	24	1 552	24	2 048	27	37 299	26
2012	3 780	31	12 032	78	3 515	17	38 821	28
2014	1 600	21	3 714	41	3 215	17	22 188	28
2016	7 299	63	2 360	52	2 420	15	27 300	39

B (Core plus shallow strata, 10–400 m). Non-target QMS species

Survey	BAR Biom. (t)	BAR CV	RSK Biom. (t)	RSK CV	SCH Biom. (t)	SCH CV	SPO Biom. (t)	SPO CV	SWA Biom. (t)	SWA CV
2007	24 938	18	1 261	16	552	21	192	30	451	43
2012	36 526	16	1 414	16	310	19	315	37	438	46
2014	46 903	19	1 597	28	547	35	320	31	626	83
2016	23 007	24	1 576	22	379	21	255	29	428	53

Table 9: Estimated biomass (t), and coefficient of variation (CV %) of recruit and pre-recruit target species in core strata (30–400 m) for all surveys (A), and core plus shallow strata (10 to 400 m) for elephantfish and red gurnard in 2007, 2012, 2014, and 2016 (B). Biomass estimates for 1991 were adjusted to allow for non-sampled strata (7 and 9, equivalent to current strata 13, 16 and 17). The sum of pre-recruit and recruit biomass values do not always match the total biomass (Table 8) for the earlier surveys because at several stations length frequencies were not measured, affecting the biomass calculations for length intervals. Biom, biomass; Pre-rec., pre-recruit biomass; Rec., recruit biomass; NA, not applicable.

A (Core strata 30–400 m)

Target species (recruited length)

		GSH (55 cm)		ELE (50 cm)		GIZ (30 cm)		GUR (30 cm)		RCO (40 cm)		SPE (20 cm)		SPD (50 cm)		NMP (25 cm)	
		Pre-rec.	Rec.	Pre-rec.	Rec.	Pre-rec.	Rec.	Pre-rec.	Rec.	Pre-rec.	Rec.	Pre-rec.	Rec.	Pre-rec.	Rec.	Pre-rec.	Rec.
1991	Biom.	292	668	NA	NA	26	646	NA	NA	1 823	2 054	70	1 483	NA	NA	305	1 414
	CV	68	40	NA	NA	22	17	NA	NA	45	37	44	30	NA	NA	38	33
1992	Biom.	574	361	54	122	35	634	21	121	2 089	2 438	51	1 441	266	9 212	288	614
	CV	54	31	83	28	14	16	58	30	50	33	28	28	27	31	26	28
1993	Biom.	1 058	1 814	60	421	19	591	26	551	1 025	4 469	178	2 770	343	13 122	2 282	1 522
	CV	40	53	56	34	16	14	45	31	51	27	76	30	72	17	62	46
1994	Biom.	1 312	1 390	22	142	10	429	2	121	3 338	2 299	78	2 264	205	14 325	494	725
	CV	35	22	51	34	25	17	42	34	40	36	24	29	49	10	31	35
1996	Biom.	1 195	1 981	338	520	13	452	8	496	590	4 029	58	1 613	3 412	31 757	519	1 137
	CV	30	23	40	26	34	11	44	26	31	34	45	25	23	16	30	27
2007	Biom.	1 854	2 629	516	518	33	722	298	1 155	190	1 295	74	1 880	5 831	29 554	822	1 766
	CV	46	26	59	21	24	18	40	35	33	25	18	22	46	27	30	24
2008	Biom.	1 644	2 119	627	777	13	592	100	1 210	129	1 695	144	1 800	1 886	26 590	739	1 123
	CV	23	29	57	27	28	14	59	33	36	50	20	24	50	22	44	25
2009	Biom.	1 965	2 364	210	387	10	464	62	1 663	833	1 038	82	1 363	2 398	22 913	525	994
	CV	21	33	38	25	34	15	34	30	50	41	18	26	30	32	42	42
2012	Biom.	3 716	6 988	66	1285	26	617	193	1 487	7 015	4 806	66	1 898	3 804	31 742	584	1 077
	CV	27	31	46	39	22	16	40	27	97	55	25	27	58	34	34	29
2014	Biom.	6912	6 225	174	777	39	751	409	1 654	1 038	1 057	182	1 986	5 683	14 266	818	1 562
	CV	27	31	32	40	17	14	45	23	58	23	29	26	34	36	26	26
2016	Biom.	8283	6 988	62	6750	22	543	63	877	597	1 670	109	2 923	2 639	18 299	342	1 121
	CV	34	24	43	68	24	18	41	30	40	61	25	30	34	50	40	33

Table 9 – *continued*

A (Core plus shallow strata 10–400 m)

		Target species (recruited length)			
		ELE (50 cm)		GUR (30 cm)	
		Pre-rec.	Rec.	Pre-rec.	Rec.
2007	Biom.	1 201	658	494	1 554
	CV	36	20	32	27
2012	Biom.	581	3 199	742	2 773
	CV	25	36	31	16
2014	Biom.	429	1 171	585	2 630
	CV	25	28	32	16
2016	Biom.	167	7 132	306	2 114
	CV	30	64	19	15

Table 10: Estimated juvenile and adult biomass (t) by sex, and coefficient of variation (CV %) (where juvenile was below and adult was equal to or above length at which 50% of fish were mature) for finfish target species from core strata (30–400 m) for all ECSI surveys (A), elasmobranch species from core strata (30–400 m) for all surveys (B), and elephantfish and red gurnard from core plus shallow strata (10–400 m) for 2007, 2012, 2014 and 2016 (C). Biomass estimates for 1991 were adjusted to allow for non-sampled strata (7 and 9). The sum of juvenile and adult biomass values do not always match the total biomass (Table 8) for the earlier surveys because at several stations length frequencies were not measured, affecting the biomass calculations for length intervals. Juv, juvenile biomass; –, not measured.

A (Finfish, core strata 30–400 m)

		Finfish target species (length at maturity, cm)									
		GIZ M =45 cm, (F=45 cm)		GUR M =22 cm, (F=22 cm)		RCO M =51 cm, (F=51 cm)		SPE M =26 cm, (F=26 cm)		NMP M =31 cm, (F=31 cm)	
		Juv.	Adult	Juv.	Adult	Juv.	Adult	Juv.	Adult	Juv.	Adult
1991	Biomass	148 (171)	87 (264)	0 (<1)	340 (420)	1 789 (1205)	292 (550))	275 (194)	668 (551)	530 (434)	352 (384)
	CV	14 (25)	25 (22)	0 (100)	42 (40)	41 (38)	42 (29)	34 (32)	28 (33)	39 (37)	34 (29)
1992	Biomass	178 (109)	69 (208)	0 (2)	49 (91)	1 752 (1364)	456 (954)	224 (221)	640 (406)	292 (274)	163 (171)
	CV	25 (26)	25 (17)	66 (58)	38 (30)	50 (47)	34 (25)	28 (30)	28 (33)	26 (24)	30 (34)
1993	Biomass	133 (121)	92 (252)	0 (0)	254 (321)	1 399 (1 466)	880 (1645)	548 (375)	1 062 (899)	496 (403)	382 (245)
	CV	13 (16)	23 (18)	100 (57)	32 (34)	39 (47)	30 (31)	67 (55)	24 (19)	30 (29)	56 (32)
1994	Biomass	106 (83)	83 (167)	0 (0)	48 (48)	1 167 (848)	536 (401)	232 (303)	938 (763)	296 (332)	93 (155)
	CV	21 (21)	22 (21)	0 (0)	51 (35)	34 (36)	33 (21)	24 (27)	27 (37)	42 (50)	32 (32)
1996	Biomass	139 (85)	72 (168)	0 (0)	280 (224)	650 (535)	1 176 (2 258)	232 (340)	651 (405)	566 (435)	214 (232)
	CV	16 (18)	20 (15)	100 (71)	27 (27)	25 (27)	34 (39)	39 (37)	24 (22)	28 (27)	34 (33)
2007	Biomass	106 (106)	34 (208)	1 (0)	793 (659)	393 (278)	188 (626)	256 (242)	882 (573)	1 046 (1 017)	186 (336)
	CV	13 (18)	33 (30)	51 (75)	34 (36)	38 (29)	34 (32)	18 (16)	24 (28)	28 (27)	22 (21)
2008	Biomass	152 (136)	60 (200)	0 (1)	587 (717)	431 (628)	214 (549)	320 (314)	764 (535)	661 (714)	140 (319)
	CV	19 (17)	23 (17)	66 (58)	40 (32)	63 (71)	47 (23)	27 (24)	28 (26)	32 (35)	25 (23)
2009	Biomass	91 (79)	66 (239)	0 (0)	864 (858)	825 (522)	112 (412)	180 (212)	620 (423)	518 (500)	263 (238)
	CV	20 (17)	32 (16)	100 (85)	32 (27)	54 (56)	33 (42)	19 (19)	30 (29)	43 (39)	48 (32)
2012	Biomass	140 (91)	132 (280)	0 (0)	877 (803)	5 870 (2 469)	1 635 (1 846)	212 (248)	855 (648)	536 (595)	216 (292)
	CV	16 (16)	26 (20)	0 (100)	31 (25)	96 (92)	75 (36)	20 (23)	30 (32)	28 (32)	40 (30)

Table 10 – *continued*

		Finfish target species (length at maturity, cm)									
		GIZ M =45 cm, (F=45 cm)		GUR M =22 cm, (F=22 cm)		RCO M =51 cm, (F=51 cm)		SPE M =26 cm, (F=26 cm)		NMP M =31 cm, (F=31 cm)	
		Juv.	Adult	Juv.	Adult	Juv.	Adult	Juv.	Adult	Juv.	Adult
2014	Biomass	167 (181)	126 (308)	6 (6)	1 021 (1028)	757 (679)	123 (480)	392 (388)	782 (605)	794 (744)	319 (436)
	CV	17 (17)	20 (16)	43 (50)	30 (24)	49 (58)	30 (17)	30 (27)	27 (34)	24 (22)	33 (35)
2016	Biomass	139 (133)	92 (199)	0 (0)	575 (366)	884 (419)	491 (458)	315 (409)	1 247 (1 055)	575 (517)	148 (199)
	CV	20 (22)	24 (20)	0 (0)	34 (30)	57 (42)	63 (63)	28 (34)	27 (40)	38 (32)	33 (26)

B (Elasmobranchs, core strata 30–400 m)

		Elasmobranch target species (length at maturity, cm)					
		GSH M=52, (F=62)		ELE M=51, (F=70)		SPD M=58, (F=72)	
		Juv.	Adult	Juv.	Adult	Juv.	Adult
1991	Biomass	72 (226)	213 (449)	1 (64)	136 (97)	–	–
	CV	77 (61)	52 (45)	73 (52)	46 (40)	–	–
1992	Biomass	252 (414)	135 (134)	25 (66)	35 (50)	471 (887)	4 645 (3 475)
	CV	62 (50)	36 (32)	81 (45)	40 (34)	28 (22)	18 (69)
1993	Biomass	340 (697)	913 (922)	39 (114)	213 (114)	603 (1 250)	7 178 (4 414)
	CV	50 (37)	49 (54)	56 (29)	37 (65)	63 (50)	17 (34)
1994	Biomass	403 (975)	674 (650)	12 (47)	43 (62)	604 (1135)	9 721 (3 057)
	CV	47 (29)	25 (25)	46 (38)	38 (41)	24 (20)	10 (30)
1996	Biomass	261 (1 042)	978 (892)	187 (378)	166 (127)	3 924 (7 829)	21 195 (2 221)
	CV	39 (36)	31 (20)	41 (32)	31 (30)	21 (28)	16 (18)
2007	Biomass	521 (1 468)	1 175 (1 316)	278 (362)	165 (225)	7 926 (12 247)	14 326 (886)
	CV	52 (39)	21 (42)	60 (41)	30 (30)	37 (35)	26 (22)

Table 10 – *continued*

		Elasmobranch target species (length at maturity, cm)					
		GSH M=52, (F=62)		ELE M=51, (F=70)		SPD M=58, (F=72)	
		Juv.	Adult	Juv.	Adult	Juv.	Adult
2008	Biomass	676 (1021)	820 (1235)	328 (512)	234 (325)	4 029 (5 690)	17 594 (1 124)
	CV	28 (19)	25 (34)	55 (44)	46 (26)	37 (26)	22 (16)
2009	Biomass	753 (1208)	1038 (1326)	131 (173)	206 (86)	5 526 (6 797)	12 073 (910)
	CV	29 (20)	29 (37)	35 (32)	29 (42)	42 (30)	32 (22)
2012	Biomass	1 015 (3 207)	3319 (3162)	39 (267)	693 (353)	5 702 (5 640)	2 2705 (1 483)
	CV	24 (34)	28 (36)	51 (32)	54 (40)	36 (26)	40 (30)
2014	Biomass	2 078 (4 361)	4032 (2619)	88 (176)	179 (508)	5 761 (5 656)	7 599 (920)
	CV	32 (29)	31 (31)	31 (31)	31 (51)	42 (37)	43 (15)
2016	Biomass	2 737 (4808)	5 267 (2 455)	49 (370)	5 875 (518)	2 887 (3 919)	13 086 (1 045)
	CV	50 (27)	27 (27)	44 (49)	75 (71)	39 (28)	53 (30)

C (Core plus shallow strata 10–400 m)

		Target species (length at maturity, cm)			
		ELE M=51, (F=70)		GUR M=22, (F=22)	
		Juv.	Adult	Juv.	Adult
2007	Biomass	574 (863)	194 (225)	8 (5)	1 008 (1 028)
	CV	34 (30)	29 (30)	54 (67)	28 (26)
2012	Biomass	278 (1013)	804 (1 685)	14 (18)	1 523 (1 958)
	CV	28 (23)	47 (49)	71 (69)	20 (15)
2014	Biomass	199 (436)	192 (773)	11 (15)	1 376 (1 811)
	CV	25 (19)	29 (36)	25 (23)	23 (15)
2016	Biomass	93 (592)	5 975 (639)	3 (2)	1 050 (1 366)
	CV	29 (35)	74 (58)	36 (40)	20 (13)

Table 11: Percent occurrence (% of stations where it was caught) for each target species, and percent total catch (% of all species caught on the survey) for each target species, and for all target species combined for all ECSI winter surveys in core strata (30–400 m) (A), and the core strata plus shallow (10 to 400 m) for ELE and GUR in 2007, 2012, 2014, and 2016 (B). Values of zero are less than 1%.

A (Core strata 30–400 m)

	Target species percent occurrence and percent of total catch																
	GSH		ELE		GIZ		RCO		GUR		SPE		SPD		NMP		All target species
	% Occ.	% catch	% Occ.	% catch	% Occ.	% catch	% Occ.	% catch	% Occ.	% catch	% Occ.	% catch	% Occ.	% catch	% Occ.	% catch	% catch
1991	27	2	35	1	85	1	89	10	49	1	82	4	96	31	71	4	55
1992	28	3	30	0	82	2	89	15	24	0	76	6	99	25	61	2	53
1993	38	9	31	1	92	1	81	13	24	1	70	4	99	23	62	5	56
1994	30	9	31	1	83	1	75	28	32	0	76	4	96	28	63	2	73
1996	44	6	31	1	70	1	84	7	30	1	58	3	98	46	63	1	64
2007	50	7	37	1	83	1	71	2	56	2	65	3	100	39	66	3	57
2008	45	7	47	1	77	1	66	3	55	1	72	3	100	39	62	2	58
2009	57	10	39	1	78	1	63	9	45	2	67	3	100	24	52	2	51
2012	37	11	38	2	74	1	70	9	58	2	71	2	98	30	63	1	57
2014	48	17	42	1	78	1	67	2	61	2	72	4	99	18	65	3	48
2016	40	21	31	12	77	1	66	3	61	1	66	5	98	15	69	2	58

B (Core plus shallow strata 10 to 400 m)

	Target species percent occurrence and percent of total catch				
	ELE		GUR		GUR and ELE
	% Occ.	% catch	% Occ.	% catch	% catch
2007	41	2	61	2	4
2012	47	4	66	3	8
2014	51	2	68	3	5
2016	40	11	68	2	13

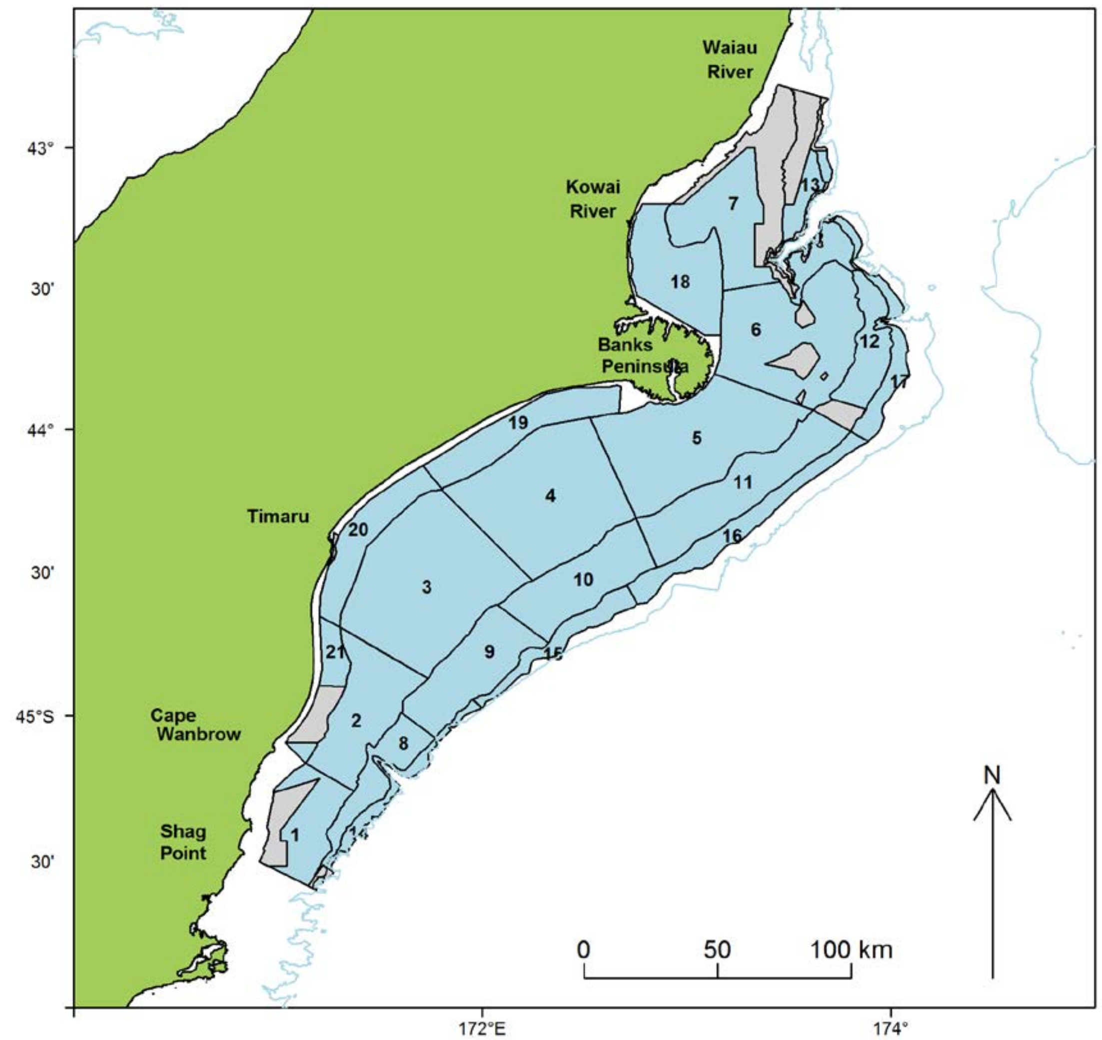


Figure 1: Strata used in the 2016 ECSI trawl survey in 10–400 m. Shaded areas are foul ground. Outer depth contour is 500 m.

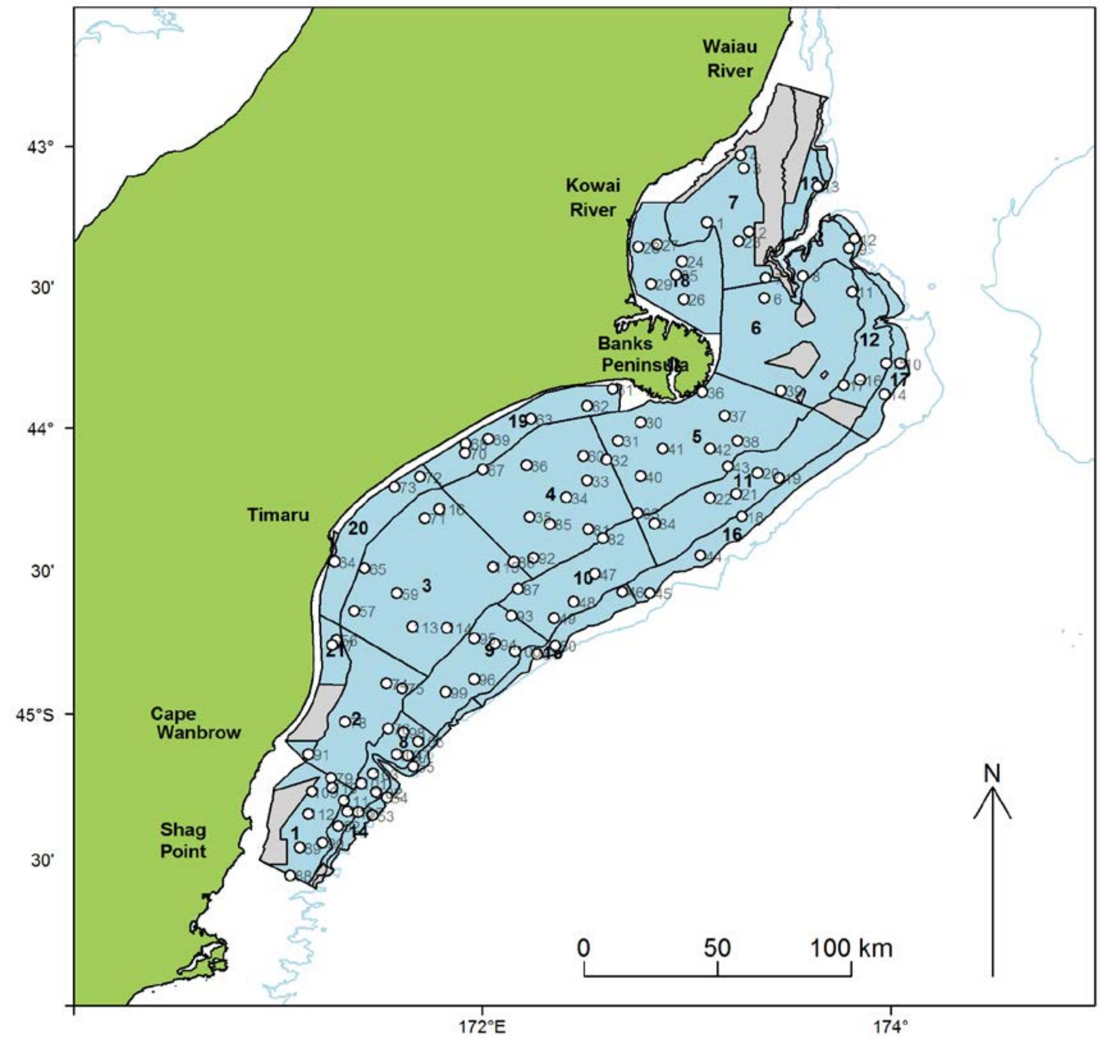


Figure 2: All tows and tow numbers from the 2016 ECSI survey. Shaded areas are foul ground. Outer depth contour is 500 m.

Dark ghost shark

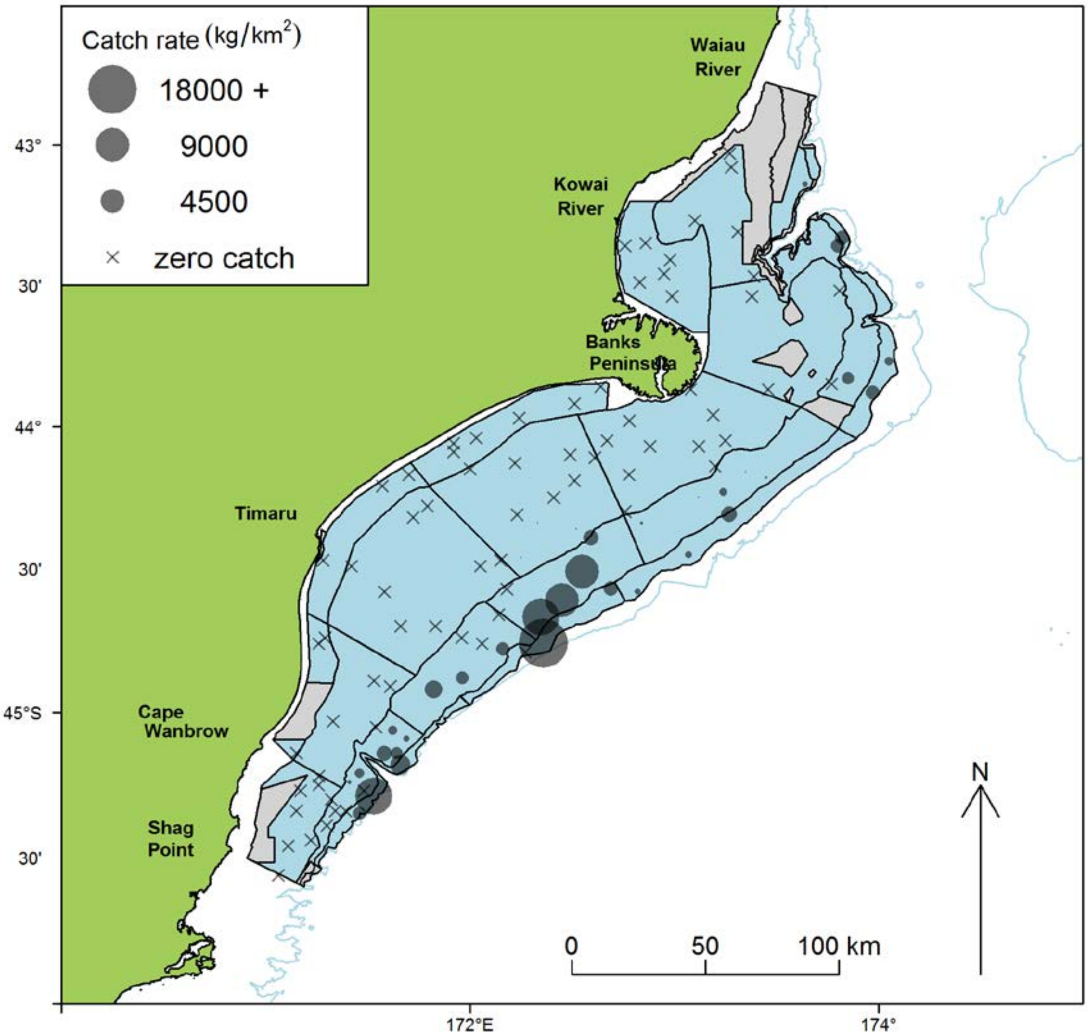


Figure 3: Catch rates (kg.km^{-2}) of target species for the 2016 ECSI survey. The legend indicates the circle size that corresponds to three catch rates; on the figure, circle size is continuous and proportional to the catch rate. Crosses indicate no catch at that station. Grey shaded areas are foul ground. The 500 m depth contour is shown.

Elephantfish

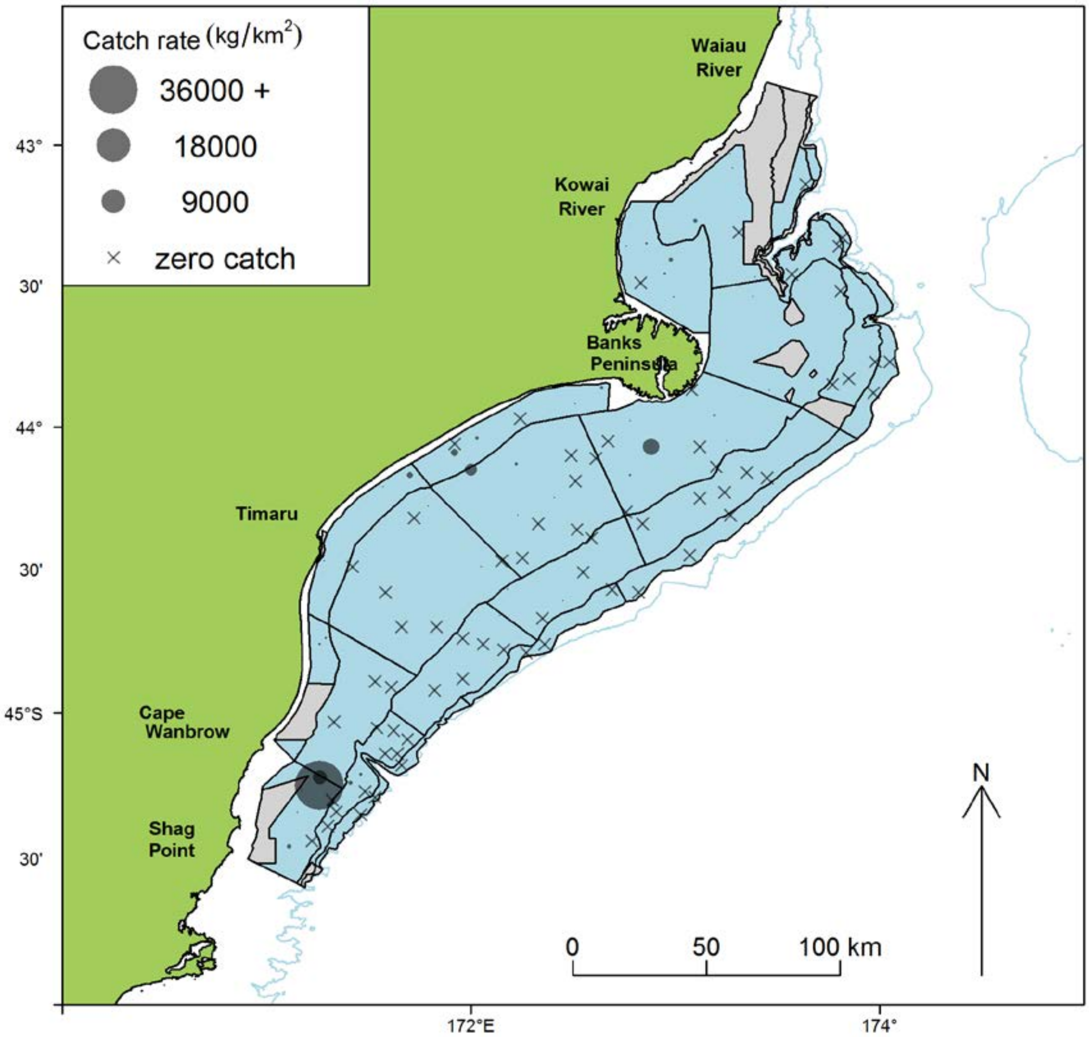


Figure 3–*continued*

Giant stargazer

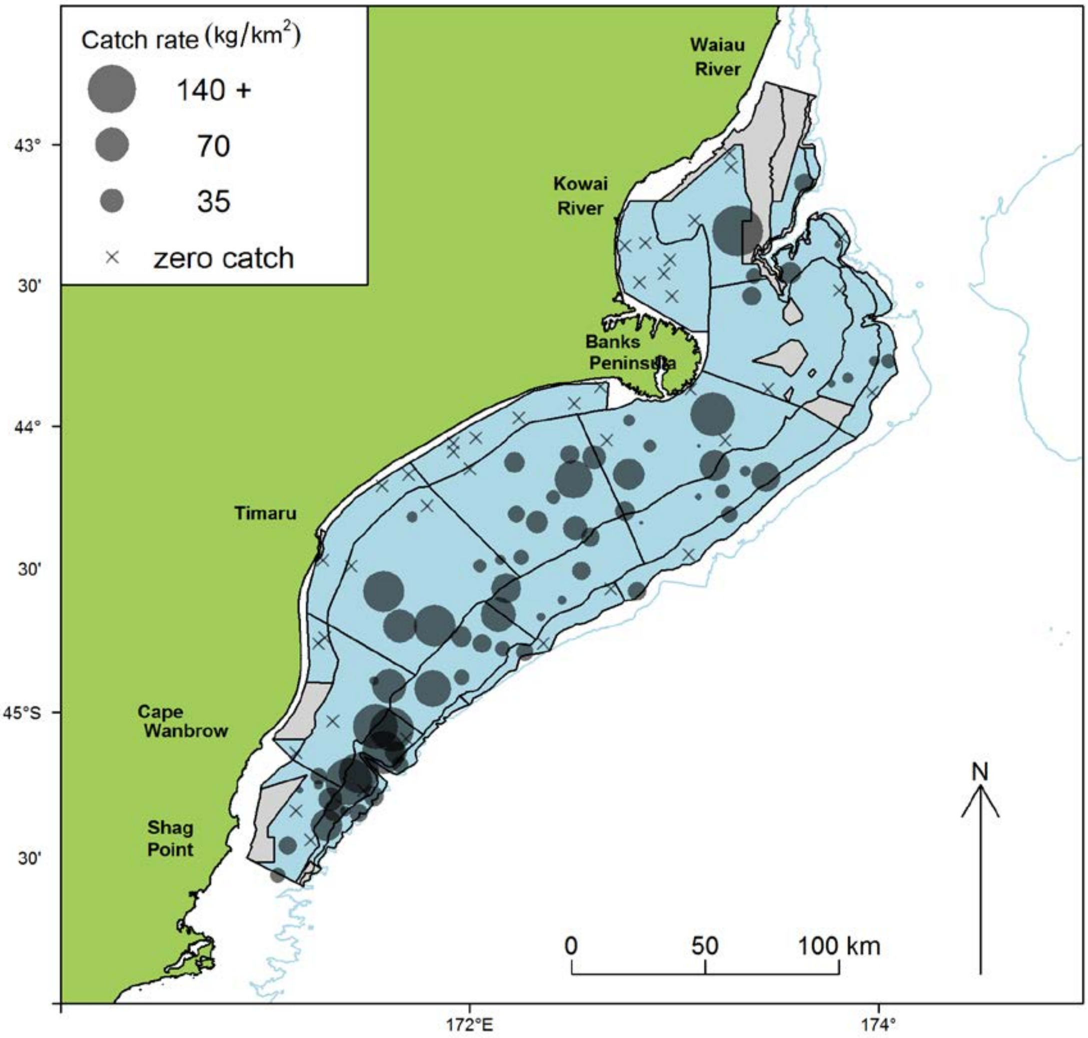


Figure 3–*continued*

Red Gurnard

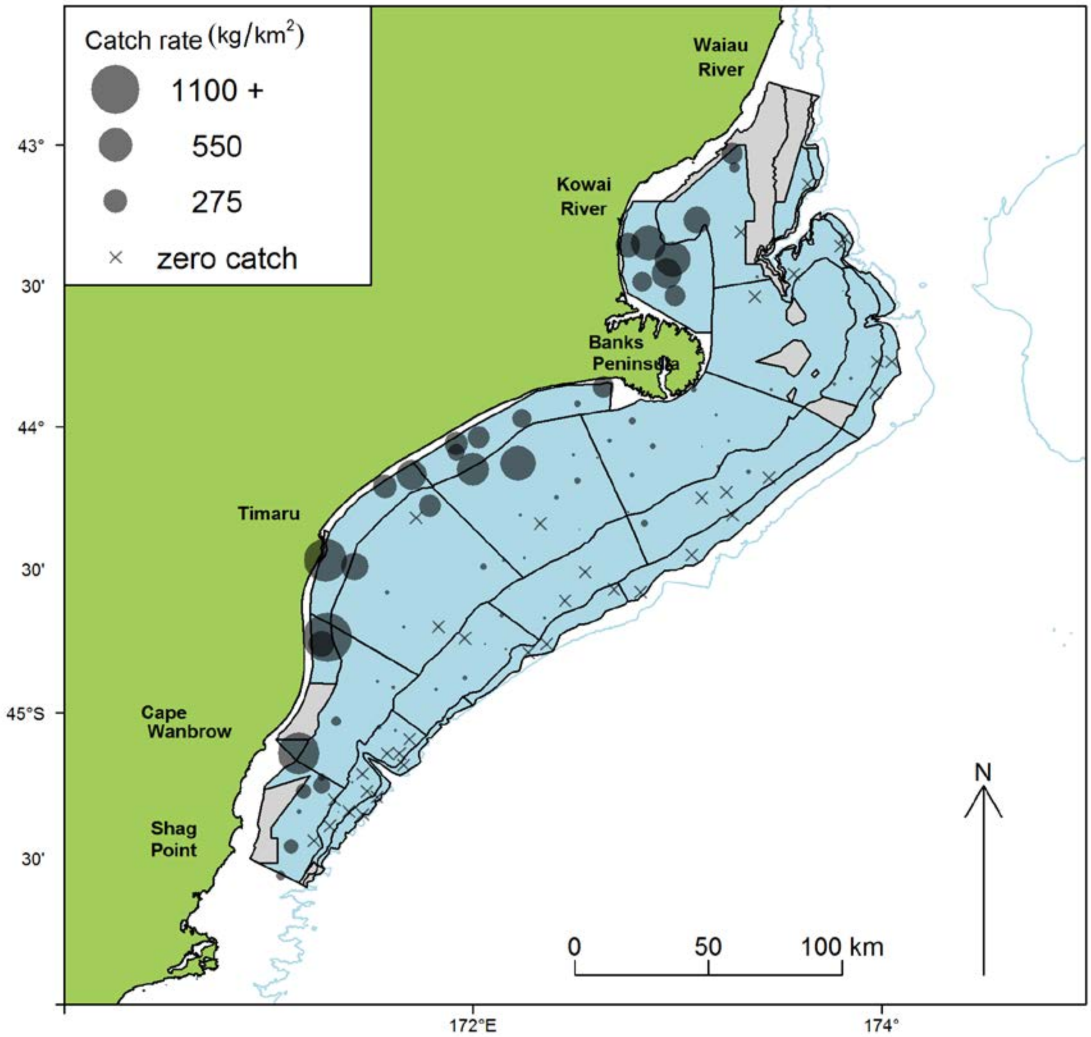


Figure 3–*continued*

Red cod

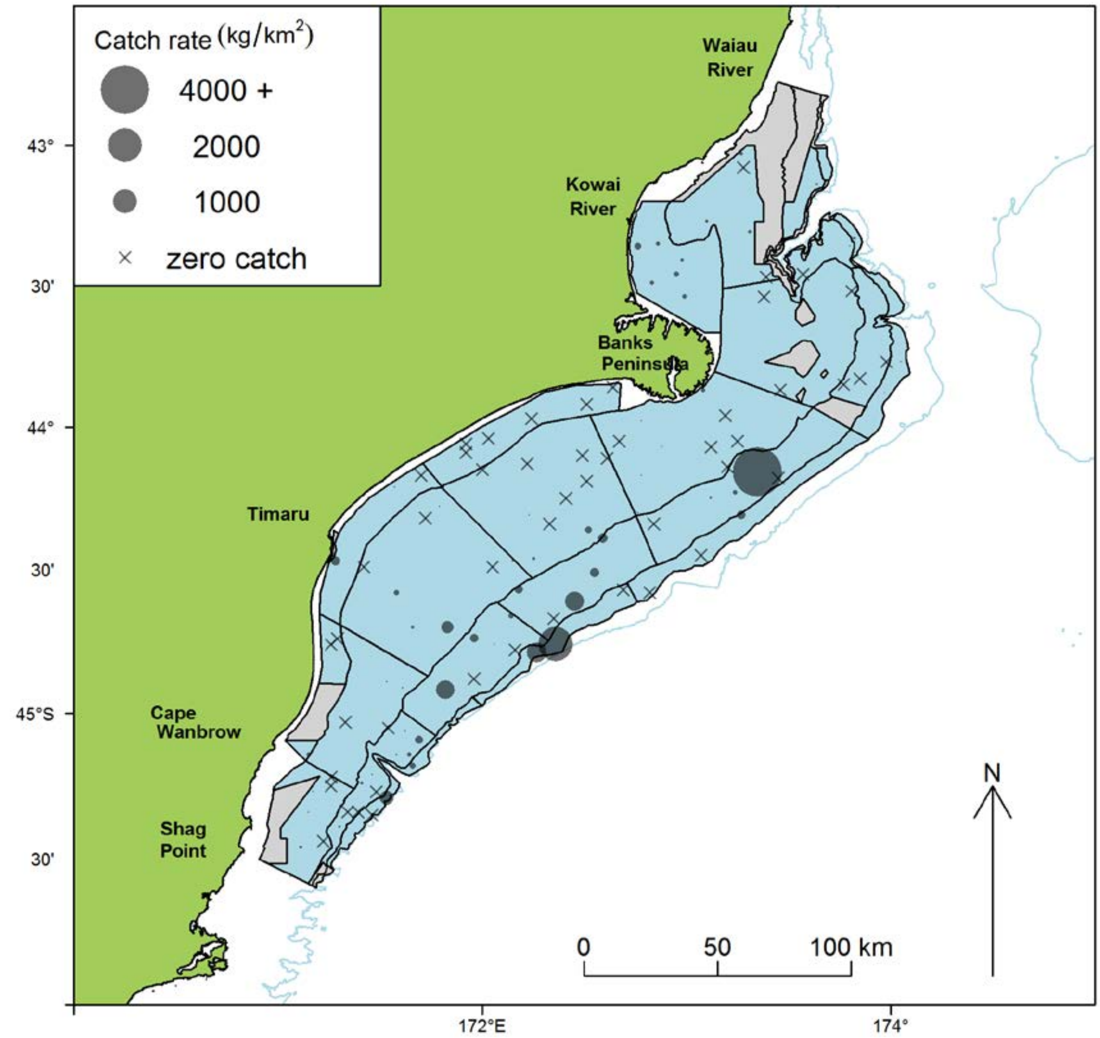


Figure 3–*continued*

Sea perch

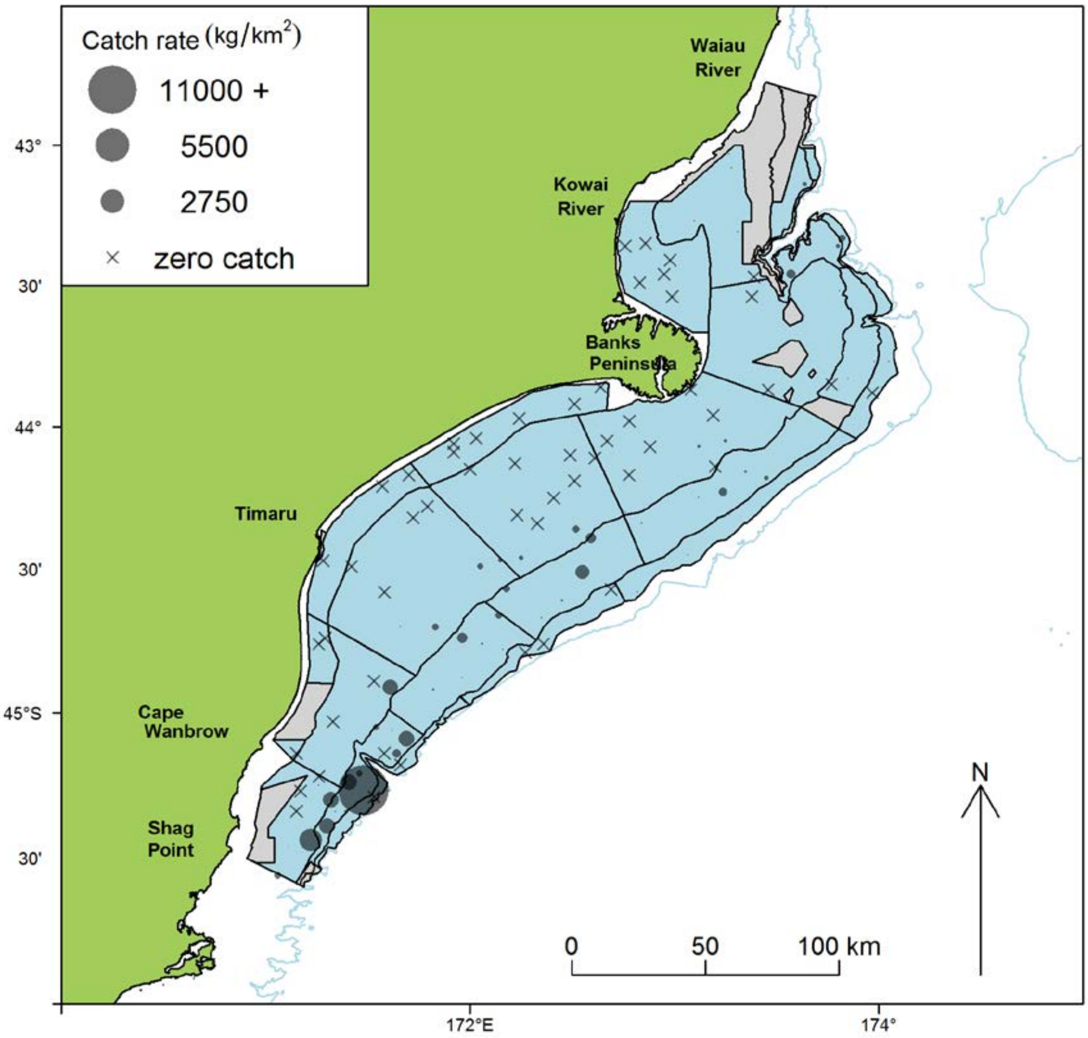


Figure 3–*continued*

Spiny dogfish

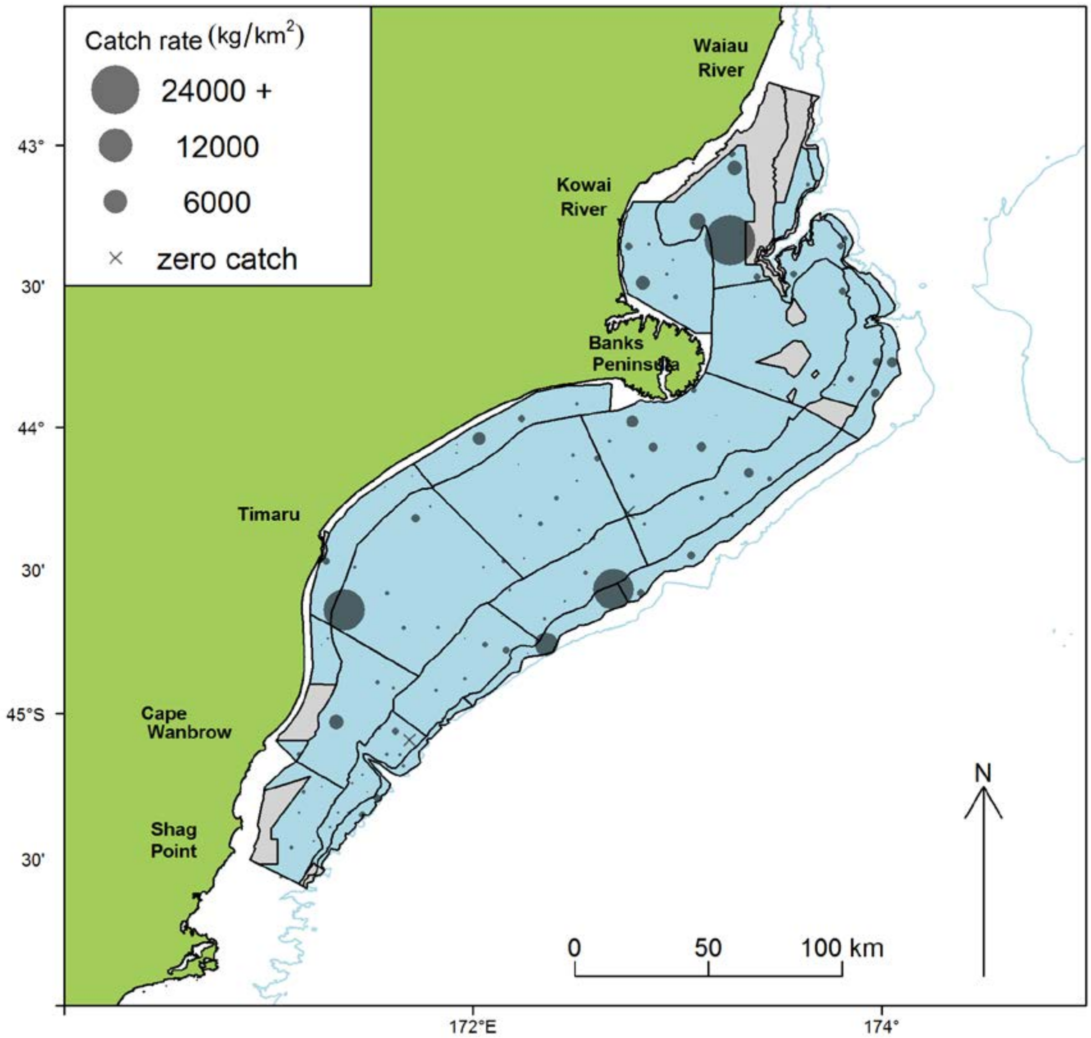


Figure 3–*continued*

Tarakihi

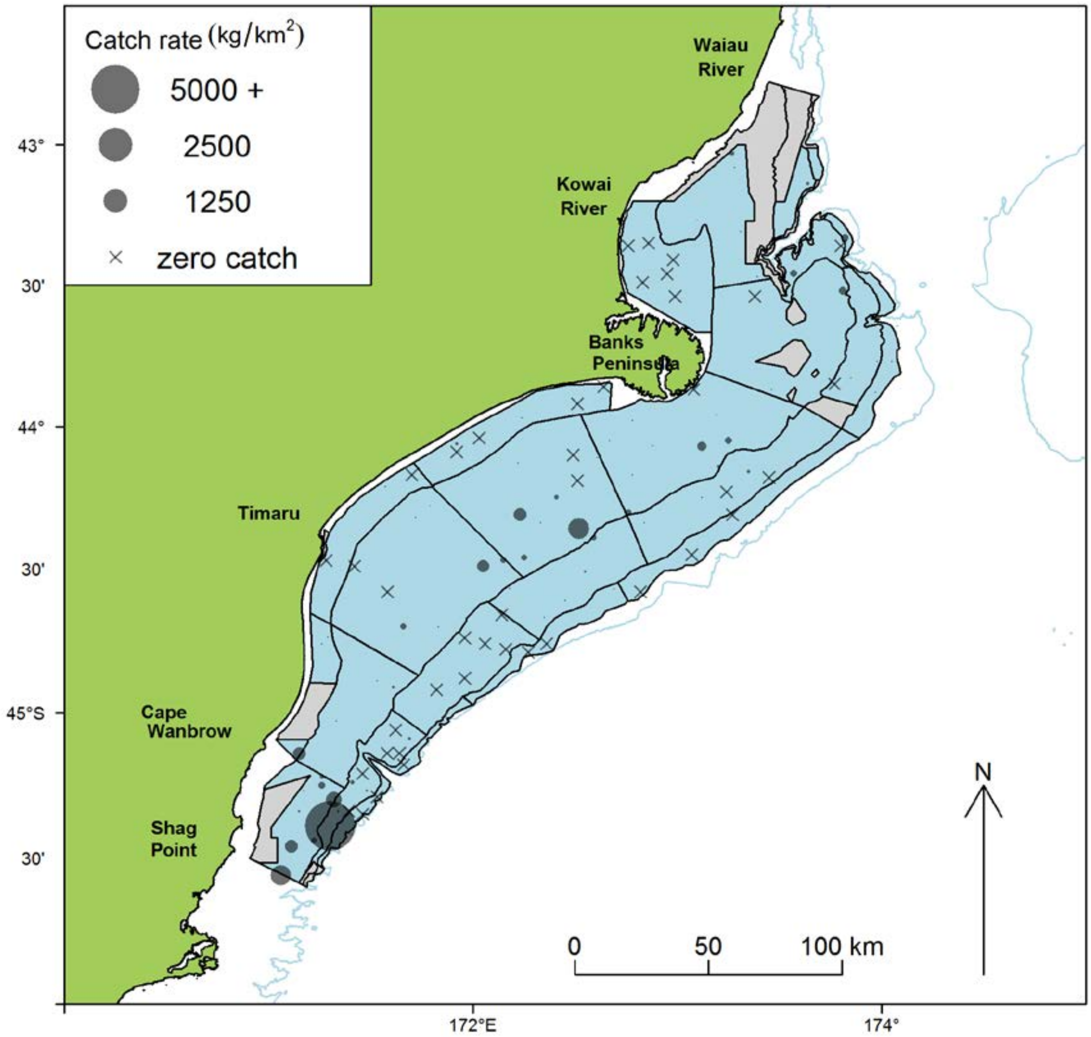
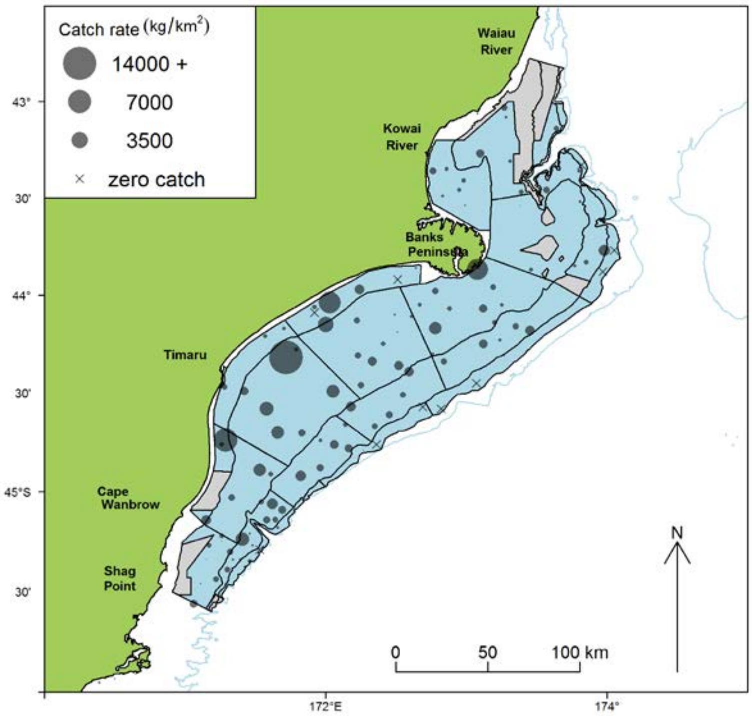


Figure 3–*continued*

Barracouta



Lemon sole

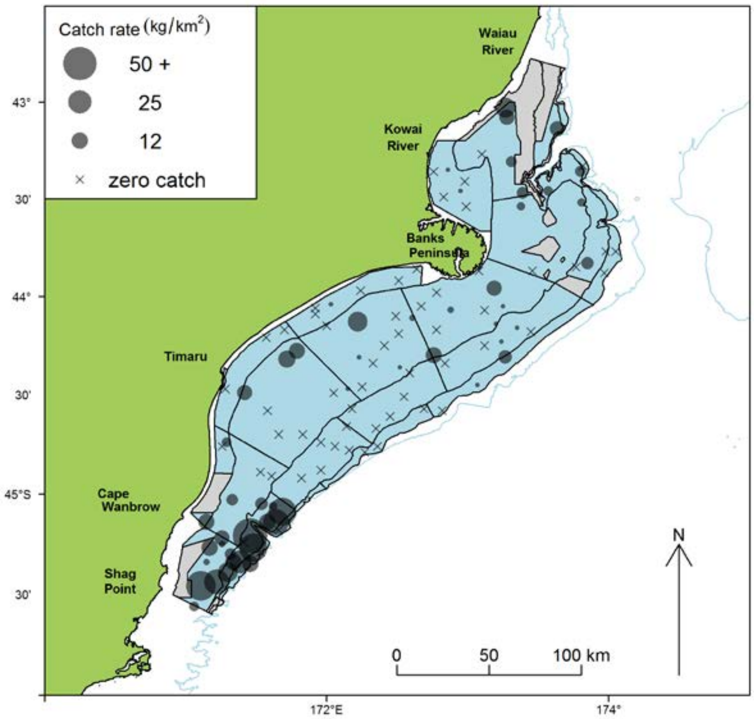
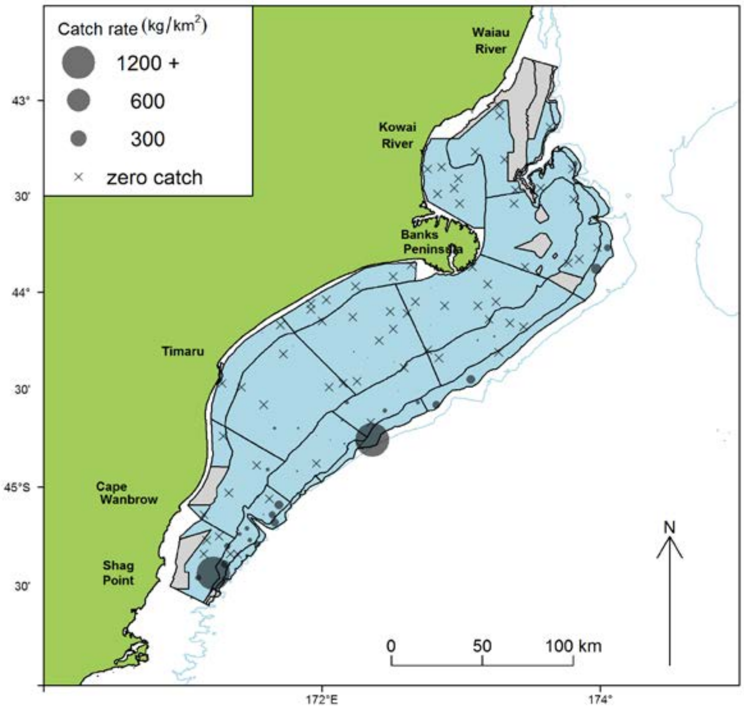


Figure 4: Catch rates (kg.km^{-2}) of key non-target QMS species for the 2014 ECSI survey. The legend indicates the circle size that corresponds to three catch rates; on the figure, circle size is continuous and proportional to the catch rate. Crosses indicate no catch at that station. Grey areas are foul ground. The 500 m depth contour is shown.

Ling



Rig

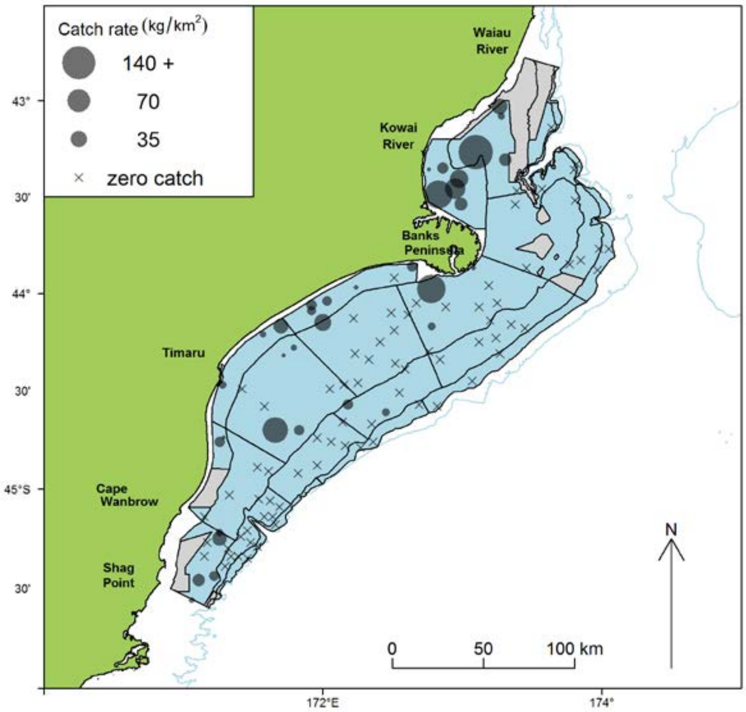
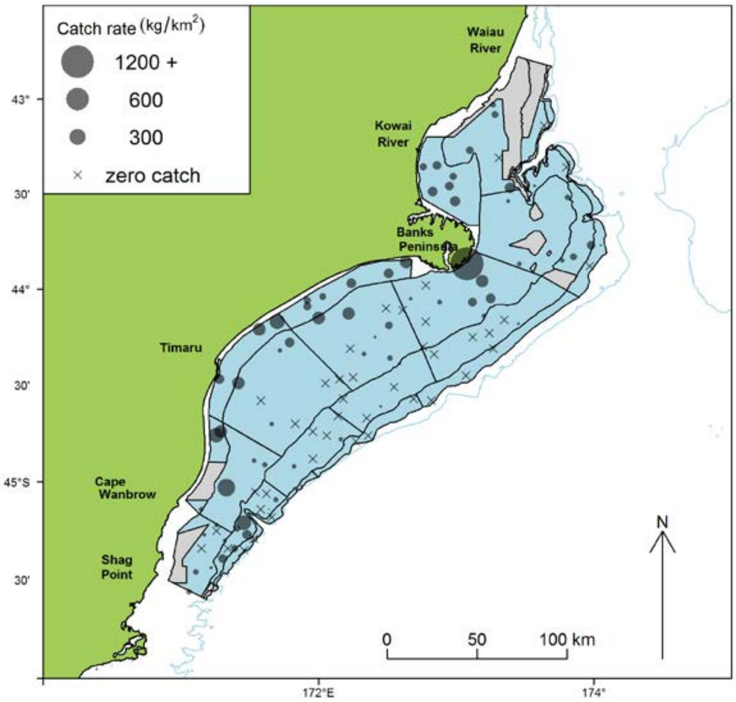


Figure 4–*continued*

Rough skate



School shark

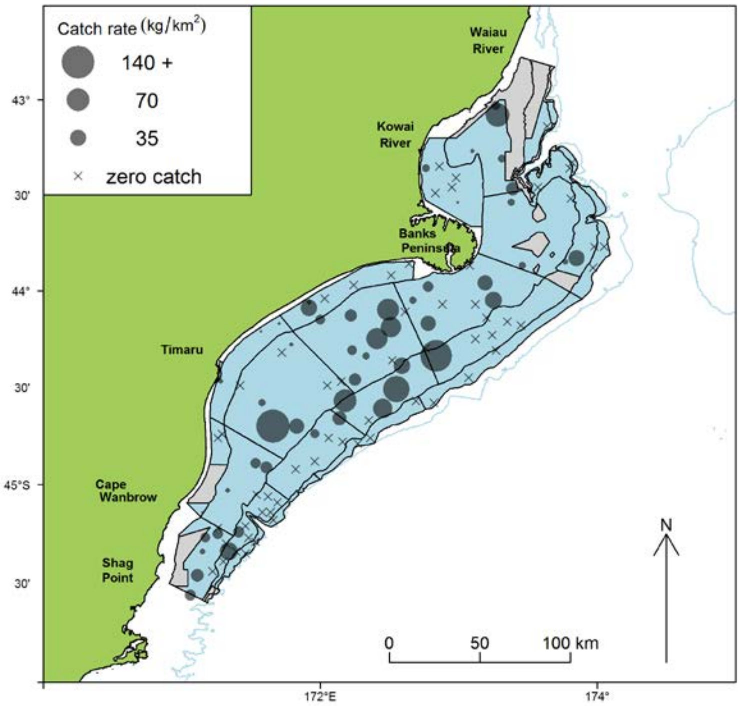
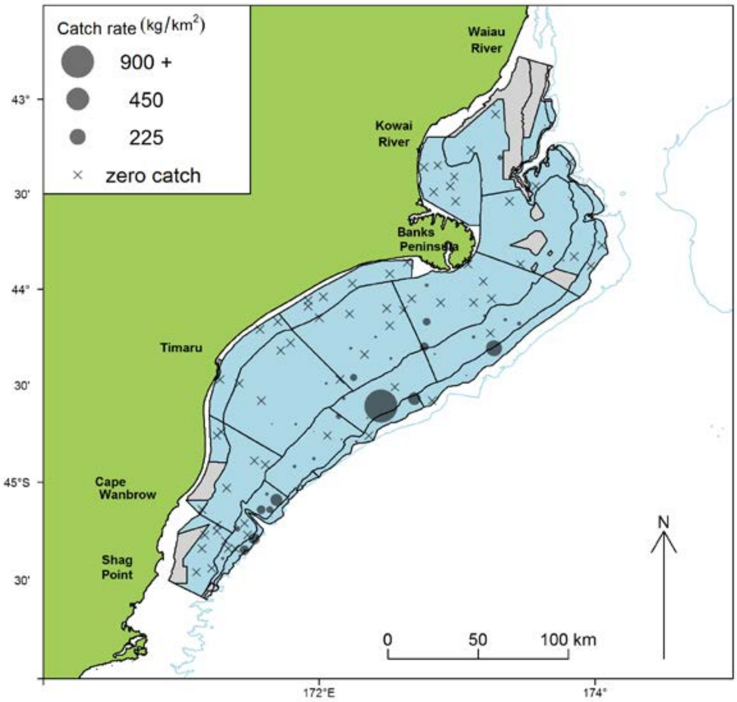


Figure 4–*continued*

Silver warehou



Smooth skate

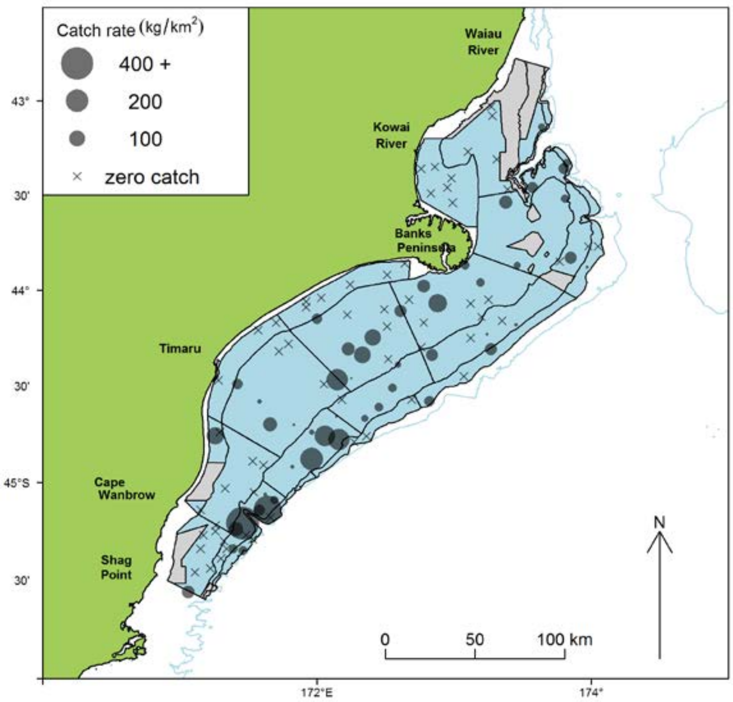


Figure 4–*continued*

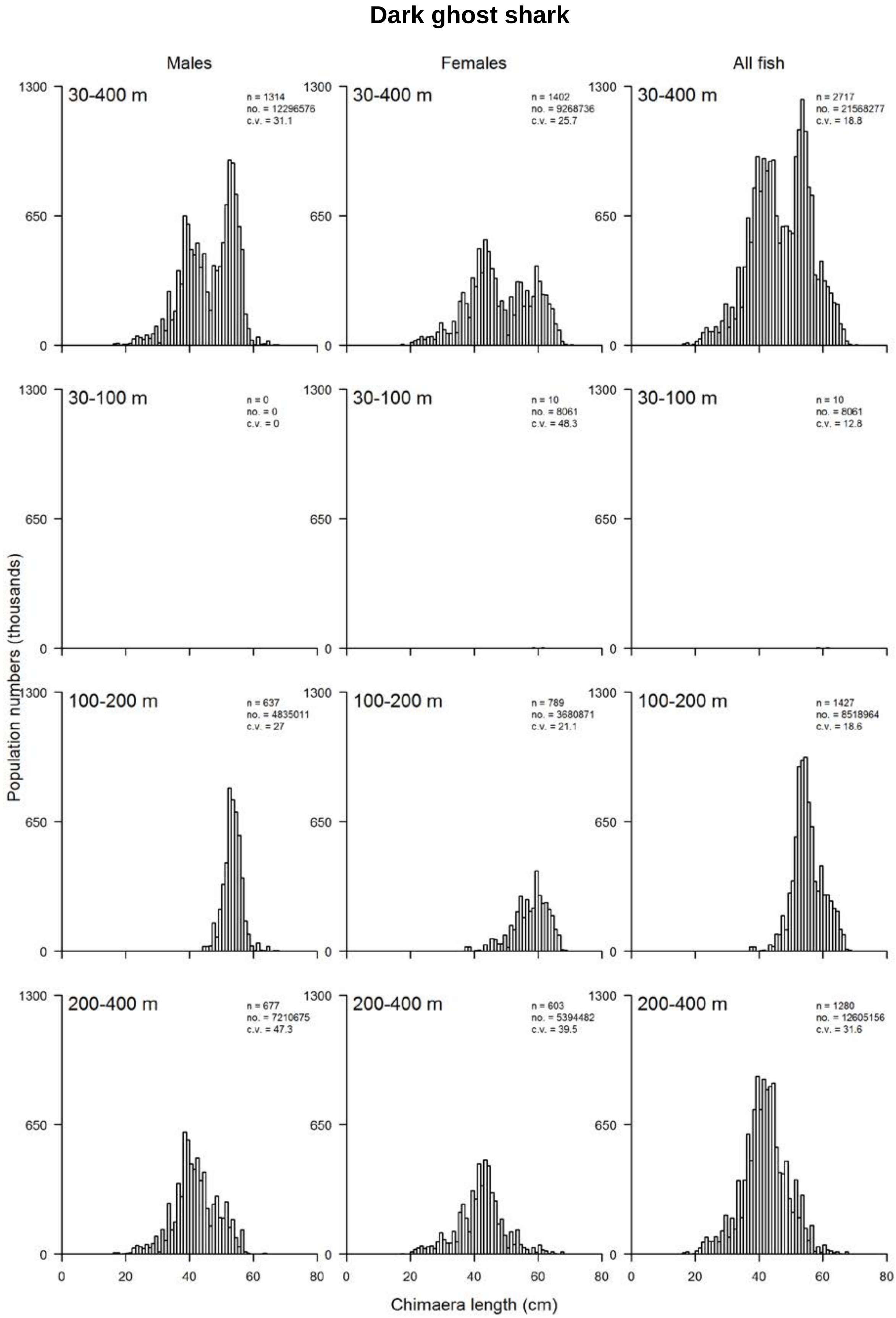


Figure 5: Scaled length frequency distributions for the target species by depth range for the 2016 survey. Population estimates are in thousands or millions of fish. The 'All fish' length distribution includes unsexed fish.

Elephantfish

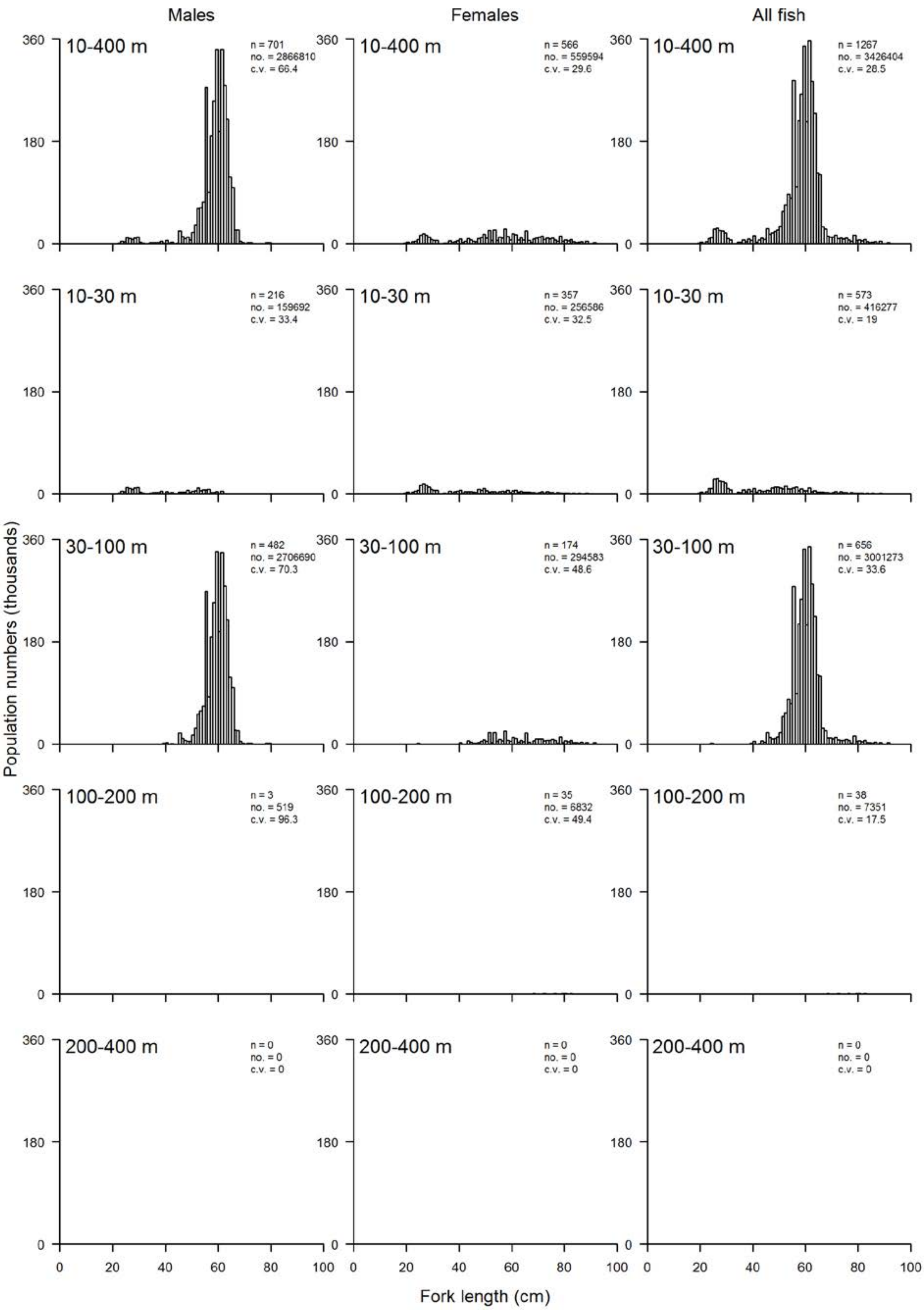


Figure 5–*continued*

Giant stargazer

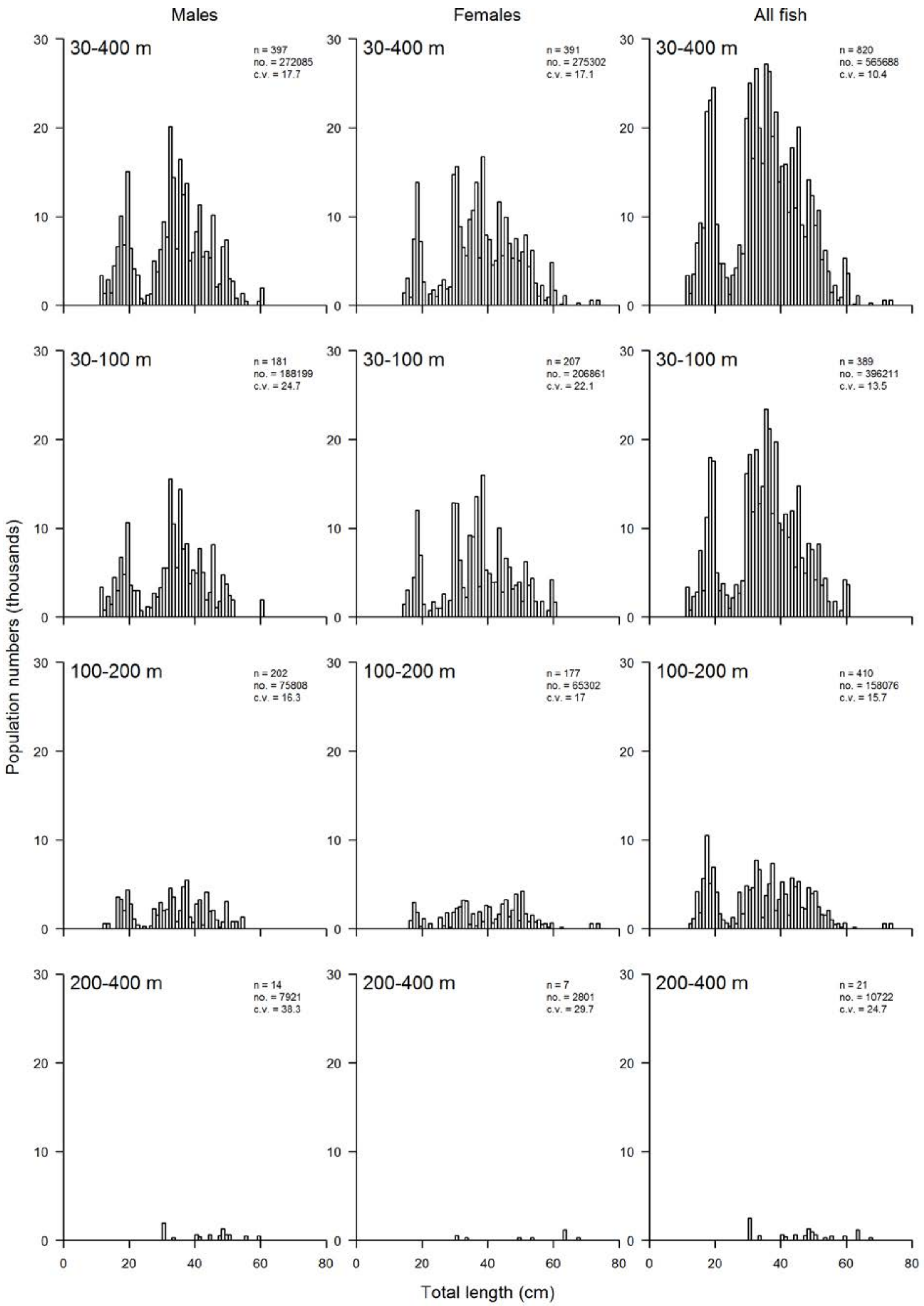


Figure 5–*continued*

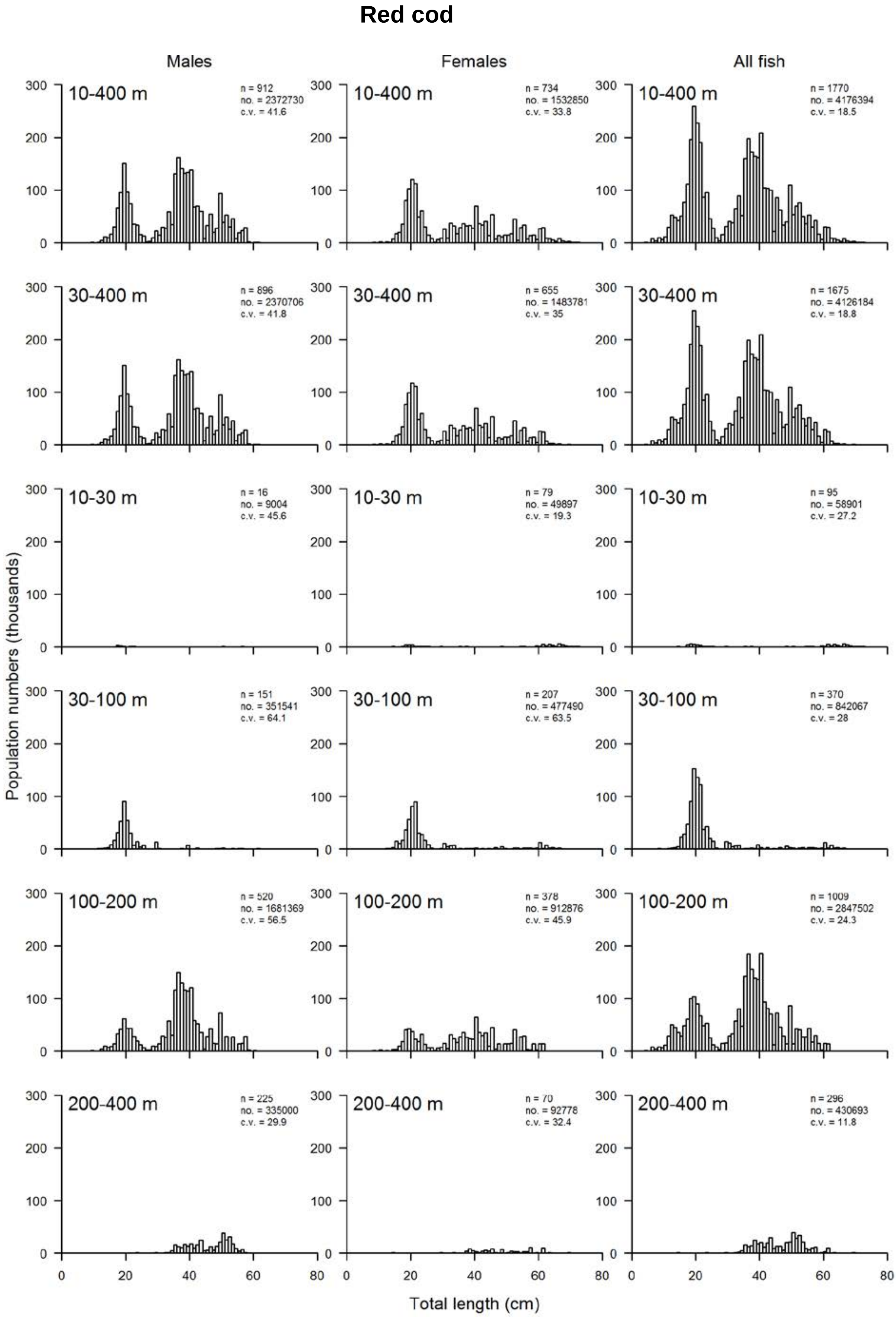


Figure 5–*continued*

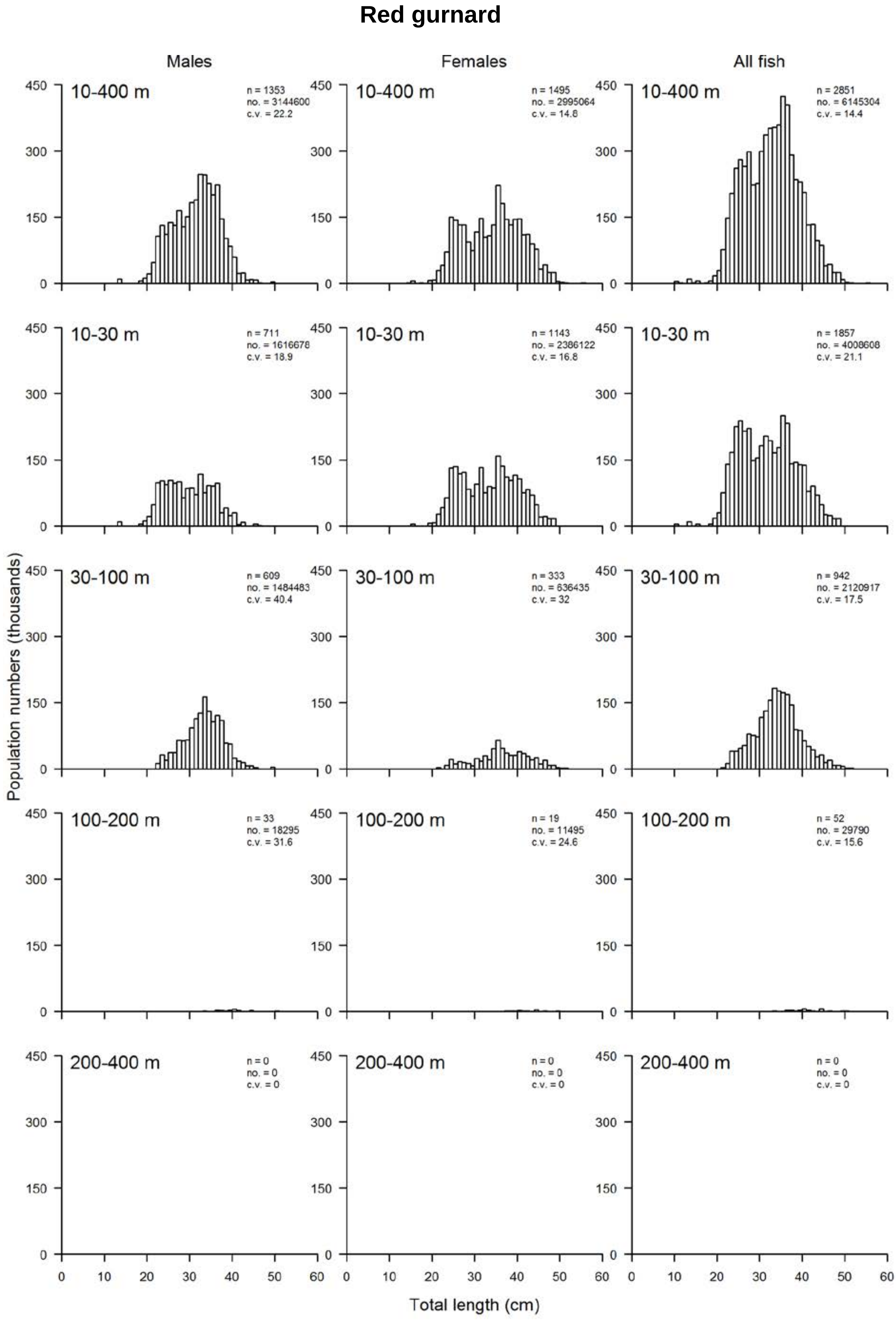


Figure 5–*continued*

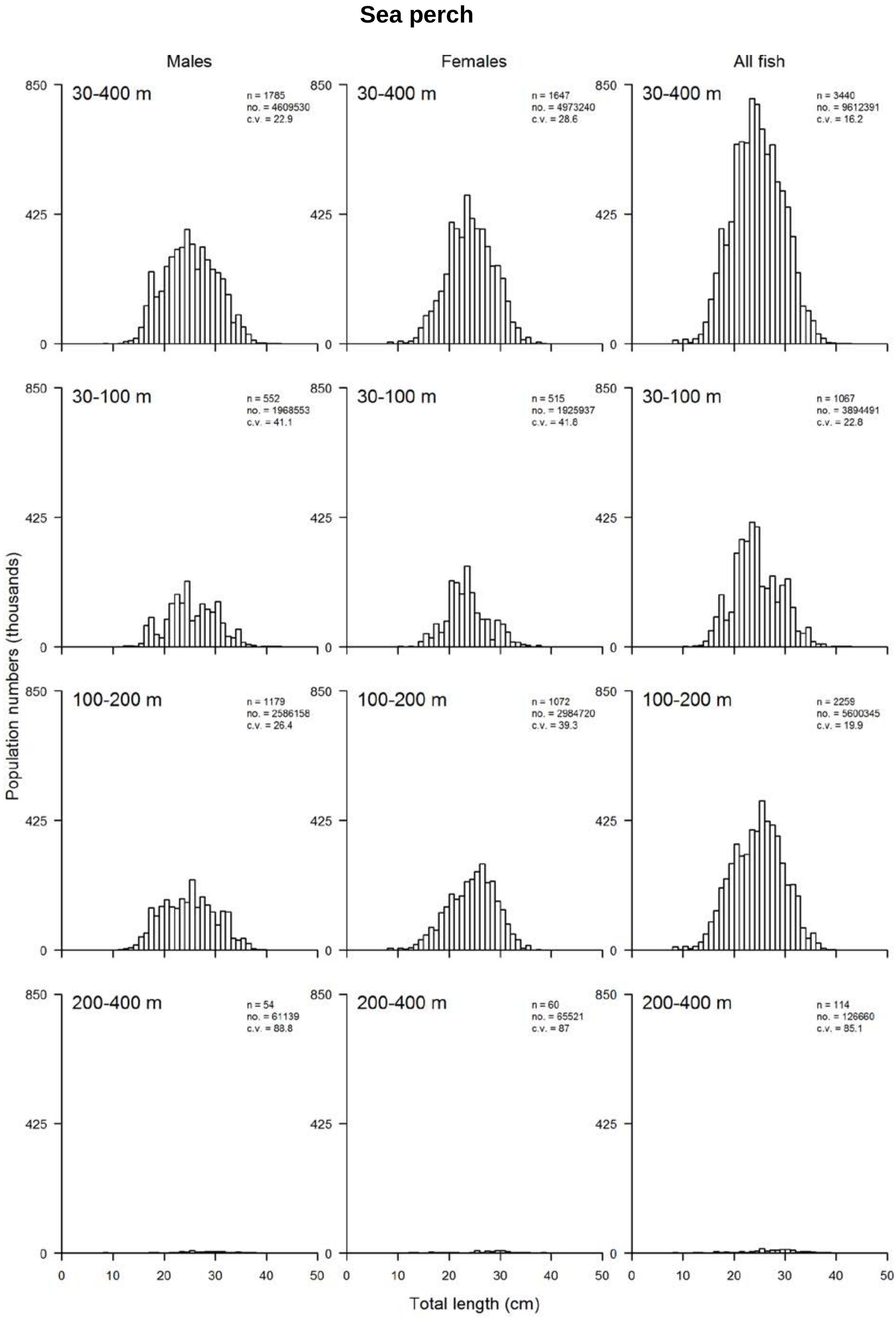


Figure 5 – *continued*

Spiny dogfish

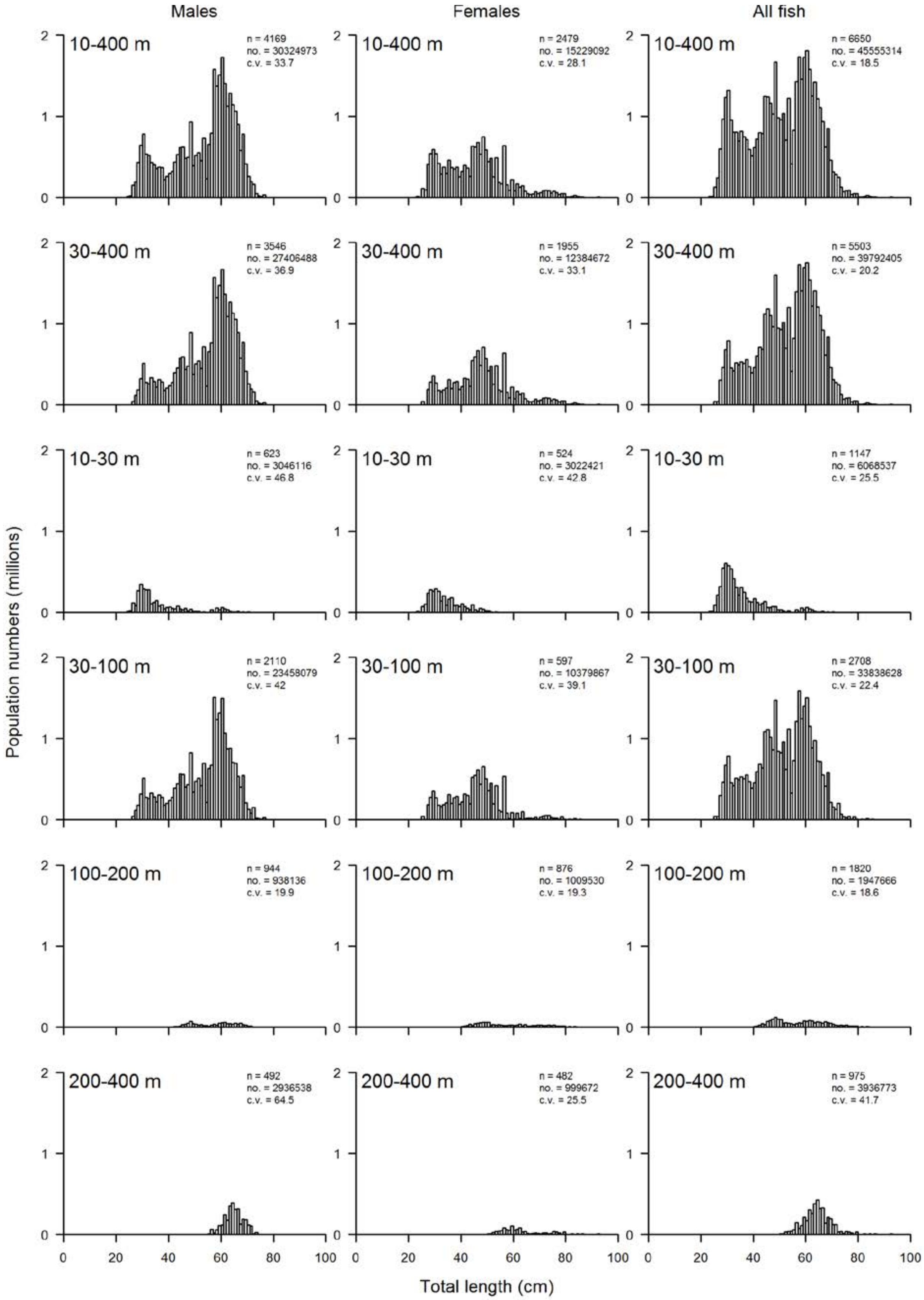


Figure 5–*continued*

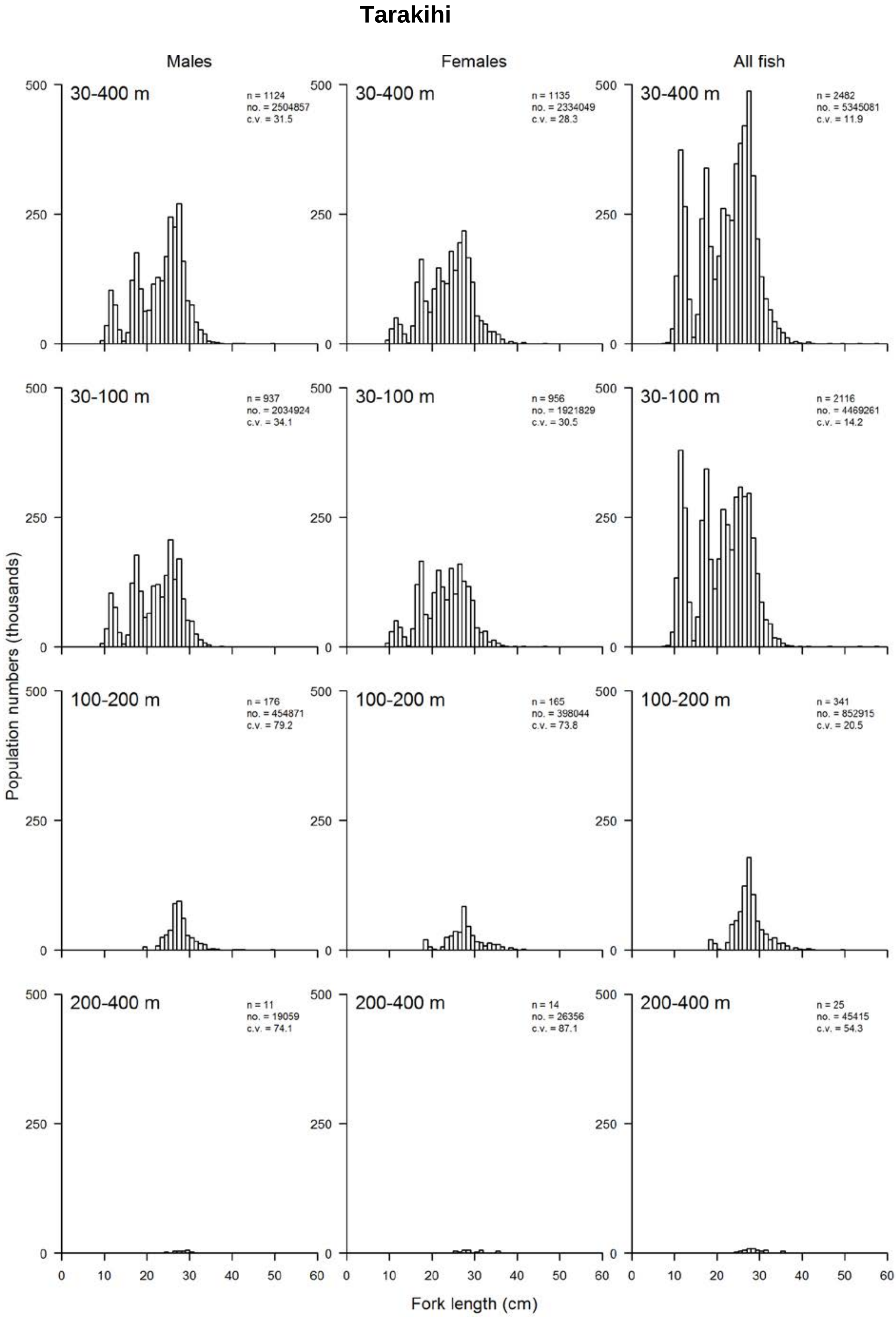
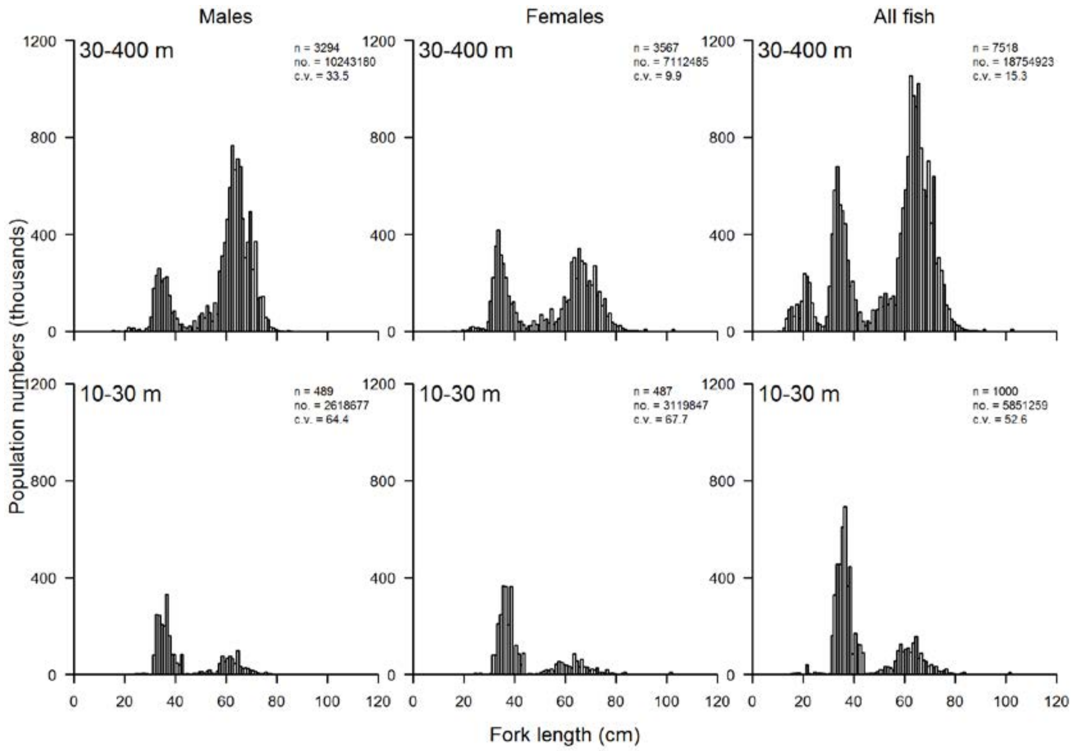


Figure 5–*continued*

Barracouta



Lemon sole

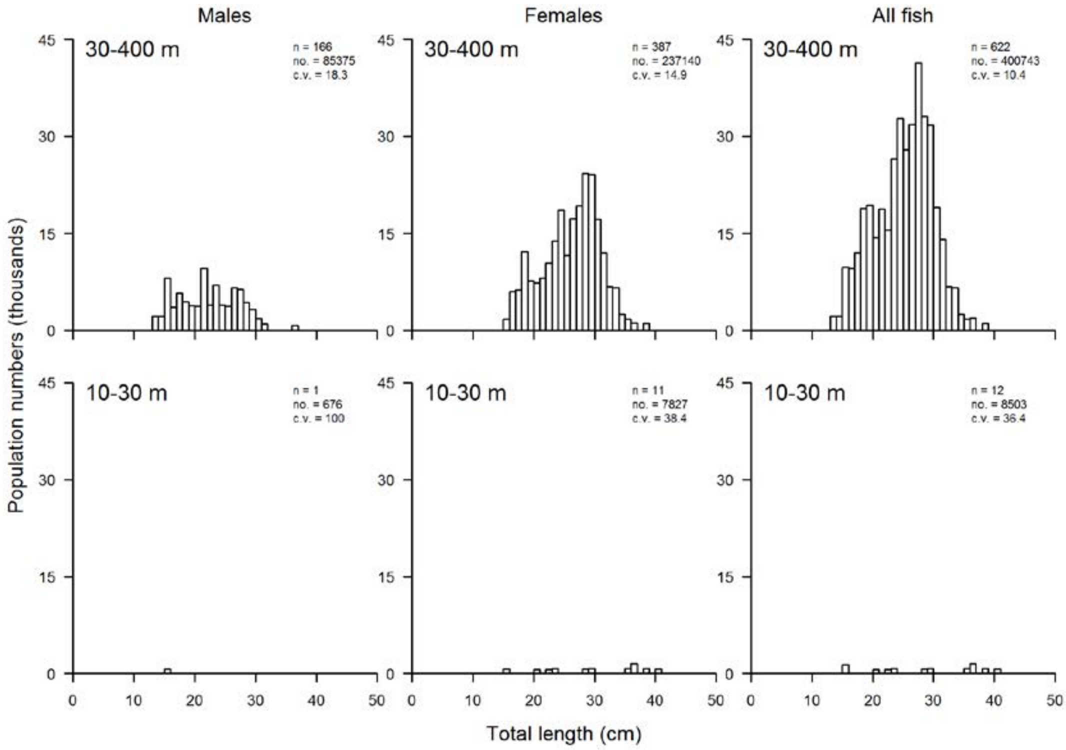
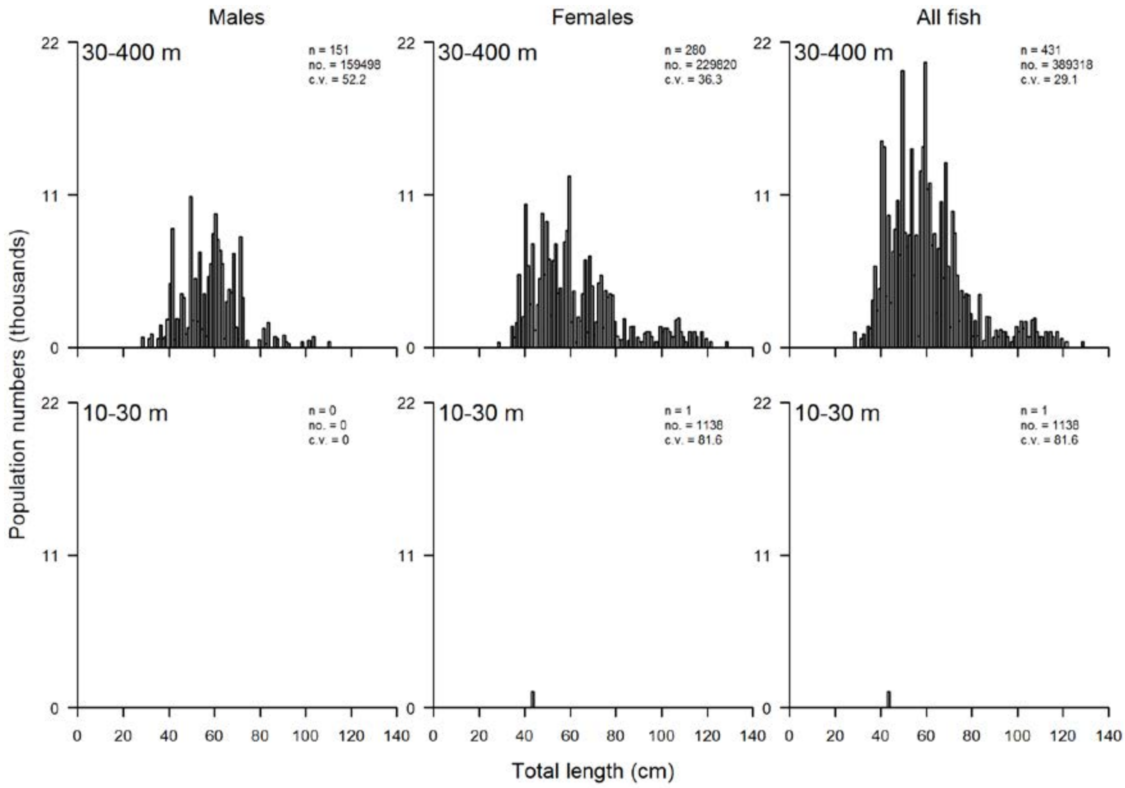


Figure 6: Scaled length frequency distributions for the key QMS species in 30–400 m, and 10–30 m for the 2016 survey. Population estimates are in thousands of fish.

Ling



Rig

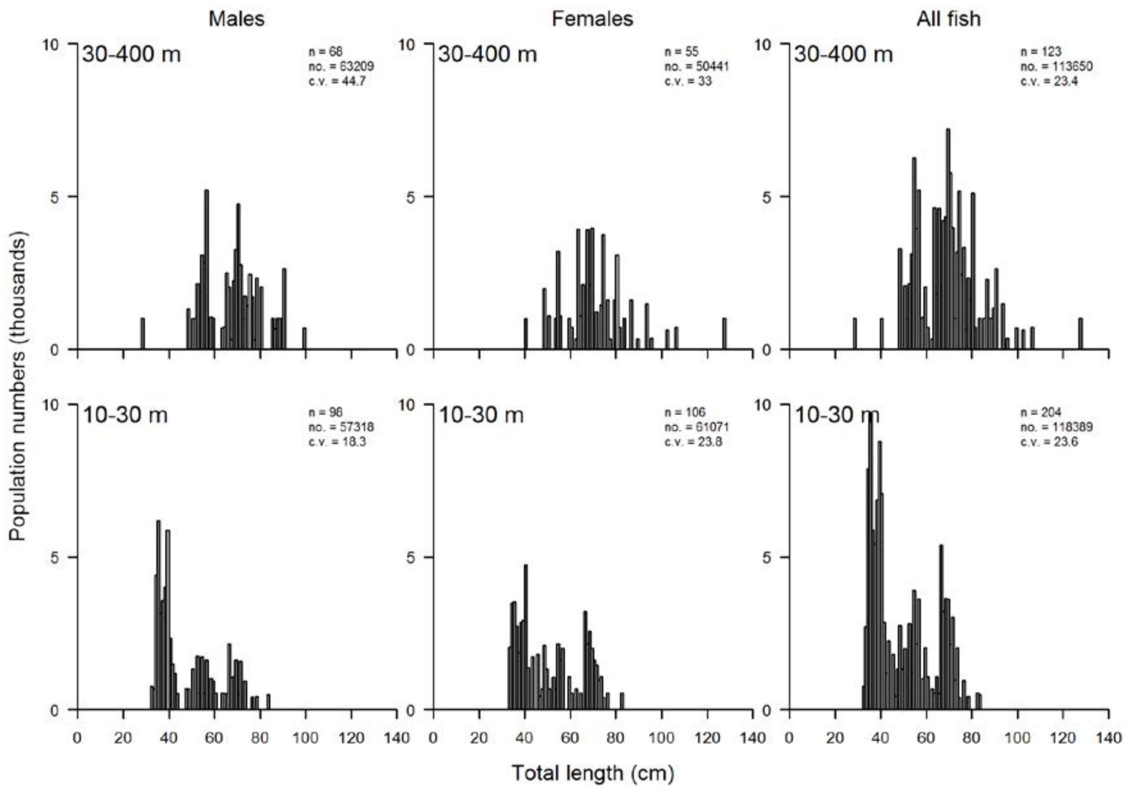
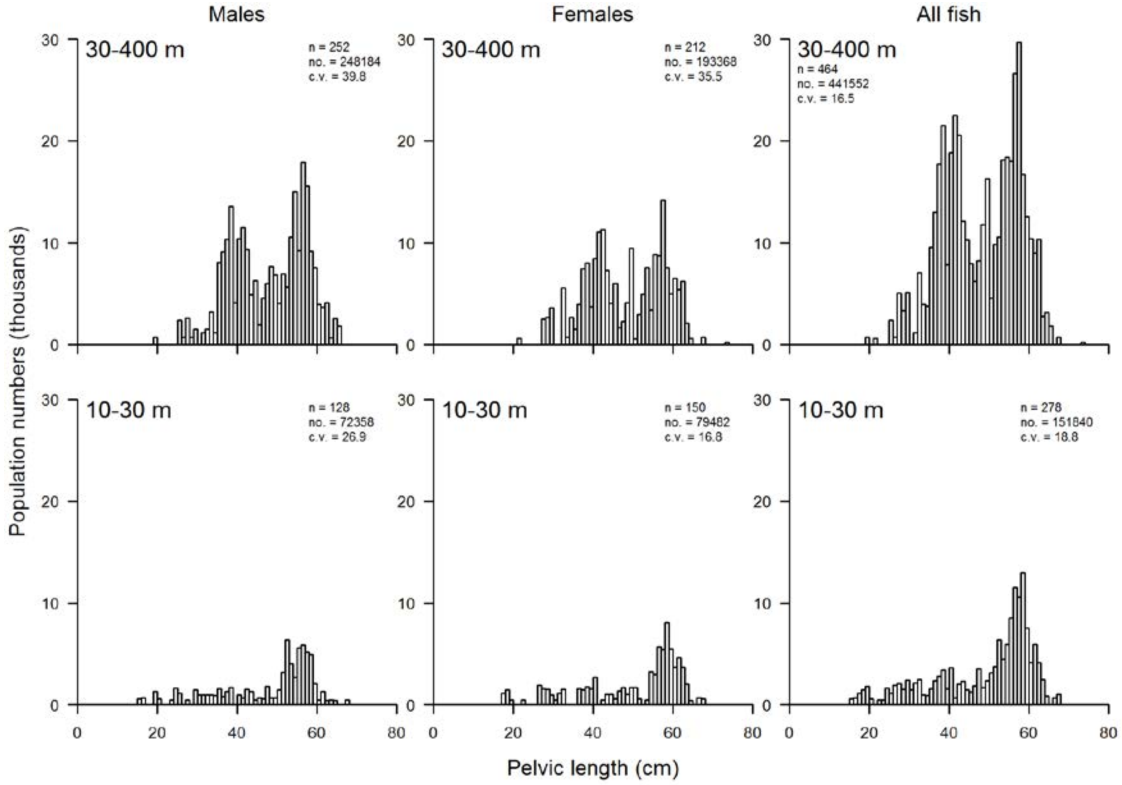


Figure 6 – ***continued***

Rough skate



School shark

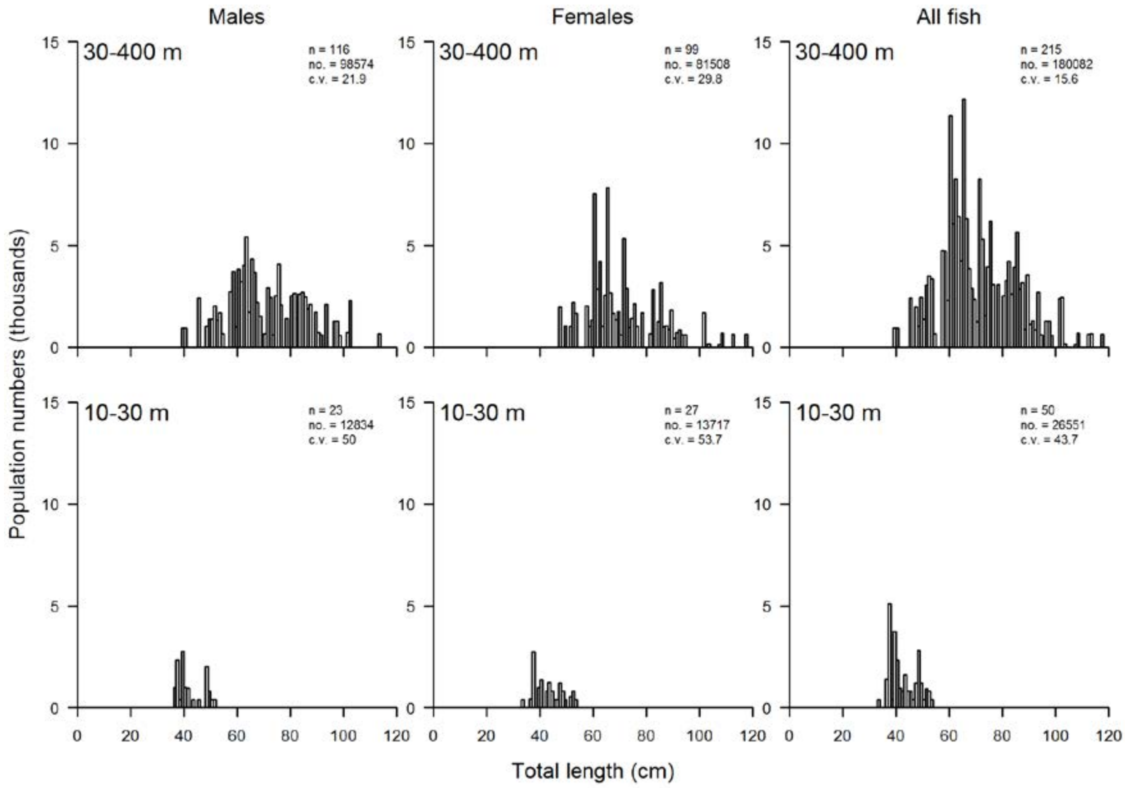
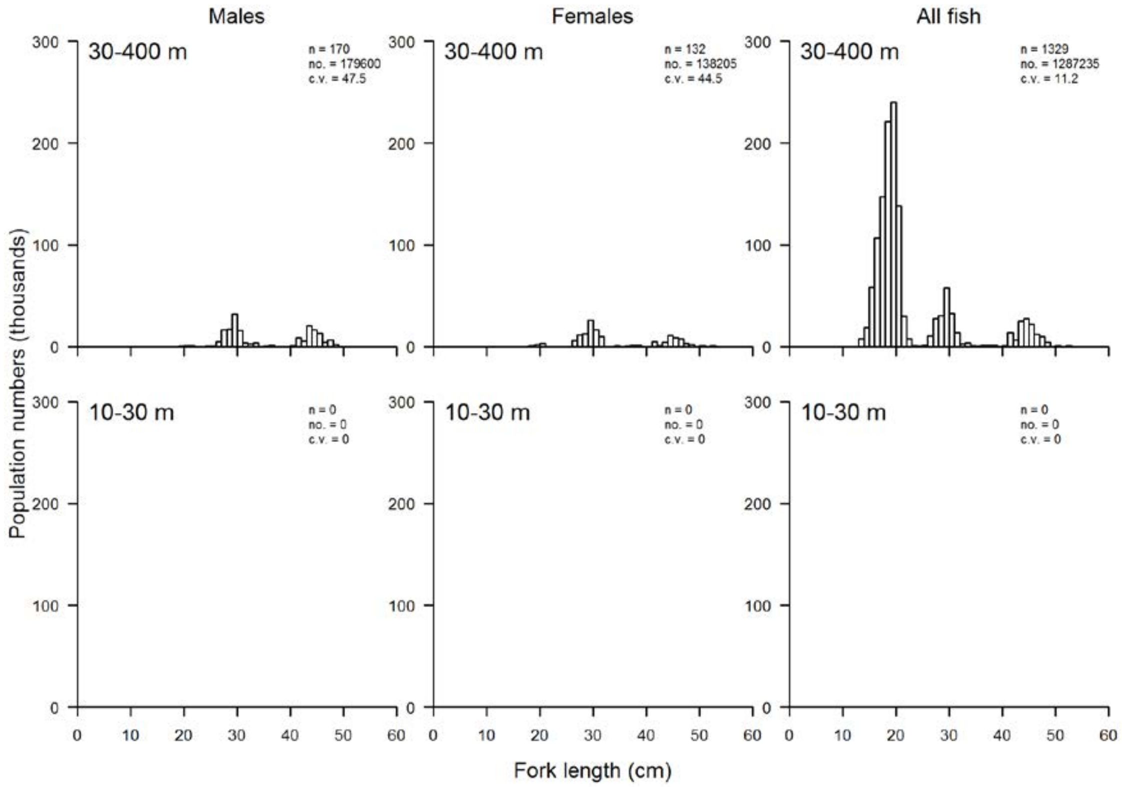


Figure 6 – ***continued***

Silver warehou



Smooth skate

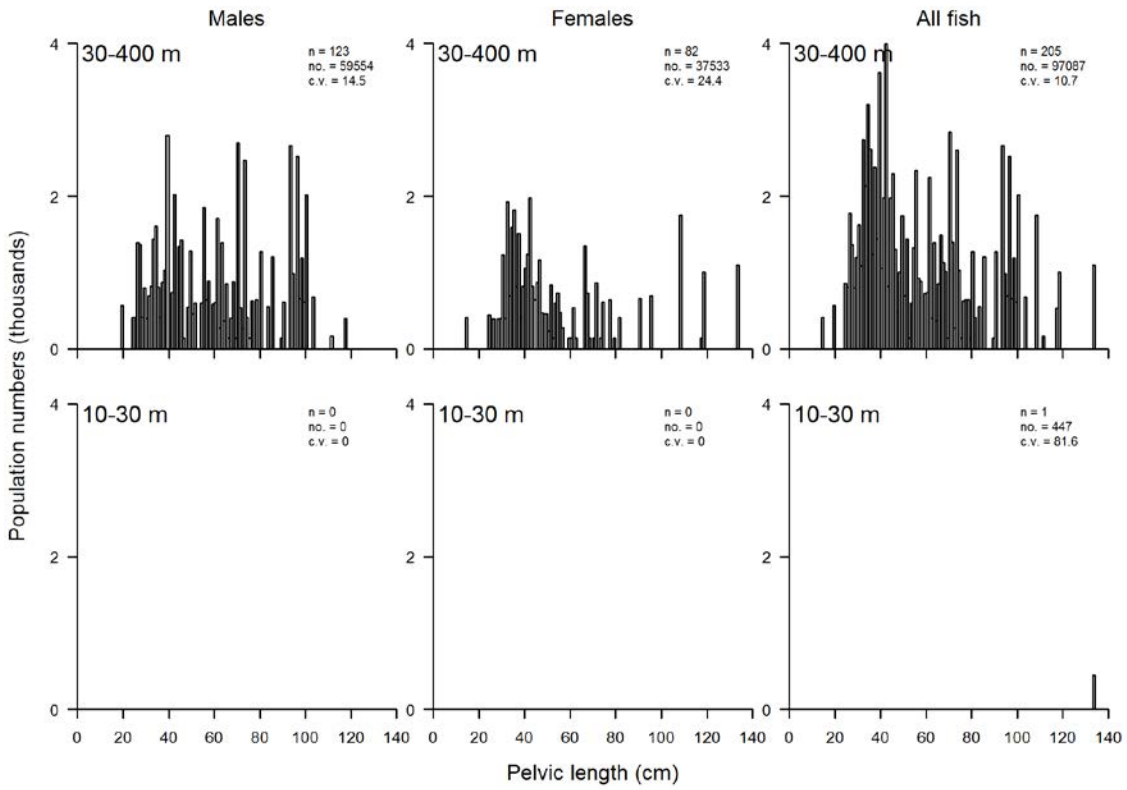
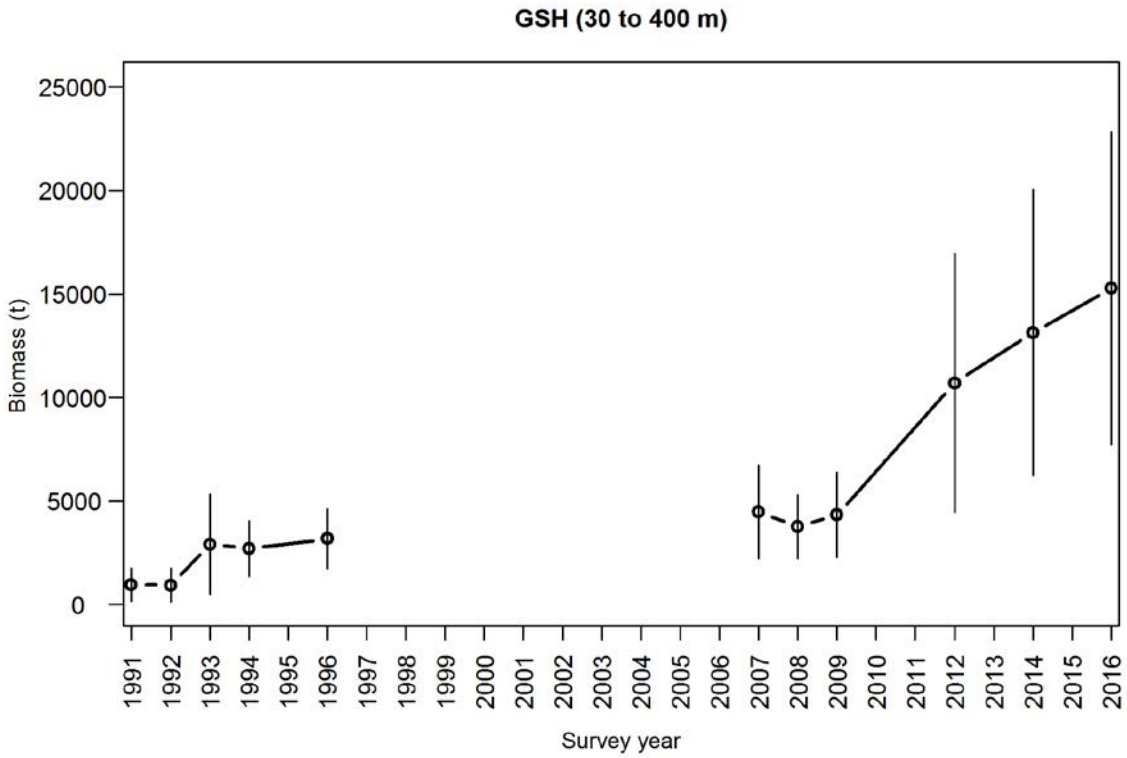


Figure 6 – ***continued***



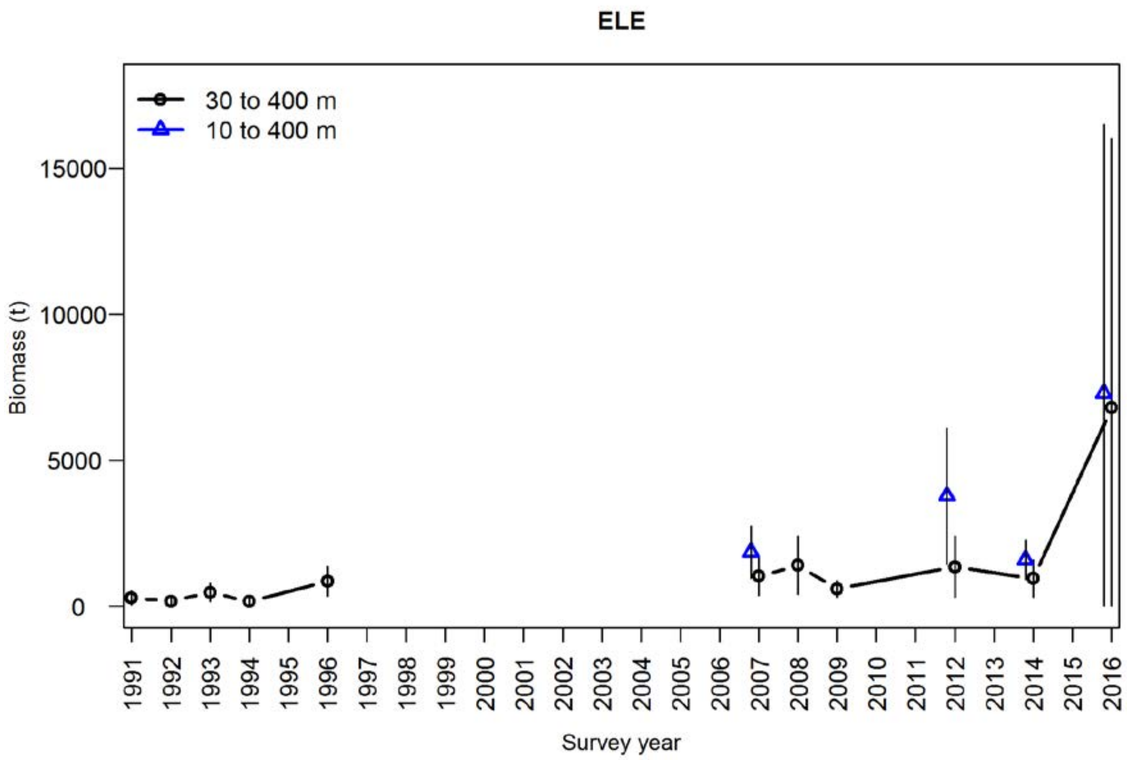
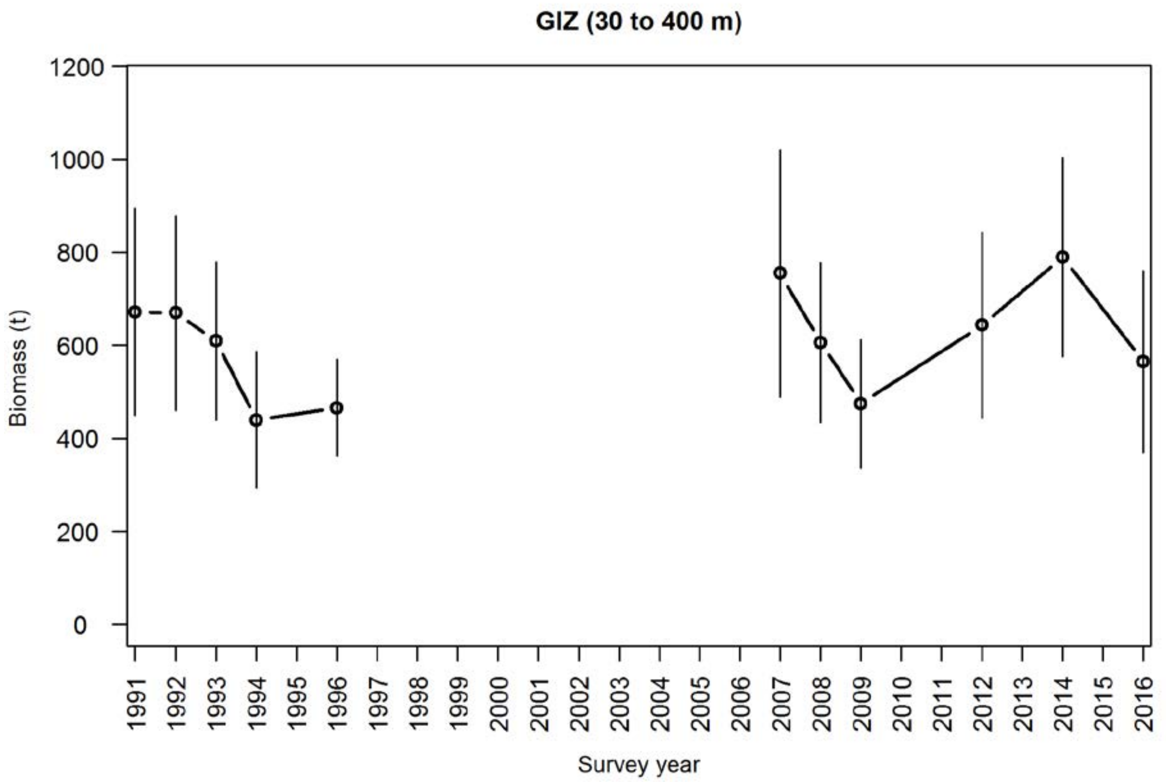


Figure 7: Target species total biomass and 95% confidence intervals for the all ECSI winter surveys in core strata (30–400 m), and core plus shallow strata (10–400 m) for species found in less than 30 m in 2007, 2012, 2014, and 2016.



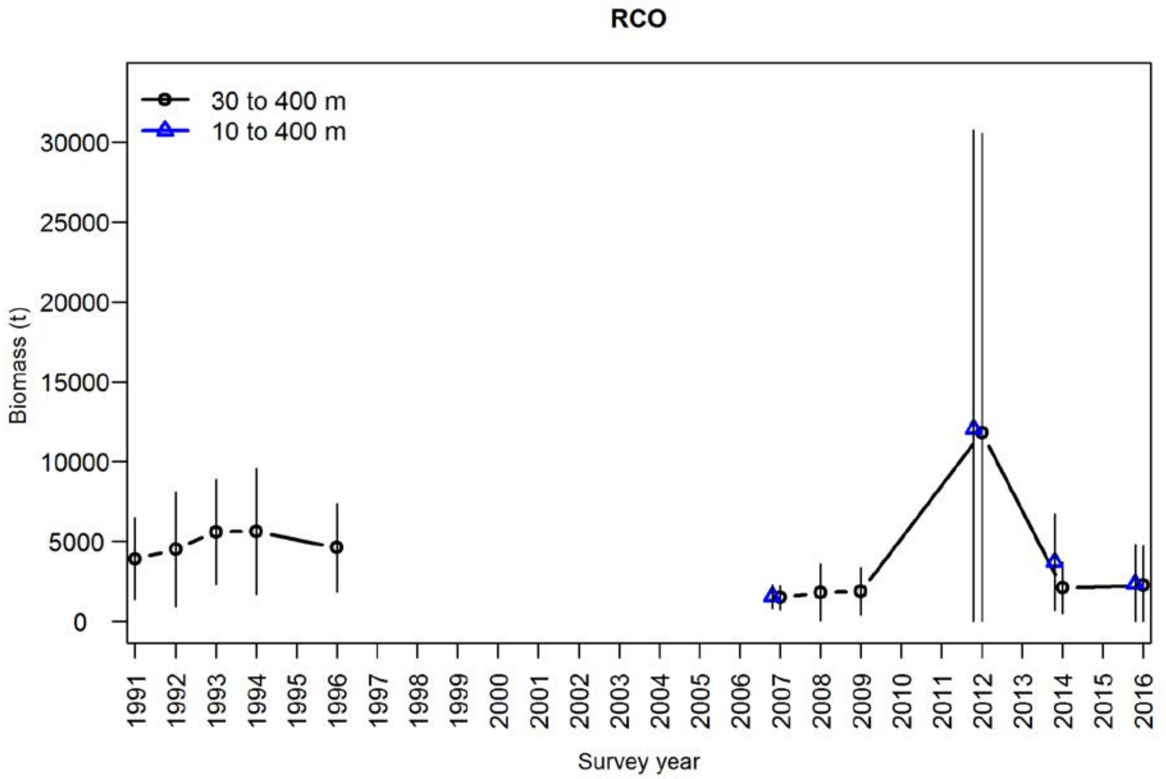
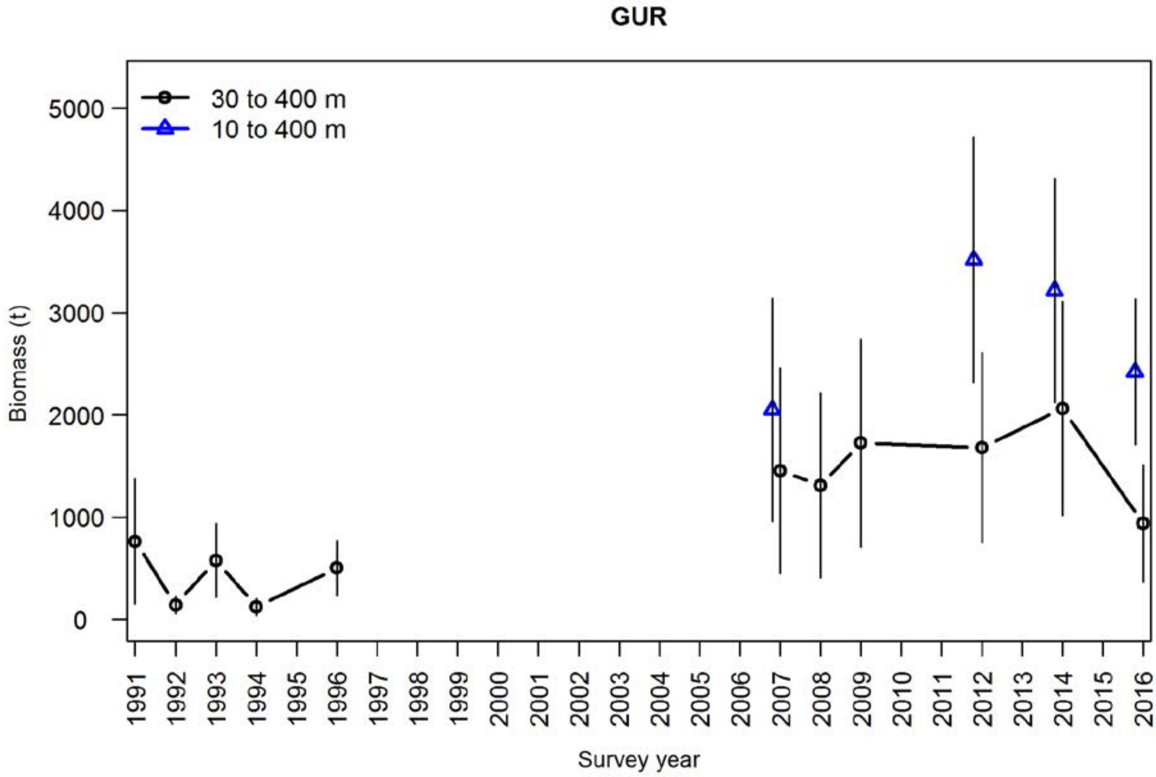


Figure 7 – ***continued***



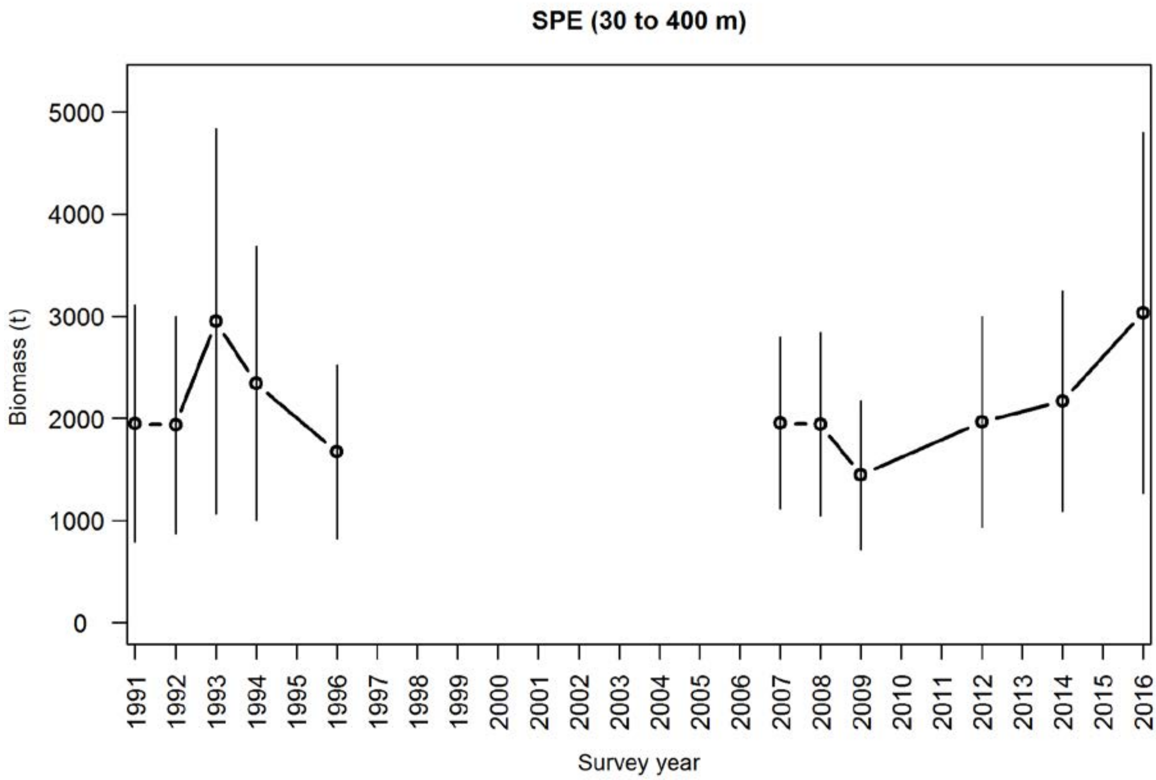
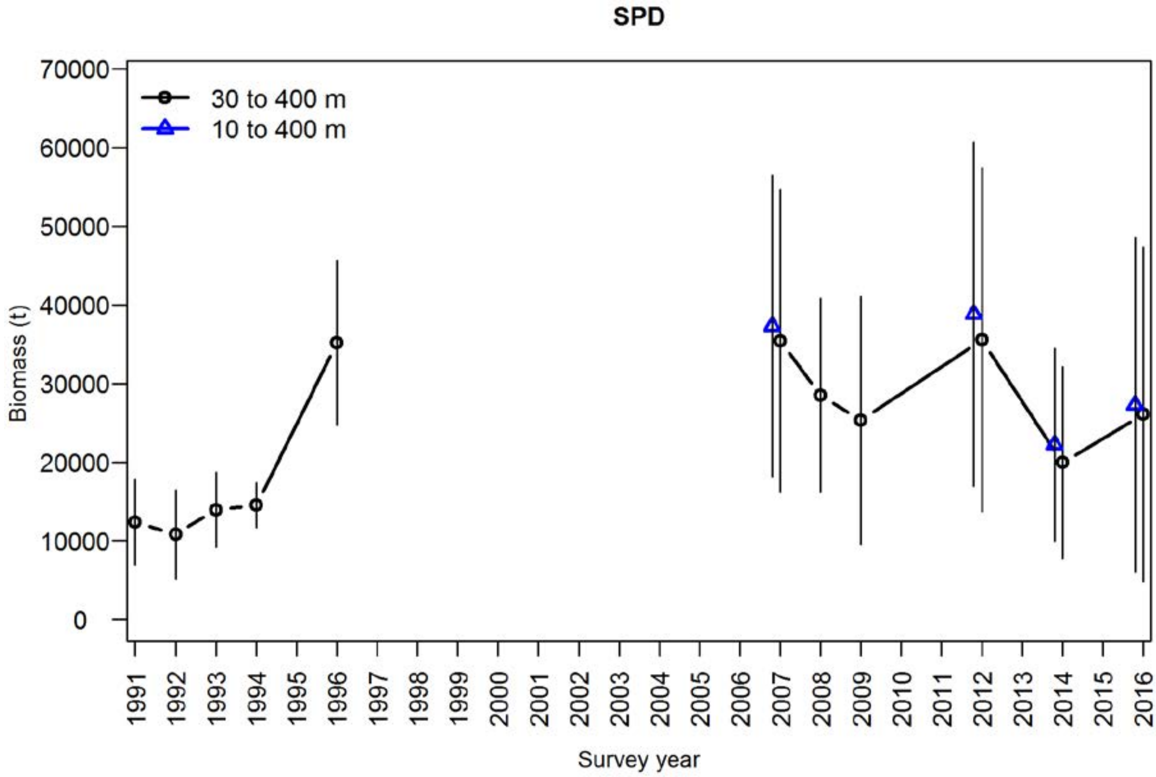


Figure 7 – ***continued***



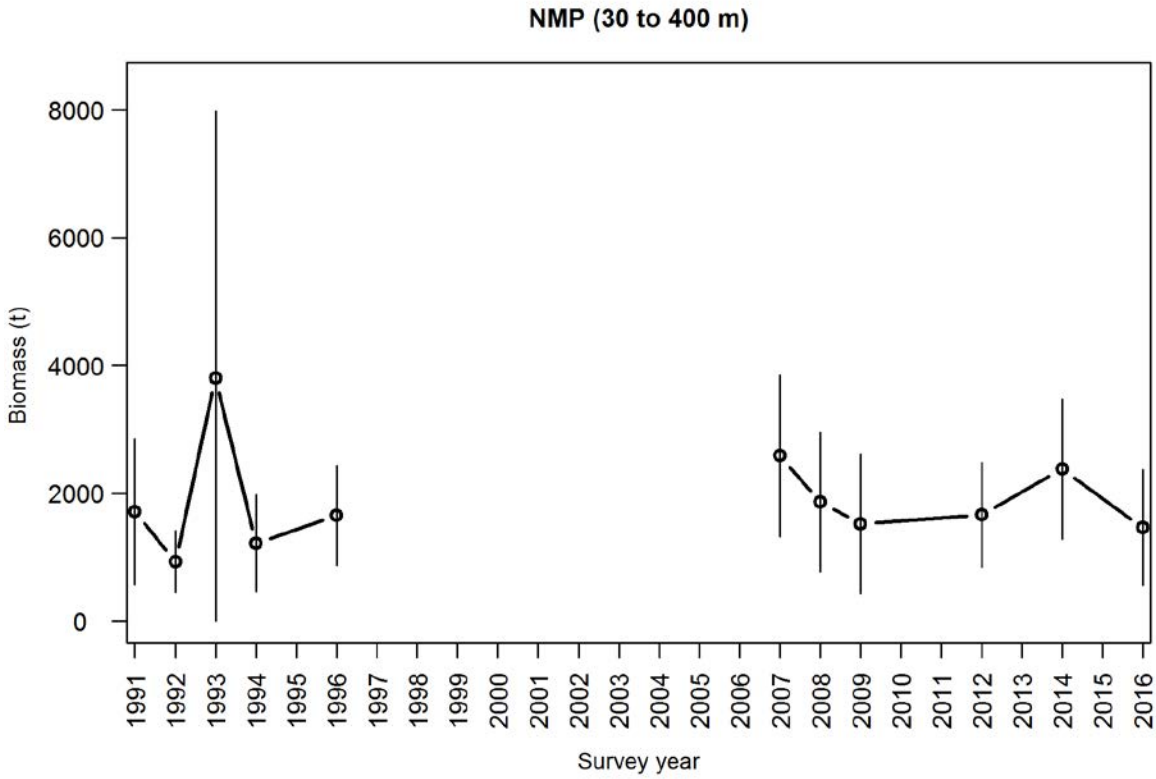


Figure 7 – ***continued***

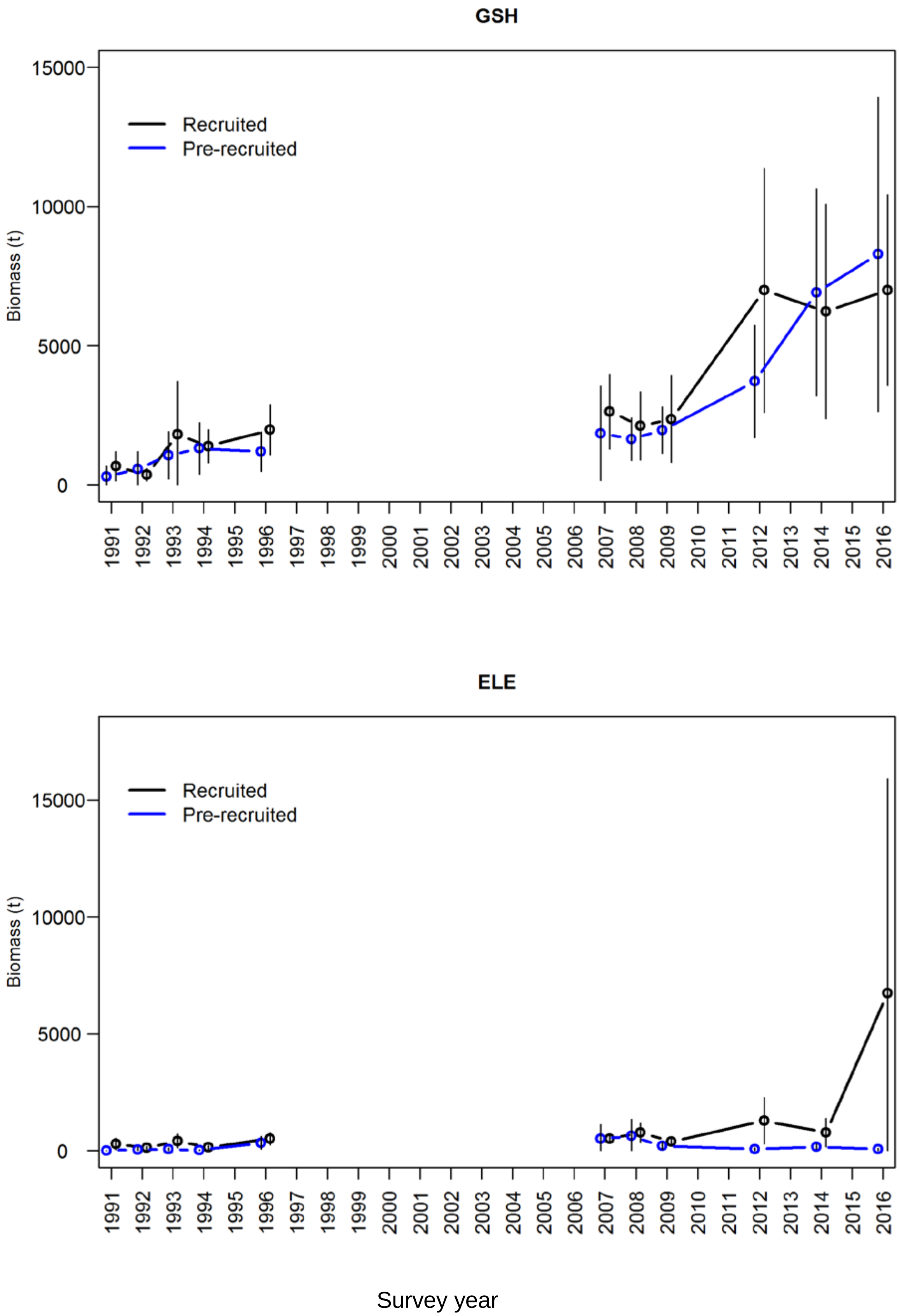


Figure 8: Target species recruited and pre-recruited biomass and 95% confidence intervals for all ECSI winter surveys in core strata (30–400 m).

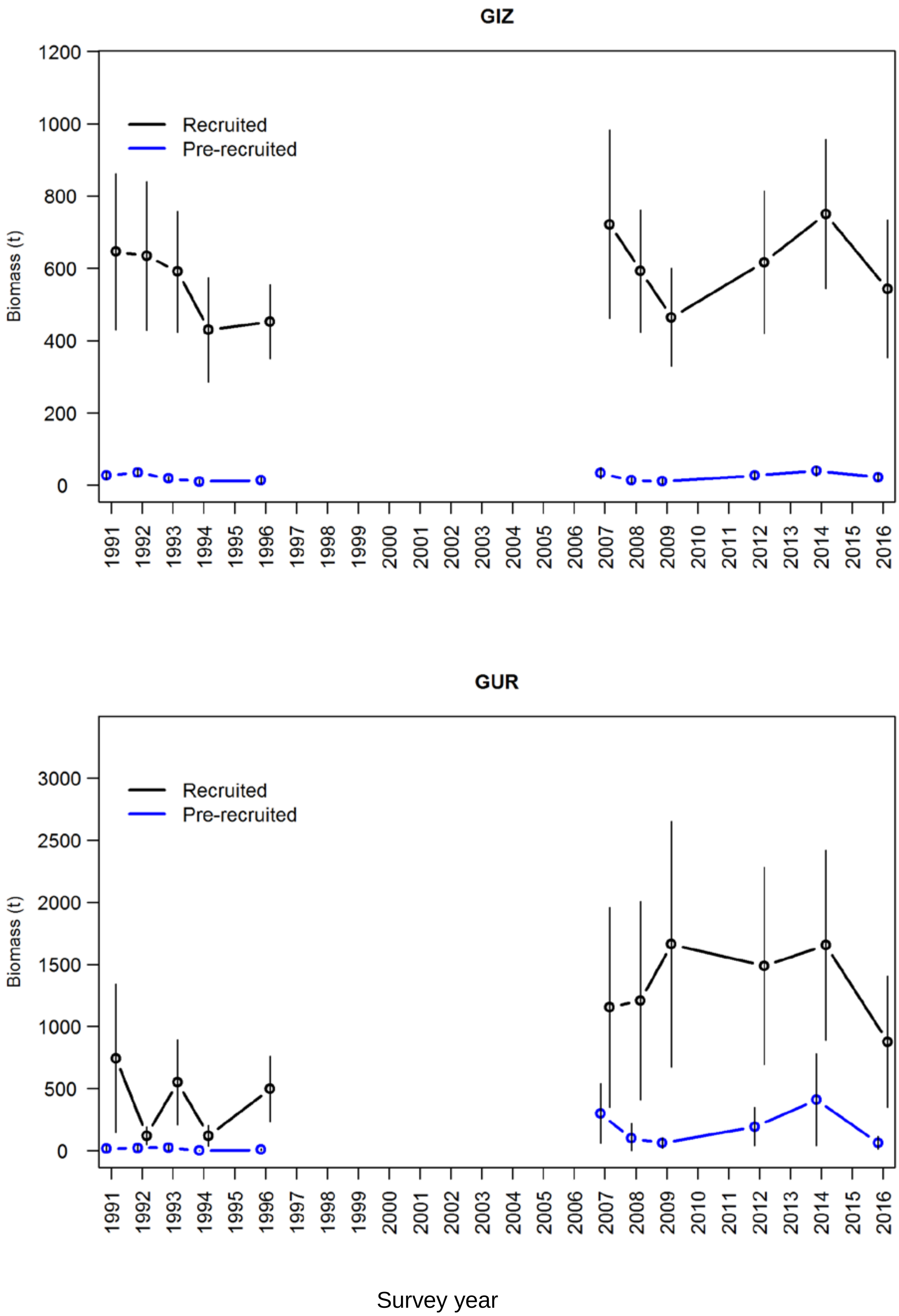
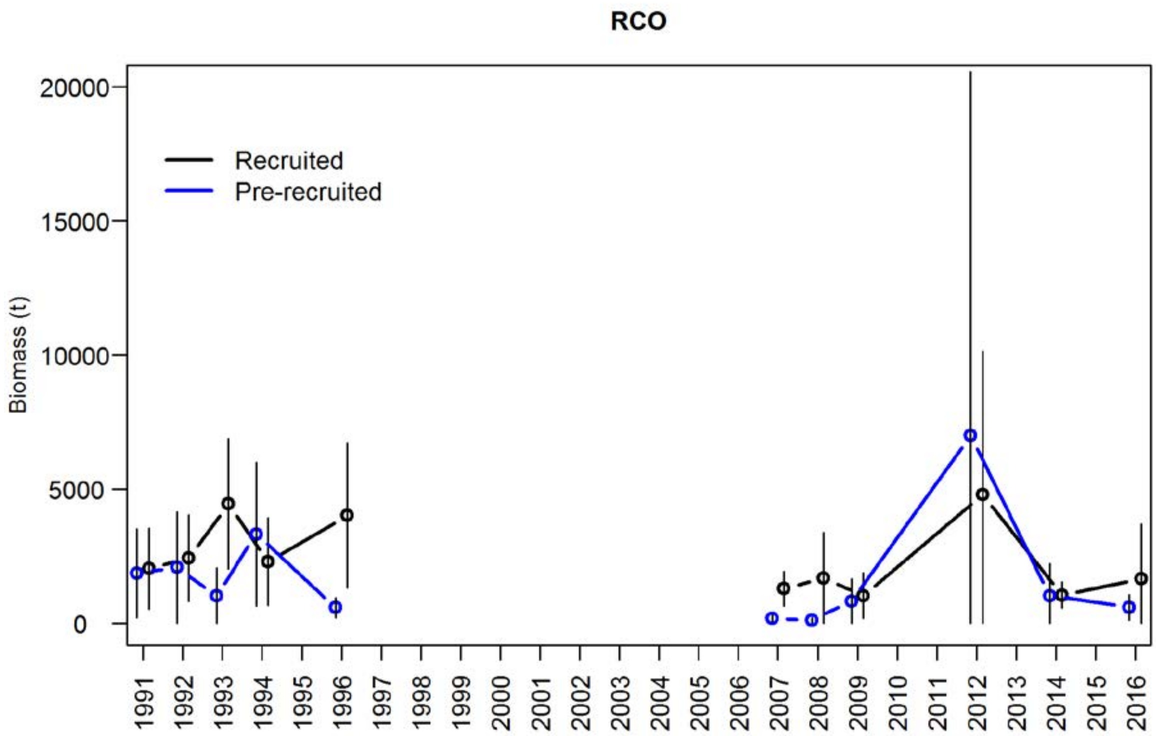


Figure 8 – ***continued***



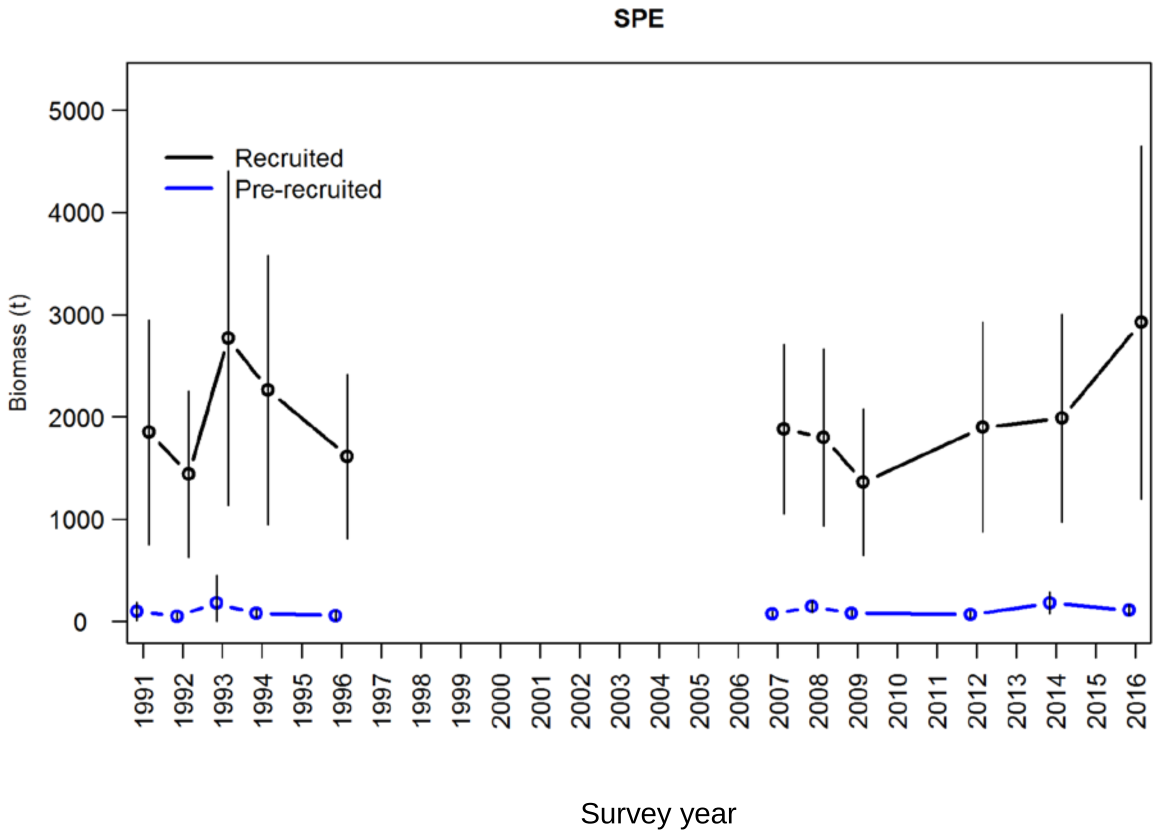


Figure 8 – ***continued***

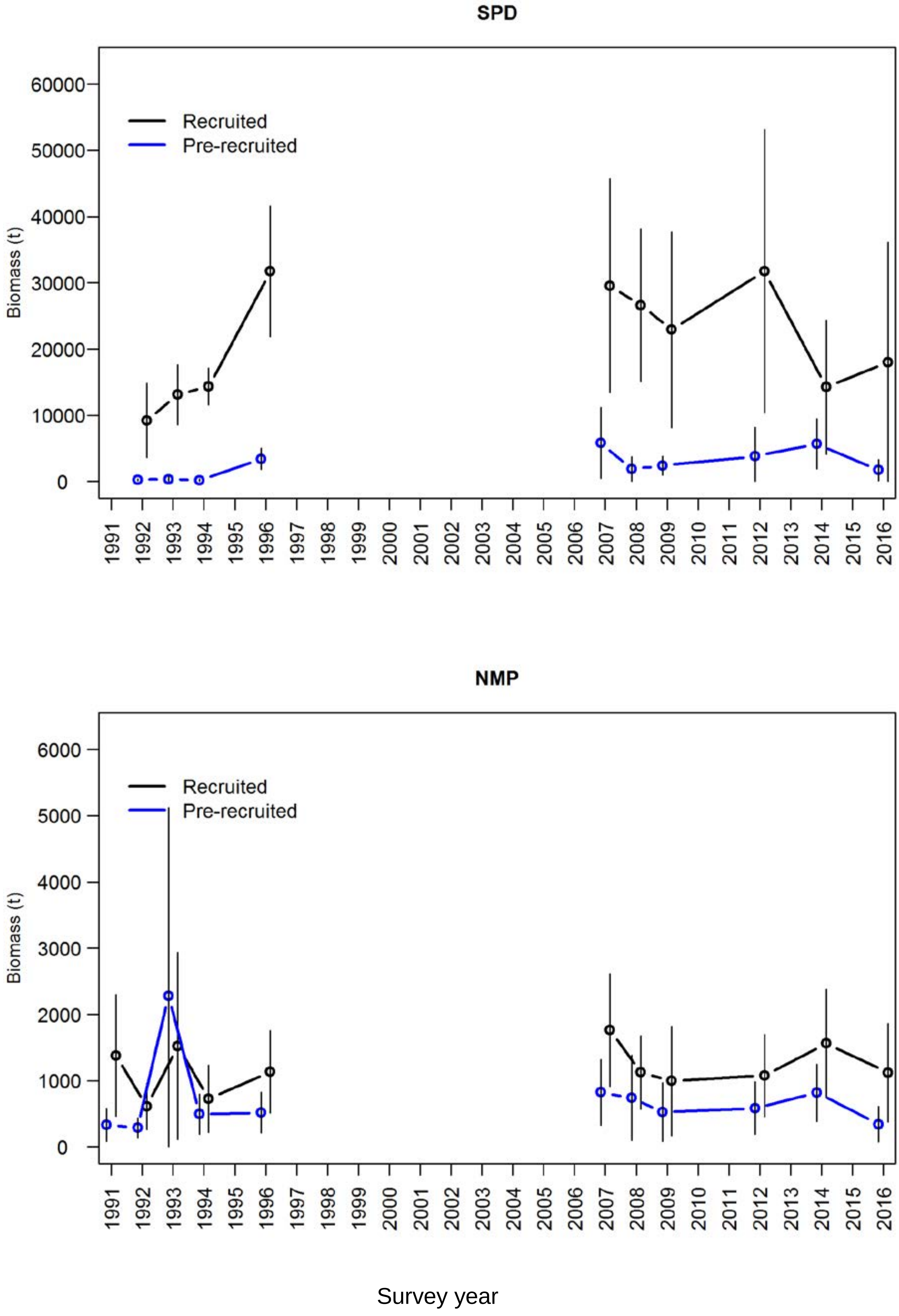


Figure 8 – ***continued***

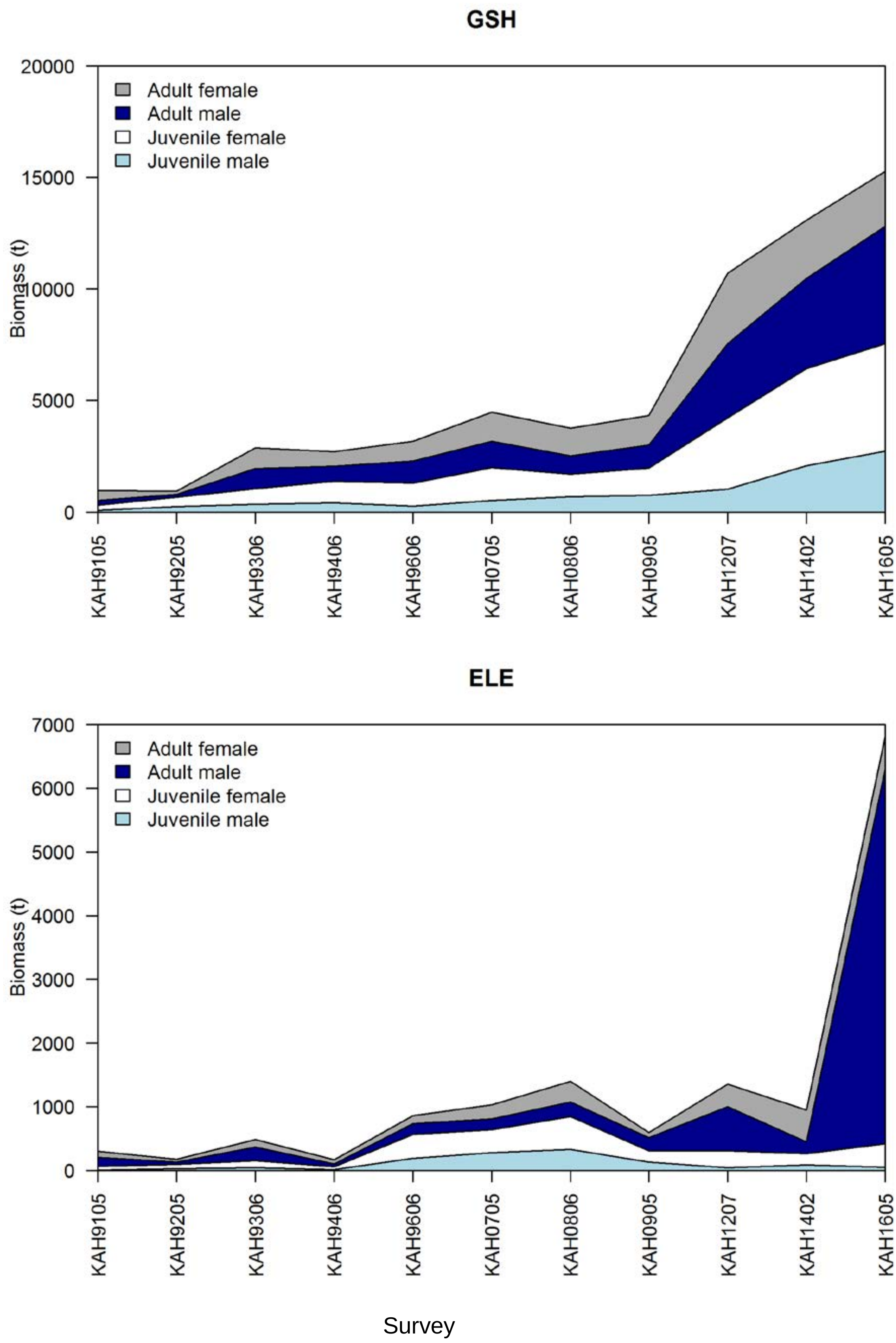
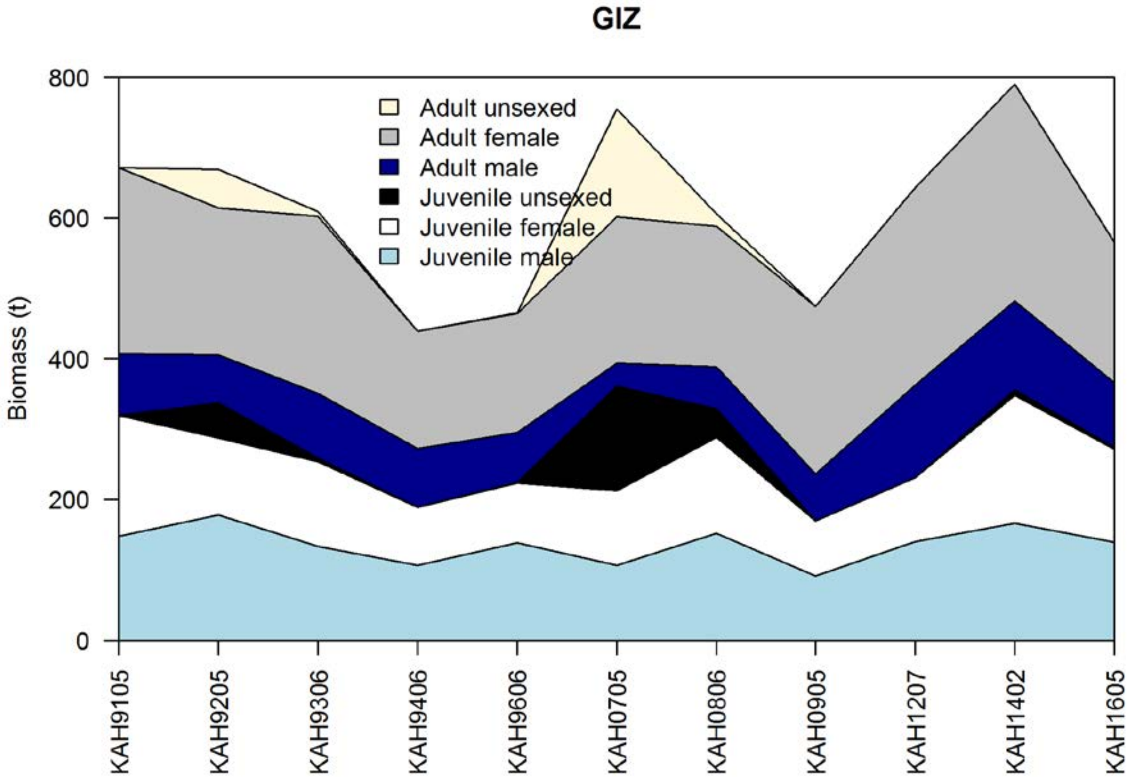


Figure 9: Target species juvenile and adult biomass for ECSI winter surveys in core strata (30–400 m), where juvenile is below and adult is equal to or above length at which 50% of fish are mature.



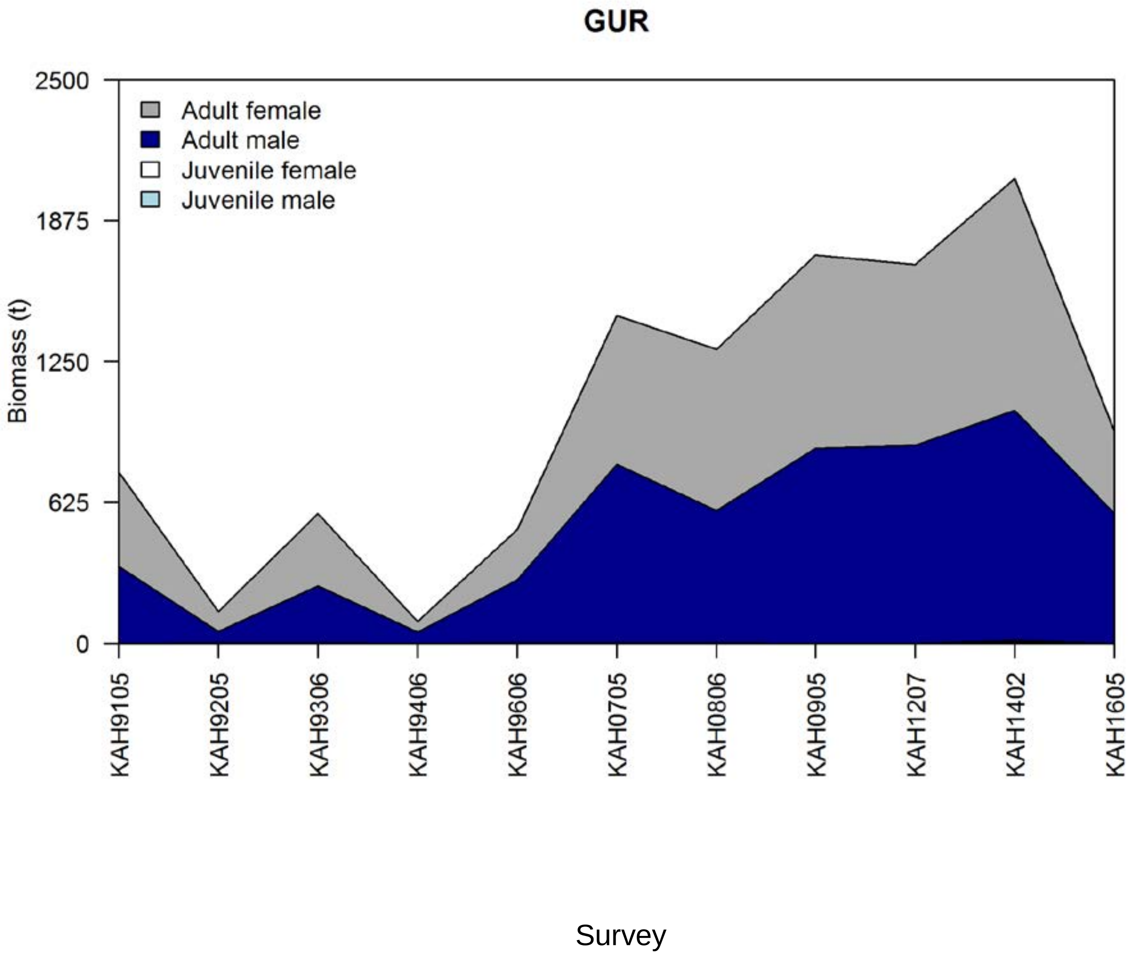
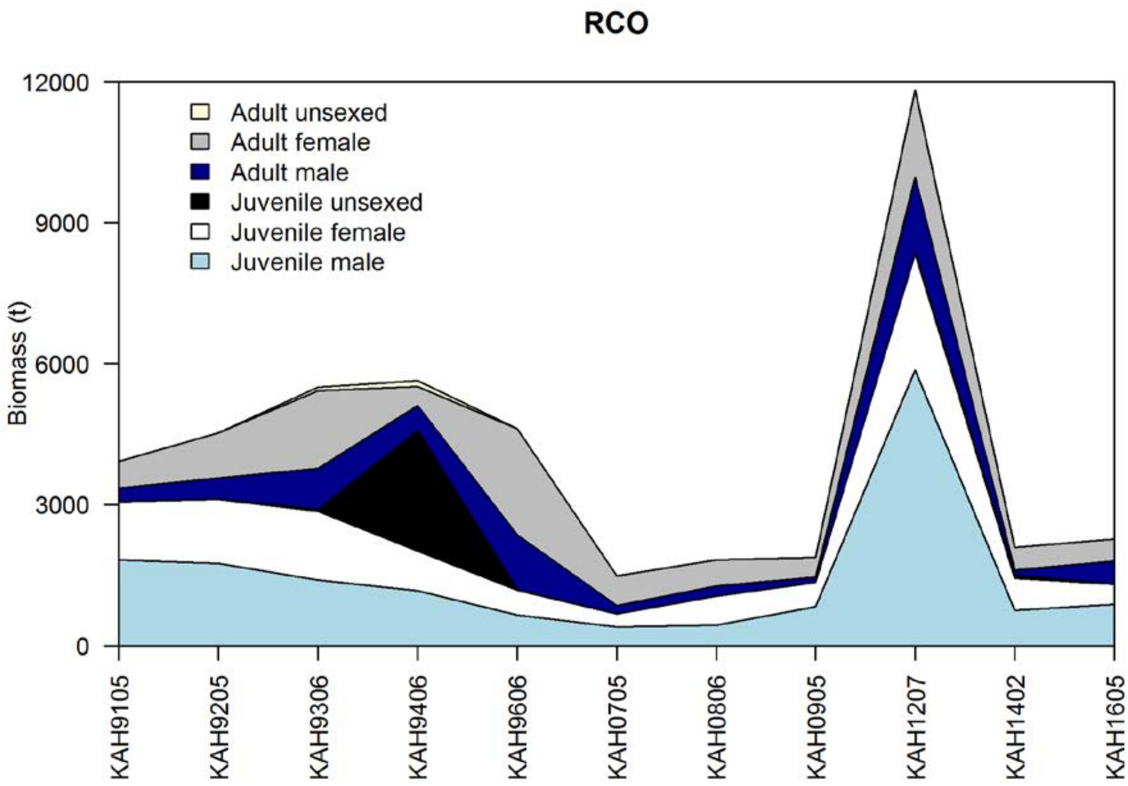
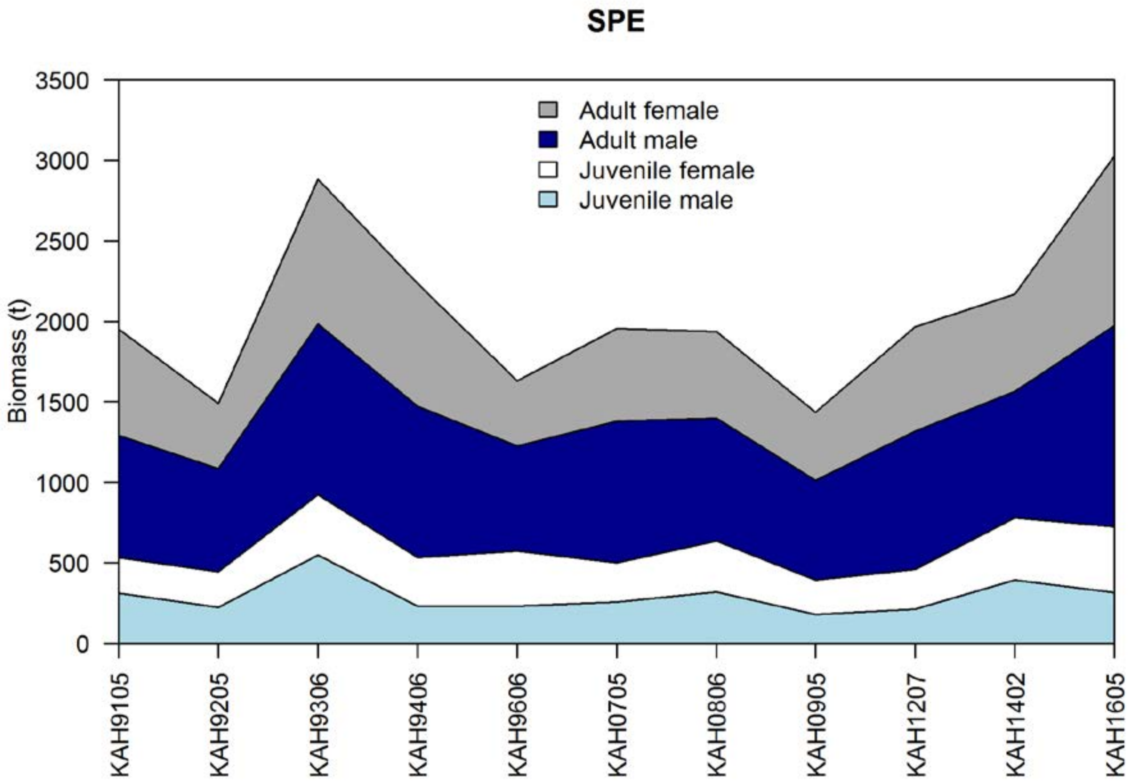


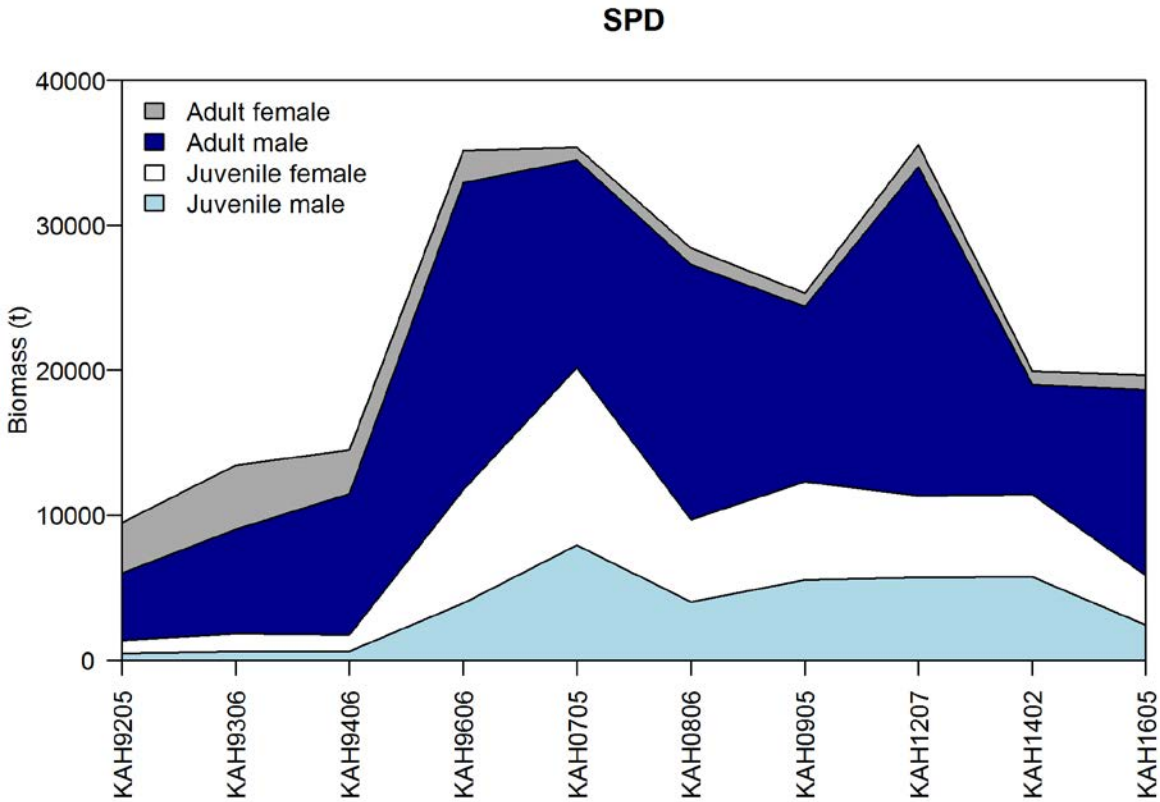
Figure 9 – ***continued***





Survey

Figure 9 – *continued*



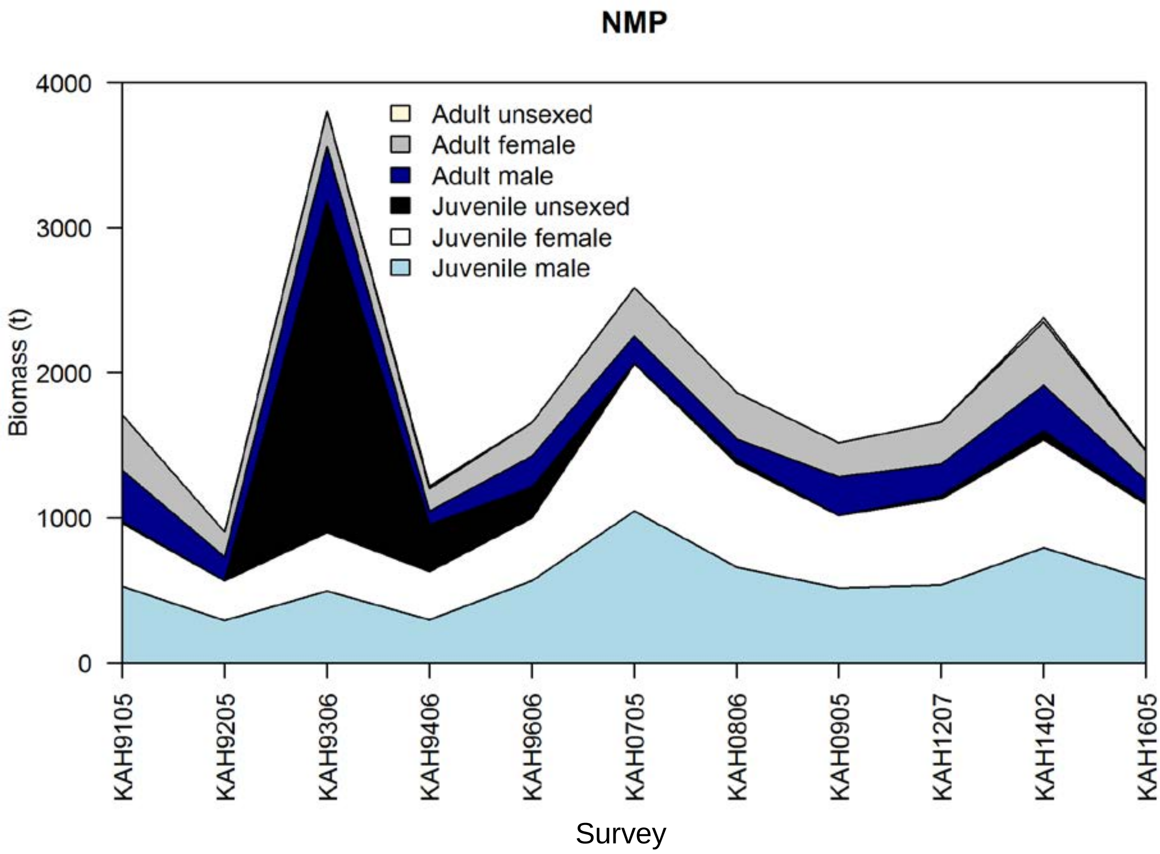


Figure 9 – *continued*.

Dark ghost shark (1991 to 1996)

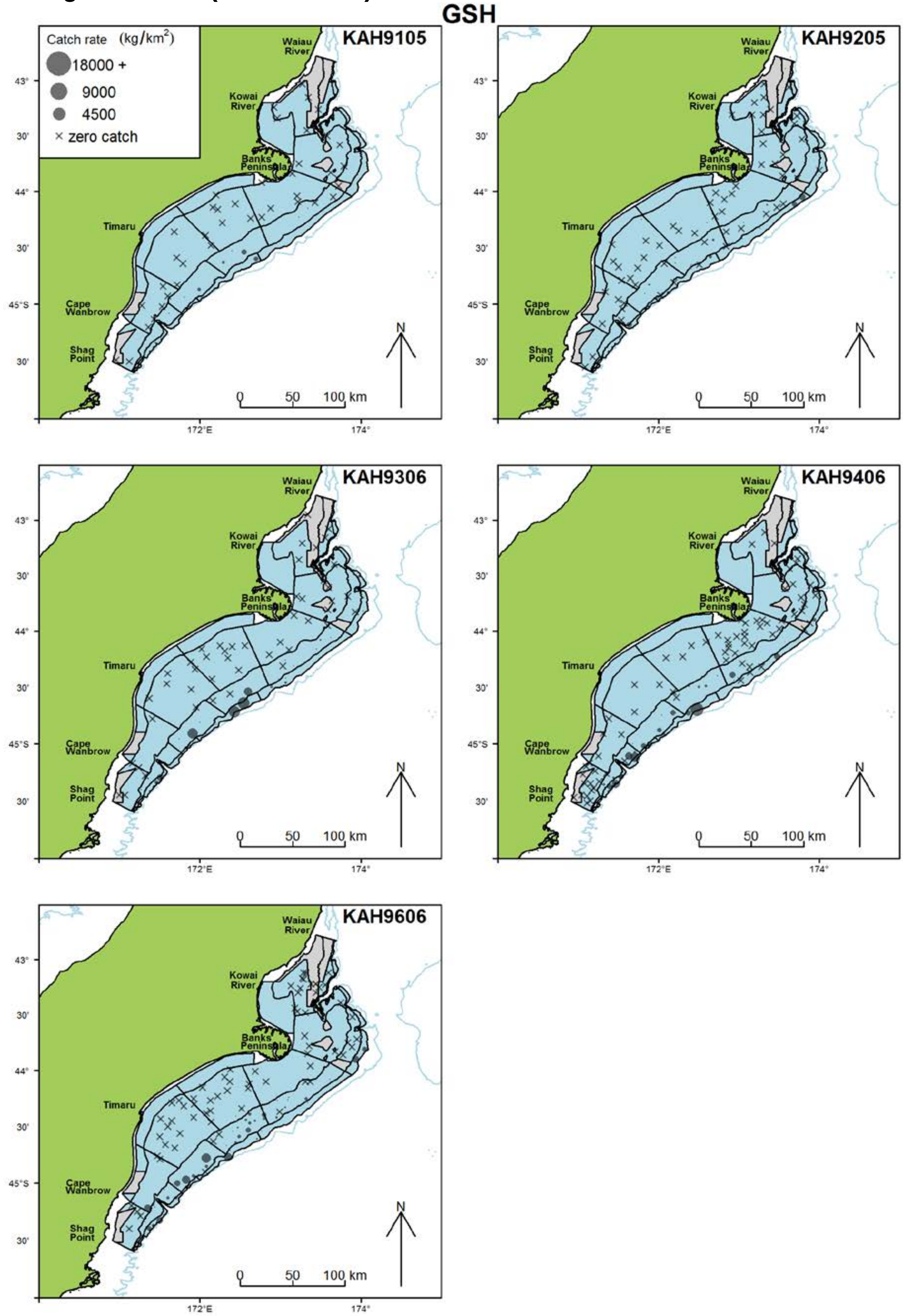


Figure 10: Target species catch rates (kg.km^{-2}) by tow plotted for the eleven ECSI winter trawl surveys.

Dark ghost shark (2007 to 2016)

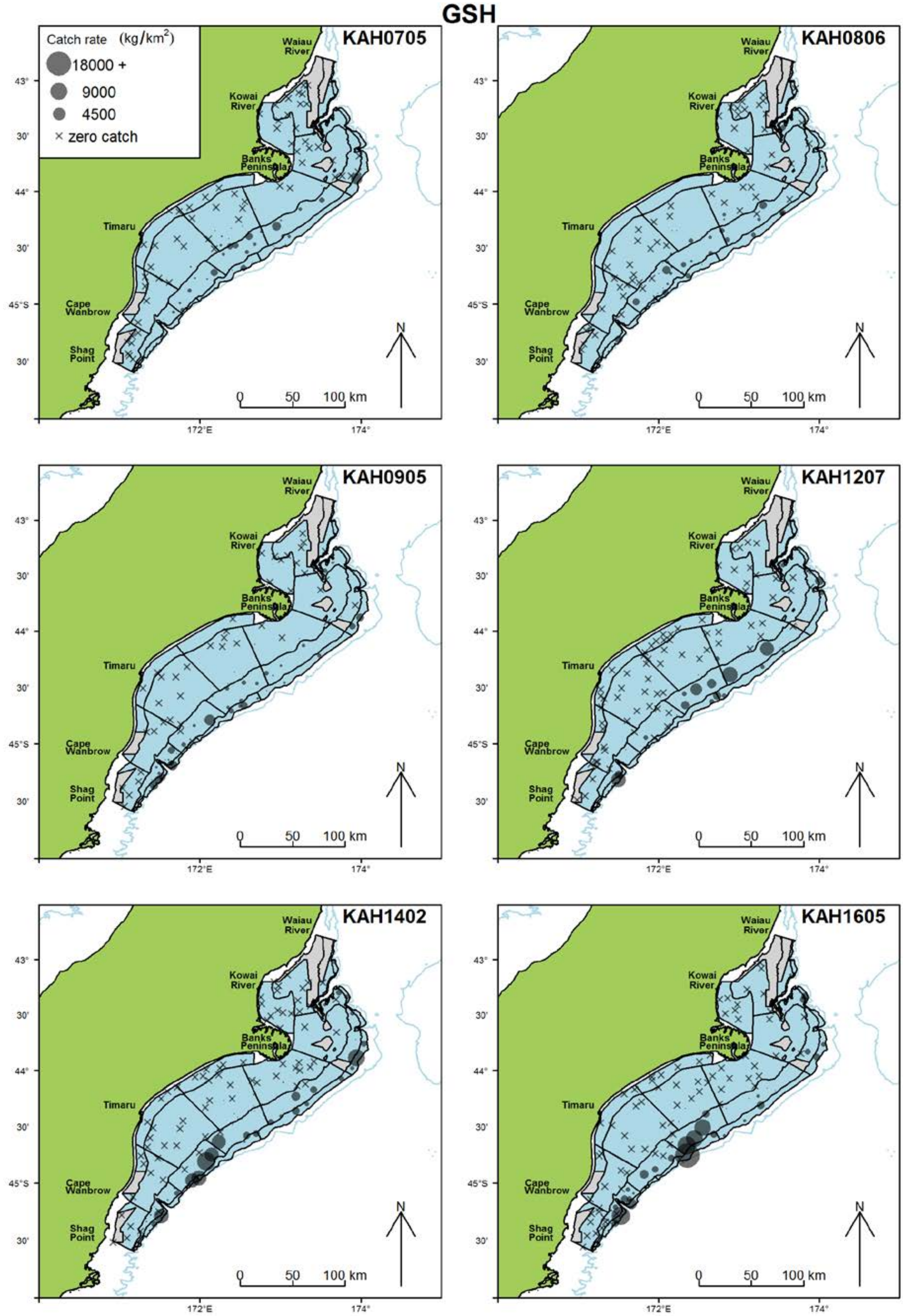


Figure 10 – ***continued***

Elephantfish (1991 to 1996)

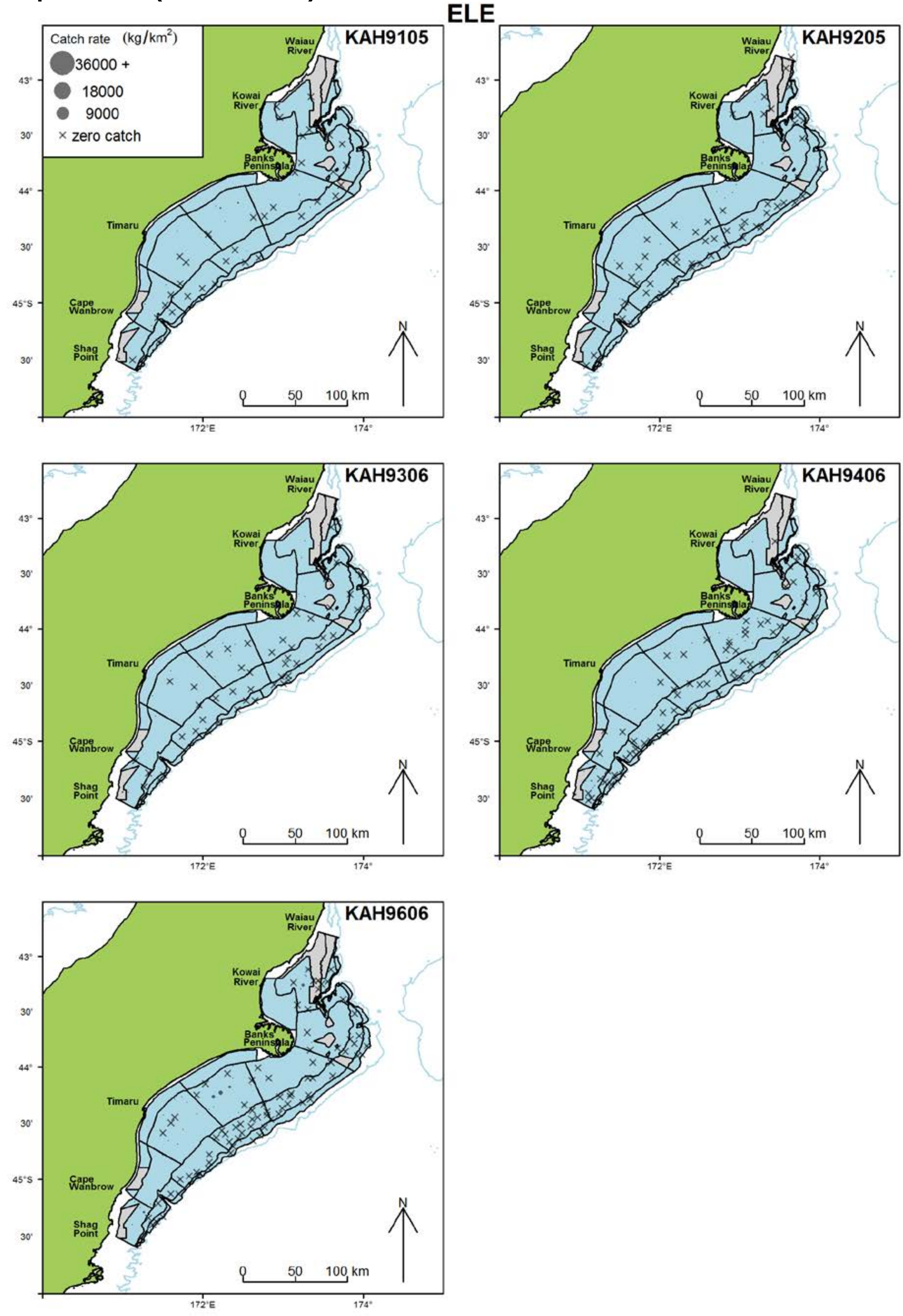


Figure 10 – ***continued***

Elephantfish (2007 to 2016)

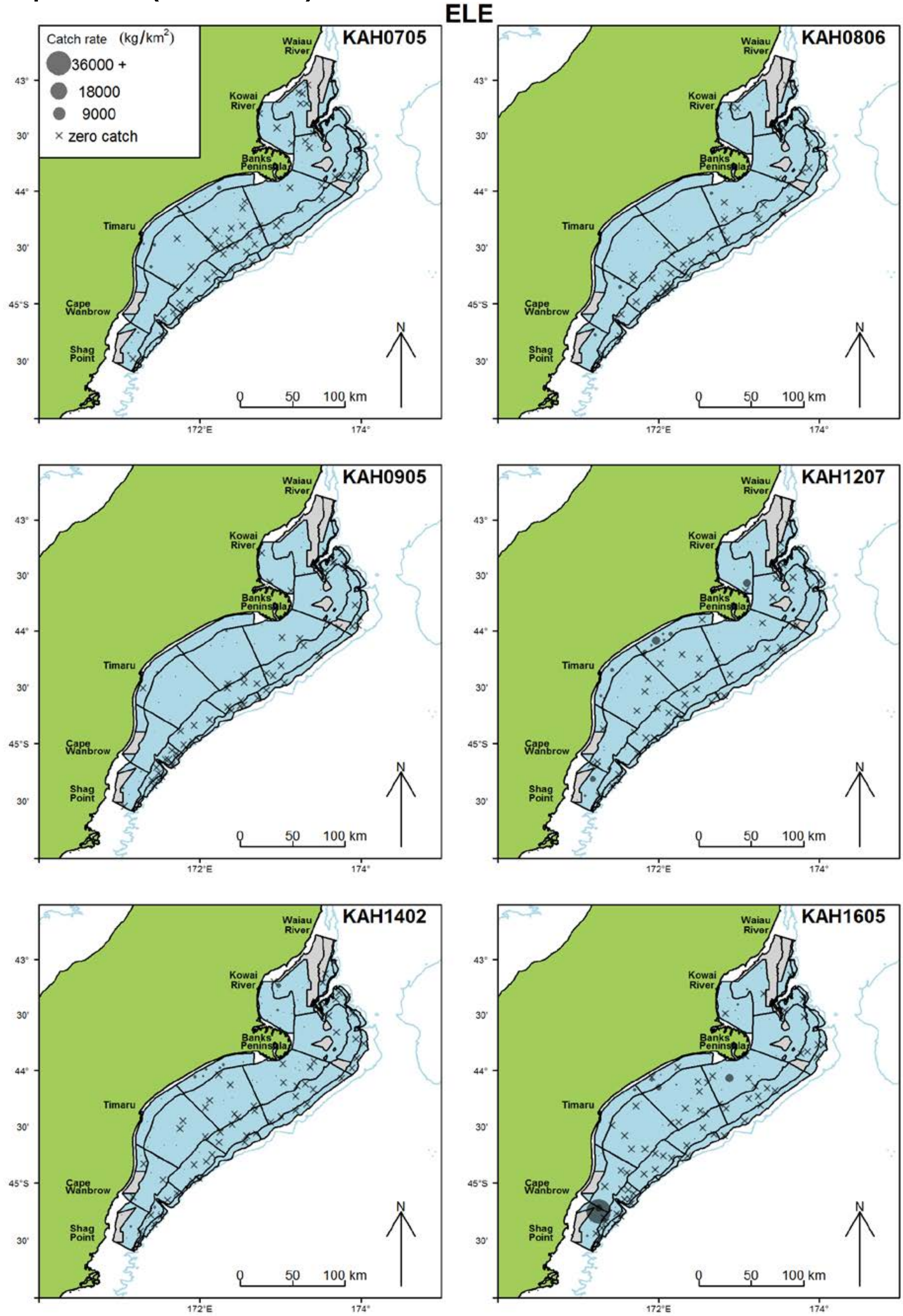


Figure 10 – ***continued***

Giant stargazer (1991 to 1996)

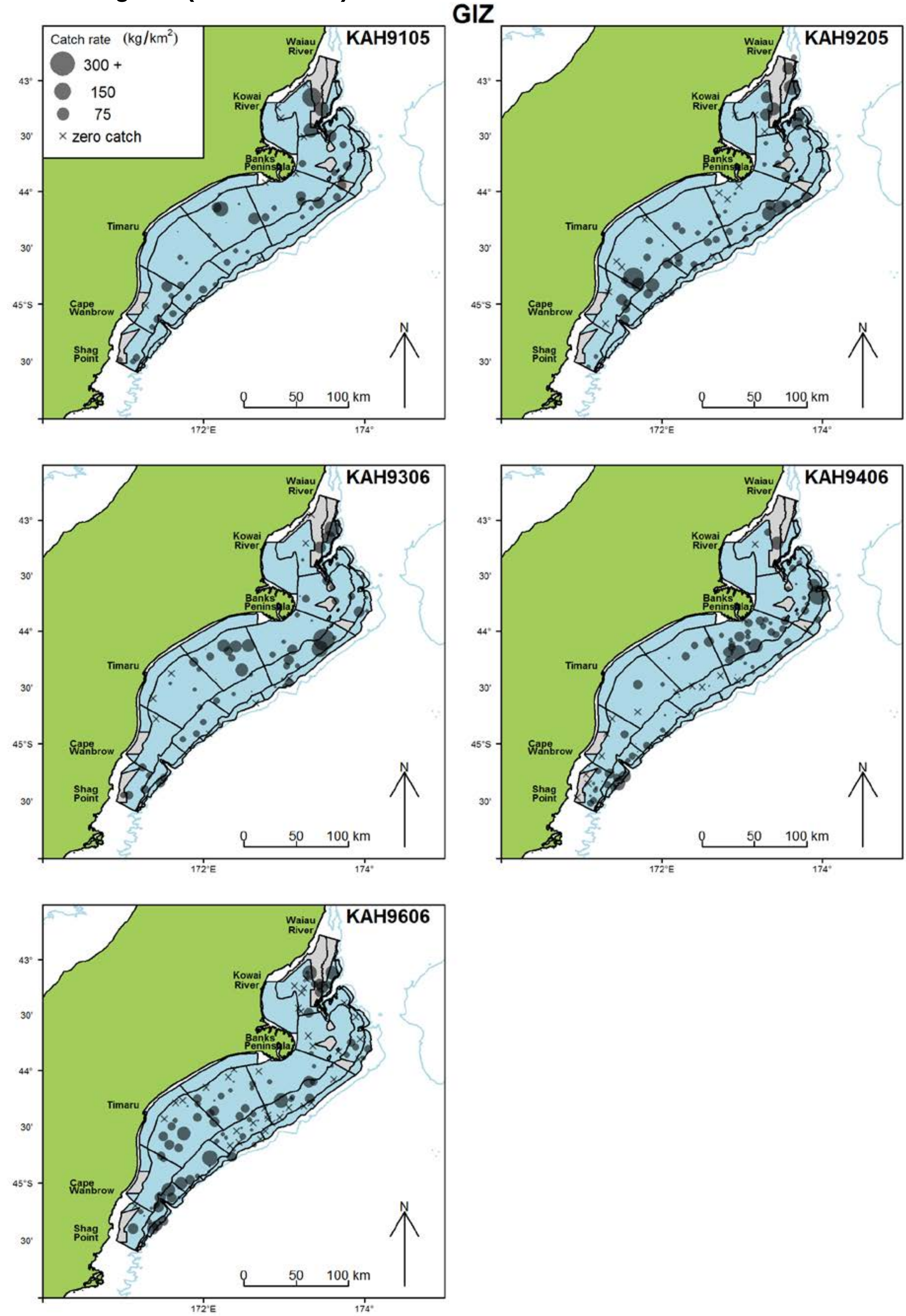


Figure 10 – ***continued***

Giant stargazer (2007 to 2016)

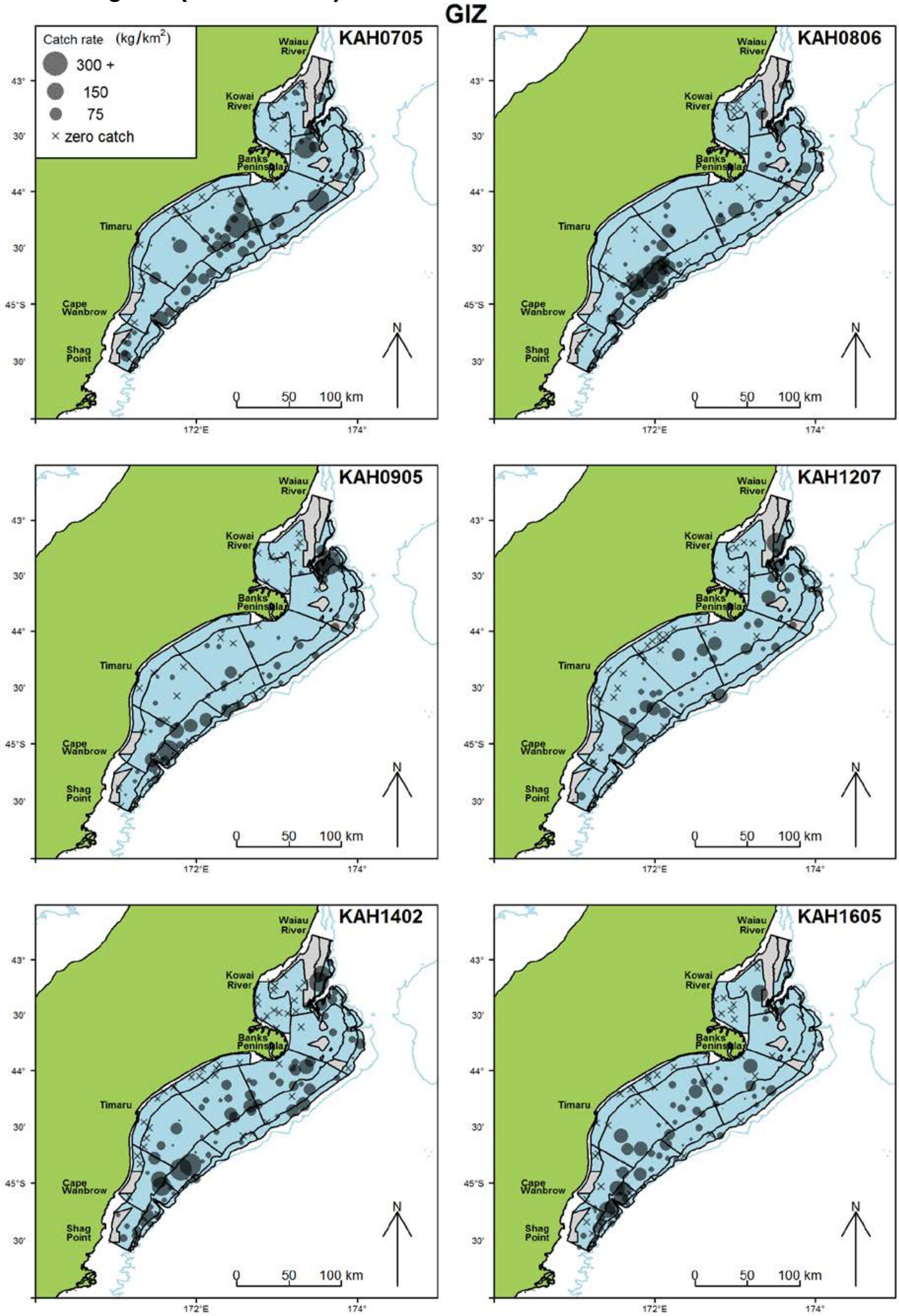


Figure 10 – ***continued***

Red gurnard (1991 to 1996)

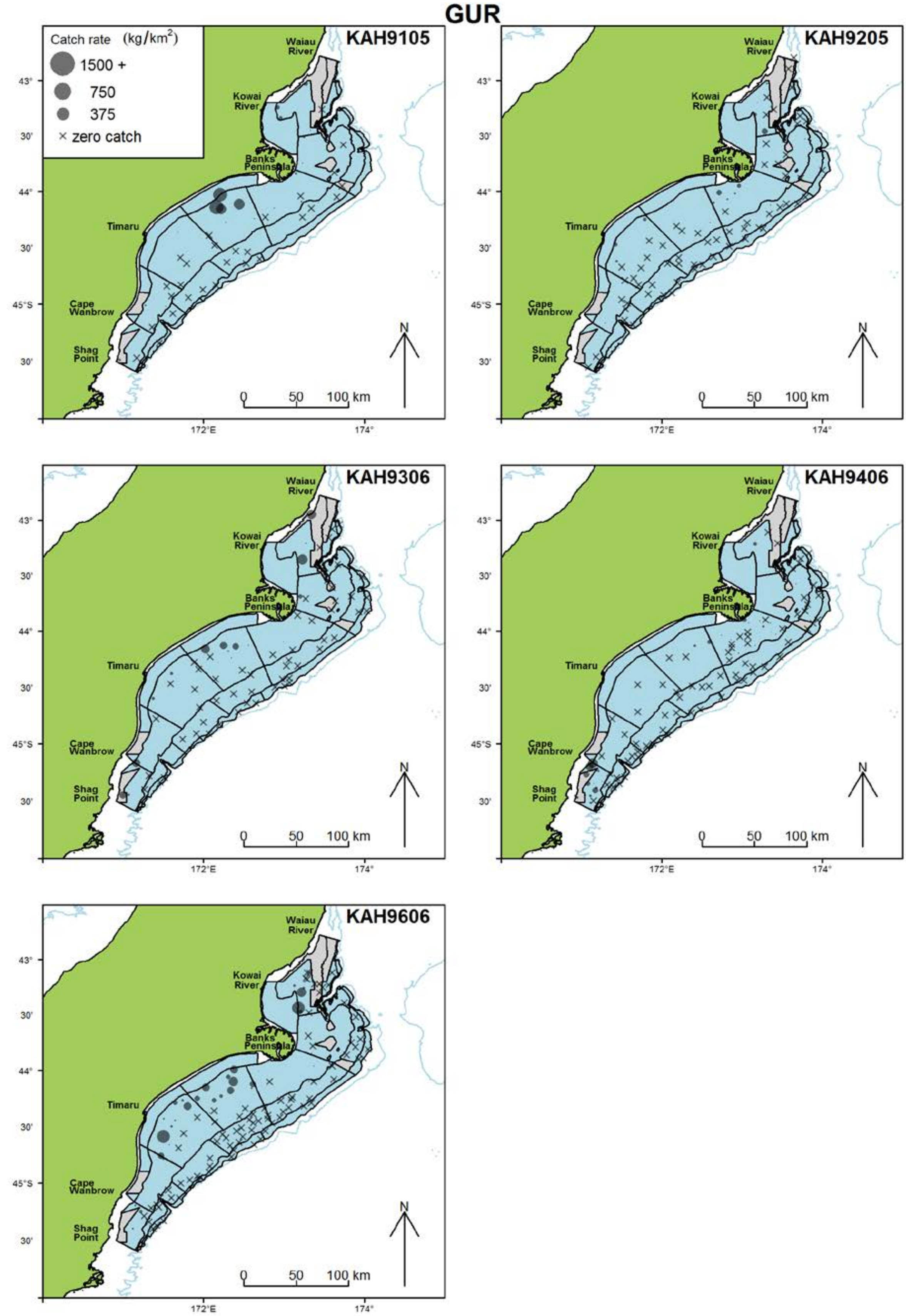


Figure 10 – ***continued***

Red gurnard (2007 to 2016)

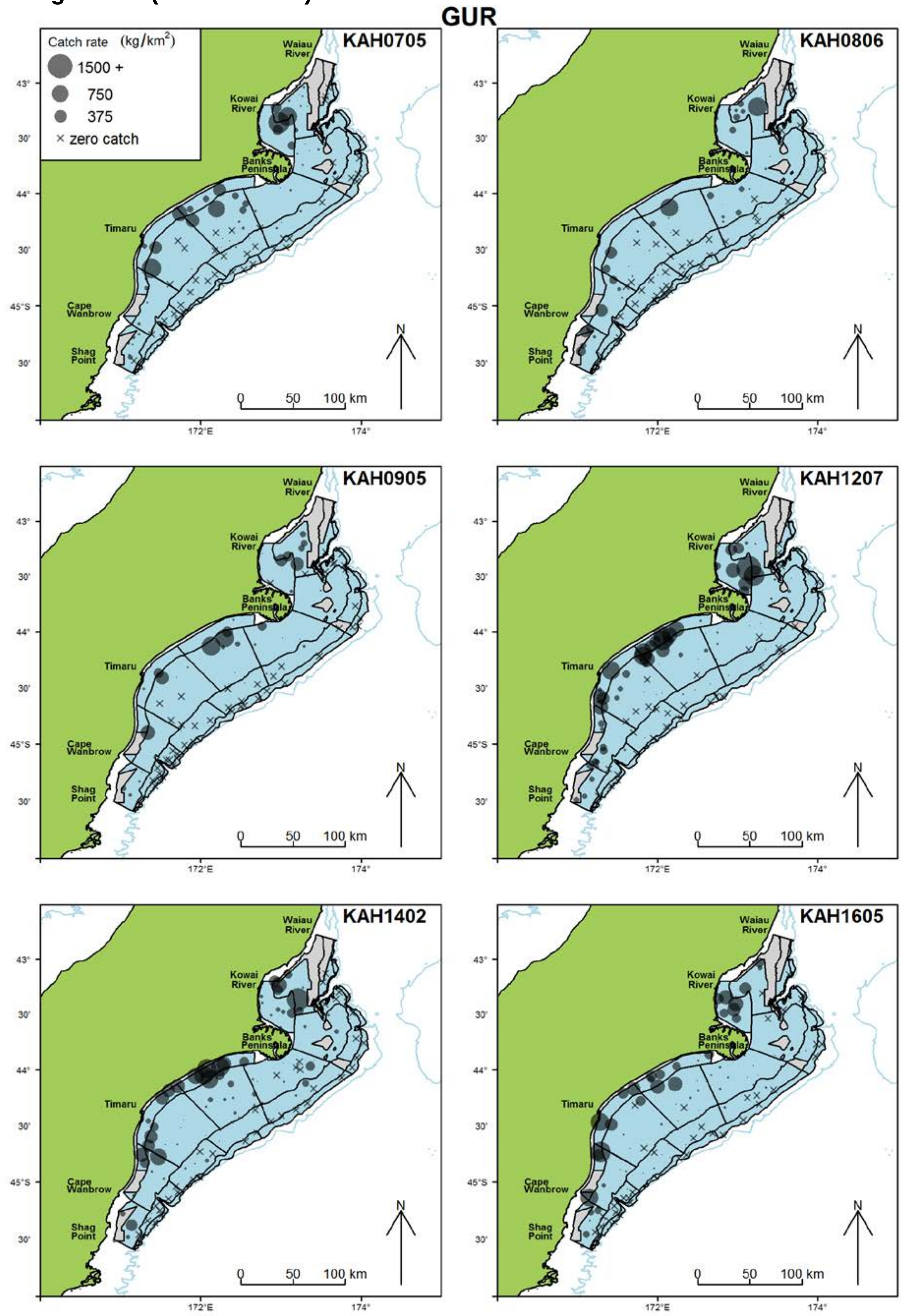


Figure 10 – ***continued***

Red cod (1991–1996)

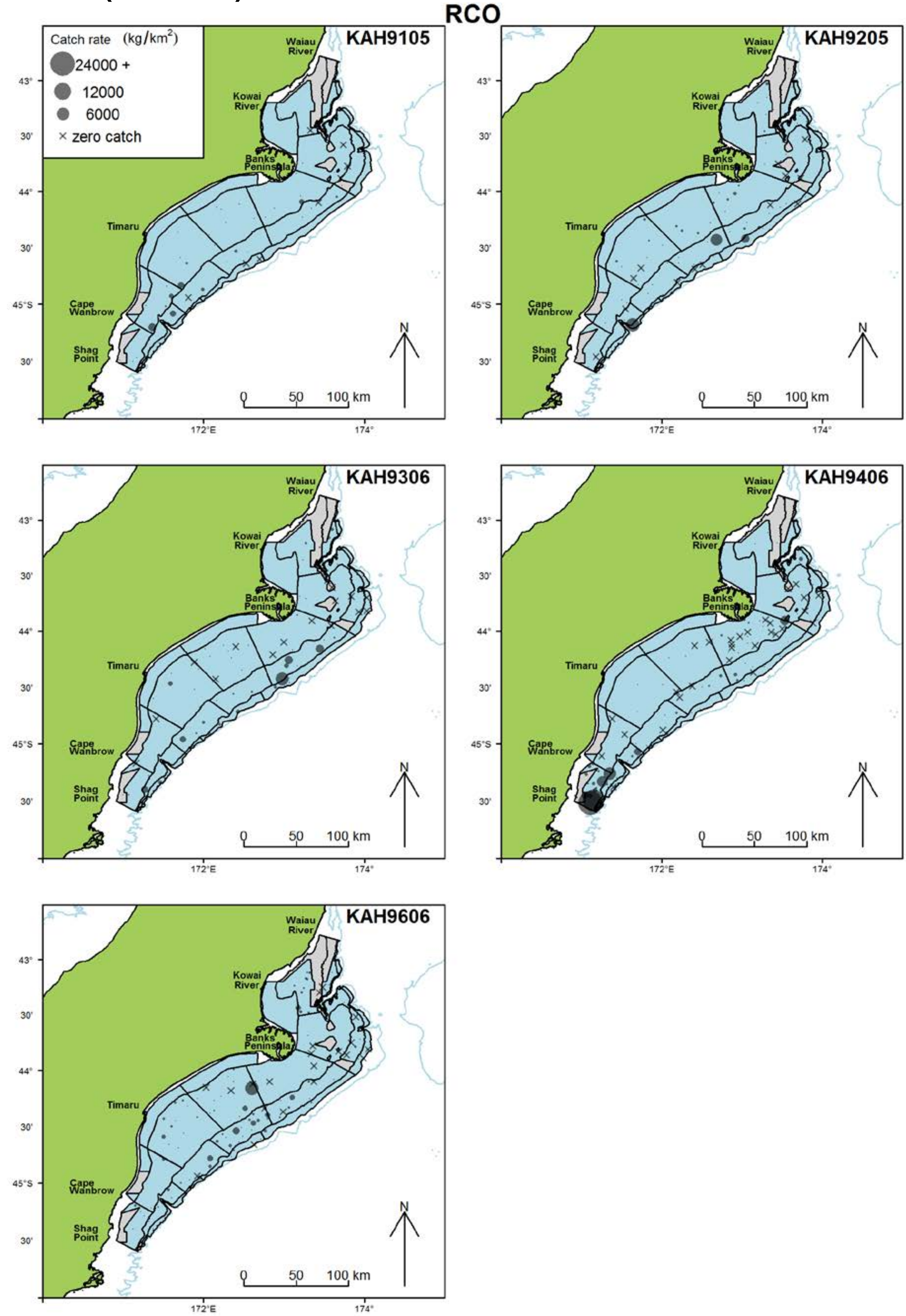


Figure 10 – ***continued***

Red cod (2007 to 2016)

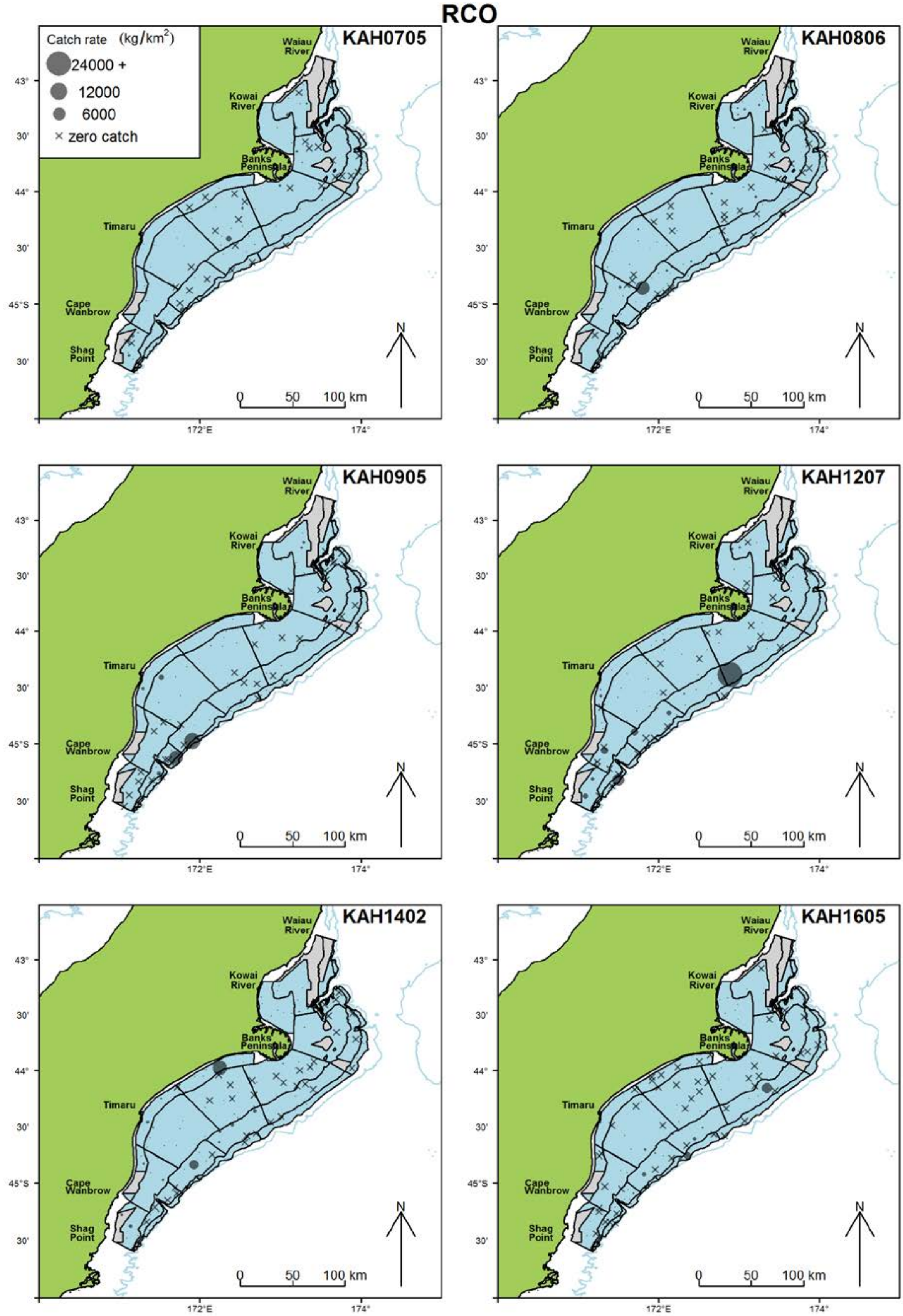


Figure 10 – ***continued***

Sea perch (1991 to 1996)

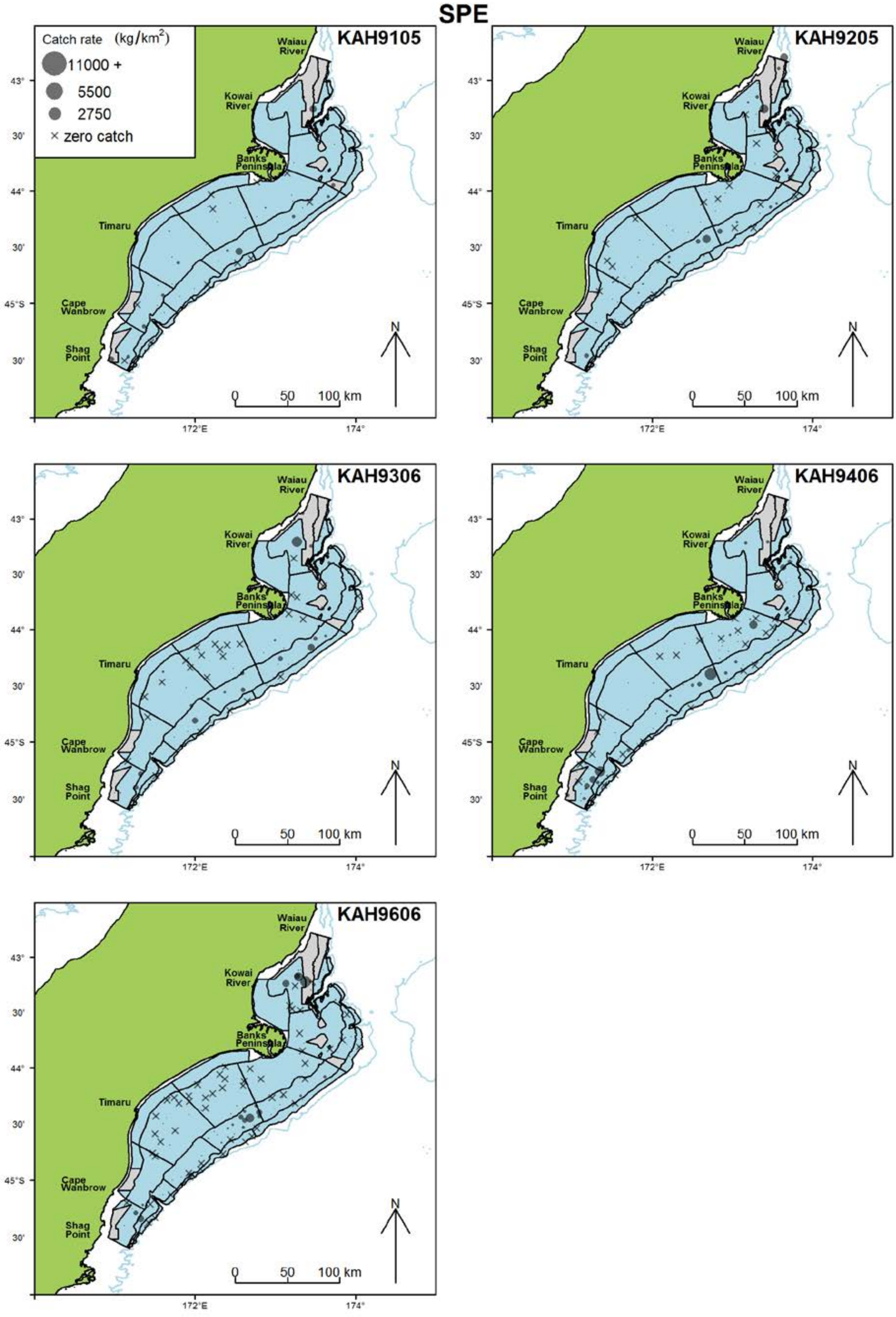


Figure 10 – ***continued***

Sea perch (2007 to 2016)

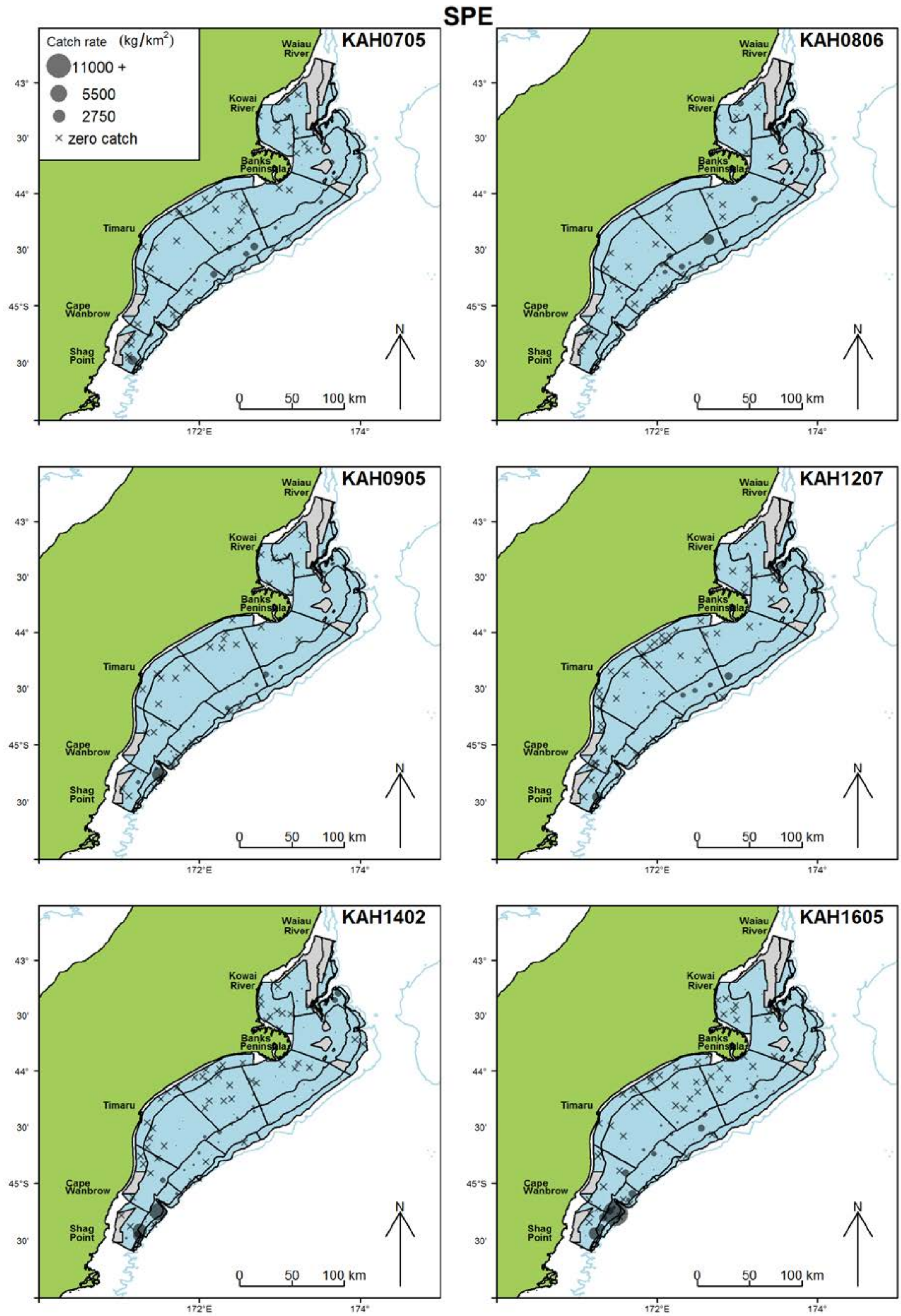


Figure 10 – ***continued***

Spiny dogfish (1991 to 1996)

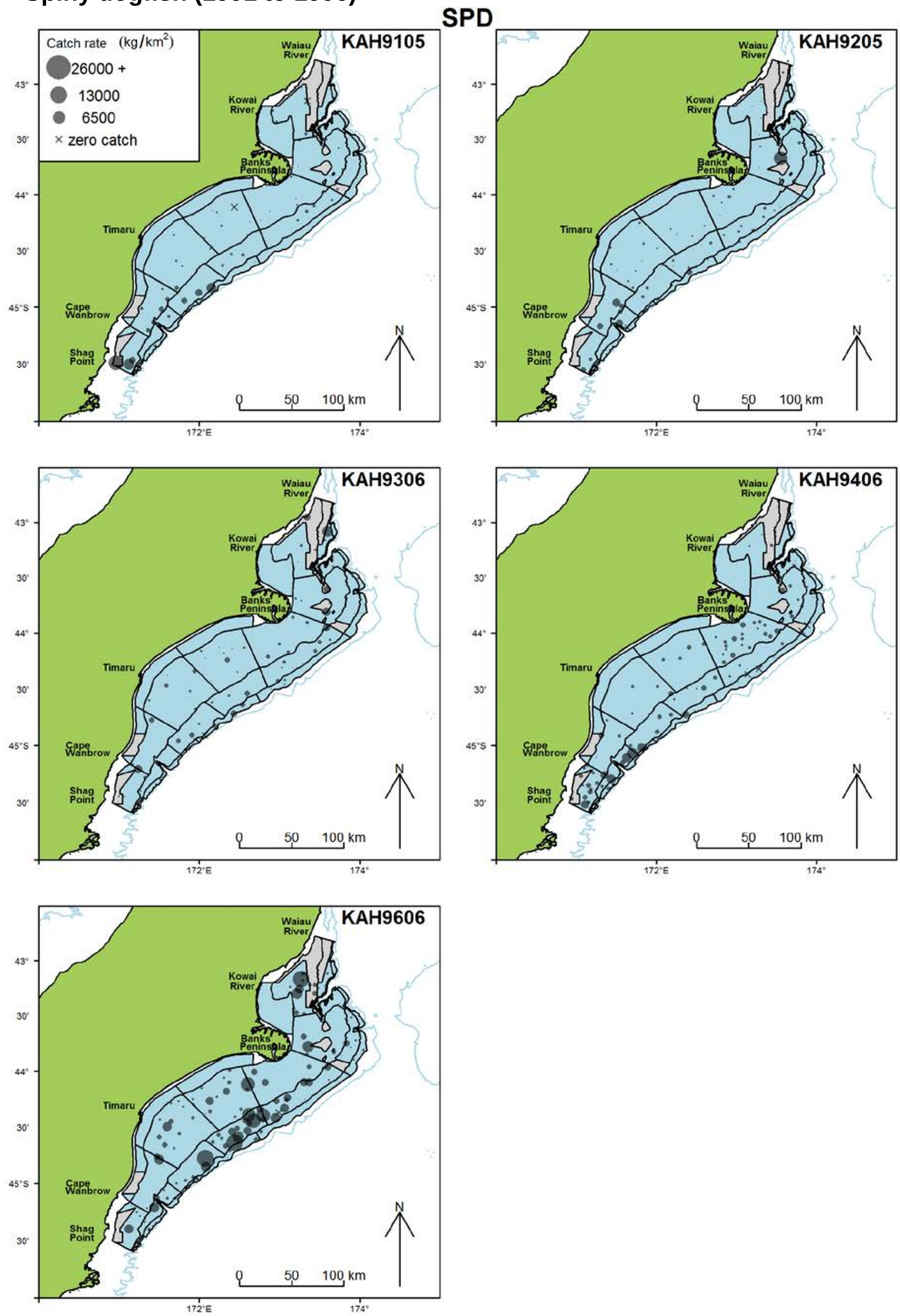


Figure 10 – ***continued***

Spiny dogfish (2007 to 2016)

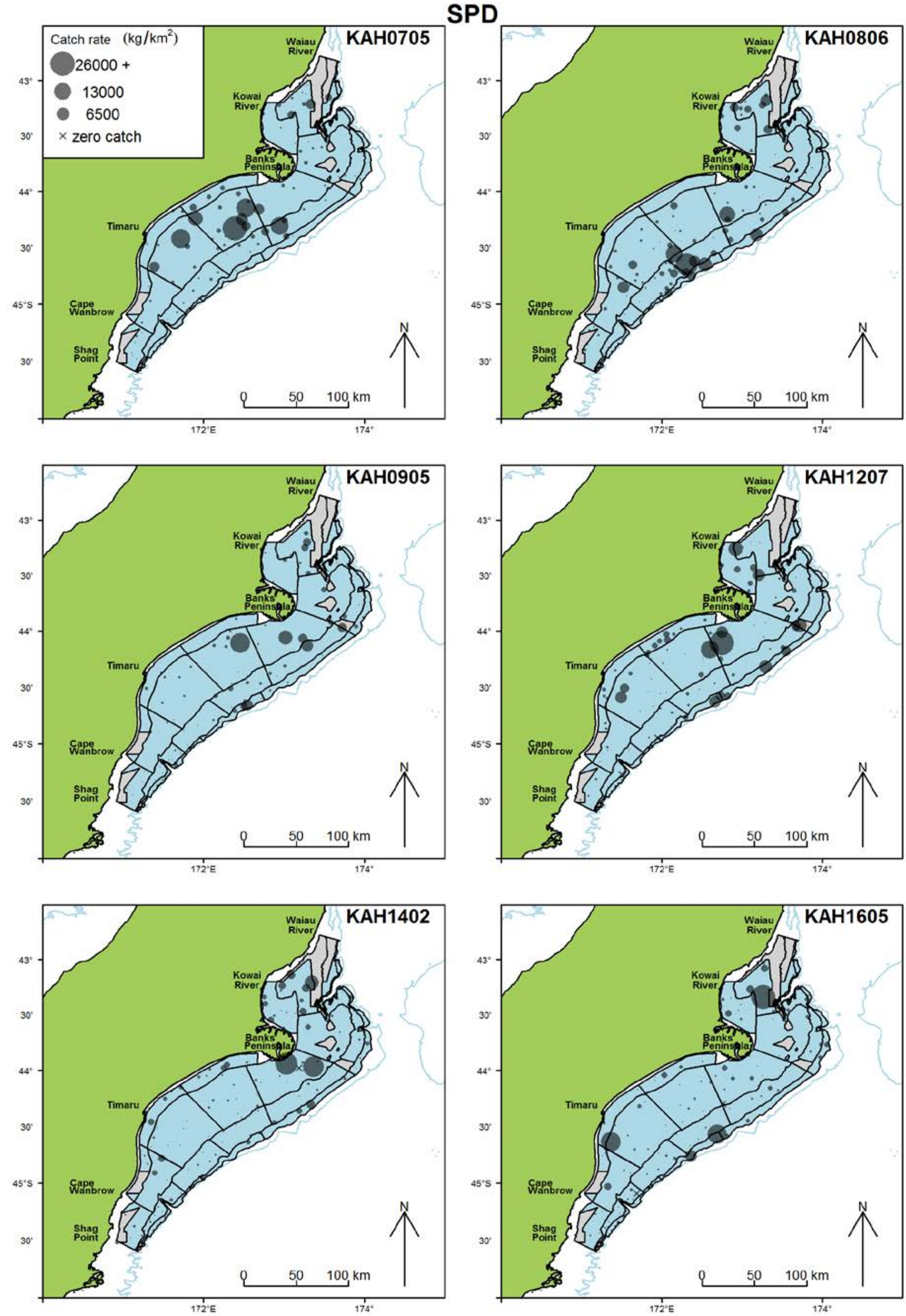


Figure 10 – ***continued***

Tarakihi (1991–1996)

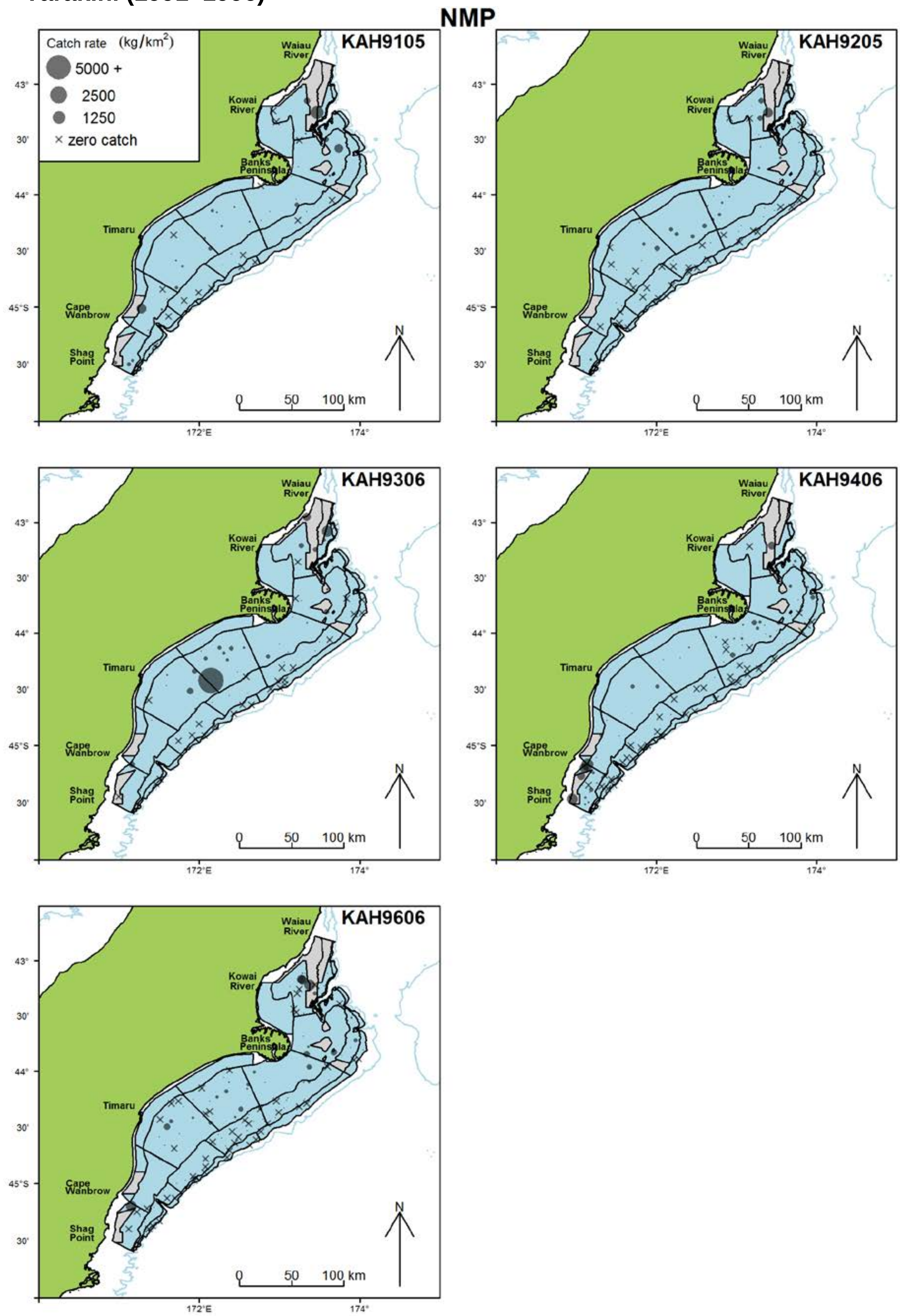


Figure 10 – ***continued***

Tarakihi (2007–2016)

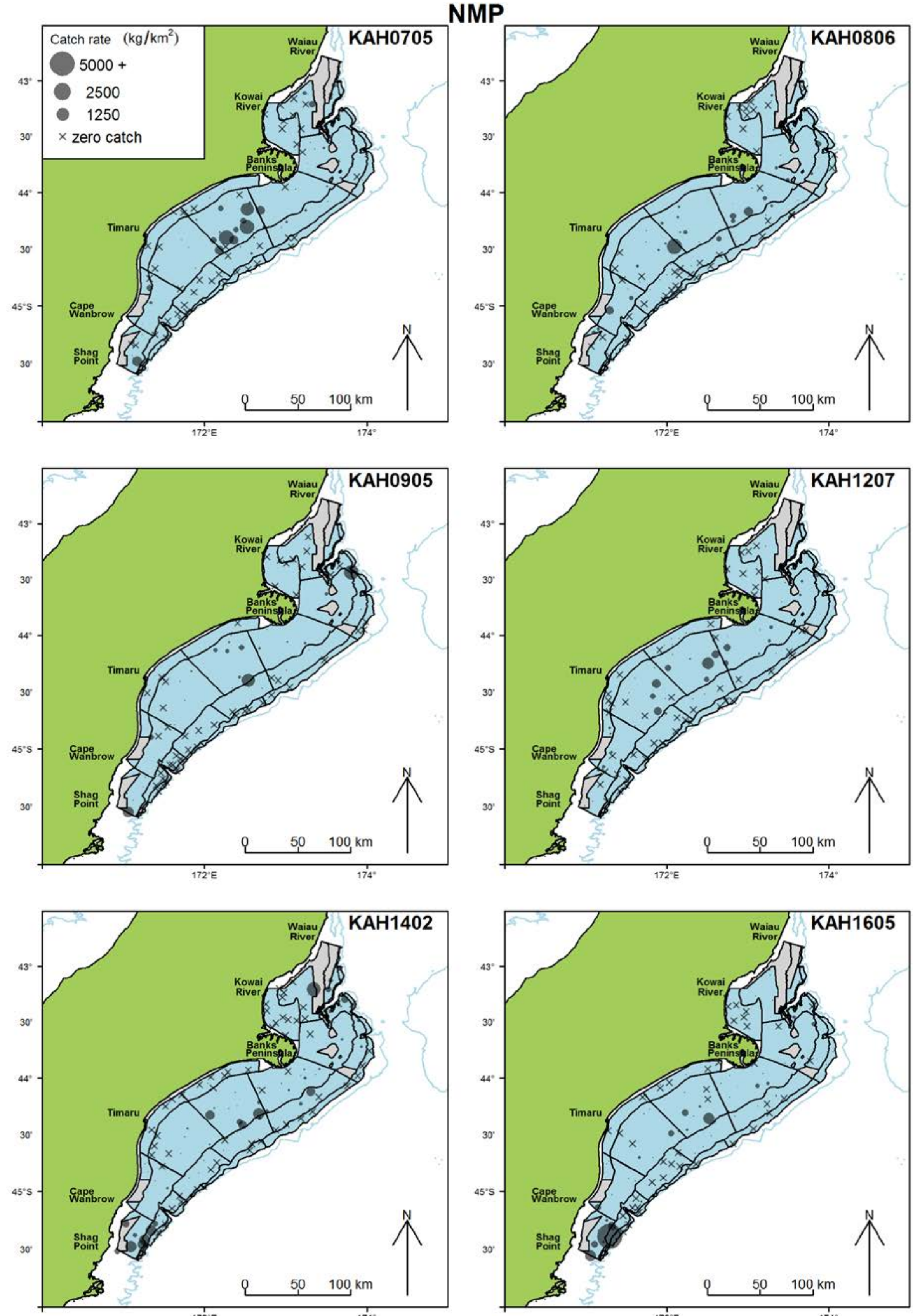


Figure 10 – ***continued***

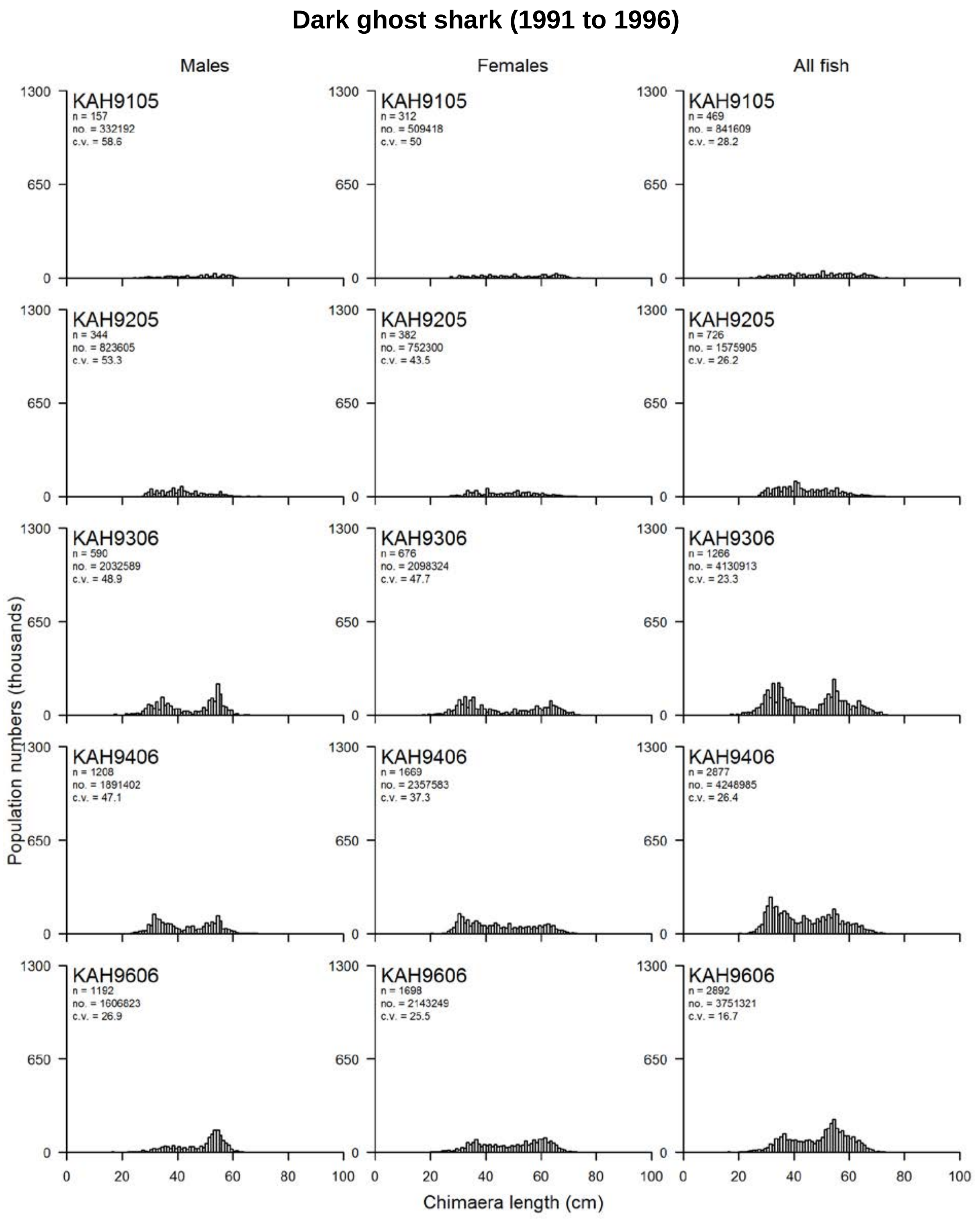


Figure 11: Scaled length frequency distributions for the target species in core strata (30–400 m) for all eleven ECSI winter surveys (1991 to 2016). The length distribution is also shown in the 10–30 m depth strata for the 2007, 2012, 2014 and 2016 surveys overlayed (not stacked) in red for ELE, GUR, RCO, and SPD. Population estimates are for the core strata only, in thousands of fish. Scales are the same for males, females and unsexed, except for NMP where total has a different scale.

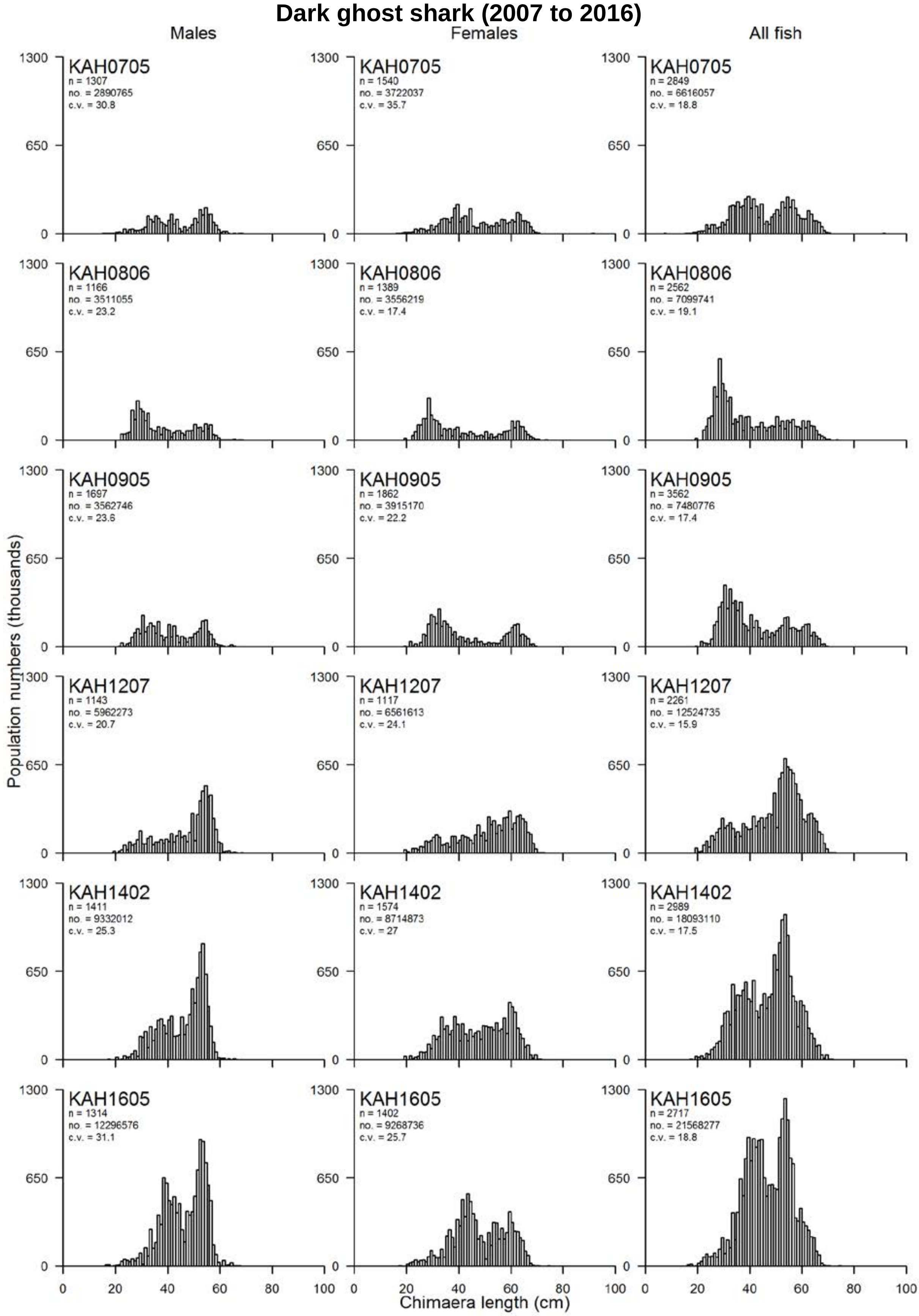


Figure 11 – ***continued***

Elephantfish (1991 to 1996)

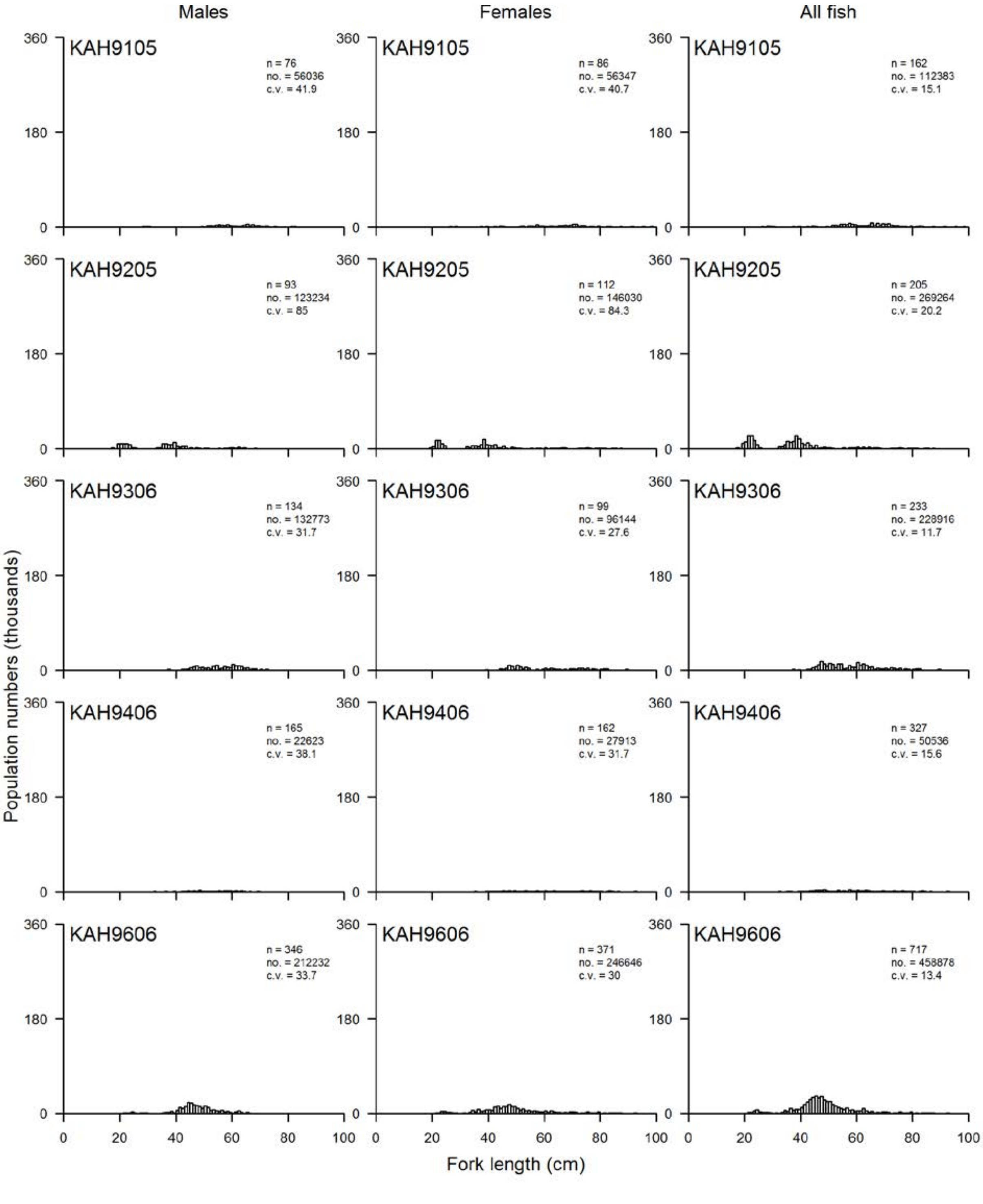


Figure 11 – ***continued***

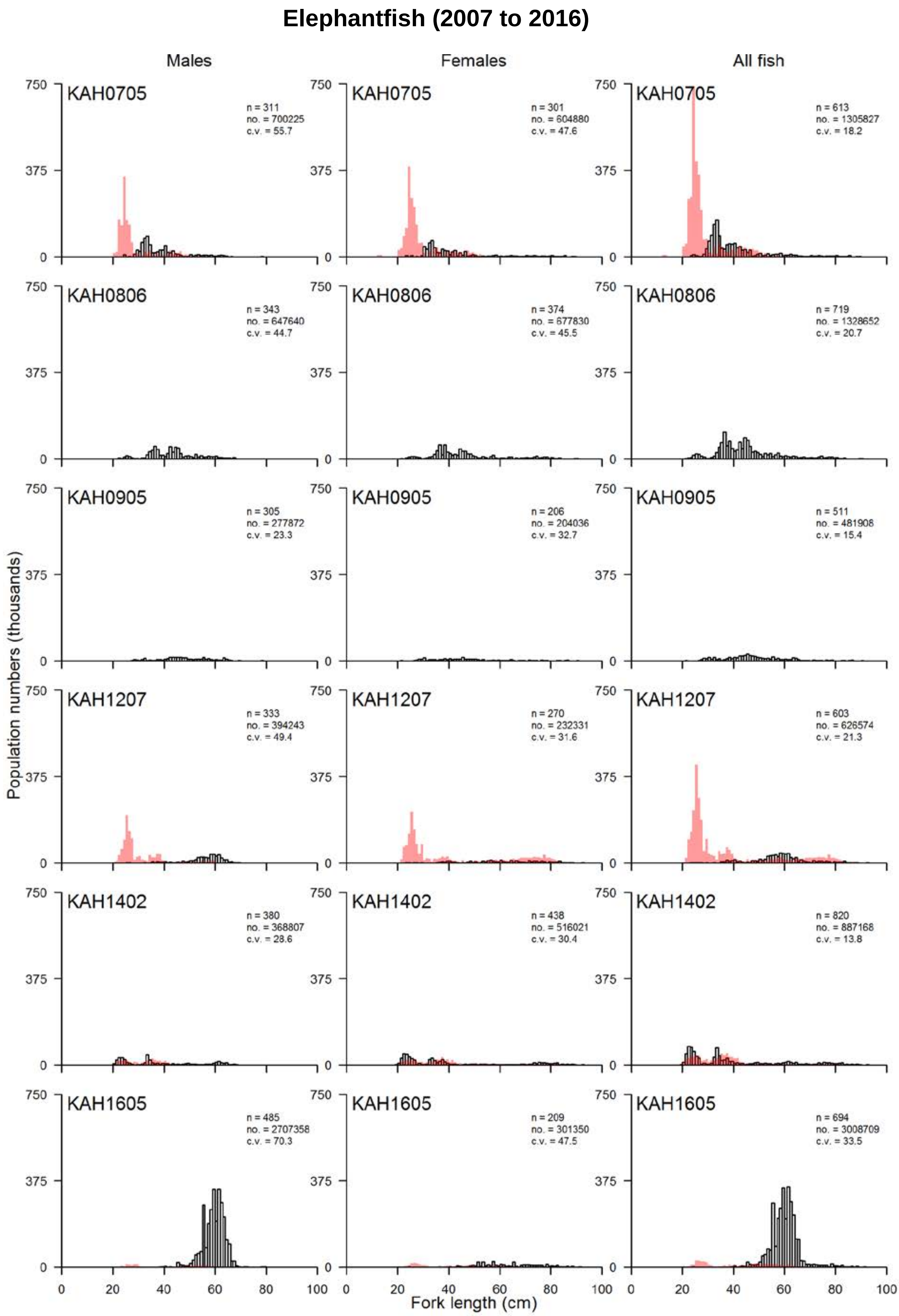


Figure 11 – ***continued***

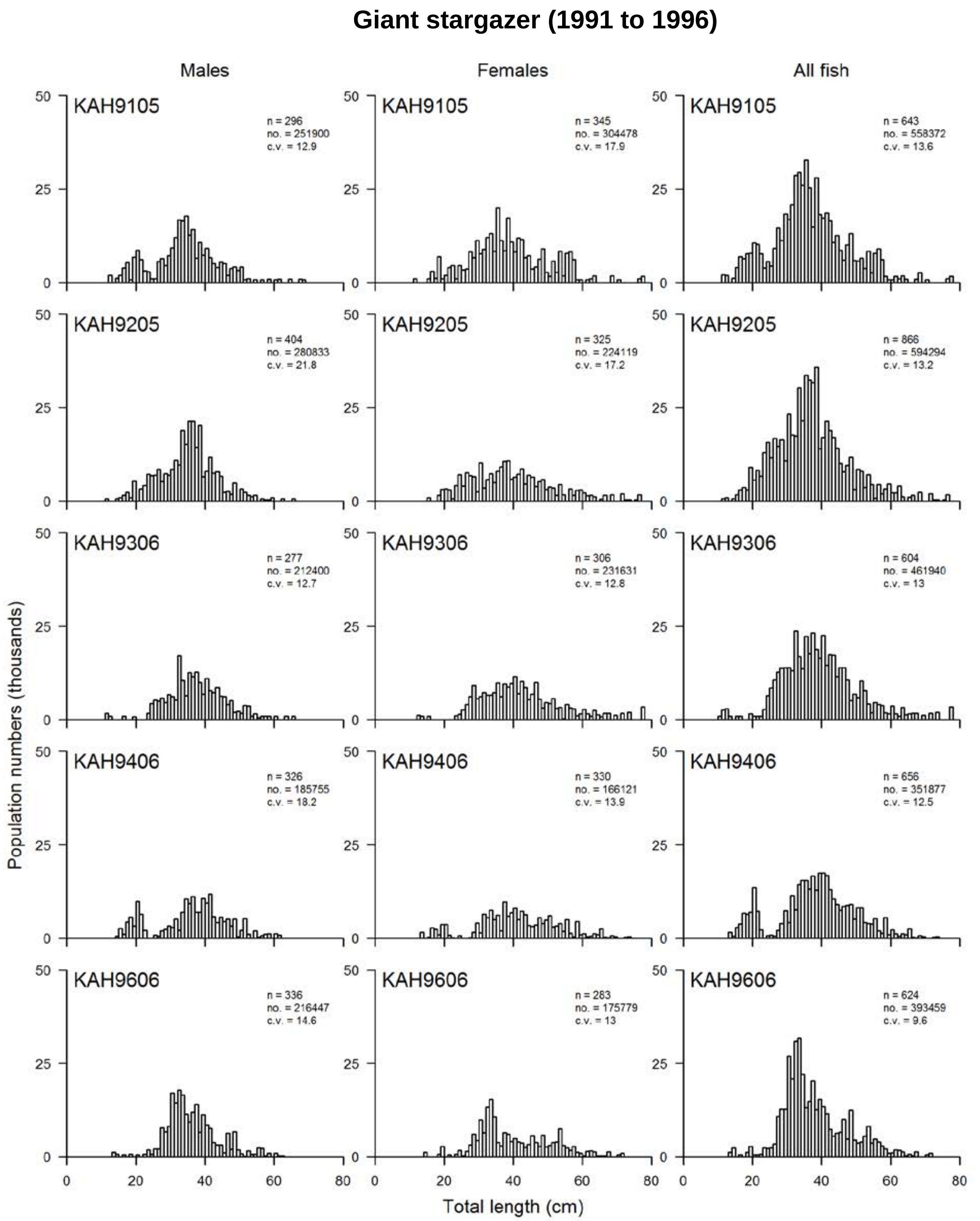


Figure 11 – ***continued***

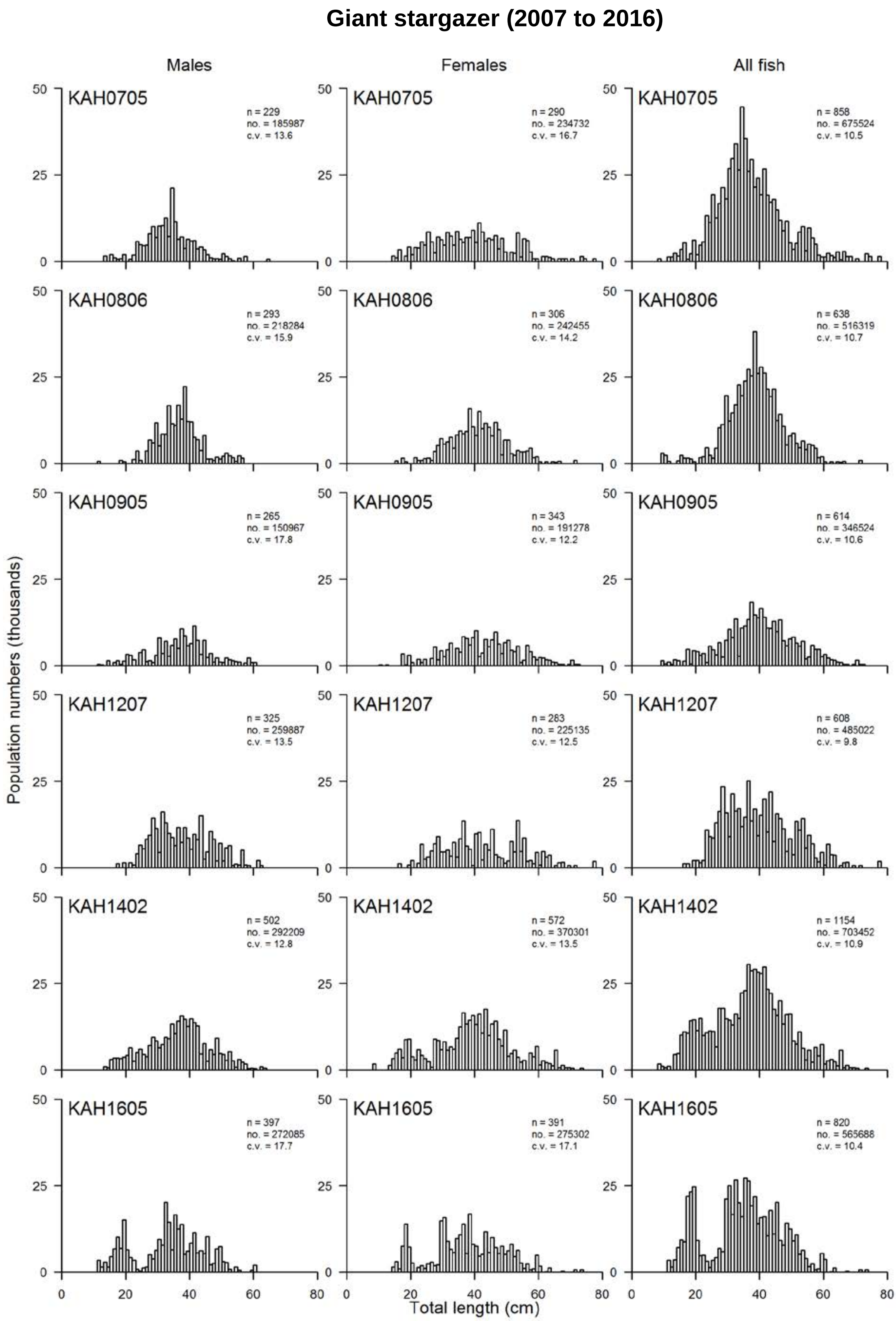


Figure 11 –*continued*

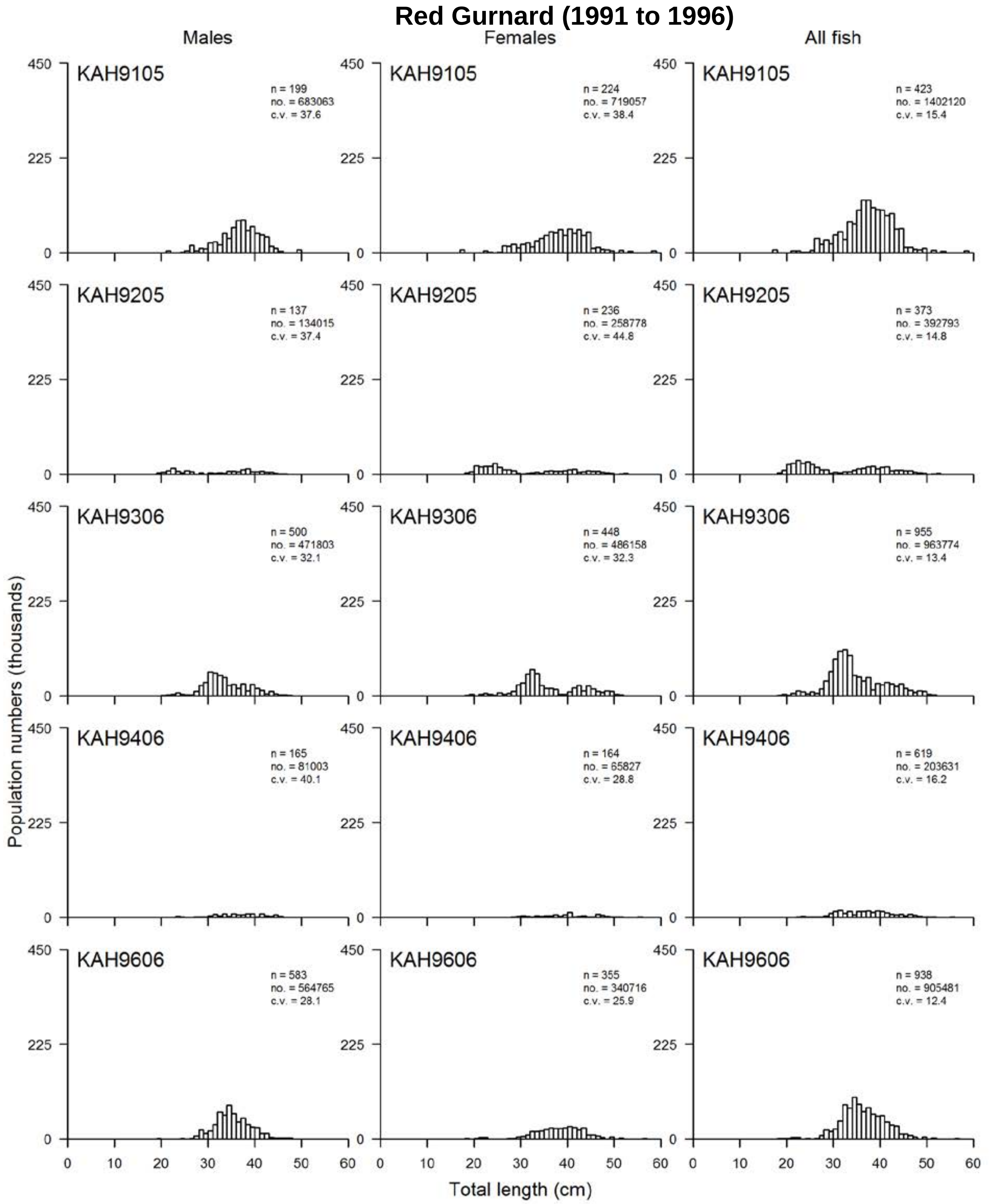


Figure 11 – ***continued***

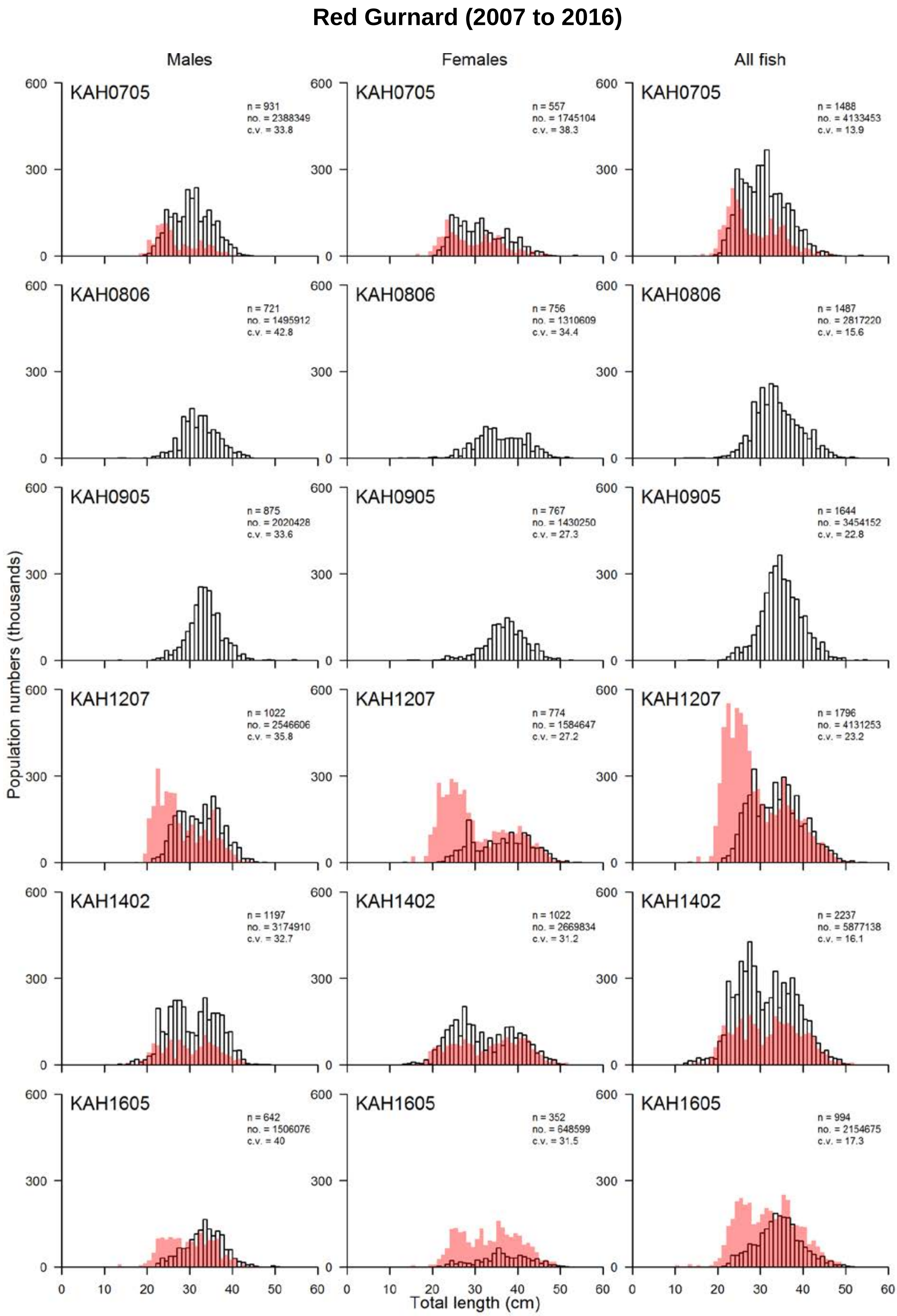


Figure 11 – ***continued***

Red cod (1991 to 1996)

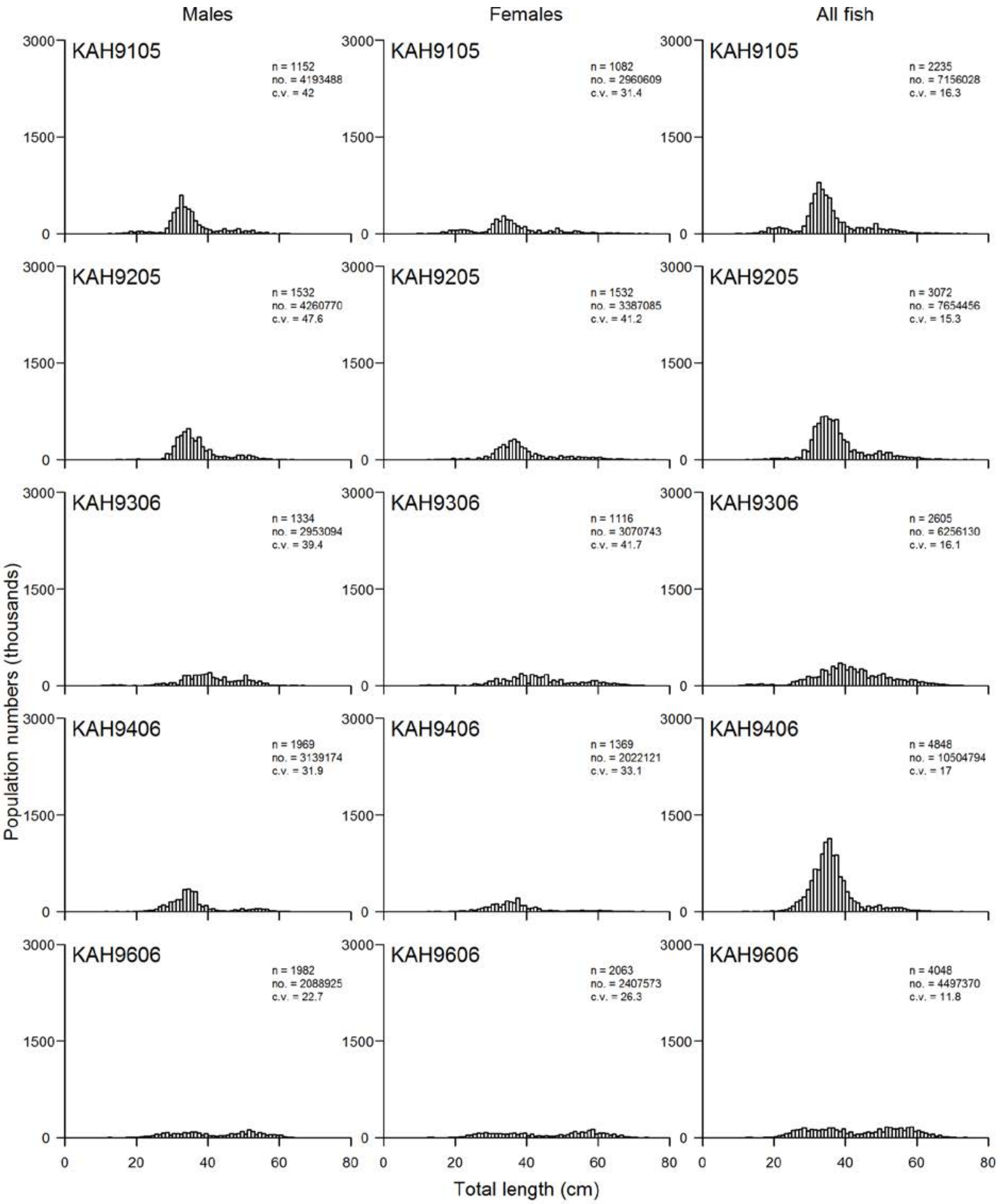


Figure 11 – ***continued***

Red cod (2007 to 2016)

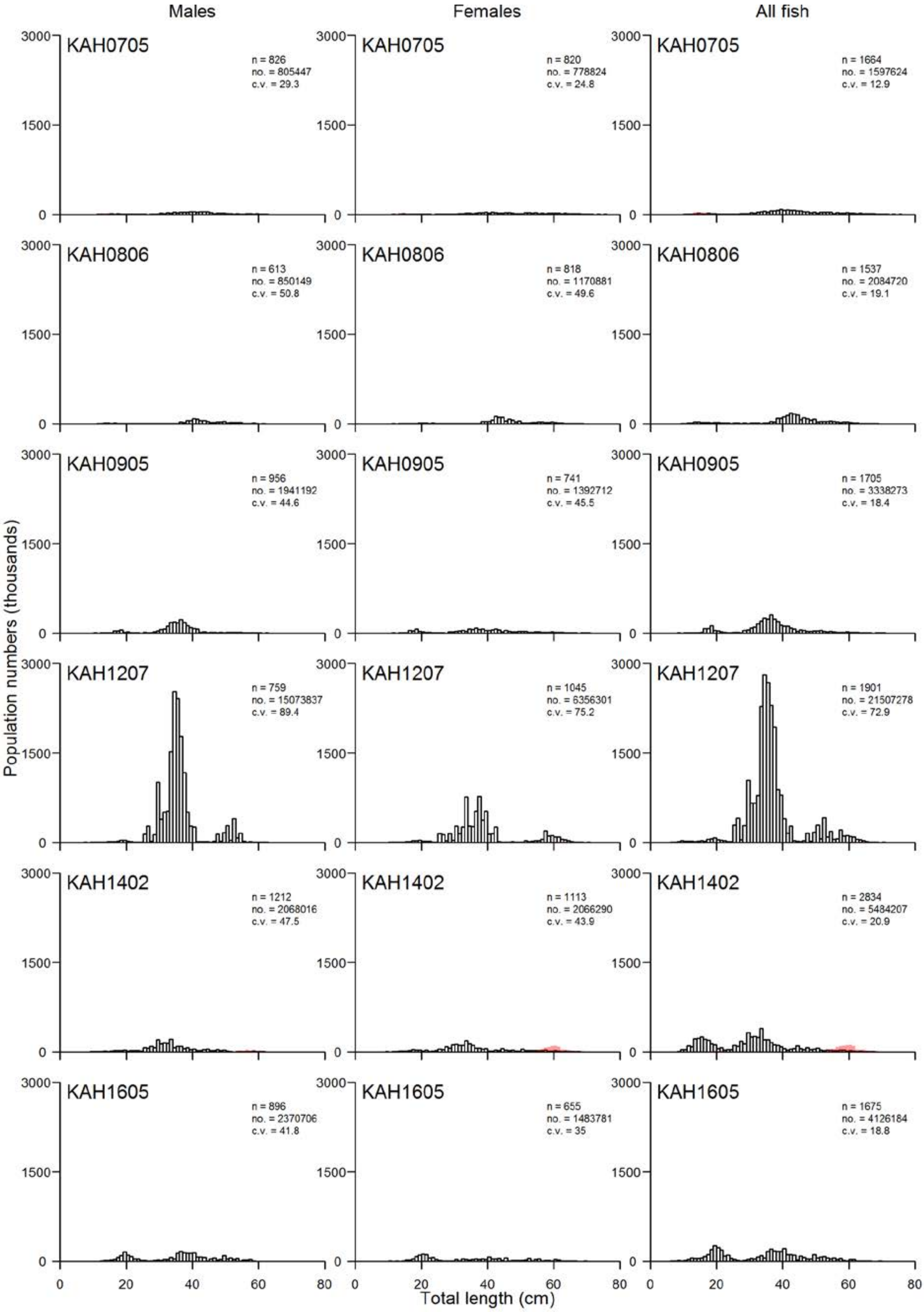


Figure 11 – ***continued***

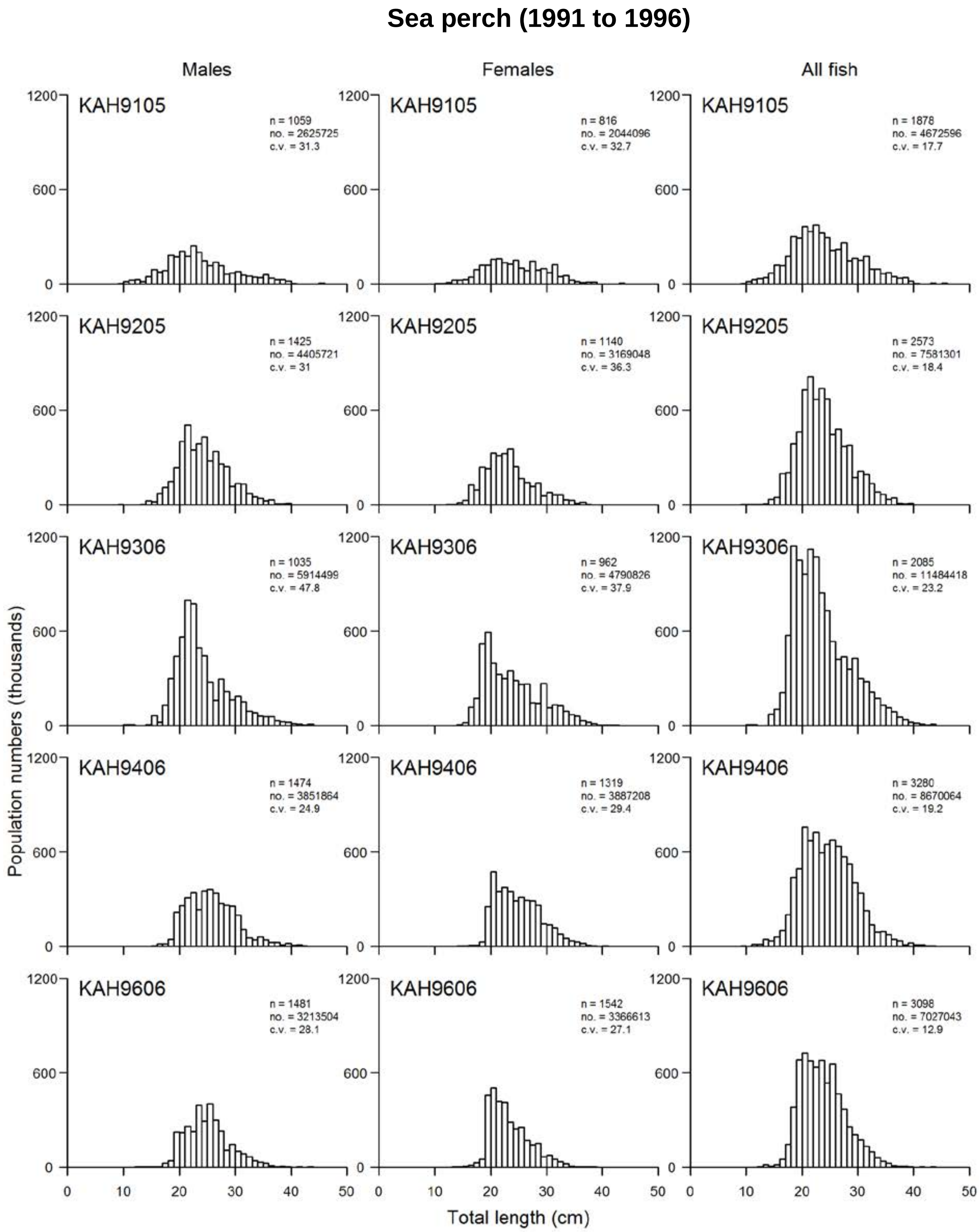


Figure 11 – *continued*

Sea perch (2007 to 2016)

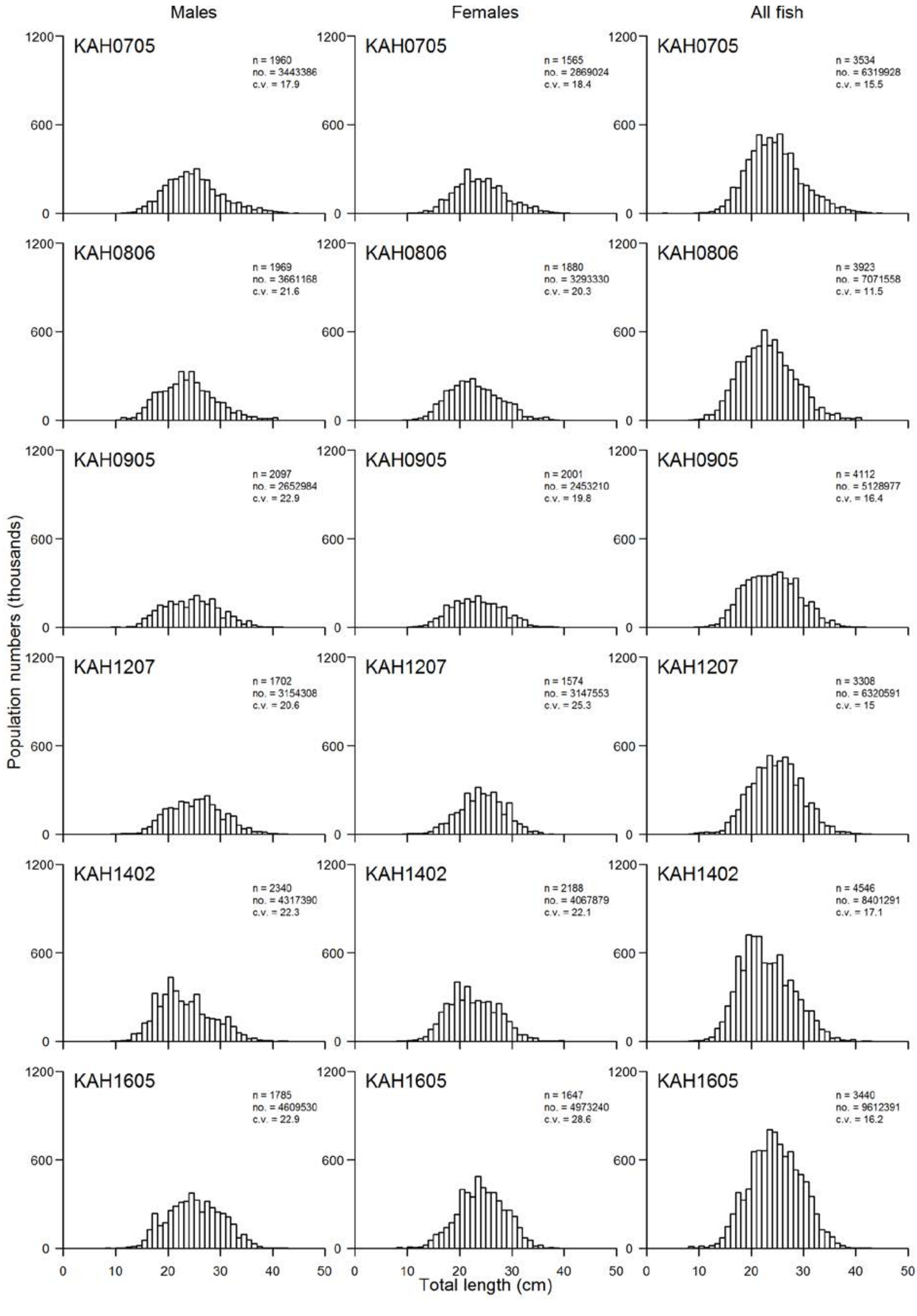


Figure 11 – ***continued***

Spiny dogfish (1991 to 1996)

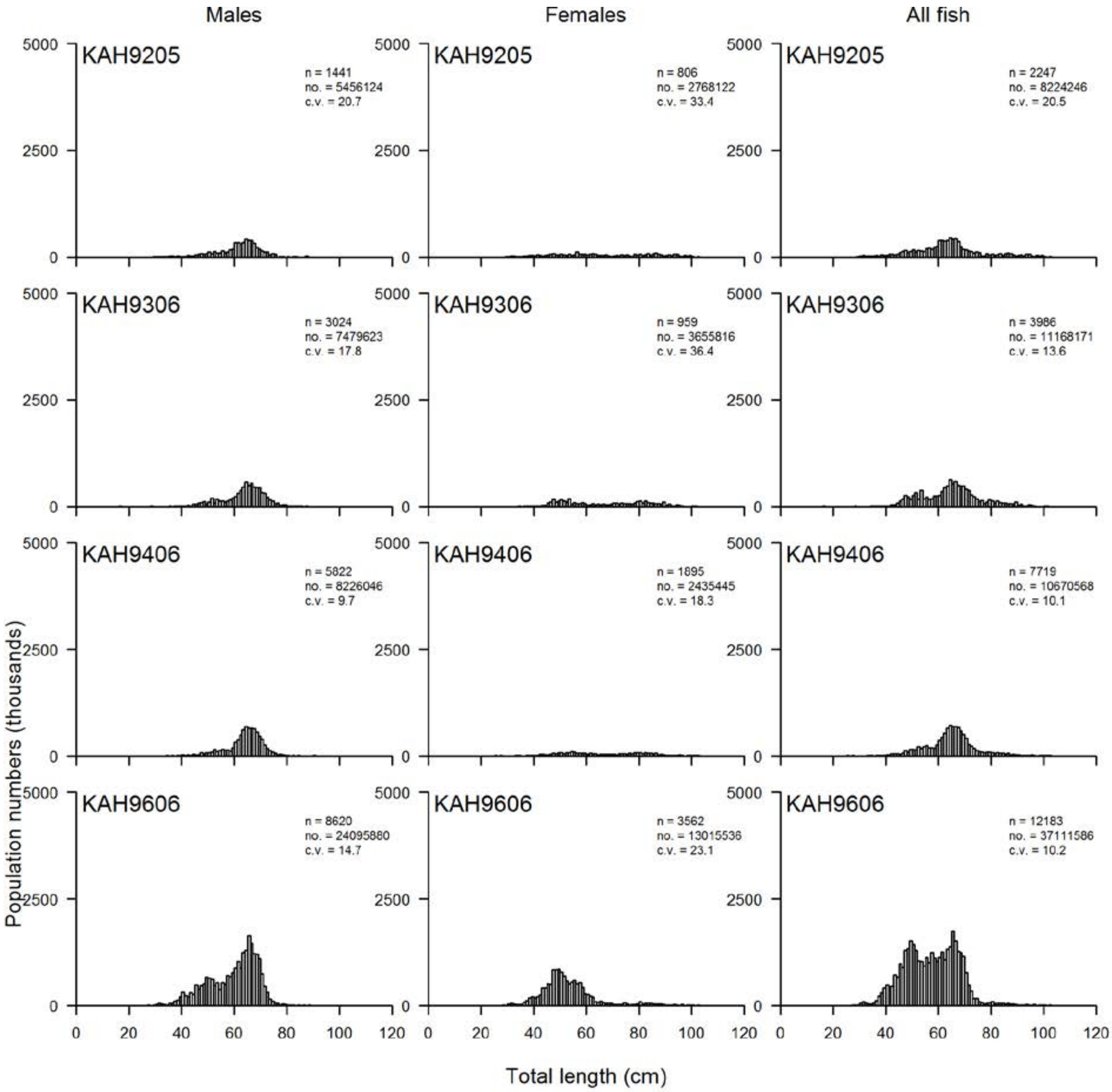


Figure 11– ***continued***

Spiny dogfish (2007 to 2016)

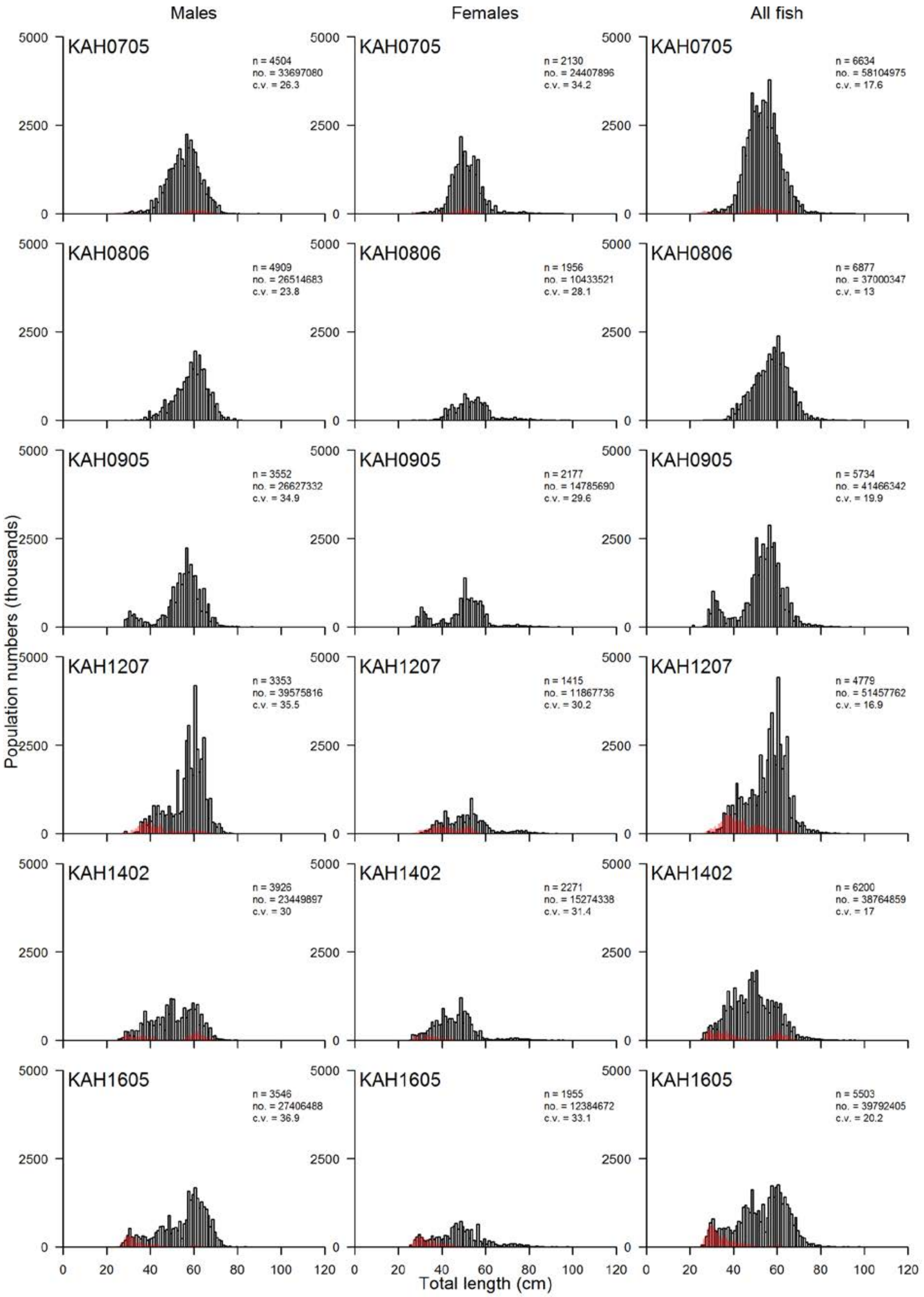


Figure 11 – ***continued***

Tarakihi (1991 to 1996)

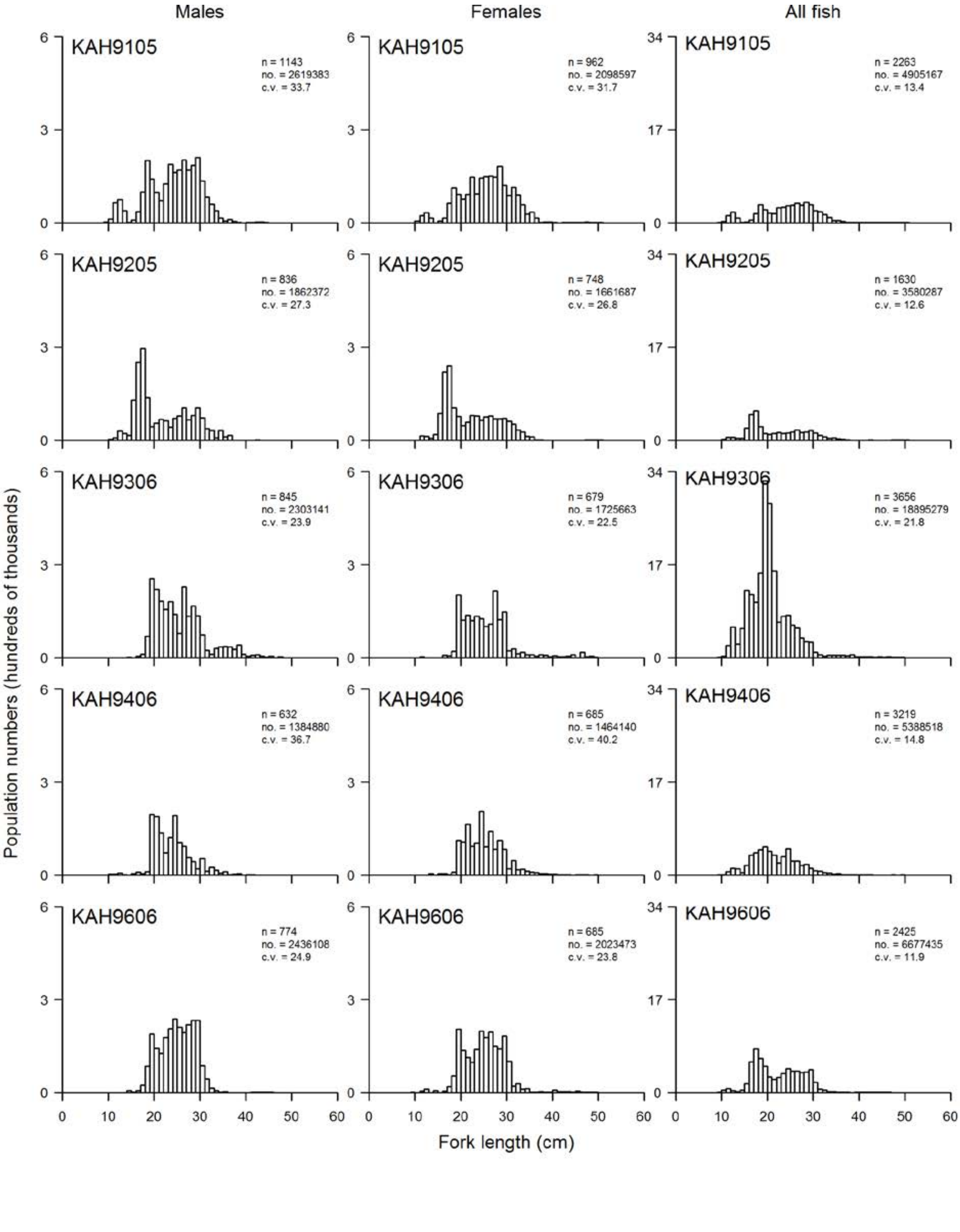


Figure 11 – ***continued***

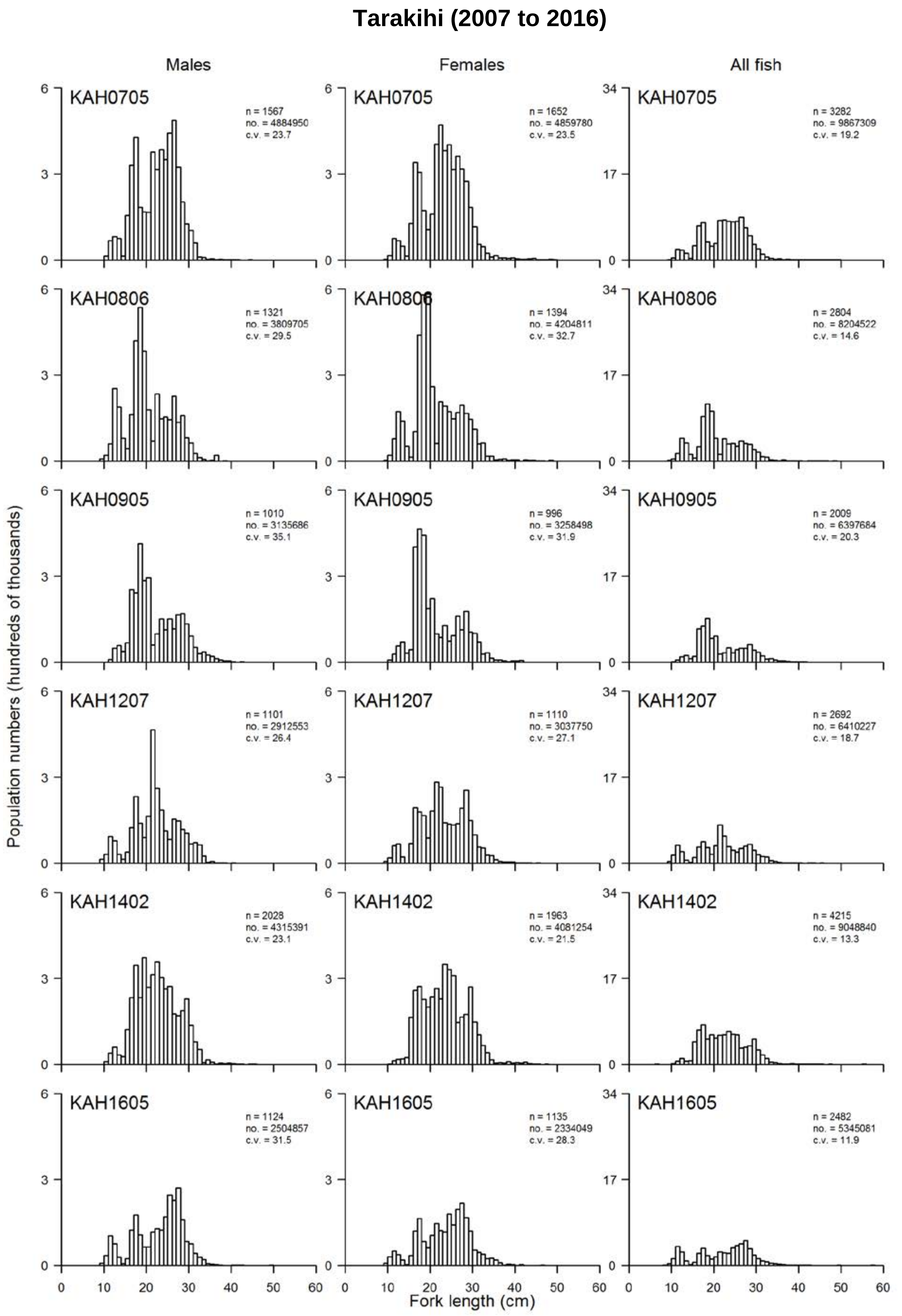
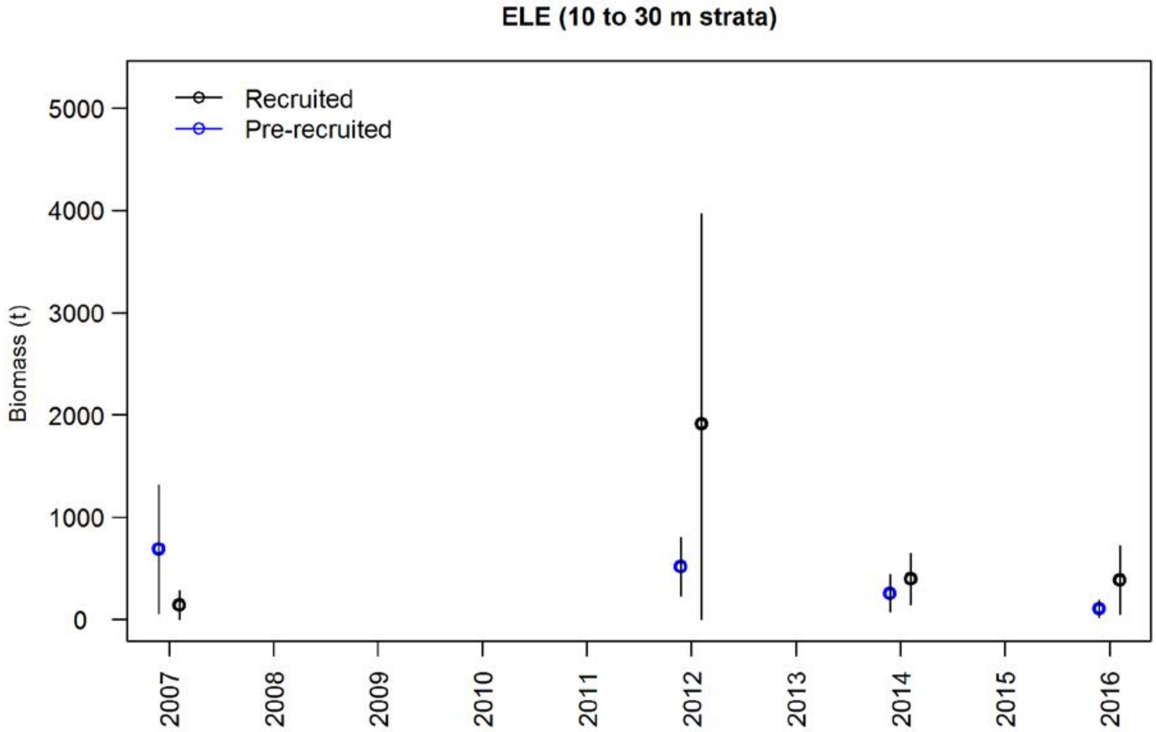


Figure 11 – ***continued***



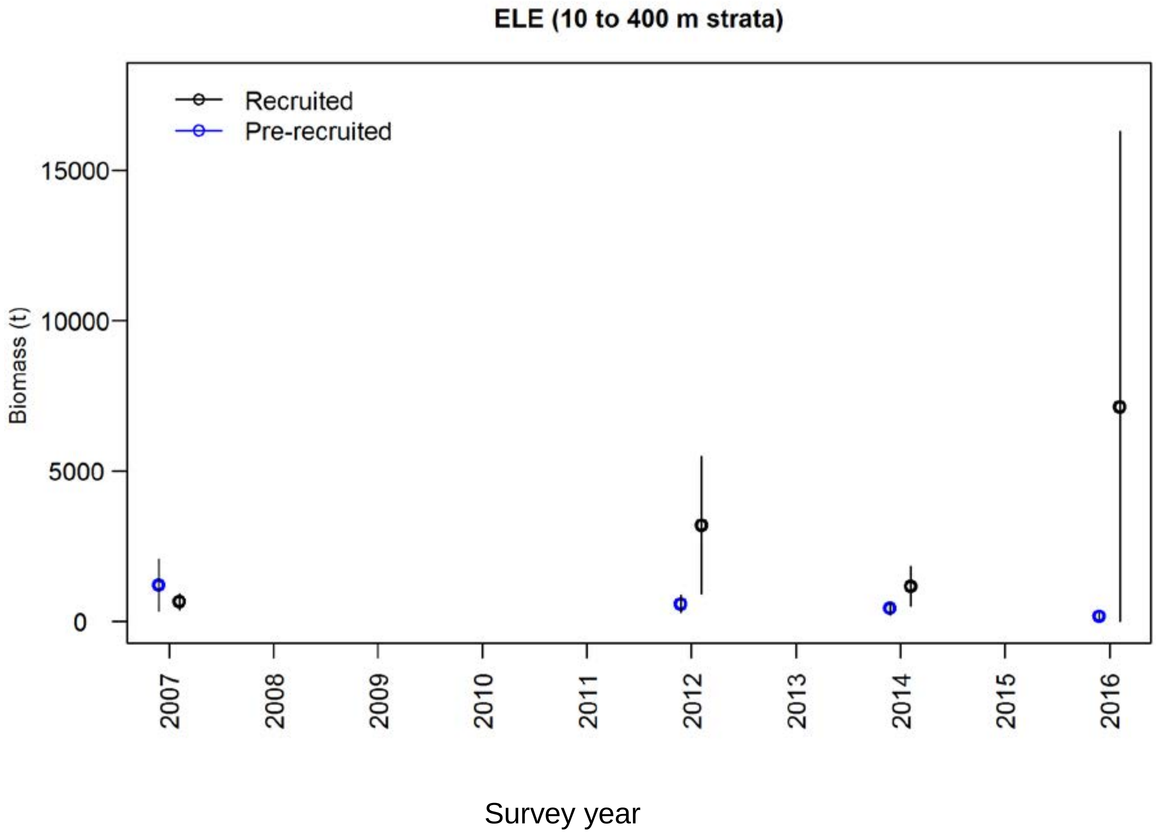


Figure 12: Elephantfish and red gurnard recruited and pre-recruited biomass and 95% confidence intervals for 2007, 2012, 2014 and 2016 ECSI surveys in 10–30 m and core plus shallow strata (10–400 m).

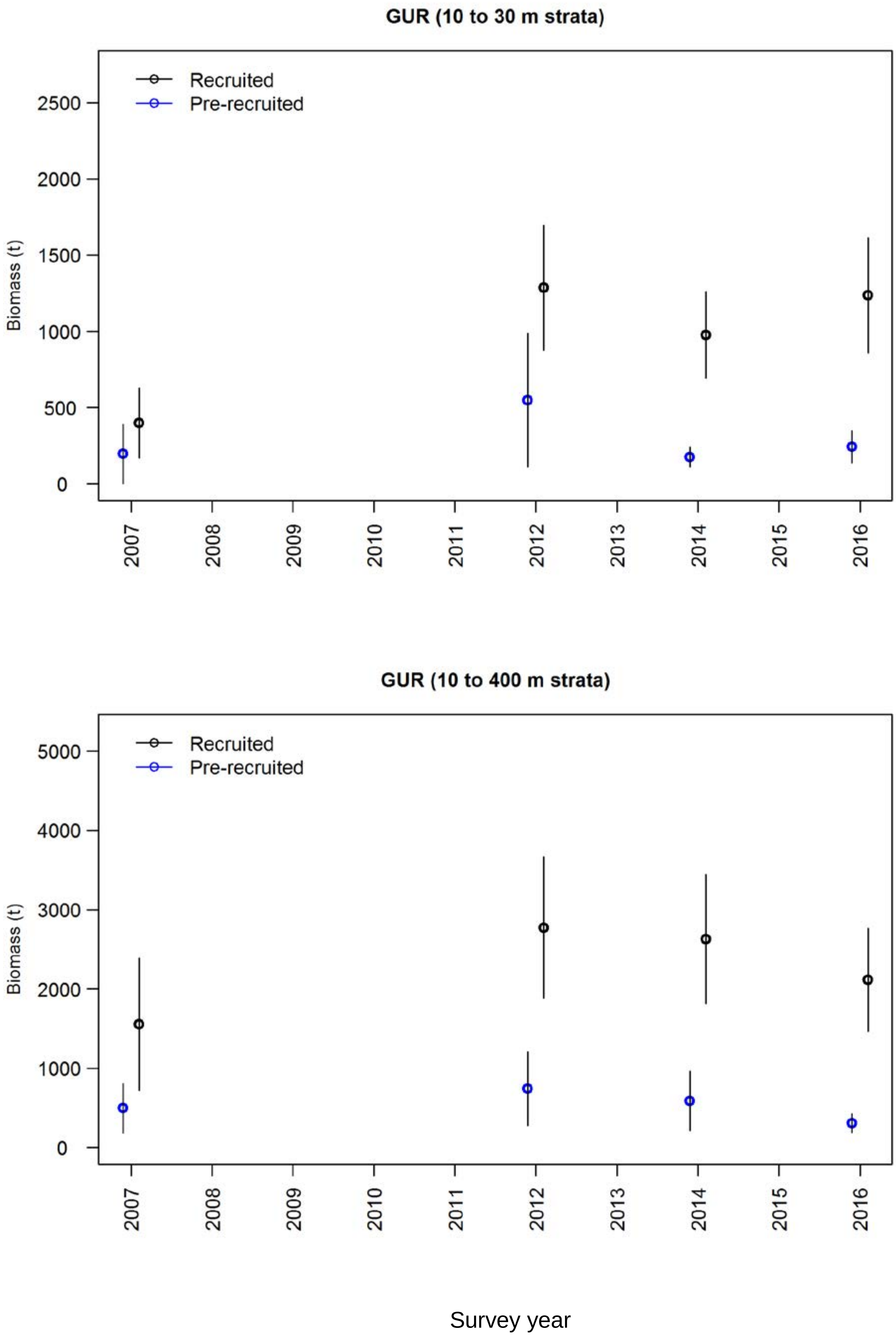


Figure 12 – ***continued***

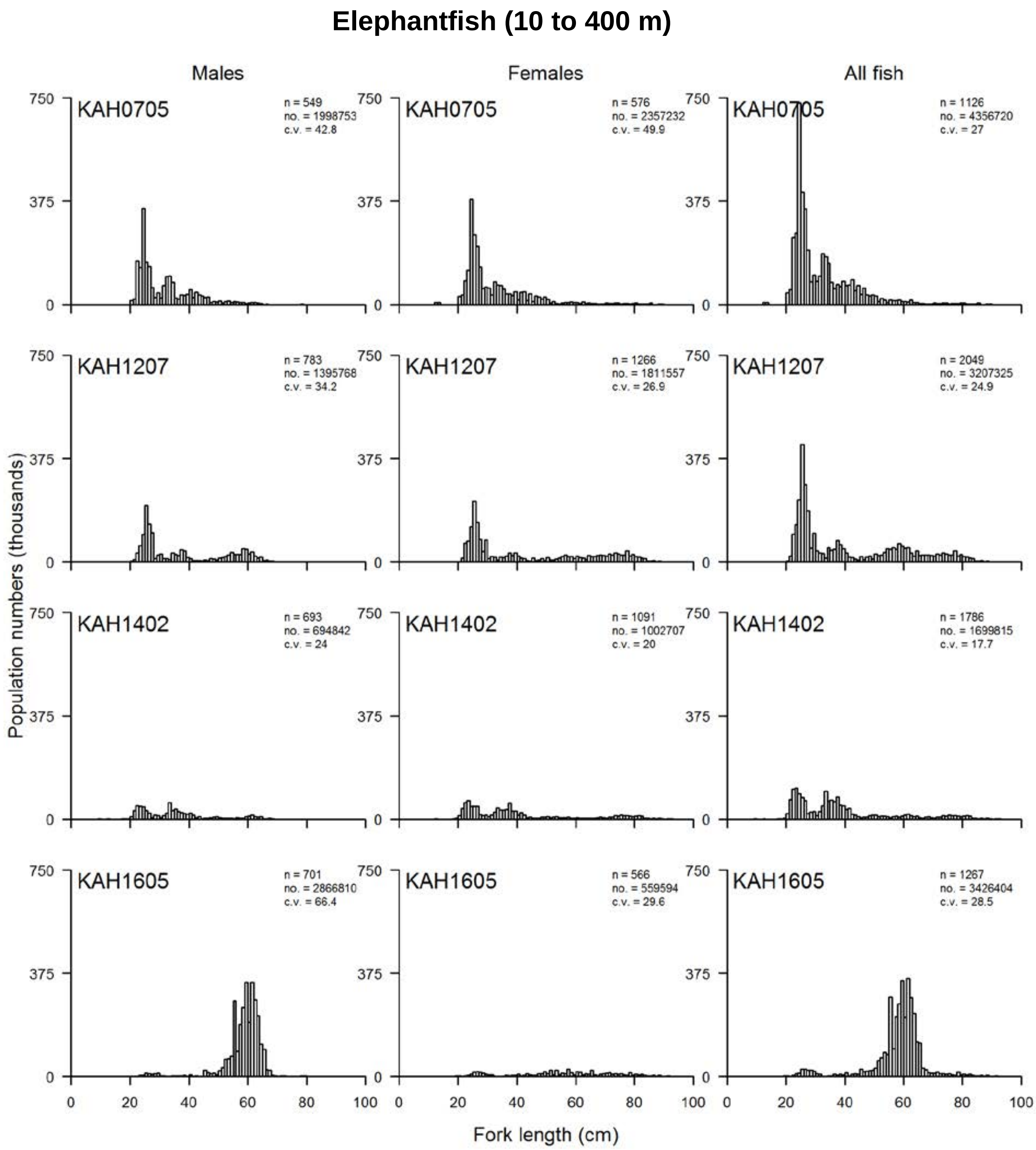


Figure 13: Scaled length frequency distributions for elephantfish and red gurnard in core plus shallow strata (10–400 m), for 2007, 2012, 2014 and 2016 ECSI surveys. Population estimates are in thousands of fish.

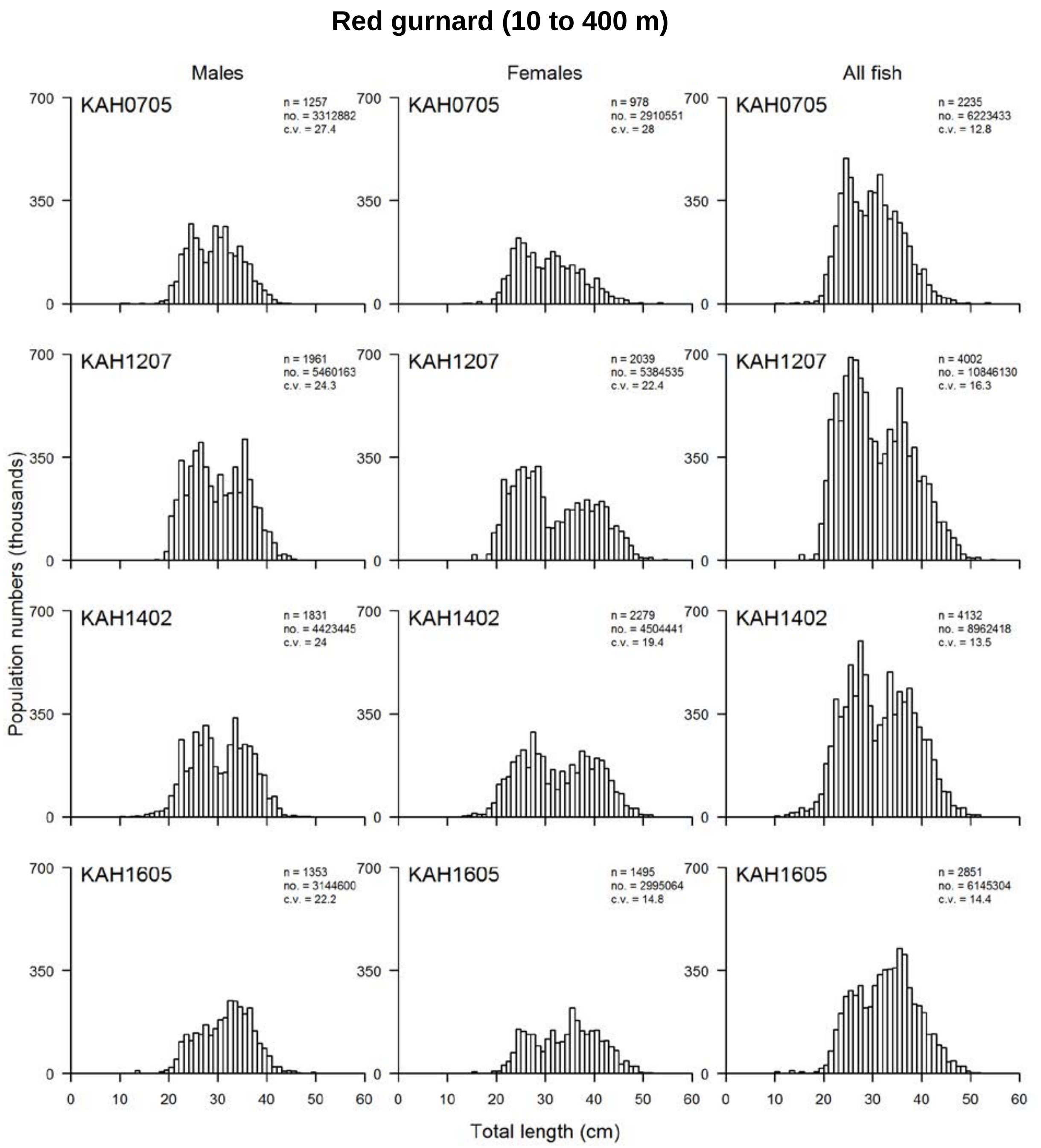


Figure 13 – ***continued***

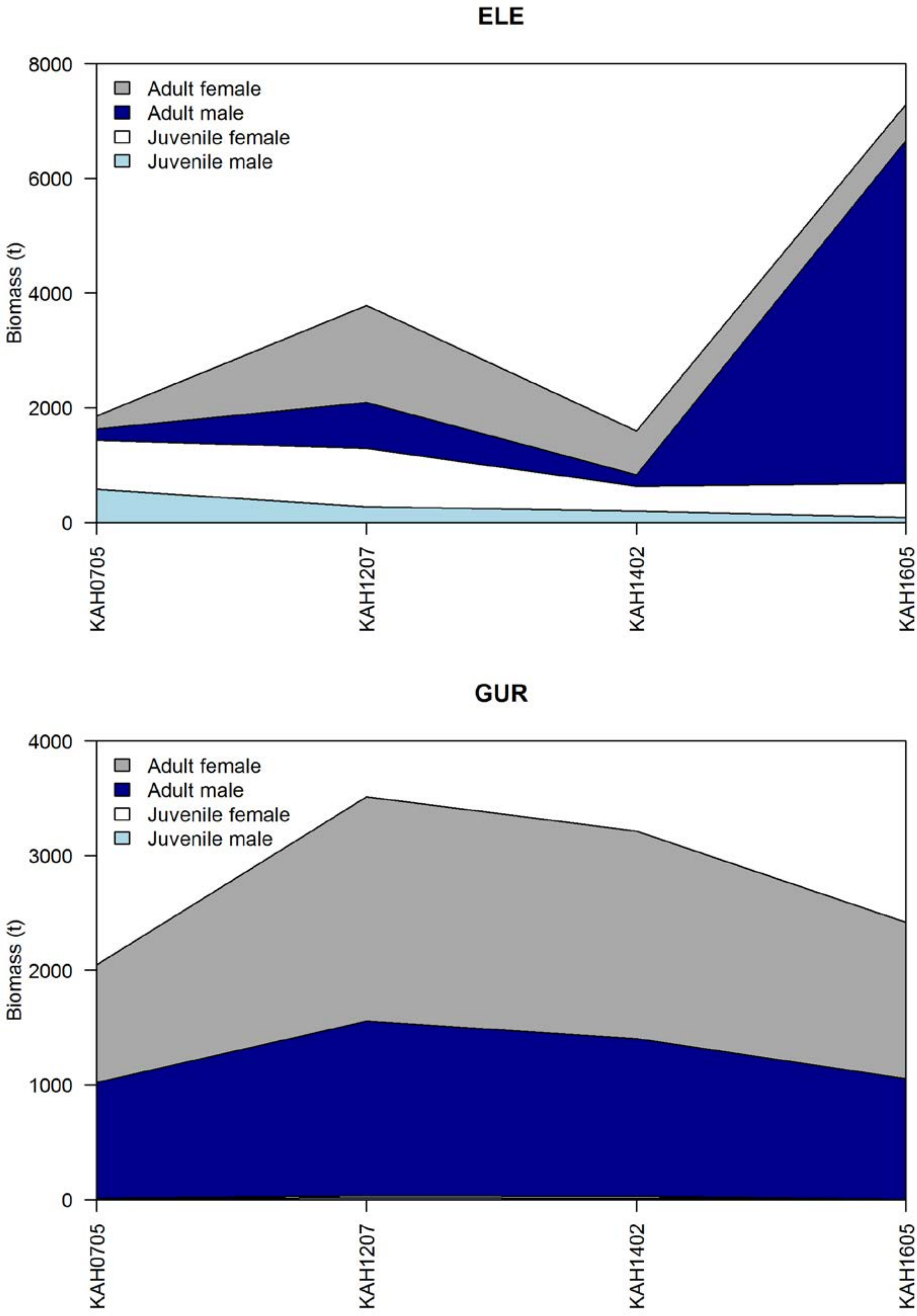
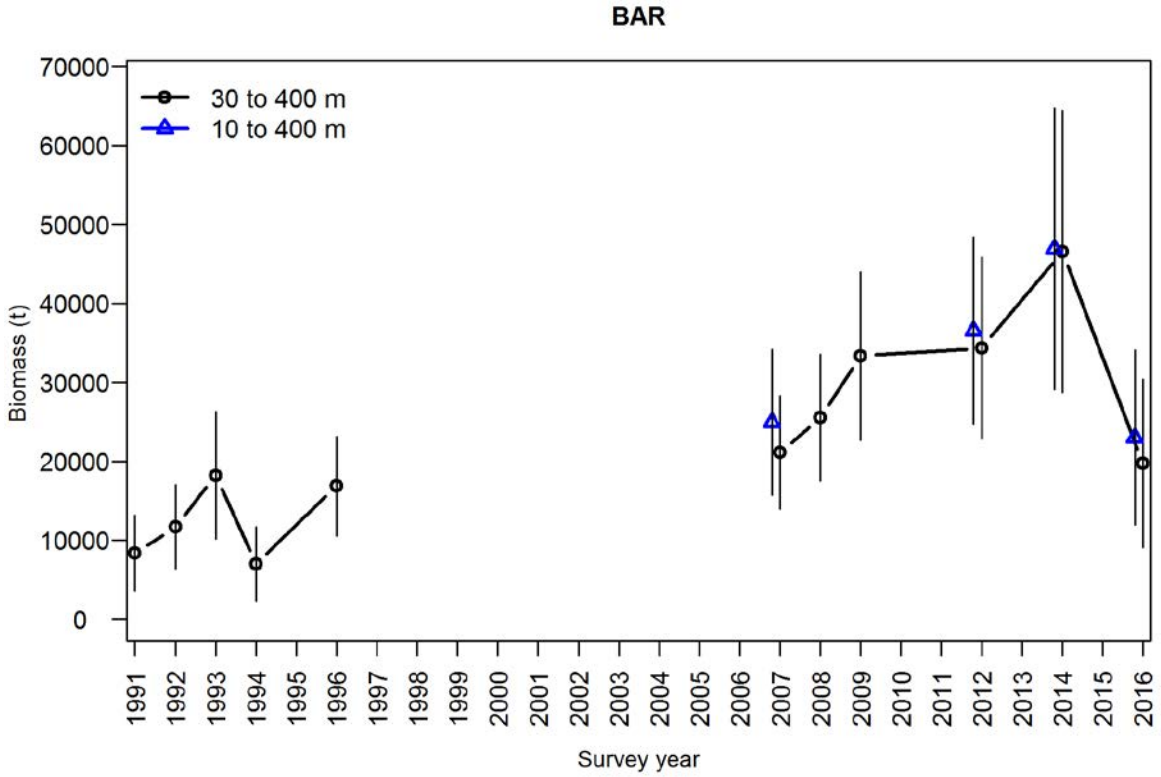


Figure 14: Elephantfish and red gurnard juvenile and adult biomass in core plus shallow strata (10–400 m) for 2007, 2012, 2014 and 2016 ECSI surveys, where juvenile is below and adult is equal to or above length at which 50% of fish are mature.



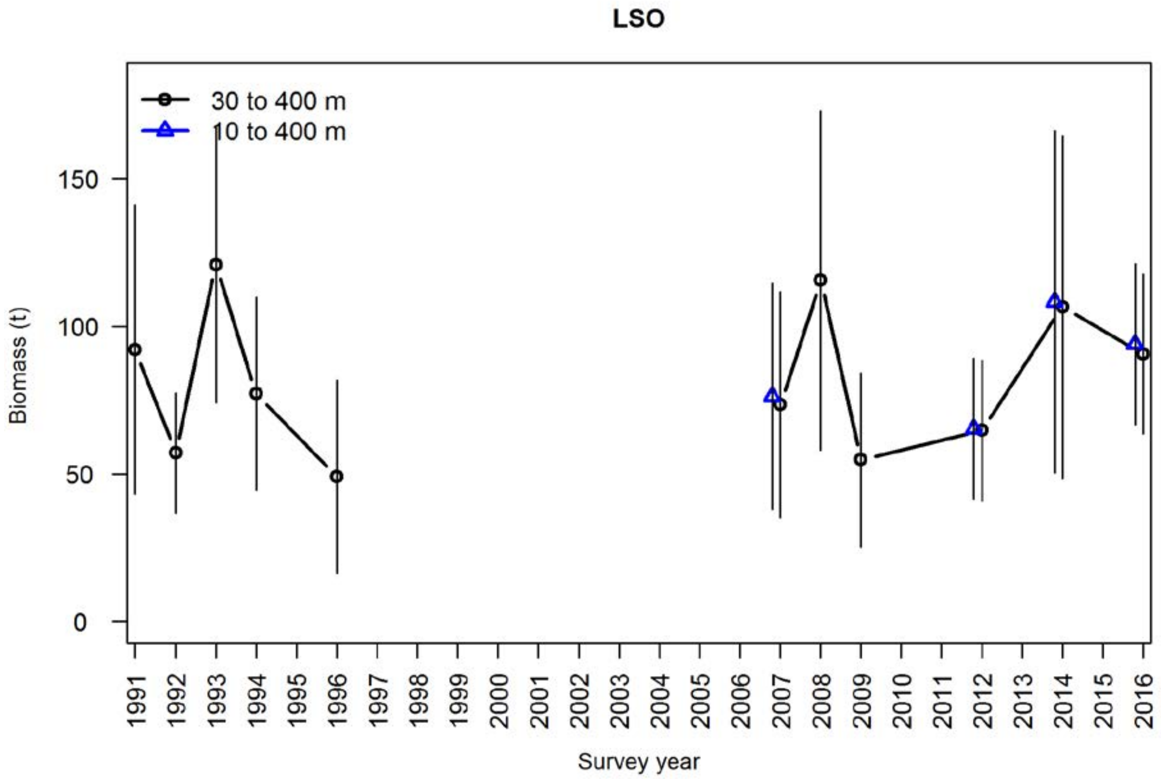
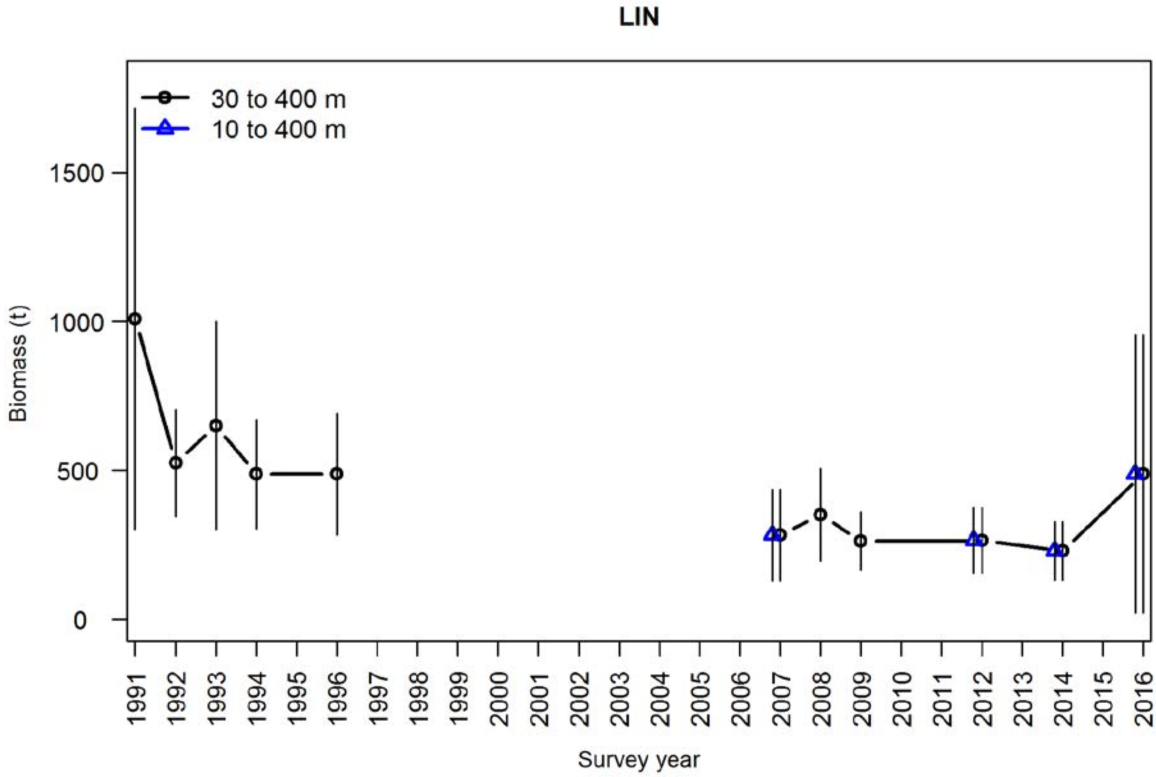


Figure 15: Key non-target QMS species total biomass and 95% confidence intervals for all ECSI winter surveys in core strata (30–400 m), and core plus shallow strata (10–400 m) in 2007, 2012, 2014 and 2016.



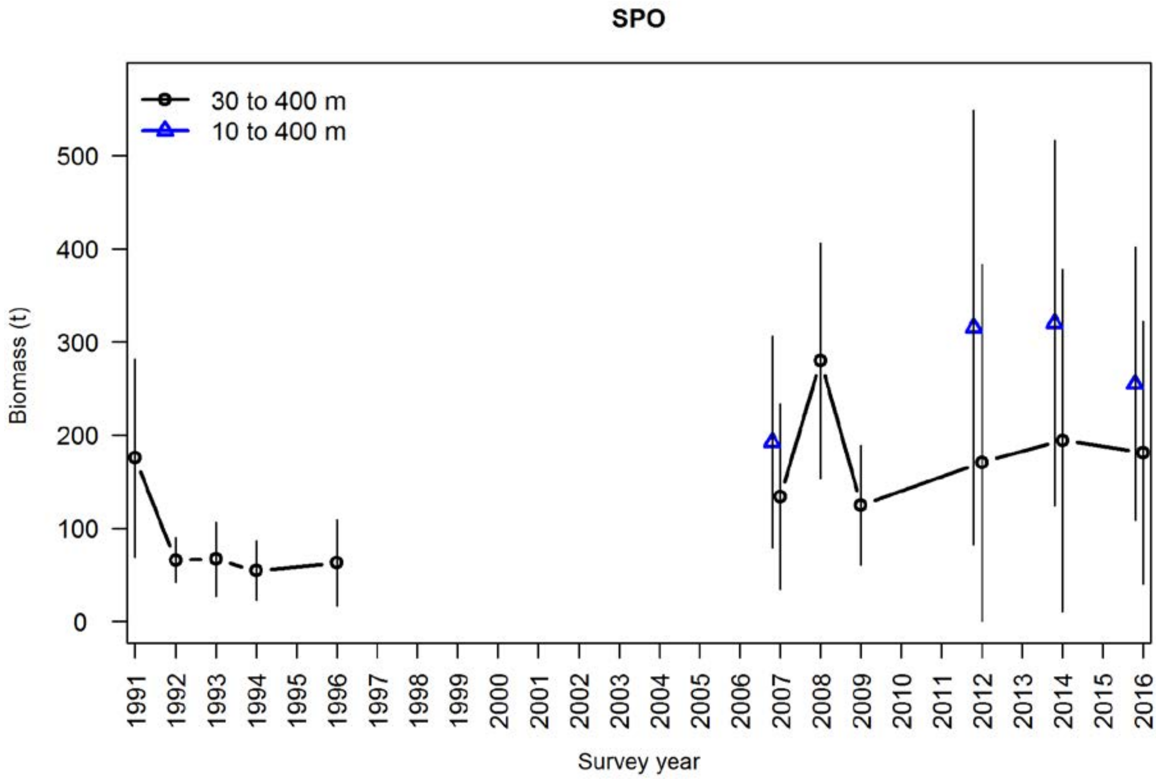
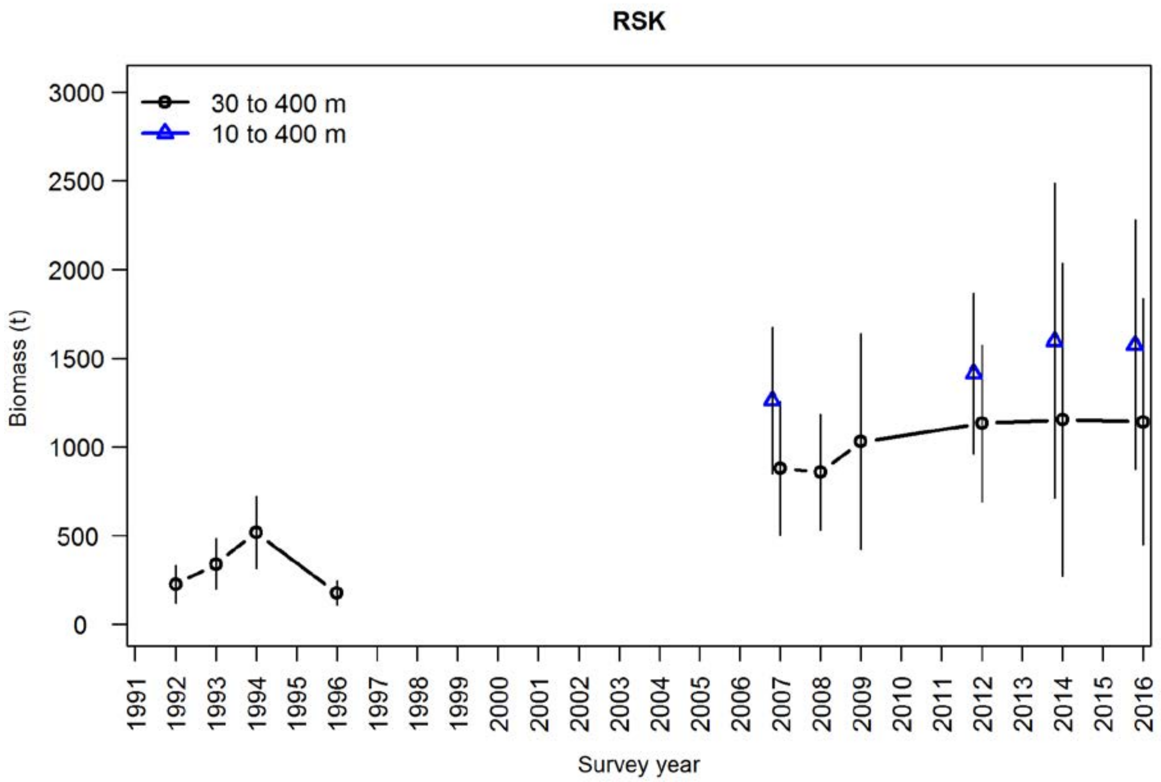


Figure 15 – ***continued***



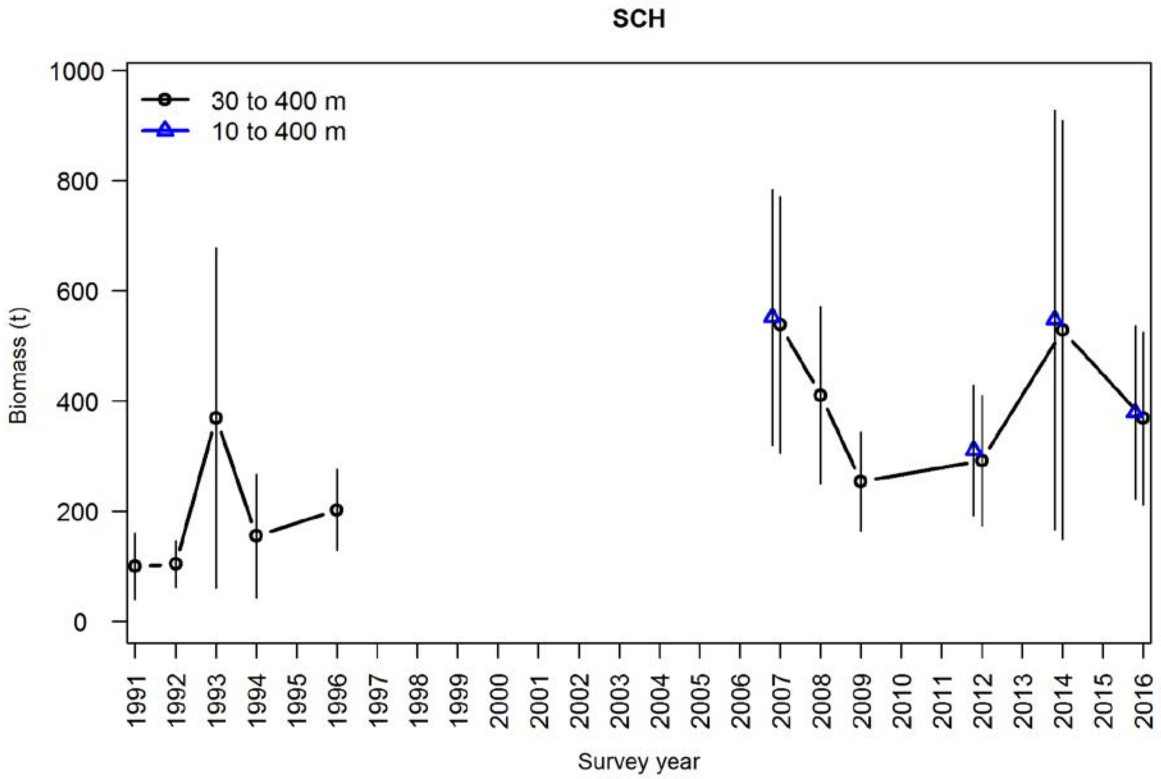
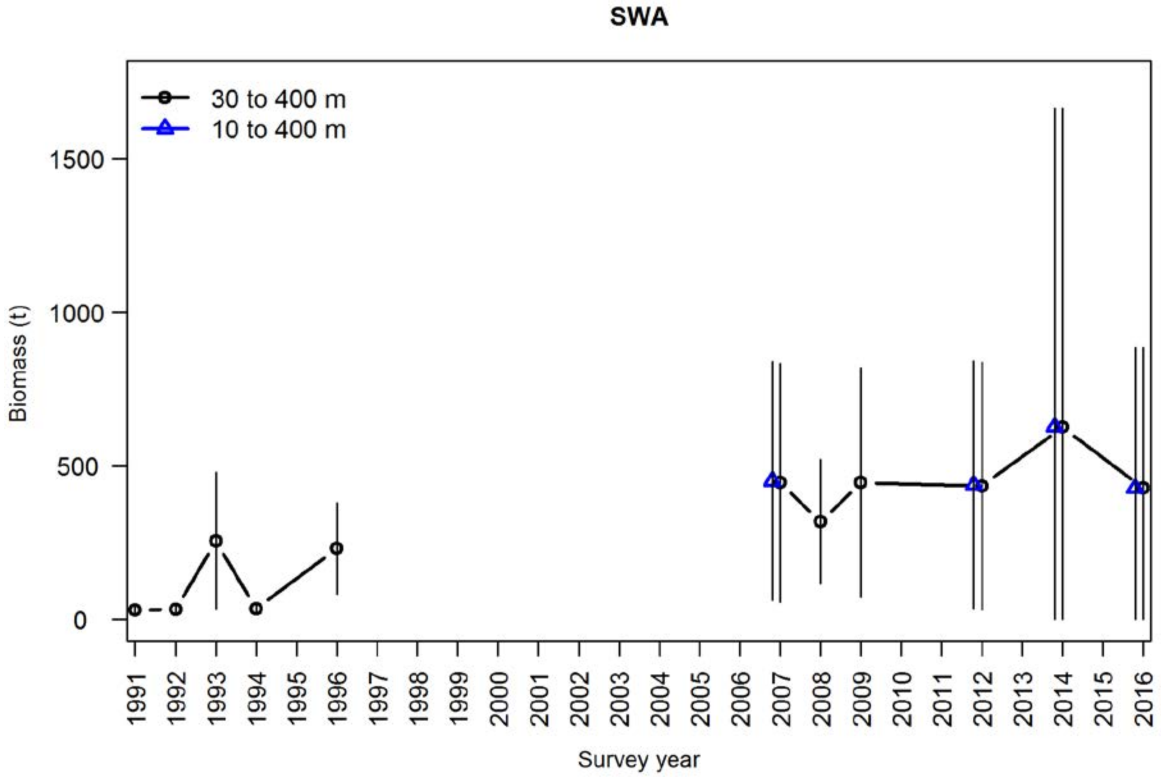


Figure 15 – ***continued***



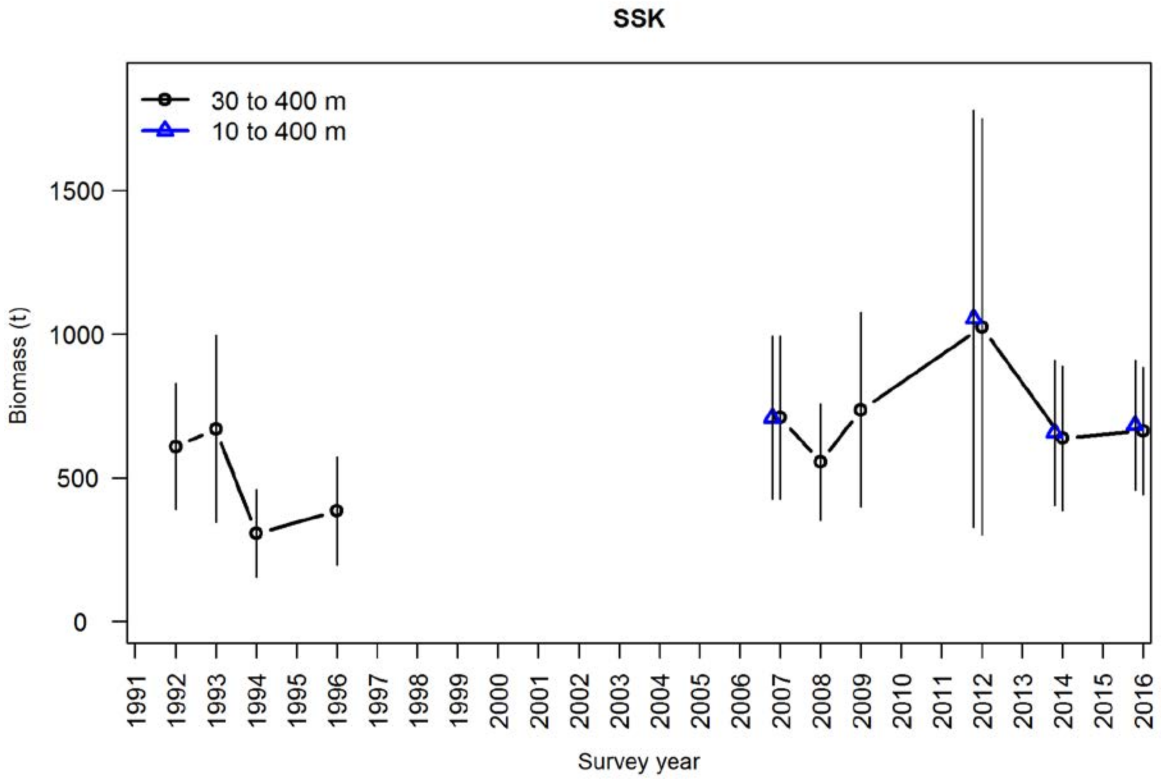


Figure 15 – ***continued***

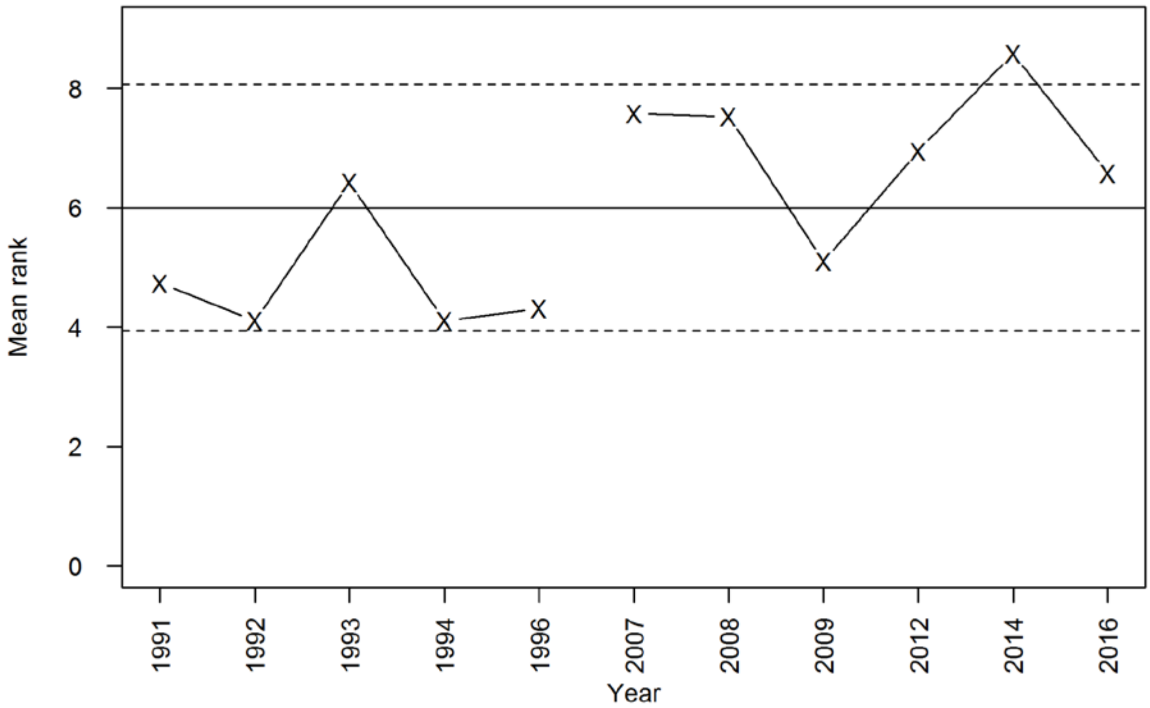


Figure 16: Mean ranks for the ECSI winter trawl surveys (core strata) for 19 species, including the target species. The solid line indicates the overall mean rank. Mean ranks outside the broken lines (95% confidence intervals) have extreme catchability.

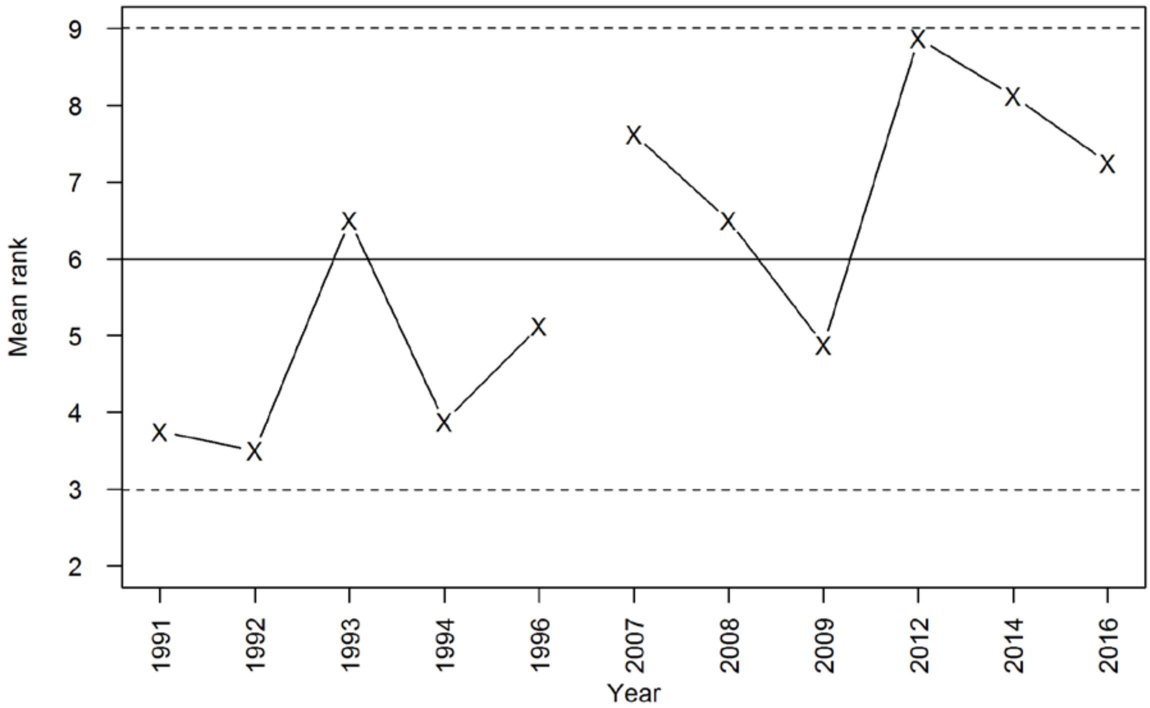


Figure 17: Mean ranks for the ECSI winter trawl surveys (core strata) for eight target species. The solid line indicates the overall mean rank. Mean ranks outside the broken lines (95% confidence intervals) have extreme catchability.

Appendix 1: Gonad stage definitions.

Finfish

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 flaccid and bloodshot).

Spiny dogfish

Males: 1, immature (claspers shorter than pelvic fins, soft and uncalcified, unable or difficult to splay open); 2, maturing (claspers longer than pelvic fins, soft and uncalcified, unable or difficult to splay open or rotate forwards); 3, mature (claspers longer than pelvic fins, hard and calcified, able to splay open and rotate forwards to expose clasper spine).

Females: 1, immature (no visible eggs in the ovary); 2, maturing (visible eggs in ovary but no yolk); 3, mature (large yolked eggs in the ovary); 4, gravid (yolked eggs in the uterus but no embryos visible); 5, pregnant (embryos visible in the uterus); 6, spent (uterus flabby and bloodshot, yolked eggs may be in the ovary).

Dark ghost shark and elephantfish

Males

1. Immature – Pelvic claspers short (less than half the length of pelvic fins), tips not swollen, cartilages uncalcified, claspers soft and flexible. Frontal tenaculum not erupted. Posterior reproductive tract undeveloped. No coiling of epididymis.
2. Maturing – Pelvic claspers beginning to elongate but not reaching pelvic fin posterior margin, tips not swollen, or if swollen, without embedded prickles; cartilages not completely calcified and may be soft and flexible or partially rigid. Frontal tenaculum erupted, but not fully developed, with hooks absent or uncalcified. Posterior reproductive tract beginning to thicken. Epididymis enlarged, but with few coils.
3. Mature – Pelvic claspers elongated, reaching or almost reaching posterior margin of pelvic fins; claspers mostly rigid with enlarged bulbous tips and embedded prickles; cartilages fully calcified. Frontal tenaculum fully developed with calcified hooks. Epididymis with many tight coils near testis.

Females

1. Immature – Oocytes small and translucent white. Uterus threadlike. Oviducal gland marked by a minor widening of the oviduct.
2. Maturing or Mature/Resting* – Oocytes of varying sizes (up to and sometimes larger than pea-sized), white to cream or pale yellow. Uterus broader especially near oviducal gland. Oviducal gland swollen (about 10–20 mm diameter) and clearly differentiated from uterus.
3. Mature – Some oocytes large and bright yellow. Uterus wide and uterine wall thick, especially near oviducal gland and vaginae where it is muscular. Oviducal gland large (greater than 20 mm diameter) and bulbous.
4. Mature and gravid – As for stage 3, plus fully or partially developed egg case present in one or both uteri.

* When not reproductively active, mature females lack large yellow oocytes (except possibly a few flaccid resorbing oocytes) and they cannot be distinguished from maturing females.

Appendix 2: Summary of station data for the 2016 survey. NA, no data; gear perf, gear performance (1–5).

				Lat/long start of tow		Lat/ long end of tow		Gear depth (m)		Dist. trawled	Headline	Door spread		Temperature (ºC)	
Station	Stratum	Date	Time	º ' S	º ' E	º ' S	º ' E	Min.	Max.	(n. miles)	height (m)	(m)	Gear perf.	Surface	Bottom
1	7	25-Apr-16	722	431639	1730607	431376	1730835	31	35	3.11	4.8	75.9	1	14.5	14.5
2	7	25-Apr-16	1034	431835	1731844	431540	1731958	61	62	3.06	4.8	77.1	1	14.2	13.8
3	7	25-Apr-16	1305	430465	1731691	430235	1731948	54	59	3.05	4.9	74.9	1	14.4	14.3
4	7	25-Apr-16	1539	430193	1731599	430406	1731311	45	45	2.99	4.8	74	1	14.6	14.4
5	6	26-Apr-16	657	434432	1732703	434319	1732730	82	84	1.14	5	68.1	4	13.6	12.9
6	6	26-Apr-16	847	433252	1732302	432936	1732243	75	78	3.18	5	75.1	1	13.9	13.1
7	7	26-Apr-16	1023	432821	1732333	432536	1732180	76	80	3.05	4.9	77.5	1	13.8	13.1
8	13	26-Apr-16	1255	432780	1733427	432507	1733599	110	116	3	4.5	80.4	1	13.1	12.1
9	13	26-Apr-16	1531	432185	1734787	431890	1734663	127	128	3.08	4.8	82.3	1	12.3	11.7
10	17	27-Apr-16	643	434637	1740283	434335	1740303	339	347	3.02	4.7	99.6	1	12.6	10.5
11	6	27-Apr-16	941	433112	1734879	432805	1734844	91	95	3.08	4.9	79.1	1	12.7	11.9
12	17	27-Apr-16	1157	431992	1734946	431710	1734817	303	320	2.97	4.5	90	1	12.6	9.9
13	13	27-Apr-16	1514	430861	1733852	430664	1733842	145	147	1.97	4.8	82.4	1	13.5	12
14	17	28-Apr-16	643	435291	1735824	435016	1740024	329	335	3.1	4.7	87.4	1	12.9	9.6
15	12	28-Apr-16	942	434635	1735872	434338	1735956	154	172	3.03	4.8	90.8	1	12.8	11.2
16	12	28-Apr-16	1212	434988	1735114	435224	1734873	111	115	2.93	4.8	78.9	1	12.8	11.4
17	12	28-Apr-16	1425	435098	1734621	435336	1734359	100	101	3.03	4.7	73.8	1	12.1	11.6
18	16	29-Apr-16	638	441873	1731638	441684	1731976	233	236	3.06	4.9	94.1	1	12.7	11.2
19	11	29-Apr-16	921	441059	1732726	440837	1733041	150	151	3.16	4.8	89.8	1	12.7	11.6
20	11	29-Apr-16	1143	440955	1732102	441129	1731764	113	115	2.98	4.5	77.5	1	13.3	12.1
21	11	29-Apr-16	1407	441388	1731466	441586	1731154	128	129	2.98	4.6	79.8	1	13.5	12.1
22	11	29-Apr-16	1603	441489	1730705	441256	1730963	112	117	2.97	4.4	74.7	1	13.5	12.3
23	7	30-Apr-16	652	432040	1731544	432299	1731528	44	48	2.59	4.8	73.8	1	14.2	13.5
24	18	30-Apr-16	1002	432465	1725884	432677	1725627	24	26	2.82	4.7	74.6	1	14.8	14.5
25	18	30-Apr-16	1144	432760	1725702	433041	1725578	22	25	2.95	4.8	73	1	15.1	14.7
26	18	30-Apr-16	1334	433268	1725924	433043	1730184	22	23	2.93	4.7	74.8	1	15.2	14.8
27	18	1-May-16	702	432107	1725146	432399	1725075	20	24	2.96	4.8	72.8	1	14.5	14.7
28	18	1-May-16	856	432158	1724581	432339	1724542	15	15	1.83	4.7	71.7	1	14.5	14.8
29	18	1-May-16	1041	432948	1724955	433209	1725137	18	18	2.92	4.8	72.6	1	14.8	15
30	5	2-May-16	656	435882	1724661	440100	1724385	49	58	2.94	4.7	71.5	1	14.4	13.4

				Lat/long start of tow		Lat/ long end of tow		Gear depth (m)		Dist. trawled	Headline	Door spread		Temperature (ºC)	
Station	Stratum	Date	Time	º ' S	º ' E	º ' S	º ' E	Min.	Max.	(n. miles)	height (m)	(m)	Gear perf.	Station	Stratum
31	5	2-May-16	854	440272	1724002	440519	1723775	57	60	2.95	4.8	69.4	1	14.3	12.9
32	4	2-May-16	1030	440678	1723662	440918	1723424	59	61	2.94	4.8	69.7	1	14.6	NA
33	4	2-May-16	1225	441117	1723087	441356	1722844	62	65	2.95	4.7	71.7	1	13.7	13.2
34	4	2-May-16	1400	441472	1722471	441657	1722146	66	68	2.97	4.7	74.8	1	14.1	13.1
35	4	2-May-16	1557	441877	1721401	442068	1721080	63	64	2.98	4.8	72.9	1	13.9	13.3
36	5	3-May-16	653	435245	1730475	435021	1730719	42	45	2.84	4.6	73.7	1	14.4	13.6
37	5	3-May-16	915	435746	1731137	435977	1730888	72	75	2.92	4.7	68.5	1	14.1	13.4
38	5	3-May-16	1116	440275	1731509	440031	1731758	77	81	3.02	4.9	77	1	14.1	13
39	6	3-May-16	1343	435214	1732783	434928	1732881	84	85	2.94	4.9	78.7	1	14.1	12.9
40	5	5-May-16	708	441025	1724654	440735	1724652	60	73	2.9	4.8	70.1	1	13.8	13.1
41	5	5-May-16	917	440440	1725304	440149	1725405	68	70	2.99	4.9	71.6	1	14.1	12.9
42	5	5-May-16	1315	440445	1730691	440627	1730515	76	82	2.21	4.8	73.1	1	13.6	12.9
43	5	5-May-16	1506	440820	1731225	441050	1730947	90	96	3.04	4.6	74.7	1	13.6	11.9
44	16	6-May-16	706	442688	1730418	442823	1730057	330	333	2.93	4.8	87.6	1	13	9.6
45	16	6-May-16	950	443474	1724926	443632	1724583	381	385	2.9	4.8	85.3	1	12.9	8.9
46	15	6-May-16	1245	443449	1724116	443566	1723849	237	237	2.23	4.4	69.8	1	13	11.2
47	10	6-May-16	1509	443072	1723315	442972	1723543	125	126	1.9	4.7	81	1	13.4	11.5
48	10	7-May-16	654	443662	1722688	443828	1722401	137	139	2.63	4.8	79.2	1	13.4	11.1
49	10	7-May-16	937	443997	1722117	444177	1721961	139	139	2.11	4.5	80.4	1	13.2	11.4
50	15	7-May-16	1150	444572	1722142	444732	1721850	353	369	2.61	4.4	75	1	13.2	8.4
51	15	7-May-16	1501	444748	1721618	444941	1721308	289	304	2.92	4.1	79.6	1	13.1	10.6
52	8	8-May-16	704	452316	1711779	452164	1711914	104	107	1.79	4.6	78	1	13.3	12.4
53	14	8-May-16	958	452096	1712774	451871	1712988	238	266	2.7	4.5	90.5	1	12.9	11.2
54	14	8-May-16	1249	451727	1713196	451466	1713394	303	309	2.95	4.5	81.3	1	12.8	10.4
55	14	8-May-16	1531	451085	1713966	450904	1714216	313	325	2.52	4.7	97.4	1	12.3	10.1
56	21	9-May-16	718	444457	1711711	444182	1711689	23	24	2.75	4.6	73.6	1	13.9	13.7
57	3	9-May-16	957	443844	1712236	443649	1712279	31	31	1.97	4.7	72.1	1	13.6	13.7
58	3	9-May-16	1148	443536	1712576	443392	1712616	38	39	1.46	4.7	73.3	1	13.6	13.7
59	3	9-May-16	1426	443483	1713488	443319	1713646	55	56	1.98	4.9	75.4	1	13	13.2
60	4	10-May-16	709	440592	1722967	440880	1722835	54	54	3.03	4.7	74.3	1	14	13.6
61	19	10-May-16	1042	435182	1723828	435339	1723484	15	16	2.93	5	70.3	1	14.2	14.5

Appendix 2 – *continued*

Station	Stratum	Date	Time	Lat/long start of tow ° ' S	Lat/long start of tow ° ' E	Lat/ long end of tow ° ' S	Lat/ long end of tow ° ' E	Gear depth (m) Min.	Gear depth (m) Max.	Dist. trawled (n. miles)	Headline height (m)	Door spread (m)	Gear perf.	Temperature (ºC) Surface	Temperature (ºC) Bottom
62	19	10-May-16	1238	435539	1723086	435712	1722745	17	21	3	5	70.1	1	13.8	14.5
63	19	10-May-16	1456	435811	1721433	440009	1721125	23	24	2.99	4.8	73.5	1	NA	NA
64	20	11-May-16	1313	442820	1711658	443053	1711528	14	15	2.5	4.7	73.8	1	13.8	14.2
65	3	11-May-16	1512	442957	1712539	442682	1712698	30	31	2.97	4.8	74	1	13.9	13.7
66	4	12-May-16	710	440795	1721299	440909	1720921	42	44	2.94	4.7	73.6	1	14.2	14
67	4	12-May-16	908	440883	1720017	441043	1715674	33	33	2.93	4.7	73.5	1	14.1	13.9
68	19	12-May-16	1229	440333	1715518	440149	1715837	12	13	2.94	4.8	73.3	1	14	13.9
69	19	13-May-16	718	440241	1720181	440038	1720437	17	18	2.74	5	72.1	1	14	13.9
70	19	13-May-16	1000	440536	1715494	440727	1715178	18	19	2.96	4.8	75.6	1	NA	NA
71	3	15-May-16	851	441905	1714323	442049	1714077	42	43	2.27	5	73	1	13.8	13
72	20	15-May-16	1157	441035	1714174	441208	1713839	17	19	2.96	5.1	72.2	1	13.9	14.1
73	20	15-May-16	1403	441251	1713422	441494	1713170	14	17	3.02	4.8	73.5	1	13.9	13.8
74	2	17-May-16	1130	445366	1713187	445068	1713259	60	65	3.02	NA	75.3	1	13.1	13.1
75	2	17-May-16	1332	445461	1713660	445752	1713580	91	96	2.96	4.9	71	1	13.1	12.9
76	8	17-May-16	1545	450296	1713246	450551	1713129	100	105	2.68	4.9	76.2	1	13.2	12.5
77	21	18-May-16	731	444569	1711589	444869	1711536	15	19	3.02	NA	73	1	13.3	13.2
78	2	18-May-16	1025	450162	1711964	450371	1711685	42	46	2.87	4.9	72.7	1	12.4	13
79	1	18-May-16	1249	451322	1711551	451571	1711284	53	56	3.12	5.2	73.9	1	12.9	12.6
80	21	18-May-16	1545	450874	1710609	450825	1710793	22	24	1.38	4.9	72	3	NA	NA
81	4	19-May-16	722	442139	1723115	442186	1723523	81	92	2.95	4.9	69.6	1	12.9	12.4
82	10	19-May-16	945	442331	1723542	442272	1723955	100	104	3	4.9	77.8	1	13.1	12.4
83	5	19-May-16	1225	441803	1724563	441750	1724972	86	89	2.97	5	75.8	1	12.9	12.2
84	11	20-May-16	724	442021	1725064	442114	1724676	100	104	2.92	4.5	78.4	1	12.7	12.3
85	4	20-May-16	1121	442033	1721995	442226	1721686	70	71	2.93	4.7	69.7	1	13	13
86	3	20-May-16	1335	442823	1720923	442976	1720572	80	82	2.93	4.7	67.6	1	14.1	12.7
87	10	20-May-16	1533	443396	1721062	443595	1720732	100	101	3.07	4.6	72.2	1	12.8	12.1
88	1	24-May-16	734	453333	1710353	453063	1710501	63	70	2.89	4.7	69.4	1	12.7	12.6
89	1	24-May-16	1000	452764	1710635	452507	1710822	56	56	2.88	4.7	74.3	1	12.9	12.7
90	1	24-May-16	1205	452665	1711312	452918	1711094	94	96	2.95	4.8	71.2	1	12.5	12.1
91	21	24-May-16	1605	450827	1710896	450620	1711058	26	27	2.36	4.7	76.3	1	12.3	12.4

Appendix 2 – *continued*

Station	Stratum	Date	Time	Lat/long start of tow ° ' S	° ' E	Lat/ long end of tow ° ' S	° ' E	Gear depth (m) Min.	Max.	Dist. trawled (n. miles)	Headline height (m)	Doors pread (m)	Gear perf.	Temperature. (ºC) Surface	Bottom
92	4	25-May-16	723	442737	1721506	442923	1721244	84	88	2.63	4.8	78.1	1	12.5	12.3
93	9	25-May-16	938	443949	1720855	444143	1720530	114	119	3.01	4.8	82.3	1	12.5	11.6
94	9	25-May-16	1136	444538	1720375	444714	1720035	125	126	2.98	4.8	87.2	1	12.3	10.9
95	9	25-May-16	1331	444420	1715768	444610	1715436	109	110	3.02	4.7	87	1	12.5	11.3
96	9	25-May-16	1537	445270	1715760	445488	1715477	126	129	2.96	4.7	83.5	1	12.3	11
97	8	26-May-16	721	450855	1713818	450652	1714124	134	137	2.96	4.6	77.1	1	12.3	10.3
98	8	26-May-16	1000	450381	1713694	450222	1713857	117	118	1.96	4.7	76.4	1	12.2	10.4
99	9	26-May-16	1228	445546	1714928	445359	1715250	121	122	2.94	4.7	78.7	1	12	10.5
100	9	26-May-16	1513	444685	1720970	444494	1721277	136	140	2.89	4.6	86.1	1	12	10.6
101	8	27-May-16	721	451439	1712460	451220	1712592	109	112	2.37	4.6	79.4	1	12.3	10.7
102	8	27-May-16	944	451618	1712889	451478	1712966	118	119	1.5	4.5	78.3	1	12.1	10.7
103	8	27-May-16	1338	451242	1712783	450952	1712680	115	117	2.98	4.6	78.8	1	12.4	10.8
104	8	27-May-16	1602	450837	1713497	450560	1713633	124	127	2.93	4.7	79.5	1	12.3	11.3
105	8	1-Jun-16	743	450563	1714116	450376	1714203	126	131	1.96	4.9	79.6	1	10.9	10.6
106	8	1-Jun-16	1327	452015	1712032	451750	1712208	104	106	2.92	5	80.5	1	11.8	11.3
107	8	1-Jun-16	1524	452034	1712356	451833	1712663	116	120	2.94	5	82.3	1	11.5	10.5
108	1	2-Jun-16	729	451762	1710108	451752	1710118	31	31	0.12	NA	73.8	3	NA	NA
109	1	2-Jun-16	943	451606	1710998	451337	1711184	47	49	2.99	5.1	75.7	1	11.8	11.9
110	1	2-Jun-16	1129	451522	1711586	451779	1711423	61	62	2.81	4.9	71	1	11.9	11.9
111	1	3-Jun-16	736	451795	1711926	451597	1712056	91	94	2.18	4.8	74.4	1	11.6	10.3
112	1	3-Jun-16	952	452064	1710889	451809	1711105	50	51	2.96	5	72.6	1	11.9	11.7
113	3	3-Jun-16	1508	444182	1713951	444004	1714062	72	73	1.94	4.9	69.6	1	11.8	11.8
114	3	4-Jun-16	737	444203	1714954	444058	1715082	91	92	1.71	4.7	85.8	2	11.7	11.5
115	3	4-Jun-16	958	442925	1720327	442682	1720090	70	75	2.96	5	74.1	1	11.8	11.7
116	3	4-Jun-16	1241	441708	1714739	441807	1714337	41	43	3.04	5	72.7	1	11.6	11.8

Appendix 3: Gear parameters for stations with satisfactory gear performance by depth range. N, number of stations; s.d., standard deviation.

		N	Mean	s.d.	Range
Core plus shallow strata					
10–400 m	Headline height (m)	113	4.8	0.17	4.1–5.2
10–400 m	Doorspread (m)	113	76.8	6.18	67.6–99.6
10–400 m	Distance (n. miles)	113	2.8	0.39	1.5–3.2
10–400 m	Warp:depth ratio	113	4.4	3.11	2.4–15.4
Core strata					
30–400 m	Headline height (m)	95	4.8	0.17	4.1–5.2
30–400 m	Doorspread (m)	95	77.5	6.47	67.6–99.6
30–400 m	Distance (n. miles)	95	2.8	0.41	1.5–3.2
30–400 m	Warp:depth ratio	95	3.2	0.9	2.4–6.7
30–100 m					
30–100 m	Headline height (m)	50	4.8	0.13	4.6–5.2
30–100 m	Doorspread (m)	50	73.6	3.2	67.6–85.8
30–100 m	Distance (n. miles)	50	2.8	0.39	1.5–3.2
30–100 m	Warp:depth ratio	50	3.6	1.05	2.4–6.7
100–200 m					
100–200 m	Headline height (m)	33	4.7	0.15	4.4–5
100–200 m	Doorspread (m)	33	80.3	4.23	72.2-90.8
100–200 m	Distance (n. miles)	33	2.7	0.47	1.5-3.2
100–200 m	Warp:depth ratio	33	2.8	0.07	2.6-2.9
200–400 m					
200–400 m	Headline height (m)	12	4.6	0.22	4.1–4.9
200–400 m	Doorspread (m)	12	86.5	8.87	69.8–99.6
200–400 m	Distance (n. miles)	12	2.8	0.26	2.2–3.1
200–400 m	Warp:depth ratio	12	2.5	0.07	2.4–2.6
Shallow strata					
10–30 m	Headline height (m)	18	4.8	0.14	4.6–5.1
10–30 m	Doorspread (m)	18	73.2	1.6	70.1–76.3
10–30 m	Distance (n. miles)	18	2.8	0.3	1.8–3
10–30 m	Warp:depth ratio	18	10.9	2.45	7.4–15.4

Appendix 4: Species codes, common names, scientific names, total catch, percent of total catch, percent occurrence, depth range and number stations caught for core strata (30–400 m) (A) and shallow strata (10–30 m) (B) in 2016. In order of catch weight. Values of zero for % catch and % occ are less than 0.1.

(A) 30–400 m

Species_code	Common name	Scientific name	Catch (kg)	% catch	% occ.	Depth Min.	Depth Max.	Stations
GSH	Ghost shark	*Hydrolagus novaezealandiae*	32 291.1	21.8	40.2	70	385	37
SPD	Spiny dogfish	*Squalus acanthias*	32 273.5	19.9	97.9	30	385	92
BAR	Barracouta	*Thyrsites atun*	25 682.4	17.3	91.3	30	325	84
SPD	Spiny dogfish	*Squalus acanthias*	32 273.5	19.9	97.9	30	385	92
ELE	Elephantfish	*Callorhinchus milii*	17 901.7	12.1	31.5	31	139	29
SPE	Sea perch	*Helicolenus spp.*	7 508.0	5.1	66.3	31	385	61
NOS	NZ southern arrow squid	*Nototodarus sloanii*	5 491.2	3.7	92.4	42	385	85
CBI	Two saddle rattail	*Coelorinchus biclinozonalis*	5 403.2	3.6	13	70	365	12
CBE	Crested bellowsfish	*Notopogon lilliei*	5 089.3	3.4	44.6	50	150	41
RCO	Red cod	*Pseudophycis bachus*	3 996.7	2.7	66.3	31	365	61
NMP	Tarakihi	*Nemadactylus macropterus*	3 229.9	2.2	69.6	31	347	64
WIT	Witch	*Arnoglossus scapha*	3 229.0	2.2	91.3	30	385	84
CAR	Carpet shark	*Cephaloscyllium isabellum*	1 927.4	1.3	84.8	30	347	78
RSK	Rough skate	*Zearaja nasuta*	1 663.9	1.1	55.4	30	347	51
SCG	Scaly gurnard	*Lepidotrigla brachyoptera*	1 405.7	0.9	72.8	42	139	67
LIN	Ling	*Genypterus blacodes*	1 326.0	0.9	46.7	43	385	43
SSK	Smooth skate	*Dipturus innominatus*	1 264.1	0.9	53.3	30	385	49
GUR	Red gurnard	*Chelidonichthys kumu*	1 252.7	0.8	60.9	30	139	56
CRM	Airy finger sponge	*Callyspongia cf ramosa*	1 196.7	0.8	8.7	47	116	8
GIZ	Giant stargazer	*Kathetostoma giganteum*	977.9	0.7	78.3	42	385	72
SWA	Silver warehou	*Seriolella punctata*	840.8	0.6	60.9	43	335	56
PYR	*Pyrosoma atlanticum*	*Pyrosoma atlanticum*	666.2	0.4	69.6	43	385	64

CAS	Oblique banded rattail	*Coelorinchus aspercephalus*	578.2	0.4	13	114	385	12
SCH	School shark	*Galeorhinus galeus*	497.0	0.3	46.7	31	139	43
SDO	Silver dory	*Cyttus novaezealandiae*	495.8	0.3	31.5	46	325	29
HAP	Hapuku	*Polyprion oxygeneios*	492.2	0.3	35.9	42	290	33
PHA	Brown seaweed	*Phaeophyta*	480.5	0.3	10.9	45	347	10
HOK	Hoki	*Macruronus novaezelandiae*	370.7	0.3	9.8	45	385	9
JAV	Javelin fish	*Lepidorhynchus denticulatus*	318.5	0.2	4.3	330	385	4
PIG	Pigfish	*Congiopodus leucopaecilus*	309.0	0.2	48.9	31	150	45
FHD	Deepsea flathead	*Hoplichthys haswelli*	298.8	0.2	8.7	172	385	8
BCO	Blue cod	*Parapercis colias*	275.2	0.2	31.5	31	150	29
RSO	Gemfish	*Rexea solandri*	253.1	0.2	27.2	107	385	25
OCT	Octopus	*Pinnoctopus cordiformis*	251.1	0.2	32.6	30	150	30
SPO	Rig	*Mustelus lenticulatus*	215.8	0.1	20.7	31	139	19
LEA	Leatherjacket	*Meuschenia scaber*	209.9	0.1	6.5	30	46	6
LSO	Lemon sole	*Pelotretis flavilatus*	204.4	0.1	56.5	30	330	52
CBO	Bollons rattail	*Coelorinchus bollonsi*	173.8	0.1	3.3	330	385	3
ANT	Anemones	Anthozoa	159.8	0.1	28.3	45	385	26
SSI	Silverside	*Argentina elongata*	131.0	0.1	47.8	54	385	44
HMT	Deepsea anemone	Hormathiidae	127.4	0.1	25	56	136	23
CON	Conger eel	Conger spp.	126.4	0.1	1.1	45	45	1
JMD	Greenback jack mackerel	*Trachurus declivis*	118.1	0.1	23.9	44	139	22
WAR	Common warehou	*Seriolella brama*	114.5	0.1	9.8	43	365	9
LDO	Lookdown dory	*Cyttus traversi*	111.0	0.1	7.6	312	385	7
KIN	Kingfish	*Seriola lalandi*	88.3	0.1	13	31	76	12
KBB	Bladder kelp	*Macrocystis pyrifera*	55.2	0	4.3	46	70	4
ONG	Sponges	Porifera	53.6	0	12	60	385	11
ERA	Electric ray	*Torpedo fairchildi*	48.2	0	4.3	30	110	4
SCC	Sea cucumber	*Stichopus mollis*	41.6	0	41.3	45	335	38
ROK	Rocks stones	Geological specimens	41.0	0	3.3	45	312	3
PDG	Prickly dogfish	*Oxynotus bruniensis*	40.4	0	4.3	139	365	4
THR	Thresher shark	*Alopias vulpinus*	40.0	0	1.1	45	45	1

MOK	Moki	*Latridopsis ciliaris*	39.7	0	7.6	45	100	7
JFI	Jellyfish		31.6	0	10.9	80	347	10
SBW	Southern blue whiting	*Micromesistius australis*	28.6	0	1.1	385	385	1
BRA	Short-tailed black ray	*Dasyatis brevicaudata*	26.3	0	2.2	31	45	2
LLC	Long-legged masking crab	*Leptomithrax longipes*	26.1	0	19.6	54	145	18
PEP	*Pentagonaster pulchellus*	*Pentagonaster pulchellus*	25.9	0	7.6	70	115	7
CIC	Orange frond sponge	*Crella incrustans*	25.0	0	1.1	70	70	1
JMM	Slender jack mackerel	*Trachurus murphyi*	24.4	0	5.4	114	139	5
BTA	Smooth deepsea skate	*Brochiraja asperula*	20.1	0	3.3	312	385	3
TOD	Dark toadfish	*Neophrynichthys latus*	14.3	0	29.3	43	385	27
BRI	Brill	*Colistium guntheri*	13.6	0	2.2	30	45	2
MDO	Mirror dory	*Zenopsis nebulosa*	13.2	0	1.1	312	312	1
ASH	Circular saw shell	*Astraea heliotropium*	12.7	0	7.6	55	115	7
WWA	White warehou	*Seriolella caerulea*	12.0	0	4.3	312	385	4
WOD	Wood	Wood	11.4	0	8.7	30	73	8
GON	*Gonorynchus forsteri* & *G. Greyi*	*Gonorynchus forsteri* & *G. greyi*	10.2	0	4.3	312	347	4
FMA	*Fusitriton magellanicus*	*Fusitriton magellanicus*	10.2	0	21.7	42	385	20
JDO	John dory	*Zeus faber*	8.9	0	3.3	63	325	3
YCO	Yellow cod	*Parapercis gilliesi*	7.2	0	3.3	110	127	3
SMO	Cross-fish	*Sclerasterias mollis*	7.0	0	26.1	45	145	24
HAK	Hake	*Merluccius australis*	6.6	0	1.1	115	115	1
SDR	Spiny seadragon	*Solegnathus spinosissimus*	6.2	0	5.4	56	94	5
SPF	Scarlet wrasse	*Pseudolabrus miles*	5.6	0	4.3	91	347	4
FRO	Frostfish	*Lepidopus caudatus*	4.6	0	1.1	347	347	1
GFL	Greenback flounder	*Rhombosolea tapirina*	4.4	0	1.1	94	94	1
ESO	N.Z. sole	*Peltorhamphus novaezeelandiae*	4.2	0	3.3	30	45	3
TRU	Trumpeter	*Latris lineata*	2.9	0	1.1	81	81	1
ZFO	Rubbish fishing other		2.9	0	4.3	63	125	4
PSI	Geometric star	*Psilaster acuminatus*	2.9	0	9.8	80	347	9
PIL	Pilchard	*Sardinops sagax*	2.7	0	2.2	45	72	2
CDO	Capro dory	*Capromimus abbreviatus*	2.7	0	16.3	46	385	15

SFL	Sand flounder	*Rhombosolea plebeia*	2.5	0	3.3	30	43	3
PAG	Pagurid	*Paguroidea*	2.3	0	17.4	30	335	16
ACS	Smooth deepsea anemones	*Actinostolidae*	2.2	0	1.1	312	312	1
SCO	Swollenhead conger	*Bassanago bulbiceps*	2.1	0	1.1	385	385	1
MUN	*Munida gregaria*	*Munida gregaria*	2.0	0	1.1	290	290	1
ATA	*Alcithoe arabica*	*Alcithoe arabica*	2.0	0	5.4	30	145	5
ASC	Sea squirt	Ascidiacea	2.0	0	5.4	45	114	5
MSL	Starfish	*Mediaster sladeni*	1.9	0	3.3	114	136	3
COF	Flabellum coral	Flabellum *spp.*	1.8	0	2.2	330	385	2
HDR	Hydroid	Hydrozoa	1.7	0	1.1	45	45	1
ALL	*Alcithoe larochei*	*Alcithoe larochei*	1.6	0	5.4	42	110	5
DIR	Pagurid	*Diacanthurus rubricatus*	1.4	0	8.7	65	116	8
JMN	Yellowtail jack mackerel	*Trachurus novaezelandiae*	1.3	0	1.1	42	42	1
NUD	Nudibranchs	Nudibranchia	1.3	0	4.3	107	312	4
NCA	Hairy red swimming crab	*Nectocarcinus antarcticus*	1.3	0	12	46	109	11
SSC	Giant masking crab	*Leptomithrax australis*	1.2	0	1.1	84	84	1
OMA	Red snakestar	*Ophiopsammus maculata*	1.1	0	2.2	55	56	2
OPA	Opalfish	*Hemerocoetes spp.*	1.1	0	10.9	49	234	10
HCO	Hairy conger	*Bassanago hirsutus*	1.0	0	1.1	385	385	1
SPM	Sprat	*Sprattus muelleri*	1.0	0	1.1	43	43	1
SPA	Slender sprat	*Sprattus antipodum*	1.0	0	1.1	43	43	1
PCO	Ahuru	*Auchenoceros punctatus*	1.0	0	1.1	43	43	1
SCI	Scampi	*Metanephrops challengeri*	1.0	0	1.1	330	330	1
HOR	Horse mussel	*Atrina zelandica*	1.0	0	1.1	33	33	1
STY	Spotty	*Notolabrus celidotus*	0.9	0	1.1	31	31	1
GPA	Sea urchin	*Goniocidaris parasol*	0.9	0	3.3	127	385	3
CPG	*Callispongia* sp	*Callispongia sp.*	0.8	0	1.1	45	45	1
DAP	Antlered crab	*Dagnaudus petterdi*	0.8	0	1.1	312	312	1
BAM	*Bathyplotes* spp.	*Bathyplotes spp.*	0.8	0	1.1	312	312	1
POP	Porcupine fish	*Allomycterus jaculiferus*	0.7	0	1.1	45	45	1
TOP	Pale toadfish	*Ambophthalmos angustus*	0.7	0	1.1	312	312	1

DMG	*Dipsacaster magnificus*	*Dipsacaster magnificus*	0.7	0	2.2	330	385	2
GAS	Gastropods	Gastropoda	0.6	0	5.4	45	172	5
OPE	Orange perch	*Lepidoperca aurantia*	0.5	0	1.1	150	150	1
BRN	Barnacle	Cirripedia	0.5	0	2.2	33	42	2
BYS	Alfonsino	*Beryx splendens*	0.5	0	2.2	31	312	2
SSQ	Bobtail squid	*Sepioloidea spp.*	0.4	0	4.3	145	347	4
ODT	Pentagonal tooth-star	*Odontaster spp.*	0.4	0	3.3	47	91	3
LCO	Dwarf swimming crab	*Liocarcinus corrugatus*	0.3	0	2.2	45	100	2
DGT	Dragonets	Callionymidae	0.3	0	3.3	100	127	3
SAL	Salps		0.3	0	2.2	91	290	2
CSS	Maurea	*Calliostoma selectum*	0.3	0	3.3	60	127	3
ASR	Asteroid (starfish)		0.3	0	2.2	107	312	2
PCH	*Penion chathamensis*	*Penion chathamensis*	0.3	0	1.1	125	125	1
CJA	Sun star	*Crossaster multispinus*	0.3	0	1.1	325	325	1
POL	Polychaete	Polychaeta	0.3	0	1.1	54	54	1
PNE	*Proserpinaster neozelanicus*	*Proserpinaster neozelanicus*	0.2	0	1.1	110	110	1
HTU	Quill worm	*Hyalinoecia tubicola*	0.2	0	2.2	330	385	2
LAN	Lantern fish	Myctophidae	0.2	0	2.2	150	347	2
LHC	Long-handed masking crab	*Leptomithrax longimanus*	0.2	0	2.2	110	114	2
GMC	Garricks masking crab	*Leptomithrax garricki*	0.2	0	1.1	100	100	1
KWH	Knobbed whelk	*Austrofucus glans*	0.2	0	2.2	73	91	2
QSC	Queen scallop	*Zygochlamys delicatula*	0.2	0	2.2	91	312	2
BPD	Lamp shells	*Brachiopoda*	0.2	0	2.2	290	325	2
COZ	Bryozoan	Bryozoa	0.2	0	1.1	54	54	1
MUS	Mussels		0.1	0	1.1	64	64	1
SEE	Silver conger	*Gnathophis habenatus*	0.1	0	1.1	63	63	1
EGC	Egg case		0.1	0	1.1	61	61	1
NHU	Policeman crab	*Neommatocarcinus huttoni*	0.1	0	1.1	31	31	1
OYS	Oysters dredge	*Ostrea chilensis*	0.1	0	1.1	106	106	1
SUA	Fleshy club sponge	*Suberites affinis*	0.1	0	1.1	330	330	1
LMI	Masking crabs	Leptomithrax spp.	0.1	0	1.1	116	116	1

PRE	Cushion starfish	*Patiriella regularis*	0.1	0	1.1	33	33	1
CIM	Fire worm, polychaete	*Chloeia inermis*	0.1	0	1.1	54	54	1
SUM	Pelagic butterfish	*Schedophilus maculatus*	0.1	0	1.1	290	290	1
OUN	Pacific & rock oyster (unidentified)		0.1	0	1.1	66	66	1
PHU	Sea urchin	*Pseudechinus huttoni*	0.1	0	1.1	312	312	1
EGG	Fish eggs		0.1	0	1.1	54	54	1
BBE	Banded bellowsfish	*Centriscops humerosus*	0.1	0	1.1	54	54	1

(B) 10–30 m

Species_code	Common name	Scientific name	Catch (kg)	% catch	% occ.	Depth (m) Min.	Depth (m) Max.	Stations
BAR	Barracouta	*Thyrsites atun*	6 880.4	37.5	88.9	13	27	16
LEA	Leatherjacket	*Meuschenia scaber*	3 250.3	17.7	55.6	13	27	10
GUR	Red gurnard	*Chelidonichthys kumu*	2 695.0	14.7	100	13	27	18
SPD	Spiny dogfish	*Squalus acanthias*	2 308.8	12.6	100	13	27	18
ELE	Elephantfish	*Callorhinchus milii*	959.5	5.2	83.3	14	27	15
RSK	Rough skate	*Zearaja nasuta*	822.5	4.5	100	13	27	18
CAR	Carpet shark	*Cephaloscyllium isabellum*	176.0	1	88.9	14	27	16
RCO	Red cod	*Pseudophycis bachus*	139.9	0.8	50	14	27	9
SPO	Rig	*Mustelus lenticulatus*	137.5	0.7	88.9	13	25	16
OCT	Octopus	*Pinnoctopus cordiformis*	135.5	0.7	38.9	13	27	7
NMP	Tarakihi	*Nemadactylus macropterus*	125.7	0.7	33.3	13	27	6
ROK	Rocks stones	Geological specimens	113.9	0.6	33.3	13	19	6
SFL	Sand flounder	*Rhombosolea plebeia*	73.9	0.4	83.3	13	25	15
WAR	Common warehou	*Seriolella brama*	64.6	0.4	38.9	15	25	7
NOS	NZ southern arrow squid	*Nototodarus sloanii*	48.6	0.3	61.1	15	27	11
CON	Conger eel	Conger spp.	48.4	0.3	33.3	15	25	6
SSK	Smooth skate	*Dipturus innominatus*	48.2	0.3	5.6	19	19	1
KIN	Kingfish	*Seriola lalandi*	40.5	0.2	11.1	18	22	2
HAP	Hapuku	*Polyprion oxygeneios*	39.6	0.2	16.7	17	23	3
TUL	Sea tulip	*Pyura pachydermatina*	37.1	0.2	22.2	13	18	4
ESO	N.Z. sole	*Peltorhamphus novaezeelandiae*	37.1	0.2	72.2	14	25	13
KAH	Kahawai	*Arripis trutta, A. xylabion*	36.6	0.2	22.2	14	25	4
ERA	Electric ray	*Torpedo fairchildi*	33.5	0.2	16.7	15	22	3
SCH	School shark	*Galeorhinus galeus*	21.4	0.1	44.4	13	27	8
GFL	Greenback flounder	*Rhombosolea tapirina*	18.0	0.1	16.7	14	27	3
JFI	Jellyfish		14.4	0.1	27.8	18	25	5
WIT	Witch	*Arnoglossus scapha*	10.5	0.1	38.9	17	27	7
YBF	Yellowbelly flounder	*Rhombosolea leporina*	7.7	0	16.7	14	17	3
LSO	Lemon sole	*Pelotretis flavilatus*	6.8	0	38.9	18	27	7

SPR	Sprats	*Sprattus antipodum, S. muelleri*	5.3	0	16.7	15	25	3
WOD	Wood	Wood	4.4	0	11.1	18	23	2
STY	Spotty	*Notolabrus celidotus*	4.3	0	16.7	13	23	3
PIL	Pilchard	*Sardinops sagax*	4.0	0	11.1	15	18	2
TUR	Turbot	*Colistium nudipinnis*	3.6	0	11.1	15	18	2
BRI	Brill	*Colistium guntheri*	2.9	0	16.7	14	15	3
SPZ	Spotted stargazer	*Genyagnus monopterygius*	1.9	0	16.7	13	25	3
JMD	Greenback jack mackerel	*Trachurus declivis*	1.7	0	5.6	18	18	1
POP	Porcupine fish	*Allomycterus jaculiferus*	1.5	0	5.6	27	27	1
SPF	Scarlet wrasse	*Pseudolabrus miles*	1.3	0	5.6	19	19	1
GLB	Globefish	*Contusus richei*	0.9	0	11.1	14	25	2
SUR	Kina	*Evechinus chloroticus*	0.9	0	5.6	19	19	1
LIN	Ling	*Genypterus blacodes*	0.7	0	11.1	14	19	2
BRN	Barnacle	Cirripedia	0.7	0	5.6	18	18	1
ATA	*Alcithoe arabica*	*Alcithoe arabica*	0.6	0	11.1	25	25	2
FZE	Sand dollar	*Fellaster zelandiae*	0.4	0	5.6	14	14	1
BCO	Blue cod	*Parapercis colias*	0.4	0	5.6	19	19	1
ONG	Sponges	Porifera	0.3	0	5.6	18	18	1
PRE	Cushion starfish	*Patiriella regularis*	0.2	0	11.1	17	23	2
CAC	Cancer crab	*Cancer novaezelandiae*	0.2	0	11.1	15	17	2
CDY	*Cosmasterias dyscrita*	*Cosmasterias dyscrita*	0.2	0	11.1	17	19	2
TOD	Dark toadfish	*Neophrynichthys latus*	0.2	0	11.1	13	23	2
CCM	Eleven-arm seastar	*Coscinasterias muricata*	0.2	0	11.1	18	23	2
ANC	Anchovy	*Engraulis australis*	0.2	0	5.6	15	15	1
SWA	Silver warehou	*Seriolella punctata*	0.1	0	5.6	15	15	1
SAZ	Sand stargazer	*Crapatalus novaezelandiae*	0.1	0	5.6	15	15	1
GMC	Garricks masking crab	*Leptomithrax garricki*	0.1	0	5.6	25	25	1
SBO	Southern boarfish	*Pseudopentaceros richardsoni*	0.1	0	5.6	27	27	1
OPA	Opalfish	*Hemerocoetes spp.*	0.1	0	5.6	23	23	1
KBB	Bladder kelp	*Macrocystis pyrifera*	0.1	0	5.6	19	19	1

Appendix 5: Length weight coefficients used to scale length frequencies for the 2016 survey. DB, MPI *Trawl* database. W = *a*L^{b} where W is weight (g) and L is length (cm).

				Length (cm)		
Species	*a*	*b*	n	Min.	Max.	Data source
Barracouta	0.0055	2.9812	429	23.8	87.2	DB, KAH9701
Dark ghost shark	0.0012	3.4015	619	18.9	75.9	This survey
Elephantfish	0.0061	3.1203	474	22.6	92.6	This survey
Giant stargazer	0.015	3.036	664	12.1	74	This survey
Lemon sole	0.008	3.1278	524	14.6	41.2	DB, KAH9809
Ling	0.0013	3.2801	179	32.2	123.7	DB, KAH0004
Red cod	0.0099	2.9927	710	9	73.6	This survey
Red gurnard	0.0058	3.1406	796	14	52.7	This survey
Rig	0.0022	3.149	215	33.3	107	This survey
Rough skate	0.0367	2.8509	502	16.8	74.8	This survey
School shark	0.0022	3.1913	213	34.7	118.4	This survey
Sea perch	0.0106	3.158	845	9.1	43.2	This survey
Silver warehou	0.0048	3.38	262	16.6	57.8	DB, TAN9502
Smooth skate	0.0331	2.8867	175	15.1	134	This survey
Spiny dogfish	0.0034	3.0322	2020	26.9	98.8	This survey
Tarakihi	0.0104	3.1797	870	10.1	54.2	This survey