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Inshore trawl survey of Canterbury Bight and Pegasus Bay April–June 2014, (KAH1402)

New Zealand Fisheries Assessment Report 2015/14

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In April–June 2014 a bottom trawl survey of the east coast South Island (ECSI) in 30–400 m (core strata) was carried out using R.V. *Kaharoa* (KAH1402). This survey was the tenth in the winter ECSI inshore time series (1991–94, 1996, 2007–2009, 2012, 2014). Four strata in 10–30 m (shallow strata), previously surveyed in 2007 and 2012, were also surveyed in 2014 to monitor elephantfish and red gurnard over their full depth range.

The survey was a stratified random trawl survey with a two-phase design optimised for the target species 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 (core plus shallow strata). A total of 97 stations (81 phase 1 and 16 phase 2) was completed from 17 core strata, and 21 stations from the four shallow 10 to 30 m strata (all phase 1). Relative abundance estimates and coefficients of variation (CV) for the target species in the core strata were: dark ghost shark 13 137 t (26%), elephantfish 951 t (34%), giant stargazer 790 t (14%), red cod 2096 t (39%), red gurnard 2063 t (25%), sea perch 2168 t (25%), spiny dogfish 19 949 t (31%), and tarakihi 2380 t (23%). Biomass estimates and CVs for elephantfish and red gurnard in the core plus shallow strata were 1600 t (21%), and 3215 t (17%), respectively, with the shallow strata accounting for 41% of the biomass of elephantfish and 36% of the biomass of red gurnard.

Dorsal spines were collected for elephantfish (460), and otoliths for red gurnard (635), tarakihi (542), sea perch (561), giant stargazer (541) and red cod (741). Macro-invertebrates collected on the survey were identified to species level, where possible, and a complete species list is provided.

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.

1. INTRODUCTION

1.1 The 2014 ECSI survey

This report presents the findings of the 2014 east coast South Island (ECSI) bottom trawl survey in 10–400 m from late April to early June using R.V. *Kaharoa* (KAH1402). This survey was the tenth in the winter ECSI time series in 30–400 m. Previous surveys were carried out in 1991–1994, 1996, 2007, 2008, 2009 and 2012 (Beentjes & Wass 1994, Beentjes 1995a, 1995b, 1998a, 1998b, Beentjes & Stevenson 2008, 2009, Beentjes et al. 2010, Beentjes et al. 2013). In the 2012 survey, red gurnard (*Chelidonichthys kumu*) and elephantfish (*Callorhinchus milii*) were added to the 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 ECSI 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). 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 AMP 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).

An MPI 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. The time series up to 2006 was reviewed by Beentjes & Stevenson (2000). 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.

Following reinstatement of the surveys in 2007, the intention was to carry out three consecutive winter 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.

1.3 Objectives

This report fulfils the final reporting requirement for Objectives 1–6 of MPI Research Project INT2013/01.

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 red cod, stargazer, sea perch, tarakihi, elephant fish, red gurnard, dark ghost shark, and spiny dogfish 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%) elephant fish (20–30%), red gurnard (20%) and dark ghost shark (20–30%).

2. To collect the data and determine the length frequency, length-weight relationship and reproductive condition of red cod, giant stargazer, sea perch, tarakihi, spiny dogfish, elephant fish, red gurnard and dark ghost shark.

3. To collect otoliths from giant stargazer, sea perch, red gurnard and tarakihi; and spines from spiny dogfish and elephant fish.

4. To collect the data to determine the length frequencies and catch weight of all other Quota Management System (QMS) species.

5. To tag and release live smooth and rough skate, rig, and school shark.

6. To identify benthic macro-invertebrates collected during the trawl survey.

At the MPI Southern Inshore Working Group on 26 March 2014, Objective 5 (tagging elasmobranchs) was withdrawn, and objective 3 was revised to include collection of red cod otoliths and remove collection of spiny dogfish spines.

2. METHODS

2.1 Survey area

Core strata (30–400 m)

The 2014 survey (KAH1402) 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 km2, including untrawlable foul ground (2018 km2), 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). Biomass estimates for core strata were made for all eight target species as well as selected non-target species.

Shallow strata (10–30 m)

The 2014 survey in the 10–30 m depth range covered the same area as 2012 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 26 918 km^2, including untrawlable foul ground (2244 km^2). Biomass estimates for these strata were made only for target species elephantfish, red gurnard, red cod, and spiny dogfish, as well as selected non-target species.

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 four winter surveys (2007, 2008, 2009, and 2012). 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 and 2012. The sum of the stratum maximum for each target species indicated that 132 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 102 stations, leaving 23 stations for phase 2 (i.e., an allocation of about 80% phase 1). To achieve this number, the maximum across each stratum (excluding red cod where CVs are usually very high), was prorated down to 102 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* v2.1), with the constraint that stations were at least 3 n. miles apart. Phase 2 stations were allocated using the NIWA program *SurvCalc*. The program calculates the phase 1 station catch rate variance for each species in each stratum and outputs a table of 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 2014 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 23 April 2014 and steamed to Lyttelton to pick up fish boxes and ice. Trawling began on 24 April, north east of Banks Peninsula and 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 Lyttelton, the vessel steamed to Wellington, arriving on 6 June for demobilisation. Seven days fishing were lost to unloading fish, bad weather, and gear damage during the survey.

2.5 Trawling procedure

Trawling procedures adhered strictly to those documented by Stevenson & Hanchet (1999) and to 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* program 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. Gonad stages were also recorded for all target species (Appendix 1).

Otoliths were stored clean and dry in small paper envelopes whereas 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 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 this procedure was modified as follows: From each tow (if sufficient numbers 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 sample. This new 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 laboratories to the lowest possible taxonomic level.

For some non-target QMS species, individual weights were recorded to provide current length-weight relationships.

2.7 Data storage

All catch, biological, and length frequency data were entered into the *Trawl* research database at NIWA Greta Point 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 *Age* research database, and the otoliths and spines were stored at NIWA, Greta Point. After identification of invertebrates, data were entered into the *Trawl* database. The parameters used in *SurvCalc* for estimating biomass and length frequency from the 2014 and earlier surveys, were archived under the project INT2013-01.

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).

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. 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; STA, 45 cm; TAR, 31 cm; GSH males 52 cm, females 62 cm; SPD males 58 cm, females 72 cm; ELE males 51, females 70 cm. For sea perch, length-at-50% maturity was estimated from the cumulative length frequencies of all the mature stages from the 2008 survey. Size corresponding to 50% in the cumulative distribution was taken as the 50% maturity value. The values were 25.5 cm for males and 26 cm for females, and therefore 26 cm was used for both sexes combined.

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 or 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 2014 were determined for all eight target species and also 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 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 four surveys from 2007 to 2012 (Beentjes et al. 2013). 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, witch flounder). This analysis was updated by including the 2014 survey results and in addition the analysis was run with the target species only.

3. RESULTS

3.1 Trawling details

In the winter survey core strata (30–400 m), 98 tows were carried out, of which all but one (station 102) had gear performance of 1 or 2 and these were used in length frequency and biomass estimation (Table 1, Appendix 2). All planned phase-one tows in core strata were completed (N = 81). 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 61 km^2 in stratum 8 to one station per 722 km^2 in stratum 6, with an overall average density of one station per 220 km^2 (Table 1). Trawlable ground represented 91% of the total survey area. 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), 21 tows with gear performance of 1 or 2 were carried out, and these were used in length frequency and biomass estimation (Table 1, Appendix 2). All planned phase 1 tows in core strata were completed (N = 21). Trawlable ground represented 94% of the total survey area of the four strata. Station positions and tow numbers are shown in Figure 2 and individual station data in Appendix 2.

Sixteen of the planned 23 phase 2 tows were achieved, the shortfall due to lost time caused by vessel gear problems, trawl net and rigging damage, and unsuitable weather and sea conditions. All phase 2 tows were allocated to six 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 77.1 m, 4.9 m, 2.8 n. miles, and 3.4:1, respectively (Appendix 3). For the shallow strata (10–30 m), means for doorspread, headline height, distance towed, and warp to depth ratio were 72.2 m, 5.0 m, 2.9 n. miles, and 10.6:1, respectively (Appendix 3). Net-A was used on all tows before station 103, and Net-B in subsequent tows after damage was sustained to Net-A when the gear became 'fast' on station 102.

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

3.2 Catch composition

Core strata (30–400 m)

The total catch from the core strata (30–400 m) was 175 t from the 97 biomass tows. Catches were highly variable, ranging from 124 to 10 404 kg per tow, with an average of 1800 kg. Vertebrate fish species caught included 13 chondrichthyans, and 73 teleosts (Appendix 4). There were also many invertebrate species caught including octopus and four squid species. 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 barracouta, spiny dogfish, dark ghost shark and sea perch with totals of 64 t, 32 t, 30 t and 7 t representing 37%, 18%, 17%, and 4% respectively, of the total catch. These four species, and the next six most abundant species (two saddle rattail, tarakihi, red cod, witch, red gurnard, and carpet shark) made up 89% of the total catch (Appendix 4). The percentage of the catch represented by the eight winter survey target species was as follows: dark ghost shark 17%; elephantfish 1%, giant stargazer 1%; red cod 2%; red gurnard 2%, sea perch 4%; spiny dogfish 18%; tarakihi 3%, making a combined total of 48%. Spiny dogfish was caught in 99% and barracouta in 94% of tows. Other non-target species commonly caught included arrow squid (90% of tows), witch (93% of tows), and carpet shark (86% of tows) (Appendix 4).

Shallow strata (10–30 m)

The total catch in 10–30 m depth range was 17.4 t from the 21 biomass tows. Catches were highly variable, ranging from 242 to 3070 kg per tow, with an average of 829 kg. Vertebrate fish species caught included 9 chondrichthyans and 35 teleosts (Appendix 4). There were also many invertebrate species caught including arrow squid. 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 spiny dogfish, red cod, red gurnard, leatherjacket, and elephantfish with totals of 4.7 t, 2.8 t, 2.6 t, 2.5 t, and 1.6 t, representing 27%, 16%, 15%, 14% and 9%, respectively, of the total catch. These five species, and the next five most abundant species (rough skate, barracouta, rig, carpet shark and sand flounder) made up 96% of the total catch (Appendix 4). The percent of the catch represented by the eight winter survey target species was as follows: dark ghost shark 0%; elephantfish 9.3%, giant stargazer 0%; red cod 16.5%; red gurnard 15.1%, sea perch 0%; spiny dogfish 27.1%; tarakihi 0.1%, making a combined total of 68.1% (Appendix 4).

Invertebrate species from the catch identified after the survey are given in Appendix 5.

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 19 949 t, followed by dark ghost shark (13 137 t), tarakihi (2380), sea perch (2168 t), red cod (2096), red gurnard (2063 t), elephantfish (951 t), and giant stargazer (790 t). Coefficients of variation for the target species in the core strata were spiny dogfish 31%, dark ghost shark 26%, tarakihi 23%, sea perch 25%, red cod 39%, red gurnard 25%, elephantfish 34%, and giant stargazer 14% (Table 3, panel A). These CVs were within the range specified in the project objectives for dark ghost shark, tarakihi, giant stargazer, and sea perch (see Section 1.5 Objectives). The CV for spiny dogfish was 11% higher than the target of 20%, and for red cod the CV was 39%, 14% higher than the objective upper target limit of 25%. 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 a few unbalanced sex ratios: spiny dogfish total biomass was 67% male, elephantfish 28% male, and giant stargazer 37% male. For the other target species biomass by sex was more balanced (Table 3, panel A).

Of the eight key QMS species, barracouta had the largest biomass of all species, including the target species, at 46 563 t and a CV of 19% (Table 3, panel A). Other species with substantial biomass included rough skate (1153 t, CV = 38%), smooth skate (637 t, CV = 20%), and silver warehou (629 t, CV = 83%).

Recruited biomass estimates and CVs for the target species and the eight key QMS species are shown in Table 3. For the target species the percentage of total biomass that was recruited fish was spiny dogfish 71%, dark ghost shark 47%, tarakihi 66%, sea perch 92%, red cod 50%, and giant stargazer 95%.

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 32 188 t, followed by red cod (3714 t), red gurnard (3215 t), and elephantfish (1600 t). Coefficients of variation for the target species were spiny dogfish 28%, red cod 41%, red gurnard 17%, and elephantfish 21% (Table 3, panel B). For both red gurnard and elephantfish the CVs were less than the target upper ranges of 20 and 30%, respectively. 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 elephantfish male biomass comprised only 24% of the total biomass, similar to that 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 50%. Red cod biomass was 33% male compared with 43% in the core strata, and spiny dogfish sex ratio was 69% male, 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 46 903 t and a CV of 19% (Table 3, panel B). The only other species with substantial biomass was rough skate (1597 t, CV = 28%).

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 73% compared to 82% for the core strata. Similarly, for red gurnard it was 82% compared with 80% for the core strata. For spiny dogfish the recruited biomass proportions were almost the same as in the core strata, and for red cod it was 72% compared to 50%.

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. The shallowest tow in the core strata (30–400 m) was 25 m and the deepest 389 m. Strata boundaries were drawn in 1990 from depth contours available at that time and were not always accurate, hence the minimum tow depth (25 m) is 5 m less the lower range depth for the core strata on this survey. The shallowest tow in the shallow strata (10–30 m) was 14 m and the deepest 27 m.

Dark ghost shark was predominantly caught in waters deeper than 100 m throughout the survey core strata (30–400 m) in 48% of tows, with the shallowest catch in 66 m and the deepest in 389 m (Appendix 5). Highest catch rates were in 100 to 400 m, strata 9 and 14, and highest biomass estimates were in 100–200 m, strata 9 and 10 (Figure 3, Tables 4 and 5).

Elephantfish was caught in the survey core strata (30–400 m) between 25 and 122 m, in 42% of tows. Core strata highest catch rates and biomass estimates were in 30 to 100 m, strata 1 and 7 (Appendix 5, Figure 3, Tables 4 and 5). In the shallow 10 to 30 m strata, elephantfish was caught from 14 to 27 m and in 90% of tows. The highest elephantfish catch rates and biomass estimates within the core plus shallow strata (10 to 400 m) were in the shallow 10 to 30 m, stratum 19.

Giant stargazer was predominantly caught in waters deeper than about 50 m throughout the survey core strata (30–400 m) in 78% of tows, with the shallowest catch in 30 m and the deepest in 389 m (Appendix 5). Highest catch rates were in 30 to 100 m, stratum 2, and 100 to 200 m, stratum 9. The highest biomass estimates were in 30 to 100 m, stratum 5, and 100 to 200 m, stratum 9 (Figure 3, Tables 4 and 5).

Red cod was caught in all depth ranges throughout the survey core strata (30–400 m) in 78% of tows, with the shallowest catch in 25 m and the deepest in 389 m (Appendix 5). The highest catch rates and biomass estimates were in 100 to 200 m, strata 9 and 10 (Figure 3, Tables 4 and 5). Red cod was also caught in the 10–30 m depth range from 14 to 27 m in 95% of tows, with the highest core plus shallow strata catch rate in 10–30 m, stratum 19.

Red gurnard was caught in the survey core strata (30–400 m) between 25 and 141 m, in 61% of tows. Highest catch rates and biomass estimates were in 30 to 100 m, strata 2, 3 and 7 (Appendix 5, Figure 3, Tables 4 and 5). In the shallow 10 to 30 m strata, red gurnard was caught from 14 to 27 m and in all tows. The highest red gurnard catch rates and biomass estimates within the core plus shallow strata (10 to 400 m) were in the shallow 10 to 30 m, stratum 19.

Sea perch was predominantly caught in waters deeper than about 50 m throughout the survey core strata (30–400 m) in 72% of tows, with the shallowest catch in 31 m and the deepest in 389 m (Appendix 5). The highest catch rates and biomass estimates were in 100 to 200 m, strata 8 and 13 (Figure 3, Tables 4 and 5).

Spiny dogfish was caught in all depth ranges throughout the survey core strata (30–400 m) from 99% of tows with the shallowest catch in 25 m and the deepest in 389 m (Appendix 5). The highest catch rates and biomass estimates were in 30 to 100 m, strata 5 and 7 (Figure 3, Tables 4 and 5). Spiny dogfish was also caught in the 10–30 m depth range from 14 to 27 m in all tows.

Tarakihi was predominantly caught in waters between about 50 and 100 m throughout the survey core strata (30–400 m) in 65% of tows, with the shallowest catch in 25 m and the deepest in 135 m (Appendix 5). The highest catch rates and biomass estimates were in 30 to 100 m, strata 1 and 4, and 100–200 m stratum 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 under 50 000 length frequency and nearly 11 000 biological records were taken from 49 species. This included otoliths from 542 giant stargazer, 741 red cod, 635 red gurnard, 561 sea perch, and 542 tarakihi. Dorsal spines were collected from 460 elephantfish.

Scaled length frequency distributions of the target species 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 the target species 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 6.

Dark ghost shark – The length frequency distribution for dark ghost shark males showed a clear mode at about 55 cm whereas for females no clear modes were present (Figure 5). The largest fish (over 60 cm) were mostly females. The male mode (47–60 cm) comprised about half pre-recruited fish (under 55 cm) and was prevalent in the 100–200 m depth range. The equivalent female fish in 100 to 200 m (about 42–63 cm) were also about half pre-recruits. The 200 to 400 m depth range had a wide size distribution, but was dominated by the small pre-recruited fish. The overall scaled numbers sex ratio (males:females) in the core strata (30–400 m) was close to 0.9:1 (Figure 5).

Elephantfish – The length frequency distributions for elephantfish showed strong juvenile modes for both males and females centred at about 25 cm (1+), and 35 cm (2+) with indications of less defined modes at about 50 cm and 60 cm for males and 50 cm and 75 cm for females (Figure 5). The female length distribution had a wider right hand tail indicating that the largest fish were mostly females. For both sexes scaled population numbers were evenly spread between 10–30 and 30–100 m and length distributions were generally similar, although males tended to be larger in 30–100 m. The overall scaled population numbers sex ratio (males:females) in core plus shallow (10–400 m) was 0.7:1, and 0.7:1 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) comprised multiple cohorts (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 200 to 400 m. Scaled population numbers were also similar between 30 to 100 m and 100 to 200 m, with less than 6% of the population found in 200–400 m. The overall scaled numbers sex ratio (males:females) in core strata (30–400 m) was 0.8:1.

Red cod – The length frequency distribution for all red cod (of which 22% of the scaled numbers were unsexed) showed well-defined modes at about 10 to 20 cm (0+) and 30–40 cm (1+), with indications of 2+ and 3+ modes (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 found in 100 to 200 m with the 0+ mode dominant in 30–100 m and largest 3+ fish dominant in 10–30 m. The overall scaled numbers sex ratio (males:females) in core strata (30–400 m) was 1:1, and in core plus shallow strata (10–400 m) was 0.8:1.

Red gurnard – The length frequency distributions for red gurnard male and female had two clear modes centred at about 25 cm and 35 cm (unsexed), 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 similar length distributions scaled numbers in 10–30 and 30–100 m. The overall scaled numbers sex ratio (males:females) in core plus shallow (10–400 m) was 1:1, and 1.2:1 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, and the largest fish was a 43 cm male (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 (males:females) in 30–400 m was 1:1.

Spiny dogfish – The length frequency distributions for spiny dogfish in 10–400 m did not have clear modal peaks, although there were indications of modes at about 50 cm and 60 cm for males, and 40 cm and 50 cm for females (Figure 5). The larger of these modes and a smaller mode were apparent in 10–30 m. 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 larger fish deeper than 100 m. The overall scaled numbers sex ratio (males:females) was strongly skewed to males at 1.5:1 in core strata (30–400 m) and 1.6:1 in the core plus shallow strata (10–400 m).

Tarakihi –The length frequency distribution for tarakihi (of which 7% of the scaled numbers were unsexed) showed no clear modes with the exception of a juvenile mode for both males and females at about 13 cm (Figure 5). There were few fish over 35 cm, although a very large fish of 56 cm was caught. Tarakihi were caught in 30 to 200 m with the bulk caught in 30–100 m. Fish from 100 to 200 m depth were slightly larger. The overall scaled numbers sex ratio (males:females) in the core strata (30–400 m) was close to 1:1.

Gonad stages

Details of the gonad stages for the target species are given in Table 7. Giant stargazer were mostly resting/immature, although 16% 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 were predominantly immature/resting, but there were reasonable numbers of fish that were spent, particularly females. Dark ghost shark showed all gonad stages and about half of males and females were mature with 5% of females in spawning condition. Spiny dogfish showed a mix of stages with all stages present for both sexes. Three quarters of the males were mature, and over half of the females were classified as pregnant (i.e., with large yolked eggs in the ovary). Most male elephantfish were immature with lesser but equal proportions maturing or mature, whereas the bulk of the females were split between immature or maturing stages.

4. DISCUSSION

4.1 2014 survey

Core strata (30–400 m)

The 2014 survey was successful in meeting all the project objectives and the CVs were within the specified range in core strata (30–400 m) for target species dark ghost shark, tarakihi, giant stargazer, sea perch and tarakihi, and within 11% for spiny dogfish (see Section 1.3 Objectives). For red cod the CV was 19% 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. 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.

Core plus shallow strata (10–400 m)

For the target species in the core plus shallow strata, the CV for red gurnard of 17% was less than the target of 20%, and for elephantfish the CV of 21% was close to the lower limit of the target range of 20–30%.

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, and three years between the 2009 and 2012 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 14-fold between 1992 and 2014 (Table 8, Figure 7). Biomass increased markedly between 1992 and 1993, was stable to increasing up to 2009, increased more than 2-fold in 2012, and in 2014 increased again by nearly one-quarter. All surveys had a large component of pre-recruit biomass ranging from 30–61% (Table 9, Figure 8) — in 2014 the pre-recruit biomass was relatively high at 53% 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 2014 the juvenile biomass was 49% of total biomass. (Table 10, Figure 9).

Dark ghost shark was present in 27–57% of core strata tows (48% in 2014), with a general trend of increasing occurrence (Table 11) and comprised 2–17% of the total catch on the surveys, with a clear increasing trend, peaking in 2014 at 17% 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 2014 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 eight surveys (1993–2014) were similar and generally bimodal (Figure 11). The 2012 and 2014 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) in that ECSI has a large component of juvenile fish, suggesting that this area may be 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 remained high with the 2014 biomass 8% below the post-1994 average of 1032 t (Table 8, Figure 7). The post 1994 average biomass was about three-fold greater than that of the early 1990s, indicating that the large increase in biomass between 1994 and 1996 was sustained. The proportion of pre-recruited biomass in the core strata varied greatly among surveys ranging from 50% in 2007 to only 5% in 2012, the latter value reflecting the high numbers of large fish present in 2012 (Table 9, Figure 8). In 2014 18% of the total biomass was pre-recruit fish. Similarly, the proportion of juvenile biomass (based on the length-at-50% maturity) in 2012 was the lowest of all surveys at 23% (Table 10, Figure 9) and in 2014 it increased to 28%.

Elephantfish were present in 30–35 % of core strata tows up to 1996, and then increased from 37 to 47% in the last five surveys (42% in 2014). Elephantfish have consistently made up 1–2% of the total catch on the surveys with no clear trend (Table 11). The distribution of elephantfish hot spots varies, 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 elephantfish were inconsistent among the ten 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 (see 2007 and 2008 surveys) (Figure 11).

The additional elephantfish biomass captured in the 10–30 m depth range accounted for 44%, 64% and 41% of the biomass in the core plus shallow strata (10–400 m) for 2007, 2012 and 2014 respectively, indicating that it is essential to continue monitoring the shallow strata for elephantfish biomass (Table 8, Figure 7). Further, the addition of the 10–30 m depth range had a significant effect on the shape of the length frequency distributions with the appearance of strong 1+ and 2+ cohorts, otherwise poorly represented in the core strata (Figures 5 and 11). 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, and

15% compared to 5% in 2012, and 27% compared to 18% in 2014), a reflection of the larger numbers of smaller elephantfish found in the shallow strata (Table 9, Figure 12).

The time series of length frequency distributions in the shallow plus core strata (10–400) included only the 2007, 2012, and 2014 surveys, and had similar distributions, showing clearly the juvenile cohorts although the 2014 1+year cohort was not as dominant as in the two previous surveys (Figure 13). For the three 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 (Table 10, Figure 14).

Giant stargazer

Biomass for giant stargazer in 2014 from the core strata was the highest in the time series, and was 23% greater than in 2012 and about one-third above the average time series biomass estimate (2014 biomass 790 t, average 612 t) (Table 8, Figure 7). Overall there is no consistent trend in giant stargazer biomass. 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 2014 it was 5% (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 2014 biomass was 44% juvenile.

Giant stargazer were present in 70–92% of core strata tows (78% in 2014) 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 ten 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 surveys (Bagley & Hurst 1996, Stevenson & Hanchet 2000, Livingston et al. 2002), suggesting that this area may be an important nursery ground for juvenile giant stargazer.

Red cod

Biomass for red cod from 2007 to 2009 core strata was largely unchanged and remained low relative to the period between 1991 and 1994. In contrast the biomass in 2012 was more than six-fold greater than in 2009, followed by a 6-fold drop in 2014 (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. The proportion of pre-recruit biomass varied greatly among surveys ranging from 7 to 59% of the total biomass and in 2014 it was 49%, reflecting relatively low numbers of adult fish rather than a strong 1+ cohort (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 2014 it was 70% (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 1996 to 2014 (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 ten 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 ten surveys in 2012 and only average in 2014. 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% and 2% of the biomass in the core plus shallow strata (10–400 m) for 2007 and 2012 respectively, but in 2014 it was 44% indicating that in terms of biomass, it is important to monitor the 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 and 2012, but in in 2014 the largest fish were in 10–30 m (Figures 5 and 11).

Red gurnard

In the 1990s, red gurnard biomass in the core strata averaged 422 t and this increased nearly four-fold to an average of 1646 t from 2007 to 2014 (Table 8, Figure 7). Since 2007 there were indications of an upward trend in biomass with 2014 23% higher than 2012 and the highest biomass of the time series. The proportion of pre-recruit biomass in the core strata varied greatly among surveys, but was generally low, 2–20%, and in 2014 was 20% (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 2014) 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% and 36% of the biomass in the core plus shallow strata (10–400 m) for 2007, 2012, and 2014 respectively, indicating that it is essential to monitor the shallow strata for red gurnard biomass (Table 8, Figure 7). 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 there was a strong 1+ cohort in 10–30 m, poorly represented in the core strata (Figures 5 and 11). The time series length frequency distributions in the shallow plus core strata (10–400) included only the 2007, 2012 and 2014 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 alone in 2007 and 2012 (i.e., 24% compared to 20%, 21% and 11% respectively), a reflection of the larger numbers of smaller red gurnard found in the shallow strata, particularly in 2012. However, in 2014 there was little difference (18% and 20%), (Table 9, Figure 12). For all three core plus shallow strata surveys, virtually all biomass was adult fish (based on the length-at-50% maturity) (Table 10, Figure 14).

Sea perch

Biomass for sea perch in 2014 (2168 t) was in the middle range of estimates for the ten surveys and was 8% above the average biomass (2008 t) with no trend over the time series (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 2014 was the highest of the ten surveys at 8% (Table 9, Figure 8). The juvenile to adult biomass ratio (based on length-at-50% maturity) was relatively constant over the time series with juvenile biomass 23–36% of total biomass with the highest estimate in 2014 (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). 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 ten 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 although it has fluctuated, remained high until 2012 before a 43% decline in 2014. This represents the first substantial change in spiny dogfish biomass since the large 2.5 fold increase in 1996 in one year. 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 2014 it was the highest at 28% (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 33 and 57% in the last six surveys (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. Spiny dogfish also had the largest biomass of any species on these surveys, with the exception of barracouta in some years, and in 2014 spiny dogfish biomass was less than half that of barracouta, a result of a relatively low spiny dogfish biomass combined with the highest barracouta biomass of the time series (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 (Figure 11). From 1996 onwards smaller fish were more prominent and for females in particular, the proportions of large fish declined. The proportion of mature spiny dogfish in 2014 was the lowest since 1994, commensurate with the relatively low biomass estimate for 2014. In 2009, 2012 and 2014, unlike previous years, there were signs of a strong juvenile cohort recruiting to the population, although this has not translated to increased adult biomass in 2014. 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), 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% and 10% of the biomass in the core plus shallow strata (10–400 m) for 2007, 2012, and 2014 respectively, indicating that it is important 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, as was evident in 2012 although in 2014 the smallest and largest fish were present in the shallow strata (Figures 5 and 11).

Tarakihi

Biomass for tarakihi increased by 43% between 2012 and 2014 and was 23% above the survey average (1934 t), although this average is inflated by a large biomass estimate with high CV (55%) in 1993, partly the result of a single large catch off Timaru (Table 8, Figure 10). There was no apparent trend in biomass over the time series (Table 8, Figure 7). Pre-recruit biomass was a major component of tarakihi total biomass estimates on all surveys, 18–60% of total biomass, and in 2014 it was 34% (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, 60–80%, and in 2014 it was 67% (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). 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 ten surveys were similar and were multi-modal, with smaller modes representing individual cohorts (Figure 11). In 2012, particularly the 0+, 1+, 2+, and possibly 3+ cohorts were evident (Beentjes et al. 2012), but less clearly 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), suggesting that this area may be an important nursery ground for juvenile tarakihi.

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 show a clear trend of increasing biomass since 1996, and the 2014 biomass was the highest in the time series and was the dominant species in terms of biomass in 2014. The 2014 barracouta biomass was also the highest recorded biomass of the ten surveys for any species.

4.3 Survey representativeness

The representativeness analysis showing the mean species ranking for each of the ECSI ten 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 2014 ECSI trawl survey. Strata 1–17 are the core strata and strata 18–21 the shallow strata.

Stratum	Depth (m)	Area (km^2)	Description	Foul ground (km^2)	No. stations Phase 1	No. stations Phase 2	Station density (km^2 per station)
1	30–100	984	Shag Point	202	4		195.6
2	30–100	1 242	Oamaru	0	3		414.1
3	30–100	3 023	Timaru	0	8		377.8
4	30–100	2 703	Rakaia	0	11		245.7
5	30–100	2 485	Banks Pen.	0	8	4	207.1
6	30–100	2 373	Pegasus	208	3		721.8
7	30–100	2 089	Conway	871	7	2	135.4
8	100–200	628	Shag Point	17	5	5	61.1
9	100–200	1 163	Oamaru	0	3	2	232.7
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		210.8
13	100–200	999	Conway	406	4	1	118.6
14	200–400	322	Oamaru Crack	17	3		101.7
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	2	111.9
Sub total		**23 339**		**2 018**	**81**	**16**	**219.8**
18	10–30	1 276	Pegasus	0	8		159.5
19	10–30	986	Rakaia	0	7		140.9
20	10–30	797	Timaru	0	3		265.7
21	10–30	520	Oamaru	226	3		97.9
Sub total		**3 579**		**226**	**21**		**159.7**
Total		**26 918**		**2 244**	**102**	**16**	**209.1**

Table 2: Simulated number of stations required to achieve the lower range target coefficients of variation (CV) for each species for the 2014 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)	STA (20)	TAR (20)	ELE (20)	GUR (20)	Stations required. Max. of 8 species (excl. RCO)	Phase 1 stations (pro-rated
30–100	1	3	3	3	3	3	3	5	3	5	4
30–100	2	3	4	3	3	3	4	3	3	4	3
30–100	3	3	4	4	10	3	10	4	6	10	8
30–100	4	3	3	3	15	4	16	4	8	16	11
30–100	5	3	3	3	11	3	6	3	3	11	8
30–100	6	3	3	3	3	4	3	3	3	4	3
30–100	7	3	4	3	4	3	3	3	9	9	7
100–200	8	3	3	6	3	3	3	3	3	6	5
100–200	9	4	13	3	3	3	3	3	3	4	3
100–200	10	3	3	7	3	3	3	3	3	7	5
100–200	11	7	20	6	4	3	3	3	3	7	5
100–200	12	3	3	3	3	3	3	3	3	3	3
100–200	13	3	3	3	3	3	5	3	3	5	4
200–400	14	3	9	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	–	–	–	–	–	–	12	4	12	8
10–30	19	–	–	–	–	–	–	11	3	11	7
10–30	20	–	–	–	–	–	–	3	3	3	3
10–30	21	–	–	–	–	–	–	3	3	3	3
	Total	56	87	62	80	53	77	84	78	132	102

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).

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	3 0364	6 111	26	6 980	27	13 137	26	55	6 225	31
Elephant fish	1 668	267	27	684	44	951	34	50	777	40
Giant stargazer	1 397	293	15	489	14	790	14	30	751	14
Red cod	3 722	880	45	1 158	36	2 096	39	30	1 057	23
Red gurnard	2 777	1 027	30	1 035	24	2 063	25	40	1 654	23
Sea perch	6 619	1 174	24	993	26	2 168	25	20	1 986	26
Spiny dogfish	32 193	13 360	34	6 576	32	19 949	31	50	14 266	36
Tarakihi	4 612	1 113	23	1 180	24	2 380	23	25	1 562	26
Barracouta	64 378	23 134	20	23 387	19	46 563	19	50	41 298	18
Lemon sole	156	14	16	90	31	107	27	25	80	30
Ling	703	90	20	138	24	230	21	65	139	29
Rig	196	107	54	87	44	194	48	90	50	36
Rough skate	1 511	619	37	534	41	1 153	38	40	1 076	38
School shark	948	278	32	251	42	529	36	90	159	69
Silver warehou	1 100	351	86	263	82	626	83	25	612	85
Smooth skate	994	315	24	322	33	637	20	40	607	20

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
Elephant fish	3290	391	21	1209	27	1600	21	50	1171	28
Red cod	6594	1194	40	2457	44	3714	41	30	2665	48
Red gurnard	5410	1388	23	1827	15	3215	17	40	2630	16
Spiny dogfish	36917	15247	30	6923	30	22188	28	50	15926	32
Barracouta	65147	23265	20	23557	19	46903	19	50	41566	18
Rig	511	166	36	154	27	320	31	90	86	28
Rough skate	2461	822	28	775	28	1597	28	40	1494	28
School shark	985	289	31	259	40	547	35	90	159	69
Silver warehou	1101	351	86	263	82	626	83	25	612	85

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	118	14	224	117	58	282	460
2	0	75	76	114	258	224	1 037	22
3	0	22	15	41	131	35	84	13
4	2	34	33	22	130	22	183	236
5	20	14	45	11	28	17	3 487	44
6	1	15	19	21	31	24	568	26
7	0	213	2	51	323	17	2 235	174
8	159	83	43	12	2	1 180	167	290
9	3 426	12	107	687	15	84	136	4
10	1 606	0	18	323	2	152	103	23
11	1 039	0	19	6	27	44	302	148
12	193	3	19	1	1	6	168	61
13	259	0	95	20	0	385	56	211
14	4 474	0	19	136	0	0	72	0
15	2 925	0	20	70	0	0	649	0
16	1 049	0	66	27	0	11	1817	0
17	2 294	0	17	69	0	67	379	0
18	0	142	0	66	55	0	583	0
19	0	405	0	1 321	699	0	652	0
20	0	86	0	209	314	0	987	0
21	0	1	0	125	274	0	129	7

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	1 085	12	24	2	66	13	0	0
2	9 815	6	2	7	348	6	0	54
3	3 358	0	2	2	43	4	1	50
4	2 077	1	2	26	68	3	1	44
5	2 357	2	0	3	17	7	0	2
6	990	20	0	30	26	13	1	0
7	816	7	3	5	87	29	2	35
8	923	6	82	0	25	17	3	9
9	2 150	0	19	13	5	210	13	71
10	2 849	0	2	0	2	60	436	41
11	428	1	4	2	4	11	22	4
12	110	1	0	0	12	10	0	48
13	348	2	0	0	4	13	2	2
14	88	19	33	0	2	10	1	30
15	34	2	55	0	1	2	7	58
16	47	0	44	0	0	0	51	3
17	20	3	53	0	11	14	2	2
18	35	0	0	49	94	2	0	0
19	223	0	0	57	104	5	0	9
20	47	0	0	6	179	13	0	13
21	72	2	0	3	154	1	0	0

Table 5: Estimated biomass (t) and coefficient of variation (%) 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	116	14	220	115	57	278	452
	CV	0	48	36	54	59	58	52	43
2	Biomass	0	94	94	142	321	278	1288	27
	CV	0	50	52	91	94	100	55	98
3	Biomass	0	66	45	125	396	107	253	38
	CV	0	52	57	41	51	79	29	48
4	Biomass	6	93	91	59	352	58	494	639
	CV	54	77	28	36	60	62	22	46
5	Biomass	48	34	111	28	70	42	8 664	109
	CV	62	37	19	77	64	71	66	34
6	Biomass	2	35	44	50	74	57	1 347	61
	CV	100	100	51	100	28	65	69	90
7	Biomass	0	446	5	106	674	36	4 669	364
	CV	0	67	100	29	44	50	38	98
8	Biomass	100	52	27	8	1	741	105	182
	CV	55	75	43	84	66	56	28	45
9	Biomass	3 986	14	124	799	18	98	158	5
	CV	64	72	55	97	57	42	20	58
10	Biomass	1 913	0	21	385	2	182	123	27
	CV	76	0	45	40	27	41	23	91
11	Biomass	1 525	0	28	8	39	65	443	217
	CV	38	0	68	100	87	39	41	84
12	Biomass	148	2	14	1	1	5	129	46
	CV	97	100	18	100	100	84	28	24
13	Biomass	259	0	95	20	0	384	56	211
	CV	75	0	35	61	0	38	11	32
14	Biomass	1 441	0	6	44	0	0	23	0
	CV	37	0	52	60	0	71	42	0
15	Biomass	1 258	0	8	30	0	0	279	0
	CV	75	0	71	100	0	100	35	0
16	Biomass	788	0	50	20	0	8	1365	0
	CV	38	0	36	44	0	64	48	0
17	Biomass	1 662	0	12	50	0	49	275	0
	CV	75	0	62	42	0	81	44	0
Total	Biomass	**13 137**	**951**	**790**	**2 096**	**2 063**	**2 168**	**19 949**	**2 380**
	CV	**26**	**34**	**14**	**39**	**25**	**25**	**31**	**23**

Table 5 – *continued*

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

Stratum		Target species biomass and CV							
		GSH	ELE	GIZ	GUR	RCO	SPE	SPD	NMP
18	Biomass	0	181	0	84	70	0	743	0
	CV	0	36	0	16	49	0	37	0
19	Biomass	0	399	0	1 303	689	0	643	0
	CV	0	24	0	97	15	0	31	100
20	Biomass	0	69	0	166	250	0	787	0
	CV	0	53	0	36	37	0	46	0
21	Biomass	0	0	0	65	142	0	67	4
	CV	0	100	0	65	56	0	22	41
Total	Biomass	**0**	**649**	**0**	**1 618**	**1 152**	**0**	**2 240**	**4**
	CV	**0**	**19**	**0**	**78**	**14**	**0**	**22**	**40**

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	1 068	12	24	2	65	13	0	0
	CV	48	29	36	100	28	58	0	0
2	Biomass	12 194	7	2	9	432	8	0	67
	CV	61	79	100	71	99	100	0	64
3	Biomass	10 151	1	6	5	130	12	2	152
	CV	34	62	49	59	47	28	100	54
4	Biomass	5 613	4	4	72	185	8	3	119
	CV	34	58	63	96	39	39	64	33
5	Biomass	5 857	4	0	8	41	19	0	6
	CV	36	37	0	75	33	39	77	91
6	Biomass	2 349	48	0	71	62	31	2	0
	CV	40	58	0	84	15	46	82	0
7	Biomass	1 704	15	7	10	182	61	4	73
	CV	32	24	71	51	21	38	29	54
8	Biomass	580	4	52	0	16	10	2	5
	CV	28	47	71	0	44	30	69	96
9	Biomass	2 501	0	22	16	6	244	15	83
	CV	34	0	61	55	62	76	92	44
10	Biomass	3 394	0	2	0	2	72	519	49
	CV	40	100	31	0	100	41	100	74
11	Biomass	628	1	5	2	6	16	33	6
	CV	37	100	82	100	66	45	67	68
12	Biomass	84	1	0	0	9	7	0	36
	CV	56	37	0	0	50	50	100	90
13	Biomass	348	2	0	0	4	13	2	2
	CV	20	49	0	0	67	61	80	60
14	Biomass	28	6	11	0	1	3	0	10
	CV	91	78	83	0	100	100	59	100

Table 5 – *continued*

Stratum		BAR	LSO	LIN	SPO	RSK	SCH	SWA	SSK
		Key QMS species biomass and CV							
	CV	91	78	83	0	100	100	59	100
15	Biomass	14	1	24	0	0	1	3	25
	CV	52	100	99	0	100	100	43	73
16	Biomass	35	0	33	0	0	0	39	3
	CV	58	0	7	0	0	0	56	100
17	Biomass	14	2	38	0	8	10	2	2
	CV	77	35	27	0	73	100	100	63
Total	Biomass	**46 563**	**107**	**230**	**194**	**1 153**	**529**	**626**	**637**
	CV	**19**	**27**	**21**	**48**	**38**	**36**	**83**	**20**

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

Stratum		BAR	LSO	LIN	SPO	RSK	SCH	SWA	SSK
		Key QMS species biomass and CV							
18	Biomass	45	0	0	63	120	3	0	0
	CV	45	100	0	47	14	47	49	0
19	Biomass	220	0	0	56	102	5	0	9
	CV	34	47	100	27	18	32	69	100
20	Biomass	37	0	0	5	143	10	0	10
	CV	58	0	0	30	25	46	100	100
21	Biomass	37	1	0	2	80	0	0	0
	CV	65	68	0	58	38	100	0	0
Total	Biomass	**340**	**2**	**0**	**126**	**444**	**18**	**0**	**19**
	CV	**25**	**50**	**100**	**27**	**12**	**28**	**39**	**71**

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. NA, not applicable.

		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	6	9	NA	NA	NA
BAR	1	105	8 584	NA	NA	NA
BCO	2	20	408	NA	NA	NA
BRI	2	9	19	NA	NA	NA
CAR	2	5	69	5	69	NA
CAS	2	2	125	NA	NA	NA
CBE	NA	1	25	1	25	NA
CBI	2	4	342	NA	NA	NA
CBO	2	2	67	NA	NA	NA
ELE	1	59	1 786	59	727	460
ESO	2	22	420	1	7	NA
FRO	1	1	1	NA	NA	NA
GFL	2	2	6	NA	NA	NA
GIZ	2	76	1 154	76	818	541
GSH	G	47	2 989	46	708	NA
GUR	2	80	4 132	79	1 140	635
HAK	2	6	39	NA	NA	NA
HAP	2	47	97	NA	NA	NA
HOK	2	13	791	NA	NA	NA
JAV	2	3	324	NA	NA	NA
JMD	1	16	42	NA	NA	NA
JMM	1	11	21	NA	NA	NA
JMN	1	3	5	NA	NA	NA
KIN	1	1	1	NA	NA	NA
LDO	2	7	57	NA	NA	NA
LEA	2	26	1 725	NA	NA	NA
LIN	2	46	412	NA	NA	NA
LSO	2	65	600	NA	NA	NA
MOK	1	12	64	NA	NA	NA
NMP	1	67	4 326	66	1 031	542
NOS	4	49	1 371	NA	NA	NA
RCO	2	85	3 411	85	1 188	741
RSK	5	78	769	78	710	NA
SBW	1	1	2	NA	NA	NA
SCH	2	77	627	77	527	NA
SCI	B	2	6	2	6	NA
SDO	2	1	74	NA	NA	NA
SFL	2	26	375	1	1	NA
SPD	2	117	8 139	115	2 287	NA
SPE	2	69	4 546	69	1 082	561
SPO	2	39	403	38	398	NA
SRB	1	4	17	NA	NA	NA
SSI	1	1	15	NA	NA	NA
SSK	5	43	206	43	197	NA

Table 6 – *continued*

Species code	Measurement method	Length frequency data: No. of samples	Length frequency data: No. of fish	Biological data+: No. of samples	Biological data+: No. of fish	Biological data+: No. of otoliths or spines
SWA	1	44	526	NA	NA	NA
TUR	2	1	1	NA	NA	NA
WAR	1	33	577	NA	NA	NA
WWA	1	2	24	NA	NA	NA
YBF	2	7	44	1	1	NA
Totals	**NA**	1 443	49 773	842	10 922	3 480

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	367	61	23	16	0	1	
	Females	424	88	9	2	0	<1	
Red cod	Males	354	95	3	1	<1	1	
	Females	476	84	16	0	0	0	
Red gurnard	Males	420	84	10	0	<1	6	
	Females	301	59	16	1	0	24	
Sea perch	Males	560	18	45	22	11	5	
	Females	494	85	12	<1	1	2	
Tarakihi	Males	412	86	5	0	0	9	
	Females	469	93	2	0	0	5	
			% 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	170	55	22	24	NA	NA	NA
	Females	227	57	42	1	0	NA	NA
Spiny dogfish	Males	1193	14	12	74	NA	NA	NA
	Females	669	23	14	6	2	54	1
			% Gonad state					
10–30 m			1	2	3	4	5	6
Elephantfish	Males	83	83	12	5	NA	NA	NA
	Females	231	52	47	<1	0	NA	NA
			% Gonad state					
			1	2	3	4	5	
Red gurnard	Males	109	83	13	0	0	4	
	Females	271	55	25	0	<1	19	

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, and 2014 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

	GSH		**ELE**		**GIZ**		**RCO**		**GUR**		**SPE**		**SPD**		**NMP**	
Survey	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	40	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	1034	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

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

	BAR		LSO		LIN		SPO		RSK		SCH		SWA		SSK	
Survey	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	8 361	29	NA	NA	1 009	35	175	30	NA	NA	100	30	29	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
2014	46 563	19	107	27	230	21	194	48	1 153	38	529	36	626	83	637	20

Table 8 – *continued*

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

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

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

	BAR		RSK		SCH		SPO		SWA	
Survey	Biom. (t)	CV	Biom. (t)	CV	Biom. (t)	CV	Biom. (t)	CV	Biom. (t)	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

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, and 2014 (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	1823	2054	70	1483	NA	NA	305	1414
	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	2089	2438	51	1441	266	9212	288	614
	CV	54	31	83	28	14	16	58	30	50	33	28	28	27	31	26	28
1993	Biom.	1058	1814	60	421	19	591	26	551	1025	4469	178	2770	343	13122	2282	1522
	CV	40	53	56	34	16	14	45	31	51	27	76	30	72	17	62	46
1994	Biom.	1312	1390	22	142	10	429	2	121	3338	2299	78	2264	205	14325	494	725
	CV	35	22	51	34	25	17	42	34	40	36	24	29	49	10	31	35
1996	Biom.	1195	1981	338	520	13	452	8	496	590	4029	58	1613	3412	31757	519	1137
	CV	30	23	40	26	34	11	44	26	31	34	45	25	23	16	30	27
2007	Biom.	1854	2629	516	518	33	722	298	1155	190	1295	74	1880	5831	29554	822	1766
	CV	46	26	59	21	24	18	40	35	33	25	18	22	46	27	30	24
2008	Biom.	1644	2119	627	777	13	592	100	1210	129	1695	144	1800	1886	26590	739	1123
	CV	23	29	57	27	28	14	59	33	36	50	20	24	50	22	44	25
2009	Biom.	1965	2364	210	387	10	464	62	1663	833	1038	82	1363	2398	22913	525	994
	CV	21	33	38	25	34	15	34	30	50	41	18	26	30	32	42	42
2012	Biom.	3716	6988	66	1285	26	617	193	1487	7015	4806	66	1898	3804	31742	584	1077
	CV	27	31	46	39	22	16	40	27	97	55	25	27	58	34	34	29
2014	Biom.	6912	6225	174	777	39	751	409	1654	1038	1057	182	1986	5683	14266	818	1562
	CV	27	31	32	40	17	14	45	23	58	23	29	26	34	36	26	26

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

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 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 and 2014 (C). Biomass estimates for 1991 were adjusted to allow for non-sampled strata (7 and 9) and are shown for both sexes combined for finfish. 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; NA, not applicable.

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	305	347	NA	NA	3 119	768	579	1136	1094	591
	CV	19	20	NA	NA	39	32	33	30	36	30
1992	Biomass	178 (109)	69 (208)	0 (2)	49 (91)	1 752 (1 364)	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 (1 645)	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)	295 (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)

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
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)
2014	Biomass	167 (181)	126 (308)	6 (6)	1021 (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)

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	90 (265)	194 (411)	–	–	–	–
	CV	73 (57)	52 (47)	–	–	–	–
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 (1 135)	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)

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
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)
2008	Biomass	676 (1 021)	820 (1 235)	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 (1 208)	1 038 (1 326)	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)	3 319 (3162)	39 (267)	693 (353)	5 702 (5 640)	22 705 (1 483)
	CV	24 (34)	28 (36)	51 (32)	54 (40)	36 (26)	40 (30)
2014	Biomass	2 078 (4 361)	4 032 (2 619)	88 (176)	179 (508)	5 761 (5 656)	7 599 (920)
	CV	32 (29)	31 (31)	31 (31)	31 (51)	42 (37)	43 (15)

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 (1 013)	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)	1376 (1 811)
	CV	25 (19)	29 (36)	25 (23)	23 (15)

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 and 2014 (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

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	7
2014	51	2	68	3	5

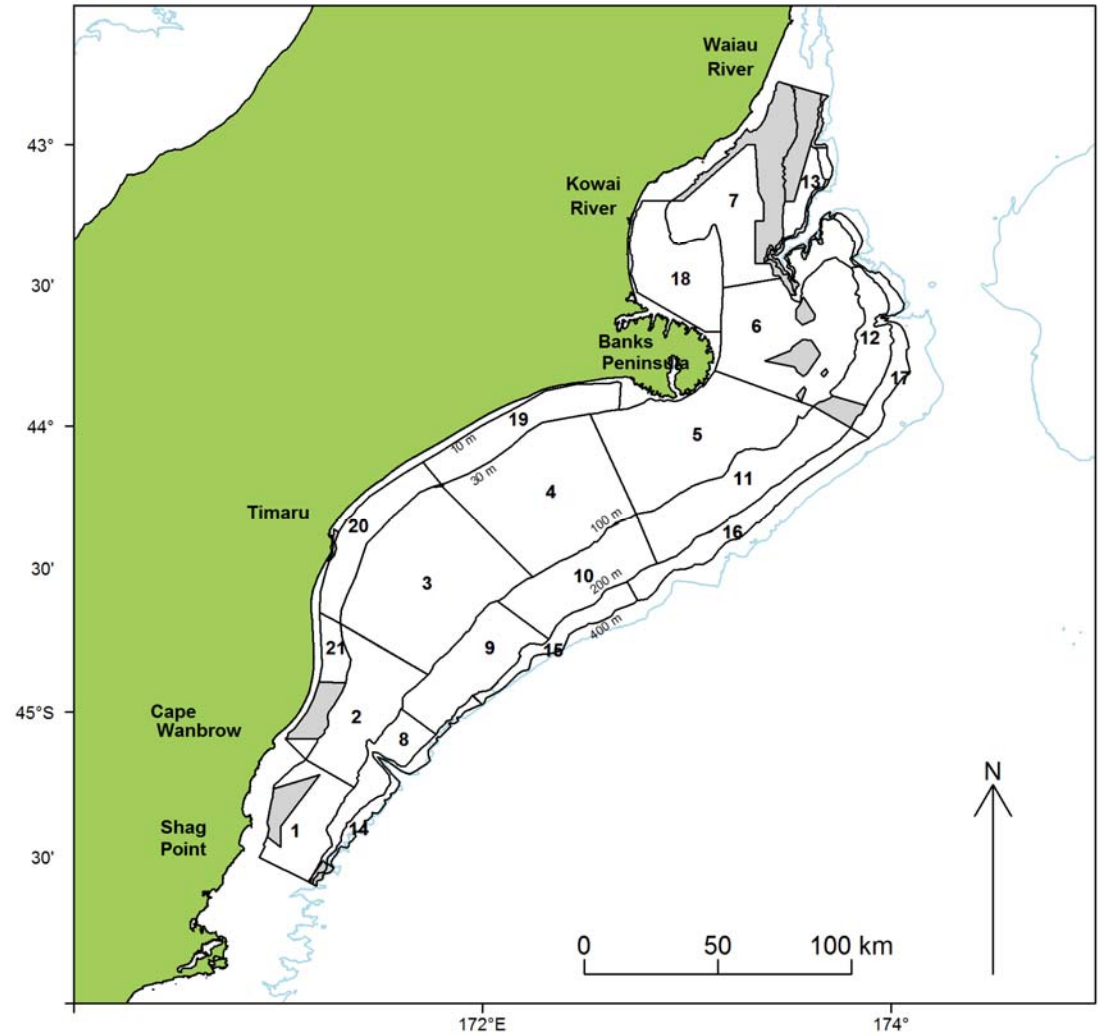


Figure 1: Strata used in the 2014 ECSI trawl survey in 10–400 m. Shaded areas are foul ground. Outer depth contour is 500 m.

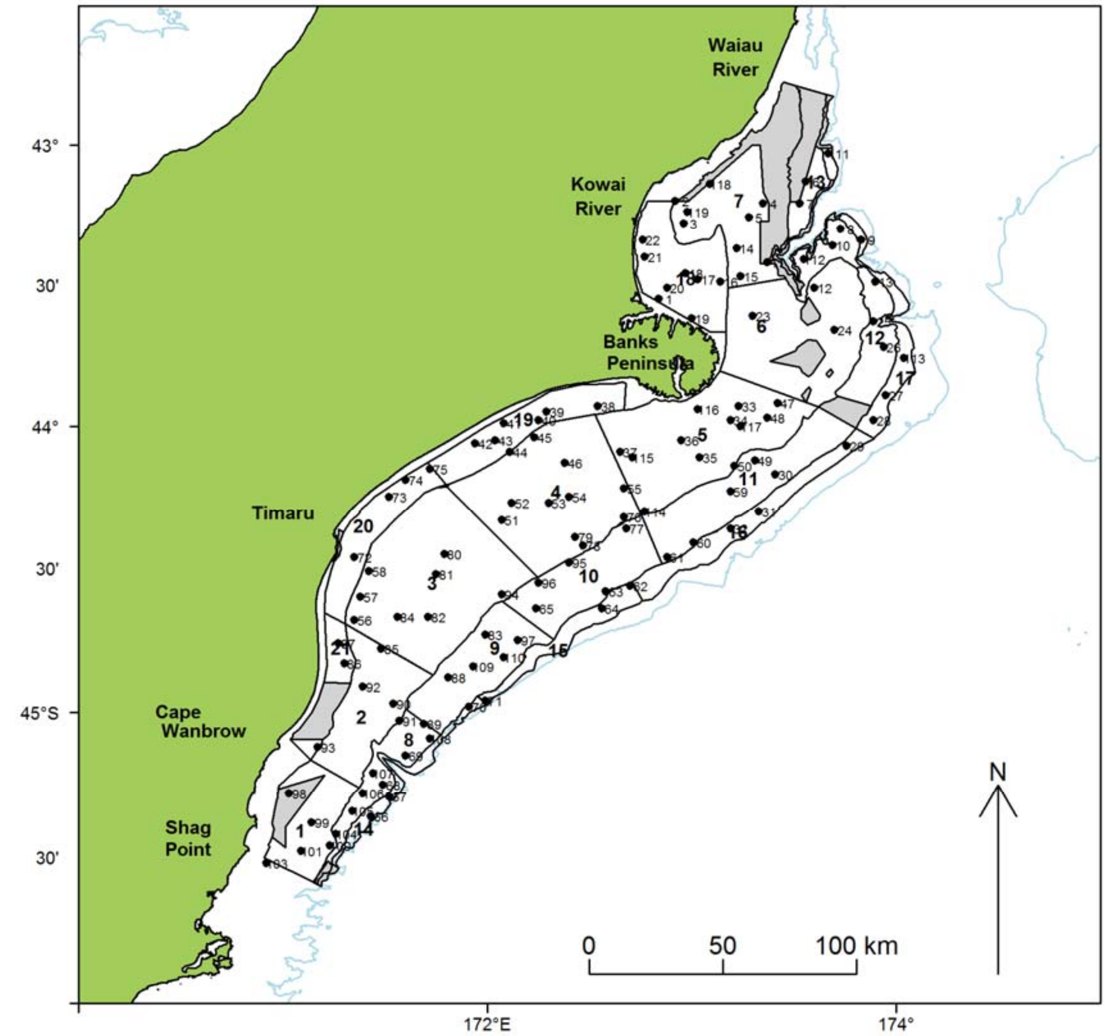


Figure 2: All tows and tow numbers from the 2014 ECSI survey. Shaded areas are foul ground. Outer depth contour is 500 m

Dark ghost shark

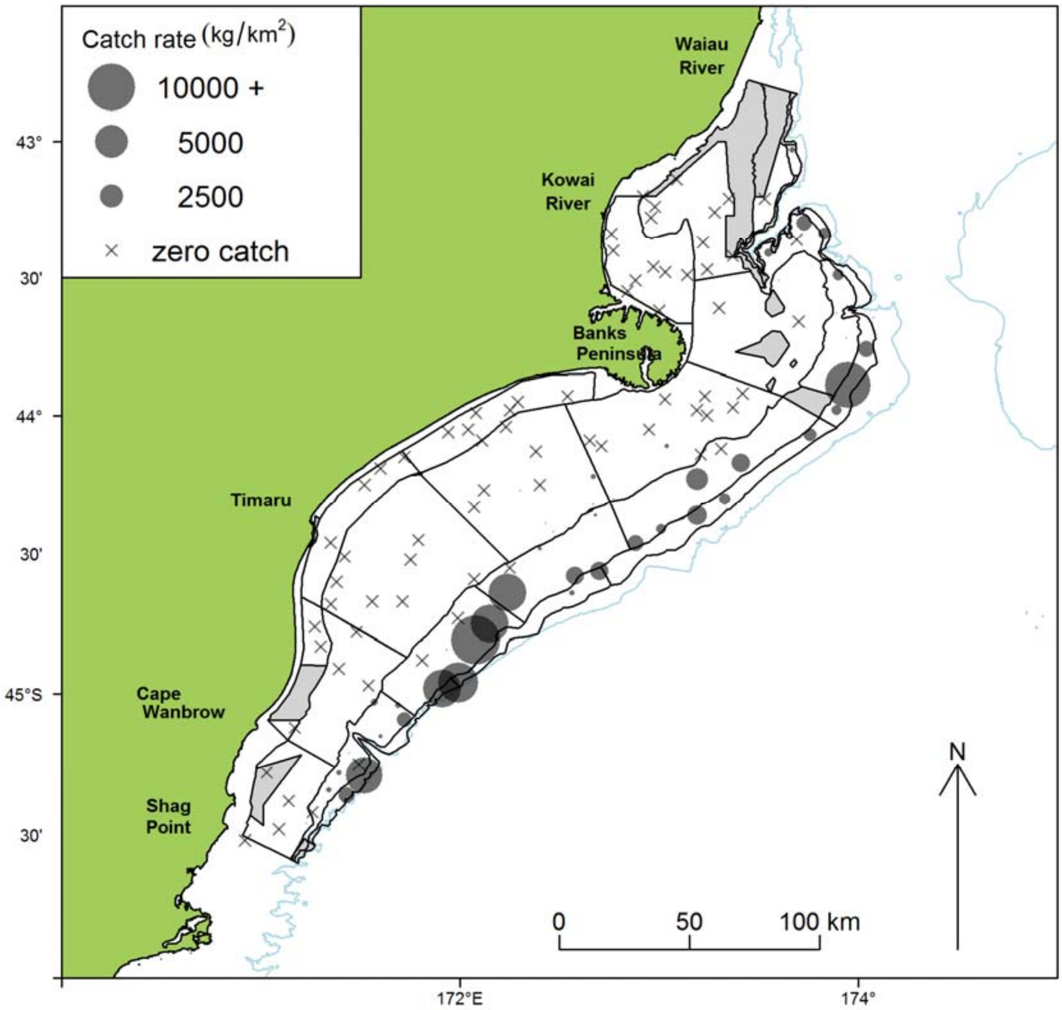


Figure 3: Catch rates (kg.km^{-2}) of target species for the 2014 ECSI survey. The legend indicates the circle size that corresponds to three catch rates; on the figure, circle size is continuous and proportional to the catch rate. Crosses indicate no catch at that station. Grey shaded areas are foul ground.

Elephantfish

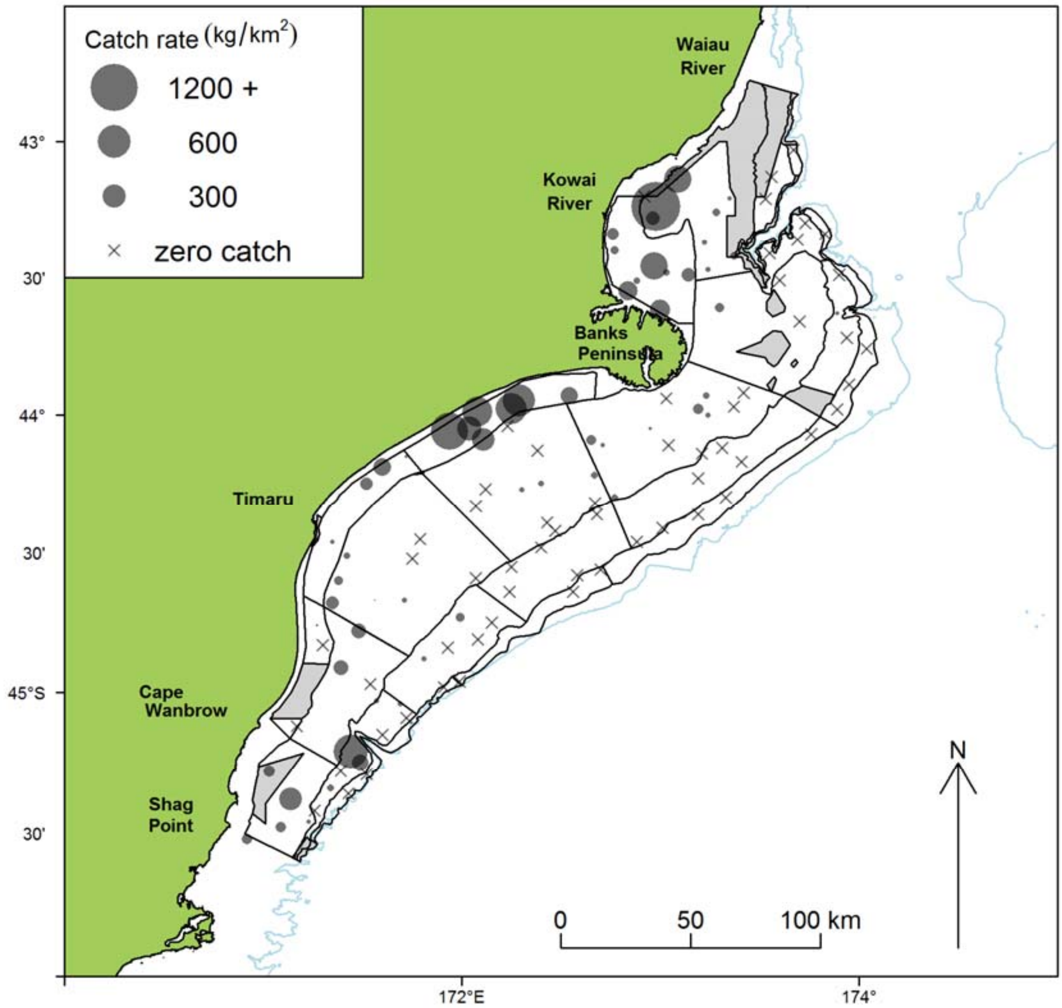


Figure 3–*continued*

Giant stargazer

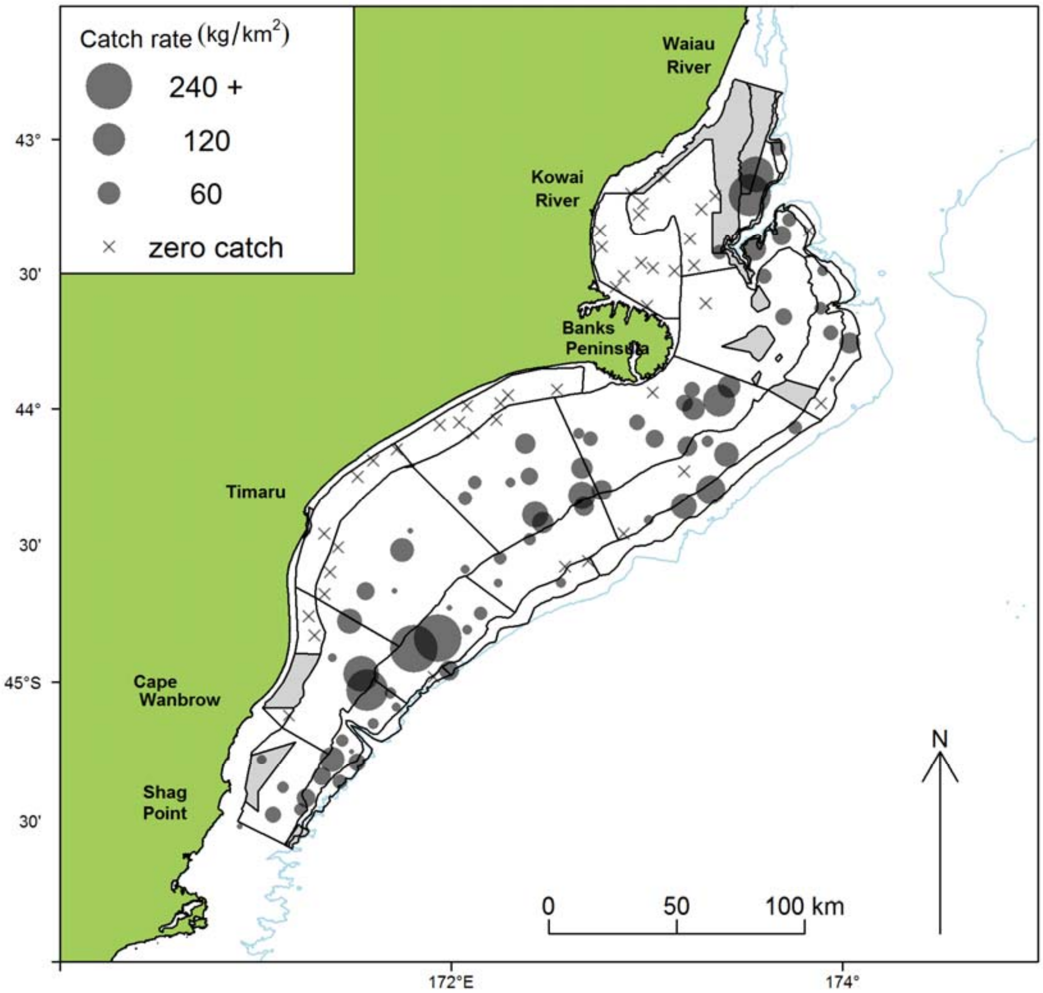


Figure 3–*continued*

Red Gurnard

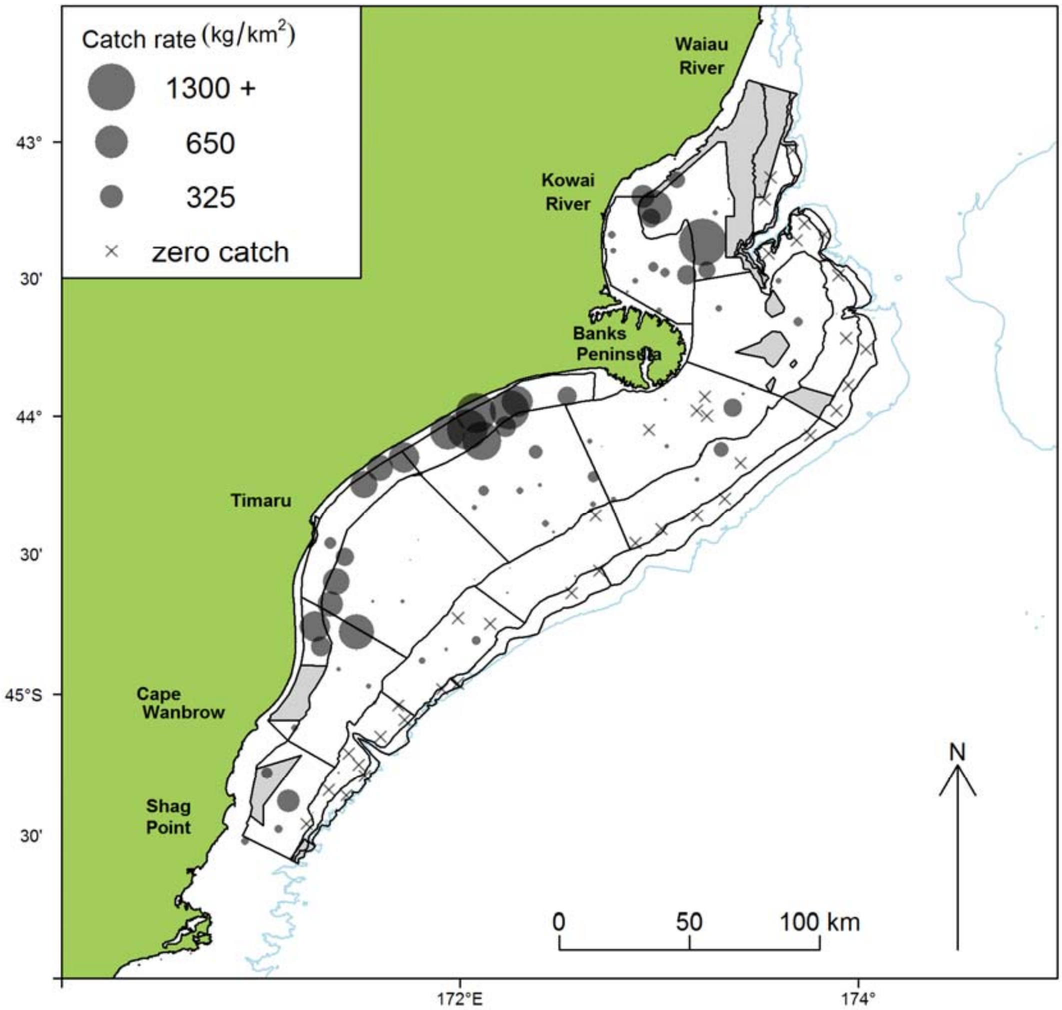


Figure 3–*continued*

Red cod

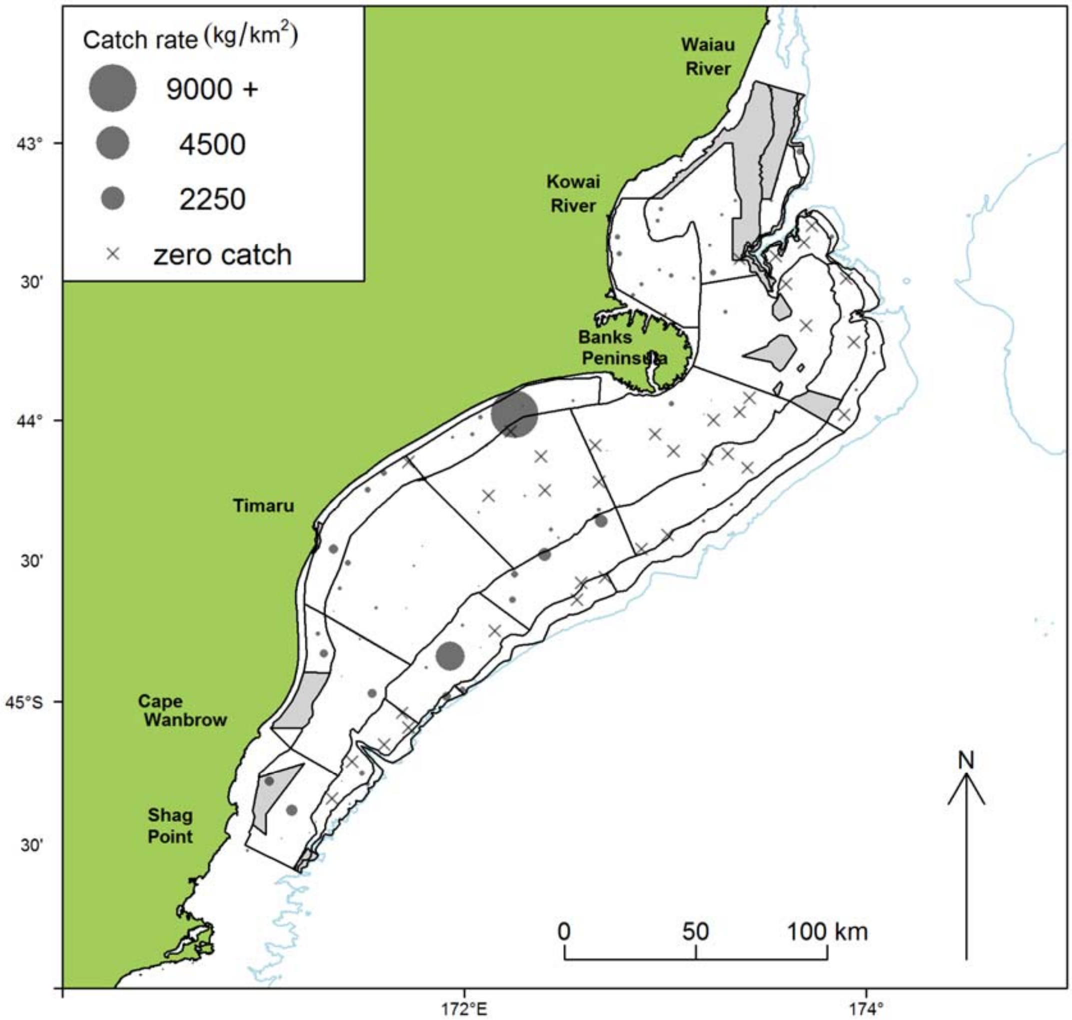


Figure 3–*continued*

Sea perch

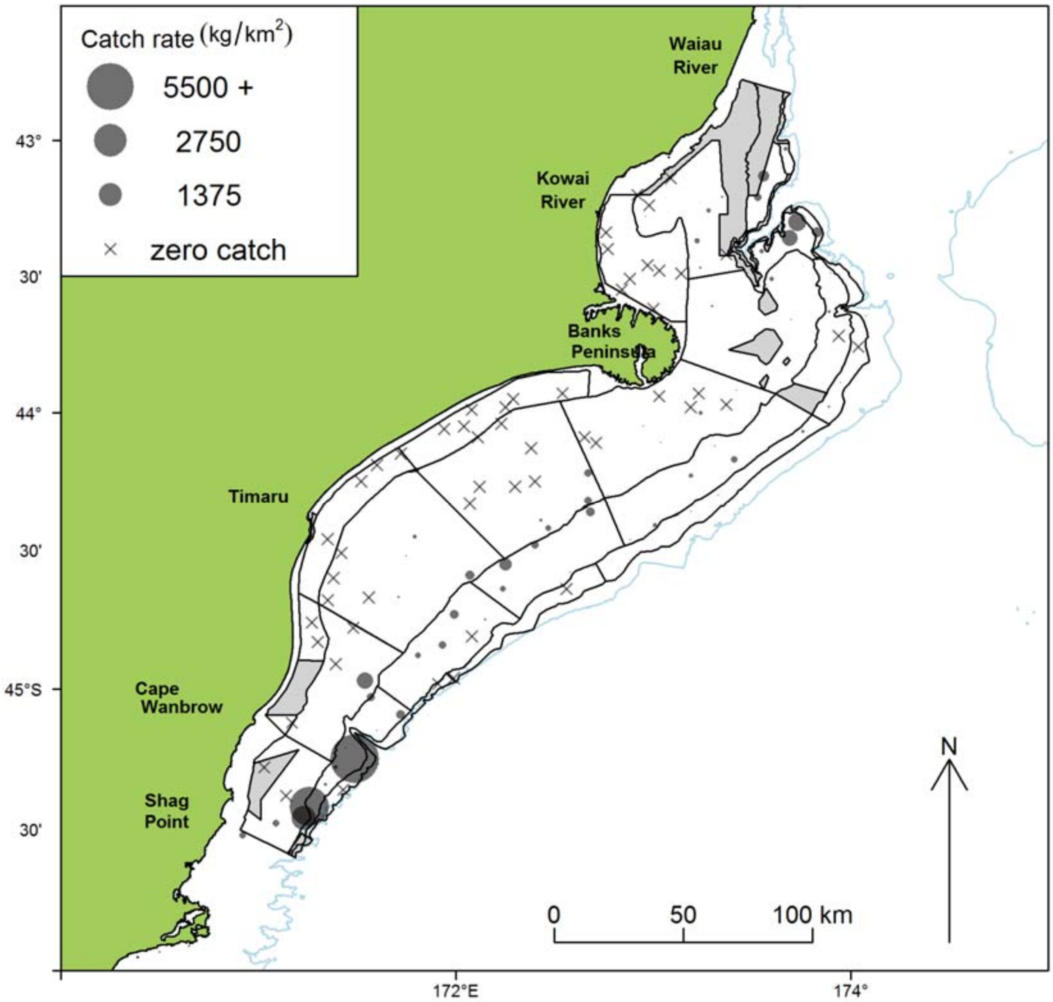


Figure 3–*continued*

Spiny dogfish

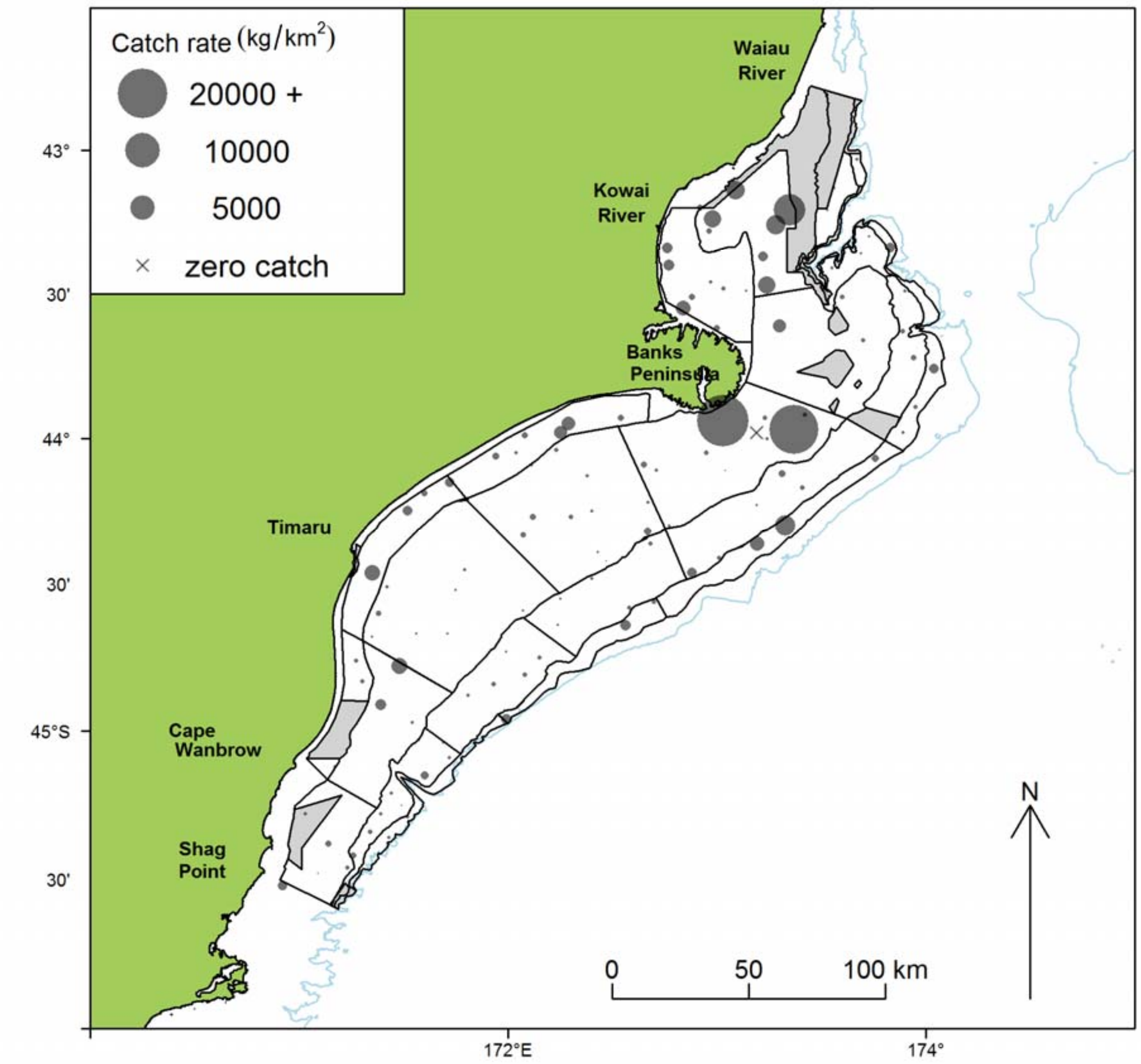


Figure 3–*continued*

Tarakihi

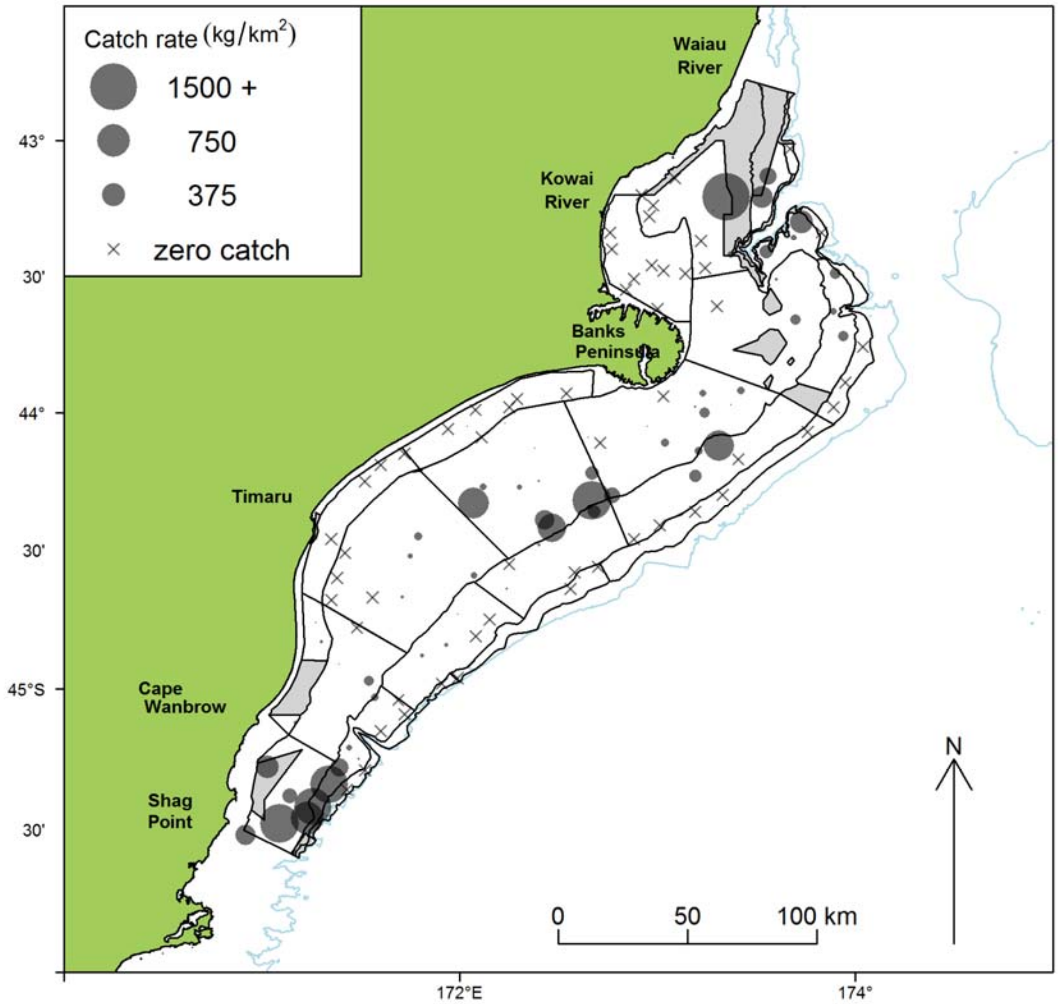
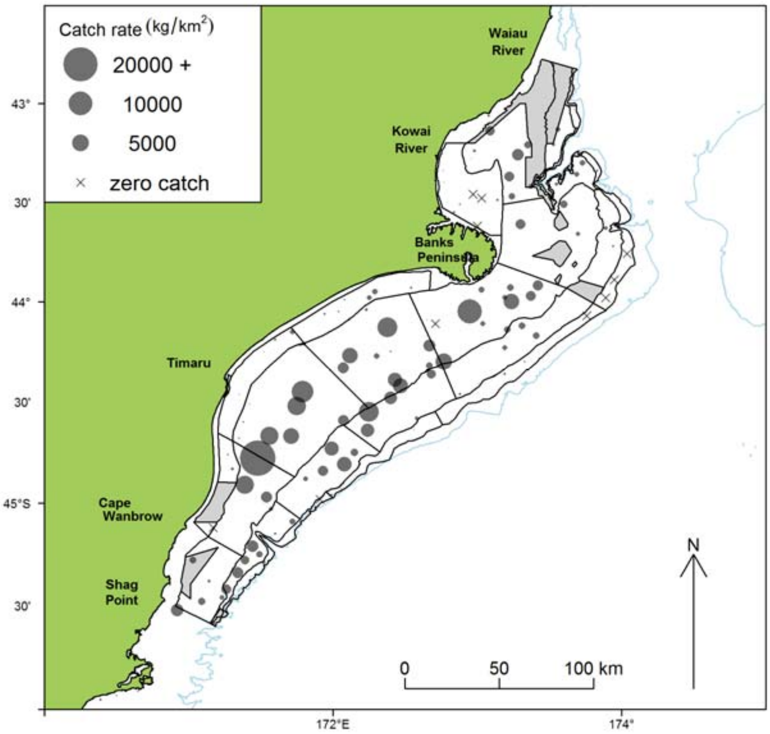


Figure 3–*continued*

Barracouta



Lemon sole

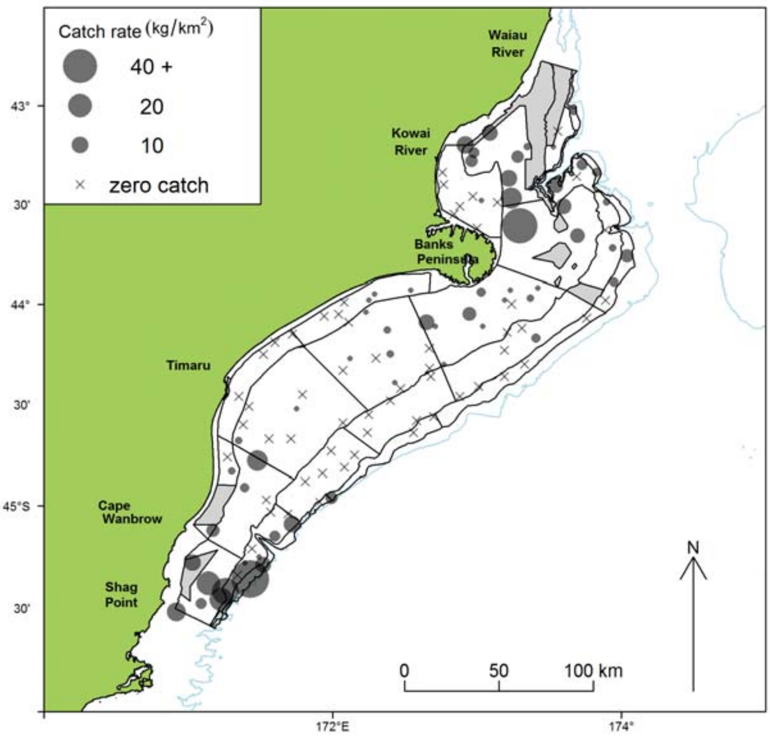
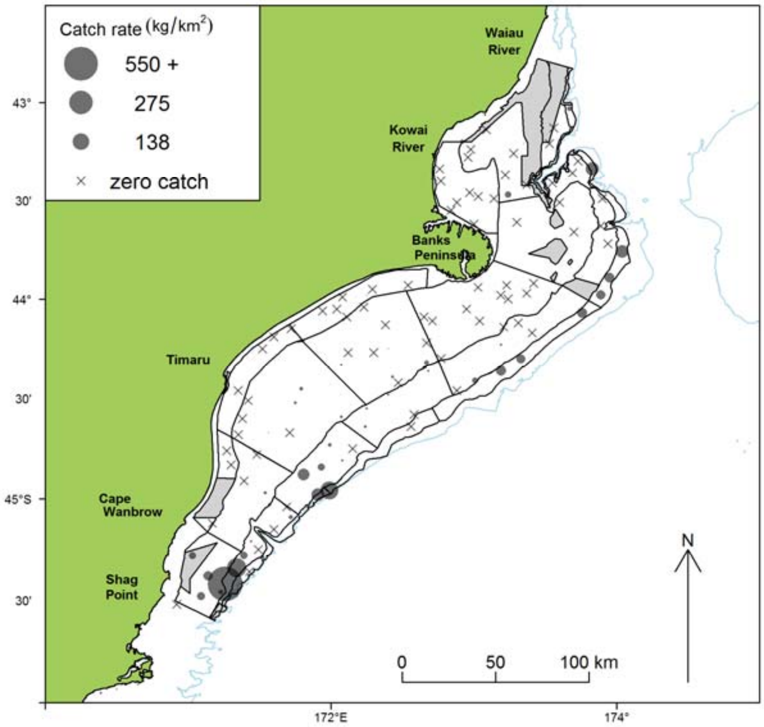


Figure 4: Catch rates (kg.km^{-2}) of key non-target QMS species for the 2014 ECSI survey. The legend indicates the circle size that corresponds to three catch rates; on the figure, circle size is continuous and proportional to the catch rate. Crosses indicate no catch at that station. Grey areas are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

Ling



Rig

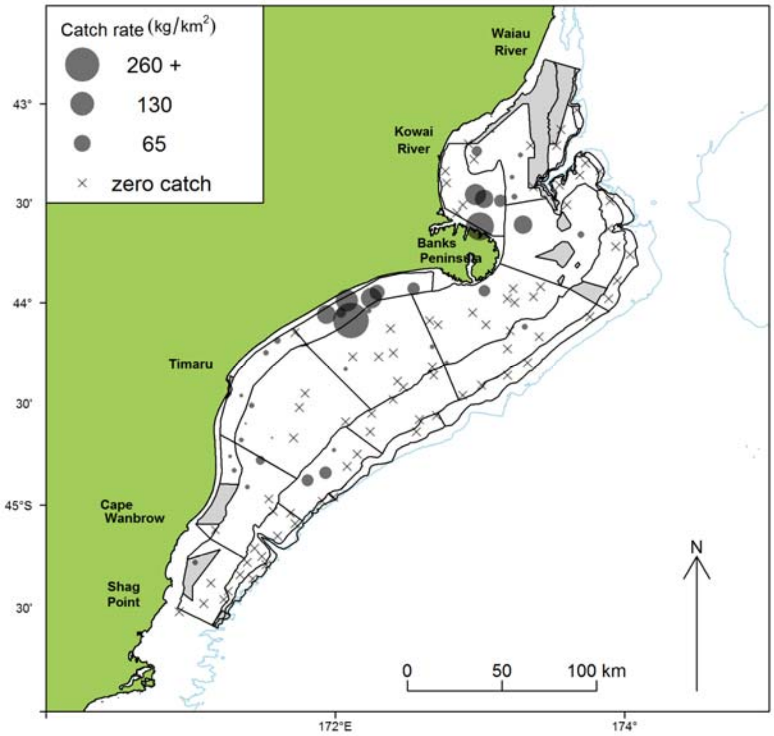
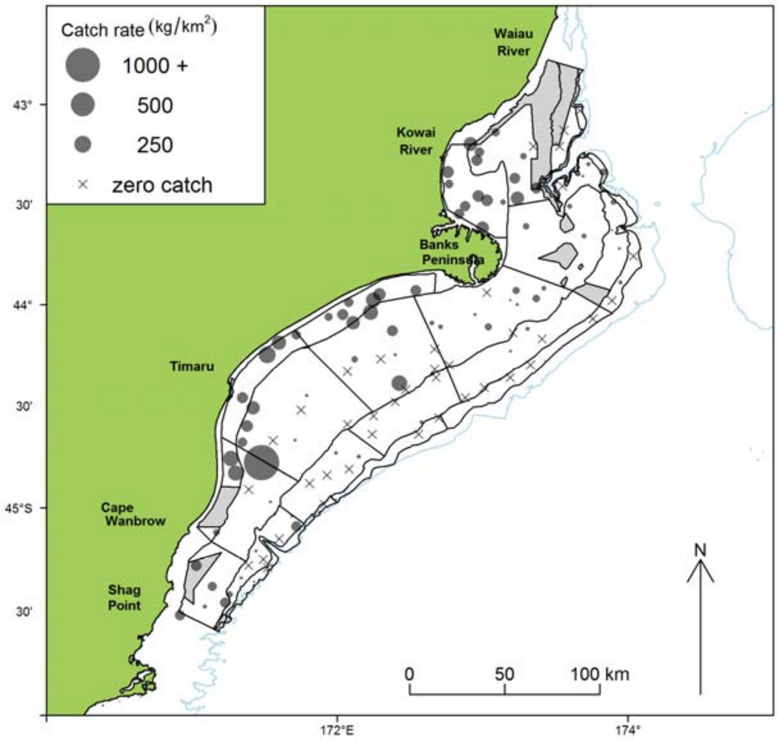


Figure 4–*continued*

Rough skate



School shark

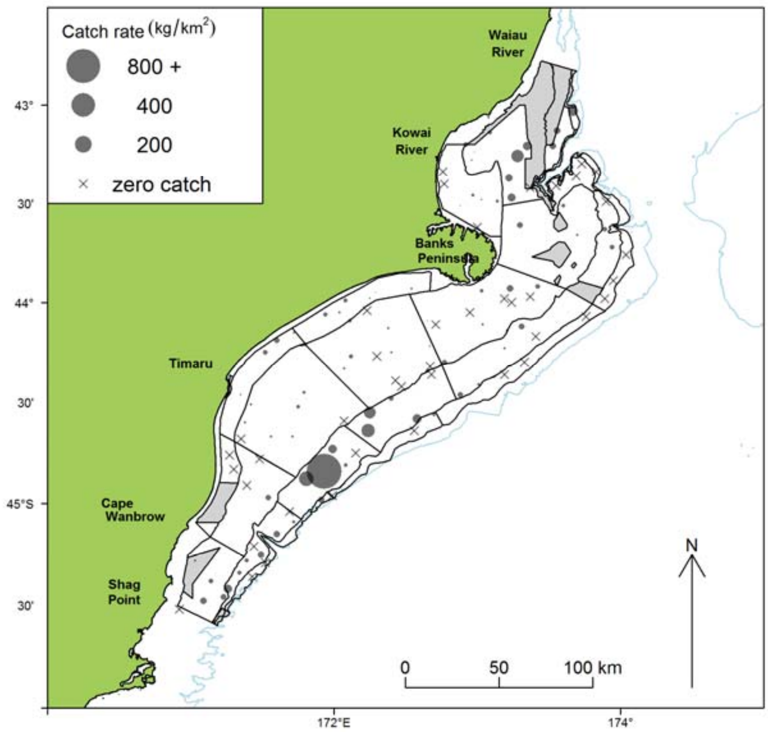
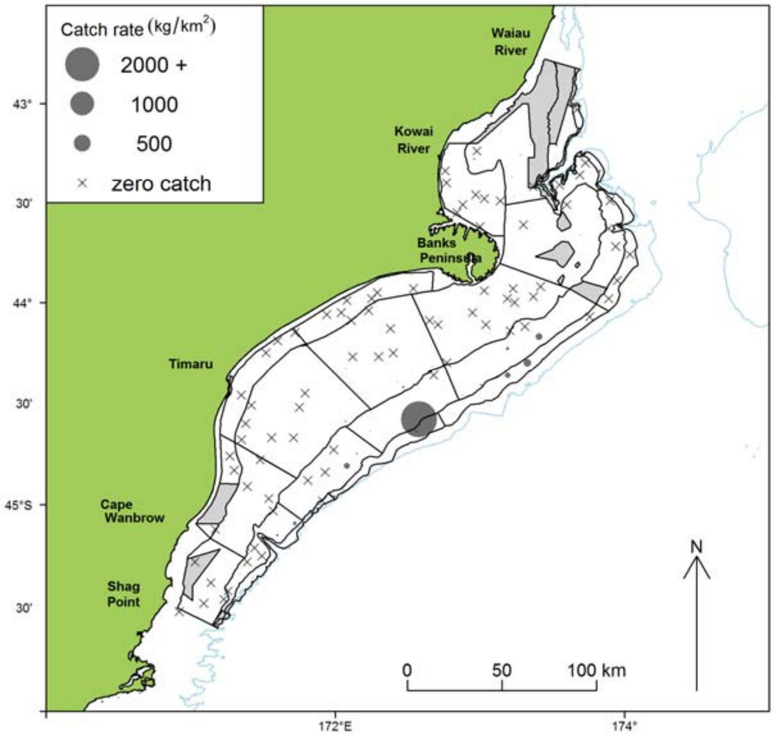


Figure 4–*continued*

Silver warehou



Smooth skate

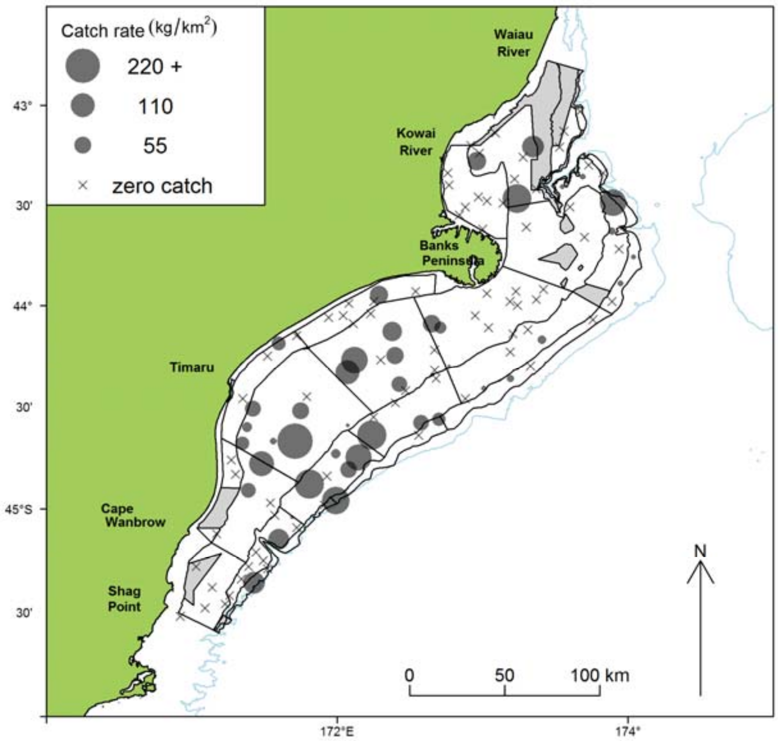


Figure 4–*continued*

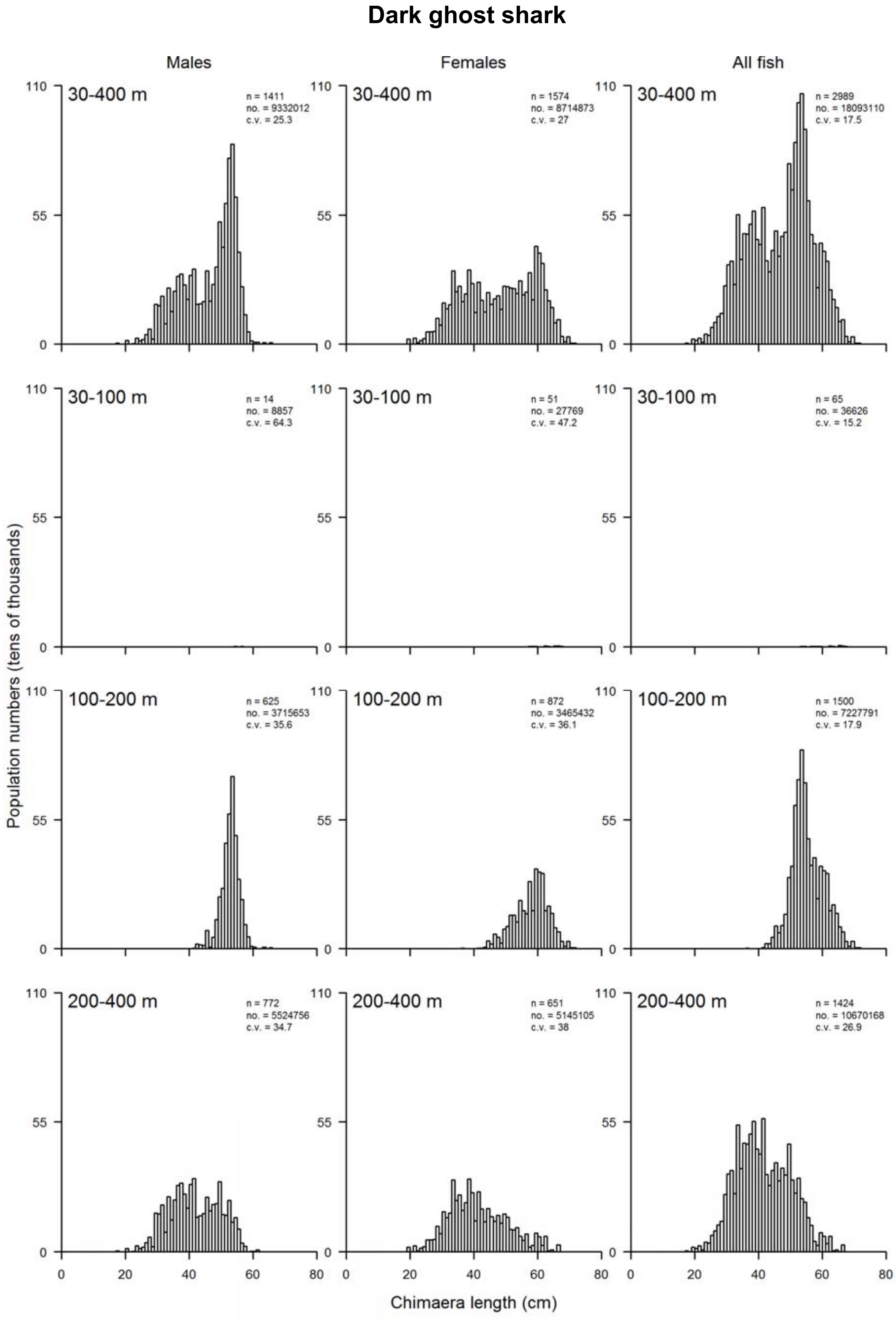


Figure 5: Scaled length frequency distributions for the target species by depth range for the 2014 survey. Population estimates are in thousands of fish. The 'All fish' length distribution includes unsexed fish.

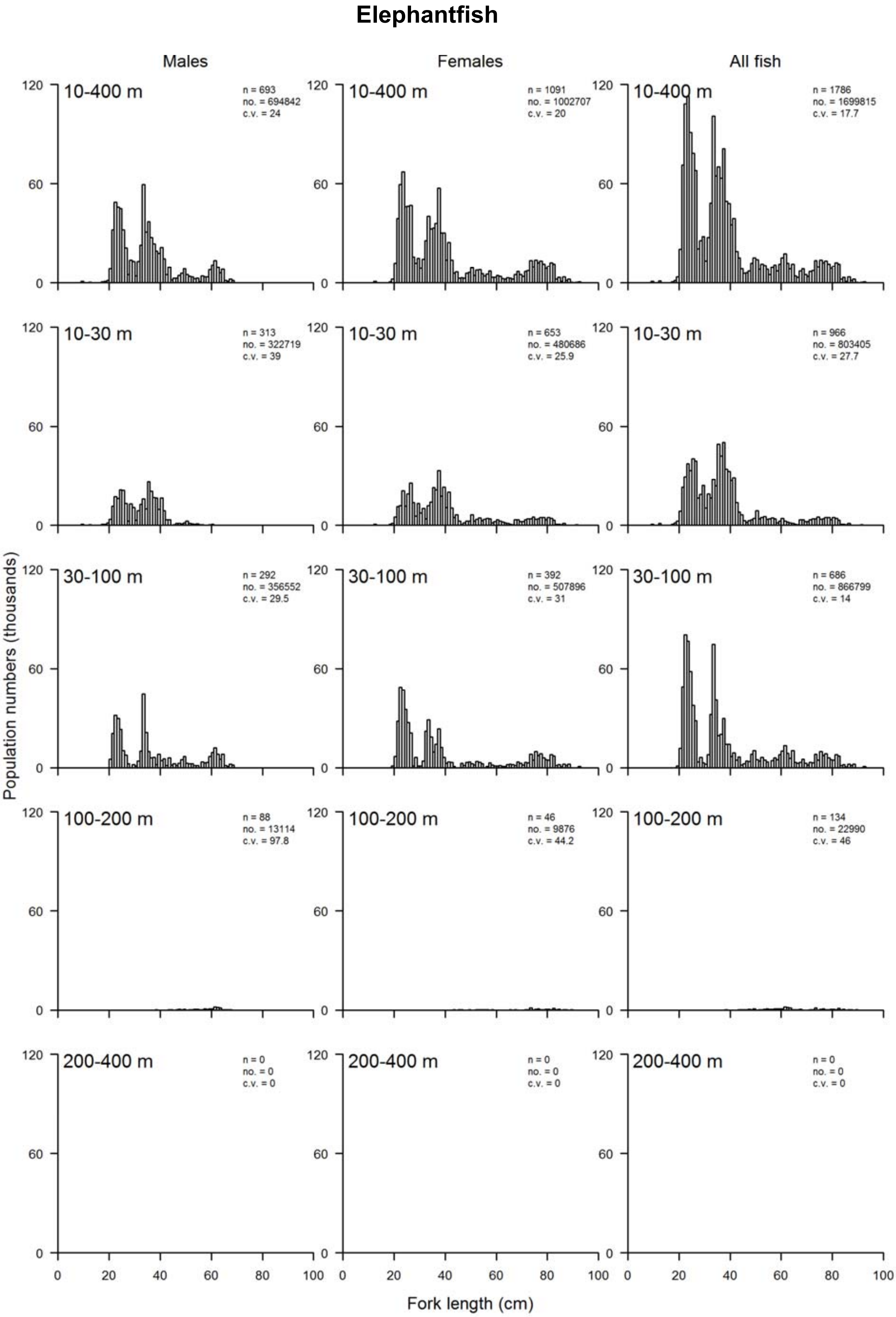


Figure 5–*continued*

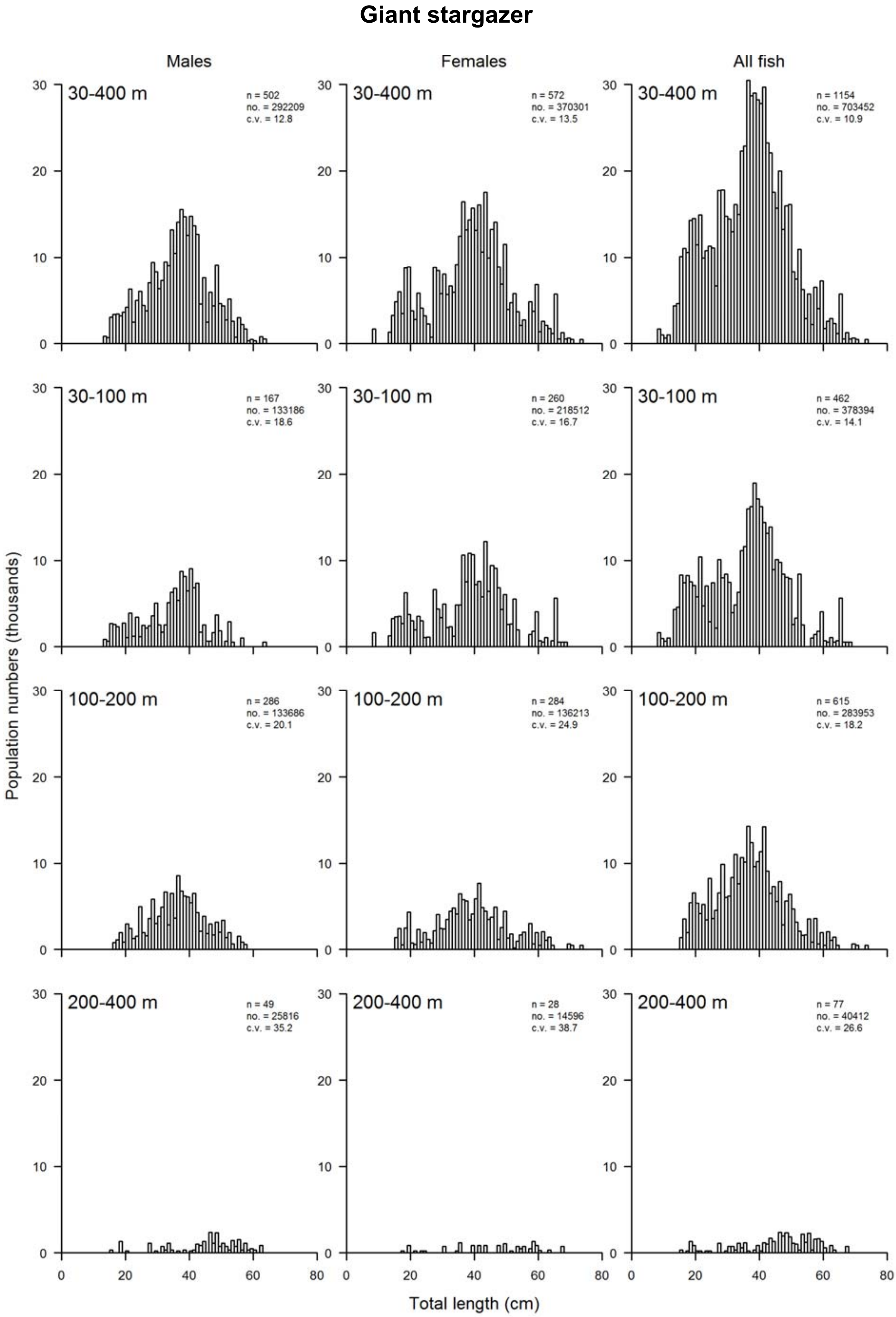


Figure 5–*continued*

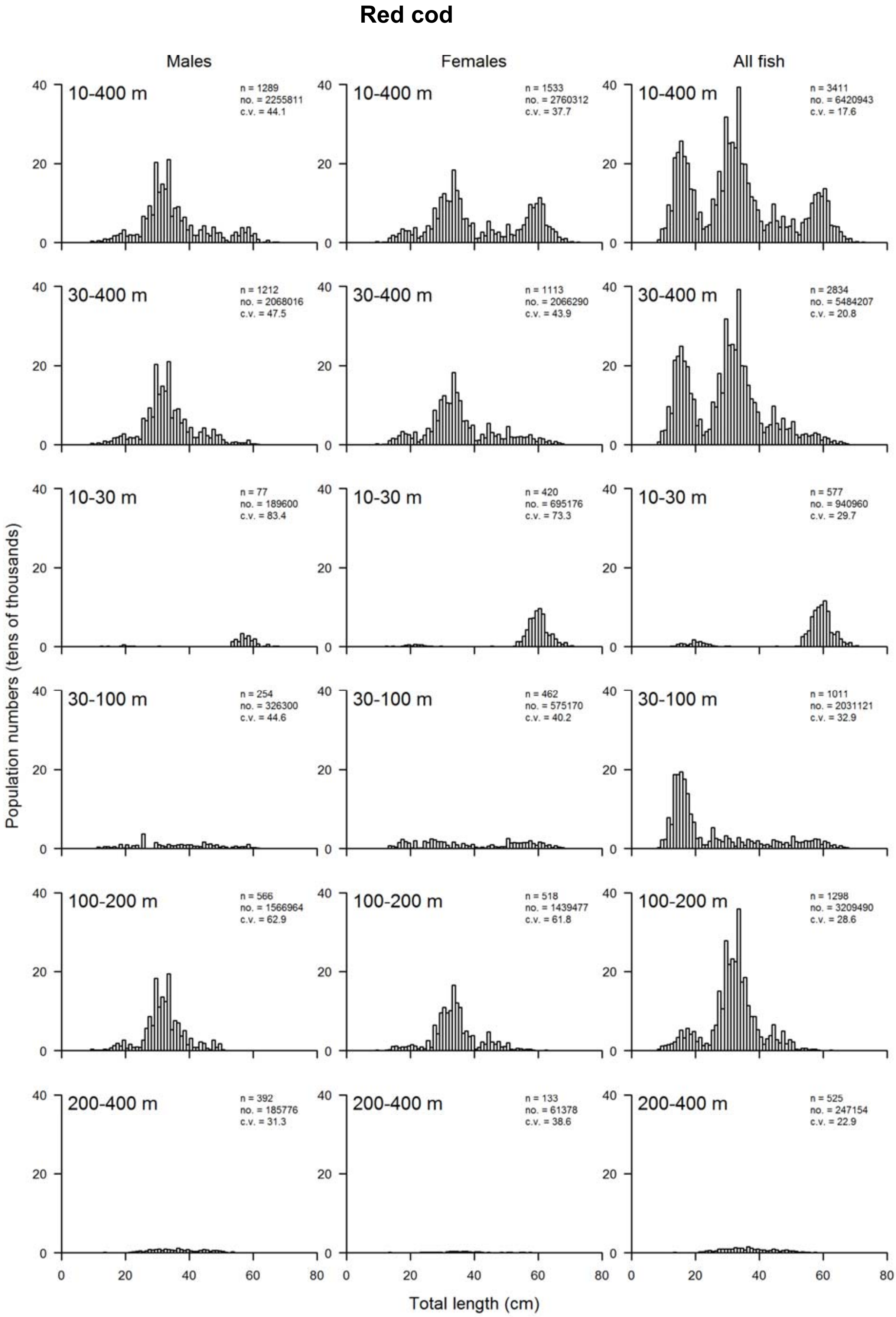


Figure 5–*continued*

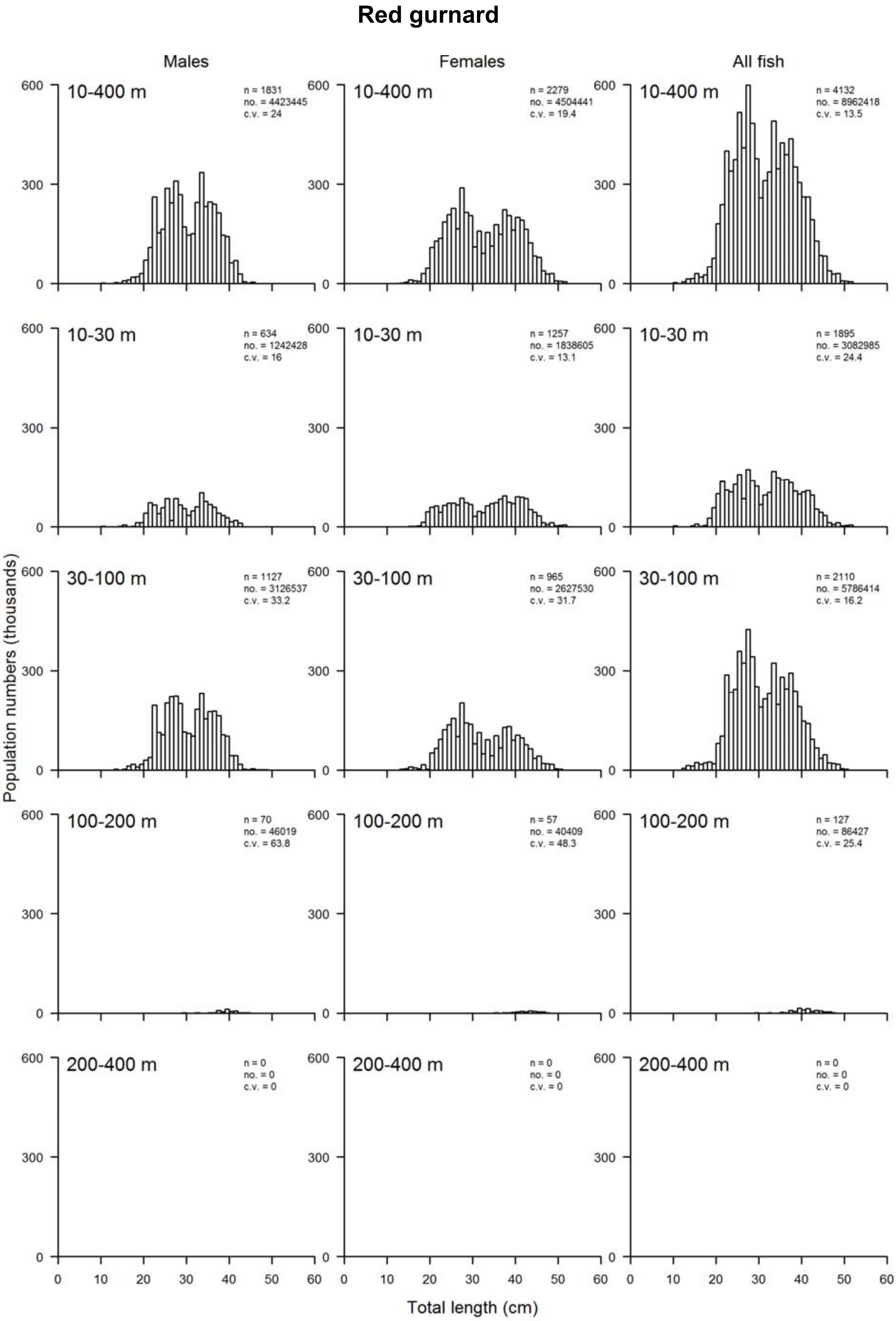


Figure 5–*continued*

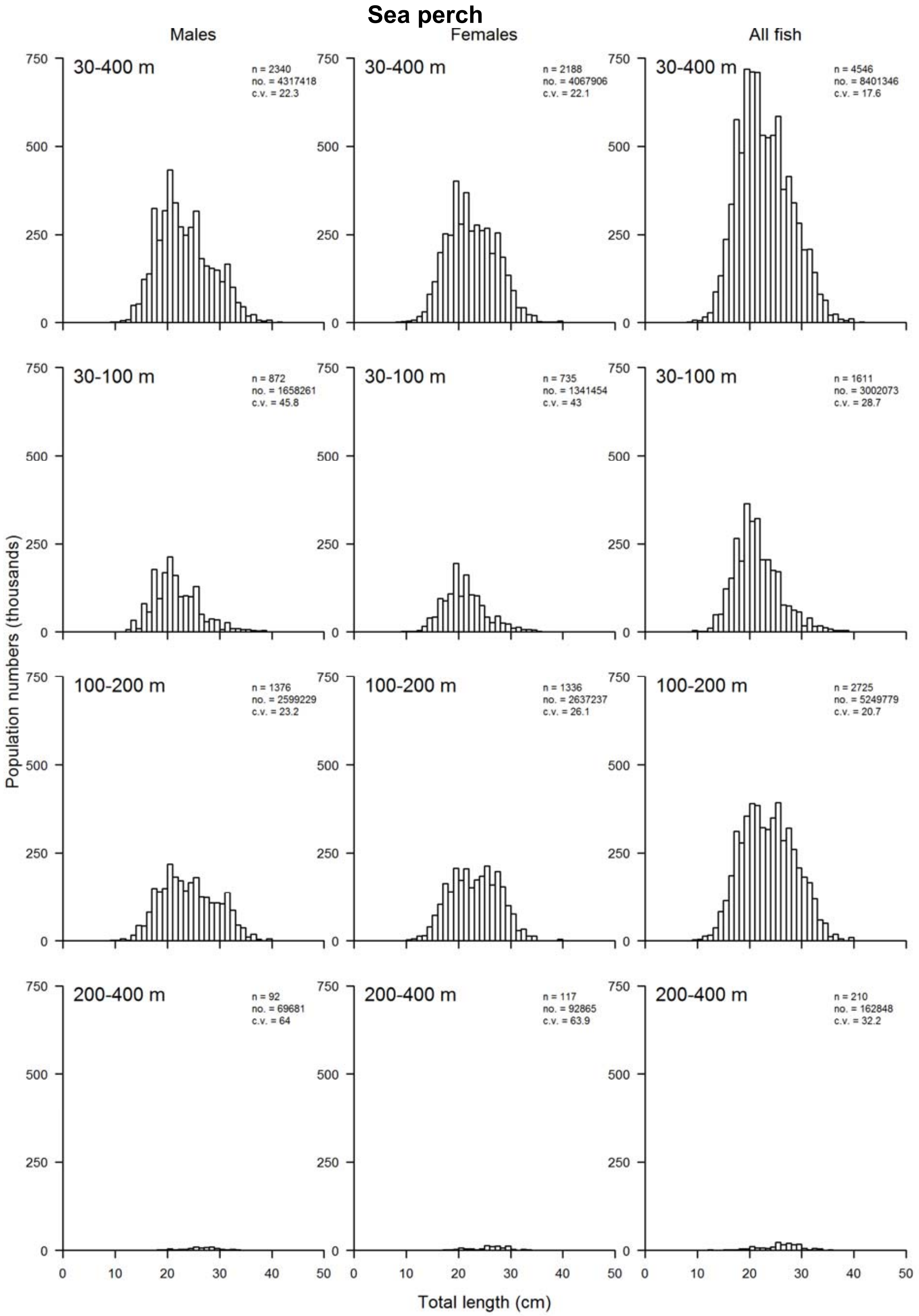


Figure 5 – *continued*

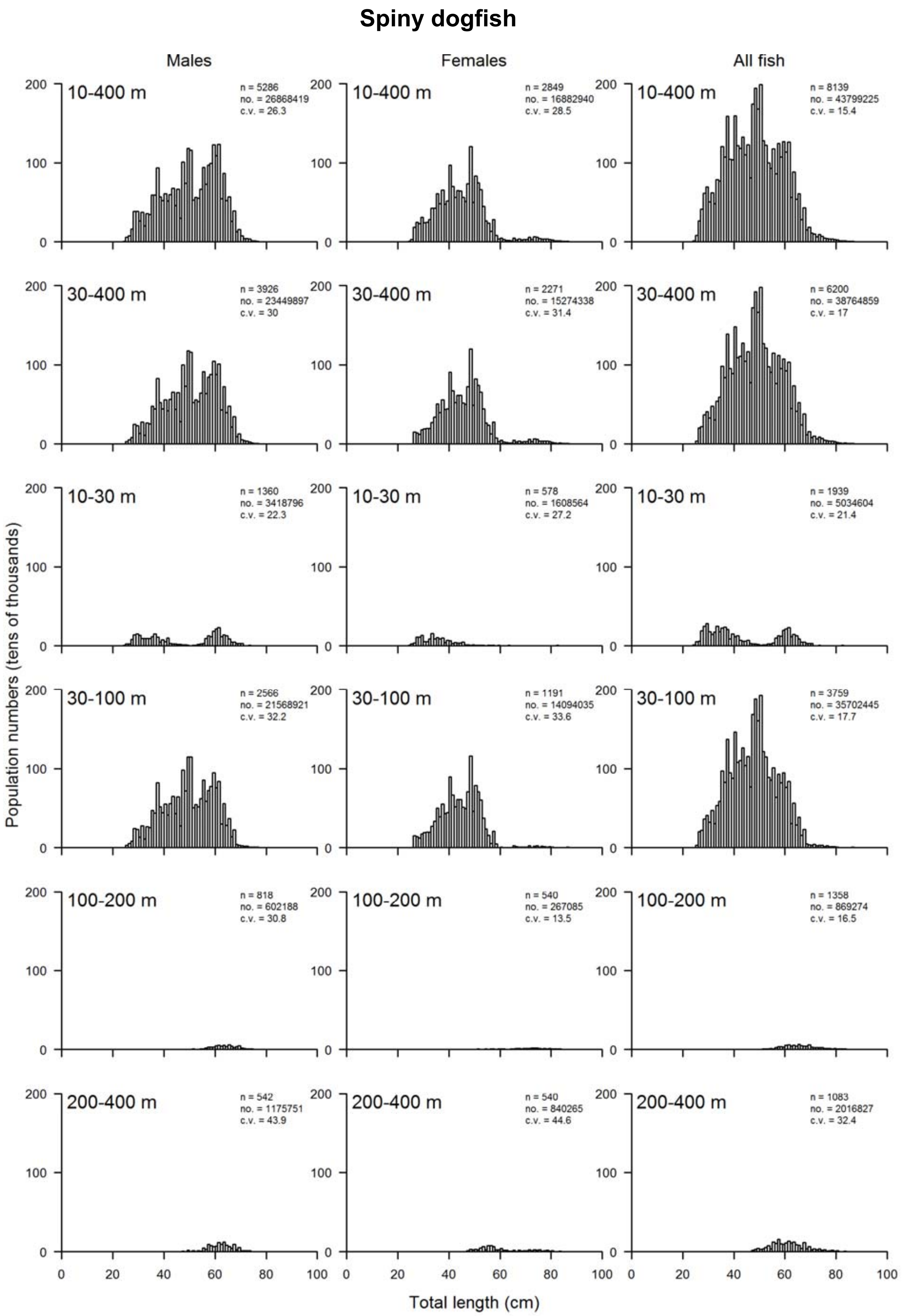


Figure 5–*continued*

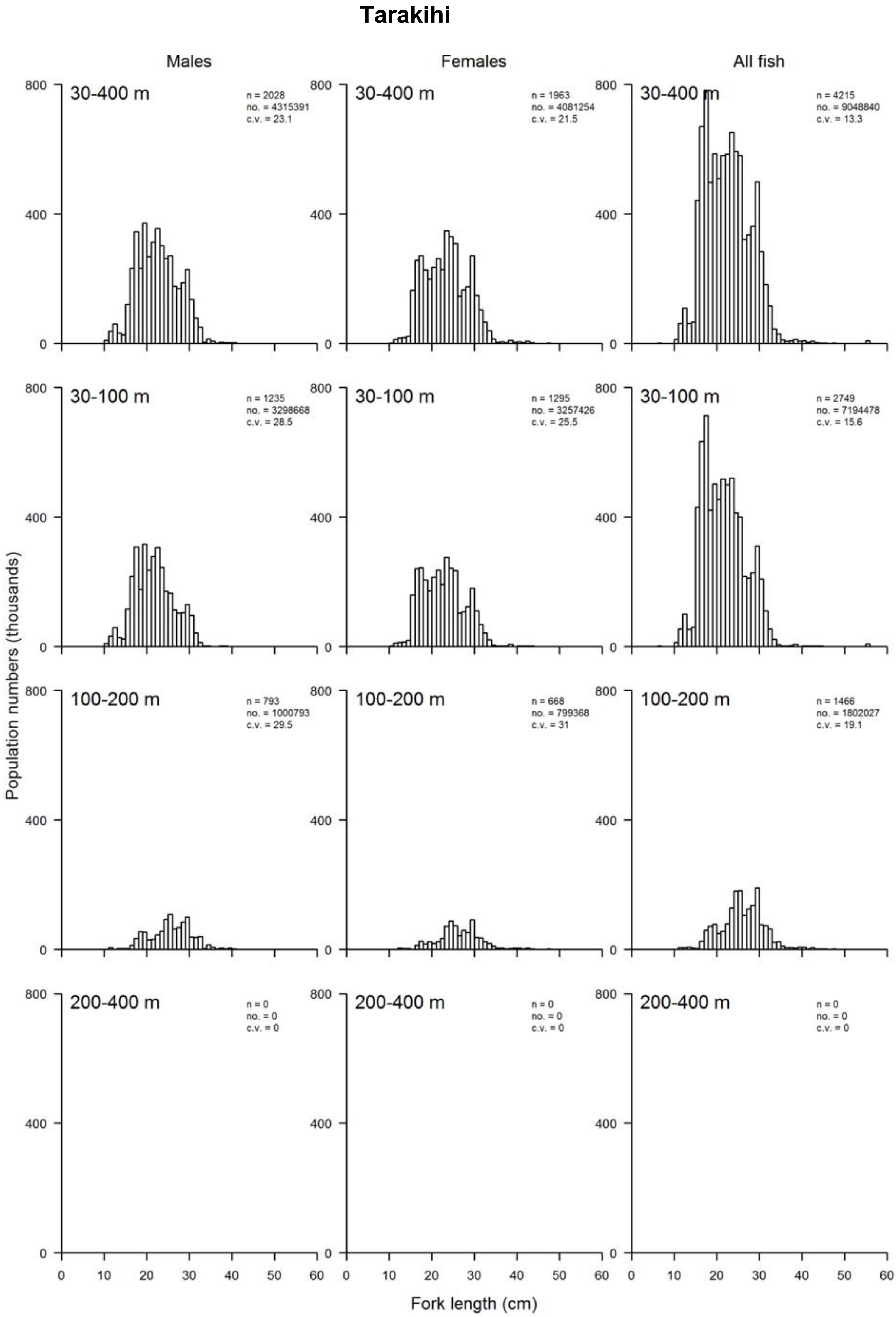


Figure 5–*continued*

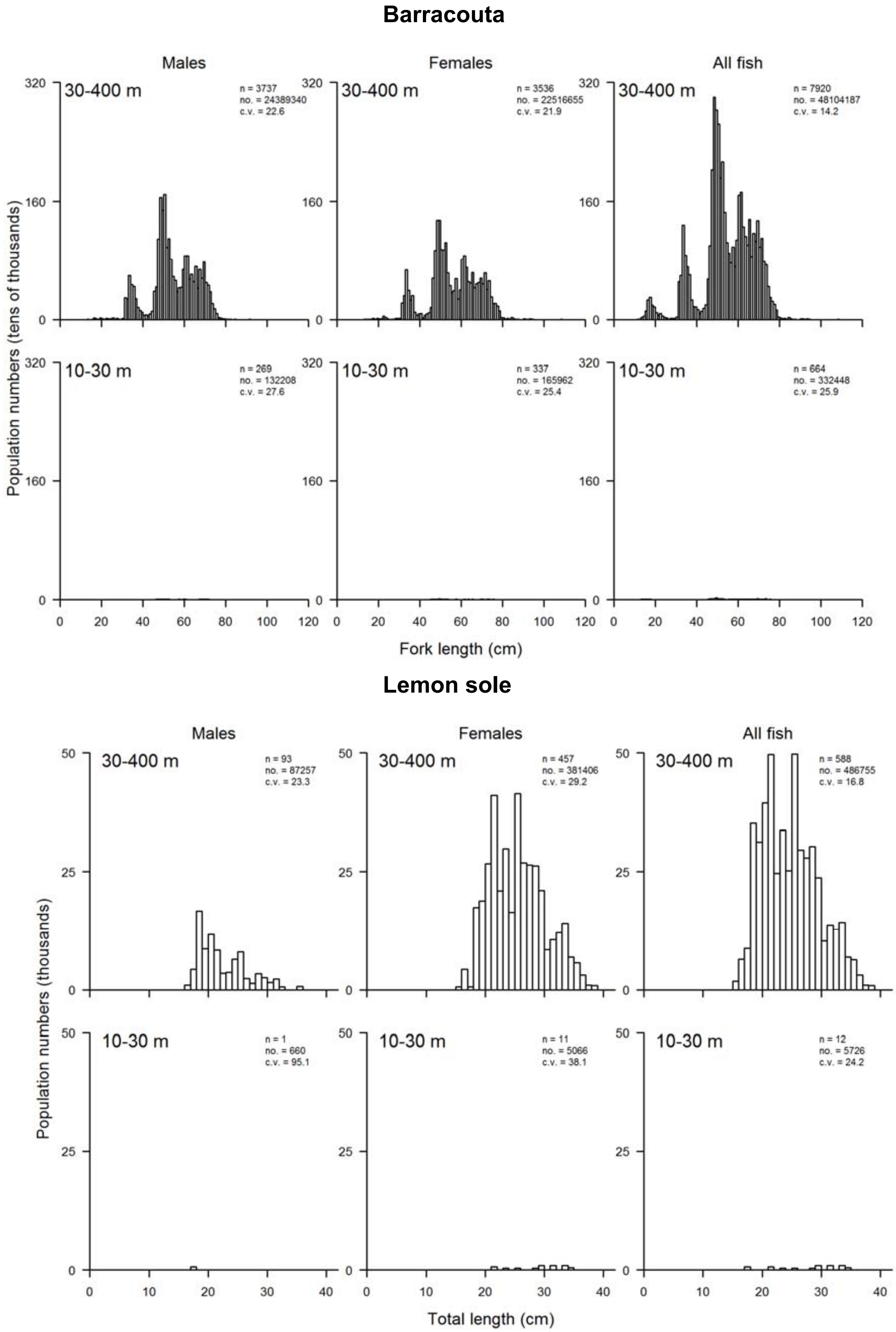
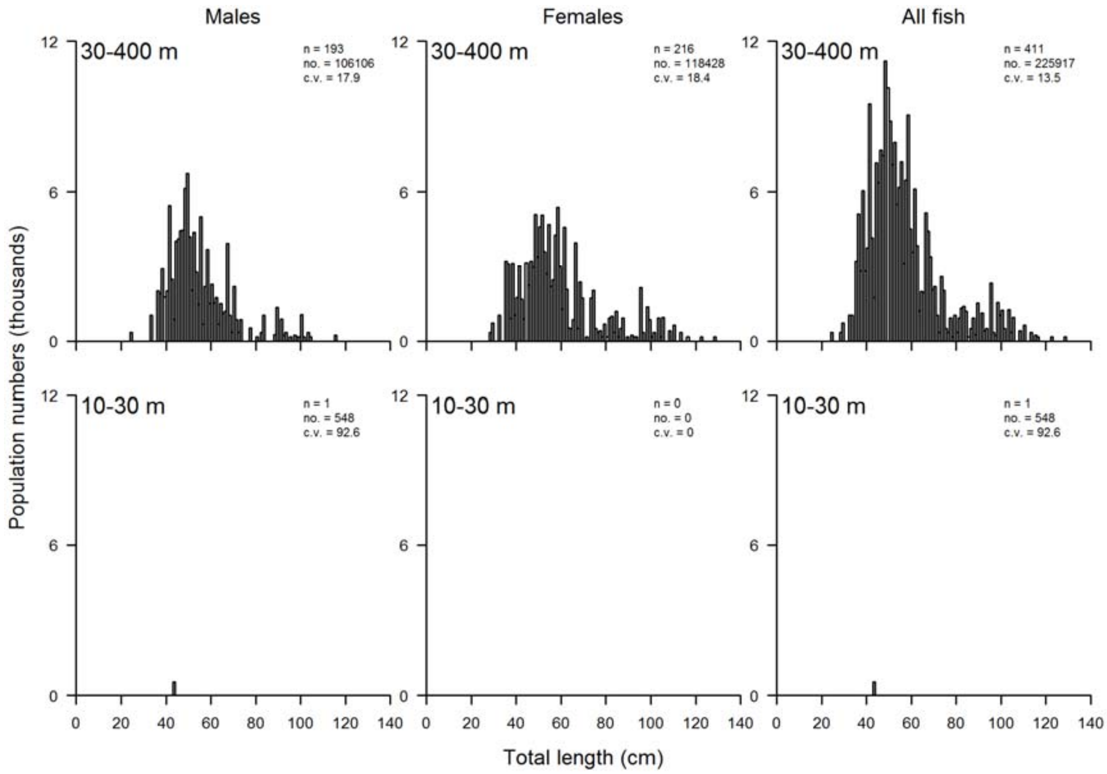


Figure 6: Scaled length frequency distributions for the key QMS species in 30–400 m, and 10–30 m for the 2014 survey. Population estimates are in thousands of fish.

Ling



Rig

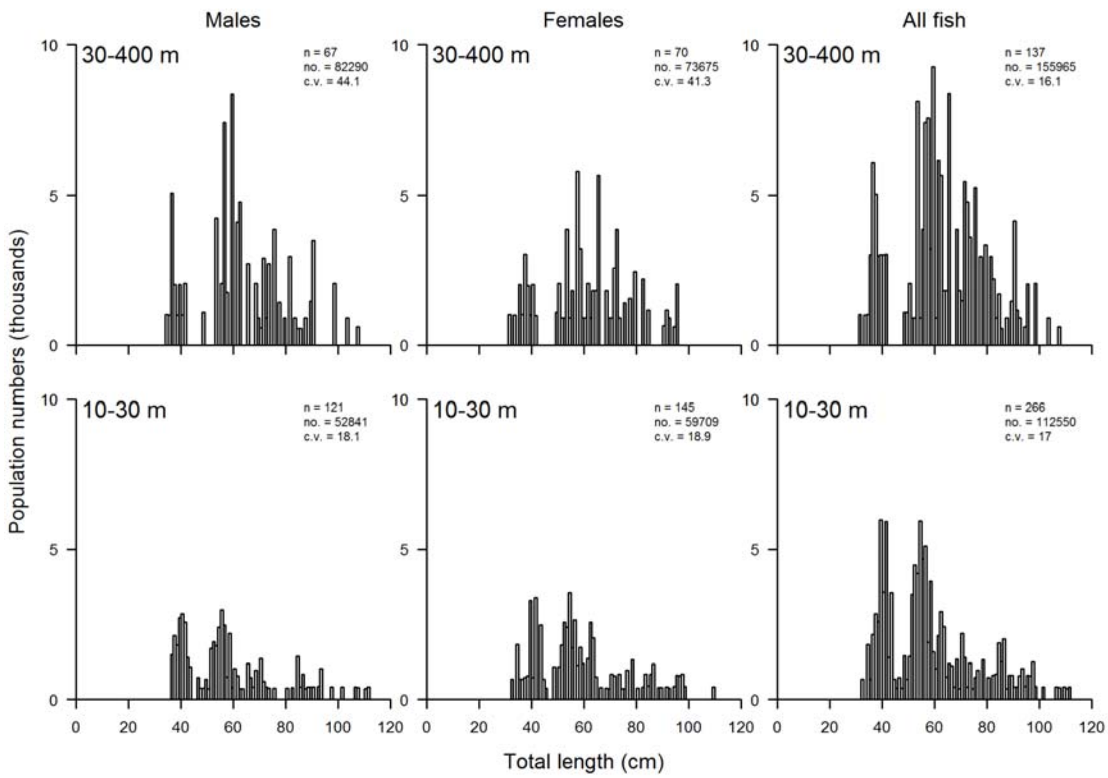
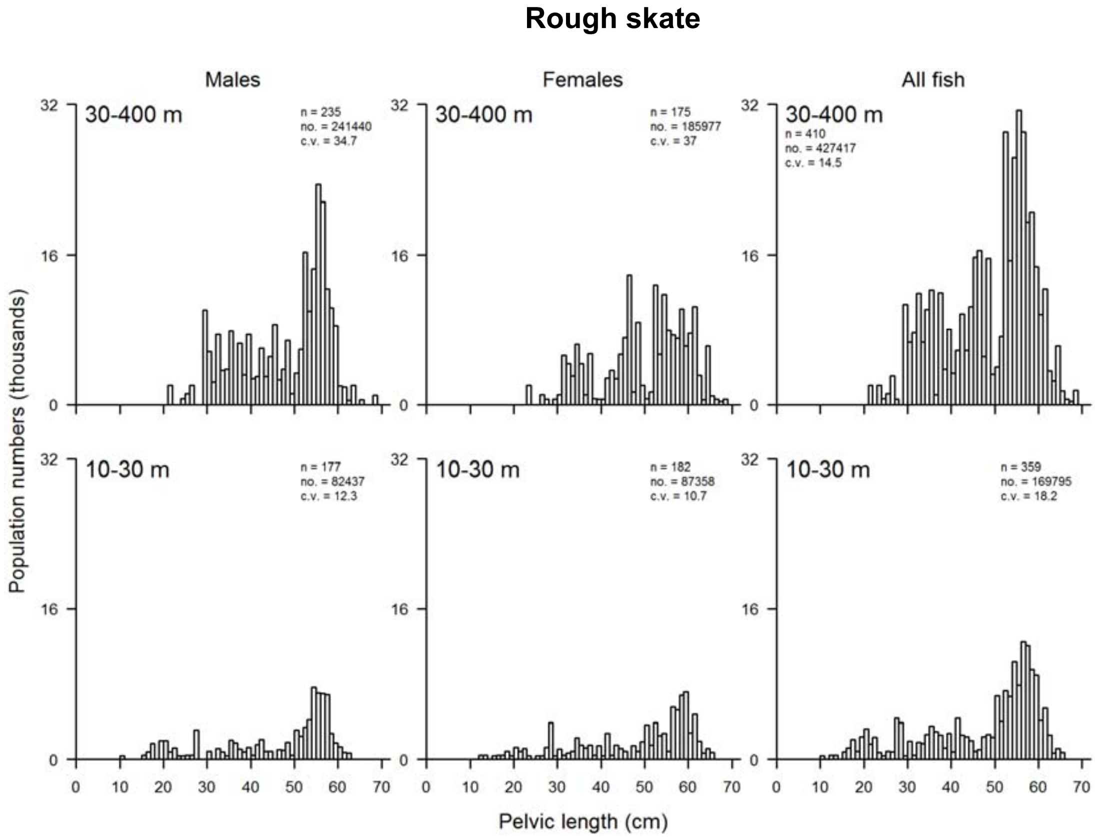


Figure 6 – *continued*



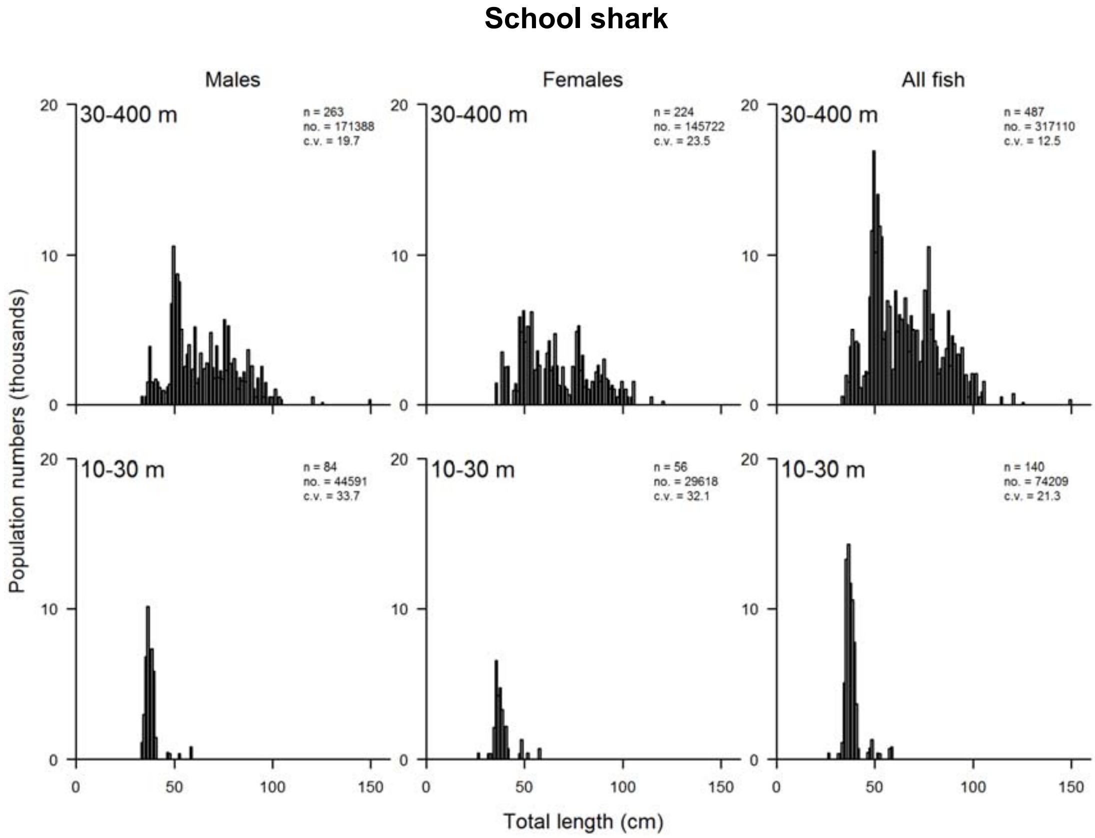
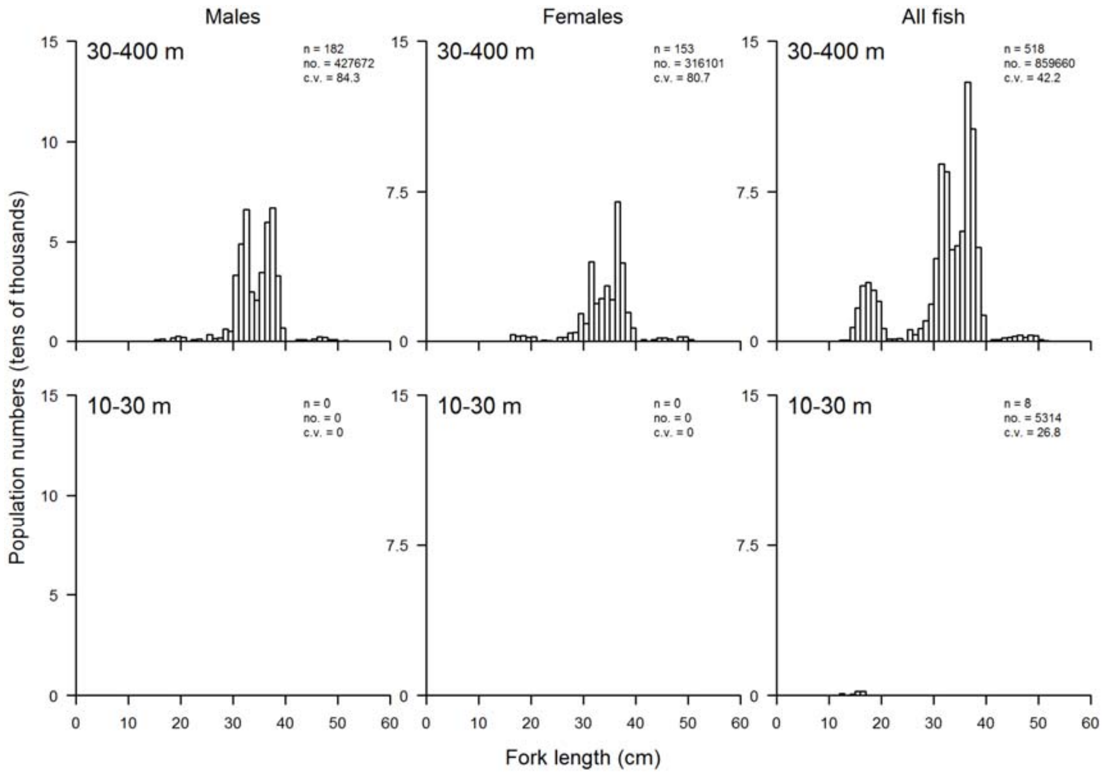


Figure 6 – *continued*

Silver warehou



Smooth skate

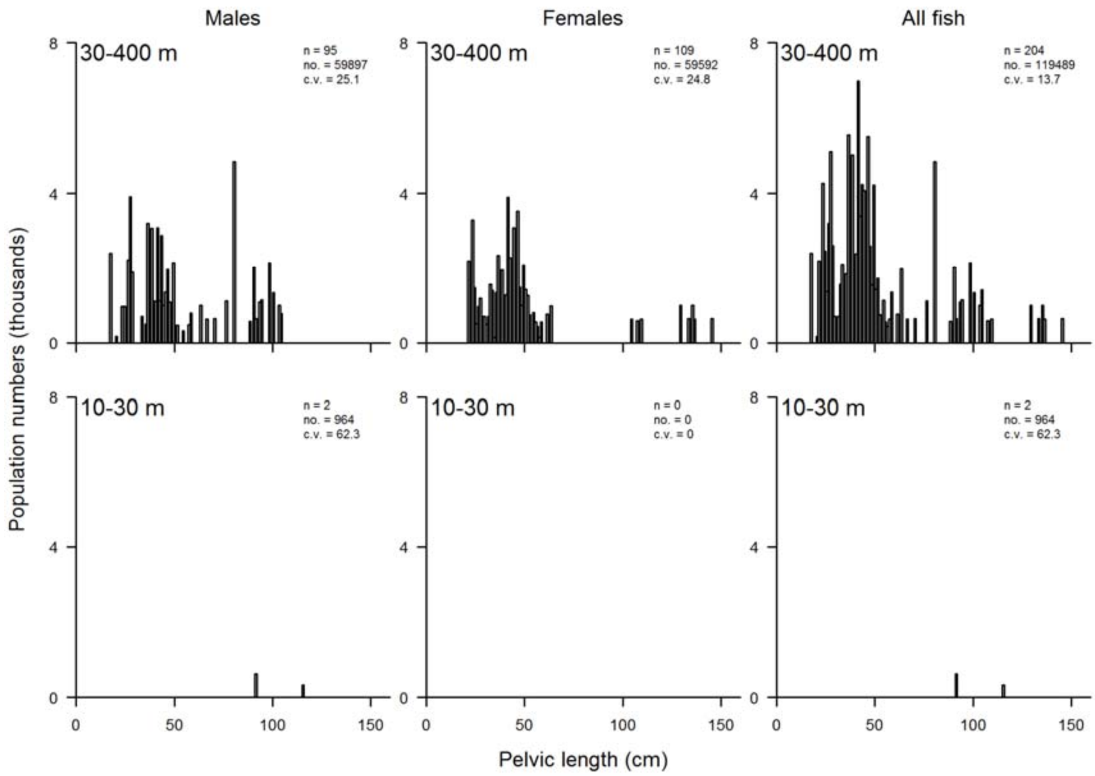
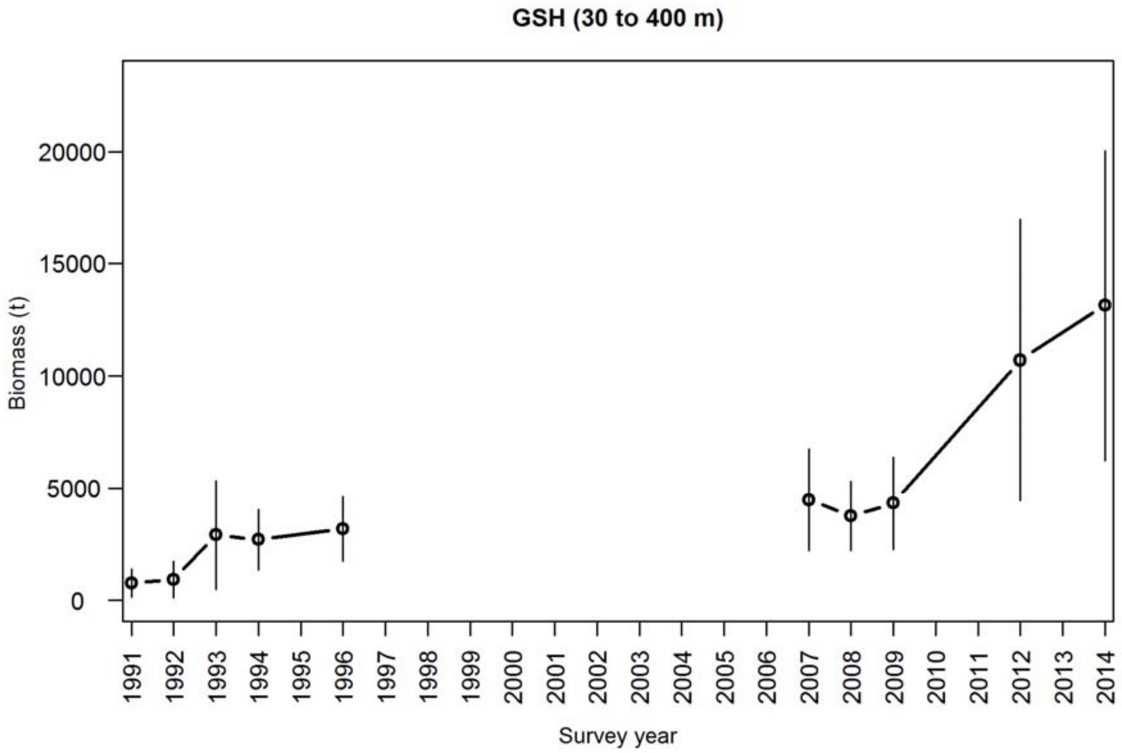


Figure 6 – *continued*



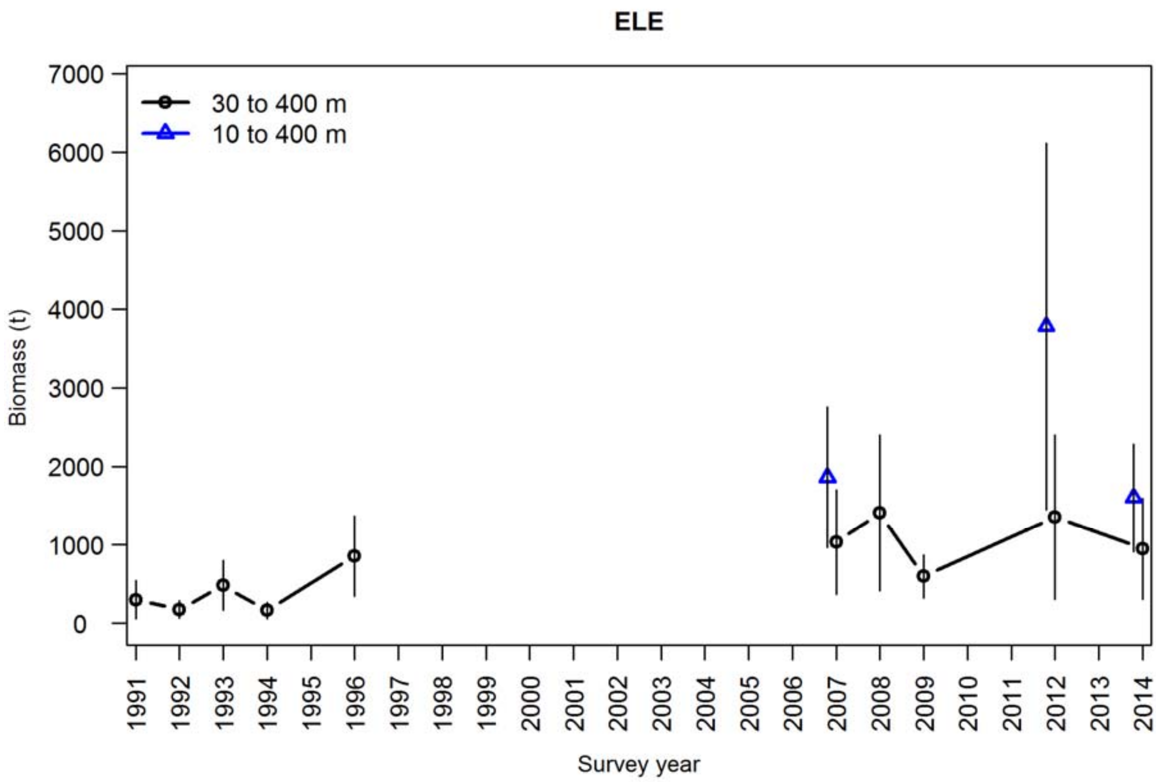
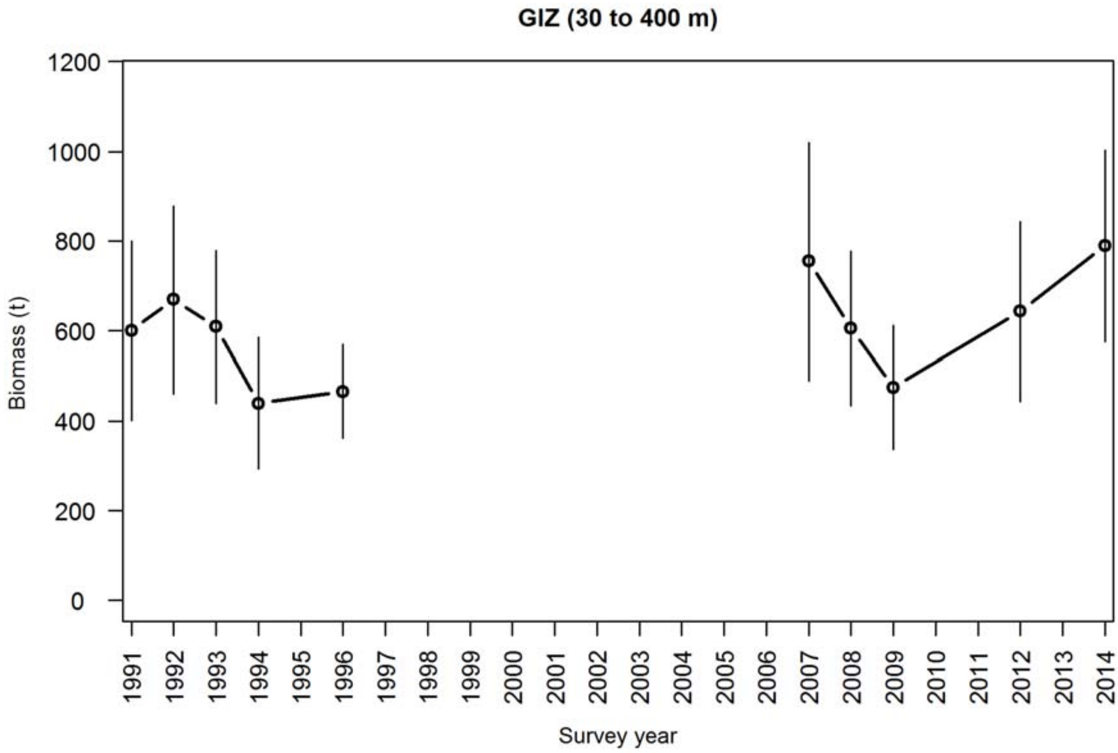


Figure 7: Target species total biomass and 95% confidence intervals for the all ECSI winter surveys in core strata (30–400 m), and core plus shallow strata (10–400 m) for species found in less than 30 m in 2007 2012, and 2014.



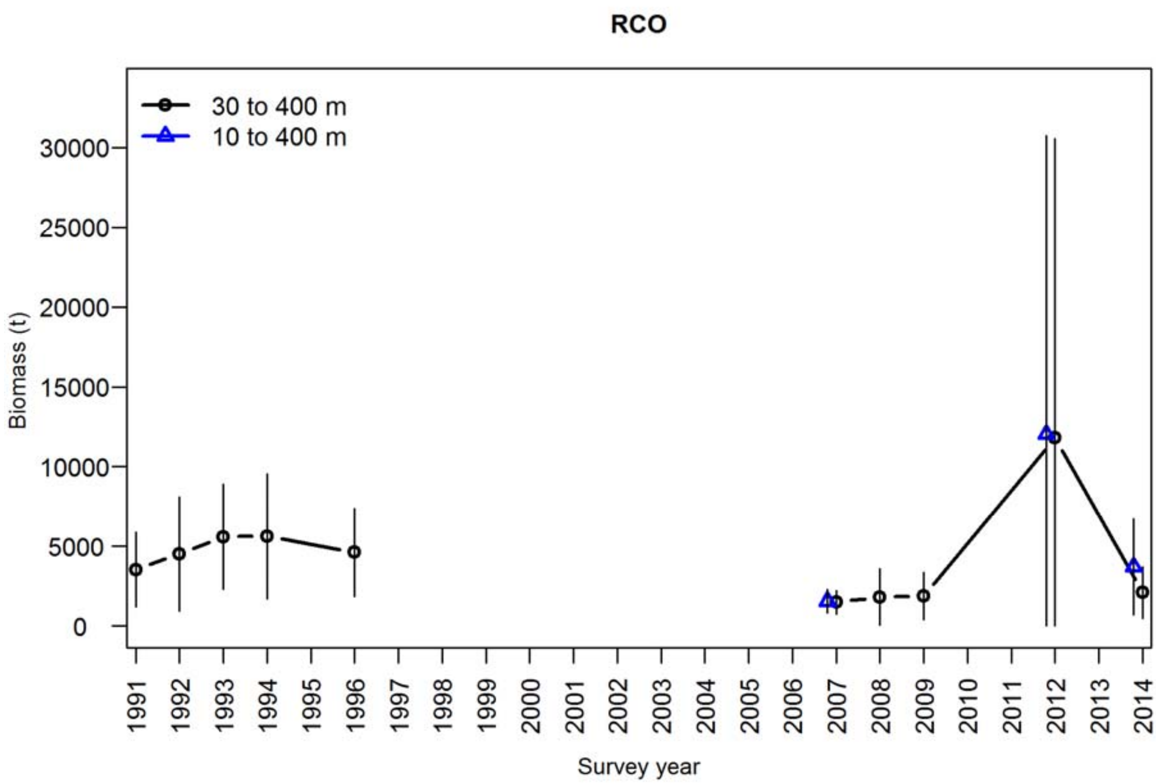
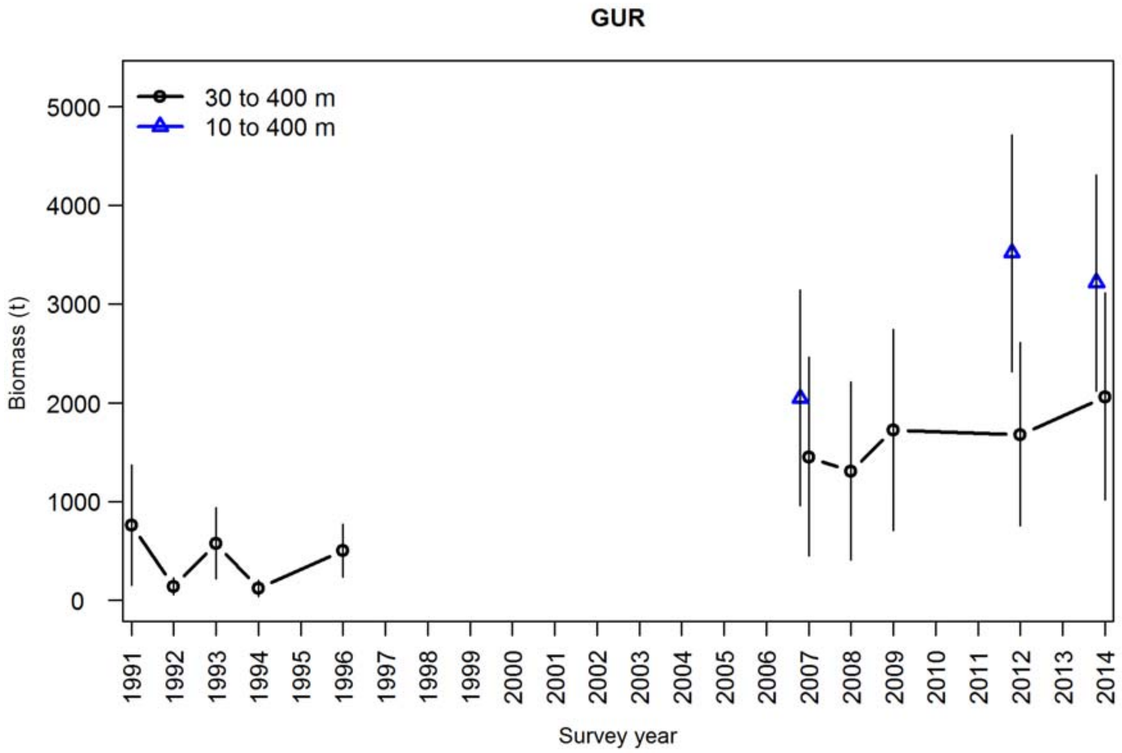


Figure 7 – ***continued***



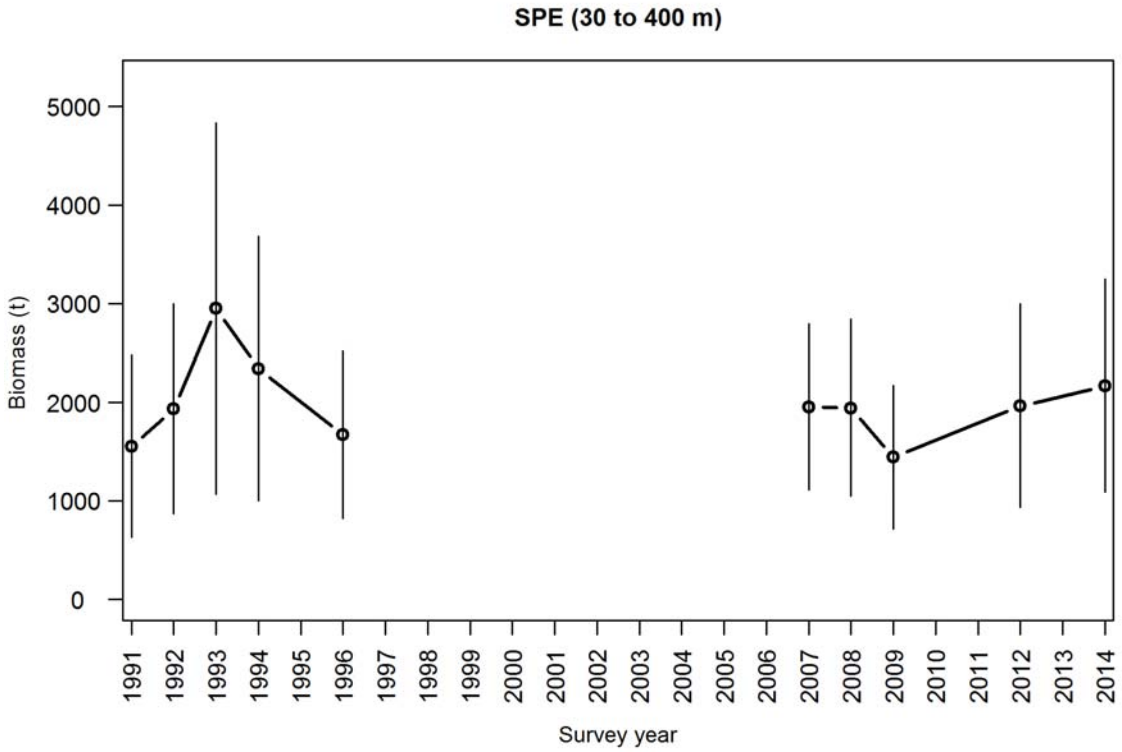
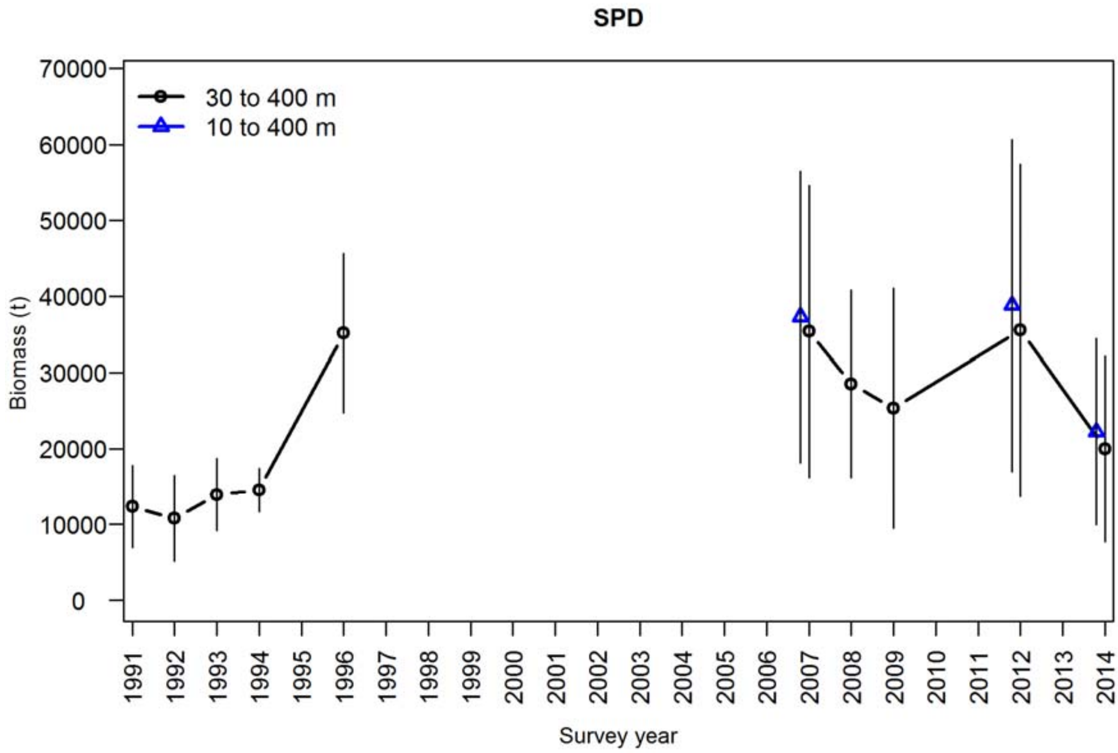


Figure 7 – *continued*



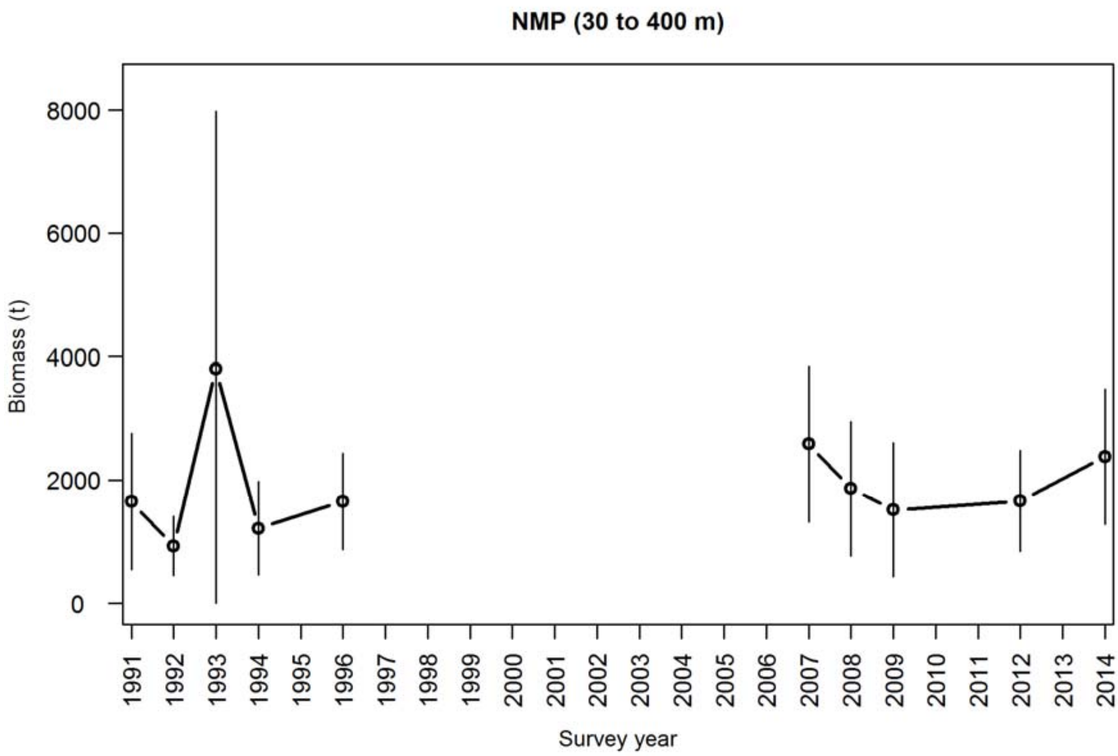


Figure 7 – *continued*

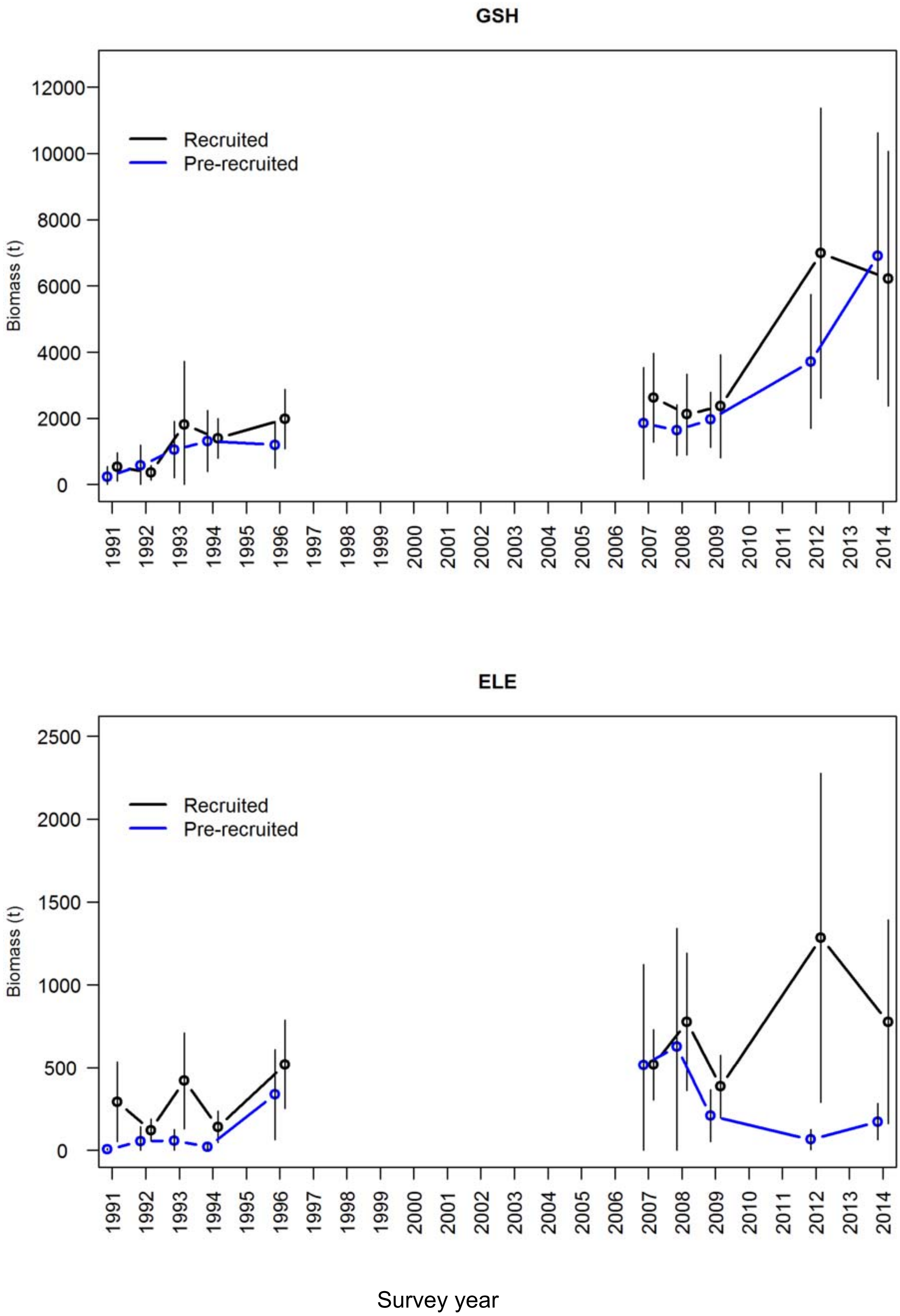


Figure 8: Target species recruited and pre-recruited biomass and 95% confidence intervals for all ECSI winter surveys in core strata (30–400 m).

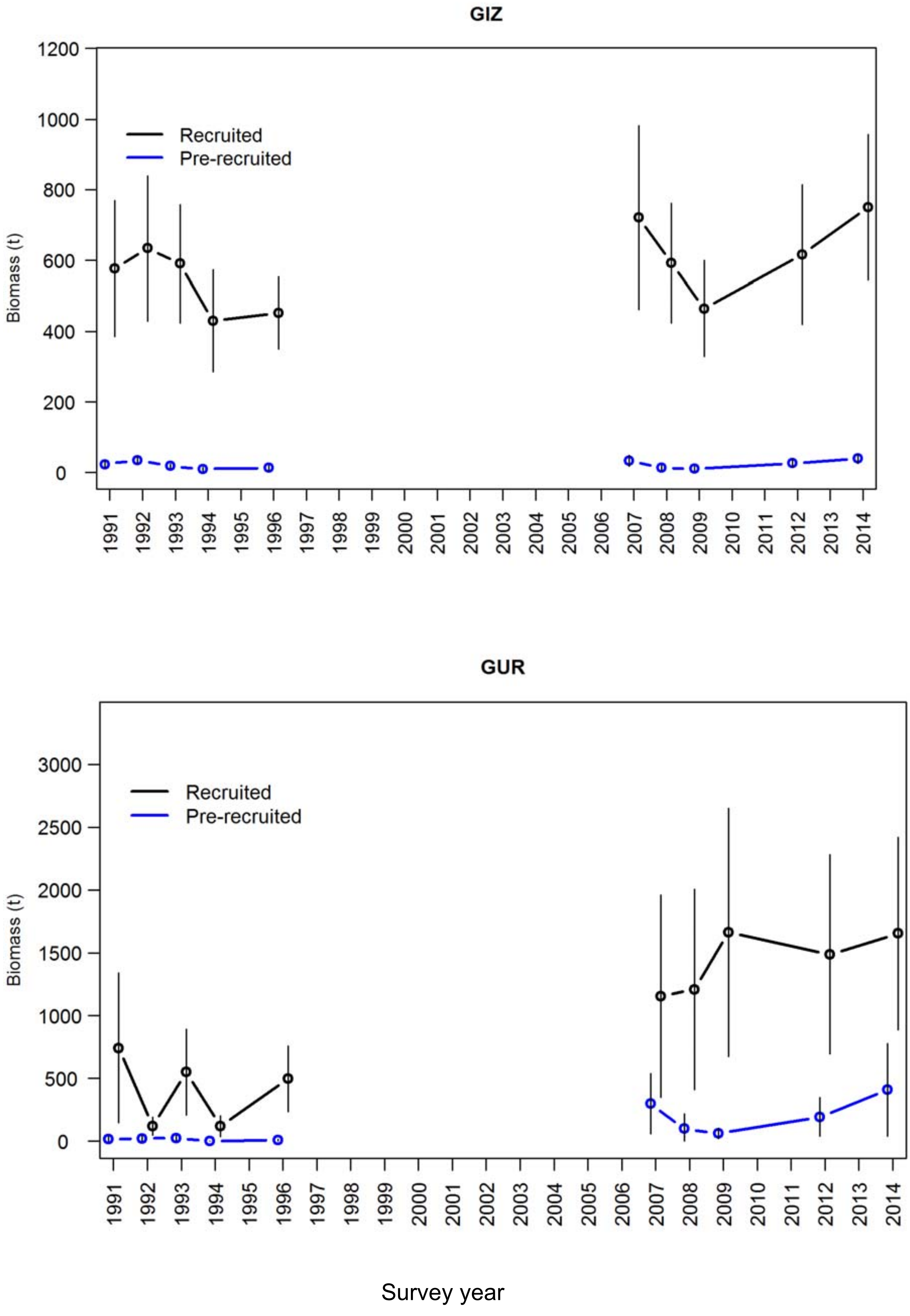


Figure 8 – ***continued***

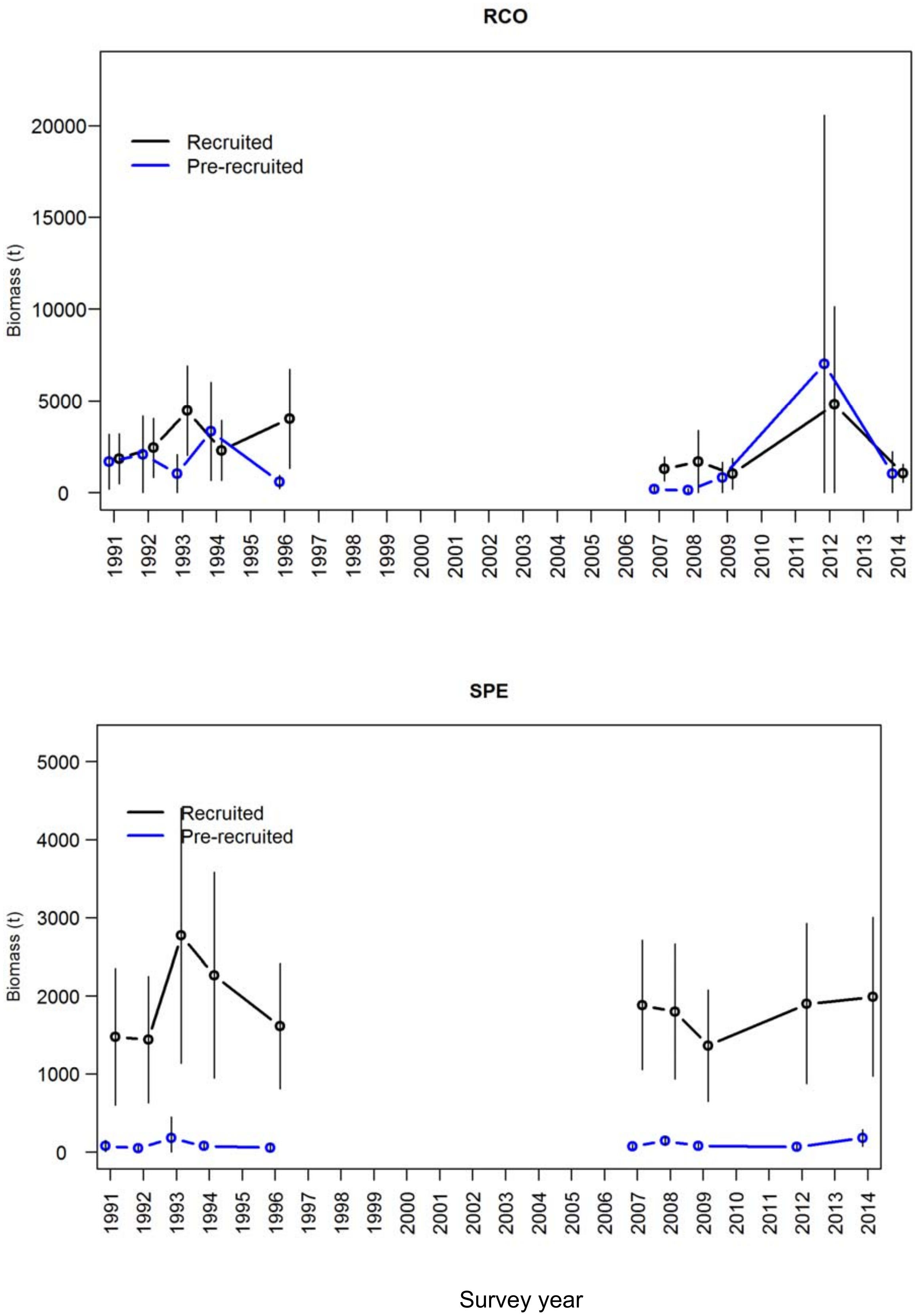
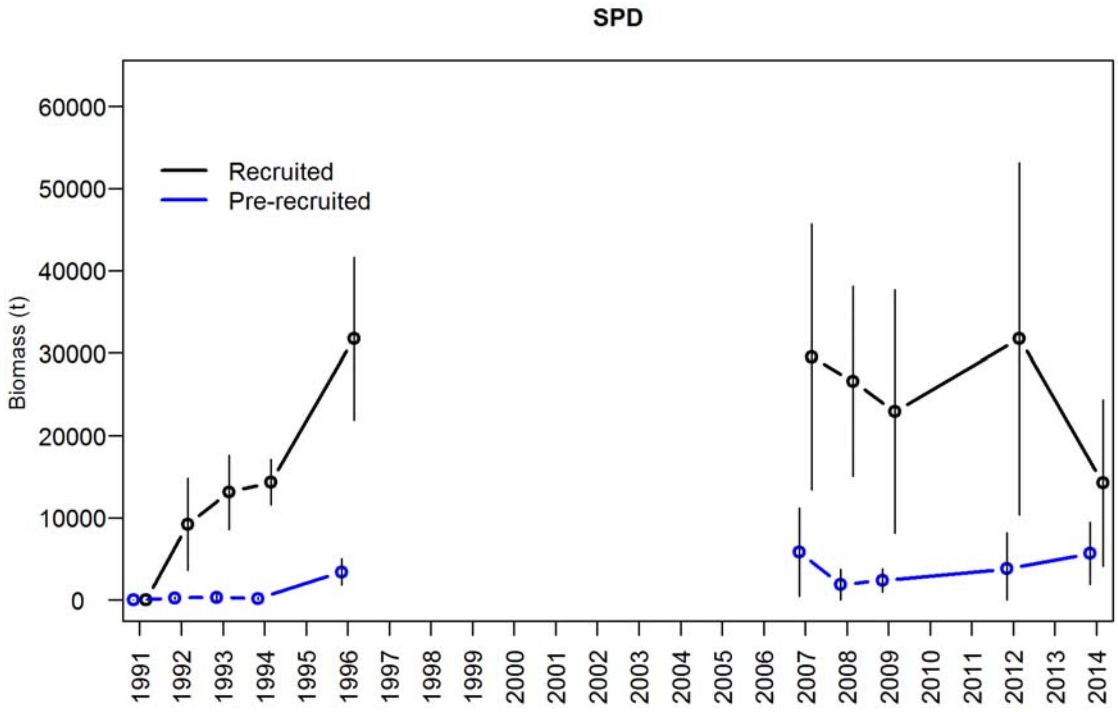


Figure 8 – *continued*



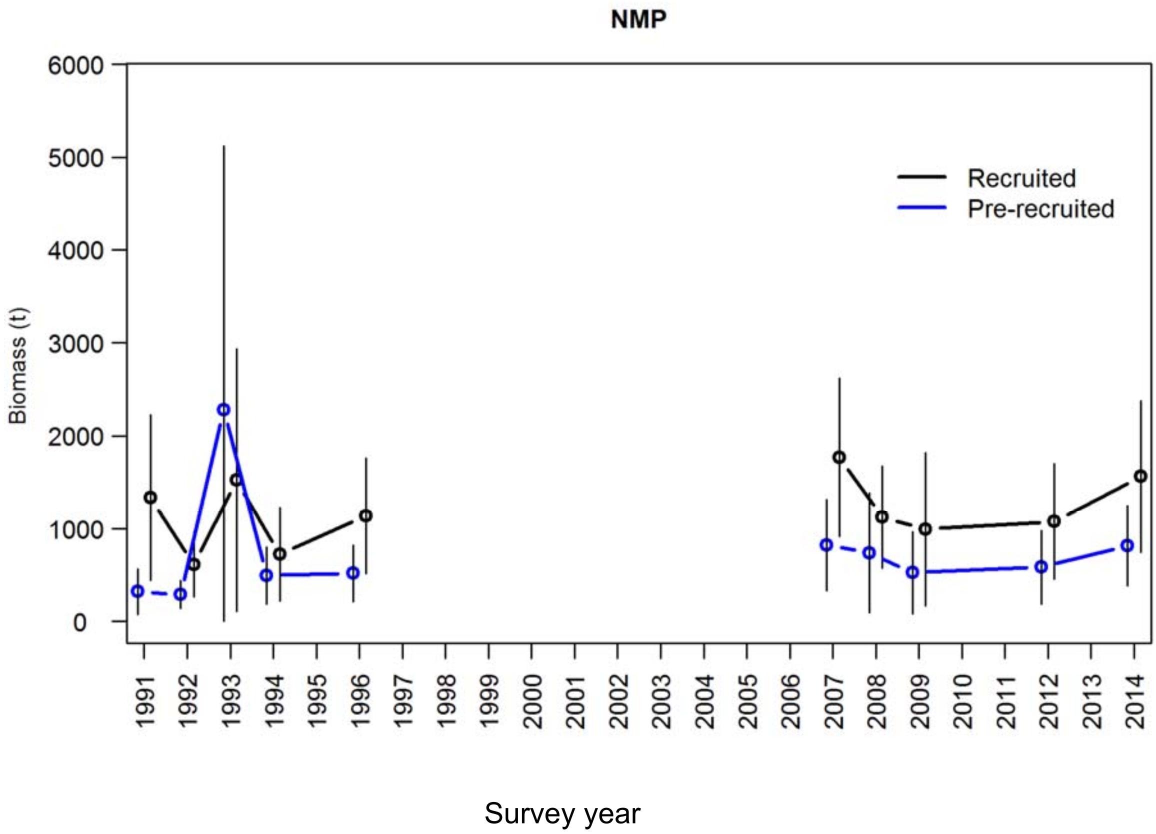


Figure 8 – ***continued***

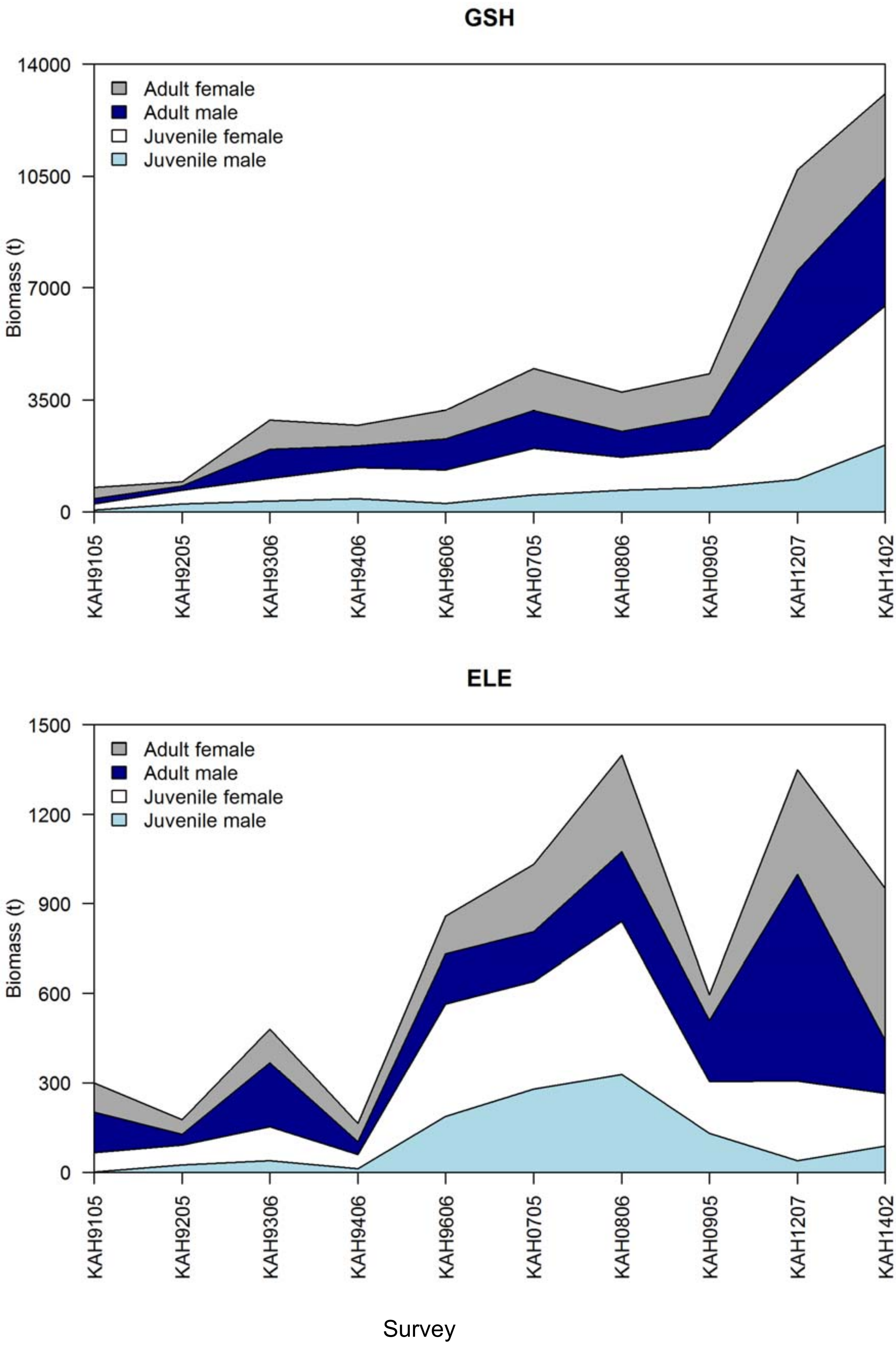
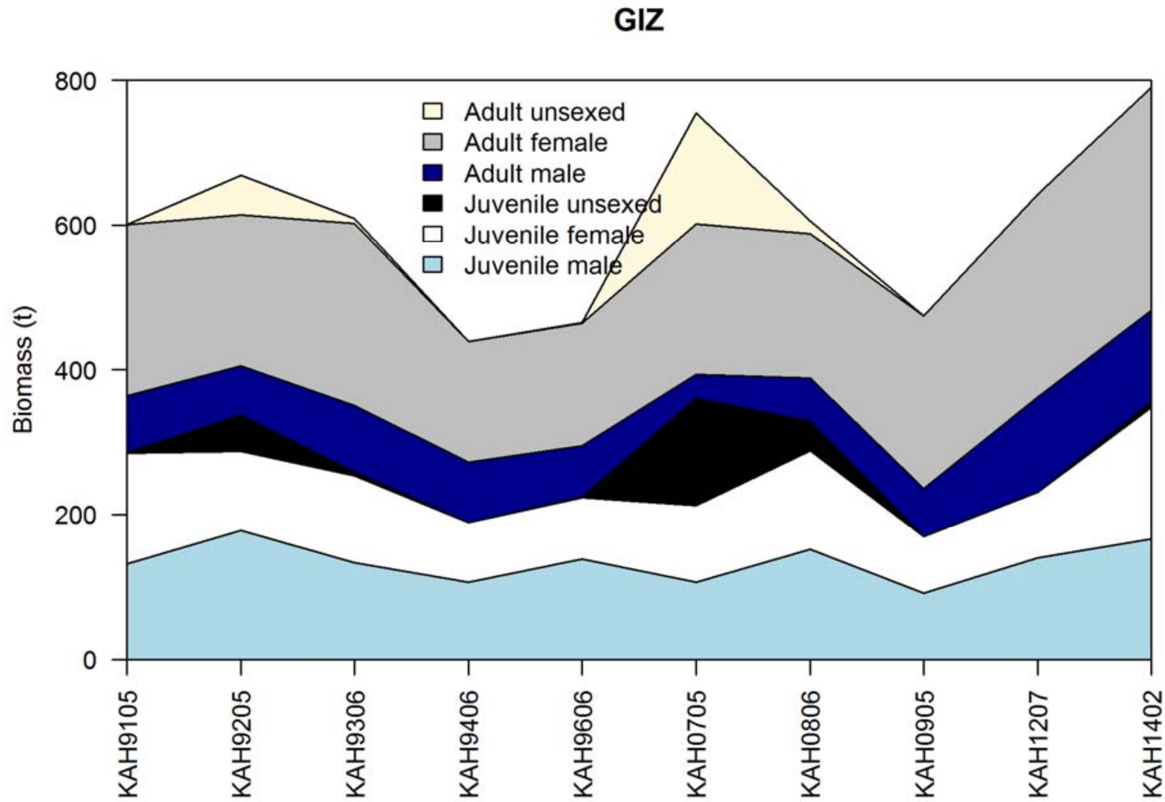
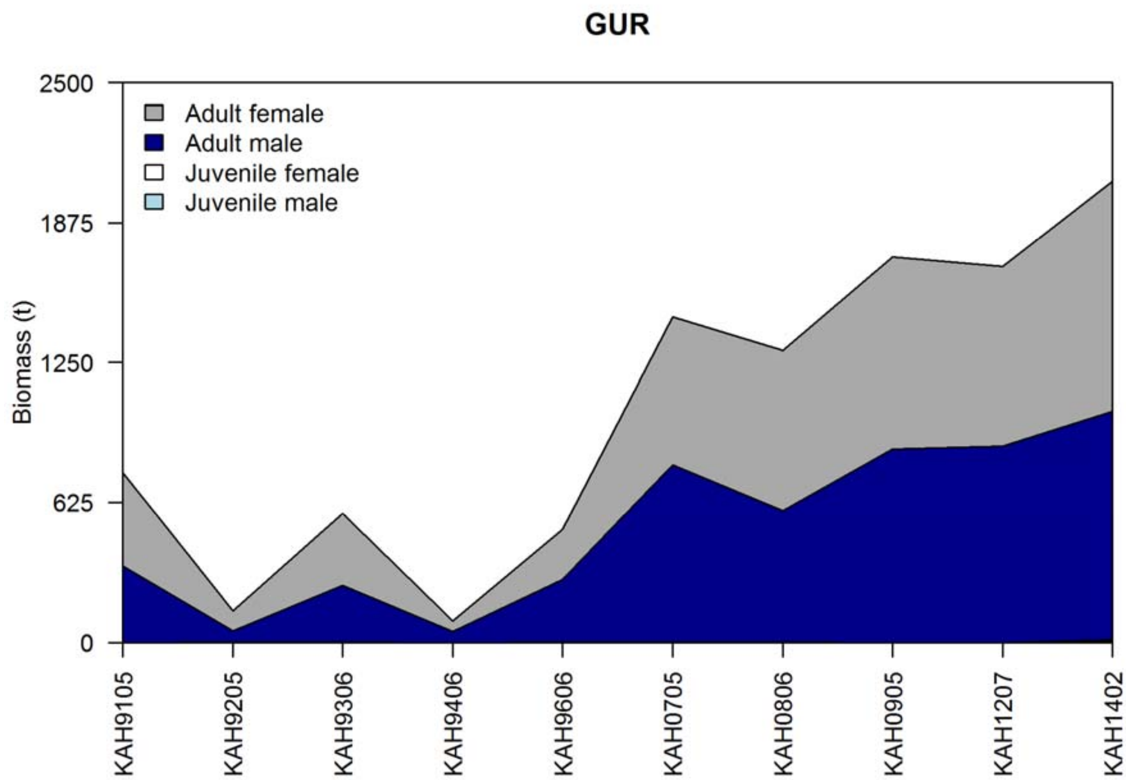


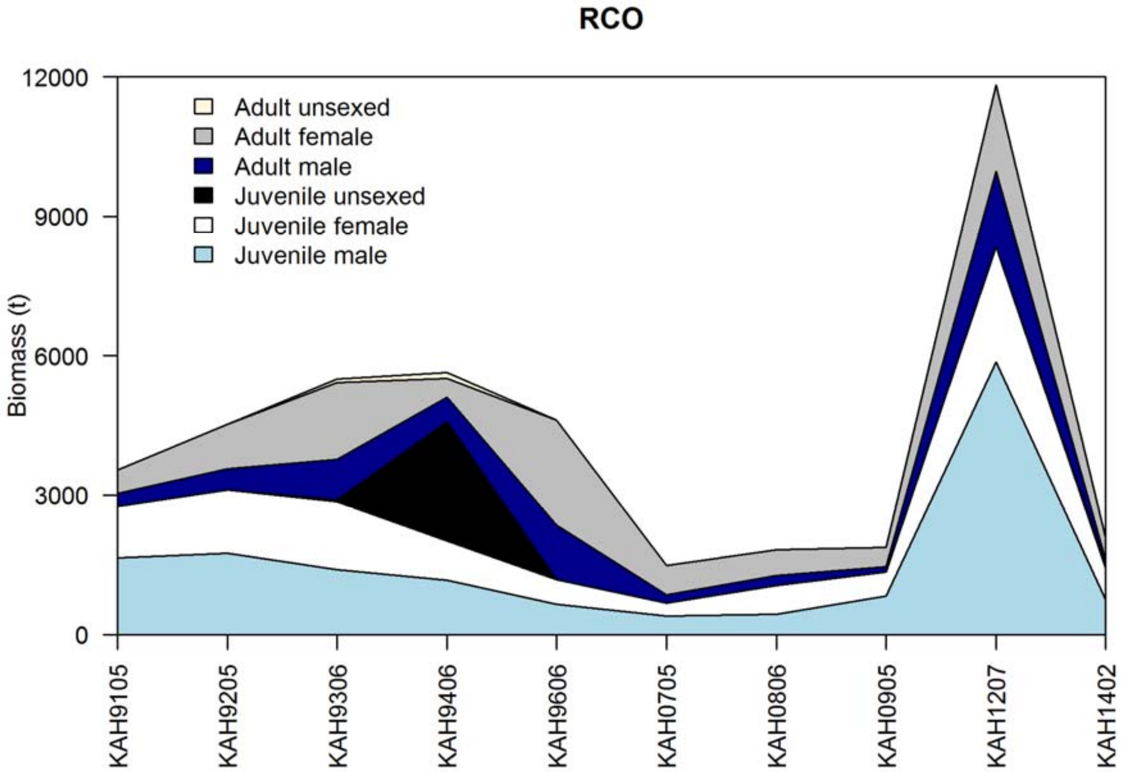
Figure 9: Target species juvenile and adult biomass for ECSI winter surveys in core strata (30–400 m), where juvenile is below and adult is equal to or above length at which 50% of fish are mature.


GIZ
Adult unsexed
Adult female
Adult male
Juvenile unsexed
Juvenile female
Juvenile male
Biomass (t)
800
600
400
200
0
KAH9105
KAH9205
KAH9306
KAH9406
KAH9606
KAH0705
KAH0806
KAH0905
KAH1207
KAH1402


GUR
Adult female
Adult male
Juvenile female
Juvenile male
Biomass (t)
2500
1875
1250
625
0
KAH9105
KAH9205
KAH9306
KAH9406
KAH9606
KAH0705
KAH0806
KAH0905
KAH1207
KAH1402

Survey

Figure 9 – *continued*



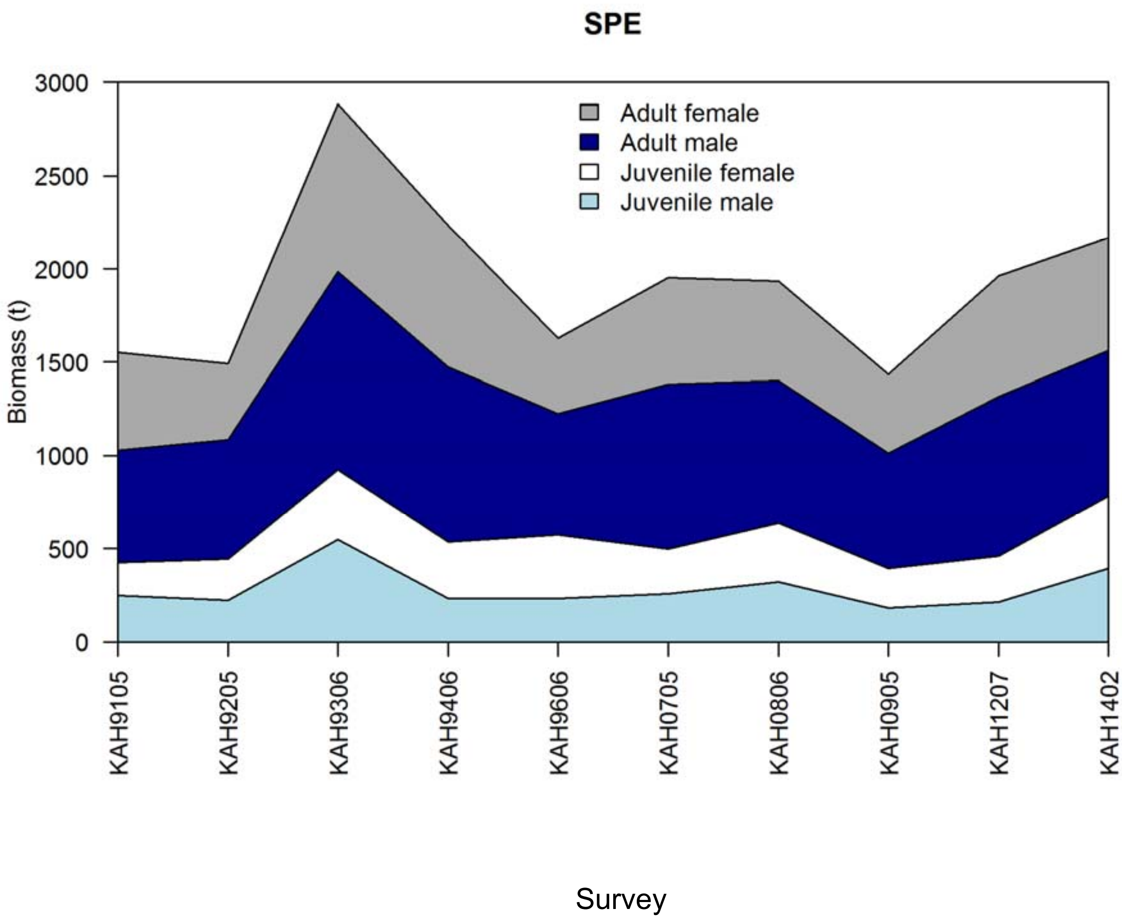


Figure 9 – *continued*

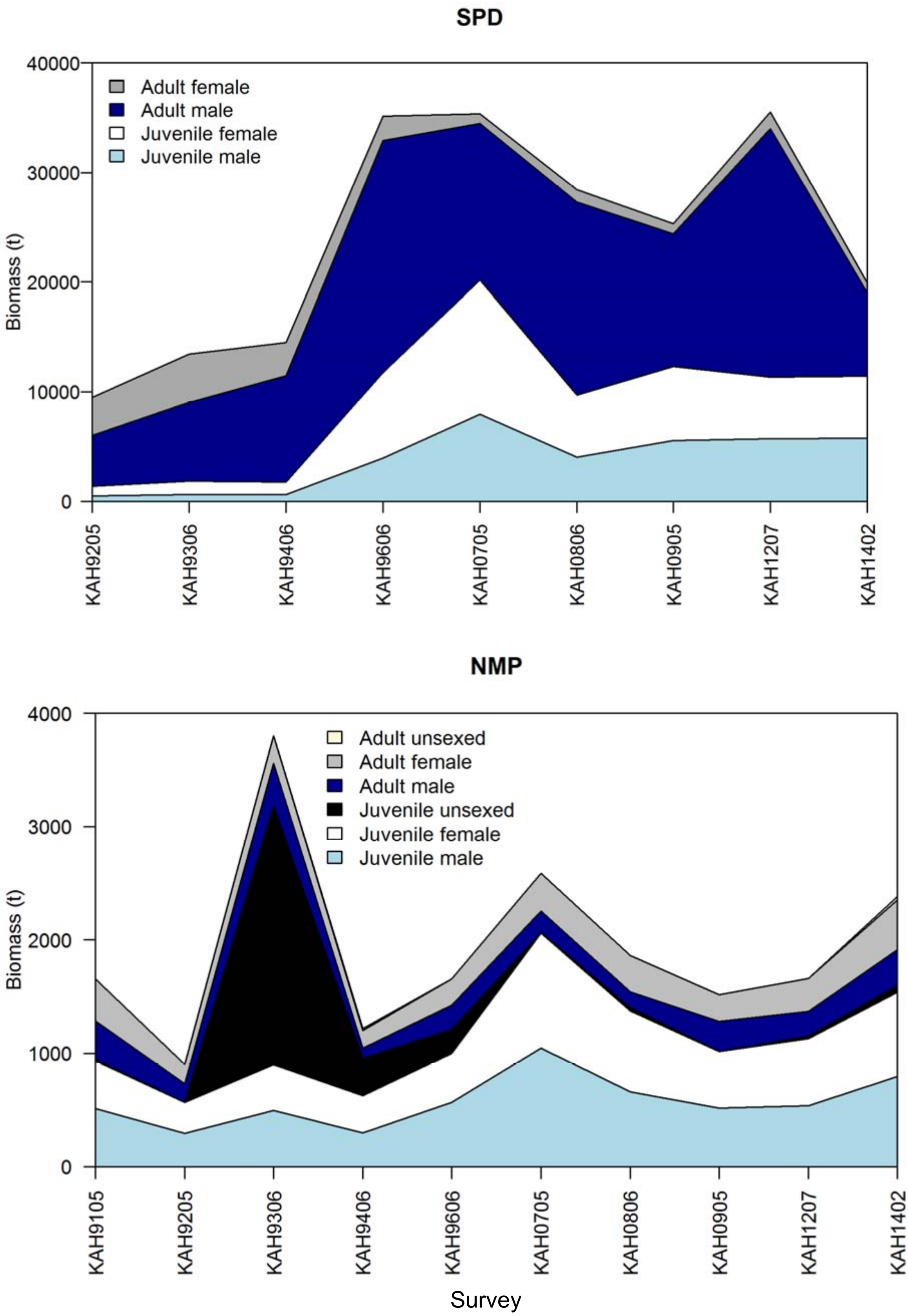


Figure 9 – *continued*.

Dark ghost shark (1991 to 1996)

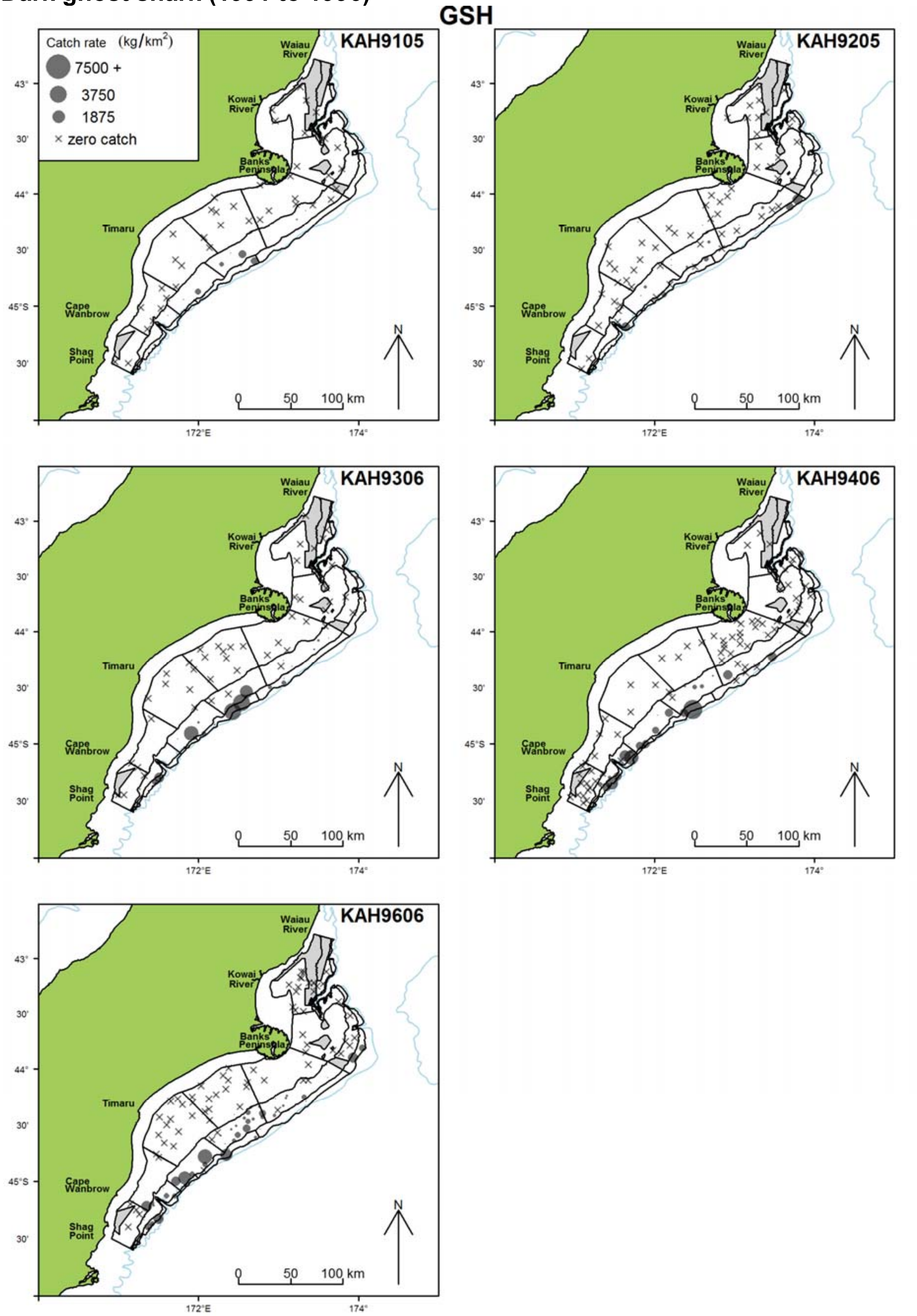


Figure 10: Target species catch rates (kg.km^{-2}) by tow plotted for the ten ECSI winter trawl surveys.

Dark ghost shark (2007 to 2014)

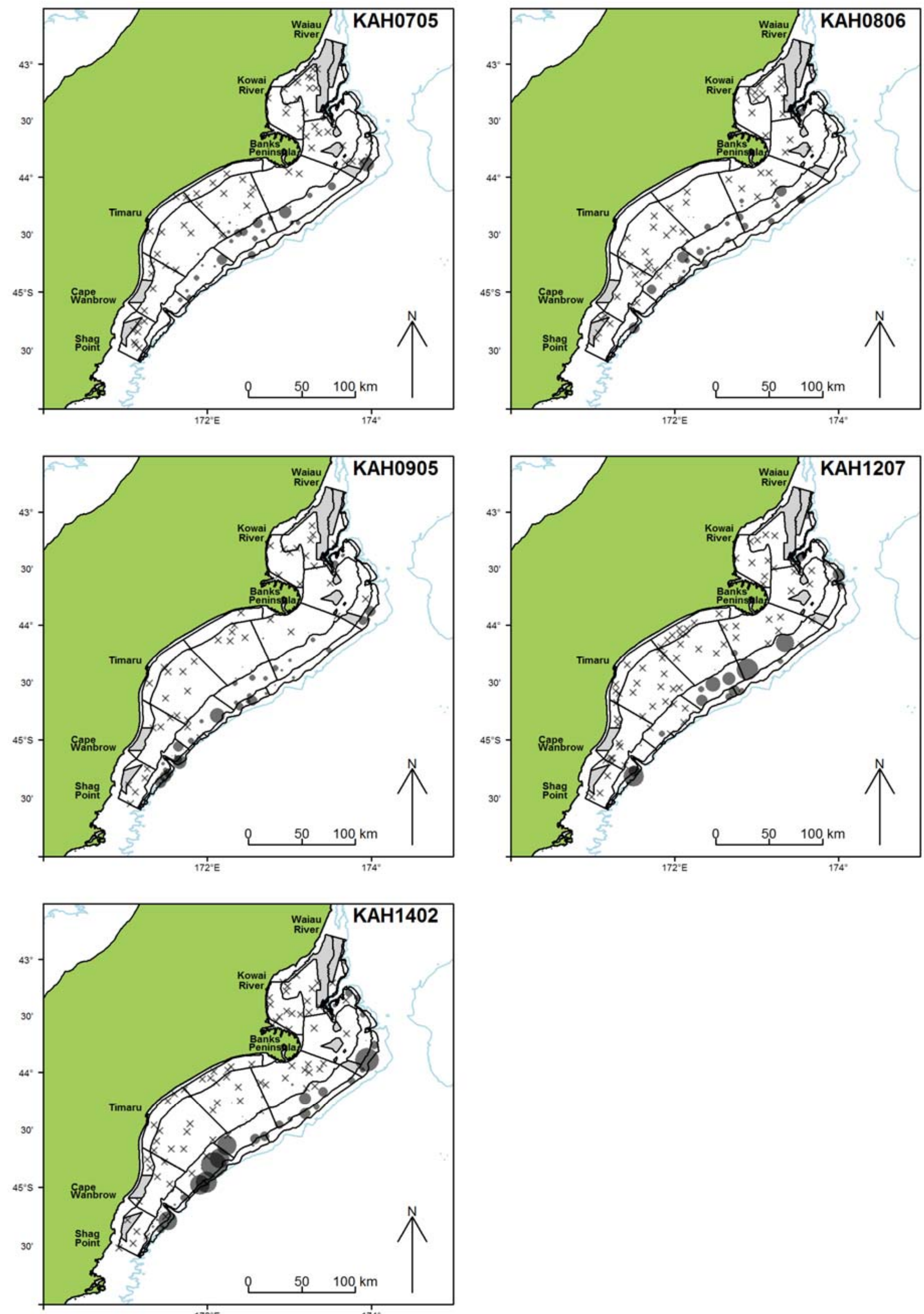


Figure 10 – ***continued***

Elephantfish (1991 to 1996)

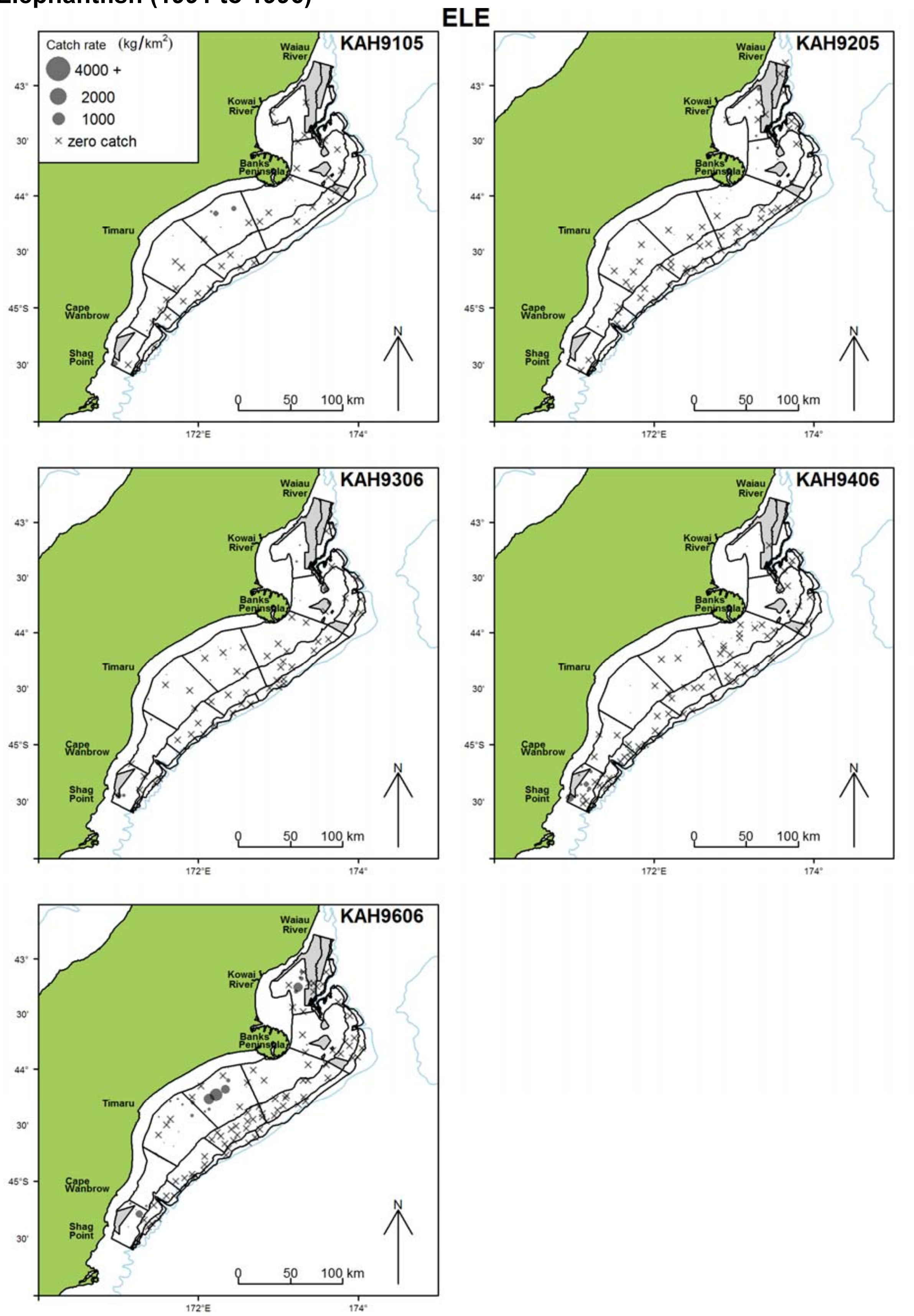


Figure 10 – ***continued***

Elephantfish (2007 to 2014)

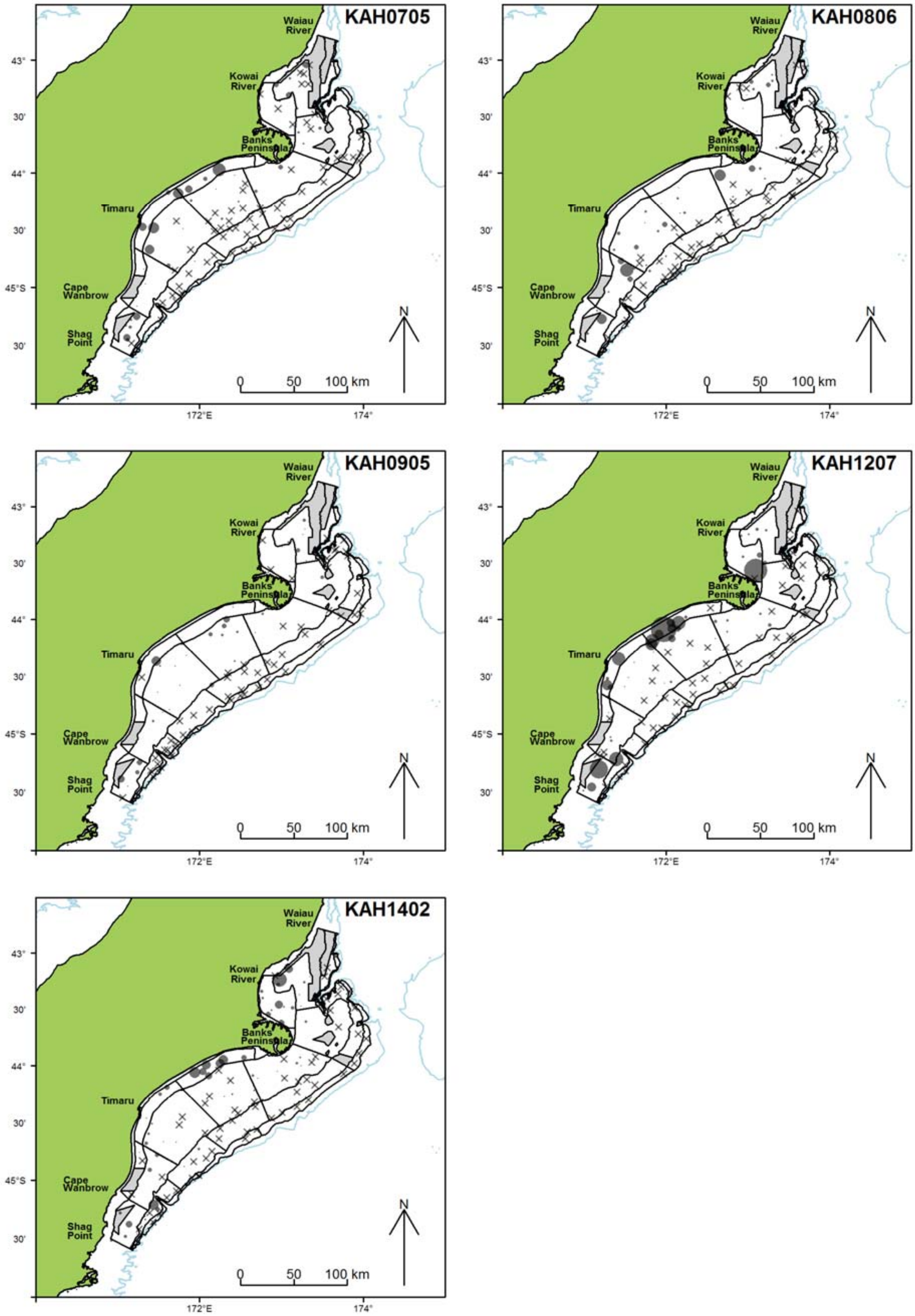


Figure 10 – ***continued***

Giant stargazer (1991 to 1996)

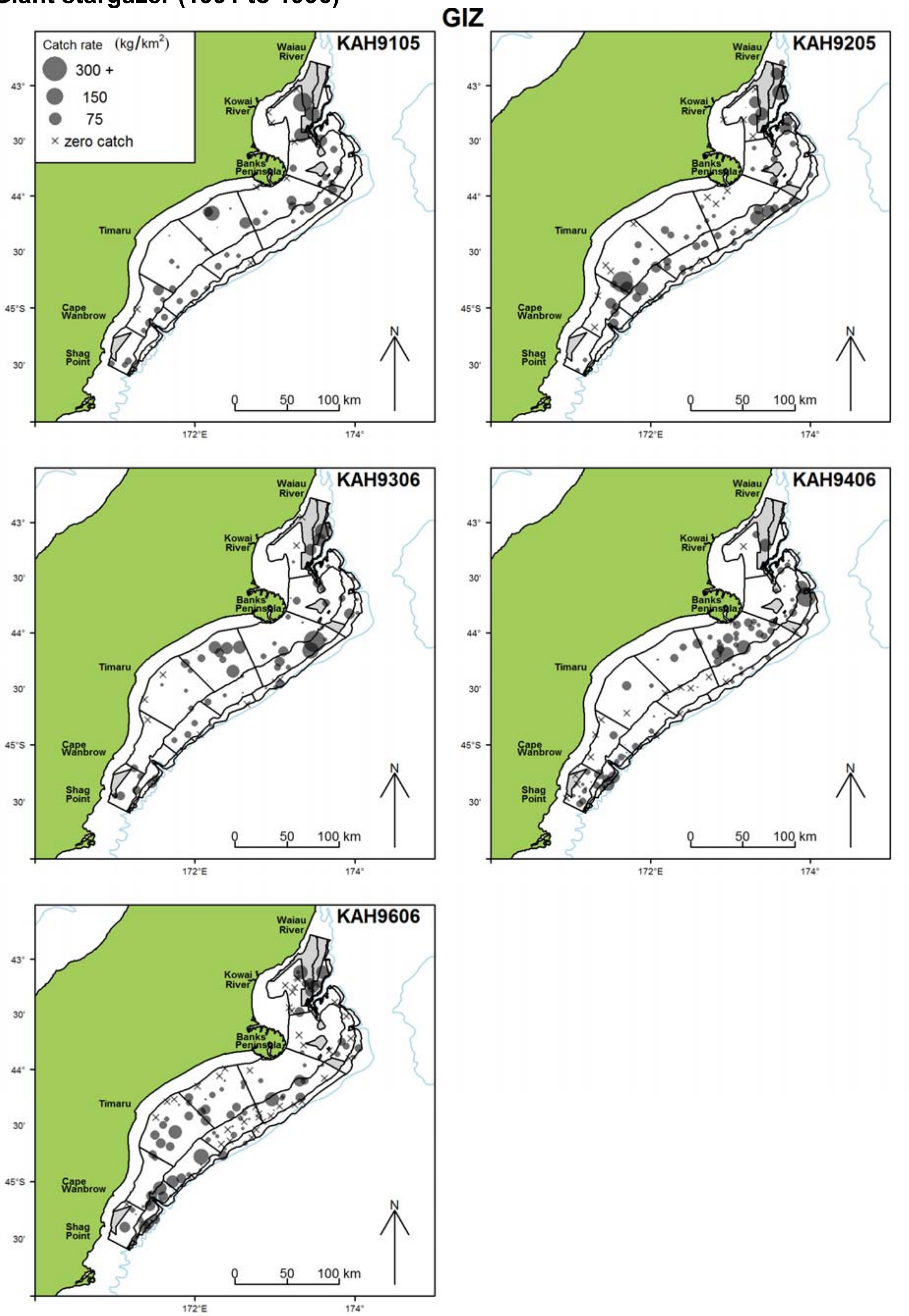


Figure 10 – ***continued***

Giant stargazer (2007 to 2014)

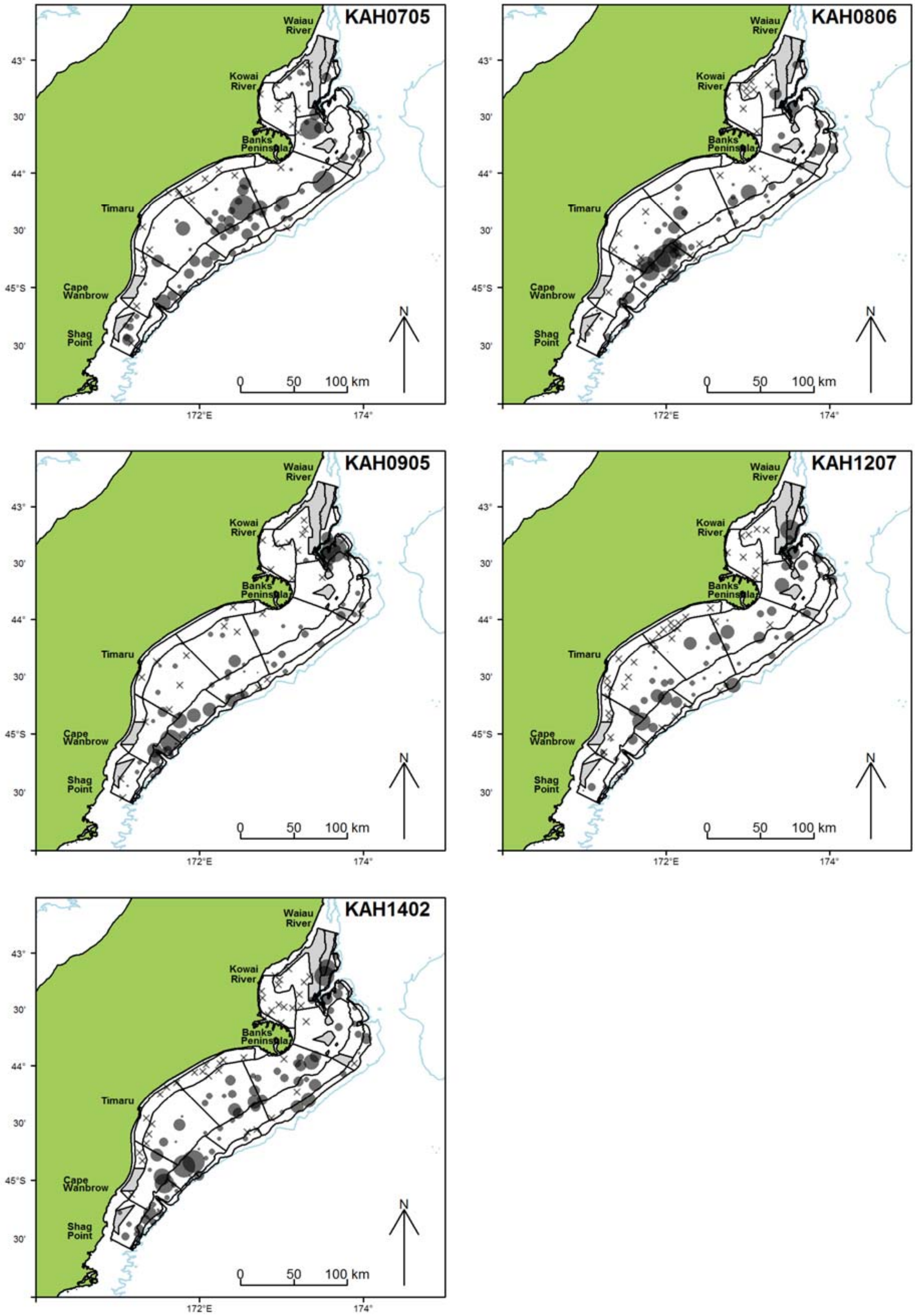


Figure 10 – ***continued***

Red gurnard (1991 to 1996)

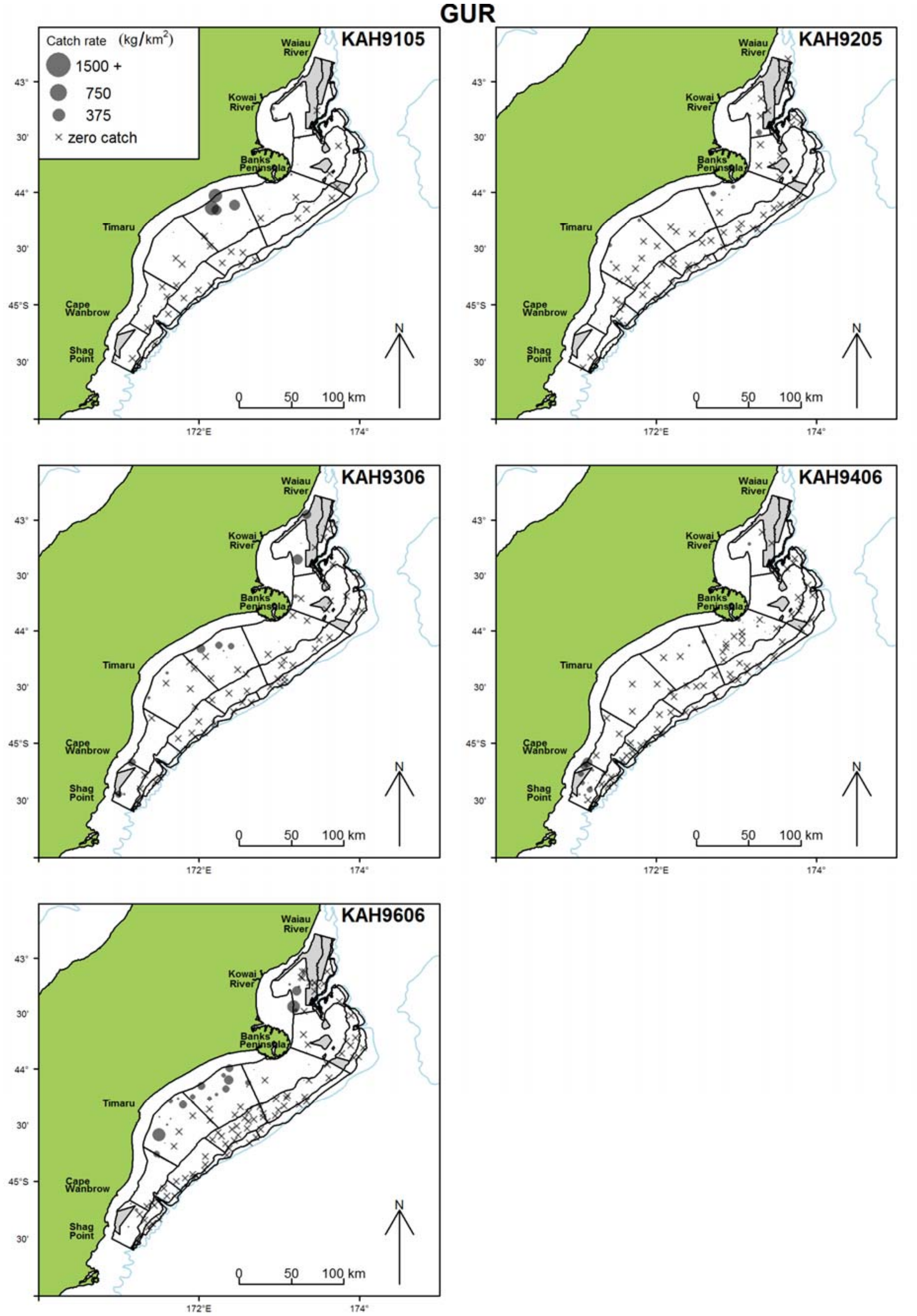


Figure 10 – ***continued***

Red gurnard (2007 to 2014)

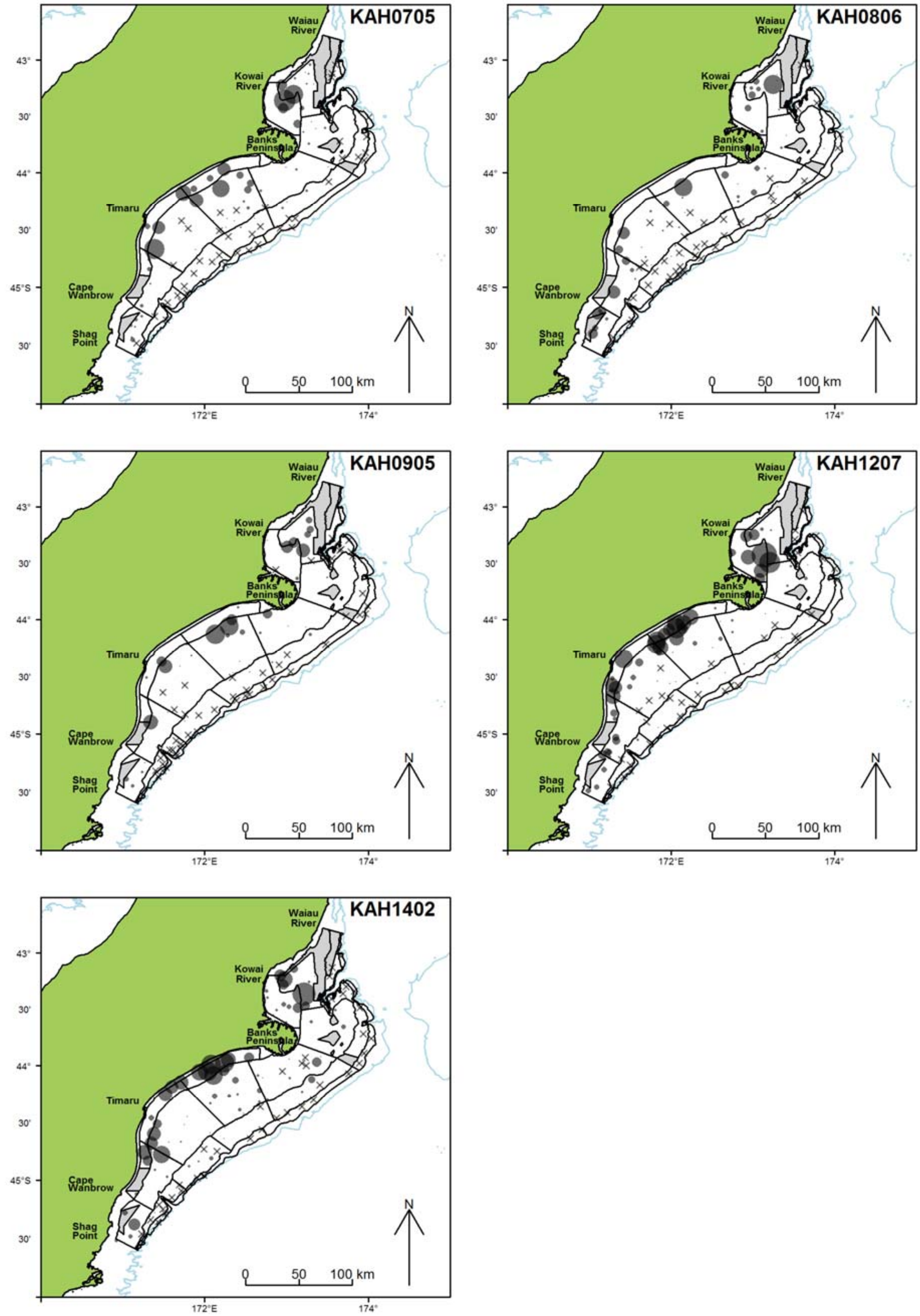


Figure 10 – ***continued***

Red cod (1991–1996)

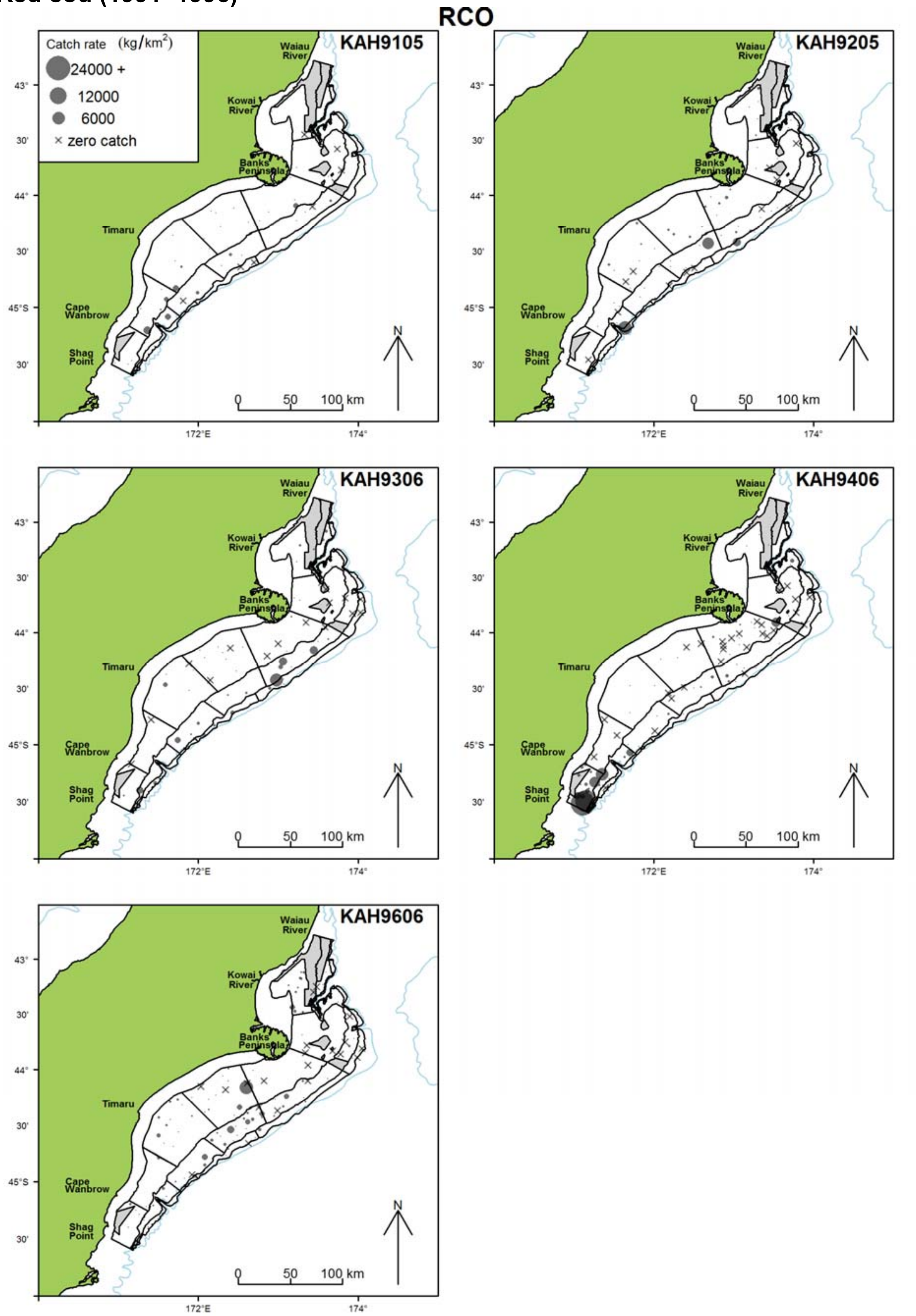


Figure 10 – ***continued***

Red cod (2007 to 2014)

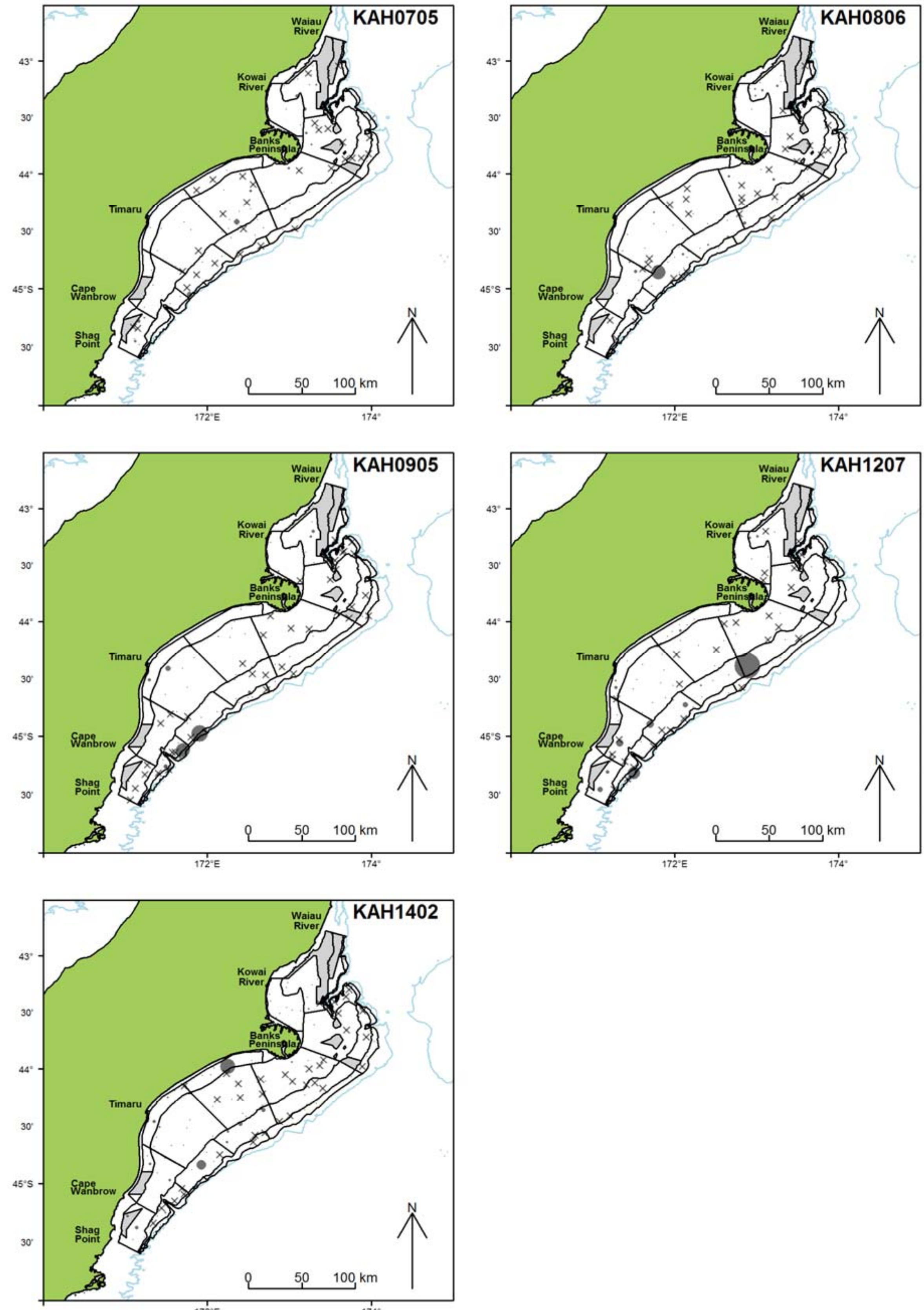


Figure 10 – *continued*

Sea perch (1991 to 1996)

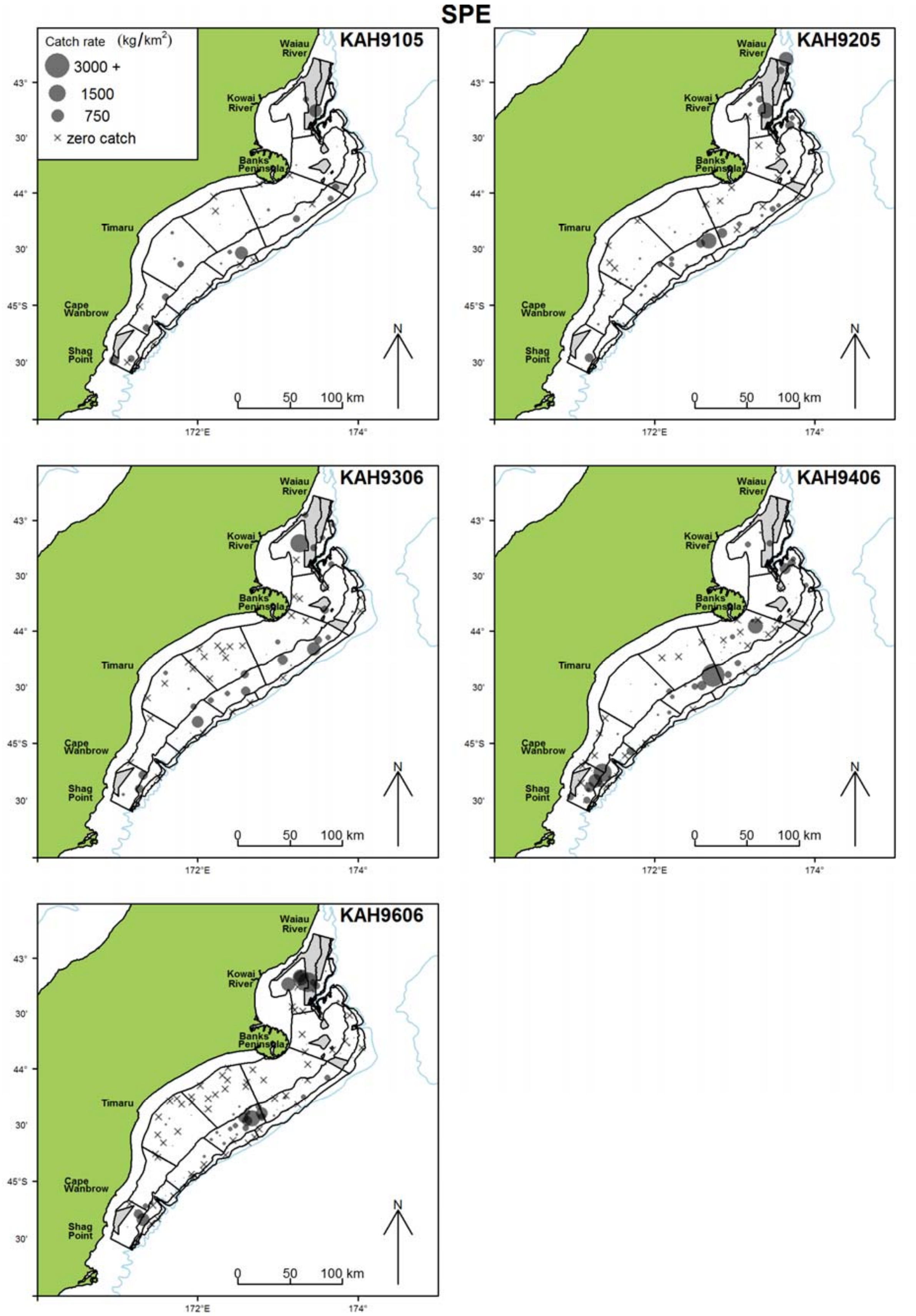


Figure 10 – ***continued***

Sea perch (2007 to 2014)

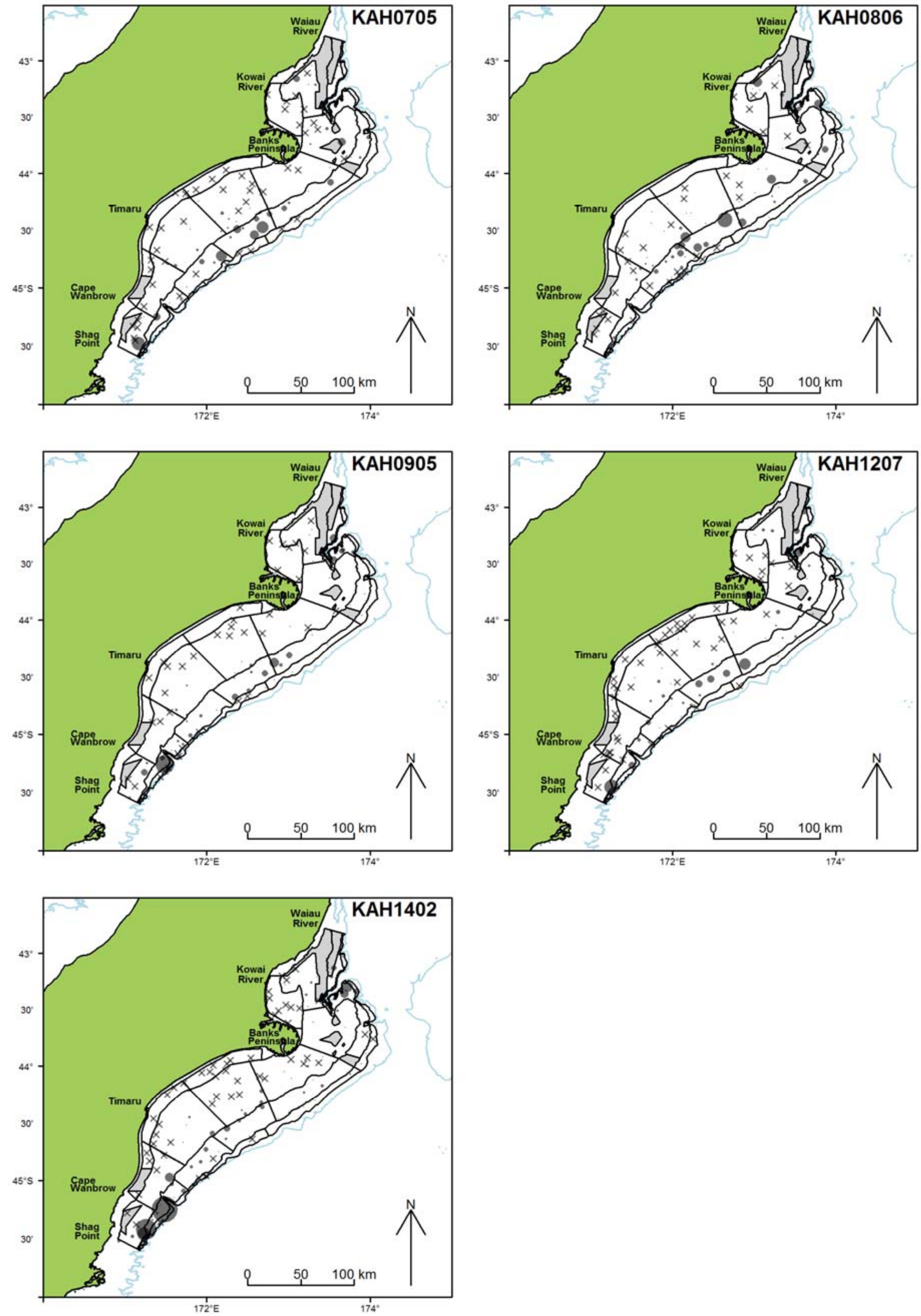


Figure 10 – ***continued***

Spiny dogfish (1991 to 1996)

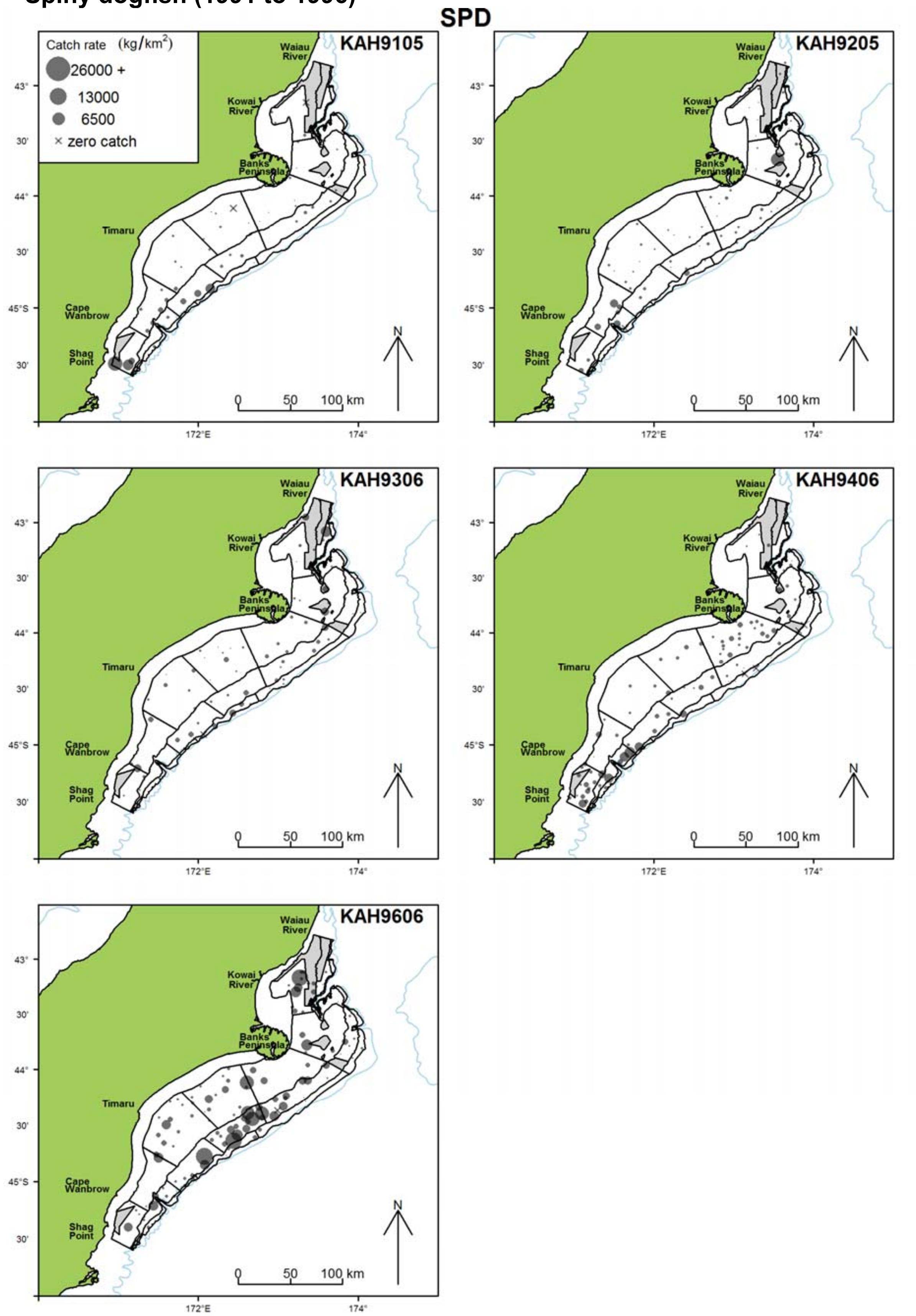


Figure 10 – ***continued***

Spiny dogfish (2007 to 2014)

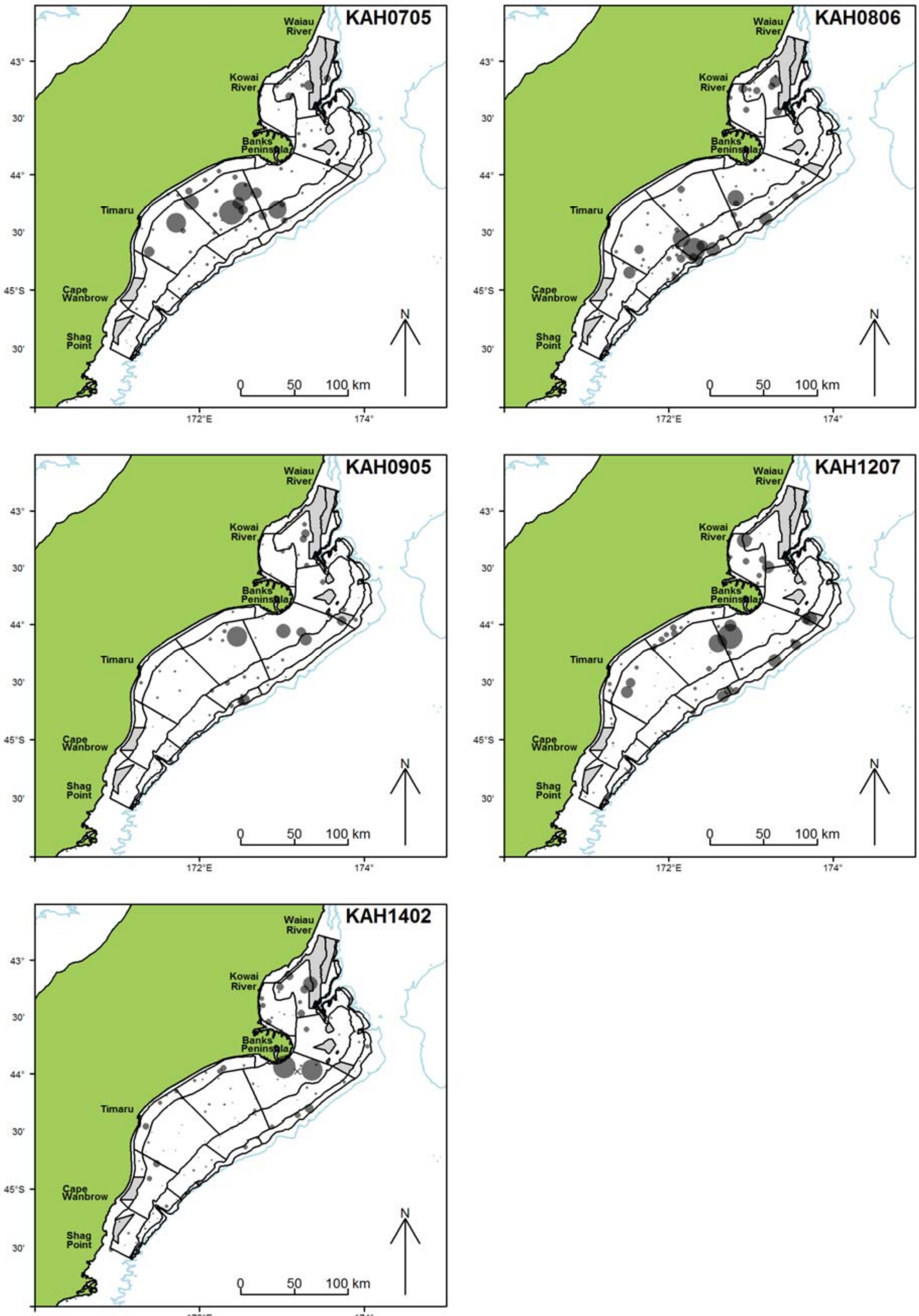


Figure 10 – ***continued***

Tarakihi (1991–1996)

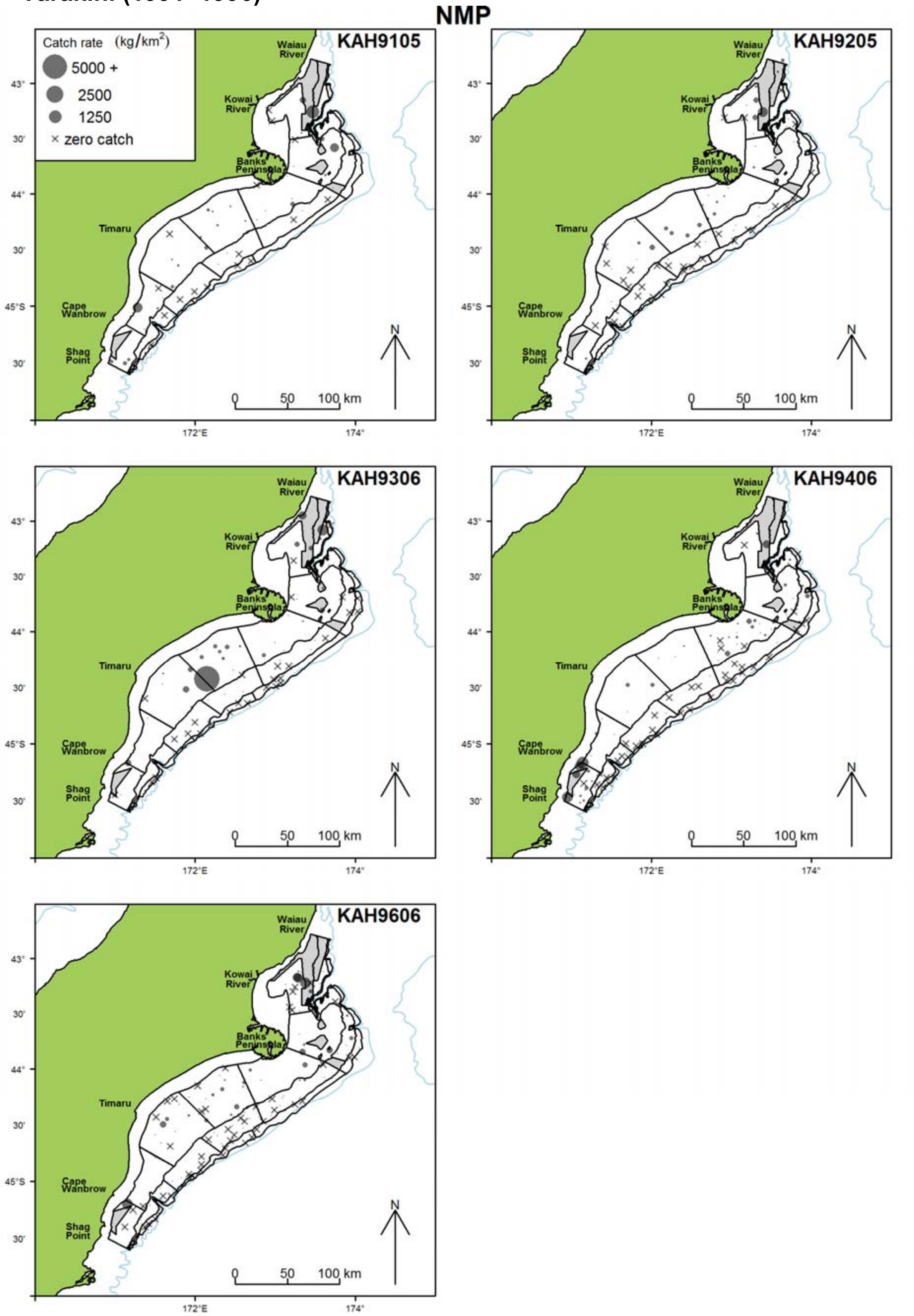


Figure 10 – *continued*

Tarakihi (2007–2014)

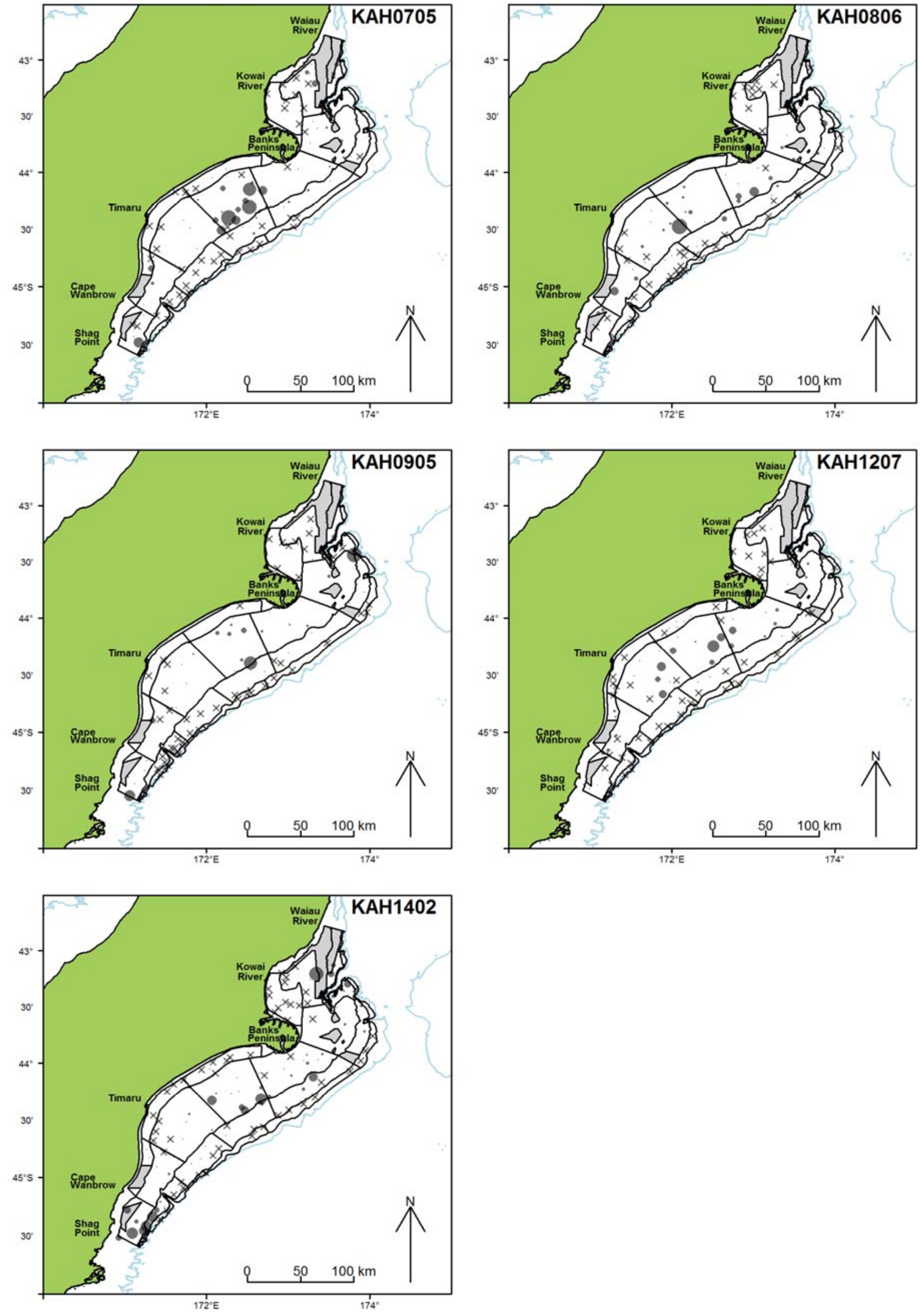


Figure 10 – *continued*

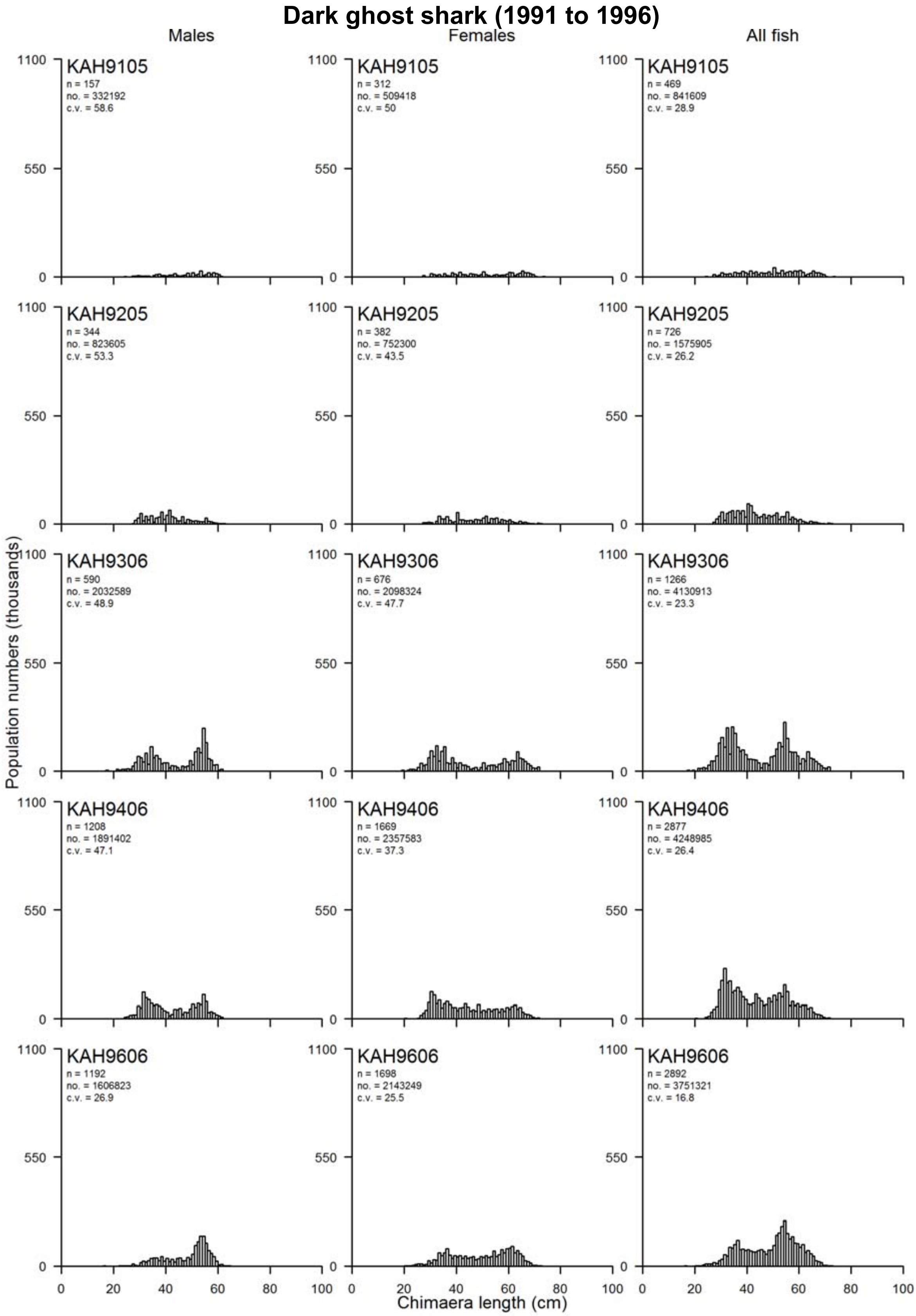


Figure 11: Scaled length frequency distributions for the target species in core strata (30–400 m) for all ten ECSI winter surveys (1991 to 2014). The length distribution is also shown in the 10–30 m depth strata for the 2007, 2012 and 2014 surveys overlayed (not stacked) in light grey for ELE, GUR, RCO, 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.

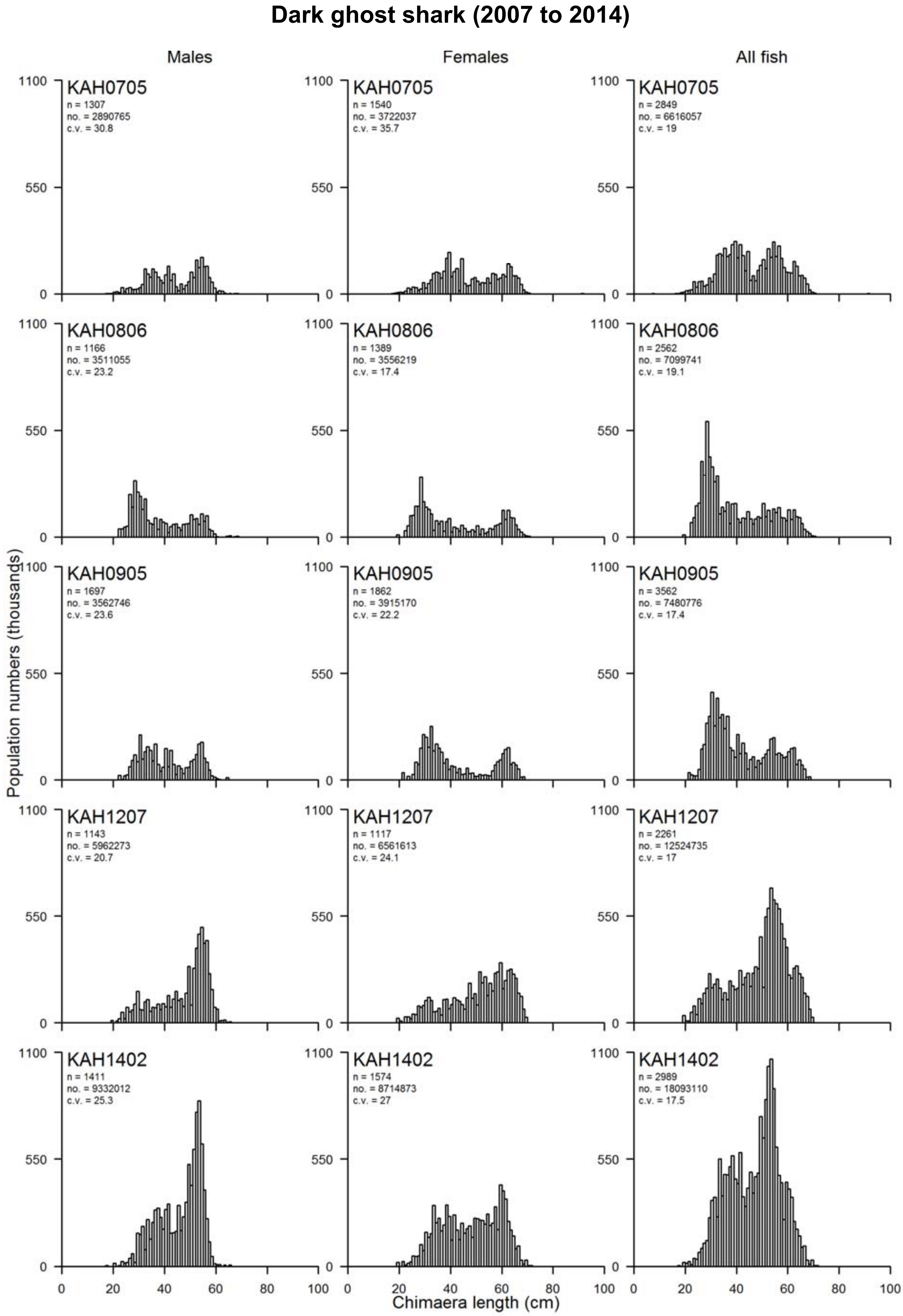


Figure 11 – ***continued***

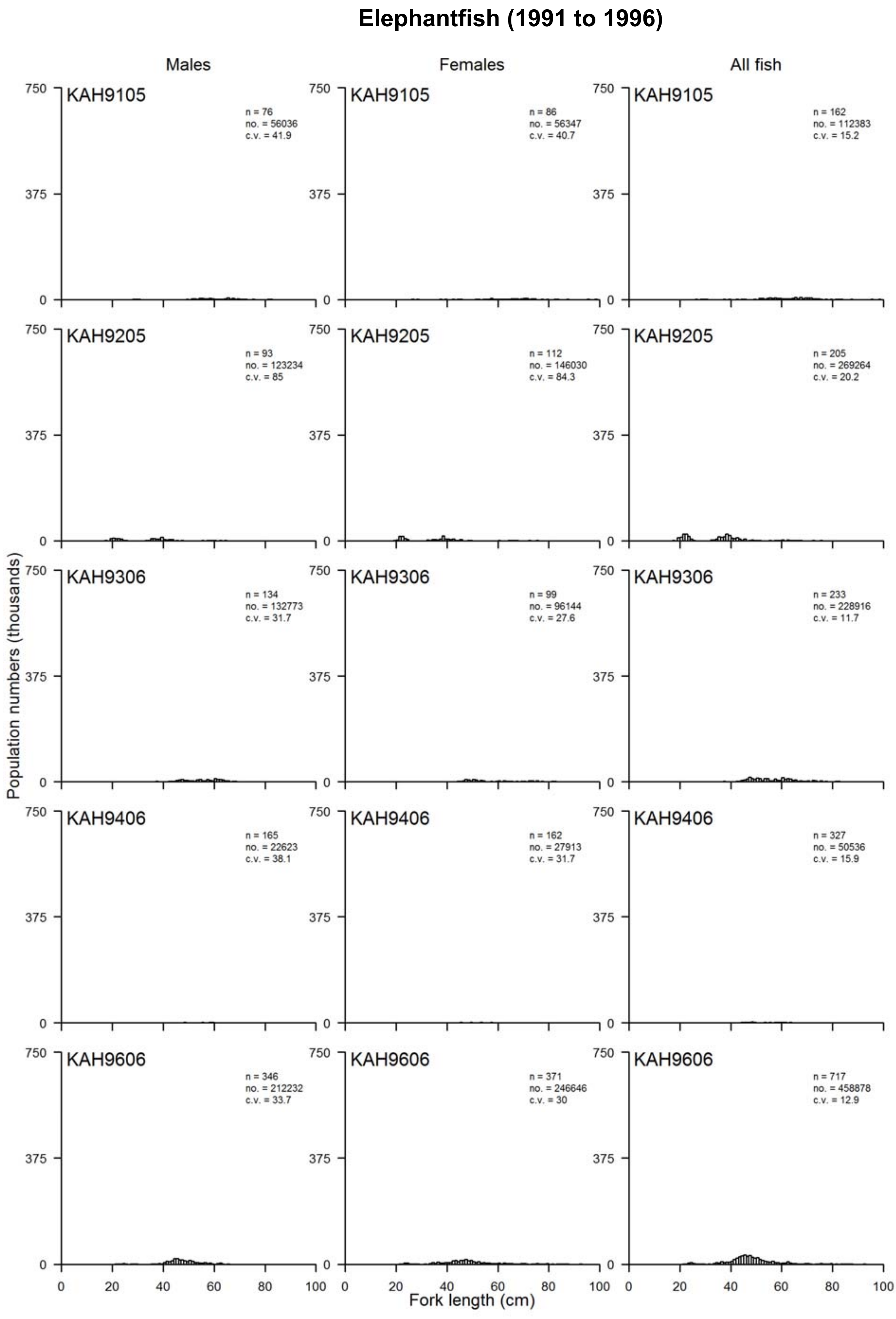


Figure 11 – ***continued***

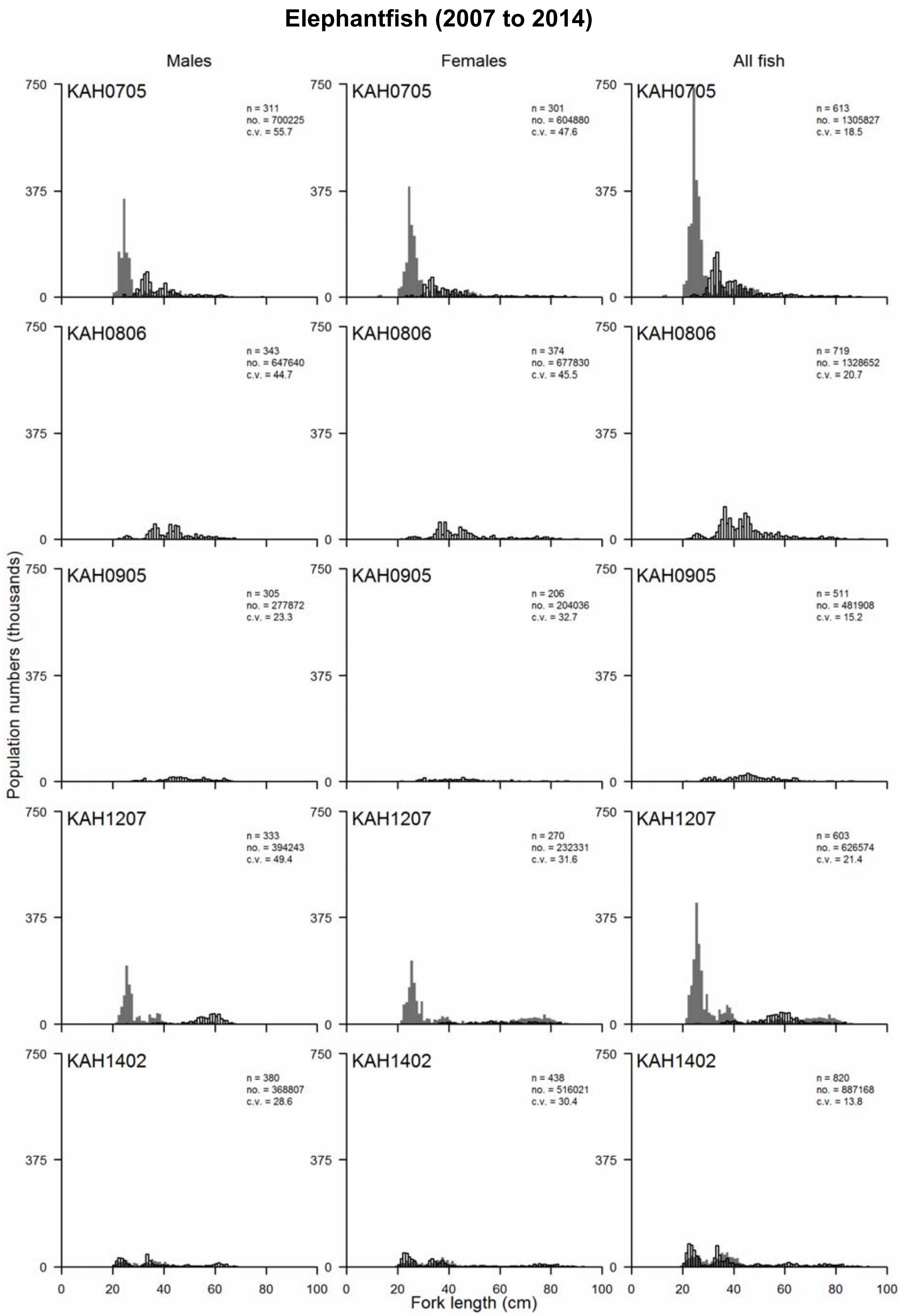


Figure 11 – ***continued***

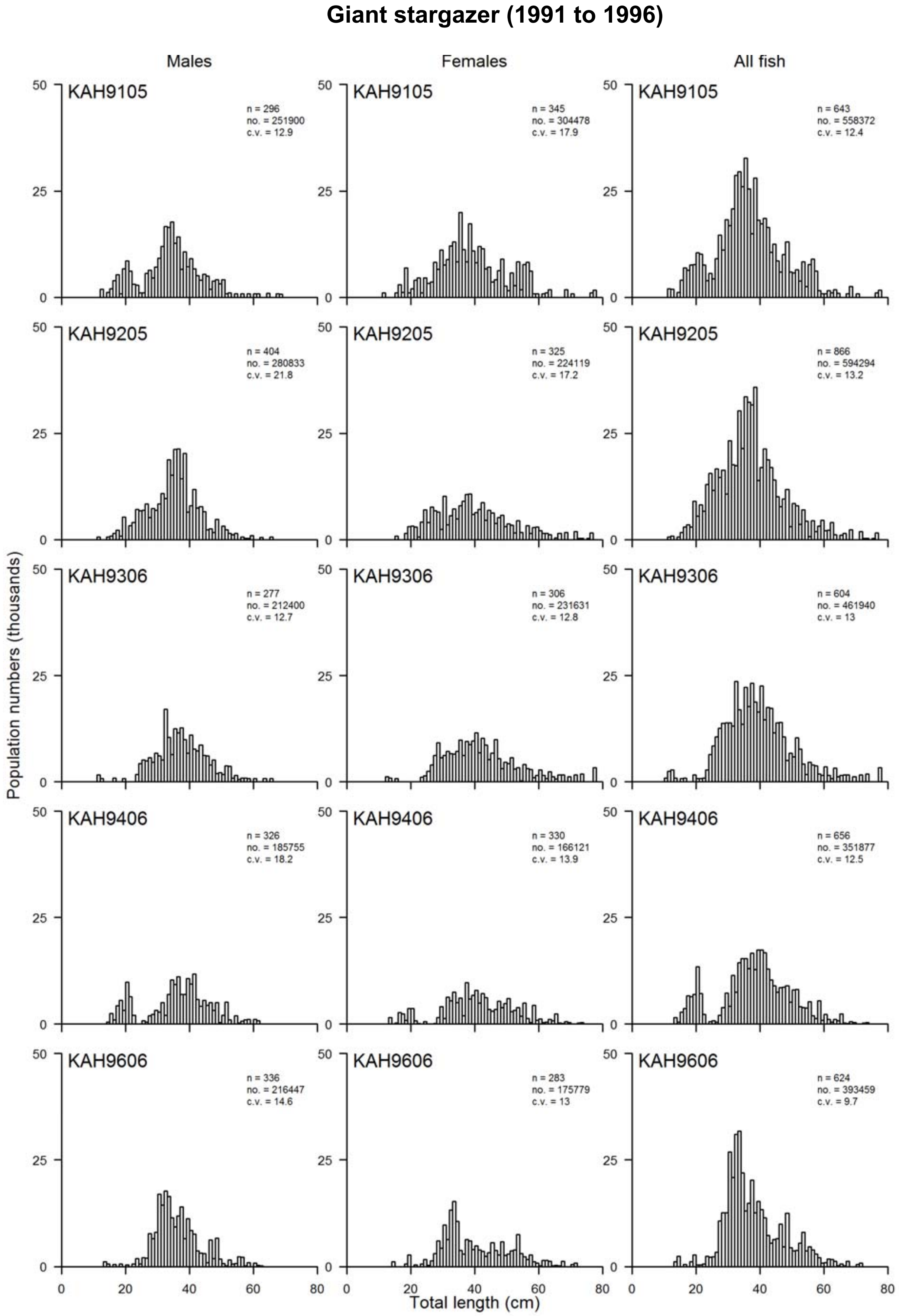


Figure 11 – *continued*

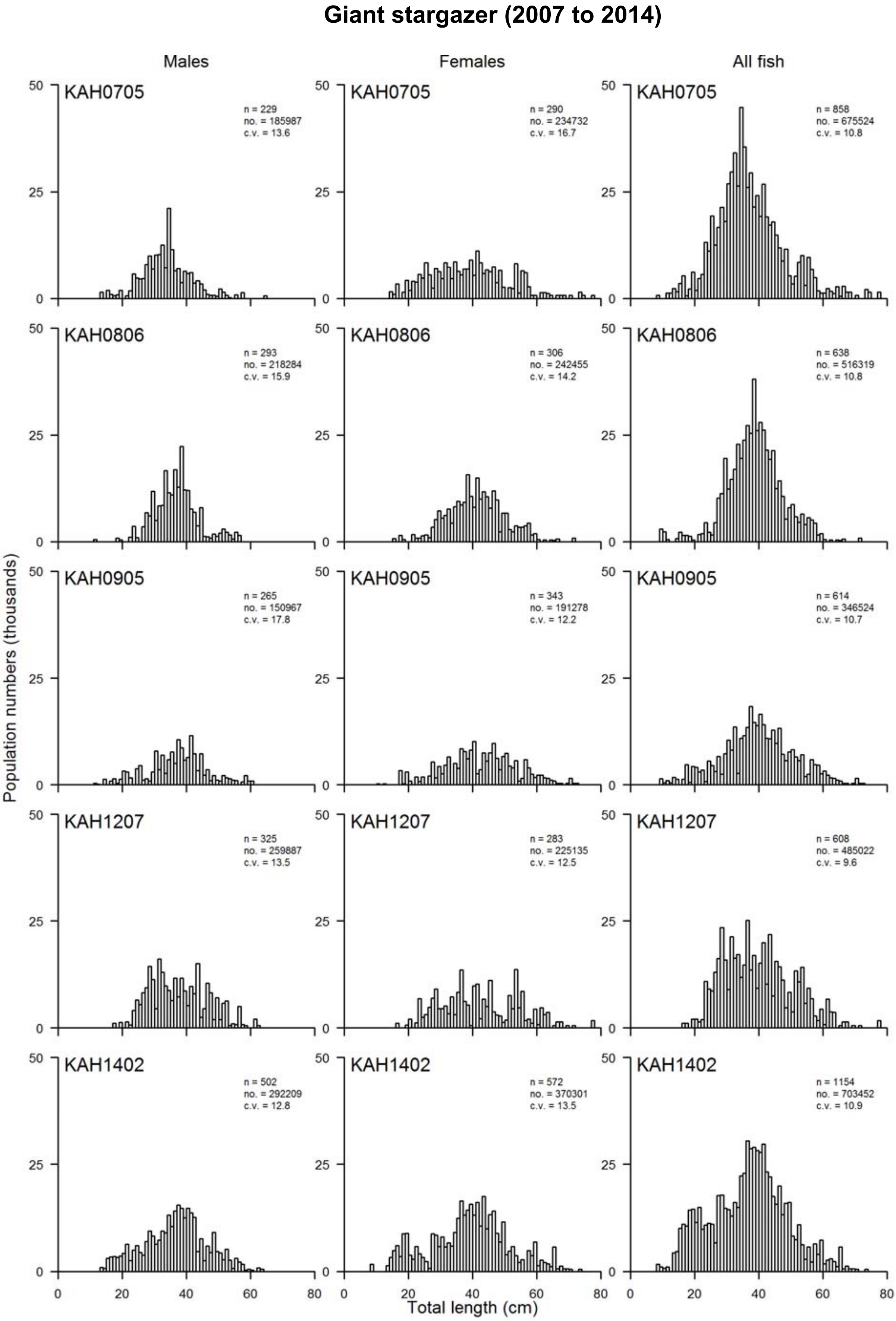


Figure 11 –*continued*

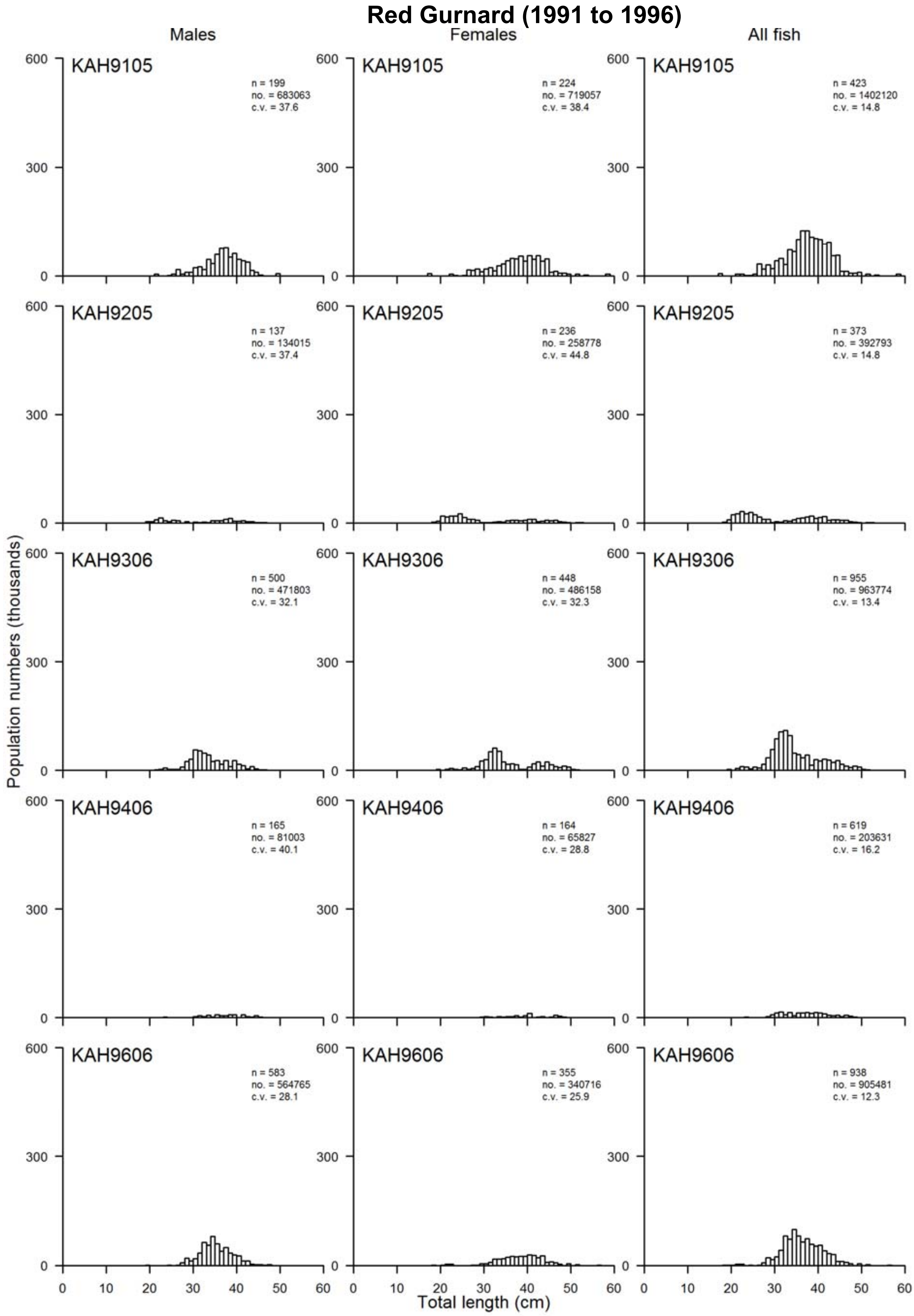


Figure 11 – ***continued***

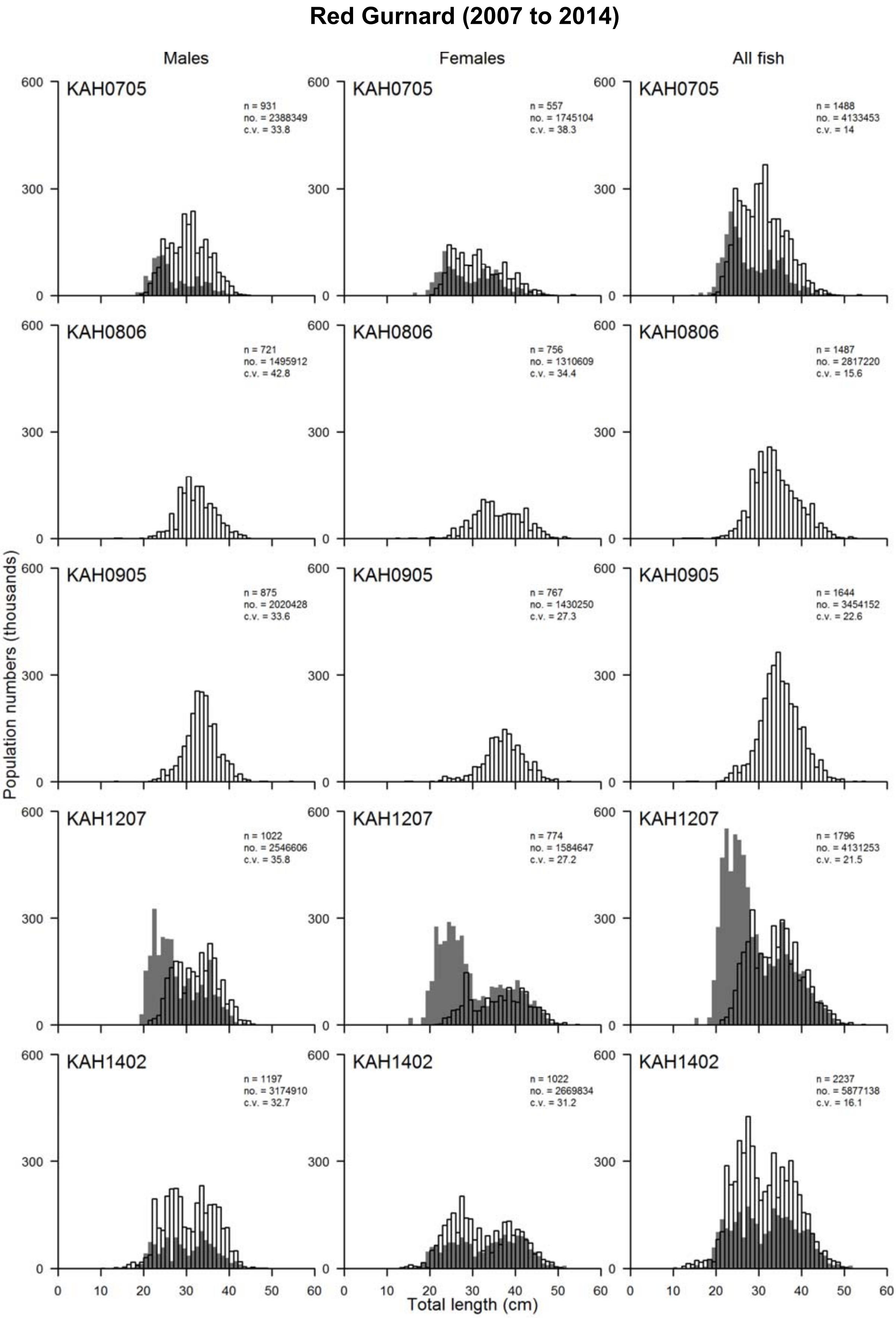


Figure 11 – *continued*

Red cod (1991 to 1996)

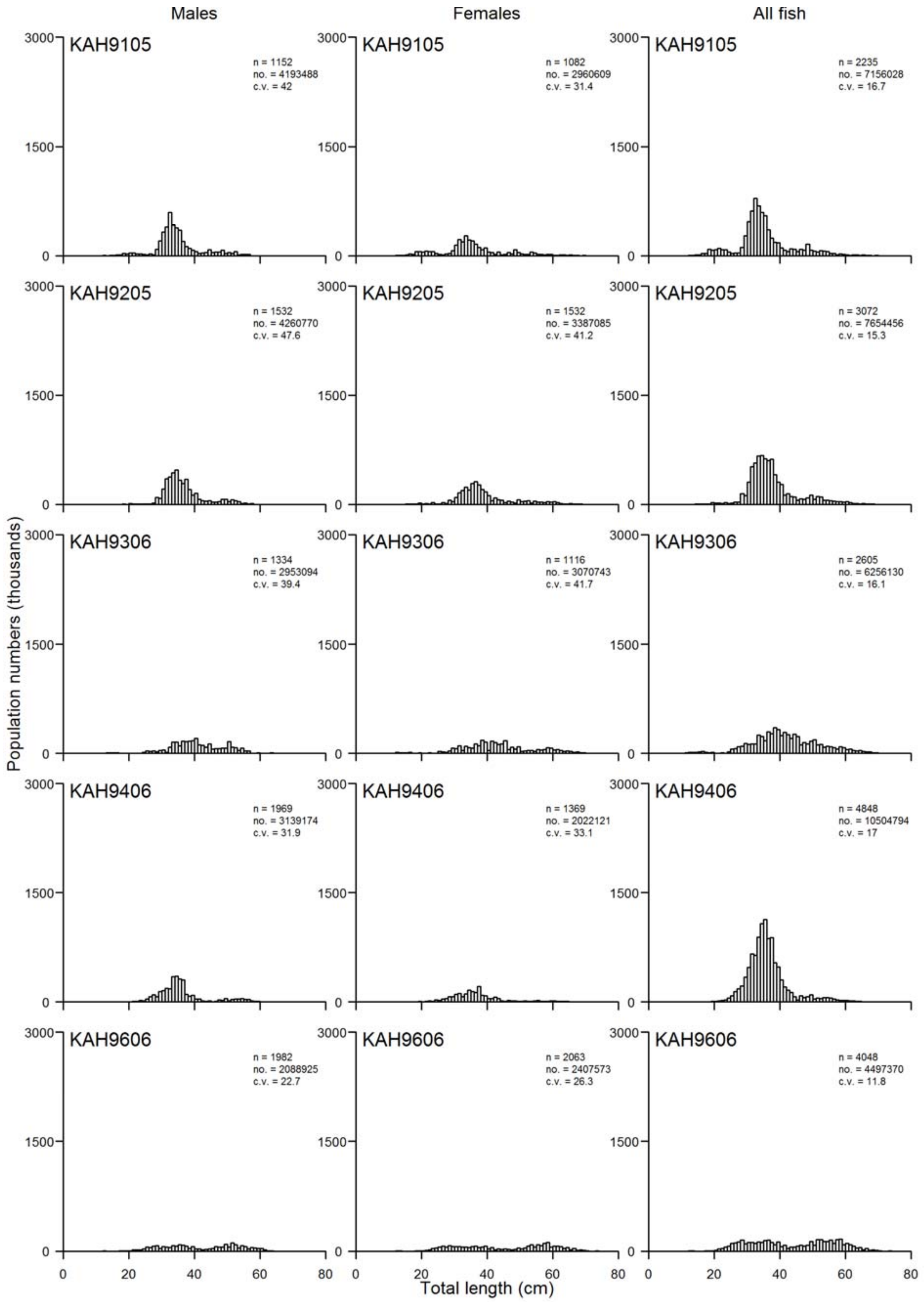


Figure 11 – *continued*

Red cod (2007 to 2014)

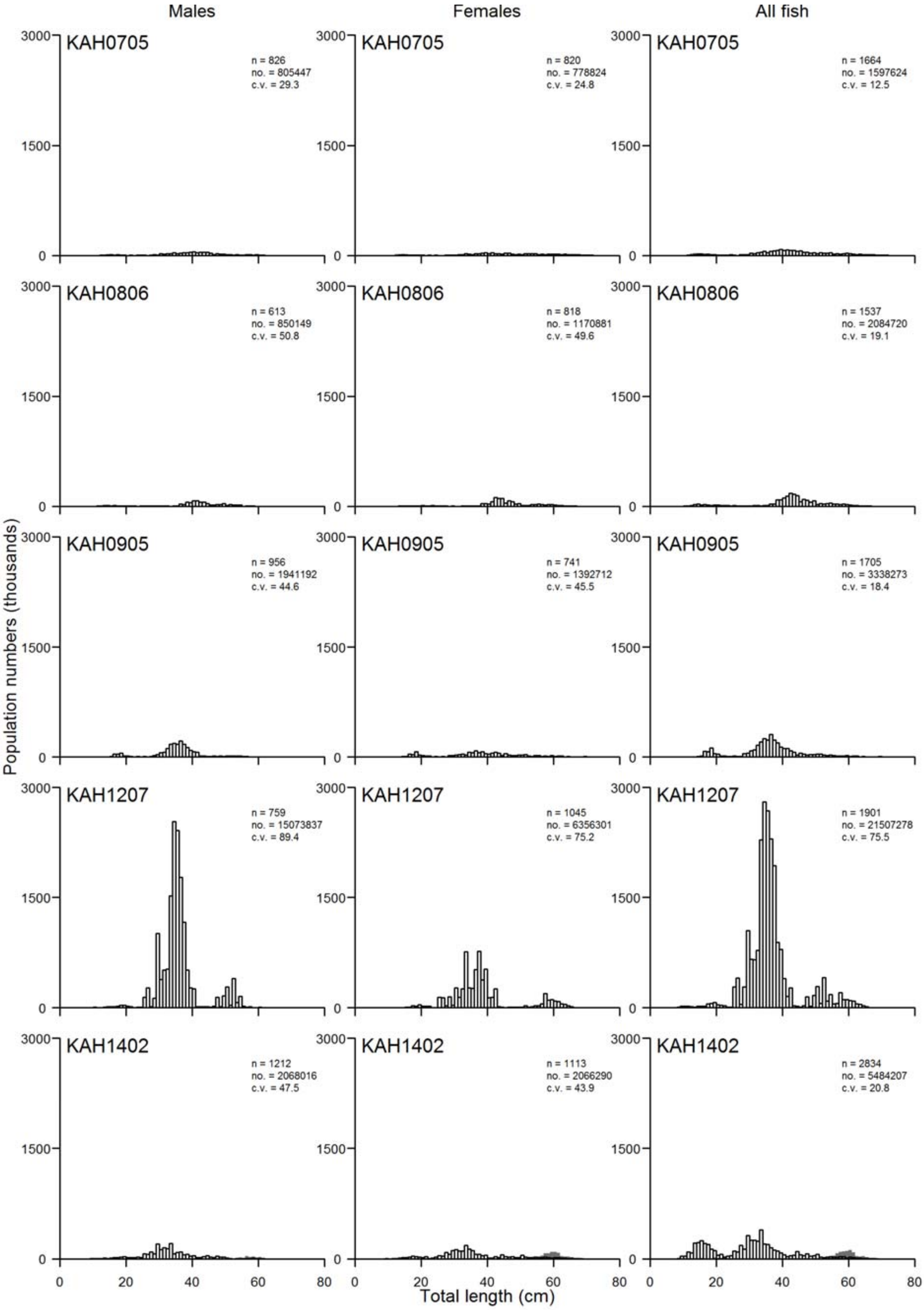


Figure 11 – ***continued***

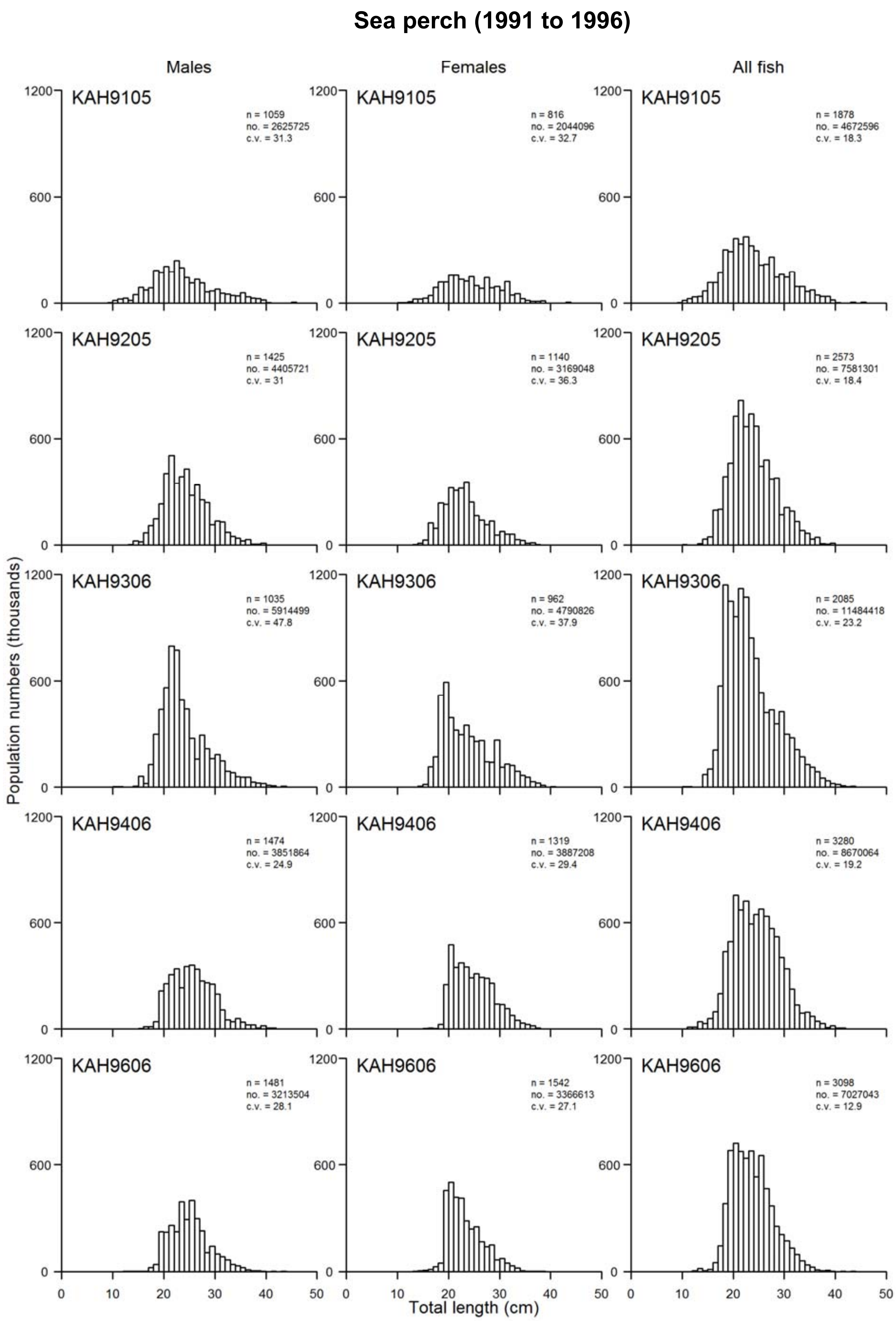


Figure 11 – *continued*

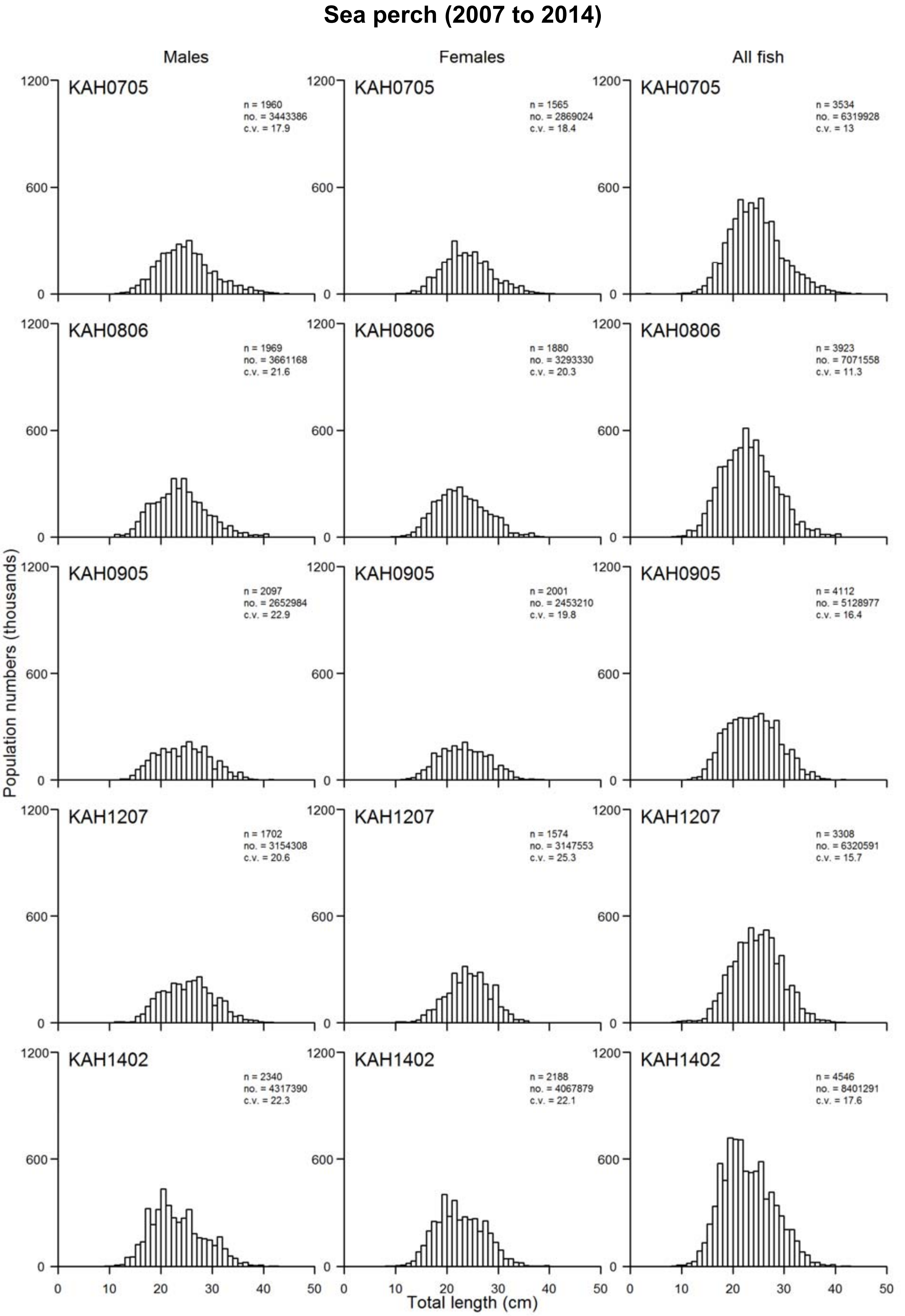


Figure 11 – ***continued***

Spiny dogfish (1991 to 1996)

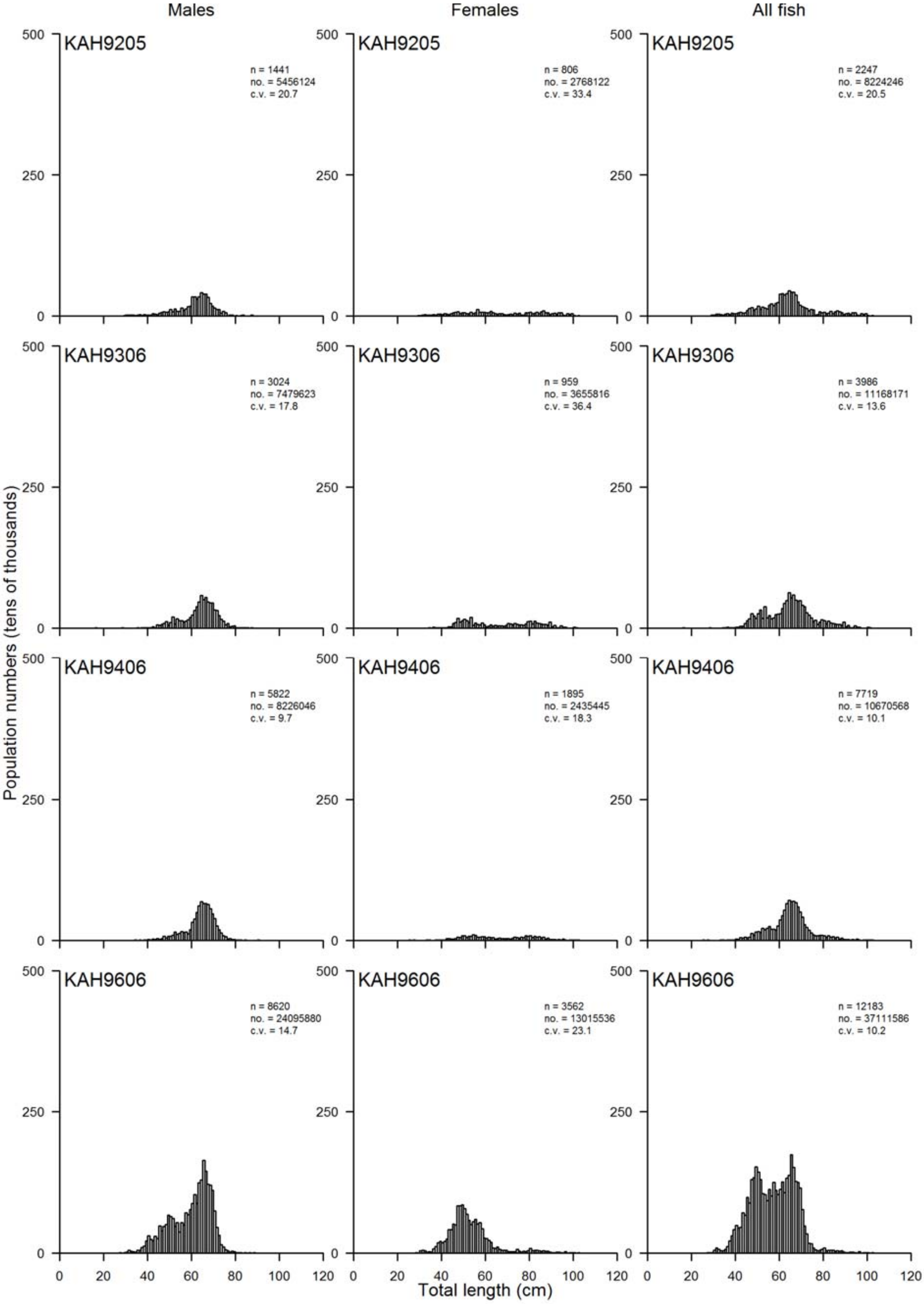


Figure 11– *continued*

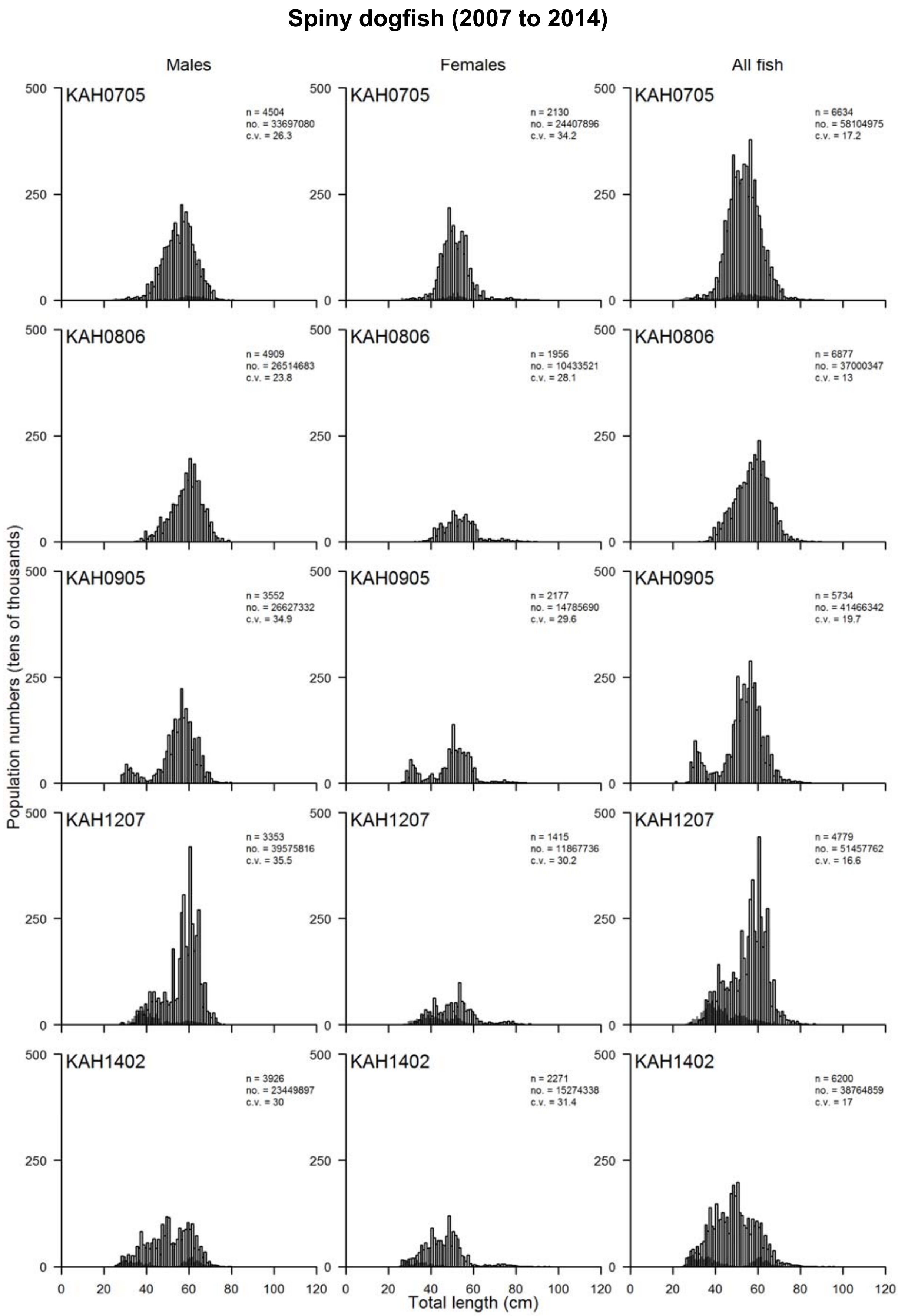


Figure 11 – ***continued***

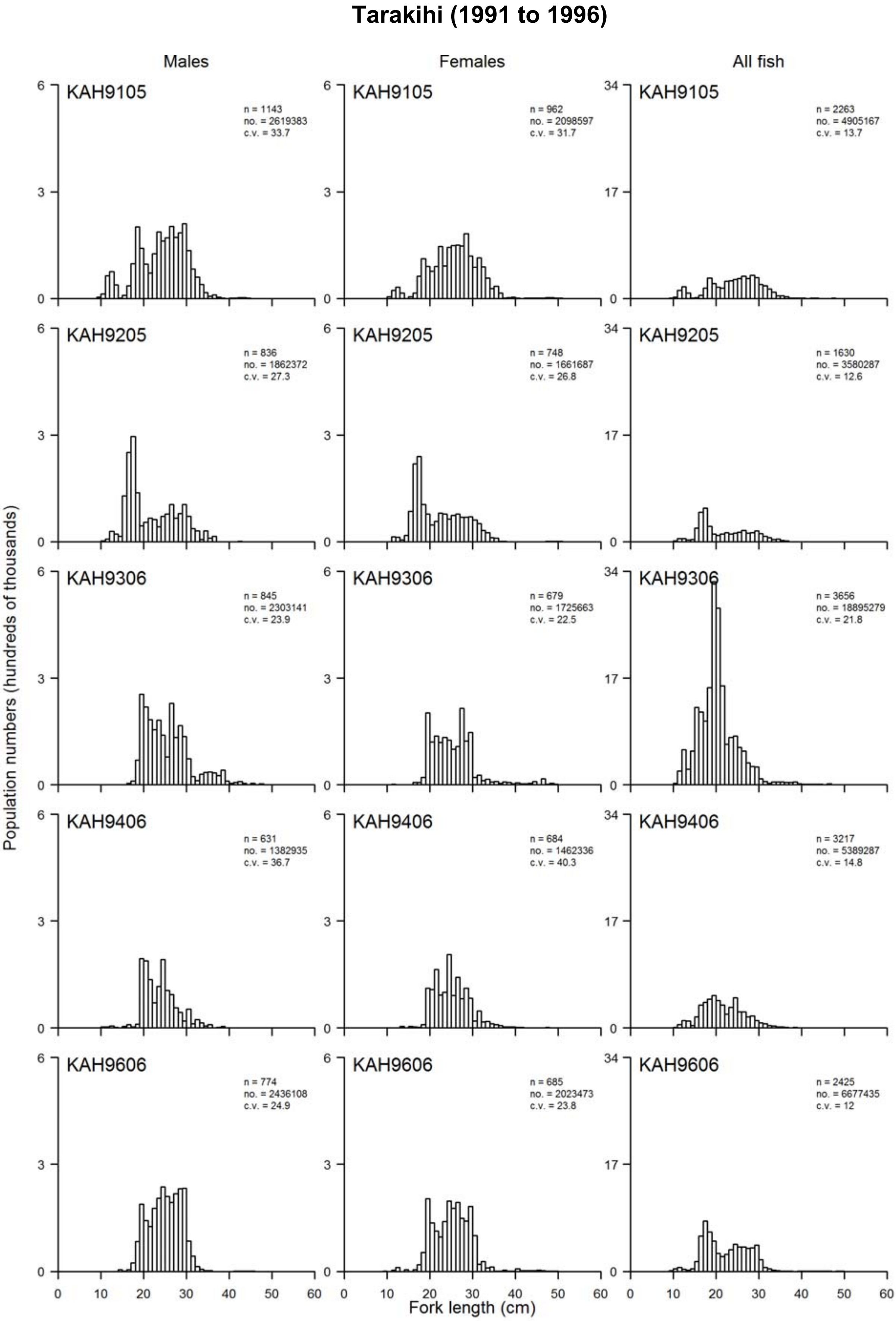


Figure 11 – ***continued***

Tarakihi (2007 to 2014)

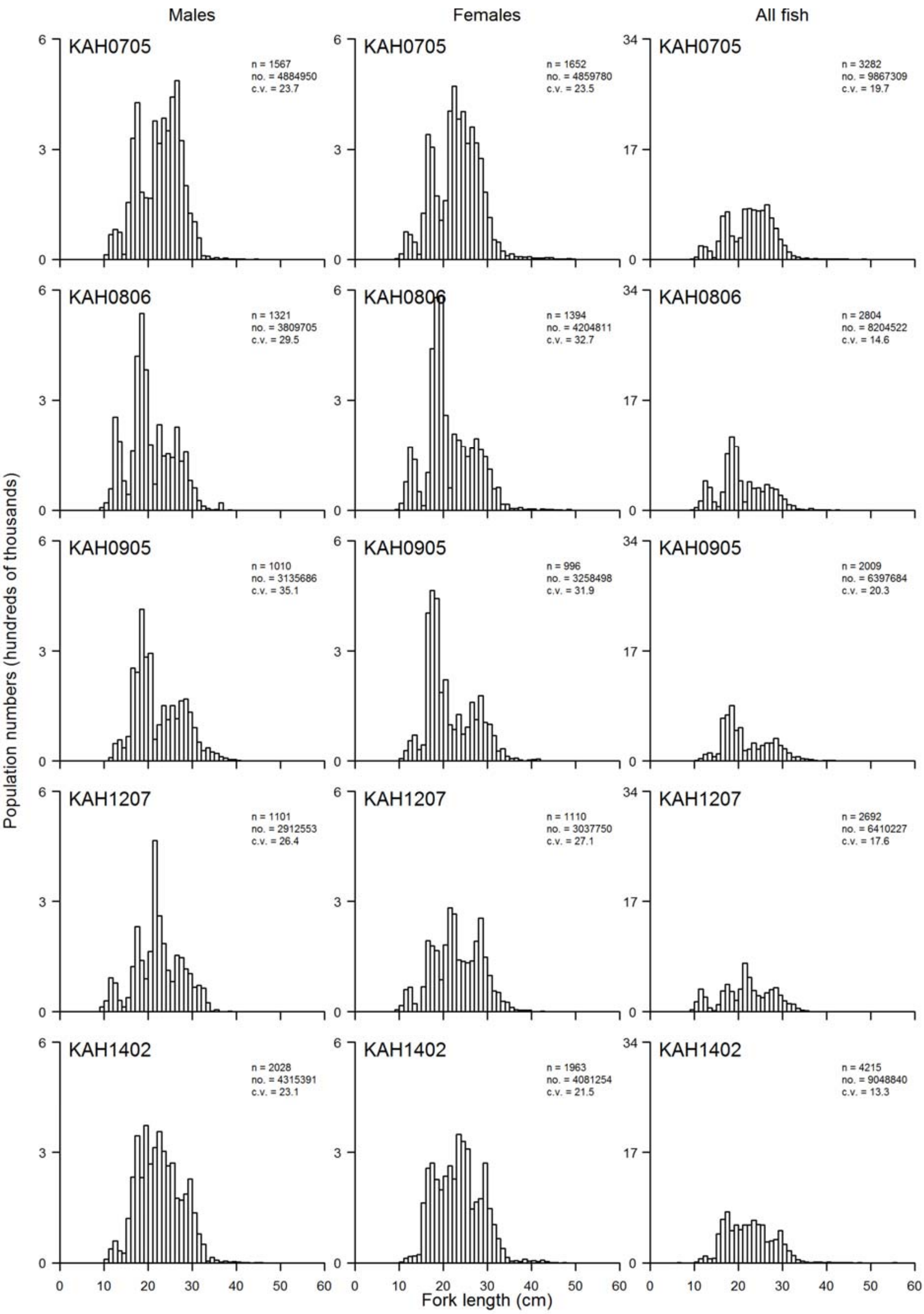
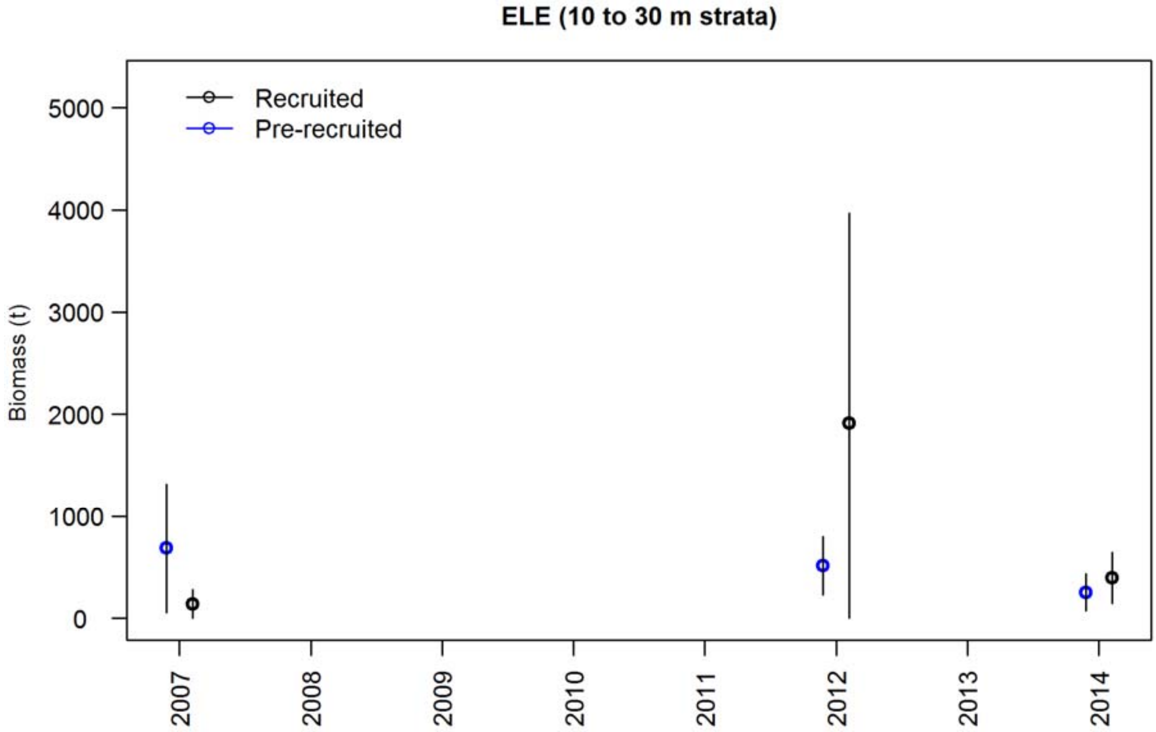


Figure 11 – ***continued***



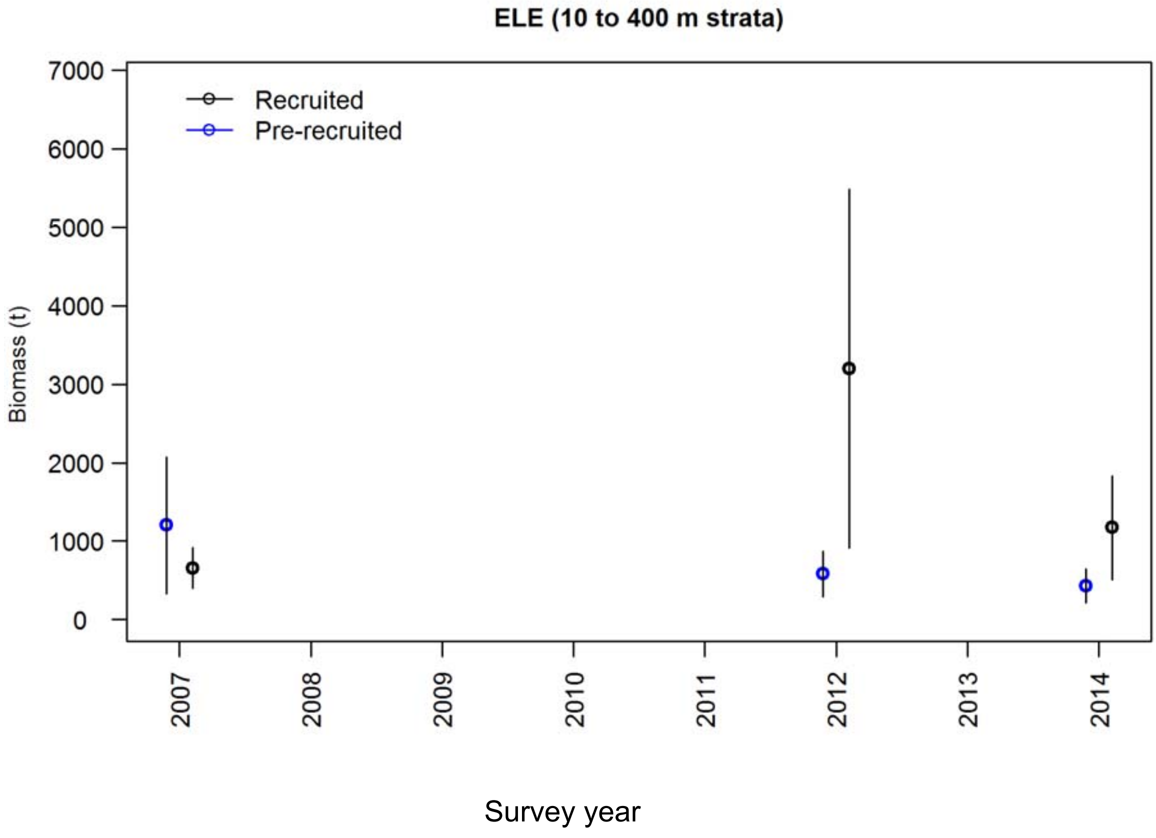


Figure 12: Elephantfish and red gurnard recruited and pre-recruited biomass and 95% confidence intervals for 2007, 2012 and 2014 ECSI surveys in 10–30 m and core plus shallow strata (10–400 m).

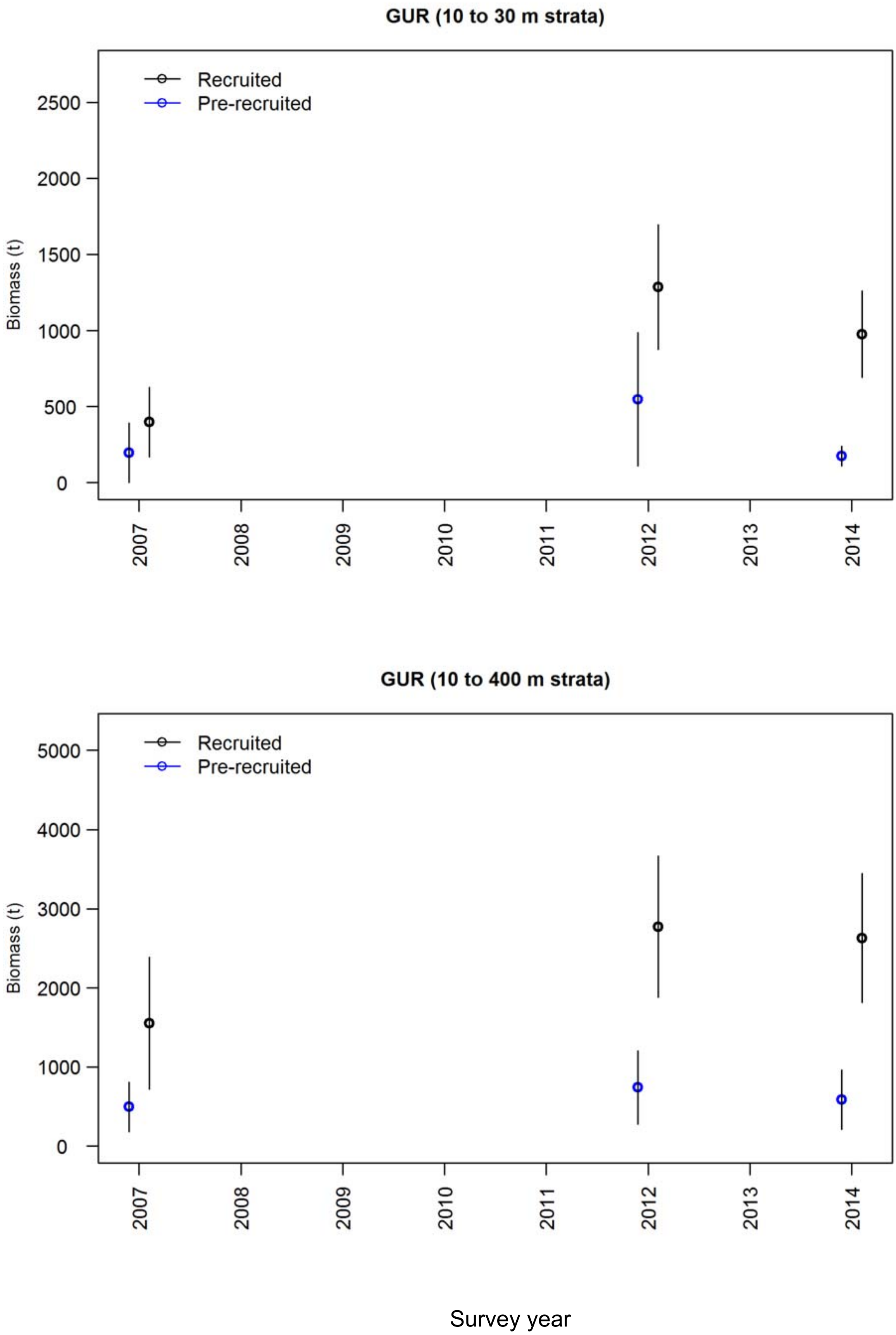


Figure 12 – ***continued***

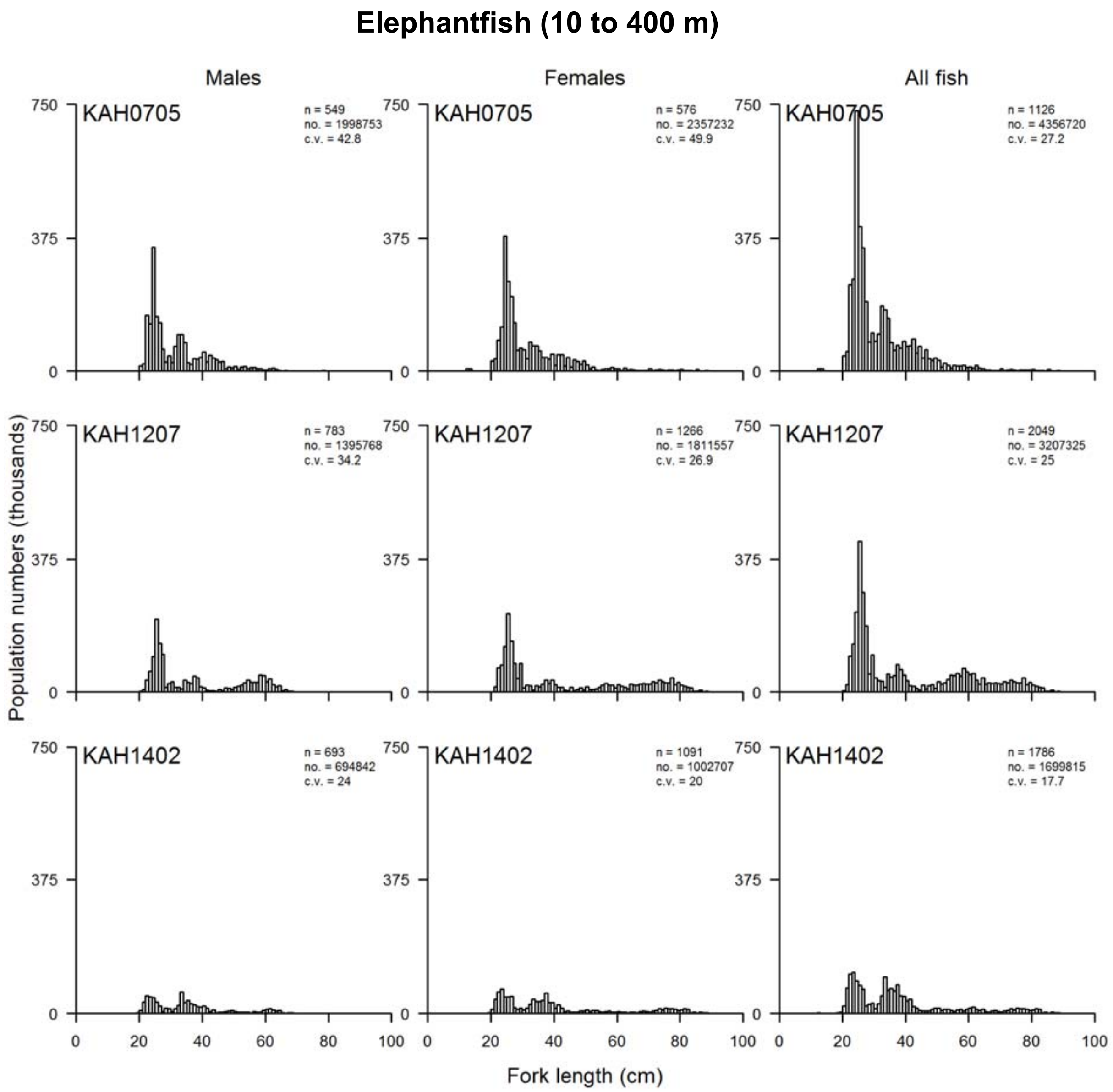


Figure 13: Scaled length frequency distributions for elephantfish and red gurnard in core plus shallow strata (10–400 m), for 2007, 2012 and 2014 ECSI surveys. Population estimates are in thousands of fish.

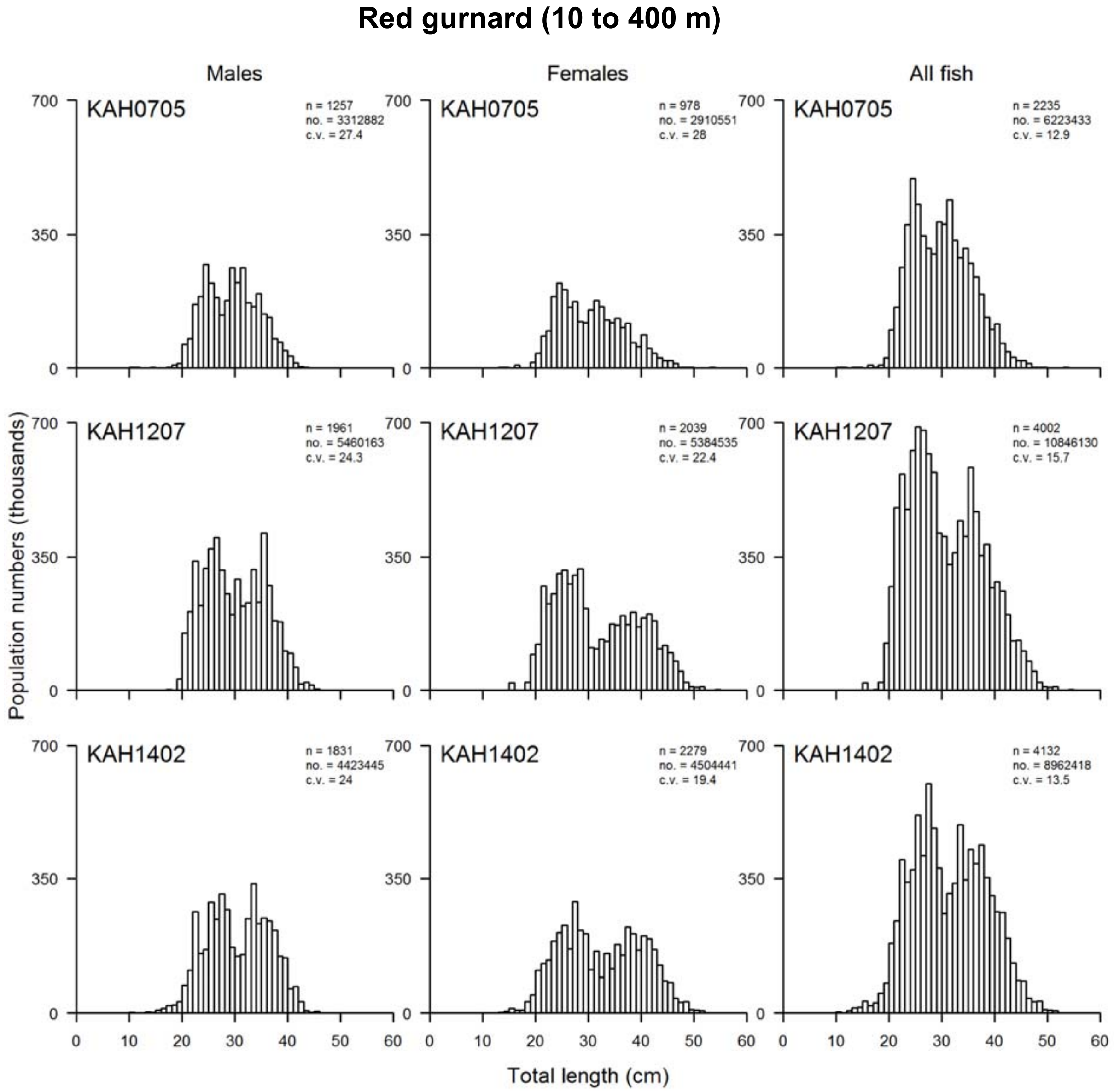
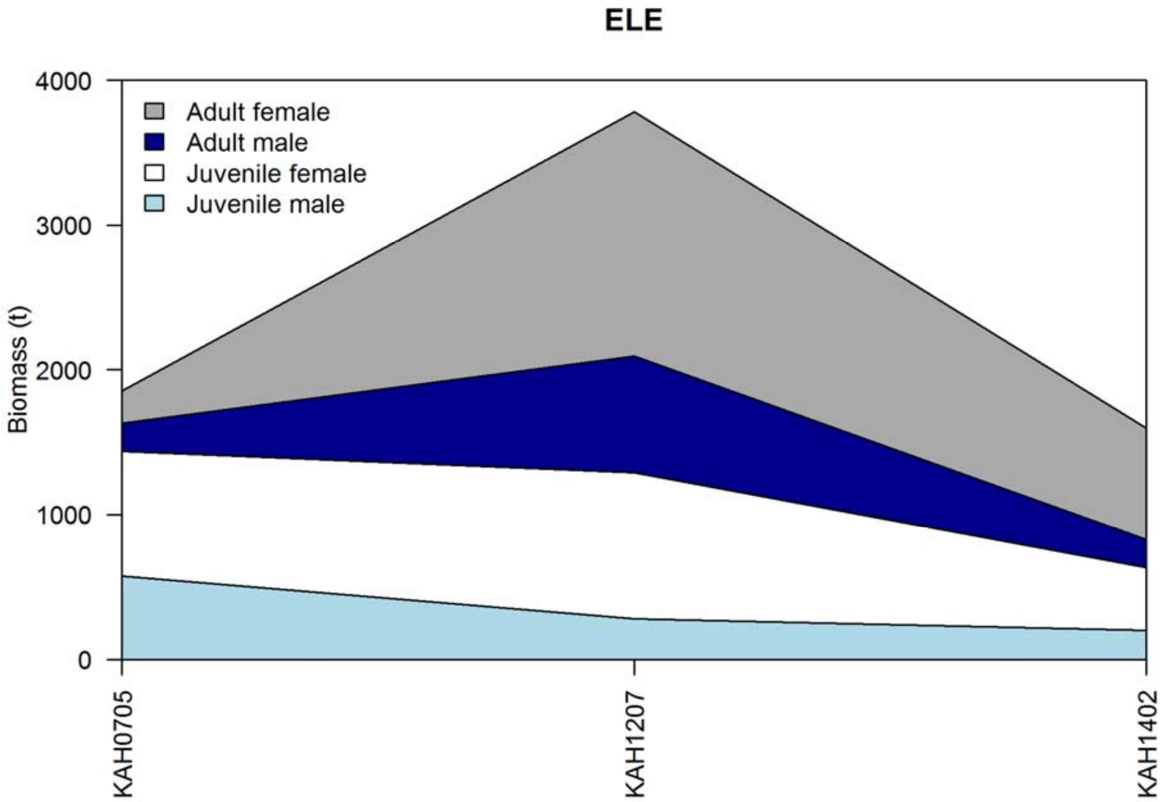


Figure 13 – ***continued***



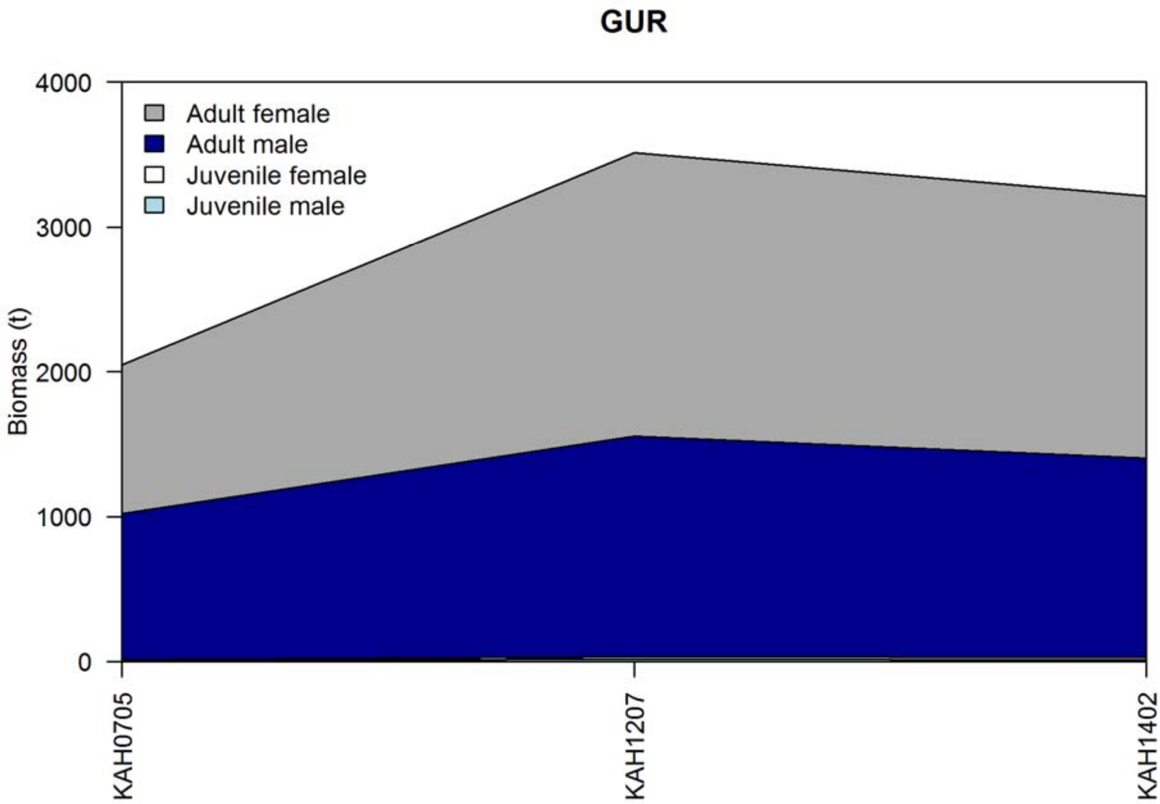


Figure 14: Elephantfish and red gurnard juvenile and adult biomass for ECSI winter surveys in core plus shallow strata (10–400 m), where juvenile is below and adult is equal to or above length at which 50% of fish are mature.

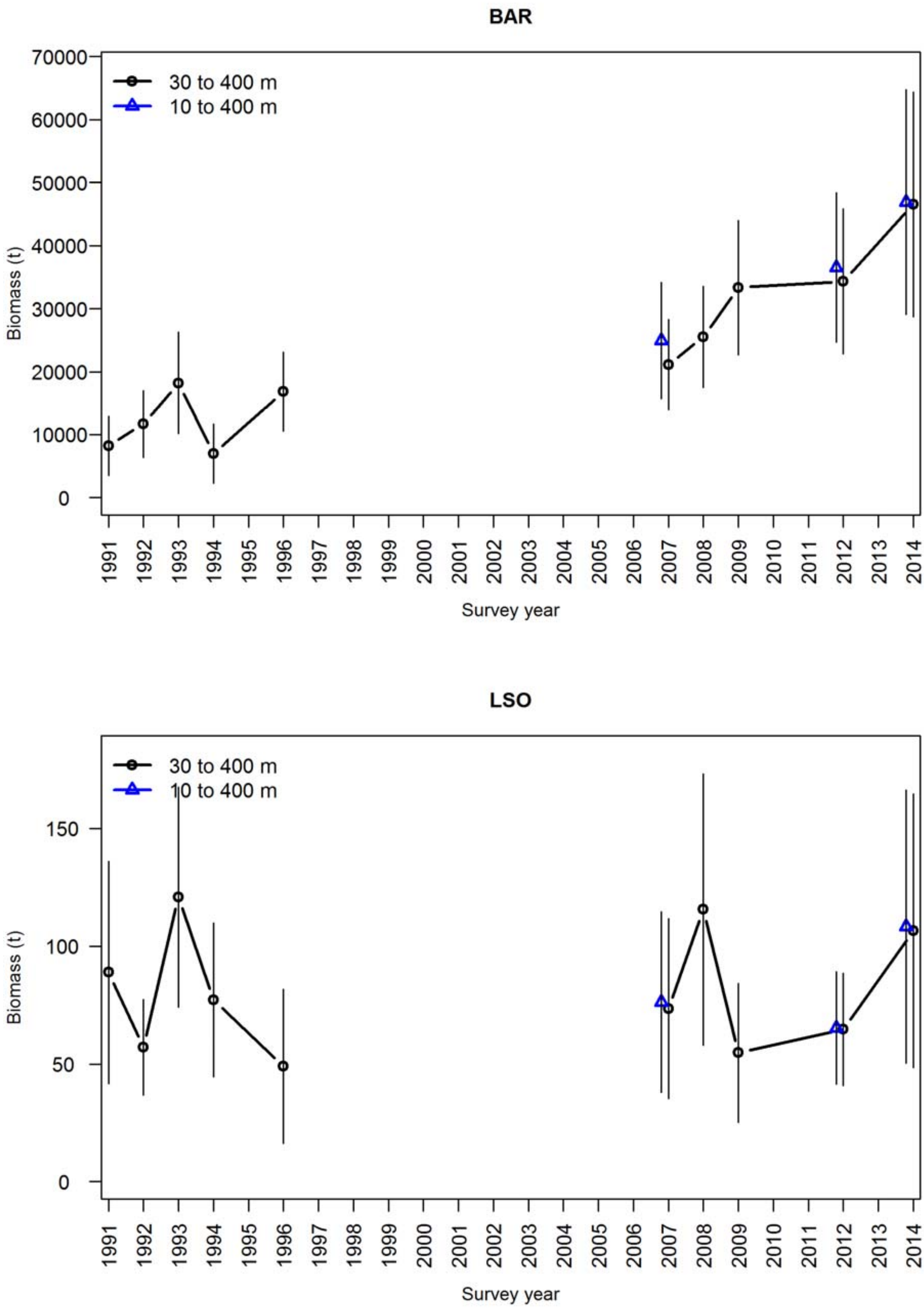
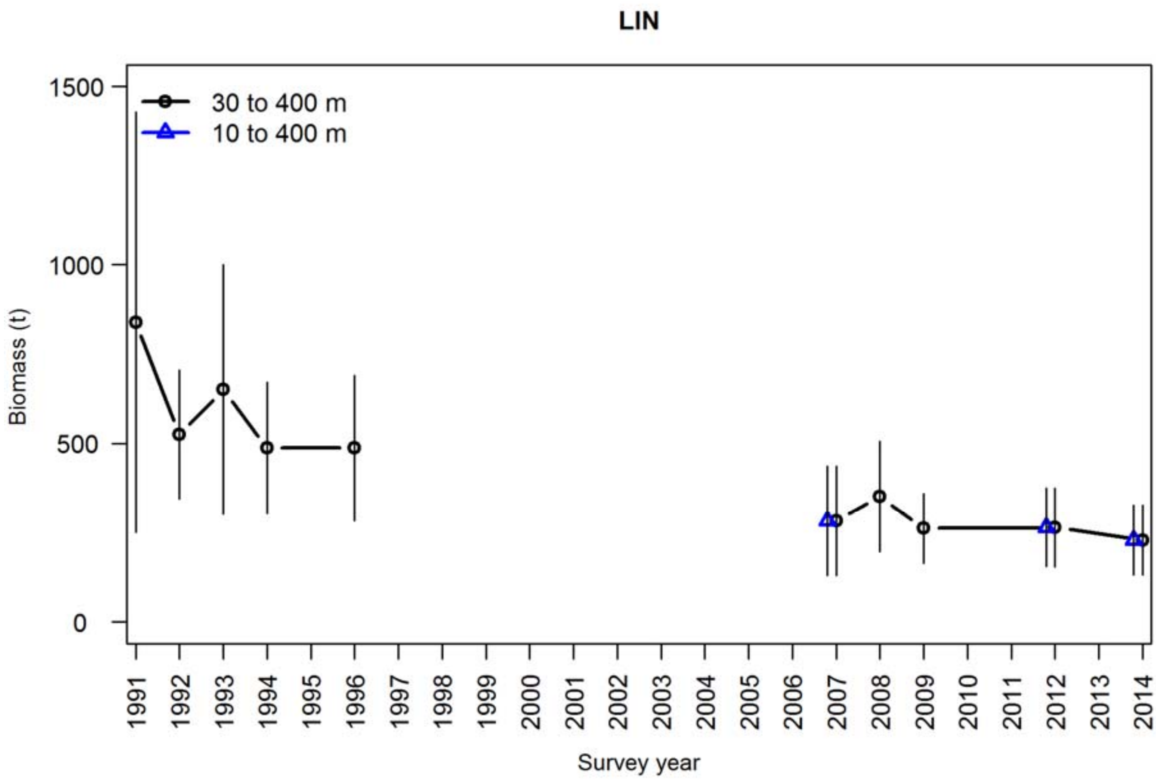


Figure 15: Key non-target QMS species total biomass and 95% confidence intervals for all ECSI winter surveys in core strata (30–400 m), and core plus shallow strata (10–400 m) in 2007, 2012 and 2014.



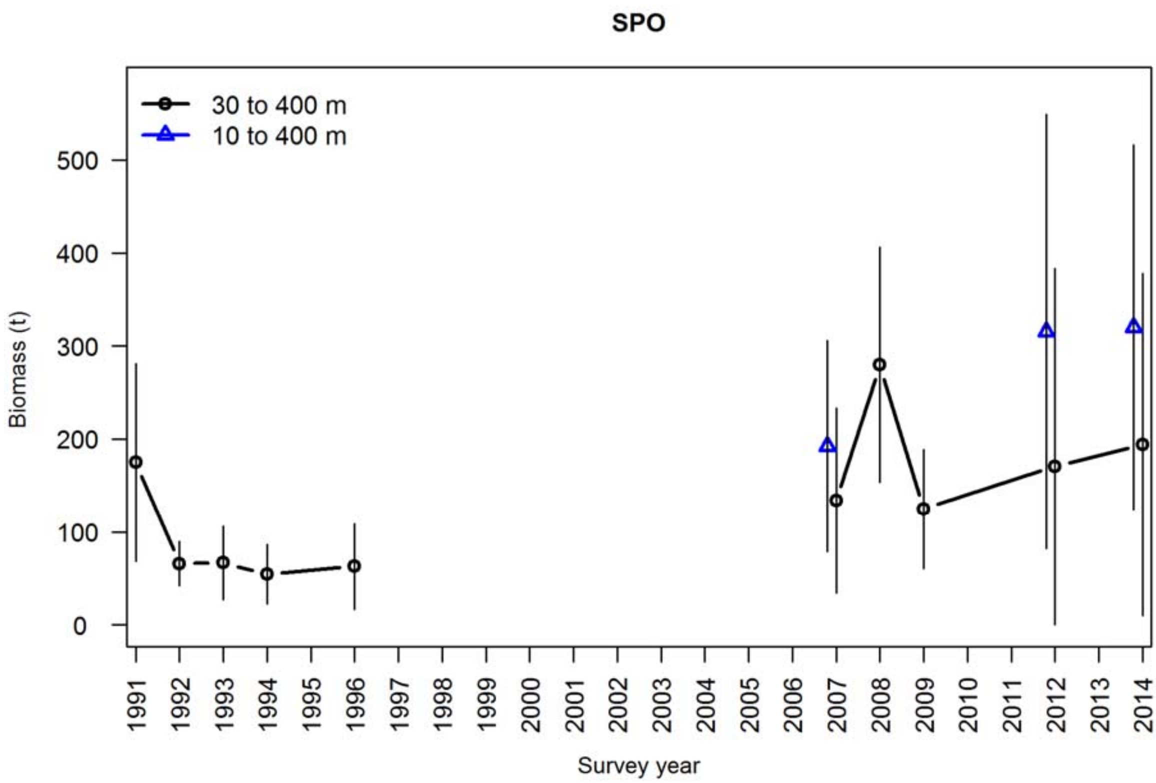
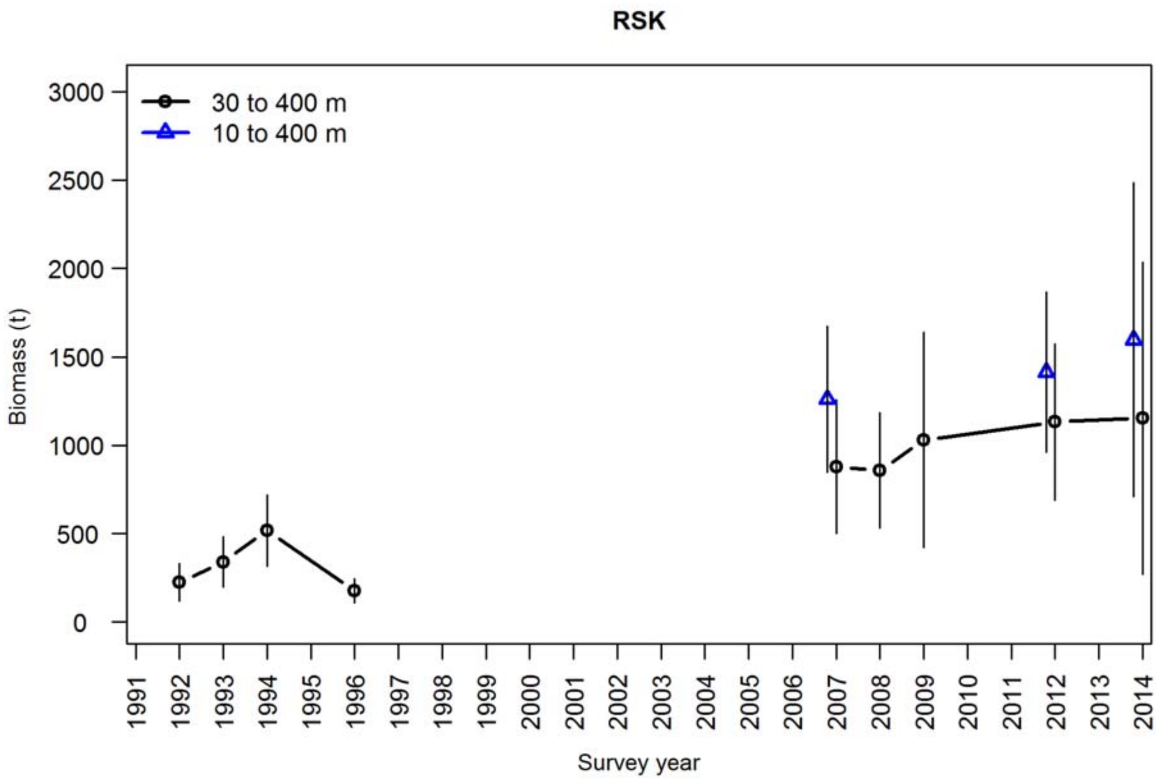


Figure 15 – ***continued***



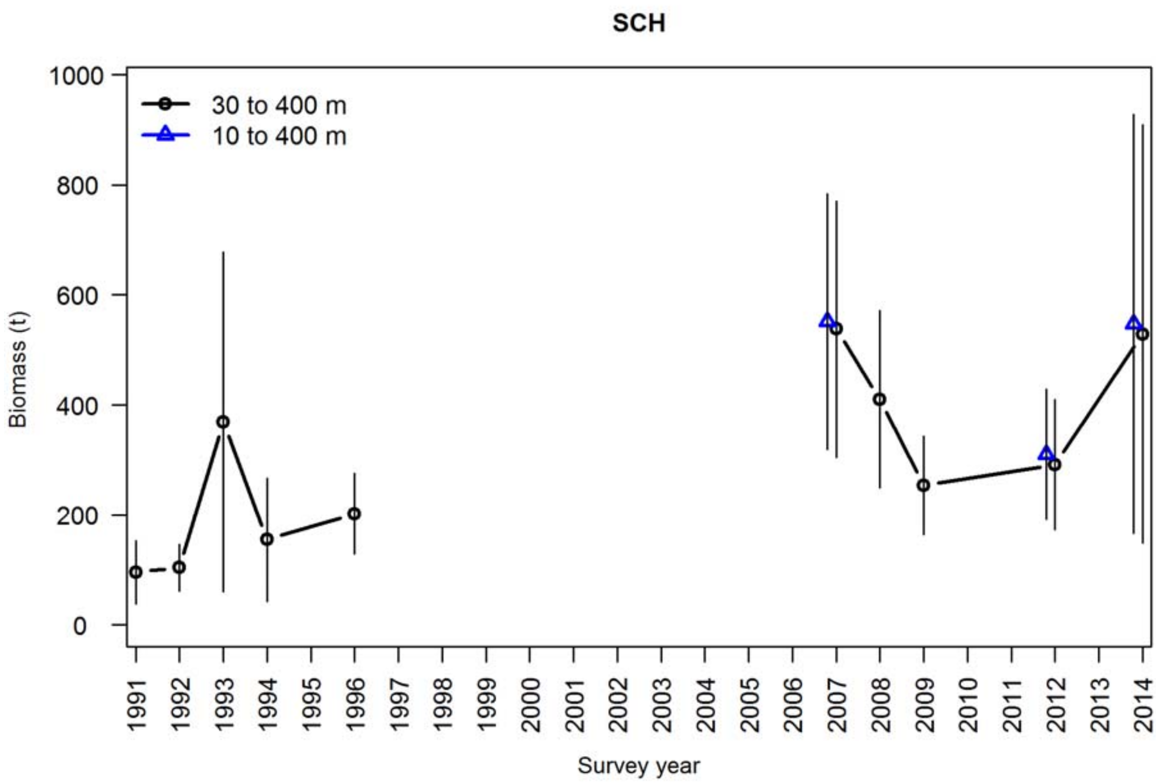
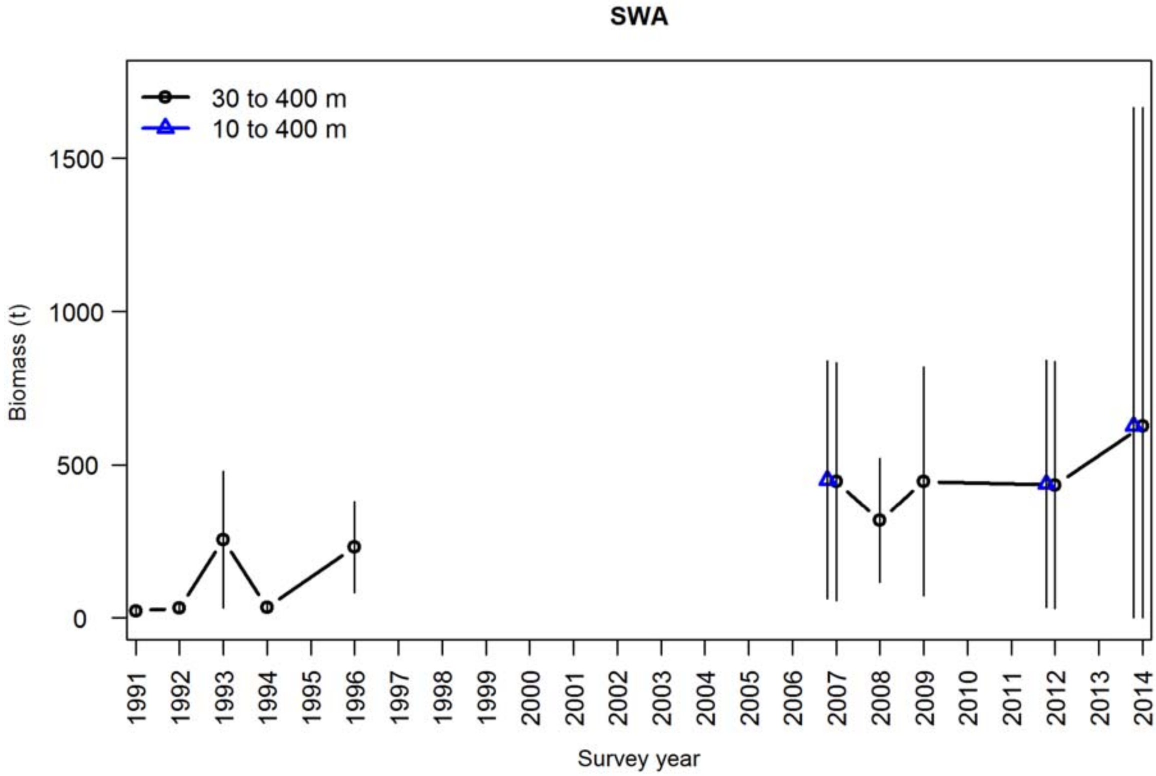


Figure 15 – *continued*



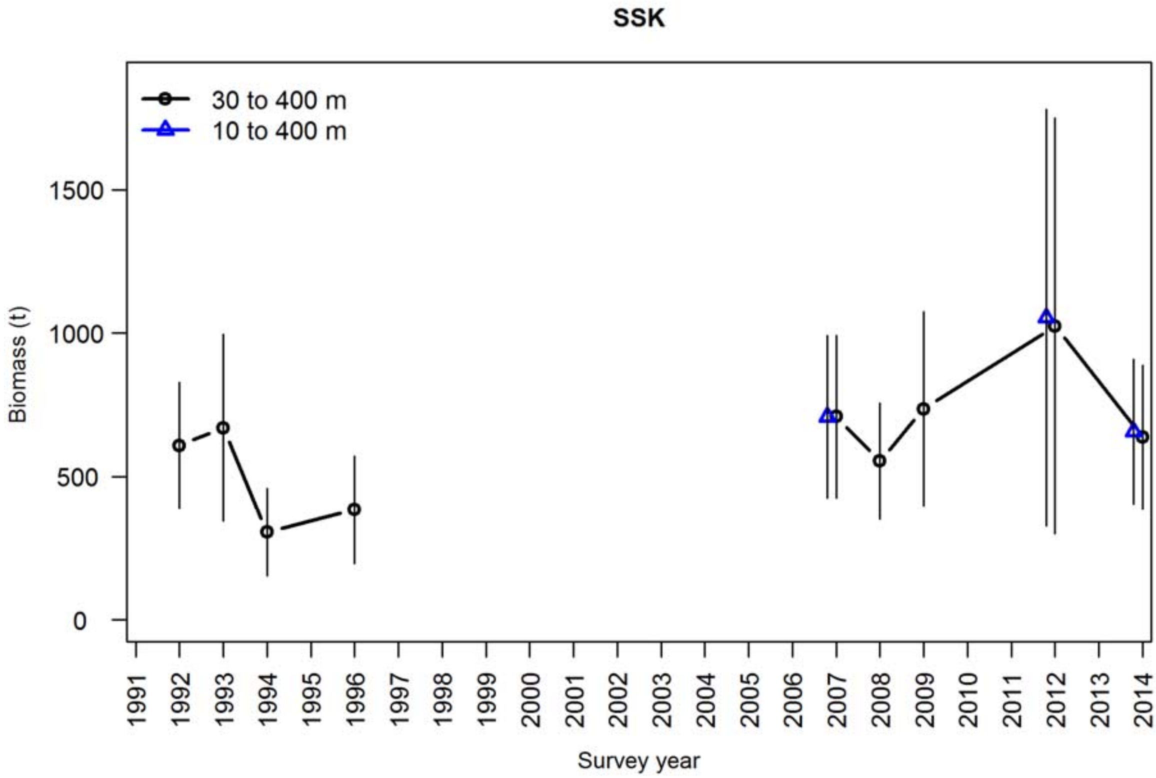


Figure 15 – ***continued***

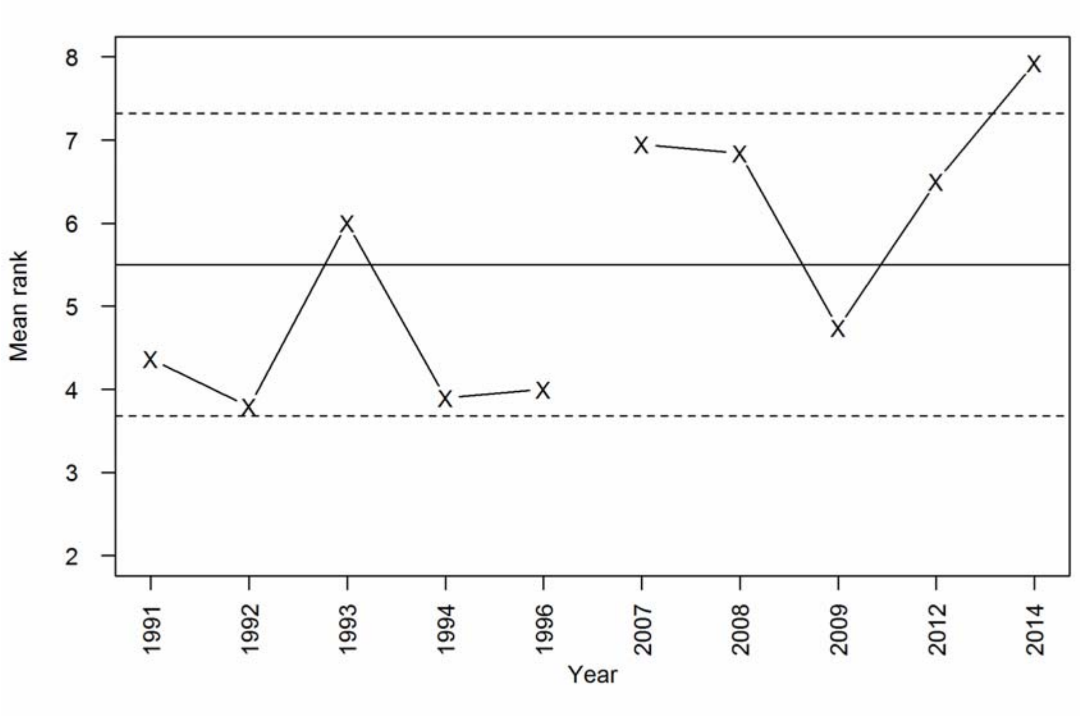


Figure 16: Mean ranks for the ECSI winter trawl surveys (core strata) for 19 species, including the target species. The solid line indicates the overall mean rank. Mean ranks outside the broken lines (95% confidence intervals) have extreme catchability.

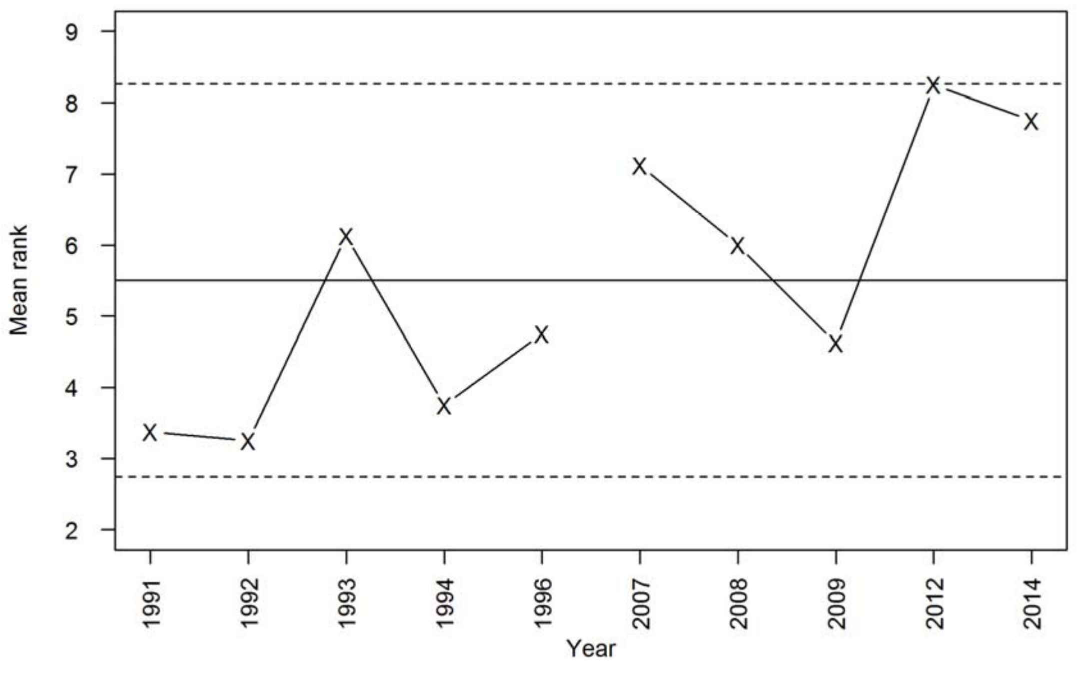


Figure 17: Mean ranks for the ECSI winter trawl surveys (core strata) for eight target species. The solid line indicates the overall mean rank. Mean ranks outside the broken lines (95% confidence intervals) have extreme catchability.

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. 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	18	24-Apr-14	1600	433322	1725067	433027	1724989	15	16	3	4.8	72.4	1	14.6	13.1
2	7	25-Apr-14	701	431181	1725528	431438	1725313	25	28	3	5.1	74.3	1	13.8	11.7
3	7	25-Apr-14	914	431679	1725763	431964	1725619	30	32	3.03	5.1	73	1	14.3	12.5
4	7	25-Apr-14	1254	431253	1732080	431532	1731962	62	64	2.91	5	69.3	1	14	11.6
5	7	25-Apr-14	1600	431571	1731653	431749	1731522	44	47	2.01	5	76.2	2	13	12.4
6	13	26-Apr-14	744	430759	1733373	431056	1733496	115	123	3.1	4.2	80.8	2	13.3	11.1
7	13	26-Apr-14	1012	431283	1733196	431583	1733295	112	119	3.08	4.8	77.4	1	13.2	11.1
8	13	26-Apr-14	1234	431784	1734402	432067	1734411	121	126	2.83	4.7	78	1	13.1	10.8
9	17	26-Apr-14	1548	432012	1734952	431735	1734822	292	317	2.92	4.7	88.9	1	13.2	9.2
10	13	27-Apr-14	657	432135	1734155	432275	1733792	113	116	2.98	4.8	80	1	12.8	10.9
11	7	27-Apr-14	940	432529	1732194	432696	1732395	72	86	2.21	4.8	73	2	13.6	10.8
12	6	27-Apr-14	1151	433042	1733598	432774	1733798	83	84	3.04	5	74.9	1	13.1	11.3
13	12	27-Apr-14	1436	432960	1735377	433229	1735528	130	135	2.9	4.9	78.2	1	13	10.3
14	7	28-Apr-14	708	432204	1731341	432479	1731463	36	43	2.88	4.7	73.8	1	13.3	13
15	7	28-Apr-14	942	432800	1731445	433042	1731687	42	56	2.98	4.8	76.1	1	13.5	12.7
16	18	28-Apr-14	1157	432937	1730854	433117	1730530	21	23	2.96	5.3	70.6	1	13.7	13.4
17	18	28-Apr-14	1346	432880	1730183	433038	1725841	24	25	2.94	5.1	72.3	1	13.9	13.8
18	18	28-Apr-14	1530	432733	1725813	432481	1730071	26	27	3.14	4.9	73.1	1	13.9	13.7
19	18	29-Apr-14	824	433719	1730026	433432	1730141	18	22	2.98	4.9	71.4	1	13.1	13.3
20	18	29-Apr-14	1054	433088	1725266	432840	1725487	19	23	2.95	5	70	1	NA	NA
21	18	29-Apr-14	1309	432420	1724631	432185	1724920	16	21	3.15	5	69.3	1	13.3	13.2
22	18	29-Apr-14	1515	432063	1724554	431822	1724849	16	21	3.22	5	70.5	2	13.2	13.1
23	6	30-Apr-14	747	433645	1731789	433340	1731828	60	64	3.06	4.7	70	1	13.1	13
24	6	01-May-14	716	433934	1734181	433641	1734196	87	89	2.93	5	74	1	12.6	11.6
25	12	01-May-14	939	433803	1735367	434110	1735396	100	105	3.07	4.7	84.5	1	12.5	11.2
26	12	01-May-14	1121	434318	1735663	434612	1735579	122	125	3	4.9	83.9	1	12.3	11.3
27	17	01-May-14	1339	435362	1735670	435605	1735433	297	307	2.96	4.8	88.9	1	12.5	10.1
28	17	03-May-14	714	435909	1735360	440044	1735152	384	390	2.01	4.8	88.9	2	12.4	8.8
29	16	03-May-14	920	440422	1734537	440553	1734325	382	389	2	4.8	88.9	2	12.5	9.5
30	11	03-May-14	1205	441030	1732479	441189	1732226	133	136	2.41	4.8	81.9	2	12.5	11.1

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)	Door spread (m)	Gear perf.	Temperature (°C) Station	Stratum
31	16	03-May-14	1409	441789	1732002	441939	1731757	299	308	2.3	4.8	83.5	2	11.5	10.3
32	16	03-May-14	1627	442179	1731138	442304	1730892	257	267	2.15	4.4	80.9	2	12.1	10.2
33	5	04-May-14	706	435604	1731391	435735	1731235	71	78	1.72	4.3	67.5	2	13.1	12.4
34	5	04-May-14	815	435892	1731152	440103	1730848	75	77	3.03	4.8	69	1	13.2	12.2
35	5	04-May-14	1014	440630	1730222	440880	1725994	77	82	2.98	5	71.7	1	13	12.1
36	5	04-May-14	1226	440296	1725707	440531	1725466	70	72	2.91	5	70.6	1	13.2	12.2
37	4	04-May-14	1525	440514	1723884	440670	1723637	58	61	2.36	5	69.4	2	13.1	12.6
38	19	05-May-14	710	435559	1723223	435770	1722928	21	25	2.99	4.9	71.7	1	13.1	13.6
39	19	05-May-14	926	435680	1721767	435943	1721570	22	29	2.98	4.9	73.7	1	13.2	13.5
40	19	05-May-14	1139	435857	1721511	440000	1721363	27	28	1.78	4.8	73.2	2	13.3	13.5
41	19	05-May-14	1509	435945	1720501	440179	1720247	15	17	2.96	4.8	73.6	1	13.5	13.5
42	19	06-May-14	714	440358	1715611	440411	1720015	15	19	2.95	4.8	72.7	1	13.2	13.4
43	19	06-May-14	929	440273	1720239	440573	1720246	20	27	3	4.8	73.1	1	13.4	13.5
44	4	06-May-14	1132	440541	1720660	440714	1720811	31	36	2.04	4.9	74.2	2	13.5	13.5
45	4	06-May-14	1312	440252	1721383	440340	1721699	34	38	2.43	4.9	74.5	2	13.3	12.9
46	4	06-May-14	1456	440780	1722310	441031	1722538	51	53	2.99	4.9	72.2	1	13.4	12.5
47	5	07-May-14	711	435534	1732518	435759	1732435	81	84	2.32	4.9	73.4	2	12.9	11.9
48	5	07-May-14	850	435801	1732192	440070	1732059	73	79	2.85	4.9	70.1	1	12.8	12
49	11	07-May-14	1219	440695	1731872	440904	1731685	101	103	2.48	4.8	79.6	2	12.8	11.9
50	5	07-May-14	1357	440818	1731238	441020	1730935	89	93	2.96	4.9	75.2	1	NA	NA
51	4	08-May-14	707	442008	1720397	441816	1720707	59	60	2.93	4.8	73.1	1	12.9	12.7
52	4	08-May-14	905	441618	1720743	441394	1721023	53	55	3	4.8	72.1	1	12.9	12.9
53	4	08-May-14	1118	441649	1721816	441410	1722063	63	66	2.97	4.9	71.2	1	13	12.6
54	4	08-May-14	1303	441471	1722395	441184	1722498	57	67	2.96	5	72.4	1	12.9	12.6
55	5	08-May-14	1536	441346	1724049	441100	1724301	72	76	3.05	4.9	74.1	1	12.6	12
56	3	10-May-14	1214	444090	1712082	443805	1712161	31	33	2.9	5.1	71.4	1	11.8	12.1
57	3	10-May-14	1401	443614	1712254	443336	1712406	31	32	2.98	5.1	72.1	1	12	12
58	3	10-May-14	1540	443048	1712523	442810	1712762	30	35	2.92	5.1	72.3	1	12.1	12
59	11	11-May-14	709	441373	1731148	441631	1730937	116	125	2.99	5	84.4	2	11.9	11.2
60	11	11-May-14	942	442484	1730061	442650	1725756	160	170	2.73	5	85.8	1	11.7	11.3
61	11	11-May-14	1140	442747	1725287	442524	1725567	145	152	2.99	5	91.3	1	11.8	11.2

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	15	11-May-14	1440	443364	1724198	443520	1723865	206	216	2.83	4.9	88	1	11.8	11.4
63	10	12-May-14	718	443471	1723451	443640	1723134	140	141	2.81	4.9	81.6	1	11.8	11.4
64	15	12-May-14	1101	443845	1723368	444007	1723029	273	276	2.9	4.9	88.9	2	11.8	11
65	10	12-May-14	1354	443831	1721418	443996	1721154	123	126	2.49	4.8	76.7	2	12	11.6
66	14	13-May-14	724	452185	1712574	451981	1712865	232	247	2.88	4.8	86.3	2	12.1	11.7
67	14	13-May-14	944	451768	1713143	451516	1713364	293	302	2.96	4.8	88.9	2	12	10.1
68	8	13-May-14	1248	451528	1712955	451333	1713049	119	121	2.05	4.8	80.5	2	12.2	11.8
69	8	13-May-14	1553	450895	1713585	450657	1713835	131	132	2.96	4.9	79.8	1	12.2	11.5
70	14	14-May-14	714	445905	1715437	445737	1715766	237	254	2.87	4.9	86.9	2	12.2	10.4
71	15	14-May-14	1020	445754	1715932	445630	1720165	342	353	2.06	4.8	88.9	2	12.1	8.8
72	20	16-May-14	722	442764	1712089	442468	1712135	18	20	2.97	5	69.5	1	11.6	12.1
73	20	16-May-14	955	441503	1713101	441317	1713423	16	17	2.96	5.1	71.5	1	11.5	13
74	20	16-May-14	1147	441153	1713571	441192	1713989	14	18	3.02	5	72.5	1	11.8	13.3
75	19	16-May-14	1426	440888	1714350	440775	1714596	15	15	2.09	5	71.4	1	12.1	12.8
76	4	17-May-14	720	441905	1724004	442089	1723672	88	91	3	4.8	72.2	1	11.9	11.7
77	10	17-May-14	936	442169	1724063	442378	1723782	101	105	2.89	4.9	80.1	1	12.3	11.6
78	4	17-May-14	1152	442538	1722796	442251	1722869	83	96	2.91	5	77.5	1	11.9	11.8
79	4	17-May-14	1424	442327	1722584	442538	1722307	80	85	2.89	4.9	71.8	1	12.1	11.8
80	3	18-May-14	720	442685	1714724	442984	1714736	57	62	2.99	4.9	74.5	1	11.9	12
81	3	18-May-14	944	443149	1714510	443425	1714364	62	65	2.94	4.9	72.1	1	12	12
82	3	18-May-14	1149	444025	1714268	444312	1714188	76	80	2.92	5	72.7	1	12.1	12.1
83	9	18-May-14	1436	444365	1715936	444136	1720209	110	111	3	4.8	86.6	1	12.2	11.9
84	3	19-May-14	718	444045	1713339	444303	1713147	51	55	2.91	4.8	74.6	1	12	12.1
85	2	19-May-14	931	444669	1712854	444945	1712660	42	47	3.08	4.8	70.6	1	NA	NA
86	21	19-May-14	1147	444985	1711803	445259	1711657	18	22	2.92	5	74.2	1	11.7	11.8
87	21	19-May-14	1403	444543	1711599	444834	1711533	15	19	2.94	5	72.8	1	11.8	11.8
88	9	20-May-14	720	445277	1714843	445479	1714550	113	115	2.89	4.8	70.4	1	12.2	12.2
89	8	20-May-14	932	450242	1714131	450512	1713959	122	128	2.96	4.8	71.7	1	12.1	11.8
90	2	20-May-14	1156	445843	1713247	450129	1713115	85	90	3	4.8	73.1	1	12.2	12.3
91	8	20-May-14	1435	450190	1713422	450470	1713292	102	110	2.94	4.8	73.5	1	12.2	12

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)	Doors pread (m)	Gear perf.	Temperature. (°C) Surface	Temperature. (°C) Bottom
92	2	21-May-14	720	445449	1712335	445732	1712462	45	51	2.96	4.8	72.1	1	11.6	12.1
93	21	21-May-14	1026	450697	1711007	450421	1711193	24	26	3.05	5.1	76.3	1	11.9	11.9
94	3	23-May-14	1518	443518	1720394	443296	1720681	92	95	3.01	5	81.4	1	12.1	12
95	10	24-May-14	723	442855	1722373	443118	1722224	101	107	2.83	4.9	78.3	1	12	12
96	10	24-May-14	921	443327	1721501	443554	1721225	102	107	3	4.9	77.3	1	12	11.9
97	9	24-May-14	1143	444512	1720901	444806	1720883	132	141	2.94	4.8	79.5	1	12	11.7
98	1	27-May-14	747	451668	1710197	451420	1710432	30	31	2.98	4.8	73.4	1	11.6	11.7
99	1	27-May-14	1025	452256	1710827	451962	1710933	49	52	3.03	4.9	72.8	1	12	12
100	8	27-May-14	1343	452789	1711370	453021	1711103	106	108	2.98	4.8	74.9	1	12	12
101	1	28-May-14	726	452861	1710526	453155	1710440	55	62	3	4.9	70.9	1	11.7	12
102	1	28-May-14	937	452707	1705851	452737	1705837	36	36	0.31	5	72.2	4	11.6	11.8
103	1	30-May-14	1112	453098	1705542	452873	1705647	37	39	2.36	5.1	71.8	2	NA	9
104	8	30-May-14	1500	452544	1711580	452296	1711813	107	111	2.97	5.4	76.2	1	12.1	12.1
105	8	31-May-14	731	452048	1712049	451875	1712196	106	107	2.01	5.3	78	1	12.1	12
106	8	31-May-14	910	451679	1712326	451405	1712475	106	108	2.93	5	76.7	1	12.1	12.1
107	8	31-May-14	1112	451276	1712655	450972	1712684	112	115	3.04	4.9	78.9	1	12	12
108	8	31-May-14	1349	450549	1714304	450316	1714564	134	136	2.96	5.2	82.2	1	11.5	11.5
109	9	01-Jun-14	721	445059	1715569	444831	1715844	123	125	3	5	79.9	1	11.8	11.7
110	9	01-Jun-14	1055	444848	1720452	444637	1720750	NA	NA	2.98	5	79.5	1	11.7	11.3
111	17	02-Jun-14	727	430164	1734027	430446	1734099	271	275	2.86	4.9	88.9	1	11.8	11
112	13	02-Jun-14	1114	432484	1733277	432796	1733336	113	117	3.14	5.1	79.2	1	11.4	11.5
113	17	02-Jun-14	1533	434534	1740253	434820	1740212	334	337	2.87	4.8	88.9	1	11.6	10.5
114	5	03-Jun-14	722	441824	1724608	441631	1724933	85	91	3.02	5.1	74.5	1	11.7	11.7
115	5	03-Jun-14	952	440657	1724239	440470	1724568	66	67	3.01	5.4	70.3	1	11.4	11.4
116	5	03-Jun-14	1239	435618	1730181	435440	1730517	65	67	3	5.1	66.3	1	11.3	11.5
117	5	03-Jun-14	1510	440003	1731419	435840	1731781	74	79	3.07	5.3	71.4	1	11.5	11.5
118	7	04-Jun-14	719	430826	1730516	431016	1730196	40	42	3	5.2	72.9	1	11.5	11.9
119	7	04-Jun-14	921	431452	1725900	431681	1725643	31	37	2.95	5.2	72.3	1	NA	NA

Appendix 3: Gear parameters for biomass stations 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)	118	4.9	0.18	4.2–5.4
10–400 m	Doorspread (m)	118	76.3	5.97	66.3–91.3
10–400 m	Distance (n. miles)	118	2.8	0.32	1.7–3.2
10–400 m	Warp:depth ratio	118	4.6	3.05	2.4–14.3
Core strata					
30–400 m	Headline height (m)	97	4.9	0.18	4.2–5.4
30–400 m	Doorspread (m)	97	77.1	6.2	66.3–91.3
30–400 m	Distance (n. miles)	97	2.8	0.32	1.7–3.1
30–400 m	Warp:depth ratio	97	3.4	1.16	2.4–8
30–100 m					
30–100 m	Headline height (m)	50	4.9	0.17	4.3–5.4
30–100 m	Doorspread (m)	50	72.6	2.49	66.3–81.4
30–100 m	Distance (n. miles)	50	2.8	0.31	1.7–3.1
30–100 m	Warp:depth ratio	50	3.9	1.38	2.7–8
100–200 m					
100–200 m	Headline height (m)	33	4.9	0.2	4.2–5.4
100–200 m	Doorspread (m)	33	79.6	4.19	70.4–91.3
100–200 m	Distance (n. miles)	33	2.9	0.27	2–3.1
100–200 m	Warp:depth ratio	33	2.8	0.07	2.7–3
200–400 m					
200–400 m	Headline height (m)	14	4.8	0.13	4.4–4.9
200–400 m	Doorspread (m)	14	87.6	2.47	80.9–88.9
200–400 m	Distance (n. miles)	14	2.6	0.4	2–3
200–400 m	Warp:depth ratio	14	2.5	0.11	2.4–2.7
Shallow strata					
10–30 m	Headline height (m)	21	5	0.13	4.8–5.3
10–30 m	Doorspread (m)	21	72.2	1.68	69.3–76.3
10–30 m	Distance (n. miles)	21	2.9	0.33	1.8–3.2
10–30 m	Warp:depth ratio	21	10.6	2.17	7.4–14.3

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 2014. In order of catch weight.

(A) 30–400 m

Species code	Common name	Scientific name	Catch (kg)	% catch	% occ.	Depth (m) Min.	Depth (m) Max.	Stations
BAR	Barracouta	*Thyrsites atun*	64 377.9	36.9	93.8	25	349	91
SPD	Spiny dogfish	*Squalus acanthias*	32 193.2	18.4	99	25	389	96
GSH	Dark ghost shark	*Hydrolagus novaezealandiae*	30 363.8	17.4	48.5	66	389	47
SPE	Sea perch	*Helicolenus spp.*	6 618.6	3.8	72.2	31	389	70
CBI	Two saddle rattail	*Coelorinchus biclinozonalis*	4 936.8	2.8	23.7	25	334	23
NMP	Tarakihi	*Nemadactylus macropterus*	4 611.7	2.6	64.9	25	135	63
RCO	Red cod	*Pseudophycis bachus*	3 722.4	2.1	67	25	389	65
WIT	Witch	*Arnoglossus scapha*	2 887.6	1.7	92.8	25	349	90
GUR	Red gurnard	*Chelidonichthys kumu*	2 777.4	1.6	60.8	25	141	59
CAR	Carpet shark	*Cephaloscyllium isabellum*	2 186.8	1.3	85.6	25	349	83
CBE	Crested bellowsfish	*Notopogon lilliei*	1 700.3	1.0	52.6	55	384	51
ELE	Elephantfish	*Callorhinchus milii*	1 667.8	1.0	42.3	25	122	41
RSK	Rough skate	*Zearaja nasuta*	1 511.2	0.9	59.8	25	349	58
GIZ	Giant stargazer	*Kathetostoma giganteum*	1 396.9	0.8	78.4	30	389	76
SCG	Scaly gurnard	*Lepidotrigla brachyoptera*	1 376.5	0.8	70.1	34	152	68
SWA	Silver warehou	*Seriolella punctata*	1 100.3	0.6	45.4	25	349	44
JAV	Javelinfish	*Lepidorhynchus denticulatus*	1 073.0	0.6	12.4	237	389	12
SSK	Smooth skate	*Dipturus innominatus*	994.3	0.6	42.3	30	349	41
SCH	School shark	*Galeorhinus galeus*	947.8	0.5	62.9	25	274	61
SDO	Silver dory	*Cyttus novaezealandiae*	891.3	0.5	48.5	30	300	47
HOK	Hoki	*Macruronus novaezelandiae*	881.7	0.5	13.4	64	389	13

NOS	NZ southern arrow squid	*Nototodarus sloanii*	819.6	0.5	89.7	25	389	87
LIN	Ling	*Genypterus blacodes*	703.3	0.4	47.4	25	389	46
CAS	Oblique banded rattail	*Coelorinchus aspercephalus*	499.2	0.3	18.6	102	389	18
PIG	Pigfish	*Congiopodus leucopaecilus*	478.4	0.3	54.6	25	334	53
LEA	Leatherjacket	*Meuschenia scaber*	413.2	0.2	21.6	25	66	21
CRM	Airy finger sponge	*Callyspongia cf ramosa*	355.2	0.2	3.1	39	107	3
CBO	Bollons rattail	*Coelorinchus bollonsi*	305.2	0.2	9.3	42	389	9
HAP	Hapuku	*Polyprion oxygeneios*	283.6	0.2	46.4	31	301	45
WAR	Common warehou	*Seriolella brama*	270.4	0.2	21.6	25	114	21
BCO	Blue cod	*Parapercis colias*	250.3	0.1	20.6	30	160	20
SPO	Rig	*Mustelus lenticulatus*	196.3	0.1	24.7	30	124	24
ZVA	*Thetys vagina*	*Thetys vagina*	190	0.1	27.8	84	389	27
FHD	Deepsea flathead	*Hoplichthys haswelli*	186.8	0.1	9.3	116	389	9
LSO	Lemon sole	*Pelotretis flavilatus*	155.5	0.1	66	25	349	64
SSI	Silverside	*Argentina elongata*	114.2	0.1	51.5	55	389	50
MOK	Moki	*Latridopsis ciliaris*	108.4	0.1	10.3	30	135	10
DSP	Deepsea pigfish	*Congiopodus coriaceus*	85.1	0.0	14.4	72	315	14
SFL	Sand flounder	*Rhombosolea plebeia*	75.8	0.0	9.3	25	42	9
CON	Conger eel	*Conger* spp.	66.7	0.0	4.1	25	42	4
OCT	Octopus	*Pinnoctopus cordiformis*	58.9	0.0	19.6	30	300	19
JMD	Greenback jack mackerel	*Trachurus declivis*	54.8	0.0	17.5	25	274	17
SEV	Broadnose sevengill shark	*Notorynchus cepedianus*	50	0.0	1	31	31	1
HMT	Deepsea anemone	Hormathiidae	47.8	0.0	29.9	79	389	29
LDO	Lookdown dory	*Cyttus traversi*	43.7	0.0	8.2	67	389	8
ERA	Electric ray	*Torpedo fairchildi*	33.6	0.0	4.1	32	81	4
JMM	Slender jack mackerel	*Trachurus murphyi*	30.6	0.0	11.3	60	274	11
SCC	Sea cucumber	*Stichopus mollis*	29.7	0.0	46.4	31	301	45
WWA	White warehou	*Seriolella caerulea*	26	0.0	2.1	300	315	2
NUD	Nudibranchia	Nudibranchia (Order)	22.8	0.0	8.2	55	274	8
PYR	*Pyrosoma atlanticum*	*Pyrosoma atlanticum*	22.5	0.0	20.6	36	389	20

ONG	Sponges	Porifera (Phylum)	22.4	0.0	25.8	25	389	25
SRB	Southern Rays bream	*Brama australis*	21.9	0.0	5.2	300	389	5
SAL	Salps	Salps	21.8	0.0	10.3	42	315	10
SPF	Scarlet wrasse	*Pseudolabrus miles*	20	0.0	4.1	39	120	4
SPR	Sprats	*Sprattus antipodum S. muelleri*	20	0.0	10.3	25	66	10
ESO	N.Z. sole	*Peltorhamphus novaezeelandiae*	17	0.0	10.3	25	64	10
CPT	*Chaetopterus*	*Chaetopterus*	15.4	0.0	4.1	36	89	4
ACS	Deepsea anemone	Actinostolidae	13.5	0.0	24.7	36	389	24
YCO	Yellow cod	*Parapercis gilliesi*	12.8	0.0	7.2	84	160	7
SMO	Cross-fish	*Sclerasterias mollis*	12.3	0.0	27.8	36	389	27
FRO	Frostfish	*Lepidopus caudatus*	12.2	0.0	3.1	66	274	3
COZ	Bryozoan	Bryozoa (Phylum)	10	0.0	1	42	42	1
FMA	*Fusitriton magellanicus*	*Fusitriton magellanicus*	9.8	0.0	35.1	36	389	34
KIN	Kingfish	*Seriola lalandi*	9.8	0.0	3.1	36	72	3
LLC	Long-legged masking crab	*Leptomithrax longipes*	8.9	0.0	15.5	79	275	15
WOD	Wood	Wood	8.6	0.0	3.1	64	116	3
GON	*Gonorynchus forsteri & G. Greyi*	*Gonorynchus forsteri & G. greyi*	7.8	0.0	7.2	64	349	7
ATT	Kahawai	*Arripis trutta*	7.1	0.0	2.1	42	64	2
DAP	Antlered crab	*Dagnaudus petterdi*	6.7	0.0	1	315	315	1
DIR	Pagurid	*Diacanthurus rubricatus*	6.7	0.0	25.8	36	389	25
HAK	Hake	*Merluccius australis*	6.2	0.0	3.1	25	37	3
TOP	Pale toadfish	*Ambophthalmos angustus*	6.1	0.0	4.1	71	389	4
BRI	Brill	*Colistium guntheri*	5.8	0.0	3.1	30	33	3
TOD	Dark toadfish	*Neophrynichthys latus*	5.6	0.0	19.6	25	257	19
MDO	Mirror dory	*Zenopsis nebulosa*	5.5	0.0	3.1	274	301	3
BTA	Smooth deepsea skate	*Brochiraja asperula*	3.6	0.0	3.1	300	389	3
JMN	Yellowtail jack mackerel	*Trachurus novaezelandiae*	3.6	0.0	3.1	25	88	3
ANT	Anemones	Anthozoa	3.6	0.0	5.2	47	116	5
PCO	Ahuru	*Auchenoceros punctatus*	3.4	0.0	5.2	30	66	5
SDR	Spiny seadragon	*Solegnathus spinosissimus*	3.2	0.0	2.1	55	64	2

GFL	Greenback flounder	*Rhombosolea tapirina*	3.1	0.0	1	106	106	1
ASC	Sea squirt	Ascidiacea	2.9	0.0	10.3	31	126	10
PSI	Geometric star	*Psilaster acuminatus*	2.8	0.0	3.1	116	274	3
ASH	Circular saw shell	*Astraea heliotropium*	2.6	0.0	7.2	55	106	7
ATA	*Alcithoe Arabica*	*Alcithoe arabica*	2.2	0.0	6.2	52	116	6
PEP	*Pentagonaster pulchellus*	*Pentagonaster pulchellus*	2.1	0.0	2.1	103	107	2
SAM	Quinnat salmon	*Oncorhynchus tshawytscha*	2	0.0	1	42	42	1
PAG	Pagurid	Paguroidea	2	0.0	7.2	55	135	7
CRB	Crab	Crab	1.9	0.0	4.1	64	135	4
PHA	Brown seaweed	Phaeophyta	1.7	0.0	1	135	135	1
STY	Spotty	*Notolabrus celidotus*	1.5	0.0	3.1	25	37	3
PNE	*Proserpinaster neozelanicus*	*Proserpinaster neozelanicus*	1.3	0.0	3.1	116	389	3
OPA	Opalfish	*Hemerocoetes* spp.	1.3	0.0	10.3	42	141	10
CDO	Capro dory	*Capromimus abbreviatus*	1.2	0.0	9.3	111	349	9
MIQ	Warty squid	*Onykia ingens*	1.2	0.0	1	301	301	1
PTB	*Pteraster bathamae*	*Pteraster bathamae*	1.2	0.0	5.2	116	152	5
BAM	*Bathyplotes* spp.	*Bathyplotes* spp.	1.2	0.0	3.1	116	389	3
ASR	Asteroid (starfish)	Asteroid (starfish)	1.1	0.0	8.2	31	123	8
GAS	Gastropods	Gastropoda	1	0.0	6.2	47	349	6
HOR	Horse mussel	*Atrina zelandica*	1	0.0	2.1	36	42	2
CCX	Small banded rattail	*Coelorinchus parvifasciatus*	0.9	0.0	1	315	315	1
SCI	Scampi	*Metanephrops challengeri*	0.9	0.0	4.1	135	389	4
EGC	Egg case	Egg case	0.9	0.0	7.2	36	257	7
ANZ	Knobbly sandpaper sponge	*Ecionemia novaezelandiae*	0.8	0.0	1	84	84	1
CSS	Maurea	*Calliostoma selectum*	0.7	0.0	4.1	36	64	4
JFI	Jellyfish	Jellyfish	0.7	0.0	2.1	76	275	2
NCA	Hairy red swimming crab	*Nectocarcinus antarcticus*	0.6	0.0	5.2	52	89	5
SSQ	Bobtail squid	*Sepioloidea* spp.	0.6	0.0	6.2	32	389	6
BPE	Butterfly perch	*Caesioperca lepidoptera*	0.6	0.0	2.1	39	55	2
MSL	Starfish	*Mediaster sladeni*	0.6	0.0	4.1	102	206	4

DCS	Dawsons catshark	*Bythaelurus dawsoni*	0.6	0.0	1	315	315	1
BYS	Alfonsino	*Beryx splendens*	0.6	0.0	2.1	243	334	2
SBW	Southern blue whiting	*Micromesistius australis*	0.5	0.0	1	389	389	1
HCO	Hairy conger	*Bassanago hirsutus*	0.5	0.0	1	315	315	1
APT	*Argobuccinum pustulosum tumidum*	*Argobuccinum pustulosum tumidum*	0.5	0.0	3.1	57	89	3
HDR	Hydroid	Hydrozoa (Class)	0.5	0.0	2.1	72	75	2
OPH	Ophiuroid (brittle star)	Ophiuroid (brittle star)	0.4	0.0	1	55	55	1
STI	*Stichopathes* spp.	*Stichopathes* spp.	0.4	0.0	2.1	257	300	2
BGZ	Banded stargazer	*Kathetostoma binigrasella*	0.4	0.0	1	123	123	1
DGT	Dragonets	Callionymidae	0.3	0.0	2.1	96	126	2
PRE	Cushion starfish	*Patiriella regularis*	0.3	0.0	2.1	34	95	2
RBT	Redbait	*Emmelichthys nitidus*	0.2	0.0	1	132	132	1
OPE	Orange perch	*Lepidoperca aurantia*	0.2	0.0	2.1	57	62	2
BRN	Barnacle	Cirripedia (Class)	0.2	0.0	1	34	34	1
POL	Polychaete	Polychaeta	0.2	0.0	2.1	42	47	2
ETL	Lucifer dogfish	*Etmopterus lucifer*	0.2	0.0	1	384	384	1
SPS	Speckled sole	*Peltorhamphus latus*	0.2	0.0	1	32	32	1
SLS	Slender sole	*Peltorhamphus tenuis*	0.2	0.0	2.1	25	32	2
GLB	Globefish	*Contusus richei*	0.2	0.0	1	32	32	1
TUL	Sea tulip	*Pyura pachydermatina*	0.2	0.0	2.1	88	101	2
PAD	Paddle crab	*Ovalipes catharus*	0.2	0.0	1	30	30	1
SEE	Silver conger	*Gnathophis habenatus*	0.2	0.0	2.1	71	79	2
RHY	Common roughy	*Paratrachichthys trailli*	0.2	0.0	1	106	106	1
NHU	Policeman crab	*Neommatocarcinus huttoni*	0.2	0.0	2.1	31	33	2
KWH	Knobbed whelk	*Austrofucus glans*	0.2	0.0	1	135	135	1
OMA	Red snakestar	*Ophiopsammus maculata*	0.1	0.0	1	389	389	1
HTU	Quill worm	*Hyalinoecia tubicola*	0.1	0.0	1	389	389	1
API	Alert pigfish	*Alertichthys blacki*	0.1	0.0	1	389	389	1
NTO	Masking crab	*Notomithrax* spp.	0.1	0.0	1	102	102	1
OYS	Oysters dredge	*Ostrea chilensis*	0.1	0.0	1	42	42	1

COF	Flabellum coral	*Flabellum* spp.	0.1	0.0	1	275	275	1
TRP	Triplefin	Tripterygiidae	0.1	0.0	1	36	36	1
SPA	Slender sprat	*Sprattus antipodum*	0.1	0.0	1	47	47	1
OCO	*Octopus* spp.	*Octopus spp.*	0.1	0.0	1	32	32	1
PYC	Sea spiders	Pycnogonida	0.1	0.0	1	135	135	1
PAT	*Patiriella* spp.	*Patiriella* spp.	0.1	0.0	1	31	31	1
CIC	Orange frond sponge	*Crella incrustans*	0.1	0.0	1	66	66	1
SEQ	Sepiolid squid	Sepiolidae	0.1	0.0	1	42	42	1
QSC	Queen scallop	*Zygochlamys delicatula*	0.1	0.0	1	135	135	1
GMC	Garricks masking crab	*Leptomithrax garricki*	0.1	0.0	1	116	116	1
Total			174 558					

(B) 10–30 m

Species code	Common name	Scientific name	Catch (kg)	% catch	% occ.	Depth (m) Min.	Max.	Stations
SPD	Spiny dogfish	*Squalus acanthias*	4 723.6	27.1	100	14	27	21
RCO	Red cod	*Pseudophycis bachus*	2 871.6	16.5	95.2	14	27	20
GUR	Red gurnard	*Chelidonichthys kumu*	2 632.6	15.1	100	14	27	21
LEA	Leatherjacket	*Parika scaber*	2 491.5	14.3	61.9	14	27	13
ELE	Elephantfish	*Callorhinchus milii*	1 621.9	9.3	90.5	14	27	19
RSK	Rough skate	*Dipturus nasutus*	950	5.5	100	14	27	21
BAR	Barracouta	*Thyrsites atun*	769.3	4.4	81	14	27	17
SPO	Rig	*Mustelus lenticulatus*	314.5	1.8	71.4	14	27	15
CAR	Carpet shark	*Cephaloscyllium isabellum*	177	1.0	61.9	15	27	13
SFL	Sand flounder	*Rhombosolea plebeia*	145.1	0.8	90.5	14	27	19
SEV	Broadnose sevengill shark	*Notorynchus cepedianus*	120	0.7	4.8	21	21	1
GLB	Globefish	*Contusus richei*	105.4	0.6	57.1	14	26	12
CON	Conger eel	*Conger* spp.	78.5	0.5	28.6	15	26	6
ESO	New Zealand sole	*Peltorhamphus novaezeelandiae*	50.2	0.3	81	14	27	17
WOD	Wood	Wood	48.1	0.3	33.3	15	26	7
SSK	Smooth skate	*Dipturus innominatus*	41.6	0.2	9.5	14	22	2
SCH	School shark	*Galeorhinus galeus*	37	0.2	76.2	14	27	16
YBF	Yellowbelly flounder	*Rhombosolea leporina*	23.1	0.1	33.3	14	20	7
ERA	Electric ray	*Torpedo fairchildi*	21.1	0.1	14.3	18	26	3
WAR	Common warehou	*Seriolella brama*	19.2	0.1	76.2	14	26	16
ATT	Kahawai	*Arripis trutta*	15.2	0.1	23.8	14	23	5
NOS	NZ southern arrow squid	*Nototodarus sloanii*	14.7	0.1	38.1	15	26	8
SUR	Sea urchin, kina, sea egg	*Evechinus chloroticus*	13.3	0.1	14.3	19	26	3
HAP	Hapuku	*Polyprion oxygeneios*	12.9	0.1	9.5	19	22	2
MOK	Blue moki	*Latridopsis ciliaris*	12.1	0.1	9.5	15	22	2

BRI	Brill	*Colistium guntheri*	10.7	0.1	28.6	16	23	6
ROK	Rocks / Stones	Geological	9.9	0.1	9.5	15	15	2
NMP	Tarakihi	*Nemadactylus macropterus*	8.8	0.1	19	19	26	4
THR	Thresher shark	*Alopias vulpinus*	6.4	0.0	4.8	23	23	1
SEO	Seaweed	Seaweed	6.1	0.0	4.8	14	14	1
SPR	Sprats	*Sprattus antipodum, S. muelleri*	5.4	0.0	47.6	15	26	10
ASC	Solitary and colonial sea squirts	Ascidiacea (Class)	4.5	0.0	19	15	19	4
LSO	Lemon sole	*Pelotretis flavilatus*	4.4	0.0	28.6	21	27	6
JFI	Jellyfish	Jellyfish	3.9	0.0	14.3	16	26	3
BCO	Blue cod	*Parapercis colias*	3.7	0.0	9.5	22	26	2
GFL	Greenback flounder	*Rhombosolea tapirina*	3.7	0.0	9.5	19	22	2
STY	Spotty	*Notolabrus celidotus*	3.4	0.0	14.3	15	22	3
WIT	Witch	*Arnoglossus scapha*	3.2	0.0	23.8	19	27	5
SPZ	Spotted stargazer	*Genyagnus monopterygius*	2.9	0.0	14.3	15	23	3
PCO	Ahuru	*Auchenoceros punctatus*	2.5	0.0	47.6	15	26	10
PHA	Brown seaweed	Phaeophyta (Phylum)	2.3	0.0	14.3	15	26	3
TUR	Turbot	*Colistium nudipinnis*	1.9	0.0	4.8	18	18	1
TUL	Sea tulip	*Pyura pachydermatina*	1.7	0.0	9.5	14	19	2
FZE	Sand dollar	*Fellaster zelandiae*	1.3	0.0	19	16	21	4
SLS	Slender sole	*Peltorhamphus tenuis*	1.1	0.0	38.1	15	27	8
SAM	Quinnat salmon	*Oncorhynchus tshawytscha*	1	0.0	4.8	14	14	1
BRN	Barnacle	Barnacle	1	0.0	9.5	15	20	2
HAK	Hake	*Merluccius australis*	1	0.0	19	15	24	4
PIG	Pigfish	*Congiopodus leucopaecilus*	0.9	0.0	28.6	14	26	6
SCG	Scaly gurnard	*Lepidotrigla brachyoptera*	0.8	0.0	9.5	21	22	2
SWA	Silver warehou	*Seriolella punctata*	0.7	0.0	28.6	14	23	6
GAS	Gastropods	Gastropoda (Class)	0.7	0.0	4.8	26	26	1
SMO	Cross-fish	*Sclerasterias mollis*	0.4	0.0	9.5	23	26	2
ATA	*Alcithoe arabica*	*Alcithoe arabica*	0.4	0.0	14.3	16	26	3

SSQ	Bobtail squid	*Sepioloidea* spp.	0.4	0.0	19	15	26	4
ASH	Circular saw shell	*Astraea heliotropium*	0.4	0.0	4.8	26	26	1
CAC	Cancer crab	*Cancer novaezelandiae*	0.3	0.0	9.5	15	18	2
LIN	Ling	*Genypterus blacodes*	0.3	0.0	4.8	27	27	1
TOD	Dark toadfish	*Neophrynichthys latus*	0.3	0.0	4.8	22	22	1
ONG	Sponges	Porifera (Phylum)	0.2	0.0	9.5	23	26	2
ANC	Anchovy	*Engraulis australis*	0.2	0.0	9.5	15	19	2
SPS	Speckled sole	*Peltorhamphus latus*	0.2	0.0	9.5	21	27	2
SOT	*Solaster torulatus*	*Solaster torulatus*	0.2	0.0	4.8	19	19	1
DIR	Pagurid	*Diacanthurus rubricatus*	0.2	0.0	9.5	15	16	2
PAD	Paddle crab	*Ovalipes catharus*	0.2	0.0	9.5	16	16	2
ASR	Asteroid (starfish)	Asteroid (starfish)	0.2	0.0	9.5	26	27	2
SAR	*Squilla armata*	*Squilla armata*	0.1	0.0	4.8	18	18	1
CSS	Maurea	*Calliostoma selectum*	0.1	0.0	4.8	26	26	1
SCC	Sea cucumber	*Stichopus mollis*	0.1	0.0	4.8	21	21	1
NCA	Red swimming crab	*Nectocarcinus antarcticus*	0.1	0.0	4.8	21	21	1
NHU	Policeman crab	*Neommatocarcinus huttoni*	0.1	0.0	4.8	16	16	1
ZSQ	Stomatopod	*Squilla* sp.	0.1	0.0	4.8	15	15	1
PRE	Cushion starfish	*Patiriella regularis*	0.1	0.0	4.8	15	15	1
HTH	Sea cucumber (other than *Stichopus mollis*)	Holothurian (Class)	0.1	0.0	4.8	15	15	1
CCM	Eleven-arm seastar	*Coscinasterias muricata*	0.1	0.0	4.8	16	16	1
SHR	Sea hare	Order aplysiomorpha	0.1	0.0	4.8	22	22	1
PIP	Pipefish	Syngnathidae (Family)	0.1	0.0	4.8	22	22	1
NTO	Masking crab	*Notomithrax* spp.	0.1	0.0	4.8	19	19	1
Total			17 408					

Appendix 5: Macro-invertebrates collected on the 2014 survey not included in Appendix 4.

Species code	Phylum	Class	Order	Family	Genus	Species
ONG	Porifera	Demospongiae	Astrophorida	Ancorinidae	*Stelletta*	n. sp. 17
HDR	Cnidaria	Hydrozoa	Leptothecata	Lafoeidae	*Cryptolaria*	*pectinata*
GMC	Arthropoda	Malacostraca	Decapoda	Majidae	*Leptomithrax*	*garricki*
NUD	Mollusca	Gastropoda Opisthobranchia	Notaspidea	Pleurobranchidae	*Berthellina*	cf. *citrina*
STI	Cnidaria	Anthozoa	Scleractinia	Flabellidae	*Flabellum*	*knoxi*
POL	Annelida	Polychaeta	Spionida	Chaetopteridae		

Appendix 6: Length weight coefficients used to scale length frequencies for the 2014 survey. DB, MPI *Trawl* database. W = aL^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	0.0016	3.3370	707	25.8	71.2	This survey
Elephantfish	0.0070	3.0802	673	13.4	93.9	This survey
Giant stargazer	0.0246	2.8958	816	9.6	74	This survey
Lemon sole	0.0080	3.1278	524	14.6	41.2	DB, KAH9809
Ling	0.0013	3.2801	179	32.2	123.7	DB, KAH0004
Red cod	0.0167	2.8436	1168	9.5	73.7	This survey
Red gurnard	0.0065	3.1073	1138	11.5	52.7	This survey
Rig	0.0042	2.9975	398	32.8	112.1	This survey
Rough skate	0.0372	2.8454	701	11.6	69.6	This survey
School shark	0.0019	3.2185	527	27.6	150	This survey
Sea perch	0.0224	2.9285	1078	10.2	43.4	This survey
Silver warehou	0.0048	3.3800	262	16.6	57.8	DB, TAN9502
Smooth skate	0.0376	2.8534	197	18	146	This survey
Spiny dogfish	0.0036	3.0188	2276	25.5	98.8	This survey
Tarakihi	0.0141	3.0839	1020	10	48.3	This survey