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

New Zealand Fisheries Assessment Report 2016/61


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

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

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

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

# 1. INTRODUCTION

## 1.1 The 2016 east coast South Island inshore trawl survey

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

## 1.2 Background to east coast South Island inshore trawl surveys

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

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

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

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

## 1.3 Objectives

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

### Overall objective

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

### Specific objectives

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

# 2. METHODS

## 2.1 Survey area

### Core strata (30–400 m)

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

### Shallow strata (10–30 m)

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

### Core plus shallow strata (10–400 m)

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

## 2.2 Survey design

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

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

## 2.3 Vessel and gear

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

## 2.4 Timetable and survey plan

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

## 2.5 Trawling procedure

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

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

## 2.6 Catch and biological sampling

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

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

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

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

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

## 2.7 Data storage

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

## 2.8 Analysis of data

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

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

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

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

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

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

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

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

## 2.9 Survey representativeness

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

# 3. RESULTS

## 3.1 Trawling details

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

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

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

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

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

## 3.2 Catch composition

### Core strata (30–400 m)

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

### Shallow strata (10–30 m)

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

## 3.3 Biomass estimates

### Core strata (30–400 m)

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

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

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

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

### Core plus shallow strata (10–400 m)

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

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

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

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

## 3.4 Strata catch rates, biomass, and distribution

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

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

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

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

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

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

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

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

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

## 3.5 Biological and length frequency data

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

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

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

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

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

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

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

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

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

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

### Gonad stages

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

# 4. DISCUSSION

## 4.1 2016 survey

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

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

## 4.2 Time series trends in biomass, distribution, and size

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

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

### 4.2.1 Target species

#### Dark ghost shark

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

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

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

### Elephantfish

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

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

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

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

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

### Giant stargazer

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

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

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

### Red cod

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

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

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

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

### Red gurnard

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

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

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

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

### Sea perch

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

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

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

### Spiny dogfish

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

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

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

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

#### Tarakihi

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

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

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

### 4.2.2 Key non-target QMS species

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

## 4.3 Survey representativeness

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

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

| 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 | 4 | 123.0 |
| 2 | 30–100 | 1 242 | Oamaru | 0 | 3 | | 414.1 |
| 3 | 30–100 | 3 023 | Timaru | 0 | 4 | 4 | 377.9 |
| 4 | 30–100 | 2 703 | Rakaia | 0 | 10 | | 270.3 |
| 5 | 30–100 | 2 485 | Banks Pen. | 0 | 10 | | 248.5 |
| 6 | 30–100 | 2 373 | Pegasus | 208 | 3 | | 791.1 |
| 7 | 30–100 | 2 089 | Conway | 871 | 5 | | 417.8 |
| 8 | 100–200 | 628 | Shag Point | 17 | 6 | 5 | 57.1 |
| 9 | 100–200 | 1 163 | Oamaru | 0 | 6 | | 193.9 |
| 10 | 100–200 | 1 191 | Timaru | 0 | 5 | | 238.3 |
| 11 | 100–200 | 1 468 | Banks Pen. | 0 | 5 | | 293.6 |
| 12 | 100–200 | 764 | Pegasus | 132 | 3 | | 254.8 |
| 13 | 100–200 | 999 | Conway | 406 | 3 | | 333.0 |
| 14 | 200–400 | 322 | Oamaru Crack | 17 | 3 | | 107.4 |
| 15 | 200–400 | 430 | Timaru | 0 | 3 | | 143.4 |
| 16 | 200–400 | 751 | Banks Pen. | 0 | 3 | | 250.5 |
| 17 | 200–400 | 724 | Conway | 165 | 3 | | 241.5 |
| **Sub total** | | **23 339** | | **2 018** | **79** | **13** | **222.3** |
| 18 | 10–30 | 1 276 | Pegasus | 0 | 6 | | 212.6 |
| 19 | 10–30 | 986 | Rakaia | 0 | 6 | | 164.9 |
| 20 | 10–30 | 797 | Timaru | 0 | 3 | | 265.7 |
| 21 | 10–30 | 520 | Oamaru | 226 | 3 | | 173.2 |
| **Sub total** | | **3 579** | | **226** | **18** | | **198.8** |
| **Total** | | **26 918** | | **2 244** | **97** | **13** | 244.7 |

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

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

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

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

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

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

## A (Target species)

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

**Table 4 – *continued***

## B (Key QMS species)

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

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

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

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

**Table 5 – *continued***

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

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

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

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

**Table 5 –** ***continued***

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

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

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

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

| | | Length frequency data | | Biological data+ | | |
|---|---|---|---|---|---|---|
| Species code | Measurement method | No. of samples | No. of fish | No. of samples | No. of fish | No. of otoliths or spines |
| ATT | 1 | 3 | 15 | 0 | 0 | 0 |
| BAR | 1 | 95 | 8 591 | 0 | 0 | 0 |
| BCO | 2 | 23 | 302 | 1 | 1 | 0 |
| BRI | 2 | 5 | 14 | 0 | 0 | 0 |
| BYS | 1 | 1 | 1 | 0 | 0 | 0 |
| CAR | 2 | 1 | 8 | 0 | 0 | 0 |
| ELE | 1 | 45 | 1 268 | 45 | 475 | 389 |
| ESO | 2 | 12 | 229 | 0 | 0 | 0 |
| GFL | 2 | 4 | 25 | 0 | 0 | 0 |
| GIZ | 2 | 71 | 825 | 71 | 669 | 468 |
| GSH | G | 36 | 2 717 | 35 | 639 | 0 |
| GUR | 2 | 74 | 2 921 | 74 | 826 | 531 |
| HAP | 2 | 35 | 161 | 17 | 62 | 0 |
| HOK | 2 | 7 | 261 | 1 | 30 | 0 |
| JAV | 2 | 2 | 214 | 0 | 0 | 0 |
| JDO | 2 | 2 | 3 | 0 | 0 | 0 |
| JMD | 1 | 19 | 77 | 0 | 0 | 0 |
| JMM | 1 | 5 | 17 | 0 | 0 | 0 |
| JMN | 1 | 1 | 1 | 0 | 0 | 0 |
| KIN | 1 | 14 | 26 | 1 | 1 | 0 |
| LDO | 2 | 3 | 51 | 0 | 0 | 0 |
| LEA | 2 | 12 | 1 109 | 0 | 0 | 0 |
| LIN | 2 | 41 | 432 | 18 | 180 | 0 |
| LSO | 2 | 42 | 640 | 0 | 0 | 0 |
| MOK | 1 | 7 | 13 | 1 | 3 | 0 |
| NMP | 1 | 70 | 2 886 | 70 | 880 | 505 |
| NOS | 4 | 40 | 1 259 | 0 | 0 | 0 |
| OPE | 1 | 1 | 2 | 0 | 0 | 0 |
| RCO | 2 | 67 | 1 770 | 68 | 736 | 512 |
| RSK | 5 | 68 | 772 | 64 | 520 | 0 |
| RSO | 1 | 19 | 502 | 1 | 1 | 0 |
| SBW | 1 | 1 | 91 | 0 | 0 | 0 |
| SCG | 1 | 1 | 11 | 0 | 0 | 0 |
| SCH | 2 | 48 | 265 | 45 | 214 | 0 |
| SFL | 2 | 14 | 178 | 0 | 0 | 0 |
| SPD | 2 | 108 | 6 777 | 108 | 2166 | 0 |
| SPE | 2 | 59 | 3 440 | 59 | 873 | 504 |
| SPO | 2 | 32 | 327 | 27 | 215 | 0 |
| SSI | 1 | 3 | 176 | 0 | 0 | 0 |
| SSK | 5 | 50 | 207 | 49 | 177 | 0 |
| SWA | 1 | 48 | 1 329 | 0 | 0 | 0 |
| THR | 2 | 1 | 2 | 1 | 2 | 0 |

**Table 6 – *continued***

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

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

| Species | Sex | No. of fish | % Gonad stage | | | | |
|---|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 | 4 | 5 |
| **30–400 m** | | | | | | | |
| Giant stargazer | Males | 327 | 65 | 18 | 13 | 2 | 1 |
| | Females | 326 | 91 | 7 | 2 | 0 | 0 |
| Red cod | Males | 327 | 89 | 8 | 3 | <1 | 0 |
| | Females | 283 | 87 | 13 | 0 | 0 | 0 |
| Red gurnard | Males | 261 | 32 | 43 | 16 | 2 | 6 |
| | Females | 170 | 19 | 60 | 13 | 1 | 7 |
| Sea perch | Males | 442 | 22 | 43 | 29 | 4 | 1 |
| | Females | 397 | 52 | 36 | 4 | 1 | 7 |
| Tarakihi | Males | 386 | 92 | 5 | <1 | 0 | 3 |
| | Females | 374 | 89 | 11 | 0 | 0 | 0 |

| | | | % Gonad state | | | |
|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 | 4 |
| Dark ghost shark | Males | 261 | 45 | 17 | 38 | NA |
| | Females | 420 | 22 | 16 | 56 | 5 |

| | | | % Gonad state | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 | 4 | 5 | 6 |
| Elephantfish | Males | 146 | 5 | 17 | 78 | NA | NA | NA |
| | Females | 88 | 15 | 56 | 30 | 0 | NA | NA |
| Spiny dogfish | Males | 1 121 | 11 | 4 | 85 | NA | NA | NA |
| | Females | 543 | 33 | 22 | 5 | 3 | 37 | 0 |

| | | | % Gonad state | | | | | |
|---|---|---|---|---|---|---|---|---|
| **10–30 m** | | | 1 | 2 | 3 | 4 | 5 | 6 |
| Elephantfish | Males | 77 | 82 | 13 | 5 | NA | NA | NA |
| | Females | 160 | 48 | 48 | 4 | 0 | NA | NA |

| | | | % Gonad state | | | | |
|---|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 | 4 | 5 |
| Red gurnard | Males | 115 | 67 | 29 | 3 | 1 | 1 |
| | Females | 248 | 54 | 39 | 3 | 0 | 4 |

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

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

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

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

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

**Table 8 – *continued***

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

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

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

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

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

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

## A (Core strata 30–400 m)

Target species (recruited length)

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

**Table 9 – *continued***

## A (Core plus shallow strata 10–400 m)

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

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

## A (Finfish, core strata 30–400 m)

Finfish target species (length at maturity, cm)

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

**Table 10 – *continued***

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

**B (Elasmobranchs, core strata 30–400 m)**

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

**Table 10 – *continued***

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

## C (Core plus shallow strata 10–400 m)

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

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

**A (Core strata 30–400 m)**

Target species percent occurrence and percent of total catch

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

**B (Core plus shallow strata 10 to 400 m)**

Target species percent occurrence and percent of total catch

| | ELE | | GUR | | GUR and ELE |
|---|---|---|---|---|---|
| | % Occ. | % catch | % Occ. | % catch | % catch |
| 2007 | 41 | 2 | 61 | 2 | 4 |
| 2012 | 47 | 4 | 66 | 3 | 8 |
| 2014 | 51 | 2 | 68 | 3 | 5 |
| 2016 | 40 | 11 | 68 | 2 | 13 |

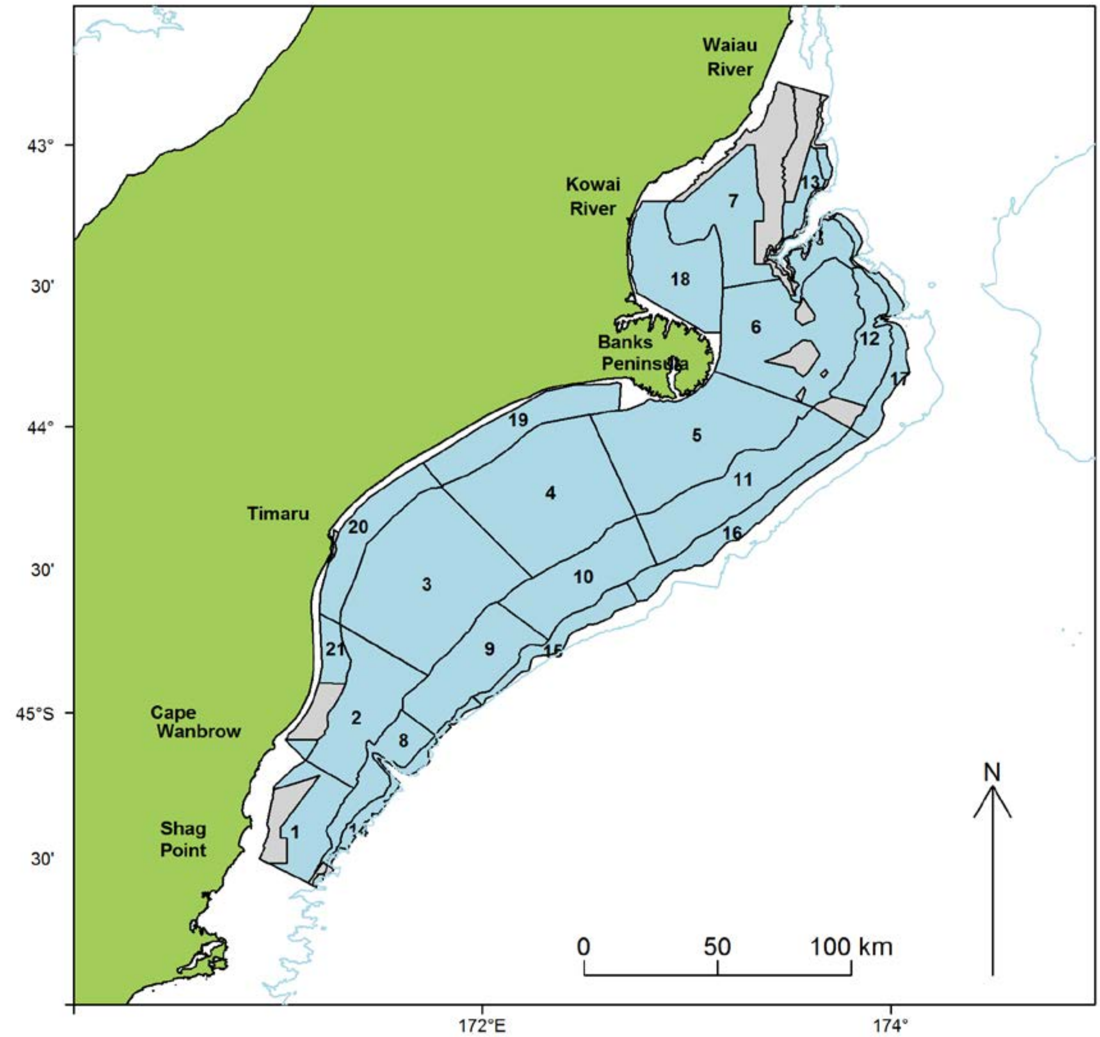



**Figure 1: Strata used in the 2016 ECSI trawl survey in 10–400 m. Shaded areas are foul ground. Outer depth contour is 500 m.**

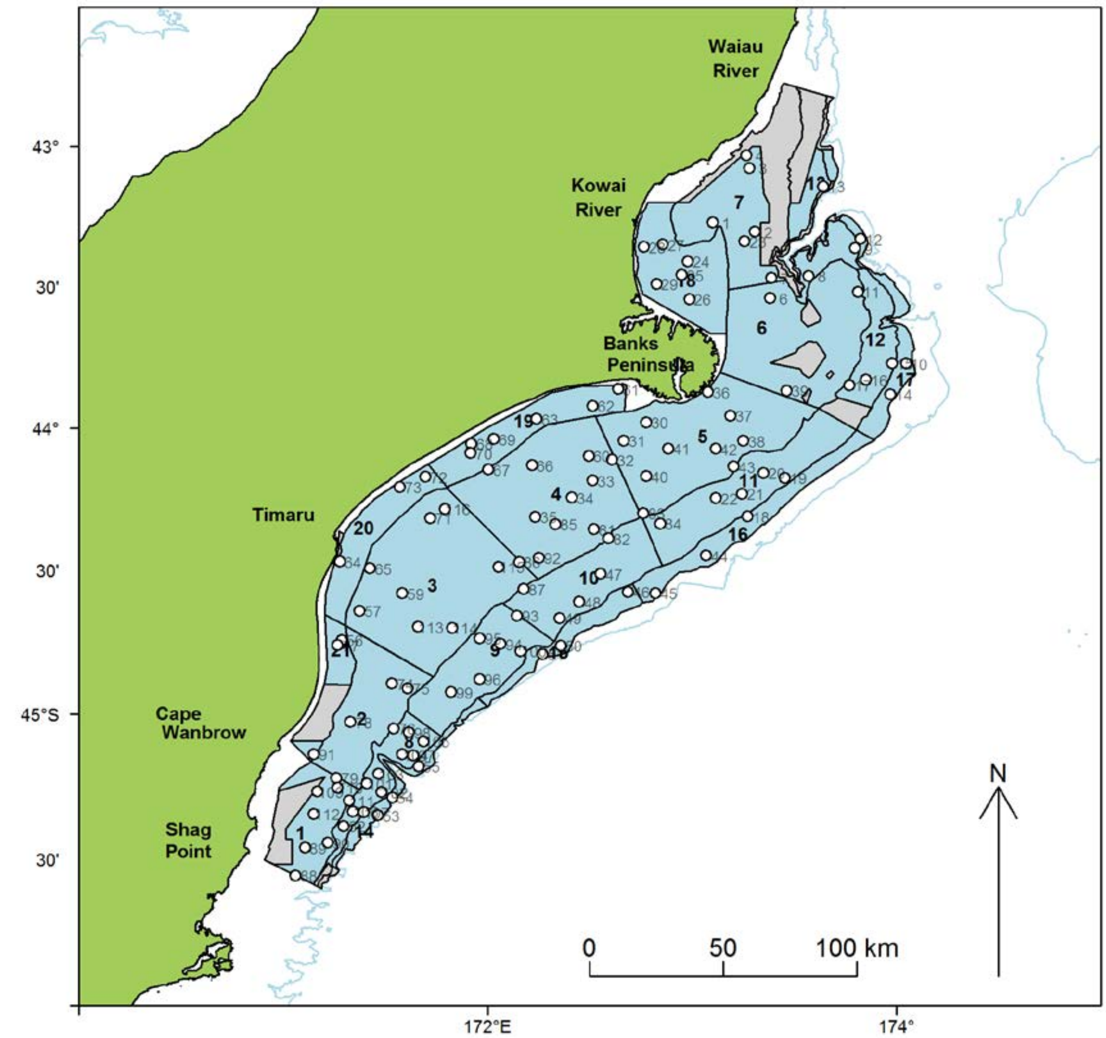



**Figure 2: All tows and tow numbers from the 2016 ECSI survey. Shaded areas are foul ground. Outer depth contour is 500 m.**

## Dark ghost shark

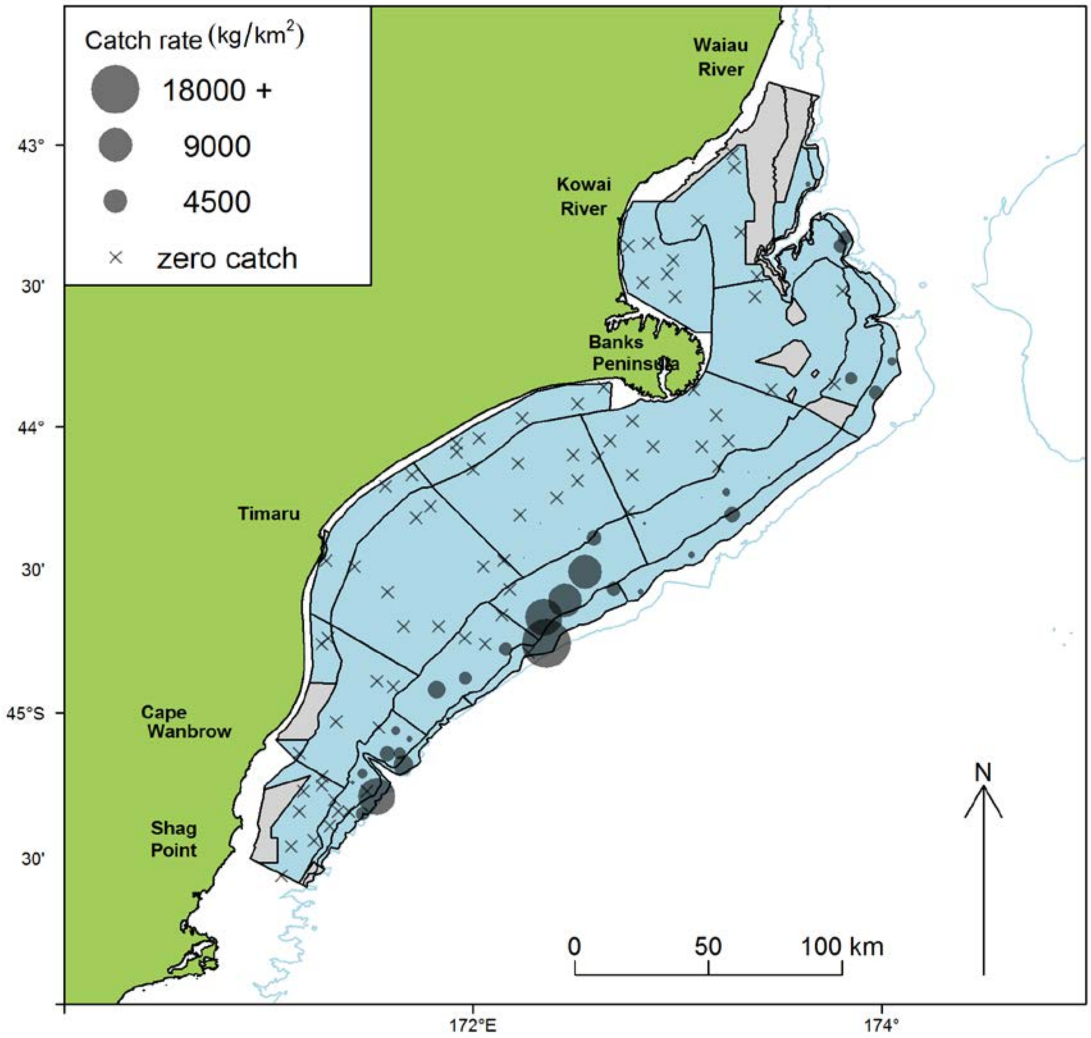



**Figure 3: Catch rates (kg.km$^{-2}$) of target species for the 2016 ECSI survey. The legend indicates the circle size that corresponds to three catch rates; on the figure, circle size is continuous and proportional to the catch rate. Crosses indicate no catch at that station. Grey shaded areas are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

## Elephantfish

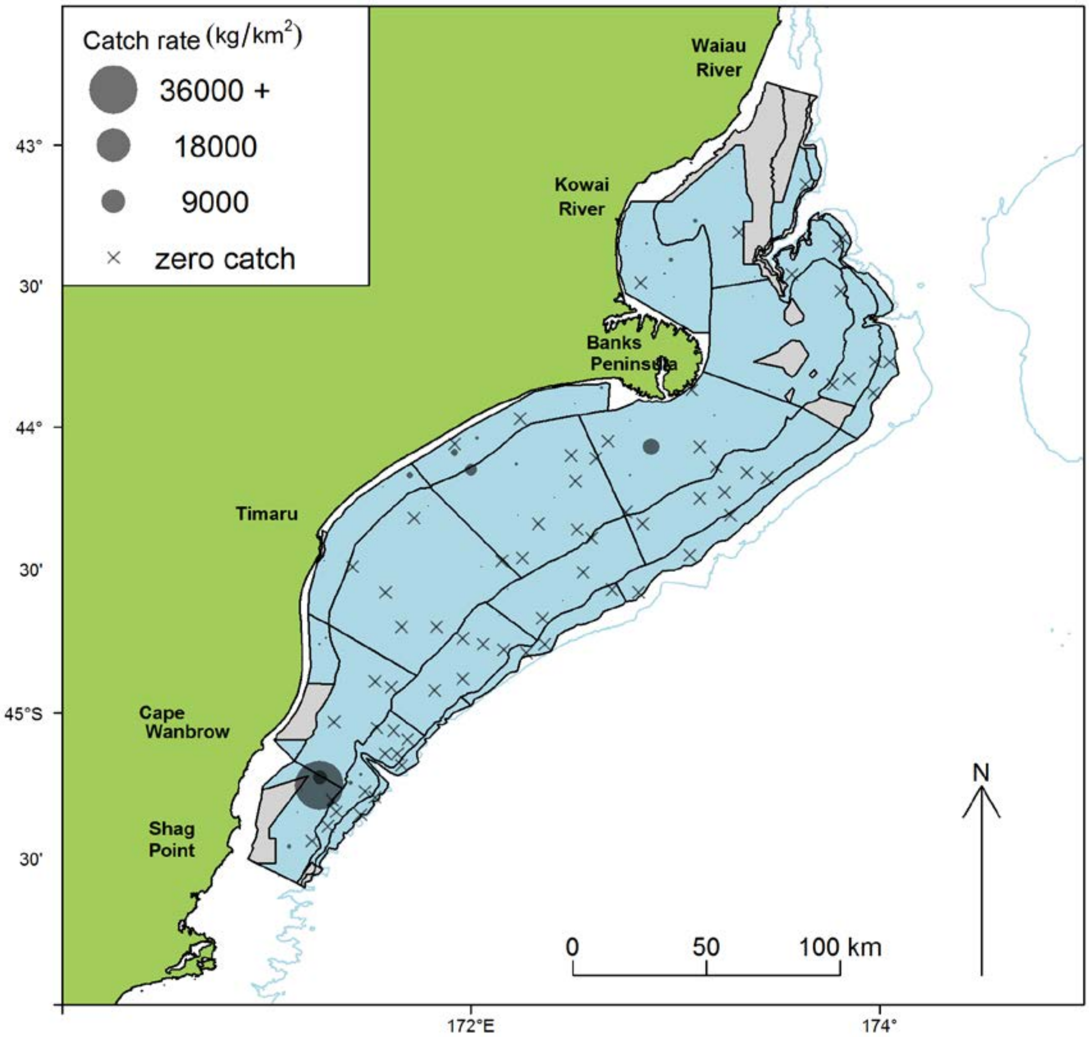



**Figure 3–*continued***

### Giant stargazer

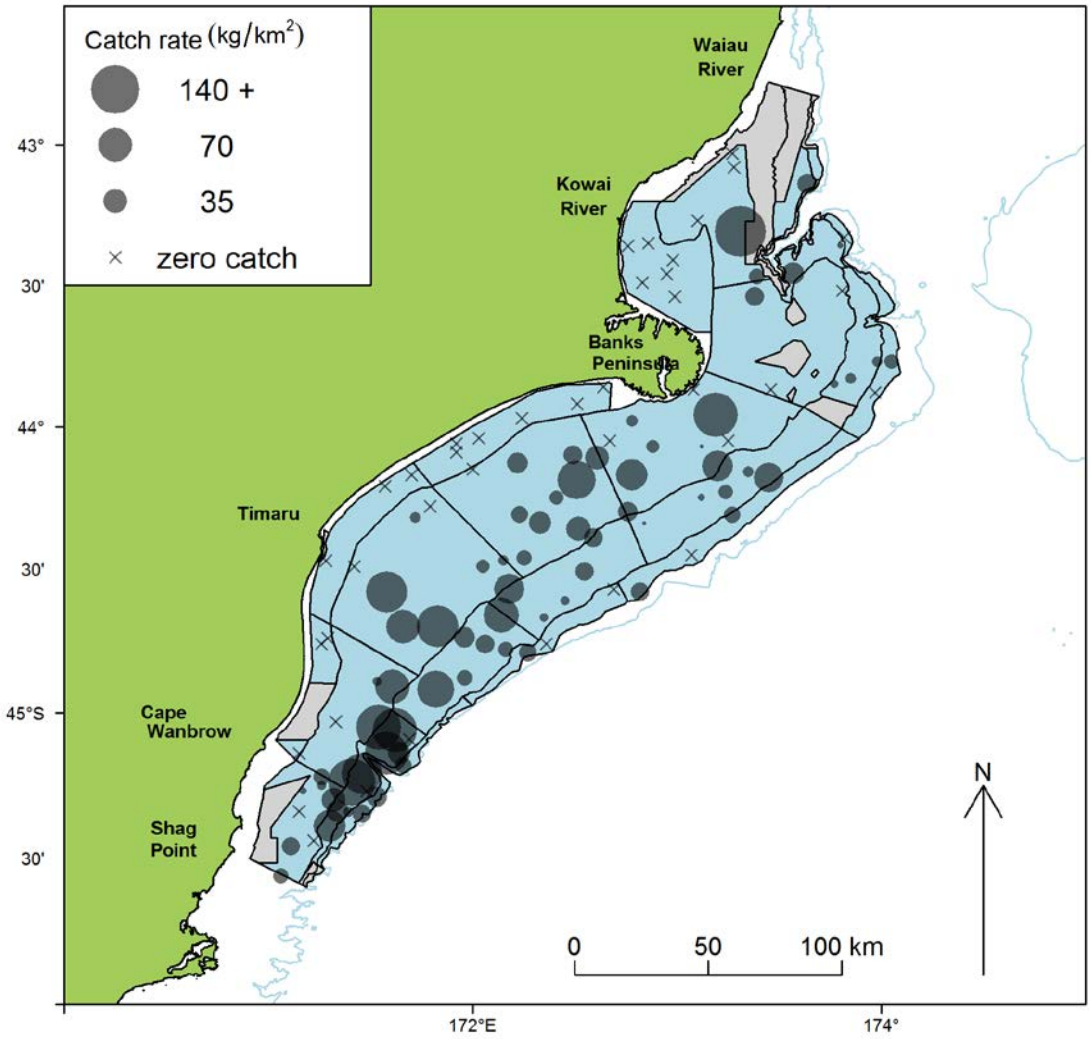



**Figure 3–*continued***

## Red Gurnard

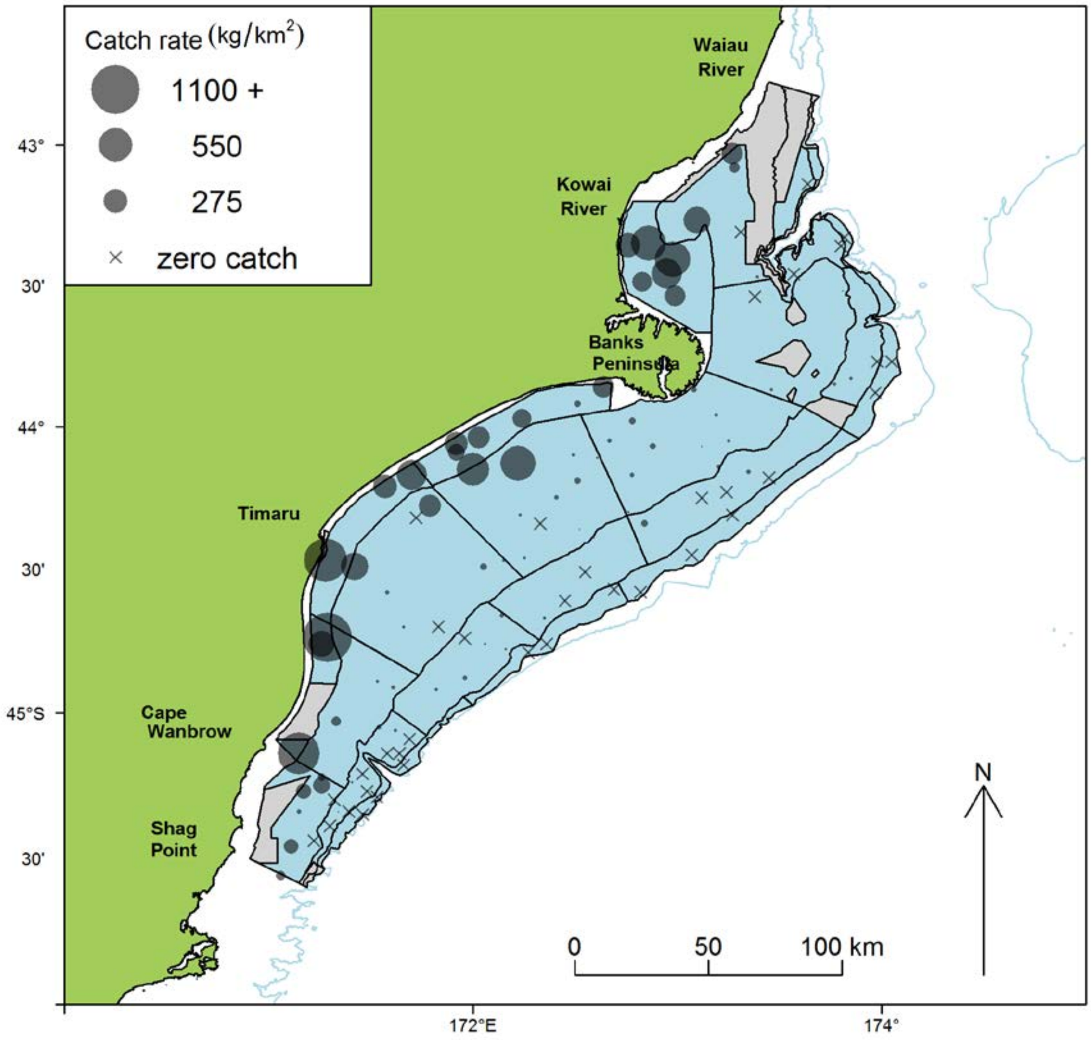



**Figure 3–*continued***

## Red cod

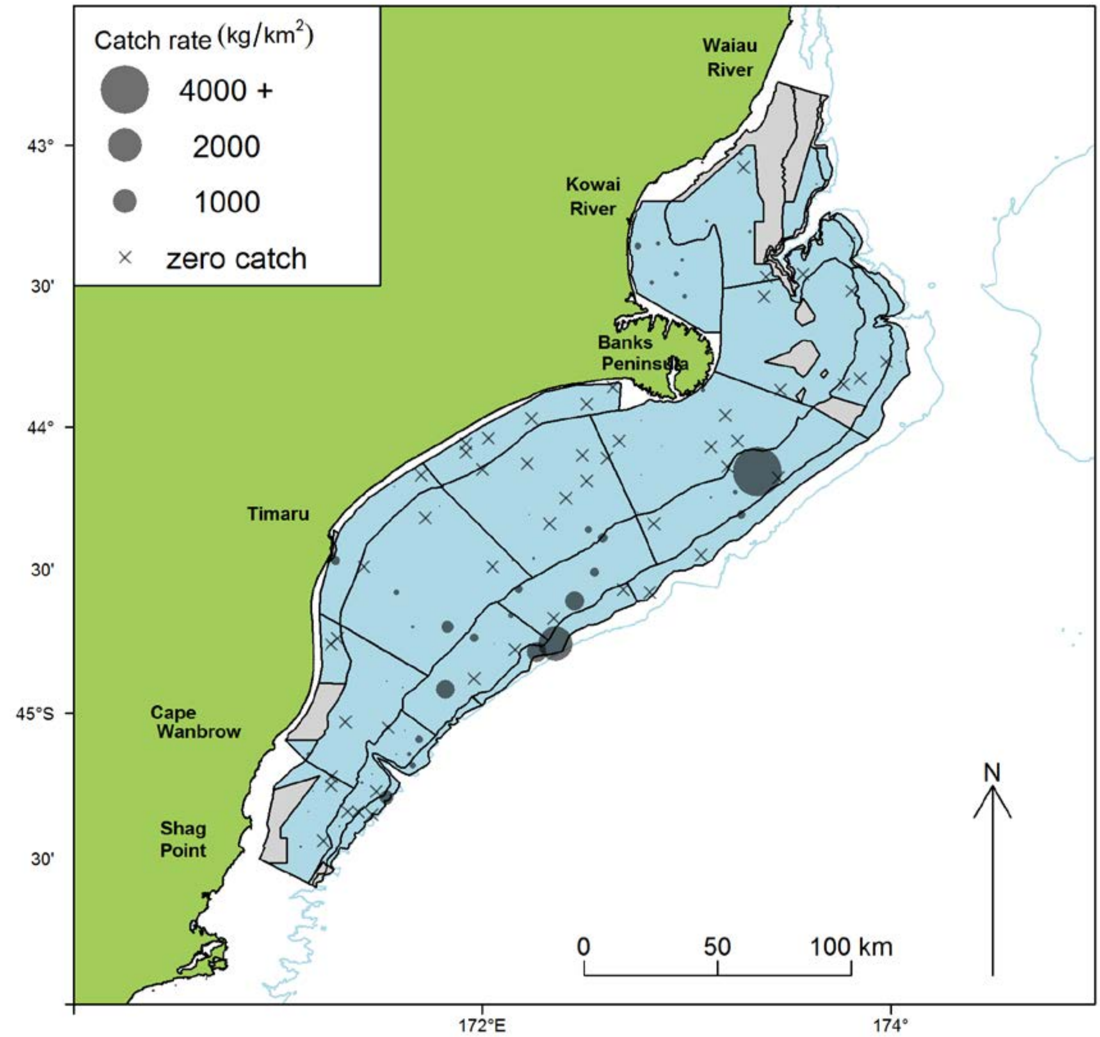



**Figure 3–*continued***

## Sea perch

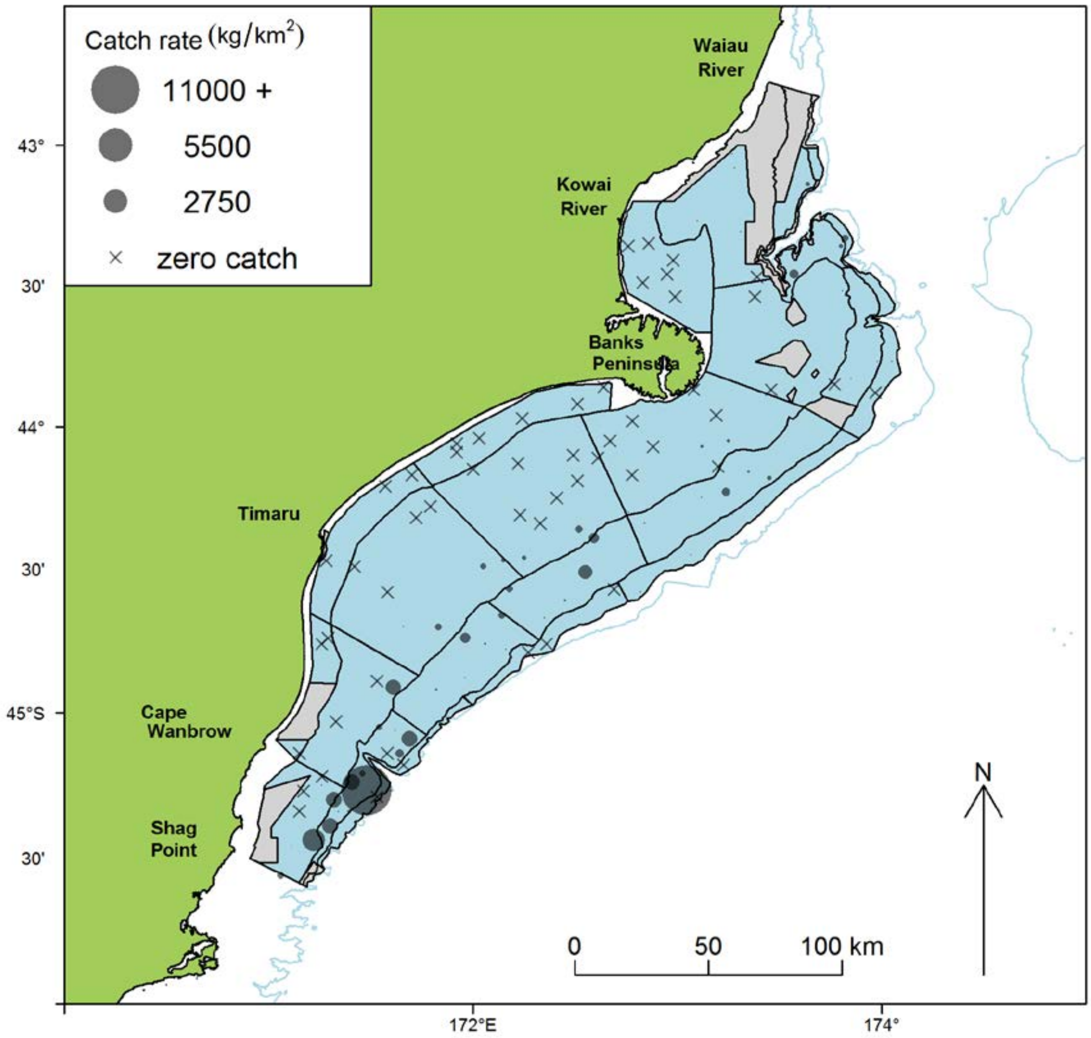



**Figure 3–*continued***

## Spiny dogfish

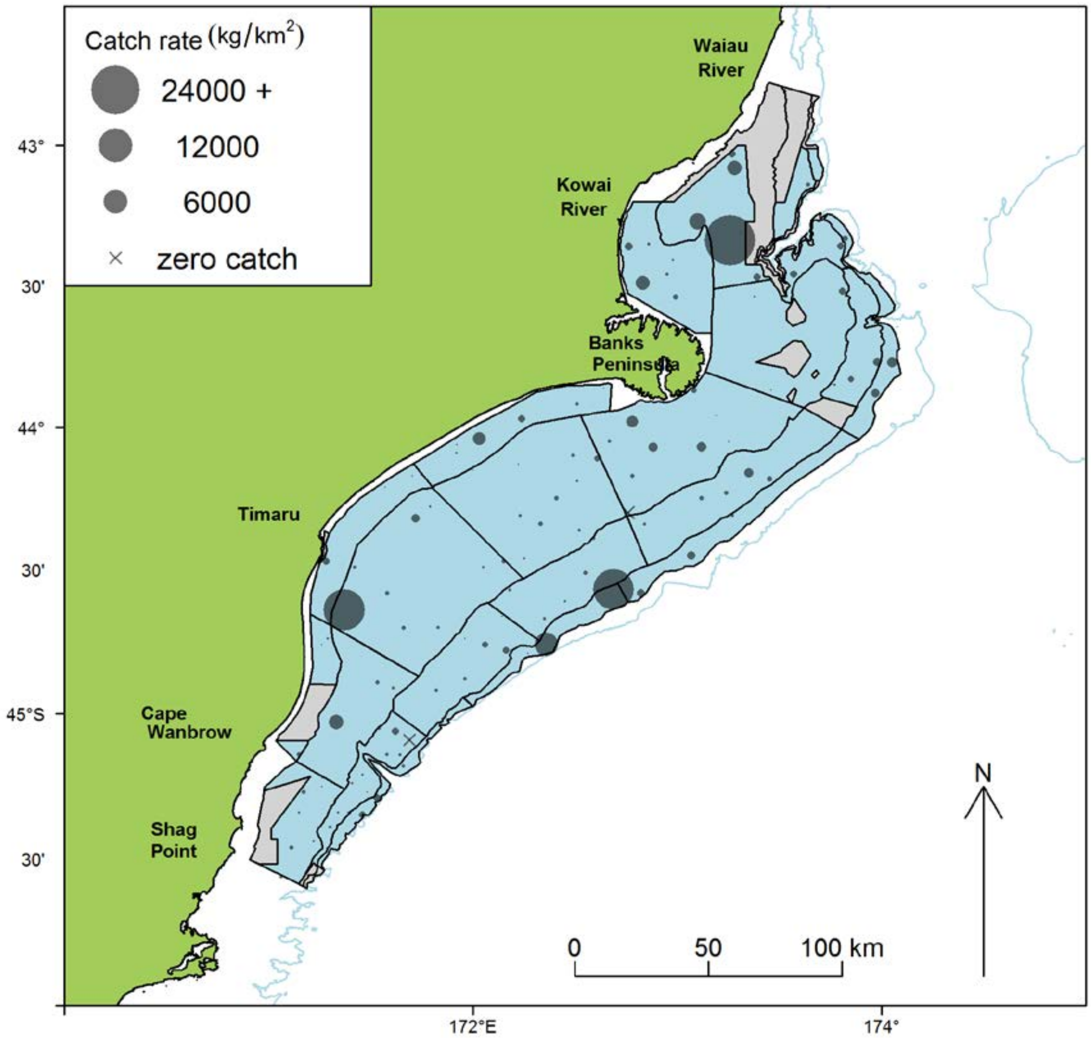



**Figure 3–*continued***

## Tarakihi

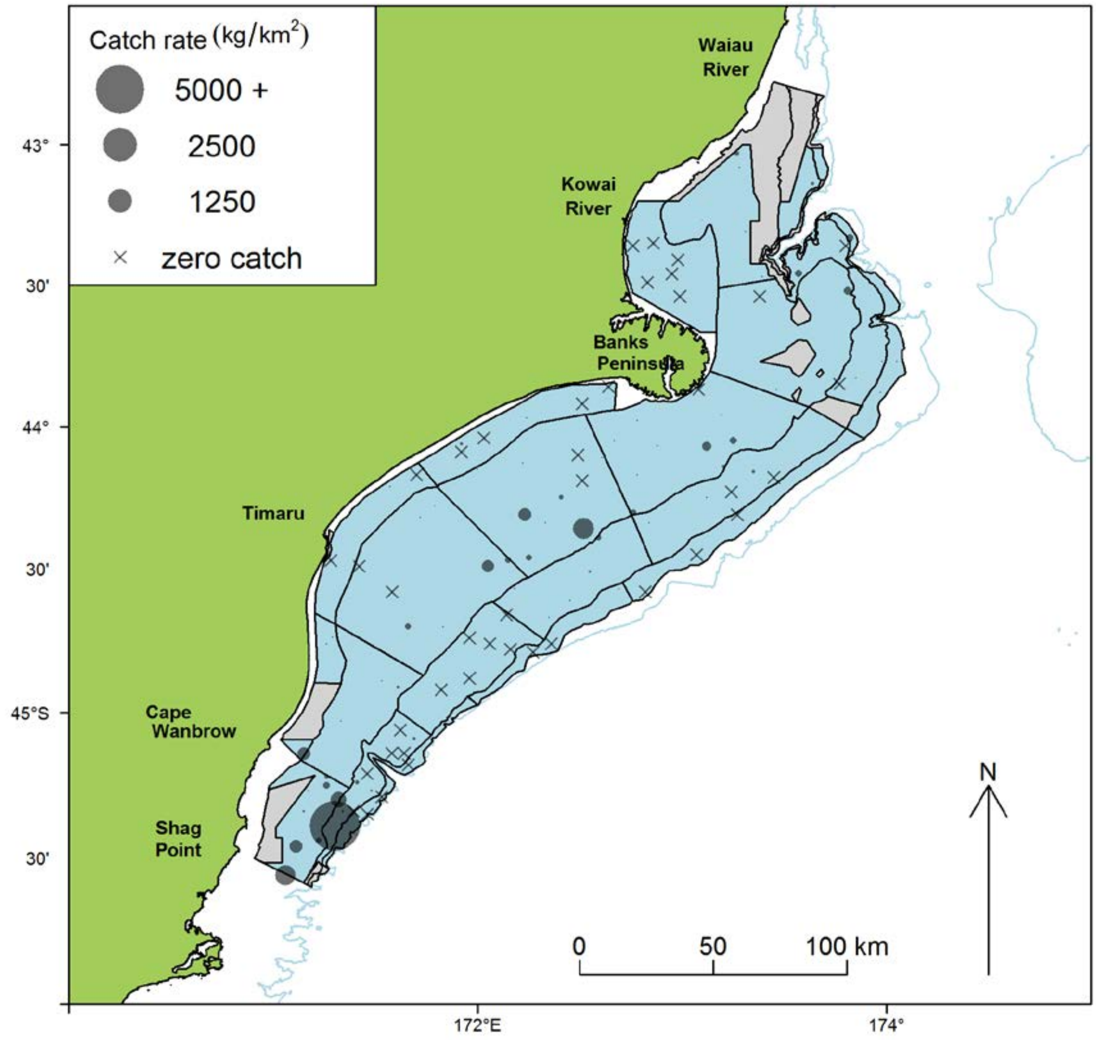
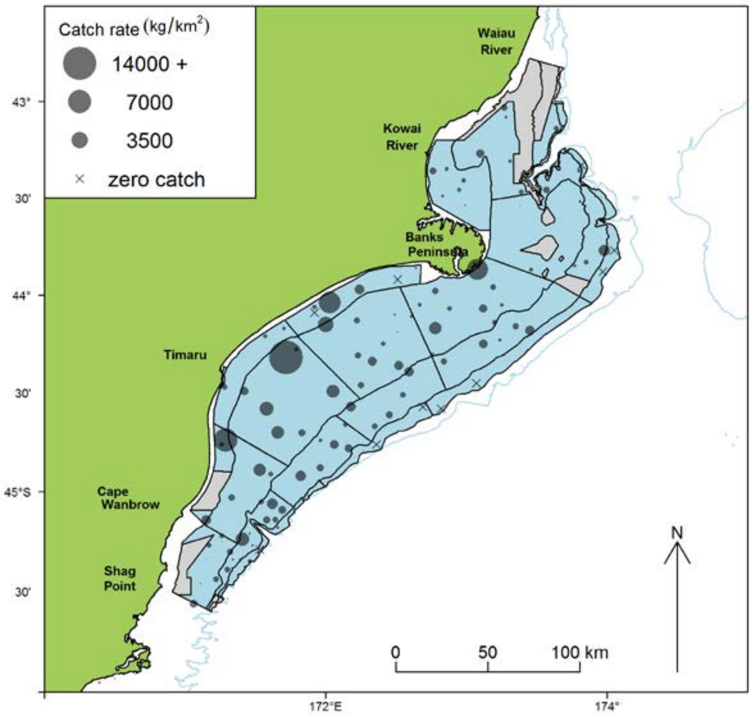



**Figure 3–*continued***

## Barracouta




## Lemon sole

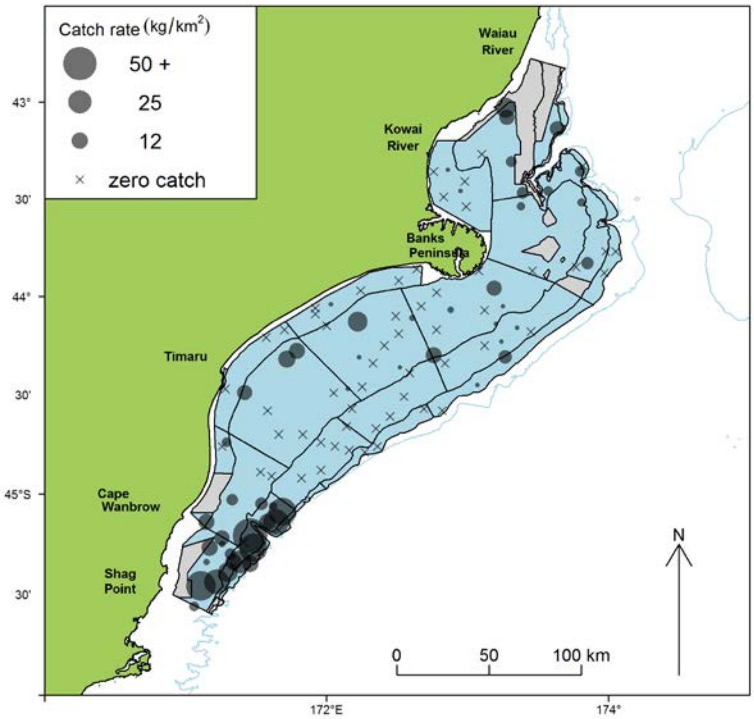
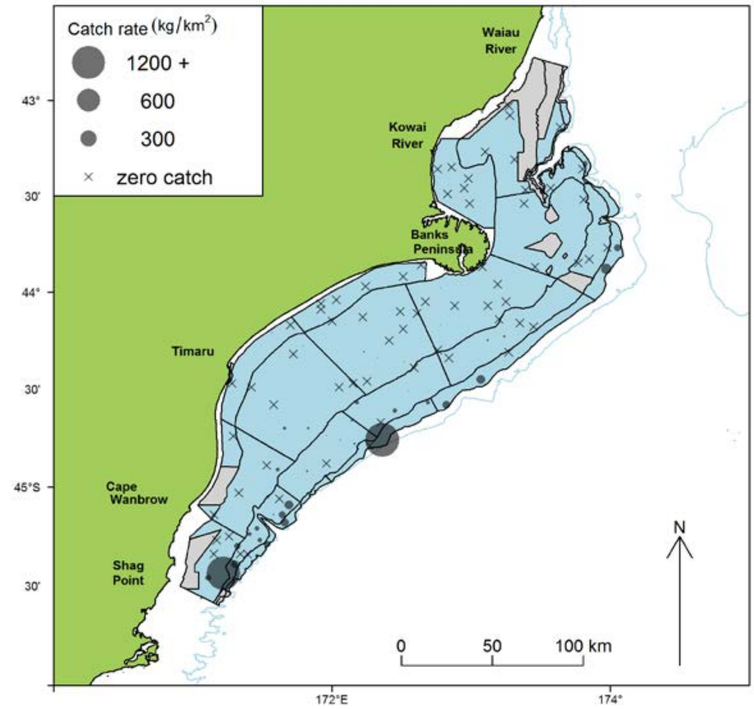



**Figure 4: Catch rates (kg.km$^{-2}$) of key non-target QMS species for the 2014 ECSI survey. The legend indicates the circle size that corresponds to three catch rates; on the figure, circle size is continuous and proportional to the catch rate. Crosses indicate no catch at that station. Grey areas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

## Ling




## Rig

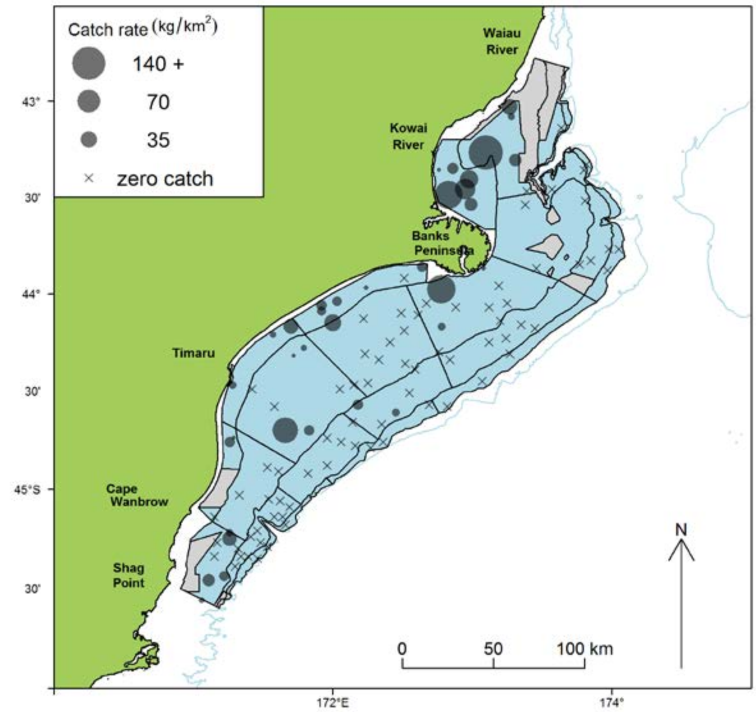
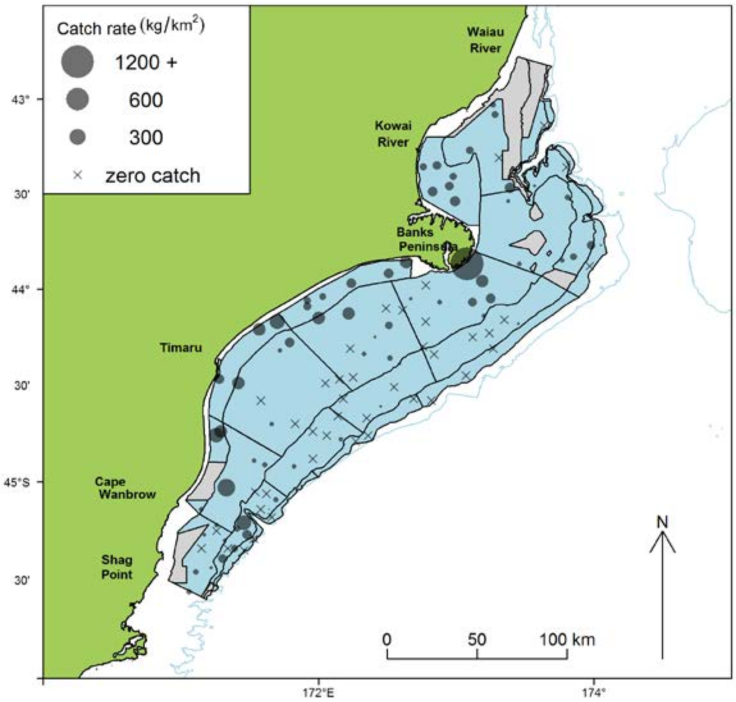



**Figure 4–*continued***

## Rough skate




## School shark

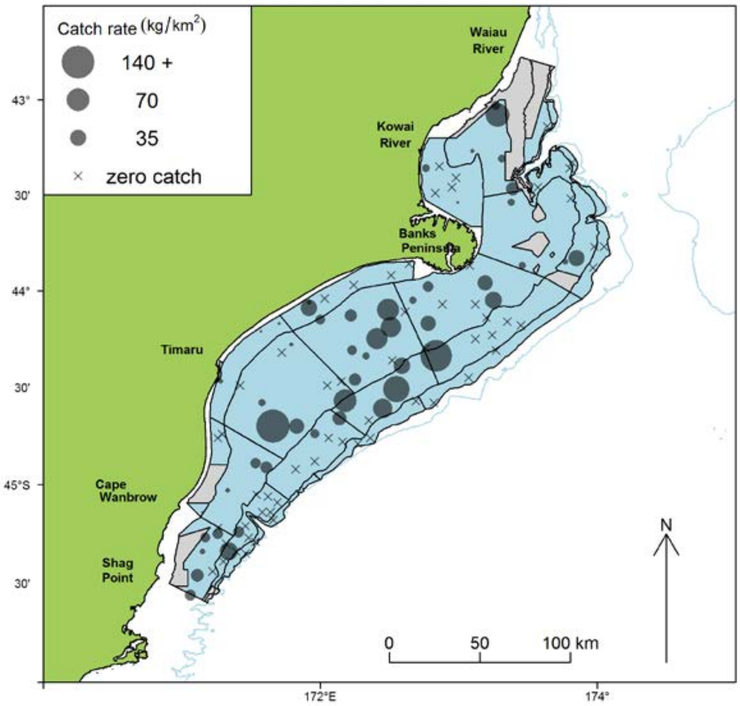
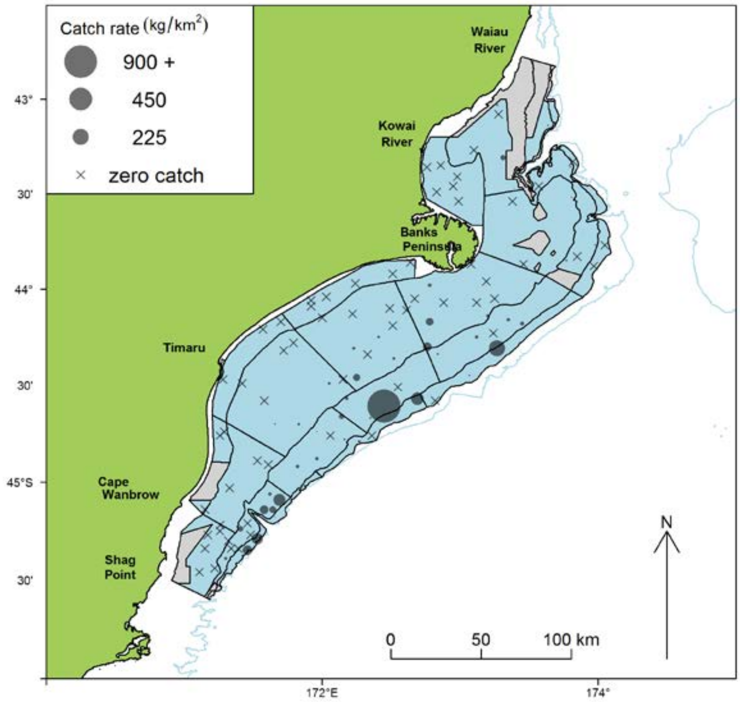



**Figure 4–*continued***

## Silver warehou




## Smooth skate

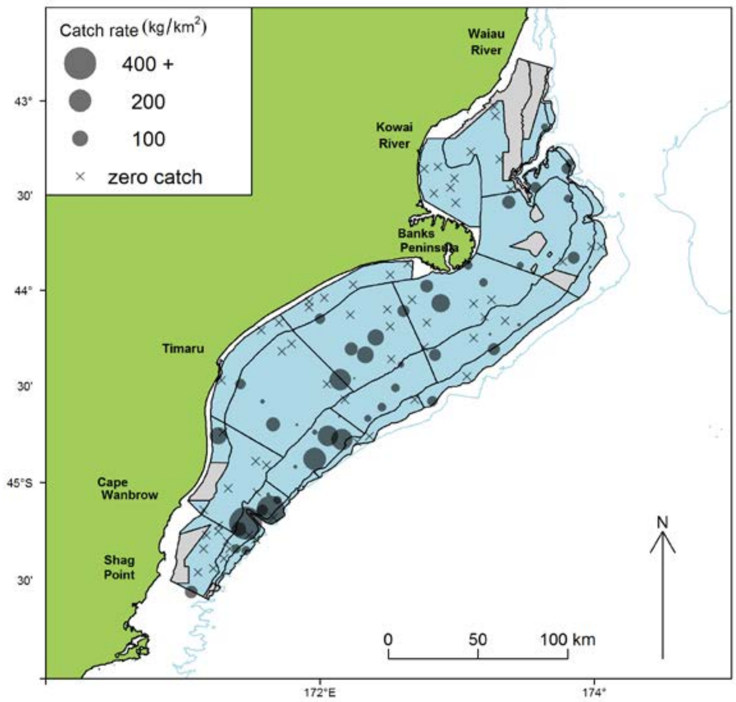



**Figure 4–*continued***

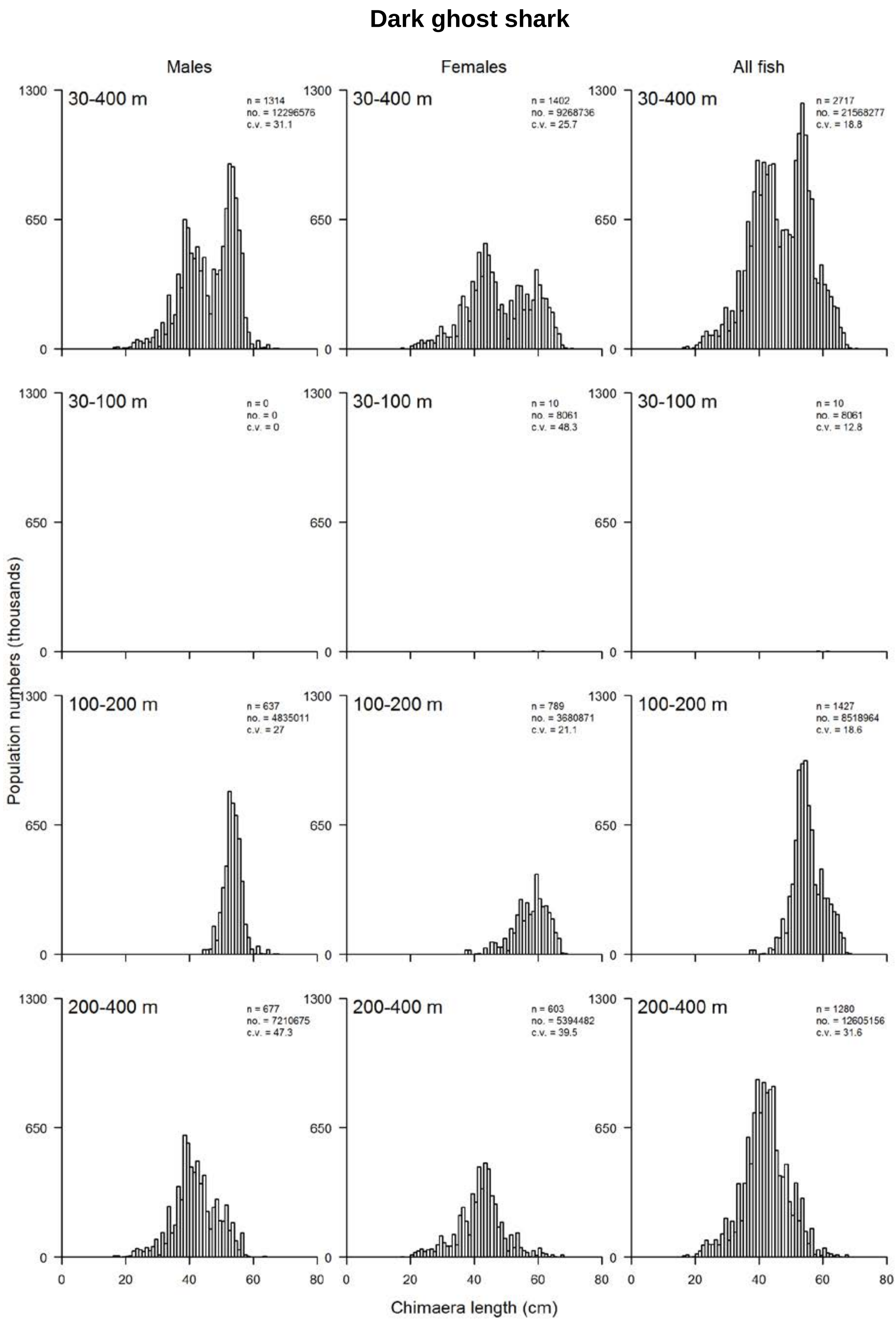



**Figure 5: Scaled length frequency distributions for the target species by depth range for the 2016 survey. Population estimates are in thousands or millions of fish. The 'All fish' length distribution includes unsexed fish.**

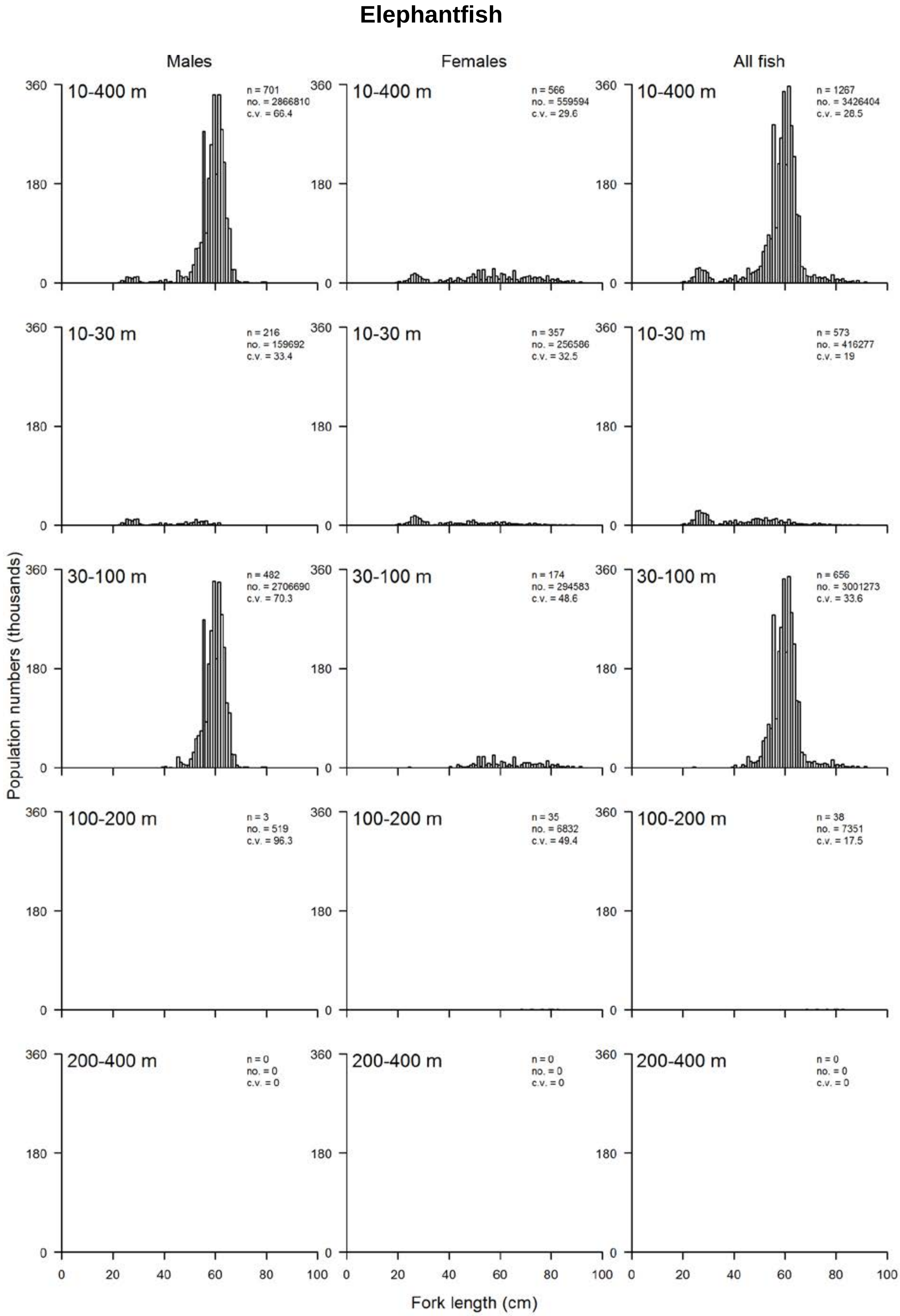



**Figure 5–*continued***

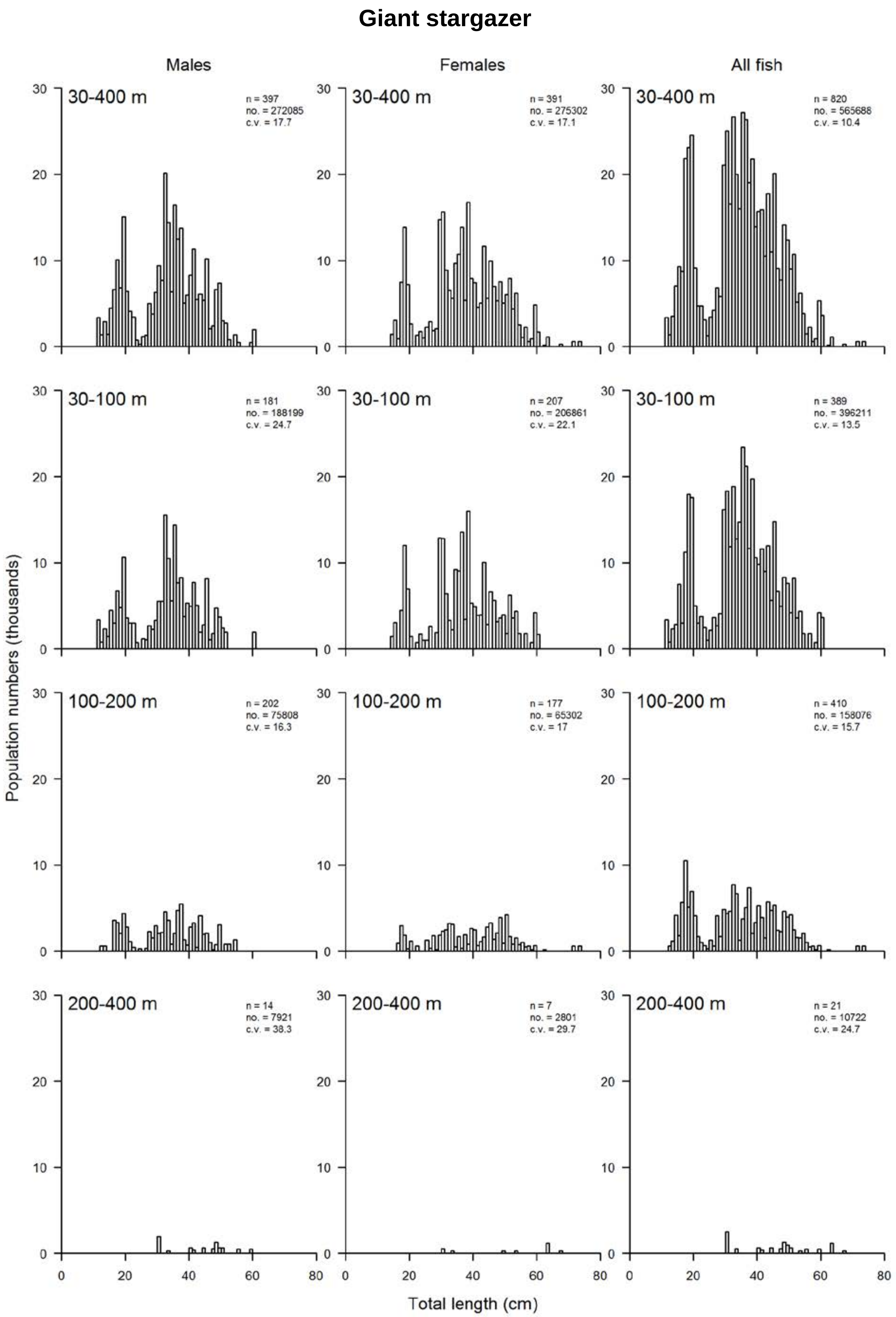



**Figure 5–*continued***

## Red cod

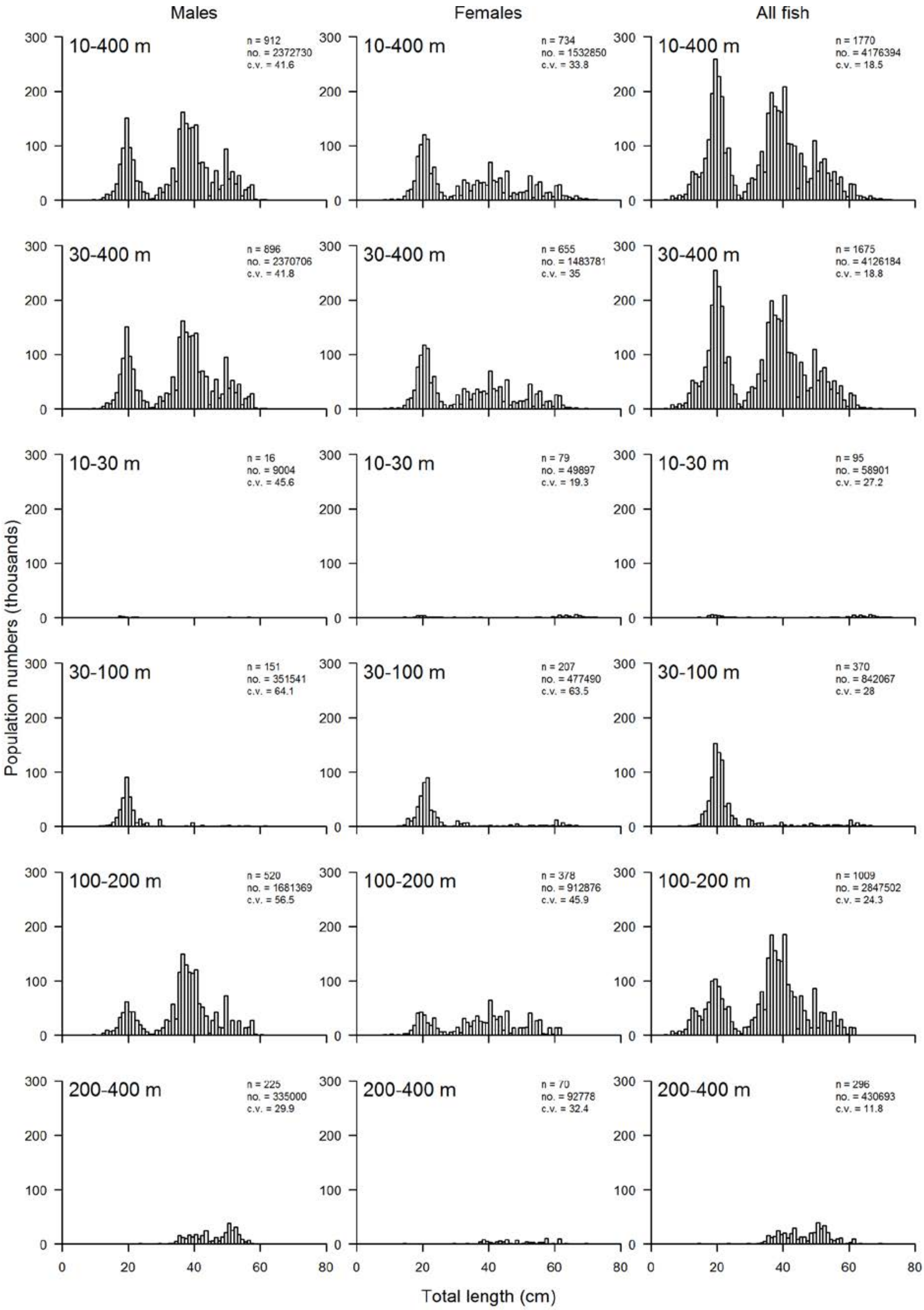



**Figure 5–*continued***

**Red gurnard**

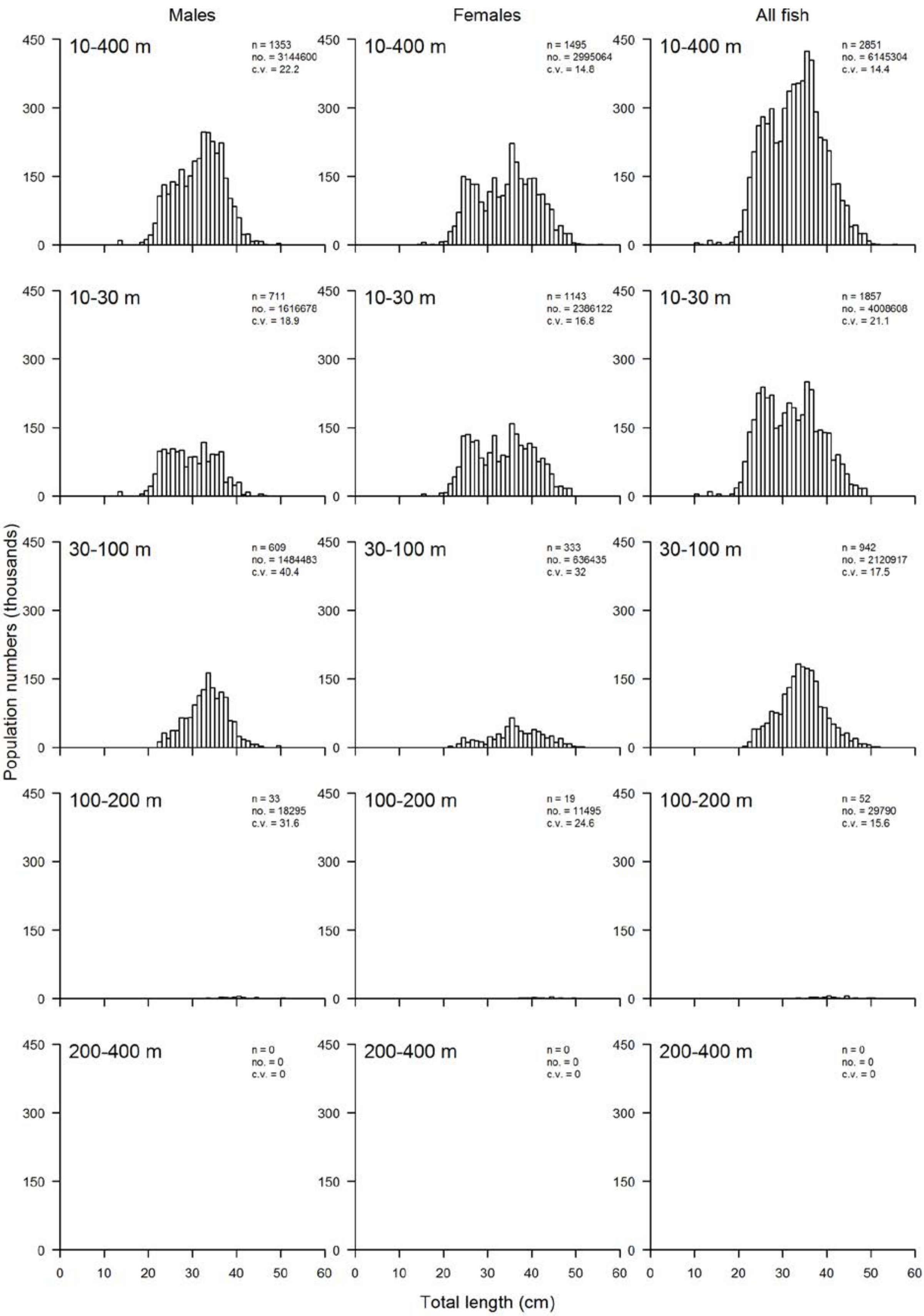



**Figure 5–*continued***

# Sea perch

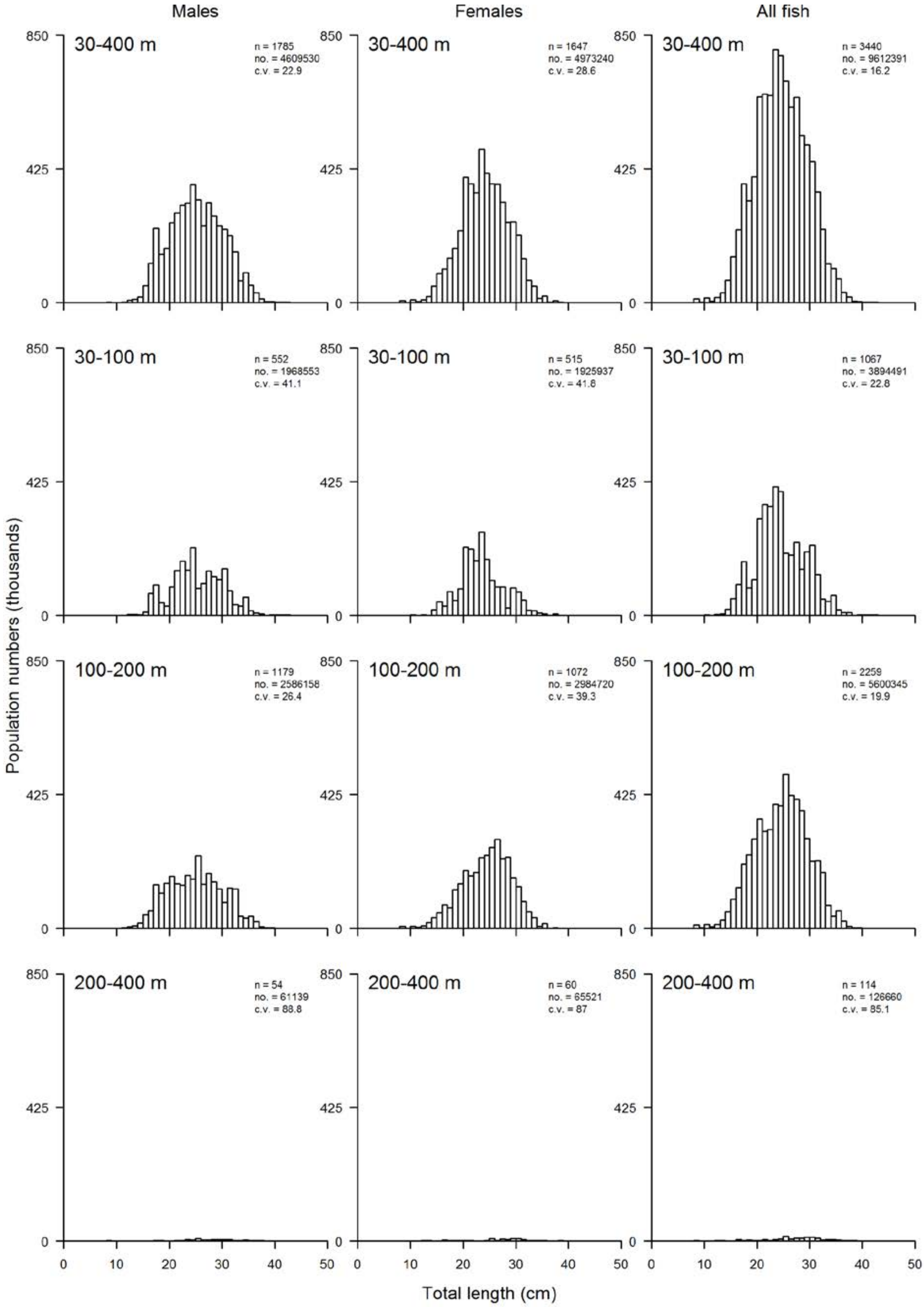



**Figure 5 – *continued***

## Spiny dogfish

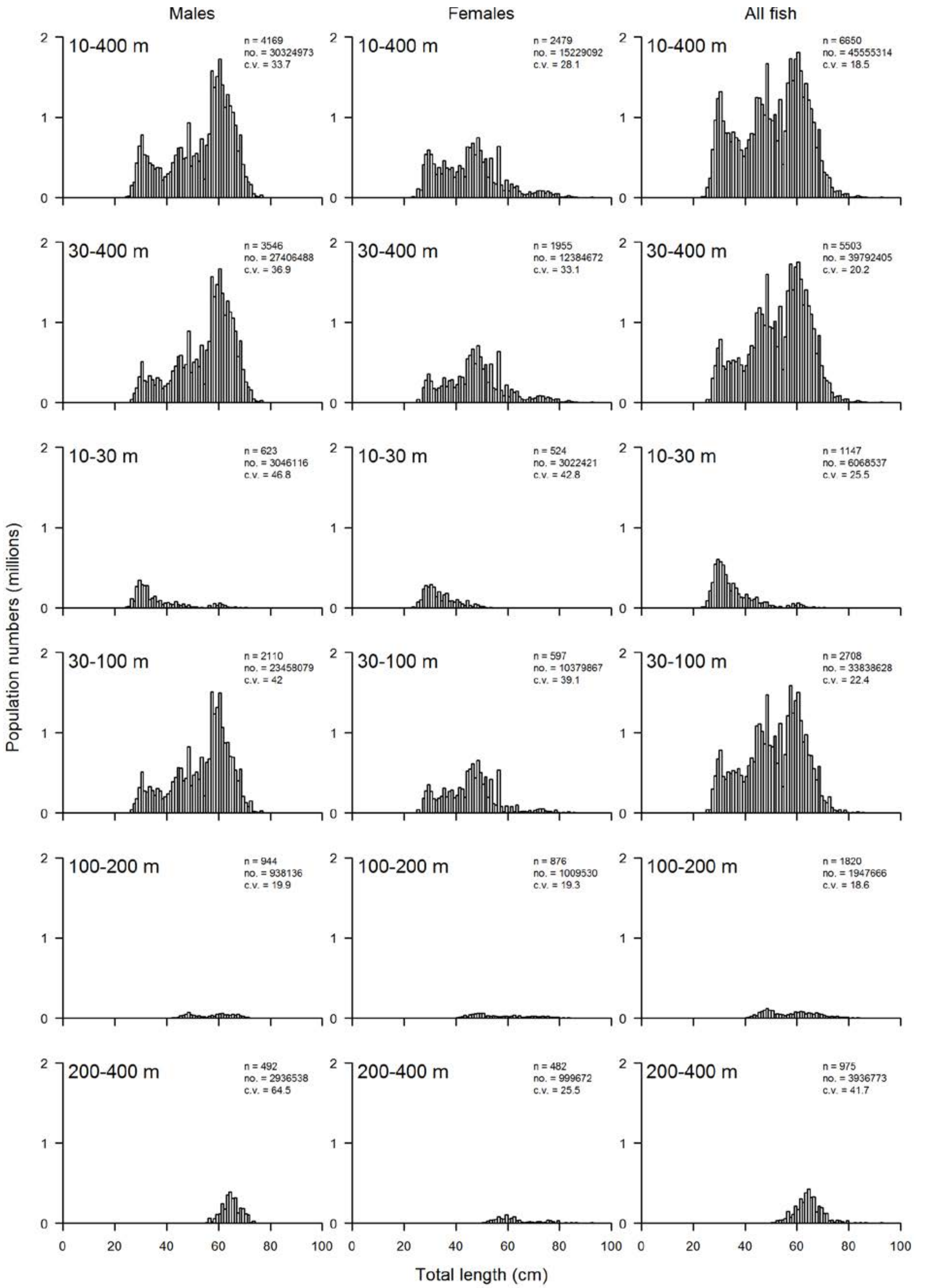



**Figure 5–*continued***

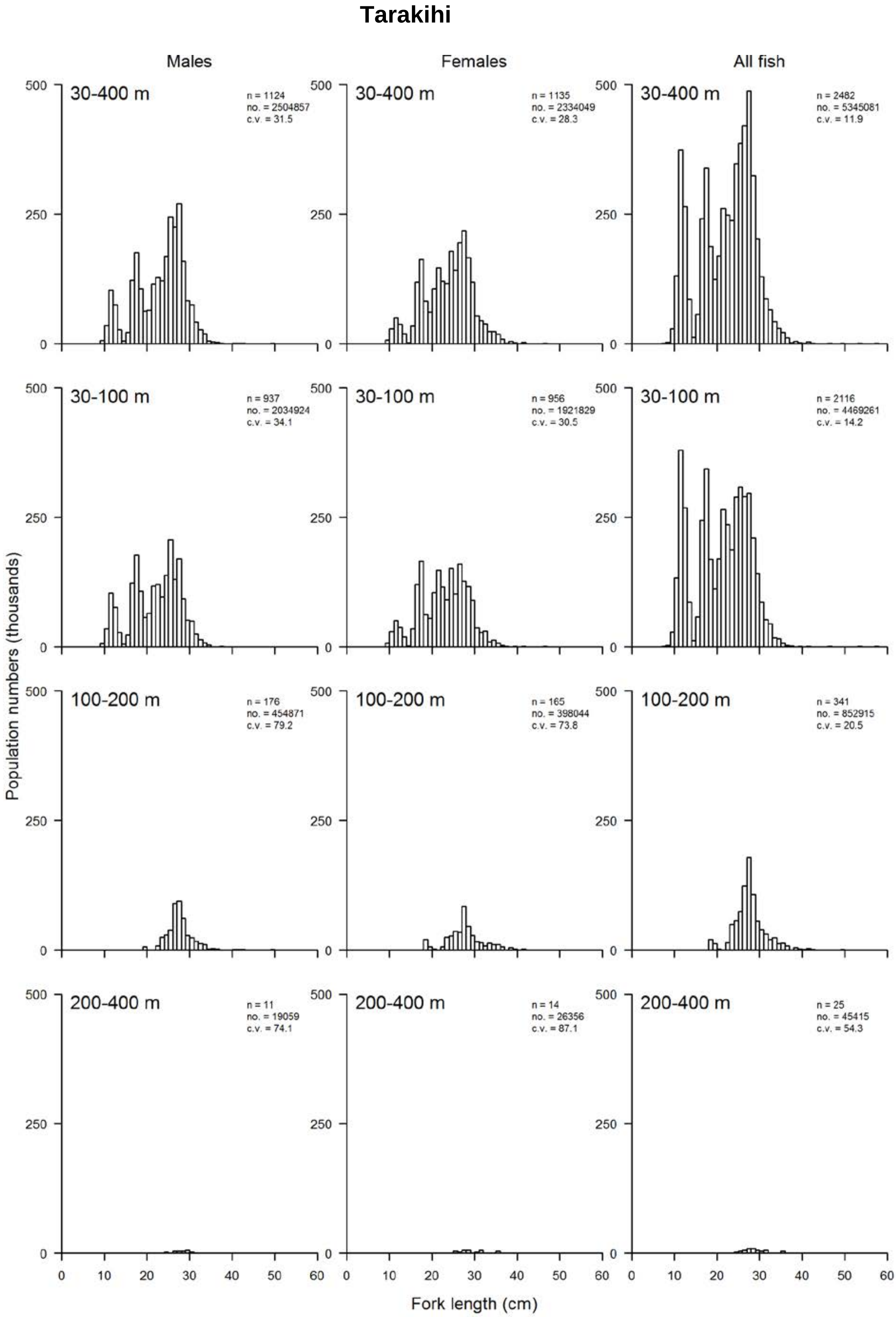



**Figure 5–*continued***

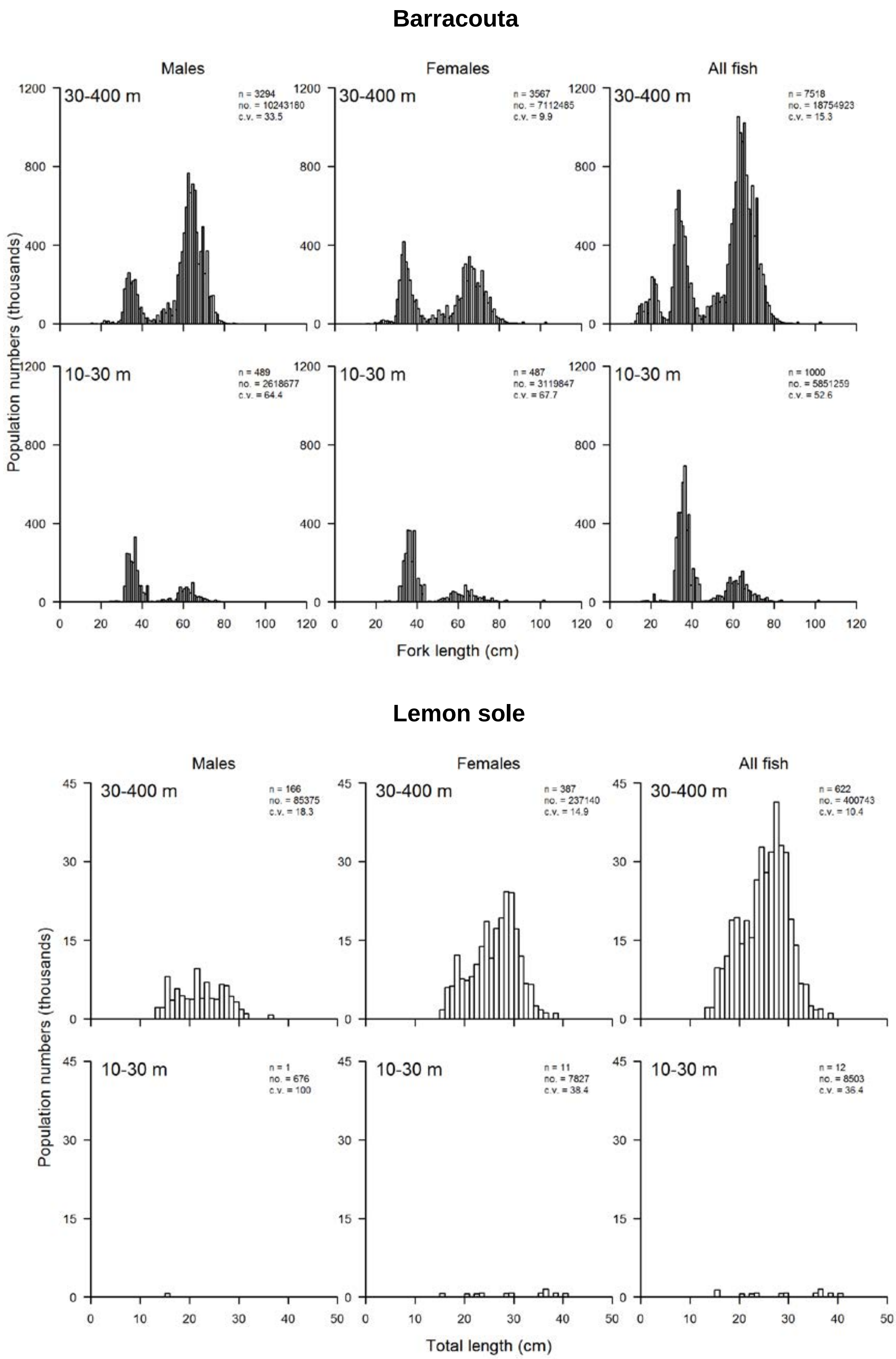
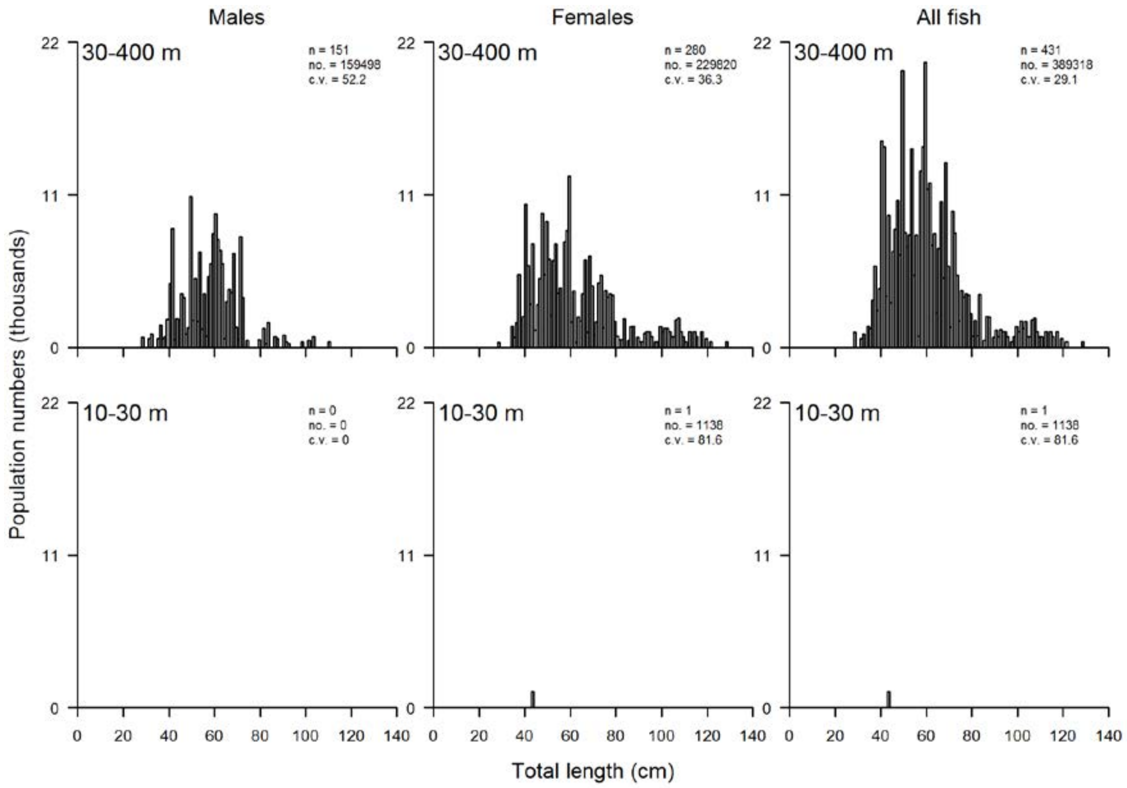



**Figure 6: Scaled length frequency distributions for the key QMS species in 30–400 m, and 10–30 m for the 2016 survey. Population estimates are in thousands of fish.**

## Ling




## Rig

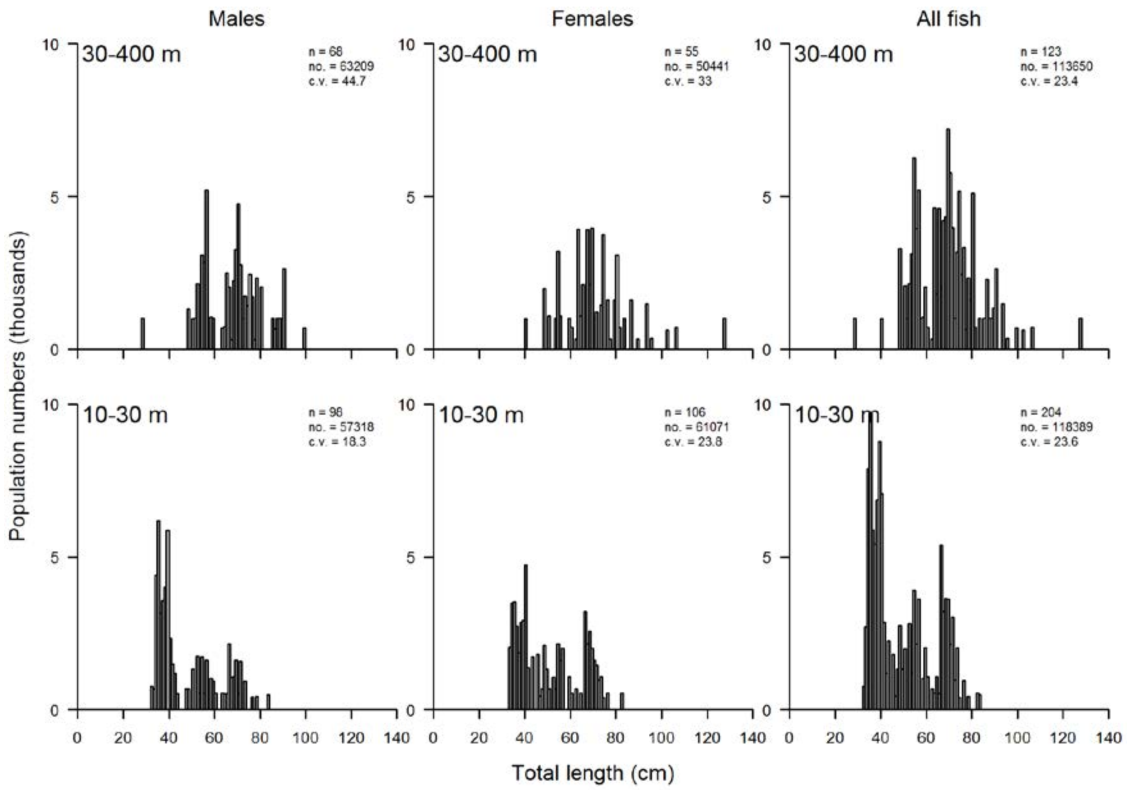
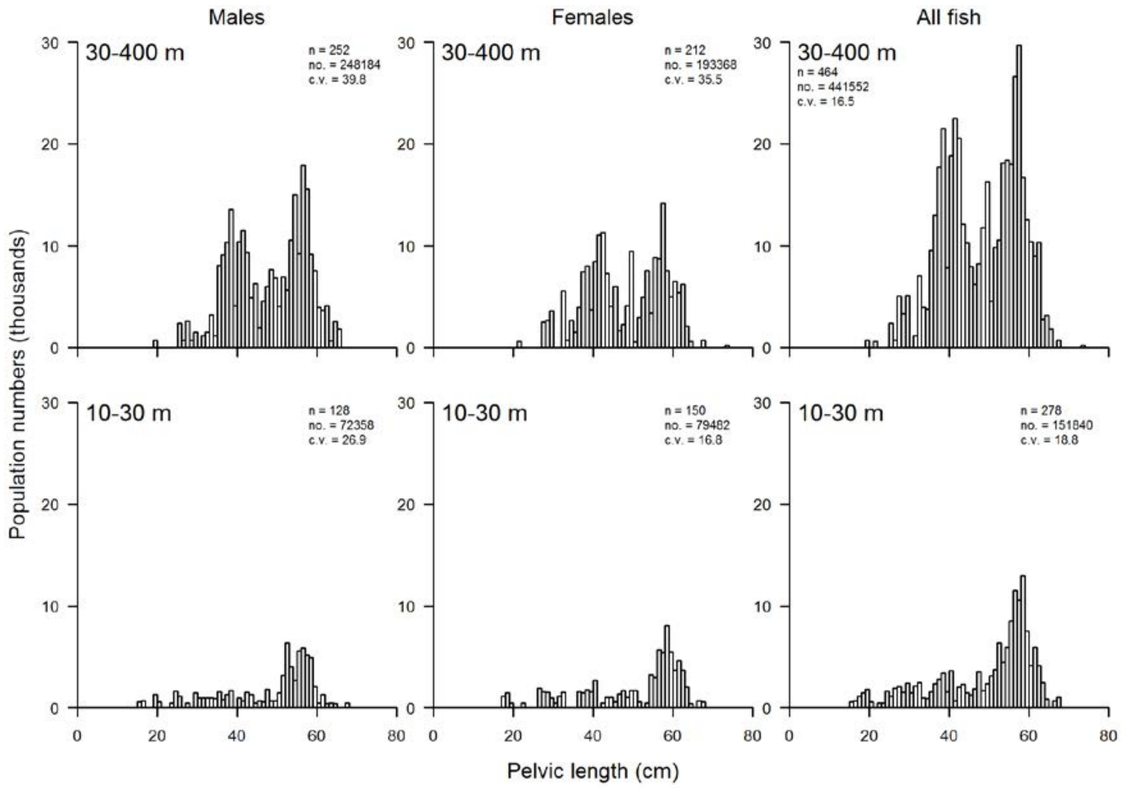



**Figure 6 –** ***continued***

**Rough skate**




**School shark**

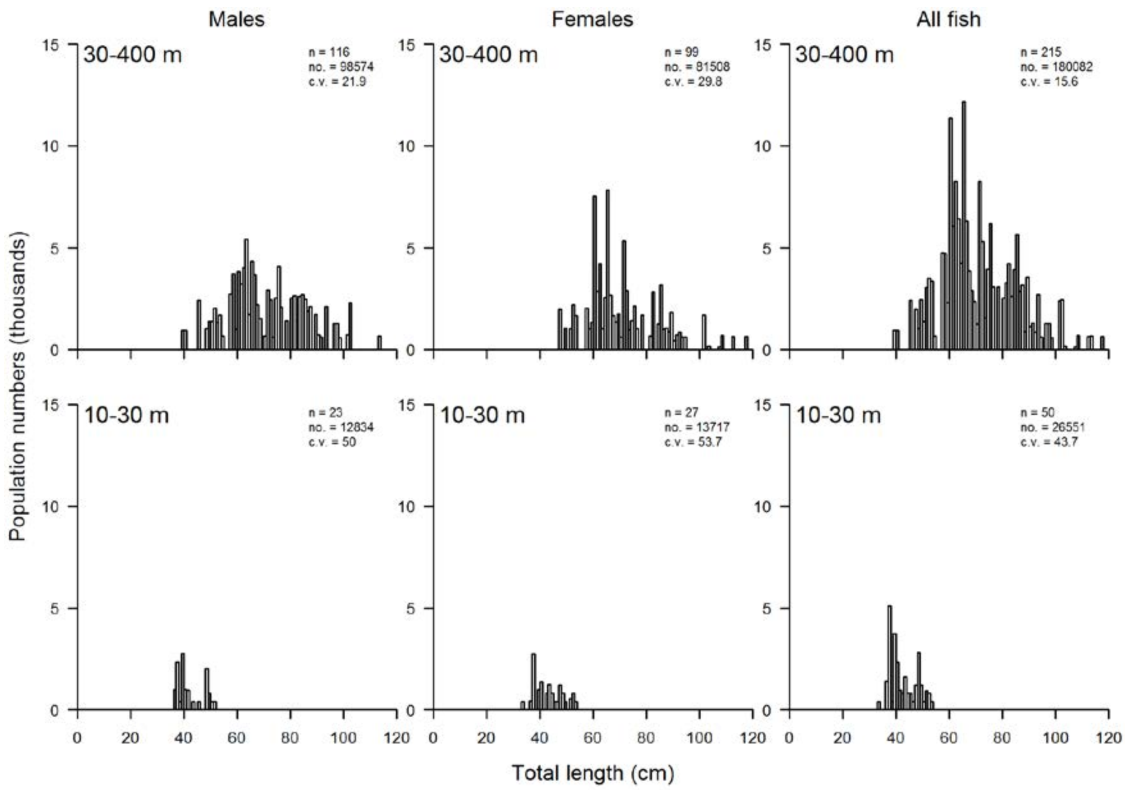
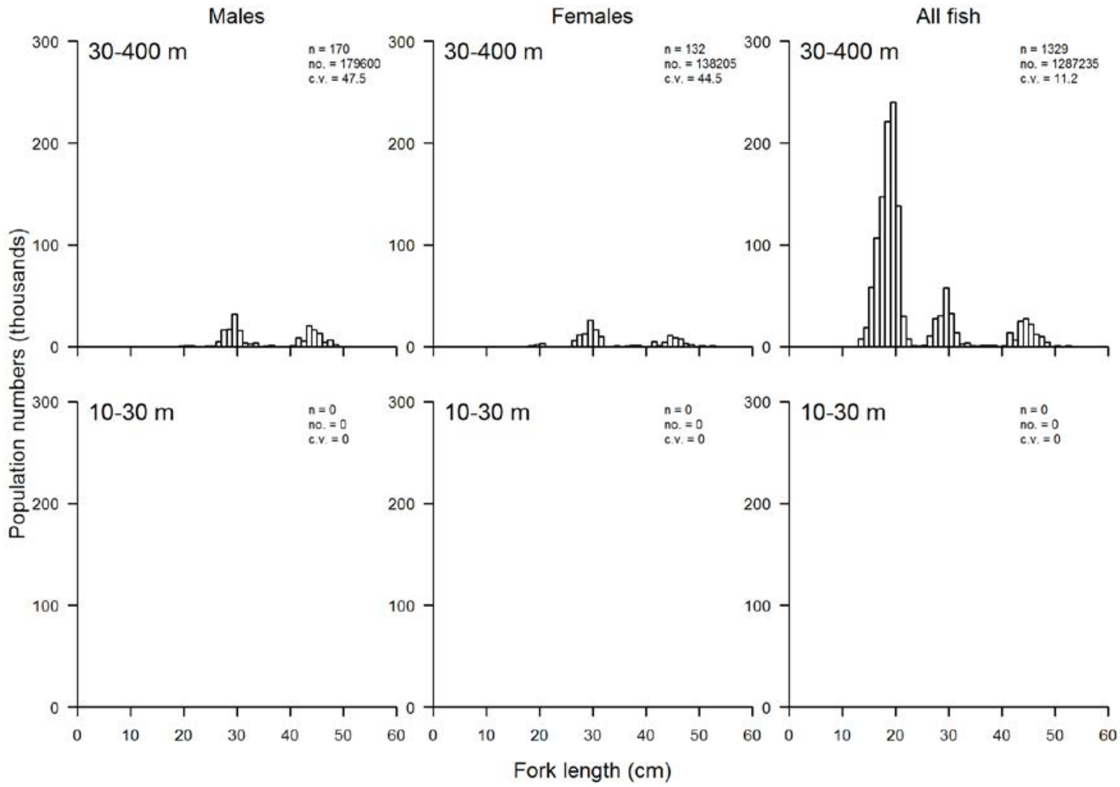



**Figure 6 –** ***continued***

## Silver warehou




## Smooth skate

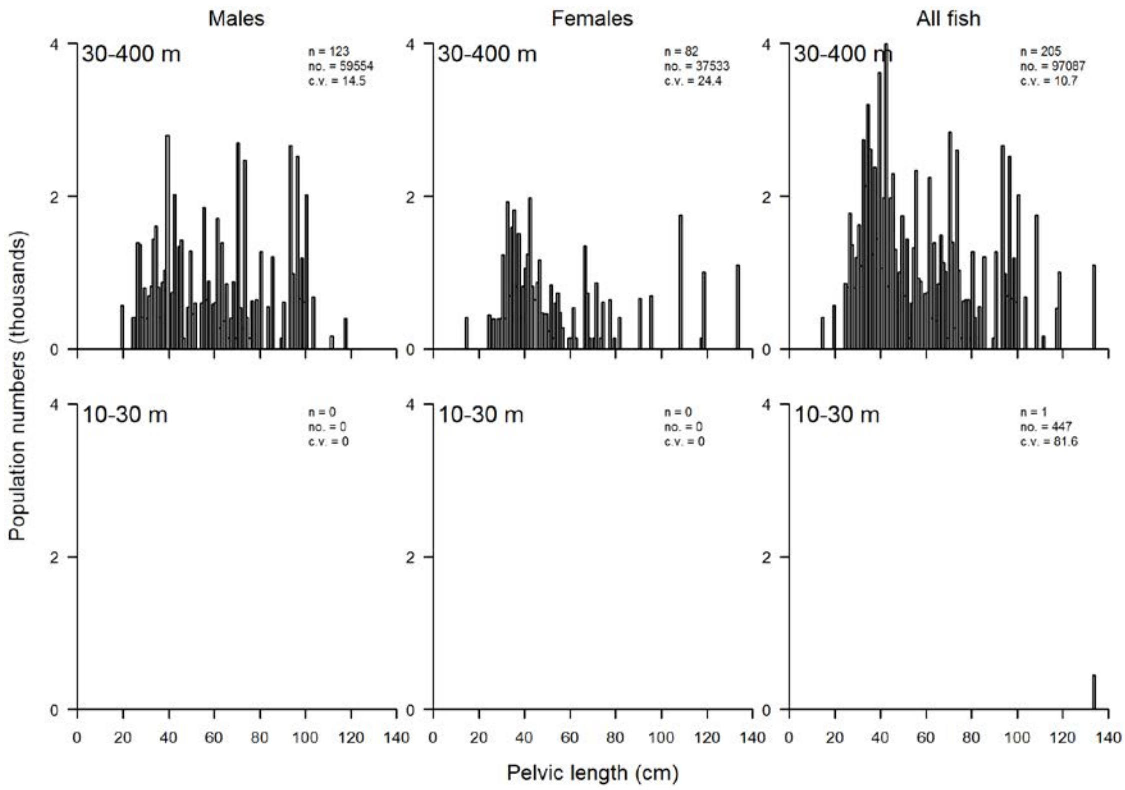
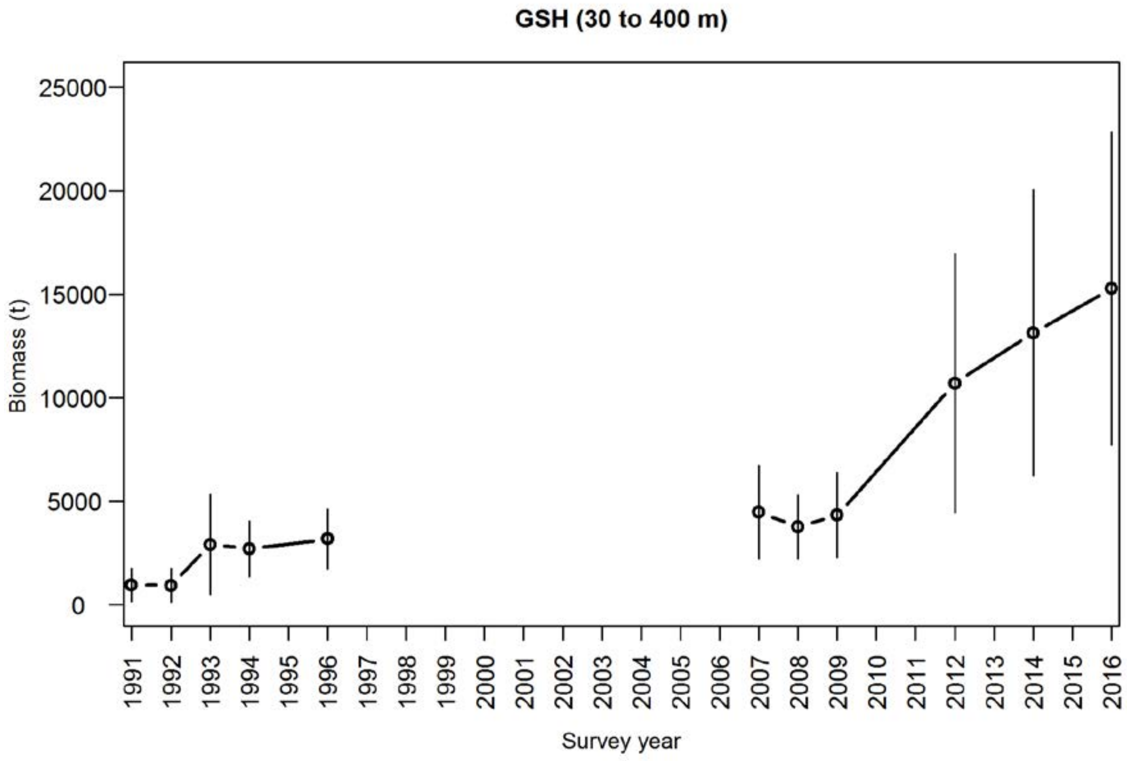



**Figure 6 –** ***continued***



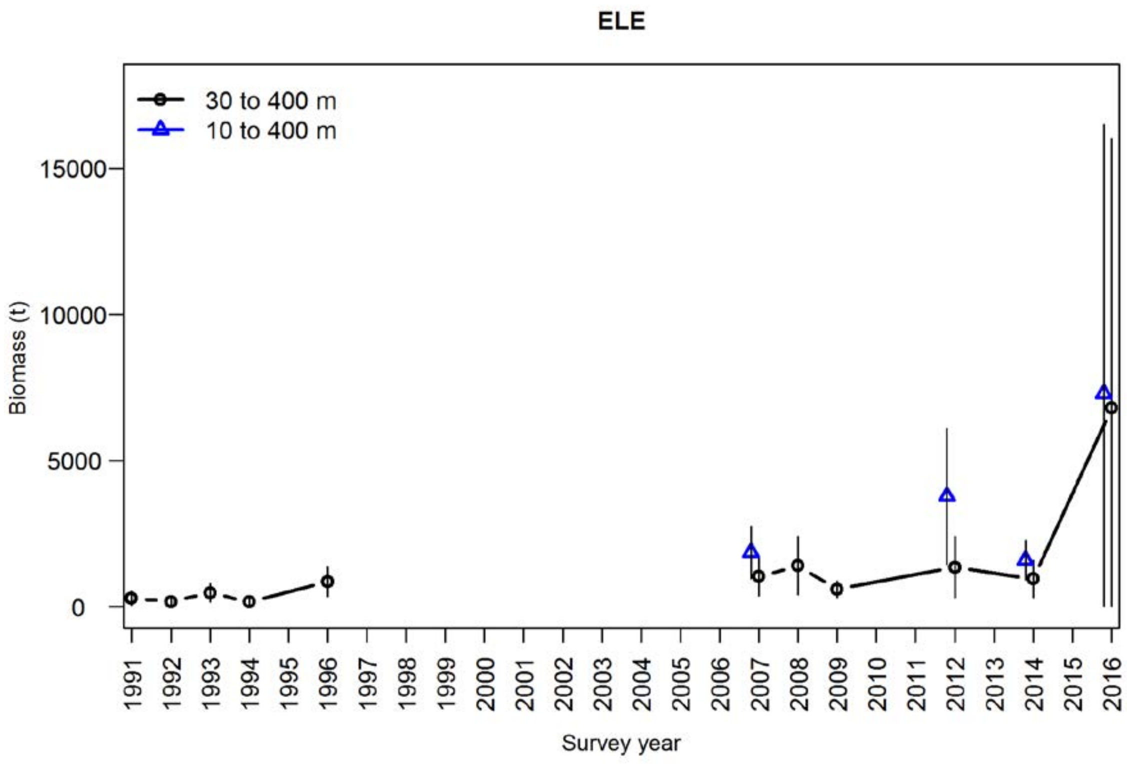
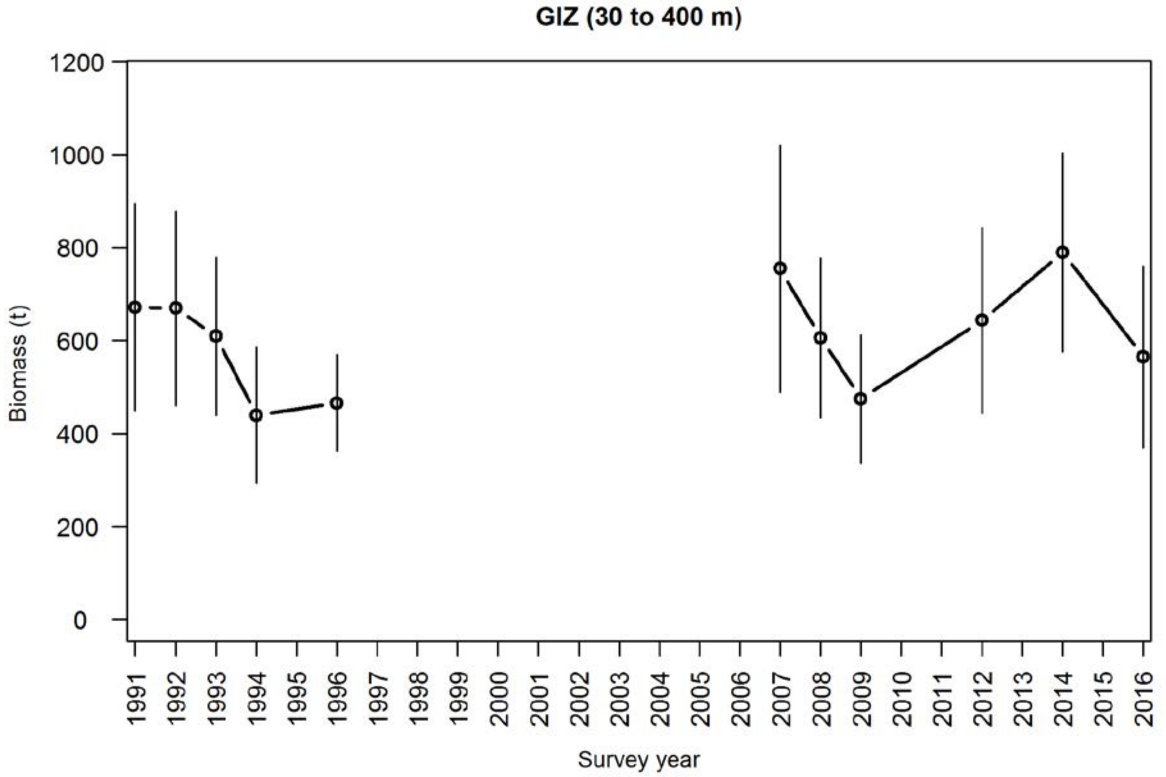




**Figure 7: Target species total biomass and 95% confidence intervals for the all ECSI winter surveys in core strata (30–400 m), and core plus shallow strata (10–400 m) for species found in less than 30 m in 2007, 2012, 2014, and 2016.**



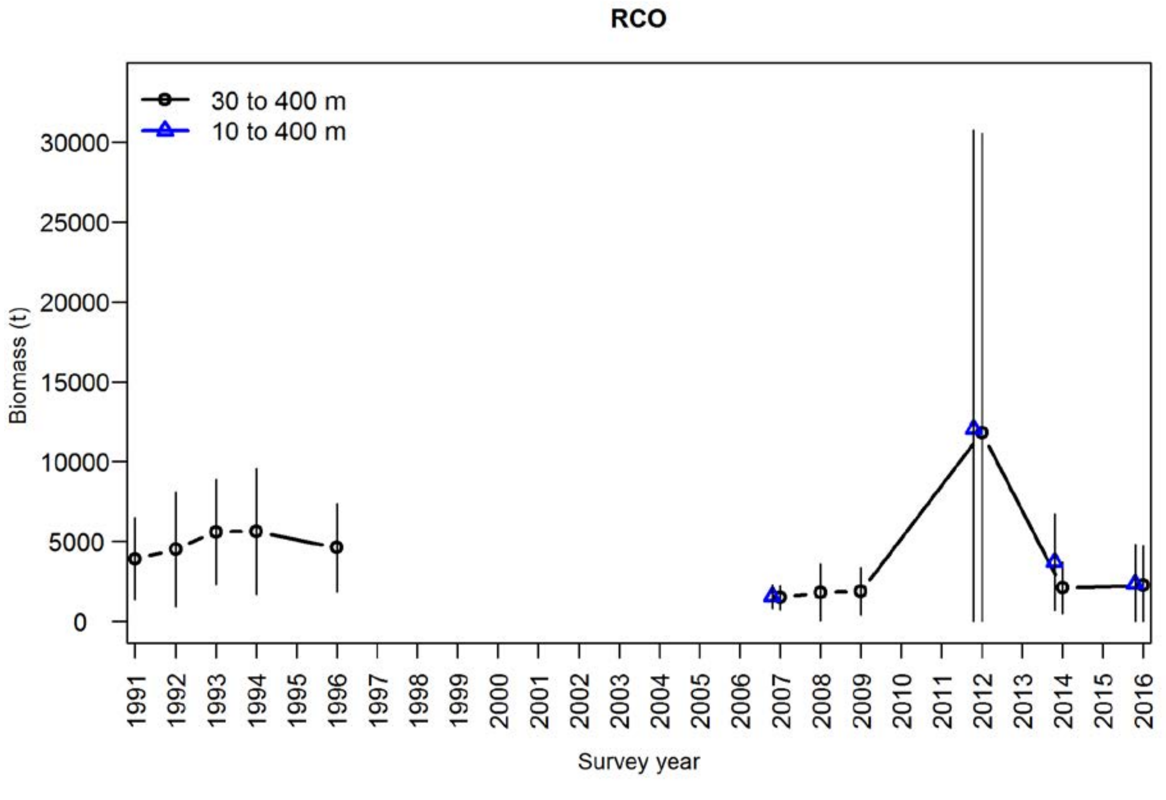
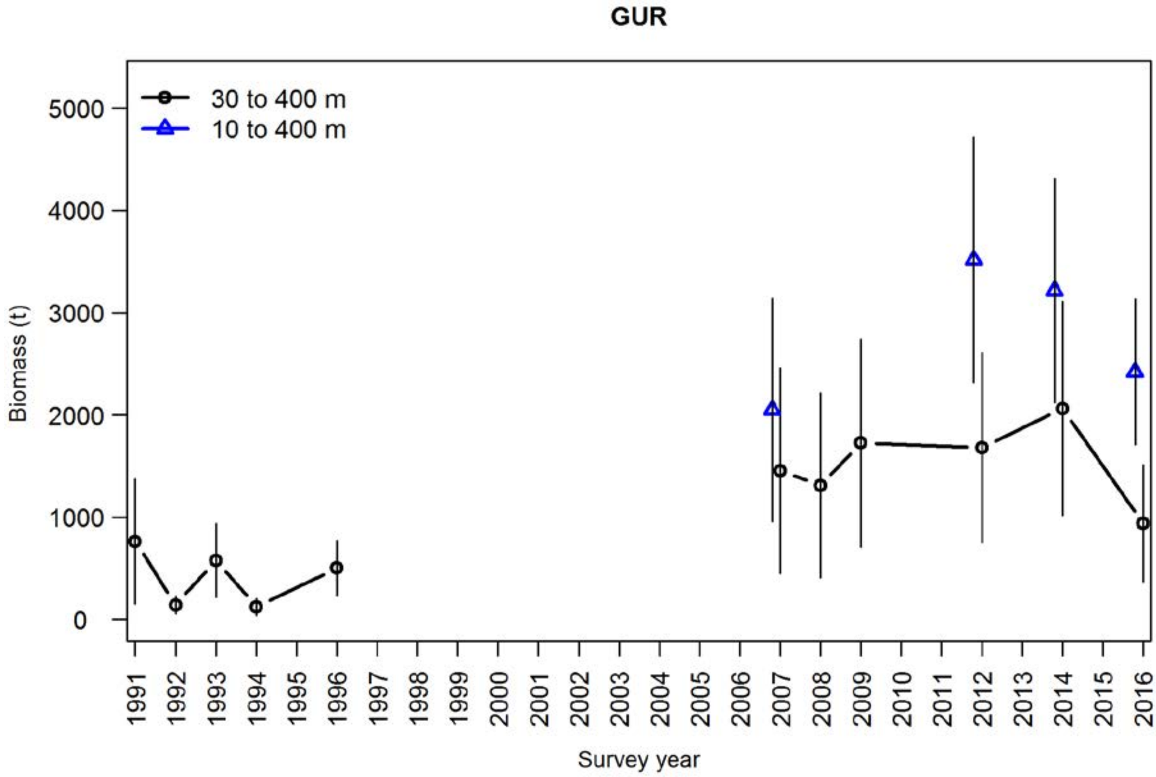




**Figure 7 – *continued***



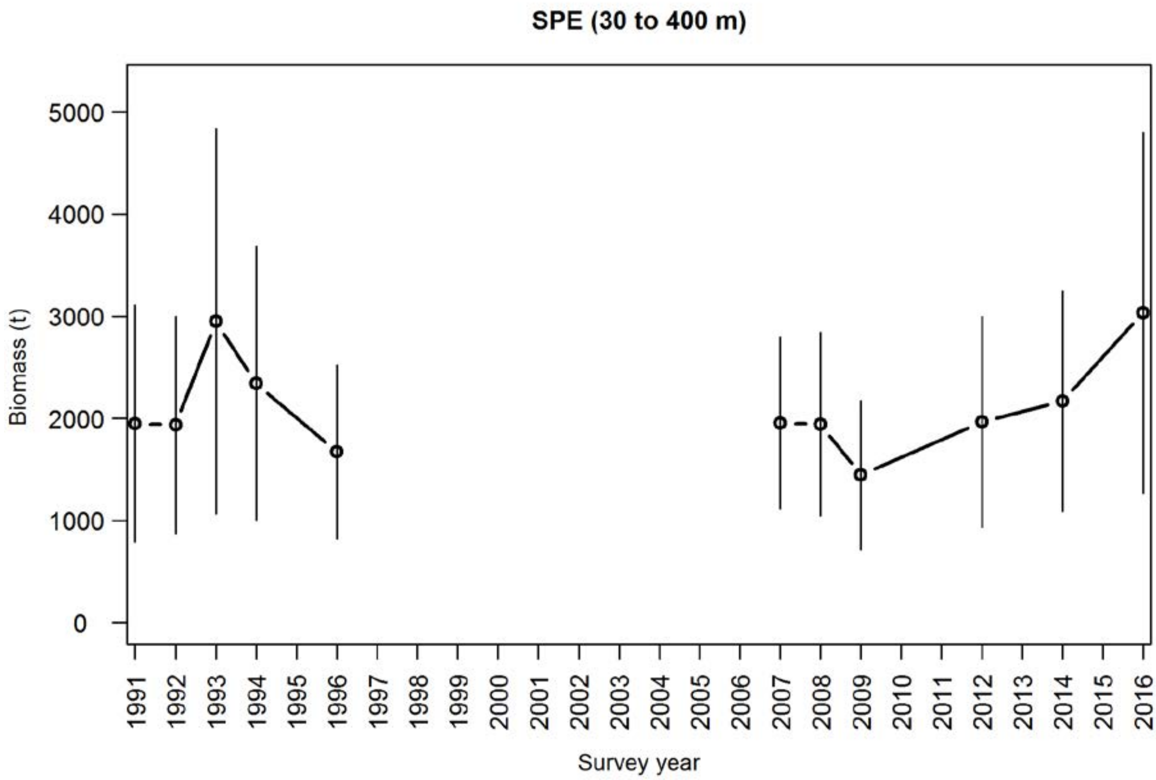
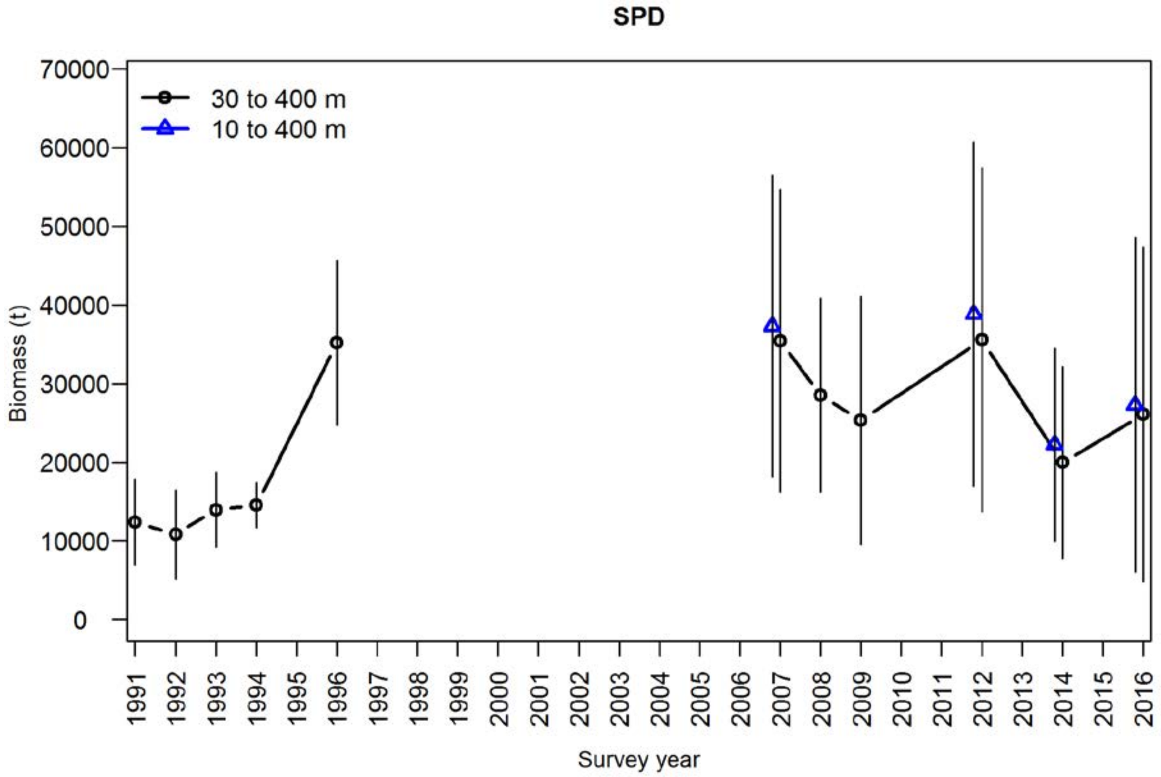




**Figure 7 – *continued***



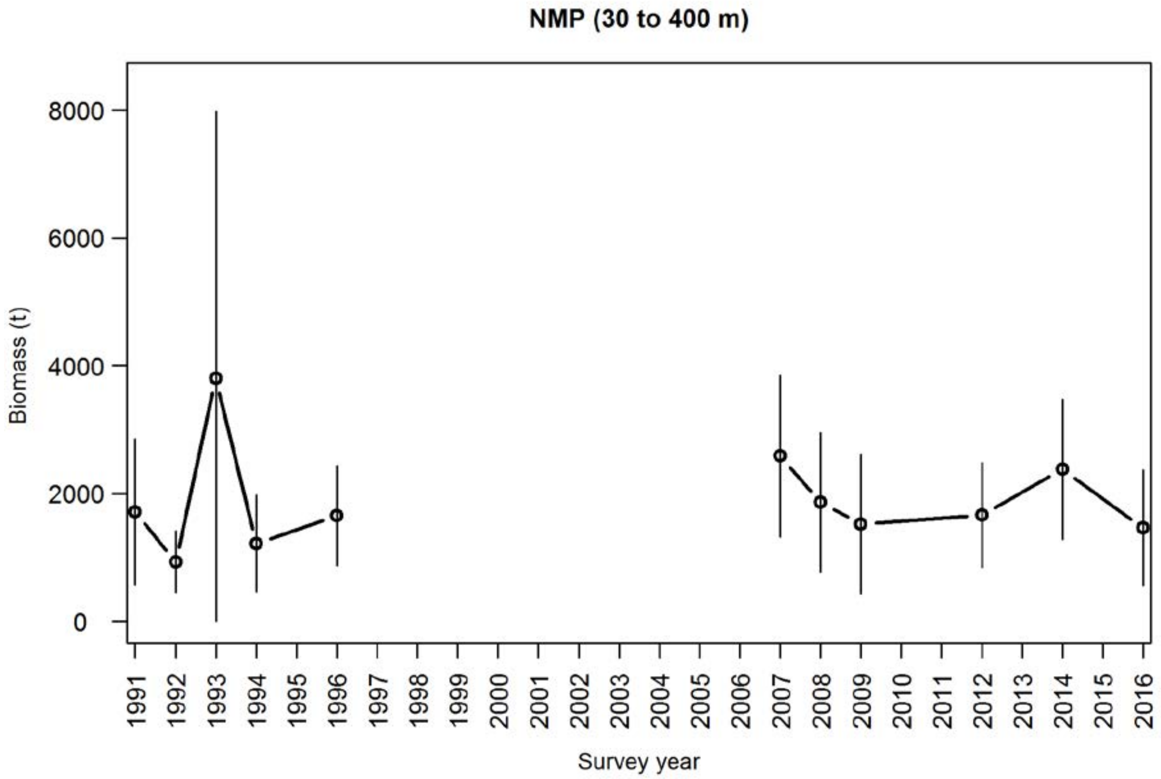




**Figure 7 –** ***continued***

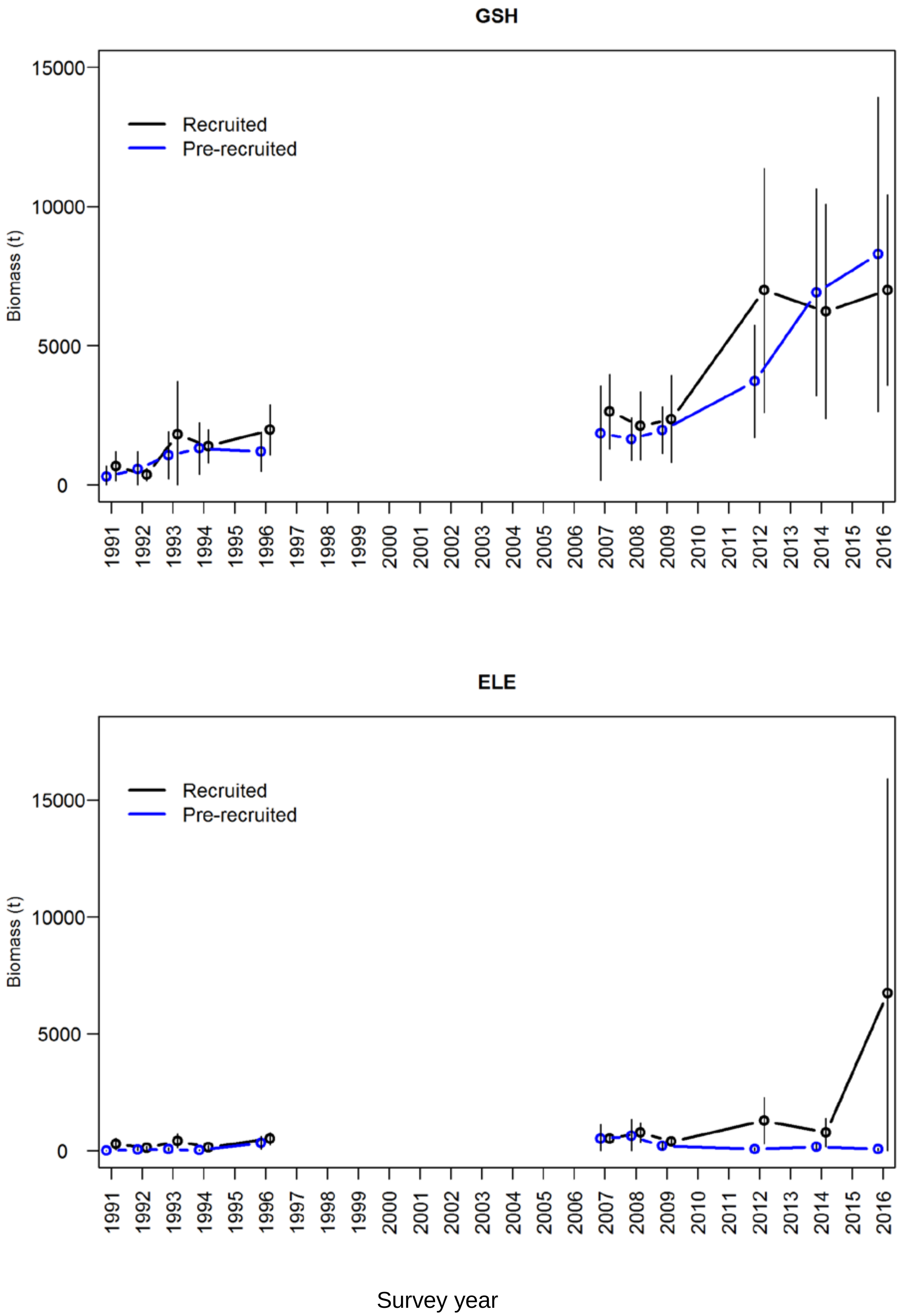



**Figure 8: Target species recruited and pre-recruited biomass and 95% confidence intervals for all ECSI winter surveys in core strata (30–400 m).**

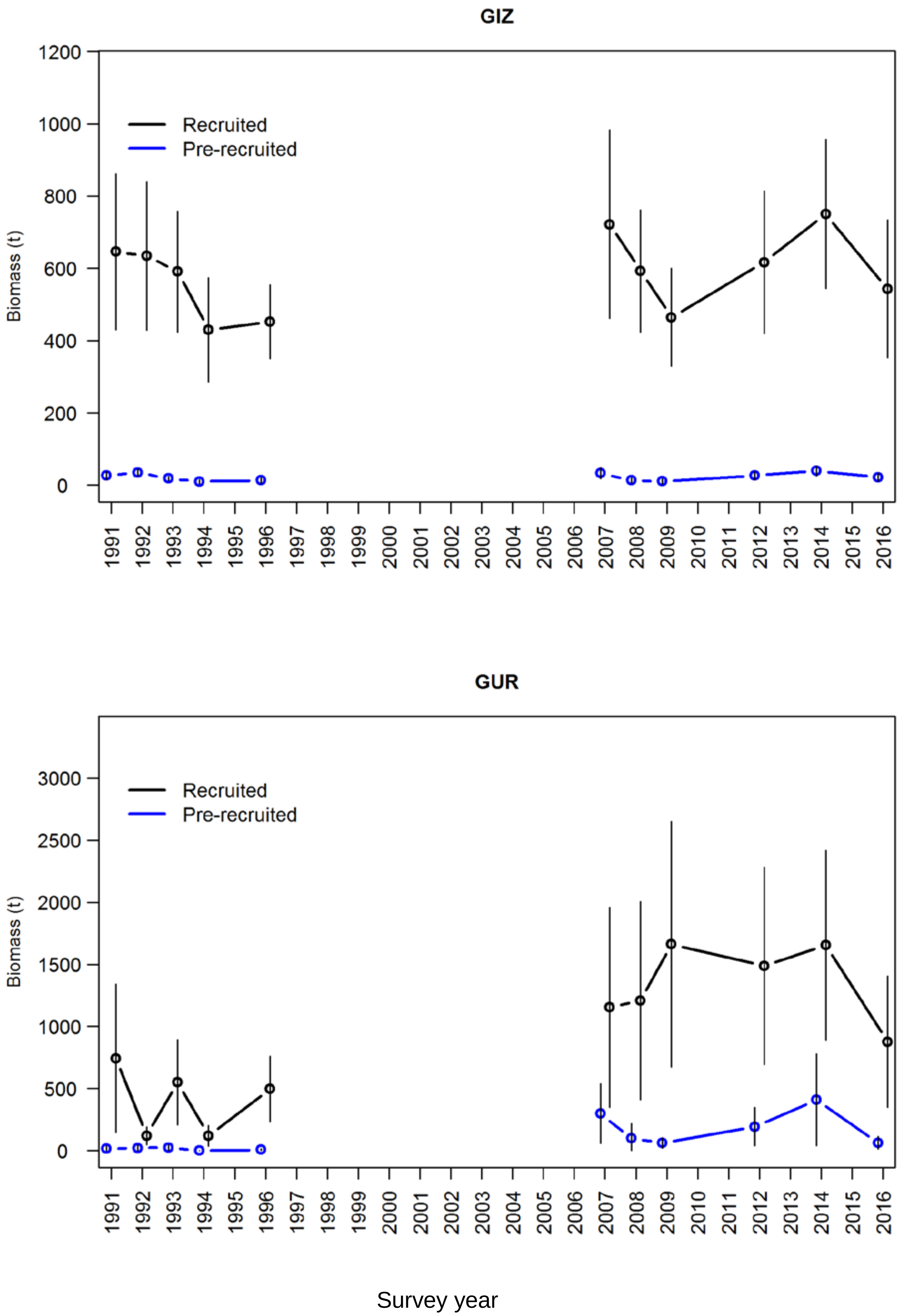



**Figure 8 –** ***continued***

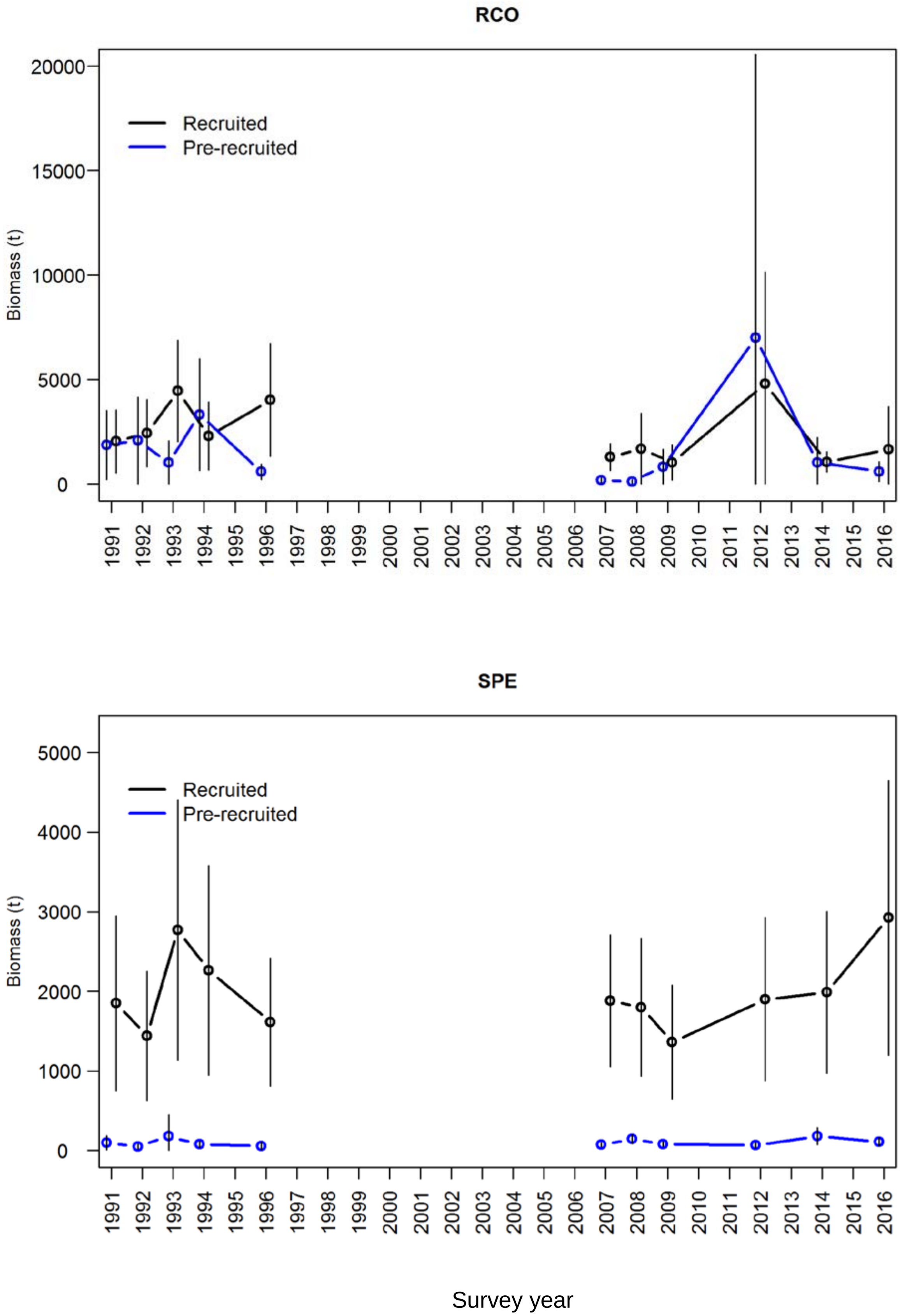



**Figure 8 –** ***continued***

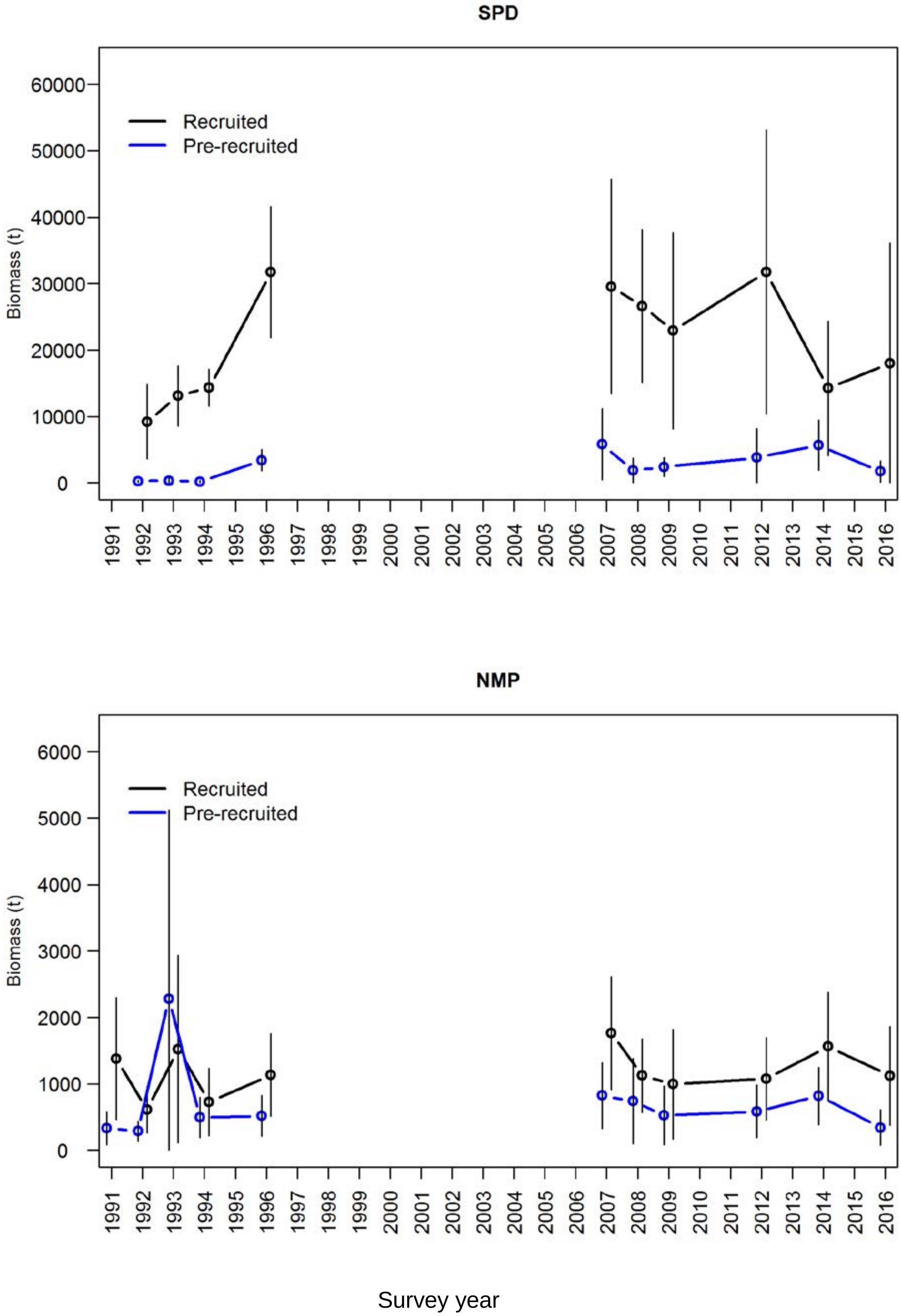



**Figure 8 – *continued***

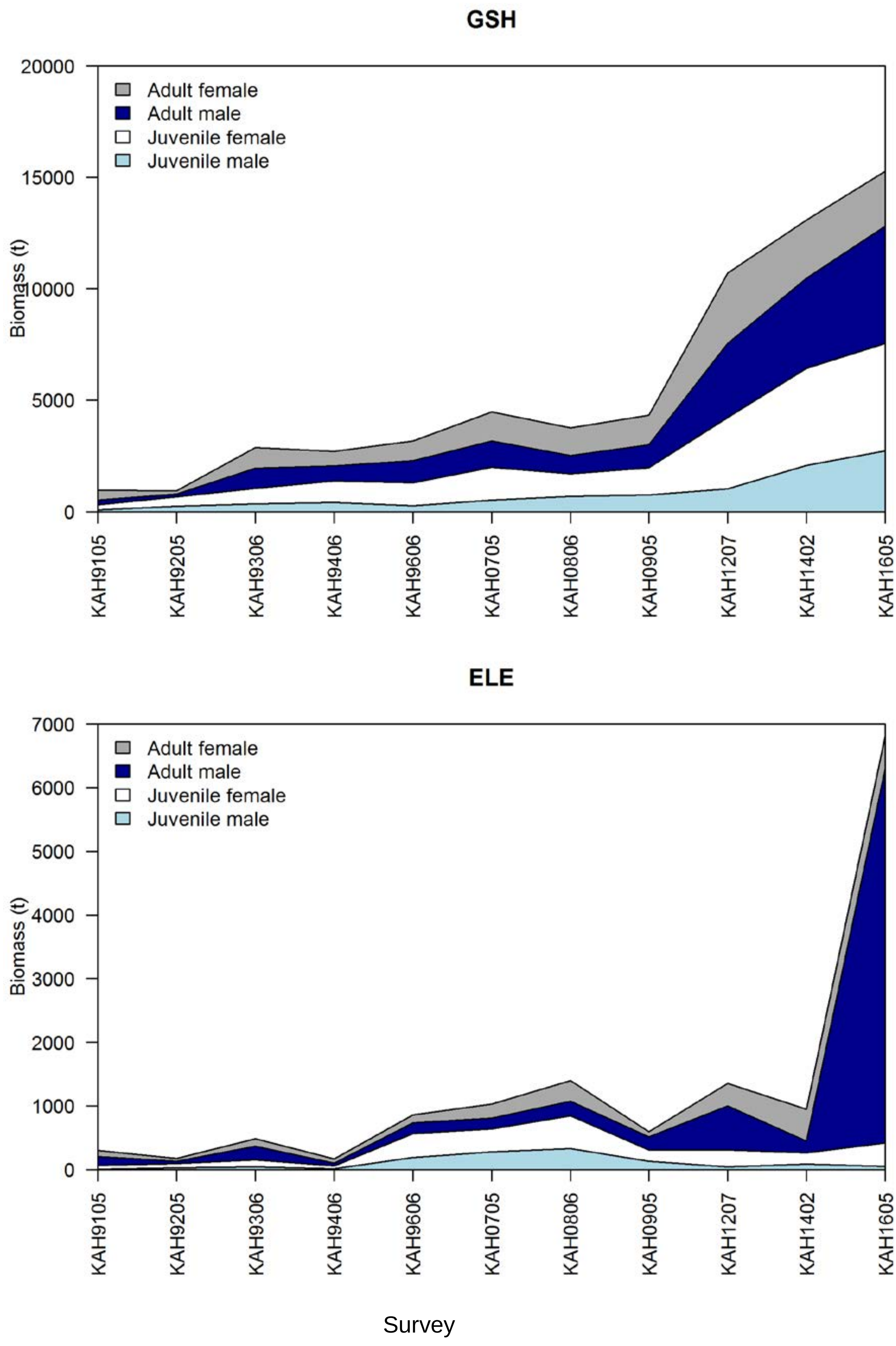
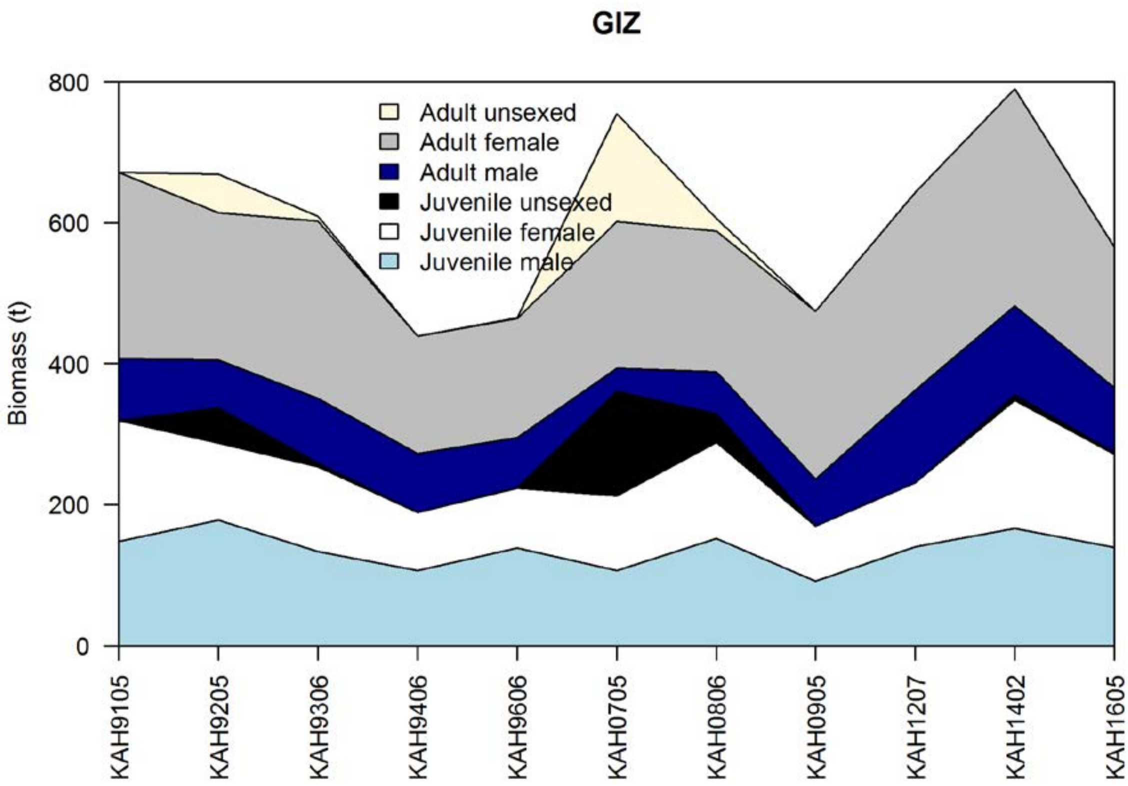



**Figure 9: Target species juvenile and adult biomass for ECSI winter surveys in core strata (30–400 m), where juvenile is below and adult is equal to or above length at which 50% of fish are mature.**



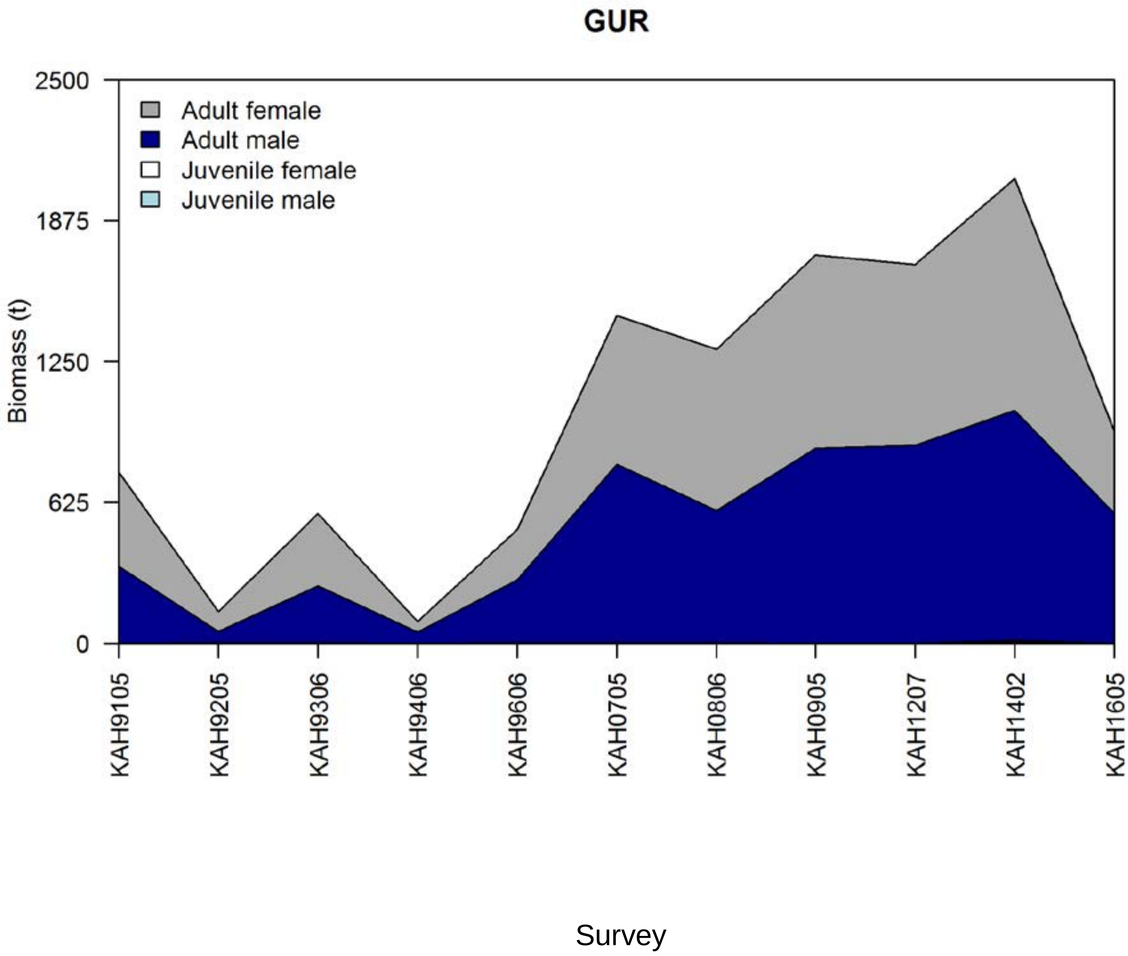
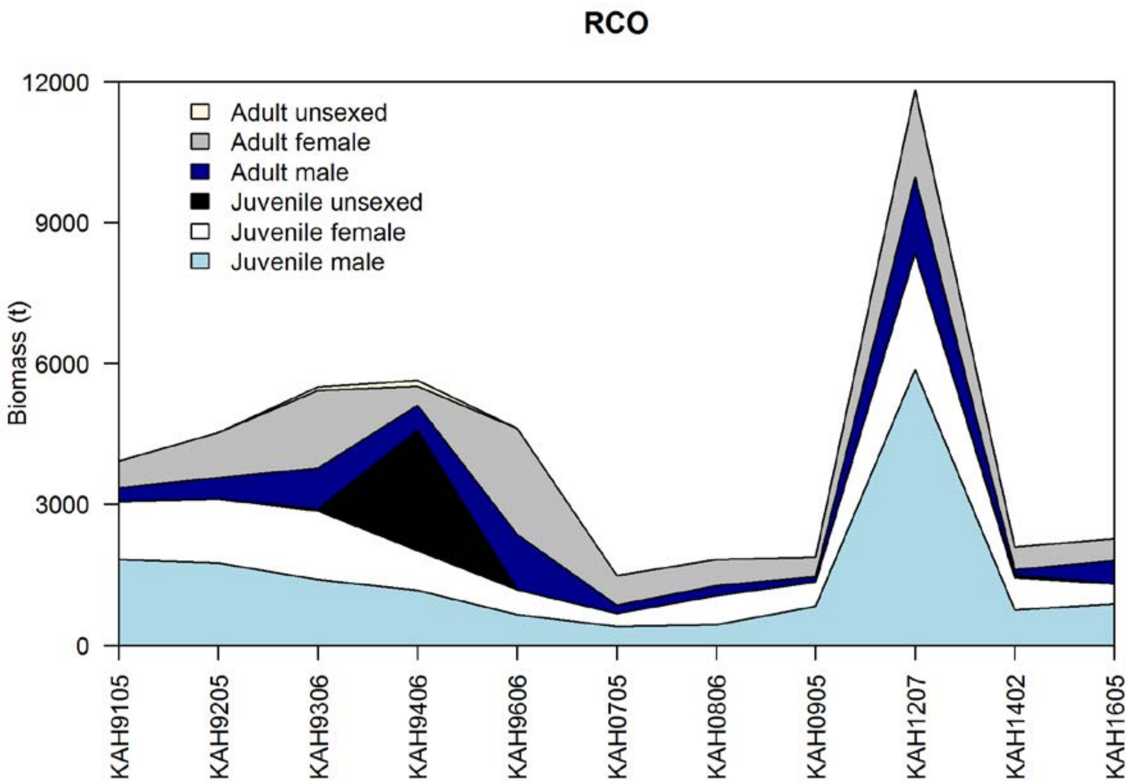




**Figure 9 – *continued***



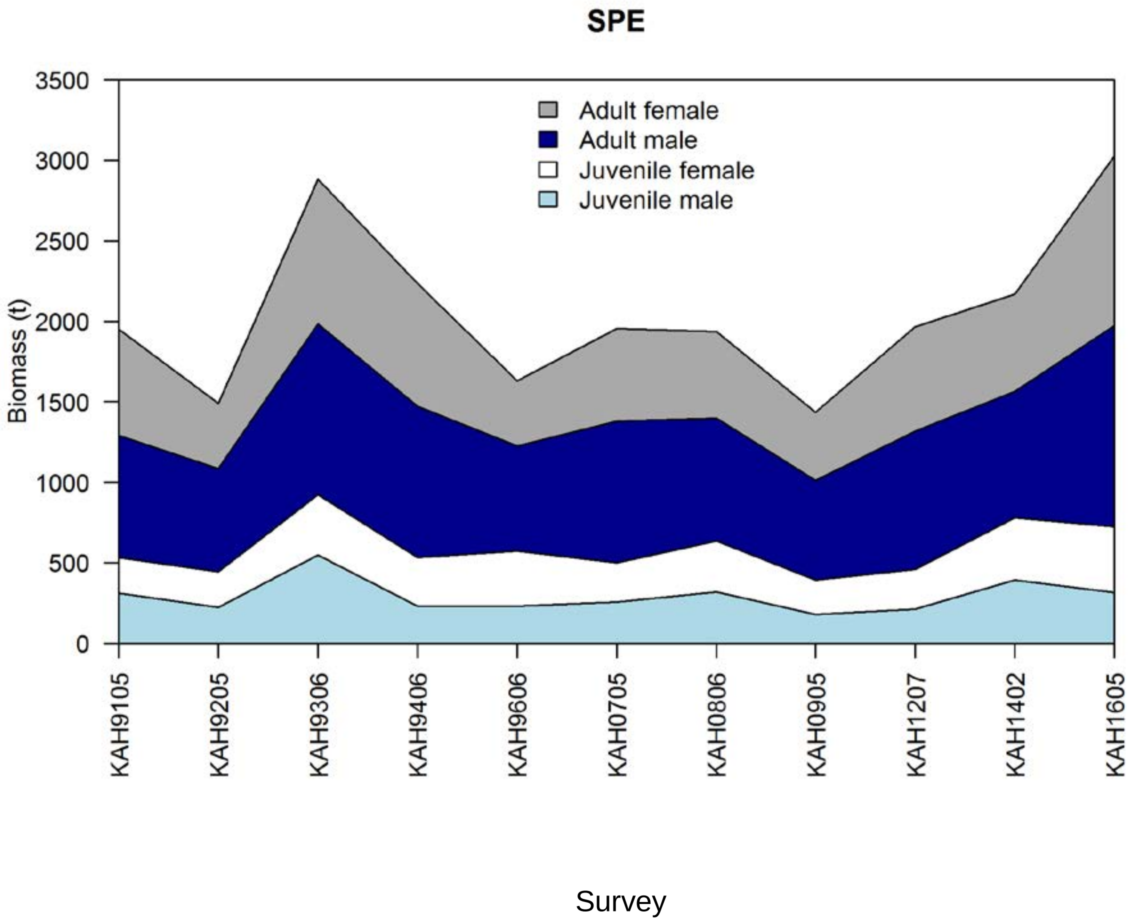
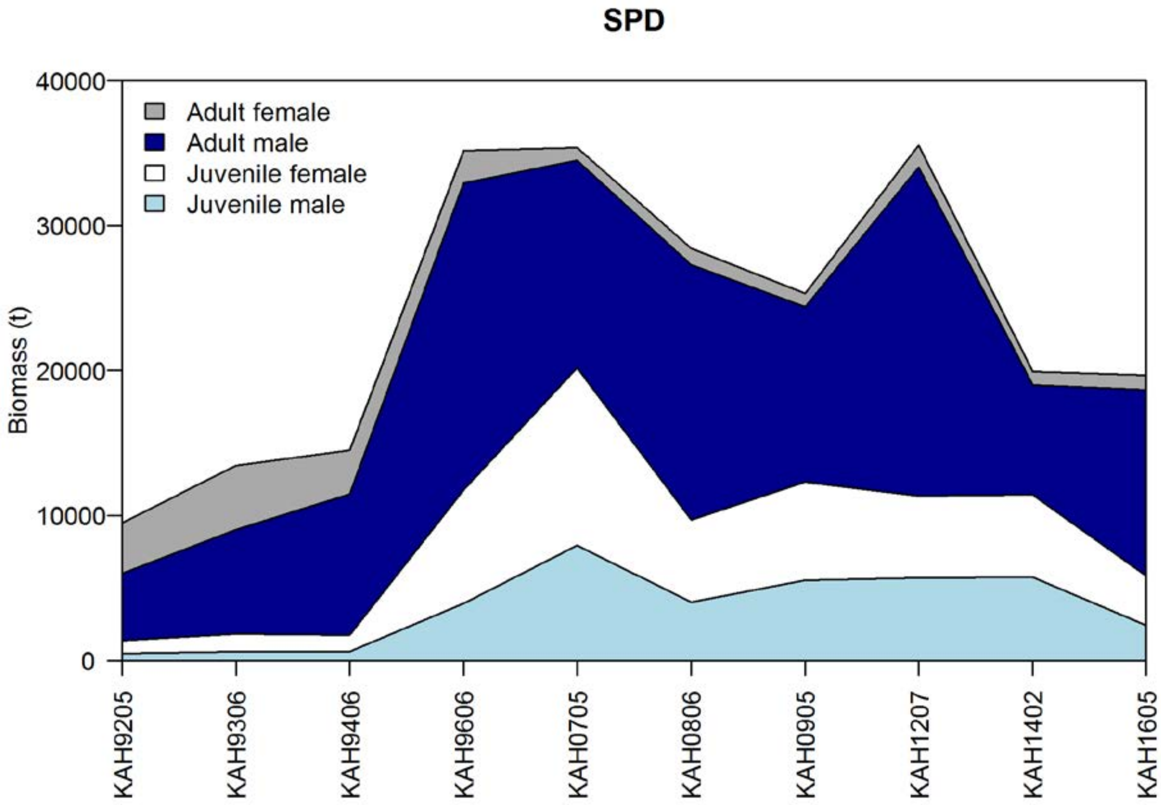




**Figure 9 –** ***continued***



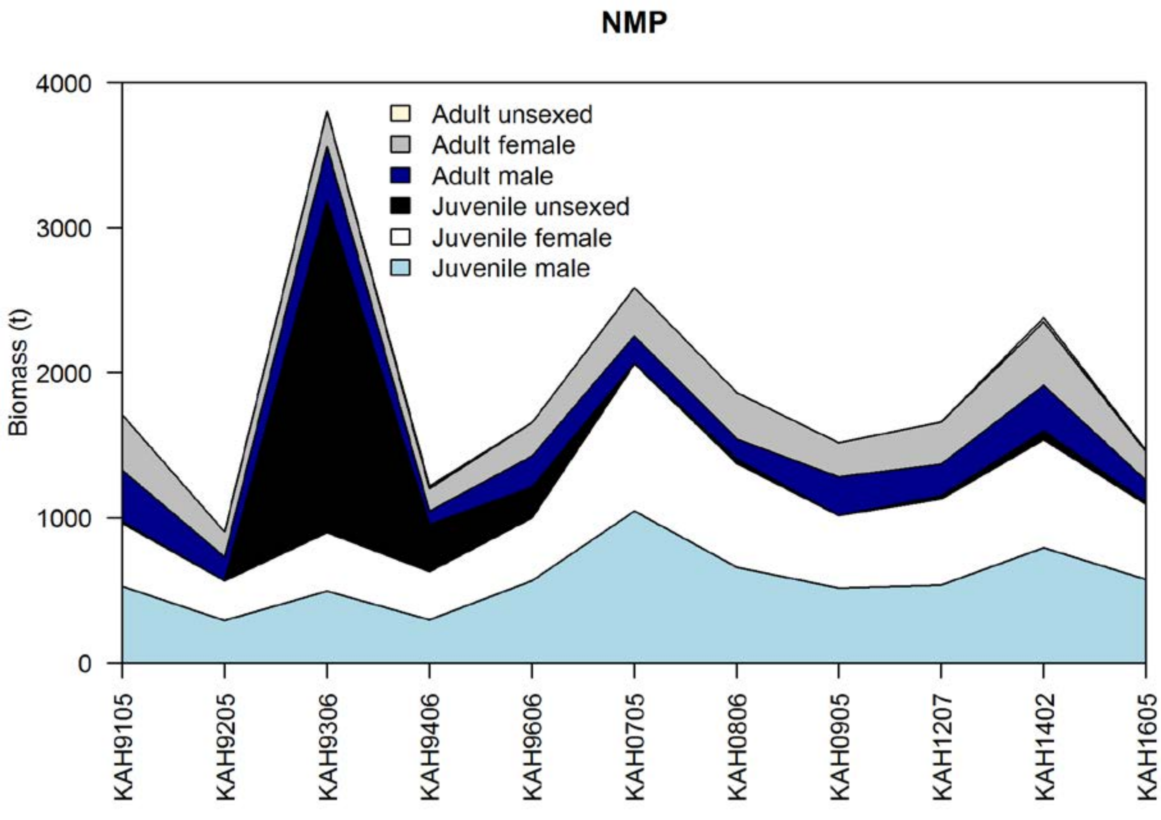




**Figure 9 –** ***continued*****.**

## Dark ghost shark (1991 to 1996)

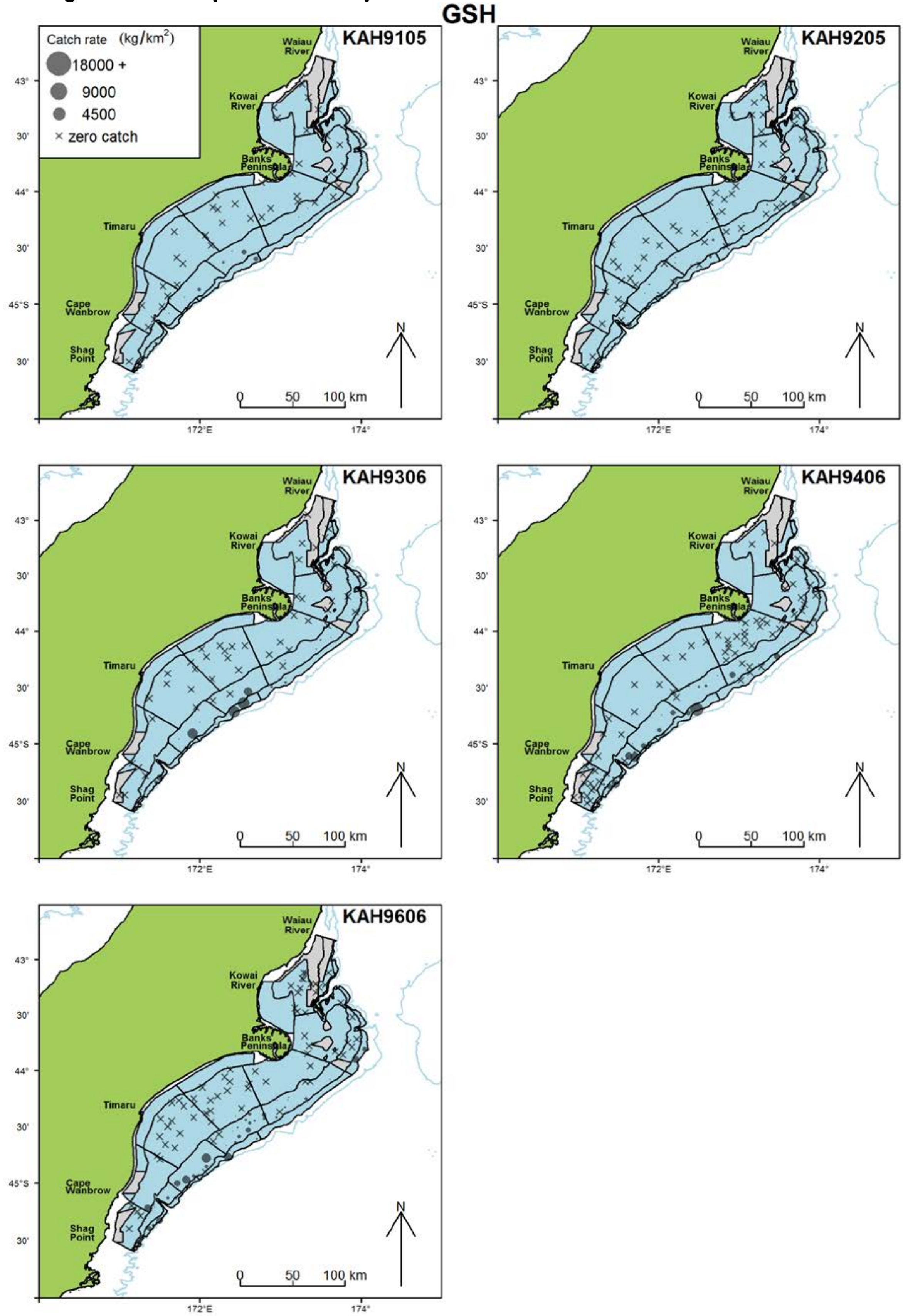



**Figure 10: Target species catch rates (kg.km$^{-2}$) by tow plotted for the eleven ECSI winter trawl surveys.**

## Dark ghost shark (2007 to 2016)

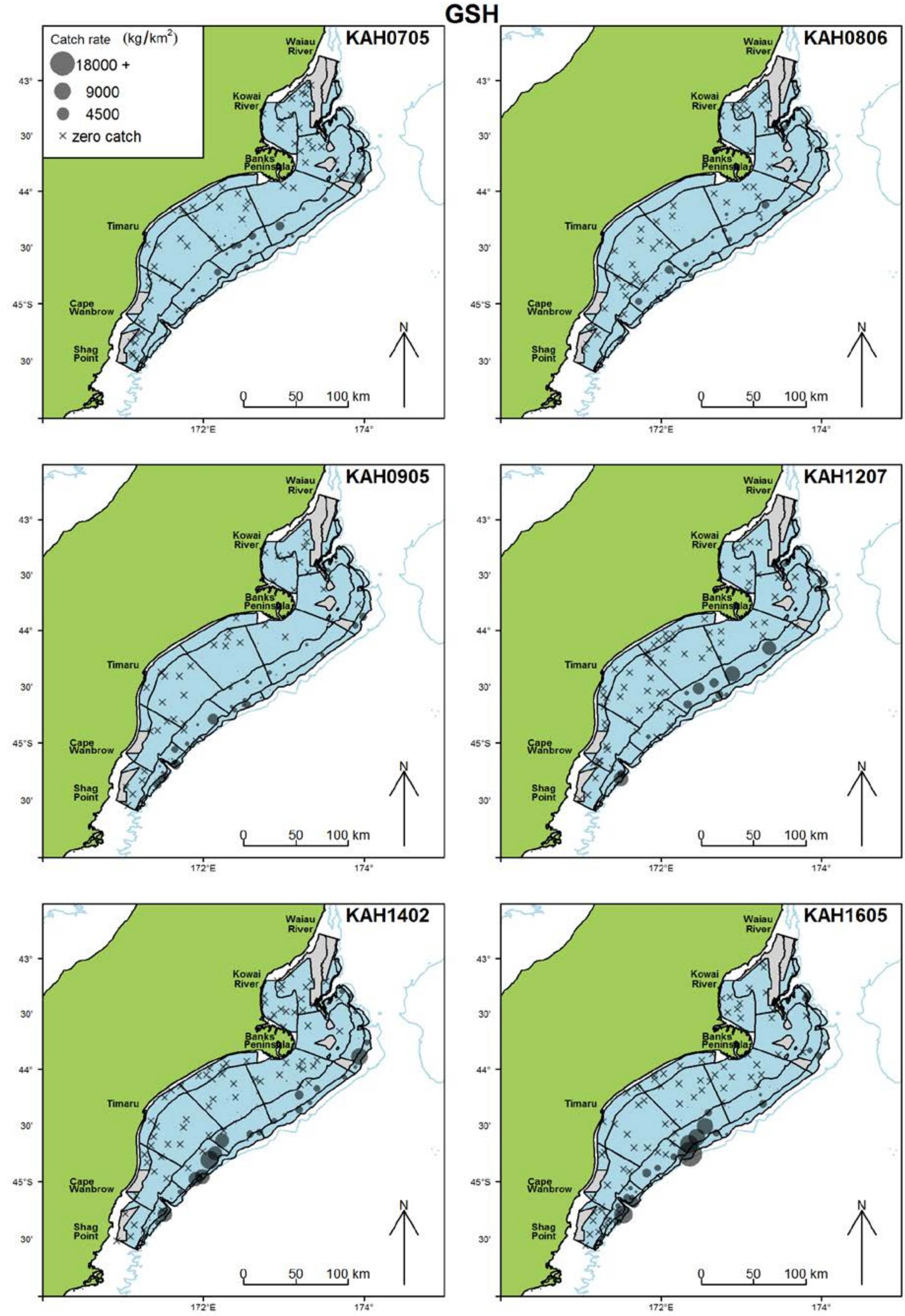



**Figure 10 –** ***continued***

## Elephantfish (1991 to 1996)

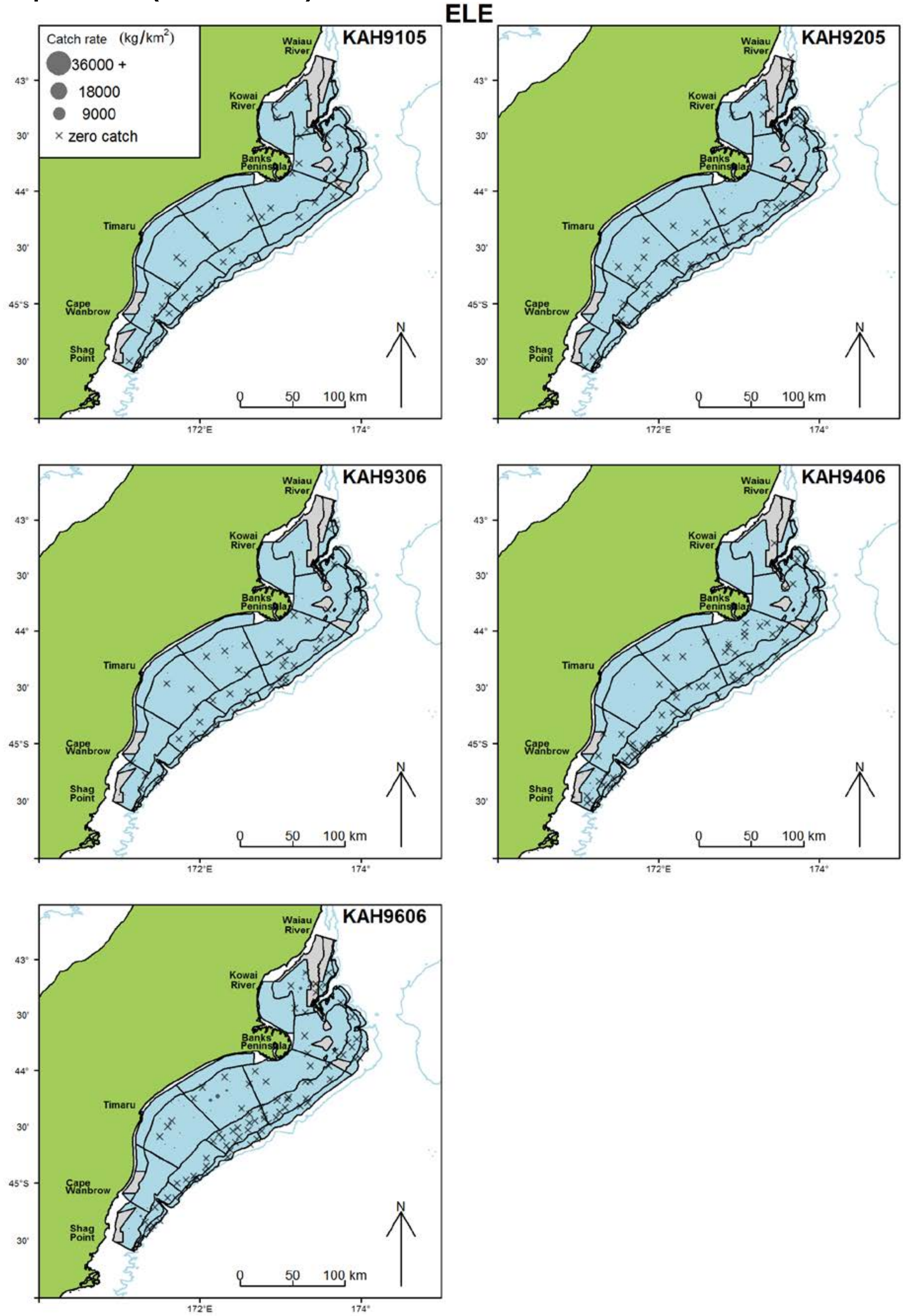



**Figure 10 –** ***continued***

## Elephantfish (2007 to 2016)

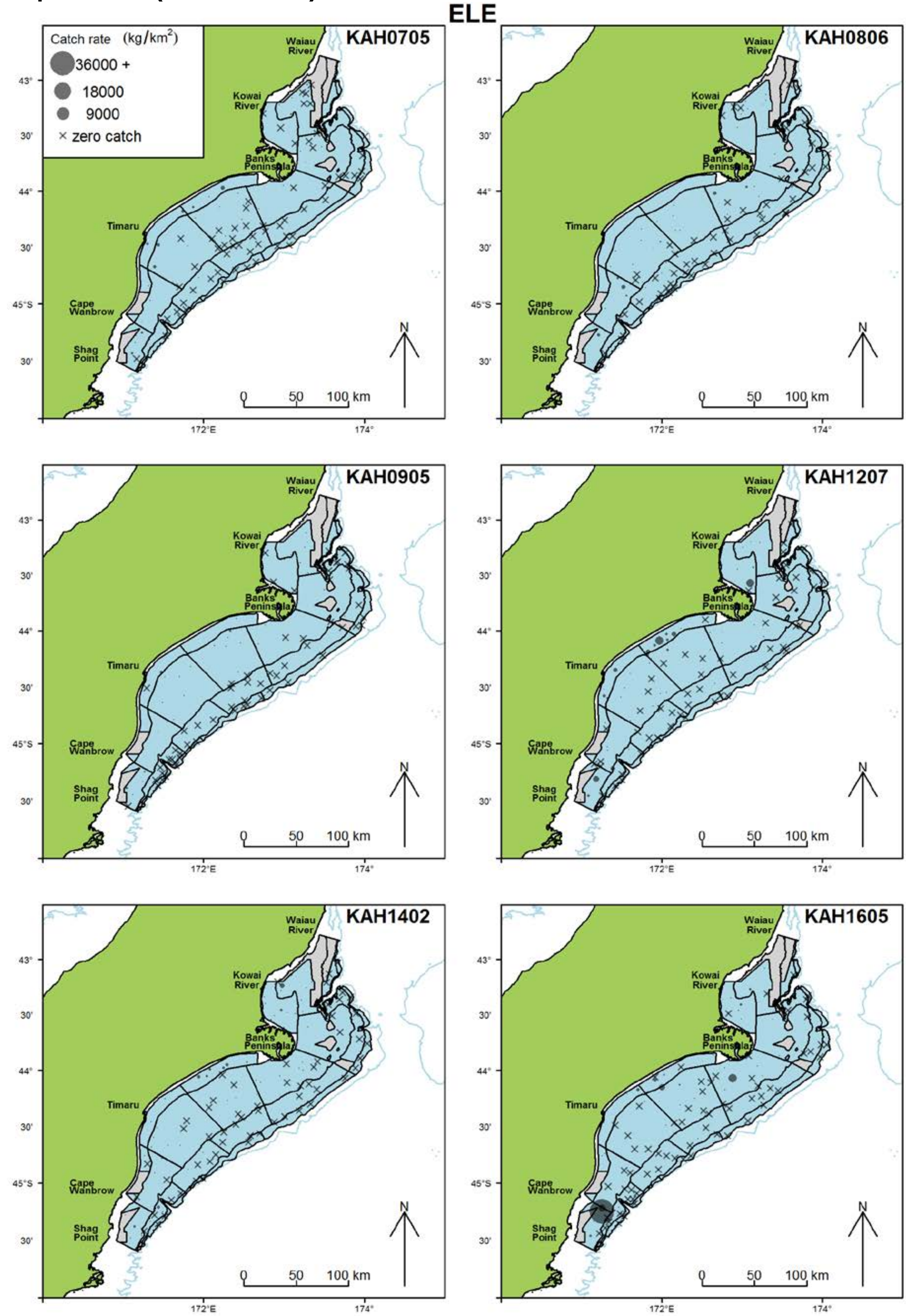



**Figure 10 –** ***continued***

## Giant stargazer (1991 to 1996)

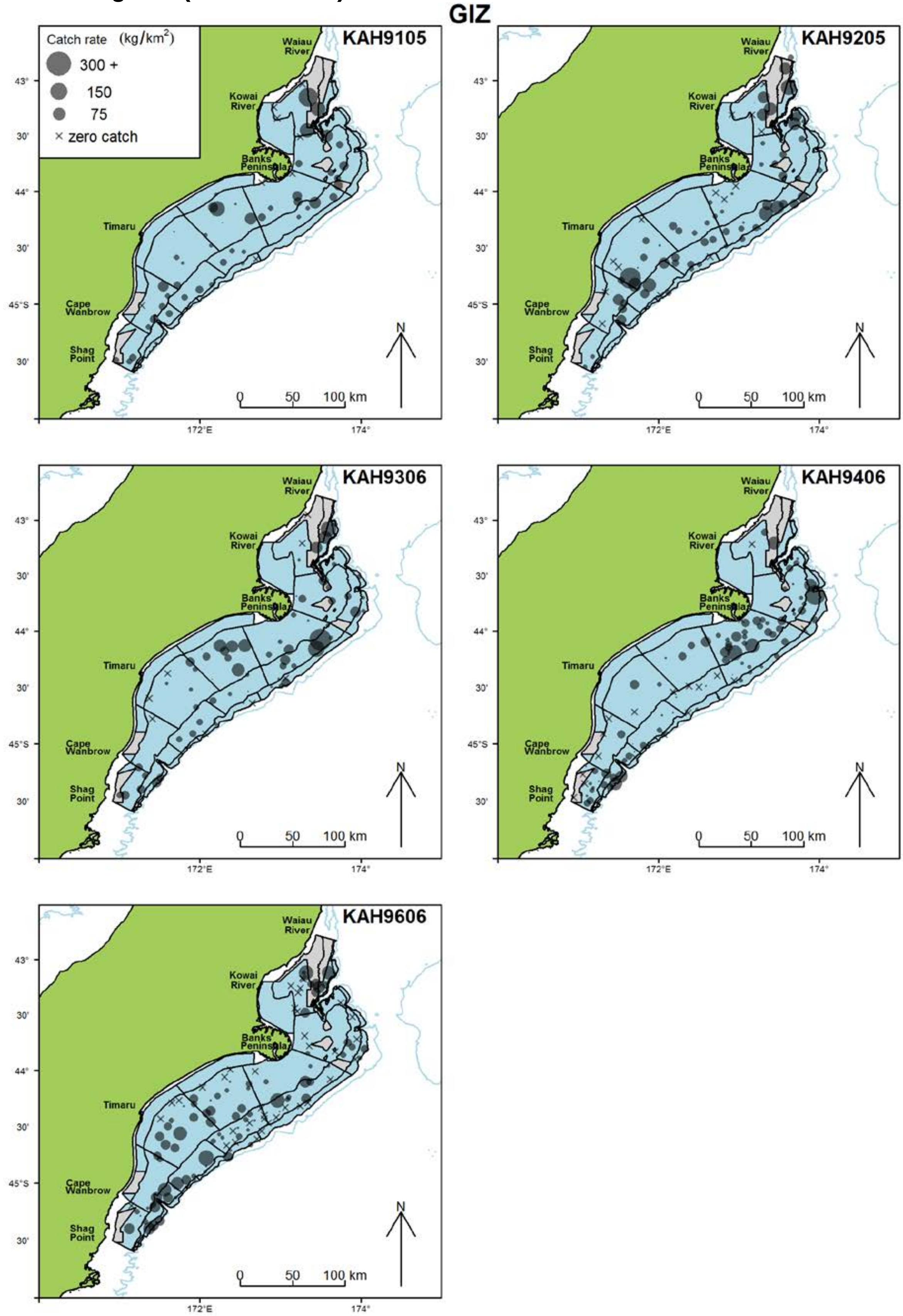



**Figure 10 –** ***continued***

## Giant stargazer (2007 to 2016)

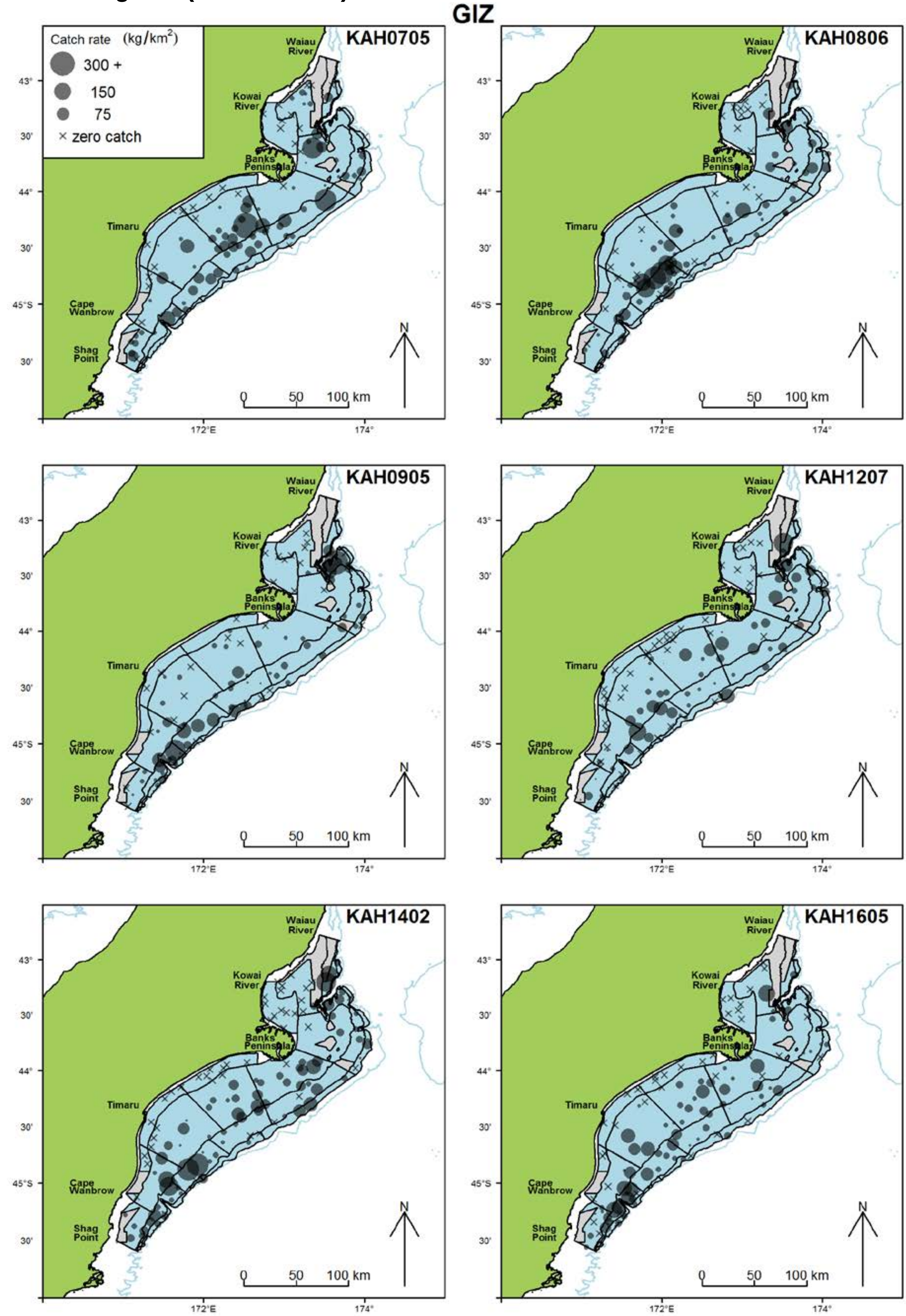



**Figure 10 –** ***continued***

## Red gurnard (1991 to 1996)

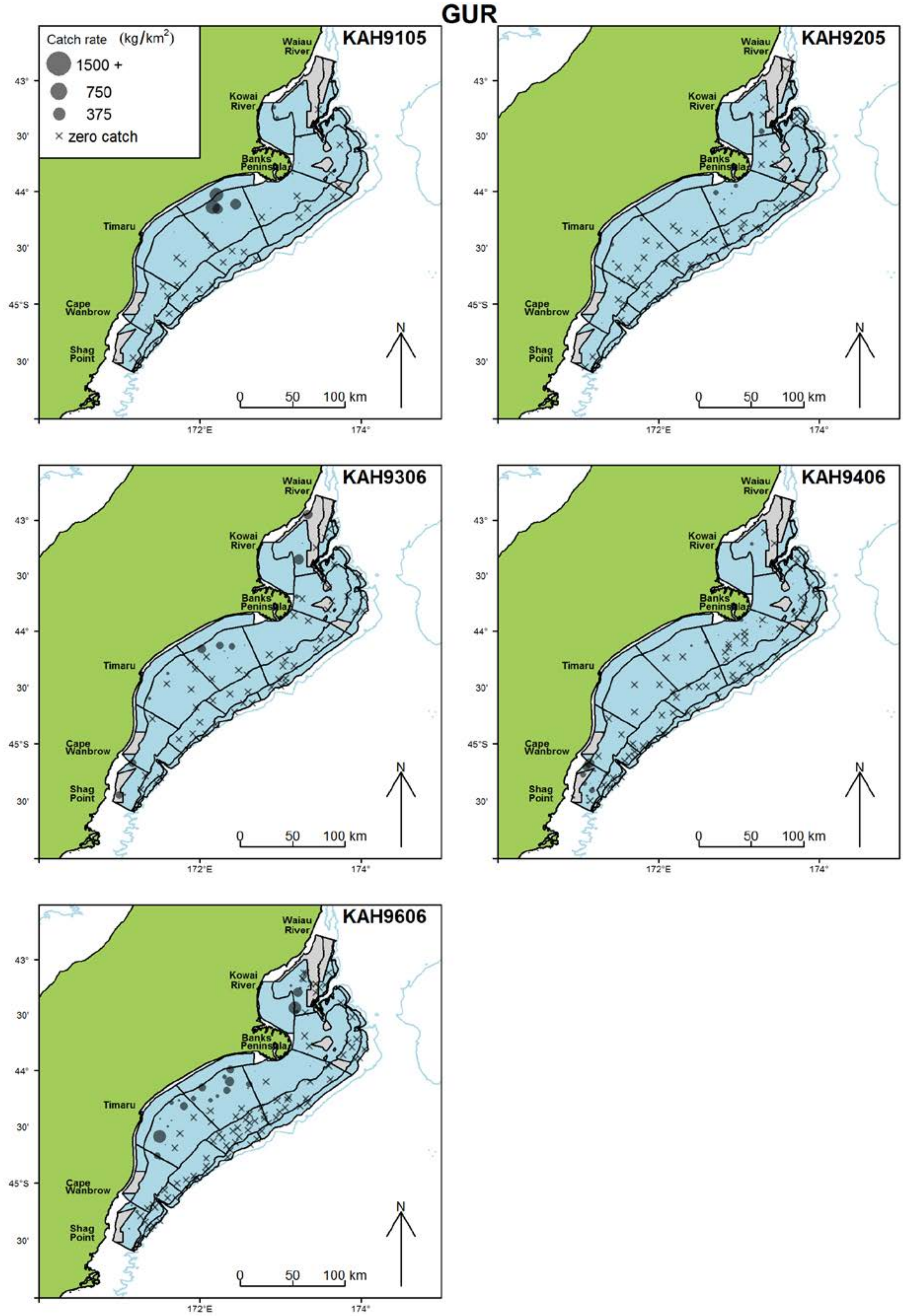



**Figure 10 –** ***continued***

## Red gurnard (2007 to 2016)

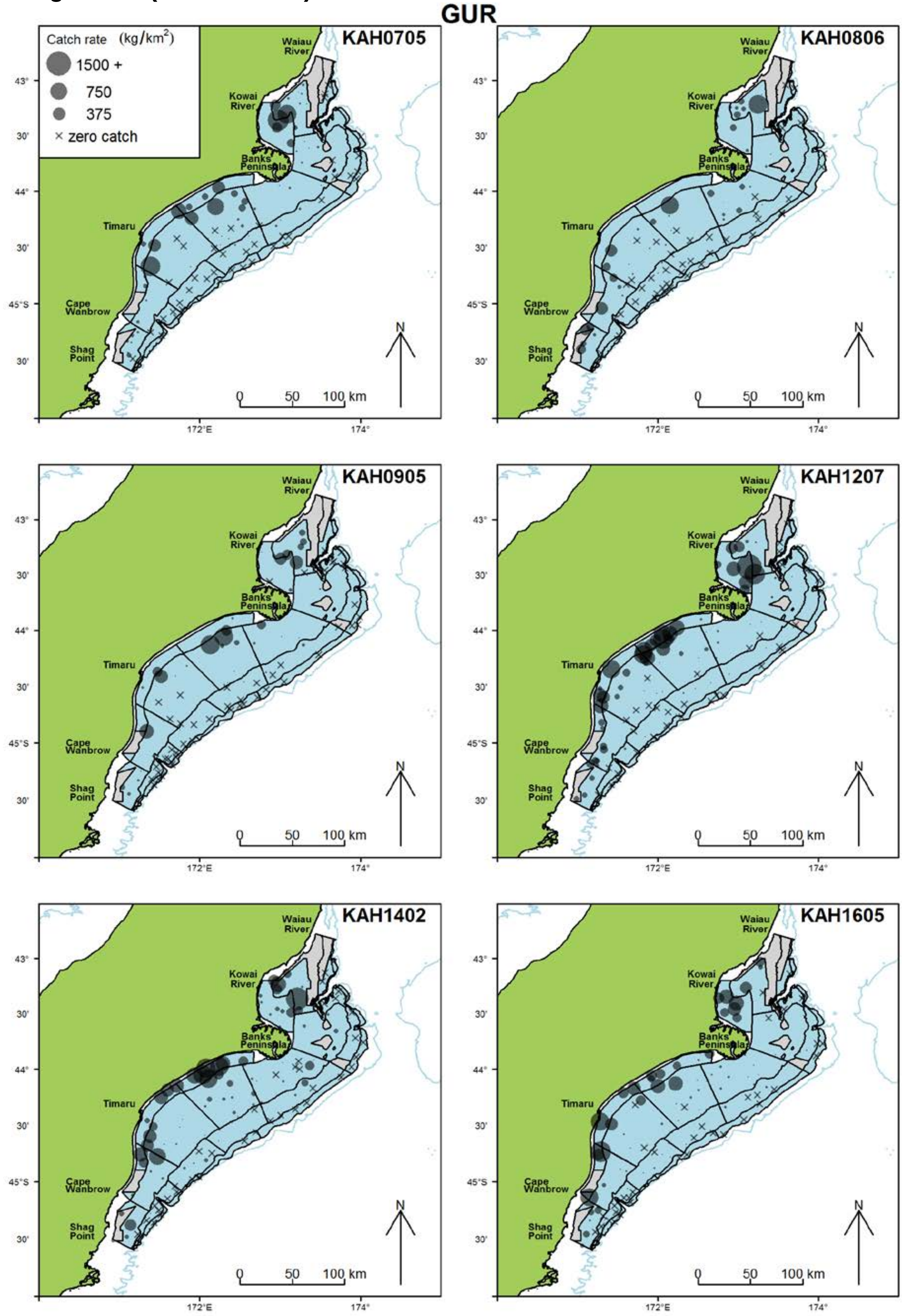



**Figure 10 –** ***continued***

## Red cod (1991–1996)

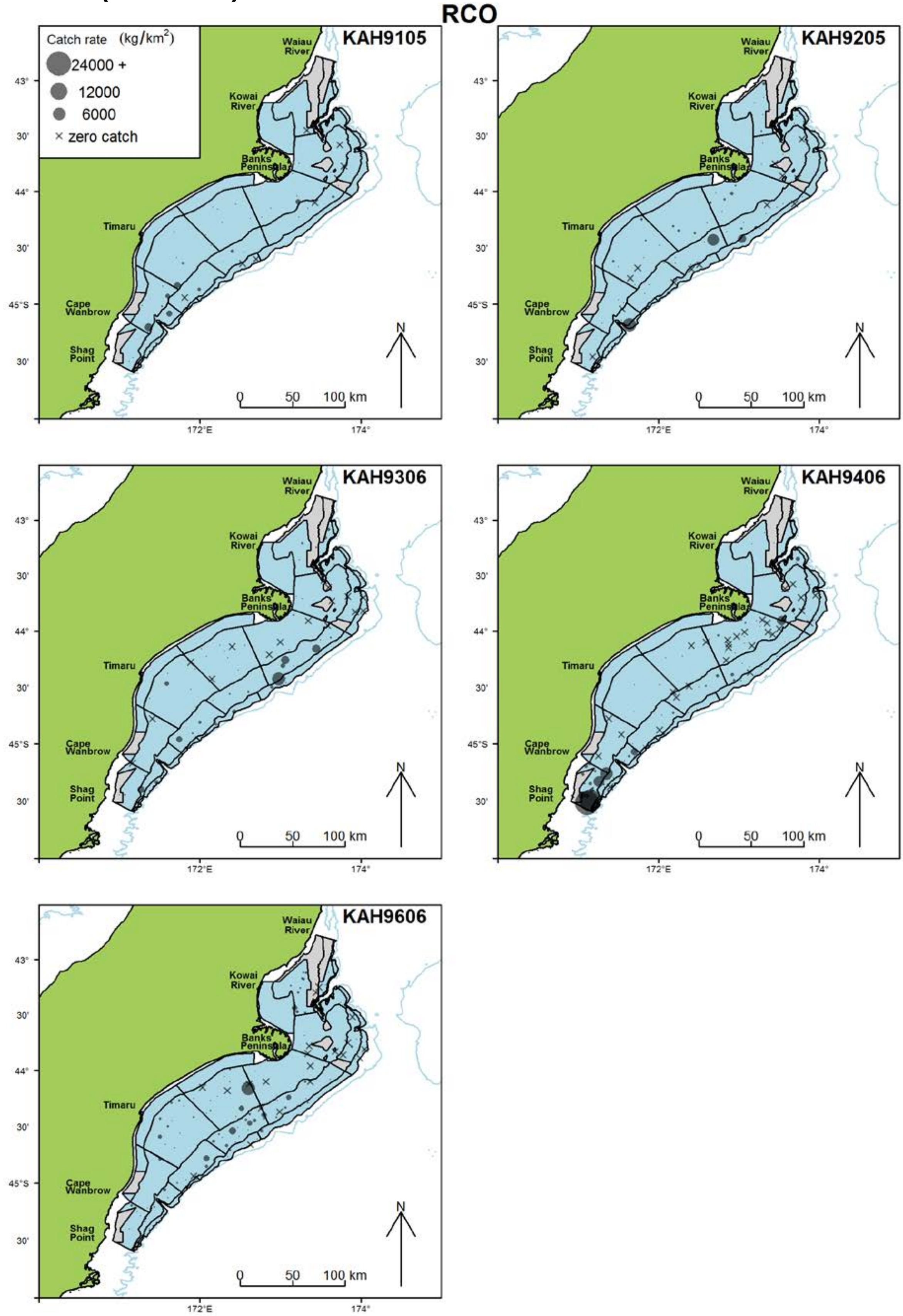



**Figure 10 –** ***continued***

## Red cod (2007 to 2016)

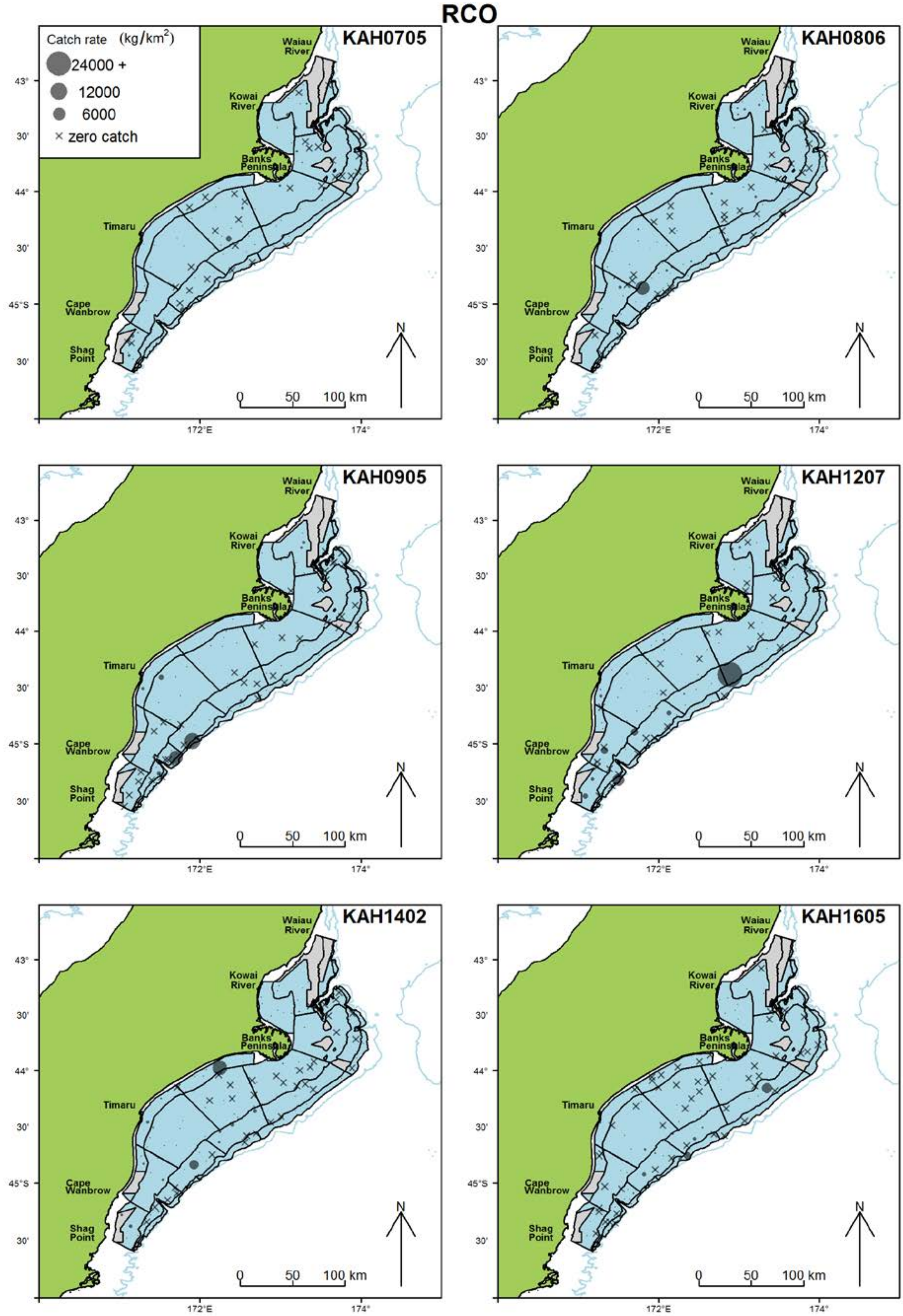



**Figure 10 –** ***continued***

## Sea perch (1991 to 1996)

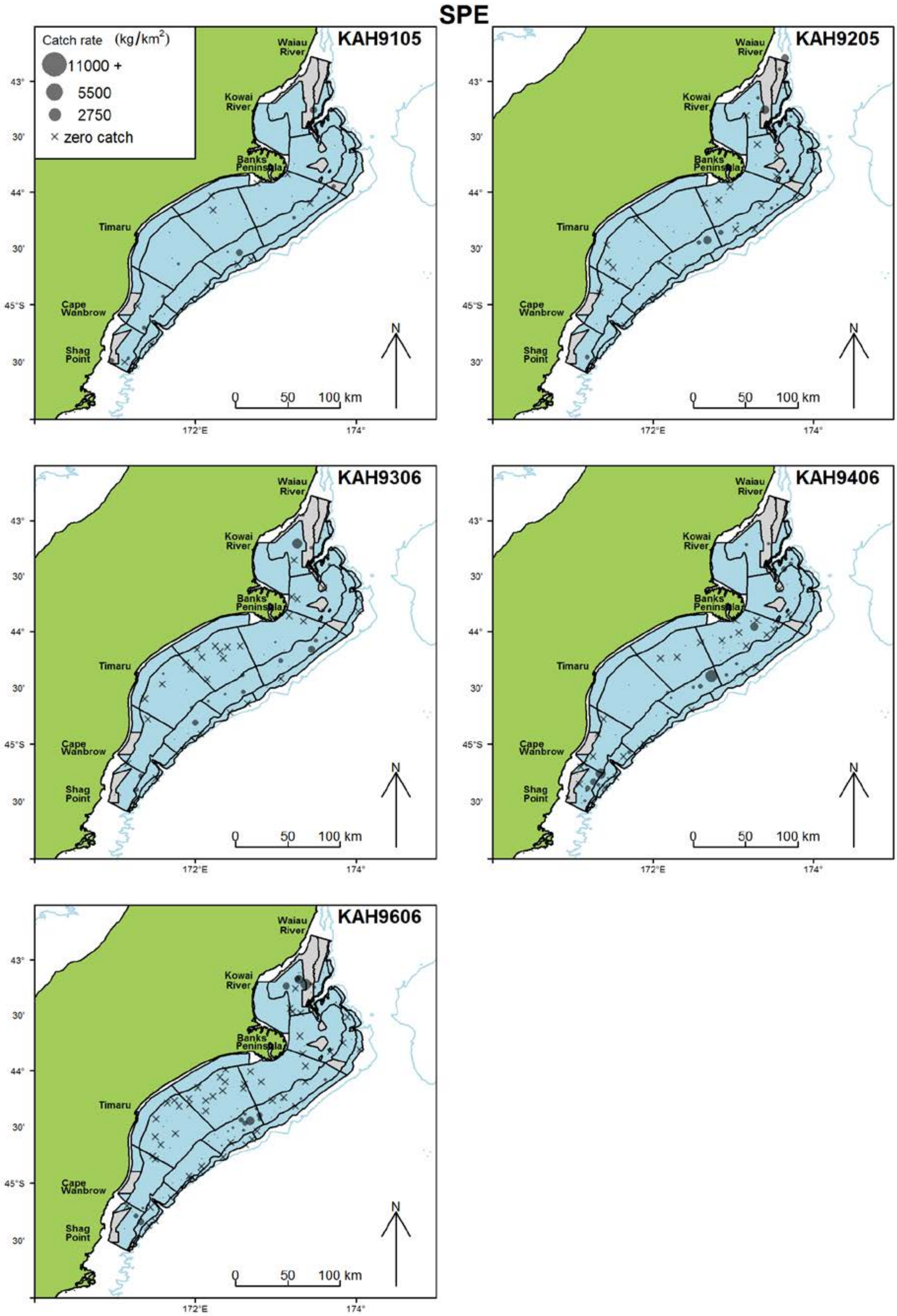



**Figure 10 –** ***continued***

## Sea perch (2007 to 2016)

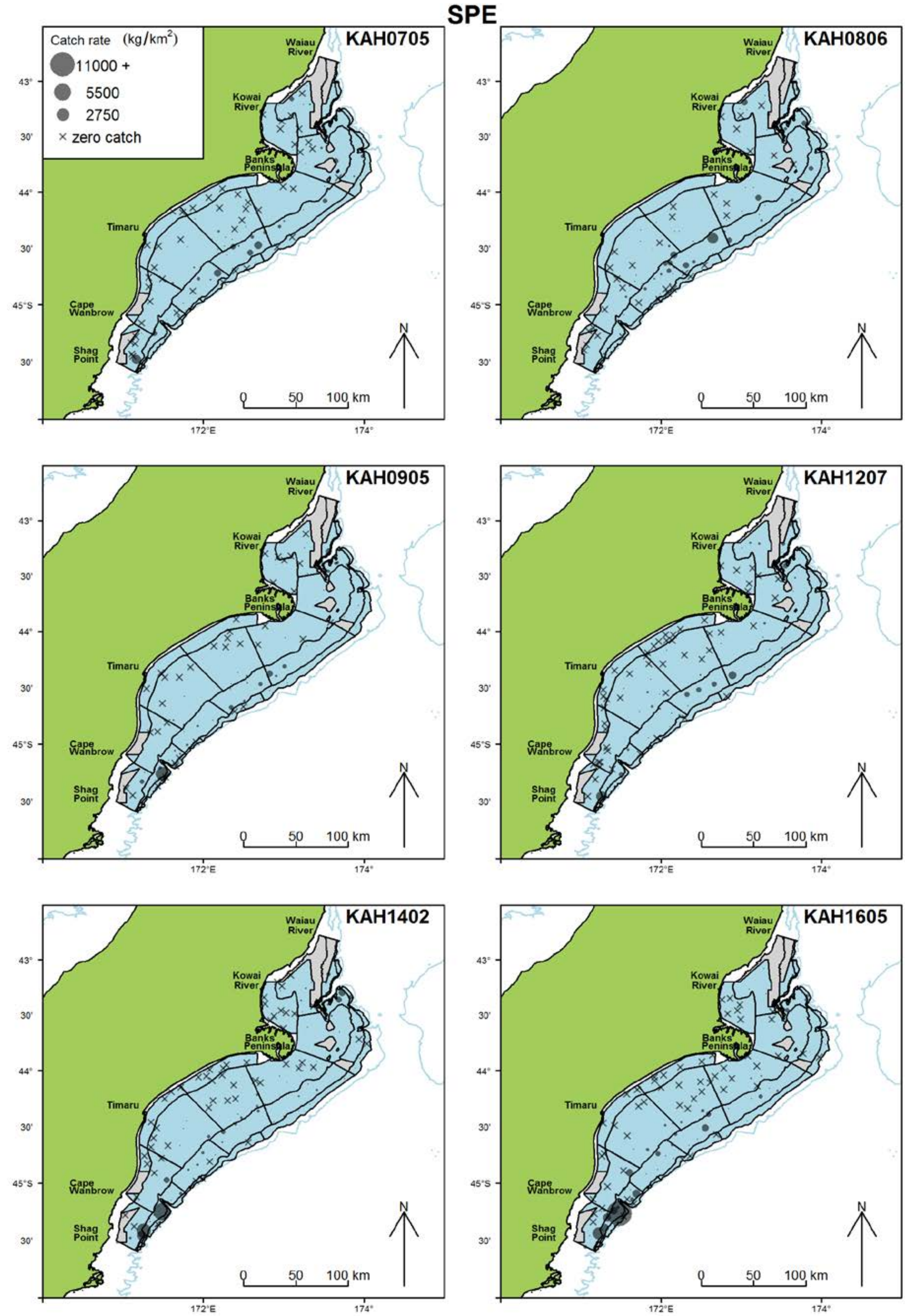



Figure 10 – *continued*

## Spiny dogfish (1991 to 1996)

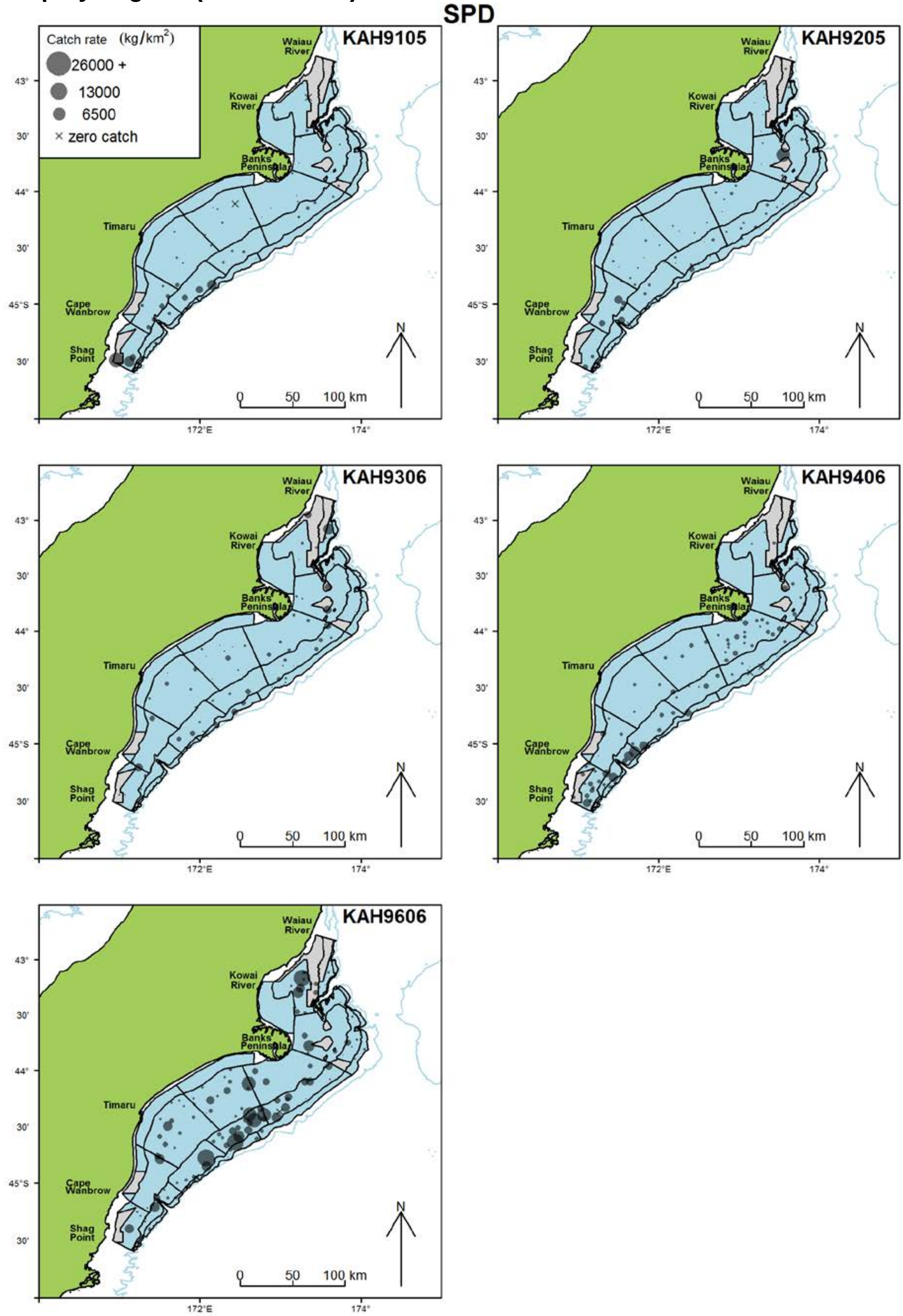



**Figure 10 –** ***continued***

## Spiny dogfish (2007 to 2016)

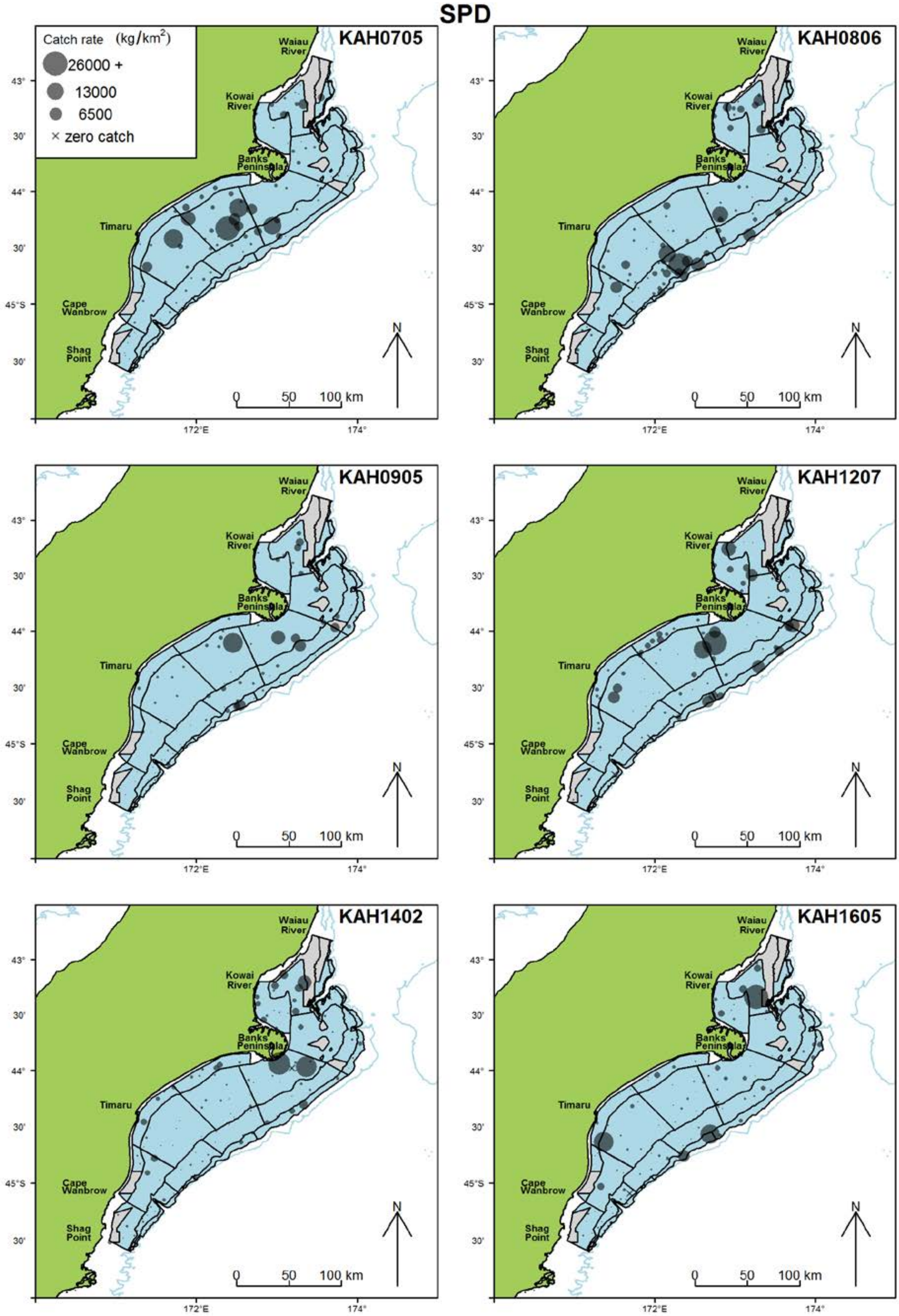



**Figure 10 –** ***continued***

**Tarakihi (1991–1996)**

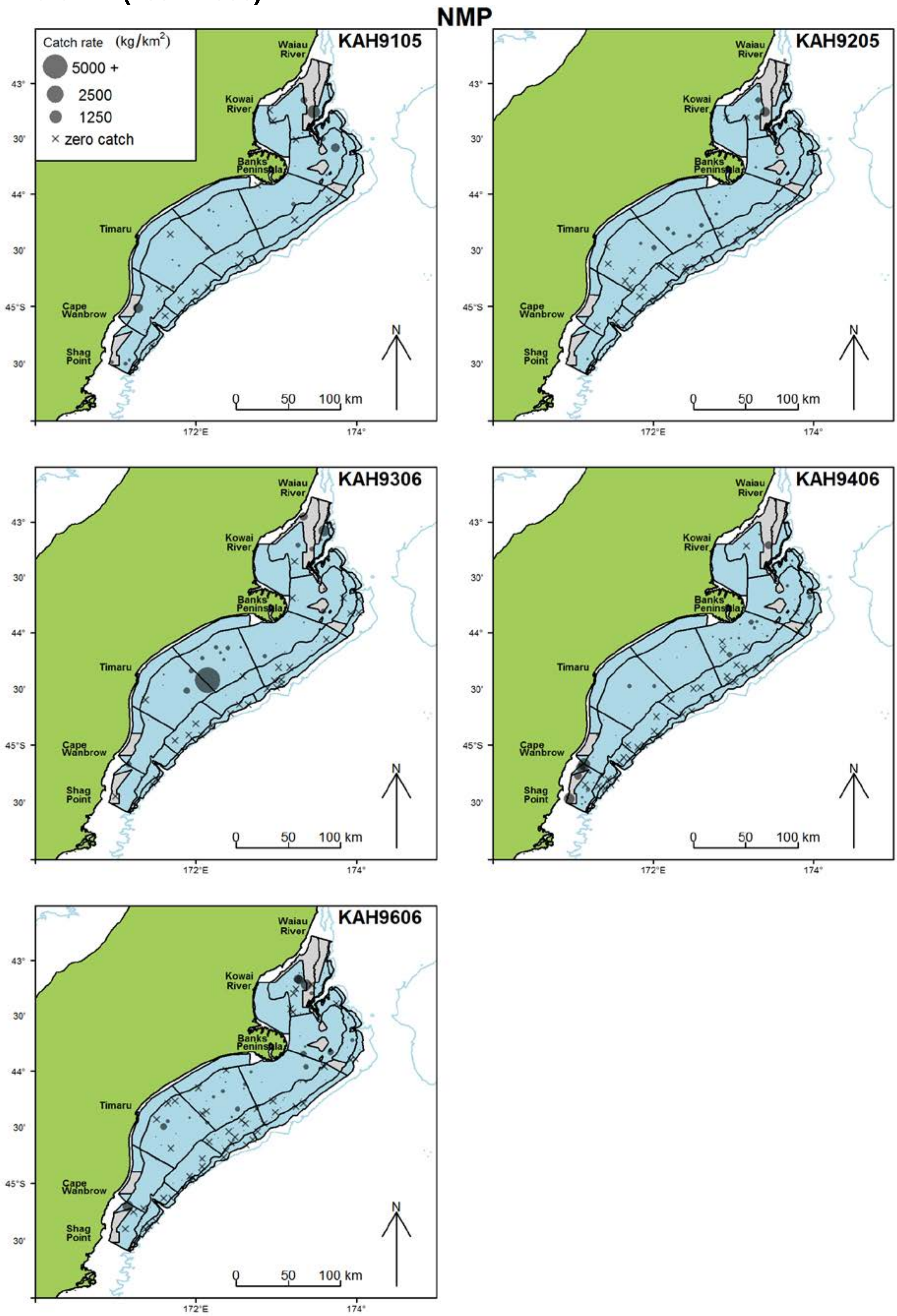



**Figure 10 –** ***continued***

## Tarakihi (2007–2016)

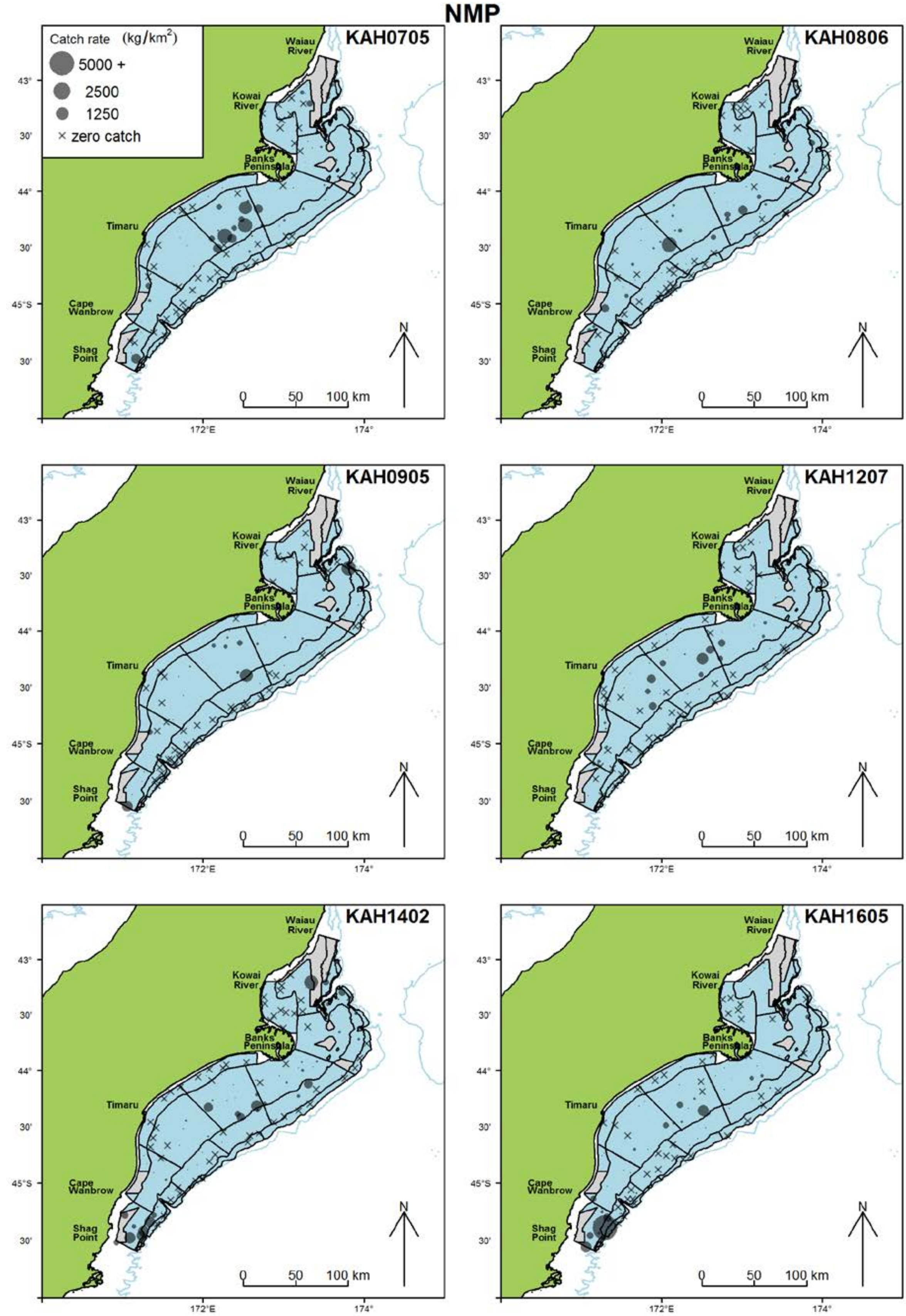



**Figure 10 –** ***continued***

## Dark ghost shark (1991 to 1996)

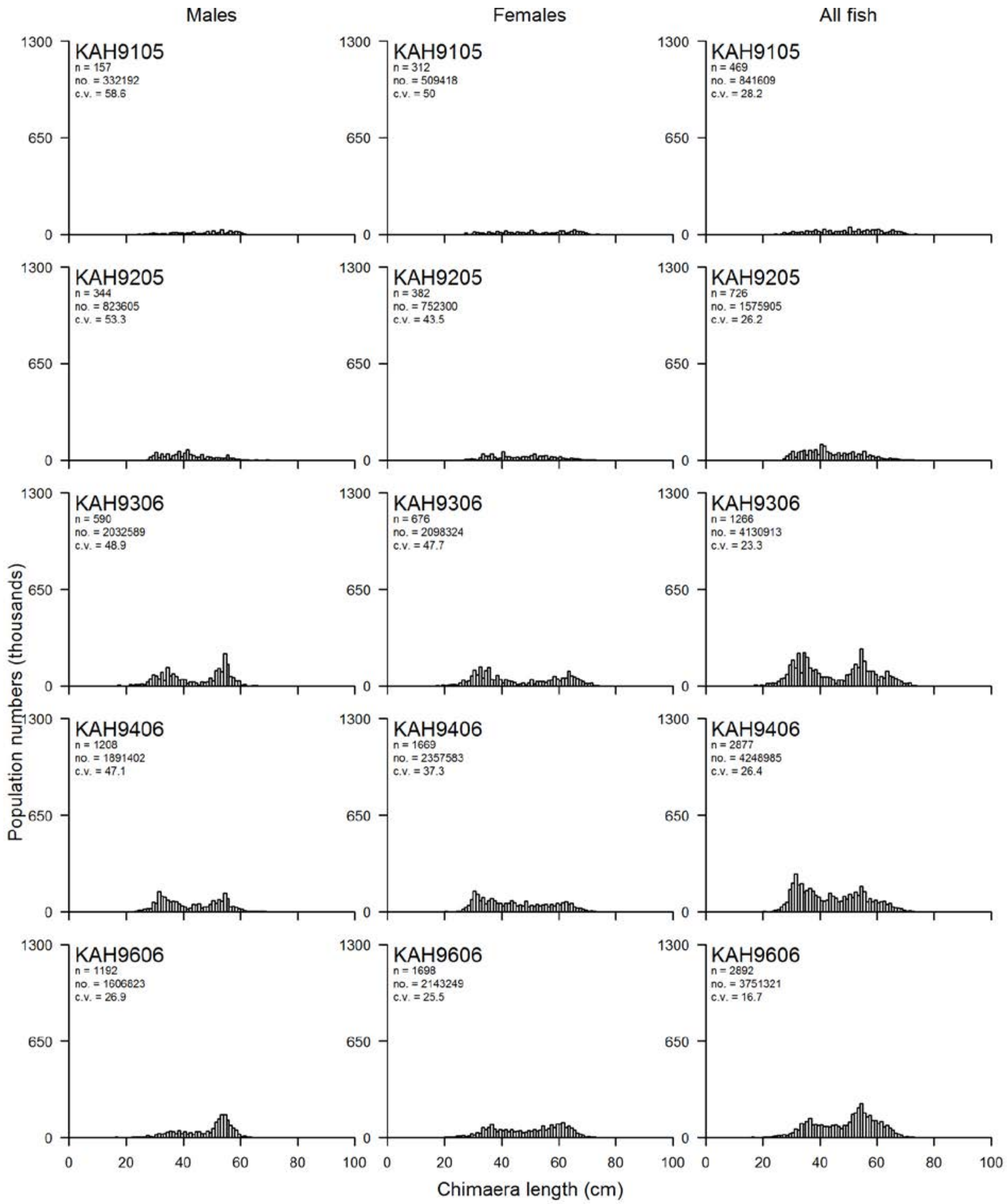



**Figure 11: Scaled length frequency distributions for the target species in core strata (30–400 m) for all eleven ECSI winter surveys (1991 to 2016). The length distribution is also shown in the 10–30 m depth strata for the 2007, 2012, 2014 and 2016 surveys overlayed (not stacked) in red for ELE, GUR,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

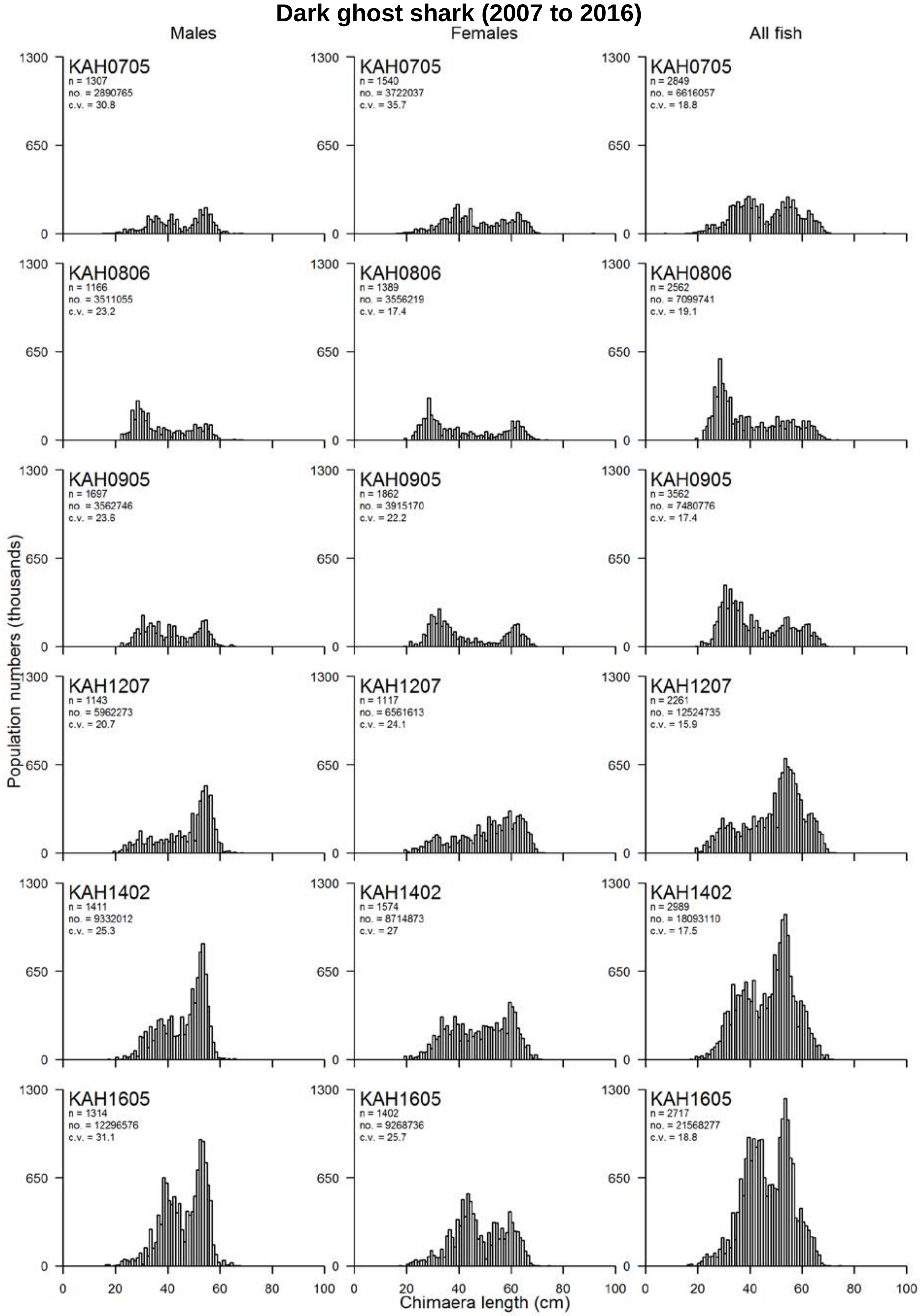



**Figure 11 –** ***continued***

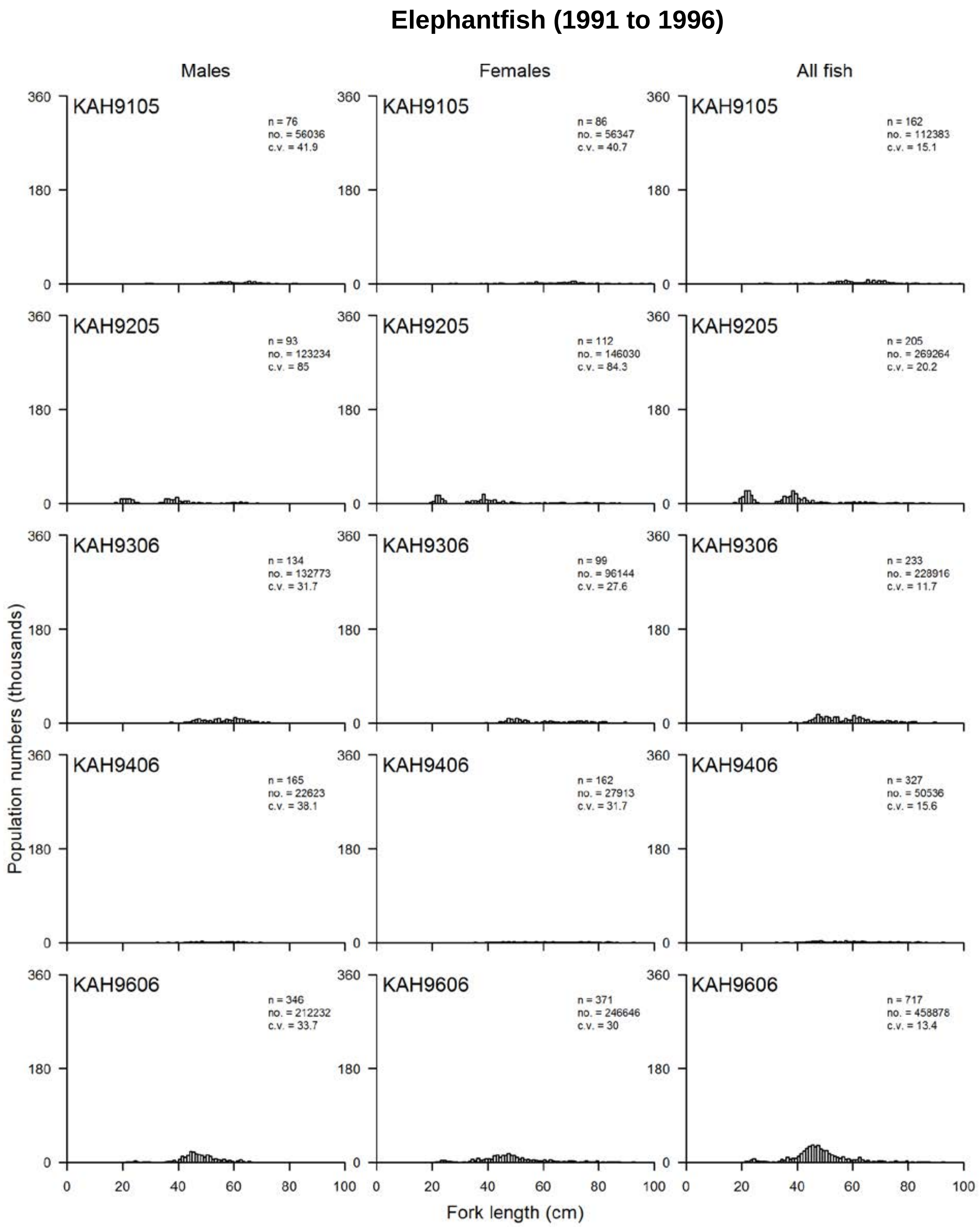



**Figure 11 –** ***continued***

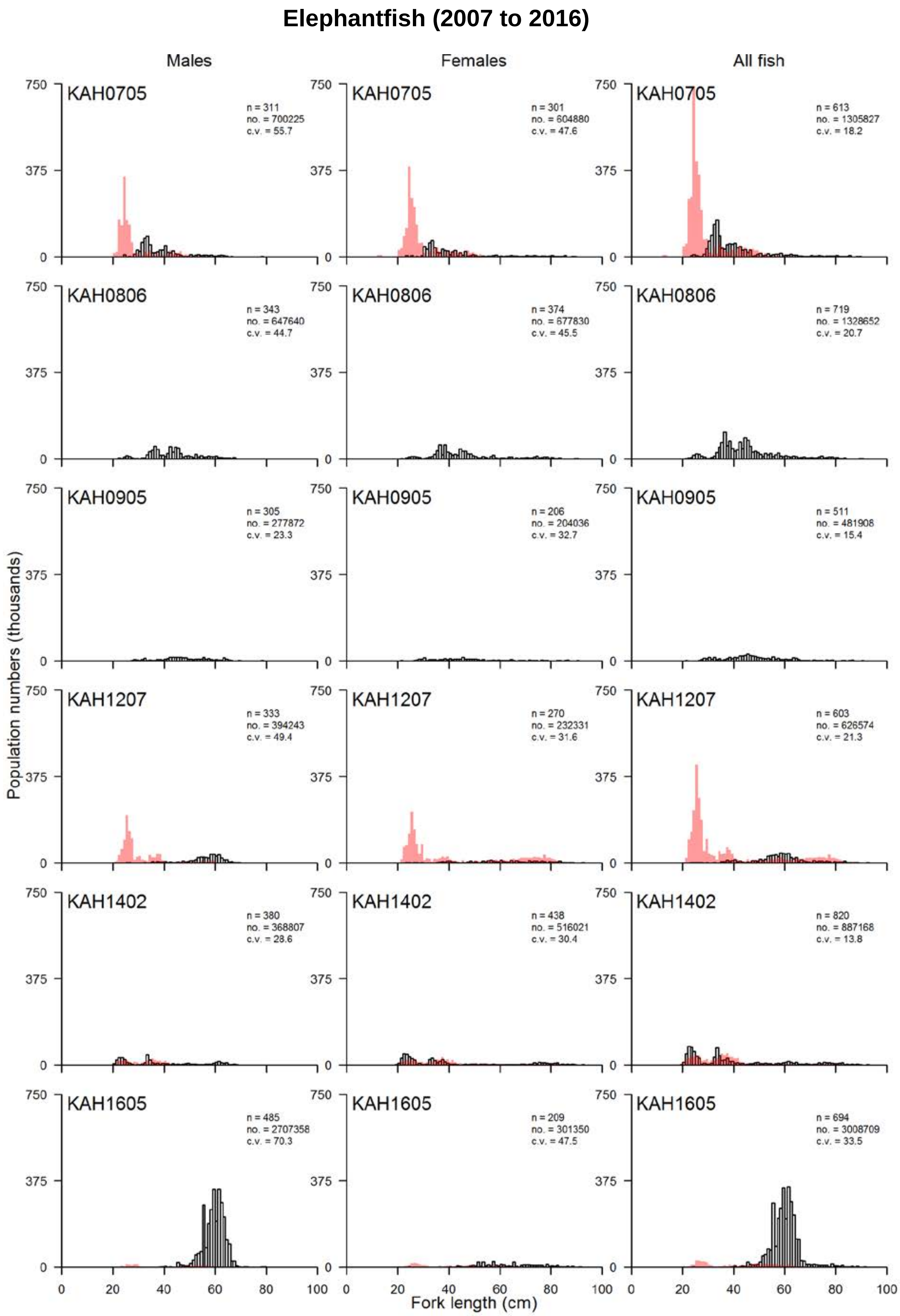



**Figure 11 –** ***continued***

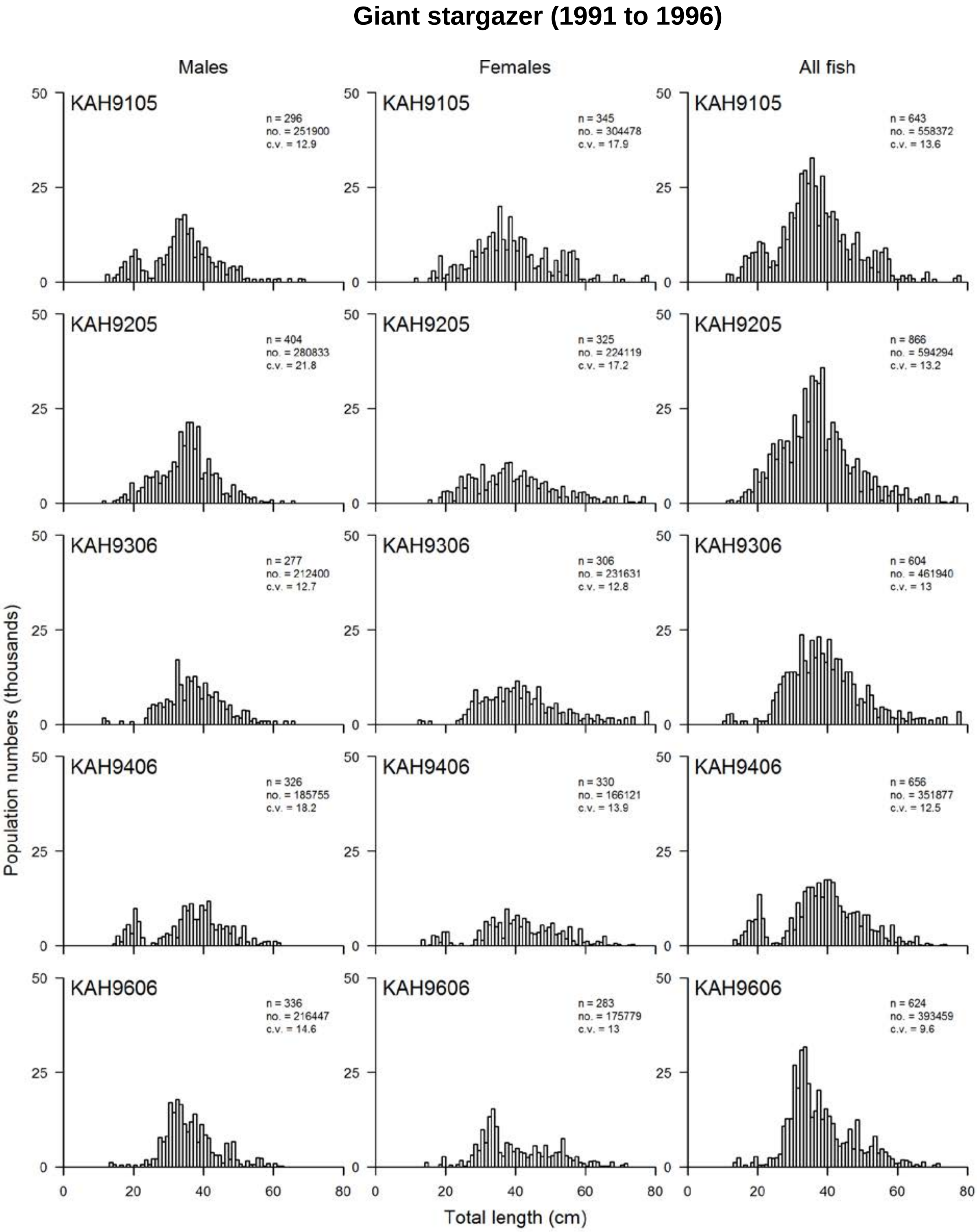



**Figure 11 –** ***continued***

## Giant stargazer (2007 to 2016)

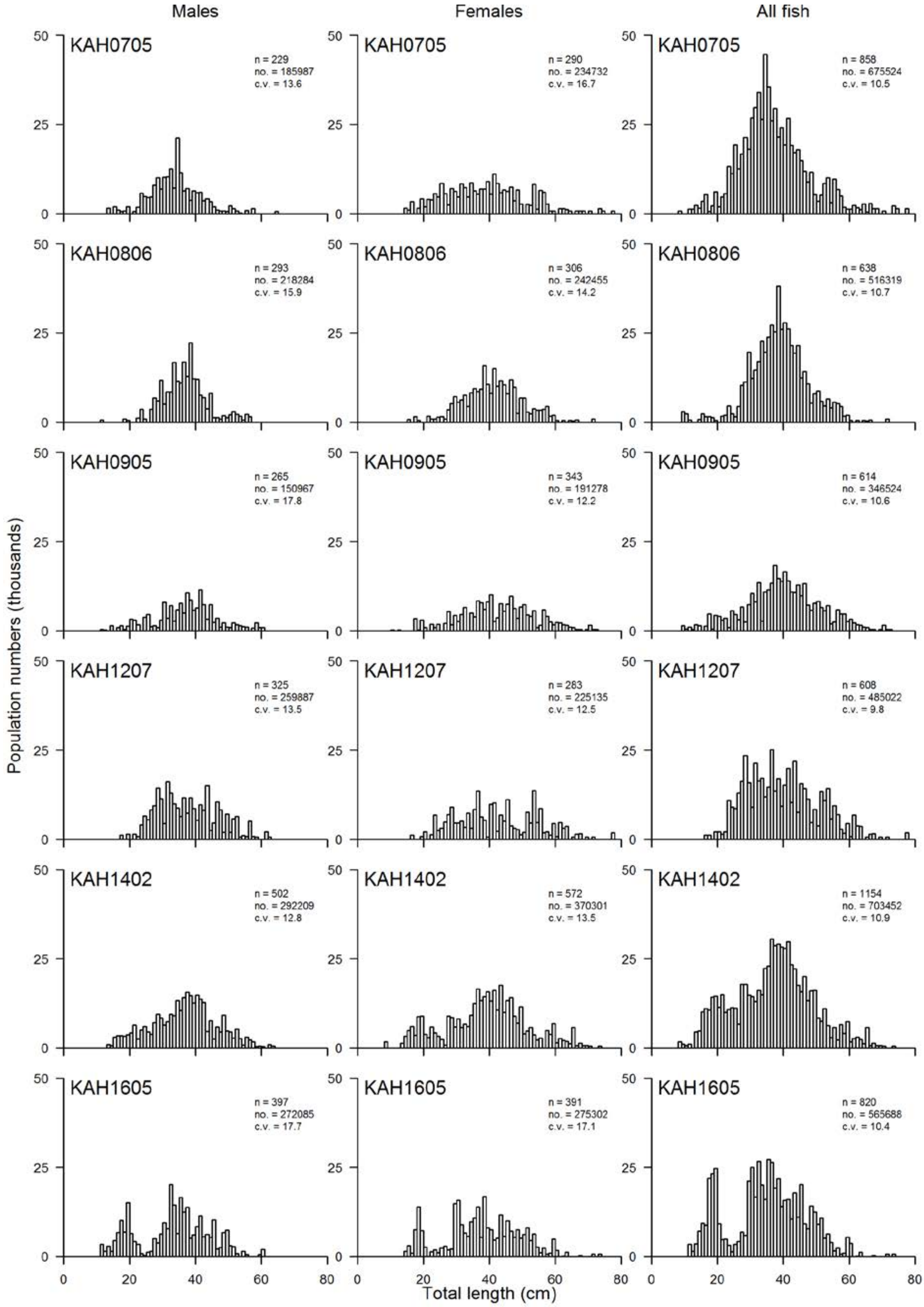



**Figure 11** *–continued*

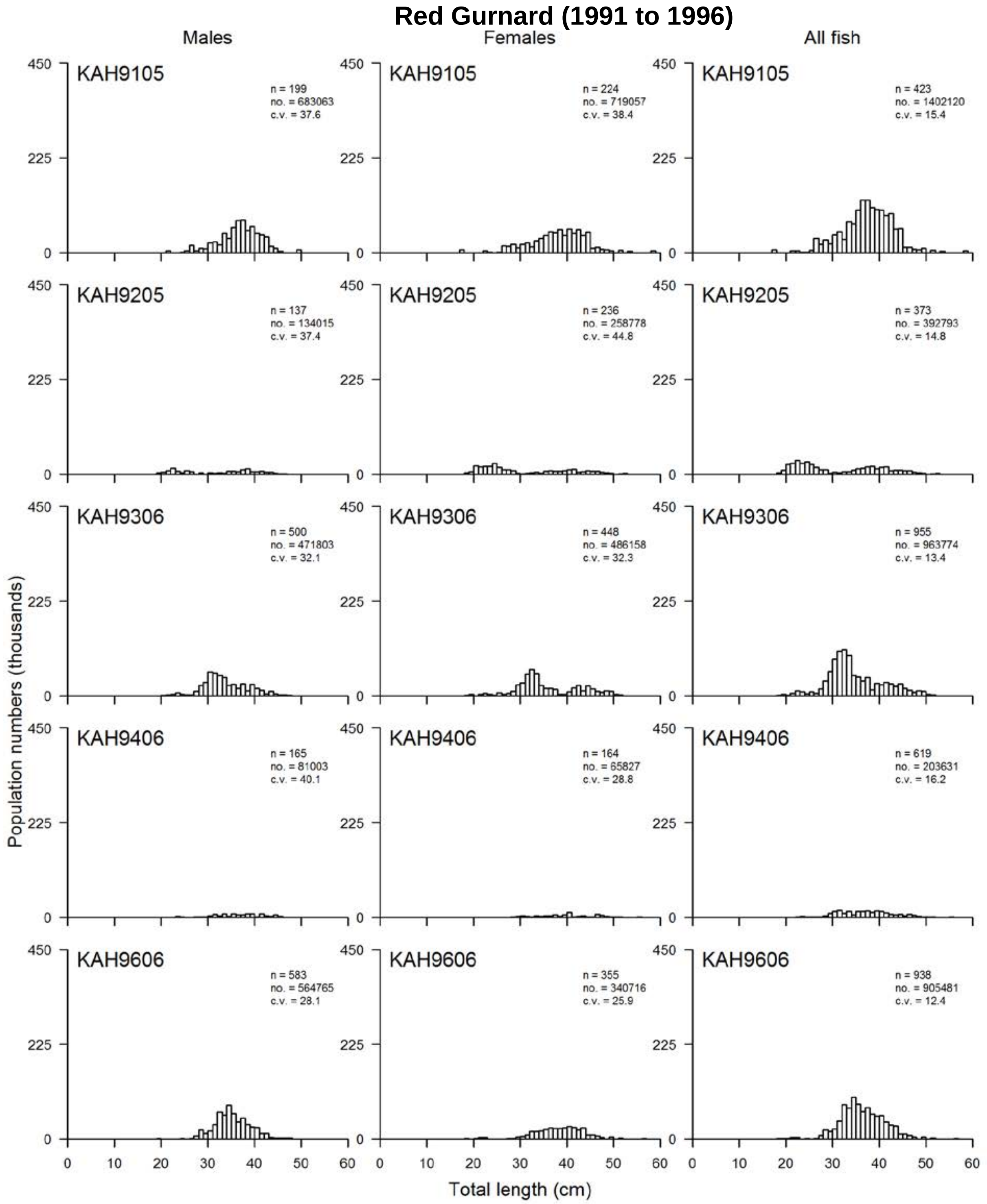



**Figure 11 –** ***continued***

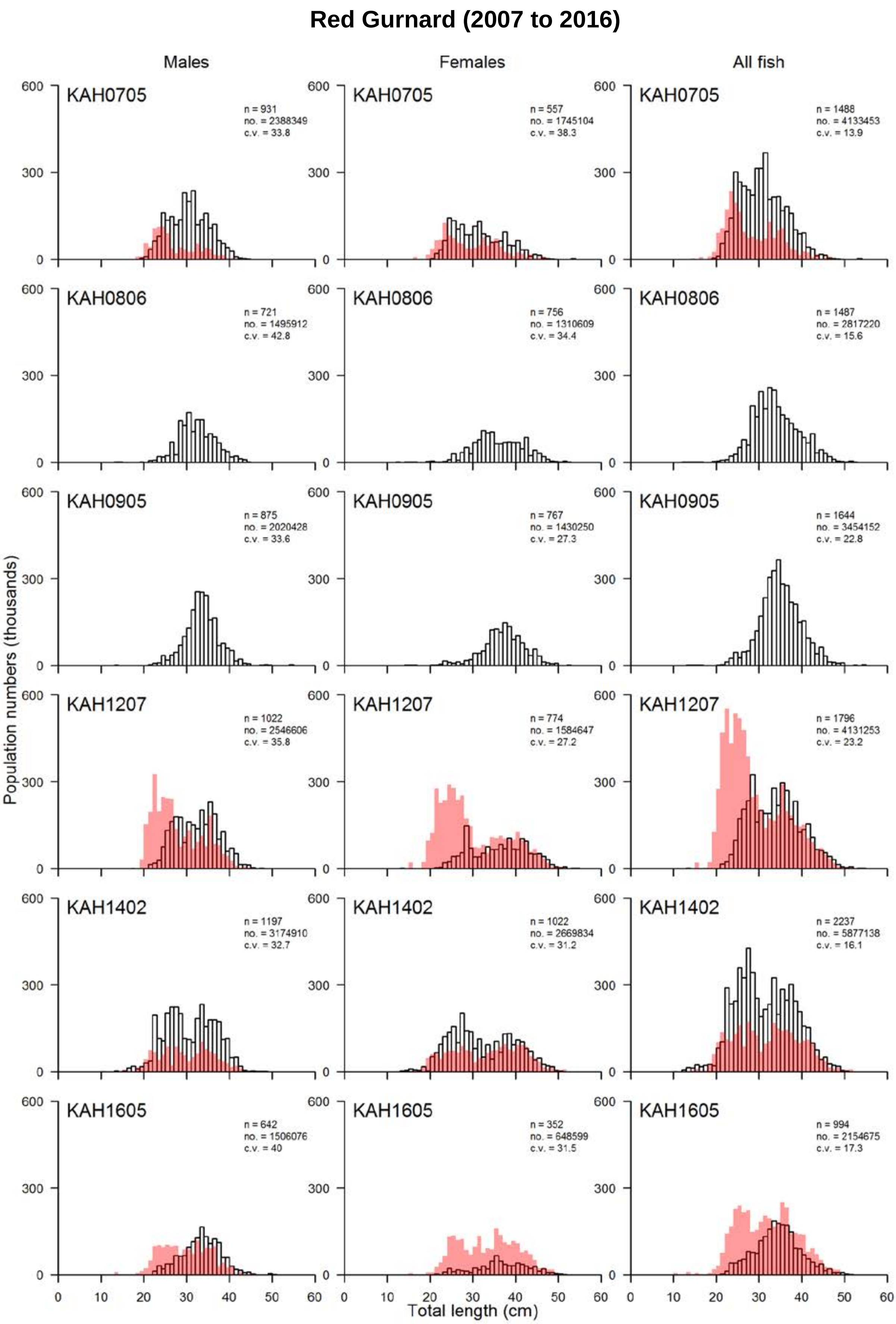



**Figure 11 –** ***continued***

## Red cod (1991 to 1996)

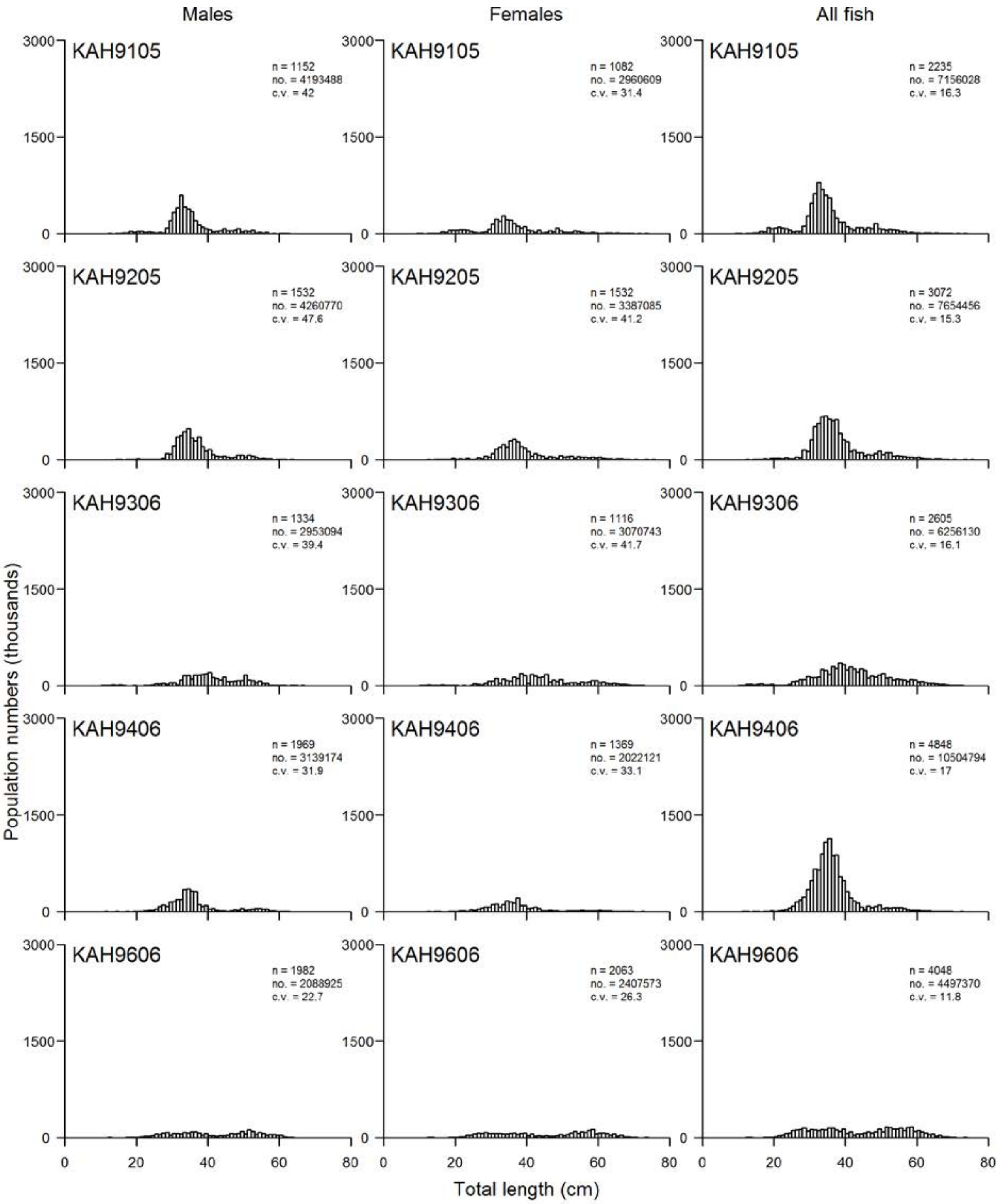



**Figure 11 – *continued***

## Red cod (2007 to 2016)

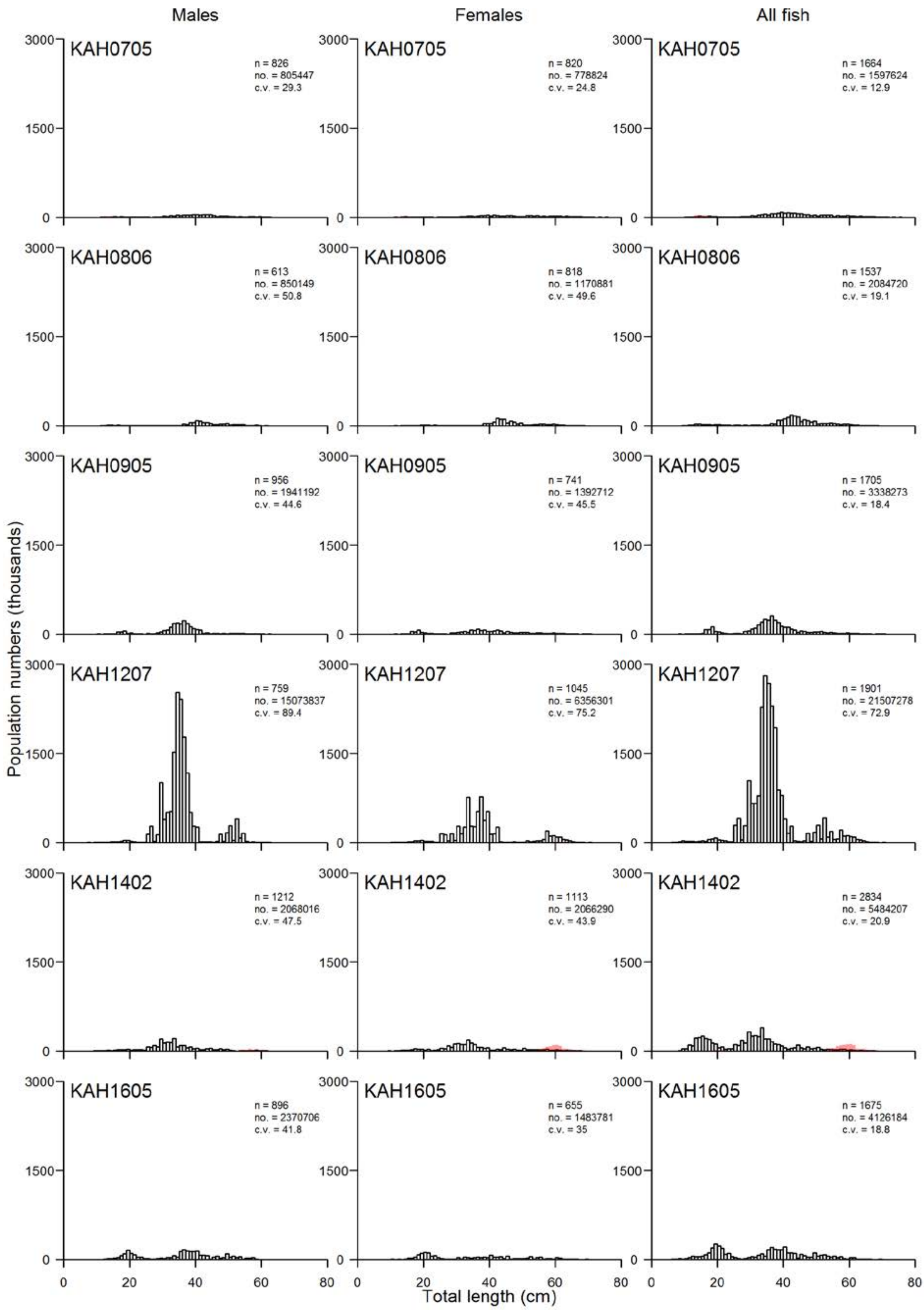



**Figure 11 –** ***continued***

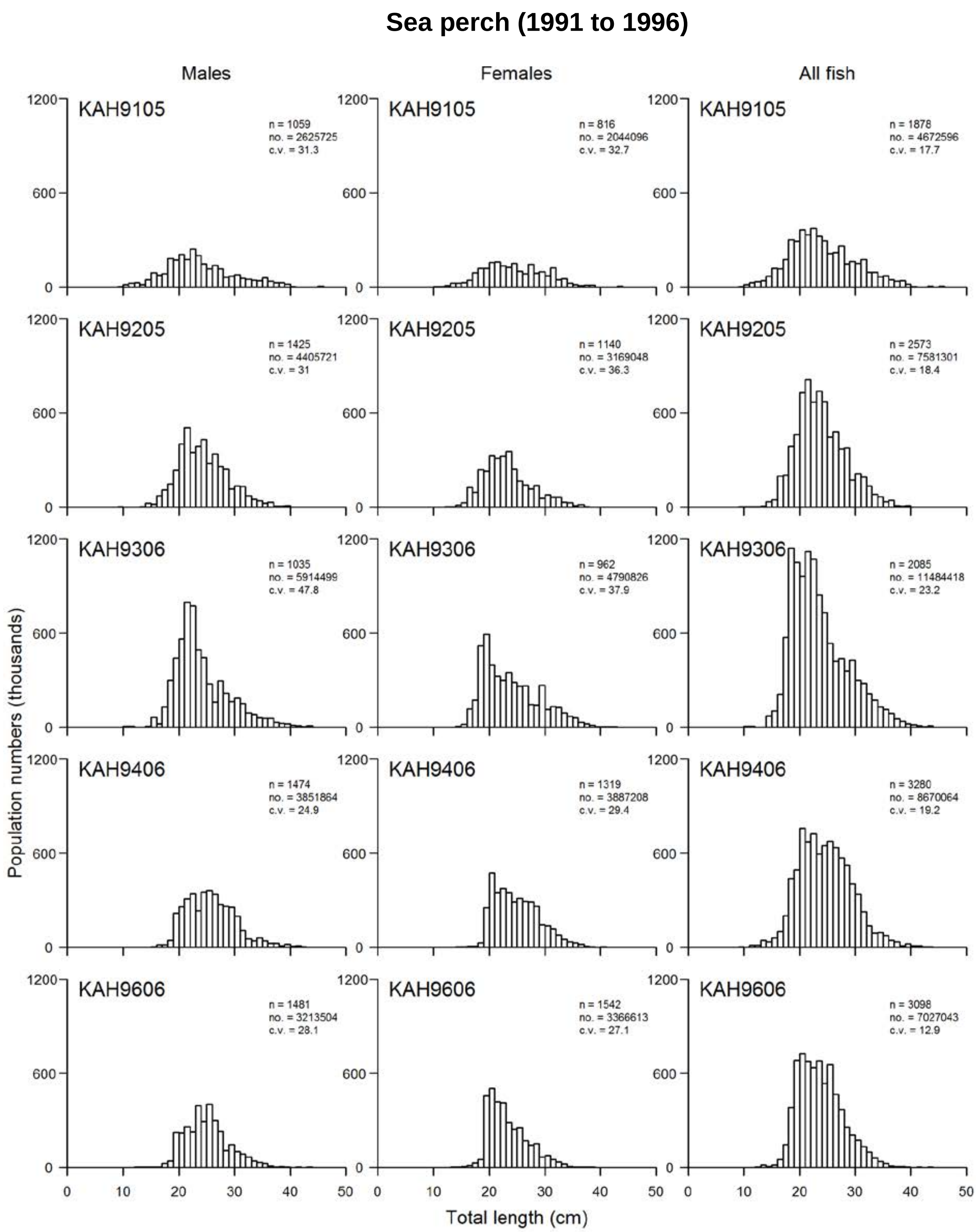



**Figure 11 – *continued***

## Sea perch (2007 to 2016)

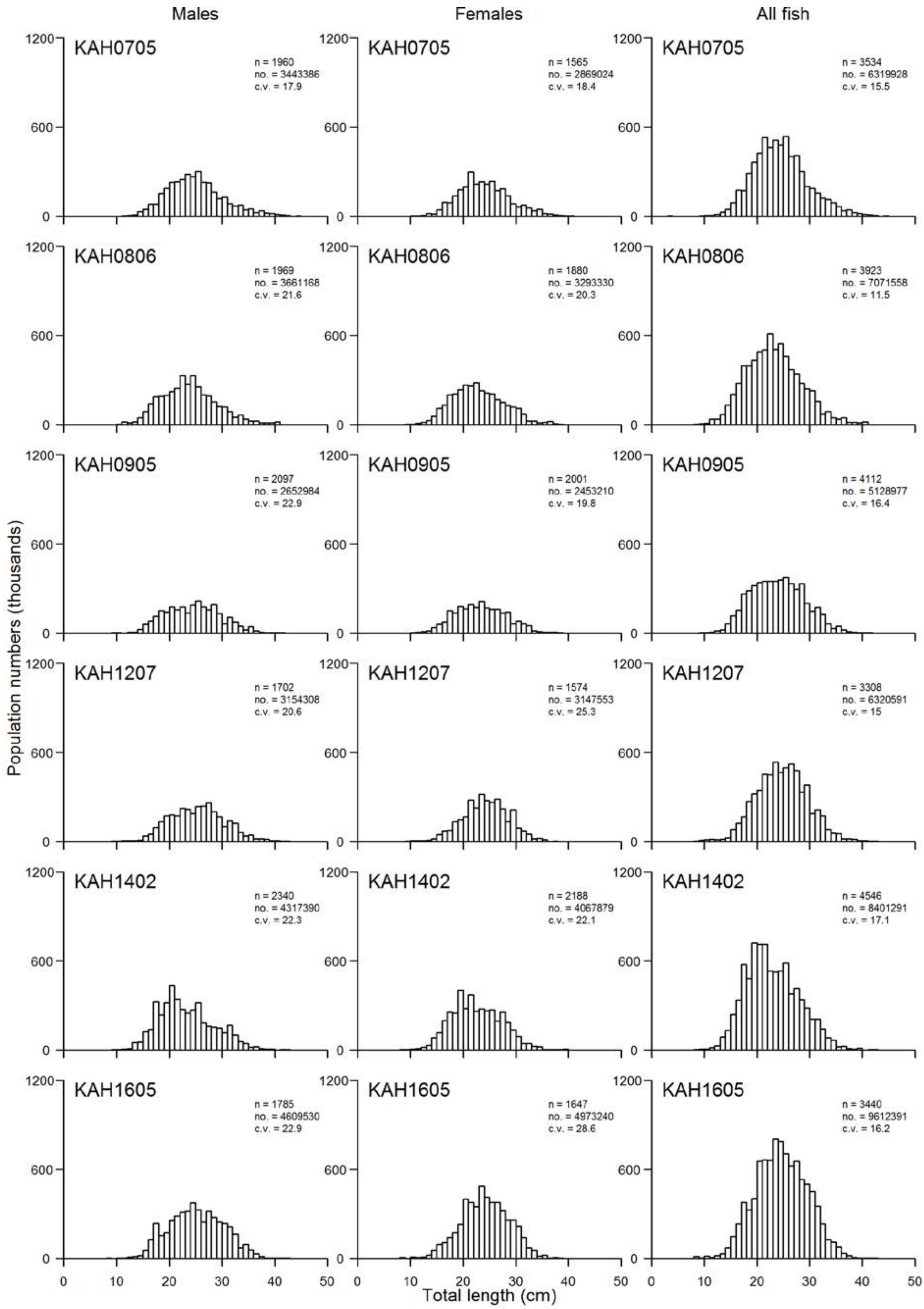



**Figure 11 –** ***continued***

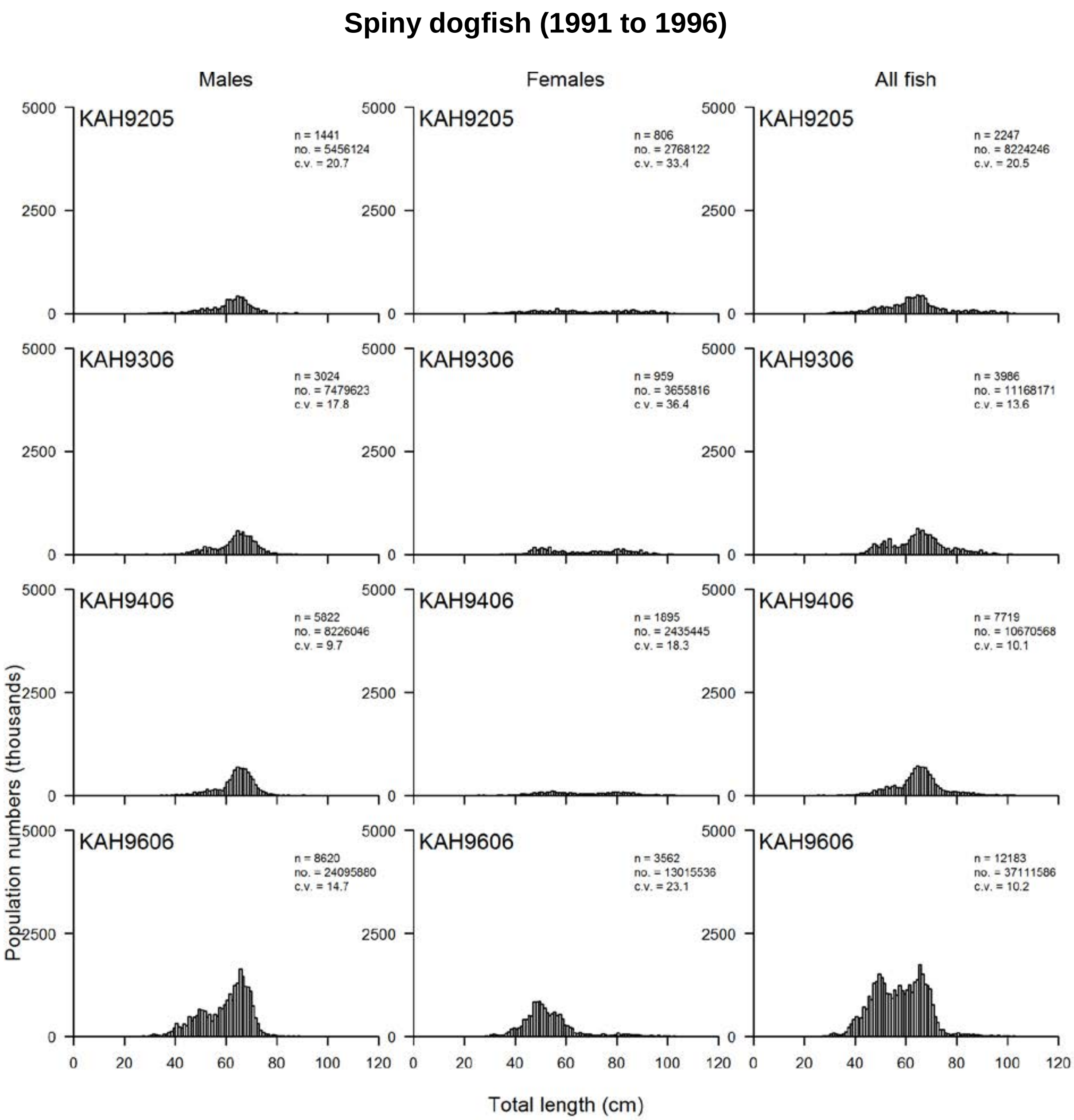



**Figure 11–** ***continued***

## Spiny dogfish (2007 to 2016)

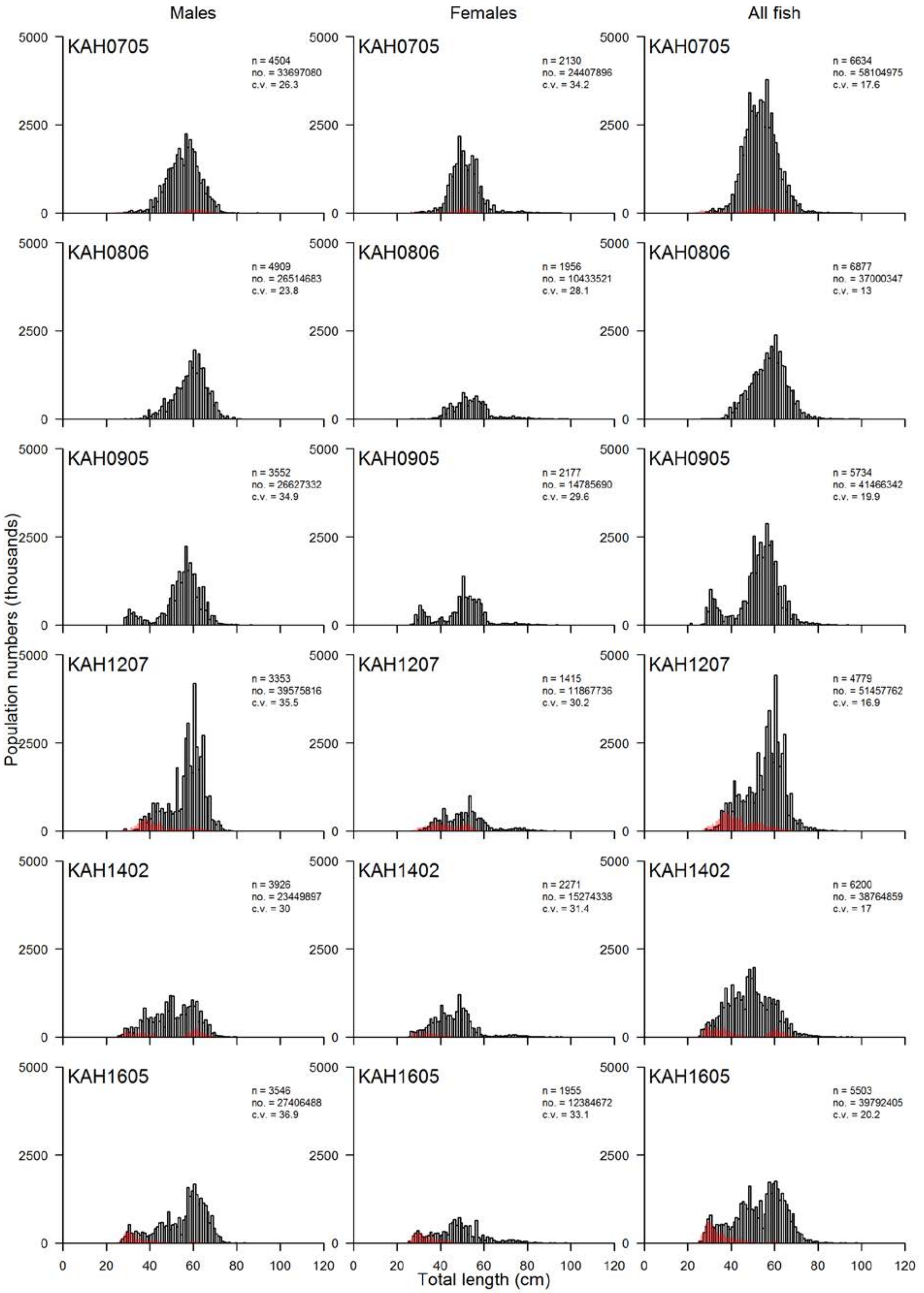



**Figure 11 –** ***continued***

**Tarakihi (1991 to 1996)**

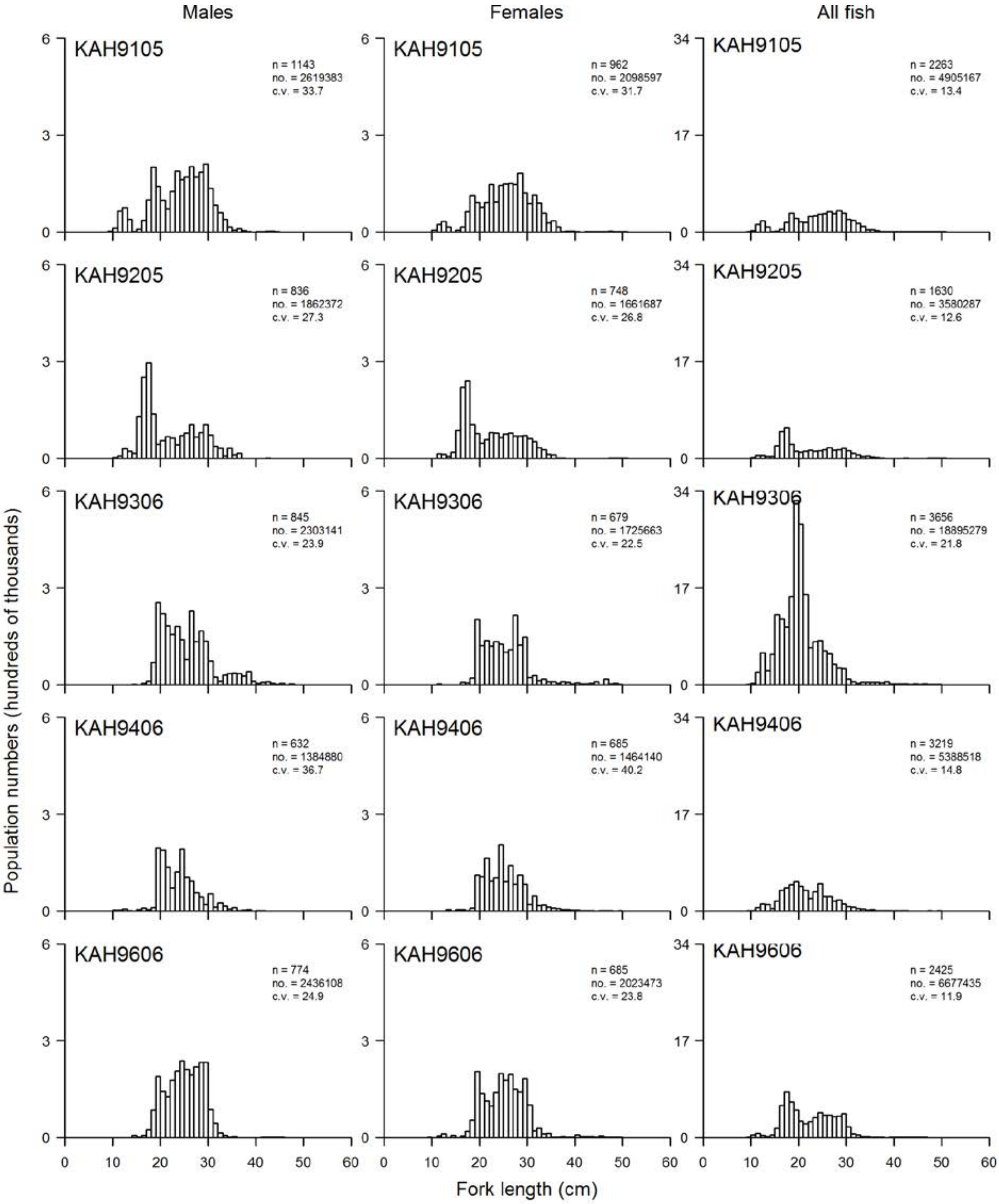



**Figure 11 –** ***continued***

**Tarakihi (2007 to 2016)**

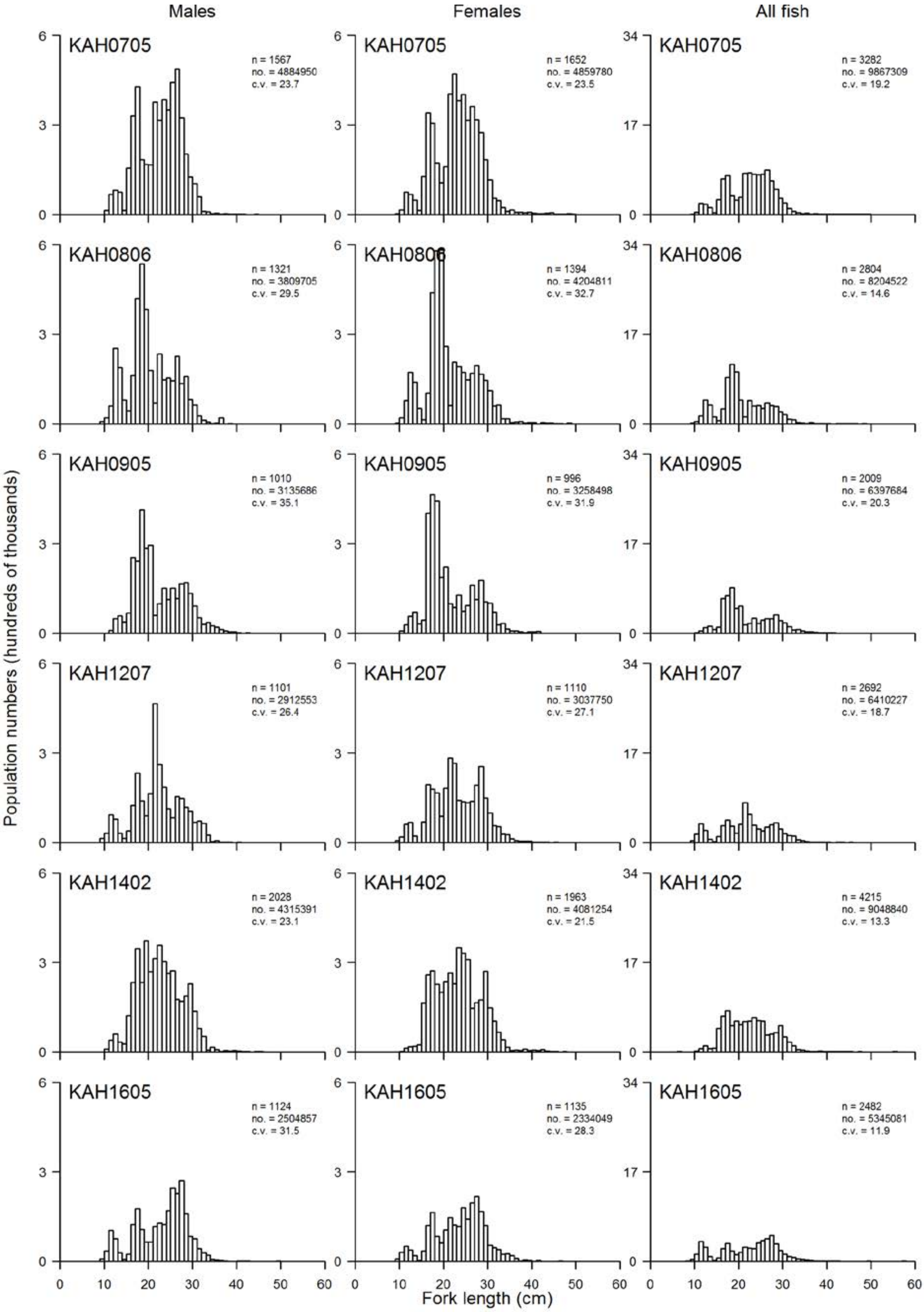



**Figure 11 –** ***continued***

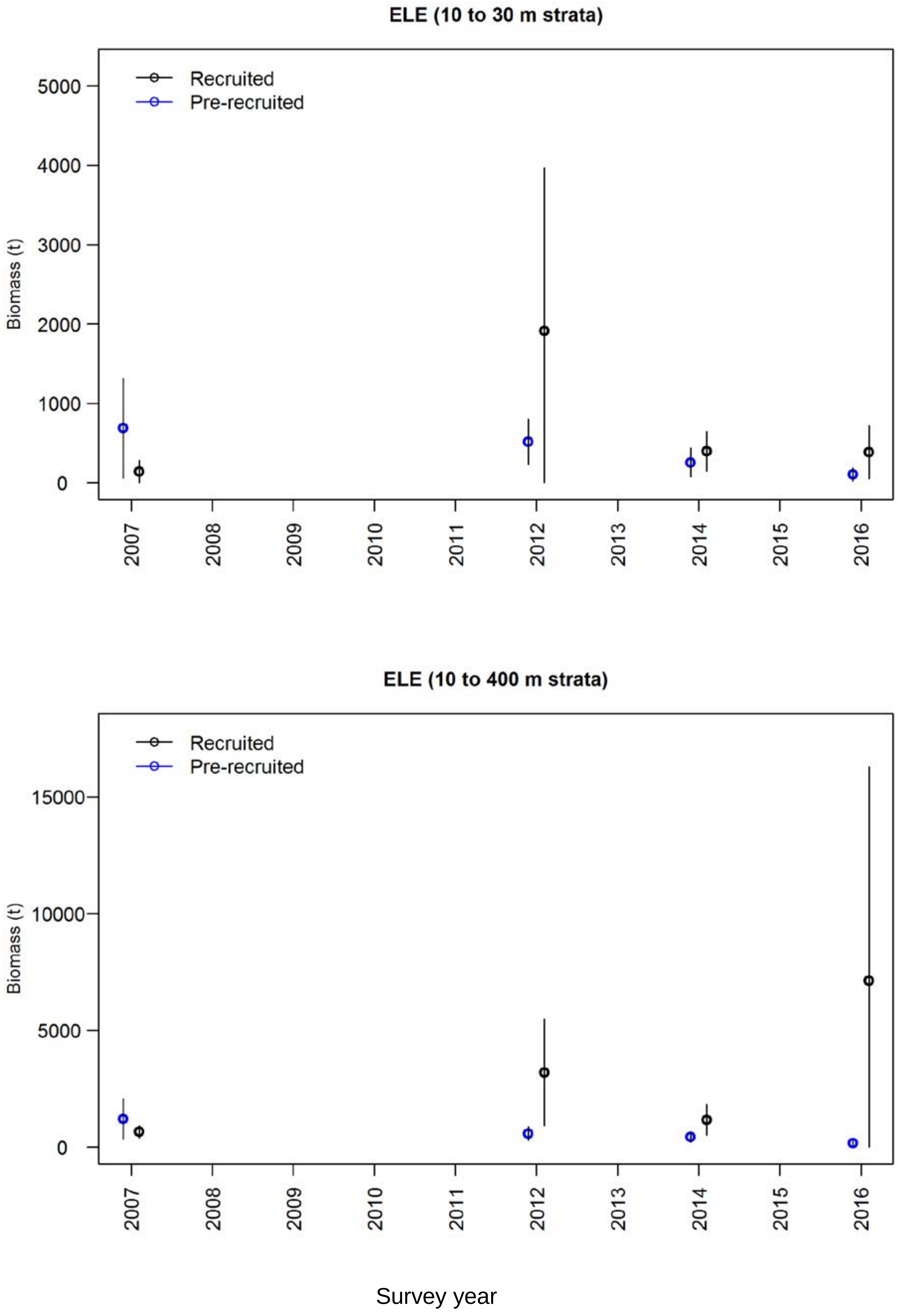
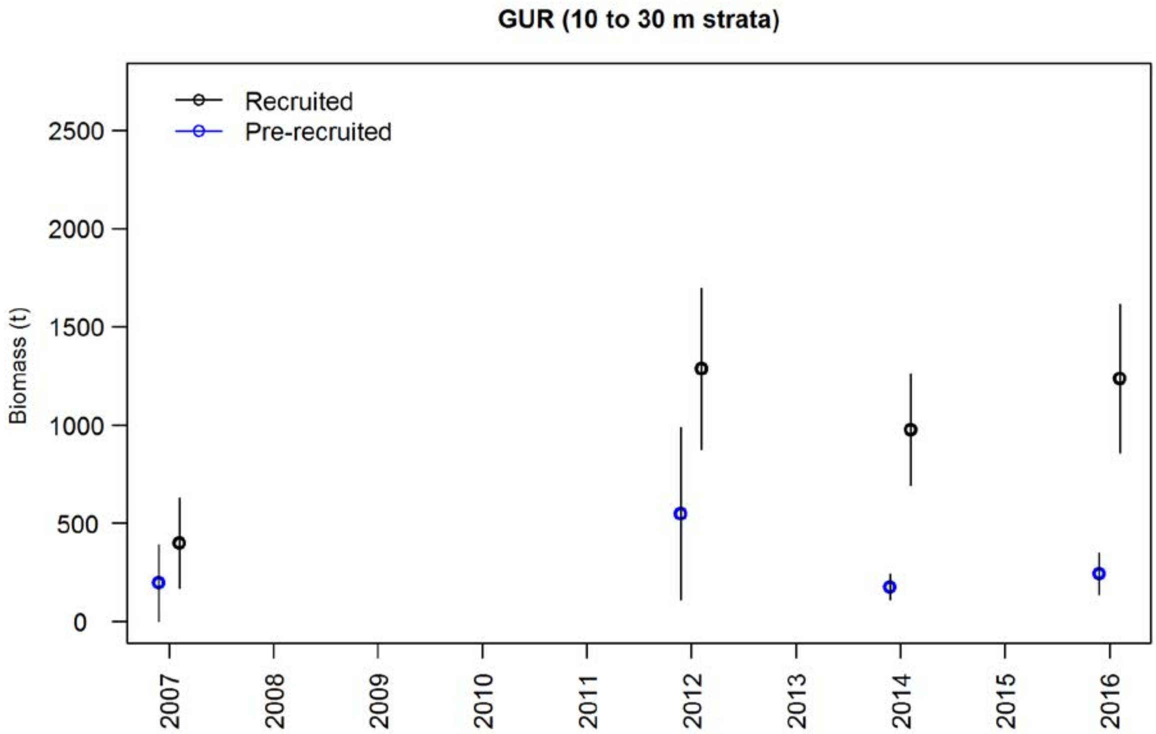
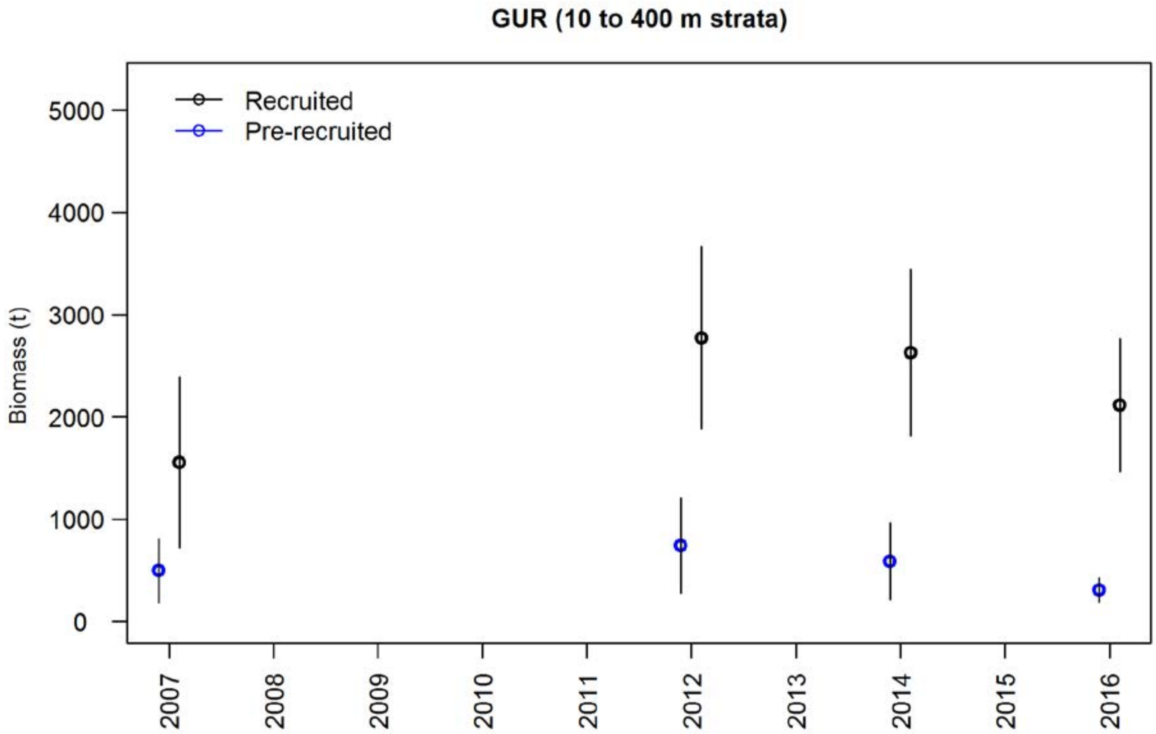



**Figure 12: Elephantfish and red gurnard recruited and pre-recruited biomass and 95% confidence intervals for 2007, 2012, 2014 and 2016 ECSI surveys in 10–30 m and core plus shallow strata (10–400 m).**




Survey year

**Figure 12 –** ***continued***

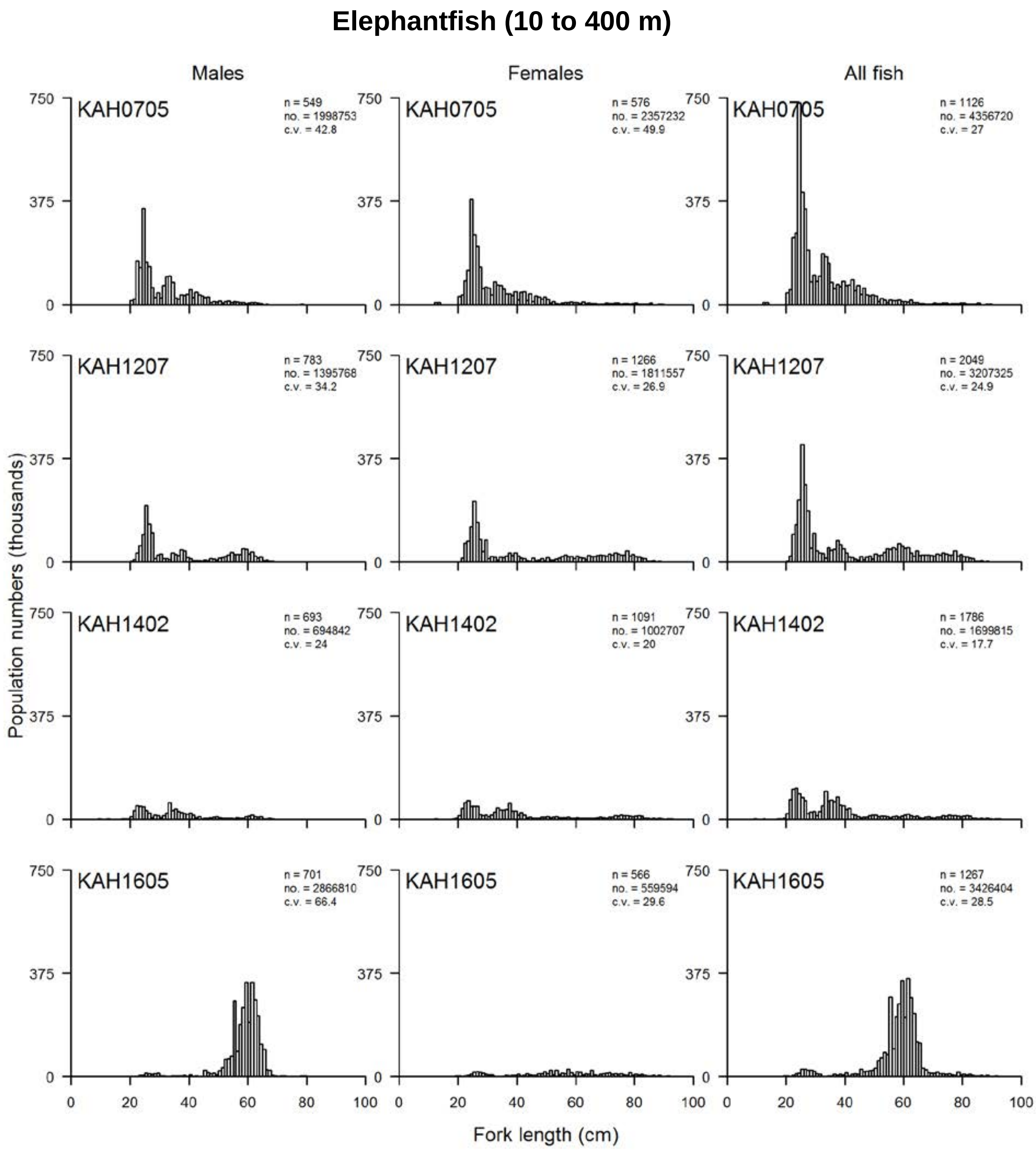



**Figure 13: Scaled length frequency distributions for elephantfish and red gurnard in core plus shallow strata (10–400 m), for 2007, 2012, 2014 and 2016 ECSI surveys. Population estimates are in thousands of fish.**

## Red gurnard (10 to 400 m)

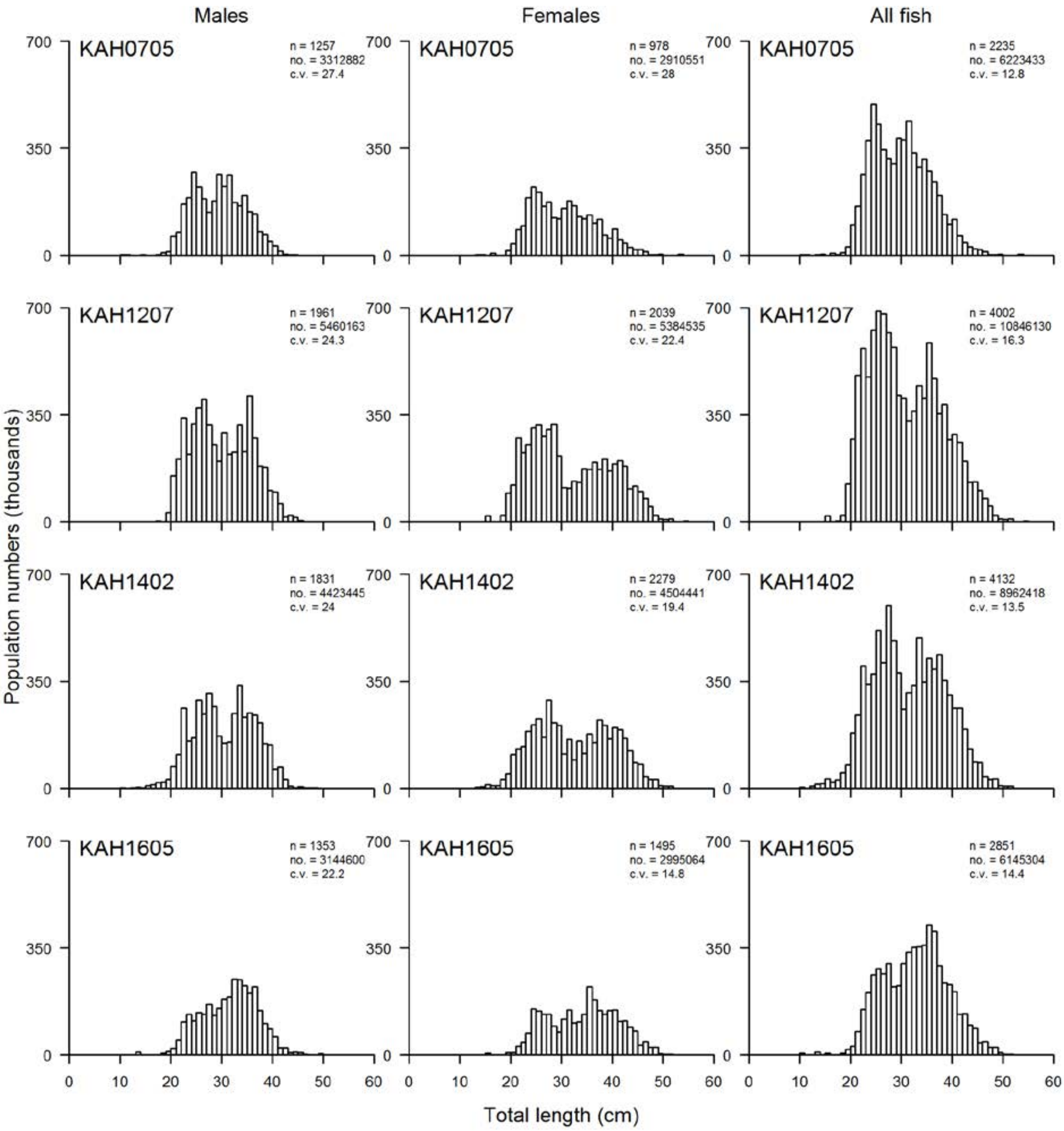
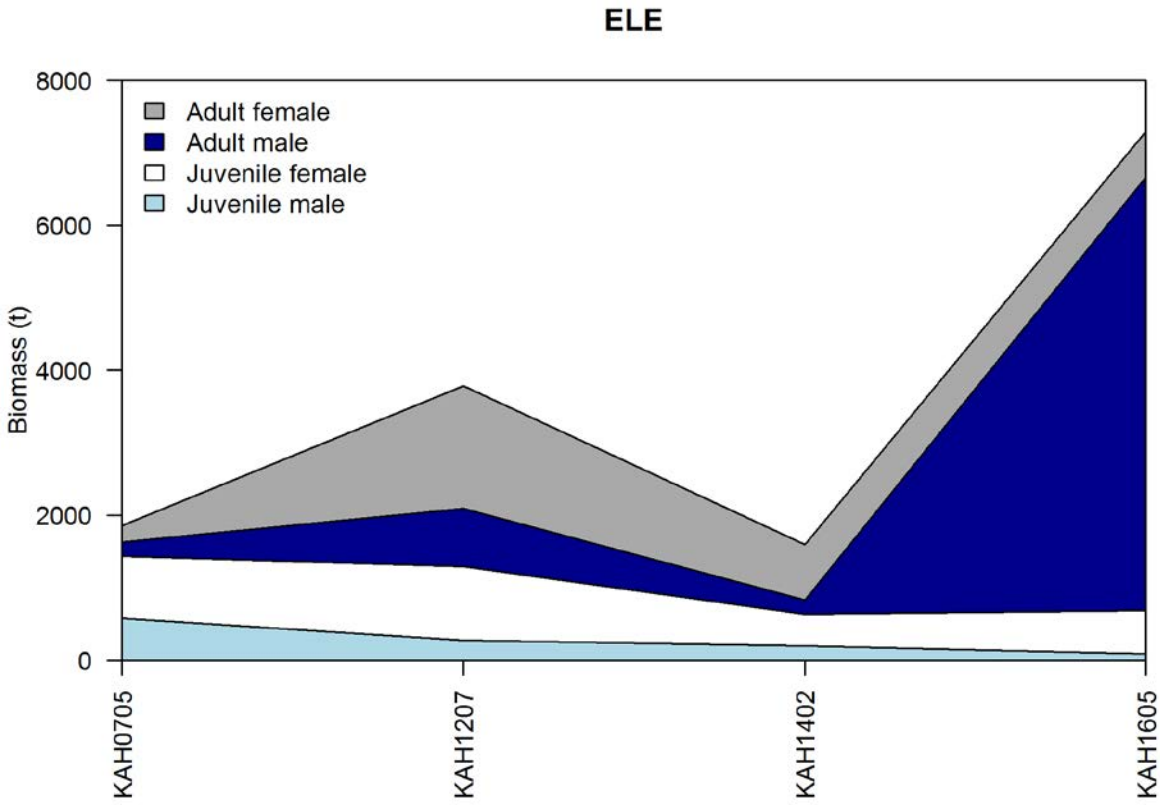



**Figure 13 –** ***continued***



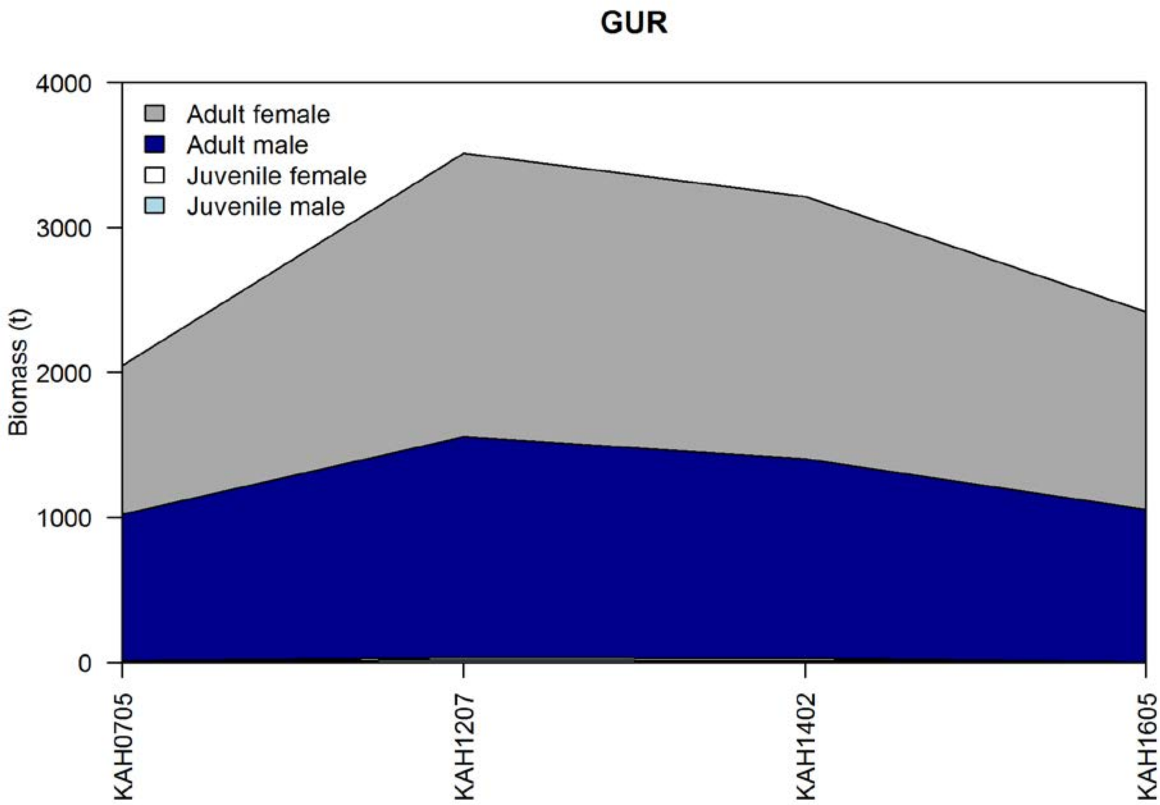
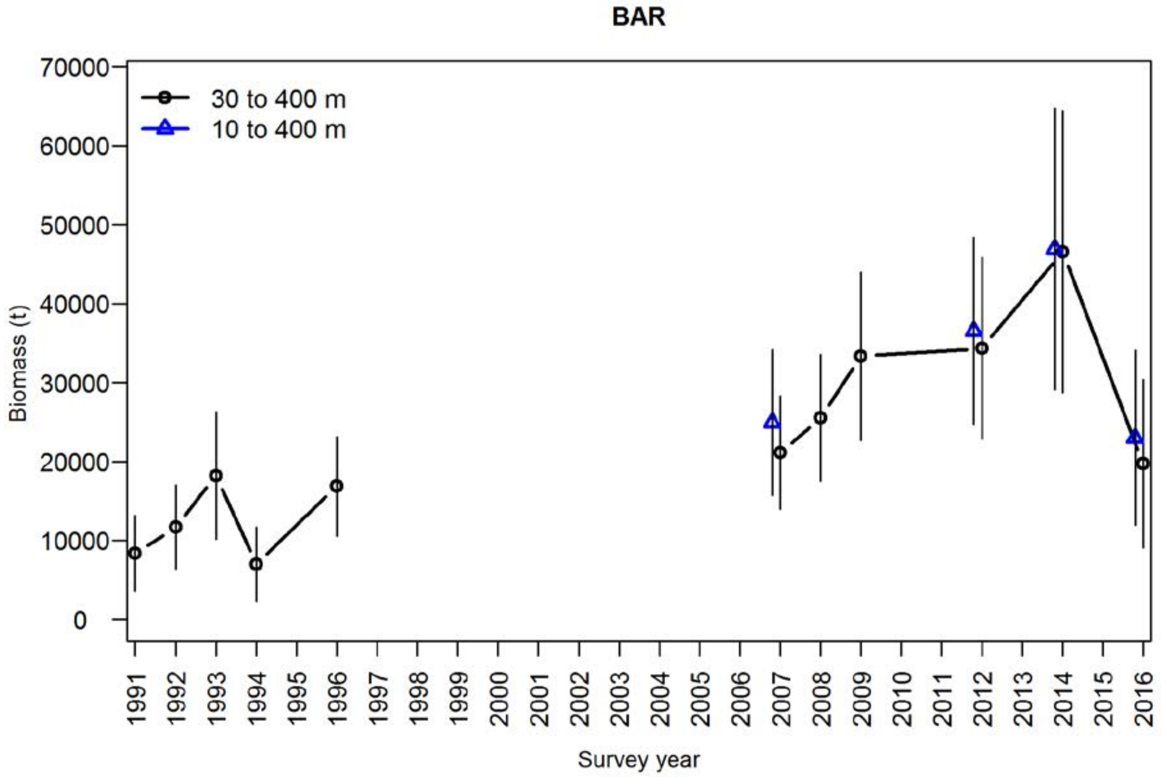




**Figure 14: Elephantfish and red gurnard juvenile and adult biomass in core plus shallow strata (10–400 m) for 2007, 2012, 2014 and 2016 ECSI surveys, where juvenile is below and adult is equal to or above length at which 50% of fish are mature.**



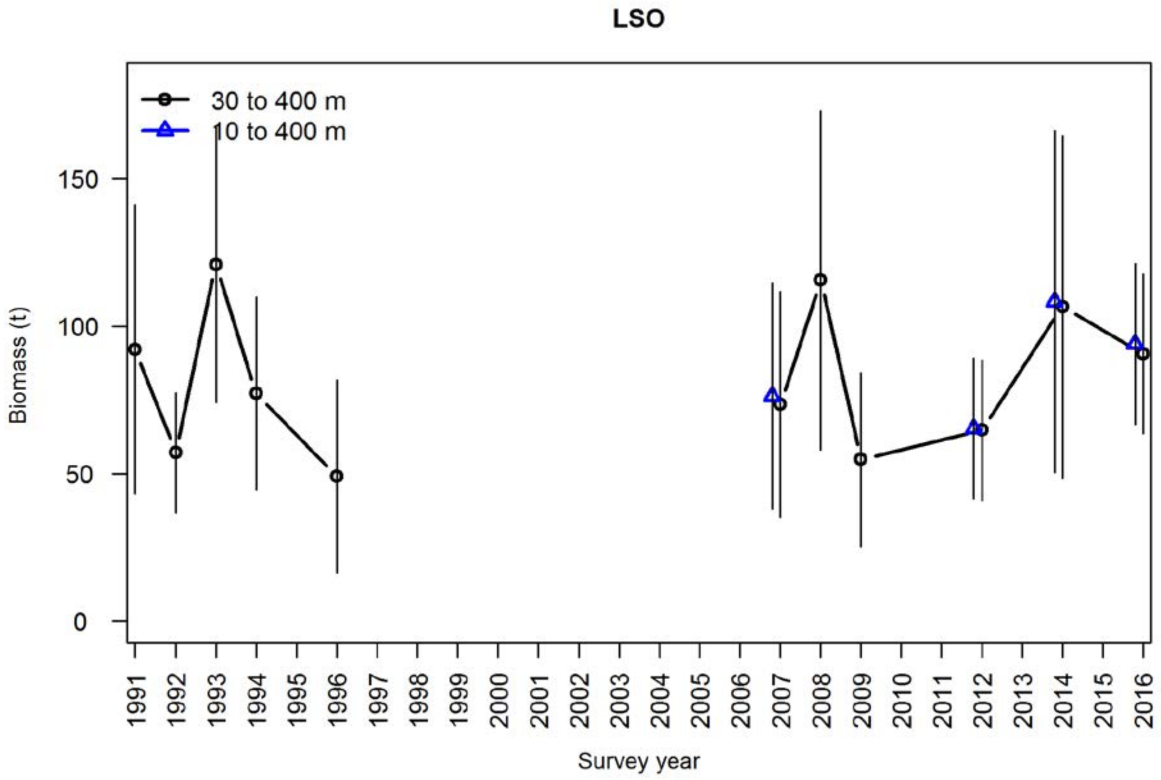
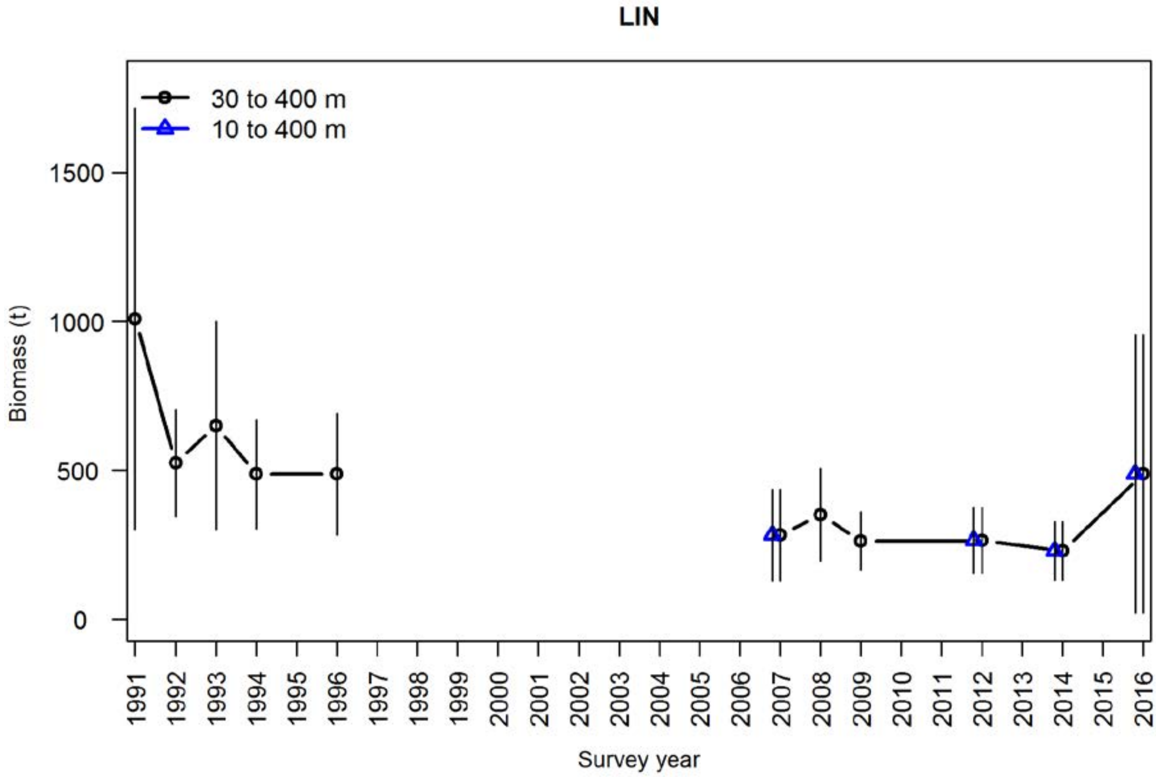




**Figure 15: Key non-target QMS species total biomass and 95% confidence intervals for all ECSI winter surveys in core strata (30–400 m), and core plus shallow strata (10–400 m) in 2007, 2012, 2014 and 2016.**



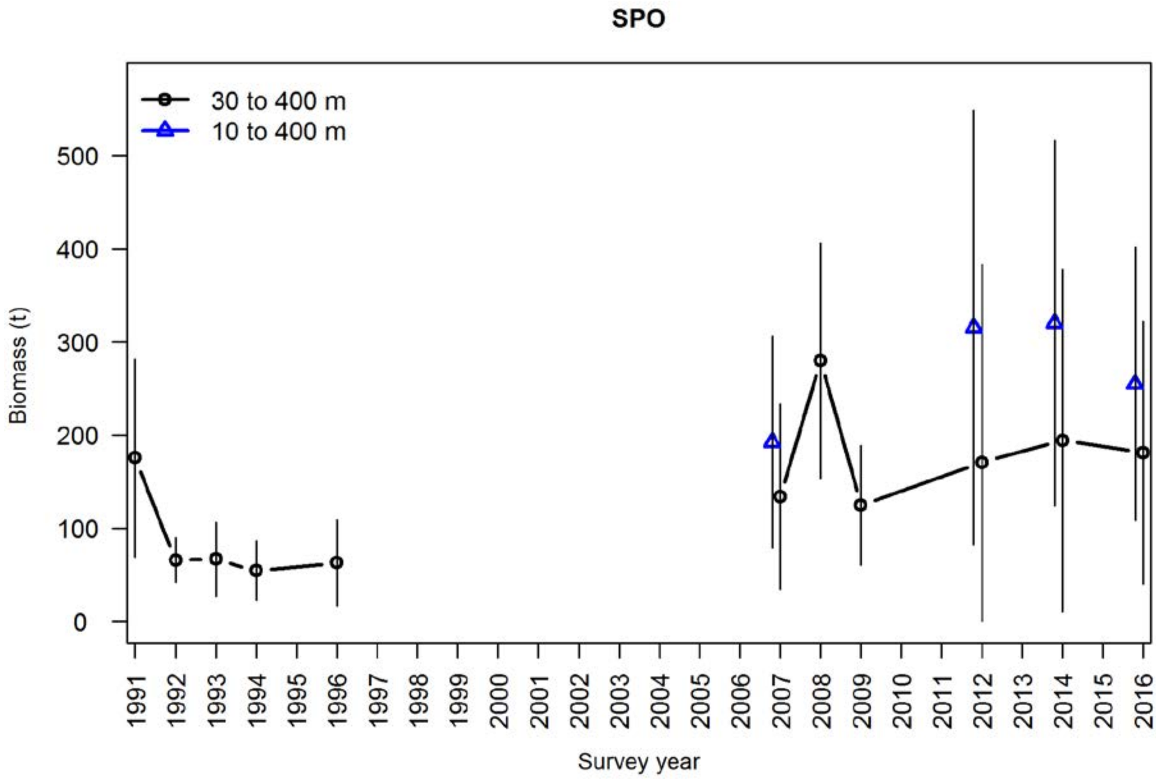
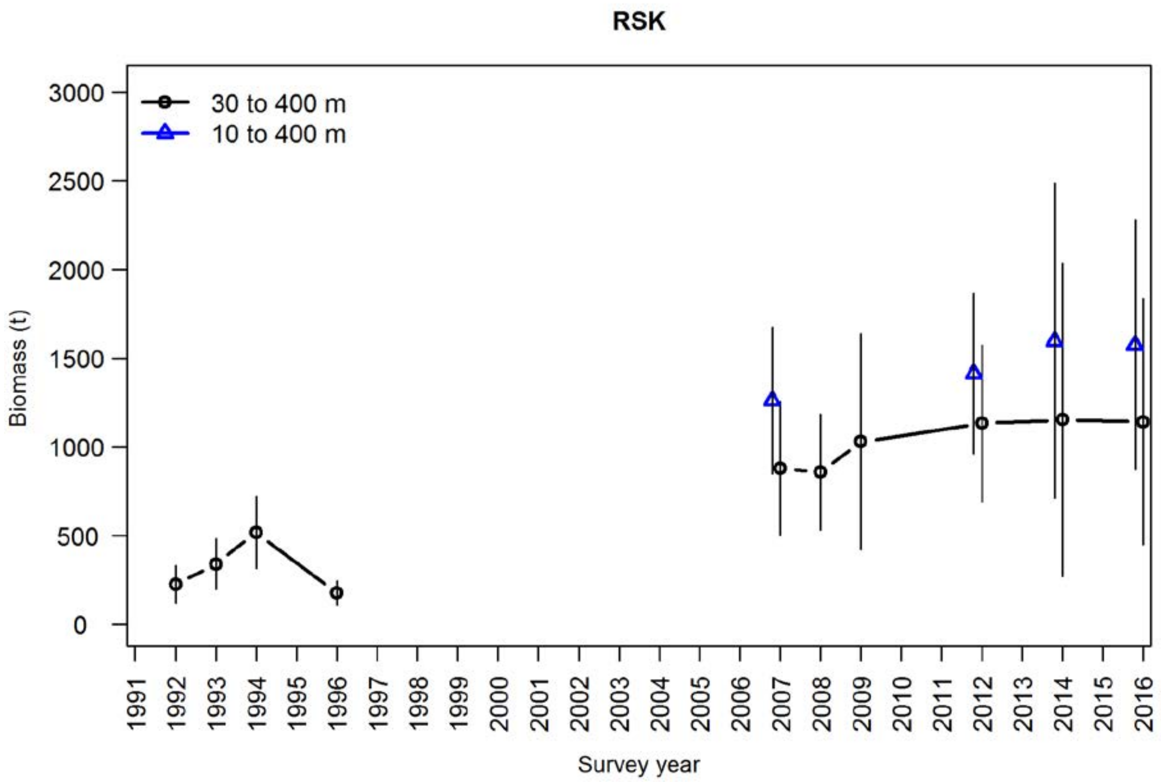




**Figure 15 –** ***continued***



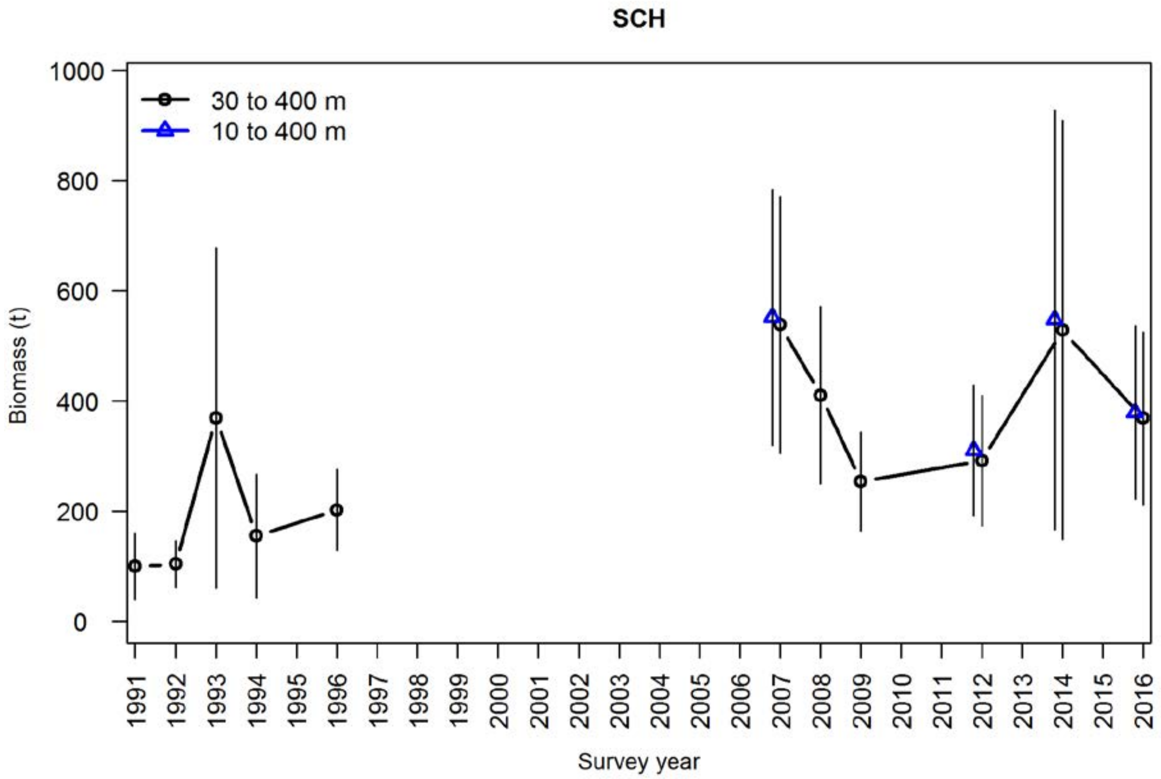
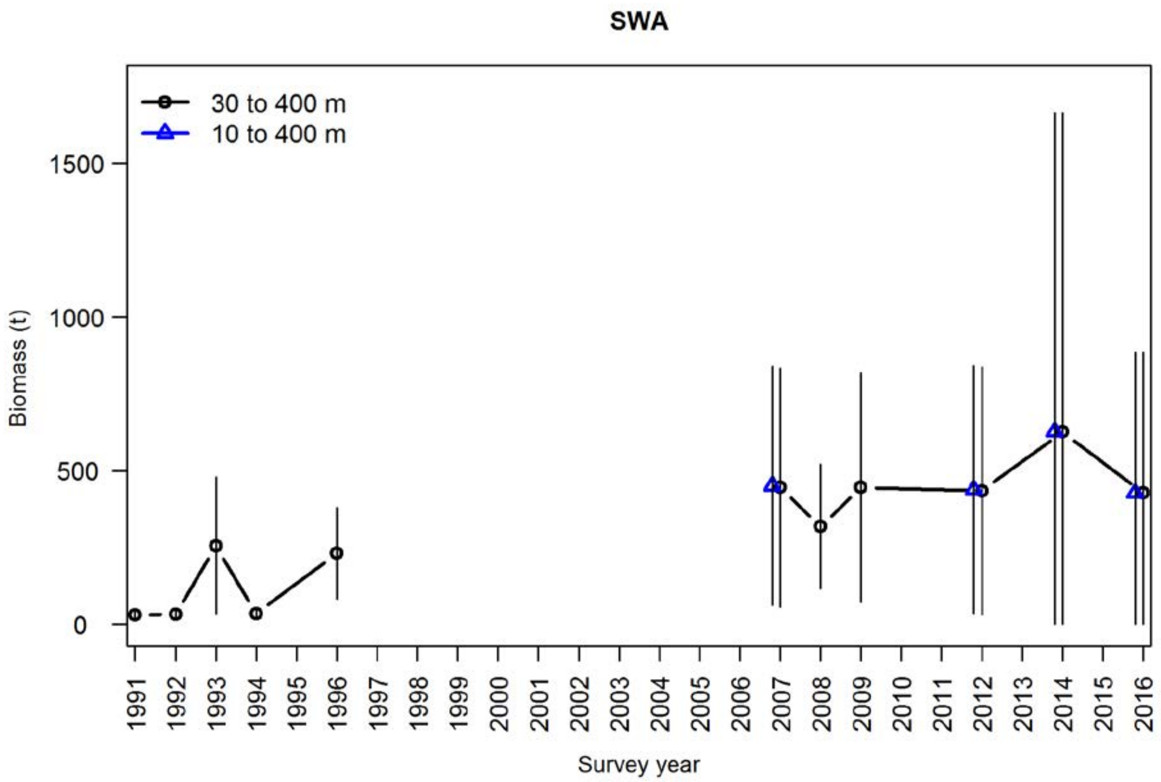




**Figure 15 –** ***continued***



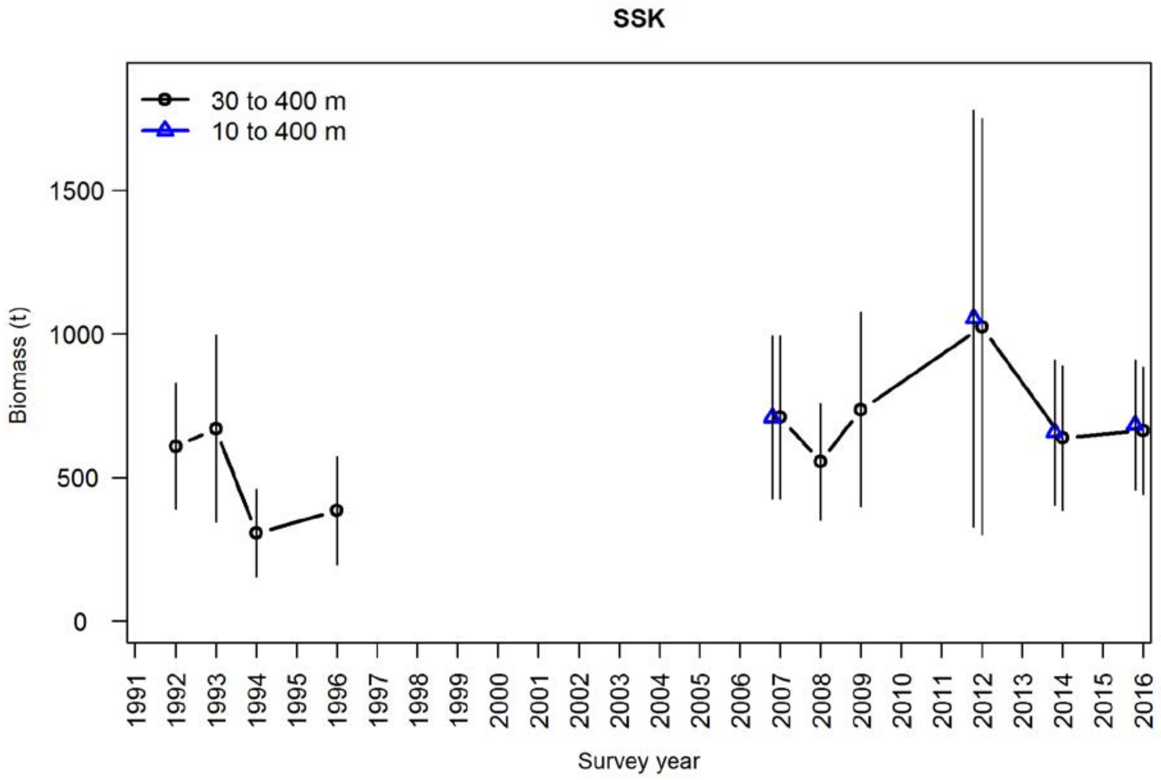




**Figure 15 –** ***continued***

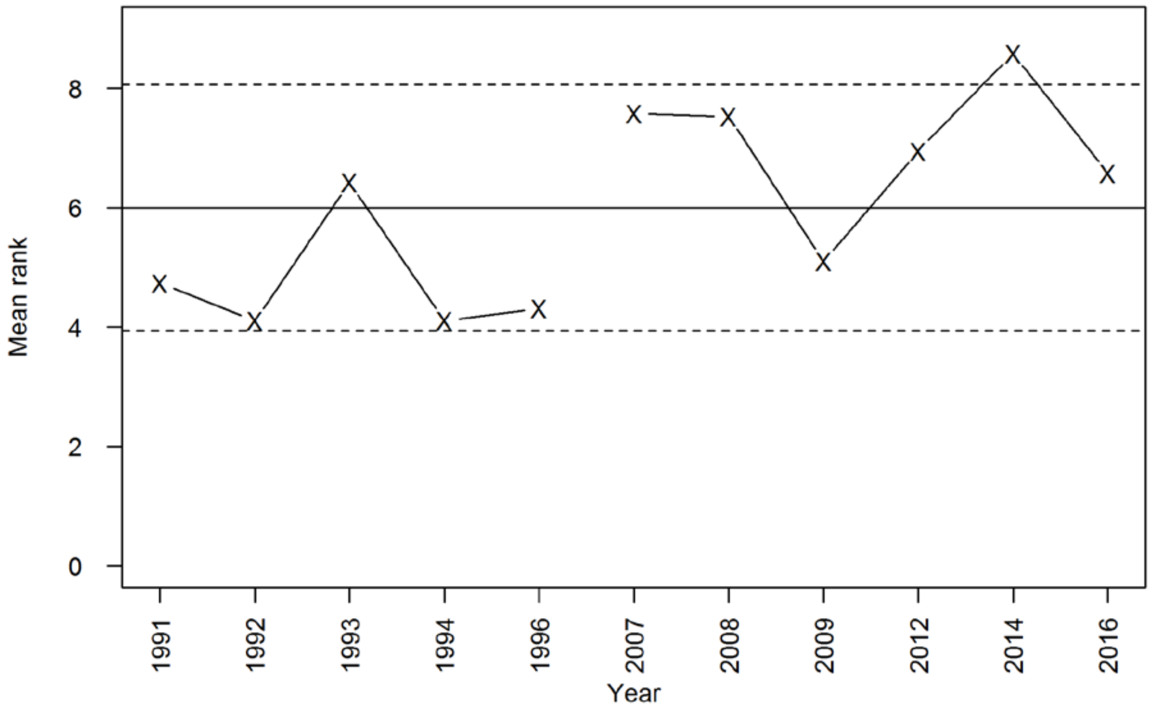



**Figure 16: Mean ranks for the ECSI winter trawl surveys (core strata) for 19 species, including the target species. The solid line indicates the overall mean rank. Mean ranks outside the broken lines (95% confidence intervals) have extreme catchability.**

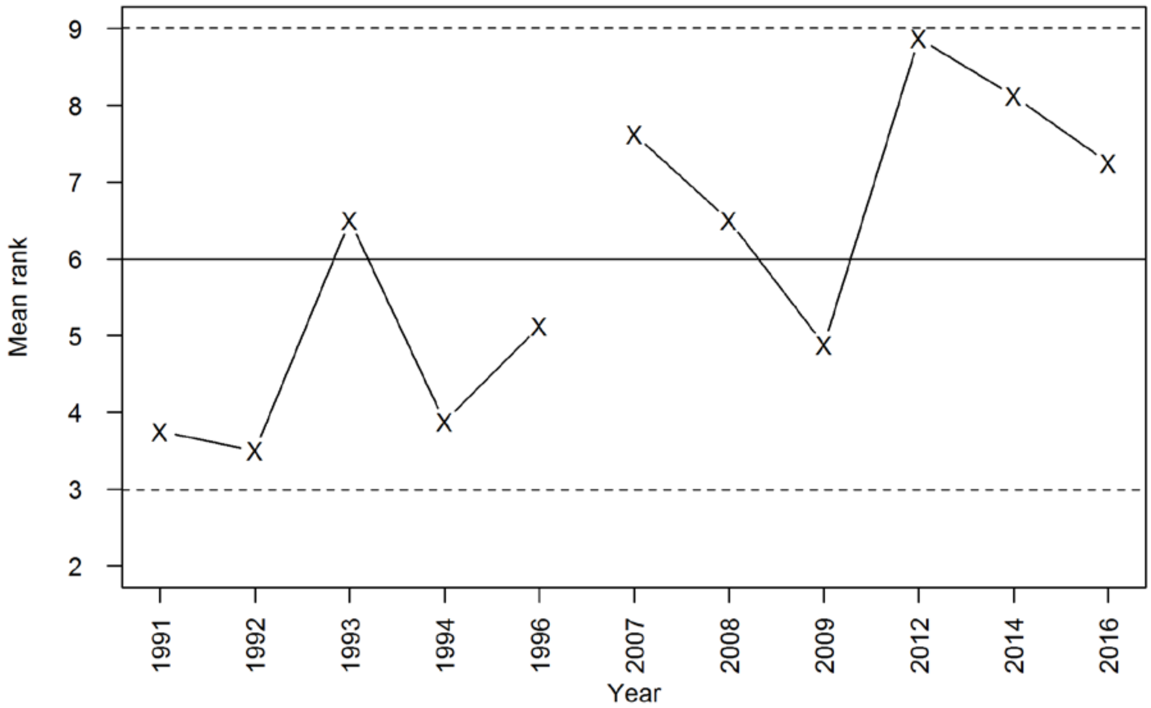



**Figure 17: Mean ranks for the ECSI winter trawl surveys (core strata) for eight target species. The solid line indicates the overall mean rank. Mean ranks outside the broken lines (95% confidence intervals) have extreme catchability.**

**Appendix 1: Gonad stage definitions.**

## Finfish

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

## Spiny dogfish

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

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

## Dark ghost shark and elephantfish

Males

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

Females

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

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

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

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

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

**Appendix 2 – *continued***

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

**Appendix 2 – *continued***

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

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

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

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

## (A) 30–400 m

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

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

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

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

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

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

## (B) 10–30 m

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

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

**Appendix 5: Length weight coefficients used to scale length frequencies for the 2016 survey. DB, MPI *Trawl* database. W = $aL^b$ 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 | 0.0012 | 3.4015 | 619 | 18.9 | 75.9 | This survey |
| Elephantfish | 0.0061 | 3.1203 | 474 | 22.6 | 92.6 | This survey |
| Giant stargazer | 0.015 | 3.036 | 664 | 12.1 | 74 | This survey |
| Lemon sole | 0.008 | 3.1278 | 524 | 14.6 | 41.2 | DB, KAH9809 |
| Ling | 0.0013 | 3.2801 | 179 | 32.2 | 123.7 | DB, KAH0004 |
| Red cod | 0.0099 | 2.9927 | 710 | 9 | 73.6 | This survey |
| Red gurnard | 0.0058 | 3.1406 | 796 | 14 | 52.7 | This survey |
| Rig | 0.0022 | 3.149 | 215 | 33.3 | 107 | This survey |
| Rough skate | 0.0367 | 2.8509 | 502 | 16.8 | 74.8 | This survey |
| School shark | 0.0022 | 3.1913 | 213 | 34.7 | 118.4 | This survey |
| Sea perch | 0.0106 | 3.158 | 845 | 9.1 | 43.2 | This survey |
| Silver warehou | 0.0048 | 3.38 | 262 | 16.6 | 57.8 | DB, TAN9502 |
| Smooth skate | 0.0331 | 2.8867 | 175 | 15.1 | 134 | This survey |
| Spiny dogfish | 0.0034 | 3.0322 | 2020 | 26.9 | 98.8 | This survey |
| Tarakihi | 0.0104 | 3.1797 | 870 | 10.1 | 54.2 | This survey |