Fisheries New Zealand
Tini a Tangaroa

# Inshore trawl survey of Canterbury Bight and Pegasus Bay April–June 2018, (KAH1803)

New Zealand Fisheries Assessment Report 2019/03

D.J. MacGibbon,
M.P. Beentjes,
W.L. Lyon,
Y. Ladroit

ISSN 1179-5352 (online)
ISBN 978-1-98-857172-0 (online)

January 2019

New Zealand Government

Requests for further copies should be directed to:

Publications Logistics Officer
Ministry for Primary Industries
PO Box 2526
WELLINGTON 6140

Email: brand@mpi.govt.nz
Telephone: 0800 00 83 33
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## EXECUTIVE SUMMARY

**MacGibbon, D.J.; Beentjes, M.P.; Lyon, W.L.; Ladroit, Y. (2019). Inshore trawl survey of Canterbury Bight and Pegasus Bay, April–June 2018 (KAH1803).**

***New Zealand Fisheries Assessment Report 2019/03.* 136 p.**

A bottom trawl survey of the east coast South Island (ECSI) at 10–400 m depths was carried out using R.V. *Kaharoa* (trip KAH1803) from 23 April to 6 June 2018. The core (30–400 m) survey was the twelfth in the winter ECSI inshore time series (1991–94, 1996, 2007–2009, 2012, 2014, 2016, and 2018). Four shallow strata (10–30 m), included in 2007, 2012, 2014 and 2016, were again surveyed in 2018 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 the core strata; and elephantfish and red gurnard in the core plus shallow strata. A total of 94 successful stations (84 phase one and 10 phase two) were completed from 17 core strata, with 12 further successful stations from the four shallow strata (all phase 1). Biomass estimates and coefficients of variation (CV) for the target species in the core strata were: dark ghost shark 6485 t (23%); elephantfish 807 t (21%); giant stargazer 738 t (18%); red cod 1500 t (83%); red gurnard 2043 t (19%); sea perch 2023 t (29%); spiny dogfish 24 758 t (28%); and tarakihi1409 t (26%). Biomass estimates and CVs for elephantfish and red gurnard in the core plus shallow strata were 1118 t (20%) and 3831 t (17%), respectively, with the shallow strata accounting for 28% of the biomass of elephantfish and 47% of the biomass of red gurnard.

Otoliths were collected from giant stargazer (467), red cod (319), red gurnard (541), sea perch (395), and tarakihi (427) to be aged under a separate project.

Data are presented on catch rates, biomass, spatial distribution, and length frequency distributions 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 catchability to be close to the mean for the time series in 2018, and that only the 2014 survey had very high catchability. When only the eight target species were examined no survey can be regarded as having extreme catchability.

# 1. INTRODUCTION

## 1.1 The 2018 east coast South Island inshore trawl survey

This report describes the results of the 2018 east coast South Island (ECSI) bottom trawl survey in 10–400 m from 23 April to 6 June using R.V. *Kaharoa* (KAH1803). The survey was the twelfth in the winter ECSI time series for core strata. Previous surveys were carried out in 1991–1994, 1996, 2007–2009, 2012, 2014 and 2016 (Beentjes & Wass 1994, Beentjes 1995a, 1995b, 1998a, 1998b, Beentjes & Stevenson 2008, 2009, Beentjes et al. 2010, Beentjes et al. 2013, 2015, Beentjes et al. 2016). The eight target species in 2018 were: red gurnard *Chelidonichthys kumu*; elephantfish *Callorhinchus milii*; dark ghost shark, *Hydrolagus novaezelandiae;* giant stargazer, *Kathetostoma giganteum*; red cod, *Pseudophycis bachus*; sea perch, *Helicolenus percoides*; spiny dogfish, *Squalus acanthias*; 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-recruit and recruit), 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). In 1996, several new species were introduced into the QMS (e.g., skates, dark ghost shark, sea perch, and spiny dogfish). 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 stratum depth ranges or of the total survey area (see strata boundaries in Beentjes 1998a). The winter survey 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.

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 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 e.g., giant stargazer (STA 3), elephantfish (ELE 3), and red gurnard (GUR 3), were incorporated in the 'Decision Rules' for Adaptive Management Species (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.

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 several inshore species. The 2007 survey marked the reinstatement of the winter survey time series, eleven years after that time series was discontinued. The 2007–09 surveys retained the core 30–400 m depth range and stratification (Figure 1), but also included four additional shallow strata in 10–30 m. There were no target species specified, nor additional days added to the survey to accommodate the extra stations in the 10–30 m shallow strata. Therefore the allocated stations in the shallow strata were not always completed due to time and resource constraints, and, because they were outside the core strata used in the historical winter time series, they were considered lower priority. In 2012, the ECSI survey range was formally expanded to include the four shallow strata, primarily to monitor elephantfish and red gurnard, but also shallow dwelling target species, and extra days were added to the survey to allow for completion of these strata.

Following reinstatement of the winter surveys in 2007, the intention was to carry out three consecutive surveys from 2007–2009, and then move to biennial surveys. There was then a three year gap (no surveys in 2010 and 2011) to align the ECSI survey with the west coast South Island survey so that they run in alternate years. Seven surveys have been completed since the time series was reinstated (2007, 2008, 2009, 2012, 2014, 2016 and 2018).

## 1.3 Objectives

This report fulfils the final reporting requirement for Objectives 1–5 of Ministry for Primary Industries (MPI) Research Project INT2017/01.

### 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*), giant stargazer (*Kathetostoma giganteum*), sea perch (*Helicolenus percoides*), tarakihi (*Nemadactylus macropterus*), spiny dogfish (*Squalus acanthias*), 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 relative abundance estimates for these species are as follows: red cod (30%), sea perch (20%), giant stargazer (20%), tarakihi (20%), spiny dogfish (20%), elephantfish (30%), red gurnard (20%) and dark ghost shark (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.
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 2018 survey 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).

### Shallow strata (10–30 m)

The 2018 survey covered the same area as 2012, 2014, and 2016 surveys, and were also identical to the four ancillary strata surveyed (or part thereof) from 2007–09 (Figure 1, Table 1). The shallow strata survey area was 3579 $km^2$, including untrawlable foul ground (226 $km^2$).

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

The combined area included all 21 strata in the 10–400 m depth range and 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 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 six winter surveys (2007–09, 2012, 2014 and 2016). Simulations were carried out for the eight target species, using the stated target CV, and requiring a minimum of three stations per stratum for the seventeen core strata (Table 2). For elephantfish and red gurnard, the same approach was used to optimise allocation in the four shallow strata, using stratum catch rates from 2007, 2012, 2014 and 2016. The 2008 and 2009 surveys were not included for these strata as the sampling was not adequate in those years. 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 the average number of tows completed per day from previous surveys, was about 96 leaving 24 stations for phase two (i.e., an allocation of 80% of the total stations in the survey being phase one). To achieve this number, the maximum across each stratum (excluding red cod where CVs are usually very high), was pro-rated down to 96 stations to achieve the number of phase one stations for the survey (Table 2).

Sufficient trawl station positions 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 and that each stratum had a minimum of three stations. Phase two stations were allocated using the NIWA program *SurvCalc* (Francis & Fu 2012). The program calculates the phase one 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 two optimisation of more than one species. The final phase two 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 two allocation, whereas acceptable CVs for red cod are virtually unobtainable without considerably more effort than is practical – neither species were included in the priority list. For elephantfish and red gurnard, phase two stations were allocated based on catch rates in the core plus shallow strata.

## 2.3 Vessel and gear

The same trawl gear used as in past surveys. All trawl gear was overhauled and specifications checked before the 2018 survey. Gear specifications were documented in Beentjes et al. (2013).

## 2.4 Timetable and survey plan

The R.V. *Kaharoa* departed Wellington on 25 April 2018 and arrived and began fishing in Pegasus Bay on 26 April in stratum 13 north east of Banks Peninsula. All phase one tows (10–400 m) north of and around Banks Peninsula were completed before heading to the southern part of the survey area (Figure 2). This is the standard survey plan followed for ECSI surveys. The shallow strata were surveyed along with the core 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 14 May when the vessel discharged fish at Timaru and there was a change of scientific staff. The last station was completed on 4 June, and after discharging the catch into Timaru the vessel steamed to Wellington, arriving in the evening on 5 June before demobilisation on 6 June. Eight days fishing were lost to bad weather.

## 2.5 Trawling procedure

Trawling procedures followed those documented by Stevenson & Hanchet (1999). All tows were carried out in daylight (shooting and hauling) between 0650 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 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 next 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 and headline height data were monitored continuously during the tow, recorded manually at 10–15 minute intervals, and averaged over the tow.

A bottom contact sensor was used to record contact of the trawl with the seabed and a CTD to record conductivity, temperature, and depth. At the end of the tow, immediately after the gear came on deck, the bottom 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 was 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 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. All specimens were labelled with the survey trip code, station number, species, and fish number.

The otolith collection method before the 2014 survey involved removing at least five otoliths per centimetre size class per sex, endeavouring to spread the collection across the entire survey area. Since

2014 this procedure was modified as follows. From each tow (if sufficient numbers were available) 10 otoliths 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 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 were entered into the MPI *age* research database, and the otoliths were stored at NIWA, Greta Point. Ageing of these otoliths is not part of this project. 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 2018 and earlier surveys, were archived under the project INT2017-01.

## 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 to derive 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-recruit, recruit, and immature and mature biomass were calculated and compared to previous surveys in the ECSI time series. Total biomass estimates are also presented for eight key non target QMS species: barracouta (BAR), lemon sole (LSO), ling (LIN), rough skate (RSK), school shark (SCH), smooth skate (SSK), rig (SPO), and silver warehou (SWA); as recommended by Beentjes & MacGibbon (2013).

Separate analyses of total biomass were carried out for the core strata and core plus shallow strata. These are plotted on the same figures to show the contribution of biomass made by the shallow strata. For the core strata, time series of total, pre-recruit, and recruit 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 estimates 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, 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 non-target 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 the percent occurrence (i.e., the percentage 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 population length frequency distributions are plotted for the target species and key non-target QMS species, and by depth range for the target species. Length-weight coefficients for 2018 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 recruit and pre-recruit and juvenile and adult 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 six surveys from 2007 to 2016 (Beentjes et al. 2016). 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, common warehou, and witch). This analysis was updated by including the 2018 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. Three tows (stations 84, 93 and 96) had unsatisfactory gear performance. The remaining 94 stations were used in length frequency and biomass estimation for all species. All 84 planned phase one tows in core strata were successfully completed with a further ten tows carried out under phase two. At least three successful stations were completed in each of the 17 strata (Table 1). Station density ranged from one station per 89.7 $km^2$ in stratum 8 to one station per 431.9 $km^2$ in stratum 3, with an overall average density of one station per 253.9 $km^2$ (Table 1). Valid station positions and tow numbers are plotted in Figure 2, and individual station data tabulated in Appendix 2.

In the shallow strata, 13 tows were carried out, and all but one (station 6) had satisfactory gear performance. The twelve successful phase one tows in the shallow strata were used in length frequency and biomass estimation (Table 1, Appendix 2). Station positions and tow numbers are shown in Figure 2 and individual station data in Appendix 2.

Only 10 of the planned 24 phase two tows were achieved, due mainly to eight days of bad weather when fishing was not possible. All phase 2 tows were allocated to three core strata (strata 6, 10, and 13) to reduce CVs for target species (Table 1, Appendix 2).

Monitoring of headline height and doorspread and observations that the doors and trawl gear were polishing well indicated that the gear was fishing hard down and efficiently throughout the survey. For the core strata, means for doorspread, headline height, distance towed, and warp to depth ratio were 78.2 m, 4.8 m, 2.9 n. miles, and 3.2:1, respectively (Appendix 3). For the shallow strata, means for doorspread, headline height, distance towed, and warp to depth ratio were 71.0 m, 4.9 m, 2.8 n. miles, and 10.0:1, respectively (Appendix 3). Net-A was used on all tows from stations 1–26 inclusive before changing to Net-B due to observation of wear and tear to the ground rope on Net-A. Net-B was then used up to and including station 67 after which Net-A was used until the end of the survey following remedial work to the ground rope.

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 was 126.3 t from the 94 successful biomass tows. Catches from the 92 tows were highly variable, 162–6828 kg per tow, with an average of 1344 kg. Catch included 12 chondrichthyans, 66 teleosts, and 39 invertebrate species or species groups (Appendix 4). Catch weights, percent catch, occurrence, and depth range of all species identified during the survey are given in Appendix 4. The catches were dominated by barracouta (39 t), spiny dogfish (35 t), and dark ghost shark (17 t), representing 31%, 28%, and 14% of the total core strata catch. These three species, and the next three most abundant species (two saddle rattail, sea perch, and red cod) made up 84% of the total core strata catch (Appendix 4). The percentage of the catch represented by the eight target species was as follows: dark ghost shark 14%; elephantfish 1%, giant stargazer 1%; red cod 3%; red gurnard 2%, sea perch 4%; spiny dogfish 28%; and tarakihi 2%, making a combined total of 55%. Spiny dogfish and barracouta were caught in 99% and 93% of tows respectively. Other non-target species commonly caught included arrow squid (92% of tows), witch (92% of tows), and carpet shark (85% of tows) (Appendix 4).

### Shallow strata (10–30 m)

The total catch in the shallow strata was 9.4 t from the 12 biomass tows. Catches were highly variable, 326–1428 kg per tow, with an average of 783 kg. Vertebrate fish species caught included eight chondrichthyans, 28 teleosts, and 11 invertebrate species or species groups (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 (2.4 t), red gurnard (1.9 t), spiny dogfish (1.7 t), and leatherjacket (1.7 t), representing 25%, 21%, 18%, and 18% respectively of the total catch. These four species, and the next four most abundant species (elephantfish, rough skate, rig, and red cod) made up 96% of the total catch (Appendix 4). The percentage of the total catch represented by the eight target species was as follows: dark ghost shark 0%; elephantfish 4.7%, giant stargazer 0%; red cod 1.3%; red gurnard 21.2%, sea perch 0%; spiny dogfish 17.9%; tarakihi 0.2%, making a combined total of 45.3% (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 are given in Table 3 (Panel A). Of the target species, spiny dogfish dominated with a biomass of 24 758 t (CV = 28%), followed by dark ghost shark (6485 t, CV = 23%), red gurnard (2043 t, CV = 19%), sea perch (2023 t, CV = 29%), red cod (1500 t, CV = 83%), tarakihi (1409 t, CV = 26%), elephantfish (807 t, CV = 21%), and giant stargazer (738 t, CV = 18%). 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 1.3 Objectives). CVs were 8% higher than the target for spiny dogfish and 9% higher for sea perch. The red cod target CV was substantially higher (by 53%) than the target CV of 30%. There were no target CVs specified for red gurnard and elephantfish in the core strata.

The breakdown of biomass for target species by sex showed a relatively even split with a range of 41 to 61% male (Table 3, panel A).

Barracouta had the largest biomass, 29 917 t and a CV of 23% (Table 3, panel A) of the eight key non-target QMS species. Other species with substantial biomass included rough skate (978 t, CV = 16%), and smooth skate (664 t, CV = 22%).

Recruit biomass estimates and CVs for the target species and the eight key non-target QMS species are shown in Table 3, Panel A. For the core strata target species the percentage of total biomass that was recruit fish was dark ghost shark 59%, giant stargazer 93%, red cod 91%, sea perch 97%, spiny dogfish 70%, and tarakihi 71%.

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

Biomass estimates and CVs for elephantfish and red gurnard, as well as target species and key non-target QMS species are given in Table 3 (panel B). Of the target species, spiny dogfish dominated the biomass with 26 049 t (CV = 26%), followed by red gurnard (3831 t, CV = 17%), red cod (1584 t, 78%), and elephantfish (1118 t, CV = 20%). The red gurnard and elephantfish CVs were both within the targets of 20 and 30% respectively. There were no target CVs specified for the other six target species in the core plus shallow strata.

The breakdown of biomass for target species by sex in the core plus shallow strata showed that males comprised 34% of the total elephantfish biomass, slightly less than the 40% seen in the core strata (Table 3, panels A and B). For red gurnard the proportion of males in the core plus shallow strata was lower at 40% compared with 56% in just the core strata only. Red cod biomass was 50% male and spiny dogfish 62% male, both almost the same as in the core strata.

Barracouta had the largest biomass of the five key non-target QMS species caught in the core plus shallow strata, with 31 723 t and a CV of 22% (Table 3, panel B). The only other species with substantial biomass was rough skate (1213 t, CV = 14%).

Recruited biomass estimates and CVs for the target species and the key non-target QMS species in the core plus shallow strata are shown in Table 3 (panel B). For elephantfish the percentage of total biomass that was recruit fish was 68%, almost identical to the core strata estimate of 67%. Red gurnard was 84% recruit compared with 85% for the core strata. The recruit biomass for spiny dogfish and red cod were the same as in the core strata at 70% and 91%, respectively.

## 3.4 Strata catch rates, biomass, and distribution

Catch rates by stratum for the eight target and eight key non-target QMS species are given in Table 4, and catch rates by station are plotted in Figure 3. Biomass by stratum is given in Table 5 and plotted in Figure

4. 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 at depths greater than 100 m throughout the survey area. They occurred in 49% of core tows, with the shallowest catch at 62 m and the deepest at 363 m (Appendix 4). Highest catch rates and biomass estimates were in 200 to 400 m in strata 14 and 17 although stratum 10 (100 to 200 m) was also important (Figures 3 and 4, Tables 4 and 5).

Elephantfish was caught at 15–114 m, in 38% of core tows and 92% of shallow tows (Appendix 4). Highest catch rates and biomass estimates were in core stratum 1, and shallow stratum 20 (Figures 3 and 4, Tables 4 and 5).

Giant stargazer was mostly caught deeper than about 50 m throughout the survey area. They occurred in 80% of core tows, with the shallowest catch at 37 m and the deepest at 363 m (Appendix 4). Highest catch rates and biomass were in strata 3 and 4 (Figure 3 and 4, Tables 4 and 5).

Red cod was caught at 15–363 m in 54% of core tows and 67% of shallow tows (Appendix 4). The highest catch rate and biomass estimate was in core stratum 11 partly due to one high catch with the resulting stratum CV being 96%. The next most important stratum was shallow stratum 20 although this is much lower than in stratum 11. Overall catch rates of red cod were low (Figures 3 and 4, Tables 4 and 5).

Red gurnard was caught at 15–137 m, in 59% of core tows and 100% of shallow tows (Appendix 4). Highest catch rates and biomass estimates were in shallow strata 18, 19 and 21, and core stratum 7 (Figures 3 and 4, Tables 4 and 5).

Sea perch was caught at 43–339 m, predominantly 50–150 m and in 61% of core tows (Appendix 4). The highest catch rates and biomass estimates were in strata 1 (30–100 m) and 10 (100–200 m) (Figures 3 and 4, Tables 4 and 5).

Spiny dogfish was caught in all depth ranges throughout the survey area at 15–363 m in 99% of core tows and 100% of shallow tows (Appendix 4). The highest catch rates and biomass estimates were in core strata 2, 5, 6, and 11. The third highest catch rates were in stratum 16 but the relatively small size of this stratum meant that biomass was low compared with strata 2, 5, 6, and 11 (Figures 3 and 4, Tables 4 and 5).

Tarakihi was caught at 15–339 m, but mostly at 50–100 m. They were caught in 67% of core tows but just 33% of shallow tows (Appendix 4). Catch rates were high in strata 1, 4 (30–100 m) and 13 (100–200 m) but this species was common throughout much of the survey area (Figures 3 and 4, Tables 4 and 5).

## 3.5 Biological and length frequency data

Details of length frequency and biological data recorded for each species are given in Table 6. Just under 40 000 length frequency and nearly 9 000 biological records were taken from 41 species. This included otoliths from 467 giant stargazer, 319 red cod, 541 red gurnard, 395 sea perch, and 427 tarakihi.

Scaled population length frequency distributions for dark ghost shark, giant stargazer, red cod, sea perch, spiny dogfish, and tarakihi are plotted from core strata as well as for the depth ranges 10–30 m (where appropriate), 30–100 m, 100–200 m, and 200–400 m (Figure 5). Length frequency distributions are shown for the core plus shallow and also for the four depth ranges for elephantfish and red gurnard. Scaled length frequency distributions for the key non-target QMS species in the core and the shallow strata 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 males showed three modes at about 25–30 cm, 30–45 cm, and 45–60 cm. The larger modes were present in all core strata depth ranges but there were fewer in the 30–100 m depth range. The smaller size classes were present only in the deeper 200–400 m depth range (Figure 5). For females, the distribution was similar although the largest size class extended to about 70 cm and there were more fish over 60 cm compared to males. The largest size class was present at all depth ranges but was least abundant at 30–100 m as seen for the males, and the smallest fish were only found at 200–400 m. The bulk of the males and females were pre-recruit fish (under 55 cm) and at 200–400 m depth they were virtually all pre-recruit fish. The overall scaled numbers in the core strata was equal, with 49.5% being male (Figure 5).

**Elephantfish** – The length frequency distributions showed a strong 1+ mode centred around 25 cm and a strong juvenile mode centred around 40 cm for both males and females. Males had two smaller modes centred around 55 cm and 60 cm. Above 50 cm there were no clear strong modes for females. There were few males over 60 cm and none over 80 cm whereas the right hand tail of the distribution for females was much longer with some fish over 90 cm (Figure 5). For both sexes the 1+ mode was much stronger in, though not restricted to, the 10–30 m depth range, and the larger size classes were more prominent in the 30–100 m depth range. There were few elephantfish deeper than 100 m and none deeper than 200 m. The overall scaled population numbers were slightly skewed towards females with the percentage of males being 43% (Figure 5).

**Giant stargazer** – The length frequency distributions for males and females had no clear modes, and based on previous ageing (Sutton 1999) were comprised of multiple cohorts (Figure 5). The female length distribution had a wider right hand tail indicating that the largest fish were mostly females. For both sexes the length distributions were generally similar in the 30–100 m, 100–200 m, and possibly 200–400 m although numbers were low in the latter depth range and the fish below 40 cm were rare in the 200–400 m range. Giant stargazer were more common in 30–100 m than 100–200 m, with less than 3% of the population found in the 200–400 m interval. The overall scaled numbers in the core strata were 49% male.

**Red cod** – The length frequency distributions showed two well defined modes at about 10–25 cm (0+) and 25–38 cm (1+), and possible modes of around 38–45 (2+) and 45–60 cm (3+) (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 fish were in 100–200 m with few fish in the other depth ranges, although this is dominated by a single large catch that comprised 82% of the total red cod catch for the survey. Less than 3% 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 population numbers were 57% male in the core strata (30–400 m) and 56% in the core plus shallow strata (10–400 m).

**Red gurnard** – The length frequency distributions for males and females had three clear modes centred at about 15 cm, 25 cm, and 35 cm (combined sexes) (Figure 5). The smallest of these probably represents 0+ fish but neither of the two larger modes is likely to represent a single cohort and based on previous ageing, the distribution comprised ages from about 1 to 13 years (Sutton 1997). The smaller mode, was likely to be mainly 1+ and 2+ fish. Female length distribution had a wider right hand tail with more fish over 40 cm compared with males, indicating that the largest fish were mostly females. Red gurnard were caught mainly in 10–100 m with few fish caught in 100–200 m and none in the 200–400 m depth range. The overall scaled population numbers by sex were even over the entire depth range at 49% male but in 10–30 m only 32% were male and in 30–100 m 64% were male.

**Sea perch** – The length frequency distribution was unimodal with peaks at about 25 cm for males and females, with little difference between sexes (Figure 5). Although found from 30–400 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 51% male.

**Spiny dogfish** – The length frequency distributions showed a relatively clear mode from about 25–40 cm for both sexes, and another relatively clear mode from about 60–80 cm in males (Figure 5). There are no clear modes in between these two size classes. They were caught in all depth ranges, including the shallow strata, but the bulk of fish were in 30–100 m, followed by 10–200 m. Fish less than 40 cm were rare deeper than 100 m. There were more larger females over 60 cm compared with males. The overall scaled population numbers were 58% male in both the core and the core plus shallow strata.

**Tarakihi** –The length frequency distribution showed modes at about 13 cm, 17 cm, and possibly 25 cm for both sexes. The largest fish were females, and there were few fish over 35 cm (Figure 5). The smallest modes were likely to be 0+ and 1+ fish. Tarakihi were caught in 30–400 m, but most were caught in 30–100 m, followed by 100–200 m. Few were caught in 200–400 m. The smallest mode was largely confined to less than 100 m and the largest fish over 25 cm were mainly found in 100–200 m. The overall scaled population numbers in the core strata (30–400 m) were 48% male.

### Gonad stages

Details of the gonad stages for the target species are given in Table 7. Giant stargazer were mostly resting/immature, although 20% of males were ripening. Red cod and tarakihi were predominantly immature/resting. Sea perch of both sexes were predominantly immature/resting although both sexes displayed all five stages with one third of males mature. More than half of red gurnard of both sexes in the core strata were maturing and a small percentage were mature or spent. Although none were running ripe, the presence of maturing and spent fish indicated some spawning activity was occurring. Red gurnard gonad stages were similar in the shallow strata, but there were no spent males and more fish of both sexes were immature or resting. Dark ghost shark males showed all gonad stages with most being mature (72%) followed by immature (23%), and 4% maturing. About 53% of female ghost shark were mature, 21% were gravid, and 27% were immature or maturing. Spiny dogfish showed a mix of stages with all stages present for both sexes. Seventy-seven percent of spiny dogfish males were mature, and 42% of females were classified as pregnant (i.e., embryos visible in the uterus). In contrast, most male and female elephantfish in the core and shallow strata were immature or maturing.

## 4. DISCUSSION

### 4.1 2018 survey

The 2018 survey was successful in meeting all the project objectives and the CVs were within the specified range in core strata for dark ghost shark and giant stargazer, and within 6, 8, and 9% of the target CV for tarakihi, spiny dogfish, and sea perch respectively (Table 3). At 83%, the CV for red cod was substantially higher than the target of 30%. 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 with many zero-catch tows and the occasional very large catch. In 2018 the catch rates of red cod were very low, with most positive catches less than 10 kg, and only one catch more than 100 kg. This catch (station 46) was 2.7 tonnes (82% of the total red cod catch), which increased the CV to well above the target of 30% (see Figure 3). In years of high red cod abundance (or recruitment) low CVs were more difficult to achieve, e.g., 2012, when a very strong 1+ cohort dominated the red cod catch and the CV was 79%. This is almost as high as the 2018 CV, although the 2018 CV is not due to one cohort (see Figure 11).

The 17% CV for red gurnard in core plus shallow strata was less than the target of 20%, and the 20% elephantfish CV was less than the target of 30% (Table 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 increased 16-fold between 1992 and 2016, from 934 t to 15 271 t, but declined substantially in 2018 to 6485 t (Table 8, Figure 7). Dark ghost shark on the Chatham Rise show a general similar trend of increasing biomass since 1995 (Stevens et al. 2017), whereas biomass from the Sub-Antarctic surveys has fluctuated without trend (Bagley et al. 2017). All ECSI inshore surveys had a large component of pre-recruit biomass ranging from 30–61% (Table 9, Figure 8), and in 2018 the pre-recruit biomass was 42% of total biomass. The juvenile and adult biomass (based on length-at-50% maturity) of both sexes have generally increased proportionally over the time series and juvenile biomass comprised about half of the total biomass. In 2018 however the juvenile biomass was 40% of total biomass, down from 49% in 2016 (Table 10, Figure 9).

Over the twelve surveys, dark ghost shark was present in 27–57% of core strata tows (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), but with a decline in 2018 to just 13% of the catch despite having a higher occurrence than in 2016. Spatial distribution over the time series has been similar and 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 eleven 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. These larger fish still account for a large proportion of the total in 2018, although overall numbers are lower than in 2016. The size distributions differ from those of the Chatham Rise and Southland/Sub-Antarctic surveys (O'Driscoll & Bagley 2001, Livingston et al. 2002, Stevens et al. 2017, Bagley et al. 2017) 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 time series high in 2016 was mainly the result of one particularly large catch, and associated CV is high as to be expected. The 2018 estimate is more similar to the post-1994 average at 1141 t. The proportion of pre-recruited biomass in the core strata has varied among surveys from 50% in 2007 to 1% in 2016, although the 2016 value is skewed due to there being few pre-recruit fish in the single large catch that caused the biomass and CV to be so large (Table 9, Figure 8). Pre-recruit biomass in 2018 was 33% of the total elephantfish biomass. The proportion of juvenile biomass (based on the length-at-50% maturity) in 2018 was 46%, slightly higher than the time series mean of 40% (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% then increasing again in 2018 to 38%, more in line with previous surveys. 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). In 2018 they comprised 1% of the total survey catch as usual. The distribution of elephantfish hot spots varies over the time series, but overall this species is consistently well represented from 10 to 100 m over the entire survey area. (Figure 10).

The size distributions of elephantfish were inconsistent among the twelve 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). In 2018, however, the distribution is different in that the 1+ and 2+ cohorts make up the bulk of the distribution, and while the wide right hand tail is still present, it accounts for fewer fish than most past surveys.

The additional elephantfish biomass captured in the 10–30 m depth range accounted for 44%, 64%, 41%, 7% and 28% of the biomass in the core plus shallow strata (10–400 m) for 2007, 2012, 2014, 2016 and 2018 respectively, indicating the importance of shallow strata for elephantfish biomass (Table 8, Figure 7). 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 10–30 m strata is usually higher than in the core strata 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, 2016 and 2018 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). In 2018, the 1+ and 2+ cohorts are again dominant, although overall numbers are the lowest in the time series since the 10–30 m strata were added. For the five 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 but back up to 47% in 2018 (Table 10, Figure 14).

### Giant stargazer

Giant stargazer biomass showed peaks in 2007, 2014, and 2016 but no trend over the time series (Table 8, Figure 7). Pre-recruited biomass has been a small but consistent component of the total biomass estimate on all surveys to 2016 (range 2–5% of total biomass) and was 7% of the total in 2018, the record for the time series (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 2018 biomass was 55% juvenile.

Giant stargazer were present in 71–92% of core strata tows (80% in 2018) 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, with highest catch rates in 2018 in 30-100 m (Figure 10).

The size distributions of giant stargazer in each of the twelve surveys were similar and generally had one large mode comprising multiple age classes, and in some years a small juvenile mode (Figure 11). The 2016 survey appeared to have a relatively abundant mode from 15–25 cm which appears to have tracked through to 2018 and is now around 25–38 cm. 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. 2017), 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 biomass in 2018 has declined further and is the second lowest in the time series, although the associated CV is high at 83%. 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 comprised of 1+ fish and appears to have resulted in commercial catches equalling 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 both 1994 and 2012, and in 2018 it was 9% (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 2018 it was 29% (Table 10, Figure 9).

Red cod was present in 63–89 % of core strata tows from 1991–2016, with indications of a declining trend of occurrence over the time series. In 2018 red cod was caught in 54% of core tows, the lowest in 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 2018 (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 twelve 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 twelve surveys in 2012 and was only average in 2014 and 2016 and slightly below average in 2018. 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%, 4% and 5% of the biomass in the core plus shallow strata (10–400 m) for 2007, 2012, 2016 and 2018 respectively. However, in 2014 biomass from the 10–30 m strata accounted for 44% of the total biomass 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, 2016, and 2018, but in in 2014 the largest fish (over 60 cm) 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). Biomass has had an upward trend from 2007 to the time series high of 2063 t in 2014 followed by a substantial decline in 2016 when biomass more than halved. The biomass has, however, increased again in 2018 to 2043 t, the second highest estimate in the time series. The proportion of pre-recruit biomass in the core strata varied greatly among surveys, but was generally low, 2–20%, and in 2018 was 15% (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 (59% in 2018), with an increasing trend from 1993 onward, although red gurnard made up only 1–2% of the total catch on the surveys (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). They are almost absent deeper than 100 m.

The size distributions of red gurnard were more consistent in the core strata from 2009 to2016 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 2018 length frequency appears more trimodal, however, with cohorts from about 15–20 cm, 20–30 cm, and 30–50 cm.

The additional red gurnard biomass captured in the 10–30 m depth range accounted for 29%, 52%, 36%, 61%, and 47 % of the biomass in the core plus shallow strata (10–400 m) for 2007, 2012, 2014, 2016 and 2018 respectively, indicating the importance of shallow strata for red gurnard biomass (Table 8, Figure 7). This also indicates that the proportion of red gurnard biomass deeper and shallower than 30 m is variable between 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 abundant 1+ cohorts in 10–30 m that were poorly represented in the core strata (Figures 5 and 11). The time series length frequency distributions in the core plus shallow strata (10–400 m) included only the 2007, 2012, 2014, 2016 and 2018 surveys 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 in most years 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 strata, particularly in 2012. However, in 2018 pre-recruited biomass was only 1% higher in the core plus shallow strata and in 2014 the pre-recruited proportion was 2% higher in the core strata (Table 9, Figure 12). For all five 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. The 2018 biomass was a 33% decrease from the time series high in 2016 (Table 8, Figure 7). Pre-recruit biomass has remained a small and reasonably constant component of the total biomass estimate on all surveys (3–8% of total biomass) and in 2018 it was 3% (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 17% 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 2018 it was present in 61% of tows and comprised 3% 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 twelve 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). However it is thought that there are at least two different species referred to as sea perch around New Zealand; *Helicolenus percoides* and *H. barathri* (Roberts et al. 2015). Bentley et al. (2014) also found notable difference in catch rates at depth with *H. percoides* occurring from 0–250 m in depth with a peak at around 150 m whereas *H. barathri* occur from around 300–1000 m in depth with a peak at around 600 m. Further, Paul & Horn (2009) found difference in growth rates, mortality, and implied year class strengths between ECSI and Chatham Rise sea perch. It is likely that most 'sea perch' caught on the ECSI winter time series are *H. percoides* although some *H. barathri* could occur in the deeper range of the 200–400 m strata.

### 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. 2017, Bagley et al. 2017). 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 2018 it was 30% (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 eight surveys, and in 2018 it was 55% 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 2018 spiny dogfish occurred on 99% of stations and comprised 28% of the total catch, close to the time series mean of 29%. Of the target species, spiny dogfish has consistently had the largest biomass on these twelve surveys (Table 8). Of all other species, only barracouta has at times had a higher biomass in some years. 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 five 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. 2017), 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%, 5% and 5% of the biomass in the core plus shallow strata (10–400 m) for 2007, 2012, 2014, 2016 and 2018 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 2018 biomass was the third lowest of the time series, down slightly from the 2016 estimate (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 2018 it was 29% (Table 9). 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 2018 it was 62% (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 metric (Table 11). In 2018 it was present in 67% 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 twelve surveys were similar and were multi-modal, with smaller modes representing individual cohorts (Figure 11). In 2012, 2016 and 2018, 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. 2017).

### 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. Biomass increased by 52% in 2018 and is close to the time series mean of 22 716 t. In 2014 the biomass of barracouta was the highest of any species in the entire time series. Biomass of the seven other key non-target QMS species has been relatively stable since 2007, although lemon sole are possibly in decline with the 2018 survey having the lowest biomass in the time series.

## 4.3 Survey representativeness

The representativeness analysis showing the mean species ranking for each of the twelve ECSI 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. The 2018 survey is the closest to the time series mean rank and is a slight decrease from 2016. Most species included in the analysis have decreased in abundance from 2016 to varying degrees. However, in this survey series there appears to be an overall trend of increasing abundance for most inshore species, which will result in a higher ranking overall for surveys from 2007 compared with the earlier period of 1991–1996. Hence, it is possible that the 2014 survey may not be extreme, but instead reflect general increased abundance of inshore species.

## 5. ACKNOWLEDGMENTS

This research was funded by Ministry for Primary Industries (MPI) under Project INT201701. Thanks to all NIWA scientific staff on board, the skipper Lindsay Copland, and the crew of *Kaharoa* for their valuable contribution. Thanks also to Peter McMillan (NIWA) for reviewing the manuscript, and Marianne Vignaux (MPI) for editorial comments.

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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 2018 ECSI trawl survey. Strata 1–17 are the core strata and strata 18–21 the shallow strata.**

| Stratum | Depth (m) | Area ($km^2$) | Description | Foul ground ($km^2$) | No. stations Phase 1 | No. stations Phase 2 | Station density ($km^2$ per station) |
|---|---|---|---|---|---|---|---|
| 1 | 30–100 | 984 | Shag Point | 202 | 7 | | 140.6 |
| 2 | 30–100 | 1 242 | Oamaru | 0 | 3 | | 414.0 |
| 3 | 30–100 | 3 023 | Timaru | 0 | 7 | | 431.9 |
| 4 | 30–100 | 2 703 | Rakaia | 0 | 11 | | 245.7 |
| 5 | 30–100 | 2 485 | Banks Pen. | 0 | 7 | | 355.0 |
| 6 | 30–100 | 2 373 | Pegasus | 208 | 3 | 3 | 395.5 |
| 7 | 30–100 | 2 089 | Conway | 871 | 6 | | 348.2 |
| 8 | 100–200 | 628 | Shag Point | 17 | 7 | | 89.7 |
| 9 | 100–200 | 1 163 | Oamaru | 0 | 3 | | 387.7 |
| 10 | 100–200 | 1 191 | Timaru | 0 | 5 | 3 | 148.9 |
| 11 | 100–200 | 1 468 | Banks Pen. | 0 | 7 | | 209.7 |
| 12 | 100–200 | 764 | Pegasus | 132 | 3 | | 254.7 |
| 13 | 100–200 | 999 | Conway | 406 | 3 | 4 | 142.7 |
| 14 | 200–400 | 322 | Oamaru Crack | 17 | 3 | | 107.3 |
| 15 | 200–400 | 430 | Timaru | 0 | 3 | | 143.3 |
| 16 | 200–400 | 751 | Banks Pen. | 0 | 3 | | 250.3 |
| 17 | 200–400 | 724 | Conway | 165 | 3 | | 241.3 |
| **Sub total** | | **23 339** | | **2 018** | **84** | **10** | **248.3** |
| 18 | 10–30 | 1 276 | Pegasus | 0 | 3 | | 425.3 |
| 19 | 10–30 | 986 | Rakaia | 0 | 3 | | 328.7 |
| 20 | 10–30 | 797 | Timaru | 0 | 3 | | 265.7 |
| 21 | 10–30 | 520 | Oamaru | 226 | 3 | | 173.3 |
| **Sub total** | | **3 579** | | **226** | **12** | | **298.3** |
| **Total** | | **26 918** | | **2 244** | **96** | **10** | **253.9** |

**Table 2: Theoretical number of stations required to achieve the target coefficients of variation (CV, %) for each species in 30–400 m (core strata) and 10–400 m (core plus shallow strata) for the 2018 ECSI winter survey (from *allocate*). The number of phase-one stations was calculated by pro-rating the species maximum down to the 96 achievable stations. Species codes are given in Appendix 4. – not applicable.**

| Depth (m) | Stratum | GSH (30) | RCO (30) | SPE (20) | SPD (20) | GIZ (20) | NMP (20) | ELE (30) | GUR (20) | Species max | Phase 1 (pro-rated) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 30–100 | 1 | 3 | 3 | 4 | 3 | 3 | 6 | 9 | 3 | 9 | 7 |
| 30–100 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| 30–100 | 3 | 3 | 3 | 4 | 8 | 3 | 8 | 3 | 5 | 8 | 7 |
| 30–100 | 4 | 3 | 3 | 3 | 8 | 3 | 18 | 3 | 6 | 18 | 11 |
| 30–100 | 5 | 3 | 3 | 3 | 12 | 3 | 5 | 3 | 3 | 12 | 7 |
| 30–100 | 6 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| 30–100 | 7 | 3 | 3 | 3 | 7 | 3 | 4 | 3 | 7 | 7 | 6 |
| 100–200 | 8 | 3 | 3 | 12 | 3 | 3 | 4 | 3 | 3 | 12 | 7 |
| 100–200 | 9 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| 100–200 | 10 | 3 | 3 | 6 | 3 | 3 | 3 | 3 | 3 | 6 | 5 |
| 100–200 | 11 | 3 | 12 | 4 | 3 | 3 | 3 | 3 | 3 | 12 | 7 |
| 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 | 3 | 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 | – | – | – | – | – | – | 3 | 3 | 3 | 3 |
| 10–30 | 19 | – | – | – | – | – | – | 3 | 3 | 3 | 3 |
| 10–30 | 20 | – | – | – | – | – | – | 3 | 3 | 3 | 3 |
| 10–30 | 21 | – | – | – | – | – | – | 3 | 3 | 3 | 3 |
| | **Total** | **51** | **60** | **66** | **74** | **51** | **79** | **69** | **72** | **124** | **96** |

**Table 3: Catch, estimated biomass for all fish and recruited fish and CV (%) for the target species (in bold) and the key non-target QMS species in 30–400 m (A), and for elephantfish, red gurnard and selected species in 10–400 m (B). 2018 winter survey. Recruited lengths are given in parentheses below species names.**

| **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 (55 cm)** | 16 997 | 2 665 | 28 | 3 806 | 21 | 6 485 | 23 | 55 | 3 815 | 22 |
| **Elephantfish (50 cm)** | 1 188 | 329 | 29 | 476 | 21 | 807 | 21 | 50 | 541 | 23 |
| **Giant stargazer (30 cm)** | 1 263 | 325 | 20 | 412 | 18 | 738 | 18 | 30 | 685 | 18 |
| **Red cod (40 cm)** | 3 176 | 782 | 89 | 715 | 76 | 1 500 | 83 | 30 | 1 363 | 86 |
| **Red gurnard (30 cm)** | 2 747 | 1 144 | 20 | 897 | 20 | 2 043 | 19 | 40 | 1 735 | 20 |
| **Sea perch (20 cm)** | 4 386 | 1 148 | 31 | 873 | 28 | 2 023 | 29 | 20 | 1 959 | 30 |
| **Spiny dogfish (50 cm)** | 34 866 | 15 143 | 26 | 9 534 | 34 | 24 758 | 28 | 50 | 17 336 | 29 |
| **Tarakihi (25 cm)** | 2 587 | 646 | 26 | 761 | 26 | 1 409 | 26 | 25 | 1 000 | 28 |
| Barracouta (50 cm) | 38 841 | 14 951 | 22 | 14 668 | 25 | 29 917 | 23 | 50 | 18 487 | 29 |
| Lemon sole (25 cm) | 69 | 9 | 34 | 34 | 21 | 43 | 20 | 25 | 74 | 16 |
| Ling (65 cm) | 300 | 23 | 30 | 94 | 34 | 121 | 30 | 65 | 338 | 52 |
| Rig (90 cm) | 128 | 51 | 30 | 47 | 29 | 98 | 28 | 90 | 38 | 35 |
| Rough skate (40 cm) | 1 335 | 468 | 18 | 509 | 16 | 978 | 16 | 40 | 1 048 | 28 |
| School shark (90 cm) | 532 | 117 | 22 | 133 | 23 | 251 | 20 | 90 | 102 | 24 |
| Silver warehou (25 cm) | 385 | 91 | 54 | 78 | 40 | 191 | 42 | 25 | 323 | 70 |
| Smooth skate (40 cm) | 1 141 | 430 | 22 | 229 | 33 | 664 | 22 | 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 (50 cm)** | 1 634 | 381 | 26 | 734 | 23 | 1 118 | 20 | 50 | 761 | 24 |
| **Red cod (40 cm)** | 3 299 | 789 | 88 | 793 | 69 | 1 584 | 78 | 30 | 1 448 | 81 |
| **Red gurnard (30 cm)** | 4 736 | 1 546 | 16 | 2 280 | 21 | 3 831 | 17 | 40 | 3 221 | 18 |
| **Spiny dogfish (50 cm)** | 36 547 | 16 149 | 25 | 9 818 | 33 | 26 049 | 26 | 50 | 18 210 | 28 |
| Barracouta (50 cm) | 41 211 | 15 853 | 21 | 15 527 | 23 | 31 723 | 22 | 50 | 29 114 | 22 |
| Rig (90 cm) | 342 | 150 | 38 | 136 | 22 | 287 | 29 | 90 | 44 | 40 |
| Rough skate (40 cm) | 1 637 | 593 | 15 | 619 | 14 | 1 213 | 14 | 40 | 1 147 | 13 |
| School shark (90 cm) | 537 | 121 | 21 | 134 | 23 | 255 | 20 | 90 | 88 | 34 |
| Silver warehou (25 cm) | 386 | 91 | 54 | 78 | 40 | 191 | 42 | 25 | 164 | 48 |

**Table 4: Catch rates (kg.km$^{-2}$) by stratum for the target species (A) and key non-target QMS species (B). Strata 1–17, core (30–400 m); strata 18–21, shallow (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 | 129 | 17 | 21 | 161 | 559 | 145 | 250 |
| 2 | 0 | 6 | 3 | 1 | 229 | 0 | 3 703 | 11 |
| 3 | 16 | 32 | 57 | 8 | 72 | 10 | 632 | 33 |
| 4 | 152 | 60 | 56 | 5 | 202 | 2 | 473 | 142 |
| 5 | 0 | 94 | 10 | 0 | 43 | 1 | 1 317 | 57 |
| 6 | 0 | 9 | 45 | 0 | 34 | 9 | 1 572 | 1 |
| 7 | 0 | 73 | 2 | 25 | 302 | 3 | 484 | 0 |
| 8 | 622 | 10 | 49 | 0 | 2 | 35 | 250 | 4 |
| 9 | 144 | 0 | 41 | 21 | 0 | 298 | 175 | 117 |
| 10 | 1 204 | 0 | 20 | 14 | 5 | 568 | 383 | 20 |
| 11 | 568 | 0 | 15 | 880 | 9 | 102 | 3 731 | 36 |
| 12 | 423 | 0 | 48 | 0 | 0 | 73 | 321 | 132 |
| 13 | 8 | 0 | 51 | 35 | 0 | 146 | 46 | 199 |
| 14 | 1 800 | 0 | 39 | 2 | 0 | 0 | 191 | 1 |
| 15 | 790 | 0 | 12 | 9 | 0 | 0 | 749 | 0 |
| 16 | 1 010 | 0 | 24 | 12 | 0 | 0 | 1 576 | 0 |
| 17 | 1 639 | 0 | 16 | 6 | 0 | 8 | 910 | 7 |
| 18 | 0 | 41 | 0 | 3 | 834 | 0 | 147 | 0 |
| 19 | 0 | 63 | 0 | 9 | 267 | 0 | 420 | 0 |
| 20 | 0 | 205 | 0 | 89 | 222 | 0 | 788 | 0 |
| 21 | 0 | 62 | 0 | 1 | 545 | 0 | 115 | 13 |

**Table 4 – *continued***

## B (Key QMS species)

| Stratum | Key non-target QMS species catch rates (kg.km$^{-2}$) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | BAR | LSO | LIN | SPO | RSK | SCH | SWA | SSK |
| 1 | 509 | 7 | 10 | 1 | 41 | 8 | 0 | 38 |
| 2 | 3 760 | 4 | 0 | 0 | 36 | 0 | 0 | 97 |
| 3 | 2 941 | 4 | 5 | 3 | 23 | 5 | 1 | 32 |
| 4 | 1 256 | 2 | 2 | 9 | 69 | 5 | 5 | 44 |
| 5 | 2 362 | 1 | 0 | 8 | 36 | 1 | 6 | 15 |
| 6 | 195 | 2 | 0 | 2 | 112 | 16 | 0 | 8 |
| 7 | 901 | 1 | 0 | 15 | 70 | 6 | 3 | 7 |
| 8 | 463 | 1 | 1 | 0 | 15 | 4 | 9 | 68 |
| 9 | 635 | 0 | 11 | 0 | 0 | 2 | 4 | 53 |
| 10 | 823 | 0 | 0 | 3 | 3 | 66 | 7 | 11 |
| 11 | 1 079 | 0 | 1 | 0 | 49 | 32 | 4 | 36 |
| 12 | 162 | 1 | 3 | 3 | 54 | 31 | 12 | 11 |
| 13 | 526 | 3 | 0 | 0 | 2 | 7 | 8 | 7 |
| 14 | 4 | 0 | 52 | 0 | 0 | 0 | 9 | 15 |
| 15 | 5 | 0 | 90 | 0 | 0 | 0 | 2 | 4 |
| 16 | 13 | 1 | 3 | 0 | 0 | 0 | 127 | 35 |
| 17 | 0 | 1 | 18 | 0 | 9 | 0 | 15 | 3 |
| 18 | 53 | 0 | 0 | 47 | 61 | 1 | 0 | 0 |
| 19 | 501 | 0 | 0 | 106 | 46 | 2 | 0 | 24 |
| 20 | 292 | 0 | 8 | 15 | 106 | 1 | 0 | 15 |
| 21 | 1 944 | 4 | 0 | 22 | 51 | 0 | 0 | 31 |

**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 non-target 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 | 127 | 16 | 21 | 159 | 551 | 143 | 246 |
| | CV | 0 | 52 | 38 | 61 | 38 | 89 | 31 | 46 |
| 2 | Biomass | 0 | 7 | 4 | 1 | 284 | 0 | 4 600 | 14 |
| | CV | 0 | 100 | 100 | 100 | 72 | 0 | 94 | 54 |
| 3 | Biomass | 50 | 96 | 172 | 25 | 218 | 30 | 1 910 | 99 |
| | CV | 95 | 58 | 58 | 48 | 28 | 61 | 56 | 44 |
| 4 | Biomass | 412 | 162 | 152 | 14 | 546 | 6 | 1 279 | 384 |
| | CV | 88 | 40 | 40 | 35 | 38 | 85 | 45 | 60 |
| 5 | Biomass | 0 | 234 | 26 | 0 | 106 | 2 | 3273 | 142 |
| | CV | 0 | 46 | 68 | 0 | 41 | 87 | 68 | 87 |
| 6 | Biomass | 0 | 22 | 106 | 0 | 80 | 21 | 3 730 | 3 |
| | CV | 0 | 77 | 52 | 0 | 64 | 96 | 89 | 67 |
| 7 | Biomass | 0 | 152 | 4 | 53 | 630 | 7 | 1 011 | 0 |
| | CV | 0 | 42 | 100 | 34 | 38 | 84 | 37 | 100 |
| 8 | Biomass | 391 | 6 | 31 | 0 | 1 | 22 | 157 | 3 |
| | CV | 54 | 78 | 37 | 0 | 83 | 60 | 13 | 62 |
| 9 | Biomass | 167 | 0 | 47 | 24 | 0 | 347 | 204 | 136 |
| | CV | 100 | 0 | 46 | 87 | 0 | 30 | 56 | 80 |
| 10 | Biomass | 1 434 | 0 | 24 | 17 | 6 | 677 | 456 | 24 |
| | CV | 38 | 0 | 53 | 65 | 40 | 46 | 24 | 77 |
| 11 | Biomass | 834 | 0 | 22 | 1 291 | 13 | 150 | 5 477 | 53 |
| | CV | 44 | 0 | 34 | 96 | 67 | 34 | 56 | 74 |
| 12 | Biomass | 323 | 0 | 37 | 0 | 0 | 56 | 245 | 101 |
| | CV | 95 | 0 | 47 | 0 | 0 | 60 | 28 | 80 |
| 13 | Biomass | 8 | 0 | 51 | 34 | 0 | 146 | 46 | 199 |
| | CV | 100 | 0 | 34 | 73 | 0 | 23 | 30 | 82 |
| 14 | Biomass | 580 | 0 | 12 | 1 | 0 | 0 | 62 | 0 |
| | CV | 34 | 0 | 73 | 57 | 0 | 0 | 45 | 100 |
| 15 | Biomass | 340 | 0 | 5 | 4 | 0 | 0 | 322 | 0 |
| | CV | 74 | 0 | 100 | 25 | 0 | 0 | 51 | 0 |
| 16 | Biomass | 759 | 0 | 18 | 9 | 0 | 0 | 1 184 | 0 |
| | CV | 28 | 0 | 30 | 59 | 0 | 100 | 71 | 0 |
| 17 | Biomass | 1 187 | 0 | 12 | 5 | 0 | 6 | 659 | 5 |
| | CV | 98 | 0 | 60 | 80 | 0 | 96 | 50 | 86 |
| Total | Biomass | 6 485 | 807 | 738 | 1 500 | 2 043 | 2 023 | 24 758 | 1 409 |
| | CV | 23 | 21 | 18 | 83 | 19 | 29 | 28 | 26 |

**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 | 53 | 0 | 4 | 1 063 | 0 | 187 | 0 |
| | CV | 0 | 84 | 0 | 52 | 44 | 0 | 36 | 0 |
| 19 | Biomass | 0 | 62 | 0 | 9 | 264 | 0 | 416 | 0 |
| | CV | 0 | 84 | 0 | 97 | 46 | 0 | 35 | 100 |
| 20 | Biomass | 0 | 163 | 0 | 71 | 177 | 0 | 628 | 0 |
| | CV | 0 | 77 | 0 | 86 | 15 | 0 | 91 | 0 |
| 21 | Biomass | 0 | 32 | 0 | 1 | 283 | 0 | 60 | 7 |
| | CV | 0 | 93 | 0 | 82 | 52 | 0 | 65 | 96 |
| **Total** | Biomass | 0 | 311 | 0 | 85 | 1 788 | 0 | 1 291 | 7 |
| | CV | 0 | 47 | 0 | 73 | 28 | 0 | 46 | 95 |

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

| Stratum | | Key QMS non-target species biomass and CV | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | BAR | LSO | LIN | SPO | RSK | SCH | SWA | SSK |
| 1 | Biomass | 501 | 7 | 10 | 1 | 40 | 7 | 0 | 37 |
| | CV | 35 | 51 | 55 | 58 | 61 | 39 | 100 | 52 |
| 2 | Biomass | 4 671 | 5 | 0 | 0 | 44 | 0 | 0 | 120 |
| | CV | 98 | 60 | 0 | 0 | 51 | 0 | 0 | 83 |
| 3 | Biomass | 8 891 | 12 | 16 | 10 | 69 | 15 | 4 | 97 |
| | CV | 55 | 50 | 95 | 80 | 39 | 52 | 58 | 65 |
| 4 | Biomass | 3 394 | 4 | 6 | 24 | 188 | 13 | 13 | 120 |
| | CV | 28 | 58 | 58 | 48 | 31 | 49 | 41 | 29 |
| 5 | Biomass | 5 868 | 2 | 0 | 21 | 90 | 2 | 14 | 36 |
| | CV | 25 | 41 | 100 | 79 | 33 | 65 | 69 | 63 |
| 6 | Biomass | 462 | 4 | 0 | 4 | 266 | 38 | 0 | 20 |
| | CV | 76 | 62 | 0 | 100 | 42 | 42 | 0 | 100 |
| 7 | Biomass | 1 882 | 3 | 0 | 32 | 146 | 12 | 7 | 15 |
| | CV | 42 | 55 | 0 | 49 | 32 | 93 | 26 | 81 |
| 8 | Biomass | 291 | 0 | 0 | 0 | 10 | 3 | 5 | 43 |
| | CV | 38 | 32 | 100 | 0 | 60 | 51 | 95 | 66 |
| 9 | Biomass | 739 | 0 | 12 | 0 | 0 | 3 | 5 | 62 |
| | CV | 65 | 0 | 92 | 0 | 0 | 100 | 53 | 100 |
| 10 | Biomass | 980 | 0 | 0 | 4 | 3 | 79 | 9 | 13 |
| | CV | 28 | 0 | 100 | 74 | 66 | 38 | 48 | 51 |
| 11 | Biomass | 1 584 | 0 | 2 | 0 | 72 | 47 | 6 | 52 |
| | CV | 24 | 74 | 100 | 0 | 78 | 57 | 58 | 38 |
| 12 | Biomass | 124 | 1 | 2 | 2 | 42 | 24 | 9 | 8 |
| | CV | 78 | 68 | 100 | 100 | 61 | 90 | 90 | 100 |
| 13 | Biomass | 526 | 3 | 0 | 0 | 2 | 7 | 8 | 7 |
| | CV | 33 | 30 | 85 | 0 | 65 | 64 | 96 | 100 |
| 14 | Biomass | 1 | 0 | 17 | 0 | 0 | 0 | 3 | 5 |
| | CV | 55 | 0 | 95 | 0 | 0 | 0 | 54 | 100 |

**Table 5 – *continued***

| Stratum | | BAR | LSO | LIN | SPO | RSK | SCH | SWA | SSK |
|---|---|---|---|---|---|---|---|---|---|
| | | Key non-target QMS species biomass and CV | | | | | | | |
| 15 | Biomass | 2 | 0 | 39 | 0 | 0 | 0 | 1 | 2 |
| | CV | 55 | 0 | 58 | 0 | 0 | 0 | 100 | 50 |
| 16 | Biomass | 10 | 1 | 3 | 0 | 0 | 0 | 96 | 26 |
| | CV | 20 | 100 | 56 | 0 | 0 | 0 | 81 | 96 |
| 17 | Biomass | 0 | 1 | 13 | 0 | 6 | 0 | 11 | 2 |
| | CV | 0 | 50 | 100 | 0 | 67 | 0 | 47 | 100 |
| Total | Biomass | 29 926 | 44 | 121 | 98 | 978 | 251 | 191 | 664 |
| | CV | 23 | 20 | 30 | 28 | 16 | 20 | 42 | 22 |

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

| Stratum | | BAR | LSO | LIN | SPO | RSK | SCH | SWA | SSK |
|---|---|---|---|---|---|---|---|---|---|
| | | Key non-target QMS species biomass and CV | | | | | | | |
| 18 | Biomass | 68 | 0 | 0 | 60 | 78 | 1 | 0 | 0 |
| | CV | 31 | 100 | 0 | 22 | 23 | 52 | 100 | 0 |
| 19 | Biomass | 496 | 0 | 0 | 105 | 46 | 2 | 0 | 24 |
| | CV | 49 | 0 | 0 | 72 | 57 | 50 | 0 | 100 |
| 20 | Biomass | 233 | 0 | 7 | 12 | 84 | 1 | 0 | 12 |
| | CV | 32 | 0 | 56 | 47 | 55 | 100 | 100 | 100 |
| 21 | Biomass | 1 010 | 2 | 0 | 11 | 26 | 0 | 0 | 16 |
| | CV | 34 | 34 | 0 | 51 | 37 | 0 | 0 | 100 |
| **Total** | Biomass | 1 806 | 2 | 7 | 188 | 235 | 4 | 0 | 52 |
| | CV | 24 | 33 | 56 | 41 | 24 | 38 | 73 | 60 |

**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 | 4 | 5 | - | - | - |
| BAR | 1 | 93 | 7 791 | - | - | - |
| BCO | 2 | 12 | 198 | - | - | - |
| BNS | 1 | 1 | 1 | - | - | - |
| BRI | 2 | 4 | 9 | - | - | - |
| CBI | 2 | 2 | 63 | - | - | - |
| ELE | 1 | 47 | 982 | 47 | 496 | - |
| ESO | 2 | 9 | 160 | - | - | - |
| FRO | 1 | 1 | 2 | - | - | - |
| GFL | 2 | 2 | 7 | - | - | - |
| GIZ | 2 | 75 | 1 093 | 75 | 714 | 467 |
| GSH | G | 46 | 2 865 | 46 | 854 | - |
| GUR | 2 | 67 | 4 218 | 67 | 1 069 | 541 |
| HAP | 2 | 14 | 58 | 1 | 2 | - |
| HOK | 2 | 12 | 590 | - | - | - |
| JDO | 2 | 2 | 2 | - | - | - |
| JMD | 1 | 13 | 128 | - | - | - |
| JMM | 1 | 1 | 1 | - | - | - |
| LDO | 2 | 2 | 69 | - | - | - |
| LEA | 2 | 22 | 1 200 | - | - | - |
| LIN | 2 | 21 | 197 | 1 | 1 | - |
| LSO | 2 | 40 | 244 | 1 | 16 | - |
| MOK | 1 | 3 | 50 | 1 | 43 | - |
| NMP | 1 | 67 | 2 907 | 67 | 796 | 427 |
| NOS | 4 | 49 | 1 392 | - | - | - |
| RCO | 2 | 59 | 1 051 | 59 | 489 | 319 |
| RSK | 5 | 67 | 497 | 67 | 414 | - |
| RSO | 1 | 26 | 559 | - | - | - |
| SCH | 2 | 50 | 219 | 50 | 219 | - |
| SCI | B | 1 | 3 | - | - | - |
| SFL | 2 | 9 | 90 | - | - | - |
| SPD | 2 | 105 | 7 741 | 103 | 2 469 | - |
| SPE | 2 | 57 | 3 286 | 57 | 874 | 395 |
| SPO | 2 | 32 | 297 | 32 | 245 | - |
| SSI | 1 | 2 | 68 | - | - | - |
| SSK | 5 | 47 | 216 | 46 | 215 | - |
| SWA | 1 | 34 | 605 | 1 | 10 | - |
| WAR | 1 | 15 | 304 | - | - | - |
| WWA | 1 | 1 | 4 | - | - | - |
| YBF | 2 | 2 | 10 | - | - | - |
| **Totals** | - | 1 116 | 39 182 | 721 | 8 926 | 2 149 |

**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 | 338 | 46 | 31 | 20 | 3 | <1 | |
| | Females | 358 | 76 | 21 | 3 | <1 | 0 | |
| Red cod | Males | 155 | 72 | 25 | 3 | 1 | 0 | |
| | Females | 209 | 75 | 23 | 0 | 0 | 2 | |
| Red gurnard | Males | 515 | 13 | 66 | 16 | 0 | 5 | |
| | Females | 312 | 19 | 55 | 7 | 0 | 19 | |
| Sea perch | Males | 447 | 14 | 50 | 34 | 1 | <1 | |
| | Females | 386 | 42 | 53 | 2 | 1 | 2 | |
| Tarakihi | Males | 377 | 87 | 7 | 5 | <1 | 0 | |
| | Females | 378 | 87 | 13 | 0 | 0 | 0 | |
| | | | % Gonad state | | | | | |
| | | | 1 | 2 | 3 | 4 | | |
| Dark ghost shark | Males | 289 | 23 | 4 | 72 | NA | | |
| | Females | 504 | 16 | 11 | 53 | 21 | | |
| | | | % Gonad state | | | | | |
| | | | 1 | 2 | 3 | 4 | 5 | 6 |
| Elephantfish | Males | 176 | 48 | 7 | 44 | NA | NA | NA |
| | Females | 199 | 60 | 13 | 24 | 4 | 0 | 0 |
| Spiny dogfish | Males | 1 268 | 18 | 6 | 77 | NA | NA | NA |
| | Females | 623 | 35 | 13 | 5 | 5 | 42 | <1 |
| | | | % Gonad state | | | | | |
| **10–30 m** | | | 1 | 2 | 3 | 4 | 5 | 6 |
| Elephantfish | Males | 39 | 85 | 0 | 15 | NA | NA | NA |
| | Females | 77 | 65 | 21 | 14 | 0 | 0 | 0 |
| | | | % Gonad state | | | | | |
| | | | 1 | 2 | 3 | 4 | 5 | |
| Red gurnard | Males | 74 | 27 | 64 | 9 | 0 | 0 | |
| | Females | 166 | 44 | 30 | 7 | 0 | 19 | |

**Table 8: Estimated biomass (Biom., 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 (A), and core plus shallow strata in 2007, 2012, 2014, 2016 and 2018 for species found in less than 30 m (B). Biomass estimates for 1991 were adjusted to allow for non-sampled strata (7 and 9 equivalents to current strata 13, 16 and 17). * Rough skate and smooth skate were not separated in 1991 (combined biomass 1993 t, CV 25%). Species in order of common name. Species codes defined in Appendix 4. NA, not applicable.**

**A (Core strata). Target species**

| Survey | GSH | | ELE | | GIZ | | RCO | | GUR | | SPE | | SPD | | NMP | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Biom. (t) | CV | Biom. (t) | CV | Biom. (t) | CV | Biom. (t) | CV | Biom. (t) | CV | Biom. (t) | CV | Biom. (t) | CV | Biom. (t) | CV |
| 1991 | 962 | 42 | 300 | 40 | 672 | 17 | 3 760 | 33 | 763 | 33 | 1 716 | 30 | 12 873 | 22 | 1 712 | 33 |
| 1992 | 934 | 44 | 176 | 32 | 669 | 16 | 4 527 | 40 | 142 | 30 | 1 934 | 28 | 10 787 | 26 | 932 | 26 |
| 1993 | 2 911 | 42 | 481 | 33 | 609 | 14 | 5 601 | 30 | 576 | 31 | 2 948 | 32 | 13 949 | 17 | 3 805 | 55 |
| 1994 | 2 702 | 25 | 164 | 32 | 439 | 17 | 5 637 | 35 | 123 | 34 | 2 342 | 29 | 14 530 | 10 | 1 219 | 31 |
| 1996 | 3 176 | 23 | 858 | 30 | 466 | 11 | 4 619 | 30 | 505 | 27 | 1 671 | 26 | 35 169 | 15 | 1 656 | 24 |
| 2007 | 4 483 | 25 | 1 034 | 32 | 755 | 18 | 1 486 | 25 | 1 453 | 35 | 1 954 | 22 | 35 386 | 27 | 2 589 | 24 |
| 2008 | 3 763 | 20 | 1 404 | 35 | 606 | 14 | 1 824 | 49 | 1 309 | 34 | 1 944 | 23 | 28 476 | 22 | 1 863 | 29 |
| 2009 | 4 329 | 24 | 596 | 23 | 475 | 14 | 1 871 | 40 | 1 725 | 30 | 1 444 | 25 | 25 311 | 31 | 1 519 | 36 |
| 2012 | 10 704 | 29 | 1 351 | 39 | 643 | 16 | 11 821 | 79 | 1 680 | 28 | 1 964 | 26 | 35 546 | 31 | 1 661 | 25 |
| 2014 | 13 137 | 26 | 951 | 34 | 790 | 14 | 2 096 | 39 | 2 063 | 25 | 2 168 | 25 | 19 949 | 31 | 2 380 | 23 |
| 2016 | 15 271 | 25 | 6 812 | 68 | 565 | 17 | 2 268 | 54 | 941 | 30 | 3 032 | 29 | 26 063 | 41 | 1 462 | 31 |
| 2018 | 6 485 | 23 | 807 | 21 | 738 | 18 | 1 500 | 83 | 2 043 | 19 | 2 023 | 29 | 24 758 | 28 | 1 409 | 26 |

**A (Core strata). Non-target QMS species**

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

**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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2012 | 34 325 | 17 | 65 | 18 | 265 | 21 | 171 | 62 | 1 133 | 20 | 292 | 20 | 434 | 46 | 1 025 | 35 |
| 2014 | 46 563 | 19 | 107 | 27 | 230 | 21 | 194 | 48 | 1 153 | 38 | 529 | 36 | 626 | 83 | 637 | 20 |
| 2016 | 19 708 | 27 | 91 | 15 | 489 | 48 | 181 | 39 | 1 142 | 30 | 369 | 21 | 428 | 53 | 663 | 17 |
| 2018 | 29 926 | 23 | 44 | 20 | 121 | 30 | 98 | 28 | 978 | 16 | 251 | 20 | 191 | 42 | 664 | 22 |

**B (Core plus shallow strata). 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 |
| 2018 | 1 118 | 20 | 1 584 | 78 | 3 831 | 17 | 26 049 | 26 |

**B (Core plus shallow strata). 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 |
| 2018 | 31 733 | 22 | 1 213 | 14 | 255 | 20 | 287 | 29 | 191 | 42 |

**Table 9: Estimated biomass (t), and coefficient of variation (CV %) of recruit (length in parentheses)and pre-recruit target species in core strata for all surveys (A), and core plus shallow strata for elephantfish and red gurnard in 2007, 2012, 2014, 2016, and 2018 (B). Biomass estimates for 1991 were adjusted to allow for non-sampled strata (7 and 9, equivalents to current strata 13, 16 and 17). The sum of pre-recruit and recruit biomass values does 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)

| | | 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. | 6 912 | 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. | 8 283 | 6 988 | 62 | 6 750 | 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***

| | | 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. |
| 2018 | Biom. | 2 670 | 3 815 | 266 | 541 | 53 | 685 | 308 | 1 735 | 137 | 1 363 | 64 | 1 959 | 7 423 | 17 336 | 409 | 1 000 |
| | CV | 30 | 22 | 34 | 23 | 33 | 18 | 24 | 20 | 60 | 86 | 19 | 30 | 55 | 29 | 28 | 28 |

**Table 9 – *continued***

## A (Core plus shallow strata)

| | | 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 |
| 2018 | Biom. | 356 | 761 | 610 | 3 221 |
| | CV | 28 | 24 | 21 | 18 |

**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 bony fish target species from core strata for all ECSI surveys (A), elasmobranch species from core strata for all surveys (B), and elephantfish and red gurnard from core plus shallow strata for 2007, 2012, 2014, 2016 and 2018 (C). Biomass estimates for 1991 were adjusted to allow for non-sampled strata (7 and 9). The sum of juvenile and adult biomass values did 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 (Bony fish, core strata)

| | | Bony fish 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) |
| 2018 | Biomass | 207 (198) | 118 (215) | 8 (4) | 1 136 (893) | 289 (145) | 493 (570) | 142 (163) | 1 006 (710) | 411 (460) | 235 (300) |
| | CV | 26 (28) | 22 (19) | 44 (51) | 20 (20) | 84 (67) | 92 (79) | 18 (20) | 34 (32) | 30 (31) | 30 (36) |

## B (Elasmobranchs, core strata)

| | | 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) |
| 2018 | Biomass | 693 (1 889) | 1 972 (1 917) | 138 (233) | 191 (244) | 6 306 (7 170) | 8 837 (2 364) |
| | CV | 28 (30) | 32 (21) | 35 (27) | 37 (27) | 36 (38) | 27 (46) |

## C (Core plus shallow strata)

| | | 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) |
| 2018 | Biomass | 174 (351) | 206 (383) | | 14 (7) | 1 532 (2 273) |
| | CV | 30 (22) | 34 (30) | | 27 (33) | 16 (21) |

**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 (A), and the core strata plus shallow for ELE and GUR in 2007, 2012, 2014, 2016, and 2018 (B). Values of zero are less than 1%.**

**A (Core strata**

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 |
| 2018 | 49 | 13 | 38 | 1 | 80 | 1 | 54 | 3 | 59 | 2 | 61 | 3 | 99 | 28 | 67 | 2 | 53 |

**B (Core plus shallow strata)**

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 |
| 2018 | 44 | 1 | 63 | 4 | 5 |

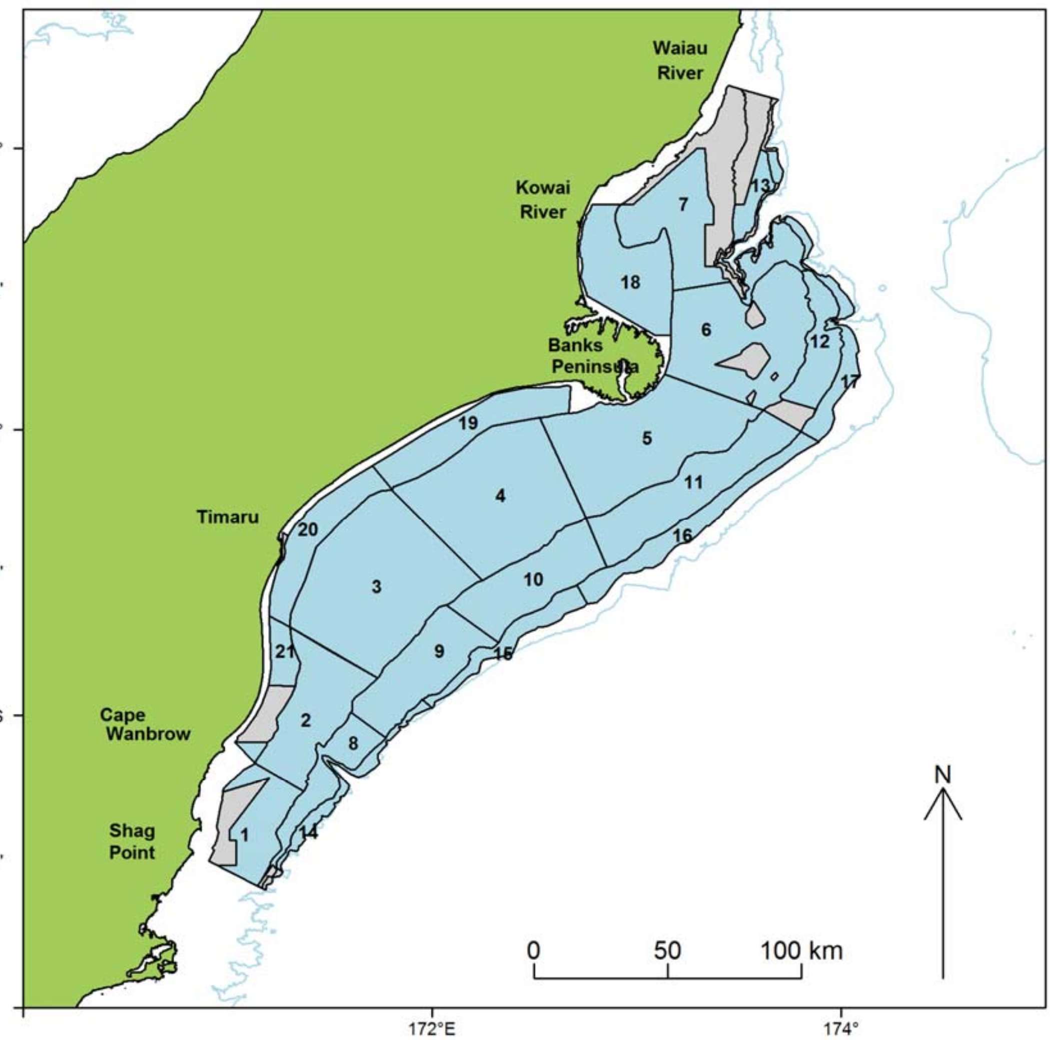



**Figure 1: Strata used in the 2018 ECSI trawl survey in 10–400 m. Grey areas are foul ground. Outer depth contour is 500 m.**

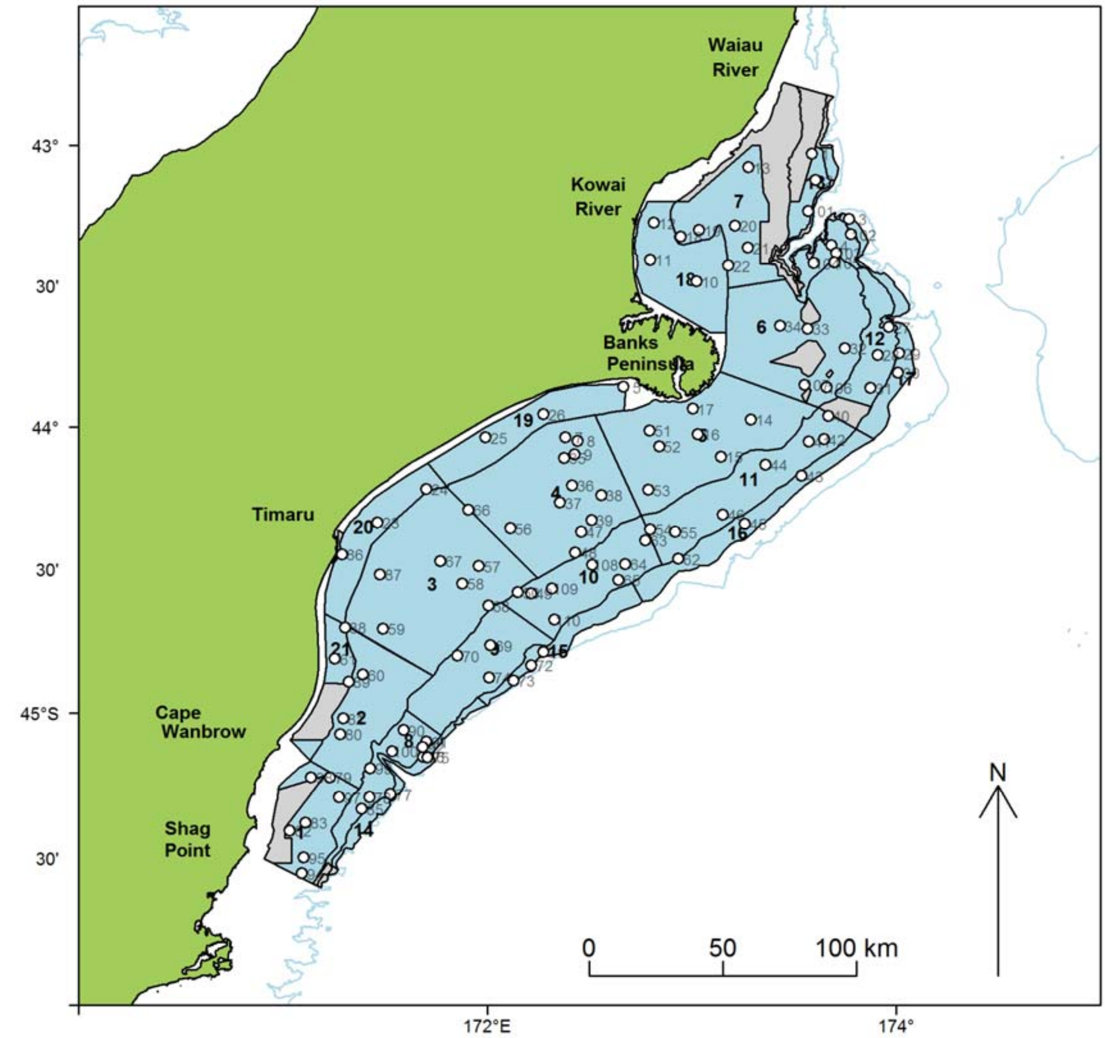



**Figure 2: All valid biomass station and station numbers from the 2018 ECSI survey. Grey areas are foul ground. Outer depth contour is 500 m.**

## Dark ghost shark

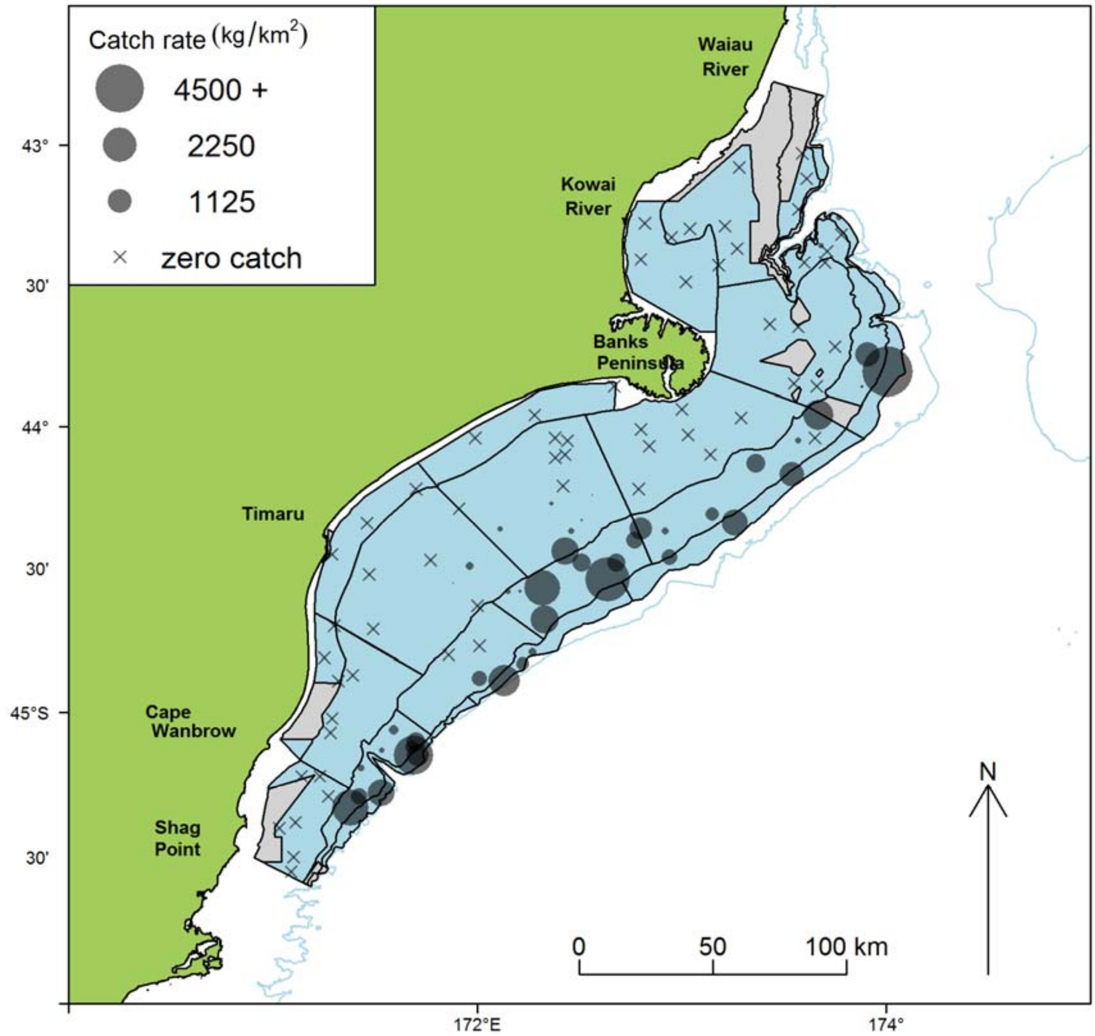



**Figure 3: Catch rates (kg.km$^{-2}$) of eight target species for the 2018 ECSI survey. The legend indicates the circle size that corresponds to three catch rates; on the figure, circle size is continuous and proportional to the catch rate. Crosses indicate no catch of the given species at that station. Grey areas are foul ground. The depth contour is 500 m.**

## Elephantfish

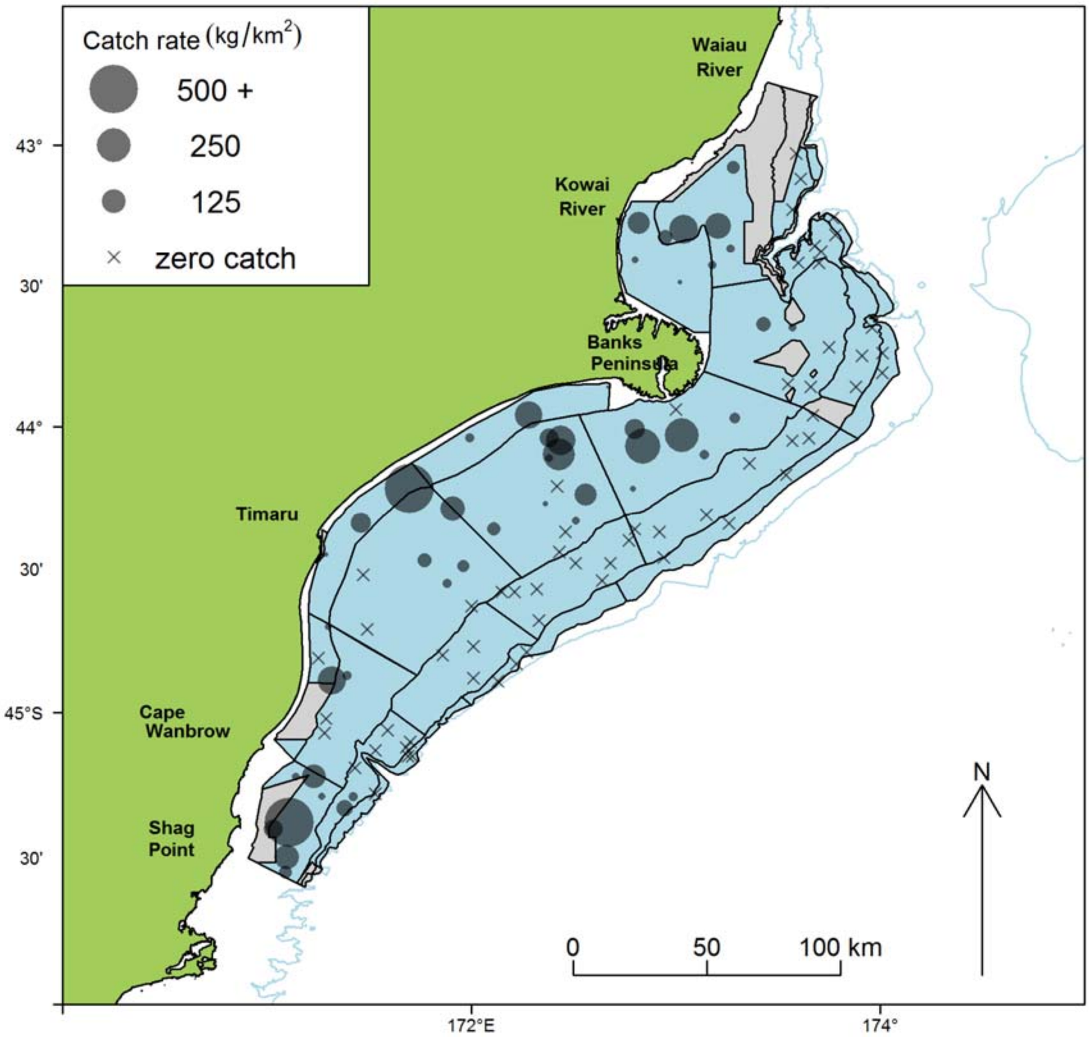



**Figure 3–*continued***

## Giant stargazer

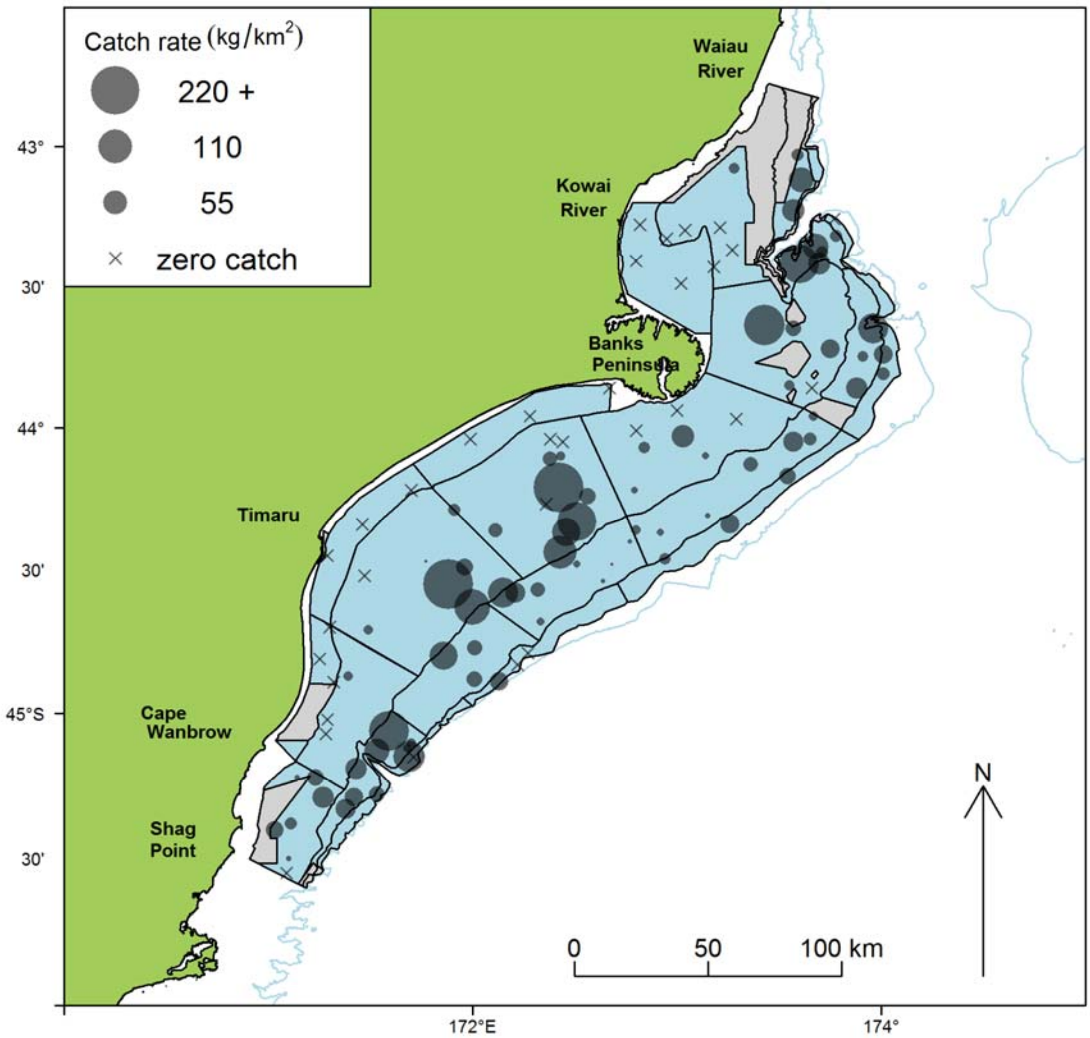



**Figure 3–*continued***

## Red Gurnard

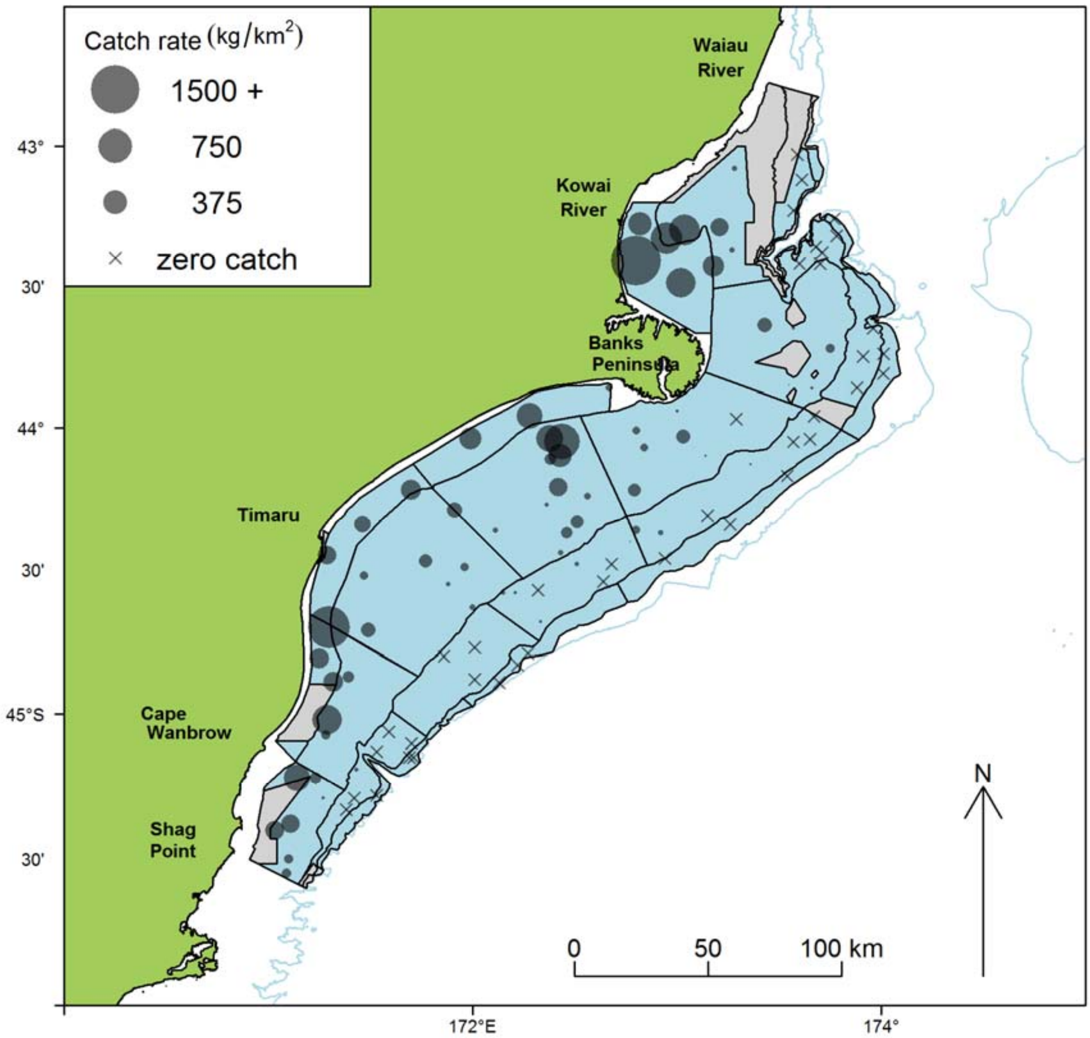



**Figure 3–*continued***

## Red cod

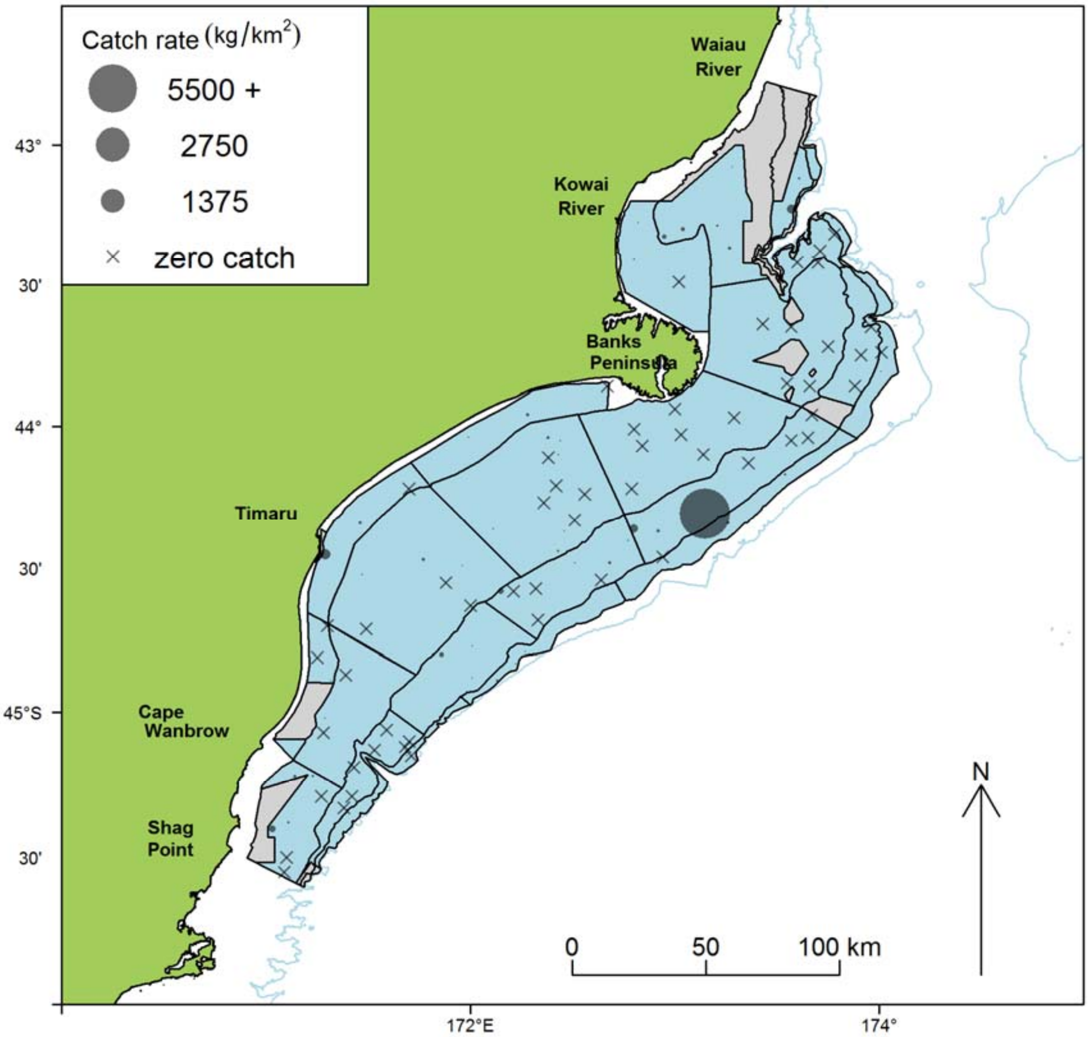



**Figure 3–*continued***

## Sea perch

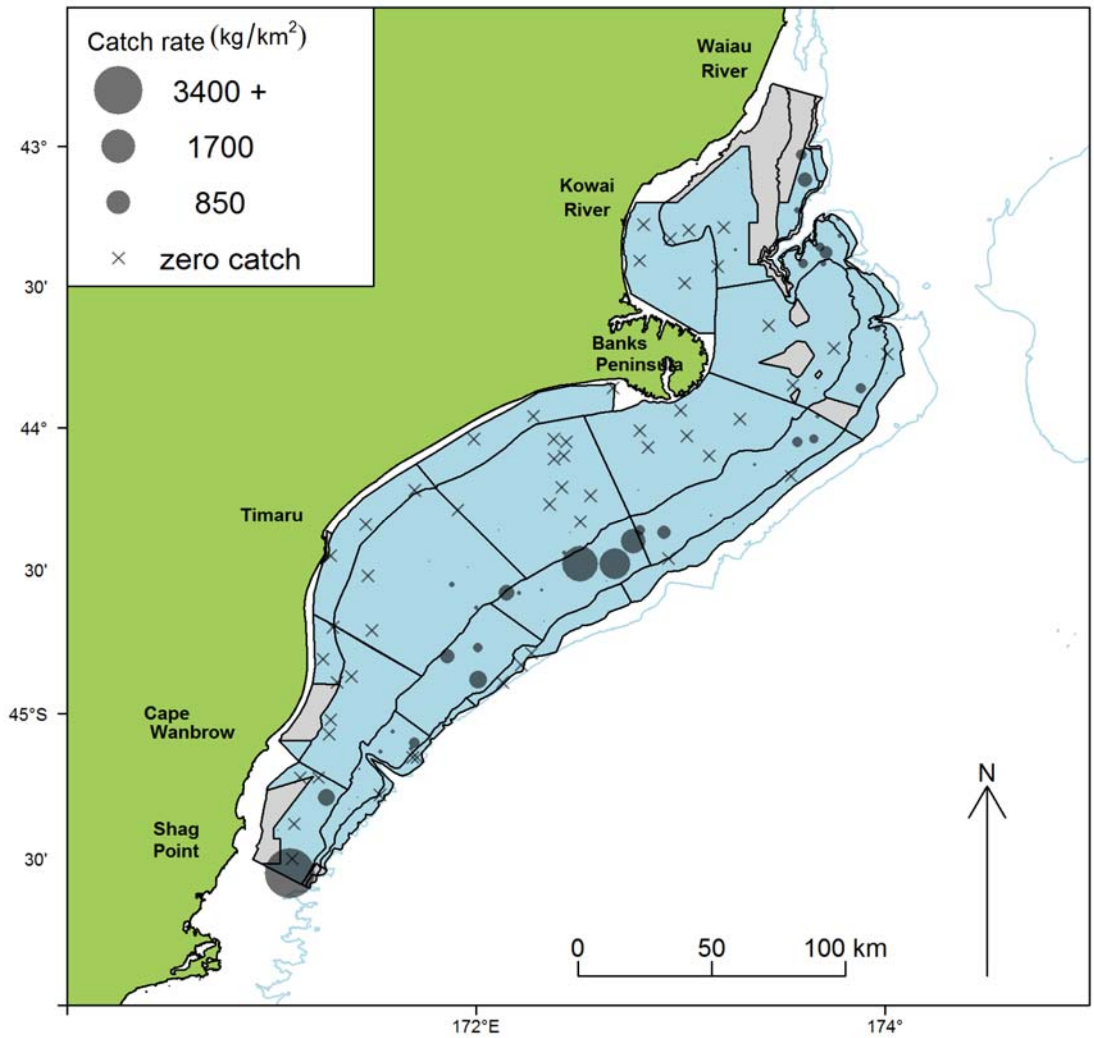



**Figure 3–*continued***

## Spiny dogfish

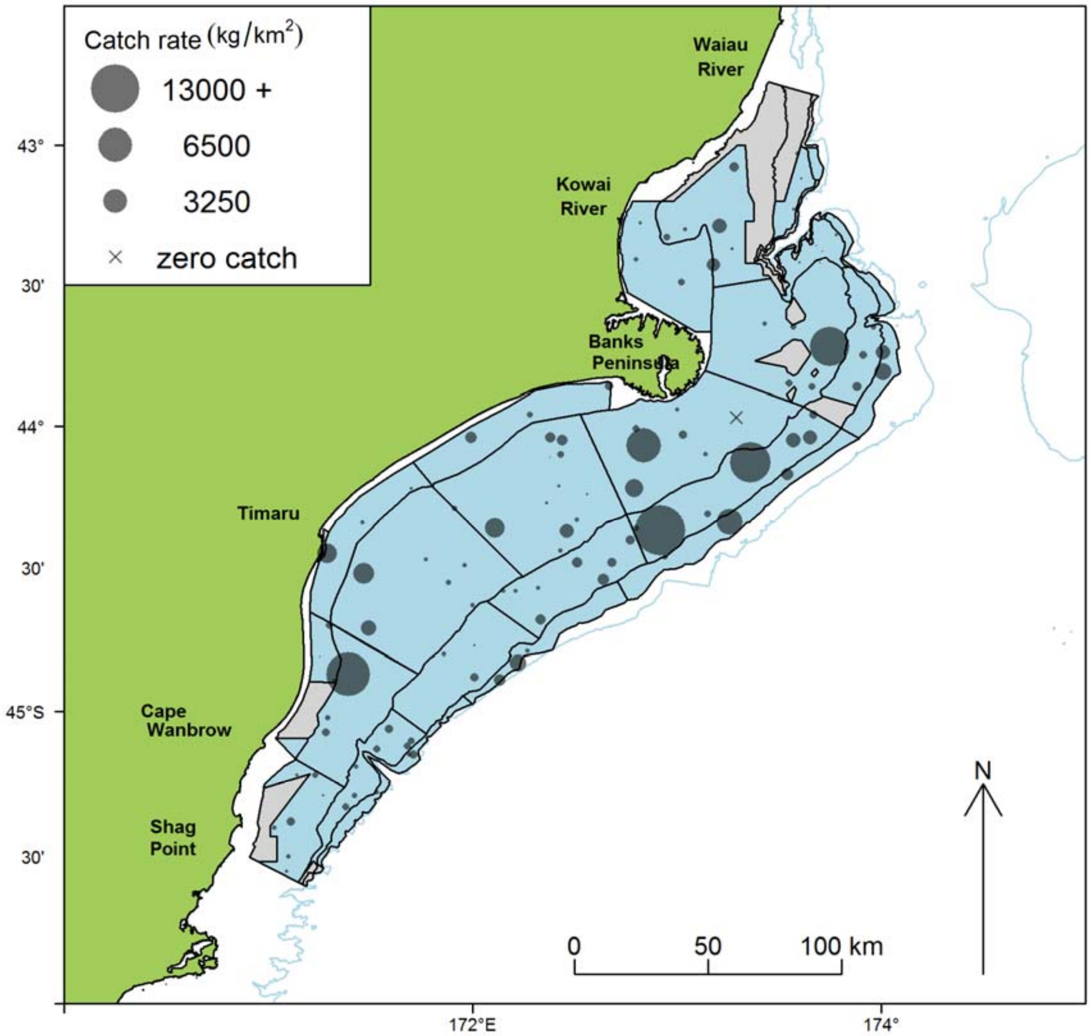



**Figure 3–*continued***

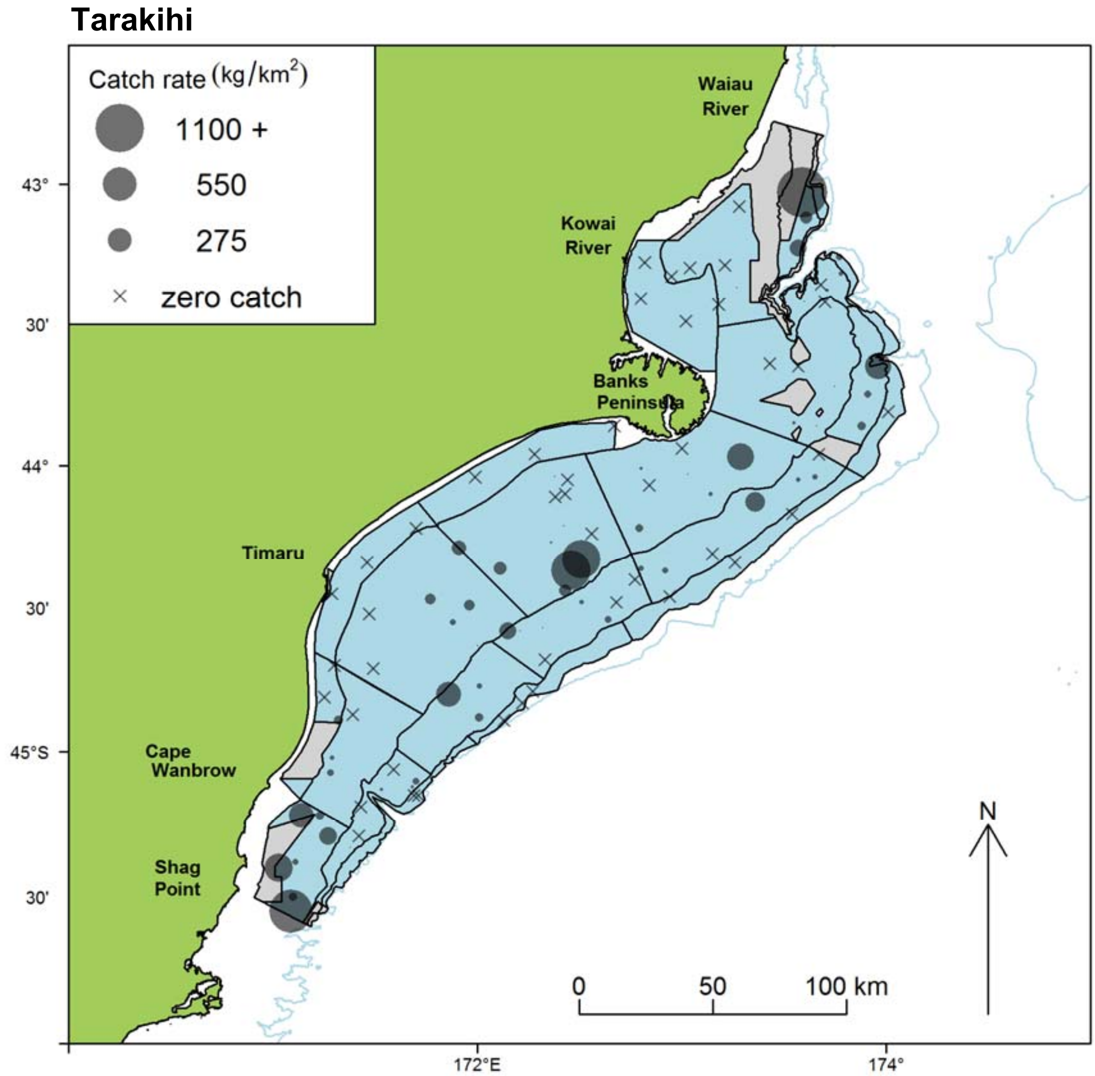
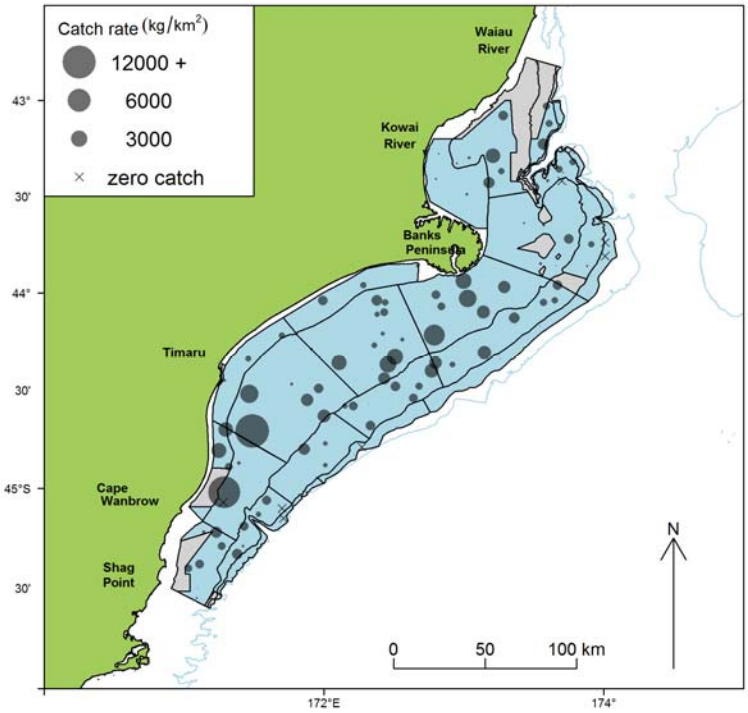



**Figure 3–*continued***

Barracouta




Lemon sole

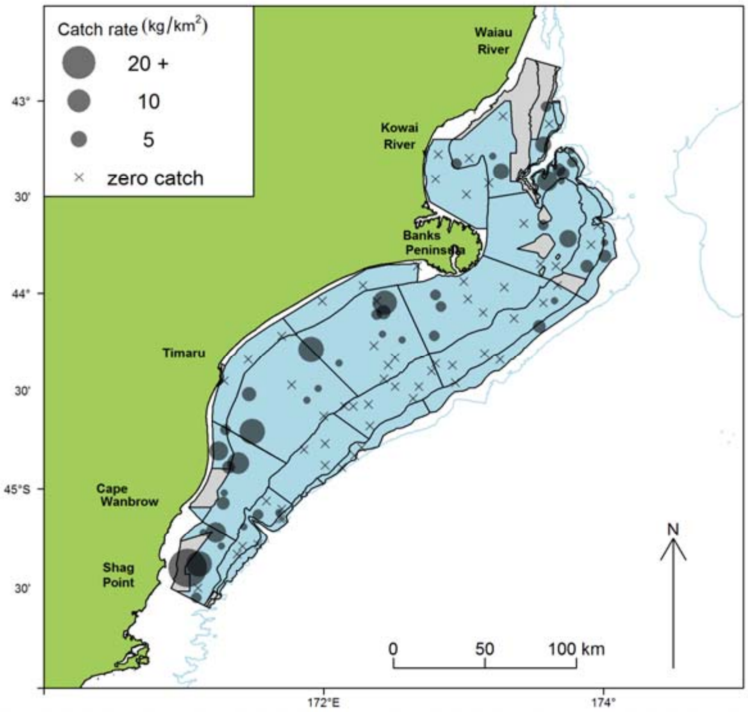
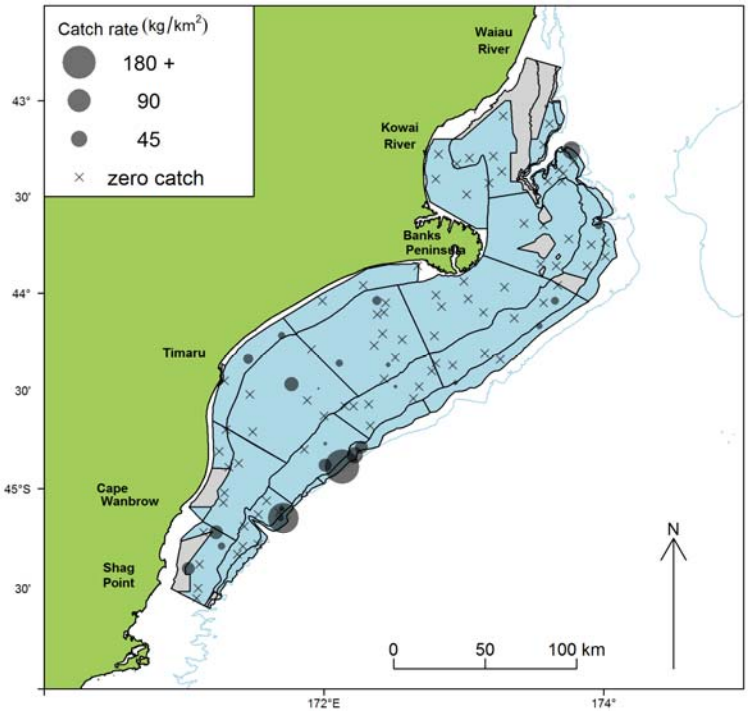



**Figure 4: Catch rates (kg.km$^{-2}$) of eight key non-target QMS species for the 2018 ECSI survey. The legend indicates the circle size that corresponds to three catch rates; on the figure, circle size is continuous and proportional to the catch rate. Crosses indicate no catch at that station. Grey areas are foul ground. The depth contour is 500 m.**

## Ling




## Rig

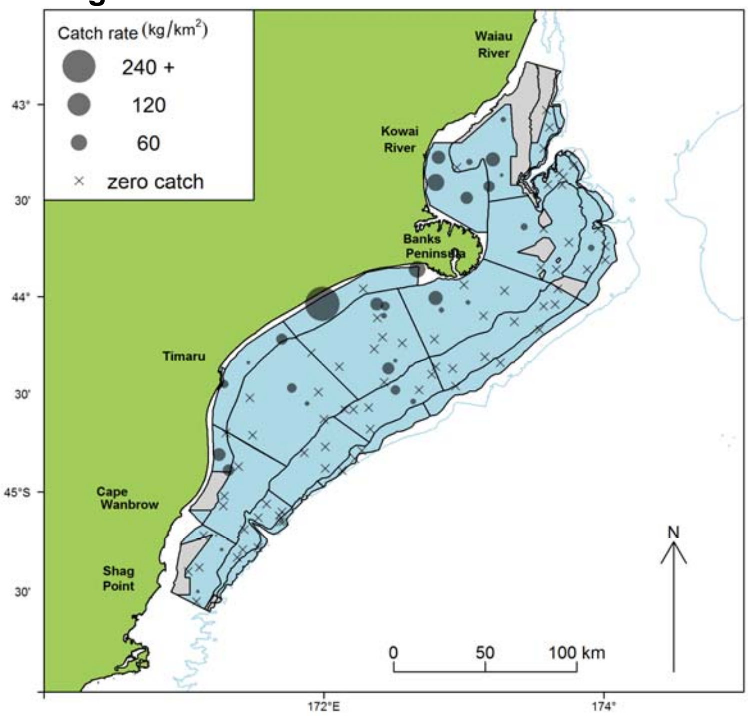
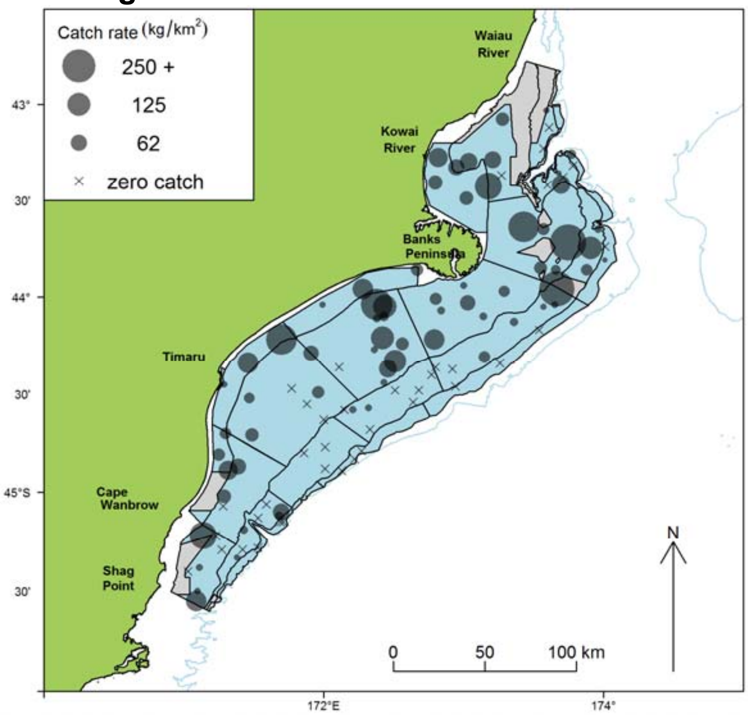



**Figure 4–*continued***

## Rough skate




## School shark

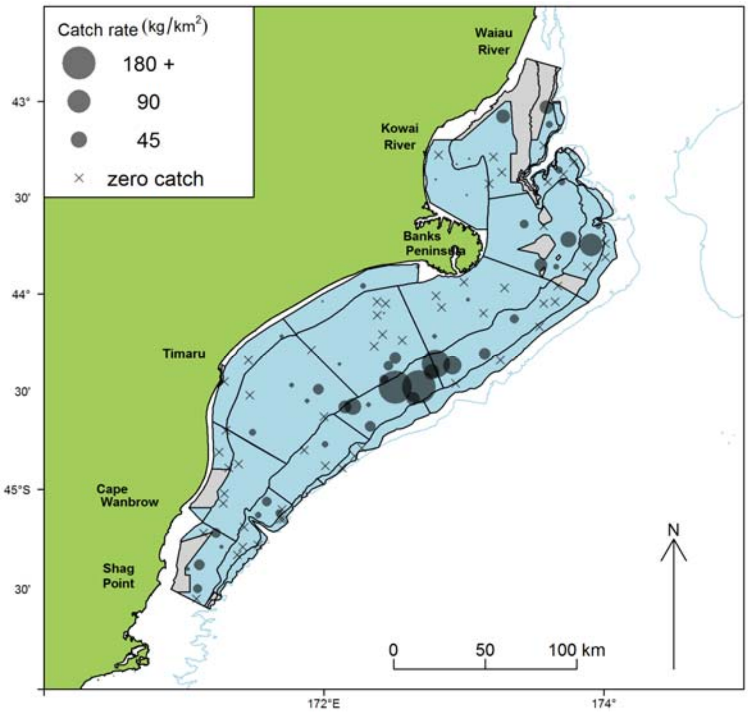
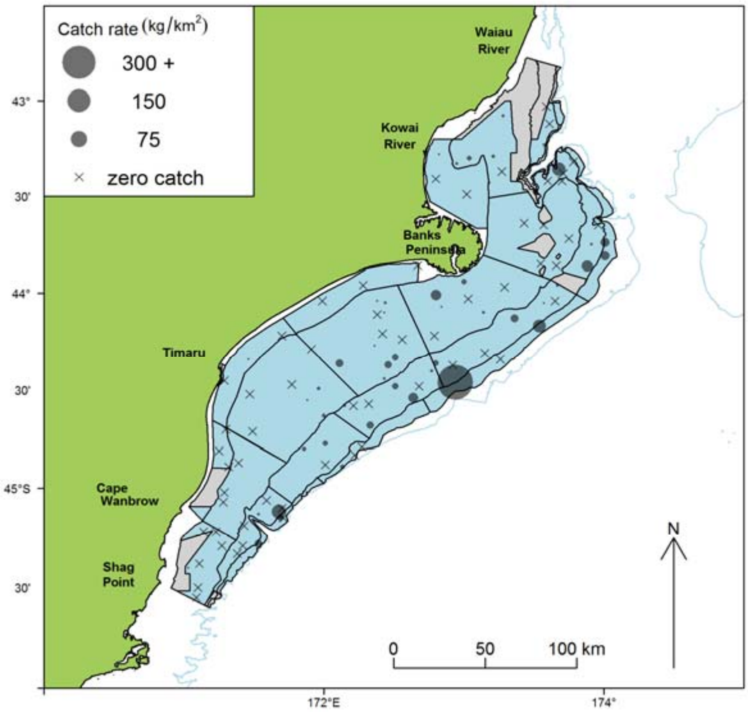



**Figure 4–*continued***

## Silver warehou




## Smooth skate

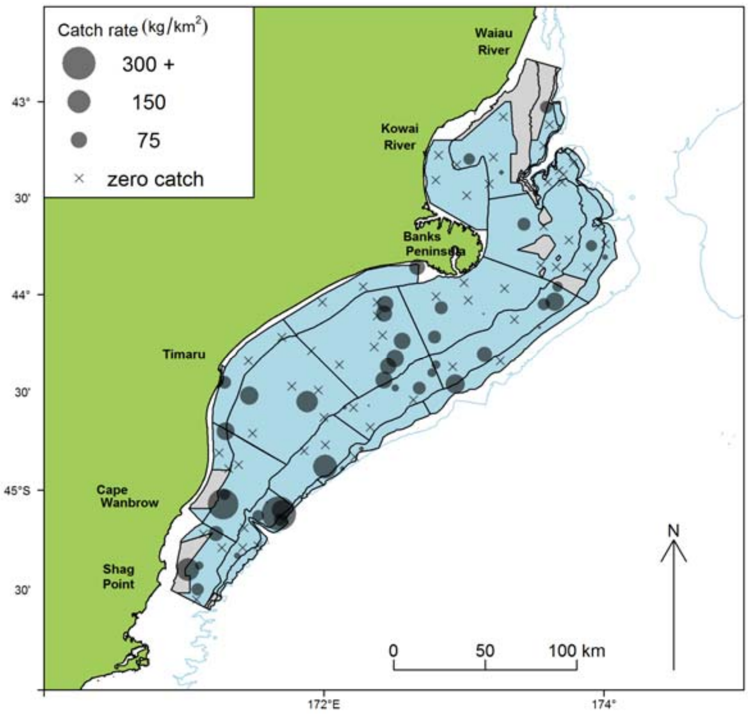



**Figure 4–*continued***

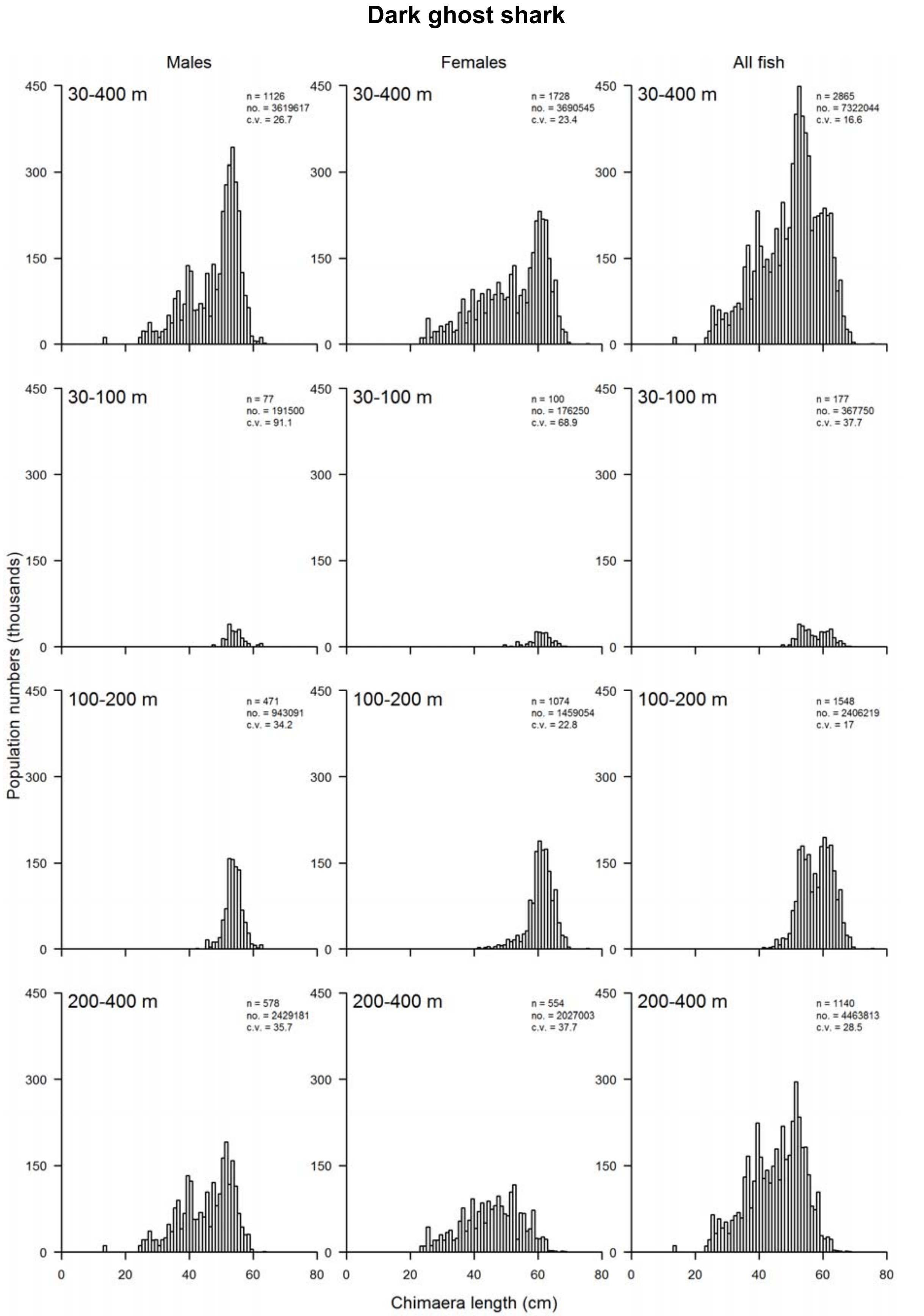



**Figure 5: Scaled length frequency distributions for the target species by depth range for the 2018 survey. Population estimates for each species are in the units given on the y-axis. The 'All fish' length distribution includes unsexed fish. n, number of fish sampled; no., scaled number of fish; C.V. (%).**

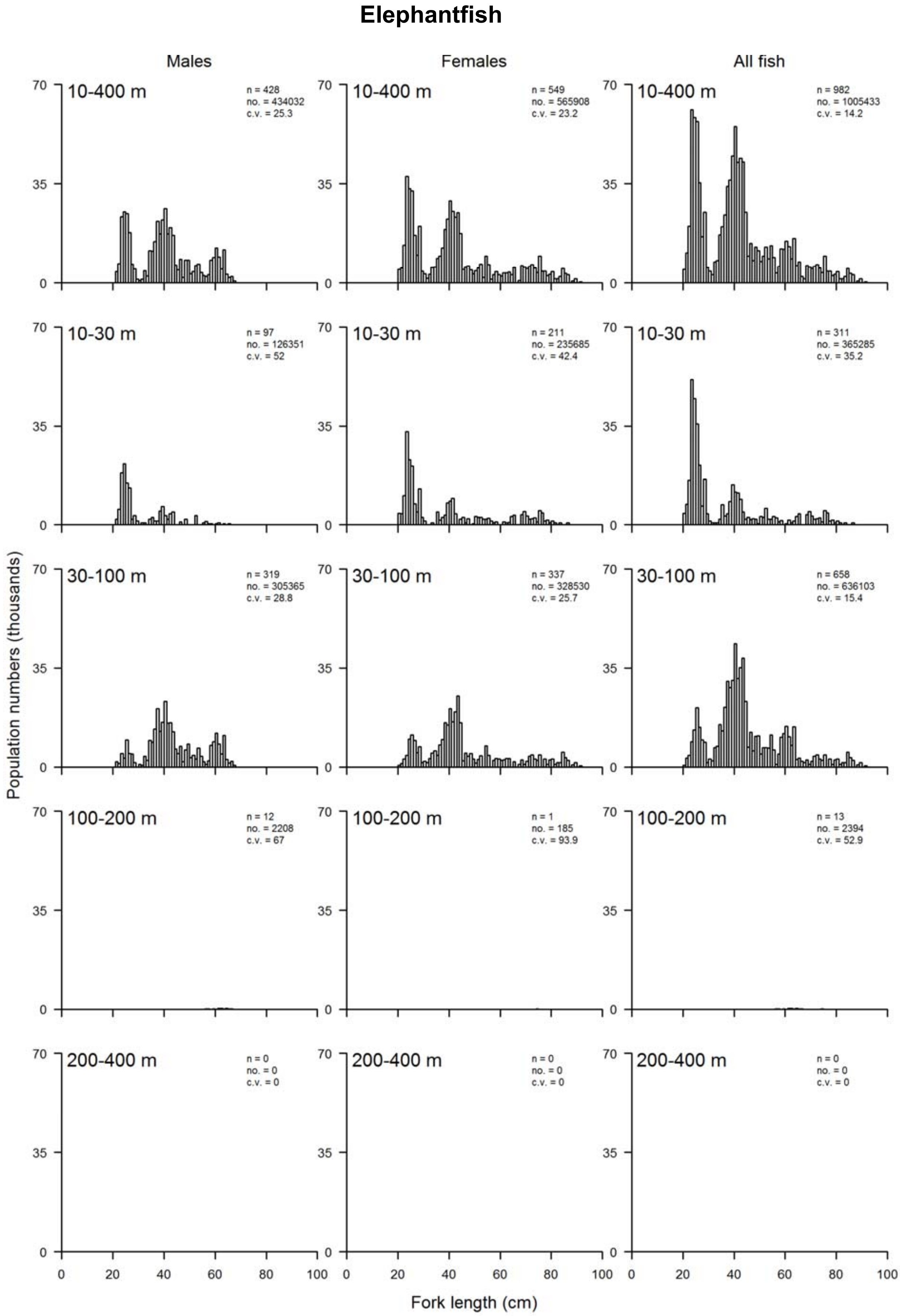



**Figure 5–*continued***

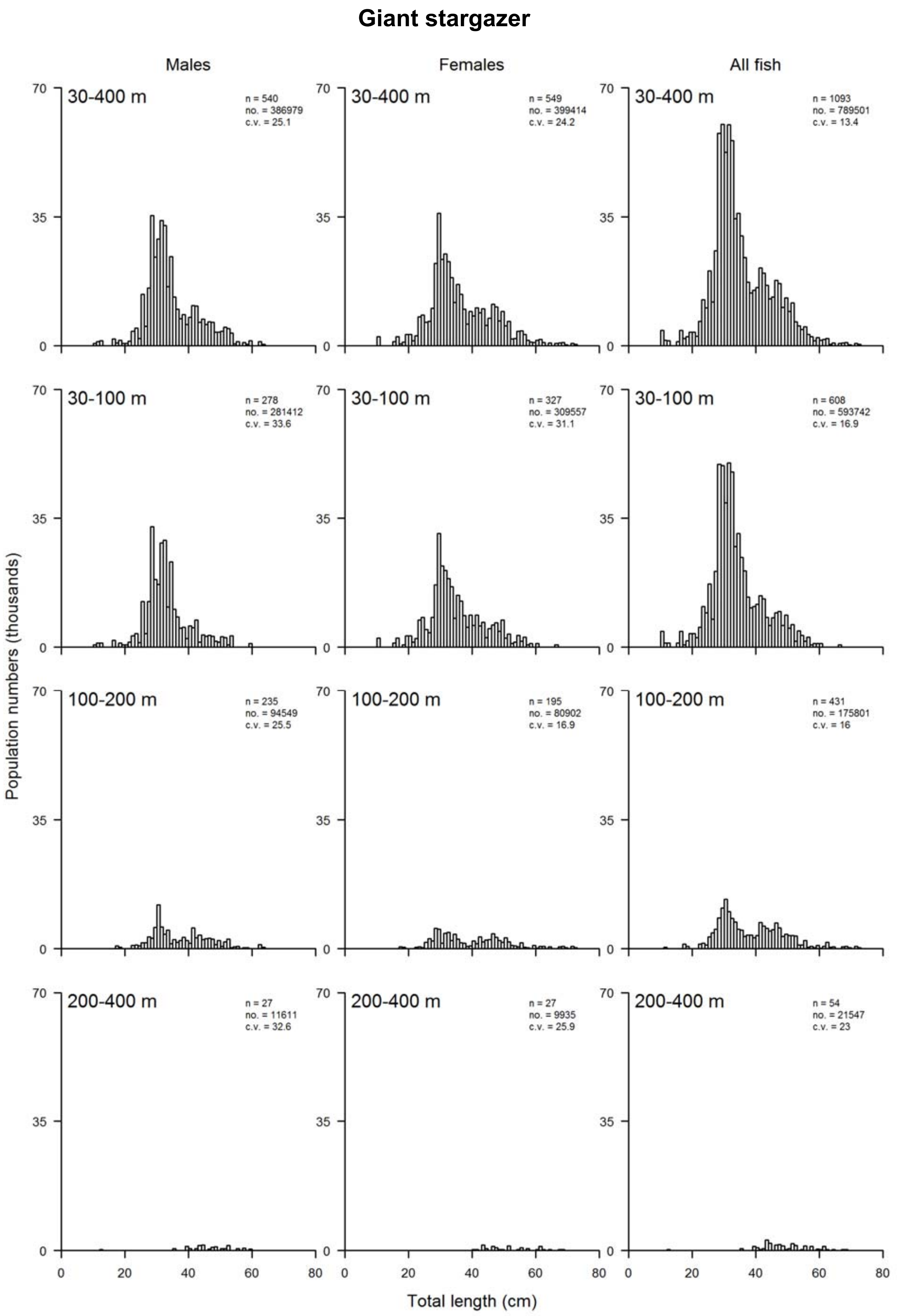



**Figure 5–*continued***

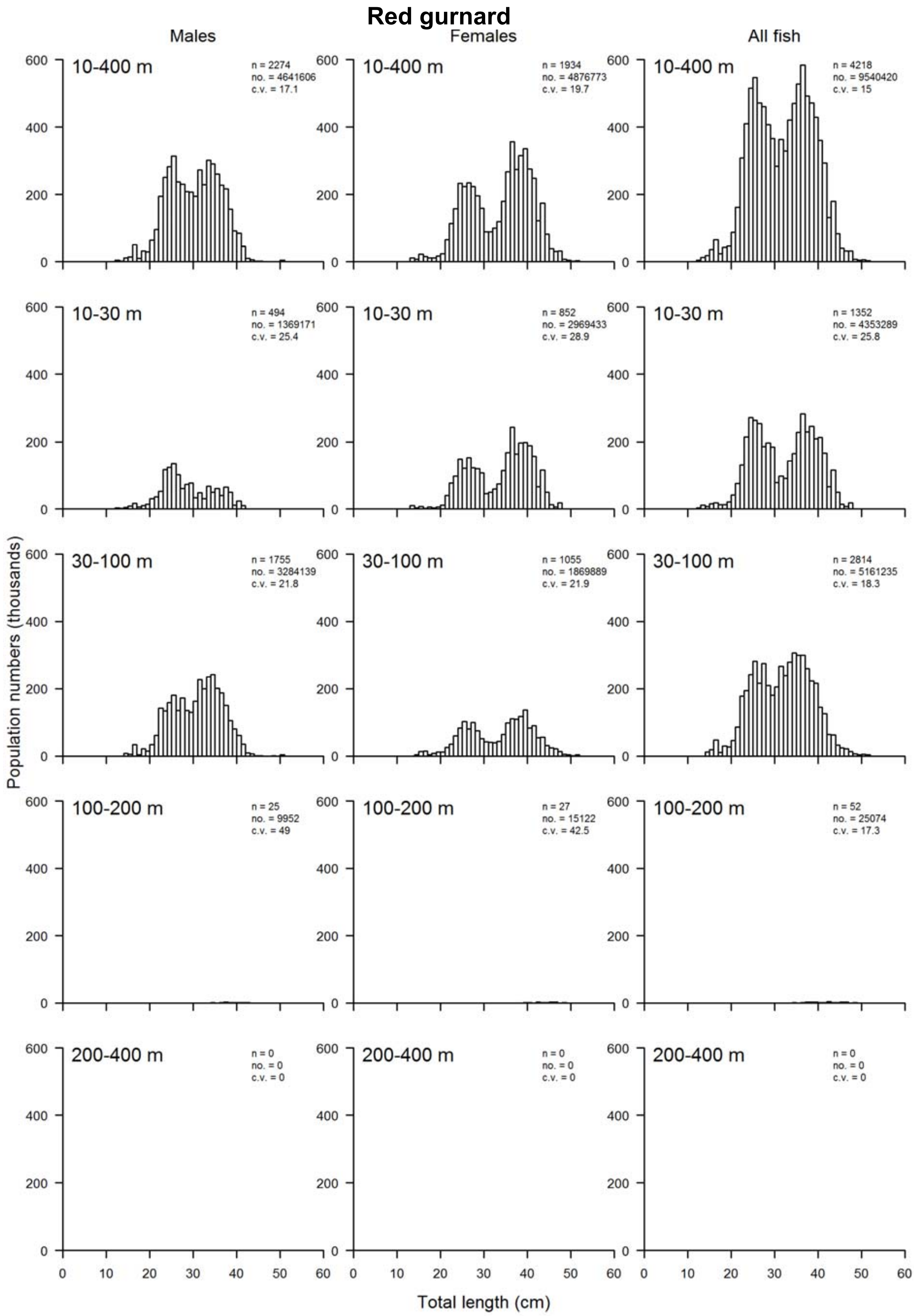



**Figure 5–*continued***

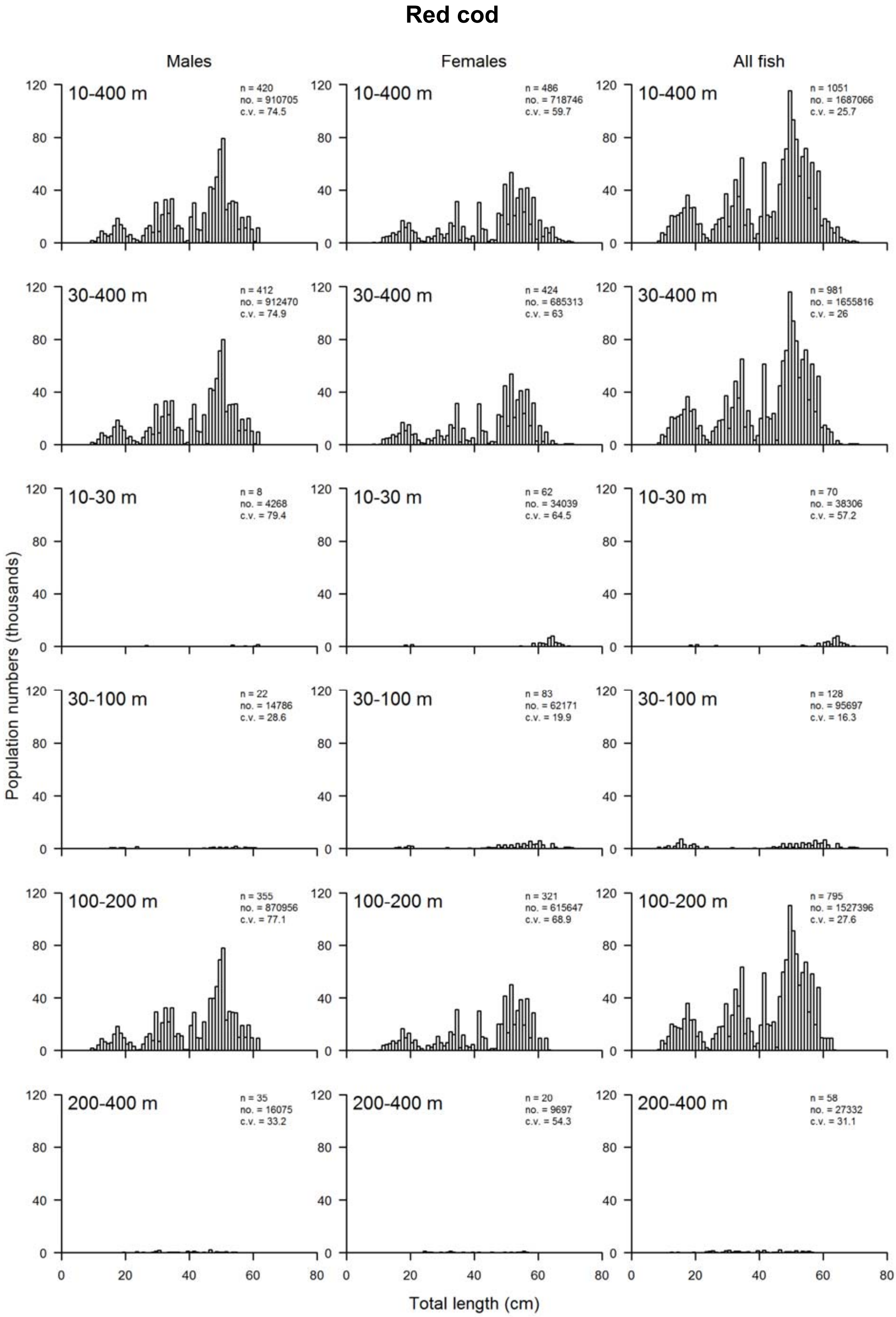



**Figure 5–*continued***

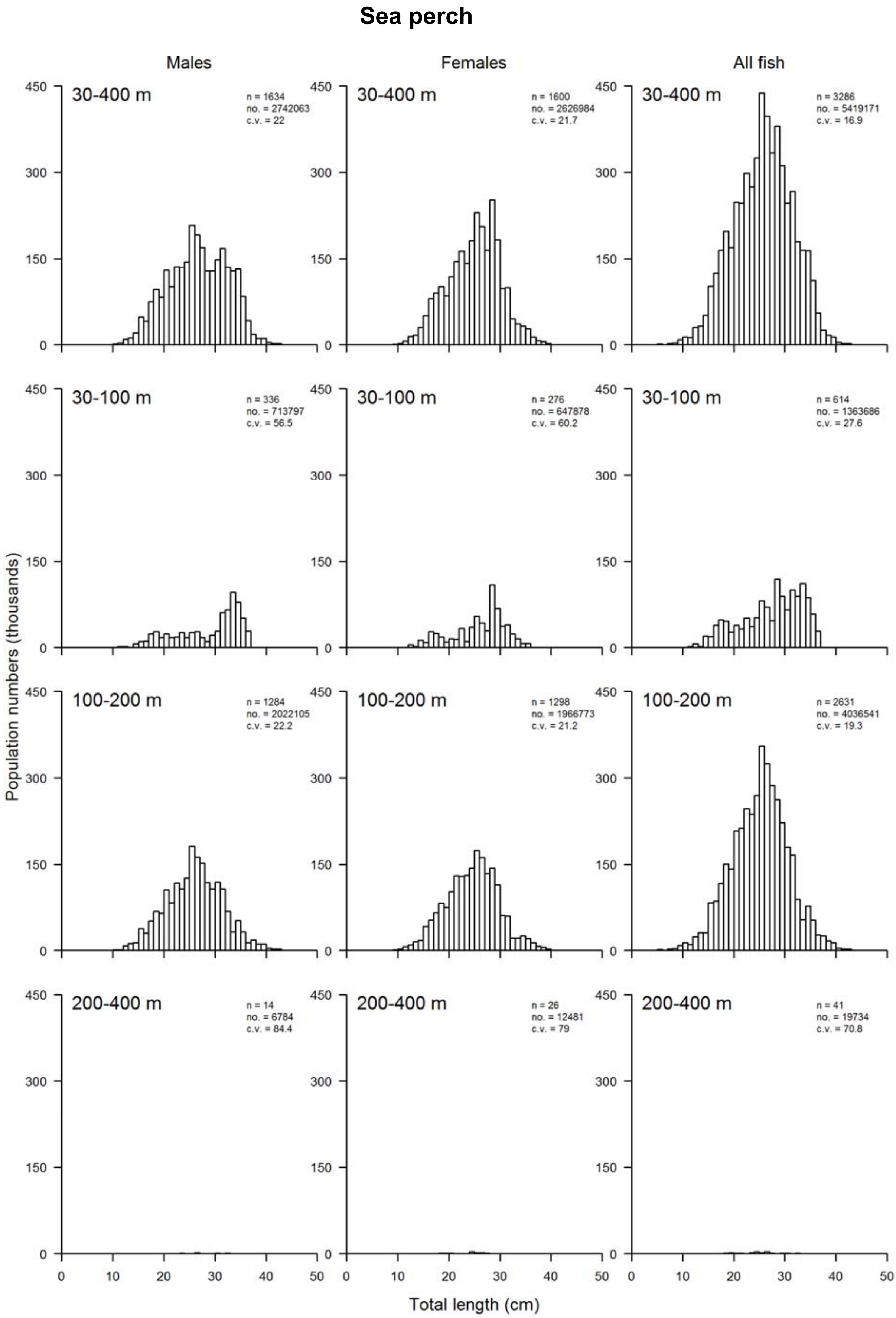



**Figure 5–*continued***

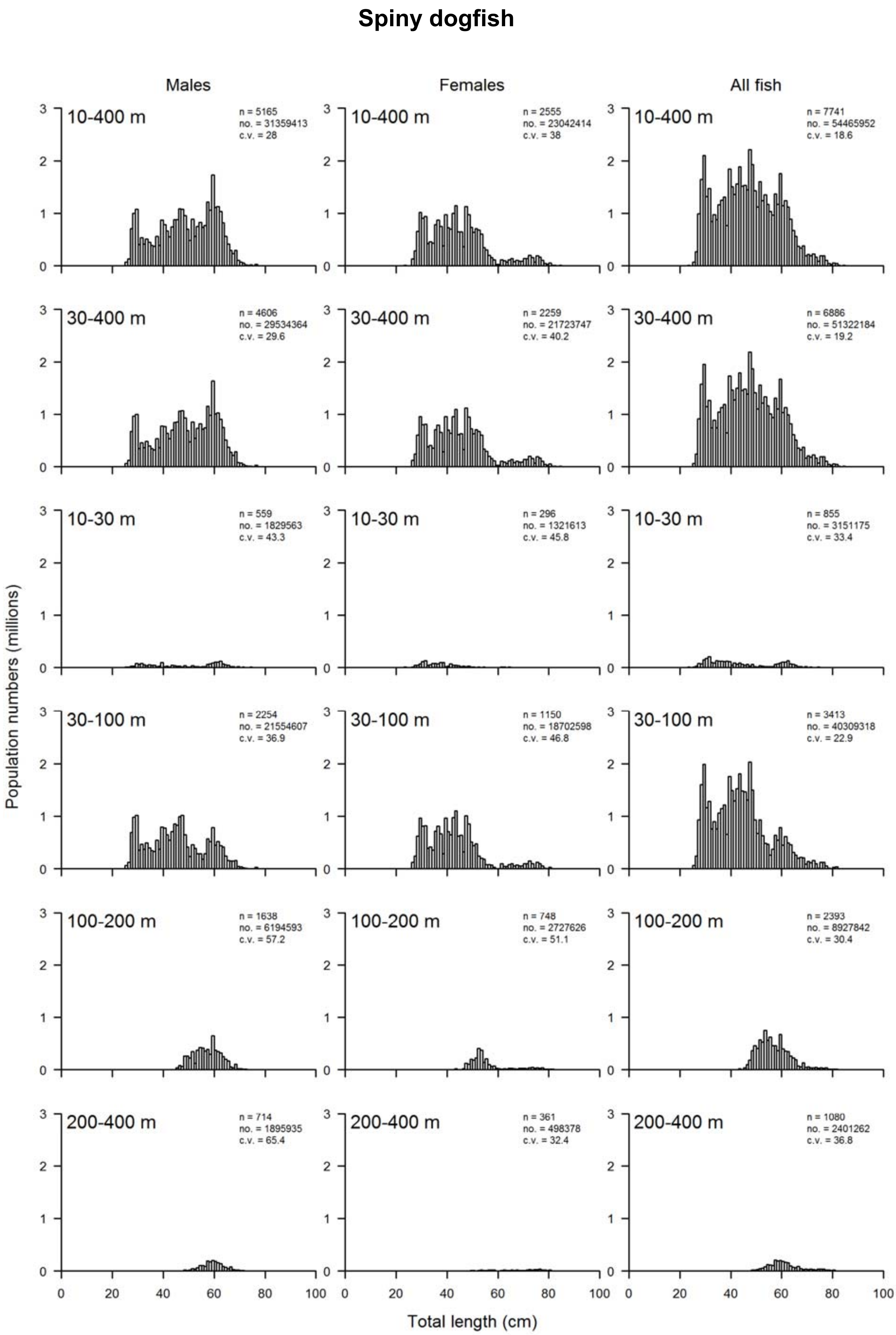



**Figure 5–*continued***

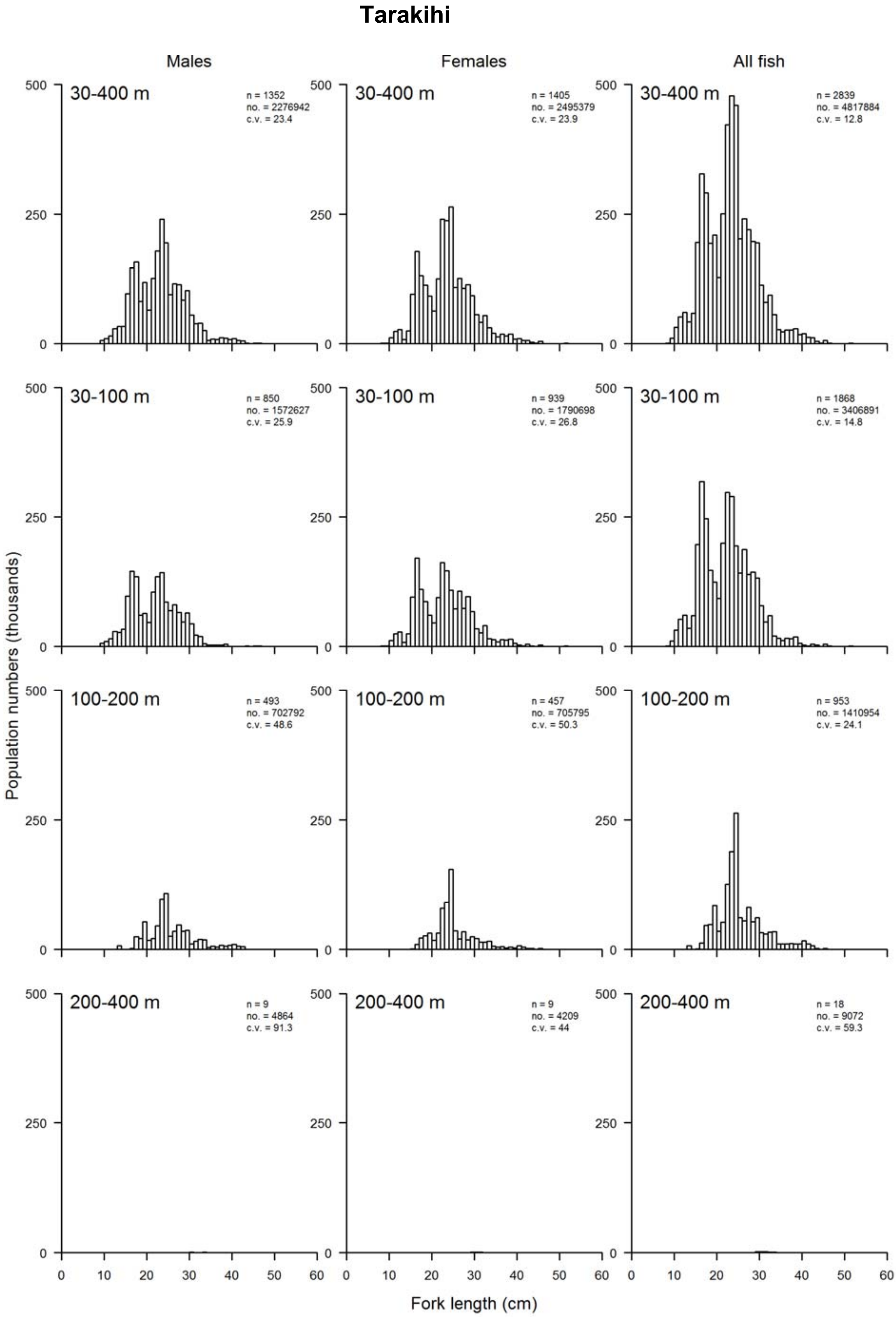
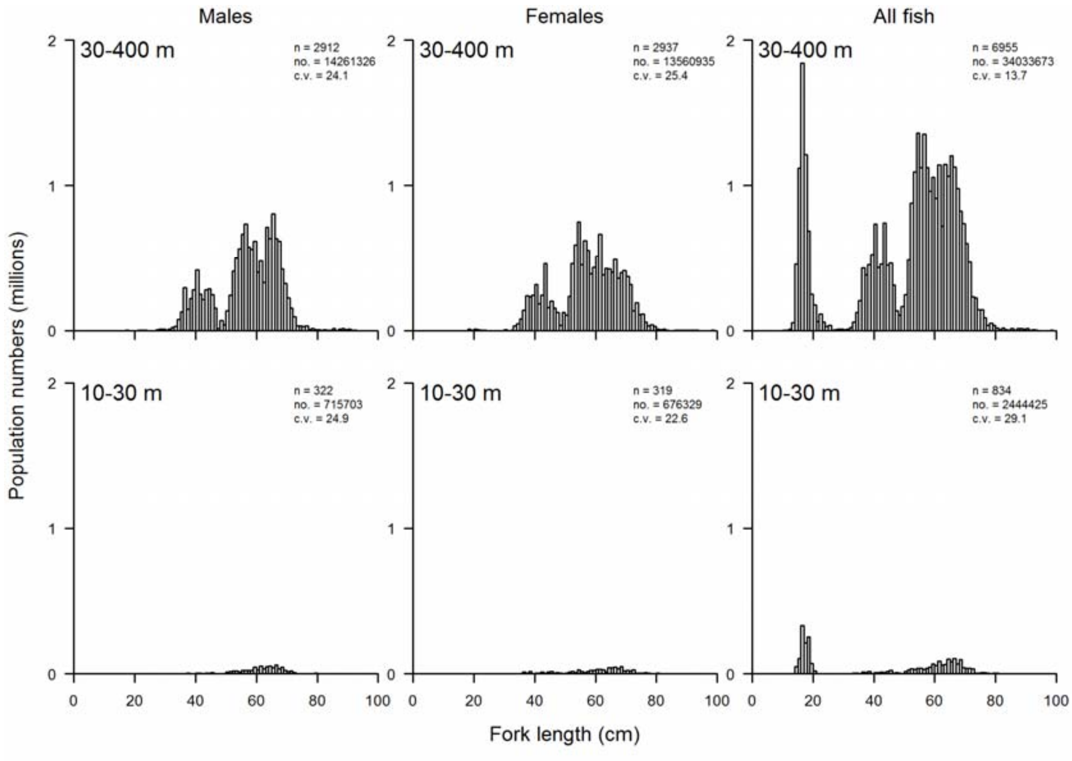



**Figure 5–*continued***

**Barracouta**




**Lemon sole**

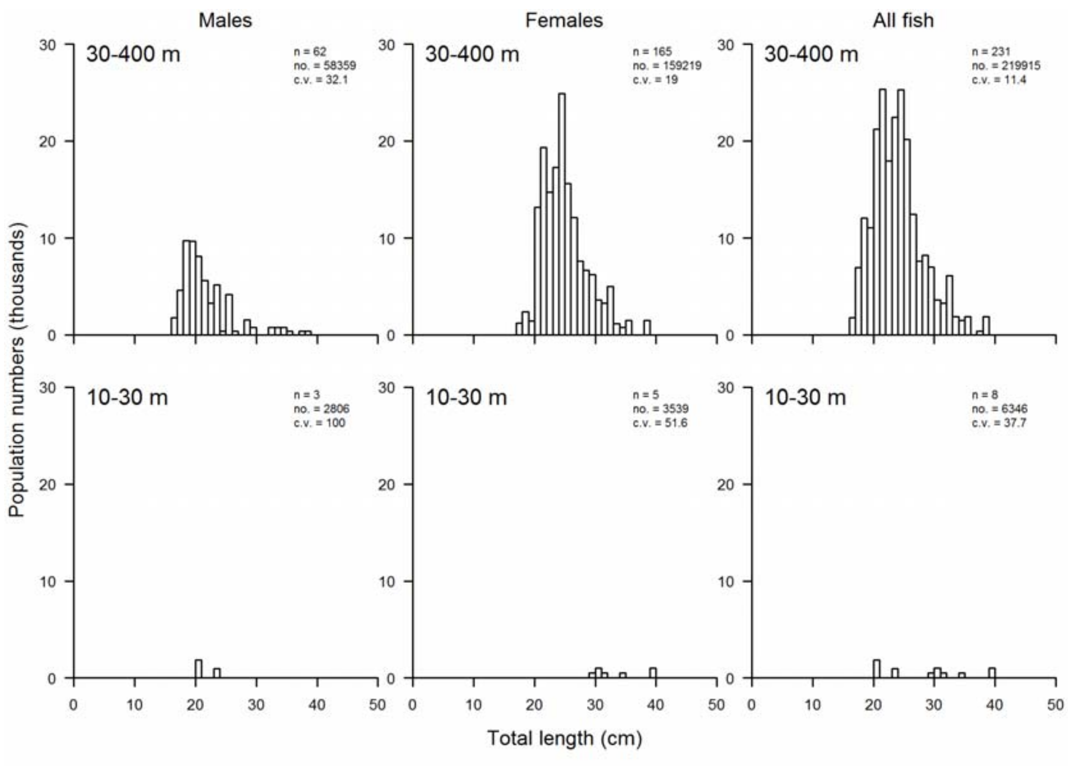
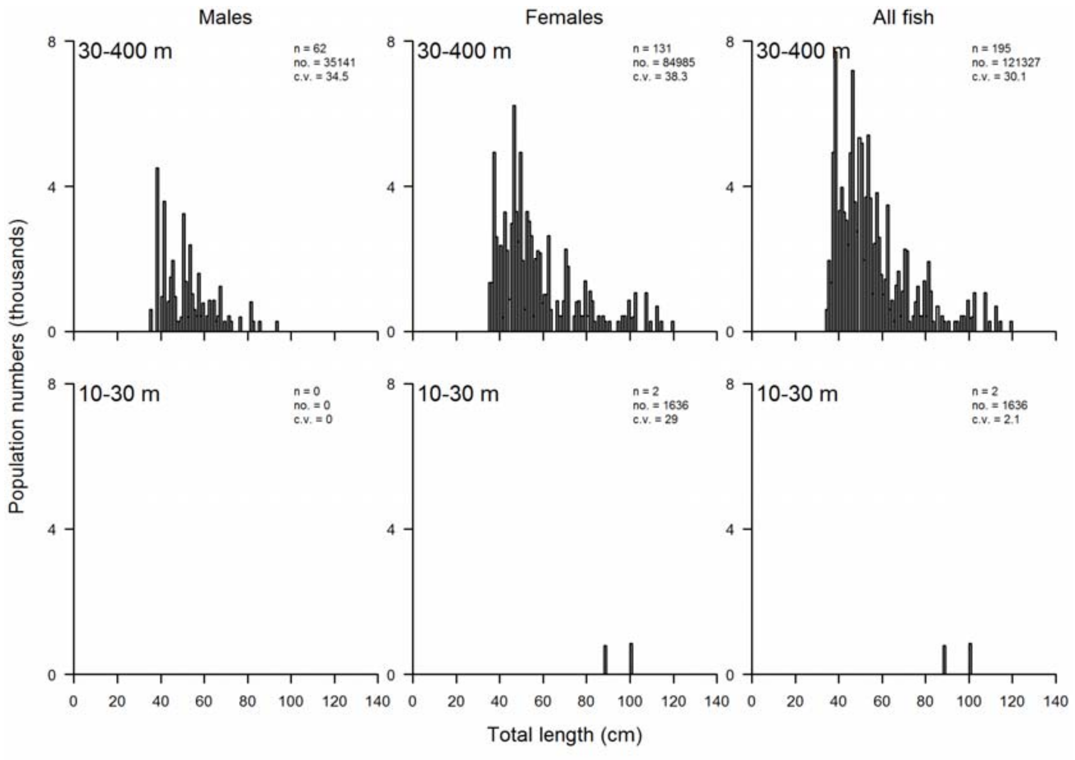



**Figure 6: Scaled length frequency distributions for the key non-target QMS species in 30–400 m, and 10–30 m for the 2018 survey. Population estimates for each species are in the units given on the y-axis. n, number of fish sampled; no., scaled number of fish; C.V. (%).**

## Ling




## Rig

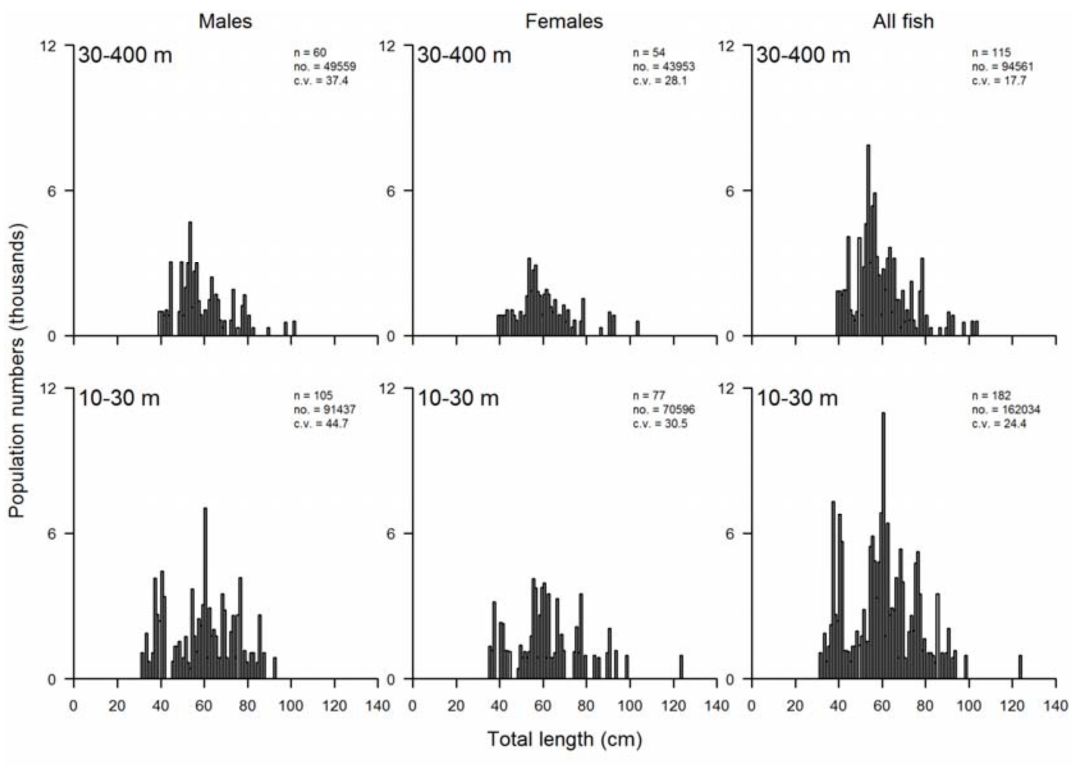
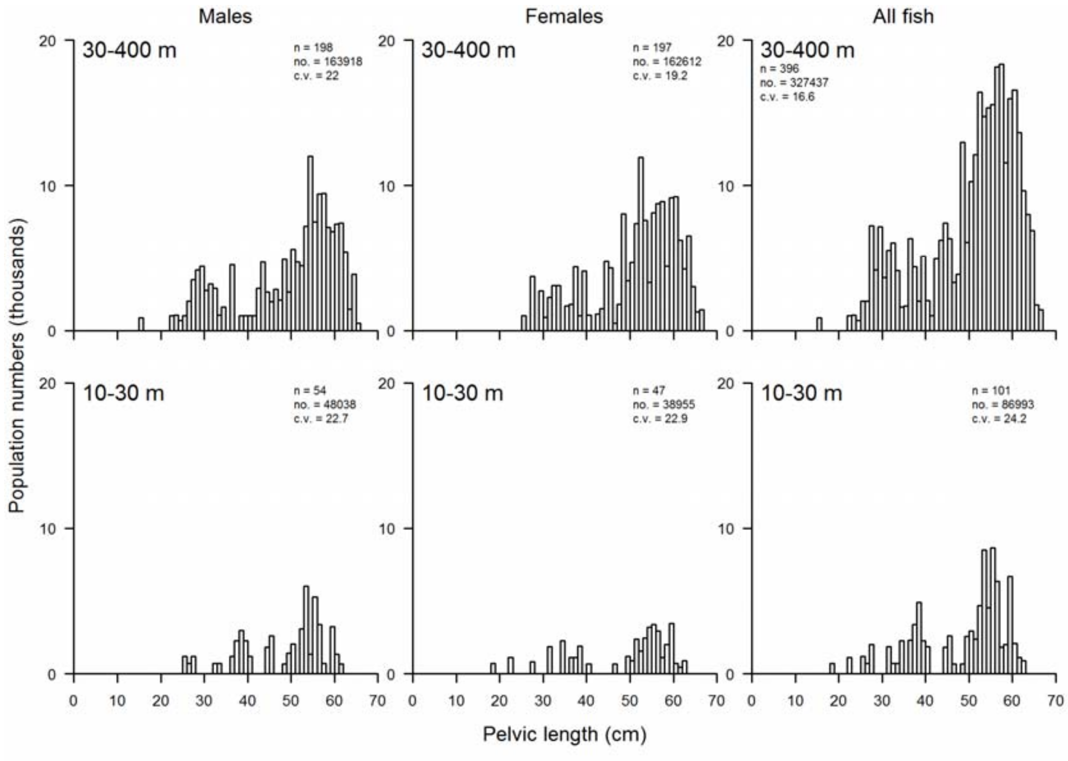



**Figure 6 –** ***continued***

**Rough skate**




**School shark**

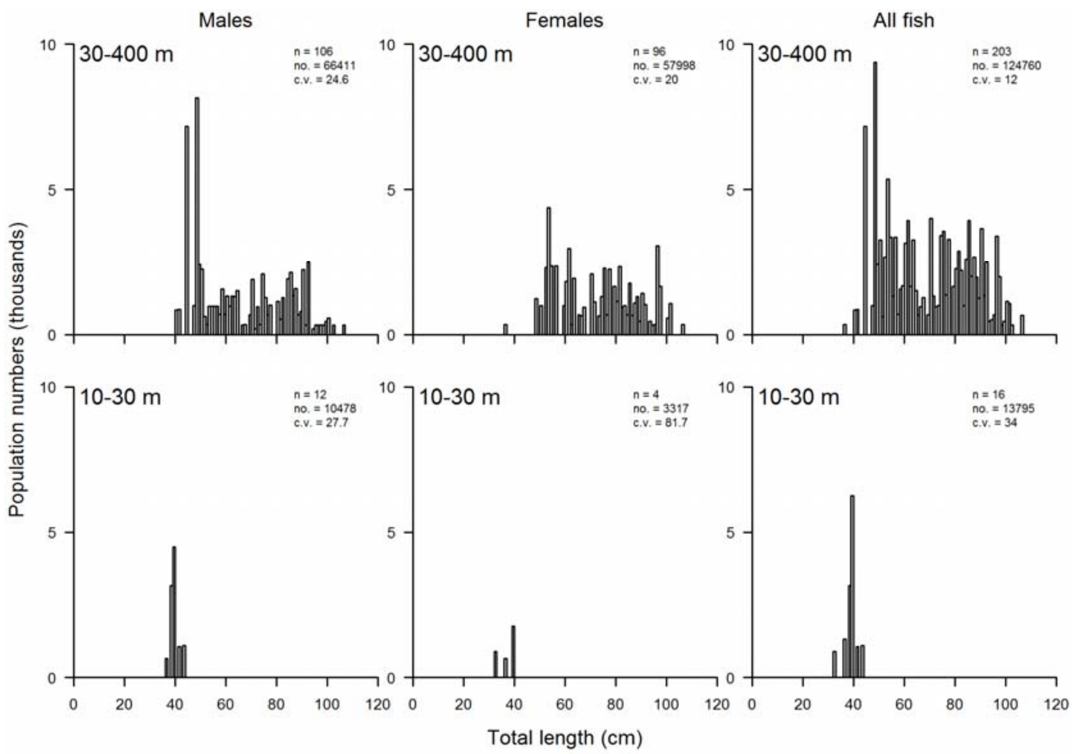
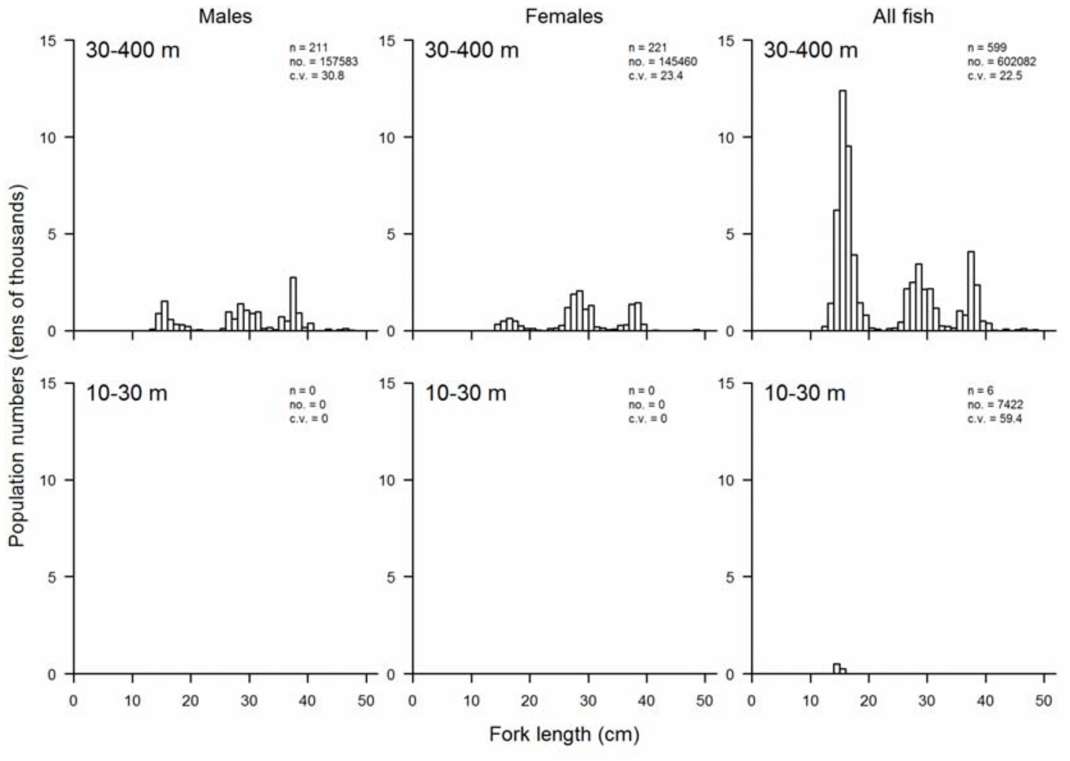



**Figure 6 –** ***continued***

## Silver warehou




## Smooth skate

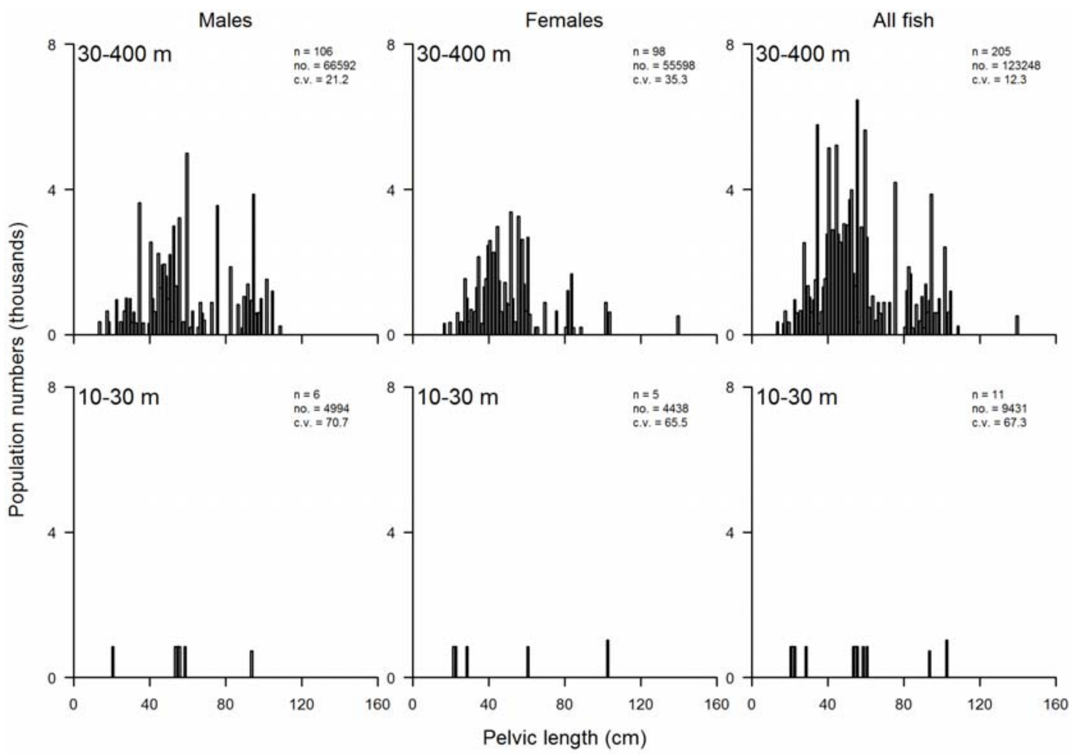
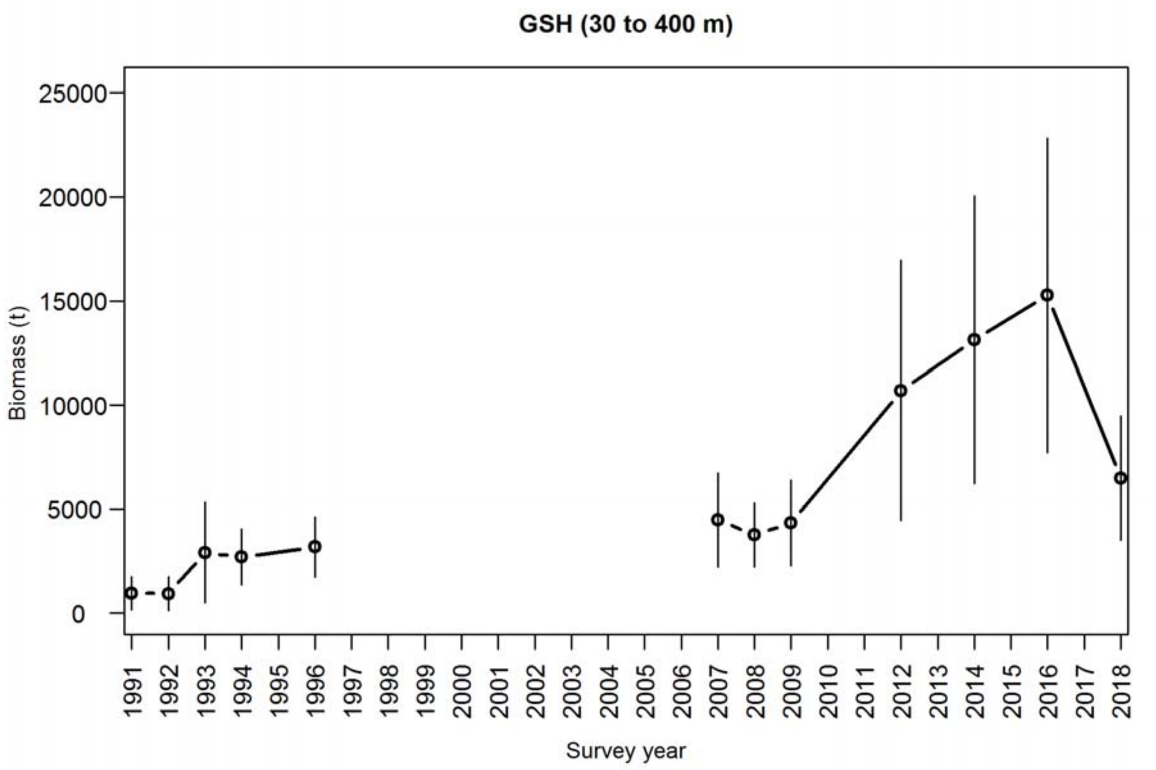



**Figure 6 –** ***continued***



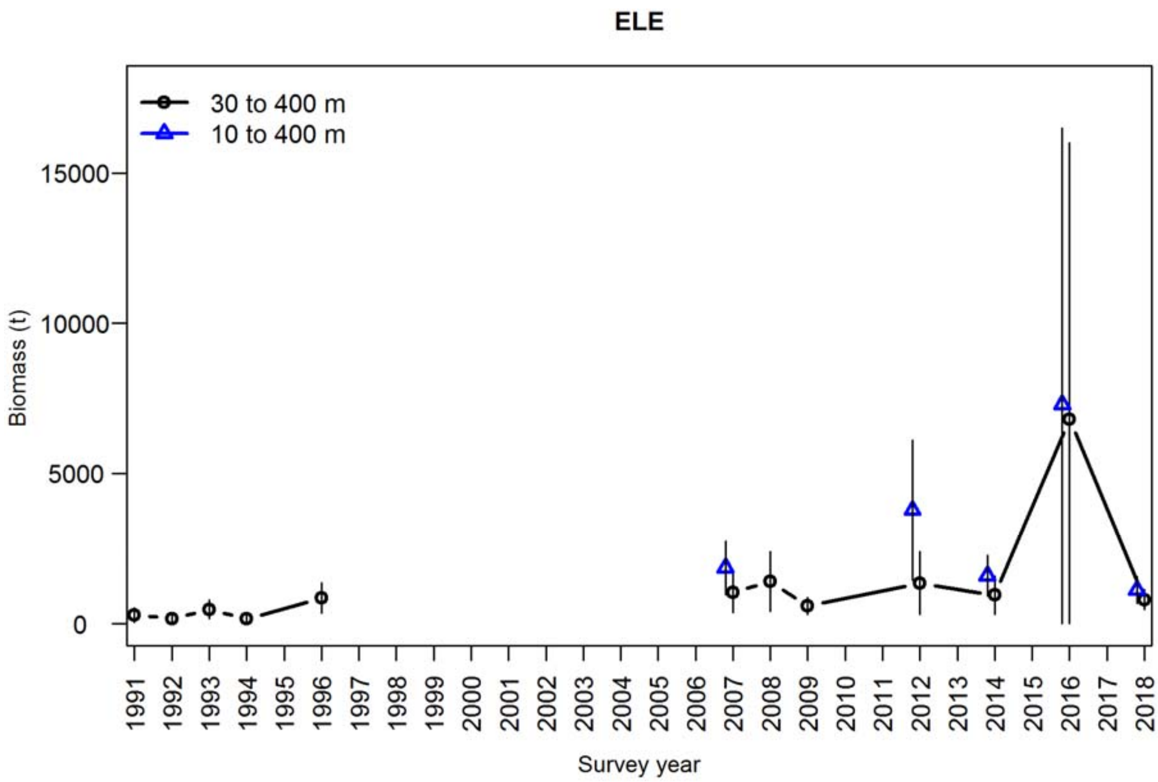
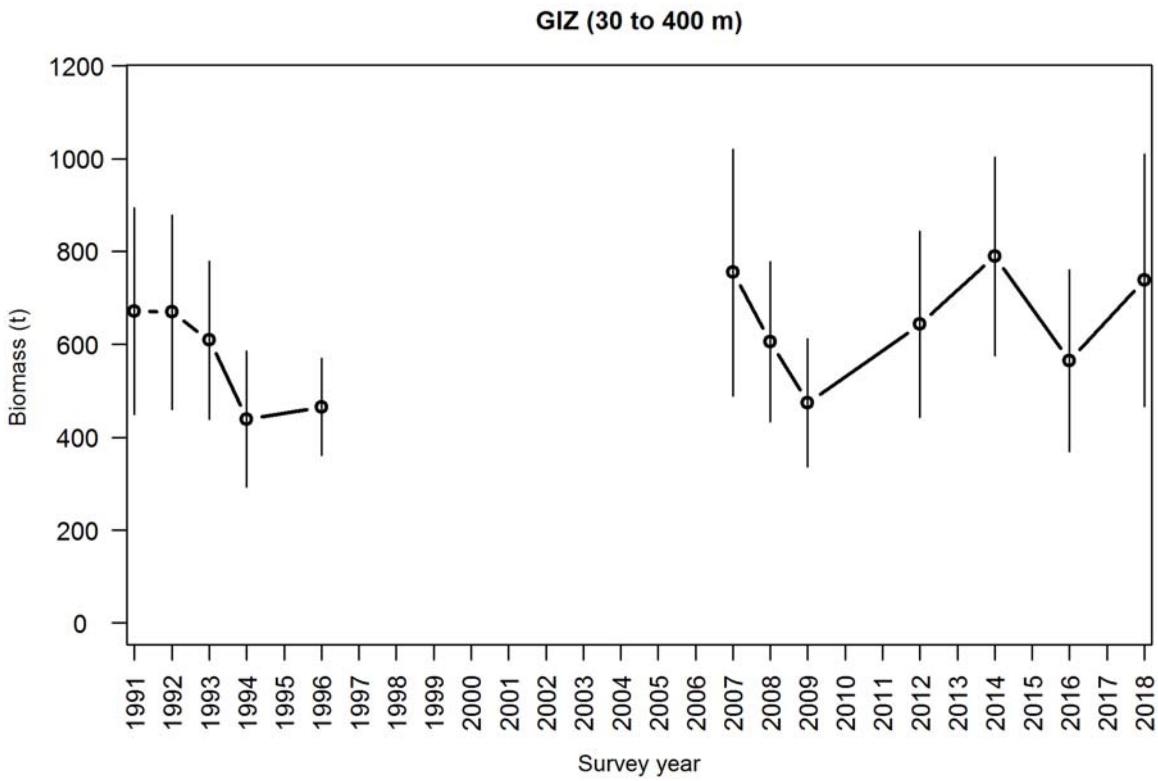




**Figure 7: Target species total biomass for the all ECSI winter surveys in core strata (30–400 m), and core plus shallow strata (10–400 m) for species found in less than 30 m in 2007, 2012, 2014, 2016 and 2018. Error bars are +/- two standard errors.**



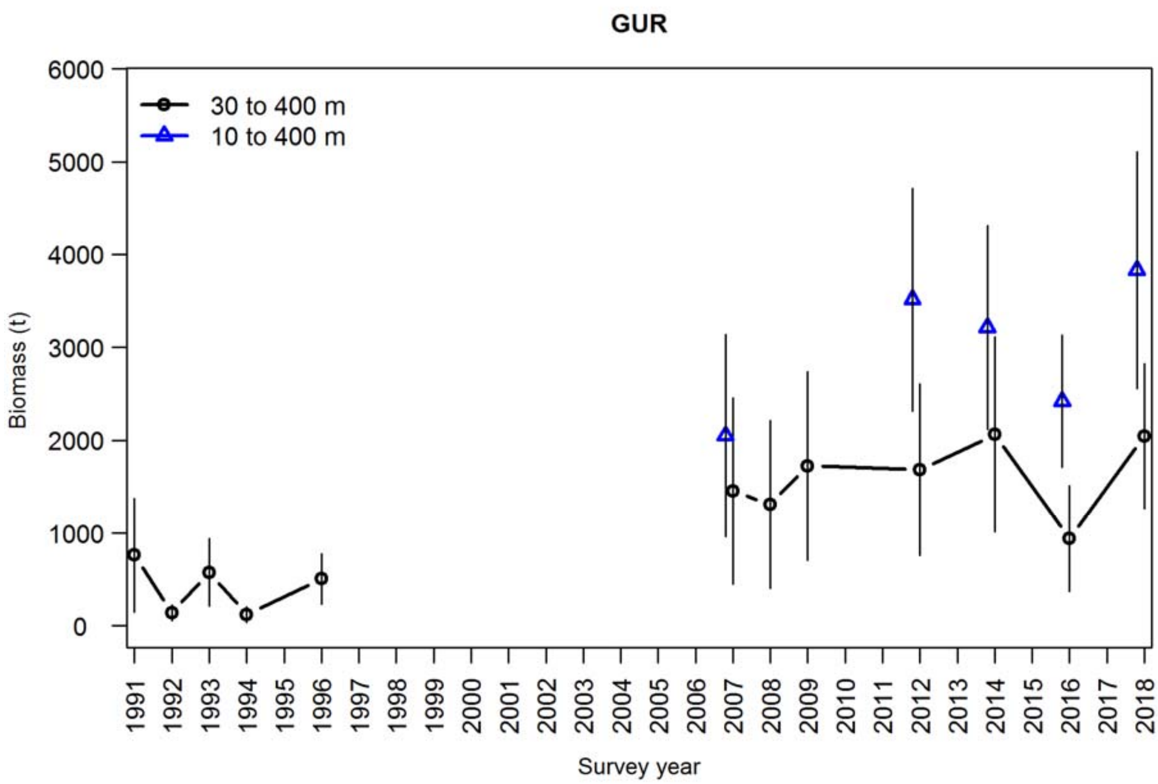
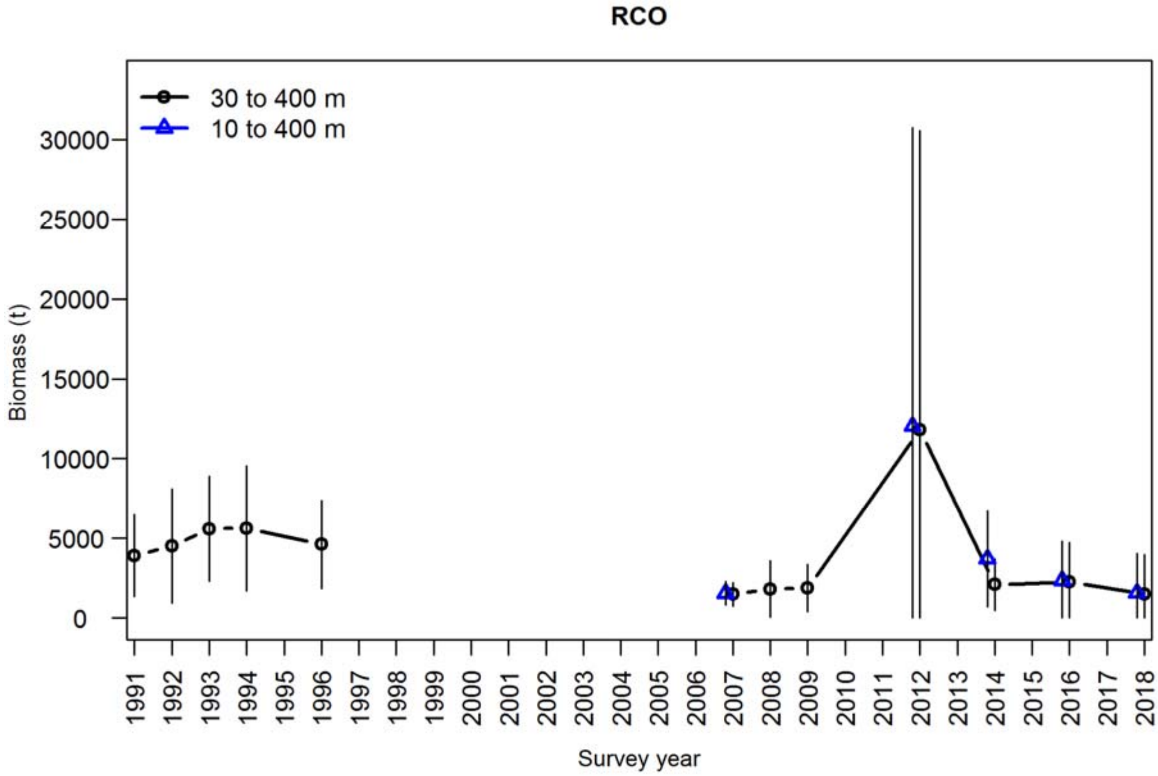




**Figure 7 – *continued***



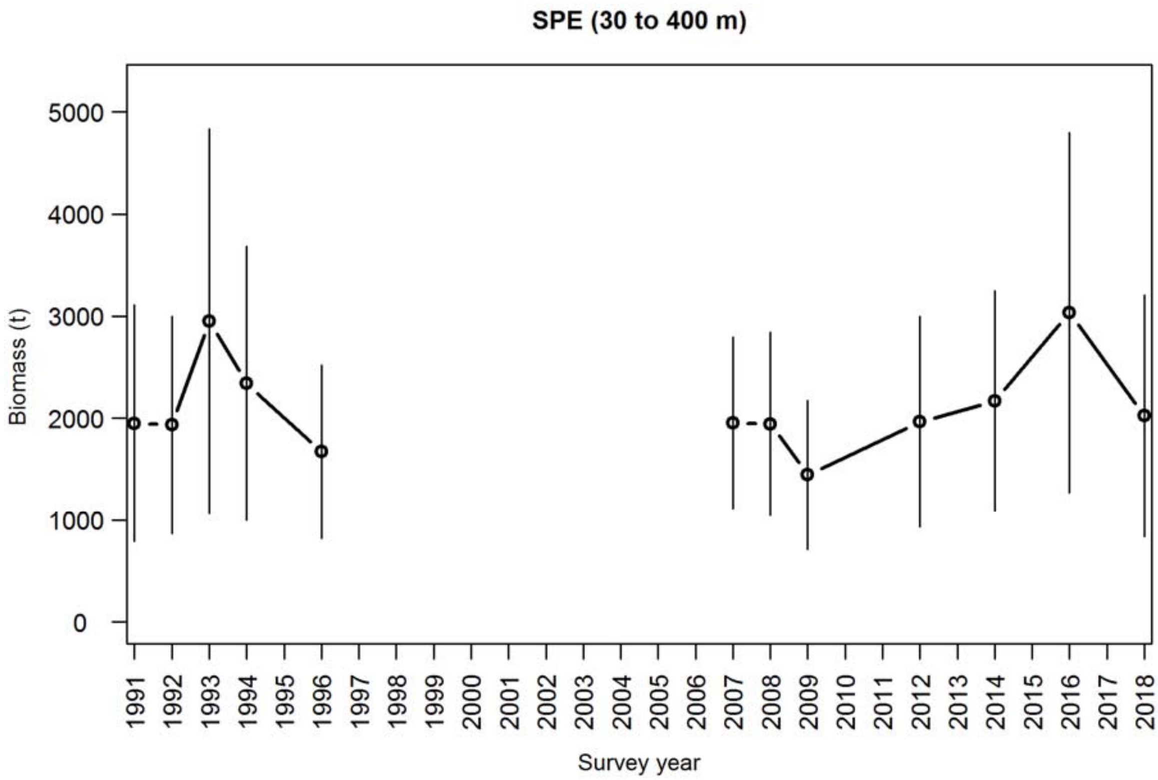
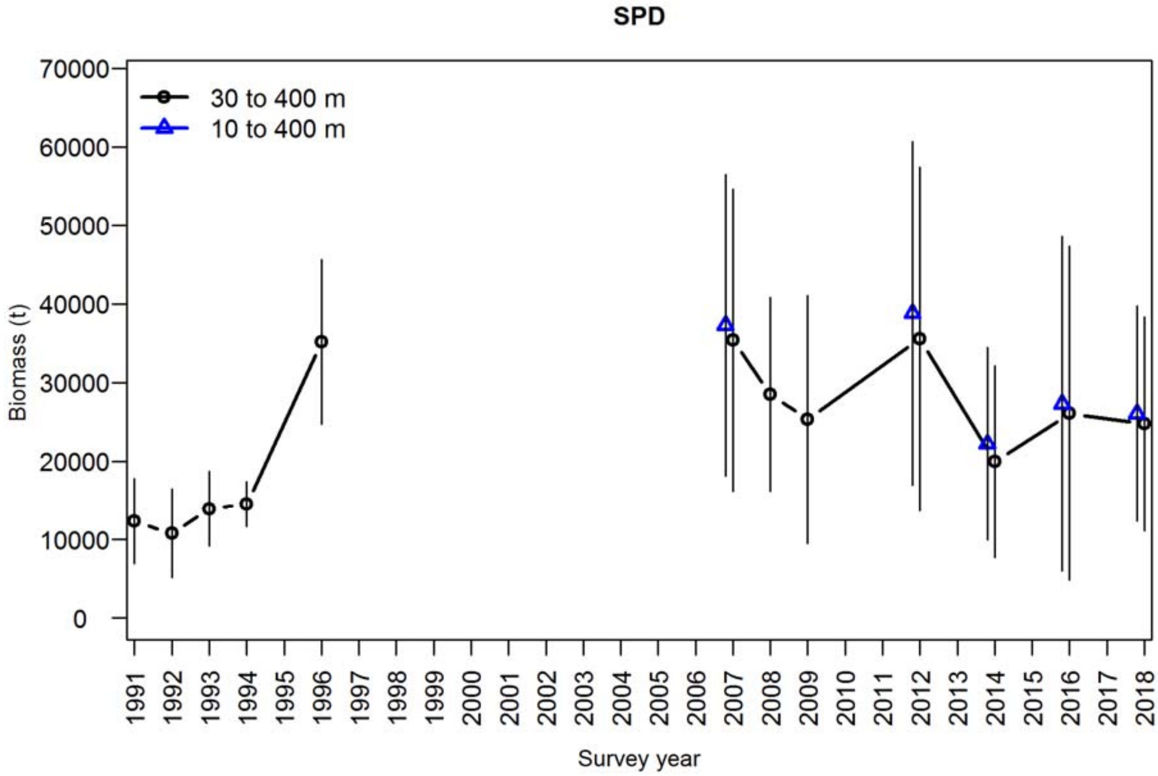




**Figure 7 –** ***continued***



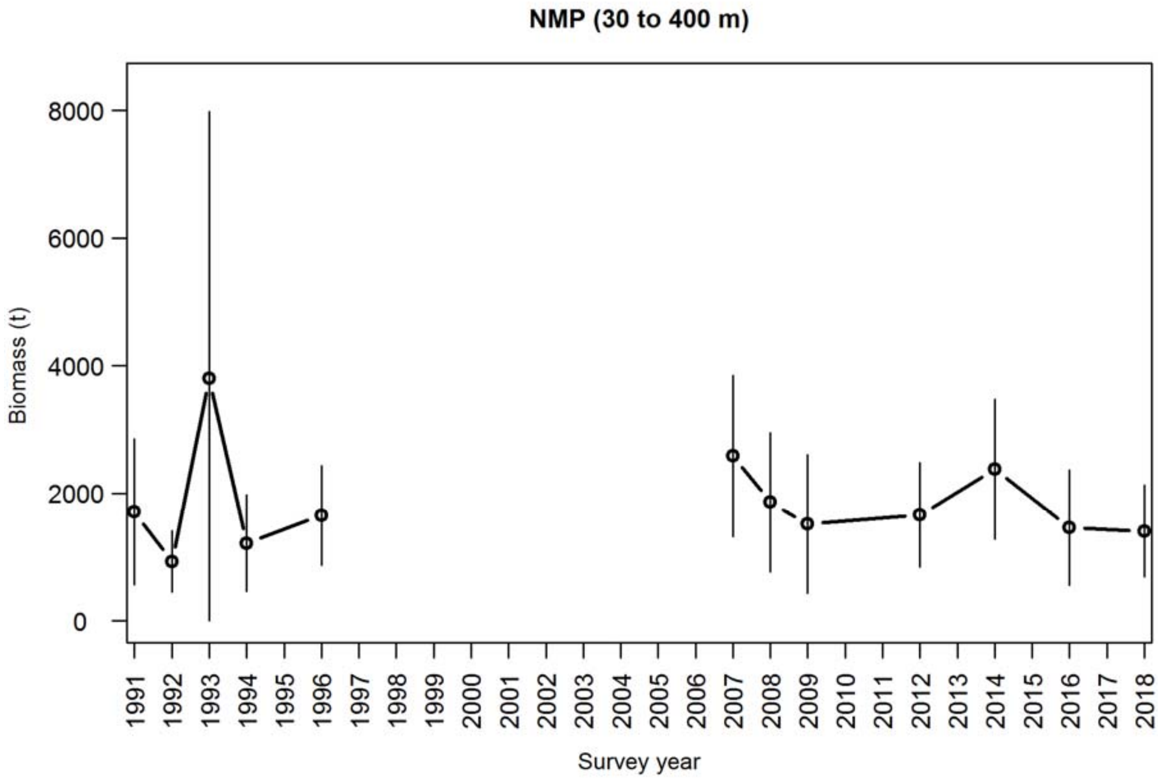




**Figure 7 – *continued***

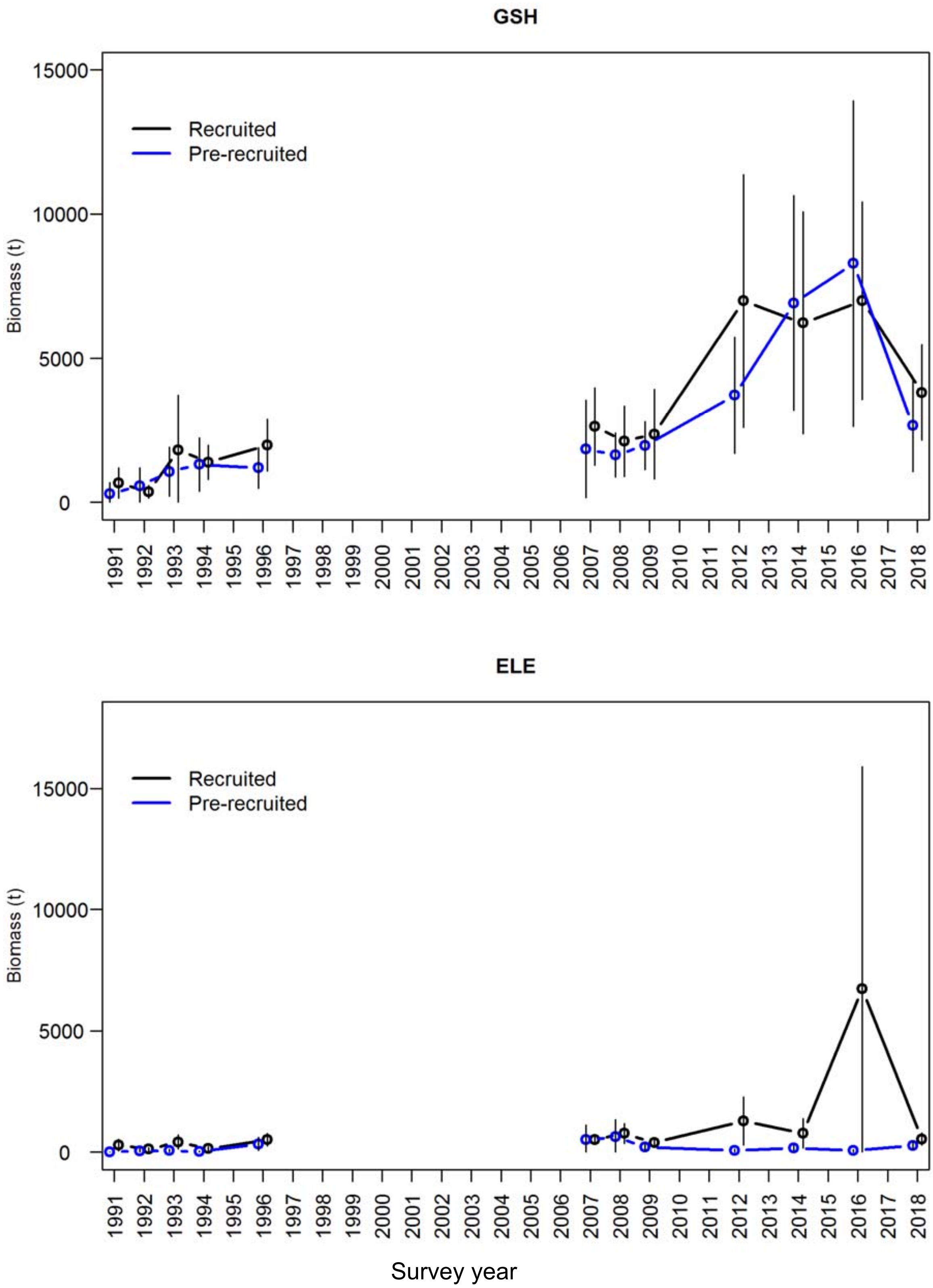
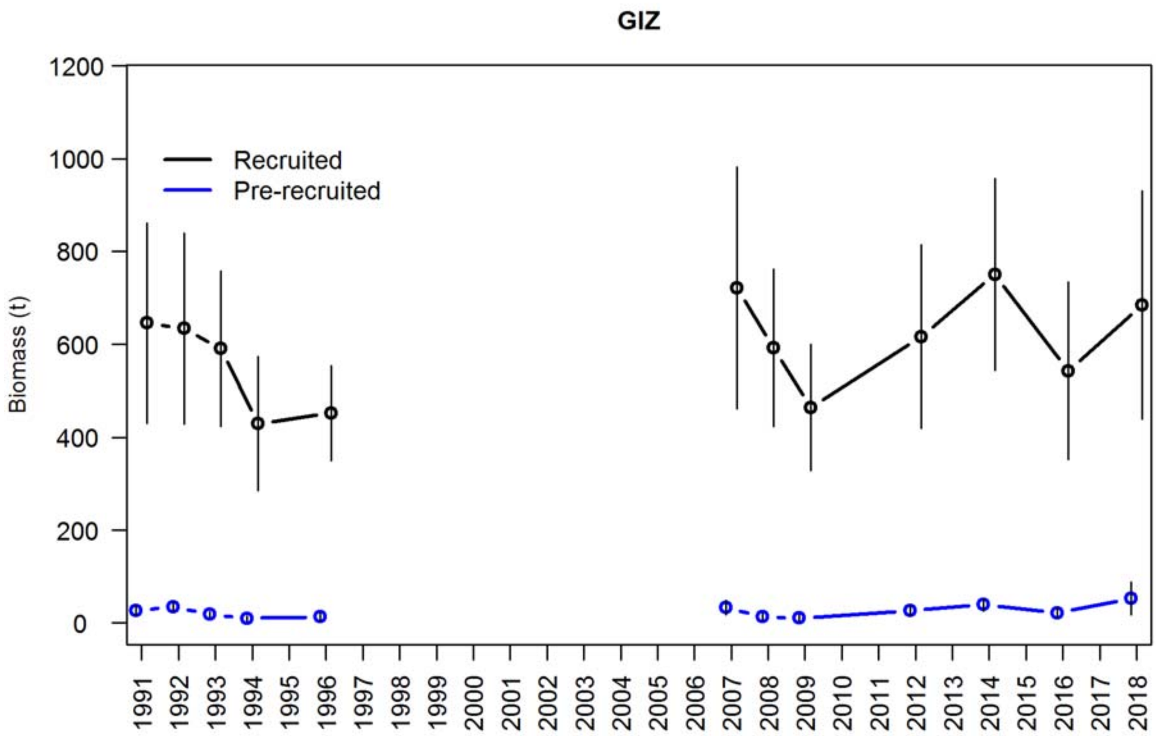



**Figure 8: Target species recruited and pre-recruited biomass and 95% confidence intervals for all ECSI winter surveys in core strata (30–400 m). Error bars are +/- two standard errors.**



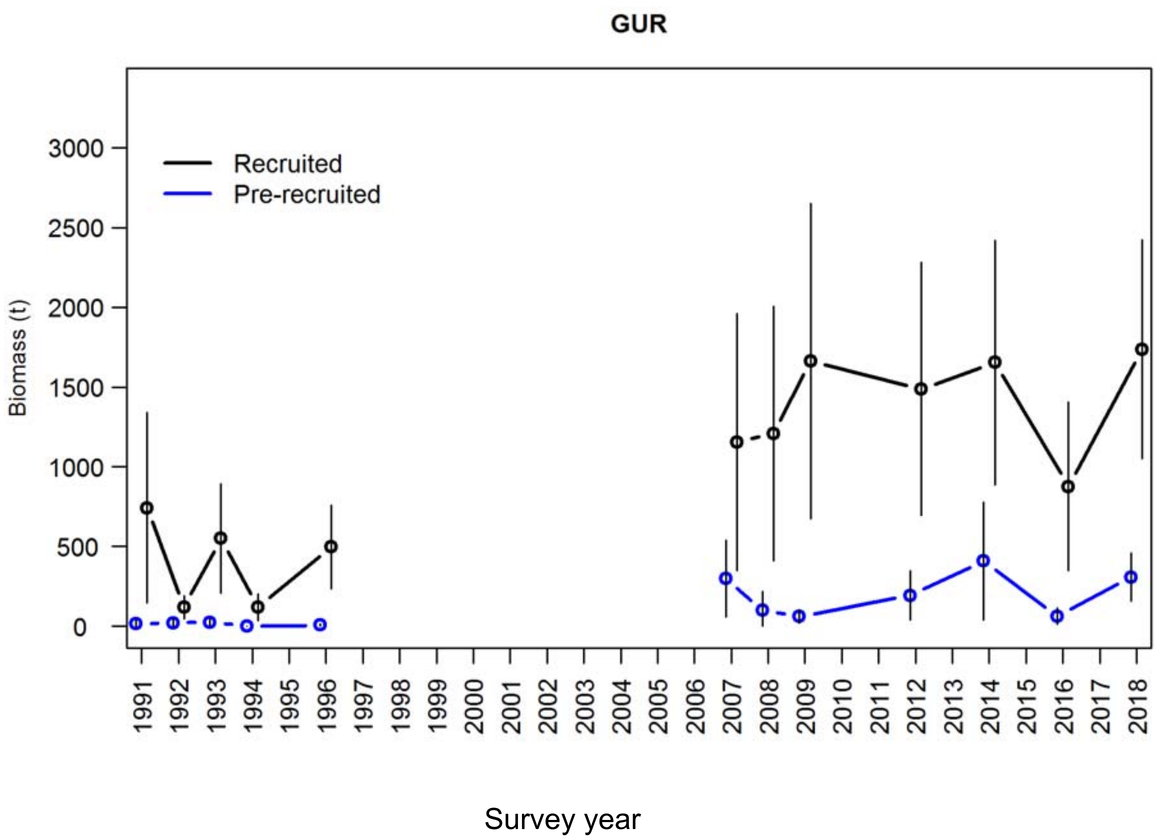
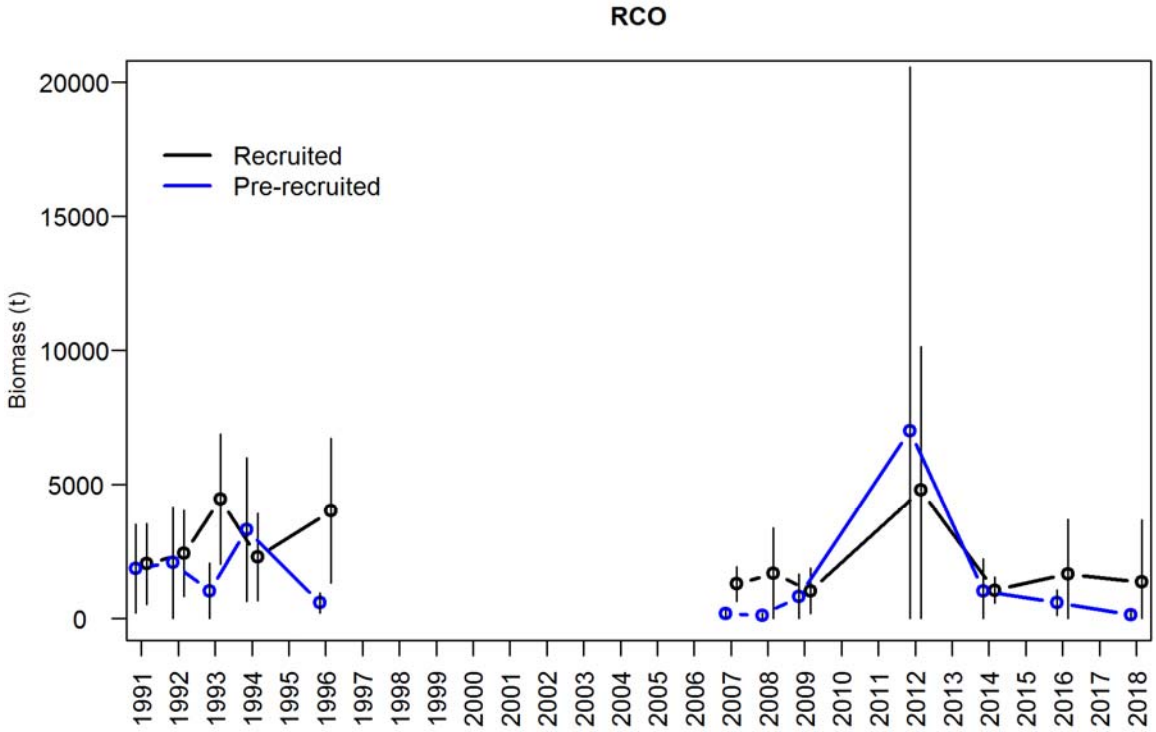




**Figure 8 –** ***continued***



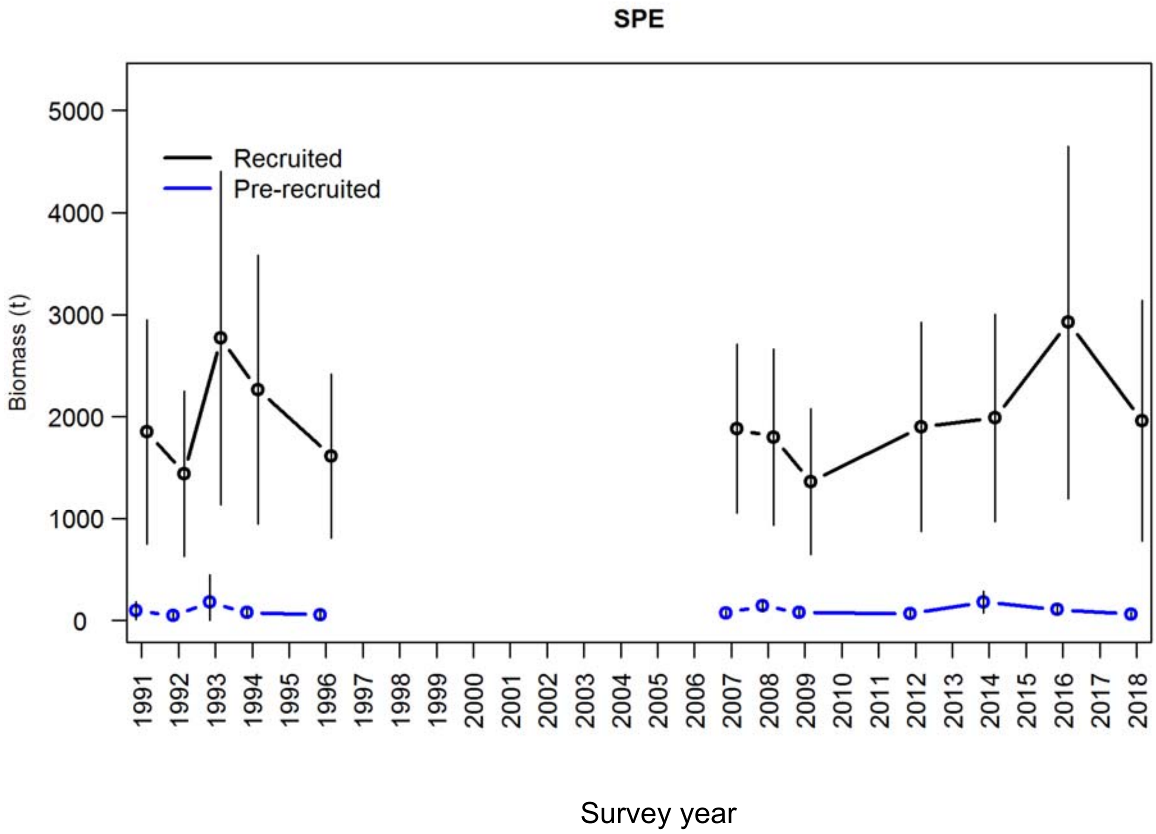




**Figure 8 – *continued***

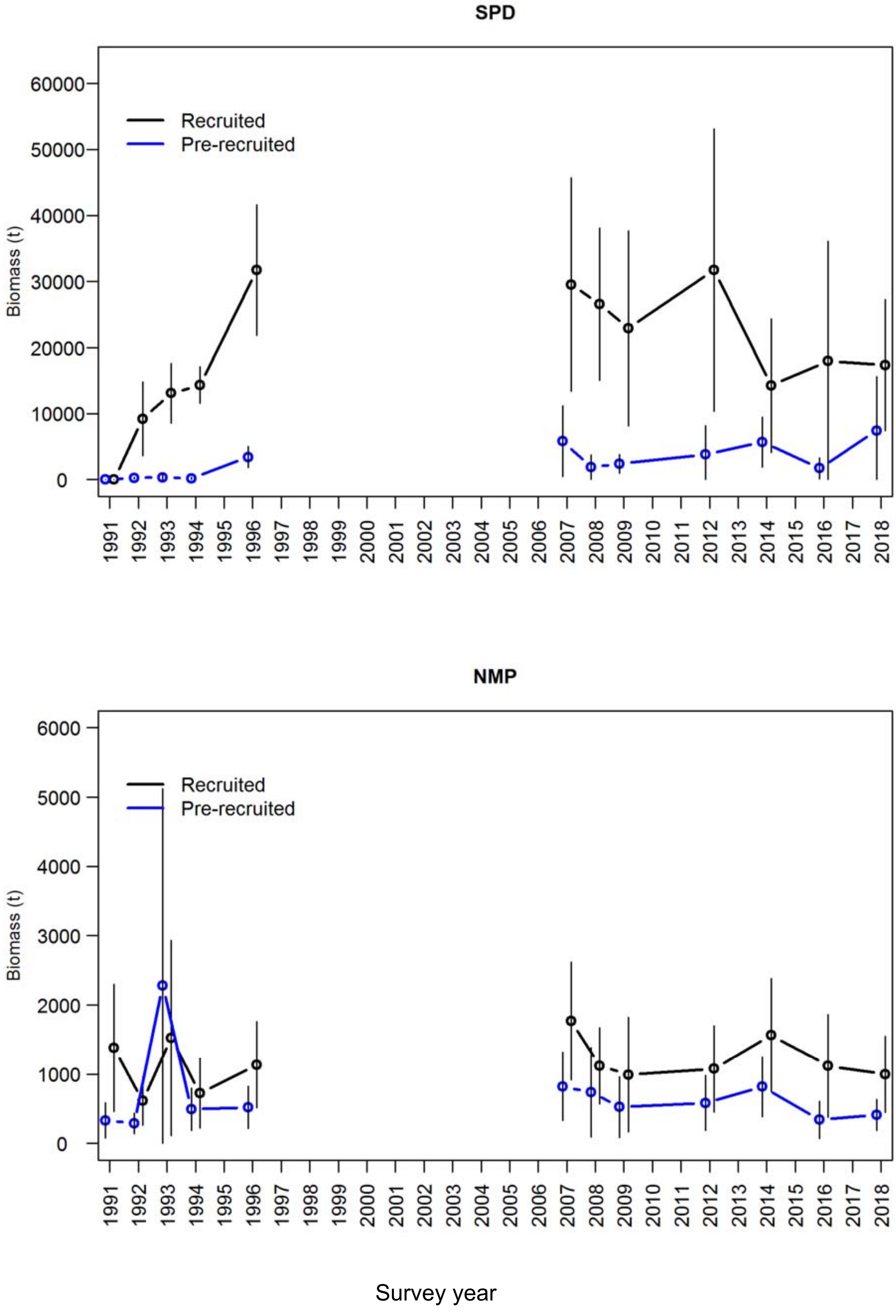



**Figure 8 –** ***continued***

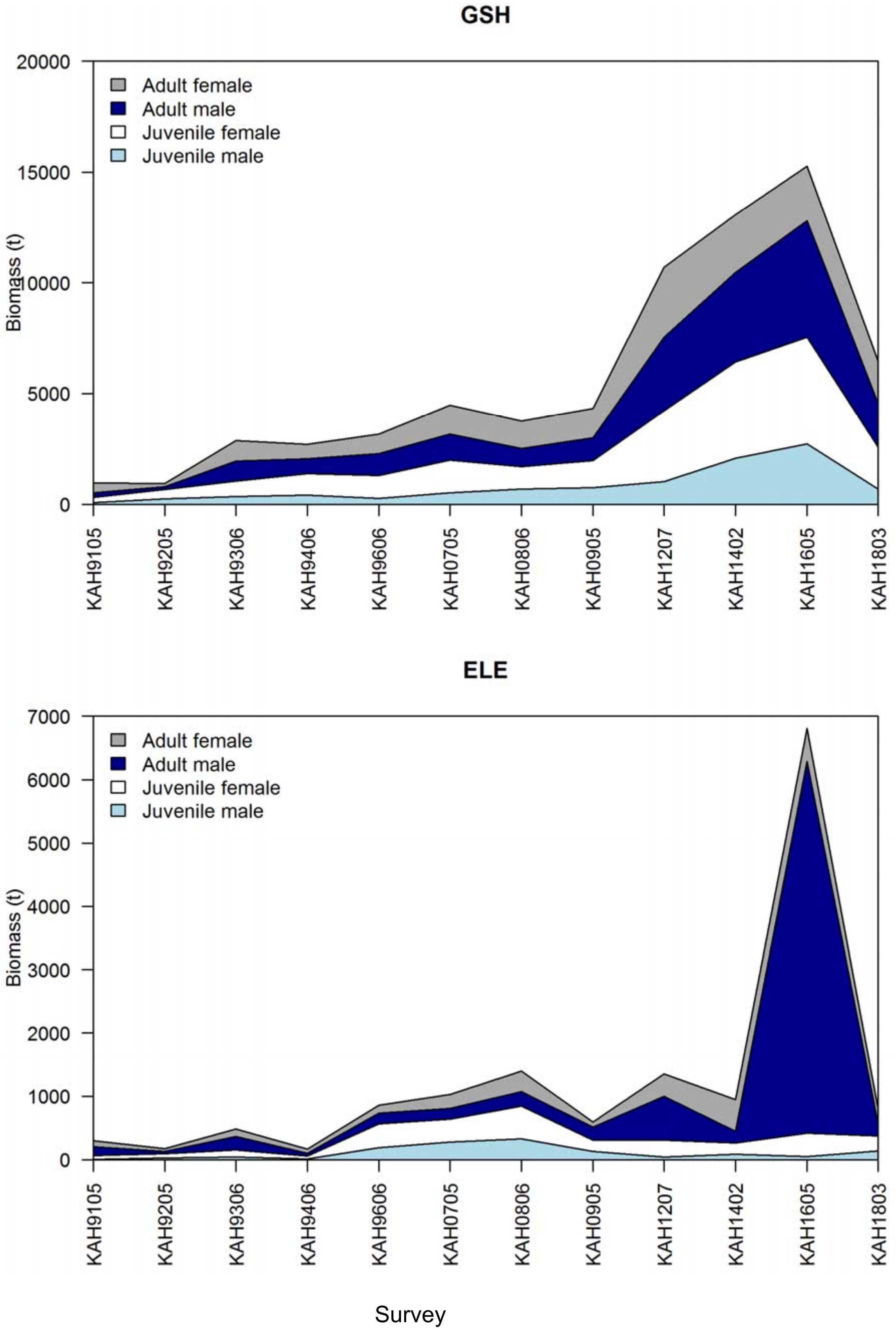
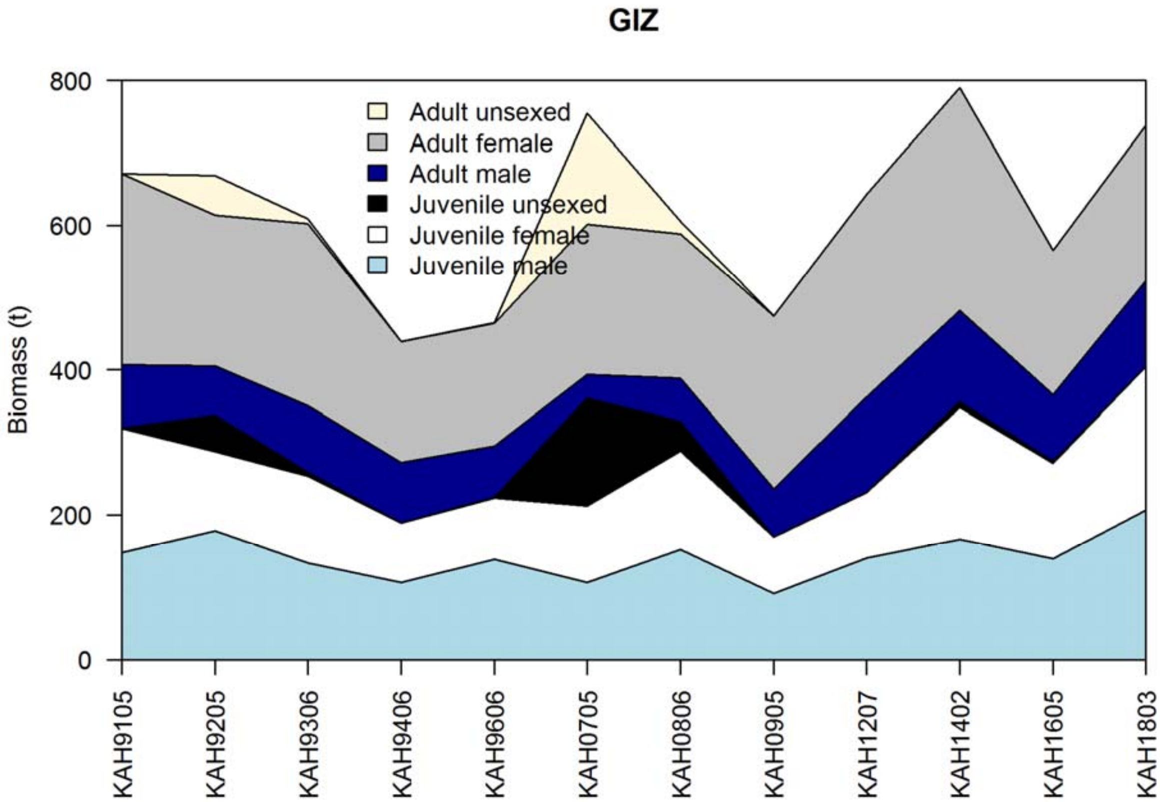



**Figure 9: Target species juvenile and adult biomass for ECSI winter surveys in core strata (30–400 m), where juvenile is below and adult is equal to or above length at which 50% of fish are mature.**



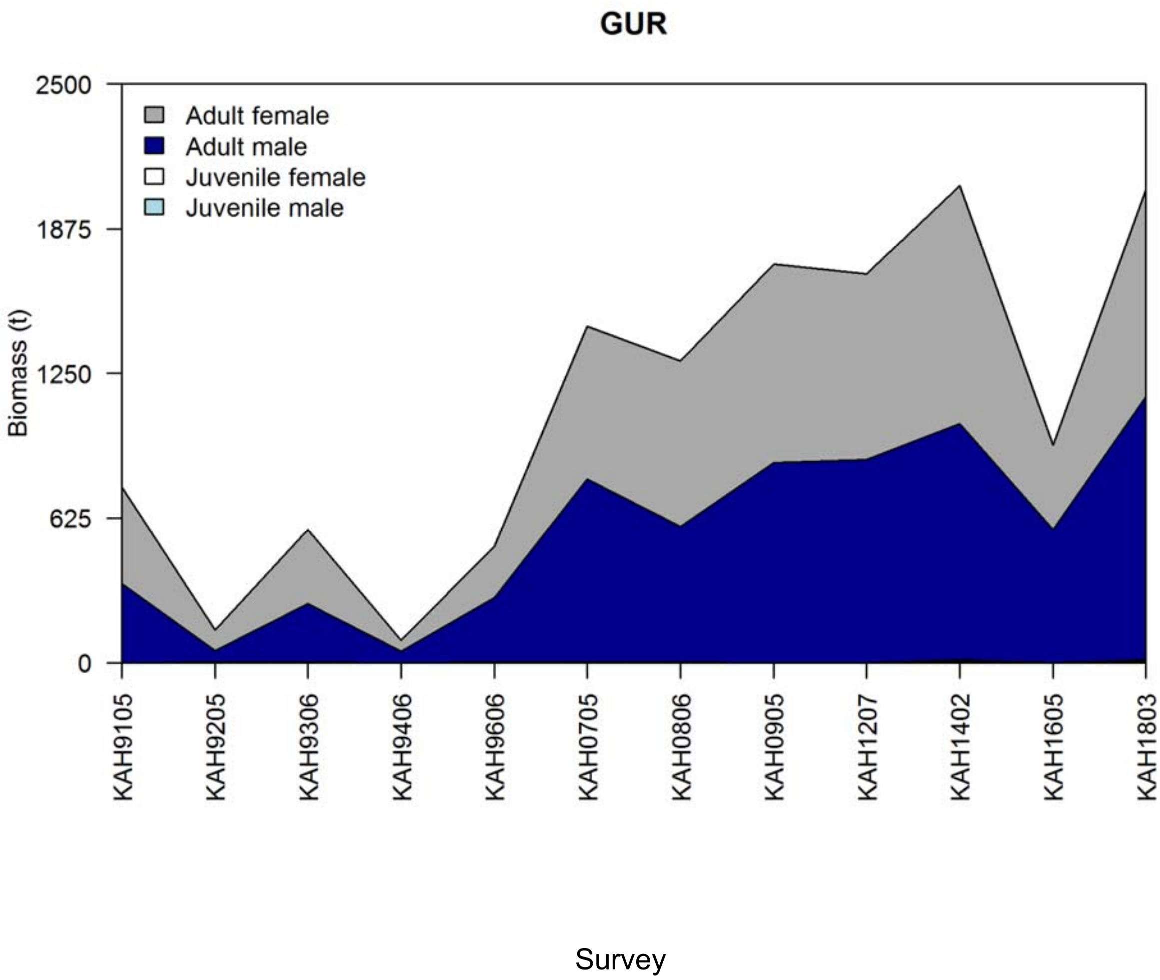




**Figure 9 –** ***continued***

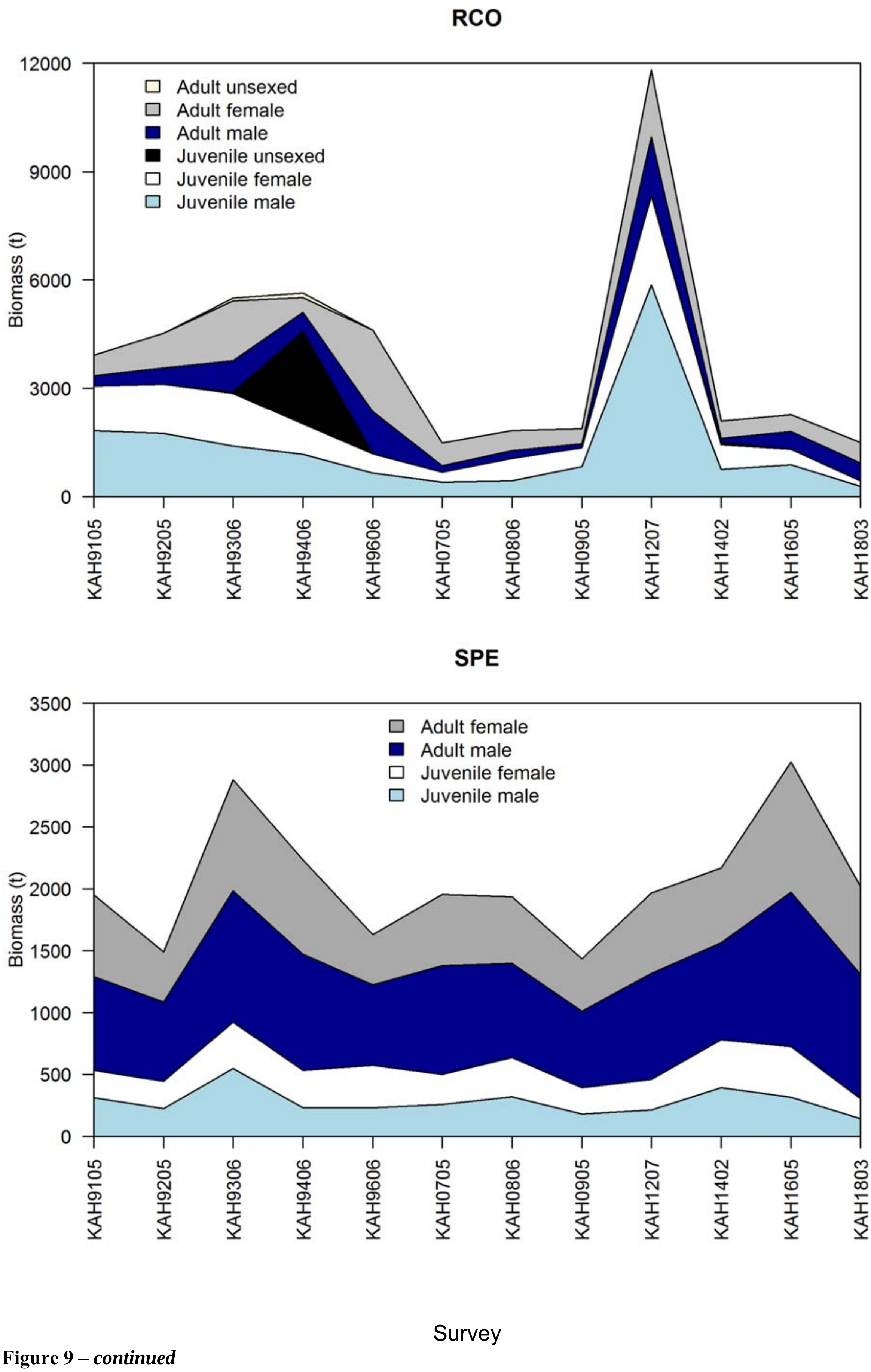
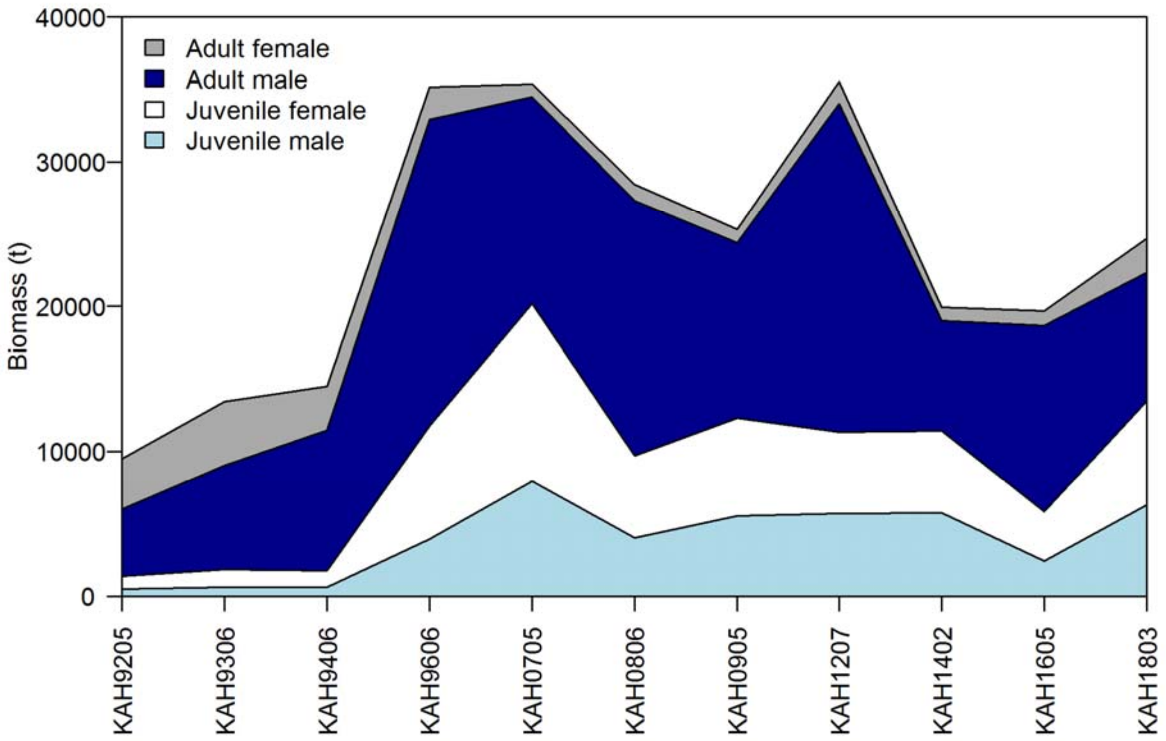



**Figure 9 –** ***continued***

SPD




NMP

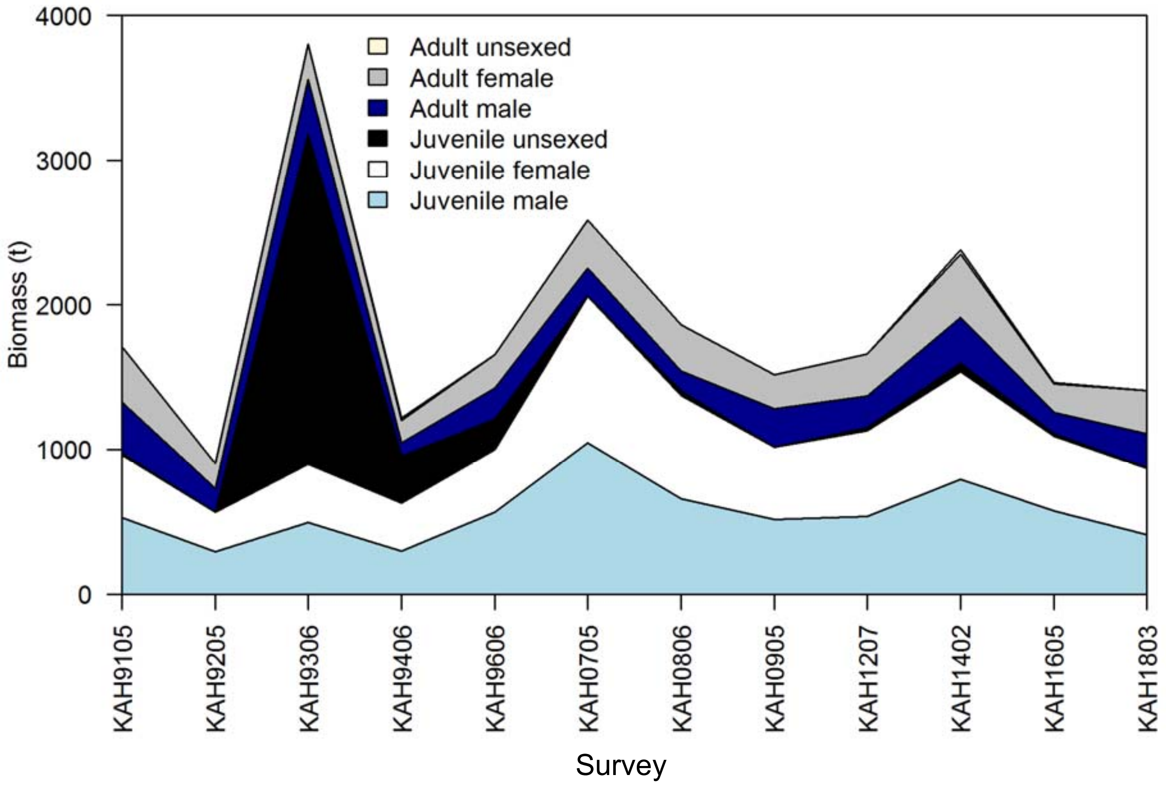



**Figure 9 –** ***continued*****.**

## Dark ghost shark

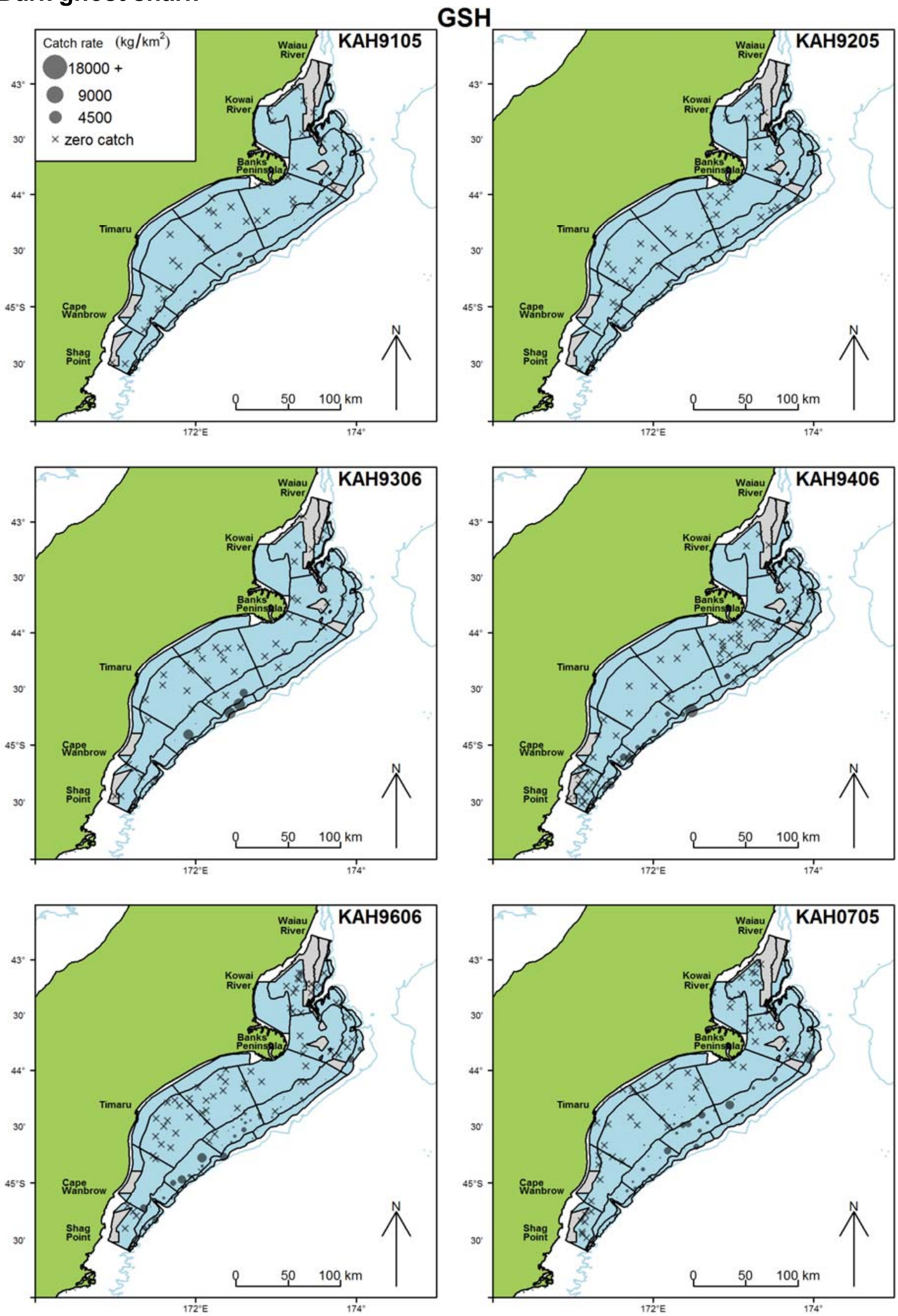



**Figure 10: Target species catch rates (kg.km$^{-2}$) by tow plotted for the ECSI winter trawl surveys time series.**

## Dark ghost shark

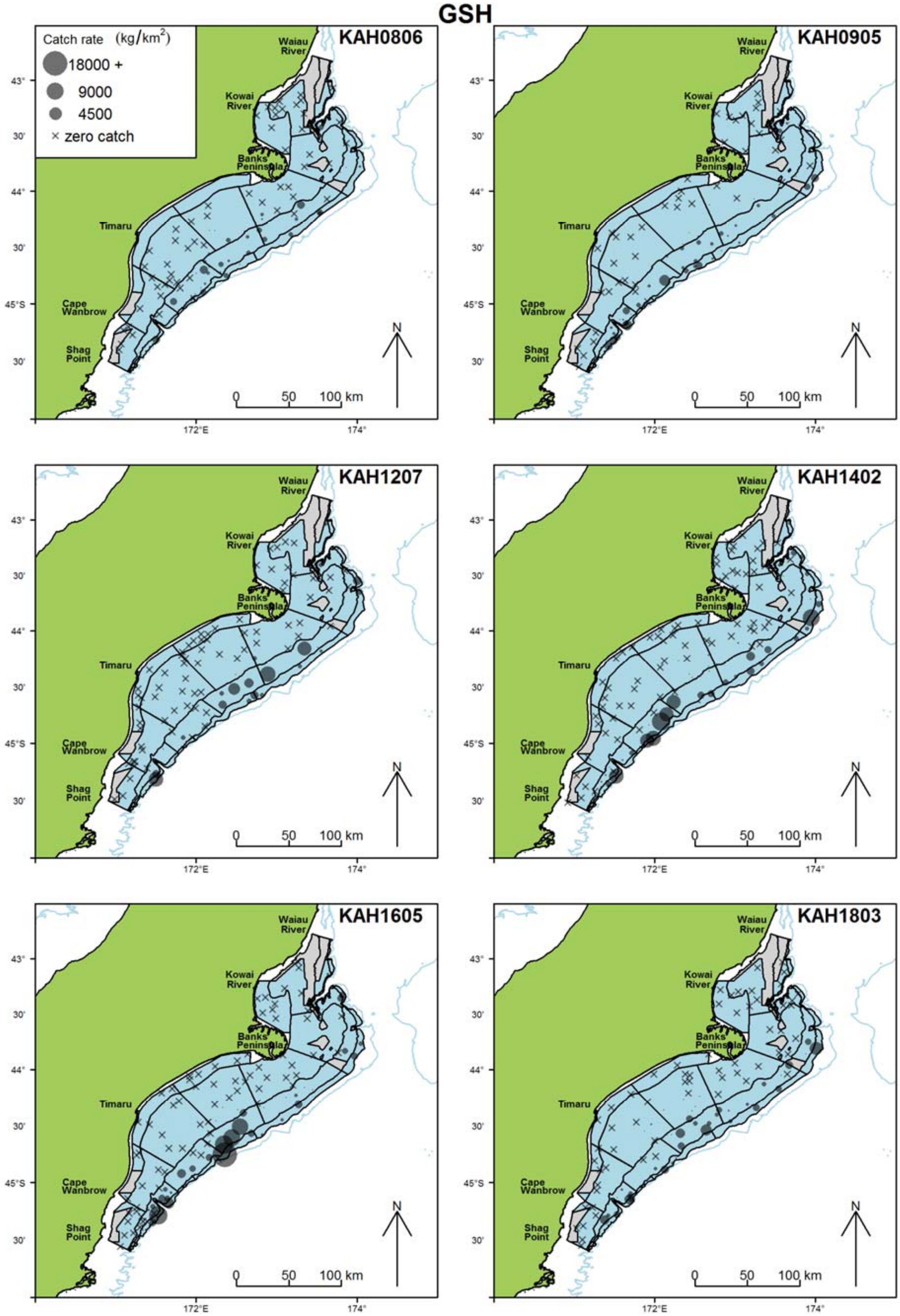



**Figure 10 – *continued***

## Elephantfish

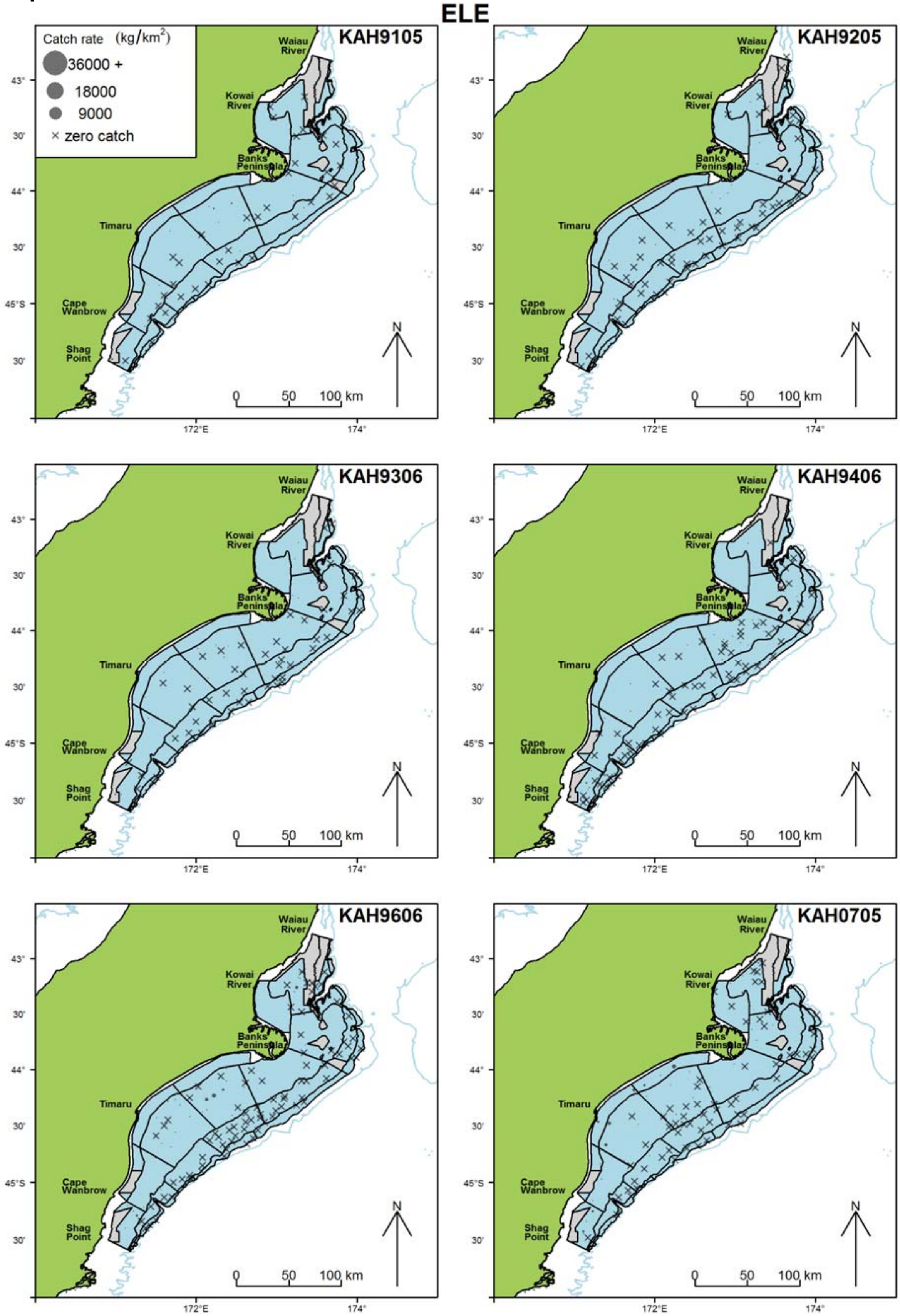



**Figure 10 – *continued***

## Elephantfish

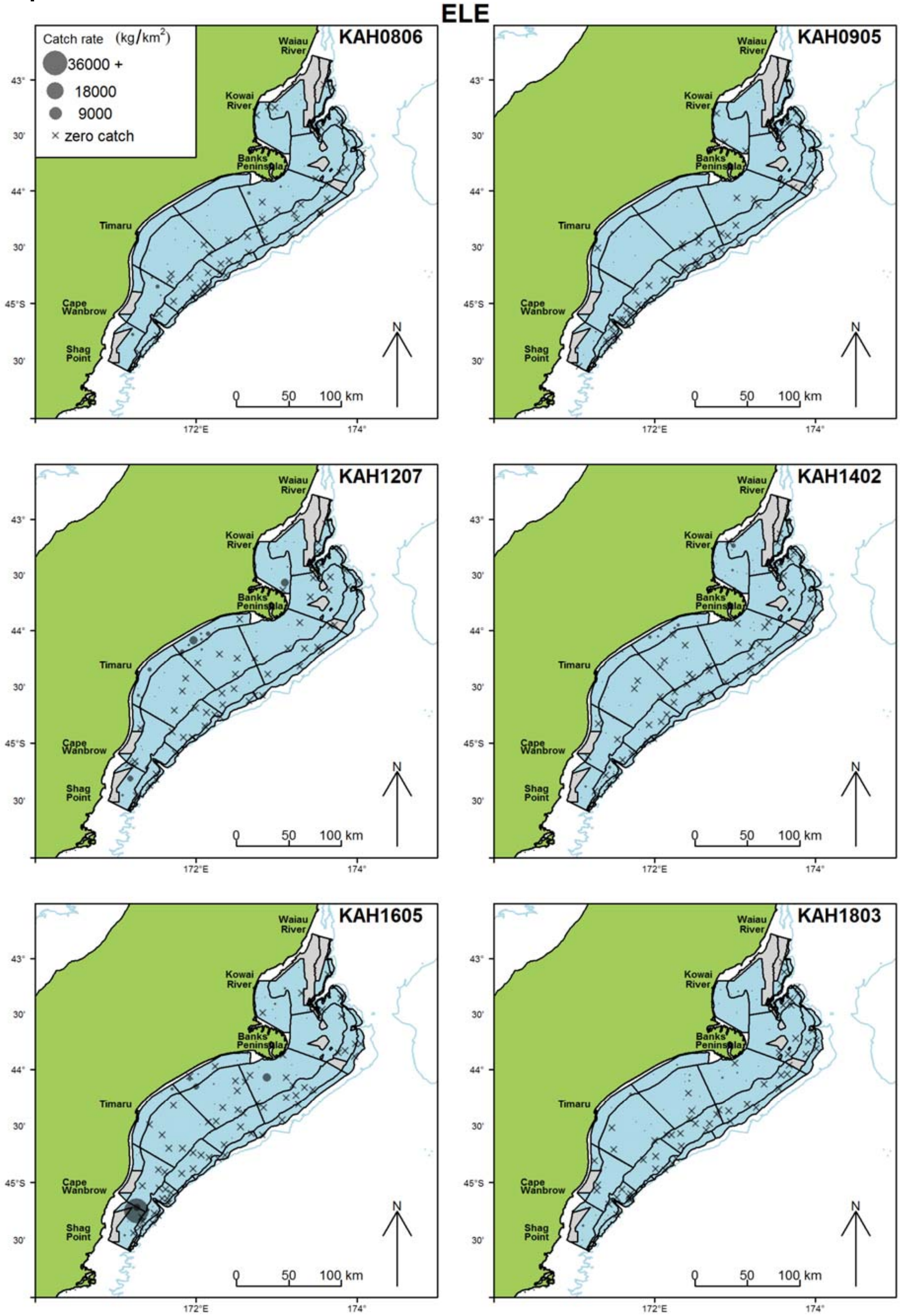



**Figure 10 –** ***continued***

## Giant stargazer

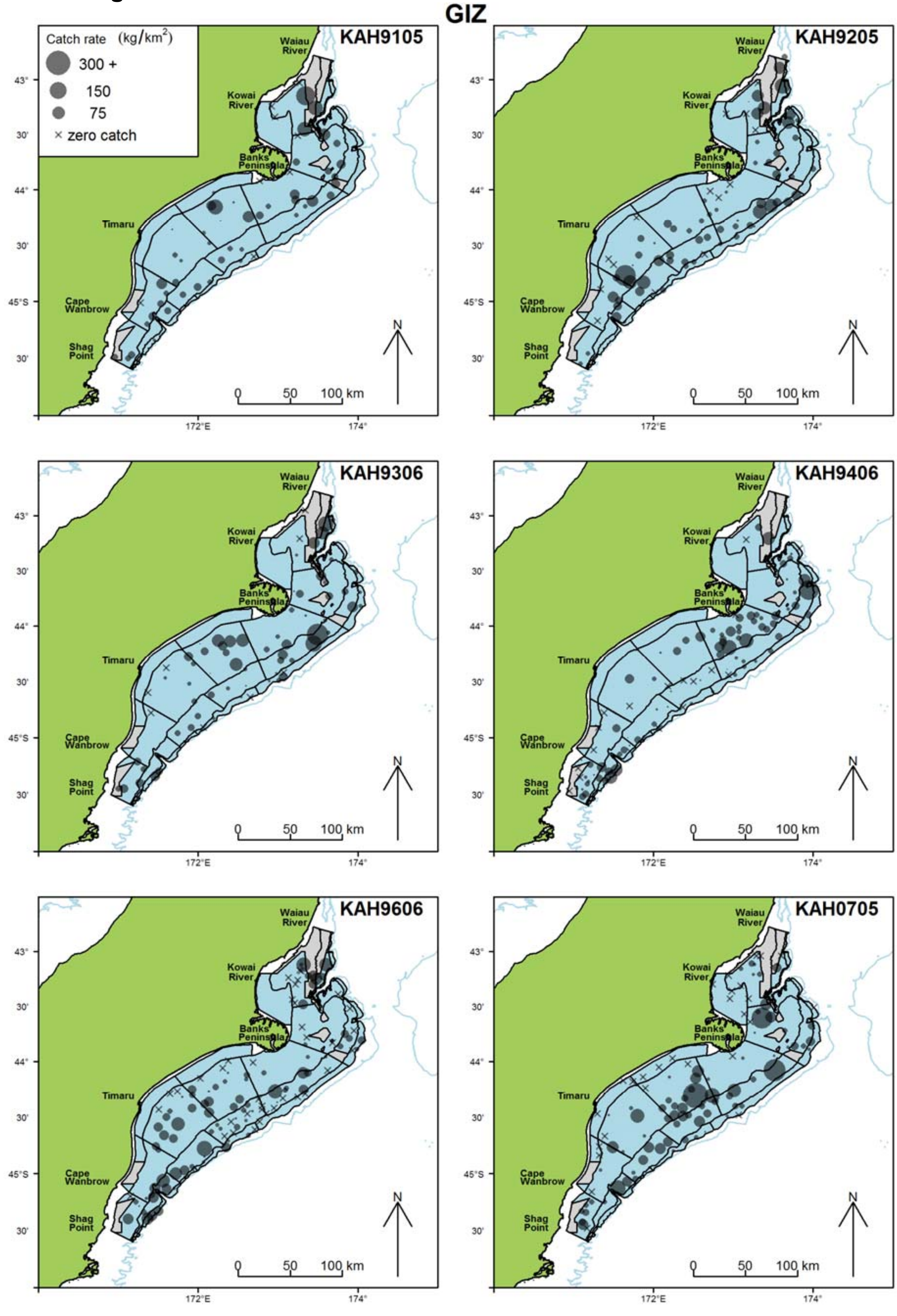



**Figure 10 –** ***continued***

## Giant stargazer

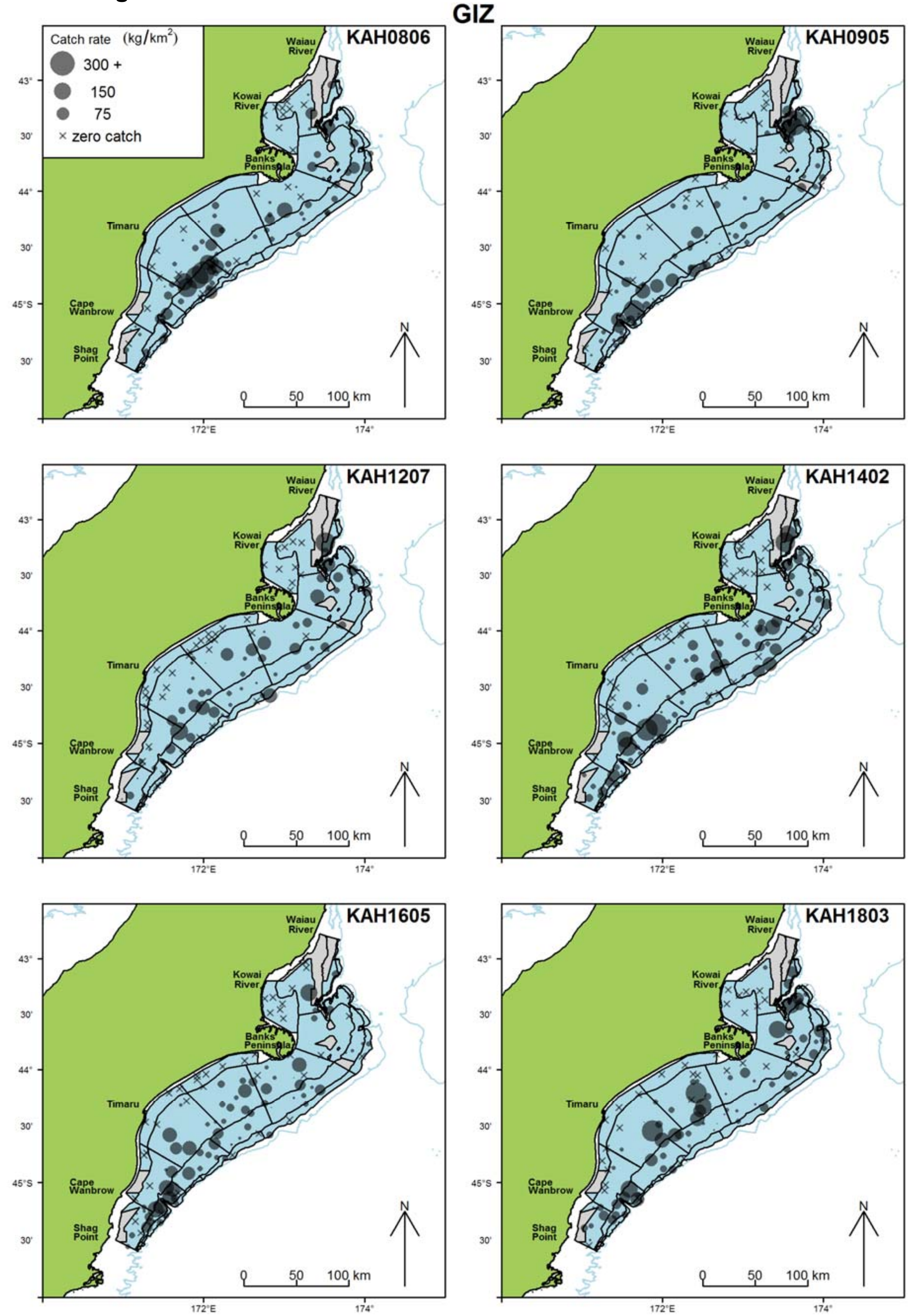



**Figure 10 –** ***continued***

## Red gurnard

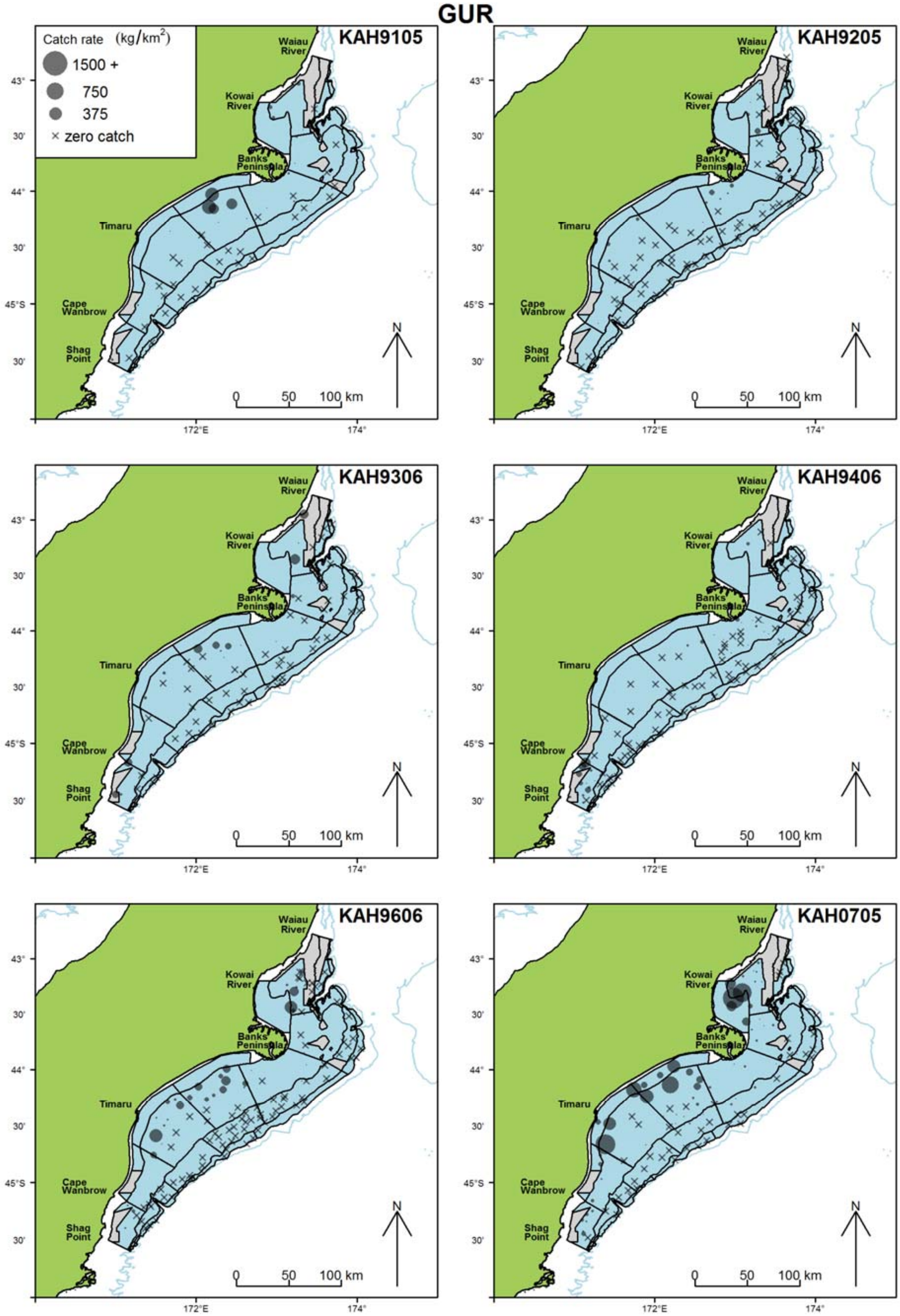



**Figure 10 –** ***continued***

## Red gurnard

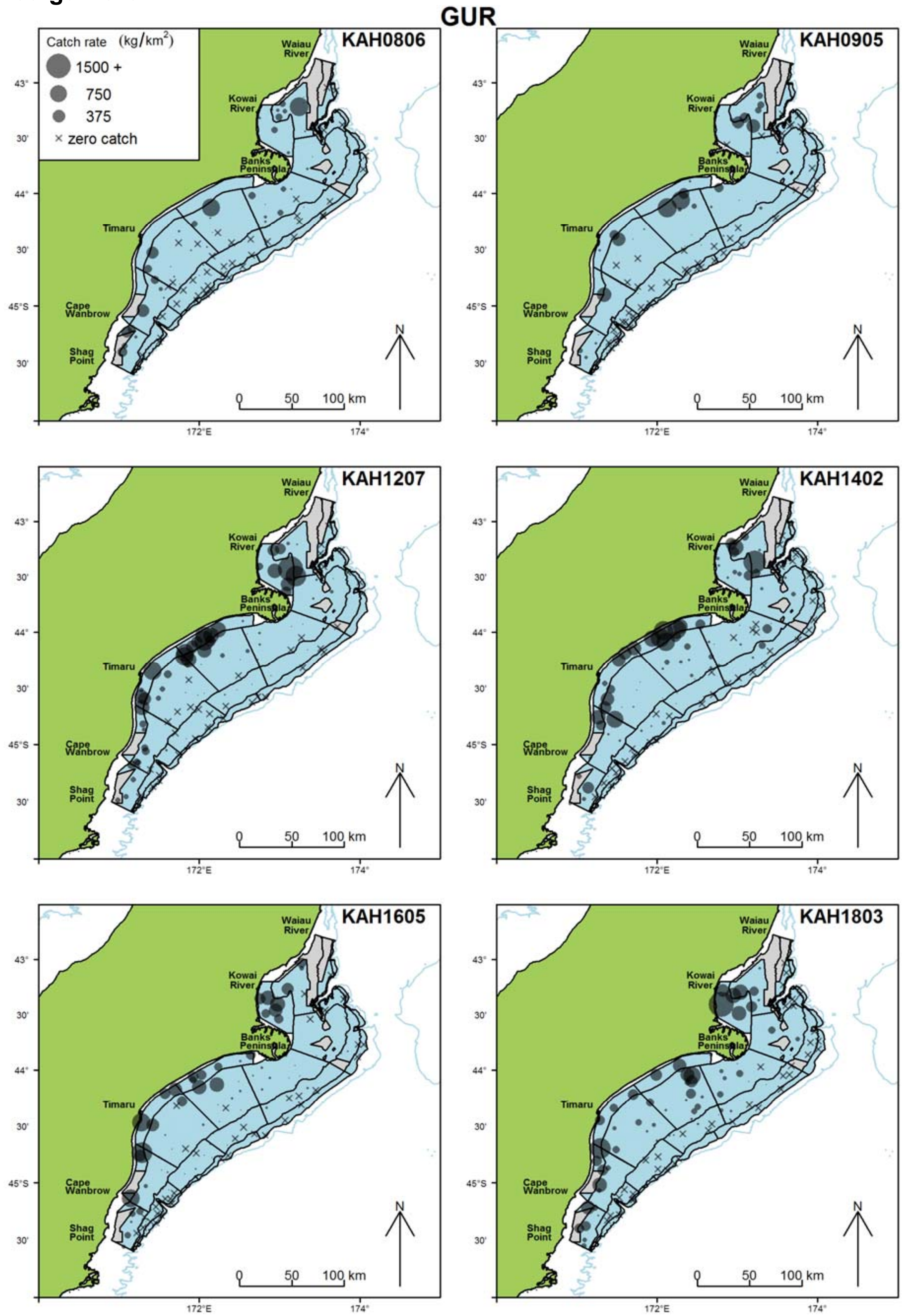



**Figure 10 –** ***continued***

## Red cod

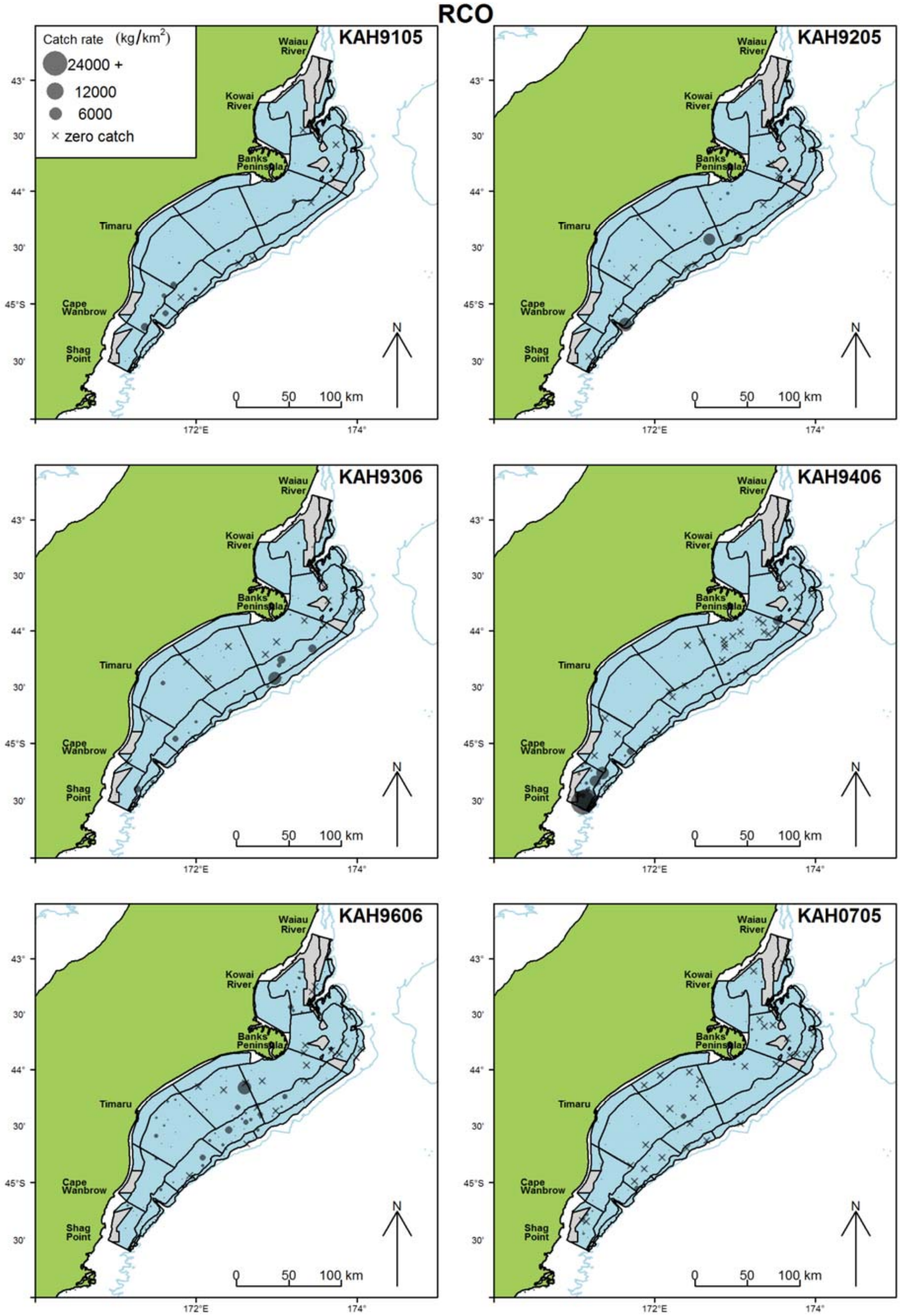



**Figure 10 –** ***continued***

## Red cod

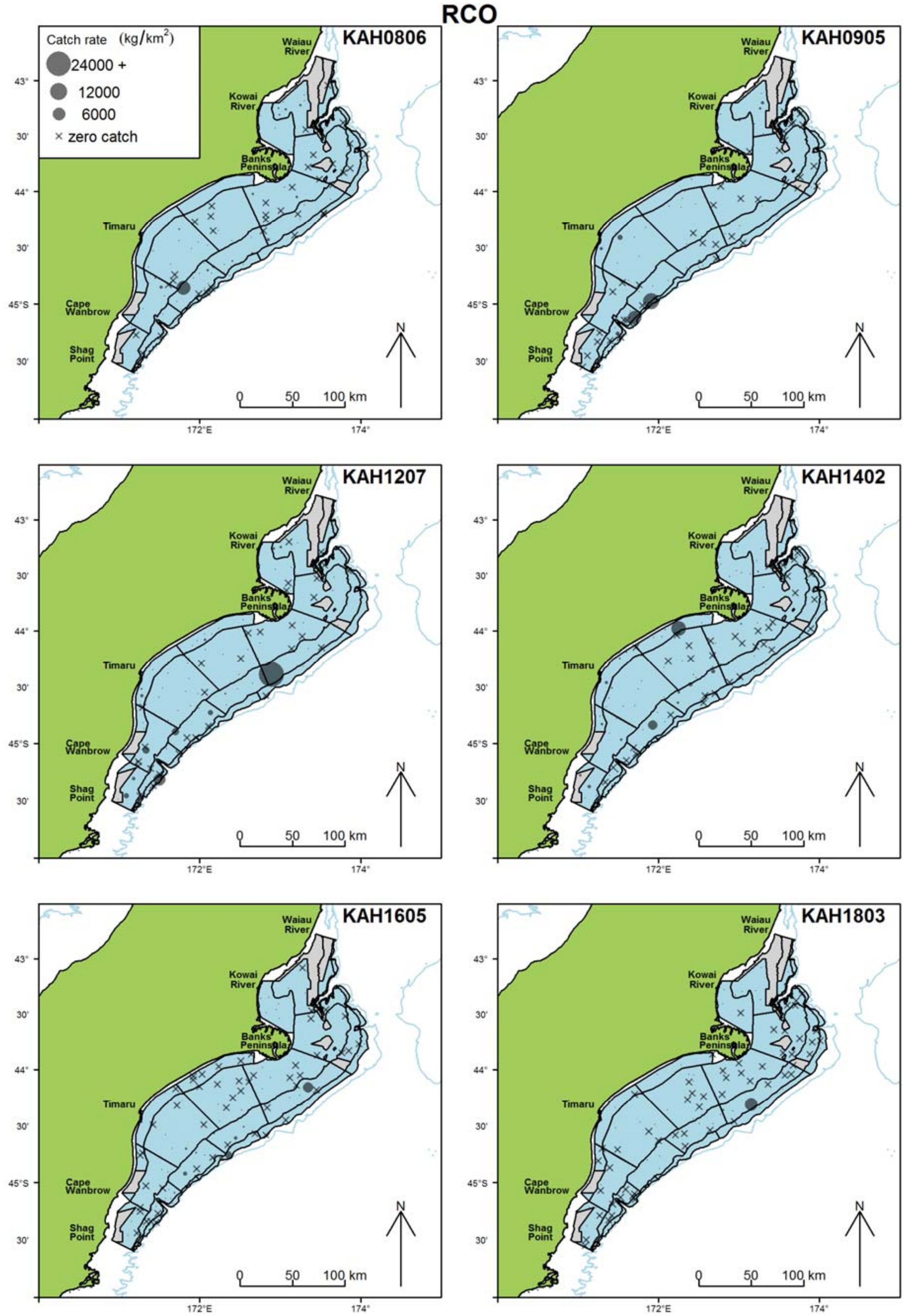



**Figure 10 –** ***continued***

## Sea perch

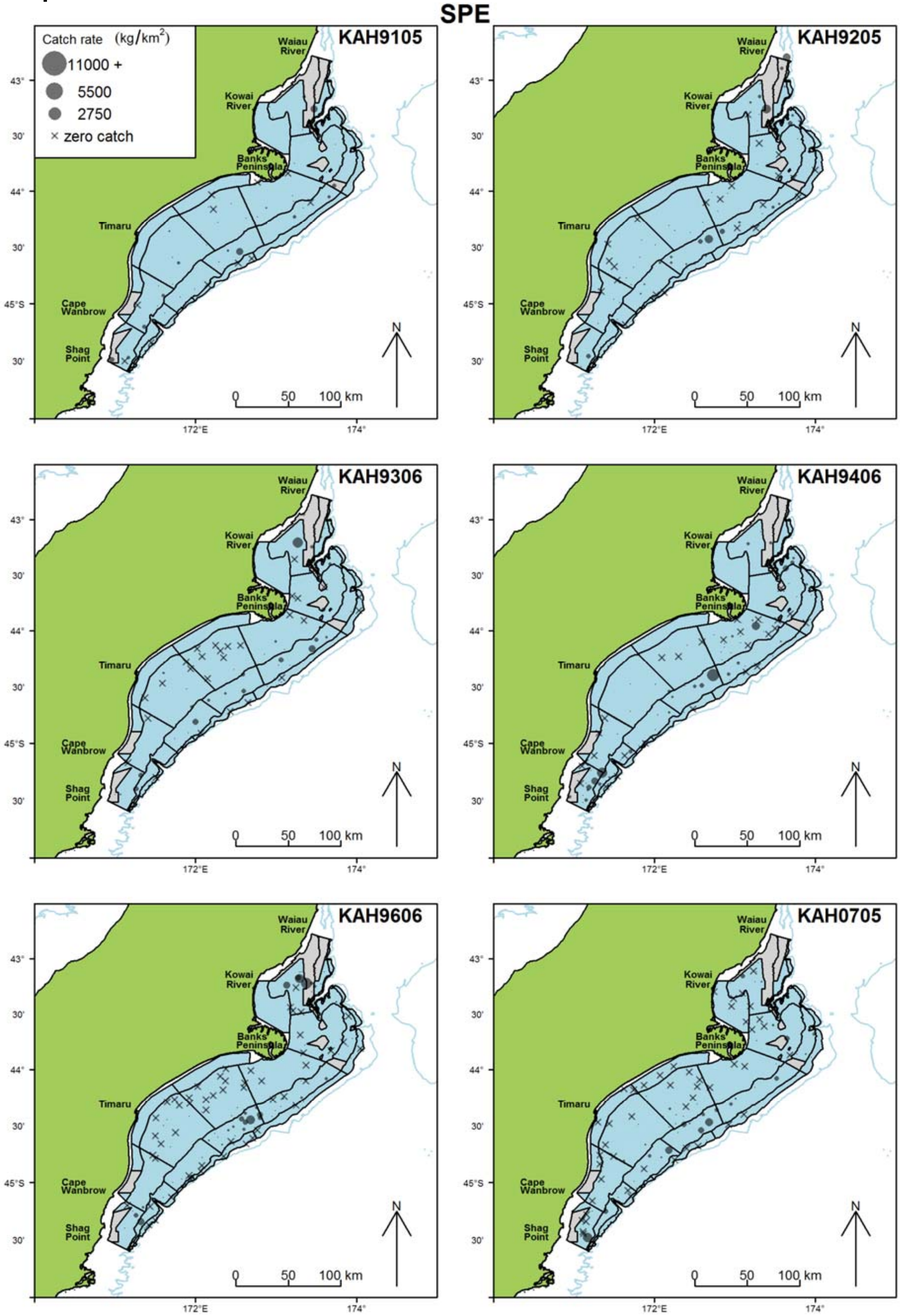



**Figure 10 – *continued***

## Sea perch

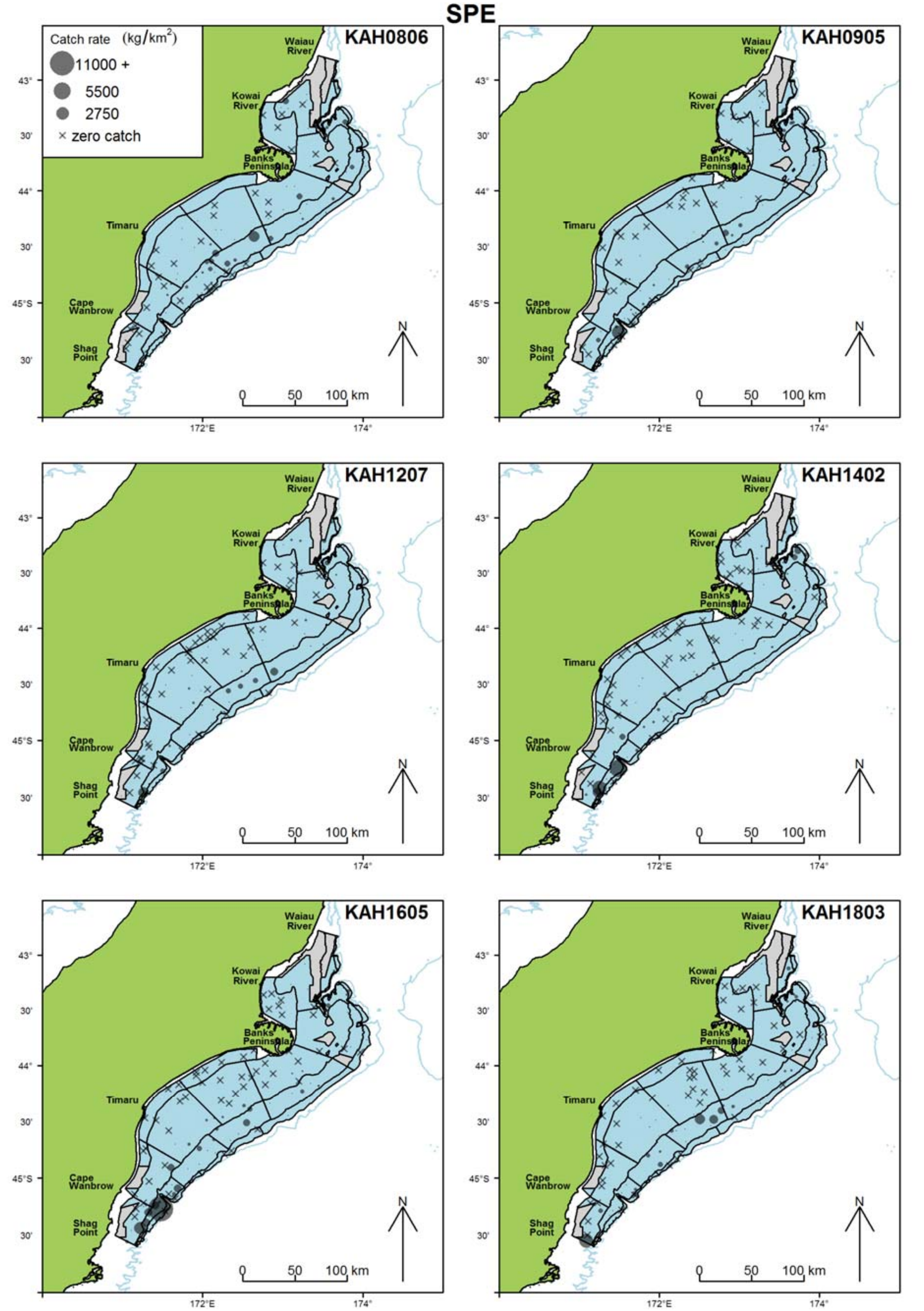



**Figure 10 – *continued***

## Spiny dogfish

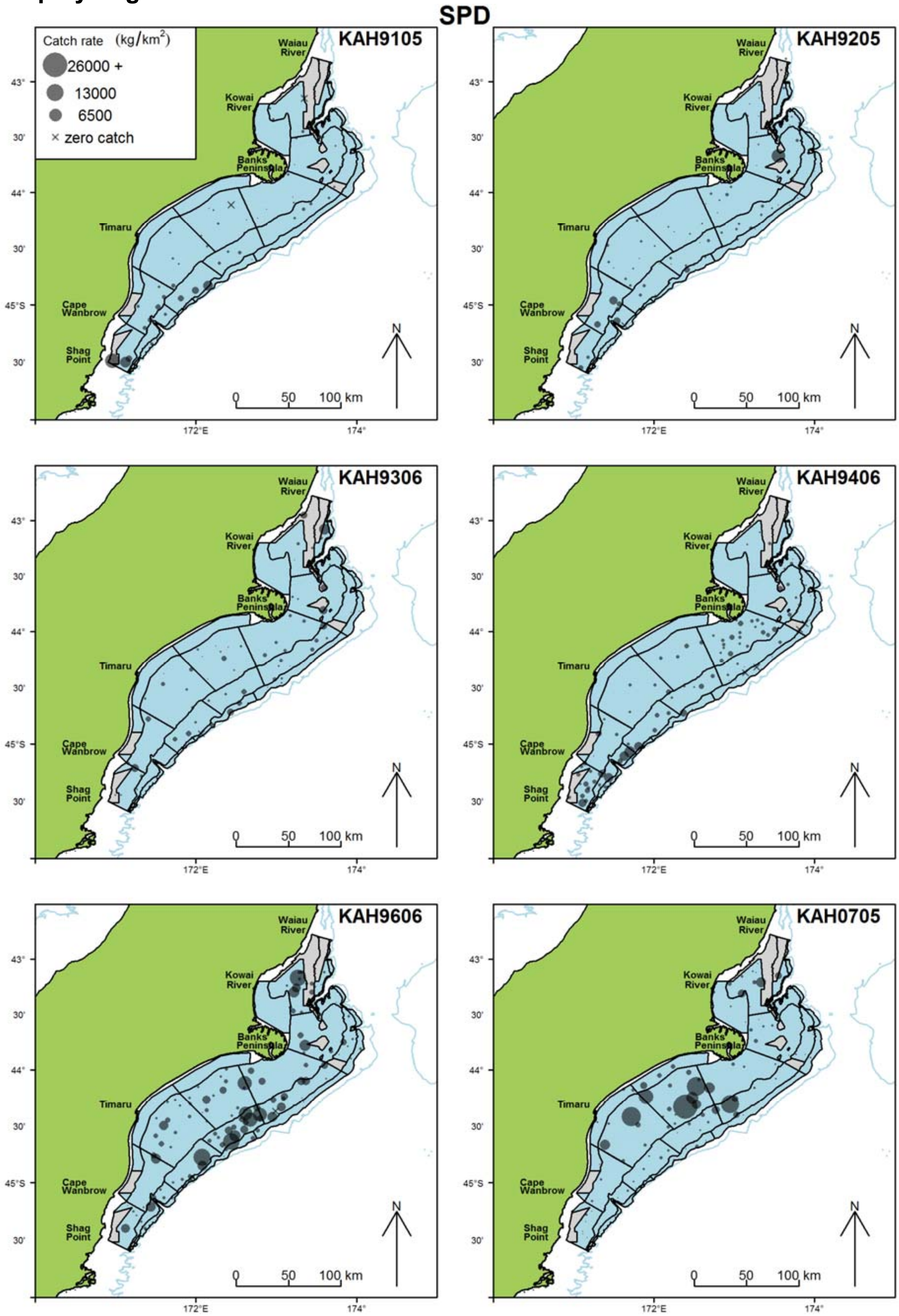



**Figure 10 –** ***continued***

## Spiny dogfish

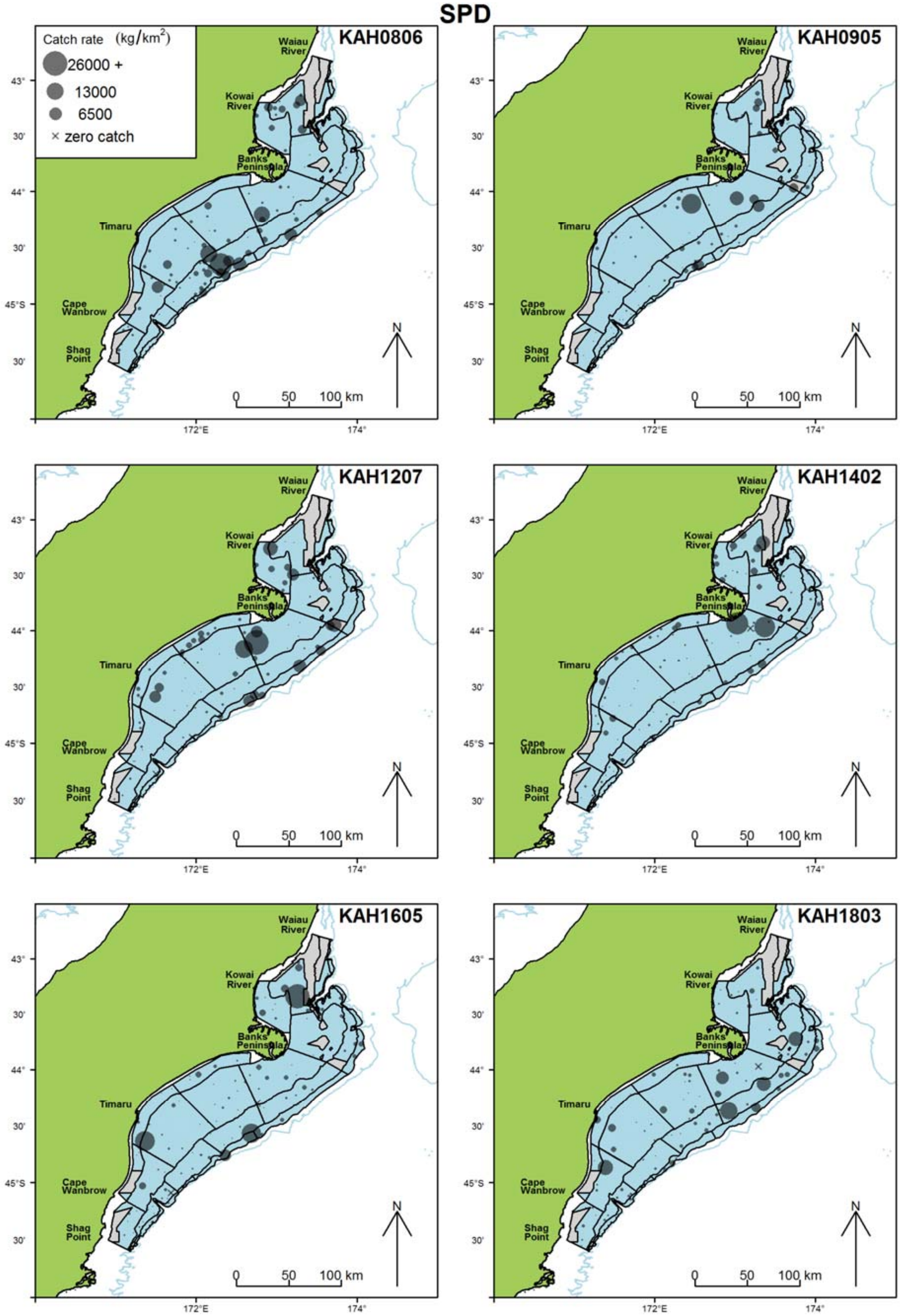



**Figure 10 –** ***continued***

## Tarakihi

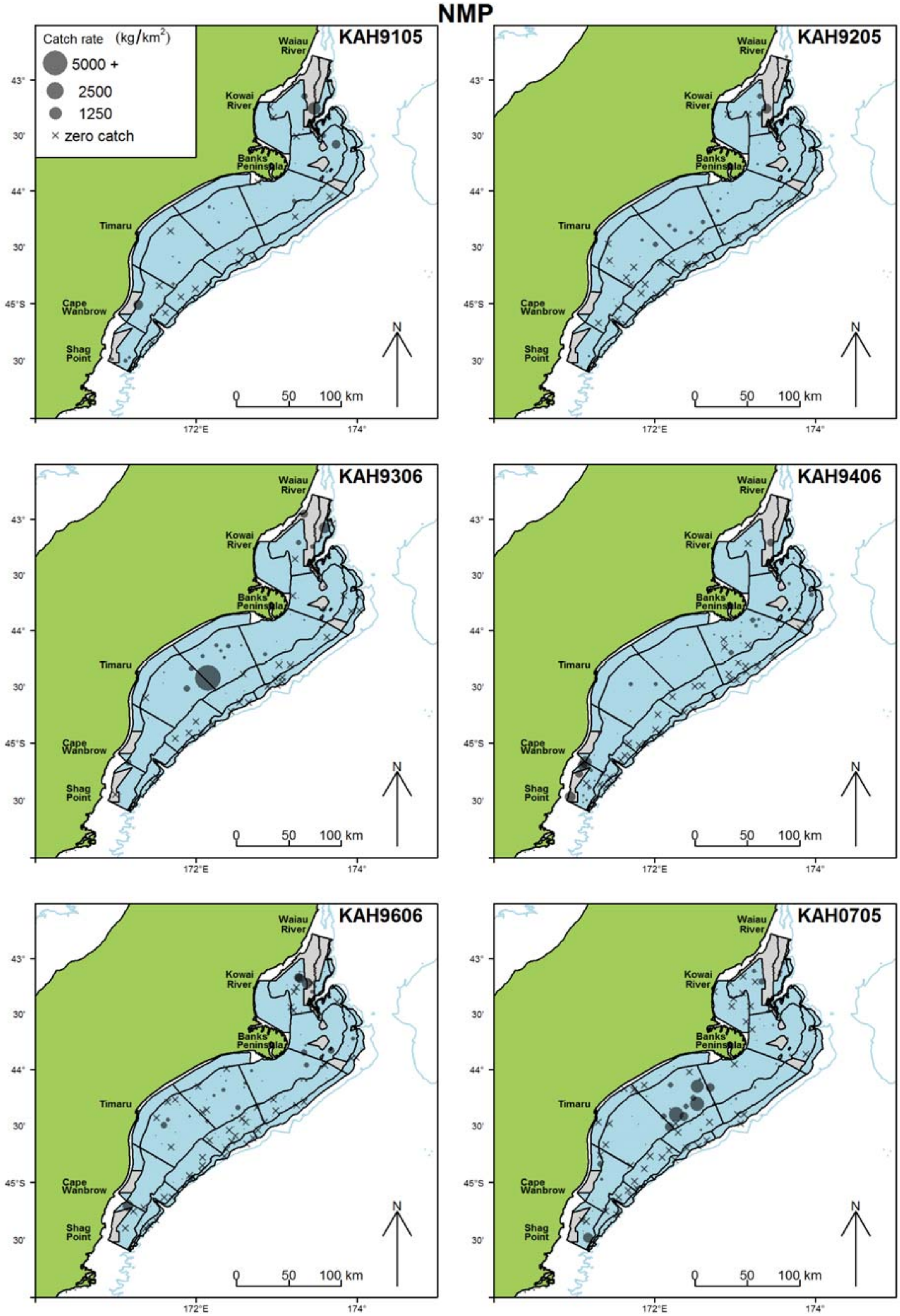



**Figure 10 –** ***continued***

## Tarakihi

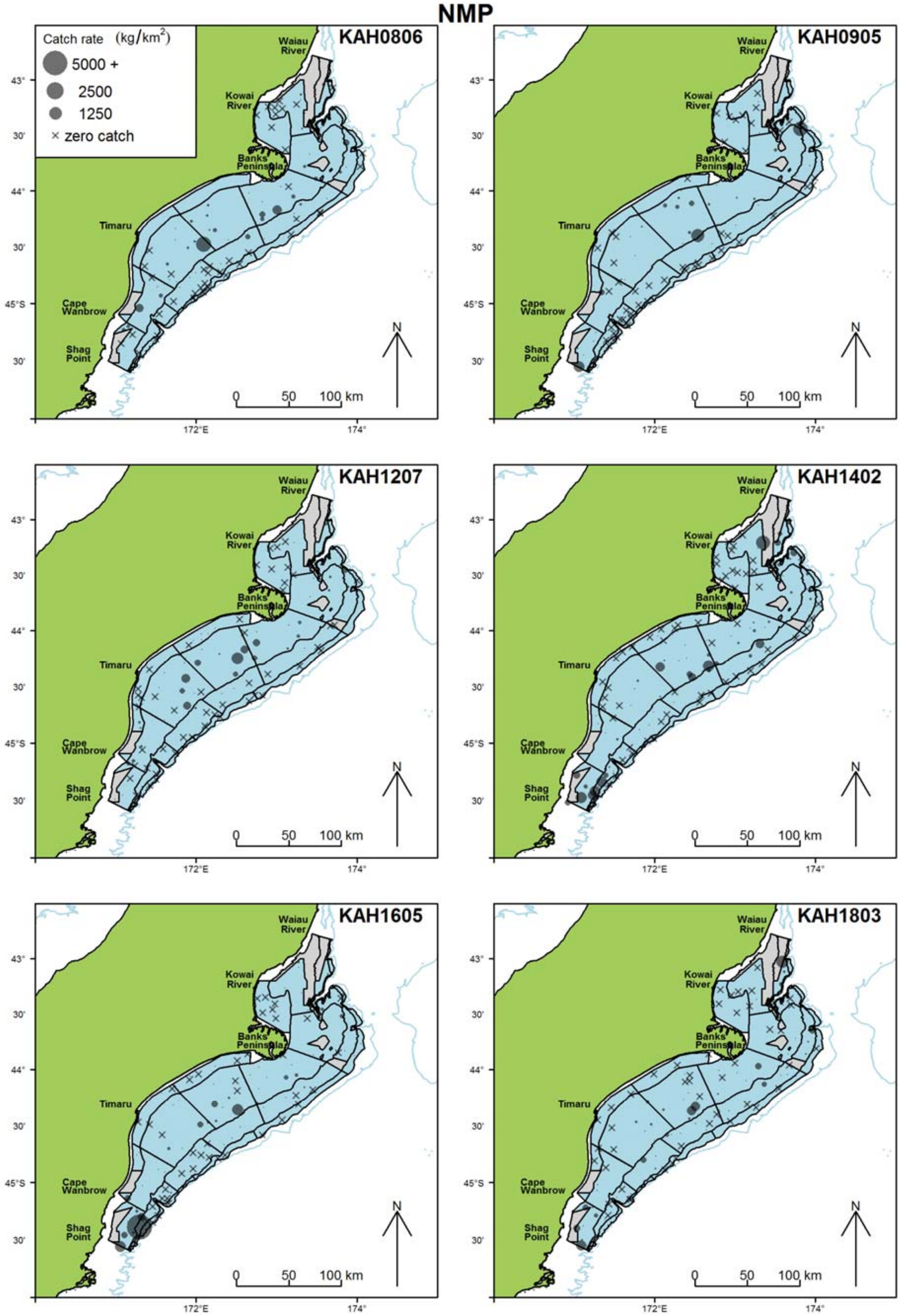



**Figure 10 –** ***continued***

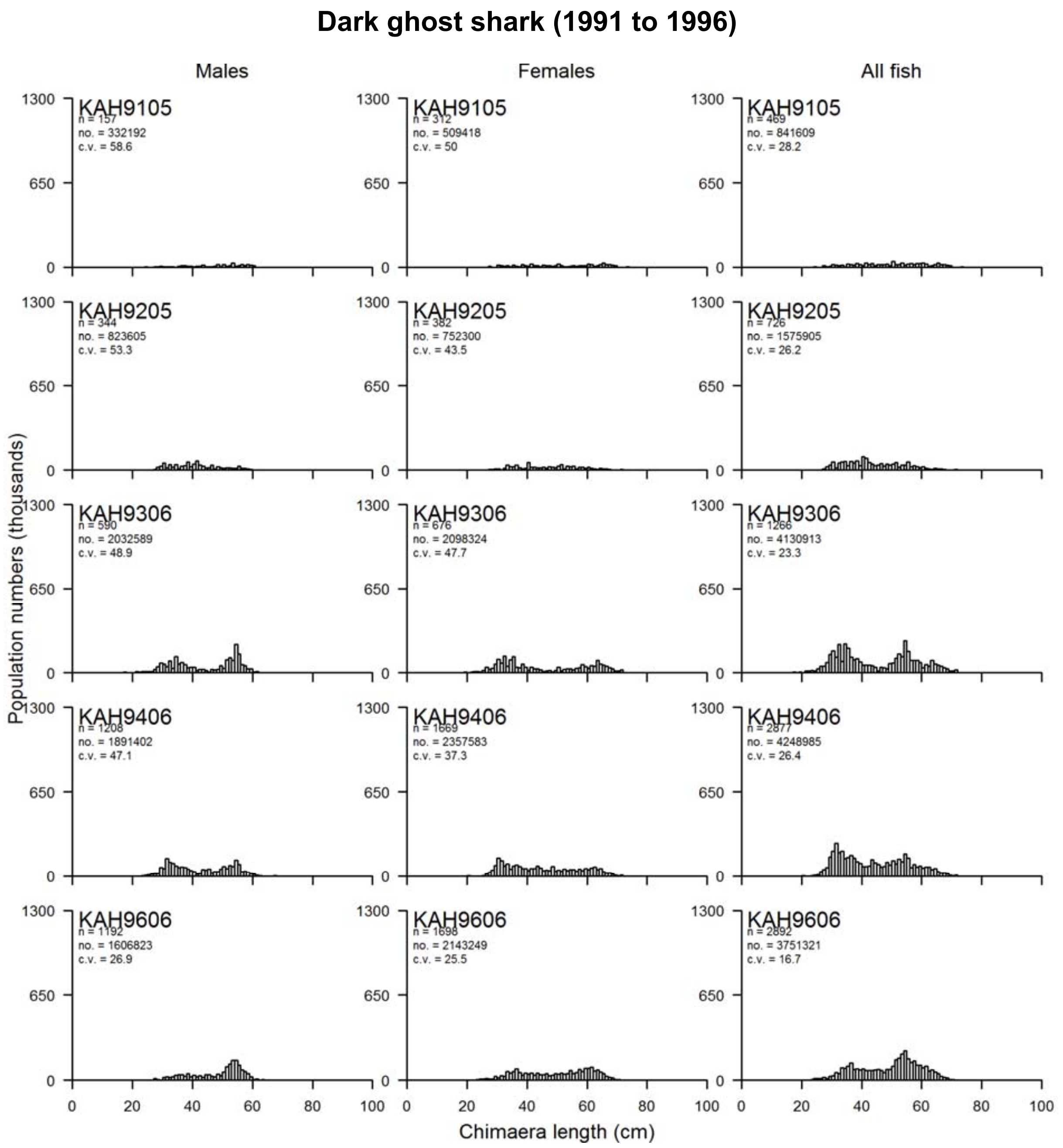



**Figure 11: Scaled population length frequency distributions for the target species in core strata (30–400 m) for the ECSI winter time series (1991 to 2018). The length distribution is also shown in the 10–30 m depth strata for the 2007, 2012, 201, 2016 and 2018 surveys overlaid (not stacked) in red 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.**

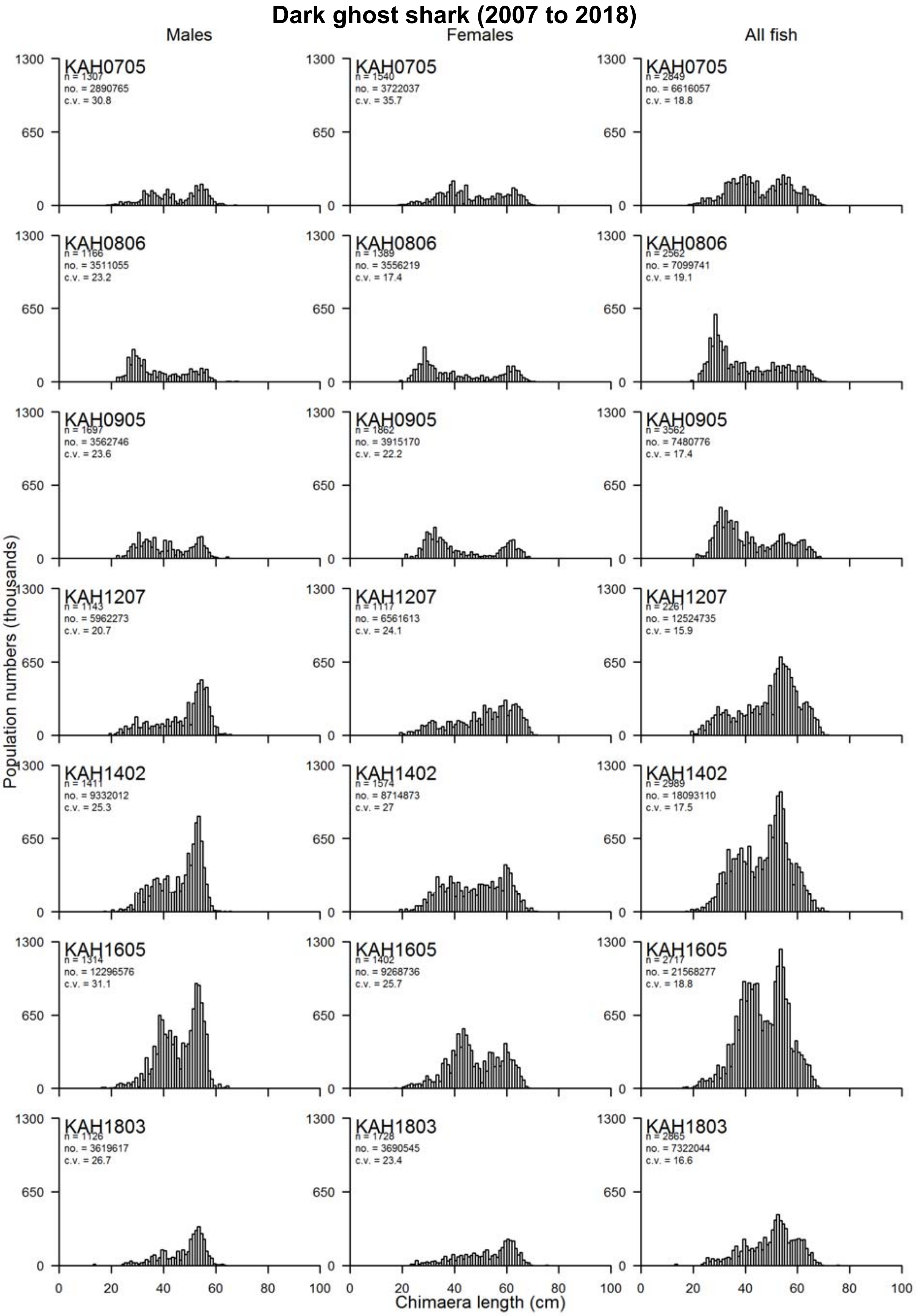



**Figure 11 –** ***continued***

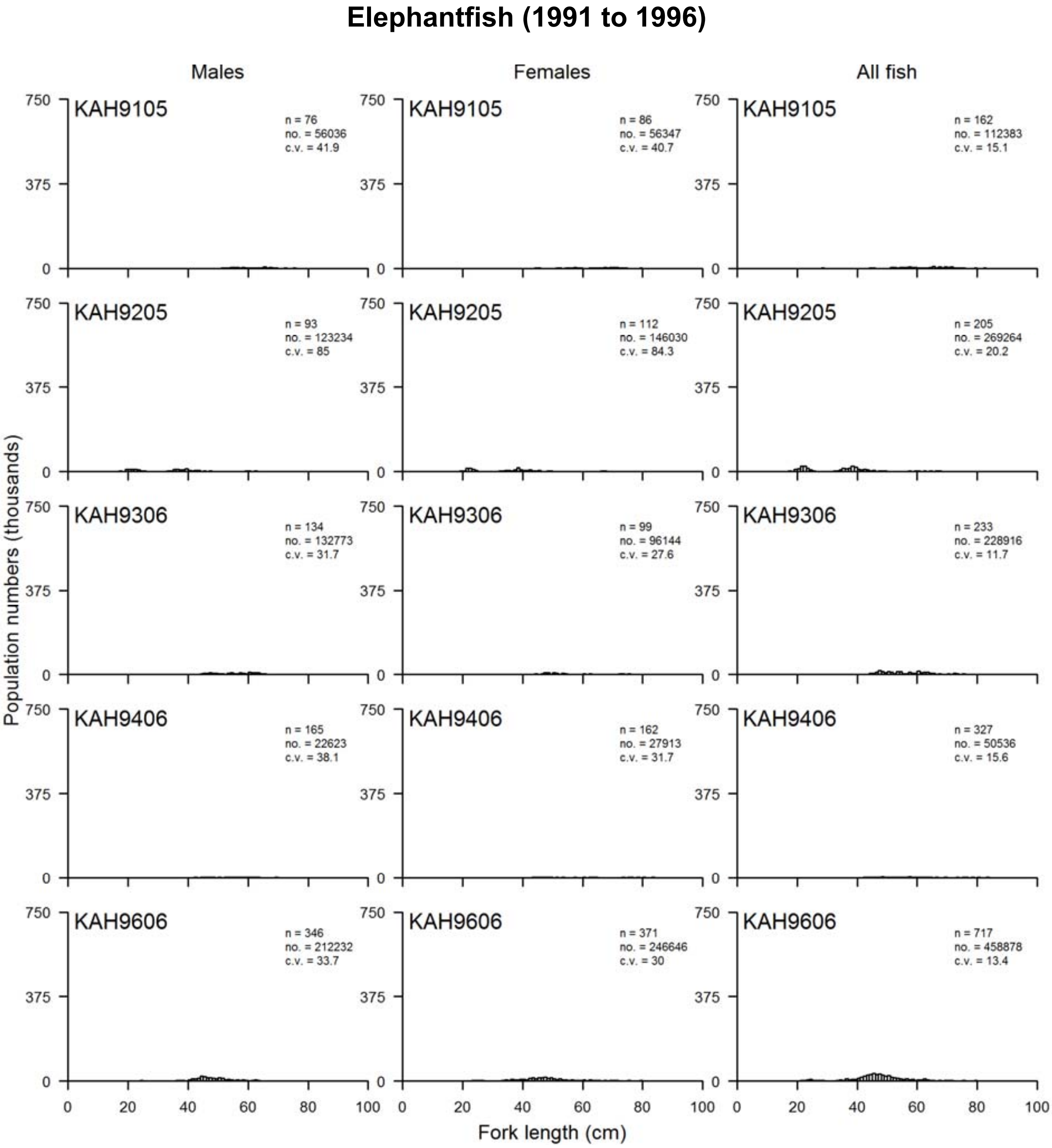



**Figure 11 –** ***continued***

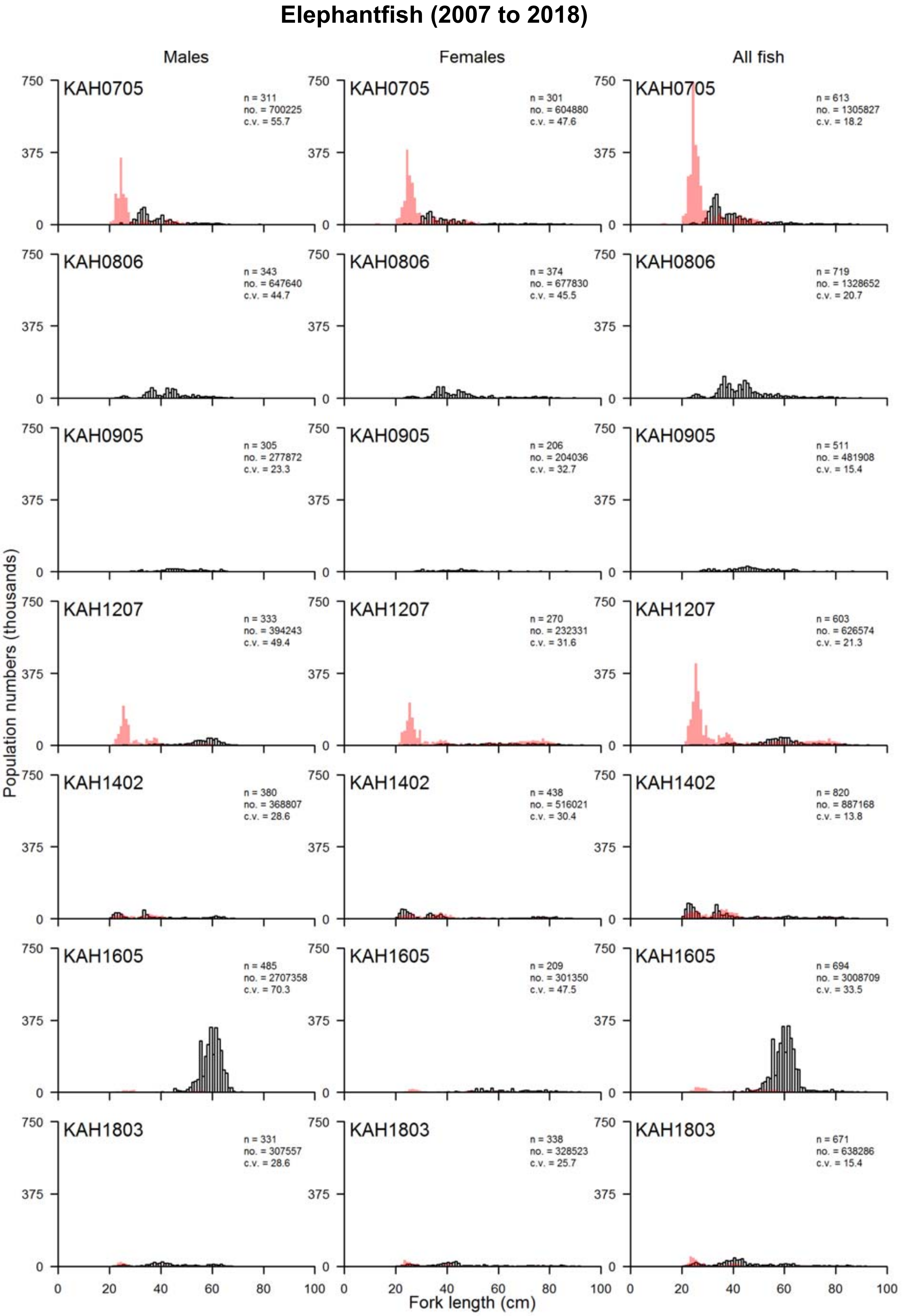



**Figure 11 –** ***continued***

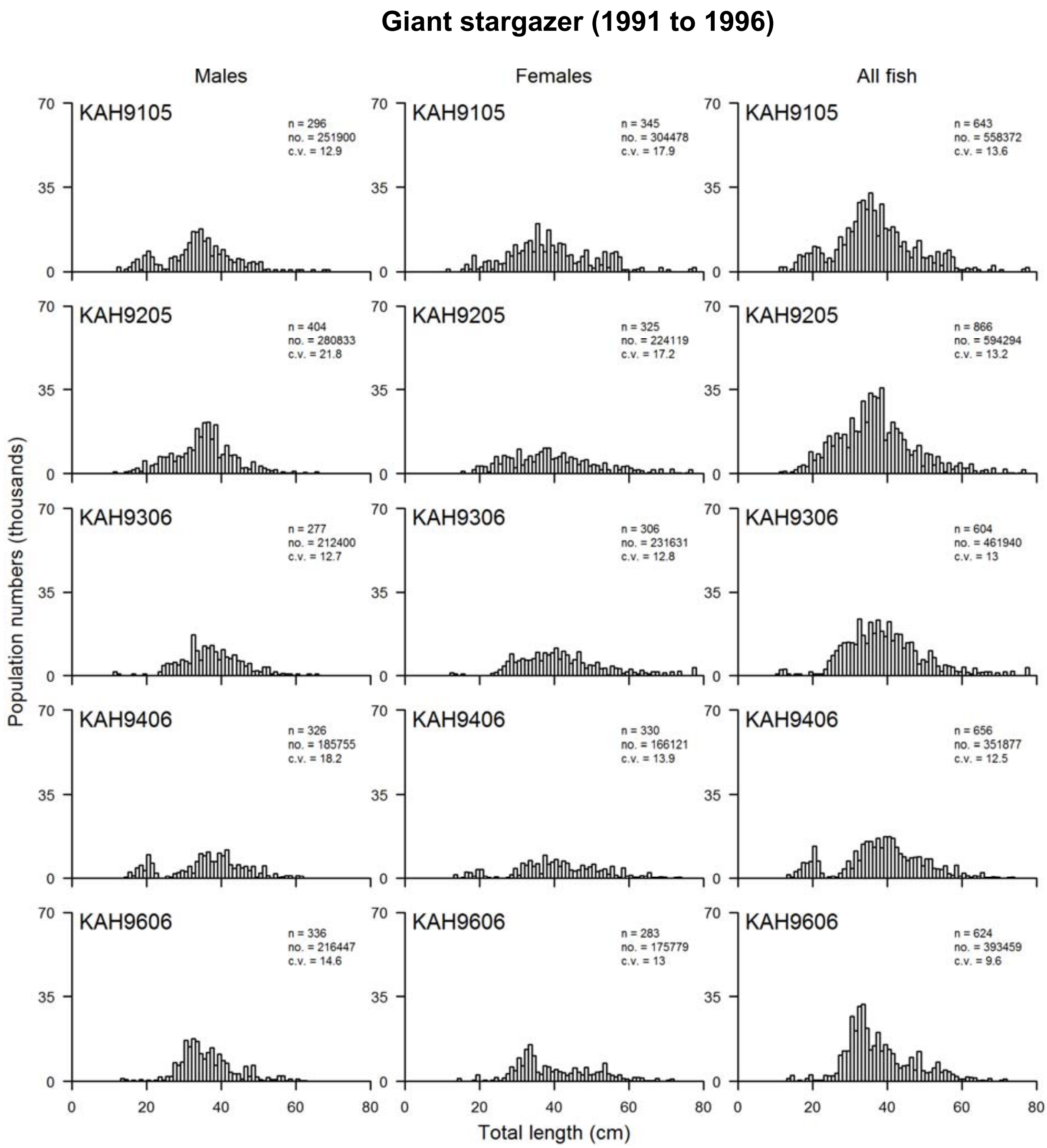



**Figure 11 –** ***continued***

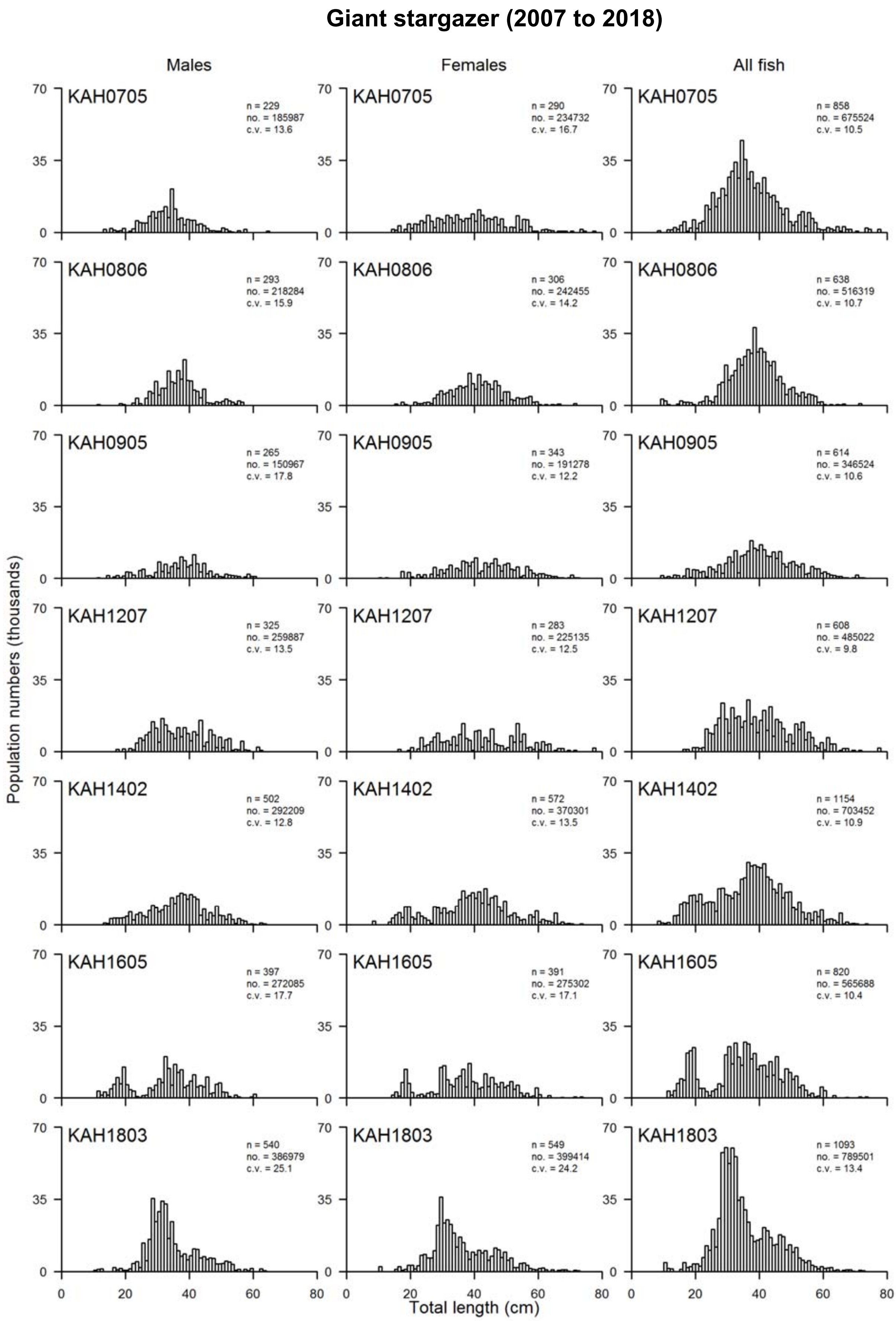



**Figure 11 –*continued***

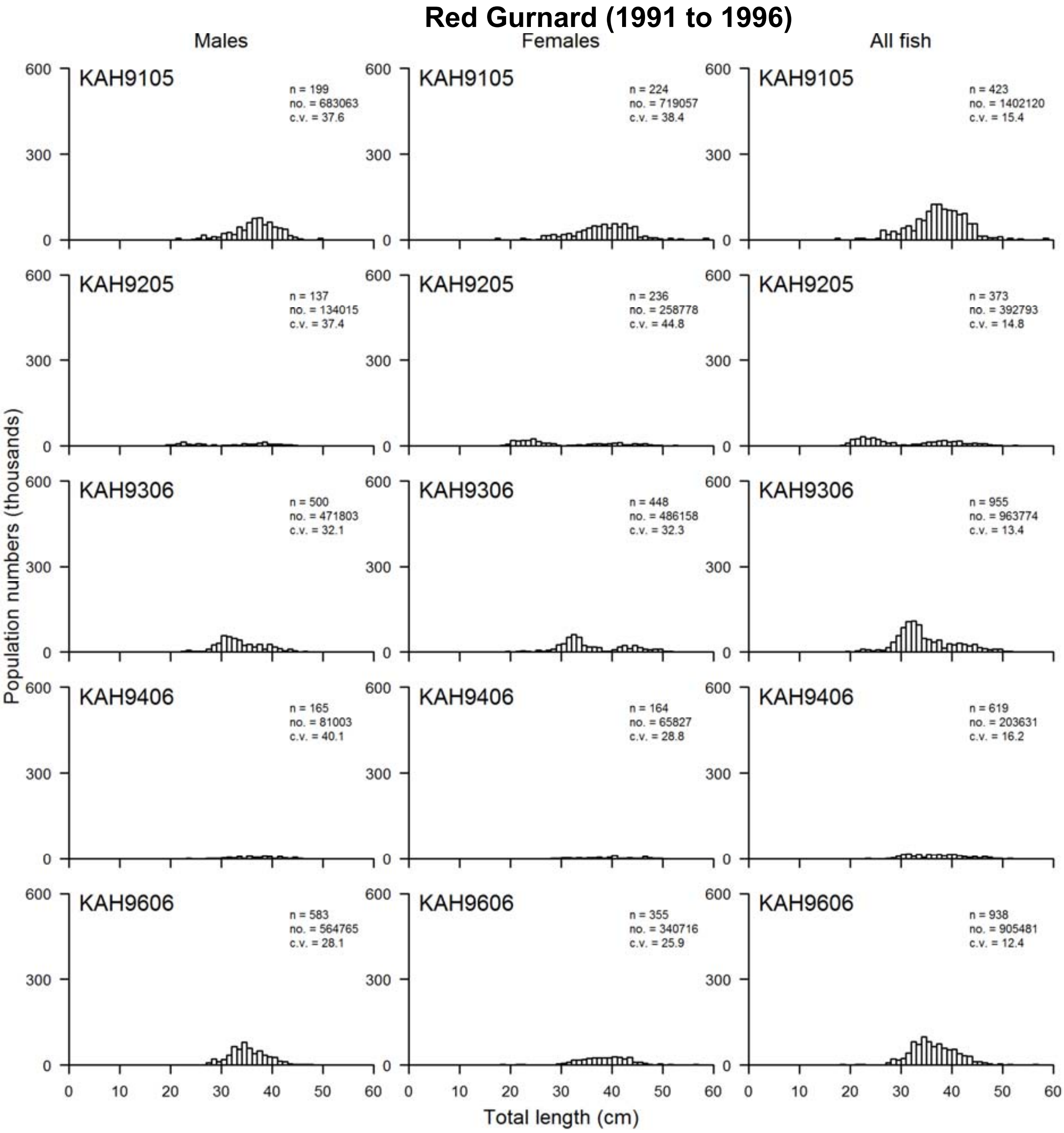



**Figure 11 –** ***continued***

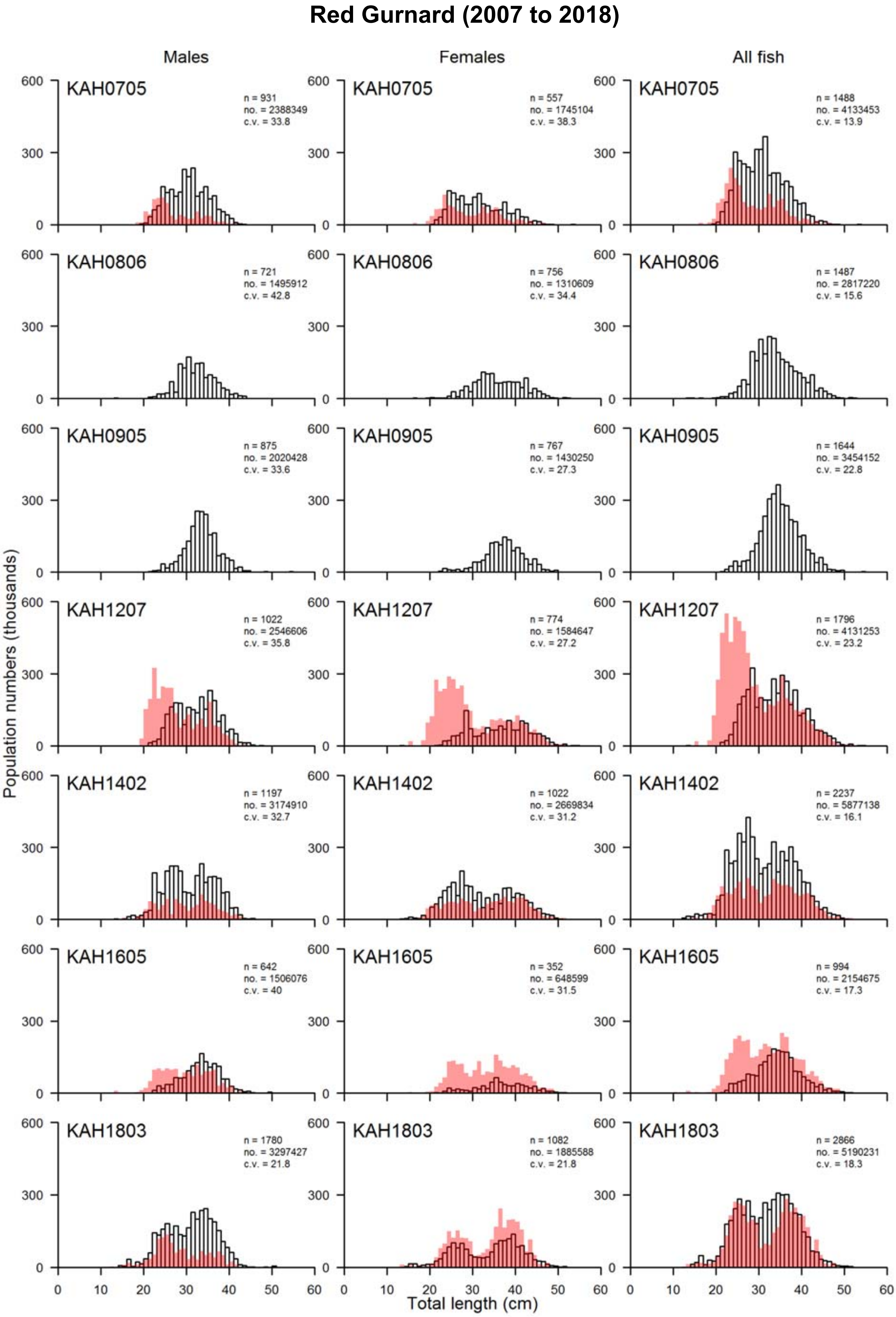



**Figure 11 –** ***continued***

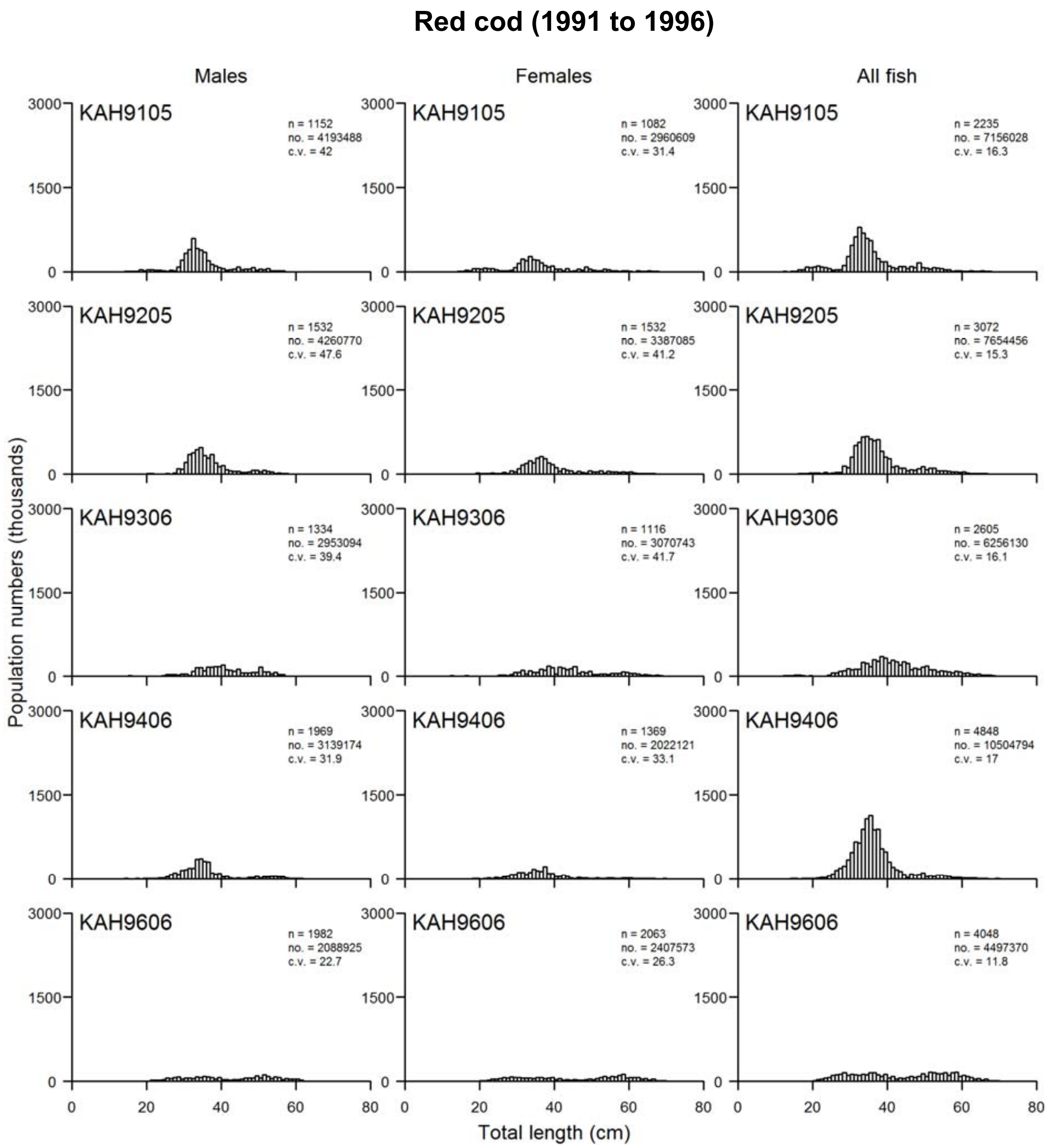



**Figure 11 –** ***continued***

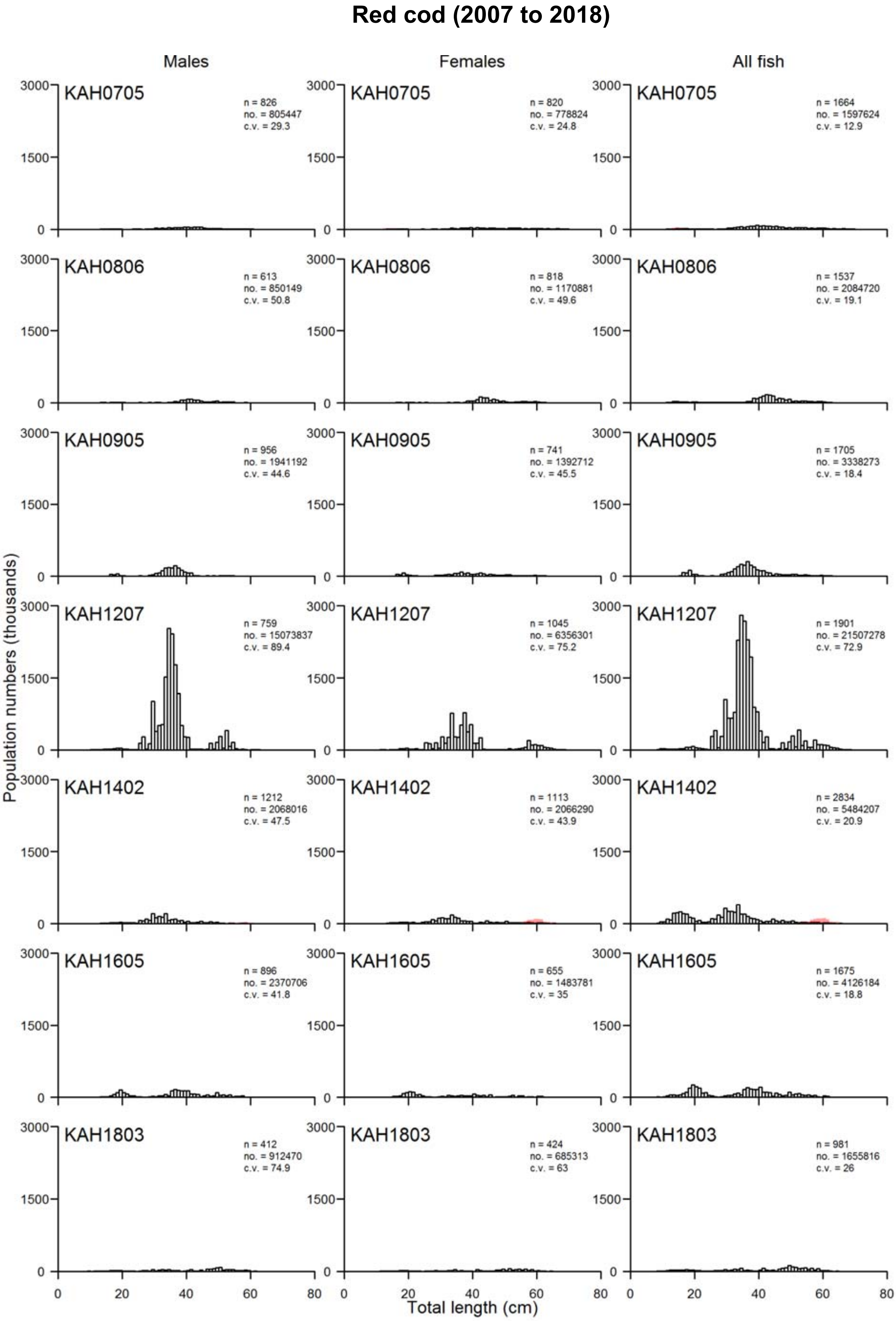



**Figure 11 –** ***continued***

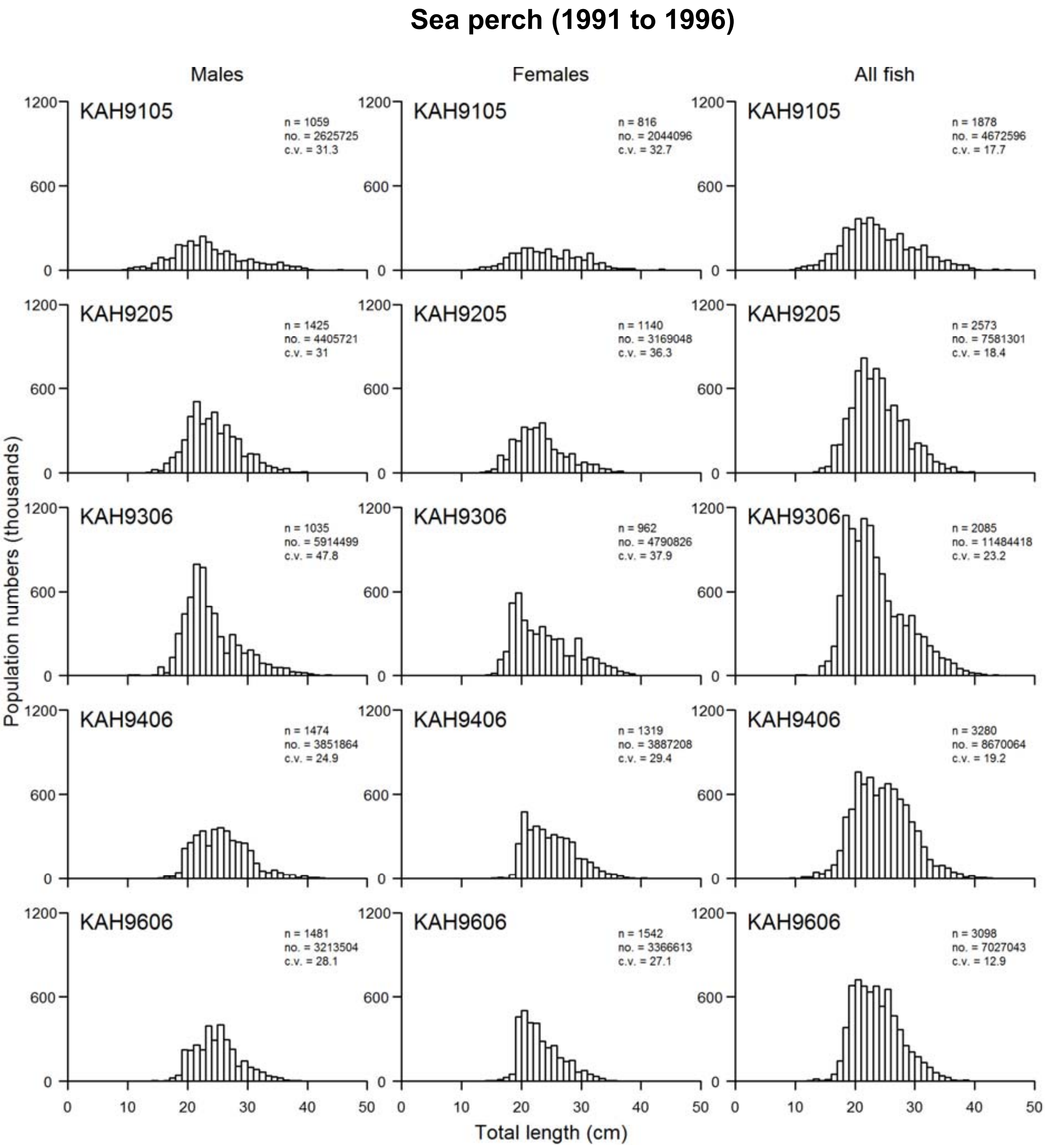



**Figure 11 –** ***continued***

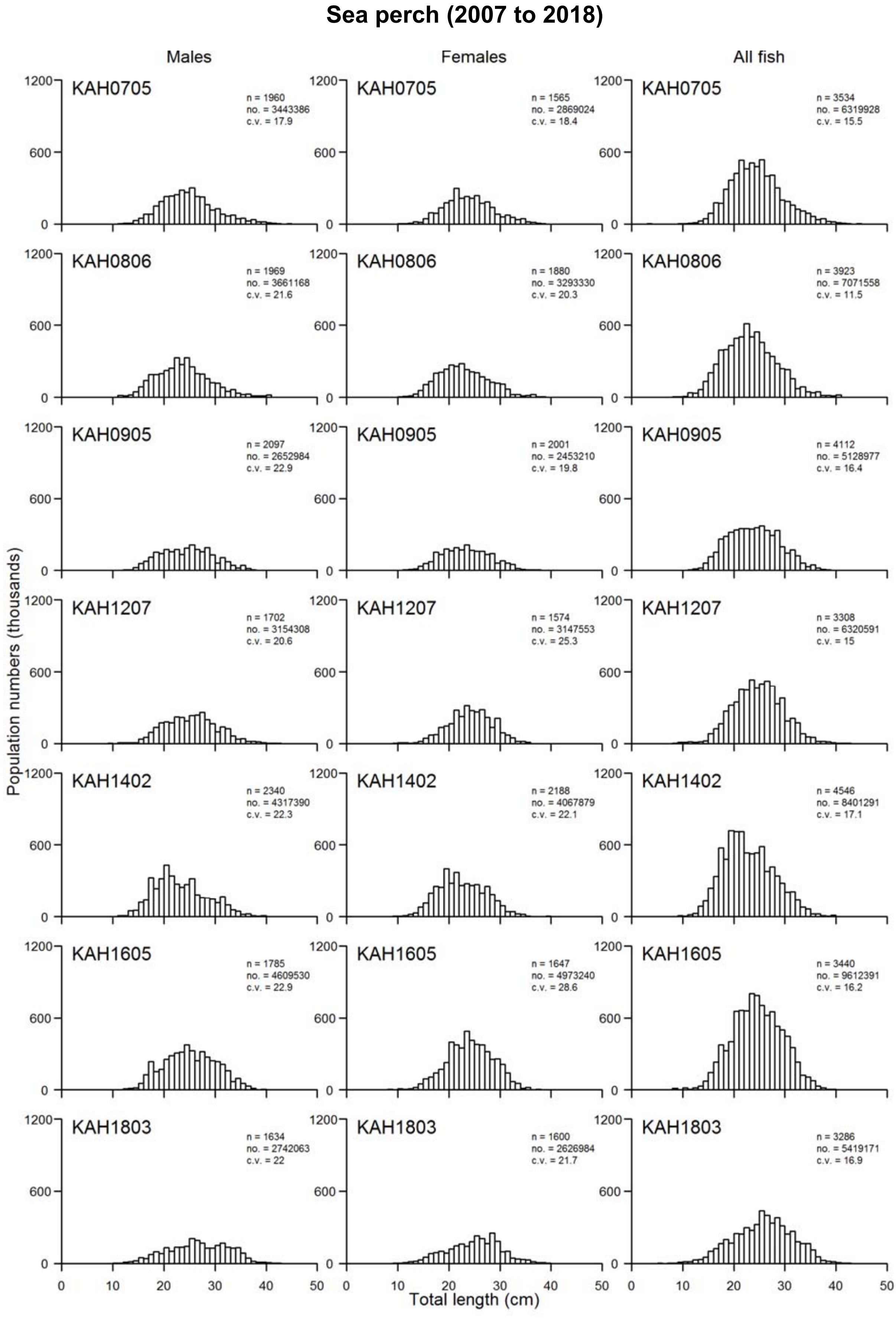



**Figure 11 –** ***continued***

## Spiny dogfish (1991 to 1996)

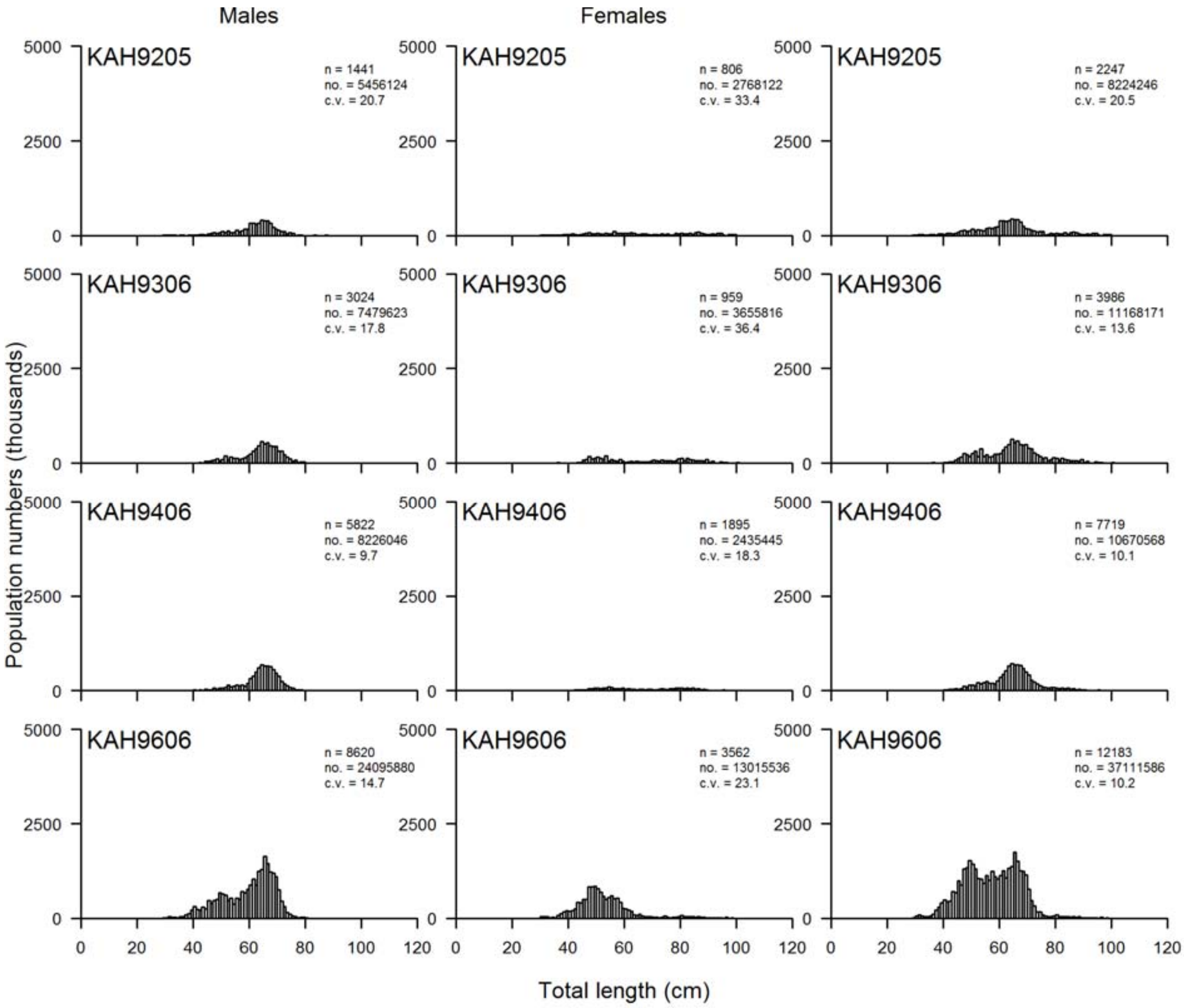



**Figure 11–** ***continued***

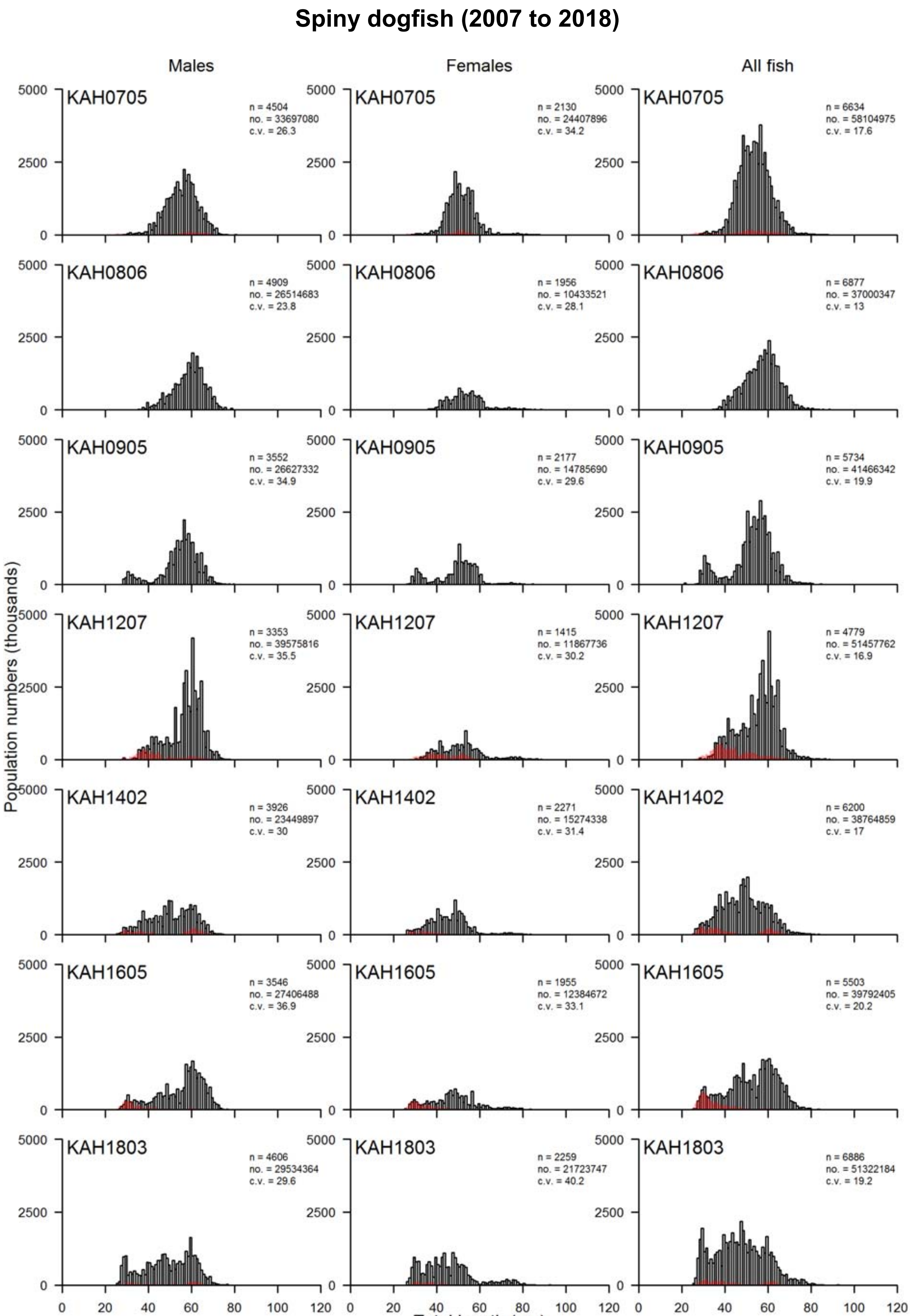



**Figure 11 –** ***continued***

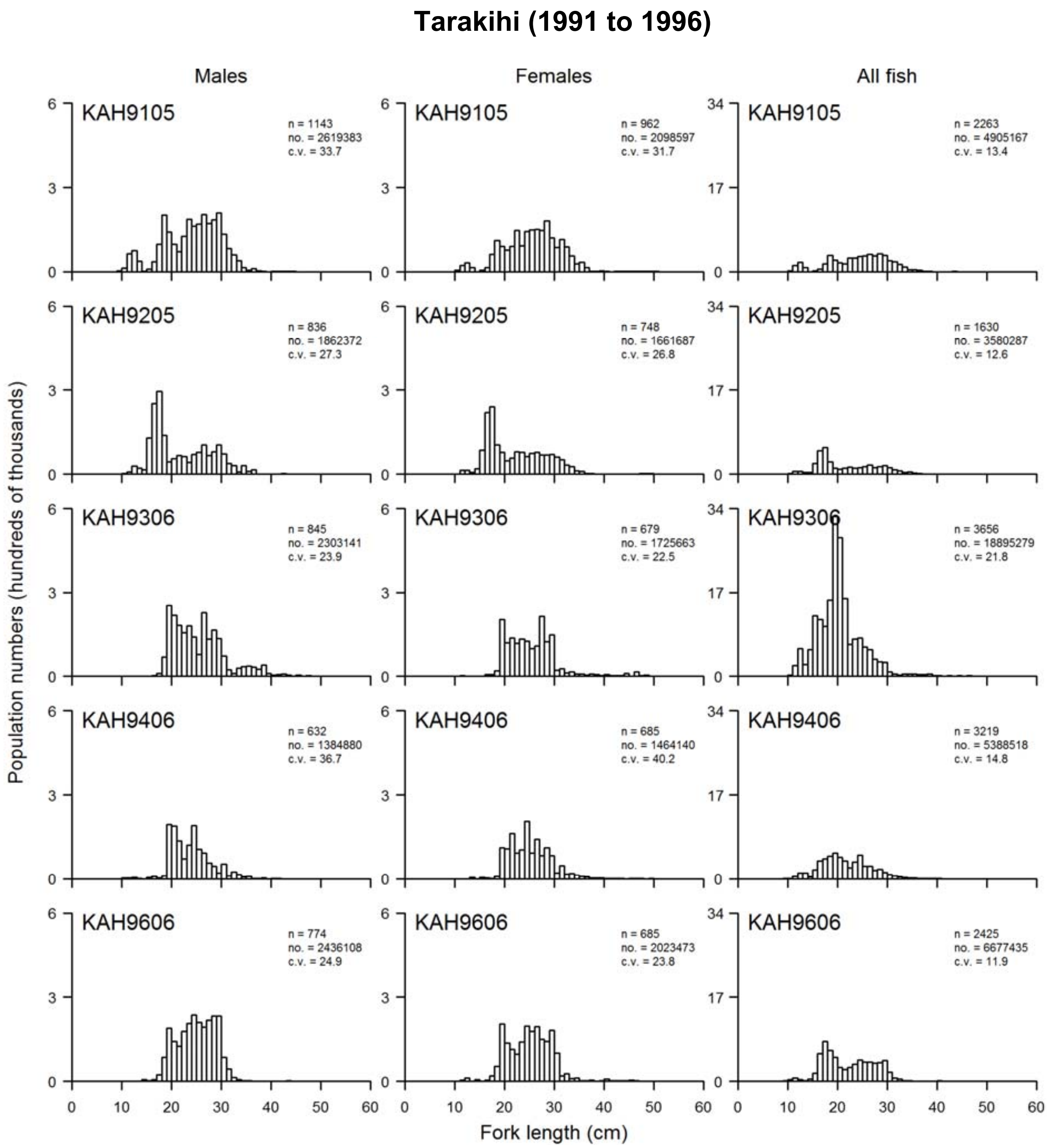



**Figure 11 –** ***continued***

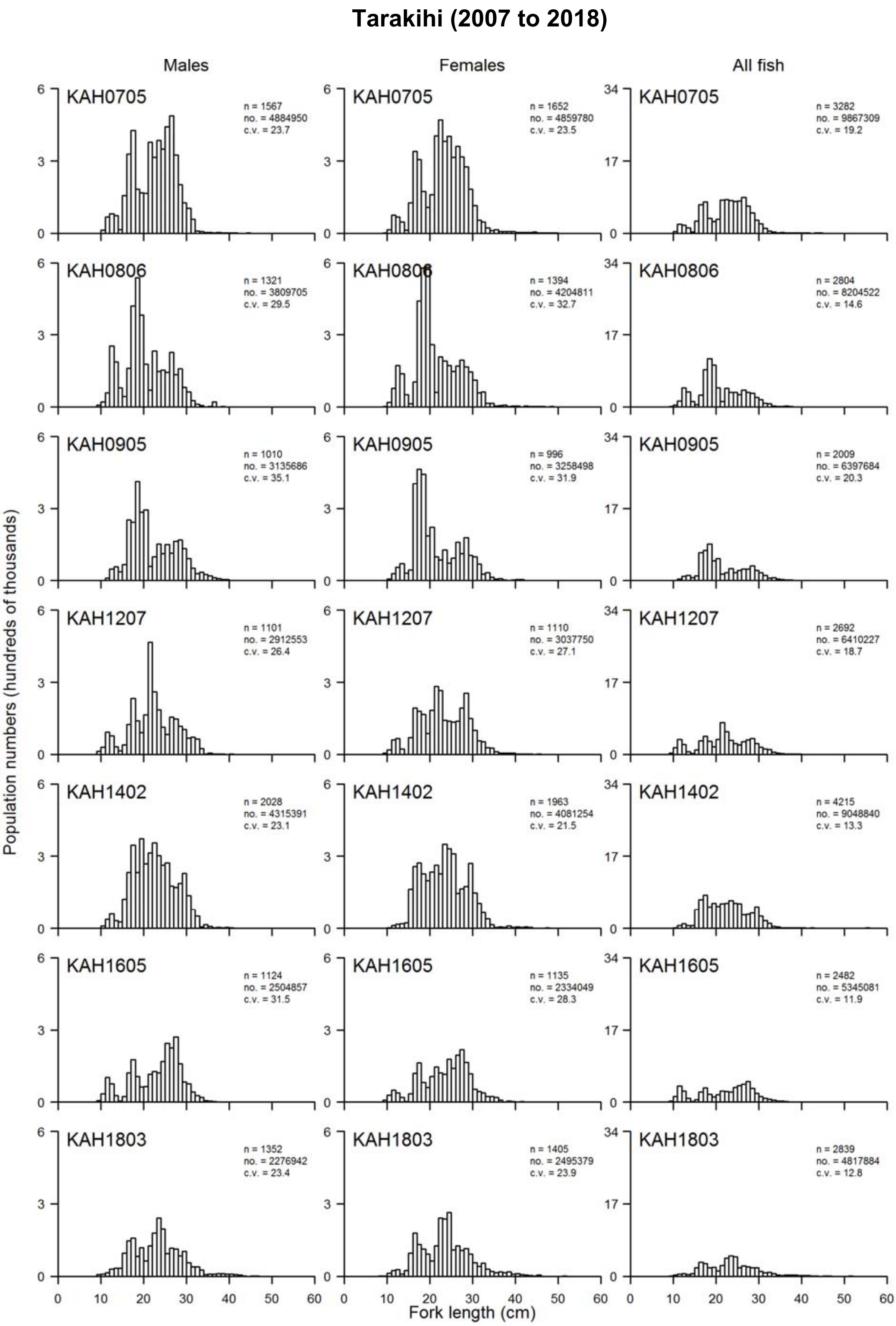



**Figure 11 –** ***continued***

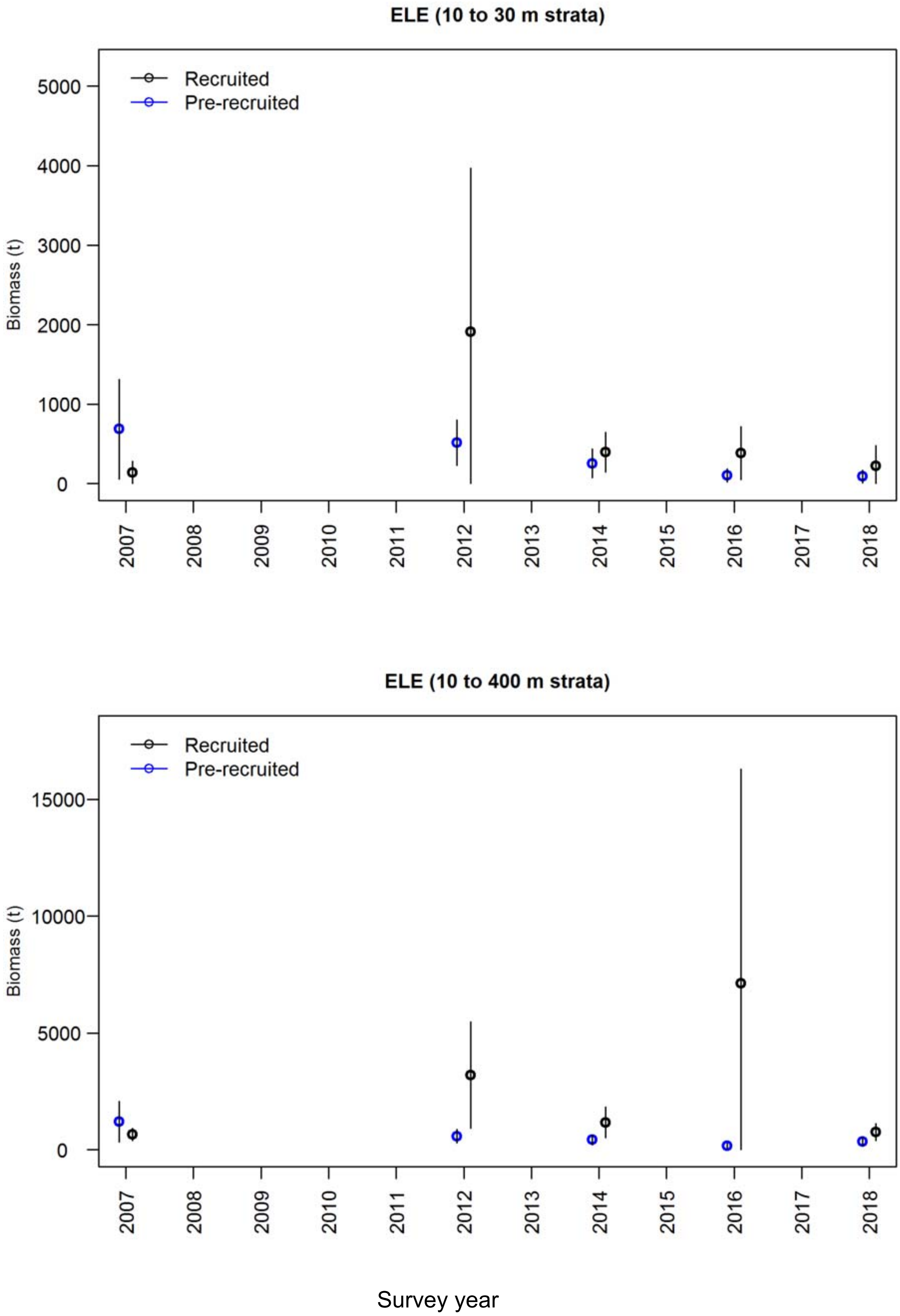
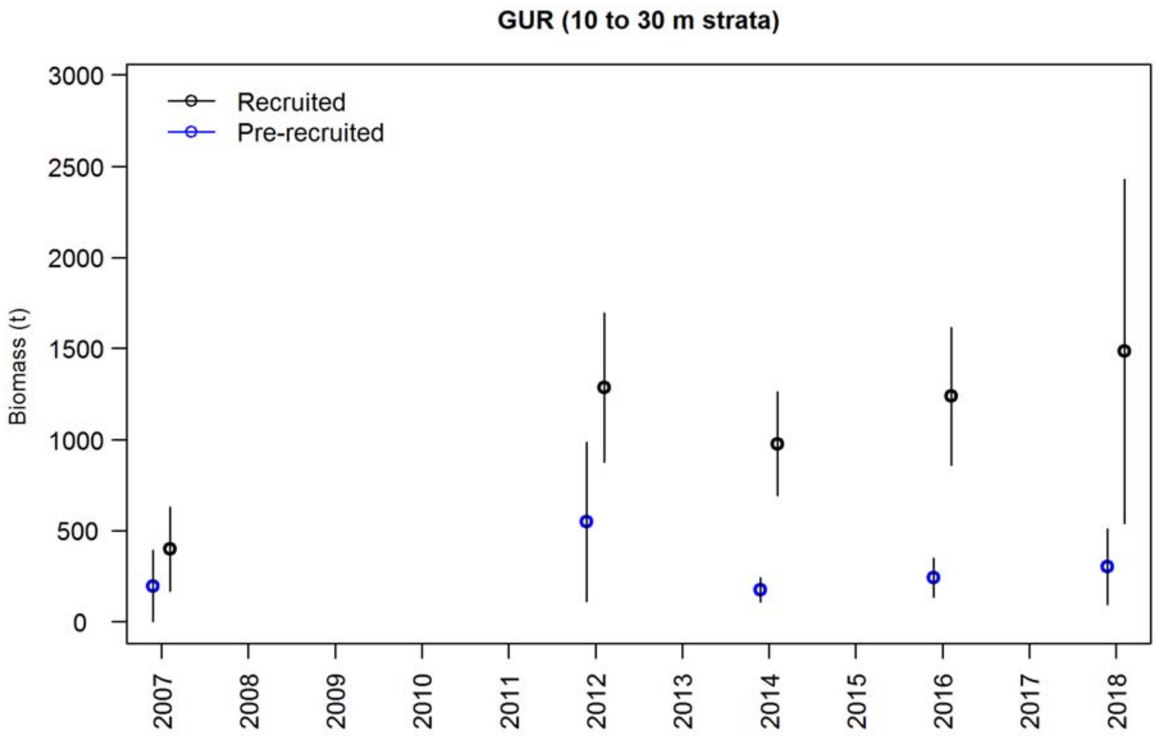



**Figure 12: Elephantfish and red gurnard recruited and pre-recruited biomass for 2007, 2012, 2014, 2016 and 2018 ECSI surveys in 10–30 m and core plus shallow strata (10–400 m). Error bars are +/- two standard errors.**



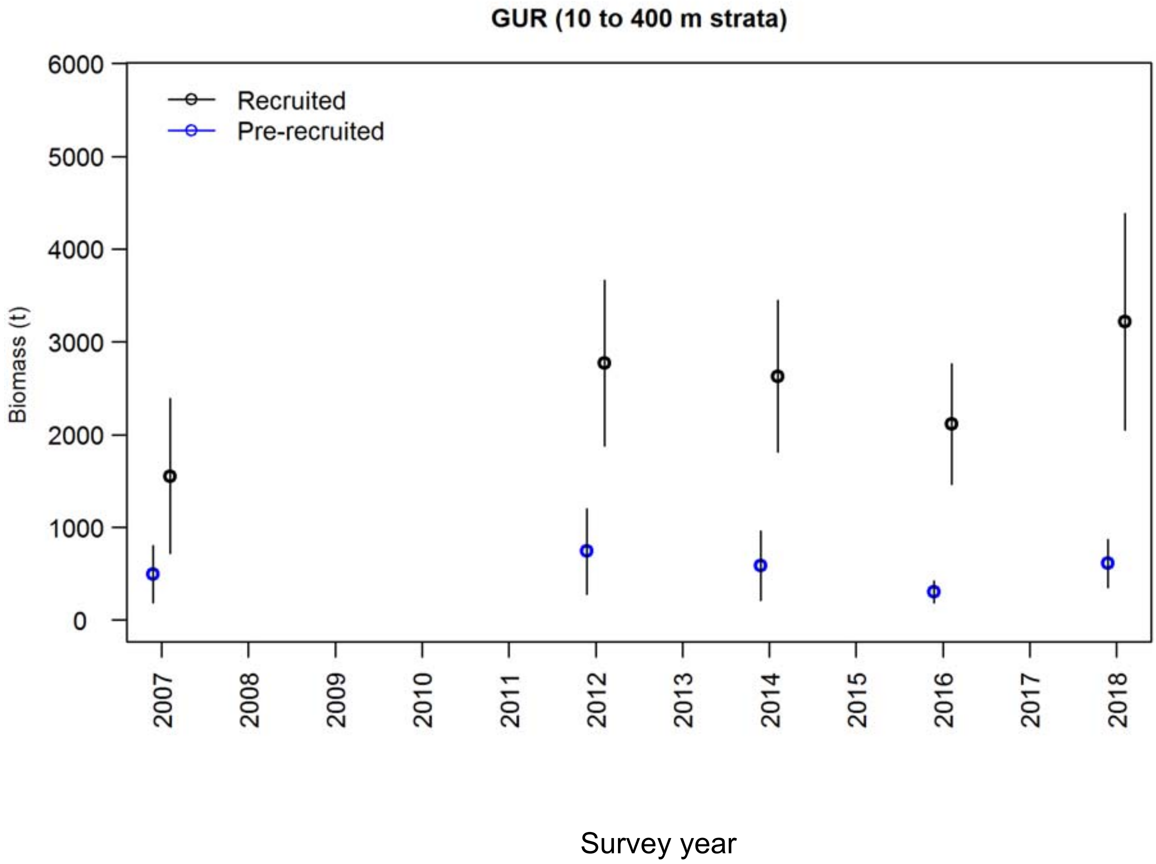




**Figure 12 – *continued***

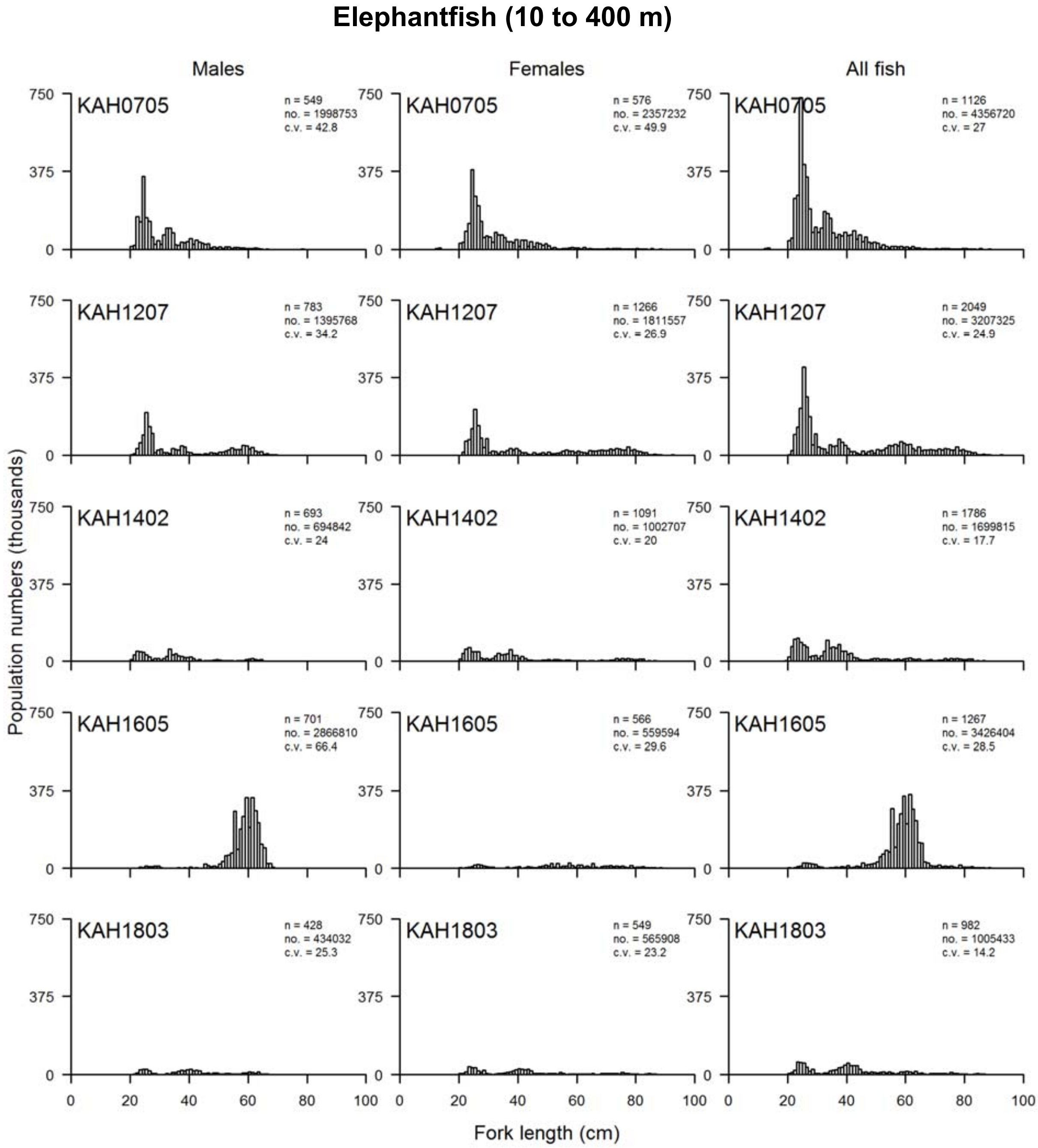



**Figure 13: Scaled length frequency distributions for elephantfish and red gurnard in core plus shallow strata (10–400 m), for 2007, 2012, 2014, 2016 and 2018 ECSI surveys. Population estimates are in thousands of fish, n, number of fish sampled; no., scaled number of fish; C.V. (%).**

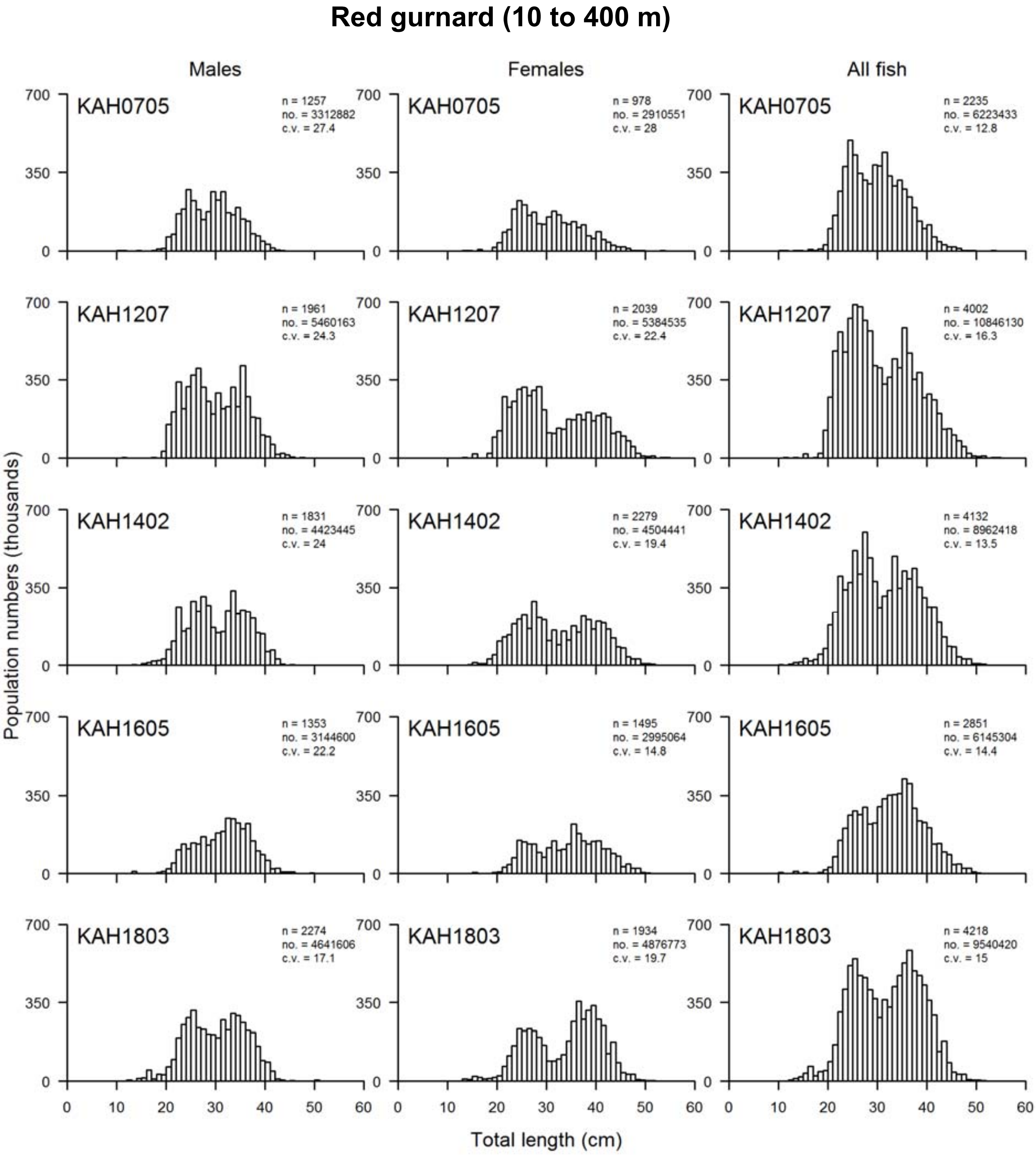
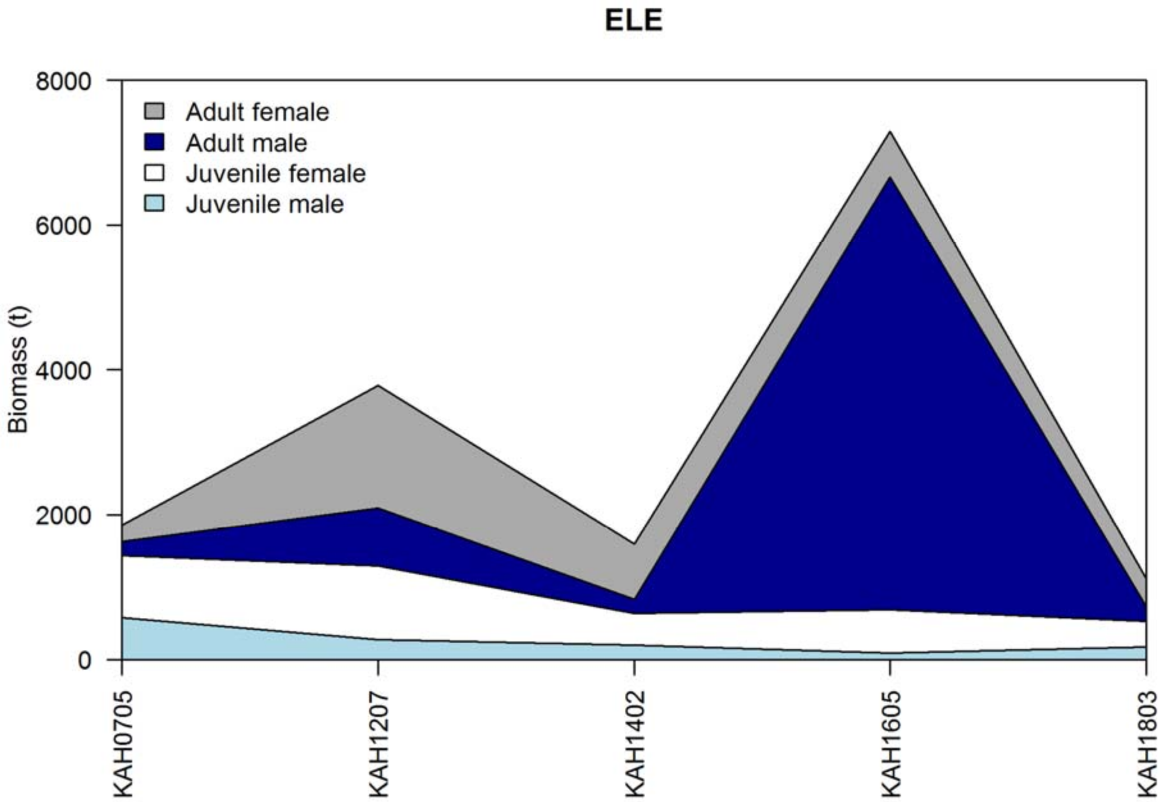



**Figure 13 –** ***continued***



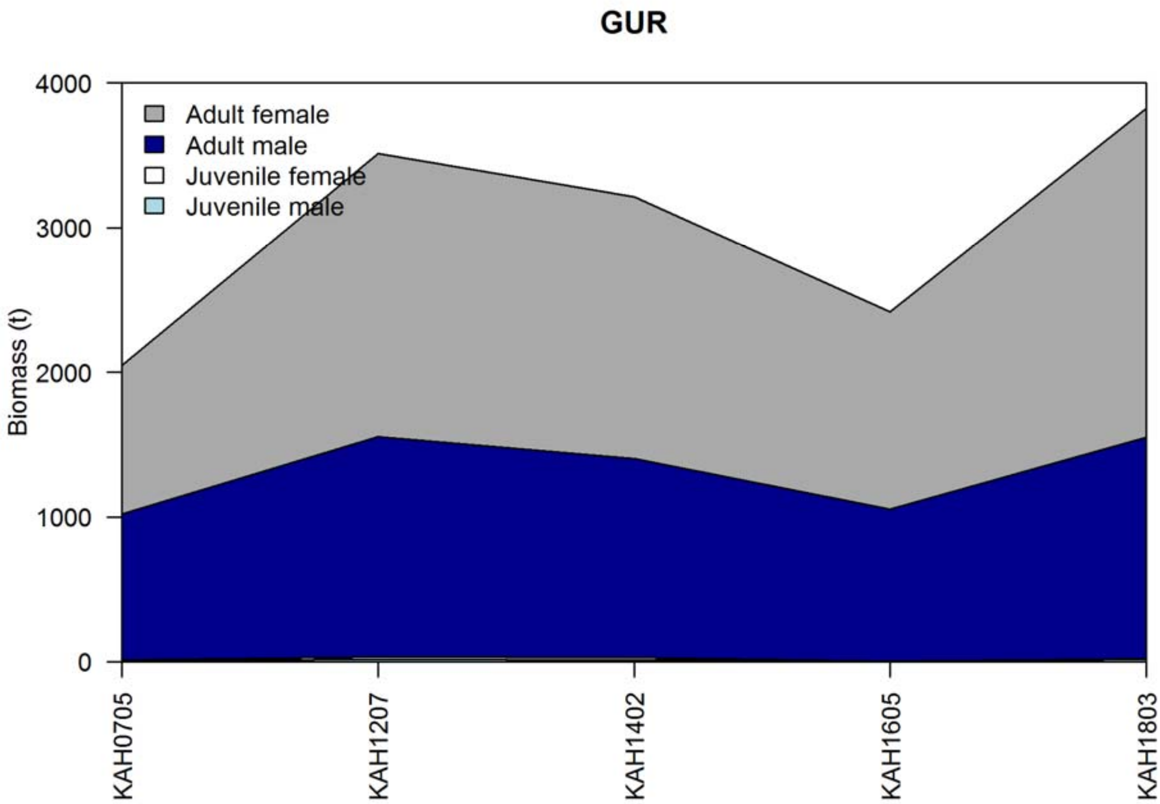
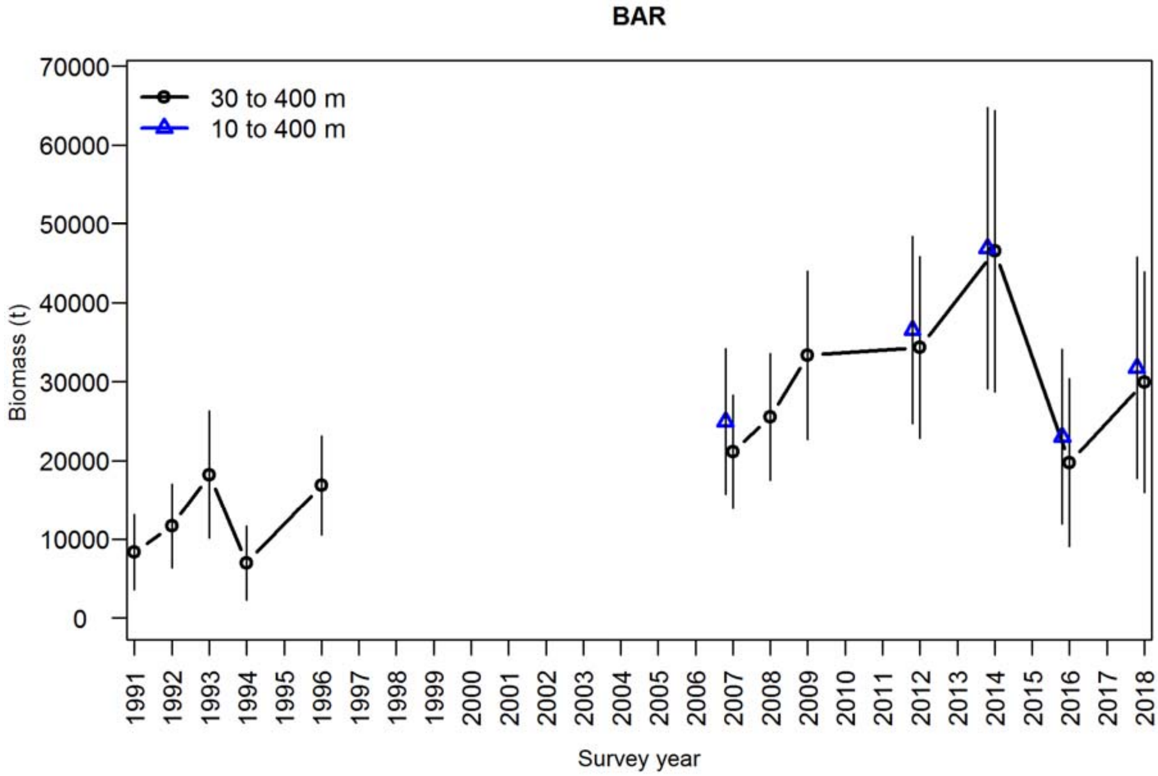




**Figure 14: Elephantfish and red gurnard juvenile and adult biomass in core plus shallow strata (10–400 m) for 2007, 2012, 2014, 2016 and 2018 ECSI surveys, where juvenile is below and adult is equal to or above length at which 50% of fish are mature.**



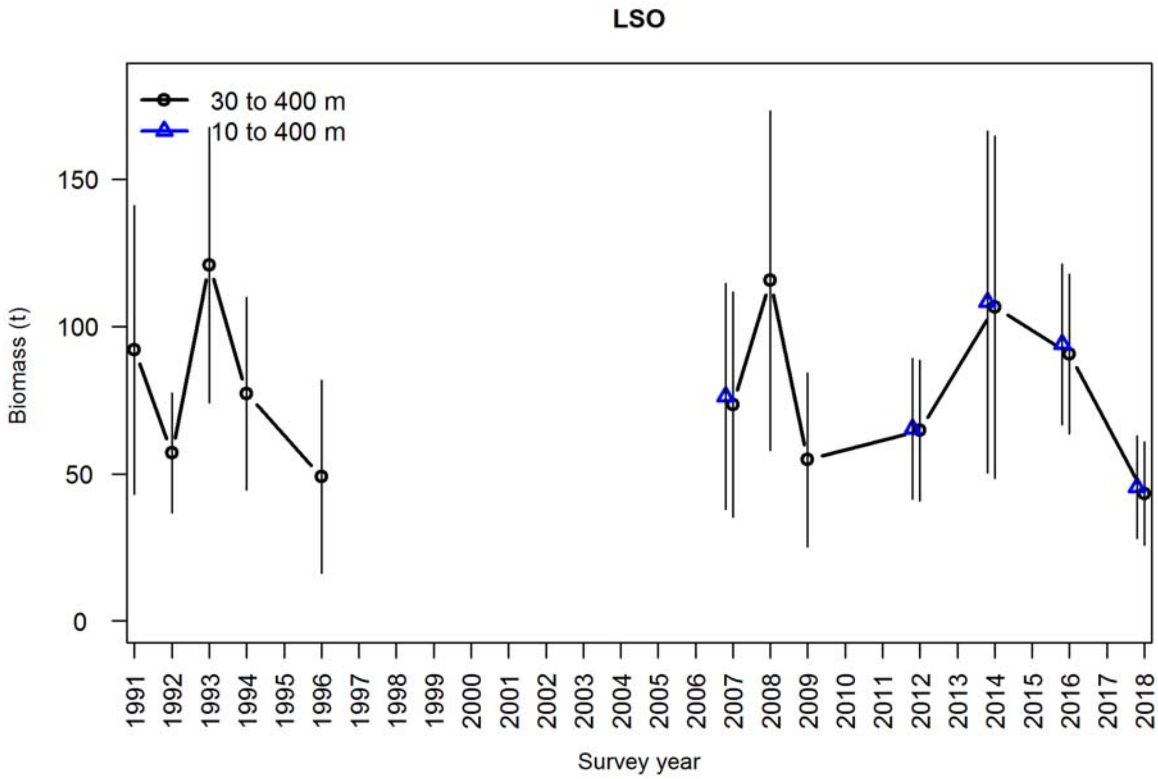
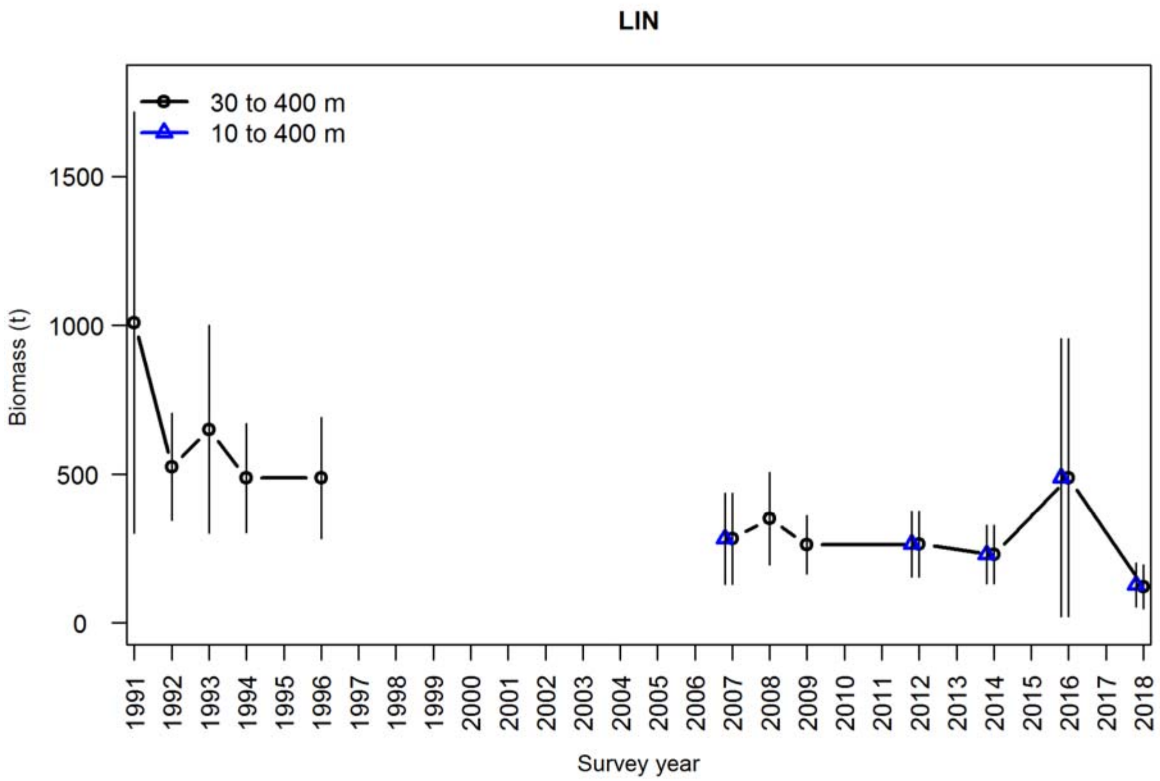




**Figure 15: Key non-target QMS species total biomass for all ECSI winter surveys in core strata (30–400 m), and core plus shallow strata (10–400 m) in 2007, 2012, 2014, 2016 and 2018. Error bars are +/- two standard deviations.**



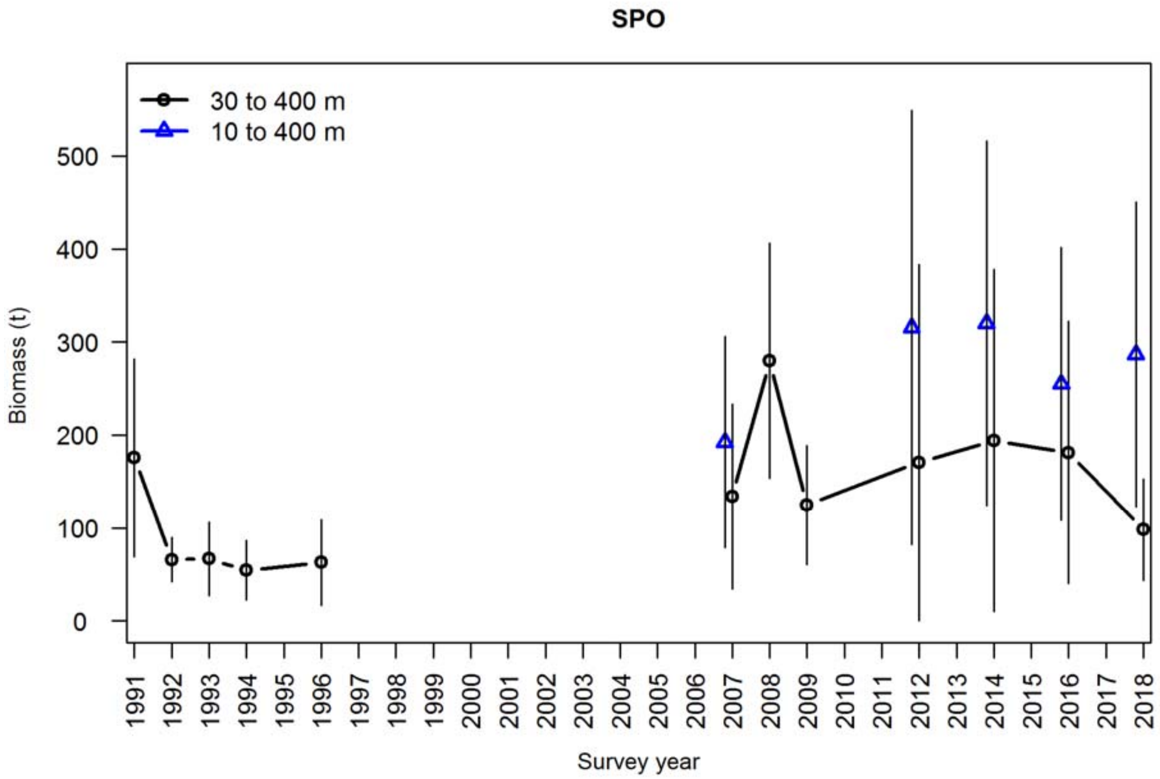
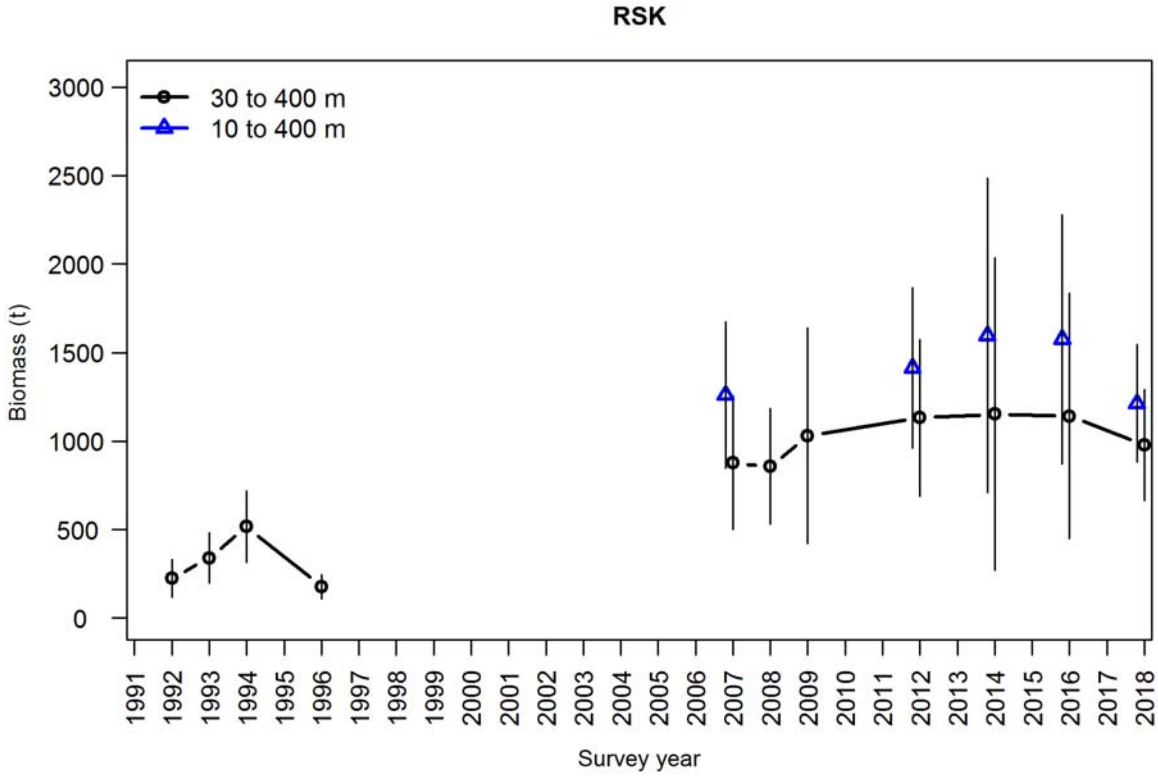




**Figure 15 –** ***continued***



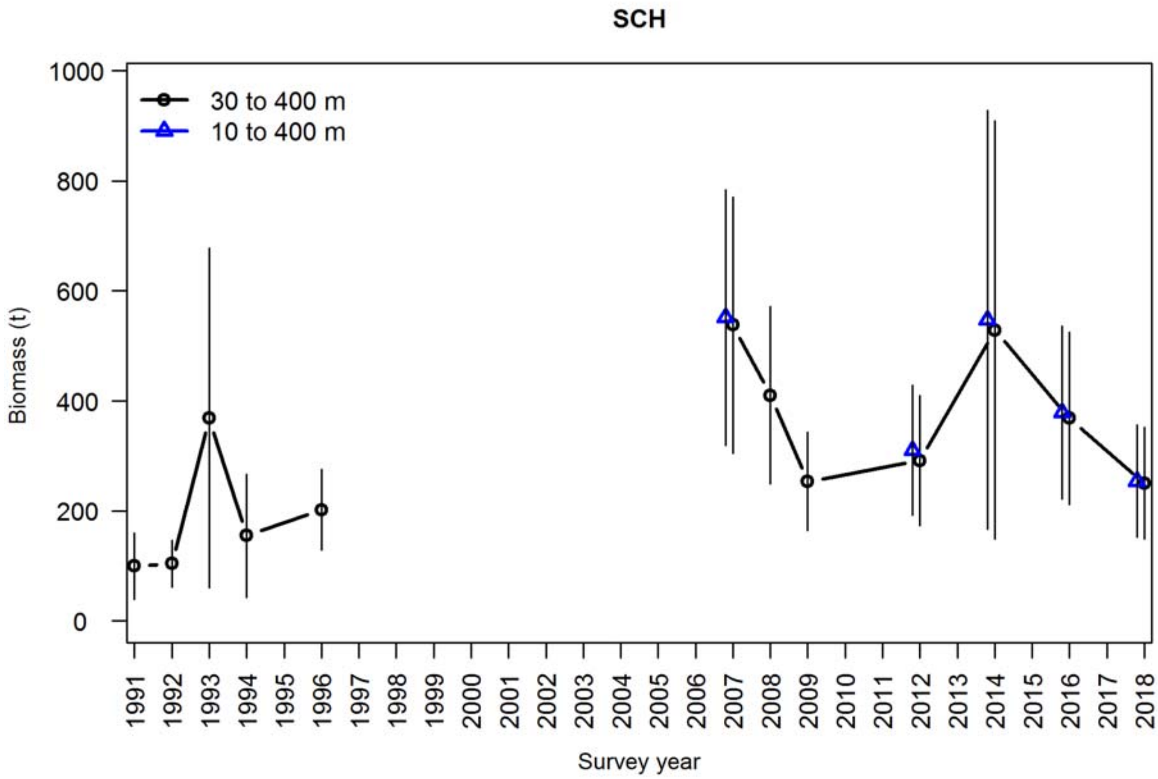
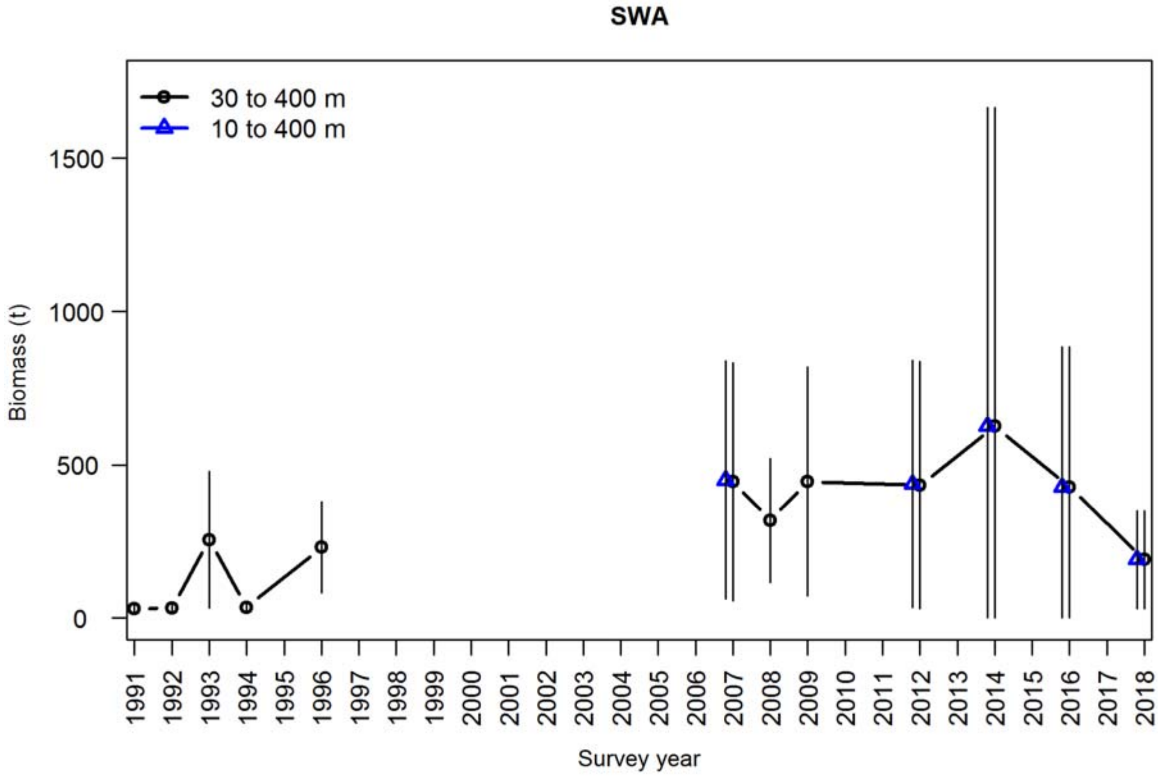




**Figure 15 – *continued***



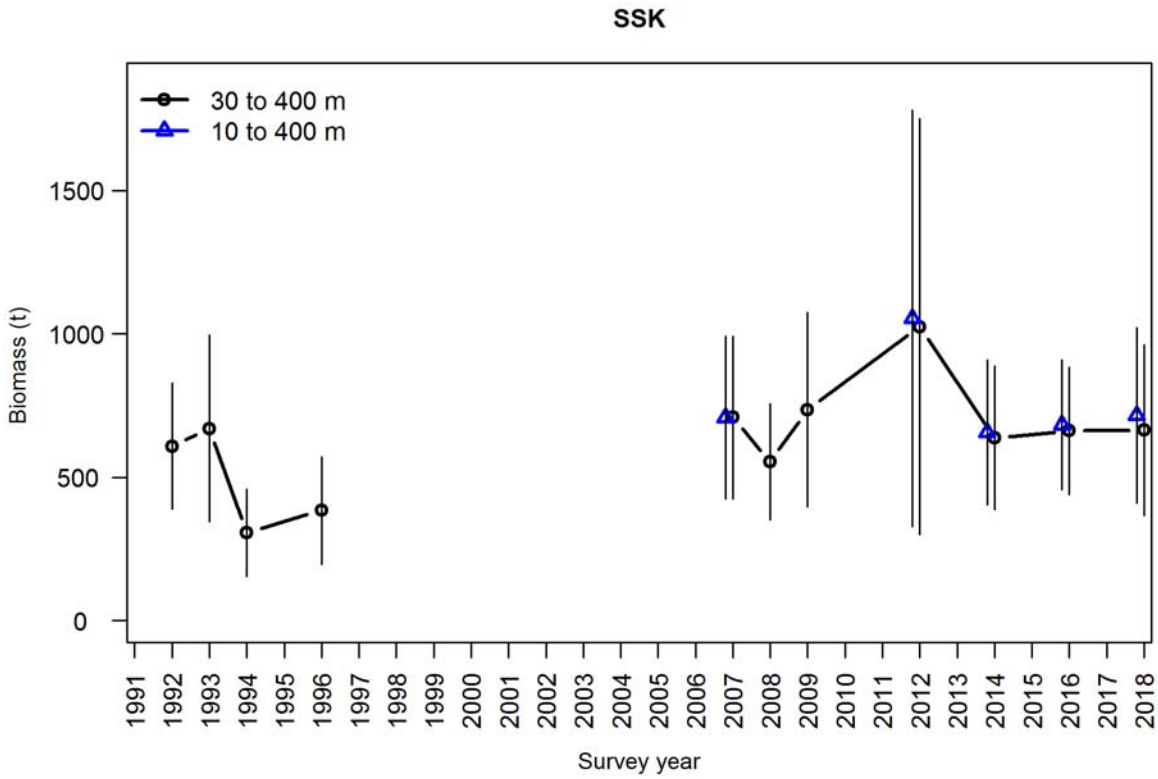




**Figure 15 –** ***continued***

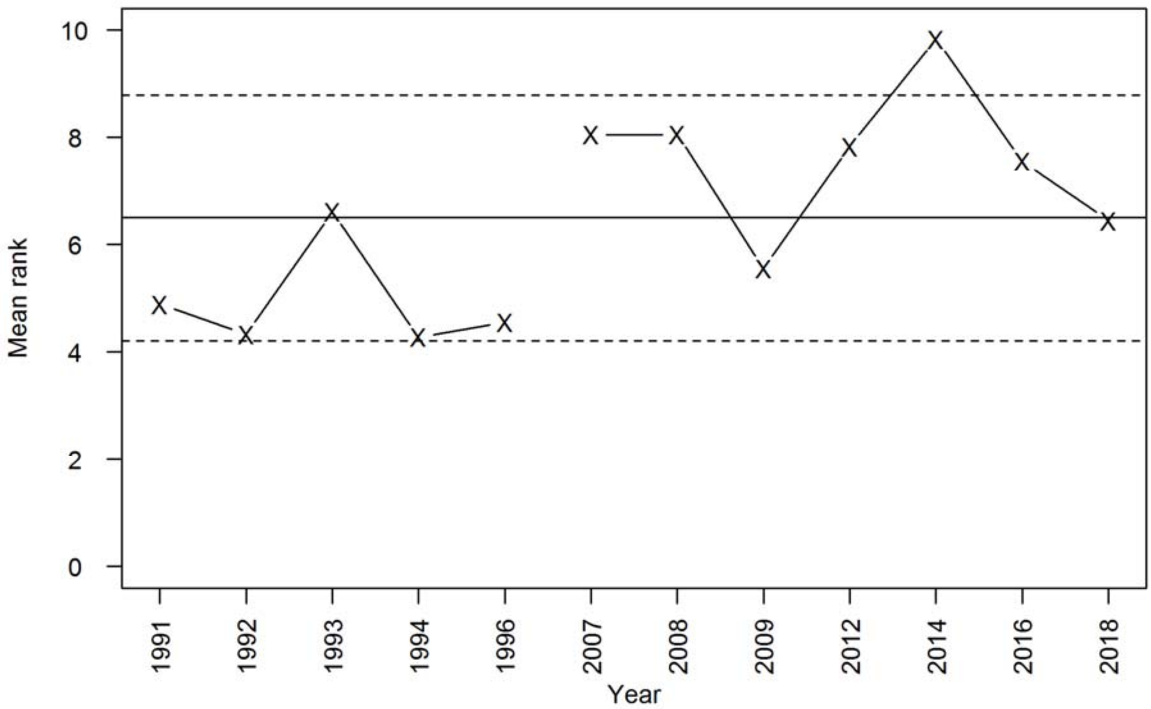



**Figure 16: Mean ranks for the ECSI winter trawl surveys (core strata) for 19 species, including the target species. The solid line indicates the overall mean rank. Mean ranks outside the broken lines (95% confidence intervals) have extreme catchability.**

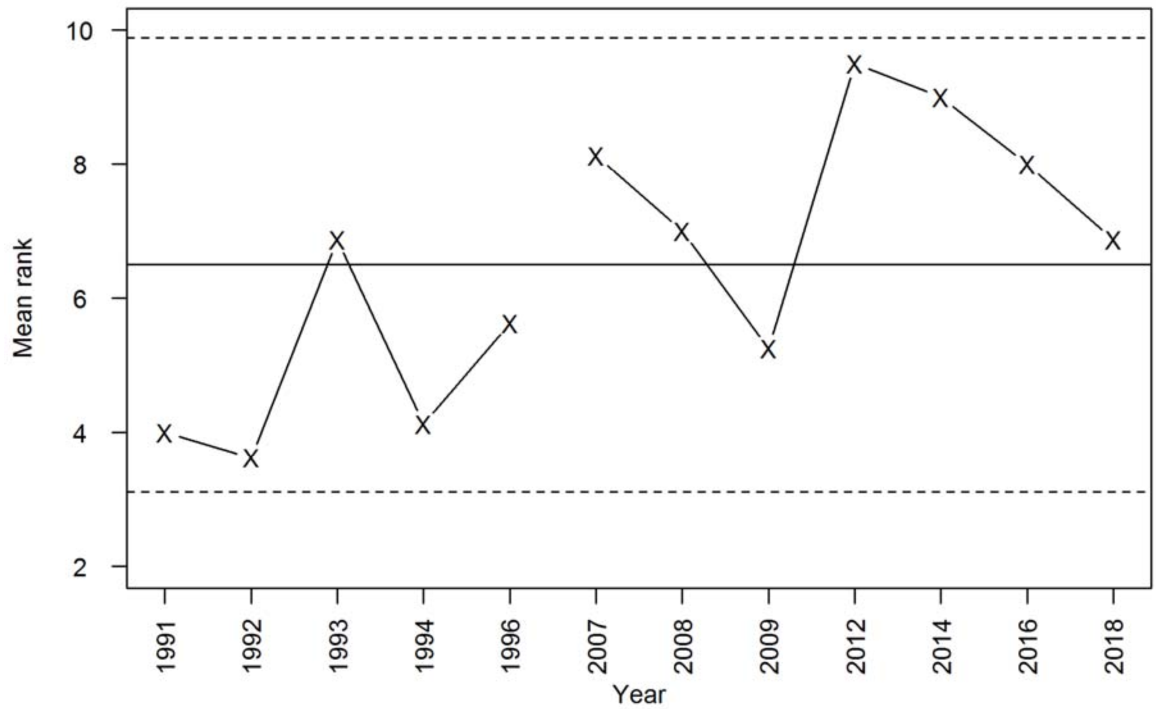



**Figure 17: Mean ranks for the ECSI winter trawl surveys (core strata) for eight target species. The solid line indicates the overall mean rank. Mean ranks outside the broken lines (95% confidence intervals) have extreme catchability.**

**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 2018 survey. NA, no data; gear perf, gear performance (1–5).**

| | | | | Lat/long start of tow | | Lat/ long end of tow | | Gear depth (m) | | Dist. trawled | Headline | Door spread | | Temperature (ºC) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Station | Stratum | Date | Time | º ' S | º ' E | º ' S | º ' E | Min. | Max. | (n. miles) | height (m) | (m) | Gear perf. | Surface | Bottom |
| 1 | 13 | 26-Apr-18 | 727 | 430187 | 1733527 | 430484 | 1733490 | 121 | 124 | 2.98 | 4.8 | 83.3 | 1 | 13.8 | 12.4 |
| 2 | 13 | 26-Apr-18 | 1043 | 430749 | 1733635 | 431025 | 1733539 | 123 | 128 | 2.84 | 4.9 | 80.5 | 1 | 13.8 | 12.7 |
| 3 | 17 | 26-Apr-18 | 1323 | 431580 | 1734626 | 431770 | 1734895 | 312 | 339 | 2.72 | 4.6 | 96.1 | 1 | 12.9 | 11 |
| 4 | 13 | 26-Apr-18 | 1544 | 432146 | 1734096 | 432270 | 1733722 | 117 | 119 | 2.98 | 4.8 | 80.4 | 1 | 12.9 | 12.5 |
| 5 | 19 | 27-Apr-18 | 650 | 435155 | 1723991 | 435315 | 1723654 | 16 | 18 | 2.9 | 5.1 | 65.8 | 1 | 13.9 | 14.2 |
| 6 | 19 | 27-Apr-18 | 929 | 435680 | 1722071 | 435713 | 1721851 | 22 | 23 | 1.61 | NA | 60.5 | 3 | 13.9 | 14.3 |
| 7 | 4 | 27-Apr-18 | 1103 | 440221 | 1722291 | 440120 | 1722691 | 41 | 42 | 3.04 | 4.9 | 71 | 1 | 14.2 | 14.1 |
| 8 | 4 | 27-Apr-18 | 1320 | 440299 | 1722651 | 440440 | 1722291 | 48 | 49 | 2.94 | 4.9 | 69.6 | 1 | 14.2 | 14 |
| 9 | 4 | 27-Apr-18 | 1533 | 440580 | 1722559 | 440465 | 1722963 | 51 | 53 | 3.12 | 4.9 | 72 | 1 | 14.2 | 14.1 |
| 10 | 18 | 28-Apr-18 | 651 | 432913 | 1730140 | 432666 | 1730384 | 23 | 24 | 3.03 | 4.9 | 70.3 | 1 | NA | NA |
| 11 | 18 | 28-Apr-18 | 936 | 432451 | 1724784 | 432143 | 1724789 | 18 | 19 | 3.08 | 4.8 | 71.6 | 1 | 14.2 | 14.4 |
| 12 | 18 | 28-Apr-18 | 1130 | 431665 | 1724892 | 431394 | 1725052 | 20 | 22 | 2.94 | 4.8 | 69.2 | 1 | 14 | 14.2 |
| 13 | 7 | 28-Apr-18 | 1502 | 430480 | 1731674 | 430288 | 1731905 | 56 | 62 | 2.55 | 4.9 | 74.8 | 1 | 14.1 | 13.8 |
| 14 | 5 | 29-Apr-18 | 658 | 435847 | 1731741 | 440083 | 1731471 | 74 | 78 | 3.05 | 4.9 | 72.9 | 1 | 14 | 13.4 |
| 15 | 5 | 29-Apr-18 | 920 | 440629 | 1730868 | 440811 | 1730543 | 82 | 86 | 2.95 | 4.8 | 75.6 | 1 | 13.7 | 13.2 |
| 16 | 5 | 29-Apr-18 | 1249 | 440158 | 1730176 | 440376 | 1725905 | 70 | 75 | 2.92 | 4.8 | 71.7 | 1 | 13.9 | 13.5 |
| 17 | 5 | 29-Apr-18 | 1542 | 435618 | 1730028 | 435447 | 1730367 | 58 | 61 | 2.98 | 4.9 | 73.8 | 1 | 13.9 | 13.9 |
| 18 | 7 | 30-Apr-18 | 700 | 431958 | 1725678 | 431709 | 1725887 | 30 | 32 | 2.91 | 5 | 73.7 | 1 | 14.1 | 14.2 |
| 19 | 7 | 30-Apr-18 | 902 | 431819 | 1730223 | 431555 | 1730413 | 30 | 33 | 2.98 | 5 | 74.4 | 1 | 14.1 | 14.2 |
| 20 | 7 | 30-Apr-18 | 1108 | 431722 | 1731268 | 431964 | 1731159 | 31 | 35 | 2.54 | 4.9 | 72.6 | 2 | 14 | 13.5 |
| 21 | 7 | 30-Apr-18 | 1313 | 432203 | 1731649 | 432486 | 1731552 | 50 | 53 | 2.91 | 5 | 74.6 | 1 | 13.9 | 13.6 |
| 22 | 7 | 30-Apr-18 | 1526 | 432576 | 1731083 | 432266 | 1731115 | 30 | 32 | 3.1 | 5 | 70.2 | 1 | 14 | 13.7 |
| 23 | 20 | 2-May-18 | 655 | 442021 | 1712773 | 441857 | 1713121 | 23 | 24 | 2.98 | 4.9 | 69.7 | 1 | 12.9 | 13 |
| 24 | 20 | 2-May-18 | 910 | 441313 | 1714212 | 441131 | 1714551 | 23 | 24 | 3.03 | 5 | 73.4 | 1 | 13.1 | 13.2 |
| 25 | 19 | 2-May-18 | 1144 | 440225 | 1715946 | 440057 | 1720286 | 14 | 15 | 2.96 | 5 | 70.6 | 1 | 13.2 | 13.4 |
| 26 | 19 | 2-May-18 | 1404 | 435740 | 1721654 | 435679 | 1722060 | 22 | 25 | 2.98 | 5 | 69.1 | 1 | 13.6 | 13.8 |
| 27 | 12 | 3-May-18 | 707 | 433886 | 1735784 | 434175 | 1735683 | 134 | 139 | 2.98 | 4.8 | 81.6 | 1 | 12.9 | 12.1 |
| 28 | 12 | 3-May-18 | 859 | 434477 | 1735464 | 434716 | 1735202 | 106 | 114 | 3.04 | 4.7 | 79.2 | 1 | 12.9 | 12.4 |
| 29 | 17 | 3-May-18 | 1131 | 434447 | 1740081 | 434741 | 1735965 | 244 | 254 | 3.05 | 4.8 | 90.6 | 1 | 12.5 | 10.1 |
| 30 | 17 | 3-May-18 | 1340 | 434852 | 1740056 | 435113 | 1735877 | 300 | 315 | 2.91 | 4.9 | 92 | 1 | 12.8 | 9.3 |

| Station | Stratum | Date | Time | Lat/long start of tow ° ' S | Lat/long start of tow ° ' E | Lat/ long end of tow ° ' S | Lat/ long end of tow ° ' E | Gear depth (m) Min. | Gear depth (m) Max. | Dist. trawled (n. miles) | Headline height (m) | Door spread (m) | Gear perf. | Temperature (ºC) Station | Temperature (ºC) Stratum |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 31 | 12 | 4-May-18 | 659 | 435183 | 1735254 | 435438 | 1735038 | 137 | 140 | 2.98 | 4.8 | 81 | 1 | 12.9 | 12 |
| 32 | 6 | 4-May-18 | 946 | 434334 | 1734499 | 434588 | 1734285 | 91 | 92 | 2.97 | 4.9 | 74.2 | 1 | 13.5 | 13.3 |
| 33 | 6 | 4-May-18 | 1254 | 433918 | 1733399 | 434187 | 1733224 | 82 | 84 | 2.97 | 4.9 | 76.6 | 1 | NA | 12 |
| 34 | 6 | 4-May-18 | 1502 | 433865 | 1732591 | 434131 | 1732414 | 77 | 81 | 2.95 | 4.9 | 72.4 | 1 | 13.9 | 13.4 |
| 35 | 4 | 5-May-18 | 703 | 440658 | 1722264 | 440824 | 1721925 | 48 | 51 | 2.94 | 4.8 | 72.5 | 1 | 13.9 | 13.4 |
| 36 | 4 | 5-May-18 | 904 | 441234 | 1722496 | 441419 | 1722171 | 57 | 63 | 2.97 | 4.8 | 71.6 | 1 | 13.5 | 13 |
| 37 | 4 | 5-May-18 | 1046 | 441599 | 1722140 | 441779 | 1721805 | 65 | 67 | 2.99 | 4.8 | 70.1 | 1 | 13.2 | 12.9 |
| 38 | 4 | 5-May-18 | 1336 | 441441 | 1723344 | 441614 | 1722998 | 67 | 70 | 3.02 | 4.9 | 69.1 | 1 | 13.5 | 13 |
| 39 | 4 | 5-May-18 | 1522 | 441966 | 1723056 | 442124 | 1722703 | 76 | 78 | 2.97 | 4.9 | 72.2 | 1 | 13.3 | 12.8 |
| 40 | 11 | 6-May-18 | 717 | 435767 | 1734004 | 435995 | 1733743 | 106 | 112 | 2.95 | 4.8 | 80.2 | 1 | 13.4 | 11.9 |
| 41 | 11 | 6-May-18 | 1046 | 440308 | 1733444 | 440505 | 1733135 | 122 | 124 | 2.96 | 4.8 | 81.5 | 1 | 13 | 11.7 |
| 42 | 11 | 6-May-18 | 1308 | 440264 | 1733880 | 440470 | 1733578 | 139 | 141 | 2.99 | 4.8 | 82.5 | 2 | 12.9 | 11.3 |
| 43 | 16 | 6-May-18 | 1550 | 441034 | 1733230 | 441215 | 1732930 | 295 | 302 | 2.81 | 4.8 | 88.5 | 1 | 13.3 | 10.2 |
| 44 | 11 | 7-May-18 | 658 | 440799 | 1732174 | 440962 | 1731836 | 101 | 104 | 2.92 | 4.7 | 76.7 | 1 | 13.3 | 12.3 |
| 45 | 16 | 7-May-18 | 1029 | 442045 | 1731567 | 442215 | 1731257 | 302 | 308 | 2.79 | 4.7 | 87.8 | 1 | 13.3 | 10.2 |
| 46 | 11 | 7-May-18 | 1302 | 441849 | 1730912 | 442016 | 1730580 | 134 | 135 | 2.9 | 4.8 | 84.1 | 1 | 13.2 | 11.1 |
| 47 | 4 | 9-May-18 | 654 | 442210 | 1722764 | 442364 | 1722406 | 80 | 82 | 2.98 | 4.7 | 69.3 | 2 | 13.2 | 13.1 |
| 48 | 4 | 9-May-18 | 927 | 442648 | 1722579 | 442800 | 1722222 | 97 | 98 | 2.96 | 4.7 | 74.8 | 1 | NA | NA |
| 49 | 10 | 9-May-18 | 1152 | 443500 | 1721284 | 443710 | 1720976 | 106 | 109 | 3.03 | 4.7 | 77.8 | 1 | 13.1 | 12.2 |
| 50 | 10 | 9-May-18 | 1352 | 443482 | 1720903 | 443674 | 1720580 | 100 | 100 | 2.99 | 4.7 | 78.1 | 1 | 13 | 12.4 |
| 51 | 5 | 10-May-18 | 657 | 440079 | 1724770 | 440248 | 1724433 | 62 | 63 | 2.95 | 4.6 | 74.2 | 1 | 13.5 | 13.3 |
| 52 | 5 | 10-May-18 | 857 | 440414 | 1725043 | 440552 | 1724669 | 69 | 69 | 3.02 | 4.8 | 67.9 | 1 | 13.3 | 12.9 |
| 53 | 5 | 10-May-18 | 1109 | 441330 | 1724727 | 441522 | 1724419 | 78 | 82 | 2.92 | 4.8 | 75 | 1 | 13.1 | 13.1 |
| 54 | 11 | 10-May-18 | 1340 | 442161 | 1724781 | 442053 | 1725172 | 113 | 115 | 2.99 | 4.8 | 83.1 | 1 | 13.3 | 12.9 |
| 55 | 11 | 10-May-18 | 1553 | 442216 | 1725515 | 442040 | 1725841 | 122 | 124 | 2.92 | 4.8 | 84.7 | 1 | 13.3 | 11.7 |
| 56 | 4 | 11-May-18 | 656 | 442141 | 1720675 | 442311 | 1720326 | 62 | 65 | 3.01 | 4.8 | 69.4 | 1 | 13.1 | 13.2 |
| 57 | 3 | 11-May-18 | 905 | 442931 | 1715757 | 443127 | 1715451 | 71 | 73 | 2.93 | 4.8 | 70.9 | 1 | 13.3 | 13.4 |
| 58 | 3 | 11-May-18 | 1056 | 443299 | 1715265 | 443455 | 1714908 | 74 | 76 | 2.98 | 4.9 | 71.6 | 1 | 12.9 | 13.4 |
| 59 | 3 | 11-May-18 | 1350 | 444243 | 1712943 | 444540 | 1712834 | 47 | 48 | 3.06 | 4.9 | 70.5 | 1 | 12.9 | 13.1 |
| 60 | 2 | 12-May-18 | 1154 | 445203 | 1712354 | 445009 | 1712401 | 42 | 43 | 1.96 | 4.8 | 72.8 | 2 | 13 | 13 |
| 61 | 21 | 12-May-18 | 1434 | 444868 | 1711526 | 444717 | 1711558 | 16 | 17 | 1.52 | 4.8 | 73.5 | 2 | 12.7 | 12.7 |

**Appendix 2 – *continued***

| Station | Stratum | Date | Time | Lat/long start of tow ° ' S | Lat/long start of tow ° ' E | Lat/ long end of tow ° ' S | Lat/ long end of tow ° ' E | Gear depth (m) Min. | Gear depth (m) Max. | Dist. trawled (n. miles) | Headline height (m) | Door spread (m) | Gear perf. | Temperature (°C) Surface | Temperature (°C) Bottom |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 62 | 16 | 13-May-18 | 708 | 442777 | 1725614 | 442916 | 1725265 | 214 | 220 | 2.85 | 4.3 | 92.9 | 1 | 12.6 | 11.2 |
| 63 | 10 | 13-May-18 | 1010 | 442387 | 1724641 | 442536 | 1724287 | 116 | 117 | 2.93 | 4.8 | 84.5 | 1 | 13 | 11.5 |
| 64 | 10 | 13-May-18 | 1249 | 442890 | 1724052 | 443051 | 1723708 | 133 | 135 | 2.93 | 5 | 85.4 | 1 | 12.9 | 11.1 |
| 65 | 10 | 13-May-18 | 1536 | 443221 | 1723847 | 443378 | 1723496 | 134 | 136 | 2.95 | 4.8 | 83 | 1 | 12.8 | 11.5 |
| 66 | 3 | 14-May-18 | 703 | 441750 | 1715444 | 441928 | 1715111 | 47 | 49 | 2.97 | 4.8 | 73.7 | 1 | 12.7 | 13.1 |
| 67 | 3 | 14-May-18 | 921 | 442827 | 1714626 | 442993 | 1714276 | 58 | 58 | 2.99 | 4.8 | 72.7 | 1 | 13.2 | 13.4 |
| 68 | 3 | 17-May-18 | 930 | 443765 | 1720030 | 443585 | 1720348 | 95 | 96 | 2.89 | 4.9 | 75 | 1 | NA | NA |
| 69 | 9 | 17-May-18 | 1236 | 444592 | 1720088 | 444794 | 1715781 | 122 | 122 | 2.97 | 4.8 | 83 | 1 | 12.6 | 11.9 |
| 70 | 9 | 17-May-18 | 1501 | 444806 | 1715131 | 445031 | 1714857 | 108 | 108 | 2.97 | 4.8 | 79 | 1 | 12.7 | 12.4 |
| 71 | 15 | 18-May-18 | 732 | 444732 | 1721642 | 444915 | 1721318 | 278 | 304 | 2.93 | 4.8 | 89 | 1 | 12.6 | 8.7 |
| 72 | 15 | 18-May-18 | 942 | 445002 | 1721292 | 445173 | 1720992 | 334 | 357 | 2.72 | 4.8 | 86 | 1 | 12.4 | 9.2 |
| 73 | 15 | 18-May-18 | 1215 | 445322 | 1720765 | 445470 | 1720444 | 339 | 363 | 2.71 | 4.7 | 82.2 | 1 | 12.5 | 9.5 |
| 74 | 9 | 18-May-18 | 1443 | 445256 | 1720062 | 445409 | 1715702 | 134 | 136 | 2.97 | 4.7 | 79.5 | 1 | 12.6 | 11.7 |
| 75 | 14 | 19-May-18 | 730 | 450915 | 1714252 | 451108 | 1713978 | 339 | 348 | 2.73 | 4.9 | 93.8 | 2 | 12.1 | 10.2 |
| 76 | 14 | 19-May-18 | 1028 | 450902 | 1714111 | 451105 | 1713807 | 250 | 266 | 2.95 | 4.7 | 85 | 1 | 12.1 | 10.7 |
| 77 | 14 | 19-May-18 | 1311 | 451681 | 1713161 | 451915 | 1712923 | 238 | 250 | 2.87 | 4.7 | 90.3 | 1 | 12.5 | 11.2 |
| 78 | 8 | 19-May-18 | 1510 | 451740 | 1712543 | 451461 | 1712756 | 114 | 117 | 3.16 | 5 | 81.5 | 1 | 12.6 | 11.9 |
| 79 | 1 | 20-May-18 | 722 | 451334 | 1711384 | 451607 | 1711227 | 53 | 54 | 2.94 | 4.9 | 72.2 | 1 | 12.5 | 12.7 |
| 80 | 2 | 20-May-18 | 1018 | 450434 | 1711684 | 450708 | 1711496 | 42 | 44 | 3.04 | 4.9 | 74 | 1 | 11.1 | 12.5 |
| 81 | 2 | 20-May-18 | 1232 | 450115 | 1711765 | 450361 | 1711571 | 36 | 37 | 2.81 | 4.9 | 75.2 | 1 | 12.1 | 12.5 |
| 82 | 1 | 21-May-18 | 734 | 452429 | 1710201 | 452137 | 1710302 | 40 | 43 | 3 | 4.9 | 72.5 | 1 | 12.1 | 12.4 |
| 83 | 1 | 21-May-18 | 1041 | 452267 | 1710664 | 451986 | 1710792 | 48 | 50 | 2.95 | 5.1 | 73.1 | 1 | 12.3 | 12.5 |
| 84 | 1 | 21-May-18 | 1257 | 451991 | 1711530 | 451902 | 1711585 | 76 | 76 | 0.97 | 5 | 65 | 3 | 12.5 | 12.6 |
| 85 | 8 | 21-May-18 | 1415 | 451984 | 1712310 | 451755 | 1712599 | 113 | 116 | 3.06 | 4.9 | 82 | 1 | 12.1 | 12.1 |
| 86 | 20 | 22-May-18 | 730 | 442687 | 1711730 | 442974 | 1711596 | 16 | 18 | 3.02 | 5 | 71.5 | 1 | 12.1 | 12.2 |
| 87 | 3 | 22-May-18 | 958 | 443104 | 1712845 | 443346 | 1712700 | 42 | 43 | 2.63 | 4.8 | 73.4 | 1 | 12.7 | 12.7 |
| 88 | 21 | 22-May-18 | 1238 | 444216 | 1711818 | 444383 | 1711825 | 27 | 28 | 1.67 | 4.9 | 72.5 | 1 | 12.1 | 12.3 |
| 89 | 21 | 29-May-18 | 723 | 445344 | 1711926 | 445044 | 1711934 | 27 | 28 | 3 | 4.9 | 74.9 | 1 | 11.2 | 11.2 |
| 90 | 8 | 29-May-18 | 1055 | 450354 | 1713539 | 450109 | 1713778 | 109 | 111 | 2.97 | 4.9 | 80.5 | 1 | 12 | 11.9 |
| 91 | 8 | 29-May-18 | 1321 | 450592 | 1714205 | 450360 | 1714470 | 132 | 133 | 2.98 | 4.8 | 85.6 | 1 | 11.5 | 11.2 |

**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 | 8 | 29-May-18 | 1545 | 450704 | 1714098 | 450908 | 1713804 | 136 | 138 | 2.9 | 4.7 | 85.6 | 1 | 10.7 | 10.5 |
| 93 | 1 | 30-May-18 | 728 | 453239 | 1710165 | 453232 | 1710171 | 53 | 54 | 0.1 | 4.8 | 69 | 3 | 11.4 | 11.8 |
| 94 | 1 | 30-May-18 | 831 | 453311 | 1710551 | 453168 | 1710647 | 79 | 81 | 1.58 | 4.8 | 70.2 | 1 | 11.9 | 11.7 |
| 95 | 1 | 30-May-18 | 1118 | 452988 | 1710605 | 452709 | 1710773 | 60 | 65 | 3.02 | 4.8 | 72.6 | 1 | 11.7 | 11.8 |
| 96 | 1 | 30-May-18 | 1358 | 452261 | 1711495 | 452357 | 1711445 | 84 | 86 | 1.02 | 4.9 | 72 | 3 | 11.8 | 11.6 |
| 97 | 1 | 30-May-18 | 1524 | 451741 | 1711649 | 451501 | 1711906 | 75 | 84 | 3 | 4.8 | 71.1 | 1 | 11.6 | 11.5 |
| 98 | 1 | 31-May-18 | 737 | 451335 | 1710825 | 451067 | 1711006 | NA | NA | 2.96 | 5 | 74.8 | 1 | 11.4 | 11.4 |
| 99 | 8 | 31-May-18 | 1014 | 451141 | 1712564 | 450851 | 1712658 | 107 | 112 | 2.97 | 4.8 | 79 | 1 | 11.8 | 10.7 |
| 100 | 8 | 31-May-18 | 1245 | 450790 | 1713209 | 450547 | 1713439 | 114 | 118 | 2.92 | 4.9 | 80.5 | 1 | 11.7 | 10.6 |
| 101 | 13 | 1-Jun-18 | 732 | 431410 | 1733416 | 431701 | 1733358 | 126 | 130 | 2.94 | 4.8 | 82.3 | 1 | 12.2 | 11.8 |
| 102 | 13 | 1-Jun-18 | 1001 | 431915 | 1734666 | 432115 | 1734787 | 128 | 130 | 2.18 | 4.9 | 83.6 | 1 | 12 | 10.6 |
| 103 | 13 | 1-Jun-18 | 1148 | 432308 | 1734239 | 432452 | 1733887 | 103 | 107 | 2.93 | 4.9 | 79.7 | 1 | 12.1 | 12 |
| 104 | 13 | 1-Jun-18 | 1341 | 432525 | 1733581 | 432799 | 1733411 | 110 | 118 | 3 | 4.9 | 82.4 | 1 | 12.3 | 11.6 |
| 105 | 6 | 2-Jun-18 | 731 | 432510 | 1734197 | 432793 | 1734089 | 85 | 90 | 2.93 | 4.8 | 74.7 | 1 | 12 | 11.9 |
| 106 | 6 | 2-Jun-18 | 1122 | 435168 | 1733953 | 435322 | 1733588 | 89 | 94 | 3.04 | 5 | 79 | 1 | 11.4 | 11 |
| 107 | 6 | 2-Jun-18 | 1310 | 435109 | 1733308 | 435297 | 1732998 | 84 | 90 | 2.92 | 5 | 77.1 | 1 | 12.1 | 11.8 |
| 108 | 10 | 3-Jun-18 | 731 | 442903 | 1723085 | 443092 | 1722768 | 113 | 115 | 2.94 | 4.9 | 80.3 | 1 | 11.9 | 11.4 |
| 109 | 10 | 3-Jun-18 | 1006 | 443402 | 1721897 | 443579 | 1721559 | 111 | 112 | 2.98 | 4.9 | 80.9 | 1 | 11.8 | 10.6 |
| 110 | 10 | 3-Jun-18 | 1246 | 444054 | 1721975 | 444259 | 1721678 | 135 | 137 | 2.94 | 4.9 | 82.4 | 1 | NA | NA |

**Appendix 3: Gear parameters for stations with satisfactory gear performance by depth range for the 2018 survey. N, number of stations; s.d., standard deviation**.

| | | *N* | Mean | s.d. | Range |
|---|---|---|---|---|---|
| Core plus shallow strata | | | | | |
| 10–400 m | Headline height (m) | 106 | 4.8 | 0.11 | 4.3–5.1 |
| 10–400 m | Doorspread (m) | 106 | 77.4 | 6.54 | 65.8–96.1 |
| 10–400 m | Distance (n. miles) | 106 | 2.9 | 0.27 | 1.5–3.2 |
| 10–400 m | Warp:depth ratio | 106 | 4 | 2.45 | 2.4–13.3 |
| Core strata | | | | | |
| 30–400 m | Headline height (m) | 94 | 4.8 | 0.11 | 4.3–5.1 |
| 30–400 m | Doorspread (m) | 94 | 78.2 | 6.45 | 67.9–96.1 |
| 30–400 m | Distance (n. miles) | 94 | 2.9 | 0.21 | 1.6–3.2 |
| 30–400 m | Warp:depth ratio | 94 | 3.2 | 0.94 | 2.4–6.7 |
| 30–100 m | | | | | |
| 30–100 m | Headline height (m) | 47 | 4.9 | 0.09 | 4.6–5.1 |
| 30–100 m | Doorspread (m) | 47 | 72.8 | 2.27 | 67.9–79 |
| 30–100 m | Distance (n. miles) | 47 | 2.9 | 0.27 | 1.6–3.1 |
| 30–100 m | Warp:depth ratio | 47 | 3.7 | 1.13 | 2.6–6.7 |
| 100–200 m | | | | | |
| 100–200 m | Headline height (m) | 35 | 4.8 | 0.08 | 4.7–5 |
| 100–200 m | Doorspread (m) | 35 | 81.6 | 2.26 | 76.7–85.6 |
| 100–200 m | Distance (n. miles) | 35 | 2.9 | 0.14 | 2.2–3.2 |
| 100–200 m | Warp:depth ratio | 35 | 2.8 | 0.05 | 2.7–2.9 |
| 200–400 m | | | | | |
| 200–400 m | Headline height (m) | 12 | 4.7 | 0.16 | 4.3–4.9 |
| 200–400 m | Doorspread (m) | 12 | 89.5 | 3.95 | 82.2–96.1 |
| 200–400 m | Distance (n. miles) | 12 | 2.8 | 0.11 | 2.7–3 |
| 200–400 m | Warp:depth ratio | 12 | 2.5 | 0.08 | 2.4–2.6 |
| Shallow strata | | | | | |
| 10–30 m | Headline height (m) | 12 | 4.9 | 0.1 | 4.8–5.1 |
| 10–30 m | Doorspread (m) | 12 | 71 | 2.46 | 65.8–74.9 |
| 10–30 m | Distance (n. miles) | 12 | 2.8 | 0.55 | 1.5–3.1 |
| 10–30 m | Warp:depth ratio | 12 | 10 | 2.2 | 7.1–13.3 |

**Appendix 4: Species codes, common names, scientific names, total catch, percent of total catch, percent occurrence, depth range and number stations caught for core strata (30–400 m) (A) and shallow strata (10–30 m) (B) in 2018. In order of catch weight. Values of zero for % catch and % occ are less than 0.1.**

## (A) 30–400 m

| Species_code | Common name | Scientific name | Catch (kg) | % catch | % occ. | Depth Min. | Depth Max. | Stations |
|---|---|---|---|---|---|---|---|---|
| BAR | Barracouta | *Thyrsites atun* | 38 841.3 | 30.8 | 92.6 | 30 | 363 | 87 |
| SPD | Spiny dogfish | *Squalus acanthias* | 34 866.4 | 27.6 | 98.9 | 30 | 363 | 93 |
| GSH | Dark ghost shark | *Hydrolagus novaezealandiae* | 16 996.9 | 13.5 | 48.9 | 62 | 363 | 46 |
| CBI | Two saddle rattail | *Coelorinchus biclinozonalis* | 4429 | 3.5 | 14.9 | 30 | 363 | 14 |
| SPE | Sea perch | *Helicolenus* spp. | 4 385.9 | 3.5 | 60.6 | 43 | 339 | 57 |
| RCO | Red cod | *Pseudophycis bachus* | 3 176.4 | 2.5 | 54.3 | 30 | 363 | 51 |
| GUR | Red gurnard | *Chelidonichthys kumu* | 2 746.9 | 2.2 | 58.5 | 30 | 137 | 55 |
| NMP | Tarakihi | *Nemadactylus macropterus* | 2 587.2 | 2 | 67 | 36 | 339 | 63 |
| SDO | Silver dory | *Cyttus novaezealandiae* | 1 560.3 | 1.2 | 55.3 | 54 | 266 | 52 |
| CAR | Carpet shark | *Cephaloscyllium isabellum* | 1554 | 1.2 | 85.1 | 30 | 363 | 80 |
| CBE | Crested bellowsfish | *Notopogon lilliei* | 1 337.5 | 1.1 | 44.7 | 58 | 348 | 42 |
| RSK | Rough skate | *Zearaja nasuta* | 1 334.6 | 1.1 | 59.6 | 30 | 339 | 56 |
| GIZ | Giant stargazer | *Kathetostoma giganteum* | 1 263.1 | 1 | 79.8 | 37 | 363 | 75 |
| ELE | Elephant fish | *Callorhinchus milii* | 1 188.0 | 0.9 | 38.3 | 30 | 114 | 36 |
| HOK | Hoki | *Macruronus novaezelandiae* | 1 148.4 | 0.9 | 13.8 | 122 | 363 | 13 |
| SSK | Smooth skate | *Dipturus innominatus* | 1 140.7 | 0.9 | 47.9 | 30 | 363 | 45 |
| WIT | Witch | *Arnoglossus scapha* | 1 042.2 | 0.8 | 91.5 | 30 | 363 | 86 |
| NOS | NZ southern arrow squid | *Nototodarus sloanii* | 838.7 | 0.7 | 91.5 | 30 | 363 | 86 |
| SCG | Scaly gurnard | *Lepidotrigla brachyoptera* | 566.9 | 0.4 | 75.5 | 35 | 139 | 71 |
| PIG | Pigfish | *Congiopodus leucopaecilus* | 557 | 0.4 | 57.4 | 30 | 348 | 54 |
| SCH | School shark | *Galeorhinus galeus* | 532.4 | 0.4 | 47.9 | 30 | 139 | 45 |
| LEA | Leatherjacket | *Meuschenia scaber* | 518.8 | 0.4 | 19.1 | 30 | 214 | 18 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| MOK | Moki | *Latridopsis ciliaris* | 482.7 | 0.4 | 4.3 | 75 | 122 | 4 |
| RSO | Gemfish | *Rexea solandri* | 412.5 | 0.3 | 35.1 | 101 | 339 | 33 |
| SWA | Silver warehou | *Seriolella punctata* | 385.2 | 0.3 | 55.3 | 30 | 363 | 52 |
| BCO | Blue cod | *Parapercis colias* | 339.8 | 0.3 | 21.3 | 37 | 139 | 20 |
| LIN | Ling | *Genypterus blacodes* | 300 | 0.2 | 27.7 | 41 | 363 | 26 |
| HAP | Hapuku | *Polyprion oxygeneios* | 225.1 | 0.2 | 18.1 | 71 | 315 | 17 |
| OCT | Octopus | *Pinnoctopus cordiformis* | 186.9 | 0.1 | 39.4 | 30 | 315 | 37 |
| CAS | Oblique banded rattail | *Coelorinchus aspercephalus* | 152.9 | 0.1 | 13.8 | 107 | 363 | 13 |
| WAR | Common warehou | *Seriolella brama* | 152 | 0.1 | 12.8 | 30 | 122 | 12 |
| SPO | Rig | *Mustelus lenticulatus* | 127.5 | 0.1 | 23.4 | 30 | 134 | 22 |
| FHD | Deepsea flathead | *Hoplichthys haswelli* | 83.5 | 0.1 | 6.4 | 135 | 363 | 6 |
| HMT | Deepsea anemone | Hormathiidae | 76.9 | 0.1 | 28.7 | 36 | 363 | 27 |
| LDO | Lookdown dory | *Cyttus traversi* | 71.3 | 0.1 | 3.2 | 298 | 348 | 3 |
| LSO | Lemon sole | *Pelotretis flavilatus* | 69.1 | 0.1 | 57.4 | 30 | 339 | 54 |
| JMD | Greenback jack mackerel | *Trachurus declivis* | 67.7 | 0.1 | 30.9 | 37 | 134 | 29 |
| SBR | Southern bastard cod | *Pseudophycis barbata* | 58.6 | 0 | 1.1 | 81 | 81 | 1 |
| ERA | Electric ray | *Torpedo fairchildi* | 53.1 | 0 | 6.4 | 30 | 339 | 6 |
| SSI | Silverside | *Argentina elongata* | 51.3 | 0 | 56.4 | 65 | 348 | 53 |
| CON | Southern conger eel | *Conger verreauxi* | 45 | 0 | 3.2 | 30 | 41 | 3 |
| CBO | Bollons rattail | *Coelorinchus bollonsi* | 39 | 0 | 2.1 | 298 | 339 | 2 |
| ACS | Deepsea anemone | *Actinostolidae* | 33.3 | 0 | 22.3 | 72 | 298 | 21 |
| JAV | Javelin fish | *Lepidorhynchus denticulatus* | 30.8 | 0 | 5.3 | 287 | 348 | 5 |
| HTH | Sea cucumber | Holothurian unidentified | 23.7 | 0 | 28.7 | 30 | 305 | 27 |
| HOR | Horse mussel | *Atrina zelandica* | 16.3 | 0 | 1.1 | 81 | 81 | 1 |
| RBT | Redbait | *Emmelichthys nitidus* | 15.4 | 0 | 5.3 | 90 | 138 | 5 |
| PYR | Salp | *Pyrosoma atlanticum* | 13.4 | 0 | 16 | 54 | 348 | 15 |
| TOD | Dark toadfish | *Neophrynichthys latus* | 12.2 | 0 | 21.3 | 36 | 133 | 20 |
| ONG | Sponges | Porifera (Phylum) | 12.1 | 0 | 14.9 | 30 | 254 | 14 |
| GAS | Gastropods | Gastropoda | 9.7 | 0 | 26.6 | 44 | 254 | 25 |
| SMO | Cross-fish | *Sclerasterias mollis* | 8.7 | 0 | 22.3 | 30 | 139 | 21 |
| POP | Porcupine fish | *Allomycterus jaculiferus* | 8.4 | 0 | 1.1 | 44 | 44 | 1 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| JDO | John dory | *Zeus faber* | 7.2 | 0 | 3.2 | 49 | 69 | 3 |
| DIR | Pagurid | *Diacanthurus rubricatus* | 6.8 | 0 | 22.3 | 48 | 315 | 21 |
| SCC | Sea cucumber | *Stichopus mollis* | 6.7 | 0 | 11.7 | 37 | 130 | 11 |
| JMM | Slender jack mackerel | *Trachurus murphyi* | 6.2 | 0 | 3.2 | 48 | 108 | 3 |
| SFL | Sand flounder | *Rhombosolea plebeia* | 6.1 | 0 | 2.1 | 30 | 41 | 2 |
| DAP | Antlered crab | *Dagnaudus petterdi* | 6 | 0 | 1.1 | 339 | 339 | 1 |
| BSH | Seal shark | *Dalatias licha* | 5.5 | 0 | 1.1 | 339 | 339 | 1 |
| CSE | Serrulate rattail | *Coryphaenoides serrulatus* | 4.9 | 0 | 1.1 | 128 | 128 | 1 |
| VOL | Volute | Volutidae (Family) | 4.6 | 0 | 7.4 | 41 | 81 | 7 |
| ATT | Kahawai | *Arripis trutta A. xylabion* | 4.3 | 0 | 2.1 | 30 | 36 | 2 |
| WOD | Wood | Wood | 4.1 | 0 | 4.3 | 48 | 62 | 4 |
| ESO | N.Z. sole | *Peltorhamphus novaezeelandiae* | 4.1 | 0 | 6.4 | 30 | 48 | 6 |
| BRI | Brill | *Colistium guntheri* | 3.5 | 0 | 2.1 | 43 | 48 | 2 |
| GON | Sandfish | *Gonorynchus forsteri & G. greyi* | 3.3 | 0 | 4.3 | 51 | 339 | 4 |
| GMC | Garricks masking crab | *Leptomithrax garricki* | 3.2 | 0 | 13.8 | 58 | 298 | 13 |
| WWA | White warehou | *Seriolella caerulea* | 2.9 | 0 | 1.1 | 348 | 348 | 1 |
| BNS | Bluenose | *Hyperoglyphe antarctica* | 2.9 | 0 | 1.1 | 315 | 315 | 1 |
| PDG | Prickly dogfish | *Oxynotus bruniensis* | 2.6 | 0 | 1.1 | 363 | 363 | 1 |
| CRN | Sea lily stalked crinoid | NA | 2.6 | 0 | 1.1 | 61 | 61 | 1 |
| TOP | Pale toadfish | *Ambophthalmos angustus* | 2.5 | 0 | 3.2 | 58 | 339 | 3 |
| ASR | Asteroid (starfish) | NA | 2.5 | 0 | 13.8 | 47 | 339 | 13 |
| PHA | Brown seaweed | Phaeophyta | 2.4 | 0 | 1.1 | 114 | 114 | 1 |
| MDO | Mirror dory | *Zenopsis nebulosa* | 2.3 | 0 | 1.1 | 250 | 250 | 1 |
| XSH | Sooty shearwater | *Puffinus griseus* | 2.1 | 0 | 1.1 | 298 | 298 | 1 |
| YCO | Yellow cod | *Parapercis gilliesi* | 1.6 | 0 | 4.3 | 118 | 134 | 4 |
| SAL | Salps | NA | 1.5 | 0 | 4.3 | 107 | 138 | 4 |
| KBL | Kelp bull | *Durvillea* spp. | 1.5 | 0 | 1.1 | 82 | 82 | 1 |
| FRO | Frostfish | *Lepidopus caudatus* | 1.4 | 0 | 2.1 | 214 | 250 | 2 |
| EGC | Egg case | NA | 1.2 | 0 | 11.7 | 47 | 305 | 11 |
| POL | Polychaete | Polychaeta | 1.2 | 0 | 2.1 | 53 | 139 | 2 |
| COZ | Bryozoan | Bryozoa (Phylum) | 1.2 | 0 | 1.1 | 56 | 56 | 1 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| GSC | Giant spider crab | *Jacquinotia edwardsii* | 1.1 | 0 | 1.1 | 315 | 315 | 1 |
| CUC | Cucumber fish | *Paraulopus nigripinnis* | 1.1 | 0 | 2.1 | 130 | 339 | 2 |
| BGZ | Banded stargazer | *Kathetostoma binigrasella* | 0.8 | 0 | 1.1 | 48 | 48 | 1 |
| PCO | Ahuru | *Auchenoceros punctatus* | 0.8 | 0 | 1.1 | 41 | 41 | 1 |
| PCH | Gastropod | *Penion chathamensis* | 0.7 | 0 | 1.1 | 139 | 139 | 1 |
| OPH | Ophiuroid (brittle star) | NA | 0.6 | 0 | 5.3 | 44 | 114 | 5 |
| ASC | Sea squirt | Ascidiacea | 0.6 | 0 | 4.3 | 66 | 139 | 4 |
| OPA | Opalfish | *Hemerocoetes* spp. | 0.6 | 0 | 5.3 | 50 | 122 | 5 |
| BPE | Butterfly perch | *Caesioperca lepidoptera* | 0.5 | 0 | 1.1 | 139 | 139 | 1 |
| ANT | Anemones | Anthozoa | 0.5 | 0 | 4.3 | 53 | 97 | 4 |
| PRU | Asteroid | *Pseudechinaster rubens* | 0.5 | 0 | 1.1 | 339 | 339 | 1 |
| CDO | Capro dory | *Capromimus abbreviatus* | 0.4 | 0 | 3.2 | 122 | 315 | 3 |
| CDY | Asteroid | *Cosmasterias dyscrita* | 0.4 | 0 | 1.1 | 254 | 254 | 1 |
| SPM | Sprat | *Sprattus muelleri* | 0.4 | 0 | 4.3 | 30 | 51 | 4 |
| FOE | Orange dragonet | *Foetorepus* sp. | 0.4 | 0 | 1.1 | 118 | 118 | 1 |
| BTA | Smooth deepsea skate | *Brochiraja asperula* | 0.4 | 0 | 1.1 | 339 | 339 | 1 |
| DGT | Dragonets | Callionymidae | 0.3 | 0 | 3.2 | 105 | 133 | 3 |
| MSL | Starfish | *Mediaster sladeni* | 0.3 | 0 | 2.1 | 107 | 254 | 2 |
| SPA | Slender sprat | *Sprattus antipodum* | 0.3 | 0 | 3.2 | 30 | 41 | 3 |
| AER | Gastropod | *Aeneator recens* | 0.3 | 0 | 1.1 | 118 | 118 | 1 |
| PAG | Pagurid | Paguroidea | 0.2 | 0 | 1.1 | 108 | 108 | 1 |
| OVM | Swimming crab | *Ovalipes molleri* | 0.2 | 0 | 1.1 | 37 | 37 | 1 |
| PIP | Pipefish | Syngnathidae | 0.2 | 0 | 1.1 | 81 | 81 | 1 |
| SCI | Scampi | *Metanephrops challengeri* | 0.2 | 0 | 1.1 | 363 | 363 | 1 |
| COF | Flabellum coral | *Flabellum* spp. | 0.2 | 0 | 1.1 | 305 | 305 | 1 |
| NCA | Hairy red swimming crab | *Nectocarcinus antarcticus* | 0.2 | 0 | 2.1 | 58 | 101 | 2 |
| BYS | Alfonsino | *Beryx splendens* | 0.2 | 0 | 1.1 | 339 | 339 | 1 |
| BAM | Holothurian | *Bathyplotes* spp. | 0.2 | 0 | 1.1 | 339 | 339 | 1 |
| PLI | Starfish | *Peribolaster lictor* | 0.1 | 0 | 1.1 | 81 | 81 | 1 |
| CRB | Crab | NA | 0.1 | 0 | 1.1 | 90 | 90 | 1 |
| RSC | Dwarf scorpionfish | *Scorpaena papillosa* | 0.1 | 0 | 1.1 | 105 | 105 | 1 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| ALP | Snapping shrimp | *Alpheus* spp. | 0.1 | 0 | 1.1 | 58 | 58 | 1 |
| MYC | Sponge | *Mycale* spp. | 0.1 | 0 | 1.1 | 130 | 130 | 1 |
| FMA | Tritons | *Fusitriton magellanicus* | 0.1 | 0 | 1.1 | 122 | 122 | 1 |
| SDR | Spiny seadragon | *Solegnathus spinosissimus* | 0.1 | 0 | 1.1 | 78 | 78 | 1 |
| PAT | Asteroid | *Patiriella* spp. | 0.1 | 0 | 1.1 | 50 | 50 | 1 |
| MUN | Squat lobster | *Munida gregaria* | 0.1 | 0 | 1.1 | 84 | 84 | 1 |
| ANC | Anchovy | *Engraulis australis* | 0.1 | 0 | 1.1 | 30 | 30 | 1 |
| STY | Spotty | *Notolabrus celidotus* | 0.1 | 0 | 1.1 | 30 | 30 | 1 |
| RHY | Common roughy | *Paratrachichthys trailli* | 0.1 | 0 | 1.1 | 51 | 51 | 1 |
| SDF | Spotted flounder | *Azygopus pinnifasciatus* | 0.1 | 0 | 1.1 | 339 | 339 | 1 |
| PSI | Geometric star | *Psilaster acuminatus* | 0.1 | 0 | 1.1 | 339 | 339 | 1 |

## (B) 10–30 m

| Species_code | Common name | Scientific name | Catch (kg) | % catch | % occ. | Depth (m) Min. | Max. | Stations |
|---|---|---|---|---|---|---|---|---|
| BAR | Barracouta | *Thyrsites atun* | 2 369.9 | 25.2 | 100 | 15 | 28 | 12 |
| GUR | Red gurnard | *Chelidonichthys kumu* | 1989 | 21.2 | 100 | 15 | 28 | 12 |
| SPD | Spiny dogfish | *Squalus acanthias* | 1 680.8 | 17.9 | 100 | 15 | 28 | 12 |
| LEA | Leatherjacket | *Meuschenia scaber* | 1 661.4 | 17.7 | 91.7 | 15 | 28 | 11 |
| ELE | Elephant fish | *Callorhinchus milii* | 445.7 | 4.7 | 91.7 | 15 | 28 | 11 |
| RSK | Rough skate | *Zearaja nasuta* | 302.2 | 3.2 | 100 | 15 | 28 | 12 |
| SPO | Rig | *Mustelus lenticulatus* | 215 | 2.3 | 83.3 | 15 | 28 | 10 |
| RCO | Red cod | *Pseudophycis bachus* | 122.2 | 1.3 | 66.7 | 15 | 28 | 8 |
| CAR | Carpet shark | *Cephaloscyllium isabellum* | 94.1 | 1 | 66.7 | 15 | 28 | 8 |
| SSK | Smooth skate | *Dipturus innominatus* | 64.2 | 0.7 | 25 | 16 | 27 | 3 |
| CRN | Sea lily stalked crinoid | NA | 59.3 | 0.6 | 25 | 15 | 25 | 3 |
| SFL | Sand flounder | *Rhombosolea plebeia* | 42.3 | 0.5 | 66.7 | 16 | 25 | 8 |
| ROK | Rocks stones | Geological specimens | 36.4 | 0.4 | 8.3 | 16 | 16 | 1 |
| WOD | Wood | Wood | 33.8 | 0.4 | 8.3 | 23 | 23 | 1 |
| ERA | Electric ray | *Torpedo fairchildi* | 32.3 | 0.3 | 25 | 16 | 25 | 3 |
| ESO | N.Z. sole | *Peltorhamphus novaezeelandiae* | 32.2 | 0.3 | 58.3 | 16 | 25 | 7 |
| WAR | Common warehou | *Seriolella brama* | 30.7 | 0.3 | 58.3 | 16 | 28 | 7 |
| CVR | Southern conger eel | *Conger verreauxi.* | 25 | 0.3 | 8.3 | 20 | 20 | 1 |
| RHO | Red seaweed | Rhodophyta | 20 | 0.2 | 8.3 | 16 | 16 | 1 |
| OCT | Octopus | *Pinnoctopus cordiformis* | 18.4 | 0.2 | 41.7 | 15 | 28 | 5 |
| NOS | NZ southern arrow squid | *Nototodarus sloanii* | 17.1 | 0.2 | 58.3 | 15 | 28 | 7 |
| NMP | Tarakihi | *Nemadactylus macropterus* | 16.5 | 0.2 | 33.3 | 15 | 28 | 4 |
| ATT | Kahawai | *Arripis trutta* | 13.2 | 0.1 | 41.7 | 17 | 25 | 5 |
| LIN | Ling | *Genypterus blacodes* | 9.9 | 0.1 | 16.7 | 23 | 24 | 2 |
| BRI | Brill | *Colistium guntheri* | 8.9 | 0.1 | 33.3 | 17 | 25 | 4 |
| YBF | Yellowbelly flounder | *Rhombosolea leporina* | 8.4 | 0.1 | 25 | 16 | 25 | 3 |
| GFL | Greenback flounder | *Rhombosolea tapirina* | 8.1 | 0.1 | 16.7 | 15 | 16 | 2 |
| PCO | Ahuru | *Auchenoceros punctatus* | 6.7 | 0.1 | 33.3 | 16 | 25 | 4 |
| SCH | School shark | *Galeorhinus galeus* | 4.7 | 0.1 | 50 | 15 | 25 | 6 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| SPA | Slender sprat | *Sprattus antipodum* | 4.2 | 0 | 58.3 | 16 | 28 | 7 |
| LSO | Lemon sole | *Pelotretis flavilatus* | 3.3 | 0 | 33.3 | 16 | 28 | 4 |
| WIT | Witch | *Arnoglossus scapha* | 3.2 | 0 | 50 | 16 | 28 | 6 |
| GLB | Globefish | *Contusus richei* | 2.5 | 0 | 25 | 20 | 25 | 3 |
| SPM | Sprat | *Sprattus muelleri* | 2.2 | 0 | 50 | 15 | 25 | 6 |
| JMD | Greenback jack mackerel | *Trachurus declivis* | 1.9 | 0 | 16.7 | 16 | 28 | 2 |
| BCO | Blue cod | *Parapercis colias* | 1.7 | 0 | 8.3 | 28 | 28 | 1 |
| SUR | Kina | *Evechinus chloroticus* | 0.8 | 0 | 8.3 | 16 | 16 | 1 |
| TOD | Dark toadfish | *Neophrynichthys latus* | 0.8 | 0 | 16.7 | 23 | 25 | 2 |
| PIG | Pigfish | *Congiopodus leucopaecilus* | 0.8 | 0 | 16.7 | 24 | 27 | 2 |
| ANC | Anchovy | *Engraulis australis* | 0.6 | 0 | 50 | 15 | 25 | 6 |
| STY | Spotty | *Notolabrus celidotus* | 0.6 | 0 | 16.7 | 15 | 16 | 2 |
| BRN | Barnacle | Cirripedia (Class) | 0.5 | 0 | 16.7 | 23 | 24 | 2 |
| ASR | Asteroid (starfish) | NA | 0.5 | 0 | 25 | 15 | 16 | 3 |
| SWA | Silver warehou | *Seriolella punctata* | 0.4 | 0 | 16.7 | 20 | 23 | 2 |
| SPZ | Spotted stargazer | *Genyagnus monopterygius* | 0.3 | 0 | 16.7 | 20 | 23 | 2 |
| ONG | Sponges | Porifera (Phylum) | 0.2 | 0 | 8.3 | 25 | 25 | 1 |
| GAS | Gastropods | Gastropoda | 0.1 | 0 | 8.3 | 28 | 28 | 1 |
| ADT | Polychaete | *Aphrodita* spp. | 0.1 | 0 | 8.3 | 24 | 24 | 1 |
| PHI | Echinoid | *Peronella hinemoae* | 0.1 | 0 | 8.3 | 16 | 16 | 1 |
| CAC | Cancer crab | *Cancer novaezelandiae* | 0.1 | 0 | 8.3 | 16 | 16 | 1 |

**Appendix 5: Length weight coefficients used to scale length frequencies for the 2018 survey. DB, MPI *Trawl* database. W = $aL^b$ where W is weight (g) and L is length (cm).**

| Species | *a* | *b* | n | Length (cm) Min. | Max. | Data source |
|---|---|---|---|---|---|---|
| Barracouta | 0.0055 | 2.9812 | 429 | 23.8 | 87.2 | DB, KAH9701 |
| Dark ghost shark | 0.0020 | 3.2802 | 795 | 14.7 | 70.2 | This survey |
| Elephantfish | 0.0066 | 3.1030 | 496 | 21.6 | 92.1 | This survey |
| Giant stargazer | 0.0134 | 3.0600 | 714 | 11.6 | 73.4 | This survey |
| Lemon sole | 0.0080 | 3.1278 | 524 | 14.6 | 41.2 | DB, KAH9809 |
| Ling | 0.0013 | 3.2801 | 179 | 32.2 | 123.7 | DB, KAH0004 |
| Red cod | 0.0099 | 2.9862 | 453 | 9.1 | 71 | This survey |
| Red gurnard | 0.0064 | 3.1328 | 1069 | 15.6 | 51.2 | This survey |
| Rig | 0.0047 | 2.9789 | 245 | 32.6 | 124 | This survey |
| Rough skate | 0.0482 | 2.7847 | 414 | 16 | 67 | This survey |
| School shark | 0.0029 | 3.1226 | 219 | 33.6 | 107 | This surv ey |
| Sea perch | 0.0112 | 3.1451 | 851 | 6.6 | 43.8 | This survey |
| Silver warehou | 0.0048 | 3.3800 | 262 | 16.6 | 57.8 | DB, TAN9502 |
| Smooth skate | 0.0342 | 2.8794 | 203 | 14.9 | 140 | This survey |
| Spiny dogfish | 0.0031 | 3.0444 | 2041 | 27 | 96.9 | This survey |
| Tarakihi | 0.0115 | 3.1385 | 796 | 11.1 | 45.3 | This survey |