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## EXECUTIVE SUMMARY

**Beentjes, M.P. ; Stevenson, M.L. (2008). Inshore trawl survey of Canterbury Bight and Pegasus Bay, May–June 2007 (KAH0705).** ***New Zealand Fisheries Assessment Report 2008/38.*** **95 p.**

We report the findings of the 2007 east coast South Island (ECSI) bottom trawl survey in May–June 2007 using R.V. *Kaharoa* (KAH0705) in 30–400 m. This survey represents a reinstatement of the discontinued winter time series of five surveys from 1991 to 1994 and 1996. An additional survey was also carried out in 10–30 m to improve sampling of various species.

The main survey in 30–400 m was a two-phase design optimised for the target species dark ghost shark, giant stargazer, red cod, sea perch, spiny dogfish, and tarakihi. A total of 94 successful stations was completed from 17 strata using a 60 mm codend. Biomass estimates, catch distribution, population length frequencies, and reproductive condition for the major species are described. Coefficients of variation (c.v.) for target species biomass estimates were within the specified target range for dark ghost shark, red cod, giant stargazer, and tarakihi, and within 1% for sea perch. For spiny dogfish the c.v. was 27%, slightly above the target of 20%.

Biomass estimates for dark ghost shark, giant stargazer, and spiny dogfish were the highest of the six surveys. Red cod biomass was the lowest of all surveys, sea perch in the mid range, and tarakihi in the upper range. The geographic distributions of all target species over the six surveys varied in terms of the areas of high density, but overall these species were consistently well represented over the entire survey area within their preferred depth range.

Pre-recruit biomass was a significant component of total biomass for dark ghost shark, tarakihi, and red cod for at least two of the surveys.

Dorsal spines were collected for spiny dogfish (423) and dark ghost shark (418), and otoliths for red cod (428), tarakihi (241), sea perch (259), and giant stargazer (420).

Seven hundred and fifty two individual elasmobranchs from four species were tagged, weighed, measured, and released. This included 356 rough skate, 186 smooth skate, 171 school shark, and 39 rig. In addition, 344 giant stargazer were tagged, weighed, measured, injected with OTC, and released.

The size distributions of all target species are smaller than those from the Chatham Rise and Southland/Sub-Antarctic surveys and in some cases the west coast South Island, suggesting that this area may be an important nursery ground for many species of juvenile sharks and finfish.

This survey also collected qualitative data on the presence of macro-invertebrates from catches.

In the supplementary survey in 10–30 m, 11 stations were successfully completed from 4 strata using a 28 mm codend. A nominal three stations per strata were allocated with no phase two stations. Coefficients of variation for biomass estimates were acceptable for only red cod, rough skate, and spiny dogfish. The survey may also be useful for red gurnard and elephantfish in future, but may require the allocation of more stations to improve precision of biomass estimates.

# 1. INTRODUCTION

We report the findings of the 2007 east coast South Island (ECSI) bottom trawl survey in May–June 2007 using R.V. *Kaharoa* (KAH0705) in 30–400 m. This survey represents a reinstatement of the discontinued winter time series of five surveys from 1991 to 1994 and 1996 (Beentjes & Wass 1994, Beentjes 1995a, 1995b, 1998a, 1998b). This time series was reviewed by Beentjes & Stevenson (2000). An additional survey was also carried out in 10–30 m.

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

The ECSI winter trawl survey time series was discontinued after the 1996 survey and replaced by a summer time series (five surveys from 1996 to 2000) (Beentjes & Stevenson 2001). There were a number of reasons for this, including high coefficients of variation for the target species red cod and other key species, the codend mesh size (60 mm) was considered too large to adequately sample pre-recruit juvenile fish, and the minimum depth range of the winter surveys (30 m) was too deep to adequately sample red gurnard, and elephantfish. The summer trawl surveys used a finer codend mesh (28 mm) to sample pre-recruit red cod and the minimum depth range was reduced to 10 m to include the distribution of red gurnard and elephantfish. The summer time series was reviewed by Beentjes & Stevenson (2001).

Francis et al. (2001) analysed biomass data from 17 series of New Zealand random bottom trawl surveys including the winter and summer ECSI time series. The summer ECSI survey series exhibited the most variation in catchability out of all the series, with extreme values in three out of four years, whereas catchability in the winter series showed some variability, but no extremes. The summer time series was discontinued after 2000 because of the extreme fluctuations in catchability between surveys. The Inshore Fisheries Working Group decided the biomass estimates for the target species were not providing reliable abundance indices, some of which were incorporated in the 'Decision Rules' for AMP species such as giant stargazer (STA 3), elephantfish (ELE 3), and red gurnard (GUR 3) (Ministry of Fisheries Science Group (comps.) 2006). With the discontinuation of both the winter and summer surveys there was no means of effectively monitoring many of the commercial ECSI inshore fish stocks. Since 1996, several new species have been introduced into the QMS (e.g., skates, dark ghost shark, sea perch, and spiny dogfish). ECSI surveys also provided a useful comparison with Chatham Rise and sub-Antarctic middle depth trawl surveys because many of the species found on the ECSI tend to be smaller than elsewhere, indicating that this may be an important nursery ground (Beentjes et al. 2004).

A workshop, held in May 2005 to discuss ways of monitoring inshore species, concluded that reinstating the winter survey time series would be the best way to monitor long-term trends in abundance of RCO 3, SPE 3, STA 3, and sub-adult TAR 3. Simulations showed the power to detect changes in biomass between 1996 and 2006 increased with increasing number of future surveys and decreasing c.v.s. (Francis & Horn 2005), and would have 63 to 100% power to detect a change in relative biomass. Francis & Horn (2005) also reviewed information on life histories and movement patterns of key target species and concluded that a maximum depth of 400 m is suitable, but that the minimum depth of 30 m should be reduced to 10 m to improve sampling of various species.

## 1.2 Elasmobranch tagging

Trawl surveys provide a relatively inexpensive opportunity to tag elasmobranchs, and recaptures should provide information on movement patterns, stock structure, and growth. The survey aimed to tag rough skate, smooth skate, school shark, and rig.

There are two species of skate that are commonly caught on the ECSI surveys, the rough skate (*Dipturus nasuta*) more common inshore, and the larger smooth skate (*D. innominatus*), more common in deeper water. There is very little known about the biological stocks of either species and hence a tagging programme should provide information on movements, home range, and possibly growth.

New Zealand school shark are assumed to comprise a single biological stock. School shark tend to be more common in shallow water under 200 m and also move inshore during summer to pup. Tagging school shark on the east coast of the South Island complements a similar programme on the west coast as part of the west coast South Island (WCSI) trawl survey, and also the long term opportunistic tagging of school shark that has occurred from most inshore research trawl surveys dating back to 1985 (Hurst et al. 1999). From 1985 to 1997 nearly 4000 school shark were tagged, with 207 recaptures. Results indicate that about half of the school sharks were recaptured within the same QMA they were tagged, but this proportion declined over time (Hurst et al. 1999). A significant number (23%) were recaptured in Australia.

Although there may have been the occasional opportunistic tagging of rig during research trawl surveys, there has only been one directed rig tagging programme between 1978 and 1985 (Francis 1988). About 2000 rig were tagged from commercial set nets and research trawls, mainly around the South Island, with about 400 recaptures. Rig move less than school shark, but there was movement of over 50 km for half the recaptures. There was evidence of separate east and west coast South Island stocks. Like school shark, rig tend to be more common in shallow water (under 200 m) and also move inshore during summer to pup. Tagging rig on the east coast of the South Island complements a similar programme as part of the WCSI trawl survey, and also the earlier tagging study of Francis (1988).

## 1.3 Giant stargazer tagging

A further objective of the 2007 ECSI trawl survey was to tag, mark with oxytetracycline, and release giant stargazer. The purpose is to validate the annual deposition of growth zones on otoliths, and secondarily to gather information on growth and movement.

Giant stargazer ages are estimated from counts of growth zones present in the sagittal otoliths, assumed to form annually, although this method is not validated (Sutton 1999, Manning & Sutton 2007). Oxytetracycline (OTC) is commonly used to chemically mark fish otoliths by chelating the calcium and magnesium present in the otolith. Recaptured fish otoliths are examined under ultra-violet light for the position of the fluorescent check on the otolith, providing a powerful method of validating age estimates from otoliths (Campana 2001). A chemical labelling (using OCT), tagging, and release study of giant stargazer was carried out on the Chatham Rise during the R.V. *Tangaroa* trawl surveys in January 2005 and January 2006 (Stevens & O'Driscoll 2006, 2007), but there have been no returns from this programme at the time of writing (May 2008).

The true stock structure of giant stargazer in New Zealand waters is unknown (Ministry of Fisheries Science Group (comps.) 2006). Tagging and release of fish in STA 3 during the ECSI survey may also help to address this issue.

## 1.4 Objectives

### Overall objective

To determine the relative abundance and distribution of 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 acanthius*), and dark ghost shark (*Hydrolagus novaezelandiae*).

### Specific objectives

1. To determine the relative abundance and distribution of red cod, stargazer, sea perch, tarakihi, spiny dogfish, and dark ghost shark off the east coast of the South Island from Shag Point to Waiau River by carrying out a trawl survey over the depth range 10 to 400 m. The target coefficients of variation (c.v.s) of the biomass estimates for these species are as follows: red cod (20–25%), sea perch (20%), giant stargazer (20%), tarakihi (20–30%), spiny dogfish (20%) and dark ghost shark (20–30%).

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

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

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

5. To tag and release live skate and school shark.

6. To tag and inject giant stargazer with oxytetracycline to validate growth zones in the otoliths.

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

## 2. METHODS

### 2.1 Survey area and design

#### 30–400 m depth range

The 2007 survey (KAH0705) in the 30–400 m depth range covered the same area as the previous winter surveys, extending from the Waiau River in the north to Shag Point in the south. The survey area of 23 357 km$^2$, including untrawlable (foul) ground, was divided into 17 strata, identical to those used in the 1996 winter survey (KAH9606) (Figure 1, Table 1).

To determine the theoretical number of stations required in each of the 17 strata to achieve the required c.v. for the target species, simulations using NIWA's Optimal Station Allocation Programme were carried out using catch rates for the six target species for all five previous winter surveys. For those surveys before 1994 that used nine strata, the stations were assigned to the equivalent strata used from 1994 onward. Simulations using the minimum and maximum of the c.v. range and requiring a minimum of three stations per stratum, were carried out. The results indicated that to achieve the lower range c.v.s, 109 stations were required in the 30–400 m depth.

As for all previous winter surveys, a two-phase random stratified station survey design was used. This design has a better chance of achieving the target c.v.s, especially when species distributions change. Sufficient trawl stations to cover both first and second phase stations were generated for each stratum using the computer program Rand_stn v2.1, with the constraint that stations were at least 3 n. miles apart. We allocated 80% of the stations to phase 1 with a minimum of 3 stations and a maximum of 10 stations per stratum. A weighted allocation was then applied on the basis of species priority (in consultation with MFish), where the order in decreasing importance was tarakihi, stargazer, sea perch, red cod, dark ghost shark, and spiny dogfish. Allocation of phase 1 takes into account the spatial distribution and biomass of the key species over the previous five winter surveys. Phase 2 stations were allocated to strata with the highest variance for each species on the 2007 survey, where the c.v. was above the required target c.v, also based on this species priority.

#### 10–30 m depth range

The extension of the winter surveys into 10 m in effect constituted a new survey in 10–30 m, and in terms of biomass estimates, is treated as an adjunct to the existing survey time series in 30 to 400 m. This is necessary because calculation of relative total biomass of the ECSI for each species is proportional to the survey area, and increasing the total area surveyed during the time series introduces additional biomass to the estimates. Further, a smaller 28 mm codend was used in the shallow depth range.

The survey area of 3577 $km^2$, including untrawlable (foul) ground, was divided into four strata, identical to those used in the ECSI summer surveys (Figure 1, Table 1). Station allocation in the 10–30 m survey was not optimised, but 3 stations were nominally allocated in each of the four strata, resulting in 12 stations. Time constraints on the survey and the large number of target species, prevented allocation of more stations and/or a phase 2 component.

### 2.2 Vessel and gear

The vessel and trawl gear specifications were the same as for all previous ECSI winter surveys. R.V. *Kaharoa* is a 28 m stern trawler with a beam of 8.2 m, displacement of 302 t, engine power of 522 kW, capable of trawling to depths of 500 m. The two-panel 'Alfredo' design net was constructed in 1991, specifically for the South Island trawl surveys; there are two nets (A and B), complete with ground rope and floatation. This net fishes hard down and achieves a headline height of about 4–5 m. Rectangular 'V' trawl doors fitted with Scanmar sensors were used. For the 10–30 m and 30–400 m surveys the codend inside measurement was 28 mm (knotless), and 60 mm (knotless), respectively. A bottom contact sensor was deployed on the ground rope, and a net sonde monitor (CN22) was attached to the headline to measure headline height on all tows. All trawl gear was overhauled and specifications checked before the 2007 survey. Following this the gear specifications were revised and documented (Appendix 1).

### 2.3 Timetable

RV *Kaharoa* departed Nelson on 4 May 2007 and trawling began on 6 May, north of Banks Peninsula, moving progressively south until all phase 1 tows in Pegasus Bay and around Banks Peninsula had been completed, including stratum 18 in 10–30 m. The survey was then based out of Timaru and tows were carried out in the most optimal manner depending on weather and the need to discharge fish, but initially were restricted to the 30–400 m depth range. The first leg was completed on 19 May when the vessel unloaded fish at Timaru and there was a change of scientific staff. Strata 19–21 in 10–30 m were completed towards the end of the survey. The survey was completed on 5 June and the vessel steamed to Wellington, arriving on 6 June 2007. The voyage leader was Michael Stevenson and skippers were Mike Baker (4 to 14 May) and Neil Pestell (15 May to 6 June).

## 2.4 Trawling procedure

Trawling procedures adhered strictly to those documented by Stevenson & Hanchet (1999). All tows were carried out in daylight hours (shooting and hauling) between 0730 and 1700 hours NZST. Tows were initially 1 hour duration at a speed of 3.0 knots over the ground, and tow length was about 3 n. miles. The minimum acceptable tow length was about 1.5 n. miles. Timing began when the net reached the bottom and settled, as indicated by the net monitor, and finished when hauling began. In some strata, large catches of dogfish made tows increasingly unmanageable and the standard towing time was reduced, usually to about 40 min. Standardised optimal warp/depth ratio for different depths was strictly adhered to. Tow direction was generally along depth contours and/or towards the nearest random station position, but was also dependent on wind direction and bathymetry. Some tow paths, particularly those on the slope in 200–400 m, were surveyed before towing to ensure that it was 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 the radius, the next alternative random station was selected. The ground contact sensor data files were downloaded at the end of the tow immediately the gear came on deck and loaded into *Boxcar*, a dedicated computer program that checks that the gear was in contact with the bottom throughout the tow. If contact was considered to be unsatisfactory, the tow was not included in the biomass estimation.

Doorspread (SCANMAR monitor) and headline height (net sonde sensors) were measured continuously during the tow and the signals transmitted remotely to the ship. Both parameters were recorded at 10–15 minute intervals, and averaged over the tow.

A CTD (conductivity, temperature, and depth) monitor was attached to the headline and the data downloaded at the end of the tow and loaded into *Seabird*, a dedicated computer program written for CTD data. Bottom and surface water temperatures were taken from the CTD data. Surface temperatures were taken at a depth of 5 m and bottom temperatures about 5 m above the sea floor because the CTD is attached to the net just behind the headline.

## 2.5 Catch and biological sampling

The catch from each tow was sorted by species, boxed, and weighed on motion-compensating 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 sub-sample of about 100 randomly selected fish.

For each tow, biological information was obtained from a random sample of up to 20 fish for target species red cod, giant stargazer, sea perch, tarakihi, spiny dogfish, and dark ghost shark during which the following records or samples were taken: sex, length to the nearest centimetre below actual length, individual fish weight to the nearest 10 g (using motion-compensating 5 kg Seaway scales), otoliths and gonad stage of finfish (standard five–stage method.), and dorsal spines of sharks.

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

For each of the target species red cod, sea perch, tarakihi, and stargazer a maximum of five sagittal otoliths per cm size class per sex were removed. Otoliths were stored clean and dry in small paper envelopes marked with the survey trip code, species, fish number, length, and sex. After the survey, otoliths were catalogued and are held for MFish at NIWA, Greta Point.

Spiny dogfish spines were excised from the second dorsal fin and dark ghost shark spines from the first dorsal fin, ensuring that the spine was removed from about 1 cm beneath the skin. We aimed to collect a minimum of five spines per centimetre size class for each sex. Spiny dogfish spines were placed into plastic vials and filled with 70% ethanol, and dark ghost shark spines were placed into zip-lock plastic bags and frozen with details of station number, fish length, and sex. After the survey, spines were catalogued and are held for MFish at NIWA, Greta Point.

If present, macro-invertebrates were collected and preserved for later identification at Greta Point laboratories to the lowest possible taxonomic level.

All catch, biological, and length frequency data were entered into *trawl* database after the survey was completed.

## 2.6 Tagging procedures

As soon as the catch was on deck, it was immediately searched for the tagging candidate species rough skate, smooth skate, school shark, rig, and giant stargazer. Those in a lively condition were placed into a 700 l Dolav box pallet tank supplied with running sea water and aeration to facilitate recovery. Once recovered, skates, school shark, and rig were individually removed from the tank, tagged using a single small dart tag (Hallprint, Australia), and carefully released. Length, weight, sex, and release position (tow number) were recorded.

Similarly, after recovery, giant stargazer were removed individually from the tank, injected with the appropriate quantity (dose relative to body weight) of OTC intramuscularly, double tagged with external T-bar anchor tags, (Hallprint, Austalia), length and weight recorded, then carefully released. The tags were positioned posteriorly along the dorsal fin as giant stargazers bury themselves in the benthos. Because giant stargazer was a target species with a requirement to collect otoliths from about 400 fish, as well as determine sex and reproductive condition, priority was given in the initial stages of the survey to the biological objectives and later in the survey we tagged and injected a greater number of giant stargazer.

Following the completion of the survey all tagging details were entered into the *tag* database at NIWA, Greta Point.

## 2.7 Analysis of data

Relative biomass was estimated by the area-swept method described by Francis (1981, 1989) using the Trawlsurvey Analysis Program (Vignaux 1994). 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.

Coefficients of variation (c.v.) were calculated as follows:

$$\text{c.v. } (\%) = S_B / B \times 100$$

where $S_B$ is the standard deviation of the biomass (B).

For the 10–30 m and 30–400 m surveys, separate analyses of biomass, catch rates, and length frequency were carried out. A combined biomass and length frequency analysis was used for deriving scaled length frequency distributions and biomass estimates. All length frequencies were scaled by the percentage of catch sampled, area swept, and stratum area. Biomass estimates included total biomass for target and important QMS species, and recruited biomass for the target species and selected QMS species.

Catch rates (kg per square km) for the target and main QMS species were tabulated by strata and plotted for each tow to show areas of relative density throughout the survey area. For the target species only, catch rates for each of the six winter surveys are plotted together to show temporal and spatial changes in distribution. Total biomass by strata was also tabulated for the target and main QMS species.

Scaled length frequency distributions are plotted for the target species and main QMS species, and also by depth range for the target species. For the target species only, length frequencies in 30–400 m for each of the six winter surveys are plotted together to show temporal changes in size distribution.

Length-weight coefficients were determined for target species red cod, giant stargazer, sea perch, tarakihi, spiny dogfish, and dark ghost shark. Coefficients were determined by regressing natural log weight against natural log length ($W=aL^b$). These length weight coefficients were used to scale length frequencies, and potentially to calculate recruited biomass. For other species, the most appropriate length weight coefficients in the *trawl* database were used.

## 3. RESULTS

### 3.1 Trawling details

In 30–400 m (strata 1–17), 97 tows were carried out and, of these, 94 stations were deemed successful and used in biomass estimation (Table 1, Appendix 2). Of the 94 successful stations there were 87 phase one and 7 phase two stations (Table 1). Phase two stations were allocated to strata 1 and 4 to reduce c.v.s for sea perch and spiny dogfish (Table 1). The additional five stations in stratum 4 lowered the c.v. for spiny dogfish by only 1% and time constraints did not allow further stations to be completed. The survey covered the same total area as the previous winter surveys with at least three successful stations completed in each of the 17 strata. (Table 1, Appendix 2). Station density ranged from 1 station per 107 $km^2$ in stratum 14 to 1 station per 416 $km^2$ in stratum 2, with an overall density of 1 station per 248 $km^2$ (Table 1). Trawlable ground represented 91% of the total survey area. Station positions and tow numbers are shown in Figure 2 and individual station data in Appendix 2.

In 10–30 m (strata 18–21), 11 tows were carried out and all were used in the biomass estimation (Table 1, Appendix 2). There were three successful tows in all four strata except stratum 21, where one of the three tows came fast, resulting in minor gear damage and the tow was abandoned. Attempts to locate trawlable ground for a replacement station were unsuccessful. There was no phase 2 component for the survey in the 10–30 m depth range. Station density ranged from 1 station per 260 $km^2$ in stratum 21 to 1 station per 425 $km^2$ in stratum 18, with an overall density of 1 station per 325 $km^2$ (Table 1). Trawlable ground represented 97% of the total survey area. Station positions and tow numbers are shown in Figure 2 and individual station data in Appendix 2.

Monitoring of headline height and doorspread, observations that the doors and trawl gear were polishing well, and information from the ground contact sensors, indicated that the gear was fishing hard down and efficiently throughout the survey. For the depth range 30–400 m, mean doorspread, headline height, distance towed, and warp to depth ratio were 4.7 m, 79 m, 2.5 n. miles, and 3.3:1, respectively

(Appendix 3). Tow distance tended to be shorter in the 100–200 m depth range where catches were largest. Net-A was on all tows except 32 to 49 when Net-B was used because of damage to Net-A.

### 3.2 Water temperatures

Isotherms estimated from CTD surface and bottom temperature recordings from *Kaharoa* are shown in Figures 3 and 4, respectively. There was little difference between the bottom and surface water temperatures inshore, but offshore, bottom temperatures were about 2° C cooler than surface water. Surface temperatures were warmer closer inshore and further north, but the difference in both cases was only 1° C. (range 11° to 13° C). Bottom water temperatures, however, showed no north south difference and a greater inshore offshore range of 4° C (range 9° to 13° C).

### 3.3 Catch composition

#### 30–400 m depth range

The total catch from the survey in 30–400 m depth range was 105.2 t from the 94 biomass tows. Catches were highly variable, ranging from 51 kg to 7019 kg per tow, with an average of 1120 kg. Seventy-six vertebrate fish species were identified (14 chondrichthyans and 62 teleosts), as well as two cephalopod species (octopus and squid). Catch weights, percent catch, and occurrence of all species identified during the survey are given in Appendix 4. The catches were dominated by spiny dogfish and barracouta with catches of 41 t and 27 t, representing 39% and 26%, respectively, of the total catch. These two species, and the next five most abundant species, dark ghost shark, tarakihi, arrow squid, sea perch, and red cod, made up 82% of the total catch (Appendix 4). The percent of the catch represented by the six target species was as follows: spiny dogfish, 39%; dark ghost shark 7%; tarakihi 3%; sea perch 3%; red cod 2%; and giant stargazer 1%, making a combined total of 55%. Spiny dogfish was caught in every tow and barracouta, giant stargazer, arrow squid, witch, and carpet shark in 83% or more of the tows.

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

#### 10–30 m depth range

The total catch from the survey in the 10–30 m depth range was 8.2 t from 11 biomass tows. Catches were also highly variable, ranging from 110 kg to 3648 kg per tow, with an average of 750 kg. Thirty-six vertebrate fish species were identified (8 chondrichthyans and 28 teleosts), as well as two cephalopod species (octopus and squid). Catch weights, percent catch, and occurrence of all species identified during the survey are given in Appendix 4. The catches were dominated by barracouta and spiny dogfish with catches of 3.2 t and 1.6 t, representing 38% and 19%, respectively, of the total catch. These two species, and the next five most abundant species, leatherjacket, elephantfish, red gurnard, arrow squid, and rough skate, made up 94% of the total catch (Appendix 4). The percent of the catch represented by the six target species was as follows: spiny dogfish 19%; tarakihi 0.9%, red cod 0.6%, dark ghost shark 0%; giant stargazer 0%; and sea perch 0%, making a combined total of 20.4%. Spiny dogfish, barracouta, and rough skate were caught in every tow, and blue warehou and leatherjacket in 82% of the tows.

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

## 3.4 Biomass estimates

### 30–400 m depth range

Biomass estimates and c.v.s for the 20 most abundant commercial species in 30–400 m, including the target species, are given in Table 2. Of the target species, spiny dogfish had by far the largest biomass at 35 386 t, followed by dark ghost shark (4483 t), tarakihi (2589 t), sea perch (1945 t), red cod (1486), and giant stargazer (755 t). Of the non-target species, barracouta had the second largest biomass of all species at 21 132 t. Coefficients of variation for the target species were spiny dogfish 27%, dark ghost shark 25%, tarakihi 24%, sea perch 21%, red cod 25%, and giant stargazer 18% (Table 2). These c.v.s were within the target range specified in the project objectives for dark ghost shark, red cod, giant stargazer, and tarakihi, and within 1% for sea perch. For spiny dogfish the c.v. was 27%, slightly above the target of 20%.

Recruited biomass estimates and c.v.s for the target species and eight of the non-target species are shown in Table 2. For the target species the percentage of total biomass that was recruited fish was spiny dogfish 83%, dark ghost shark 59%, tarakihi 68%, sea perch 96%, red cod 87%, and giant stargazer 96%.

### 10–30 m depth range

Biomass estimates and c.v.s in 10–30 m for the 20 most abundant commercially species, including the target species, are given in Table 3. Of the target species, only spiny dogfish, red cod, and tarakihi were represented in the catch. The dominant species in terms of biomass (over 550 t) were spiny dogfish, barracouta, leatherjacket, elephantfish, red gurnard, and arrow squid. However, only three species had acceptable levels of precision around the biomass estimates, spiny dogfish (22%), red cod (22%), and rough skate (22%). All other c.v.s were greater than 35%.

Recruited biomass estimates for the two species with acceptable c.v.s show that the percentage of total biomass that was recruited fish was spiny dogfish 85%, and red cod 86%.

## 3.5 Catch rates and distribution

Catch rates by stratum (1–21, 10–400 m), for the 20 most abundant commercially important species, including the target species are given in Table 4, and catch rates of target species by station are shown in Figure 5. Biomass by stratum (1–21, 10–400 m), for the 20 most abundant commercially important species, including the target species, are given in Table 5.

### 3.5.1 Target species

Dark ghost shark was predominantly caught in waters deeper than 100 m throughout the survey area, with the shallowest catch in 67 m. Highest catch rates were in the 100 to 200 m strata 11, 10, and 9, and the 200 to 400 m strata 17 and 14. The highest biomass estimates were in 100 to 200 m strata 11, 10, and 9, and 200 to 400 m stratum 17.

Giant stargazer was predominantly caught in waters deeper than about 30 m throughout the survey area, with the shallowest catch in 36 m and the deepest in 391 m. Highest catch rates were in 30 to 100 m strata 4 and 6, and 100 to 200 m strata 11, 8, and 9. The highest biomass estimates were in the 30 to 100 m strata 4 and 6, and 100 to 200 m stratum 11.

Red cod was caught in all depth ranges throughout the survey area, with the shallowest catch in 13 m and the deepest in 362 m. Highest catch rates were in 30 to 100 m strata 1 and 7, 100 to 200 m stratum 11, and 200 to 400 m stratum 14. The highest biomass estimates were in 30 to 100 m strata 4, 7, and 6, and 100 to 200 stratum 11.

Sea perch was predominantly caught in waters deeper than about 50 m throughout the survey area, with the shallowest catch in 33 m and the deepest in 391 m. Highest catch rates were in the south in 30 to 100 m strata 1 and 100 to 200 m strata 10, 9, 11, and 8. The highest biomass estimates were in 30 to 100 m strata 1 and 6, and 100 to 200 m stratum 10, 9, and 11.

Spiny dogfish was caught in all depth ranges throughout the survey area from all tows, with the shallowest catch in 13 m and the deepest in 391 m. Highest catch were rates in 10 to 30 m stratum 19, 30 to 100 m strata 3, 4, and 5, and 100 to 200 m stratum 11. The highest biomass estimates were in 10 to 30 m stratum 19, 30 to 100 m strata 4, 3, 5, 7, and 6, and 100 to 200 m stratum 11.

Tarakihi was predominantly caught in waters between about 30 and 200 m throughout the survey area, with the shallowest catch in 24 m and the deepest in 395 m. Highest catch rates and biomass estimates were in the central Canterbury Bight in 30 to 100 m stratum 4, and were about three-fold greater than the next highest. Other strata with high catch rates included 10 to 30 m stratum 21, 30 to 100 m strata 5 and 1, and 100 to 200 m stratum 13. Similarly, high biomass estimates were in 30 to 100 m strata 5 and 3, and 100 to 200 m stratum 13.

### 3.5.2 Other species

Catch rates of non-target species by station are shown in Figure 6 and Table 4. Barracouta were caught mainly shallower than 200 m throughout the survey area, with shallowest catch in 13 m and the deepest in 314 m. Consistently high catch rates were recorded in the central Canterbury Bight in strata 4 and 10 close to the 100 m depth contour. Elephantfish were caught mainly in the four 10 to 30 m strata with a few catches in the deeper 30–100 m strata. Red gurnard were caught mainly in the four 10 to 30 m strata, but many smaller catches were also made in the 30–100 m strata.

## 3.6 Biological and length frequency data

Details of length frequency and biological data recorded for each species are given in Table 6. Over 37 000 length frequency and 12 000 biological records were taken from 43 species. This included otoliths from 428 red cod, 423 sea perch, 420 giant stargazer, and 241 tarakihi. Dorsal spines were collected from 423 spiny dogfish and 418 dark ghost shark.

Scaled length frequency distributions of the target species over the 30–400 m depth range as well as for the depth ranges 10–30 m, 30–100 m, 100–200 m, and 200–400 m are plotted in Figure 7. Scaled length frequency distributions of the non-target species over the 30–400 m depth range, and also the 10–30 m depth range for species with a shallow distribution, are plotted in Figure 8. The length-weight coefficients used to scale the length frequency data are shown in Appendix 6.

The length frequency distribution for dark ghost shark is bimodal (Figure 7), although the smaller mode is less well defined. These modes are further to the right for females, indicating faster growth. The large mode (males 50–65 cm) comprises mainly recruited fish (over 55 cm) and is prevalent in the 30–200 m and particularly the 100–200 m depth range. Conversely the smaller mode (males 20–50 cm) is pre-recruited fish and is dominant in 200–400 m. The overall sex ratio (males:females) in 30–400 m is 0.77:1.

The length frequency distributions for giant stargazer for males/unsexed shows one strong mode of large fish (20–55 cm), and a mode of small fish at about 10–20 cm (Figure 7). The large number of unsexed fish represent those that were tagged and released. Female distributions have no discernible modes. For both sexes the distributions were similar in all depth ranges, but relatively few fish were caught in 200–400 m. The overall sex ratio (males:females) in 30–400 m is 0.79:1.

The length frequency distribution for red cod shows three defined modes at 10–20 cm (0+), 30–50 cm (1+ and 2+ combined), and 50–60 for males and 50–70 for females (females grow larger and faster than males), representing 3+/4+ fish (Figure 7). The 1+ mode is more evident in 100–200 m (25–35 m). Size varies with depth with the largest fish in 30–100 m, although some large females were also caught in the shallow 10–30 m depth range. The overall sex ratio (males:females) in 30–400 m is 1.03:1.

The length frequency distribution for sea perch is unimodal with peaks at about 25 cm for both males and females (Figure 7). The bulk of fish were caught in 30–100 m and 100–200 m. The overall sex ratio (males:females) in 30–400 m is 1.2:1.

The length frequency distribution for spiny dogfish is unimodal with peaks at about 56 cm for males and 53 cm for females (Figure 7). Although caught in all depth ranges, the bulk of fish were in 30–100 m. The overall sex ratio (males:females) in 30–400 m is 1.38:1.

The length frequency distributions for tarakihi show three distinct modes, with similar shapes for both males and females (Figure 7). The first mode (10–15 cm) has a peak at about 13 cm, the second (15–21 cm) at about 18 cm, and the third (20–33 cm) at about 26 cm. The bulk of the fish were caught at 30–100 m, although there was a large number of fish from the smallest mode in 10–30 m. The overall sex ratio (males:females) in 30–400 m is 0.98:1.

Details of the gonad stages for the finfish target species are given in Table 7. Tarakihi and red cod were predominantly immature/resting (stage 1), and to a lesser extent maturing (stage 2), but there were also a few red cod with more advanced stages. Sea perch and giant stargazer were also mostly in the immature/resting and maturing stage, but there were considerable numbers in the more advanced stages of development, particularly males.

### 3.7 Tagging

A total of 752 individual skates and sharks from four species were tagged, length and weight recorded, and released during the survey (see Table 6). The total included 356 rough skate, 186 smooth skate, 171 school shark, and 39 rig. In addition, 344 giant stargazer were double tagged, length and weight recorded, injected with OTC, and released.

## 4. DISCUSSION

### 4.1 2007 survey

We report the findings of the 2007 ECSI bottom trawl survey in May–June 2007 using R.V. *Kaharoa* (KAH0705) in 30–400 m. This survey represents a reinstatement of the discontinued winter time series of 5 previous surveys, the last of which was in 1996. The 2007 survey was successful in meeting all the project objectives with the exception of the c.v.s for spiny dogfish (maximum target c.v. = 20%, c.v. achieved = 27.2%) and sea perch (maximum target c.v. = 20%, c.v. achieved = 21.5%). The high spiny dogfish c.v. was also greater than for any previous winter survey, and was caused, to a large extent, by a few very large catches of spiny dogfish in stratum 4 (see Table 4,

Figure 5). There was insufficient time to allocate phase 2 stations required to reduce the spiny dogfish c.v., and it was also low on the priority list for allocation of phase 2 stations.

The ancillary inshore survey in 10–30 m yielded a different species composition from the main survey area. Only three of the target species were represented (red cod, spiny dogfish, and tarakihi) and, of these, c.v.s were acceptable only for red cod (22%) and spiny dogfish (22%). It may also be useful for rough skate (c.v. 22%), and possibly for red gurnard and elephantfish, but without the allocation of more stations, and a phase 2 component, the c.v.s are likely to be high for these two species. The ECSI summer survey time series, for example, allocated considerably more stations to these strata and achieved variable but generally acceptable c.v.s for red gurnard and elephantfish (Beentjes & Stevenson 2001, Stevenson & Beentjes 2002).

## 4.2 Trends in biomass, distribution and size

Implicit in our interpretation of trends in biomass, geographic distribution, and length distribution is the 11 year interval separating the last two surveys. During this period we have no information on these variables.

Biomass for dark ghost shark was the highest of the six surveys and continues the trend of increasing biomass from 1991 to 2007 (Table 8, Figure 9). The 2007 biomass is about four-fold greater than in 1991. All surveys have a large component of pre-recruited fish (range 30 to 62% of total biomass) (Table 9, Figure 10). The distribution of dark ghost shark over the time series is similar and was confined to the continental slope and edge, although the large biomass in 2007 is commensurate with a slightly expanded distribution throughout the survey area in this depth and into Pegasus Bay (Figure 11). The size distributions of dark ghost shark in each of the last four surveys are similar and generally bimodal (Figure 12). The distributions differ from those of the Chatham Rise and Southland/Sub-Antarctic surveys (O'Driscoll & Bagley 2001, Livingston et al. 2002) in that ECSI has a large component of pre-recruited fish (under 55 cm) suggesting that this area may be an important nursery ground for juvenile dark ghost shark.

Biomass for giant stargazer was the highest of the six surveys, and biomass appears to have increased following a general decline from 1991 to 1994 (see Table 8, Figure 9). Pre-recruited biomass is a small component of the total biomass estimate on all surveys (range 2 to 5% of total biomass) (Table 9, Figure 10). The distribution of giant stargazer varies in terms of the geographic areas of high density, but overall this species is consistently well represented over the entire survey area, most commonly from 30 m to about 200 m (see Figure 11). The size distributions of giant stargazer in each of the six surveys are similar and generally bimodal for males, and less defined for females (Figure 12). Giant stargazer on the ECSI overall are generally smaller than those from the Chatham Rise, Southland, and WCSI surveys (Bagley & Hurst 1996, Stevenson & Hanchet 2000, Livingston et al. 2002), suggesting that this area may be an important nursery ground for juvenile giant stargazer.

Biomass for red cod was the lowest of the six surveys, and is almost one-quarter of that in 1994 when it peaked (see Table 8, Figure 9). The high biomass in 1994 and the very low biomass in 2007 are consistent with the size of commercial landings in RCO 3 at these times. Pre-recruited biomass is a small component of the total biomass in the 1996 and 2007 surveys (13% and 13%) compared to 1994 when pre-recruited biomass was 59% of total biomass (Table 9, Figure 10). The distribution of red cod varies in terms of the geographic areas of high density, but overall this species is consistently well represented over the entire survey area, most commonly from 30 m to about 300 m (see Figure 11), but is also found in waters shallower than 30 m. The size distributions of red cod in each of the six surveys are 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. The 1996 and particularly the 2007 surveys show very poor recruitment of 1+ fish compared to earlier surveys. In contrast the 1994 survey indicated the presence of a very strong 1+ cohort which resulted in high commercial catches in the following years.

Red cod on the ECSI, overall, are generally smaller than those from Southland (Bagley & Hurst 1996) suggesting that this area may be an important nursery ground for juvenile red cod.

Biomass for sea perch lies in the mid range of those of previous surveys and there is no trend in biomass over the time series (see Table 8, Figure 9). Pre-recruited biomass is a very small component of the total biomass estimate on all surveys (range 3 to 6% of total biomass) (see Table 9, Figure 10). The distribution of sea perch varies in terms of the geographic areas of high density, but overall this species is consistently well represented over the entire survey area, most commonly from about 70 m to 300 m (see Figure 11). The size distributions of sea perch on each of the six surveys are similar and generally unimodal with a right hand tail (Figure 12). Sea perch on the ECSI, overall, are generally smaller than those from the Chatham Rise and Southland surveys (Bagley & Hurst 1996, Livingston et al. 2002). This suggests that this area may be an important nursery ground for juvenile sea perch and/or that sea perch tend to be larger at greater depths (Beentjes et al. 2007) and the ECSI survey does not extend to the full depth range of sea perch which are found as deep as 800 m.

Biomass for spiny dogfish was the highest of the six surveys. Biomass increased almost three-fold between 1994 and 1996 and appears to have remained at this high level (see Table 8, Figure 9). Spiny dogfish has had the largest biomass of all species with the exception of barracouta in 1992 and 1993. Pre-recruited biomass was a small component of the total biomass estimate in the 1992 to 1994 surveys (1 to 3 % of total biomass), but has increased markedly to 10% in 1996 and 16% in 2007 (see Table 9, Figure 10). The distribution of spiny dogfish varies in terms of the geographic areas of high density, but overall this species is consistently well represented over the entire survey area, most commonly from 30 m to about 350 m (see Figure 11), but is also common in waters shallower than 30 m. The size distributions of spiny dogfish in each of the 1992 to 1994 surveys are similar and generally bimodal for males, and less defined for females (Figure 12). In 1996 and 2007 the distributions are dominated by smaller fish. Spiny dogfish on the ECSI, overall are considerably smaller than those from the Chatham Rise, Southland, and the sub-Antarctic surveys (Bagley & Hurst 1996, O'Driscoll & Bagley 2001, Livingston et al. 2002), suggesting that this area may be an important nursery ground for juvenile spiny dogfish.

Biomass for tarakihi lies in the upper range of those of previous surveys and there is no apparent trend in biomass over the time series (see Table 8, Figure 9). Pre-recruited biomass is a major component of the total biomass estimate on all surveys (ranging from 18 to 59% of total biomass) (see Table 9, Figure 10). The distribution of tarakihi varies in terms of the geographic areas of high density, but overall this species is consistently well represented over the entire survey area, most commonly from 30 m to about 150 m (see Figure 11), but is also common in waters shallower than 30 m. The size distributions of tarakihi in each of the six surveys are similar and generally multi-modal, representing individual cohorts in the smaller modes (Figure 12). Tarakihi on the ECSI, overall, are generally smaller than those from the West coast South Island (Stevenson & Hanchet 2000), suggesting that this area may be an important nursery ground for juvenile tarakihi.

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**Table 1: Stratum depth ranges, survey area, non-trawlable area, number of successful phase 1 and phase 2 stations, and station density.**

| 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 | 5 | 2 | 141 |
| 2 | 30–100 | 1 247 | Oamaru | 0 | 3 | 0 | 416 |
| 3 | 30–100 | 3 023 | Timaru | 0 | 8 | 0 | 378 |
| 4 | 30–100 | 2 703 | Rakaia | 0 | 8 | 5 | 208 |
| 5 | 30–100 | 2 485 | Banks Pen. | 0 | 6 | 0 | 414 |
| 6 | 30–100 | 2 373 | Pegasus | 208 | 8 | 0 | 297 |
| 7 | 30–100 | 2 089 | Conway | 871 | 10 | 0 | 209 |
| 8 | 100–200 | 628 | Shag Point | 17 | 3 | 0 | 209 |
| 9 | 100–200 | 1 163 | Oamaru | 0 | 5 | 0 | 233 |
| 10 | 100–200 | 1 191 | Timaru | 0 | 7 | 0 | 170 |
| 11 | 100–200 | 1 482 | Banks Pen. | 0 | 5 | 0 | 296 |
| 12 | 100–200 | 764 | Pegasus | 132 | 3 | 0 | 255 |
| 13 | 100–200 | 999 | Conway | 406 | 3 | 0 | 333 |
| 14 | 200–400 | 321 | Oamaru Crack | 17 | 3 | 0 | 107 |
| 15 | 200–400 | 430 | Timaru | 0 | 4 | 0 | 108 |
| 16 | 200–400 | 751 | Banks Pen. | 0 | 3 | 0 | 250 |
| 17 | 200–400 | 724 | Conway | 165 | 3 | 0 | 241 |
| **Subtotal (average)** | | **23 357** | | **2 018** | **87** | **7** | **(248)** |
| 18 | 10–30 | 1 276 | Pegasus | 0 | 3 | 0 | 425 |
| 19 | 10–30 | 987 | Rakaia | 0 | 3 | 0 | 329 |
| 20 | 10–30 | 794 | Timaru | 0 | 3 | 0 | 265 |
| 21 | 10–30 | 520 | Oamaru | 226 | 2 | 0 | 260 |
| **Subtotal (average)** | | **3 577** | | **226** | **11** | **0** | **(325)** |
| **Total (average)** | | **26 934** | | **2 244** | **98** | **7** | **(257)** |

Table 2: Catch and estimated biomass for top 20 commercial species, including target species (bold) in 30–400 m. * not measured.

| | | Males | | Females | | All fish | | Recruited | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Common name | Catch (kg) | Biomass (t) | c.v. (%) | Biomass (t) | c.v. (%) | Biomass (t) | c.v. (%) | Size (cm) | Biomass (t) | c.v. (%) |
| **Dark ghost shark** | 7 120 | 1 696 | 24.9 | 2 783 | 28.3 | 4 483 | 25.3 | >55 | 2 626 | 25.7 |
| **Giant stargazer** | 1 059 | 140 | 12.9 | 314 | 23.4 | 755 | 17.6 | >30 | 722 | 18.0 |
| **Red cod** | 2 476 | 581 | 30.3 | 904 | 27.6 | 1 486 | 24.8 | >40 | 1 295 | 25.2 |
| **Sea perch** | 2 709 | 1 138 | 21.4 | 816 | 22.8 | 1 954 | 21.5 | >20 | 1 880 | 22.0 |
| **Spiny dogfish** | 40 832 | 22 253 | 25.4 | 13 133 | 32.8 | 35 386 | 27.2 | >50 | 29 555 | 27.3 |
| **Tarakihi** | 3 165 | 1 232 | 25.6 | 1 353 | 23.8 | 2 589 | 24.5 | >25 | 1 766 | 24.2 |
| Arrow squid | 3 030 | * | | * | | 1 242 | 23.1 | | | |
| Barracouta | 26 916 | 10 129 | 17.2 | 10 911 | 17.5 | 21 132 | 17.0 | | | |
| Blue warehou | 1 797 | 661 | 79.1 | 757 | 79.0 | 1 418 | 79.0 | >45 | 155 | 38.6 |
| Elephantfish | 1 182 | 444 | 41.5 | 587 | 28.1 | 1 034 | 32.3 | >50 | 518 | 20.7 |
| Hapuku | 335 | 125 | 33.8 | 124 | 24.3 | 248 | 27.6 | >65 | 75 | 67.5 |
| Hoki | 258 | 67 | 66.4 | 66 | 57.5 | 134 | 61.9 | | | |
| Leatherjacket | 178 | * | | * | | 96 | 44.1 | | | |
| Ling | 607 | 98 | 29.9 | 184 | 26.8 | 283 | 27.1 | >65 | 190 | 31.4 |
| Red gurnard | 1 926 | 794 | 34.0 | 660 | 36.1 | 1 453 | 34.6 | >30 | 1 155 | 34.9 |
| Rig | 152 | 67 | 32 | 67 | 49.9 | 134 | 37.3 | >90 | 32 | 70.8 |
| Rough skate | 1 123 | 453 | 22.5 | 421 | 22.04 | 878 | 21.6 | | | |
| School shark | 672 | 308 | 23.9 | 230 | 24.9 | 538 | 21.6 | >90 | 187 | 30.1 |
| Silver warehou | 794 | 200 | 47.0 | 212 | 46.9 | 445 | 43.6 | >25 | 392 | 49.2 |
| Smooth skate | 970 | 449 | 24.5 | 256 | 25.2 | 705 | 20.1 | | | |

* Not sexed

**Table 3: Catch and estimated biomass for top 20 commercial species, including target species (bold) in 10–30 m. * not measured.**

| | | Males | | Females | | All fish | | Recruited | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Common name | Catch (kg) | Biomass (t) | c.v. (%) | Biomass (t) | c.v. (%) | Biomass (t) | c.v. (%) | Size (cm) | Biomass (t) | c.v. (%) |
| **Dark ghost shark** | 0 | 0 | – | 0 | – | 0 | – | >55 | 0 | – |
| **Giant stargazer** | 0 | 0 | – | 0 | – | 0 | – | >30 | 0 | – |
| **Red cod** | 47 | 4 | 49.4 | 63 | 23.0 | 66 | 22 | >40 | 56.8 | 24.2 |
| **Sea perch** | 0 | 0 | – | 0 | – | 0 | – | >20 | 0 | – |
| **Spiny dogfish** | 1 569 | 1 195 | 15.7 | 718 | 51.6 | 1 913 | 22 | >50 | 1 634 | 20.2 |
| **Tarakihi** | 71 | 43 | 99.4 | 35.7 | 99.0 | 85 | 92 | >25 | 5.85 | 100.0 |
| | | | | | | | | | | |
| Arrow squid | 447 | * | | * | | 536 | 89 | | | |
| Barracouta | 3 149 | 2 043 | 80.4 | 1 762 | 72.4 | 3 806 | 77 | | | |
| Blue warehou | 54 | 16 | 72.5 | 15 | 83.3 | 64 | 47 | >45 | 0 | – |
| Elephantfish | 728 | 324 | 33.2 | 501 | 41.4 | 825 | 36 | >50 | 139 | 52.4 |
| Hapuku | 6 | 4 | 72.7 | 5 | 100.0 | 9 | 50 | | | |
| Hoki | 0 | 0 | – | 0 | – | 0 | | >65 | 0 | |
| Leatherjacket | 1 024 | * | – | * | – | 1 230 | 60 | | | |
| Ling | 0 | 0 | – | 0 | – | 0 | – | >65 | | |
| Red gurnard | 489 | 222 | 39.0 | 373 | 33.5 | 595 | 35 | >30 | 398 | 29.0 |
| Rig | 39 | 24 | 67.4 | 34 | 56.5 | 59 | 46 | >90 | 12 | 100.0 |
| Rough skate | 323 | 189 | 27.6 | 189 | 17.0 | 383 | 22 | | | |
| School shark | 11 | 4 | 39.7 | 10 | 37.1 | 14 | 36 | >90 | 0 | – |
| Silver warehou | 4 | 3 | 73.6 | 2 | 60.3 | 6 | 59 | >25 | 0 | – |
| Smooth skate | 0 | 0 | – | 0 | – | 0 | – | | | |

**Table 4: Catch rates (kg.km$^{-2}$) and standard deviation ( ) by stratum (1–21) for the 20 most abundant commercial species, including target species. Species codes are given in Appendix 4. * less than 5 kg.km$^{-2}$.**

| | Target species | | | | | | Other species | | |
|---|---|---|---|---|---|---|---|---|---|
| Stratum | GSH | RCO | SPD | SPE | STA | TAR | BAR | ELE | GUR |
| 1 | 0 | 140 | 55 | 210 | 22 | 109 | 636 | 130 | 23 |
| | | (198) | (71) | (553) | (16) | (277) | (728) | (138) | (20) |
| 2 | 0 | 22 | 149 | 0 | 26 | 26 | 18 | 14 | 15 |
| | | (27) | (80) | | (39) | (44) | (22) | (10) | (17) |
| 3 | 13 | 13 | 3 059 | 29 | 18 | 77 | 356 | 177 | 175 |
| | (36) | (14) | (5 772) | (42) | (32) | (213) | (271) | (298) | (363) |
| 4 | 31 | 126 | 4 865 | 18 | 53 | 529 | 2 799 | 10 | 123 |
| | (68) | (329) | (7 611) | (35) | (84) | (688) | (3 678) | (17) | (220) |
| 5 | 4 | 37 | 1 035 | 1 | 27 | 158 | 1 289 | 35 | 7 |
| | (7) | (85) | (1 917) | (2) | (46) | (251) | (1 433) | (60) | (7) |
| 6 | 60 | 81 | 241 | 93 | 49 | 38 | 728 | 18 | 6 |
| | (171) | (118) | (277) | (188) | (79) | (44) | (1 381) | (26) | (6) |
| 7 | 0 | 128 | 906 | 45 | 4 | 34 | 856 | 71 | 244 |
| | | (208) | (1 355) | (109) | (5) | (101) | (1 351) | (91) | (420) |
| 8 | 133 | 29 | 110 | 156 | 68 | 0 | 591 | 25 | 0 |
| | (182) | (38) | (108) | (271) | (67) | | (491) | (43) | |
| 9 | 528 | 1 | 260 | 255 | 44 | 0 | 875 | 3 | 0 |
| | (664) | (1) | (114) | (416) | (20) | | (764) | (6) | |
| 10 | 761 | 32 | 677 | 439 | 34 | 17 | 1 415 | 0 | 3 |
| | (502) | (31) | (1 007) | (401) | (17) | (24) | (920) | | (4) |
| 11 | 838 | 110 | 3 724 | 166 | 79 | 24 | 1 078 | 0 | 6 |
| | (898) | (213) | (6 165) | (157) | (98) | (33) | (943) | | (8) |
| 12 | 0 | 0 | 84 | 81 | 26 | 8 | 290 | 0 | 1 |
| | | | (54) | (81) | (9) | (12) | (476) | | (2) |
| 13 | 107 | 46 | 770 | 55 | 16 | 161 | 194 | 34 | 0 |
| | (39) | (59) | (1 073) | (28) | (22) | (18) | (60) | (21) | |
| 14 | 380 | 332 | 29 | 2 | 10 | 0 | 0 | 0 | 0 |
| | (178) | (562) | (15) | (3) | (10) | | | | |
| 15 | 263 | 8 | 210 | * | 11 | 0 | 2 | 0 | 0 |
| | (484) | (15) | (248) | (*) | (11) | | (5) | | |
| 16 | 141 | 12 | 51 | 1 | 6 | * | 1 | 0 | 0 |
| | (162) | (12) | (31) | (2) | (7) | (1) | (1) | | |
| 17 | 1 245 | 4 | 80 | 8 | 16 | 10 | 8 | 0 | 0 |
| | (2 023) | (8) | (76) | (12) | (22) | (13) | (14) | | |
| 18 | 0 | 38 | 204 | 0 | 0 | 0 | 76 | 0 | 142 |
| | | (18) | (170) | | | | (66) | | (126) |
| 19 | 0 | 5 | 1 305 | 0 | 0 | 7 | 3 681 | 494 | 206 |
| | | (8) | (673) | | | (11) | (5 109) | (475) | (181) |
| 20 | 0 | 11 | 403 | 0 | 0 | 0 | 94 | 418 | 242 |
| | | (9) | (255) | | | | (93) | (275) | (342) |
| 21 | 0 | 9 | 87 | 0 | 0 | 150 | 3 | 10 | 37 |
| | | (11) | (18) | | | (212) | (1) | (2) | (12) |

**Table 4–*continued***

| | | | | | | | | | | Other species | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Stratum | HAP | HOK | LEA | LIN | NOS | RSK | SCH | SPO | SSK | SWA | WAR |
| 1 | 1 | 0 | * | 54 | 18 | 64 | 1 | 0 | 25 | * | 14 |
| | (3) | | (*) | (75) | (17) | (59) | (2) | | (56) | (*) | (36) |
| 2 | 0 | 0 | 4 | 9 | 13 | 151 | 1 | 1 | 8 | * | 28 |
| | | | (7) | (16) | (15) | (136) | (2) | (100) | (13) | (*) | (33) |
| 3 | 7 | 0 | * | 2 | 13 | 37 | 51 | 0 042 | 61 | 1 | 5 |
| | (9) | | (*) | (5) | (10) | (81) | (84) | (0 044) | (79) | (1) | (9) |
| 4 | 32 | 0 | 6 | 3 | 20 | 43 | 5 | 0 034 | 32 | 4 | 4 |
| | (84) | | (14) | (6) | (25) | (52) | (9) | (0 058) | (88) | (4) | (6) |
| 5 | 8 | 0 | 0 | 0 | 15 | 20 | 3 | 0 041 | 12 | 2 | 0 |
| | (14) | | | | (11) | (32) | (5) | (0 100) | (29) | (2) | (1) |
| 6 | 9 | 0 | 0 | 0 | 38 | 80 | 53 | 2 | 15 | 1 | 470 |
| | (8) | | | | (48) | (139) | (37) | (100) | (30) | (2) | (1 328) |
| 7 | 3 | 0 | 36 | 1 | 14 | 43 | 33 | 4 | 13 | 16 | 77 |
| | (3) | | (62) | (2) | (11) | (56) | (45) | (0 053) | (23) | (23) | (174) |
| 8 | 19 | 0 | 0 | 16 | 19 | 51 | 8 | 0 | 75 | 1 | 59 |
| | (33) | | | (17) | (16) | (88) | (8) | | (69) | (2) | (79) |
| 9 | 8 | 0 | 0 | 4 | 34 | 0 | 21 | 1 | 59 | 1 | 0 |
| | (8) | | | (9) | (15) | | (23) | (100) | (96) | (1) | |
| 10 | 14 | 0 | 0 | 7 | 20 | 1 | 1 | 7 | 21 | 9 | 7 |
| | (21) | | | (6) | (21) | (4) | (2) | (0 072) | (25) | (10) | (14) |
| 11 | 25 | 0 | 0 | 31 | 10 | 2 | 5 | 0 000 | 67 | 9 | 1 |
| | (14) | | | (58) | (7) | (5) | (8) | | (77) | (11) | (2) |
| 12 | 14 | 0 | 0 | 0 | 25 | 24 | 4 | 0 | 40 | 31 | 0 |
| | (8) | | | | (32) | (2) | (7) | | (35) | (28) | |
| 13 | 0 | 0 | 0 | 0 | 78 | 0 | 127 | 0 | 0 | 126 | 22 |
| | | | | | (94) | | (103) | | | (213) | (38) |
| 14 | 6 | 2 | 0 | 30 | 340 | 2 | 0 | 0 | 0 | 8 | 0 |
| | (10) | (4) | | (39) | (346) | (3) | | | | (8) | |
| 15 | 0 | 1 | 0 | 105 | 551 | 6 | 0 | 0 | 76 | 25 | 0 |
| | | (1) | | (181) | (376) | (7) | | | (83) | (28) | |
| 16 | 4 | 97 | 0 | 33 | 323 | 11 | 0 | 0 | 10 | 265 | 0 |
| | (7) | (162) | | (46) | (516) | (20) | | | (16) | (340) | |
| 17 | 4 | 82 | 0 | 77 | 251 | 6 | 0 | 0 | 2 | 3 | 0 |
| | (7) | (102) | | (90) | (290) | (5) | | | (3) | (4) | |
| 18 | 6 | 0 | 0 | 0 | 6 | 7 | 2 | 53 | 0 | 4 | 21 |
| | (6) | | | | (8) | (7) | (2) | (50) | | (5) | (27) |
| 19 | 0 | 0 | 520 | 0 | 48 | 166 | 9 | 0 005 | 0 | * | 6 |
| | | | (439) | | (20) | (61) | (8) | (100) | | (1) | (4) |
| 20 | 0 | 0 | 16 | 0 | 3 | 121 | 3 | 1 | 0 | 1 | 39 |
| | | | (27) | | (4) | (118) | (4) | (100) | | (2) | (49) |
| 21 | 3 | 0 | 1 355 | 0 | 922 | 219 | 0 | 0 | 0 | 0 | 0 |
| | (4) | | (1 895) | | (1 304) | (141) | | | | | |

**Table 5: Estimated biomass (t) and coefficient of variation ( ) by stratum (1–21) for the 20 most abundant commercial species, including target species. Species codes are given in Appendix 4. * less than 0.5 t.**

| | Target species | | | | | | Other species | | |
|---|---|---|---|---|---|---|---|---|---|
| Stratum | GSH | RCO | SPD | SPE | STA | TAR | BAR | ELE | GUR |
| 1 | 0 | 138 | 54 | 207 | 22 | 107 | 626 | 128 | 22 |
| | | (53) | (49) | (99) | (28) | (96) | (43) | (40) | (33) |
| 2 | 0 | 27 | 186 | 0 | 32 | 32 | 22 | 17 | 19 |
| | | (71) | (31) | | (87) | (97) | (71) | (43) | (65) |
| 3 | 40 | 40 | 9 194 | 87 | 55 | 231 | 1 070 | 532 | 526 |
| | (95) | (38) | (67) | (51) | (61) | (98) | (27) | (59) | (73) |
| 4 | 84 | 341 | 13 179 | 48 | 143 | 1 434 | 7 582 | 26 | 334 |
| | (60) | (73) | (43) | (56) | (44) | (36) | (36) | (48) | (50) |
| 5 | 11 | 93 | 2 574 | 3 | 66 | 393 | 3 207 | 87 | 17 |
| | (66) | (93) | (76) | (65) | (71) | (65) | (45) | (71) | (44) |
| 6 | 143 | 191 | 571 | 220 | 116 | 91 | 1 727 | 44 | 15 |
| | (100) | (52) | (41) | (71) | (57) | (41) | (67) | (49) | (33) |
| 7 | 0 | 268 | 1 889 | 94 | 8 | 71 | 1 785 | 148 | 508 |
| | | (51) | (47) | (76) | (46) | (94) | (50) | (41) | (54) |
| 8 | 82 | 18 | 68 | 97 | 42 | 0 | 366 | 15 | 0 |
| | (79) | (75) | (57) | (100) | (57) | | (48) | (100) | |
| 9 | 613 | 1 | 302 | 296 | 51 | 0 | 1 016 | 3 | 0 |
| | (56) | (69) | (20) | (73) | (21) | | (39) | (100) | |
| 10 | 920 | 39 | 820 | 532 | 41 | 21 | 1 712 | 0 | 3 |
| | (25) | (37) | (56) | (34) | (18) | (52) | (25) | | (51) |
| 11 | 1 243 | 164 | 5 527 | 246 | 118 | 36 | 1 600 | 0 | 9 |
| | (48) | (86) | (74) | (42) | (55) | (60) | (39) | | (59) |
| 12 | 0 | 0 | 64 | 62 | 20 | 6 | 221 | 0 | 1 |
| | | | (37) | (57) | (20) | (90) | (95) | | (100) |
| 13 | 106 | 46 | 764 | 54 | 16 | 160 | 192 | 34 | 0 |
| | (21) | (73) | (80) | (29) | (79) | (6) | (18) | (35) | |
| 14 | 121 | 106 | 9 | 1 | 3 | 0 | 0 | 0 | 0 |
| | (27) | (98) | (29) | (80) | (55) | | | | |
| 15 | 112 | 3 | 89 | 0 | 5 | 0 | 1 | 0 | 0 |
| | (92) | (97) | (59) | (71) | (47) | | (100) | | |
| 16 | 107 | 9 | 39 | 1 | 5 | * | 1 | 0 | 0 |
| | (66) | (58) | (35) | (94) | (66) | (100) | (100) | | |
| 17 | 899 | 3 | 58 | 6 | 11 | 7 | 6 | 0 | 0 |
| | (94) | (100) | (55) | (84) | (80) | (78) | (100) | | |
| 18 | 0 | 48 | 260 | 0 | 0 | 0 | 98 | 0 | 181 |
| | | (27) | (48) | | | | (50) | | (51) |
| 19 | 0 | 5 | 1 288 | 0 | 0 | 7 | 3 633 | 488 | 203 |
| | | (100) | (30) | | | (87) | (80) | (55) | (51) |
| 20 | 0 | 9 | 320 | 0 | 0 | 0 | 74 | 332 | 192 |
| | | (47) | (37) | | | | (57) | (38) | (82) |
| 21 | 0 | 5 | 46 | 0 | 0 | 78 | 2 | 5 | 19 |
| | | (85) | (14) | | | (100) | (24) | (17) | (23) |

**Table 5–*continued***

| Stratum | HAP | HOK | LEA | LIN | NOS | RSK | SCH | SPO | SSK | Other species SWA | WAR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 0 | * | 53 | 18 | 63 | 1 | 0 | 24 | 0 | 14 |
| | (100) | | (43) | (53) | (35) | (35) | (100) | | (86) | (100) | (100) |
| 2 | 0 | 0 | 5 | 12 | 16 | 188 | 2 | 1 | 10 | 0 | 34 |
| | | | (100) | (96) | (66) | (52) | (100) | (100) | (100) | (100) | (69) |
| 3 | 22 | 0 | * | 6 | 38 | 110 | 154 | 42 | 183 | 3 | 14 |
| | (44) | | (70) | (85) | (28) | (78) | (58) | (44) | (46) | (46) | (67) |
| 4 | 87 | 0 | 15 | 7 | 55 | 118 | 12 | 34 | 87 | 10 | 12 |
| | (72) | | (70) | (65) | (34) | (33) | (54) | (58) | (76) | (31) | (38) |
| 5 | 19 | 0 | 0 | 0 | 37 | 49 | 7 | 41 | 30 | 4 | 1 |
| | (76) | | | | (30) | (66) | (73) | (100) | (99) | (65) | (68) |
| 6 | 20 | 0 | 0 | 0 | 91 | 189 | 127 | 2 | 34 | 3 | 1114 |
| | (34) | | | | (44) | (61) | (24) | (100) | (73) | (51) | (100) |
| 7 | 7 | 0 | 75 | 2 | 30 | 90 | 68 | 4 | 27 | 32 | 161 |
| | (33) | | (54) | (56) | (25) | (41) | (43) | (53) | (56) | (47) | (71) |
| 8 | 12 | 0 | 0 | 10 | 12 | 32 | 5 | 0 | 47 | 1 | 37 |
| | (100) | | | (64) | (47) | (100) | (55) | | (53) | (100) | (77) |
| 9 | 9 | 0 | 0 | 5 | 40 | 0 | 24 | 1 | 68 | 1 | 0 |
| | (49) | | | (88) | (19) | | (48) | (100) | (73) | (53) | |
| 10 | 17 | 0 | 0 | 8 | 24 | 2 | 1 | 7 | 25 | 11 | 8 |
| | (57) | | | (34) | (39) | (100) | (100) | (72) | (45) | (44) | (78) |
| 11 | 36 | 0 | 0 | 45 | 15 | 4 | 7 | 0 | 99 | 14 | 1 |
| | (25) | | | (85) | (33) | (100) | (73) | | (52) | (52) | (100) |
| 12 | 10 | 0 | 0 | 0 | 19 | 18 | 3 | 0 | 30 | 24 | 0 |
| | (34) | | | | (75) | (4) | (100) | | (50) | (52) | |
| 13 | 0 | 0 | 0 | 0 | 77 | 0 | 126 | 0 | 0 | 125 | 22 |
| | | | | | (70) | | (47) | | | (98) | (100) |
| 14 | 2 | 1 | 0 | 9 | 109 | 0 | 0 | 0 | 0 | 2 | 0 |
| | (100) | (100) | | (77) | (59) | (100) | | | | (60) | |
| 15 | 0 | 0 | 0 | 45 | 235 | 3 | 0 | 0 | 32 | 10 | 0 |
| | | (100) | | (86) | (34) | (58) | | | (55) | (58) | |
| 16 | 3 | 74 | 0 | 25 | 245 | 9 | 0 | 0 | 8 | 201 | 0 |
| | (100) | (96) | | (80) | (92) | (100) | | | (89) | (74) | |
| 17 | 3 | 59 | 0 | 56 | 181 | 4 | 0 | 0 | 1 | 2 | 0 |
| | (100) | (72) | | (67) | (67) | (51) | | | (100) | (73) | |
| 18 | 7 | 0 | 0 | 0 | 8 | 9 | 2 | 53 | 0 | 4 | |
| | (56) | | | | (78) | (54) | (51) | (50) | | (75) | 27 |
| 19 | 0 | 0 | 513 | 0 | 47 | 163 | 9 | 5 | 0 | * | (73) |
| | | | (49) | | (24) | (21) | (50) | (100) | | (100) | 6 |
| 20 | 0 | 0 | 13 | 0 | 2 | 96 | 2 | 1 | 0 | 1 | (37) |
| | | | (95) | | (100) | (56) | (77) | (100) | | (71) | 31 |
| 21 | 2 | 0 | 705 | 0 | 480 | 114 | 0 | 0 | 0 | 0 | (72) |
| | (100) | | (99) | | (100) | (46) | | | | | 0 |

**Table 6: Number of biological, length frequency, and tagging 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, spines.**

| | Length frequency data | | | Biological data+ | | | Tagging | |
|---|---|---|---|---|---|---|---|---|
| Species code | Measurement method | No. of samples | No. of fish | No. of samples | No. of fish | No. of otoliths or spines | No. of fish | Size range (cm) |
| BAR | 1 | 100 | 7 764 | | | | | |
| BCO | 2 | 21 | 170 | | | | | |
| BRA | 5 | 1 | 1 | 1 | 1 | | | |
| BRI | 2 | 1 | 7 | | | | | |
| BYS | 1 | 1 | 1 | | | | | |
| ELE | 1 | 43 | 1 126 | | | | | |
| EMA | 1 | 1 | 1 | | | | | |
| ESO | 2 | 13 | 58 | | | | | |
| GFL | 2 | 1 | 3 | | | | | |
| GSH | G | 47 | 2 849 | 42 | 1 821 | 418 | | |
| GUR | 2 | 64 | 2 235 | 1 | 14 | | | |
| HAK | 2 | 3 | 18 | | | | | |
| HAP | 2 | 50 | 123 | | | | | |
| HOK | 2 | 7 | 417 | | | | | |
| JDO | 2 | 2 | 2 | | | | | |
| JMD | 1 | 21 | 50 | | | | | |
| JMM | 1 | 9 | 14 | | | | | |
| JMN | 1 | 4 | 9 | | | | | |
| KAH | 1 | 1 | 1 | | | | | |
| KIN | 1 | 1 | 1 | | | | | |
| LDO | 2 | 6 | 88 | | | | | |
| LEA | 2 | 14 | 1 060 | | | | | |
| LIN | 2 | 40 | 423 | 1 | 28 | | | |
| LSO | 2 | 42 | 427 | | | | | |
| MDO | 2 | 1 | 1 | | | | | |
| MOK | 1 | 6 | 6 | | | | | |
| RCO | 2 | 76 | 1 830 | 65 | 1 245 | 428 | | |
| RSK | 5 | 60 | 535 | 60 | 479 | | 356 | 21–70 |
| SCH | 2 | 48 | 308 | 47 | 307 | | 171 | 34–157 |
| SCI | B | 1 | 5 | 1 | 5 | | | |
| SFL | 2 | 12 | 98 | | | | | |
| SPD | 2 | 105 | 7 830 | 76 | 3 440 | 423 | | |
| SPE | 2 | 61 | 3 534 | 53 | 1 945 | 259 | | |
| SPO | 2 | 24 | 115 | 22 | 113 | | 39 | 53–96 |
| SPZ | 2 | 1 | 3 | | | | | |
| SSK | 5 | 47 | 300 | 47 | 299 | | 186 | 15–123 |
| STA | 2 | 80 | 867 | 80 | 867 | 420 | 344 | 18–78 |
| SWA | 1 | 70 | 1 112 | | | | | |
| TAR | 1 | 66 | 3 521 | 49 | 1 764 | 241 | | |
| TRU | 1 | 1 | 1 | | | | | |
| TUR | 2 | 1 | 1 | | | | | |
| WAR | 1 | 41 | 859 | | | | | |
| WWA | 1 | 2 | 6 | | | | | |
| Total | | | 37 780 | | 12 328 | | 1 096 | |

**Table 7: Gonad stages of finfish target species.**

| Species | Sex | No. of fish | Gonad state 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|---|
| 30–400 m | | | | | | | |
| Giant stargazer | Males | 150 | 95 | 36 | 11 | 3 | 5 |
| | Females | 213 | 190 | 13 | 8 | 1 | 1 |
| Red cod | Males | 283 | 191 | 64 | 1 | 4 | 23 |
| | Females | 310 | 179 | 130 | 1 | – | – |
| Sea perch | Males | 383 | 54 | 196 | 93 | 31 | 9 |
| | Females | 267 | 193 | 40 | 7 | 2 | 25 |
| Tarakihi | Males | 320 | 300 | 13 | 1 | – | 6 |
| | Females | 376 | 333 | 23 | – | – | 20 |
| 10–30 m | | | | | | | |
| Red cod | Males | 2 | 2 | – | – | – | – |
| | Females | 15 | 10 | 5 | – | – | – |

Gonad stage for males and females: stage 1– immature/resting; 2– maturing; 3– ripening; 4– running ripe; 5– spent

**Table 8: Estimated biomass (t), coefficient of variation (c.v.), for the target species (bold) and major commercial species for each ECSI winter survey. Biomass estimates for 1991 have been adjusted to allow for non-sampled strata (7 & 9). * Rough and smooth skates not separated, combined biomass = 1 993 t (c.v. 25%).**

| | 1991 | | 1992 | | 1993 | | 1994 | | 1996 | | 2007 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Biomass | c.v. (%) | Biomass | c.v. (%) | Biomass | c.v. (%) | Biomass | c.v. (%) | Biomass | c.v. (%) | Biomass | c.v. (%) |
| **Dark ghost shark** | 962 | 42 | 934 | 44 | 2 911 | 42 | 2 702 | 25 | 3 176 | 23 | 4 483 | 25 |
| **Giant stargazer** | 672 | 17 | 669 | 16 | 609 | 14 | 439 | 17 | 465 | 11 | 755 | 18 |
| **Red cod** | 3 760 | 33 | 4 527 | 40 | 5 601 | 30 | 5 637 | 35 | 4 619 | 30 | 1 486 | 25 |
| **Sea perch** | 1 716 | 30 | 1 934 | 28 | 2 948 | 32 | 2 342 | 29 | 1 671 | 25 | 1 954 | 22 |
| **Spiny dogfish** | 12 873 | 22 | 10 787 | 26 | 13 949 | 17 | 14 530 | 10 | 35 169 | 15 | 35 386 | 27 |
| **Tarakihi** | 1 712 | 33 | 932 | 26 | 3 805 | 55 | 1 219 | 31 | 1 656 | 24 | 2 589 | 24 |
| Arrow squid | 443 | 22 | 1 303 | 32 | 1 062 | 17 | 1 421 | 25 | 1 204 | 30 | 1 242 | 23 |
| Barracouta | 8 361 | 29 | 11 672 | 23 | 18 197 | 22 | 6 965 | 34 | 16 848 | 19 | 21 132 | 17 |
| Blue warehou | 104 | 90 | 116 | 43 | 50 | 39 | 165 | 78 | 238 | 64 | 1 418 | 79 |
| Chilean jack mackerel | 47 | 26 | 200 | 31 | 225 | 28 | 155 | 38 | 1 585 | 34 | 18 | 37 |
| Elephantfish | 300 | 40 | 176 | 32 | 481 | 33 | 164 | 32 | 858 | 30 | 1 034 | 32 |
| Hapuku | 186 | 24 | 104 | 35 | 177 | 31 | 54 | 32 | 102 | 19 | 248 | 28 |
| Hoki | 61 | 93 | 108 | 75 | 413 | 32 | 125 | 49 | 460 | 32 | 134 | 62 |
| Leatherjacket | 44 | 57 | 14 | 76 | 7 | 58 | 29 | 60 | 10 | 58 | 96 | 44 |
| Ling | 1009 | 35 | 525 | 17 | 651 | 27 | 488 | 19 | 488 | 21 | 283 | 27 |
| Red gurnard | 763 | 40 | 142 | 30 | 576 | 31 | 123 | 34 | 505 | 27 | 1 453 | 35 |
| Rig | 175 | 30 | 66 | 18 | 67 | 30 | 54 | 29 | 63 | 37 | 134 | 37 |
| Rough skate | * | * | 224 | 24 | 335 | 21 | 517 | 20 | 177 | 19 | 878 | 22 |
| School shark | 100 | 30 | 104 | 21 | 369 | 42 | 155 | 36 | 202 | 18 | 538 | 22 |
| Silver warehou | 29 | 21 | 32 | 22 | 256 | 44 | 35 | 28 | 231 | 32 | 445 | 44 |
| Smooth skate | * | * | 605 | 18 | 658 | 25 | 306 | 25 | 385 | 24 | 705 | 20 |

**Table 9: Estimated biomass (t), coefficient of variation (c.v.), of recruited and pre-recruited target species for each ECSI winter surveys. Biomass estimates for 1991 have been adjusted to allow for non-sampled strata (7 & 9). – , not measured.**

| | Recruited length (cm) | 1991 | | 1992 | | 1993 | | 1994 | | 1996 | | 2007 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Biomass | c.v. (%) | Biomass | c.v. (%) | Biomass | c.v. (%) | Biomass | c.v. (%) | Biomass | c.v. (%) | Biomass | c.v. (%) |
| Dark ghost shark | 55 | | | | | | | | | | | | |
| Pre-recruit | | 292 | 68 | 576 | 54 | 1 064 | 40 | 1 314 | 35 | 1 195 | 30 | 1 857 | 46 |
| Recruited | | 668 | 40 | 358 | 31 | 1 808 | 53 | 1 388 | 22 | 1 981 | 23 | 2 626 | 26 |
| Giant stargazer | 30 | | | | | | | | | | | | |
| Pre-recruit | | 26 | 22 | 34 | 14 | 19 | 16 | 10 | 25 | 13 | 34 | 33 | 24 |
| Recruited | | 646 | 17 | 635 | 16 | 590 | 14 | 430 | 17 | 452 | 11 | 722 | 18 |
| Red cod | 40 | | | | | | | | | | | | |
| Pre-recruit | | 1 823 | 45 | 2 089 | 50 | 1 026 | 51 | 3 342 | 40 | 584 | 31 | 190.45 | 33 |
| Recruited | | 2 054 | 37 | 2 438 | 33 | 4 468 | 27 | 2 296 | 36 | 4 036 | 33 | 1 295 | 25 |
| Sea perch | 20 | | | | | | | | | | | | |
| Pre-recruit | | 70 | 44 | 49 | 28 | 178 | 76 | 70 | 24 | 52 | 45 | 73 | 18 |
| Recruited | | 1 483 | 30 | 1 443 | 28 | 2 770 | 30 | 2 272 | 29 | 1 619 | 25 | 1 880 | 22 |
| Spiny dogfish | 50 | | | | | | | | | | | | |
| Pre-recruit | | — | | 300 | 26 | 367 | 71 | 208 | 49 | 3 444 | 23 | 5 830 | 46 |
| Recruited | | | | 9 177 | 31 | 13 098 | 17 | 14 322 | 10 | 31 725 | 16 | 29 555 | 27 |
| Tarakihi | 25 | | | | | | | | | | | | |
| Pre-recruit | | 305 | 38 | 273 | 26 | 2 234 | 62 | 493 | 31 | 519 | 30 | 823 | 30 |
| Recruited | | 1 415 | 33 | 630 | 28 | 1 571 | 47 | 726 | 35 | 1 137 | 27 | 1 766 | 24 |

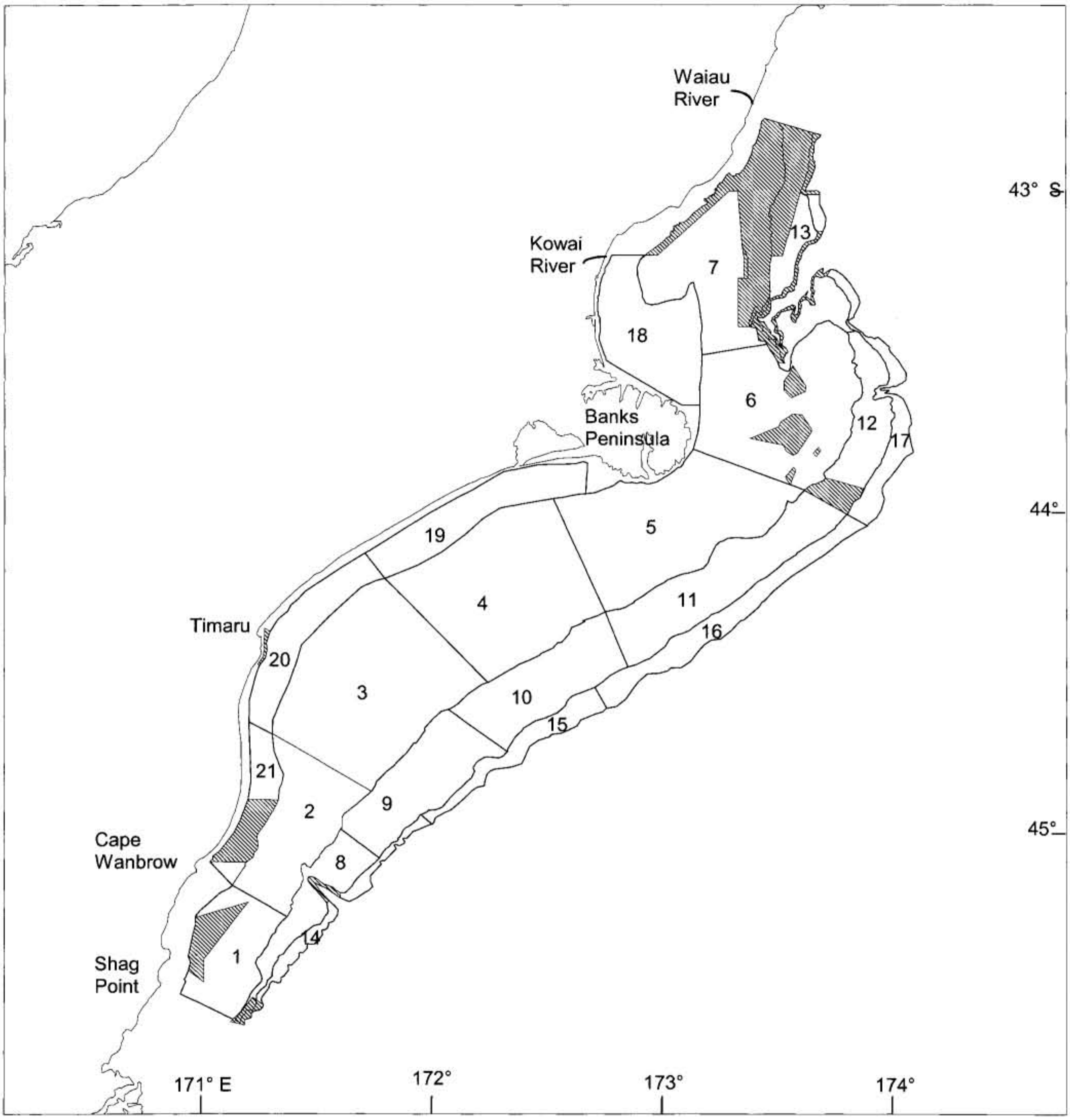



**Figure 1: Strata used in ECSI winter trawl surveys in 2007 (30–400 m, strata 1–17) and shallow strata in 10–30 m (strata18–21). Hashed areas are foul ground.**

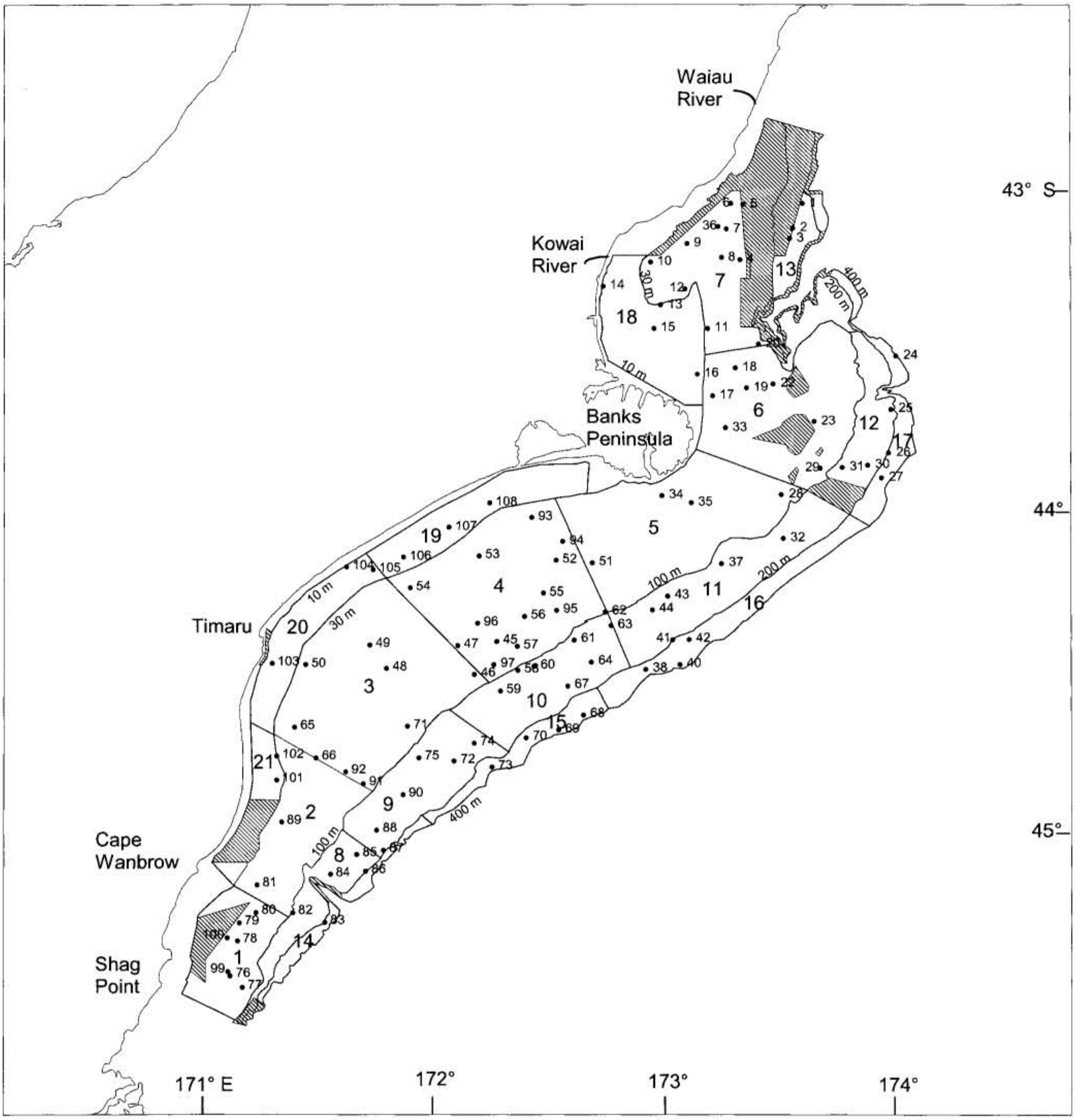



**Figure 2: All tows and tow numbers from the 2007 ECSI survey. Hashed areas are foul ground.**

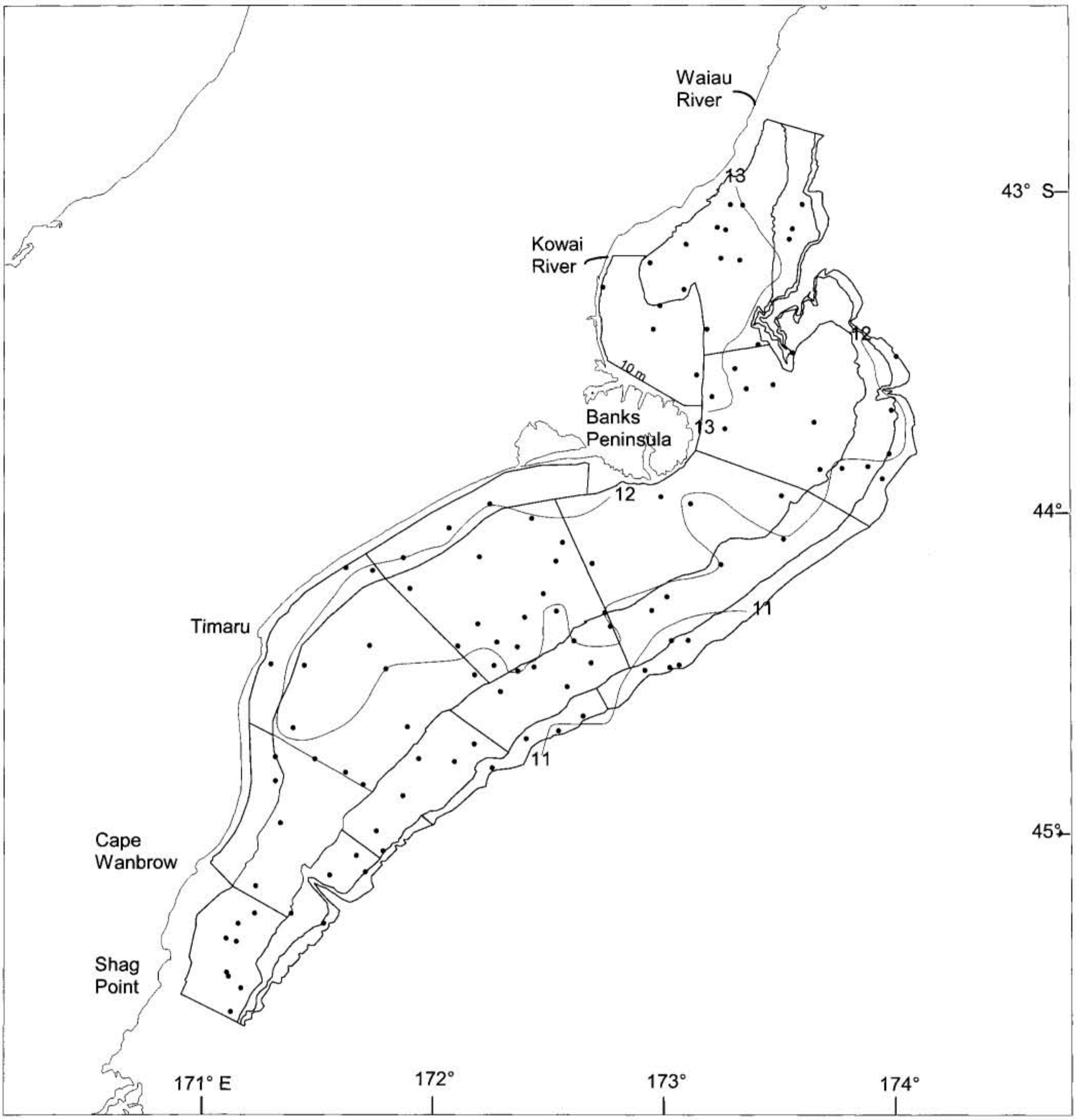



**Figure 3: Positions of CTD surface temperature recordings from *Kaharoa* during the 2007 survey and estimated isotherms.**

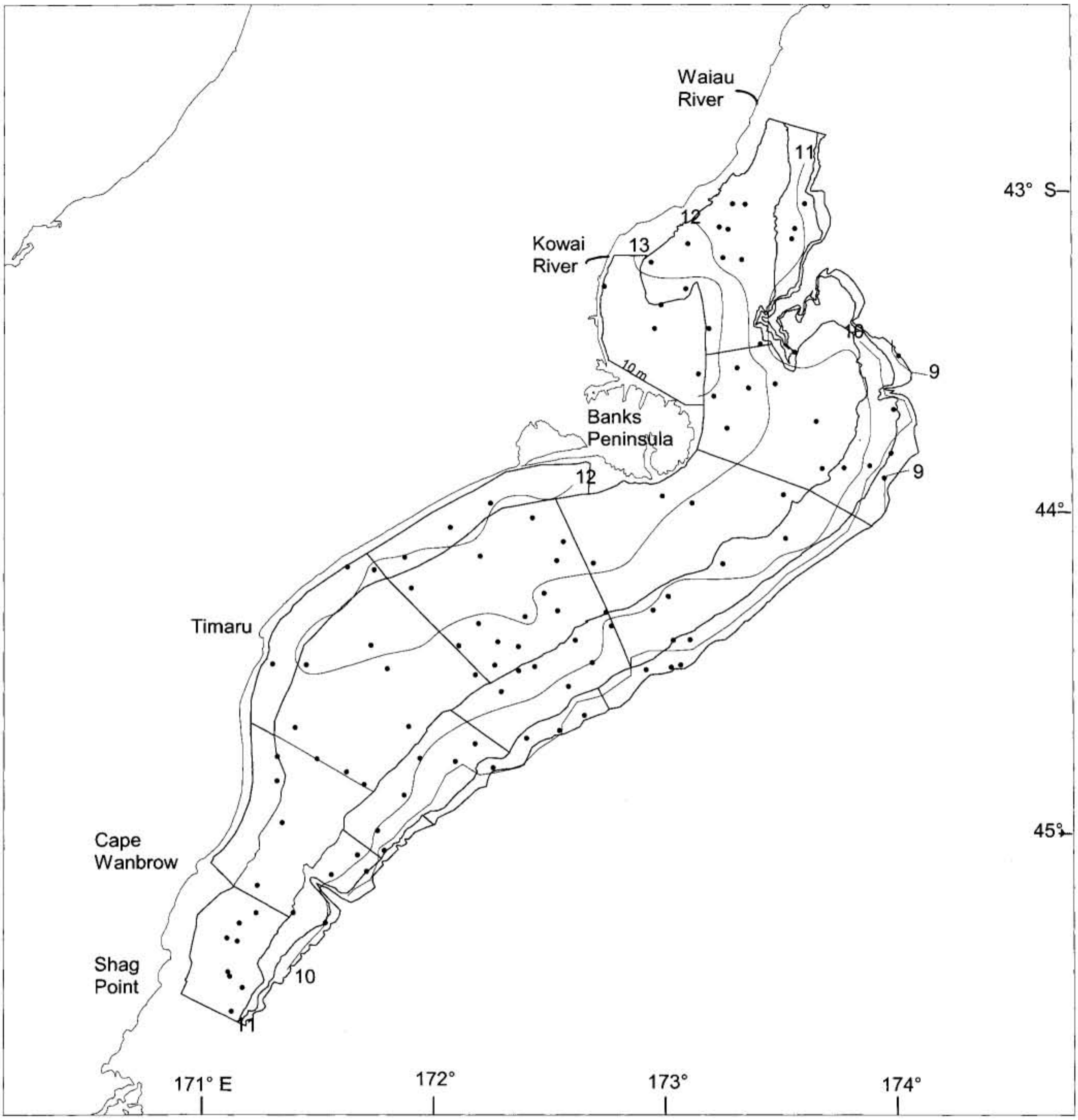



**Figure 4: Positions of CTD bottom temperature recordings from *Kaharoa* during the 2007 survey and estimated isotherms.**

# Dark ghost shark

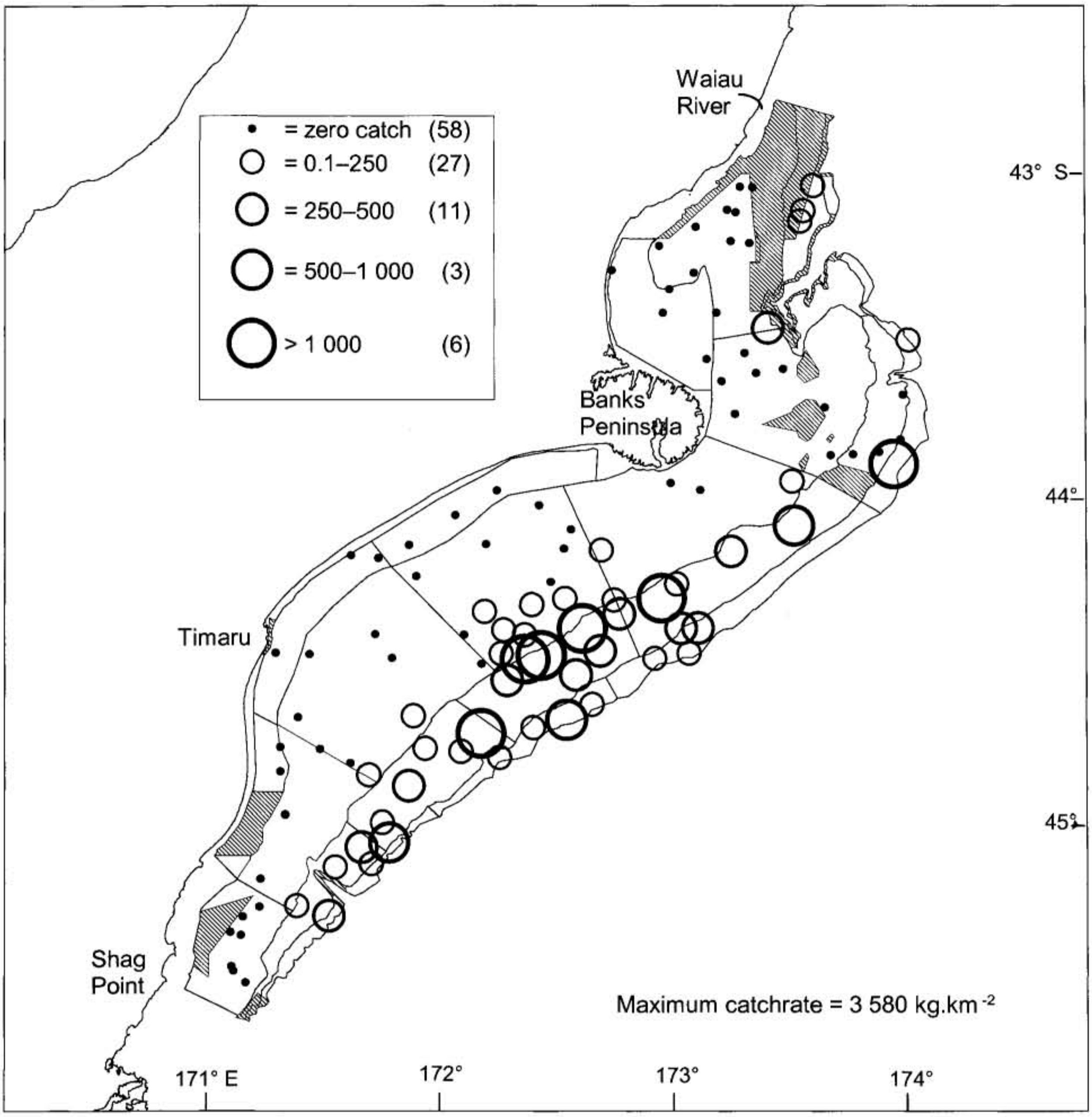



**Figure 5: Catch rates (kg.km$^{-2}$) of target species. Number of stations in parentheses. Hashed areas are foul ground.**

## Giant stargazer

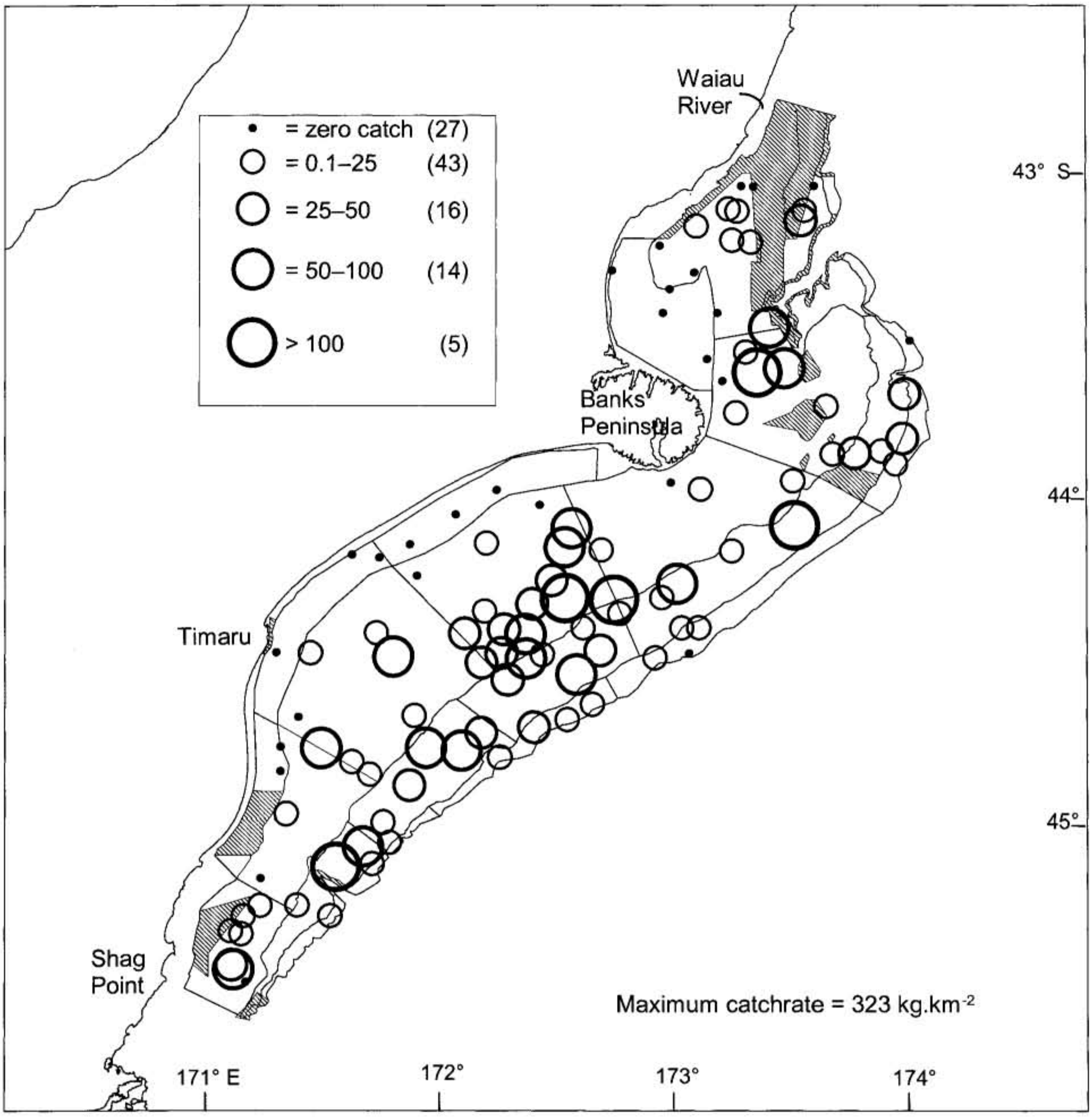



**Figure 5–*continued***

**Red cod**

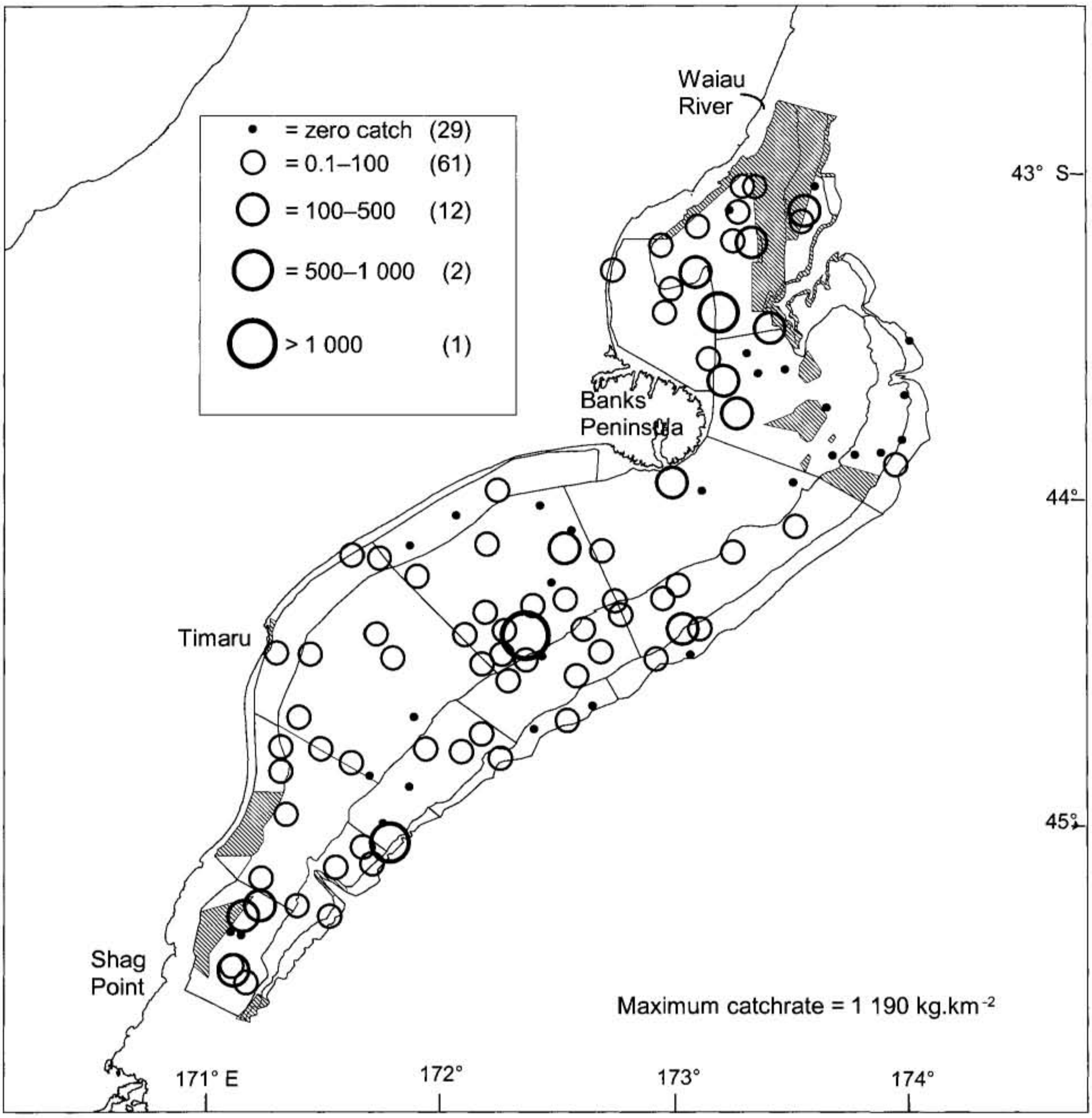



**Figure 5–*continued***

## Sea perch

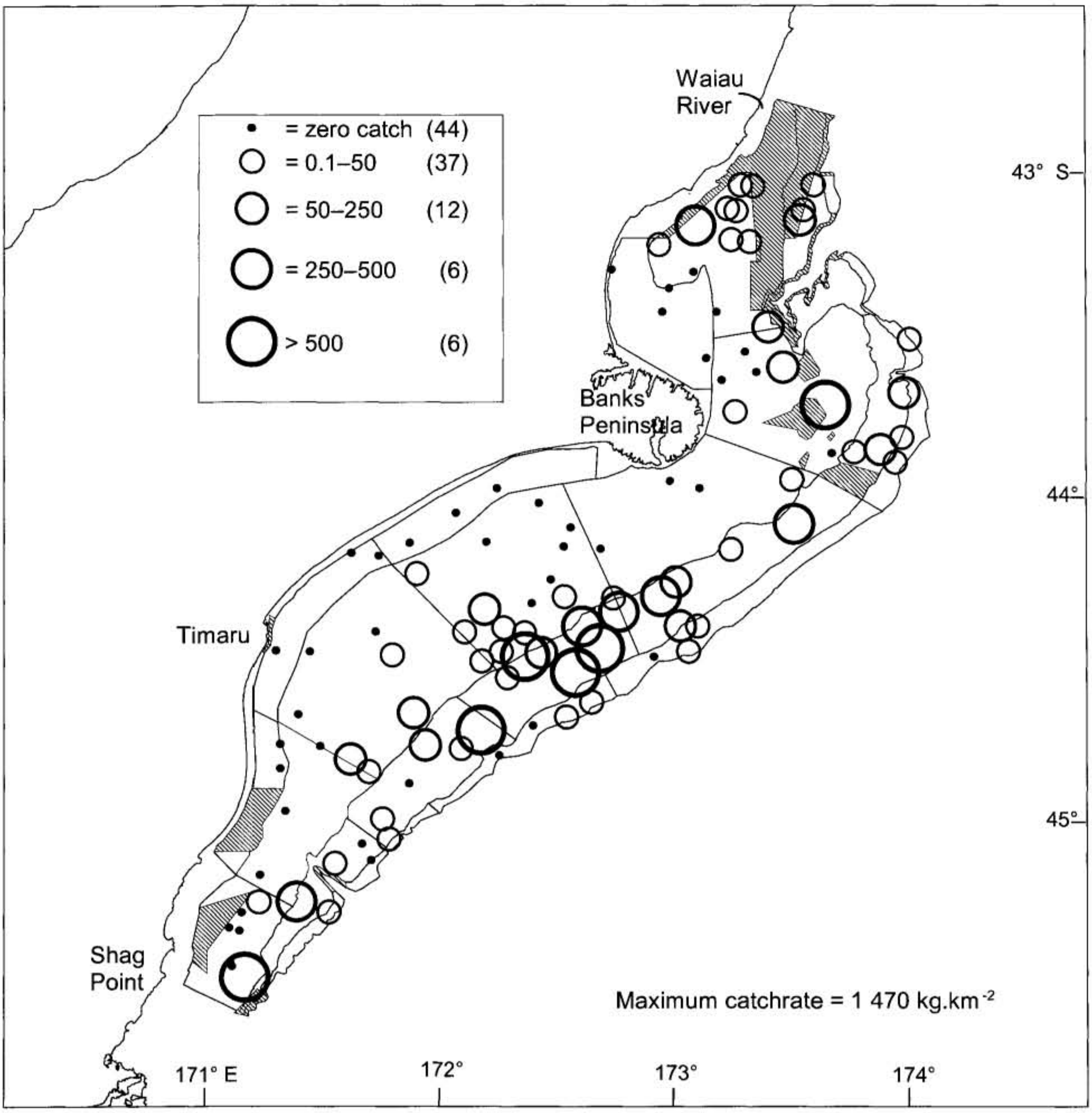



**Figure 5**–*continued*

## Spiny dogfish

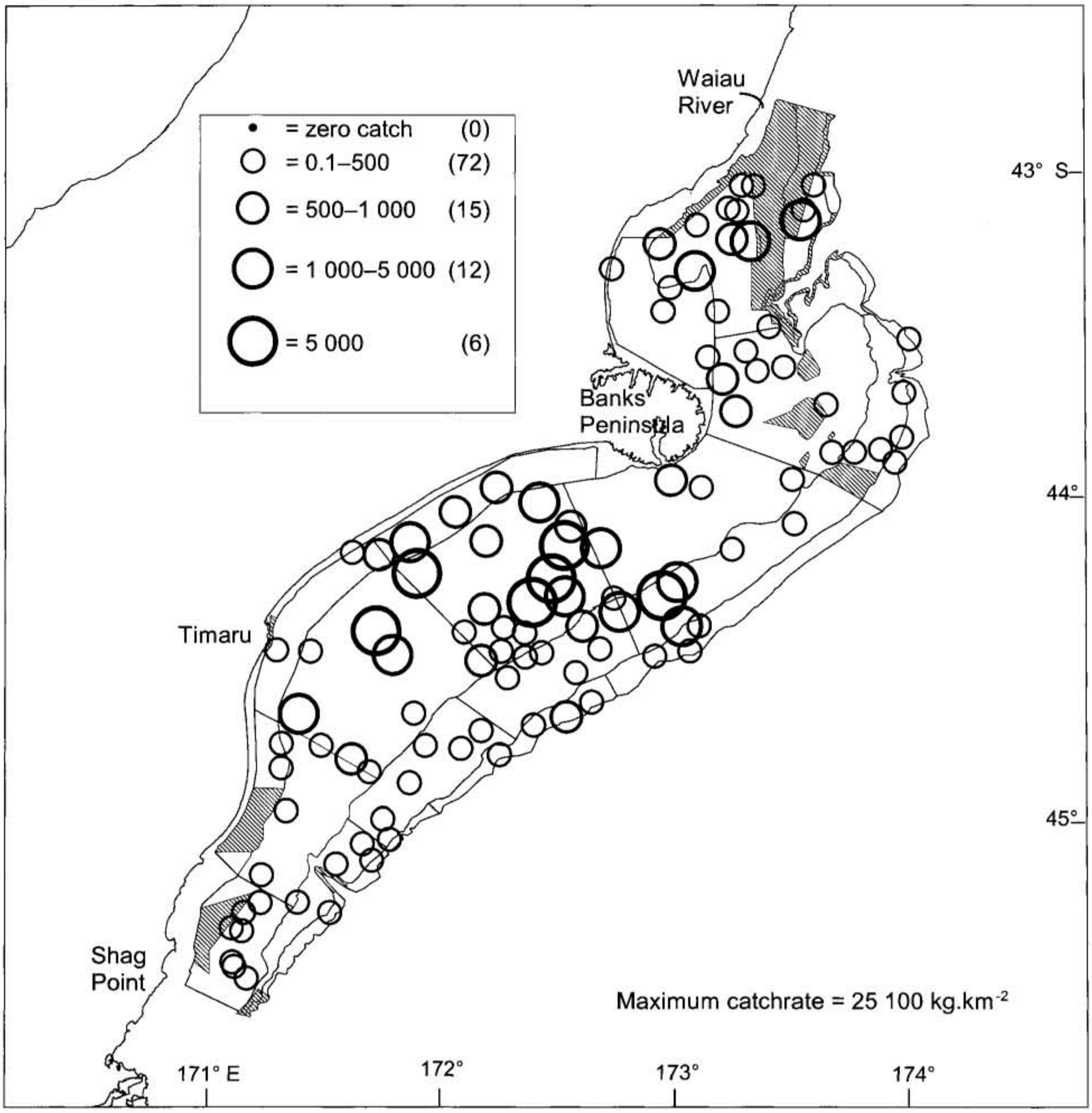



**Figure 5–*continued***

**Tarakihi**

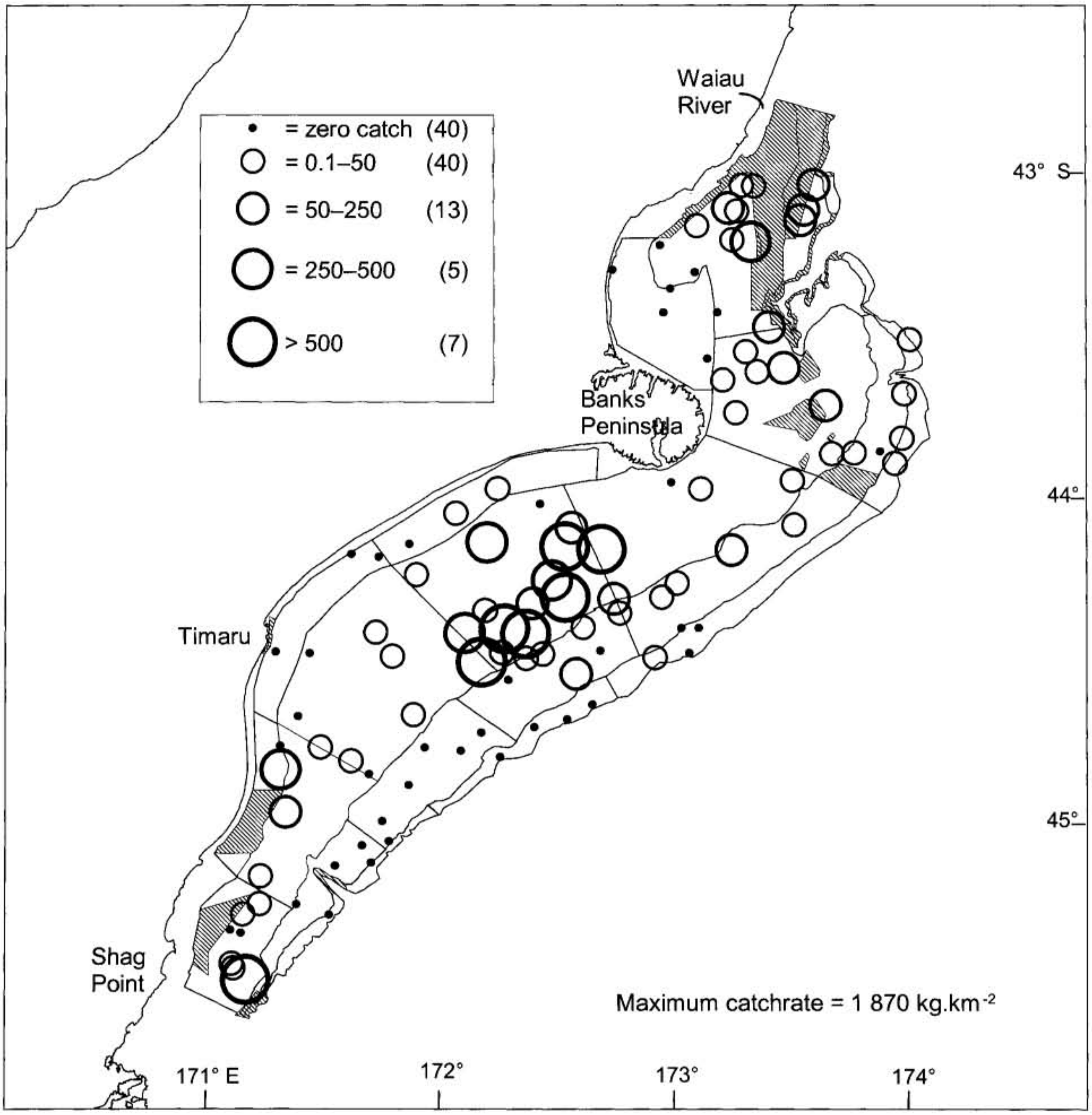
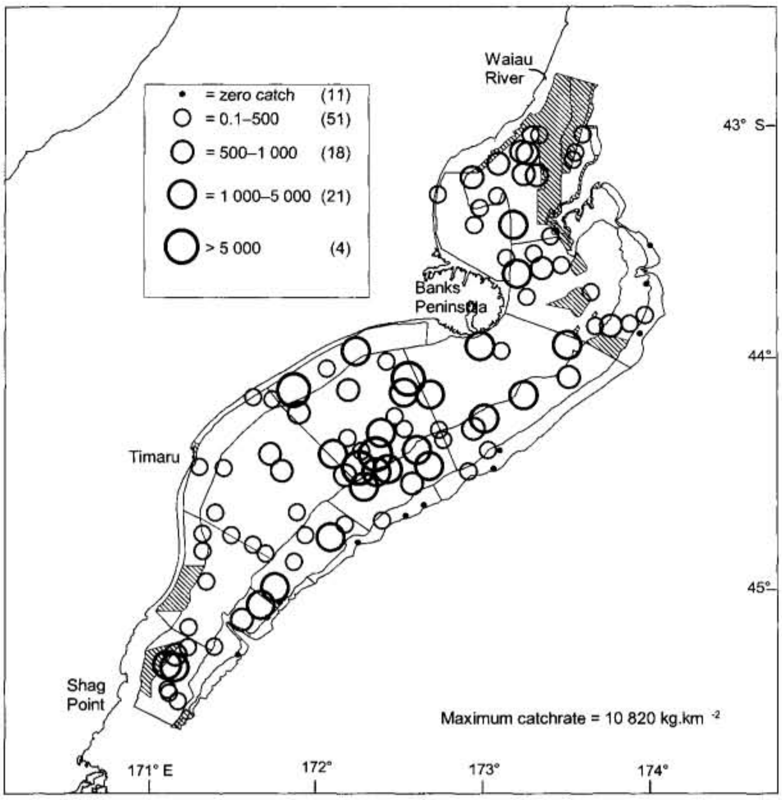



**Figure 5**–*continued*

## Barracouta




## Blue warehou

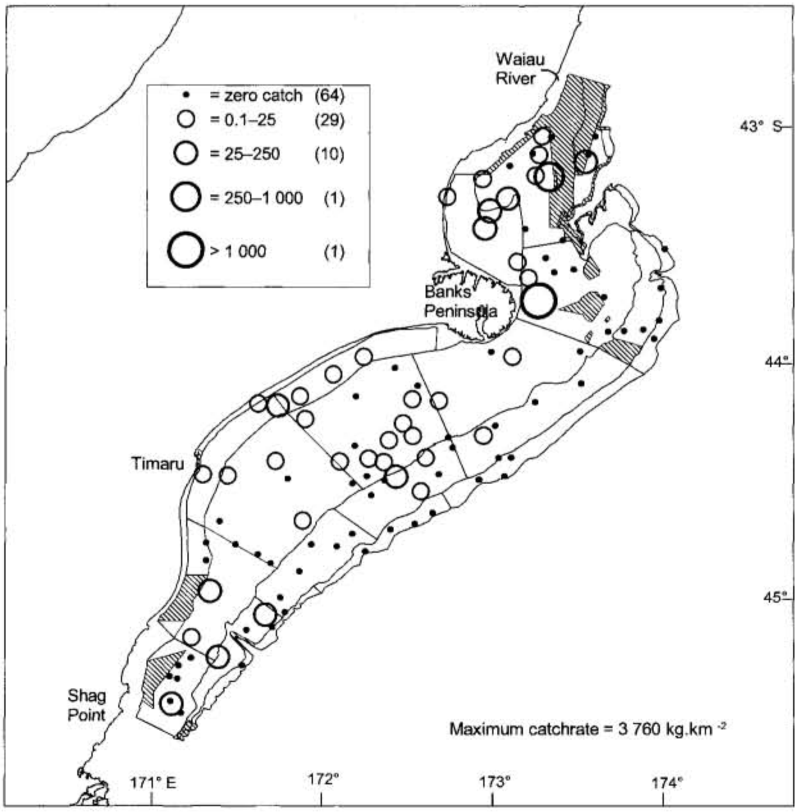
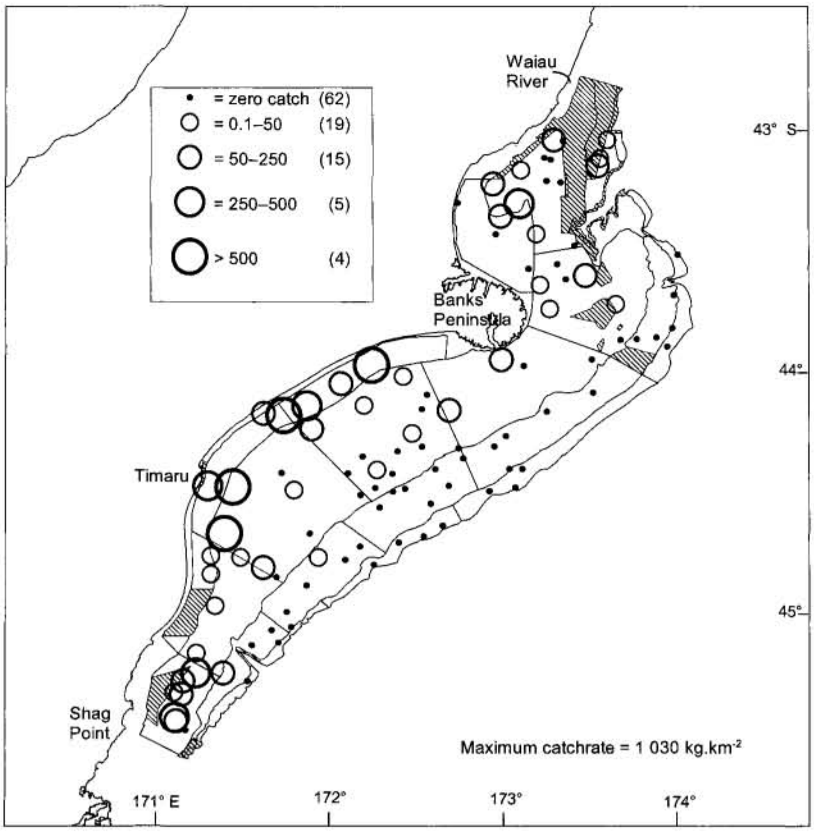



**Figure 6: Catch rates (kg.km$^{-2}$) of non-target species. Number of stations in parentheses. Hashed areas are foul ground.**

## Elephantfish




## Hapuku

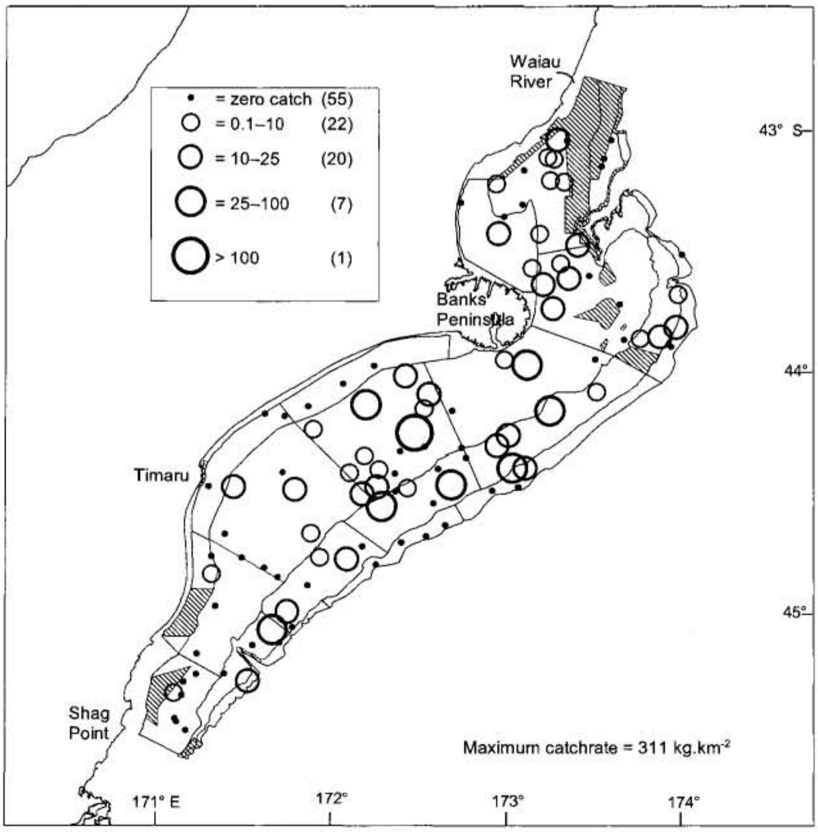
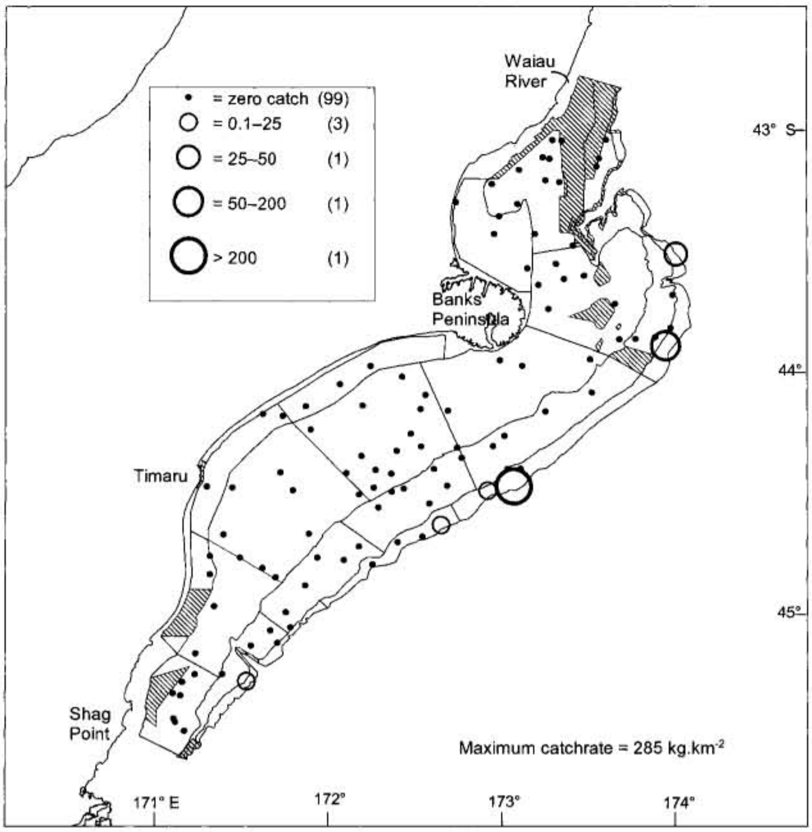



**Figure 6–*continued***

## Hoki




## Leatherjacket

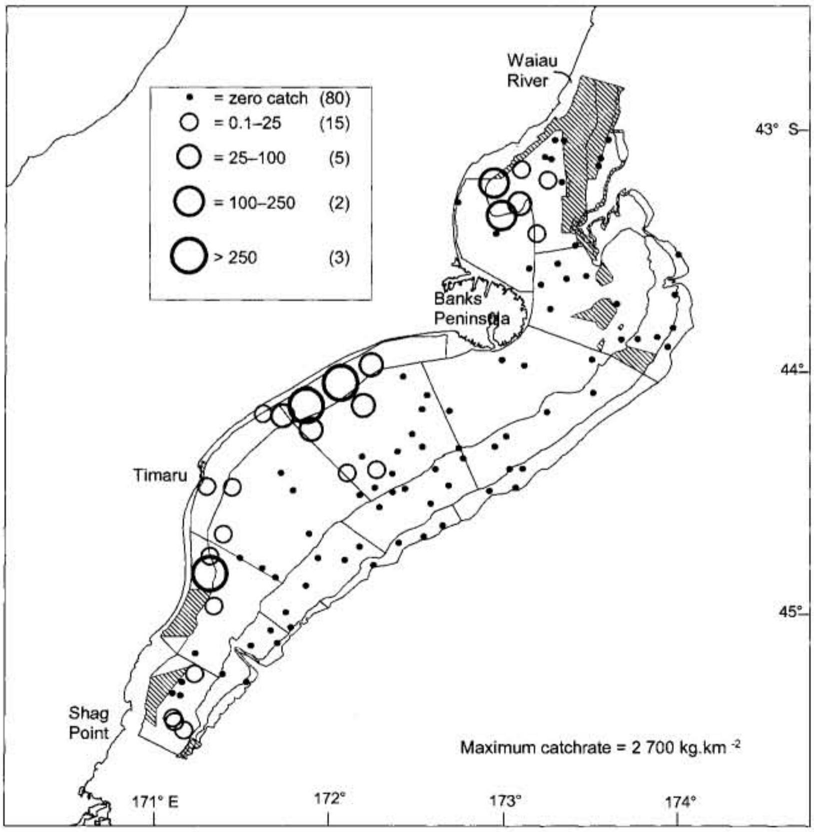
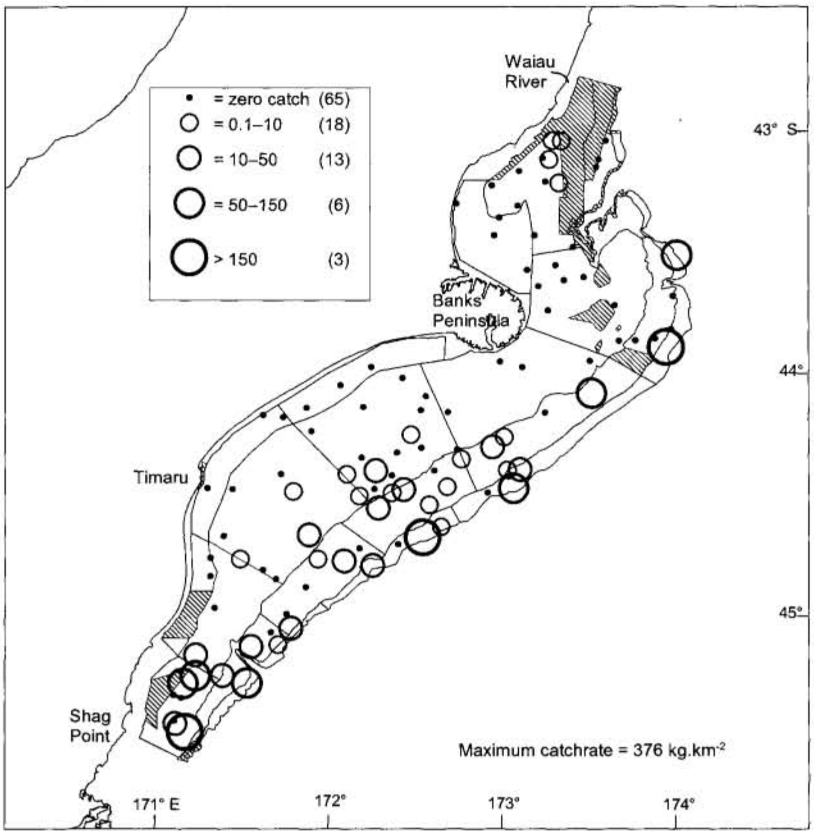



**Figure 6–*continued***

## Ling




## Arrow squid

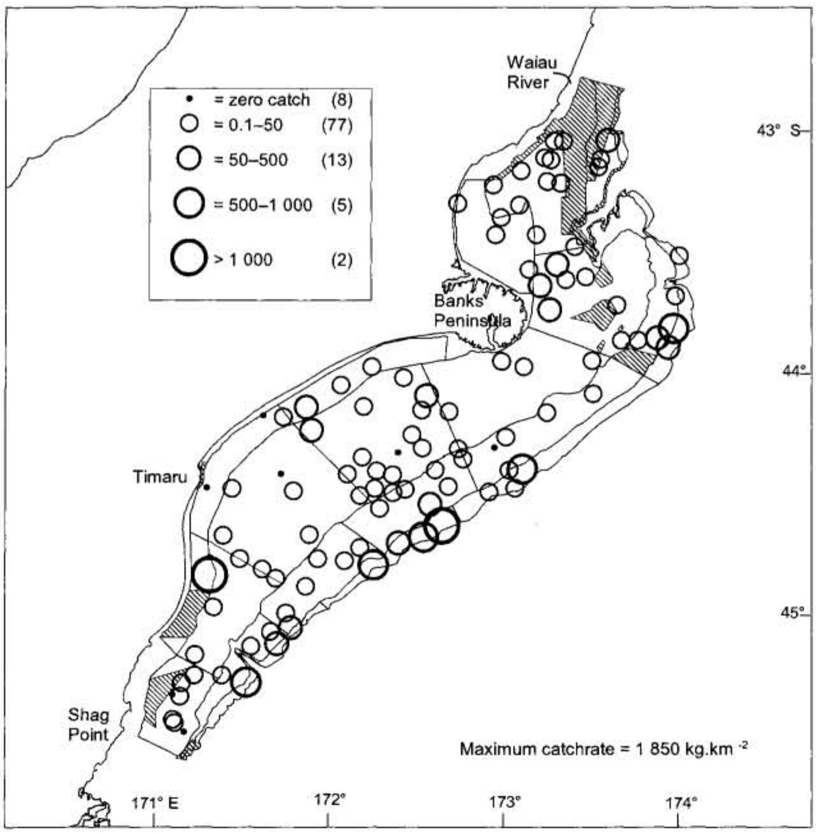
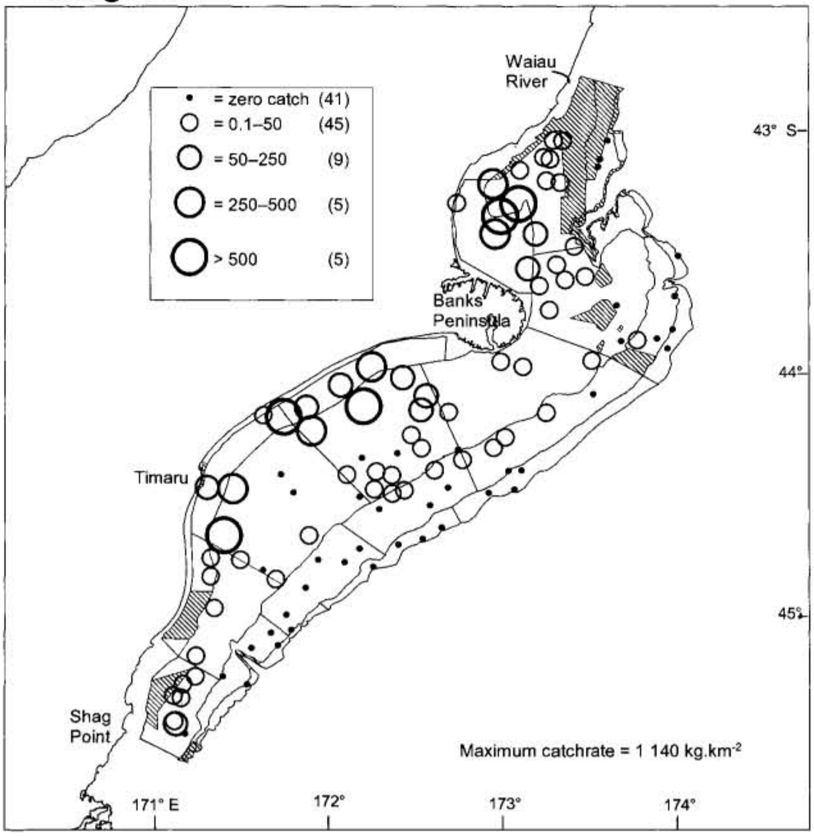



**Figure 6–*continued***

## Red gurnard




## Rig

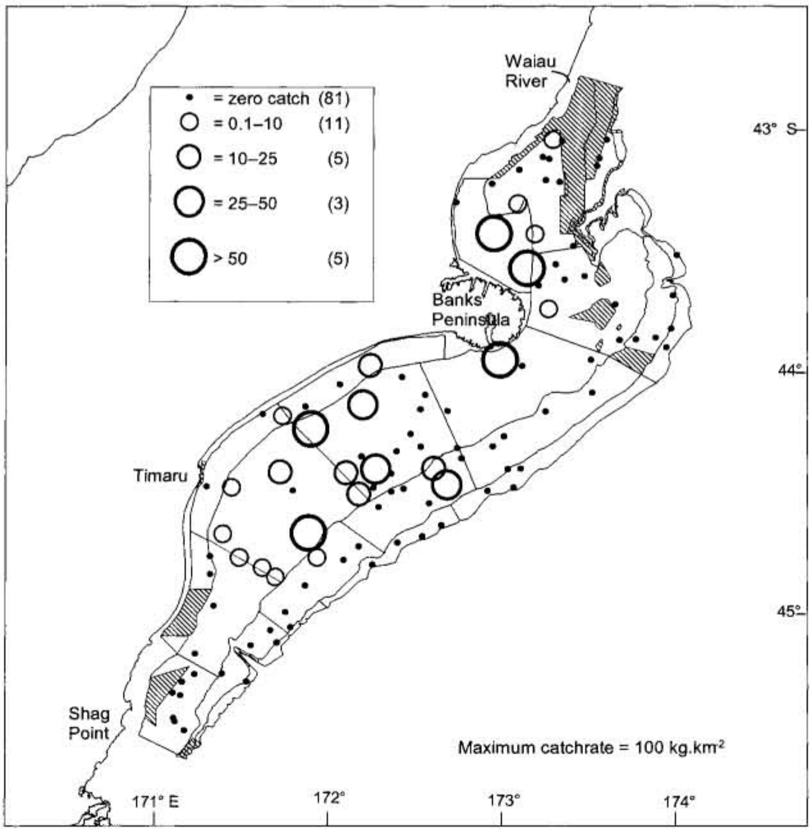
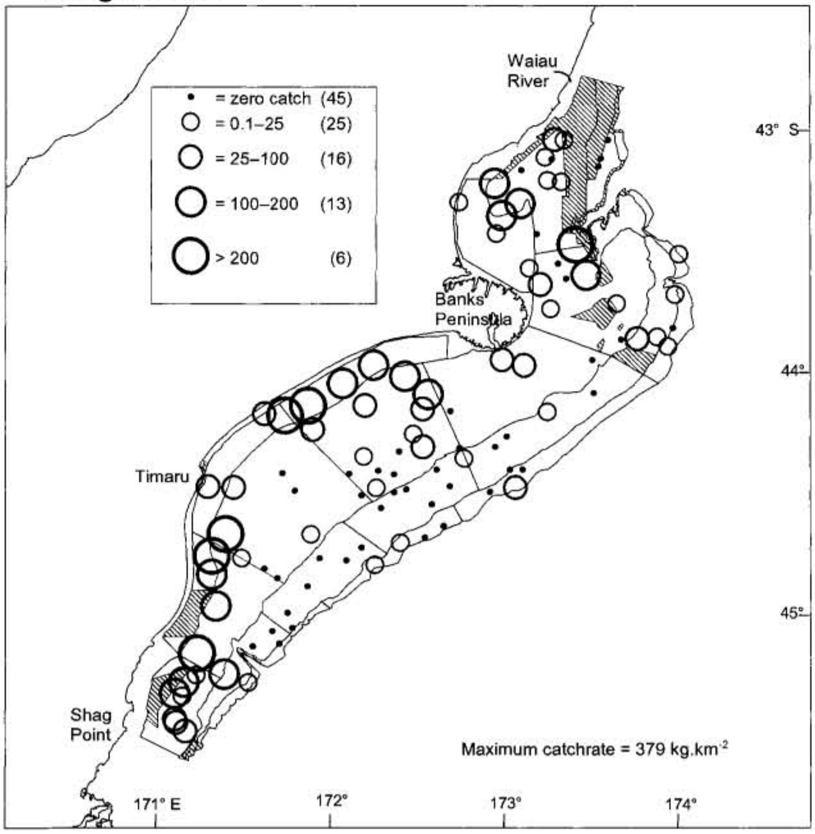



**Figure 6–*continued***

## Rough skate




## School shark

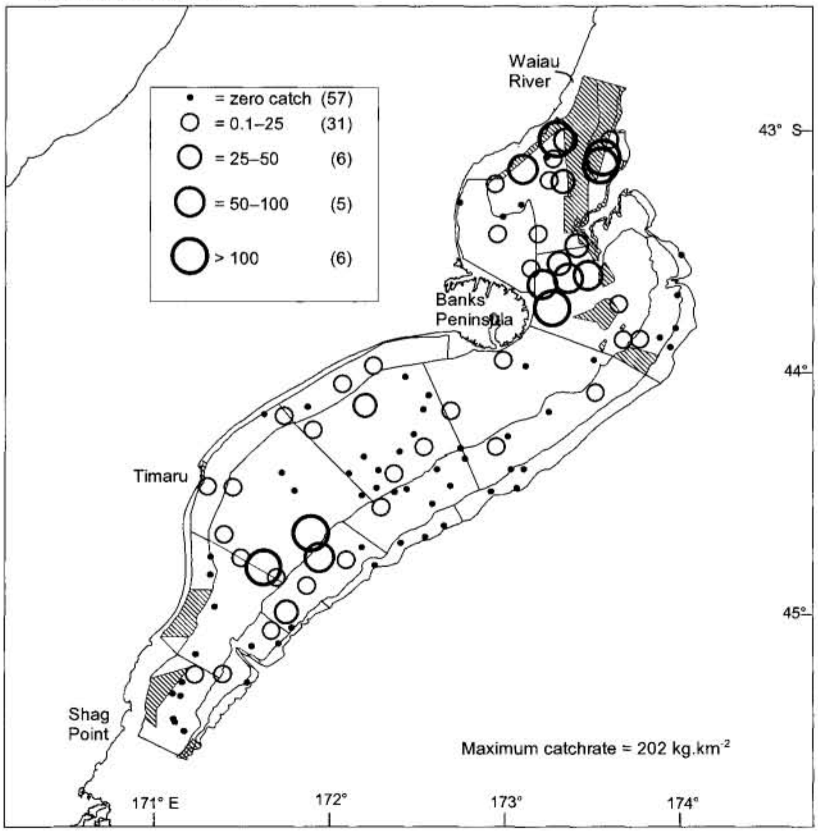
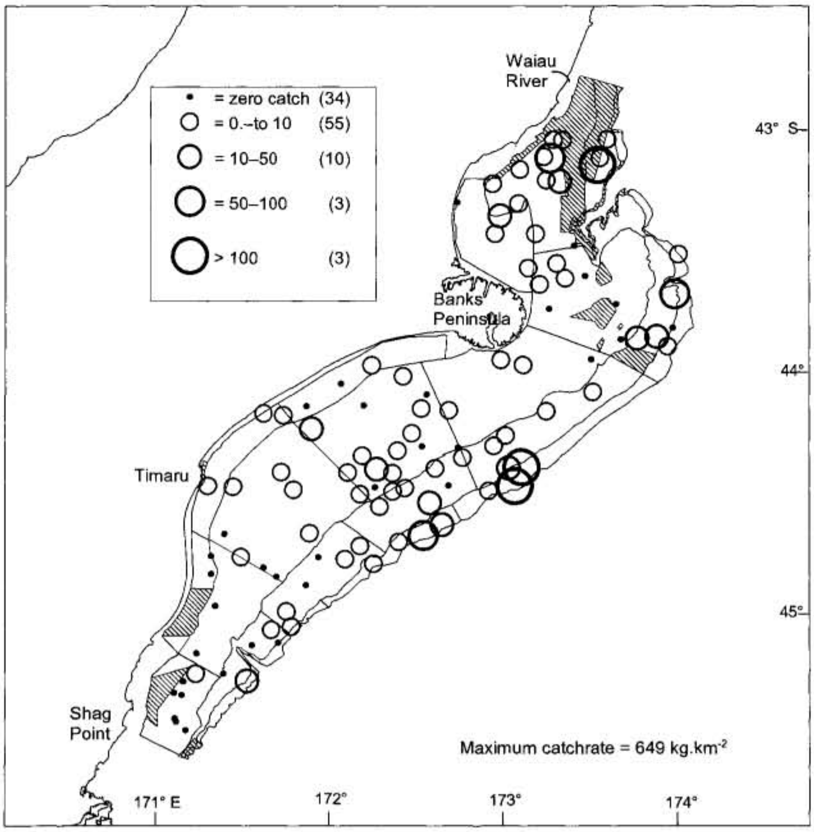



**Figure 6–*continued***

## Silver warehou




## Smooth skate

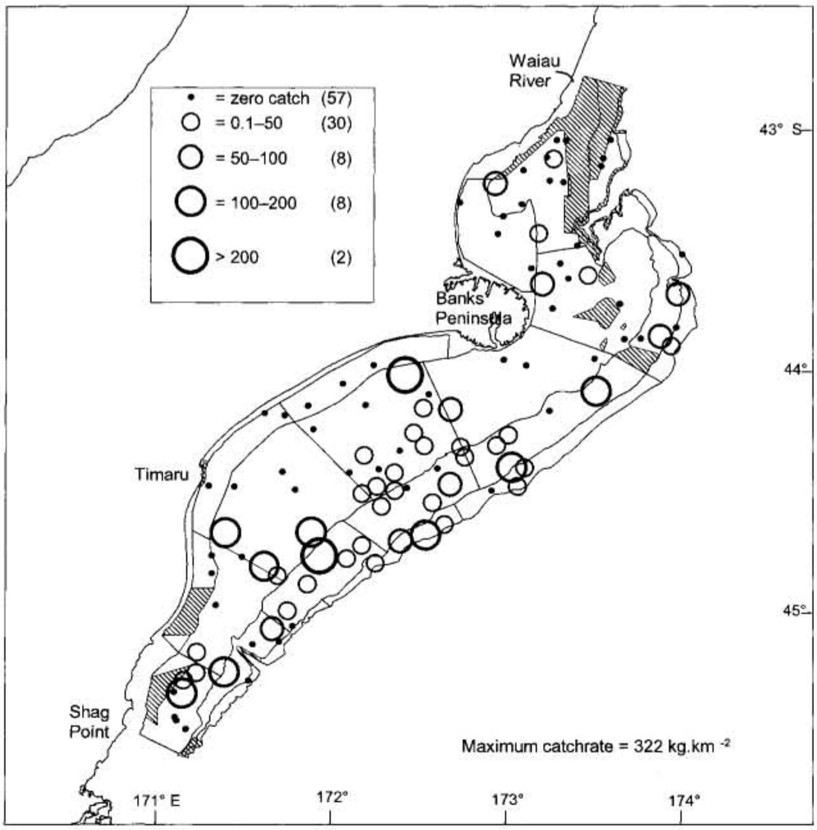
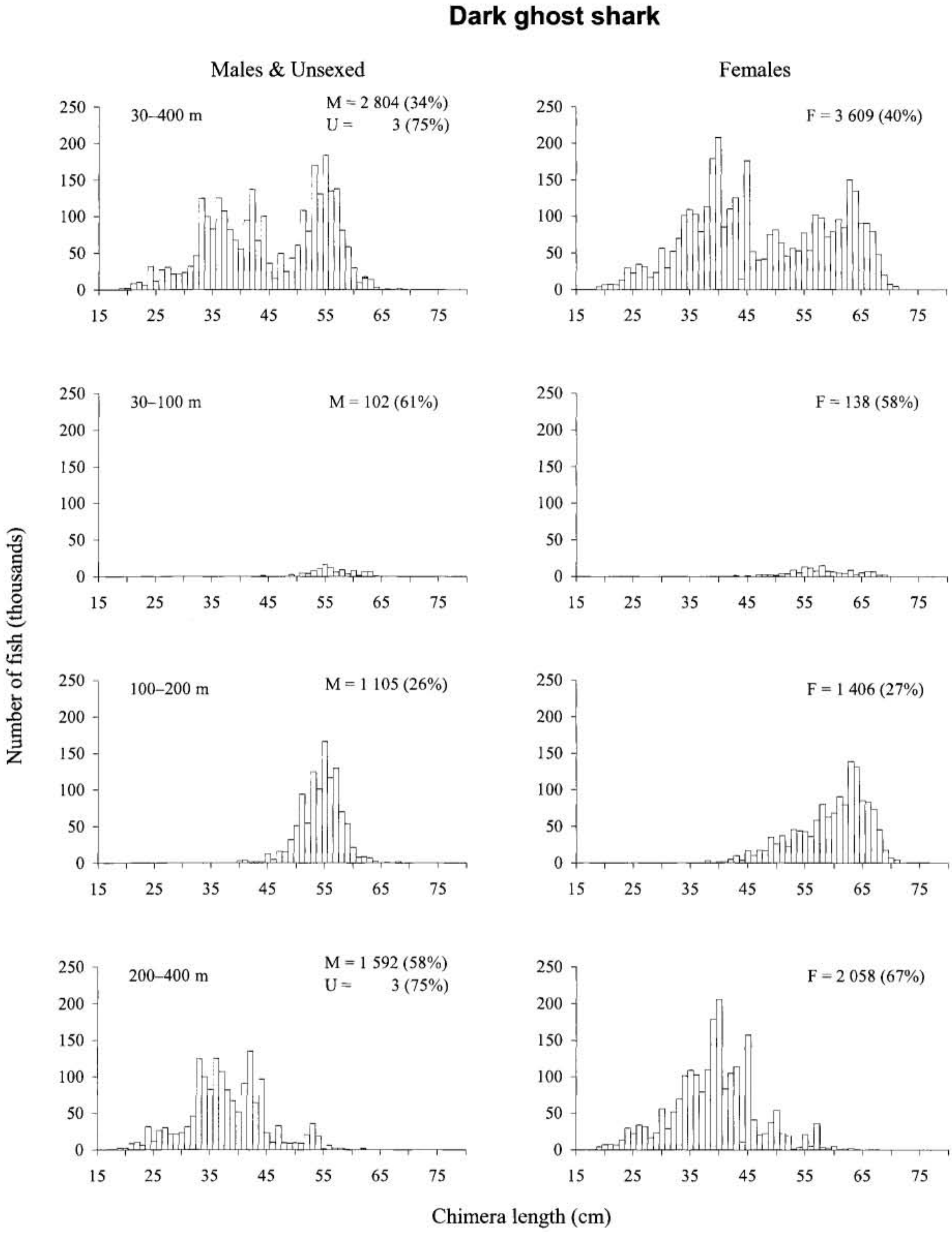
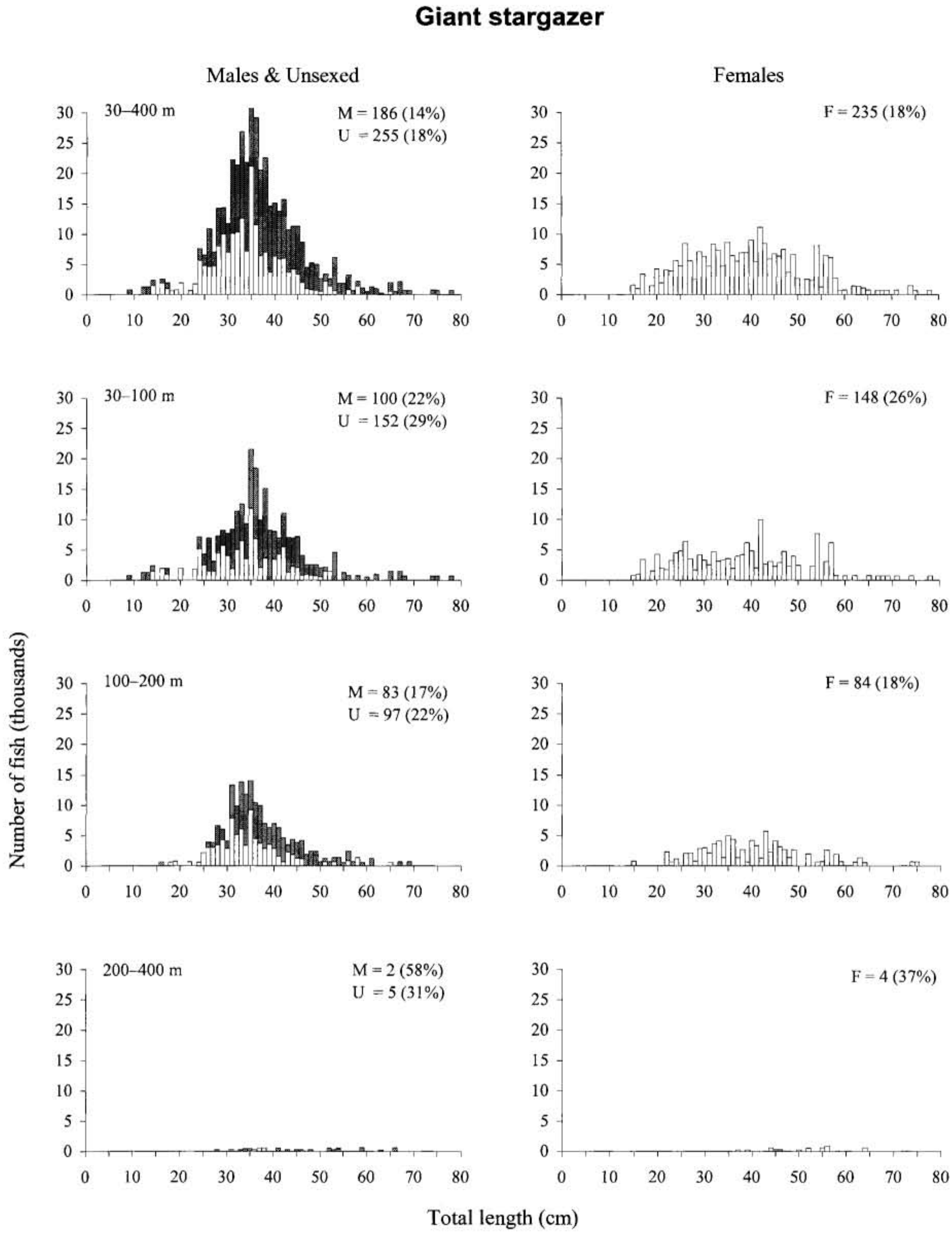



**Figure 6–*continued***




10–30 m
No catch

**Figure 7: Scaled length frequency distributions for the target species by depth range for the 2007 survey. Population estimates are in thousands of fish. M, number of males; F, number of females; U, unsexed; ( ), c.v. Shaded areas represent unsexed fish.**




10–30 m
No catch

**Figure 7–*continued***

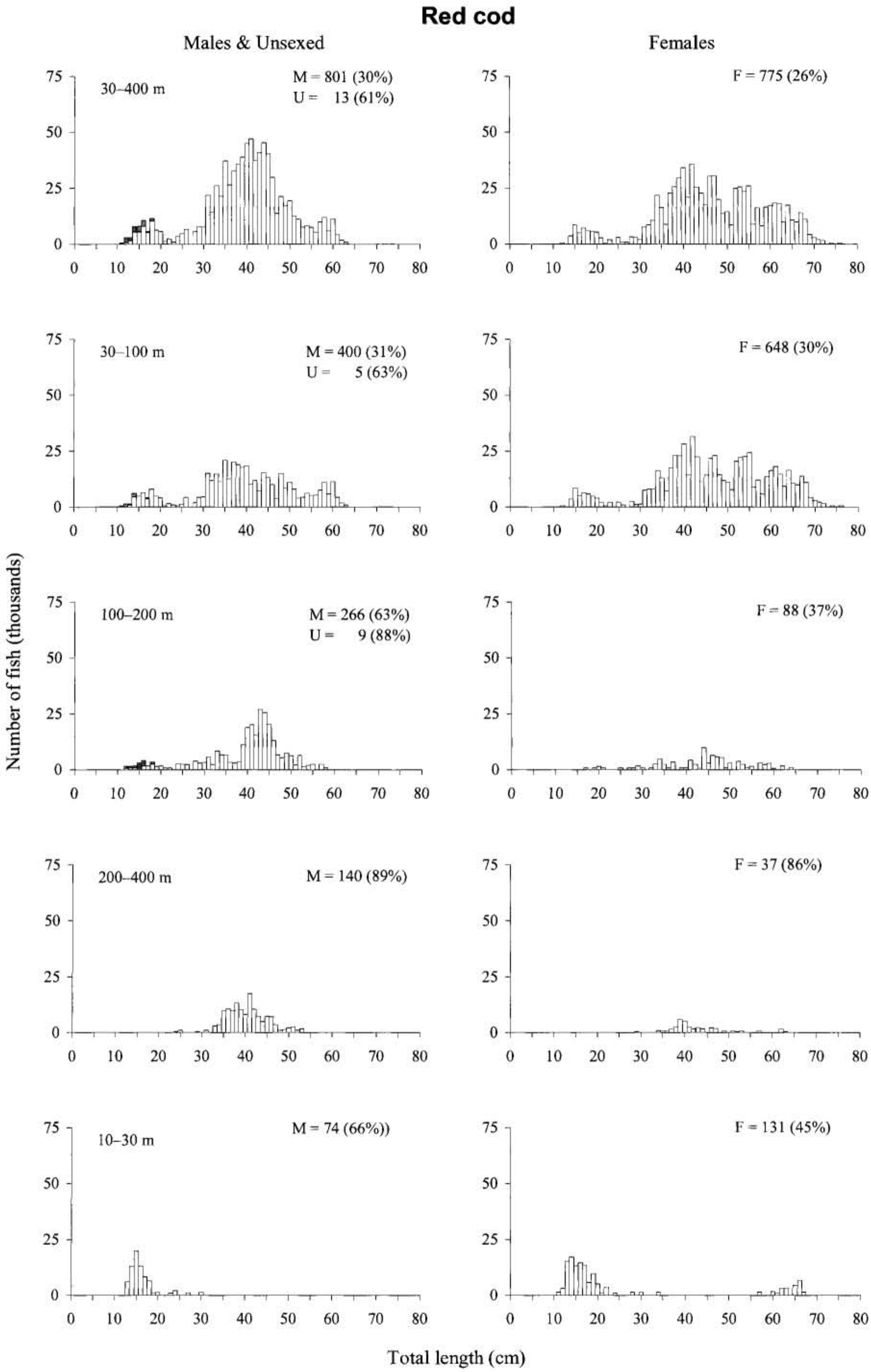



**Figure 7–*continued***

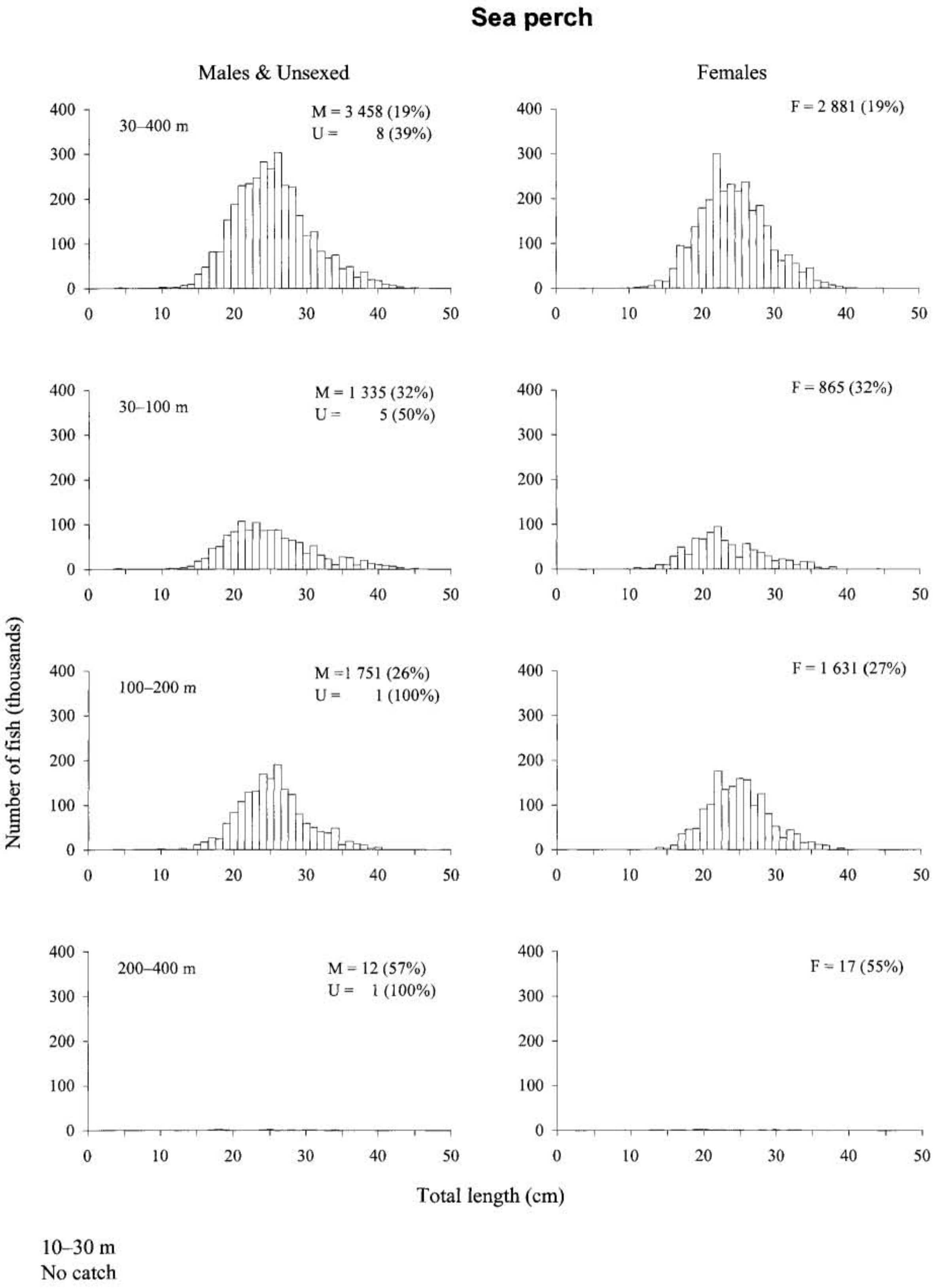



**Figure 7–*continued***

## Spiny dogfish

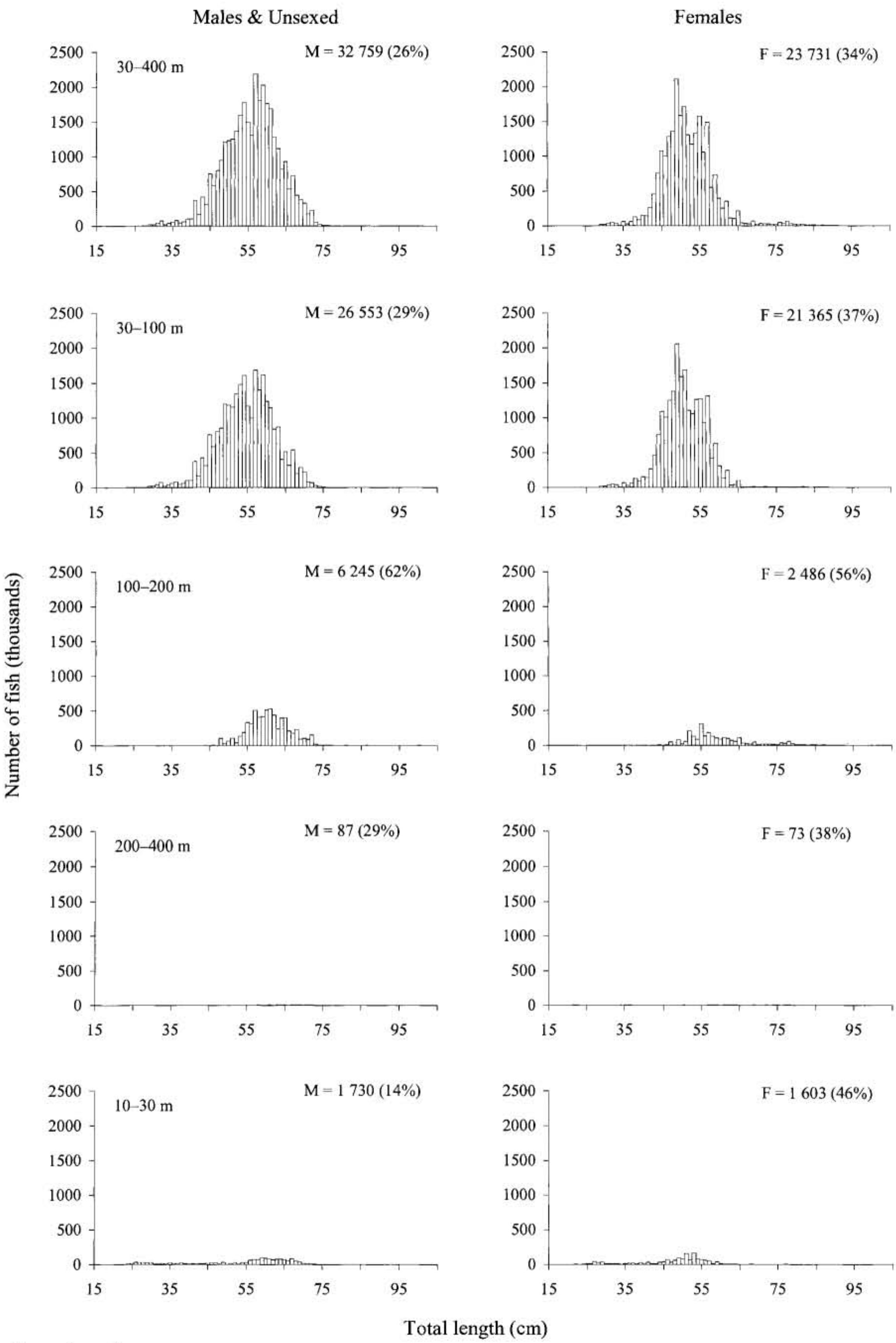



**Figure 7–*continued***

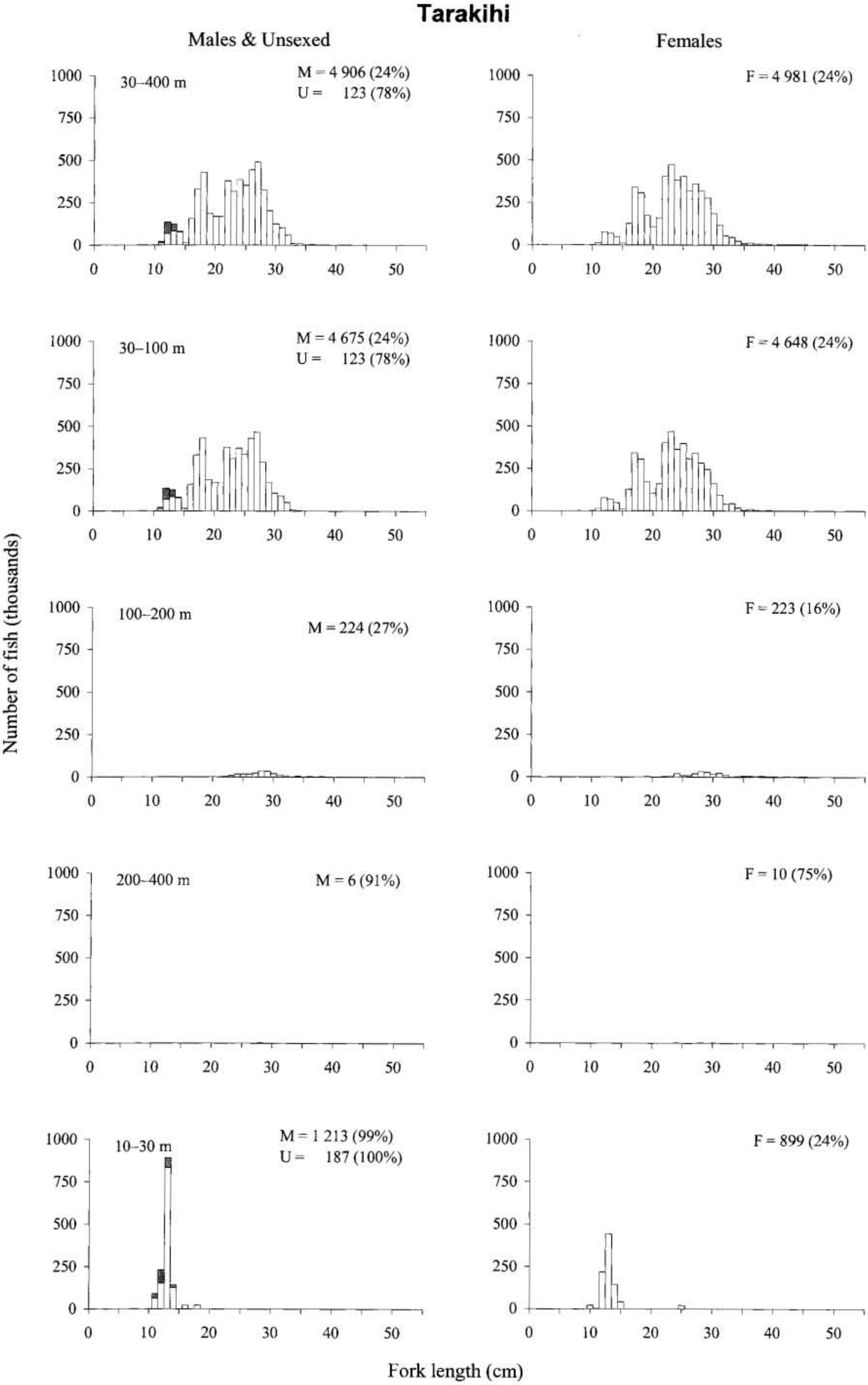



**Figure 7–*continued***

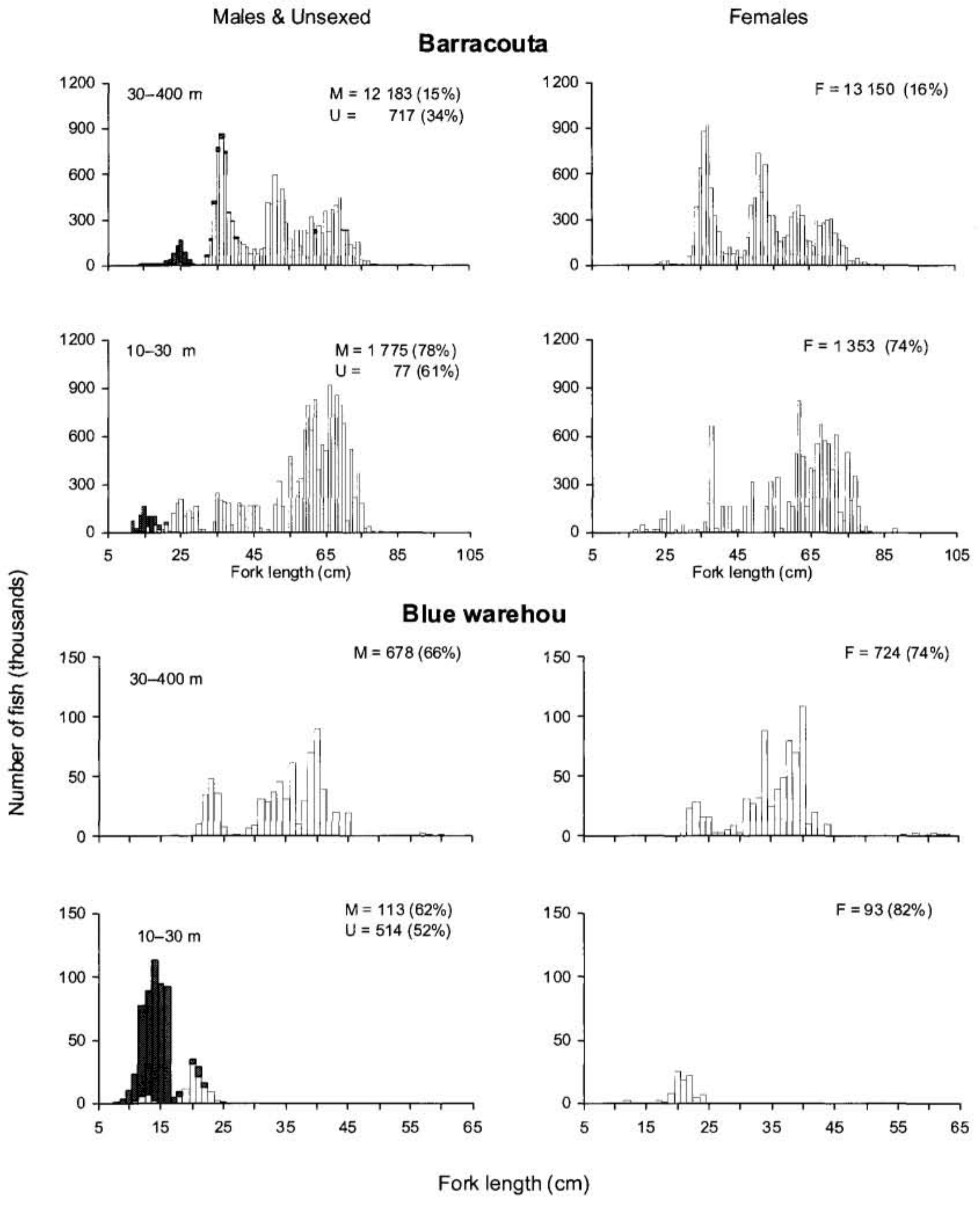



**Figure 8: Scaled length frequency distributions for the main non-target species in 30–400 m, and also 10–30 m for species with a shallow distribution for the 2007 survey. Population estimates are in thousands of fish. M, number of males; F, number of females; U, unsexed; ( ), c.v. Shaded areas represent unsexed fish.**

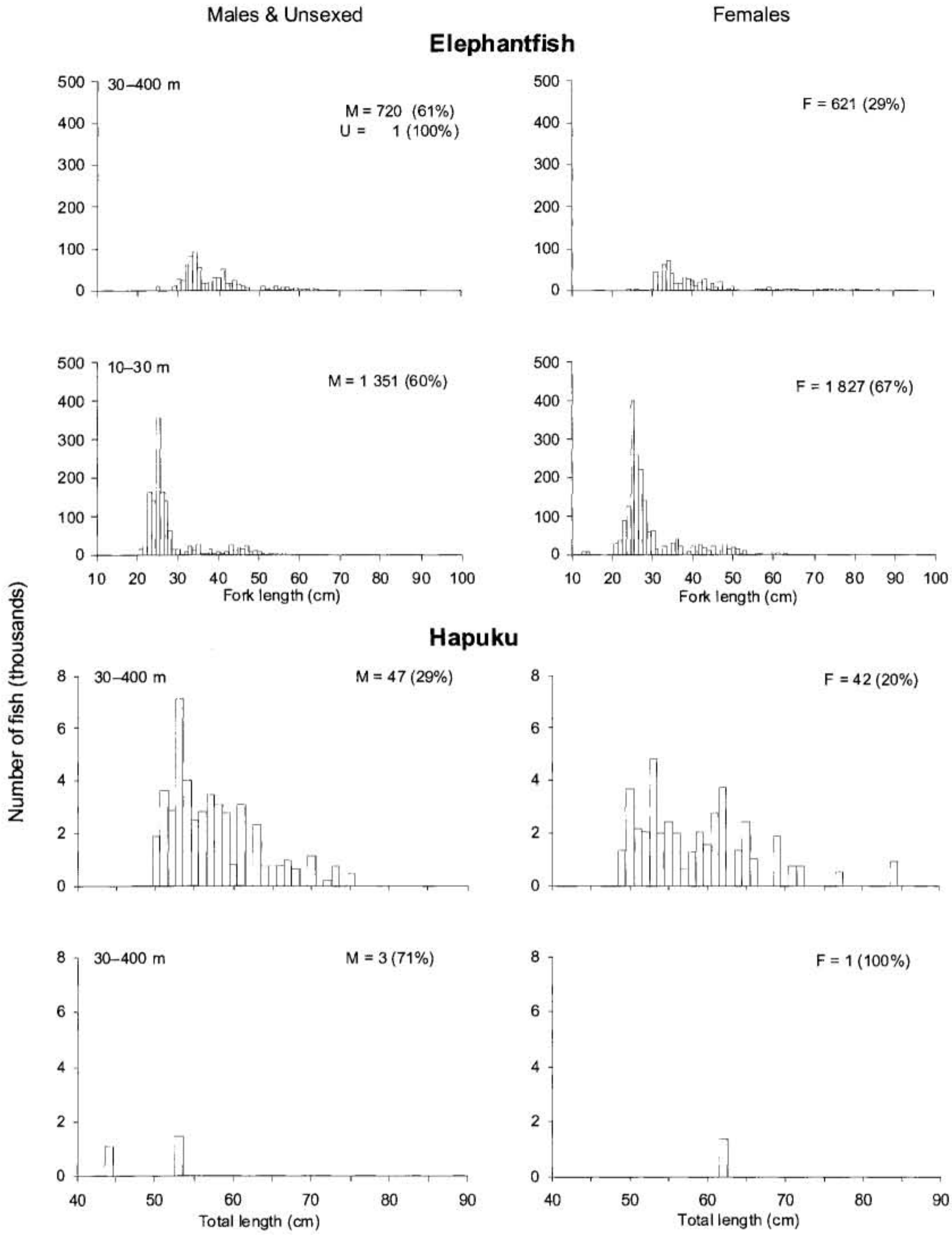
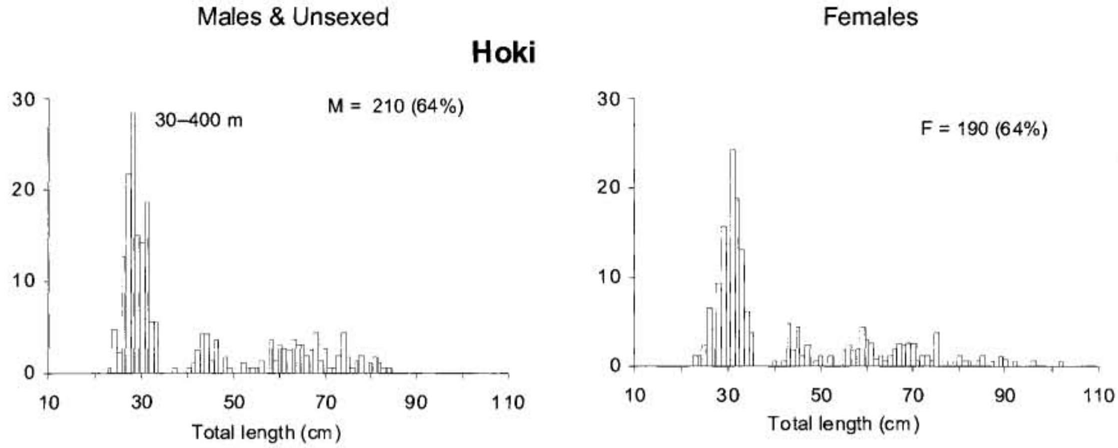



**Figure 8–*continued***




10–30 m
No catch

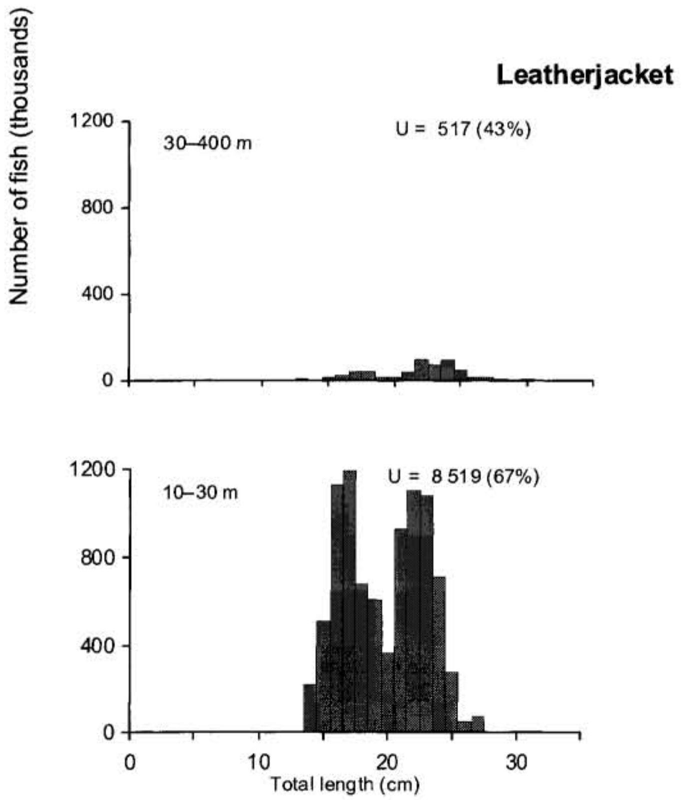
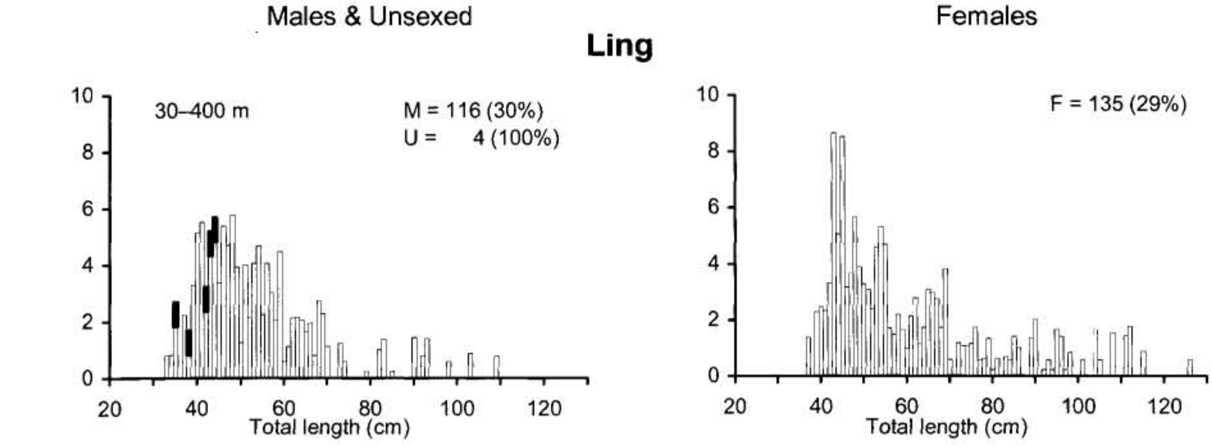



**Figure 8–*continued***




10–30 m
No catch

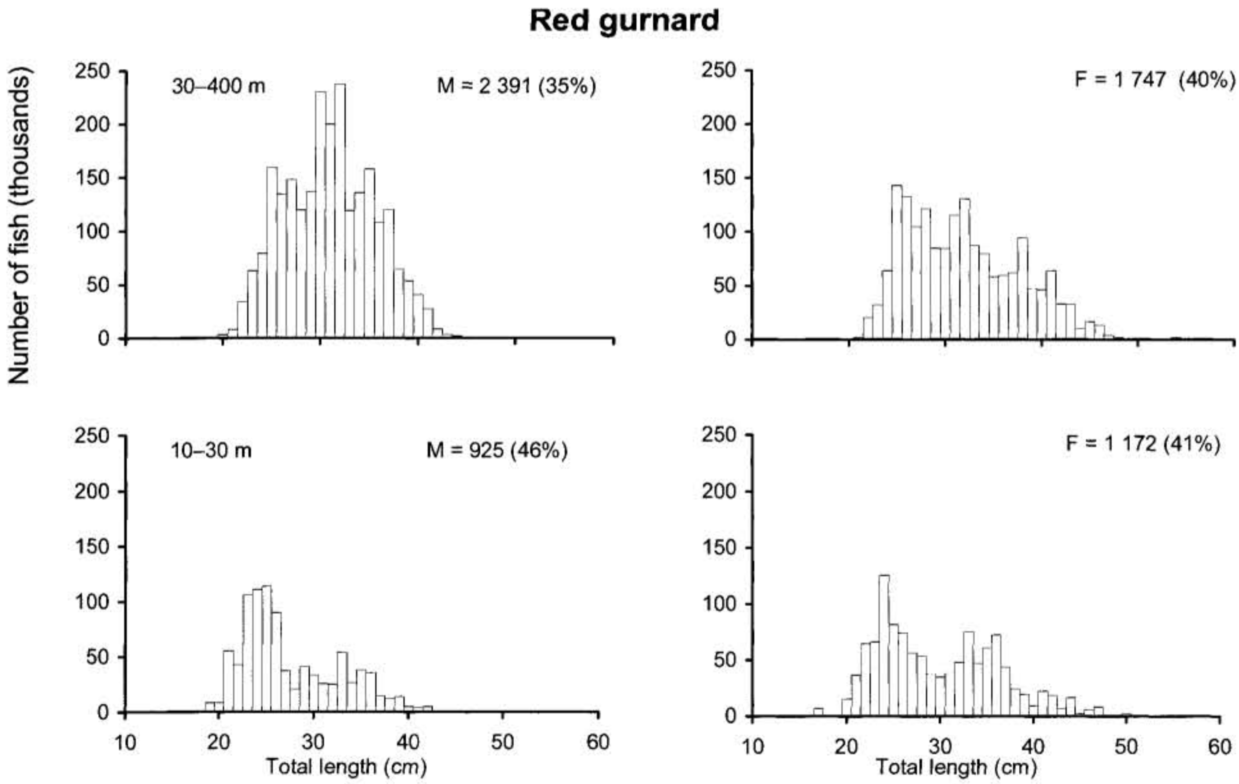



**Figure 8**–*continued*

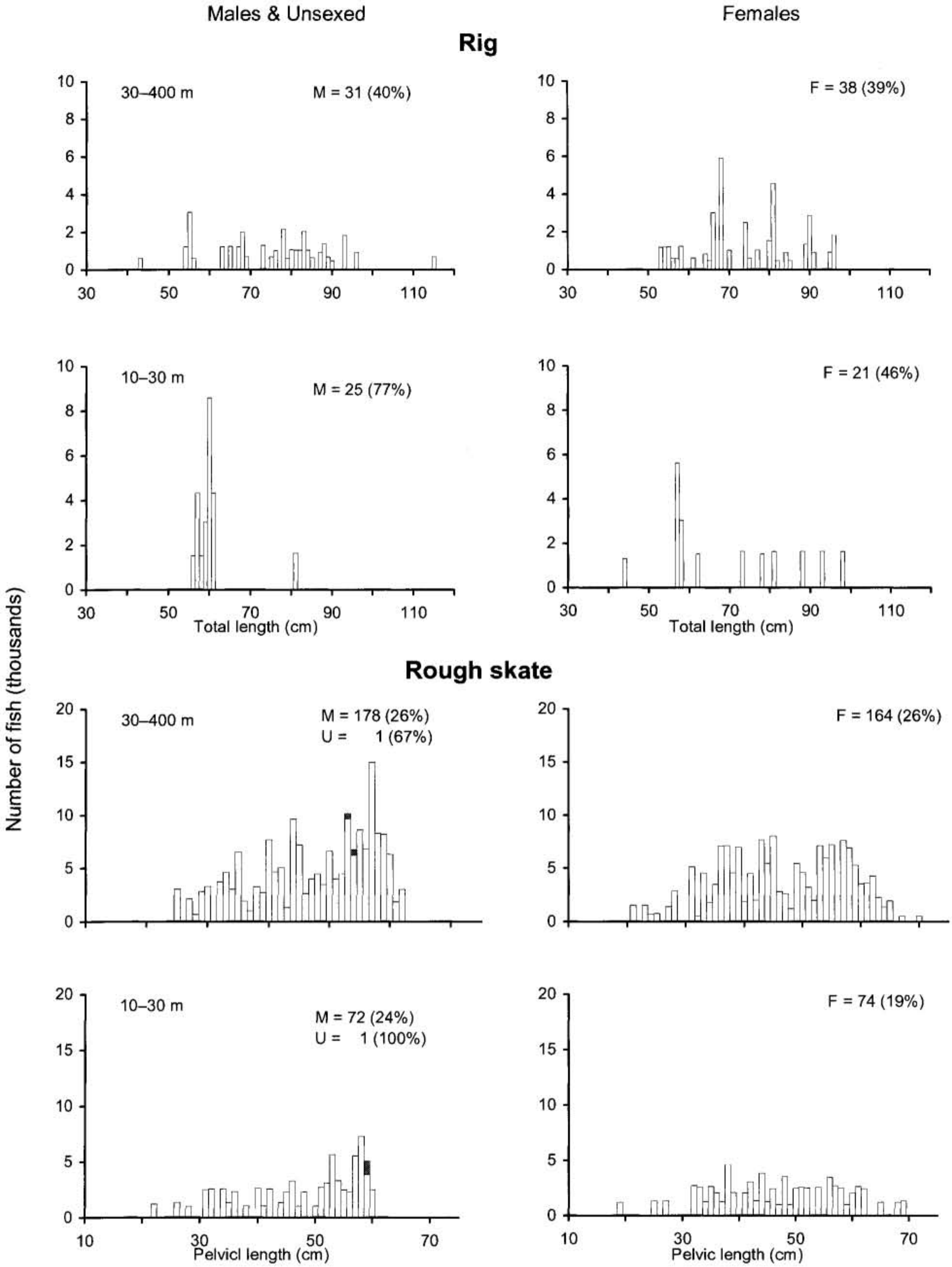



Figure 8–*continued*

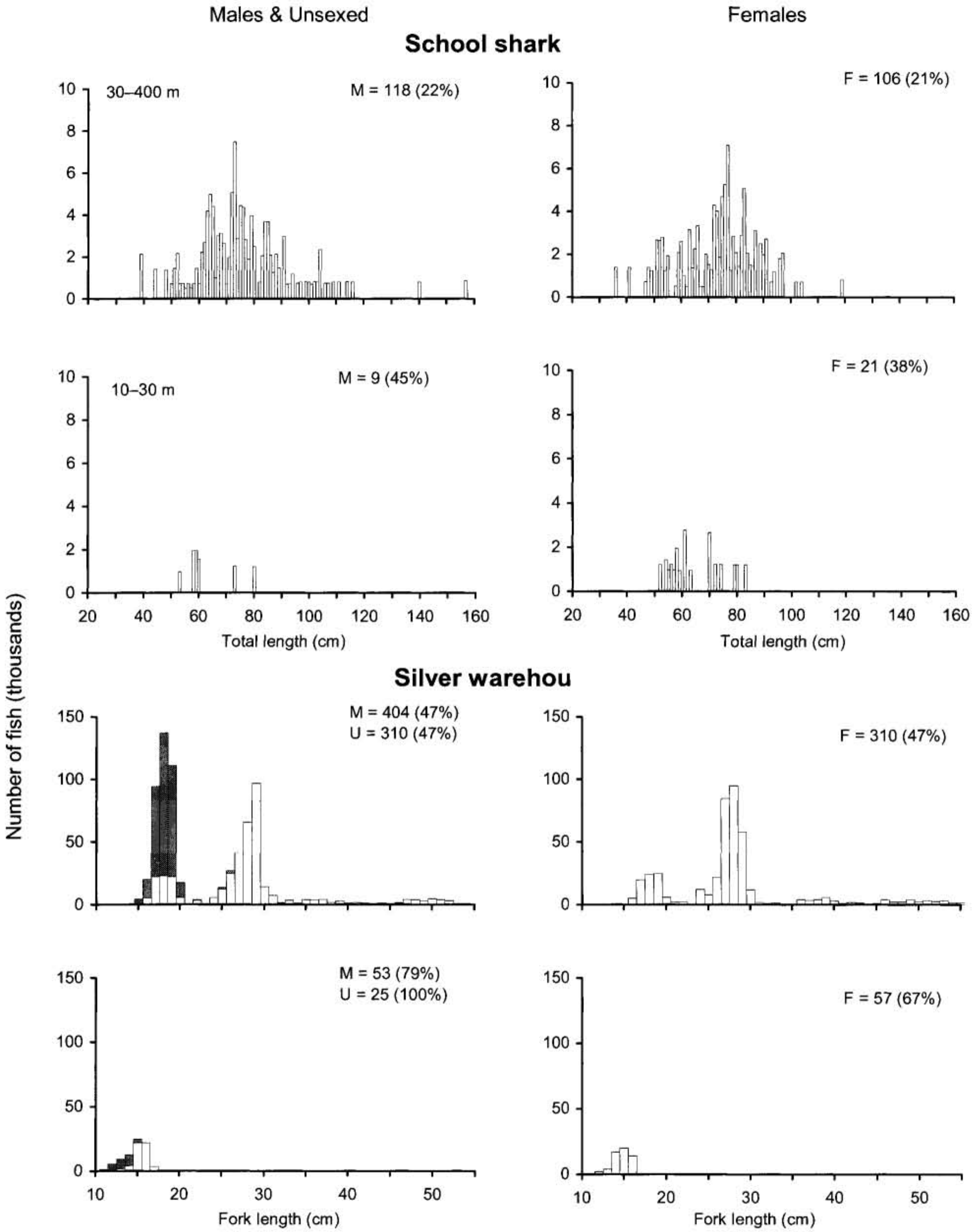



**Figure 8–*continued***

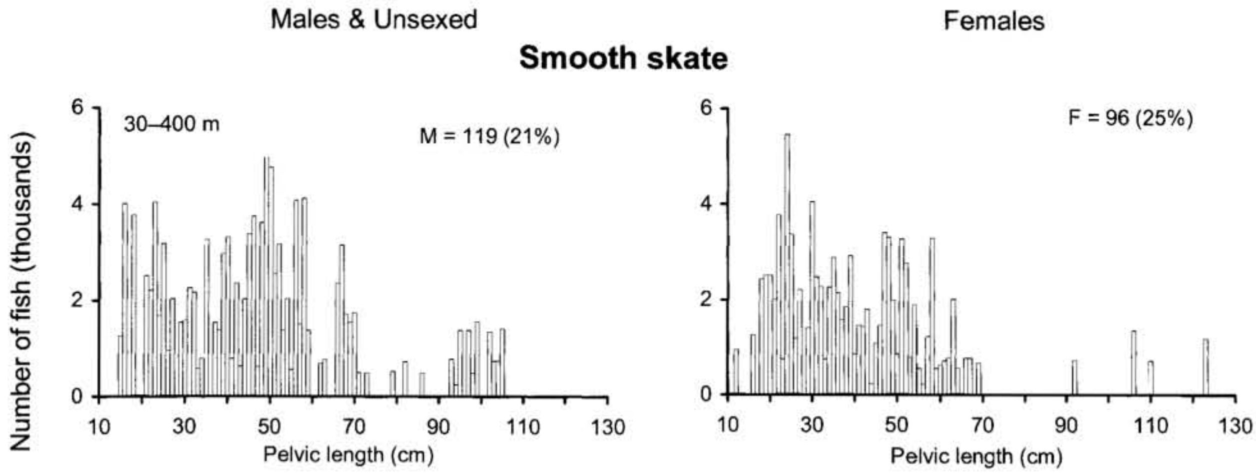



**Figure 8**–*continued*

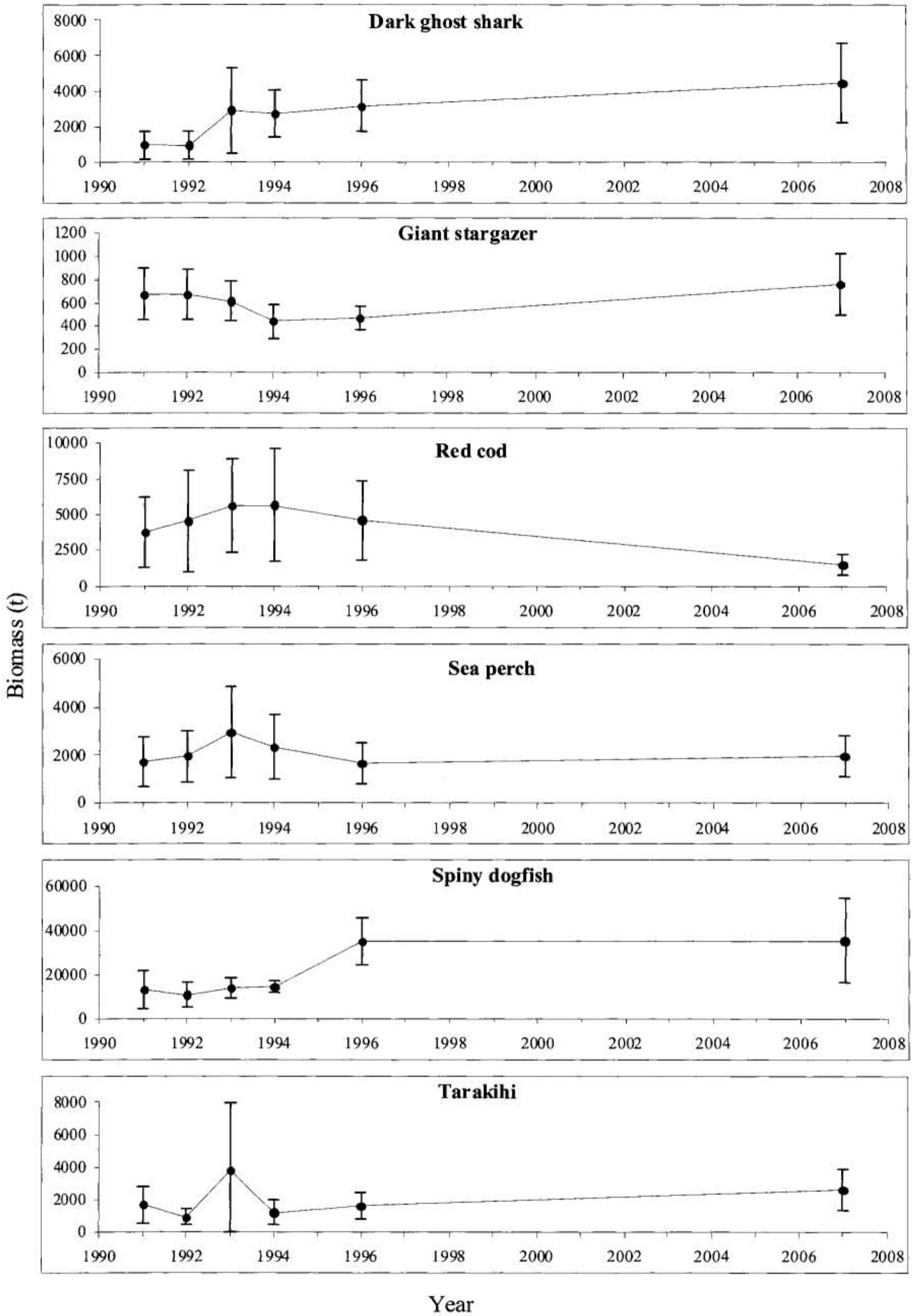



**Figure 9: Target species biomass and 95% confidence intervals for the six ECSI winter surveys.**

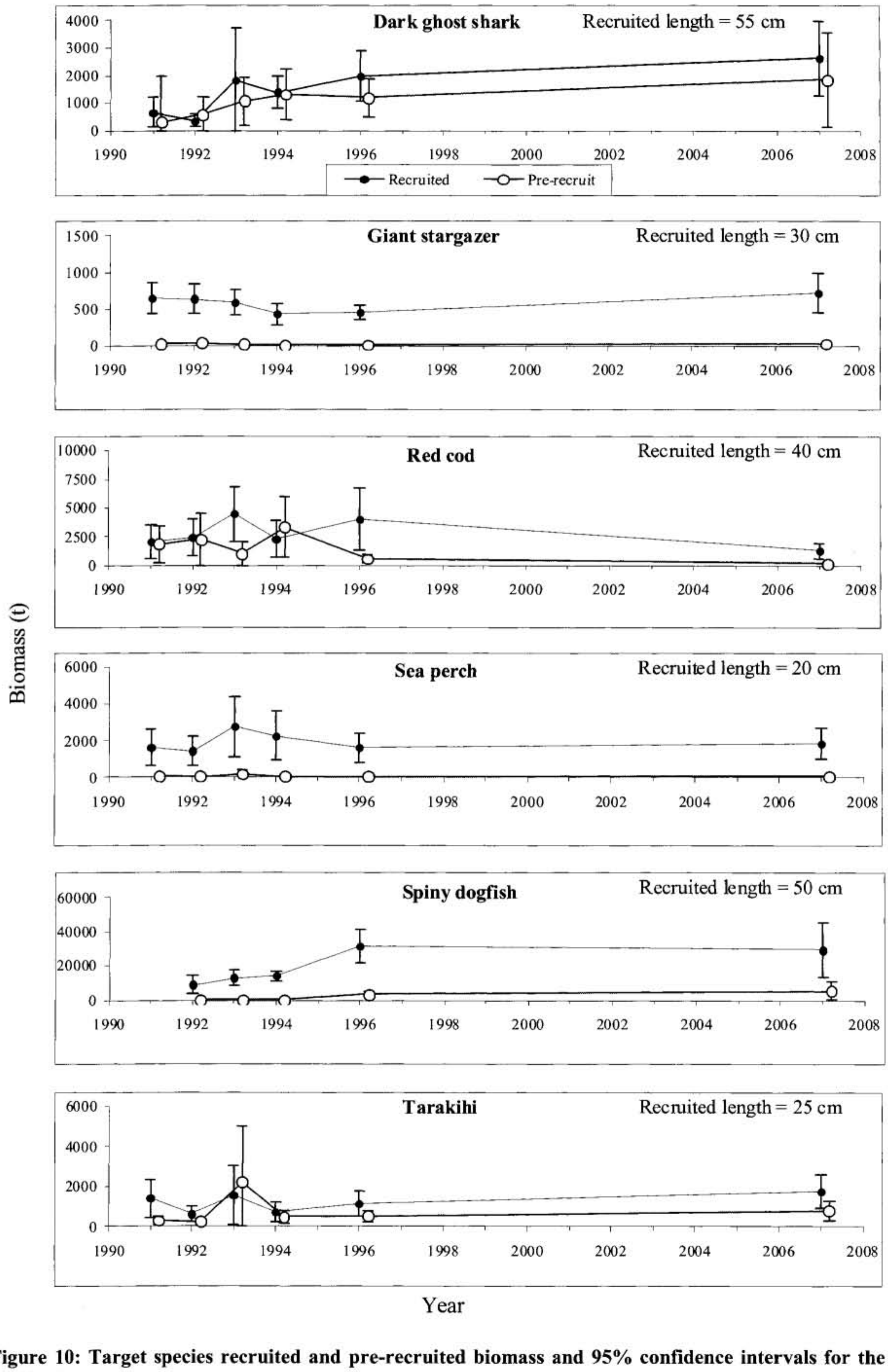



**Figure 10: Target species recruited and pre-recruited biomass and 95% confidence intervals for the six ECSI winter surveys.**

## Dark ghost shark

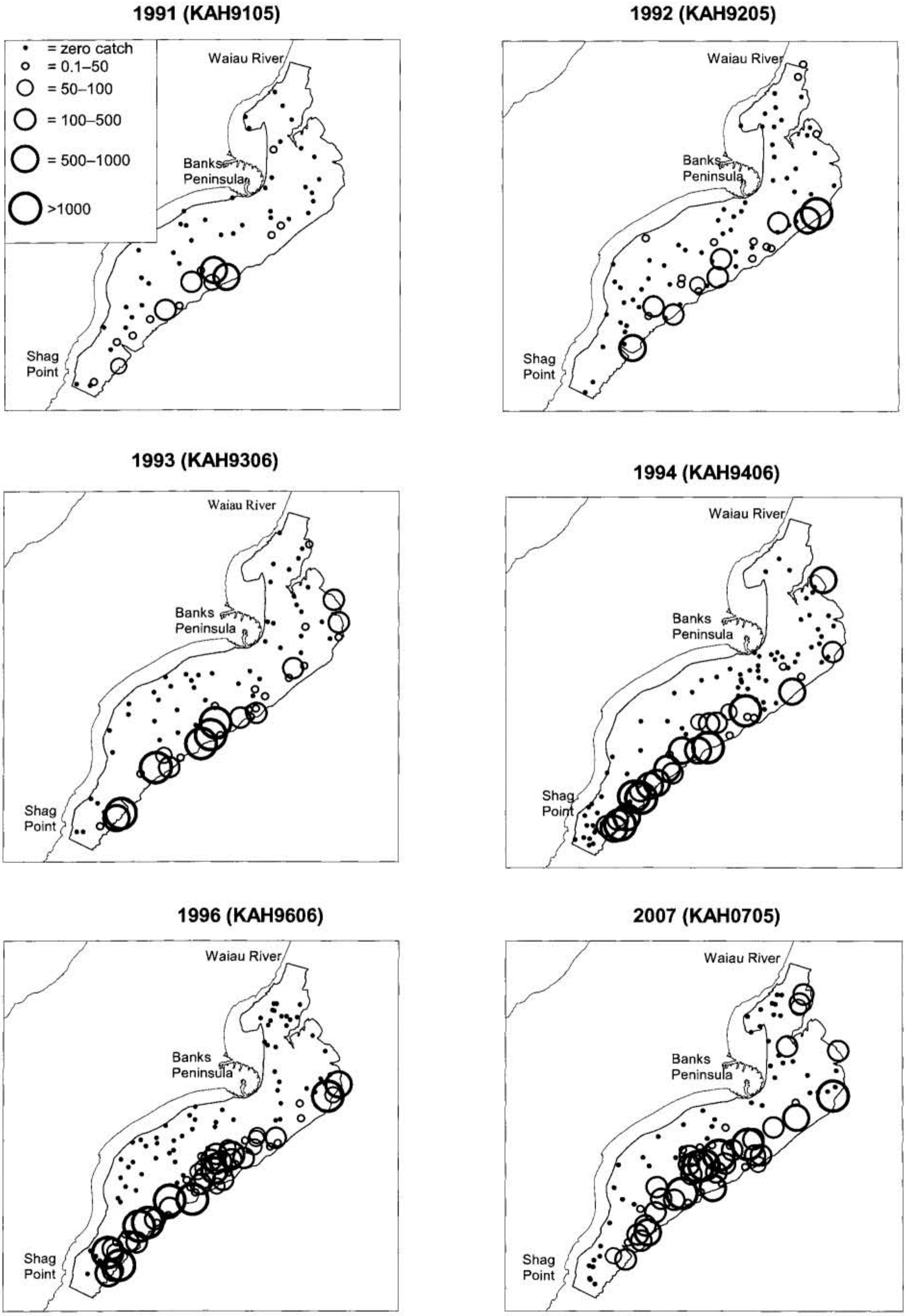



**Figure 11: Catch rates (kg.km$^{-2}$) of target species for the six ECSI winter trawl surveys in 30–400 m.**

## Giant stargazer

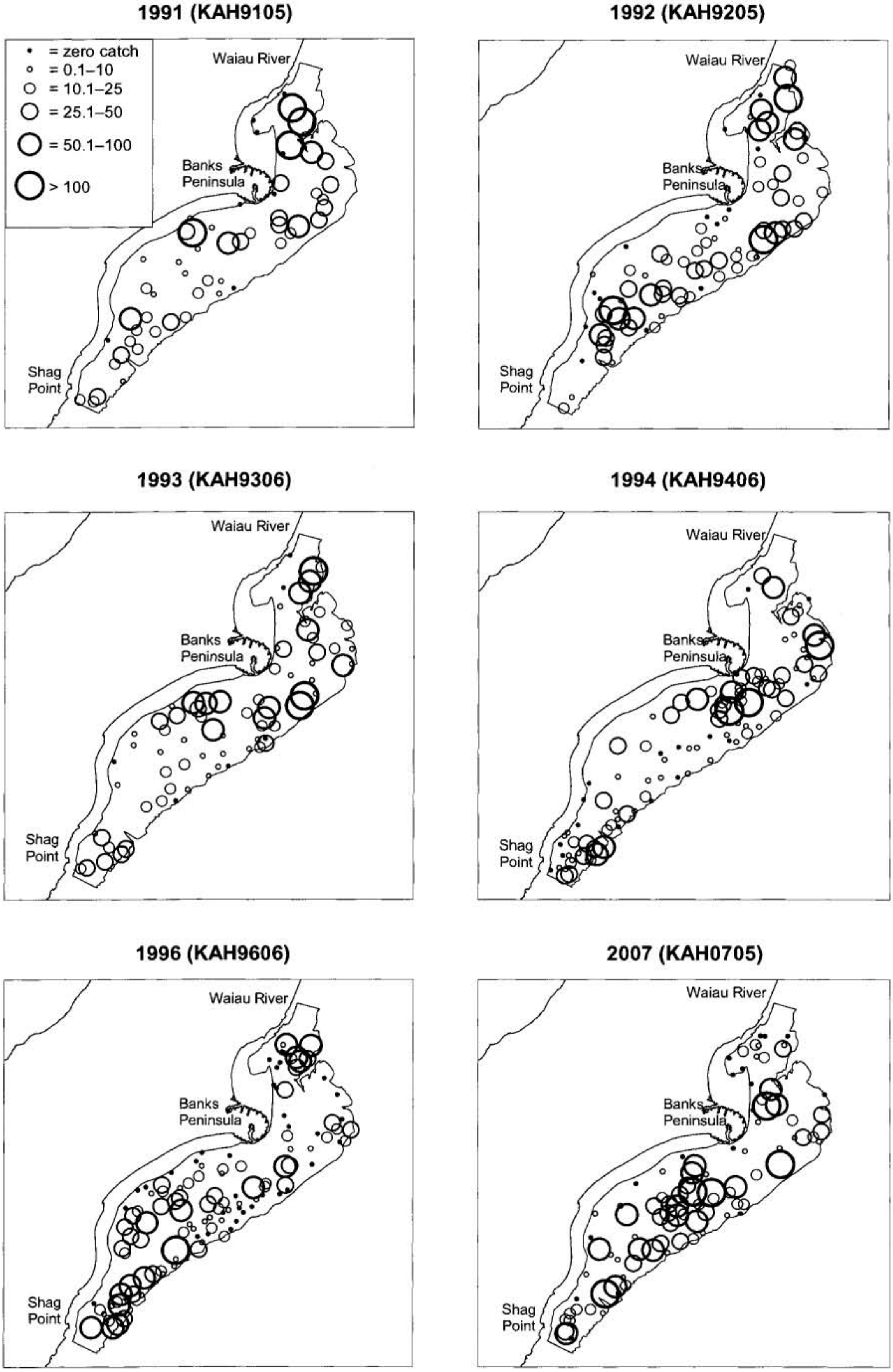



**Figure 11–*continued***

## Red cod

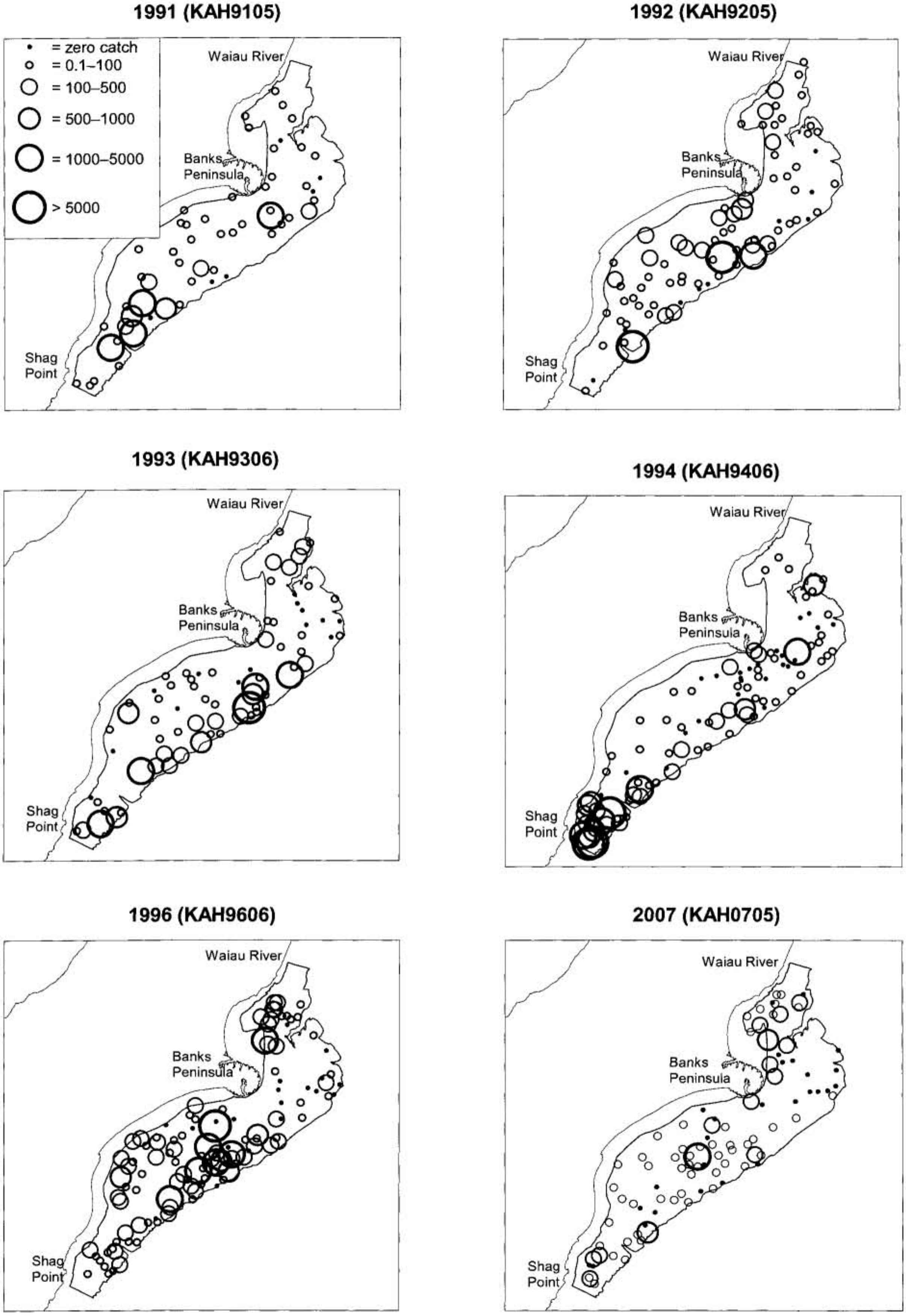



**Figure 11–*continued***

## Sea perch

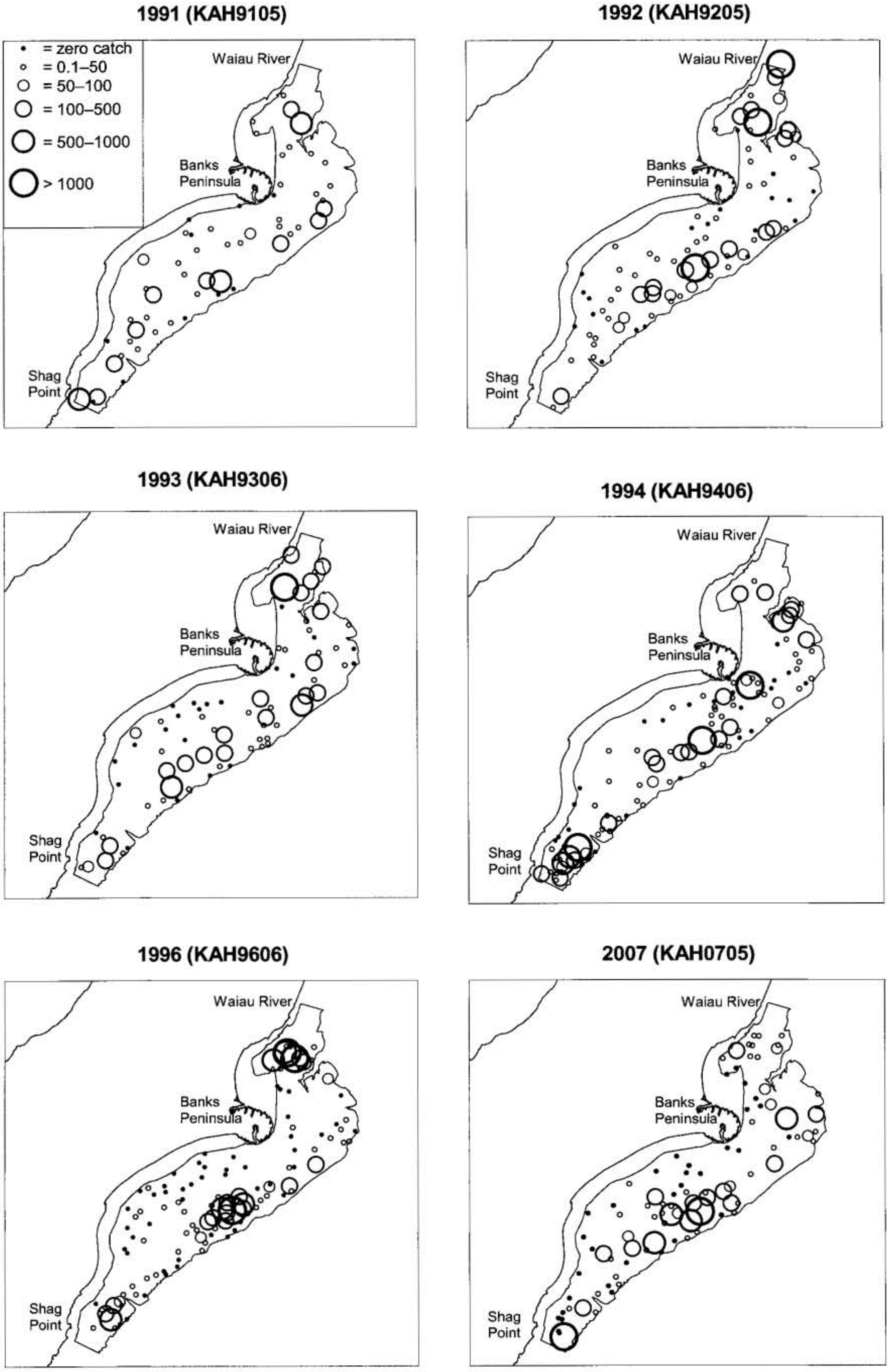



**Figure 11**–*continued*

## Spiny dogfish

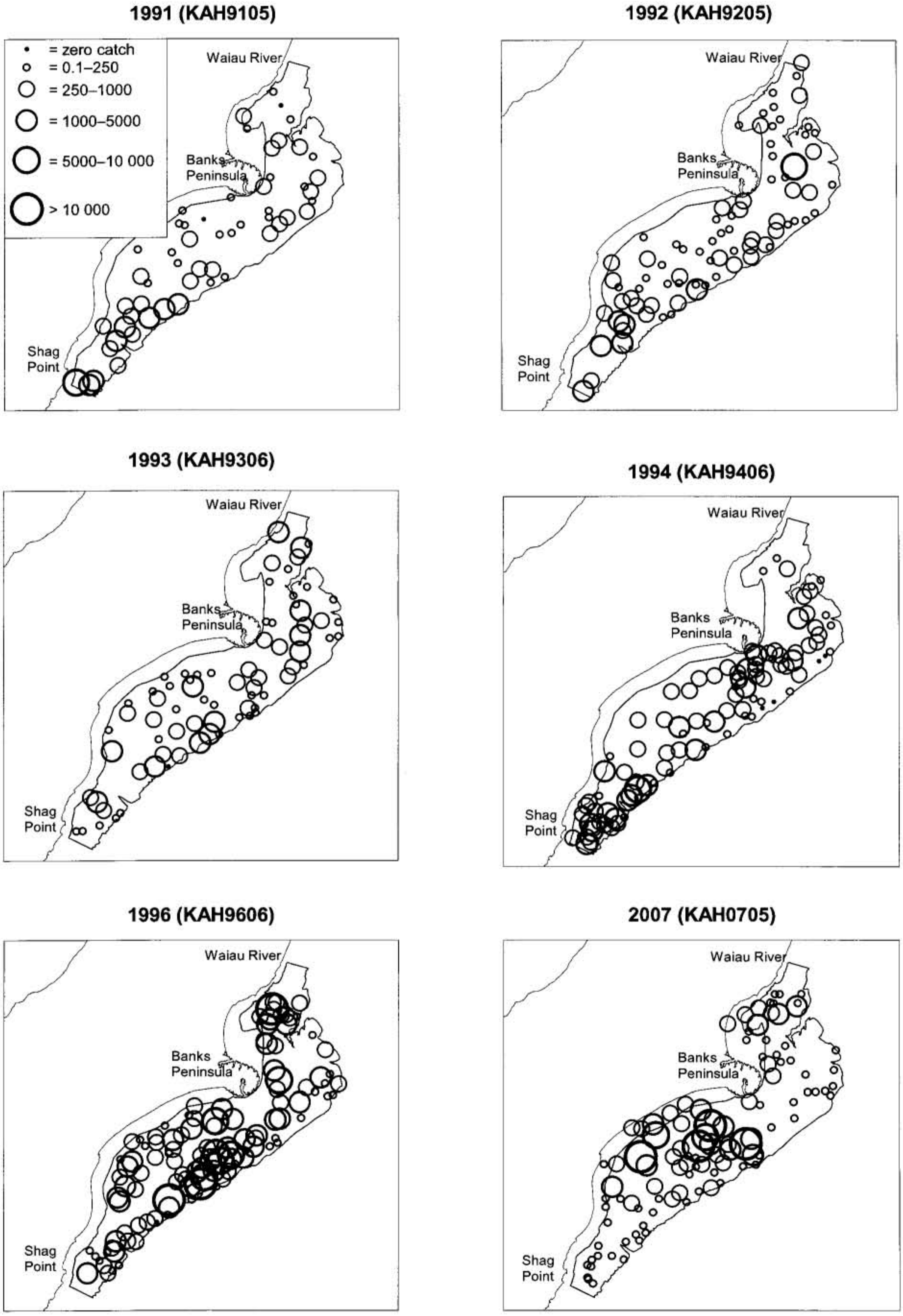



**Figure 11–*continued***

## Tarakihi

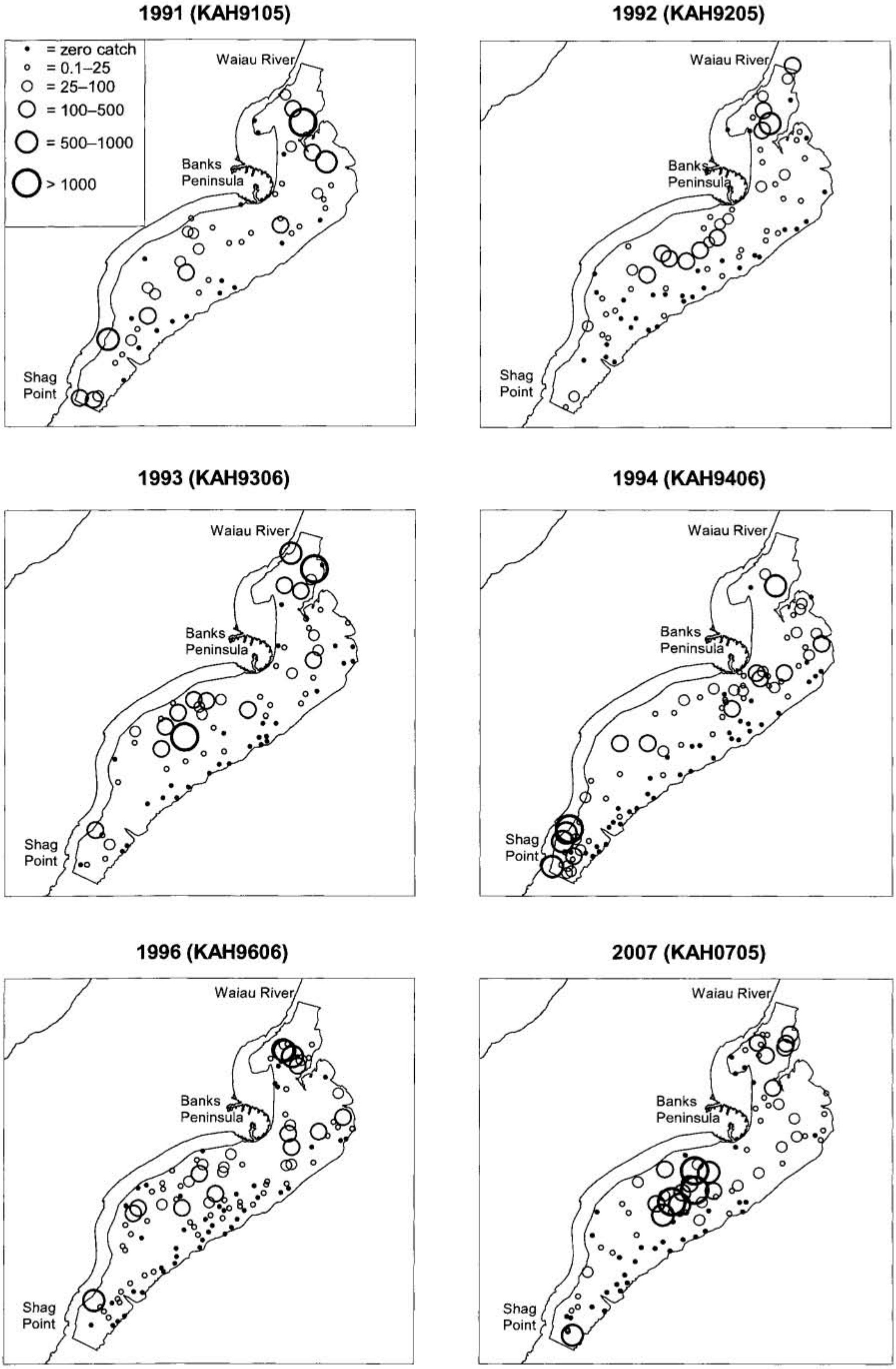



**Figure 11–*continued***

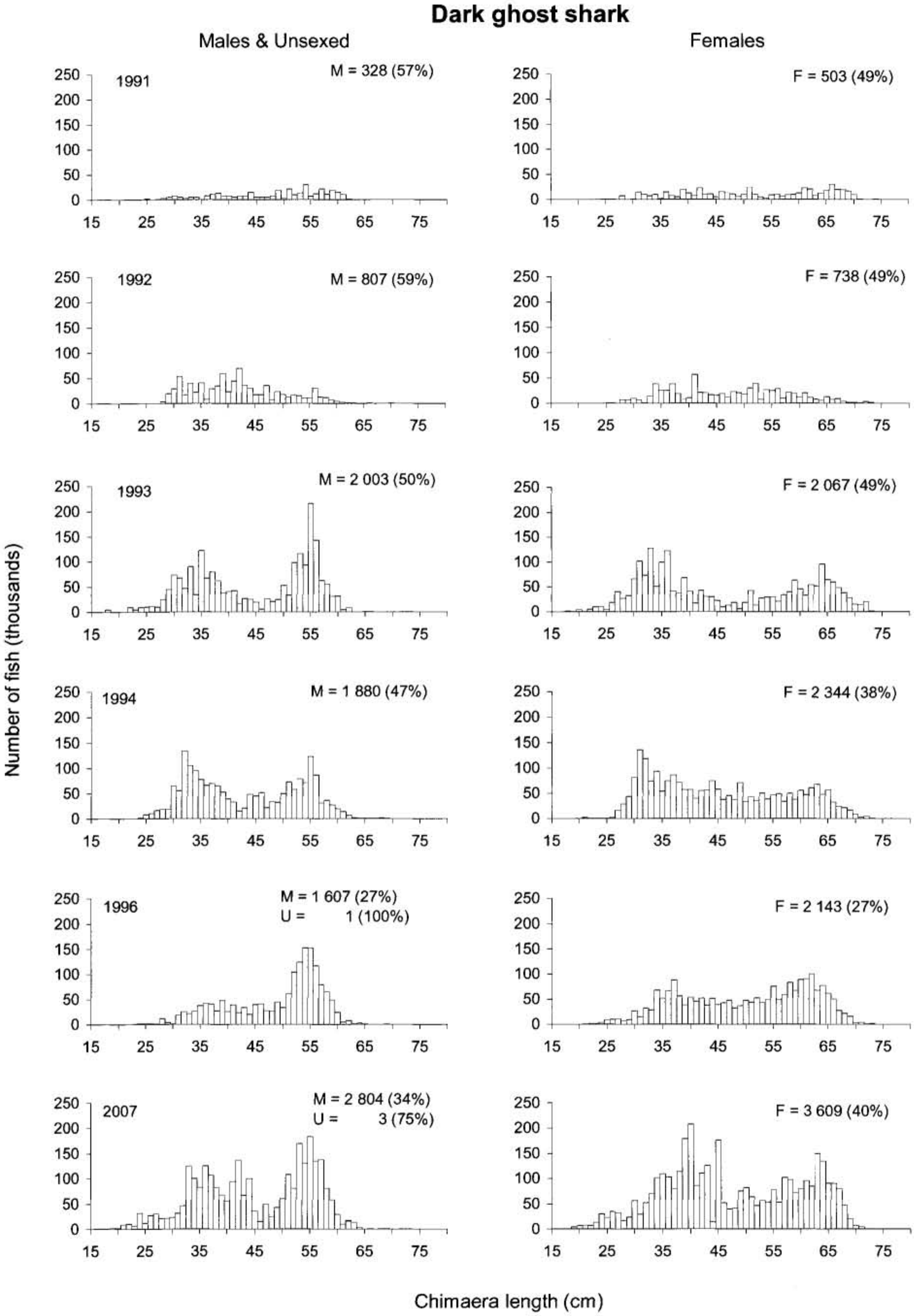



**Figure 12: Scaled length frequency distributions for the target species in 30–400 m, for all six winter ECSI surveys. Population estimates are in thousands of fish. M, males; F, females; U, unsexed; ( ), c.v. Shaded areas represent unsexed fish.**

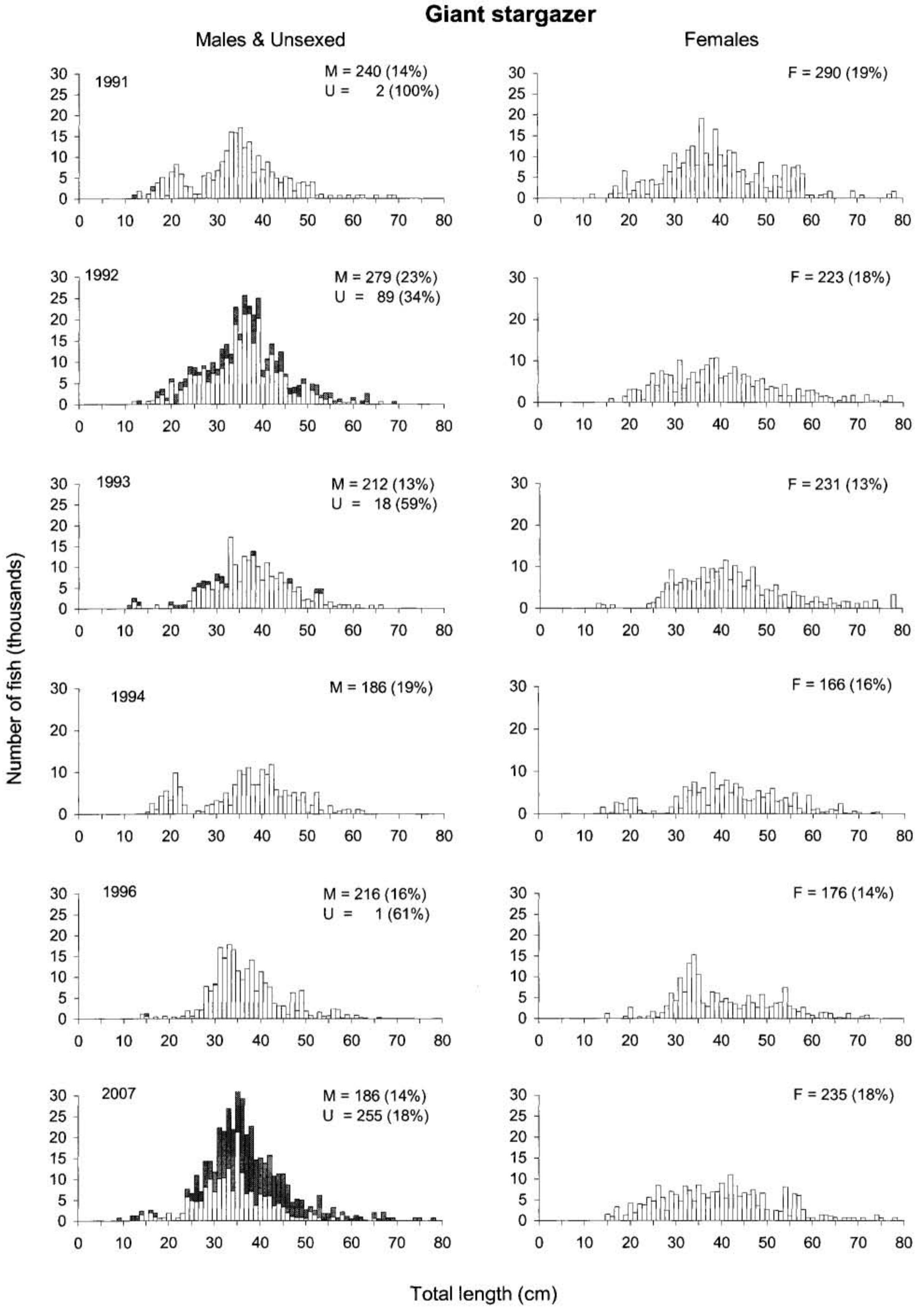



**Figure 12–*continued***

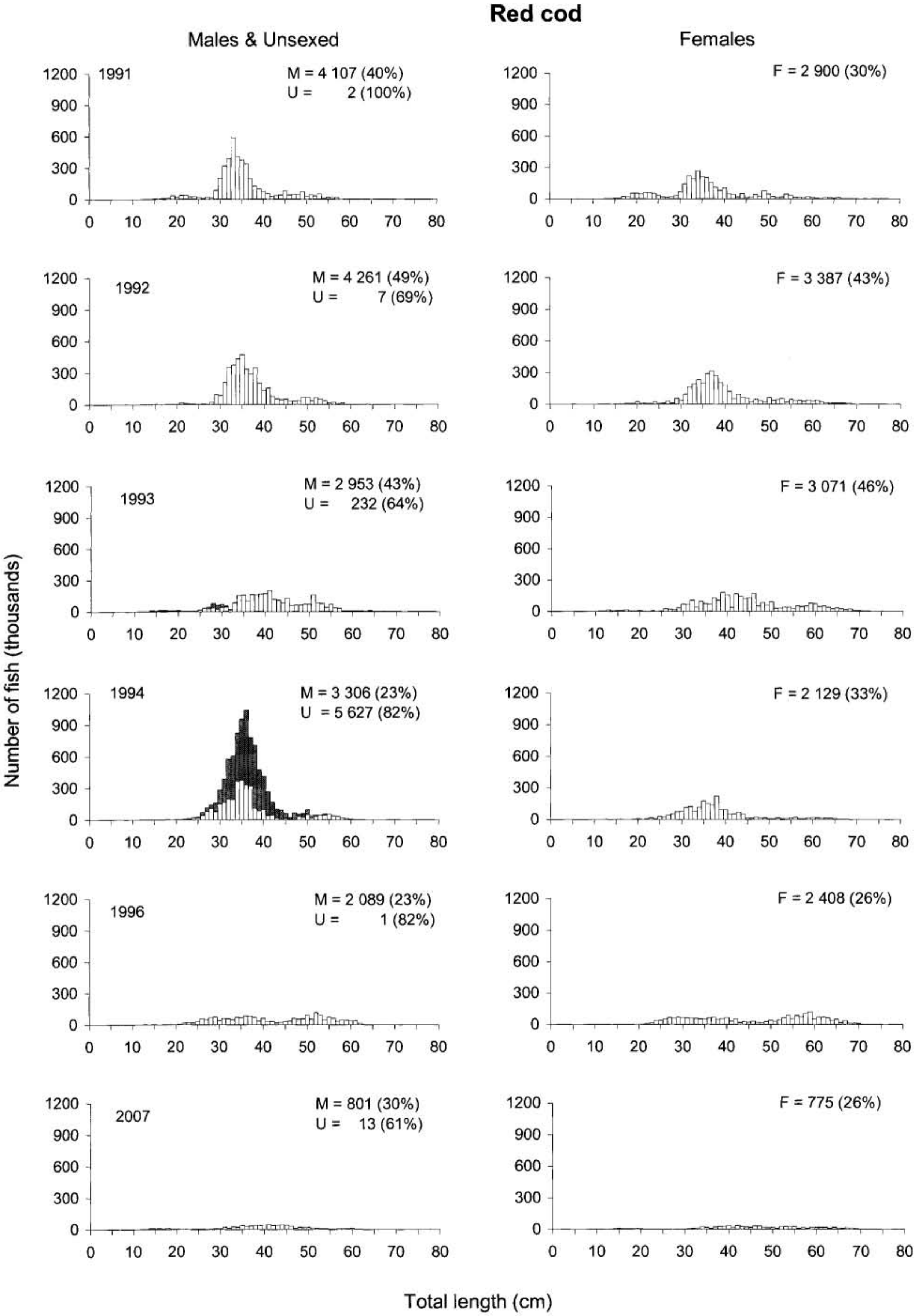



**Figure 12–*continued***

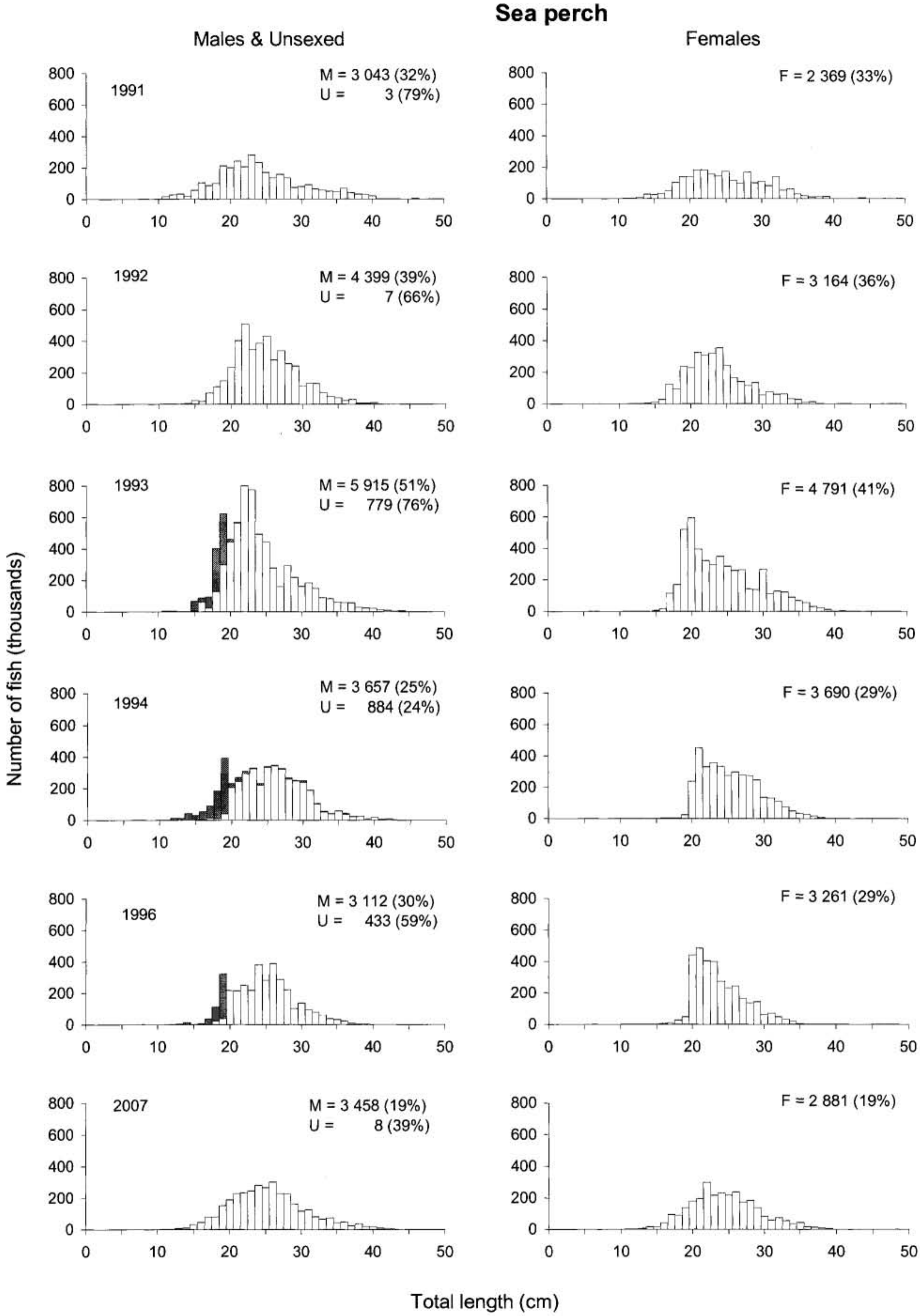



**Figure 12–*continued***

# Spiny dogfish

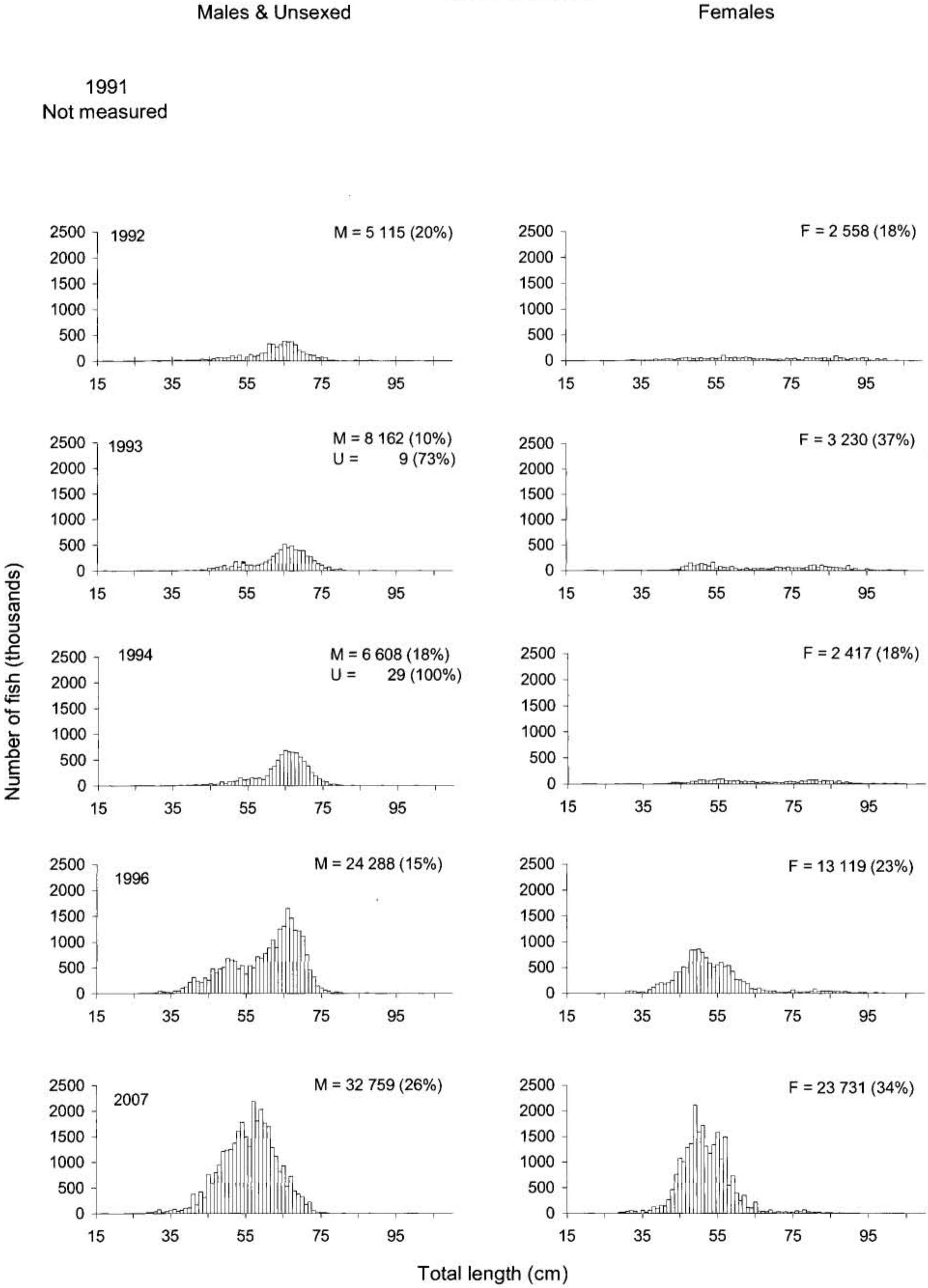



**Figure 12–*continued***

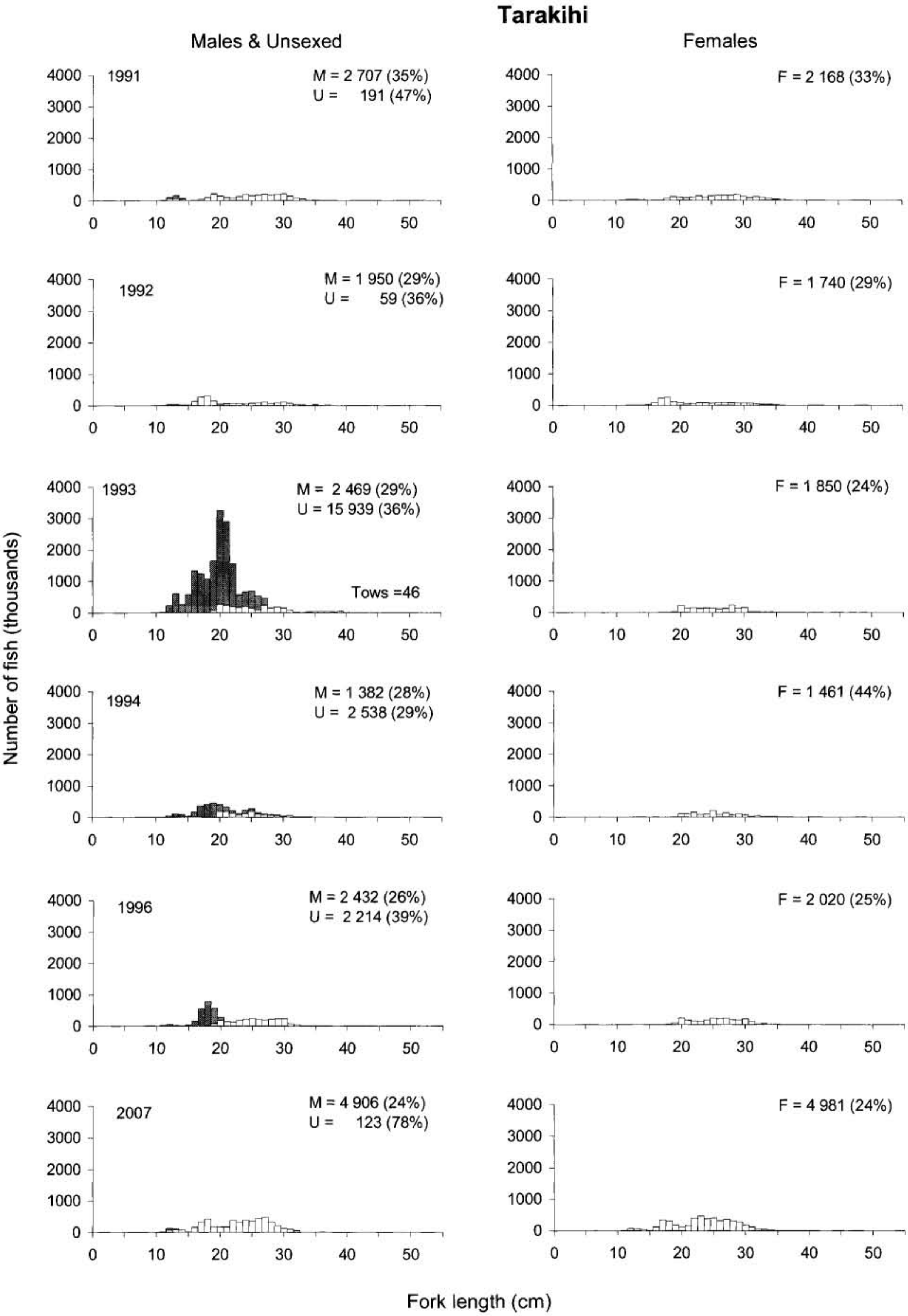



**Figure 12–*continued***

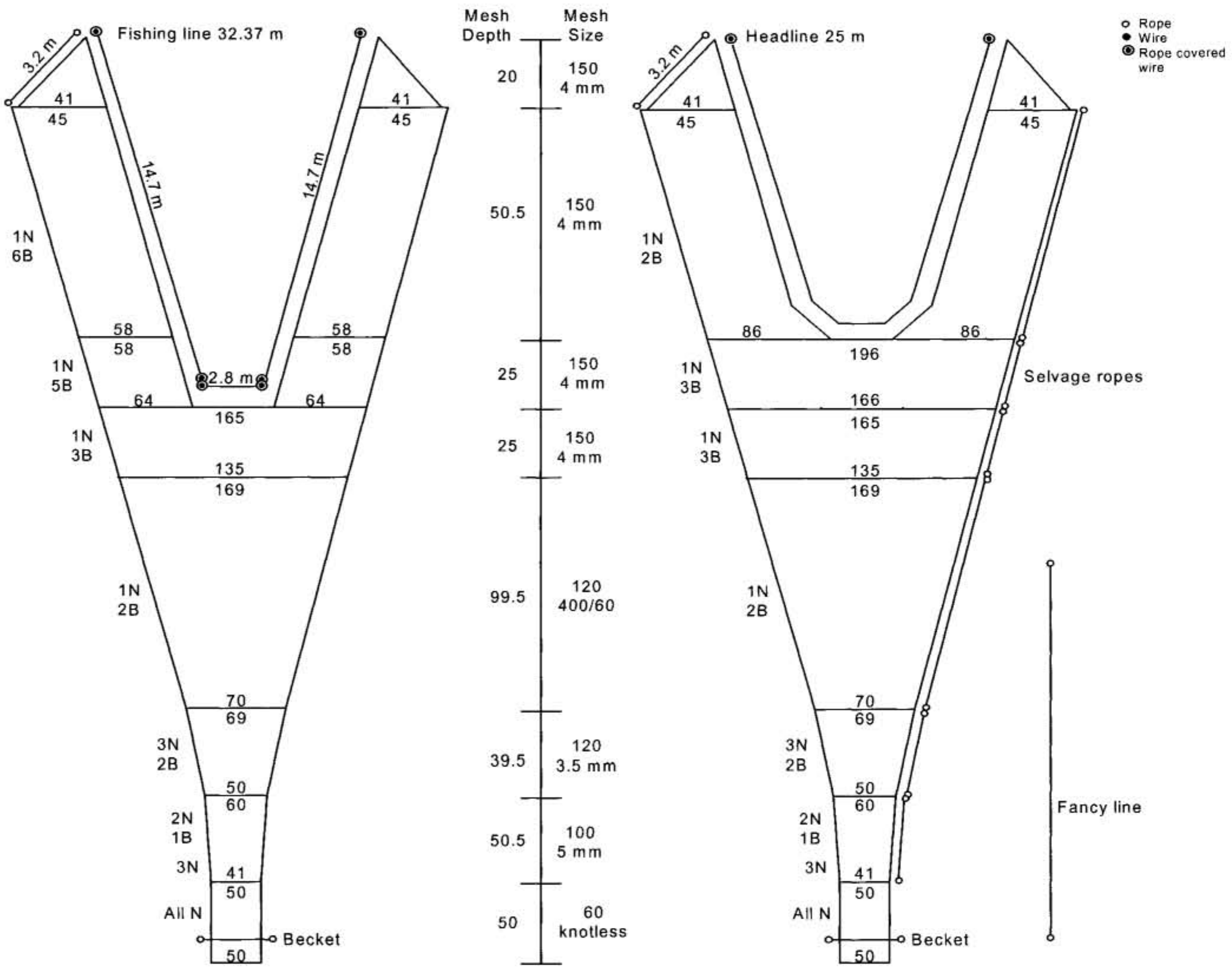
**Appendix 1: R.V. *Kaharoa* bottom trawl gear specifications, and details of net plan, codend, flotation, ground rope, sweeps, and bridals.**

| | | | |
|---|---|---|---|
| Trawl warp | | | 16 mm, 6 x 19 PPC |
| Trawl doors – rectangular V | | | 3.2 $m^2$ 630 kg |
| Backstrop length | | | 7.5 m |
| Sweep length | | | 55 m |
| Bridle length | top | | 12 mm 55 m |
| | bottom | | 16 mm 55 m |
| Layback | | | 150 mm |
| Approximate doorspread | | | 60 – 90 m |
| Optimum wingspread | Using (Prado 1990) | | 12.35 m |
| Angle of attack of sweeps and bridles | | | $14^{\circ}$ @ 69.4 m |
| | | | $16^{\circ}$ @ 77.4 m |
| | | | $19^{\circ}$ @ 89.4 m |
| Flotation | Net A | | |
| | headline | 2 | 330 mm diameter floats |
| | | 20 | 300 mm diameter floats |
| | net sonde | 2 | fender floats |
| | CTD logger | 3 | fender floats |
| | total buoyancy | | ~ 250 kg |
| Ground rope specifications | wire rope | | 35 m 18 mm (6 x 19) |
| | rubber rollers | 48 | 110 x 170 mm |
| | rubber spacers | 464 | 40 x 80 mm |
| | steel balls | 12 | 150 mm diameter, 12 kg |
| | toggled hangers | 50 | |
| Net attachments | BCS | | 7.1 kg |
| | Net sonde | | 15 kg |
| | CTD logger | | 15 kg |
| | total weight | | ~ 280 kg |
| V-line specifications | 'Hi-man' Superline | | 24 mm, 6.4 m |
| Headline specifications | Rope covered wire | | 25.05 m |
| Fishing line specifications | Rope covered wire | | 2 x 14.7 m, 1 x 2.8 m |

**Appendix 1–*continued***

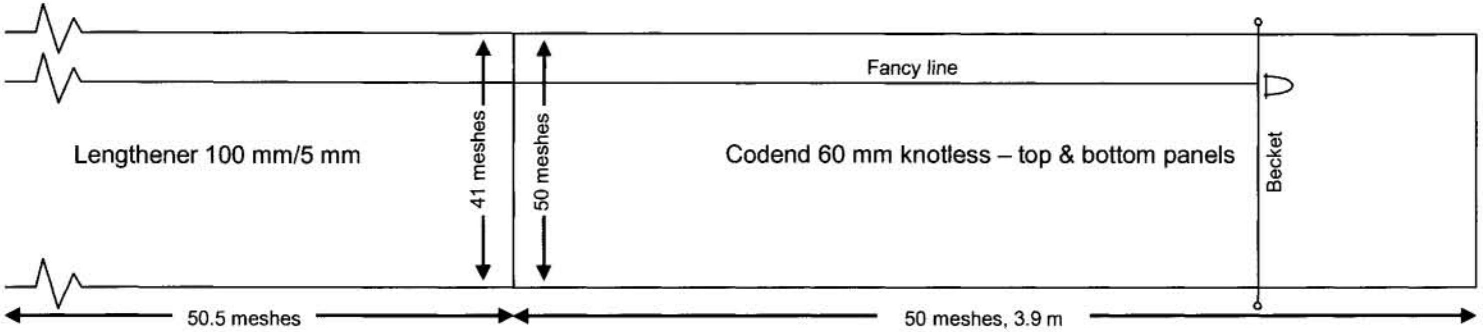
# Net Plan: R.V. *Kaharoa* Bottom Trawl

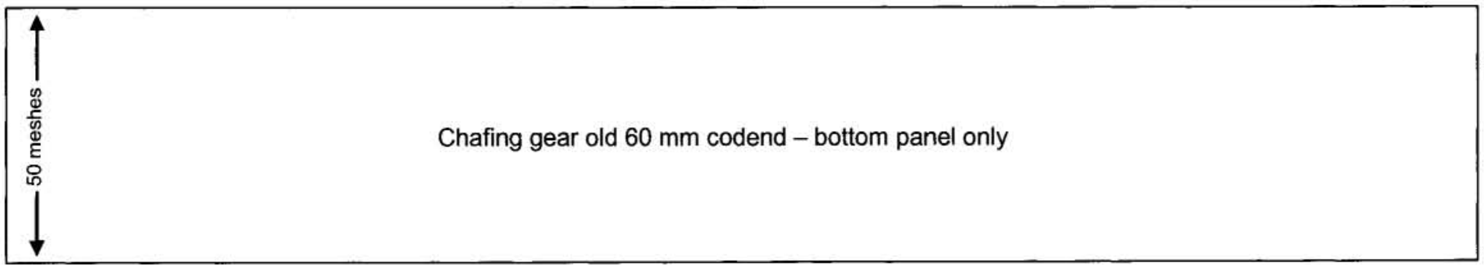
| Mesh and twine size | No. meshes deep | Selvage ropes nylon 26 mm |
|---|---|---|
| 150 mm 4 mm (type) | 20 | V-lines 24 mm Hi-man superline 6.4 m |
| 150 mm 4 mm (type) | 50.5 | 6.3 m |
| 150 mm 4 mm (type) | 25 | 3.3 m |
| 150 mm 4 mm (type) | 25 | 3.3 m |
| 120 mm 400/60 (pe) | 99.5 | 10.8 m |
| 120 mm 3.5 mm (type) | 39.5 | 4.0 m |
| 100 mm 5 mm (type) | 50.5 | 4.2 m |
| 60 mm knotless (type) | 50 | - |



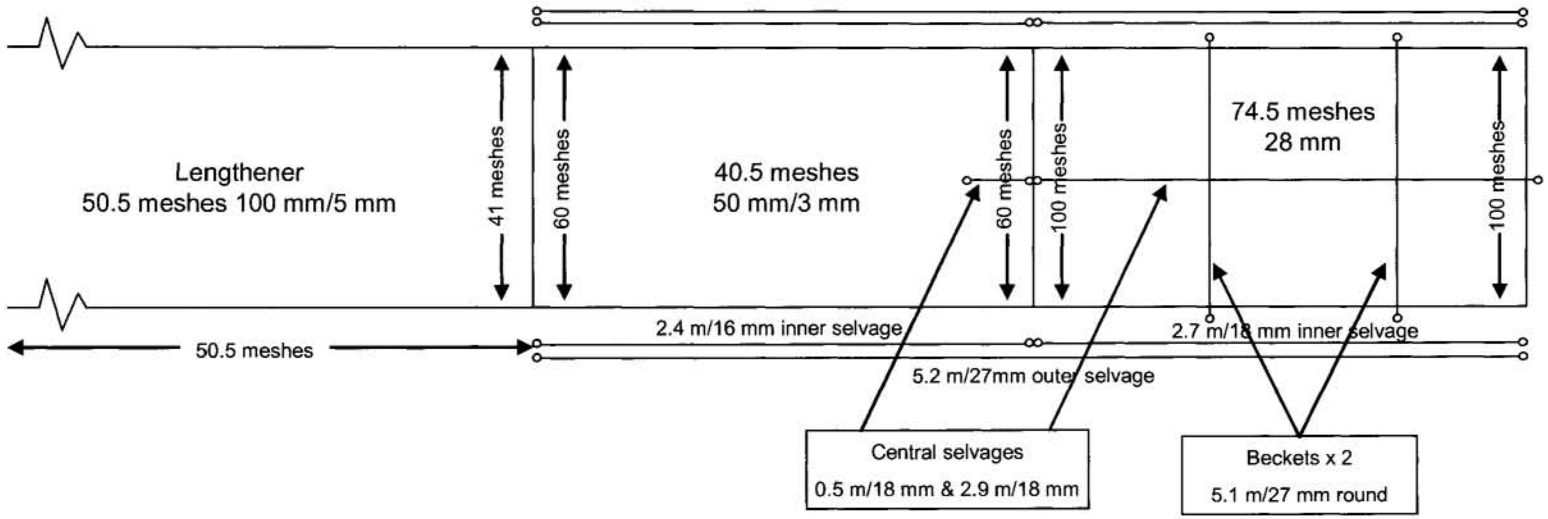
Appendix 1 –*continued*

## Codend for ECSI Inshore (30 – 400 m) trawl survey



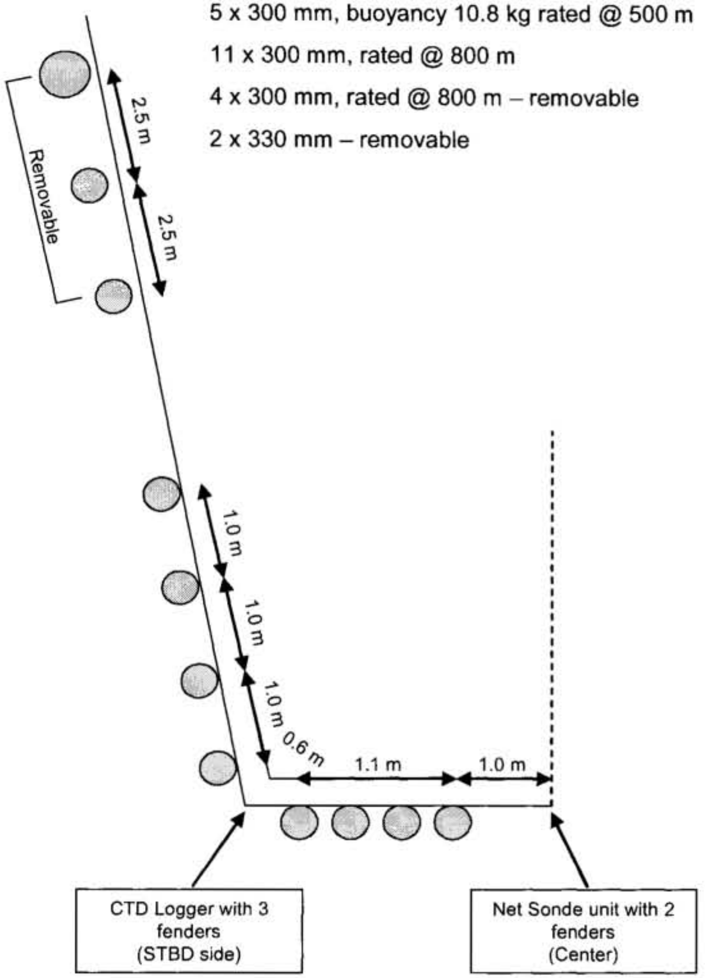
# Codend for ECSI Inshore (10 – 30 m) trawl survey



Appendix 1 –*continued*

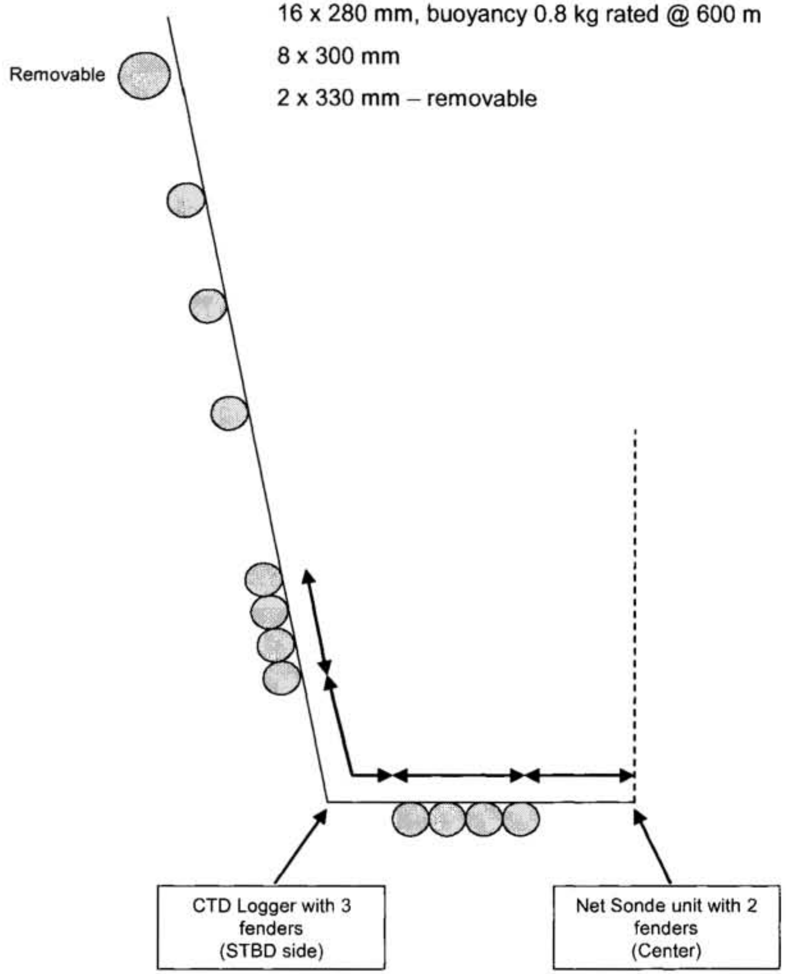
## Float Plan: R.V. *Kaharoa* Bottom Trawl Net A

### Total Floats: 22 on headline

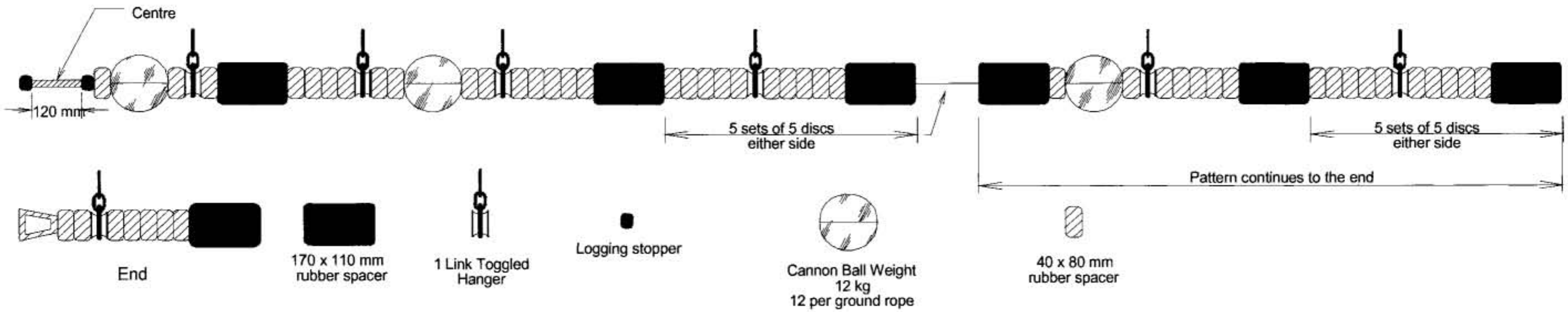



## Float Plan: R.V. *Kaharoa* Bottom Trawl Net B

### Total Floats: 26 on headline



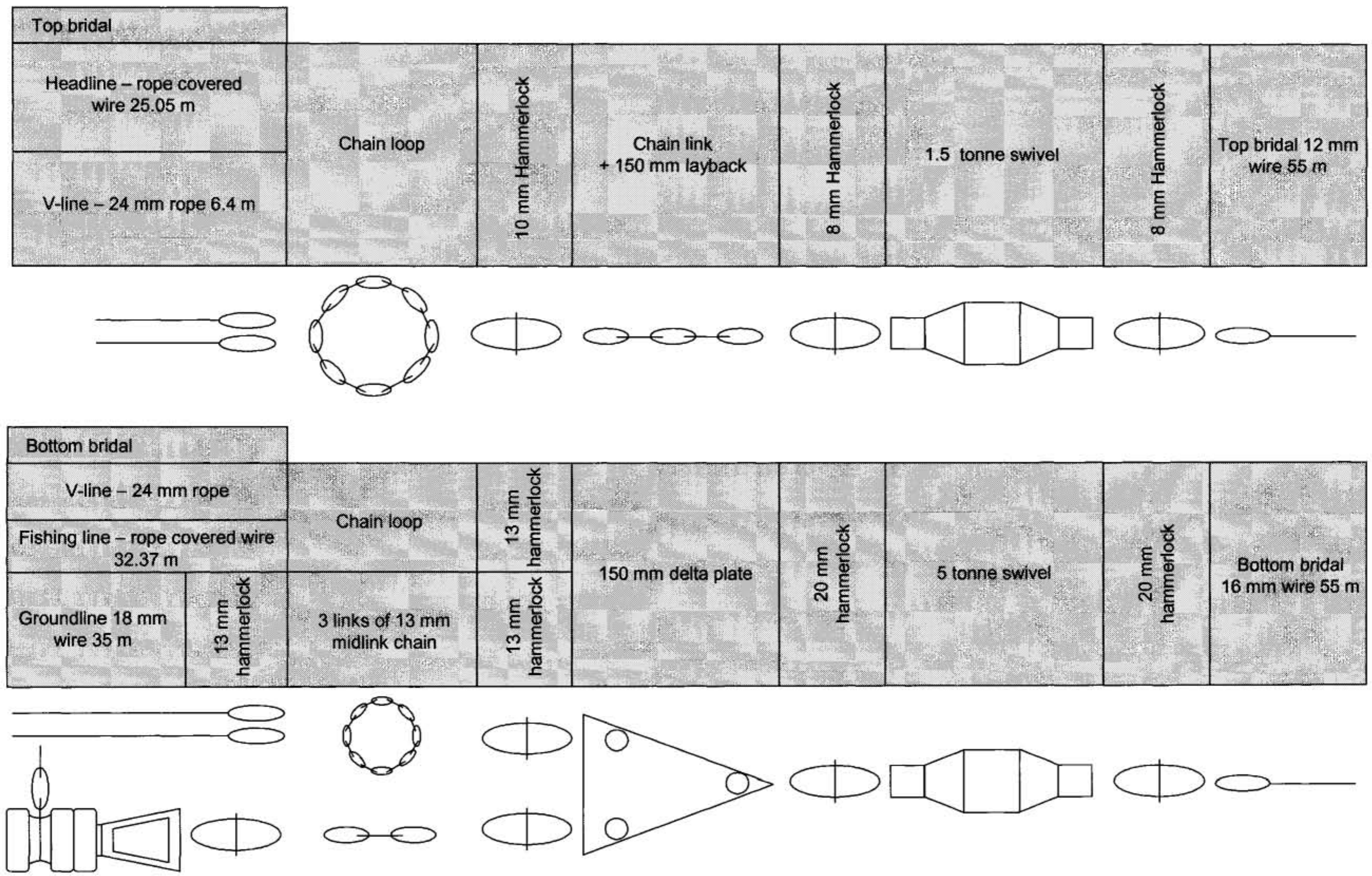
# Ground Rope Assembly: R.V. *Kaharoa* Bottom Trawl




31.950 m x 18 mm 6/19 wire + 1 x 13 mm H/lock & 3 links of 13 mm midlink chain each end

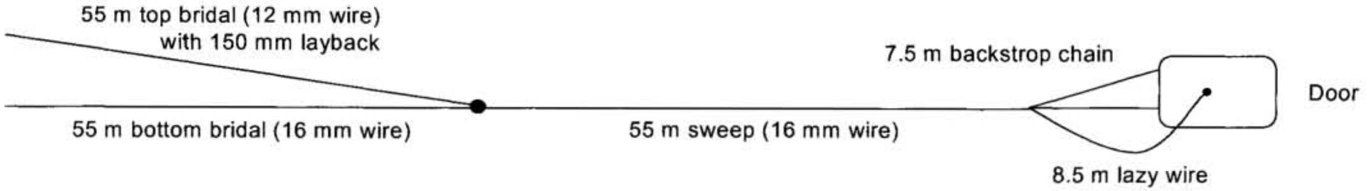
Appendix 1–*continued*

## Net to Bridal Assembly: R.V. *Kaharoa* Bottom Trawl with 150 mm layback



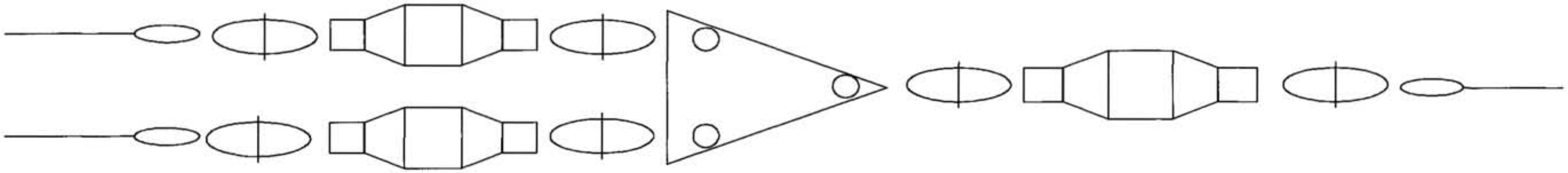
**Appendix1–*continued***

## Sweeping Gear: R.V. *Kaharoa* Bottom Trawl



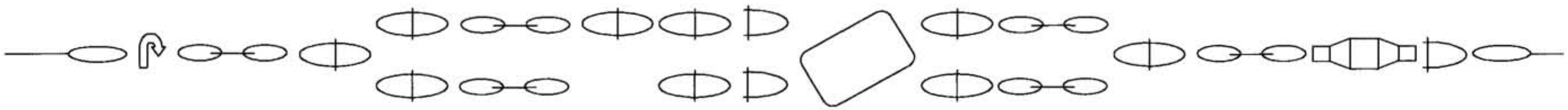

**Bridal to sweep connection**

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Top bridal 55 m 12 mm wire | 13 mm hammerlock | 3 tonne swivel | 16 mm hammerlock | 150 mm delta plate | 16 mm hammerlock | 5 tonne swivel | 16 mm hammerlock | Sweep wire 55 m 16 mm |
| Bottom bridal 55 m 16 mm wire | 13 mm hammerlock | 3 tonne swivel | 16 mm hammerlock | | | | | |



**Trawl door setting**

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sweep wire 55 m 16 mm | Hook | Chain | 14 mm H/L | 10 mm H/L | Chain | 10 mm H/L | 10 mm H/L | Shackle | Door Rectangular V 2.4 m x 1.5 m 3.2 m² 630 kg | 16 mm H/L | Chain | 14 mm H/L | Chain | Dry swivel | Shackle | Trawl warp wire 16 mm |
| | | | | 10 mm H/L | Chain | | 10 mm H/L | Shackle | | 16 mm H/L | Chain | | | | | |



## Appendix 2: Summary of station data.

| Station | Strata | Date | Time | Start of tow ° ' S | Start of tow ° ' E | End of tow ° ' S | End of tow ° ' E | Gear depth (m) Min. | Gear depth (m) Max. | Dist. trawled (n. miles) | Headline height (m) | Doorspread (m) | Surface temp. (°C) | Bottom temp. (°C) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 13 | 5-May-07 | 1553 | 43 02.41 | 173 36.05 | 43 05.30 | 173 35.15 | 128 | 130 | 2.96 | 4.6 | 83.7 | 12.8 | 10.9 |
| 2 | 13 | 6-May-07 | 646 | 43 07.02 | 173 33.51 | 43 09.90 | 173 34.70 | 120 | 124 | 3 | 4.5 | 75.5 | 12.9 | 11.3 |
| 3 | 13 | 6-May-07 | 922 | 43 08.95 | 173 32.71 | 43 11.78 | 173 31.32 | 114 | 116 | 3 | 4.5 | 74.4 | 12.8 | 11.3 |
| 4 | 7 | 6-May-07 | 1254 | 43 12.87 | 173 19.82 | 43 10.08 | 173 21.02 | 61 | 64 | 2.92 | 4.6 | 74.2 | 13.5 | 11.7 |
| 5 | 7 | 6-May-07 | 1541 | 43 02.57 | 173 20.66 | 43 05.07 | 173 18.43 | 59 | 59 | 2.98 | 4.7 | 74.1 | 13 | 11.4 |
| 6 | 7 | 7-May-07 | 641 | 43 02.47 | 173 17.47 | 43 04.61 | 173 14.65 | 55 | 60 | 2.97 | 4.6 | 75.2 | 13.2 | 11.9 |
| 7 | 7 | 7-May-07 | 922 | 43 07.19 | 173 16.29 | 43 09.66 | 173 13.93 | 50 | 55 | 3.01 | 4.8 | 77.8 | 13.3 | 11.9 |
| 8 | 7 | 7-May-07 | 1130 | 43 12.48 | 173 15.02 | 43 12.20 | 173 10.92 | 42 | 46 | 3 | 4.8 | 76.1 | 13.4 | 11.9 |
| 9 | 7 | 7-May-07 | 1322 | 43 09.86 | 173 05.93 | 43 12.00 | 173 02.96 | 42 | 46 | 3.04 | 4.6 | 77.3 | 13.3 | 12.3 |
| 10 | 7 | 7-May-07 | 1516 | 43 13.35 | 172 56.51 | 43 16.17 | 172 54.90 | 33 | 35 | 3.05 | 4.6 | 76.3 | 13.6 | 12.5 |
| 11 | 7 | 8-May-07 | 644 | 43 25.75 | 173 11.29 | 43 22.70 | 173 11.40 | 34 | 34 | 3.05 | 4.5 | 72 | 13.2 | 13.1 |
| 12 | 7 | 8-May-07 | 906 | 43 18.35 | 173 05.42 | 43 18.97 | 173 01.43 | 32 | 32 | 2.96 | 4.7 | 71.6 | 13.7 | 13.5 |
| 13 | 7 | 8-May-07 | 1143 | 43 21.38 | 172 59.08 | 43 19.64 | 172 55.64 | 30 | 31 | 3.04 | 4.6 | 73.3 | 13.7 | 13.5 |
| 14 | 18 | 8-May-07 | 1447 | 43 17.90 | 172 44.23 | 43 19.88 | 172 44.10 | 13 | 15 | 1.98 | 4.7 | 70.4 | 13.8 | 13.8 |
| 15 | 18 | 9-May-07 | 652 | 43 25.74 | 172 57.33 | 43 27.59 | 172 58.65 | 27 | 28 | 2.08 | 4.6 | 75.1 | 13.6 | 13.5 |
| 16 | 18 | 9-May-07 | 913 | 43 34.28 | 173 08.65 | 43 36.31 | 173 08.90 | 24 | 25 | 2.03 | 4.7 | 71.4 | 13.4 | 13.4 |
| 17 | 6 | 9-May-07 | 1117 | 43 38.37 | 173 12.59 | 43 35.44 | 173 13.05 | 46 | 48 | 2.94 | 4.3 | 76.7 | 13.2 | 12.9 |
| 18 | 6 | 9-May-07 | 1403 | 43 33.15 | 173 18.52 | 43 36.24 | 173 18.36 | 64 | 65 | 3.09 | 4.8 | 72.5 | 12.8 | 12.5 |
| 19 | 6 | 9-May-07 | 1550 | 43 36.84 | 173 21.48 | 43 39.94 | 173 21.45 | 75 | 75 | 3.1 | 4.6 | 73.8 | 12.7 | 12.4 |
| 20 | 6 | 10-May-07 | 650 | 43 28.64 | 173 24.53 | 43 31.54 | 173 25.54 | 86 | 89 | 2.99 | 4.6 | 73.4 | 12.7 | 11.1 |
| 21* | 13 | 10-May-07 | 927 | 43 30.19 | 173 33.39 | 43 32.18 | 173 32.76 | 92 | 132 | 2.03 | 4.5 | 78.8 | – | – |
| 22 | 6 | 10-May-07 | 1149 | 43 36.12 | 173 28.37 | 43 39.24 | 173 28.26 | 88 | 91 | 3.12 | 4.5 | 73.4 | 12.6 | 11.4 |
| 23 | 6 | 10-May-07 | 1439 | 43 43.12 | 173 39.03 | 43 46.24 | 173 38.20 | 90 | 90 | 3.17 | 4.9 | 79.7 | 12.4 | 11.3 |
| 24 | 17 | 11-May-07 | 710 | 43 30.86 | 174 00.41 | 43 33.44 | 174 02.70 | 351 | 365 | 3.06 | 4.5 | 85 | 11.3 | 8.6 |
| 25 | 12 | 11-May-07 | 952 | 43 40.84 | 173 59.07 | 43 43.72 | 173 58.10 | 151 | 151 | 2.96 | 4.1 | 82.3 | 12.1 | 10.7 |
| 26 | 17 | 11-May-07 | 1244 | 43 49.03 | 173 58.47 | 43 51.82 | 173 56.64 | 218 | 220 | 3.08 | 4.4 | 84 | 12.3 | 9.3 |
| 27 | 17 | 11-May-07 | 1511 | 43 53.70 | 173 56.71 | 43 56.10 | 173 54.41 | 310 | 314 | 2.91 | 4.2 | 88 | 11.2 | 8.7 |
| 28 | 5 | 12-May-07 | 1331 | 43 56.88 | 173 30.46 | 43 55.20 | 173 33.73 | 95 | 95 | 2.89 | 4.7 | 80.9 | 12.3 | 11.4 |
| 29 | 6 | 12-May-07 | 1532 | 43 51.92 | 173 40.56 | 43 49.97 | 173 43.45 | 97 | 99 | 2.85 | 4.8 | 80.2 | 12.5 | 11.3 |
| 30 | 12 | 13-May-07 | 647 | 43 51.34 | 173 52.99 | 43 53.90 | 173 50.94 | 138 | 144 | 2.95 | 4.5 | 84.8 | 11.1 | 10.8 |

**Appendix 2–*continued***

| | | | | Start of tow | | End of tow | | Gear depth (m) | | Dist. trawled | Headline | Doorspread | Surface temp. | Bottom temp. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Station | Strata | Date | Time | ° ' S | ° ' E | ° ' S | ° ' E | Min. | Max. | (n. miles) | height (m) | (m) | (°C) | (°C) |
| 31 | 12 | 13-May-07 | 852 | 43 51.78 | 173 46.28 | 43 53.82 | 173 43.74 | 105 | 106 | 2.74 | 4.5 | 79.9 | 11.8 | 11.1 |
| 32 | 11 | 13-May-07 | 1624 | 44 05.05 | 173 30.98 | 44 06.73 | 173 27.66 | 122 | 125 | 2.91 | 4.1 | 81.2 | 12 | 11.2 |
| 33 | 6 | 14-May-07 | 643 | 43 44.34 | 173 15.96 | 43 41.65 | 173 17.04 | 66 | 68 | 2.8 | 4.1 | 67.9 | 12.5 | 12.4 |
| 34 | 5 | 15-May-07 | 653 | 43 57.08 | 172 59.31 | 43 54.72 | 173 01.96 | 55 | 68 | 3.03 | 4.6 | 72.6 | 12.3 | 12.3 |
| 35 | 5 | 15-May-07 | 925 | 43 58.40 | 173 06.93 | 43 56.44 | 173 10.04 | 75 | 75 | 2.97 | 4.7 | 73.5 | 11.9 | 11.7 |
| 36 | 5 | 15-May-07 | 1209 | 43 06.73 | 173 14.07 | 43 08.81 | 173 10.84 | 92 | 96 | 3.14 | 4.2 | 77.3 | 11.9 | 11.6 |
| 37 | 11 | 15-May-07 | 1405 | 44 09.76 | 173 14.85 | 44 08.09 | 173 18.31 | 102 | 111 | 2.99 | 4.7 | 85.7 | 11.6 | 11.5 |
| 38 | 16 | 16-May-07 | 658 | 44 29.51 | 172 55.09 | 44 28.35 | 172 58.89 | 313 | 314 | 2.94 | 5.1 | 96.7 | 10.7 | 9.4 |
| 39* | 16 | 16-May-07 | 913 | 44 29.00 | 173 01.60 | 44 28.25 | 173 05.82 | 374 | 393 | 3.1 | 4.5 | 92.6 | 10.4 | 9.5 |
| 40 | 16 | 16-May-07 | 1124 | 44 28.58 | 173 04.00 | 44 29.35 | 173 00.16 | 357 | 391 | 2.84 | 4.5 | 88.9 | 10.5 | 9.6 |
| 41 | 11 | 16-May-07 | 1350 | 44 24.00 | 173 02.00 | 44 21.75 | 173 04.76 | 151 | 161 | 2.99 | 4.6 | 88.2 | 10.7 | 10.4 |
| 42 | 16 | 17-May-07 | 651 | 44 23.91 | 173 06.35 | 44 22.19 | 173 09.69 | 230 | 242 | 2.94 | 5.1 | 94.5 | 10.6 | 10.4 |
| 43 | 11 | 17-May-07 | 1003 | 44 15.84 | 173 00.80 | 44 17.06 | 172 56.83 | 106 | 110 | 3.09 | 4.2 | 83.7 | 11.9 | 10.8 |
| 44 | 11 | 17-May-07 | 1312 | 44 18.38 | 172 56.87 | 44 19.28 | 172 54.38 | 117 | 120 | 1.99 | 4.4 | 80.4 | 11.9 | 10.9 |
| 45 | 4 | 18-May-07 | 645 | 44 24.27 | 172 16.47 | 44 25.93 | 172 14.83 | 80 | 83 | 2.03 | 4.6 | 78.5 | 12.1 | 11.7 |
| 46 | 3 | 18-May-07 | 841 | 44 30.40 | 172 10.70 | 44 28.13 | 172 10.05 | 84 | 90 | 2.31 | 4.7 | 78.2 | 11.6 | 11.2 |
| 47 | 4 | 18-May-07 | 1015 | 44 25.03 | 172 06.33 | 44 22.38 | 172 04.34 | 67 | 72 | 3 | 4.8 | 71.1 | 12.2 | 11.8 |
| 48 | 3 | 18-May-07 | 1306 | 44 29.30 | 171 47.76 | 44 30.11 | 171 43.73 | 63 | 65 | 2.98 | 4.9 | 71.4 | 12 | 11.8 |
| 49 | 3 | 18-May-07 | 1459 | 44 24.90 | 171 43.45 | 44 21.96 | 171 42.69 | 50 | 53 | 2.98 | 4.7 | 71.9 | 12.6 | 12.5 |
| 50 | 3 | 19-May-07 | 1555 | 44 28.60 | 171 26.56 | 44 30.47 | 171 27.57 | 36 | 42 | 2 | 5.5 | 73.3 | 12.7 | 12.6 |
| 51 | 5 | 20-May-07 | 653 | 44 09.59 | 172 41.33 | 44 09.46 | 172 38.42 | 67 | 73 | 2.09 | 4.4 | 69.4 | 12.2 | 12.1 |
| 52 | 4 | 20-May-07 | 843 | 44 09.15 | 172 31.88 | 44 09.29 | 172 29.08 | 59 | 63 | 2.02 | 4.5 | 68.7 | 12.2 | 12.1 |
| 53 | 4 | 20-May-07 | 1229 | 44 08.30 | 172 11.90 | 44 09.10 | 172 09.43 | 45 | 46 | 1.94 | 4.8 | 75.3 | 12.5 | 12.8 |
| 54 | 4 | 20-May-07 | 1505 | 44 14.26 | 171 54.00 | 44 15.37 | 171 51.34 | 43 | 45 | 2.2 | 4.7 | 75.7 | 12.7 | 12.8 |
| 55 | 4 | 21-May-07 | 653 | 44 15.27 | 172 28.53 | 44 16.80 | 172 26.64 | 75 | 76 | 2.04 | 4.7 | 73.2 | 12.4 | 11.7 |
| 56 | 4 | 21-May-07 | 848 | 44 19.61 | 172 23.62 | 44 20.74 | 172 22.25 | 77 | 78 | 1.49 | 4.9 | 74.1 | 12.6 | 12.1 |
| 57 | 4 | 21-May-07 | 1202 | 44 25.18 | 172 21.82 | 44 26.62 | 172 22.47 | 86 | 91 | 1.51 | 4.9 | 80.3 | 12.4 | 11.5 |
| 58 | 10 | 21-May-07 | 1433 | 44 29.65 | 172 21.92 | 44 31.07 | 172 21.32 | 105 | 108 | 1.48 | 4.8 | 82.6 | 12.2 | 11.3 |
| 59 | 10 | 21-May-07 | 1633 | 44 33.53 | 172 17.41 | 44 34.52 | 172 15.93 | 110 | 112 | 1.44 | 4.7 | 82.2 | 11.6 | 11.4 |
| 60 | 10 | 22-May-07 | 700 | 44 28.90 | 172 26.12 | 44 28.03 | 172 27.84 | 110 | 110 | 1.5 | 4.7 | 82.4 | 11.8 | 11.3 |

**Appendix 2–*continued***

| Station | Strata | Date | Time | Start of tow ° ' S | Start of tow ° ' E | End of tow ° ' S | End of tow ° ' E | Gear depth (m) Min. | Gear depth (m) Max. | Dist. trawled (n. miles) | Headline height (m) | Doorspread (m) | Surface temp. (°C) | Bottom temp. (°C) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 61 | 10 | 22-May-07 | 844 | 44 24.00 | 172 36.60 | 44 23.50 | 172 38.58 | 109 | 110 | 1.5 | 4.8 | 82.8 | 12 | 11.2 |
| 62 | 5 | 22-May-07 | 1048 | 44 18.78 | 172 44.61 | 44 18.03 | 172 46.91 | 94 | 96 | 1.85 | 4.7 | 80.4 | 12 | 11.1 |
| 63 | 10 | 22-May-07 | 1256 | 44 21.33 | 172 46.08 | 44 22.76 | 172 44.17 | 110 | 114 | 1.97 | 4.7 | 80.4 | 12 | 10.8 |
| 64 | 10 | 22-May-07 | 1510 | 44 28.15 | 172 41.08 | 44 29.05 | 172 39.41 | 131 | 135 | 1.49 | 4.8 | 81.4 | 11.7 | 11 |
| 65 | 3 | 24-May-07 | 1349 | 44 40.24 | 171 23.62 | 44 42.27 | 171 24.17 | 40 | 41 | 2.06 | 4.8 | 73 | 12.4 | 11.8 |
| 66 | 2 | 24-May-07 | 1550 | 44 46.05 | 171 29.34 | 44 48.99 | 171 30.79 | 50 | 56 | 3.11 | 4.7 | 77.4 | 11.8 | 11.7 |
| 67 | 10 | 25-May-07 | 656 | 44 32.60 | 172 34.88 | 44 33.79 | 172 32.62 | 136 | 139 | 2 | 4.6 | 82.9 | 11.4 | 10.4 |
| 68 | 15 | 25-May-07 | 923 | 44 38.00 | 172 39.00 | 44 39.51 | 172 35.56 | 360 | 365 | 2.87 | 4.7 | 84.9 | 11.3 | 9.9 |
| 69 | 15 | 25-May-07 | 1146 | 44 40.80 | 172 32.56 | 44 42.03 | 172 28.86 | 361 | 362 | 2.9 | 4.5 | 84.5 | 10.8 | 10 |
| 70 | 15 | 25-May-07 | 1440 | 44 42.25 | 172 24.05 | 44 44.04 | 172 20.69 | 227 | 234 | 2.98 | 4.4 | 87.6 | 11.5 | 10.4 |
| 71 | 3 | 26-May-07 | 702 | 44 40.06 | 171 53.28 | 44 38.46 | 171 55.22 | 96 | 96 | 2.11 | 4.7 | 83.1 | 11.5 | 11.1 |
| 72 | 9 | 26-May-07 | 922 | 44 46.56 | 172 05.44 | 44 48.30 | 172 06.89 | 135 | 136 | 2.02 | 4.4 | 84.8 | 11 | 10.7 |
| 73 | 15 | 26-May-07 | 1118 | 44 47.73 | 172 15.30 | 44 49.72 | 172 12.29 | 270 | 318 | 2.91 | 4.4 | 86.7 | 11.2 | 10.3 |
| 74 | 9 | 26-May-07 | 1333 | 44 43.28 | 172 10.62 | 44 41.82 | 172 10.38 | 130 | 135 | 1.46 | 4.7 | 85.3 | 11.3 | 10.3 |
| 75 | 9 | 26-May-07 | 1544 | 44 46.02 | 171 56.28 | 44 46.29 | 171 53.39 | 109 | 116 | 2.06 | 4.4 | 83.4 | 11.5 | 11 |
| 76 | 1 | 27-May-07 | 657 | 45 26.79 | 171 06.96 | 45 28.23 | 171 06.40 | 59 | 62 | 1.53 | 4.8 | 73.1 | 11.4 | 11.5 |
| 77 | 1 | 27-May-07 | 841 | 45 28.96 | 171 10.17 | 45 27.72 | 171 11.57 | 94 | 95 | 1.58 | 4.4 | 63.8 | 11.5 | 11.5 |
| 78 | 1 | 27-May-07 | 1135 | 45 20.24 | 171 08.93 | 45 19.15 | 171 10.39 | 53 | 54 | 1.49 | 5.4 | 72.5 | 11.4 | 11.4 |
| 79 | 1 | 28-May-07 | 705 | 45 16.86 | 171 09.40 | 45 14.99 | 171 10.76 | 49 | 50 | 2.1 | 4.7 | 73.5 | 11.4 | 11.5 |
| 80 | 1 | 28-May-07 | 826 | 45 14.97 | 171 13.73 | 45 13.25 | 171 15.33 | 57 | 58 | 2.05 | 5 | 73.3 | 11.4 | 11.5 |
| 81 | 2 | 28-May-07 | 949 | 45 09.86 | 171 13.96 | 45 07.91 | 171 14.63 | 48 | 50 | 2 | 5 | 72.8 | 11.4 | 11.4 |
| 82 | 8 | 28-May-07 | 1207 | 45 14.93 | 171 23.27 | 45 14.31 | 171 26.08 | 101 | 116 | 2.07 | 4.9 | 82.4 | 11.6 | 11.5 |
| 83 | 14 | 28-May-07 | 1400 | 45 16.80 | 171 31.65 | 45 14.08 | 171 33.49 | 257 | 275 | 3.01 | 4.9 | 98.4 | 11.2 | 11.1 |
| 84 | 8 | 28-May-07 | 1609 | 45 07.81 | 171 33.18 | 45 05.82 | 171 34.75 | 117 | 120 | 2.27 | 4.5 | 85 | 11.4 | 11.1 |
| 85 | 8 | 29-May-07 | 710 | 45 04.11 | 171 40.02 | 45 05.59 | 171 39.75 | 129 | 129 | 1.49 | 4.4 | 80.3 | 11.4 | 11.3 |
| 86 | 14 | 29-May-07 | 846 | 45 07.20 | 171 42.39 | 45 04.93 | 171 44.95 | 210 | 255 | 2.9 | 5.1 | 93.3 | 11.2 | 10.1 |
| 87 | 14 | 29-May-07 | 1039 | 45 03.30 | 171 46.98 | 45 01.19 | 171 49.77 | 225 | 260 | 2.88 | 4.8 | 89.1 | 11.2 | 9.9 |
| 88 | 9 | 29-May-07 | 1237 | 44 59.57 | 171 45.27 | 44 57.61 | 171 45.52 | 125 | 126 | 1.96 | 4.8 | 83.5 | 11.1 | 11 |
| 89 | 2 | 29-May-07 | 1533 | 44 58.06 | 171 20.39 | 44 55.07 | 171 21.10 | 40 | 47 | 3.03 | 4.5 | 72.2 | 11.3 | 11.3 |
| 90 | 9 | 30-May-07 | 716 | 44 52.91 | 171 52.12 | 44 52.03 | 171 49.47 | 116 | 124 | 2.07 | 4.5 | 82.1 | 11.1 | 11.1 |

**Appendix 2–*continued***

| Station | Strata | Date | Time | Start of tow ° ' S | Start of tow ° ' E | End of tow ° ' S | End of tow ° ' E | Gear depth (m) Min. | Gear depth (m) Max. | Dist. trawled (n. miles) | Headline height (m) | Doorspread (m) | Surface temp. (°C) | Bottom temp. (°C) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 91 | 3 | 30-May-07 | 856 | 44 50.87 | 171 41.75 | 44 49.82 | 171 39.34 | 90 | 97 | 2 | 4.5 | 81.9 | 11.4 | 11.2 |
| 92 | 3 | 30-May-07 | 1021 | 44 48.57 | 171 37.16 | 44 50.54 | 171 36.86 | 79 | 83 | 1.98 | 4.8 | 77.3 | 11.3 | 11.3 |
| 93 | 4 | 1-Jun-07 | 717 | 44 01.14 | 172 25.53 | 44 01.57 | 172 28.31 | 41 | 49 | 2.04 | 4.6 | 72.6 | 12 | 12.2 |
| 94 | 4 | 1-Jun-07 | 854 | 44 05.63 | 172 33.64 | 44 06.92 | 172 34.83 | 57 | 57 | 1.54 | 4.7 | 71.4 | 12.2 | 12 |
| 95 | 4 | 1-Jun-07 | 1104 | 44 18.50 | 172 32.02 | 44 20.52 | 172 32.11 | 76 | 82 | 2.02 | 4.6 | 76.1 | 11.6 | 11.6 |
| 96 | 4 | 1-Jun-07 | 1345 | 44 20.87 | 172 11.50 | 44 22.91 | 172 11.61 | 69 | 71 | 2.04 | 4.6 | 71.1 | 11.9 | 11.7 |
| 97 | 4 | 1-Jun-07 | 1527 | 44 28.63 | 172 15.76 | 44 30.12 | 172 15.25 | 92 | 97 | 1.53 | 4.6 | 77.9 | 11.5 | 11.3 |
| 98* | 1 | 2-Jun-07 | 726 | 45 33.36 | 171 07.44 | 45 32.66 | 171 07.84 | 97 | 97 | 0.75 | 4.6 | 67.7 | 11.5 | 11.5 |
| 99 | 1 | 2-Jun-07 | 847 | 45 25.97 | 171 06.46 | 45 24.10 | 171 07.47 | 56 | 57 | 1.99 | 4.7 | 72.4 | 11.5 | 11.5 |
| 100 | 1 | 2-Jun-07 | 1011 | 45 19.66 | 171 06.26 | 45 17.73 | 171 07.17 | 45 | 46 | 2.03 | 4.9 | 71.9 | 11.3 | 11.5 |
| 101 | 21 | 3-Jun-07 | 728 | 44 50.18 | 171 19.02 | 44 48.44 | 171 19.39 | 29 | 30 | 1.75 | 4.4 | 67.2 | 11.2 | 11.2 |
| 102 | 21 | 3-Jun-07 | 912 | 44 45.69 | 171 19.03 | 44 44.39 | 171 17.78 | 26 | 31 | 1.57 | 4.6 | 67.5 | 11.2 | 11.2 |
| 103 | 20 | 3-Jun-07 | 1146 | 44 28.36 | 171 17.82 | 44 26.60 | 171 19.46 | 20 | 21 | 2.11 | 4.5 | 69.1 | 11.9 | 11.9 |
| 104 | 20 | 3-Jun-07 | 1520 | 44 10.34 | 171 37.25 | 44 09.75 | 171 39.94 | 16 | 17 | 2.01 | 4.8 | 69 | 11.8 | 11.8 |
| 105 | 20 | 3-Jun-07 | 1635 | 44 10.89 | 171 44.20 | 44 11.59 | 171 46.70 | 23 | 29 | 1.92 | 4.7 | 74.1 | 12.1 | 12.1 |
| 106 | 19 | 4-Jun-07 | 724 | 44 08.48 | 171 52.19 | 44 07.42 | 171 54.60 | 25 | 25 | 2.02 | 4.3 | 73.3 | 12 | 12 |
| 107 | 19 | 4-Jun-07 | 914 | 44 02.94 | 172 04.06 | 44 02.23 | 172 06.56 | 24 | 24 | 1.93 | 4.7 | 74.2 | 11.9 | 11.9 |
| 108 | 19 | 4-Jun-07 | 1052 | 43 58.43 | 172 14.62 | 43 58.02 | 172 17.28 | 28 | 29 | 1.95 | 4.7 | 72.1 | 12 | 12 |

* Station not used for biomass estimates because of poor gear performance

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

| | *n* | Mean | s.d. | Range |
|---|---|---|---|---|
| **All stations** | | | | |
| Headline height (m) | 105 | 4.6 | 0.23 | 4.1–5.5 |
| Doorspread (m) | 105 | 78.0 | 6.68 | 63.8–98.4 |
| Distance (n. miles) | 105 | 2.4 | 0.60 | 1.44–3.17 |
| Warp:depth ratio | 105 | 3.9 | 2.01 | 2.40–14.29 |
| **Standard survey (30–400 m)** | | | | |
| 30–400 m | | | | |
| Headline height (m) | 94 | 4.7 | 0.24 | 4.1 –5.5 |
| Doorspread (m) | 94 | 78.8 | 6.71 | 63.8–98.4 |
| Distance (n. miles) | 94 | 2.5 | 0.59 | 1.44–3.17 |
| Warp:depth ratio | 94 | 3.3 | 0.85 | 2.40–6.56 |
| 30–100 m | | | | |
| Headline height (m) | 55 | 4.7 | 0.23 | 4.1–5.5 |
| Doorspread (m) | 55 | 74.5 | 3.67 | 63.8–83.1 |
| Distance (n. miles) | 55 | 2.5 | 0.58 | 1.49–3.17 |
| Warp:depth ratio | 55 | 3.6 | 0.96 | 2.6–6.6 |
| 100–200 m | | | | |
| Headline height (m) | 26 | 4.6 | 0.21 | 4.1–4.9 |
| Doorspread (m) | 26 | 82.4 | 2.90 | 74.4–88.2 |
| Distance (n. miles) | 26 | 2.2 | 0.62 | 1.44–3.09 |
| Warp:depth ratio | 26 | 2.9 | 0.19 | 2.6–3.6 |
| 200–400 m | | | | |
| Headline height (m) | 13 | 4.7 | 0.31 | 4.2–5.1 |
| Doorspread (m) | 13 | 89.4 | 4.84 | 84 –98.4 |
| Distance (n. miles) | 13 | 2.9 | 0.07 | 2.84–3.08 |
| Warp:depth ratio | 13 | 2.6 | 0.16 | 2.4–2.9 |
| **Inshore survey (10–30 m)** | | | | |
| Headline height (m) | 11 | 4.6 | 0.15 | 4.3–4.8 |
| Doorspread (m) | 11 | 71.2 | 2.78 | 67.2–75.1 |
| Distance (n. miles) | 11 | 1.9 | 0.16 | 1.57 –2.11 |
| Warp:depth ratio | 11 | 8.8 | 2.39 | 6.8–14.3 |

**Appendix 4: Species codes, common names, scientific names, total catch, and occurrence for stations in 30–400 m and 10–30 m, in order of catch weight.**

**30–400 m depth range**

| Species code | Common name | Scientific name | Catch (kg) | % of total catch | Occurrence (% stations) |
|---|---|---|---|---|---|
| SPD | Spiny dogfish | *Squalus acanthias* | 40 832.3 | 38.8 | 100 |
| BAR | Barracouta | *Thyrsites atun* | 26 916.3 | 25.6 | 88 |
| GSH | Dark ghost shark | *Hydrolagus novaezelandiae* | 7 120.4 | 6.8 | 50 |
| TAR | Tarakihi | *Nemadactylus macropterus* | 3 164.9 | 3.0 | 66 |
| NOS | NZ southern arrow squid | *Nototodarus sloanii* | 3 030.0 | 2.9 | 97 |
| SPE | Sea perch | *Helicolenus* spp. | 2708.8 | 2.6 | 65 |
| RCO | Red cod | *Pseudophycis bachus* | 2 475.8 | 2.4 | 71 |
| RUB | Rubbish other than fish | | 2 000.0 | 1.9 | 1 |
| GUR | Red gurnard | *Chelidonichthys kumu* | 1 925.7 | 1.8 | 56 |
| WAR | Blue warehou | *Seriolella brama* | 1 797.4 | 1.7 | 34 |
| CAR | Carpet shark | *Cephaloscyllium isabella* | 1 372.3 | 1.3 | 83 |
| ELE | Elephantfish | *Callorhinchus milii* | 1 182.0 | 1.1 | 37 |
| RSK | Rough skate | *Dipturus nasutus* | 1 123.3 | 1.1 | 53 |
| SCG | Scaly gurnard | *Lepidotrigla brachyoptera* | 1 107.3 | 1.1 | 76 |
| STA | Giant stargazer | *Kathetostoma giganteum* | 1 059.2 | 1.0 | 85 |
| SSK | Smooth skate | *Dipturus innominatus* | 970.3 | 0.9 | 51 |
| SWA | Silver warehou | *Seriolella punctata* | 794.4 | 0.8 | 69 |
| SCH | School shark | *Galeorhinus galeus* | 672.1 | 0.6 | 45 |
| LIN | Ling | *Genypterus blacodes* | 607.4 | 0.6 | 43 |
| SDO | Silver dory | *Cyttus novaezelandiae* | 526.9 | 0.5 | 50 |
| CBE | Crested bellowsfish | *Notopogon lilliei* | 453.7 | 0.4 | 47 |
| WIT | Witch | *Arnoglossus scapha* | 441.7 | 0.4 | 90 |
| HAP | Hapuku | *Polyprion oxygeneios* | 335.2 | 0.3 | 50 |
| PIG | Pigfish | *Congiopodus leucopaecilus* | 328.9 | 0.3 | 59 |
| JAV | Javelinfish | *Lepidorhynchus denticulatus* | 327.4 | 0.3 | 6 |
| HOK | Hoki | *Macruronus novaezelandiae* | 258.0 | 0.2 | 6 |
| LEA | Leatherjacket | *Parika scaber* | 177.5 | 0.2 | 18 |
| CBI | Two saddle rattail | *Caelorinchus biclinozonalis* | 168.8 | 0.2 | 27 |
| SPO | Rig | *Mustelus lenticulatus* | 151.5 | 0.1 | 21 |
| FHD | Deepsea flathead | *Hoplichthys haswelli* | 142.7 | 0.1 | 7 |
| BCO | Blue cod | *Parapercis colias* | 133.0 | 0.1 | 22 |
| LSO | Lemon sole | *Pelotretis flavilatus* | 96.0 | 0.1 | 40 |
| ERA | Electric ray | *Torpedo fairchildi* | 85.5 | 0.1 | 12 |
| CAS | Oblique banded rattail | *Caelorinchus aspercephalus* | 75.2 | 0.1 | 19 |
| CBO | Bollons's rattail | *C. bollonsi* | 65.9 | 0.1 | 3 |
| LDO | Lookdown dory | *Cyttus traversi* | 55.3 | 0.1 | 6 |
| JMD | N.Z. jack mackerel | *Trachurus declivis* | 52.4 | <0.1 | 21 |
| SCC | Sea cucumber | *Stichopus mollis* | 49.5 | <0.1 | 38 |
| BRA | Short-tailed black ray | *Dasyatis brevicaudata* | 39.7 | <0.1 | 1 |
| SSI | Silverside | *Argentina elongata* | 38.6 | <0.1 | 43 |
| OCT | Octopus | *Pinnoctopus cordiformis* | 36.5 | <0.1 | 16 |
| SPF | Scarlet wrasse | *Pseudolabrus miles* | 25.4 | <0.1 | 2 |
| SFL | Sand flounder | *Rhombosolea plebeia* | 23.7 | <0.1 | 6 |
| MOK | Moki | *Latrisopsis ciliaris* | 22.5 | <0.1 | 6 |
| JMM | Chilean jack mackerel | *T. symmetricus murphyi* | 20.5 | <0.1 | 9 |
| TOD | Dark toadfish | *Neophrynichthys latus* | 14.1 | <0.1 | 30 |
| UNI | Unidentified | | 13.7 | <0.1 | 17 |
| CRB | Crab | Decapoda | 13.4 | <0.1 | 29 |

**Appendix 4–*continued***

**30–400 m depth range**

| Species code | Common name | Scientific name | Catch (kg) | % of total catch | Occurrence (% stations) |
|---|---|---|---|---|---|
| ONG | Sponges | Porifera (phylum) | 12.7 | <0.1 | 12 |
| KIN | Kingfish | *Seriola lalandi* | 12.1 | <0.1 | 1 |
| COF | Flabellum coral | Flabellidae | 11.7 | <0.1 | 6 |
| ANT | Anemones | Anthazoa | 6.7 | <0.1 | 13 |
| PAG | Hermit crab | Paguroidea | 6.6 | <0.1 | 30 |
| BTS | *Pavoraja spinifera* | *Pavoraja spinifera* | 6.0 | <0.1 | 2 |
| GFL | Greenback flounder | *Rhombosolea tapirina* | 5.9 | <0.1 | 1 |
| ESO | N.Z. sole | *Peltorhamphus novaezelandiae* | 5.6 | <0.1 | 7 |
| JMN | N.Z. jack mackerel | *T. novaezelandiae* | 5.4 | <0.1 | 4 |
| SAM | Quinnat salmon | *Oncorhynchus tshawytscha* | 3.9 | <0.1 | 2 |
| HAK | Hake | *Merluccius australis* | 3.4 | <0.1 | 2 |
| WWA | White warehou | *Seriolella caerulea* | 3.2 | <0.1 | 2 |
| CTU | Cook's turban shell | *Cookia sulcata* | 3.1 | <0.1 | 10 |
| GON | Sandfish | *Gonorynchus* sp. | 2.9 | <0.1 | 3 |
| BBE | Banded bellowsfish | *Centriscops humerosus* | 2.7 | <0.1 | 1 |
| CON | Conger eel | *Conger* spp. | 2.3 | <0.1 | 1 |
| KAH | Kahawai | *Arripis trutta* | 2.3 | <0.1 | 1 |
| EMA | Blue mackerel | *Scomber australasicus* | 2.2 | <0.1 | 1 |
| ASR | Starfish | Asteroidea | 2.1 | <0.1 | 9 |
| SPR | Sprats | *Sprattus antipodum, S. muelleri* | 2.0 | <0.1 | 3 |
| GAS | Gastropod | Gastropoda | 1.9 | <0.1 | 9 |
| COU | Coral (unspecified) | Anthozoa | 1.8 | <0.1 | 3 |
| CRU | Crustacean (unspecified) | Crustacea | 1.6 | <0.1 | 5 |
| GPF | Girdled wrasse | *Notolabrus cinctus* | 1.5 | <0.1 | 1 |
| DSP | Deepsea pigfish | *Congiopodus coriaceus* | 1.3 | <0.1 | 3 |
| HAG | Hagfish | *Eptatretus cirrhatus* | 1.2 | <0.1 | 1 |
| JDO | John dory | *Zeus faber* | 1.2 | <0.1 | 2 |
| MDO | Mirror dory | *Zenopsis nebulosus* | 1.2 | <0.1 | 1 |
| YCO | Yellow cod | *Parapercis gillesi* | 1.1 | <0.1 | 1 |
| MSL | Sladen's star | *Medialter sladini* | 1.0 | <0.1 | 4 |
| SUR | Kina | *Evechinus chloroticus* | 1.0 | <0.1 | 3 |
| AGR | Ribbonfish | *Agrostichthys parkeri* | 0.9 | <0.1 | 1 |
| OPA | Opalfish | *Hemerocoetes* spp. | 0.9 | <0.1 | 10 |
| ETL | Lucifer dogfish | *Etmopterus lucifer* | 0.8 | <0.1 | 1 |
| TRU | Trumpeter | *Latris lineata* | 0.8 | <0.1 | 1 |
| QSC | Queen scallop | *Chlamys delicatula* | 0.6 | <0.1 | 2 |
| BYS | Alfonsino | *Beryx splendens* | 0.5 | <0.1 | 1 |
| DCS | Dawson's catshark | *Halaelurus sawsoni* | 0.5 | <0.1 | 2 |
| SCO | Swollenhead conger | *Bassanago bulbiceps* | 0.5 | <0.1 | 1 |
| SHO | Seahorse | *Hippocampus abdominalis* | 0.5 | <0.1 | 4 |
| STY | Spotty | *Notolabrus celidotus* | 0.5 | <0.1 | 2 |
| TOP | Pale toadfish | *Neophrynichthys angustus* | 0.5 | <0.1 | 1 |
| MSB | Blue mussel | *Mytilus galloprovincialis* | 0.4 | <0.1 | 1 |
| POL | Sea worm | Polychaeta | 0.4 | <0.1 | 2 |
| SCI | Scampi | *Metanephrops challengeri* | 0.4 | <0.1 | 1 |
| GPA | Parasol urchin | *Gonocisaris parasol* | 0.3 | <0.1 | 2 |
| HDR | Hydroid | *Hydrozoa* | 0.3 | <0.1 | 3 |
| OYS | Dredge oyster | *Tiostrea chilensis* | 0.3 | <0.1 | 3 |
| SPM | Sprat | *Sprattus muelleri* | 0.3 | <0.1 | 1 |

**Appendix 4–*continued***

**30–400 m depth range**

| Species code | Common name | Scientific name | Catch (kg) | % of total catch | Occurrence (% stations) |
|---|---|---|---|---|---|
| BTA | *Pavoraja asperula* | *Pavoraja asperula* | 0.2 | <0.1 | 1 |
| LFB | Longfinned boarfish | *Zanclistius elevatus* | 0.2 | <0.1 | 1 |
| SDR | Spiny seadragon | *Solegnathus spinosissimus* | 0.2 | <0.1 | 2 |
| SHR | Sea hare | Aplysiomorpha | 0.2 | <0.1 | 2 |
| CCX | Small banded rattail | *Caelorinchus parvifasciatus* | 0.1 | <0.1 | 1 |
| DGT | Dragonets | Callionymidae | 0.1 | <0.1 | 1 |
| FIS | Fish (unspecified) | | 0.1 | <0.1 | 1 |
| GLB | Globefish | *Contusus richei* | 0.1 | <0.1 | 1 |
| GOU | Umbrella urchin | *Gonocisaris umbraculum* | 0.1 | <0.1 | 1 |
| GRM | Deepsea kina | *Gracilechinus multisentatus* | 0.1 | <0.1 | 1 |
| PCO | Ahuru | *Auchenoceros punctatus* | 0.1 | <0.1 | 1 |
| RHY | Common roughy | *Paratrachichthys trailli* | 0.1 | <0.1 | 1 |
| SFI | Starfish | Asteroidea | 0.1 | <0.1 | 1 |
| | | Total | 105 162 | | |

**10–30 m depth range**

| Species code | Common name | Scientific name | Catch (kg) | % of total catch | Occurrence (% stations) |
|---|---|---|---|---|---|
| BAR | Barracouta | *Thyrsites atun* | 3 148.8 | 38.2 | 100 |
| SPD | Spiny dogfish | *Squalus acanthias* | 1 568.5 | 19.0 | 100 |
| LEA | Leatherjacket | *Parika scaber* | 1 023.9 | 12.4 | 73 |
| ELE | Elephantfish | *Callorhinchus milii* | 727.6 | 8.8 | 73 |
| GUR | Red gurnard | *Chelidonichthys kumu* | 489.1 | 5.9 | 100 |
| NOS | NZ southern arrow squid | *Nototodarus sloanii* | 447.4 | 5.4 | 73 |
| RSK | Rough skate | *Dipturus nasutus* | 323.4 | 3.9 | 100 |
| TAR | Tarakihi | *Nemadactylus macropterus* | 70.7 | 0.9 | 27 |
| CAR | Carpet shark | *Cephaloscyllium isabella* | 69.6 | 0.8 | 73 |
| WAR | Blue warehou | *Seriolella brama* | 53.6 | 0.6 | 82 |
| RCO | Red cod | *Pseudophycis bachus* | 46.5 | 0.6 | 82 |
| GLB | Globefish | *Contusus richei* | 43.8 | 0.5 | 55 |
| ERA | Electric ray | *Torpedo fairchildi* | 40.4 | 0.5 | 27 |
| SPO | Rig | *Mustelus lenticulatus* | 39.4 | 0.5 | 36 |
| SPR | Sprats | *Sprattus antipodum, S. muelleri* | 38.2 | 0.5 | 55 |
| SFL | Sand flounder | *Rhombosolea plebeia* | 27.6 | 0.3 | 55 |
| SEV | Broadnose sevengill shark | *Notorynchus cepedianus* | 24.5 | 0.3 | 9 |
| ESO | N.Z. sole | *Peltorhamphus novaezelandiae* | 13.3 | 0.2 | 55 |
| SCH | School shark | *Galeorhinus galeus* | 11.1 | 0.1 | 55 |
| WIT | Witch | *Arnoglossus scapha* | 6.3 | 0.1 | 55 |
| HAP | Hapuku | *Polyprion oxygeneios* | 6.1 | 0.1 | 27 |
| BRI | Brill | *Colistium guntheri* | 5.8 | 0.1 | 9 |
| TUR | Turbot | *Colistium nudipinnis* | 4.4 | 0.1 | 9 |
| SWA | Silver warehou | *Seriolella punctata* | 4.3 | 0.1 | 55 |
| SPZ | Spotted stargazer | *Genyagnus monopterygius* | 3.7 | <0.1 | 9 |
| YBF | Yellow-belly flounder | *Rhombosolea leporina* | 2.6 | <0.1 | 9 |
| JMM | Chilean jack mackerel | *T. symmetricus murphyi* | 2.5 | <0.1 | 9 |
| LSO | Lemon sole | *Pelotretis flavilatus* | 2.4 | <0.1 | 45 |
| PCO | Ahuru | *Auchenoceros punctatus* | 1.7 | <0.1 | 45 |

**Appendix 4–*continued***

**10–30 m depth range**

| Species code | Common name | Scientific name | Catch (kg) | % of total catch | Occurrence (% stations) |
|---|---|---|---|---|---|
| STY | Spotty | *Notolabrus celidotus* | 1.3 | <0.1 | 18 |
| HAG | Hagfish | *Eptatretus cirrhatus* | 0.8 | <0.1 | 9 |
| HOR | Horse mussel | *Atrina zelandica* | 0.5 | <0.1 | 9 |
| CRB | Crab | Decapoda | 0.4 | <0.1 | 9 |
| HAK | Hake | *Merluccius australis* | 0.4 | <0.1 | 9 |
| TOD | Dark toadfish | *Neophrynichthys latus* | 0.4 | <0.1 | 18 |
| SAZ | Sand stargazer | *Crapatalus novaezelandiae* | 0.3 | <0.1 | 18 |
| ASR | Starfish | Asteroidea | 0.2 | <0.1 | 9 |
| JMD | N.Z. jack mackerel | *Trachurus declivis* | 0.2 | <0.1 | 9 |
| SPS | Speckled sole | *Peltorhamphus latus* | 0.2 | <0.1 | 18 |
| ANC | Anchovy | *Engraulis australis* | 0.1 | <0.1 | 9 |
| CRU | Crustacean (unspecified) | Crustacea | 0.1 | <0.1 | 9 |
| OCT | Octopus | *Pinnoctopus cordiformis* | 0.1 | <0.1 | 9 |
| PAD | Paddle crab | *Ovalipes catharus* | 0.1 | <0.1 | 9 |
| PIG | Pigfish | *Congiopodus leucopaecilus* | 0.1 | <0.1 | 9 |
| SAM | Quinnat salmon | *Oncorhynchus tshawytscha* | 0.1 | <0.1 | 9 |
| SCC | Sea cucumber | *Stichopus mollis* | 0.1 | <0.1 | 9 |
| SLS | Slender sole | *Peltorhamphus tenuis* | 0.1 | <0.1 | 9 |
| | | Total | 8 253 | | |
| | | Grand Total (10–400 m) | 113 415 | | |

**Appendix 5: Macro-invertebrates collected on the 2007 survey.**

| Taxon | Occurance |
|---|---|
| **Porifera** | |
| *Callyspongia* n. sp. 12 | 2 |
| *Chondropsis* cf n. sp. 4 | 2 |
| *Crella incrustans* (Carter, 1885) sensu Bergquist & Fromont (1988) | 2 |
| *Dactylia* n. sp. 1 | 1 |
| *Ircina aucklandensis* Cook & Bergquist, 1999 | 1 |
| *Ircinia akaroa* Cook & Bergquist, 1999 | 2 |
| *Psammocinia cf maorimotu* Cook & Bergquist, 1998 | 2 |
| *Psammocinia* sp. D Cook & Bergquist, 1998 | 1 |
| *Tedania diversirhaphidiophora* Brondsted, 1923 | 1 |
| **Cnidaria: Anthozoa** | |
| Actinotolidae | 54 |
| *Flabellum* sp. | 6 |
| Hormathiidae | 30 |
| cf. *Bathyphellia australis* Dunn, 1983 | 1 |
| *Parabunodactis* sp. Carlgren 1928 | 4 |
| Indeterminate family | 1 |
| **Cnidaria: Hydrozoa** | |
| *Cryptolaria prima* Busk,1857 | 1 |
| **Mollusca: Gastropoda** | |
| *Aeneator otagoensis* | 1 |
| *Alcithoe arabica* | 2 |
| *Alcithoe larochei* | 9 |
| Aplysiomorpha | 2 |
| *Archidoris wellingtonensis* | 4 |
| *Argobuccinum pustulosum tumidum* | 4 |
| *Austrofusus glans* | 3 |
| *Calliostoma punctulatum* | 2 |
| *Calliostoma turnerarum* | 3 |
| *Cookia sulcata* | 9 |
| Dorididae | 1 |
| *Fusitriton magellanicus laudansus* | 34 |
| *Provocator mirabilis* | 1 |
| **Mollusca: Bivalvia** | |
| *Dosinia greyi* | 1 |
| *Mytilus galloprovincialis* | 1 |
| *Modiolarca impacta* | 1 |
| *Ostrea chilensis* | 3 |
| *Psychrochlamys delicanula* | 2 |
| teredo 'worms' | 2 |
| **Mollusca: Octopoda** | |
| *Pinnoctopus cordiformis* | 16 |

| | |
|---|---|
| **Polychaeta** | |
| *Aphrodita talpa* | 1 |
| *Euphione squamosa* | 3 |
| *Protula bispiralis* | 1 |
| *Pseudopotamilla laciniosa* | 1 |
| *Salmacina australis* (Haswell, 1885) | 1 |
| *Spirobranchus latiscapus* | 1 |
| *Spirobranchus polytrema* | 1 |
| | |
| **Crustacea: Stomatopoda** | |
| *Pterygosquila schizodontia* (Richardson, 1953) | 5 |
| | |
| **Crustacea: Brachyura** | |
| *Leptomithrax longipes* (Thomson, 1902) | 8 |
| *Nectocarcinus antarcticus* (Jacquinot, 1853) | 2 |
| *Thacanophrys filholi* (A. Milne Edwards, 1876) | 7 |
| | |
| **Crustacea: Cirripedia** | |
| *Megabalanus decorus* | 1 |
| *Notobalanus vestitus* | 3 |
| *Notomegabalanus decorus* | 2 |
| | |
| **Crustacea: Decapoda** | |
| *Diacanthurus rubricatus* (Henderson, 1888) | 15 |
| *Diacanthurus spinulimanus* (Miers, 1876) | 8 |
| *Ovalipes catharus* | |
| *Paguristes pilosus* (H. Milne Edwards, 1836) | 1 |
| *Phylladiorhynchus pusillus* | 2 |
| | |
| **Bryozoa** | |
| *Adeonellopsis cf. pentapora* (Canu & Bassler, 1929) | 1 |
| *Aetea australis* (Jullien, 1888) | 1 |
| *Aimulosia marsupium* (MacGillivray, 1869) | 1 |
| *Arachnopusia unicornis* (Hutton, 1873) | 3 |
| *Beania discodermiae* (Ortmann, 1890) | 1 |
| *Bitectipora rostrata* (MacGillivray, 1887) | 1 |
| *Caberea rostrata* (Busk, 1884) | 2 |
| *Caberea solida (*Gordon, 1986) | 1 |
| *Caberea* sp. | 1 |
| *Calloporina angustipora* (Hincks, 1885) | 1 |
| *Cellaria tenuirostris* (Busk, 1852) | 1 |
| *Celleporaria agglutinans* (Hutton, 1873) | 2 |
| *Celleporina grandis* (Gordon, 1989) | 1 |
| *Celleporina sinuata* (Gordon, 1989) | 3 |
| *Chaperia granulosa (*Gordon, 1986) | 1 |
| *Chaperiopsis cervicornis* (Busk, 1854) | 1 |
| *Chaperiopsis funda* (Uttley & Bullivant, 1972) | 1 |
| *Chaperiopsis lanceola* (Hayward & Thorpe, 1988) | 1 |
| *Chiastosella enigma* (Brown, 1954) | 2 |
| *Corbulella corbula* (Hincks, 1880) | 1 |
| *Crassimarginatella cucullata* (Waters, 1898) | 1 |
| *Crisia tenuis* (MacGillivray, 1879) | 1 |
| *Diaperoecia purpurascens* (Hutton, 1873) | 1 |
| *Disporella pristis* (MacGillivray, 1884) | 1 |

| | |
|---|---|
| *Ellisina sericea* (MacGillivray, 1890) | 1 |
| *Entalophoroecia* sp. | 1 |
| *Escharella spinosissima* (Hincks, 1881) | 3 |
| *Eurystrotos* sp. | 1 |
| *Exochella conjuncta* (Brown, 1952) | 1 |
| *Exochella jullieni* (Gordon, 1989) | 1 |
| *Fenestrulina incompta* (Gordon, 1984) | 1 |
| *Fenestrulina multicava* (Gordon, 1989) | 1 |
| *Fenestrulina reticulata* (Powell, 1967) | 1 |
| *Figularia huttoni* (Brown, 1952) | 4 |
| *Foveolaria elliptica* (Busk, 1884) | 1 |
| *Galeopsis polyporus* (Brown, 1952) | 2 |
| *Hemismittoidea hexaspinosa* (Uttley & Bullivant, 1972) | 1 |
| *Hippomenella vellicata* (Hutton, 1873) | 1 |
| *Hornera foliacea* (MacGillivray, 1869) | 1 |
| *Idmidronea* sp. | 1 |
| *Liripora pseudosarniensis* (Taylor & Gordon, 2001) | 1 |
| *Micropora* sp. | 1 |
| *Microporella agonistes* (Gordon, 1984) | 3 |
| *Odontionella cyclops* (Busk, 1854) | 4 |
| *Parasmittina aotea* (Brown, 1952) | 1 |
| *Parkermavella incurvata* (Uttley & Bullivant, 1972) | 1 |
| *Parkermavella punctigera* (MacGillivray, 1883) | 1 |
| *Penetrantia parva* (Silén, 1946) | 1 |
| *Rhynchozoon cf. larreyi* (Audouin, 1826) | 1 |
| *Schizosmittina conjuncta* (Uttley & Bullivant, 1972) | 2 |
| *Smittina rosacea* (Powell, 1967) | 3 |
| *Smittina torques* (Powell, 1967) | 1 |
| *Smittoidea maunganuiensis* (Waters, 1906) | 4 |
| *Telopora lobata* (Tenison-Woods, 1880) | 1 |
| *Tubulipora* sp. bilobate | 1 |
| *Tubulipora* sp. blue | 1 |
| *Tubulipora* sp. white | 1 |
| **Echinodermata: Echinoidea** | |
| *Evechinus chloroticus* | 3 |
| *Goniocidaris parasol* | 3 |
| *Goniocidaris umbraculum* | 1 |
| *Gracilechinus multidentatus* | 1 |
| *Pseudechinus huttoni* | 1 |
| **Echinodermata: Asteroidea** | |
| Asteriidae, unknown genus and species | 1 |
| *Diplodontias dilatatus* | 1 |
| *Diplodontias miliaris* | 2 |
| *Dipsacaster magnificus* | 2 |
| *Henricia ralphae* | 1 |
| *Mediaster sladeni* | 4 |
| *Odontaster aucklandensis* | 1 |
| *Odontaster benhami* | 1 |
| *Patiriella regularis* | 2 |
| *Pentagonaster pulchellus* | 1 |
| *Pseudechinaster rubens* | 1 |
| *Psilaster acuminatus* | 11 |
| *Pteraster (Pteraster) robertsoni* | 3 |

| | |
|---|---|
| **Echinodermata: Holothuroidea** | |
| *Bathyplotes moselyi* | 1 |
| *Neothyonidium dearmatum* | 1 |
| *Stichopus mollis* | 40 |
| **Echinodermata: Ophiuroidea** | |
| *Pectinura maculata* (Verrill, 1869) | 1 |
| **Tunicata:Ascidacea** | |
| *Cnemidocarpa bicornuta* | 1 |
| *Cnemidocarpa madagascariensis var. regalis* | 1 |
| *Pyura picta* | 4 |

**Appendix 6: Length weight coefficients used to scale length frequencies. W = $aL^b$ where W is weight (g) and L is length (cm);* data missing. DB, NIWA trawl database.**

| Species | $a$ | $b$ | n | Range (cm) Min. | Max. | Data source |
|---|---|---|---|---|---|---|
| Barracouta | 0.0055 | 2.9812 | 429 | 23.8 | 87.2 | DB, KAH9701 |
| Blue warehou | 0.0144 | 3.1050 | 338 | 27.4 | 69.6 | DB, TAN9604 |
| Dark ghost shark | 0.0013 | 3.3707 | 1187 | 19 | 71.9 | This survey |
| Elephantfish | 0.0049 | 3.1654 | 378 | 13.4 | 91 | DB, KAH9618 |
| Giant stargazer | 0.0114 | 3.0999 | 867 | 9 | 78.3 | This survey |
| Hapuku | 0.0078 | 3.1400 | 307 | 49 | 108 | DB, TAN9301 |
| Hoki | 0.0046 | 2.8840 | 525 | 22 | 110 | DB, SHI8301 |
| Leatherjacket | 0.0088 | 3.2110 | * | * | * | DB, IKA8003 |
| Ling | 0.0013 | 3.2801 | 179 | 32.2 | 123.7 | DB, KAH0004 |
| Red cod | 0.0075 | 3.0610 | 783 | 12.4 | 76.8 | This survey |
| Red gurnard | 0.0087 | 3.0540 | 384 | 27 | 57 | Db, KAH9606 |
| Rig | 0.0033 | 3.0568 | 113 | 43.9 | 115 | This survey |
| Rough skate | 0.0321 | 2.8988 | 479 | 19.9 | 70 | This survey |
| School shark | 0.0025 | 3.1602 | 306 | 32.7 | 157 | This survey |
| Sea perch | 0.0092 | 3.1953 | 862 | 4.5 | 43.9 | This survey |
| Silver warehou | 0.0048 | 3.3800 | 262 | 16.6 | 57.8 | DB, TAN502 |
| Smooth skate | 0.0338 | 2.8798 | 299 | 12.6 | 123 | This survey |
| Spiny dogfish | 0.0014 | 3.2350 | 1 687 | 23.6 | 96.5 | This survey |
| Tarakihi | 0.0091 | 3.2154 | 780 | 11.1 | 49.7 | This survey |