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# Inshore trawl survey of the west coast South Island and Tasman and Golden Bays, March-April 2011 (KAH1104)

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M.L. Stevenson

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# Contents

## EXECUTIVE SUMMARY

**Stevenson, M.L. (2012). Inshore trawl survey of the west coast South Island and Tasman and Golden Bays, March-April 2011 (KAH1104).**

***New Zealand Fisheries Assessment Report 2012/50.* 77 p.**


This report gives the results of the tenth in a time series of inshore trawl surveys along the west coast of the South Island from Farewell Spit to the Haast River mouth and within Tasman and Golden Bays at depths from 20 to 400 m using RV *Kaharoa*.

The survey took place in March-April 2011 and used a two-phase design optimised for giant stargazer, red cod, red gurnard, spiny dogfish, and tarakihi. A total of 65 stations were successfully completed. Trends in biomass estimates, catch distribution for the target species, and population length frequencies for the major species are described.

The biomass estimates for the target species were giant stargazer, 1 645 t; red gurnard, 1 070 t; red cod, 2 087 t; spiny dogfish, 6 402 t; and tarakihi, 1 188 t. Target c.v.s were met for giant stargazer (16%), red gurnard (17%), spiny dogfish (19%), and tarakihi (15%). The c.v for red cod (27%) was slightly higher than the target.

The estimate of total biomass for red gurnard (1 070 t) was the highest for any survey in the series. The estimate for giant stargazer (1 645 t), whilst less than the high of 2009, was the second highest in the series. The estimate for red cod was lower than for 2009 and the midrange for the series. The estimate for tarakihi was similar to the previous two surveys and in the range of most previous surveys.

Other commercial species with c.v.s less than 20% were arrow squid, John dory, lemon sole, rig, and school shark. The biomass estimates for six non-target commercial species were the highest in the series whilst that for arrow squid was the lowest estimate in the series. For John dory, the strong pulse of 1+ fish seen in 2009 is evidenced in this survey by the increase in biomass and the higher numbers of large females.

The tarakihi tagging was completed during several days of bad weather on the west coast. A total of 912 juvenile tarakihi were tagged in Tasman Bay to clarify stock affiliations. During the survey, 233 school shark, 45 rig, 116 rough skate, and 17 smooth skate were tagged and released.

# 1. INTRODUCTION

This report presents results from the tenth in a time series of stratified random trawl surveys with RV *Kaharoa* in waters between 20 and 400 m off the west coast of the South Island, and within Tasman and Golden Bays. The survey was optimised for giant stargazer (*Kathetostoma giganteum*), red cod (*Pseudophycis bachus*), red gurnard (*Chelidonichthys kumu*), spiny dogfish (*Squalus acanthias*), and tarakihi (*Nemadactylus macropterus*). The results of earlier surveys in this series were reported by Drummond & Stevenson (1995a, 1995b, 1996), Stevenson (1998, 2002, 2004, 2006, 2007a), and Stevenson & Hanchet 2010). The first four surveys in the series were reviewed by Stevenson & Hanchet (2000).

The principal objective of the surveys is to develop a time series of relative abundance indices for giant stargazer, red cod, red gurnard, spiny dogfish, and tarakihi for the inshore waters of the west coast of the South Island and within Tasman and Golden Bays. Changes in the relative abundance and length frequency distributions over time should reflect changes in the abundance and size distributions of the underlying fish populations. A standardised index of relative abundance estimates for key inshore species will therefore provide the basis for stock assessment and management strategies.

This report details the survey design and methods, and provides relevant stock assessment data for commercially important species managed under the Quota Management System (QMS) and non-QMS species.

This report fulfils in part the requirements of Ministry of Fisheries contract INT200801.

## 1.1 Programme objective

To determine the relative abundance and distribution of inshore finfish species off the west coast of the South Island, and Tasman Bay and Golden Bay; focusing on red cod (*Pseudophycis bachus*), red gurnard (*Chelidonichthys kumu*), giant stargazer (*Kathetostoma giganteum*), tarakihi (*Nemadactylus macropterus*) and spiny dogfish (*Squalus acanthias*).

### Specific objectives (2011)

1. To determine the relative abundance and distribution of red cod, red gurnard, giant stargazer, and tarakihi off the west coast of the South Island from Farewell Spit to the Haast River mouth, and within Tasman Bay and Golden Bay by carrying out a trawl survey. The target coefficients of variation (c.v.s) of the biomass estimates for these species are as follows: red cod (20–25%), red gurnard (20%), giant stargazer (20%), tarakihi (20%), and spiny dogfish (20%). Recruited and spawning biomass will be reported separately.

2. To collect the data and determine the length frequency, length-weight relationship, and reproductive condition of red cod, red gurnard, giant stargazer, and tarakihi.

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

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

5. To tag live skate, school shark, and rig

6. To determine stock affiliation of pre-recruit tarakihi in Tasman/Golden Bays nursery area using mark recapture.

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

8. To report on biomass trends for monitored ITQ species.

## 1.3 Timetable and personnel

RV *Kaharoa* departed Wellington on 25 March and berthed at Nelson on 26 March to offload some equipment and allow two science staff to board. Trawling started on 26 March in Tasman Bay and moved to the west coast on 30 March. Twenty-four stations were successfully completed before bad weather on 1 April forced an early entry to Westport to unload fish and exchange two science staff. The weather did not improve and the decision was made on 4 April to return to Tasman and Golden bays to complete the tarakihi tagging. Over 900 tarakihi were tagged in three days. The weather finally eased on the west coast on 8 April and the survey was resumed. Phase one stations were completed on 16 April. The weather again deteriorated and no phase 2 stations were possible. *Kaharoa* returned to Nelson on 17 April to offload fish and disembark four science staff.

Michael Stevenson was project leader and voyage leader and was responsible for final database editing. The skipper was Simon Wadsworth.

# 2. METHODS

## 2.1 Survey area and design

The survey was a two-phase stratified random survey after Francis (1984). The survey area covered depths of 20–200 m off the west coast of the South Island from Cape Farewell to Karamea; 25–400 m from Karamea to Cape Foulwind; 20–400 m from Cape Foulwind to the Haast River mouth; and within Tasman and Golden Bays inside a line drawn between Farewell Spit and Stephens Island (Figure 1). The maximum depth on the west coast north of Karamea was limited to 200 m because of historically low catch rates in the 200–400 m range.

The survey area of 25 594 $km^2$, including untrawlable ground, was divided into 16 strata by area and depth (Table 1, Figure 1). Strata were identical to those used in previous surveys. The trawlable ground within the survey area represented 84% of the total survey area.

Phase 1 station allocation was optimised using the R function *allocate* to achieve the target c.v.s. Stratum area and catch rate data from previous *Kaharoa* trawl surveys were used to simulate optimal allocation and simulations were run for each target species separately. Results showed that gurnard and red cod required the most effort to achieve the target predicted c.v.s, with 74 stations required, The proposed phase 1 survey design of 65 stations was based on 80% of the maximum number of stations required for each species in each stratum.

Before the survey began, sufficient trawl stations to cover both first and second phase stations were randomly generated for each stratum by the computer programme ‘Rand_stn v2.1’ (Vignaux 1994). The stations were required to be a minimum of 5.6 km (3 n. miles) apart. Non-trawlable ground was identified before the voyage from data collected during previous trawl surveys in the area and excluded from the station allocation program. The distribution of non-trawlable ground is given in Table 1 and shown in Figures 1a and 1b.

## 2.2 Vessel, gear, and trawling procedure

RV *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 trawl net used during the survey was designed and constructed in 1991 specifically for South Island inshore trawl surveys and is based on an ‘Alfredo’ design. The net was fitted with a 60 mm (inside measurement) knotless codend. Details of the net design were given by Beentjes & Stevenson (2008). Gear specifications were the same as for previous surveys (Drummond & Stevenson 1996).

Procedures followed those recommended by Stevenson & Hanchet (1999). All tows were undertaken in daylight, and four to six tows a day were planned. For each tow the vessel steamed to the station position and, if necessary, the bottom was checked with the depth sounder. Once the station was considered trawlable, the gear was set away so that the midpoint of the tow would coincide as nearly as possible with the station position. The direction of the tow was influenced by a combination of factors including weather conditions, tides, bottom contours, and the location of the next tow but was usually in the direction of the next tow.

If the station was found to be in an area of foul or the depth was out of the stratum range, an area within 5 km of the station was searched for a replacement. If the search was unsuccessful, the station was abandoned and the next alternative station from the random station list was chosen. Standard tows were of 1 h duration at a speed over the ground of 3 kn and the distance covered was measured by GPS. The tow was deemed to have started when the net monitor indicated that the net was on the bottom, and was completed when hauling began.

A warp length of 200 m was used for all tows at less than 70 m depth. At greater depths, the warp to depth ratio decreased linearly to about 2.4:1 at 400 m.

## 2.3 Water temperatures

The surface and bottom temperatures at each station were recorded by the CTD unit. Surface temperatures were taken at a depth of 5 m and bottom temperatures when the net settled on the bottom. Bottom temperatures were taken at about 5 m above the sea floor because the CTD rests on the net just behind the headline.

## 2.4 Catch and biological sampling

The catch from each tow was sorted into species on deck and weighed on 100 kg electronic motion-compensating Seaway scales to the nearest 0.1 kg. Finfish, squid, and scampi were classified to species level: other crustaceans, shellfish, and invertebrate species not readily identified were frozen for later identification because of difficulty in identifying individual species and the limited sorting time available between tows. Unidentified specimens were placed in sealed plastic bags with a label noting the trip code and station number.

Length, to the nearest whole centimetre below the actual length, and sex (where possible) were recorded for all species managed under the QMS, either for the whole catch or a randomly selected subsample of up to 200 fish per tow.

Individual fish weights and/or reproductive state were collected for the target species, hake (*Merluccius australis*), rig (*Mustelus lenticulatus*), rough skate (*Zearaja nasutus*), smooth skate (*Dipturus innominatus*), and school shark (*Galeorhinus galeus*). Individual fish weights were taken to enable length-weight relationships to be determined for scaling length frequency data and calculation of biomass for length intervals. Samples were selected non-randomly from the random length frequency sample to ensure a wide range was obtained for each species.

Prior to the 2009 survey discussions were held with MFish about concerns that the standard protocol for collecting otoliths and spines might not sample southern west coast strata adequately because stations were sampled generally in a north to south direction. Therefore, to ensure an even representation of otoliths throughout the area up to 10 otoliths or spines were collected from each station for red gurnard, giant stargazer, spiny dogfish, and tarakihi. Previous aging work on red cod showed that there was no difference in growth rates between fish from the northern and southern west coast (Beentjes 2000). Otoliths for tarakihi and red gurnard were placed in 0.5 ml vials to reduce breakage. Posterior dorsal spines were collected from spiny dogfish and stored in 70% ethanol in 5 ml vials.

## 2.5 Data analysis

Relative biomass estimates and scaled length-frequency distributions and their associated c.v.s were estimated by the area-swept method (Francis 1981, 1989) using the SurvCalc Program (Francis & Fu in 2012. All data were entered into the Ministry of Fisheries *trawl* database.

The following assumptions were made for extracting biomass estimates with the SurvCalc Programme.

1. The area swept during each tow equalled the distance between the doors multiplied by the distance towed.
2. Vulnerability was 1.0. This assumes that all fish in the area swept were caught and there was no escapement.
3. Vertical availability was 1.0. This assumes that all fish in the water column were below the headline height and available to the net.
4. Areal availability was 1.0. This assumes that the fishstock being sampled was entirely within the survey area at the time of the survey.
5. Within the survey area, fish were evenly distributed over both trawlable and non-trawlable ground.

Although these assumptions are unlikely to be correct, their adoption provides the basis for a time series of relative biomass estimates (Stevenson & Hanchet 1999). All assumptions listed are consistent with those used for previous surveys in the series.

All stations where the gear performance was excellent or satisfactory, codes 1 or 2, (65 stations) were used for biomass estimation.

Length frequencies were scaled by the percentage of catch sampled, area swept, and stratum area. The geometric mean functional relationship was used to calculate the length-weight coefficients for species where sufficient length-weight data were collected on this survey. For other species, coefficients were chosen from the *trawl* database and a selection made on the basis of whether coefficients were available from previous surveys in the series or on the best match between the size range of the fish used to calculate the coefficients and the sample size range from this survey (Appendix 1).

Sex ratios were calculated using scaled population numbers and are expressed as the ratio of males to females.

## 2.6 Elasmobranch tagging

As soon as the net was brought on board, whenever possible, lively rig, school shark, and rough and smooth skate were separated from the catch, placed in an aerated tank of seawater, and tagged with Hallprint dart tags. Length, weight, and sex were recorded for each tagged fish.

### 2.7 Tarakihi tagging

Tarakihi tagging was undertaken in Tasman Bay where small tarakihi had been caught during the regular survey. Short tows were made for the purpose of catching juvenile (15–25 cm) tarakihi for a tagging experiment. The CTD and BCS were not deployed for this portion of the project. Tow duration was 10–15 minutes and the end of the tow the codend was quickly lowered into an aerated tank to minimise the time fish spent out of the water. Prior to release, tagged fish were placed in a second aerated tank. Fish were vented when necessary before tagging. Tagged fish were then released before travelling to the next station. If more than ten fish were tagged, the next station was a minimum of 1 n. mile away.

## 3. RESULTS AND DISCUSSION

Biomass estimates and c.v.s by stratum and catch rates by stratum are given for the 20 most abundant commercially important species. Trends in biomass and comparative length frequency distributions are presented for the target species and for those species it is thought the surveys could be monitoring adults and/or pre-recruit abundance (Stevenson 2007b). Length frequency distributions for other species are given for this survey only if the species is commercially important and more than 100 were measured. In addition, snapper (*Pagrus auratus)* are included for this survey because of the numbers of 14–19 cm fish caught in 2009 to review the opinion that they could represent a strong year class. Catch rate figures are only given for the target species.

### 3.1 Survey area, design, and gear performance

Sixty-five phase one stations were successfully completed. Station 14 was not included in the biomass estimates because the gear came fast during the tow. No phase two stations were possible because of time lost to bad weather. Station density ranged from one station per 102 km$^2$ in stratum 17 to one station per 1 078 km$^2$ in stratum 6, with an average density of one station per 394 km$^2$ (Table 1). At least three stations were completed in all 16 strata and all project and survey objectives were achieved. The survey area, with stratum boundaries and station positions, is shown in Figures 1a and 1b and individual station data are given in Appendix 2.

A summary of gear and tow parameters by depth are shown in Table 2. Doorspread varied from 66.5 to 96.5 m and headline height varied between 4.4 and 5.2 m (Table 2, Appendix 2). Measurements of headline height and doorspread, together with BCS output and observations that the doors and trawl gear were polishing well, indicated that the gear was, in general, operating correctly. Gear parameters were similar to those of previous surveys indicating consistency between surveys (Stevenson & Hanchet 2000).

### 3.2 Catch composition

A total of about 43.3 t of fish was caught from the 65 tows of the main survey at an average of 585.5 kg per tow. Amongst the fish catch, 14 elasmobranchs, and 69 teleosts were recorded. Species codes, common names, scientific names, and catch weights of all species identified during the survey are given in Appendix 3. Invertebrate species identified from the catch are given in Appendix 4.

The most abundant species by weight was spiny dogfish with 7.3 t caught (16.9% of the total catch). The top four species, spiny dogfish, barracouta (*Thyrsites atun*), red cod, and hoki (*Macruronus novaezelandiae*) made 48% of the total. Giant stargazer, red cod, red gurnard, and tarakihi made up 4.7, 7.4, 3.7, and 4.2% of the catch, respectively. School shark, carpet shark (*Cephaloscyllium isabellum*), barracouta, and spiny dogfish occurred in over 90% of the tows.

Thirty-four species of invertebrates were identified during the survey or from retained specimens (Appendix 4). The numbers of invertebrate species does not necessarily indicate reduced biodiversity in the survey area because the gear is not designed to collect benthic macroinvertebrates. In addition, station location strongly influences the incidence of some groups (e.g. bryozoans).

## 3.3 Catch rates and species distribution

Distribution by stratum and catch rates for the target species are shown in Figures 2a–2e (biomass tows only). Catch rates are given in kilograms per square kilometre. On average a standard tow covers 0.44 $km^2$, therefore a catch rate of 100 $kg.km^{-2}$ equates to a catch of 44 kg.

Mean catch rates by stratum for the 20 most abundant commercially important species are given in Table 3.

## 3.4 Biomass estimation

Relative biomass estimates for species managed under the QMS caught in all surveys in the series are given in Table 4. For this year's survey spiny dogfish had the largest estimated biomass followed by barracouta and red cod. Estimated biomass and coefficients of variation for the target species were: giant stargazer, 1 645 t (16%); red gurnard, 1 070 t (17%); red cod, 2 087 t (27%); spiny dogfish, 6 402 t (13%); and tarakihi, 1 188 t (15%) (Table 4).

Biomass estimates of recruited fish for barracouta, blue warehou (*Seriolella brama*), giant stargazer, hoki, John dory (*Zeus faber*), ling, red cod, red gurnard, rig, sand flounder (*Rhombosolea plebeia*), school shark, silver warehou (*Seriolella punctata*), and tarakihi are given in Table 5. For giant stargazer, red cod, red gurnard, and tarakihi, the percentage of total biomass comprising recruited fish were 98%, 47%, 78%, and over 99% respectively.

Biomass estimates by year class (where discernible from the length frequency distributions) for barracouta, blue warehou, hake, hoki, jack mackerel (*Trachurus novaezelandiae*), red cod, red gurnard, school shark, silver warehou, and tarakihi are given in Table 6. For red cod, the 1+ cohort made up about 52% of the total biomass. For red gurnard, the 2+ cohort made up 10% of the total biomass and for tarakihi the 1+ and 2+ cohorts made up 2% and 24% of the total respectively

The relative biomass estimates and c.v.s for the 20 most abundant commercially important species are given by stratum in Table 7.

Trends in biomass for selected species are shown in Figure 3 and discussed in section 3.7.

## 3.5 Water temperatures

Isotherms estimated from CTD surface temperature recordings are shown in Figure 4. Isotherms estimated from CTD bottom temperature recordings are shown in Figure 5. Temperatures cannot be directly compared to surveys prior to 2005 because earlier data were not taken from calibrated recordings. Both surface and bottom temperatures were generally lower than in 2007.

## 3.6 Length frequency and biological data

The numbers of length frequency and biological samples taken during the survey are given in Table 8. Comparative scaled length frequency distributions for the target species and for the eight other species the surveys may be monitoring are shown in Figures 6a-m in alphabetical order by common name. Scaled length frequency distributions from this survey for other commercial species where more than 100 fish were measured are shown in Figure 7 in alphabetical order by common name.

Length-weight coefficients were determined for giant stargazer, red cod, red gurnard, spiny dogfish, tarakihi, rig, rough skate, school shark, hake from data collected on this survey (Appendix 1). Individual length and weight data for hake were included in this survey because length-weight coefficients available were derived from surveys which caught mainly large fish whilst hake taken in this series are seldom larger than 45 cm.

Ageing material collected included 372 pairs of otoliths from giant stargazer, 319 from red cod, 257 from red gurnard, and 366 from tarakihi. Spines were collected from 371 spiny dogfish.

Details of gonad stages for giant stargazer, red cod, red gurnard, and tarakihi are given in Table 9a whilst maturity stage details for spiny dogfish are given in Table 9b.

## 3.7 Trends in target species

### 3.7.1 Giant stargazer

Giant stargazer were caught at 48 stations with the highest catch rates south of Cape Foulwind in depths of 100–200 m (strata 8, 12, and 15) (Figure 2a, Table 3). Total biomass was fairly constant for the first four surveys but declined in 2000 and again in 2003 to a low of 834 t. The biomass has steadily increased since then with the highest estimate in the series (1952 t) in 2009 the 2011 estimate of 1645 t is the second highest in the series (Table 4, Figure 3). Eighty two percent of the biomass was south of Cape Foulwind, and 79% was within the 100–200 m depth range (Table 7). Biomass of adult fish (over 45 cm) was 1382 t and juveniles continue to represent about 15% of the total. (Table 5, Figure 8). There were not as many fish less than 45 cm caught on this survey than in 2009 (Figure 6d). No clear year class modes were apparent in the length frequency distribution. The sex ratio (male:female) was 1.24:1 overall (Figure 6d). Virtually all females under 50 cm total length were immature or had resting gonads, but above this size, most had maturing gonads. Most males under 40 cm were immature or resting, and most males over 40 cm were maturing (Table 9a). This is consistent with the winter spawning period of giant stargazer.

### 3.7.2 Red cod

Red cod were caught at 56 stations, with the highest catch rates in strata 1, 7, 11, and 14 (Figure 2b, Table 3). Total biomass estimates were fairly stable for the first four surveys varying from 2546 t to 3168 t. There was a sharp decline in 2000 to 414 t but the biomass gradually recovered to 2782 t in 2009. The biomass estimate of 2087 t from this survey is the fourth lowest in the series (Table 4, Figure 3). However, the estimated population was 15% higher than in 2009 because of a more dominant 1+ year class and fewer fish over 40 cm (Figure 6h). The decrease was mainly from stratum 19, outer Tasman Bay, which fell from 598 t in 2009 to only 50 t. Sixty-one percent of the total biomass was south of Cape Foulwind and 95% was from depths less than 200 m (Table 7). Adult biomass (over 51 cm) was 259 t, only 12% of the total (Table 5, Figure 8). Very few fish in the 10–20 cm range (0+ fish) were caught which is consistent with previous surveys except 1995 and 1997 (Figure 6h). The sex ratio was 1.22:1 overall (Figure 6h). Most red cod examined had immature or resting gonads but some fish were at later stages of reproductive development (Table 9a). Since red cod spawn from late winter to spring (Ministry of Fisheries 2009), it would not be expected to find a significant proportion of maturing or ripe gonads.

### 3.7.3 Red gurnard

Red gurnard were caught at all Tasman and Golden Bay and at all but one station in depths less than 100 m along the west coast (Figure 2c). The highest catch rates were in strata 5, 7, 11, and 19 (Table 3). The biomass estimates were consistent from 1992–2000 but showed a sharp decline in 2003. There has been a steady recovery over the last three surveys and the estimate for 2011 (1 070 t) was higher than any previous survey and 64% higher than 2009, the previous record (Table 4, Figure 3). The length frequency distribution was similar to that of 1997, 2000, and 2009 with high numbers of pre-recruit fish but with greater numbers of recruited fish (Figure 6i). The recruited and adult biomass estimates (30 cm or over) were 798 t (75% of the total) with 554 t occurring on the west coast (Table 5, Figure 8). Almost 98% of red gurnard biomass was at depths less than 100 m and no gurnard were caught deeper than 200 m (Table 7). The overall sex ratio was 1.85:1 (Figure 6i). Most red gurnard longer than 30 cm and a few smaller fish had developing or mature gonads (Table 9a). Red gurnard have a long spawning period and ripe individuals can be found in the Hauraki Gulf throughout the year (Ministry of Fisheries, 2009).

### 3.7.4 Spiny dogfish

Spiny dogfish were caught at 63 stations with the highest catch rates in strata 1, 2, and 14 (Table 3, Figure 2d). The biomass estimates were relatively stable from 1992 to 2007 but there was a sharp increase in 2009 to 10 270 t which was the highest of any survey in the series (Table 4, Figure 3). For 2011, the biomass was 6 402 t which is similar to 2007. There were considerably fewer fish greater than 50 cm caught on this survey than in 2009 but the number of fish less than 50 cm was similar (Figure 6l). Adult fish made up about 70% of the total biomass (Table 5, Figure 8). Over 94% of the estimated biomass was at depths less than 200 m (Table 7). The sex ratio of 0.80:1 was the lowest recorded (from 1997) (Figure 6l).

### 3.7.5 Tarakihi

Tarakihi were caught at 54 stations with the highest catch rates in strata 12, 15, and 17 (Table 3, Figure 2e). The biomass estimates show a declining trend to 2003 with a sharp increase in 2005 and a subsequent drop in the last three surveys to 1997 levels (Table 4, Figure 3). Over 87% of the biomass estimate was recruited fish (25 cm or over) (Tables 4 and 5) whilst the adult biomass (over 31 cm) was 704 t (Table 5). The juvenile biomass has increased as a proportion of the total for the last four surveys whilst the adult biomass has declined over the same period (Figure 8). The length frequency data exhibits a mode at 10–14 cm (0+ fish) similar to 1997 and a second mode at 16–21 cm (1+ fish). The mode at 25–28 cm, probably 2+ fish is the strong mode of 0+ fish seen in 2009 (Figure 6m). Of the total tarakihi biomass (1188 t), over 97% was on the west coast, and over 80% (871 t) of this was at depths between 100 to 200 m (Table 7). The sex ratio for the estimated population was 0.73:1 (Figure 6m). There was little reproductive development in tarakihi under 30 cm FL, but for bigger fish the full range of gonad stages was recorded (Table 9) which is consistent with tarakihi spawning in summer and autumn.

### 3.7.6 Trends in other species

Barracouta

Barracouta were caught at 64 stations and represented 16.8% of the total catch (Appendix 3). The highest catch rates were in strata 1 and 14 (Table 3). The biomass has varied almost 3-fold during the series but does not show a consistent trend (Tables 4, Figure 3). The 2011 estimate of 5361 t is the highest for the series. The length frequency distribution usually has a very strong mode of 0+ fish but the 2011 mode is one of the weakest in the series (Figure 6a).

Blue warehou

Blue warehou were caught at 38 stations with the highest catch rates in strata 14 and 15 (Table 3). The biomass estimate for 2011 is in the mid-range of the series estimates (Table 4, Figure 3). The strong mode in the length frequency distribution for 2009 at 10–23 cm (0+ fish) is not seen in 2011 (Figure 6b). Stevenson & Hanchet (2000) noted that because of the poor precision in the biomass estimates the surveys are probably not suitable for monitoring adult or pre-recruit blue warehou. However, Stevenson (2007b) suggested that the survey may be able to provide information on year class strengths, but aging of the commercial catch would be required to show if this is the case.

Gemfish

Gemfish were only caught in low numbers at 10 stations (Appendix 3, Table 8). The biomass estimates from the series do not show a definite trend (Table 4, Figure 3) but the length frequency distributions occasionally show apparently strong year classes (Figure 6c). There are no strong year classes visible in the last three surveys.

Hake

Hake were taken in low numbers from 21 stations (Table 8) and no fish larger than 45 cm were caught (Figure 7). The biomass estimate was the second lowest in the series but the biomass estimates have varied widely through the series (Table 4).

Hoki

Hoki were taken from 23 stations, all on the west coast south of Cape Foulwind (Tables 3 and 8). The length frequency distribution for hoki shows a strong mode at 31–44 cm (1+ fish) (Figure 7). This is the first time that the mode for 1+ fish is stronger than that for 0+ fish (Stevenson 2007a, Stevenson 2007b, Stevenson & Hanchet 2010).

Jack mackerel (*Trachurus declivis*)

*T. declivis* was present in the catch from 32 stations and the biomass estimate is the highest in the series (Appendix 3, Table 4). The length frequency distribution shows a mode at 14–20 cm 0+ fish and an adult mode at 39–46 cm (Figure 6e). This is the largest adult mode in the series and is the source of the high biomass estimate.

John dory

John dory were caught at 35 stations with the highest catch rates in strata 1 and 17 (Appendix 3, Table 3). The biomass estimate of 378 t is the highest in the series (Table 4, Figure 3). The length frequency distribution shows a mode at 26–34 cm (1+ fish) but it is not as strong as the 1+ mode from 2009. The numbers of adults, especially females, is greater than in 2009 and is the reason for the high biomass estimate (Figure 6f). The strong 1+ mode seen in 2009 is now fully recruited into the adult population and the size of the 1+ mode from this survey could mean John dory will continue to maintain the higher biomass seen in the last 6 surveys.

Ling

Ling were caught at 34 stations with the highest catch rates in stratum 16 (Appendix 3, Table 3). The biomass estimate of 223 t is similar to several other surveys in the series and there does not appear to be a trend over the series (Table 4, Figure 3). The scaled length frequency distribution for 2011 shows a strong mode at 36–48 cm for both sexes (Figure 6g). This is the strongest mode since 1995.

Rig

Rig were caught at 35 stations, with the highest catch rates in stratum 19 (Appendix 3, Table 3). The estimated biomass of 307 t is higher than for 2009 and in the mid-range for the series (Table 4, Figure 3). The length frequency distributions for 2011 show two strong modes at 32–42 cm and 42–58 for both sexes and two more at 59–64 cm and 65–79 for males (Figure 6j). The two larger modes were seen in the length frequency distributions for 2009. The lack of the two longer modes in the female length frequency indicates that the survey does not sample adult female rig well.

School shark

School shark were caught at 62 stations with the highest catch rates in strata 17 and 18 (Appendix 3, Table 3). The estimated biomass of 1155 t was the highest since 1997 and the third highest in the series and continues a gradual increase since the low of 2003 (Table 4, Figure 3). The length frequency distribution for 2011 shows a mode at 33–42 cm for both sexes but no strong mode as seen in 2009 (Figure 6k).

### 3.8 Biomass trends by area

In 2000, an analysis was developed to determine whether any survey in a time series produced an anomalous result (Francis et al. 2001). Biomass estimates for selected species were compared between surveys and if the estimates of all species for a particular survey were uniformly higher or lower than other surveys in a series, the survey was determined to be ‘extreme’.

This analysis was updated for the west coast South Island inshore series with separate analyses for Tasman and Golden Bays and the west coast and using different indicator species for each area. An additional five surveys have been completed since the original analysis and the plotted results are presented in this report. For Tasman and Golden Bays, the updated calculations suggest that 2005 and 2009 were extreme years, with biomass estimates for many species being lower than normal in 2005 and higher than normal in 2009 (Appendix 5). For the West Coast of the South Island, 1995 and 2003 appear to be extreme (Appendix 5). In both Tasman and Golden Bays and the West Coast of the South Island, the 2011 survey was within the expected limits and was therefore not classified as extreme (Appendix 5).

### 3.9 Tagging

A total of 233 school shark were tagged (94 females and 139 males) ranging in length from 46 cm to 148 cm. In addition, 45 rig (15 females, 30 males), 116 rough skate (73 females, 43 males), and 17 smooth skate (9 female, 8 males) were tagged (Table 8).

A total of 912 juvenile tarakihi were tagged and released if Tasman Bay (Table 8).

# 4 CONCLUSIONS

The 2011 survey successfully extended the March-April RV *Kaharoa* time series for the west coast of the South Island and Tasman and Golden Bays. The results show that the series continues to monitor the target species and adults and/or pre-recruits and juveniles of several other species. The biomass estimate of red gurnard is the highest in the series, whilst those for the other target species are within the range of previous surveys. The snapper catch did not indicate a strong year class as it did in 2009. However, it was noted during the tarakihi tagging that good numbers of snapper in the 25–30 cm size class were being caught.

### The SurvCalc program

Biomass, catch rate by stratum and length frequency data were analysed using SurvCalc, which replaces the TrawlSurvey Analysis program used for previous trawl survey data analysis. SurvCalc is a C++ based program and uses some of the code from TrawlSurvey Analysis.

A major advantage using SurvCalc is the ability to calculate biomass estimates and scaled length frequencies for several species at once. In addition, only minor changes to the input files will be required for analysis of any other survey. A sample input file is given in Appendix 5.

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

| Stratum | Depth (m) | Area ($km^2$) | Non-trawlable area ($km^2$) | Number of stations Phase 1 | Number of stations Phase 2 | Station density ($km^2$ per station) |
|---|---|---|---|---|---|---|
| 1 | 20–100 | 1 343 | 102 | 4 | 0 | 336 |
| 2 | 100–200 | 4 302 | 300 | 5 | 0 | 860 |
| 5 | 25–100 | 1 224 | 0 | 3 | 0 | 408 |
| 6 | 100–200 | 3 233 | 238 | 3 | 0 | 1 078 |
| 7 | 25–100 | 927 | 0 | 4 | 0 | 232 |
| 8 | 100–200 | 2 354 | 214 | 4 | 0 | 589 |
| 9 | 200–400 | 1 877 | 1 456 | 3 | 0 | 626 |
| 11 | 25–100 | 1 438 | 63 | 7 | 0 | 205 |
| 12 | 100–200 | 2 054 | 501 | 6 | 0 | 342 |
| 13 | 200–400 | 1 101 | 466 | 3 | 0 | 367 |
| 14 | 25–100 | 851 | 36 | 4 | 0 | 213 |
| 15 | 100–200 | 881 | 373 | 3 | 0 | 294 |
| 16 | 200–400 | 319 | 35 | 3 | 0 | 106 |
| 17 | 20–33 | 307 | 27 | 3 | 0 | 102 |
| 18 | 20–42 | 947 | 30 | 3 | 0 | 316 |
| 19 | 20–70 | 2 436 | 193 | 7 | 0 | 348 |
| Total (average) | | 25 594 | 4 034 | 65 | 0 | (394) |

**Table 2: Gear and tow (recorded values only) parameters for biomass stations by depth range (*n* number of stations; s.d., standard deviation).**

| | *n* | Mean | s.d. | Range |
|---|---|---|---|---|
| **All stations** | 65 | | | |
| Headline height (m) | | 4.8 | 0.15 | 4.4–5.2 |
| Doorspread (m) | | 80.3 | 7.82 | 66.5–96.5 |
| Distance (n. miles) | | 3.0 | 0.21 | 1.76–3.20 |
| Warp:depth ratio | | 3.8 | 1.53 | 2.42–8.89 |
| **Tasman/Golden Bays** | | | | |
| 20–70 m | 13 | | | |
| Headline height (m) | | 4.8 | 0.19 | 4.4–5.2 |
| Doorspread (m) | | 74.5 | 3.72 | 68.1–84.1 |
| Distance (n. miles) | | 2.9 | 0.24 | 1.93–3.20 |
| Warp:depth ratio | | 4.1 | 1.57 | 2.8–8.89 |
| **West coast** | | | | |
| 20–400 m | 52 | | | |
| Headline height (m) | | 4.8 | 0.16 | 4.4–5.2 |
| Doorspread (m) | | 82.1 | 7.63 | 68.1–96.5 |
| Distance (n. miles) | | 2.9 | 0.23 | 1.76–3.20 |
| Warp:depth ratio | | 3.3 | 1.22 | 2.42–8.89 |
| 20–100 m | 22 | | | |
| Headline height (m) | | 4.8 | 0.19 | 4.4–5.2 |
| Doorspread (m) | | 74.5 | 3.72 | 68.1–84.1 |
| Distance (n. miles) | | 2.9 | 0.24 | 1.93–3.20 |
| Warp:depth ratio | | 4.1 | 1.57 | 2.80–8.89 |
| 100–200 m | 21 | | | |
| Headline height (m) | | 4.8 | 0.13 | 4.5–5.0 |
| Doorspread (m) | | 85.6 | 2.44 | 79.9–89.7 |
| Distance (n. miles) | | 3.0 | 0.06 | 2.84–3.10 |
| Warp:depth ratio | | 2.8 | 0.11 | 2.61–3.1 |
| 200–400 m | 9 | | | |
| Headline height (m) | | 4.8 | 0.11 | 4.6–4.9 |
| Doorspread (m) | | 92.6 | 2.28 | 90.7–96.5 |
| Distance (n. miles) | | 2.9 | 0.42 | 1.76–3.09 |
| Warp:depth ratio | | 2.6 | 0.15 | 2.42–2.90 |

**Table 3: Mean catch rates (kg.km$^{-2}$) by stratum for the 20 most abundant commercially important species in order of catch abundance. Species codes are given in Appendix 3.**

| | Species code | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Stratum | SPD | BAR | RCO | HOK | STA | GSH | TAR | GUR | SCH | SPE |
| 1 | 458 | 1 204 | 431 | 0 | 1 | 95 | 22 | 43 | 76 | 0 |
| 2 | 344 | 55 | 1 | 0 | 4 | 163 | 58 | 3 | 22 | 1 |
| 5 | 176 | 29 | 127 | 0 | 1 | 53 | 17 | 126 | 48 | 0 |
| 6 | 157 | 114 | 5 | 0 | 73 | 270 | 63 | 3 | 27 | 76 |
| 7 | 131 | 285 | 340 | 0 | 26 | 86 | 3 | 190 | 27 | 0 |
| 8 | 338 | 146 | 8 | 1 | 149 | 130 | 37 | 1 | 48 | 47 |
| 9 | 0 | 5 | 1 | 16 | 0 | 2 | 1 | 0 | 12 | 7 |
| 11 | 346 | 565 | 194 | 0 | 87 | 0 | 45 | 117 | 88 | 0 |
| 12 | 304 | 62 | 127 | 9 | 221 | 10 | 87 | 1 | 50 | 34 |
| 13 | 295 | 41 | 79 | 1 000 | 67 | 90 | 45 | 0 | 47 | 50 |
| 14 | 807 | 640 | 261 | 1 | 85 | 0 | 7 | 93 | 78 | 0 |
| 15 | 102 | 212 | 90 | 7 | 268 | 14 | 174 | 0 | 45 | 10 |
| 16 | 106 | 21 | 39 | 1 152 | 31 | 184 | 46 | 0 | 31 | 100 |
| 17 | 159 | 17 | 5 | 0 | 10 | 0 | 155 | 60 | 122 | 21 |
| 18 | 25 | 113 | 14 | 0 | 1 | 0 | 38 | 43 | 184 | 2 |
| 19 | 143 | 269 | 21 | 0 | 15 | 10 | 18 | 148 | 20 | 3 |

| | Species code | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | LIN | SPO | RSK | WAR | JDO | ELE | JMD | LEA | JMN | NSD |
| 1 | 0 | 3 | 32 | 6 | 47 | 1 | 5 | 1 | 5 | 3 |
| 2 | 0 | 1 | 1 | 1 | 29 | 0 | 8 | 0 | 1 | 4 |
| 5 | 9 | 2 | 24 | 1 | 27 | 0 | 3 | 0 | 1 | 0 |
| 6 | 1 | 0 | 1 | 3 | 9 | 0 | 6 | 0 | 0 | 47 |
| 7 | 6 | 3 | 41 | 6 | 9 | 31 | 0 | 1 | 4 | 0 |
| 8 | 1 | 1 | 1 | 0 | 6 | 0 | 5 | 0 | 0 | 33 |
| 9 | 0 | 0 | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 55 |
| 11 | 6 | 6 | 32 | 23 | 7 | 97 | 3 | 0 | 5 | 0 |
| 12 | 17 | 3 | 0 | 17 | 0 | 0 | 54 | 0 | 0 | 0 |
| 13 | 88 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 1 | 12 |
| 14 | 27 | 2 | 21 | 79 | 0 | 0 | 14 | 0 | 1 | 0 |
| 15 | 2 | 0 | 0 | 111 | 0 | 0 | 7 | 0 | 0 | 0 |
| 16 | 146 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 17 | 1 | 3 | 0 | 7 | 39 | 0 | 0 | 2 | 32 | 0 |
| 18 | 0 | 3 | 4 | 1 | 20 | 0 | 0 | 3 | 5 | 0 |
| 19 | 0 | 23 | 58 | 2 | 28 | 0 | 9 | 7 | 62 | 0 |

**Table 4: Relative biomass estimates and c.v.s by trip from the entire survey area for species managed under the QMS.**

| | KAH9204 | | KAH9404 | | KAH9504 | | KAH9701 | | KAH0004 | | KAH0304 | | KAH0503 | | KAH0704 | | KAH0904 | | KAH1104 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Species | Biomass | cv% | Biomass | cv% | Biomass | cv% | Biomass | cv% | Biomass | cv% | Biomass | cv% | Biomass | cv% | Biomass | cv% | Biomass | cv% | Biomass | cv% |
| Arrow squid | 2 960 | 18 | 1 199 | 9 | 3 450 | 14 | 966 | 13 | 523 | 11 | 2 255 | 12 | 889 | 9 | 1 228 | 9 | 402 | 16 | 158 | 14 |
| Barracouta | 2 478 | 14 | 5 298 | 16 | 4 480 | 13 | 2 993 | 19 | 1 787 | 11 | 4 485 | 20 | 2 763 | 13 | 2 582 | 14 | 3 512 | 17 | 5 361 | 21 |
| Blue warehou | 123 | 40 | 80 | 22 | 115 | 29 | 842 | 31 | 272 | 37 | 191 | 66 | 116 | 40 | 286 | 50 | 175 | 27 | 267 | 26 |
| Dark ghost shark | 271 | 24 | 722 | 14 | 767 | 24 | 1 591 | 21 | 2 259 | 9 | 544 | 15 | 832 | 22 | 2 215 | 21 | 900 | 17 | 2 363 | 23 |
| Elephantfish | 21 | 42 | 167 | 33 | 85 | 35 | 94 | 32 | 42 | 63 | 48 | 34 | 59 | 33 | 28 | 53 | 185 | 83 | 170 | 53 |
| Frostfish | 25 | 32 | 27 | 23 | 89 | 31 | 259 | 32 | 316 | 16 | 494 | 22 | 423 | 45 | 529 | 39 | 835 | 35 | 251 | 29 |
| Gemfish | 145 | 19 | 68 | 29 | 21 | 55 | 704 | 83 | 120 | 30 | 137 | 23 | 474 | 49 | 101 | 19 | 143 | 29 | 102 | 34 |
| Giant stargazer | 1 302 | 12 | 1 350 | 17 | 1 551 | 16 | 1 450 | 15 | 1 023 | 12 | 834 | 15 | 1 458 | 19 | 1 630 | 12 | 1 952 | 19 | 1 645 | 16 |
| Hake | 391 | 25 | 99 | 31 | 5 244 | 27 | 1 019 | 46 | 15 | 36 | 55 | 47 | 1 673 | 30 | 359 | 35 | 212 | 56 | 44 | 36 |
| Hoki | 405 | 17 | 826 | 49 | 3 616 | 21 | 1 100 | 25 | 103 | 50 | 233 | 22 | 701 | 55 | 772 | 52 | 1 302 | 46 | 1 527 | 61 |
| Jack mackerel | | | | | | | | | | | | | | | | | | | | |
| *Trachurus declivis* | 92 | 24 | 99 | 26 | 106 | 20 | 162 | 19 | 168 | 33 | 87 | 21 | 118 | 21 | 62 | 23 | 79 | 23 | 231 | 35 |
| *T. novaezelandiae* | 281 | 58 | 69 | 23 | 57 | 29 | 363 | 27 | 194 | 46 | 126 | 49 | 98 | 20 | 214 | 62 | 399 | 24 | 193 | 44 |
| John dory | 102 | 29 | 59 | 26 | 27 | 36 | 17 | 31 | 141 | 16 | 288 | 19 | 222 | 14 | 174 | 26 | 269 | 23 | 378 | 16 |
| Leatherjacket | 203 | 29 | 230 | 23 | 153 | 34 | 231 | 34 | 236 | 50 | 254 | 18 | 139 | 20 | 252 | 40 | 323 | 27 | 191 | 24 |
| Lemon sole | 88 | 18 | 77 | 25 | 126 | 21 | 68 | 21 | 59 | 19 | 2 | 44 | 21 | 42 | 119 | 46 | 62 | 16 | 83 | 14 |
| Ling | 286 | 19 | 261 | 20 | 367 | 16 | 151 | 30 | 95 | 46 | 150 | 33 | 274 | 37 | 180 | 27 | 291 | 37 | 235 | 43 |
| New Zealand sole | 68 | 33 | 68 | 16 | 39 | 30 | 45 | 29 | 16 | 32 | 21 | 57 | 27 | 45 | 39 | 71 | 75 | 32 | 27 | 41 |
| Northern spiny dogfish | 146 | 20 | 159 | 21 | 86 | 28 | 164 | 46 | 256 | 18 | 111 | 27 | 180 | 22 | 134 | 29 | 189 | 28 | 368 | 29 |
| Red cod | 2 719 | 13 | 3 169 | 18 | 3 123 | 15 | 2 546 | 23 | 414 | 26 | 906 | 24 | 2 610 | 18 | 1 638 | 19 | 2 782 | 25 | 2 087 | 27 |
| Red gurnard | 573 | 16 | 559 | 15 | 584 | 19 | 471 | 13 | 625 | 14 | 270 | 20 | 442 | 17 | 553 | 17 | 651 | 18 | 1 070 | 17 |
| Rig | 288 | 14 | 380 | 10 | 490 | 10 | 308 | 18 | 333 | 18 | 144 | 22 | 153 | 19 | 383 | 33 | 274 | 26 | 307 | 18 |
| Rough skate | 173 | 27 | 196 | 23 | 251 | 22 | 185 | 30 | 186 | 23 | 43 | 34 | 58 | 30 | 256 | 23 | 114 | 21 | 347 | 23 |
| Sand flounder | 100 | 31 | 203 | 23 | 132 | 28 | 106 | 28 | 62 | 22 | 10 | 33 | 62 | 25 | 67 | 47 | 170 | 32 | 102 | 23 |
| School shark | 933 | 22 | 1 151 | 41 | 1 204 | 35 | 1 432 | 25 | 896 | 13 | 655 | 18 | 774 | 14 | 816 | 20 | 1 085 | 16 | 1 155 | 13 |
| Sea perch | 242 | 22 | 426 | 18 | 667 | 23 | 338 | 14 | 302 | 22 | 76 | 25 | 150 | 20 | 163 | 19 | 336 | 20 | 558 | 39 |
| Silver warehou | 292 | 38 | 66 | 35 | 38 | 20 | 204 | 20 | 99 | 34 | 69 | 27 | 72 | 28 | 165 | 20 | 80 | 24 | 70 | 32 |
| Smooth skate | 339 | 19 | 341 | 18 | 315 | 20 | 302 | 26 | 140 | 29 | 91 | 79 | 80 | 30 | 55 | 44 | 67 | 61 | 185 | 33 |
| Spiny dogfish | 3 919 | 15 | 7 145 | 7 | 8 370 | 10 | 5 275 | 13 | 4 777 | 12 | 4 446 | 15 | 6 175 | 12 | 6 291 | 14 | 10 270 | 19 | 6 402 | 13 |
| Tarakihi | 1 409 | 14 | 1 394 | 13 | 1 389 | 10 | 1 087 | 12 | 964 | 19 | 912 | 20 | 2 050 | 12 | 1 189 | 21 | 1 088 | 22 | 1 188 | 15 |

**Table 5: Recruited biomass estimates (t) and target species adult biomass estimates.**

| Species | Recruited length (cm) | Tasman and Golden Bays Biomass | Tasman and Golden Bays c.v.% | West coast Biomass | West coast c.v.% | Total survey area Biomass | Total survey area c.v.% | 50% maturity length (cm) | Total survey area Biomass | Total survey area c.v.% |
|---|---|---|---|---|---|---|---|---|---|---|
| Barracouta | 50 | 695 | 56 | 4 324 | 25 | 5 019 | 23 | | | |
| Blue warehou | 45 | 0 | | 231 | 30 | 231 | 30 | | | |
| Giant stargazer | 30 | 38 | 39 | 1 588 | 16 | 1 626 | 16 | 45 | 1 382 | 17 |
| Hoki | 65 | 0 | | 179 | 55 | 179 | 55 | | | |
| John dory | 25 | 100 | 13 | 277 | 21 | 377 | 16 | | | |
| Ling | 65 | 0 | | 155 | 63 | 155 | 63 | | | |
| Red cod | 40 | 45 | 47 | 792 | 23 | 392 | 27 | 51 | 259 | 25 |
| Red gurnard | 30 | 245 | 19 | 554 | 25 | 798 | 19 | 30 | 798 | 19 |
| Rig | 90 | 16 | 62 | 76 | 33 | 91 | 29 | | | |
| Sand flounder | 25 | 69 | 25 | 7 | 70 | 76 | 24 | | | |
| Spiny dogfish | | | | | | | | Males 58 | 2 035 | 18 |
| | | | | | | | | Females 72 | 2 431 | 20 |
| School shark | 90 | 47 | 63 | 462 | 19 | 509 | 18 | | | |
| Silver warehou | 25 | 0 | | 60 | 35 | 60 | 35 | | | |
| Tarakihi | 25 | 62 | 43 | 974 | 17 | 1 036 | 16 | 31 | 704 | 17 |

**Table 6: Biomass estimates (t) by year class estimated from length frequency distributions.**

| Species | Year class | Length range (cm) | Biomass | c.v.% |
|---|---|---|---|---|
| Barracouta | 0+ | <15 | <0.05 | 91 |
| | 1+ | 15– 25 | 17 | 44 |
| | 2+ | 26–36 | 1 | 50 |
| | 3+ | 37–52 | 333 | 62 |
| Blue warehou | 0+ | <21 | 6 | 23 |
| | 1+ | 22–31 | 19 | 35 |
| | 2+ | 32–42 | 4 | 71 |
| Hake | 0+ | <19 | 1 | 45 |
| | 1+ | 19–28 | 5 | 48 |
| | 2+ | 29–42 | 37 | 38 |
| Hoki | 0+ | 15–30 | 29 | 23 |
| | 1+ | 31–44 | 1 007 | 69 |
| Jack mackerel | | | | |
| (*T. novaezelan* | 1+ | 13–20 | 43 | 34 |
| Red cod | 0+ | <20 | 5 | 36 |
| | 1+ | 21–35 | 1 078 | 40 |
| Red gurnard | 0+ | <17 | 0.3 | 37 |
| | 2+ | 17–27 | 106 | 19 |
| School shark | 0+ | < 44 | 16 | 23 |
| | 1+ | 44–54 | 49 | 23 |
| Silver warehou | 1+ | 13–23 | 10 | 40 |
| Tarakihi | 0+ | 10–14 | 5 | 18 |
| | 1+ | 15–21 | 28 | 23 |
| | 2+ | 22–28 | 281.8 | 24.7 |

**Table 7: Estimated biomass (t) (and c.v.%) by stratum for the 20 most abundant commercially important species in order of catch abundance. Species codes are given in Appendix 3.**

| | Species code | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Stratum | SPD | BAR | RCO | HOK | STA | GSH | TAR | GUR | SCH | SPE |
| 1 | 616 (54) | 1 617 (57) | 579 (83) | 0 | 2 (41) | 128 (47) | 30 (55) | 57 (53) | 102 (15) | + (100) |
| 2 | 1 482 (39) | 235 (28) | 3 (64) | 0 | 19 (95) | 700 (35) | 248 (47) | 12 (78) | 93 (32) | 6 (68) |
| 5 | 200 (25) | 33 (64) | 144 (45) | 0 | 1 (100) | 60 (25) | 19 (40) | 143 (85) | 55 (31) | + (100) |
| 6 | 509 (17) | 369 (37) | 18 (100) | + (100) | 235 (69) | 871 (50) | 204 (16) | 10 (100) | 88 (100) | 246 (84) |
| 7 | 121 (32) | 264 (45) | 315 (67) | + (100) | 24 (77) | 80 (58) | 2 (69) | 176 (48) | 25 (32) | 0 |
| 8 | 797 (42) | 344 (46) | 20 (71) | 2 (62) | 352 (35) | 305 (50) | 87 (25) | 2 (58) | 114 (38) | 110 (37) |
| 9 | 0 | 9 (58) | 1 (100) | 30 (100) | 0 | 3 (100) | 2 (100) | 0 | 23 (51) | 13 (92) |
| 11 | 497 (33) | 813 (41) | 279 (48) | 1 (72) | 126 (27) | + (100) | 64 (72) | 169 (30) | 126 (33) | + (68) |
| 12 | 625 (18) | 128 (19) | 262 (45) | 19 (29) | 454 (15) | 21 (80) | 179 (11) | 3 (100) | 103 (23) | 70 (31) |
| 13 | 324 (59) | 45 (42) | 87 (31) | 1101 (80) | 73 (21) | 99 (43) | 49 (50) | 0 | 51 (43) | 55 (44) |
| 14 | 686 (30) | 544 (44) | 222 (48) | 1 (100) | 73 (55) | 0 | 6 (60) | 79 (54) | 66 (58) | 0 |
| 15 | 90 (22) | 187 (29) | 80 (49) | 6 (69) | 237 (52) | 13 (100) | 153 (69) | 0 | 40 (59) | 9 (40) |
| 16 | 34 (42) | 7 (45) | 13 (50) | 367 (84) | 10 (53) | 59 (36) | 15 (97) | 0 | 10 (32) | 32 (72) |
| 17 | 49 (83) | 5 (25) | 2 (98) | 0 | 3 (69) | 0 | 48 (67) | 19 (39) | 37 (52) | 7 (62) |
| 18 | 24 (24) | 107 (39) | 13 (31) | 0 | 1 (100) | 0 | 36 (42) | 41 (9) | 174 (48) | 2 (53) |
| 19 | 349 (45) | 654 (60) | 50 (60) | 0 | 36 (41) | 25 (100) | 45 (61) | 360 (21) | 48 (41) | 8 (56) |

\+ < 0.5 t.

**Table 7–continued.**

| | Species code | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Stratum | LIN | SPO | RSK | SPE | WAR | JDO | ELE | JMD | LEA | JMN |
| 1 | + | + | 49 | 43 | 8 | 63 | 2 | 7 | + | 7 |
| | (100) | (100) | (55) | (42) | (66) | 24 | (100) | (69) | (100) | (46) |
| 2 | 6 | 1 | 5 | 5 | 3 | 124 | 0 | 33 | 0 | 5 |
| | (68) | (100) | (100) | (100) | (100) | (44) | | (94) | | (63) |
| 5 | + | 10 | 15 | 28 | 1 | 30 | 0 | 3 | 0 | 2 |
| | (100) | (69) | (50) | (17) | (100) | (41) | | (100) | | (100) |
| 6 | 246 | 3 | 0 | 3 | 8 | 29 | 0 | 19 | 0 | 2 |
| | (84) | (64) | | (100) | (77) | (10) | | (61) | | (100) |
| 7 | 0 | 5 | 34 | 38 | 6 | 8 | 28 | 0 | + | 4 |
| | | (100) | (61) | (73) | (92) | (61) | (63) | | (100) | (42) |
| 8 | 110 | 3 | 4 | 3 | 0 | 15 | 0 | 13 | 0 | 0 |
| | (37) | (61) | (100) | (100) | | (84) | | (82) | | |
| 9 | 13 | 0 | 0 | 14 | 0 | 0 | 0 | 0 | 0 | 0 |
| | (92) | | | (79) | | | | | | |
| 11 | 0 | 9 | 57 | 46 | 33 | 9 | 139 | 4 | 0 | 7 |
| | (68) | (75) | (53) | (58) | (41) | (56) | (64) | (46) | | (70) |
| 12 | 70 | 34 | 16 | 0 | 35 | 0 | 0 | 111 | 0 | 1 |
| | (31) | (57) | (64) | | (42) | | | (65) | | (100) |
| 13 | 55 | 97 | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 1 |
| | (44) | (95) | | (100) | | | | | | (100) |
| 14 | 0 | 23 | 22 | 18 | 67 | 0 | + | 12 | 0 | 1 |
| | | (38) | (62) | (63) | (94) | | (100) | (61) | | (76) |
| 15 | 9 | 2 | 0 | 0 | 98 | 0 | 0 | 7 | 0 | 0 |
| | (40) | (39) | | | (23) | | | (50) | | |
| 16 | 32 | 47 | 0 | 0 | 0 | 0 | 0 | + | 0 | 0 |
| | (72) | (63) | | | | | | (100) | | |
| 17 | 7 | 0 | 12 | 0 | 2 | 12 | 0 | 0 | 11 | 10 |
| | (62) | (51) | (19) | | (59) | (6) | | | (54) | (39) |
| 18 | 2 | + | 36 | 4 | 1 | 19 | 0 | 0 | 61 | 4 |
| | (53) | (100) | (41) | (100) | (29) | (12) | | | (8) | (47) |
| 19 | 8 | 1 | 57 | 141 | 4 | 69 | 1 | 23 | 118 | 150 |
| | (56) | (100) | (35) | (45) | (64) | (18) | (100) | (60) | (39) | (57) |

\+ < 0.5 t.

**Table 8: Number of biological and length frequency records.**

| Species code | Measurement method | Length frequency data No. of samples | No. of fish | Biological data+ No. of samples | No. of fish | No. of otoliths or spines | No. of tagged fish |
|---|---|---|---|---|---|---|---|
| BAR | 1 | 63 | 2 858 | | | | |
| BCO | 2 | 14 | 270 | | | | |
| BRI | 2 | 4 | 8 | | | | |
| BRZ | 2 | 3 | 5 | | | | |
| BSH | 2 | 1 | 1 | 1 | 1 | | |
| BTA | 5 | 1 | 2 | | | | |
| CBI | 2 | 45 | 3 183 | | | | |
| ELE | 1 | 10 | 117 | | | | |
| EMA | 5 | 3 | 8 | | | | |
| ESO | 2 | 10 | 335 | | | | |
| FRO | 1 | 27 | 335 | | | | |
| GSH | G | 31 | 1 704 | | | | |
| GUR | 1 | 41 | 2 976 | 40 | 694 | 257 | |
| HAK | 2 | 20 | 261 | 20 | 261 | | |
| HAP | 2 | 8 | 12 | | | | |
| HEP | 2 | 1 | 1 | | | | |
| HOK | 2 | 23 | 1506 | | | | |
| JDO | 2 | 33 | 265 | | | | |
| JMD | 1 | 29 | 448 | | | | |
| JMM | 1 | 4 | 8 | | | | |
| JMN | 1 | 32 | 854 | | | | |
| KAH | 1 | 6 | 46 | | | | |
| LEA | 2 | 11 | 980 | | | | |
| LIN | 2 | 33 | 450 | | | | |
| LSO | 2 | 33 | 794 | | | | |
| NSD | 4 | 16 | 143 | | | | |
| OPE | 2 | 2 | 29 | | | | |
| RBM | 1 | 1 | 6 | | | | |
| RCO | 2 | 55 | 3 763 | 55 | 965 | 319 | |
| RSK | 5 | 31 | 221 | 31 | 221 | | 116 |
| SCH | 2 | 61 | 944 | 61 | 783 | | 233 |
| SDO | 2 | 5 | 668 | | | | |
| SFL | 2 | 15 | 598 | | | | |
| SKI | 1 | 10 | 45 | | | | |
| SNA | 1 | 8 | 97 | | | | |
| SPD | 2 | 62 | 4 082 | 62 | 1 187 | 371 | |
| SPE | 2 | 39 | 1 998 | | | | |
| SPO | 2 | 34 | 423 | 34 | 366 | | 45 |
| SSH | 2 | 3 | 20 | | | | |
| SSK | 5 | 22 | 44 | 22 | 44 | | 17 |
| STA | 2 | 48 | 896 | 48 | 701 | 372 | |
| SWA | 1 | 28 | 260 | | | | |
| TAR | 1 | 69* | 3207* | 51 | 957 | 366 | 912 |
| TRE | 1 | 1 | 1 | | | | |
| TUR | 2 | 2 | 2 | | | | |
| WAR | 1 | 38 | 399 | | | | |

Measurement methods: 1, fork length; 2, total length; 4, mantle length; 5, pelvic length;
G, total length excluding tail filament
+ Data include one or more of the following: fish length, fish weight, gonad stage, otoliths, spines
* Includes tagging stations

**Table 9: Numbers of the four target species sampled at each reproductive stage (small fish of undetermined sex are not included).**

**a: Teleosts**

| | Males | | | | | Females | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Gonad stage | | | | | Gonad stage | | | | | |
| Length (cm) | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 | |
| **Giant stargazer** | | | | | | | | | | | |
| 11–20 | 6 | 0 | 0 | 0 | 0 | 8 | 0 | 0 | 0 | 0 | |
| 21–30 | 28 | 0 | 0 | 0 | 0 | 20 | 0 | 0 | 0 | 0 | |
| 31–40 | 60 | 15 | 4 | 0 | 0 | 50 | 0 | 0 | 0 | 0 | |
| 41–50 | 22 | 74 | 28 | 3 | 8 | 57 | 4 | 0 | 0 | 0 | |
| 51–60 | 6 | 52 | 22 | 3 | 7 | 31 | 48 | 3 | 0 | 3 | |
| 61–70 | 0 | 10 | 5 | 0 | 2 | 72 | 76 | 11 | 0 | 84 | |
| > 70 | 0 | 1 | 2 | 3 | 4 | 0 | 3 | 0 | 0 | 1 | |
| Total | 122 | 152 | 61 | 9 | 21 | 238 | 131 | 14 | 0 | 88 | 836 |
| **Red cod** | | | | | | | | | | | |
| 11–20 | 4 | 0 | 0 | 0 | 0 | 13 | 0 | 0 | 0 | 0 | |
| 21–30 | 225 | 11 | 3 | 0 | 0 | 106 | 1 | 0 | 0 | 0 | |
| 31–40 | 74 | 4 | 9 | 1 | 0 | 119 | 1 | 0 | 0 | 0 | |
| 41–50 | 59 | 24 | 23 | 2 | 0 | 72 | 2 | 1 | 0 | 0 | |
| 51–60 | 8 | 10 | 7 | 0 | 0 | 63 | 10 | 5 | 1 | 0 | |
| > 60 | 0 | 0 | 0 | 0 | 0 | 4 | 1 | 1 | 2 | 0 | |
| Total | 370 | 49 | 42 | 3 | 0 | 377 | 15 | 7 | 3 | 0 | 866 |
| **Red gurnard** | | | | | | | | | | | |
| < 21 | 2 | 6 | 0 | 0 | 0 | 6 | 0 | 0 | 0 | 0 | |
| 21–30 | 30 | 51 | 29 | 10 | 0 | 62 | 26 | 2 | 0 | 0 | |
| 31–40 | 8 | 55 | 67 | 49 | 21 | 43 | 61 | 27 | 1 | 17 | |
| >40 | 0 | 5 | 5 | 10 | 5 | 3 | 22 | 21 | 6 | 10 | |
| Total | 40 | 117 | 101 | 69 | 26 | 114 | 109 | 50 | 7 | 27 | 660 |
| **Tarakihi** | | | | | | | | | | | |
| 11–20 | 56 | 1 | 0 | 0 | 1 | 47 | 2 | 0 | 0 | 0 | |
| 21–30 | 159 | 9 | 3 | 0 | 3 | 191 | 5 | 1 | 0 | 0 | |
| 31–40 | 29 | 8 | 18 | 8 | 46 | 93 | 104 | 17 | 5 | 5 | |
| >40 | 0 | 2 | 4 | 1 | 9 | 3 | 61 | 12 | 2 | 3 | |
| Total | 244 | 20 | 25 | 9 | 59 | 334 | 172 | 30 | 7 | 8 | 908 |

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 flacid and bloodshot)

## Table 9b: Elasmobranchs

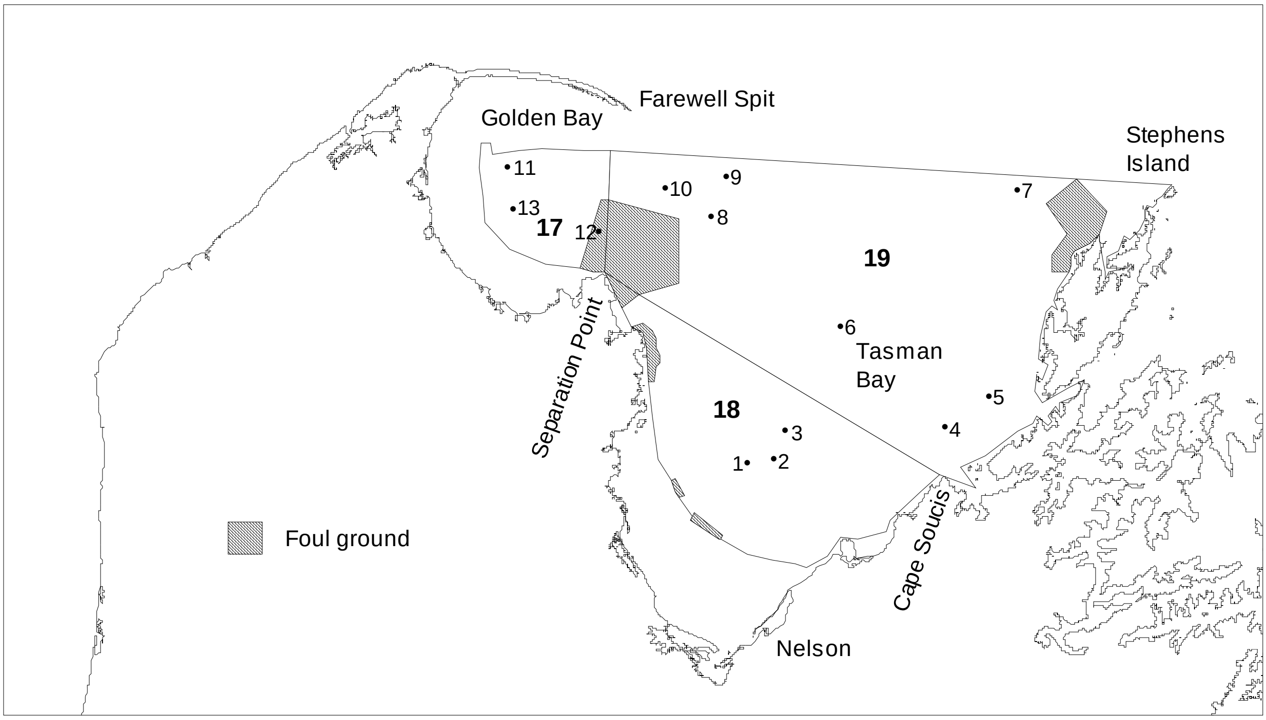
### Spiny dogfish

| Length (cm) | Males Gonad stage 1 | 2 | 3 | Females Gonad stage 1 | 2 | 3 | 4 | 5 | 6 | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Spiny dogfish** | | | | | | | | | | |
| <40 | 22 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 41–50 | 51 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 51–60 | 6 | 22 | 70 | 26 | 0 | 0 | 0 | 0 | 0 | |
| 61–70 | 2 | 18 | 276 | 46 | 37 | 12 | 21 | 3 | 4 | |
| 71–80 | 0 | 3 | 23 | 8 | 20 | 92 | 119 | 7 | 7 | |
| >80 | 0 | 1 | 0 | 2 | 4 | 50 | 60 | 1 | 0 | |
| Total | 81 | 46 | 369 | 82 | 61 | 154 | 200 | 11 | 11 | 1 015 |

Maturity stages used were:

Males
1. Immature (claspers shorter than the pelvic fins)
2. Maturing (Claspers at least as long as the pelvic fins but soft)
3. Mature (claspers longer than the pelvic fins and hard and firm)
4. Running ripe (milt expressible with light pressure)

Females
1. Immature (No eggs visible in the ovary)
2. Maturing (Non-yolked eggs visible in the ovary);
3. Mature (Yolked eggs in the ovary, uterus small and firm);
4. Ripe ('Candle' of eggs in the uterus, no embryos visible)
5. Running ripe (embryos visible in the uterus);
6. Spent (Uterus flabby and may be bloodshot. Yolked eggs may be present in the ovary)



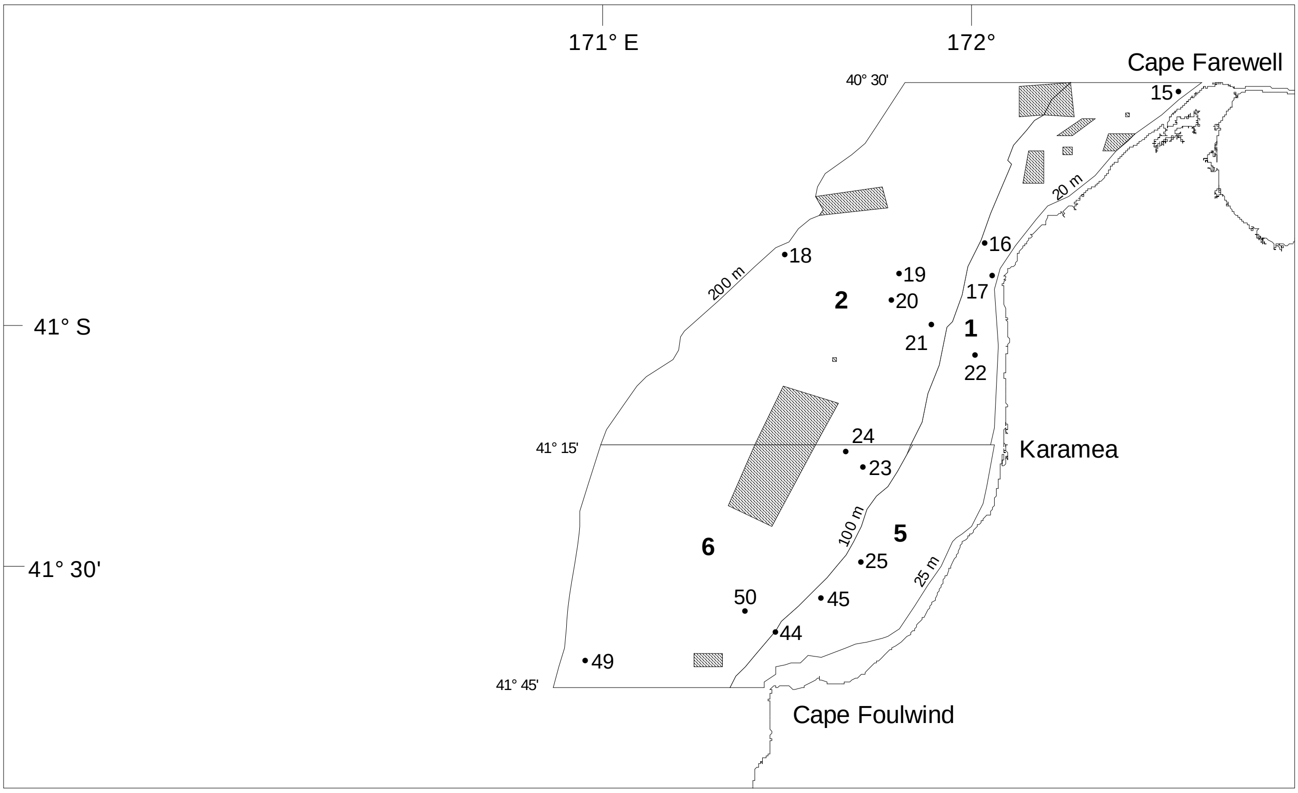




**Figure 1a: Survey area showing strata boundaries and numbers (bold type) for Tasman and Golden Bays (top) and the west coast north of Cape Foulwind (bottom) with station positions and numbers.**


**Figure 1b: Strata boundaries and numbers (bold type) south of Cape Foulwind with station positions and numbers.**

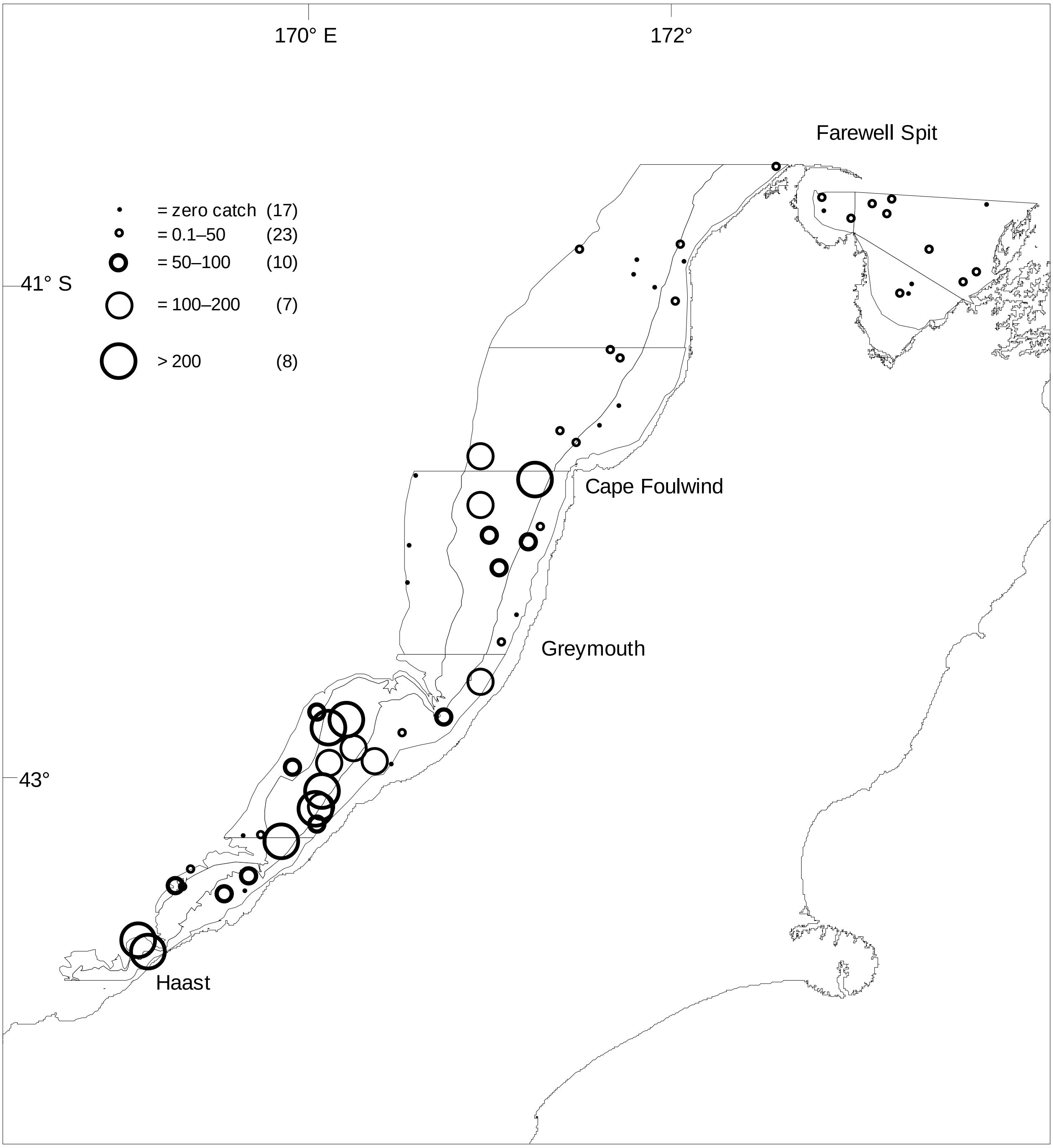



**Figure 2: Catch rates (kg.km$^{-2}$) and distribution for the target species in alphabetical order by common name (numbers in parentheses are the number of stations within the given range).**

**a: Giant stargazer (maximum catch rate = 530 kg.km$^{-2}$)**

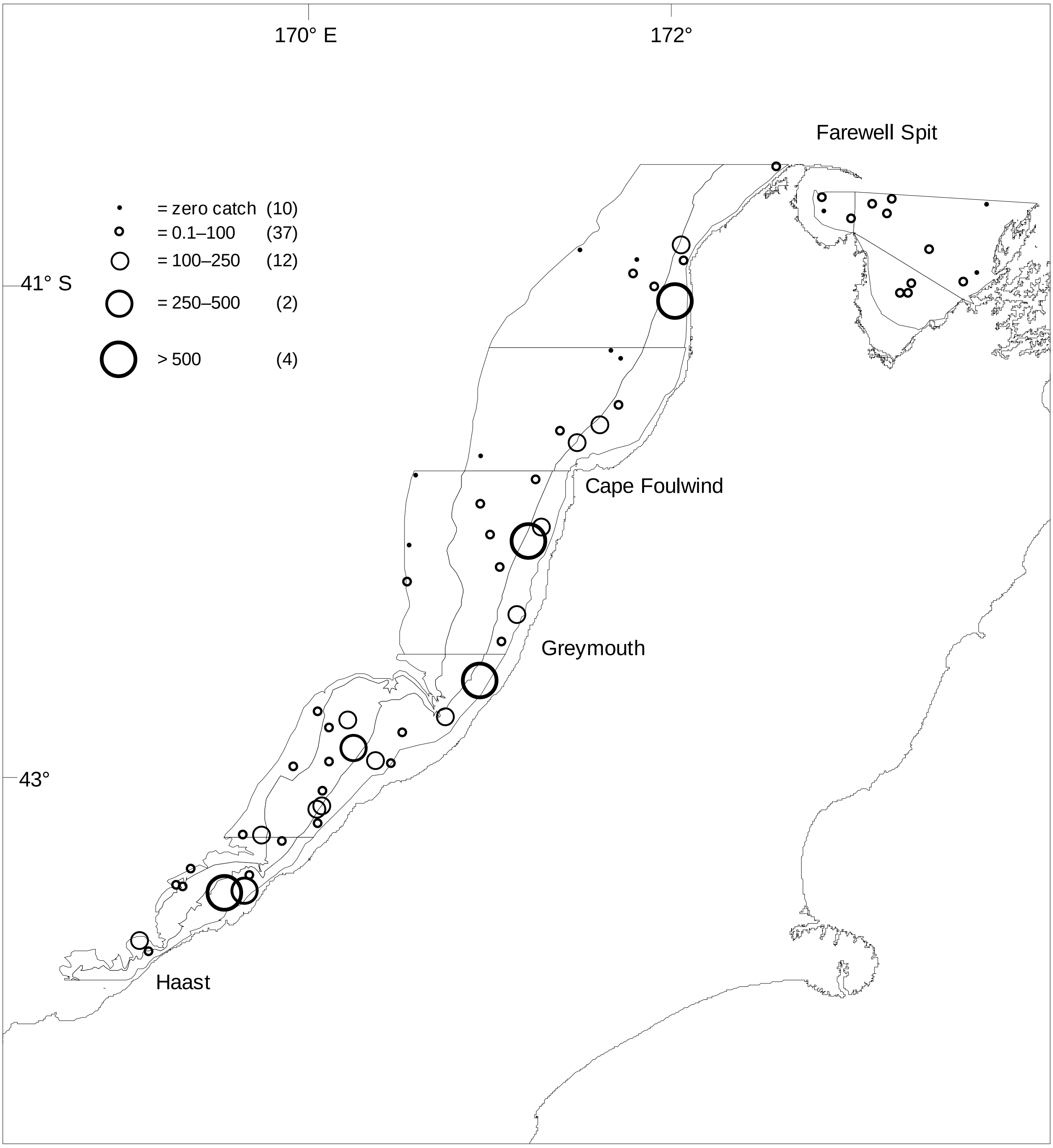



**Figure 2b: Red cod (maximum catch rate = 1 510 kg.km$^{-2}$).**

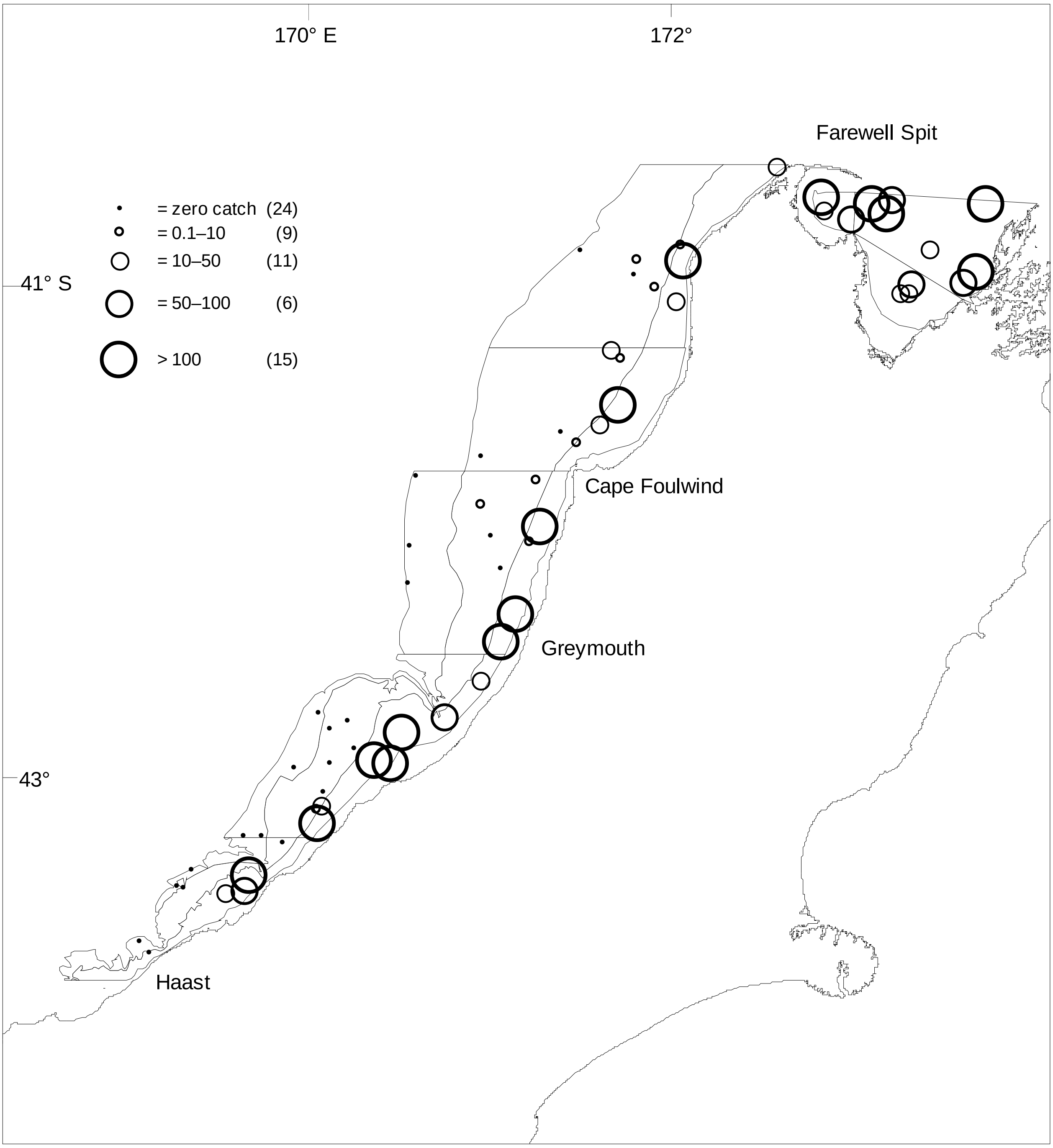



**Figure 2c: Red gurnard (maximum catch rate = 434 kg.km$^{-2}$).**

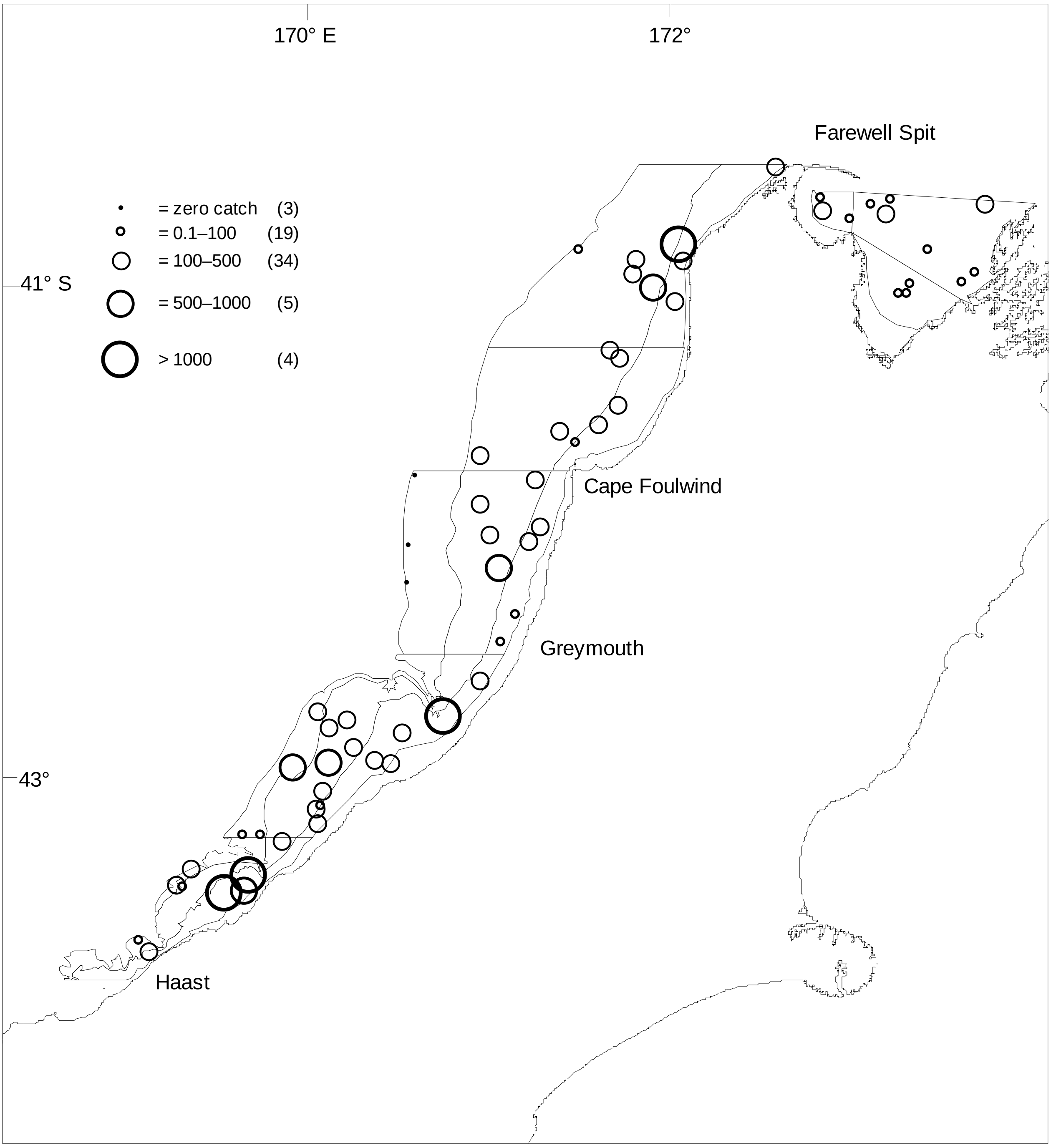



**Figure 2d: Spiny dogfish (maximum catch rate = 1 270 kg.km$^{-2}$).**

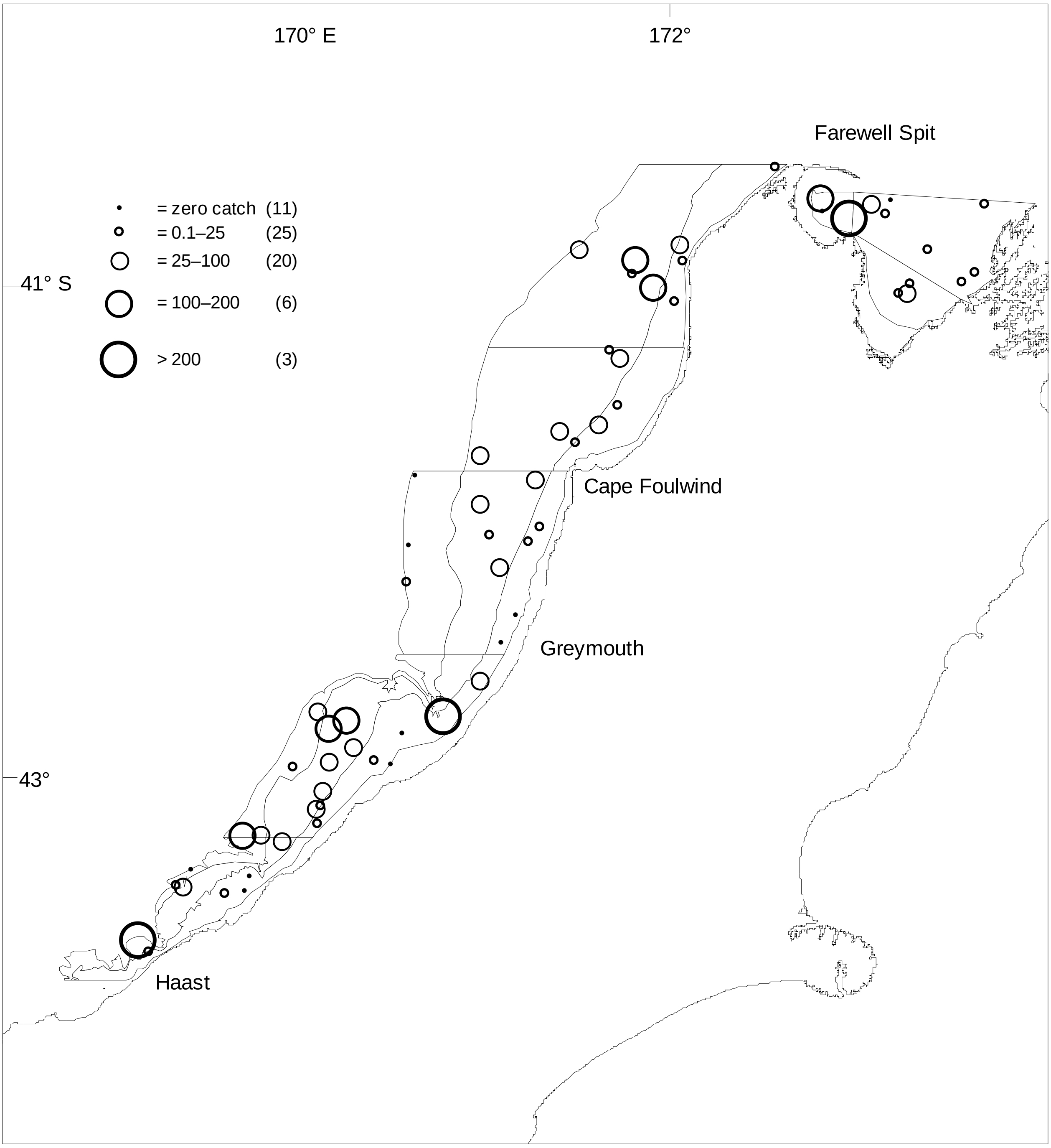



**Figure 2e: Tarakihi (maximum catch rate = 434 kg.km$^{-2}$).**

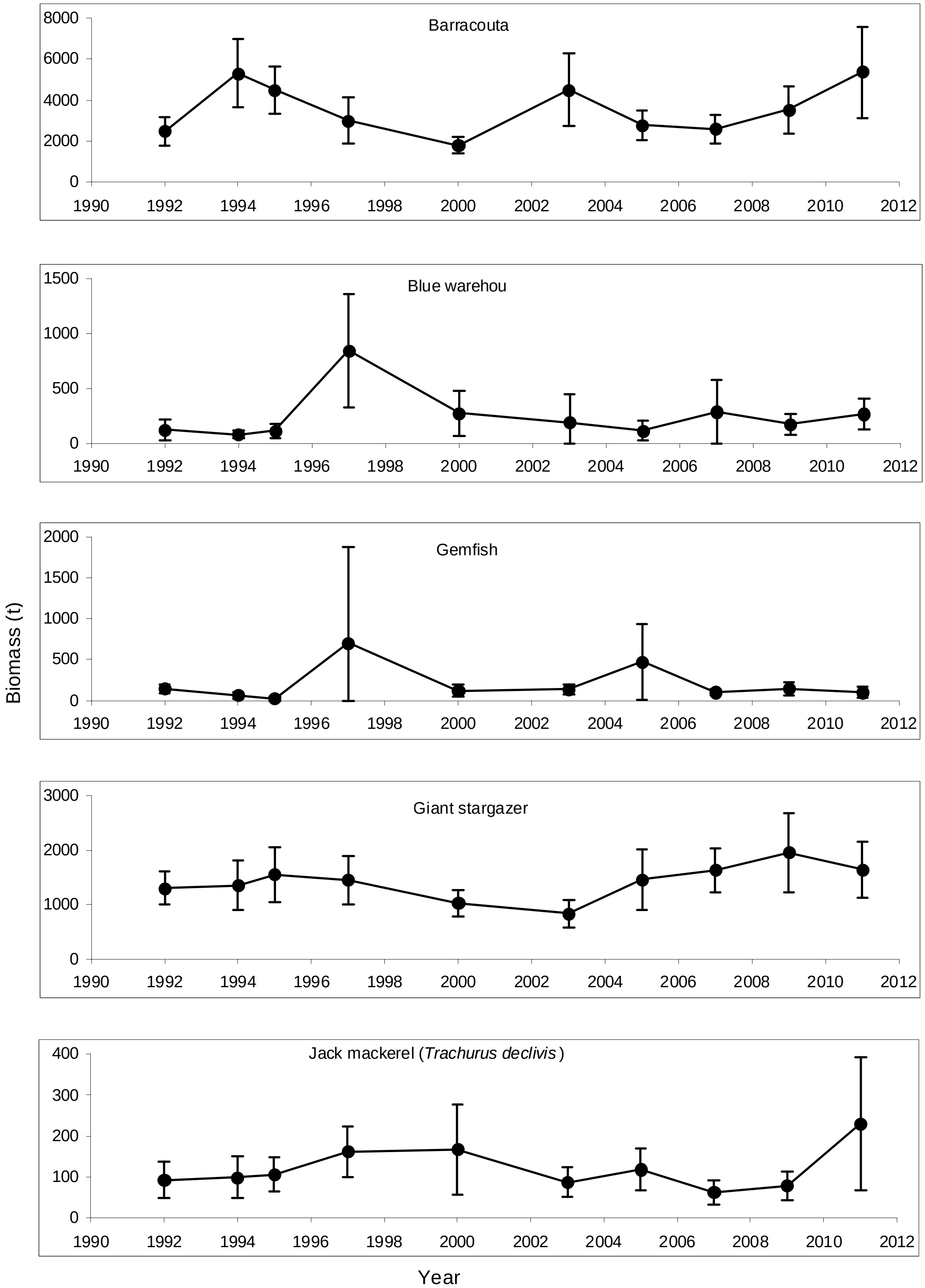



**Figure 3: Trends in total biomass for the target species and other species for which the survey time series is likely to be monitoring adult or pre-recruit abundance.**

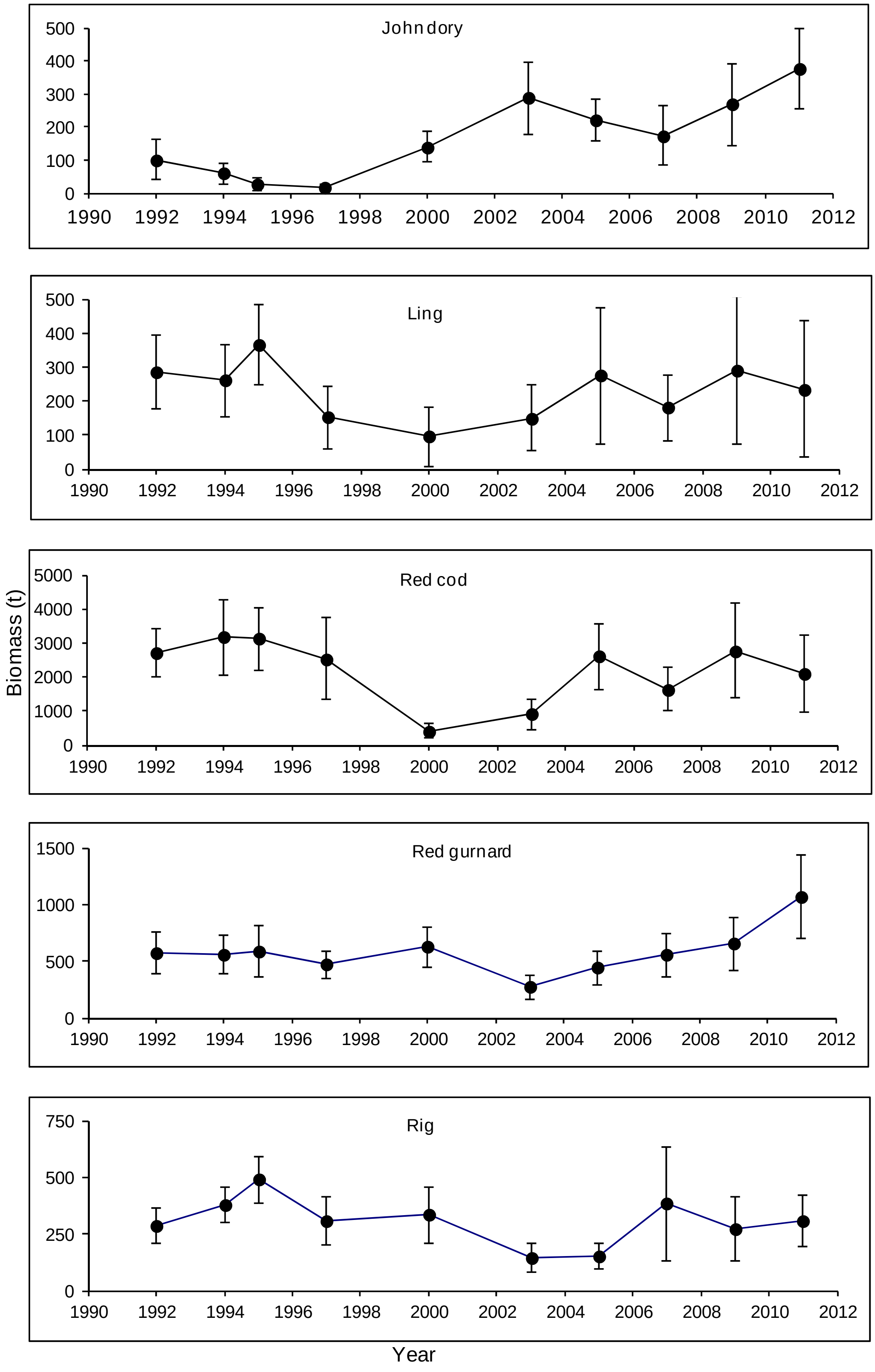



**Figure 3—continued**

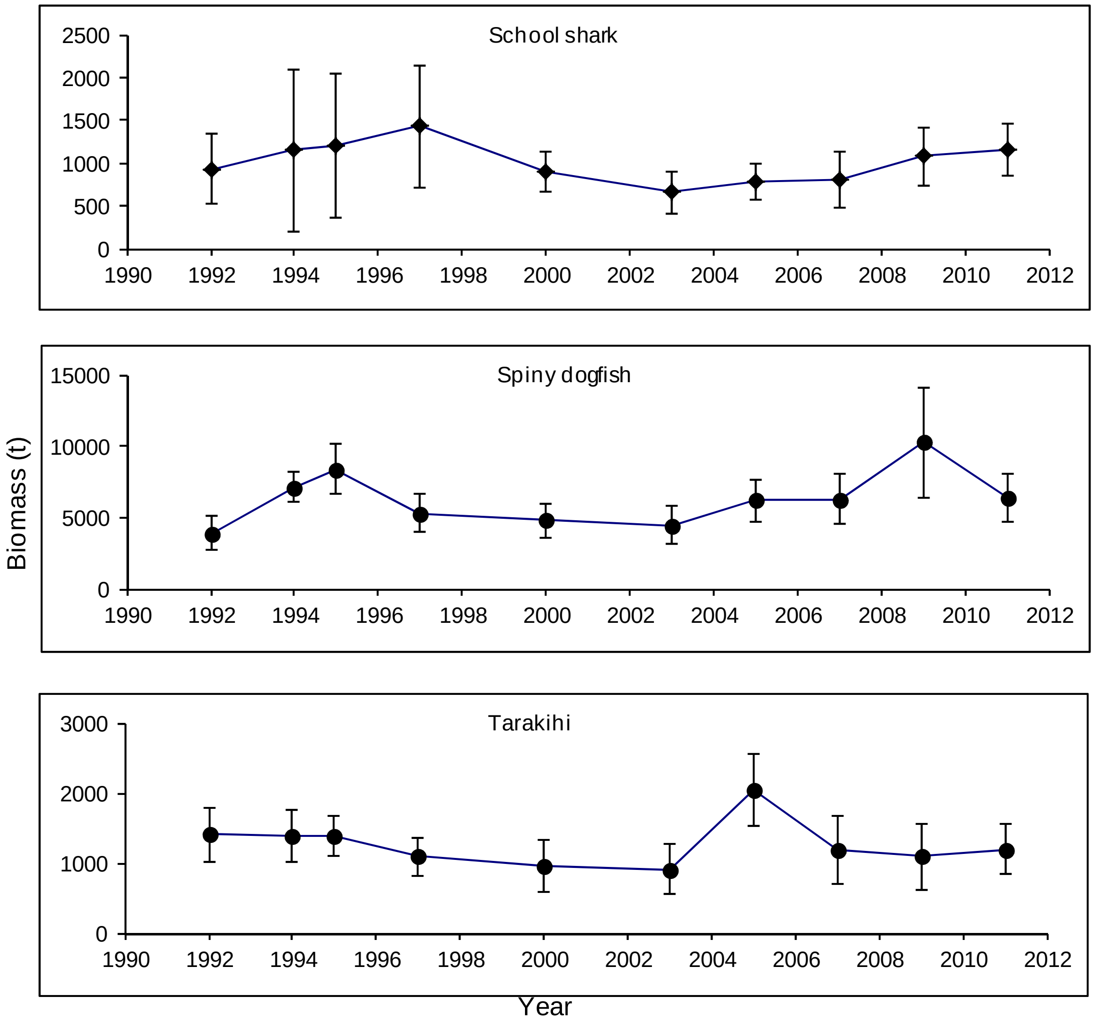



**Figure 3—continued**

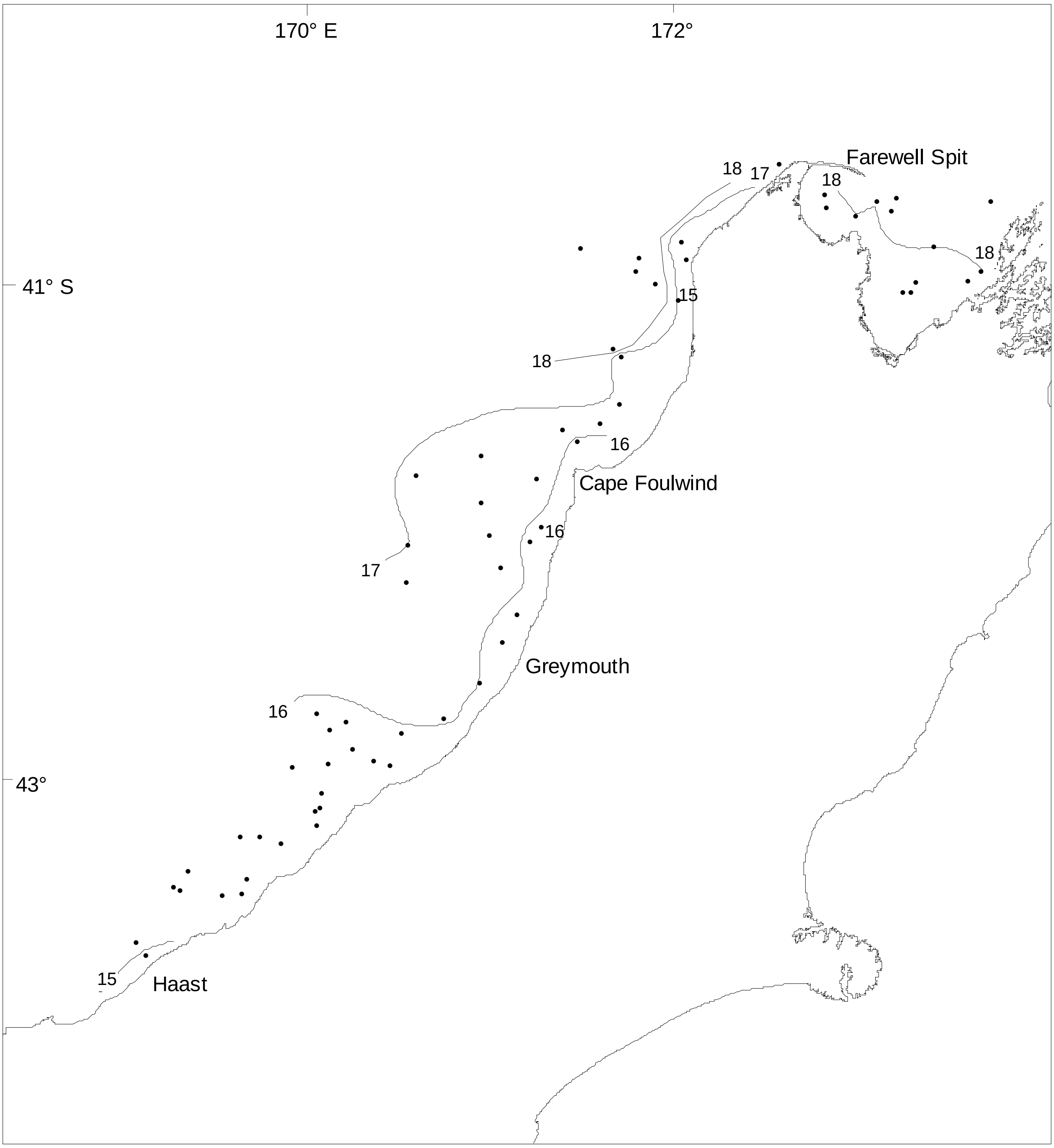



**Figure 4: Positions of CTD sea surface temperature recordings and isotherms estimated from the data.**

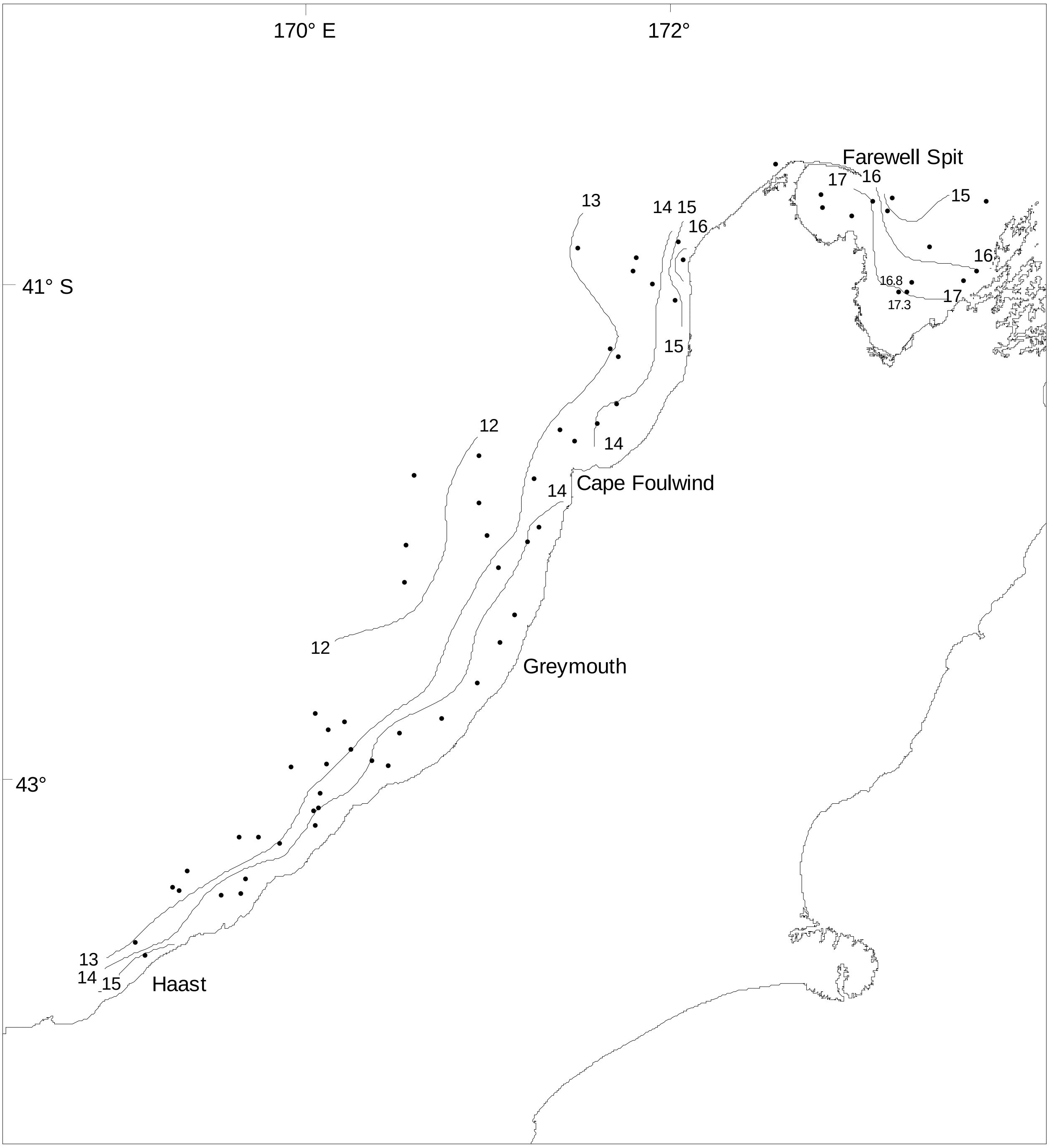



**Figure 5: Positions of CTD bottom temperature recordings and isotherms estimated from the data.**

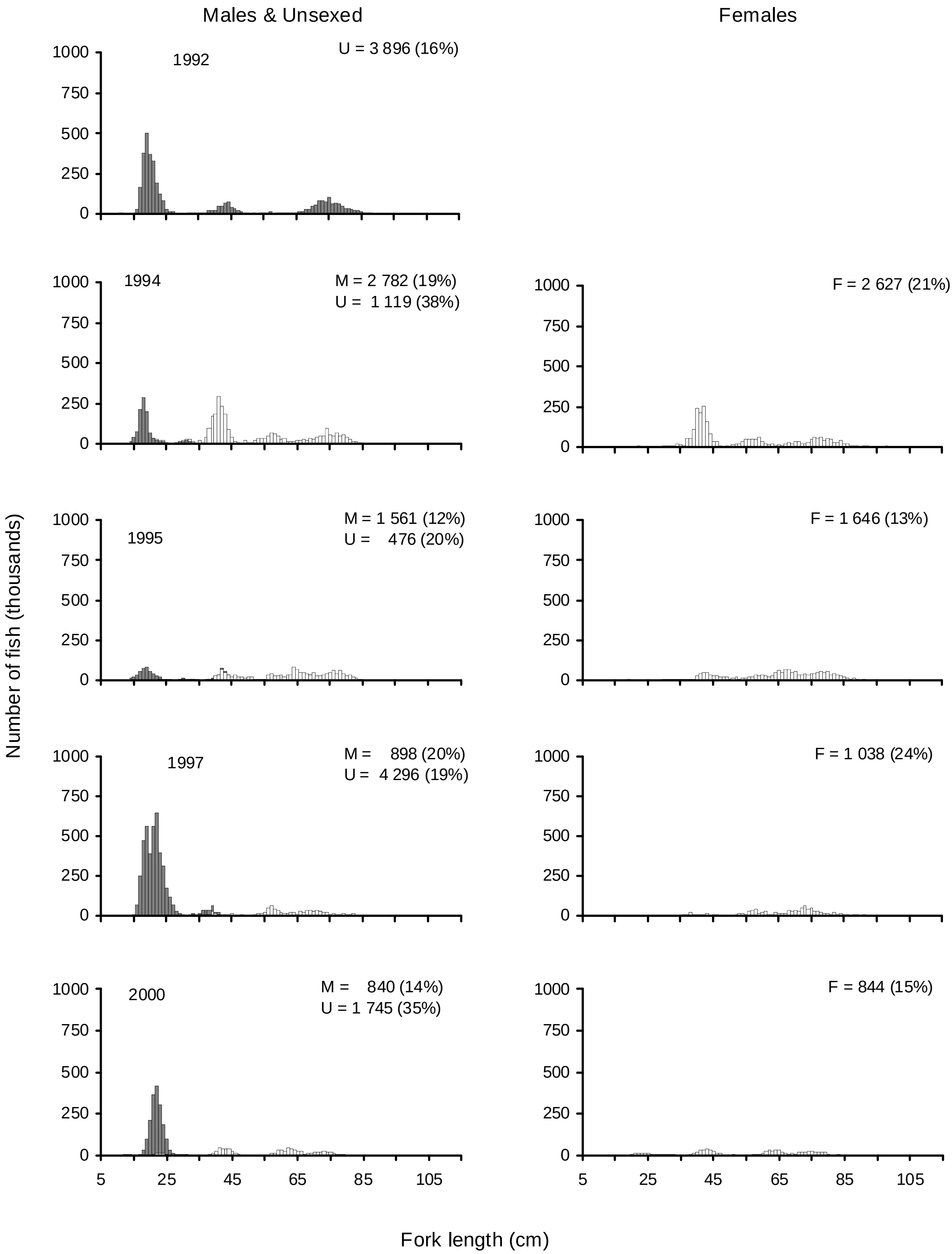



**Figure 6: Comparative scaled length frequencies for the target species and those species where the surveys are monitoring adult or pre-recruit abundance. Estimated population in thousands and c.v.%. (M, males; F, females; U, unsexed)**
**a: Barracouta**

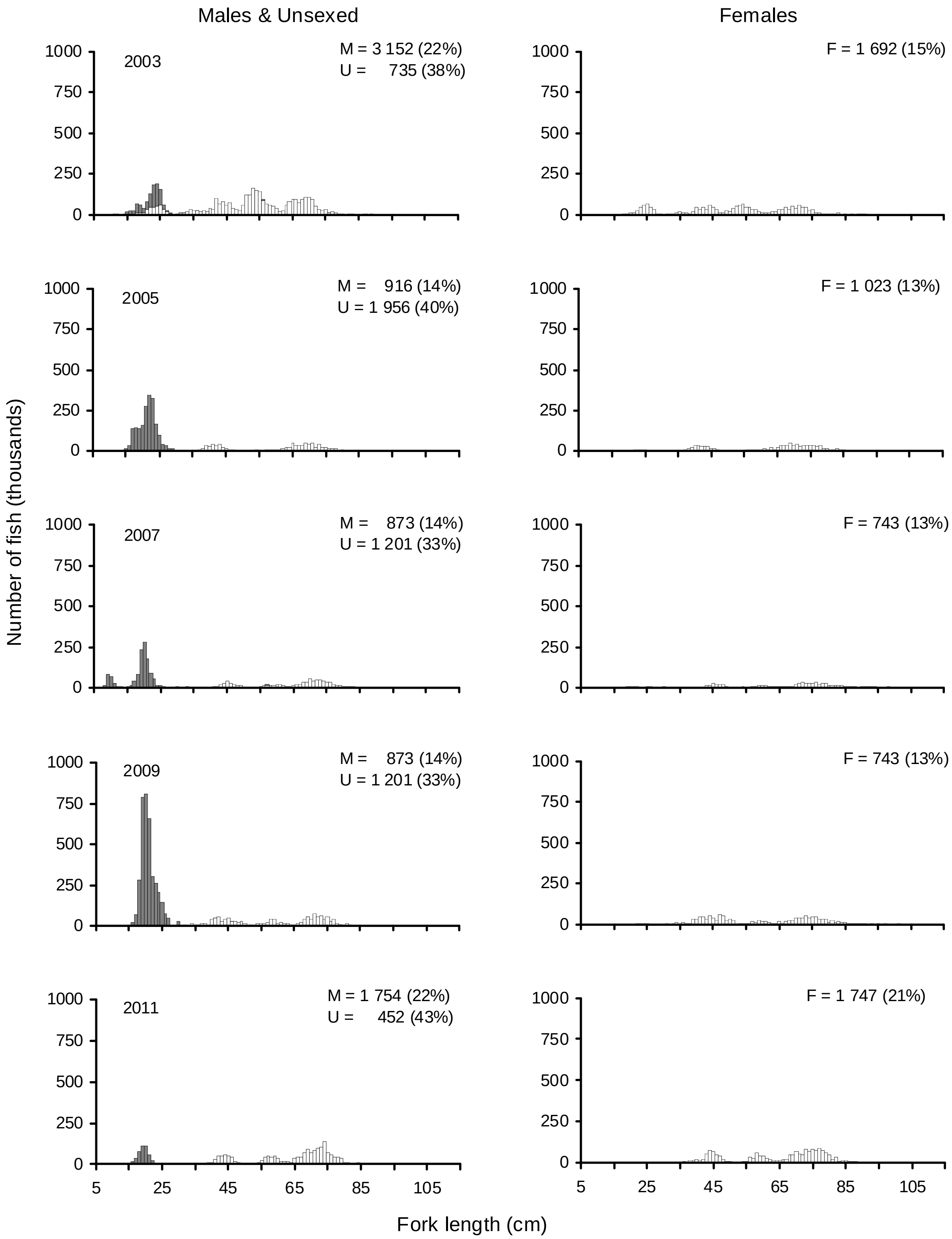



**Figure 6a—continued**

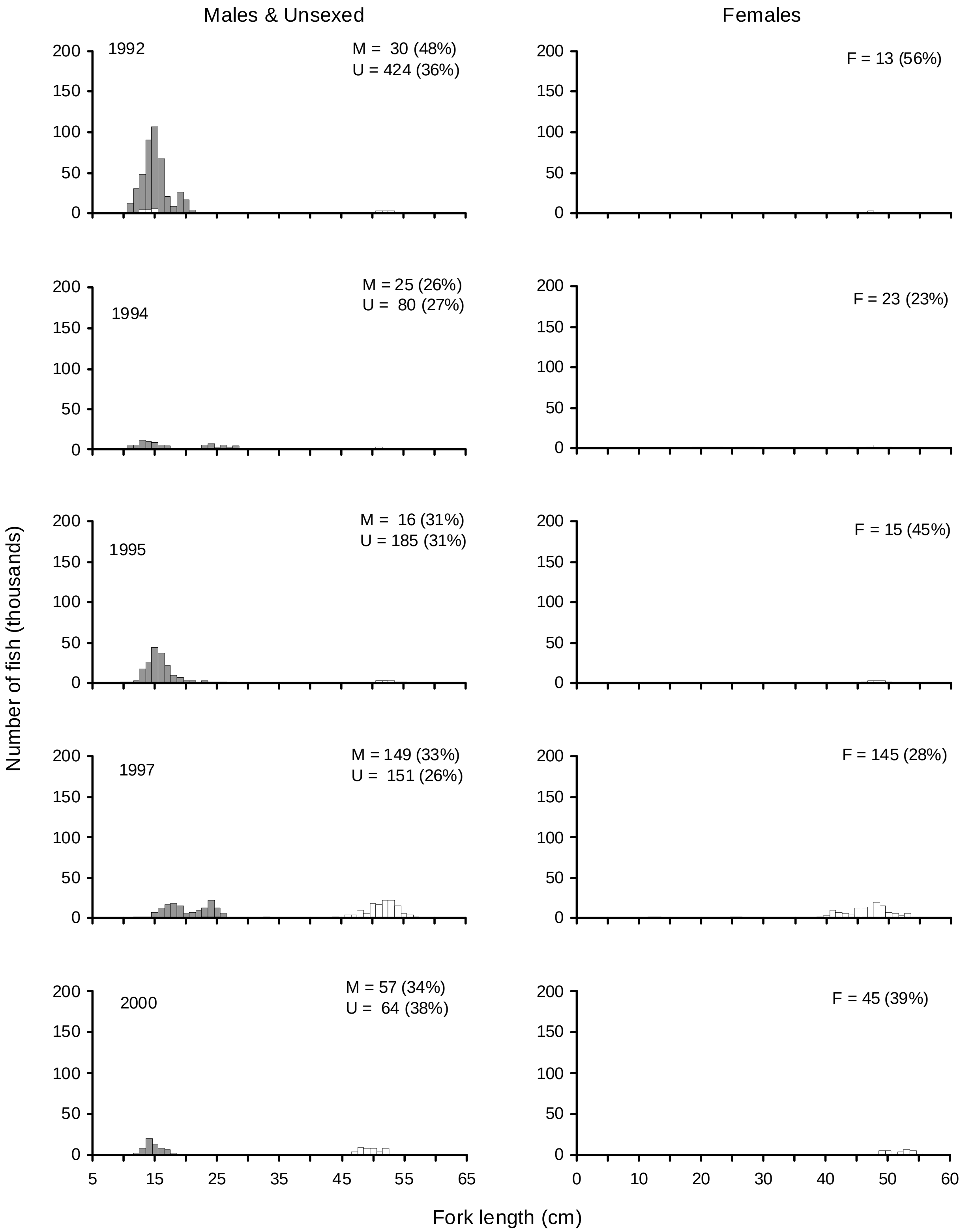



**Figure 6b: Blue warehou**

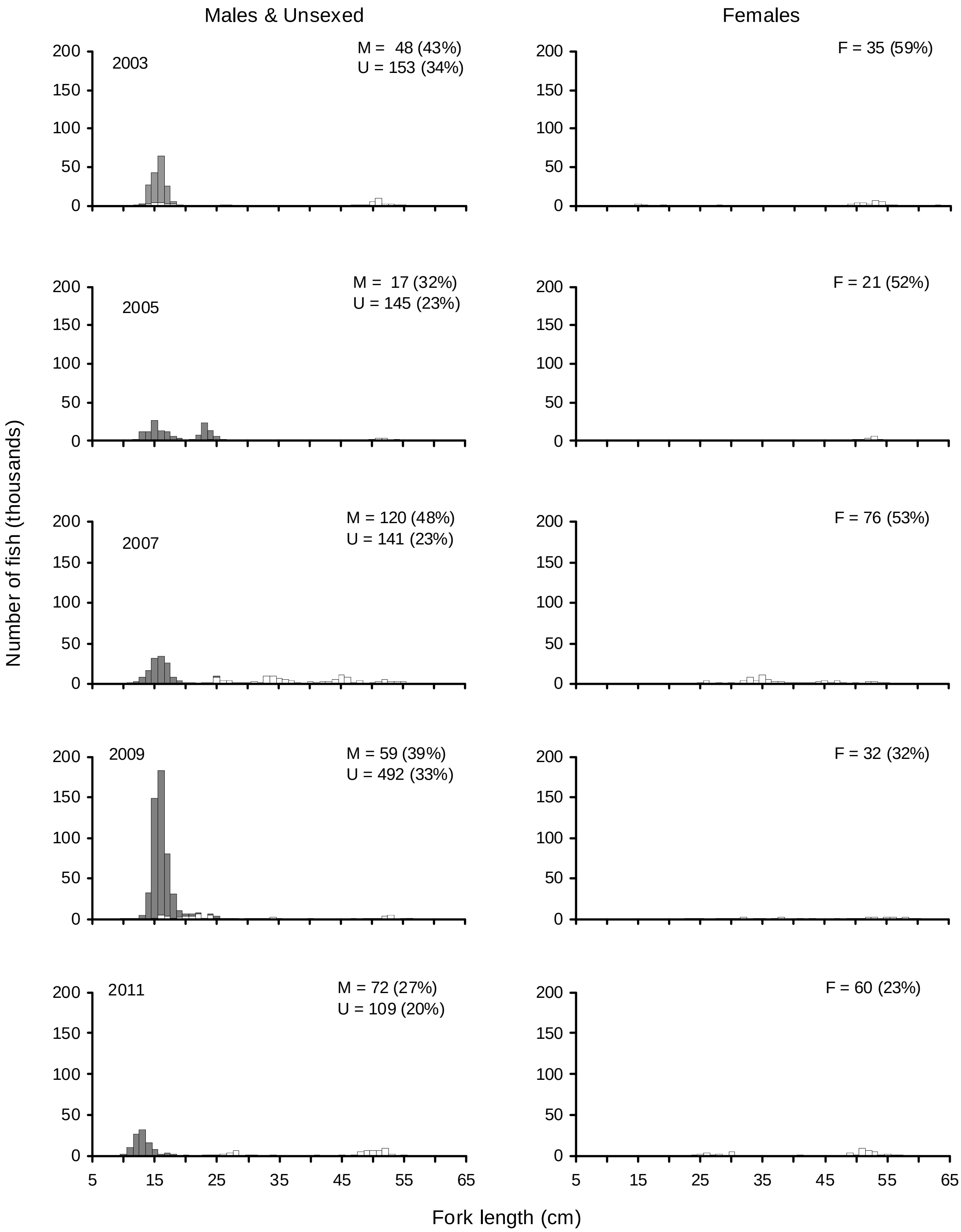



**Figure 6b—continued**

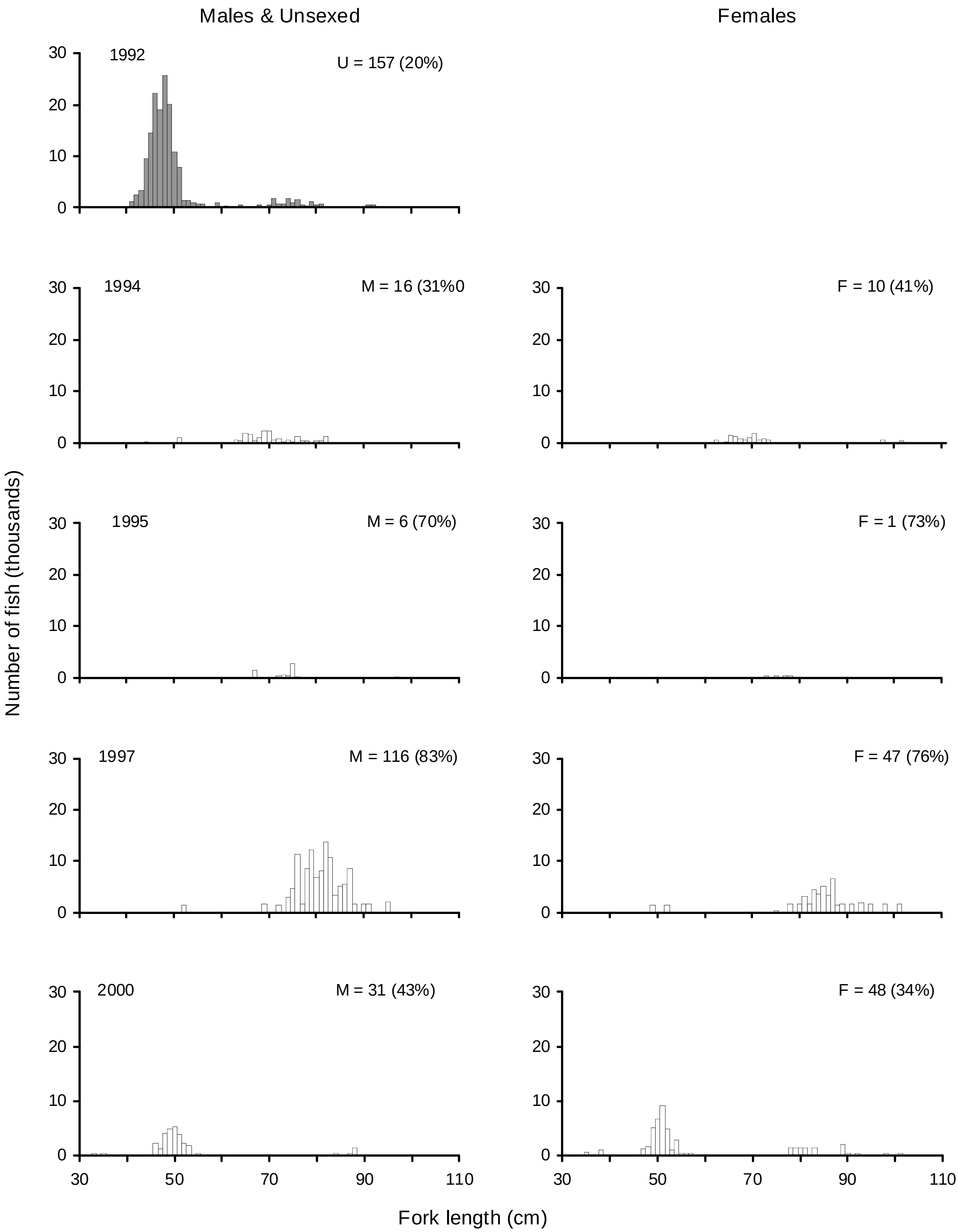



**Figure 6c: Gemfish (100% of fish from the west coast).**

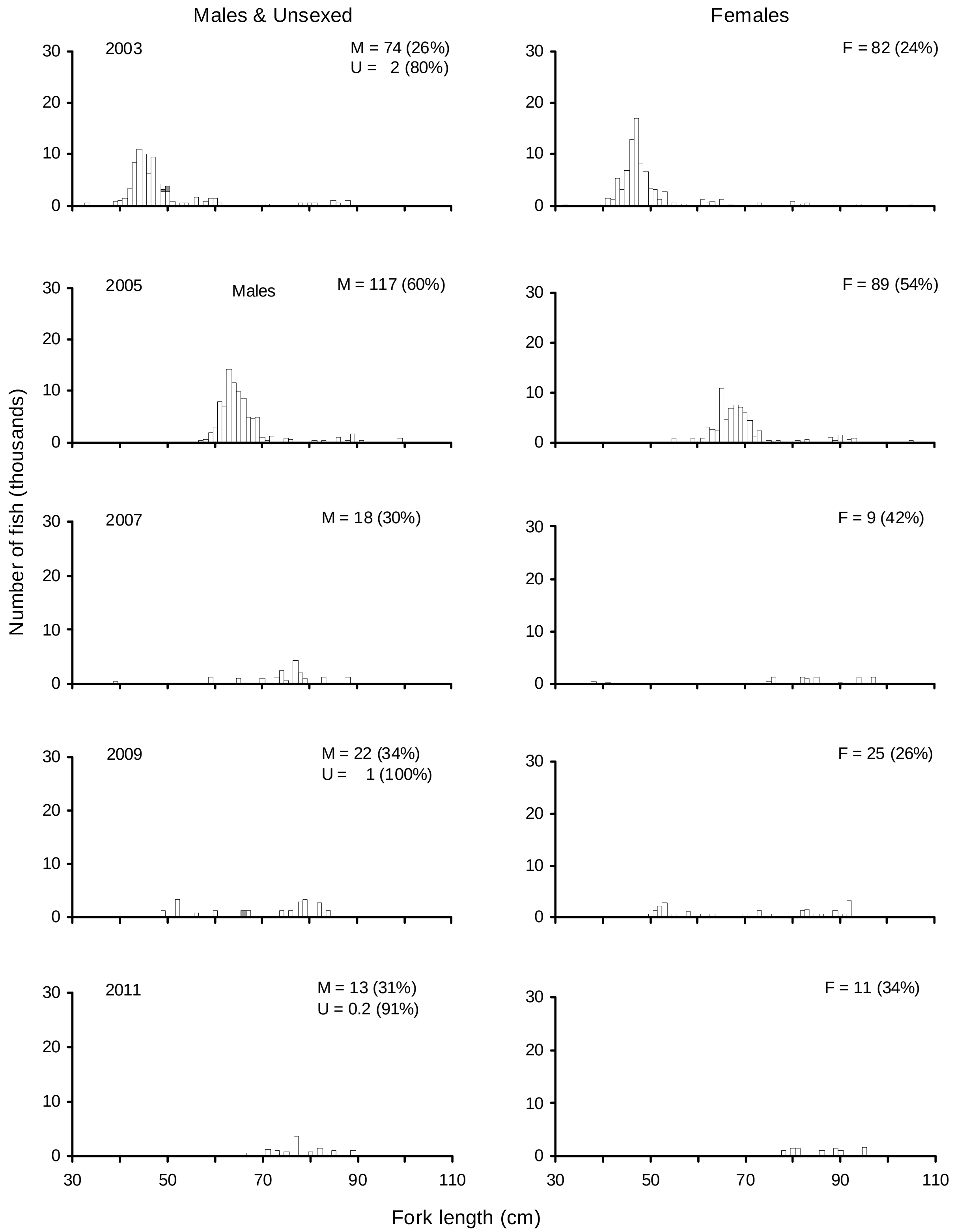



**Figure 6c—continued**

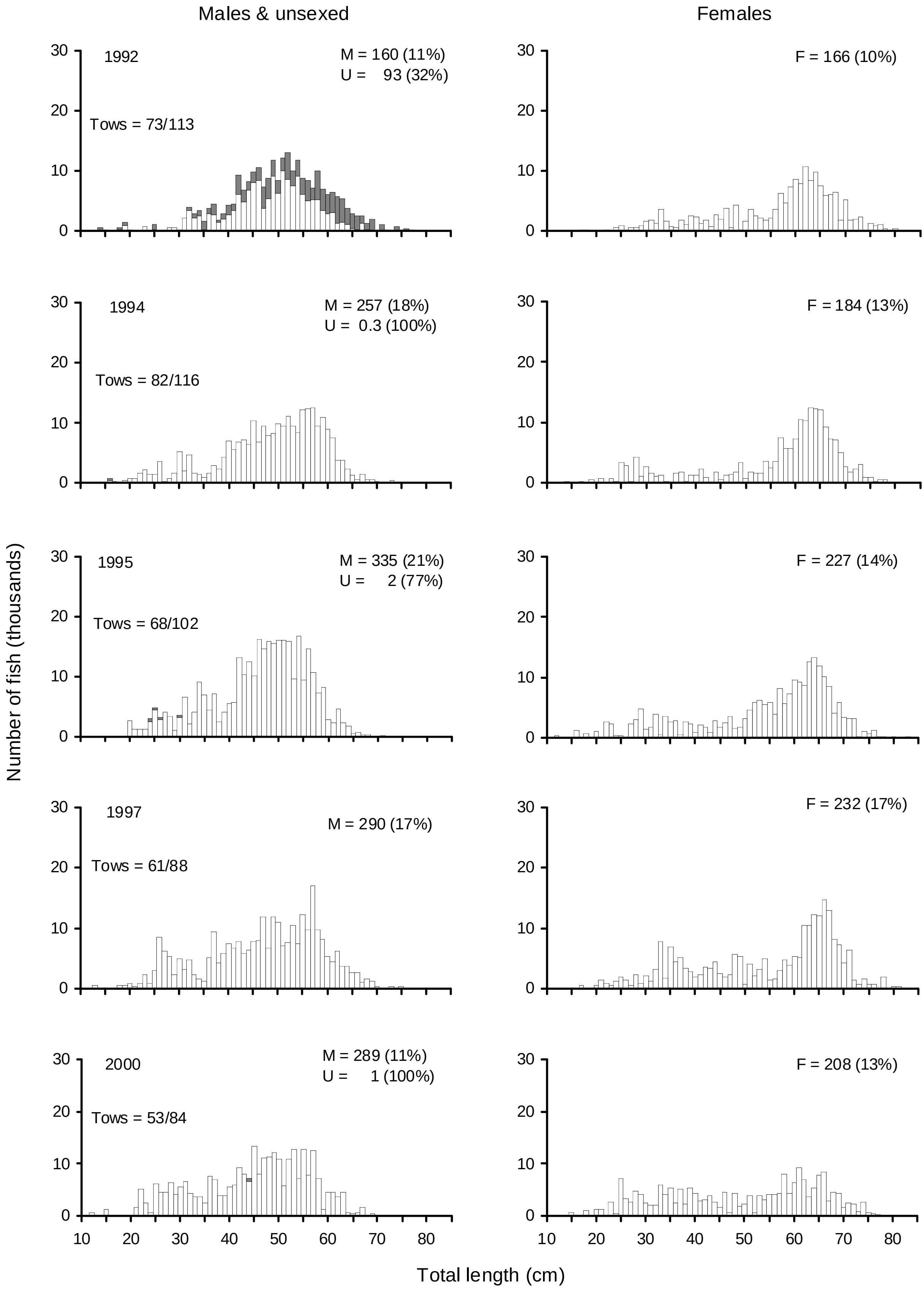



**Figure 6d: Giant stargazer.**

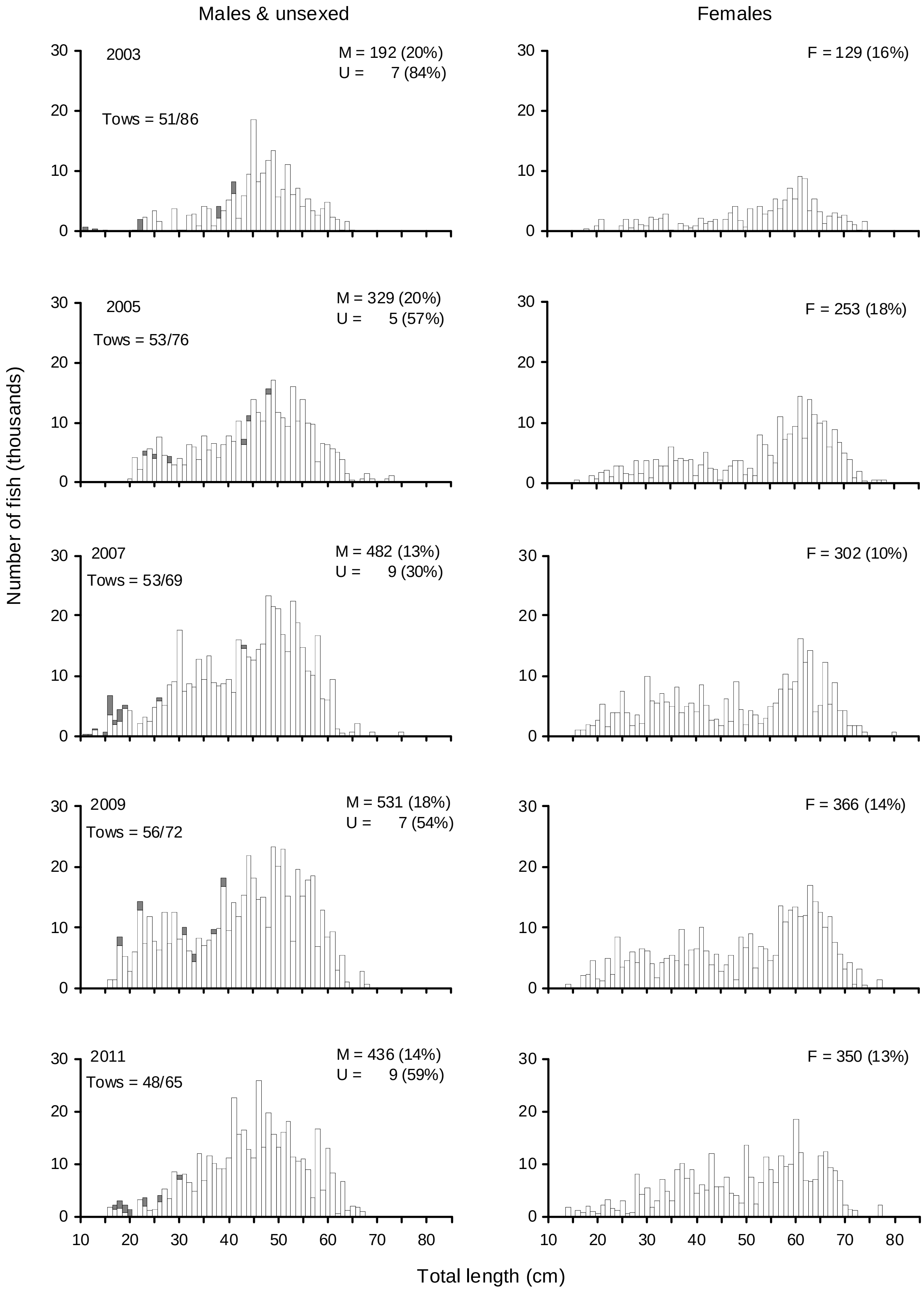



**Figure 6d—continued.**

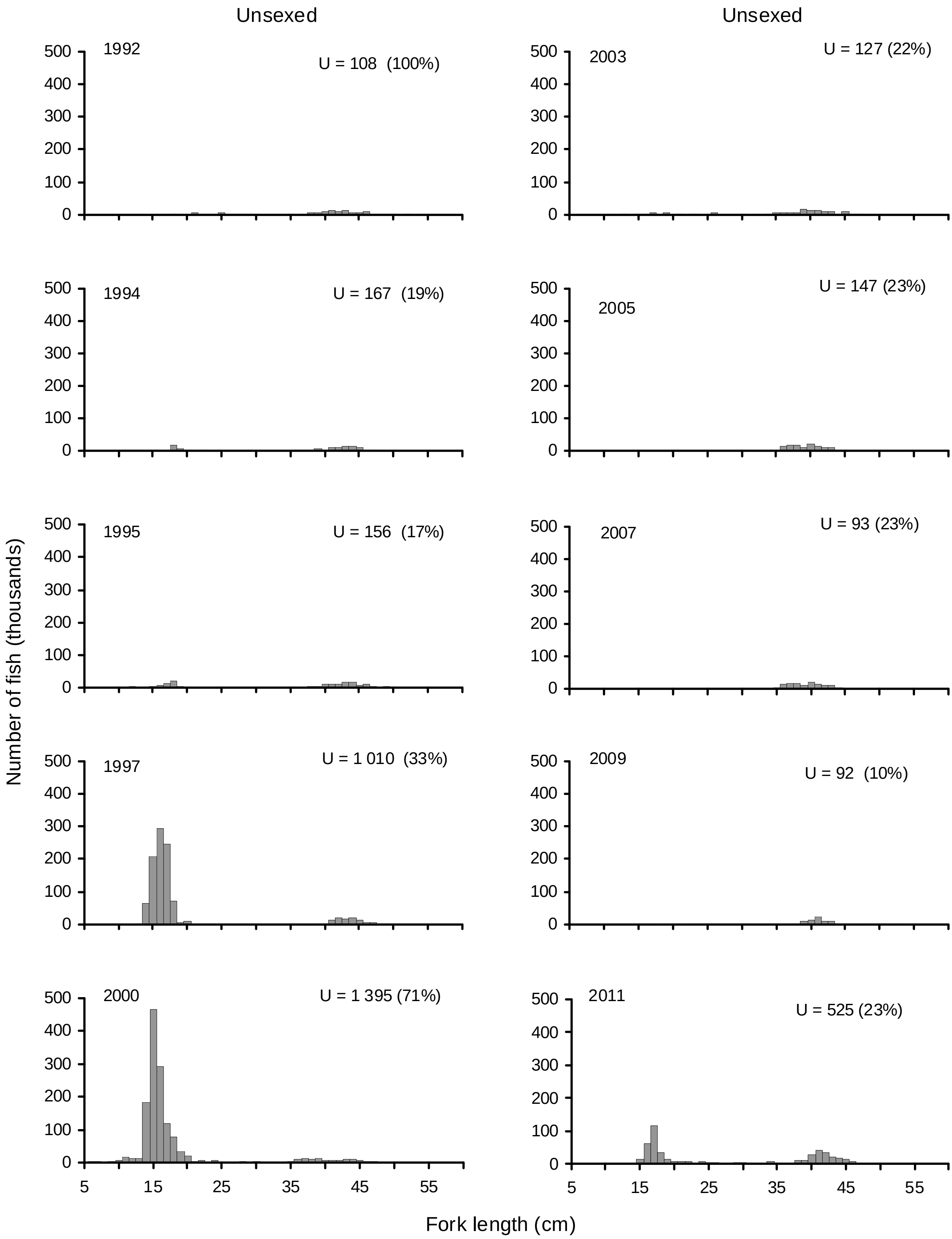



**Figure 6e: Jack mackerel (*Trachurus declivis*). Fish were not sexed for some years so all years are plotted as unsexed for better comparison.**

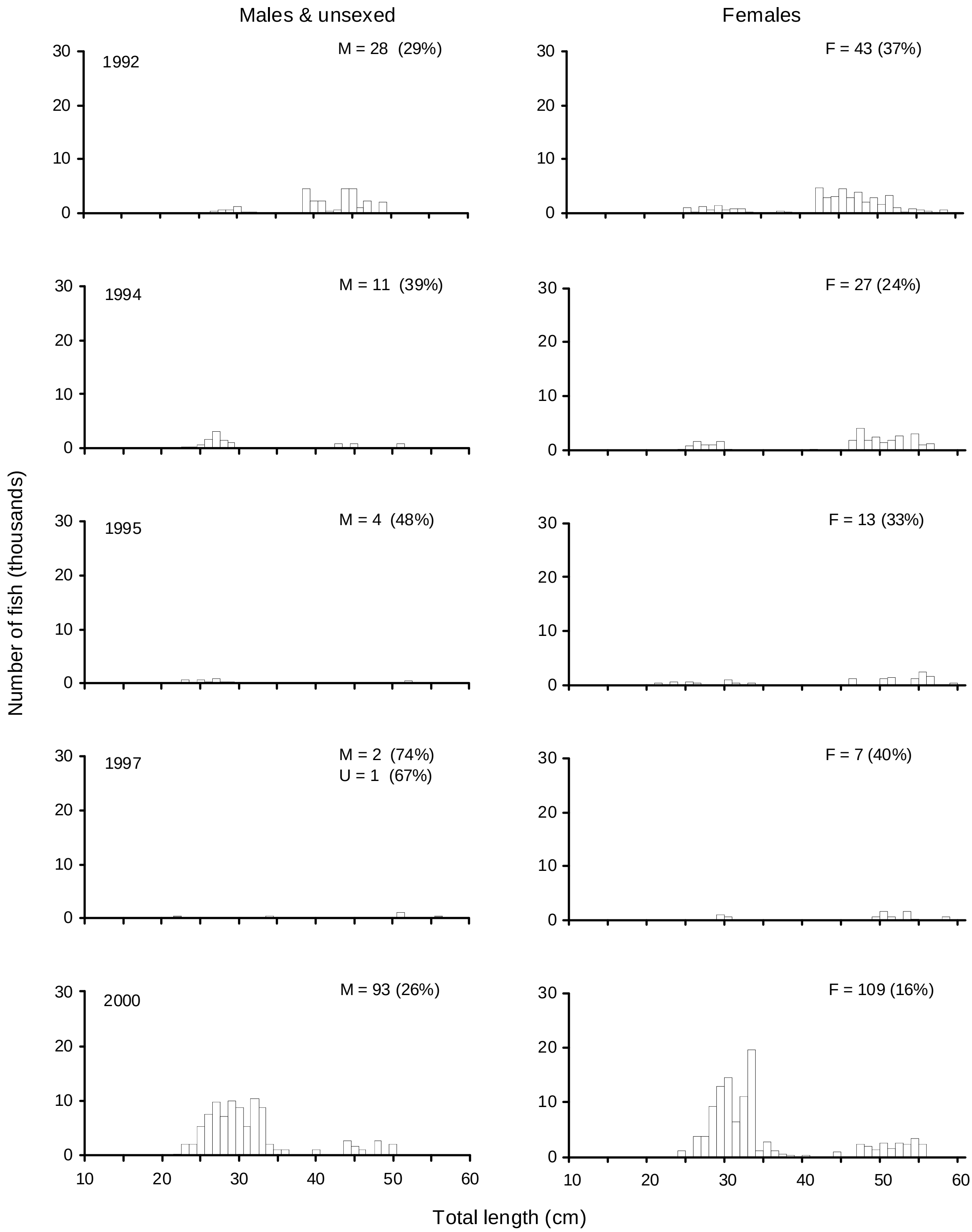



**Figure 6f: John dory.**

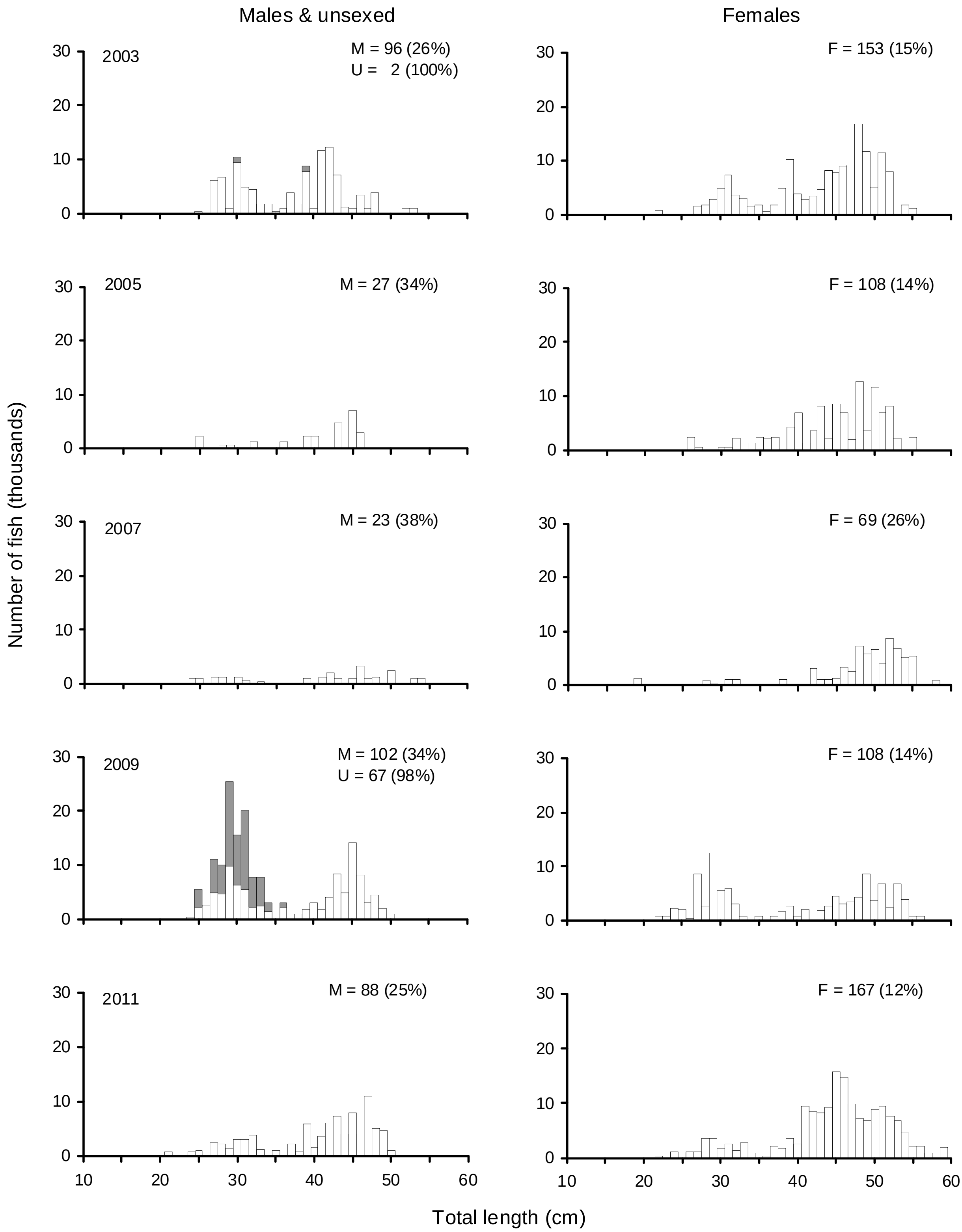



**Figure 6f—continued.**

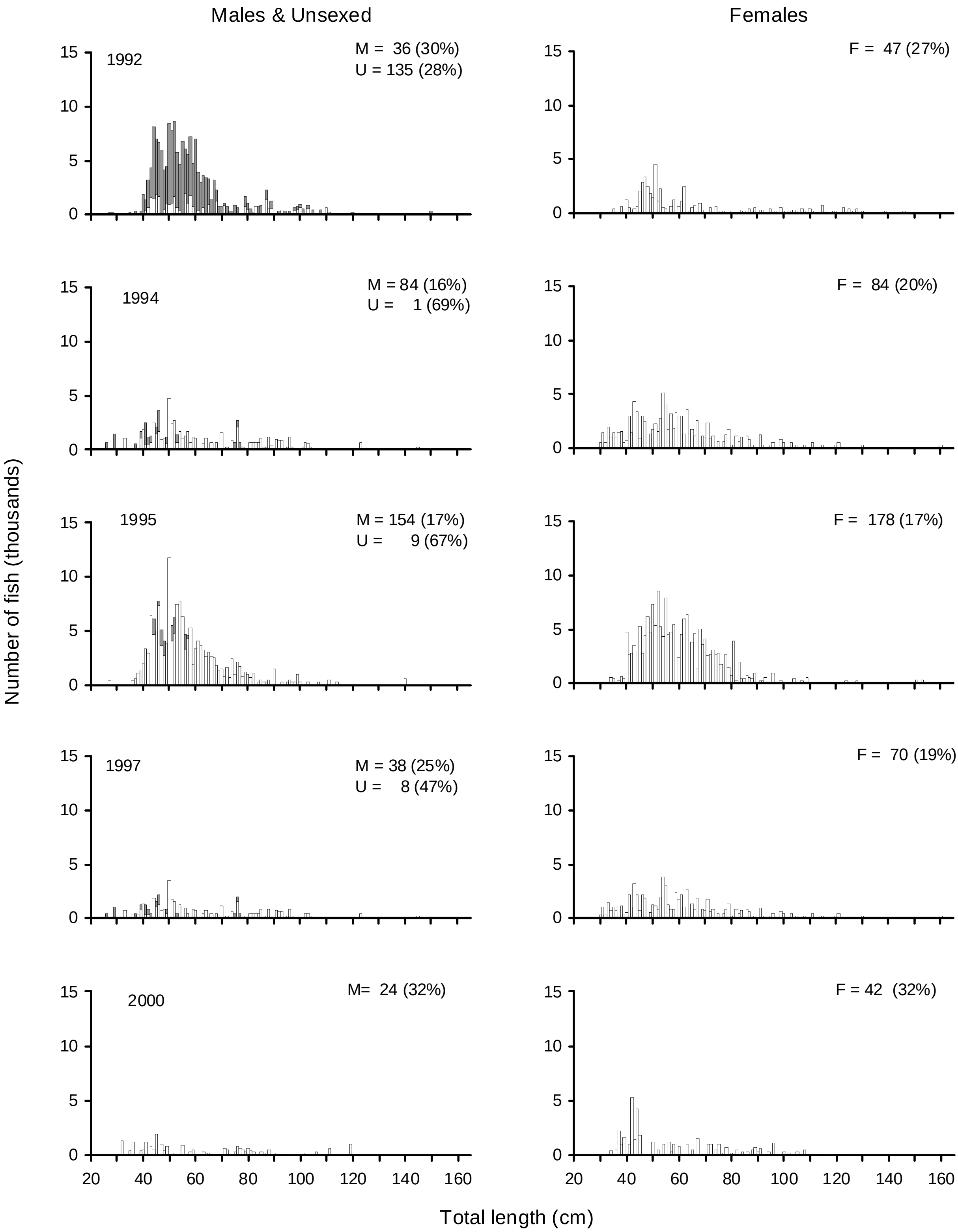



**Figure 6g: Ling.**

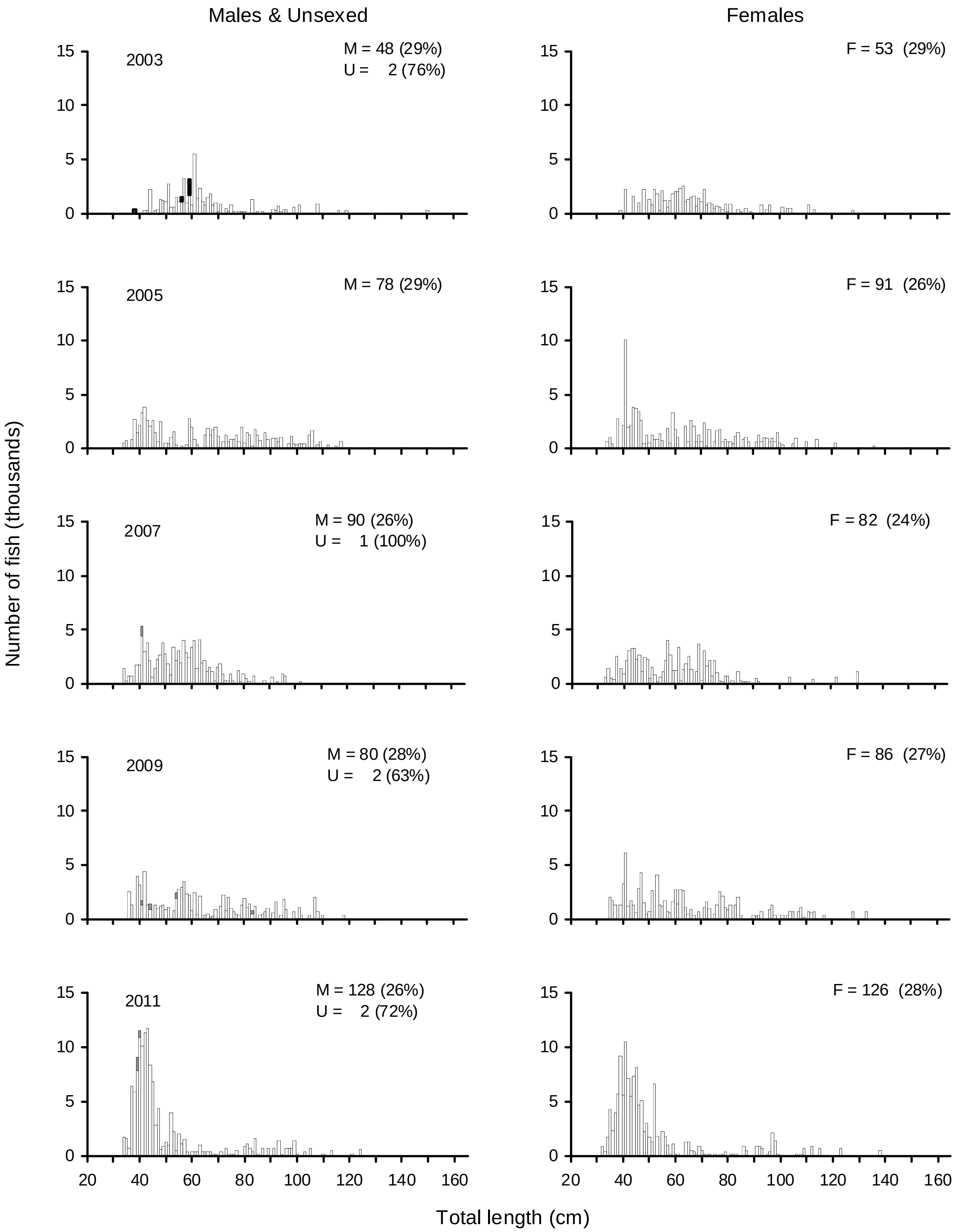



**Figure 6g—continued.**

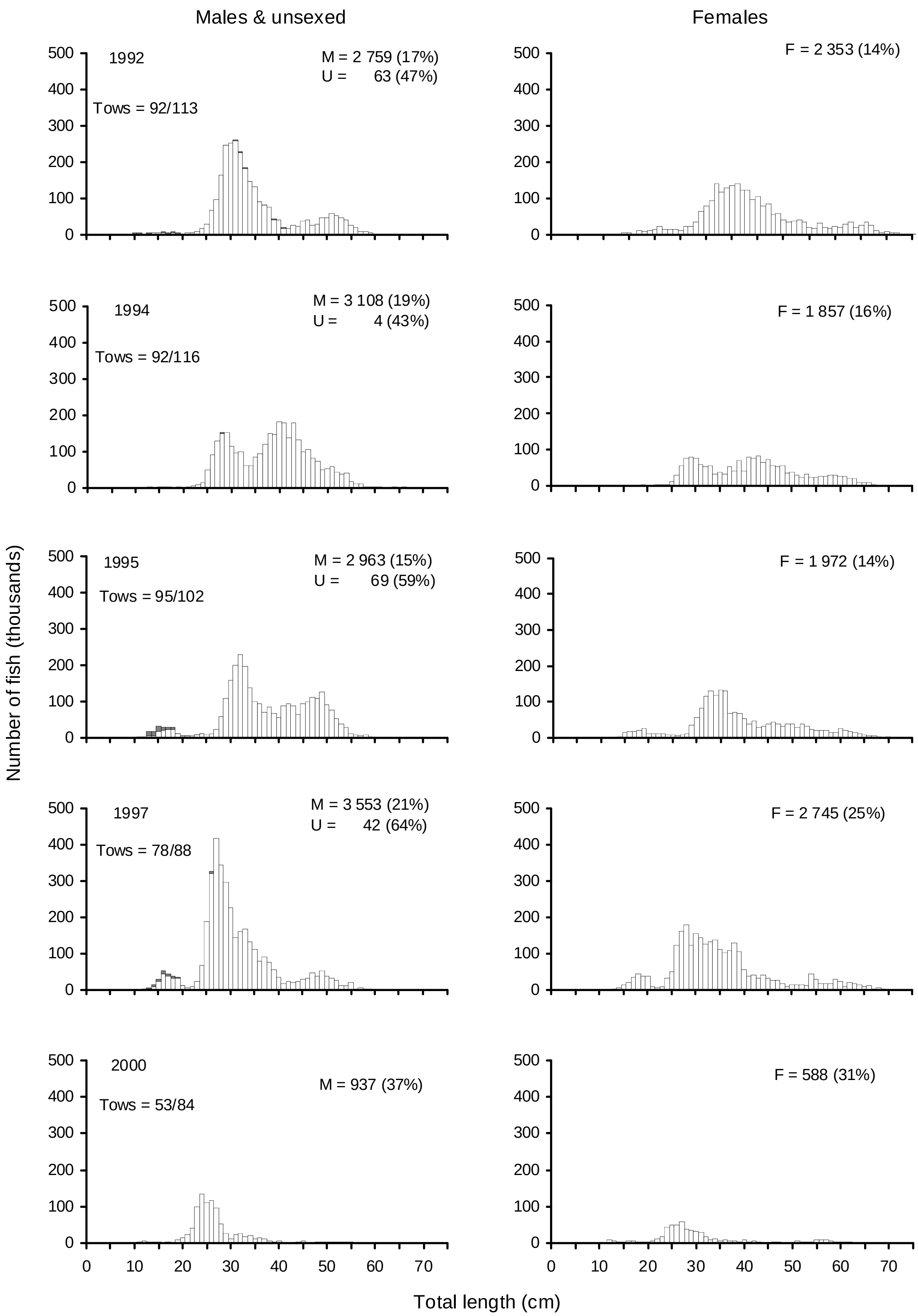



**Figure 6h: Red cod.**

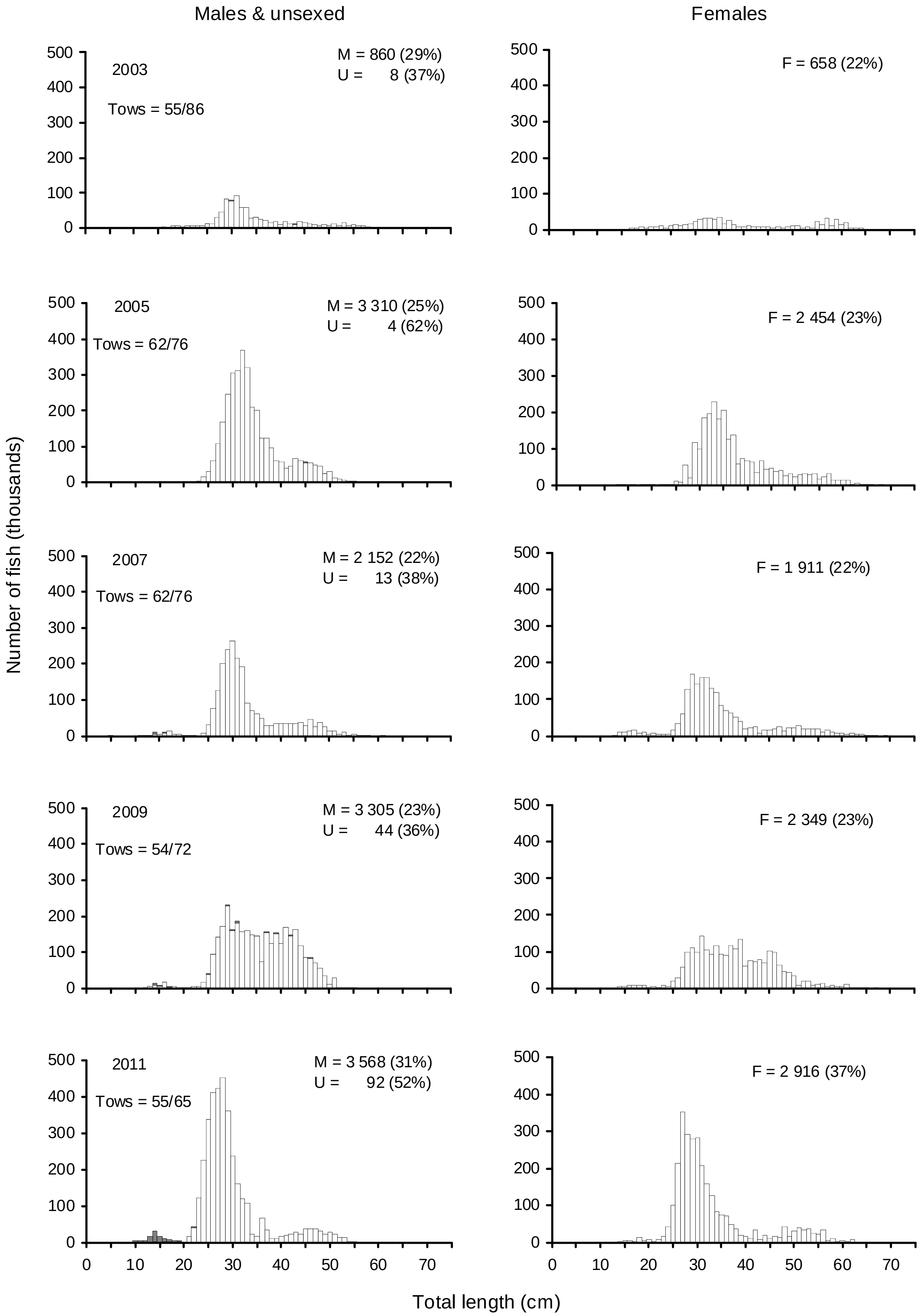



**Figure 6h—continued.**

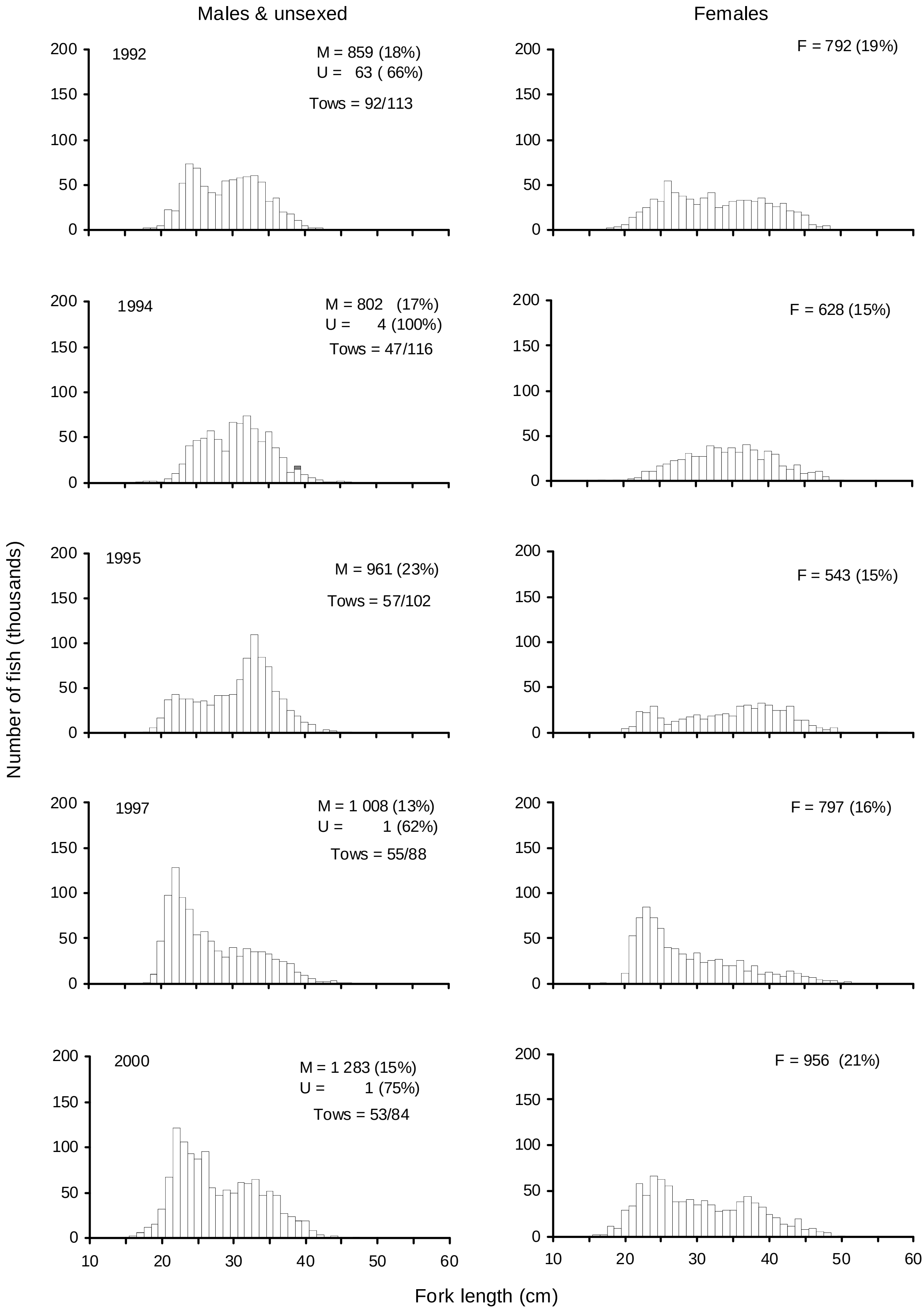



**Figure 6i: Red gurnard.**

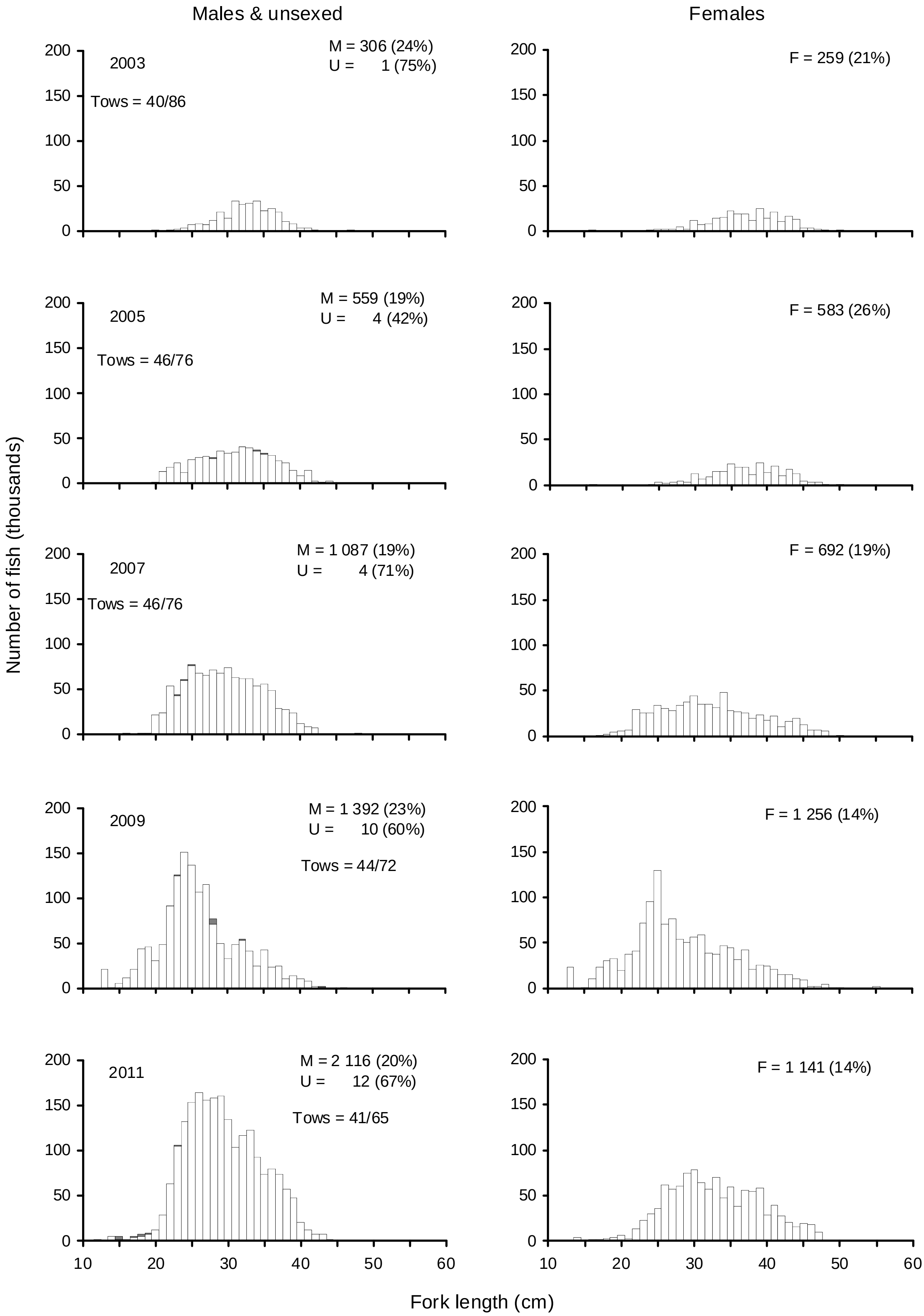



**Figure 6i—continued.**

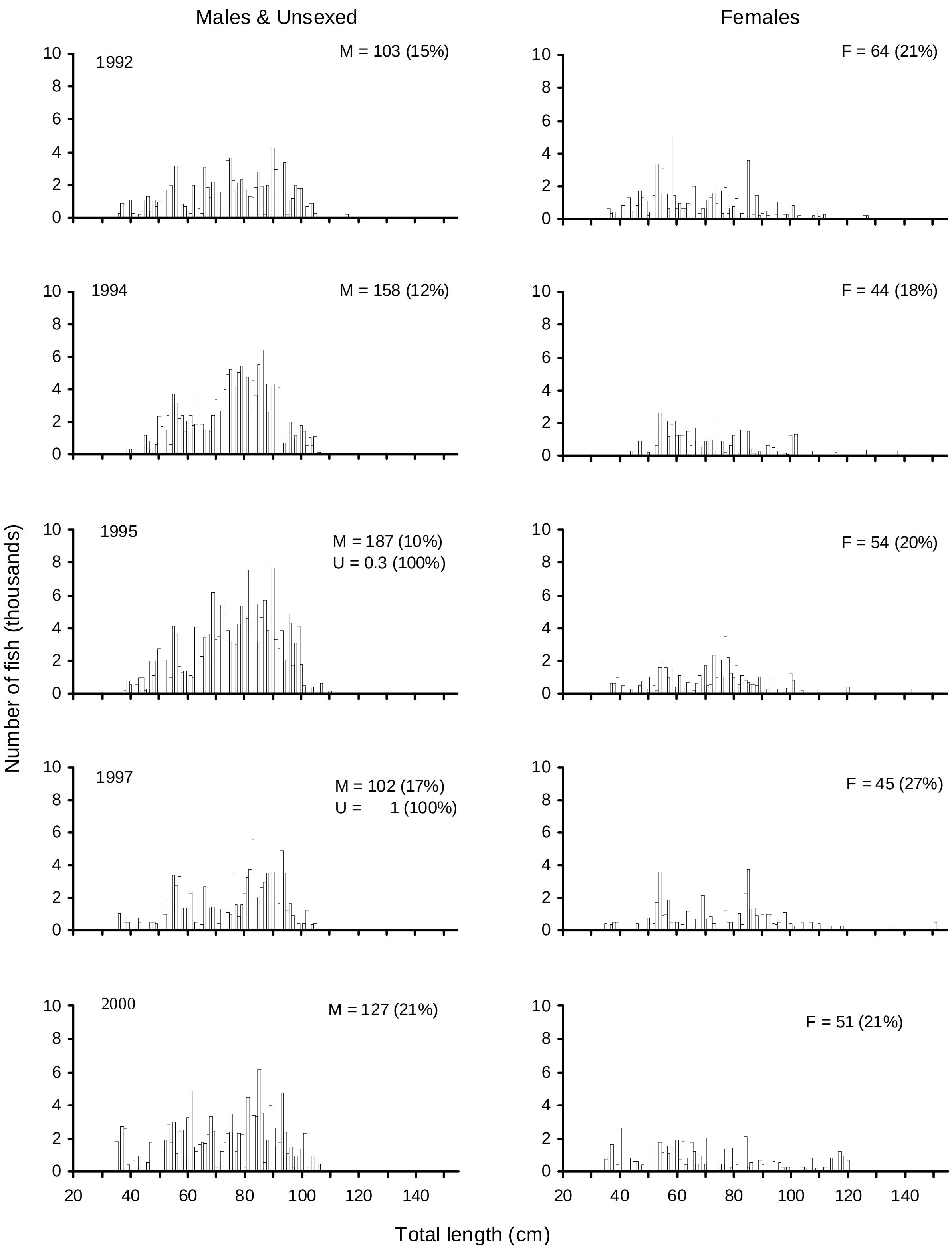



**Figure 6j: Rig**.

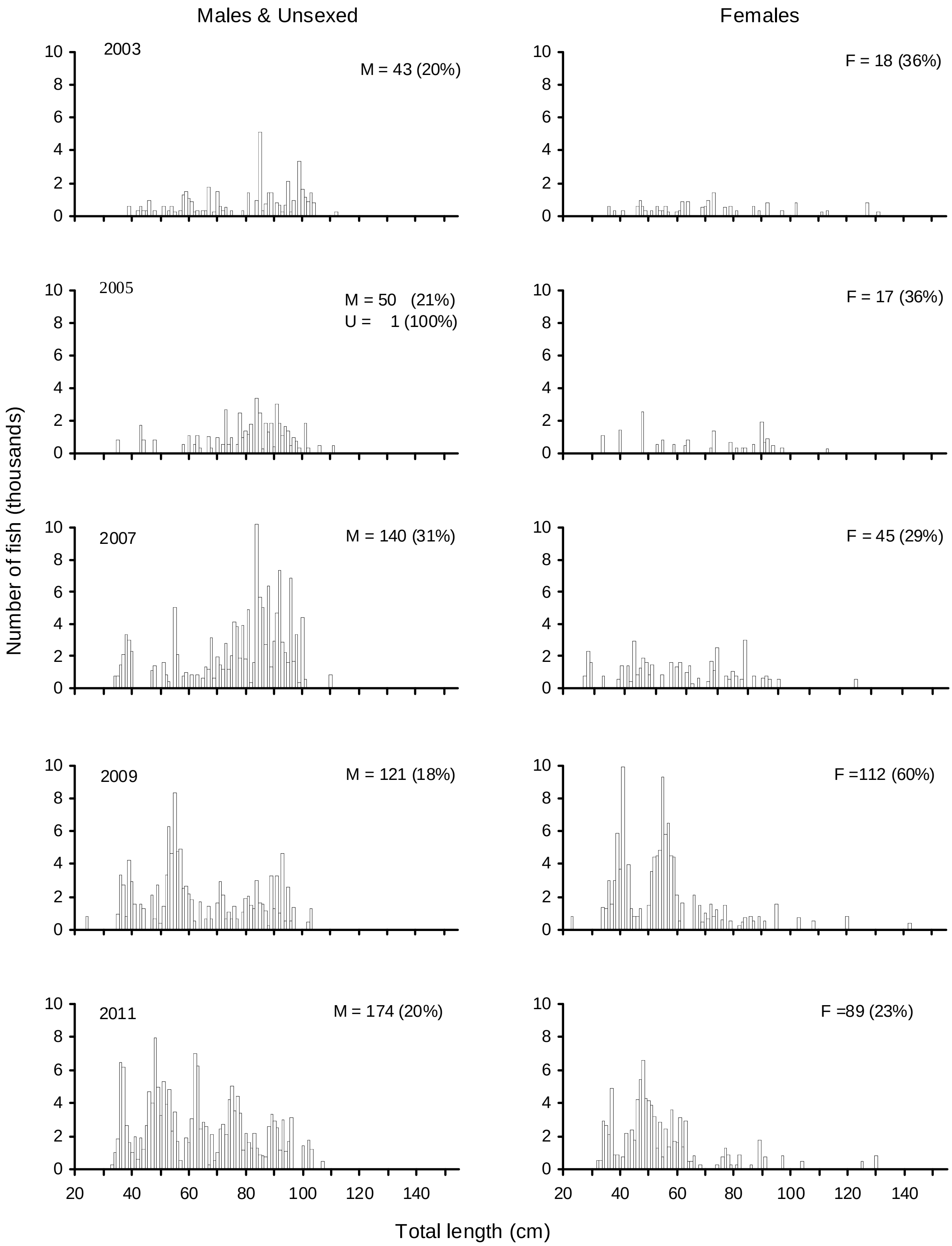



**Figure 6j—continued.**

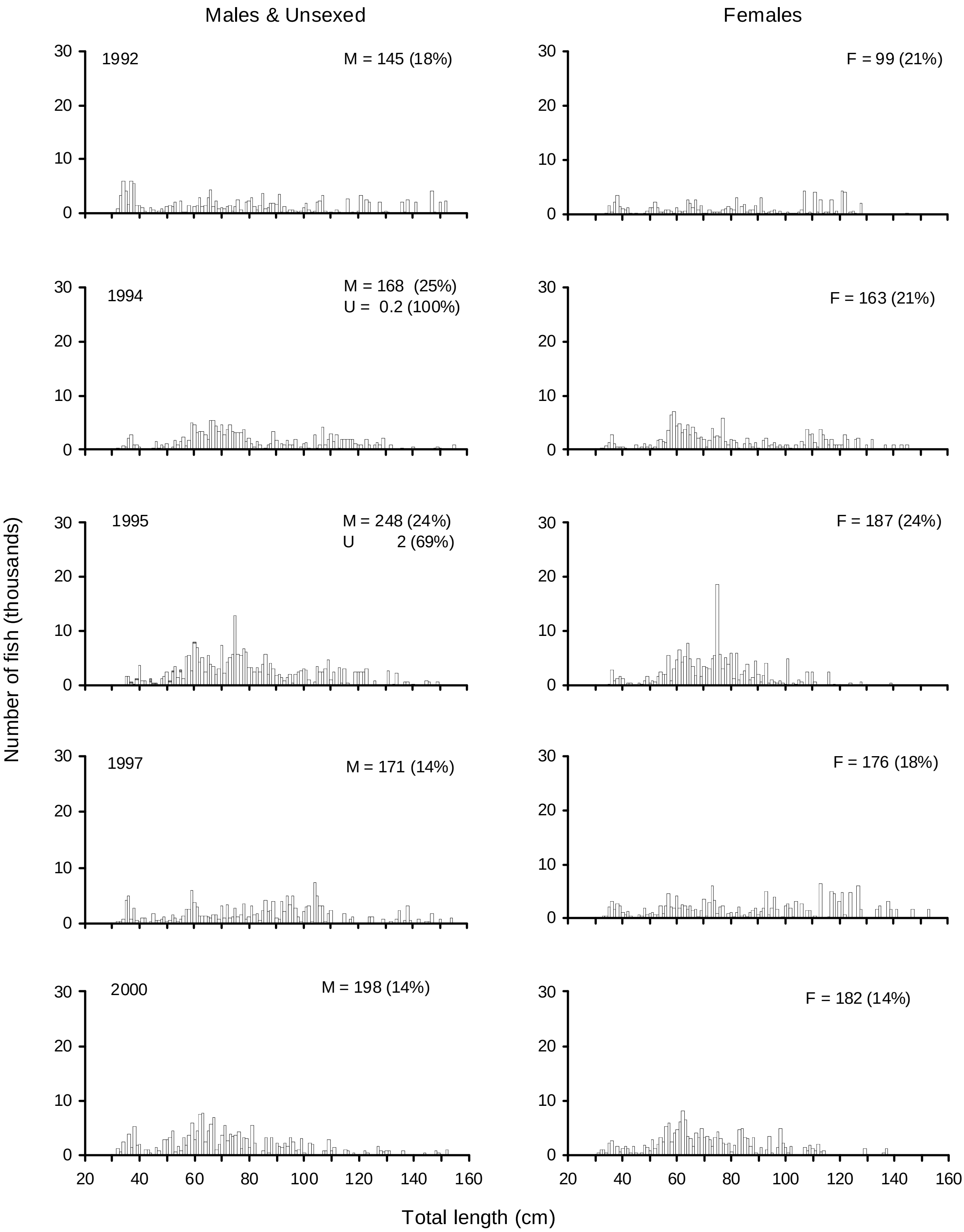



**Figure 6k: School shark.**

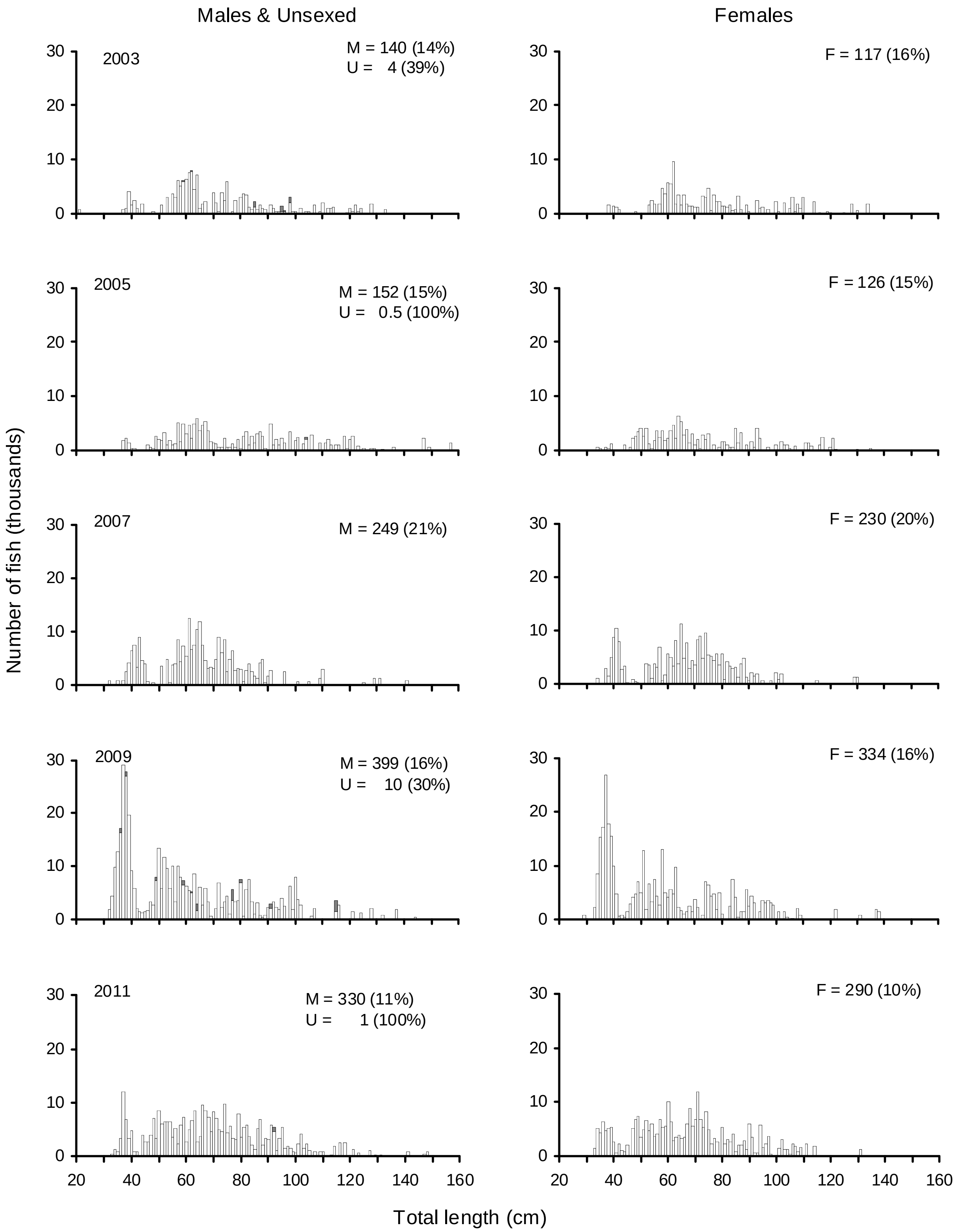



**Figure 6k—continued.**

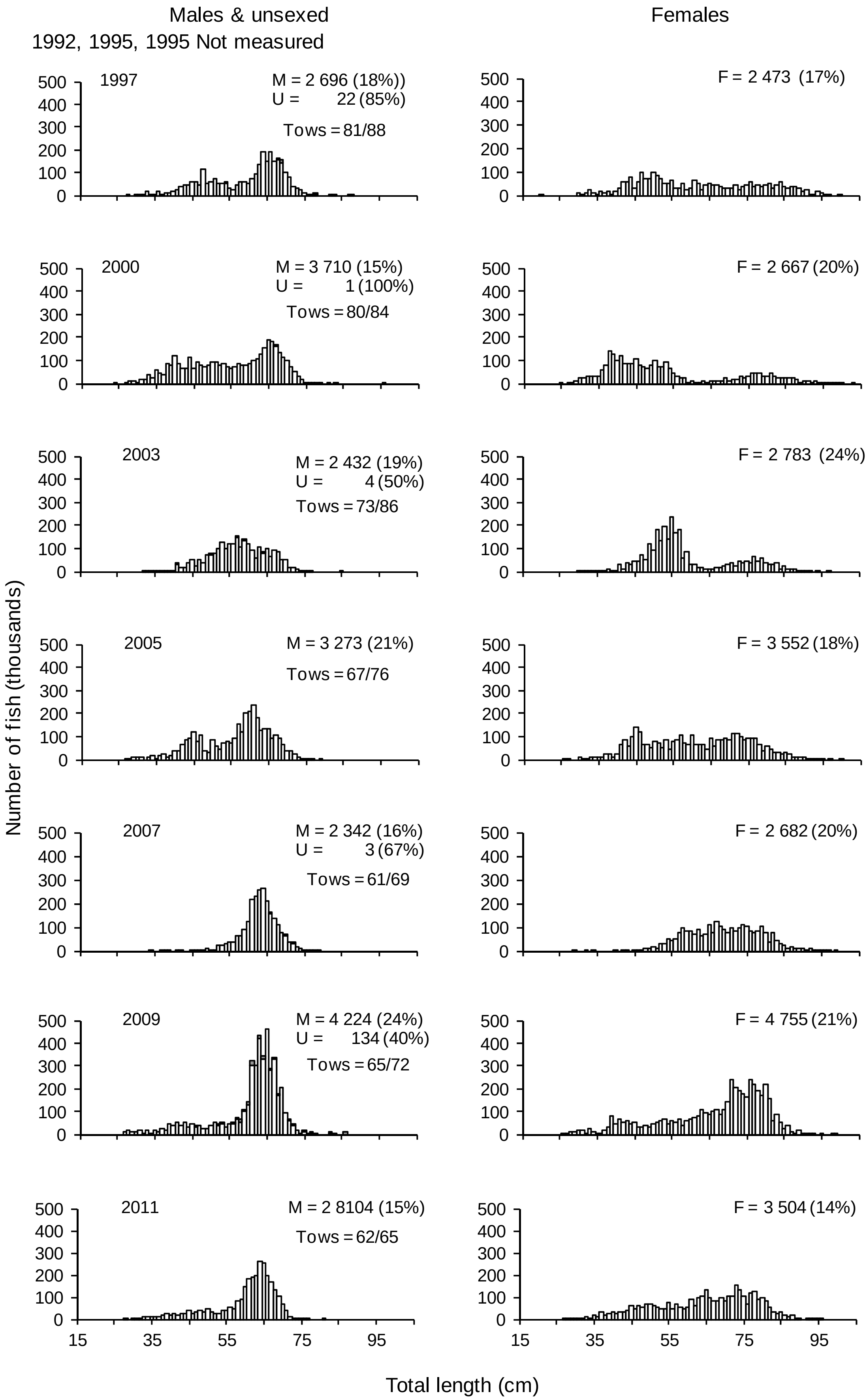



**Figure 6l: Spiny dogfish.**

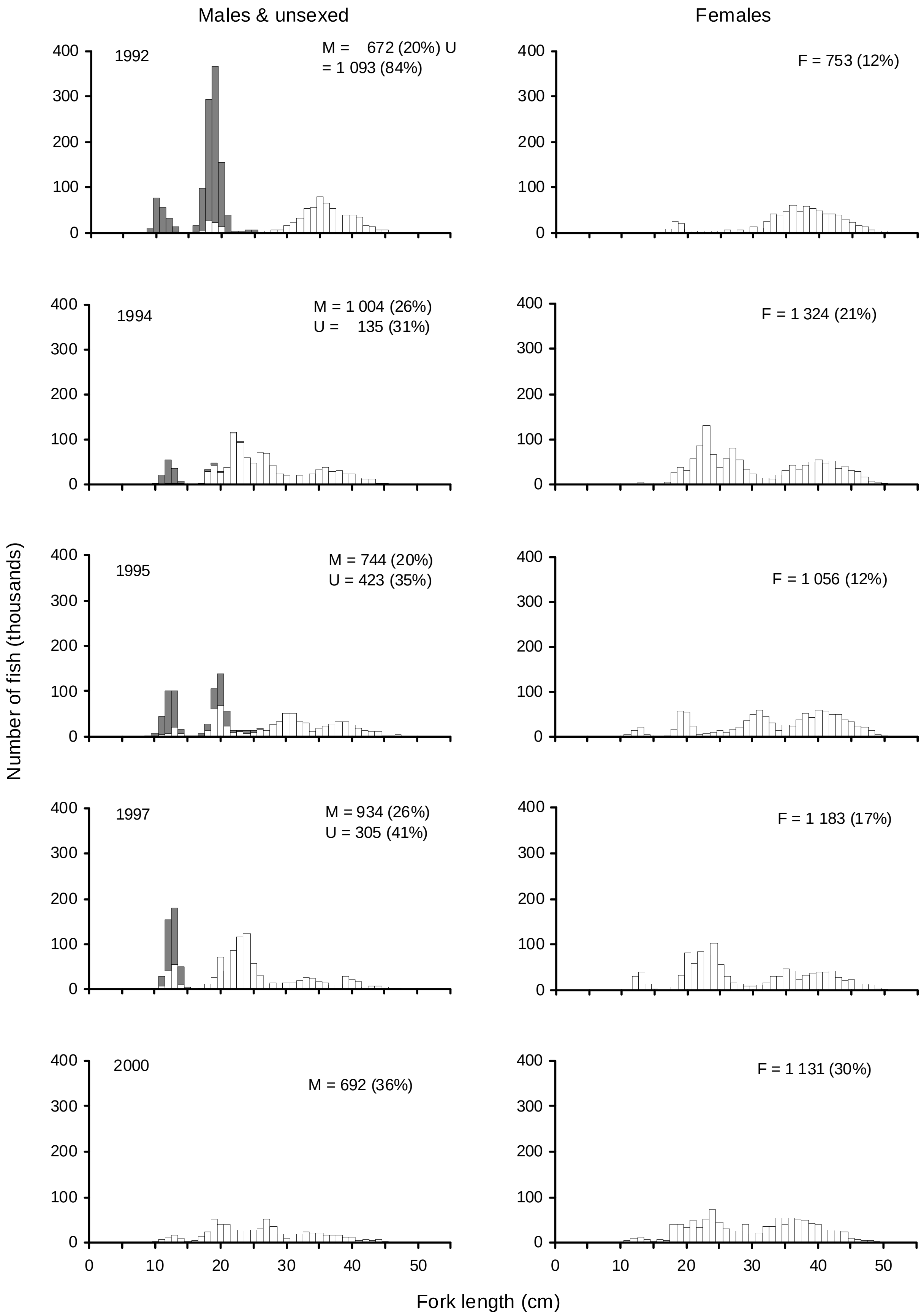



**Figure 6m: Tarakihi.**

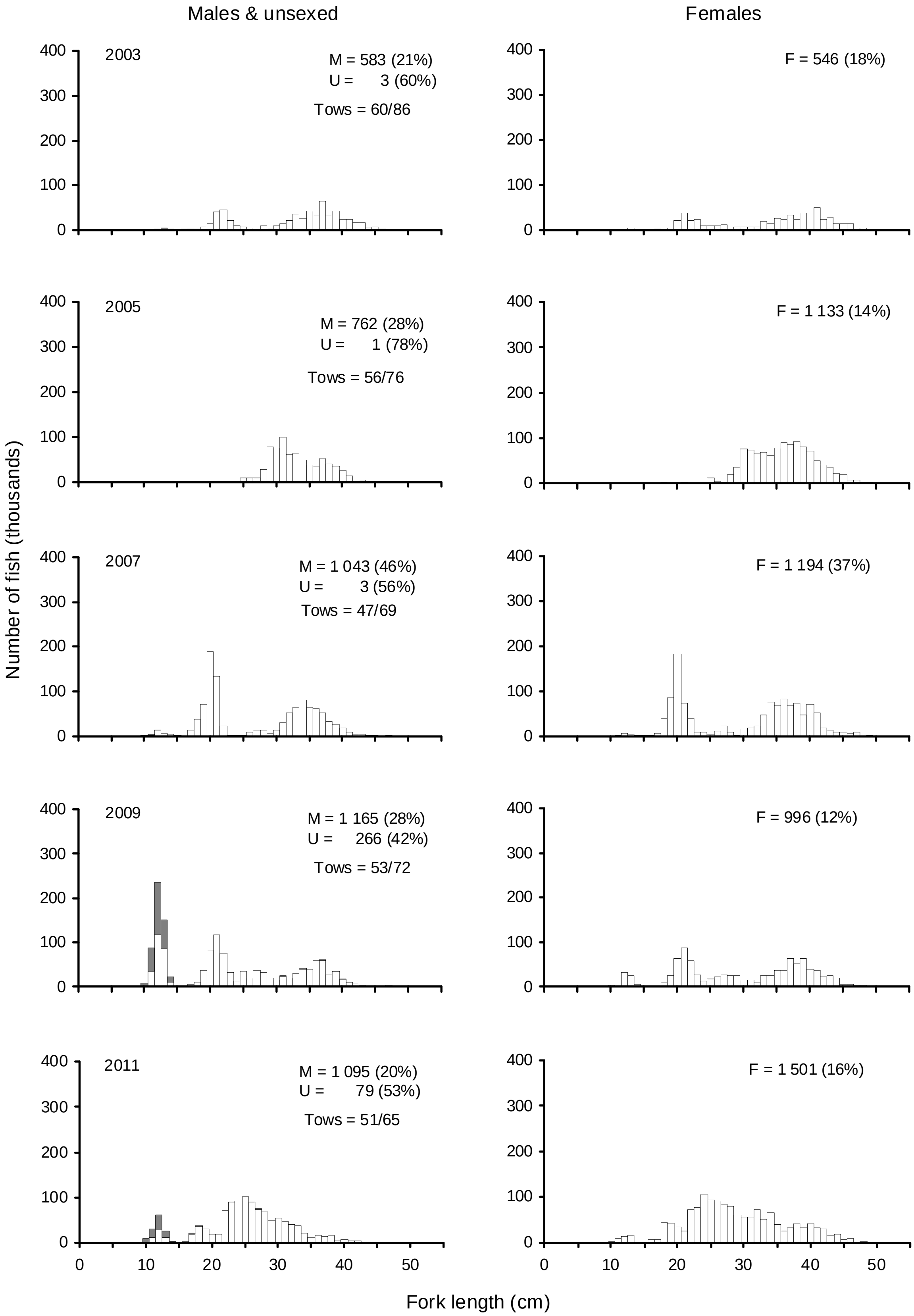



**Figure 6m—continued.**

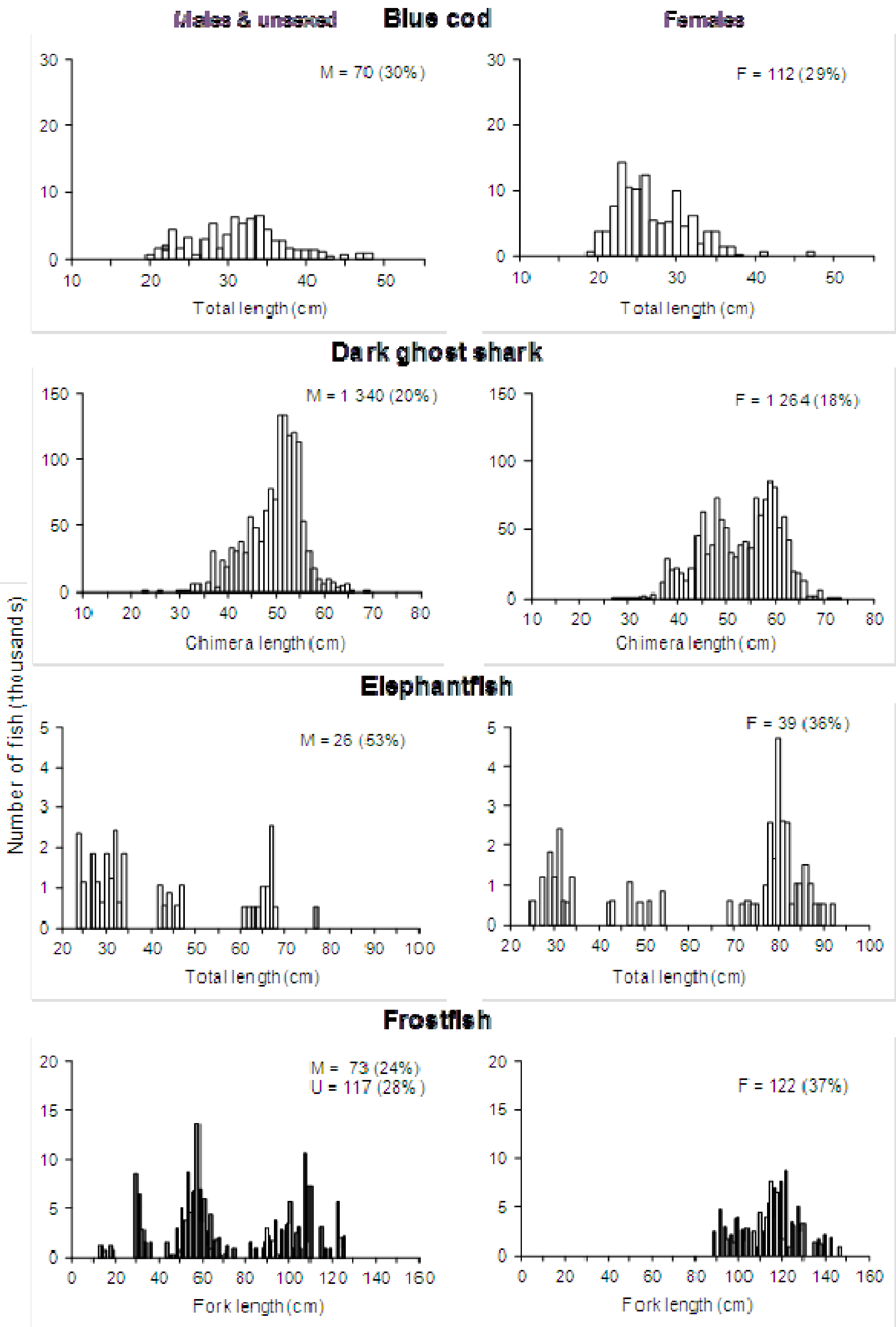



**Figure 7: Scaled length frequency distributions for the non-monitored commercial species where more than 100 fish were measured. Estimated population in thousands and c.v.%. M, male; F, female; U, unsexed (shaded).**

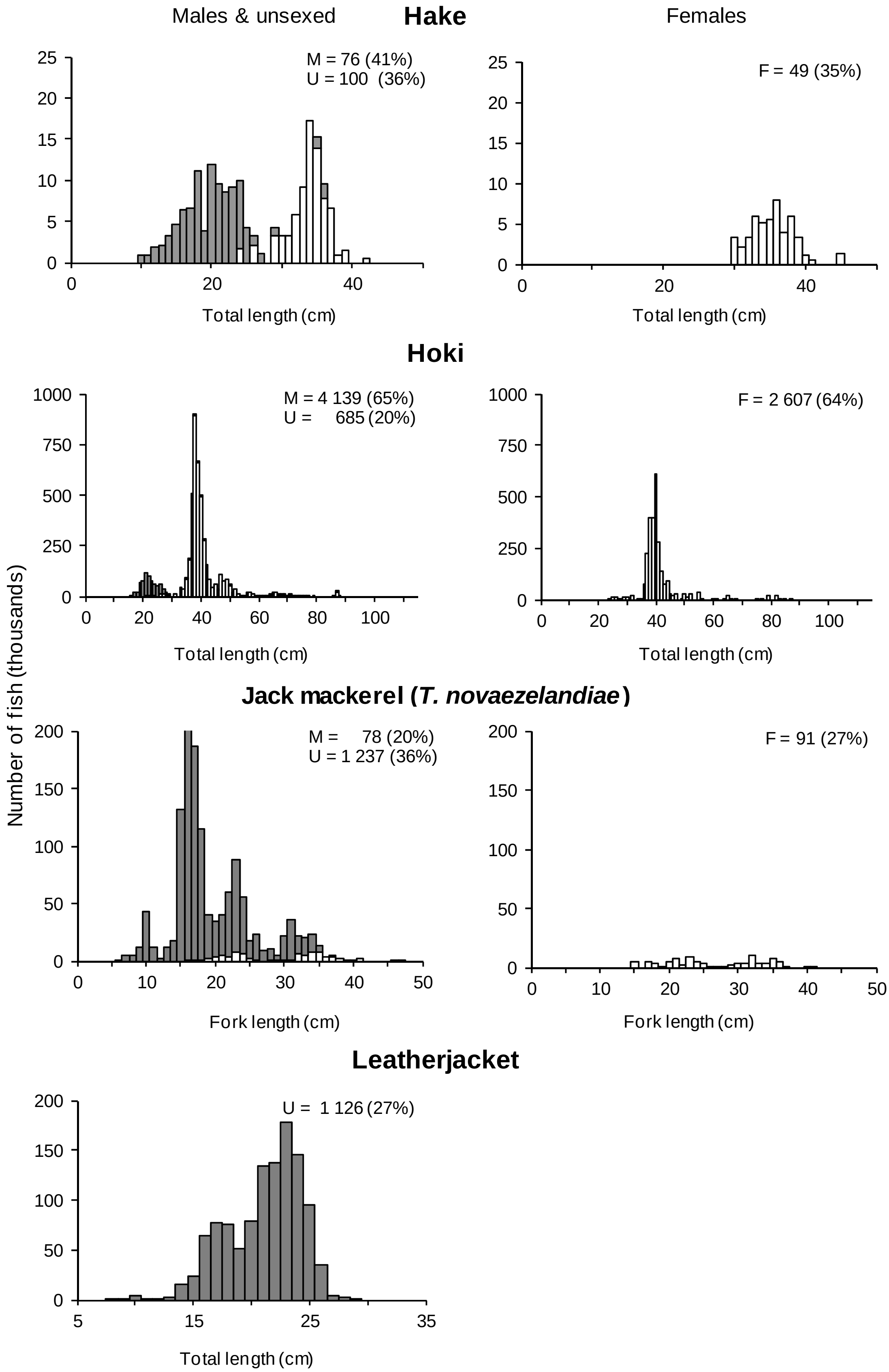



**Figure 7—continued.**

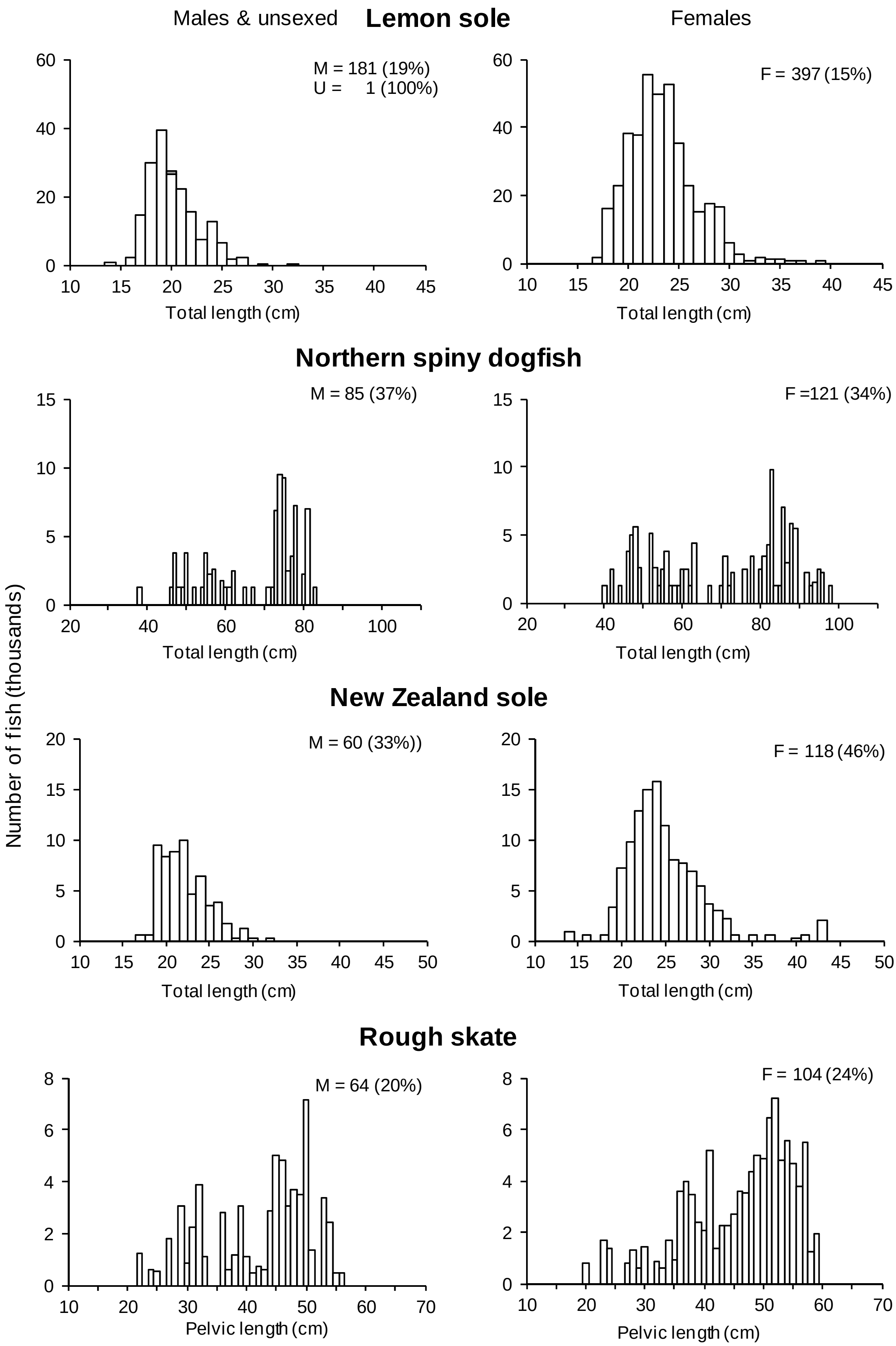



**Figure 7—continued.**

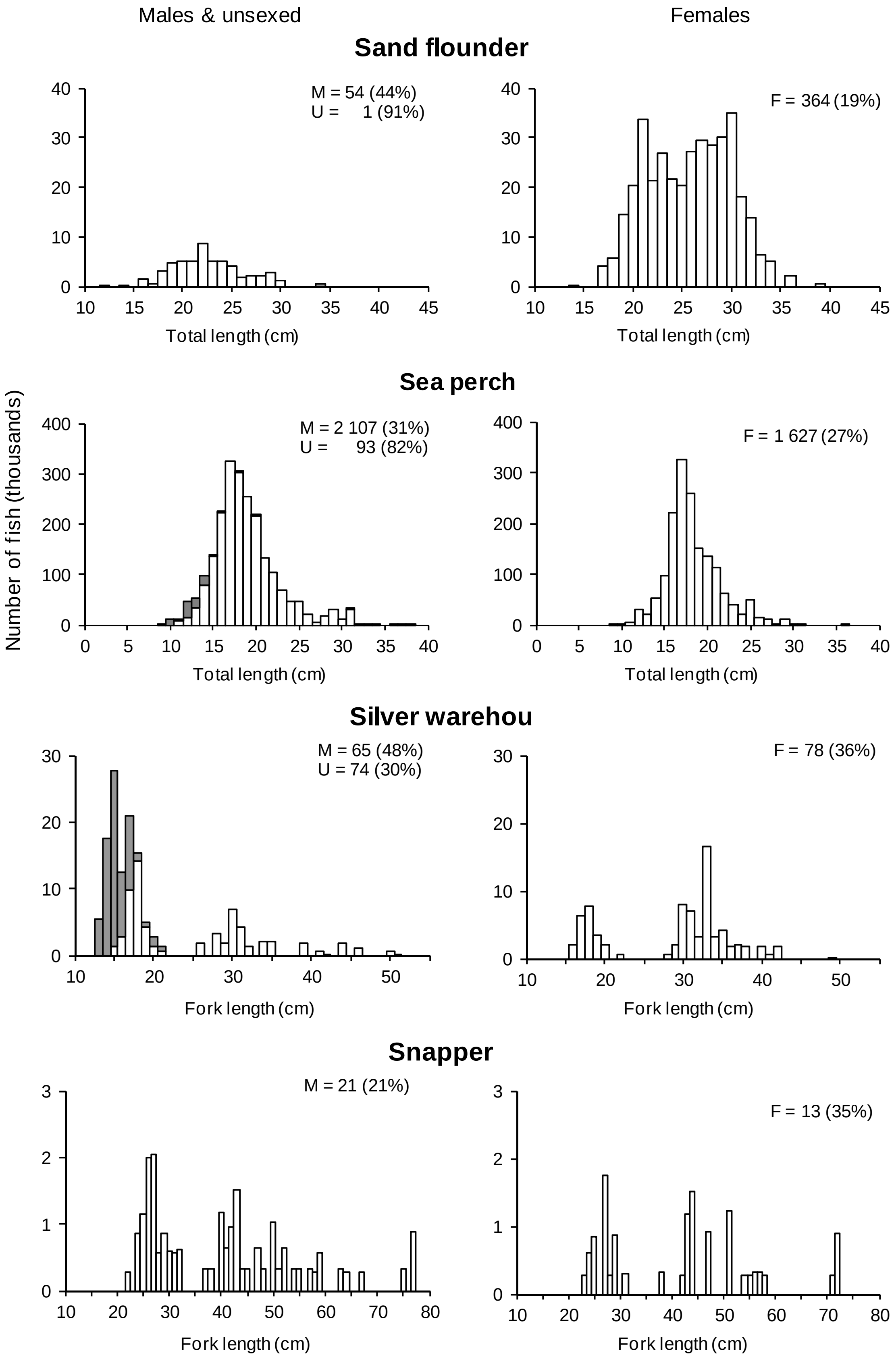



**Figure 7—continued.**

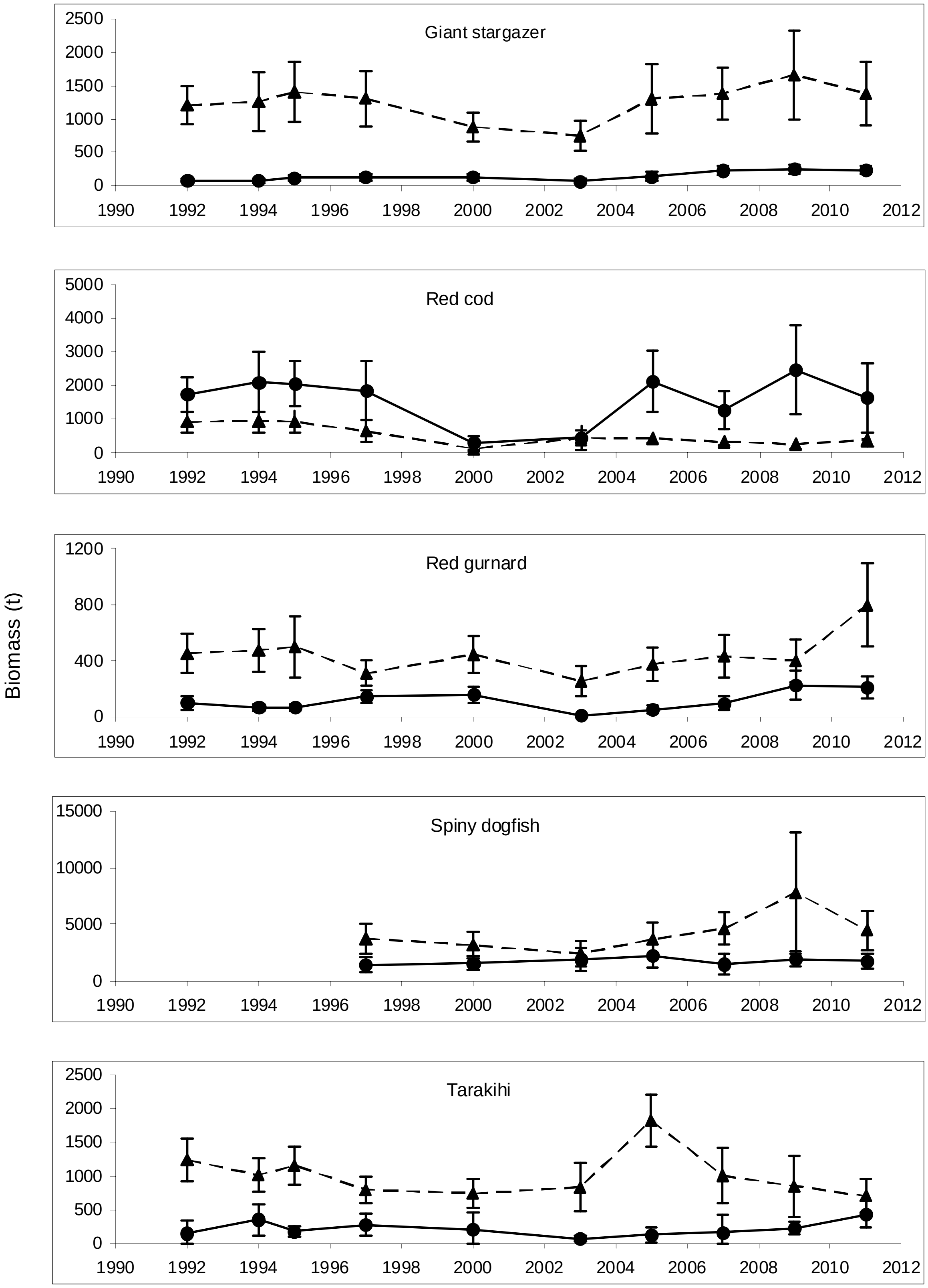



**Figure 8: Biomass trends with 95% confidence intervals for juveniles (circles) and adults (triangles) for the target species (all sexes combined) from all surveys in the series. For 50% maturity lengths, see Table 5.**

**Appendix 1: Length-weight relationship parameters used to scale length frequencies and calculate length class biomass estimates. (DB, Ministry for Primary Industries database *trawl*; –, no data; n, sample size.)**

$W = a L^b$ where W is weight (g) and L is length (cm);

| Species | *a* | *b* | n | Length range (cm) Min. | Max. | Data source |
|---|---|---|---|---|---|---|
| Barracouta | 0.0055 | 2.9812 | 429 | 23.8 | 87.2 | DB, KAH9701 |
| Blue cod | 0.0122 | 3.0746 | 2 137 | 12 | 47 | DB, LHR9501 |
| Blue warehou | 0.0144 | 3.1050 | 338 | 27.4 | 69.6 | DB, TAN9604 |
| Carpet shark | 0.0069 | 3.0068 | 532 | 24.5 | 99.4 | DB, KAH0904 |
| Dark ghost shark | 0.0015 | 3.3611 | 332 | 21.2 | 67.9 | DB, KAH9704 |
| Elephantfish | 0.0049 | 3.1654 | 378 | 13.4 | 91 | DB, KAH9618 |
| Frostfish | 0.0004 | 3.1629 | 450 | 10.4 | 153 | DB, KAH0004 |
| Gemfish | 0.0017 | 3.3419 | 391 | 32 | 107 | DB, KAH9304, KAH9602 |
| Giant stargazer | 0.0113 | 3.0984 | 689 | 14.9 | 77.4 | This survey |
| Hake | 0.0049 | 3.1072 | 260 | 10.7 | 45.2 | This survey |
| Hapuku | 0.0078 | 3.1400 | 307 | 49 | 108 | DB, TAN9301 |
| Hoki | 0.0046 | 2.8840 | 525 | 22 | 110 | DB, SHI8301 |
| Jack mackerel | | | | | | |
| (*Trachurus declivis*) | 0.0165 | 2.9300 | 200 | 15 | 53 | DB, COR9001 |
| (*T. novaezelandiae*) | 0.0163 | 2.9230 | 200 | 15 | 40 | DB, COR9001 |
| John dory | 0.0065 | 3.2499 | 352 | 18.4 | 54.3 | DB, KAH9902 |
| Leatherjacket | 0.0088 | 3.2110 | | | | DB, IKA8003 |
| Lemon sole | 0.0080 | 3.1278 | 524 | 14.6 | 41.2 | DB, KAH9809 |
| Ling | 0.0014 | 3.2883 | 137 | 35.8 | 112.3 | DB, KAH0904 |
| New Zealand sole | 0.0049 | 3.2151 | 114 | 20 | 48 | DB, KAH0304 |
| Northern spiny dogfish | 0.0034 | 3.0781 | 207 | 43 | 90.3 | DB, combined surveys |
| Red cod | 0.0118 | 2.9230 | 0 893 | 10.1 | 64.7 | This survey |
| Red gurnard | 0.0057 | 3.1674 | 661 | 14.2 | 50.2 | This survey |
| Rig | 0.0035 | 3.0351 | 334 | 32.2 | 130 | This survey |
| Rough skate | 0.0337 | 2.8774 | 221 | 20.4 | 59 | This survey |
| Sand flounder | 0.0207 | 2.8768 | 282 | 13.5 | 44.5 | DB, KAH9809 |
| School shark | 0.0026 | 3.1312 | 750 | 33.6 | 148 | This survey |
| Sea perch | 0.0262 | 2.9210 | 210 | 7 | 42 | DB, KAH9618 |
| Silver dory | 0.0191 | 2.9650 | 506 | 13.2 | 27.5 | DB, KAH0904 |
| Silver warehou | 0.0048 | 3.3800 | 262 | 16.6 | 57.8 | DB, TAN502 |
| Smooth skate | 0.0254 | 2.9356 | 44 | 20.3 | 125 | This survey |
| Snapper | 0.0447 | 2.7930 | 780 | 8 | 71 | DB, Paul, FRD Bull. 13 |
| Spiny dogfish | 0.0013 | 3.2558 | 1 171 | 28.9 | 96.9 | This survey |
| Tarakihi | 0.0160 | 3.0358 | 933 | 10.2 | 50.7 | This survey |
| Two-saddle rattail | 0.0015 | 3.31 | 605 | 18 | 55.8 | DB, KAH0904 |

**Appendix 2: Summary of station data.**

| | | | | Start of tow | | | | End of tow | | | | Gear depth (m) | | Distance trawled | Headline | Doorspread | Surface temp | Bottom temp |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Station | Stratum | Date | Time | ° | ' S | ° | ' E | ° | ' S | ° | ' E | Min. | Max. | (n. miles) | height (m) | (m) | (°C) | (°C) |
| 1 | 18 | 26-Mar-11 | 1320 | 41 | 02.10 | 173 | 14.96 | 41 | 05.09 | 173 | 15.03 | 31 | 35 | 2.97 | 4.6 | 74.4 | 18.7 | 17.3 |
| 2 | 18 | 26-Mar-11 | 1534 | 41 | 01.91 | 173 | 17.64 | 41 | 04.84 | 173 | 17.77 | 33 | 37 | 2.95 | 4.6 | 75.6 | 18.8 | 16.8 |
| 3 | 18 | 27-Mar-11 | 857 | 40 | 59.61 | 173 | 18.95 | 41 | 01.55 | 173 | 22.04 | 37 | 39 | 3.00 | 4.7 | 73.2 | 18.7 | 16.9 |
| 4 | 19 | 27-Mar-11 | 1126 | 40 | 59.31 | 173 | 35.82 | 40 | 57.54 | 173 | 38.91 | 41 | 43 | 2.97 | 4.7 | 75.0 | 18.6 | 16.2 |
| 5 | 19 | 27-Mar-11 | 1321 | 40 | 56.80 | 173 | 40.50 | 40 | 57.57 | 173 | 44.40 | 39 | 44 | 3.00 | 4.6 | 76.4 | 18.3 | 16.4 |
| 6 | 19 | 27-Mar-11 | 1626 | 40 | 51.15 | 173 | 24.74 | 40 | 49.03 | 173 | 21.88 | 47 | 47 | 3.00 | 4.8 | 75.3 | 18.0 | 15.8 |
| 7 | 19 | 28-Mar-11 | 620 | 40 | 40.19 | 173 | 43.53 | 40 | 39.02 | 173 | 40.08 | 60 | 60 | 2.98 | 4.7 | 69.4 | 17.4 | 15.6 |
| 8 | 19 | 28-Mar-11 | 953 | 40 | 42.35 | 173 | 11.08 | 40 | 39.39 | 173 | 10.74 | 42 | 44 | 2.98 | 4.7 | 75.8 | 17.4 | 14.9 |
| 9 | 19 | 28-Mar-11 | 1200 | 40 | 39.03 | 173 | 12.64 | 40 | 37.05 | 173 | 15.59 | 45 | 47 | 3.00 | 4.7 | 74.0 | 17.4 | 14.3 |
| 10 | 19 | 28-Mar-11 | 1406 | 40 | 40.01 | 173 | 06.19 | 40 | 41.45 | 173 | 02.76 | 36 | 39 | 2.97 | 4.8 | 74.1 | 18.1 | 17.0 |
| 11 | 17 | 29-Mar-11 | 608 | 40 | 38.35 | 172 | 49.47 | 40 | 37.51 | 172 | 53.36 | 27 | 27 | 3.05 | 4.8 | 70.0 | 18.1 | 17.7 |
| 12 | 17 | 29-Mar-11 | 855 | 40 | 43.49 | 172 | 59.19 | 40 | 43.76 | 172 | 55.39 | 26 | 31 | 2.93 | 4.5 | 71.0 | 18.0 | 17.5 |
| 13 | 17 | 29-Mar-11 | 1051 | 40 | 41.63 | 172 | 50.02 | 40 | 44.02 | 172 | 52.15 | 22 | 24 | 2.89 | 4.6 | 66.5 | 18.1 | 17.9 |
| 14 # | 1 | 30-Mar-11 | 617 | 40 | 30.98 | 172 | 32.11 | 40 | 31.86 | 172 | 30.45 | 72 | 72 | 1.52 | 4.8 | 74.8 | 17.5 | 14.3 |
| 15 | 1 | 30-Mar-11 | 812 | 40 | 31.14 | 172 | 34.52 | 40 | 32.69 | 172 | 31.12 | 61 | 61 | 2.99 | 4.9 | 75.0 | 17.6 | 15.2 |
| 16 | 1 | 30-Mar-11 | 1330 | 40 | 49.99 | 172 | 02.68 | 40 | 52.72 | 172 | 01.08 | 93 | 93 | 3.00 | 4.8 | 74.5 | 16.5 | 15.4 |
| 17 | 1 | 30-Mar-11 | 1601 | 40 | 54.04 | 172 | 03.95 | 40 | 56.96 | 172 | 03.10 | 60 | 64 | 3.00 | 4.8 | 72.6 | 16.9 | 16.5 |
| 18 | 2 | 31-Mar-11 | 618 | 40 | 51.39 | 171 | 29.78 | 40 | 53.74 | 171 | 27.33 | 166 | 169 | 3.00 | 4.7 | 89.0 | 18.7 | 13.7 |
| 19 | 2 | 31-Mar-11 | 929 | 40 | 53.74 | 171 | 48.57 | 40 | 56.66 | 171 | 47.66 | 125 | 125 | 3.00 | 4.9 | 85.1 | 18.4 | 13.4 |
| 20 | 2 | 31-Mar-11 | 1102 | 40 | 57.11 | 171 | 47.45 | 41 | 00.02 | 171 | 46.71 | 125 | 126 | 3.00 | 4.8 | 84.7 | 18.1 | 13.4 |
| 21 | 2 | 31-Mar-11 | 1304 | 41 | 00.17 | 171 | 54.05 | 41 | 03.09 | 171 | 54.09 | 101 | 104 | 2.96 | 4.7 | 79.9 | 18.3 | 13.9 |
| 22 | 1 | 31-Mar-11 | 1458 | 41 | 03.91 | 172 | 01.24 | 41 | 06.79 | 172 | 01.89 | 58 | 64 | 2.98 | 5.0 | 74.1 | 17.0 | 15.8 |
| 23 | 6 | 1-Apr-11 | 626 | 41 | 17.78 | 171 | 42.89 | 41 | 15.14 | 171 | 44.54 | 115 | 117 | 2.98 | 4.8 | 88.2 | 17.1 | 13.1 |
| 24 | 2 | 1-Apr-11 | 838 | 41 | 15.82 | 171 | 40.00 | 41 | 12.97 | 171 | 41.38 | 122 | 123 | 3.04 | 4.8 | 83.9 | 18.3 | 13.9 |
| 25 | 5 | 1-Apr-11 | 1210 | 41 | 29.40 | 171 | 42.38 | 41 | 26.84 | 171 | 44.52 | 65 | 65 | 3.04 | 4.9 | 72.1 | 17.2 | 14.2 |
| 26 * | 19 | 5-Apr-11 | 852 | 40 | 41.93 | 173 | 04.38 | 40 | 41.58 | 173 | 05.16 | 38 | 39 | 0.69 | 4.8 | 75.0 | 17.1 | 16.1 |
| 27 * | 19 | 5-Apr-11 | 1027 | 40 | 40.18 | 173 | 10.37 | 40 | 40.85 | 173 | 09.96 | 44 | 45 | 0.71 | 4.8 | 75.9 | 17.4 | 15.4 |
| 28 * | 17 | 5-Apr-11 | 1242 | 40 | 37.81 | 173 | 00.08 | 40 | 37.75 | 172 | 59.08 | 34 | 35 | 0.74 | 4.8 | 74.9 | 17.6 | 15.8 |
| 29 * | 17 | 5-Apr-11 | 1354 | 40 | 37.40 | 172 | 59.84 | 40 | 37.39 | 172 | 58.52 | 30 | 31 | 1.00 | 4.7 | 73.0 | 17.8 | 16.3 |
| 30 * | 17 | 5-Apr-11 | 1530 | 40 | 37.85 | 172 | 57.00 | 40 | 38.46 | 172 | 55.97 | 29 | 30 | 0.99 | 4.9 | 70.4 | 17.6 | 17.1 |
| 31 * | 17 | 5-Apr-11 | 1717 | 40 | 38.94 | 172 | 57.96 | 40 | 38.88 | 172 | 59.17 | 31 | 32 | 0.91 | 4.6 | 75.0 | 17.8 | 16.5 |

**Appendix 2—*continued***

| Station | Stratum | Date | Time | Start of tow ° | ' S | ° | ' E | End of tow ° | ' S | ° | ' E | Gear depth (m) Min. | Max. | Distance trawled (n. miles) | Headline height (m) | Doorspread (m) | Surface temp (°C) | Bottom temp (°C) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 32 * | 17 | 6-Apr-11 | 639 | 40 | 37.66 | 172 | 51.87 | 40 | 37.54 | 172 | 53.10 | 25 | 26 | 0.94 | 4.8 | 72.4 | 7.2 | 17.2 |
| 33 * | 17 | 6-Apr-11 | 811 | 40 | 38.49 | 172 | 54.41 | 40 | 37.74 | 172 | 55.16 | 29 | 29 | 0.94 | 4.7 | 67.8 | 17.6 | 17.0 |
| 34 * | 17 | 6-Apr-11 | 1003 | 40 | 39.88 | 172 | 54.88 | 40 | 40.51 | 172 | 53.95 | 31 | 32 | 0.94 | 4.7 | 74.8 | 17.8 | 16.5 |
| 35 * | 19 | 6-Apr-11 | 1145 | 40 | 37.58 | 173 | 02.04 | 40 | 37.38 | 173 | 03.28 | 31 | 35 | 0.95 | 4.9 | 73.4 | 17.6 | 16.2 |
| 36 * | 19 | 6-Apr-11 | 1331 | 40 | 37.42 | 173 | 15.44 | 40 | 38.09 | 173 | 14.54 | 48 | 49 | 0.95 | 4.7 | 75.8 | 18.1 | 15.7 |
| 37 * | 19 | 6-Apr-11 | 1521 | 40 | 41.57 | 173 | 29.06 | 40 | 41.53 | 173 | 30.38 | 52 | 52 | 0.99 | 4.8 | 76.9 | 18.3 | 15.4 |
| 38 * | 19 | 6-Apr-11 | 1714 | 40 | 44.06 | 173 | 39.62 | 40 | 44.26 | 173 | 40.89 | 51 | 51 | 0.98 | 5.1 | 74.3 | 17.8 | 16.2 |
| 39 * | 19 | 7-Apr-11 | 648 | 40 | 45.47 | 173 | 41.17 | 40 | 46.25 | 173 | 40.36 | 62 | 63 | 1.00 | 5.1 | 74.4 | 17.4 | 15.5 |
| 40 * | 19 | 7-Apr-11 | 851 | 40 | 46.00 | 173 | 40.31 | 40 | 45.34 | 173 | 41.33 | 63 | 64 | 1.02 | 4.5 | 70.9 | 17.4 | 16.3 |
| 41 * | 19 | 7-Apr-11 | 1040 | 40 | 45.47 | 173 | 41.57 | 40 | 46.38 | 173 | 40.80 | 65 | 66 | 1.08 | 5.1 | 72.4 | 17.2 | 16.7 |
| 42 * | 19 | 7-Apr-11 | 1241 | 40 | 46.22 | 173 | 41.09 | 40 | 47.11 | 173 | 40.46 | 66 | 66 | 1.01 | 4.5 | 73.4 | 17.4 | 16.5 |
| 43 * | 19 | 7-Apr-11 | 1355 | 40 | 44.68 | 173 | 41.76 | 40 | 45.27 | 173 | 41.30 | 59 | 63 | 0.70 | 4.5 | 71.9 | 17.6 | 16.7 |
| 44 | 5 | 8-Apr-11 | 1335 | 41 | 38.28 | 171 | 28.33 | 41 | 36.89 | 171 | 31.66 | 83 | 98 | 2.85 | 4.8 | 74.4 | 15.9 | 13.7 |
| 45 | 5 | 8-Apr-11 | 1525 | 41 | 34.03 | 171 | 36.00 | 41 | 32.70 | 171 | 39.58 | 62 | 75 | 2.99 | 4.6 | 68.1 | 16.5 | 14.5 |
| 46 | 9 | 9-Apr-11 | 657 | 42 | 12.62 | 170 | 32.74 | 42 | 09.86 | 170 | 34.29 | 359 | 375 | 3.00 | 4.9 | 90.7 | 15.6 | 11.7 |
| 47 | 9 | 9-Apr-11 | 947 | 42 | 03.58 | 170 | 33.24 | 42 | 00.89 | 170 | 34.98 | 348 | 387 | 3.04 | 4.8 | 91.6 | 17.0 | 11.1 |
| 48 | 9 | 9-Apr-11 | 1252 | 41 | 46.52 | 170 | 35.67 | 41 | 43.63 | 170 | 36.37 | 384 | 400 | 2.96 | 4.8 | 90.8 | 16.8 | 11.1 |
| 49 | 6 | 9-Apr-11 | 1610 | 41 | 41.75 | 170 | 57.21 | 41 | 44.48 | 170 | 55.75 | 175 | 176 | 2.95 | 5.0 | 88.1 | 16.5 | 12.8 |
| 50 | 6 | 10-Apr-11 | 652 | 41 | 35.71 | 171 | 23.43 | 41 | 38.71 | 171 | 22.63 | 132 | 135 | 3.04 | 4.9 | 85.3 | 16.8 | 13.2 |
| 51 | 8 | 10-Apr-11 | 910 | 41 | 47.44 | 171 | 15.37 | 41 | 50.44 | 171 | 14.80 | 125 | 133 | 3.03 | 4.8 | 85.3 | 16.5 | 13.2 |
| 52 | 7 | 10-Apr-11 | 1116 | 41 | 59.01 | 171 | 16.61 | 42 | 01.63 | 171 | 14.61 | 59 | 64 | 2.99 | 4.4 | 75.1 | 15.7 | 14.7 |
| 53 | 7 | 10-Apr-11 | 1308 | 42 | 02.74 | 171 | 12.81 | 42 | 05.55 | 171 | 11.09 | 74 | 77 | 3.05 | 4.8 | 76.4 | 15.6 | 14.0 |
| 54 | 8 | 10-Apr-11 | 1617 | 41 | 53.42 | 170 | 56.86 | 41 | 50.73 | 170 | 58.32 | 170 | 174 | 2.91 | 4.7 | 84.8 | 16.2 | 12.7 |
| 55 | 8 | 11-Apr-11 | 644 | 42 | 01.03 | 171 | 00.00 | 42 | 03.94 | 170 | 59.29 | 171 | 174 | 2.96 | 4.9 | 88.3 | 16.0 | 12.8 |
| 56 | 8 | 11-Apr-11 | 838 | 42 | 08.84 | 171 | 03.52 | 42 | 11.81 | 171 | 02.64 | 122 | 129 | 3.04 | 5.0 | 83.8 | 16.3 | 13.2 |
| 57 | 7 | 11-Apr-11 | 1100 | 42 | 20.51 | 171 | 09.00 | 42 | 23.18 | 171 | 07.18 | 28 | 30 | 2.97 | 4.9 | 70.6 | 15.6 | 15.4 |
| 58 | 7 | 11-Apr-11 | 1301 | 42 | 27.18 | 171 | 04.17 | 42 | 30.17 | 171 | 03.07 | 34 | 37 | 3.04 | 5.0 | 71.7 | 15.6 | 15.3 |
| 59 | 11 | 11-Apr-11 | 1502 | 42 | 36.96 | 170 | 56.80 | 42 | 39.70 | 170 | 54.89 | 54 | 61 | 3.04 | 4.9 | 74.5 | 16.0 | 14.7 |
| 60 | 11 | 11-Apr-11 | 1713 | 42 | 45.69 | 170 | 44.95 | 42 | 46.20 | 170 | 41.00 | 53 | 57 | 2.97 | 4.9 | 71.9 | 16.2 | 14.5 |
| 61 | 11 | 12-Apr-11 | 639 | 42 | 49.34 | 170 | 31.16 | 42 | 51.51 | 170 | 28.33 | 37 | 40 | 3.00 | 4.9 | 71.6 | 15.8 | 15.2 |
| 62 | 11 | 12-Apr-11 | 831 | 42 | 56.98 | 170 | 27.53 | 42 | 58.78 | 170 | 24.27 | 22 | 23 | 3.00 | 5.2 | 71.1 | 16.2 | 15.2 |

**Appendix 2—*continued***

| | | | | | | | | | | | | | | Distance | | | Surface | Bottom |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Start of tow | | | | | End of tow | | | | Gear depth (m) | | trawled | Headline | Doorspread | temp | temp |
| Station | Stratum | Date | Time | ° | ' S | ° | ' E | ° | ' S | ° | ' E | Min. | Max. | (n. miles) | height (m) | (m) | (°C) | (°C) |
| 63 | 11 | 12-Apr-11 | 1016 | 42 | 56.04 | 170 | 22.14 | 42 | 58.31 | 170 | 19.60 | 48 | 50 | 2.93 | 4.6 | 75.3 | 15.8 | 14.2 |
| 64 | 12 | 12-Apr-11 | 1211 | 42 | 53.17 | 170 | 15.03 | 42 | 50.26 | 170 | 15.88 | 117 | 124 | 3.00 | 4.5 | 86.0 | 16 | 13 |
| 65 | 12 | 12-Apr-11 | 1405 | 42 | 46.38 | 170 | 13.02 | 42 | 48.28 | 170 | 10.17 | 144 | 155 | 2.88 | 4.5 | 89.7 | 15.6 | 12.7 |
| 66 | 12 | 12-Apr-11 | 1554 | 42 | 48.39 | 170 | 07.45 | 42 | 45.45 | 170 | 06.90 | 165 | 168 | 3.00 | 4.8 | 83.3 | 15.4 | 12.8 |
| 67 | 13 | 13-Apr-11 | 643 | 42 | 44.47 | 170 | 03.40 | 42 | 47.21 | 170 | 01.85 | 240 | 241 | 2.96 | 4.6 | 91.2 | 15.5 | 12.8 |
| 68 | 13 | 13-Apr-11 | 1316 | 42 | 57.63 | 169 | 55.30 | 42 | 59.10 | 169 | 54.13 | 259 | 292 | 1.76 | 4.7 | 95.4 | 15.4 | 12.6 |
| 69 | 12 | 13-Apr-11 | 1536 | 42 | 56.58 | 170 | 07.12 | 42 | 59.21 | 170 | 05.20 | 142 | 146 | 2.99 | 4.8 | 86.4 | 15.3 | 12.6 |
| 70 | 12 | 13-Apr-11 | 1726 | 43 | 03.73 | 170 | 04.97 | 43 | 06.49 | 170 | 03.82 | 112 | 124 | 2.89 | 4.7 | 84.2 | 15.7 | 13.2 |
| 71 | 11 | 14-Apr-11 | 639 | 43 | 07.27 | 170 | 04.60 | 43 | 10.25 | 170 | 04.15 | 64 | 92 | 2.97 | 4.6 | 84.1 | 15.6 | 13.4 |
| 72 | 12 | 14-Apr-11 | 831 | 43 | 08.02 | 170 | 02.92 | 43 | 05.30 | 170 | 01.14 | 107 | 140 | 3.05 | 4.8 | 82.9 | 15.9 | 13.1 |
| 73 | 11 | 14-Apr-11 | 1042 | 43 | 11.76 | 170 | 03.48 | 43 | 14.14 | 170 | 01.03 | 42 | 46 | 2.99 | 4.5 | 76.5 | 15.6 | 15 |
| 74 | 15 | 14-Apr-11 | 1247 | 43 | 16.12 | 169 | 51.69 | 43 | 18.10 | 169 | 48.30 | 140 | 143 | 3.10 | 4.6 | 83.1 | 15.3 | 13 |
| 75 | 13 | 14-Apr-11 | 1445 | 43 | 14.57 | 169 | 44.94 | 43 | 11.88 | 169 | 43.42 | 210 | 217 | 3.01 | 4.9 | 91.1 | 15.1 | 12.5 |
| 76 | 16 | 14-Apr-11 | 1659 | 43 | 14.44 | 169 | 38.59 | 43 | 16.92 | 169 | 36.32 | 286 | 299 | 3.03 | 4.8 | 91.5 | 15.2 | 12.3 |
| 77 | 14 | 15-Apr-11 | 658 | 43 | 24.45 | 169 | 40.72 | 43 | 27.15 | 169 | 38.31 | 40 | 47 | 3.20 | 4.6 | 75.5 | 15.4 | 15.2 |
| 78 | 14 | 15-Apr-11 | 909 | 43 | 28.13 | 169 | 39.10 | 43 | 30.42 | 169 | 36.50 | 30 | 34 | 2.99 | 4.6 | 74.7 | 15.5 | 15.2 |
| 79 | 14 | 15-Apr-11 | 1056 | 43 | 28.70 | 169 | 32.77 | 43 | 26.00 | 169 | 34.00 | 52 | 59 | 2.93 | 4.6 | 76.0 | 15.4 | 15.1 |
| 80 | 16 | 15-Apr-11 | 1333 | 43 | 22.75 | 169 | 21.43 | 43 | 24.70 | 169 | 18.24 | 326 | 345 | 3.03 | 4.6 | 96.5 | 15.8 | 12.1 |
| 81 | 16 | 15-Apr-11 | 1621 | 43 | 26.70 | 169 | 16.65 | 43 | 28.89 | 169 | 13.65 | 263 | 266 | 3.09 | 4.8 | 94.9 | 15.7 | 12.5 |
| 82 | 14 | 16-Apr-11 | 648 | 43 | 43.15 | 169 | 07.72 | 43 | 44.68 | 169 | 06.05 | 75 | 81 | 1.93 | 4.8 | 83.8 | 14.9 | 14.7 |
| 83 | 15 | 16-Apr-11 | 843 | | 4340.1 | | 16904.27 | | 4342.57 | | 16902.31 | 109 | 128 | 2.84 | 4.8 | 88.2 | 15.2 | 13 |
| 84 | 15 | 16-Apr-11 | 1251 | | 4327.2 | | 16918.93 | | 4329.92 | | 16917.35 | 130 | 135 | 2.96 | 4.8 | 87.0 | 14.9 | 12.8 |

# Not used for biomass estimates

* Tow for tarakihi tagging, not used for biomass estimates

**Appendix 3: Catch summary in alphabetical order by species code (Occ. = occurrence).**

| Species code | Common name | Scientific name | Catch (kg) | % of total catch | Occ. | Depth (m) Min. | Depth (m) Max. |
|---|---|---|---|---|---|---|---|
| ALL | Deepwater sea snail | *Alcithoe larochei* | 3.5 | * | 11 | 30 | 155 |
| ANT | Anemones | Anthozoa | 0.4 | * | 1 | 39 | 44 |
| ASC | Sea squirt | Ascidiacea | 46.0 | * | 7 | 26 | 47 |
| ASR | Starfish | Asteroidea | 2.3 | * | 17 | 26 | 400 |
| BAR | Barracouta | *Thyrsites atun* | 7 296.7 | 17 | 64 | 22 | 400 |
| BCO | Blue cod | *Parapercis colias* | 110.8 | * | 15 | 26 | 128 |
| BPD | Lamp shells | Brachiopoda | 0.1 | * | 1 | 26 | 31 |
| BRI | Brill | *Colistium guntheri* | 4.6 | * | 4 | 22 | 64 |
| BRN | Barnacle | Cirripdeia (Class) | 0.4 | * | 3 | 132 | 400 |
| BRZ | Brown stargazer | *Xenocephalus armatus* | 2.1 | * | 3 | 101 | 126 |
| BSH | Seal shark | *Dalatias licha* | 10.4 | * | 1 | 263 | 266 |
| BSQ | Broad squid | *Sepioteuthis australis* | 4.5 | * | 7 | 22 | 64 |
| BTA | Smooth deepsea skate | *Notoraja asperula* | 3.6 | * | 3 | 348 | 400 |
| CAR | Carpet shark | *Cephaloscyllium isabellum* | 1 041.6 | 2 | 60 | 22 | 375 |
| CBI | Two saddle rattail | *Caelorinchus biclinozonalis* | 2 175.6 | 5 | 46 | 26 | 375 |
| CBO | Bollons's rattail | *Caelorinchus bollonsi* | 1.3 | * | 1 | 326 | 345 |
| CCX | Small banded rattail | *Caelorinchus parvifasciatus* | 88.7 | * | 8 | 112 | 375 |
| CDO | Capro dory | *Capromimus abbreviatus* | 255.9 | 1 | 22 | 107 | 400 |
| CEG | White finger bryozoan | *Celleporina grandis* | 56.8 | * | 1 | 26 | 31 |
| COL | Oliver's rattail | *Caelorhinchus oliverianus* | 0.4 | * | 1 | 326 | 345 |
| CON | Conger eel | *Conger* spp. | 43.0 | * | 11 | 27 | 98 |
| CPG | *Callyspongia* sp. | *Callyspongia* sp. | 11.6 | * | 16 | 22 | 387 |
| CUC | Cucumberfish | *Chlorophthalmus nigripinnis* | 182.5 | * | 22 | 93 | 400 |
| EGG | Fish eggs | | 0.4 | * | 2 | 22 | 50 |
| EGR | Eagle ray | *Myliobatis tenuicaudatus* | 20.6 | * | 3 | 26 | 43 |
| ELE | Elephantfish | *Callorhinchus milii* | 329.4 | 1 | 10 | 22 | 64 |
| EMA | Blue mackerel | *Scomber australasicus* | 5.6 | * | 5 | 26 | 124 |
| ERA | Electric ray | *Torpedo fairchildi* | 73.8 | * | 12 | 22 | 124 |
| ESO | N.Z. sole | *Peltorhamphus novaezeelandiae* | 50.8 | * | 13 | 22 | 64 |
| FHD | Deepsea flathead | *Hoplichthys haswelli* | 4.8 | * | 6 | 259 | 400 |
| FLL | Shell fragments | | 105.4 | * | 11 | 27 | 266 |
| FRO | Frostfish | *Lepidopus caudatus* | 223.7 | 1 | 28 | 53 | 345 |
| GAS | Gastropods | Gastropoda | 0.5 | * | 4 | 31 | 146 |
| GLB | Globefish | *Contusus richei* | 0.9 | * | 1 | 30 | 34 |
| GRM | Sea urchin | *Gracilechinus multidentatus* | 0.2 | * | 2 | 122 | 135 |
| GSH | Dark ghost shark | *Hydrolagus novaezealandiae* | 1 859.5 | 4 | 31 | 45 | 375 |
| GUR | Red gurnard | *Chelidonichthys kumu* | 1 580.0 | 4 | 42 | 22 | 174 |
| HAK | Hake | *Merluccius australis* | 69.5 | * | 21 | 28 | 345 |
| HAP | Hapuku | *Polyprion oxygeneios* | 72.9 | * | 8 | 60 | 299 |
| HDR | Hydroid | Hydrozoa (Class) | 0.8 | * | 5 | 26 | 98 |
| HEP | Sharpnose sevengill shark | Heptranchias perlo | 10.2 | * | 1 | 359 | 375 |
| HOK | Hoki | *Macruronus novaezelandiae* | 2 945.8 | 7 | 23 | 53 | 375 |
| INV | Invertebrate | *Invertebrate, unknown* | 0.1 | * | 1 | 166 | 169 |
| JAV | Javelinfish | *Lepidorhynchus denticulatus* | 62.1 | * | 9 | 210 | 400 |
| JDO | John dory | *Zeus faber* | 389.0 | 1 | 35 | 22 | 176 |
| JFI | Jellyfish | | 111.4 | * | 19 | 22 | 98 |
| JGU | Spotted gurnard | *Pterygotrigla picta* | 0.1 | * | 1 | 166 | 169 |
| JMD | N.Z. jack mackerel | *Trachurus declivis* | 261.9 | 1 | 32 | 22 | 345 |
| JMM | Chilean jack mackerel | *Trachurus murphyi* | 10.7 | * | 4 | 30 | 169 |
| JMN | N.Z. jack mackerel | *Trachurus novaezelandiae* | 258.0 | 1 | 33 | 22 | 217 |
| KAH | Kahawai | *Arripis trutta* | 82.6 | * | 6 | 22 | 39 |

**Appendix 3—continued.**

| Species code | Common name | Scientific name | Catch (kg) | % of total catch | Occ. | Depth (m) Min. | Max. |
|---|---|---|---|---|---|---|---|
| KIN | Kingfish | *Seriola lalandi* | 21.1 | * | 2 | 28 | 37 |
| KWH | Knobbed whelk | *Austrofucus glans* | 0.6 | * | 5 | 64 | 375 |
| LAN | Lantern fish | Myctophidae | 0.1 | * | 1 | 348 | 387 |
| LEA | Leatherjacket | *Parika scaber* | 260.1 | 1 | 14 | 26 | 64 |
| LIN | Ling | *Genypterus blacodes* | 504.8 | 1 | 34 | 22 | 345 |
| LSO | Lemon sole | *Pelotretis flavilatus* | 130.8 | * | 36 | 22 | 299 |
| MDO | Mirror dory | *Zenopsis nebulosus* | 3.4 | * | 1 | 40 | 47 |
| MUS | Mussels | | 4.1 | * | 1 | 31 | 35 |
| NOS | NZ southern arrow squid | *Nototodarus sloanii* | 187.3 | * | 58 | 26 | 400 |
| NSD | Northern spiny dogfish | *Squalus griffini* | 244.3 | 1 | 16 | 93 | 400 |
| NUD | Nudibranchia | Nudibranchia | 3.6 | * | 3 | 27 | 39 |
| OCT | Octopus | *Pinnoctopus cordiformis* | 17.9 | * | 10 | 26 | 60 |
| ONG | Sponges | Porifera (Phylum) | 125.1 | * | 6 | 31 | 47 |
| OPA | Opalfish | *Hemerocoetes* spp. | 0.4 | * | 4 | 37 | 292 |
| OPE | Orange perch | *Lepidoperca aurantia* | 17.0 | * | 2 | 109 | 375 |
| PAG | Hermit crab | Paguroidea | 1.1 | * | 10 | 42 | 387 |
| PCO | Ahuru | *Auchenoceros punctatus* | 2.4 | * | 7 | 28 | 75 |
| PIG | Pigfish | *Congiopodus leucopaecilus* | 4.0 | * | 10 | 26 | 217 |
| PIL | Pilchard | *Sardinops neopilchardus* | 12.9 | * | 3 | 26 | 39 |
| POP | Porcupine fish | *Allomycterus jaculiferus* | 64.2 | * | 8 | 28 | 125 |
| PRK | Prawn killer | *Ibacus alticrenatus* | 11.3 | * | 14 | 28 | 299 |
| RBM | Ray's bream | *Brama brama* | 14.4 | * | 1 | 54 | 61 |
| RBT | Redbait | *Emmelichthys nitidus* | 38.2 | * | 16 | 53 | 299 |
| RCO | Red cod | *Pseudophycis bachus* | 3 206.0 | 7 | 56 | 22 | 375 |
| RHY | Common roughy | *Paratrachichthys trailli* | 261.0 | * | 5 | 72 | 345 |
| RMU | Red mullet | Upeneichthys lineatus | 0.5 | * | 2 | 26 | 37 |
| RSK | Rough skate | *Zearaja nasutus* | 473.9 | * | 32 | 28 | 400 |
| SAR | Mantis shrimp | *Squilla armata* | 0.1 | * | 1 | 93 | 93 |
| SCA | Scallop | *Pecten novaezelandiae* | 0.3 | * | 2 | 36 | 39 |
| SCC | Sea cucumber | *Stichopus mollis* | 4.9 | * | 7 | 27 | 98 |
| SCG | Scaly gurnard | *Lepidotrigla brachyoptera* | 778.6 | 2 | 54 | 26 | 375 |
| SCH | School shark | *Galeorhinus galeus* | 1 565.0 | 4 | 62 | 22 | 387 |
| SDO | Silver dory | *Cyttus novaezealandiae* | 1 314.2 | 3 | 29 | 75 | 400 |
| SDR | Spiny seadragon | *Solegnathus spinosissimus* | 0.8 | * | 4 | 59 | 299 |
| SFL | Sand flounder | *Rhombosolea plebeia* | 170.4 | * | 16 | 22 | 72 |
| SHO | Seahorse | *Hippocampus abdominalis* | 0.3 | * | 3 | 33 | 43 |
| SKI | Gemfish | *Rexea solandri* | 171.7 | * | 10 | 122 | 387 |
| SNA | Snapper | *Pagrus auratus* | 175.8 | * | 9 | 22 | 65 |
| SPA | Slender sprat | *Sprattus antipodum* | 0.7 | * | 1 | 65 | 65 |
| SPD | Spiny dogfish | *Squalus acanthias* | 7 338.3 | 17 | 63 | 22 | 345 |
| SPE | Sea perch | *Helicolenus* spp. | 594.8 | 1 | 42 | 26 | 400 |
| SPO | Rig | *Mustelus lenticulatus* | 485.8 | 1 | 35 | 22 | 169 |
| SPR | Sprats | *Sprattus antipodum, S. muelleri* | 17.6 | * | 18 | 22 | 92 |
| SPS | Speckled sole | *Peltorhamphus latus* | 0.2 | * | 2 | 37 | 43 |
| SPT | Heart urchin | *Spatangus multispinus* | 18.5 | * | 7 | 83 | 135 |
| SPZ | Spotted stargazer | *Genyagnus monopterygius* | 0.3 | * | 1 | 33 | 37 |
| SRH | Silver roughy | *Hoplostethus mediterraneus* | 4.0 | * | 2 | 286 | 375 |
| SSH | Slender smoothhound | *Gollum attenuatus* | 52.0 | * | 3 | 348 | 400 |
| SSI | Silverside | *Argentina elongata* | 15.8 | * | 25 | 54 | 387 |

**Appendix 3—continued.**

| Species code | Common name | Scientific name | Catch (kg) | % of total catch | Occ. | Depth (m) Min. | Max. |
|---|---|---|---|---|---|---|---|
| SSK | Smooth skate | *Dipturus innominatus* | 205.1 | * | 23 | 31 | 400 |
| STA | Giant stargazer | Kathetostoma giganteum | 2 020.0 | 5 | 48 | 26 | 345 |
| STR | Stingray | *Dasyatis* sp. | 35.2 | * | 3 | 26 | 47 |
| STY | Spotty | *Notolabrus celidotus* | 19.3 | * | 6 | 22 | 39 |
| SWA | Silver warehou | *Seriolella punctata* | 64.2 | * | 30 | 37 | 375 |
| TAR | Tarakihi | *Nemadactylus macropterus* | 1 810.7 | 4 | 54 | 25 | 375 |
| TOD | Dark toadfish | *Neophrynichthys latus* | 1.5 | * | 13 | 112 | 387 |
| TRE | Trevally | *Pseudocaranx dentex* | 2.3 | * | 1 | 36 | 39 |
| TUR | Turbot | *Colistium nudipinnis* | 4.9 | * | 2 | 22 | 30 |
| WAR | Blue warehou | *Seriolella brama* | 408.9 | 1 | 38 | 22 | 168 |
| WIT | Witch | *Arnoglossus scapha* | 418.0 | 1 | 64 | 22 | 400 |
| WOD | Wood | Wood | 129.3 | * | 8 | 30 | 241 |
| YBO | Yellow boarfish | *Pentaceros decacanthus* | 12.4 | * | 3 | 40 | 375 |
| YEM | Yellow-eyed mullet | *Aldrichetta forsteri* | 1.8 | * | 2 | 27 | 35 |
| | | Total | 43 328.2 | | | | |

* less than 0.5%

**Appendix 4: Benthic macro-invertebrates taken as by catch during the survey.**

| Taxon | No. of stations |
|---|---|
| **Porifera (Demospongiae)** | |
| *Suberites affinis* Brondsted, 1923 | 6 |
| *Callyspongia* sp. | 3 |
| | |
| **Annelida: Echiura** | |
| Echiuroida | 1 |
| | |
| **Bryozoa** | |
| *Celleporina grandis* | 1 |
| *Celleporaria agglutinans* | 1 |
| *Parasmittina delicatula* | 1 |
| *Hippomenella vellicata* | 1 |
| *Smittoidea maunganuiensis* | 1 |
| *Idmidronea sp.* | 1 |
| | |
| **Cnidaria: Hydrozoa** | |
| Hydrozoa indeterminate. | 5 |
| *Nemertesia elongata* | 1 |
| | |
| **Cnidaria: Anthozoa** | |
| Hormathiidae (Family) | 5 |
| | |
| **Crustacea: Palinura** | |
| *Ibaccus alticrenatus* | 14 |
| | |
| **Crustacea: Decapoda** | |
| *Diacanthurus rubricatus* | 4 |
| *Antarctus mawsoni* | 1 |
| | |
| **Crustacea: Paguridae** | |
| *Diacanthurus rubricatus* (Henderson, 1888) | 10 |
| | |
| **Crustacea: Stomatopoda** | |
| *Pterygosquilla schizodontia* (Richardson, 1953) | 1 |
| | |
| **Crustacea: Anomura** | |
| *Ovalipes catharus* | 2 |
| *Nectocarcinus antarcticus* | 1 |
| | |
| **Crustacea: Maxillopoda** | |
| *Graviscalpellum pedunculatum* | 3 |
| | |
| **Arthropoda: Cirripedia** | |
| *Calantica studeri* | 3 |

**Appendix 4—continued**

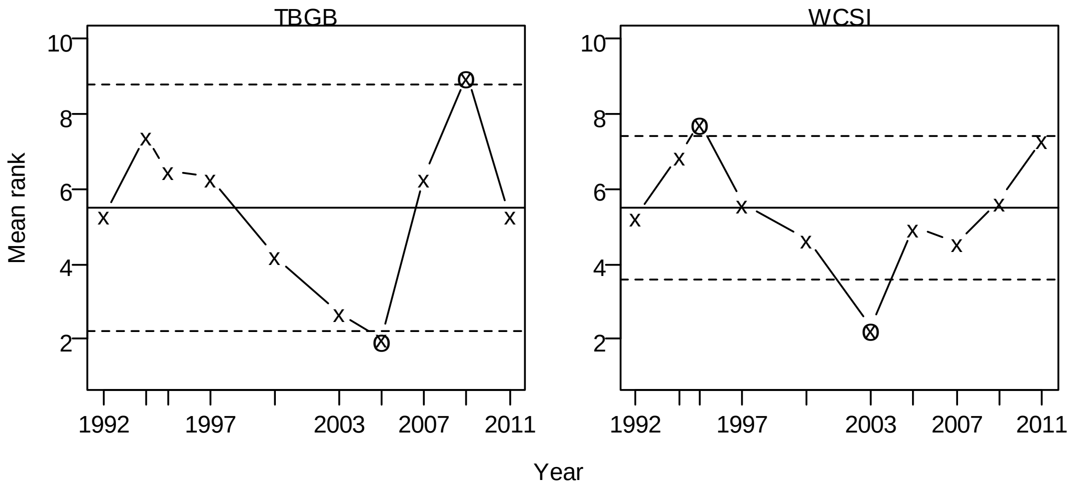
| Taxon | No. of stations |
| --- | --- |
| **Mollusca: Bivalvia** | |
| *Pecten novaezelandiae* | 2 |
| *Perna canaliculus* | |
| **Mollusca: Gastropoda Prosobranchia** | |
| *Austrofusus glans* | 7 |
| *Ranella olearium* | 1 |
| *Alcithoe larochei* | 11 |
| **Mollusca: Gastropoda Opisthobranchia** | |
| *Archidoris wellingtonensis* | 1 |
| **Mollusca: Cephalopoda** | |
| *Pinnoctopus cordiformis* | 10 |
| **Urochordata: Ascidiacea** | |
| Ascidiacea | 7 |
| **Echinodermata :Astreoidea** | |
| *Proserpinaster neozelanicus* | 1 |
| *Psilaster acuminatus* | 2 |
| *Mediaster sladeni* | 1 |
| **Echinodermata:Echinoidea** | |
| *Spatangus multispinus* | 7 |
| **Echinodermata: Holothuroidea** | |
| *Australostichopus mollis* | 8 |

**Appendix 5**: **Updated mean ranks for the two survey areas.**

This note updates, for the WCSI and TBGB survey series, the extreme-year analysis described in section 4.4 of Francis et al.(2001). Since the original analysis was done, an additional five years of data (for surveys in 2003, 2005, 2007, 2009, 2011) have become available.

For TBGB, the updated calculations suggest that 2005 and 2009 were extreme years, with biomass estimates for many species being lower than normal in 2005 and higher than normal in 2009 (Figure 5.1, left panel). For WCSI, 1995 and 2003 appear to be extreme (Figure 5.1, right panel).

These analyses used biomass estimates for five species in TBGB (LEA BCO ESO LSO SFL) and eighteen species in WCSI (BAR SPD RCO TAR STA SPE GUR GSH RSK SSK CAR SCH SPO JMD JMM LIN SDO NSD).



**Appendix 6: Input file for biomass analysis of several species using SurvCalc.**

```
@trips   kah1104

@species kah1104
codes   SPD BAR RCO HOK CBI STA GSH TAR GUR SCH

@input_from_database
database Empress

@where
t_station gear_perf < 3

@preferences
distance_towed recorded_distance recorded_speed*time from_lat_long
width_swept recorded_doorspread
catch_weight   recorded calculated

@sub_populations SPD
sexes all male male female female
Lmin 0 0 58 0 72
Lmax 120 57 120 71 120
labels all m_to58 m_58+ f_to72 f_72+

@lw_coeff kah1104_SPD
a 0.001288
b 3.25578

@sub_populations BAR
sexes all all all
Lmin 0 0  50
Lmax 120 49 120
labels all to50 50+

@lw_coeff kah1104_BAR
a 0.00552
b 2.9812

@sub_populations RCO
sexes all all all all all male female
Lmin 0 0 40 0 51 0 0
Lmax 85 39 85 50 85 85 85
labels all to40 40+ to_51 51+ male_a female_a

@lw_coeff kah1104_RCO
a 0.011795
b 2.92305

@sub_populations HOK
sexes all all all
Lmin 0 0  65
Lmax 140 64 140
labels all to65 65+
```

```
@lw_coeff kah1104_HOK
a 0.004612
b 2.884

@sub_populations STA
sexes all all all all all
Lmin 0 0 30 0 45
Lmax 86 29 86 44 86
labels all to30 30+ to45 45+

@lw_coeff kah1104_STA
a 0.011336
b 3.098441

@sub_populations GSH
sexes all male male female female
Lmin 0 0 52 0 62
Lmax 80 51 80 61 80
labels all m_to52 m_52+ f_to62 f_62+

@lw_coeff kah1104_GSH
a 0.0015
b 3.3611

@sub_populations TAR
sexes all all all all all
Lmin 0 0 25 0 31
Lmax 60 24 60 30 60
labels all to25 25+ juv adult

@lw_coeff kah1104_TAR
a 0.01601
b 3.03575

@sub_populations GUR
sexes all all all
Lmin 0 0 30
Lmax 60 29 60
labels all to30 30+

@lw_coeff kah1104_GUR
a 0.005715
b 3.167405

@sub_populations SCH
sexes all all all
Lmin 0 0 90
Lmax 160 89 160
labels all to90 90+

@lw_coeff kah1104_SCH
a 0.00258
b 3.13167
```

```
@output_tables
sub_biomass_by_stratum T
biomass_by_species T
biomass_by_species_stratum T

@output_precision
quantity  density    biomass    LF_number  cv         gain
type      dec_place  dec_place  sig_fig    dec_place  dec_place
precision 0          0          8          0          1
```