



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

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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 km², 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 km² in stratum 17 to one station per 1 078 km² in stratum 6, with an average density of one station per 394 km² (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 (*Thyrssites 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 km², 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 in 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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6. REFERENCES

- Beentjes, M.P. (2000). Assessment of red cod stocks (RCO 3 and RCO 7) for 1999. *New Zealand Fisheries Assessment Report 2000/25*. 78 p.
- Beentjes, M.P.; Stevenson, M.L. (2008). Inshore trawl survey of Canterbury Bight and Pegasus Bay, May-June 2007 (KAH0705). *New Zealand Fisheries Assessment Report 2008/38*. 95 p.
- Drummond, K.L.; Stevenson, M.L. (1995a). Inshore trawl survey of the west coast South Island and Tasman and Golden Bays, March-April 1992 (KAH9204). *New Zealand Fisheries Data Report No. 63*. 58 p.
- Drummond, K.L.; Stevenson, M.L. (1995b). Inshore trawl survey of the west coast South Island and Tasman and Golden Bays, March-April 1994 (KAH9404). *New Zealand Fisheries Data Report No. 64*. 55 p.
- Drummond, K.L.; Stevenson, M.L. (1996). Inshore trawl survey of the west coast South Island and Tasman and Golden Bays, March-April 1995 (KAH9504). *New Zealand Fisheries Data Report No. 74*. 60 p.
- Francis, R.I.C.C. (1981). Stratified random trawl surveys of deep-water demersal stocks around New Zealand. *Fisheries Research Division Occasional Publication No. 32*. 28 p.
- Francis, R.I.C.C. (1984). An adaptive strategy for stratified random trawl surveys. *New Zealand Journal of Marine and Freshwater Research* 18: 59–71.

- Francis, R.I.C.C. (1989). A standard approach to biomass estimation from bottom trawl surveys. New Zealand Fisheries Assessment Research Document 89/3. 3 p. (Unpublished report held in NIWA library, Wellington.)
- Francis, R.I.C.C.; Hurst, R.J.; Renwick, J.A. (2001). An evaluation of catchability assumptions in New Zealand stock assessments. *New Zealand Fisheries Assessment Report 2001/1*. 37 p.
- Francis, R.I.C.C.; Fu, D (2012) SruvCalc Users Manual v1.2-2011-09-28 *NIWA Technical Report 134* 54p.
- Ministry of Fisheries (2009). Report from the Fishery Assessment Plenary, May 2009: stock assessments and yield estimates. Ministry of Fisheries, Wellington, New Zealand, 1036 p. (Unpublished report held in NIWA library, Wellington.)
- Stevenson, M.L. (1998). Inshore trawl survey of west coast South Island and Tasman and Golden Bays, March-April 1997 (KAH9701). *NIWA Technical Report 12*. 70 p.
- Stevenson, M.L. (2002). Inshore trawl survey of west coast South Island and Tasman and Golden Bays, March-April 2000 (KAH0004). *NIWA Technical Report 115*. 71 p.
- Stevenson, M.L. (2004). Inshore trawl survey of the west coast South Island and Tasman and Golden Bays, March-April 2003 (KAH0304). *New Zealand Fisheries Assessment Report 2004/04*. 69 p.
- Stevenson, M.L. (2006). Inshore trawl survey of the west coast South Island and Tasman and Golden Bays, March-April 2005 (KAH0504). *New Zealand Fisheries Assessment Report 2006/04*. 69 p.
- Stevenson, M.L. (2007a). Inshore trawl survey of the west coast South Island and Tasman and Golden Bays, March-April 2007 (KAH0704). *New Zealand Fisheries Assessment Report 2007/41*. 64 p.
- Stevenson, M.L. (2007b). Review of data collected by the WCSI series to determine for which species relative abundance trends and size comparison information should be provided in each survey report. *Final Research Report for Ministry of Fisheries Research Project INT2006-01*. Unpublished report held in NIWA library, Wellington.
- Stevenson, M.L.; Hanchet, S.M. (Comps.) (1999). Trawl survey design and data analysis procedures for inshore fisheries research. *NIWA Technical Report 53*. 20 p.
- Stevenson, M.L.; Hanchet, S.M. (2000). Review of the inshore trawl survey series of the west coast of the South Island and Tasman and Golden Bays, 1992-97. *NIWA Technical Report 82*. 79 p.
- Stevenson, M.L.; Hanchet, S.M (2010). Inshore trawl survey of the west coast South Island and Tasman and Golden Bays, March-April 2009. *New Zealand Fisheries Assessment Report 2010/11*. 77 p
- Vignaux, M. (1994). Documentation of Trawlsurvey Analysis Program. MAF Fisheries Greta Point Internal Report No. 255. 44 p. (Unpublished report held in NIWA library, Wellington)

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)	<u>Number of stations</u>		Station density (km ² per station)
				Phase 1	Phase 2	
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).

	<i>n</i>	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.

Stratum	Species code									
	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.

Species	KAH9204		KAH9404		KAH9504		KAH9701		KAH0004		KAH0304		KAH0503		KAH0704		KAH0904		KAH1104	
	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																				
<i>Trachurus declivis</i>	92	24	99	26	106	20	162	19	168	33	87	21	118	21	62	23	79	23	231	35
<i>T. novaezelandiae</i>	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		West coast		Total survey area		50% maturity length (cm)	Total survey area	
		Biomass	c.v.%	Biomass	c.v.%	Biomass	c.v.%		Biomass	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 (<i>T. novaezeland</i>)	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.

Stratum	Species code									
	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.

Stratum	Species code									
	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		Biological data+			No. of tagged fish
		No. of samples	No. of fish	No. of samples	No. of fish	No. of otoliths or spines	
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											
Length (cm)	Males					Females					
	Gonad stage					Gonad stage					
	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			Females						
	Gonad stage			Gonad stage						
	1	2	3	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)

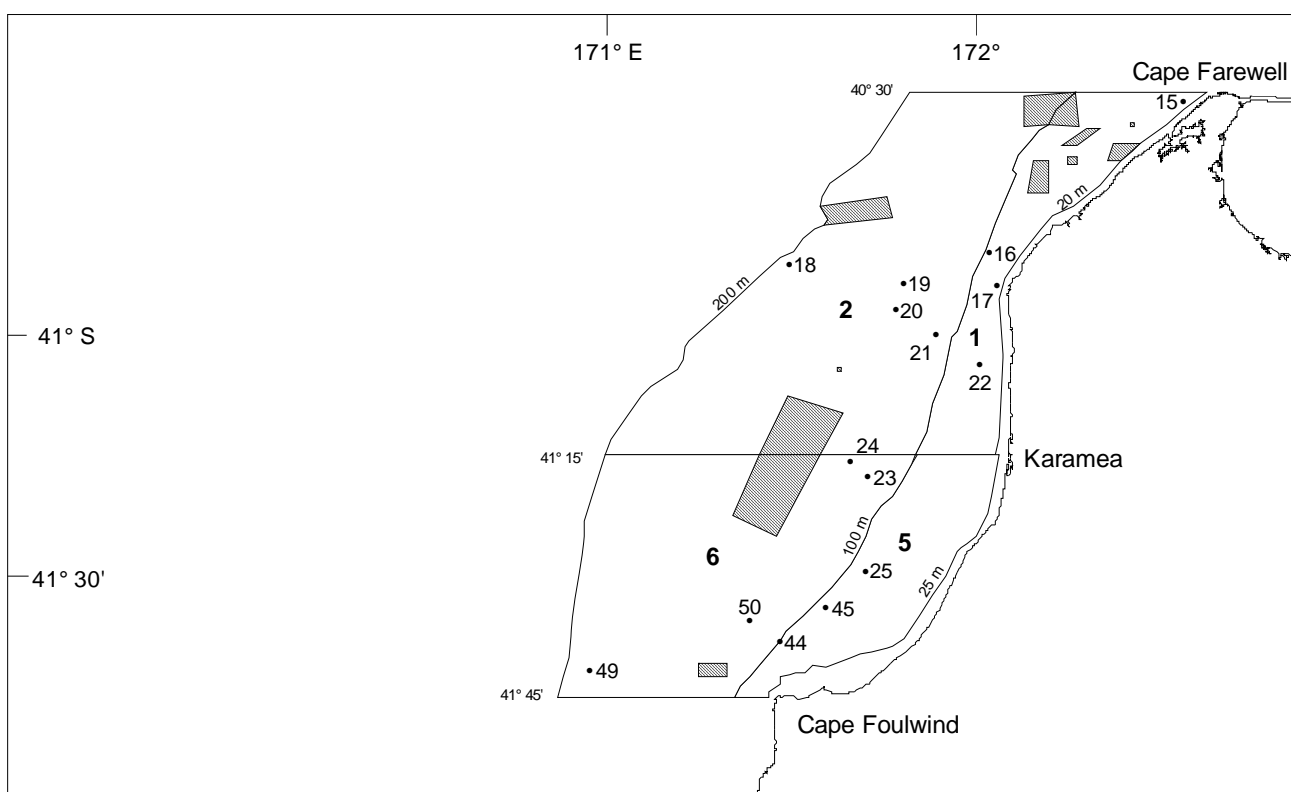
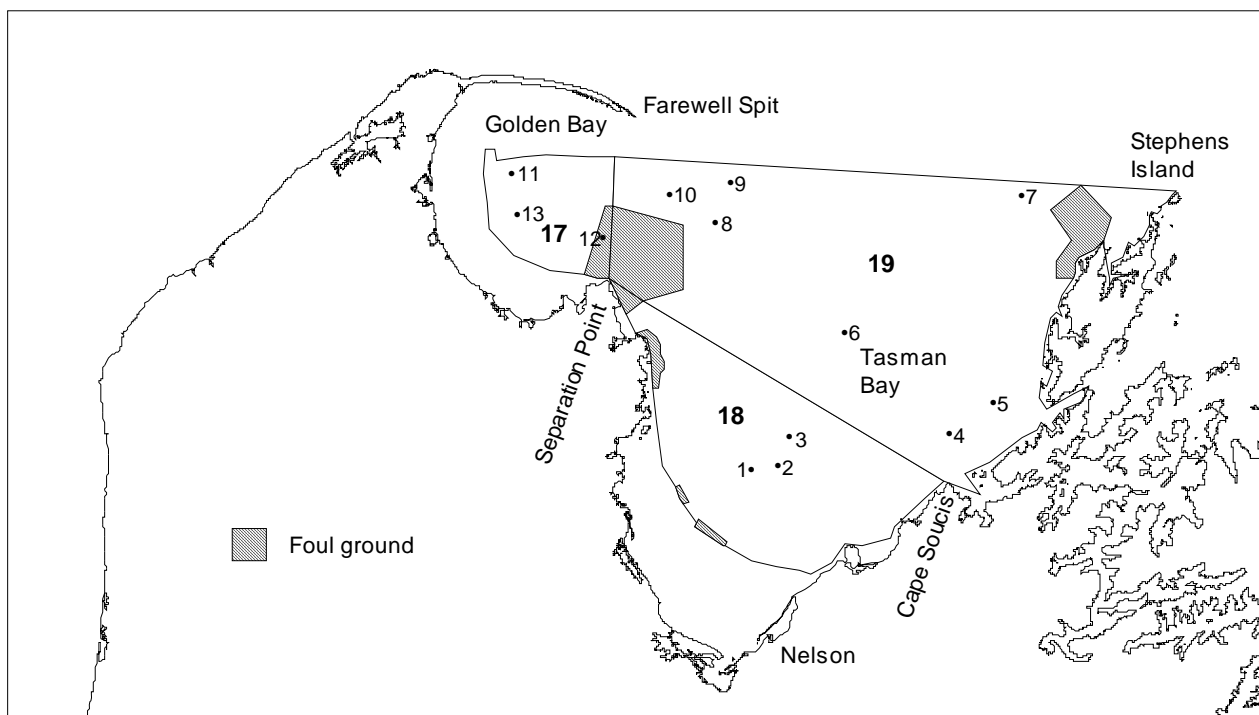


Figure 1a: Survey area showing strata boundaries and numbers (bold type) for Tasman and Golden Bays (top) and the west coast north of Cape Foulwind (bottom) with station positions and numbers.

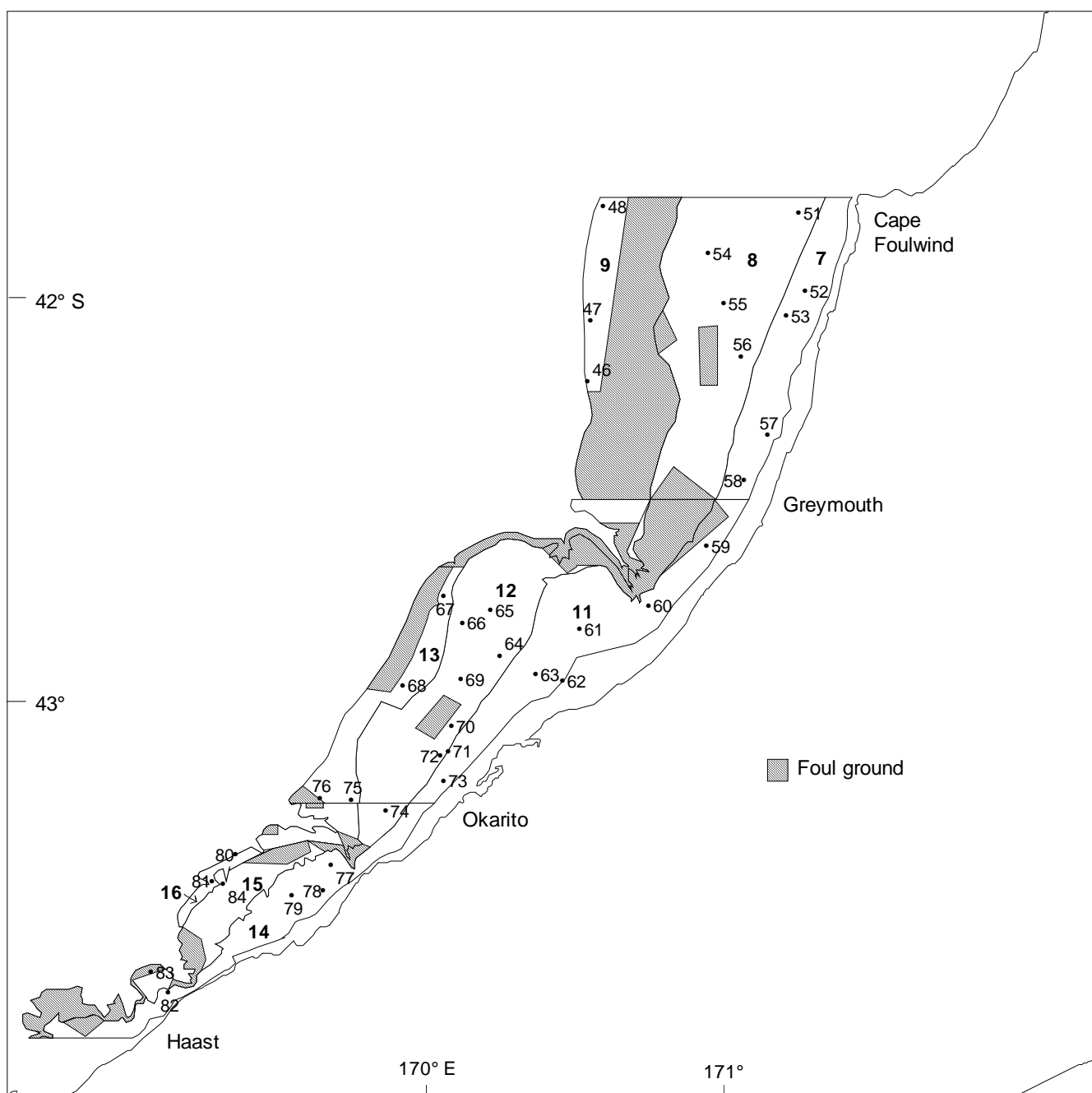


Figure 1b: Strata boundaries and numbers (bold type) south of Cape Foulwind with station positions and numbers.

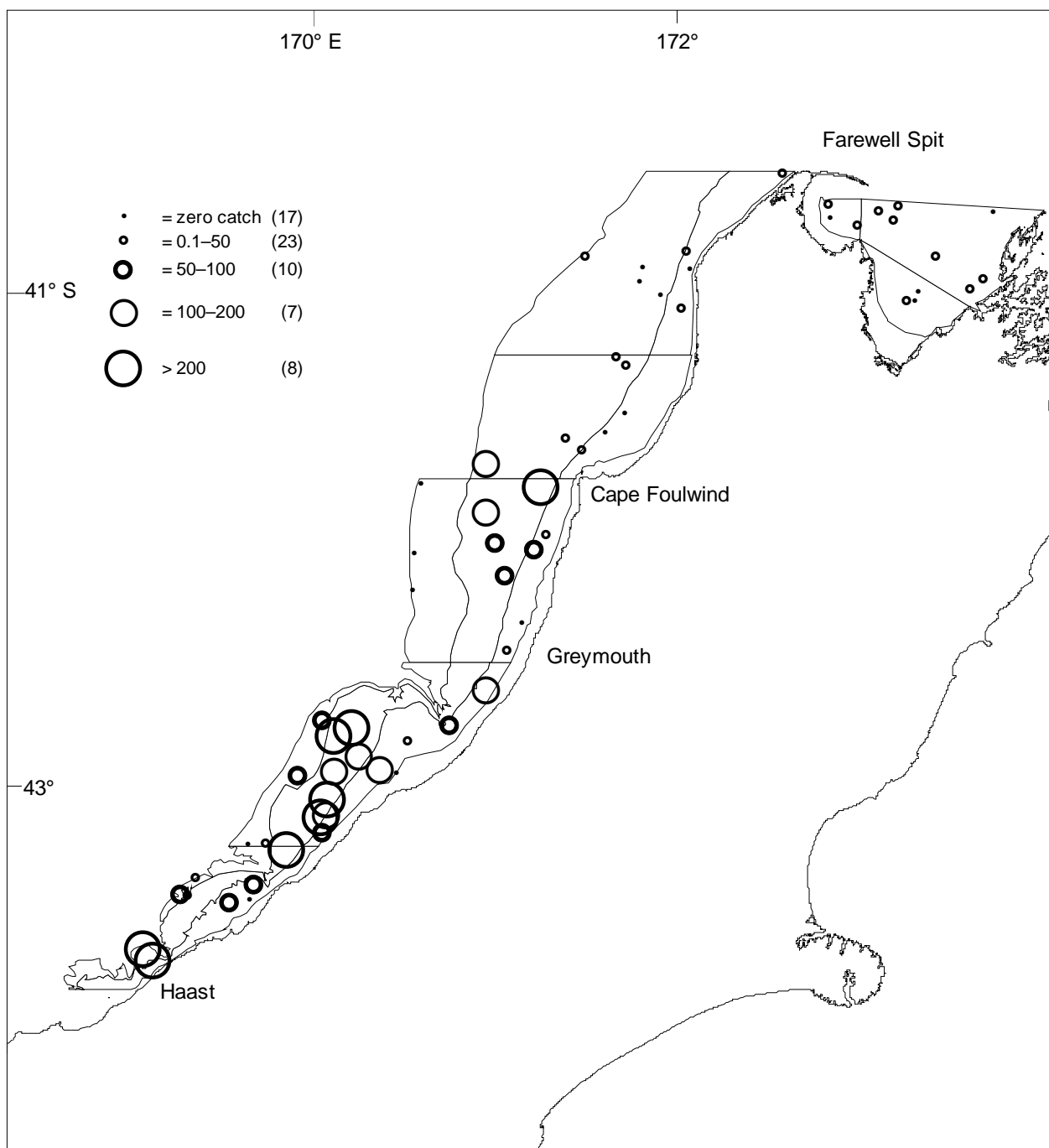


Figure 2: Catch rates (kg.km⁻²) and distribution for the target species in alphabetical order by common name (numbers in parentheses are the number of stations within the given range).

a: Giant stargazer (maximum catch rate = 530 kg.km⁻²)

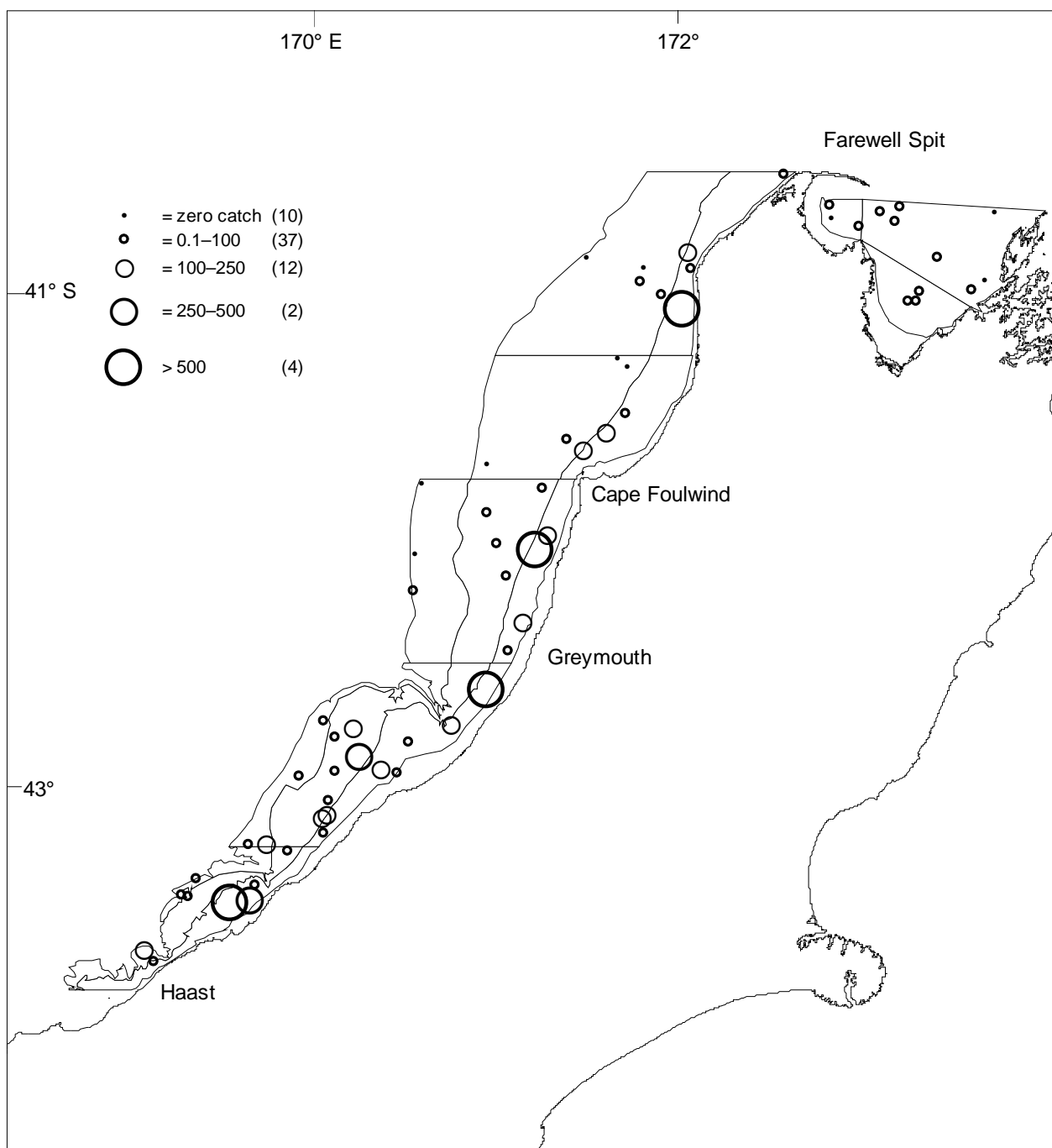


Figure 2b: Red cod (maximum catch rate = 1 510 kg.km⁻²).

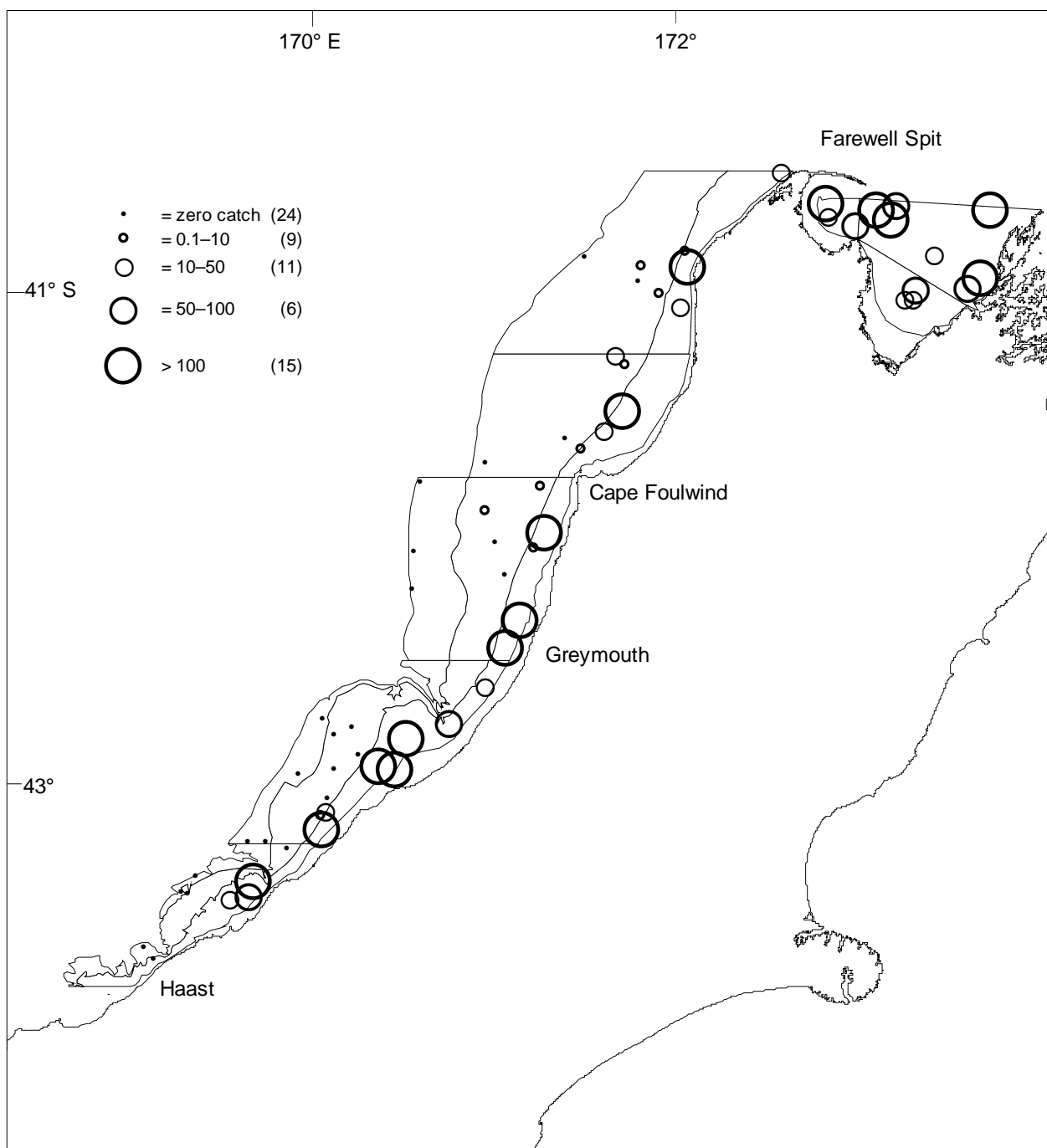


Figure 2c: Red gurnard (maximum catch rate = 434 kg.km⁻²).

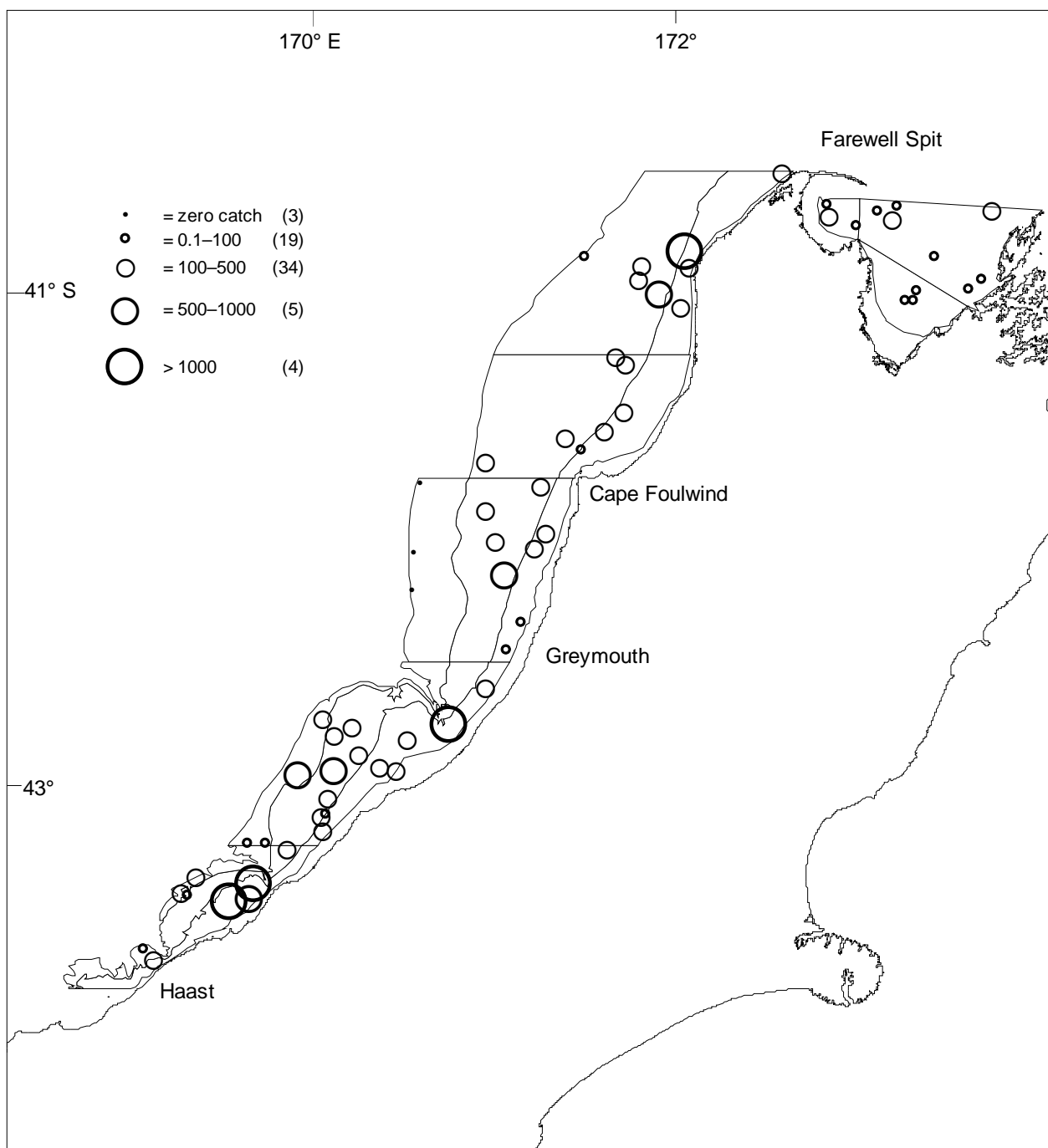


Figure 2d: Spiny dogfish (maximum catch rate = 1 270 kg.km⁻²).

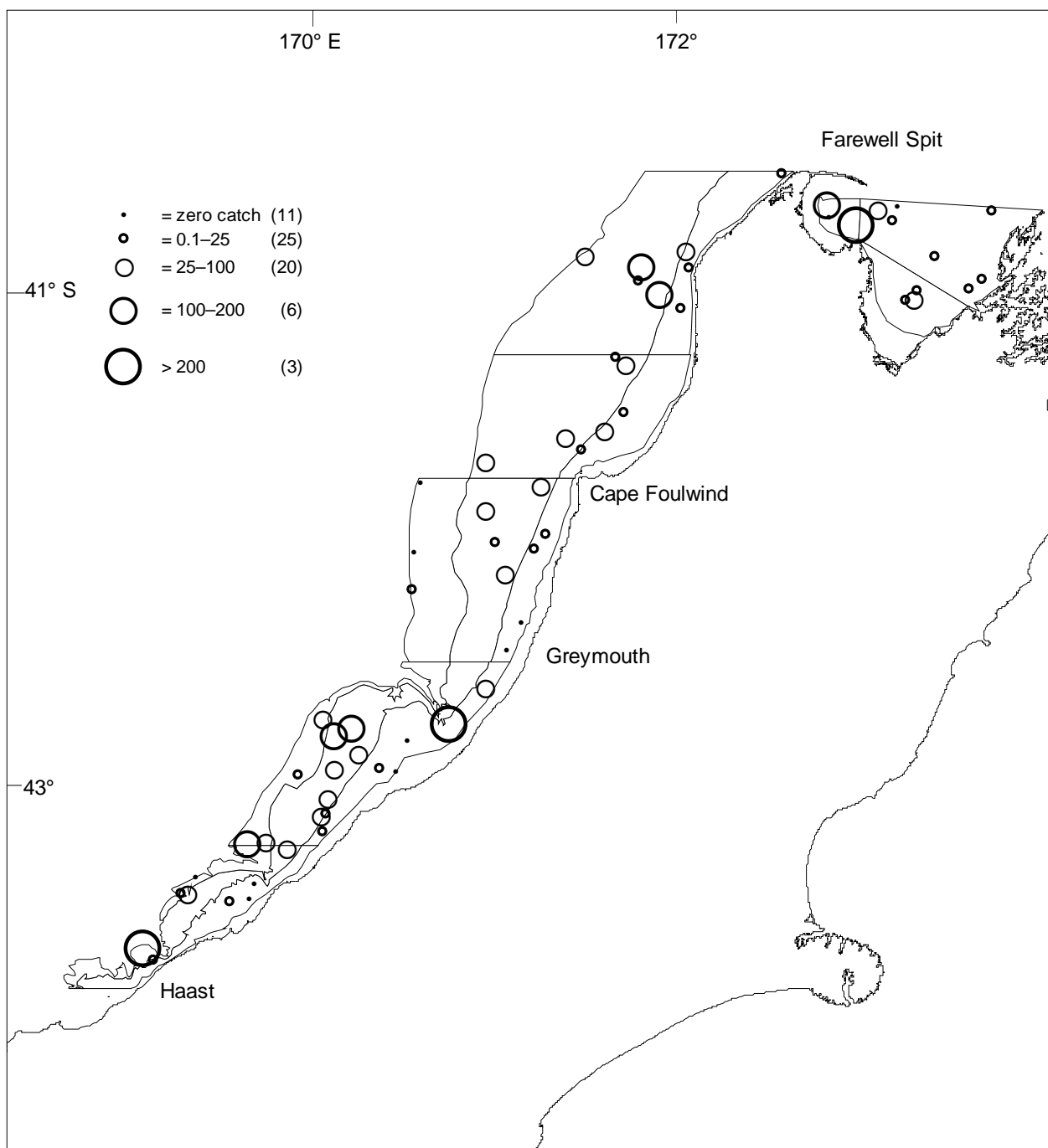


Figure 2e: Tarakihi (maximum catch rate = 434 kg.km⁻²).

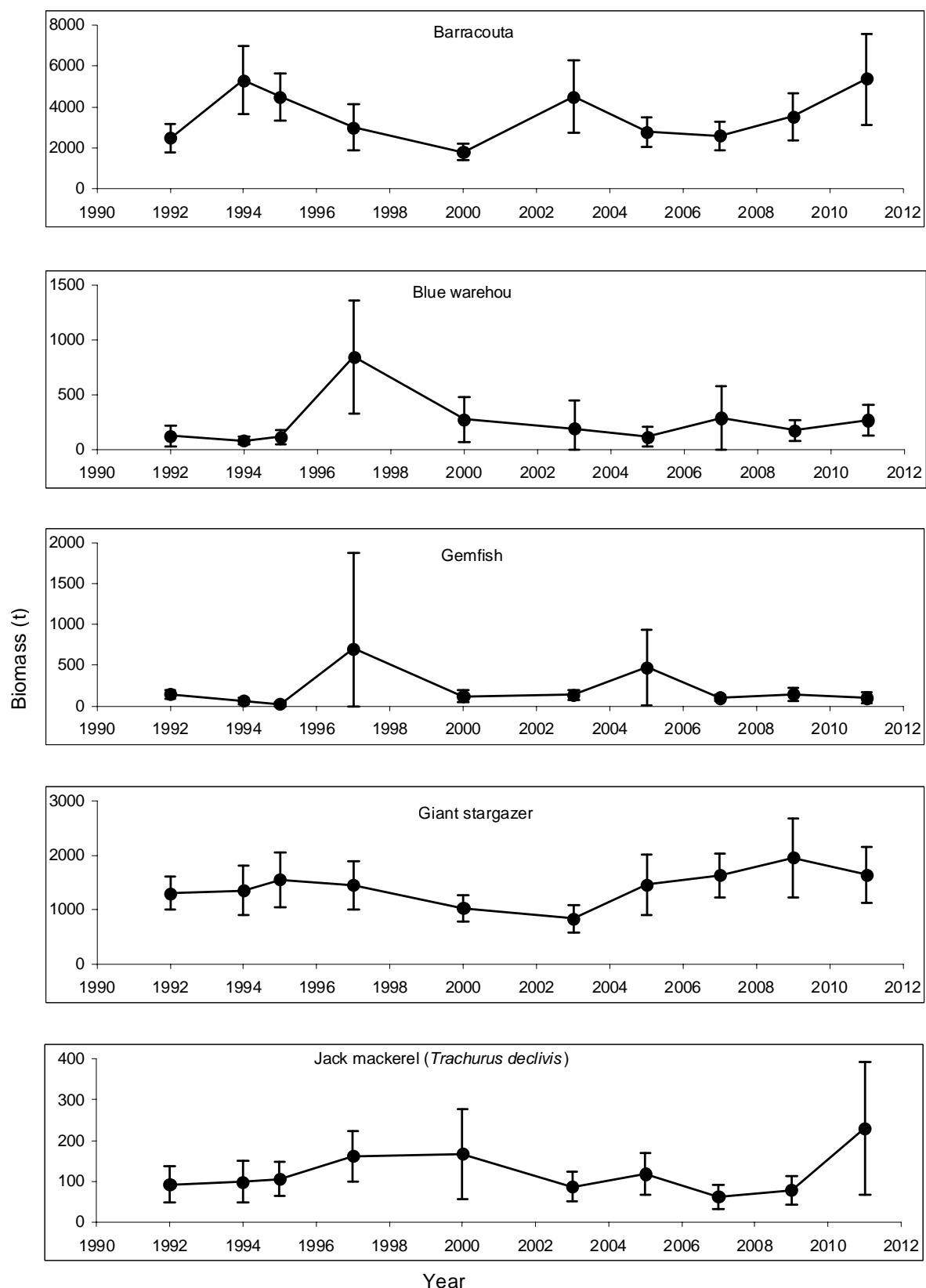


Figure 3: Trends in total biomass for the target species and other species for which the survey time series is likely to be monitoring adult or pre-recruit abundance.

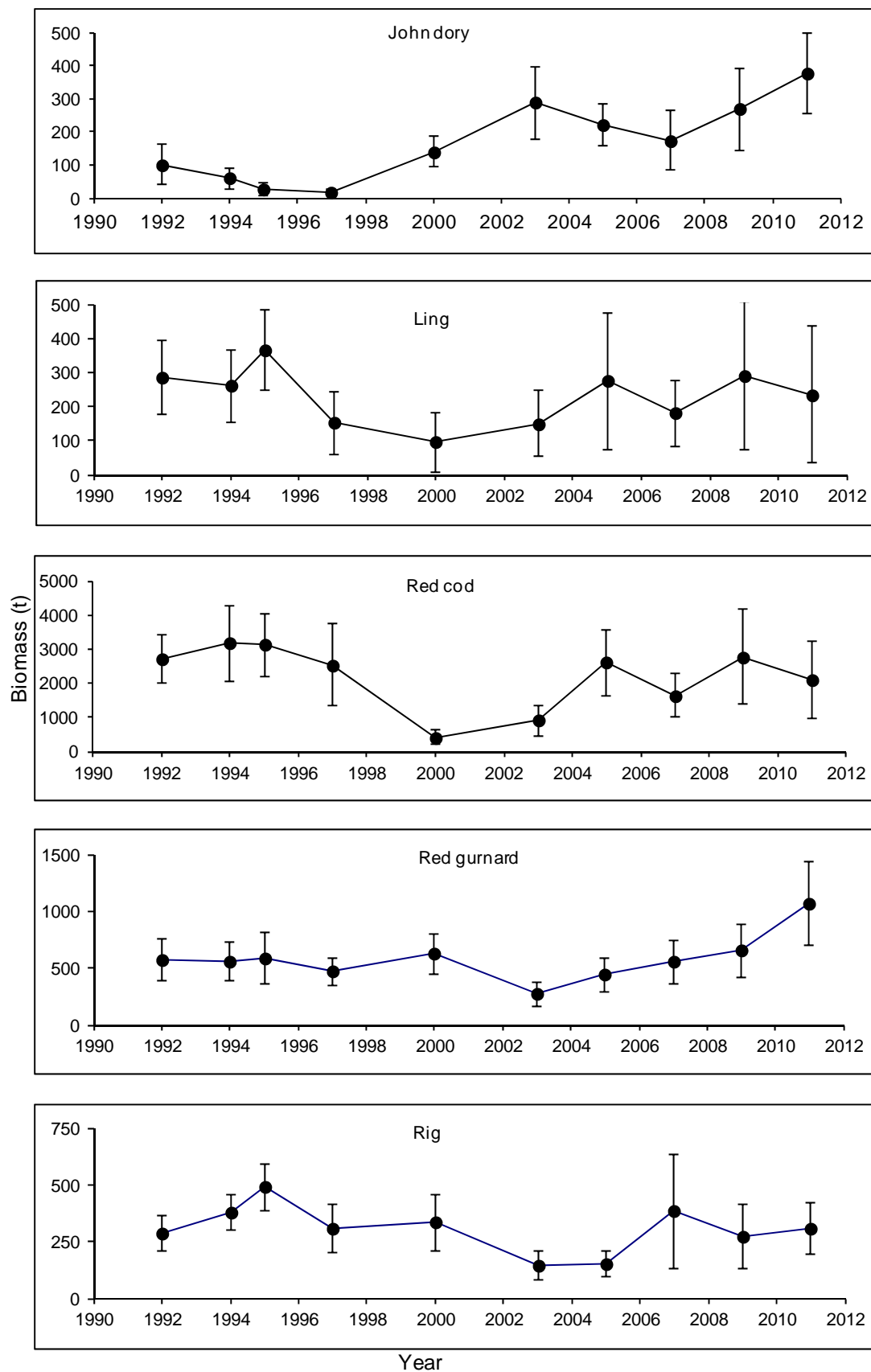


Figure 3—continued

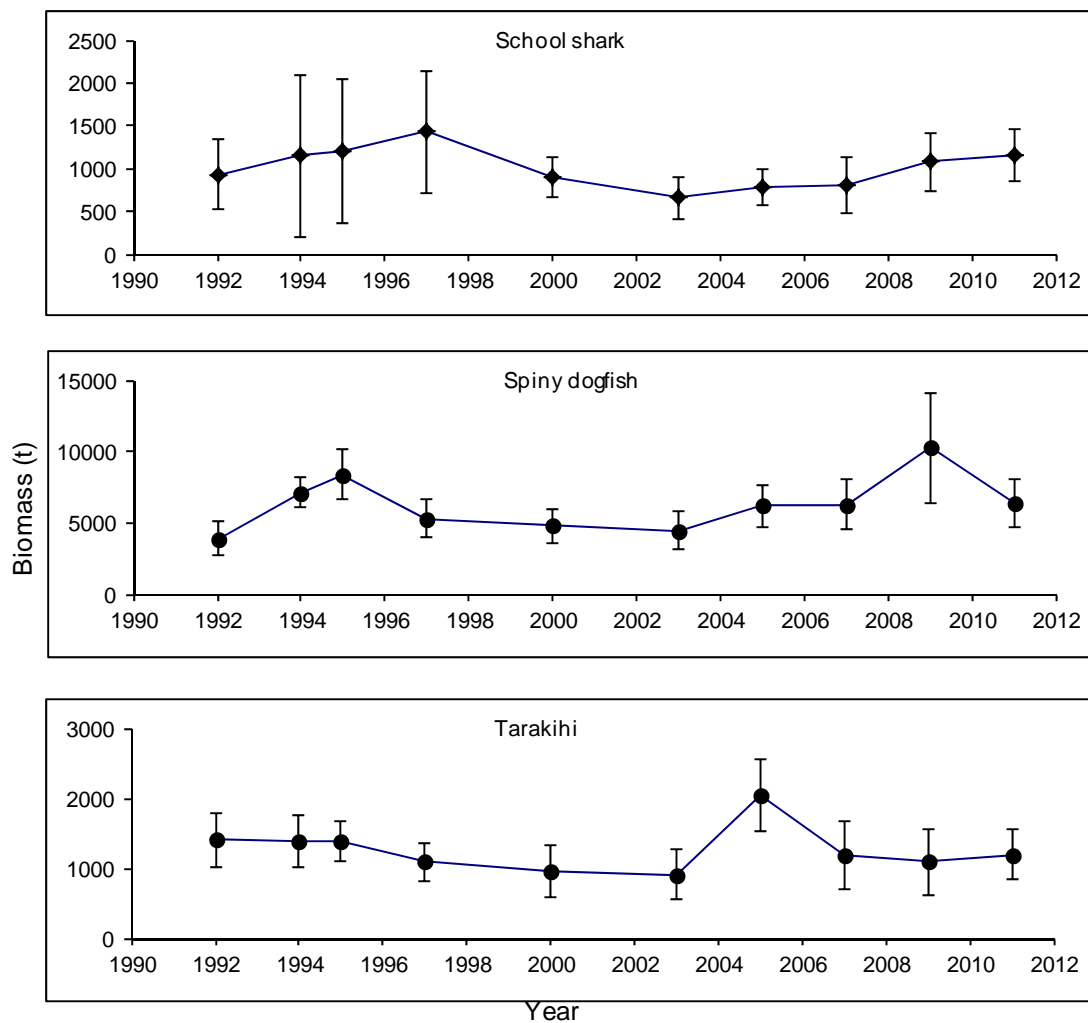


Figure 3—continued

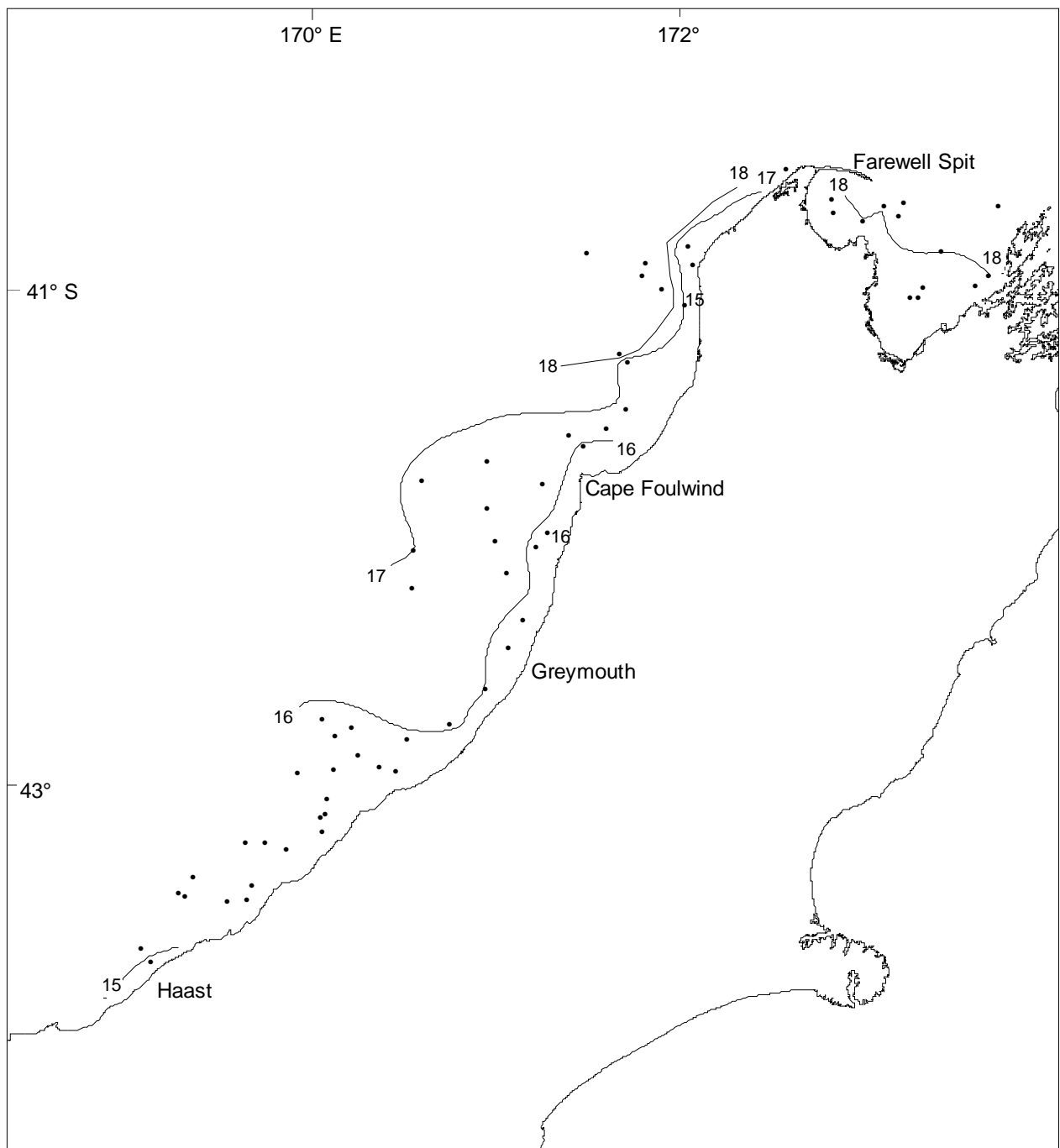


Figure 4: Positions of CTD sea surface temperature recordings and isotherms estimated from the data.

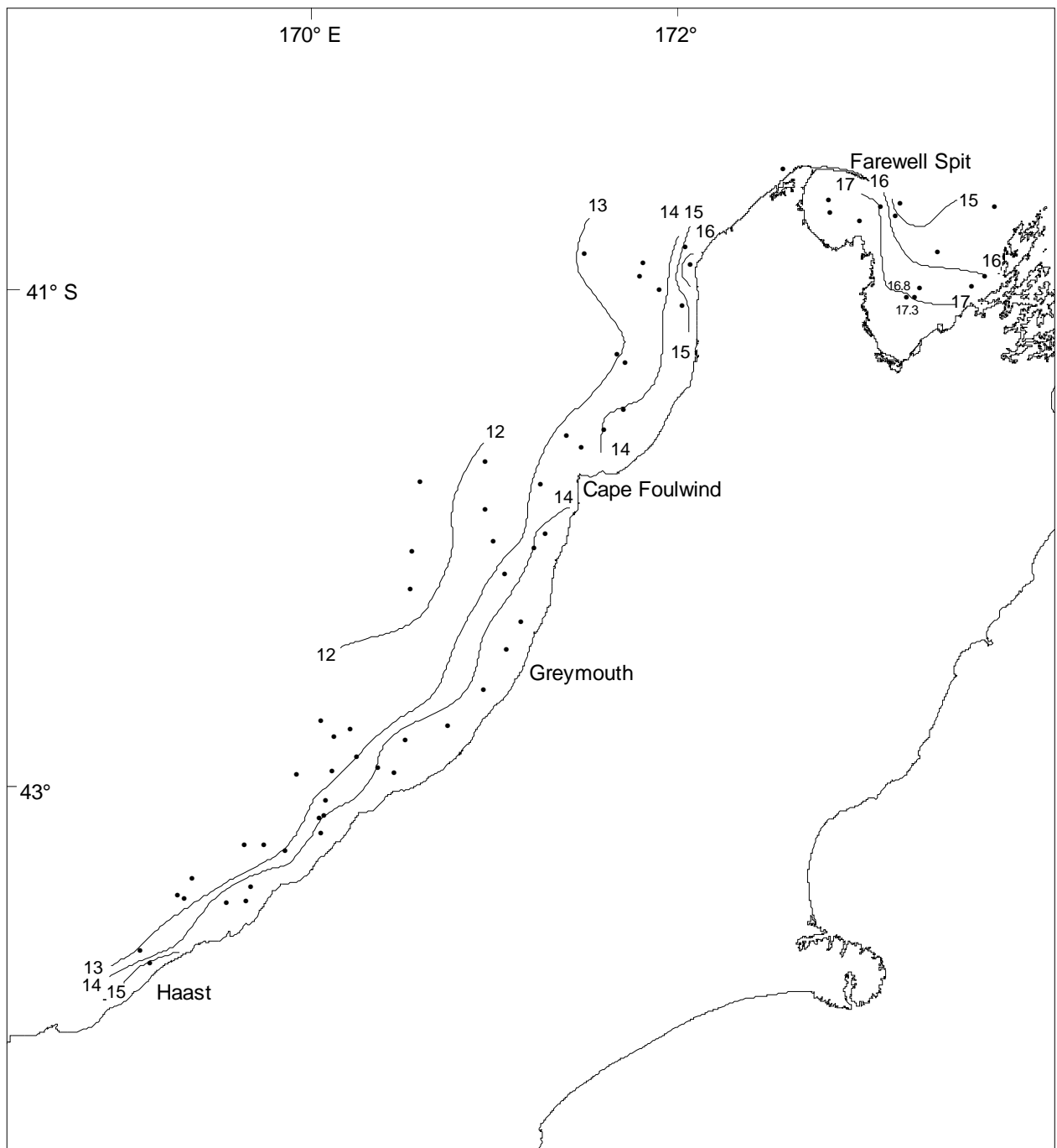


Figure 5: Positions of CTD bottom temperature recordings and isotherms estimated from the data.

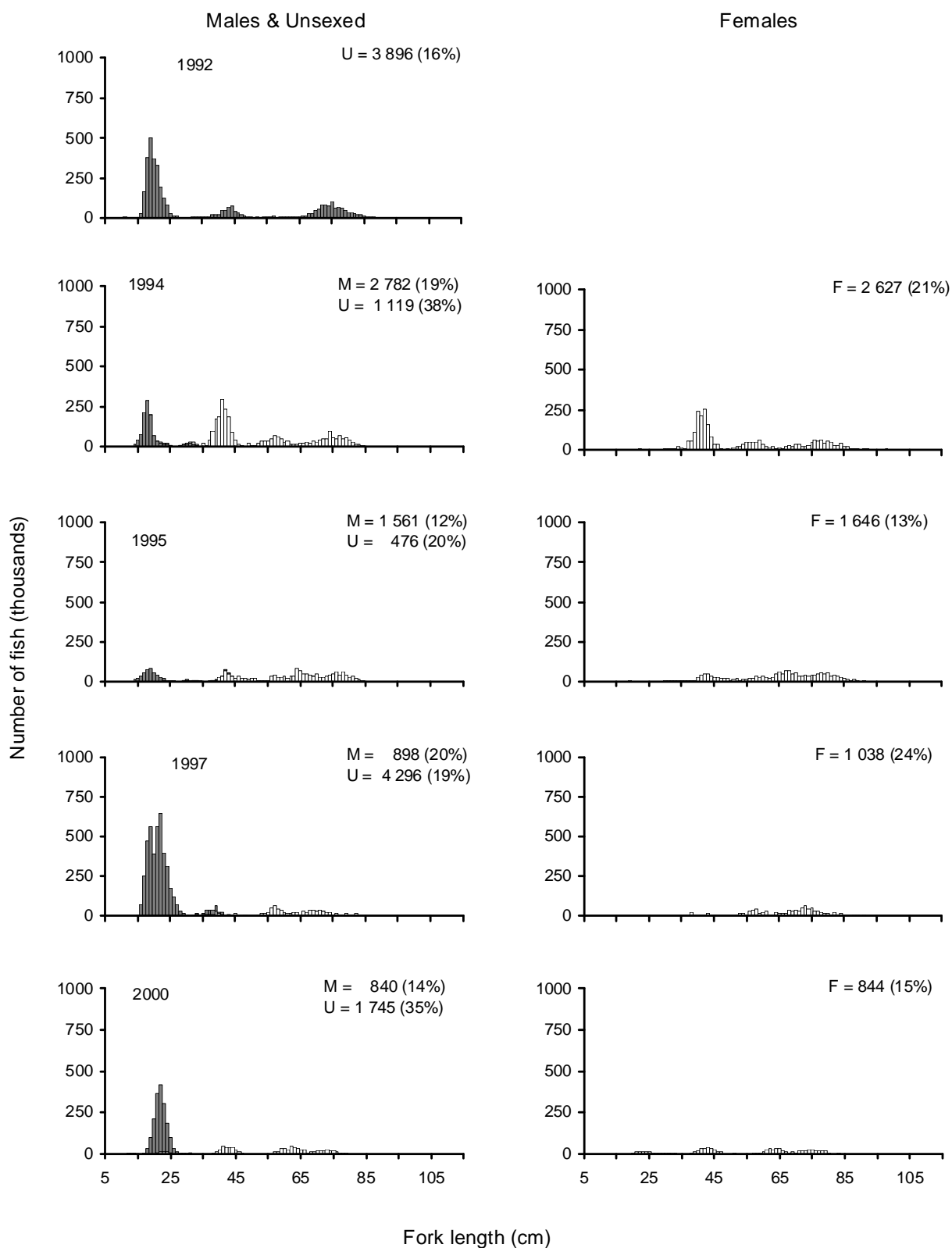


Figure 6: Comparative scaled length frequencies for the target species and those species where the surveys are monitoring adult or pre-recruit abundance. Estimated population in thousands and c.v.%. (M, males; F, females; U, unsexed)
a: Barracouta

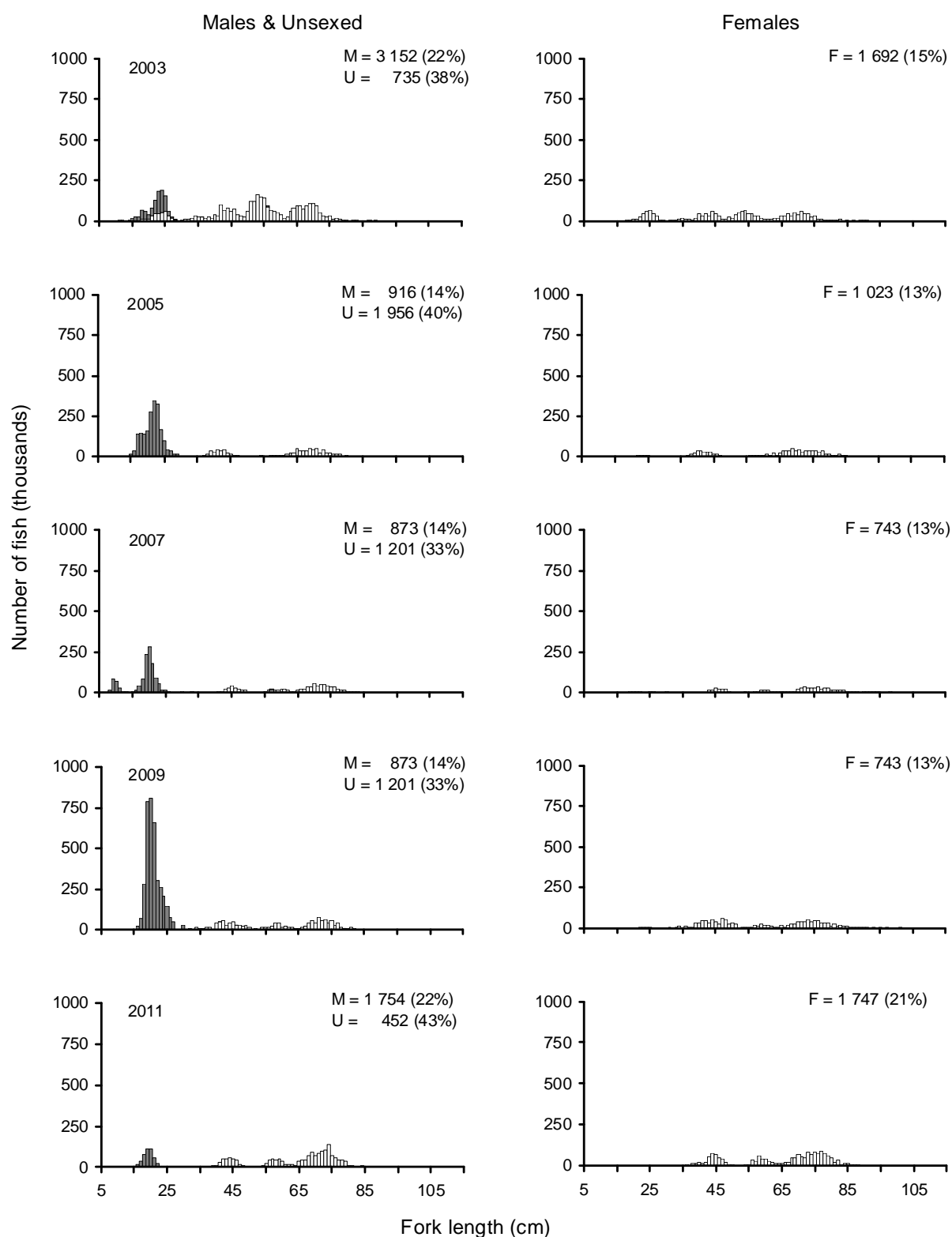


Figure 6a—continued

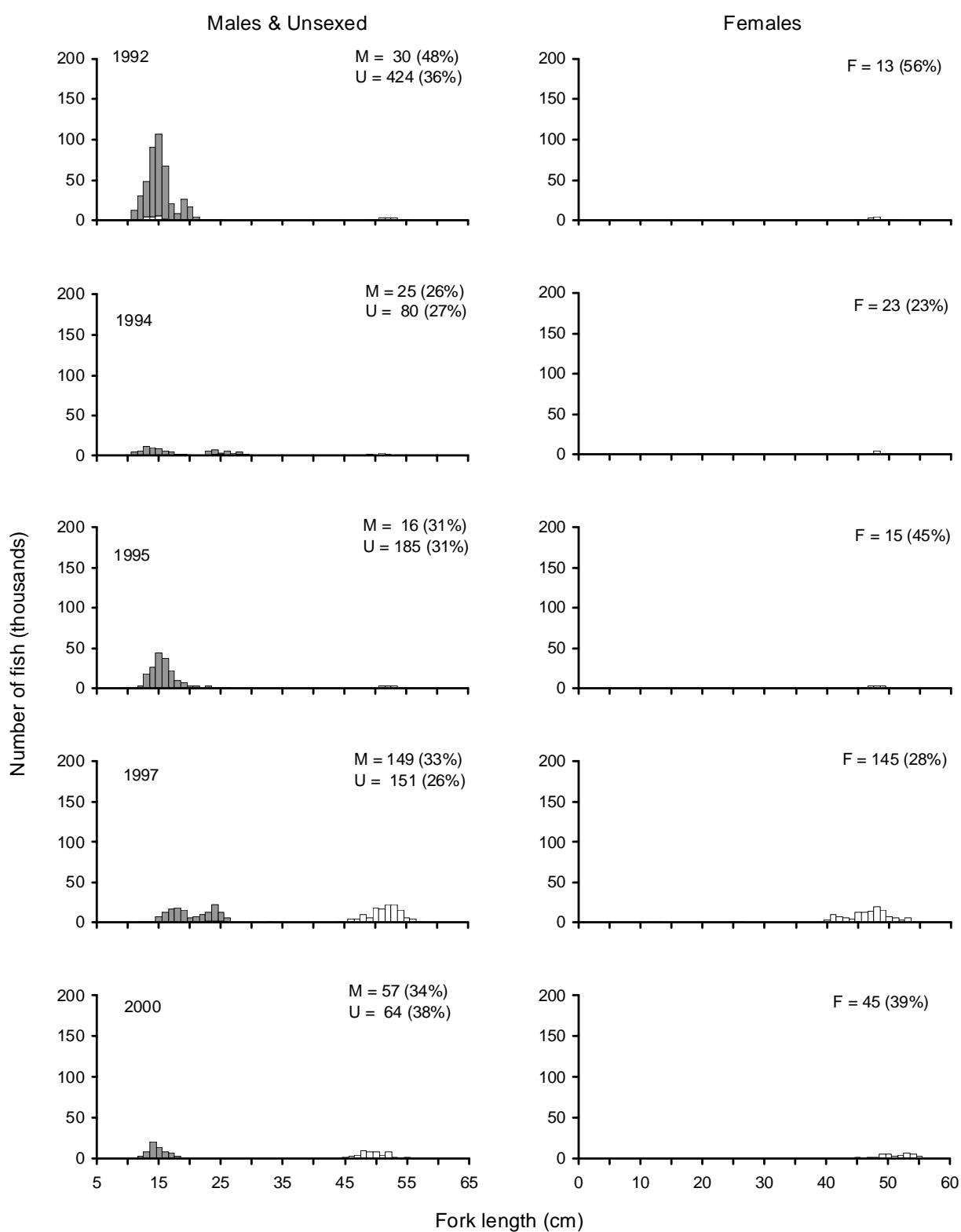


Figure 6b: Blue warehou

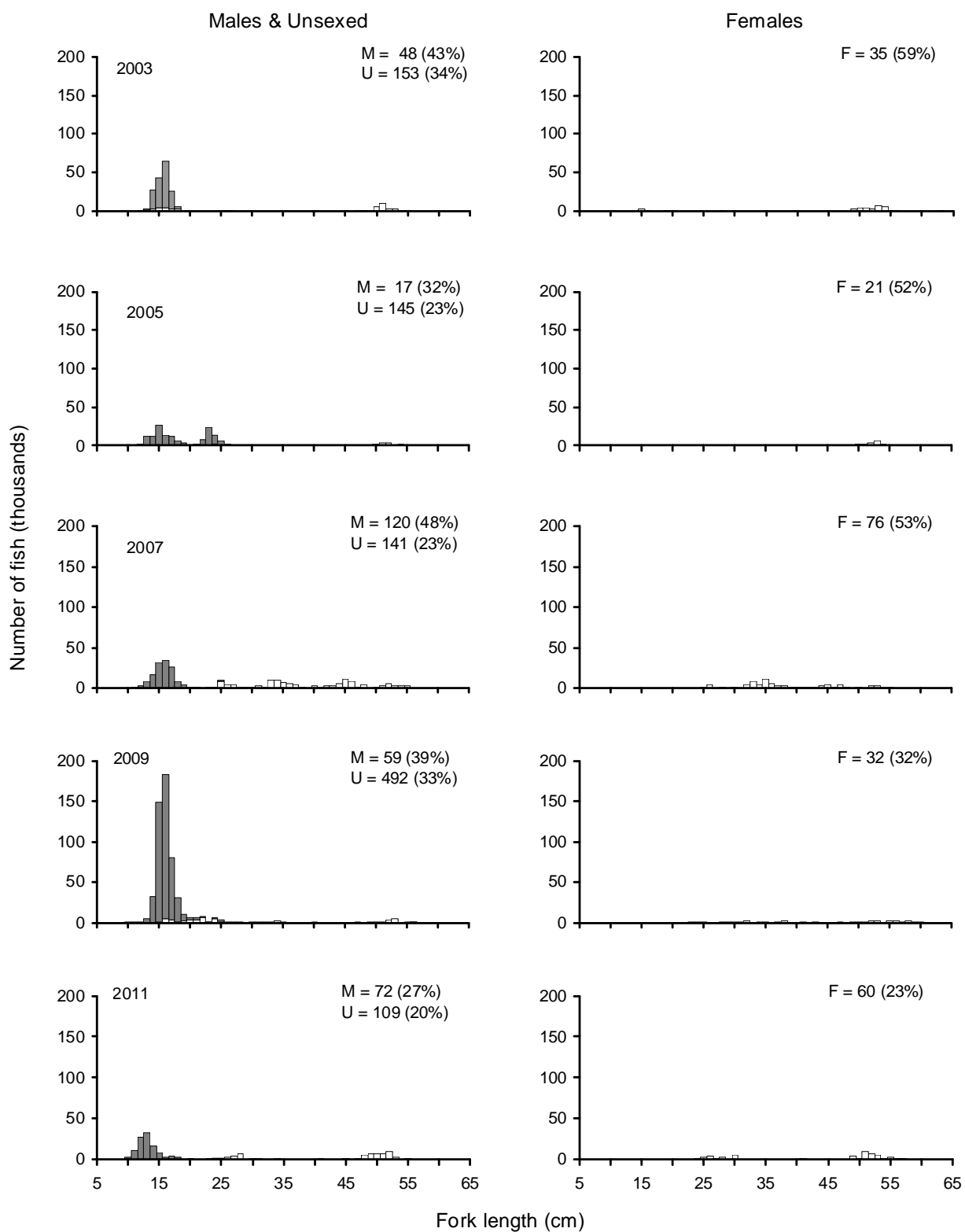


Figure 6b—continued

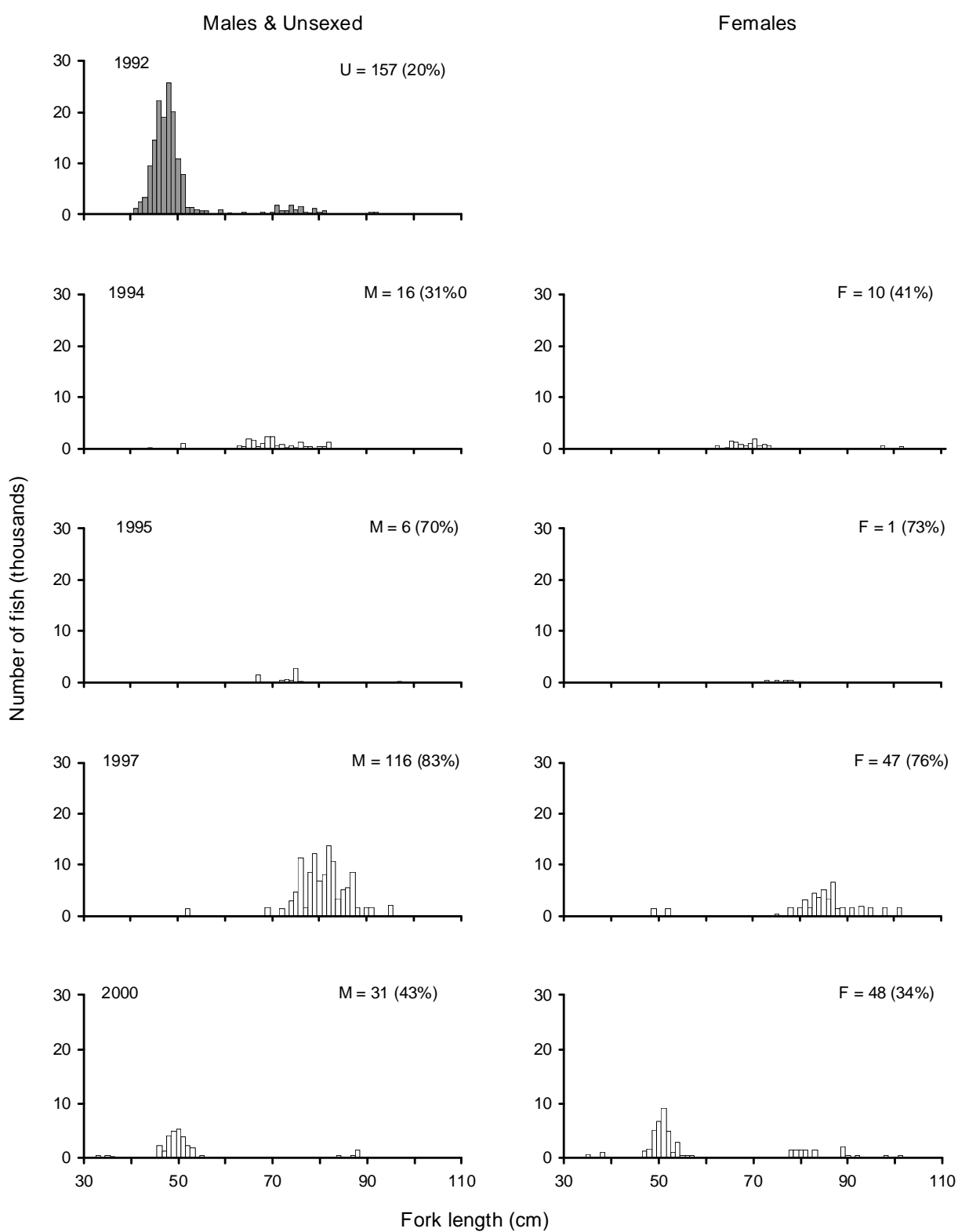


Figure 6c: Gemfish (100% of fish from the west coast).

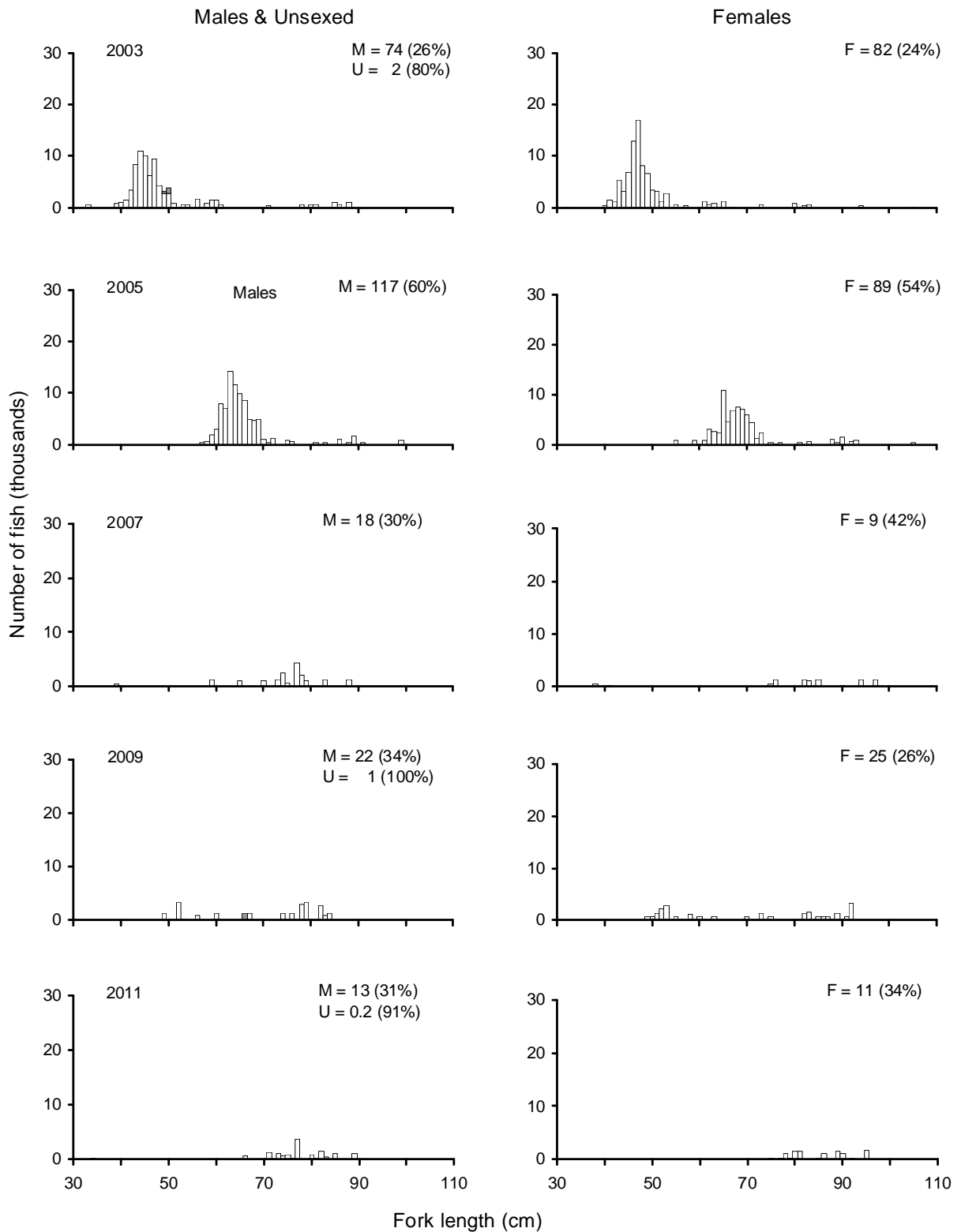


Figure 6c—continued

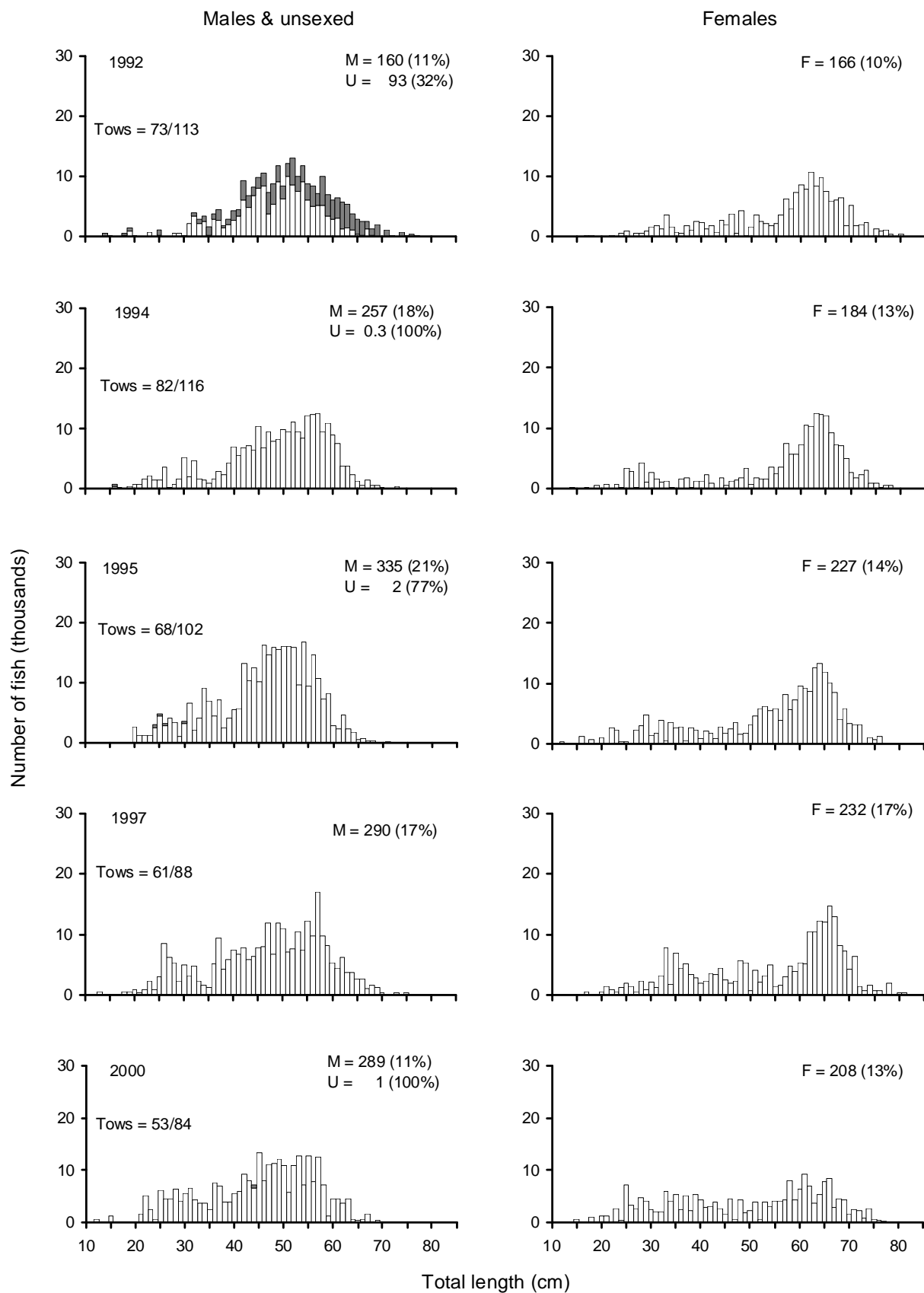


Figure 6d: Giant stargazer.

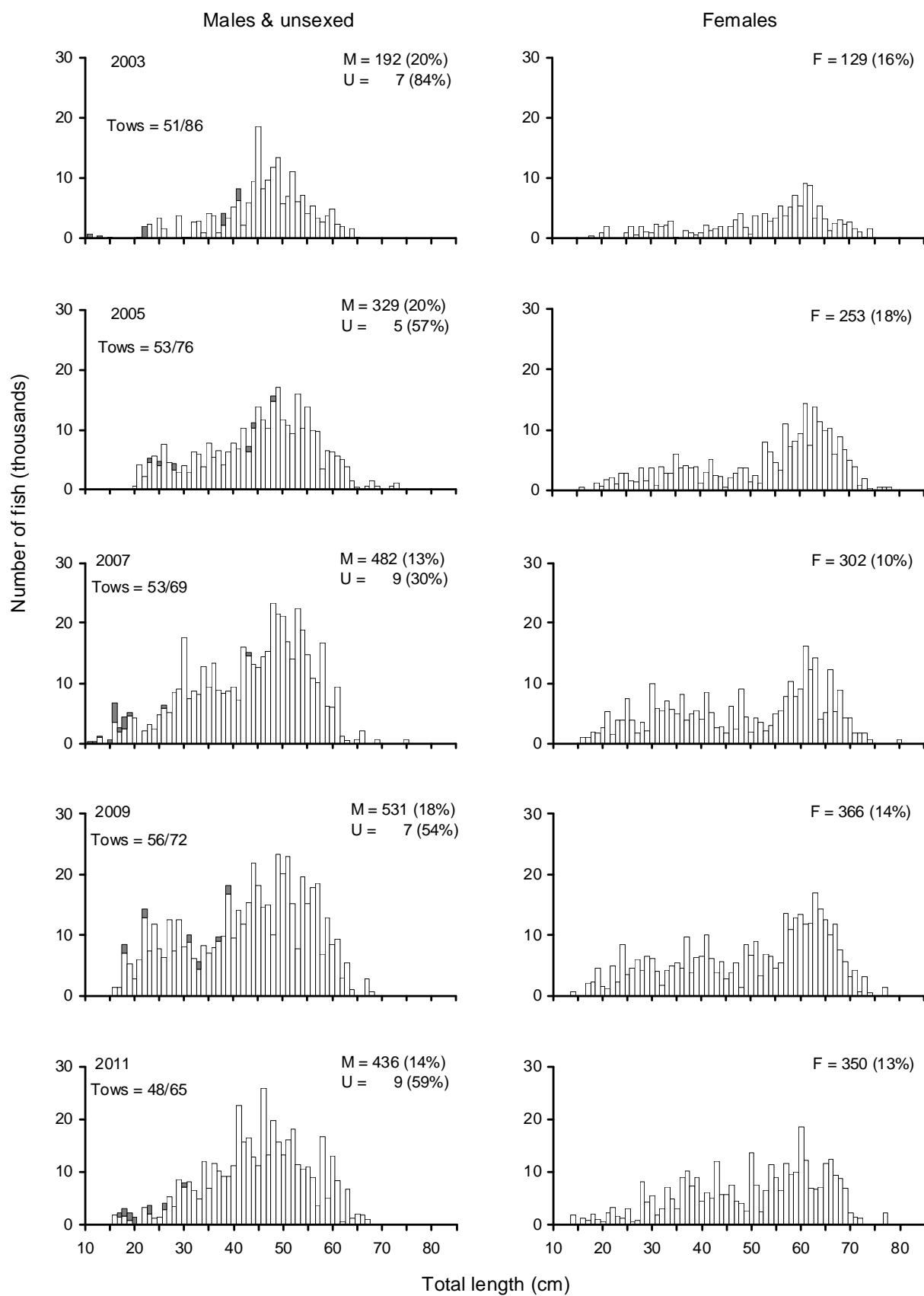


Figure 6d—continued.

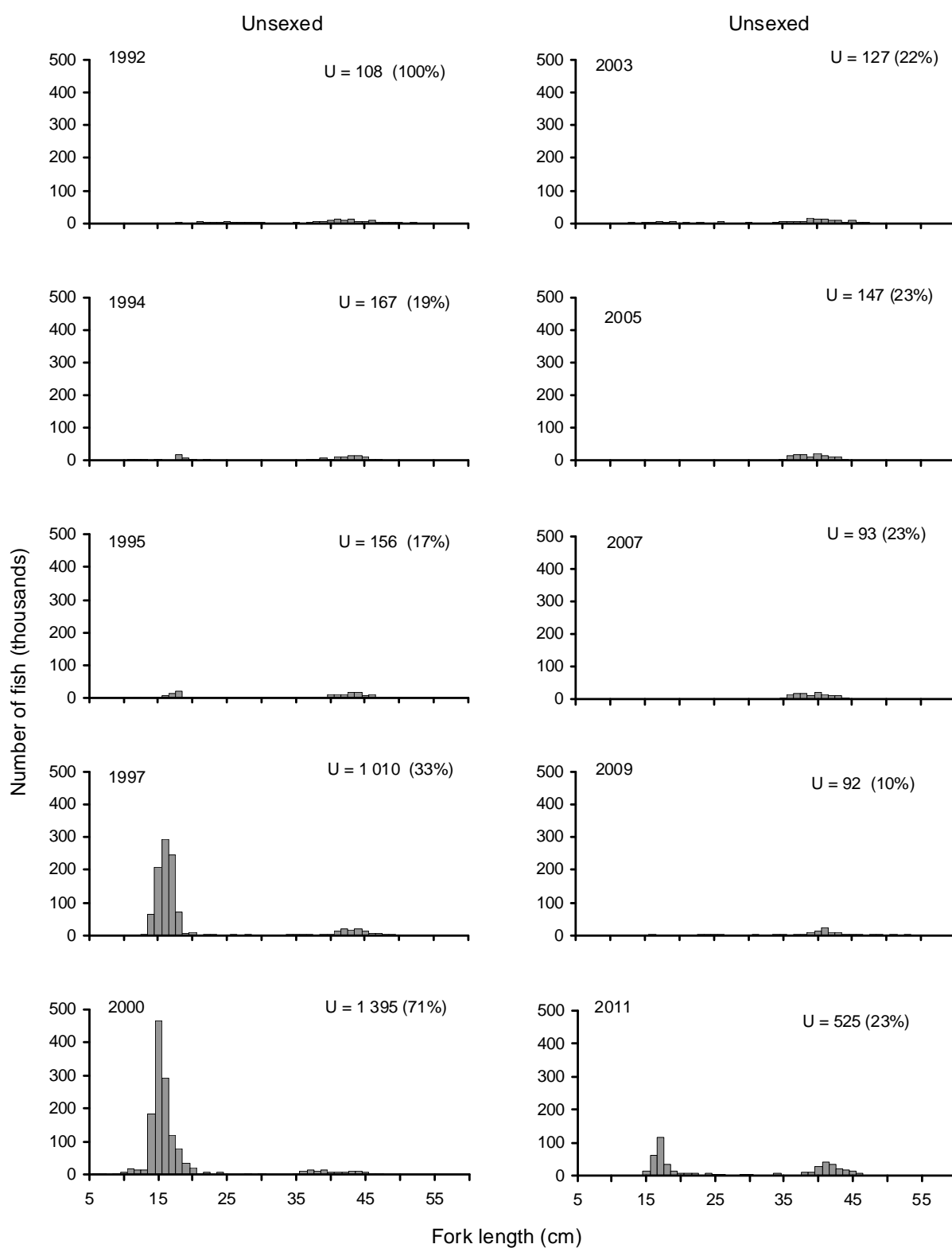


Figure 6e: Jack mackerel (*Trachurus declivis*). Fish were not sexed for some years so all years are plotted as unsexed for better comparison.

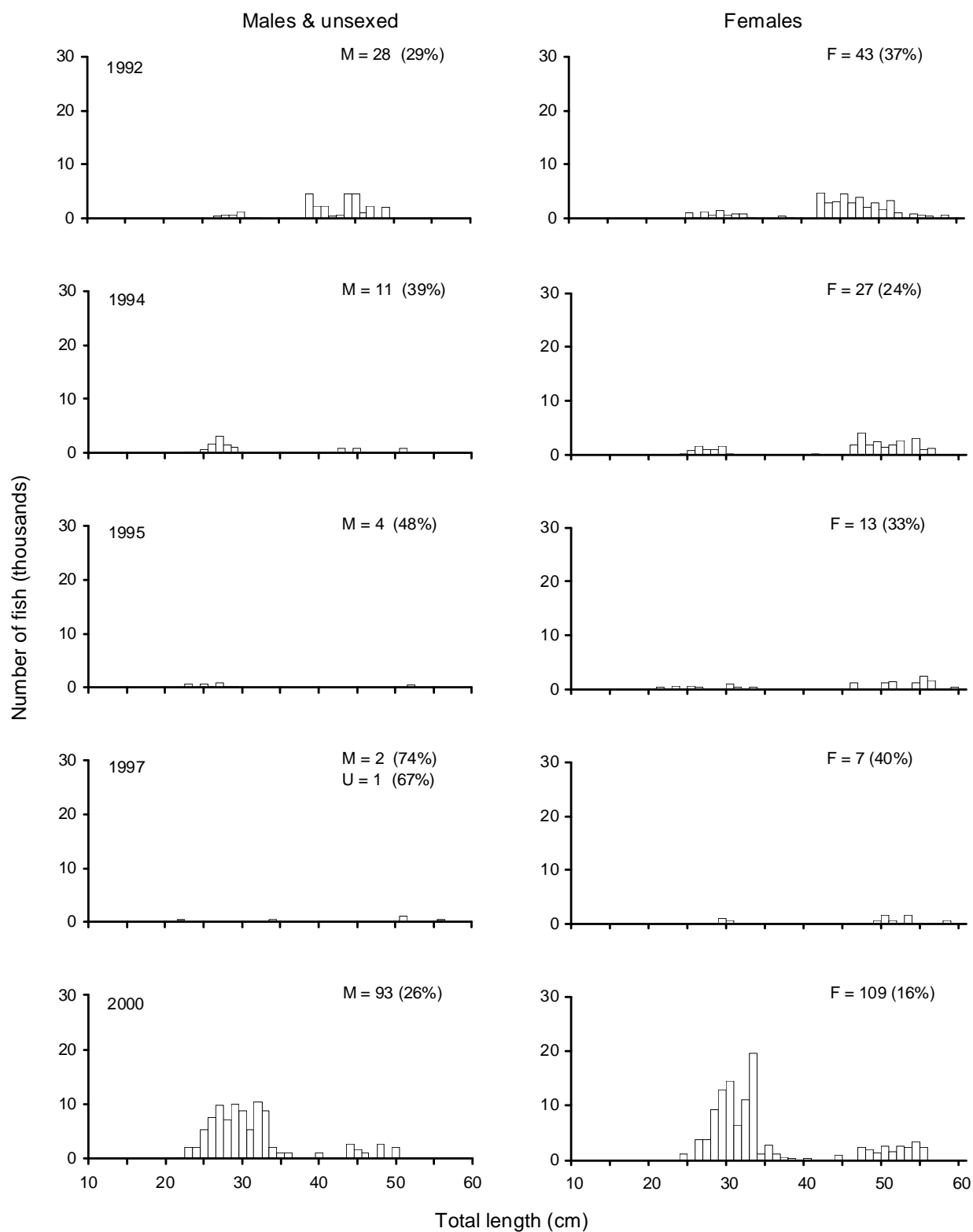


Figure 6f: John dory.

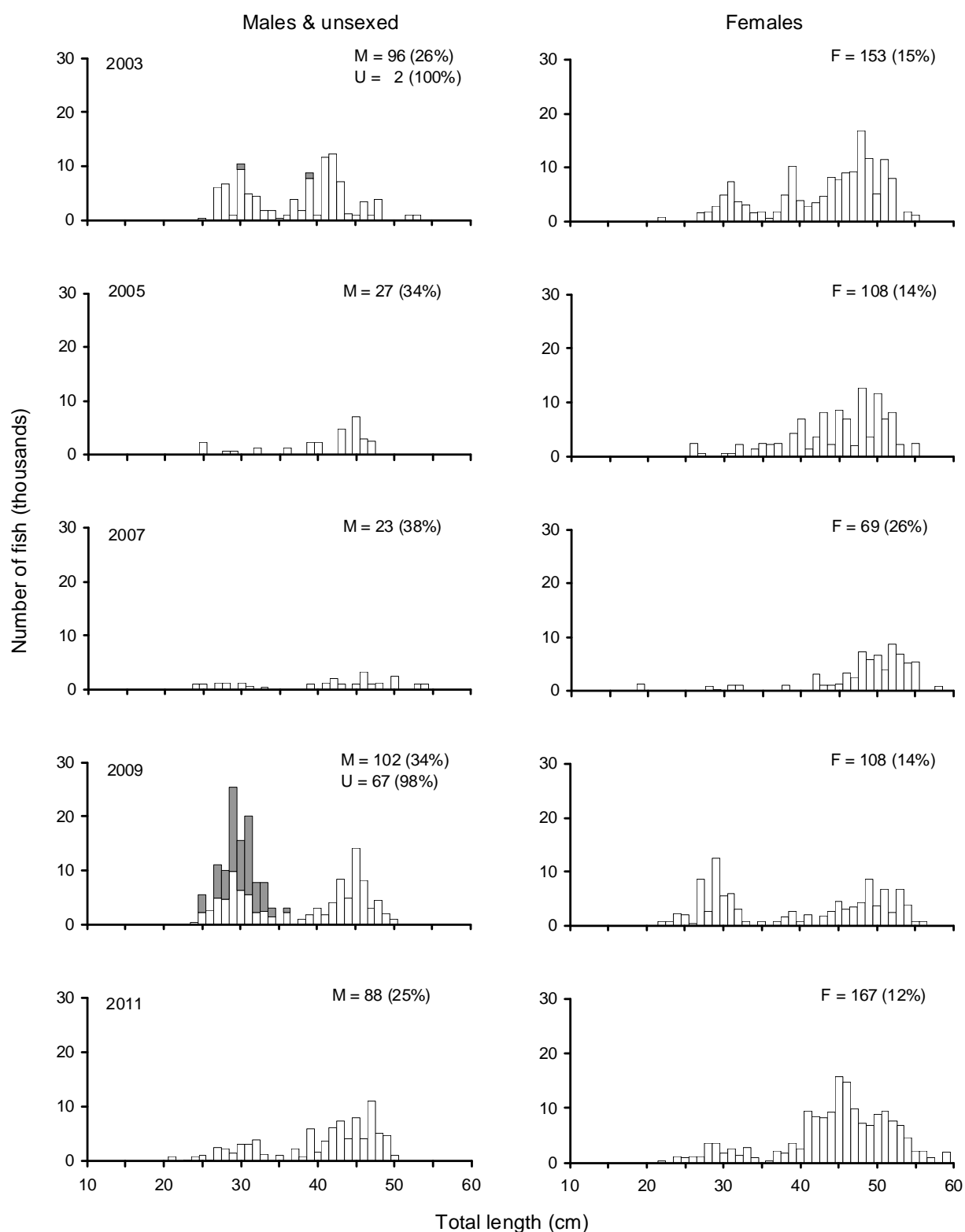


Figure 6f—continued.

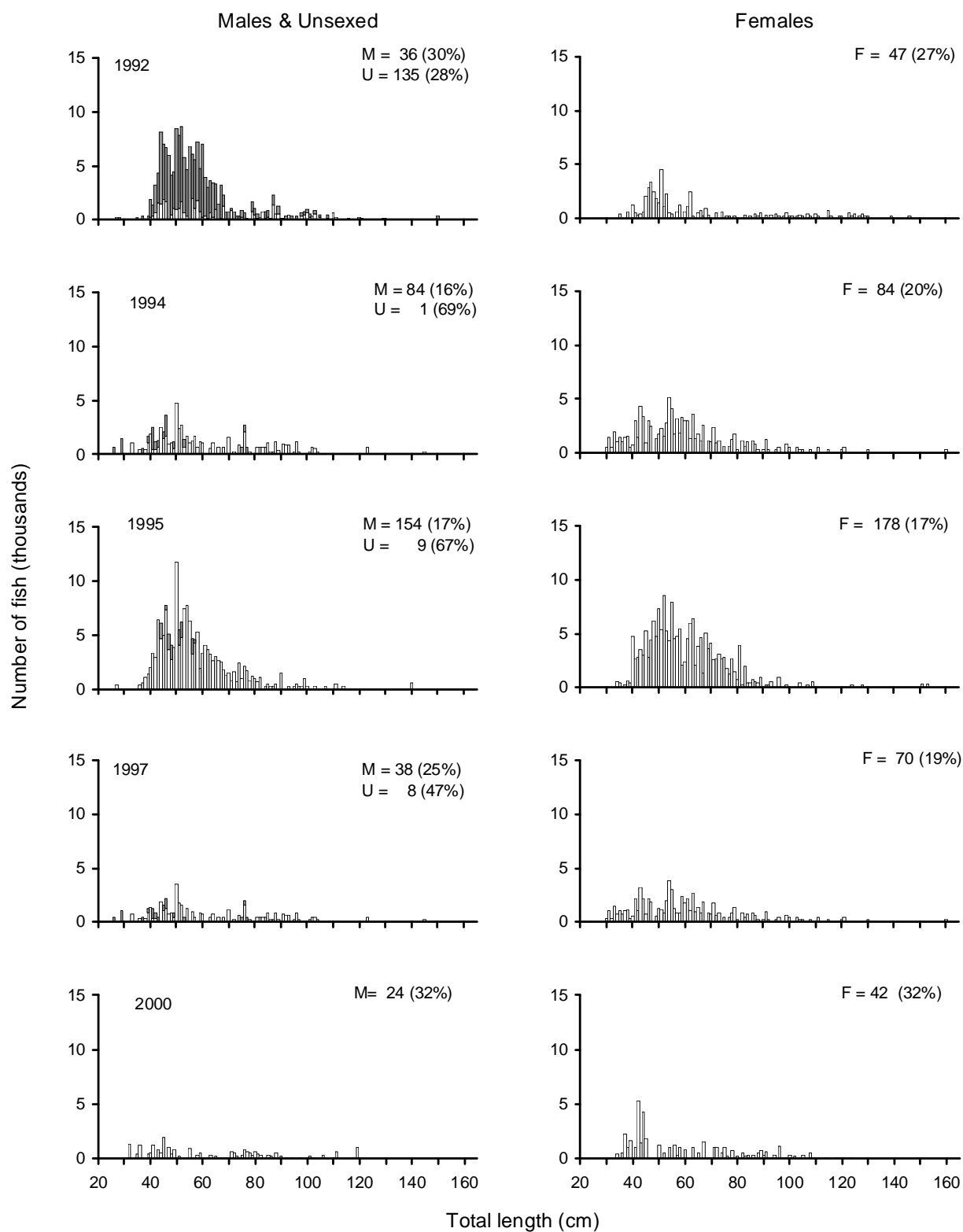


Figure 6g: Ling.

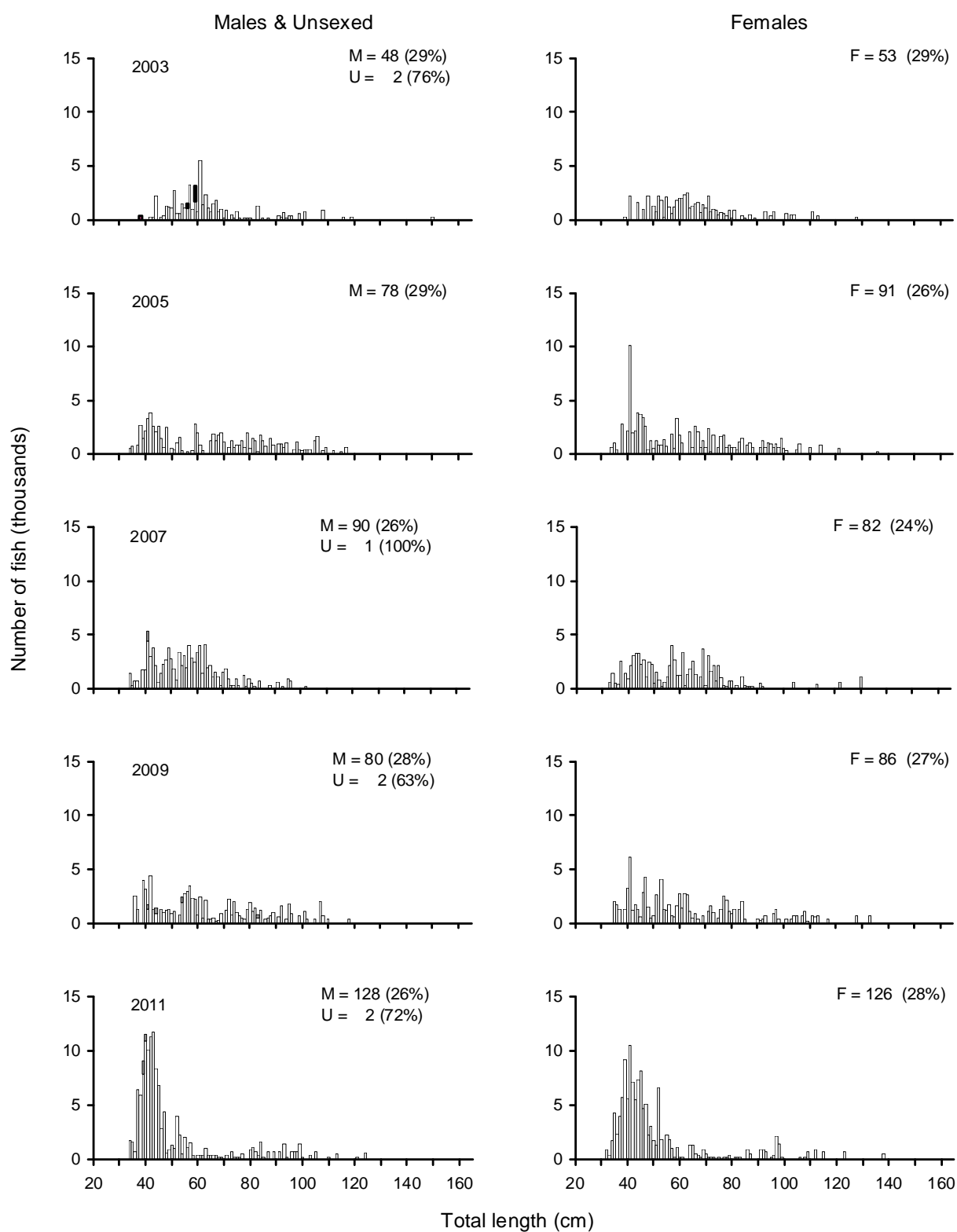


Figure 6g—continued.

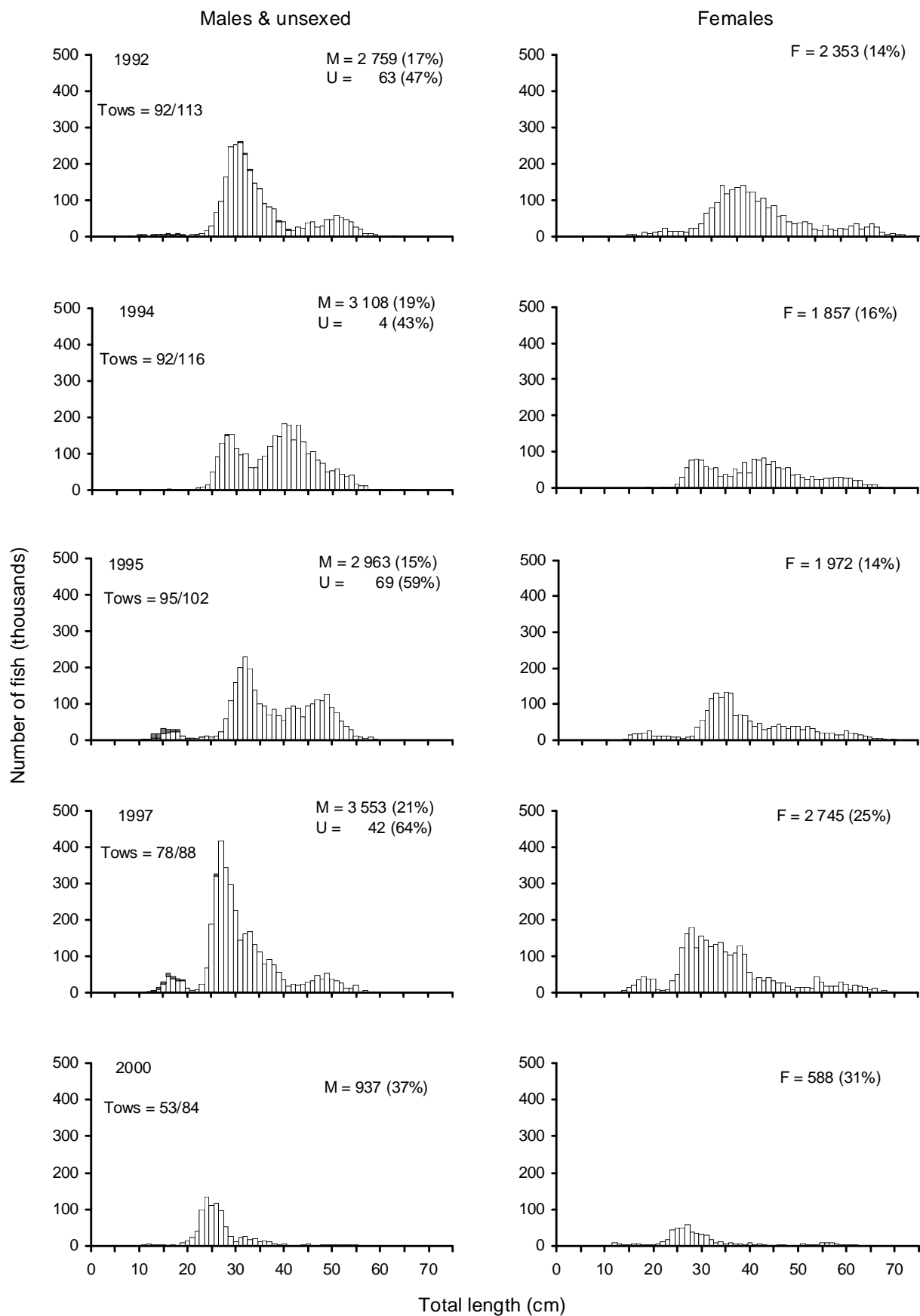


Figure 6h: Red cod.

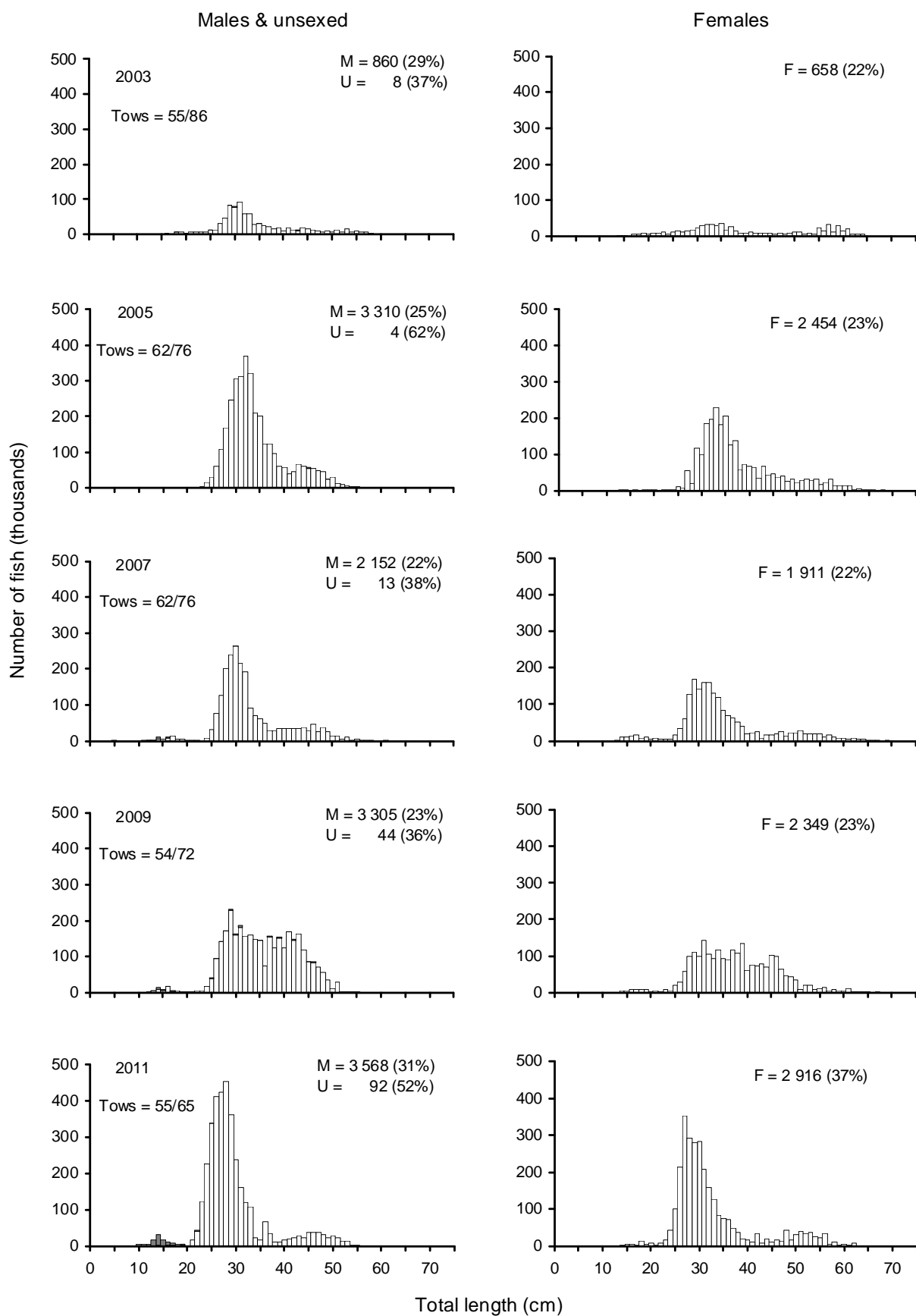


Figure 6h—continued.

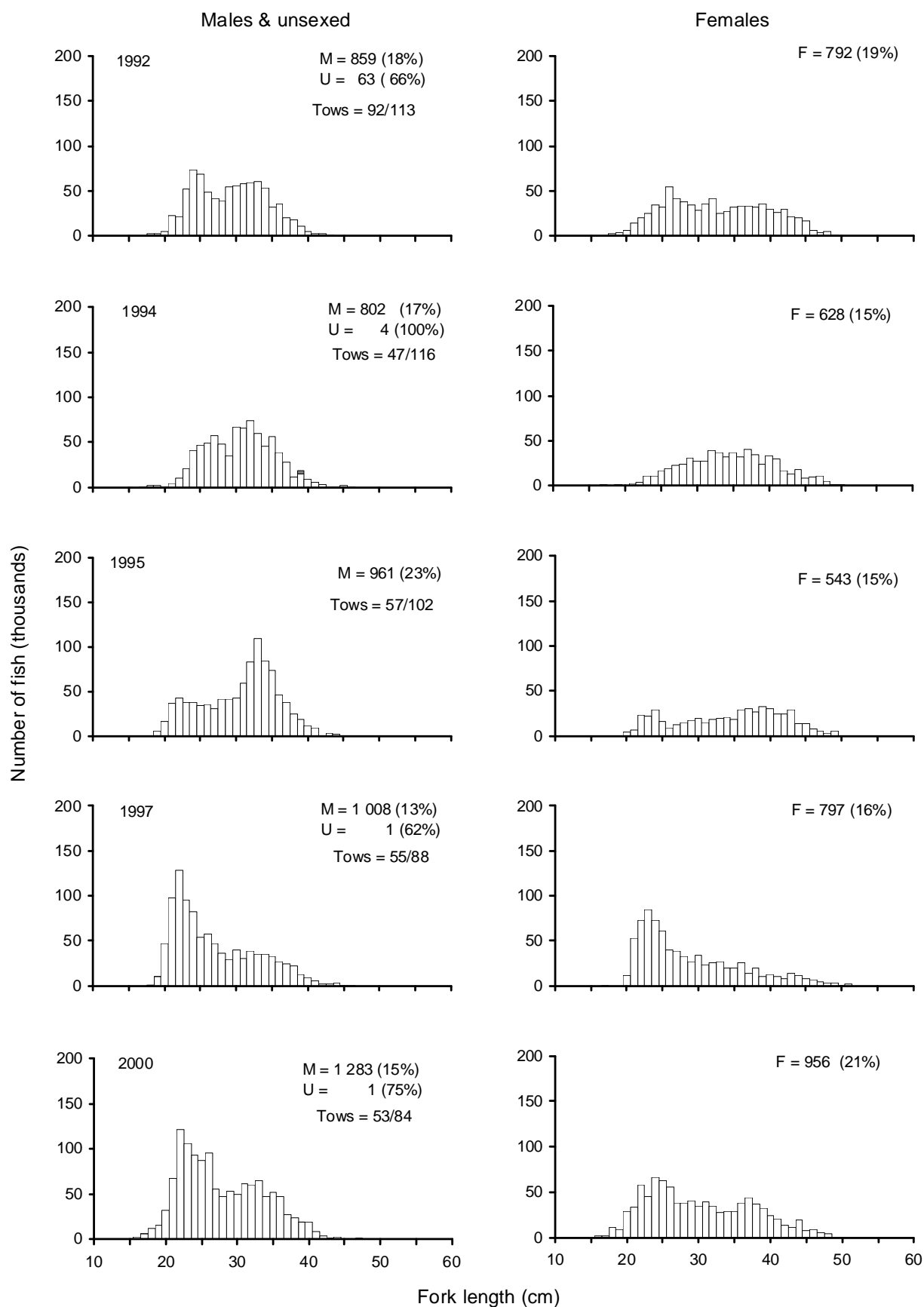


Figure 6i: Red gurnard.

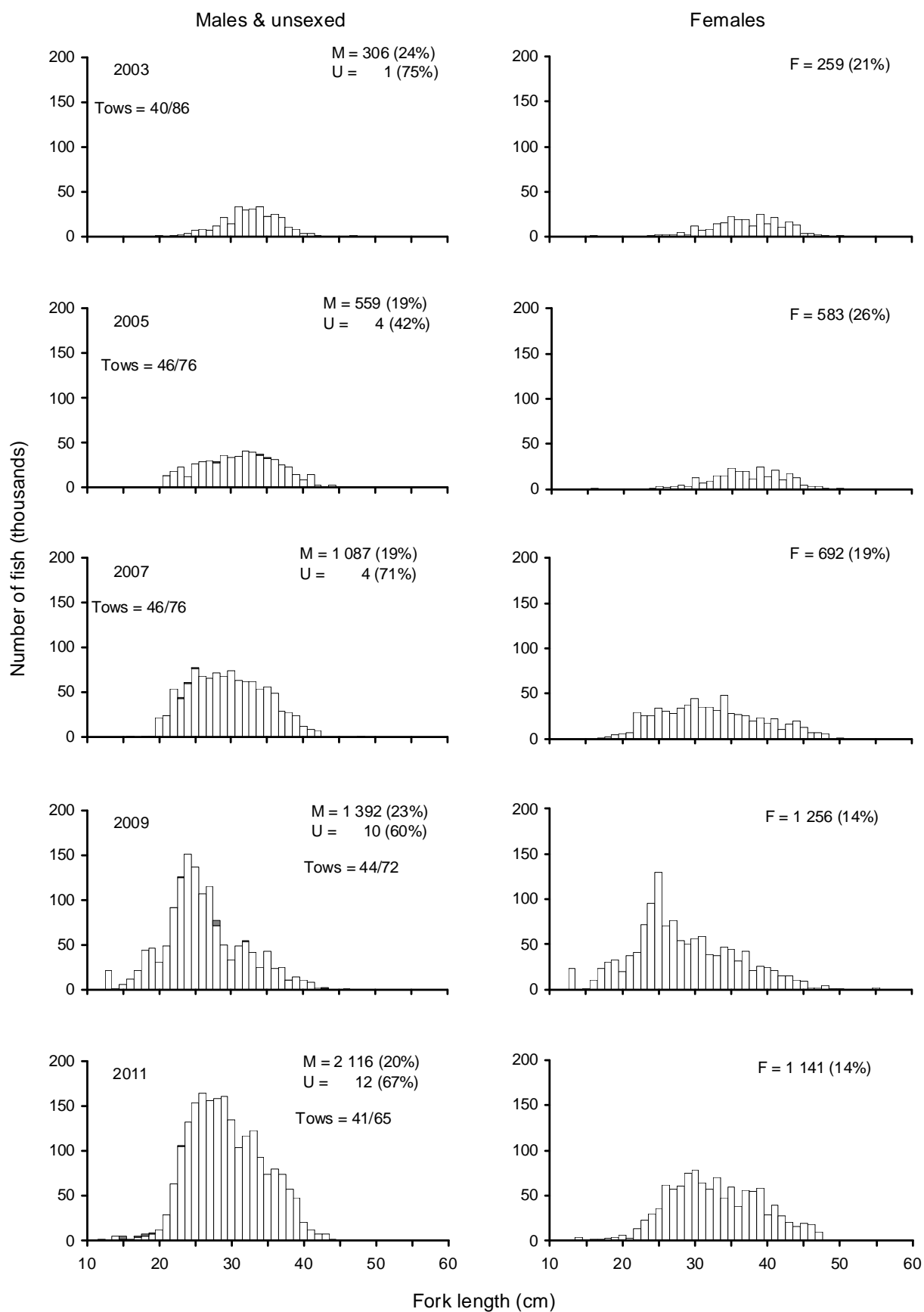


Figure 6i—continued.

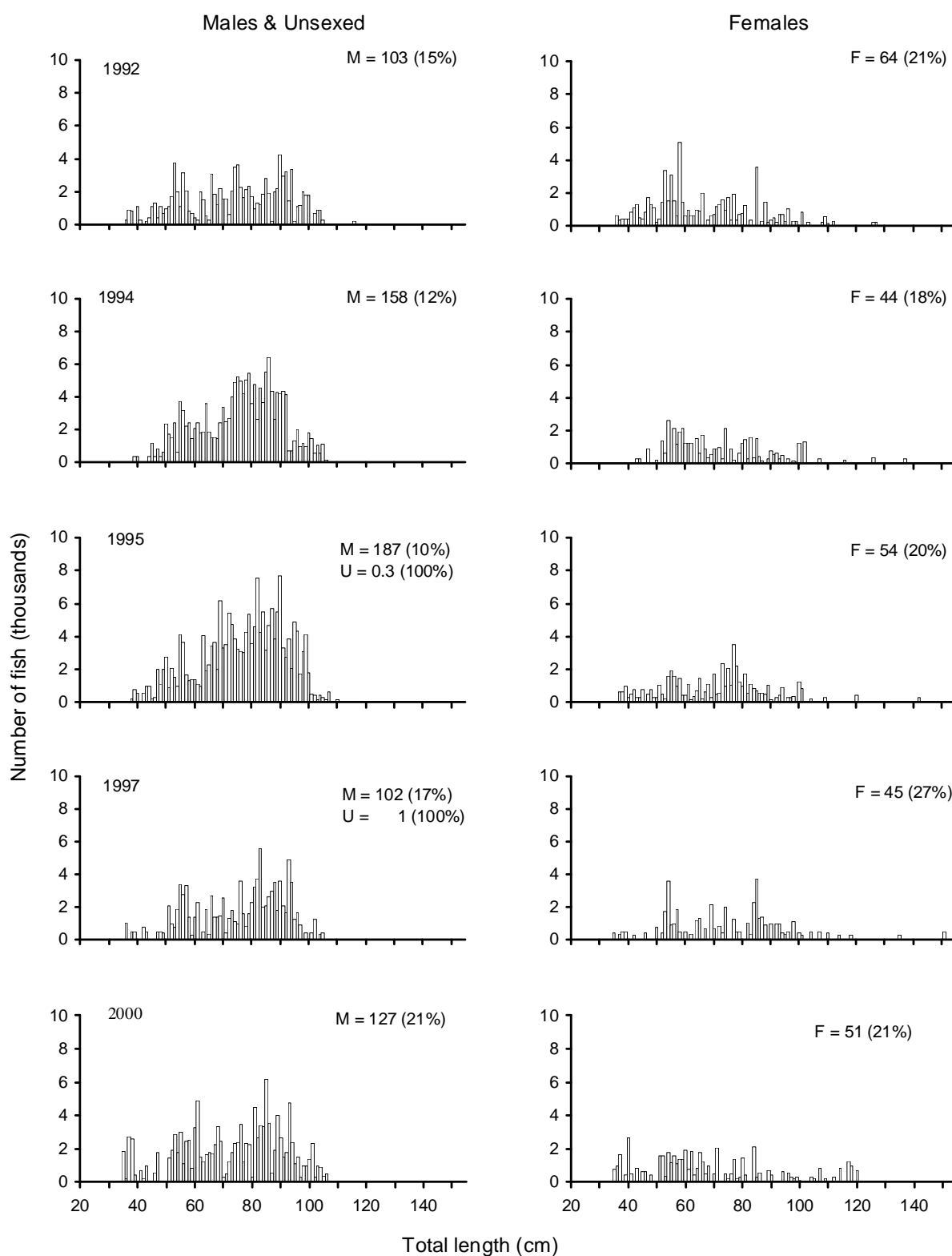


Figure 6j: Rig.

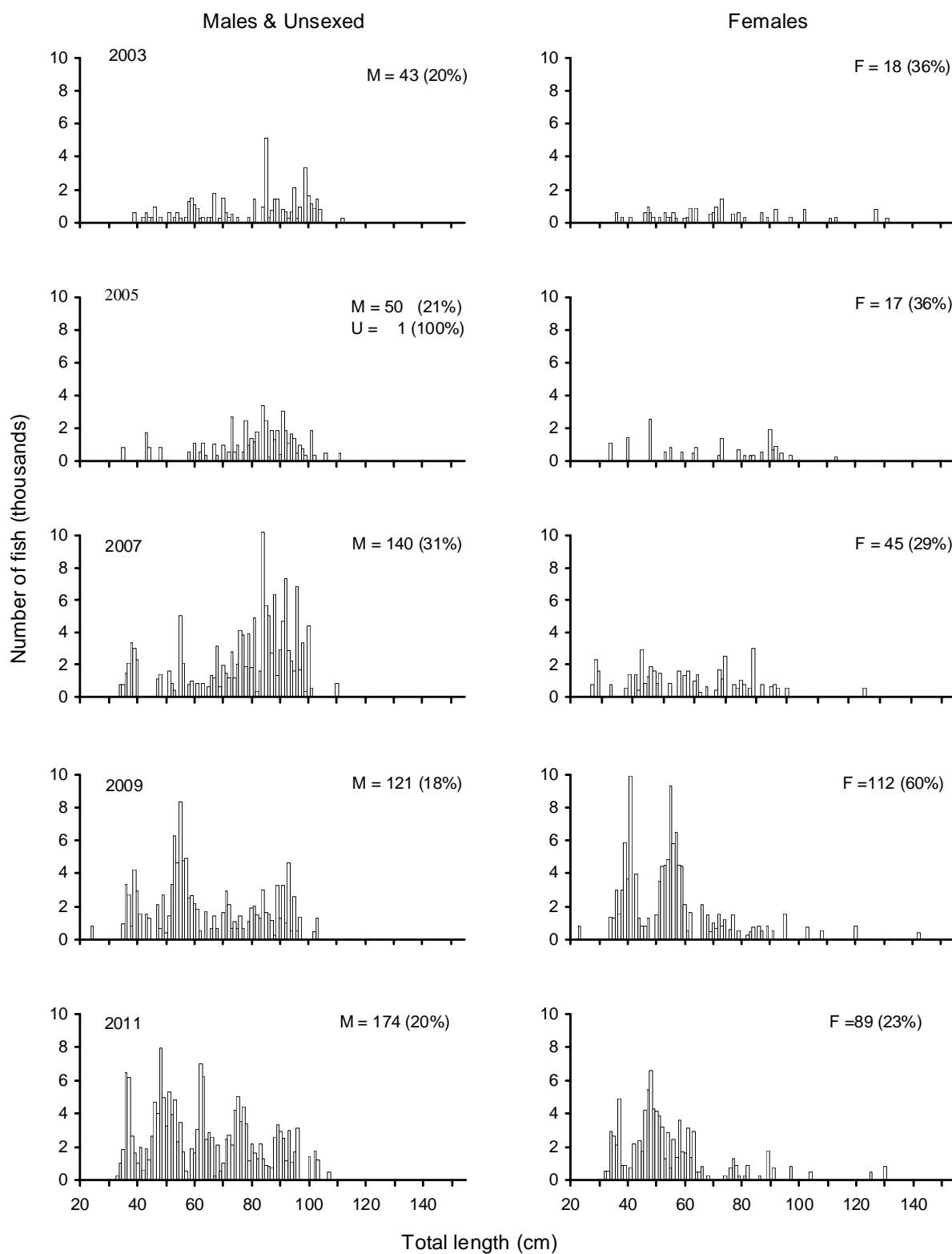


Figure 6j—continued.

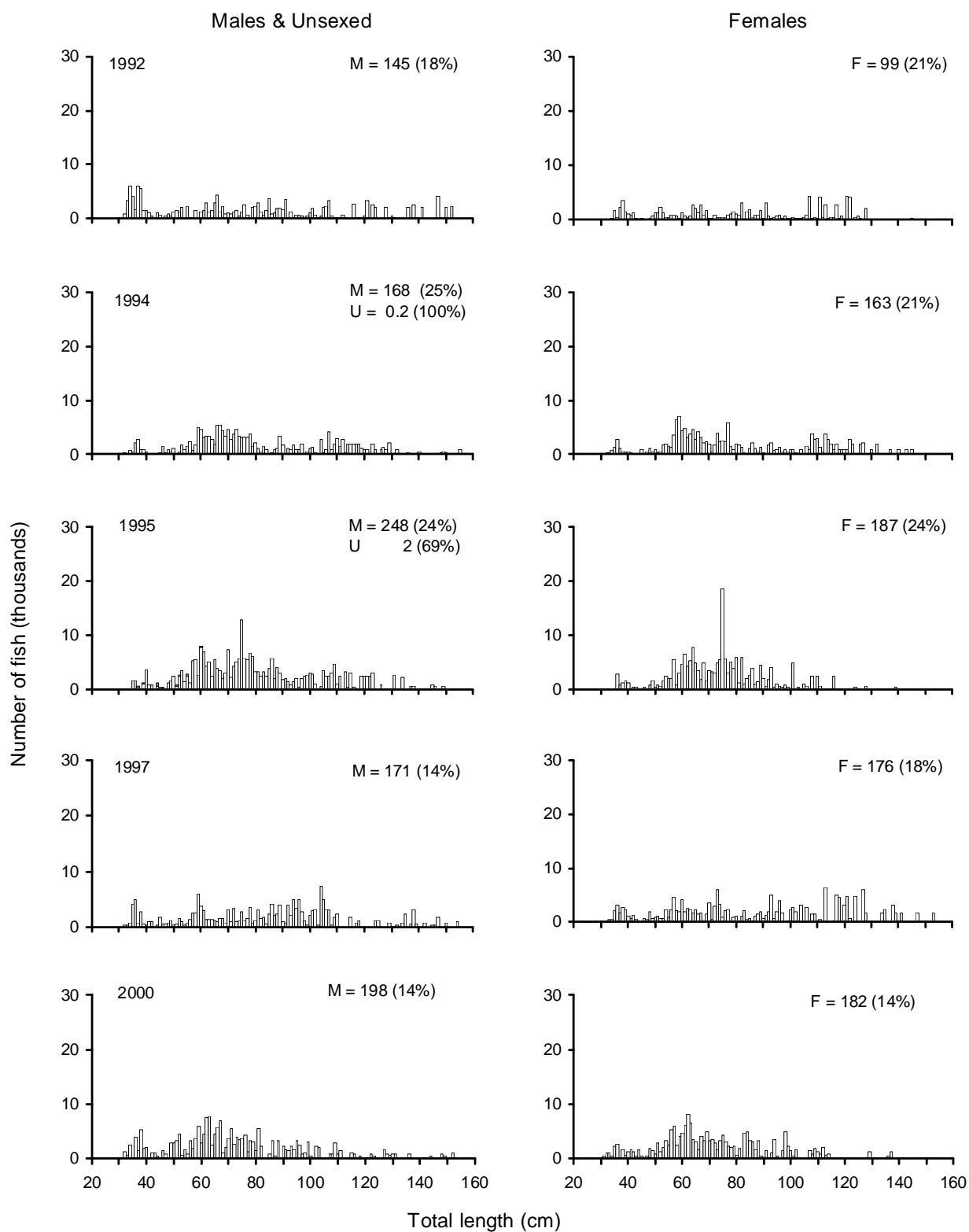


Figure 6k: School shark.

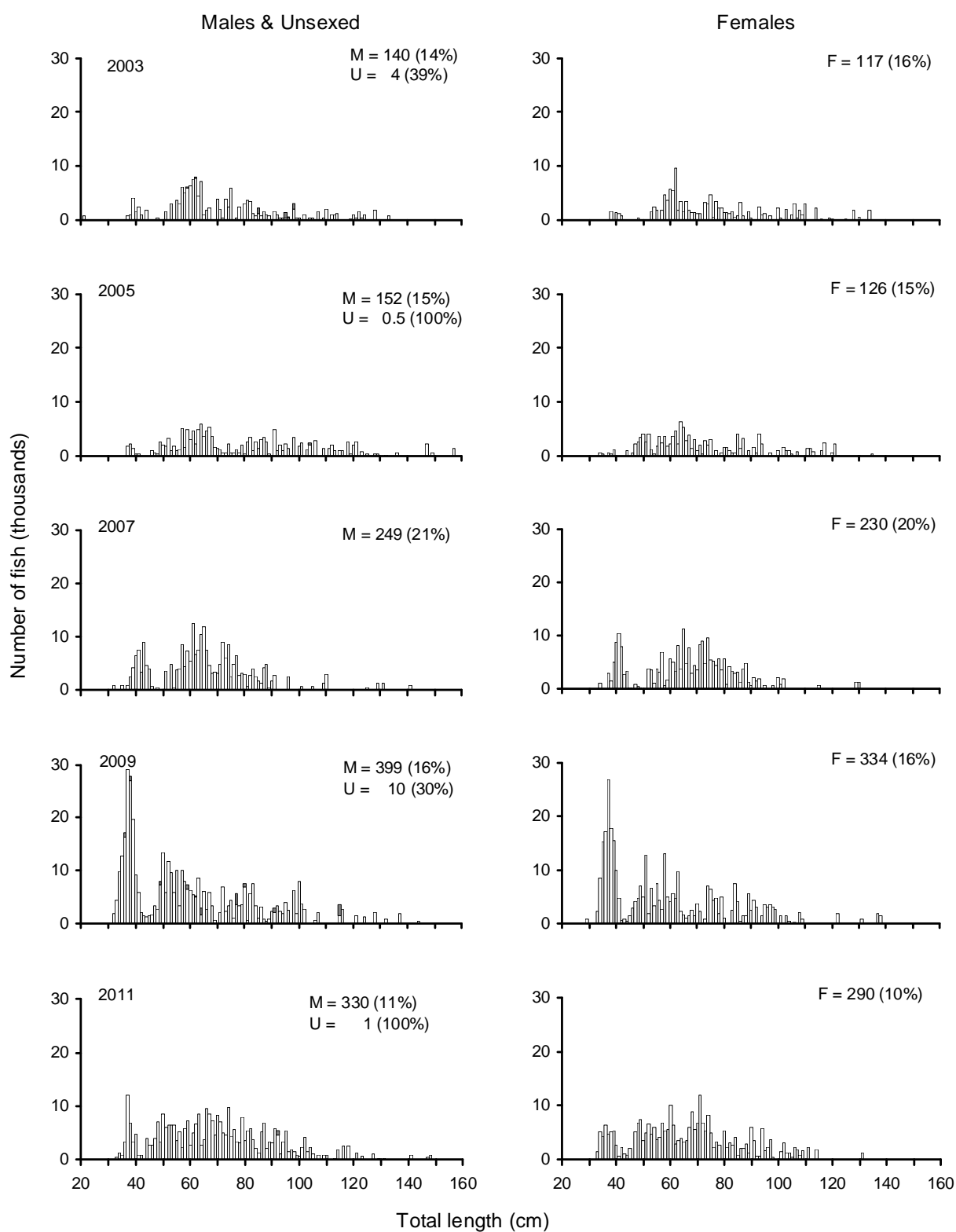


Figure 6k—continued.

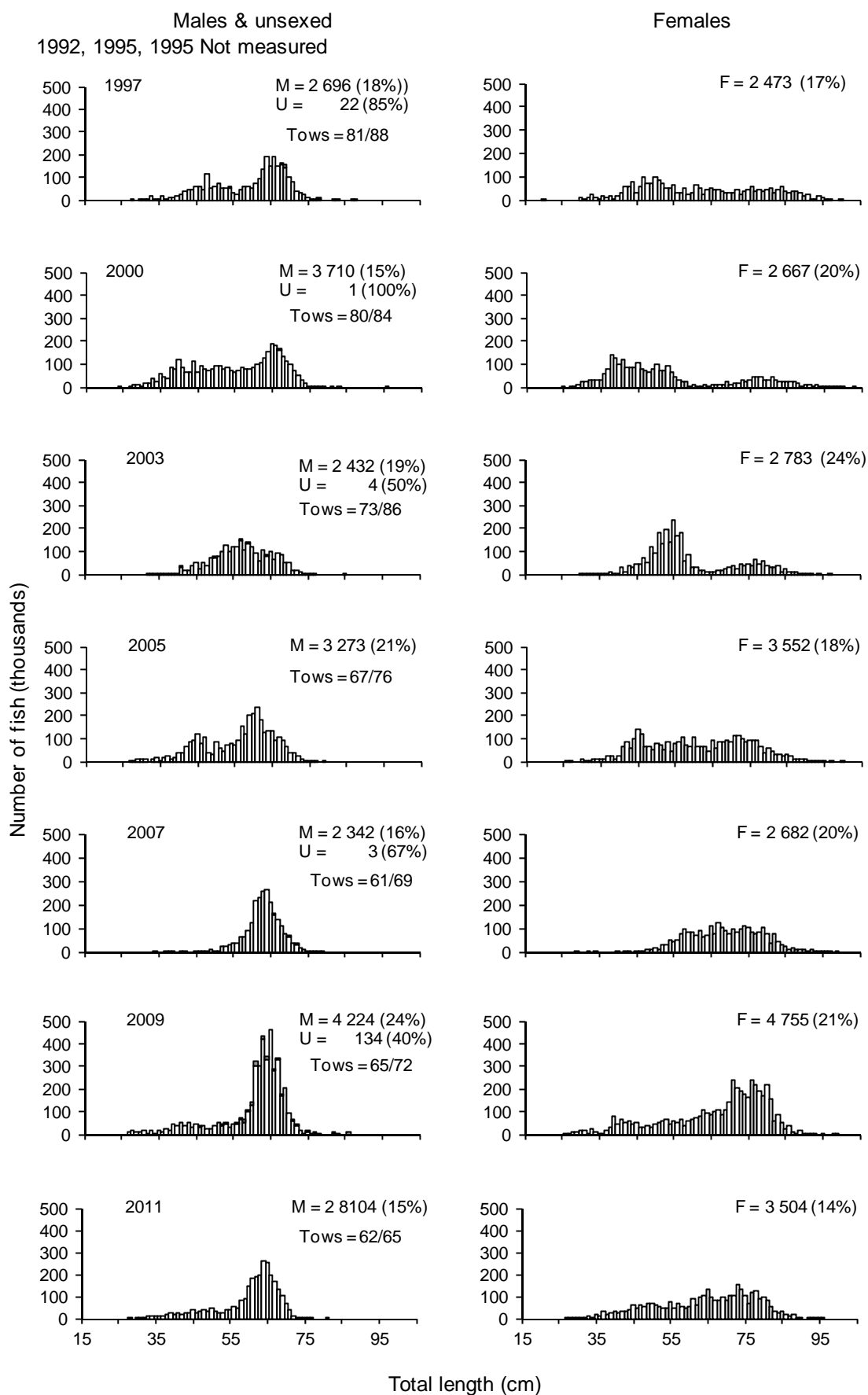


Figure 6I: Spiny dogfish.

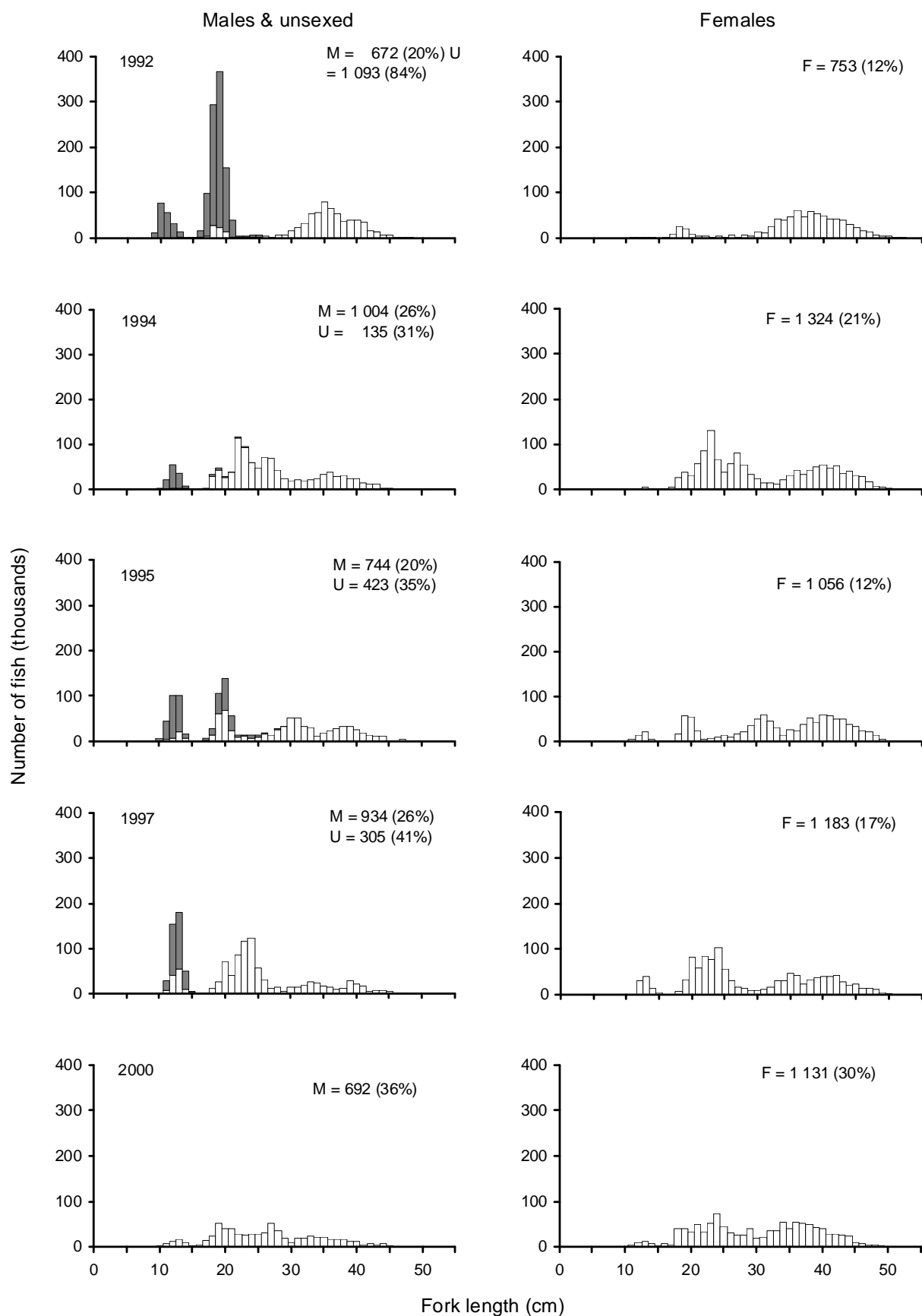


Figure 6m: Tarakihi.

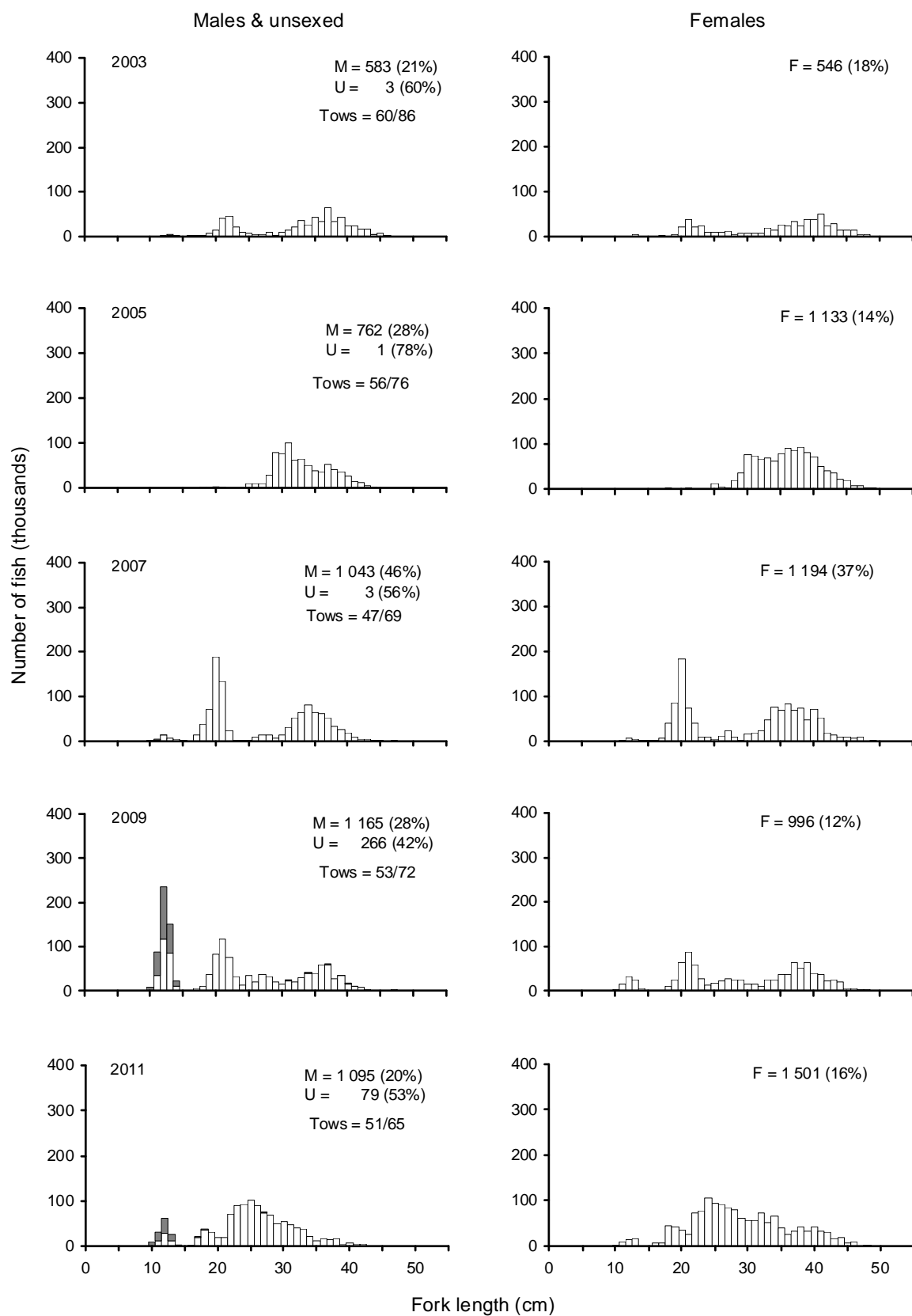


Figure 6m—continued.

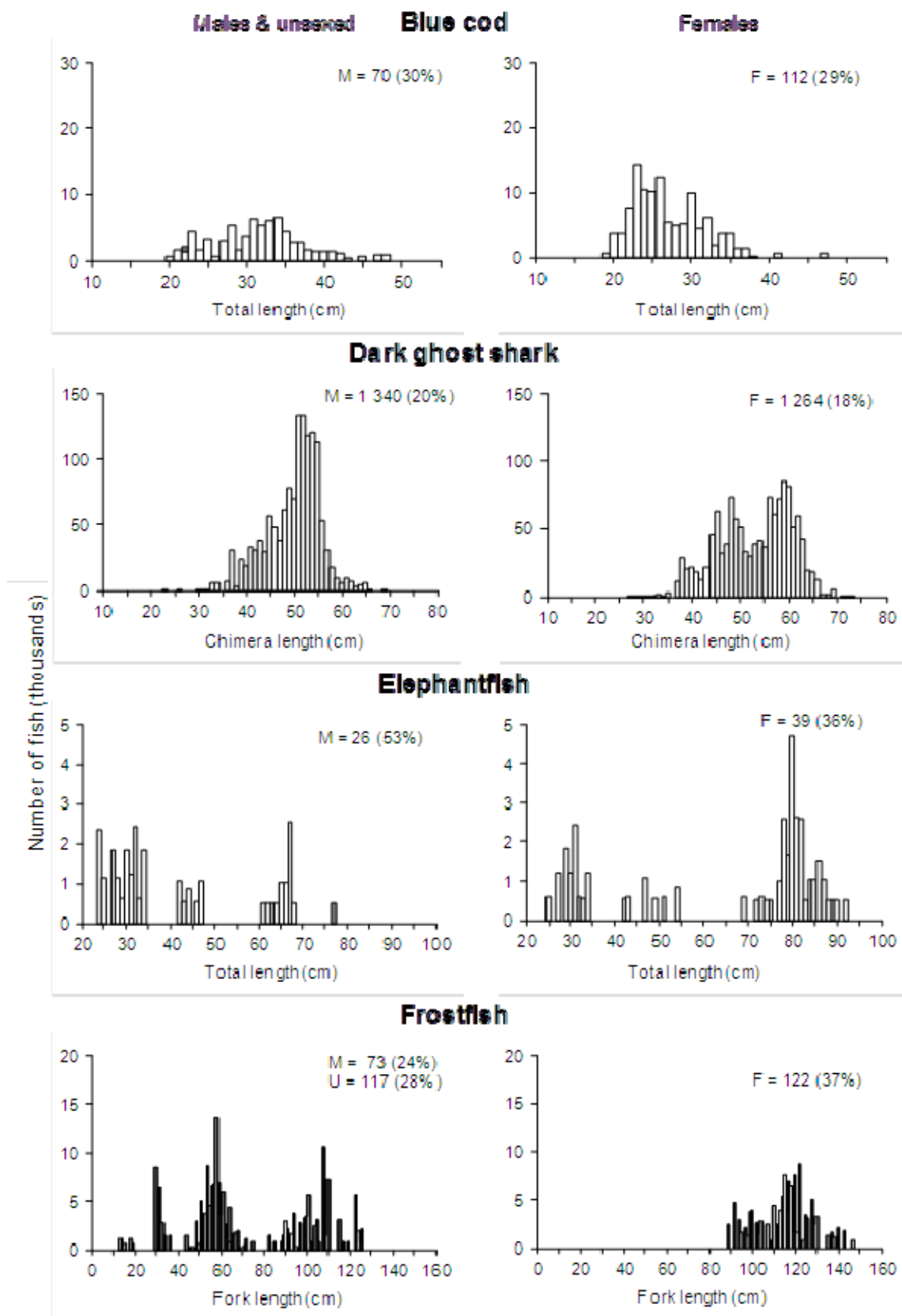


Figure 7: Scaled length frequency distributions for the non-monitored commercial species where more than 100 fish were measured. Estimated population in thousands and c.v.%. M, male; F, female; U, unsexed (shaded).

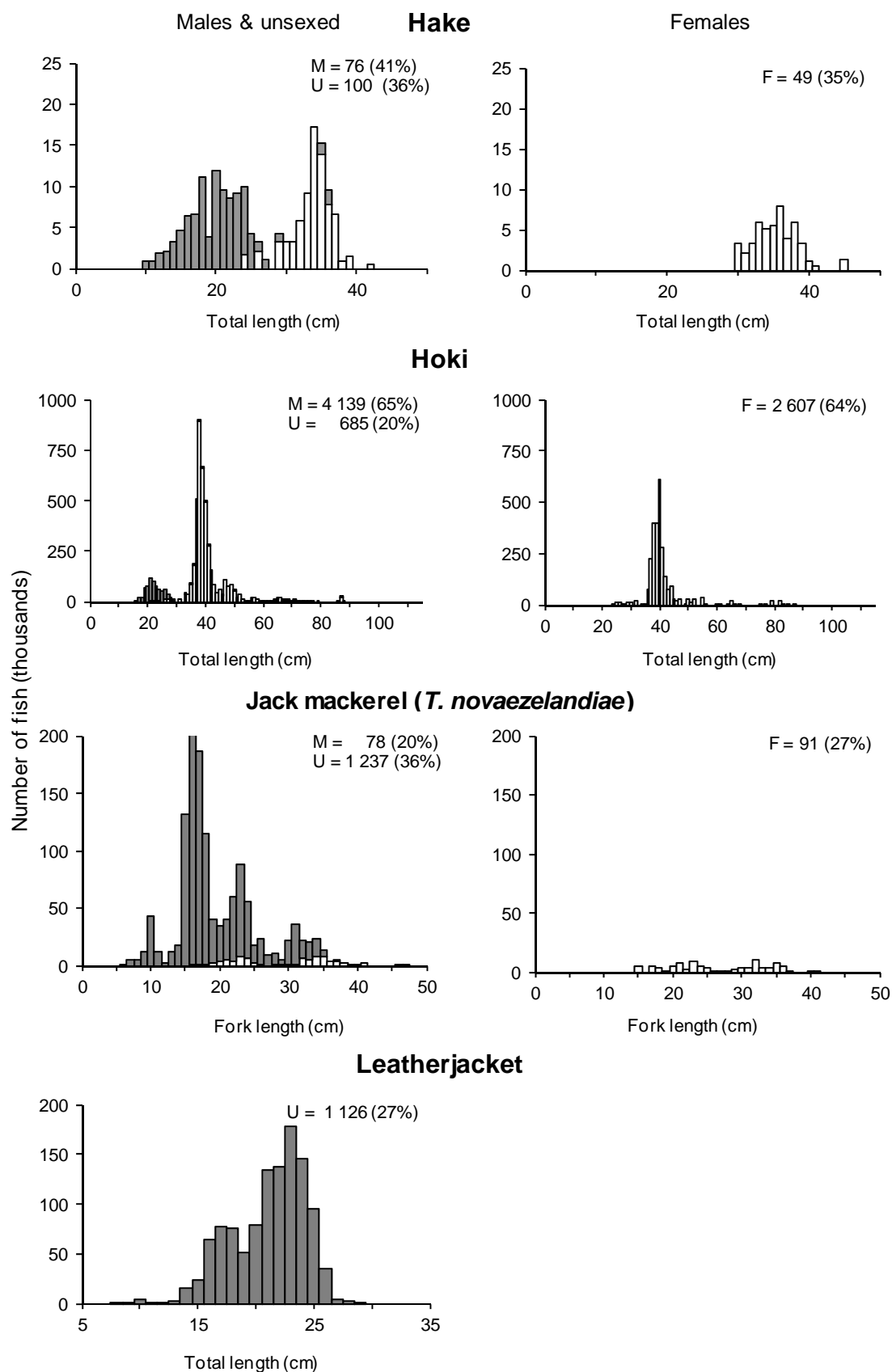


Figure 7—continued.

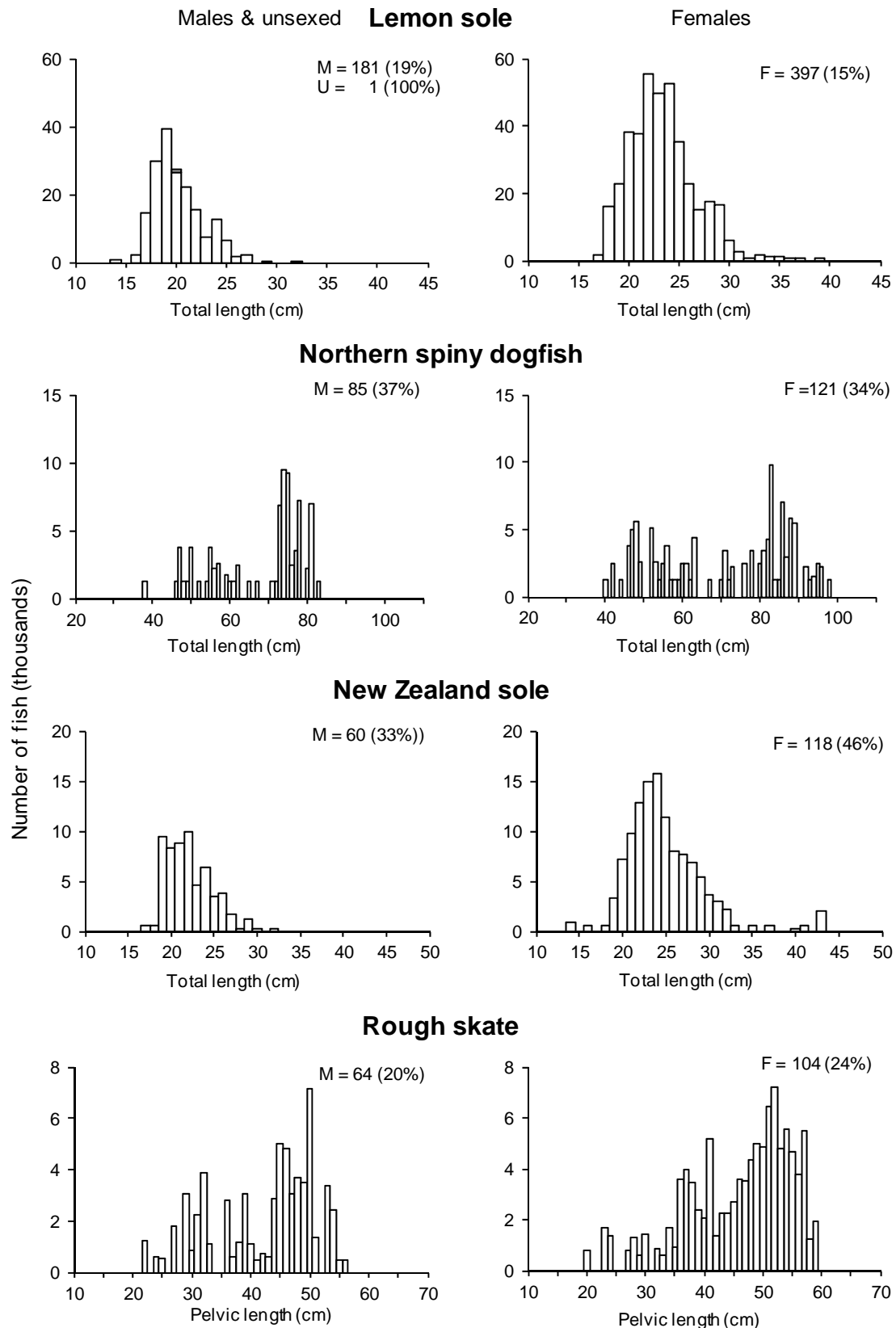


Figure 7—continued.

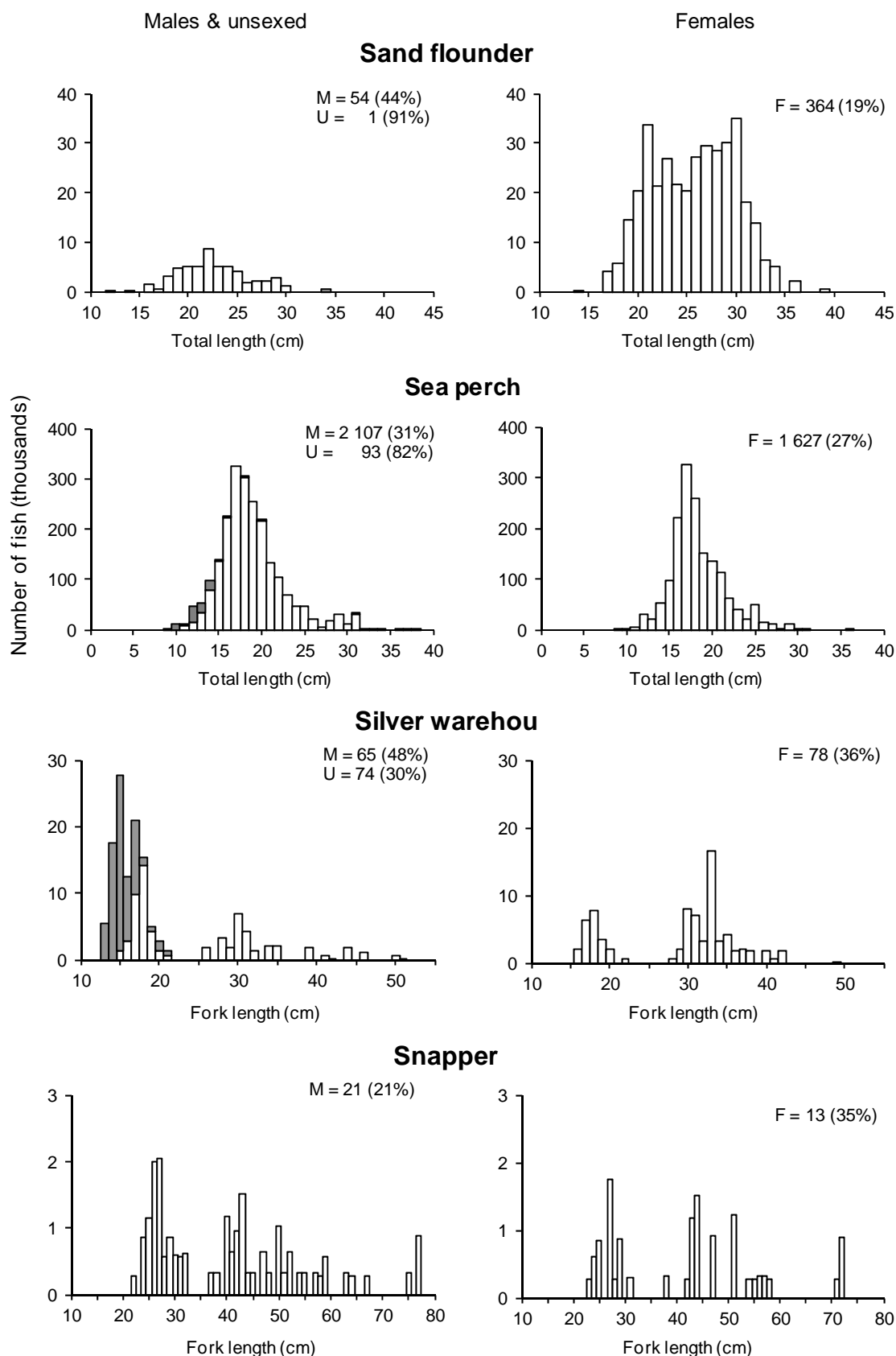


Figure 7—continued.

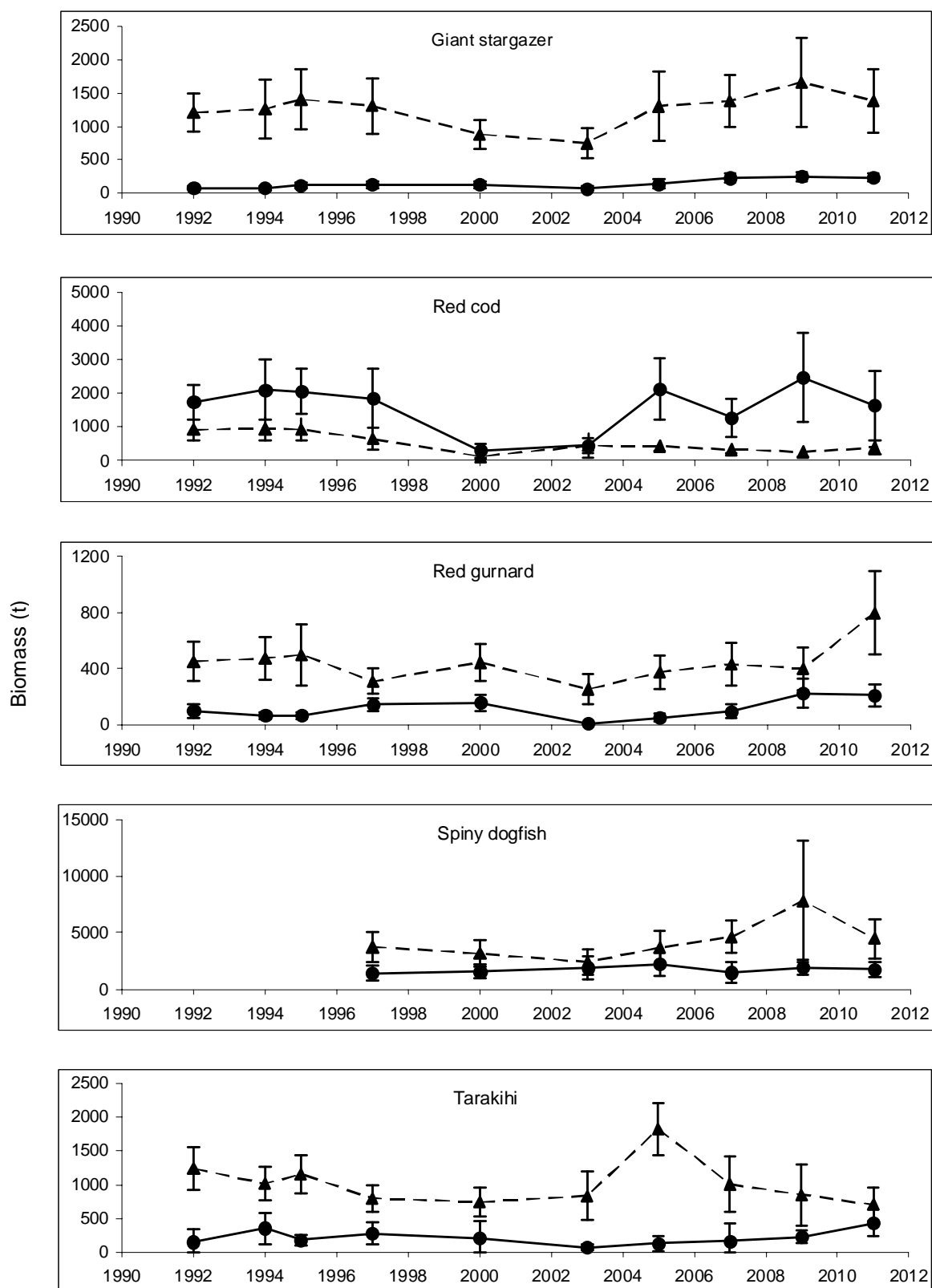


Figure 8: Biomass trends with 95% confidence intervals for juveniles (circles) and adults (triangles) for the target species (all sexes combined) from all surveys in the series. For 50% maturity lengths, see Table 5.

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.)

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

Species	<i>a</i>	<i>b</i>	n	Length range (cm)		Data source
				Min.	Max.	
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						
(<i>Trachurus declivis</i>)	0.0165	2.9300	200	15	53	DB, COR9001
(<i>T. novaezelandiae</i>)	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.

Station	Stratum	Date	Time	Start of tow				End of tow				Gear depth (m)		Distance	Headline height (m)	Doorspread (m)	Surface	Bottom		
				°	'	S	°	'	E	°	'	S	°	'			E	Min.	Max.	(n. miles)
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				End of tow				Gear depth (m)		Distance trawled (n. miles)	Headline height (m)	Doorspread (m)	Surface temp (°C)	Bottom temp (°C)				
				°	'	S	°	'	E	°	'	S	°						'	E	Min.	Max.
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

Station	Stratum	Date	Start of tow				End of tow				Gear depth (m)		Distance	Headline	Doorspread	Surface	Bottom	
			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	169	04.27		4342.57	169	02.31	109	128	2.84	4.8	88.2	15.2	13
84	15	16-Apr-11	1251		4327.2	169	18.93		4329.92	169	17.35	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.	Max.
ALL	Deepwater sea snail	<i>Alcithoe larochei</i>	3.5	*	11	30	155
ANT	Anemones	Anthozoa	0.4	*	1	39	44
ASC	Sea squirt	Ascidacea	46.0	*	7	26	47
ASR	Starfish	Asteroidea	2.3	*	17	26	400
BAR	Barracouta	<i>Thyrsites atun</i>	7 296.7	17	64	22	400
BCO	Blue cod	<i>Parapercis colias</i>	110.8	*	15	26	128
BPD	Lamp shells	Brachiopoda	0.1	*	1	26	31
BRI	Brill	<i>Colistium guntheri</i>	4.6	*	4	22	64
BRN	Barnacle	Cirripedia (Class)	0.4	*	3	132	400
BRZ	Brown stargazer	<i>Xenoccephalus armatus</i>	2.1	*	3	101	126
BSH	Seal shark	<i>Dalatias licha</i>	10.4	*	1	263	266
BSQ	Broad squid	<i>Sepioteuthis australis</i>	4.5	*	7	22	64
BTA	Smooth deepsea skate	<i>Notoraja asperula</i>	3.6	*	3	348	400
CAR	Carpet shark	<i>Cephaloscyllium isabellum</i>	1 041.6	2	60	22	375
CBI	Two saddle rattail	<i>Caelorinchus biclinozonalis</i>	2 175.6	5	46	26	375
CBO	Bollons's rattail	<i>Caelorinchus bollonsi</i>	1.3	*	1	326	345
CCX	Small banded rattail	<i>Caelorinchus parvifasciatus</i>	88.7	*	8	112	375
CDO	Capro dory	<i>Capromimus abbreviatus</i>	255.9	1	22	107	400
CEG	White finger bryozoan	<i>Celleporina grandis</i>	56.8	*	1	26	31
COL	Oliver's rattail	<i>Caelorhynchus oliverianus</i>	0.4	*	1	326	345
CON	Conger eel	<i>Conger</i> spp.	43.0	*	11	27	98
CPG	<i>Callyspongia</i> sp.	<i>Callyspongia</i> sp.	11.6	*	16	22	387
CUC	Cucumberfish	<i>Chlorophthalmus nigripinnis</i>	182.5	*	22	93	400
EGG	Fish eggs		0.4	*	2	22	50
EGR	Eagle ray	<i>Myliobatis tenuicaudatus</i>	20.6	*	3	26	43
ELE	Elephantfish	<i>Callorhynchus milii</i>	329.4	1	10	22	64
EMA	Blue mackerel	<i>Scomber australasicus</i>	5.6	*	5	26	124
ERA	Electric ray	<i>Torpedo fairchildi</i>	73.8	*	12	22	124
ESO	N.Z. sole	<i>Peltorhampus novaezealandiae</i>	50.8	*	13	22	64
FHD	Deepsea flathead	<i>Hoplichthys haswelli</i>	4.8	*	6	259	400
FLL	Shell fragments		105.4	*	11	27	266
FRO	Frostfish	<i>Lepidopus caudatus</i>	223.7	1	28	53	345
GAS	Gastropods	Gastropoda	0.5	*	4	31	146
GLB	Globefish	<i>Contusus richiei</i>	0.9	*	1	30	34
GRM	Sea urchin	<i>Gracilechinus multidentatus</i>	0.2	*	2	122	135
GSH	Dark ghost shark	<i>Hydrolagus novaezealandiae</i>	1 859.5	4	31	45	375
GUR	Red gurnard	<i>Chelidonichthys kumu</i>	1 580.0	4	42	22	174
HAK	Hake	<i>Merluccius australis</i>	69.5	*	21	28	345
HAP	Hapuku	<i>Polyprion oxygeneios</i>	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	<i>Macruronus novaezealandiae</i>	2 945.8	7	23	53	375
INV	Invertebrate	<i>Invertebrate, unknown</i>	0.1	*	1	166	169
JAV	Javelinfish	<i>Lepidorhynchus denticulatus</i>	62.1	*	9	210	400
JDO	John dory	<i>Zeus faber</i>	389.0	1	35	22	176
JFI	Jellyfish		111.4	*	19	22	98
JGU	Spotted gurnard	<i>Pterygotrigla picta</i>	0.1	*	1	166	169
JMD	N.Z. jack mackerel	<i>Trachurus declivis</i>	261.9	1	32	22	345
JMM	Chilean jack mackerel	<i>Trachurus murphyi</i>	10.7	*	4	30	169
JMN	N.Z. jack mackerel	<i>Trachurus novaezealandiae</i>	258.0	1	33	22	217
KAH	Kahawai	<i>Arripis trutta</i>	82.6	*	6	22	39

Appendix 3—continued.

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

Appendix 3—continued.

Species		Scientific name	Catch (kg)	% of total catch	Occ.	Depth (m)	
code	Common name					Min.	Max.
SSK	Smooth skate	<i>Dipturus innominatus</i>	205.1	*	23	31	400
STA	Giant stargazer	<i>Kathetostoma giganteum</i>	2 020.0	5	48	26	345
STR	Stingray	<i>Dasyatis</i> sp.	35.2	*	3	26	47
STY	Spotty	<i>Notolabrus celidotus</i>	19.3	*	6	22	39
SWA	Silver warehou	<i>Seriolella punctata</i>	64.2	*	30	37	375
TAR	Tarakihi	<i>Nemadactylus macropterus</i>	1 810.7	4	54	25	375
TOD	Dark toadfish	<i>Neophrynichthys latus</i>	1.5	*	13	112	387
TRE	Trevally	<i>Pseudocaranx dentex</i>	2.3	*	1	36	39
TUR	Turbot	<i>Colistium nudipinnis</i>	4.9	*	2	22	30
WAR	Blue warehou	<i>Seriolella brama</i>	408.9	1	38	22	168
WIT	Witch	<i>Arnoglossus scapha</i>	418.0	1	64	22	400
WOD	Wood	Wood	129.3	*	8	30	241
YBO	Yellow boarfish	<i>Pentaceros decacanthus</i>	12.4	*	3	40	375
YEM	Yellow-eyed mullet	<i>Aldrichetta forsteri</i>	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)	
<i>Suberites affinis</i> Brondsted, 1923	6
<i>Callyspongia</i> sp.	3
Annelida: Echiura	
Echiuroida	1
Bryozoa	
<i>Celleporina grandis</i>	1
<i>Celleporaria agglutinans</i>	1
<i>Parasmittina delicatula</i>	1
<i>Hippomenella vellicata</i>	1
<i>Smittoidea maunganuiensis</i>	1
<i>Idmidronea</i> sp.	1
Cnidaria: Hydrozoa	
Hydrozoa indeterminate.	5
<i>Nemertesia elongata</i>	1
Cnidaria: Anthozoa	
Hormathiidae (Family)	5
Crustacea: Palinura	
<i>Ibaccus alticrenatus</i>	14
Crustacea: Decapoda	
<i>Diacanthurus rubricatus</i>	4
<i>Antarctus mawsoni</i>	1
Crustacea: Paguridae	
<i>Diacanthurus rubricatus</i> (Henderson, 1888)	10
Crustacea: Stomatopoda	
<i>Pterygosquilla schizodontia</i> (Richardson, 1953)	1
Crustacea: Anomura	
<i>Ovalipes catharus</i>	2
<i>Nectocarcinus antarcticus</i>	1
Crustacea: Maxillopoda	
<i>Graviscapellum pedunculatum</i>	3
Arthropoda: Cirripedia	
<i>Calantica studeri</i>	3

Appendix 4—continued

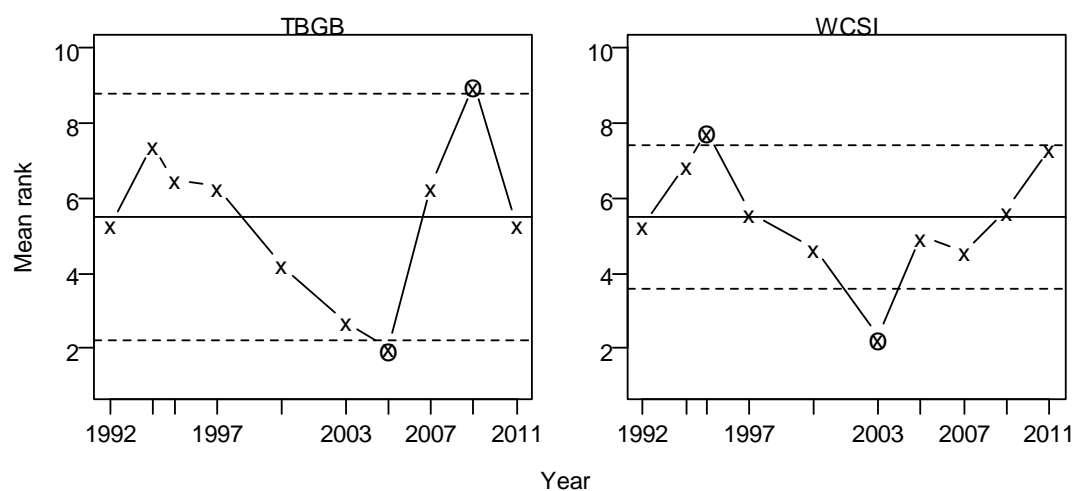
Taxon	No. of stations
Mollusca: Bivalvia	
<i>Pecten novaezelandiae</i>	2
<i>Perna canaliculus</i>	
Mollusca: Gastropoda Prosobranchia	
<i>Austrofusus glans</i>	7
<i>Ranella olearium</i>	1
<i>Alcithoe larochei</i>	11
Mollusca: Gastropoda Opisthobranchia	
<i>Archidoris wellingtonensis</i>	1
Mollusca: Cephalopoda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