Inshore trawl survey of the west coast of the South Island and Tasman and Golden Bays, March–April 2009 (KAH0904)

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EXECUTIVE SUMMARY

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This report gives the results of the ninth 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 2009 and used a two-phase design optimised for giant stargazer, red cod, red gurnard, spiny dogfish, and tarakihi. Seventy-two stations (67 phase 1 and 5 phase 2) 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, 1952 t; red gurnard, 651 t; red cod, 2782 t; spiny dogfish, 10 270 t; and tarakihi, 1088 t. Target c.v.s were met for red cod (25%), giant stargazer (19%), red gurnard (18%), and spiny dogfish (19%). The c.v for tarakihi (22%) was slightly higher than the target.

The estimates of total biomass for giant stargazer, red gurnard, and spiny dogfish were the highest for any survey in the series. The estimate for red cod was higher than for 2007 and similar to the first four surveys. The estimate for tarakihi was slightly lower than in 2007 but still in the range of most previous surveys.

Other commercial species with c.v.s less than 20% were barracouta, dark ghost shark, lemon sole, school shark, and arrow squid. For hoki, the number of 0+ fish is the second highest in the series, exceeded only by the 1995 survey (the strong 1994 year class). For John dory, a strong pulse of 1+ fish, similar to one found during the 2000 survey, is seen in the length frequency distribution. In addition, more snapper were caught on this survey than on any previous survey including over 150 juveniles in the 14–19 cm size range (2+). The biomass estimate for five non-target species was the highest recorded from the series.

At the end of the survey a total of 614 juvenile tarakihi were tagged in Tasman Bay to clarify stock affiliations. During the survey, 151 school shark, 29 rig, 40 rough skate, and 3 smooth skate were tagged and released.

1. INTRODUCTION

This report presents results from the ninth in a time series of stratified random trawl surveys with RV *Kaharoa* in waters between 20 and 400 m deep off the west coast of the South Island, and within Tasman and Golden Bays. The survey was optimised for giant stargazer (*Kathetostoma* spp.), 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) and Stevenson (1998, 2002, 2004, 2006, 2007a). 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 Individual Transferable Quota (ITQ) and non-ITQ 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*), stargazer (*Kathetostoma giganteum*), tarakihi (*Nemadactylus macropterus*) and spiny dogfish (*Squalus acanthias*).

Specific objectives (2009)

1. To determine the relative abundance and distribution of red cod, red gurnard, 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%), spiny dogfish (20%), and tarakihi (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 collect biological data from carpet shark, two saddle rattail, eagle ray, electric ray, and silver dory.

9. To collect hull based acoustic survey data for future analysis.

2. METHODS

2.1 Survey area and design

The survey used a two-phase stratified random design (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, respectively. The proposed phase 1 survey design of 74 stations was based on 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). Doorspread and headline height measurements were recorded from Scanmar monitoring equipment and an average taken of five readings at 10–15 min intervals during each tow. When no direct readout was possible, doorspread value was calculated as being equal to the mean of the doorspread from stations within the same stratum depth range for which direct readings were available.

A Seabird CTD was used to record sea temperatures, conductivity, and water pressure. A Mac Marine Bottom Contact Sensor (BCS) was mounted near the centre of the groundrope and used to determine if the net was in adequate contact with the sea floor. If the graphic output showed the net had not travelled smoothly, it was reviewed by the voyage leader who made a determination on the suitability of the tow. Acoustic data were collected using a hull-mounted Simrad EK60 38 kHz echosounder and a splitbeam transducer. Recordings were made during trawls and when steaming between stations (day and night).

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 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 crustaceans (scampi) were classified to species level: crabs, shellfish, and other 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 ITQ species, 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, eagle ray, electric ray, silver dory, two-saddle rattail, rig, rough skate, smooth skate, and school shark. 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. Before the survey discussions were held with the Ministry of Fisheries 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 ageing work on red cod showed that there was no difference in growth rates between fish from the northern and southern west coast (Beentjes 2000).

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 unpublished report). SurvCalc is a C++ based program which replaced the TrawlSurvey Analysis program (Vigneaux 1994) used in previous years (Stevenson 2007b, Stevenson & Hanchet 1999). All data were entered into the Ministry of Fisheries *trawl* database.

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

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 code was 1 or 2 (72 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, lively rig (*Mustelus lenticulatus*), school shark (*Galeorhinus galeus*), and rough skate (*Raja nasuta*) and smooth skate (*R. innominata*) were separated from the catch and tagged with Hallprint dart tags whenever possible. Length, weight, and sex were recorded for each tagged fish.

2.7 Tarakihi tagging

At the end of the survey, the vessel returned to a location in Tasman Bay where small tarakihi had been caught during the regular survey. Short tows were made to catch 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 minutes and at the end of the tow the codend was quickly lowered into an aerated tank to minimise the time fish spent out of the water. Tagging began immediately or after tarakihi had been sorted from the rest of the catch, and tagged fish placed in a second aerated tank. Tagged fish were then released before travelling to the next station. If more than 10 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 one of the 20 most abundant commercially important species. In addition, snapper (*Pagrus auratus)* are included for this survey because of the numbers of 14–19 cm fish caught. Catch rate figures are given for only the target species.

3.1 Survey area, design, and gear performance

Trawling began in Tasman and Golden Bays and after 4 days continued on the west coast in a generally north to south direction. Parts of two days were lost to bad weather and one day was used unloading fish.

Seventy-two stations was successfully completed, 67 in phase 1 and 5 in phase 2. Station density ranged from one station per 102 km^2 in stratum 17 to one station per 860 km^2 in stratum 2, with an average density of one station per 355 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.

The phase 2 stations were primarily used to reduce the c.v.s for giant stargazer and spiny dogfish but also helped reduce the c.v. for tarakihi. Catch rates of the remaining target species were not used for allocation of phase 2 stations because the c.v.s for these species were within target levels.

Tow and gear parameters by depth are shown in Table 2. Doorspread varied from 67.8 to 93.8 m and headline height varied between 4.4 and 5.3 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

About 47.5 t of fish were caught from the 72 tows of the main survey at an average of 641.9 kg per tow (range 94.1–3558.2 kg). Amongst the fish catch, 12 elasmobranchs and 56 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 11.8 t caught (24.9% of the total catch). The top four species, spiny dogfish, red cod, barracouta (*Thyrsites atun*), and silver dory (*Cyttus novaezealandiae*) made up over 51% of the total. Giant stargazer, red cod, red gurnard, and tarakihi made up 5.6, 10.7, 2.3, and 3.5% of the catch, respectively. Arrow squid (*Nototodarus sloanii*), barracouta, and spiny dogfish occurred in over 90% of the tows.

Thirty-eight species of invertebrates were identified during the survey or from retained specimens (Appendix 4). This is fewer than in 2007 primarily because of a lack of bryozoans. However, the lower 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 ITQ species caught in 2009 are given in Table 4. 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, 1952 t (19%); red gurnard, 651 t (18%); red cod, 2782 t (25%); spiny dogfish, 10 270 t (19%); and tarakihi, 1088 t (22%) (Table 4).

Biomass estimates of recruited fish for barracouta, blue warehou (*Seriolella brama*), giant stargazer, hoki, John dory (*Zeus faber*), red cod, red gurnard, rig (*Mustelus lenticulatus*), sand flounder (*Rhombosolea plebeia*), school shark (*Galeorhinus galeus*), 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 (*Merluccius australis*), hoki (*Macruronus novaezelandiae*), 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 43% of the total biomass. For red gurnard, the 2+ cohort made up 23% of the total biomass and for tarakihi the 1+ and 2+ cohorts made up 7% and 5% of the total respectively (Table 6).

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 can not be directly compared to surveys Before 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, carpet shark (*Cephaloscyllium isabellum*), silver dory (*Cyttus novaezealandiae*), and two saddle rattail (*Caelorinchus biclinozonalis*) from data collected on this survey (Appendix 1). Length-weight data were also collected for electric ray (*Torpedo fairchildi*) and eagle ray (*Myliobatis tenuicaudatus*) but too few were caught to calculate a reliable length-weight regression.

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 81% of all stations with the highest catch rates south of Cape Foulwind in depths of 100–200 m (strata 6, 8, 12, and 15) (see 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) from 2009. (see Table 4, Figure 3). The proportion of juveniles has increased from less than 6% in the first two surveys to 14% and 13% in 2007 and 2009 respectively (Figure 5) Seventy-three percent of the biomass was south of Cape Foulwind, and 77% was within the 100–200 m depth range (Table 7). Biomass of adult fish (over 45 cm) was 1661 t (see Table 5). There were more fish less than 45 cm caught on this survey than in previous years (see Figure 6d) but no clear year class modes were apparent in the length frequency distribution. The sex ratio (male:female) was 1.45:1 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 9). This is consistent with the winter spawning period of giant stargazer.

3.7.2 Red cod

Red cod were caught at over 78% of all stations, with the highest catch rates in strata 5, 7, 11, 14, and 19 (see 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 (see Table 4, Figure 3). Juvenile biomass has always exceeded adult biomass and in 2009 made up over 90% of the total (Figure 8). Only 42% of the total biomass was south of Cape Foulwind and 95% was from depths less than 200 m (see Table 7). Adult biomass (over 51 cm) was 259 t (Table 5). The length frequency data show the 1+ cohort (24–38 cm) was not as dominant in 2009 as it has been in previous surveys. Very few fish in the 10–20 cm range (0+ fish) were caught, which is consistent with previous surveys except 1995 and 1997 (see Figure 6h). The sex ratio of 1.4:1 was similar to surveys before 2007. Most red cod examined had immature or resting gonads but some fish were at later stages of reproductive development (Table 9). Since red cod spawn from late winter to spring (Ministry of Fisheries 2009), it would be expected to not find a significant proportion of maturing or ripe gonads.

3.7.3 Red gurnard

Red gurnard were caught at all but three stations in Tasman and Golden Bay and at all but five stations in depths less than 100 m along the west coast (see Figure 2c). The highest catch rates were in strata 2, 6, and 19 (see Table 3). The biomass estimates were consistent from 1992 to 2000 but showed a sharp decline in 2003. There has been a steady recovery over the last three surveys and the estimate for 2009 (651 t) was higher than any previous survey (see Table 4, Figure 3). The proportion of juveniles has varied from a low of less than 4% in 2003 to a high of over 30% in 2009 (Figure 4). The length frequency distribution was similar to that of 1997 and 2000 with high numbers of pre-recruit fish (see Figure 6i). The recruited and adult biomass estimates (30 cm or over) were 407 t (63% of the total) with 223 t occurring on the west coast (see Table 5). Almost 99% of red gurnard biomass was at depths less than 100 m and no gurnard were caught deeper than 200 m (see Table 7). The overall sex ratio was 0.9:1 (see Figure 6i). Most red gurnard longer than 30 cm and a few smaller fish had developing or mature gonads (Table 9). 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 over 93% of all biomass stations with the highest catch rates in strata 7 and 8 (see Table 3, Figure 2d). The biomass estimates have been 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 (see Table 4, Figure 3).). Adults abundance has always been greater than that of juveniles and in 2009 represented more than 80% of the total (see Figure 8). There were considerably more fish under 50 cm caught on this survey than in 2007 (see Figure 6l). Almost 99% of the estimated biomass was at depths less than 200 m (see Table 7). The sex ratio of 0.89:1 was similar to the previous three surveys but lower than in 1997 and 2000 (see Figure 6l).

3.7.5 Tarakihi

Tarakihi were caught at 88% of all biomass stations with the highest catch rates in strata 5, 12, and 16 (see Table 3, Figure 2e). The biomass estimates show a declining trend to 2003 with a sharp increase in 2005 and a subsequent drop in 2007 and 2009 to 1997 levels (see Table 4 Figure 3). Adult biomass has always been greater than juvenile biomass and in 2009 made up 80% of the total (see Figure 8). Over 88% of the biomass estimate was recruited fish (25 cm or over) (see Tables 4 and 5) whilst the adult biomass (over 31 cm) was 848 t (see Table 5). The length frequency data exhibits a strong mode at 10–14 cm (0+ fish) similar to 1997 and a second strong mode at 17–24 cm (1+ fish) and a few fish at 25–28 cm, probably 2+ fish (see Figure 6m). Of the total tarakihi biomass (1189 t), over 89% was on the west coast, and over 62% (744 t) of this was at depths between 100 and 200 m (see Table 7). The sex ratio for the estimated population was 0.87:1 (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 over 94% of all biomass stations and represented 10.3% of the total catch (Appendix 3). The highest catch rates were in strata 5 and 15 (see Table 3). The biomass has varied almost 3-fold during the series but does not show a consistent trend (see Table 4). The 2009 estimate of 3512 t is in the mid-range for the series. The length frequency distribution usually has a very strong mode of 0+ fish with the 2009 mode one of the strongest in the series (see Figure 6a).

Blue warehou

Blue warehou were caught at 60% of all biomass stations with the highest catch rates in strata 11 and 15 (Table 3). The biomass estimate for 2009 is in the mid-range of the series estimates (see Table 4, Figure 3). However, the mode in the length frequency distribution at 10–23 cm (0+ fish) is the strongest in any survey in the series (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. Although, Stevenson (2007b) suggested that the survey may be able to provide information on year class strengths, ageing of the commercial catch would be required to show this.

Gemfish

Gemfish were caught in low numbers at only 10 stations (Appendix 3, Table 8). The biomass estimates from the series do not show a definite trend (see Table 4, Figure 3) but the length frequency distributions occasionally show apparently strong year classes (see Figure 6b). There are no strong year classes visible in 2009.

Hake

There were few juveniles compared to 2007 (see Figure 7) but numbers were similar to most surveys in the series (Stevenson 2007b).

Hoki

The length frequency distribution for hoki shows a strong mode at 17–26 cm (0+ fish) (see Figure 7). This is the second highest number of 0+ fish in the series, exceeded only by the 1995 survey (the strong 1994 year class) (Stevenson 2007b).

Jack mackerel (*Trachurus declivis*)

Trachurus declivis was present in the catch from 27 stations but only in low numbers (Appendix 3, Table 8). The biomass estimate of 79 t was slightly higher than in 2007, which was the lowest of any survey in the series (see Table 4, Figure 3). The length frequency distribution is similar to those from the previous three surveys with few small fish and a weak adult mode (see Figure 6e).

John dory

John dory were caught at 32 biomass stations with the highest catch rates in strata 1 and 19 (see Table 3, Appendix 3). The biomass estimate of 269 t is the second highest in the series (see Table 4, Figure 3). The length frequency distribution shows a strong mode at 25–35 cm (1+ fish) and good numbers of adults of both sexes. This is similar to the 2000 survey and the strong year class seen then continued to be present in the adult mode in the length frequency distributions from the next 2 surveys (see Figure 6f). This could mean John dory will continue to maintain the higher biomass seen in the last five surveys.

Ling

Ling were caught at 54% of all biomass stations with the highest catch rates in stratum 16 (Appendix 3, Table 3). The biomass estimate of 291 t is one of the highest in the series and similar to 1992, 1994, and 2005 but there doesn't appear to be a trend over the series (see Table 4, Figure 3). The scaled length frequency distribution for 2009 does not show evidence of any strong year class (see Figure 6g).

Rig

Rig were also caught at 54% of the biomass stations, with the highest catch rates in strata 18 and 14 (Appendix 3, Table 3). The estimated biomass of 274 t is lower than for 2007 but within the mid-range of the series (see Table 4, Figure 3). The length frequency distribution shows two strong modes at 34–44 cm and 48–60 cm. There were few fish over 100 cm, which is typical of the series (see Figure 6j).

School shark

School shark were caught at 89% of all biomass stations with the highest catch rates in strata 17 and 5 (Appendix 3, Table 3). The estimated biomass of 1085 t was the highest since 1997 and the fourth highest in the series and continues a gradual increase since the low of 2003 (see Table 4, Figure 3). The length frequency distributions for 2009 show a very strong mode at 33–43 cm for both sexes compared to previous surveys (see Figure 6k).

3.8 Tagging

A total of 147 school shark were tagged (65 females and 82 males) ranging in length from 40 to 144 cm. In addition, 29 rig (9 females, 20 males), 41 rough skate (21 females, 20 males), and 4 smooth skate (1 female, 3 males) were tagged.

A total of 641 juvenile tarakihi was tagged and released in Tasman bay.

4. CONCLUSIONS

The 2009 survey successfully extended the March-April *Kaharoa* time series for the west coast of the South Island and Tasman and Golden Bays. The results show the series continues to monitor the target species and adults and/or pre-recruits and juveniles of several other species. Biomass estimates of giant stargazer, red gurnard, and spiny dogfish are the highest in the series, whilst those for red cod and tarakihi are within the range of previous surveys. The catch of snapper is of special interest because juveniles had never been caught on any previous survey. Since most snapper tend to leave the Tasman and Golden Bays by the time of the survey, this result could indicate the presence of a strong year class.

The SurvCalc program

Biomass, catchrate by stratum, and length frequency data were analysed using a new program, 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. Analysis of data for the target species from a previous survey was run to compare the results to ensure comparative results. The resulting outputs were identical for biomass and scaled length frequency numbers (Table 10).

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	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	1	306
6	100–200	3 233	238	3	2	647
7	25–100	927	0	4	2	155
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	9	0	271
Total (average)		25 594	4 034	67	5	(355)

Table 2: Gear parameters for bimass stations by depth range (n, number of stations; s.d., standard deviation). Data for gear trials shown separately.

	n	Mean	s.d.	Range
All stations	72			
Headline height (m)		4.9	0.20	4.4–5.3
Doorspread (m)		79.7	7.38	67.8–93.8
Distance (n. miles)		3.0	0.19	1.96–3.33
Warp:depth ratio		3.9	1.67	2.42–9.30
Tasman/Golden Bays				
20–70 m	15			
Headline height (m)		4.9	0.16	4.8–5.3
Doorspread (m)		73.0	2.09	67.8–75.6
Distance (n. miles)		3.0	0.13	2.82–3.38
Warp:depth ratio		5.7	1.85	3.41–8.89
West coast				
20–400 m	57			
Headline height (m)		4.9	0.21	4.4–5.3
Doorspread (m)		81.5	7.25	69.2–93.8
Distance (n. miles)		3.0	0.19	1.96–3.28
Warp:depth ratio		3.5	1.42	2.42–7.55
20–100 m	25			
Headline height (m)		5.0	0.23	4.5–5.3
Doorspread (m)		74.4	3.57	69.2–81.8
Distance (n. miles)		3.0	0.06	2.93–3.20
Warp:depth ratio		4.5	1.66	2.75–7.55
100–200 m	23			
Headline height (m)		4.9	0.18	4.7–5.3
Doorspread (m)		85.6	3.12	78.9–92.2
Distance (n. miles)		3.0	0.23	1.96–3.28
Warp:depth ratio		2.8	0.09	2.47–2.89
200–400 m	9			
Headline height (m)		4.8	0.22	4.4–5.1
Doorspread (m)		90.6	2.47	86.6–93.8
Distance (n. miles)		2.9	0.29	2.14–3.07
Warp:depth ratio		2.6	0.07	2.42–2.64

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	RCO	BAR	STA	HOK	TAR	SCH	FRO	GSH	GUR
1	322	*	87	6	0	25	19	11	51	14
2	329	1	42	2	0	20	44	3	68	1
5	430	295	522	8	5	8	113	9	48	92
6	299	5	136	157	14	28	54	16	64	1
7	627	502	250	41	54	12	41	6	31	70
8	1 692	54	117	239	323	31	59	42	36	1
9	0	0	12	6	2	17	16	0	0	0
11	474	430	225	69	107	47	14	2	26	43
12	293	39	209	165	39	203	20	247	8	0
13	96	94	40	85	34	35	19	56	31	0
14	556	354	38	10	0	0	37	0	0	12
15	236	48	314	99	46	77	53	37	18	0
16	78	100	37	407	388	123	8	106	201	0
17	118	17	16	10	0	84	131	0	0	54
18	197	58	31	3	0	30	94	0	0	93
19	33	246	205	19	0	28	29	0	0	114

	Species code									
	LIN	JMN	LEA	SPE	SPO	HAK	ELE	NOS	WAR	JDO
1	0	*	8	0	1	0	1	14	0	35
2	*	0	*	2	1	0	0	31	0	17
5	1	32	*	*	31	107	*	1	6	8
6	5	0	0	20	2	0	0	23	1	6
7	3	*	*	0	14	40	21	7	2	3
8	1	0	0	34	8	1	0	11	1	5
9	4	0	0	12	0	0	0	27	0	0
11	8	*	0	0	8	22	110	14	48	0
12	5	0	0	39	1	*	0	7	0	0
13	61	0	0	25	3	0	0	8	0	0
14	16	*	0	0	53	1	6	1	12	0
15	16	0	0	7	5	1	0	14	47	0
16	421	0	0	64	0	51	0	8	0	0
17	10	103	32	45	34	0	0	6	17	21
18	0	165	129	0	80	0	0	11	5	17
19	1	72	73	5	15	1	0	9	12	33

+ < 0.5 kg.km^{-2}

Table 4: Relative biomass estimates and c.v.s (cv%) by trip from the entire survey area for ITQ species.

	KAH9204		KAH9404		KAH9504		KAH9701		KAH0004		KAH0304		KAH0503		KAH0704		KAH0904	
Species	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
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
Blue warehou	123	40	80	22	115	29	842	31	272	37	191	66	116	40	286	50	175	27
Dark ghost shark	271	24	722	14	767	24	1 591	21	2 259	9	544	15	832	22	2 215	21	900	17
Elephantfish	21	42	167	33	85	35	94	32	42	63	48	34	59	33	28	53	185	83
Frostfish	25	32	27	23	89	31	259	32	316	16	494	22	423	45	529	39	835	35
Gemfish	145	19	68	29	21	55	704	83	120	30	137	23	474	49	101	19	143	29
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
Hake	391	25	99	31	5 244	27	1 019	46	15	36	55	47	1 673	30	359	35	212	56
Hoki	405	17	826	49	3 616	21	1 100	25	103	50	233	22	701	55	772	52	1 302	46
Jack mackerel																		
Trachurus declivis	92	24	99	26	106	20	162	19	168	33	87	21	118	21	62	23	79	23
T. novaezelandiae	281	58	69	23	57	29	363	27	194	46	126	49	98	20	214	62	399	24
John dory	102	29	59	26	27	36	17	31	141	16	288	19	222	14	174	26	269	23
Leatherjacket	203	29	230	23	153	34	231	34	236	50	254	18	139	20	252	40	323	27
Lemon sole	88	18	77	25	126	21	68	21	59	19	2	44	21	42	119	46	62	16
Ling	286	19	261	20	367	16	151	30	95	46	150	33	274	37	180	27	291	37
New Zealand sole	68	33	68	16	39	30	45	29	16	32	21	57	27	45	39	71	75	32
Northern spiny dogfish	146	20	159	21	86	28	164	46	256	18	111	27	180	22	134	29	189	28
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
Red gurnard	573	16	559	15	584	19	471	13	625	14	270	20	442	17	553	17	651	18
Rig	288	14	380	10	490	10	308	18	333	18	144	22	153	19	383	33	274	26
Rough skate	173	27	196	23	251	22	185	30	186	23	43	34	58	30	256	23	114	21
Sand flounder	100	31	203	23	132	28	106	28	62	22	10	33	62	25	67	47	170	32
School shark	933	22	1 151	41	1 204	35	1 432	25	896	13	655	18	774	14	816	20	1 085	16
Sea perch	242	22	426	18	667	23	338	14	302	22	76	25	150	20	163	19	336	20
Silver warehou	292	38	66	35	38	20	204	20	99	34	69	27	72	28	165	20	80	24
Smooth skate	339	19	341	18	315	20	302	26	140	29	91	79	80	30	55	44	67	61
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
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

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	270	56	2 682	18	2 952	17			
Blue warehou	45	21	100	88	47	108	42			
Giant stargazer	30	44	21	1 655	20	1 912	19	45	1 661	20
Hoki	65	0		32	40	32	40			
John dory	25	103	28	165	33	268	23			
Ling	65	0		229	45	229	45			
Red cod	40	267	79	1 346	28	1 614	27	51	259	25
Red gurnard	30	185	26	223	27	407	19	30	407	19
Rig	90	16	62	69	25	84	23			
Sand flounder	25	102	44	7	60	109	41			
Spiny dogfish								Males 58	3 318	29
								Females 72	4 528	38
School shark	90	14	25	505	22	519	21			
Silver warehou	25	0		60	31	60	31			
Tarakihi	25	8	48	950	24	958	24	31	848	26.6

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	<0.1	99
	1+	15– 29	180	39
	2+	29–39	20	67
	3+	39–53	402	44
Blue warehou	0+	< 23	44	30
	1+	23–29	5	35
	2+	30–39	12	54
Hake	0+	<19	1	56
	1+	19–28	2	45
	2+	29–45	196	59
Hoki	0+	17–33	1 128	53
	1+	34–49	79	35
Jack mackerel				
(*T. novaezelan*	1+	13–24	238	38
Red cod	0+	<23	5	27
	1+	23–38	708	25
Red gurnard	0+	10–16	0.3	68
	2+	17–26	127	21
School shark	0+	< 44	59	32
	1+	44–53	47	28
Silver warehou	1+	13–21	17	22
Tarakihi	0+	10–15	19	26
	1+	16–23	91	34
	2+	24–28	58.5	25.8

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	RCO	BAR	STA	HOK	TAR	SCH	FRO	GSH	GUR
1	432	+	117	7	0	33	25	15	68	18
	(32)	(100)	(51)	(45)		(82)	(34)	(82)	(70)	(75)
2	1 415	2	180	7	0	86	189	13	290	4
	(51)	(100)	(61)	(58)		(37)	(44)	(88)	(34)	(63)
5	488	335	594	9	6	9	129	10	55	105
	(48)	(50)	(48)	(100)	(97)	(100)	(61)	(84)	(60)	(39)
6	967	17	441	508	45	90	174	53	206	2
	(23)	(84)	(29)	(48)	(98)	(29)	(48)	(50)	(36)	(100)
7	581	465	232	38	50	11	38	6	28	65
	(44)	(79)	(29)	(68)	(100)	(64)	(78)	(97)	(72)	(55)
8	3 985	126	277	562	761	74	138	100	84	3
	(42)	(33)	(35)	(37)	(77)	(13)	(43)	(42)	(42)	(100)
9	0	0	22	11	5	32	31	0	0	0
			(74)	(51)	(100)	(92)	(55)			
11	682	618	323	100	154	68	20	3	38	61
	(49)	(47)	(46)	(30)	(56)	(47)	(47)	(77)	(100)	(57)
12	603	79	428	339	80	417	40	507	16	0
	(35)	(13)	(68)	(36)	(56)	(52)	(29)	(55)	(56)	
13	106	104	43	93	37	39	21	62	35	0
	(29)	(40)	(55)	(25)	(11)	(53)	(26)	(85)	(100)	
14	473	301	33	8	+	0	32	0	0	10
	(30)	(15)	(43)	(71)	(63)		(43)			(38)
15	208	43	277	87	41	68	47	33	16	0
	(16)	(12)	(82)	(17)	(48)	(48)	(60)	(33)	(77)	
16	25	32	12	130	124	39	3	34	64	0
	(86)	(82)	(100)	(78)	(49)	(100)	(100)	(54)	(58)	
17	36	5	5	3	0	26	40	0	0	17
	(53)	(56)	(74)	(67)		(94)	(68)			(27)
18	187	55	29	3	0	28	89	0	0	88
	(96)	(55)	(44)	(100)		(49)	(39)			(36)
19	82	598	500	47	0	68	70	0	0	278
	(48)	(82)	(45)	(19)		(42)	(33)			(33)

\+ < 0.5 t.

Table 7–continued.

	Species code									
Stratum	LIN	JMN	LEA	SPE	SPO	HAK	ELE	NOS	WAR	JDO
1	0	+	11	0	2	0	2	19	0	48
		(100)	(100)		(100)		(100)	(36)		(58)
2	1	0	1	10	6	0	0	133	0	75
	(100)		(100)	(45)	(100)			(41)		(60)
5	2	36	+	+	35	121	+	2	6	9
	(94)	(88)	(100)	(100)	(39)	(93)	(100)	(35)	(38)	(29)
6	16	0	0	63	8	0	0	73	2	19
	(90)	(0)	(0)	(58)	(65)			(25)	(100)	(52)
7	3	+	+	0	13	37	20	6	2	3
	(89)	(63)	(100)	(0)	(62)	(78)	(62)	(45)	(52)	(63)
8	3	0	0	80	20	2	0	25	3	12
	(53)		(0)	(55)	(43)	(100)		(33)	(65)	(93)
9	8	0	0	22	0	0	0	50	0	0
	(100)			(68)				(39)		
11	12	+	0	+	12	31	158	21	69	0
	(39)	(100)		(56)	(42)	(60)	(97)	(36)	(58)	
12	11	0	0	81	2	+	0	15	0	0
	(92)			(17)	(100)	(100)		(39)		
13	67	0	0	27	3	0	0	9	0	0
	(50)			(53)	(100)			(24)		
14	14	+	0	0	45	1	5	1	11	0
	(54)	(100)			(26)	(34)	(63)	(59)	(70)	
15	14	0	0	6	4	1	0	13	42	0
	(100)			(33)	(68)	(100)		(58)	(32)	
16	134	0	0	20	0	16	0	2	0	0
	(74)			(90)		(62)		(41)		
17	3	32	10	14	11	0	0	2	5	6
	(15)	(38)	(49)	(94)	(30)			(37)	(40)	(20)
18	0	156	122	0	76	0	0	11	5	16
	(0)	(51)	(64)		(85)			(42)	(68)	(34)
19	3	174	179	11	38	3	0	21	30	81
	(40)	(21)	(21)	(36)	(31)	(76)		(18)	(69)	(35)

+ < 0.5 t.

Table 8: Number of biological and length frequency records.

Species code	Measurement method	Length frequency data No. of samples	Length frequency data No. of fish	Biological data+ No. of samples	Biological data+ No. of fish	Biological data+ No. of otoliths or spines	No. of tagged fish
BAR	1	76	3 258				
BCO	2	12	506				
BRI	2	8	16				
CAR	2	37	655	37	655		
CBI	2	30	1 932	26	1 213		
EGR	5	4	4	4	4		
ELE	1	11	130				
ERA	5	12	20	13	21		
ESO	2	17	467				
FRO	1	24	810				
GSH	G	31	939				
GUR	1	45	3 088	42	592	338	
HAK	2	20	613				
HAP	2	4	5				
HOK	2	27	2 236				
JDO	2	31	317				
JMD	1	26	117				
JMM	1	5	9				
JMN	1	31	1 990				
KAH	1	3	6				
KIN	1	1	1				
LEA	2	16	1 578				
LIN	2	38	328	17	137	38	
LSO	2	28	575				
MDO	2	2	2				
MOK	1	1	5				
NSD	4	15	59				
OPE	2	3	58				
RBM	1	4	9				
RCO	2	56	3 911	56	1 118	330	
RSK	5	29	93	29	93		40
SCH	2	64	1 086	63	902		151
SDO	2	19	1 574	19	721		
SFL	2	19	860				
SKI	1	10	47				
SNA	1	13	238				
SPD	2	66	4 193	65	2 842	501	
SPE	2	40	1 896				
SPO	2	39	349	39	349		29
SSH	2	2	16				
SSK	5	10	14	10	14		3
STA	2	58	1 045	58	694	418	
SWA	1	36	417				
TAR	1	63	3 108	60	1 568	388	641
THR	2	2	4				
TRE	1	1	4				
TUR	2	4	8				
WAR	1	42	823	1	3		
YBF	2	1	74				

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

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	11	0	0	0	0	5	0	0	0	0	
21–30	57	0	0	0	0	42	1	0	0	0	
31–40	58	10	0	0	0	48	3	0	0	0	
41–50	15	53	30	3	1	31	2	0	0	0	
51–60	4	42	35	3	0	32	39	2	2	0	
61–70	0	5	7	1	1	3	76	3	0	0	
> 70	0	0	0	0	0	0	9	0	0	0	
Total	145	110	72	7	2	161	130	5	2	0	634
Red cod											
11–20	3	0	0	0	0	7	0	0	0	0	
21–30	194	27	2	0	0	84	1	0	0	0	
31–40	112	47	18	2	1	138	15	0	0	0	
41–50	31	63	20	4	2	70	19	0	0	0	
51–60	2	3	5	1	0	37	13	8	2	0	
> 60	0	0	0	0	0	11	10	4	0	0	
Total	342	140	45	7	3	347	58	12	2	0	956
Red gurnard											
< 21	8	0	0	0	0	22	0	0	0	0	
21–30	86	29	4	0	0	86	15	4	0	2	
31–40	31	59	9	2	1	49	57	35	6	2	
>40	2	7	2	2	2	3	28	20	3	3	
Total	127	95	15	4	3	160	100	59	9	7	579
Tarakihi											
11–20	69	2	0	0	0	56	1	0	0	0	
21–30	119	14	0	1	0	137	2	0	0	0	
31–40	11	12	23	29	30	47	164	15	4	3	
>40	0	1	5	5	4	2	71	9	1	1	
Total	199	29	28	35	34	242	238	24	5	4	838

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: Spiny dogfish

Length (cm)	Males Gonad stage 1	2	3	4	5	Females Gonad stage 1	2	3	4	5	6	
Spiny dogfish												
<40	18	0	0	0	0	22	1	0	0	0	0	
41–50	46	9	0	0	0	40	4	0	0	0	0	
51–60	9	8	35	16	0	25	40	0	0	0	0	
61–70	1	1	171	102	0	6	53	35	3	42	4	
71–80	0	0	21	4	1	0	5	20	31	199	7	
>80	0	0	0	0	0	0	0	0	14	86	0	
Total	74	18	227	122	1	93	103	55	48	327	11	1 079

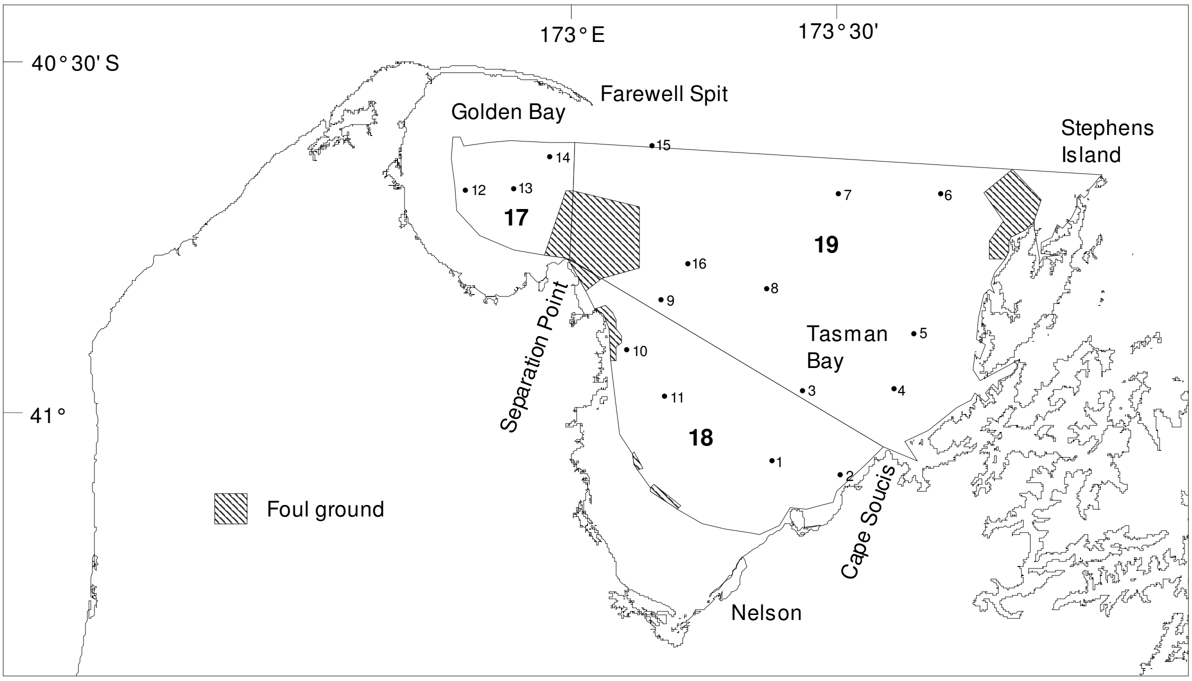
Maturity stages used were:

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)

Table 10: Comparrison of outputs from the TrawlSurvey Analysis aand SurvCalc programs.

	Species	Year	Biomass	c.v.%	Estimated population
Trawl Survey Analysis	GUR	2007	553	17.4	1 783 061
SurvCalc	GUR	2007	553	17.4	1 783 061
Trawl Survey Analysis	RCO	2007	1637.57	19.34	4 076 193
SurvCalc	RCO	2007	1637.57	19.34	4 076 194
Trawl Survey Analysis	SPD	2007	6291.03	14.05	5 027 383
SurvCalc	SPD	2007	6291.03	14.05	5 027 383
Trawl Survey Analysis	STA	2007	1629.59	12.49	792 944
SurvCalc	STA	2007	1629.59	12.49	792 945
Trawl Survey Analysis	TAR	2007	1188.96	20.85	2 240 354
SurvCalc	TAR	2007	1188.96	20.85	2 240 354



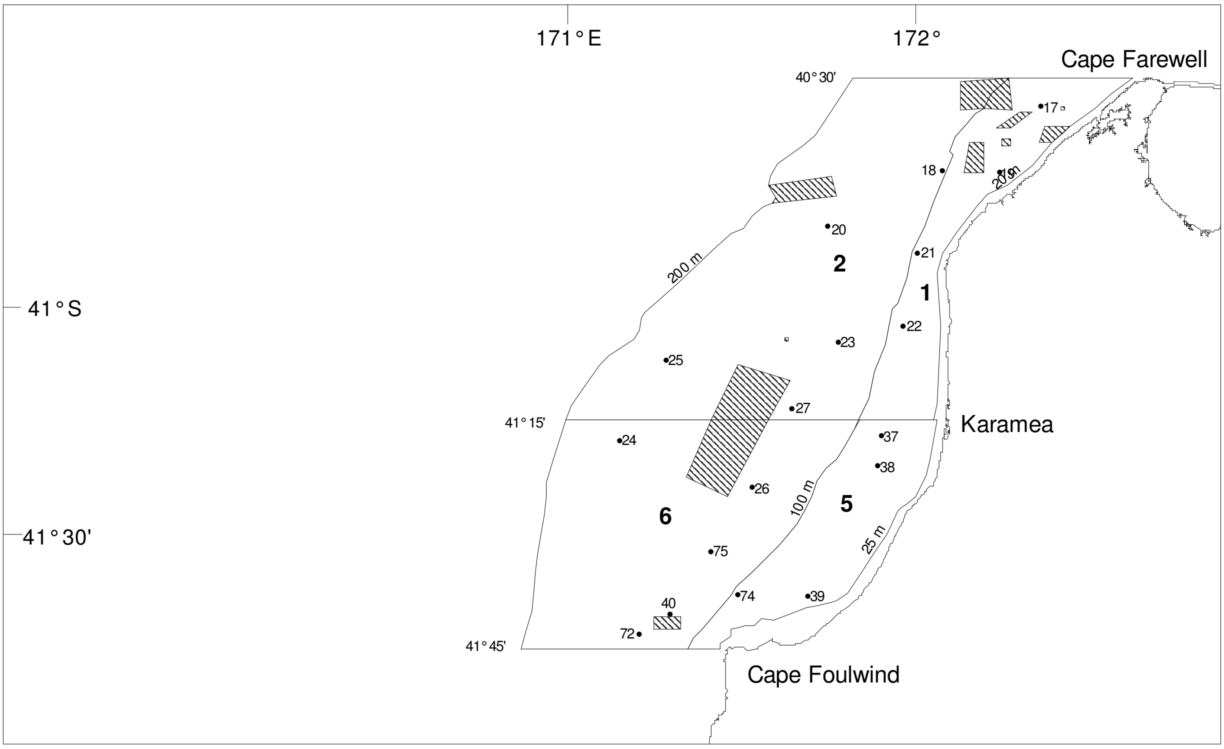


Figure 1a: Survey area showing strata boundaries and numbers (bold type) for Tasman and Golden Bays (top) and the west coast north of Cape Foulwind (bottom) with station positions and numbers.

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

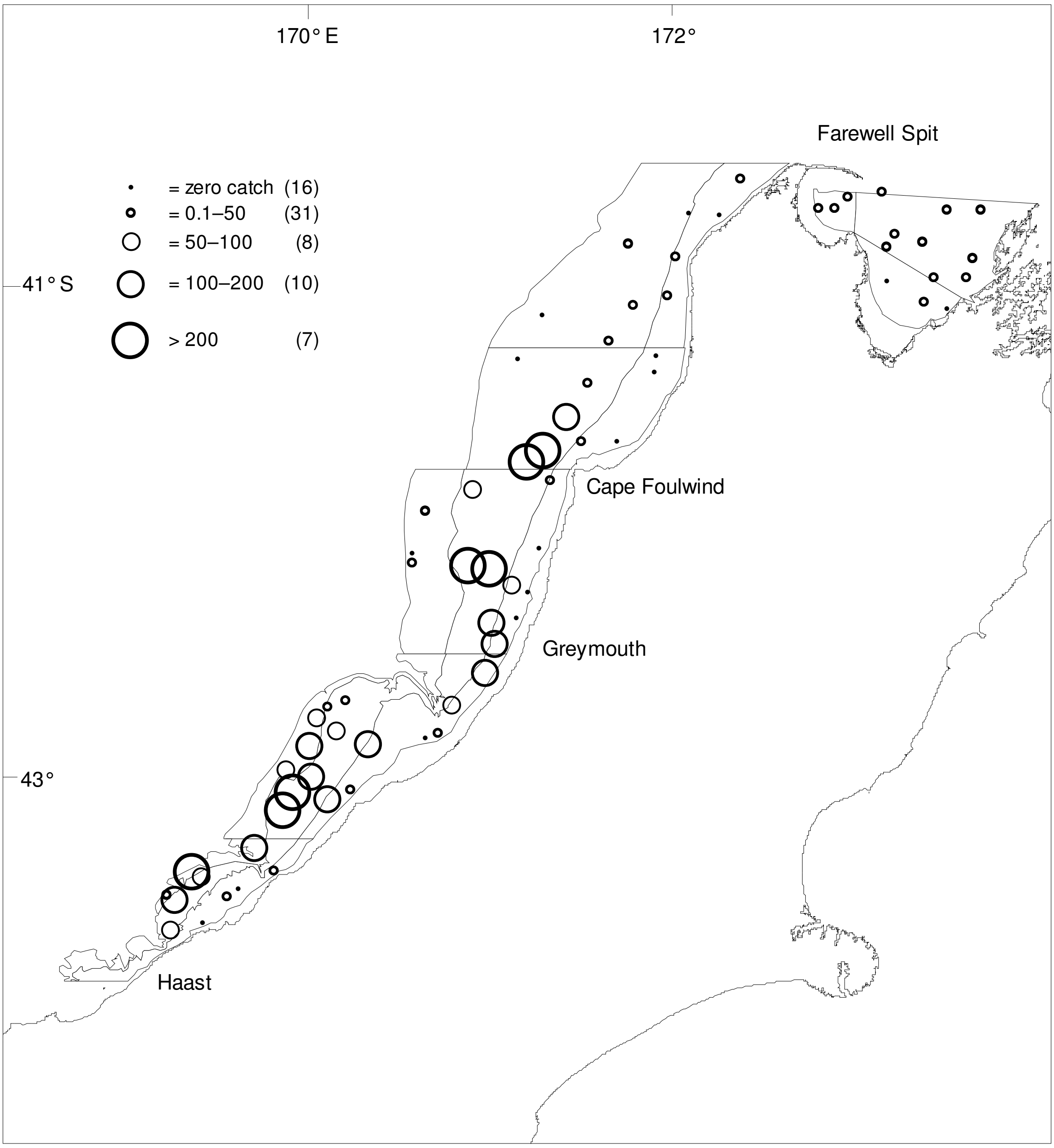


Figure 2: Catch rates (kg.km^{-2}) and distribution for the target species in alphabetical order by common name (numbers in parentheses are the number of stations within the given range).

a: Giant stargazer (maximum catch rate = 1040 kg.km^{-2})

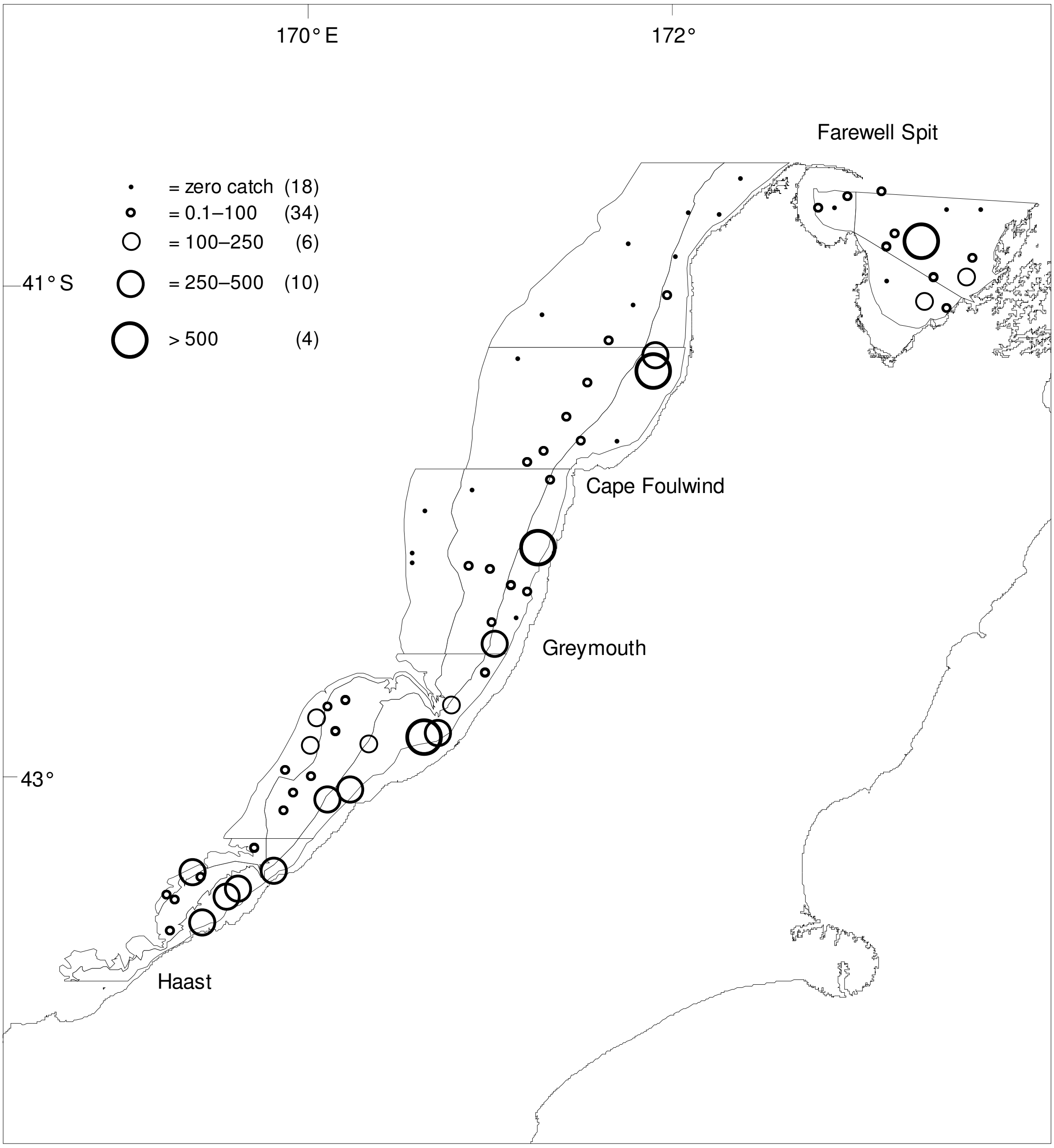


Figure 2b: Red cod (maximum catch rate = 2460 kg.km^{-2}.

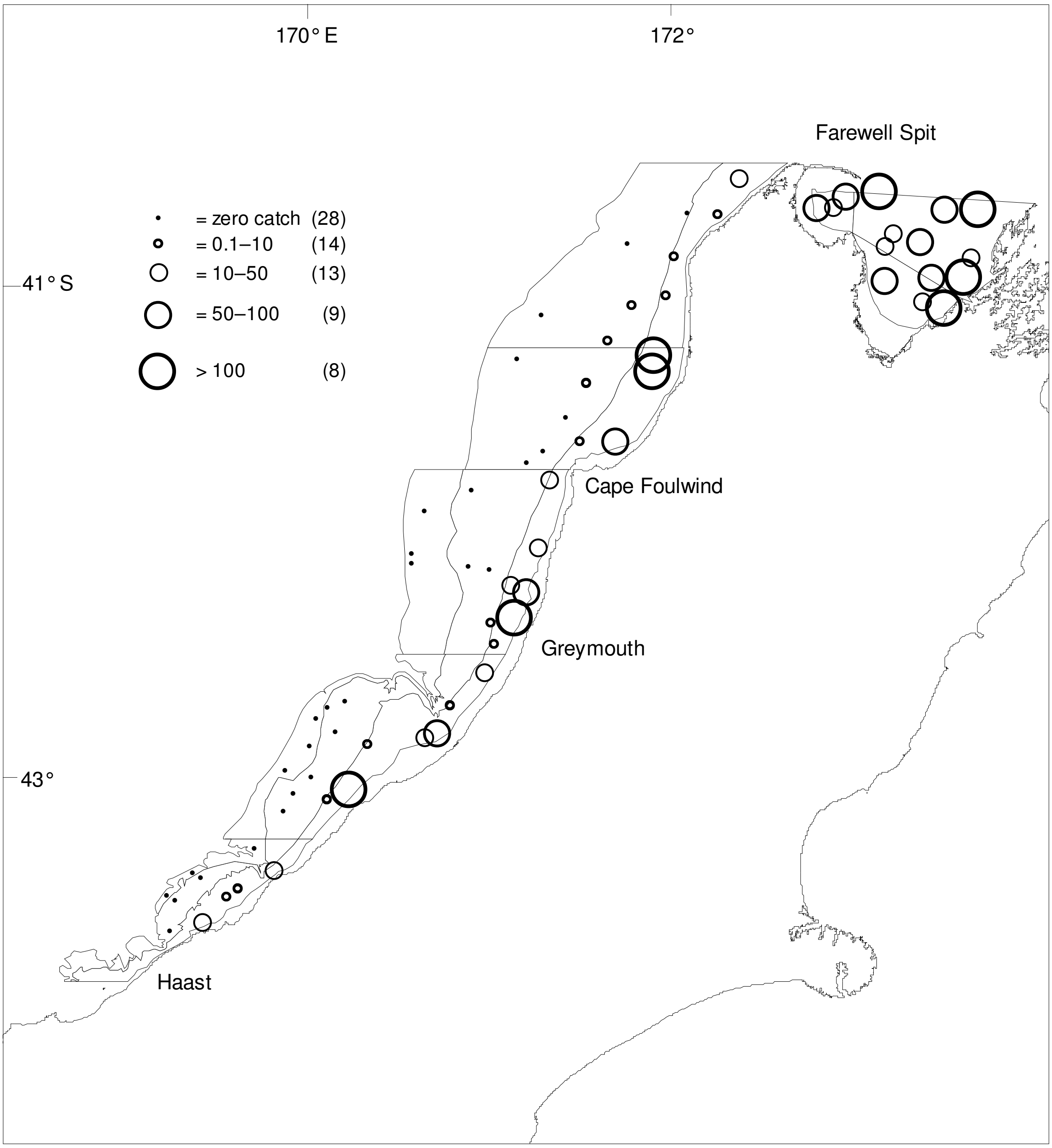


Figure 2c: Red gurnard (maximum catch rate = 380 kg.km^{-2}).

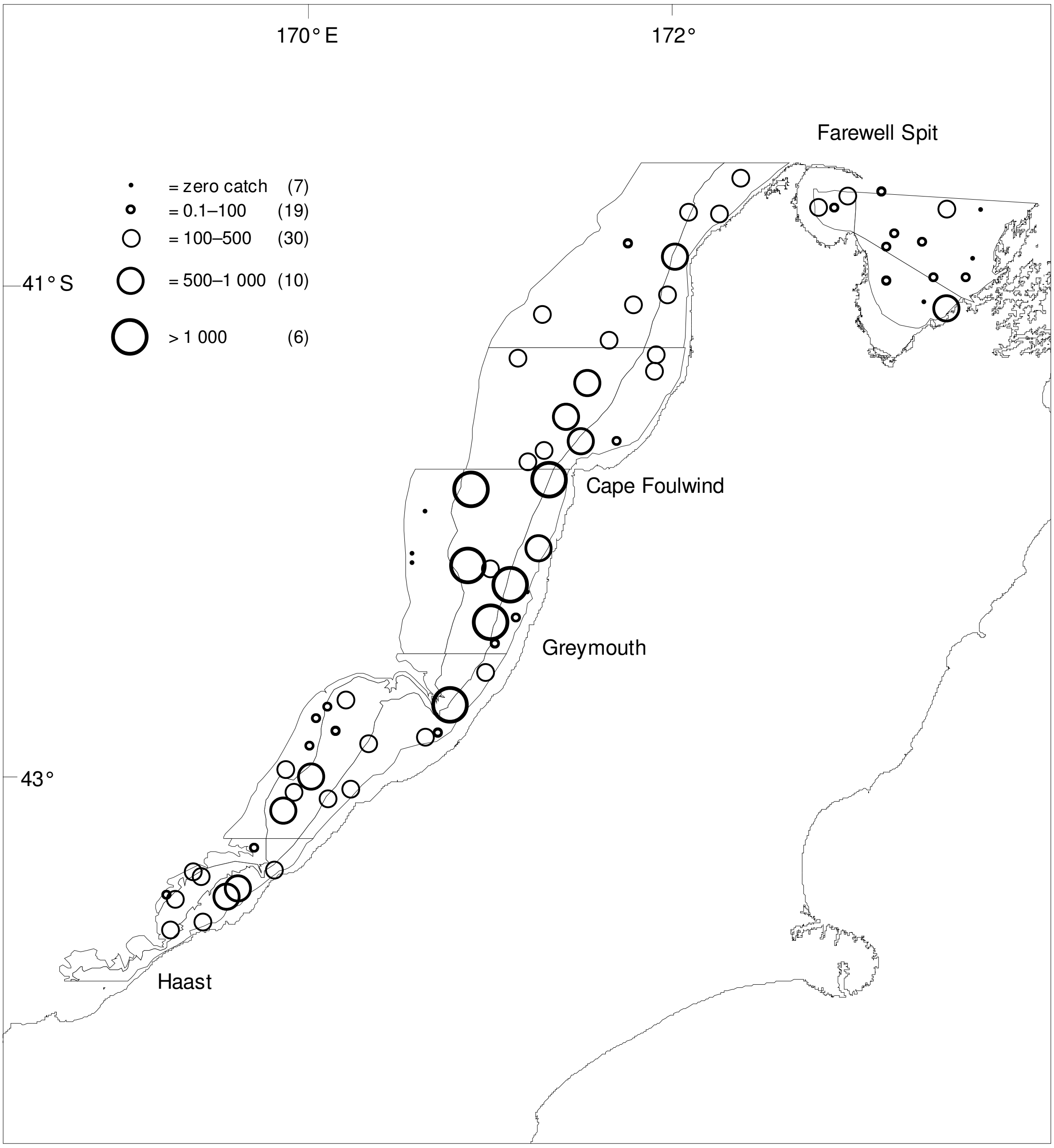


Figure 2d: Spiny dogfish (maximum catch rate = 3700 kg.km^{-2}).

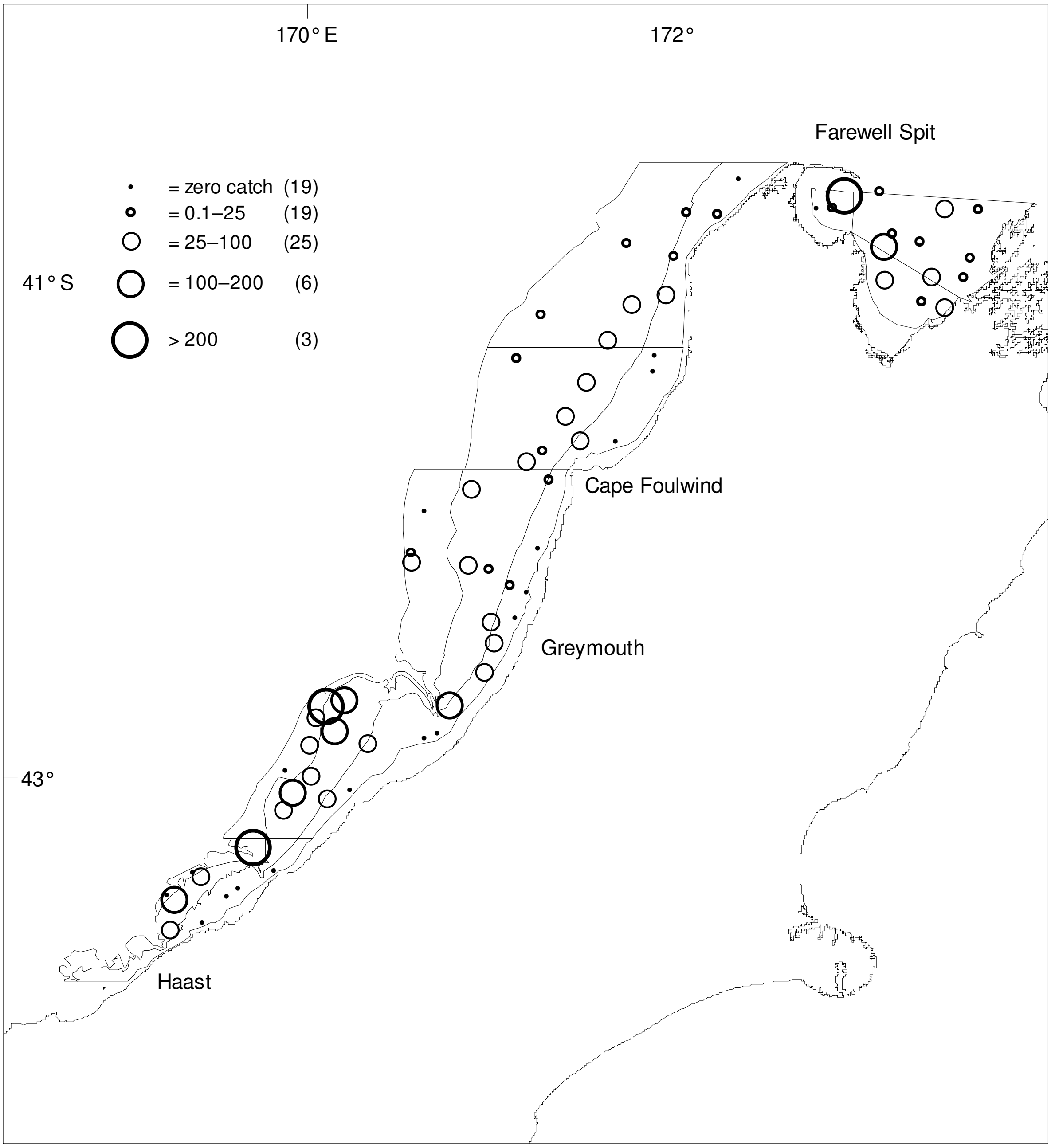


Figure 2e: Tarakihi (maximum catch rate = 720 kg.km^{-2}).

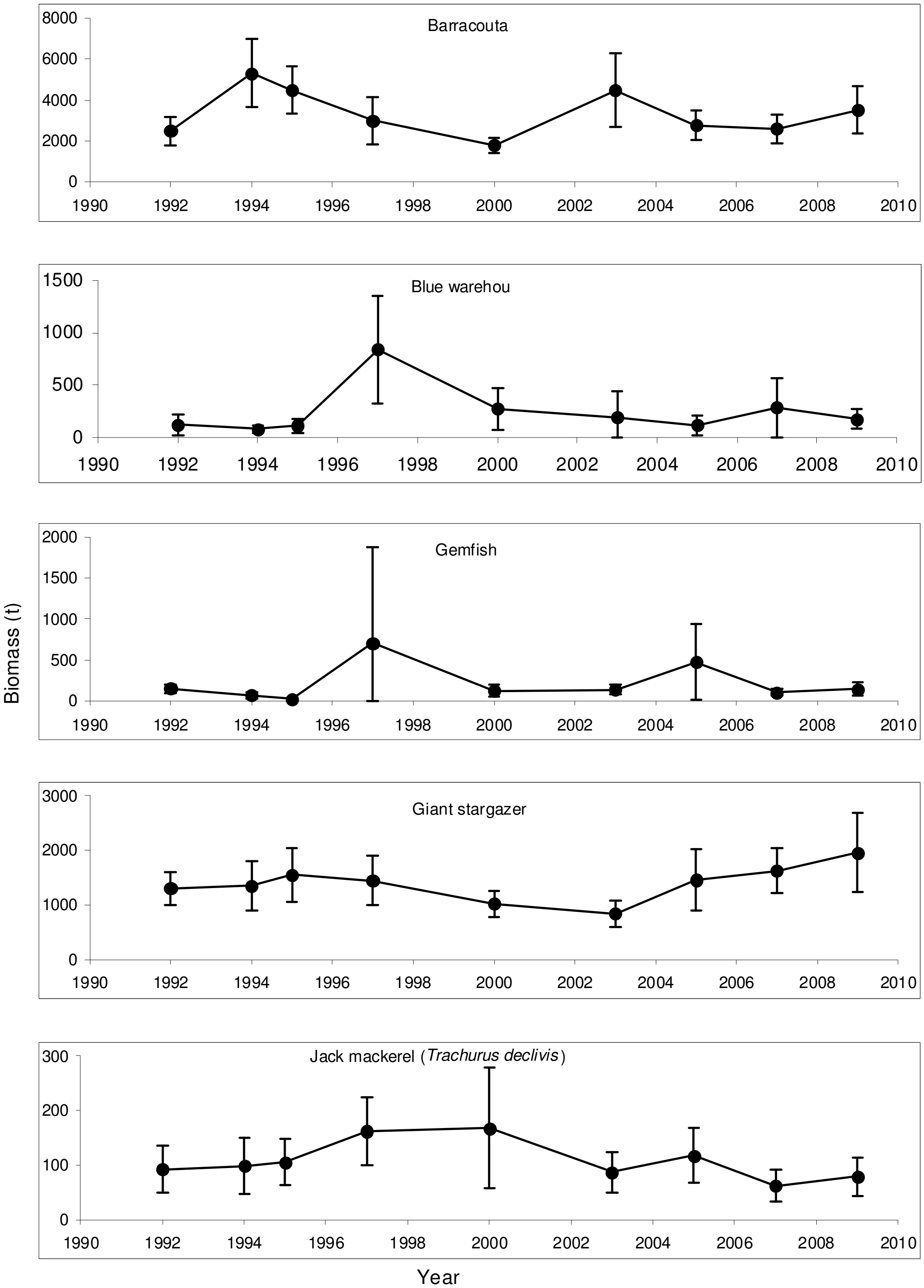


Figure 3: Trends in total biomass for the target species and other species for which the survey time series is likely to be monitoring adult or pre-recruit abundance.

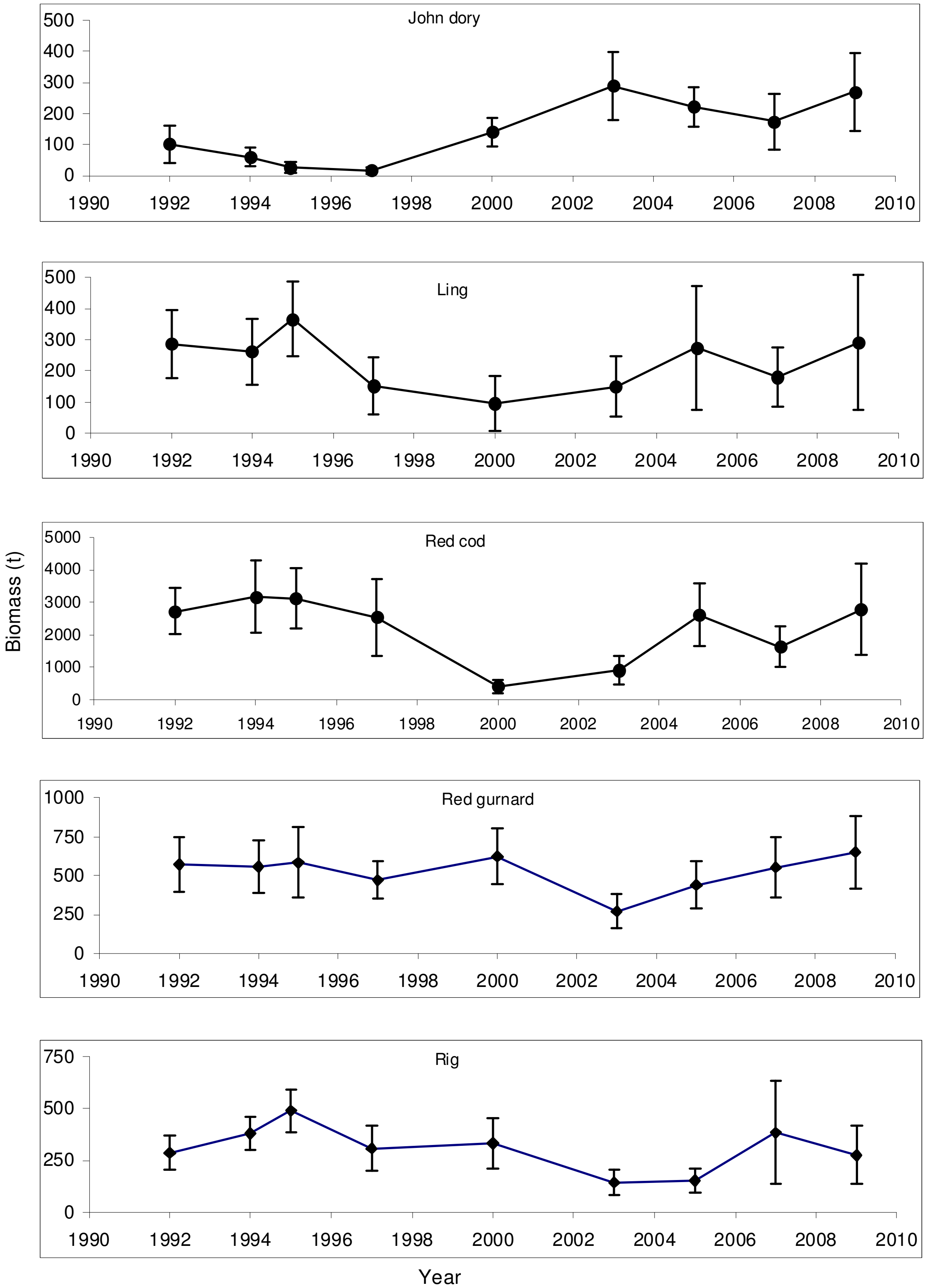


Figure 3—continued

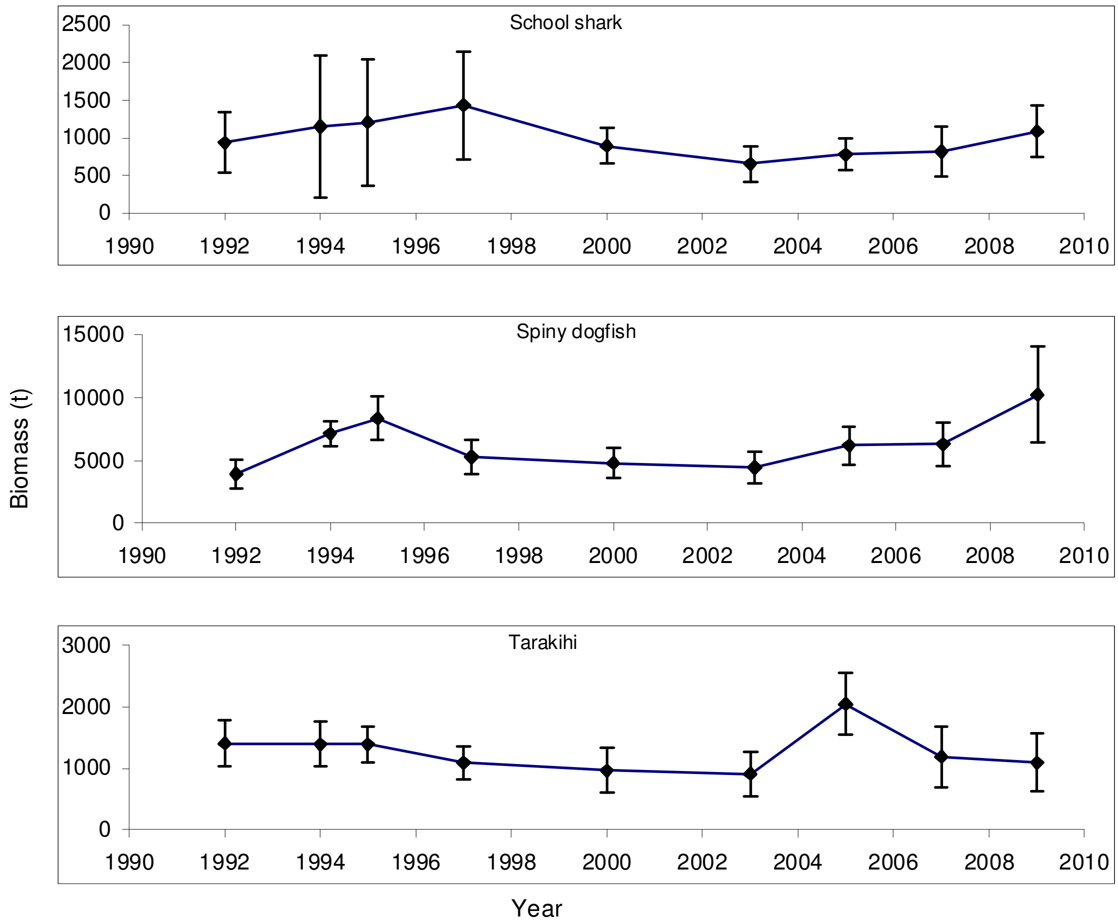


Figure 3—continued

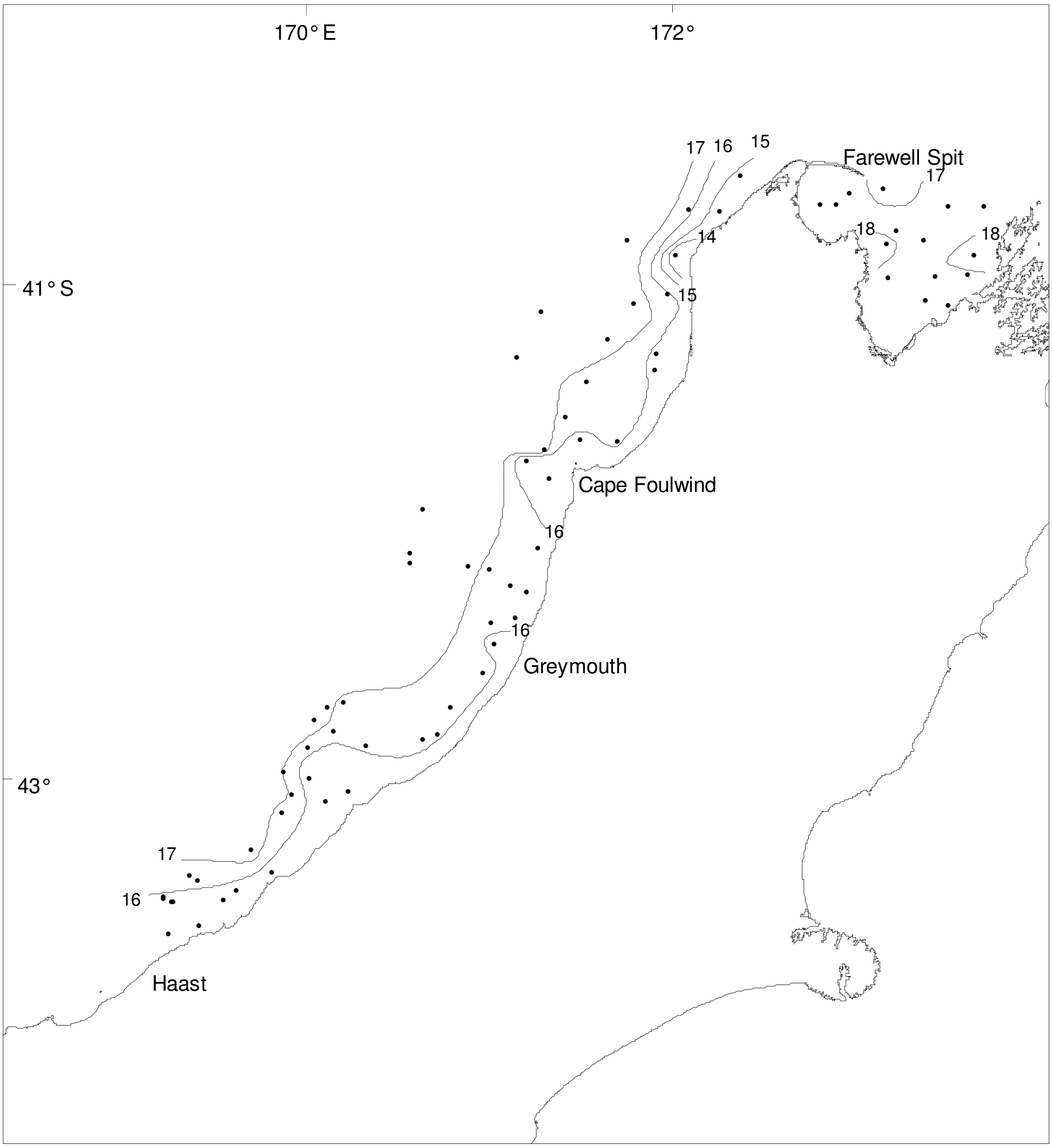


Figure 4: Positions of CTD sea surface temperature recordings and isotherms estimated from the data.

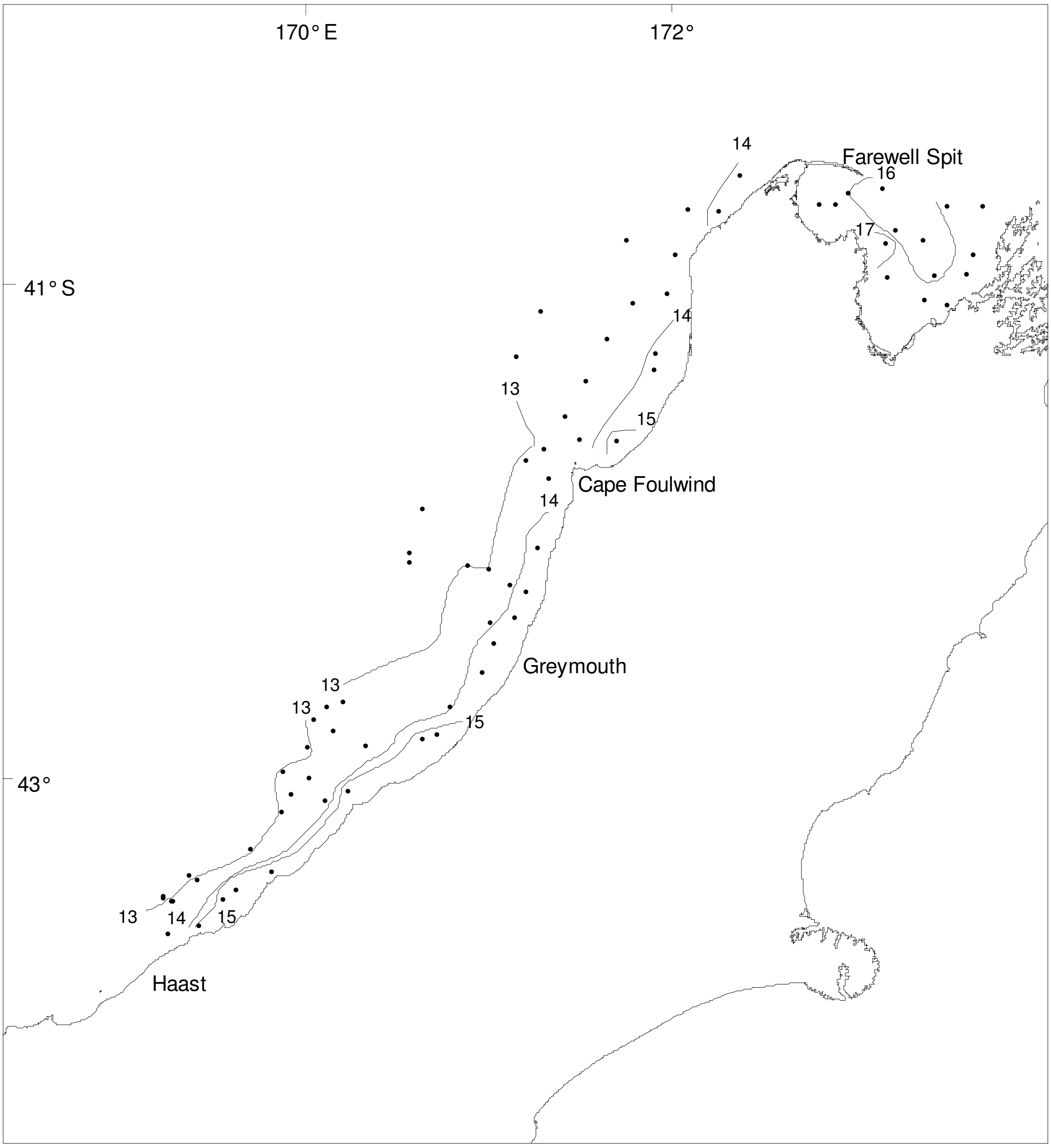


Figure 5: Positions of CTD bottom temperature recordings and isotherms estimated from the data.

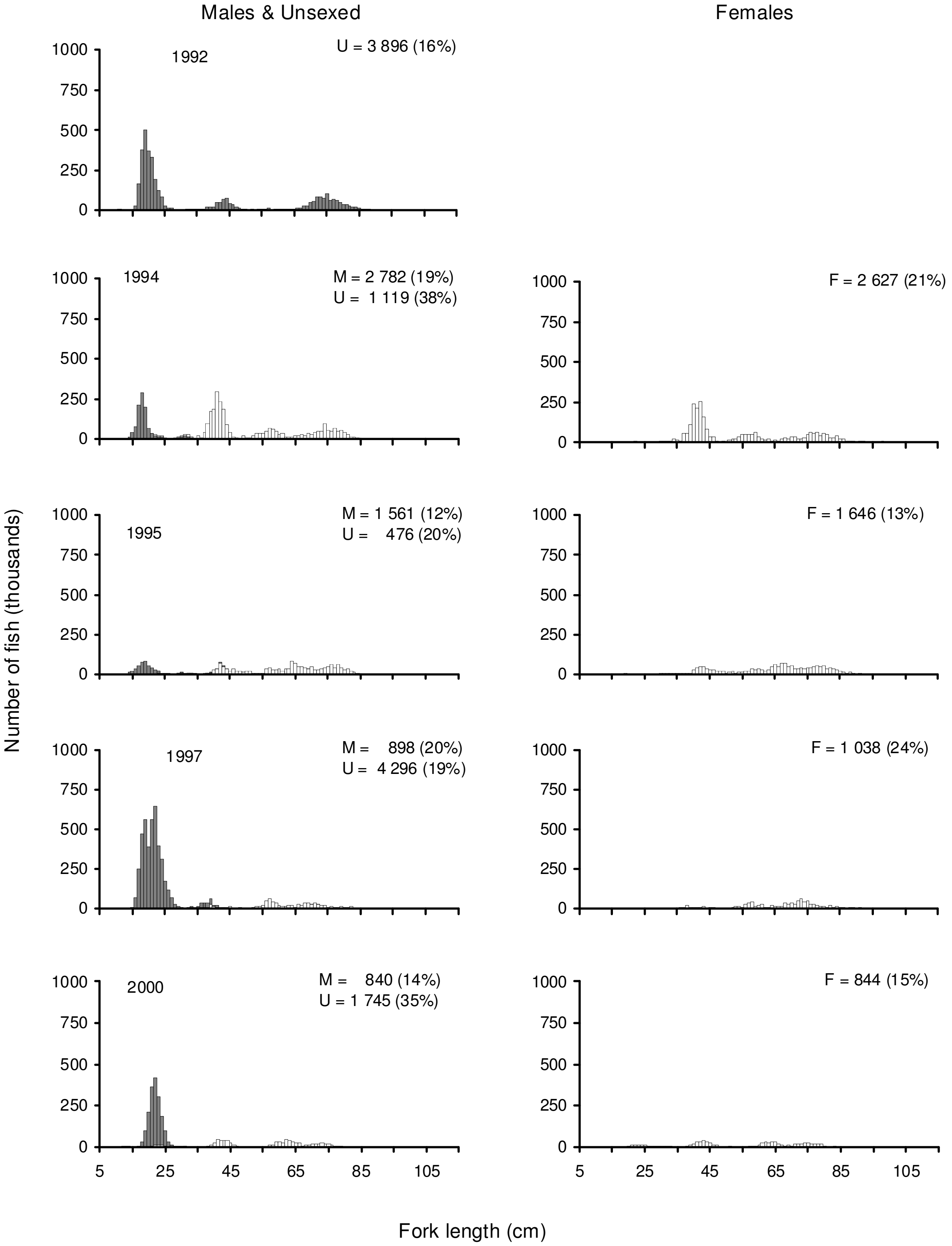


Figure 6: Comparative scaled length frequencies for the target species and those species where the surveys are monitoring adult or pre-recruit abundance. Estimated population in thousands and c.v.%. (M, males; F, females; U, unsexed)

a: Barracouta

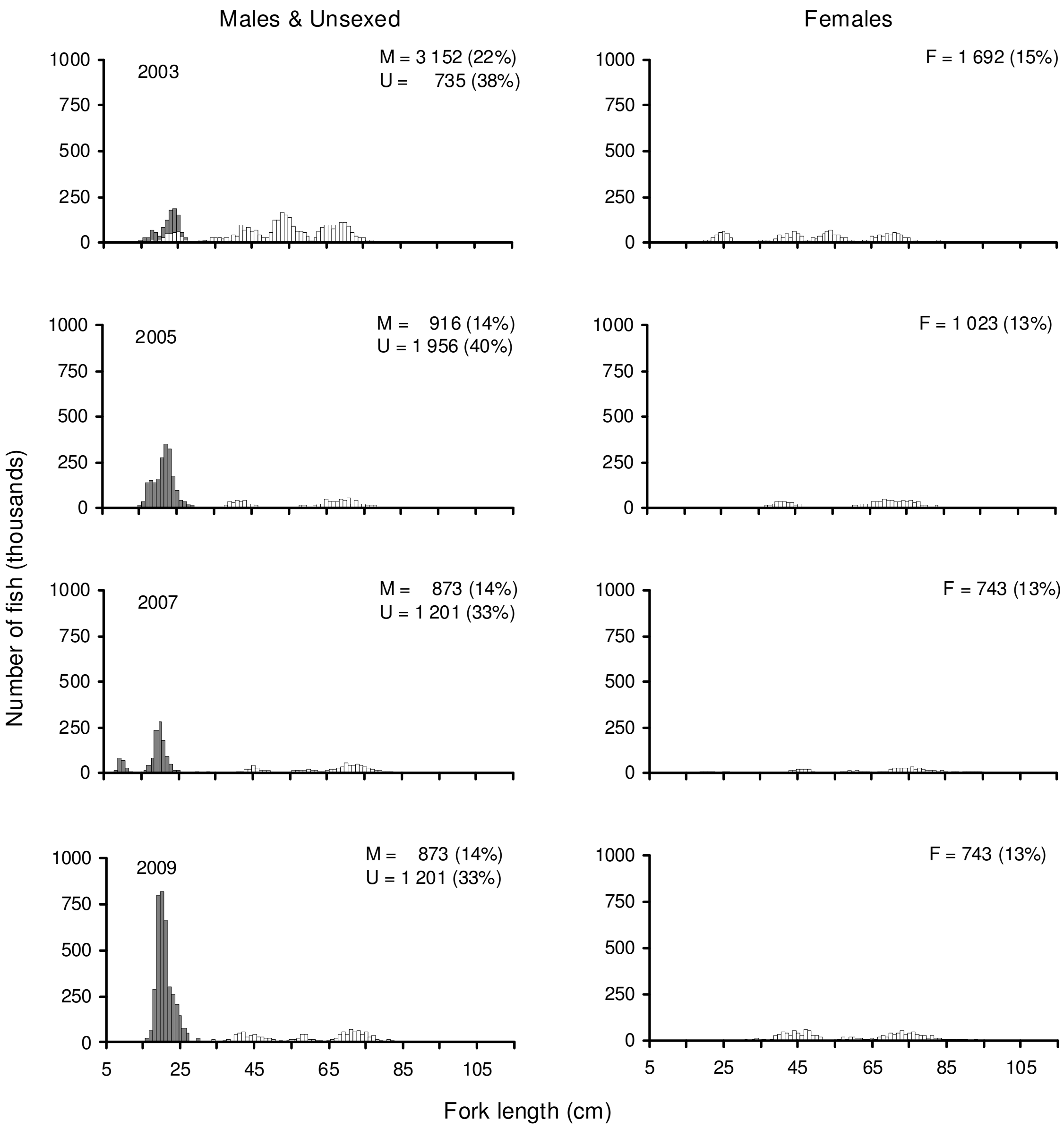


Figure 6a—continued

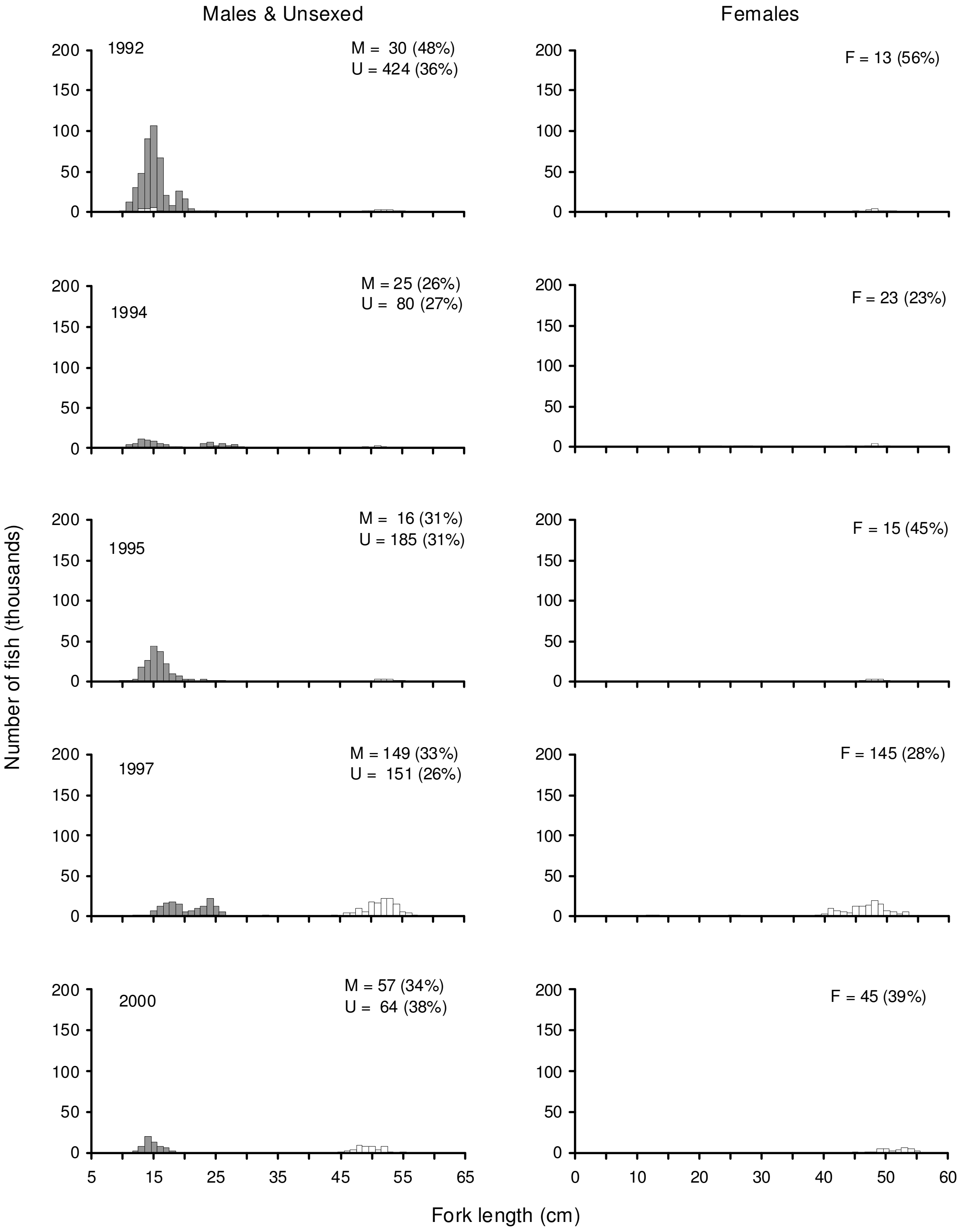


Figure 6b: Blue warehou

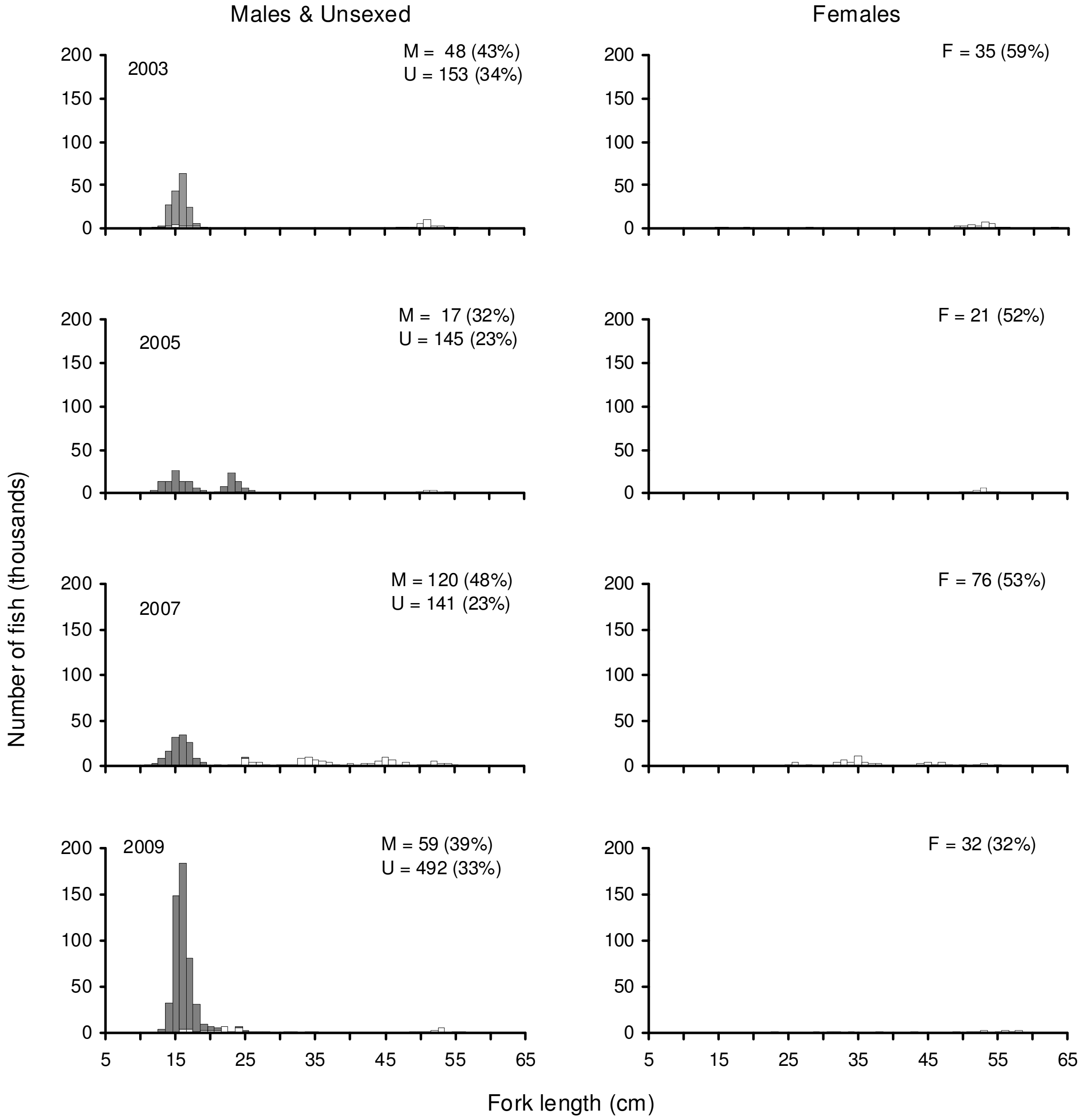


Figure 6b—continued

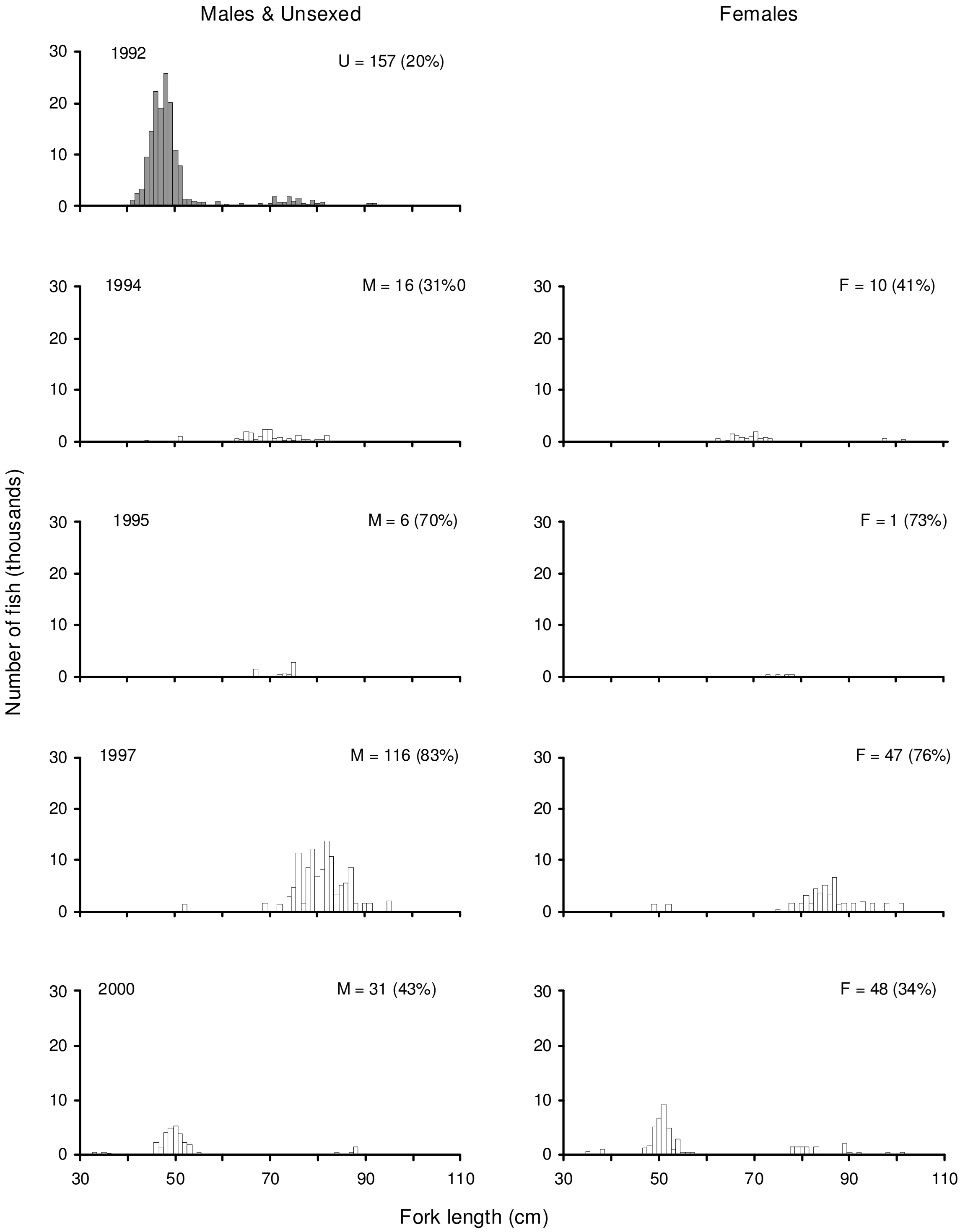


Figure 6c: Gemfish (100% of fish from the west coast).

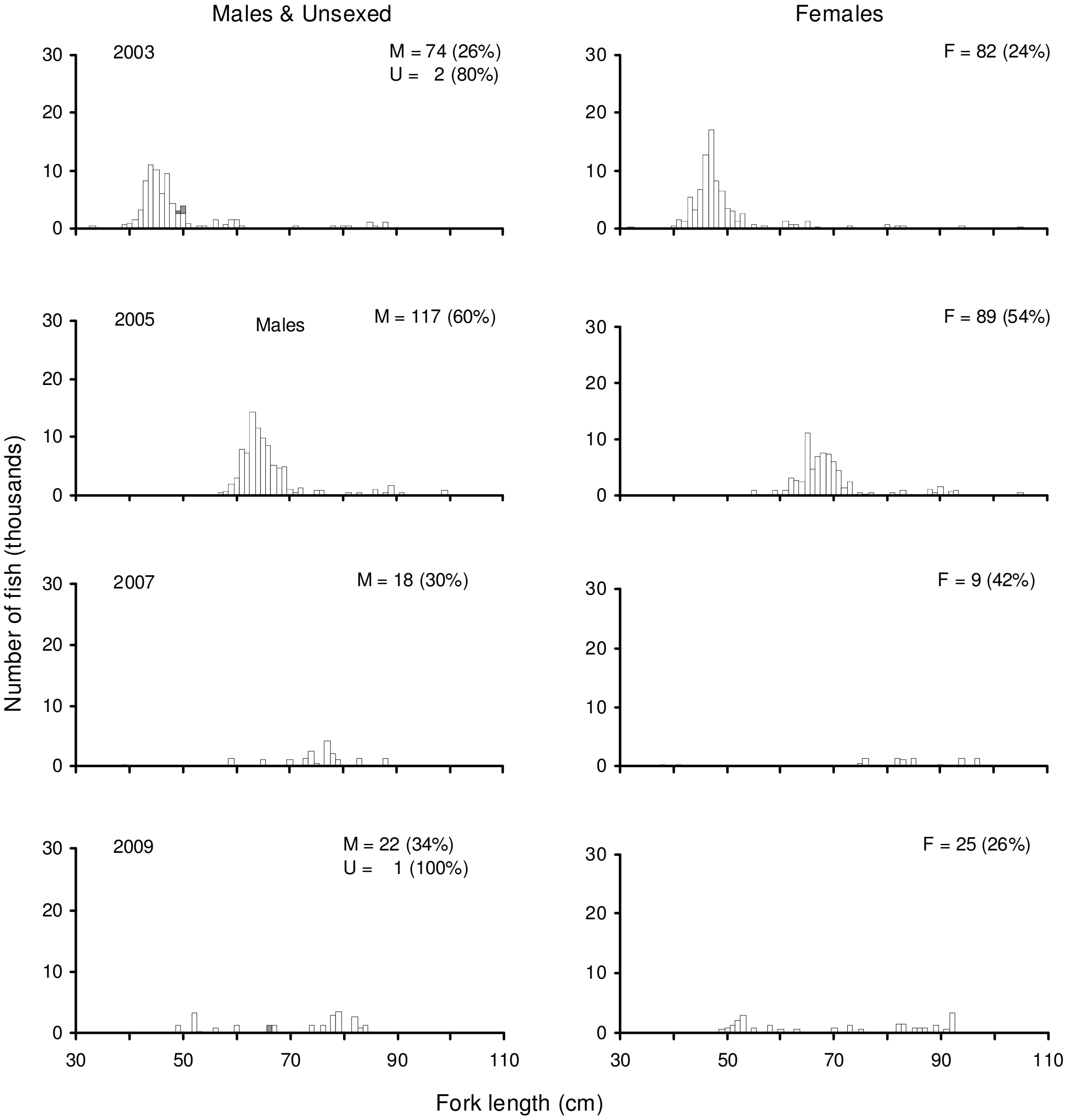


Figure 6c—continued

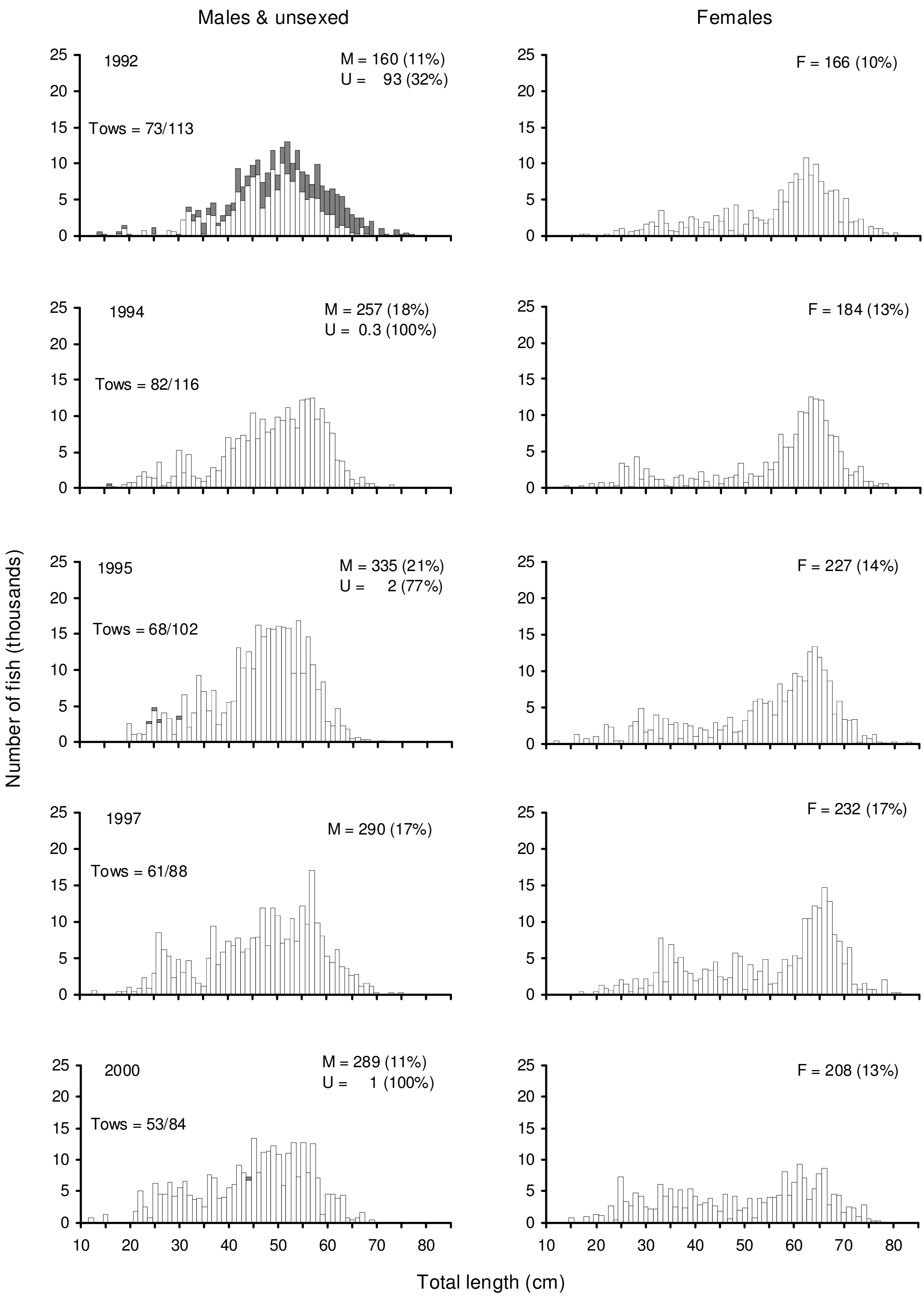


Figure 6d: Giant stargazer.

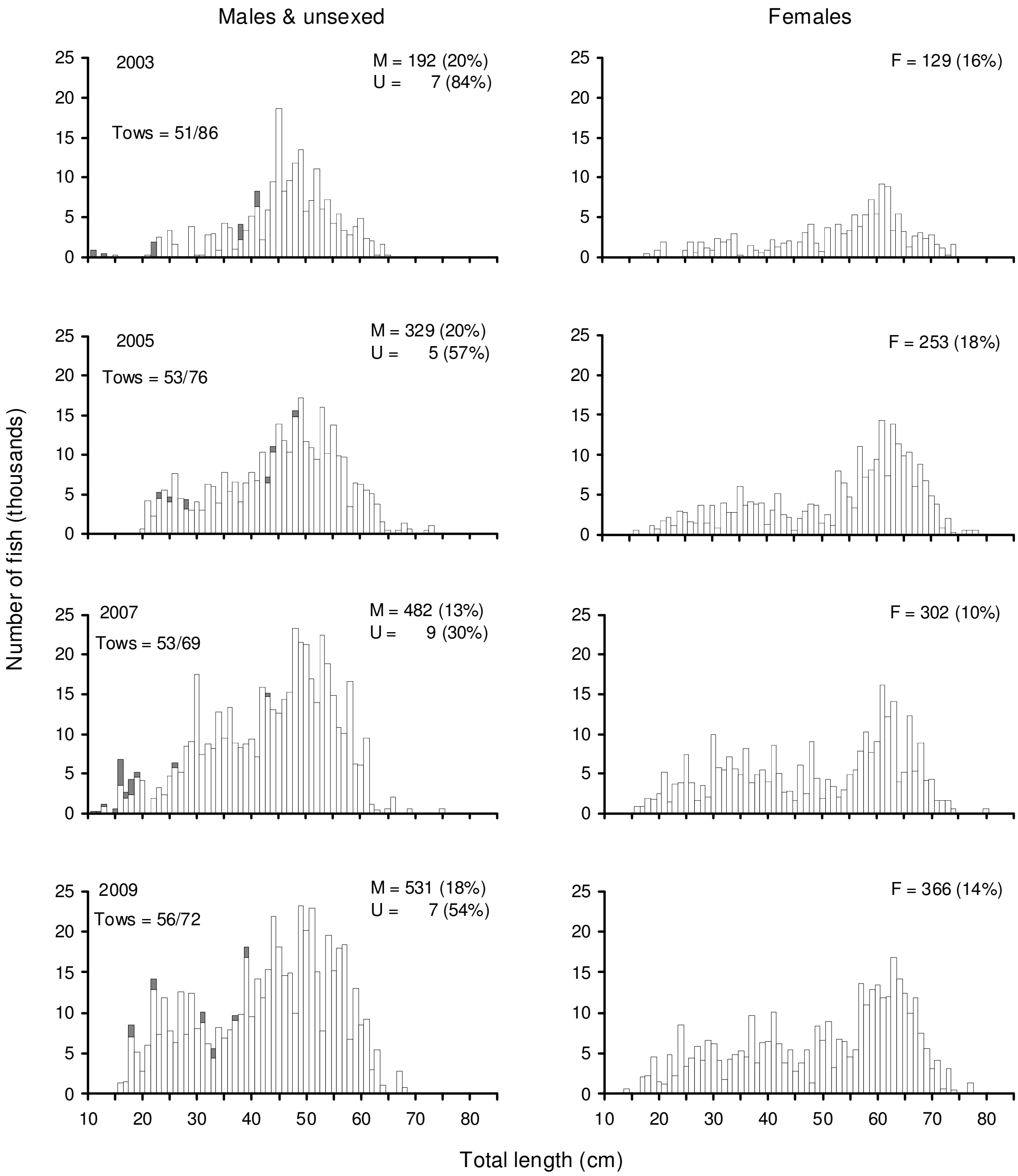


Figure 6d—continued.

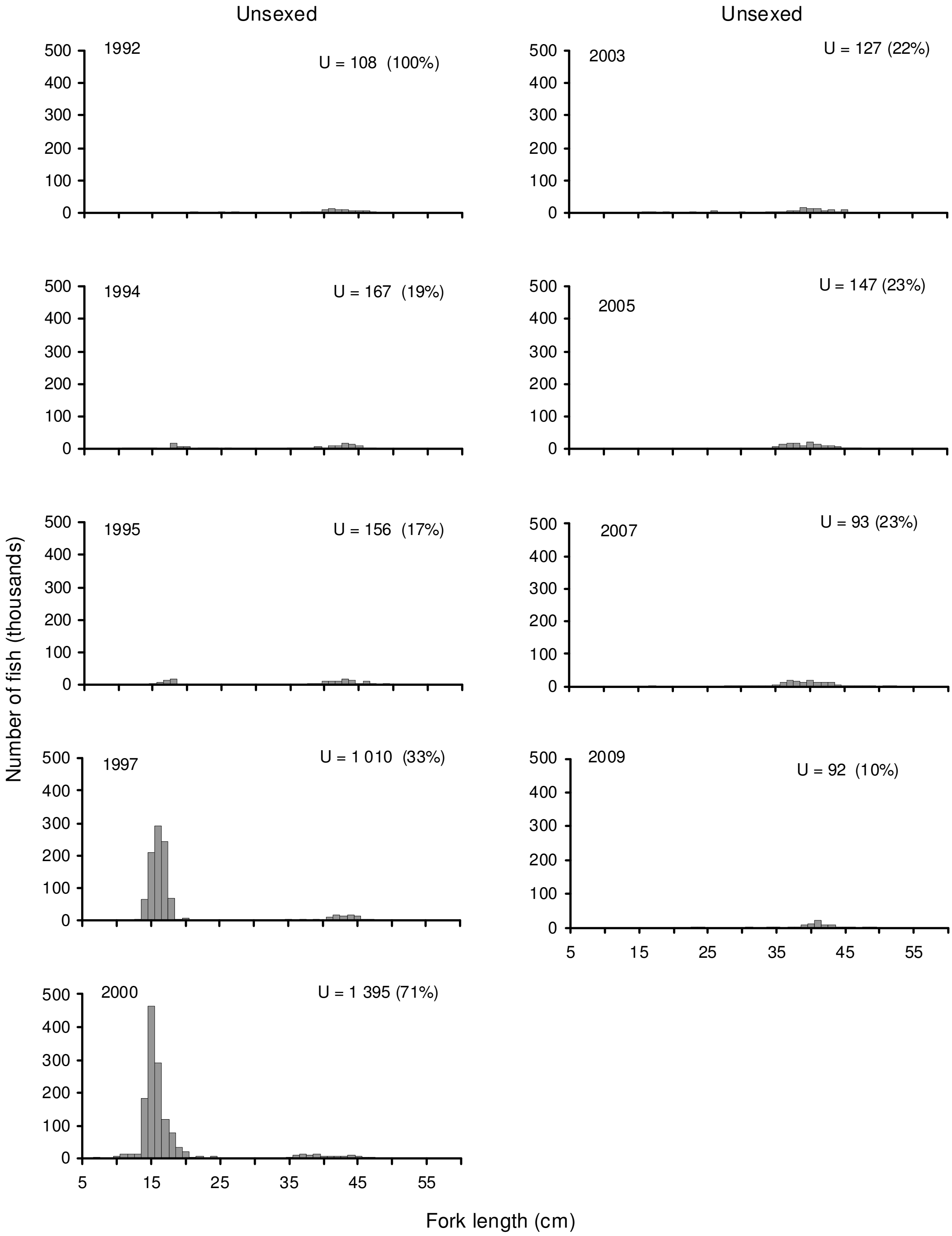


Figure 6e: Jack mackerel (*Trachurus declivis*). Fish were not sexed for some years so all years are plotted as unsexed for better comparison.

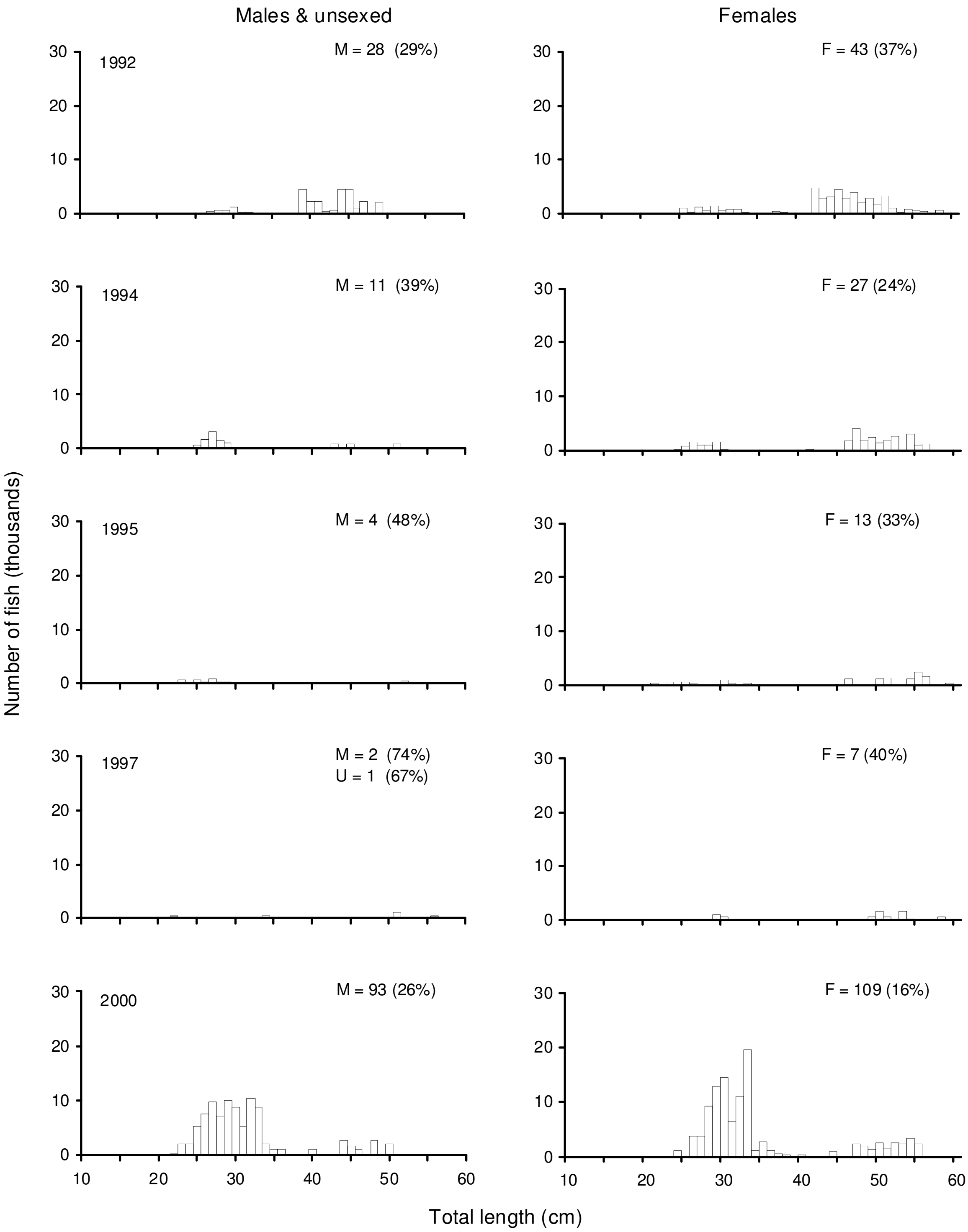


Figure 6f: John dory.

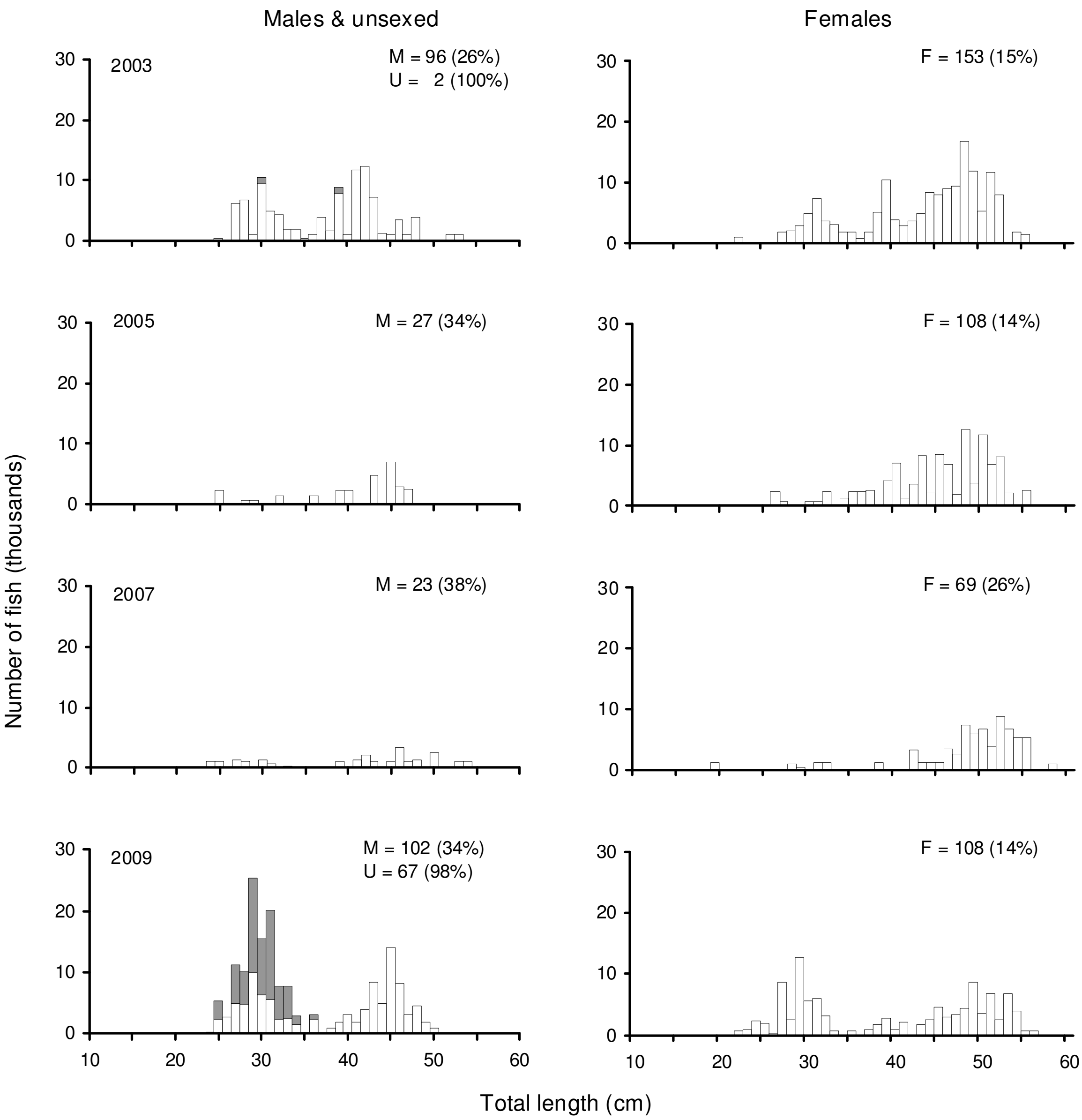


Figure 6f—continued.

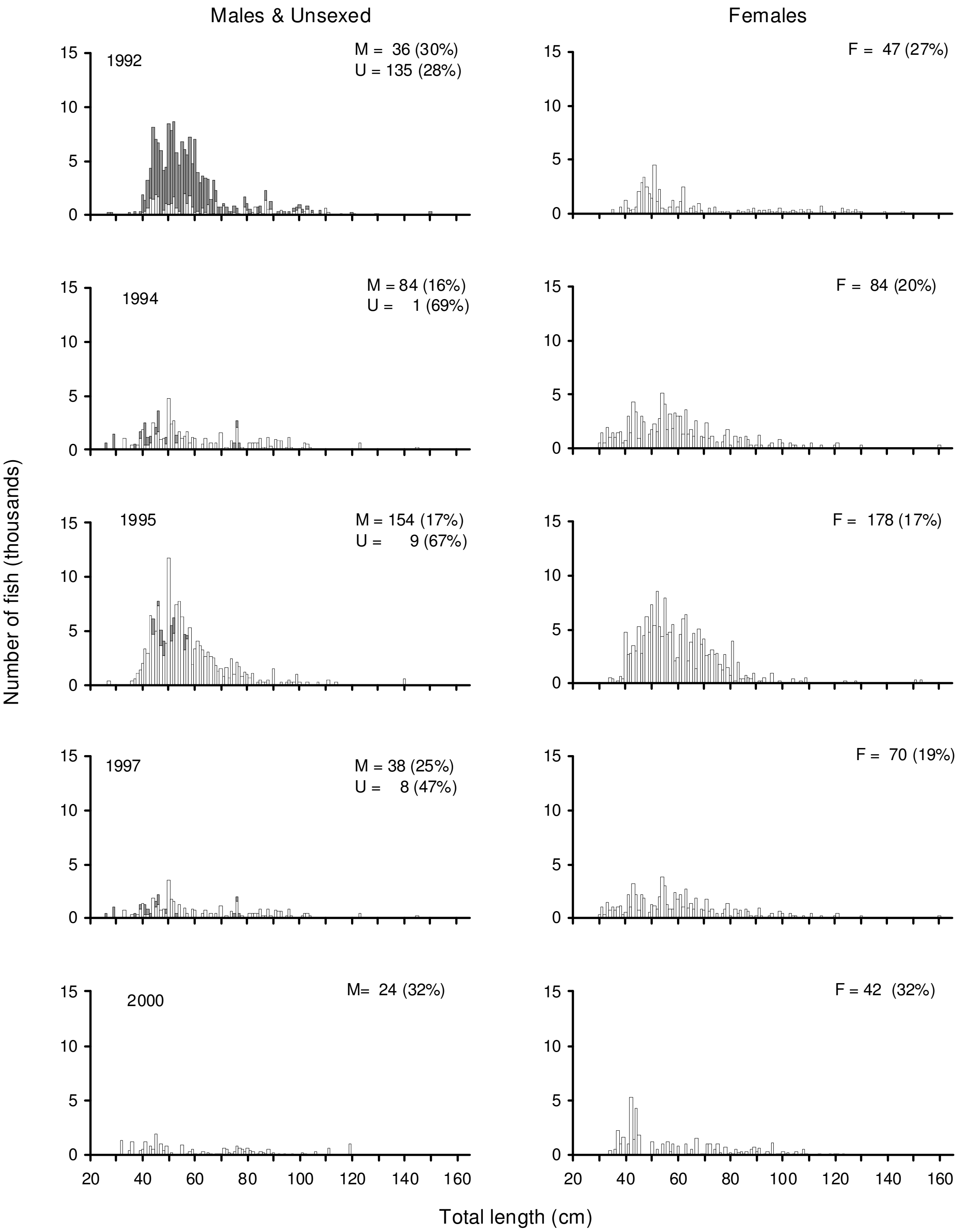


Figure 6g: Ling.

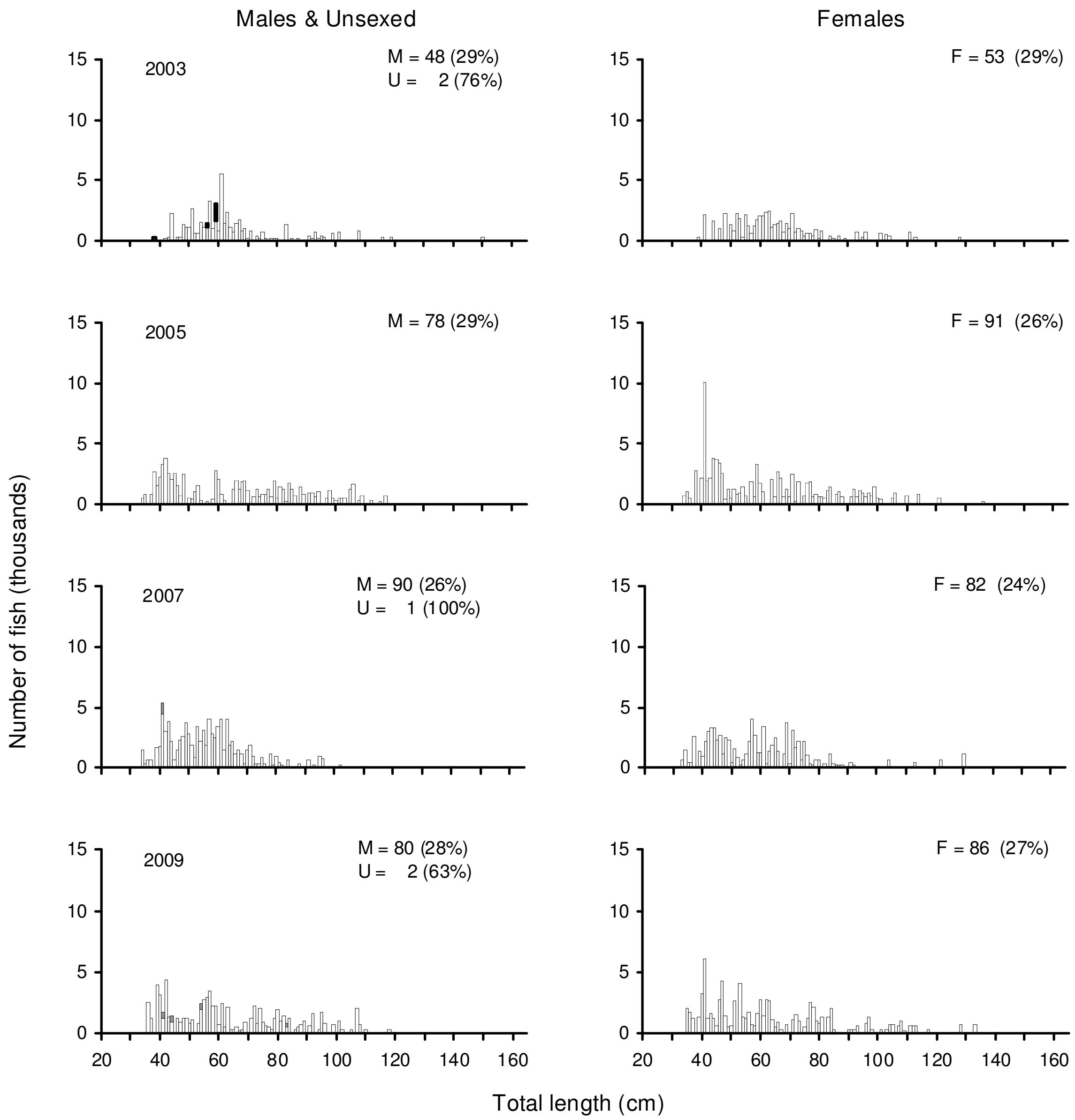


Figure 6g—continued.

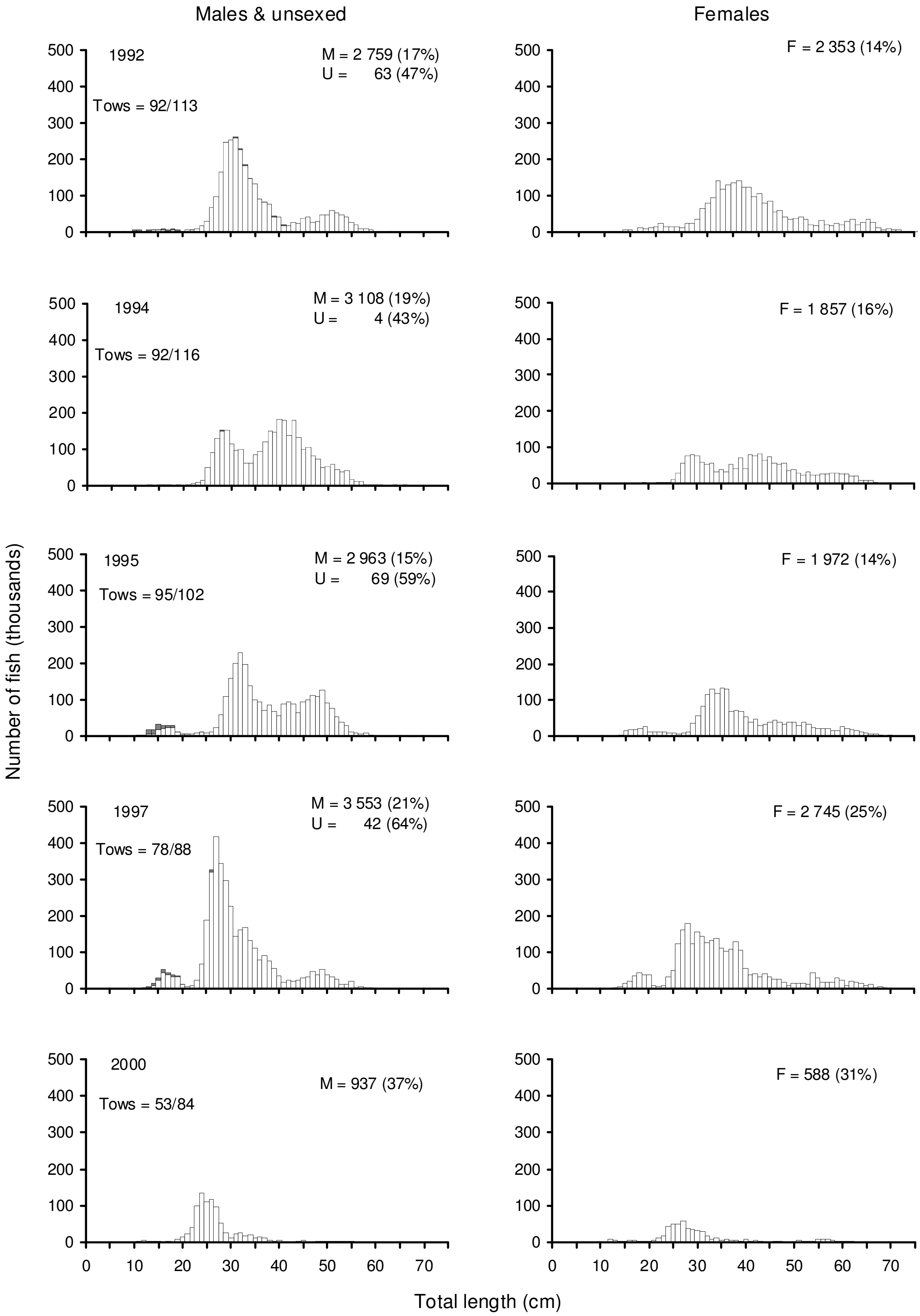


Figure 6h: Red cod.

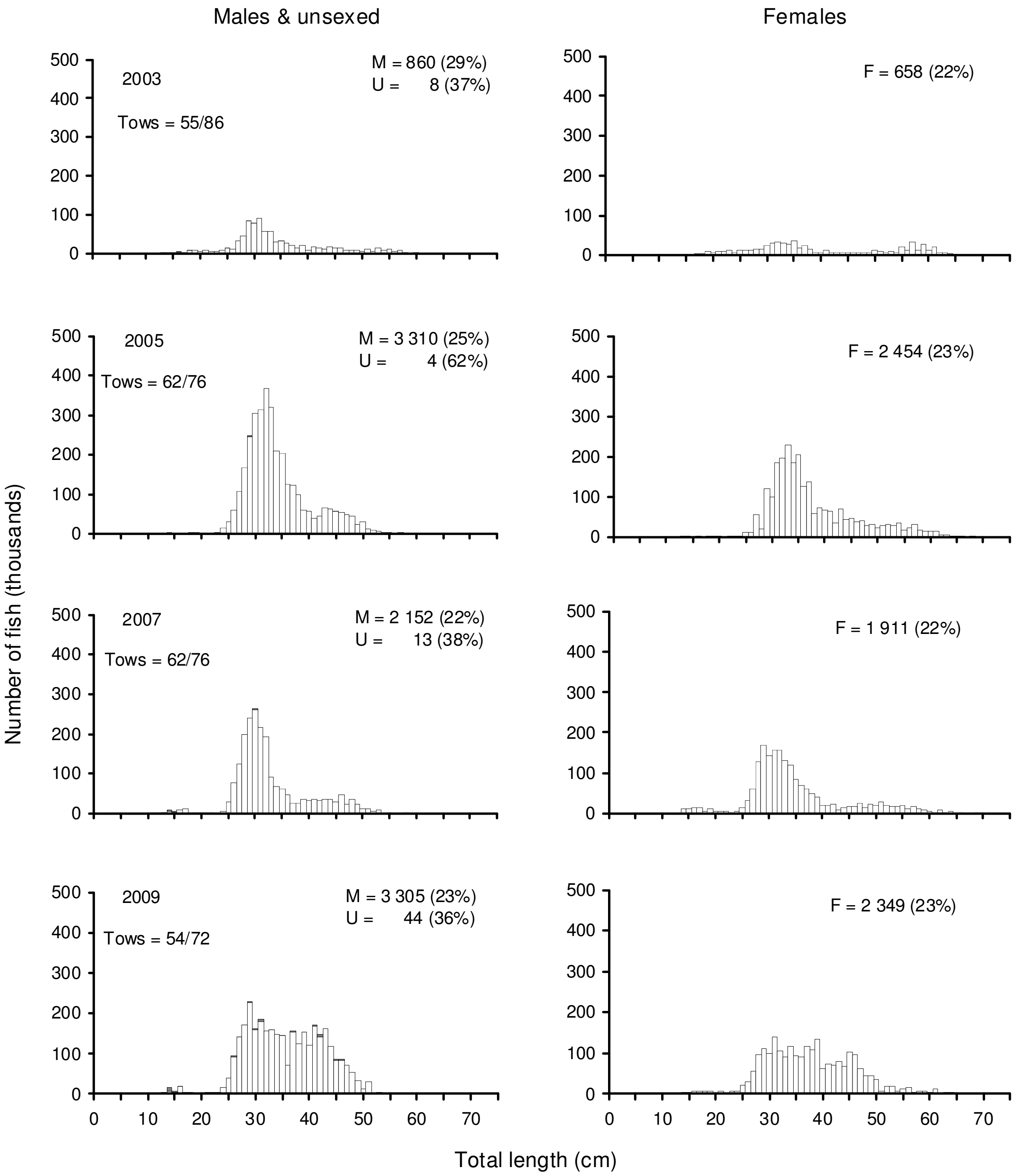


Figure 6h—continued.

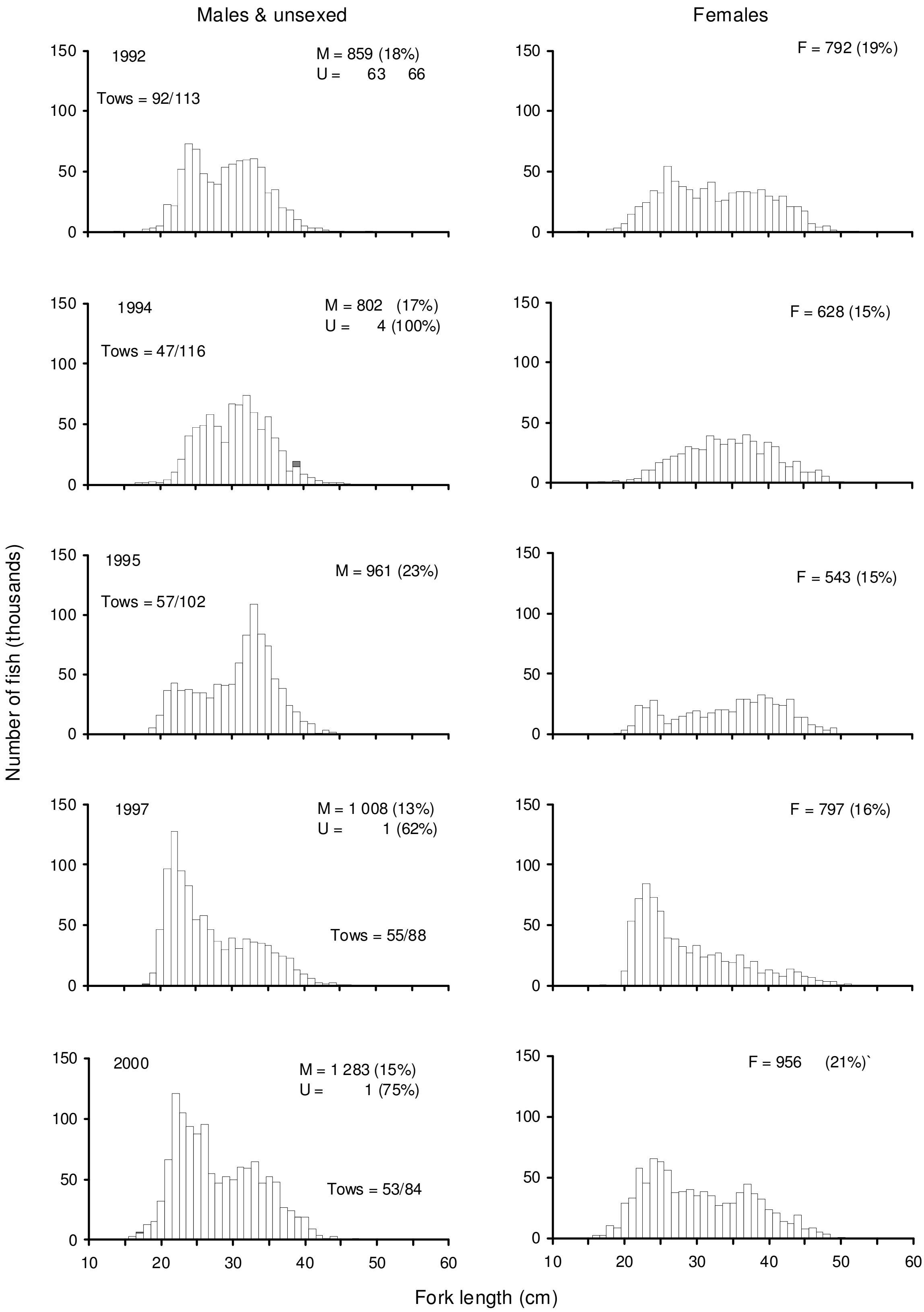


Figure 6i: Red gurnard.

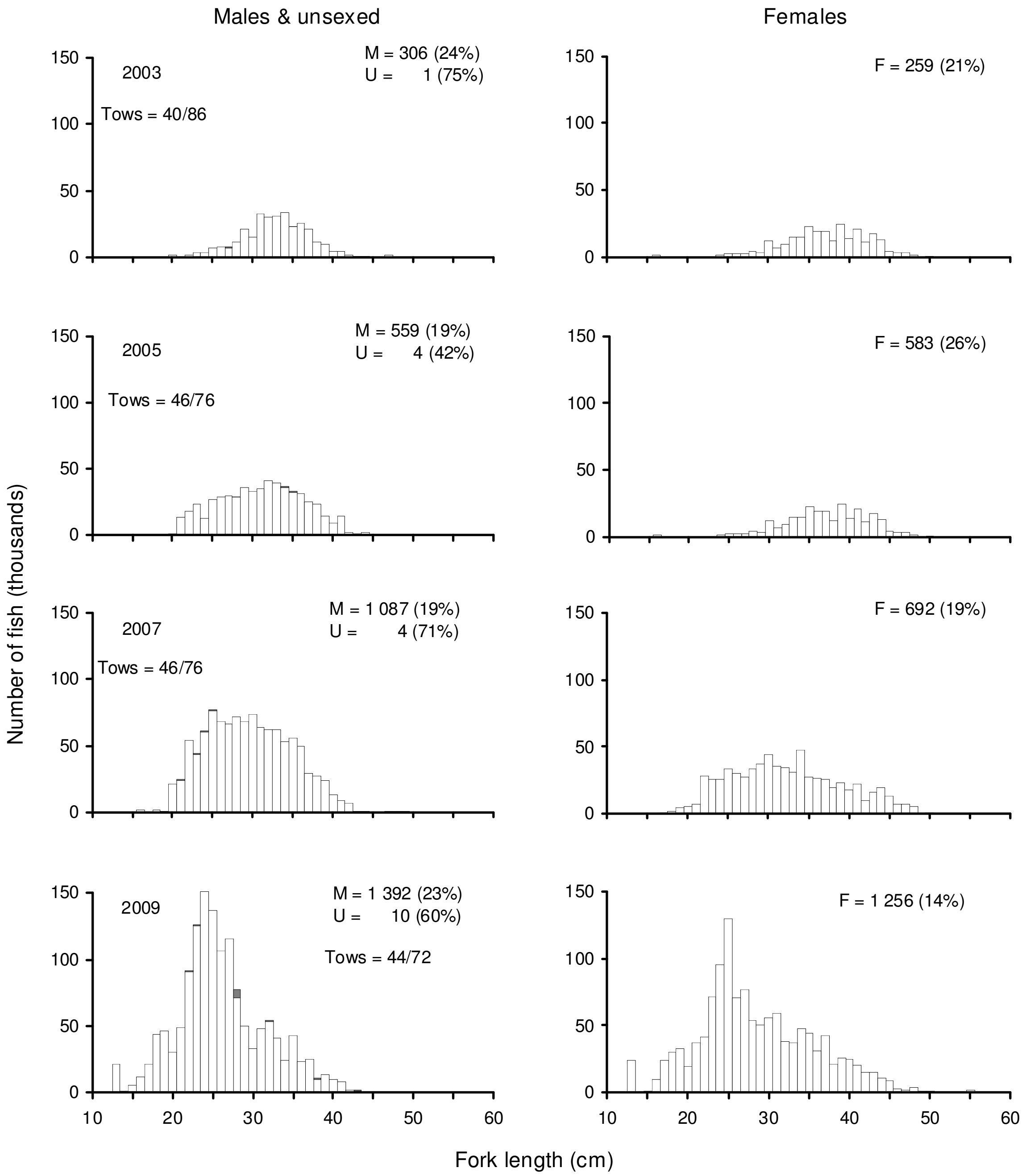


Figure 6i—continued.

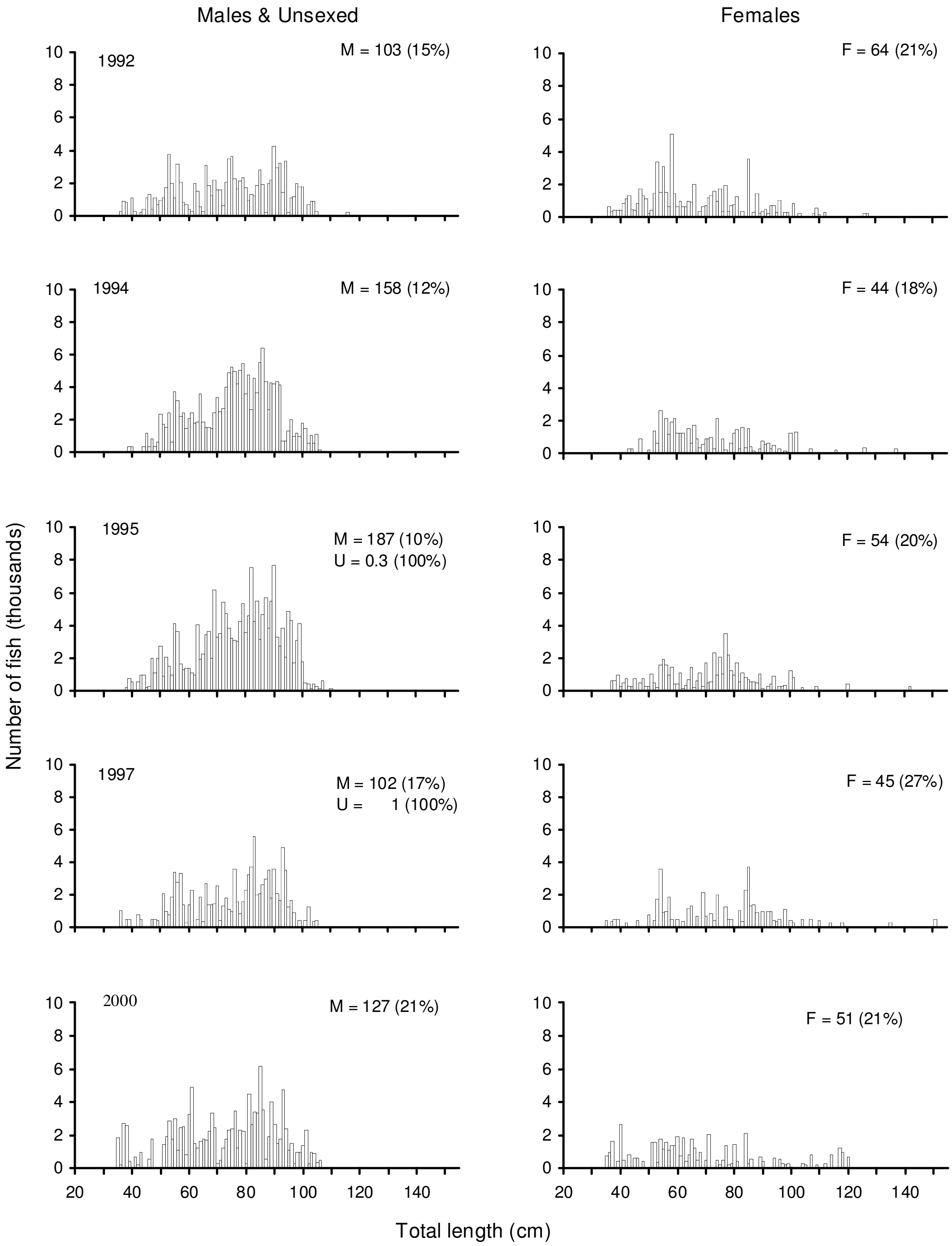


Figure 6j: Rig.

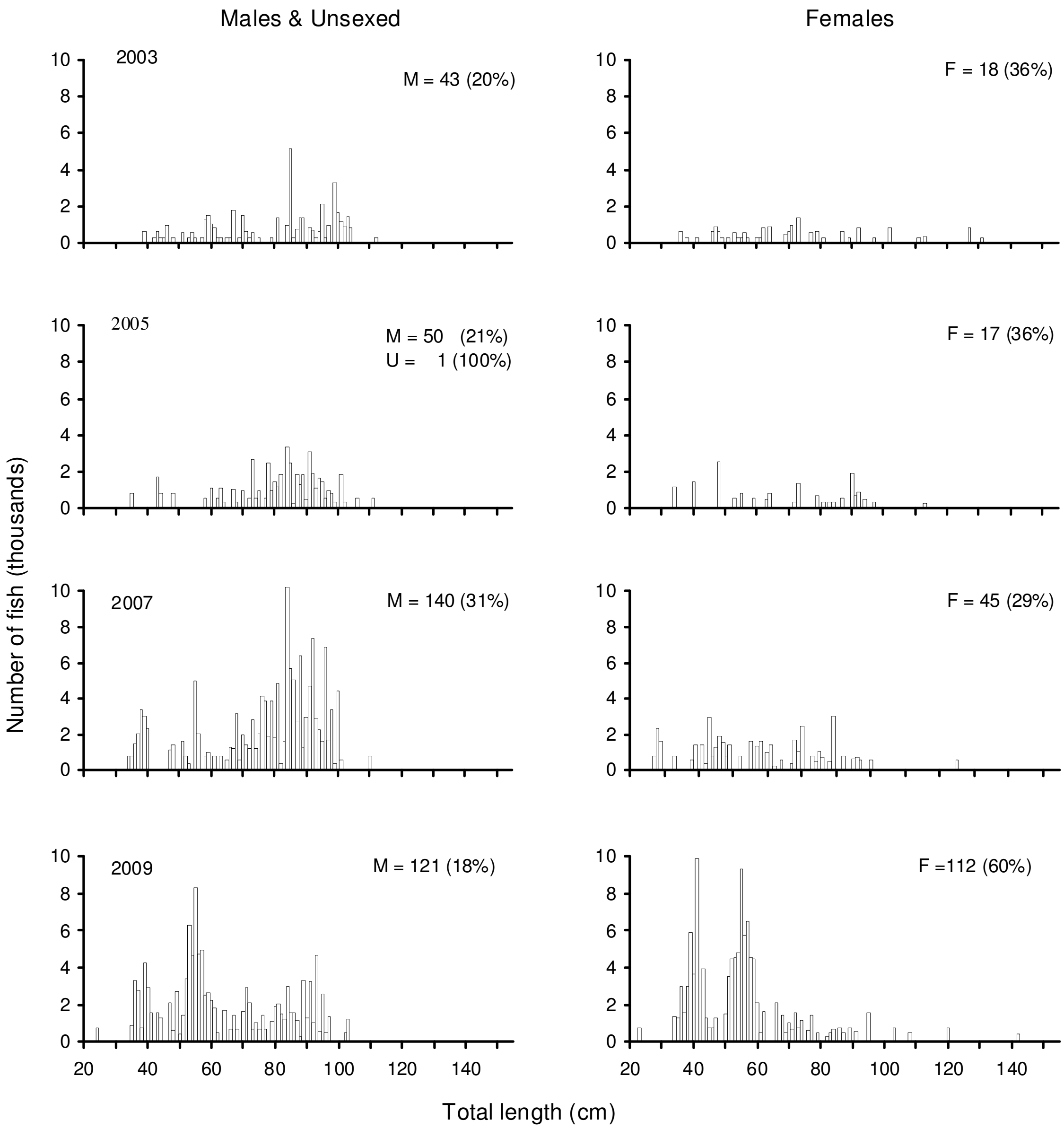


Figure 6j—continued.

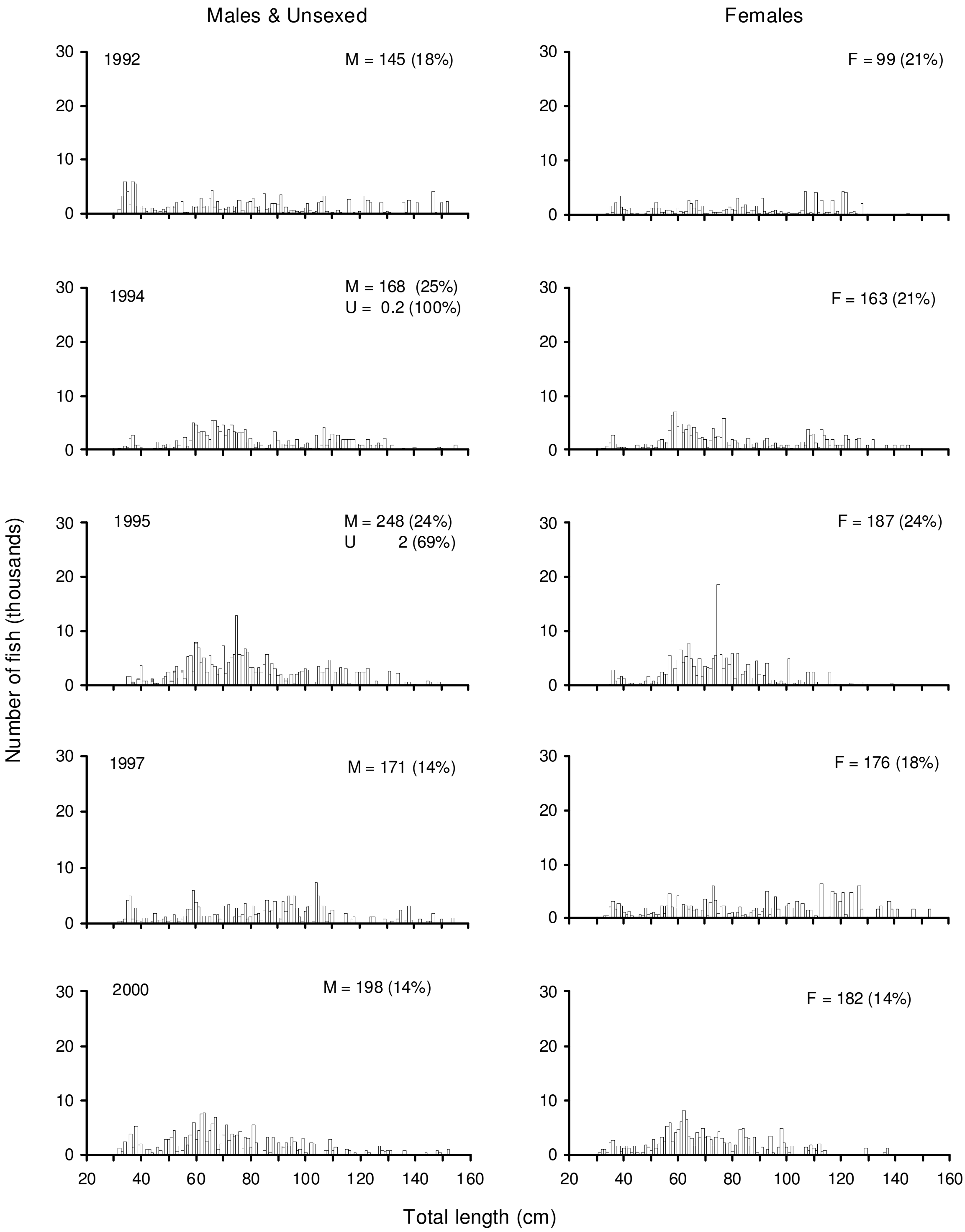


Figure 6k: School shark.

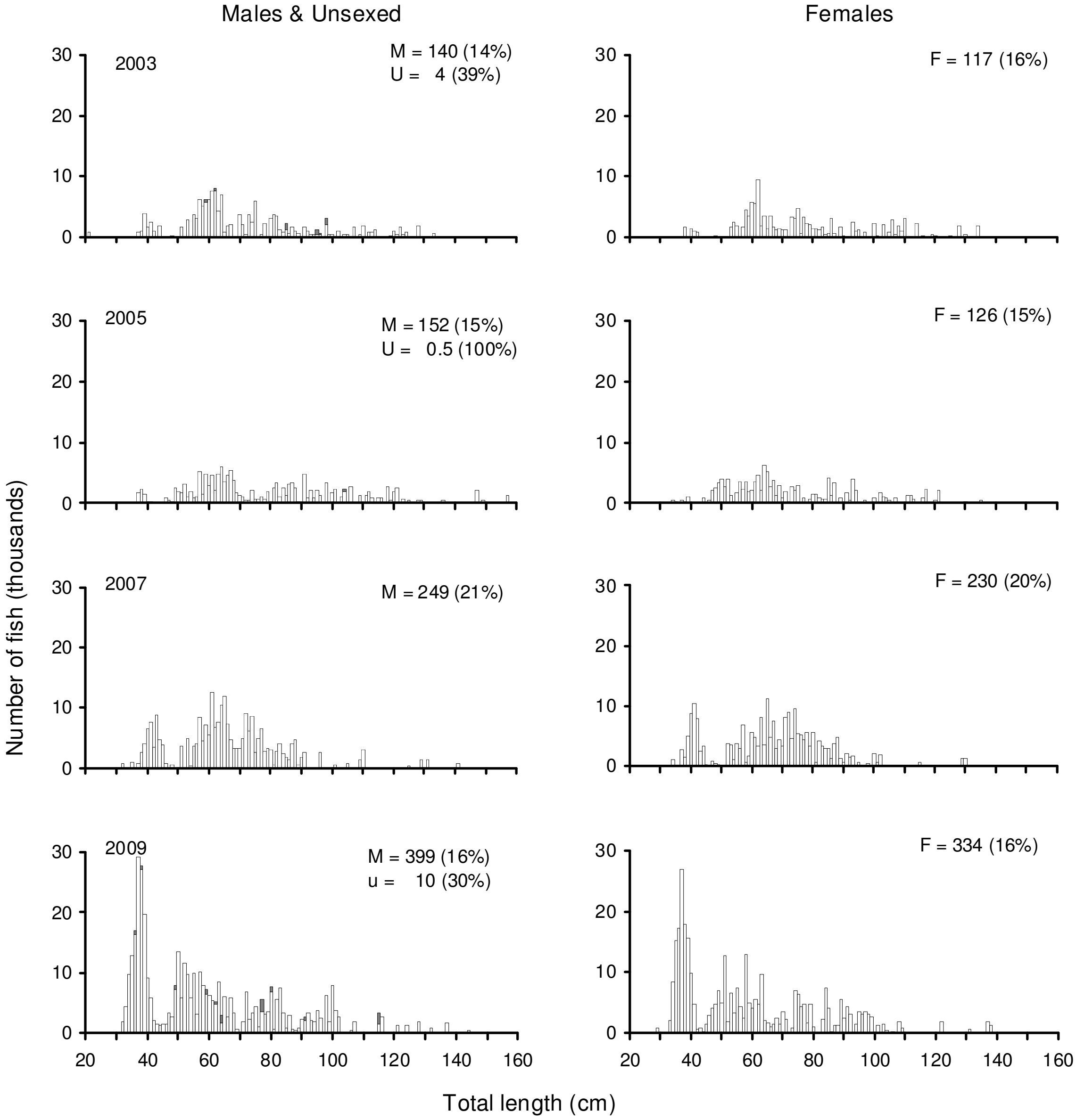


Figure 6k—continued.

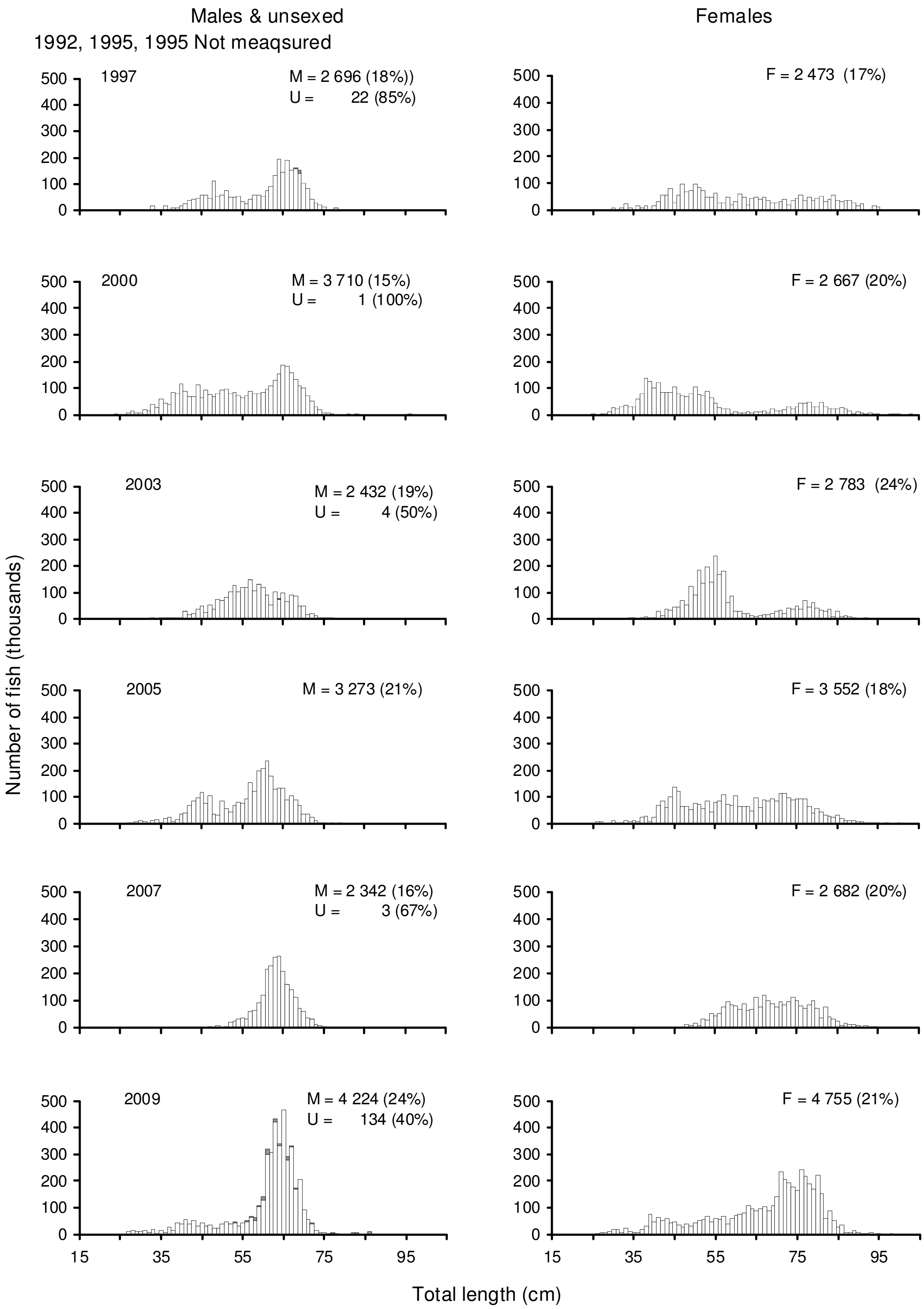


Figure 6l: Spiny dogfish.

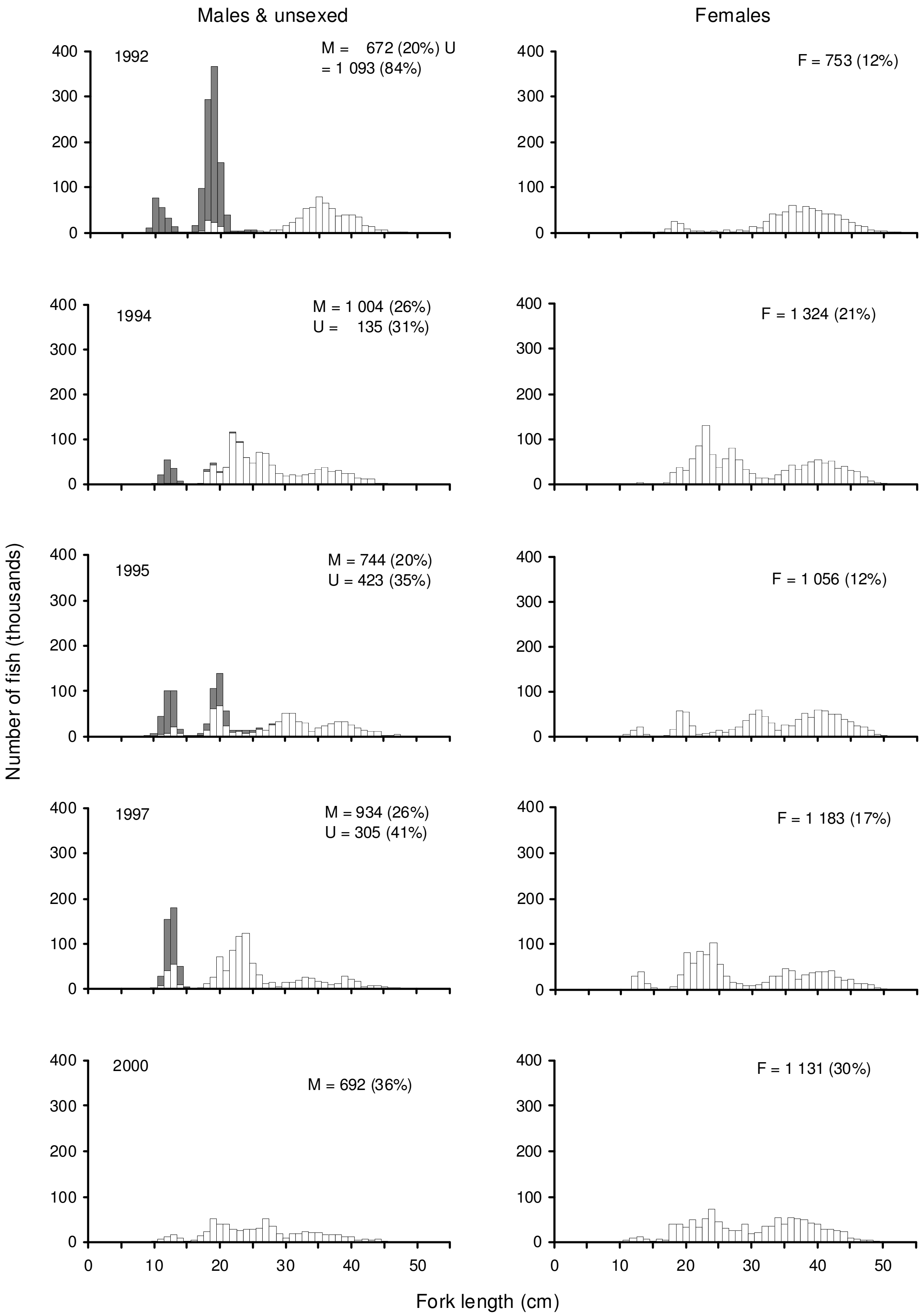


Figure 6m: Tarakihi.

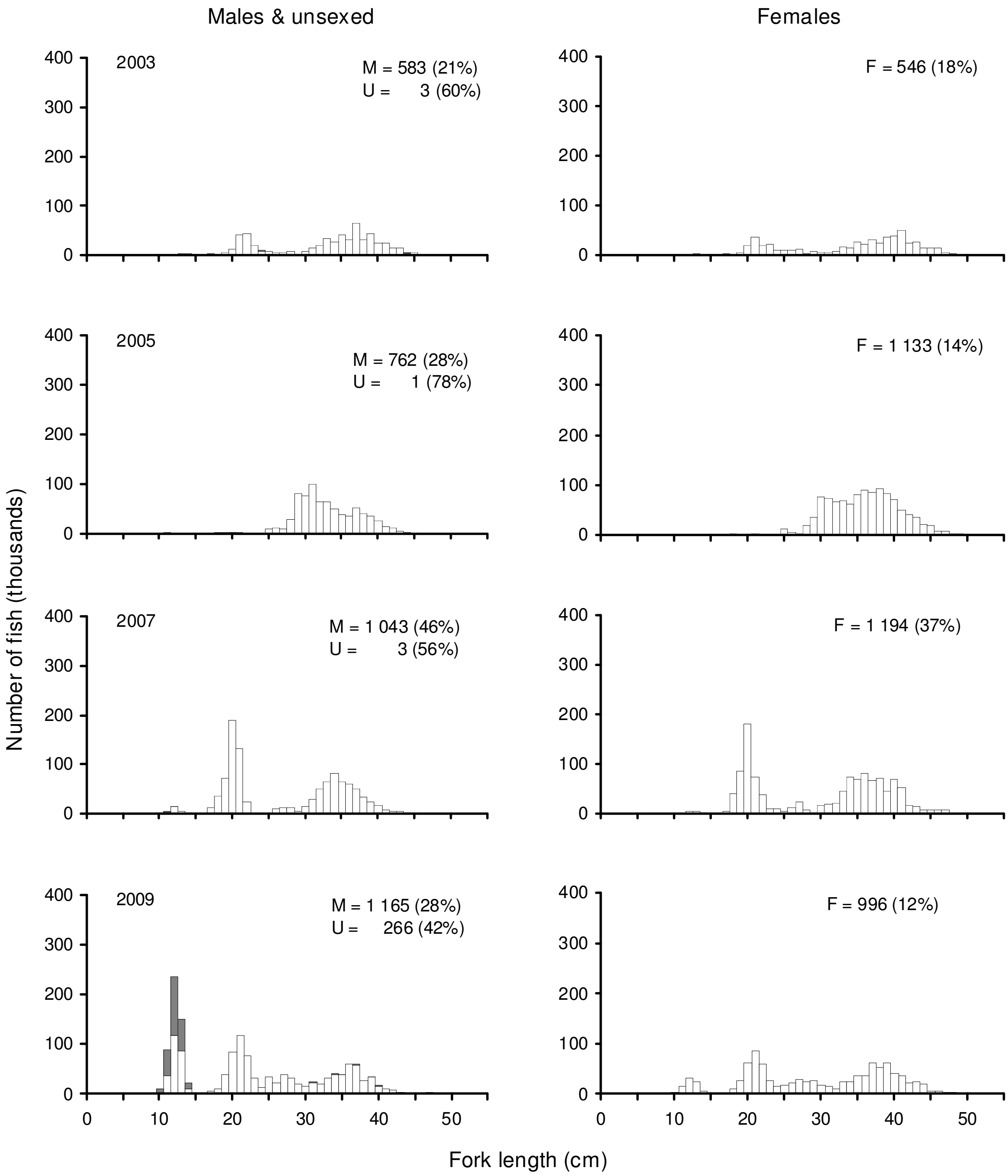


Figure 6m—continued.

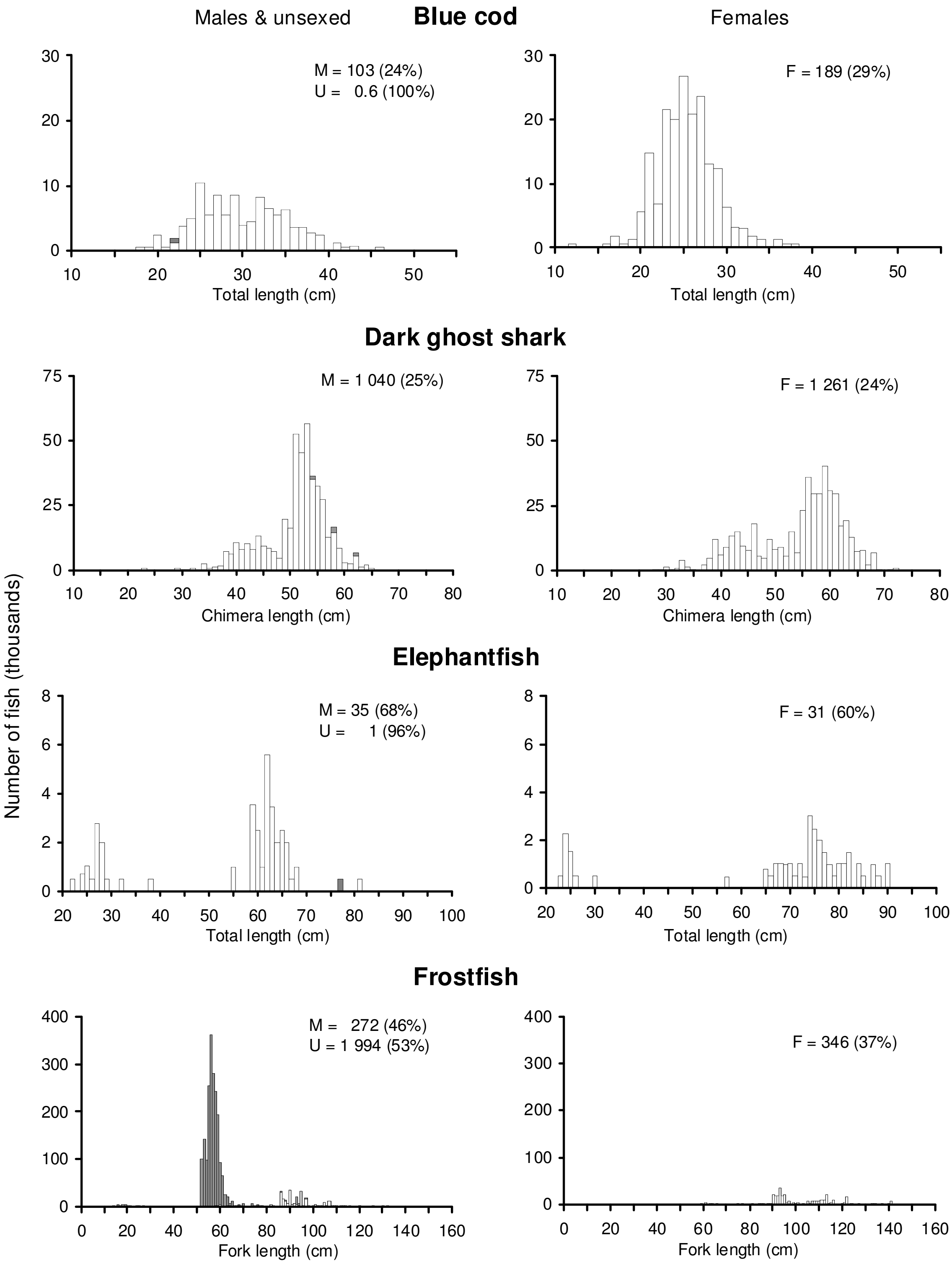
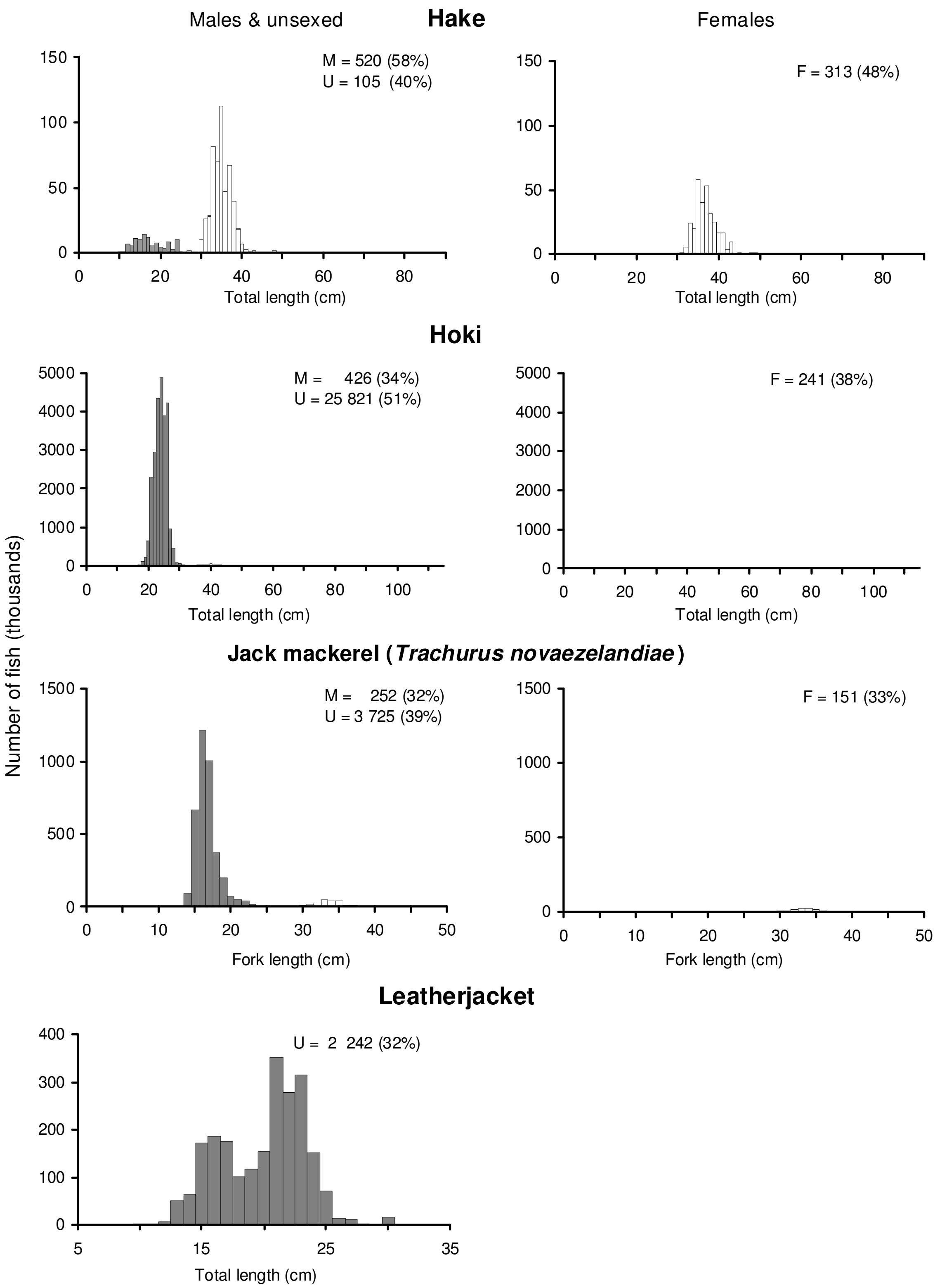


Figure 7: Scaled length frequency distributions for the non-monitored commercial species where more than 100 fish were measured. Estimated population in thousands and c.v.%. M, male; F, female; U, unsexed (shaded).



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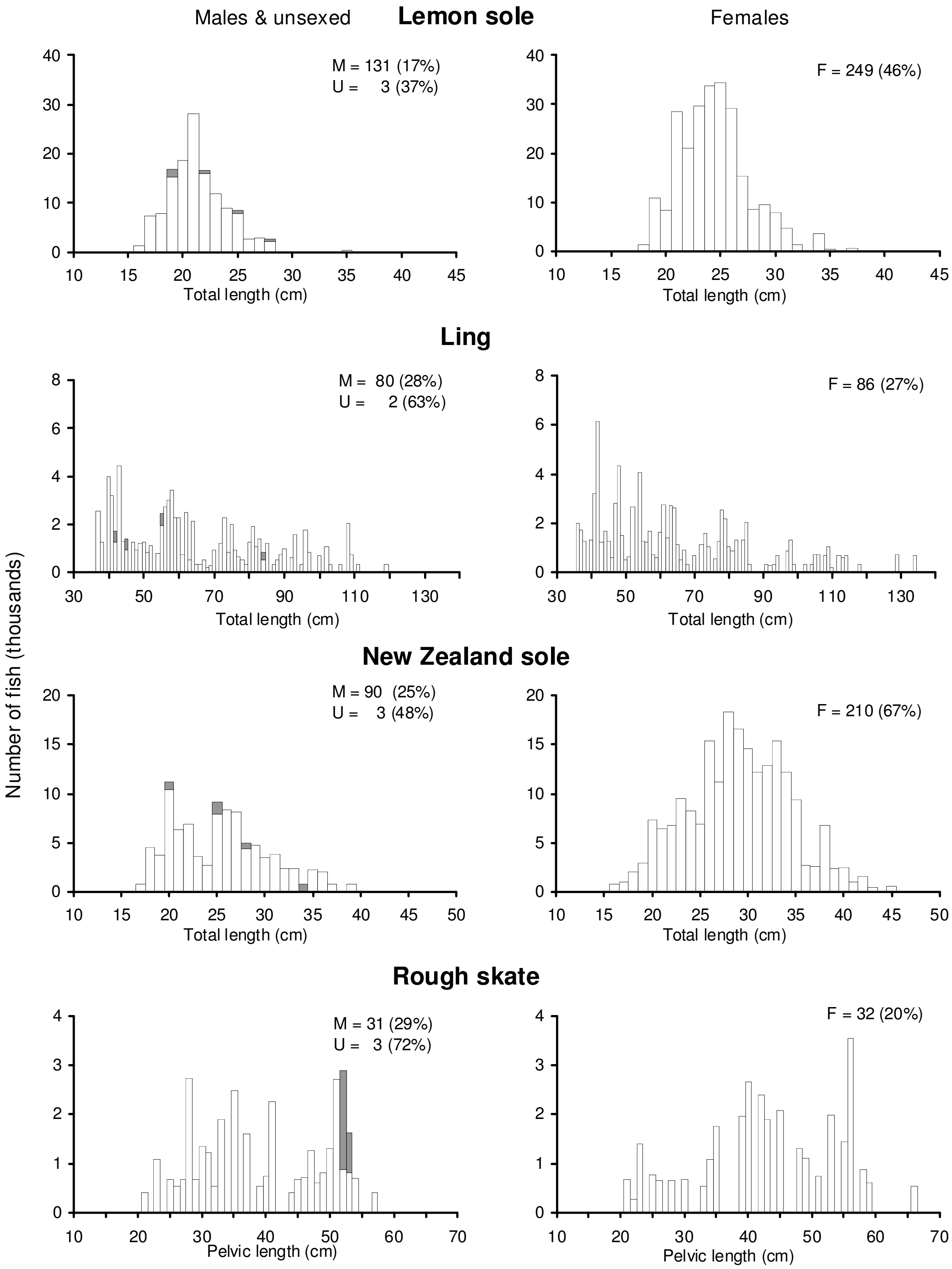

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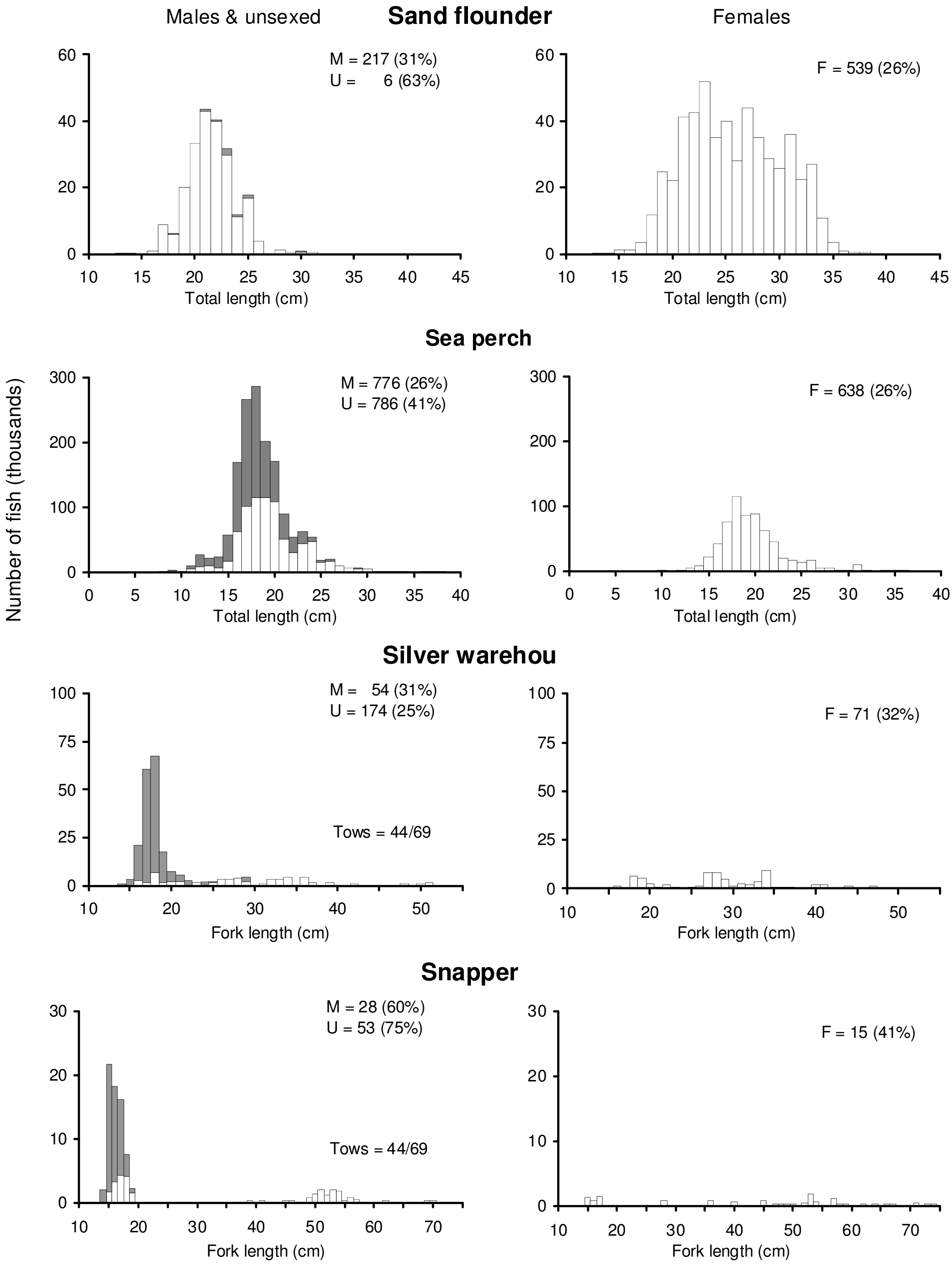

Figure 7—continued.

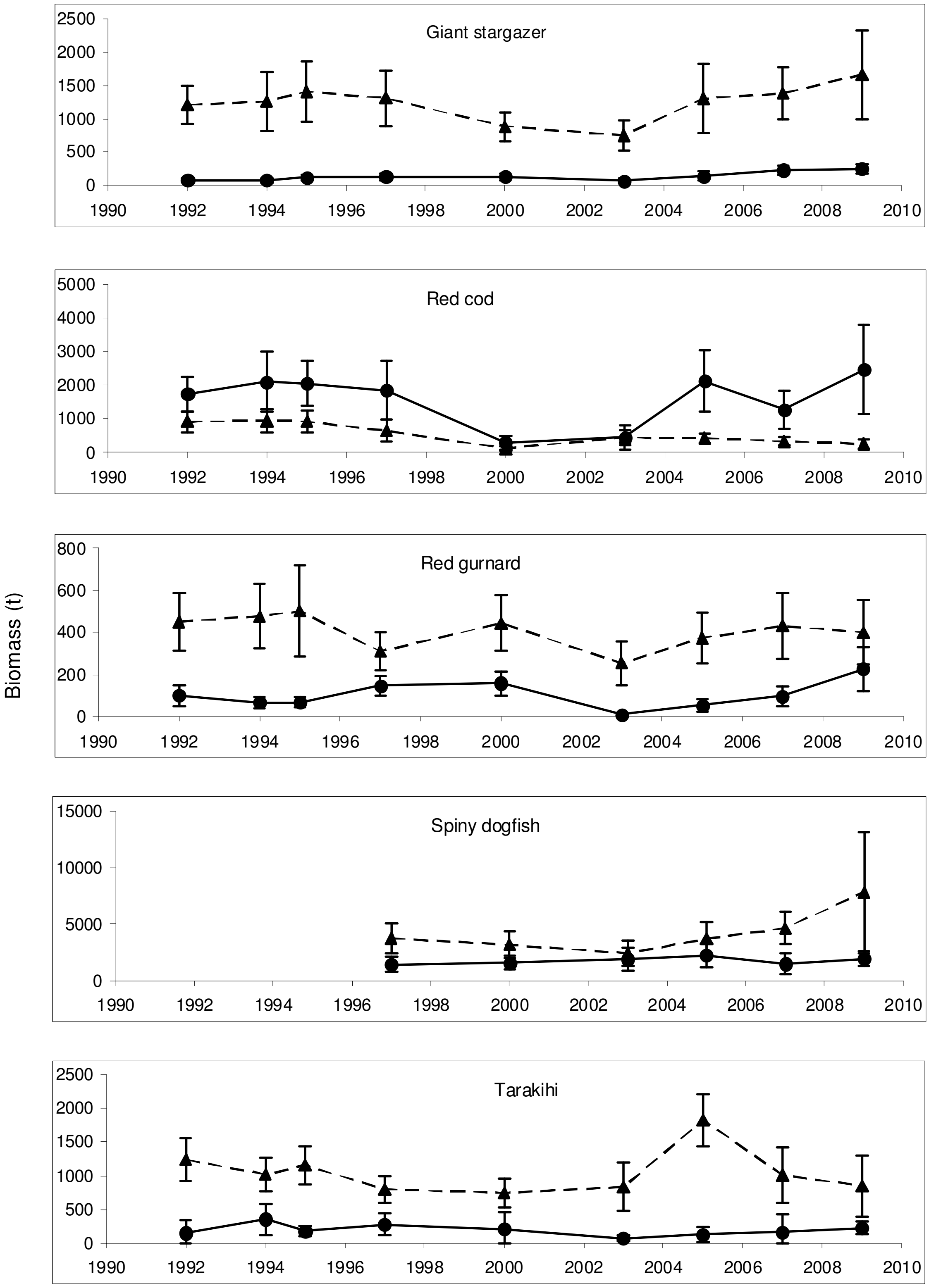

Figure 8: Biomass trends with 95% confidence intervals for juveniles (circles) and adults (triangles) for the target species (all sexes combined) from all surveys in the series. For 50% maturity lengths, see Table 5.

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

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

				Length range (cm)		
Species	*a*	*b*	n	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	This survey
Dark ghost shark	0.0015	3.3611	332	21.2	67.9	DB, KAH9704
Frostfish	0.0004	3.1629	450	10.4	153	DB, KAH0004
Gemfish	0.0017	3.3419	391	32	107	DB, KAH9304, KAH9602
Giant stargazer	0.0120	3.1004	650	14.3	74.5	This survey
Hake	0.0014	3.3770	333	33	123	DB, TAN9601
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	This survey
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	0.0124	2.9084	1 085	13.4	67.4	This survey
Red gurnard	0.0068	3.1147	589	16.2	50.9	This survey
Rig	0.0107	2.7859	270	23	142	This survey
Rough skate	0.0413	2.8198	93	21.9	66	This survey
Sand flounder	0.0207	2.8768	282	13.5	44.5	DB, KAH9809
School shark	0.0037	3.0552	729	29.7	144	This survey
Sea perch	0.0262	2.9210	210	7	42	DB, KAH9618
Silver dory	0.0191	2.9650	506	13.2	27.5	This survey
Silver warehou	0.0048	3.3800	262	16.6	57.8	DB, TAN502
Smooth skate	0.0292	2.8978	70	23	134	DB, KAH9701
Snapper	0.0447	2.7930	780	8	71	DB, Paul, FRD Bull. 13
Spiny dogfish	0.0014	3.2487	1 157	28.7	98.9	This survey
Tarakihi	0.0148	3.0552	863	10.7	51.5	This survey
Two-saddle rattail	0.0015	3.31	605	18	55.8	This survey

Group B: $W = a L^b L^{c\,(\ln L)}$

	a	*b*	*c*	n	Range (cm)	Data source
Arrow squid	0.2777	1.4130	0.2605	2 792	3–45	DB, *James Cook*, east coast South Island, 1982–83

Appendix 2: Summary of station data.

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)
1	18	24-Mar-09	1210	41	04.18	173	22.60	41	01.72	173	24.84	33	37	3.01	5	73.9	17.8	16.7
2	18	25-Mar-09	617	41	05.40	173	30.40	41	07.70	173	27.76	23	28	3.03	5.3	71.6	17.7	16.8
3	19	25-Mar-09	913	40	58.13	173	26.05	40	56.33	173	29.25	44	49	3.02	4.8	75.6	17.9	15.9
4	19	25-Mar-09	1227	40	58.02	173	36.40	40	56.75	173	39.93	43	44	3	5.1	73.9	17.8	16.3
5	19	25-Mar-09	1531	40	53.22	173	38.67	40	51.78	173	41.98	48	50	2.96	4.8	73.4	18.4	16.3
6	19	26-Mar-09	618	40	41.35	173	41.65	40	39.06	173	44.39	58	62	3.1	4.8	67.8	17.4	16.5
7	19	26-Mar-09	844	40	41.35	173	30.14	40	41.96	173	26.38	53	55	2.97	5	74.5	17.7	16.2
8	19	26-Mar-09	1057	40	49.41	173	22.09	40	49.86	173	18.14	43	48	3.02	4.9	74.1	17.8	15.6
9	19	26-Mar-09	1454	40	50.44	173	10.23	40	53.15	173	11.95	36	37	3.09	4.8	74.4	18.2	17.3
10 #	18	27-Mar-09	616	40	54.68	173	06.33	40	56.33	173	07.07	26	28	1.75	5.1	72.3		
11	18	27-Mar-09	1246	40	58.71	173	10.59	41	01.87	173	11.18	29	31	3.19	4.8	72.2	17.7	16.6
12	17	28-Mar-09	615	40	41.01	172	48.15	40	38.01	172	47.67	21	22	3.04	5	69	17.3	16.3
13	17	28-Mar-09	825	40	40.88	172	53.48	40	43.36	172	55.66	29	30	2.99	4.8	73.1	17.2	16.4
14	17	28-Mar-09	1032	40	38.23	172	57.61	40	37.70	173	01.00	33	35	2.46	5.2	73.2	17.2	16
15	19	28-Mar-09	1238	40	37.17	173	09.03	40	40.16	173	07.64	40	47	3.16	4.8	73.7	16.7	15.1
16	19	28-Mar-09	1449	40	47.31	173	13.17	40	50.52	173	14.34	39	41	3.33	5	73.9	17.6	15.7
17	1	29-Mar-09	626	40	33.79	172	22.39	40	32.67	172	26.17	66	68	3.08	5.2	69.4	14.5	14.3
18	2	29-Mar-09	1116	40	42.13	172	05.18	40	39.24	172	06.55	100	100	3.06	5	78.9	16.7	13.8
19	1	29-Mar-09	1352	40	42.52	172	15.29	40	40.22	172	18.06	34	46	3.11	5.3	74.8	14.2	14.1
20	2	30-Mar-09	617	40	49.58	171	45.36	40	47.41	171	47.96	138	143	2.95	5.3	91.9	17.5	13.5
21	1	30-Mar-09	950	40	53.06	172	01.01	40	50.30	172	02.55	94	95	2.99	5.3	79.3	13.7	12
22	1	30-Mar-09	1313	41	02.58	171	58.43	40	59.74	171	59.82	86	86	2.99	5.3	79.1	16.4	13.6
23	2	30-Mar-09	1611	41	04.77	171	47.12	41	01.86	171	48.19	117	122	3.02	4.7	86.1	17.4	13.4
24	6	31-Mar-09	617	41	17.78	171	09.04	41	15.08	171	10.65	181	184	2.95	5.2	89	17.6	13.4
25	2	31-Mar-09	850	41	07.06	171	17.14	41	04.30	171	18.56	167	168	3	5.3	92.2	18	13.3
26	2	31-Mar-09	1245	41	23.82	171	31.96	41	21.15	171	33.60	130	132	2.94	5.2	82.7	16.7	13
27	6	31-Mar-09	1505	41	13.47	171	39.02	41	11.51	171	42.04	124	128	3	5	83.3	17.2	13.1
28	9	1-Apr-09	624	42	07.80	170	34.21	42	05.03	170	33.76	370	373	2.8	4.9	91.2	17.6	12.5
29	9	1-Apr-09	845	42	05.63	170	34.10	42	02.62	170	34.50	356	360	3.04	4.8	92.2	17.8	12.5
30	9	1-Apr-09	1111	41	54.93	170	38.36	41	52.05	170	39.25	308	323	2.98	5.1	89.5	18	12.5
31	8	1-Apr-09	1405	41	50.15	170	54.23	41	47.81	170	56.77	167	180	3	4.9	84.4		

Appendix 2—*continued*

Station	Stratum	Date	Start of tow Time	°	' 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	8	2-Apr-09	613	42	08.76	170	52.98	42	05.73	170	53.08	191	193	3.02	4.7	84.3	17.3	13
33	8	2-Apr-09	854	42	09.52	170	59.88	42	06.63	171	00.65	153	156	2.96	5	81.9	16.1	13
34	7	2-Apr-09	1125	42	13.32	171	07.00	42	10.60	171	08.52	76	76	2.94	5.2	71.1	16.5	13.6
35	7	2-Apr-09	1346	42	15.02	171	12.17	42	12.26	171	13.60	26	27	2.97	5.2	69.2	16.5	15.8
36	7	2-Apr-09	1553	42	04.17	171	15.95	42	01.33	171	17.16	47	50	2.99	5	70.9	16.4	14.5
37	5	3-Apr-09	614	41	17.00	171	54.65	41	18.95	171	51.70	62	68	2.97	5.1	72.9	15.9	14.3
38	5	3-Apr-09	820	41	21.09	171	53.96	41	23.74	171	52.11	44	47	2.98	5.1	76.6	15.9	14.6
39	5	3-Apr-09	1122	41	38.25	171	41.74	41	39.56	171	38.08	27	28	3.03	5.1	71.6	16.1	15.1
40	6	3-Apr-09	1423	41	40.47	171	17.86	41	37.92	171	19.99	138	140	2.99	5	85.6	17.3	13.1
41	7	5-Apr-09	621	42	21.39	171	08.75	42	24.17	171	07.23	28	29	2.99	4.5	70.6	16.1	16.1
42	8	5-Apr-09	852	42	22.37	171	00.35	42	25.30	170	59.34	108	111	3.02	5	85.6	16.6	13.5
43	11	5-Apr-09	1114	42	34.73	170	58.09	42	37.55	170	56.03	65	66	3.2	5	73.2	16.5	14.9
44	11	5-Apr-09	1401	42	42.71	170	47.39	42	44.75	170	44.43	73	96	2.98	4.8	79.7	12.2	13.9
45	11	6-Apr-09	700	42	49.59	170	43.03	42	49.97	170	38.99	31	33	2.98	4.8	73.8	16.3	15.8
46	11	6-Apr-09	902	42	50.58	170	38.55	42	50.87	170	34.46	29	30	3.01	5.2	72.3	16.3	15.4
47	11	6-Apr-09	1136	42	52.20	170	19.92	42	54.70	170	17.54	93	95	3.04	4.6	81.8	16.7	13.6
48	11	6-Apr-09	1350	43	03.11	170	13.80	43	05.24	170	10.86	36	39	3.02	4.8	75.5	16	15.9
49	11	6-Apr-09	1605	43	05.80	170	06.68	43	08.41	170	04.57	78	80	3.03	4.8	76.8	15.7	13.8
50	16	7-Apr-09	659	43	17.51	169	42.29	43	18.61	169	44.82	221	244	2.14	5.1	92.1	17.1	12.9
51	16	7-Apr-09	1046	43	23.59	169	21.94	43	23.22	169	25.85	247	285	2.86	4.4	93.8	16.9	12.8
52	15	7-Apr-09	1457	43	24.76	169	24.82	43	24.66	169	27.52	136	145	1.96	4.9	86.8	16.2	13.1
53 #	16	8-Apr-09	618	43	29.07	169	13.36	43	26.99	169	16.33	266	277	2.99	4.9	96.5	16.8	13
54 #	15	8-Apr-09	1439	43	29.98	169	16.35	43	28.48	169	20.03	128	132	3.07	4.9	85.7	16	13.4
55	15	9-Apr-09	615	43	37.92	169	14.88	43	35.22	169	16.89	113	122	3.06	4.9	87	15.5	13.7
56	14	9-Apr-09	826	43	35.90	169	25.07	43	34.30	169	28.55	34	40	2.98	4.8	74	14.2	16.2
57	14	9-Apr-09	1017	43	29.61	169	33.18	43	27.57	169	36.19	43	47	2.98	4.8	71.3	15.2	15.8
58	14	9-Apr-09	1205	43	27.43	169	37.08	43	25.36	169	40.05	40	43	2.98	4.7	74.1	15.2	15.8
59	14	9-Apr-09	1430	43	22.94	169	49.10	43	24.62	169	45.57	30	35	3.06	4.8	72.6	15.8	15.9
60	16	10-Apr-09	615	43	28.89	169	13.59	43	26.79	169	16.60	259	271	3.03	4.7	92.5	15	12.9
61	15	10-Apr-09	820	43	30.12	169	16.16	43	28.67	169	19.71	130	133	2.95	4.8	83.8	15.3	13.3
62	12	10-Apr-09	1302	43	08.41	169	52.19	43	05.89	169	54.20	174	178	2.91	4.8	82.1	16.8	13

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)
63	12	10-Apr-09	1547	43	04.12	169	55.31	43	01.49	169	57.14	170	172	2.95	4.8	86.6	17.1	13.2
64	13	11-Apr-09	620	42	58.68	169	52.44	42	56.90	169	55.87	307	312	3.07	4.7	89.3	17	13.1
65	12	11-Apr-09	855	43	00.00	170	01.18	42	58.06	170	04.81	151	156	3.28	4.7	83.5	15.3	13.3
66	13	11-Apr-09	1130	42	52.72	170	00.41	42	49.81	170	00.54	250	254	2.91	4.7	85.6	16	12.9
67	12	11-Apr-09	1350	42	48.85	170	09.28	42	45.86	170	08.83	158	160	3	4.7	85	16.1	13.4
68	12	11-Apr-09	1547	42	42.90	170	06.75	42	40.25	170	08.71	167	171	3.01	4.8	85.4	17.4	13.4
69	13	12-Apr-09	611	42	45.91	170	02.91	42	43.08	170	04.32	225	237	3.01	4.8	89.2	17.1	13.4
70	12	12-Apr-09	821	42	41.58	170	12.29	42	39.45	170	15.26	148	156	3.05	4.9	85	16.3	13.5
71	7	12-Apr-09	1453	42	27.67	171	01.61	42	24.74	171	02.90	68	71	3.08	4.9	72.2	15.7	14.6
72	6	13-Apr-09	608	41	43.16	171	12.52	41	41.65	171	16.04	138	146	3.03	4.9	89.8	15.9	13.2
73	7	13-Apr-09	819	41	47.52	171	19.95	41	44.87	171	22.05	83	88	3.07	5.1	78.5	15.4	13.8
74	5	13-Apr-09	1223	41	38.08	171	29.71	41	35.75	171	32.10	88	90	2.93	4.9	79.4	15.6	13.6
75	6	13-Apr-09	1516	41	32.33	171	25.03	41	29.36	171	25.69	132	136	3.01	4.8	86.9	16.3	13.4
76 *		15-Apr-09	623	40	57.88	173	36.05	40	57.65	173	36.78			0.59				
77 *		15-Apr-09	729	40	57.37	173	38.02	40	57.16	173	38.64			0.51				
78 *		15-Apr-09	823	40	56.68	173	39.35	40	56.32	173	39.90			0.54				
79 *		15-Apr-09	1005	40	46.84	173	37.72	40	46.33	173	37.87			0.52				
80 *		15-Apr-09	1104	40	46.69	173	37.95	40	46.27	173	38.31			0.5				
81 *		15-Apr-09	1154	40	46.23	173	38.16	40	46.37	173	37.41			0.58				
82 *		15-Apr-09	1259	40	44.64	173	39.19	40	44.21	173	39.66			0.55				
83 *		15-Apr-09	1400	40	44.09	173	39.19	40	44.10	173	40.27			0.81				
84 *		15-Apr-09	1530	40	43.43	173	40.23	40	43.20	173	39.67			0.48				

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	*Alcithoe larochei*	1.2	*	3	113	156
ANC	Anchovy	*Engraulis australis*	0.9	*	6	34	68
ANT	Anemones	Anthozoa	0.3	*	2	23	49
ASC	Sea squirt	Ascidiacea	12.8	*	5	21	49
ASR	Starfish		1.2	*	2	23	40
BAR	Barracouta	*Thyrsites atun*	4 878.3	10	68	21	373
BCO	Blue cod	*Parapercis colias*	166.1	*	12	23	62
BPD	Lamp shells	Brachiopoda	0.7	*	2	21	49
BRI	Brill	*Colistium guntheri*	10.5	*	9	26	50
BRN	Barnacle	Cirripdeia (Class)	0.2	*	1	27	28
BRZ	Brown stargazer	*Xenocephalus armatus*	0.1	*	1	151	156
BSQ	Broad squid	*Sepioteuthis australis*	5.0	*	5	33	47
CAR	Carpet shark	*Cephaloscyllium isabellum*	1 176.6	2	59	21	373
CBI	Two saddle rattail	*Caelorinchus biclinozonalis*	1 842.7	4	41	29	373
CBO	Bollons's rattail	*Caelorinchus bollonsi*	9.3	*	2	247	373
CCX	Small banded rattail	*Caelorinchus parvifasciatus*	13.0	*	6	170	312
CDO	Capro dory	*Capromimus abbreviatus*	26.8	*	19	78	373
CON	Conger eel	*Conger* spp.	101.0	*	16	23	76
COU	Coral (unspecified)	Anthozoa (Class)	4.1	*	1	221	244
COZ	Bryozoan	Bryozoa (Phylum)	0.1	*	1	44	49
CRM	Airy finger sponge	*Callyspongia* cf *ramosa*	1.8	*	2	23	49
CUC	Cucumberfish	*Chlorophthalmus nigripinnis*	142.1	*	24	48	373
DIR	Pagurid	*Diacanthurus rubricatus*	0.2	*	2	221	312
EGR	Eagle ray	*Myliobatis tenuicaudatus*	14.9	*	4	23	49
ELE	Elephantfish	*Callorhinchus milii*	389.3	1	12	26	96
ERA	Electric ray	*Torpedo fairchildi*	235.0	*	14	21	277
ESO	N.Z. sole	*Peltorhamphus novaezeelandiae*	155.8	*	17	23	111
ETL	Lucifer dogfish	*Etmopterus lucifer*	0.5	*	1	259	271
FHD	Deepsea flathead	*Hoplichthys haswelli*	0.3	*	1	307	312
FLL	Shell fragments		20.3	*	5	23	49
FMA	Triton	*Fusitriton magellanicus*	0.1	*	1	158	160
FRO	Frostfish	*Lepidopus caudatus*	1 268.0	3	32	47	312
GAS	Gastropods	Gastropoda	0.4	*	3	29	312
GLB	Globefish	*Contusus richei*	166.5	*	5	26	39
GLM	Green-lipped mussel	*Perna canaliculus*	1.6	*	1	29	31
GSH	Dark ghost shark	*Hydrolagus novaezealandiae*	1 117.0	2	33	62	312
GUR	Red gurnard	*Chelidonichthys kumu*	1 083.2	2	44	21	132
GVE	Convoluted ostrich egg sponge	*Geodinella vestigifera*	2.2	*	1	58	62
HAK	Hake	*Merluccius australis*	421.1	1	24	29	285
HAP	Hapuku	*Polyprion oxygeneios*	60.1	*	4	174	323
HDR	Hydroid	Hydrozoa (Class)	0.3	*	3	21	49
HOK	Hoki	*Macruronus novaezelandiae*	1 960.4	4	30	40	373
HTH	Sea cucumber	Holothurian unidentified	0.3	*	2	21	28
JAV	Javelinfish	*Lepidorhynchus denticulatus*	4.9	*	4	221	373
JDO	John dory	*Zeus faber*	312.3	1	32	21	193
JFI	Jellyfish		116.8	*	18	21	132
JMD	N.Z. jack mackerel	*Trachurus declivis*	95.7	*	27	30	254
JMM	Chilean jack mackerel	*Trachurus murphyi*	13.2	*	5	30	244
JMN	N.Z. jack mackerel	*Trachurus novaezelandiae*	640.3	1	24	21	90
KAH	Kahawai	*Arripis trutta*	11.6	*	3	29	48

Appendix 3—continued.

Species code	Common name	Scientific name	Catch (kg)	% of total catch	Occ.	Depth (m) Min.	Max.
KIN	Kingfish	*Seriola lalandi*	5.6	*	1	58	62
LEA	Leatherjacket	*Parika scaber*	485.3	1	19	21	143
LEH	Leech (generic)	Hirudinea	0.1	*	1	307	312
LIN	Ling	*Genypterus blacodes*	859.4	2	39	21	373
LSK	Softnose skate (Longtail skate)	*Arhynchobatis asperrimus*	2.5	*	1	356	360
LSO	Lemon sole	*Pelotretis flavilatus*	112.4	*	33	21	277
MDO	Mirror dory	*Zenopsis nebulosus*	12.9	*	3	221	373
MOK	Moki	*Latridopsis ciliaris*	20.2	*	1	34	46
NCA	Smooth red swimming crab	*Nectocarcinus antarcticus*	0.1	*	1	138	146
NOS	NZ southern arrow squid	*Nototodarus sloanii*	388.9	1	70	21	373
NSD	Northern spiny dogfish	*Squalus griffini*	177.2	*	16	34	373
OCT	Octopus	*Pinnoctopus cordiformis*	24.4	*	12	23	180
ONG	Sponges	Porifera (Phylum)	43.4	*	9	21	62
OPE	Orange perch	*Lepidoperca aurantia*	59.9	*	3	221	373
OYS	Dredge oyster	*Ostrea chilensis*	0.1	*	1	21	22
PAD	Paddle crab	*Ovalipes catharus*	13.0	*	2	26	50
PAG	Hermit crab	Paguroidea	0.3	*	2	66	122
PCO	Ahuru	*Auchenoceros punctatus*	5.1	*	10	29	88
PIG	Pigfish	*Congiopodus leucopaecilus*	3.9	*	7	40	244
PIL	Pilchard	*Sardinops neopilchardus*	0.1	*	1	53	55
PMO	Sea cucumber	*Pseudostichopus mollis*	0.2	*	1	39	41
PNN	Purple sea pen	*Pennatula* spp.	0.2	*	1	308	323
POP	Porcupine fish	*Allomycterus jaculiferus*	102.2	*	9	29	168
PRK	Prawn killer	*Ibacus alticrenatus*	8.1	*	15	130	373
PSI	Geomwetric star	*Psilaster acuminatus*	0.2	*	2	124	136
PTU	Sea pens	Pennatulacea (Order)	3.4	*	4	151	244
PYR	Colonial thaliacean	*Pyrosoma atlanticum*	1.7	*	5	31	237
RBM	Ray's bream	*Brama brama*	16.8	*	6	36	184
RBT	Redbait	*Emmelichthys nitidus*	1.9	*	10	94	193
RCO	Red cod	*Pseudophycis bachus*	5 095.9	11	56	21	312
RHY	Common roughy	*Paratrachichthys trailli*	205.9	*	4	221	373
RMU	Red mullet	*Upeneichthys lineatus*	3.0	*	4	23	49
RSK	Rough skate	*Dipturus nasutus*	159.2	*	29	23	285
SAL	Salps	Salpida (Order)	8.7	*	4	83	360
SAR	Mantis shrimp	*Squilla armata*	0.1	*	1	44	47
SAZ	Sand stargazer	*Crapatalus novaezelandiae*	0.1	*	1	26	27
SBR	Southern bastard cod	*Pseudophycis barbata*	0.4	*	1	53	55
SCC	Sea cucumber	*Stichopus mollis*	3.4	*	3	23	49
SCG	Scaly gurnard	*Lepidotrigla brachyoptera*	448.8	1	54	23	323
SCH	School shark	*Galeorhinus galeus*	1 323.8	3	64	21	360
SCI	Scampi	*Metanephrops challengeri*	0.2	*	2	259	312
SDO	Silver dory	*Cyttus novaezealandiae*	2 674.0	6	41	62	373
SDR	Spiny seadragon	*Solegnathus spinosissimus*	0.5	*	4	158	254
SFI	Starfish	Asteroidea & Ophiuroidea	0.9	*	2	21	37
SFL	Sand flounder	*Rhombosolea plebeia*	272.0	1	20	21	62
SKI	Gemfish	*Rexea solandri*	143.0	*	10	108	373
SNA	Snapper	*Pagrus auratus*	248.9	1	13	21	62
SPA	Slender sprat	*Sprattus antipodum*	0.2	*	2	29	33
SPD	Spiny dogfish	*Squalus acanthias*	11 827.8	25	67	21	312
SPE	Sea perch	*Helicolenus* spp.	432.4	1	45	29	373

Appendix 3—continued.

Species code	Common name	Scientific name	Catch (kg)	% of total catch	Occ.	Depth (m) Min.	Max.
SPH	Tusk shells	Scaphopoda	0.1	*	1	29	31
SPM	Stout sprat	*Sprattus muelleri*	4.9	*	14	29	95
SPO	Rig	*Mustelus lenticulatus*	429.8	1	39	21	312
SPR	Sprats	*Sprattus antipodum, S. muelleri*	3.4	*	6	30	71
SPS	Speckled sole	*Peltorhamphus latus*	0.3	*	3	29	41
SPT	Heart urchin	*Spatangus multispinus*	1.8	*	6	117	271
SPZ	Spotted stargazer	*Genyagnus monopterygius*	4.4	*	2	21	28
SSH	Slender smoothhound	*Gollum attenuatus*	37.7	*	2	356	373
SSI	Silverside	*Argentina elongata*	7.2	*	28	65	312
SSK	Smooth skate	*Dipturus innominatus*	110.5	*	10	36	312
STA	Giant stargazer	*Kathetostoma giganteum*	2 653.4	6	58	21	373
STY	Spotty	*Notolabrus celidotus*	58.9	*	8	21	44
SWA	Silver warehou	*Seriolella punctata*	98.9	*	40	29	373
TAR	Tarakihi	*Nemadactylus macropterus*	1 683.7	4	63	23	373
THR	Thresher shark	*Alopias vulpinus*	98.7	*	2	40	47
TOD	Dark toadfish	*Neophrynichthys latus*	0.8	*	5	108	285
TRE	Trevally	*Pseudocaranx dentex*	3.5	*	1	34	46
TUR	Turbot	*Colistium nudipinnis*	13.8	*	4	27	43
WAR	Blue warehou	*Seriolella brama*	331.3	1	43	21	156
WIT	Witch	*Arnoglossus scapha*	189.2	*	64	21	373
WOD	Wood	Wood	49.2	*	9	29	136
YBF	Yellow-belly flounder	*Rhombosolea leporina*	32.4	*	1	23	28
YBO	Yellow boarfish	*Pentaceros decacanthus*	0.1	*	1	221	244
YEM	Yellow-eyed mullet	*Aldrichetta forsteri*	2.3	*	5	29	49
			Total 47 502.1				

* less than 0.5%

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

Taxon	No. of stations
Porifera (Demospongiae)	
Amorphinopsis n. sp. 1	1
Dactylia n. sp. 1	1
Suberites affinis Brondsted, 1923	5
Callyspongia sp.	3
Annelida:Hirudinea	
Hirudinea	1
Echiura	
Echiuroida	1
Bryozoa	
Cellaria immersa	1
Cnidaria: Hydrozoa	
Leptothecata	2
Cnidaria: Anthozoa	
Anthoptilum sp.	5
Desmophyllum dianthus	1
Pennatula	1
Phlyctenactis tuberculosa	1
Actiniaria	2
Crustacea: Palinura	
Ibaccus alticrenatus	15
Crustaces: Decapoda	
Diacanthurus rubricatus	3
Crustacea: Paguridae	
Diacanthurus rubricatus (Henderson, 1888)	2
Crustacea: Stomatopoda	
Pterygosquilla schizodontia (Richardson, 1953)	1
Crustacea: Anomura	
Ovalipes catharus	2
Nectocarcinus antarcticus	1
Crustacea: Maxillopoda	
Notomegabalanus decorus	1
Arthropoda: Cirripedia	
Calantica studeri	1
Brachiopoda	
Brachiopoda	2

Appendix 4—continued

Taxon	No. of stations
Mollusca: Bivalvia	
Ostrea chilensis	1
Mollusca: Gastropoda	
Alcithoe arabica (Gmelin, 1791)	3
Maoricolpus roseus	1
Fusitriton magellanicus	1
Mollusca: Scaphopoda	
Scaphopoda	1
Mollusca: Cephalopoda	
Pinnoctopus cordiformis	12
Urochordata: Ascidiacea	
Cnemidocarpa nisiotis	1
Ascidiacea [Urochordata or Tunicates]	1
Cnemidocarpa nisiotis	1
Thaliacea [Salps]	1
Echinodermata :Astreoidea	
Coscinasterias muricata	1
Patiriella regularis	1
Psilaster acuminatus	2
Echinodermata :Ophiuroidea	
Ophiuroidea	2
Echinodermata:Echinoidea	
Spatangus multispinus	6
Echinodermata: Holothuroidea	
Australostichopus mollis	3

Appendix 5: Input file for biomass analysis of several species using SurvCalc.

```
@trips   kah0904

@species kah0904
codes   NOS BAR BCO WAR GSH ELE FRO SKI STA HAK HOK LIN

@input_from_database
database Empress

@where
t_station gear_perf < 3 and station_no < 76

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


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

@lw_coeff kah0904_BAR
a 0.00552
b 2.9812

@sub_populations WAR
sexes all all all
Lmin 0 0 45
Lmax 75 44 75
labels all to45 45+

@lw_coeff kah0904_WAR
a 0.014359
b 3.104987

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

@lw_coeff kah0904_GSH
a 0.0015
b 3.3611

@sub_populations STA
sexes all all all all
Lmin 0 30 0 45
Lmax 29 86 44 86
```

```
labels to30 30+ to45 45+

@lw_coeff kah0904_STA
a 0.012032
b 3.100435

@sub_populations HOK
sexes all all
Lmin 0  65
Lmax 64 200
labels to65 65+

@lw_coeff kah0904_HOK
a 0.0078
b 3.14

@sub_populations LIN
sexes all all all
Lmin 0 0  65
Lmax 200 64 200
labels all to65 65+

@lw_coeff kah0904_LIN
a 0.001395
b 3.288348

@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
```