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Taihoro Nukurangi

Inshore trawl survey of the Canterbury Bight and Pegasus Bay, December 1998-January 1999

M. L. Stevenson and M. P. Beentjes

Final Research Report for
Ministry of Fisheries Research Project INT9802

National Institute of Water and Atmospheric Research

June 1999

Final Research Report

Author: M. Stevenson and M. Beentjes

Title: Inshore trawl survey of the Canterbury Bight and Pegasus Bay, December 1998-January 1999

Date: 22 June 1999

Contractor: National Institute of Water and Atmospheric Research Limited

Project Title: Estimation of inshore fish abundance along the east coast of the South Island from Kaikoura to Shag Point using trawl surveys.

Project Code: INT9802

Project Leader: Michael Beentjes

Duration of Project:

Start Date: 1 October 1998
Completion date: 30 June 1999

Executive Summary:

The trawl survey was successfully completed in December 1998-Januray 1999 and the data have been checked and loaded onto the *trawl* database. Preliminary results were presented to Inshore Working Groups 1 & 2 in February 1999.

A NIWA Technical Report has been prepared (see the attached). Biomass estimates for the most abundant species and other commercially important species for which more than 200 kg were caught have been determined. Catch rates, distribution, and scaled length frequencies for the major commercial species have been charted. Length-weight relationships for the target species, rough skate, smooth skate, dark ghost shark, lemon sole, new Zealand dole, sand flounder, and hapuku have been calculated from the data.

Target coefficients of variation were achieved on all four target species, elephantfish, red gurnard, giant stargazer, and juvenile red cod < 41 cm total length. Biomass estimates for the target species were greater than the previous two surveys except for red gurnard which was only greater than the second survey. Adult elephantfish were well represented on this survey with the bulk of the biomass (90%) composed of 2+ and older fish.

Length frequency results from the three surveys suggest that it may be possible to develop recruitment indices for the target species as well as barracouta, lemon sole, New Zealand sole, sand flounder, school shark, spiny dogfish, tarakihi and perhaps ling. Ageing of otoliths collected on the surveys would be useful to establish age frequency time series for key species and determine if the surveys are achieving adequate coefficients of variation on specific age classes. A time series of recruitment indices would be valuable for validation of ageing techniques.

Objectives:

Programme Objective:

1. To determine the relative abundance and distribution of inshore fish abundance along the east coast of the South Island from Kaikoura to Shag Point using trawl surveys.

Objectives for 1998/99

1. To determine the relative abundance and distribution primarily of elephantfish, red gurnard, giant stargazer, and juvenile red cod (under 41 cm) along the east coast of the South Island by carrying out a trawl survey. The target coefficients of variation (*c.v.*s) of the biomass estimates for these species are as follows: elephantfish, 20–25%; red gurnard, 25–30%; giant stargazer, 15–20%; juvenile red cod < 41 cm total length, 20–30%;

   Survey completed. Relative abundance and distribution determined. Biomass estimates and c.v.s for the target species were: elephantfish, 404 t and 18.2%; red gurnard, 317 t and 16.2%; juvenile red cod < 41 cm, 4 426 t and 24.3%; and stargazer 543 t and 11.4%.

   Voyage programme and Voyage Report completed and distributed. Reports to Inshore Working Groups 1 & 2 presented. Technical Report published.

2. To collect the data and to determine the population length frequency, length-weight relationship, and reproductive condition of elephantfish, red cod red gurnard, and giant stargazer caught on the trawl survey.

   Data collected during the trawl survey. Length frequencies, length-weight relationships, and reproductive condition determined from the data. Reports to Inshore Working Groups 1 & 2 presented. Technical Report prepared.

3. To collect otoliths from red cod, red gurnard and stargazer and spines from elephantfish.

   Up to four pair of otoliths per centimetre size class per sex were collected from red cod (334 total) , red gurnard (219), and giant stargazer (281) and up to four spines per centimetre size class per sex from elephantfish (389).

4. To collect the data to determine relative biomass and distribution and population length frequencies of all other Quota Management System (QMS) species, and dark ghost shark, (*Hydrolagus novaezelandiae*), rough skate (*Raja nasuta*), smooth skate (*Raja innominata*), spiny dogfish (*Squalus acanthias*), and sea perch (*Helicolenus* spp.).

   Data collected during the survey. Biomass estimates, distributions, and population length frequencies determined for all QMS and other required species.

Methods:

See the attached Technical Report.

Results:

See the attached Technical Report.

Conclusions:

See the Executive Summary of this report and the Discussion section of the Technical Report.

Publications:

Technical Report attached.

Data Storage:

Data from the survey is stored on the Ministry of Fisheries *trawl* database.

Inshore trawl survey of the Canterbury Bight and Pegasus Bay December 1998 - January 1999 (KAH9809)

Michael L. Stevenson
and
Michael P. Beentjes

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Inquiries to:
Publication Services, NIWA
PO Box 14-901, Wellington, New Zealand.

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Contents

Introduction

This report presents the results from the third in a time series of summer inshore trawl surveys along the east coast of the South Island from the Waiau River to Shag Point in the depth range 10–400 m. The survey design was optimised for elephantfish, giant stargazer, red gurnard, and juvenile red cod (< 41 cm). The survey also collected data on other important commercial species, including barracouta, dark ghost shark, ling, rough and smooth skate, sea perch, spiny dogfish, and tarakihi.

Red cod support the major east coast South Island inshore trawl fishery, with an average annual catch in 1994–95 to 1996–97 of about 11 000 t (Annala *et al.* 1998). Catches of elephantfish, giant stargazer, and red gurnard, combined, have averaged about 2000 t in the same period and have all approached or exceeded quota limits. The latter three species have all had Total Allowable Commercial Catch (TACC) increases in recent years under the Adaptive Management Programme. The Ministry of Fisheries require adaptive management species to be monitored to determine if the TACC increases are sustainable. The winter time series and the current summer time series of trawl surveys have provided relevant data for this programme. Data include estimates of relative biomass, length frequency distributions, ageing material, and reproductive condition. Commercial landings of red cod have fluctuated widely between years as a result of variable recruitment and few year classes in the fishery (Beentjes 1992, Annala *et al.* 1998). The summer surveys have provided information on year class strength of both 0+ and 1+ cohorts which has been shown to be useful for predicting the commercial fishery for the following one or two years.

A pilot trawl survey was undertaken in December 1996–January 1997 to determine whether summer trawl surveys could effectively monitor the abundance of important commercial species in the survey area (Stevenson 1997). The timing of the winter series (five surveys in May–June from 1991–96; Beentjes 1996) proved to be inappropriate to meet the project objectives. Results of the pilot survey indicated that a summer series of trawl surveys would be more effective for monitoring fish abundance in this area. The pilot summer survey used a smaller mesh codend than the winter series to better sample 0+ red cod juveniles and the survey area was extended to include areas in the 10–30 m depth range to better sample elephantfish and red gurnard. Rig was dropped as a target species after the pilot survey because of low catches and high coefficients of variation (*c.v.*s). The pilot survey was successful for all the other target species and was the first in the time series followed by the second survey in December 1997–January 1998 (Stevenson & Hurst 1998).

This report fulfils part of the requirements of the Ministry of Fisheries contract INT9802, "Estimation of inshore fish abundance along the east coast of the South Island from Kaikoura to Shag Point using trawl surveys".

Programme objective

To determine the relative abundance and distribution of inshore fish abundance along the east coast of the South Island from Kaikoura to Shag Point using trawl surveys.

Survey objectives

1. To determine the relative abundance and distribution of elephantfish, red gurnard, stargazer, and juvenile red cod along the east coast of the South Island from Kaikoura to Shag Point by carrying out a trawl survey. The target coefficients of variation (c.v.s) of the biomass estimates for these species are as follows: elephantfish (20 to 30 %); juvenile red cod < 2 years old (20 to 30 %); red gurnard (25 to 30 %); stargazer (15 to 20 %).

2. To collect the data and determine the population length frequency, length-weight relationship and reproductive condition of elephantfish, red cod, red gurnard and stargazer.
3. To collect otoliths from red cod, red gurnard and stargazer and spines from elephantfish.
4. To collect the data to determine relative biomass, and distribution and population length frequencies of all other Quota Management System (QMS) species, and dark ghost shark (*Hydrolagus novaezelandiae*), rough skate (*Raja nasuta*), smooth skate (*R. innominata*), spiny dogfish (*Squalus acanthias*), and sea perch (*Helicolenus spp.*).

Timetable and personnel

The voyage started and finished in Wellington and was divided into two parts, the first from 12 to 23 December 1998 and the second from 28 December 1998 to 13 January 1997.

Michael Beentjes was project leader and Michael Stevenson was voyage leader and was also responsible for final database editing. The skipper was Arthur Muir.

Methods

Survey area and design

The survey area (Figure 1) covered depths of 10–400 m off the east coast of the South Island from the Waiau River to Shag Point, except at the northern end from the Kowai River to Waiau River, the southern end from Cape Wanbrow to Shag Point, and around Banks Peninsula where the minimum depth was 30 m. These areas have extensive areas of foul ground in the form of inshore rocky reefs and were likely to have different species composition to other parts of the survey area.

The survey area of 26 938 km^2, including untrawlable (foul) ground, was divided into 23 strata by area and depth (Table 1, Figure 1). Depth ranges were 10–30 m, 30–100 m, 100–200 m, and 200–400 m, except for strata 3 and 4 which were divided into 30–50 m and 50–100 m depth ranges. Strata were identical to the 1997–98 survey (Stevenson & Hurst 1998), except that the 1997–98 stratum 5 was split into two (5 and 5A) to maximise sampling efficiency for elephantfish.

In order to achieve the required *c.v.*s for the target species, a simulation study of precision versus number of stratified random stations completed was made using data from the first two surveys (R. I. C. C. Francis, NIWA, pers. comm.). Results indicated that 120 stations and a two-phase design (*after* Francis 1984) were required to achieve the target *c.v.*s with about 75% of stations allocated to phase 1. Allocation of phase 1 stations was proportional to the product of the stratum area and a weighting factor, with the constraint that at least three stations were allocated to each stratum. Phase 1 station allocation was weighted between 1 and 4, based on previous catch rates of the target species. Phase 2 stations were targeted at species which had simulated *c.v.*s above target *c.v.*s after the allocation of phase 1 stations.

Before the survey began, sufficient trawl stations to cover both first and second phase stations were generated using the computer program 'Rand_stn v2.1' (Vignaux 1994). The stations were required to be a minimum of 3.7 km (2 n. miles) apart to coincide with the tow length established in the survey design. Non-trawlable ground was identified before the voyage from information collected during previous surveys by RV *Kaharoa*. Ninety-four station were allocated to phase 1.

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 was constructed in 1991 specifically for South Island inshore trawl surveys and is based on an 'Alfredo' design. Gear specifications are the same as for previous summer surveys (*see* Stevenson 1997, Appendix 1 for details). The codend mesh size was 28 mm. Four strengthening ropes placed down the length of the codend in 1997–98 were retained to minimise damage (a problem in the first survey) and a blow-out panel was installed about 2 m in front of the codend for tows in strata 1, 2 and 8 where there was the greatest risk of very large catches.. The panel was designed to burst automatically when the catch filled the net to that point.

Doorspread and headline height measurements were recorded using SCANMAR monitoring equipment with an average of five readings at 10 min intervals during each tow. Technical problems with the SCANMAR readout prevented direct measurement of doorspread for almost half of all tows. For tows where no direct readout was possible, doorspread value was estimated as being equal to the mean from stations within the same strata depth range, from the previous two surveys.

All tows were undertaken in daylight between 0500 and 1700 hours NZST. At each station it was planned to tow 2 n. miles (measured by GPS from when the gear reached the bottom to the start of hauling) at 3.0 knots (speed over the ground). Tow direction was dependent on weather conditions, but usually followed the bottom contour or was in the direction of the next station to reduce steaming time.

If untrawlable ground was encountered, an area within a 2 n. mile radius of the station was searched for suitable ground. If no suitable ground could be found within the radius, the next alternative station was chosen from the random station list.

For depths less than 70 m a constant warp length of 200 m was used. At depths greater than 70 m a variable warp to depth ratio was used starting at 3:1 and decreasing to 2.5:1 (Table 2).

Water temperatures

Sea surface temperatures (SST) were not recorded during the survey because the hull-mounted temperature sensor was not installed. Mean sea surface temperatures from satellite imagery for 9–11 January were obtained from NIWA SST Archive (NSA). These data are corrected to represent temperature at a depth of 1 m below the surface. Bottom temperatures were recorded from the SCANMAR sensor on 120 tows.

Catch and biological sampling

The catch from in each tow was sorted on deck into species and weighed on Seaway 100 kg motion-compensating scales to the nearest 0.1 kg. Finfish, squids, and crustaceans (except crabs) were classified by species: crabs and shellfish were given general classifications because of difficulty in identifying individual species and the limited sorting time available between tows.

Length, to the nearest whole centimetre below actual length, and sex (where possible) were recorded for all ITQ species and for rough skate, smooth skate, and spiny dogfish. Sample sizes were either the whole catch or a randomly selected subsample of up to 200 fish.

Individual fish weights and/or reproductive state were collected for the target species and rough skate, smooth skate, hapuku, dark ghost shark, tarakihi, sand flounder, lemon sole, New Zealand sole, greenback flounder and yellowbelly flounder. Individual fish weights were measured 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 as full a size range as possible for each species. Up to four otoliths (or spines) per sex per centimetre size class were collected from length frequency samples for elephantfish, giant stargazer, hapuku, red cod, and red gurnard. Vertebrae were collected from all smooth skate and from up to two rough skate per centimetre size class per sex for skate over 40 cm PL, with the remainder spread over sizes less than 40 cm to achieve a total sample size of 150. A block of 4–6 of the largest vertebrae from the rear half of the body cavity were removed, trimmed of excess muscle, labelled with sex, length , and maturity stage, placed in a sealed plastic bag and frozen.

Reproductive maturity stages for elephantfish, rough skate, and smooth skate were recorded. For males the stages were: immature (1), claspers short (not extending beyond the pelvic fins) and uncalcified; maturing (2), claspers extend beyond pelvic fins but soft and uncalcified (rarely some calcification may have begun); mature (3), claspers extend well beyond pelvic fins and are hard, rigid and calcified. For females the stages were: immature (1), ovary invisible or contains only small (pinhead size) ova that have no trace of yellow or orange yolk; maturing (2), ovary contains medium (pinhead to pea-sized) ova that may be yellow or orange, uteri may have visible swellings at anterior or posterior ends but no uterine eggs present; mature (3), ovary contains large (greater than pea-sized) yellow or orange ova, uteri enlarged (>1 cm diameter) and may contain eggs.

Data analysis

Relative biomass estimates and scaled length-frequency distributions were estimated by the area-swept method (Francis 1981, 1989) using the Trawlsurvey Analysis Program (Vignaux 1994). All data were entered into the Ministry of Fisheries *trawl* database.

The following assumptions were made for extracting biomass estimates with the TrawlSurvey Analysis 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 volume 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, they have been retained for this analysis to allow for a time series of relative abundance estimates to be developed. Problems with the assumption that relative catchability remains the same between trawl surveys are discussed later.

Biomass estimates were calculated using data from all stations where gear performance was considered to be satisfactory, i.e. gear performance code of 1 or 2. The *c.v.* associated with estimates of biomass was calculated by the method of Vignaux (1994).

A combined biomass and length frequency analysis was used for deriving scaled length frequency distributions and biomass estimates for recruited fish and/or year classes. The length-weight coefficients used are given in Appendix 1. The geometric mean functional relationship was used to calculate the length-weight coefficients. For coefficients chosen from the database, a selection was made on the basis of the best match between the size range of the fish used to calculate the coefficients and the sample size range from this survey. All length frequencies were scaled by the percentage of catch sampled, area swept, and stratum area using the Trawlsurvey Analysis Program.

Results

Survey area and design and gear performance

A total of 120 successful tows were completed, 96 in phase 1 and 24 in phase 2 . The completed station density ranged from 1 station per 79 km^2 in stratum 8, to 1 station per 397 km^2 in stratum 10, with an overall density of 1 station per 224 km^2 (*see* Table 1). At least three stations were completed in each stratum and all project and survey objectives were addressed. The survey area, with stratum boundaries and station positions, is shown in Figure 1 and individual station data are given in Appendix 2. The trawlable ground represented 92% of the total survey area with the untrawlable (foul) ground confined to strata 1, 6, 7, 8, 12, 13, 14, and 17.

Sampling began in the north, travelling southward covering the inshore strata (<100 m; 1, 2, 3, 3A, 4A, 5, 5A, 6, 7, 21, 20, 19, and 18, but not in this order) where the four target species tend to be found at this time of year. Strata 19 and 20 (principle elephant fish strata in 1997–98) were sampled last in the first leg, ensuring that the potential period between phase 1 and phase 2 in these strata would be minimised if phase 2 stations were required in these strata. The deeper water strata and phase 2 stations were sampled during the second leg. Again, the direction of the survey was generally from north to south so that time would be minimised between phase 1 and 2 stations.

Five phase 2 stations were allocated to stratum 8 where the highest catch rates of juvenile red cod occurred, 2–4 stations were allocated to strata 3, 5, 19, and 20 for elephantfish, and the remainder to strata with the highest catch rates of red gurnard. All but 3 phase 2 stations were allocated south of Banks Peninsula. Catch rates of giant stargazer were not used for allocation of phase 2 stations because the *c.v.* was less than 15% at the completion of phase 1.

Measurements of headline height and doorspread, together with observations that the doors and trawl gear were polishing well, indicate that the gear was fishing hard down and as designed. Retaining the strengthening ropes on the codend prevented the damage suffered in the first survey. The stronger codend allowed most tows to be the planned length of 2 n. miles. Eleven tows were limited to a length of 1 n. mile to reduce the risk of very large catches. For the total depth range, recorded doorspread varied from 63.8 to 99.6 m. and headline height varied between 4.5 and 6.0 m (*see* Table 2, Appendix 2). For each depth range, and overall, the doorspreads recorded for this survey were higher than, but not significantly different from, those recorded during the previous surveys. The higher values for doorspread were the result of a warp to depth ratio of 3 being used for several tows at depths greater than 70 m. There is considerable overlap in the between-survey data for both doorspread and headline height and the differences are not thought to affect comparability.

Water temperatures

Bottom temperatures are shown in Figure 2. There was no apparent difference in bottom temperatures between the first and second legs of the voyage.

Mean surface temperatures for 9–11 January are shown in Figure 3. Persistent cloud cover prevented collection of satellite data for other periods.

Catch composition

About 123 t of fish, crustaceans, echinoderms, and molluscs were caught from 122 tows at an average of 1 010 kg per tow (range 133.7–8337 kg). A total of 102 species was identified during the survey: 1 agnathan, 14 elasmobranchs, 79 teleosts, 3 cephalopods, 1 echinoderm, and 4 crustaceans. Species codes, common names, scientific names, and catch weights of all species caught on the survey are given in Appendix 3.

Total catch from all but two stations were weighed and measured. The catches not weighed were from stations 43 (large amount of *Macrocystis* sp. fouled gear) and 83 (catch too large to get on the deck).

Total catch weights of species where catch was greater than 200 kg and sand flounder are given in Table 3 in order of decreasing weight. The most abundant species by weight was barracouta with a catch of 26.3 t (21% of the total catch). The four most abundant species, barracouta, spiny dogfish, red cod, and dark ghost shark, made up about 64% of the total catch (*see* Table 3). The target species, elephantfish, giant stargazer, red gurnard, and red cod, made up 2.2, 0.9, 0.5, and 16.0 % of the catch, respectively. Species caught in over 80% of the tows were spiny dogfish, barracouta, red cod, arrow squid, and witch.

Biomass, distribution, and distribution

Relative biomass estimates and *c.v.*s for species where catch was greater than 200 kg and sand flounder are given in Table 3. Spiny dogfish had the largest estimated biomass followed by barracouta, red cod, and dark ghost shark. Coefficients of variation for the target species were all less than 18% except for elephantfish which was 28% (*see* Table 3).

Recruited biomass estimates and *c.v.*s for barracouta, blue warehou, elephantfish, giant stargazer, hoki, lemon sole, NZ sole, red cod, red gurnard, rig, sand flounder, school shark, silver warehou, and tarakihi are given in Table 4. For the target species elephantfish, giant stargazer, red gurnard, and red cod the percentage of total biomass that was recruited fish was 84%, 92%, 92%, and 70% respectively. Biomass estimates by year class are given in Table 5 for barracouta, blue warehou, elephantfish, hoki, red cod, red gurnard, school shark, silver warehou, and tarakihi. Year class length intervals were estimated from the scaled length frequency distributions. The 1+ year class for red cod is 24% of the total estimated biomass for the species.

Catch rates by stratum for the 20 most abundant commercial species are given in Table 6. Distributions and ranges of catch rates by station for the 23 most abundant (catch greater than 150 kg) commercial species are shown in Figure 4 in alphabetical order by common name. Barracouta were caught throughout the survey area although catch rates east of Banks Peninsula were low. Spiny dogfish were also caught throughout the survey area with the highest catch rates off Omaru in 30–200 m. For the target species, elephantfish catch rates were highest off Timaru and Lake Ellesmere in depths of 30–50 m. Giant stargazer were caught in all areas except the 10–30 m depth range with the highest catch rates in the 50–200 m depth range. Red cod were caught throughout the survey area with the highest catch rates in the south in the 30–200 m depth range. Red gurnard were confined to depths less than 100 m and catch rates were highest in depths less than 50 m in Pegasus Bay, off Lake Ellesmere, and between Timaru and Omaru.

Biomass and *c.v.*s for the 20 most abundant commercially important species are given by stratum in Table 7 and generally reflect the distribution of high and low catch rates.

Biological and length frequency data

Species length frequency, and biological samples collected and measurement methods are given in Table 8.

Scaled length-frequency distributions of the major commercial species (more than 100 fish measured) and smooth skate are shown in Figure 5 in alphabetical order by common name. Length frequencies are given by depth range for red cod, giant stargazer, and red gurnard.

The length frequency distribution for elephantfish shows two clear modes for the 0+ and 1+ cohorts at 12–21 cm and 22–32 cm fork length, respectively. The sex ratio (males : females) for elephantfish was 0.85:1 and varied little by depth, however, most fish < 40 cm were in depths of less than 30 m.

The length frequency distributions for giant stargazer were similar from the 30–100 and 100–200 m depth ranges. Modal patterns are difficult to interpret. The sex ratio for giant stargazer was 0.89:1 overall, 0.80:1 in 30–100 m, and 1.13:1 in 100–200m..

The length frequency distribution for red gurnard shows a distinct mode for 1+ fish at 14–25 cm but other year classes are difficult to interpret. Larger fish (over 25 cm) were more common in the 30–100 m depth range, whereas the 1+ cohort occurred mainly in less than 30 m depth. For red gurnard the sex ratios were 0.96:1 overall; 0.32:1 in 10–30 m; and 1.47:1 in 30–100 m.

The length frequency distribution for red cod shows a strong mode for 1+ fish at 15–35 cm and a mode for 0+ fish at 6–14 cm. The sex ratios for red cod were 1.15:1 overall; 0.24:1 in 10–30 m; 0.83:1 in 30–100 m; and 1.69:1 in 100–200 m.

Length at maturity data for elephantfish, rough skate, and smooth skate are shown in Figure 6. The results indicate that elephantfish mature at about 55 cm for males and 65 cm for females, and rough skate at 51 cm for males and 58 cm for females. The low numbers of large smooth skate make it difficult to estimate length at maturity for this species, however it appears that males mature at between 85–95 cm.

Details of the gonad stages for giant stargazer, red cod, and red gurnard are given in Table 9. Almost all giant stargazer were immature or resting, (94% males and 92% females) while a small percentage were maturing. For red cod, the majority of gonads were classified as immature or resting (76% males and 94% females). The remaining males were fairly evenly spread between mature, running ripe, and spent, while nearly all other females were maturing. The majority of red gurnard males were immature or resting (34%), or maturing (64%). Female red gurnard showed a wide range of gonad development with 37% immature or resting, 22% maturing, 30% mature, and 9% running ripe.

Discussion

The third in the time series of summer south east South Island trawl surveys was completed during December 1998–January 1999, meeting all objectives. Coefficients of variation associated with biomass estimates for the target species were all substantially better than the specified target range except elephantfish, which was within the target limits. In general *c.v.*s were lower than in past surveys, particularly for red cod and giant stargazer.

All biomass estimates for target species were greater than the first (1996–97) and second (1997–98) surveys, except for red gurnard which was only greater than the second survey. Catch rates during the second survey were low compared to the first, and caution was advised when interpreting these estimates, particularly for inclusion in the time series (Stevenson & Hurst 1998). Weather patterns influencing water temperature, and the earlier timing of the second survey compared to the first, were suggested as potential causes of the low catch rates. The observed differences in relative abundance are, therefore, unlikely to reflect actual changes in abundance. Given that biomass estimates for this survey are more in line with the first survey, it may be that environmental factors at the time of the second survey affected catchability of many species. Surface water temperatures for January (NIWA SST archive) on this survey were warmer than both previous surveys but bottom temperatures outside 100 m were cooler. It is clear that water temperatures fluctuate widely in a complex manner both within and between surveys and it is difficult and probably unfounded to relate water temperature fluctuations to catch rates.

Adult elephantfish (> 40 cm) were not well represented in the 1997–98 survey and the low catch rates and biomass for elephant fish could be related to the low catch rates for most species. Adult elephant fish were well represented on this survey as the bulk of the biomass (90%) was composed of 2+ and older fish and mature fish made up about one third of the scaled numbers (i.e. fish larger than 52 cm) (*see* Figures 5 & 6). It has been suggested that elephantfish vulnerability to capture by *Kaharoa* is low and also that the depth range should be extended into depths shallower than 10 m to target elephant fish more effectively. This can only be tested by running a concurrent survey using an industry vessel that surveys both the same area as the *Kaharoa* and also areas less than 10 m.

Juvenile year classes are clearly distinguishable for the target species red cod, red gurnard and elephant fish and it should be possible to develop recruitment indices for these species. Red cod recruitment indices for the winter trawl survey time series indicated that commercial catches were related to the strength of 1+ year class from the previous year (Beentjes 1996). The summer surveys also provide an index for the 1+ as well as the 0+ red cod year classes. Results of the three surveys suggest that it may be possible to develop recruitment indices for other species such as barracouta, lemon sole, New Zealand sole, sand flounder, school shark, spiny dogfish, tarakihi, and perhaps ling. Time series of such recruitment data are also valuable for validation of ageing techniques.

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

Stratum	Depth (m)	Area (km^2)	Non-trawlable area (km^2)	Number of stations Phase 1	Number of stations Phase 2	Station density (km^2 per station)
1	30–100	984	202	3	0	328
2	30–100	1 242	0	4	0	311
3	50–100	1 920	0	6	3	213
3A	30–50	1 111	0	5	0	222
4	50–100	1 853	0	6	4	185
4A	30–50	845	0	4	2	141
5	50–100	1 528	0	4	0	382
5A	30–50	971	0	5	0	194
6	30–100	2 373	208	6	3	264
7	30–100	2 089	871	7	0	298
8	100–200	628	17	3	5	79
9	100–200	1 163	0	3	2	233
10	100–200	1 191	0	3	0	397
11	100–200	1 468	0	4	0	367
12	100–200	764	132	3	0	255
13	100–200	999	406	3	0	333
14	200–400	752	41	3	0	251
16	200–400	751	0	3	0	250
17	200–400	724	165	3	0	241
18	10–30	1 276	0	6	0	213
19	10–30	986	0	5	2	141
20	10–30	797	0	4	2	133
21	10–30	520	0	3	1	130
Total (average)		26 938	2 042	96	24	(224)

Table 2 : **Tow and gear parameters by depth range**

Tow parameters	*n*	Mean	*s.d.*	Range
Tow length (n. mile)	120	1.90	0.29	1.0–2.07
Gear parameters (m)				
10–30 m				
Headline height	21	5.4	0.3	4.8–5.7
Doorspread	8	72.4	3.9	63.8–76.4
Warp/depth ratio	22	8.7	2.1	6.4–13.3
30–100 m				
Headline height	63	5.3	0.3	4.7–6.0
Doorspread	25	76.6	4.7	70.2–86.5
Warp/depth ratio	63	3.7	0.9	2.5–5.7
100–200 m				
Headline height	26	5.2	0.3	4.5–5.6
Doorspread	22	81.3	6.5	69.1–91.5
Warp/depth ratio	26	2.7	0.3	2.3–3.1
200–400 m				
Headline height	9	4.9	0.2	4.7–5.3
Doorspread	7	95.4	2.5	92.6–99.6
Warp/depth ratio	9	2.8	0.4	2.3–3.2
10–400 m				
Headline height	119	5.2	0.3	4.5–6
Doorspread	62	79.8	8.1	63.8–99.6
Warp/depth ratio	120	4.3	2.4	2.3–13.3

Table 3 : **Total catch and relative biomass estimates (for fish of all lengths) for species where more than 200 kg were caught, and sand flounder**

	Catch		Biomass	
	Weight (kg)	% of total	(t)	*c.v.* %
Barracouta	26 331	21.4	21 877	14
Spiny dogfish	24 106	19.6	22 842	16
Red cod (all)	19 677	16.0	12 823	17
Juvenile red cod (< 41 cm)	–	–	3 770	15
Dark ghost shark	8 762	7.1	7 416	27
Hoki	6 561	5.3	4 812	29
Two saddle rattail	5 597	4.5	5 291	16
Tarakihi	4 980	4.0	4 277	24
Blue warehou	3 726	3.0	4 030	95
Sea perch	3 464	2.8	3 889	41
Elephantfish	2 711	2.2	1 718	28
Witch	1 639	1.3	1 082	20
Bollon's rattail	1 620	1.3	1 185	52
Rough skate	1 462	1.2	1 175	10
Carpet shark	1 412	1.1	1 167	11
Arrow squid	1 200	1.0	970	12
Giant stargazer	1 161	0.9	999	10
Oblique banded rattail	1 113	0.9	838	39
Ling	842	0.7	705	18
Red gurnard	675	0.5	493	13
Smooth skate	586	0.5	450	26
School shark	438	0.4	343	23
Southern pigfish	412	0.3	441	17
Scaly gurnard	365	0.3	317	16
Silver warehou	352	0.3	269	19
Lemon sole	310	0.3	269	35
Sprats	307	0.2	206	55
Silverside	300	0.2	279	18
Rig	298	0.2	214	52
Chilean jack mackerel	276	0.2	275	36
Javelin fish	275	0.2	202	31
Hapuku	265	0.2	242	19
NZ sole	226	0.2	148	21
Sand flounder	162	0.1	120	26
Other species	1 624	1.3		
All species combined	123 233		102 543	

– Actual catch data not available

Table 4 : **Total and recruited biomass estimates (t) for barracouta, blue warehou, elephantfish, hoki, lemon sole, NZ sole, red cod, red gurnard, rig, sand flounder, school shark, silver warehou, and tarakihi**

Species	Recruited length (cm)	Total biomass	*c.v.* %	Recruited biomass	*c.v.* %
Barracouta	50	21 877	14	18 396	15
Blue warehou	45	4 030	95	677	88
Elephantfish	50	1 718	28	1 457	33
Giant stargazer	30	999	10	922	10
Hoki	60	4 812	29	1 348	38
Lemon sole	25	269	35	214	24
NZ sole	25	148	21	123	22
Red cod	41	12 823	17	9 053	23
Red gurnard	30	493	13	453	13
Rig	90	214	52	105	29
Sand flounder	25	120	26	116	26
School shark	90	343	23	59	30
Silver waerhou	25	269	35	233	40
Tarakihi	25	4 277	24	2 142	29

Table 5 : **Biomass estimates (t) by year class* for barracouta, blue warehou, elephantfish, hoki, red cod, red gurnard, school shark, silver warehou, and tarakihi**

Species	Year class	Length range (cm)	Biomass	*c.v.* %
Barracouta	0+	<20	24	41
	1+	20–40	1 531	20
	2+	41–55	4 965	20
Blue warehou	0+	<11	<0.5	75
	1+	11–24	40	29
	2+	25–35	243	99
Elephantfish	0+	10–20	3	40
	1+	21–33	147	52
Hoki	1+	30–46	2 631	50
Red cod	0+	5–14	51	38
	1+	15–35	3 050	16
Red gurnard	1+	12–26	10	45
School shark	0+	21–34	2	39
	1+	35–50	23	31
Silver warehou	0+	6–12	2	41
	1+	13–19	22	37
	2+	20–31	199	46
Tarakihi	1+	12–17	177	29

* Estimated from length frequency distributions.

Table 6 **: Catch rates (kg.km^{-2}) with standard deviations (in parentheses) by stratum, for the 20 most abundant commercially important species***

		Species code									
Stratum	Depth (m)	BAR	ELE	GSH	GUR	HOK	JMM	LIN	LSO	RCO	RSK
1	30–100	68	2	0	11	0	6	91	12	388	90
		(63)	(4)		(10)		(10)	(128)	(9)	(283)	(32)
2	30–100	2 191	21	0	19	0	2	9	66	1 570	109
		(2 512)	(37)		(18)		(2)	(18)	(54)	(2 130)	(65)
3	50–100	1 860	25	5	10	4	7	61	3	1 164	4
		(1 362)	(49)	(12)	(13)	(9)	(11)	(103)	(4)	(1 291)	(7)
3A	30–50	1 726	190	0	12	0	0	20	19	161	63
		(1 883)	(95)		(11)			(39)	(24)	(195)	(77)
4	50–100	838	324	111	22	3	8	11	1	125	12
		(572)	(763)	(180)	(26)	(10)	(6)	(9)	(1)	(101)	(25)
4A	30–50	1 192	301	0	81	0	2	3	10	158	88
		(1 501)	(240)		(77)		(3)	(6)	(14)	(244)	(35)
5	30–70	314	0	55	10	0	36	2	4	62	83
		(401)		(110)	(5)		(70)	(2)	(4)	(73)	(55)
5A	70–100	909	18	0	20	+	3	1	2	214	58
		(686)	(11)		(21)	(+)	(3)	(1)	(3)	(276)	(42)
6	30–100	812	1	0	22	9	3	+	4	93	48
		(1 813)	(4)		(44)	(26)	(6)	(1)	(3)	(220)	(47)
7	30–100	1 395	4	0	53	120	4	4	5	193	38
		(1 770)	(8)		(27)	(300)	(10)	(5)	(9)	(218)	(45)
8	100–200	474	0	479	11	0	51	77	23	5 119	73
		(386)		(878)	(21)		(75)	(87)	(22)	(6 243)	(101)
9	100–200	674	0	628	1	8	106	132	0	1 940	3
		(382)		(721)	(3)	(13)	(157)	(108)		(1 219)	(6)
10	100–200	1 223	0	618	0	2	0	17	0	683	0
		(515)		(212)		(3)	(0)	(12)		(421)	
11	100–200	10	0	1 294	0	1	4	3	2	65	0
		(12)		(1 479)		(2)	(7)	(2)	(4)	(112)	
12	100–200	34	0	1 518	0	6	0	16	10	7	14
		(29)		(2 625)		(10)		(27)	(7)	(7)	(12)
13	100–200	67	0	8	0	0	0	3	48	120	33
		(116)		(8)				(3)	(57)	(155)	(57)
14	200–400	76	0	1 314	0	1 988	0	77	0	9	0
		(99)		(1 262)		(758)		(45)		(6)	
16	200–400	17	0	155	0	2 205	0	54	2	43	0
		(30)		(243)		(2 509)		(47)	(4)	(38)	
17	200–400	127	0	1 625	0	1 875	0	118	5	66	28
		(105)		(2 353)		(1 798)		(102)	(5)	(46)	(24)
18	10–30	314	128	0	25	0	1	1	5	45	58
		(416)	(237)		(32)		(2)	(1)	(5)	(37)	(30)
19	10–30	808	169	0	29	+	0	+	+	79	101
		(1 010)	(167)		(43)	(+)		(+)	(1)	(158)	(102)
20	10–30	132	249	0	1	0	0	0	2	30	35
		(140)	(155)		(2)				(3)	(38)	(35)
21	10–30	1 403	35	0	91	0	3	1	44	60	166
		(1 834)	(25)		(71)		(7)	(2)	(38)	(94)	(119)

* Species codes are given in Appendix 3

+ < 0.5

Table 6 —continued

		Species code									
Stratum	Depth (m)	SCH	SPD	SPE	SPO	SQU	SSK	STA	SWA	TAR	WAR
1	30–100	0	4 824	174	0	9	20	22	3	874	79
			(4 809)	(284)		(13)	(35)	(9)	(4)	(1 336)	(131)
2	30–100	9	2 561	29	0	37	0	16	1	345	0
		(12)	(2 717)	(56)		(52)		(14)	(2)	(484)	
3	50–100	4	409	60	0	25	19	82	5	100	3
		(11)	(644)	(97)		(24)	(33)	(49)	(8)	(118)	(6)
3A	30–50	14	294	26	0	12	13	19	+	363	+
		(26)	(441)	(43)		(14)	(27)	(10)	(+)	(420)	(+)
4	50–100	2	66	27	0	14	49	70	60	321	0
		(5)	(79)	(50)		(12)	(71)	(31)	(147)	(237)	
4A	30–50	6	99	5	0	12	9	8	7	698	0
		(15)	(98)	(12)		(24)	(23)	(12)	(15)	(1 236)	
5	30–70	7	375	1	4	22	0	49	18	70	0
		(14)	(153)	(2)	(7)	(15)		(43)	(21)	(42)	
5A	70–100	1	637	+	3	12	51	51	6	121	82
		(3)	(476)	(+)	(6)	(11)	(55)	(49)	(8)	(236)	(171)
6	30–100	32	876	6	11	43	0	33	21	32	2
		(81)	(712)	(13)	(23)	(39)		(37)	(37)	(45)	(7)
7	30–100	24	430	421	8	5	4	42	+	156	1 841
		(27)	(756)	(858)	(12)	(7)	(11)	(62)	(+)	(294)	(4 845)
8	100–200	0	3 341	194	6	174	16	77	21	2	0
			(3 134)	(410)	(16)	(90)		(59)	(35)	(3)	
9	100–200	7	1 721	179	11	163	21	85	6	0	0
		(16)	(1 156)	(272)	(24)	(137)	(34)	(67)	(4)		
10	100–200	0	1 860	1 589	0	47	24	26	8	229	0
			(1 421)	(2 048)		(33)	(41)	(18)	(5)	(393)	
11	100–200	0	144	37	0	11	55	37	10	95	0
			(77)	(60)		(8)	(103)	(49)	(16)	(182)	
12	100–200	0	1 083	46	0	87	0	41	4	71	0
			(1 090)	(66)		(90)		(26)	(3)	(65)	
13	100–200	0	613	245	0	21	2	37	0	83	0
			(793)	(266)		(21)	(4)	(29)		(40)	
14	200–400	0	141	+	0	181	0	10	1	0	0
			(99)	(+)		(125)		(2)	(2)		
16	200–400	0	182	2	0	47	4	12	1	0	0
			(238)	(3)		(62)	(7)	(13)	(1)		
17	200–400	0	483	41	0	33	85	50	2	0	0
			(410)	(71)		(14)	(142)	(29)	(4)		
18	10–30	52	98	0	20	+	0	+	+	0	9
		(22)	(144)		(25)	(+)		(+)	(1)		(10)
19	10–30	39	378	0	12	6	0	0	2	10	5
		(30)	(291)		(17)	(8)			(3)	(20)	(8)
20	10–30	19	319	0	2	1	14	+	+	+	13
		(17)	(303)		(3)	(2)	(33)	(+)	(+)	(+)	(13)
21	10–30	65	217	0	206	3	0	+	1	52	0
		(103)	(344)		(412)	(3)		(+)	(2)	(52)	

* Species codes are given in Appendix 3

+ < 0.5

Table 7 **: Estimated biomass (t) and coefficient of variation (*c.v.*) by stratum of the 20 most abundant commercially important species***

										Species code
Stratum	BAR	ELE	GSH	GUR	HOK	JMM	LIN	LSO	RCO	RSK
1	67.1	2.3	0	10.4	0	5.5	89.9	11.7	381.8	89
	(53)	(100)		(55)		(100)	(81)	(45)	(42)	(21)
2	2 721.8	26.5	0	23.4	0	2.5	11.4	82.3	1 950.4	135
	(57)	(78)		(47)		(58)	(100)	(41)	(68)	(30)
3	3 571.3	48.3	8.93	18.6	7.2	12.7	116.7	5.6	2 236.1	8
	(23)	(62)	(83)	(41)	(74)	(54)	(53)	(44)	(35)	(53)
3A	1 916.9	211.3	0	13.6	0	0	22.3	21.3	178.9	70
	(55)	(25)		(47)			(98)	(63)	(61)	(61)
4	1 553.0	600.1	205.44	41.3	5.6	14.3	20.7	2.3	232.1	22
	(22)	(75)	(51)	(37)	(100)	(24)	(27)	(26)	(26)	(68)
4A	1 004.4	253.5	0	68.5	0	2.0	2.6	8.8	133.1	74
	(51)	(33)		(39)		(45)	(86)	(56)	(63)	(16)
5	479.9	0	83.81	14.7	0	55.0	2.5	6.6	94.1	127
	(64)		(100)	(27)		(97)	(58)	(41)	(59)	(33)
5A	882.1	17.6	0	19.8	0.1	2.7	0.6	2.3	207.7	56
	(34)	(27)		(46)	(100)	(41)	(67)	(55)	(58)	(33)
6	1 927.3	3.6	0	52.8	20.2	6.2	0.5	8.7	219.6	113
	(74)	(100)		(65)	(100)	(77)	(100)	(24)	(79)	(33)
7	2 913.8	7.4	0	111.2	250.3	9.2	8.7	9.5	404.3	80
	(48)	(81)		(19)	(95)	(86)	(47)	(78)	(43)	(44)
8	297.6	0	300.79	7.2	0	32.2	48.3	14.3	3 215.3	46
	(29)		(65)	(65)		(52)	(40)	(34)	(43)	(49)
9	784.4	0	730.91	1.7	9.6	123.3	153.4	0	2 257.5	3
	(25)		(51)	(100)	(71)	(66)	(36)		(28)	(100)
10	1 456.9	0	736.6	0	2.1	0	20.7	0	813.5	0
	(24)		(20)		(100)		(39)		(36)	
11	15.3	0	1899.2	0	1.6	6.6	5.1	3.1	95.1	0
	(56)		(57)		(100)	(81)	(27)	(100)	(86)	
12	25.6	0	1160.31	0	4.4	0	12.6	7.8	5.7	11
	(50)		(100)		(100)		(95)	(37)	(56)	(50)
13	66.8	0	7.53	0	0	0	3.0	47.8	119.7	33
	(100)		(60)				(51)	(69)	(75)	(100)
14	57.2	0	988.27	0	1 495.7	0	58.1	0	7.1	0
	(75)		(55)		(22)		(34)		(35)	
16	12.9	0	116.7	0	1 656.8	0	40.6	1.6	32.1	0
	(100)		(90)		(66)		(50)	(100)	(51)	
17	91.7	0	1177.07	0	1 358.6	0	85.7	3.9	47.5	20
	(48)		(84)		(55)		(50)	(53)	(40)	(50)
18	400.5	163.6	0	32.5	0	1.0	1.0	6.4	57.7	75
	(54)	(75)		(51)		(100)	(68)	(39)	(33)	(21)
19	796.5	166.9	0	28.3	0.1	0	0.2	0.4	78.2	100
	(47)	(37)		(57)	(100)		(100)	(67)	(75)	(38)
20	105.0	198.1	0	1.0	0	0	0	1.6	24.2	28
	(43)	(26)		(58)				(58)	(52)	(41)
21	729.0	18.4	0	47.5	0	1.8	0.5	22.9	31.2	86
	(65)	(32)		(39)		(100)	(85)	(44)	(78)	(36)

* Species codes are given in Appendix 3

\+ < 0.5 t.

Table 7 —continued

	Species code									
Stratum	SCH	SPD	SPE	SPO	SQU	SSK	STA	SWA	TAR	WAR
1	0	4 748.2	171.6	0	9.1	20.0	22.1	2.8	860.2	77.4
		(58)	(94)		(79)	(100)	(24)	(76)	(88)	(96)
2	11.0	3 181.3	36.5	0	46.6	0	20.0	1.4	428.9	0
	(69)	(53)	(95)		(70)		(44)	(100)	(70)	
3	8.1	784.5	114.9	0	47.1	37.1	156.5	8.9	191.6	5.4
	(82)	(50)	(51)		(31)	(53)	(19)	(56)	(37)	(68)
3A	15.6	326.6	29.3	0	12.9	14.8	20.7	0.3	402.9	0
	(91)	(75)	(82)		(60)	(100)	(27)	(33)	(58)	
4	2.9	122.0	49.3	0	25.3	90.8	129.2	111.6	594.2	0
	(100)	(38)	(59)		(29)	(46)	(14)	(77)	(23)	
4A	5.3	83.4	4.5	0	10.4	7.8	6.5	6.1	588.3	5.2
	(100)	(41)	(95)		(79)	(100)	(62)	(85)	(72)	(100)
5	11.1	572.7	1.3	5.5	33.1	0	74.7	28.2	106.5	3 846.2
	(100)	(20)	(100)	(100)	(35)		(44)	(58)	(30)	(99)
5A	1.4	618.2	0.1	2.5	11.5	49.4	49.7	5.7	117.8	0
	(100)	(33)	(100)	(100)	(40)	(48)	(43)	(63)	(87)	
6	77.0	2 079.4	13.2	27.2	102.2	0	78.0	49.7	75.7	0
	(83)	(27)	(80)	(68)	(30)		(38)	(59)	(47)	
7	49.3	898.8	880.0	17.7	9.8	9.0	87.5	0.3	324.9	0
	(43)	(66)	(77)	(56)	(59)	(100)	(56)	(47)	(71)	
8	0	2 098.8	121.6	3.6	109.0	10.0	48.1	13.1	98.0	0
		(33)	(75)	(100)	(18)	(59)	(27)	(59)	(67)	
9	8.4	2 002.3	208.1	12.5	189.1	24.6	98.4	7.1	0	0
	(100)	(30)	(68)	(100)	(38)	(73)	(36)	(28)		
10	0	2 216.6	1 893.3	0	56.3	28.9	31.3	10.0	273.3	0
		(44)	(74)		(40)	(99)	(40)	(35)	(99)	
11	0	211.5	54.8	0	16.6	80.3	54.9	14.4	138.8	0
		(27)	(80)		(35)	(95)	(66)	(81)	(96)	
12	0	827.6	35.3	0	66.3	0	31.2	2.8	54.4	0
		(58)	(82)		(60)		(37)	(40)	(53)	
13	0	612.3	244.4	0	20.5	2.1	37.4	0	82.5	0
		(75)	(63)		(58)	(100)	(46)		(28)	
14	0	105.8	0.1	0	136.1	0	7.7	1.0	0	10.9
		(41)	(100)		(40)		(9)	(100)		(48)
16	0	136.4	1.3	0	35.5	3.1	8.9	0.5	0	5.0
		(76)	(100)		(76)	(100)	(65)	(100)		(61)
17	0	350.1	29.9	0	23.7	61.4	36.5	1.8	0	10.4
		(49)	(99)		(24)	(97)	(33)	(100)		(40)
18	66.9	125.5	0	25.6	0.1	0	0.1	0.6	0	0
	(17)	(60)		(50)	(100)		(100)	(52)		
19	38.0	373.1	0	11.4	5.8	0	0	1.7	9.4	0.2
	(29)	(29)		(55)	(51)			(63)	(80)	(100)
20	14.9	254.1	0	1.6	1.0	10.8	0.2	0.3	0.1	69.1
	(37)	(39)		(51)	(65)	(100)	(100)	(34)	(100)	(85)
21	33.7	112.8	0	106.9	1.8	0	0.1	0.4	27.1	0
	(79)	(79)		(100)	(38)		(100)	(100)	(50)	

* Species codes are given in Appendix 3

\+ < 0.5 t.

Table 8 : **Numbers of length frequency and biological samples collected (species codes are given in Appendix 3)**

	Length frequency data					Biological data+		
Species code	Measurement method	No. of samples	No. of fish	No. of males	No. of females	No. of samples	No. of fish	No. of otolith spine, or scale samples
BAR	1	112	7 515	2 893	2 967	–	–	–
BCO	2	15	139	59	80	–	–	–
BRI	2	6	9	#	#	6	9	–
BTA	5	1	2	2	0	–	–	–
BUT	2	1	1	0	1	–	–	–
BYD	1	1	1	#	#	–	–	–
BYS	1	1	2	#	#	–	–	–
ELE	1	54	1 364	631	733	54	933	389
ESO	2	32	803	#	#	22	363	–
GFL	2	1	18	#	#	1	18	–
GSH	G	32	2 088	912	1 176	12	296	–
GSP	G	2	13	0	13	–	–	–
GUR	1	75	1 461	660	743	75	846	219
HAK	2	8	40	1	3	–	–	–
HAP	2	39	98	45	52	38	98	98
HOK	2	25	1 266	460	484	–	–	–
JDO	2	2	3	3	0	–	–	–
JMD	1	13	50	29	16	–	–	–
JMM	1	42	213	112	94	–	–	–
JMN	1	4	4	2	0	–	–	–
KAH	1	9	13	6	7	–	–	–
LDO	2	6	42	1	41	–	–	–
LIN	2	73	1 199	533	661	–	–	–
LSO	2	78	1 318	#	#	49	522	–
MOK	1	4	9	2	1	–	–	–
OPE	2	1	1	1	0	–	–	–
RBM	1	8	28	12	16	–	–	–
RCO	2	125@	7 938	3 146	3 820	102	1 652	334
RSK	5	74	629	326	303	54	344	162
SAM	1	9	26	18	3	5	17	13
SBW	2	1	73	46	27	–	–	–
SCH	2	41	384	199	185	–	–	–
SFL	2	27	366	#	#	23	282	
SKI	1	1	1	0	1	–	–	–
SPD	2	118	8 580	5 749	2 829	–	–	–
SPE	2	64	2 753	1318	1353	–	–	–
SPO	2	20	130	78	52	–	–	–
SPZ	2	6	9	4	4	–	–	–
SQU	4	98	3 718	1 201	1 332	–	–	–
SSK	5	34	73	39	32	34	73	73
STA	2	91	1 091	506	562	89	917	281
SWA	1	77	1 302	219	284	–	–	–
TAR	1	75	4 478	2 230	2 063	14	398	–
TRU	1	2	4	2	2	–	–	–
WAR	1	29	999	148	117	–	–	–
WSQ	4	2	2	0	2	–	–	–
WWA	1	8	61	35	26	–	–	–
YBF	2	3	14	#	#	3	14	–
YCO	2	2	26	2	0	–	–	–

Measurement methods: 1, fork length; 2, total length; 4, mantle length; 5, pelvic length; G, total length less tail filament;
\+ Data include one or more of the following: fish weight, gonad stage, otoliths, vertebrae, dorsal spines
– No data.
\# Not sexed
@ Includes subsamples

Table 9 : **Numbers of giant stargazer, red cod, and red gurnard sampled at each reproductive stage***

Total length (cm)	Males Gonad stage 1	2	3	4	5	Females Gonad stage 1	2	3	4	5	
Giant stargazer											
11–20	9	0	0	0	0	7	0	0	0	0	
21–30	118	0	0	0	0	115	4	0	0	0	
31–40	164	4	0	0	0	130	2	0	0	0	
41–50	74	10	0	0	1	137	10	0	0	1	
51–60	20	6	0	0	1	38	12	0	0	1	
61–70	1	0	0	0	0	2	4	2	0	2	
71–80	0	0	0	0	0	1	0	0	0	0	
Total	386	20	0	0	2	430	32	2	0	4	876
Red cod											
11–20	70	0	0	0	0	72	0	0	0	0	
21–30	141	1	0	1	0	189	1	0	0	0	
31–40	82	12	11	16	3	68	5	0	0	0	
41–50	176	21	9	18	25	216	12	2	0	0	
51–60	20	7	13	11	2	225	22	0	0	1	
61–70	1	0	3	0	0	72	10	1	0	0	
71–80						1	2	0	0	0	
Total	490	41	36	46	30	843	52	3	0	1	1542
Red gurnard											
11–20	14	0	0	0	0	19	0	0	0	0	
21–30	65	41	2	0	0	73	6	0	1	0	
31–40	57	171	12	2	4	55	45	24	8	1	
41–50	10	39	5	1	0	1	36	95	29	1	
51–60	0	0	0	0	0	0	4	1	0	0	
Total	146	251	19	3	4	148	91	120	38	2	822

* Small fish of indeterminate sex are not included.
Gonad stages used were: 1, immature or resting; 2, maturing (oocytes visible in females); 3, mature (hyaline oocytes in females, milt expressible in males); 4, running ripe (eggs and milt free flowing); 5, spent.

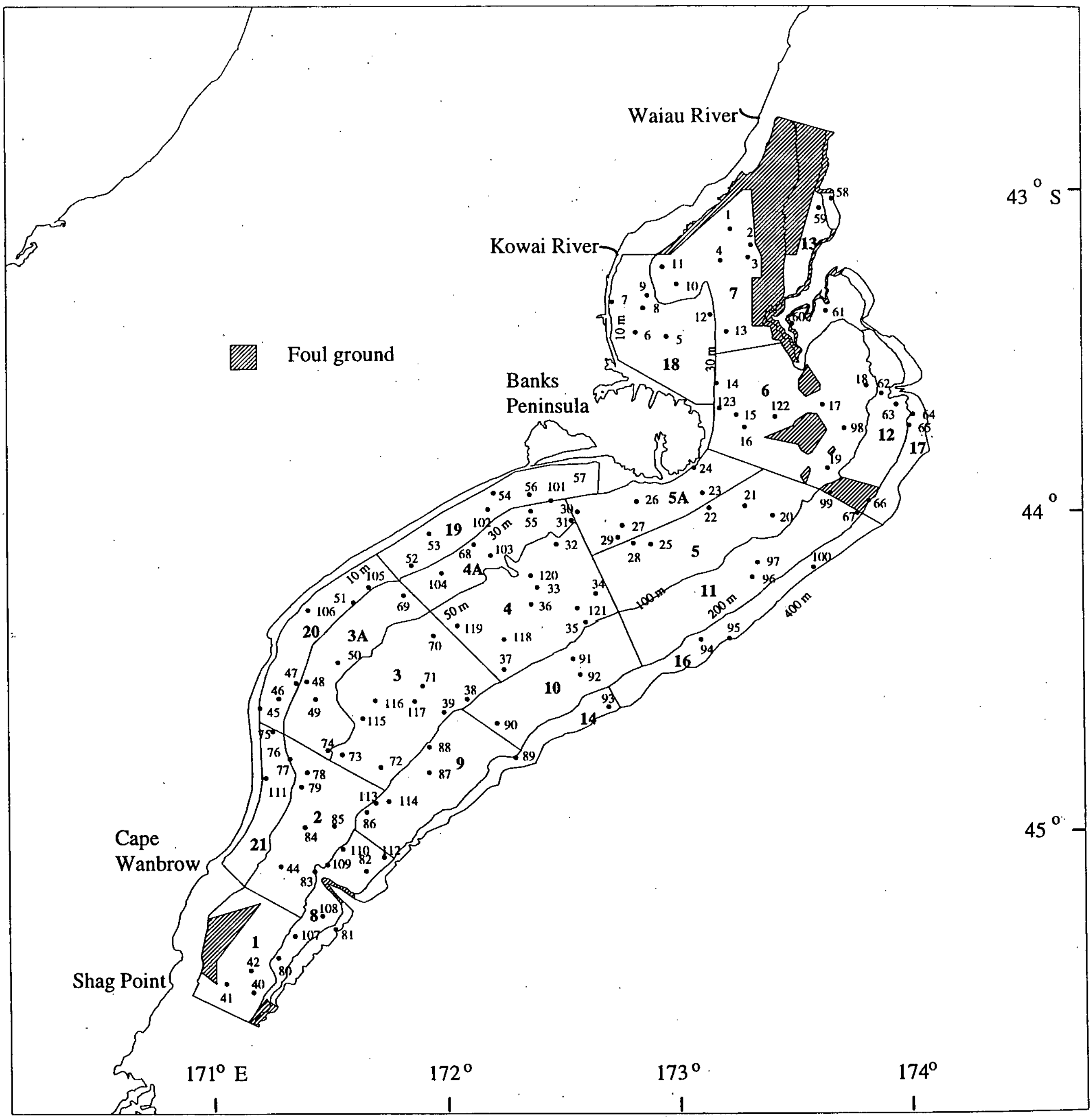


Figure 1: **Trawl survey area showing stratum boundaries (bold type), areas of untrawlable (foul) ground, and trawl station positions.**

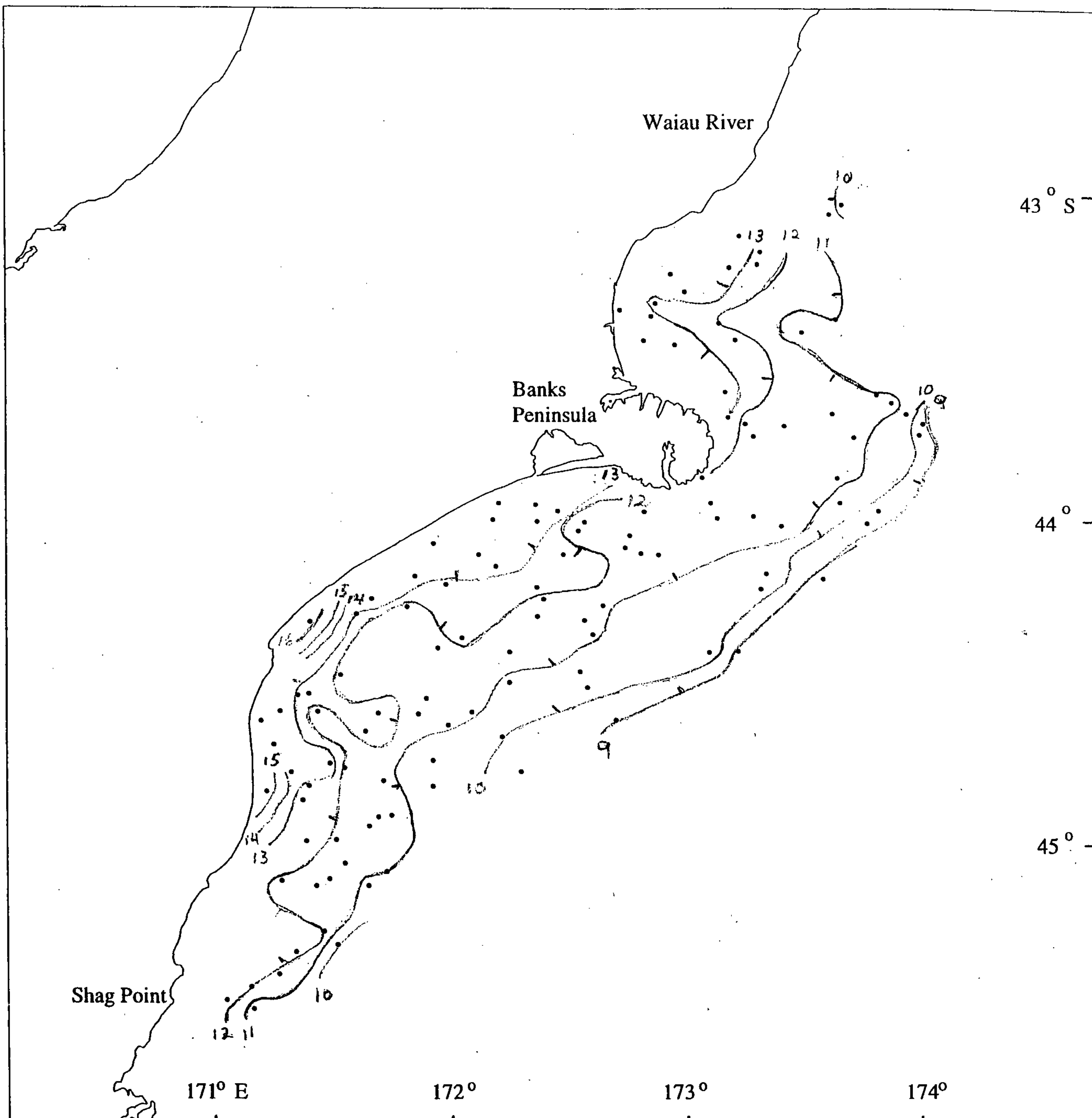


Figure 2 : **Positions of bottom temperature recordings and isotherms estimated from these data.**

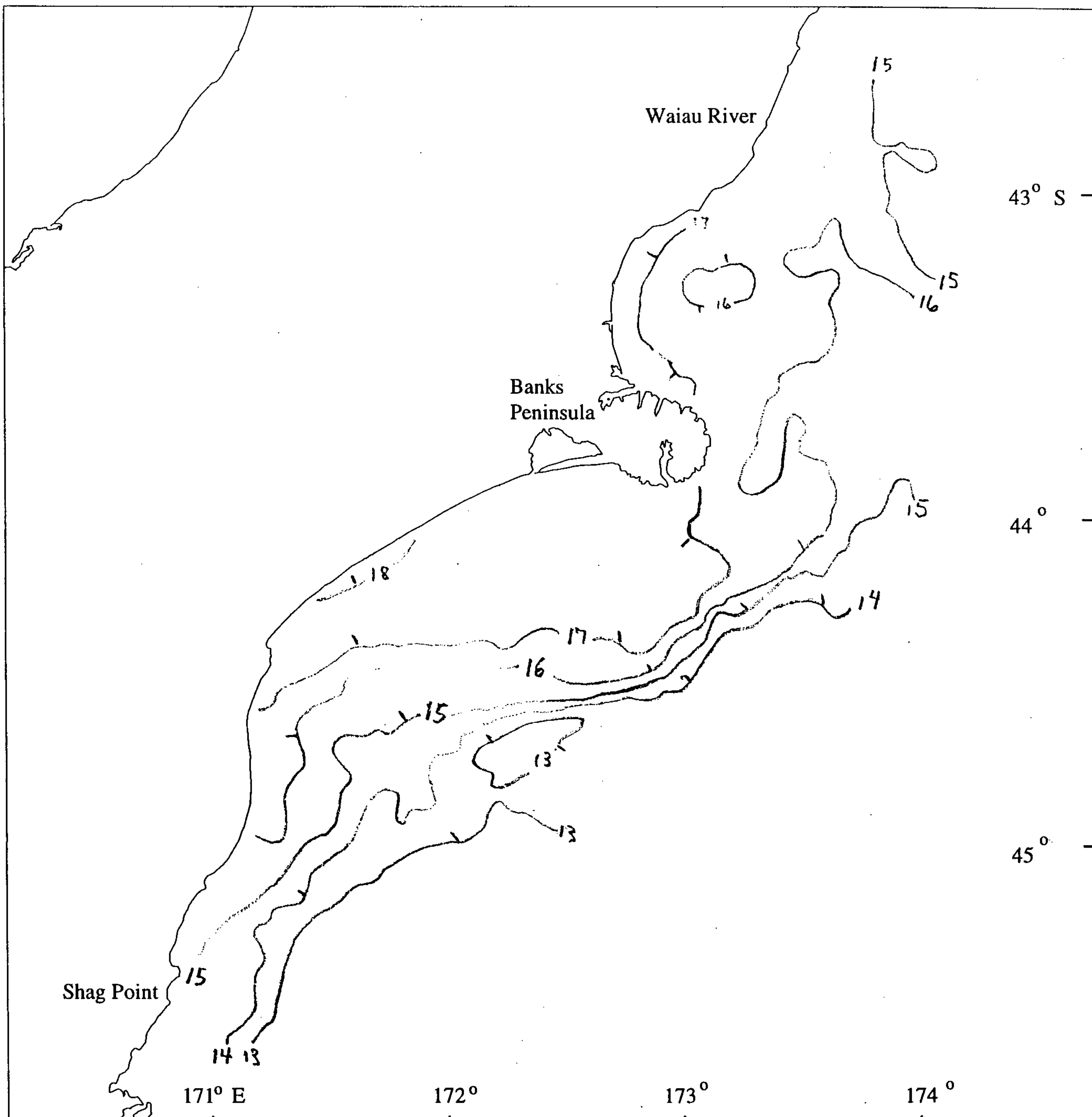


Figure 3 **: Mean sea surface isotherms for 9–11 January 1999 (from NIWA SST Archive).**

Arrow squid

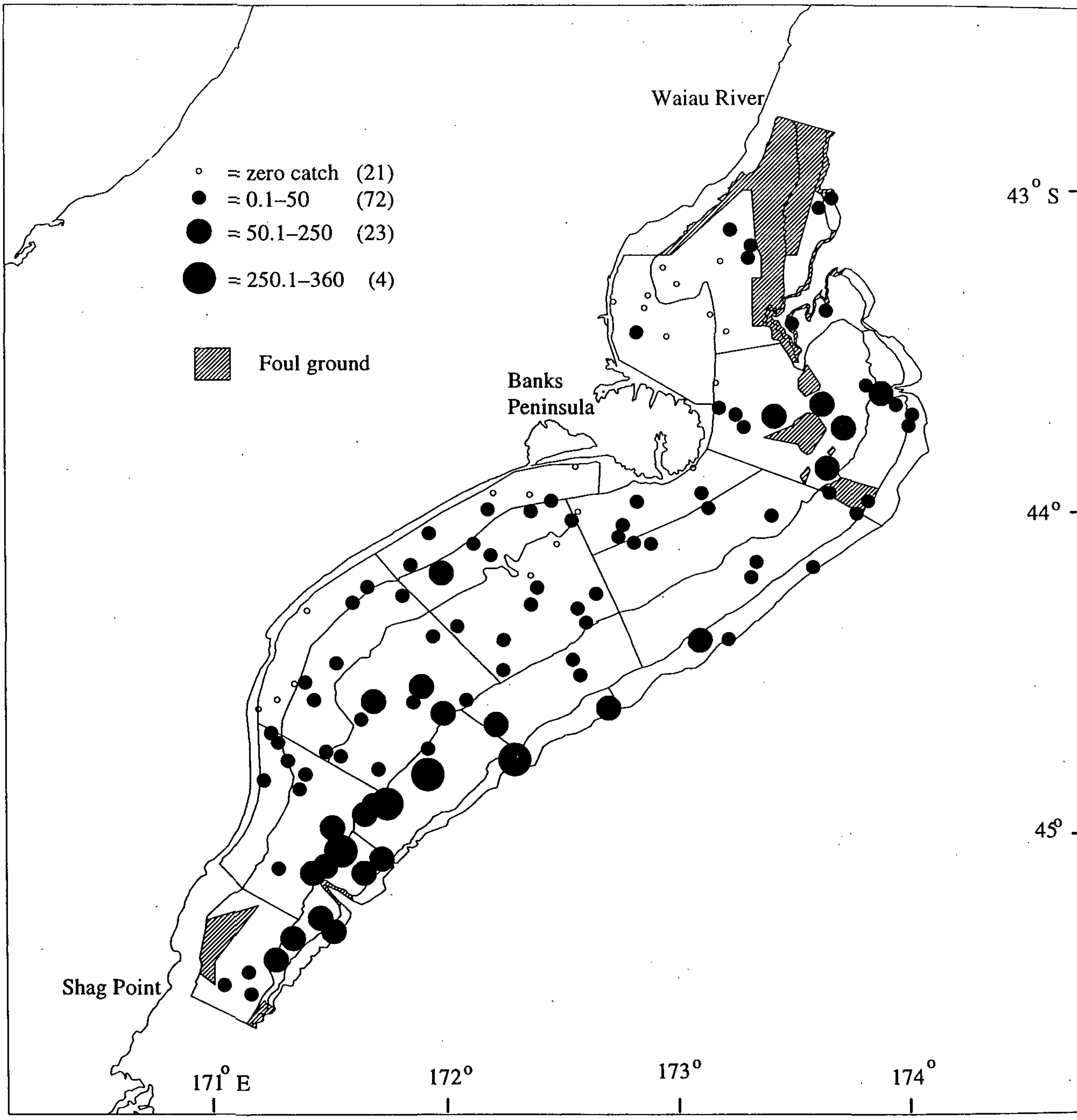


Figure 4 **: Catch rates (kg.km^{-2}) of the major commercial species (numbers in parenthesis are the number of stations at the given catch rate).**

Barracouta

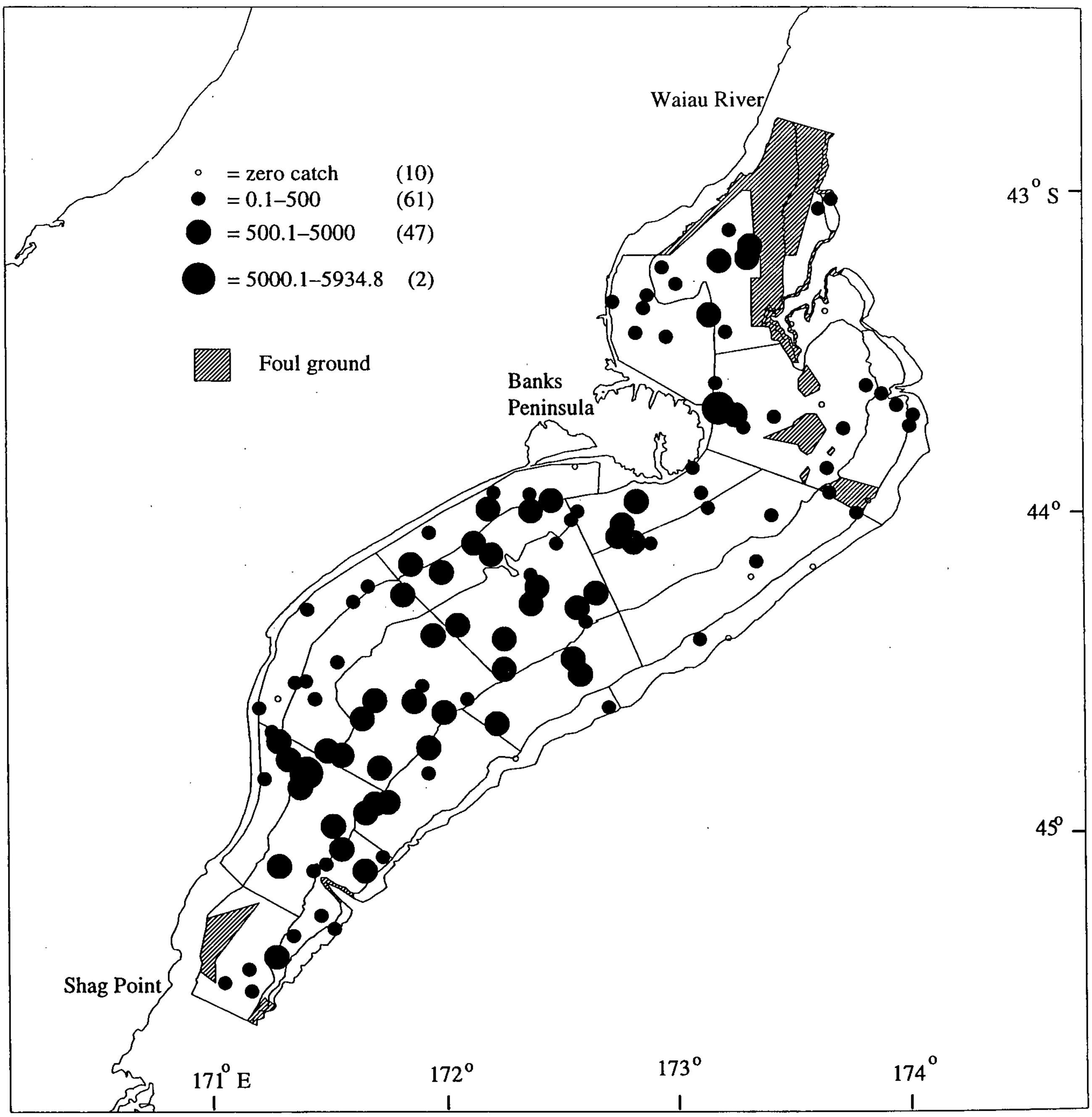


Figure 4—continued

Blue warehou

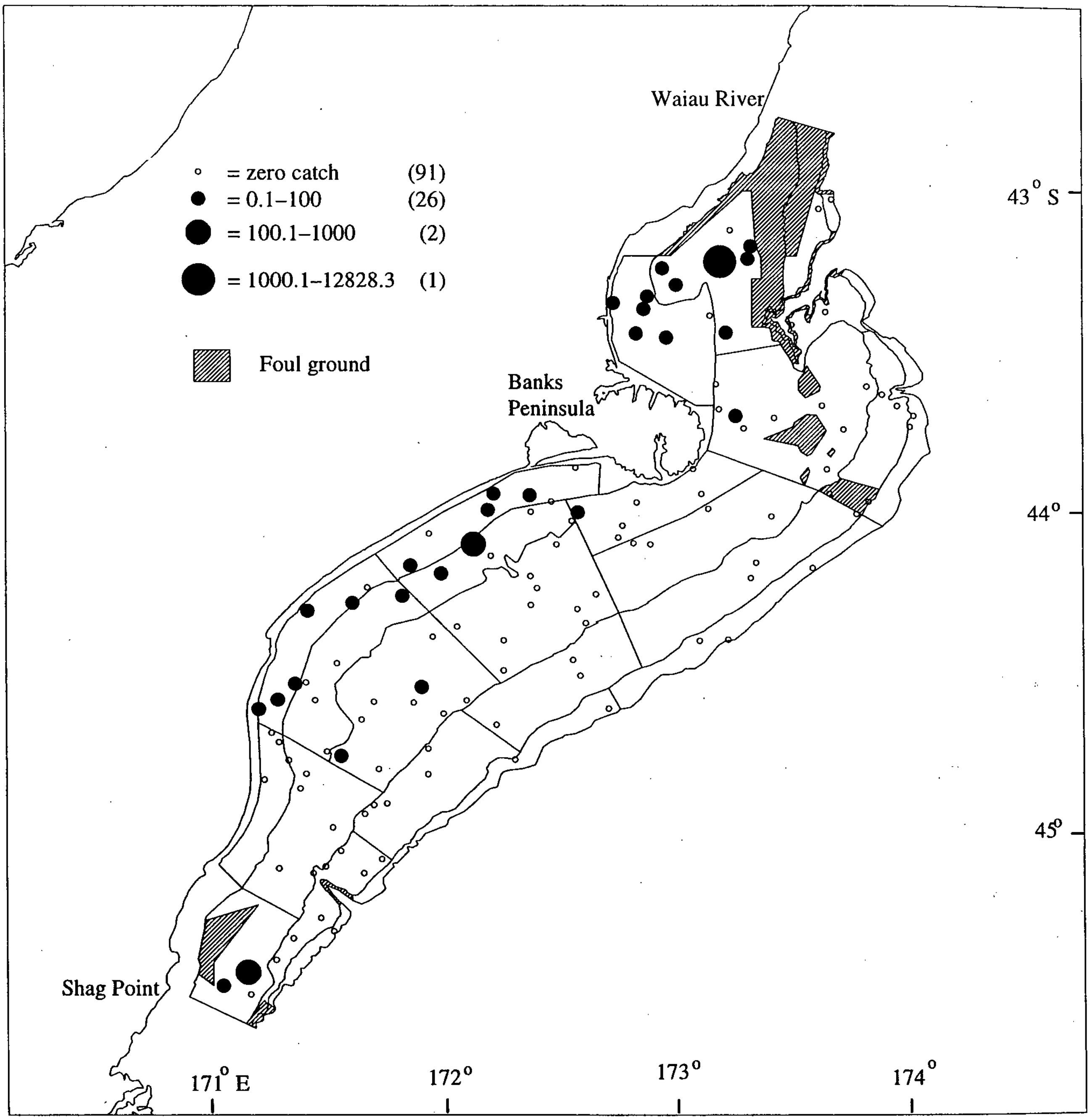


Figure 4—continued

Chilean jack mackerel

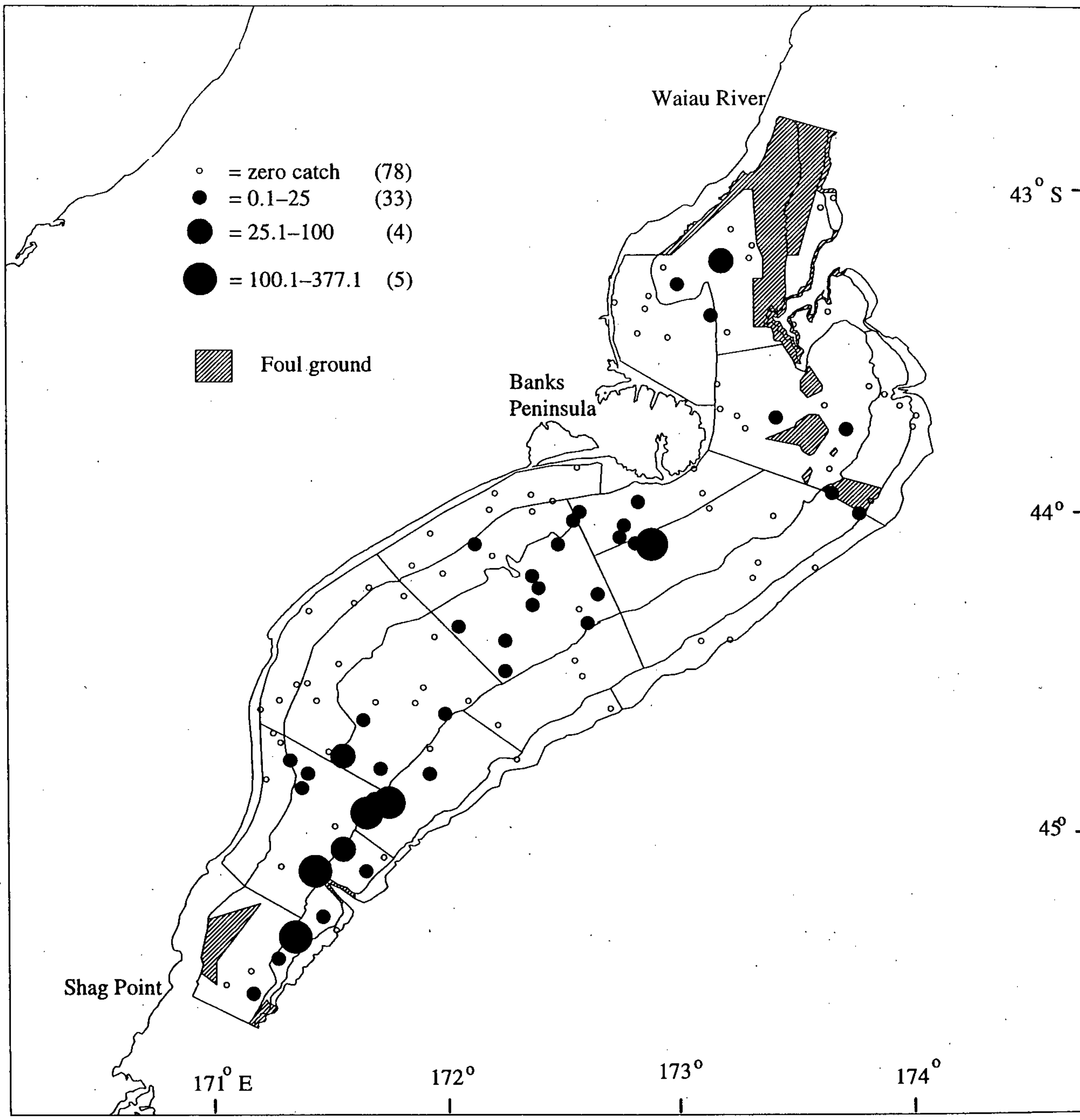


Figure 4—continued

Dark ghost shark

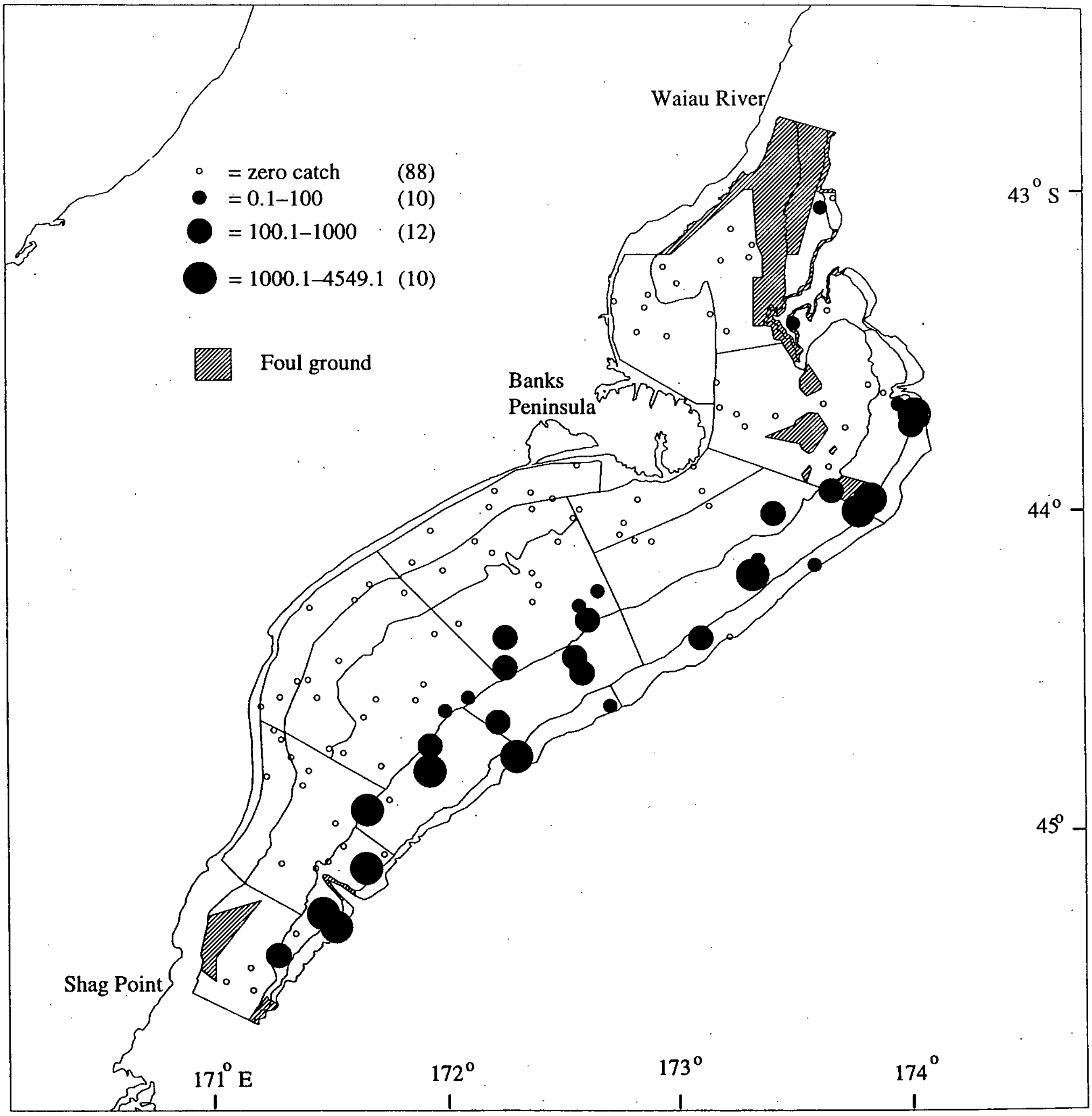


Figure 4—continued

Elephantfish

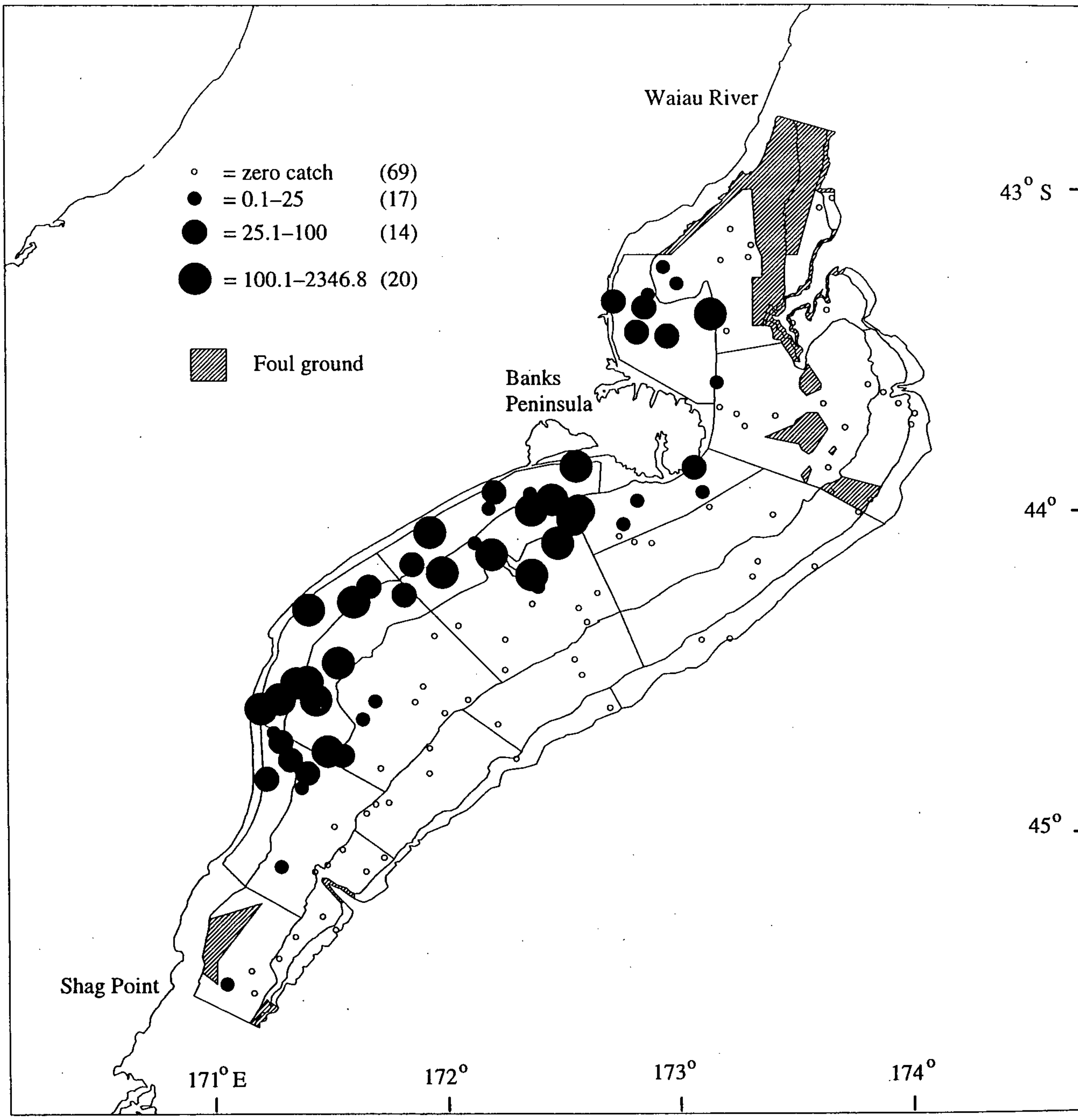


Figure 4—continued

Giant stargazer

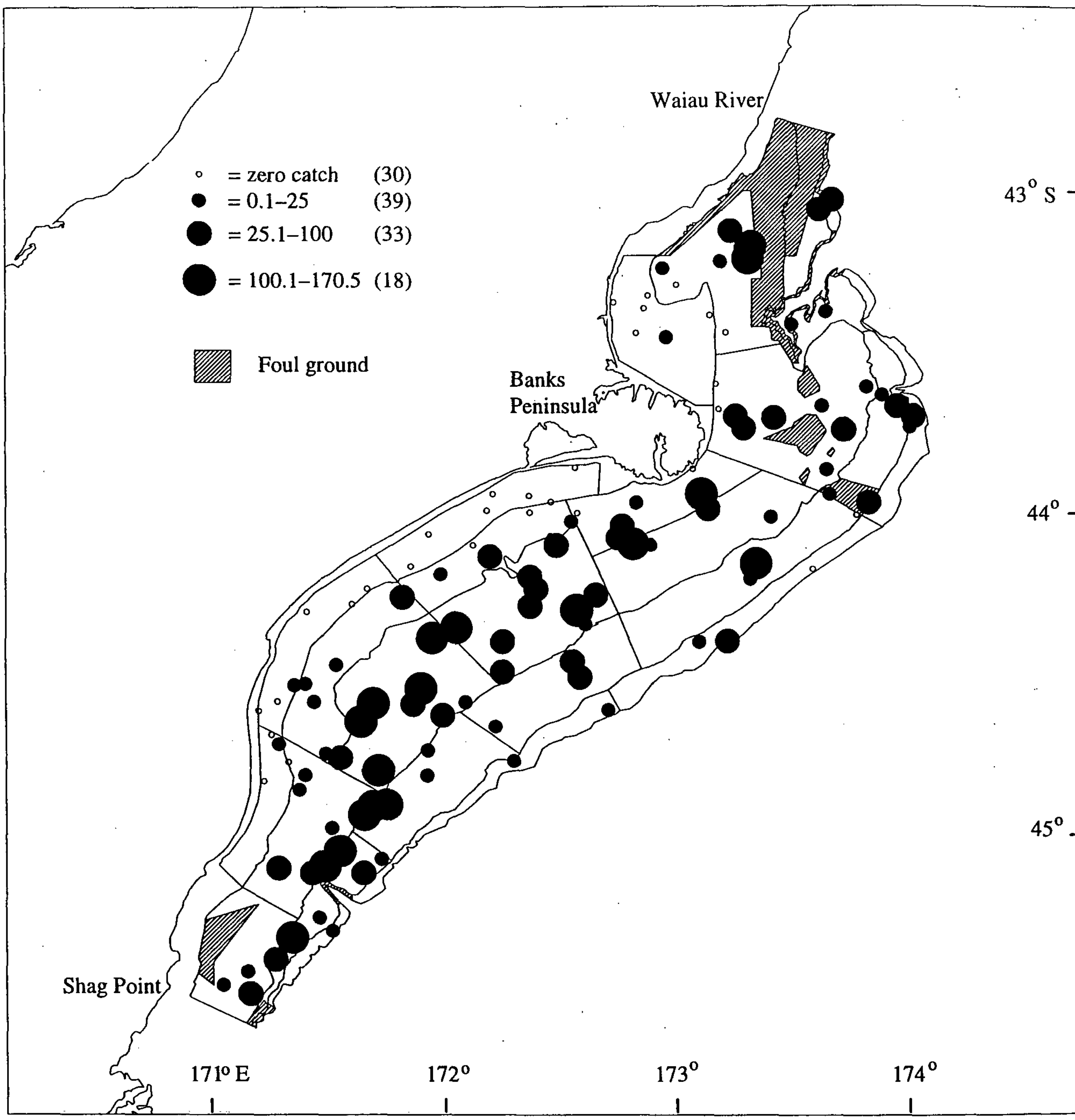


Figure 4—continued

Hapuku

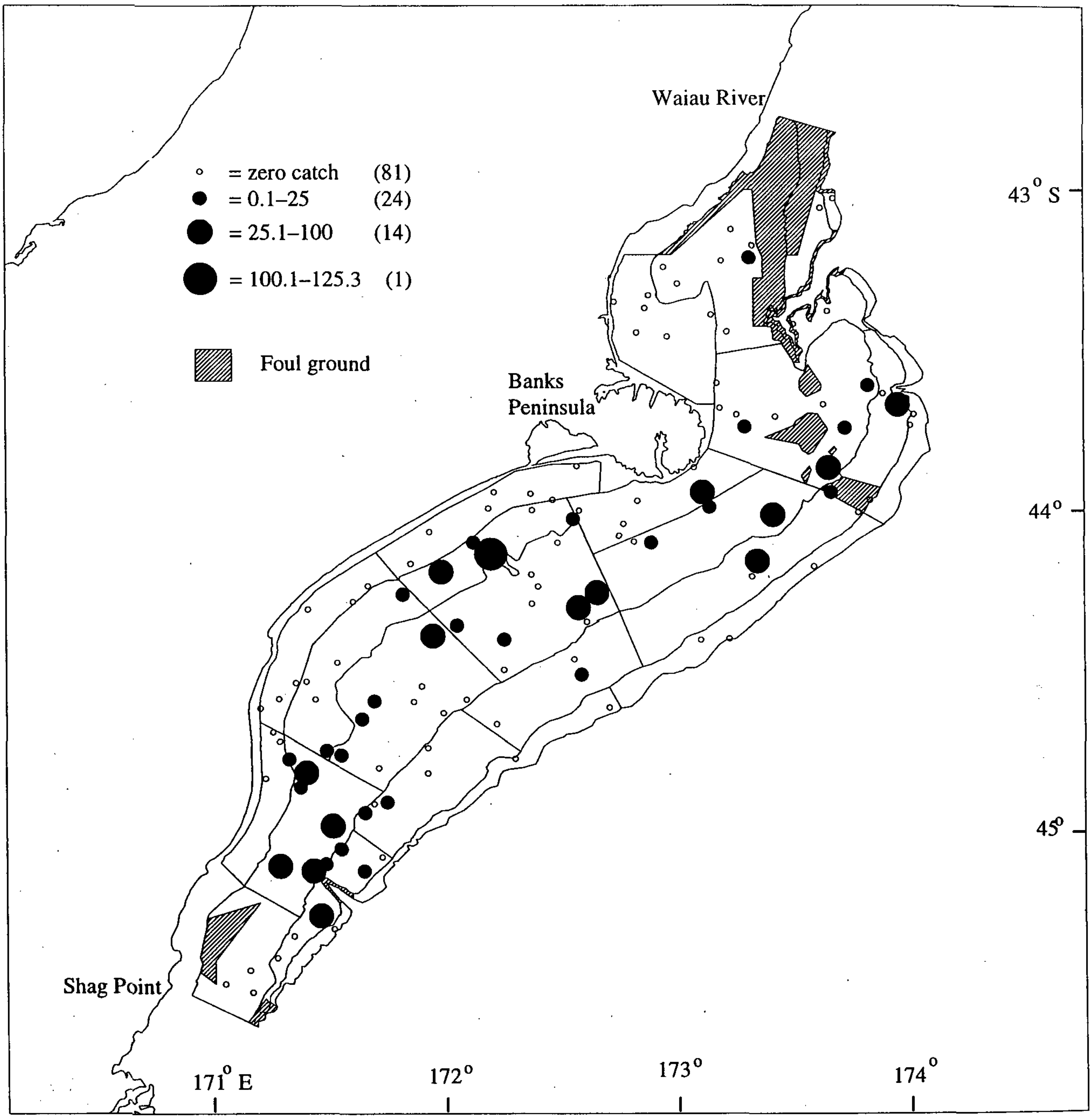


Figure 4—continued

Hoki

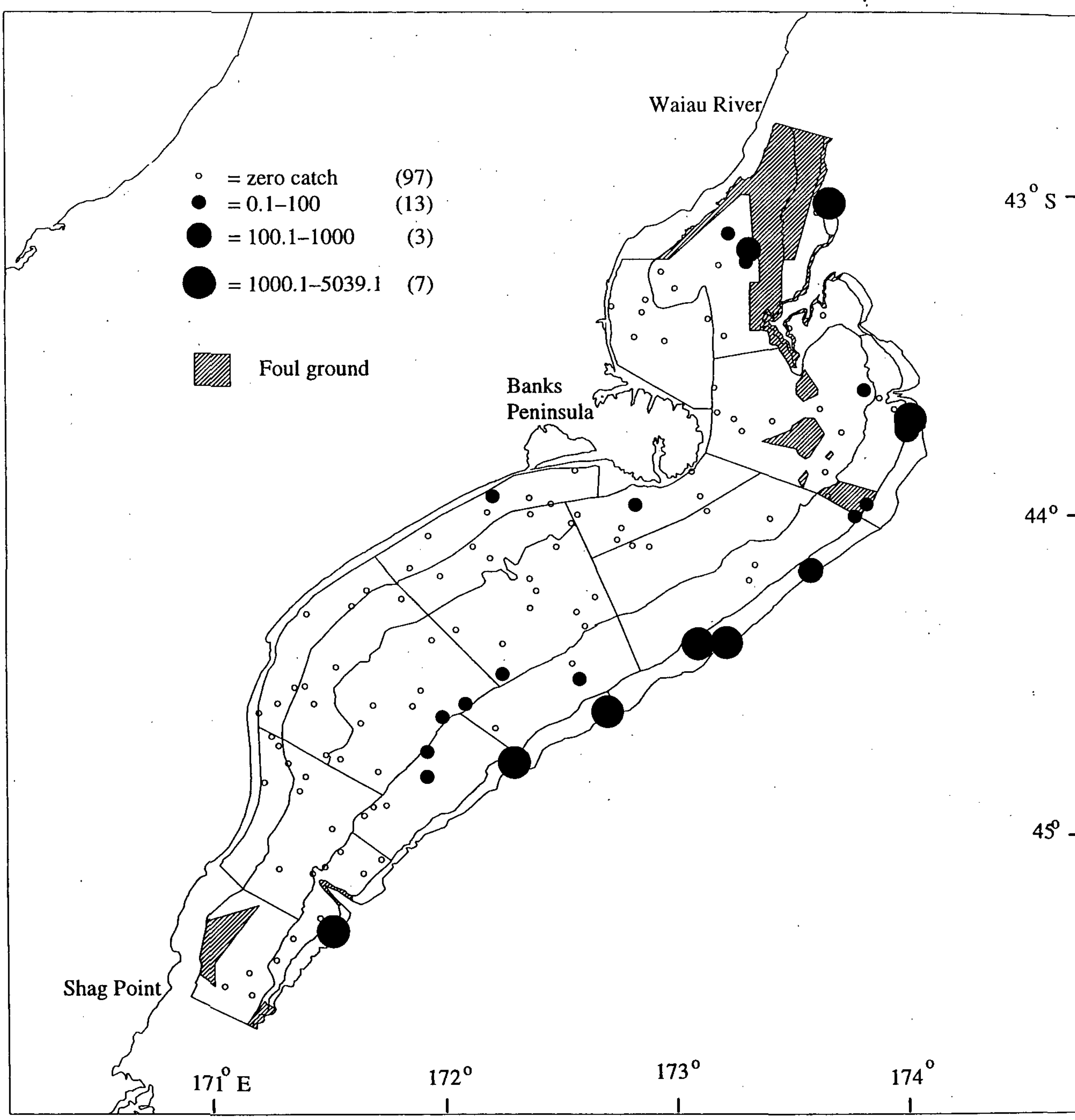


Figure 4—continued

Lemon sole

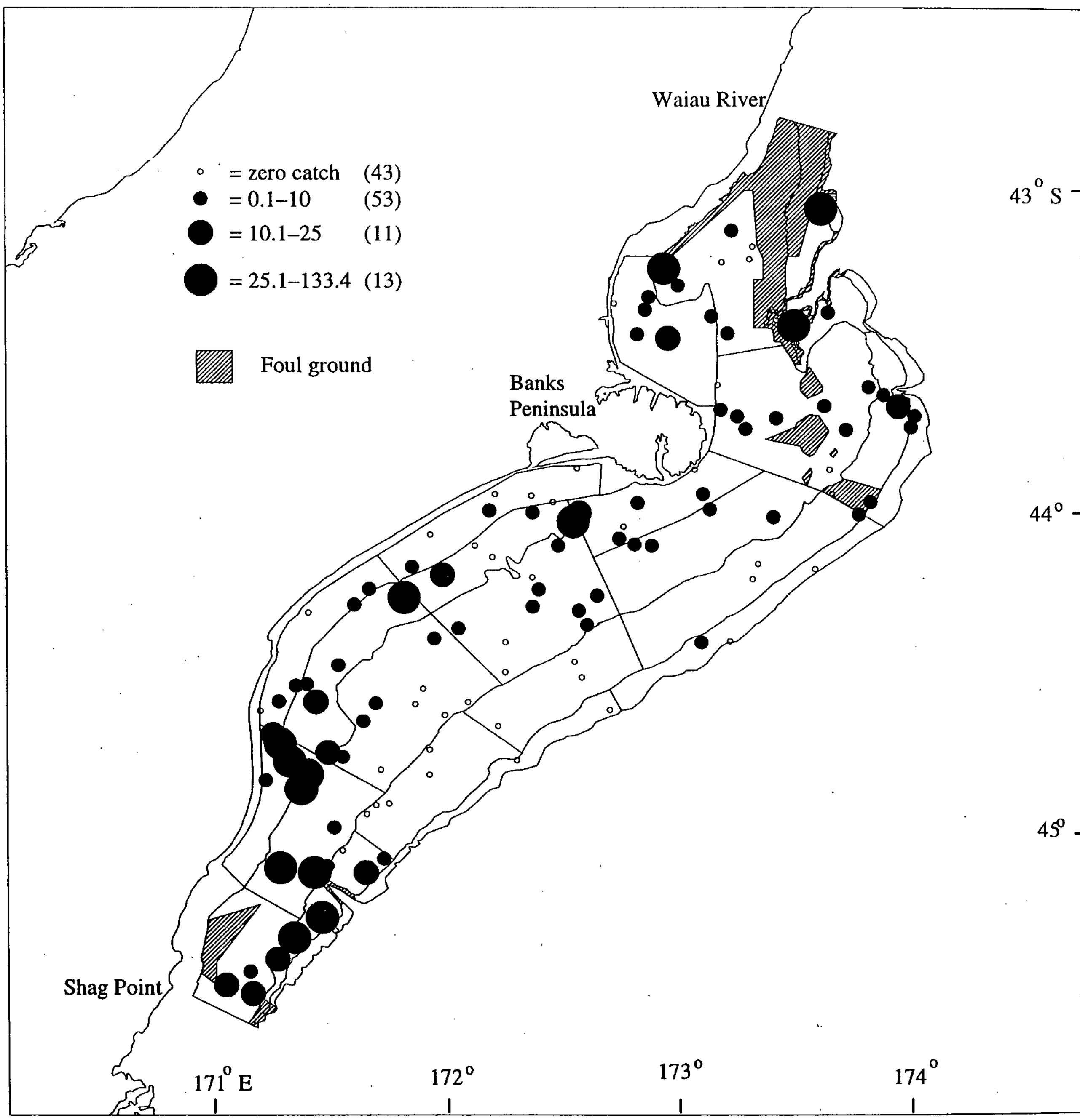


Figure 4—continued

Ling

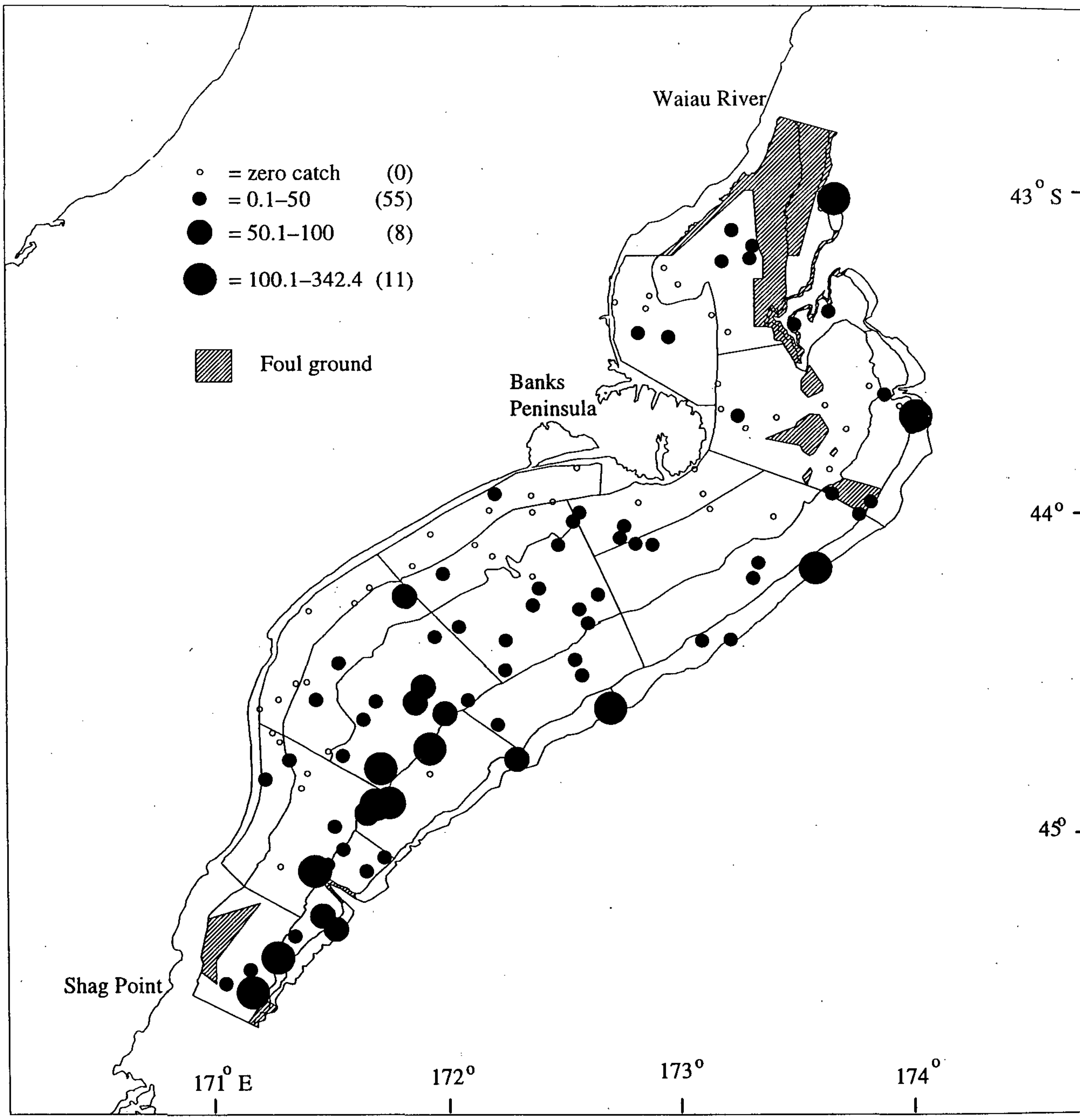


Figure 4—continued

New Zealand sole

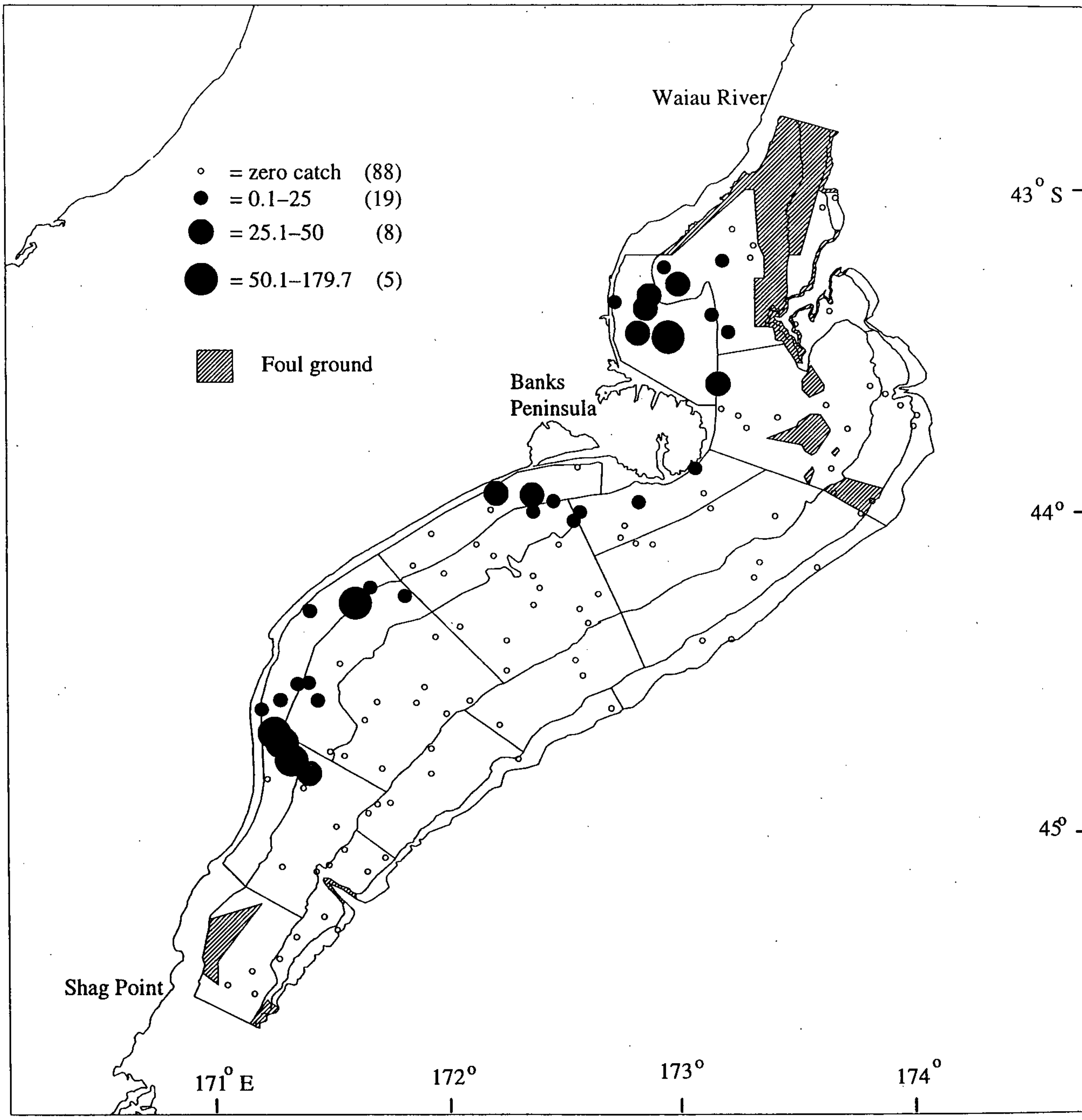


Figure 4—continued

Red cod

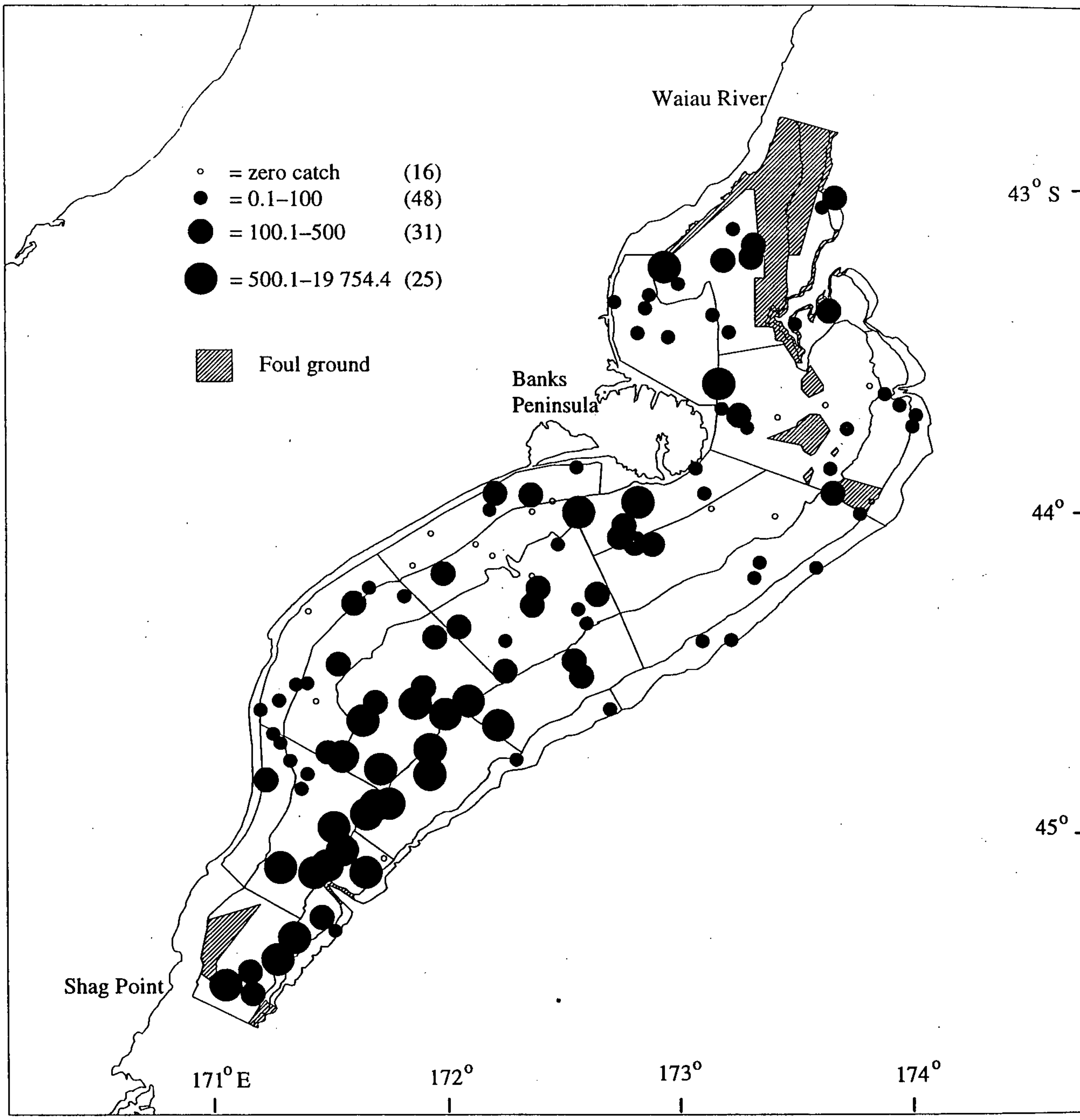


Figure 4—continued

Red gurnard

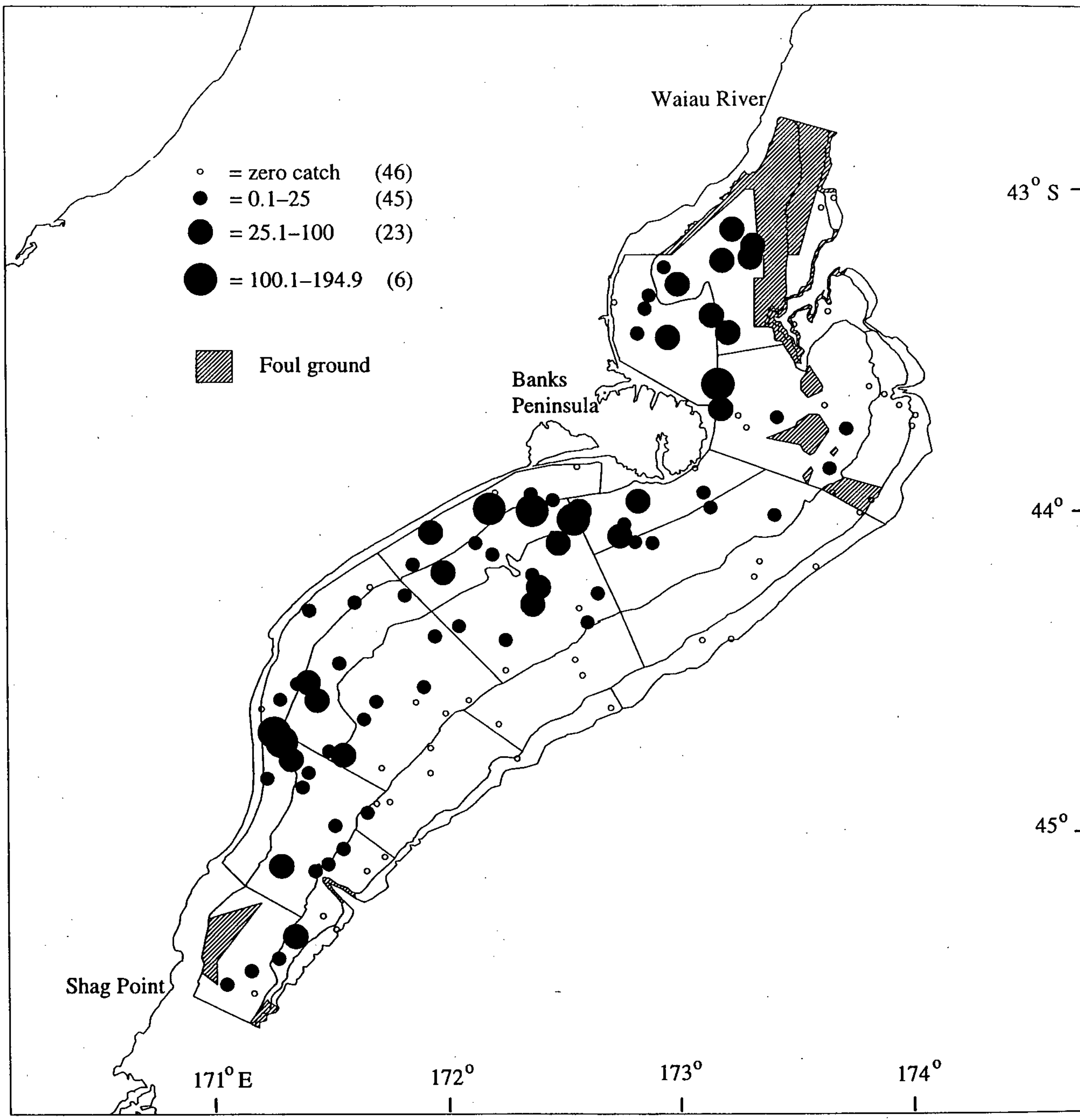


Figure 4—continued

Rig

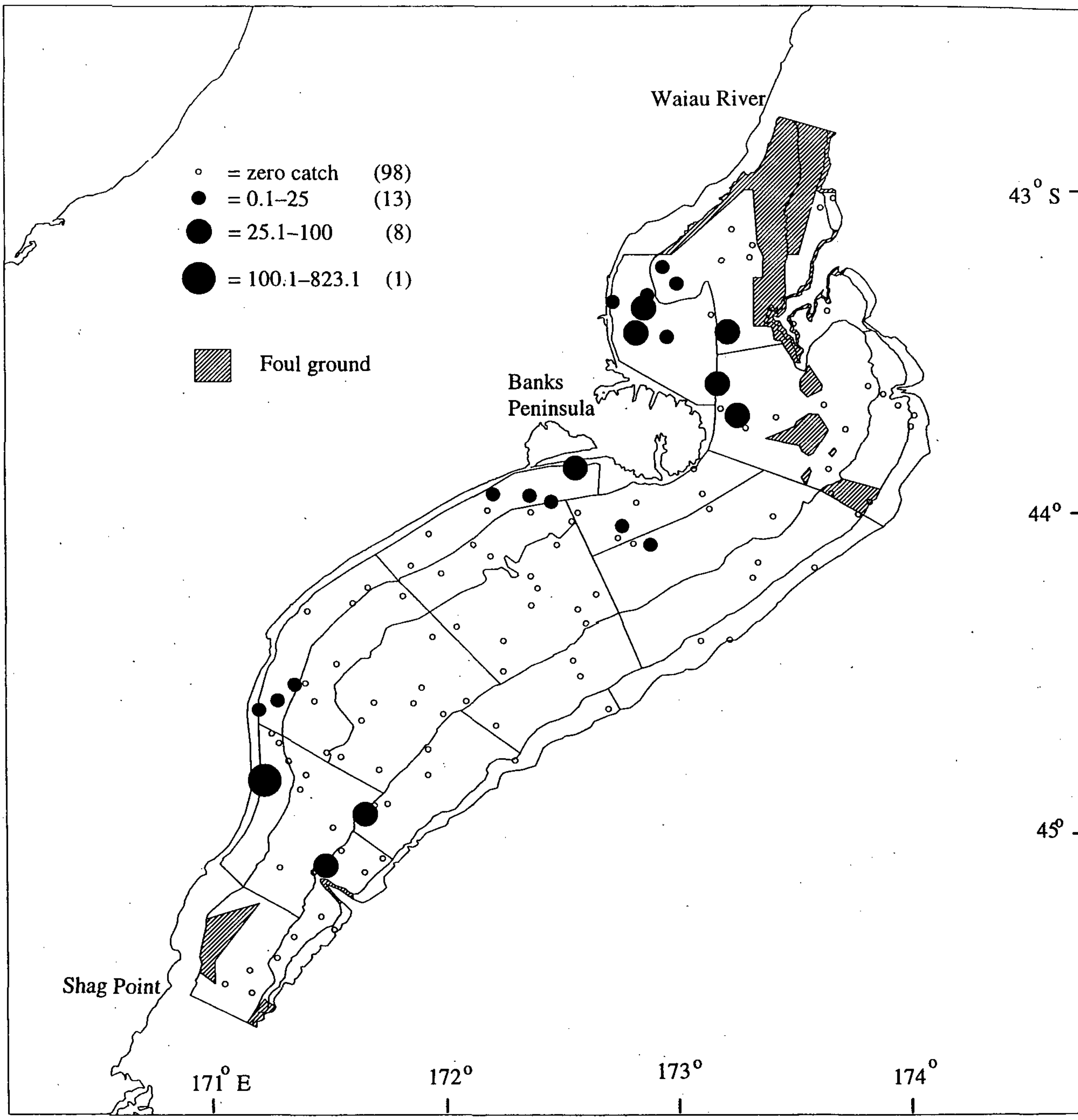


Figure 4—continued

Rough skate

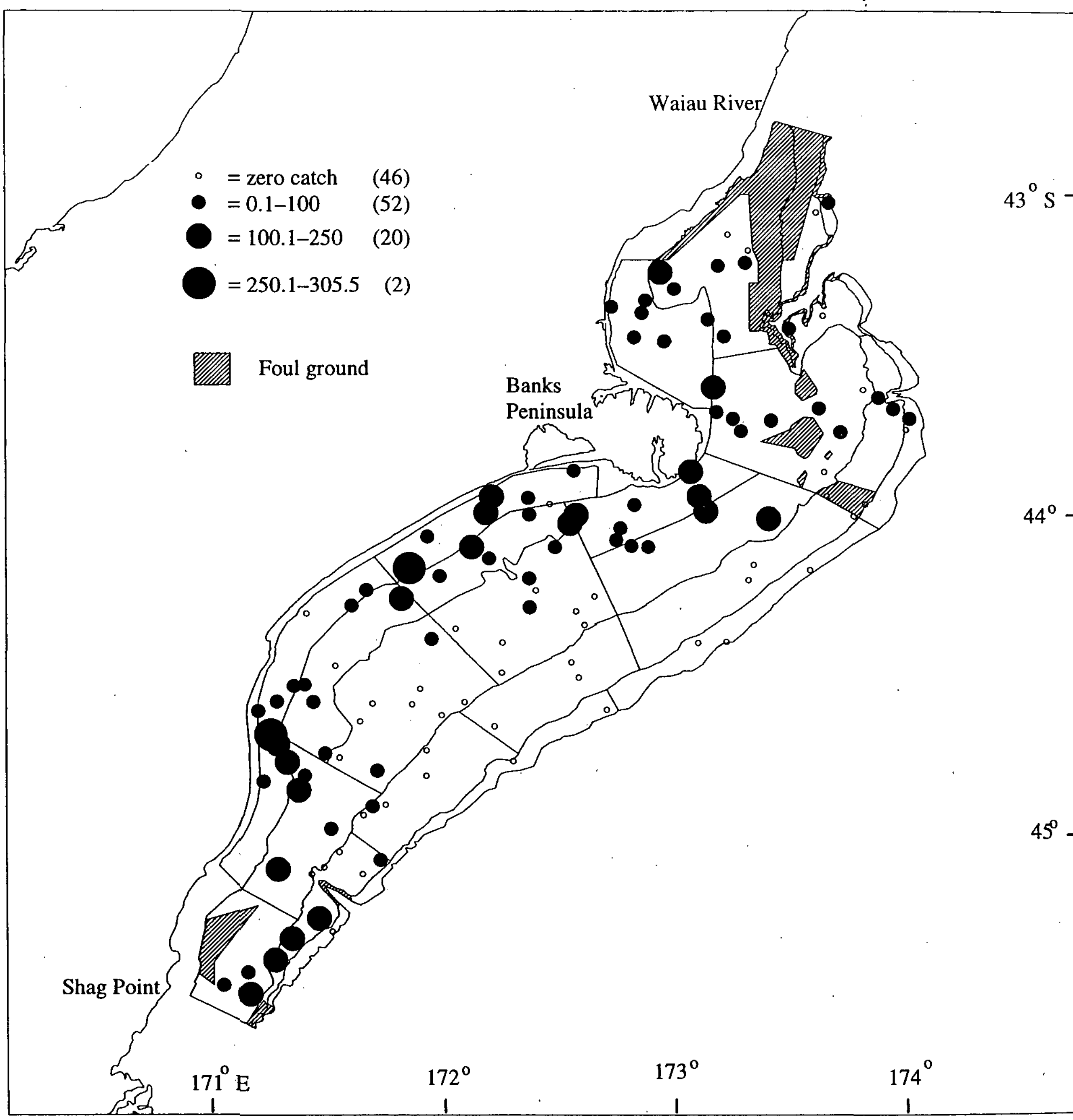


Figure 4—continued

Sand flounder

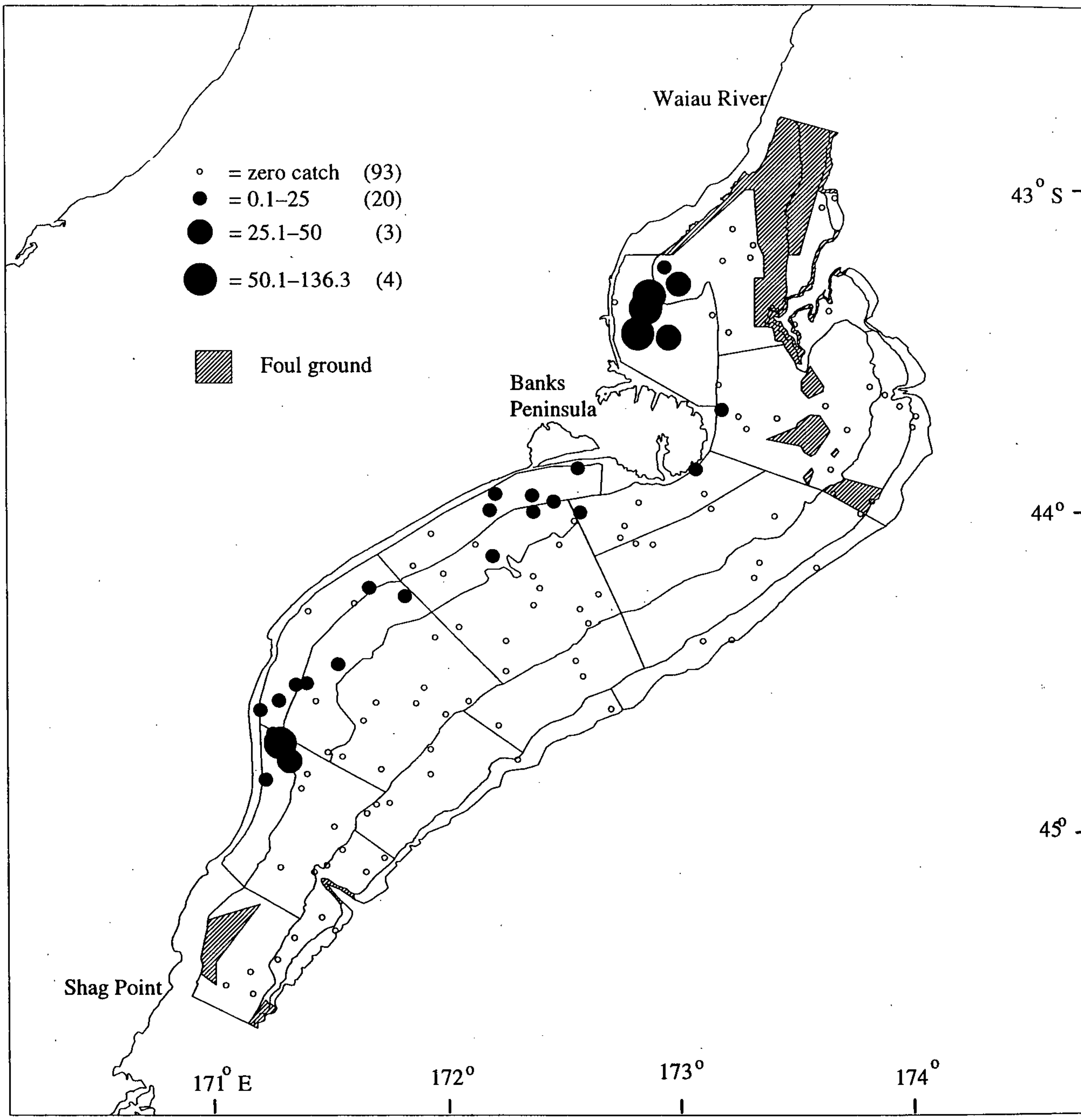


Figure 4—continued

School shark

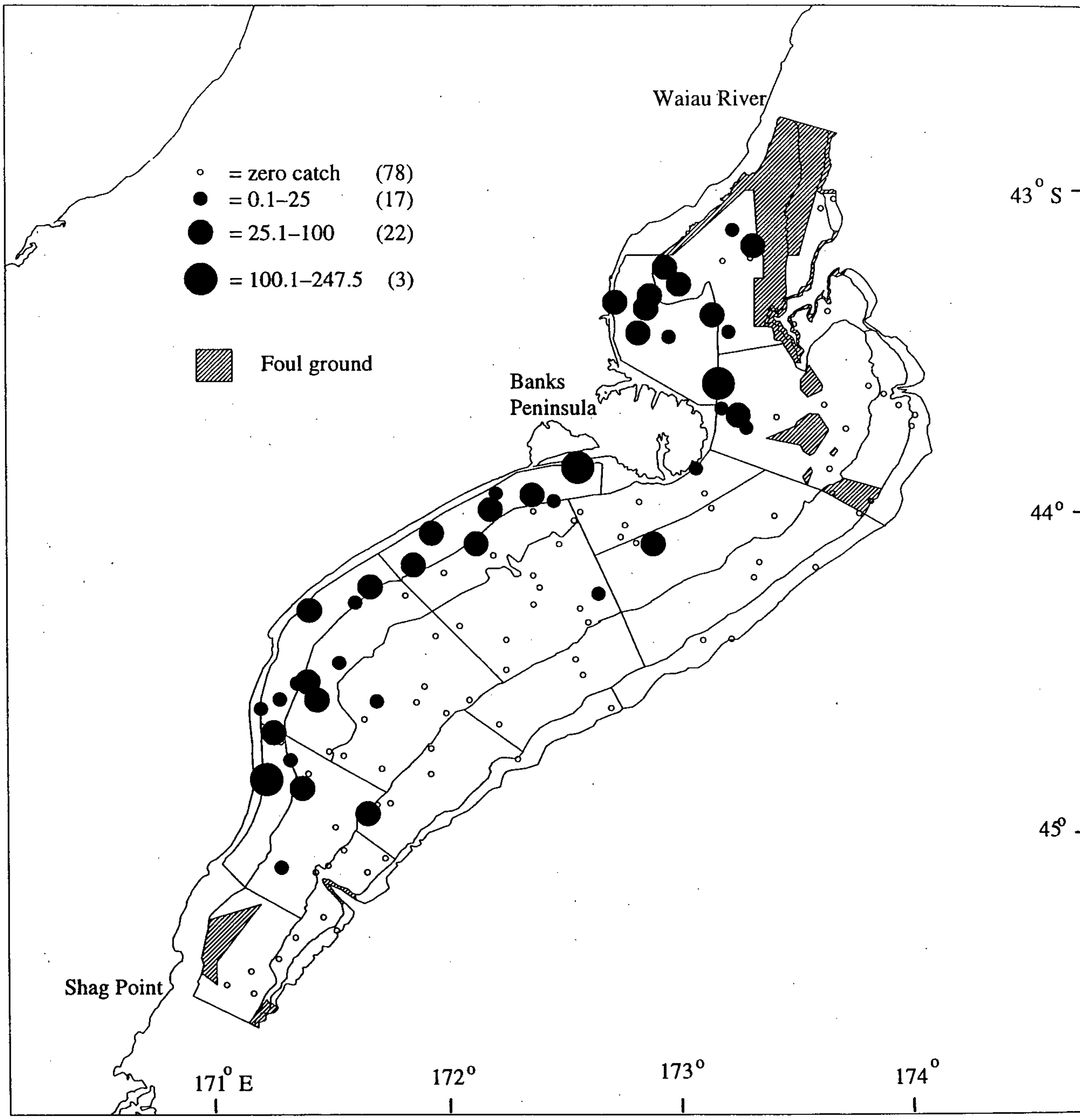


Figure 4—continued

Sea perch

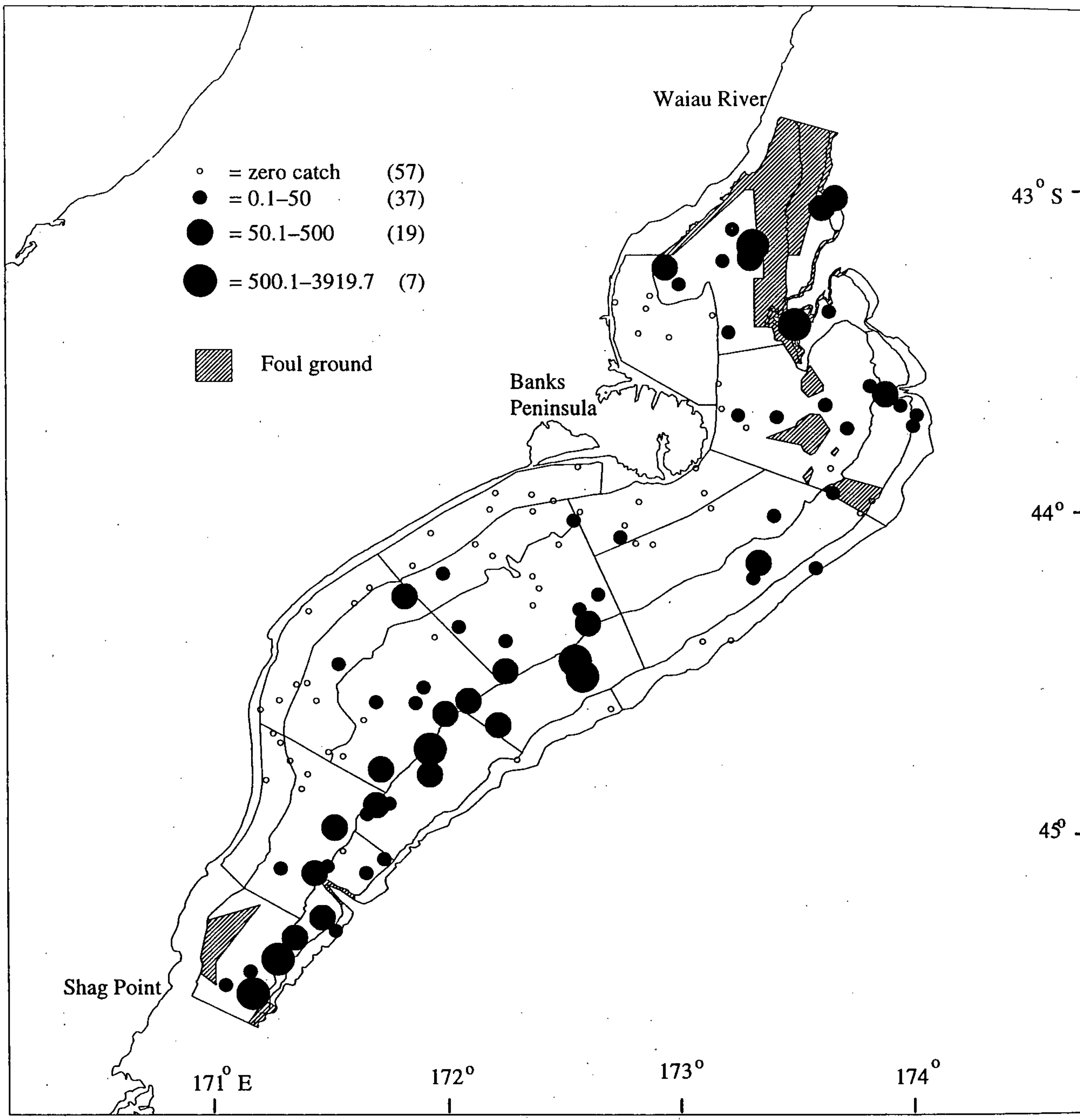


Figure 4—continued

Silver warehou

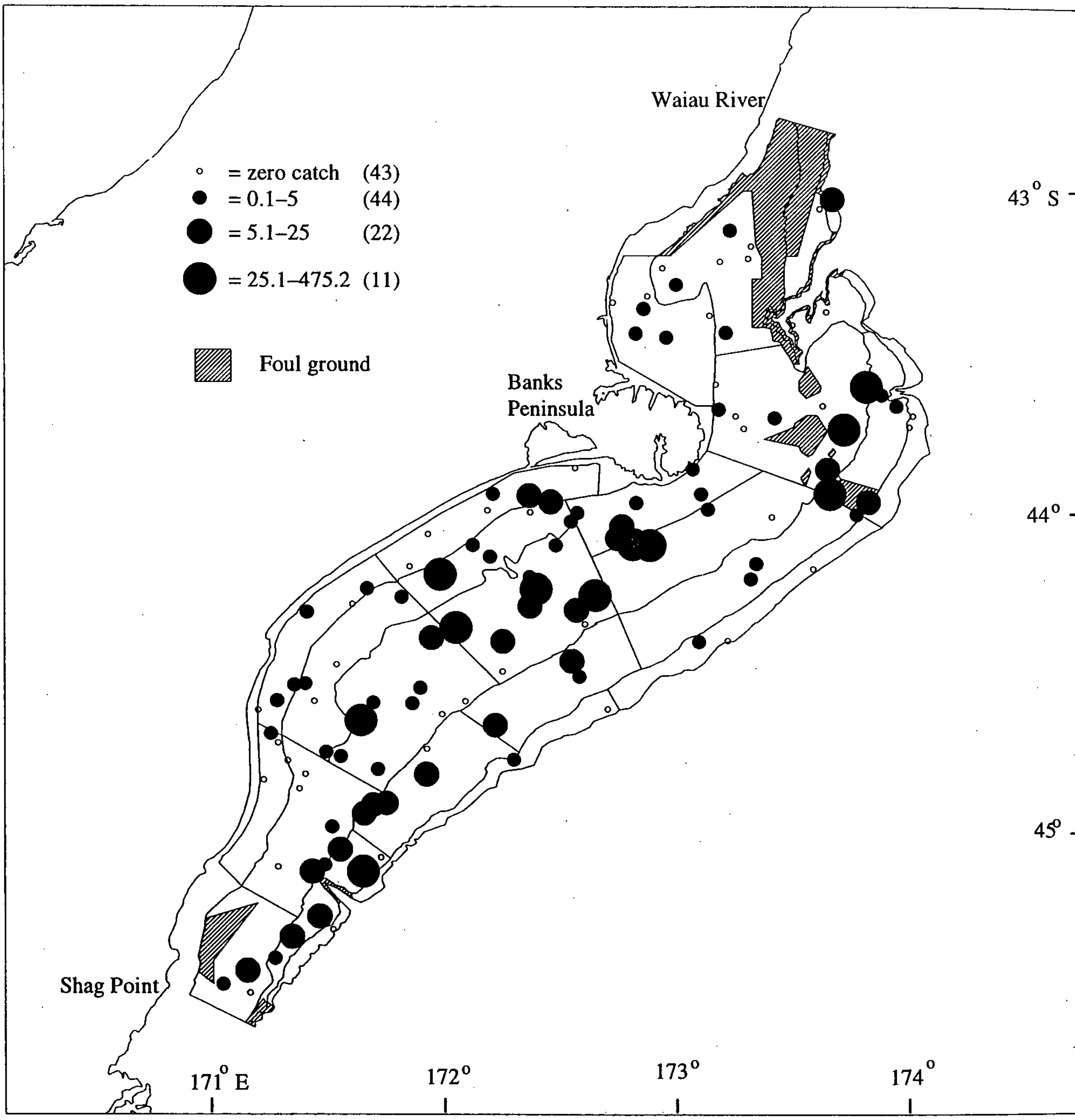


Figure 4—continued

Smooth skate

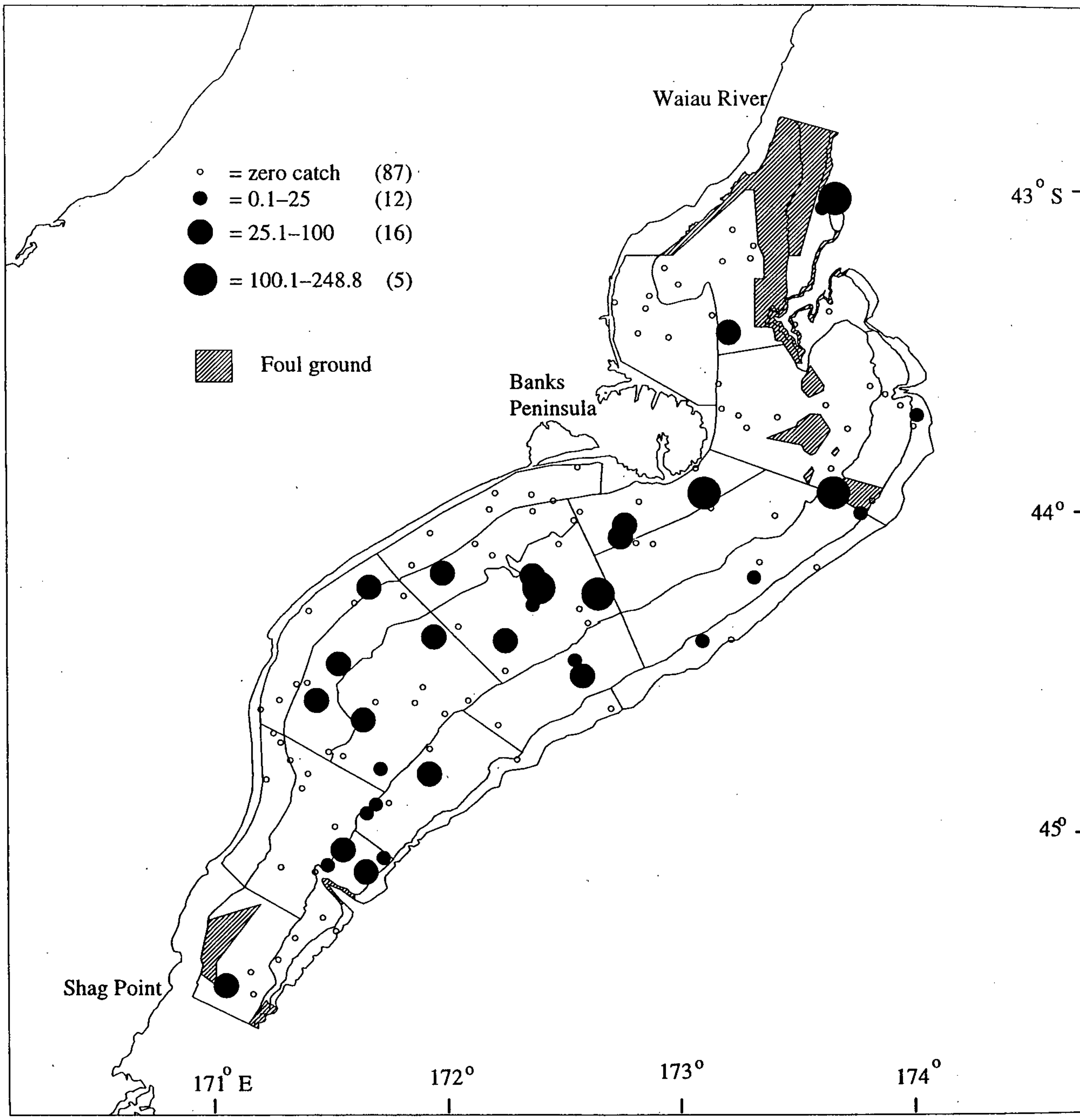


Figure 4—continued

Spiny dogfish

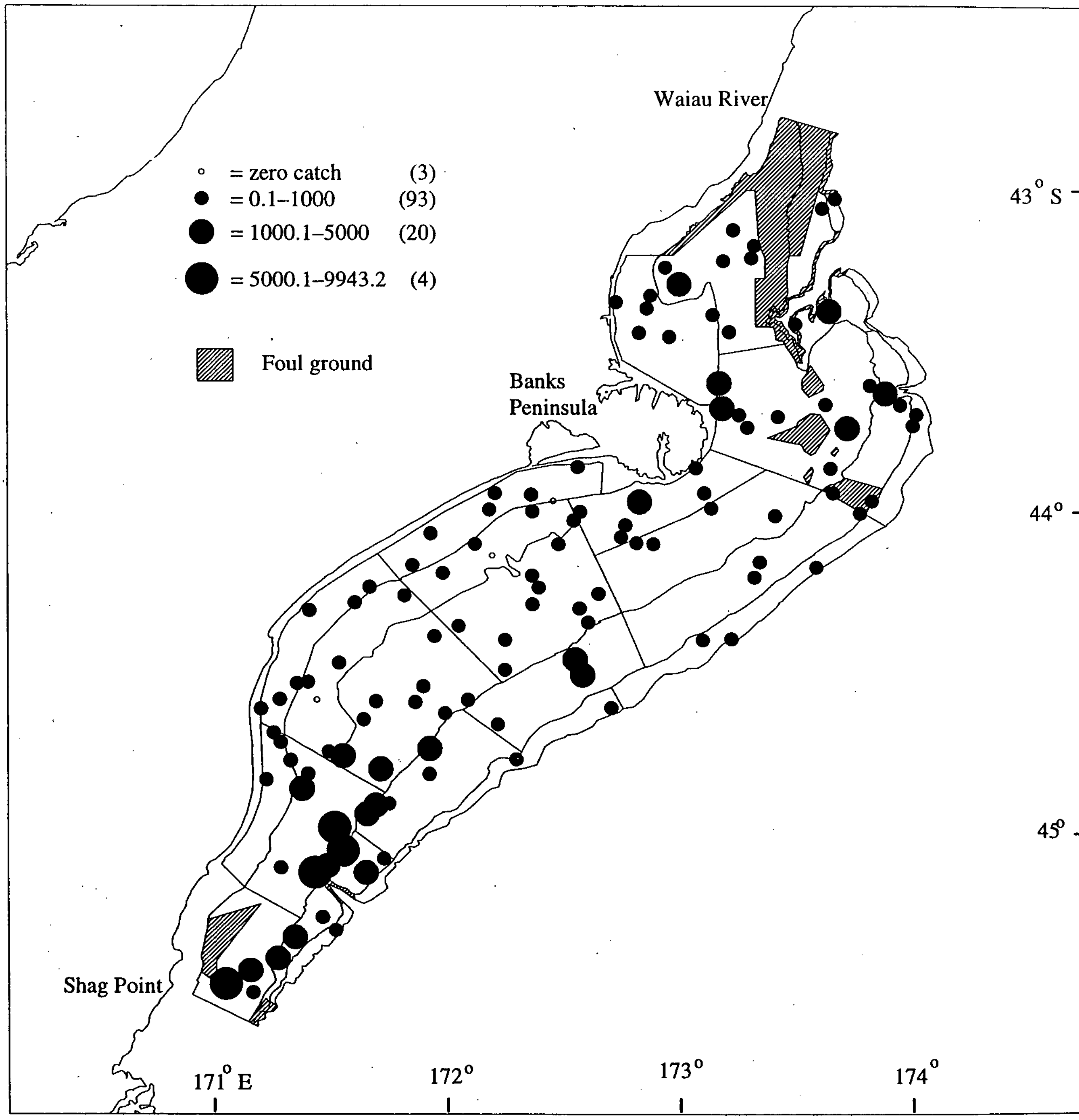


Figure 4—continued

Tarakihi

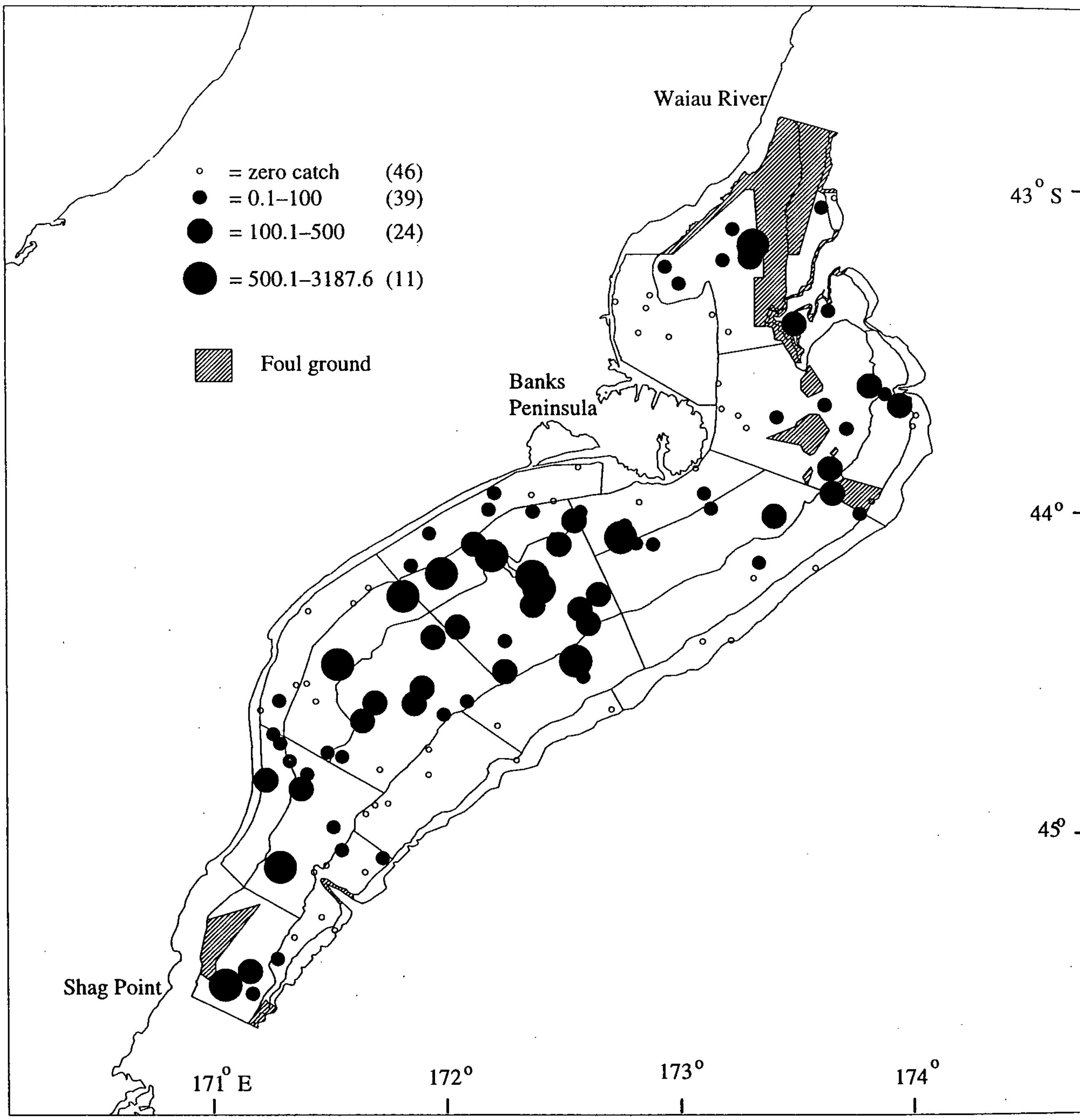


Figure 4—continued

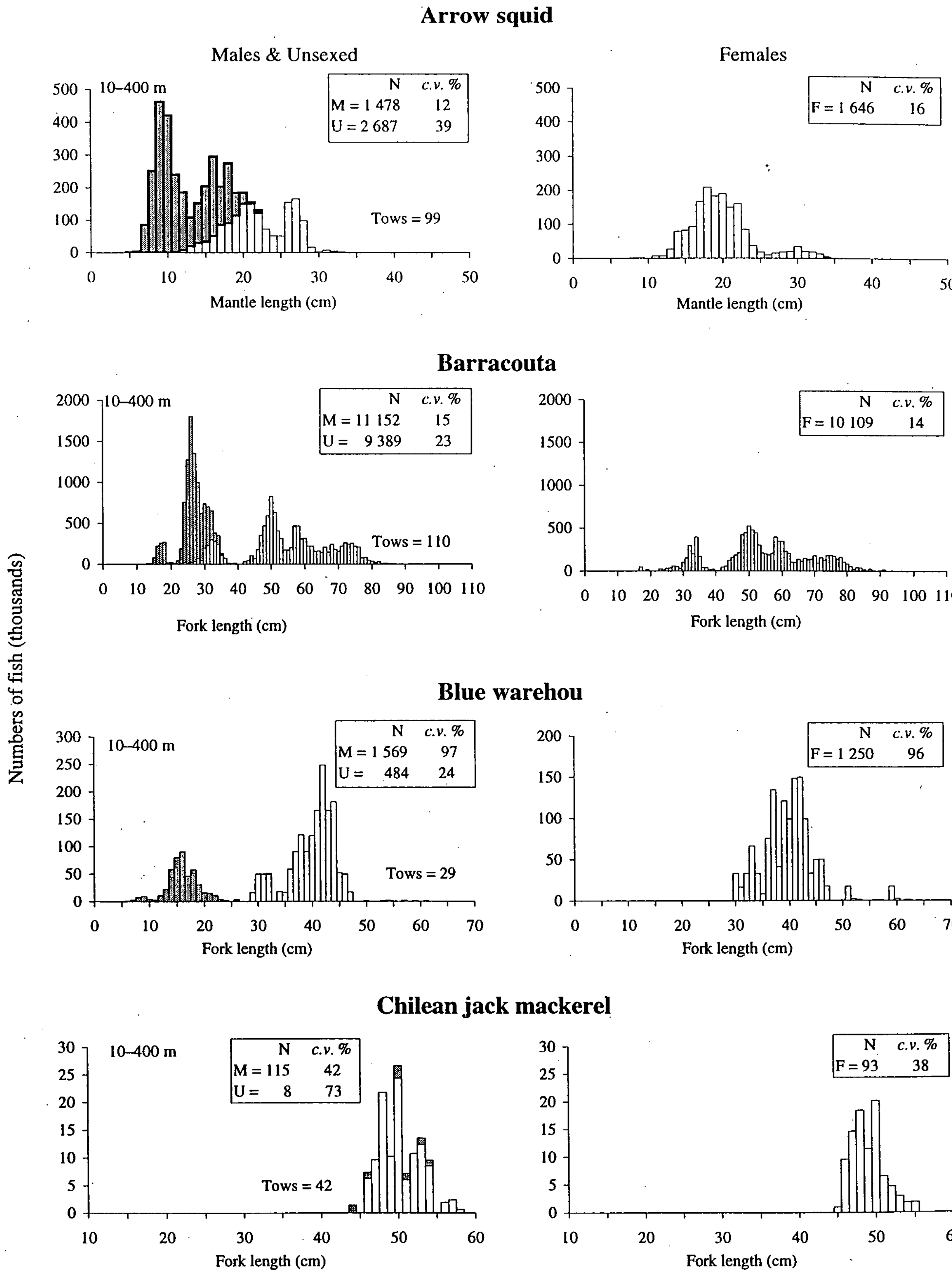


Figure 5 **: Length frequency distributions for the major commercial species, by depth where appropriate. N, estimated population (scaled, thousands); M, male; F, female; U, unsexed (shaded); Tows, number of stations at which species was caught.**

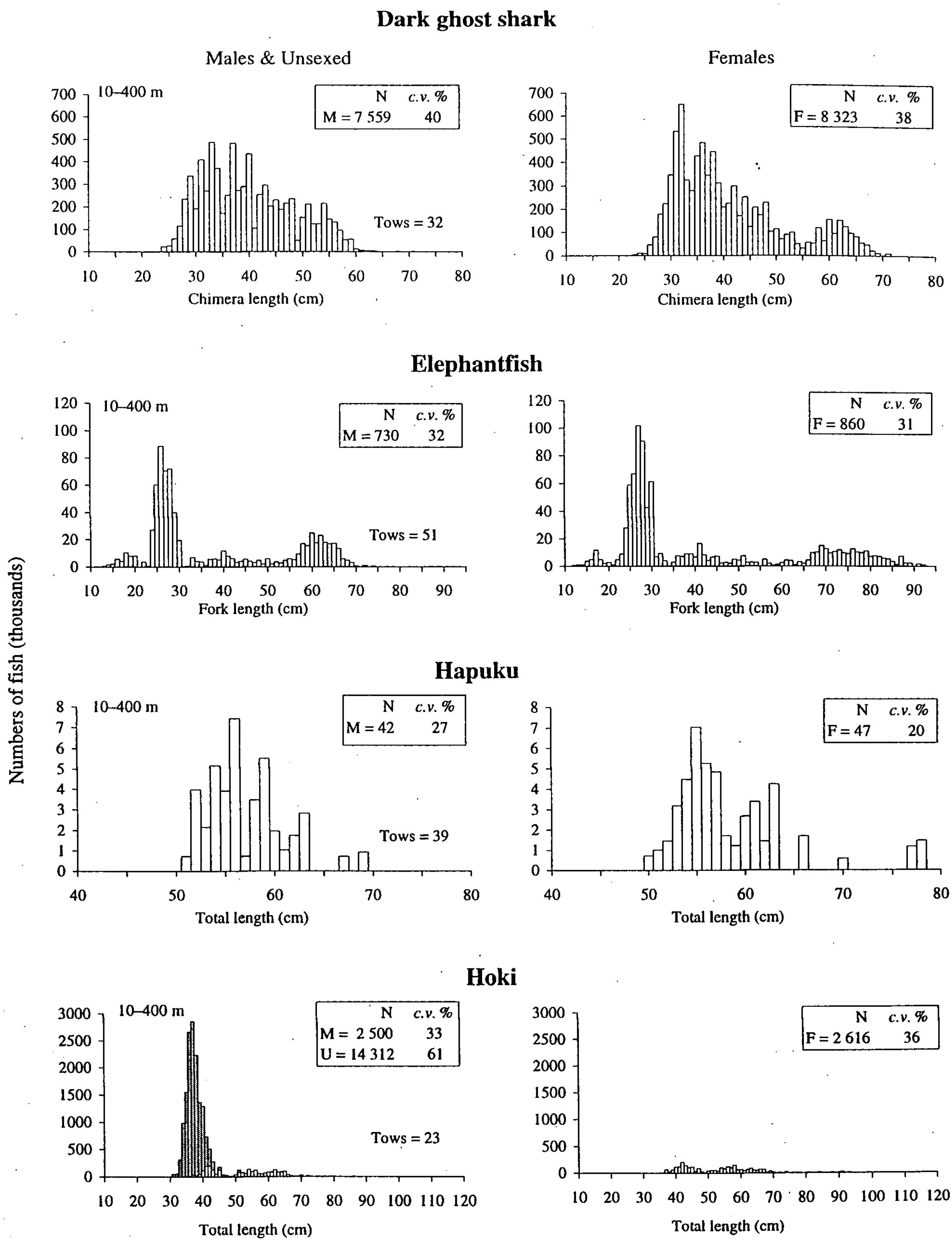


Figure 5 —continued

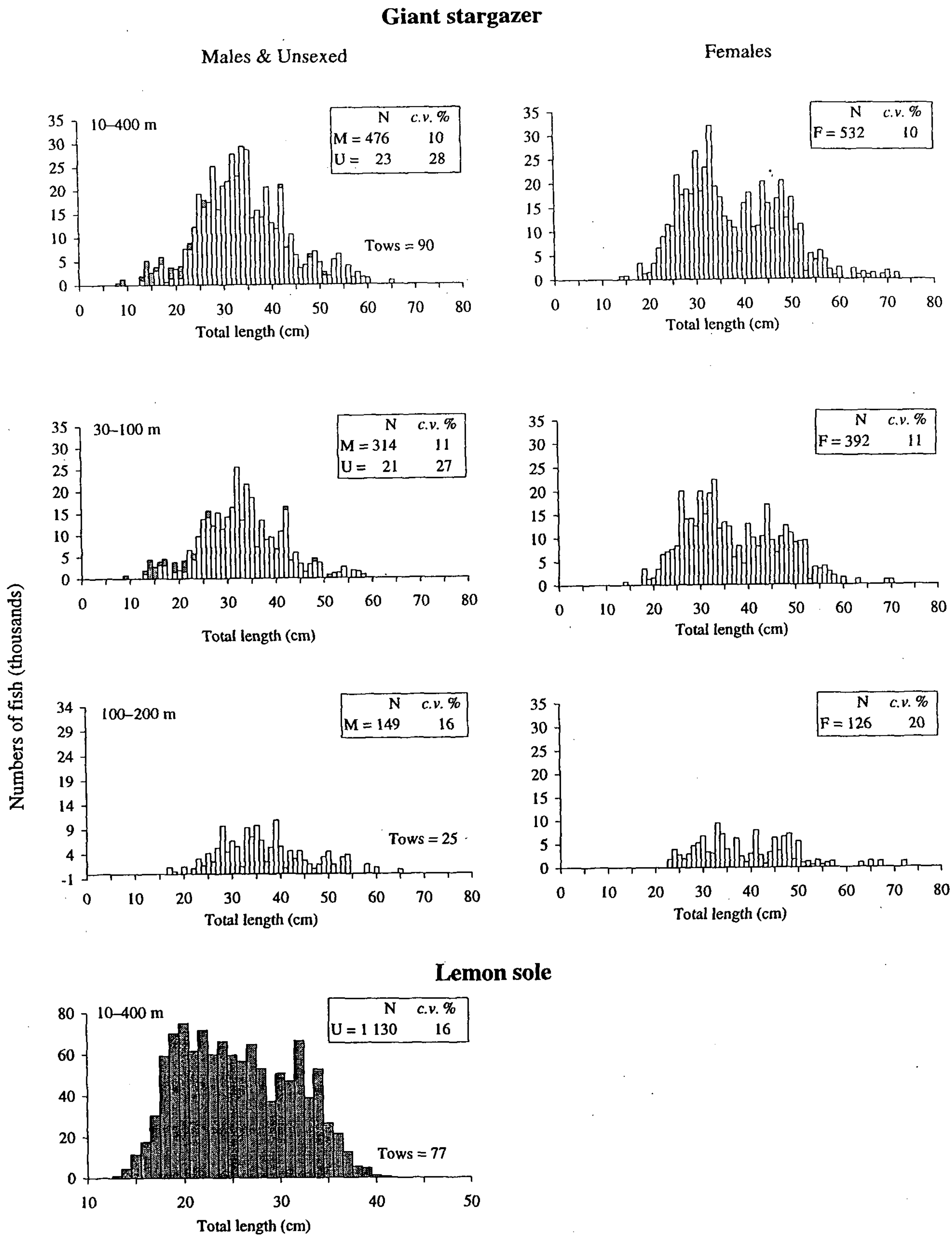


Figure 5 —continued

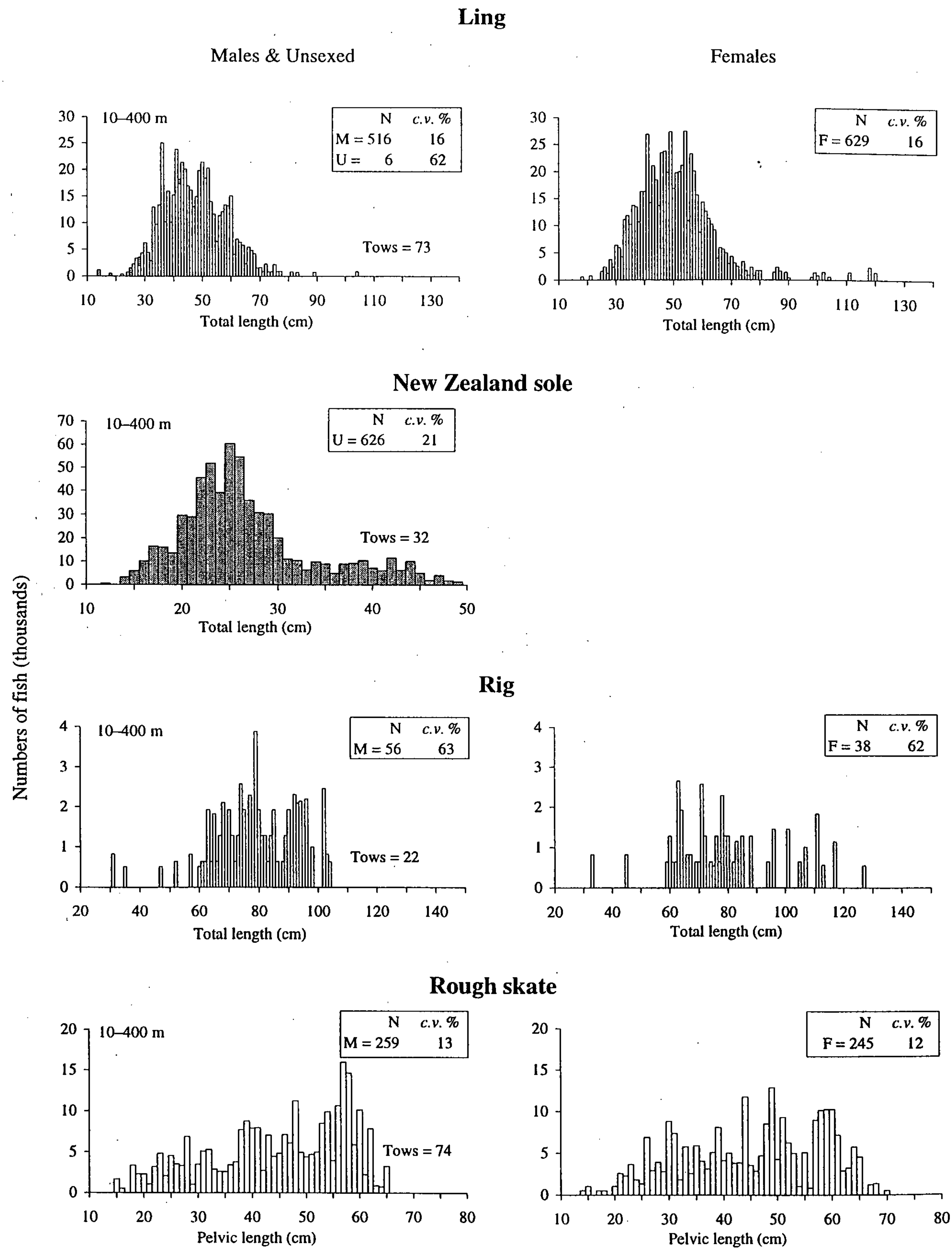


Figure 5 —continued

Red cod

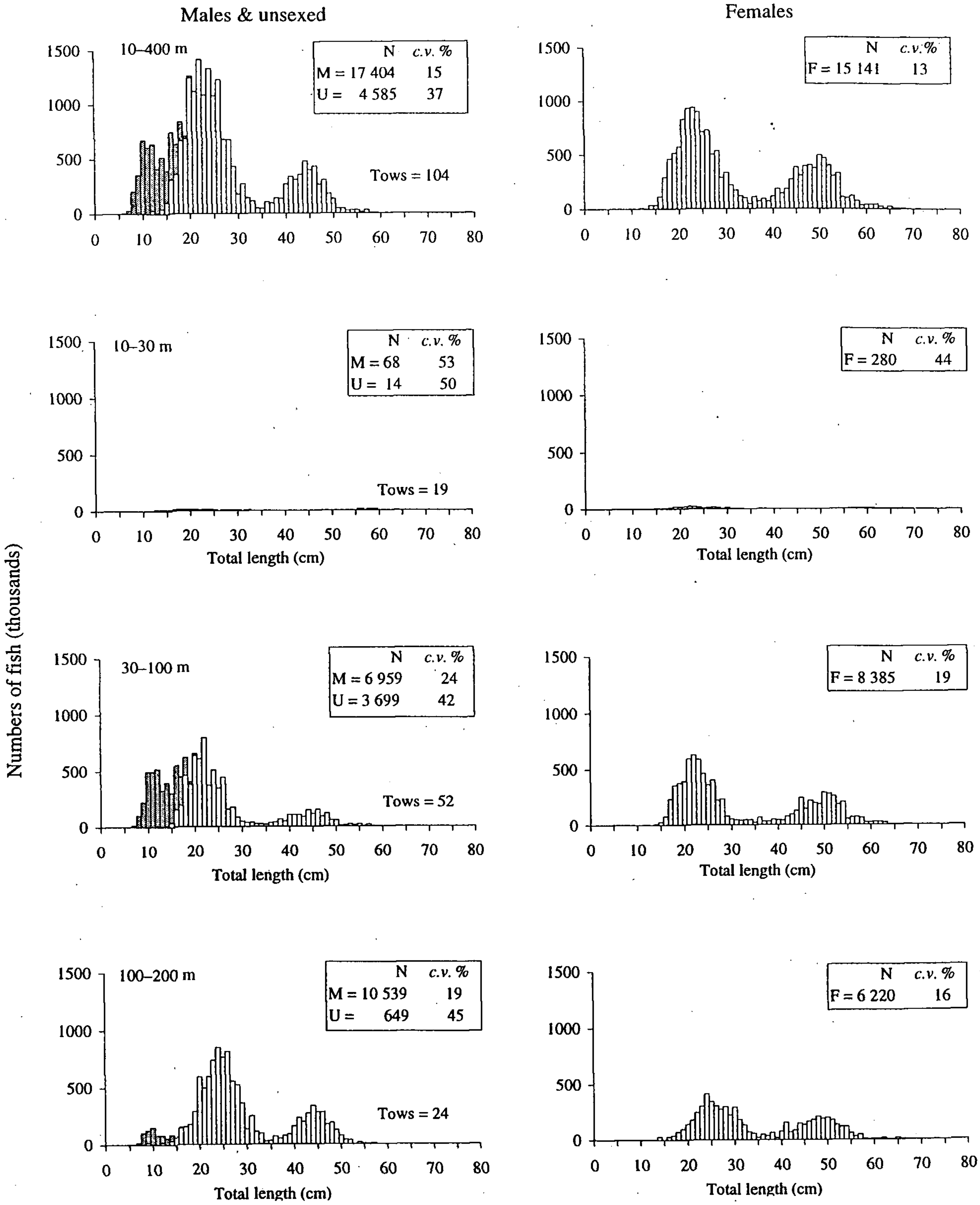
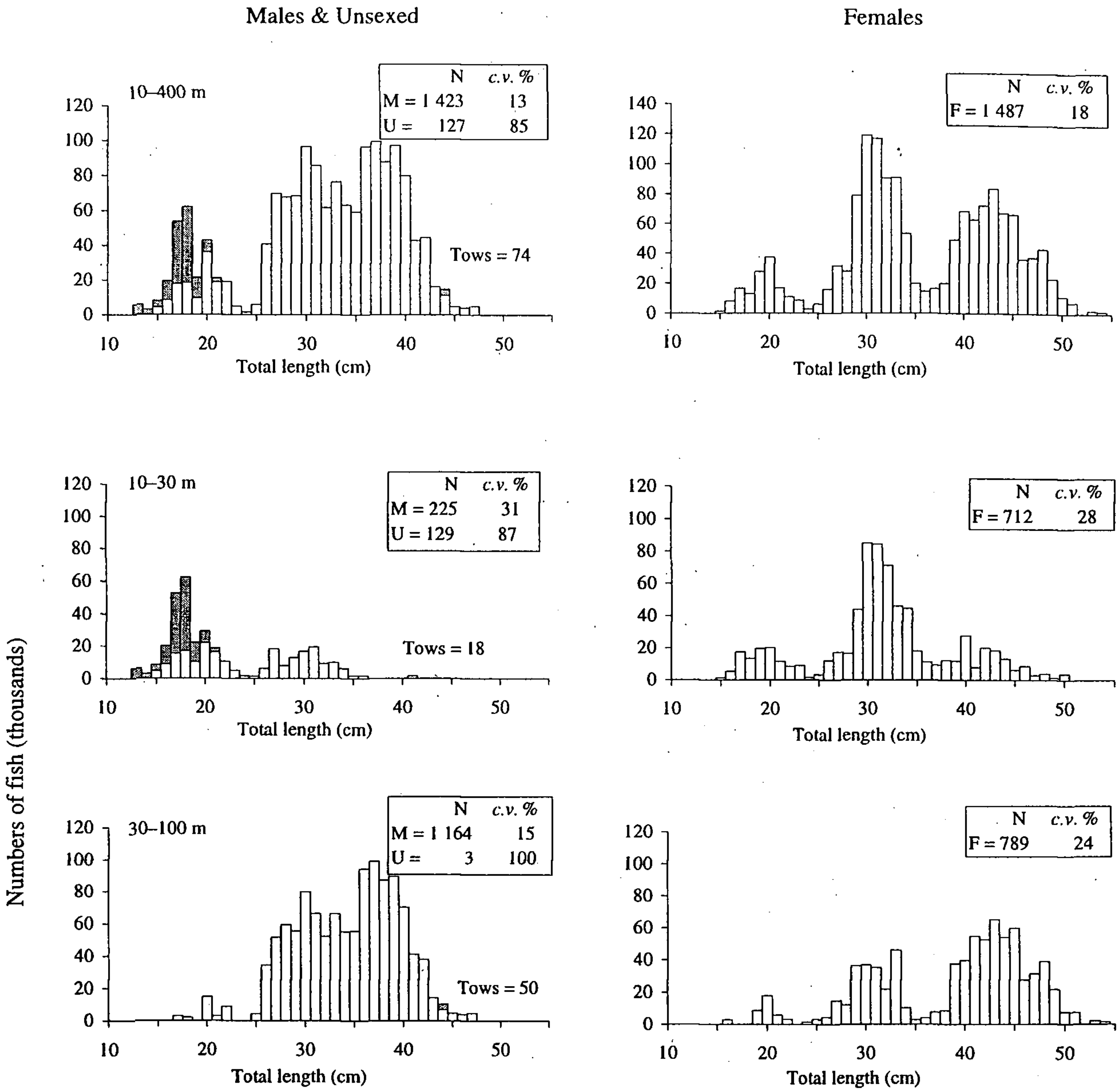


Figure 5 —continued

Red gurnard



Sand flounder

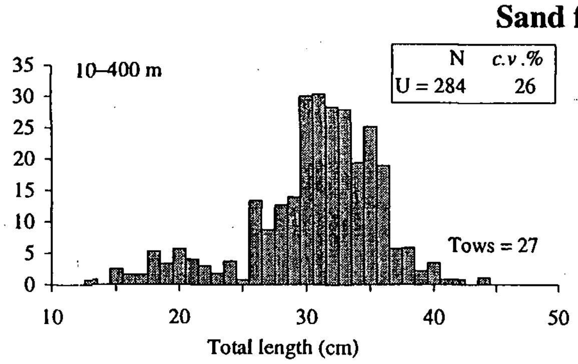


Figure 5 —continued

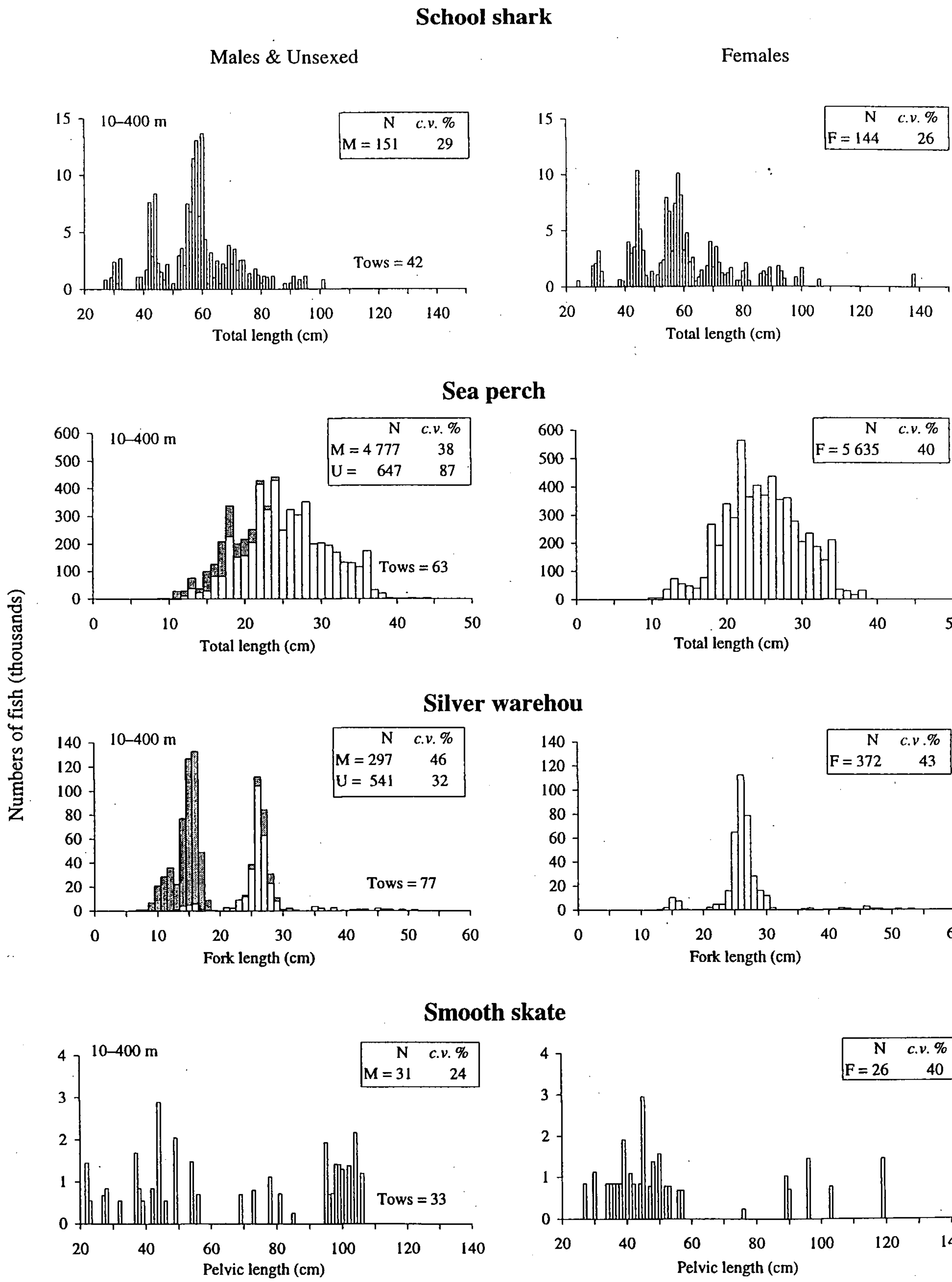


Figure 5 —continued

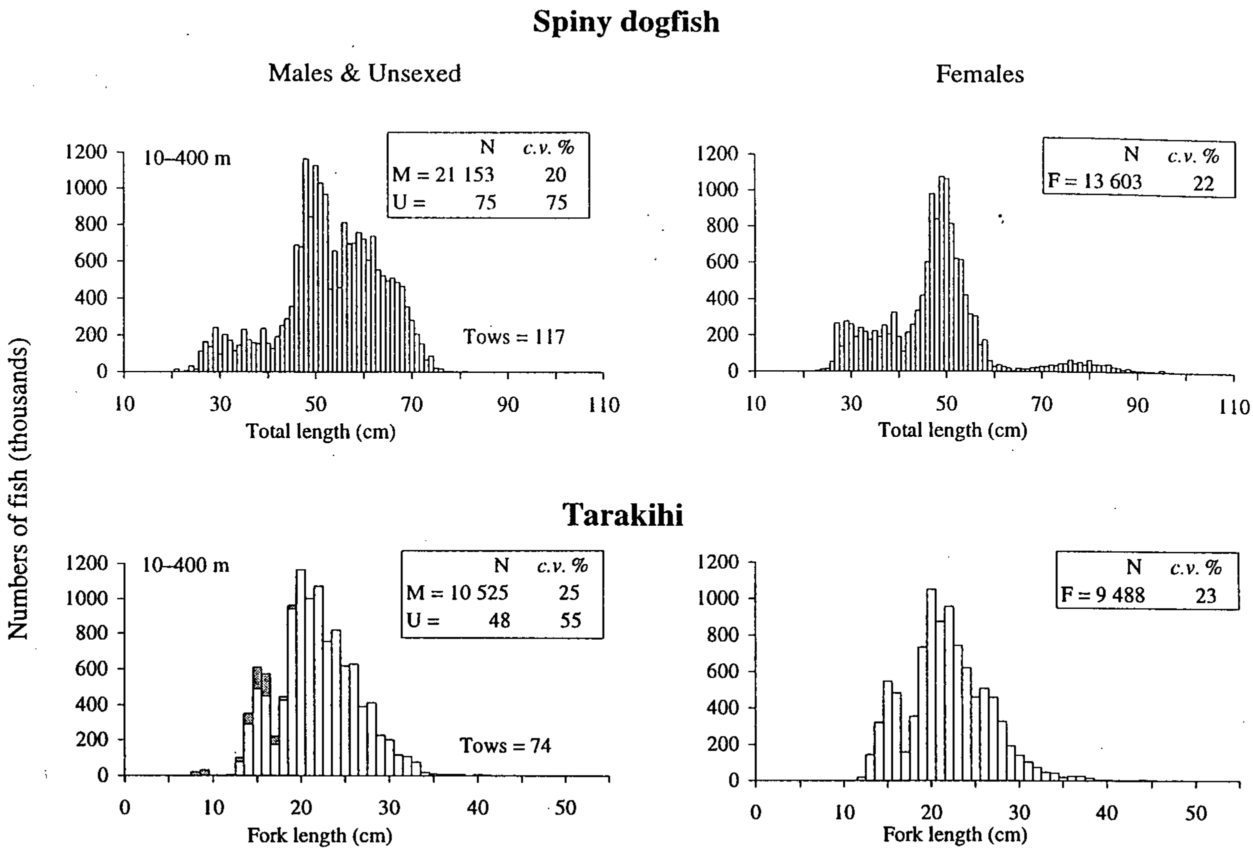


Figure 5 —continued

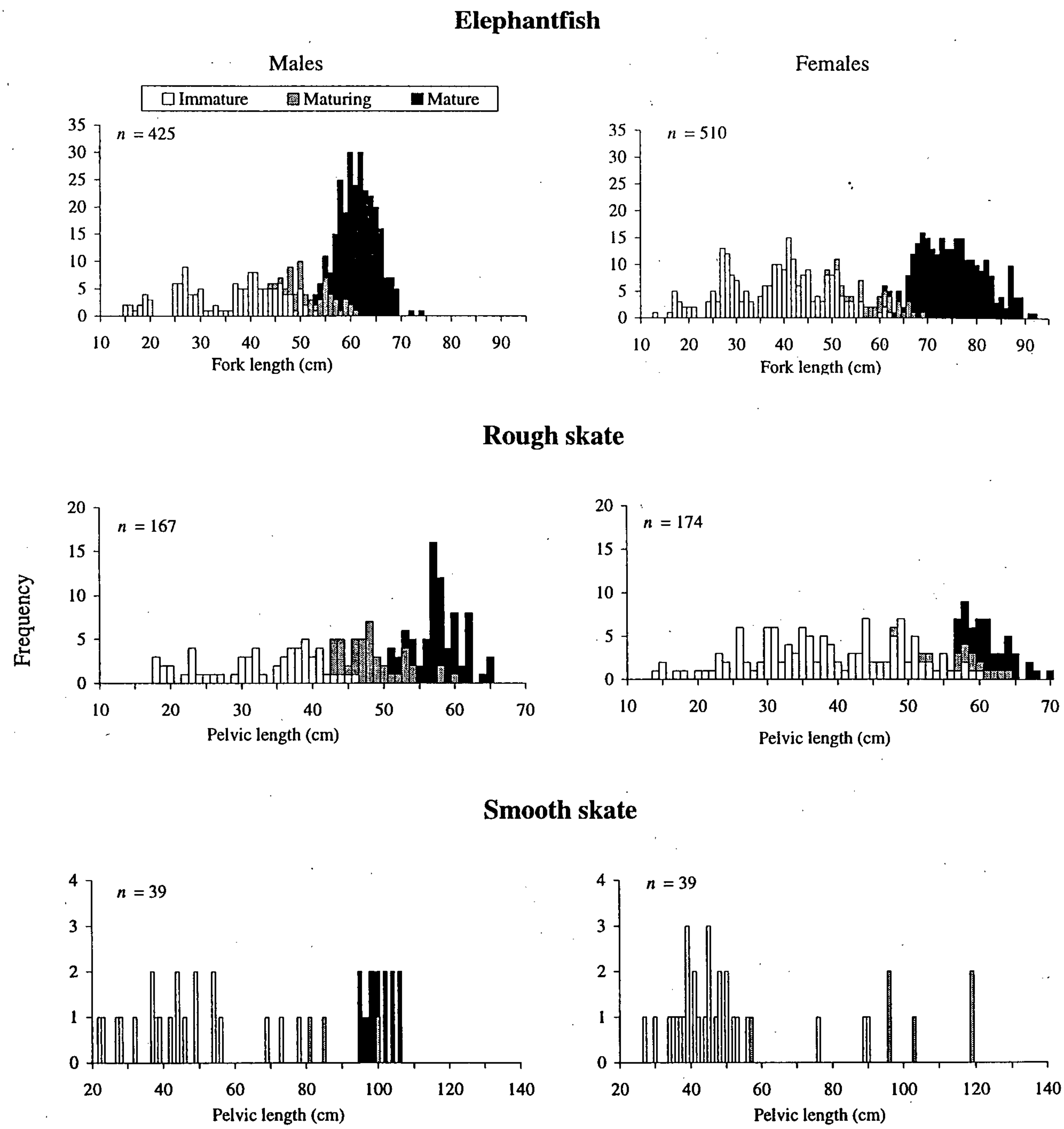


Figure 6 **: Length at maturity for elephantfish, rough skate, and smooth skate (*n* , sample size).**

Appendix 1 : **Length-weight relationship parameters used to scale length frequencies and calculate length class biomass estimates. Source of data was NIWA trawl database.**

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

Species	*a*	*b*	n	Range (cm)	Raw data source
Barracouta	0.0055	2.9812	429	22.8–87.2	KAH9704
Blue warehou	0.0144	3.1050	338	27.4–69.6	TAN9604
Chilean jack mackerel	0.0104	2.9966	184	43.7–61.6	TAN9604
Dark ghost shark	0.0014	3.3733	296	26–71.2	This survey
Elephantfish	0.0050	3.1587	931	13.8–92.5	This survey
Giant stargazer	0.0213	2.9353	917	8.6–72.4	This survey
Hapuku	0.0025	3.4155	98	50.2–78.6	This survey
Hoki	0.0036	2.9490	1 511	34–102	TAN9601
Lemon sole	0.0080	3.1278	524	14.6–41.2	This survey
Ling	0.0011	3.3411	482	32–162	TAN9501
New Zealand sole	0.0098	3.0014	363	12.7–49.7	This survey
Red cod	0.0100	2.9787	1 652	9.1–75.5	This survey
Red gurnard	0.0016	3.2237	846	13.2–54.6	This survey
Rig	0.0031	3.0593	123	29.1–115.7	KAH9704
Rough skate	0.0340	2.8767	336	14.6–70.4	This survey
Sand flounder	0.0207	2.8768	282	13.5–44.5	This survey
School shark	0.0042	3.0303	523	32–154	KAH9701
Sea perch	0.0262	2.9210	210	7–42	KAH9618
Silver warehou	0.0048	3.3800	262	16.6–57.8	TAN9502
Smooth skate	0.0317	2.8954	81	22–119	This survey
Spiny dogfish	0.0007	3.4500	1 052	43.4–104.4	TAN9502
Tarakihi	0.0111	3.1467	398	9.4–54.2	This survey

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

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

DB, NIWA (previously MAF Fisheries) trawl database
n, Sample size

Appendix 2: Summary of station data

Station	Stratum	Date	Time	Start of tow ° ' S	Start of tow ° ' E	End of tow ° ' S	End of tow ° ' E	Gear depth (m) Min.	Gear depth (m) Max.	Doorspread (m)	Distance trawled (n. miles)	Headline height (m)	Bottom temp (°C)
1	7	13-Dec-98	552	43 07.34	173 14.40	43 09.17	173 15.50	51	54	84.3	2.00	5.7	13.0
2	7	13-Dec-98	714	43 10.29	173 19.73	43 12.28	173 19.73	59	60	73.7	2.00	5.7	12.0
3	7	13-Dec-98	1029	43 12.56	173 18.99	43 14.52	173 19.51	58	64	85.7	2.00	5.5	12.2
4	7	13-Dec-98	1343	43 13.12	173 11.81	43 15.10	173 12.09	39	41	72.5	2.00	5.8	13.3
5	18	14-Dec-98	505	43 27.33	172 57.81	43 25.54	172 56.57	27	27	72.3	2.00	5.0	13.5
6	18	14-Dec-98	631	43 26.55	172 49.95	43 24.89	172 48.43	21	22	72.3	2.00	5.7	13.8
7	18	14-Dec-98	759	43 20.85	172 44.01	43 18.85	172 43.98	14	15	72.3	2.00	5.7	14.3
8	18	14-Dec-98	938	43 22.00	172 51.94	43 20.01	172 52.22	26	28	72.3	2.00	5.7	13.1
9	18	14-Dec-98	1055	43 19.63	172 52.96	43 17.63	172 52.93	29	29	72.3	2.00	5.6	12.8
10	7	14-Dec-98	1218	43 14.33	172 56.87	43 13.10	172 59.02	37	40	73.7	2.00	5.5	13.2
11	7	14-Dec-98	1350	43 17.49	173 00.41	43 19.49	173 00.39	33	37	73.7	2.00	5.4	13.3
12	18	15-Dec-98	503	43 23.27	173 09.10	43 25.27	173 09.16	28	28	72.3	2.00	5.7	13.7
13	7	15-Dec-98	625	43 26.42	173 13.23	43 28.41	173 12.97	39	40	73.7	2.00	6.0	13.7
14	6	15-Dec-98	807	43 36.01	173 10.61	43 38.00	173 11.01	33	36	73.7	2.01	5.7	13.7
15	6	15-Dec-98	938	43 41.92	173 15.72	43 43.90	173 16.17	65	70	73.7	2.00	5.7	11.6
16	6	15-Dec-98	1056	43 44.22	173 17.80	43 46.23	173 18.00	76	83	73.7	2.00	5.7	11.4
17	6	15-Dec-98	1325	43 40.03	173 38.05	43 38.23	173 39.24	90	91	73.7	2.00	5.7	11.2
18	6	15-Dec-98	1511	43 36.48	173 49.41	43 38.44	173 49.96	98	99	73.7	2.00	5.0	11.0
19	6	16-Dec-98	504	43 51.89	173 39.27	43 53.32	173 37.33	96	96	73.7	2.00	5.5	11.2
20	5	15-Dec-98	703	44 00.71	173 24.94	44 01.89	173 22.70	90	90	73.7	2.00	5.5	11.3
21 *	5	15-Dec-98	831	43 58.90	173 17.73	43 58.89	173 15.93	75	78	73.7	1.30	5.5	11.2
22	5	16-Dec-98	953	43 59.27	173 08.51	43 59.01	173 05.76	75	77	73.7	2.00	5.0	11.3
23	5A	16-Dec-98	1104	43 56.46	173 06.80	43 54.75	173 08.23	72	73	73.7	2.00	5.1	11.3
24	5A	16-Dec-98	1235	43 51.79	173 04.63	43 53.04	173 02.48	39	40	73.7	2.00	5.2	12.0
25	5	16-Dec-98	1454	44 05.95	172 53.52	44 06.45	172 50.83	75	77	73.7	2.00	5.4	11.6
26	5A	17-Dec-98	504	43 58.07	172 49.94	43 58.32	172 47.10	51	54	73.7	2.07	5.0	11.8
27	5A	17-Dec-98	634	44 02.41	172 46.26	44 01.92	172 48.99	66	68	73.7	2.03	5.0	11.8
28	5	17-Dec-98	756	44 05.71	172 49.09	44 06.90	172 46.85	72	73	73.7	2.01	5.0	11.6
29	5A	17-Dec-98	919	44 04.64	172 45.16	44 05.46	172 42.63	67	69	73.7	2.00	5.5	11.9
30	4A	17-Dec-98	1102	43 59.91	172 34.71	44 00.37	172 31.88	44	45	73.7	2.06	5.0	11.9
31	4A	17-Dec-98	1225	44 01.50	172 33.13	44 02.31	172 30.60	54	54	73.7	2.00	5.0	11.8

Appendix 2—*continued*

				Start of tow		End of tow		Gear depth (m)			Distance	Headline	Bottom
Station	Stratum	Date	Time	° ' S	° ' E	° ' S	° ' E	Min.	Max.	Doorspread (m)	trawled (n. miles)	height (m)	temp (°C)
32	4	17-Dec-98	1339	44 05.91	172 29.23	44 07.45	172 27.50	56	57	73.7	2.00	5.2	12.9
33	4	17-Dec-98	1510	44 14.08	172 24.10	44 15.44	172 22.06	68	69	73.7	2.00	5.5	11.8
34	4	18-Dec-98	533	44 15.26	172 39.36	44 15.91	172 36.73	80	83	73.7	2.00	5.5	11.1
35	4	18-Dec-98	657	44 20.62	172 36.67	44 21.79	172 34.42	92	92	73.7	2.00	5.5	11.1
36	4	18-Dec-98	849	44 17.27	172 22.54	44 16.21	172 20.19	67	71	73.7	2.00	5.5	11.7
37	4	18-Dec-98	1103	44 29.53	172 15.34	44 30.77	172 13.15	93	95	73.7	2.00	5.4	10.9
38	3	18-Dec-98	1235	44 35.08	172 05.67	44 36.09	172 03.25	100	100	73.7	2.00	5.6	11.1
39	3	18-Dec-98	1412	44 37.55	171 59.65	44 38.59	171 57.26	99	100	73.7	2.00	5.6	11.1
40	1	19-Dec-98	515	45 29.64	171 10.02	45 28.02	171 11.38	96	97	73.7	1.89	5.4	10.6
41	1	19-Dec-98	712	45 28.01	171 03.11	45 26.01	171 03.20	49	53	73.7	2.01	4.7	12.4
42	1	19-Dec-98	917	45 25.53	171 09.43	45 23.65	171 10.41	64	65	73.7	2.00	4.9	12.0
43 *	21	19-Dec-98	1205	45 04.91	171 06.84	45 04.17	171 07.12	17	17	72.3	0.77		
44	2	19-Dec-98	1508	45 06.18	171 17.28	45 04.25	171 18.02	51	54	73.7	2.00	5.0	11.9
45	20	20-Dec-98	508	44 36.70	171 12.34	44 34.72	171 12.76	18	19	72.3	2.00	5.4	13.7
46	20	20-Dec-98	627	44 34.93	171 17.14	44 33.11	171 18.30	25	25	73.2	2.00	5.4	13.5
47	20	20-Dec-98	756	44 31.99	171 21.58	44 30.11	171 22.54	27	27	72.3	2.00	5.4	13.0
48	3A	20-Dec-98	911	44 31.72	171 24.31	44 33.61	171 25.22	32	38	73.7	2.00	5.4	12.2
49	3	20-Dec-98	1022	44 35.05	171 26.56	44 36.87	171 27.62	44	46	73.7	2.00	5.4	11.8
50	3A	20-Dec-98	1212	44 28.19	171 32.34	44 26.48	171 33.78	47	47	73.7	2.00	5.2	11.8
51	20	20-Dec-98	1400	44 16.85	171 36.44	44 15.78	171 38.78	30	30	72.3	2.00	5.4	12.1
52	19	21-Dec-98	505	44 09.83	171 51.40	44 08.57	171 53.56	27	28	72.3	2.00	4.8	13.7
53	19	21-Dec-98	628	44 03.90	171 56.10	44 02.62	171 58.25	18	19	72.3	2.00	5.2	13.6
54	19	21-Dec-98	835	43 56.42	172 12.85	43 55.79	172 15.49	19	20	72.3	2.01	5.2	13.9
55	4A	21-Dec-98	1020	43 59.81	172 22.58	44 00.72	172 25.05	31	36	73.7	2.00	5.2	12.5
56	19	21-Dec-98	1154	43 56.73	172 22.27	43 55.86	172 24.76	22	23	72.3	2.00	5.2	13.4
57	19	21-Dec-98	1334	43 51.55	172 34.14	43 51.35	172 36.89	19	20	73.2	2.00		
58	17	29-Dec-98	552	43 01.61	173 40.64	43 03.58	173 41.14	303	310	84.1	2.00	4.7	9.9
59	13	29-Dec-98	816	43 03.39	173 37.38	43 01.39	173 37.92	139	149	75.4	2.03	4.9	10.1
60	13	29-Dec-98	1202	43 24.99	173 30.30	43 23.09	173 31.11	125	160	91.5	2.00	5.3	10.4
61	13	29-Dec-98	1348	43 22.58	173 39.05	43 21.67	173 41.51	118	120	79.8	2.01	4.8	11.0
62	12	30-Dec-98	509	43 37.98	173 53.34	43 39.97	173 53.55	105	106	83.9	2.00	4.8	11.1

Appendix 2—*continued*

Station	Stratum	Date	Time	Start of tow ° ' S	Start of tow ° ' E	End of tow ° ' S	End of tow ° ' E	Gear depth (m) Min.	Gear depth (m) Max.	Doorspread (m)	Distance trawled (n. miles)	Headline height (m)	Bottom temp (°C)
63	12	30-Dec-98	638	43 40.06	173 57.16	43 41.99	173 56.48	128	138	75.4	2.00	5.3	10.3
64	17	30-Dec-98	809	43 41.89	174 01.39	43 43.86	174 00.97	260	295	95.8	2.00	4.7	8.8
65	17	30-Dec-98	1057	43 43.94	174 00.43	43 45.92	173 59.84	219	231	95.0	2.02	4.7	9.3
66	12	30-Dec-98	1330	43 57.95	173 49.84	43 59.37	173 47.89	190	193	87.9	2.00	4.5	9.3
67	11	30-Dec-98	1517	44 00.25	173 46.86	44 01.54	173 44.74	194	200	89.6	2.00	4.7	9.3
68	4A	31-Dec-98	509	44 05.89	172 07.67	44 07.15	172 05.52	36	36	77.9	2.00	5.0	13.5
69	3A	31-Dec-98	730	44 15.54	171 49.30	44 17.25	171 50.74	42	48	73.7	2.00	5.1	11.8
70	3	31-Dec-98	909	44 23.14	171 57.04	44 23.97	171 54.50	63	64	73.6	2.00	5.0	11.4
71	3	31-Dec-98	1059	44 32.58	171 54.08	44 33.46	171 51.57	78	78	75.1	2.00	5.0	11.8
72	3	31-Dec-98	1331	44 47.86	171 43.03	44 48.92	171 40.66	92	96	78.0	2.00	5.0	11.1
73	3	1-Jan-99	506	44 45.46	171 33.29	44 43.48	171 32.93	57	59	76.1	2.00	5.1	11.8
74	3A	1-Jan-99	654	44 44.67	171 29.56	44 43.08	171 27.70	47	51	73.7	2.07	5.2	13.4
75	21	1-Jan-99	846	44 41.13	171 15.55	44 42.94	171 16.75	24	27	71.6	2.00	5.6	13.9
76	21	1-Jan-99	957	44 42.87	171 17.41	44 44.71	171 18.51	29	31	72.3	2.00	5.6	13.4
77	21	1-Jan-99	1142	44 46.24	171 19.84	44 47.96	171 19.38	32	35	70.5	1.75	5.6	
78	2	1-Jan-99	1310	44 48.76	171 24.26	44 50.72	171 23.69	44	44	73.4	2.00	5.5	12.8
79	2	1-Jan-99	1436	44 51.45	171 22.74	44 53.36	171 21.90	42	44	70.2	2.00	5.6	12.5
80	8	2-Jan-99	523	45 23.23	171 16.49	45 24.96	171 16.22	101	109	69.8	1.75	4.6	11.8
81	14	2-Jan-99	800	45 17.89	171 31.18	45 16.29	171 32.88	283	319	97.5	2.00	5.0	10.0
82	8	2-Jan-99	1005	45 07.07	171 39.11	45 05.12	171 39.72	131	131	85.8	2.00	5.4	10.9
83	8	4-Jan-99	511	45 07.11	171 25.98	45 06.31	171 26.84	100	100	86.5	1.01	4.9	11.4
84 *	2	4-Jan-99	725	44 58.92	171 23.50	44 58.07	171 24.25	55	56	76.3	1.00	4.9	12.3
85	2	4-Jan-99	915	44 58.68	171 31.03	44 58.20	171 32.27	82	87	83.7	1.00	5.3	11.4
86	9	4-Jan-99	1042	44 56.19	171 39.36	44 55.61	171 40.50	103	104	89.8	1.00	5.0	11.1
87	9	4-Jan-99	1235	44 48.79	171 55.63	44 47.05	171 55.97	120	121	86.4	1.75	5.2	10.8
88	9	4-Jan-99	1421	44 44.09	171 55.69	44 43.16	171 56.87	108	109	83.0	1.25	5.0	10.7
89	14	5-Jan-99	520	44 46.10	172 18.18	44 47.07	172 15.73	231	267	92.6	2.00	5.3	9.7
90	10	5-Jan-99	808	44 39.64	172 13.40	44 38.86	172 14.28	130	131	88.8	1.00	5.0	10.0
91	10	5-Jan-99	1027	44 27.58	172 33.34	44 26.92	172 35.98	113	114	75.4	2.00	5.4	10.3
92	10	5-Jan-99	1239	44 30.49	172 35.23	44 29.79	172 37.85	130	133	75.4	2.00	5.5	10.3
93	14	5-Jan-99	1506	44 36.58	172 42.51	44 35.69	172 45.02	360	366	84.1	2.00	5.0	9.0

Appendix 2—*continued*

Station	Stratum	Date	Time	Start of tow ° ' S	Start of tow ° ' E	End of tow ° ' S	End of tow ° ' E	Gear depth (m) Min.	Gear depth (m) Max.	Doorspread (m)	Distance trawled (n. miles)	Headline height (m)	Bottom temp (°C)
94	16	6-Jan-99	523	44 23.96	173 06.22	44 22.69	173 08.37	215	230	99.6	2.00	4.9	11.7
95	16	6-Jan-99	1019	44 23.75	173 13.59	44 22.40	173 15.64	371	379	93.3	2.00	5.2	9.0
96	11	6-Jan-99	1228	44 12.22	173 19.54	44 10.74	173 21.42	130	133	83.4	2.00	5.1	10.2
97	11	6-Jan-99	1347	44 09.40	173 20.97	44 07.82	173 22.66	105	113	81.5	2.00	5.4	10.3
98	6	7-Jan-99	507	43 44.43	173 43.57	43 46.08	173 42.02	94	95	76.1	2.00	5.2	11.1
99	11	7-Jan-99	737	43 56.46	173 39.96	43 57.83	173 37.95	106	106	69.1	2.00	5.1	10.9
100	16	7-Jan-99	1224	44 10.36	173 35.55	44 11.66	173 33.44	383	386	93.7	2.00	4.8	8.9
101	19	8-Jan-99	529	43 57.88	172 27.88	43 58.23	172 25.16	26	26	74.8	2.00	4.9	13.5
102	19	8-Jan-99	717	43 59.47	172 11.40	44 00.51	172 09.05	25	26	75.0	2.00	5.5	13.5
103	4A	8-Jan-99	907	44 08.03	172 12.08	44 09.24	172 09.87	45	48	77.8	2.00	5.3	11.8
104	4A	8-Jan-99	1049	44 11.32	171 59.25	44 12.36	171 56.88	40	41	76.6	2.00	5.3	12.5
105	20	8-Jan-99	1255	44 13.97	171 40.30	44 15.29	171 38.21	28	28	76.4	2.00	5.0	13.2
106	20	8-Jan-99	1446	44 18.30	171 24.76	44 19.91	171 23.12	16	18	71.4	2.00	5.0	16.5
107	8	9-Jan-99	517	45 19.21	171 20.81	45 18.46	171 21.75	106	109	74.6	1.00	5.5	12.5
108	8	9-Jan-99	640	45 15.45	171 27.86	45 14.64	171 28.69	119	119	76.9	1.00	5.5	12.0
109	8	9-Jan-99	854	45 05.83	171 29.21	45 05.01	171 30.01	104	105	78.9	1.00	5.1	11.9
110	8	9-Jan-99	1023	45 02.96	171 33.17	45 02.15	171 33.98	106	106	78.6	1.00	5.4	11.8
111	21	9-Jan-99	1256	44 49.80	171 13.68	44 48.02	171 13.63	14	15	63.8	1.78	5.4	15.8
112	8	10-Jan-99	513	45 04.48	171 43.72	45 03.60	171 44.39	134	136	82.5	1.00	5.4	11.0
113	9	10-Jan-99	641	44 54.51	171 41.71	44 53.71	171 42.55	105	105	74.8	1.00	5.1	11.4
114	9	10-Jan-99	747	44 54.22	171 45.08	44 52.98	171 46.25	111	112	78.2	1.50	5.3	11.4
115	3	10-Jan-99	955	44 38.68	171 38.59	44 36.75	171 37.89	65	68	74.1	2.00	4.9	12.2
116	3	10-Jan-99	1211	44 35.32	171 41.81	44 37.16	171 42.89	69	73	72.8	2.00	5.2	12.7
117	3	10-Jan-99	1407	44 35.47	171 51.98	44 34.48	171 54.40	83	83	81.2	2.00	5.2	11.9
118	4	11-Jan-99	507	44 23.88	172 15.42	44 25.46	172 13.71	78	79	71.1	2.00	5.2	11.6
119	4	11-Jan-99	652	44 21.25	172 03.28	44 19.29	172 03.87	63	66	74.9	2.00	5.3	12.2
120	4	11-Jan-99	918	44 11.86	172 22.45	44 10.68	172 24.69	56	58	74.8	2.00	5.2	12.7
121	4	11-Jan-99	1148	44 17.99	172 34.51	44 17.20	172 37.07	79	80	70.8	2.00	5.1	11.4
122	6	12-Jan-99	500	43 42.30	173 25.72	43 40.33	173 25.24	82	83	79.0	2.00	5.2	11.1
123	6	12-Jan-99	656	43 40.68	173 11.36	43 38.69	173 11.09	37	42	77.4	2.00	5.0	13.0

* Gear performance > 2

Appendix 3 : **Common names, scientific names, total catch, occurrence (Occ.), and depth ranges of all species caught**

Species code	Common name	Scientific name	Catch (kg)	Occ.	Depth (m) Min	Max
ANT	Anemones	Anthozoa	80.3	12	78	386
API	Alert pigfish	*Alertichthys blacki*	0.2	2	371	386
BAR	Barracouta	*Thyrsites atun*	26 330.5	111	14	366
BCO	Blue cod	*Parapercis colias*	129.9	15	14	160
BER	Numbfish	*Typhlonarke* spp.	8.4	2	75	160
BPF	Banded wrasse	*Notolabrus fucicola*	0.3	2	96	106
BRI	Brill	*Colistium guntheri*	8.4	6	14	40
BTA	Smooth bluntnosed skate	*Pavoraja asperula*	1.2	1	360	366
BUT	Butterfish	*Odax pullus*	0.2	1	14	15
BYD	Longfinned beryx	*Beryx decadactylus*	0.2	1	303	310
BYS	Alfonsino	*Beryx splendens*	0.1	1	303	310
CAR	Carpet shark	*Cephaloscyllium isabella*	1 411.5	82	14	319
CAS	Oblique banded rattail	*Caelorinchus aspercephalus*	1113	30	83	386
CBE	Crested bellowsfish	*Notopogon lilliei*	142.6	42	32	319
CBI	Two saddle rattail	*Caelorinchus biclinozonalis*	5 597.1	65	21	267
CBO	Bollons' rattail	*C. bollonsi*	1 620.2	5	283	386
CDO	Capro dory	*Capromimus abbreviatus*	0.1	1	78	78
CON	Conger eel	*Conger* spp.	16.7	2	37	40
CRA	Rock lobster	*Jasus edwardsii*	5.3	2	14	78
CRB	Crab	Unspecified	9.2	4	25	310
DSP	Deepsea pigfish	*Congiopodus coriaceus*	3.1	4	83	133
ELE	Elephantfish	*Callorhinchus milii*	2 710.8	51	14	73
ERA	Electric ray	*Torpedo fairchildi*	154.4	12	14	106
ESO	N.Z. sole	*Peltorhamphus novaezeelandiae*	225.5	32	14	54
FHD	Deepsea flathead	*Hoplichthys haswelli*	107.7	11	125	386
FRO	Frostfish	*Lepidopus caudatus*	6.2	4	65	83
GFL	Greenback flounder	*Rhombosolea tapirina*	21.8	1	96	97
GLB	Globefish	*Contusus richei*	105.6	13	14	30
GON	Sandfish	*Gonorynchus forsteri*	23.6	13	14	295
GSH	Dark ghost shark	*Hydrolagus novaezelandiae*	8 761.8	32	78	386
GSP	Pale ghost shark	*Hydrolagus* sp.	32	2	360	386
GUR	Red gurnard	*Chelidonichthys kumu*	675	75	14	109
HAG	Hagfish	*Eptatretus cirrhatus*	0.7	1	120	121
HAK	Hake	*Merluccius australis*	11.3	8	19	310
HAP	Hapuku	*Polyprion oxygeneios*	264.9	39	32	138
HCO	Hairy conger	*Bassanago hirsutus*	0.8	2	371	386
HOK	Hoki	*Macruronus novaezelandiae*	6 560.9	23	19	386
JAV	Javelinfish	*Lepidorhynchus denticulatus*	275.3	7	231	386
JDO	John dory	*Zeus faber*	5.4	2	32	44
JMD	N.Z. jack mackerel	*Trachurus declivis*	56.2	13	36	104
JMM	Chilean jack mackerel	*T. murphyi*	276	42	28	200
JMN	N.Z. jack mackerel	*T. novaezelandiae*	1.4	4	27	57
KAH	Kahawai	*Arripis trutta*	30.7	9	16	40
LDO	Lookdown dory	*Cyttus traversi*	54	6	215	379
LEA	Leatherjacket	*Parika scaber*	184.8	19	14	48
LIN	Ling	*Genypterus blacodes*	841.7	74	14	386
LSO	Lemon sole	*Pelotretis flavilatus*	310.3	78	14	295
MDO	Mirror dory	*Zenopsis nebulosus*	0.4	1	139	149
MOK	Moki	*Latridopsis ciliaris*	14.7	4	14	109
OCT	Octopus	*Octopus cordiformis*	24.1	12	32	379
OPA	Opalfish	*Hemerocoetes* spp.	2.4	21	42	379
OPE	Orange perch	*Lepidoperca aurantia*	0.4	1	231	267

Appendix 3 —continued

Species code	Common name	Scientific name	Catch (kg)	Occ.	Depth (m) Min	Max
PAD	Paddle crab	*Ovalipes catharus*	39.8	4	14	29
PCO	Ahuru	*Auchenoceros punctatus*	8.3	6	14	25
PDG	Prickly dogfish	*Oxynotus bruniensis*	7.4	1	360	366
PIG	Southern pigfish	*Congiopodus leucopaecilus*	412	73	14	160
PIP	Pipefish	Syngnathidae	0.3	3	75	121
RBM	Ray's bream	*Brama brama*	46.8	8	139	386
RBT	Redbait	*Emmelichthys nitidus*	0.5	3	94	120
RCO	Red cod	*Pseudophycis bachus*	19 677.1	104	14	386
RHY	Common roughy	*Paratrachichthys trailli*	0.1	1	283	319
RSK	Rough skate	*Raja nasuta*	1 461.9	74	14	310
SAM	Quinnat salmon	*Oncorhynchus tshawytscha*	32.8	9	16	45
SAR	Mantis shrimp	*Squilla armata*	0.2	2	21	73
SAZ	Sand stargazer	*Crapatalus novaezelandiae*	2.9	6	14	28
SBW	Southern blue whiting	*Micromesistius australis*	16.3	1	360	366
SCG	Scaly gurnard	*Lepidotrigla brachyoptera*	365.4	54	42	133
SCH	School shark	*Galeorhinus galeus*	437.8	42	14	104
SCI	Scampi	*Metanephrops challengeri*	3.3	4	303	386
SCO	Swollenhead conger	*Bassanago bulbiceps*	4.6	2	360	386
SDF	Spotted flounder	*Azygopus pinnifasciatus*	0.1	1	371	379
SDO	Silver dory	*Cyttus novaezelandiae*	7.9	21	49	386
SDR	Spiny seadragon	*Solegnathus spinosissimus*	0.3	3	58	97
SEV	Broadnose sevengill shark	*Notorynchus cepedianus*	23.1	1	14	15
SFI	Starfish	Unspecified	0.3	1	371	379
SFL	Sand flounder	*Rhombosolea plebeia*	161.9	27	14	48
SHO	Seahorse	*Hippocampus abdominalis*	0.4	4	21	35
SKI	Gemfish	*Rexea solandri*	4	1	99	100
SLS	Slender sole	*Peltorhamphus tenuis*	9	12	14	42
SPD	Spiny dogfish	*Squalus acanthias*	24 105.9	118	14	386
SPE	Sea perch	*Helicolenus* spp.	3 463.5	64	33	386
SPF	Scarlet wrasse	*Pseudolabrus miles*	6.7	2	96	133
SPO	Rig	*Mustelus lenticulatus*	298.1	22	14	105
SPR	Sprats	*Sprattus antipodum*, *S. muelleri*	307	29	14	96
SPS	Speckled sole	*Peltorhamphus latus*	2.8	8	16	38
SPZ	Spotted stargazer	*Genyagnus monopterygius*	5.5	6	21	41
SQU	Arrow squid	*Nototodarus sloanii*, *N. gouldi*	1 199.7	100	14	386
SSI	Silverside	*Argentina elongata*	299.7	59	47	386
SSK	Smooth skate	*Raja innominata*	586.4	34	28	310
STA	Giant stargazer	*Kathetostoma giganteum*	1 160.7	91	27	379
STY	Spotty	*Notolabrus celidotus*	35.4	16	14	64
SWA	Silver warehou	*Seriolella punctata*	352.2	77	16	310
TAR	Tarakihi	*Nemadactylus macropterus*	4 980.4	75	14	200
TKT	Topknot	*Notoclinus fenestratus*	0.1	1	14	15
TOD	Dark toadfish	*Neophrynichthys latus*	26.8	42	16	379
TOP	Pale toadfish	*N. angustus*	15.5	4	260	386
TRU	Trumpeter	*Latris lineata*	4.9	2	49	160
WAR	Common warehou	*Seriolella brama*	3 725.7	29	14	78
WIT	Witch	*Arnoglossus scapha*	1639	99	18	310
WSQ	Warty squid	*Moroteuthis* spp.	4.6	3	131	386
WWA	White warehou	*Seriolella caerulea*	47.1	8	190	379
YBF	Yellowbelly flounder	*Rhombosolea leporina*	9.8	3	16	20
YCO	Yellow cod	*Parapercis gilliesi*	9.9	2	125	160
YEM	Yelloweyed mullet	*Aldrichetta forsteri*	1.7	3	26	40
			123 232.9			