Inshore trawl survey of the Canterbury Bight and Pegasus Bay, December 1999–January 2000, (KAH9917 & CMP9901)

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Abstract

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The results of the fourth in a 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 by RV *Kaharoa* are reported. In addition, the results of a concurrent survey by FV *Compass Rose* in the 5–30 m depth range are included and compared with the *Kaharoa* results.

The *Kaharoa* survey was of a two-phase design optimised for elephantfish (*Callorhinchus milii*), giant stargazer (*Kathetostoma* spp.), red gurnard (*Chelidonichthys kumu*), and 0+ and 1+ red cod (*Pseudophycis bachus*). Biomass estimates, catch distribution, and population length frequencies for the major species are described. Coefficients of variation associated with biomass indices for the target species were all within the specified target range, except 1+ red cod (target c.v. 30%, actual c.v. 45%).

The *Compass Rose* survey was of a one-phase design optimised for elephantfish. The biomass estimates and catch distribution for elephantfish and the major species are reported. Population length frequencies for elephantfish are also reported. The main objective of the *Compass Rose* survey was to determine elephantfish biomass in less than 10 m depth (not available to *Kaharoa* surveys), to include in the total elephantfish biomass estimate for east coast South Island. Based on the relative biomass estimates in the depth range surveyed by both vessels (10–30 m), a scaling factor was investigated. In this common depth range, length frequency distributions of elephantfish were different between the two vessels, and c.v.s for *Compass Rose* elephantfish biomass were high (73%) indicating that a scaling factor was not appropriate.

Comparison of the *Compass Rose* proportion of biomass of the 10 most abundant commercial species in the 5–10 m and 10–30 m depth ranges, indicates that the shallow strata are important only for elephantfish, and therefore for other target species the current minimum depth of 10 m is appropriate for *Kaharoa* surveys.

For other species from the *Kaharoa* catch, biomass estimates were generally lower than for previous surveys. Comparison over all four surveys in the time series indicates that for 8 of 13 major species, including all target species, biomass estimates declined in 1997–98, increased in 1998–99, and then declined again in 1999–2000. This result suggests that there may be a catchability difference between surveys. Bottom water temperatures in the east coast South Island summer trawl surveys appear to be higher for the 1997–98 and 1999–2000 surveys and may partly explain the fluctuations in biomass estimates between surveys.

Introduction

This report presents the results from the fourth 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 (*Callorhinchus milii*), giant stargazer (*Kathetostoma* spp.), red gurnard (*Chelidonichthys kumu*), 0+ red cod (*Pseudophycis bachus*), and 1+ red cod. The survey also collected data on other important commercial species, including barracouta (*Thyrsites atun*), dark ghost shark (*Hydrolagus novaezelandiae*), ling (*Genypterus blacodes*), rough and smooth skate (*Dipturus natusus, D. innominatus*), sea perch (*Helicolenus* spp.), spiny dogfish (*Squalus acanthias*), and tarakihi (*Nemadactylus macropterus*). The results of the first three surveys (1996–97, 1997–98, and 1998–99) in the series have been reported previously (Stevenson 1997, Stevenson & Hurst 1998, Stevenson & Beentjes 1999).

Red cod are a major component of the east coast South Island inshore trawl fishery, with an average annual catch in the fishing years 1994–95 to 1998–99 of about 11 000 t (Annala et al. 2000). 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 last three species have all had Total Allowable Commercial Catch (TACC) increases in recent years under the Adaptive Management Programme (AMP). The Ministry of Fisheries (MFish) requires AMP species to be monitored to determine if the TACC increases are sustainable. The previous winter time series in the area (1991 to 1996) and the current summer time series have provided relevant data for monitoring this programme. Data include estimates of relative biomass, length frequency distributions, ageing material, and reproductive condition. Commercial landings of red cod have fluctuated as much as four fold between years of lowest and highest catches, as a result of variable recruitment and few year classes in the fishery (Beentjes 1992, Annala et al. 2000). 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.

In 1996–97 the timing of the surveys was changed from winter to summer as it was considered that summer was a more appropriate time for sampling red gurnard and elephantfish. The summer surveys also use a smaller mesh codend than the winter series to better sample 0+ red cod and the survey area was extended to include areas in the 10–30 m depth range to better sample elephantfish and red gurnard. The results of the first three summer surveys suggest this series is capable of providing a monitoring tool for the target species: elephantfish, red gurnard, stargazer, and juvenile red cod.

In 1999, the Inshore Fishery Assessment Working Group was concerned that the east coast South Island trawl survey may not be adequately sampling elephantfish as there may be substantial biomass in depths less than 10 m (10 m is the minimum *Kaharoa* depth). MFish requested that the 1999–2000 survey include a single commercial vessel survey of the 5–10 m and 10-30 m depth ranges in the Canterbury Bight, concurrently with RV *Kaharoa*, to estimate the relative abundance of elephantfish in 5–10 m compared to 10–30 m, so that an appropriate scaling factor for *Kaharoa* surveys could be determined.

This survey also collected data on the presence of macroinvertebrates from tows, an objective not undertaken on any previous survey in this area.

Programme objective

To determine the relative abundance and distribution of inshore finfish species along the east coast of the South Island, focusing on elephantfish, juvenile red cod, red gurnard, and stargazer.

Programme objectives 1999–2000

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 are as follows: elephantfish (20–30%); juvenile red cod: 0+ (30%), 1+ (30%); red gurnard (25–30%); stargazer (15–20%).

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, distribution, and length frequencies of all other Quota Management System (QMS) species, and rough skate (*Dipturus nasutus*), smooth skate (*D. innominatus*), and spiny dogfish (*Squalus acanthias*).

5. To collect and identify benthic macroinvertebrates taken during the survey.

Objectives for the commercial vessel survey

1. To determine the relative biomass of elephantfish in 5–10 m and 10–30 m depth, using a commercial trawler.
2. To determine the population length frequency and sex ratio of elephantfish in 5–10 and 10–30 m depth, using a commercial trawler.
3. To calculate a scaling factor which can be applied to the *Kaharoa* estimate of elephantfish biomass for the 1999–2000 survey, if appropriate.

Timetable and personnel

The *Kaharoa* voyage started and finished in Wellington and was divided into two parts, the first from 15 to 22 December 1999 and the second from 28 December 1999 to 15 January 2000. Michael Beentjes was project leader and Michael Stevenson was voyage leader and was also responsible for final database editing. The skipper was Arthur Muir.

The commercial vessel survey using *Compass Rose* started and finished in Timaru. The skipper was Raymond Mitchell and Neil Bagley was voyage leader and was also responsible for final database editing.

Methods

Survey area and design

Kaharoa (KAH9917)

The *Kaharoa* survey area 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 from other parts of the survey area. The survey area of 26 938 km^2, including untrawlable (foul) ground, was divided into 23 strata, identical to the 1998–99 survey (Figure 1, Table 1).

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 three surveys (Brian Bull, 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 85% 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 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. mile) 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 *Kaharoa*. A total of 104 stations was allocated to phase 1.

Compass Rose (CMP9901)

The commercial vessel *Compass Rose* was chartered by NIWA to conduct an elephantfish survey in existing strata 19 and 20 (depth range 10–30 m) and also in two newly defined strata, 22 and 23 (5–10 m) (Figure 2). The *Compass Rose* survey was of a one phase design of 36 stations (*see* Table 1) and the survey area of 1977 km^2 was divided into four strata as described above.

Vessel, gear, and trawling procedure

Kaharoa

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 large catches. The panel was designed to burst automatically when the catch filled the net to that point. No catches were large enough for the blow-out panel to have to function.

Doorspread and headline height measurements were recorded using Scanmar monitoring equipment with an average of five readings at 10 min intervals during each tow. For tows where no reading was possible, the mean doorspread of stations within the same depth range was used.

All tows were undertaken in daylight between 0500 and 1700 hours NZST. At each station it was planned to tow 2 n. mile (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 about 3.5:1 and decreasing to about 2.2:1 at greater depths (Table 2).

Compass Rose

The *Compass Rose* is a 15.2 m commercial stern trawler, with an engine power of 114 kW. One NIWA staff member was aboard the *Compass Rose* to coordinate towing procedures, which were the same as for *Kaharoa* except that standard commercial trawling gear (Russel-Rayner 80 ft wing trawl, codend 100 mm) was employed, towing speed was 2.5 knots, and tows were generally parallel with the shore. Headline height was maintained at 2.5 m. Warp length was maintained at 110 m, except on four tows where shallow water and, or large swells required a reduced doorspread of 30 m to be used. Doorspread was estimated using the method of Koyama (1974) and varied between 30 and 51 m. Mean warp to depth ratio over all tows was 7.6 (*see* Table 2).

Water temperatures

The surface temperature at each station was recorded from hull-mounted sensors on *Kaharoa* and *Compass Rose*. Calibration readings were taken using a Brannan 75 mm mercury immersion thermometer with a range of –1 to 51 °C. At the start of each of the first 10 tows, a 10 l bucket was lowered on the starboard side (opposite the engine outlet) to a depth of about 1 m and a reading taken as soon as possible. Results indicated the hull sensor readings were 0.1–0.2 °C higher than the calibration temperatures. Because the hull sensor was positioned at a depth of 3 m the difference was not thought to be significant. Bottom temperatures were recorded by *Kaharoa* using the Scanmar net monitor.

Catch and biological sampling

Kaharoa

The catch from each *Kaharoa* 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, shellfish, and other invertebrate species were preserved in 10% buffered formalin for later identification.

Length, to the nearest whole centimetre below actual length, and sex (where possible) were recorded for all ITQ species except frostfish. 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, dark ghost shark, spiny dogfish, and tarakihi. 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 a wide range was obtained 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, red cod, red gurnard, and brill. Vertebrae were collected from all smooth skate greater than 60 cm PL, and all rough skate greater than 65 cm PL. A block of four to six of the largest vertebrae from the rear half of the body cavity was removed, trimmed of excess muscle, labelled with sex, length, and maturity stage, placed in a sealed plastic bag, and frozen. Samples (whole fish or heads) of dark ghost shark were collected for ageing studies. Each sample was individually labelled with length, sex, station number, 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 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 (over 1 cm diameter) and may contain eggs.

Compass Rose

The catch from each *Compass Rose* station was sorted on deck into species and weighed on Seaway 100 kg motion-compensating scales to the nearest 0.1 kg. Length, to the nearest whole centimetre below actual length, and sex were recorded for elephantfish only. Sample sizes were either the whole catch or a randomly selected subsample of up to 200 fish. Reproductive stages were not recorded.

Data analysis

Relative biomass estimates and scaled length-frequency distributions were estimated for both surveys 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 a time series of relative abundance estimates to be developed.

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. For *Kaharoa* all 120 stations were included in the analysis (Appendix 2). For *Compass Rose*, four tows were not used in biomass calculations because of poor gear performance (Appendix 3). 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, firstly, 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. All length frequencies were scaled by the percentage of catch sampled, area swept, and stratum area using the Trawlsurvey Analysis Program.

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

Results

Survey area, design, and gear performance

Kaharoa

Kaharoa completed 120 successful tows, 104 in phase 1 and 16 in phase 2 . All 120 stations were used in biomass estimation. The completed station density ranged from 1 station per 99 km^2 in stratum 20 to 1 station per 522 km^2 in stratum 7, 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 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. 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 and moved south, covering, as much as possible, the inshore strata (under 100 m; 1–7, 18–21) where the four target species tend to be found in summer. Strata 19 and 20 were sampled in conjunction with *Compass Rose* as far as practicable. Any remaining inshore stations, 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. Four days were lost to bad weather.

Phase two stations were mainly required to reduce c.v.s of 1+ red cod and all but one were allocated south of Banks Peninsula. Six phase 2 stations were allocated to stratum 9 where the highest catch rates of 1+ red cod occurred, one to four stations were allocated to strata 1, 3, and 7, also for 1+ red cod, and 3 in stratum 5A for elephantfish (see Table 1). Catch rates of giant stargazer and red gurnard were not used for allocation of phase 2 stations because the c.v.s were within target levels.

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. Twelve tows were shorter than the planned 2 n. mile to avoid large patches of *Macrocystis* (stratum 21), or to reduce the risk of large catches (strata 1 and 2). For the total depth range, recorded doorspread varied from 68 to 93 m and headline height varied between 4.9 and 6.2 m (see Table 2, Appendix 2). For each depth range, and overall, the doorspreads recorded for this survey were within the range recorded during the previous surveys.

Compass Rose

Compass Rose completed 40 stations of which 4 (stations 7, 11, 29, and 31) were not used in biomass calculations because of poor gear performance. Station density ranged from 1 station per 12 km^2 in stratum 23 to 1 station per 99 km^2 in stratum 19, with an overall density of 1 station per 55 km^2(see Table 1). At least eight 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 2 and individual station data are given in Appendix 3.

Water temperatures

Isotherms estimated from surface temperature recordings from *Kaharoa* and *Compass Rose* are shown in Figures 3a and 3b respectively. Isotherms estimated from the *Kaharoa* bottom temperature records are shown in Figure 4.

Catch composition

Kaharoa

Kaharoa caught about 104 t of fish, crustaceans, echinoderms, and molluscs from 120 tows at an average of 865 kg per tow (range 53–7708 kg). A total of 87 vertebrate fish species was identified during the survey: 1 agnathan, 11 elasmobranchs, and 75 teleosts. Species codes, common names, scientific names, and catch weights of all species identified during the survey are given in Appendix 4. Total catches from all stations were weighed and samples from each catch were measured. Invertebrate species identified from the *Kaharoa* catch are given in Appendix 5.

Total catch weights of species for which the *Kaharoa* catch was greater than 200 kg and for blue cod and rig (but excluding thresher shark) are given in Table 3 in order of decreasing weight. The most abundant species by weight was spiny dogfish with a catch of 45.4 t (44% of the total catch). The four most abundant species, spiny dogfish, barracouta, red cod, and tarakihi, made up about 81% of the total catch (see Table 3). The target species, elephantfish, giant stargazer, red gurnard, and red cod, made up 1.5, 0.2, 0.5, and 9.2 % of the catch, respectively. Spiny dogfish, barracouta, red cod, and arrow squid were each caught in over 80% of the tows (see Appendix 4).

Compass Rose

Compass Rose caught about 9.5 t of fish, squid, and crustaceans from 40 tows at an average of 238 kg per tow (range 42–3451 kg). Species codes, common names, scientific names, and catch weights are given in Appendix 6. Total catch weights and relative biomass indices of species for which catch was greater than 50 kg and for brill are given in Table 4 in order of decreasing weight. Elephantfish was the most abundant species with a catch of 6 t (63% of the total) and was caught in 37 of the 40 tows. The four most abundant species, elephantfish, spiny dogfish, rough skate, and school shark, made up about 84% of the total catch (see Table 4).

Biomass and distribution

Kaharoa

Relative biomass indices and c.v.s for species for which the *Kaharoa* catch was greater than 200 kg and for blue cod and rig (but excluding thresher shark) are given in Table 3. Spiny dogfish had the largest estimated biomass, followed by barracouta and red cod; these were followed by a group of species with roughly equal biomass that included two saddle rattail, tarakihi, dark ghost shark, and sea perch. Coefficients of variation for the target species were: elephantfish, 28%; 0+ red cod 27%; 1+ red cod, 43%; red gurnard, 20%; and giant stargazer, 14% (see Table 3).

Recruited biomass estimates and c.v.s for barracouta, blue warehou, elephantfish, giant stargazer, hoki, lemon sole, New Zealand sole, red cod, red gurnard, rig, sand flounder, school shark, silver warehou, and tarakihi are given in Table 3. For the target species, elephantfish, giant stargazer, red gurnard, and red cod, the percentage of total biomass that was recruited fish was 87%, 96%, 95%, and 59%, 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 biomass of 1+ year class for red cod was 33% 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 major commercial species are shown in Figure 5 in alphabetical order by common name. Barracouta were caught throughout the survey area, though catch rates east of Banks Peninsula were low. Spiny dogfish were also caught throughout the survey area, with the highest catch rates in the 30–200 m depth range. 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 mostly 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 Oamaru.

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

Compass Rose

Relative biomass indices and c.v.s for species for which the *Compass Rose* catch was over 50 kg and for brill are given (see Table 4). Elephantfish had the highest estimated biomass followed by spiny dogfish and rough skate. The c.v. for elephantfish biomass was 55%.

For the target species elephantfish, recruited biomass was 52% of the total (*see* Table 5). Biomass estimates by year class are given in Table 5 for elephantfish where year class length intervals were estimated from the scaled length frequency distributions.

Catch rates by stratum for the 10 most abundant commercial species are given in Table 8. Distributions and ranges of catch rates for the major commercial species are shown in Figure 6. Elephantfish were caught throughout this inshore area with the highest catch rates in the north in the 5–10 m depth range (stratum 22). For red gurnard, rig, rough skate, school shark, and yellowbelly flounder, catch rates were highest in the northern strata (strata 19 & 22). New Zealand sole, red cod, and spiny dogfish were also caught throughout the area but with no apparent pattern to the catch rates.

Biomass indices by stratum for the major species are given in Table 9.

Between vessel comparison of elephantfish biomass

A comparison of elephantfish estimated biomass by depth range is summarised in Table 10. In the common strata and depth range (strata 19 & 20, 10–30 m), *Compass Rose* estimated biomass was more than double that of *Kaharoa* (802 t compared to 292 t), but the c.v. for *Compass Rose* was high (73 %) and the difference is not statistically significant. Elephantfish catches for *Compass Rose* were dominated by the high catch rate in stratum 22, which was about six times higher than the stratum with the next highest catch rate (stratum 19) (see Table 8). The high catch rate in stratum 22 was a result of one large catch of predominantly large females and this is reflected in the biomass and c.v.s (see Tables 8 & 9).

Biological and length frequency data

Kaharoa

Species length frequency data, numbers of biological samples collected, and measurement methods are given in Table 11.

Scaled length-frequency distributions of the major commercial species (more than 100 fish measured) and smooth skate are shown in Figure 7 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. Most fish under 40 cm were in depths of less than 30 m. The sex ratios (male:female) for elephantfish were 0.93:1 overall; 0.69:1 in 10–30 m and 1.1:1 in 30–400 m.

The length frequency distributions for giant stargazer were similar for the 30–100 and 100–200 m depth ranges (see Figure 7). Modal patterns are difficult to interpret. The sex ratio (male:female) for giant stargazer was 1.15:1 overall, and varied little by depth.

The length frequency distribution for red cod shows a strong mode for 1+ fish at 15–34 cm and a mode for 0+ fish at 8–14 cm. The sex ratios (male:female) for red cod were 1.08:1 overall; 0.05:1 in 10–30 m; 0.96:1 in 30–100 m; and 1.29:1 in 100–200 m.

The length frequency distribution for red gurnard shows a distinct mode for 1+ fish at 18–25 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 (see Figure 7). For red gurnard, the sex ratios (male:female) were 1.06:1 overall; 0.21:1 in 10–30 m; and 1.37:1 in 30–100 m.

Length at maturity data for elephantfish, rough skate, and smooth skate are shown in Figure 8. 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 56 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 and 95 cm.

Details of the gonad stages for giant stargazer, red cod, and red gurnard are given in Table 12. Most giant stargazer were immature or resting (77% males and 62% females), and a small percentage were maturing. For red cod, most gonads were classified as immature or resting (61% males and 62% females). Over half (61%) of the remaining males were maturing with decreasing numbers of mature, running ripe, and spent fish. About 74% of other females were maturing. Most red gurnard males were immature or resting (42%), or maturing (47%). Female red gurnard showed a wide range of gonad development with 24% immature or resting, 18% maturing, 40% mature, and 16% running ripe. All three species showed a more advanced state of reproductive condition than in the previous survey (Stevenson & Beentjes 1999).

Compass Rose

Species length frequency data, numbers of biological samples collected, and measurement methods are given in Table 12.

Scaled length-frequency distributions for elephantfish from *Compass Rose* are shown in Figure 9. There is a dominant mode at 27–40 cm which probably comprises 1+ and 2+ fish and a smaller mode at 13–21 cm (0+ fish). Fish in the 5–10 depth range were predominately large females (over 65 cm). The sex ratio (male:female) for all fish was 0.85:1, but varied considerably with depth (0.17:1 in 5–10 m and 0.97:1 in 10–30 m).

Between vessel comparisons of elephantfish length frequency

A comparison of elephantfish length frequency distributions caught in each depth range by *Kaharoa* and *Compass Rose* is shown in Figure 10. Length frequency distributions in the common depth range (10–30 m) were distinctly different for the two surveys. *Kaharoa* elephantfish length frequency distributions for all depths (10–400 m) were similar to those for the 10–30 m depth range suggesting that depth did not greatly influence the size range of fish caught, and a wide size range of both sexes from 0+ to mature was represented. *Compass Rose* distributions, in contrast, were dominated by large females in the 5–10 m depth range and by smaller fish of age 1+ and 2+ in the 10–30 m depth range. The *Kaharoa* was probably more effective in sampling small elephantfish (0+ and 1+) because of the smaller codend mesh used (*Compass Rose* 100 mm, *Kaharoa* 28 mm).

Adult elephant fish were well represented in *Kaharoa* catches with recruited biomass comprising 86% of total biomass (see Table 5), and mature fish (i.e., over 52 cm) made up about one third of the scaled numbers (see Figure 10). *Compass Rose* recruited biomass comprised about 52% of the total biomass and mature fish made up only 13% of the scaled numbers of which the bulk were female. The sex ratio (male:female) of elephantfish caught on *Compass Rose* in the common depth range (10–30 m) was 0.97:1 compared with 0.69:1 for *Kaharoa*.

Discussion

Kaharoa survey

The fourth in the time series of summer southeast South Island trawl surveys was completed during December 1999–January 2000, meeting all objectives. Coefficients of variation associated with biomass indices for the target species were all within the specified target range, except 1+ red cod (target c.v. 30 %, actual c.v. 45 %). Two large catches of red cod in stratum 9 and almost no catch at the other seven stations in the stratum resulted in high variability.

All biomass estimates for target species were the lowest for any of the surveys except for elephantfish, for which only 1997–98 was lower (Appendix 7). Further, comparison over all four surveys indicates that for 8 of the 13 species listed in Appendix 7, including all target species, biomass estimates declined in 1997–98, increased in 1998–99, and then declined again in 1999–2000. This result suggests that there may be a catchability difference between surveys. Studies off southern Namibia indicate that water temperature can have a significant effect on biomass estimates for many commercial species which have been shown to be more available to bottom trawl in summer than winter, and also in warm summers when water temperature is higher than normal (MacPherson et al. 1991, MacPherson & Gordoa 1992). Cape hake (*Merluccius capensis*), for example, are thought to concentrate closer to the bottom when water temperature is warm making them more available to capture by trawl (MacPherson et al. 1991). Bottom water temperatures in the east coast South Island summer trawl surveys appear to be higher for the 1997–98 and 1999–2000 surveys and may partly explain the fluctuations in biomass estimates between surveys.

Juvenile year classes are clearly distinguishable for the target species red cod, red gurnard, and elephantfish 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 (Annala et al. 2000). The summer surveys also provide an index for the 1+ as well as the 0+ red cod year classes. Results of the four 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.

Compass Rose survey

It had been suggested that the east coast South Island trawl survey should be extended into depths shallower than 10 m to target elephantfish more effectively. This was tested by having the commercial vessel *Compass Rose* survey two new strata (22 & 23) in the 5–10 m depth range and also two of the 10–30 m strata (19 & 20) in conjunction with *Kaharoa* to directly compare catches.

The main objective of the *Compass Rose* survey was to determine elephantfish biomass in waters shallower than 10 m not available to *Kaharoa* surveys. It was envisaged that, based on a comparison of biomass estimates from both vessels in the common depth range (10–30 m), a scaling factor could be calculated and applied to the shallow water biomass estimate so that it could be included in the total *Kaharoa* elephantfish biomass estimate for east coast South Island. A scaling factor is necessary because the two vessels have different catching characteristics resulting from different vessel power, trawl gear, and codend mesh size (*Compass Rose* 100 mm and *Kaharoa* 28 mm). Although the biomass in the 10–30 m depth range from the *Kaharoa* was less than half that of *Compass Rose*, c.v.s for the latter were high (73%), and there was no significant difference between the two biomass estimates. The length frequency distributions were also distinctly different within the same depth range (10–30 m) (see Table 5 & Figure 7), indicating that the two vessels were not sampling the elephantfish population in the same representative way, and this may have been due, in part, to the different codends used. The difference in the length frequency distributions of elephantfish, combined with the high c.v.s for the *Compass Rose* biomass estimates in the common depth range (10–30 m), suggest that a scaling factor may not be appropriate.

Comparison of the proportion of biomass of the 10 most abundant commercial species in the 5–10 m and 10–30 m depth ranges, indicates that the shallow strata are important only for elephantfish and brill (see Table 9), and therefore for other target species the current minimum depth of 10 m is appropriate for *Kaharoa* surveys.

The results of the *Compass Rose* survey suggest that there is considerable biomass of mature female elephantfish inside 10 m at this time of year. Most of the adult female elephantfish taken by *Compass Rose* were caught at one station in stratum 22 (5–10 m) indicating that elephantfish in these shallow waters were in dense aggregations, probably to drop egg cases. High variability in catch rates by *Compass Rose* in the shallow strata might be expected given these aggregations, but we have no explanation for the high c.v.s in the 10–30 m depth range (73%) where c.v.s for *Kaharoa* were 25%.

It is recommended that any future survey using a commercial vessel to survey elephantfish concurrently with *Kaharoa* should use a 2 phase sampling design (Francis 1984) and re-stratify the shallow strata. A finer mesh codend mesh size might also be appropriate.

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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 for *Kaharoa* and *Compass Rose.***

Kaharoa stations

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	6	2	123
2	30–100	1 242	0	12	0	104
3	50–100	1 920	0	8	4	160
3A	30–50	1 111	0	3	0	370
4	50–100	1 853	0	11	0	168
4A	30–50	845	0	3	0	282
5	75–100	1 513	0	3	0	504
5A	30–75	961	0	3	3	160
6	30–100	2 373	208	3	0	791
7	30–100	2 089	871	3	1	522
8	100–200	628	17	3	0	209
9	100–200	1 163	0	3	6	129
10	100–200	1 192	0	3	0	397
11	100–200	1 483	0	3	0	494
12	100–200	764	132	3	0	255
13	100–200	997	406	3	0	332
14	200–400	752	17	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	3	0	425
19	10–30	987	0	8	0	123
20	10–30	794	0	8	0	99
21	10–30	520	226	3	0	173
Total (average)		26 923	2 244	104	16	(224)

Compass Rose stations

Stratum	Depth (m)	Area (km^2)	Non-trawlable area (km^2)	Number of stations	Station density (km^2 per station)
19	10–30	987	0	10	99
20	10–30	794	0	10	79
22	5–10	101	0	8	13
23	5–10	95	8	8	12
Total (average)		1 977	8	36	(55)

Table 2: **Tow and gear parameters by depth range for *Kaharoa* and *Compass Rose*.**

Kaharoa

Tow parameters	*n*	Mean	*s.d.*	Range
Tow length (n. mile)	120	1.9	0.2	1.0–2.01
Gear parameters (m)				
10–30 m				
Headline height	22	5.7	0.2	5.5–6.2
Doorspread	22	72.0	2.2	68.5–80.5
Warp:depth ratio	22	9.4	2.3	6.7–14.3
30–100 m				
Headline height	64	5.7	0.2	4.9–6.0
Doorspread	64	74.1	2.5	68.2–79.6
Warp:depth ratio	64	3.5	0.9	2.5–6.6
100–200 m				
Headline height	25	5.7	0.1	5.5–6.0
Doorspread	25	76.6	3.4	69.2–82.5
Warp:depth ratio	25	2.5	0.3	1.7–3.4
200–400 m				
Headline height	9	5.7	0.1	5.5–6.0
Doorspread	9	86.8	3.7	80.2–92.7
Warp:depth ratio	9	2.3	0.1	2.2–2.5
10–400 m				
Headline height	120	5.7	0.2	4.9–6.2
Doorspread	120	75.2	4.5	68.2–92.7
Warp:depth ratio	120	4.3	2.7	1.7–14.3

Compass Rose

Tow parameters				
Tow length (n. mile)	19	2.0	0.2	1.1–2.1
Headline height set at a constant 2.5 m				
Gear parameters (m)				
5–10 m				
Doorspread	19	39.3	6.3	30–48.9
Warp:depth ratio	19	9.9	2.2	6.0–13.8
10–30 m				
Doorspread	21	46.2	2.7	42.1–51.2
Warp:depth ratio	21	5.4	1.1	4.0–7.9
5–30 m				
Doorspread	40	43.0	5.8	30–51.2
Warp:depth ratio	40	7.6	2.9	4.0–13.8

Table 3: **Total catch, relative biomass indices, and coefficients of variation (c.v.) for species caught on *Kaharoa* where more than 200 kg were caught, and blue cod and rig, but excluding thresher shark together with estimates of recruited biomass for selected ITQ species.**

	Catch		Biomass		Recruited		
	Weight (kg)	% of total	(t)	c.v. %	Length (cm)	Biomass (t)	c.v.%
Spiny dogfish	45 436	43.8	49 832	37			
Barracouta	24 784	23.9	21 476	14	50	17 690	14
Red cod (all)	9 593	9.2	6 690	30	40	3 962	40
Red cod (0+)	—		8	27			
Red cod (1+)	—		2 204	43			
Tarakihi	3 933	3.8	2 606	15	25	1 702	17
Dark ghost shark	3 530	3.4	2 512	19			
Two saddle rattail	2 030	2.0	2 857	21			
Sea perch	2 027	2.0	2 203	27			
Elephantfish (total)	1 591	1.5	1 097	25	50	949	24
Strata 19 & 20	701	0.7	292	28		258	30
Arrow squid	1 111	1.1	838	12			
Hoki	1 004	1.0	773	23	60	225	32
Crested bellowsfish	726	0.7	762	63			
Blue warehou	656	0.6	608	39	45	316	58
Ling	625	0.6	450	18			
Carpet shark	539	0.5	366	19			
Giant stargazer	521	0.5	472	14	30	455	14
Southern pigfish	477	0.5	302	36			
School shark	461	0.4	389	27	90	77	37
Oblique banded rattail	435	0.4	355	48			
Silver warehou	434	0.4	444	23	25	413	24
Smooth skate	392	0.4	369	30			
Rough skate	378	0.4	329	23			
Chilean jack mackerel	311	0.3	282	29			
Hapuku	293	0.3	283	22			
Leatherjacket	220	0.2	150	24			
Red gurnard	217	0.2	202	20	30	192	19
Blue cod	127	0.1	62	98			
Rig	102	0.1	86	38	90	39	44
Lemon sole	56	0.1	36	27	25	31	26
N.Z. sole	27	< 0.05	21	39	25	16	48
Sand flounder	13	< 0.05	12	58	25	11	59
Other species	1 056	1.0					
All species combined	103 804						

– Actual catch data not available

Table 4: **Total catch, relative biomass indices, and coefficients of variation (c.v.) from *Compass Rose* (for fish of all lengths) for fish species where more than 50 kg were caught, and brill.**

	Catch		Biomass		Recruited		
	Weight (kg)	% of total	(t)	c.v. %	Length (cm)	Biomass (t)	c.v.%
Elephantfish							
Strata 19 & 20 (10–30 m)	1 531	16	802	73	50	194	21
Strata 22 & 23 (5–10 m)	4 440	47	475	79		472	80
Total	5 972	63	1 278	55		666	57
Spiny dogfish	1 098	12	405	15			
Rough skate	716	8	259	16			
School shark	266	3	78	19			
Carpet chark	255	3	122	44			
N.Z. sole	177	2	69	20			
Leatherjacket	155	2	80	33			
Red cod	84	1	30	35			
Rig	83	1	34	31			
Electric ray	76	1	25	47			
Red gurnard	70	1	38	32			
Yellowbelly flounder	51	1	12	44			
Brill	45	< 1	10	30			
Total (ITQ secies)	8 734						
Total (all species)	9 538						

Table 5: **Biomass estimates by year class (length intervals estimated from length frequency distributions).**

	Year class	Length range (cm)	Biomass (t)	*c.v.* %
Kaharoa				
Barracouta	0+	< 19	1	47
	1+	19–39	2 004	17
	2+	40–53	2 437	21
Blue warehou	0+	< 12	2	55
	1+	12–25	222	30
Elephantfish	0+	<23	15	75
	1+	23–32	29	65
Hoki	1+	30–49	17	36
	2+	49–61	540	30
Red cod	0+	<16	8	27
	1+	16–32	2 204	43
Red gurnard	2+	18–25	3	38
School shark	0+	< 35	2	42
	1+	35–52	13	27
Silver warehou	0+	< 14	1	25
	1+	14–21	27	35
	2+	21–32	225	29
Tarakihi	0+	< 12	< 0.5	57
	1+	12–19	105	24
Compass Rose				
Elephantfish	0+	<23	1	24
	1+	23–32	50	79

Table 6: **Catch rates (kg.km^{-2}) with standard deviations (in parentheses) by stratum, for the 20 most abundant commercially important species from *Kaharoa*.Species codes are given in Appendix 4; +, less than 0.5 t.**

		Species code									
Stratum	Depth (m)	BAR	BCO	ELE	GSH	GUR	HAP	HOK	JMM	LIN	RCO
1	30–100	1 462	2	1	2	10	4	0	3	6	755
		(2 128)	(63)	(2)	(5)	(15)	(10)		(7)	(13)	(1 302)
2	30–100	430	0	18	71	9	21	0	5	36	383
		(533)		(27)	(247)	(16)	(30)		(6)	(112)	(583)
3	50–100	1 776	0	26	0	7	7	0	12	56	660
		(1 425)		(76)	(0)	(10)	(14)		(20)	(94)	(1 006)
3A	30–50	212	0	245	64	10	11	0	0	1	14
		(152)		(143)	(134)	(8)	(20)			(2)	(23)
4	50–100	1 595	0	0	5	9	16	0	3	5	108
		(675)			(7)	(7)	(13)		(6)	(10)	(134)
4A	30–50	1 424	0	60	0	11	58	0	0	0	9
		(1 916)		(76)		(4)	(63)			(0)	(15)
5	30–70	2 082	0	0	0	2	13	0	6	1	59
		(1 829)				(2)	(22)		(10)	(1)	(103)
5A	70–100	1 131	0	243	421	10	12	0	3	0	21
		(1 701)		(547)	(606)	(11)	(31)		(4)	(0)	(22)
6	30–100	368	0	0	438	10	5	0	0	0	187
		(634)			(662)	(16)	(4)			(1)	(182)
7	30–100	1 039	0	45	525	33	10	4	1	1	26
		(847)		(85)	(284)	(28)	(12)	(8)	(2)	(3)	(35)
8	100–200	1 688	0	0	110	0	5	0	51	25	68
		(2 919)			(91)		(4)		(86)	(36)	(45)
9	100–200	815	0	1	0	+	5	1	34	30	1 164
		(1 159)		(2)		(1)	(8)	(2)	(76)	(35)	(2 674)
10	100–200	919	0	0	58	0	7	13	126	88	110
		(833)			(50)		(12)	(8)	(101)	(38)	(90)
11	100–200	212	0	0	494	0	33	0	5	17	47
		(355)			(337)		(46)		(5)	(26)	(48)
12	100–200	52	0	0	158	2	22	0	0	0	2 040
		(43)			(179)	(4)	(38)				(3 528)
13	100–200	232	0	0	257	0	0	0	0	8	97
		(168)			(446)					(1)	(20)
14	200–400	69	0	0	0	0	2	32	0	22	33
		(81)					(4)	(28)		(19)	(24)
16	200–400	64	0	0	0	0	0	389	0	39	35
		(111)						(225)		(31)	(30)
17	200–400	0	0	0	0	0	0	596	0	55	27
								(360)		(36)	(6)
18	10–30	34	0	38	0	4	0	0	2	0	22
		(22)		(51)		(8)			(4)		(19)
19	10–30	194	0	141	0	14	0	0	0	0	9
		(300)		(146)		(14)					(15)
20	10–30	74	0	191	0	+	0	0	0	0	8
		(63)		(227)		(1)					(9)
21	10–30	572	0	56	0	2	0	0	0	1	4
		(420)		(57)		(2)				(2)	(7)

Table 6—continued

Stratum	Depth (m)	RSK	SCH	SPD	SPE	SQU	SSK	STA	SWA	TAR	WAR
											Species code
1	30–100	32	4	1 693	154	32	0	9	1	423	0
		(26)	(8)	(3 248)	(164)	(36)		(9)	(1)	(345)	
2	30–100	7	14	5 562	20	54	5	28	1	159	12
		(17)	(25)	(9 476)	(25)	(61)	(13)	(25)	(2)	(277)	(26)
3	50–100	2	15	621	28	34	6	37	13	207	41
		(6)	(34)	(1 210)	(37)	(18)	(21)	(42)	(13)	(162)	(59)
3A	30–50	9	0	74	3	5	0	10	+	44	1
		(9)		(12)	(4)	(8)		(11)	(+)	(66)	(2)
4	50–100	15	0	745	25	25	44	22	32	485	25
		(16)		(632)	(53)	(20)	(58)	(21)	(26)	(387)	(53)
4A	30–50	17	32	117	0	1	0	0	0	62	8
		(30)	(50)	(119)		(1)		(0)		(88)	(14)
5	30–70	19	0	8 145	+	18	28	30	29	54	0
		(32)		(12 681)	(1)	(5)	(49)	(35)	(4)	(42)	(0)
5A	70–100	4	29	528	3	37	0	4	+	45	8
		(7)	(49)	(543)	(6)	(82)		(4)	(1)	(74)	(15)
6	30–100	8	31	6 407	1	20	0	28	+	102	11
		(7)	(54)	(10 246)	(1)	(11)		(20)	(1)	(170)	(19)
7	30–100	7	32	125	210	6	21	5	4	2	152
		(8)	(51)	(120)	(318)	(6)	(42)	(6)	(8)	(2)	(215)
8	100–200	30	0	1 084	226	41	77	21	48	2	0
		(52)		(473)	(389)	(50)	(123)	(6)	(78)	(4)	
9	100–200	4	0	1 790	53	48	10	9	8	38	3
		(9)		(1 649)	(84)	(37)	(23)	(17)	(11)	(117)	(11)
10	100–200	0	0	1 868	424	21	32	24	103	33	0
				(970)	(359)	(11)	(50)	(10)	(103)	(55)	
11	100–200	8	0	2 251	125	44	40	19	18	12	0
		(14)		(758)	(145)	(25)	(69)	(12)	(16)	(19)	
12	100–200	89	0	844	38	32	13	20	5	39	0
		(135)		(1 039)	(38)	(51)	(23)	(28)	(4)	(57)	
13	100–200	0	0	151	548	30	0	54	60	73	0
				(66)	(624)	(20)		(59)	(84)	(39)	
14	200–400	14	0	306	0	285	0	10	49	1	0
		(24)		(162)		(154)		(14)	(77)	(1)	
16	200–400	0	0	285	2	66	22	11	12	0	0
				(305)	(3)	(81)	(37)	(6)	(21)		
17	200–400	7	0	106	11	13	0	21	3	1	0
		(11)		(72)	(19)	(10)		(18)	(5)	(1)	
18	10–30	15	36	149	1	0	0	0	+	0	12
		(23)	(32)	(58)	(2)				(+)		(14)
19	10–30	20	76	127	0	1	0	0	+	1	65
		(20)	(50)	(75)		(1)			(+)	(1)	(161)
20	10–30	3	8	178	0	+	0	0	1	0	28
		(7)	(9)	(124)		(+)			(1)		(27)
21	10–30	16	27	25	0	1	0	0	0	29	4
		(15)	(8)	(29)		(3)				(11)	(5)

Table 7: **Estimated biomass (t) and coefficient of variation (c.v.) by stratum of the 20 most abundant commercially important species from *Kaharoa*. Species codes are given in Appendix 4; +, less than 0.5 t.**

										Species code
Stratum	BAR	BCO	ELE	GSH	GUR	HAP	HOK	JMM	LIN	RCO
1	1 439	62	1	2	10	4	0	3	6	743
	(51)	(98)	(100)	(100)	(51)	(100)		(80)	(79)	(61)
2	534	0	23	89	12	26	0	6	45	476
	(36)		(43)	(100)	(5)	(41)		(36)	(89)	(44)
3	3 410	0	51	0	13	13	0	23	108	1 268
	(24)		(88)		(43)	64		(51)	(51)	(46)
3A	235	0	272	119	11	13	0	0	1	16
	(42)		(34)	(63)	(46)	(100)			(100)	(94)
4	2 956	0	0	7	17	30	0	5	9	201
	(13)			(92)	(23)	(25)		(67)	(61)	(37)
4A	1 201	0	51	0	10	49	0	0	0	7
	(78)		(73)		(18)	(63)				(100)
5	3 180	0	0	0	4	19	0	9	1	91
	(51)				(51)	(100)		(100)	(100)	(100)
5A	1 098	0	236	265	10	12	0	2	0	20
	(61)		(92)	(83)	(42)	(100)				(44)
6	874	0	0	510	25	12	0	0	1	444
	(99)			(48)	(88)	(50)			(100)	(56)
7	2 171	0	95	625	68	21	8	2	3	54
	(41)		(94)	(31)	(43)	(58)	(100)	(100)	(100)	(68)
8	1 060	0	0	161	0	3	0	32	15	43
	(100)			(48)		(52)		(97)	(86)	(38)
9	948	0	1	0	0	6	1	39	35	1 355
	(45)		(100)		(68)	(46)	(100)	(71)	(37)	(73)
10	1 095	0	0	58	0	8	15	150	105	131
	(52)			(50)		(100)	(37)	(47)	(25)	(47)
11	312	0	0	371	0	48	0	7	26	69
	(97)			(39)		(81)		(56)	(85)	(60)
12	39	0	0	119	2	17	0	0	0	1 559
	(48)			(65)	(100)	(100)				(100)
13	232	0	0	186	0	0	0	0	8	97
	(42)			(100)					(10)	(12)
14	52	0	0	0	0	2	24	0	17	25
	(68)					(100)	(51)		(48)	(42)
16	48	0	0	0	0	0	293	0	30	26
	(100)						(33)		(45)	(50)
17	0	0	0	0	0	0	432	0	40	20
							(35)		(37)	(13)
18	44	0	48	0	6	0	0	3	0	29
	(37)		(77)		(100)			(100)		(50)
19	191	0	139	0	14	0	0	0	0	9
	(55)		(36)		(36)					(58)
20	59	0	152	0	0	0	0	0	0	6
	(30)		(42)		(60)					(41)
21	297	0	29	0	1	0	0	0	1	2
	(42)		(58)		(72)				(100)	(100)

Table 7—continued

										Species code
Stratum	RSK	SCH	SPD	SPE	SQU	SSK	STA	SWA	TAR	WAR
1	31	4	1 667	151	31.53	0	9	1	417	0
	(29)	(67)	(68)	(38)	(39)		(35)	(39)	(29)	
2	9	18	6 910	25	67.55	6.69	35	2	197	15
	(65)	(50)	(49)	(37)	(32)	(72)	(26)	(52)	(50)	(64)
3	5	29	1 192	53	65.42	11.92	70	26	398	79
	(68)	(68)	(59)	(41)	(16)	(100)	(35)	(30)	(24)	(43)
3A	10	0	83	3	5.95	0	12	0	49	1
	(55)		(9)	(100)	(90)		(59)	(100)	(87)	(84)
4	28	0	1 381	47	46.07	81.7	42	60	899	46
	(32)		(26)	(63)	(24)	(40)	(29)	(25)	(24)	(66)
4A	15	27	98	0	1.15	0	0	0	52	7
	(100)	(90)	(59)		(51)				(82)	(98)
5	29	0	12 444	1	27.05	42.93	45	44	83	0
	(100)		(90)	(100)	(17)	(100)	(68)	(7)	(45)	
5A	4	28	512	3	35.69	0	4	0	44	8
	(70)	(69)	(42)	(83)	(91)		(45)	(54)	(67)	(76)
6	18	74	15 204	3	47.33	0	67	1	241	26
	(50)	(100)	(92)	(66)	(30)		(40)	(100)	(96)	(100)
7	14	67	262	439	11.58	43.49	10	9	3	318
	(58)	(80)	(48)	(76)	(55)	(100)	(60)	(100)	(70)	(71)
8	19	0	681	142	25.91	48.08	13	30	1	0
	(100)		(25)	(100)	(70)	(93)	(17)	(93)	(100)	
9	4	0	2 082	62	55.59	11.31	10	10	44	4
	(75)		(29)	(50)	(24)	(75)	(62)	(41)	(97)	(100)
10	0	0	2 226	505	24.65	37.8	28	122	40	0
			(30)	(49)	(30)	(91)	(24)	(58)	(95)	
11	12	0	3 304	183	64.06	58.73	28	26	17	0
	(100)		(19)	(67)	(33)	(100)	(36)	(51)	(92)	
12	68	0	645	29	24.12	10.19	16	4	30	0
	(88)		(71)	(58)	(93)	(100)	(80)	(52)	(85)	
13	0	0	151	547	29.93	0	54	60	73	0
			(25)	(66)	(38)		(63)	(81)	(31)	
14	10	0	230	0	214.2	0	8	37	1	0
	(100)		(31)		(31)		(79)	(90)	(56)	
16	0	0	214	2	49.57	16.26	8	9	0	0
			(62)	(93)	(71)	(100)	(33)	(100)		
17	5	0	77	8	9.32	0	15	2	+	0
	(100)		(39)	(95)	(43)		(50)	(100)	(100)	
18	19	46	190	2	0	0	0	+	0	16
	(90)	(51)	(22)	(100)				(58)		(65)
19	20	75	125	0	0.56	0	0	+	0.79	65
	(35)	(23)	(21)		(74)			(100)	(54)	(87)
20	2	6	142	0	0.08	0	0	+	0	22
	(76)	(41)	(25)		(65)			(31)		(34)
21	8	14	13	0	0.76	0	0	0	15	2
	(57)	(18)	(68)		(100)				(23)	(75)

Table 8: **Catch rates (kg.km^{-2}) with standard deviations (in parentheses) by stratum, for the 10 most abundant commercially important species from *Compass Rose*.***

		Species code									
Stratum	Depth (m)	BRI	ELE	ESO	GUR	RCO	RSK	SCH	SPD	SPO	YBF
19	10–30	4	713	22	36	13	193	62	226	26	8
		(8)	(1 888)	(27)	(38)	(22)	(131)	(44)	(131)	(32)	(16)
20	10–30	3	124	56	3	18	65	7	196	8	2
		(3)	(83)	(42)	(4)	(32)	(39)	(8)	(186)	(10)	(3)
22	5–10	19	4 476	22	0	6	98	83	182	12	15
		(21)	(10 477)	(21)		(14)	(64)	(126)	(132)	(14)	(15)
23	5–10	9	233	7	0	16	69	24	79	3	11
		(8)	(417)	(7)		(21)	(72)	(40)	(56)	(10)	(13)

* Species codes are given in Appendix 4

Table 9: **Estimated biomass (t) and coefficients of variation (in parentheses) by stratum, for the 10 most abundant commercially important species from *Compass Rose*.***

		Species code									
		BRI	ELE	ESO	GUR	RCO	RSK	SCH	SPD	SPO	YBF
Stratum	Depth (m)										
19	10–30	4	703	22	35	13	191	61	223	26	8
		(59)	(84)	(39)	(33)	(51)	(21)	(22)	(18)	(39)	(65)
20	10–30	3	99	44	2	15	52	6	156	7	1
		(33)	(21)	(24)	(53)	(55)	(19)	(32)	(30)	(37)	(51)
22	5–10	2	453	2	0	1	10	8	18	1	1
		(41)	(83)	(33)		(78)	(23)	(54)	(26)	(42)	(36)
23	5–10	1	22	1	0	1	7	2	7	+	1
		(34)	(63)	(36)		(47)	(37)	(58)	(25)	(100)	(42)

* Species codes are given in Appendix 4
\+ < 0.5 t.

Table 10: **Comparison of elephantfish biomass estimates by depth.**

Depth (m)		*Kaharoa*		*Compass Rose*	
		Biomass (t)	c.v.	Biomass (t)	c.v.
5–10		—		475	79
10–30	Strata 19 & 20	292	28	802	73
	Total	369	25	802	73
30–100		727	36	—	
100–200		1	100	—	
200–400		0		—	

— Depth range not surveyed

Table 11 : **Numbers of length frequency and biological samples collected (species codes are given in Appendix 3) (Only elephantfish were measured on *Compass Rose*).**

Species	Measurement method	Length frequency data: No. of samples	No. of fish	No. of males	No. of females	Biological data+: No. of samples	No. of fish	No. of otoliths spines, other ageing samples
BAR	1	117@	8 908	4 374	3 832	7	350	–
BCO	2	2	68	49	19	–	–	–
BRI	2	4	4	#	#	3	3	–
ELE	1							
Kaharoa		43	1 072	493	579	43	702	368
Compass Rose		38	1 129	734	349	–	–	–
ESO	2	20	145	#	#	–	–	–
GFL	2	4	26	#	#	–	–	–
GSH	G	33	2 167	885	1 281	–	–	207
GUR	1	68	403	200	199	68	402	200
HAK	2	7	27			–	–	–
HAP	2	39	106	61	45	–	–	–
HOK	2	12	590	249	340	–	–	–
JDO	2	2	2			–	–	–
JMD	1	16	24			–	–	–
JMM	1	35	240	147	90	–	–	–
JMN	1	1	1			–	–	–
KAH	1	4	4			–	–	–
LDO	2	4	16			–	–	–
LIN	2	66	1 065	525	536	–	–	–
LSO	2	36	196	#	#	–	–	–
MDO	2	1	1			–	–	–
MIQ	4	4	4			–	–	–
MOK	1	4	25			–	–	–
RBM	1	7	57			–	–	–
RCO	2	104@	4 869	2 042	2 495	103	1658	405
RSK	5	49	116	56	60	48	115	6
SAM	1	5	12			–	–	–
SCH	2	40	293	164	128	1	5	–
SDF	2	2	3	#	#	–	–	–
SFL	2	11	28	#	#	–	–	–
SLS	2	1	1	#	#	–	–	–
SPD	2	117	9 463	5 124	4 337	10	441	–
SPE	2	64	2 561	1 287	1 241	–	–	–
SPO	2	20	59	32	27	1	1	–
SQU	4	97	4 370	1 342	1 620	–	–	–
SSK	5	19	27	14	13	19	27	20
STA	2	75	475	265	207	75	453	261
SWA	1	81	1 288	344	358	–	–	–
TAR	1	77	4 788	2 359	2 291	9	331	–
THR	2	1	1		1	–	–	–
TRU	1	2	3			–	–	–
WAR	1	47	2 241	94	91	–	–	–
WWA	1	7	104			–	–	–
YBF	2	6	14	#	#	–	–	–

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

Table 12: **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	17	0	0	0	0	4	0	0	0	0	
21–30	51	1	0	0	0	25	1	0	0	0	
31–40	96	27	8	1	0	42	24	0	0	0	
41–50	23	12	5	1	0	34	21	2	0	1	
51–60	4	0	1	2	0	14	15	2	3	1	
61–70	0	0	0	0	0	2	1	0	1	0	
71–80	0	0	0	0	0	0	1	0	0	0	
Total	191	40	14	4	0	121	63	4	4	2	443
Red cod											
11–20	22	0	0	0	0	27	0	0	0	0	
21–30	99	1	0	0	0	160	0	0	0	0	
31–40	128	25	9	0	1	67	27	2	0	0	
41–50	146	104	44	11	9	153	137	30	3	1	
51–60	33	37	11	17	2	157	89	29	15	7	
61–70	0	0	0	0	0	38	18	4	3	1	
71–80	0	0	0	0	0	1	0	0	0	0	
Total	428	167	64	28	12	603	271	65	21	9	1 668
Red gurnard											
11–20	7	0	0	0	0	12	0	0	0	0	
21–30	21	14	0	1	0	23	2	0	0	0	
31–40	50	61	11	4	0	14	27	26	5	1	
41–50	7	18	5	1	0	0	7	51	27	1	
51–60	0	0	0	0	0	0	0	1	0	0	
Total	85	93	16	6	0	49	36	78	32	2	397

* 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.

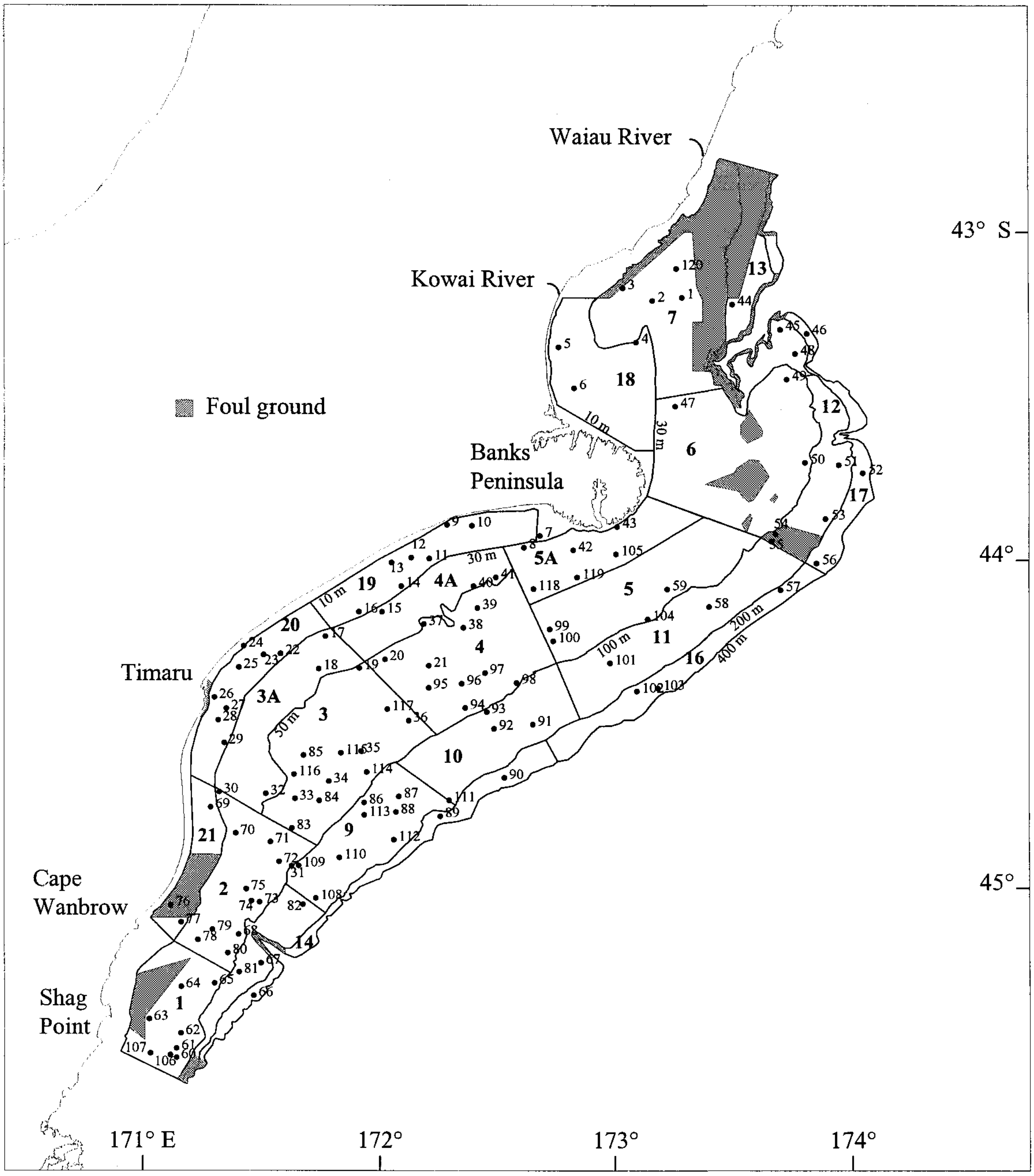


***Figure 1*: Survey area for *Kaharoa* showing stratum boundaries and numbers (bold type), areas of untrawlable (foul) ground, and trawl station positions and numbers.**

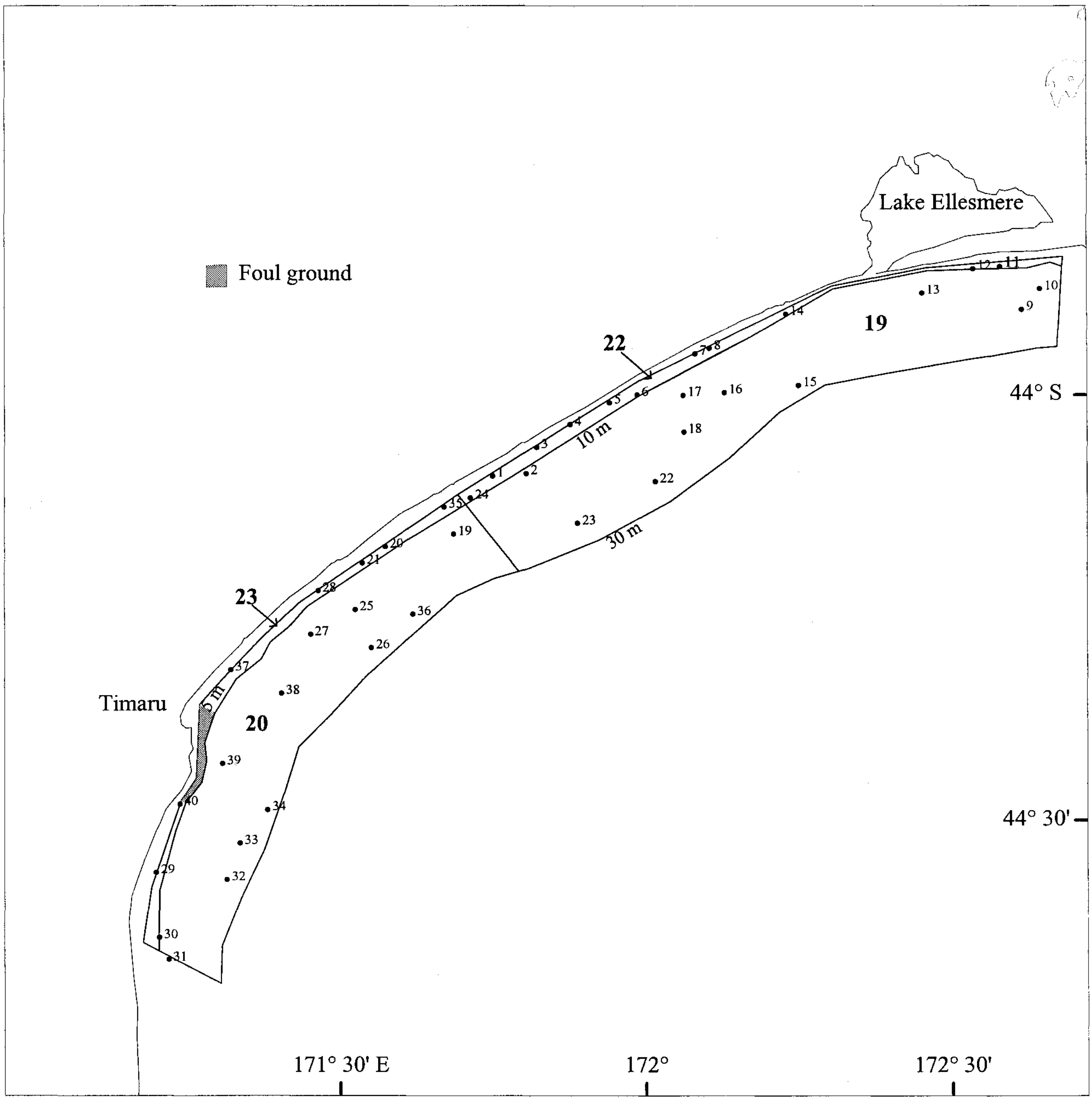


***Figure 2*: Trawl survey area for *Compass Rose* showing stratum boundaries and numbers (bold type), areas of untrawlable (foul) ground, and trawl station positions and numbers.**

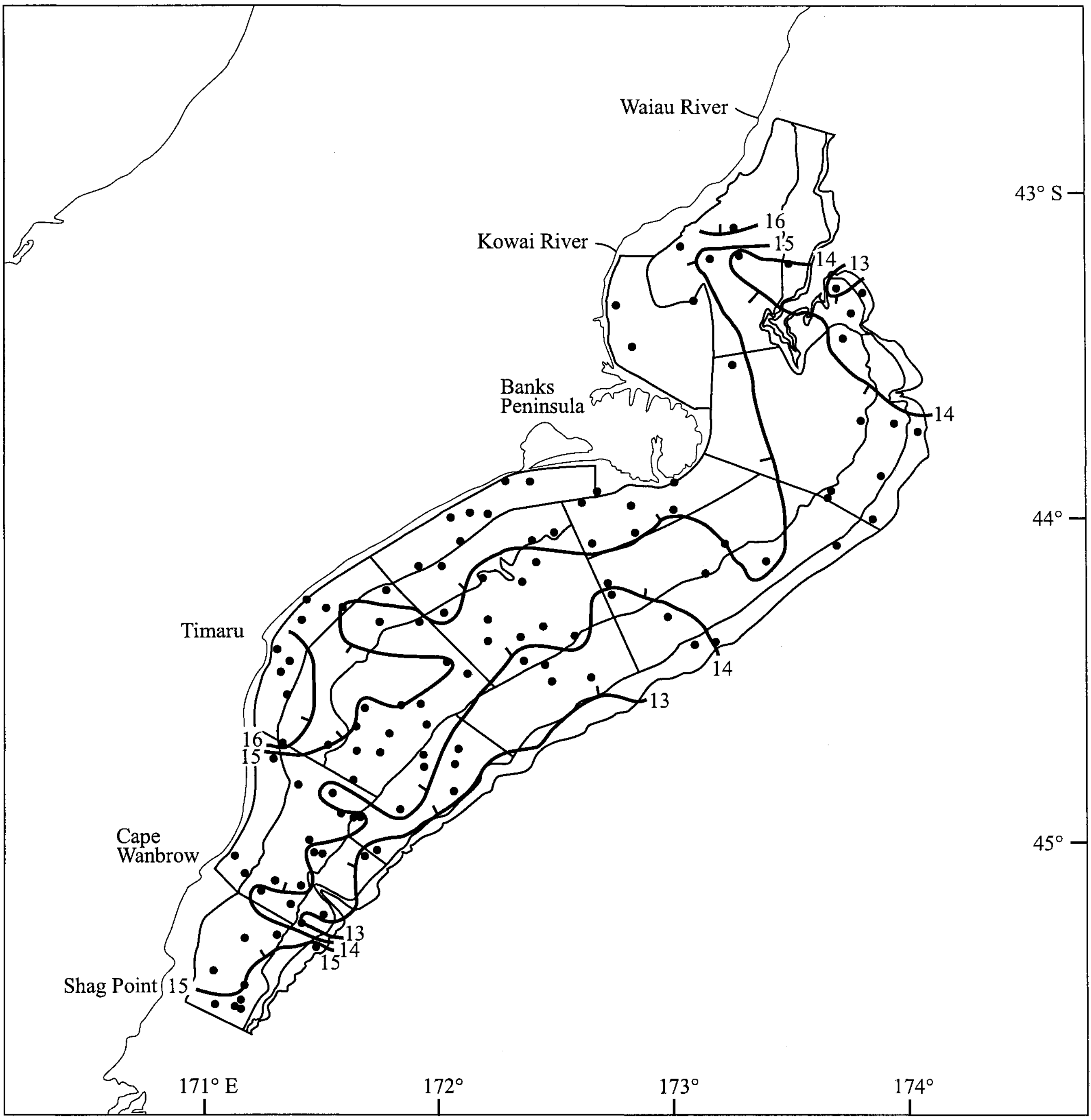


***Figure 3a*: Positions of sea surface temperature recordings from *Kaharoa* and isotherms estimated from temperature recordings.**

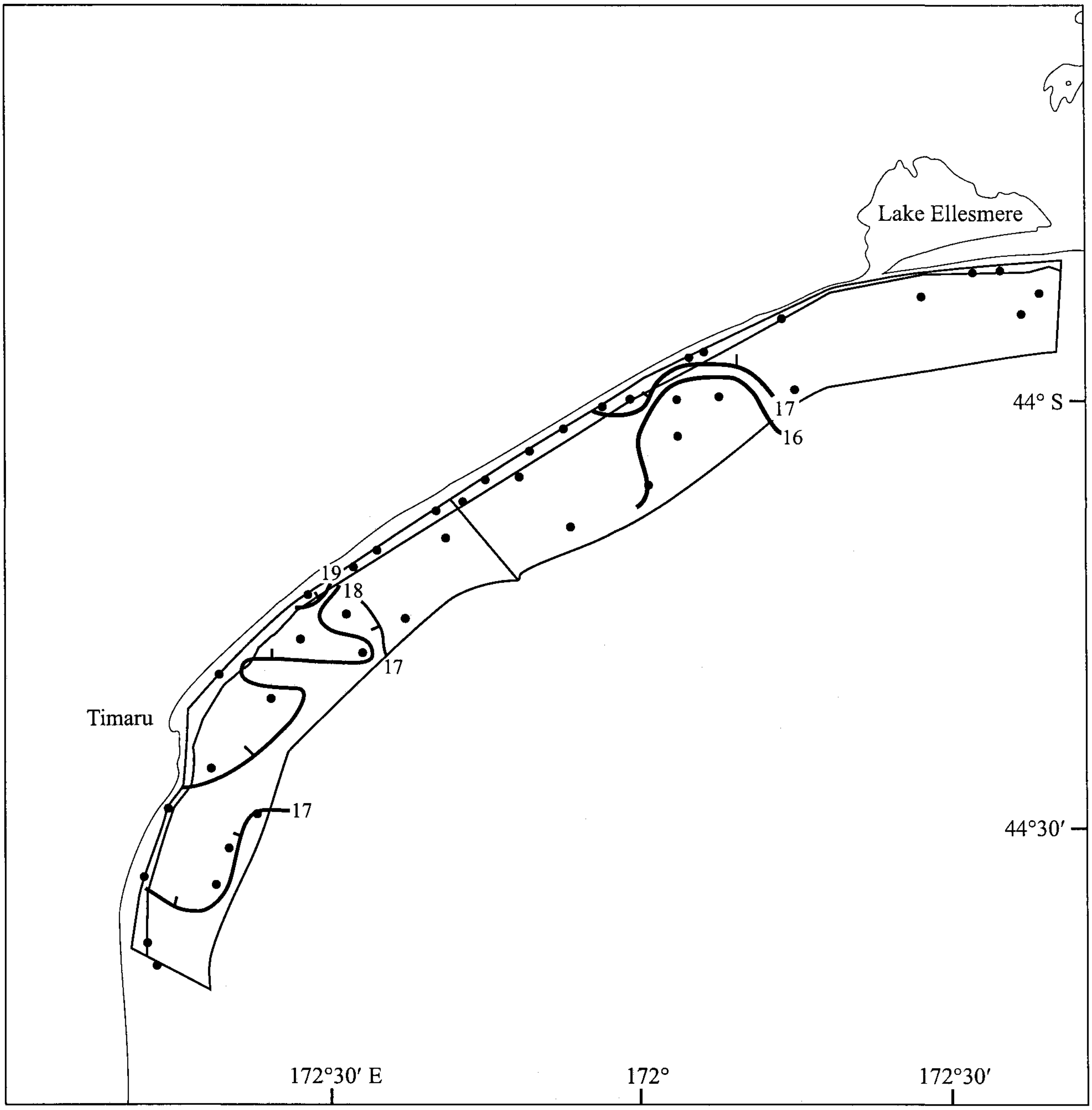


Figure 3b: **Positions of surface temperature recordings from *Compass Rose* and isotherms estimated from temperature recordings.**

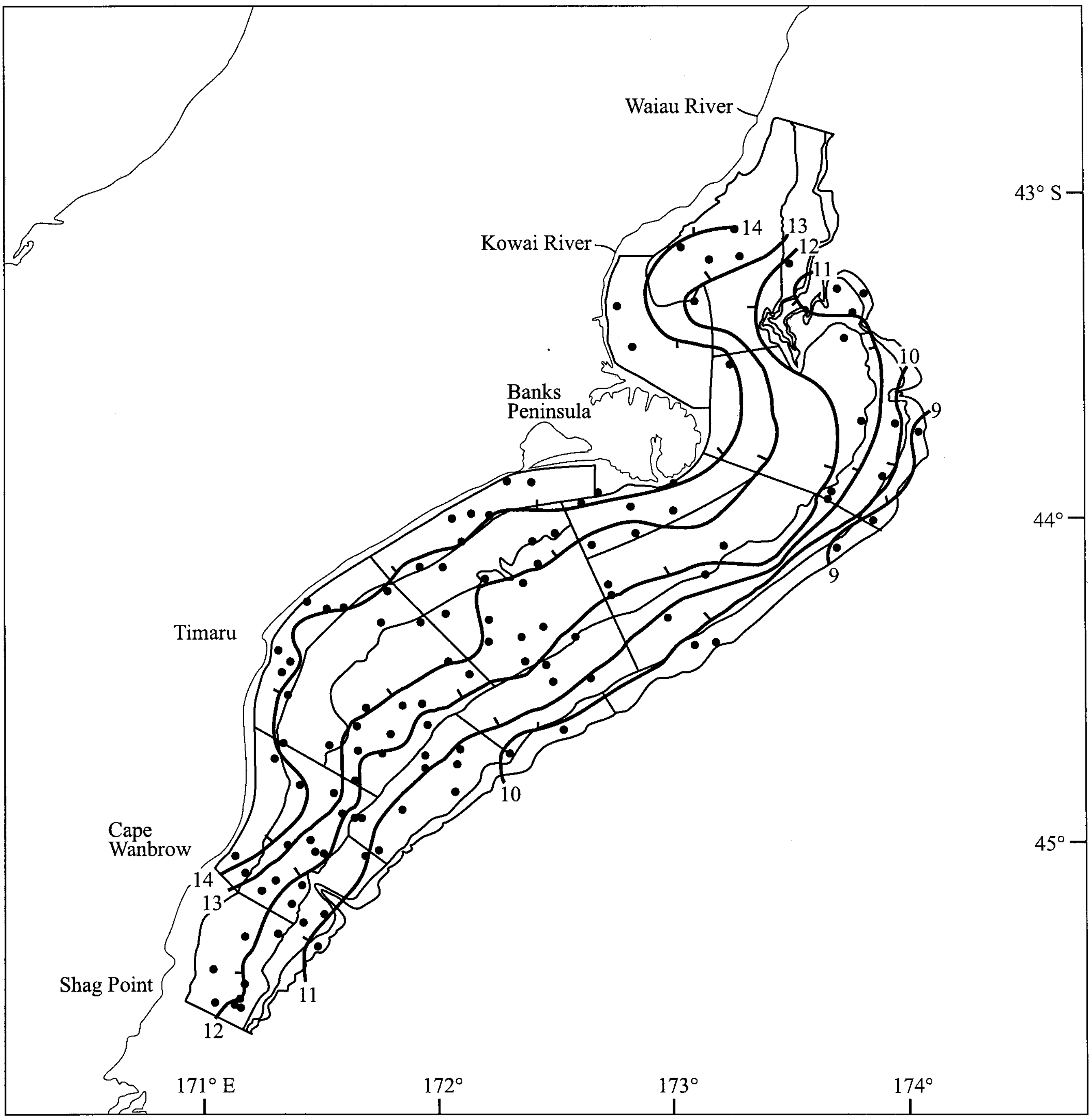


***Figure 4*: Positions of bottom temperature recordings from *Kaharoa* and isotherms estimated from temperature recordings.**

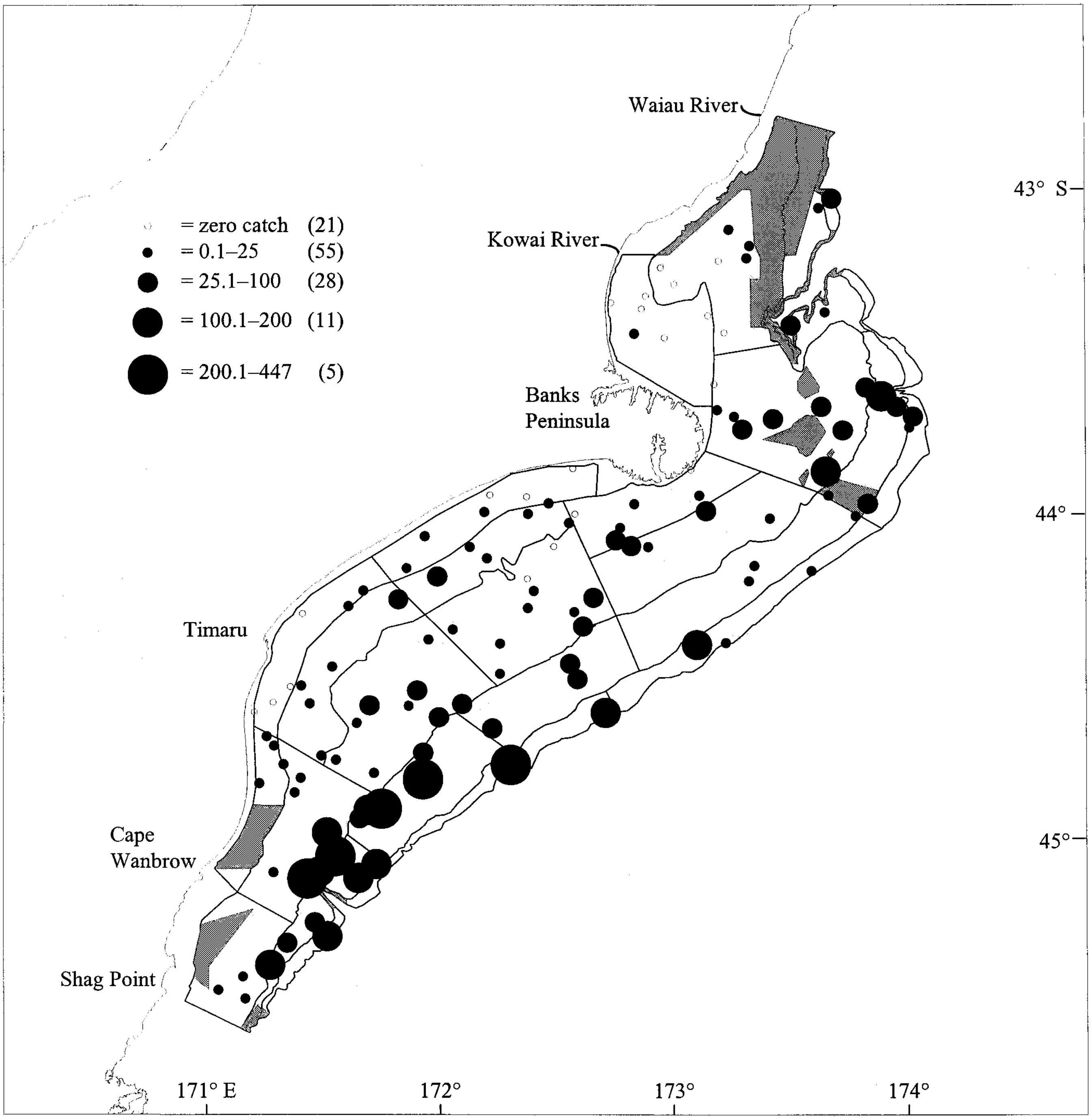


***Figure 5*: Catch rates (kg.km^{-2}) of the major commercial species for *Kaharoa* (numbers in parentheses are the number of stations at the given catch rate).**

Barracouta

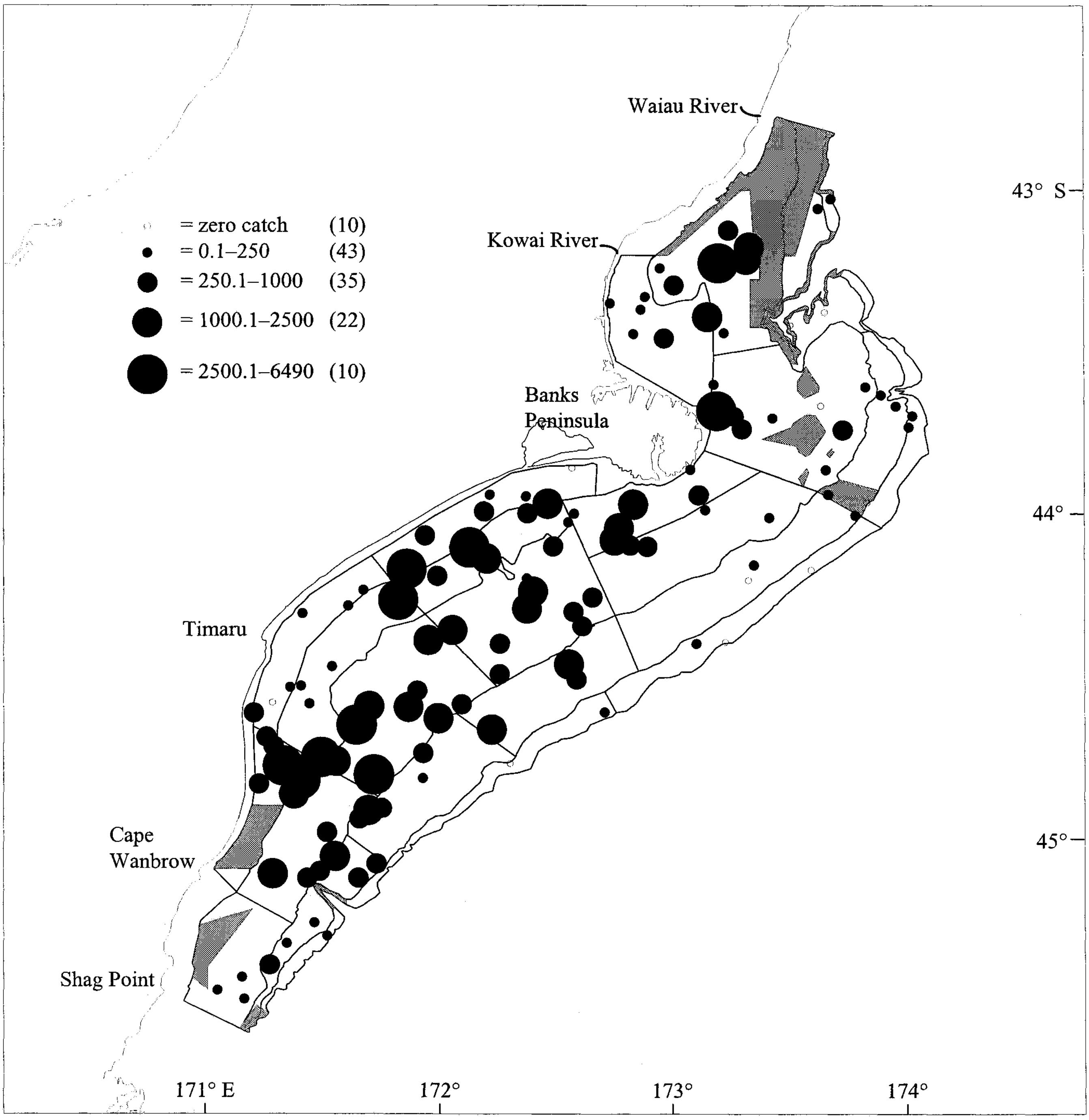


Figure 5—continued

Blue warehou

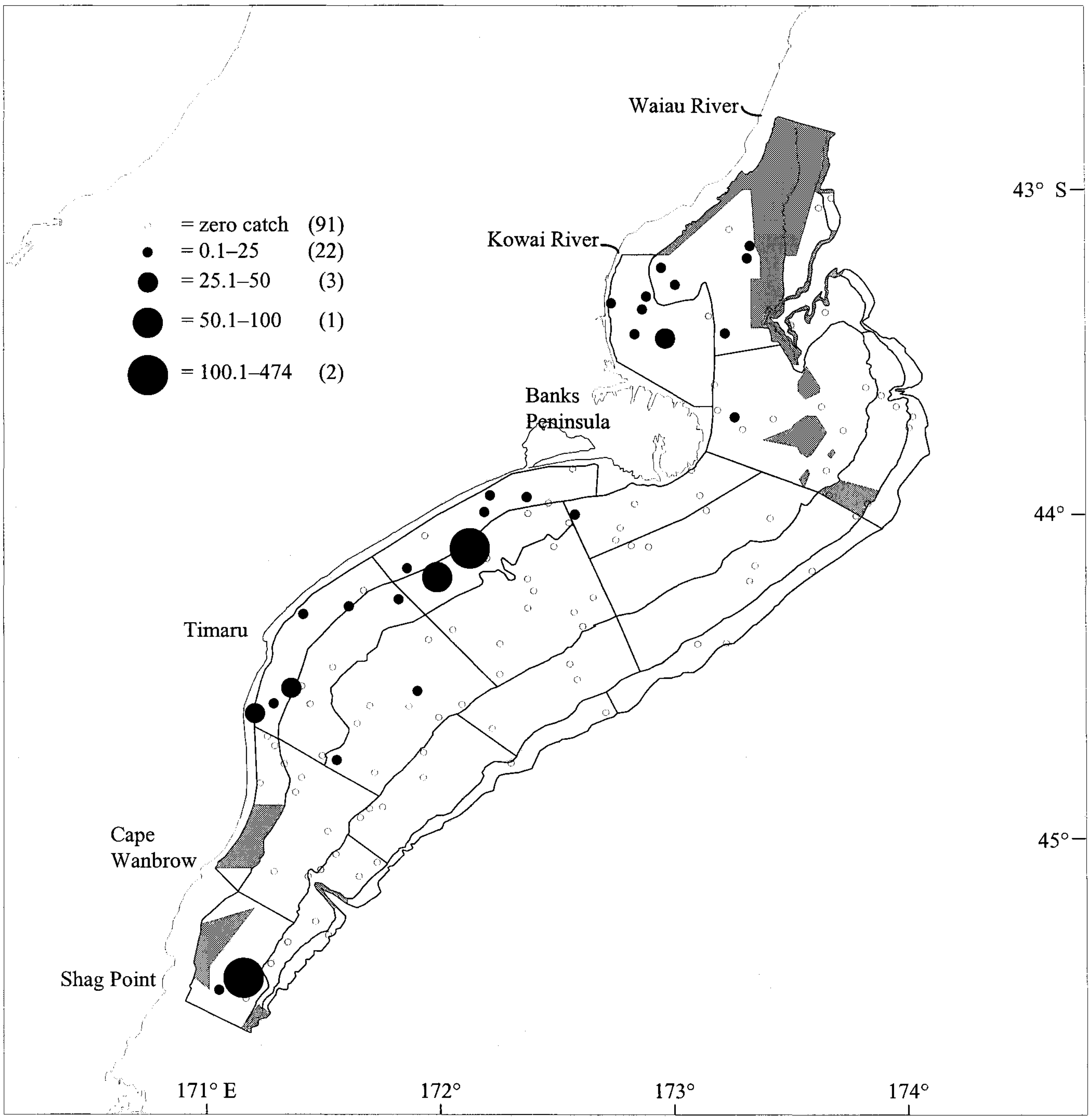


Figure 5—continued

Chilean jack mackerel

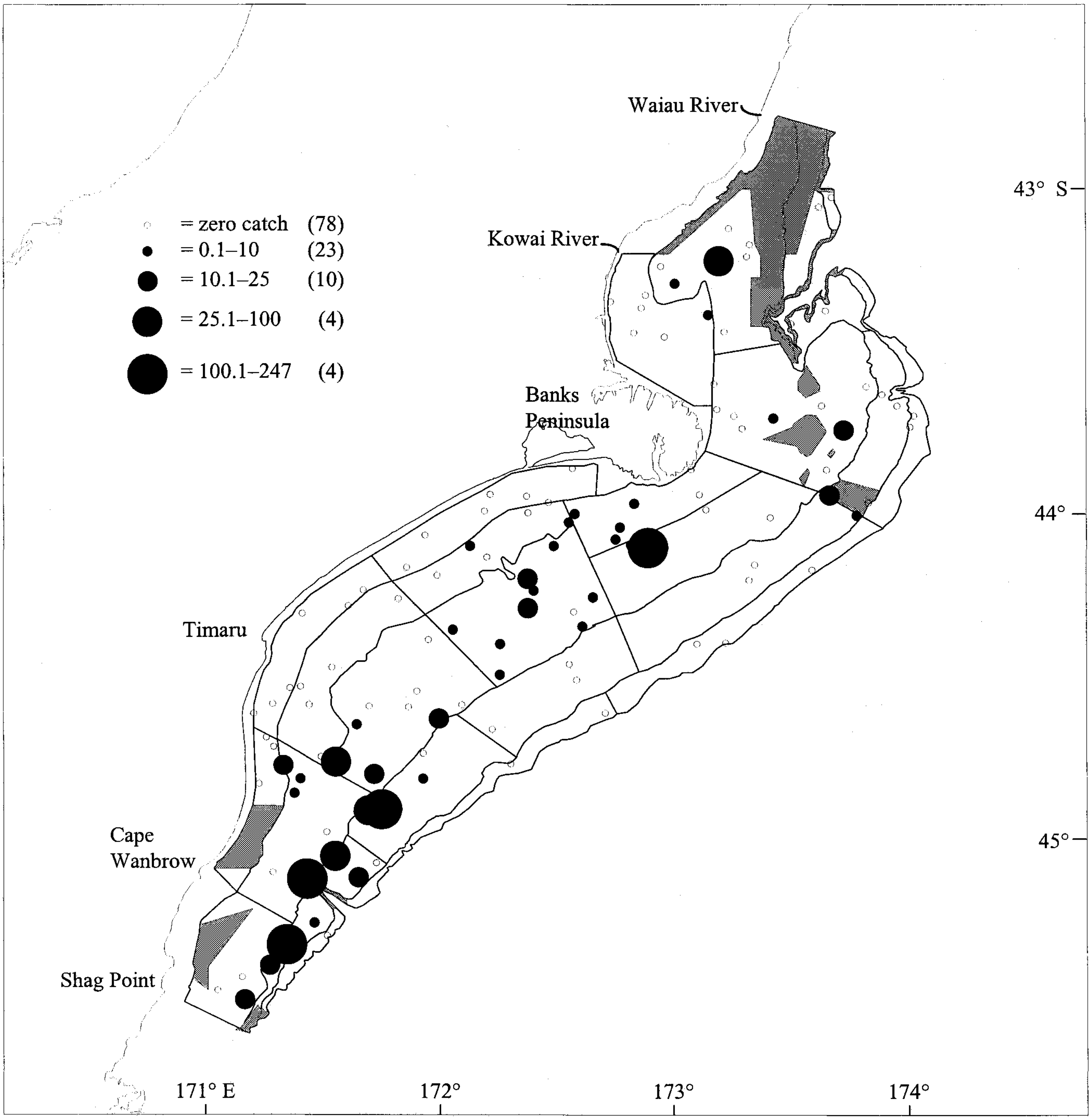


Figure 5—continued

Dark ghost shark

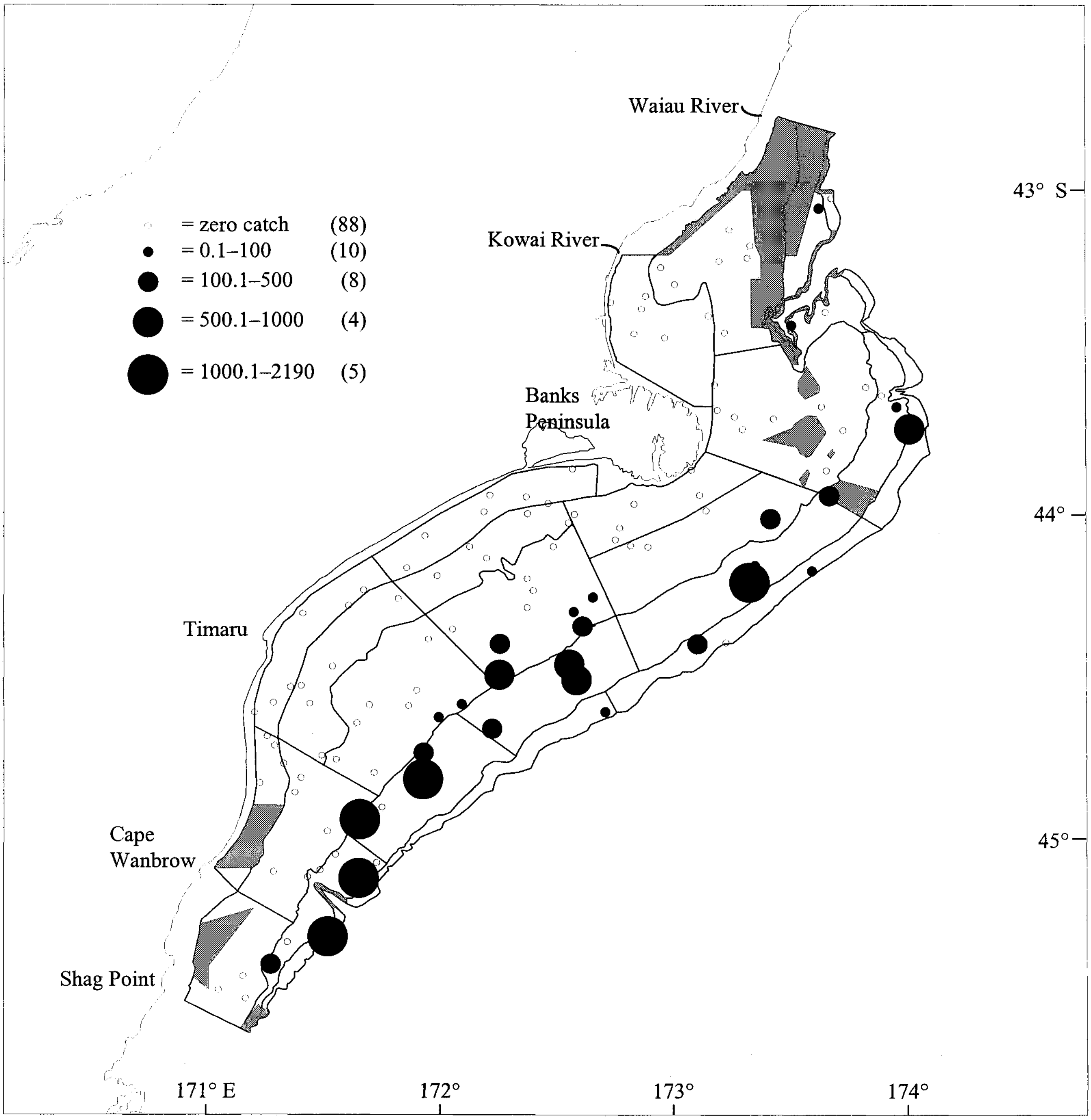


Figure 5—continued

Elephantfish

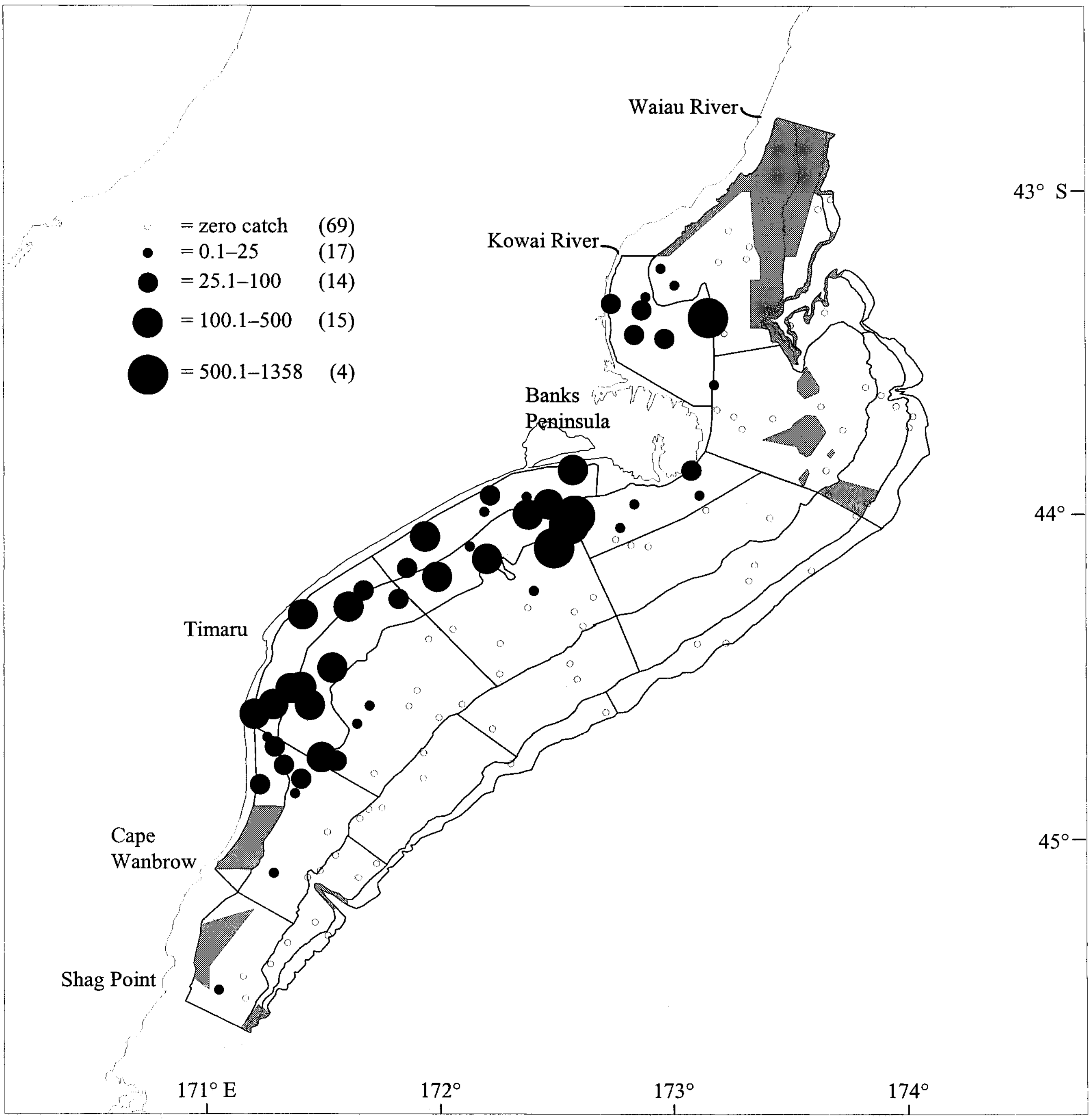


Figure 5—continued

Giant stargazer

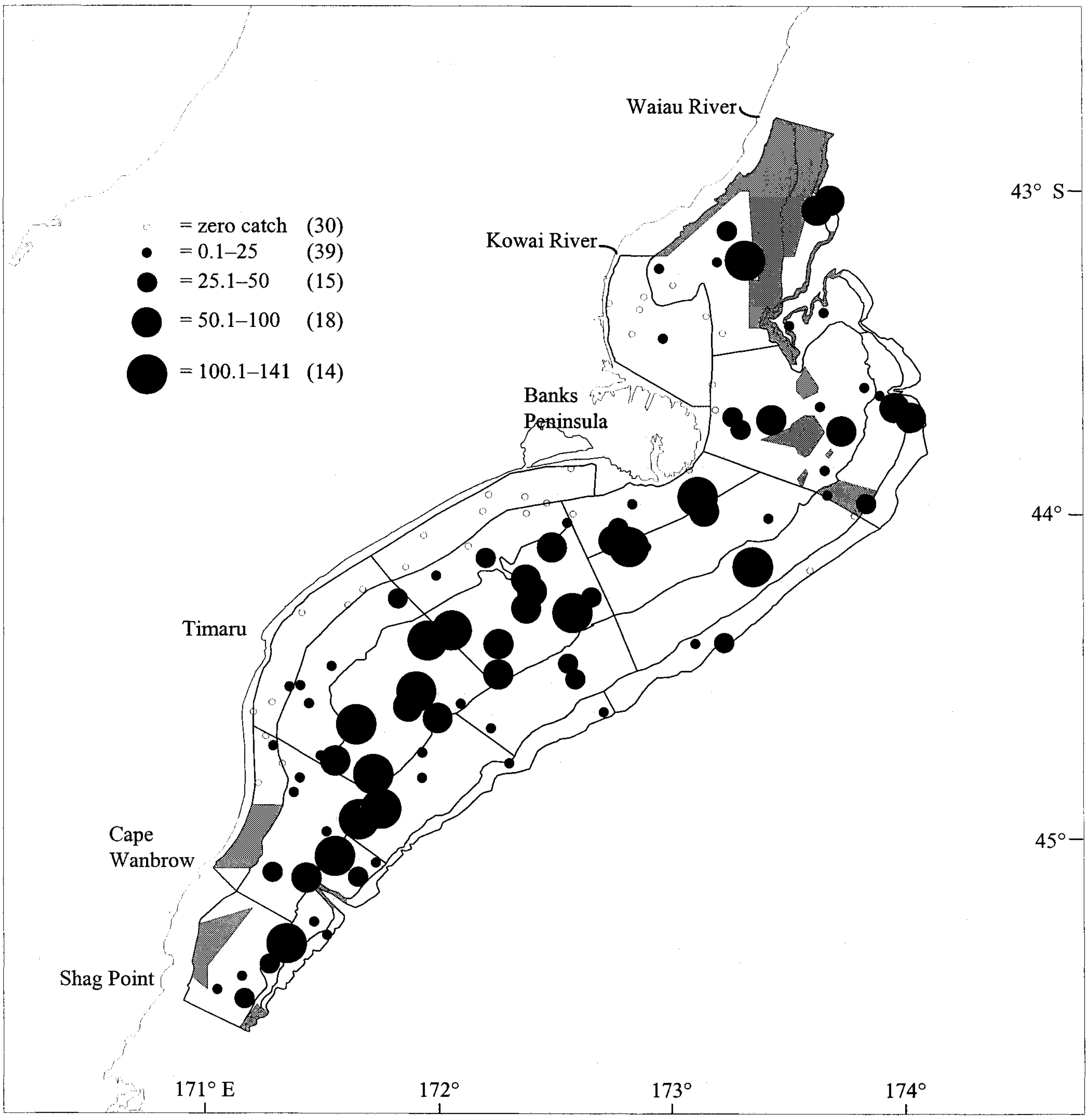


Figure 5—continued

Hapuku

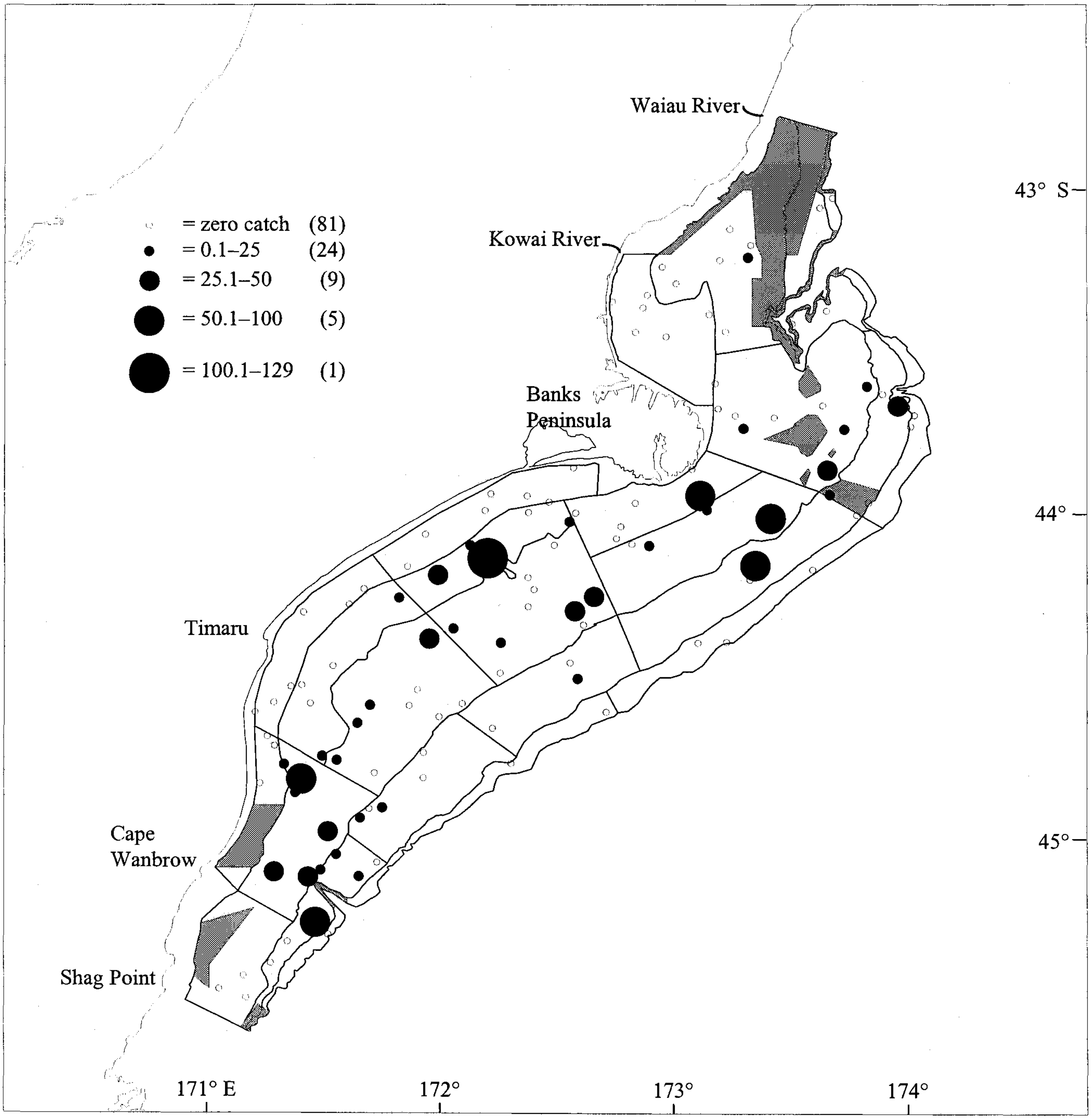


Figure 5—continued

Hoki

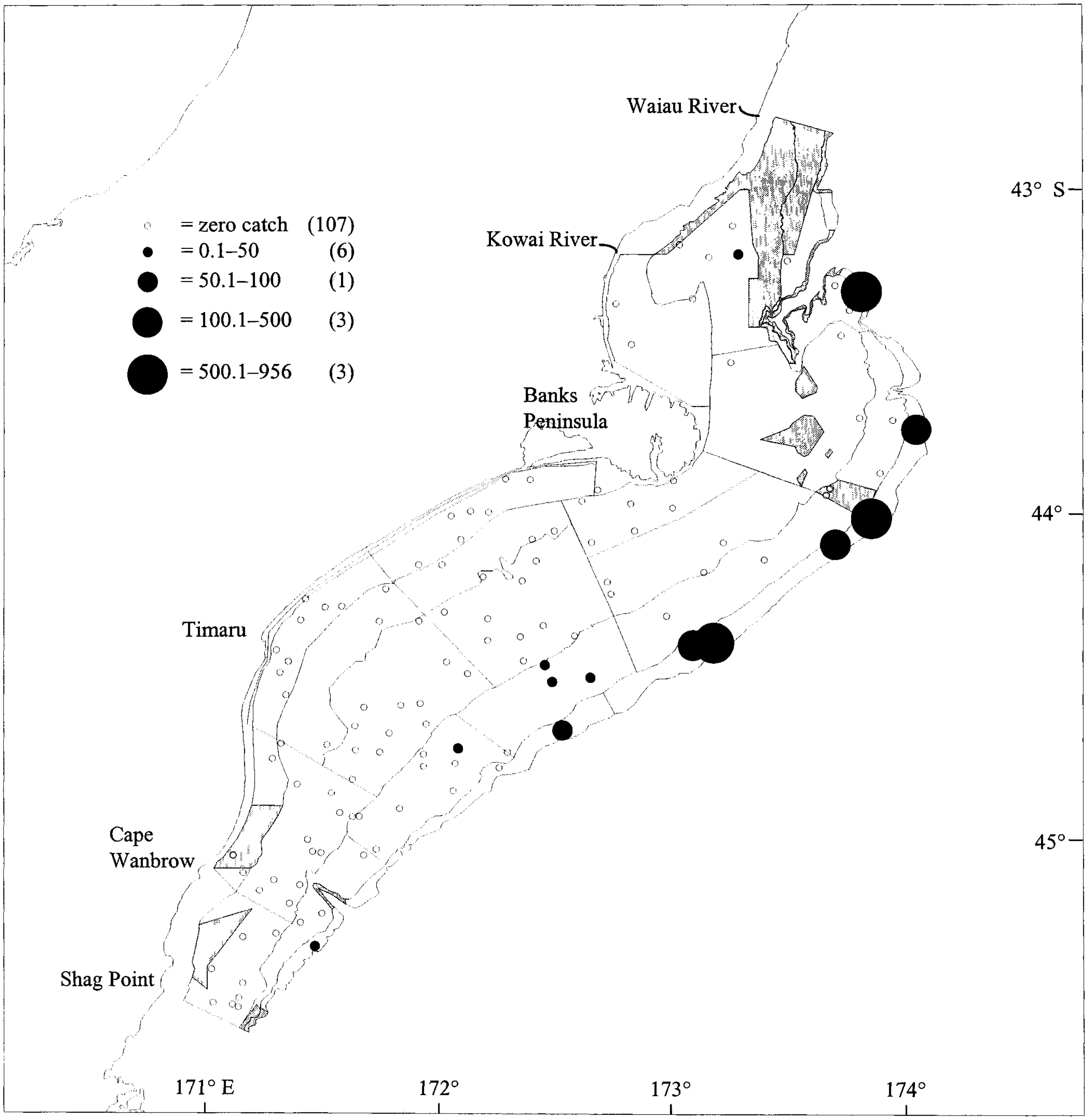


Figure 5—continued

Leatherjacket

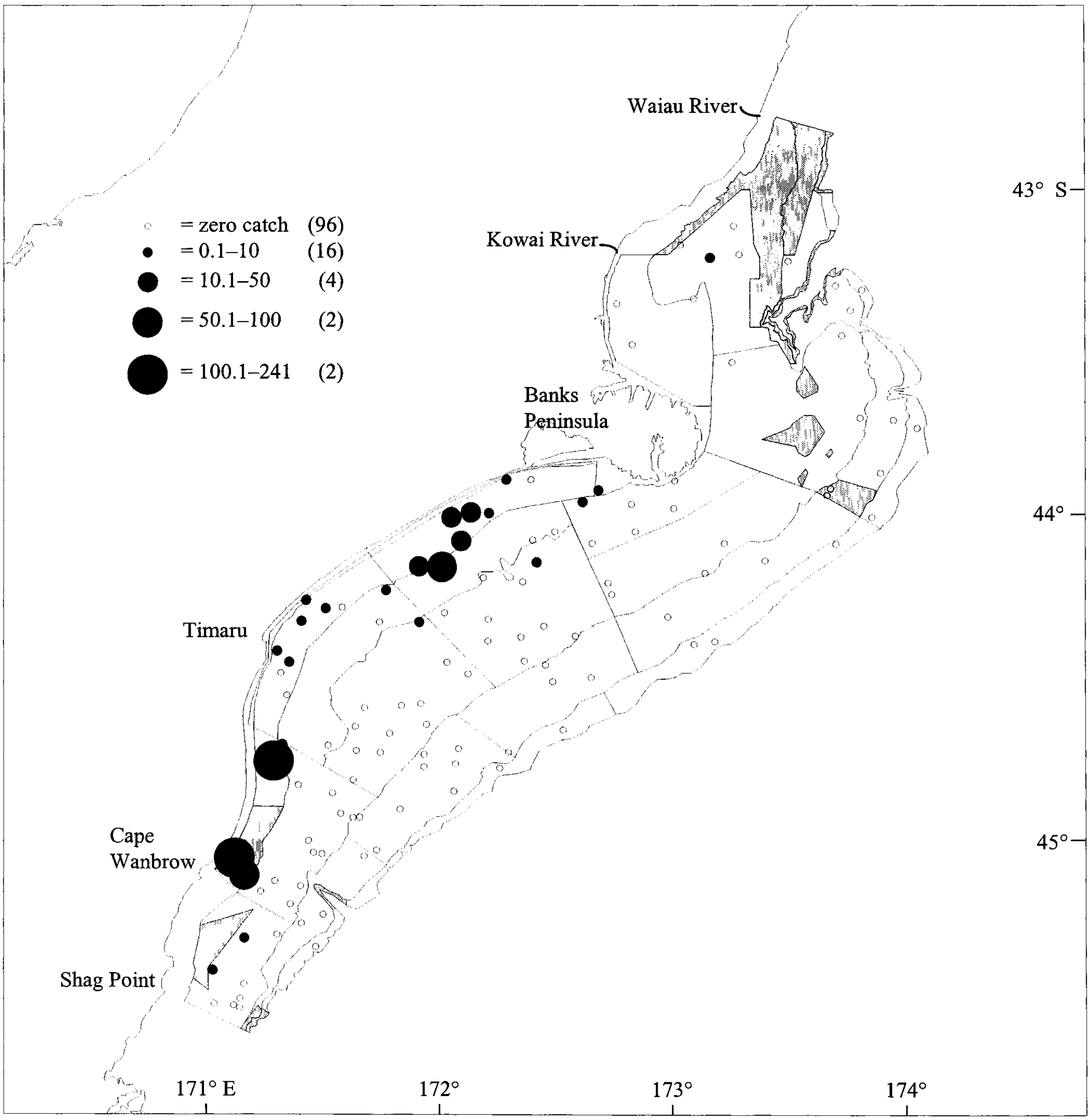


Figure 5—continued

Hoki

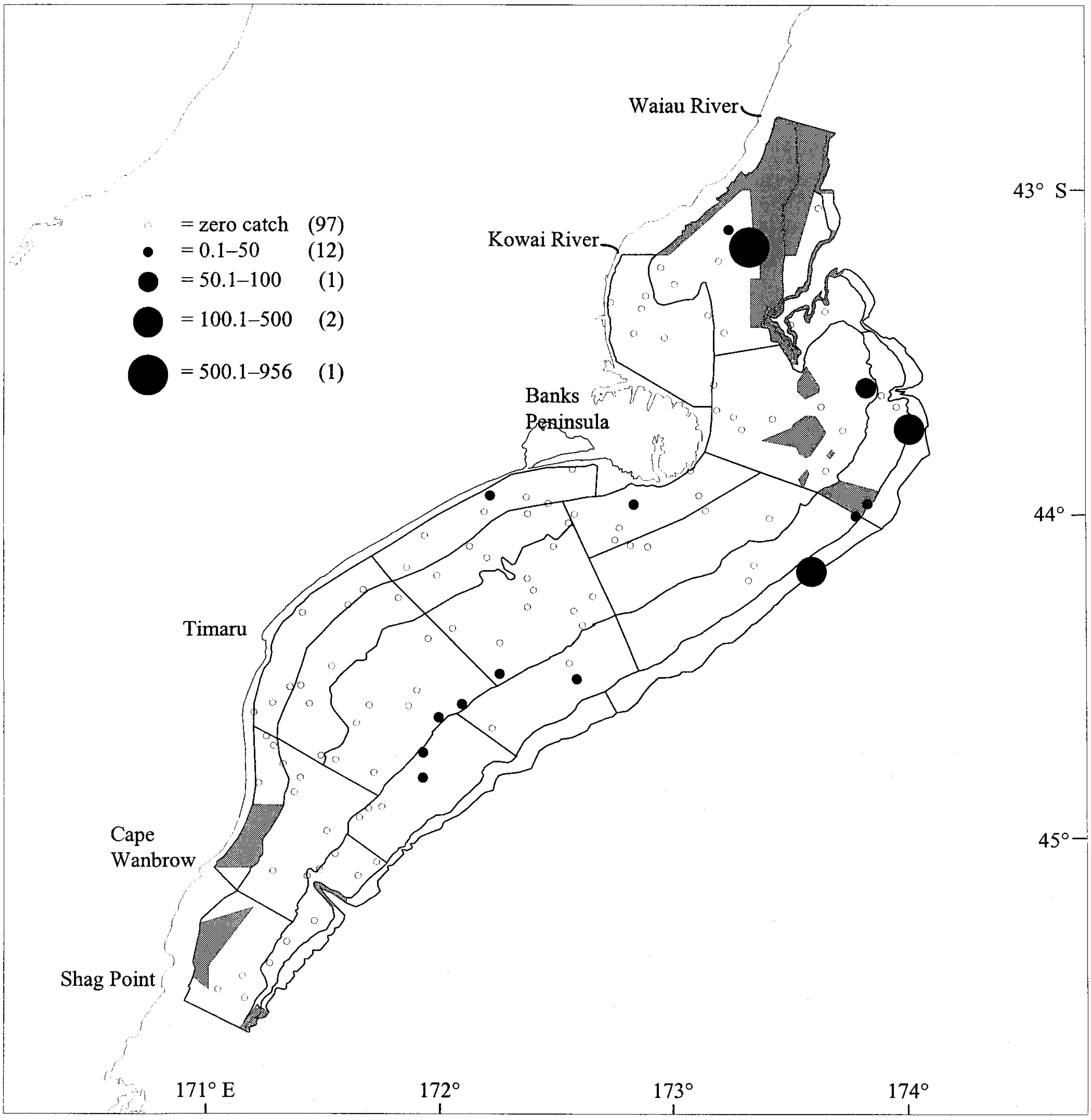


Figure 5—continued

Leatherjacket

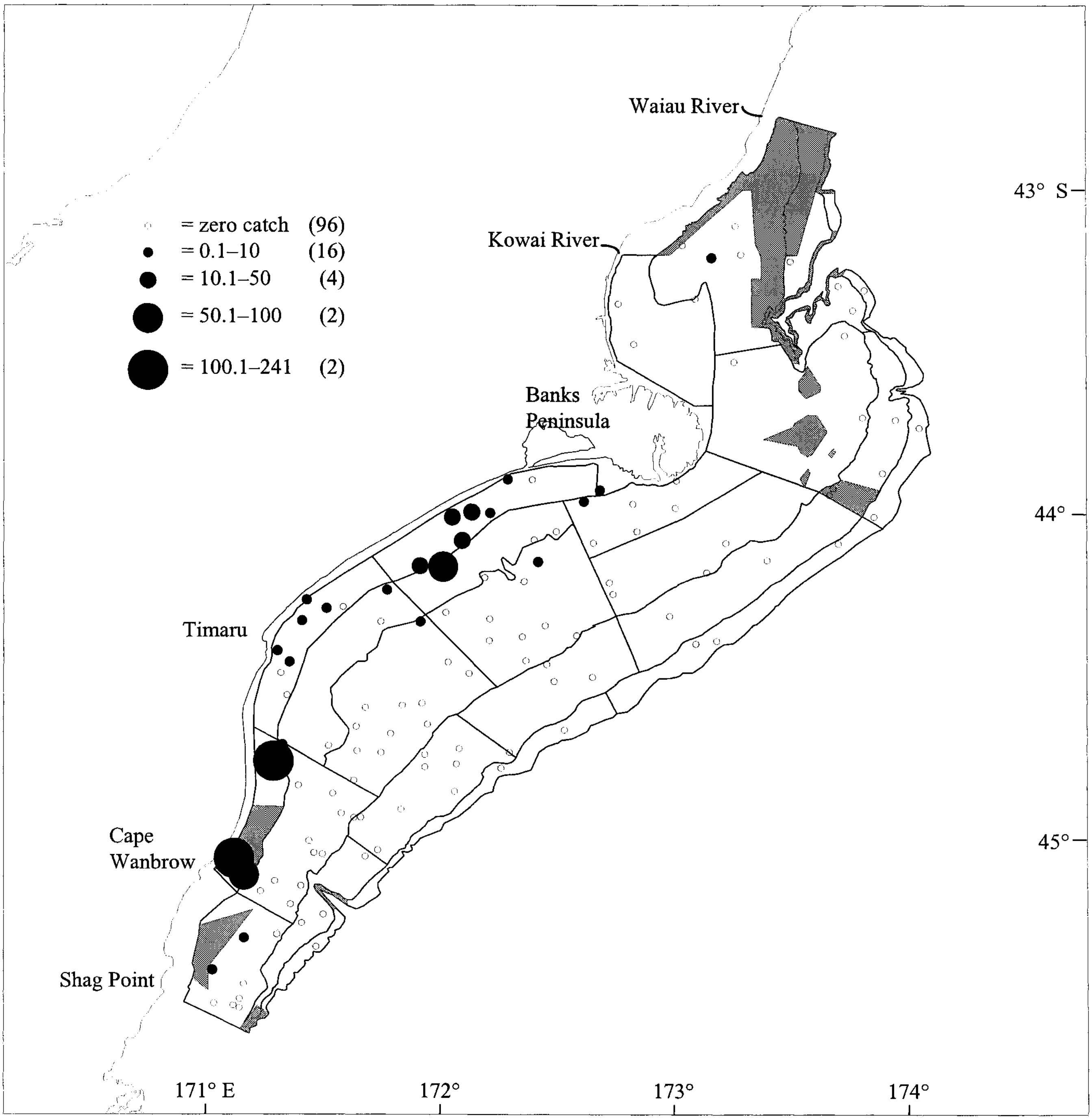


Figure 5—continued

Ling

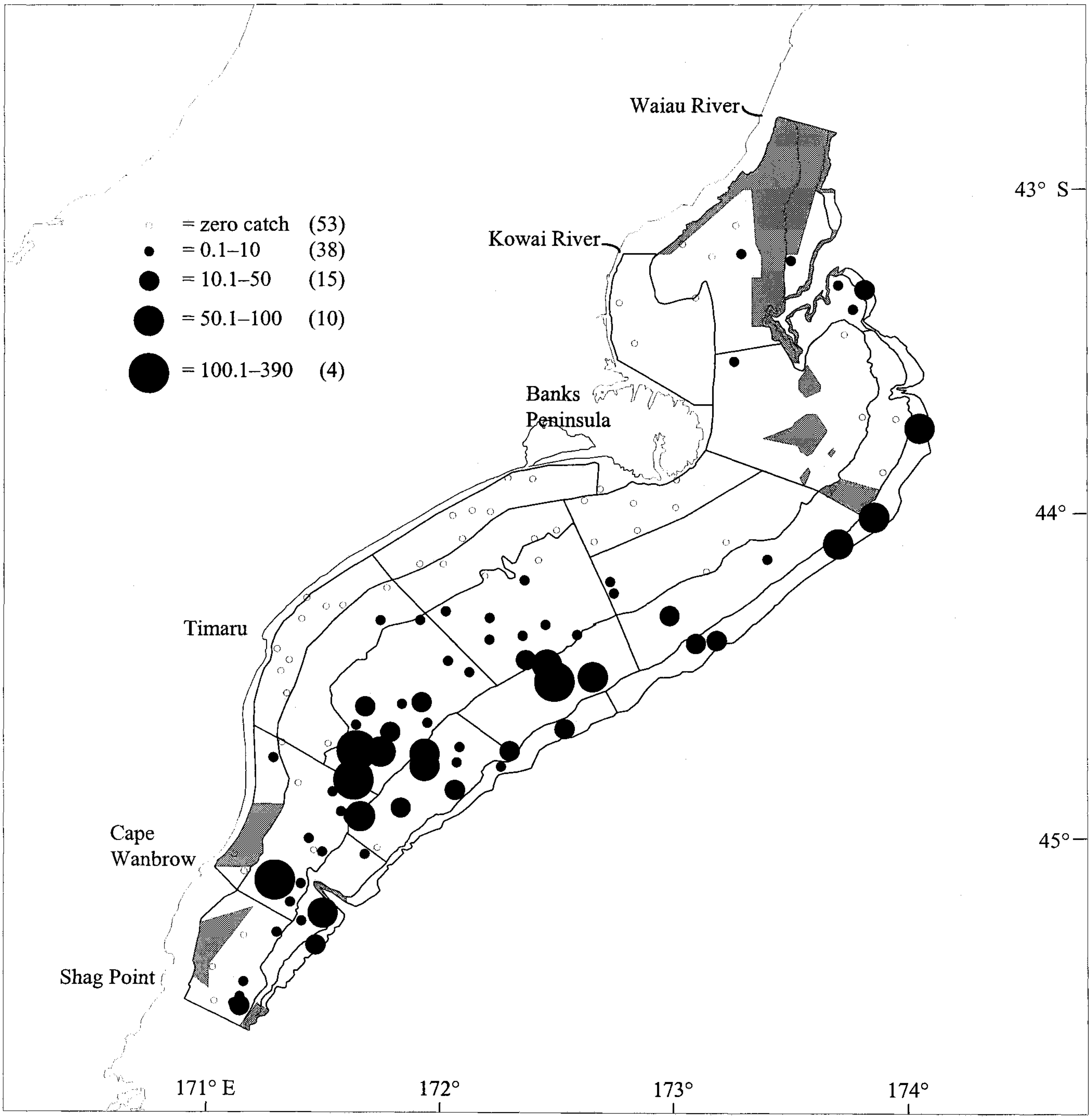


Figure 5—continued

Lemon sole

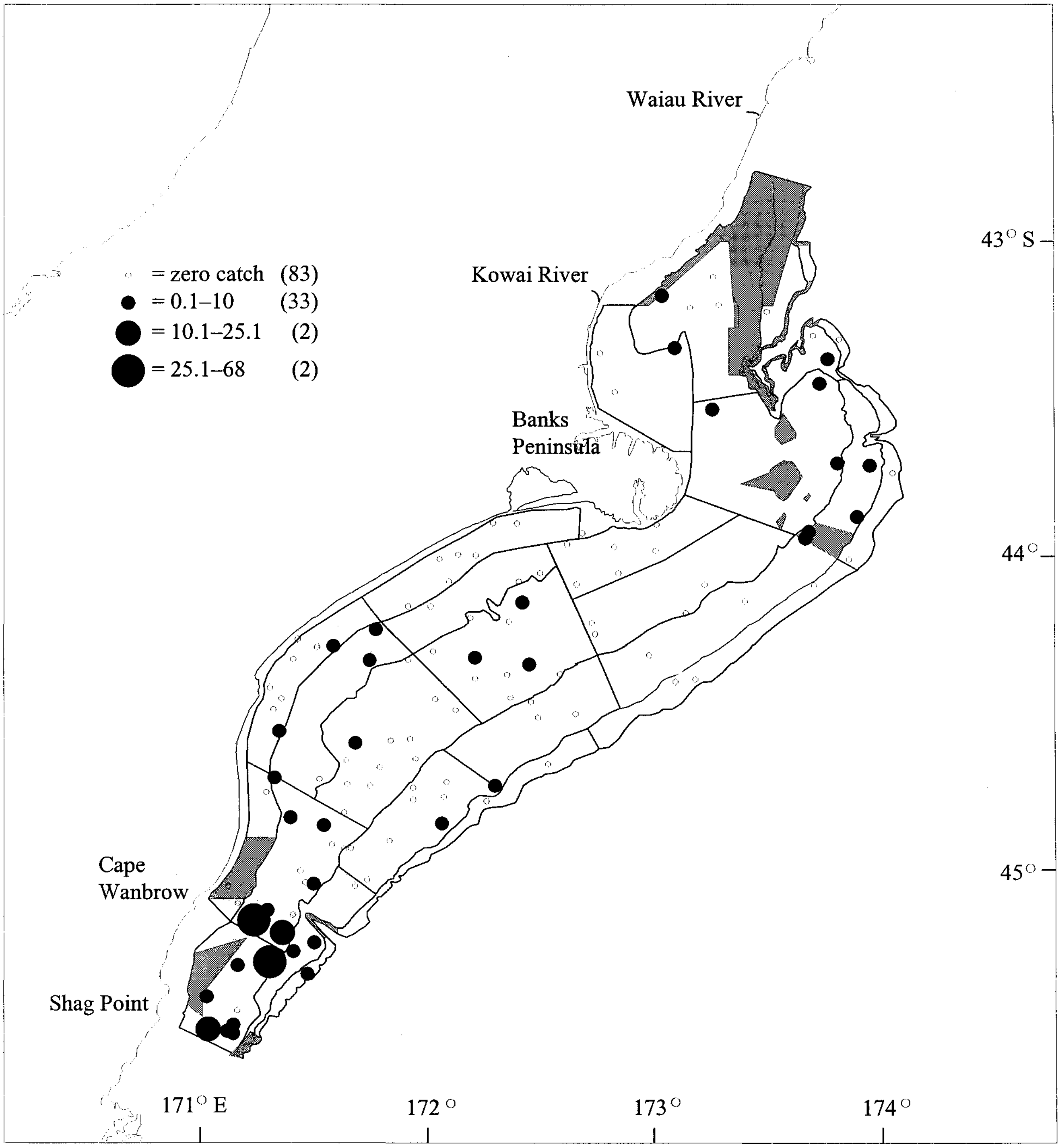


Figure 5—continued

Red cod

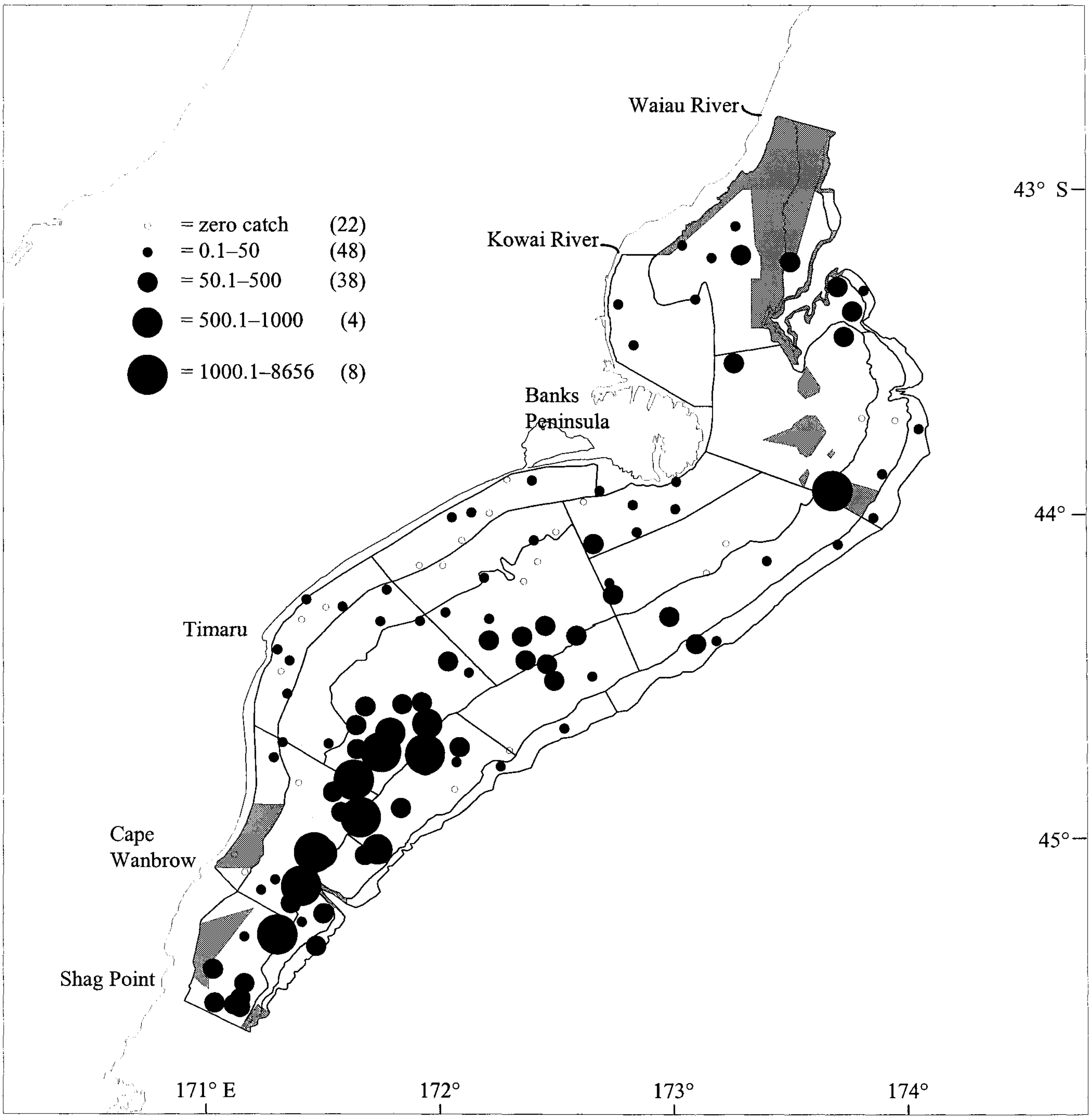


Figure 5—continued

Red gurnard

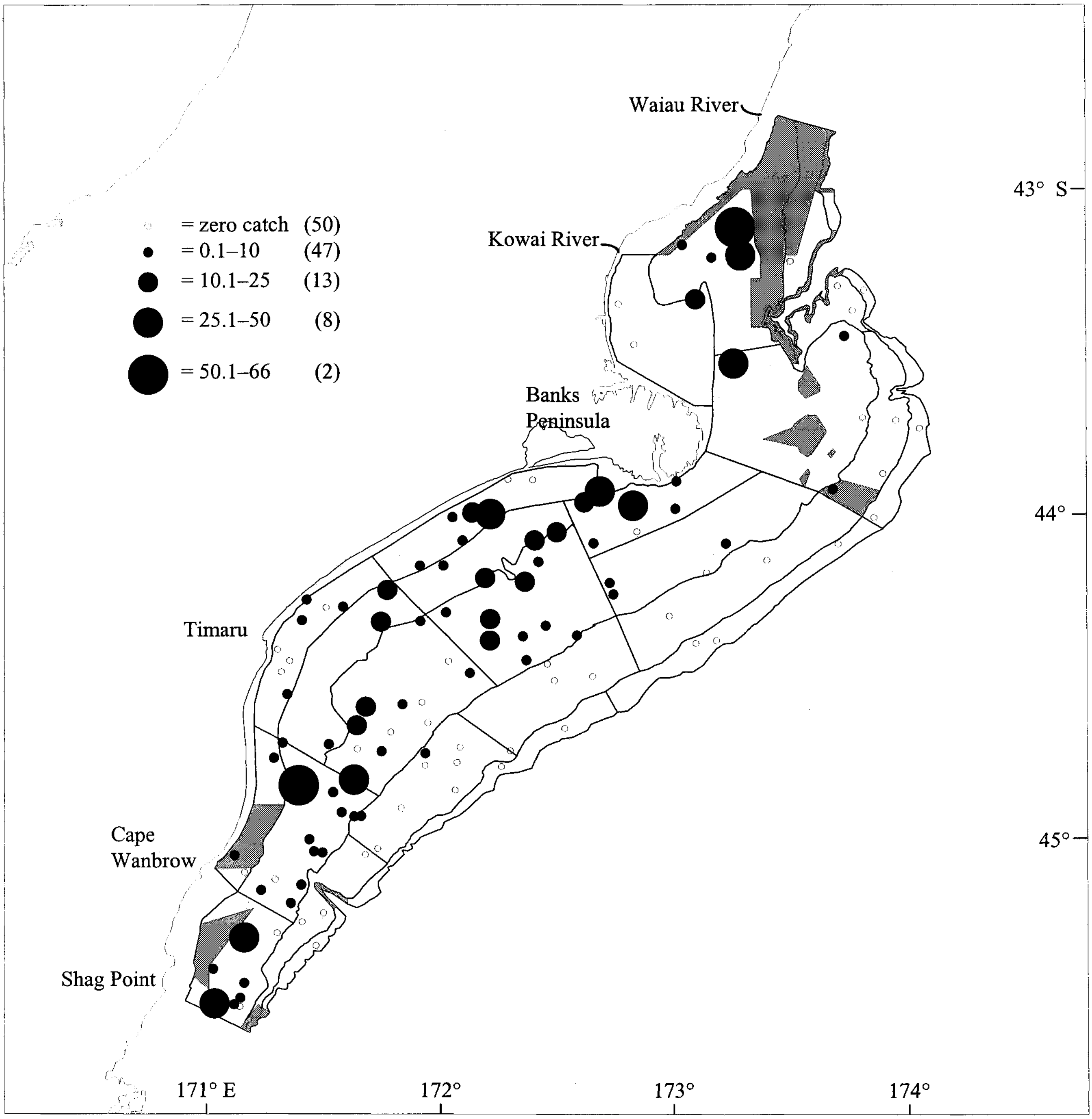


Figure 5—continued

Rig

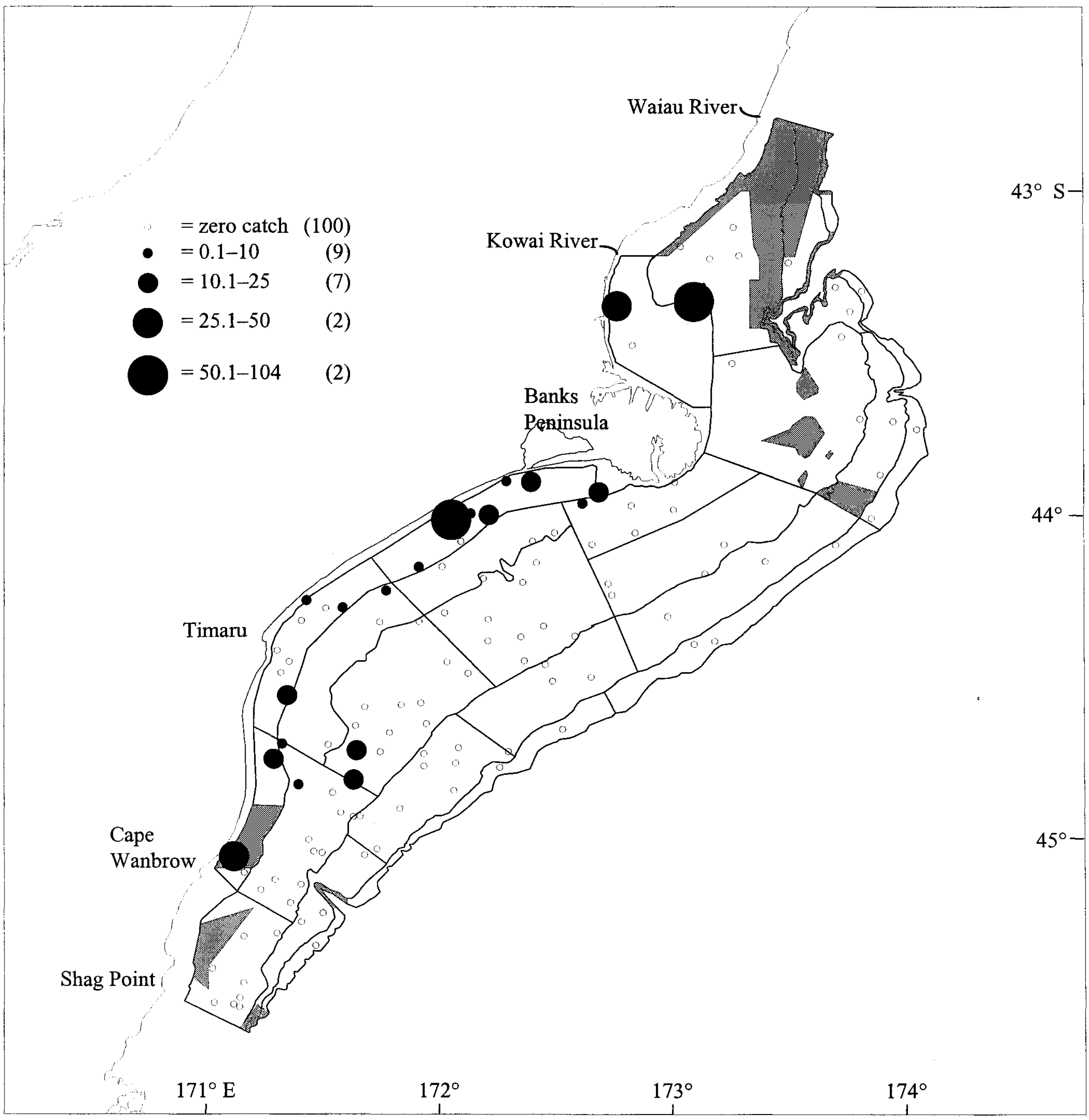


Figure 5—continued

Rough skate

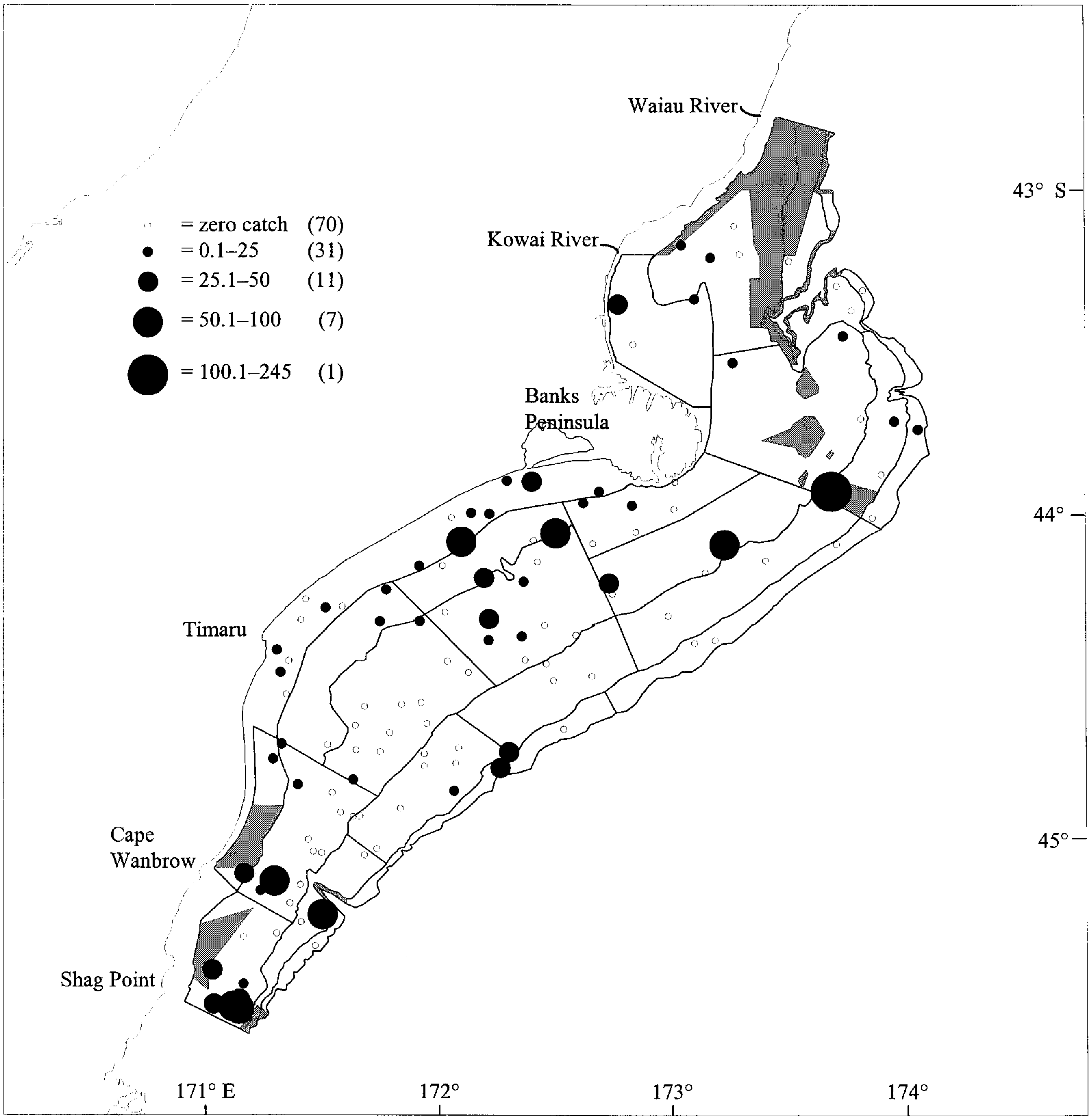


Figure 5—continued

School shark

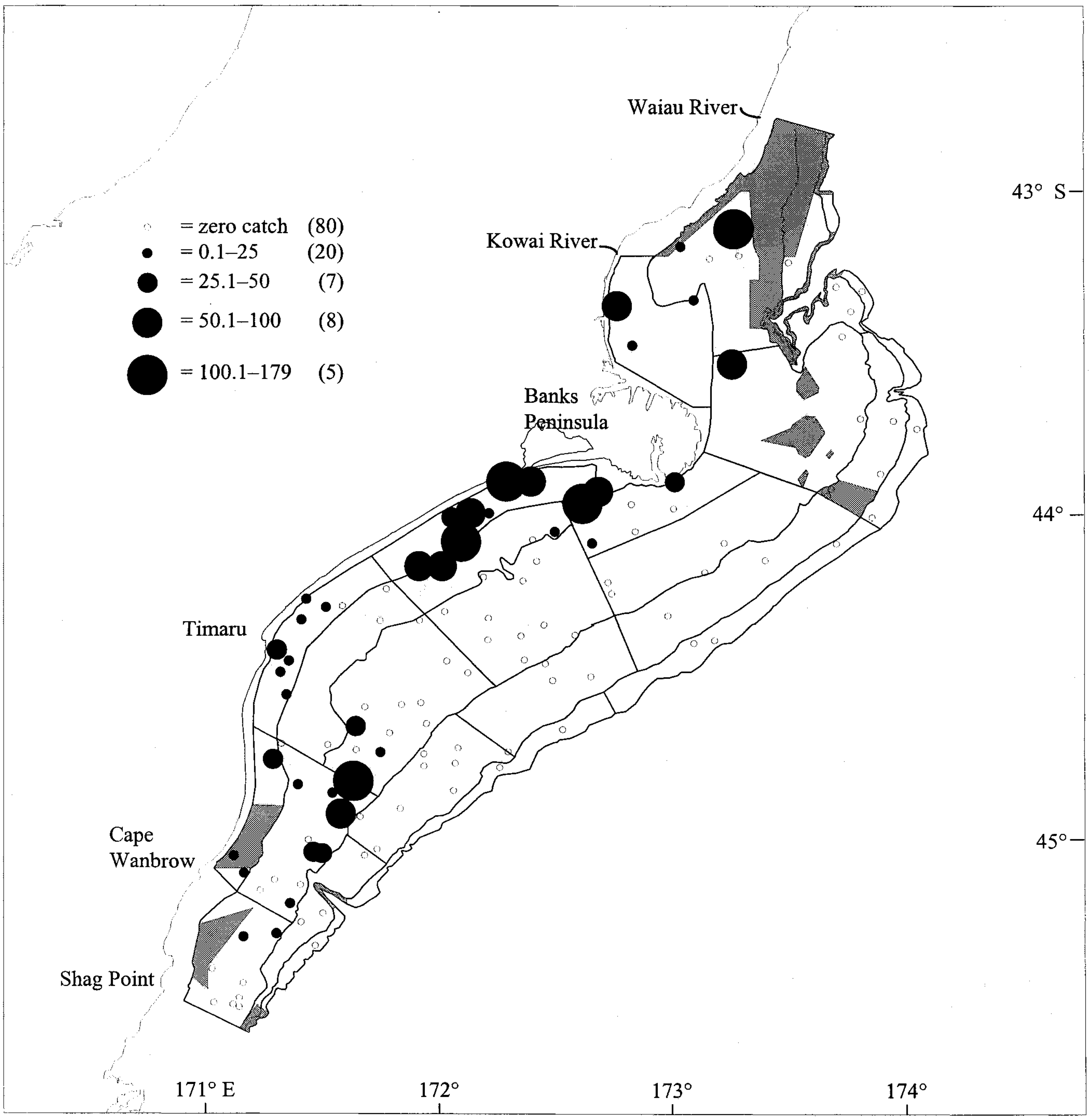


Figure 5—continued

Sea perch

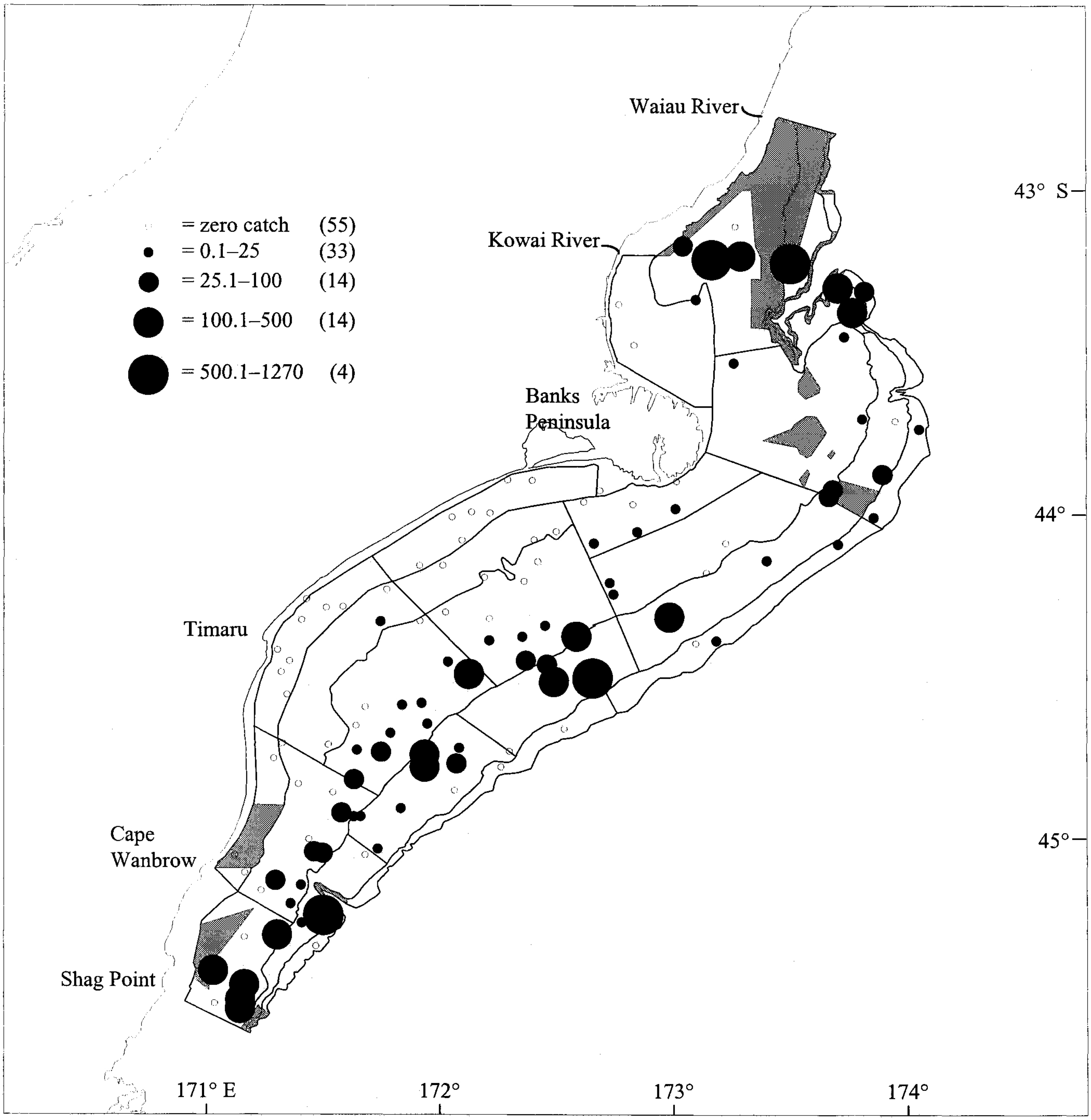


Figure 5—continued

Silver warehou

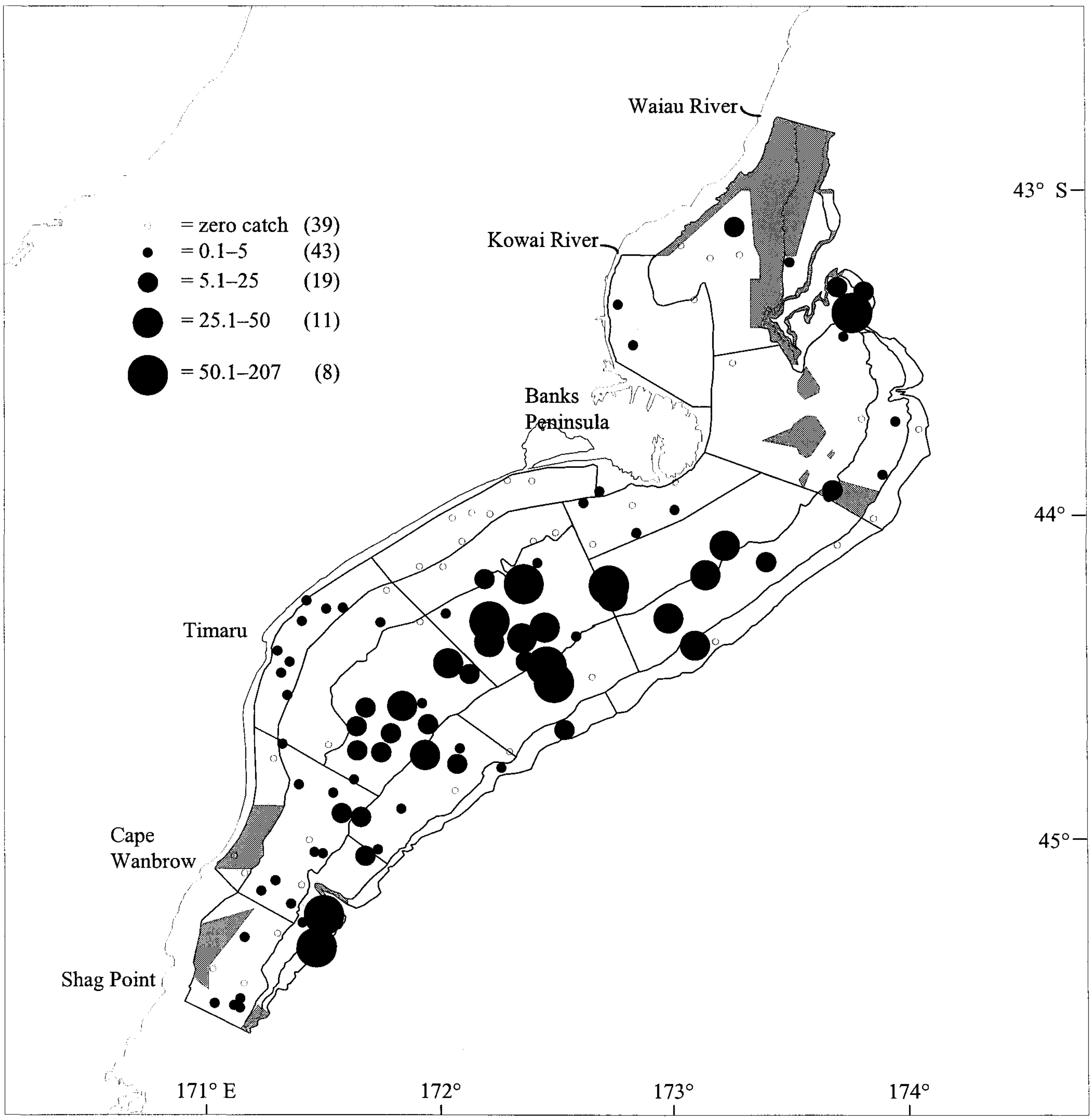


Figure 5—continued

Smooth skate

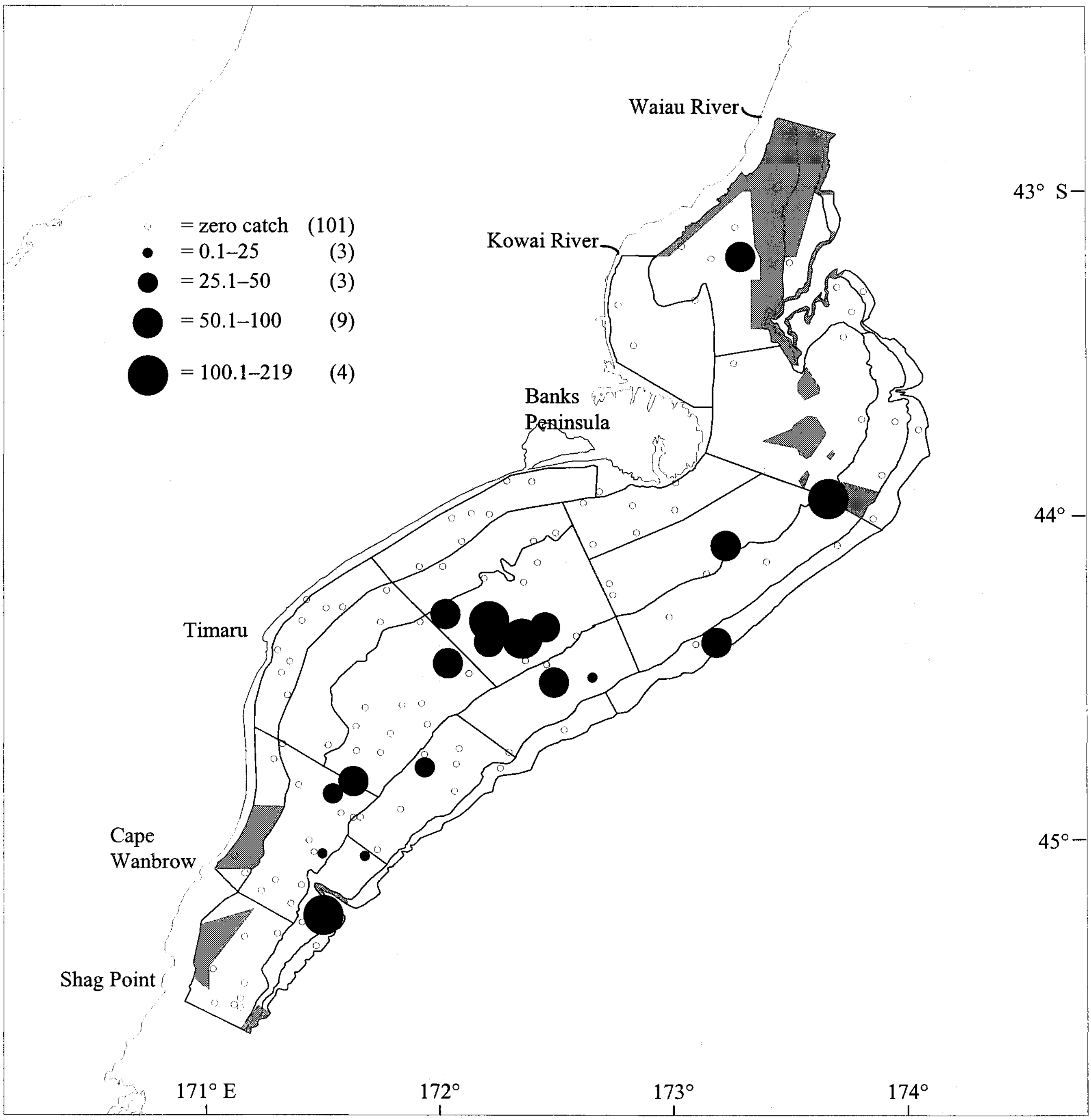


Figure 5—continued

Spiny dogfish

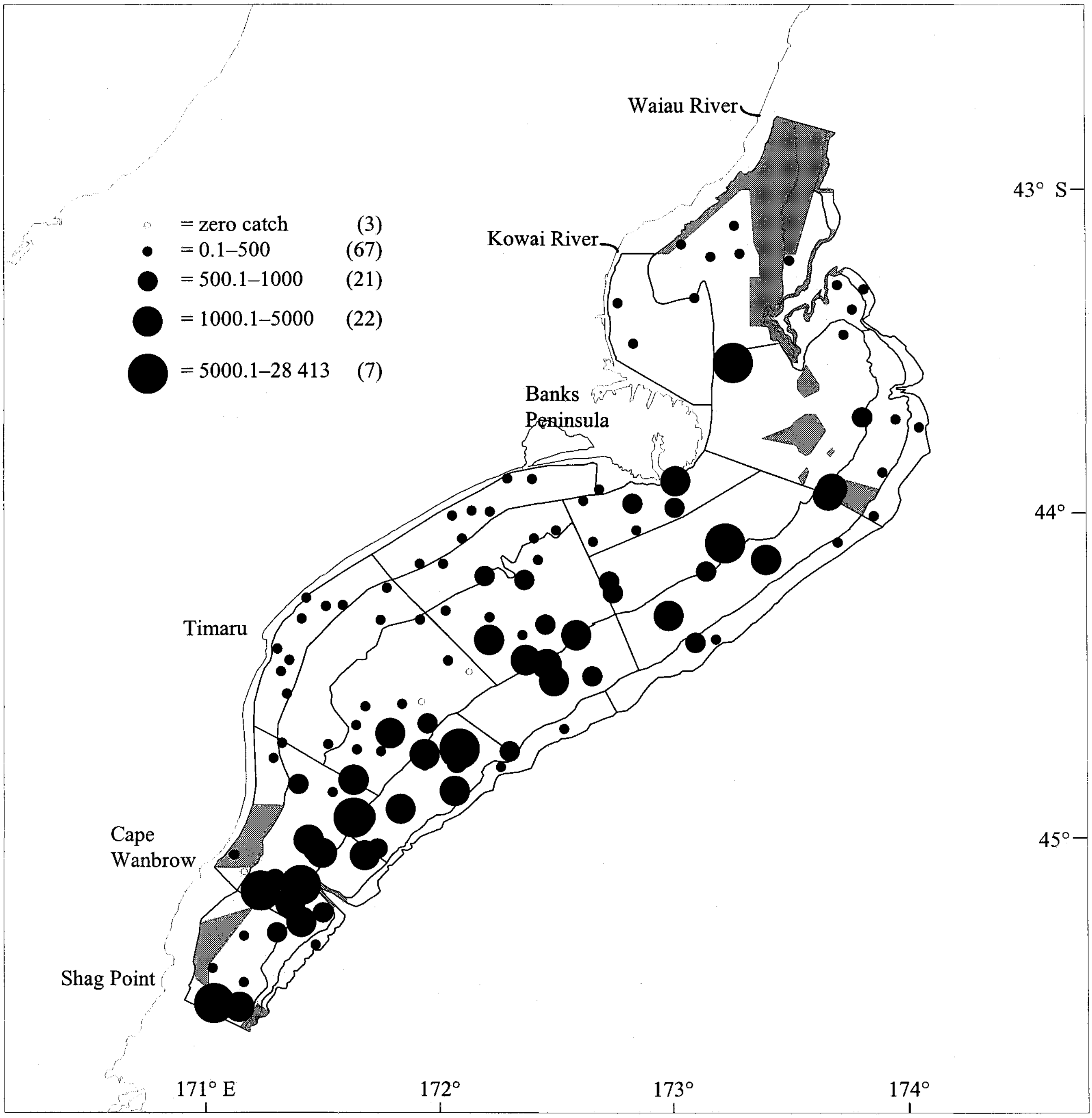


Figure 5—continued

Tarakihi

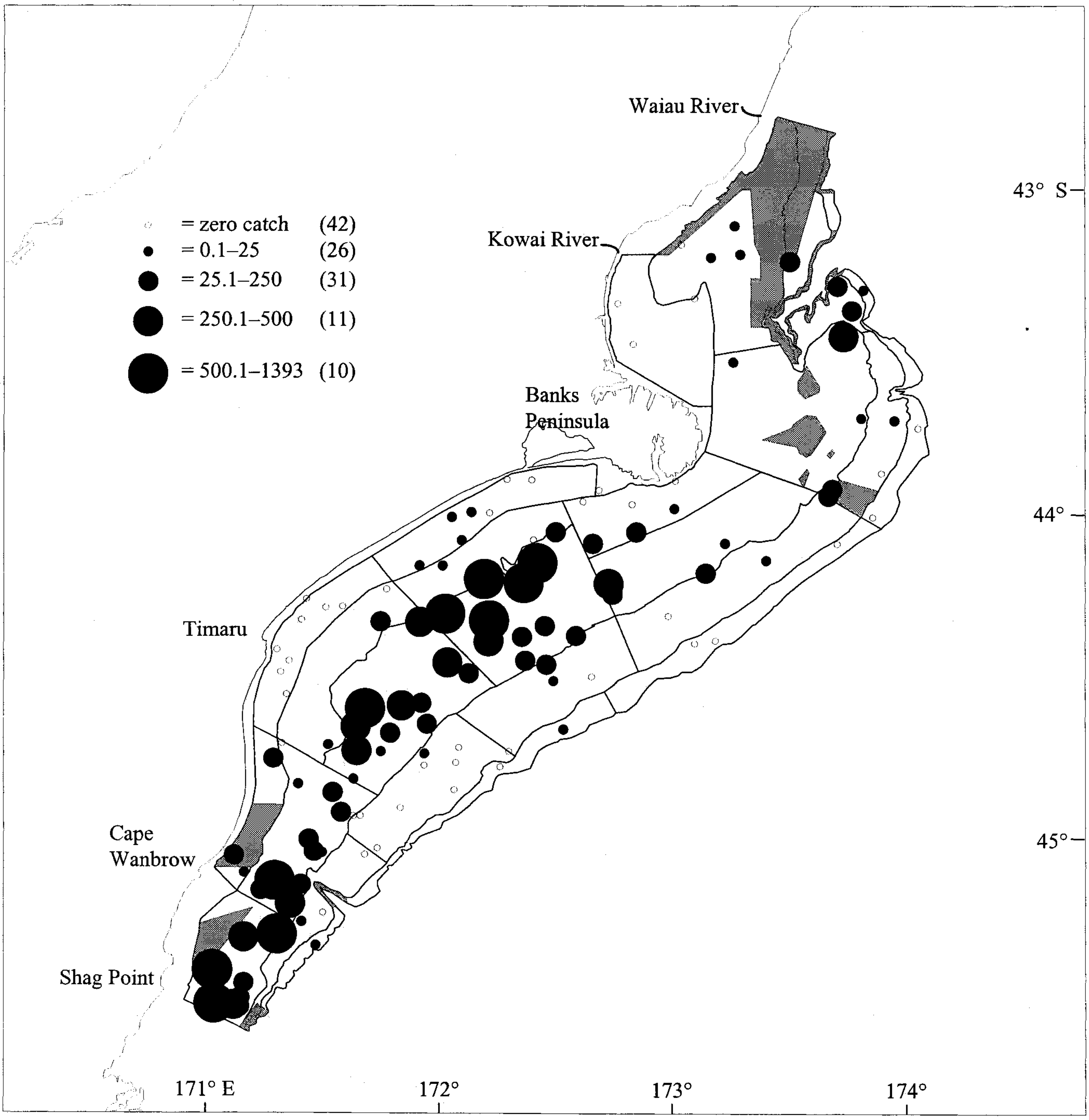


Figure 5—continued

Elephantfish

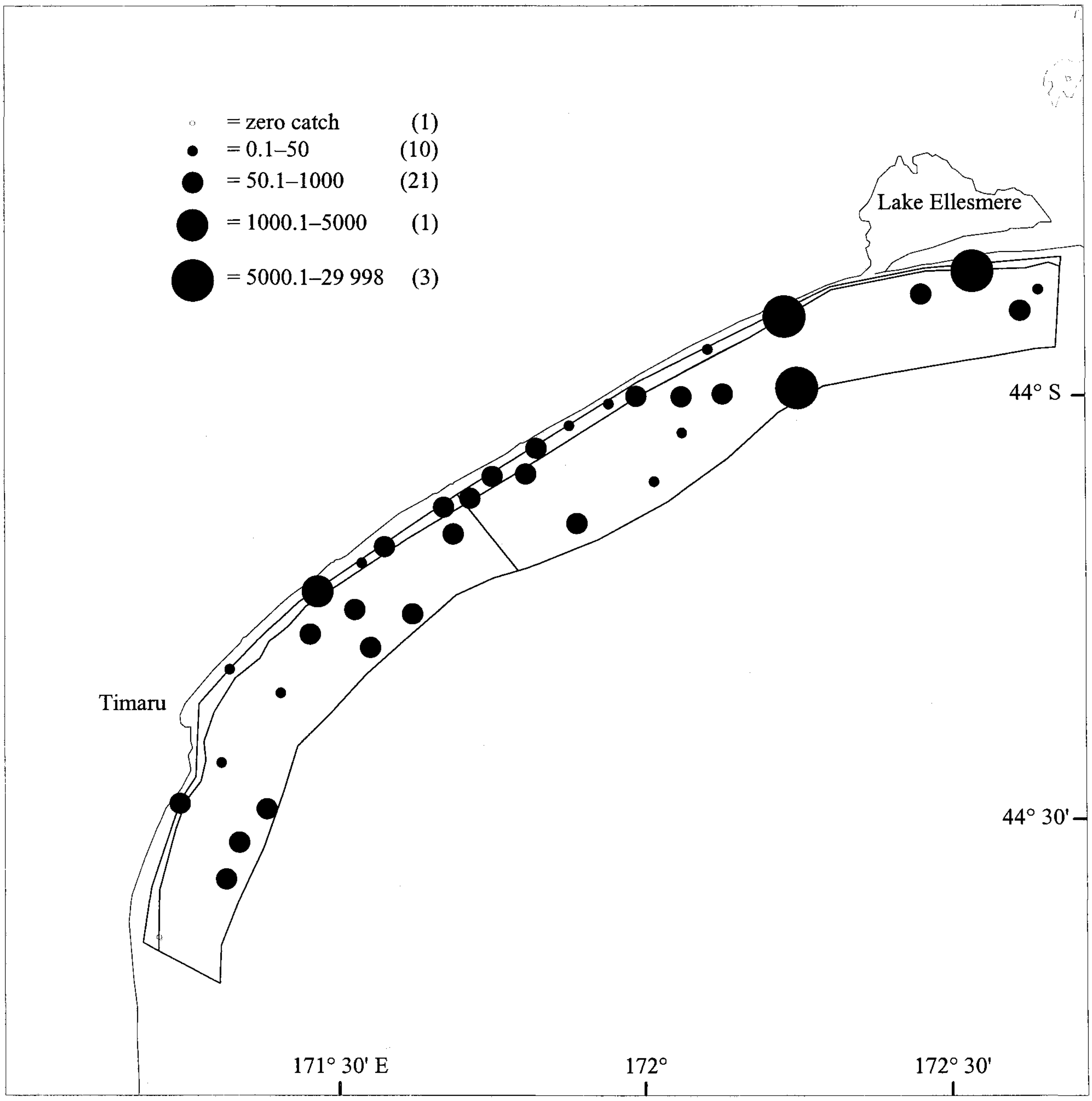


Figure 6: **Catch rates (kg.km^{-2}) for the major commercial species for *Compass Rose* from stations used to calculate biomass estimates (numbers in parentheses are the number of stations at the given catch rate).**

New Zealand sole

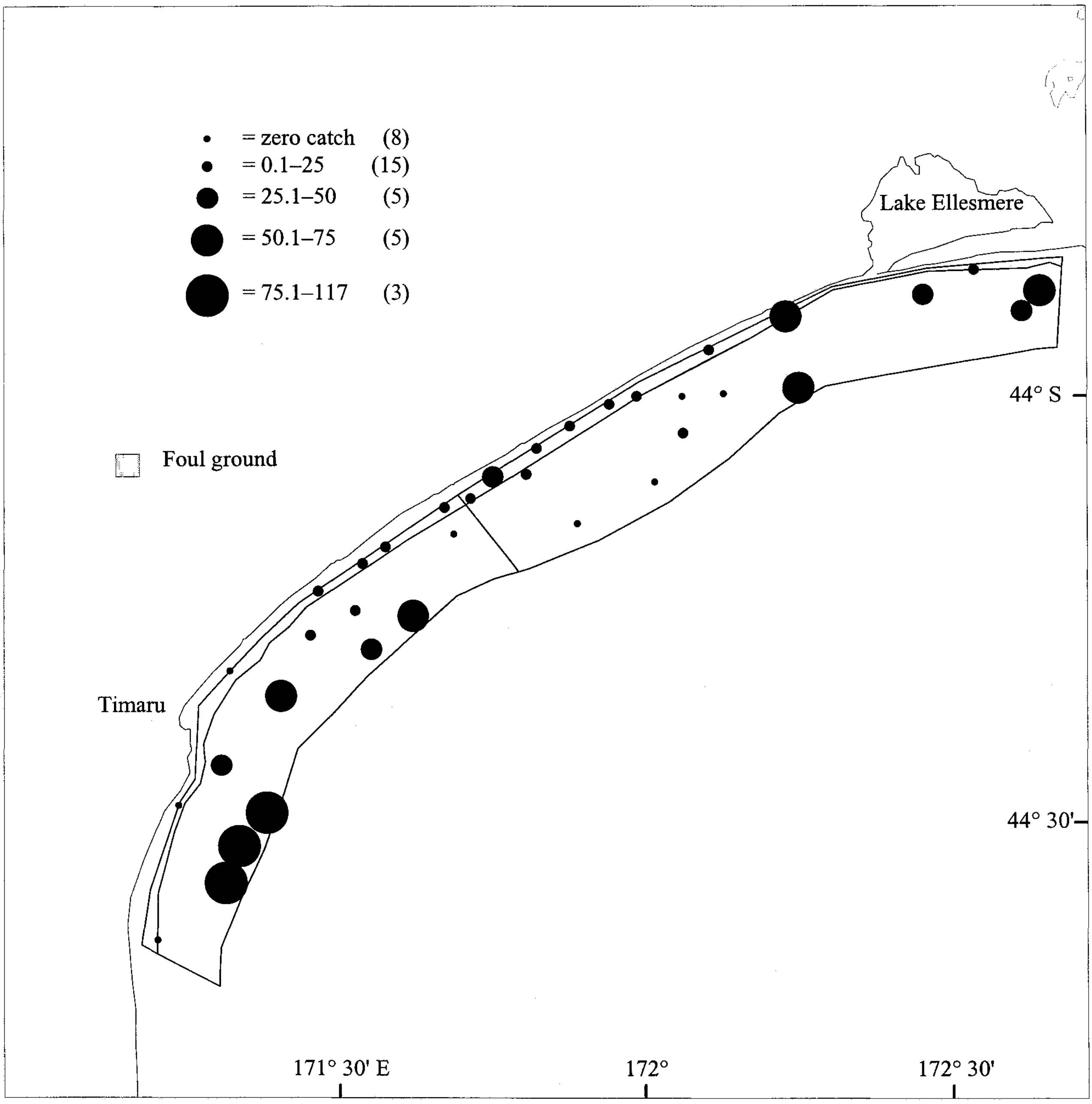


Figure 6—continued

Red cod

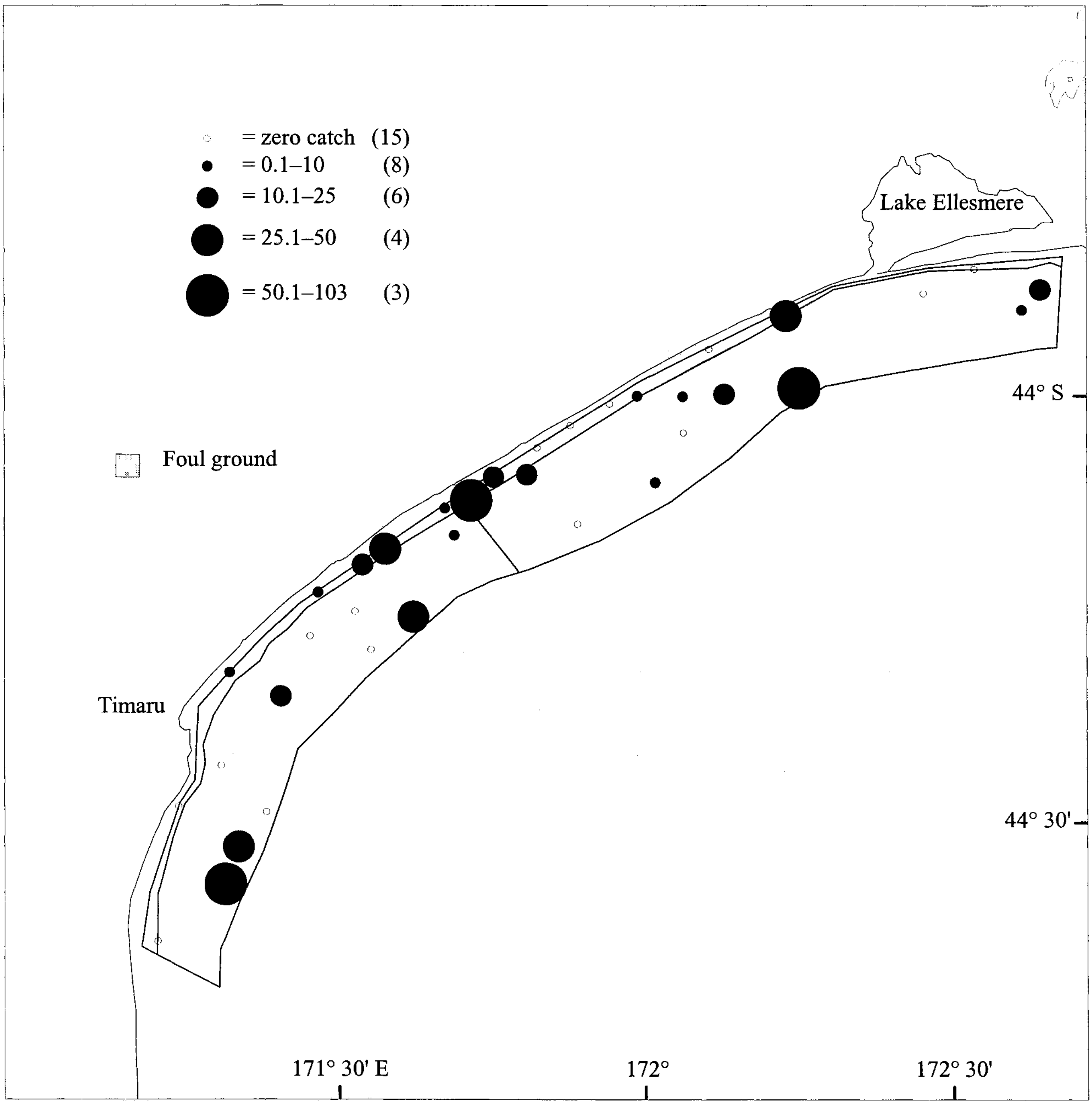


Figure 6—continued

Red gurnard

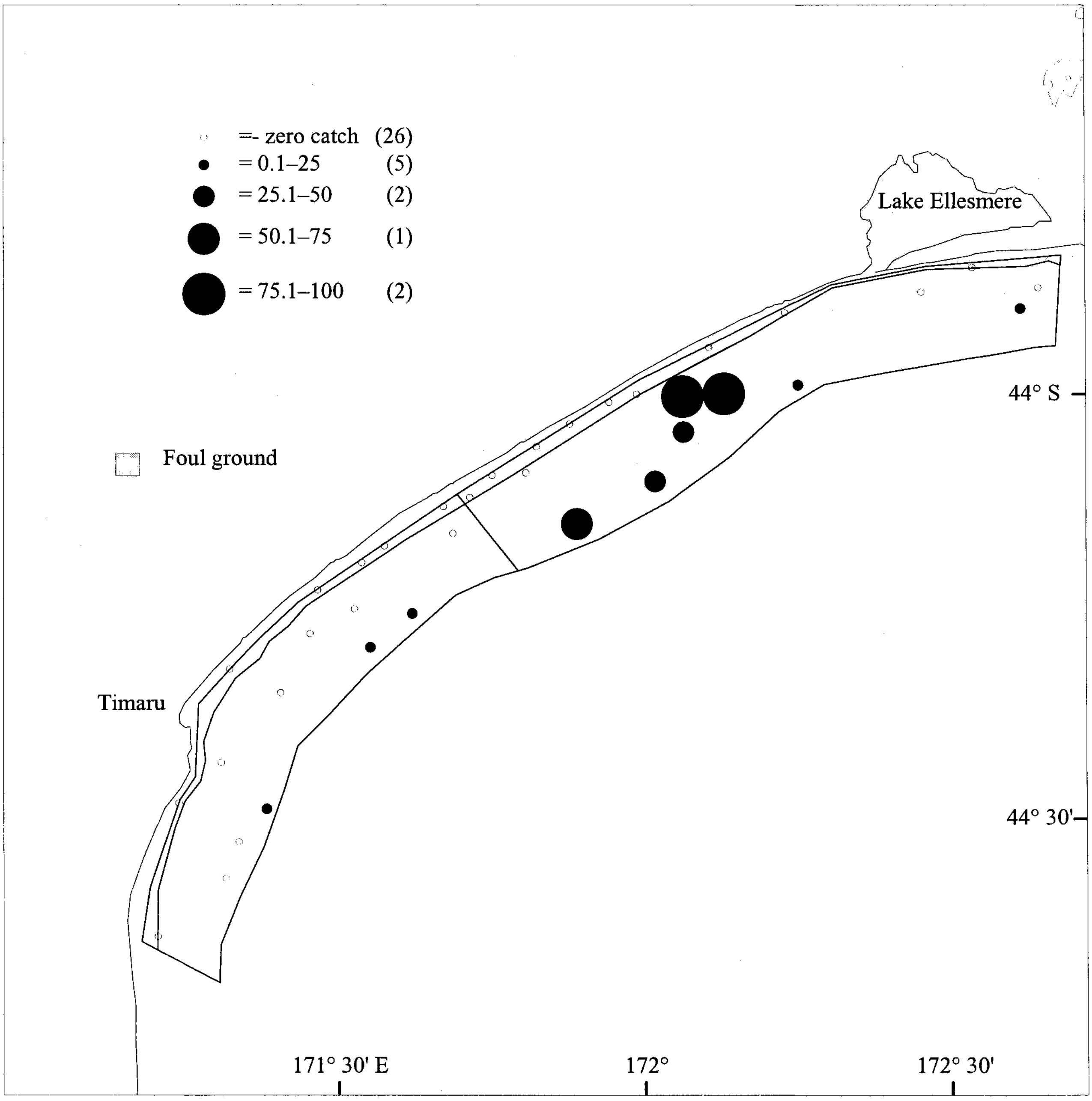


Figure 6—continued

Rig

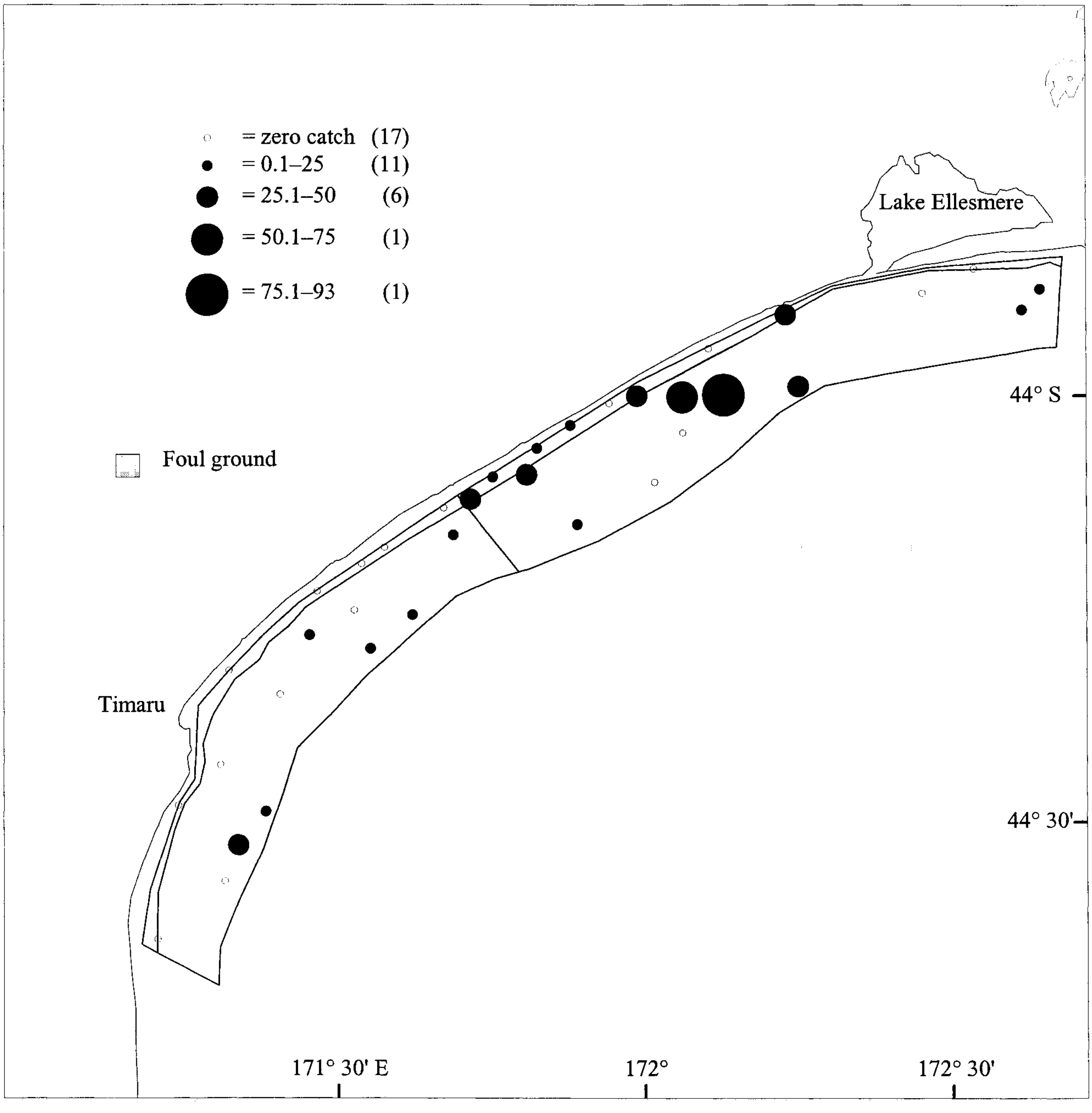


Figure 6—continued

Rough skate

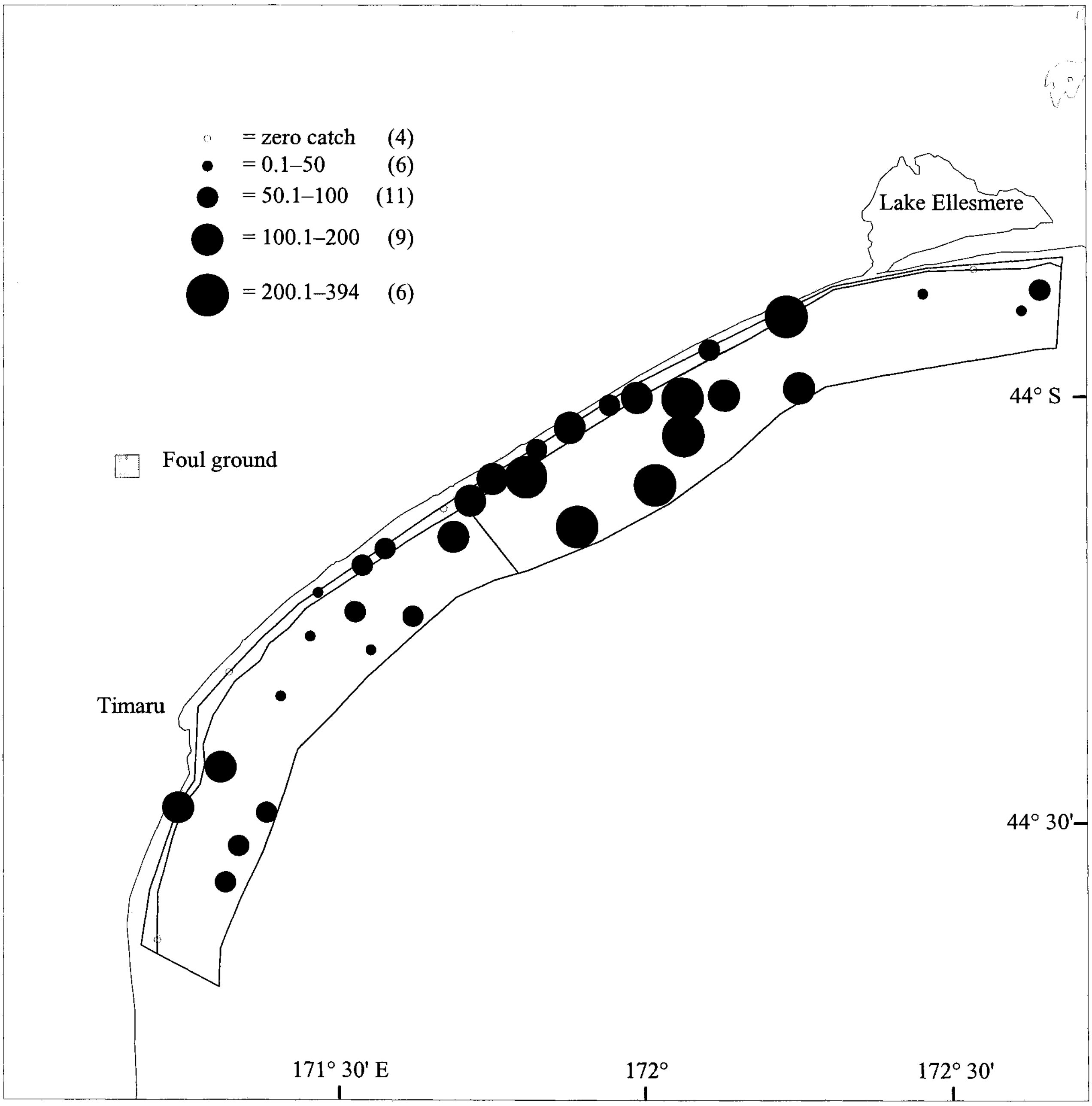


Figure 6—continued

School shark

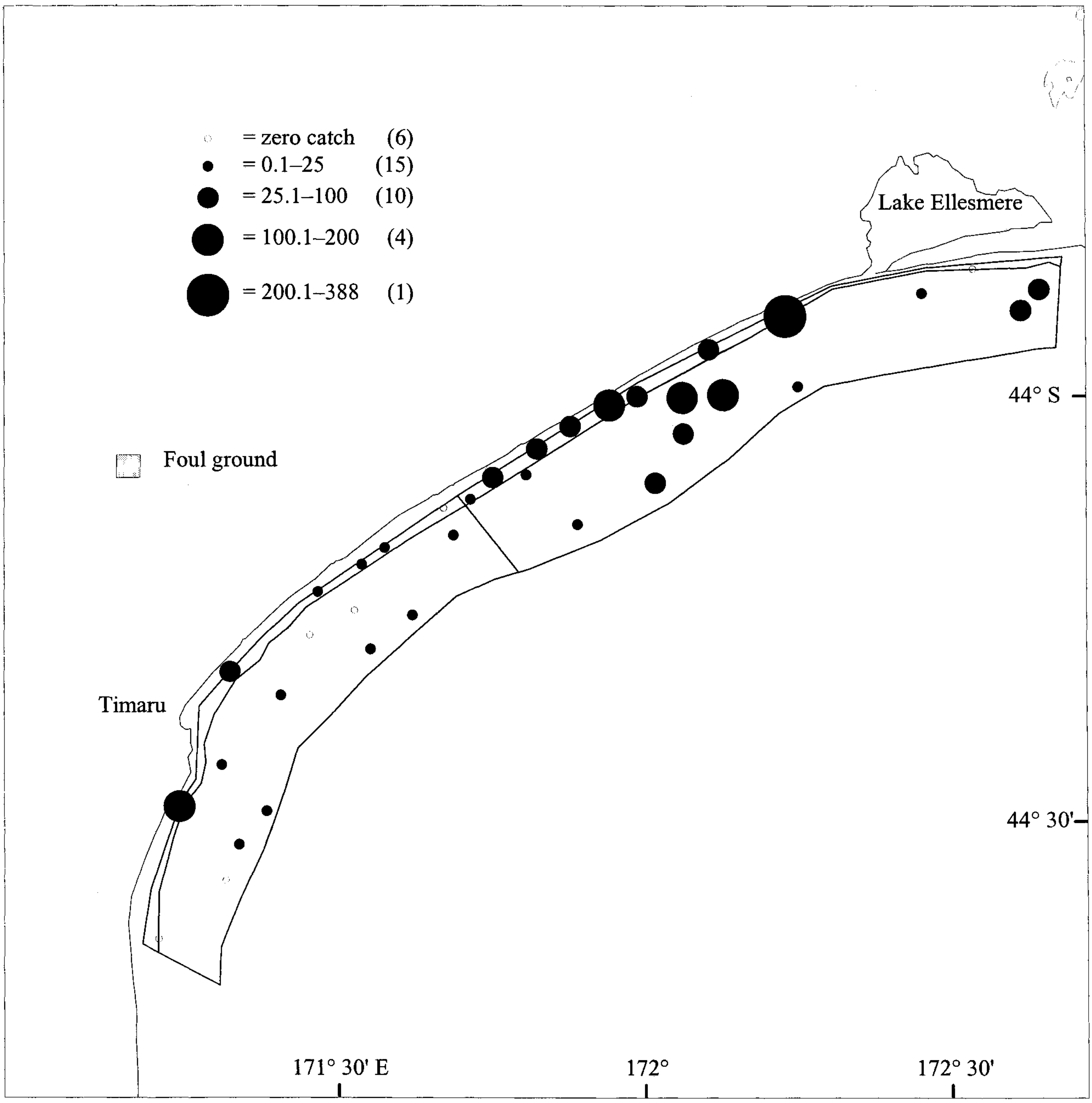


Figure 6—continued

Spiny dogfish

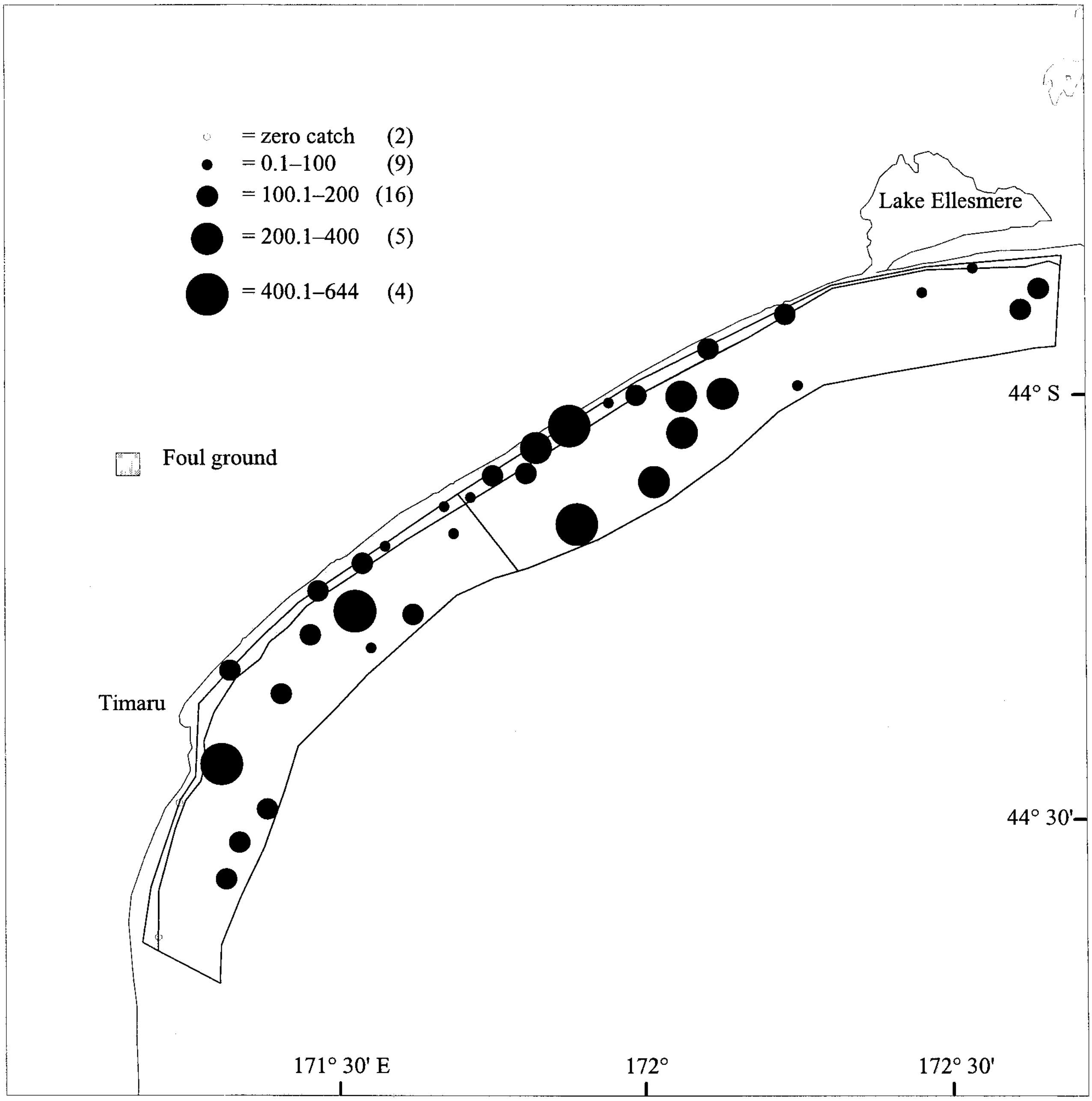


Figure 6—continued

Yellowbelly flounder

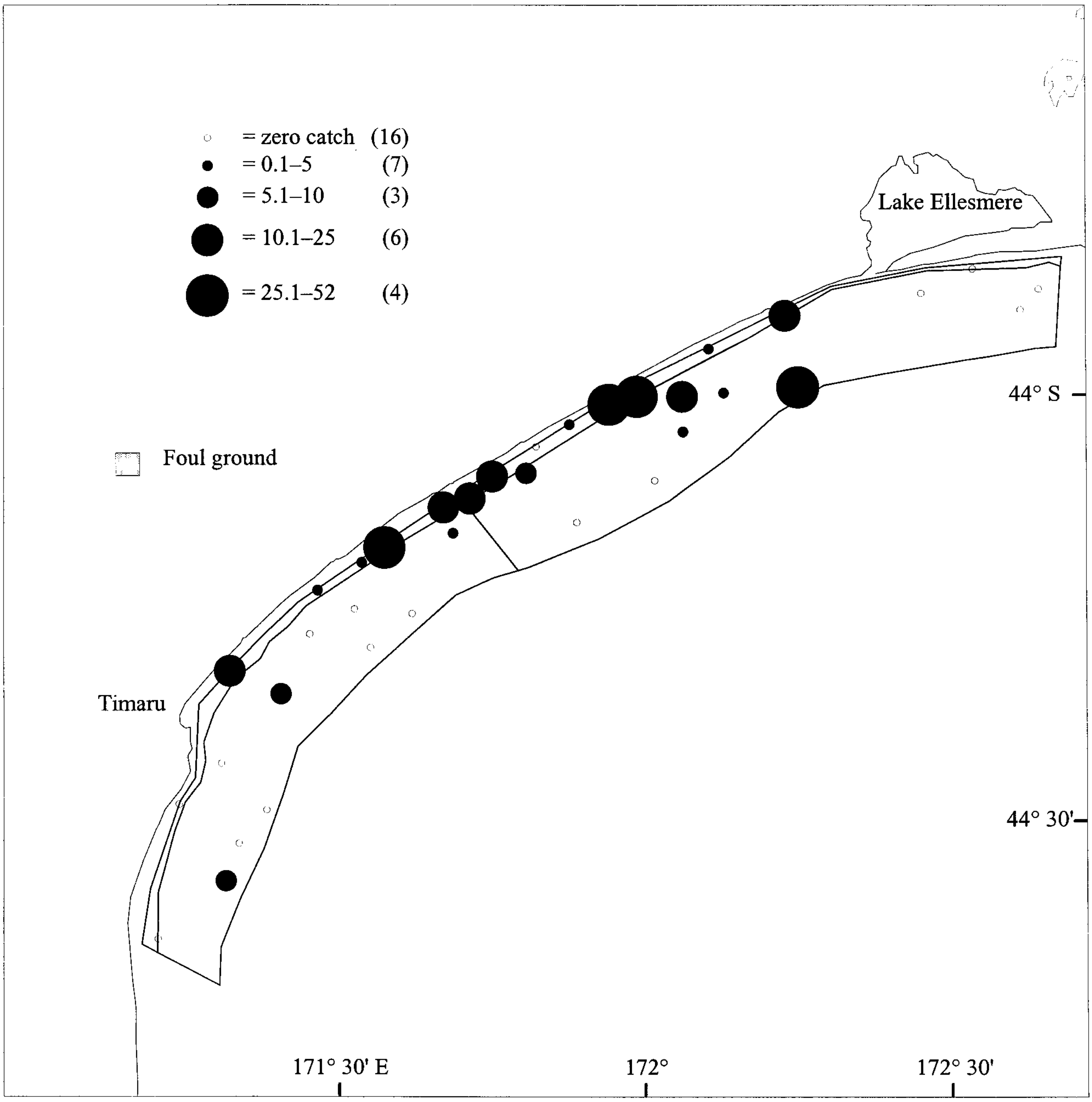


Figure 6—continued

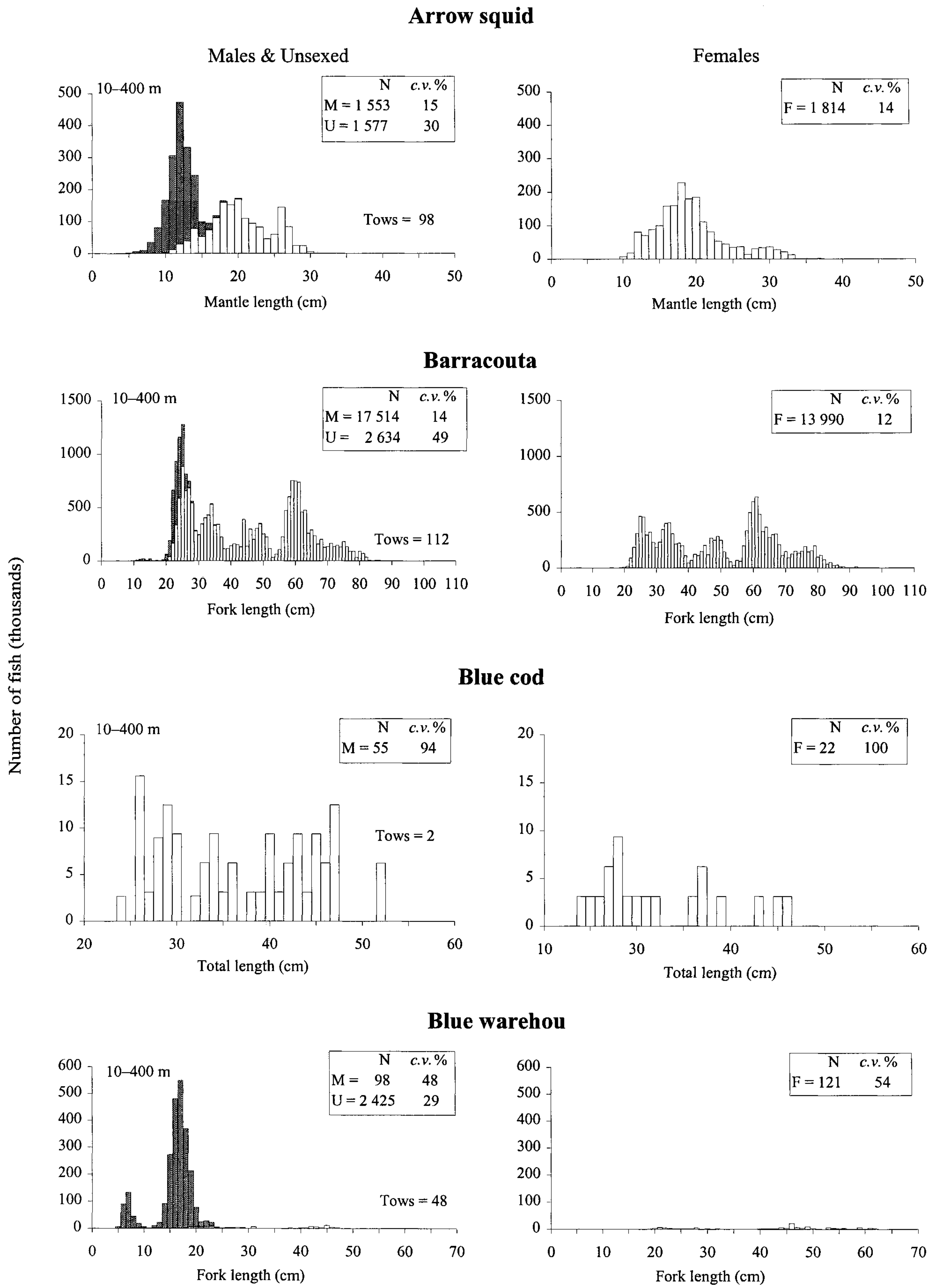


***Figure 7*: Scaled length frequency distributions for the major commercial species, by depth where appropriate. N, estimated population (scaled, thousands); M, male; F, female; U, unsexed (shaded); Tows, number of stations at which species was caught.**

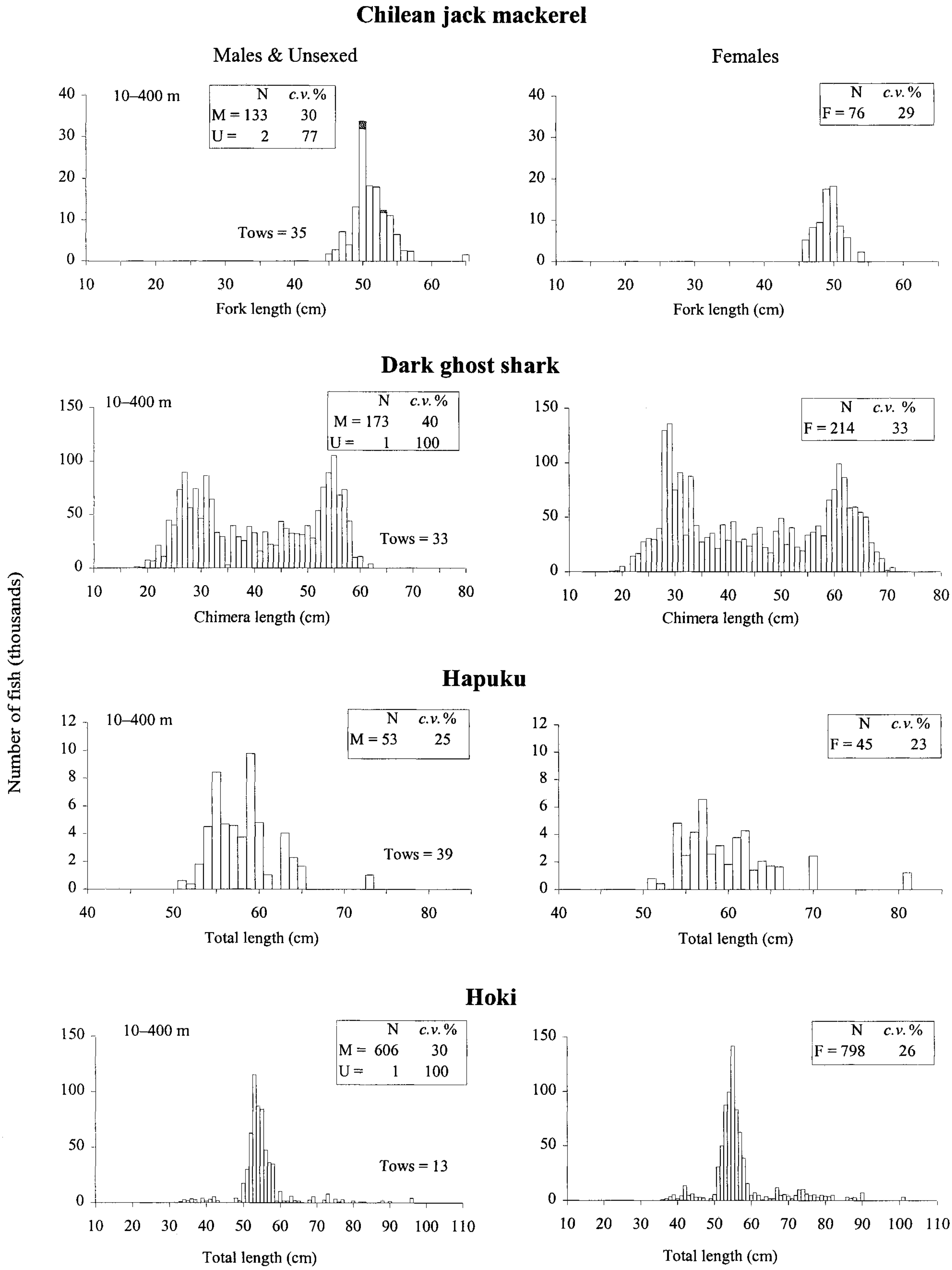


Figure 7—continued

Elephantfish

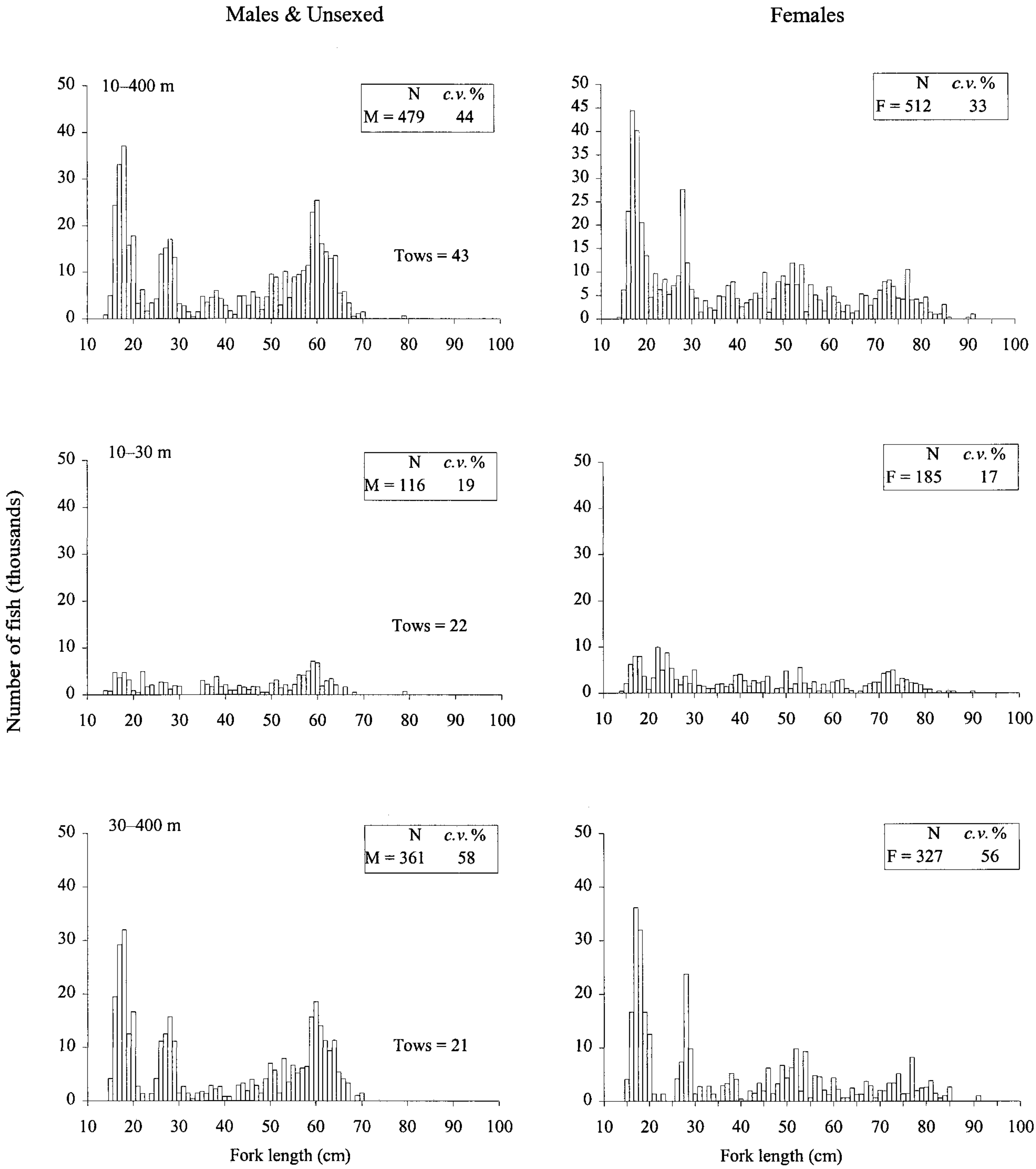


Figure 7—continued

Giant stargazer

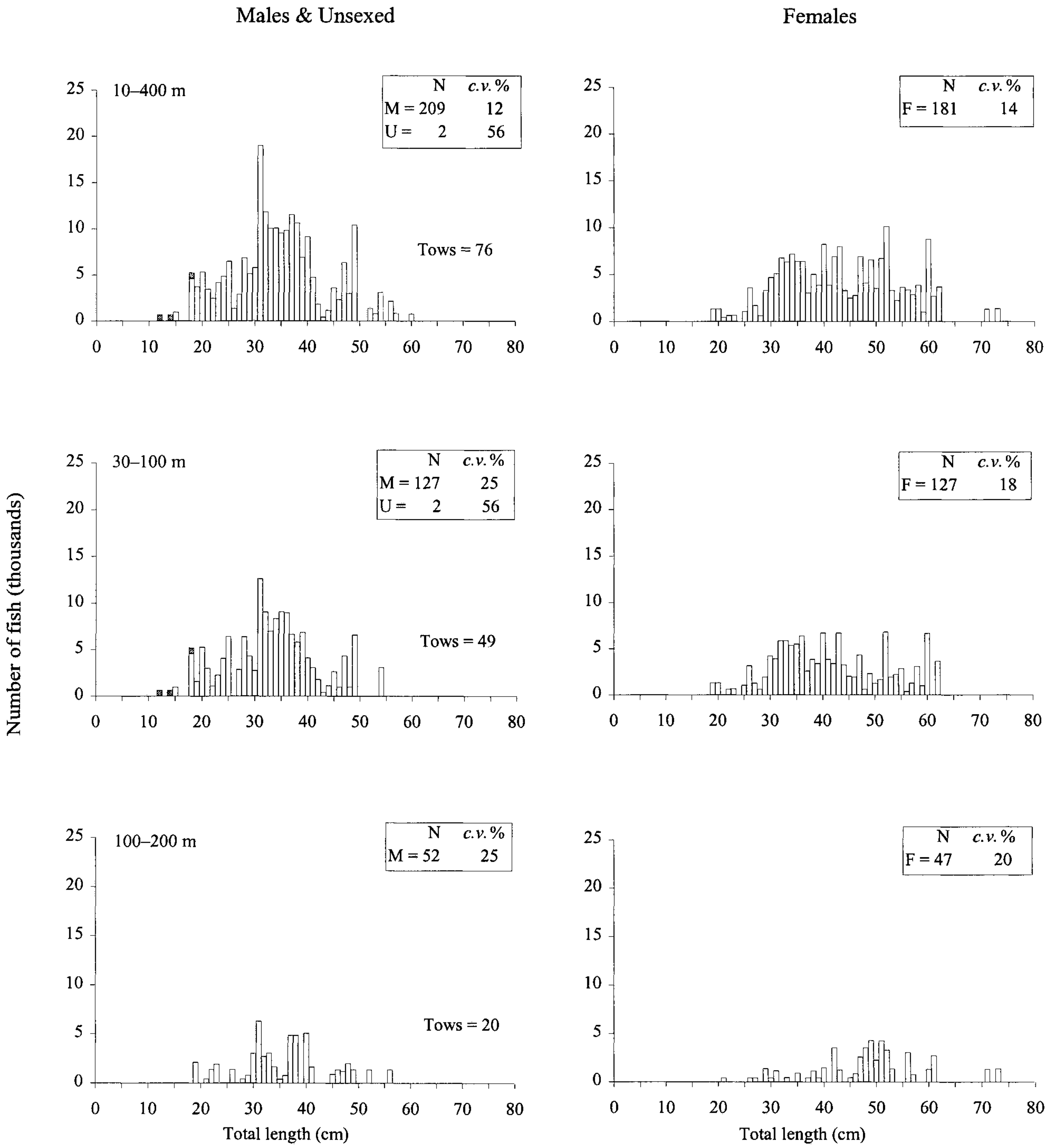


Figure 7—continued

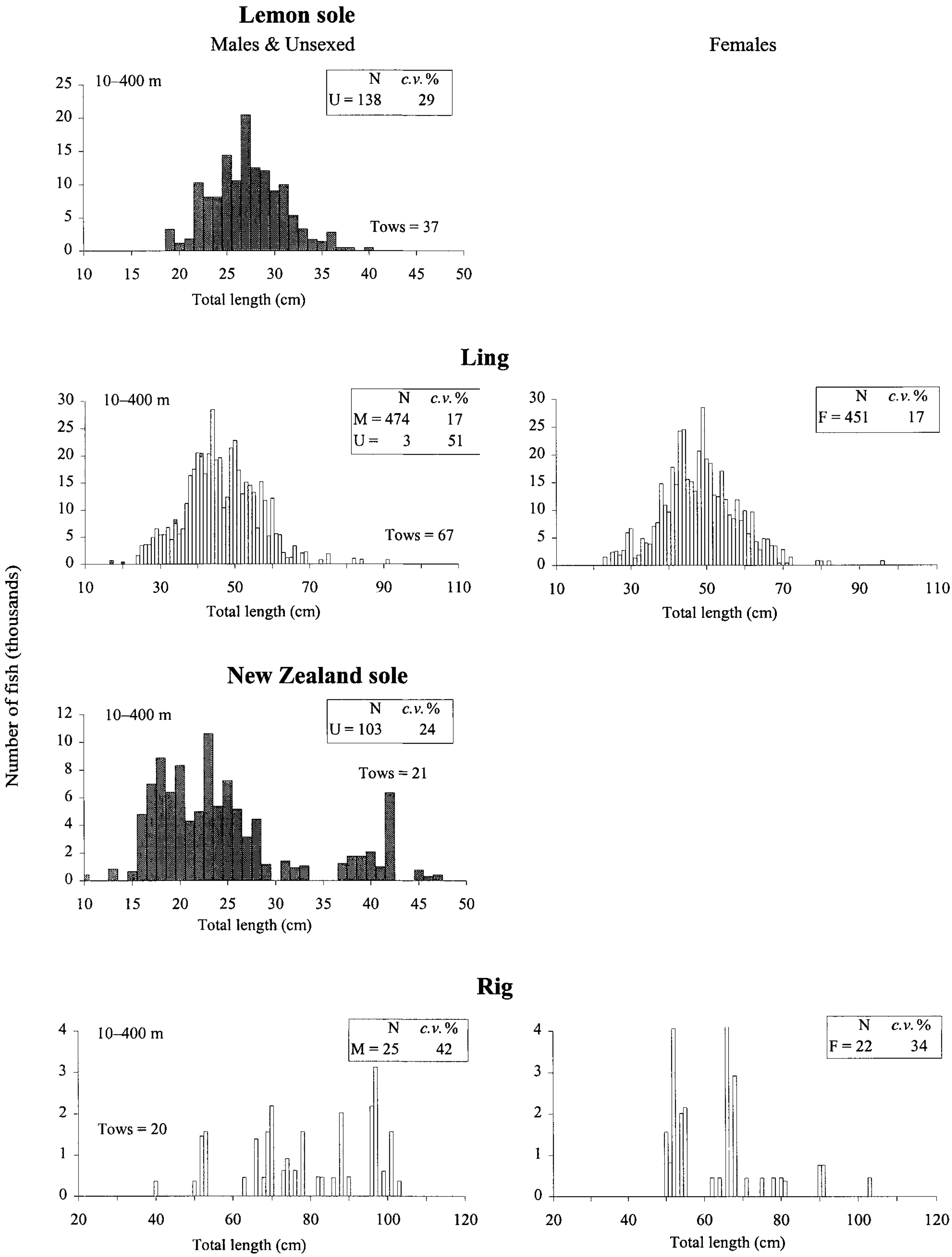


Figure 7—continued

Red cod

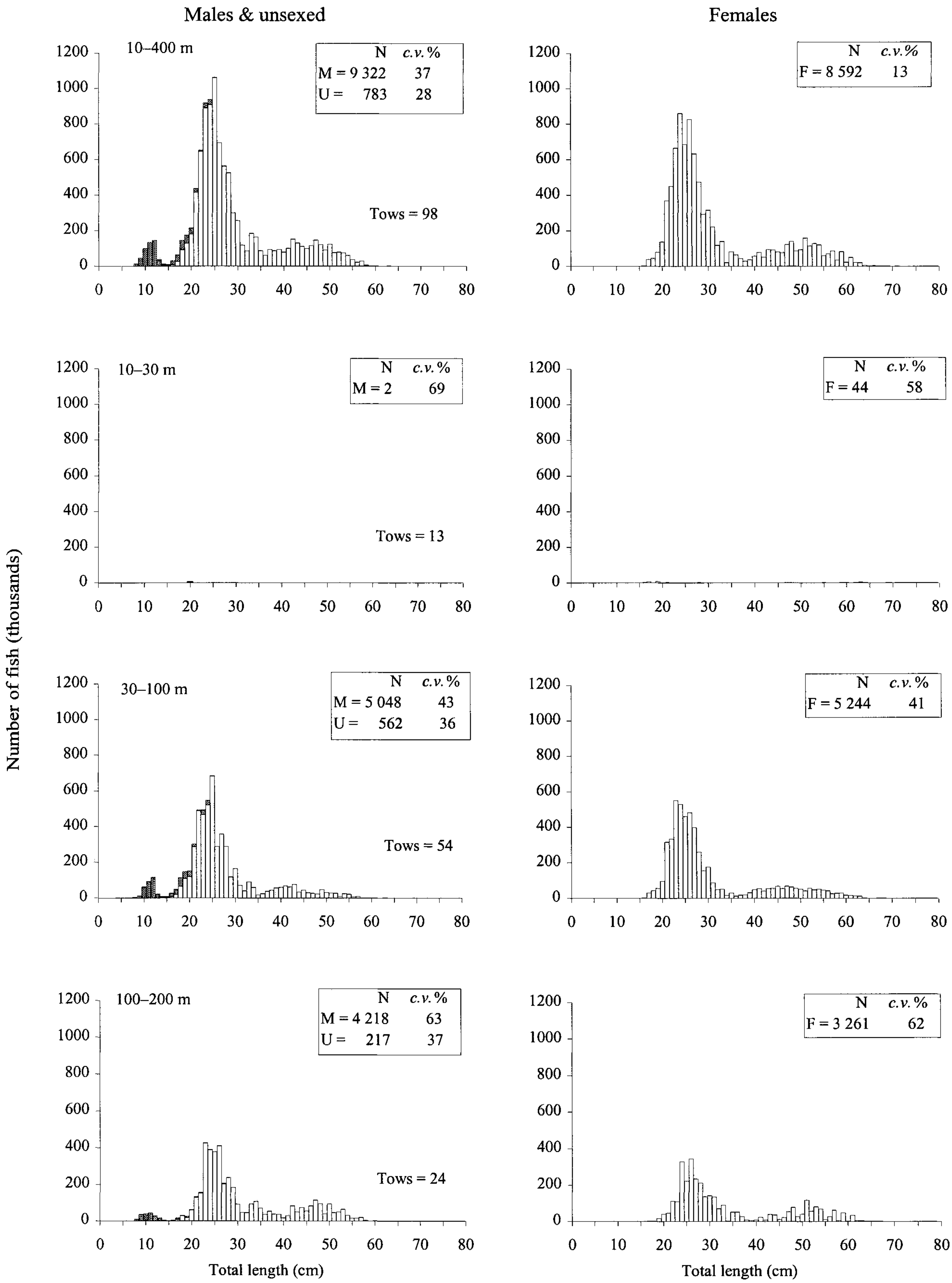
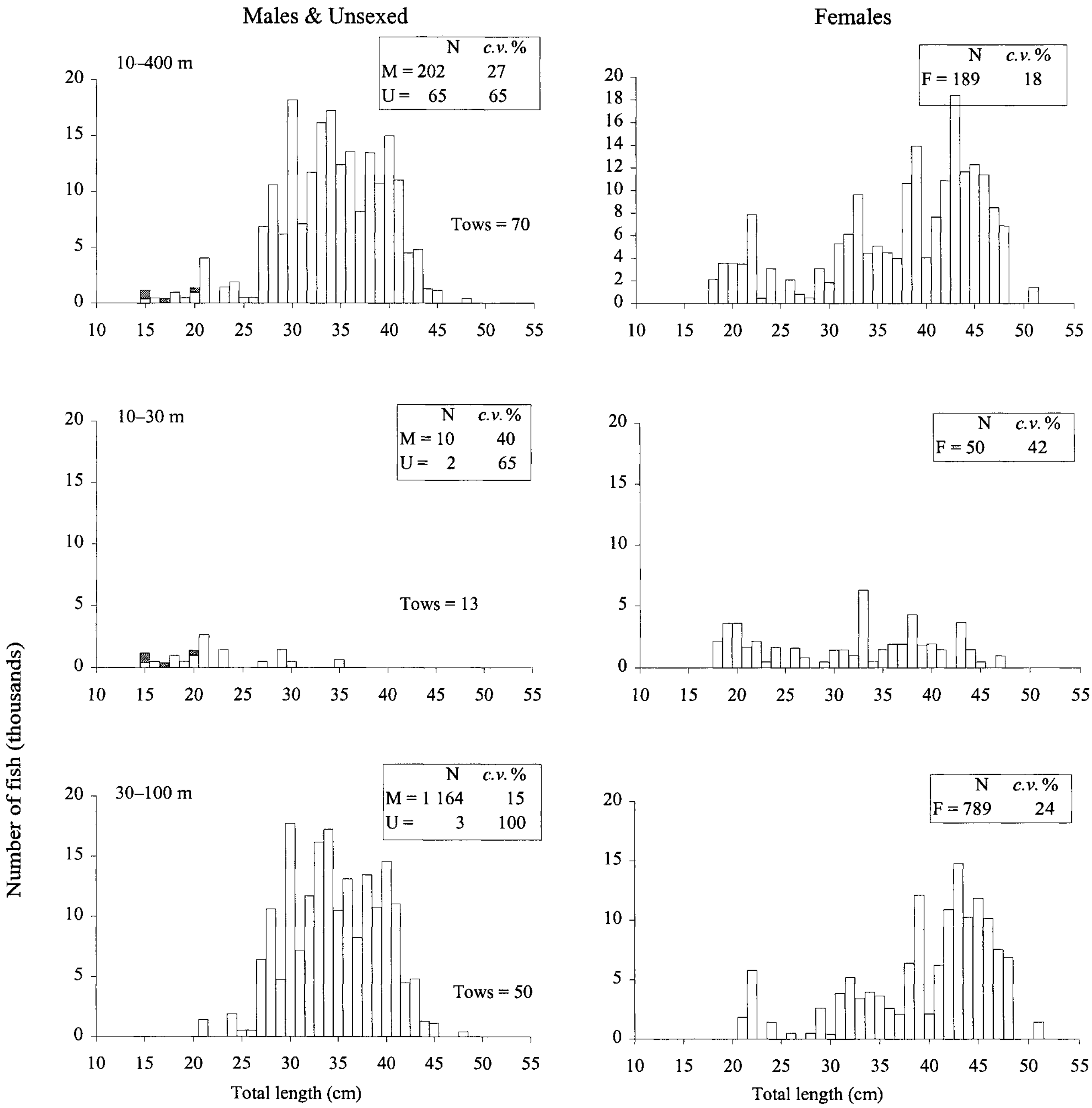


Figure 7—continued

Red gurnard



Rough skate

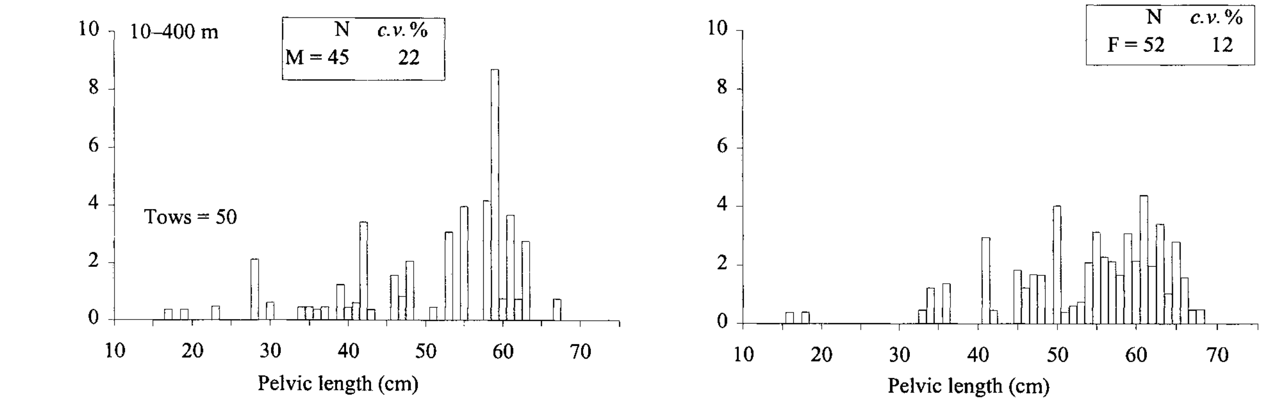


Figure 7—continued

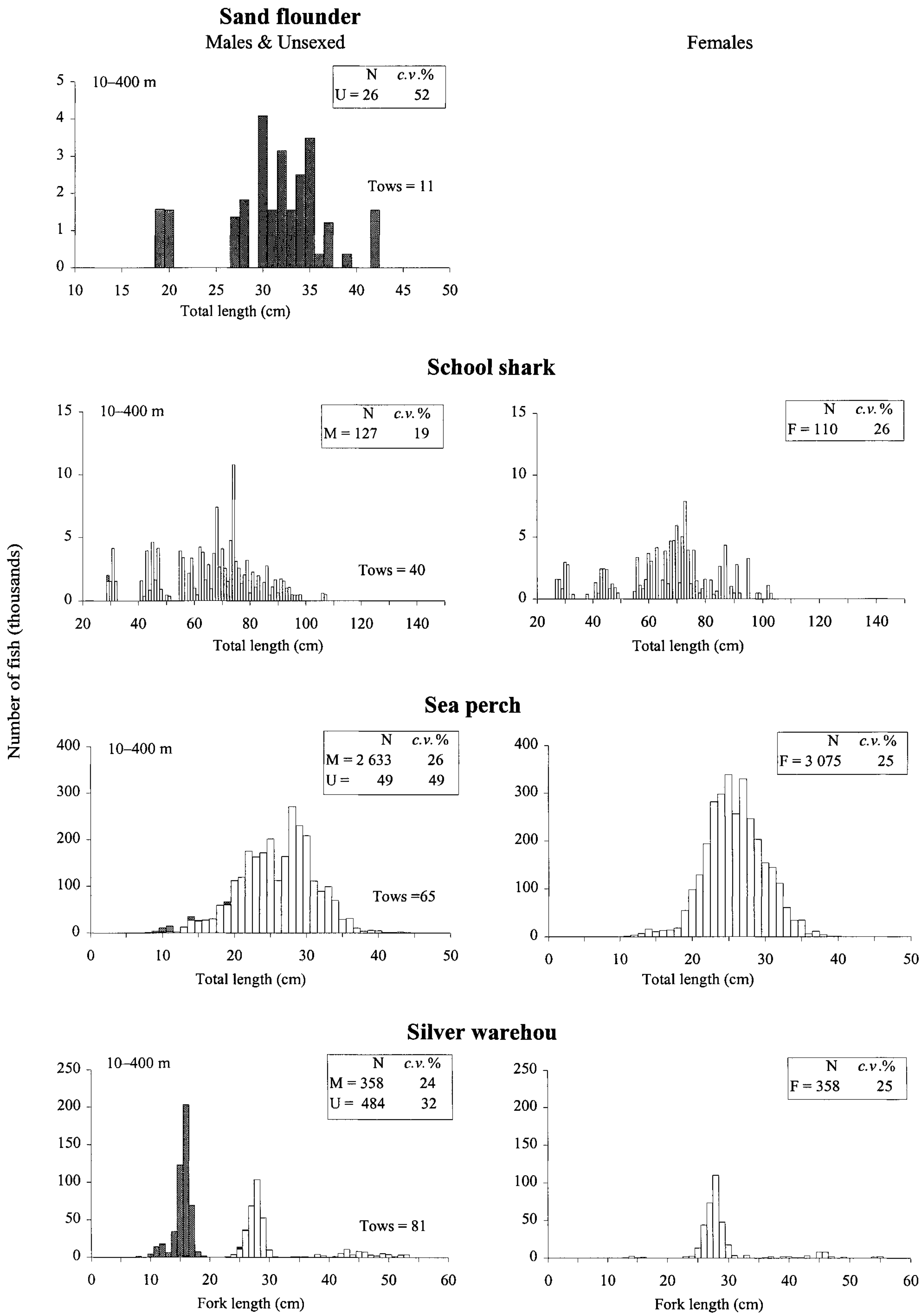


Figure 7—continued

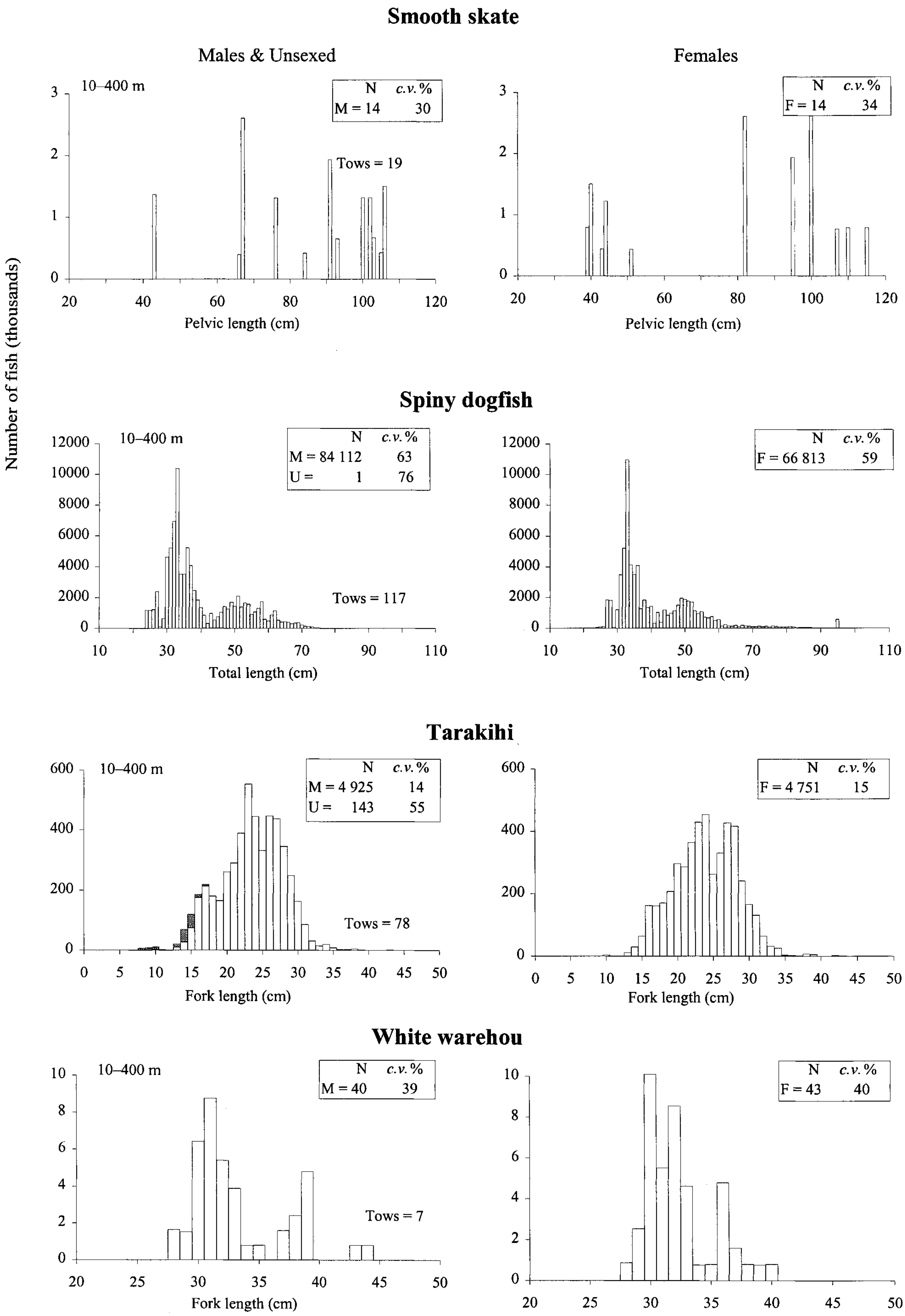


Figure 7—continued

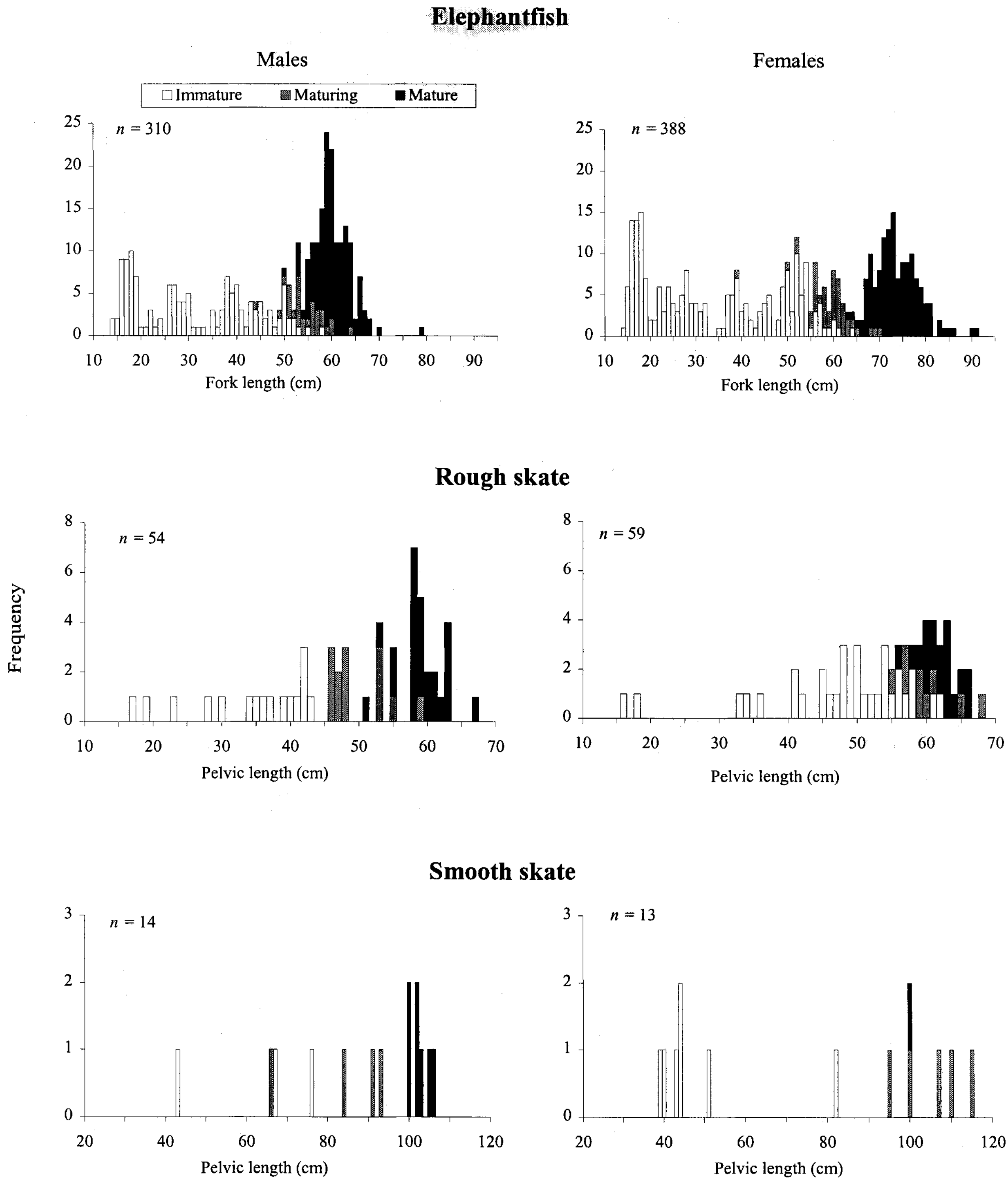


Figure 8 : **Length at maturity for elephantfish, rough skate, and smooth skate (*n*, sample size).**

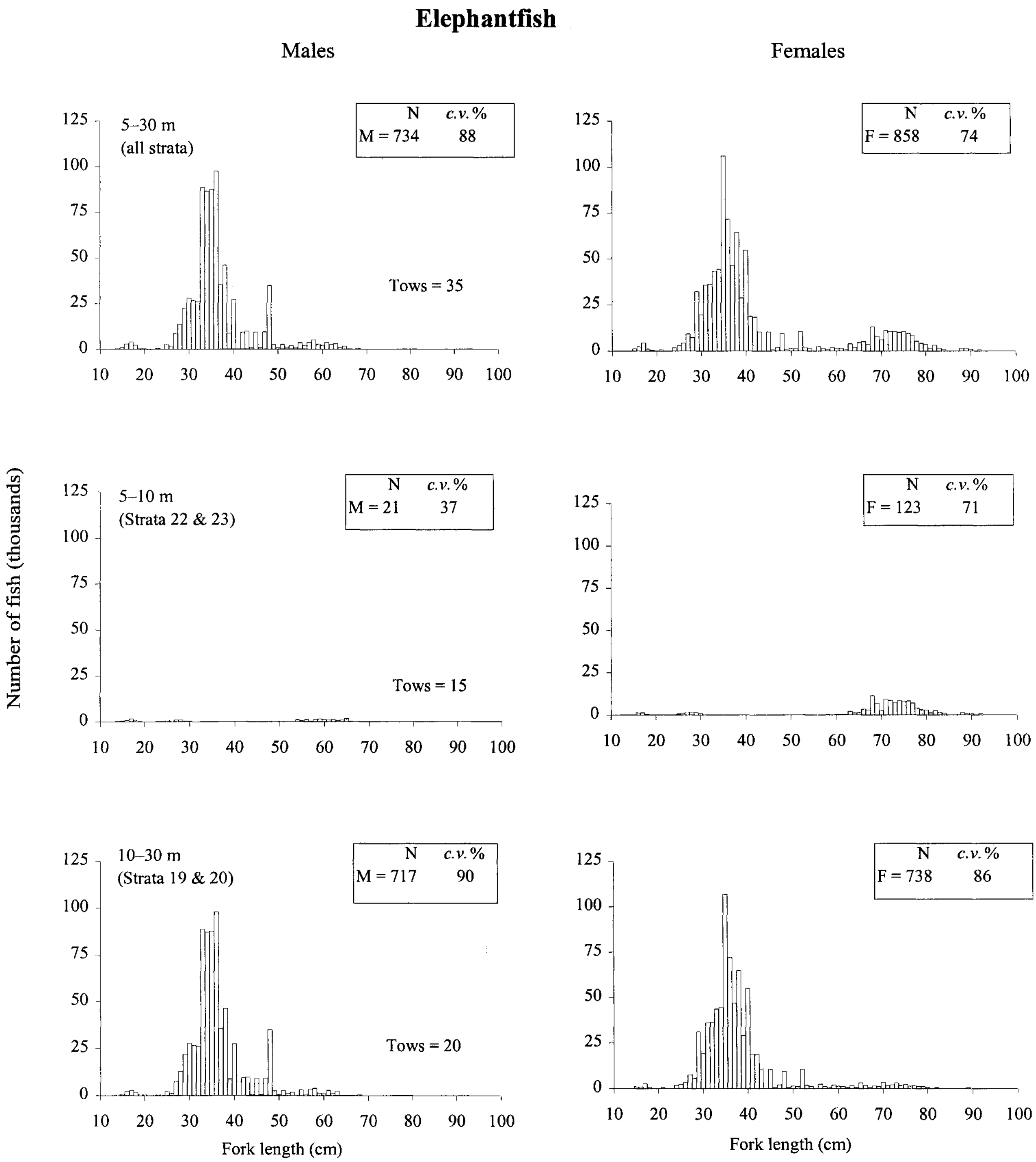


Figure 9: **Scaled length frequency distribution for elephantfish from *Compass Rose*. N, estimated population (thousands); M, male; F, female; Tows, number of stations at which species was caught.**

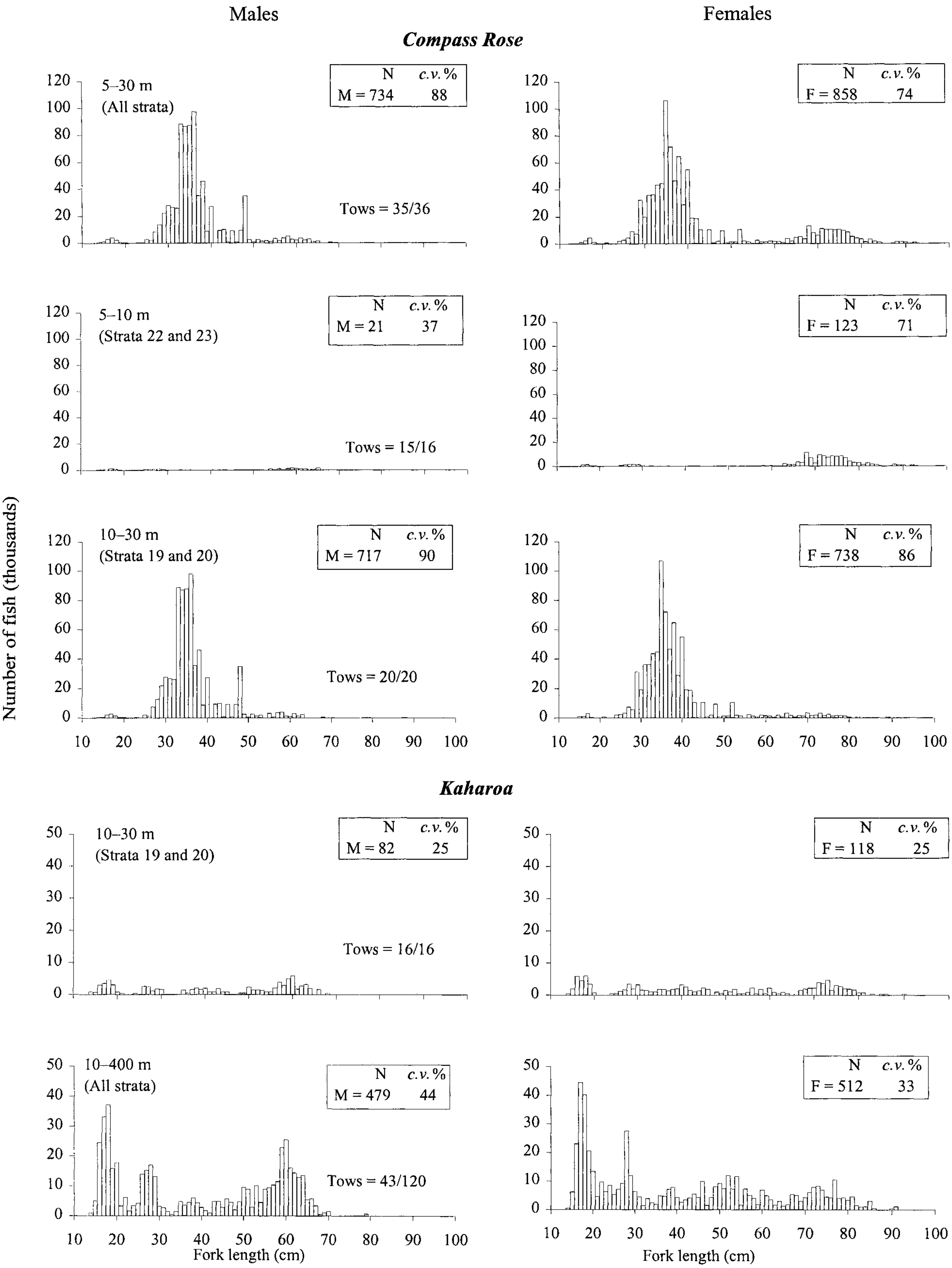


***Figure 10*: Comparison of elephantfish length frequency distributions from *Kaharoa* and *Compass Rose*. N, estimated population (scaled, thousands); M, male; F, female; Tows, number of stations where elephantfish were caught/total number of stations in the area. Note y-axes scales are different for *Compass Rose* and *Kaharoa*.**

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	0.0158	2.6871	350	21.8–92.8	This survey
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	KAH9809
Elephantfish	0.0058	3.1271	702	14.7–91.4	This survey
Giant stargazer	0.0159	3.0130	45	15.8–73.9	This survey
Hapuku	0.0025	3.4155	98	50.2–78.6	KAH9809
Hoki	0.0036	2.9490	1 511	34–102	TAN9601
Lemon sole	0.0080	3.1278	524	14.6–41.2	KAH9809
Ling	0.0011	3.3411	482	32–162	TAN9501
New Zealand sole	0.0098	3.0014	363	12.7–49.7	KAH9809
Red cod	0.0159	2.8580	1 656	8.4–74.3	This survey
Red gurnard	0.0048	3.2031	398	15.4–51.5	This survey
Rig	0.0031	3.0593	123	29.1–115.7	KAH9704
Rough skate	0.0190	3.0227	115	16.1–68	This survey
Sand flounder	0.0207	2.8768	282	13.5–44.5	KAH9809
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	KAH9809
Spiny dogfish	0.0038	3.0108	441	26.6–93.1	This survey
Tarakihi	0.0084	3.2382	326	14.4–43.9	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

Appendix 2: **Summary of *Kaharoa* station data (# indicates phase 2 station).**

				Start of tow		End of tow		Gear depth (m)			Distance	Headline	Surface	Bottom
										Doorspread	trawled	height	temp	temp
Station	Stratum	Date	Time	° ' S	° ' E	° ' S	° ' E	Min.	Max.	(m)	(n. miles)	(m)	(°C)	(°C)
1	7	16-Dec-99	633	43 11.96	173 17.31	43 13.88	173 16.54	49	52	74.9	2	4.9	13.6	13.3
2	7	16-Dec-99	825	43 12.54	173 09.82	43 12.09	173 07.16	42	45	75.2	2	5.5	14.3	13.7
3	7	16-Dec-99	944	43 10.22	173 02.31	43 11.73	173 00.51	41	43	73.7	2	5.2	15.3	13.3
4	18	16-Dec-99	1137	43 20.17	173 05.69	43 22.16	173 05.68	29	31	71.8	2	5.5	15.3	12.5
5	18	16-Dec-99	1400	43 21.09	172 45.90	43 23.08	172 45.79	18	19	72.1	2	5.7	15.9	14.8
6	18	16-Dec-99	1525	43 28.61	172 49.83	43 30.55	172 50.50	20	21	72.7	2	5.7	16.1	14.8
7	19	17-Dec-99	508	43 55.56	172 41.14	43 55.33	172 38.39	24	26	69.8	2	5.6	15.5	14.1
8	005A	17-Dec-99	618	43 57.66	172 37.04	43 58.01	172 34.31	30	31	72.4	2	5.8	15.3	14.0
9	19	17-Dec-99	830	43 53.56	172 17.40	43 54.60	172 15.05	13	15	68.5	2	6.2	15.3	14.2
10	19	17-Dec-99	1126	43 53.69	172 23.74	43 53.32	172 26.46	19	19	69.8	2	5.5	16.2	14.2
11	19	17-Dec-99	1329	43 59.71	172 12.88	44 00.52	172 10.36	26	28	72.4	2	5.7	16.6	14.0
12	19	17-Dec-99	1431	43 59.55	172 08.19	43 59.35	172 05.44	17	20	70.6	2	5.7	16.6	14.1
13	19	17-Dec-99	1532	44 00.43	172 03.18	44 01.42	172 00.78	17	18	71.6	2	5.5	16.3	14.4
14	19	18-Dec-99	510	44 04.72	172 05.73	44 05.49	172 03.17	29	29	72.9	2	5.7	15.3	14.0
15	004A	18-Dec-99	625	44 09.39	172 00.80	44 09.95	171 58.14	35	36	74.7	2	5.6	15.5	14.0
16	19	18-Dec-99	732	44 09.39	171 54.78	44 10.37	171 52.36	29	30	71.6	2	5.5	15.5	13.9
17	003A	18-Dec-99	852	44 13.85	171 46.29	44 14.43	171 43.63	33	35	72.2	2	5.5	15.5	13.8
18	003A	18-Dec-99	1012	44 19.75	171 44.66	44 21.52	171 43.35	48	49	74.3	2.01	5.5	14.8	13.0
19	3	18-Dec-99	1153	44 19.68	171 54.88	44 19.35	171 57.62	56	57	74.3	2	5.5	14.6	13.0
20	4	18-Dec-99	1318	44 18.06	172 01.51	44 17.01	172 03.88	56	57	74.3	2	5.5	15.3	13.0
21	4	18-Dec-99	1455	44 19.25	172 12.74	44 21.24	172 12.93	67	69	71.6	2	5.7	14.8	12.7
22	20	19-Dec-99	507	44 17.01	171 34.97	44 18.72	171 33.52	27	29	71.6	2	5.6	15.0	14.0
23	20	19-Dec-99	615	44 17.20	171 30.69	44 15.21	171 30.92	20	23	71.6	2	5.6	15.5	14.0
24	20	19-Dec-99	732	44 15.66	171 25.65	44 17.61	171 25.05	12	17	71.6	2	5.9	15.7	15.1
25	20	19-Dec-99	837	44 19.53	171 24.45	44 21.10	171 22.72	19	19	71.6	2	6	15.7	14.0
26	20	19-Dec-99	959	44 25.04	171 18.23	44 27.00	171 17.69	18	19	71.6	2	5.5	16.3	14.0
27	20	19-Dec-99	1109	44 27.09	171 21.28	44 29.04	171 20.66	24	24	71.6	2	5.5	16.8	14.2
28	20	19-Dec-99	1208	44 29.18	171 19.17	44 31.18	171 19.16	24	25	71.6	2	5.5	16.6	14.5
29	20	19-Dec-99	1312	44 33.34	171 20.72	44 35.31	171 20.21	28	30	71.6	2	5.5	16.8	
30	2	19-Dec-99	1442	44 42.35	171 19.47	44 44.34	171 19.33	33	33	71.6	2	5.7	16.6	13.4

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)	Surface temp (°C)	Bottom temp (°C)
31	2	20-Dec-99	503	44 55.92	171 37.80	44 54.37	171 39.57	99	99	72.1	2	5.4	14.6	11.3
32	003A	20-Dec-99	852	44 42.63	171 31.28	44 42.81	171 32.75	53	56	71.4	1.06	5.6	15.0	13.3
33	3	20-Dec-99	952	44 43.57	171 38.62	44 42.32	171 40.82	75	80	75.8	2	5.6	14.8	12.0
34	3	20-Dec-99	1138	44 40.38	171 47.21	44 38.82	171 48.95	88	90	75.7	2	5.7	14.8	12.6
35	3	20-Dec-99	1308	44 34.86	171 55.32	44 33.78	171 57.67	87	87	78.1	2	5.8	14.8	12.4
36	3	20-Dec-99	1454	44 29.31	172 07.53	44 27.84	172 09.40	81	85	77.4	2	5.9	14.8	12.2
37	4	21-Dec-99	506	44 11.62	172 11.45	44 11.62	172 14.23	52	52	74.1	2	5.6	14.6	13.0
38	4	21-Dec-99	630	44 12.32	172 21.66	44 11.60	172 24.25	56	58	72.9	2	5.6	14.8	12.7
39	4	21-Dec-99	740	44 08.70	172 25.20	44 07.32	172 27.20	54	55	72.1	2	5.6	14.8	13.0
40	004A	21-Dec-99	852	44 04.71	172 24.22	44 03.10	172 25.85	49	51	72	2	5.6	15.3	13.3
41	004A	21-Dec-99	1003	44 03.13	172 29.92	44 01.65	172 31.77	53	54	72.6	2	5.6	15.9	13.3
42	005A	21-Dec-99	1210	43 58.15	172 49.62	43 56.95	172 51.83	46	54	72.5	2	5.6	15.9	13.4
43	005A	21-Dec-99	1352	43 53.88	173 00.80	43 54.64	172 58.24	40	42	69.7	2	5.5	15.7	14.0
44	13	29-Dec-99	527	43 13.26	173 30.00	43 15.26	173 29.98	106	108	69.2	2	6	14.1	11.2
45	13	29-Dec-99	729	43 17.83	173 42.08	43 19.29	173 43.94	127	130	81.7	2	5.7	12.9	10.7
46	17	29-Dec-99	910	43 18.57	173 48.82	43 20.37	173 50.01	310	320	85.4	2	5.8	13.8	9.2
47	6	29-Dec-99	1534	43 31.93	173 15.55	43 33.89	173 15.00	51	53	76.7	2	6	15.4	14.2
48	13	30-Dec-99	504	43 22.32	173 45.82	43 24.08	173 47.12	118	124	77.2	2	5.8	13.9	11.0
49	6	30-Dec-99	623	43 27.00	173 43.72	43 27.37	173 41.03	87	91	76	2	5.8	13.6	11.9
50	6	30-Dec-99	857	43 42.23	173 48.29	43 44.06	173 47.19	97	98	71.3	2	5.6	14.3	11.8
51	12	30-Dec-99	1040	43 42.64	173 56.78	43 40.63	173 56.78	132	133	80.8	2	5.8	14.1	10.7
52	17	30-Dec-99	1228	43 44.13	174 02.83	43 46.08	174 02.23	338	348	87.2	2	5.7	14.3	8.2
53	12	30-Dec-99	1426	43 52.47	173 53.48	43 54.15	173 51.98	150	151	78.8	2	5.8	14.3	10.7
54	12	31-Dec-99	517	43 55.29	173 40.83	43 56.36	173 39.38	103	103	73.8	1.5	5.8	14.5	11.4
55	11	31-Dec-99	658	43 56.55	173 39.88	43 57.91	173 37.86	104	105	72.2	2	5.8	14.8	11.5
56	17	31-Dec-99	925	44 00.57	173 51.25	44 01.88	173 49.16	391	391	86.6	2	5.6	14.1	8.2
57	16	31-Dec-99	1119	44 05.47	173 42.16	44 06.79	173 40.07	352	354	86.6	2	5.5	14.8	8.9
58	11	31-Dec-99	1334	44 08.50	173 24.07	44 09.56	173 21.72	112	117	76.5	2	5.8	15.3	12.0
59	5	31-Dec-99	1525	44 05.32	173 13.50	44 06.50	173 12.23	87	94	74.3	1.5	5.7	15.0	12.2
60	1	1-Jan-00	648	45 31.21	171 08.65	45 32.13	171 08.09	97	97	68.7	1	5.8	14.8	11.8

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)	Surface temp (°C)	Bottom temp (°C)
61	1	1-Jan-00	810	45 29.53	171 08.67	45 27.57	171 09.23	75	85	73.2	2	5.8	15.0	12.2
62	1	1-Jan-00	952	45 26.79	171 09.72	45 24.85	171 10.40	69	75	68.2	2	6	15.0	12.0
63	1	1-Jan-00	1113	45 24.15	171 01.76	45 22.24	171 02.58	43	45	68.6	2	5.8	15.5	12.5
64	1	1-Jan-00	1259	45 18.17	171 09.80	45 16.75	171 11.79	51	55	74.1	2	5.8	15.7	12.7
65	1	1-Jan-00	1423	45 17.55	171 18.25	45 16.61	171 19.41	90	94	74.6	1.25	5.7	15.9	11.9
66	14	2-Jan-00	514	45 19.85	171 28.17	45 18.19	171 29.73	204	207	84.7	2	5.6	14.6	10.4
67	8	2-Jan-00	650	45 13.85	171 30.02	45 12.10	171 28.66	118	120	76.2	2	5.7	15.1	11.4
68	2	2-Jan-00	832	45 08.54	171 24.35	45 07.66	171 25.01	97	99	74.7	1	5.7	15.7	11.8
69	21	5-Jan-00	537	44 45.15	171 17.30	44 47.14	171 17.30	25	27	73.6	2	5.7	14.3	14.1
70	2	5-Jan-00	703	44 49.93	171 23.67	44 51.93	171 23.77	42	44	71.9	2	5.7	14.6	14.2
71	2	5-Jan-00	835	44 51.48	171 32.47	44 53.46	171 32.10	63	67	71.2	2	5.8	13.8	13.3
72	2	5-Jan-00	1002	44 55.17	171 34.56	44 56.53	171 32.51	81	89	76.3	2	5.7	13.4	12.6
73	2	5-Jan-00	1208	45 02.64	171 29.76	45 04.34	171 28.28	94	96	74.6	2	5.7	12.9	12.2
74	2	5-Jan-00	1359	45 02.40	171 27.64	45 00.78	171 29.28	84	84	79.6	2	5.8	13.4	12.1
75	2	5-Jan-00	1522	45 00.16	171 26.31	45 01.87	171 24.85	64	65	76.7	2	5.8	14.1	12.6
76	21	6-Jan-00	505	45 03.13	171 07.23	45 04.51	171 06.38	15	16	80.5	1.5	5.6	14.3	14.1
77	21	6-Jan-00	611	45 06.34	171 09.82	45 08.23	171 08.89	25	29	73.8	2	5.7	14.3	13.2
78	2	6-Jan-00	732	45 09.55	171 14.04	45 07.92	171 15.67	49	51	73.2	2	5.7	13.8	12.7
79	2	6-Jan-00	905	45 07.64	171 17.70	45 09.56	171 18.49	57	60	77.1	2	5.7	14.2	12.5
80	2	6-Jan-00	1021	45 11.98	171 21.62	45 13.96	171 22.01	95	99	76.1	2	5.8	13.8	11.6
81	8	6-Jan-00	1213	45 15.50	171 24.51	45 14.00	171 26.38	113	117	76.6	2	5.7	12.7	11.4
82	8	6-Jan-00	1432	45 03.05	171 40.66	45 01.87	171 42.94	127	129	75.8	2	5.5	12.9	11.1
83	3	7-Jan-00	504	44 49.00	171 37.81	44 47.71	171 39.95	84	87	74.7	2	5.5	14.1	12.3
84	3	7-Jan-00	715	44 43.90	171 44.80	44 42.77	171 44.05	87	90	72.4	1.25	5.7	14.1	12.4
85	3	7-Jan-00	920	44 35.63	171 40.79	44 34.28	171 38.73	62	66	76.9	2	5.7	14.8	13.2
86	9	8-Jan-00	511	44 44.30	171 56.14	44 42.46	171 57.24	108	110	78.4	2	5.6	14.3	11.6
87	9	8-Jan-00	705	44 43.20	172 05.06	44 45.20	172 05.15	127	130	77.3	2	5.7	13.2	10.6
88	9	8-Jan-00	843	44 46.05	172 04.30	44 48.05	172 04.32	131	136	72.5	2	5.6	13.1	10.3
89	14	8-Jan-00	1101	44 46.81	172 15.68	44 45.50	172 17.79	200	217	86.3	2	5.8	12.2	10.5
90	14	8-Jan-00	1315	44 39.72	172 32.02	44 38.55	172 34.29	297	302	91.5	2	5.8	12.0	9.9

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)	Surface temp (°C)	Bottom temp (°C)
91	10	8-Jan-00	1515	44 30.02	172 39.27	44 28.87	172 41.57	139	139	82.5	2	5.8	13.1	11.0
92	10	9-Jan-00	500	44 30.76	172 29.38	44 29.98	172 26.81	112	120	75.3	2	5.6	13.1	11.2
93	10	9-Jan-00	634	44 27.70	172 27.53	44 27.80	172 25.46	104	107	70.5	1.5	5.7	13.1	11.8
94	4	9-Jan-00	759	44 26.95	172 22.09	44 26.15	172 19.54	86	91	73	2	5.7	13.5	12.1
95	4	9-Jan-00	936	44 23.26	172 12.69	44 22.23	172 10.33	69	71	73.9	2	5.7	14.8	13.0
96	4	9-Jan-00	1151	44 22.55	172 21.21	44 21.72	172 23.76	76	77	76.9	2	5.4	15.9	12.5
97	4	9-Jan-00	1309	44 20.54	172 27.08	44 20.67	172 29.86	76	80	74.6	2	5.7	16.6	12.3
98	4	9-Jan-00	1439	44 22.35	172 35.16	44 21.54	172 37.71	97	100	74.6	2	5.7	16.1	11.8
99	4	10-Jan-00	507	44 12.57	172 43.61	44 13.71	172 42.91	77	78	77.2	1.25	5.8	14.1	12.0
100	5	10-Jan-00	616	44 14.71	172 44.51	44 15.38	172 47.13	84	85	77.8	2	5.7	13.8	12.0
101	11	10-Jan-00	812	44 18.78	172 58.95	44 18.08	173 01.56	121	124	76.4	2	5.7	13.6	10.9
102	16	10-Jan-00	1004	44 23.90	173 05.79	44 22.86	173 08.16	216	220	80.2	2	6	13.4	9.8
103	16	10-Jan-00	1133	44 23.38	173 11.12	44 22.28	173 13.46	321	325	92.7	2.01	5.7	14.1	9.1
104	5	10-Jan-00	1350	44 10.74	173 08.52	44 09.91	173 09.32	98	99	74.5	1	5.6	14.3	11.5
105 #	005A	10-Jan-00	1540	43 58.91	173 00.52	43 59.04	172 59.15	74	76	73.7	1	5.7	15.0	13.3
106 #	1	11-Jan-00	509	45 30.75	171 07.06	45 32.45	171 05.57	81	81	75.7	2	5.7	12.7	11.7
107 #	1	11-Jan-00	634	45 30.40	171 02.11	45 28.42	171 02.46	53	55	71.4	2	5.8	14.1	12.5
108 #	9	11-Jan-00	1127	45 01.90	171 43.89	45 00.52	171 45.93	127	129	81.8	2	5.8	12.9	10.9
109 #	9	11-Jan-00	1310	44 55.87	171 39.55	44 54.17	171 41.02	102	102	73.1	2	5.8	13.1	11.1
110 #	9	11-Jan-00	1505	44 54.42	171 49.86	44 52.56	171 50.87	120	123	77.5	2	5.7	14.1	10.5
111 #	9	12-Jan-00	501	44 43.86	172 17.93	44 45.17	172 15.82	138	142	78.4	2	5.7	13.1	9.7
112 #	9	12-Jan-00	705	44 51.10	172 03.80	44 52.74	172 02.20	139	144	77.8	2.01	5.7	13.1	10.3
113 #	9	12-Jan-00	852	44 46.58	171 56.13	44 44.69	171 57.03	113	118	76.3	2	5.7	14.3	11.0
114 #	3	12-Jan-00	1025	44 38.70	171 56.78	44 36.78	171 57.59	94	98	72.5	2	5.7	14.6	11.6
115 #	3	12-Jan-00	1157	44 35.19	171 50.22	44 36.88	171 48.73	79	81	73.2	2	5.6	15.0	12.6
116 #	3	12-Jan-00	1339	44 39.09	171 38.38	44 37.11	171 38.11	64	67	77.9	2	5.7	15.0	12.9
117 #	3	13-Jan-00	503	44 27.21	172 02.10	44 25.64	172 03.81	72	74	78.3	2	5.6	15.0	13.0
118 #	005A	13-Jan-00	917	44 05.25	172 39.50	44 03.85	172 41.48	63	65	76.7	2	5.6	15.5	12.7
119 #	005A	13-Jan-00	1053	44 03.15	172 50.64	44 02.43	172 53.23	72	74	77.2	2	5.7	15.9	12.5
120 #	7	14-Jan-00	453	43 06.68	173 15.90	43 08.15	173 14.04	52	55	78	2	5.7	16.3	14.0

Appendix 3 : **Summary of *Compass Rose* station data (* indicates stations with poor gear performance).**

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)	Warp length	Surface temp (°C)
1	22	16-Dec-99	600	44 05.68	171 45.07	44 04.84	171 47.81	9	11	45.2	2.10	2.5	110	16.3
2	19	16-Dec-99	731	44 05.50	171 48.37	44 04.46	171 50.82	14	14	46.7	2.06	2.5	110	16.0
3	22	16-Dec-99	908	44 03.66	171 49.38	44 02.55	171 51.47	9	10	43.6	2.08	2.5	110	16.3
4	22	16-Dec-99	1025	44 02.07	171 52.67	44 01.29	171 55.45	9	10	42.1	2.02	2.5	110	16.6
5	22	16-Dec-99	1152	44 00.54	171 56.53	43 59.30	171 58.73	7	9	45.2	2.04	2.5	110	17.5
6	22	16-Dec-99	1330	43 59.99	171 59.22	43 58.76	172 01.60	11	11	45.1	2.10	2.5	110	17.6
7 *	22	16-Dec-99	1514	43 57.51	172 04.09	43 56.97	172 05.47	9	9	45.1	1.11	2.5	110	17.8
8	22	16-Dec-99	1627	43 56.71	172 06.30	43 57.68	172 03.69	9	9	33.3	2.08	2.5	60	17.2
9	19	17-Dec-99	501	43 53.95	172 36.73	43 54.62	172 34.01	19	20	49.7	2.07	2.5	110	16.2
10	19	17-Dec-99	640	43 52.49	172 38.48	43 51.72	172 39.81	18	18	42.1	2.05	2.5	110	16.5
11 *	22	17-Dec-99	829	43 50.48	172 34.70	43 50.91	172 31.91	9	10	32.3	2.02	2.5	110	16.3
12	22	17-Dec-99	920	43 51.08	172 32.12	43 50.62	172 34.89	8	12	30	2.04	2.5	60	16.3
13	19	17-Dec-99	1205	43 52.80	172 27.11	43 53.27	172 24.34	16	16	45.1	2.00	2.5	110	17.7
14	22	17-Dec-99	1410	43 54.28	172 13.83	43 55.21	172 11.13	7	11	32.3	2.11	2.5	110	17.9
15	19	17-Dec-99	1616	43 59.32	172 15.06	43 58.60	172 18.03	26	29	45.1	2.18	2.5	110	18.8
16	19	18-Dec-99	510	43 59.83	172 07.76	43 00.37	172 05.52	17	19	48.2	2.04	2.5	110	15.4
17	19	18-Dec-99	647	44 00.02	172 03.72	44 02.03	172 03.62	16	20	49.7	2.00	2.5	110	15.4
18	19	18-Dec-99	810	44 02.59	172 03.79	44 04.68	172 03.78	22	26	45.1	2.08	2.5	110	15.5
19	20	18-Dec-99	1226	44 09.77	171 41.22	44 11.76	171 39.94	17	20	49.7	2.02	2.5	110	16.3
20	23	18-Dec-99	1419	44 10.66	171 34.45	44 12.48	171 33.10	10	12	45.2	2.09	2.5	110	16.6
21	23	18-Dec-99	1552	44 11.83	171 32.22	44 13.70	171 30.34	10	11	48.9	2.00	2.5	110	16.4
22	19	19-Dec-99	516	44 06.06	172 01.00	44 07.43	171 59.00	26	27	51.2	2.00	2.5	110	16.0
23	19	19-Dec-99	656	44 09.02	171 53.40	44 10.04	171 50.49	25	25	46.7	2.01	2.5	110	16.6
24	23	19-Dec-99	906	44 07.23	171 42.88	44 08.55	171 40.66	12	14	45.2	2.05	2.5	110	16.6
25	20	19-Dec-99	1131	44 15.09	171 31.52	44 14.44	171 32.34	19	19	45.2	2.04	2.5	110	17.9
26	20	19-Dec-99	1318	44 17.79	171 33.08	44 19.38	171 31.51	26	27	45.1	2.03	2.5	110	18.2
27	20	19-Dec-99	1453	44 16.84	171 27.12	44 14.92	171 27.59	14	17	44.2	1.94	2.5	110	18.4
28	23	19-Dec-99	1610	44 13.76	171 27.88	44 15.09	171 25.66	9	9	32.3	2.04	2.5	110	19.1
29 *	23	20-Dec-99	513	44 33.74	171 12.05	44 35.70	171 11.50	13	14	39.1	2.00	2.5	110	16.6

Appendix 3—*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)	Warp length	Surface temp (°C)
30	23	20-Dec-99	726	44 38.33	171 12.29	44 40.10	171 12.59	15	17	34.5	1.49	2.5	110	16.5
31 *	20	20-Dec-99	936	44 40.05	171 13.40	44 37.94	171 13.17	19	19	43.6	2.08	2.5	110	16.4
32	20	20-Dec-99	1201	44 34.20	171 18.90	44 32.40	171 19.48	25	25	42.1	2.02	2.5	110	17.1
33	20	20-Dec-99	1330	44 31.61	171 20.18	44 29.69	171 21.25	24	24	45.1	2.03	2.5	110	17.0
34	20	20-Dec-99	1511	44 29.24	171 22.89	44 27.00	171 23.20	23	25	43.6	2.25	2.5	110	16.9
35	23	21-Dec-99	512	44 07.87	171 40.29	44 09.00	171 37.94	10	11	42.1	2.05	2.5	110	16.7
36	20	21-Dec-99	725	44 15.40	171 37.20	44 16.64	171 34.96	24	25	45.1	2.00	2.5	110	16.4
37	23	21-Dec-99	1021	44 19.37	171 19.26	44 19.95	171 18.27	7	7	31.5	2.00	2.5	60	18.0
38	20	21-Dec-99	1219	44 21.02	171 24.26	44 22.82	171 22.88	20	21	49.7	2.11	2.5	110	19.9
39	20	21-Dec-99	1404	44 25.97	171 18.47	44 27.88	171 17.63	19	19	48.2	2.00	2.5	116	18.0
40	23	21-Dec-99	1537	44 28.84	171 14.31	44 30.61	171 12.85	8	9	34.5	2.00	2.5	60	18.9

Appendix 4: **Species codes, common names, scientific names, total catch, percent occurrence (Occ. %), and depth ranges of all species caught by *Kaharoa***

Species code	Common name	Scientific name	Catch (kg)	Occ. %	Depth (m) Min	Max
ANC	Anchovy	*Engraulis australis*	1.6	3	18	33
API	Alert pigfish	*Alertichthys blacki*	0.1	1	352	354
BAR	Barracouta	*Thyrsites atun*	24 783.9	93	12	302
BCO	Blue cod	*Parapercis colias*	127	2	43	97
BRI	Brill	*Colistium guntheri*	3.3	3	13	26
CAR	Carpet shark	*Cephaloscyllium isabella*	538.6	54	25	217
CAS	Oblique banded rattail	*Caelorinchus aspercephalus*	434.9	14	112	391
CBE	Crested bellowsfish	*Notopogon lilliei*	726.3	40	40	144
CBI	Two saddle rattail	*Caelorinchus biclinozonalis*	2029.5	41	18	302
CBO	Bollons' rattail	*C. bollonsi*	110	3	204	391
CDO	Capro dory	*Capromimus abbreviatus*	6.2	3	72	220
CON	Conger eel	*Conger* spp.	2.4	1	20	21
DCS	Dawson's catchark	*Halaelurus dawsoni*	2.7	2	310	354
DEA	Dealfish	*Trachipterus trachypterus*	0.1	1	112	117
DSP	Deepsea pigfish	*Congiopodus coriaceus*	0.6	3	84	102
ELE	Elephantfish	*Callorhinchus milii*	1591.2	36	12	123
ERA	Electric ray	*Torpedo fairchildi*	95.9	6	12	105
ESO	N.Z. sole	*Peltorhamphus novaezeelandiae*	26.9	18	13	55
FHD	Deepsea flathead	*Hoplichthys haswelli*	15.7	8	98	354
FRO	Frostfish	*Lepidopus caudatus*	7.1	2	94	99
GFL	Greenback flounder	*Rhombosolea tapirina*	24.3	3	15	97
GLB	Globefish	*Contusus richei*	58.7	17	12	42
GON	Sandfish	*Gonorynchus forsteri*	4.4	5	17	207
GPF	Girdled wrasse	*Notolabrus cinctus*	1.2	1	43	45
GSH	Dark ghost shark	*Hydrolagus novaezelandiae*	3 530.1	28	76	354
GUR	Red gurnard	*Chelidonichthys kumu*	216.5	58	12	110
HAG	Hagfish	*Eptatretus cirrhatus*	0.7	1	49	51
HAK	Hake	*Merluccius australis*	3.7	6	20	80
HAP	Hapuku	*Polyprion oxygeneios*	293.3	33	35	207
HOK	Hoki	*Macruronus novaezelandiae*	1 003.8	11	49	391
JAV	Javelinfish	*Lepidorhynchus denticulatus*	166.8	6	204	391
JDO	John dory	*Zeus faber*	3.7	2	25	52
JMD	N.Z. jack mackerel	*Trachurus declivis*	28.1	13	46	129
JMM	Chilean jack mackerel	*T. symmetricus murphyi*	311.1	29	29	139
JMN	N.Z. jack mackerel	*T. novaezelandiae*	0.5	1	112	117
KAH	Kahawai	*Arripis trutta*	8.9	3	18	45
LDO	Lookdown dory	*Cyttus traversi*	20	3	310	354
LEA	Leatherjacket	*Parika scaber*	220	20	12	57
LIN	Ling	*Genypterus blacodes*	625.2	56	25	391
LSO	Lemon sole	*Pelotretis flavilatus*	55.7	31	27	207
MDO	Mirror dory	*Zenopsis nebulosus*	1.2	1	216	220
MIQ	Warty squid	*Moroteuthis ingens*	7	3	310	391
MOK	Moki	*Latridopsis ciliaris*	46.7	3	15	55
OCT	Octopus	*Octopus cordiformis*	6.9	5	49	105
OPA	Opalfish	*Hemerocoetes* spp.	0.1	1	106	108
PAD	Paddle crab	*Ovalipes catharus*	50.4	10	12	31
PCO	Ahuru	*Auchenoceros punctatus*	19	10	12	30
PIG	Southern pigfish	*Congiopodus leucopaecilus*	476.7	55	29	220
PIL	Pilchard	*Sardinops neopilchardus*	0.1	1	52	55

Appendix 4—continued

Species code	Common name	Scientific name	Catch (kg)	Occ.	Depth (m) Min	Max
PIP	Pipefish	Syngnathidae	0.7	6	69	91
POP	Porcupinefish	*Allomycterus jaculiferus*	2.9	1	54	55
RAG	Ragfish	*Icichthys australis*	0.1	1	121	124
RBM	Ray's bream	*Brama brama*	96.1	6	127	354
RBT	Redbait	*Emmelichthys nitidus*	0.5	3	81	108
RCO	Red cod	*Pseudophycis bachus*	9 593.2	82	12	391
RHY	Common roughy	*Paratrachichthys trailli*	0.2	1	352	354
RSK	Rough skate	*Raja nasuta*	378.1	42	13	348
SAM	Quinnat salmon	*Oncorhynchus tshawytscha*	0.9	5	12	24
SAZ	Sand stargazer	*Crapatalus novaezelandiae*	6.7	10	12	31
SCG	Scaly gurnard	*Lepidotrigla brachyoptera*	170.5	51	46	130
SCH	School shark	*Galeorhinus galeus*	460.7	33	12	99
SCI	Scampi	*Metanephrops challengeri*	1.3	3	321	391
SDF	Spotted flounder	*Azygopus pinnifasciatus*	0.2	2	352	391
SDO	Silver dory	*Cyttus novaezelandiae*	79.4	30	52	207
SDR	Spiny seadragon	*Solegnathus spinosissimus*	0.1	1	69	75
SFL	Sand flounder	*Rhombosolea plebeia*	13	9	12	35
SHO	Seahorse	*Hippocampus abdominalis*	0.2	2	51	85
SLS	Slender sole	*Peltorhamphus tenuis*	0.6	3	18	29
SPD	Spiny dogfish	*Squalus acanthias*	45 436.4	98	12	391
SPE	Sea perch	*Helicolenus* spp.	2 026.7	54	29	391
SPF	Scarlet wrasse	*Pseudolabrus miles*	13.7	4	43	120
SPO	Rig	*Mustelus lenticulatus*	102.4	17	12	87
SPR	Sprats	*Sprattus antipodum*, *S. muelleri*	129.8	19	12	53
SPS	Speckled sole	*Peltorhamphus latus*	0.3	3	20	33
SPZ	Spotted stargazer	*Genyagnus monopterygius*	0.9	1	18	19
SQU	Arrow squid	*Nototodarus sloanii*, *N. gouldi*	1 111.4	82	20	391
SSI	Silverside	*Argentina elongata*	57.9	32	53	391
SSK	Smooth skate	*Raja innominata*	391.7	16	49	325
STA	Giant stargazer	*Kathetostoma giganteum*	520.9	63	42	391
STY	Spotty	*Notolabrus celidotus*	9.3	6	15	53
SWA	Silver warehou	*Seriolella punctata*	434	68	12	320
TAR	Tarakihi	*Nemadactylus macropterus*	3 932.7	65	15	320
THR	Thresher shark	*Alopias vulpinus*	250	1	69	71
TOD	Dark toadfish	*Neophrynichthys latus*	0.9	4	19	67
TOP	Pale toadfish	*N. angustus*	4.5	3	297	391
TRU	Trumpeter	*Latris lineata*	4	2	43	55
TUB	Raftfish	*Tubbia tasmanica*	0.1	2	20	78
WAR	Common warehou	*Seriolella brama*	655.6	40	12	99
WIT	Witch	*Arnoglossus scapha*	134.6	56	25	348
WWA	White warehou	*Seriolella caerulea*	85.8	6	200	354
YBF	Yellowbelly flounder	*Rhombosolea leporina*	5.8	5	12	21
YEM	Yelloweyed mullet	*Aldrichetta forsteri*	0.2	1	12	17
			103 803.8			

Appendix 5: **Invertebrates (excluding arrow squid) collected during the survey. Identification is to the lowest possible taxonomic level.**

Taxon	No. of stations
Mollusca: Octopoda	
Octopus campbelli	1
Octopus huttoni	4
Octopus kaharoa	1
Pinnoctopus cordiformis	8
Mollusca: Decapoda	
Moroteuthis ingens	3
Sepioloidea pacifica	1
Mollusca: Gastropoda	
Argobuccinum tumidum	2
Astraea heliotropium	4
Austrofusus glans	2
Calliostoma punctulata	3
Calliostoma waikanae	1
Crepidula monoxyla	1
Malluvium calcareus	1
Maoricolpus roseus	1
Tugali elegans	1
Mollusca: Bivalvia	
Anomia sp.	1
Anomia trigonopsis	1
Atrina pectinata zelandica	1
Chlamys delicatula	2
Chlamys dieffenbachi	4
Chlamys gemmulata	1
Chlamys taiaroa	1
Chlamys zelandiae	1
Lima colorata zelandica	1
Modiolus areolatus	2
Ostrea lutaria	2
Mollusca: Opisthobranchia	
Opisthobranchia (unidentified)	2
Crustacea: Anomura	
Diacanthurus spinulimannus	4
Galathea pusilla	2
Lophopagurus thompsoni	4
Munida gregaria	4
Paguristes pilosus	1
Paguristes barbatus	2
Petrocheles spinosus	1
Crustacea: Brachyura	
Cancer novaezelandiae	1
Elamena longirostris	1
Hymenosoma depressum	1
Leptomithrax australis	1
Leptomithrax longimannus	1
Leptomithrax longipes	1
Nectocarcinus bennetti	9

Appendix 5—continued

Taxon	No. of stations
Crustacea: Brachyura	
Neommatocarcinus huttoni	1
Notomithrax peronii	1
Thacanophrys filholi	4
Trichoplatus huttoni	1
Crustacea: Cirripedia	
Balanus decorus	3
Balanus vestitus	4
Lepas sp.	1
Crustacea: Alpheiidae	
Alpheus sp.	3
Crustacea: Stomatopoda	
Lysiosquilla sp.	2
Crustacea: Isopoda	1
Cirolanidae	2
Ciliacea sp.	1
Urochordata	
Asterocarpa caerulea	2
?*Cnemidocarpa bicornuta*	2
Compound ascidian sp.1	5
Compound ascidian sp.2	1
Didemnum sp.	1
Pyura pachydermatina	1
Solitary ascidian sp. 1	1
Solitary ascidian sp. 2	1
Solitary ascidian sp. 3	1
Solitary ascidian sp. 4	2
Solitary ascidian sp. 5	1
Echinodermata: Echinoidea	
Fellaster zelandiae	2
Pseudechinus albocinctus	5
Echinodermata: Asteroidea	
Asterodon millaris	2
Coscinasterias muricata	1
Pentagonaster pulchellus	1
Sclerasterias mollis	4
Echinodermata: Holothuroidea	
Heterothyone ocnoides	1
Paracaudina chilensis	1
Stichopus mollis	3
Echinodermata: Ophiuroidea	
Ophiopsammus maculata	3
Clarkcoma bollonsi	2
Annelida: Hirudinea	
Pontobdella benhami	3
Hirudinea (unidentified)	1

Appendix 5—continued

Taxon	No. of stations
Annelida: Polychaeta	
Aphrodita talpa	2
Chaetopterus sp.	3
Eunice sp.	1
Euphione squamosa	3
Nephtys sp.	1
Amphinomidae	1
Terebellidae	1
Polychaeta (unidentified)	3
Hrdrozoa: Hydroida	
Cryptolaria prima	2
Solandaria cf. *secunda*	2
Hydroid (unidentified)	7
Anthozoa: Actinaria	
Actinaria sp. 1	8
Actinaria sp. 2	3
Anthozoa: Ceriantharia	
Cerianthus sp.	2
Anthozoa: Zoanthidea	
Bathyzoanthus sp.	1
Bryozoa: Ctenostomata	
Alcyonidium multigemmatum	1
Alcyonidium sp.	3
Elzerina binderi	1
Immergentia zelandica	1
Penetrantia parva	1
Penetrantia irregularis	1
Triticella n. sp.	1
Bryozoa: Cyclostomata	
Crisia tenuis	1
Diaperoecia purpurascens	2
Disporella buski	2
Disporella novaezelandiae	1
Hornera foliacea	1
Hornera robusta	4
Idmidronea sp.	4
Liripora pseudosarniensis	1
Plagioecia sp.	4
Reptotubigera sp.	1
Telopora lobata	3
Tubulipora sp.	2
Bryozoa: Cheilostomata	
Aetea truncata	1
Aimulosia marsupium	4
Akatopora circumsaepta	3
Amphiblestrum blandum	1
Arachnopusia unicornis	2

Appendix 5—continued

Taxon	No. of stations
Bryozoa: Cheilostomata	
Beania discodermiae	5
Beania magellanica	2
Bitectipora mucronifera	1
Bitectipora rostrata	2
Buffonellodes sp.	1
Caberea helicina	3
Caberea rostrata	2
Calloporina angustipora	3
Cellaria immersa	3
Celleporella bathamae	3
Celleporina grandis	1
Celleporina hemiperistomata	2
Chaperia granulosa	1
Chaperiopsis cervicornis	1
Chaperiopsis funda	2
Chaperiopsis lanceola	2
Chiastosella enigma	4
Crassimarginatella fossa	1
Crepidacantha crinispina	1
Crepidacantha zelanica	3
Electra pilosa	1
Ellisina sericea	3
Escharella spinosissima	3
Escharoides angela	1
Exochella conjuncta	2
Exochella jullieni	1
Exochella levinseni	2
Fenestrulina incompta	1
Fenestrulina multicava	1
Fenestrulina reticulata	2
Figularia sp.	5
Galeopsis polyporus	3
Gregarinidra serrata	2
Hemismittoidea hexaspinosa	1
Hippomenella vellicata	3
Hippothoa flagellum	4
Malakosaria sinclairii	1
Micropora sp.	2
Microporella agonistes	5
Odontionella cyclops	3
Opaeophora lepida	2
Osthimosia socialis	1
Osthimosia turrita	1
Parasmittina aotea	2
Schizosmittina cinctipora	5
Schizosmittina conjuncta	2
Smittina palisada	3
Smittina purpurea	5
Smittina rosacea	1

Appendix 5—continued

Taxon		No. of stations
Bryozoa: Cheilostomata		
	Smittoidea mauganuiensis	1
	Valdemunitella pyrula	1
Bryozoa: Entoprocta		
	Pedicellina whiteleggei	2
Porifera		
	Adocia sp.	1
	Axilella tricaliciformis	1
	Callyspongia ramosa	6
	Callyspongia sp.	1
	Crella incrustans	10
	Chondropsis kirkii	1
	Chondropsis sp. 1	1
	Chondropsis sp. 2	2
	Chondropsis sp. 3	1
	Dactylia palmata	4
	Dactylia sp.	1
	Dysidea sp.	1
	Iophon laevistylus	1
	Iophon sp.	2
	Mycales sp.	1
	Parapoxya pulchra	1
	Polymastia masciilus	1
	Tedania diversiraphidophora	1

Appendix 6 : **Species codes, common names, scientific names, total catch, percentage occurrence (Occ. %), and depth ranges of all species caught on the *Compass Rose*.**

Species code	Common name	Scientific name	Catch (kg)	Occ. %	Depth (m) Min	Max
BAR	Barracouta	*Thyrsites atun*	43.6	38	8	27
BCO	Blue cod	*Parapercis colias*	0.2	5	25	27
BRI	Brill	*Colistium guntheri*	45.3	58	7	29
CAC	Cancer crab	*Cancer novaezelandiae*	1.8	15	7	25
CAR	Carpet shark	*Cephaloscyllium isabella*	254.8	38	10	29
ELE	Elephantfish	*Callorhinchus milii*	5 971.6	93	7	29
ERA	Electric ray	*Torpedo fairchildi*	75.5	15	9	25
ESO	N.Z. sole	*Peltorhamphus novaezeelandiae*	176.9	75	7	29
GLB	Globefish	*Contusus richei*	45.1	65	7	29
GUD	Graham's gudgeon	*Gahamichthys radiatus*	0.1	3	12	14
GUR	Red gurnard	*Chelidonichthys kumu*	69.7	25	16	29
HAK	Hake	*Merluccius australis*	0.6	5	12	14
HDO	Hector's dolphin	*Cephalorhynchus hectori*	80	3	7	7
JDO	John dory	*Zeus faber*	6.4	3	26	27
KAH	Kahawai	*Arripis trutta*	5.3	5	17	29
LEA	Leatherjacket	*Parika scaber*	154.5	33	9	27
LSO	Lemon sole	*Pelotretis flavilatus*	6.1	18	17	27
NCA		*Nectocarcinus antarcticus*	1	10	16	26
PAD	Paddle crab	*Ovalipes catharus*	151.5	25	7	25
PCO	Ahuru	*Auchenoceros punctatus*	2.7	20	7	25
PIG	Southern pigfish	*Congiopodus leucopaecilus*	6.2	13	16	29
RCO	Red cod	*Pseudophycis bachus*	84.3	55	7	29
RSK	Rough skate	*Raja nasuta*	716.2	85	7	29
SAZ	Sand stargazer	*Crapatalus novaezelandiae*	1.3	18	7	29
SCH	School shark	*Galeorhinus galeus*	265.9	80	7	29
SEQ	Sepiolid squid	Sepiolidae	0.1	3	25	25
SFL	Sand flounder	*Rhombosolea plebeia*	30.5	48	7	27
SKA	Skate	Rajidae	38.7	3	10	11
SLS	Slender sole	*Peltorhamphus tenuis*	3.8	13	9	25
SPA	Slender sprat	*Sprattus antipodum*	1.9	25	7	25
SPD	Spiny dogfish	*Squalus acanthias*	1 098.2	90	7	29
SPM	Sprat	*Sprattus mulleri*	2.3	35	7	25
SPO	Rig	*Mustelus lenticulatus*	82.5	50	7	29
SPR	Sprats	*Sprattus antipodum*, *S. muelleri*	0.1	3	9	11
SPZ	Spotted stargazer	*Genyagnus monopterygius*	4.5	8	20	27
SSK	Smooth skate	*Raja innominata*	32.7	3	9	10
SWA	Silver warehou	*Seriolella punctata*	0.2	5	10	25
TAR	Tarakihi	*Nemadactylus macropterus*	2.2	20	12	29
TOD	Dark toadfish	*Neophrynichthys latus*	1.3	10	10	25
WAR	Common warehou	*Seriolella brama*	11.3	35	7	29
WIT	Witch	*Arnoglossus scapha*	9.9	18	17	29
YBF	Yellowbelly flounder	*Rhombosolea leporina*	51.2	53	7	29
			9 538.0			

Appendix 7: **Relative biomass estimates (to the nearest tonne) and coefficients of variation (c.v.%) for the target species, spiny dogfish, barracouta, dark ghost shark, sea perch, tarakihi (pre-recruit and recruited), rough skate, smooth skate, rig (pre-recruit and recruited), and school shark.**

	KAH9618		KAH9704		KAH9809		KAH9917	
Common name	Biomass	c.v. %	Biomass	c.v. %	Biomass	c.v. %	Biomass	c.v. %
Spiny dogfish	35 776	27.7	29 765	24.5	22 842	16.1	49 832	36.9
Barracouta	21 513	34.1	11 843	24.6	21 877	14.0	21 476	13.7
Red cod (all)	10 634	22.7	7 536	23.0	12 823	17.3	6 690	30.1
Red cod (0+ cohort)	195	35	12	40	51	38.0	8	27
Red cod (1+ cohort)	2 149	24	3 155	27	3 050	16.0	2 204	43
Dark ghost shark	3 066	18	5 870	33.2	7 416	27.0	2 512	19.0
Sea perch	4 041	47.2	1 638	24.7	3 889	40.9	2 203	26.6
Tarakihi (all)	3 818	20.7	2 036	21.3	4 277	24.4	2 606	14.6
Tarakihi (< 25 cm)	1 924	25.1	1 054	26.3	2 136	25.4	904	17.8
Tarakihi (25+ cm)	1 894	23.4	982	18.5	2 142	28.7	1 702	17.1
Rough skate	1 336	15.5	1 082	12.6	1 175	9.9	329	23.5
Elephantfish	1 127	30.5	404	18.2	1 718	28.1	1 097	25.0
Giant stargazer	897	12.3	543	11.4	999	9.8	472	13.7
Red gurnard (all)	765	12.6	317	16.2	493	12.6	202	19.5
Red gurnard (< 30 cm)	41	26.1	4	26.3	40	25.1	9	39.6
Red gurnard (30+ cm)	724	12.8	313	16.2	453	12.8	192	19.5
Smooth skate	721	31.8	485	21.3	450	26.4	369	29.7
Rig (all)	139	40.4	35	33.0	214	51.7	86	37.8
Rig (90+ cm)	93	35.4	10	50.0	110	83.0	47	37.2
Rig (<90 cm)	45	56.6	25	39.7	105	28.5	39	44.5
School shark	256	23	476	23.6	343	22.7	389	26.7