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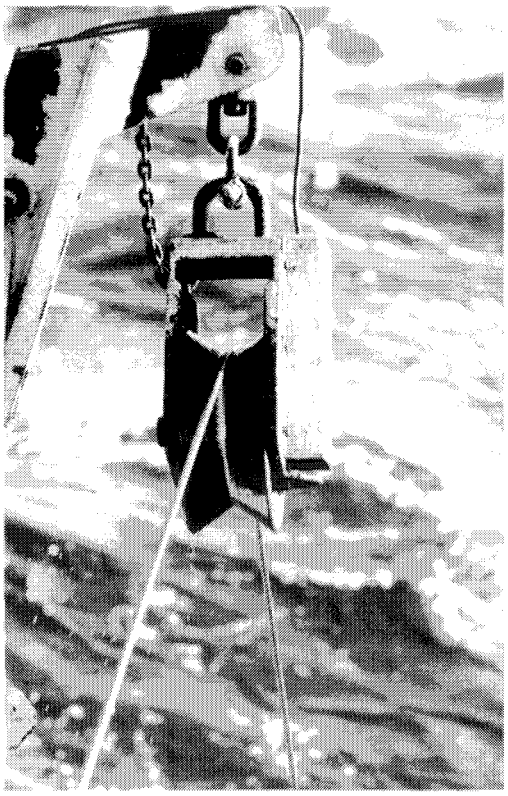

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Abstract

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This was the fifth in a series of annual summer trawl surveys along the east coast of the South Island from the Waiau River to Shag Point in the depth range 10–400 m (previous surveys were in December–January 1996–97, 1997–98, 1998–99, and 1999–2000). The survey was a two phase design undertaken between 9 December 2000 and 8 January 2001 on the RV *Kaharoa* and was optimised for the target species elephantfish, giant stargazer, juvenile red cod (0+ and 1+), and red gurnard. 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 within the specified target range for elephantfish and giant stargazer, but low catches of 0+ (0.5 kg) and 1+ red cod and red gurnard resulted in large increases in variation and made it very difficult to achieve the target c.v.s. This survey also collected qualitative data on the presence of macroinvertebrates from catches.

Kaharoa biomass estimates were generally lower than for previous surveys, and for 20 of the 23 most abundant commercial species, including all target species, biomass estimates declined from the 1999–2000 survey and for 14 species biomass was the lowest in the series. The synchronous change in the biomass estimates for the most of the species is a notable feature of this series. The results support previous conclusions that there are catchability differences between surveys. The strong positive correlation between sea surface water temperature and biomass found for many species in the first four surveys did not hold for the 2000–2001 survey. Concerns were raised by the Inshore Fisheries Assessment Working Group (27 March 2001) as to the reliability of the biomass estimates because of the annual variability of the biomass estimates and it was recommended that this time series be discontinued.

The commercial vessel *Compass Rose* was chartered by NIWA to conduct the second in a time series of elephantfish surveys from 9 to 18 December 2000. The survey area was identical to that of the 1999–2000 survey and included *Kaharoa* strata 19 (subdivided in two) and 20 (depth range 10–30 m), with the addition of two specially defined strata in the 5–10 m depth range adjacent to strata 19 and 20. Improvements to *Compass Rose* survey design in 2000–01 included increasing the number of strata from four to six, surveying more stations, and incorporating a two-phase design. Additionally, a smaller codend mesh was used (28 mm compared to 100 mm) to increase the length frequency size range of elephantfish taken. Biomass estimates, catch distribution, and population length frequencies for elephantfish and the major species are described.

Elephantfish catch rates by *Compass Rose* were substantially higher than those by *Kaharoa* in the same depth range, and a scaling factor of 0.281 was determined. Multiplying the *Compass Rose* elephantfish biomass estimate in the 5–10 m strata by the scaling factor converted that biomass from 84 to 24 t making it equivalent to a theoretical estimate from *Kaharoa.*

The length frequency distributions differed between vessels within the 10–30 m depth range, particularly for small fish, and it is possible that the different trawl gear used by these vessels have different selectivities and that the *Kaharoa* favours larger fish.

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 for the target species 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. Location of elephantfish aggregations can vary between surveys as about half of the estimated biomass was in less than 10 m in 1999–2000 compared with only 6% in 2000–2001.

Introduction

This report presents the results from the fifth in a time series of summer inshore trawl surveys by *Kaharoa* 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 giganteum*), 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 nasutus, D. innominatus*), sea perch (*Helicolenus* spp.), spiny dogfish (*Squalus acanthias*), and tarakihi (*Nemadactylus macropterus*). The results of the first four surveys (1996–97, 1997–98, 1998–99, and 1999–2000) in the series have been reported previously (Stevenson 1997, Stevenson & Hurst 1998, Stevenson & Beentjes 1999, Stevenson & Beentjes 2001), and reviewed by Beentjes & Stevenson (2001).

Red cod are a major component of the east coast South Island inshore trawl fishery. The average annual catch in the fishing years 1994–95 to 1998–99 of about 11 000 t decreased sharply in 1999–2000 to 4824 t (Annala et al. 2000). 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, 2000, Annala et al. 1999). 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. Combined 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 this area (1991 to 1996) and the current summer time series have provided data for monitoring this programme. Data include estimates of relative biomass, length frequency distributions, ageing material, and reproductive condition.

In 1999, the Inshore Fishery Assessment Working Group (IFAWG) was concerned that the east coast South Island trawl survey may not be adequately sampling elephantfish as there may be substantial biomass of elephantfish in depths less than 10 m (10 m is the minimum trawl depth for *Kaharoa*). MFish requested that the 1999–2000 survey include a single commercial vessel to survey the 5–10 m and 10–30 m depth ranges in the Canterbury Bight, concurrently with *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. In the common depth range (10–30 m), 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. The IFAWG recommended a concurrent survey be repeated in 2000–01.

The *Compass Rose* survey in 2000–01 implemented the recommendations of Stevenson & Beentjes (2001): improved survey design to increase precision (six strata instead of four, more stations, and a two-phase design) (see Figure 2), and a small mesh (28 mm) codend liner to increase the length frequency size range of elephantfish taken.

Information on the presence of macroinvertebrates species was collected from *Kaharoa* tows.

Programme objective

To determine the relative abundance and distribution of inshore finfish species along the east coast of the South Island, focusing on elephantfish (*Callorhinchus milii*), juvenile red cod (*Pseudophycis bachus*), red gurnard (*Chelidonichthys kumu*), and stargazer (*Kathetostoma* spp.).

Programme objectives 2000–01

1. To determine the relative abundance and distribution of elephantfish, red gurnard, stargazer, and juvenile red cod along the east coast of the South Island from Kaikoura to Shag Point by carrying out a trawl survey. The target coefficients of variation (c.v.s) of the biomass estimates for these species are as follows: elephantfish (20–30%); juvenile red cod: 0+ (30%), 1+ (30%); red gurnard (25 to 30%); stargazer (15 to 20%).

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

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

4. To collect the data to determine relative biomass, distribution, and length frequencies of all other Quota Management System (QMS) species, and rough skate (*Raja nasuta*), smooth skate (*R. innominata*), and spiny dogfish (*Squalus acanthias*).

5. To collect and identify benthic macroinvertebrates collected 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 m 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 9 to 23 December 2000 and the second from 28 December 2000 to 8 January 2001. Michael Beentjes was project leader and Michael Stevenson was voyage leader and also responsible for final database editing. The skipper was Arthur Muir.

The commercial vessel survey using *Compass Rose* started and finished in Timaru and ran from 9 to 18 December 2000. The skipper was Raymond Mitchell, and Owen Anderson and Colin Sutton were voyage leaders and also responsible for final database editing.

Methods

Survey area and design

Kaharoa

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 26 935 km^2, including untrawlable (foul) ground, was divided into 23 strata, identical to the 1998–99 and 1999–2000 surveys (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 four 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. Phase 1 stations were allocated so as to minimise c.v.s for target species, with the constraint that at least three stations were allocated to each stratum. Phase 2 stations were to be targeted at species which hadc.v.s above target c.v.s after the completion of phase 1 stations.

Before the survey began, sufficient trawl stations to cover both first and second phase stations were generated using the computer program 'Rand_stn v2.1' (Vignaux 1994). The stations were required to be a minimum of 3.7 km (2 n. miles) apart to coincide with the tow length established in the survey design. Non-trawlable ground was identified before the voyage from information collected during previous surveys by *Kaharoa*. A total of 108 stations was allocated to phase 1.

Compass Rose

The commercial vessel *Compass Rose* was chartered by NIWA to conduct an elephantfish survey from 9 to 18 December 2000. The survey area was identical to that of the 1999–2000 survey and included *Kaharoa* strata 19 (subdivided in two) and 20 (depth range 10–30 m), with the addition of two specially defined strata in the 5–10 m depth range adjacent to strata 19 and 20 (Figure 2). The *Compass Rose* survey in 2000–01 implemented the recommendations of Stevenson & Beentjes (2001) aimed at improving survey design and increasing precision. These included increasing the number of strata from four to six, including more stations, and incorporating a two-phase design (see Figure 2). Additionally, a smaller codend mesh was used (28 mm compared to 100 mm) to increase the length frequency size range of elephantfish taken. Forty phase 1 and 15 phase 2 stations were planned. Non-trawlable ground was identified before the voyage from information collected during the previous survey. A NIWA staff member was aboard the *Compass Rose* to coordinate towing procedures, as well as to weigh the catch and measure elephantfish.

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 specifically for South Island inshore trawl surveys and is based on an 'Alfredo' design. Gear specifications were 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 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.

Doorspread was 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 of recorded doorspread from stations within the same strata depth range was used. Headline height measurements were recorded from a net sonde.

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

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

For depths less than 70 m, a constant warp length of 200 m was used. At depths greater than 70 m, a variable warp to depth ratio was used starting at about 3:1 and decreasing to about 2.2:1 at greater depths (Table 2).

Compass Rose

Compass Rose is a 15.2 m commercial stern trawler, with an engine power of 114 kW. Towing procedures were the same as for *Kaharoa*, except that standard commercial trawling gear (Russel-Rayner 80 ft wing trawl, with a 28 mm codend) 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 for station number 5 where it was 55 m because shallow water and large swells required a reduced doorspread to be used. Doorspread was estimated using the method of Koyama (1974).

Water temperatures

The surface temperature was not recorded from *Kaharoa* because of a readout failure. Surface temperatures were recorded at each station from *Compass Rose* by a hull-mounted sensor. Bottom temperatures were recorded by *Kaharoa* using the net sonde.

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: samples of crabs, shellfish, and other invertebrate species were preserved in 10% buffered formalin or frozen for later identification.

Length, to the nearest whole centimetre below actual length, and sex (where possible) were recorded for all ITQ species. 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, sea perch, 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 five otoliths (or spines) per sex per centimetre size class were collected from length frequency samples for elephantfish, giant stargazer, red cod, red gurnard, sea perch, dark ghost shark, and tarakihi.

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. For teleosts, reproductive staging followed Beentjes & Wass (1994).

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. In a few cases a stratified sampling procedure was used, i.e., all large fish were measured and a subsample of small 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 *Compass Rose*, one tow (tow 6) was not used in biomass calculations because of poor gear performance (Appendix 3). The c.v.s associated with estimates of biomass were 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 length-weight coefficients for species for which data was collected on *Kaharoa*. For other species, coefficients were chosen from the *trawl* database on the basis of whether coefficients were available from previous surveys in the series or on the best match between the size range of the fish used to calculate the coefficients and the 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 123 successful tows, 108 in phase 1 and 15 in phase 2. All 123 stations were used in biomass estimation. The completed station density ranged from 1 station per 114 km^2 in stratum 20 to 1 station per 791 km^2 in stratum 6, with an overall density of 1 station per 219 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, 17, and 21.

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 at this time of year. Strata 19 and 20 were sampled in conjunction with *Compass Rose* as much 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. One day was lost to bad weather.

Phase two stations were required to attempt to reduce c.v.s of 0+ and 1+ red cod and all but two were allocated south of Banks Peninsula. Six phase 2 stations were allocated to stratum 10 where the highest catch rates of 0+ red cod occurred, seven stations were allocated to stratum 11, and two stations to stratum 7 for 1+ red cod (see Table 1). Catch rates of elephantfish, giant stargazer, and red gurnard were not used for allocation of phase 2 stations because the c.v.s were within target levels at the end of phase 1.

Measurements of headline height and doorspread, together with observations that the doors and trawl gear were polishing well, indicate that the gear was fishing hard down and as designed. Six tows were shorter than the planned 2 n. miles to reduce the risk of large catches (strata 1, 3, and 9). For the total depth range, recorded doorspread varied from 68.8 to 91.4 m and headline height 5.0 to 6.3 m (see Table 2, Appendix 2). For each depth range, and overall, doorspread values recorded for this survey were within the range recorded during the previous surveys. Mean warp to depth ratio over all tows was 4.1 (see Table 2).

Compass Rose

Compass Rose completed 56 stations of which one was not used in biomass calculations because of poor gear performance (station 6) leaving 40 successful phase 1 and 15 phase 2 stations. Station density ranged from 1 station per 7 km^2 in stratum 22A to 1 station per 80 km^2 in stratum 20, with an overall density of 1 station per 36 km^2. For phase 2, 10 stations were allocated to stratum 19 and five to stratum 19A (see Table1). At least five stations were completed in each stratum and all project and survey objectives were achieved. The survey area, with stratum boundaries and positions, is shown in Figure 2 and individual station data are given in Appendix 3. Headline height was assumed to be a constant 2.5 m, doorspread ranged from 43.5 to 68.9 m with a mean of 59.5 m, and warp to depth ratio averaged 7.4 (range 3.4–14.7).

Water temperatures

Satellite-derived sea surface isotherms from the NIWA SST Archive are shown in Figures 3a and 3b. Isotherms estimated from bottom temperature recordings from *Kaharoa* are shown in Figures 3c and 3d respectively. Isotherms estimated from the *Compass Rose* surface temperature records are shown in Figure 4. Sea surface temperatures increased from December 2000 to January 2001 north of Banks Peninsula, but were lower to the south. Surface temperatures were warmer closer inshore.

Catch composition

Kaharoa

Kaharoa caught about 90 t of fish, crustaceans, echinoderms, and molluscs from 123 tows at an average of 728 kg per tow (range 5.1–7083 kg). Seventy-seven vertebrate fish species were identified: 12 elasmobranchs and 65 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 over 150 kg plus rig and white warehou (but excluding broadnose sevengill shark) are given in Table 3. The most abundant species by weight was spiny dogfish with a catch of 37 t (41% of the total catch). The four most abundant species, spiny dogfish, barracouta, crested bellowsfish, 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 1.4, 0.3, 0.2, and 1.5% of the catch, respectively. Spiny dogfish, barracouta, and arrow squid were each caught in over 80% of the tows (see Appendix 4).

Compass Rose

Compass Rose caught about 23 t of fish, squid, and crustaceans from 56 tows at an average of 403 kg per tow (range 102.6–1786.4 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 are given in Table 4. Elephantfish, the most abundant species with a catch of 8.5 t (38% of the total), was caught at all stations. The three most abundant species, elephantfish, spiny dogfish, and rough skate, made up about 65% 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 over 140 kg and for rig (but excluding broadnose sevengill shark) are given in Table 3. Species with an estimated biomass over 1500 t were spiny dogfish, barracouta, dark ghost shark, crested bellowsfish, sea perch, and tarakihi. Coefficients of variation for the target species were: elephantfish, 18%; 0+ red cod 55%; 1+ red cod, 33%; red gurnard, 34%; and giant stargazer, 16% (see Table 3).

Recruited biomass estimates and c.v.s for barracouta, blue warehou, dark ghost shark, elephantfish, giant stargazer, hoki, red cod, red gurnard, rig, 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 81%, 93%, 88%, and 92%, 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.

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 less than 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 but at much lower catch rates than on previous surveys. 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 are given in Table 4. Elephantfish had the highest estimated biomass followed by spiny dogfish and rough skate. The c.v. for the elephantfish total biomass estimate was 27%. For the target species elephantfish, recruited biomass was 66% of the total. Biomass estimates for elephantfish by year class are given in Table 5 where year class length intervals were estimated from the scaled length frequency distribution.

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 the inshore area with the highest catch rates in the north in the 10-30 m depth range (strata 19 and 19A). For barracouta, red gurnard, and rough skate, catch rates were highest in the northern strata (strata 19, 19A, 22, and 22A). Rig were most common in the 5–10 m depth range in the central part of the survey area. New Zealand sole, red cod, sand flounder, school shark, and spiny dogfish were also caught throughout the area, but with no apparent pattern to the catch rates. Tarakihi were restricted to the 10–30 m depth range, mostly in stratum 19.

Biomass indices by stratum for the 10 most abundant commercial species are given in Table 9.

Between vessel comparison of elephantfish biomass

A comparison of elephantfish estimated biomass caught in different depth ranges by *Kaharoa* and *Compass Rose* is given in Table 10. In the common area (10–30 m *Kaharoa* strata 19 and 20, *Compass Rose* strata 19, 19A, and 20), *Compass Rose* estimated biomass was more than 3.5 times that of *Kaharoa* (1229 t compared to 346 t) and the c.v. was 29%, a considerable improvement from 1999–2000 (73%). It appears that there is a significant catchability difference between the vessels with *Compass Rose* catch rates being consistently higher. For all target species, biomass estimates from the 1999–2000 and 2000–01 surveys were two to three times greater for *Compass Rose*, with the exception of giant stargazer in 1999–2000 where *Kaharoa* biomass was greater. Elephantfish catches for *Compass Rose* were dominated by the high catch rate in strata 19 and 19A, which was 65% higher than the stratum with the next highest catch rate (stratum 22A) (see Table 8).

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 elephantfish, giant stargazer, red cod, and red gurnard. Cut off lengths for year classes were estimated by eye from the scaled length frequency distributions. Assigned year classes were from growth data given by Annala et al. (2000).

The length frequency distribution for elephantfish shows two modes for the 0+ and 1+ cohorts at 15–21 cm and 22–32 cm fork length, respectively. Most elephantfish were caught in 10–30 m and fish from deeper than 30 m tended to be over 50 cm. The sex ratios (males:females) for elephantfish were 0.96:1 overall; 0.91:1 in 10–30 m and 1.31:1 in 30–400 m.

The length frequency distributions for giant stargazer were dissimilar for the 30–100 and 100–200 m depth ranges, with more small fish in shallower waters. Modal patterns are difficult to interpret. The sex ratio (males:females) was 1.11:1 overall, 0.89 in 30–100 m, and 1.75 in 100–200 m.

The length frequency distribution for red cod shows a mode for 0+ fish at 8–14 cm and another for 1+ fish at 15–31 cm (Figure 7). The mode for 1+ fish is weaker and represents a smaller proportion of the population than in previous surveys (Beentjes & Stevenson 2001). Red cod were found at all depths, but mainly between 100–200 m: there were no small fish in 200–400 m. The sex ratios (males:females) were 0.72:1 overall; 0.52:1 in 10–30 m; 0.67:1 in 30–100 m; 0.70:1 in 100–200 m; and 11.0:1 in 200–400. For previous surveys in the series, overall sex ratios favoured males.

The length frequency distribution for red gurnard shows a distinct mode for 1+ or 2+ fish at 18–25 cm, but other year classes are difficult to interpret. The bulk of fish were caught in 30–100 m, but larger fish (over 25 cm) were more common in this depth range (Figure 7). The sex ratios (males:females) were 0.6:1 overall; 0.15:1 in 10–30 m; and 0.81:1 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 53 cm for males and 56 cm for females. The low numbers of large smooth skate make it difficult to estimate length at maturity, although the smallest mature males and females were 98 cm and 113 cm, respectively.

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 (97% males; 92% females), and a small percentage were maturing. For red cod, most gonads were classified as immature or resting (88% males; 95% females). Most red gurnard males were immature or resting (68%), or maturing (29%). Female red gurnard showed a wider range of gonad development with 34% immature or resting, 36% maturing, and 27% mature. All three species showed a less advanced state of reproductive condition than in the previous survey (Stevenson & Beentjes 2001).

Compass Rose

Numbers of elephantfish samples collected and number of fish measured are given in Table 11.

Scaled length-frequency distributions for elephantfish from *Compass Rose* are shown in Figure 9. There is a dominant 0+ mode at 13–21 cm and a weaker 1+ mode at 22–31 cm. The use of a 28 mm mesh codend increased the proportion of smaller elephantfish caught compared to the 1999–2000 survey. In addition, most elephantfish were caught in 10–30 m compared to 5–10 m in 1999–2000. The sex ratio (males:females) for all fish was 0.69:1, but varied with depth (0.93:1 in 5–10 m and 0.68:1 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. The length frequency distributions for *Kaharoa* and *Compass Rose* were substantially different in the 1999–2000 survey for both sexes with *Compass Rose* taking a higher proportion of smaller fish despite the larger 100 mm codend used compared to 28 mm for the *Kaharoa*. In 2000–01 length frequency distributions in the common depth range (10–30 m) were substantially different between vessels for fish smaller than about 40 cm, but for larger fish distributions were similar (note the different y-axis scales). *Compass Rose* again caught a higher proportion of smaller fish and this was partly due to the smaller codend.

Kaharoa elephantfish length frequency distributions showed a wide size range for both sexes from 0+ to mature. Fish caught at depths greater than 30 m were usually over 50 cm but those from the 10–30 m depth range were from all length classes. *Compass Rose* distributions were dominated by 0+ fish in the 10–30 m depth range but this was mainly due to three tows (stations 7, 28, and 29) where large numbers of 0+ fish were caught and this is shown by the large c.v. (90%). The numbers of fish over 20 cm were similar between the vessels, but overall *Kaharoa* took proportionally more large fish.

Adult elephantfish were well represented in *Kaharoa* catches, with recruited biomass making up 81% of total biomass (see Table 3) and mature fish over 52 cm about 30% of the scaled numbers (see Figure 10). *Compass Rose* recruited biomass made up about 66% of the total biomass and mature fish only 9% of the scaled numbers which were evenly divided between males and females. The sex ratio (males:females) of elephantfish caught by *Compass Rose* in the common depth range (10–30 m) was 0.68:1 compared with 0.80:1 for *Kaharoa*, and the overall ratios were 0.68:1 for *Compass Rose* and 0.96:1 for *Kaharoa*.

Invertebrates

Most species were ubiquitous and the number collected was lower than in 1999–2000 survey (KAH9917). Species of interest were the anthozoan *Flabellum knoxi*, the bryozoan *Hippomenella vellicata*, and the octopus *Enteroctopus zelandicus*.

Flabellum knoxi is not an uncommon species in NIWA collections, historically having a widespread distribution. However, the number of individuals from one sample and large size of the specimens is unusual, giving evidence of a stable unperturbed habitat, as does the largest clump of *H. vellicata* which is one of the largest seen by NIWA staff. Both these specimens were collected in depths of 75–100 m toward the southern end of stratum 1.

Enteroctopus zelandicus had not been previously collected from any survey in this series.

Discussion

Kaharoa survey

The fifth in the time series of ECSI summer trawl surveys was completed during December 2000–January 2001 and met most objectives. Coefficients of variation associated with biomass indices for the target species were within the specified target range for elephantfish and giant stargazer. Low catches of 0+ and 1+ red cod and red gurnard made it very difficult to achieve the target c.v.s because small catches (as small as 0.5 kg for 0+ red cod) resulted in high coefficients of variation.

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 with the previous four surveys indicates that for 20 of the 23 species listed in Appendix 7, including all target species, biomass estimates declined from 1999–2000, with 21 estimates below the previous average. In addition, 14 estimates were the lowest for any year. This result suggests strongly that there may be a catchability difference between surveys. Beentjes & Stevenson (2001) noted that biomass fluctuated synchronously between the bulk of species on the ECSI over the first four surveys, indicating a strong species correlation; this synchronous trend has continued in 2000–01. Francis et al. (2001) analysed catchability in New Zealand research trawl survey time series and concluded that catchability differences exist and can be extreme. They examined the first four surveys in the time series (1996–97 to 1999–2000) and found that three out of four surveys had extreme catchability differences (wide variance from the mean catch rates). It is likely that the catchability variation of the 2000–01 survey also ranked as extreme. Studies of commercial fisheries off southern Namibia indicate that water temperature can have a significant effect on biomass estimates for many 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). Although biomass for many species, including the target species, were positively correlated with satellite sea surface temperature (NIWA SST Archive) for the first four surveys (Beentjes & Stevenson 2001), the results of the 2000–2001 survey do not agree, and consequently there are likely to be other factors besides water temperature that are influencing catchability. Based on the inherent problems in obtaining comparable relative biomass estimates and length frequency distributions between surveys, the Inshore Stock Assessment Working Group (17 March 2001) recommended that the ECSI summer trawl survey time series be discontinued.

Juvenile year classes are clearly distinguishable for the target species, red cod, red gurnard, and elephantfish, but it may be difficult to develop recruitment indices for these and other species because of the problems associated with determining catchability. 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. 1999). The summer surveys have provided an index for the 1+ as well as the 0+ red cod year classes and, despite the issue of catchability associated with these surveys, the relative strength of these pre-recruits year classes is consistent with the magnitude of commercial catches. Results of the five 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**

The survey depth range was extended into depths shallower than 10 m to target elephantfish more effectively. This was tested in 1999–2000 by having FV *Compass Rose* survey two new strata (22 and 23) in the 5–10 m depth range and also two of the 10–30 m strata (19 and 20) concurrently with *Kaharoa* to directly compare catches. The commercial vessel survey was repeated in 2000–01, but incorporating changes to the survey design and using a 28 mm codend.

The main objective of the *Compass Rose* survey was to determine elephantfish biomass in less than 10 m depth, which is 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 and trawl gear. *Compass Rose* elephantfish catch rates were substantially higher than those from *Kaharoa* for both surveys. Changes incorporated into the *Compass Rose* survey in 2000–01 aided in improving the precision of the elephantfish biomass estimate allowing a scaling factor to be calculated. Thus a scaling factor of 0.281 could theoretically be applied to the *Compass Rose* elephantfish biomass estimate in the 5–10 m strata converting that biomass from 84 to 24 t making it equivalent to a theoretical estimate from *Kaharoa* had it sampled the 5–10 m depth range.

The length frequency distributions were distinctly different between vessels within the same depth range (10–30 m), particularly for small fish (see Figure 10). However, the c.v. for the estimated population from *Compass Rose* was high (90%) because of large numbers of 0+ fish in only three tows. Elephantfish school by size and can be highly aggregated, therefore it is not unexpected that a few tows should be dominated by a single cohort. It is harder to explain why *Kaharoa* caught larger fish than *Compass Rose* on both the 1999–2000 and 2000–01 surveys. We cannot rule out the possibility that the trawl gear of these vessels have different selectivities and that *Kaharoa* favours larger fish.

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, rough skate, school shark, spiny dogfish, rig, and blue warehou (see Table 9). Therefore, for all target species except elephantfish, the current minimum depth of 10 m is appropriate for *Kaharoa* surveys.

Comparison of the 1999–2000 and 2000–01 surveys indicates that the location of elephantfish aggregations can vary between surveys. For example in 1999–2000 about half of the estimated biomass including large mature fish were in less than 10 m compared with only 6% of biomass in 2000–01. In addition there were few mature fish in 5–10 m in 2000–01.

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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*.**

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)
Kaharoa						
1	30–100	984	202	6		164
2	30–100	1 242	0	10		124
3	50–100	1 920	0	10		192
3A	30–50	1 111	0	5		222
4	50–100	1 853	0	10		185
4A	30–50	843	0	4		211
5	75–100	1 528	0	3		509
5A	30–75	971	0	5		194
6	30–100	2 373	208	3		791
7	30–100	2 089	871	3	2	418
8	100–200	628	17	3		209
9	100–200	1 163	0	4		291
10	100–200	1 191	0	3	6	132
11	100–200	1 468	0	3	7	147
12	100–200	764	132	3		255
13	100–200	999	406	3		333
14	200–400	752	17	3		251
16	200–400	751	0	3		250
17	200–400	724	165	3		241
18	10–30	1 276	0	4		319
19	10–30	986	0	7		141
20	10–30	797	0	7		114
21	10–30	520	0	3		173
Total (average)		26 935	2 018	108	15	(219)
Compass Rose						
19	10–30	453	0	5	10	30
19A	10–31	535	0	7	5	45
20	10–30	797	0	10		80
22	5–10	65	0	5		13
22A	5–10	37	0	5		7
23	5–10	95	15	8		12
Total (average)		1 981	15	40	15	(36)

***Table 2*: Tow and gear parameters (recorded values only) by depth range for *Kaharoa* and *Compass Rose*.**

Kaharoa

Tow parameters	*n*	Mean	s.d.	Range
Tow length (n. mile)	123	1.96	0.18	1–2.03
Gear parameters				
10–30 m				
Headline height (m)	21	5.8	0.3	5.4–6.3
Doorspread (m)	5	71.1	1.2	69.6–72.5
Warp/depth ratio	21	8.8	1.9	8.8–13.3
30–100 m				
Headline height (m)	61	5.6	0.2	5.0–6.0
Doorspread (m)	46	75.0	3.0	69.8–81.1
Warp/depth ratio	61	3.8	1.2	2.5–6.6
100–200 m				
Headline height (m)	32	5.6	0.1	5.1–5.8
Doorspread (m)	29	75.3	3.1	68.8–82.0
Warp/depth ratio	32	2.3	0.1	2.1–2.6
200–400 m				
Headline height (m)	9	5.6	0.2	5.3–5.8
Doorspread (m)	8	81.6	6.6	73.1–91.4
Warp/depth ratio	9	2.3	0.1	2.2–2.7
10–400 m				
Headline height (m)	123	5.6	0.2	5–6.3
Doorspread (m)	88	75.5	4.0	68.8–91.4
Warp/depth ratio	123	4.1	0.1	2.1–13.3

Compass Rose

Tow parameters				
Tow length (n. mile)	56	1.99	0.2	0.65–2.11
Headline height set at a constant 2.5 m				
Gear parameters				
5–10 m				
Doorspread (m)		57.9	5.5	45.5–65.8
Warp/depth ratio		8.6	3.4	3.4–14.7
10–30 m				
Doorspread (m)		61.6	5.6	48.9–68.9
Warp/depth ratio		5.9	1.5	3.7–8.8
5–30 m				
Doorspread (m)		59.5	5.8	43.5–68.9
Warp/depth ratio		7.4	3.0	3.4–14.7

Table 3: **Total catch, relative biomass indices, and coefficients of variation (c.v.) for species caught on *Kaharoa* where more than 150 kg were caught (plus rig and white warehou but excluding broadnose sevengill shark) together with estimates of recruited biomass for selected ITQ species.**

	Catch		Biomass		Recruited		
	Weight (kg)	% of total	(t)	c.v. %	Size range (cm)	Biomass (t)	c.v.%
Spiny dogfish	37 015	41.3	30 508	34.2			
Barracouta	27 117	30.3	21 808	18.7	> 50	14 887	20.9
Dark ghost shark	4 917	5.5	2 950	18.1	> 55	1 797	19.4
Crested bellowsfish	3 458	3.9	2 342	53.1			
Sea perch	2 669	3.0	1 792	19.9			
Tarakihi	1 988	2.2	1 540	12.8	> 25	1 148	14.2
Arrow squid	1 656	1.8	1 063	30.8			
Red cod (all)	1 365	1.5	1 402	81.8	> 40	1 283	88.5
Red cod (0+)	—		1	55			
Red cod (1+)	—		71	33			
Hoki	1 313	1.5	1 038	35.6	> 60	281	23.9
Elephantfish	1 241	1.4	696	18.1	> 50	561	20.8
Two saddle rattail	1 117	1.2	1052	60.7			
Carpet shark	695	0.8	434	15.4			
Southern pigfish	428	0.5	230	31.4			
Silverside	380	0.4	228	19.4			
Smooth skate	357	0.4	248	33.5			
Silver dory	323	0.4	284	38.2			
Giant stargazer	298	0.3	214	16.3	>30	198	17.1
Ray's bream	291	0.3	229	59.2			
Silver warehou	248	0.3	178	28.5	> 25	173	29.2
Hapuku	233	0.3	209	22.3			
Rough skate	204	0.2	222	34.3			
School shark	187	0.2	133	21.7	> 90	25	45.1
Blue warehou	164	0.2	122	39.1	> 25	47	79.4
Ling	164	0.2	121	24.3			
Red gurnard	157	0.2	146	33.7	> 30	129	32.2
Oblique banded rattail	155	0.2	120	23.4			
White warehou	145	0.2	123	68.0			
Rig	77	0.1	48	35.4	> 90	21	45.5
Other species	1 307	1.5					
All species combined	89 590		70 375	16.4			

– 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 of which more than 50 kg were caught, and brill.**

	Catch		Biomass		Recruited		
	Weight (kg)	% of total	(t)	c.v. %	Size range (cm)	Biomass (t)	c.v.%
Elephantfish							
10–30 m (strata 19, 19A, 20)			1 229	29	> 50	817	41
5–10 m (strata 22, 22A, & 23)			84	23	> 50	52	32
Total	8 503	38	1 314	27	> 50	868	39
Spiny dogfish	3 969	18	580	24			
Rough skate	2 230	10	350	13			
Barracouta	896	4	124	32			
Blue warehou	882	4	196	58			
Red gurnard	864	4	155	21			
School shark	701	3	73	15			
Rig	505	2	66	26			
Red cod	311	1	50	39			
N.Z. sole	290	1	50	21			
Sand flounder	159	1	30	23			
Tarakihi	116	1	16	49			
Smooth skate	63	< 0.5	14	89			
Yellowbelly flounder	62	< 0.5	8	42			
Brill	51	< 0.5	8	34			
Total (ITQ secies)	19 734						
Total (all species)	22 569						

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

Survey	Species	Year class	Size range (cm)	Biomass (t)	c.v.%
Kaharoa					
	Barracouta	0+	< 19	1.2	61
		1+	19–36	1621	27
		2+	36–52	6424	23
	Blue warehou	0+	< 12	0.3	62
		1+	12–23	73	36
	Elephantfish	0+	< 23	5.1	48
		1+	23–32	23	38
	Hoki	1+	33–48	210	46
		2+	48–62	581	53
	Red cod	0+	< 15	0.6	55
		1+	15–32	71	33
	Red gurnard	2+	18–26	8.3	61
	School shark	0+	< 35	0.2	73
		1+	35–52	5.9	27
	Silver warehou	0+	< 19	4.6	20
		1+	19–32	61	47
	Tarakihi	0+	< 12	0.1	54
		1+	12–18	34	26
		2+	18–22	151	20
Compass Rose					
	Elephantfish	0+	< 23	109	43
		1+	23–32	80	32

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 kg.km^{-2}**

		Species code									
Stratum	Depth (m)	BAR	ELE	GSH	GUR	HAP	HOK	LIN	RBM	RCO	RSK
1	30–100	529	1	1	0	3	0	7	0	10	9
		(637)	(3)	(2)	(1)	(8)		(14)		(15)	(23)
2	30–100	1 162	34	29	8	7	0	5	0	9	3
		(1 064)	(41)	(89)	(13)	(10)		(13)		(18)	(6)
3	50–100	2 270	11	16	+	8	0	3	0	21	0
		(1 692)	(33)	(38)	(1)	(15)		(5)		(39)	
3A	30–50	756	125	0	4	0	0	1	0	10	0
		(612)	(56)		(6)			(1)		(7)	
4	50–100	1 490	1	122	4	7	0	+	0	2	9
		(1 373)	(3)	(285)	(3)	(11)		(+)		(4)	(21)
4A	30–50	2 510	9	0	2	11	0	+	0	5	0
		(3 359)	(9)		(2)	(23)		(+)		(4)	
5	30–70	105	0	0	0	8	0	+	0	0	33
		(181)				(15)		(+)			(57)
5A	70–100	441	7	0	7	7	0	0	0	2	6
		(400)	(11)		(14)	(13)				(3)	(8)
6	30–100	47	0	0	1	12	0	0	0	0	4
		(42)			(1)	(14)					(8)
7	30–100	2 859	3	0	40	14	0	0	0	14	42
		(3 659)	(7)		(50)	(31)		(1)		(20)	(57)
8	100–200	560	0	60	0	4	0	23	5	9	9
		(765)		(98)	(4)	(7)		(21)	(8)	(11)	(9)
9	100–200	626	0	303	2	14	0	1	0	4	0
		(842)		(403)	(1)	(28)		(2)		(5)	
10	100–200	438	0	969	0	14	1	5	0	33	0
		(882)		(690)		(18)	(3)	(5)		(70)	
11	100–200	553	0	325	+	12	0	1	0	10	0
		(1 377)		(525)	(1)	(15)		(1)		(20)	
12	100–200	83	0	0	0	18	0	0	5	4	15
		(90)				(19)			(8)	(7)	(13)
13	100–200	28	0	0	0	10	0	1	5	1162	0
		(22)				(17)		(1)	(8)	(1987)	
14	200–400	67	0	522	0	5	228	22	4	15	0
		(60)		(573)		(9)	(294)	(14)	(3)	(1)	
16	200–400	66	0	319	0	0	905	31	220	19	0
		(114)		(114)			(750)	(13)	(290)	(10)	
17	200–400	122	0	3	0	0	256	51	69	3	3
		(111)		(4)			(289)	(62)	(119)	(4)	(5)
18	10–30	2	1	0	1	0	0	0		0	0
		(4)	(1)		(1)						
19	10–30	76	183	0	18	0	0	0	0	12	6
		(56)	(143)		(31)					(26)	(9)
20	10–30	380	207	0	7	0	0	0	0	28	3
		(803)	(118)		(10)					(47)	(6)
21	10–30	42	235	0	2	0	0	0	0	0	23
		(62)	(338)		(2)						(22)

Table 6—continued

Stratum	Depth (m)	Species code SCH	SPD	SPE	SQU	SSK	STA	SWA	TAR	WAR	WWA
1	30–100	0	6 297	133	50	0	4	0	81	0	0
			(9 811)	(219)	(62)		(7)		(64)		
2	30–100	17	2 438	11	7	+	14	0	78	0	0
		(20)	(4 855)	(31)	(9)	(1)	(13)		(141)		
3	50–100	4	681	25	41	8	3	28	126	0	0
		(6)	(1 473)	(31)	(80)	(26)	(4)	(55)	(118)		
3A	30–50	2	1 046	4	14	13	4	+	49	+	0
		(4)	(2 008)	(9)	(24)	(29)	(4)	(+)	(53)	(+)	
4	50–100	0	1 138	14	15	13	27	29	242	5	0
			(2 903)	(24)	(12)	(34)	(41)	(52)	(200)	(12)	
4A	30–50	1	15	0	10	0	+		62	11	0
		(2)	(18)		(7)		(1)	(+)	(42)	(12)	
5	30–70	0	1 331	2	18	41	13	1	38	0	1
			(1 359)	(3)	(18)	(70)	(13)	(1)	(14)		(+)
5A	70–100	0	565	1	5	0	4	+	44	3	0
			(615)	(2)	(6)		(7)	(1)	(54)		
6	30–100	0	469	1	14	0	2	+	61	0	0
			(324)	(2)	(12)		(2)	(+)	(48)		
7	30–100	11	127	31	3	0	3	+	22	20	1
		(15)	(182)	(49)	(2)		(7)	(+)	(47)	(42)	(+)
8	100–200	0	1 012	232	41	0	16	0	11	0	0
			(1 097)	(202)	(48)		(+)		(20)		
9	100–200	14	8 142	46	30	0	8	6	4	0	0
		(28)	(15 677)	(81)	(24)		(8)	(4)	(7)		
10	100–200	4	931	450	360	28	8	6	11	0	0
		(9)	(886)	(554)	(777)	(55)	(7)	(11)	(17)		
11	100–200	1	451	147	54	29	24	7	23	0	0
		(4)	(405)	(265)	(60)	(33)	(25)	(14)	(39)		
12	100–200	0	304	112	74	0	21	7	173	0	0
			(365)	(123)	(67)		(33)	(6)	(191)		
13	100–200	0	32	429	16	0	11	4	87	0	0
			(26)	(354)	(10)		(8)	(7)	(34)		
14	200–400	0	183	1	166	48	5	3	0	0	2
			(148)	(1)	(175)	(83)	(9)	(5)			(13)
16	200–400	0	186	2	27	0	2	18	0	0	3
			(117)	(3)	(16)		(4)	(26)			(134)
17	200–400	0	25	43	22	0	2	24	0	0	2
			(7)	(45)	(27)		(4)	(41)			(17)
18	10–30	16	16	0	0	0	0	+	0	5	0
		(14)	(12)					(+)		(3)	
19	10–30	16	170	0	1	0	0	+	+	45	0
		(19)	(203)		(1)			(+)	(+)	(67)	
20	10–30	12	75	0	0	26	0	+	0	9	0
		(19)	(77)			(44)		(+)		(18)	
21	10–30	21	83	0	+	0	0	0	+	0	0
		(34)	(56)		(+)				(+)		

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	ELE	GSH	GUR	HAP	HOK	LIN	RBM	RCO	RSK
1	521	1	2	+	3	0	7	0	10	9
	(49)	(100)	(100)	(100)	(100)		(79)		(62)	(100)
2	1 444	42	89	10	9	0	6	0	11	4
	(29)	(38)	(100)	(48)	(45)		(85)		(63)	(67)
3	4 359	22	0	+	15	0	6	0	41	0
	(24)	(92)		(100)	(59)		(50)		(58)	
3A	840	139	0	5	0	0	1	0	11	0
	(36)	(20)		(61)			(100)		(33)	
4	2 761	2	119	7	14	0	+	0	4	17
	(29)	(100)	(63)	(20)	(48)		(100)		(51)	(75)
4A	2 116	8	0	2	10	0	+	0	4	0
	(67)	(48)		(44)	(100)		(100)		(42)	
5	160	0	7	0	13	0	+	0	0	50
	(99)		(92)		(100)		(100)			(100)
5A	428	7	0	7	7	0	0	0	2	5
	(41)	(69)		(87)	(82)				(100)	(66)
6	111	0	0	3	29	0	0	0	0	11
	(52)			(52)	(65)					(100)
7	5 972	6	0	83	29	0	1	0	29	87
	(57)	(100)		(56)	(100)		(100)		(64)	(61)
8	352	0	265	0	3	0	14	3	6	5
	(79)		(83)		(100)		(52)	(100)	(67)	(62)
9	728	0	510	2	16	0	1	0	5	0
	(67)		(48)	(100)	(100)		(71)		(62)	
10	522	0	625	+	16	1	6	0	39	0
	(67)		(31)	(100)	(43)	(100)	(30)		(71)	
11	812	0	161	+	18	0	1	0	15	0
	(79)		(48)	(100)	(39)		(63)		(64)	
12	64	0	0	0	14	0	0	3	3	12
	(62)				(62)			(100)	(100)	(51)
13	28	0	58	0	10	0	1	5	1160	0
	(44)		(50)		(100)		(52)	(100)	(99)	
14	51	0	371	0	4	172	17	3	12	0
	(52)		(39)		(100)	(74)	(37)	(51)	(3)	
16	49	0	119	0	0	680	24	165	14	0
	(100)		(65)			(48)	(24)	(76)	(30)	
17	88	0	186	0	0	185	37	50	2	2
	(53)		(100)			(65)	(71)	(100)	(100)	(100)
18	2	1	0	1	0	0	0		0	0
	(100)	(100)		(66)						
19	75	181	0	18	0	0	0	0	12	6
	(28)	(30)		(65)					(85)	(57)
20	303	165	0	5	0	0	0	0	22	2
	(80)	(22)		(55)					(63)	(73)
21	22	122	0	1	0	0	0	0	0	12
	(84)	(83)		(59)						(55)

Table 7—continued

Stratum	Species code									
	SCH	SPD	SPE	SQU	SSK	STA	SWA	TAR	WAR	WWA
1	0	6 198	131	49	0	4	0	80	0	0
		(64)	(67)	(51)		(75)		(32)		
2	22	3 029	14	8	1	17	0	97	0	0
	(37)	(63)	(87)	(44)	(100)	(31)		(57)		
3	7	1 307	47	78	16	6	55	242	0	0
	(55)	(68)	(40)	(62)	(100)	(39)	(61)	(30)		
3A	2	1 162	24	16	14	4	+	54	+	0
	(100)	(86)	(47)	(76)	(100)	(49)	(61)	(49)	(67)	
4	0	2 109	3	27	23	50	54	448	9	0
		(81)	(70)	(26)	(86)	(47)	(57)	(26)	(72)	
4A	1	13	3	8	0	0	+	52	9	0
	(100)	(58)	(100)	(37)		(100)	(100)	(34)	(59)	
5	0	2 033	65	28	62	19	1	58	0	+
		(59)	(70)	(58)	(100)	(60)	(100)	(22)		(100)
5A	0	548	146	5	0	4	0.48	43	3	0
		(49)	(50)	(55)		(70)	(65)	(55)	(73)	
6	0	1 112	54	34	0	5	1	144	0	0
		(40)	(87)	(48)		(50)	(50)	(46)		
7	23	265	536	5	0	7	+	45	42	+
	(64)	(64)	(41)	(38)		(97)	(61)	(98)	(93)	(100)
8	0	635	216	26	0	10	0	7	0	0
		(63)	(57)	(67)		(2)		(100)		
9	16	9 473	86	35	0	9	6	4	0	0
	(100)	(96)	(63)	(39)		(51)	(36)	(100)		
10	5	1 109	429	429	33	9	7	13	0	0
	(74)	(32)	(48)	(72)	(66)	(29)	(64)	(50)		
11	2	662	1	79	42	35	11	33	0	0
	(100)	(28)	(100)	(35)	(36)	(33)	(59)	(54)		
12	0	233	1	57	0	16	5	132	0	0
		(69)	(91)	(52)		(92)	-51%	(64)		
13	0	32	31	16	0	11	4	87	0	0
		(47)	(60)	(38)		(44)	(100)	(23)		
14	0	138	0	125	36	4	2	0	0	10
		(46)		(61)	(100)	(100)	(100)			(67)
16	0	140	0	20	0	2	14	0	0	100
		(36)		(34)		(100)	(82)			(82)
17	0	18	0	16	0	2	17	0	0	12
		(17)		(72)		(100)	(100)			(87)
18	20	21	0	0	0	0	+	0	7	0
	(44)	(36)					(33)		(32)	
19	16	167	4	1	0	0	+	+	45	0
	(44)	(45)	(100)	(81)			(47)	(100)	(56)	
20	9	60	0	0	20	0	+	0	7	0
	(63)	(39)			(66)		(65)		(78)	
21	11	43	1	+	0	0	0	+	0	0
	(91)	(39)	(93)	(100)				(100)		

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)	BAR	ELE	ESO	GUR	RCO	RSK	SCH	SPD	SPO	WAR
19	10–30	217	983	2	136	4	302	29	373	29	8
		(337)	(1 960)	(5)	(84)	(8)	(224)	(27)	(260)	(66)	(26)
19A	10–30	20	990	45	97	34	93	46	379	39	20
		(27)	(1 752)	(44)	(114)	(95)	(62)	(53)	(864)	(58)	(35)
20	10–30	17	320	26	51	29	170	21	190	24	206
		(28)	(236)	(31)	(104)	(49)	(148)	(16)	(68)	(47)	(454)
22	5–10	6	354	17	4	27	112	61	276	84	117
		(9)	(246)	(17)	(6)	(23)	(68)	(43)	(179)	(63)	(112)
22A	5–10	17	646	65	2	16	122	64	677	9	44
		(18)	(972)	(61)	(4)	(20)	(136)	(96)	(501)	(11)	(55)
23	5–10	+	394	10	0	51	167	132	146	73	93
		(+)	(214)	(9)		(63)	(115)	(157)	(57)	(86)	(122)

* Species codes are given in Appendix 6
+, less than 0.5

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									
		BAR	ELE	ESO	GUR	RCO	RSK	SCH	SPD	SPO	WAR
Stratum	Depth (m)										
19	10–30	98	445	1	62	2	137	13	169	13	4
		(40)	(51)	(56)	(16)	(62)	(19)	(24)	(18)	(59)	(86)
19A	10–30	11	529	24	52	18	50	25	203	21	11
		(38)	(51)	(28)	(34)	(81)	(19)	(33)	(66)	(43)	(51)
20	10–30	14	255	21	41	23	135	16	151	19	164
		(51)	(23)	(38)	(65)	(53)	(28)	(24)	(11)	(62)	(70)
22	5–10	+	23	1	+	2	7	4	18	5	8
		(72)	(31)	(45)	(76)	(38)	(27)	(32)	(29)	(33)	(43)
22A	5–10	1	24	2	+	1	5	2	25	+	2
		(46)	(67)	(42)	(94)	(56)	(50)	(67)	(33)	(55)	(56)
23	5–10	+	37	1	0	5	16	13	14	7	9
		(75)	(19)	(31)		(44)	(24)	(42)	(14)	(42)	(47)

* Species codes are given in Appendix 6
+, less than 0.5

***Table 10*: Comparison of elephantfish biomass estimates by depth for *Kaharoa* and *Compass Rose*.**

Depth (m)		*Kaharoa*		*Compass Rose*	
		Biomass (t)	c.v.%	Biomass (t)	c.v.%
5–10		—		84	23
10–30	Equal areas	346	19	1 229	29
	Total*	469	26	1 229	29
30–100		228	17	—	
100–200		0		—	
200–400		0		—	
	Total	696	18	1 314	27

— Depth range not surveyed

* Includes biomass estimate from strata 18 & 21 which were not surveyed by *Compass Rose*

Table 11: **Numbers of length frequency and biological samples collected (species codes are given in Appendix 4). (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	113@	7 617	3 534	3 183	–	–	–
BCO	2	6	11	6	3	–	–	–
BTA	5	1	2	0	2	–	–	–
ELE	1							
Kaharoa		41	837	418	418	40	500	294
Compass Rose		54	4 206	1 902	2 304	–	–	–
ESO	2	11	25	#	#	–	–	–
GFL	2	3	10	#	#	–	–	–
GSH	G	40	2 024	916	1 106	5	325	200
GUR	1	50	365	138	227	50	267	214
HAK	2	3	7	0	2	–	–	–
HAP	2	35	67	34	33	–	–	–
HOK	2	9	555	292	261	–	–	–
JDO	2	3	6	2	4	–	–	–
JMD	1	6	12	4	1	–	–	–
JMM	1	5	19	7	3	–	–	–
JMN	1	4	4	1	1	–	–	–
KAH	1	6	9	6	3	–	–	–
LDO	2	5	40	5	35	–	–	–
LEA	2	17	280	1	2	–	–	–
LIN	2	41	182	73	109	–	–	–
LSO	2	26	69	#	#	–	–	–
MDO	2	1	1	0	1	–	–	–
MIQ	4	1	1	0	1	–	–	–
MOK	1	2	7	4	3	–	–	–
RBM	1	9	120	61	59	–	–	–
RCO	2	67	1 043	588	424	67	620	314
RSK	5	26	78	30	48	26	78	–
SAM	1	2	3	2	1	–	–	–
SBW	1	1	1	1	0	–	–	–
SCH	2	35	115	57	58	1	1	–
SEV	2	1	1	0	1	–	–	–
SFL	2	8	33	#	#	–	–	–
SPD	2	122	7 256	3 979	3 276	–	–	–
SPE	2	65	2 981	1 470	1 450	–	–	298
SPO	2	10	52	26	26	9	36	–
SQU	4	101	4 330	964	1 370	–	–	–
SSK	5	23	74	34	39	23	74	–
STA	2	69	259	129	128	68	252	181
SWA	1	51	366	154	113	–	–	–
TAR	1	76	3 727	1 884	1 822	38	732	205
THR	2	1	1	0	1	–	–	–
TRU	1	1	1	1	0	–	–	–
WAR	1	25	759	23	19	–	–	–
WWA	1	9	120	66	52	–	–	–
YBF	2	1	1	#	#	–	–	–
YCO	2	2	3	2	1	–	–	–

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 hea

– 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	6	0	0	0	0	4	0	0	0	0	
21–30	39	0	0	0	0	34	0	0	0	0	
31–40	49	2	0	0	0	36	0	0	0	0	
41–50	13	1	0	0	0	19	0	0	0	0	
51–60	6	1	0	0	0	20	2	0	0	0	
61–70	1	0	0	0	0	3	5	0	0	1	
71–80	0	0	0	0	0	0	1	0	0	0	
Total	114	4	0	0	0	116	8	0	0	1	243
Red cod											
11–20	75	0	0	0		38	0	0	0	0	
21–30	118	2	0	0		114	0	0	0	0	
31–40	47	3	1	0		25	0	0	3	0	
41–50	19	12	5	8		38	2	0	6	0	
51–60	12	2	3	1		28	1	0	0	0	
61–70	3	2	0	0		22	2	1	0	0	
71–80	0	0	0	0		0	0	0	0	0	
Total	274	21	9	9	0	265	5	1	9	0	593
Red gurnard											
11–20	0	0	0	0	0	12	0	0	0	0	
21–30	31	7	0	0	0	20	4	0	0	1	
31–40	38	21	3	0	0	16	29	14	0	0	
41–50	2	2	0	0	0	0	17	23	2	0	
51–60	0	0	0	0	0	0	0	1	0	0	
Total	71	30	3	0	0	48	50	38	2	1	243

* Small fish of undetermined 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.

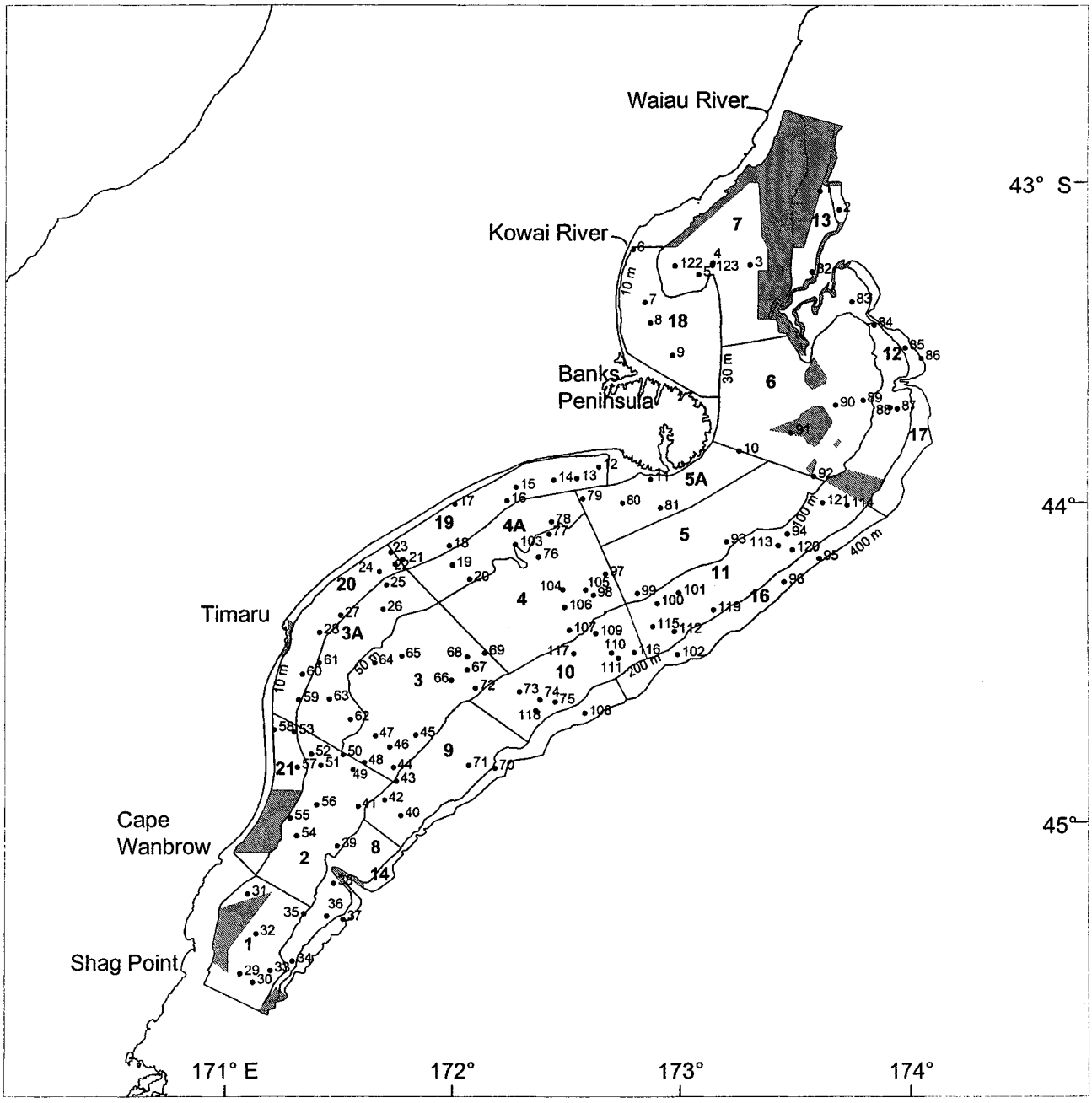


Figure 1: **Survey area for *Kaharoa* showing stratum boundaries and numbers (bold type), areas of untrawlable (foul) ground (shaded), and trawl station numbers and start positions.**

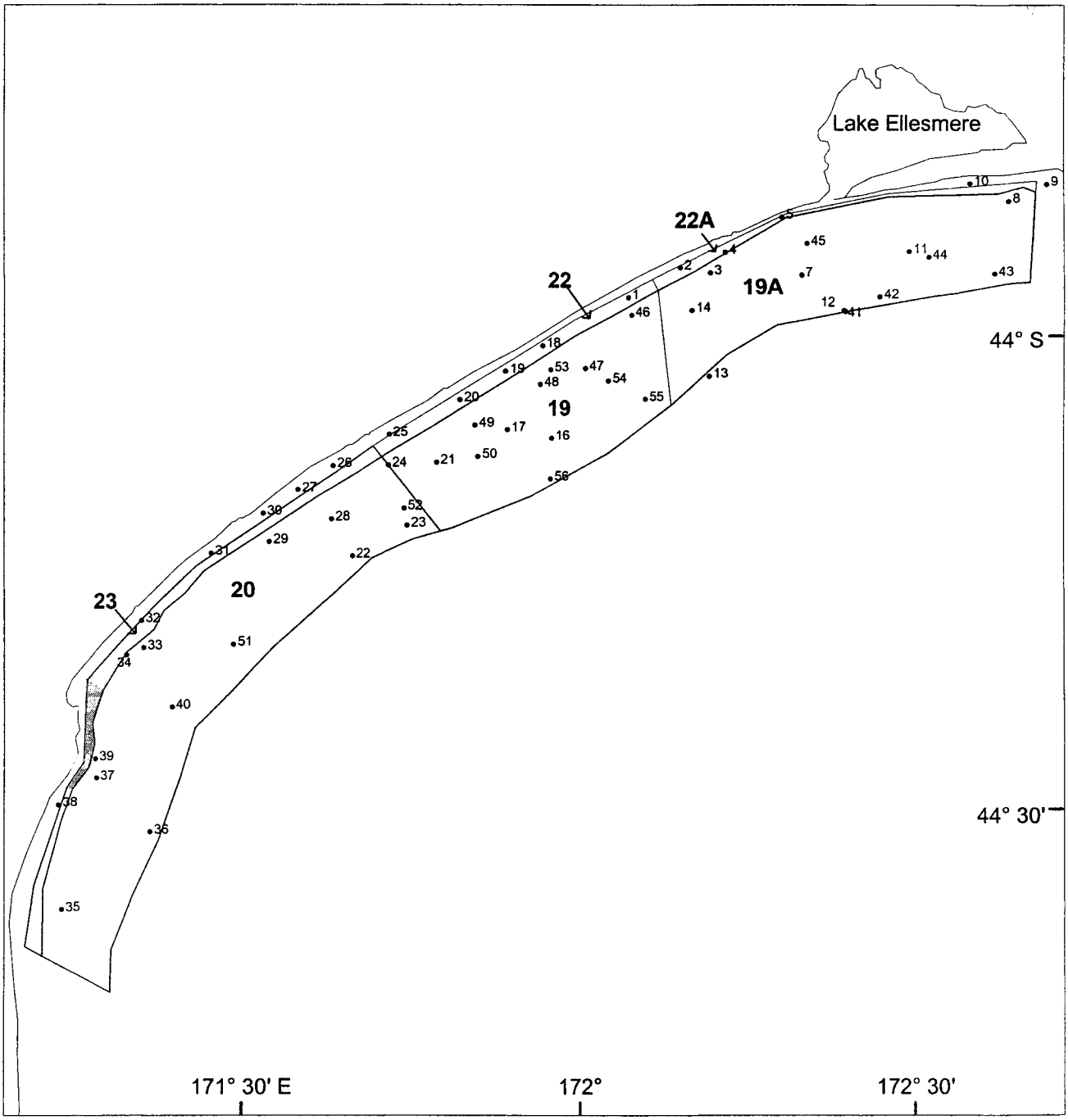


Figure 2: **Survey area for *Compass Rose* showing stratum boundaries and numbers (bold type), areas of untrawlable (foul) ground (shaded), and trawl station numbers and start positions.**

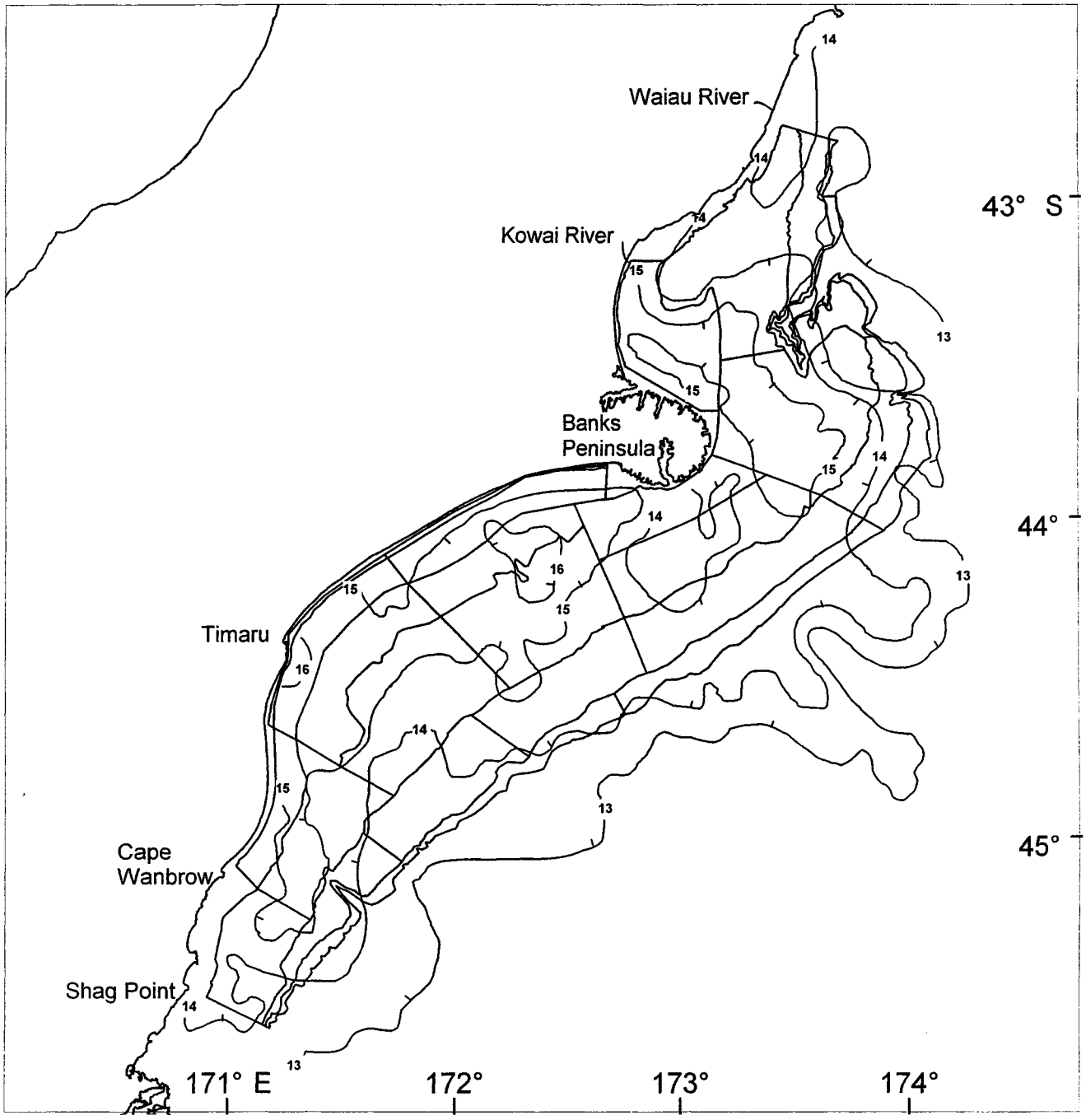


Figure 3a: **Mean sea surface temperatures for 12–15 December 2000 from NIWA SST Archive.**

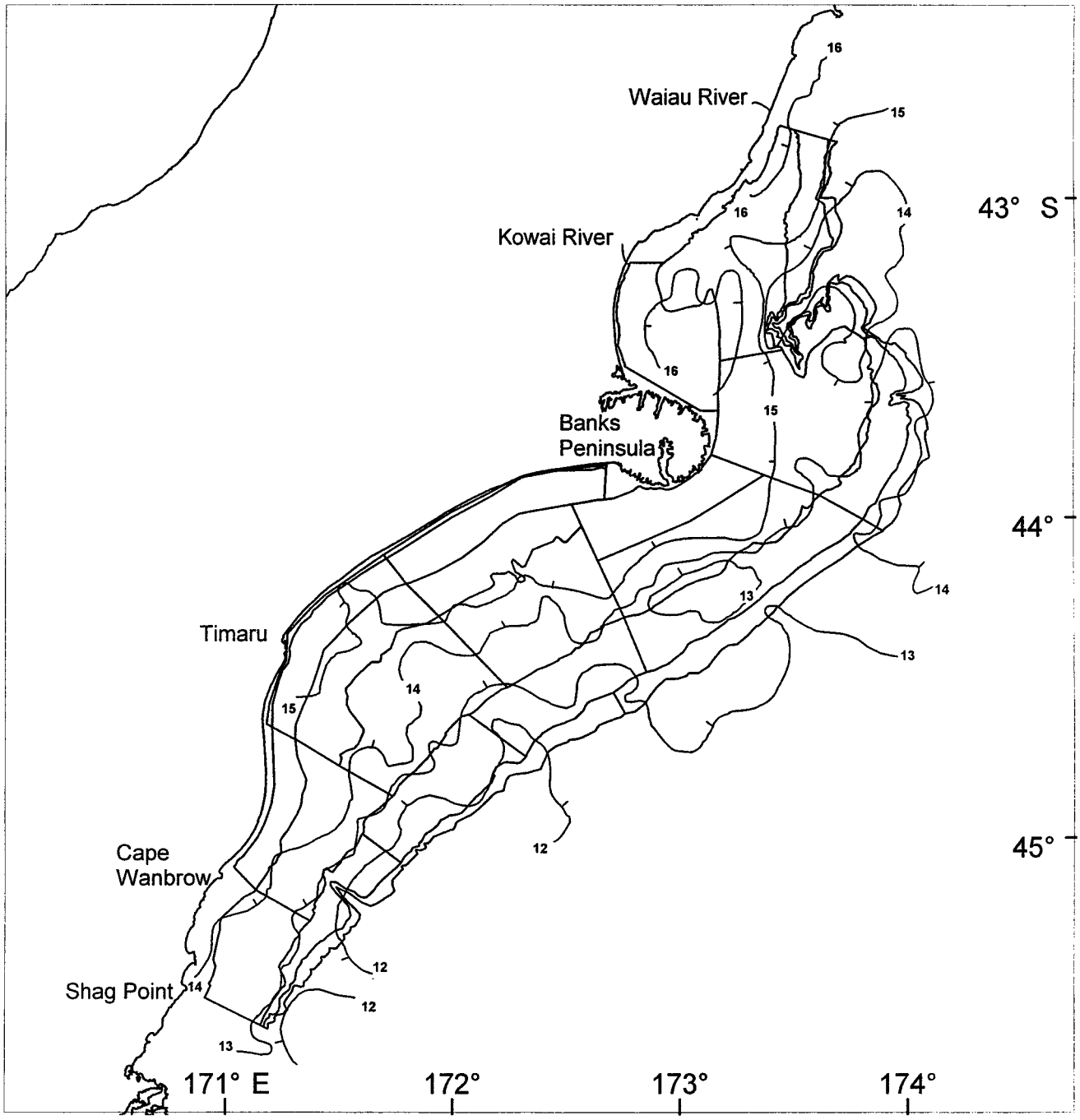


Figure 3b: **Mean sea surface temperatures for 2–5 January 2001 from NIWA SST Archive.**

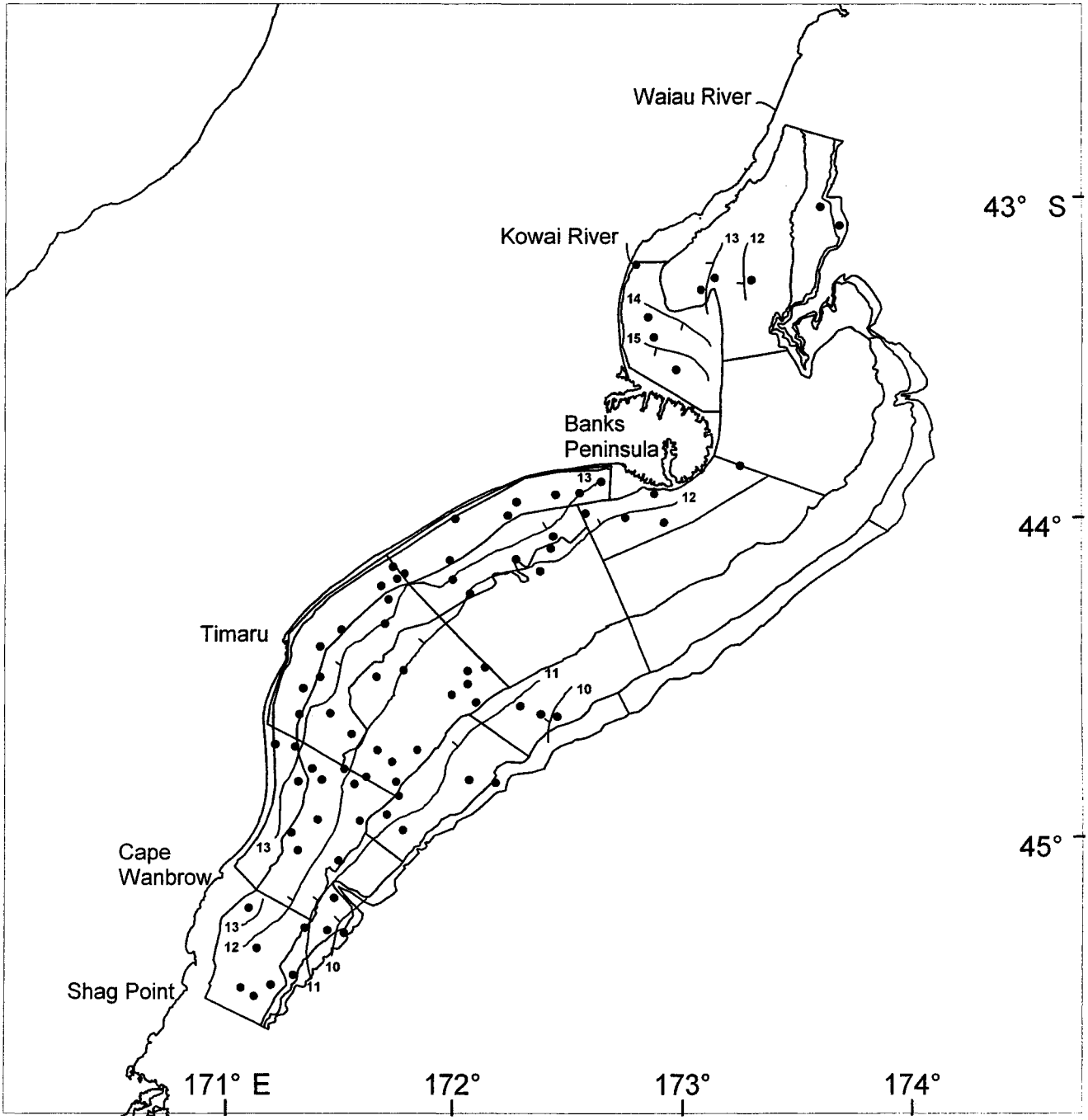


Figure 3c: **Positions of bottom temperature recordings from *Kaharoa* for the first leg (10–21 December 2000) and isotherms estimated from temperature recordings.**

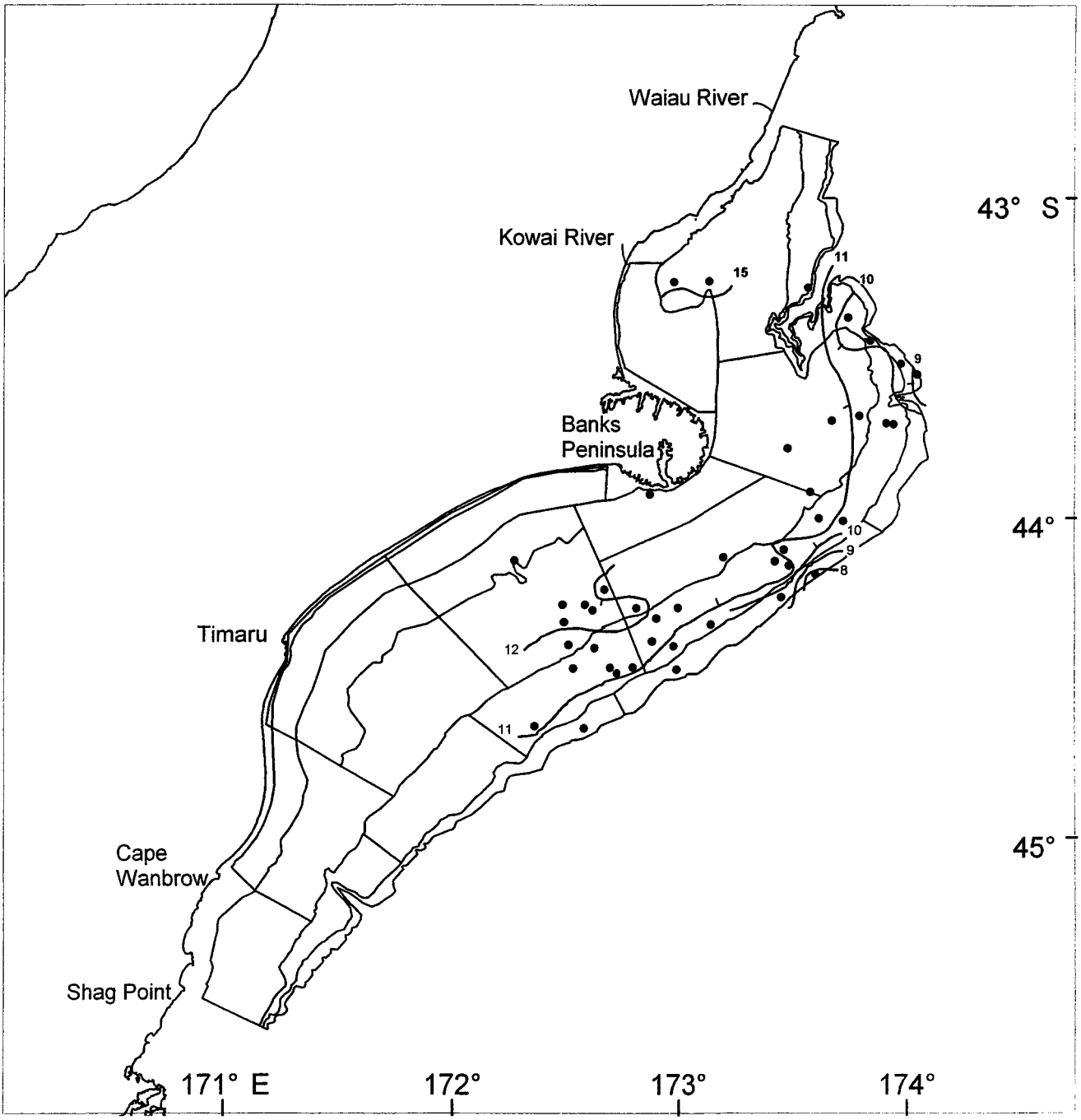


Figure 3d: **Positions of bottom temperature recordings from *Kaharoa* for the second leg (28 December 2000 to 9 January 2001) and isotherms estimated from temperature recordings.**

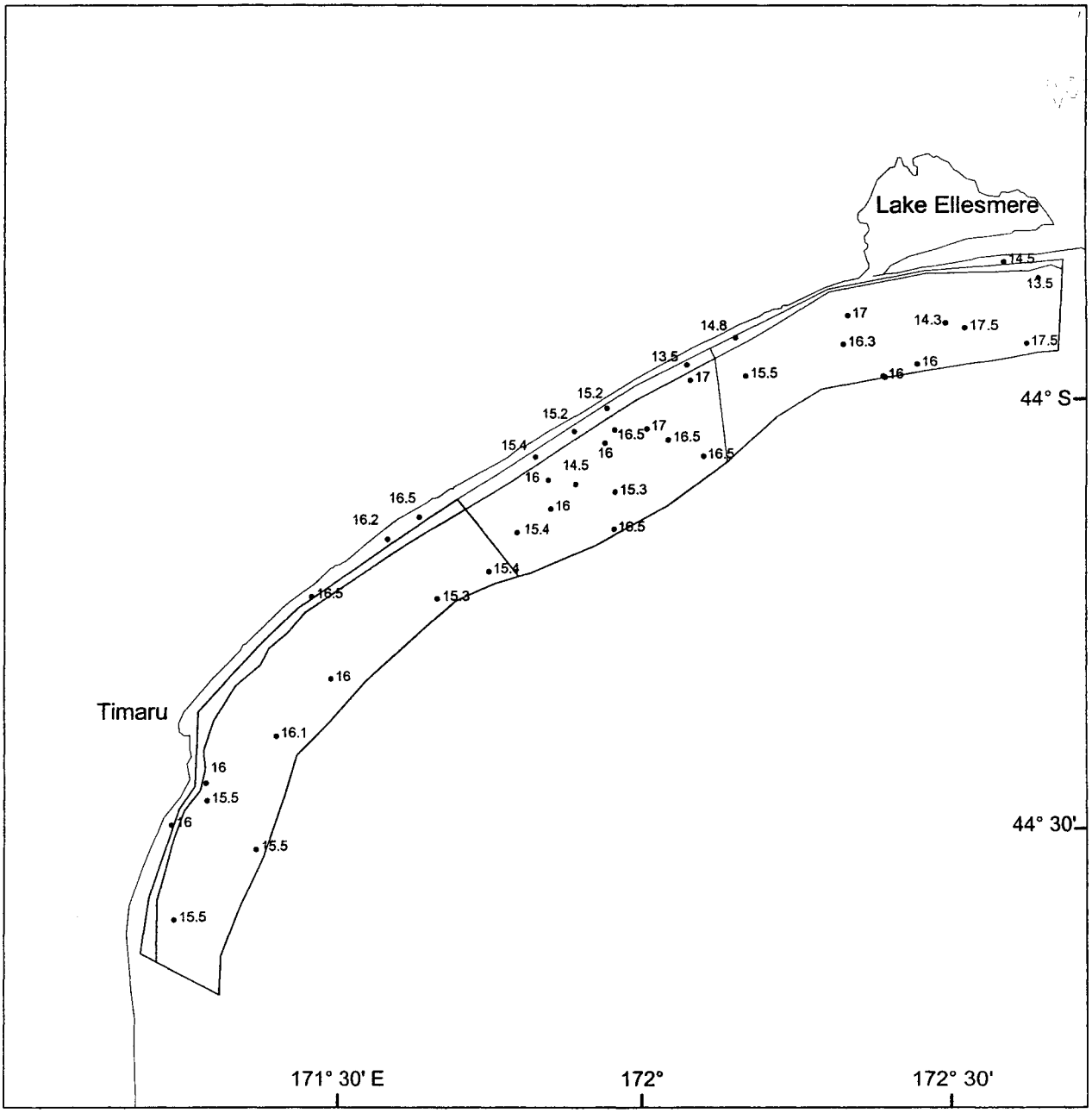


Figure 4: **Positions of surface temperature recordings (°C) from *Compass Rose*.**

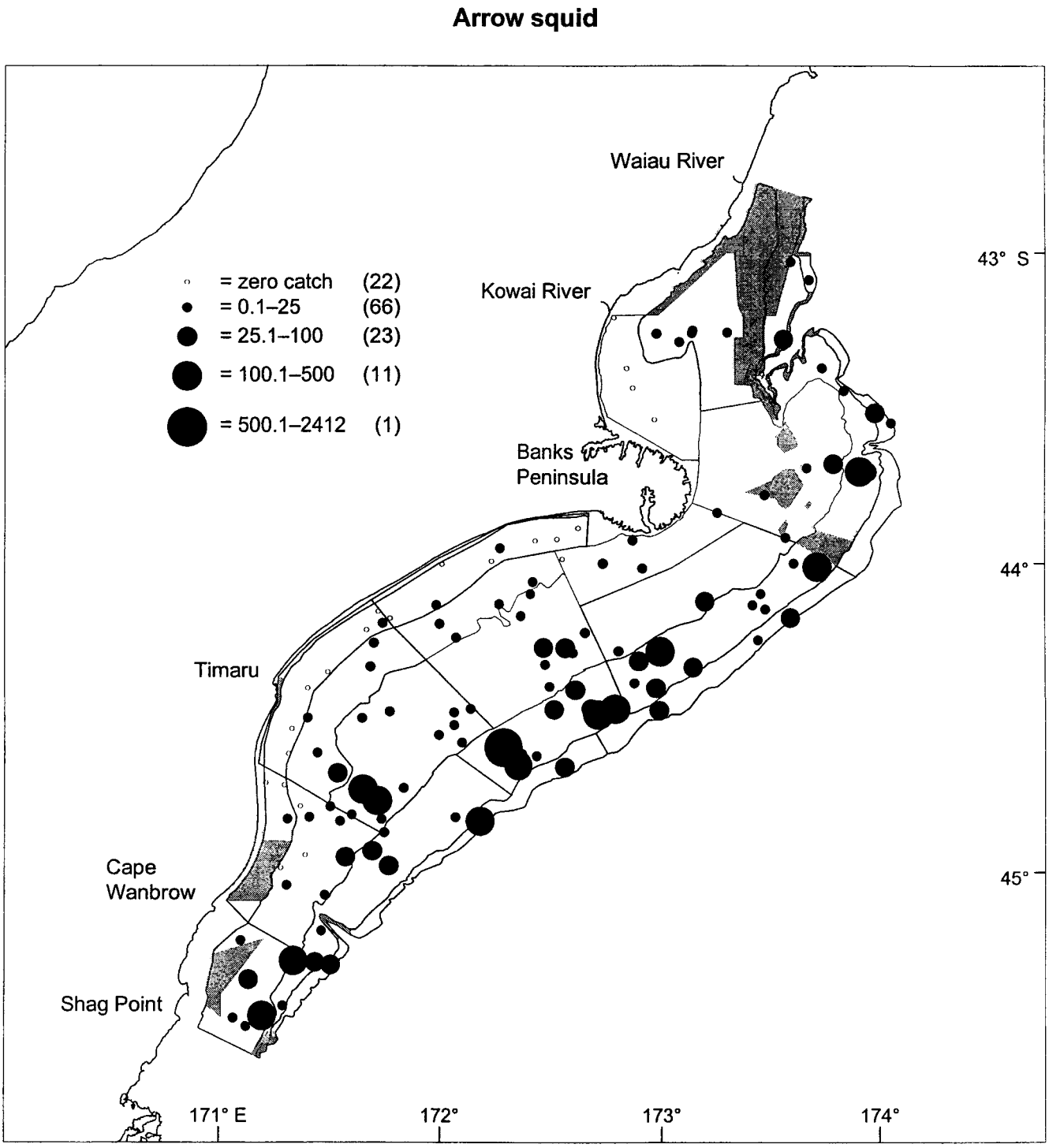
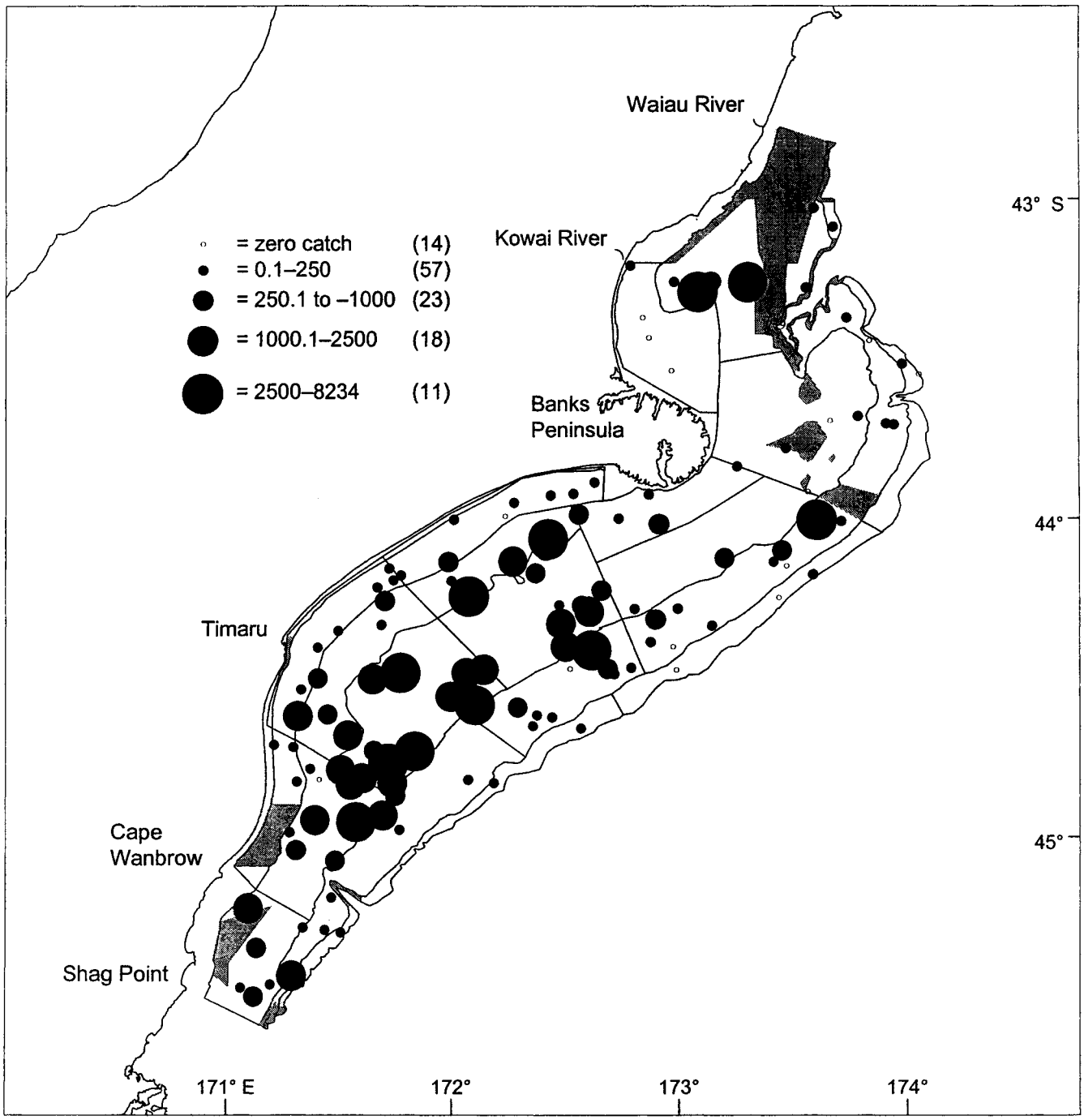


Figure 5: **Catch rates (kg.km^{-2}) of the major commercial species for *Kaharoa* (numbers in parenthesis are the number of stations at the given catch rate).**



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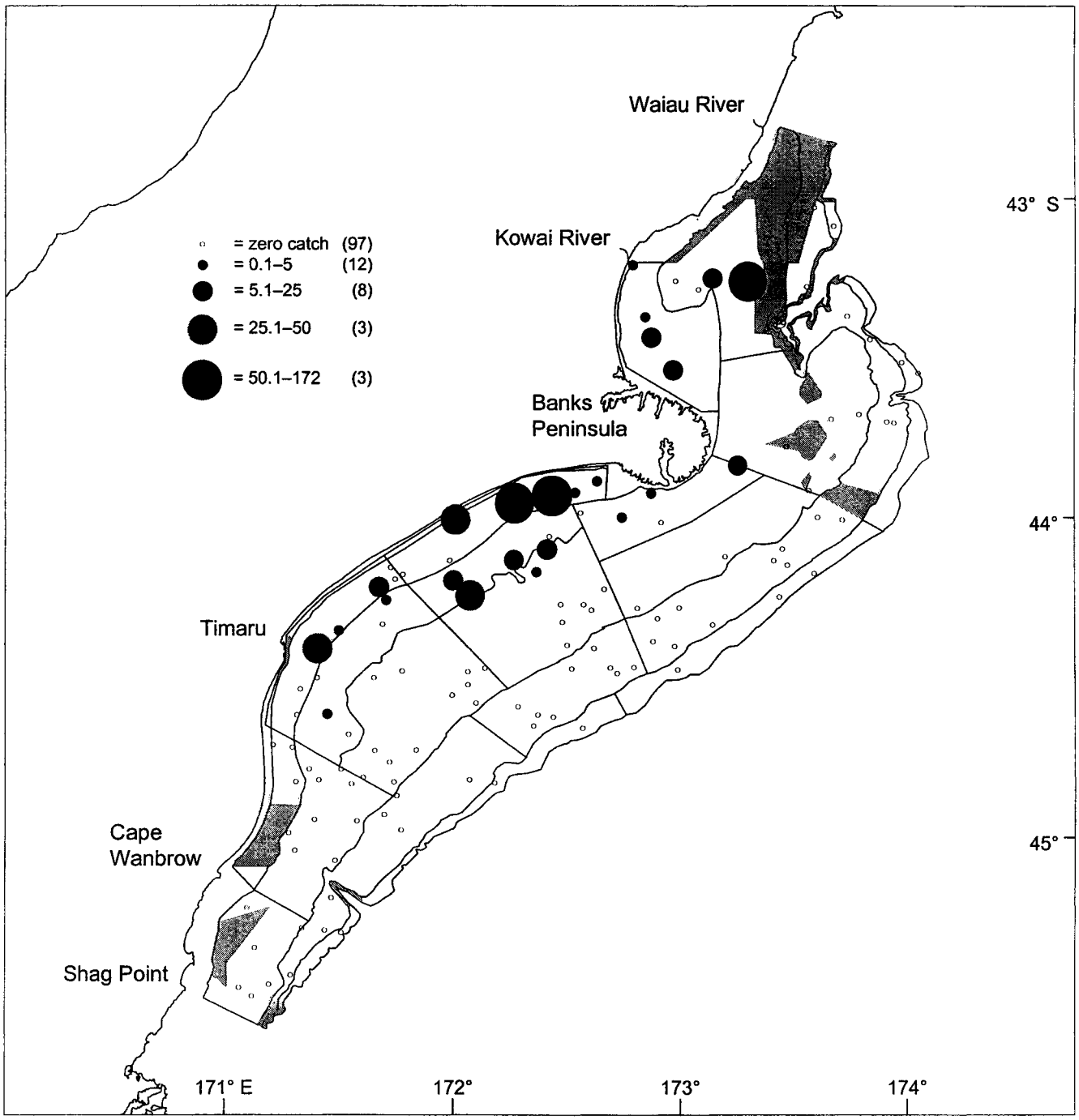

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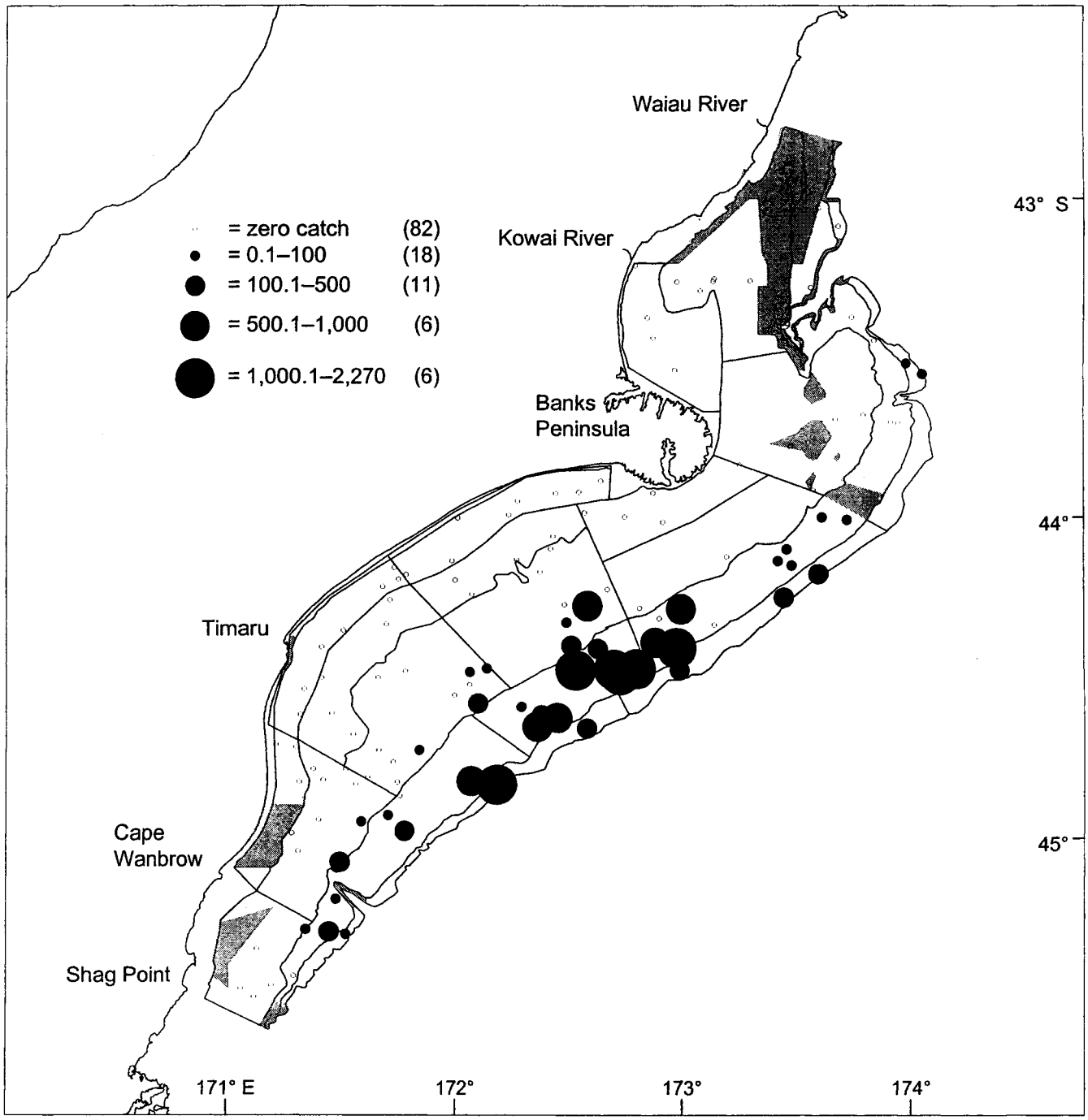


Figure 5—continued

Elephantfish

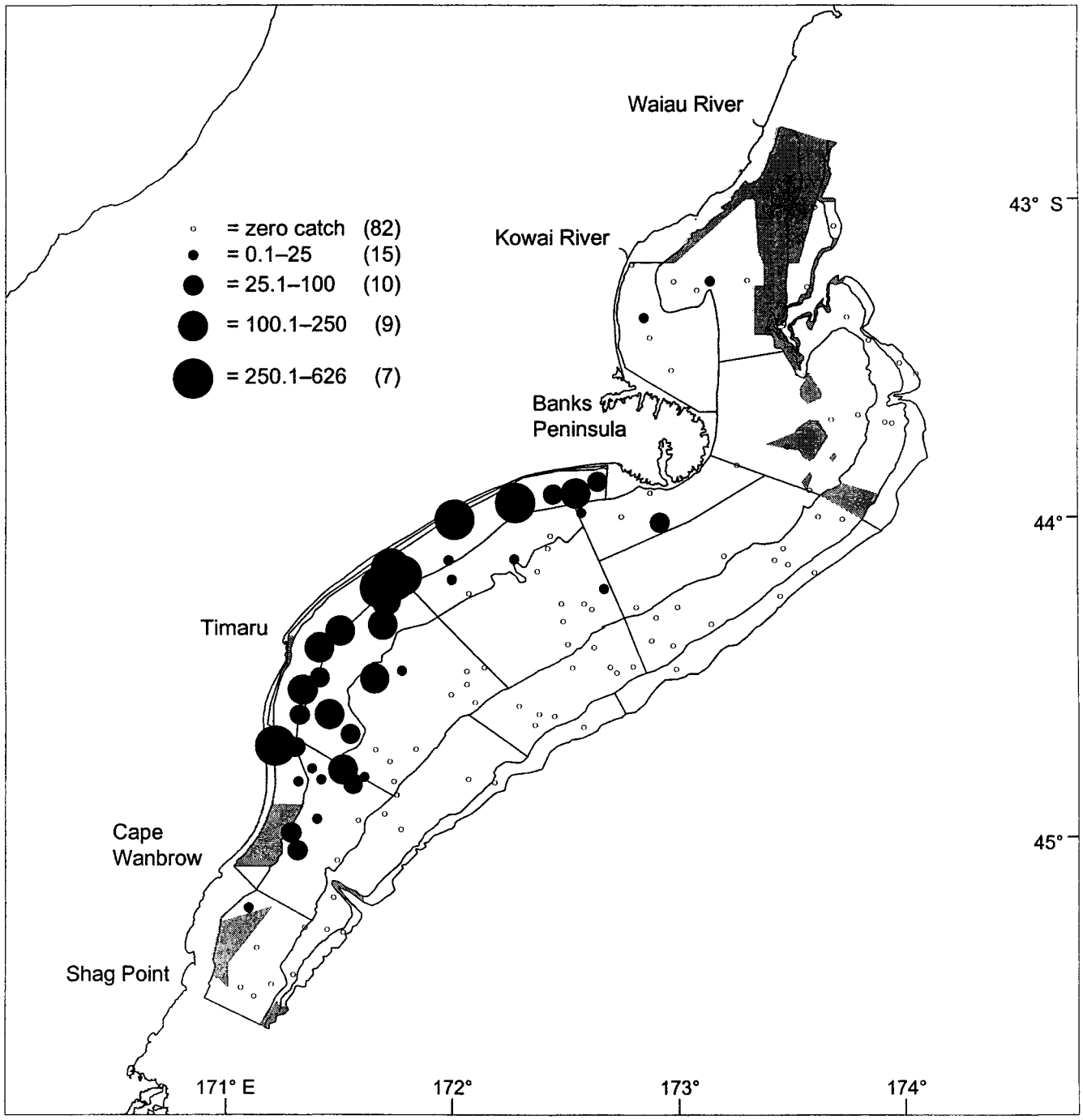


Figure 5—continued

Giant stargazer

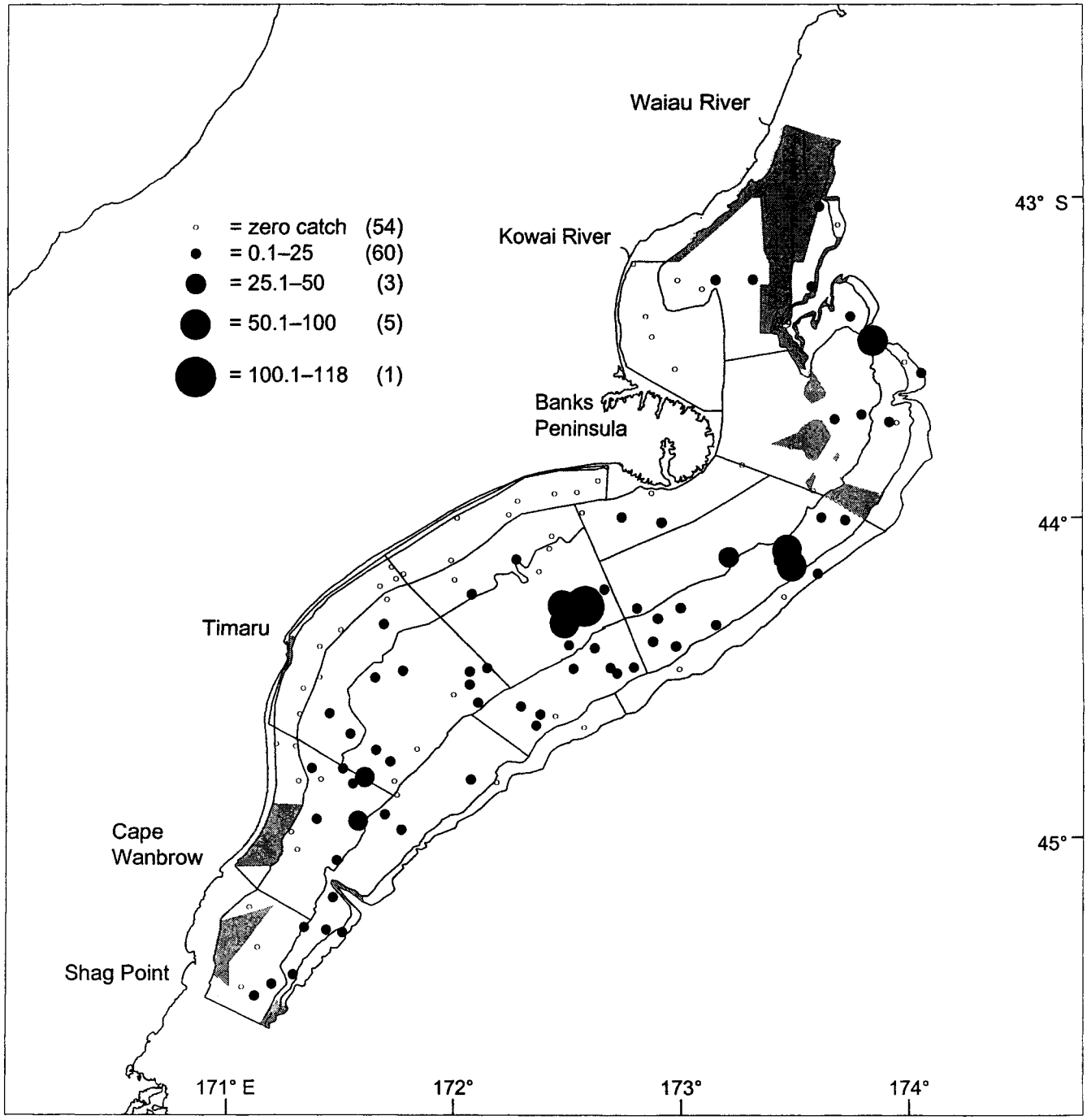
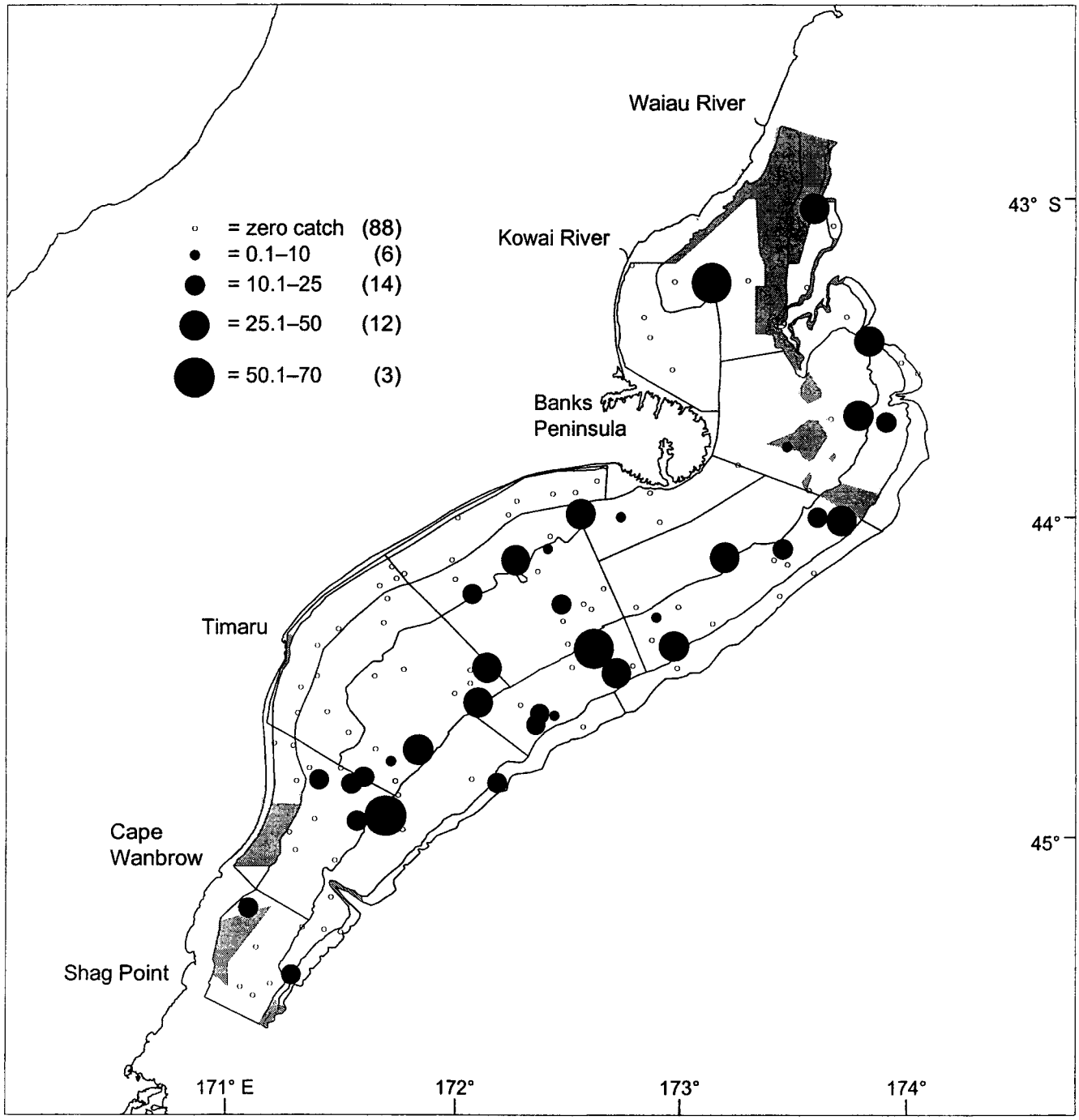


Figure 5—continued

Hapuku



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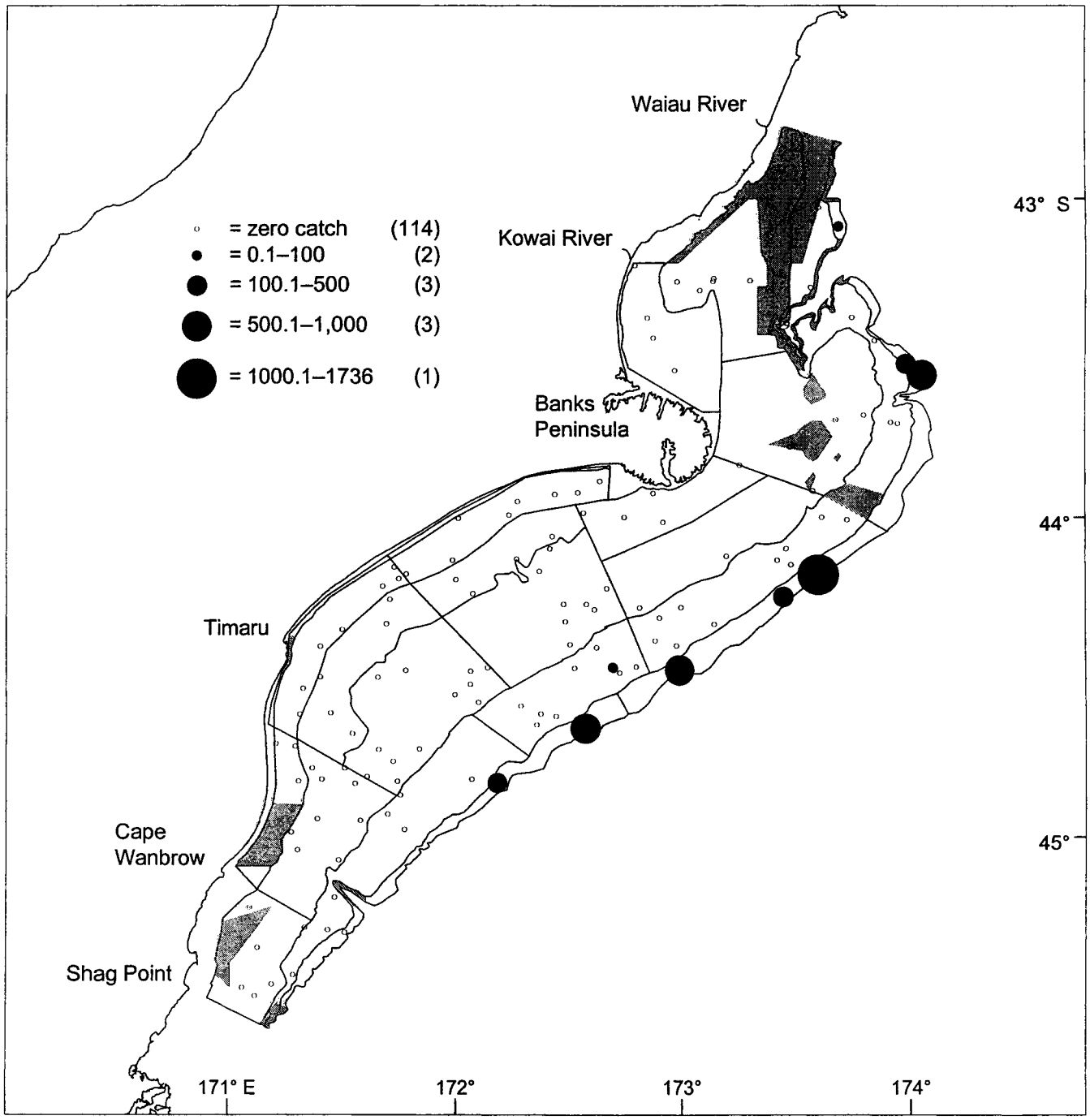

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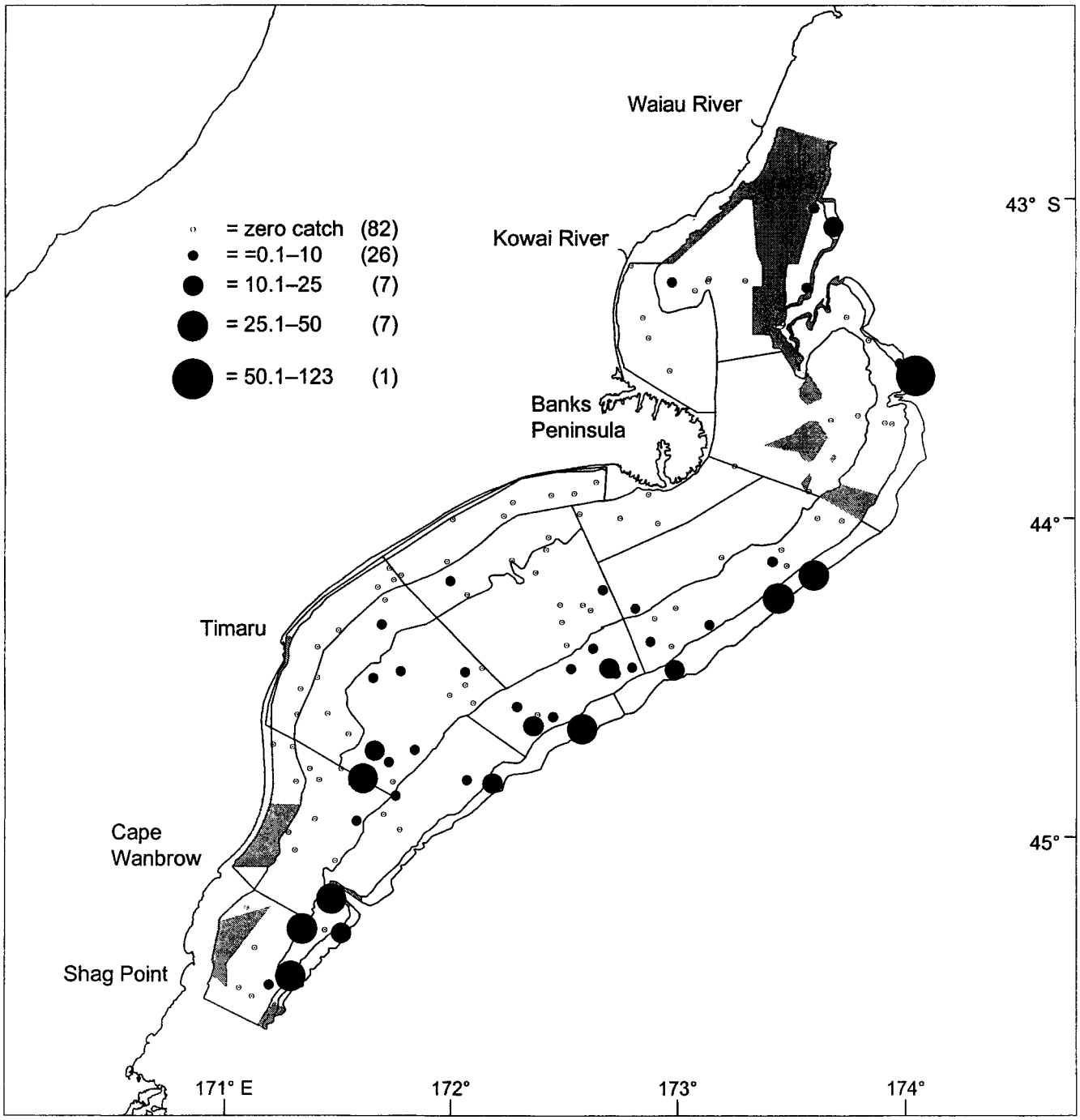

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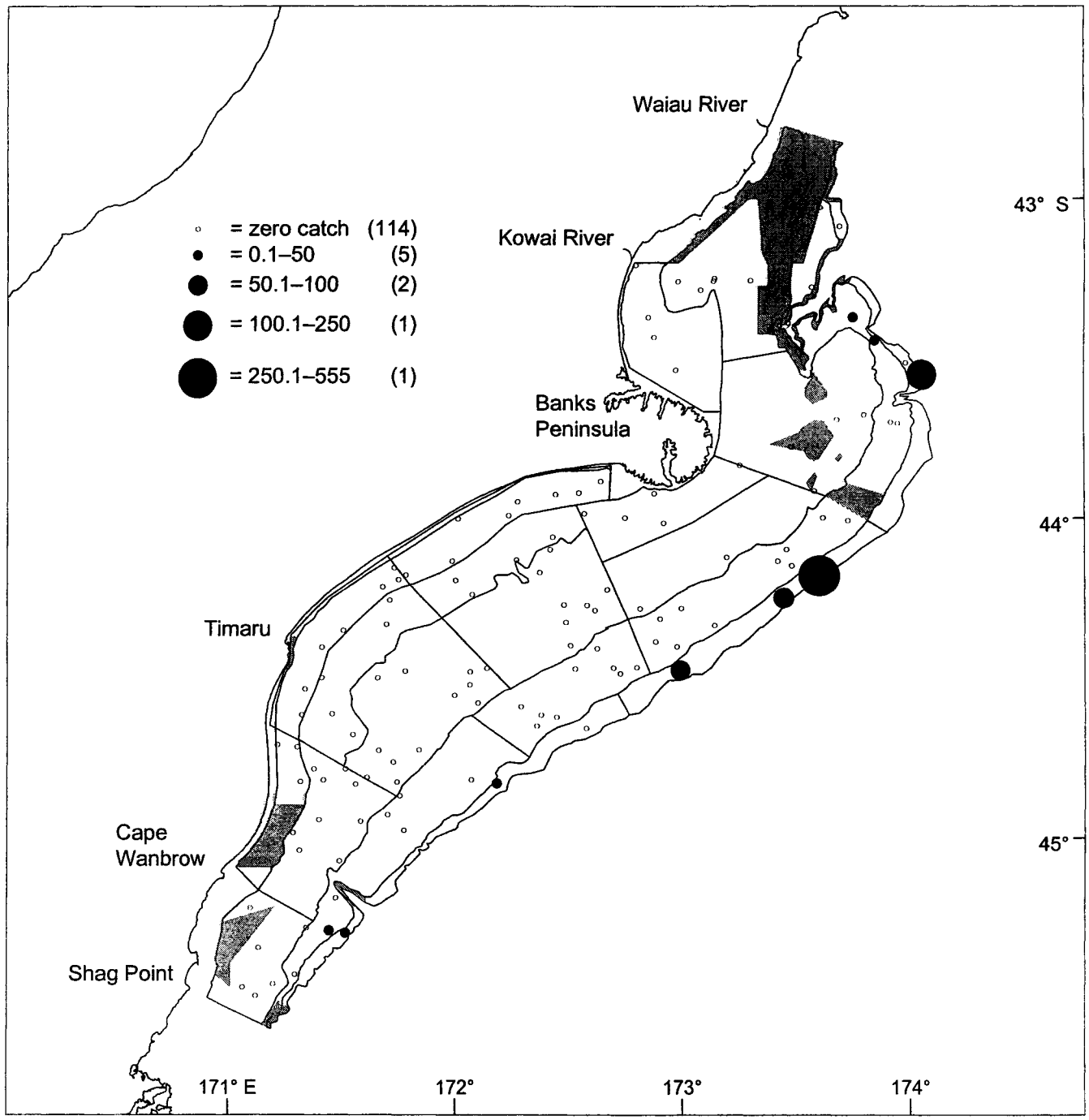

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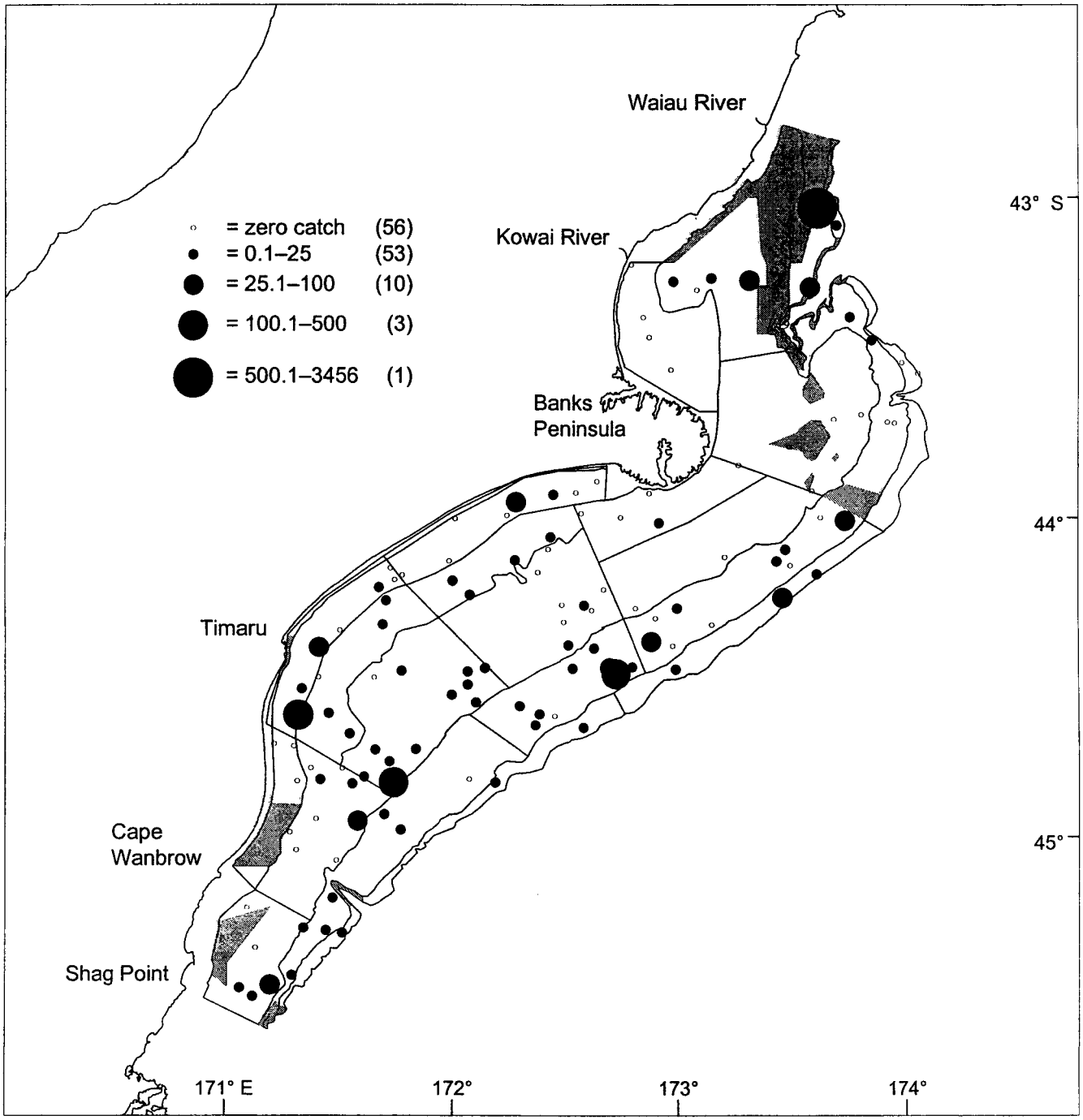

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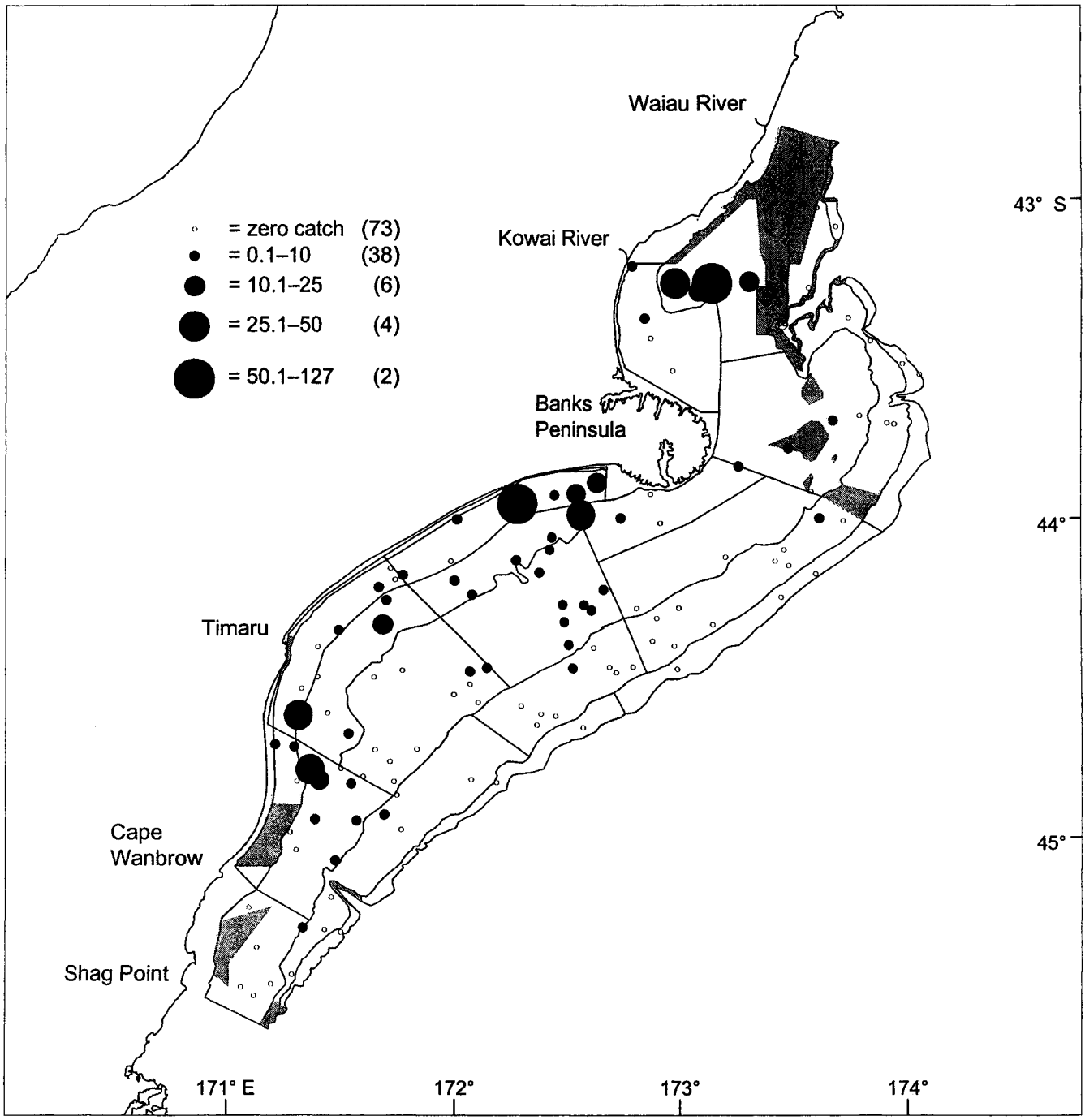

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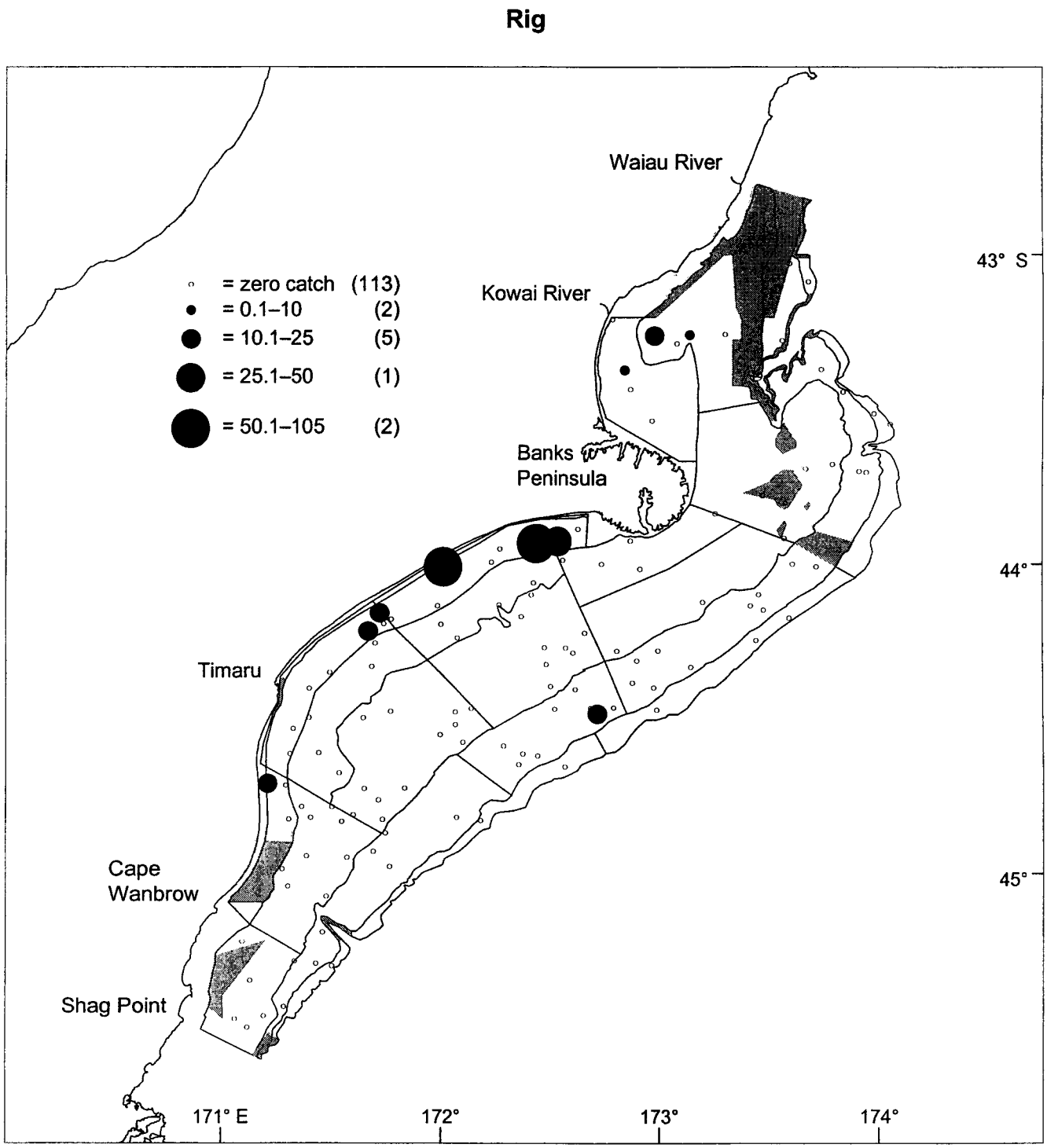

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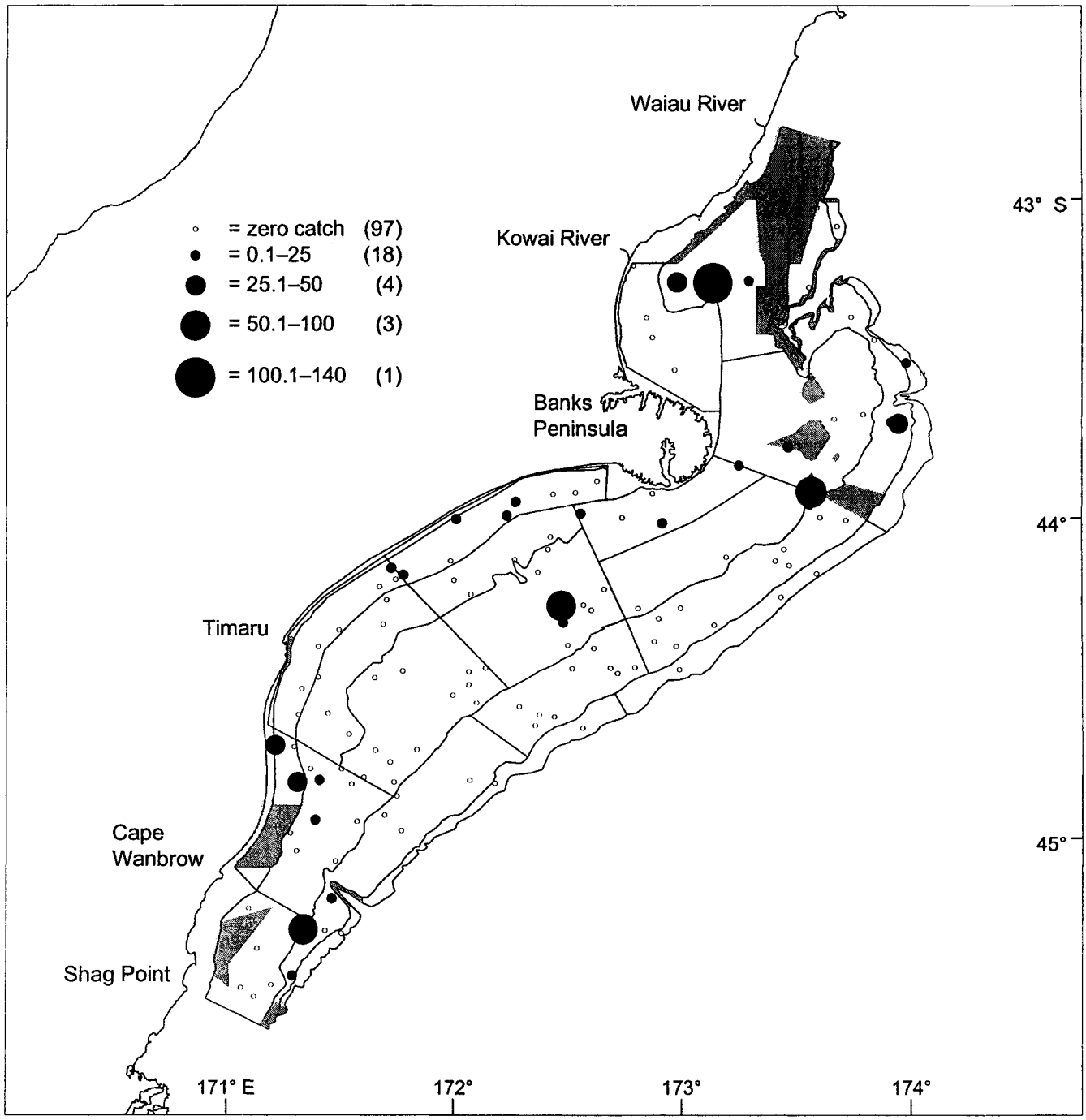


Figure 5—continued

School shark

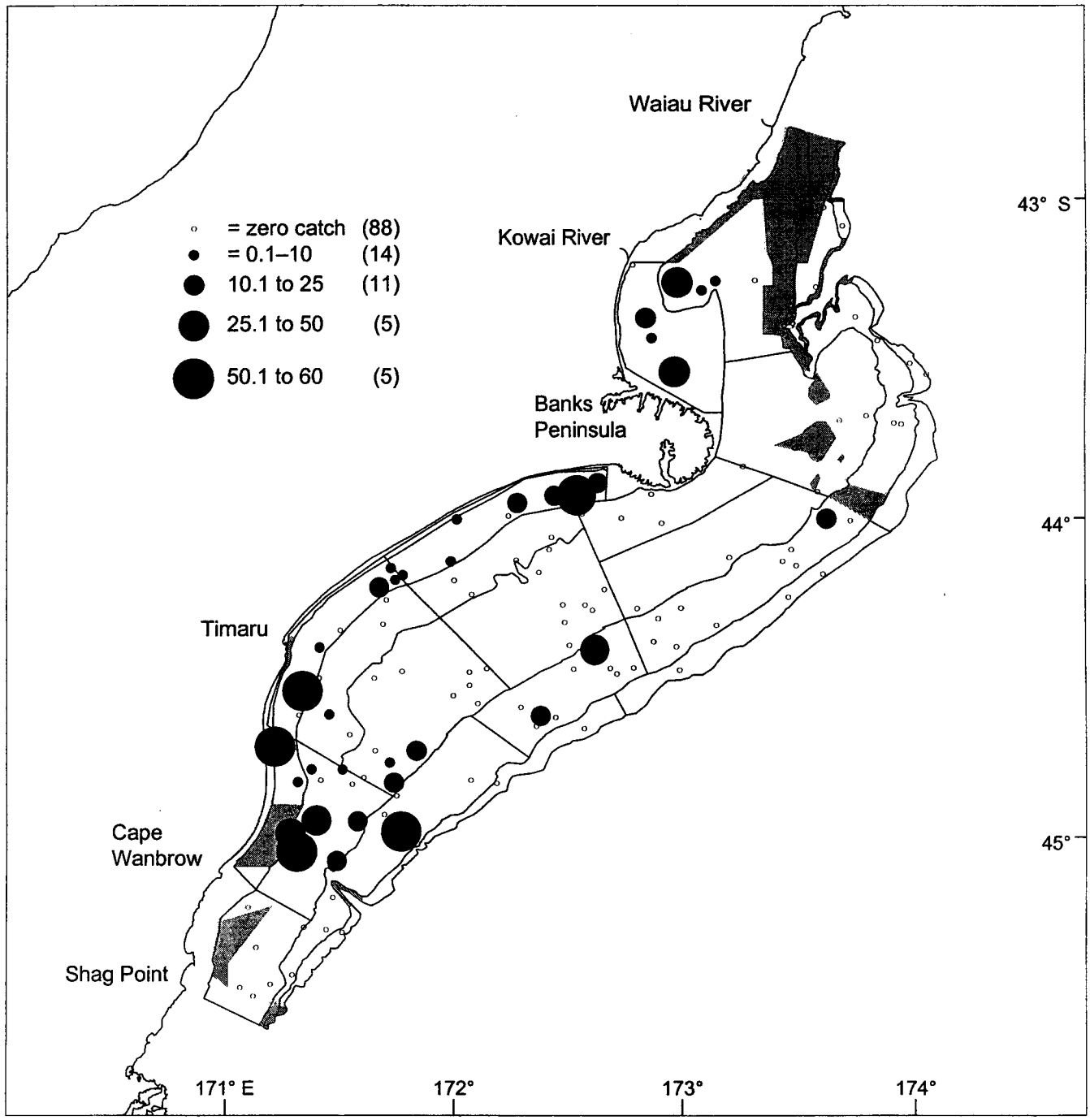
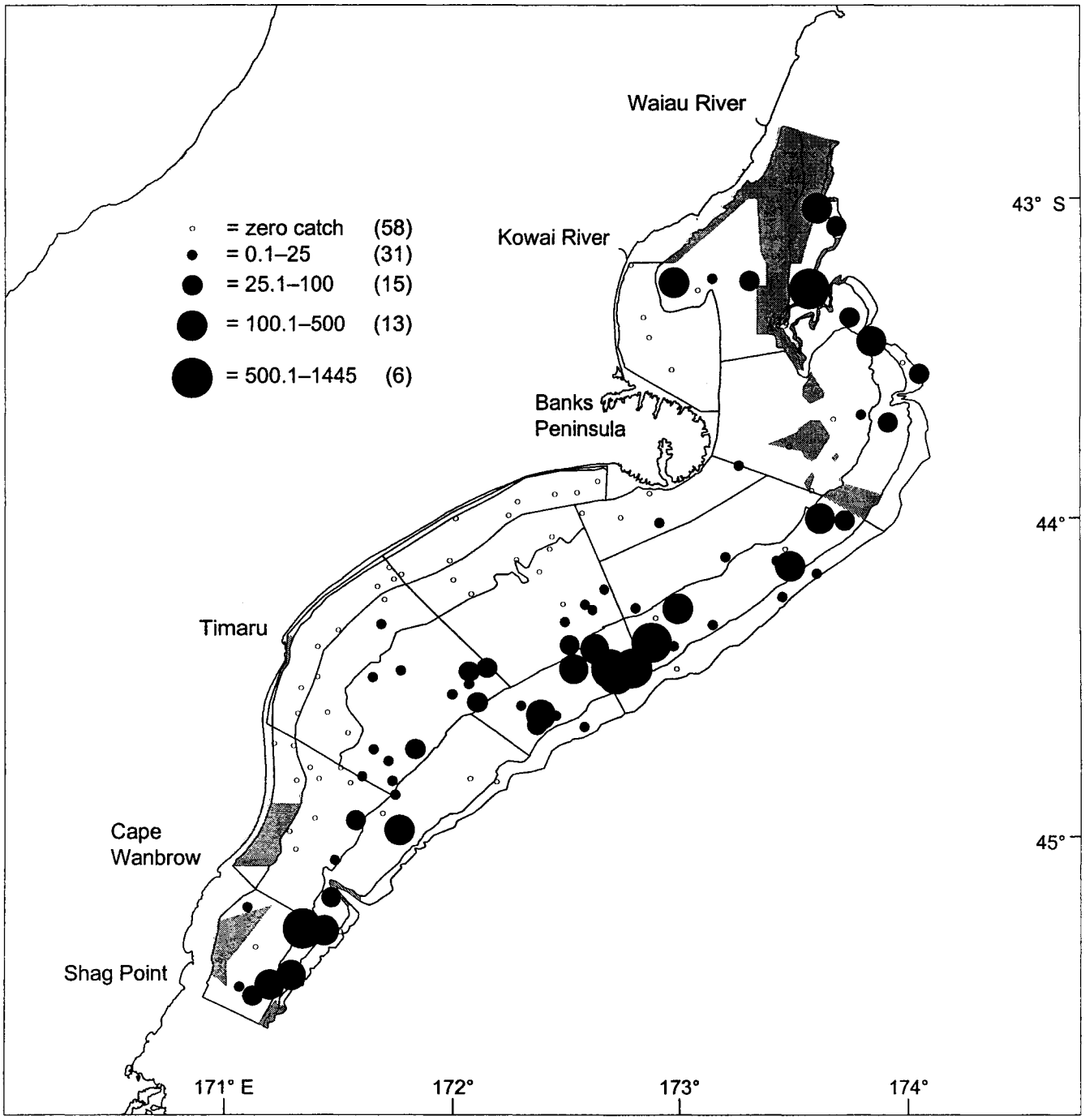


Figure 5—continued

Sea perch



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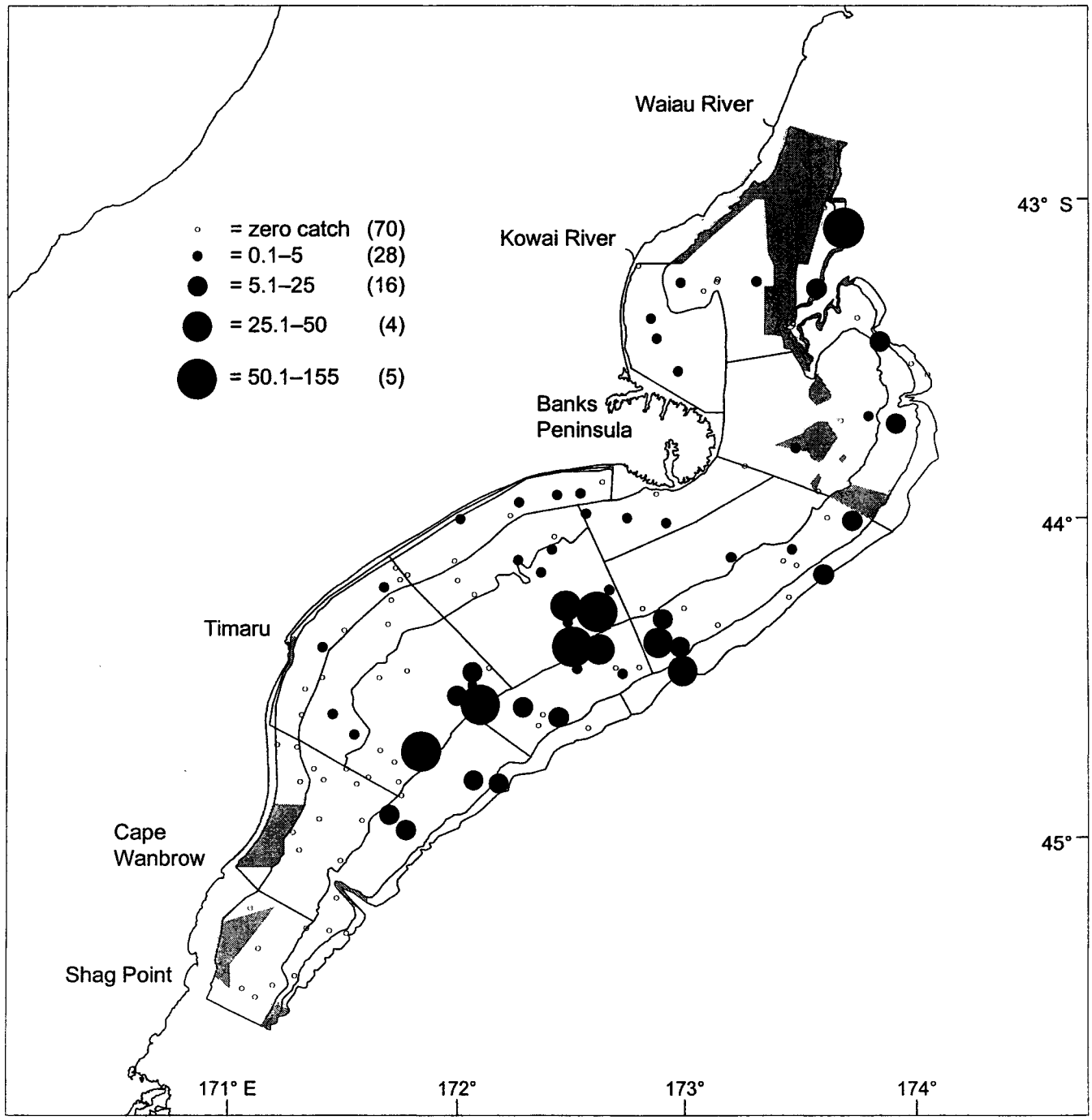
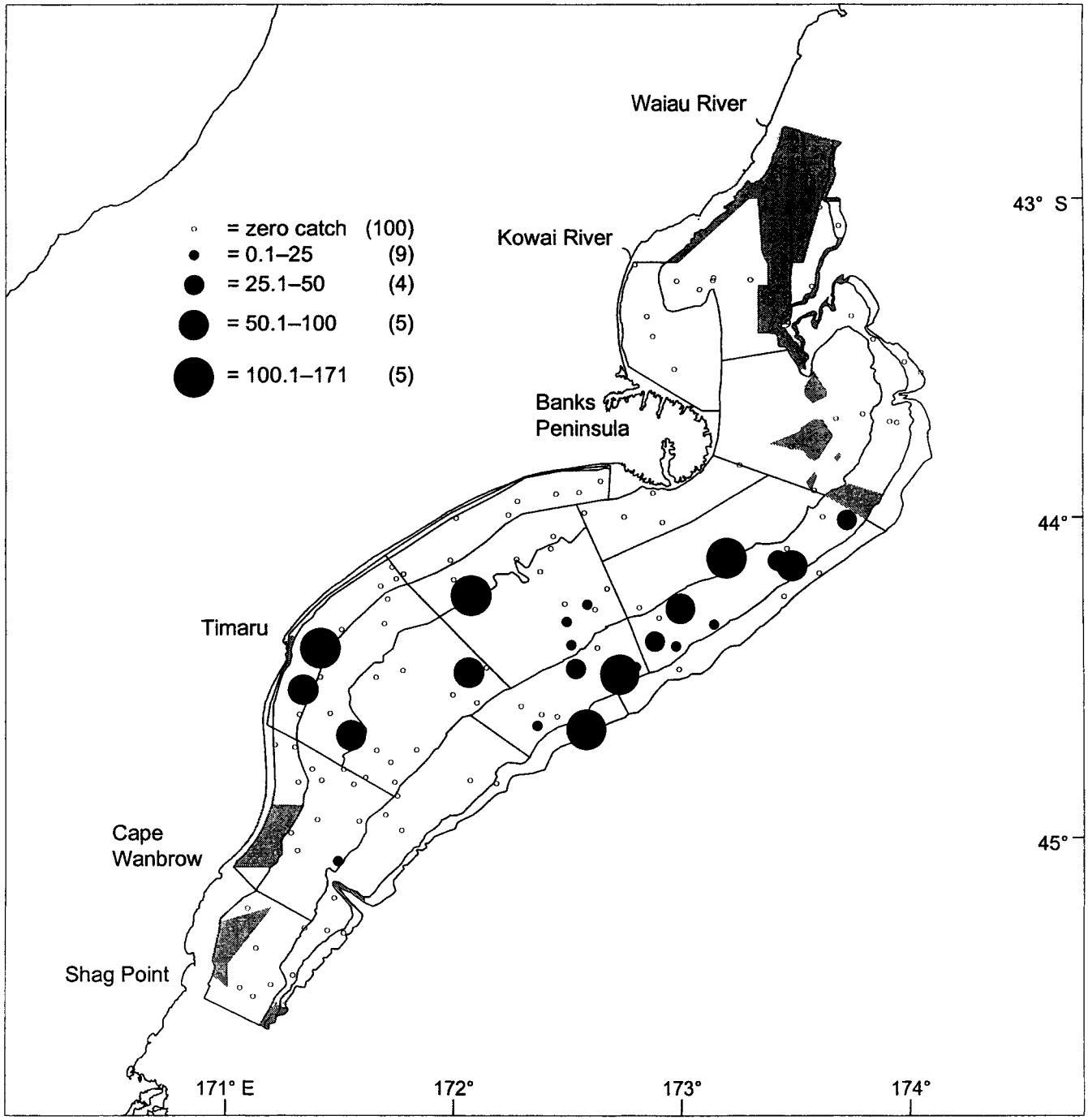


Figure 5—continued

Smooth skate



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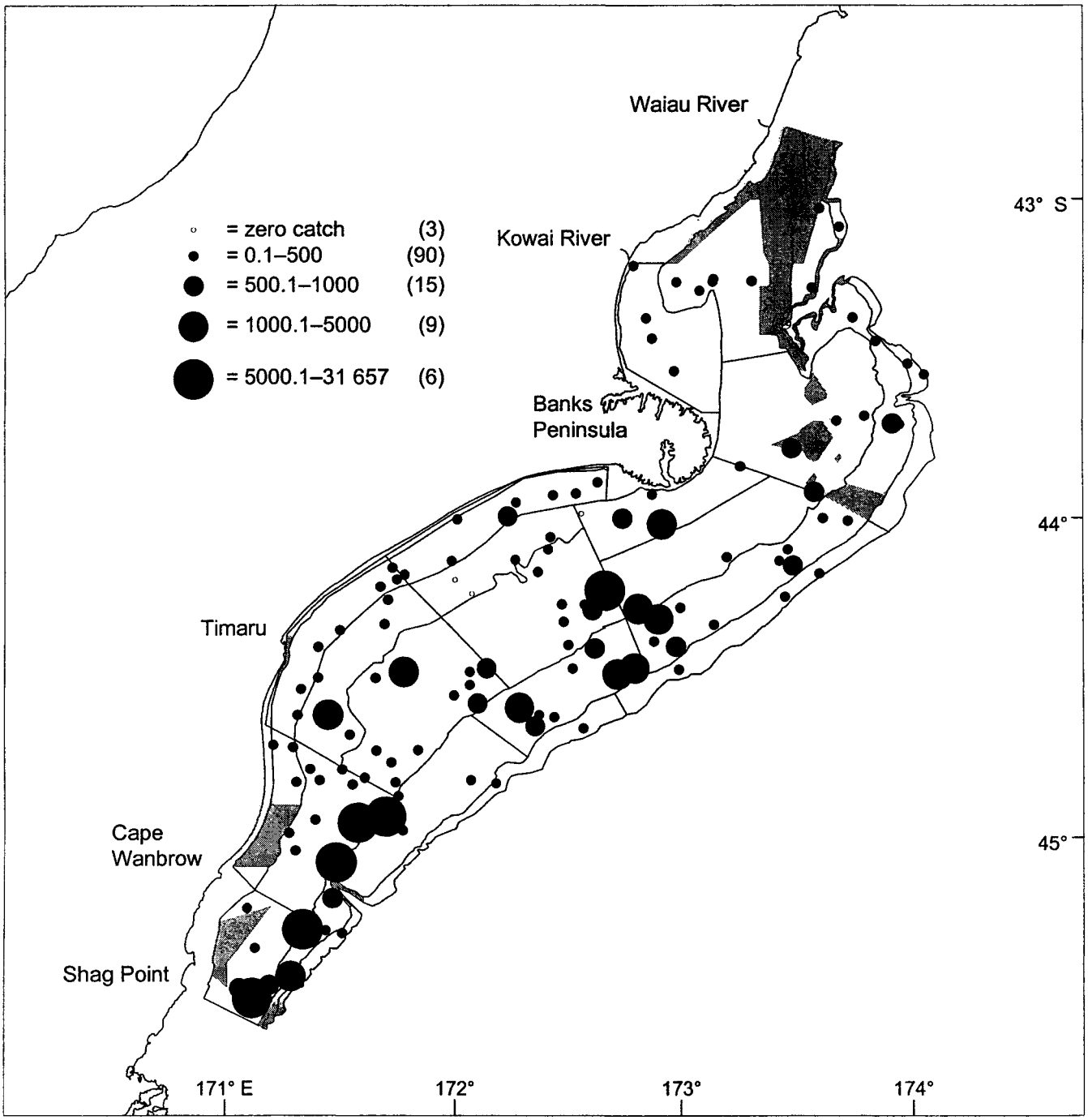
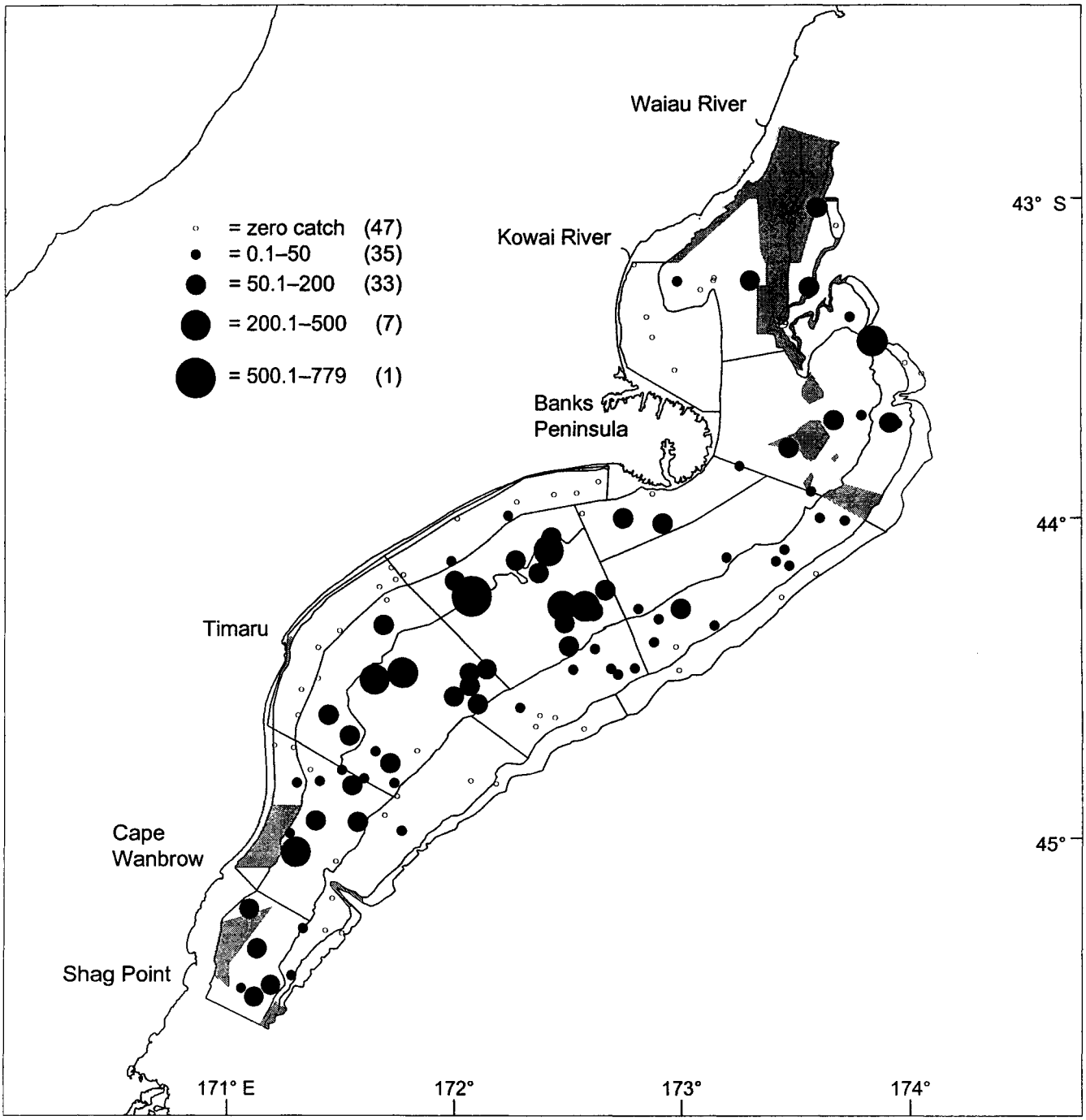


Figure 5—continued

Tarakihi



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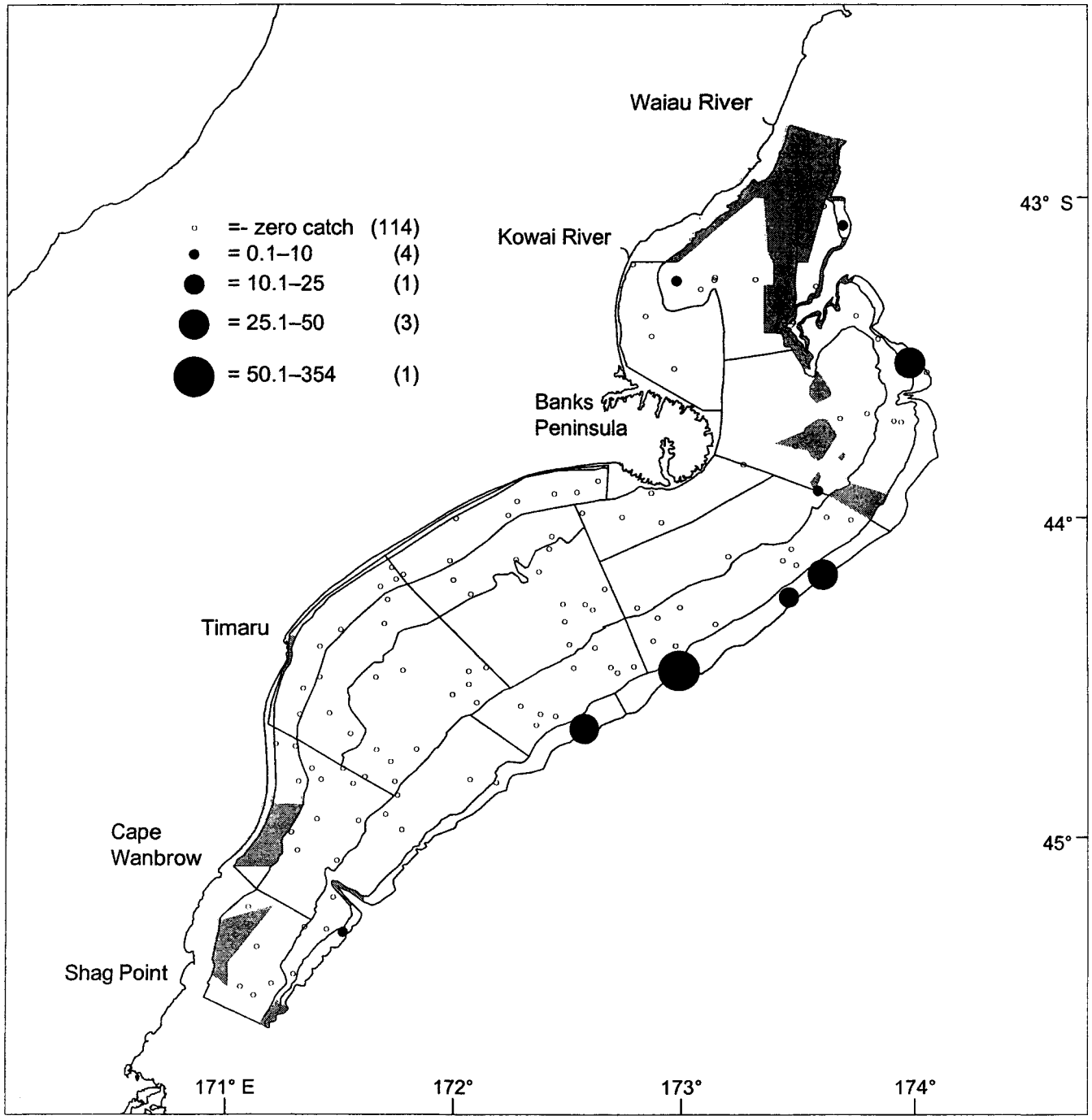


Figure 5—continued

Barracouta

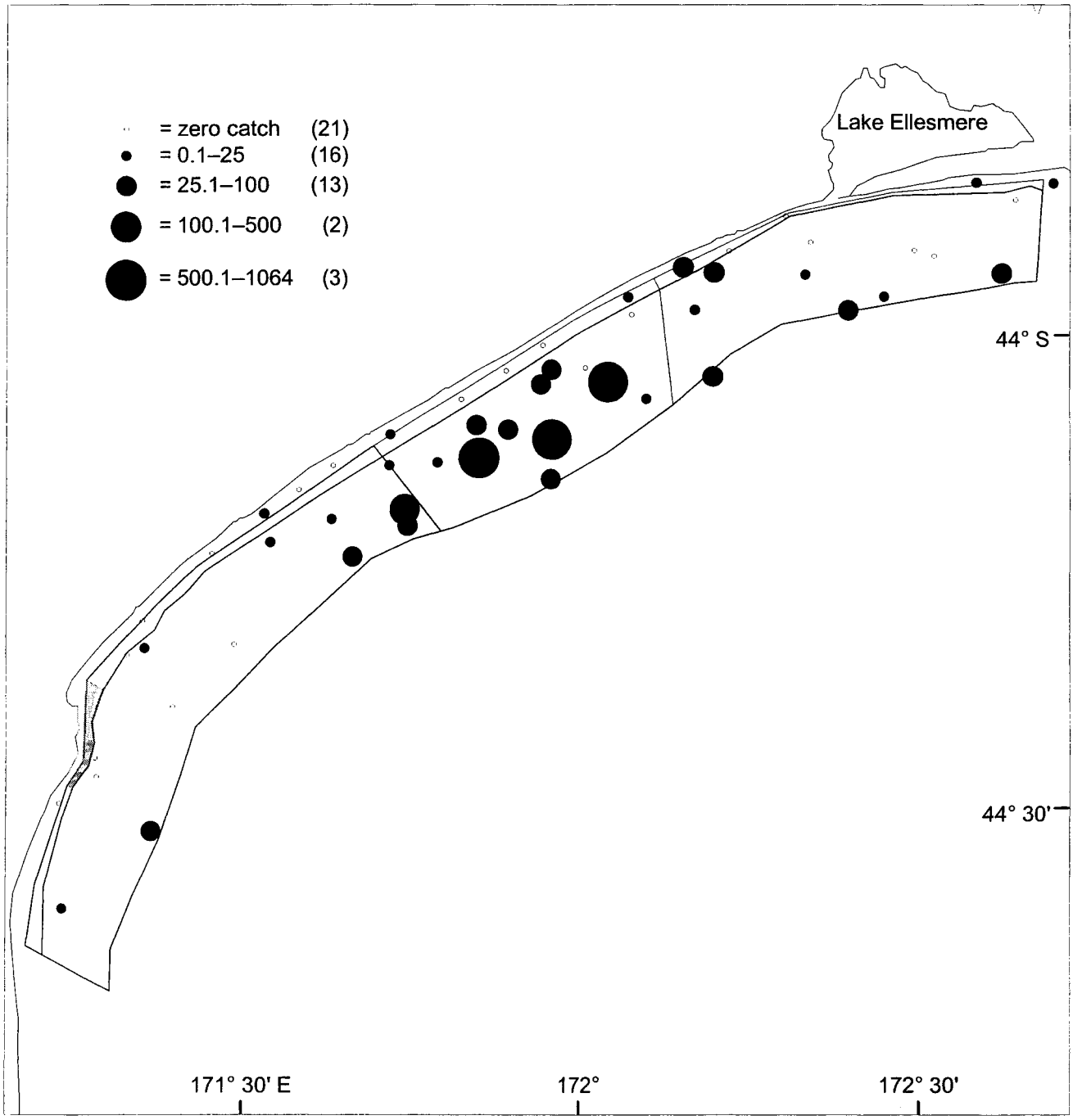


Figure 6: **Catch rates (kg.km^{-2}) for the major commercial species for *Compass Rose* from stations used to calculate biomass estimates (numbers in parentheses are the number of stations at the given catch rate).**

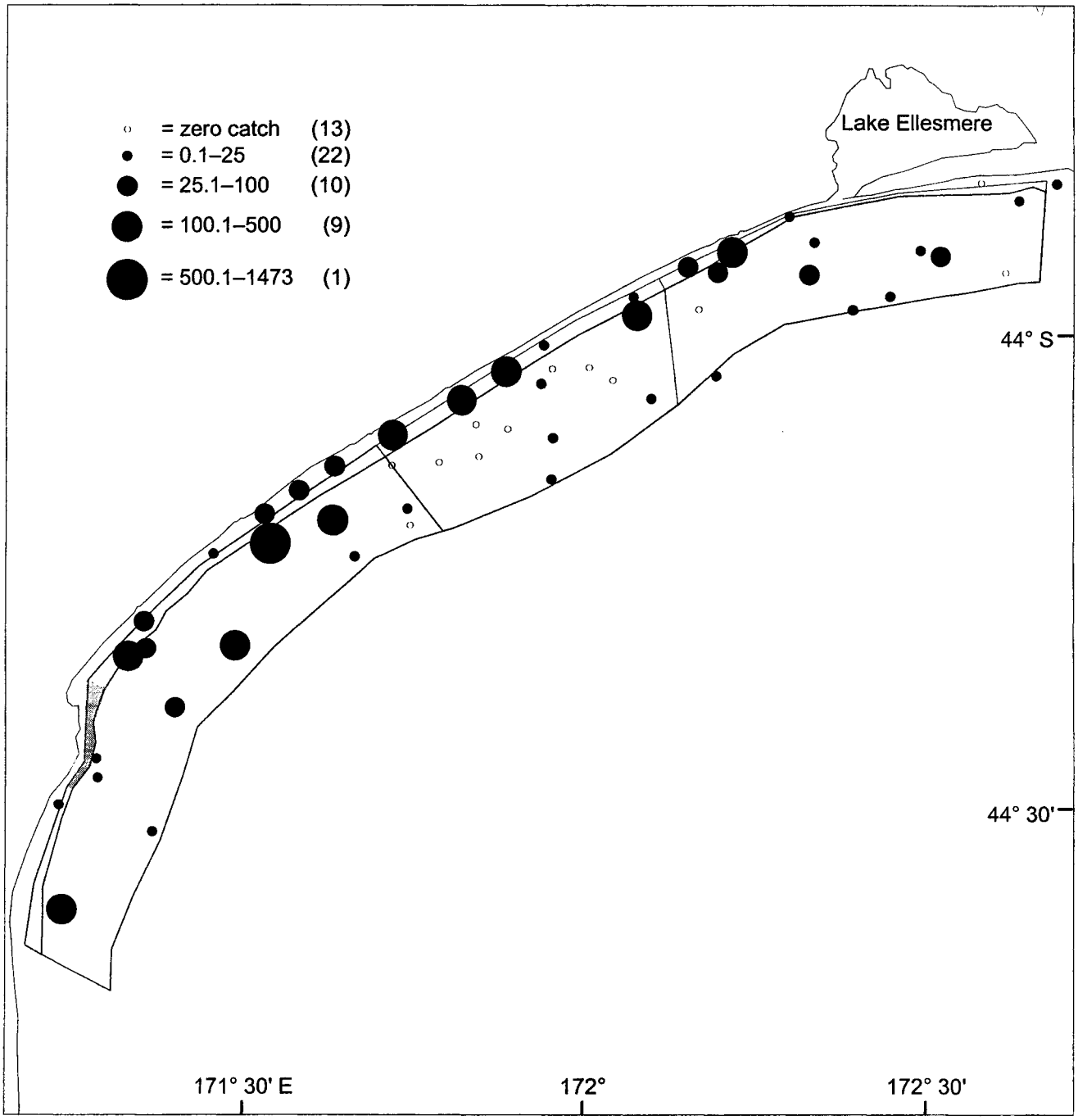


Figure 6—continued

Elephantfish

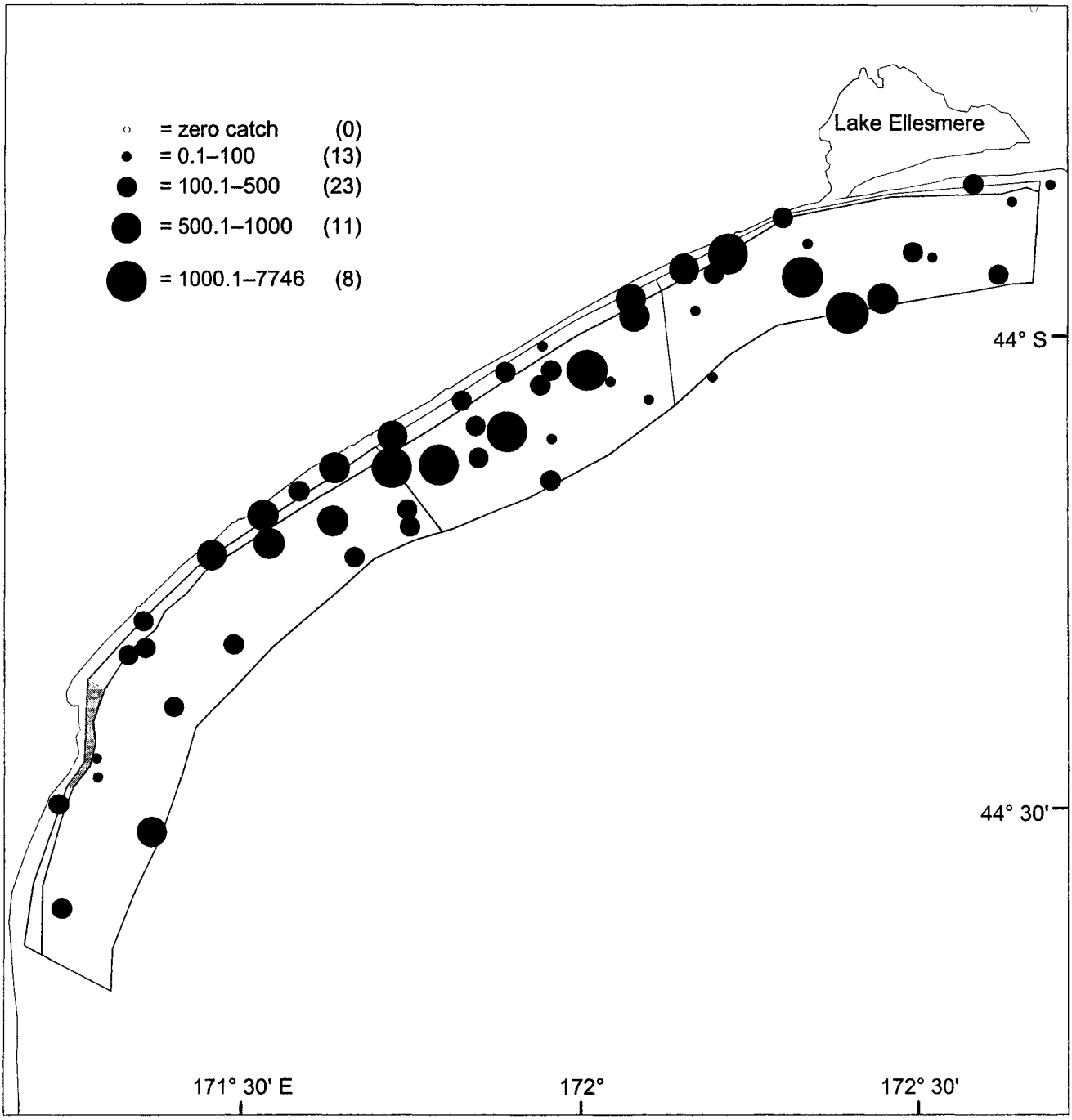


Figure 6—continued

New Zealand sole

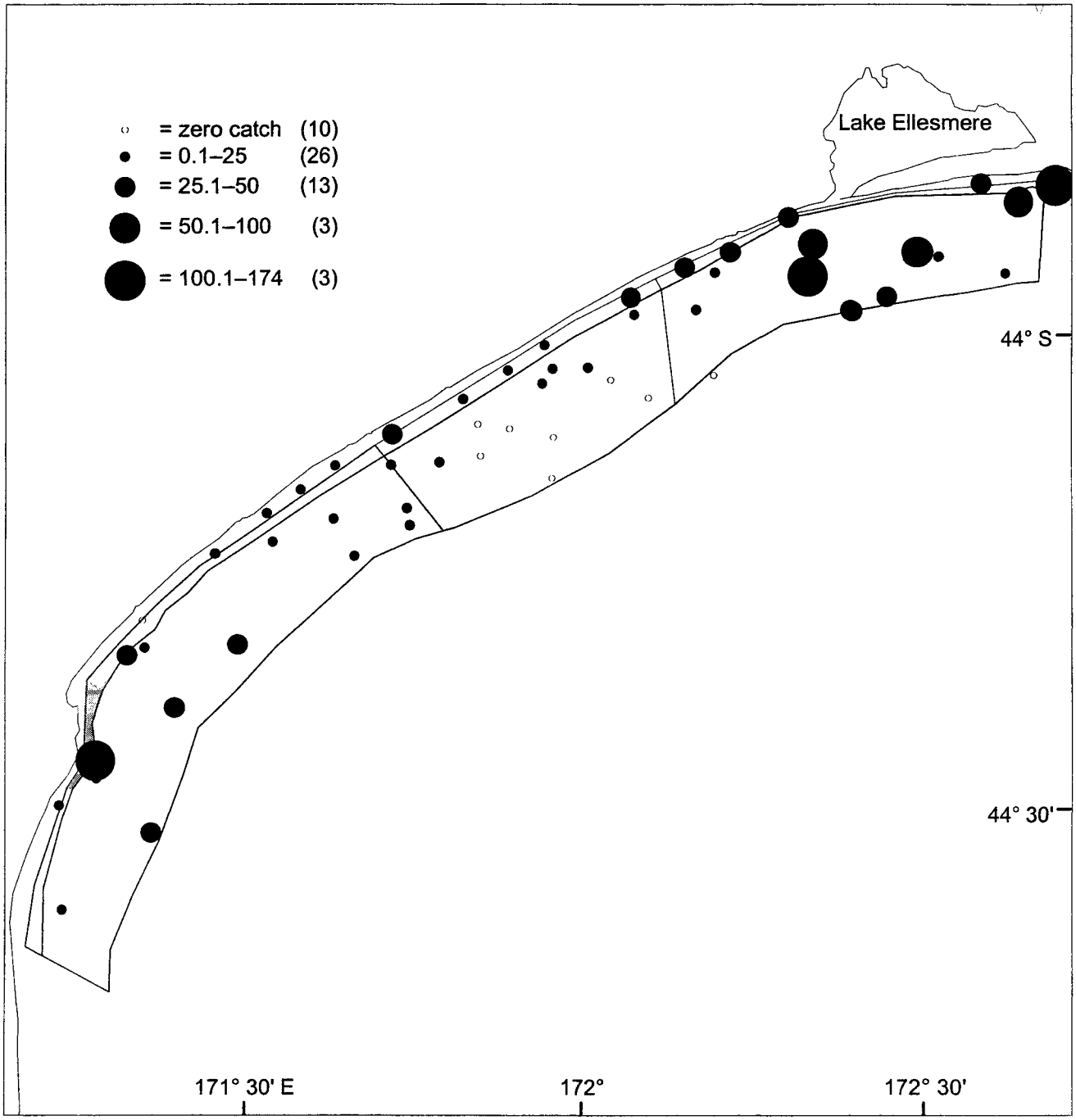


Figure 6—continued

Red cod

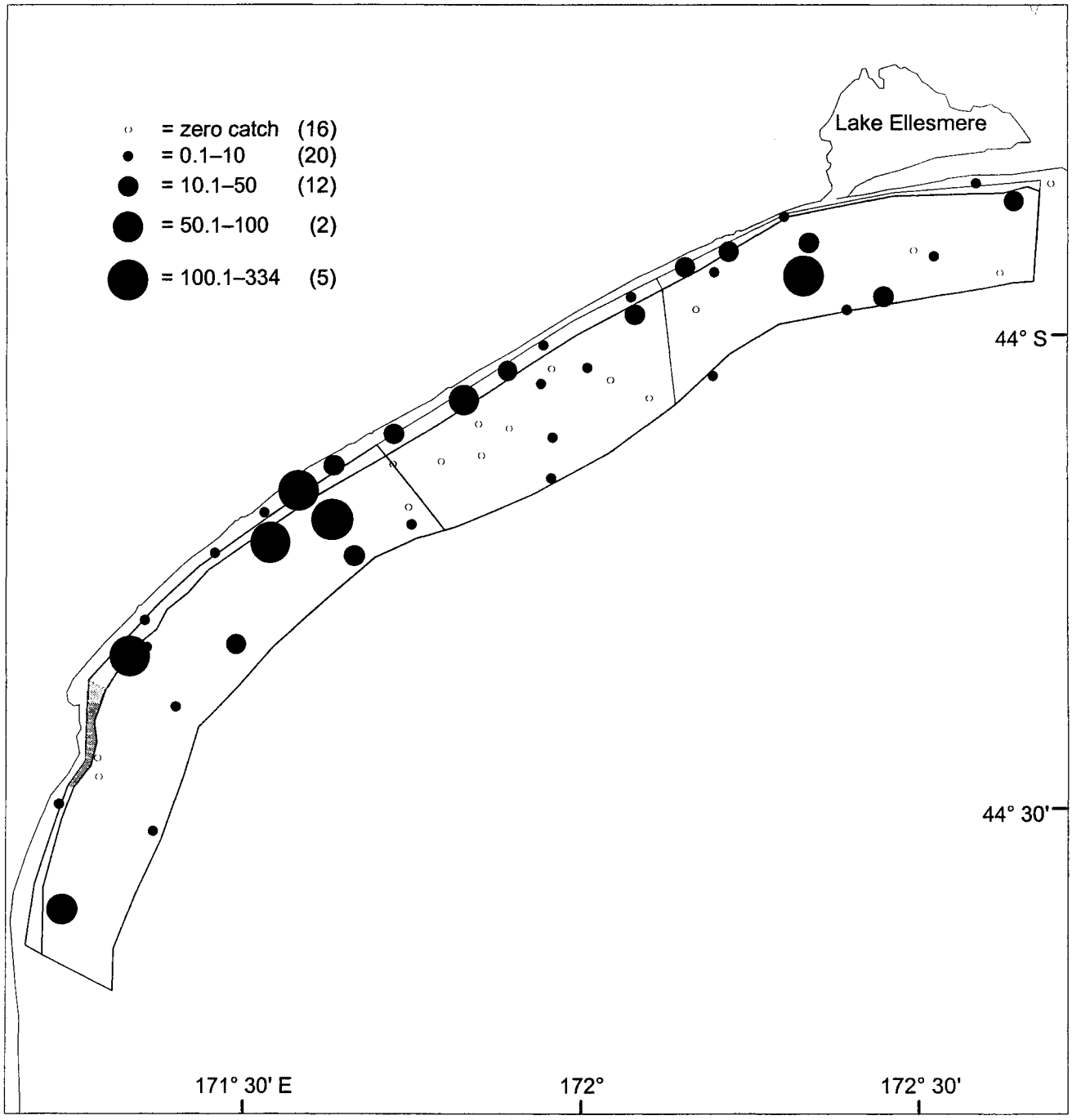


Figure 6—continued

Red gurnard

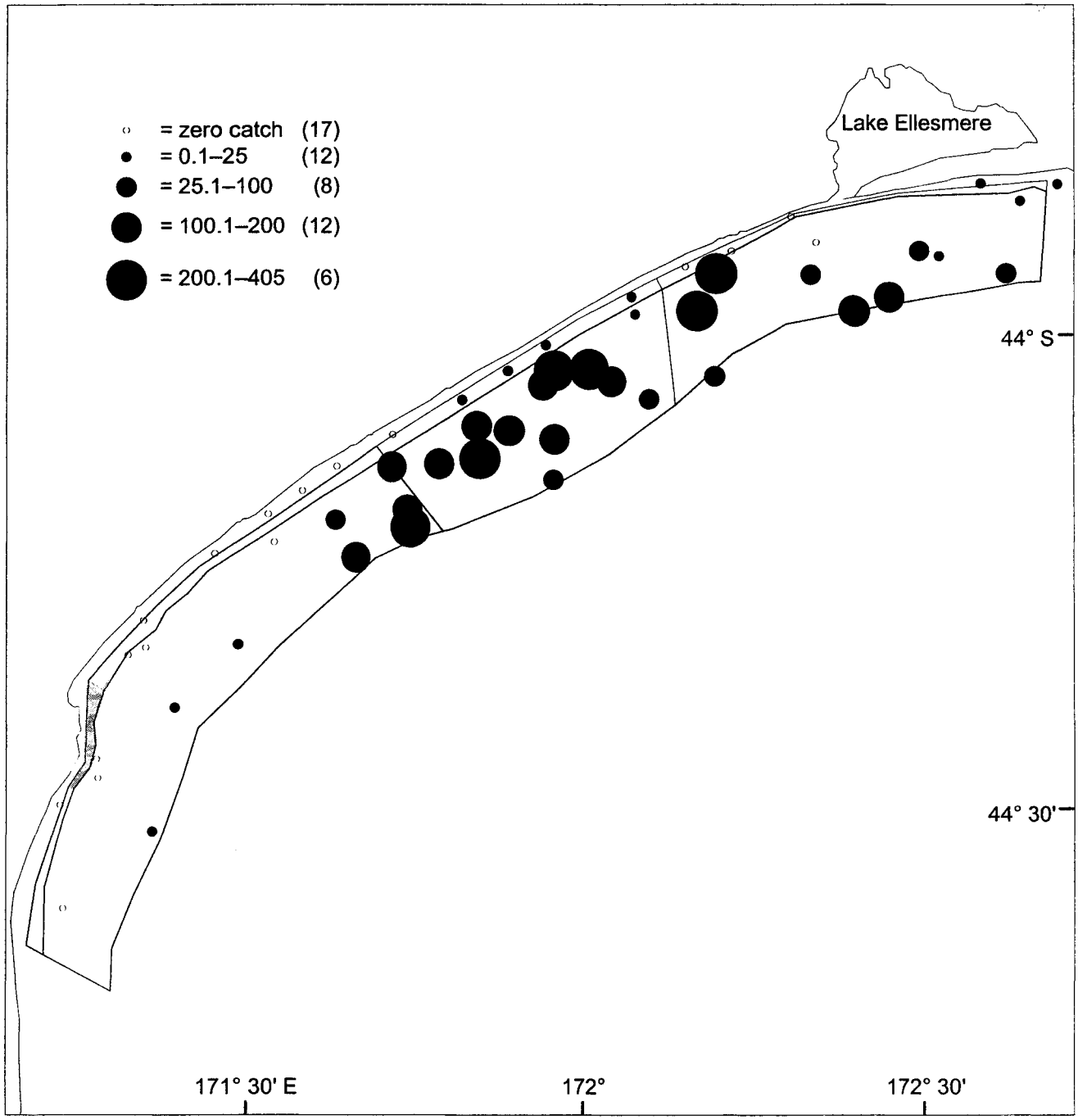
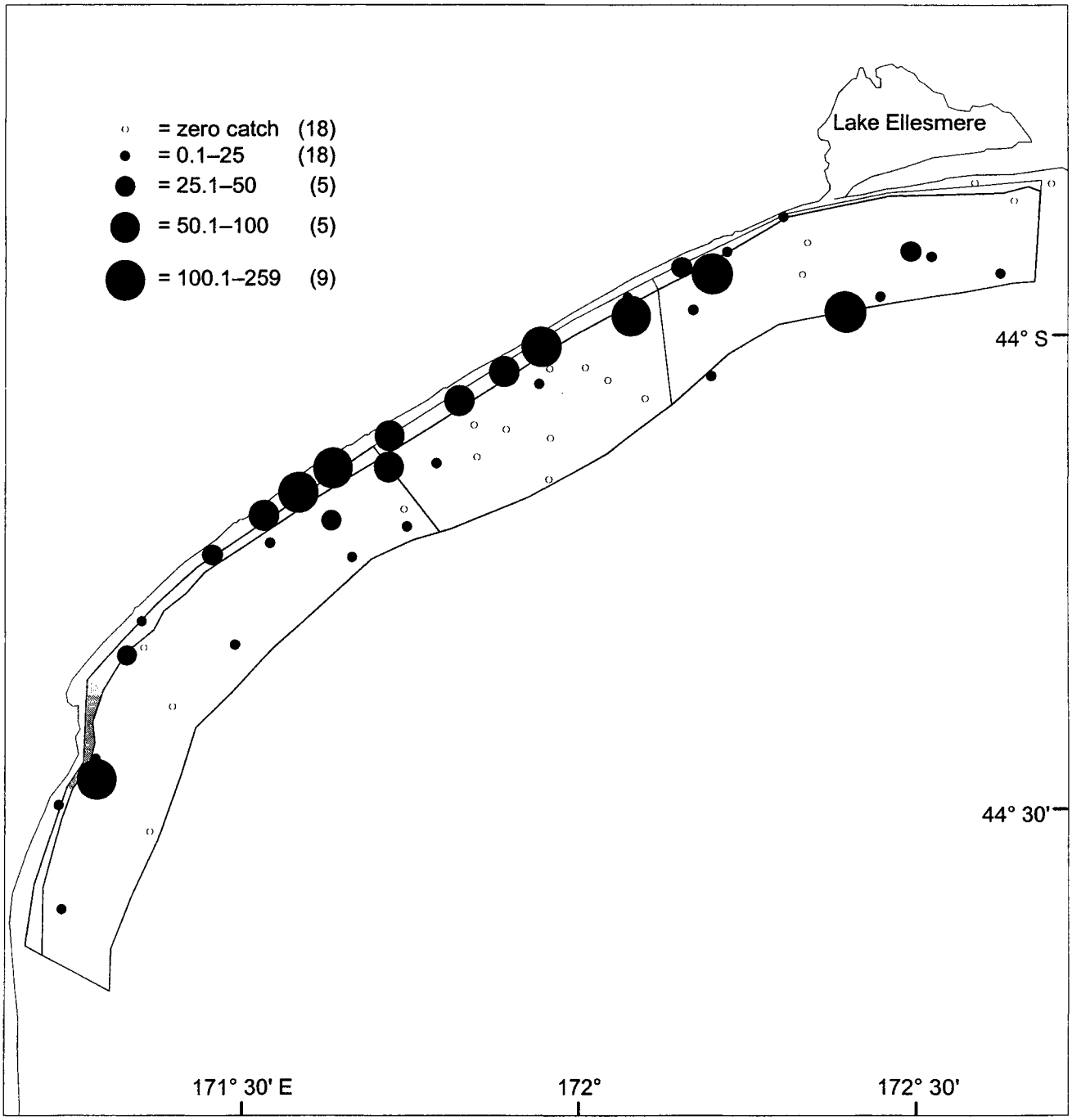


Figure 6—continued

Rig



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Rough skate

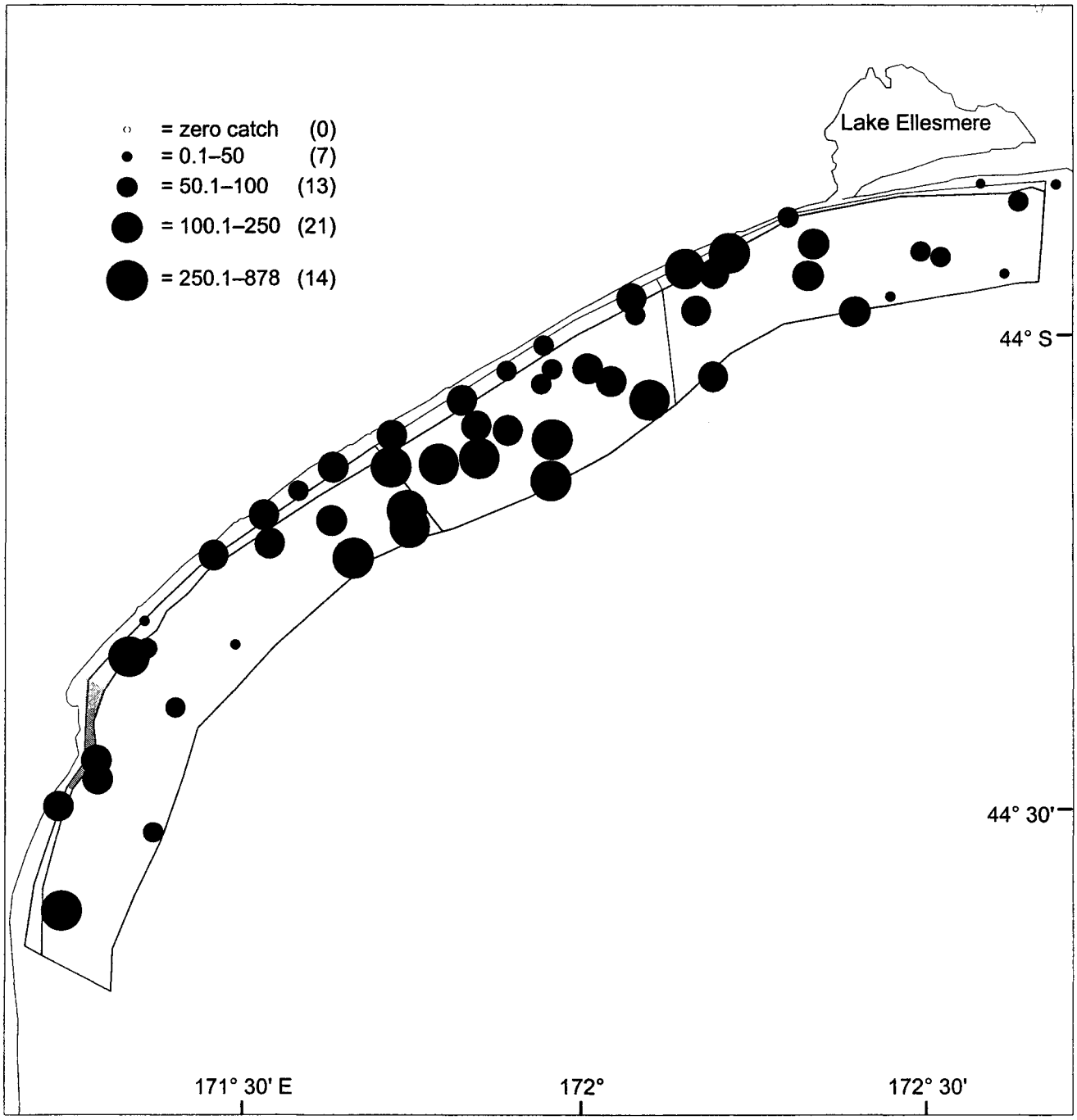


Figure 6—continued

Sand flounder

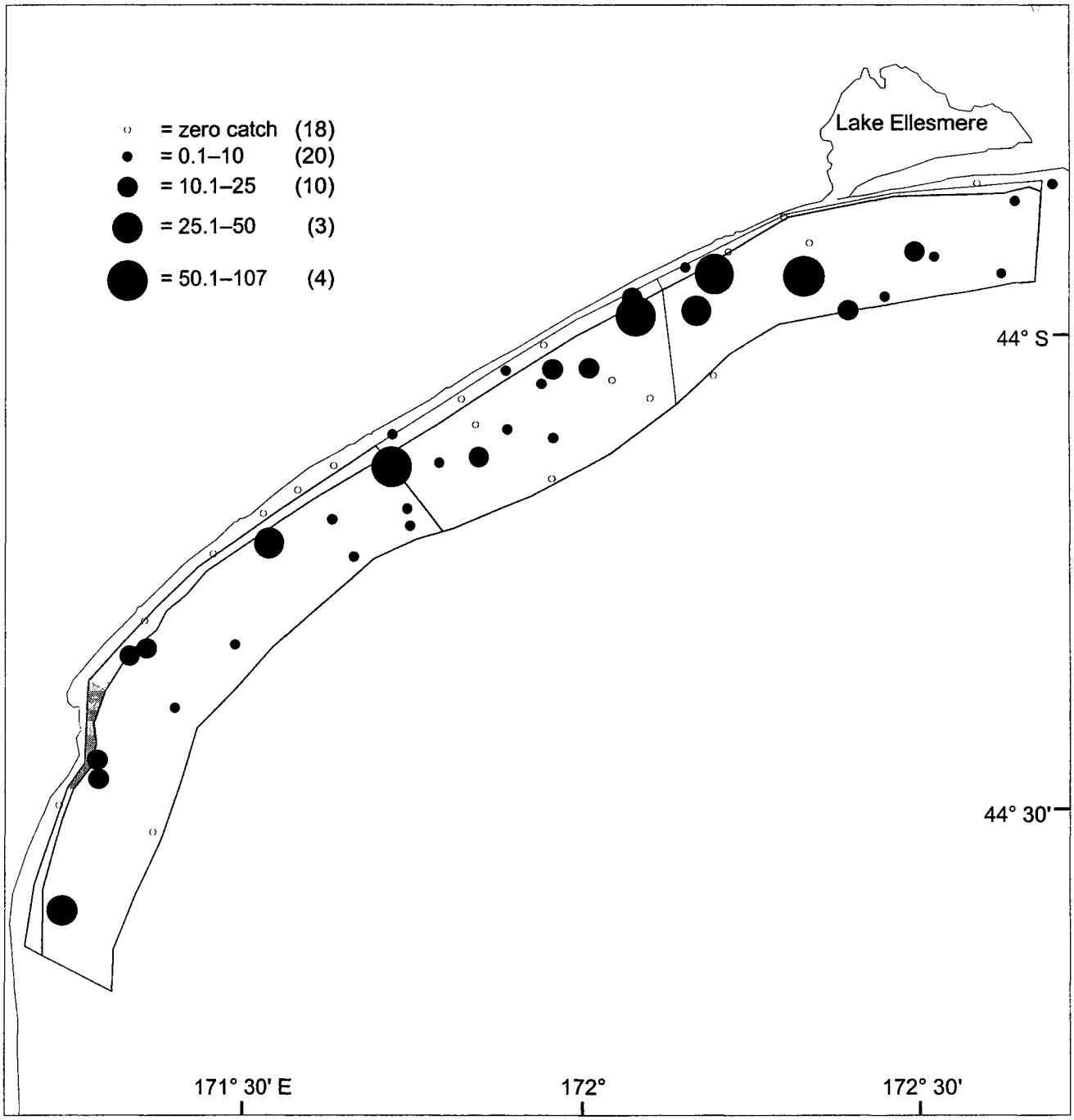


Figure 6—continued

School shark

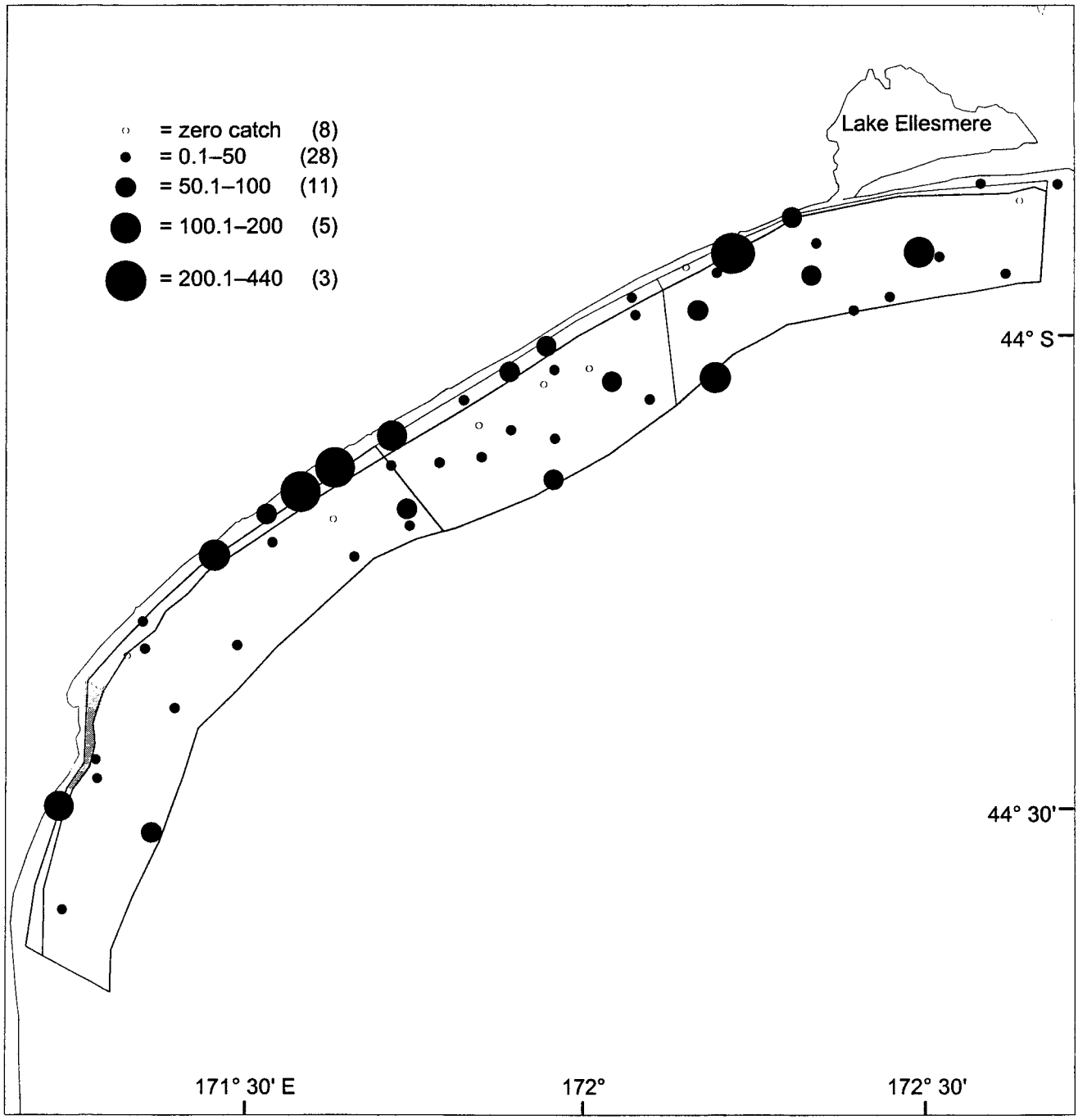


Figure 6—continued

Spiny dogfish

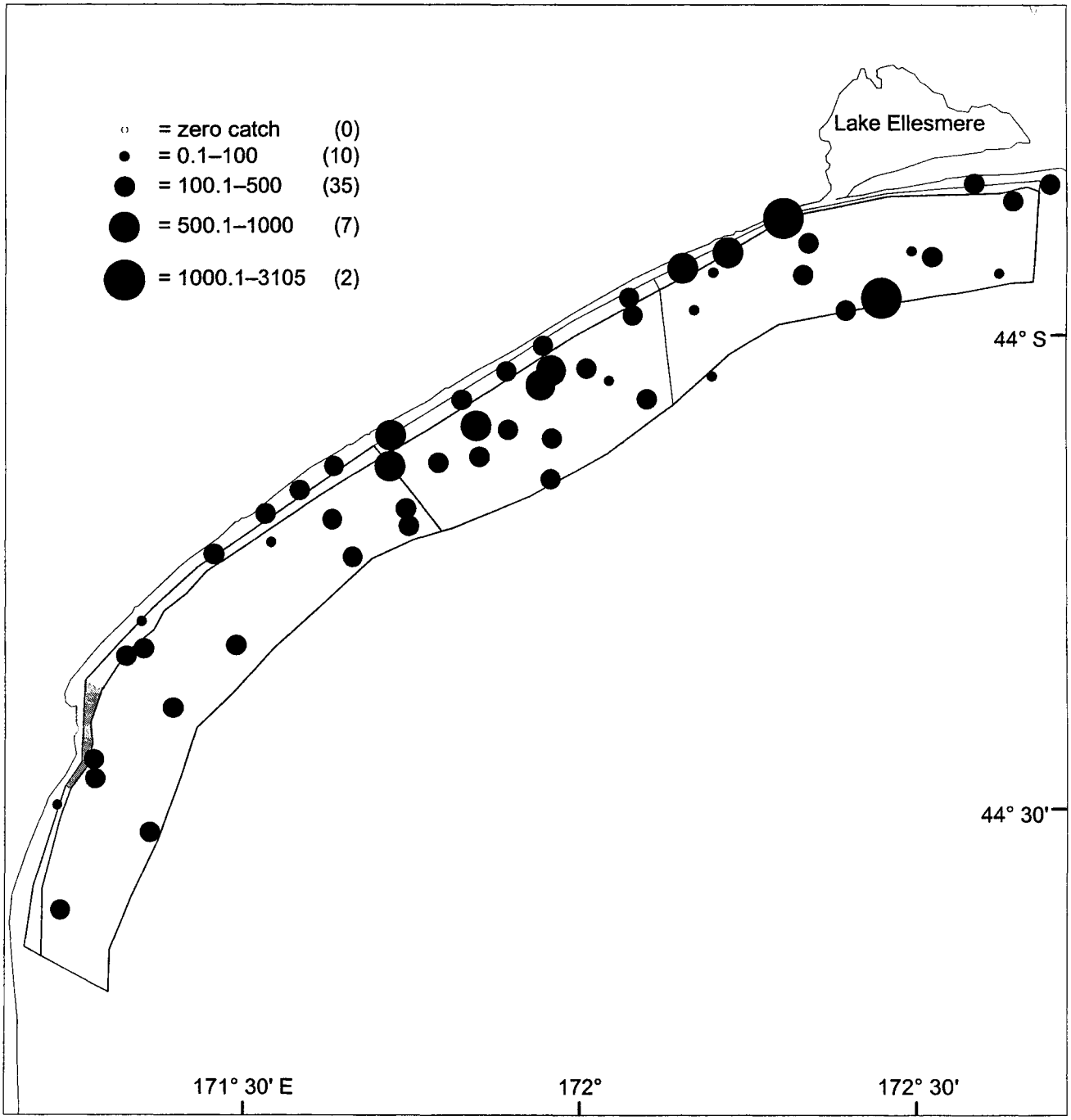
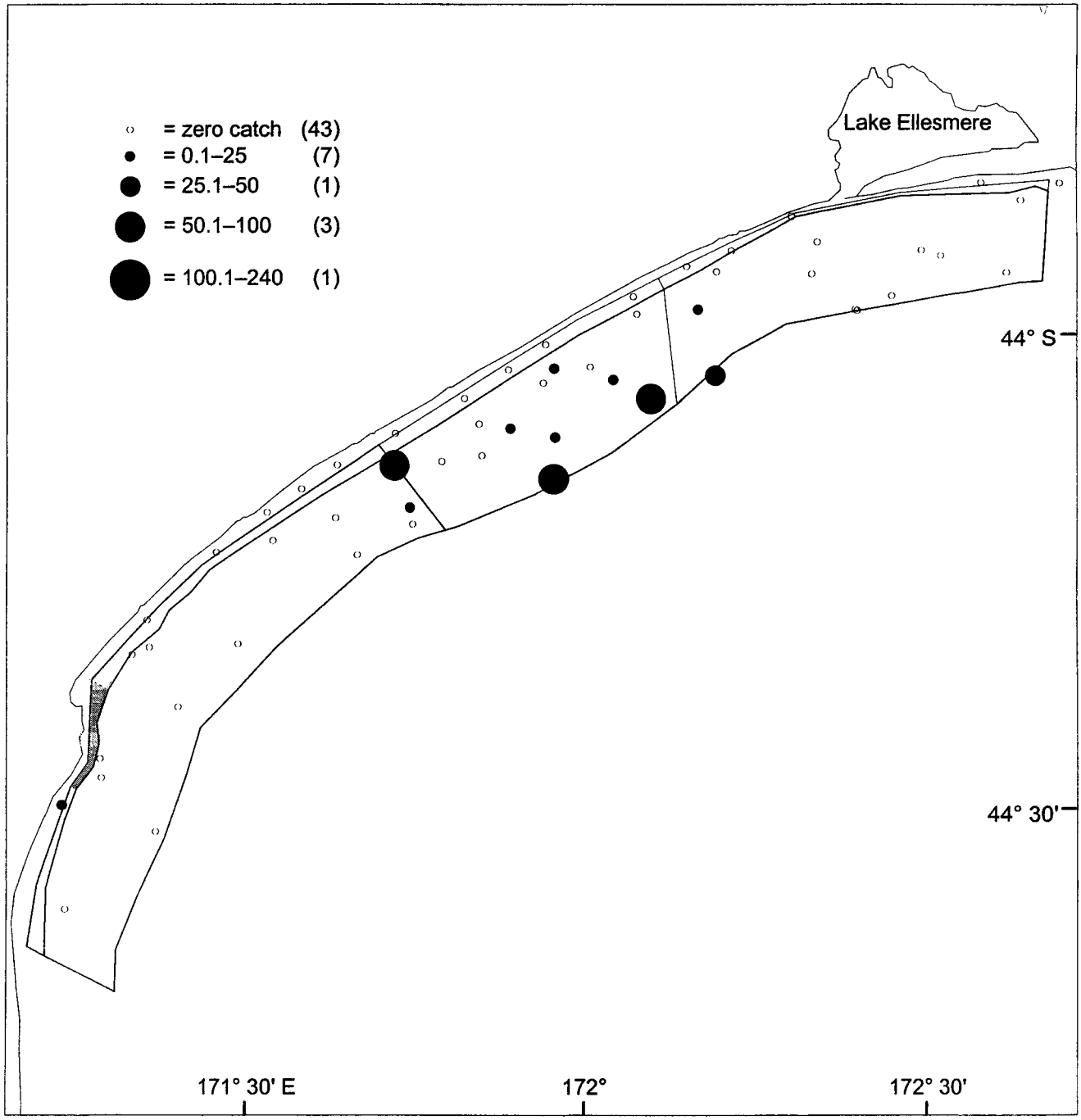


Figure 6—continued

Tarakihi



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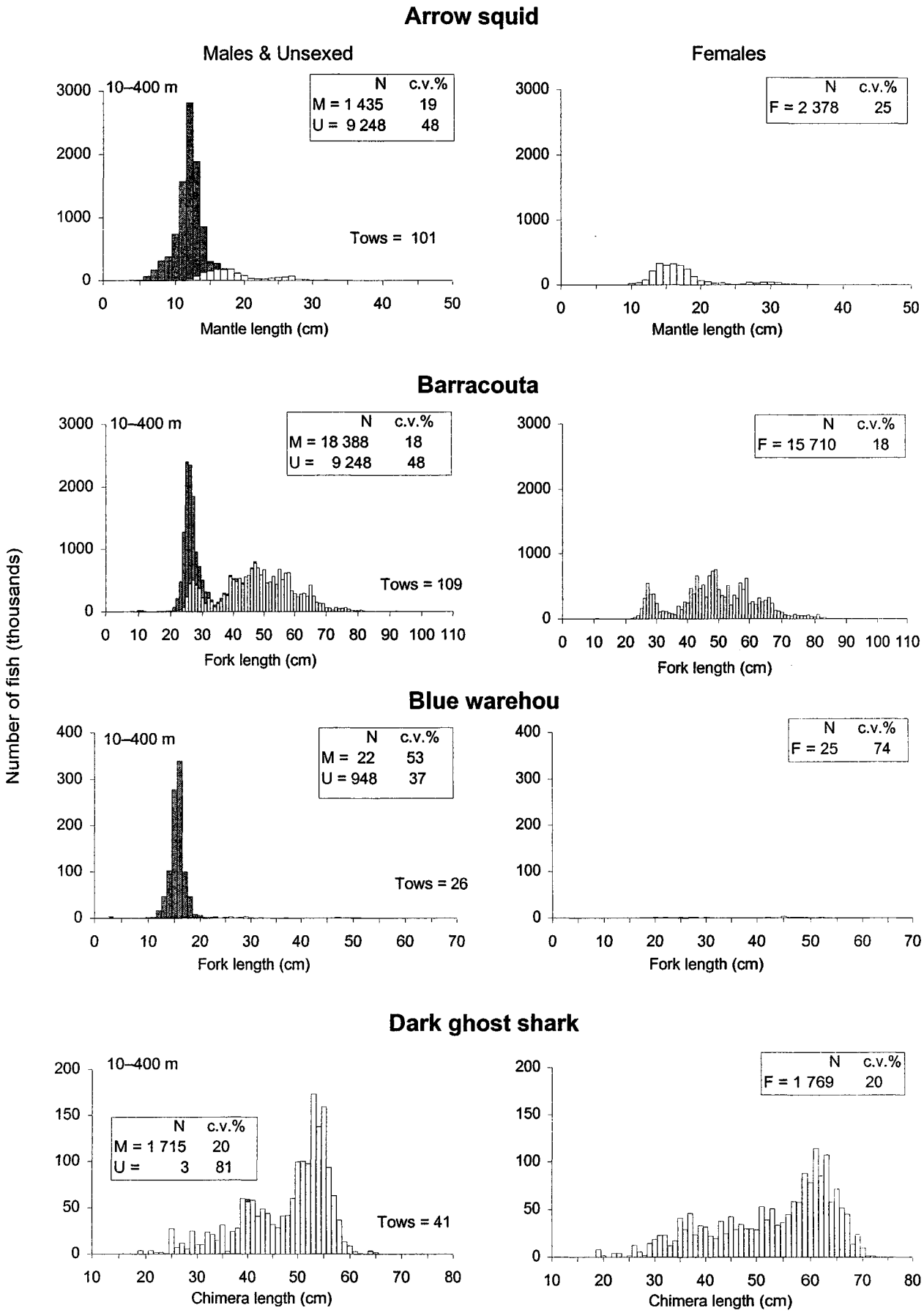
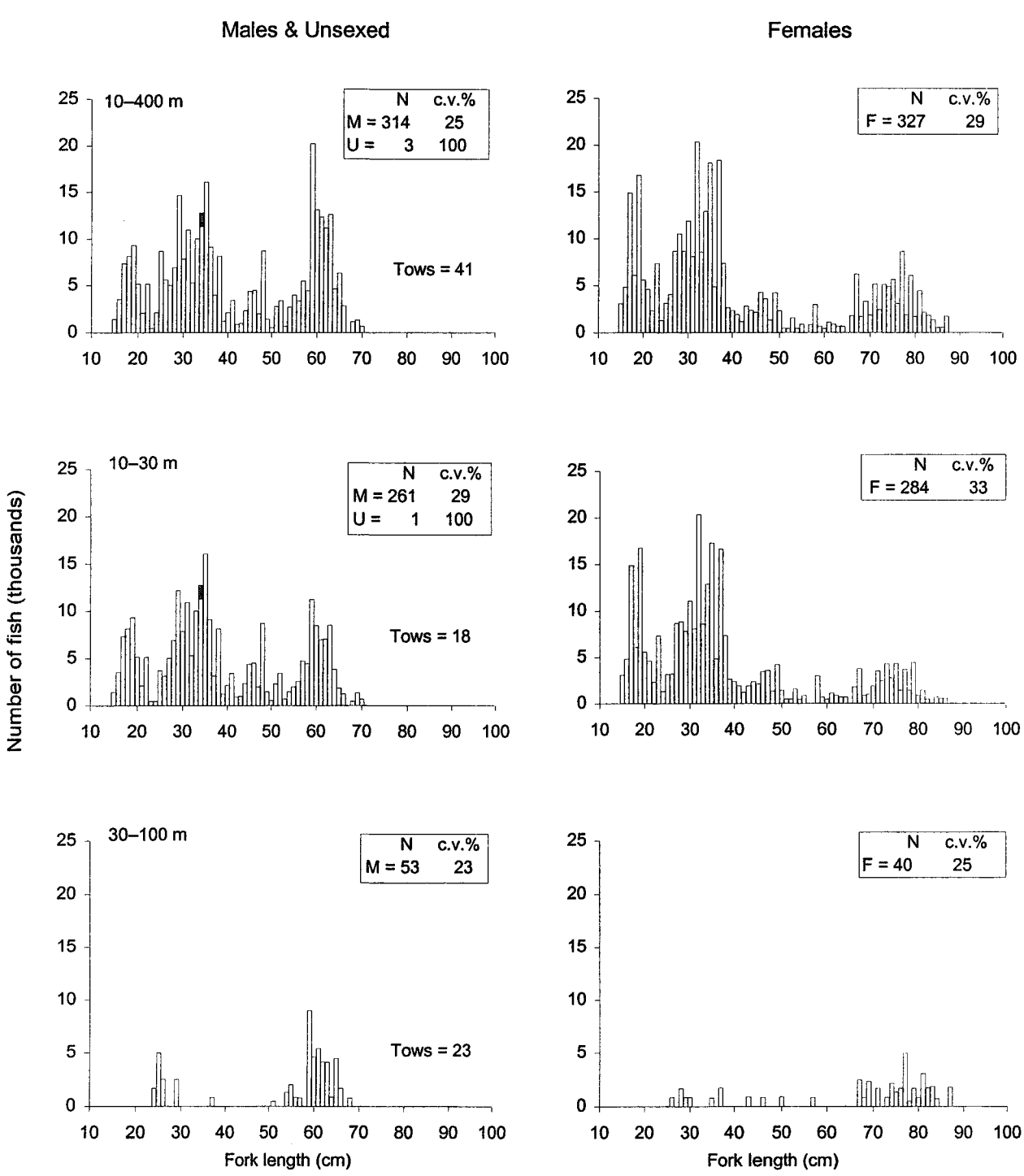


Figure 7: **Scaled length frequency distributions for the major commercial species, by depth where appropriate. N, estimated population (scaled, thousands); M, male; F, female; U, unsexed (shaded); Tows, number of stations at which species was caught.**



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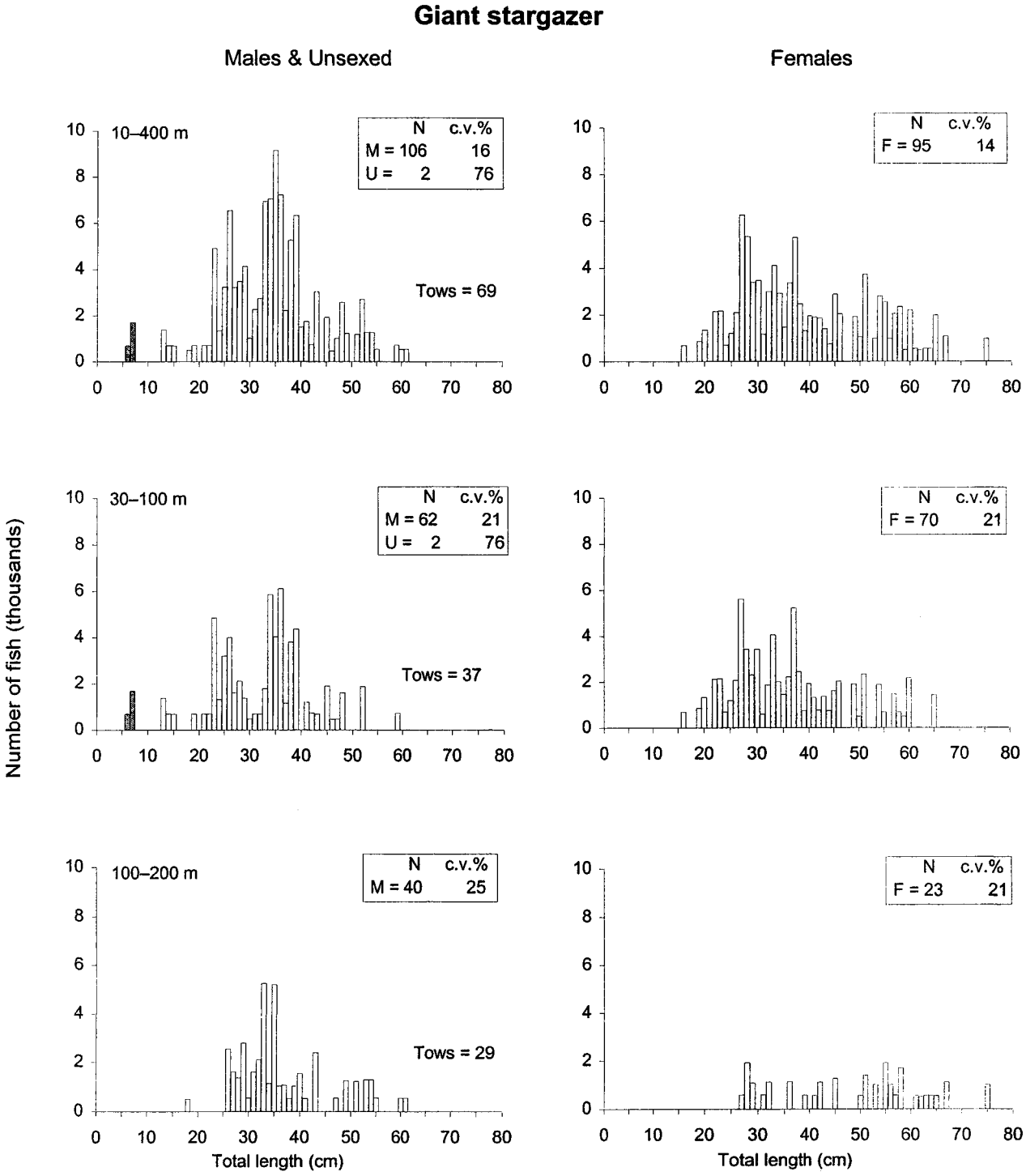

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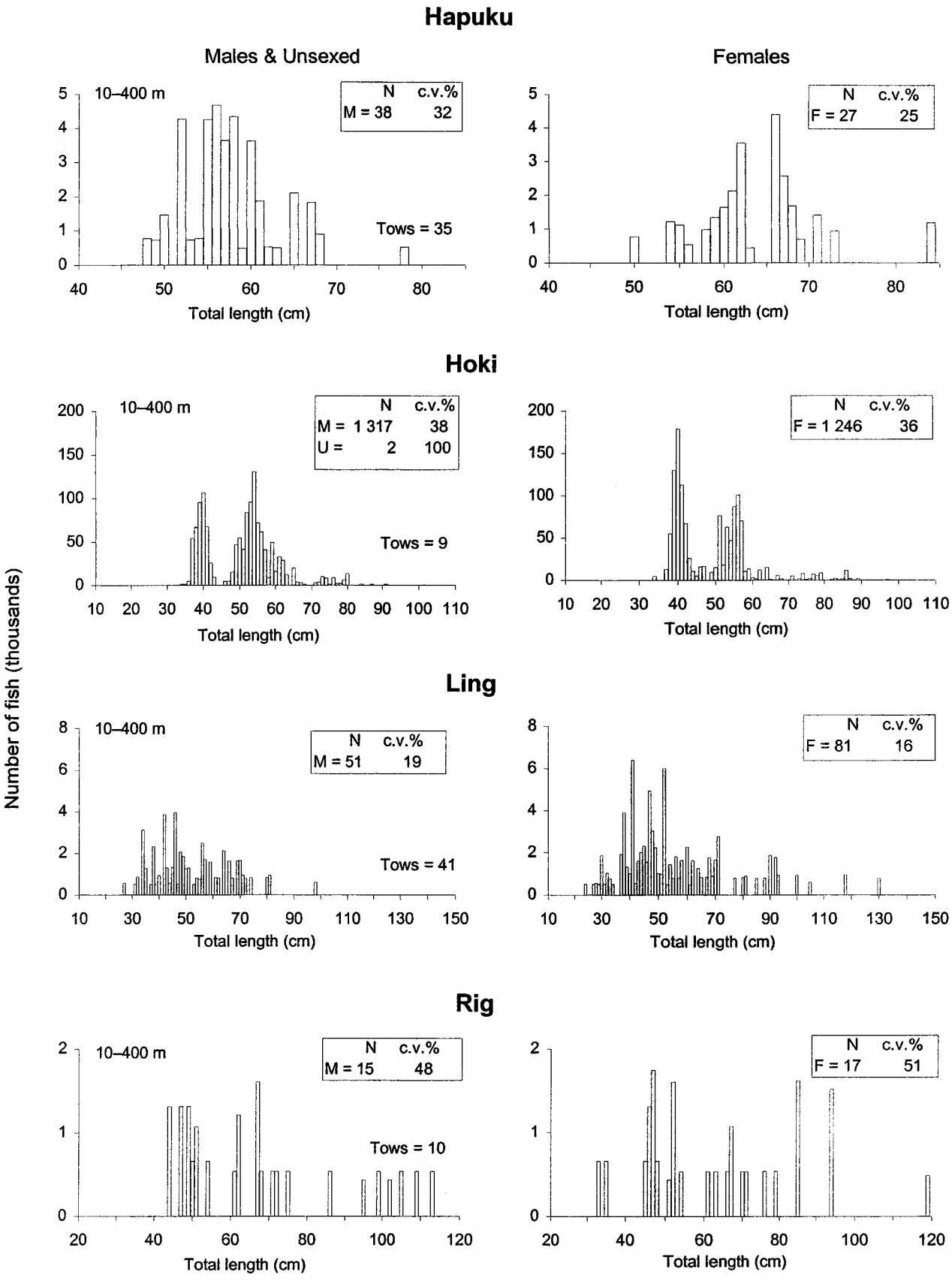

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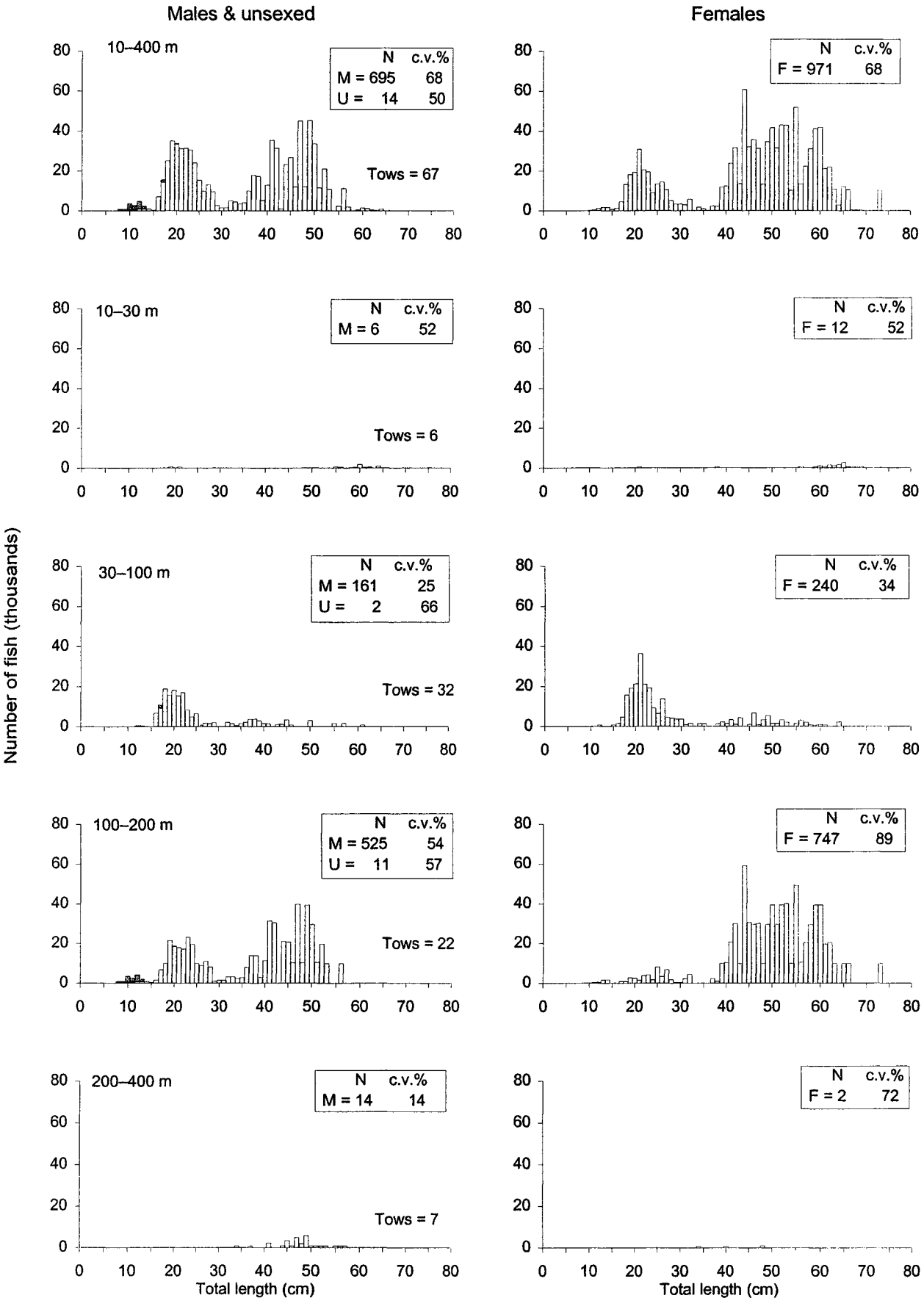

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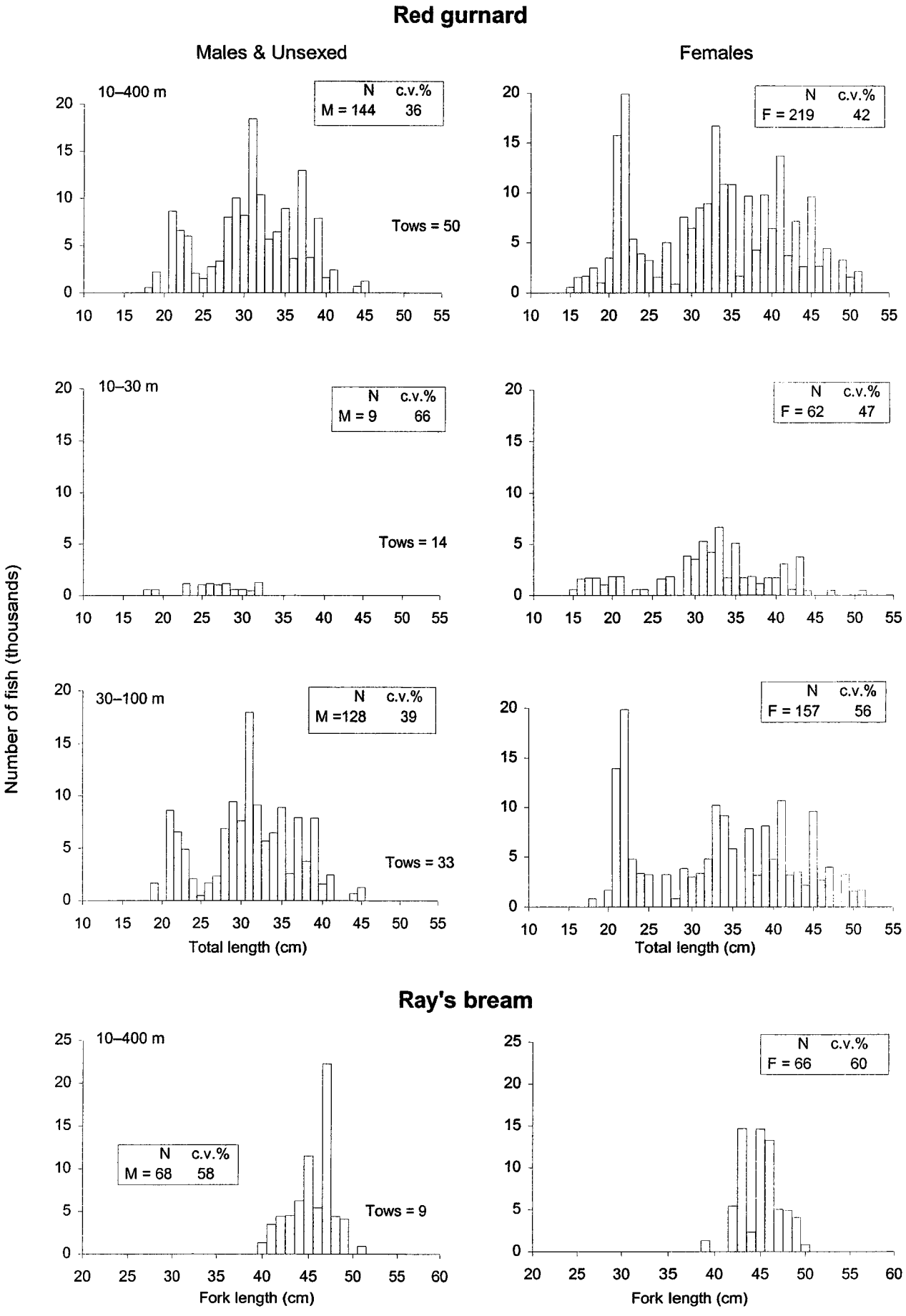

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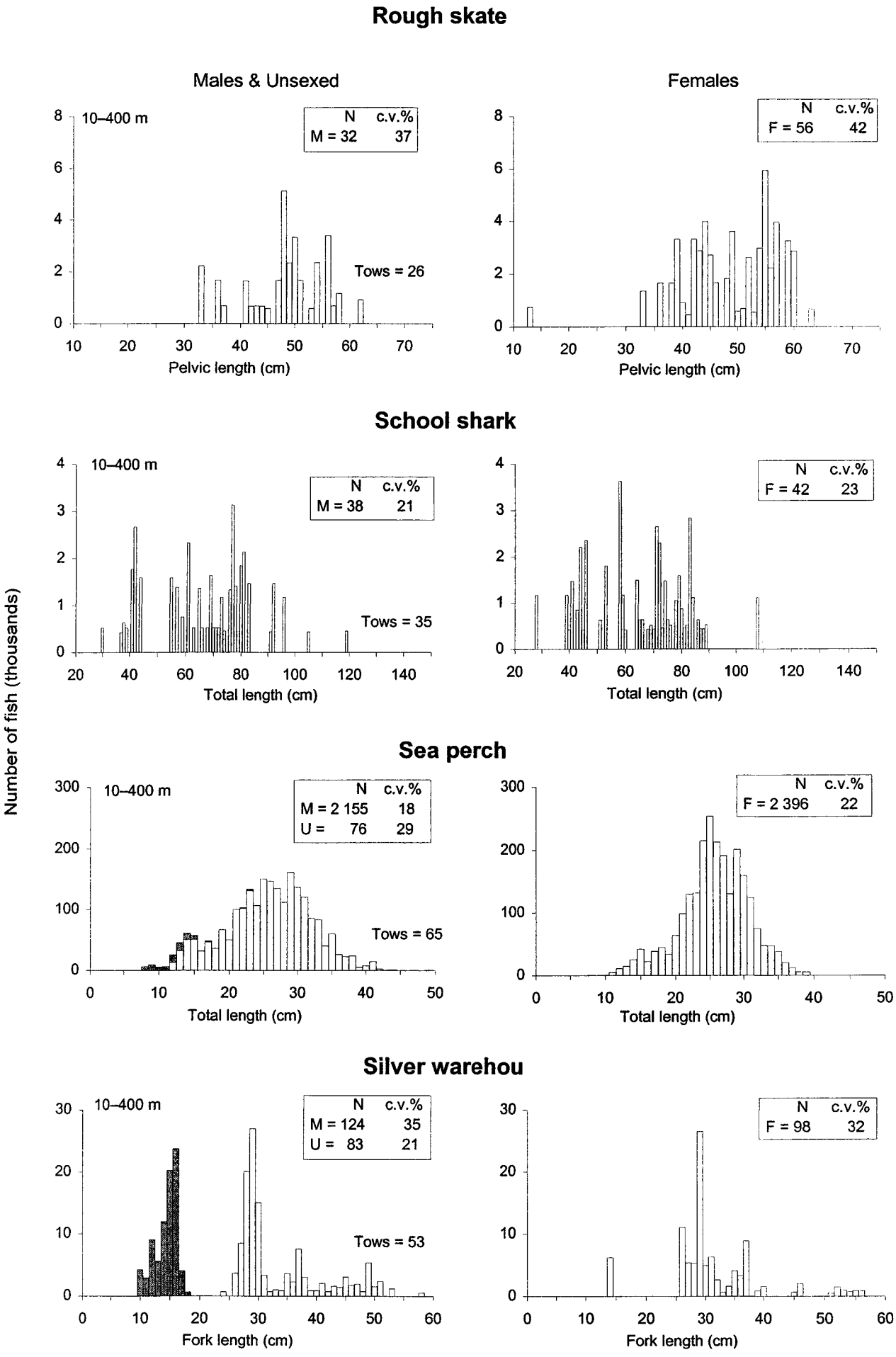

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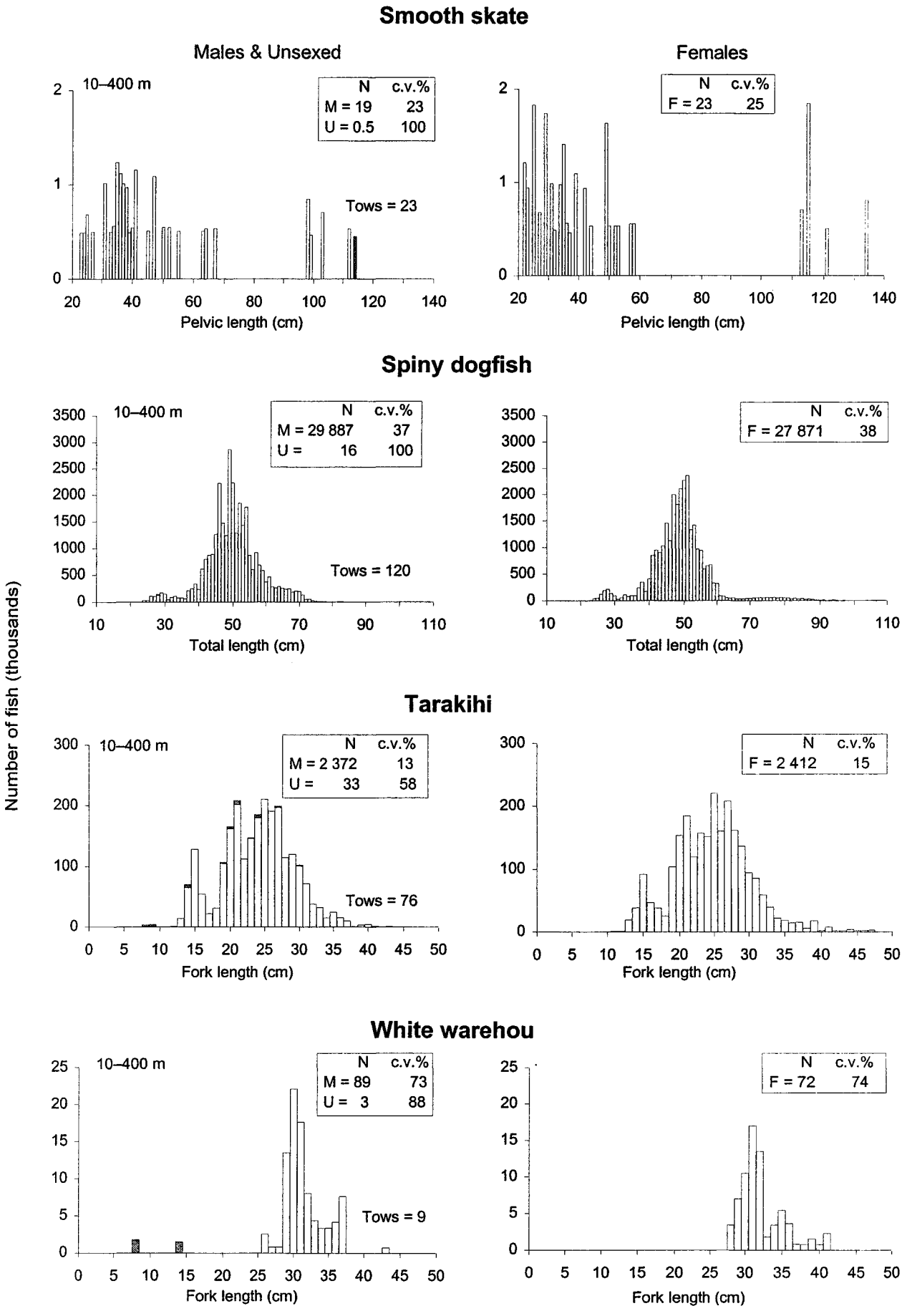

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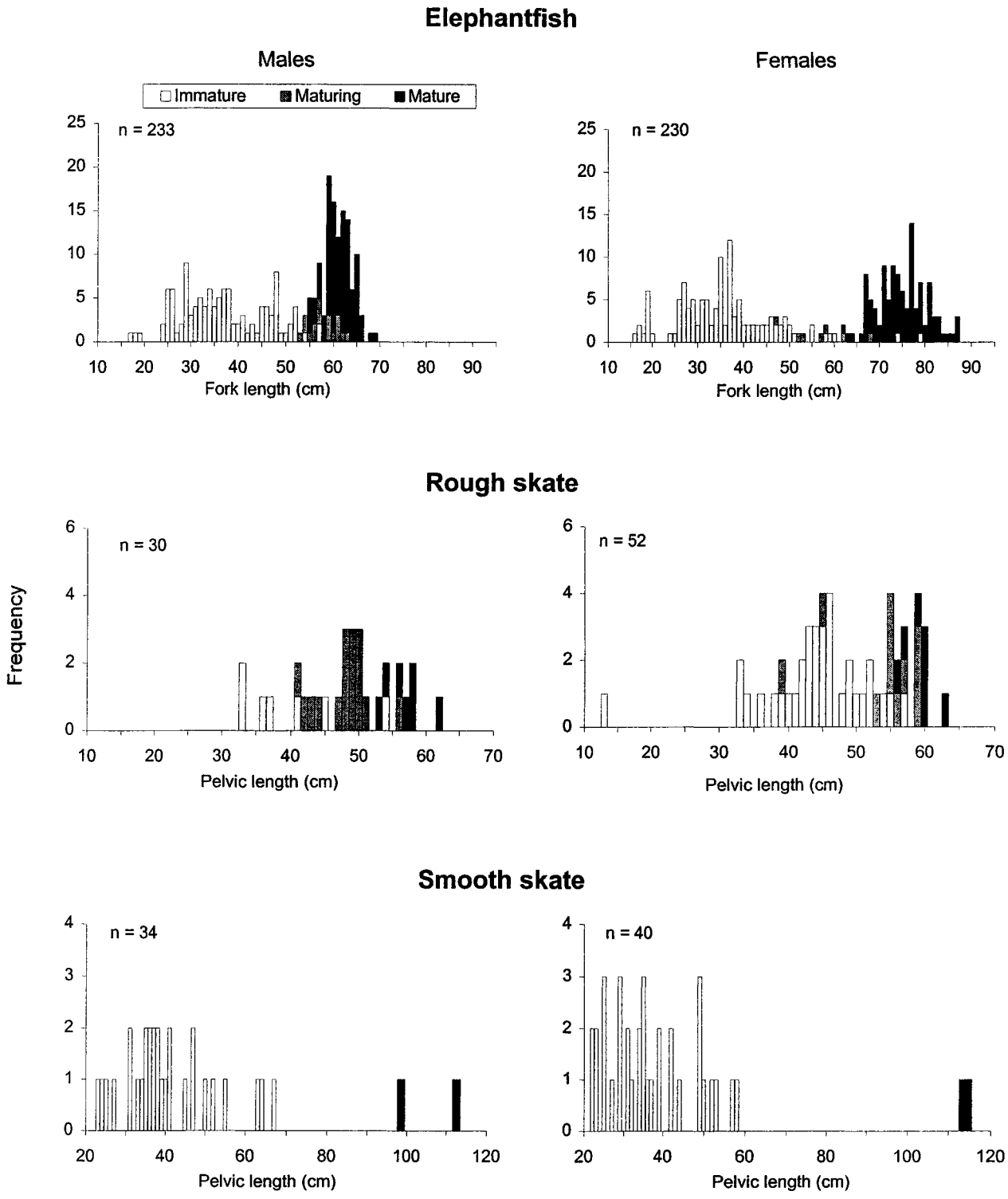

Figure 8: **Length at maturity for elephantfish, rough skate, and smooth skate (*n*, sample size).**

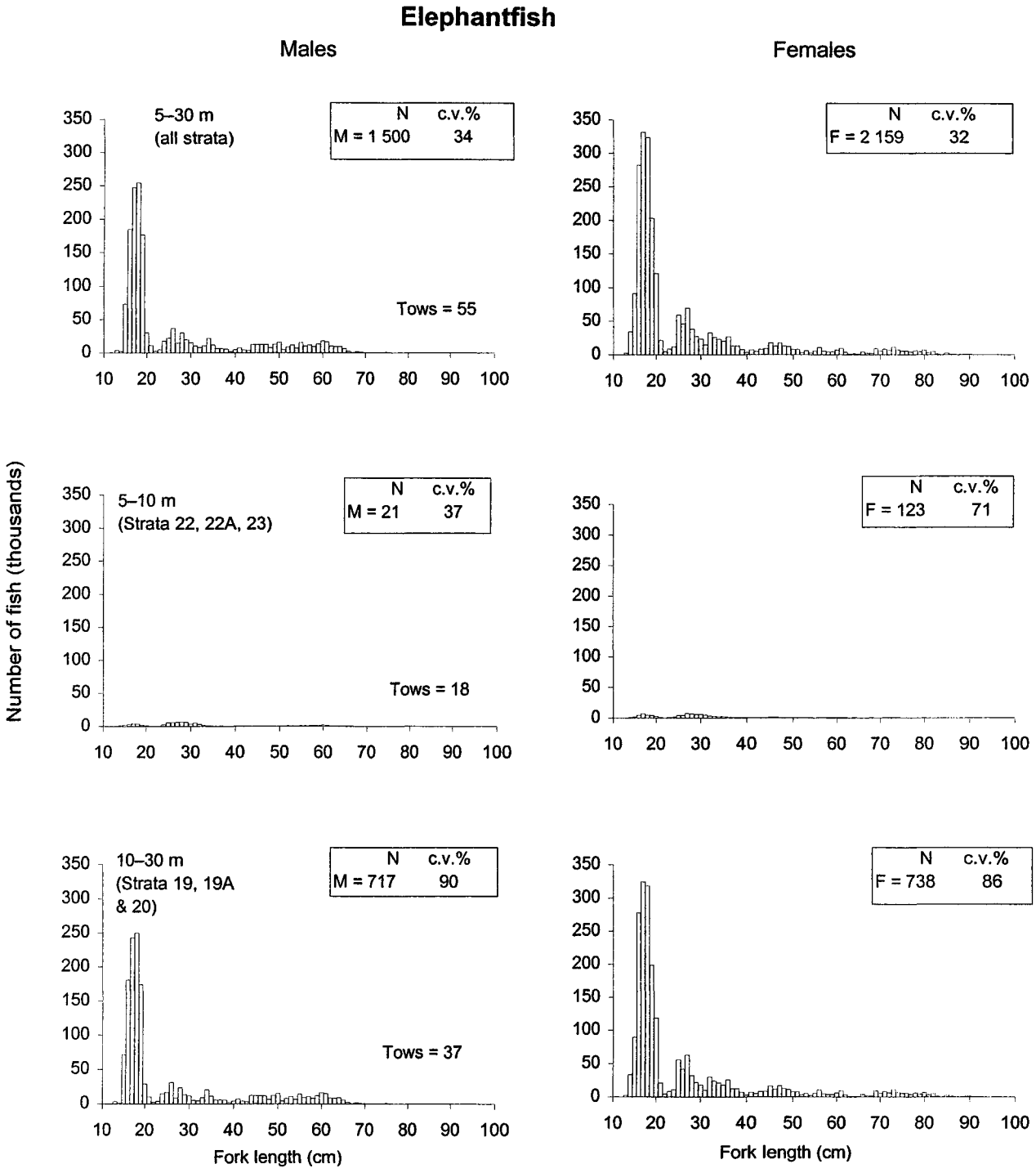

Figure 9: **Scaled length frequency distribution for elephantfish from *Compass Rose*. N, estimated population (thousands); M, male; F, female; Tows, number of stations at which species was caught.**

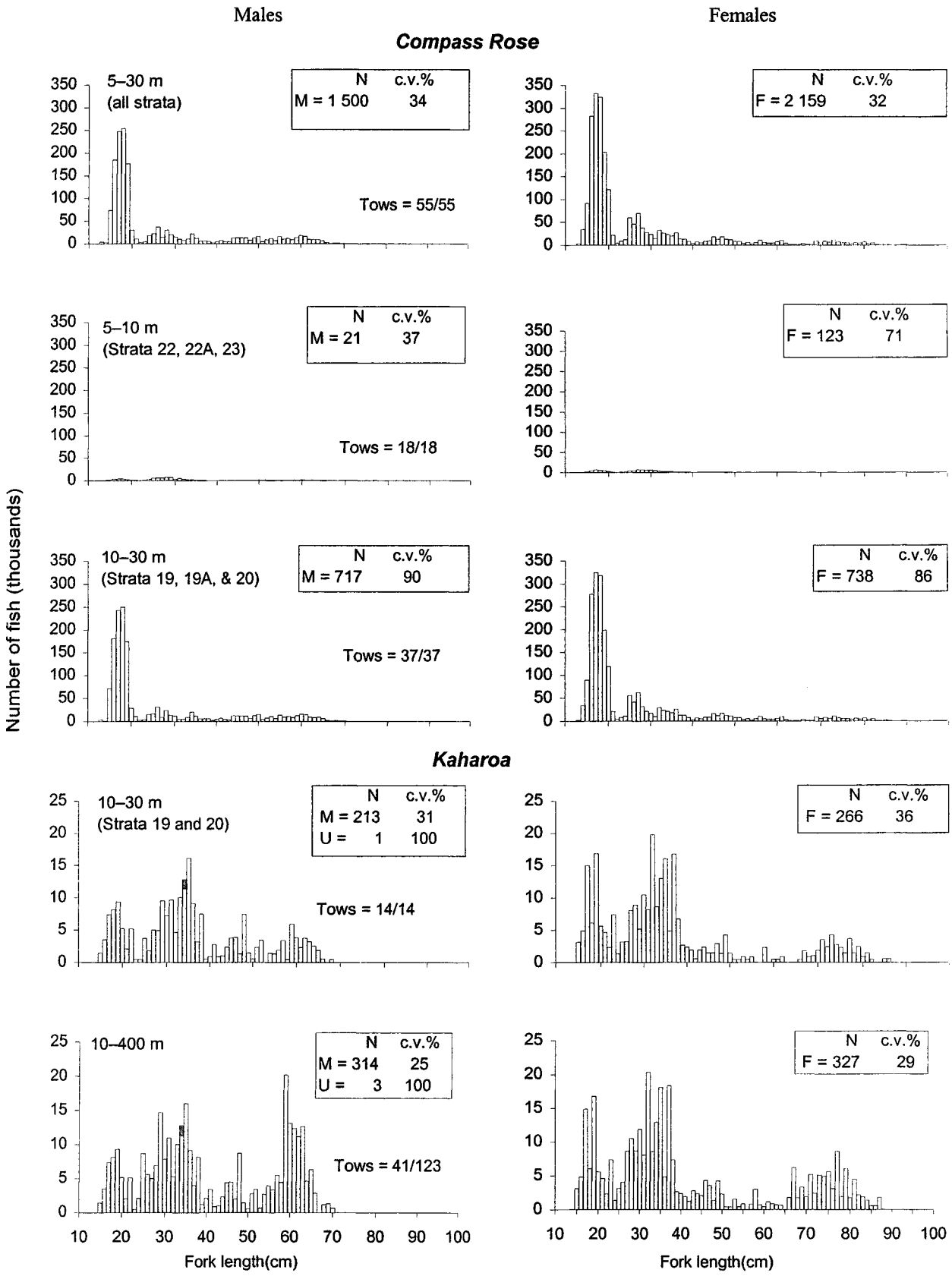

Figure 10: **Comparison of elephantfish length frequency distributions from *Kaharoa* and *Compass Rose*. N, estimated population (scaled, thousands); M, male; F, female; Tows, number of stations where elephantfish were caught/total number of stations in the area. Note y-axes scales are different for *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	KAH9917
Blue warehou	0.0144	3.1050	338	27.4–69.6	TAN9604
Dark ghost shark	0.0011	3.4089	325	19.5–70.3	This survey
Elephantfish	0.0048	3.1622	500	15–87.6	This survey
Giant stargazer	0.0149	3.0190	252	6.9–75.4	This survey
Hapuku	0.0025	3.4155	98	50.2–78.6	KAH9809
Hoki	0.0036	2.9490	1 511	34–102	TAN9601
Ling	0.0013	2.8007	179	32.2–123.7	KAH0004
New Zealand sole	0.0098	3.0014	363	12.7–49.7	KAH9809
Ray's bream	0.0112	3.1271	146	28–50.2	*Tangaroa* surveys
Red cod	0.0160	2.8493	620	8.7–69.8	This survey
Red gurnard	0.0053	3.1837	267	15.4–51.7	This survey
Rig	0.0031	3.0593	123	29.1–115.7	KAH9704
Rough skate	0.0295	2.9088	78	13.4–63.1	This survey
School shark	0.0042	3.0303	523	32–154	KAH9701
Sea perch	0.0111	3.1766	690	8.2–49.9	This survey
Silver warehou	0.0048	3.3800	262	16.6–57.8	TAN9502
Smooth skate	0.0241	2.9578	74	18.5–134.5	This survey
Spiny dogfish	0.0038	3.0108	441	26.6–93.1	KAH9917
Tarakihi	0.0142	3.0937	732	7.3–47.3	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).**

Station	Stratum	Date	Start of tow			End of tow			Gear depth (m)		Distance trawled	Headline height	Doorspread	Bottom temp
			Time	° ' S	° ' E	° ' S	° ' E		Min.	Max.	(n. miles)	(m)	(m)	(°C)
1	13	10-Dec-00	736	43 01.70	173 35.81	43 03.72	173 35.78		129	130	2.02	5.4	77.4	10.5
2	17	10-Dec-00	912	43 05.18	173 40.78	43 07.17	173 41.15		259	268	2	5.3	87.3	9.6
3	7	10-Dec-00	1201	43 15.38	173 18.05	43 17.10	173 16.65		53	57	2	5.4	74.1	12
4	7	10-Dec-00	1335	43 14.97	173 08.42	43 15.22	173 05.71		36	37	2	5.5	74.1	13
5	7	10-Dec-00	1439	43 17.16	173 04.74	43 19.07	173 03.92		32	35	2	5.4	74.1	13.4
6	18	11-Dec-00	505	43 12.46	172 47.33	43 14.30	172 46.25		15	15	2	5.4	71.9	13.6
7	18	11-Dec-00	649	43 22.25	172 50.58	43 24.12	172 51.55		24	25	2	5.4	71.9	
8	18	11-Dec-00	753	43 26.02	172 52.12	43 27.94	172 52.88		24	24	2	5.4	71.9	
9	18	11-Dec-00	919	43 32.17	172 57.99	43 33.94	172 59.28		24	24	2	6	71.9	15.2
10	5A	11-Dec-00	1230	43 50.16	173 15.22	43 51.94	173 13.95		76	78	2	6	74.1	11.6
11	5A	11-Dec-00	1503	43 55.41	172 52.17	43 55.74	172 49.44		35	38	2	5.7	74.1	12.2
12	19	12-Dec-00	508	43 53.14	172 37.94	43 53.88	172 35.38		22	22	2	6.3	71.9	13
13	19	12-Dec-00	617	43 55.29	172 32.28	43 55.71	172 29.58		22	23	2	6.3	71.9	13
14	19	12-Dec-00	720	43 55.57	172 26.23	43 55.85	172 23.50		22	22	2	6.3	71.9	13.2
15	19	12-Dec-00	842	43 56.93	172 16.33	43 58.64	172 14.90		25	29	2	5.7	71.9	13.2
16	19	12-Dec-00	953	43 59.48	172 14.03	44 00.75	172 11.89		29	30	2	5.7	71.9	
17	19	12-Dec-00	1132	44 00.09	172 00.46	44 01.24	171 58.20		15	15	2	5.7	71.9	13
18	4A	12-Dec-00	1306	44 07.94	171 58.97	44 09.94	171 59.18		31	36	2	5.7	74.1	13.2
19	4A	12-Dec-00	1409	44 11.55	171 59.86	44 13.07	172 01.65		42	48	2	5.7	74.1	12.2
20	4	12-Dec-00	1517	44 14.19	172 04.39	44 15.17	172 06.82		53	55	2	5.7	74.1	12
21	20	13-Dec-00	505	44 10.51	171 46.58	44 11.83	171 44.49		25	27	2	5.8	71.9	12.7
22	19	13-Dec-00	604	44 11.41	171 44.56	44 09.48	171 45.44		22	25	2.03	5.8	71.9	13.1
23	20	13-Dec-00	708	44 09.19	171 43.41	44 10.59	171 41.42		18	20	2	5.8	71.9	13.2
24	20	13-Dec-00	812	44 12.78	171 40.31	44 14.04	171 38.14		24	26	2	5.8	71.9	13.6
25	3A	13-Dec-00	926	44 15.23	171 42.25	44 17.21	171 41.84		32	37	2	5.8	74.1	
26	3A	13-Dec-00	1030	44 19.80	171 41.36	44 21.76	171 40.76		43	46	2	5.8	74.1	
27	20	13-Dec-00	1210	44 20.93	171 29.89	44 22.08	171 27.61		26	28	2	5.8	71.9	12.8
28	20	13-Dec-00	1318	44 24.08	171 24.37	44 25.44	171 22.34		23	24	2	5.8	71.9	13
29	1	14-Dec-00	519	45 28.15	171 03.87	45 30.09	171 03.18		56	57	2	5.8	69.8	11.3
30	1	14-Dec-00	630	45 29.76	171 07.29	45 28.00	171 08.65		75	77	2	5.7	78.3	11.2
31	1	14-Dec-00	1146	45 13.21	171 05.88	45 15.13	171 06.71		32	38	2	5.7	74.1	13

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.	Distance trawled (n. miles)	Headline height (m)	Doorspread (m)	Bottom temp (°C)
32	1	14-Dec-00	1521	45 20.71	171 08.05	45 22.46	171 08.07	52	55	1.75	5.5	74.1	11.9
33	1	15-Dec-00	520	45 27.58	171 11.75	45 26.70	171 12.42	94	96	1.01	5.8	74.1	11.6
34	8	15-Dec-00	620	45 25.81	171 17.45	45 23.96	171 18.54	116	119	2	5.8	77.5	11.4
35	1	15-Dec-00	758	45 16.96	171 20.46	45 15.04	171 21.24	99	99	2	5.8	79	11.3
36	8	15-Dec-00	1010	45 17.41	171 26.31	45 16.00	171 28.32	119	122	2	5.8	73.3	10.8
37	14	15-Dec-00	1153	45 17.93	171 30.64	45 16.22	171 32.12	244	253	2.01	5.8	81.6	9.8
38	8	15-Dec-00	1328	45 11.32	171 28.08	45 09.55	171 26.76	119	121	2.01	5.8	73.2	11.1
39	2	15-Dec-00	1453	45 04.37	171 29.09	45 02.57	171 30.32	96	98	2	5.7	75.5	11.2
40	9	16-Dec-00	704	44 58.60	171 46.22	44 59.92	171 44.11	125	125	2	5.7	68.8	10.5
41	2	16-Dec-00	851	44 56.87	171 34.67	44 54.93	171 35.38	90	93	2	5.5	74.8	11.4
42	9	16-Dec-00	1108	44 55.69	171 41.84	44 54.83	171 42.57	108	109	1	5.7	73.5	11.1
43	9	16-Dec-00	1248	44 52.12	171 45.04	44 51.26	171 45.75	105	107	1	5.7	77.9	11
44	3	16-Dec-00	1341	44 49.52	171 44.28	44 48.62	171 44.89	99	99	1	5.7	75.3	11.1
45	3	16-Dec-00	1455	44 43.45	171 50.17	44 41.73	171 51.60	97	99	2	5.5	70.2	11.1
46	3	17-Dec-00	508	44 45.72	171 43.22	44 43.93	171 44.50	91	91	2.01	5.5	73.2	11.2
47	3	17-Dec-00	631	44 43.54	171 39.36	44 45.35	171 38.18	78	78	2	5.4	72	11.4
48	2	17-Dec-00	746	44 48.61	171 36.41	44 50.49	171 35.46	77	77	2	5.6	71.1	11.3
49	2	17-Dec-00	859	44 49.92	171 33.26	44 47.93	171 33.39	62	65	2	5.6	76.7	11.5
50	2	17-Dec-00	1014	44 47.08	171 30.60	44 48.82	171 29.22	53	54	2	5.6	72.2	12
51	2	17-Dec-00	1130	44 49.10	171 24.78	44 47.18	171 23.99	42	44	2	5.7	71.5	12.5
52	2	17-Dec-00	1233	44 47.01	171 22.30	44 45.36	171 20.74	36	39	2	5.6	71.3	12.3
53	21	17-Dec-00	1406	44 42.90	171 17.89	44 40.91	171 17.50	28	29	2	5.6	70.8	13.9
54	2	18-Dec-00	507	45 02.43	171 18.57	45 00.56	171 19.57	44	46	2	5.8	75.2	12.5
55	2	18-Dec-00	621	44 59.09	171 16.88	44 57.13	171 17.45	30	31	2	5.7	74.9	12.9
56	2	18-Dec-00	742	44 56.59	171 23.66	44 54.61	171 23.33	48	52	2	5.7	72.1	12.3
57	21	18-Dec-00	919	44 49.46	171 18.72	44 47.72	171 17.34	25	29	2	5.5	72.5	12.9
58	21	18-Dec-00	1045	44 42.45	171 12.75	44 40.47	171 12.42	17	18	2	5.5	72.1	13.3
59	20	18-Dec-00	1224	44 36.79	171 19.00	44 34.79	171 19.00	27	29	2	5.7	70.6	13
60	20	18-Dec-00	1335	44 31.95	171 19.94	44 29.96	171 20.26	23	25	2	5.6	69.6	13.1
61	3A	18-Dec-00	1454	44 29.82	171 24.30	44 31.59	171 25.59	29	36	2	5.6	70.3	13.5
62	3A	19-Dec-00	526	44 40.48	171 32.50	44 38.84	171 30.91	52	55	2	5.6	74.1	12.1

Appendix 2—continued

Station	Stratum	Date	Time	Start of tow ° ' S	Start of tow ° ' E	End of tow ° ' S	End of tow ° ' E	Gear depth (m) Min.	Gear depth (m) Max.	Distance trawled (n. miles)	Headline height (m)	Doorspread (m)	Bottom temp (°C)
63	3A	19-Dec-00	643	44 36.62	171 26.96	44 34.76	171 28.05	46	47	2.01	5.5	74.5	12.3
64	3	19-Dec-00	834	44 29.84	171 39.13	44 29.52	171 41.90	56	60	2	5.5	75.5	12.1
65	3	19-Dec-00	959	44 28.58	171 46.39	44 29.13	171 49.07	64	67	2	5.6	77.3	12.2
66	3	19-Dec-00	1159	44 33.13	171 59.64	44 31.54	172 01.34	84	88	2	5.4	77.7	11
67	3	19-Dec-00	1309	44 31.16	172 03.83	44 29.63	172 05.63	84	85	2	5.7	78.6	11.1
68	3	19-Dec-00	1418	44 28.72	172 03.81	44 27.13	172 05.50	75	77	2	5.7	76.8	11.6
69	4	19-Dec-00	1529	44 28.03	172 08.38	44 26.97	172 10.74	79	81	2	5.5	76.9	11.2
70	14	20-Dec-00	520	44 49.70	172 11.02	44 48.33	172 13.07	205	206	2	5.7	73.1	10.1
71	9	20-Dec-00	703	44 49.12	172 04.24	44 47.15	172 04.71	133	136	2	5.6	70.5	10.4
72	3	20-Dec-00	916	44 34.59	172 05.97	44 33.83	172 07.93	100	100	1.6	5	76.9	11.1
73	10	20-Dec-00	1042	44 35.30	172 17.34	44 35.79	172 20.05	117	128	2	5.6	71.6	11
74	10	20-Dec-00	1213	44 36.79	172 22.61	44 36.21	172 25.29	134	135	2	5.5	71	10.1
75	10	20-Dec-00	1323	44 37.22	172 26.66	44 36.94	172 29.43	144	144	2	5.6	73	9.9
76	4	20-Dec-00	507	44 10.05	172 22.21	44 08.11	172 22.89	55	55	2	5.3	72.9	12
77	4	21-Dec-00	621	44 05.77	172 24.97	44 04.12	172 27.59	53	55	2	5.5	73.2	12.1
78	4A	21-Dec-00	730	44 03.46	172 25.58	44 02.29	172 27.82	50	51	2	5.5	73.3	12.2
79	5A	21-Dec-00	856	43 59.10	172 33.73	43 58.65	172 36.42	37	37	2	5.5	71.7	
80	5A	21-Dec-00	1025	43 59.88	172 44.35	43 59.87	172 47.11	60	62	2	5.5	74.1	11.9
81	5A	21-Dec-00	1152	44 00.87	172 54.76	44 00.11	172 57.32	73	74	2	5.5	77	11.6
82	13	29-Dec-00	716	43 16.64	173 33.77	43 18.06	173 31.84	129	132	2	5.7	76.2	10.7
83	13	29-Dec-00	927	43 22.24	173 44.29	43 20.39	173 45.32	117	126	2	5.7	72.7	10
84	12	29-Dec-00	1139	43 26.59	173 50.13	43 28.52	173 50.82	105	118	2	5.7	75.1	10.7
85	17	29-Dec-00	1325	43 30.85	173 58.48	43 32.66	173 59.64	236	246	2	5.7	80.8	10
86	17	29-Dec-00	1519	43 32.86	174 02.78	43 34.79	174 03.49	373	382	2	5.7	74	8.5
87	12	30-Dec-00	508	43 42.22	173 56.39	43 44.22	173 56.27	124	127	2	5.7	74.6	10.9
88	12	30-Dec-00	622	43 42.04	173 54.48	43 40.34	173 53.04	103	111	2	5.7	79	10.7
89	6	30-Dec-00	741	43 40.67	173 47.29	43 41.77	173 44.99	95	97	2	5.7	72.6	11
90	6	30-Dec-00	859	43 41.56	173 40.08	43 42.80	173 37.92	91	92	2	5.5	81.1	11.2
91	6	30-Dec-00	1042	43 46.74	173 28.42	43 48.73	173 28.61	87	87	2	5.7	74.2	11.5
92	5	30-Dec-00	1221	43 54.98	173 34.29	43 56.94	173 34.85	94	98	2	5.7	78.8	11.2
93	5	31-Dec-00	646	44 07.23	173 11.84	44 06.83	173 14.55	94	98	2	5.7	77.4	11.1

Appendix 2—continued

Station	Stratum	Date	Time	Start of tow ° ' S	Start of tow ° ' E	End of tow ° ' S	End of tow ° ' E	Gear depth (m) Min.	Gear depth (m) Max.	Distance trawled (n. miles)	Headline height (m)	Doorspread (m)	Bottom temp (°C)
94	11	31-Dec-00	832	44 05.83	173 27.42	44 04.45	173 29.42	113	114	2	5.7	78.8	10.9
95	16	31-Dec-00	1036	44 10.38	173 35.68	44 09.14	173 37.86	378	387	2	5.7	91.4	7.6
96	16	31-Dec-00	1314	44 14.75	173 26.67	44 16.11	173 24.63	339	343	2	5.7	86.9	9.3
97	4	2-Jan-01	604	44 13.25	172 39.79	44 14.72	172 37.90	75	78	2	5.7	79.6	11.9
98	4	2-Jan-01	755	44 17.16	172 36.54	44 17.16	172 39.32	82	83	2	5.7	80.6	12
99	5	2-Jan-01	930	44 16.81	172 48.52	44 16.24	172 51.18	85	92	2	5.7	79.1	11.9
100	11	2-Jan-01	1100	44 18.70	172 53.88	44 17.50	172 56.10	103	105	2	5.7	80	12
101	11	2-Jan-01	1222	44 16.76	172 59.59	44 15.82	173 02.05	112	114	2	5.7	78.5	11.6
102	16	2-Jan-01	1509	44 28.31	172 59.27	44 29.16	172 56.75	308	310	2	5.7	77.9	9.4
103	4A	3-Jan-01	501	44 07.75	172 16.14	44 09.25	172 17.98	46	51	2	5.7	75.7	12.8
104	4	3-Jan-01	816	44 16.13	172 28.60	44 16.24	172 31.38	70	74	2	5.4	76.9	12.4
105	4	3-Jan-01	937	44 16.17	172 34.54	44 17.35	172 32.30	71	80	2	5.5	71.6	12.2
106	4	3-Jan-01	1059	44 19.42	172 29.09	44 21.41	172 28.97	68	84	2	5.4	76.8	12.6
107	4	3-Jan-01	1237	44 23.70	172 30.27	44 23.26	172 32.99	92	97	2	5.4	77.5	11.6
108	14	3-Jan-01	1528	44 39.33	172 34.32	44 40.28	172 31.86	322	322	2	5.4	87.3	10.2
109 #	10	4-Jan-01	511	44 24.29	172 37.15	44 23.86	172 39.87	109	111	2	5.7	77.3	11.5
110 #	10	4-Jan-01	647	44 27.99	172 41.41	44 27.19	172 43.96	130	134	2	5.7	75.5	11.1
111 #	10	4-Jan-01	815	44 29.01	172 43.21	44 30.72	172 41.78	139	143	2	5.7	74.3	11.6
112 #	11	4-Jan-01	1113	44 23.97	172 58.41	44 22.86	173 00.73	142	144	2	5.6	77.4	11.1
113 #	11	4-Jan-01	1429	44 08.00	173 25.12	44 06.87	173 27.40	120	121	2	5.6	75.1	11.3
114 #	11	5-Jan-01	502	44 00.42	173 42.96	44 01.89	173 41.09	146	149	2	5.7	76.2	11.1
115 #	11	5-Jan-01	1016	44 23.03	172 52.71	44 23.71	172 50.09	126	126	2	5.5	74	11.1
116 #	10	5-Jan-01	1149	44 27.89	172 47.67	44 29.09	172 45.44	141	143	2	5.5	74	11.1
117 #	10	5-Jan-01	1448	44 28.12	172 31.46	44 29.59	172 29.57	113	115	1.99	5.5	77.4	11.3
118 #	10	6-Jan-01	510	44 38.88	172 21.55	44 37.65	172 23.76	138	139	2	5.1	82	11.1
119 #	11	6-Jan-01	957	44 19.94	173 08.56	44 18.76	173 10.81	145	146	2	5.6	77.1	11
120 #	11	6-Jan-01	1233	44 08.79	173 28.71	44 07.18	173 30.37	138	143	2	5.5	78.1	11.1
121 #	11	6-Jan-01	1422	43 59.94	173 36.58	43 58.83	173 38.87	109	111	2	5.6	74.2	11.3
122 #	7	7-Jan-01	501	43 15.54	172 58.58	43 13.81	172 59.93	37	39	2	5.5	75.2	14.7
123 #	7	7-Jan-01	648	43 15.44	173 08.21	43 17.06	173 06.62	32	34	2	5.6	70.5	15.6

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

Station	Stratum	Date	Start of tow 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)	Warp length	Surface temp (°C)
1	22	10-Dec-00	615	43 57.57	172 04.36	43 56.95	172 07.08	11	12	55.1	2.01	110	13.5
2	22A	10-Dec-00	752	43 55.67	172 09.15	43 55.10	172 11.97	10	11	57.4	2	110	14.8
3	19A	10-Dec-00	926	43 56.00	172 11.80	43 56.47	172 08.77	13	14	61.7	2.04	110	
4	22A	10-Dec-00	1109	43 54.69	172 13.11	43 55.86	172 15.30	10	10	55	2	110	
5	22A	10-Dec-00	1250	43 52.48	172 18.03	43 51.98	172 20.92	7	9	60.4	2.1	55	
6 *	19A	10-Dec-00	1436	43 53.87	172 22.03	43 53.60	172 22.79	19	19	60.4	0.65	110	
7	19A	10-Dec-00	1618	43 56.16	172 19.79	43 56.11	172 17.09	22	23	65.8	2	110	16.3
8	19A	11-Dec-00	608	43 51.48	172 38.25	43 51.19	172 40.98	17	18	56.6	2	110	13.5
9	22A	11-Dec-00	742	43 50.41	172 41.61	43 50.20	172 39.21	12	13	62.8	2.01	110	
10	22A	11-Dec-00	904	43 50.37	172 34.85	43 50.84	172 32.00	7	9	59.7	2.03	110	14.5
11	19A	11-Dec-00	1056	43 54.65	172 29.47	43 55.29	172 26.86	18	19	56.6	2	110	14.3
12	19A	11-Dec-00	1231	43 58.46	172 23.76	43 59.78	172 21.41	24	31	60.4	2.11	110	14.3
13	19A	11-Dec-00	1451	44 02.56	172 11.68	44 03.34	172 09.02	31	33	55	2.04	110	
14	19A	11-Dec-00	1715	43 58.36	172 10.15	43 59.53	172 07.77	19	20	60.4	2	110	15.5
15	19	12-Dec-00	605	45 05.26	172 01.34	45 06.26	171 58.88	26	26	62.8	2	110	15.2
16	19	12-Dec-00	726	44 06.50	171 57.40	44 07.94	171 55.46	24	25	67.4	2	110	15.3
17	19	12-Dec-00	902	44 05.96	171 53.45	44 04.71	171 55.76	17	18	67.3	2	110	14.5
18	22	12-Dec-00	1103	44 00.61	171 56.58	44 01.65	171 54.12	9	10	62.8	2.06	110	15.2
19	22	12-Dec-00	1305	44 02.23	171 53.28	44 03.54	171 51.06	10	12	64.3	2.06	110	15.2
20	22	12-Dec-00	1429	44 04.05	171 49.33	44 05.13	171 47.03	12	12	64.3	2.03	110	15.4
21	19	12-Dec-00	1612	44 08.06	171 47.28	44 09.36	171 44.99	18	20	64.3	2.1	110	15.4
22	20	13-Dec-00	643	44 13.96	171 39.72	44 12.69	171 41.77	25	27	67.3	2.05	110	15.3
23	20	13-Dec-00	757	44 12.04	171 44.68	44 10.49	171 44.41	21	24	61.2	2.03	110	15.4
24	19	13-Dec-00	941	44 08.24	171 43.02	44 06.94	171 45.12	13	14	62.8	2	110	
25	22	13-Dec-00	1118	44 06.27	171 43.09	44 07.19	171 40.63	8	9	60.4	2	110	
26	23	13-Dec-00	1354	44 08.27	171 37.95	44 09.21	171 35.43	8	8	61.2	2.01	110	16.5
27	23	13-Dec-00	1517	44 09.81	171 34.87	44 10.83	171 32.46	8	9	60.4	2.05	110	16.2
28	20	13-Dec-00	1714	44 11.63	171 37.82	44 12.92	171 35.81	19	20	67.3	1.94	110	
29	20	14-Dec-00	618	44 13.06	171 32.34	44 11.79	171 34.66	16	16	60.4	2.04	110	

Appendix 3—**continued**

Station			Start of tow			End of tow		Gear depth (m)		Doorspread	Distance trawled	Warp	Surface temp
	Stratum	Date	Time	° ' S	° ' E	° ' S	° ' E	Min.	Max.	(m)	(n. miles)	length	(°C)
30	23	14-Dec-00	750	44 11.29	171 31.81	44 12.47	171 29.57	9	9	61.2	2.01	110	
31	23	14-Dec-00	921	44 13.80	171 27.32	44 15.12	171 25.05	9	10	60.4	2.06	110	16.5
32	23	14-Dec-00	1102	44 18.02	171 21.14	44 19.23	171 18.88	5	10	58.1	2.03	110	
33	20	14-Dec-00	1245	44 19.74	171 21.32	44 18.08	171 23.02	12	13	60.4	2.07	110	
34	23	14-Dec-00	1430	44 20.20	171 19.79	44 21.48	171 17.52	9	10	59.7	1.98	110	
35	23	15-Dec-00	629	44 36.36	171 13.94	44 38.59	171 13.85	20	22	43.5	2.01	110	15.5
36	20	15-Dec-00	907	44 31.44	171 21.90	44 29.59	171 23.29	26	27	58.1	2	110	15.5
37	20	15-Dec-00	1100	44 28.01	171 17.08	44 29.71	171 15.51	16	17	58.1	2	110	15.5
38	23	15-Dec-00	1240	44 29.71	171 13.68	44 28.48	171 15.94	8	13	56.6	2.02	110	16
39	20	15-Dec-00	1415	44 26.79	171 16.97	44 24.83	171 17.92	15	16	48.9	2.03	110	16
40	20	15-Dec-00	1612	44 23.50	171 23.88	44 22.04	171 25.79	21	22	53.5	2	110	16.1
41	19A	16-Dec-00	610	43 58.39	172 23.61	43 57.31	172 25.94	24	25	52	2	110	16
42	19A	16-Dec-00	725	43 57.54	172 26.82	43 57.14	172 29.54	24	25	52	2	110	16
43	19A	16-Dec-00	930	43 56.07	172 37.04	43 54.95	172 39.39	24	26	59.7	2	110	17.5
44	19A	16-Dec-00	1130	43 55.00	172 31.22	43 55.71	172 28.61	20	20	45.8	2	110	17.5
45	19A	16-Dec-00	1330	43 54.14	172 20.24	43 54.79	172 17.57	16	17	44.9	2	110	17
46	19	16-Dec-00	1601	43 58.66	172 04.69	43 59.59	170 01.98	13	13	64.3	2	110	17
47	19	16-Dec-00	1714	44 02.06	172 00.50	44 03.62	171 58.45	16	18	56.6	2	110	17
48	19	17-Dec-00	602	44 03.07	171 56.39	44 04.16	171 54.00	15	16	67.3	2	110	16
49	19	17-Dec-00	740	44 05.67	171 50.63	44 06.92	171 48.52	16	17	60.4	2	110	16
50	19	17-Dec-00	918	44 07.68	171 50.90	44 08.65	171 48.44	20	20	56.6	2	110	16
51	20	17-Dec-00	1253	44 19.51	171 29.27	44 20.78	171 27.12	22	22	50.4	2	110	16
52	19	18-Dec-00	703	44 10.97	171 44.41	44 09.91	171 46.86	22	22	68.9	2	110	16.5
53	19	18-Dec-00	940	44 02.14	171 57.33	44 00.96	171 59.59	15	16	64.3	2	110	16.5
54	19	18-Dec-00	1110	44 02.85	172 02.55	44 01.55	172 03.86	19	20	67.3	2	110	16.5
55	19	18-Dec-00	1250	44 04.01	172 05.97	44 06.22	172 02.82	29	30	67.3	2	110	16.5
56	19	18-Dec-00	1425	44 09.10	171 57.28	44 10.29	171 54.99	30	30	56.6	2	110	16.5

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*	0.1	1	23	24
ANT	Anenomes	Anthozoa	47.4	11	84	146
BAR	Barracouta	*Thyrsites atun*	27 116.9	89	15	387
BBE	Banded bellowsfish	*Centriscops humerosus*	0.5	2	124	382
BCO	Blue cod	*Parapercis colias*	12.9	5	32	149
BTA	Deepsea skate	*Pavoraja asperula*	1.0	1	322	322
CAR	Carpet shark	*Cephaloscyllium isabellum*	694.7	50	24	253
CAS	Oblique banded rattail	*Caelorinchus aspercephalus*	154.5	15	109	387
CBE	Crested bellowsfish	*Notopogon lilliei*	3 457.8	46	37	322
CBI	Two saddle rattail	*Caelorinchus biclinozonalis*	1 116.9	31	24	253
CBO	Bollons' rattail	*C. bollonsi*	108.1	7	94	387
CCX	Small banded rattail	*C. parvifasciatus*	0.1	1	373	382
CDO	Capro dory	*Capromimus abbreviatus*	43.9	5	75	253
CRB	Crab	Decapoda	0.6	2	22	246
DCS	Dawson's catchark	*Halaelurus dawsoni*	0.2	1	378	387
DSP	Deepsea pigfish	*Congiopodus coriaceus*	4.6	5	130	149
ELE	Elephantfish	*Callorhinchus milii*	1 240.8	33	15	78
ESO	N.Z. sole	*Peltorhamphus novaezeelandiae*	9.1	9	22	55
FHD	Deepsea flathead	*Hoplichthys haswelli*	24.7	2	322	343
GFL	Greenback flounder	*Rhombosolea tapirina*	7.2	2	15	99
GLB	Globefish	*Contusus richei*	65.0	12	15	37
GON	Sandfish	*Gonorynchus forsteri*	4.1	7	17	246
GSH	Dark ghost shark	*Hydrolagus novaezelandiae*	4 916.8	33	68	387
GUR	Red gurnard	*Chelidonichthys kumu*	157.3	41	15	115
HAK	Hake	*Merluccius australis*	0.8	2	15	29
HAP	Hapuku	*Polyprion oxygeneios*	232.7	28	32	206
HOK	Hoki	*Macruronus novaezelandiae*	1 313.1	7	130	387
JAV	Javelinfish	*Lepidorhynchus denticulatus*	68.4	5	244	387
JDO	John dory	*Zeus faber*	9.3	2	30	55
JMD	N.Z. jack mackerel	*Trachurus declivis*	12.8	5	46	78
JMM	Chilean jack mackerel	*T. symmetricus murphyi*	33.7	4	46	143
JMN	N.Z. jack mackerel	*T. novaezelandiae*	1.5	3	32	55
KAH	Kahawai	*Arripis trutta*	21.2	5	22	35
LAN	Lanternfish	Myctophidae	0.1	1	205	206
LDO	Lookdown dory	*Cyttus traversi*	40.8	4	308	387
LEA	Leatherjacket	*Parika scaber*	96.1	16	15	55
LIN	Ling	*Genypterus blacodes*	163.5	33	37	387
LSO	Lemon sole	*Pelotretis flavilatus*	20.2	21	25	268
MDO	Mirror dory	*Zenopsis nebulosus*	1.3	1	259	268
MIQ	Warty squid	*Moroteuthis ingens*	1.9	1	308	310
MOK	Moki	*Latridopsis ciliaris*	18.3	2	32	38
OCT	Octopus	*Octopus cordiformis*	3.5	4	53	99
OPA	Opalfish	*Hemerocoetes* spp.	0.6	5	70	322
PAD	Paddle crab	*Ovalipes catharus*	0.2	2	15	36
PCO	Ahuru	*Auchenoceros punctatus*	1.2	3	15	25
PIG	Southern pigfish	*Congiopodus leucopaecilus*	427.8	40	28	322
RBM	Ray's bream	*Brama brama*	291.1	7	105	387

Appendix 4—continued

Species code	Common name	Scientific name	Catch (kg)	Occ. %	Depth (m) Min	Max
RBT	Redbait	*Emmelichthys nitidus*	0.4	2	117	134
RCO	Red cod	*Pseudophycis bachus*	1 364.7	54	22	387
RSK	Rough skate	*Dipturus nasutus*	203.5	21	15	246
SAM	Quinnat salmon	*Oncorhynchus tshawytscha*	4.5	2	15	29
SAZ	Sand stargazer	*Crapatalus novaezelandiae*	0.7	2	24	25
SBW	Southern blue whiting	*Micromesistius australis*	0.3	1	378	387
SCC	Sea cucumber	*Stichopus mollis*	0.3	1	129	130
SCG	Scaly gurnard	*Lepidotrigla brachyoptera*	143.2	38	32	146
SCH	School shark	*Galeorhinus galeus*	186.5	28	15	135
SCI	Scampi	*Metanephrops challengeri*	0.6	2	308	387
SCO	Swollenheaded conger	*Bassanago bulbiceps*	0.5	1	378	387
SDO	Silver dory	*Cyttus novaezelandiae*	323.3	37	56	253
SDR	Spiny seadragon	*Solegnathus spinosissimus*	0.3	1	68	84
SEV	Broadnose sevengill shark	*Notorynchus cepedianus*	150.0	1	24	24
SFL	Sand flounder	*Rhombosolea plebeia*	16.6	7	15	29
SHO	Seahorse	*Hippocampus abdominalis*	0.1	1	53	57
SLS	Slender sole	*Peltorhamphus tenuis*	0.1	1	25	29
SPD	Spiny dogfish	*Squalus acanthias*	37 014.7	98	15	387
SPE	Sea perch	*Helicolenus* spp.	2 669.1	53	32	387
SPF	Scarlet wrasse	*Pseudolabrus miles*	3.5	6	32	143
SPO	Rig	*Mustelus lenticulatus*	77.3	8	15	143
SPR	Sprats	*Sprattus antipodum, S. muelleri*	76.4	15	15	37
SPS	Speckled sole	*Peltorhamphus latus*	0.1	1	15	15
SQU	Arrow squid	*Nototodarus sloanii*	1 656.4	82	22	387
SSI	Silverside	*Argentina elongata*	380.4	53	42	387
SSK	Smooth skate	*Dipturus innominatus*	357.0	19	23	322
STA	Giant stargazer	*Kathetostoma giganteum*	298.2	56	32	387
STY	Spotty	*Notolabrus celidotus*	4.0	4	15	46
SWA	Silver warehou	*Seriolella punctata*	248.4	43	15	387
TAR	Tarakihi	*Nemadactylus macropterus*	1 987.9	62	25	149
THR	Thresher shark	*Alopias vulpinus*	38.0	1	35	38
TOP	Pale toadfish	*Neophrynichthys angustus*	3.9	3	70	343
TRU	Trumpeter	*Latris lineata*	3.8	1	105	118
WAR	Common warehou	*Seriolella brama*	163.6	21	15	78
WIT	Witch	*Arnoglossus scapha*	118.9	46	24	343
WWA	White warehou	*Seriolella caerulea*	145.7	7	37	387
YBF	Yellowbelly flounder	*Rhombosolea leporina*	0.5	1	17	18
YCO	Yellow cod	*Parapercis gilliesi*	1.0	2	105	143

Appendix 5: **Invertebrates (excluding arrow squid and *Octopus* (*Pinnoctopus*?) *cordiformis*) collected during the *Kaharoa* survey. Identification is to the lowest possible taxonomic level.**

	No. of stations
Mollusca: Octopoda	
Octopus huttoni	1
Enteroctopus zelandicus	1
Mollusca: Decapoda	
Sepioloidea pacifica	1
Sepioloidea pacifica egg masses	2
Sepioloidea sp. nov. egg mass	1
Mollusca: Gastropoda	
Austrofusus glans (eggs)	1
Austrofusus glans (animals)	1
Crepidula monoxyla	1
Fusitriton magellanicus	1
Semicassis pyrum	1
Mollusca: Bivalvia	
Chlamys sp.	1
Dosina zelandica	1
Hiatella arctica	1
Venericardia purpurata	1
Mollusca: Opisthobranchia	
Opisthobranchia (unidentified)	2
Crustacea: Anomura	
Bathypaguropsis yaldwyni	1
Diacanthurus rubricatus	2
Galathea pusillis	1
Lophopagurus foresti	1
Crustacea: Brachyura	
Jacquinotia edwardsii	1
Leptomithrax longipes	1
Nectocarcinus benneti	4
Ovalipes catharus	2
Paromola petterdi	1
Crustacea: Isopoda	
Elthusa raynaudii	1
Nerocila orbignyi	1
Crustacea: Cirripedia	
Balanus decorus	2
Lepas australis	2
Crustacea: Stomatopoda	1
Actinaria	
Actinaria (large, white, warty)	8
Actinaria (medium, white, warty)	6
Actinaria (large, white, smooth)	1
Actinaria (small, brown, conical, warty)	2

Appendix 5—continued

	No. of stations
Urochordata	
Ascidiacea	5
Pyura pachydermatina	1
Didmenum sp.	1
Echinodermata: Echinoidea	
Goniocidaris parasol	1
Echinodermata: Asteroidea	
Psilaster acuminatus	1
Sclerasterias mollis	2
Echinodermata: Holothuroidea	
Stichopus mollis	4
Annelida: Polychaeta	
Sabellidae	1
Chaetopterygiidae	1
Polychaeta indet	2
Amphinomidae	1
Miscellaneous (single species)	
Alcyonacea	1
Gorgonacea	1
Hydroidea	1
Anthozoa: Scleractinia	
Flabellum knoxi	1
Brachiopoda	
Neothyris lenticularis	1
Bryozoa: Ctenostomata	
Penetrantia parva	1
Bryozoa: Cyclostomata	
Crisia tenuis	1
Diaperoecia purpurascens	1
Disporella novaehollandiae	1
Disporella pristis	1
Disporella wanganuiensis	1
Entalophoroecia sp.	2
Erkosonea sp.	1
Hastingsia sp.	1
Hornera caespitosa	1
Hornera foliacea	1
Hornera robusta	1
Idmidronea sp.	1
Liripora pseudosarniensis	1
Nevianipora sp.	1
Plagioecia sp.	1
Stomatopora sp.	1

Appendix 5—continued

	No. of stations
Bryozoa: Cyclostomata (cont.)	
Telopora lobata	1
Tubulipora sp. 1	1
Tubulipora sp. 2	1
Bryozoa: Cheilostomata	
Adeonellopsis cf. yarraensis	1
Aetea australis	1
Aetea truncata	1
Alderina pacifera	1
Aimulosia marsupium	1
Amphiblestrum blandum	1
Bryozoa: Cheilostomata	
Beania discodermiae	1
Caberea rostrata	1
Caberea solida	2
Cellaria immersa	1
Cellaria tenuirostris	1
Celleporina grandis	1
Celleporina hemiperistomata	1
Celleporina sinuata	1
Chaperiopsis cervicornis	1
Chaperiopsis funda	1
Chaperiopsis lanceola	1
Chiastosella enigma	1
Cinctipora elegans	1
Crassimarginatella cucullata	1
Crepidacantha zelanica	1
Ellisina sericea	1
Escharella spinosissima	3
Exochella conjuncta	1
Figularia huttoni	2
Figularia spinea	1
Lagenipora cf. *pinnacula*	1
Galeopsis polyporus	2
Galeopsis porcellanicus	1
Hippomenella vellicata	1
Hippothoa flagellum	2
Micropora gracilis	1
Micropora inarmata	1
Microporella agonistes	2
Microporella sp.	1
Odontionella cyclops	1
Osthimosia cf. *bicornis*	1
Parkermavella punctigera	1
Phonicosia circinata	1
Rhynchozoon larreyi	2
Schizosmittina conjuncta	1
Smittina rosacea	1
Smittina torques	1

Appendix 5—continued

		No. of stations
Porifera		
	Porifera sp. 1	3
	Crella incrustans	1
	Dactylia palmata	1
	Callispongia ramosa	1
	Iophon laevistylis	1
	Callispongia sp. 2	1

Appendix 6: **Species codes, common names, scientific names, total catch, percentage occurrence (Occ. %), and depth ranges of fish, cephalopods, and crabs caught by *Compass Rose*.**

Species code	Common name	Scientific name	Catch (kg)	Occ. %	Depth (m) Min	Max
BAR	Barracouta	*Thyrsites atun*	896	61	7	33
BCO	Blue cod	*Parapercis colias*	10.9	16	15	33
BFL	Black flounder	*Rhombosolea retiaria*	0.9	4	9	16
BRI	Brill	*Colistium guntheri*	50.5	54	5	31
CAR	Carpet shark	*Cephaloscyllium isabellum*	549.4	41	13	33
CON	Conger eel	*Conger* spp.	2.4	2	20	22
CRB	Crab		77.2	25	9	33
ELE	Elephantfish	*Callorhinchus milii*	8502.7	100	5	33
ERA	Electric ray	*Torpedo fairchildi*	97.4	16	8	27
ESO	N.Z. sole	*Peltorhamphus novaezeelandiae*	289.6	82	7	31
FLA	Flatfish		4.6	2	13	14
GFL	Greenback flounder	*Rhombosolea tapirina*	0.1	2	22	22
GLB	Globefish	*Contusus richei*	367.8	73	5	27
GON	Sandfish	*Gonorynchus gonorynchus*	10	30	8	33
GUR	Red gurnard	*Chelidonichthys kumu*	863.7	68	7	33
HAK	Hake	*Merluccius australis*	32.7	16	7	22
JDO	John dory	*Zeus faber*	2.3	2	26	26
JMD	N.Z. jack mackerel	*Trachurus declivis*	0.3	4	29	30
JMN	N.Z. jack mackerel	*T. novaezelandiae*	0.8	4	12	26
KAH	Kahawai	*Arripis trutta*	4.2	2	22	23
LEA	Leatherjacket	*Parika scaber*	406.5	39	9	33
LIN	Ling	*Genypterus blacodes*	9	5	13	23
LSO	Lemon sole	*Pelotretis flavilatus*	35.4	36	5	33
MCH	Maori chief	*Paranotothenia angustata*	2.5	4	9	12
NCA		*Nectocarcinus antarcticus*	11	2	19	20
NEC		*Nematocarcinus* sp.	60.8	9	15	30
OCT	Octopus	*Octopus cordiformis*	15	14	19	33
OPA	Opalfish	*Hemerocoetes* spp.	1	9	22	33
PAD	Paddle crab	*Ovalipes catharus*	573.8	43	5	31
PCO	Ahuru	*Auchenoceros punctatus*	256.2	45	5	22
PIG	Southern pigfish	*Congiopodus leucopaecilus*	10.6	18	19	33
PIP	Pipefish	Syngnathidae	0.1	2	25	27
RCO	Red cod	*Pseudophycis bachus*	311.3	71	5	33
RSK	Rough skate	*Dipturus nasutus*	2229.7	100	5	33
SAM	Quinnat salmon	*Oncorhynchus tshawytscha*	0.4	5	7	10
SBW	Southern blue whiting	*Micromesistius australis*	5.5	7	10	19
SCH	School shark	*Galeorhinus galeus*	700.6	86	5	33
SEV	Broadnose sevengill shark	*Notorynchus cepedianus*	27.2	4	7	14
SFL	Sand flounder	*Rhombosolea plebeia*	159.1	68	8	31
SHO	Seahorse	*Hippocampus abdominalis*	0.8	7	13	27
SPD	Spiny dogfish	*Squalus acanthias*	3969.1	98	5	33
SPO	Rig	*Mustelus lenticulatus*	504.6	68	5	33
SPR	Sprats	*Sprattus antipodum*, *S. muelleri*	140.3	59	5	27
SPZ	Spotted stargazer	*Genyagnus monopterygius*	44.3	43	5	27
SQU	Arrow squid	*Nototodarus sloani*	0.9	7	11	27
SSK	Smooth skate	*Dipturus innominatus*	63.4	4	12	27
STA	Giant stargazer	*Kathetostoma giganteum*	2.4	7	12	27
STY	Spotty	*Notolabrus celidotus*	1.6	7	13	18
SWA	Silver warehou	*Seriolella punctata*	24.4	36	5	23

Appendix 6—continued

Species code	Common name	Scientific name	Catch (kg)	Occ. %	Depth (m) Min	Depth (m) Max
TAR	Tarakihi	*Nemadactylus macropterus*	115.8	21	8	33
THR	Thresher shark	*Alopias vulpinus*	50.2	2	18	19
TOD	Dark toadfish	*Neophrynichthys latus*	3.2	23	5	30
TOP	Pale toadfish	*N. angustus*	0.3	2	31	33
TRE	Trevally	*Pseudocaranx dentex*	0.1	2	16	18
TUR	Turbot	*Colistium nudipinnis*	3.1	2	18	19
WAR	Common warehou	*Seriolella brama*	882.3	77	5	33
WIT	Witch	*Arnoglossus scapha*	75.2	38	9	33
WSE	Wrasses	Labridae (family)	6.1	7	9	26
YBF	Yellowbelly flounder	*Rhombosolea leporina*	61.8	32	8	23
YEM	Yelloweyed mullet	*Aldrichetta forsteri*	2	7	9	16

Appendix 7: **Estimated biomass (t), coefficient of variation (*c.v.*), for the 23 major commercial species, and total biomass for all species combined, 1996–97 to 2000–01.**

	KAH9618		KAH9704		KAH9809		KAH9917		KAH0014	
Common name	Biomass	c.v. %	Biomass	c.v. %	Biomass	c.v. %	Biomass	c.v. %	Biomass	c.v. %
Arrow squid	1 522	17	629	34	970	12	838	12	1 063	31
Barracouta	21 513	34	11 843	25	21 877	14	21 476	14	21 808	19
Blue warehou	2 101	54	619	51	4 030	95	608	39	122	39
Chilean jack mackerel	180	24	33	49	275	36	282	29	20	63
Dark ghost shark	3 066	18	5 870	33	7 416	27	2 512	19	2 950	18
Elephantfish	1 127	31	404	18	1 718	28	1 097	25	696	18
Giant stargazer	897	12	543	11	999	10	472	14	214	16
Hapuku	207	17	133	26	242	19	283	22	209	22
Hoki	3 106	24	2 189	41	4 812	29	773	23	1 038	36
Leatherjacket	212	31	122	18	111	25	150	24	73	40
Lemon sole	246	15	228	18	269	35	36	27	15	27
Ling	1 202	26	919	64	705	18	450	18	121	24
New Zealand sole	226	22	128	27	148	21	21	39	9	37
Red cod	10 634	23	7 536	23	12 823	17	6 690	30	1 402	82
Red gurnard	765	13	317	16	493	13	202	20	146	34
Rig	139	40	35	33	214	52	86	38	48	35
Rough skate	1 336	15	1 082	13	1 175	10	329	23	222	34
School shark	256	23	476	24	343	23	389	27	133	22
Sea perch	4 041	47	1 638	25	3 889	41	2 203	27	1 792	20
Silver warehou	307	35	474	90	269	19	444	23	178	29
Smooth skate	721	32	485	21	450	26	369	30	248	33
Spiny dogfish	35 776	28	29 765	25	22 842	16	49 832	37	30 508	34
Tarakihi	3 818	21	2 036	21	4 277	24	2 606	15	1 540	13
All species combined	90 424	11	78 195	12	102 543	7	98 129	19	70 375	16