Inshore trawl survey of the west coast South Island and Tasman and Golden Bays, March-April 1997 (KAH9701)

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NIWA Technical Report 12
ISSN 1174-2631
1998

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Published by NIWA
Wellington
1998

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

ISSN 1174-2631
ISBN 0-478-08428-5

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Contents

Introduction

This report presents results from the fourth in a time series of stratified random trawl surveys with RV *Kaharoa* in waters between 20 and 400 m deep off the west coast of the South Island, and within Tasman and Golden Bays. Previous surveys in this series in 1992, 1994, and 1995 were described by Drummond & Stevenson (1995a, 1995b, 1996). Surveys were scheduled to occur biennially following completion of the third survey in the series in 1995.

The principal aim of the time series is to estimate the relative abundance of the species that are both important to the inshore fishery and vulnerable to bottom trawl within the survey area over the survey period. The four main species that meet these criteria are giant stargazer (*Kathetostoma giganteum*), red cod (*Pseudophycis bachus*), red gurnard (*Chelidonichthys kumu*), and tarakihi (*Nemadactylus macropterus*). A standardised index of relative abundance estimates for key inshore species will assist with stock assessment and management strategies.

This report details the survey design and methods, and provides relevant stock assessment data for commercially important Individual Transferable Quota (ITQ) and non-ITQ species.

This report fulfils in part the requirements of Ministry of Fisheries contract CETS01, "Estimation of fish abundance in the Challenger area using trawl surveys".

Project objectives

1. To determine the distribution and develop a time series of relative abundance indices for giant stargazer, red cod, red gurnard, and tarakihi in the inshore waters of the west coast of the South Island and Tasman and Golden Bays.
2. To provide parameter inputs for the stock assessment of the target species caught by collecting and analysing biological data, i.e., length and age frequency, weight, reproductive condition, and fecundity.

Survey objectives

1. To obtain relative biomass data for giant stargazer, red cod, red gurnard, tarakihi, and other commercially important species sampled by bottom trawl in the inshore waters of the west coast of the South Island and Tasman and Golden Bays.
2. To collect data on the length, sex, age, and reproductive condition of giant stargazer, red cod, red gurnard, and tarakihi.
3. To collect data on the length and sex of all other ITQ and selected non-ITQ species.
4. To tag lively school shark, as part of a national study on the growth and movement of this species.
5. To collect invertebrate specimens for the NIWA invertebrate collection.
6. To collect specimens for a study on seabird food by NIWA, Christchurch.
7. To collect fish specimens for the Museum of New Zealand.
8. To collect specimens of sea perch for species identification work (by Larry Paul, NIWA, Wellington).

9. To collect tissue samples from deepwater shark species.

Timetable and personnel

The survey was divided into two parts: the first started from Wellington on 19 March and ended in Nelson on 3 April; the second started in Nelson on 4 April with a changeover of most scientific staff and finished in Wellington on 13 April.

Michael Stevenson was project and voyage leader and was responsible for final database editing. Skipper for the voyage was Arthur Muir.

Methods

Survey area

The survey area covered depths of 20–400 m off the west coast of the South Island from Farewell Spit to Haast River mouth (25–400 m south of Karamea), and within Tasman and Golden Bays inside a line drawn between Farewell Spit and Stephens Island (Figure 1). The survey area totalled 25 594 km^2, representing 41% of the 62 500 km^2 inside the 400 m depth contour within the Challenger Fishery Management Area (QMA7).

The area covered was the same as in previous surveys. The trawlable ground within the survey area represented 85% of the total survey area.

Survey design

The survey used a two-phase stratified random design (Francis 1984). The two-phase methodology was applied separately to the west coast and the Tasman and Golden Bay zones because of the geographic separation of the two areas and the variable weather patterns anticipated on the west coast. The depth range trawled reflected the distribution of the main species of interest. All strata used during the previous surveys were retained.

Sufficient trawl stations to cover both first and second phase stations were randomly generated for each stratum by the computer programme 'Rand_stn v2.1' (*see* Vignaux 1994). The stations were required to be a minimum of 5.6 km (3 n. miles) apart. Non-trawlable ground was identified before the voyage from data collected during previous trawl surveys in the area by GRVs *W. J. Scott* (1981–83), *James Cook* (1983–84), and *Kaharoa* (1990, 1992, 1994, 1995). The distribution of non-trawlable ground is given in Table 1 and shown in Figures 1a and 1b.

For the two-phase methodology, giant stargazer, red cod, red gurnard, and tarakihi were designated as the target species for which the survey design was optimised. In total, 80 stations were assigned to the first phase, with a minimum of 3 stations per stratum. The balance of phase 1 stations was allocated to minimise the variance of the expected catch rates of the four target species, where the expected catch rates were assumed to be the combined catch rates obtained during the 1995 survey (*see* Stevenson 1996 for details). Catch rates for 1995 were used because the general distribution of the target species has been fairly consistent and any differences would be compensated for in allocation of phase 2 stations. Phase 2 stations were allocated after phase 1 had been completed and were based on the catch rates of

red cod because the coefficients of variation of the biomass estimates for the other target species were less than 20% at the end of phase 1.

Vessel and gear

RV *Kaharoa*, a 28 m stern trawler with a beam of 8.2 m, a displacement of 302 t, and engine power of 522 kW, is capable of trawling to depths of 500 m. The two-panel trawl net used during the survey was designed and constructed in 1991 specifically for South Island inshore trawl surveys. The net is based on an 'Alfredo' design, and is similar to one used during the 1980s for *W. J. Scott* South Island surveys. The net was fitted with a 74 mm (inside measurement) knotless codend. Details of the net design were given by Drummond & Stevenson (1995a).

In 1995 *Kaharoa* was equipped with new trawl doors based on the design of the old doors but heavier. Comparative details are given in Drummond & Stevenson (1996). Doorspread and headline height measurements were read off Scanmar monitoring equipment with an average of five readings at 10–15 min intervals during each tow.

Trawling procedure

All tows were undertaken in daylight, and four to six tows a day were planned. For each tow the vessel steamed to the station position and, if necessary, the bottom was checked with the depth sounder. Once the tow was considered trawlable, the gear was set away so that the midpoint of the tow would coincide as nearly as possible with the station position. The direction of the tow was influenced firstly by the combination of weather conditions and bottom contours, and secondly by the location of the next tow.

If the station was found to be in an area of foul or the depth was out of the stratum range, an area within 5 km of the station was searched for a replacement. If the search was unsuccessful, the station was abandoned and the next alternative from the random station list was chosen. Standard tows were of 1 h duration at a speed over the ground of 3 kn and the distance covered was measured by GPS. The tow was deemed to have started when the net monitor indicated the net was on the bottom, and was completed when hauling began.

A minimum of 200 m of warp was used during towing. At depths below 70 m a decreasing warp to depth ratio was used, starting at 3 : 1 at 70 m and decreasing to 2.4 : 1 at 400 m.

Water temperatures

The surface temperature at each station was recorded from a 10 l bucket of water filled from the starboard side and using a hand-held Checktemp 1 microprocessor thermometer. Bottom temperatures were recorded by the Scanmar net monitor, with an average of five readings recorded at 10–15 min intervals during each tow.

Catch and biological sampling

The catch was sorted into species on deck and weighed on 100 kg electronic motion-compensating Seaway scales to the nearest 0.1 kg. The weight of some tagged school shark was estimated from the length weight coefficients given in Appendix 1. Finfish (excluding rattails), squids, shellfish, and crustaceans (except crabs) were classified by species. Crabs and rattails were given general classifications because of the difficulty identifying individual species and the limited sorting time available between tows. Other invertebrates were not immediately identified, but placed in plastic bags and frozen for identification by NIWA invertebrate experts in Wellington.

Length, to the nearest whole centimetre below the actual length, and sex (where possible) were recorded for all ITQ species, either for the whole catch or a randomly selected subsample of up to 200 fish per tow. Biological data, including one or more of the following, weight to the nearest 10 g, reproductive condition, and otoliths, were collected from a sample of up to 20 fish per tow for giant stargazer, red cod, red gurnard, and tarakihi. Additional biological data for school shark, rig, rough skate, and smooth skate consisted of individual fish length, weight to the nearest 10 g, and reproductive condition. These samples were selected non-randomly to ensure that a full size range of each species was sampled.

Up to four pairs of otoliths per 1 cm size class, per sex, were collected for ageing from the target species and blue warehou.

School shark tagging

Lively school shark were measured, sexed, and tagged using a single dart tag, and released within minutes of being removed from the codend. Release location was recorded as the finish position of the tow where the tagged fish were caught. For each tagged school shark, a release factor was assigned on a scale of 1–3, with 1 corresponding to the fish swimming away slowly, 2 freely, and 3 vigorously. A handling factor, on the same 1–3 scale, was also recorded to assess the liveliness of individual sharks before release.

Specimen collection

Most fish and invertebrate specimens were placed in plastic bags and an identification label showing trip code and station number was placed in each bag. Large fish were placed in fish bins with an accompanying trip code and station number label. All specimens were stored in the on-board blast freezer until they could be shipped by refrigerated transport or off-loaded directly.

Pea-sized samples of muscle tissue from deepwater sharks were collected and placed in vials of preservative. Each sample was thinly sliced to improve effectiveness of the preservative. Samples were forwarded to Yale University for genetic studies.

Data analysis

Relative biomass was estimated using the area-swept method described by Francis (1981, 1989) and the Trawlsurvey Analysis Program described by Vignaux (1994).

The following assumptions were made.

1. The area swept during each tow equalled the distance between doors multiplied by the distance towed.
2. Vulnerability was 1.0. This assumed that all fish in the volume swept were caught and there was no escapement.
3. Vertical availability was 1.0. This assumed that all fish in the water column were below the headline height and available to the net.
4. Areal availability was 1.0. This assumed that the fishstock being sampled was entirely within the area being sampled at the time of the survey.
5. Within the survey area, fish were distributed evenly over both trawlable and non-trawlable ground.

Although these assumptions are unlikely to be correct, their adoption provides the basis for a time series of relative biomass estimates. All assumptions listed are consistent with those of Drummond & Stevenson (1995a, 1995b, 1996).

A combined biomass and length frequency analysis (Trawlsurvey Analysis Program, Vignaux 1994) was used to estimate biomass and to derive scaled length frequency distributions. The length-weight coefficients used are given in Appendix 1. Where more than one set of coefficients was available on the database, a selection was made based on a comparison of the size range of the fish used to calculate the coefficients and size range of the sample. All length frequencies were scaled by the percentage of catch sampled, area swept, and stratum area. All stations where the gear performance code was 1 or 2 were used for biomass estimation.

Results

Trawl stations and gear performance

Eighty phase 1 stations and 8 phase 2 stations were successfully completed (Figures 1a and 1b, Table 1, Appendix 2). All 80 planned phase 1 stations were successfully completed, although two stations were substituted for stations that were untrawlable because of foul ground. Three days were lost to bad weather. At least three stations were completed in all 16 strata. An average station density of one per 291 km^2 was achieved.

Tow and gear parameters by depth are shown in Table 2. Doorspread varied from 70.6 to 96.4 m and headline height varied between 4.4 and 5.5 m (Table 2, Appendix 2).

Catch composition

A total of about 61 t of fish was caught during the 88 tows at an average of 694 kg per tow (range 76.4–3496.5 kg). Amongst the wetfish catch, 1 agnathan, 16 elasmobranchs, and 67 teleosts were recorded, together with 4 cephalopods, 4 crustaceans, 3 bivalves, and 1 echinoderm. Other bivalves, crustaceans, and echinoderms were caught, but not always

identified. Over 50% of the catch was made up of spiny dogfish, rattails, red cod, barracouta, and giant stargazer (Appendix 3).

Red cod, giant stargazer, tarakihi, and red gurnard made up 8.6, 5.3, 3.3, and 1.6% of the catch, respectively. Arrow squid, barracouta, carpet shark, red cod, school shark, spiny dogfish, tarakihi, and witch flounder were all caught in over 80% of the tows.

Catch by station for the 15 most abundant commercially important species by catch weight and all species combined is given in Appendix 4 in alphabetical order by species code.

Catch rates and species distribution

Distribution by stratum and catch rates for the 20 most abundant commercially important species by catch weight are shown in Figure 2 in alphabetical order by common name. Catch rates are given in terms of kilograms per square kilometre, therefore a catch rate of 1000 $kg.km^{-2}$ equates to a catch of 440 kg in a standard tow as it covers 0.44 km^2 on average.

Mean catch rates for the 20 most abundant commercially important species by stratum are given in Table 3 in order of catch abundance.

Biomass estimation

Relative biomass estimates for the 24 most abundant ITQ species, seven most abundant non-ITQ species, rough skate, and smooth skate are given by sub-area in Table 4 in order of descending biomass. The biomass estimate for rattails is for all rattail species combined. Biomass estimates of pre-recruit and recruited fish are provided for red cod, hoki, tarakihi, and red gurnard. For red cod the processing size has varied between years (38 cm in 1992, 45 cm in 1994, and 40 cm since 1995). The 40 cm size limit is used as the minimum size of recruited red cod in this report. The relative biomass estimates for the 20 most abundant commercially important species by stratum are given in Table 5 in order of estimated biomass.

Water temperatures

The accuracy of the Checktemp thermometer varied (as checked with a calibrated mercury thermometer) during the trip, and although raw data are included in Appendix 2, isotherms for surface temperature were not estimated from station data. Bottom isotherms estimated from the station data are shown in Figure 3.

School shark tagging

One hundred and fifty-seven school shark (89 males and 68 females) were tagged and released. The total length of tagged school shark ranged from 53 to 154 cm. Data are lodged on the Ministry of Fisheries school shark tagging database, Wellington.

Specimen collection

Specimens of 10 species of fish were sent to the Museum of New Zealand for inclusion in their collections: longtailed skate (*Arhynchobatis asperrimus*), snapper (*Pagrus auratus*), elephantfish (*Callorhinchus milii*), scabbardfish (*Benthodesmus* sp.), porcupine fish (*Allomycterus jaculiferus*), spotted stargazer (*Genyagnus monopterygius*), speckled sole (*Peltorhamphus latus*), globefish (*Contusus richei*), dark toadfish (*Neophrynichthys latus*), and giant stargazer (*Kathetostoma giganteum*). Specimens of opalfish, ahuru, octopus, and red cod were sent to NIWA, Christchurch for a seabird diet study. A preliminary list of invertebrates collected and forwarded to NIWA, Wellington for identification is given in Appendix 5.

Tissue samples were collected from sharpsnouted sevengill shark (*Heptranchias perlo*) and slender smooth hound (*Gollum atenuatus*).

Length frequency and biological data

The numbers of length frequency and biological samples taken during the survey are given in Table 6. The scaled length frequency distributions for the 15 most abundant ITQ species and other important species are given in Figure 4 in alphabetical order by common name.

Length-weight coefficients were determined for giant stargazer, red cod, red gurnard, tarakihi, rig, school shark, rough skate, and smooth skate using the geometric mean functional relationship and are given in Appendix 1.

Target species

Giant stargazer. Eighty percent of the relative biomass estimate was south of Cape Foulwind, and 54% was within the 100–200 m depth range (*see* Table 5). No giant stargazer larger than 47 cm were caught in Tasman and Golden Bays. The sex ratios (male : female) along the west coast were 0.50 : 1 at depths less than 100 m, 1.37 : 1, at 100–200 m, and 1.85 : 1 at 200–400 m (*see* Figure 4). Virtually all females less than 50 cm total length were immature or had resting gonads. Above this size, most had maturing gonads (Table 7).

Red cod. Forty-seven percent of the estimated total relative biomass was recruited biomass (40 cm or over) (*see* Table 4). Fifty-five percent of the biomass was in depths less than 200 m on the west coast (*see* Table 5). The length frequency data show a dominant 1+ cohort present on the west coast at the time of the survey. A second modal group at 50 cm probably consists of two or three cohorts aged 3+ years and older. A small mode (15–20 cm) represents 0+ fish. Noticeably missing from the west coast is a definite mode at about 30–40 cm which is present in the catch from Tasman and Golden Bays and represents the 2+ year class. This cohort was much more strongly represented on the west coast in previous surveys (Drummond & Stevenson 1995a, 1995b, 1996). The sex ratio in Tasman and Golden Bays favoured females (0.65 : 1), while on the west coast it favoured males at all depths (1.54 : 1 inside 100 m, 2.49 : 1 at 100–200 m, and 4.70 : 1 at 200–400 m) (*see* Figure 4). Most female red cod examined had immature or resting gonads: some large fish on the west coast were at later stages of reproductive development (*see* Table 7).

Red gurnard. The relative biomass estimate of 471 t (*c.v.* = 13%) was evenly divided between Tasman and Golden Bays (233 t) and the west coast (237 t) (*see* Table 4). There was a significant difference in the length frequency distributions between the sub-areas with most of the pre-recruit biomass (86.3%) occurring in Tasman and Golden Bays. The recruited biomass estimate (30 cm or over) was 310 t (65.8% of the total) with 215 t occurring on the west coast. Ninety-four percent of red gurnard biomass was at depths less than 100 m and none occurred at depths greater than 200 m (*see* Table 5). Sex ratios favoured males 1.09 : 1 in Tasman and Golden Bays and 1.79 : 1 on the west coast (*see* Figure 4). On the west coast, females generally had developing or well developed gonads. In Tasman and Golden Bays, females were typically spent or developing (*see* Table 7).

Tarakihi. Eighty-one percent of the relative biomass estimate was recruited fish (25 cm or over) (*see* Table 4). The length frequency data for Tasman and Golden Bays showed three successive cohorts of ages 1+ to 3+ years with modes at 10–15, 17–21, and 21–27 cm respectively. No tarakihi longer than 33 cm were caught in Tasman and Golden Bays. These year classes were present in smaller numbers on the west coast (*see* Figure 4). Average size increased with increasing depth on the west coast. Of the total tarakihi biomass, 80% was on the west coast, and about half (531 t) of this was at 100–200 m depth (*see* Table 5). The sex ratios (male : female) on the west coast were 0.66 : 1 inside 100 m, 0.26 : 1 at 100–200 m, and 3.05 : 1 at 200–400 m (*see* Figure 4). There was little reproductive development in tarakihi below 30 cm FL, but for bigger fish a full range of gonad stages was recorded (*see* Table 7).

Discussion

For the fourth successive survey the *c.v.*s associated with the biomass estimates for giant stargazer, red gurnard, and tarakihi were below 20%. The *c.v.* associated with the biomass estimate for red cod (23%) was slightly higher than on previous surveys. This was caused by a much higher proportion of the total biomass occurring in Tasman and Golden Bays than in previous years. The *c.v.*s for red cod biomass estimates in Tasman and Golden Bays have consistently been higher than on the west coast (Drummond & Stevenson 1995a, 1995b, 1996). Despite the slightly higher *c.v.* for red cod in this survey, the survey design provides satisfactory indices of abundance for the target species. For giant stargazer, the length frequency data suggest that fish less than 30 cm are not well sampled.

The best precision (*c.v.* under 15%) was associated with the relative biomass estimates for spiny dogfish, tarakihi, carpet shark, arrow squid, witch, red gurnard, and sea perch. Spiny dogfish was once again the species caught in the greatest quantity (9.6 t or 15.7% of the total catch). The total catch of 61 t was the lowest of the series (68 t in 1992, 86 t in 1994, and 107 t in 1995), while the mean catch per station was lower than in 1995 (1047 kg) it was comparable to 1992 (579 kg) and 1994 (735 kg). The most notable decreases compared to 1995 were in the catches of spiny dogfish (7.8 t vs. 17.9 t in 1995), hoki (2.9 t vs. 10.7 t) and hake (1.9 t vs. 15.9 t).

The completion of a fourth survey in 1997 continues the time series of relative abundance estimates. However, in making comparisons between surveys it should be noted that although the 1992 and 1994 catches were obtained using the old doors which generated greater doorspread, the overall vulnerability of fish to the trawl may have been lower because of overspreading of the gear. In view of this, the revised 1992 and 1994 estimates (Drummond & Stevenson 1996) are probably low.

Acknowledgments

This research was carried out under Ministry of Fisheries contract CESN01.

I thank the skipper of RV *Kaharoa,* A. Muir, and his crew for their active cooperation and enthusiastic assistance during the trawl survey. Other scientific staff were Ron Blackwell, Ralph Dickson, Michelle McLean, Rob Merrilees, Jill Parkyn, and Don Tindale. Their hard work and dedication were much appreciated.

Thanks also to Steve O'Shea and the NIWA invertebrate group for identification of invertebrate specimens. Michael Beentjes provided very useful comments as referee.

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

Stratum	Depth (m)	Area (km^2)	Non-trawlable area (km^2)	Number of stations		Station density (km^2 per station)
				Phase 1	Phase 2	
1	20–100	1 343	102	3	0	448
2	100–200	4 302	300	3	0	1 434
5	25–100	1 224	0	3	0	408
6	100–200	3 233	238	4	0	808
7	25–100	927	0	5	0	185
8	100–200	2 354	214	7	0	336
9	200–400	1 877	1 456	3	0	626
11	25–100	1 438	63	10	0	144
12	100–200	2 054	501	10	0	205
13	200–400	1 101	466	6	0	184
14	25–100	851	36	5	0	170
15	100–200	881	373	6	0	147
16	200–400	319	35	3	0	106
17	20–33	307	27	3	0	102
18	20–42	947	30	5	0	189
19	20–70	2 436	193	4	8	203
Total (average)		25 594	3 841	80	8	(291)

Table 2: Gear parameters by depth range (*n*, number of stations; *s.d.*, standard deviation)

	n	Mean	*s.d.*	Range
All stations				
Headline height (m)	88	4.9	0.21	4.4–5.5
Doorspread (m)	88	78.9	5.79	70.6–96.4
Distance (n. miles)	88	2.99	0.12	2.26–3.19
Warp:depth ratio	88	3.44	1.47	2.14–8.33
Tasman/Golden Bays				
20-70 m				
Headline height (m)	20	4.9	0.12	4.6–5.1
Doorspread (m)	20	75.9	1.87	71.9–78.3
Distance (n. miles)	20	3.01	0.09	2.9–3.2
Warp:depth ratio	20	4.90	1.38	3.4–8.3
West coast				
20–400 m				
Headline height (m)	68	4.9	0.23	4.4–5.5
Doorspread (m)	68	79.8	6.25	70.6–96.4
Distance (n. miles)	68	2.98	0.13	2.26–3.17
Warp:depth ratio	68	3.01	1.20	2.14–8.33
20–100 m				
Headline height (m)	26	5.0	0.31	4.4–5.5
Doorspread (m)	26	75.9	3.06	70.8–83.2
Distance (n. miles)	26	3.01	0.09	2.9–3.2
Warp:depth ratio	26	4.02	1.45	2.50–8.33
100–200 m				
Headline height (m)	31	4.9	0.16	4.5–5.2
Doorspread (m)	31	79.8	4.66	70.6–88.4
Distance (n. miles)	31	2.97	0.16	2.26–3.17
Warp:depth ratio	31	2.76	0.83	2.20–5.88
200–400 m				
Headline height (m)	11	4.9	0.12	4.7–5.0
Doorspread (m)	11	88.4	6.40	75.1–96.4
Distance (n. miles)	11	2.92	0.10	2.74–3.09
Warp:depth ratio	11	2.39	0.10	2.20–2.59

Table 3: Mean catch rates (kg.km^{-2}) with standard deviations (in parentheses) by stratum f 20 most abundant commercially important species*

Stratum	Species code									
	SPD	RCO	BAR	STA	HOK	WAR	TAR	HAK	SCH	SKI
1	407	28	9	0	0	16	59	78	69	0
	(330)	(48)	(6)	(0)	(0)	(28)	(63)	(135)	(29)	(0)
2	95	0	9	18	0	0	13	0	86	0
	(48)	(0)	(11)	(32)	(0)	(0)	(11)	(0)	(69)	(0)
5	306	215	213	1	+	0	16	339	16	0
	(273)	(191)	(153)	(2)	(+)	(0)	(13)	(544)	(25)	(0)
6	164	40	180	6	5	0	23	0	132	0
	(107)	(66)	(138)	(7)	(10)	(0)	(15)	(0)	(189)	(0)
7	197	143	47	1	7	7	11	28	33	0
	(258)	(149)	(69)	(1)	(12)	(14)	(10)	(32)	(24)	(0)
8	239	61	198	76	39	0	48	0	75	0
	(138)	(68)	(174)	(100)	(64)	(0)	(18)	(0)	(47)	(0)
9	0	1	54	0	10	0	32	0	0	57
	(0)	(2)	(52)	(0)	(16)	(0)	(51)	(0)	(0)	(92)
11	545	250	391	114	58	201	23	128	42	0
	(619)	(191)	(1 036)	(253)	(178)	(345)	(36)	(180)	(54)	(0)
12	208	71	110	158	108	46	105	3	47	0
	(106)	(37)	(73)	(46)	(150)	(56)	(62)	(6)	(31)	(0)
13	46	35	53	252	94	0	106	1	16	537
	(59)	(40)	(60)	(153)	(185)	(0)	(94)	(1)	(10)	(1 286)
14	727	63	70	214	15	109	18	8	26	0
	(848)	(66)	(84)	(293)	(32)	(108)	(25)	(11)	(35)	(0)
15	668	168	136	199	486	355	84	292	81	2
	(820)	(102)	(103)	(167)	(583)	(540)	(65)	(664)	(94)	(5)
16	17	5	0	94	361	0	3	12	0	10
	(29)	(3)	(0)	(31)	(339)	(0)	(5)	(16)	(0)	(11)
17	50	39	26	3	0	7	88	0	21	0
	(41)	(33)	(35)	(3)	(0)	(5)	(113)	(0)	(27)	(0)
18	75	79	80	+	+	5	15	2	19	0
	(83)	(113)	(48)	(1)	(+)	(4)	(33)	(4)	(39)	(0)
19	45	412	156	7	+	7	74	5	10	0
	(24)	(775)	(91)	(6)	(+)	(11)	(102)	(10)	(13)	(0)

* Species codes are given in Appendix 3.

+ < 0.5

Table 3—*continued*

Stratum	Species code									
	SQU	GSH	GUR	JMN	SPE	SPO	SSK	LIN	SWA	RSK
1	25	0	23	48	0	22	1	1	2	8
	(34)	(0)	(14)	(82)	(0)	(12)	(1)	(1)	(4)	(13)
2	65	136	3	0	5	2	12	0	5	5
	(43)	(119)	(5)	(0)	(4)	(3)	(21)	(0)	(9)	(8)
5	11	81	31	24	0	12	24	4	5	1
	(17)	(110)	(25)	(33)	(0)	(20)	(22)	(7)	(5)	(3)
6	27	145	1	0	3	0	18	1	7	14
	(15)	(45)	(1)	(0)	(4)	(0)	(21)	(1)	(11)	(28)
7	8	15	47	1	0	38	12	6	1	11
	(9)	(24)	(34)	(1)	(0)	(44)	(27)	(13)	(2)	(10)
8	55	77	5	0	12	5	1	2	11	1
	(34)	(47)	(5)	(0)	(18)	(12)	(2)	(3)	(15)	(2)
9	53	102	0	0	3	0	17	0	4	4
	(46)	(105)	(0)	(0)	(3)	(0)	(29)	(0)	(5)	(4)
11	9	0	28	0	0	34	13	15	2	35
	(12)	(0)	(32)	(1)	(0)	(53)	(41)	(11)	(4)	(48)
12	57	0	0	0	66	9	2	4	5	3
	(19)	(0)	(0)	(0)	(48)	(10)	(4)	(4)	(3)	(3)
13	38	20	0	0	65	2	25	23	14	2
	(23)	(31)	(0)	(0)	(45)	(4)	(36)	(46)	(27)	(4)
14	23	0	67	0	0	34	1	2	5	5
	(18)	(0)	(109)	(0)	(+)	(55)	(2)	(3)	(8)	(11)
15	59	12	0	0	17	20	37	22	3	7
	(47)	(29)	(1)	(0)	(31)	(20)	(41)	(42)	(3)	(6)
16	30	54	0	0	8	0	83	158	0	0
	(11)	(40)	(0)	(0)	(7)	(0)	(63)	(198)	(0)	(0)
17	5	0	79	105	63	41	0	2	0	5
	(3)	(0)	(37)	(156)	(80)	(22)	(0)	(2)	(0)	(5)
18	11	0	56	66	1	48	0	1	1	0
	(8)	(0)	(22)	(59)	(2)	(71)	(0)	(1)	(2)	(0)
19	21	0	64	71	12	15	3	2	31	8
	(11)	(0)	(38)	(85)	(19)	(14)	(11)	(2)	(32)	(10)

* Species codes are given in Appendix 3.

+ < 0.5

Table 4: Relative doorspread biomass estimates by sub–area of the 24 most abundant ITQ species, 7 most abundant non-ITQ species, and other important species

	Tasman and Golden Bays		West coast		Total survey area	
Common name	Biomass (t)	*c.v.* (%)	Biomass (t)	*c.v.* (%)	Biomass (t)	*c.v.* (%)
Spiny dogfish	195	20.4	5 080	13.2	5 275	12.7
Rattails	28	93.8	4 373	24.7	4 400	24.6
Silver dory	0		2 949	33.1	2 949	33.1
Barracouta	463	14.6	2 530	22.3	2 993	19.0
Red cod (all)	1 090	50.2	1 456	15.2	2 546	23.2
Red cod (< 40 cm)	624	52.7	729	24.0	1 353	27.5
Red cod (≥ 40 cm)	467	48.1	727	18.1	1 194	21.8
Dark ghost shark	0		1 591	21.2	1 591	21.2
Giant stargazer	18	25.8	1 433	15.5	1 450	15.3
School shark	47	41.1	1385	25.8	1 432	25.0
Hoki (all)	+	78.6	1 100	24.9	1 100	24.9
Hoki (< 65 cm)	+	78.6	899	23.7	898	23.7
Hoki (≥ 65 cm)	0		201	58.8	201	58.8
Tarakihi (all)	222	34.2	865	12.4	1 087	12.1
Tarakihi (< 25 cm)	174	35.1	27	56.6	201	31.3
Tarakihi (≥ 25 cm)	47	39.7	838	12.1	885	11.6
Hake	15	50.3	1 004	47.0	1 019	46.4
Arrow squid (*Nototodarus sloanii & N. gouldi*)	63	62.6	904	14.3	966	13.4
Blue warehou	25	33.2	817	31.4	842	30.5
Gemfish	0		704	83.4	704	83.4
Carpet shark	196	26.1	594	11.5	790	10.8
Red gurnard (all)	233	12.5	237	21.9	471	12.7
Red gurnard (< 30 cm)	138	15.0	22	53.7	161	14.9
Red gurnard (≥ 30 cm)	95	14.6	215	19.9	310	14.5
Witch	42	23.6	424	15.6	466	14.3
Jack mackerel (*Trachurus novaezelandiae*)	268	26.4	95	71.0	363	26.9
Sea perch	50	39.8	288	15.2	338	14.2
Rig	95	33.6	213	20.5	308	17.6
Smooth skate	8	100.0	294	26.6	302	26.0
Silver warehou	77	29.0	127	27.3	204	20.2
Rough skate	20	33.9	165	33.9	185	30.5
Jack mackerel (*T. declivis*)	52	37.6	110	22.2	162	19.3
Ling	6	33.3	146	31.4	151	30.3
Snapper	77	55.0	39	93.1	115	48.1
Blue cod	108	30.8	2	100.0	110	30.3
Sand flounder	105	28.4	+	81.1	106	28.4
Elephantfish	0		94	32.5	94	32.5
Lemon sole	31	17.7	36	36.2	68	21.1
Jack mackerel (*T. murphyi*)	0		49	19.1	49	19.1
N.Z. sole	5	36.7	40	32.2	45	29.1
Hapuku	0		26	37.3	26	37.3

+ < 0.5

Table 5: Estimated biomass (and *c.v.* %) by stratum for the 20 most abundant species*

	Species code									
Stratum	SPD	RCO	BAR	STA	HOK	WAR	TAR	HAK	SKI	SCH
1	546	37	13	0	0	22	79	105	0	92
	(47)	(99)	(37)			(100)	(61)	(100)		(25)
2	410	0	38	78	0	0	55	0	0	370
	(29)		(75)	(100)			(51)			(46)
5	375	263	261	1	+	0	20	416	0	19
	(51)	(51)	(41)	(100)	(100)		(46)	(93)		(93)
6	531	129	583	19	16	0	74	0	0	428
	(33)	(83)	(38)	(62)	(100)		(33)			(71)
7	183	133	43	1	7	7	10	26	0	31
	(58)	(47)	(66)	(62)	(74)	(88)	(43)	(52)		(33)
8	563	144	465	180	92	0	113	+	0	177
	(22)	(42)	(33)	(49)	(61)		(14)	(100)		(24)
9	0	3	101	0	18	0	61	0	108	0
		(100)	(56)		(100)		(91)		(92)	
11	783	359	562	164	83	290	33	184	0	60
	(36)	(24)	(84)	(70)	(97)	(54)	(50)	(45)		(41)
12	427	147	232	325	223	94	215	6	0	97
	(16)	(16)	(2)	(9)	(44)	(39)	(19)	(71)		(21)
13	51	38	58	278	104	0	116	1	591	18
	(53)	(47)	(46)	(25)	(80)		(36)	(100)	(98)	(25)
14	618	53	60	182	13	93	15	7	0	22
	(52)	(47)	(53)	(61)	(95)	(44)	(62)	(62)		(60)
15	589	148	120	175	429	313	74	257	2	71
	(50)	(25)	(31)	(34)	(49)	(62)	(31)	(93)	(100)	(47)
16	5	2	0	30	115	0	1	4	3	0
	(100)	(31)		(19)	(54)		(100)	(81)	(62)	
17	15	12	8	1	0	2	27	+	0	6
	(48)	(50)	(79)	(52)		(39)	(74)	(66)		(74)
18	71	75	75	+	+	5	14	2	0	18
	(50)	(64)	(27)	(100)	(100)	(36)	(97)	(91)		(93)
19	109	1004	379	16	+	17	180	13	0	23
	(16)	(54)	(17)	(27)	(87)	(45)	(40)	(57)		(40)

* Species codes are given in Appendix 3

+ < 0.5 t.

Table 5—*continued*

Stratum	Species code									
	SQU	GSH	GUR	JMN	SPE	SPO	SSK	LIN	SWA	RSK
1	33	0	31	64	0	29	1	1	3	10
	(79)		(34)	(99)		(33)	(100)	(100)	(100)	(100)
2	278	587	11	0	21	8	51	0	23	20
	(38)	(50)	(100)		(42)	(100)	(100)		(96)	(100)
5	14	100	39	30	0	14	29	5	6	2
	(85)	(78)	(46)	(79)		(100)	(53)	(100)	(60)	(100)
6	89	468	4	0	8	0	57	4	23	45
	(27)	(16)	(59)		(87)		(60)	(46)	(75)	(100)
7	8	13	43	1	0	35	11	5	1	10
	(51)	(75)	(33)	(62)		(51)	(100)	(98)	(79)	(41)
8	130	181	11	0	29	12	3	5	27	2
	(24)	(23)	(42)		(56)	(89)	(63)	(59)	(51)	(100)
9	100	192	0	0	5	0	31	0	7	7
	(50)	(59)			(63)		(100)		(68)	(64)
11	13	0	40	+	0	49	18	22	3	51
	(43)		(36)	(100)		(49)	(100)	(23)	(54)	(43)
12	117	0	+	0	136	18	5	7	11	5
	(11)		(100)		(23)	(37)	(54)	(32)	(21)	(42)
13	42	22	0	0	72	2	28	25	15	2
	(25)	(64)			(28)	(100)	(58)	(83)	(80)	(100)
14	19	0	57	0	+	29	1	2	4	4
	(35)		(72)		(100)	(72)	(100)	(62)	(73)	(100)
15	52	11	+	0	15	17	33	20	2	6
	(33)	(100)	(100)		(75)	(42)	(46)	(77)	(45)	(38)
16	10	17	0	0	3	0	27	50	0	0
	(20)	(43)			(52)		(43)	(72)		
17	1	0	24	32	19	13	0	1	0	1
	(39)		(27)	(85)	(74)	(31)		(74)		(56)
18	10	0	53	63	1	46	0	1	1	0
	(33)		(18)	(40)	(100)	(65)		(72)	(71)	
19	51	0	156	173	30	36	8	4	75	18
	(15)		(17)	(35)	(46)	(27)	(100)	(40)	(29)	(36)

* Species codes are given in Appendix 3

\+ < 0.5 t.

Table 6: Numbers of length frequency and biological samples collected (species codes are given in Appendix 3)

		Length frequency data				Biological data+		
Species code	Measure-ment method	No. of samples	No. of fish	No. of males	No. of females	No. of samples	No. of fish	No. of otoliths
BAR	1	130	5 443	885	1 072	0	0	0
BCO	2	18	527	171	310	0	0	0
BNS	1	2	2	1	1	0	0	0
BRI	2	5	8	4	3	0	0	0
BSQ	4	1	12	0	3	0	0	0
CON	2	1	1	–	–	0	0	0
EGR	5	1	1	–	–	0	0	0
ELE	1	9	54	22	32	0	0	0
EMA	1	3	5	2	3	0	0	0
ESO	2	17	419	95	103	0	0	0
GSH	G	30	1 230	592	638	0	0	0
GUR	1	55	2 930	1 629	1 298	55	783	410
HAK	2	42	1 470	124	276	0	0	0
HAP	2	7	9	3	6	0	0	0
HEP	2	1	1	0	1	0	0	0
HOK	2	59	3 077	291	341	0	0	0
JDO	2	11	18	2	15	0	0	0
JMD	1	45	720	40	42	0	0	0
JMM	1	29	96	31	14	0	0	0
JMN	1	44	2 235	21	21	0	0	0
KAH	1	2	2	2	0	0	0	0
KIN	1	3	3	2	1	0	0	0
LDO	2	3	21	3	17	0	0	0
LIN	2	50	288	102	168	0	0	0
LSK	5	2	5	2	3	0	0	0
LSO	2	45	771	44	61	0	0	0
MDO	2	2	2	0	2	0	0	0
MOK	1	1	1	0	1	0	0	0
OPE	2	3	17	5	12	0	0	0
RCO	2	78	5 829	3 468	2 268	78	1 328	368
RSK	5	42	137	81	56	41	135	0
SCH	2	74	579	308	271	67	523	0
SFL	2	18	1 147	–	–	0	0	0
SKI	1	7	105	74	31	0	0	0
SNA	1	8	49	25	22	0	0	0
SPD	2	80	3 926	2 081	1 838	0	0	0
SPE	2	47	2 383	946	965	0	0	0
SPO	2	53	316	218	96	49	272	0
SQU	4	84	4 449	855	1 163	0	0	0
SSK	5	31	70	25	45	31	70	0
STA	1	61	1 047	573	474	60	662	354
SWA	1	66	1 413	99	78	0	0	0
TAR	1	73	2 494	711	1 370	70	1 135	259
THR	2	1	1	0	1	0	0	0
TRE	1	2	12	2	10	0	0	0
TUR	2	3	4	1	3	0	0	0
WAR	1	47	896	257	275	2	14	31
YBF	2	3	37	–	–	0	0	0

Measurement methods: 1, fork length; 2, total length; 4, mantle length; 5, pelvic length; G total length excluding tail filament;
+ Data include one or more of the following: fish weight, gonad stage, otoliths.
– Not sexed

Table 7: Numbers of the four target species sampled at each reproductive stage (small fish of undetermined sex are not included)

	Males Gonad stage					Females Gonad stage					
Total length (cm)	1	2	3	4	5	1	2	3	4	5	
Giant stargazer											
West coast											
11–20	1	0	0	0	0	0	0	0	0	0	
21–30	19	2	0	0	0	9	0	0	0	0	
31–40	30	9	3	0	0	19	1	0	0	0	
41–50	14	88	19	1	2	30	0	0	0	0	
51–60	5	62	56	4	5	16	26	4	0	1	
61–70	2	23	14	0	0	3	128	23	0	0	
71–80	0	0	0	0	0	0	21	2	0	0	
Total	71	184	92	5	7	77	176	29	0	1	642
Tasman and Golden Bays											
11–20	4	0	0	0	0	2	0	0	0	0	
21–30	18	0	0	0	0	12	0	0	0	0	
31–40	9	0	0	0	0	12	0	0	0	0	
41–50	2	0	1	0	0	2	0	0	0	0	
51–60	0	0	0	0	0	0	0	0	0	0	
Total	33	0	1	0	0	28	0	0	0	0	62
Red cod											
West coast											
11–20	16	0	0	0	0	20	0	0	0	0	
21–30	228	3	2	0	0	69	1	0	0	0	
31–40	161	14	8	3	2	113	7	0	0	0	
41–50	65	23	17	18	7	44	3	0	0	0	
51–60	12	11	19	20	5	44	29	4	0	0	
61–70	0	0	0	0	0	19	14	3	0	0	
Total	482	51	46	41	14	309	54	7	0	0	1 004
Tasman and Golden Bays											
11–20	1	0	0	0	0	10	0	0	0	0	
21–30	15	0	0	0	0	15	0	0	0	0	
31–40	31	1	0	0	0	99	1	0	0	0	
41–50	4	0	0	0	0	62	0	0	0	1	
51–60	6	1	1	0	5	42	1	0	0	0	
61–70	0	0	0	0	0	26	0	0	0	1	
Total	57	2	1	0	5	254	2	0	0	2	323

Table 7—*continued*

Fork length (cm)	Males Gonad stage 1	2	3	4	5	Females Gonad stage 1	2	3	4	5	
Red gurnard											
West coast											
11–20	1	0	0	0	0	0	0	0	0	0	
21–30	20	15	4	0	1	14	3	0	0	0	
31–40	37	103	61	7	20	10	24	8	2	0	
41–50	1	11	6	1	2	2	21	15	2	2	
51–60	0	0	0	0	0	0	1	1	0	0	
Total	59	129	71	8	23	26	49	24	4	2	395
Tasman and Golden Bays											
11–20	3	0	0	0	0	3	0	0	0	0	
21–30	130	16	2	0	5	86	7	1	0	1	
31–40	12	2	2	0	4	34	39	0	0	12	
41–50	0	0	0	0	0	4	17	0	0	8	
Total	145	18	4	0	9	127	63	1	0	21	388
Tarakihi											
West coast											
11–20	1	0	0	0	0	3	0	0	0	0	
21–30	41	3	0	1	1	64	1	0	0	1	
31–40	33	21	13	51	16	89	224	19	6	2	
41–50	0	4	4	15	3	12	214	13	3	2	
51–60	0	0	0	0	0	0	1	0	0	0	
Total	74	28	17	67	20	165	440	32	9	5	857
Tasman and Golden Bays											
11–20	51	0	0	0	0	37	0	0	0	0	
21–30	61	0	0	0	1	81	1	0	0	0	
31–40	0	1	0	0	0	0	0	0	0	0	
Total	112	1	0	0	1	118	1	0	0	0	233

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.

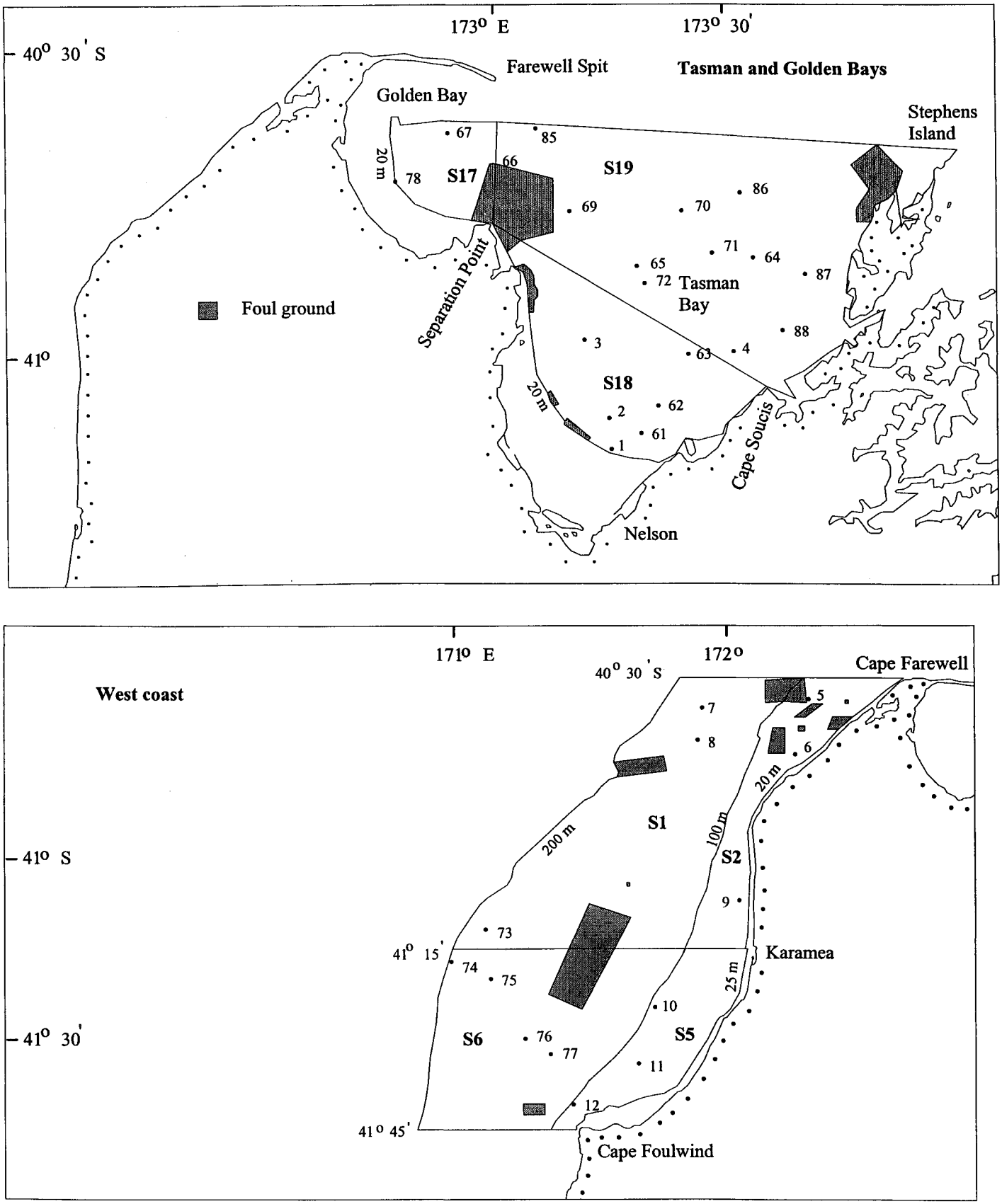


Figure 1a: Survey area showing stratum boundaries (Tasman and Golden Bays and west coast north of Cape Foulwind) with station positions and numbers.

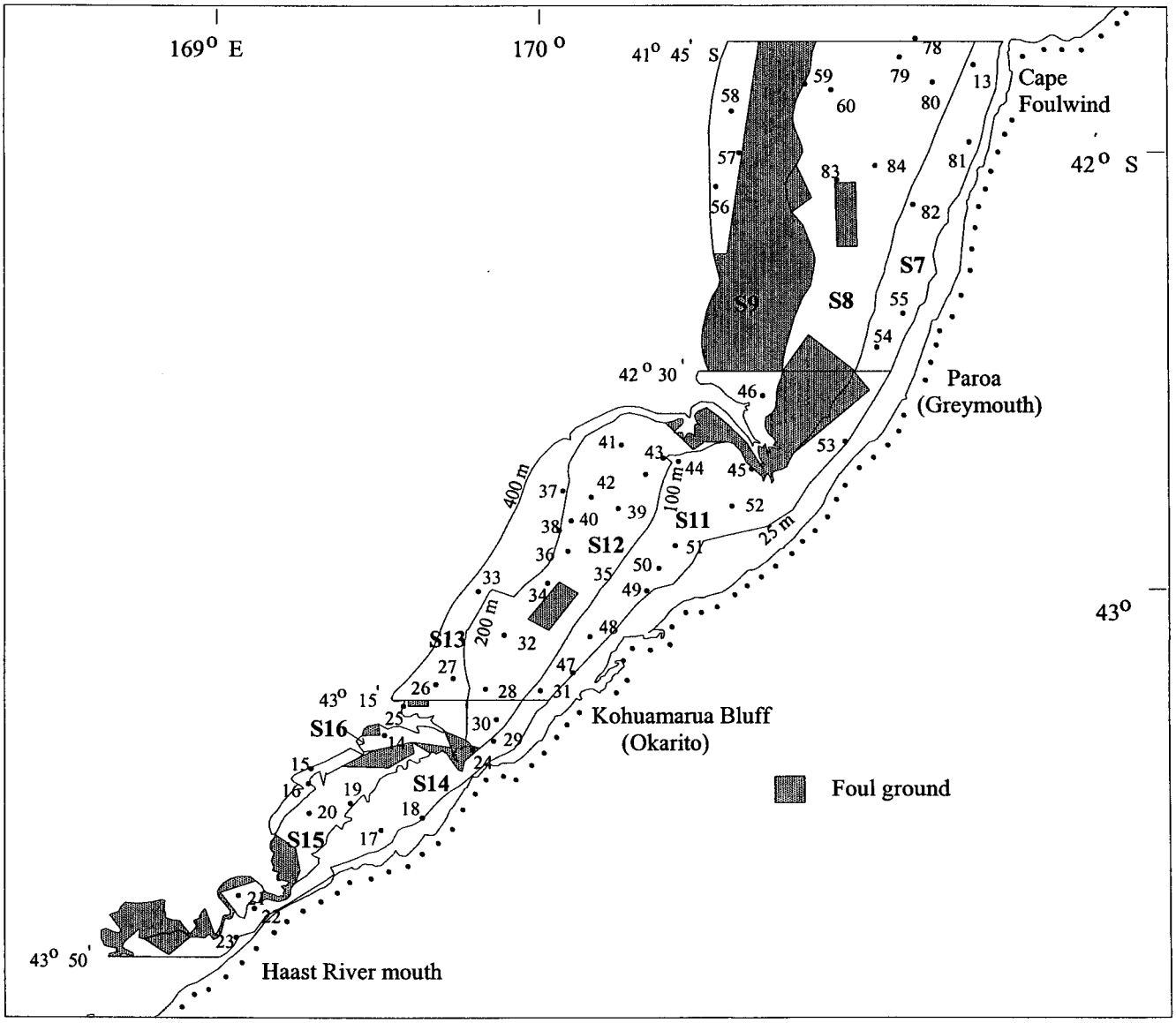


Figure 1b: Stratum boundaries (west coast south of Cape Foulwind) with station positions and numbers.

Arrow squid

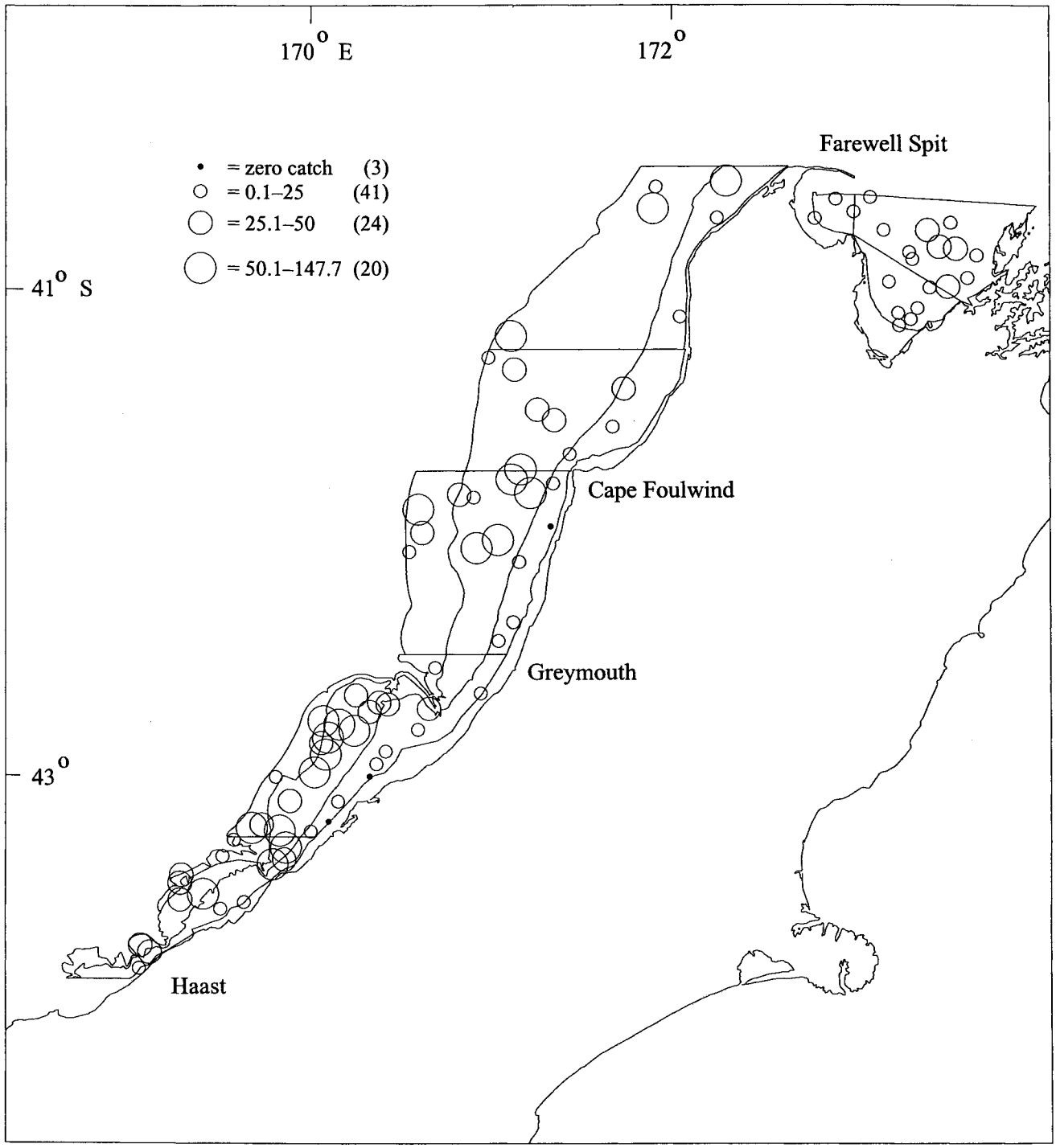


Figure 2: Catch rates (kg.km^{-2}) and distribution by stratum for the 20 most abundant commercially important species (numbers in parentheses are the number of stations at the given catch rate).

Barracouta

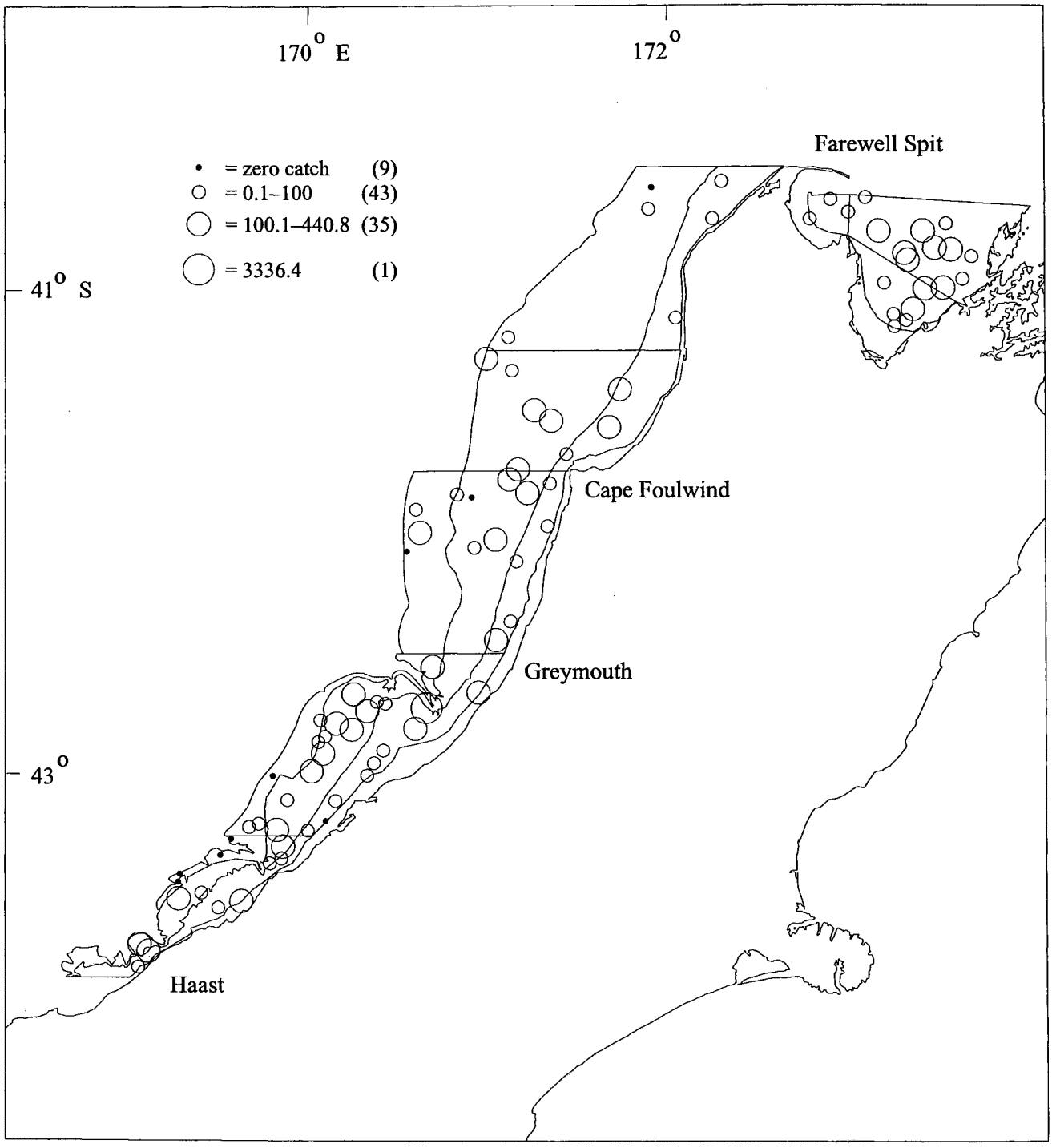


Figure 2—*continued*

Blue warehou

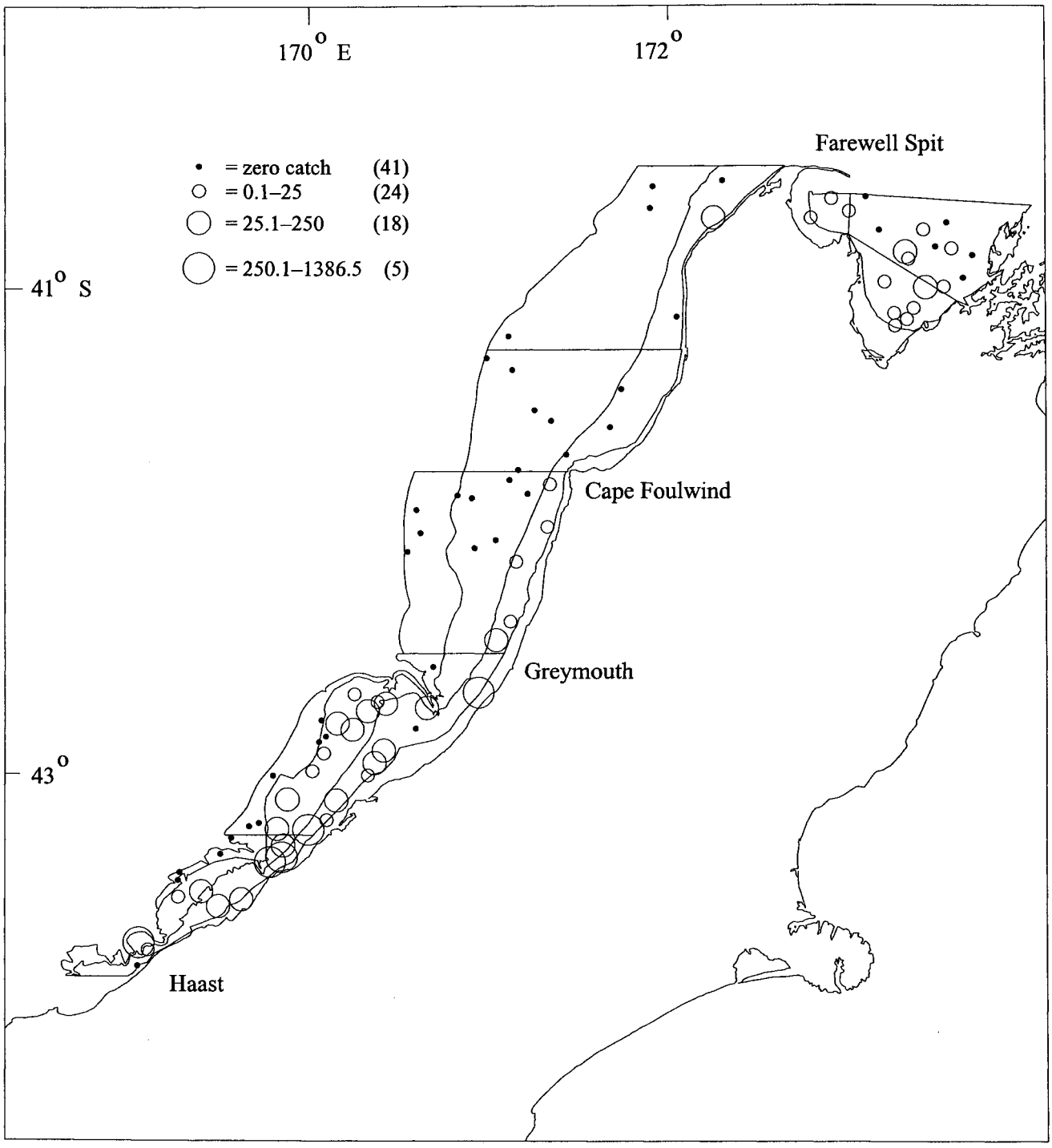


Figure 2—*continued*

Dark ghost shark

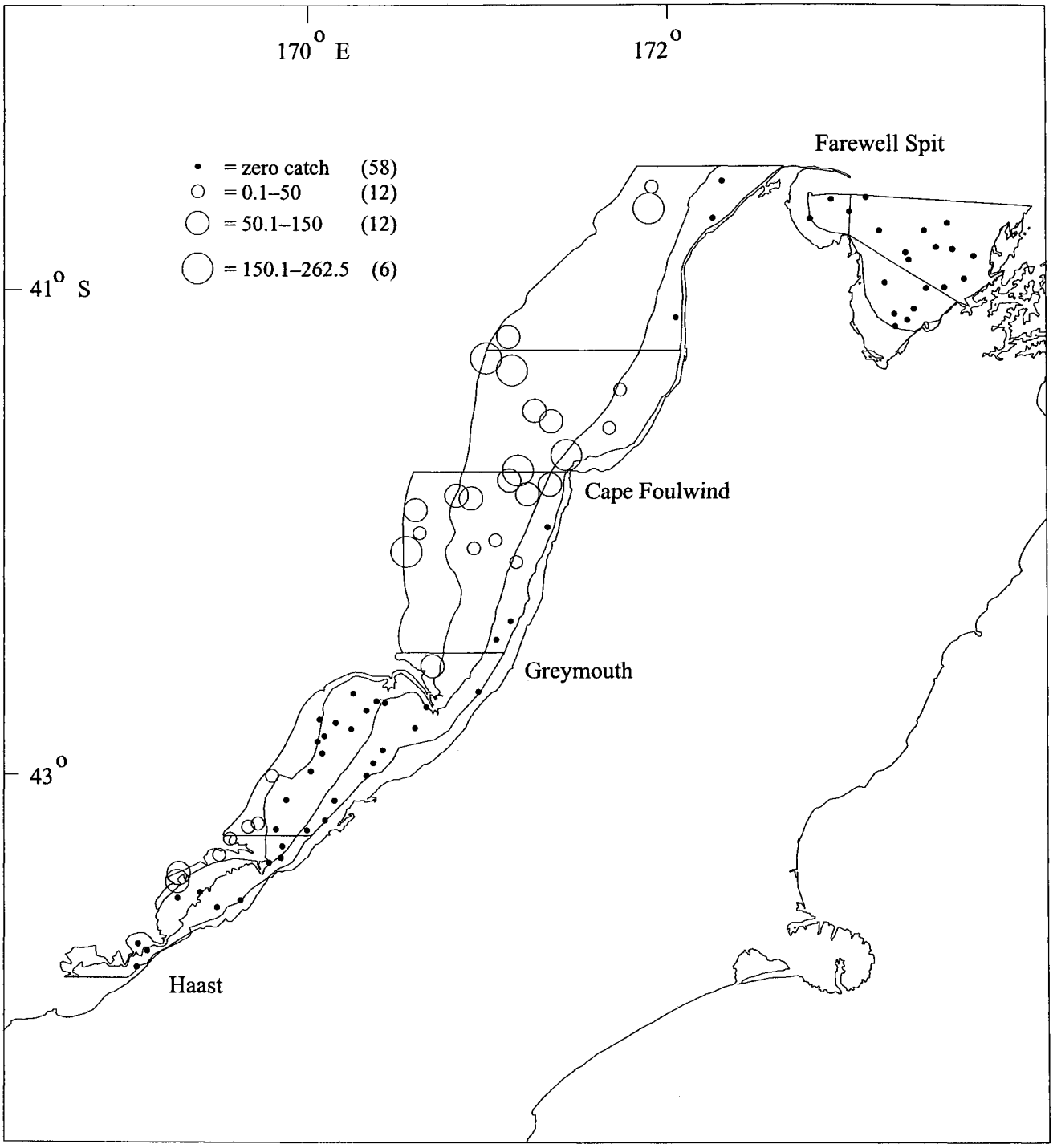


Figure 2—*continued*

Gemfish

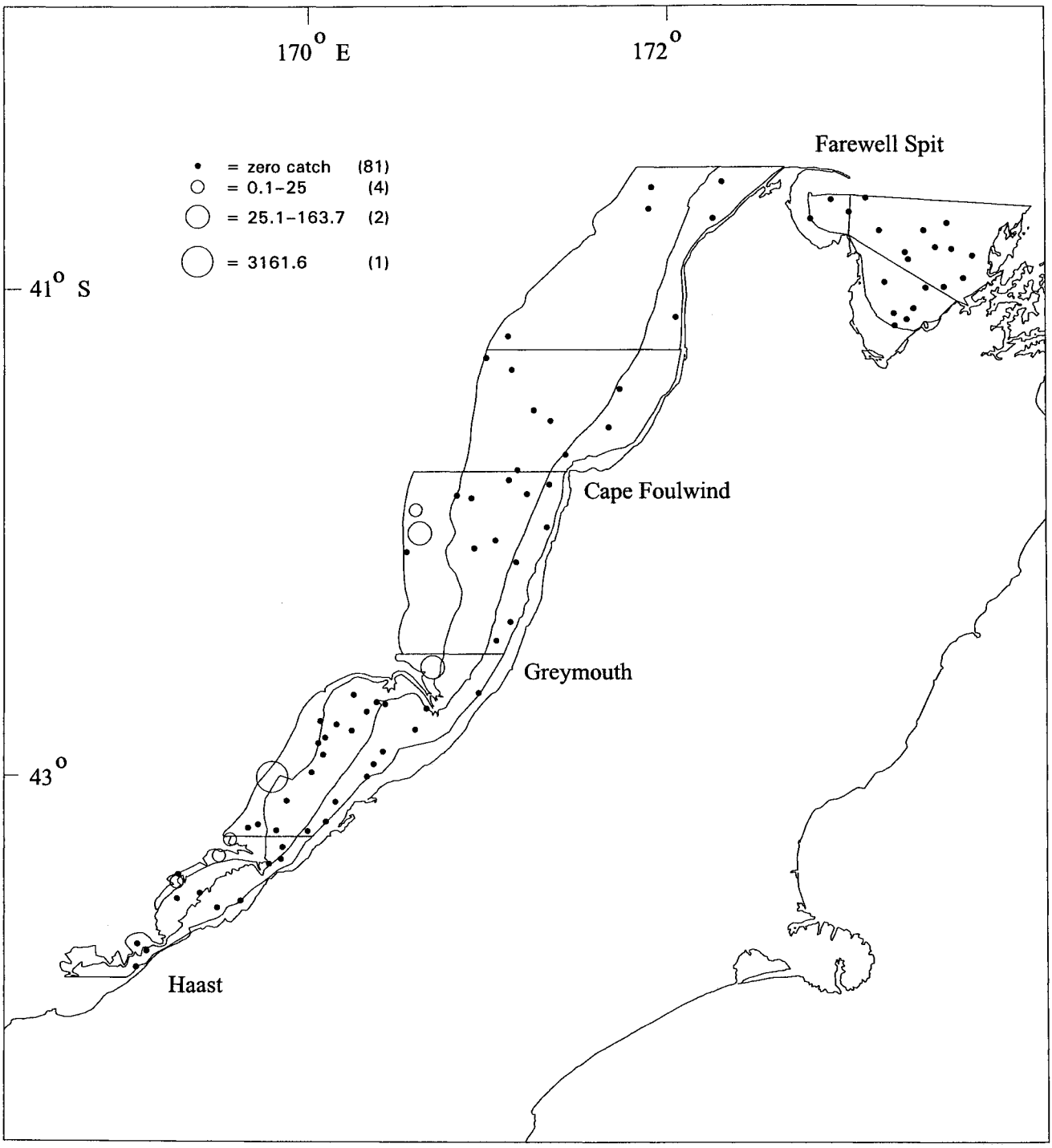


Figure 2—*continued*

Giant stargazer

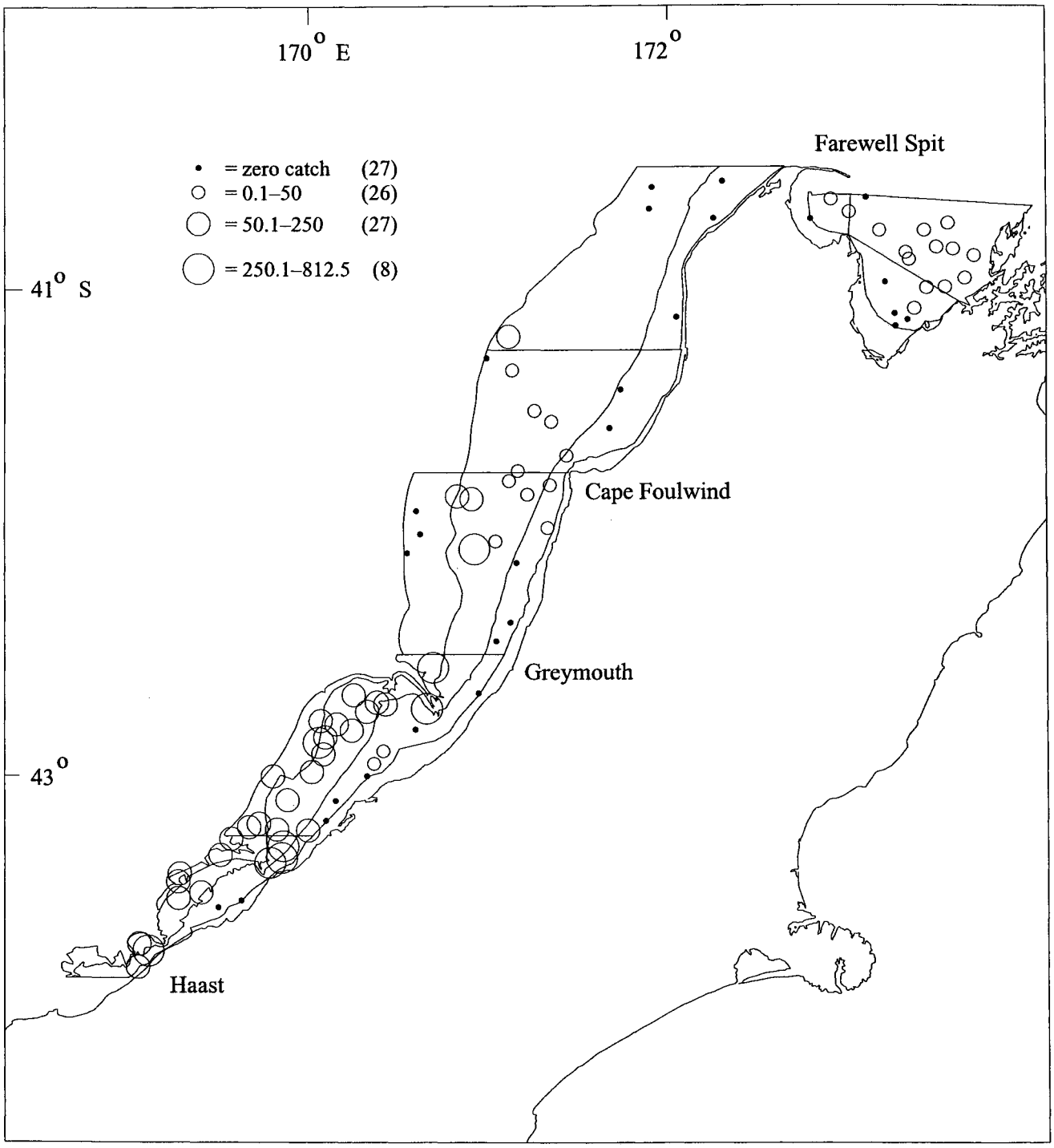


Figure 2—*continued*

Hake

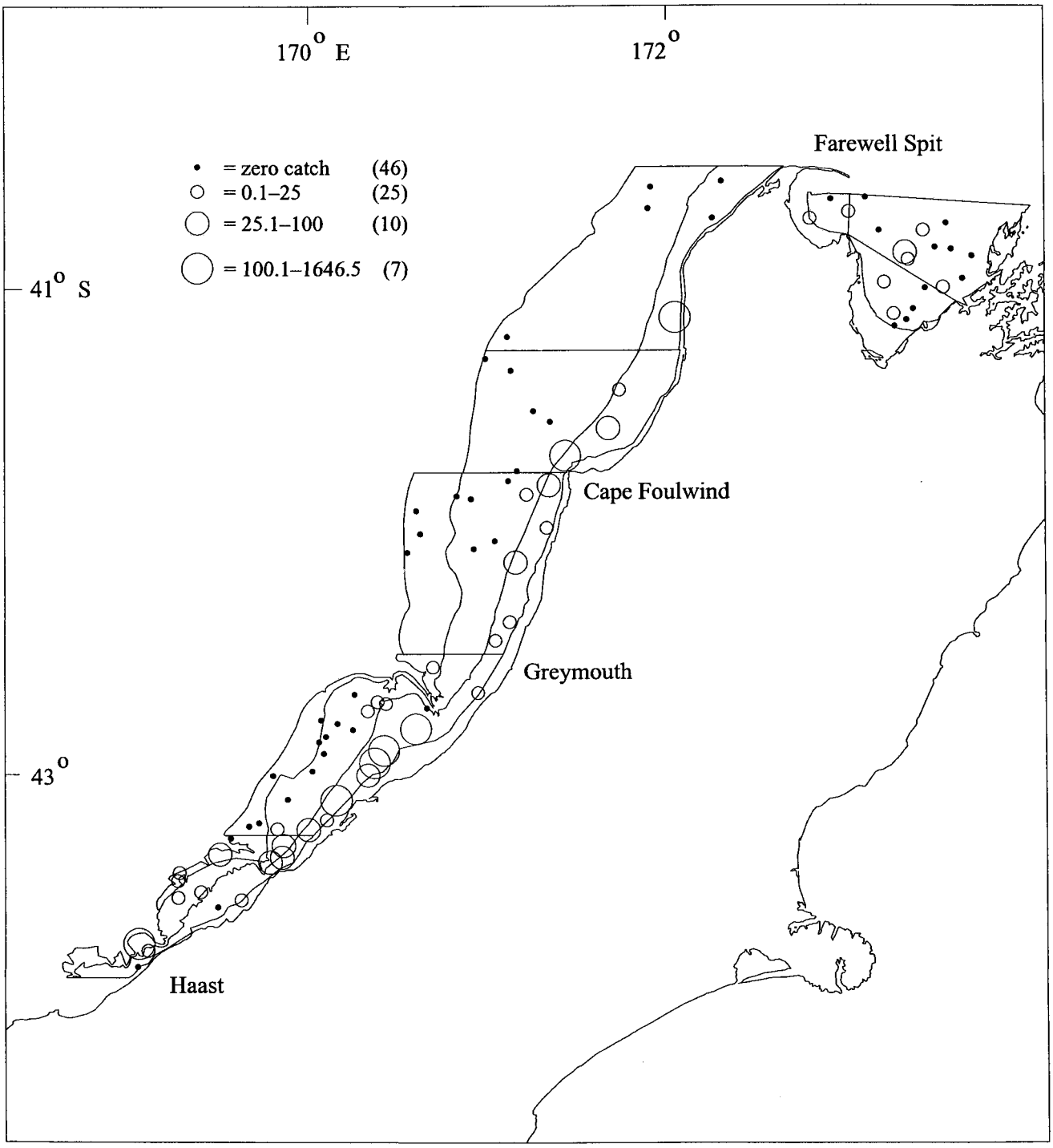


Figure 2—*continued*

Hoki

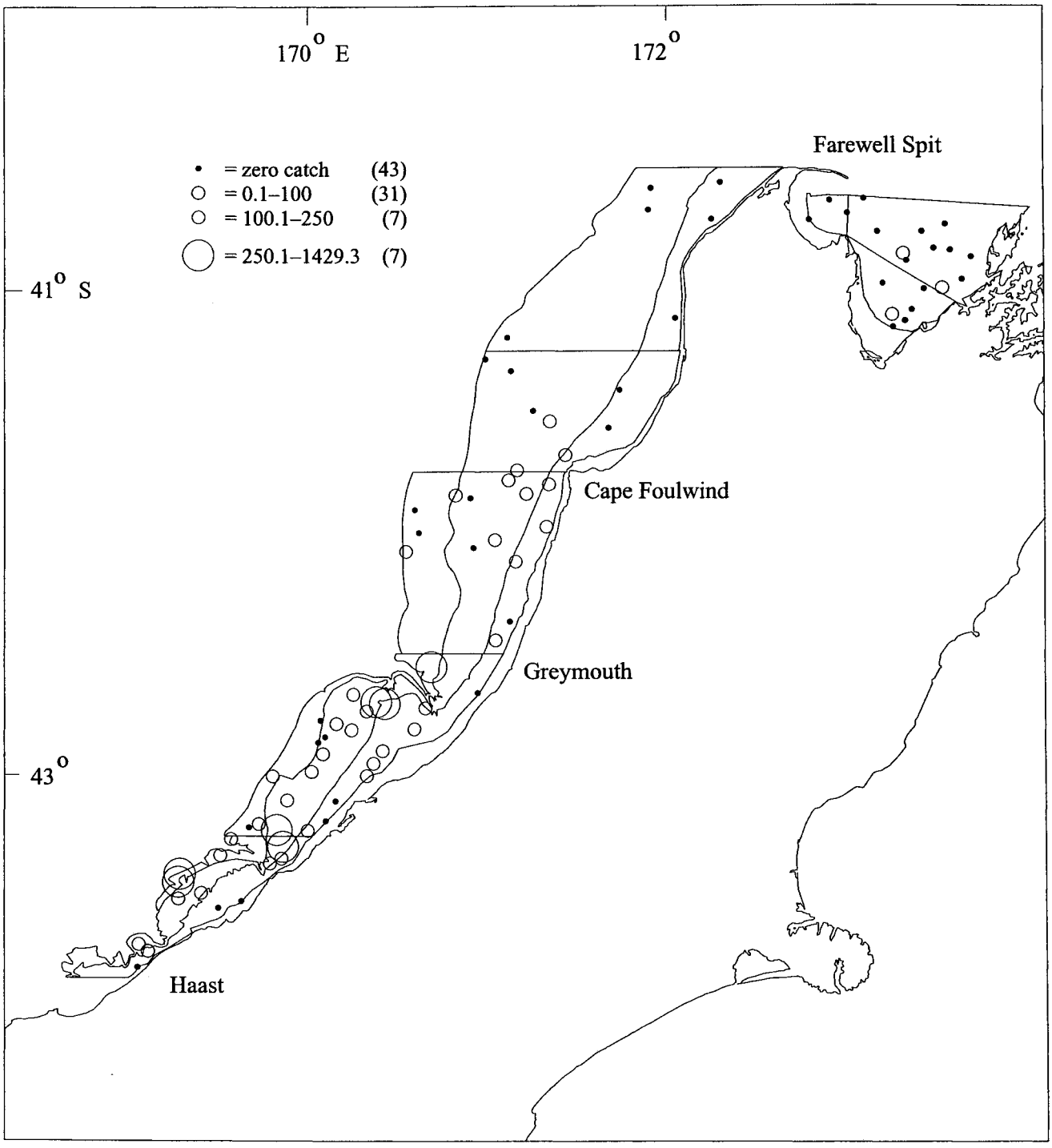


Figure 2—*continued*

Jack mackerel

Trachurus novaezelandiae

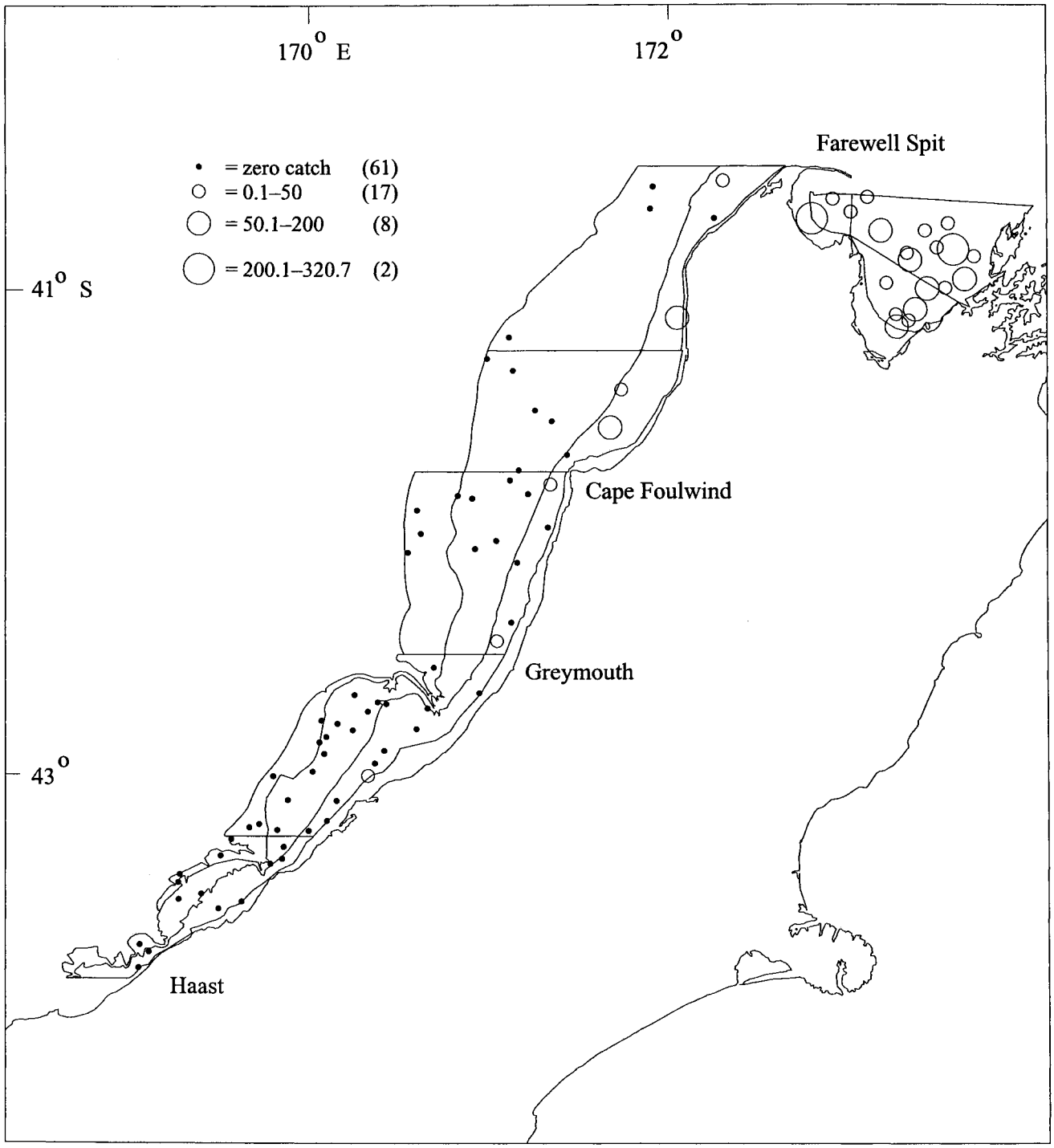


Figure 2—*continued*

Ling

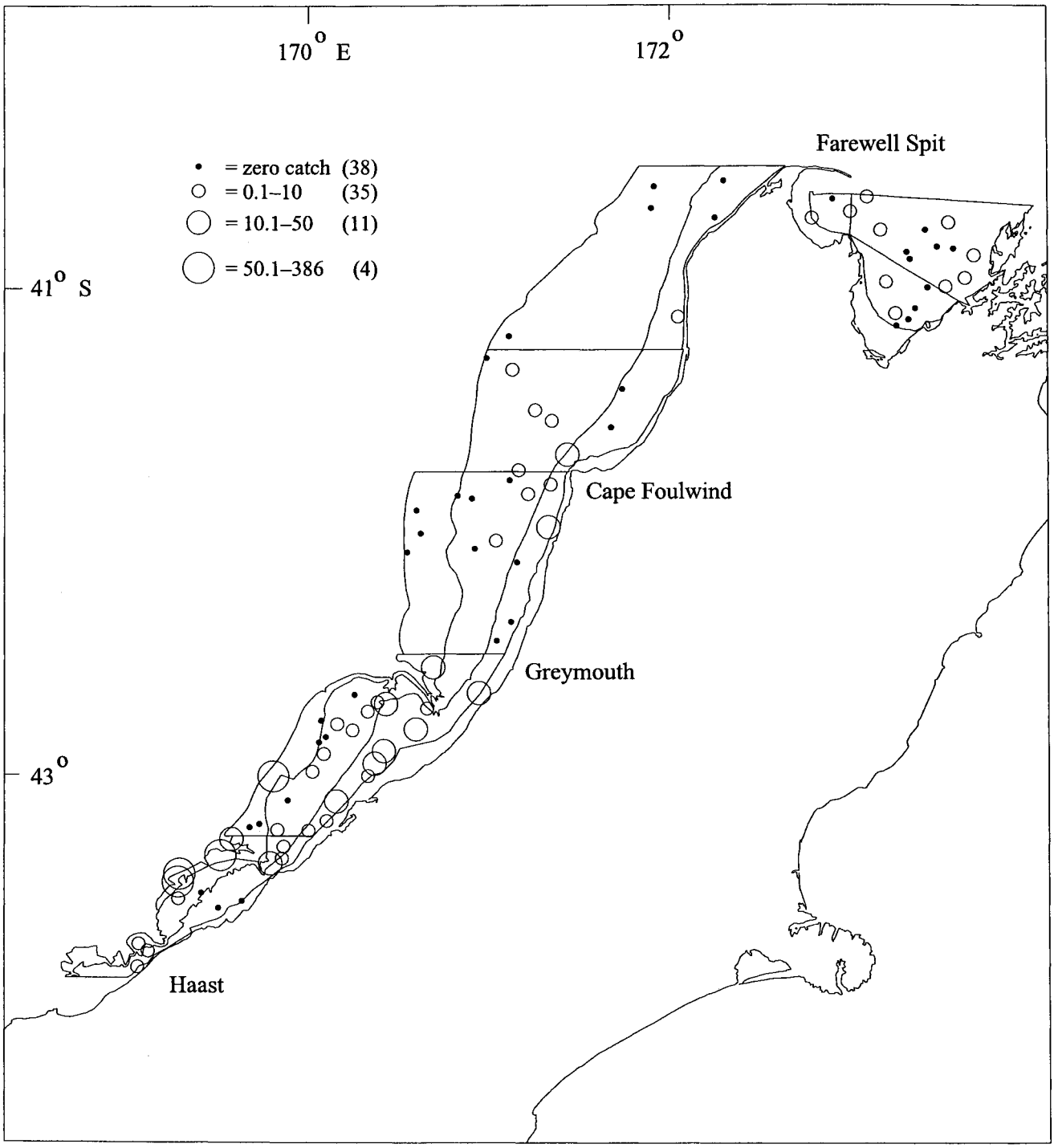


Figure 2—*continued*

Red cod

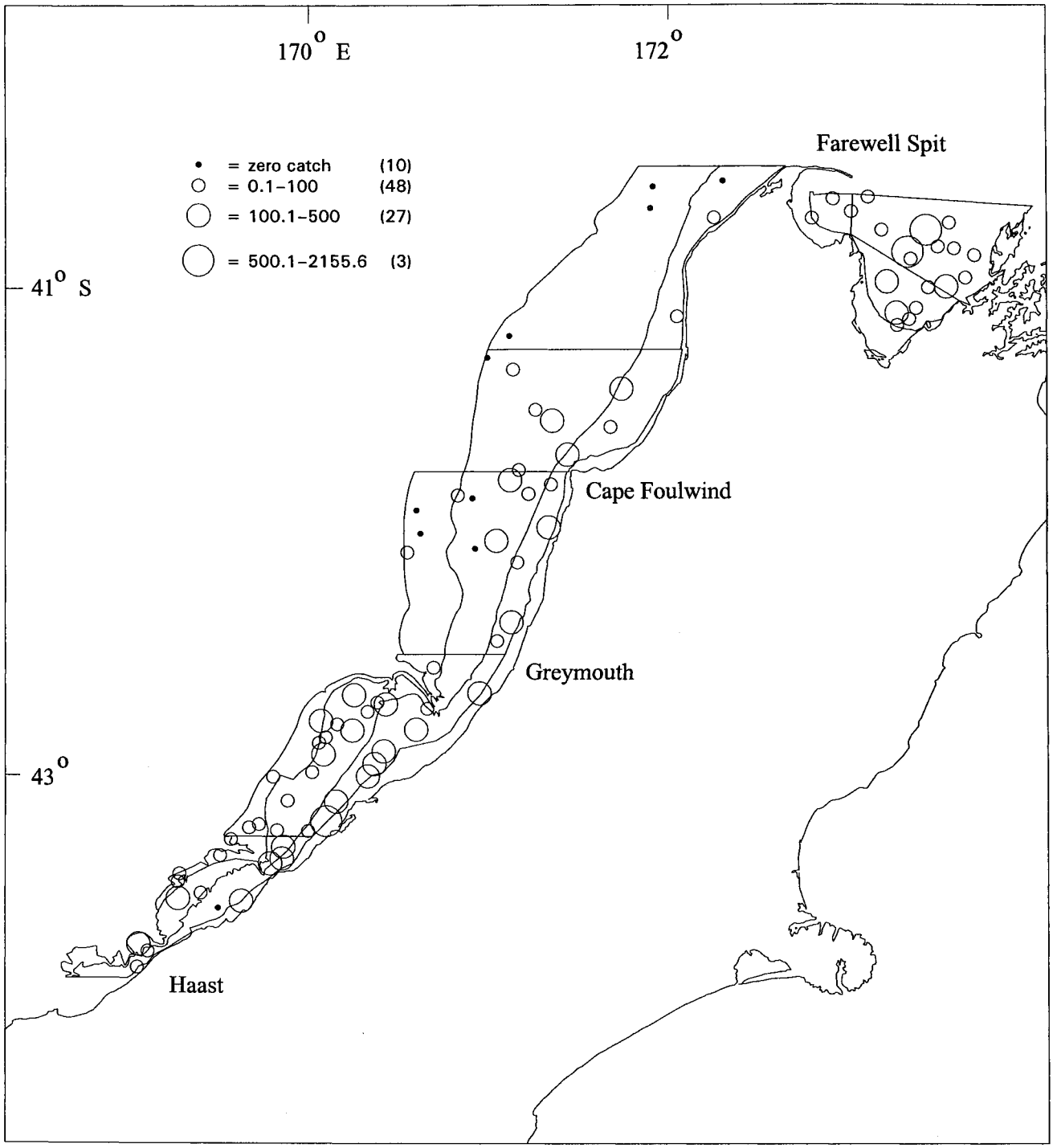


Figure 2—*continued*

Red gurnard

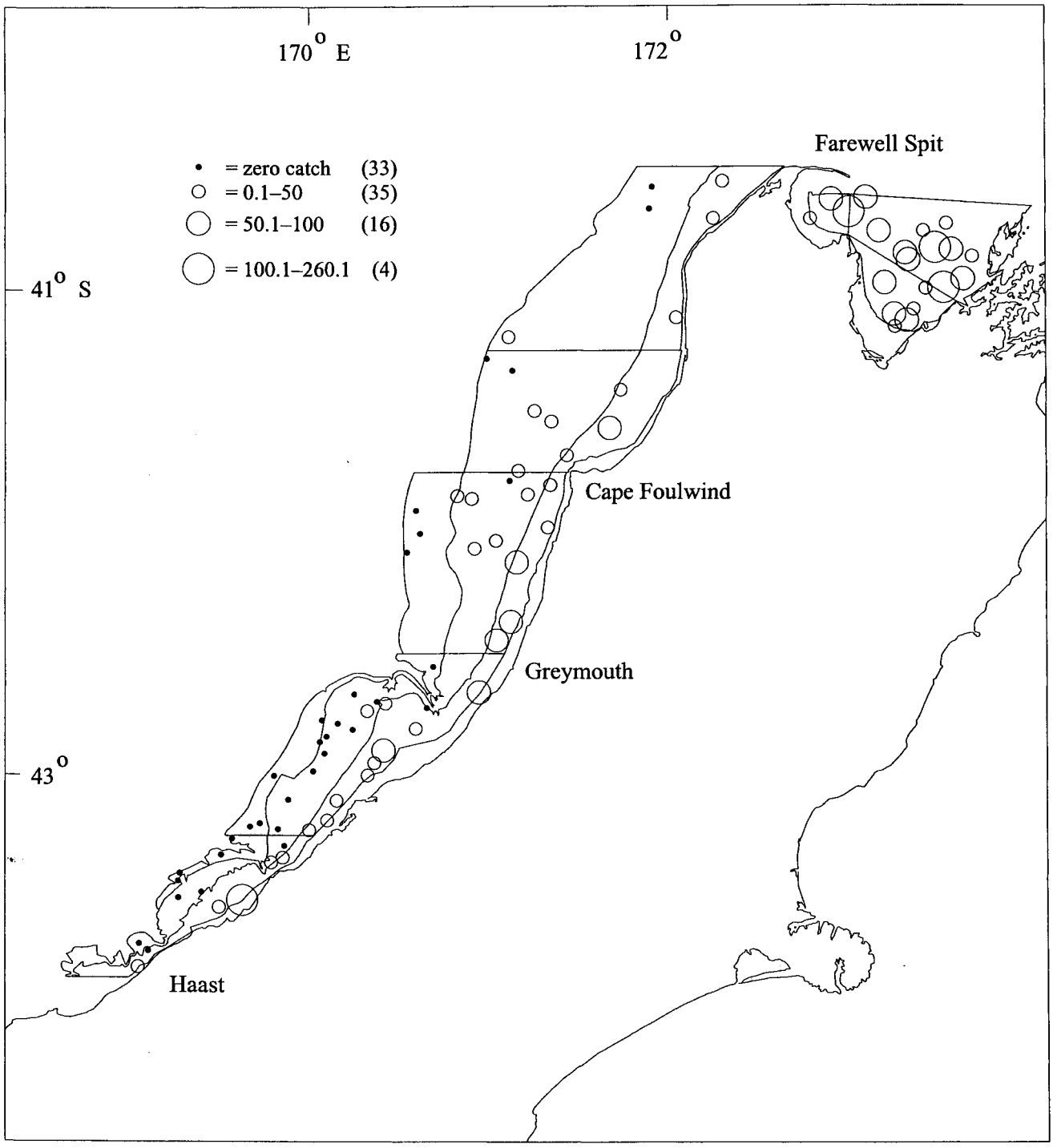


Figure 2—*continued*

Rig

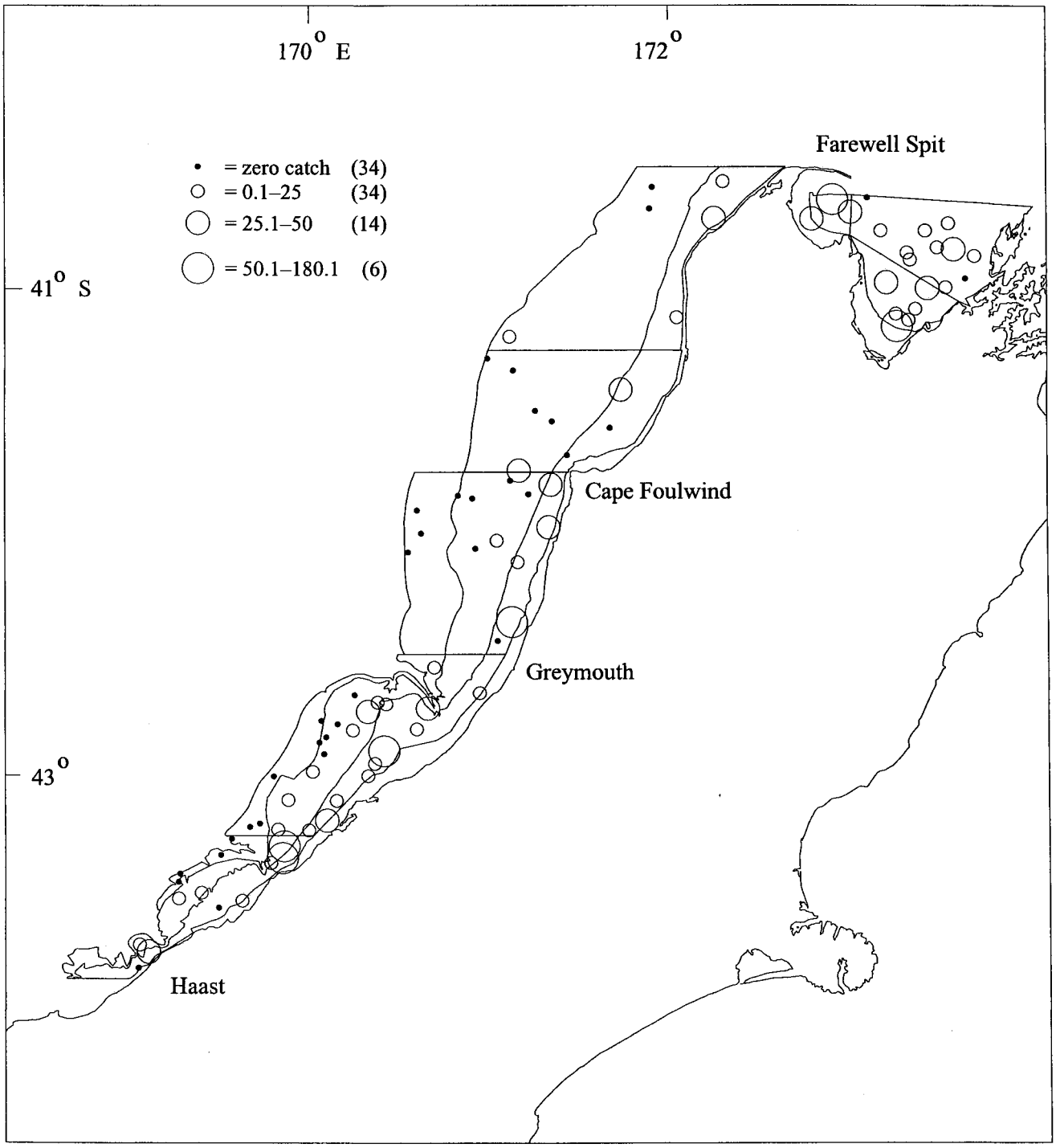


Figure 2—*continued*

Rough skate

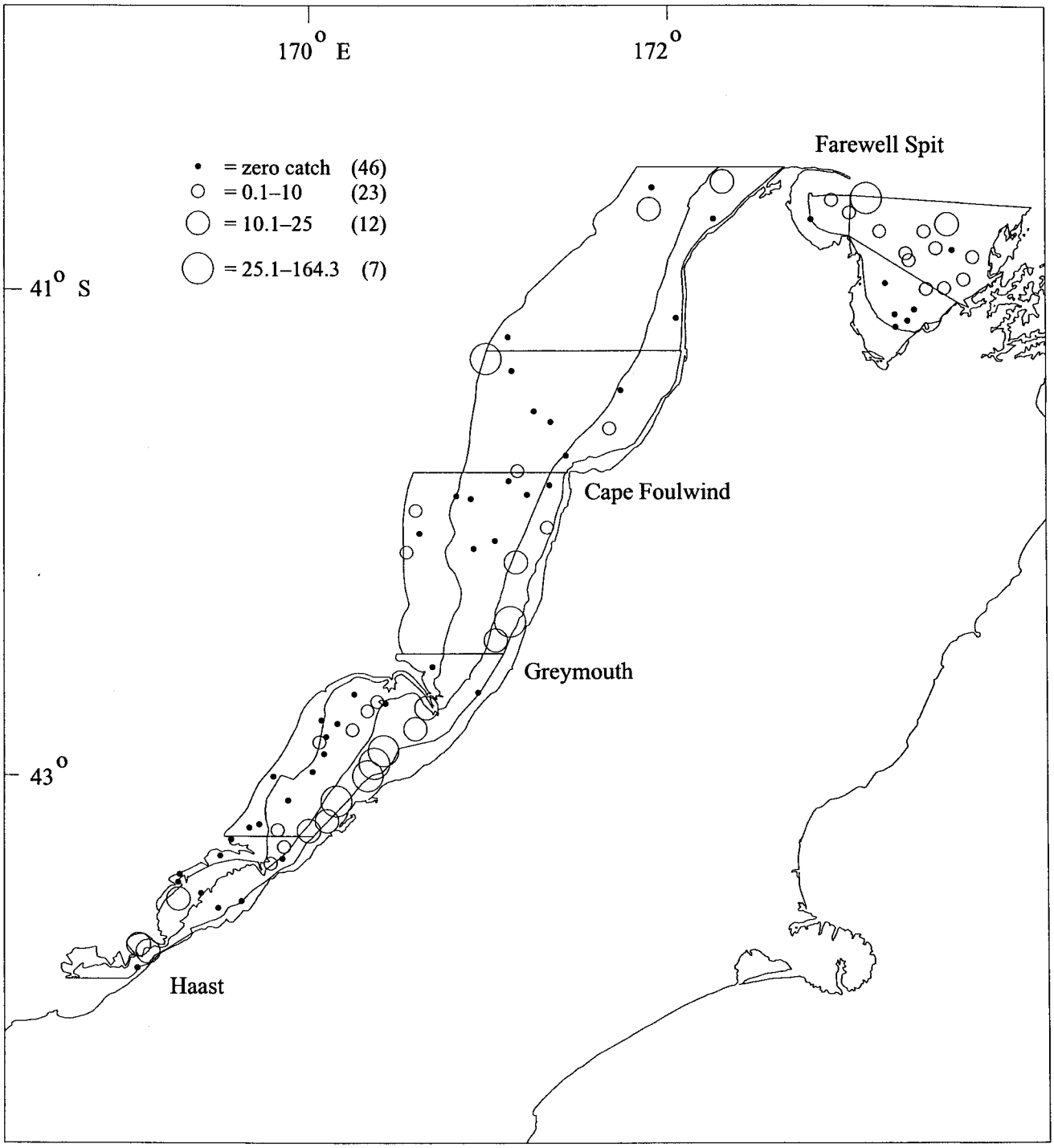


Figure 2—*continued*

School shark

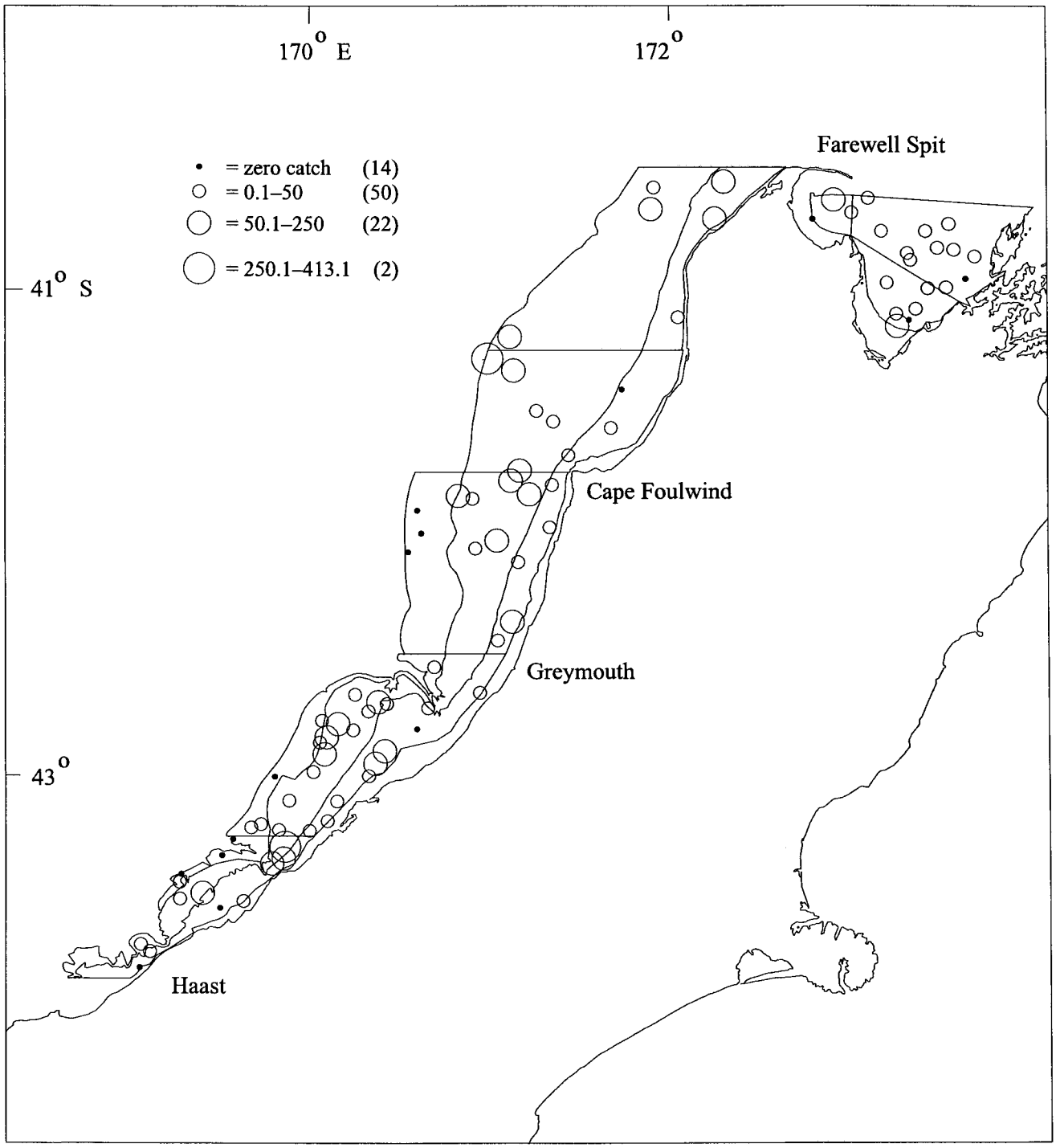


Figure 2—*continued*

Sea perch

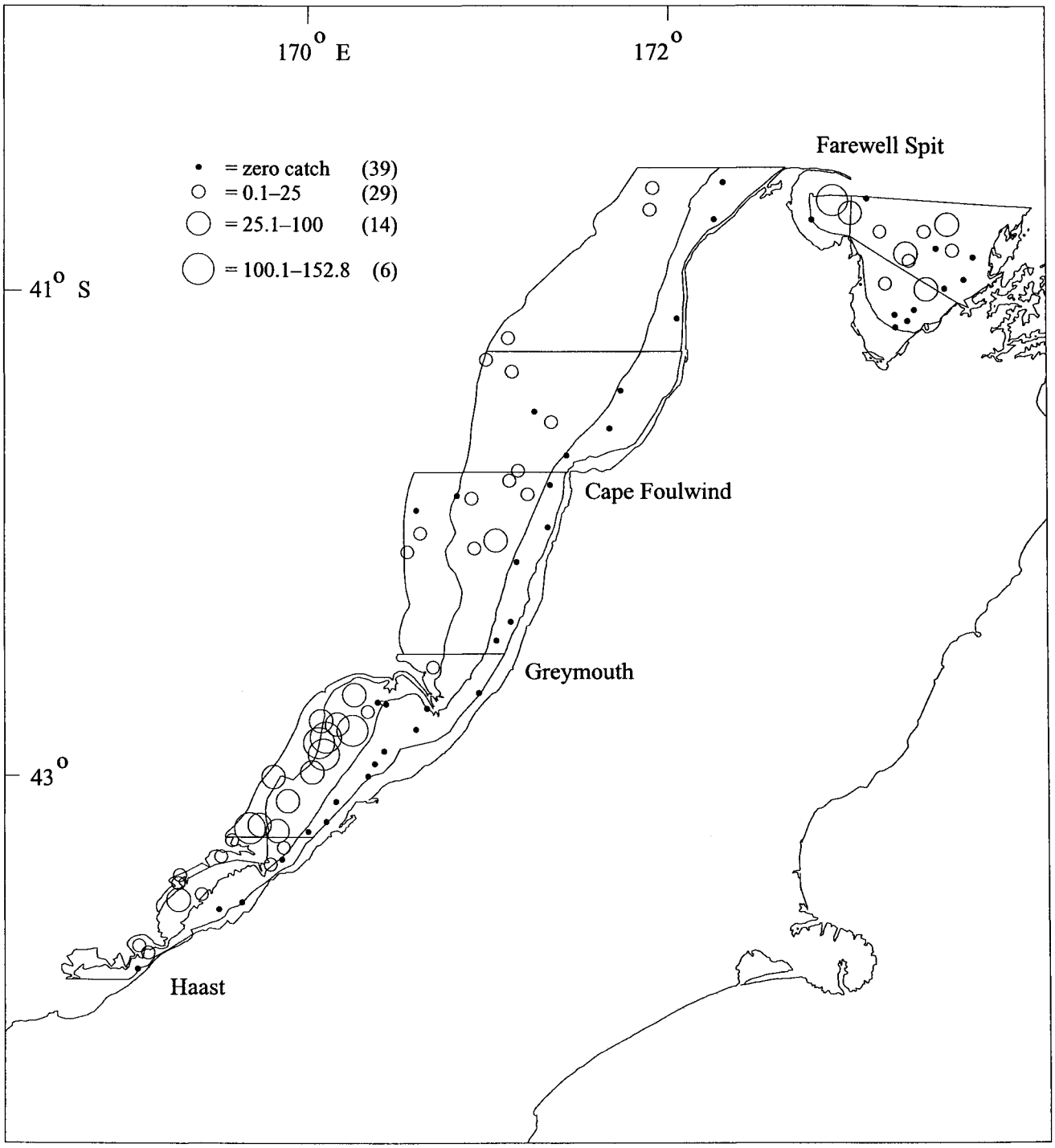


Figure 2—*continued*

Silver warehou

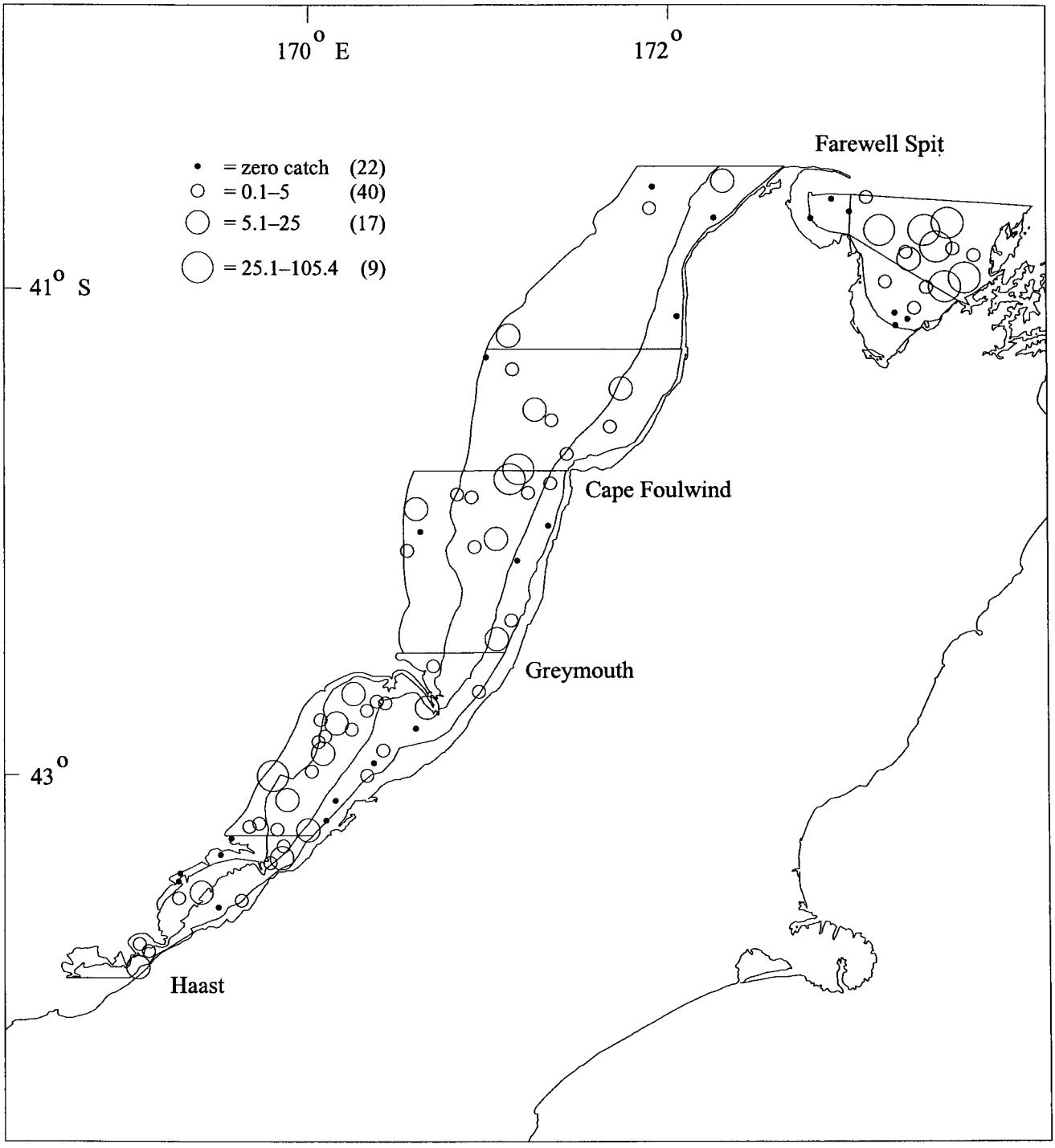


Figure 2—*continued*

Smooth skate

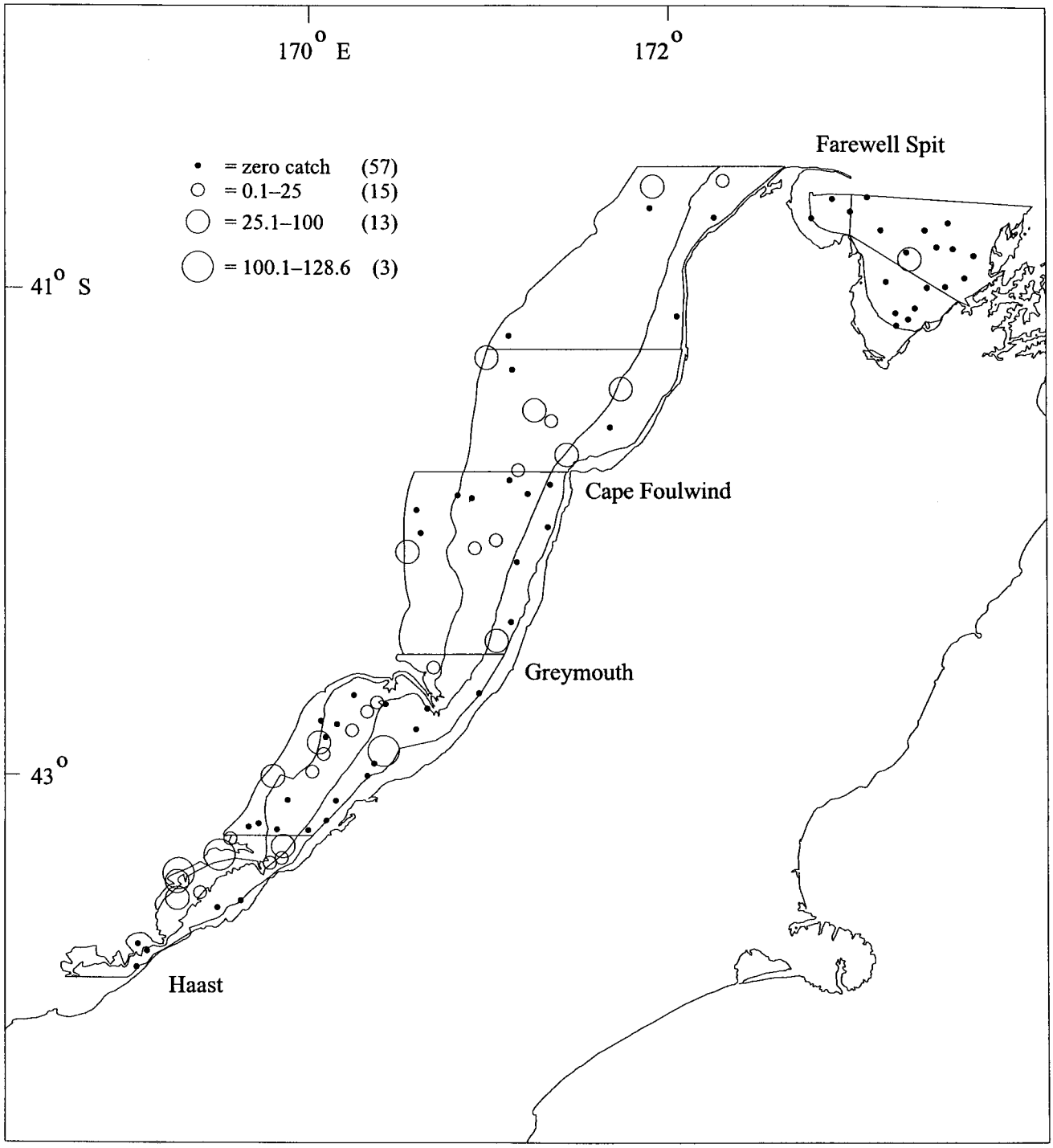


Figure 2—*continued*

Spiny dogfish

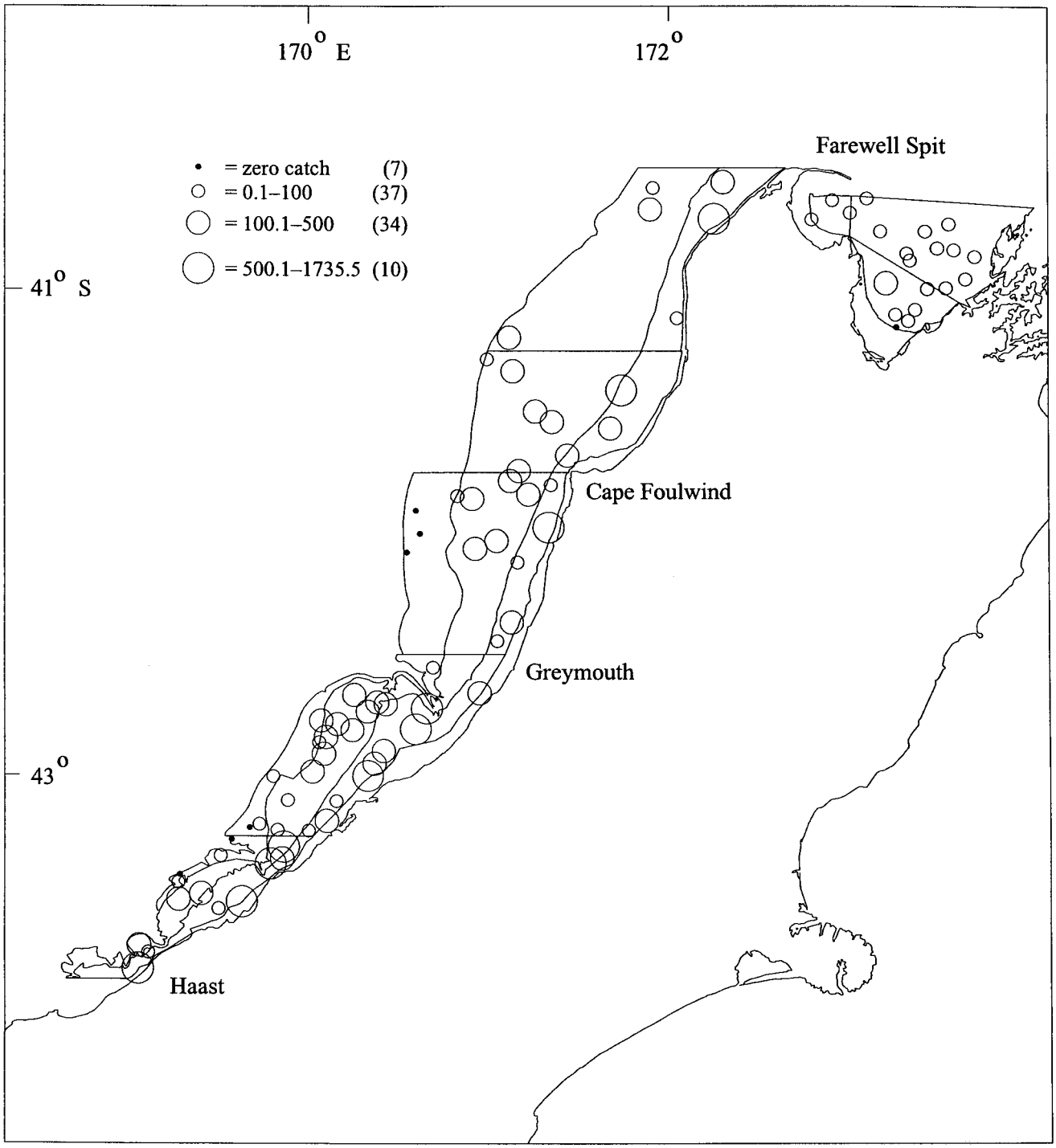


Figure 2—*continued*

Tarakihi

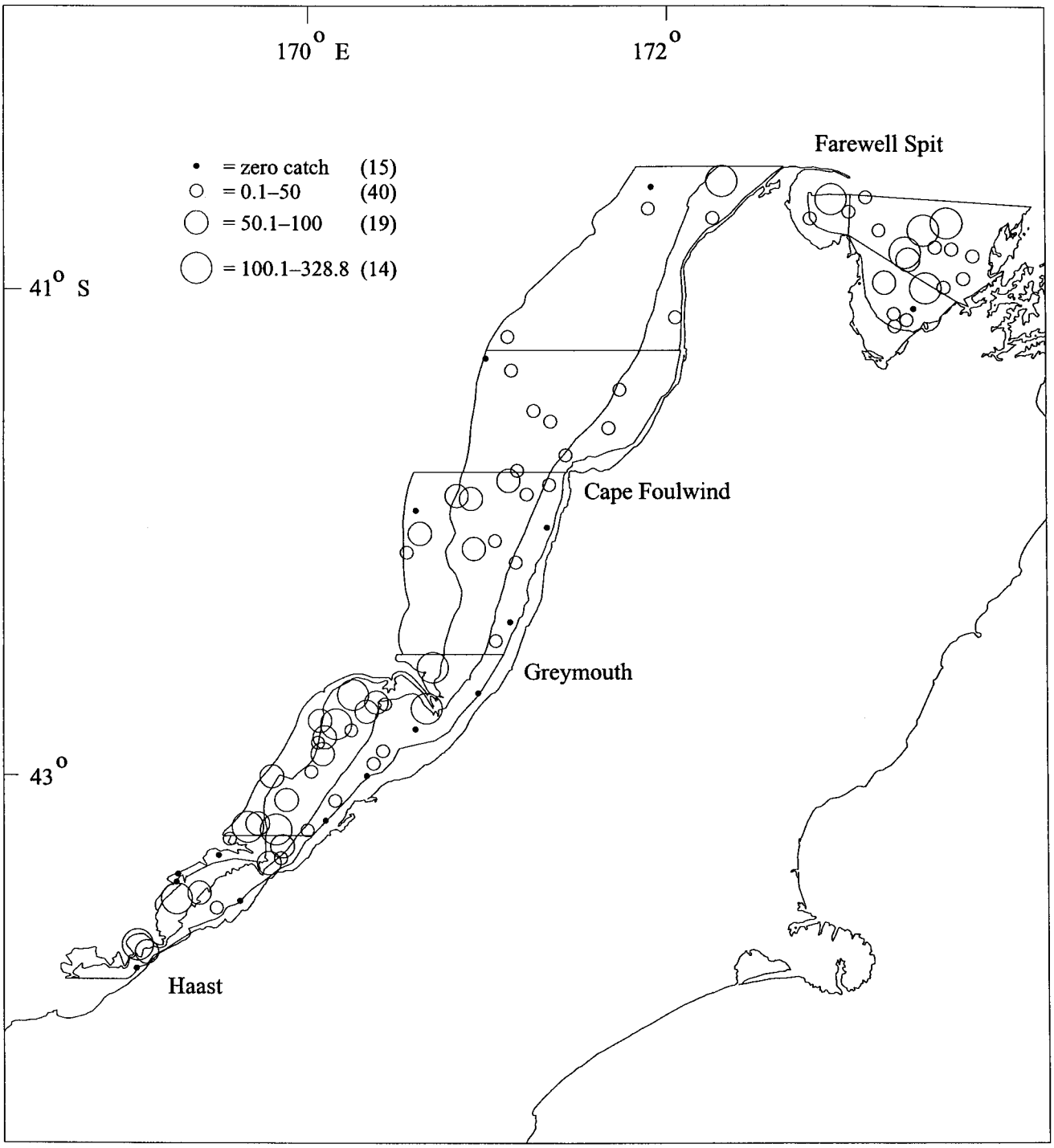


Figure 2—*continued*

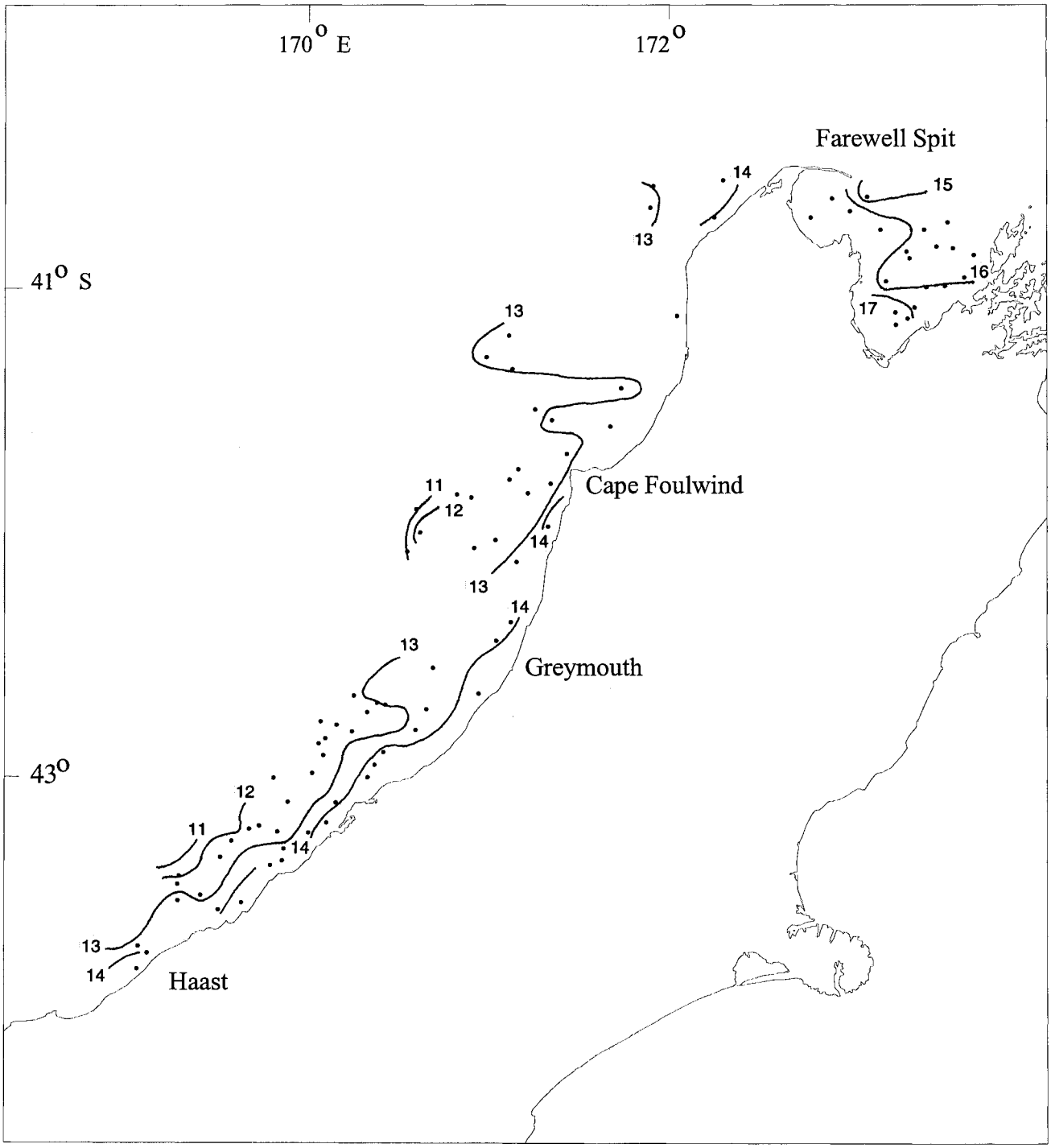


Figure 3: Bottom isotherms estimated from station data.

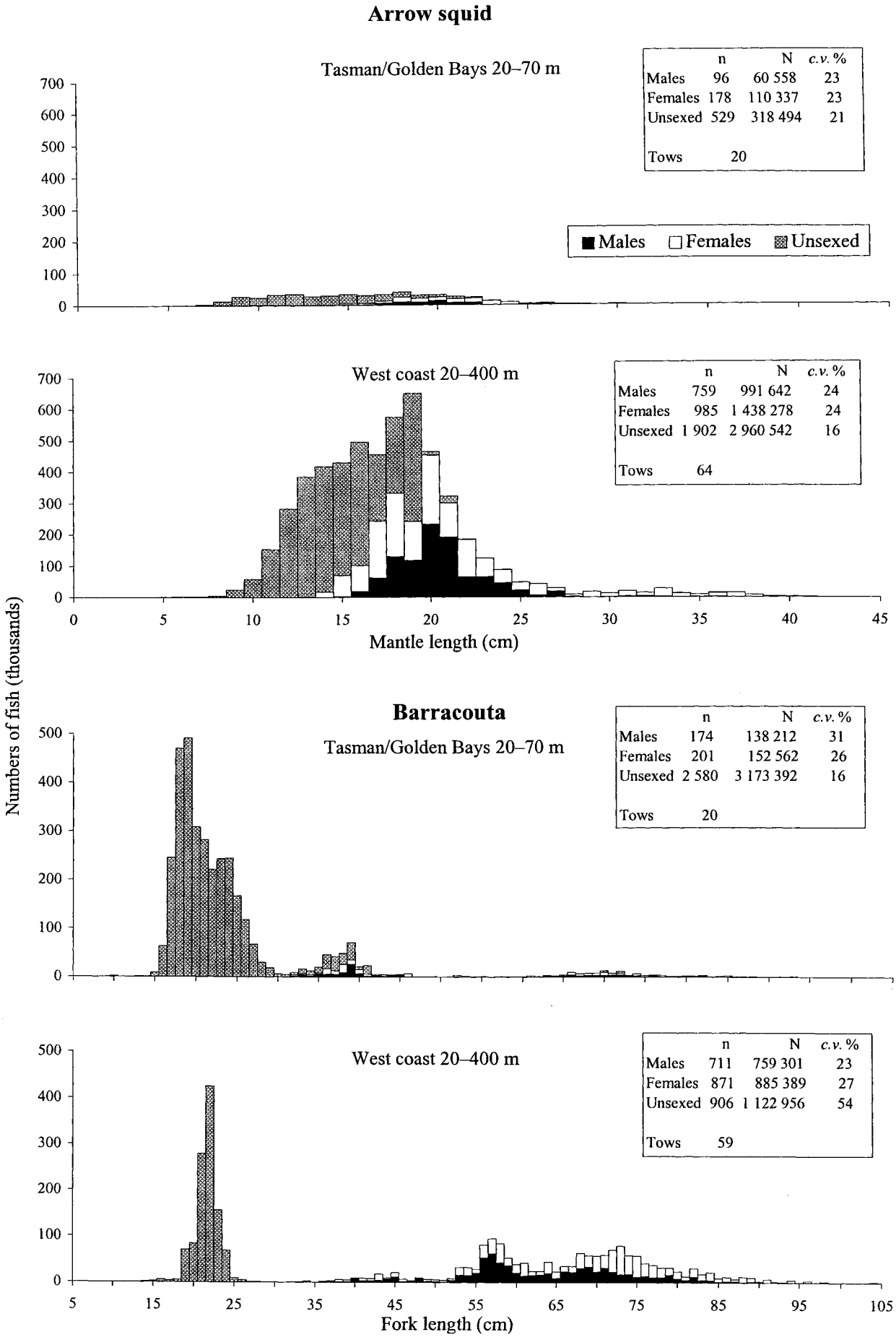
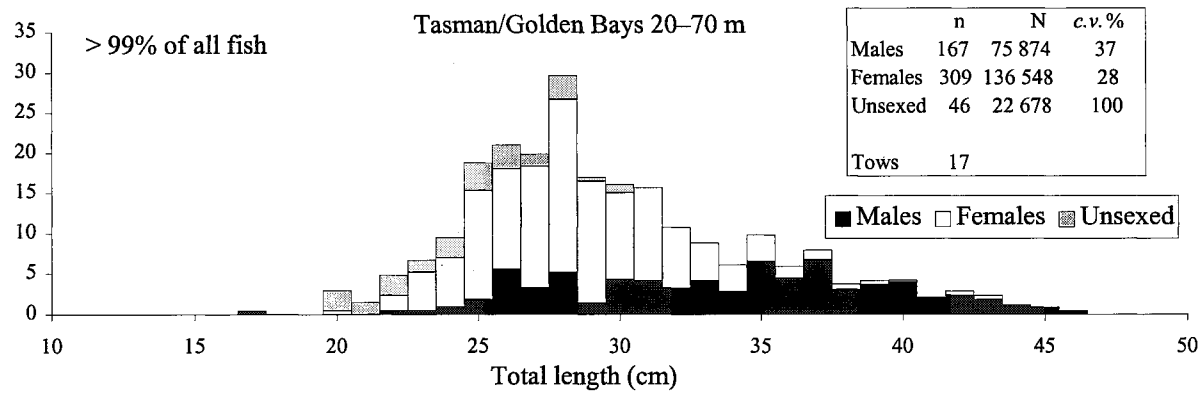


Figure 4: Scaled length frequency data for major commercial species (catch > 100 kg) (n, number of fish measured; N, estimated population; *c.v.*, coefficient of variation; Tows, number of stations where species was caught).

Blue cod



Blue warehou

Tasman/Golden Bays 20–70 m

	n	N	c.v.%
Males	10	5 268	100
Females	4	2 107	100
Unsexed	310	143 340	30
Tows	14		

West coast 20–400 m

	n	N	c.v.%
Males	247	144 181	34
Females	271	142 639	28
Unsexed	54	22 138	36
Tows	33		

Numbers of fish (thousands)

Fork length (cm)

Dark ghost shark

West coast 20–400 m

	n	N	c.v.%
Males	592	931 486	23
Females	638	928 789	20
Tows	30		

Chimaera length (cm)

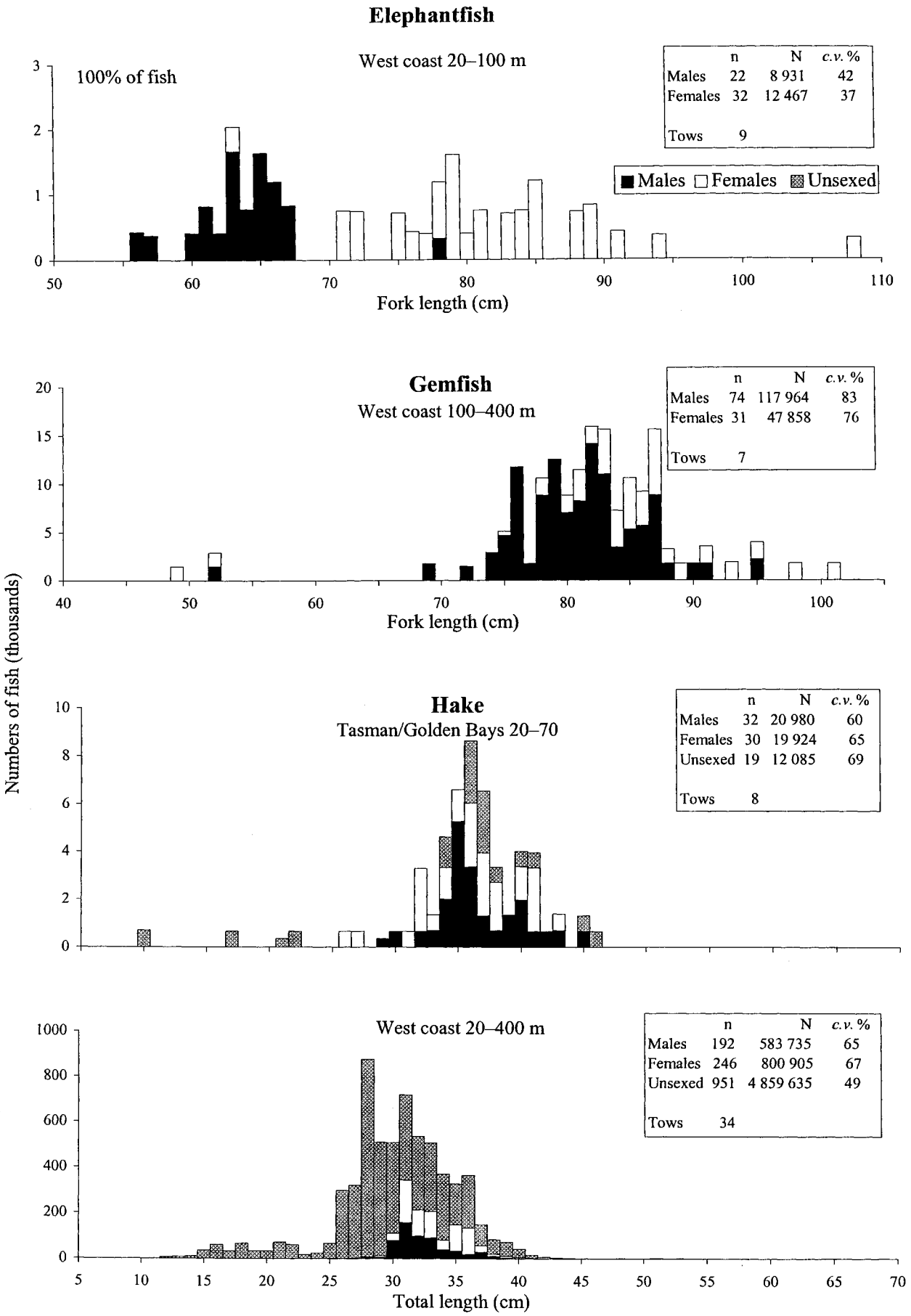


Figure 4—*continued*

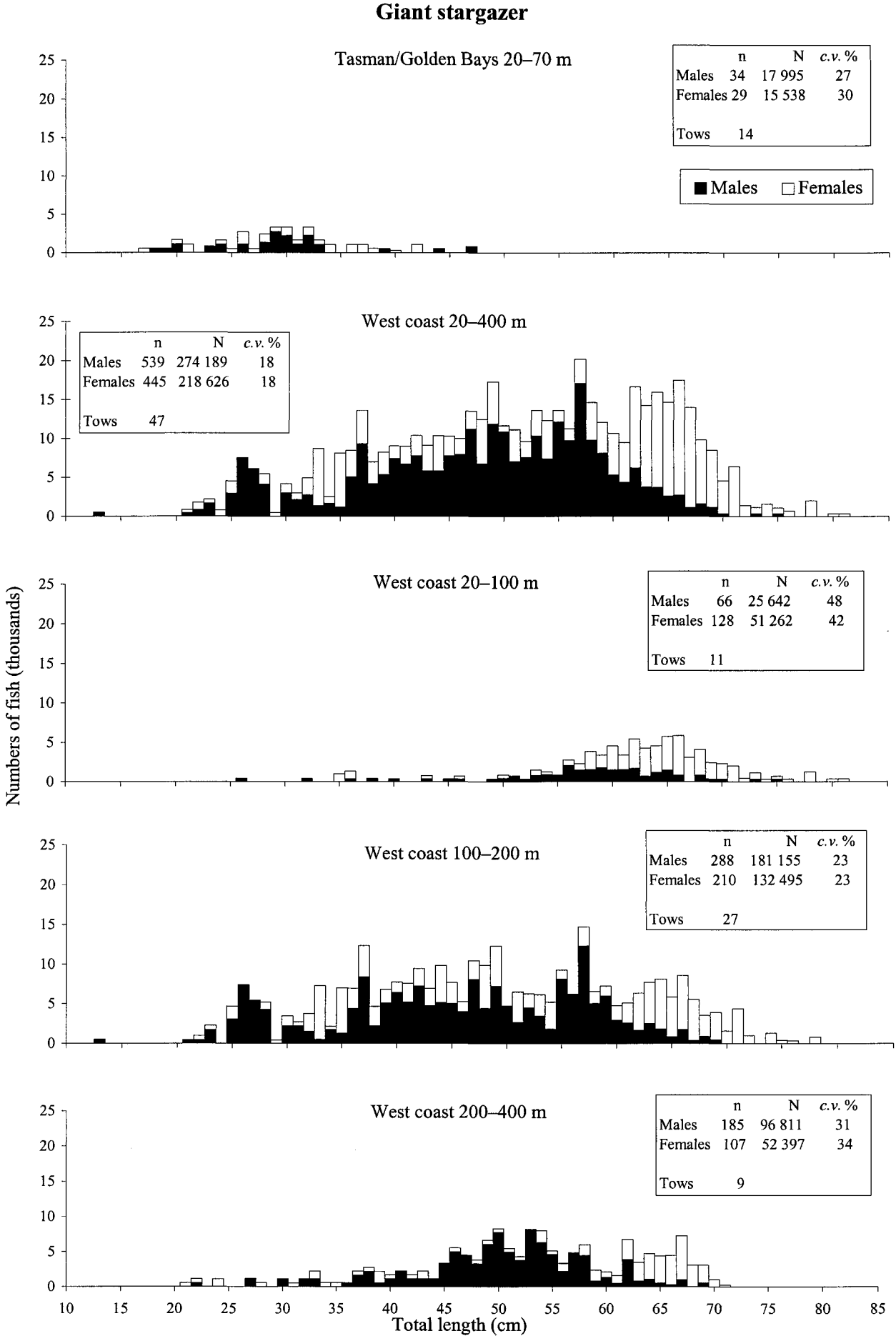


Figure 4—*continued*

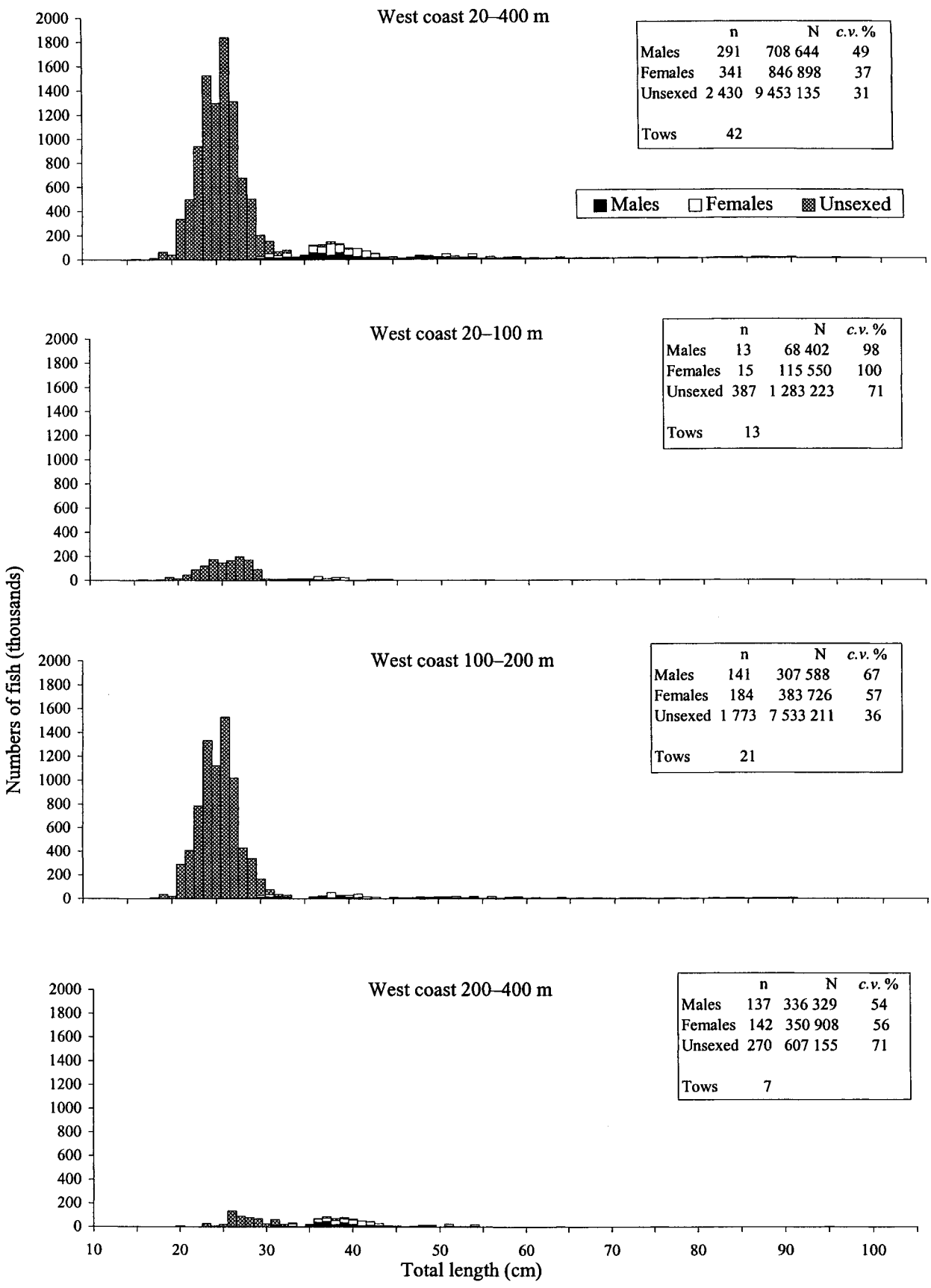
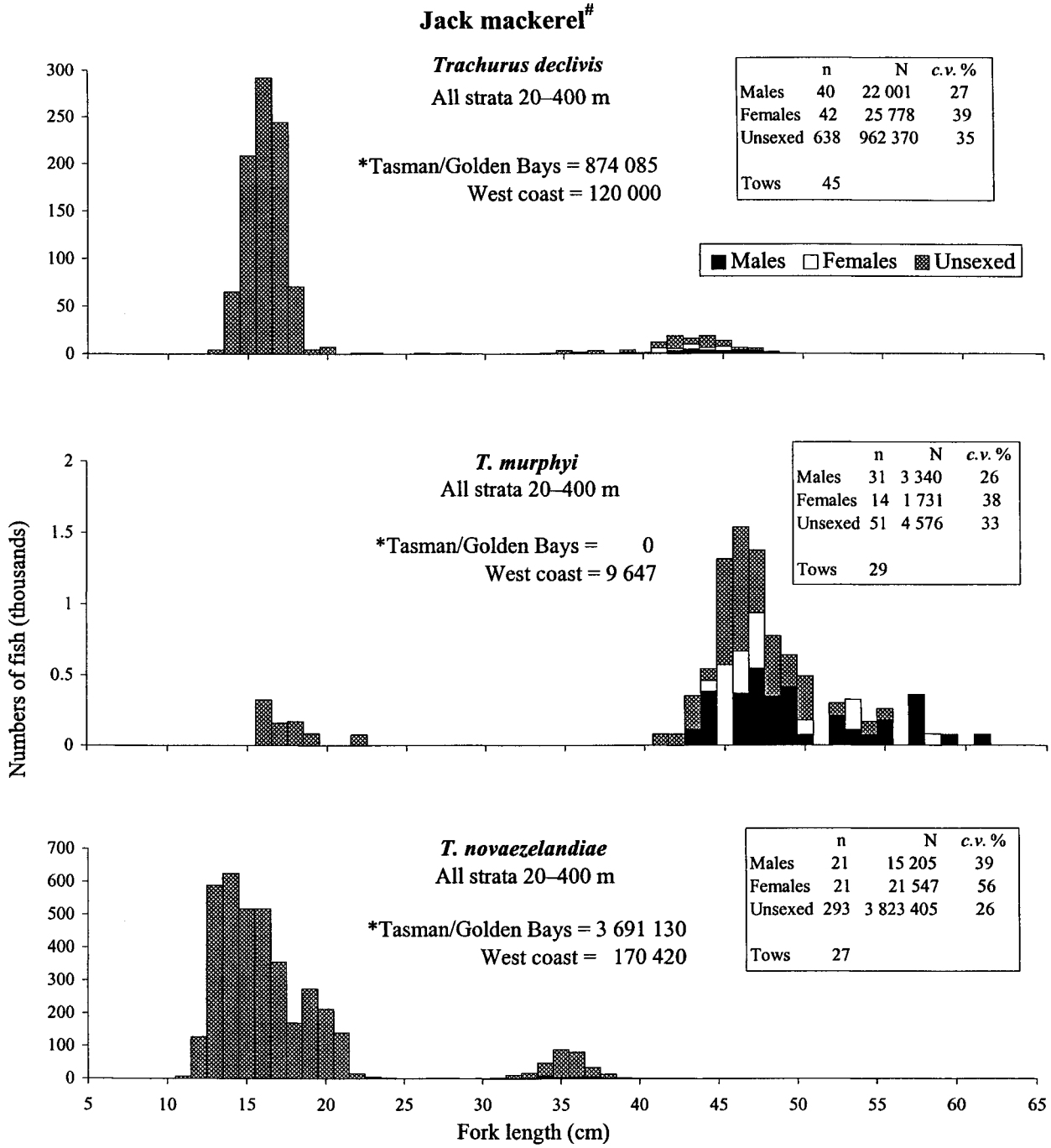


Figure 4—*continued*



Length frequencies are for Tasman/Golden Bays and west coast combined
* Estimated population size for each sub-area

Figure 4—*continued*

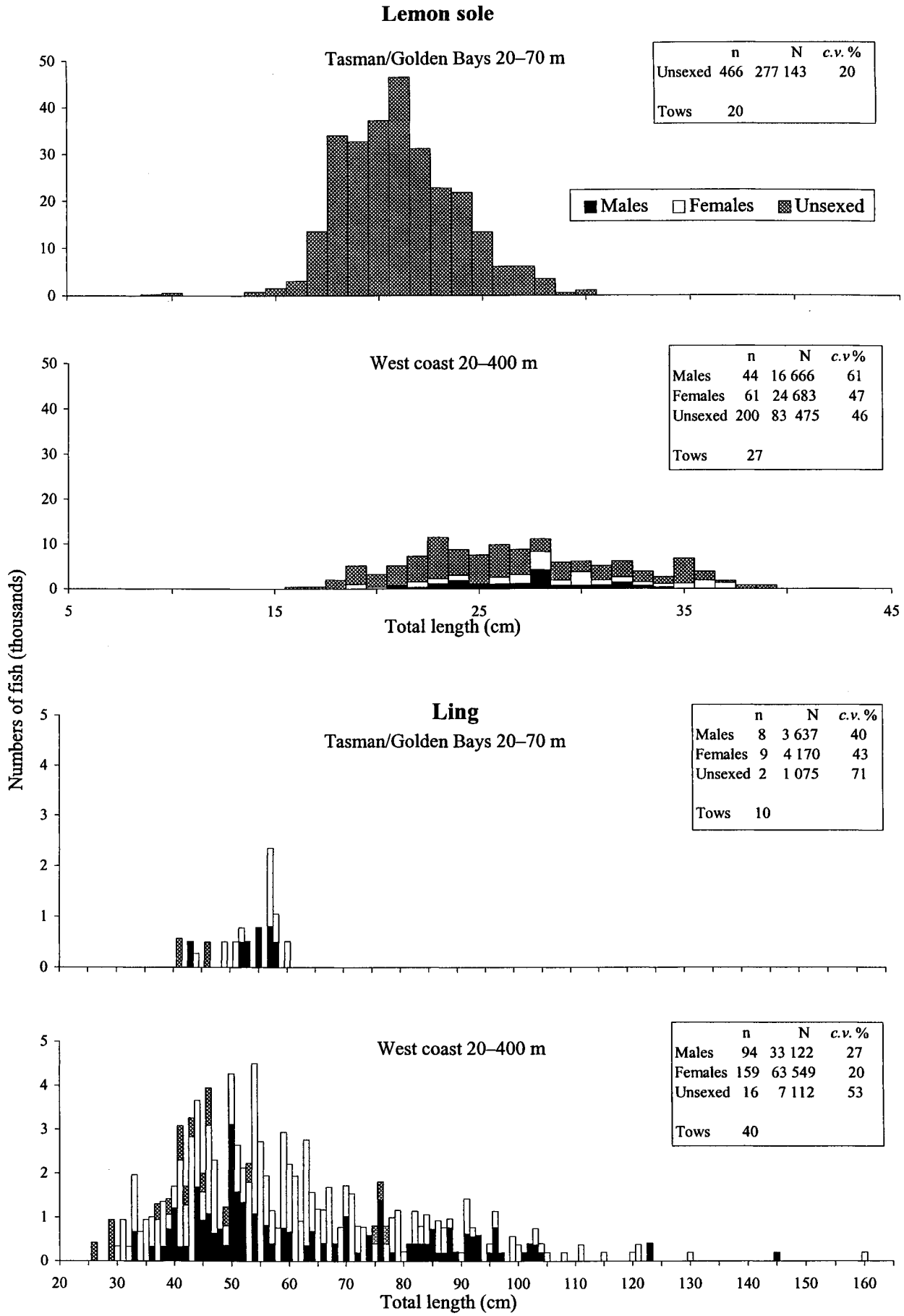


Figure 4—*continued*

Figure 4—*continued*

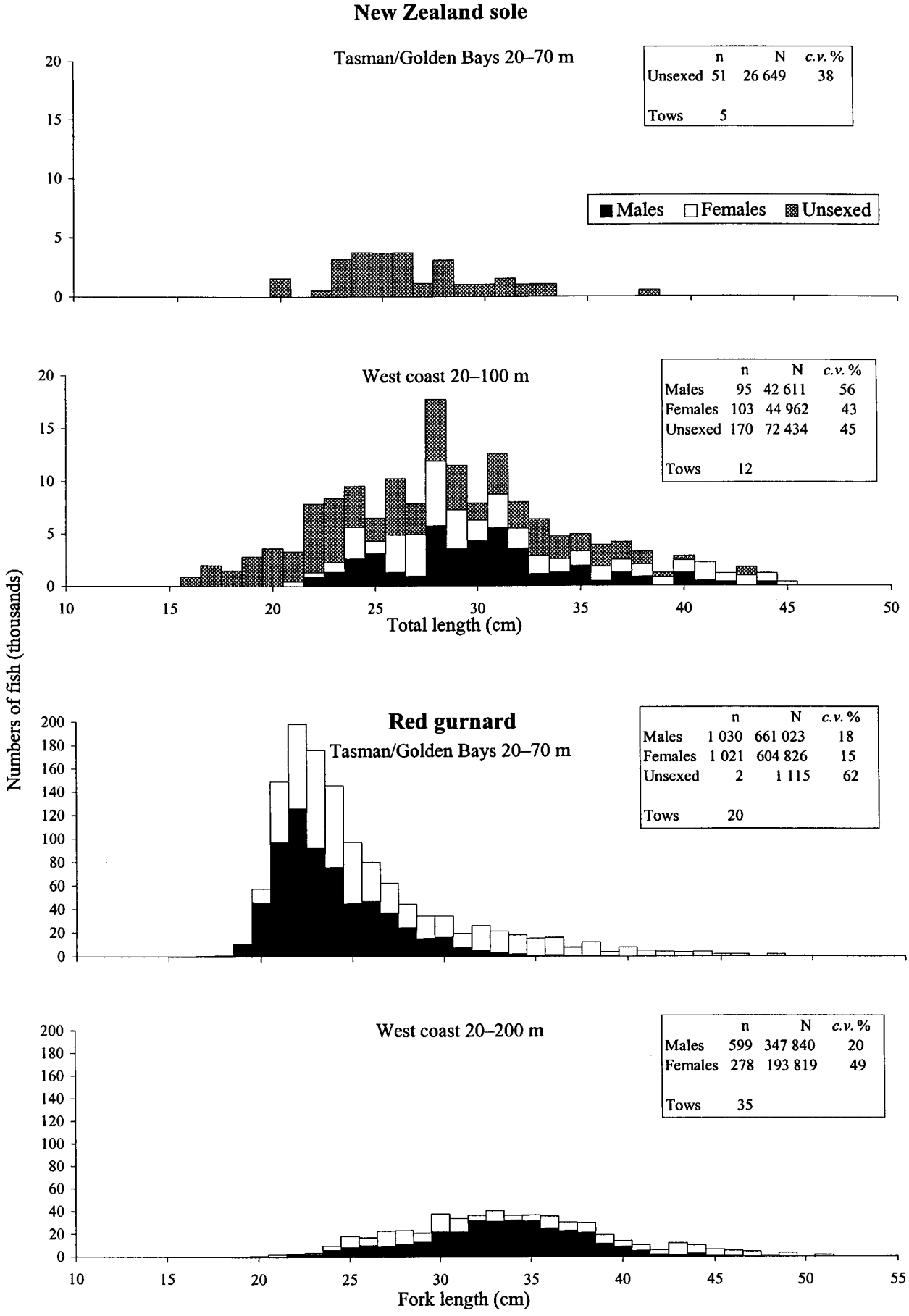


Figure 4—*continued*

Figure 4—*continued*

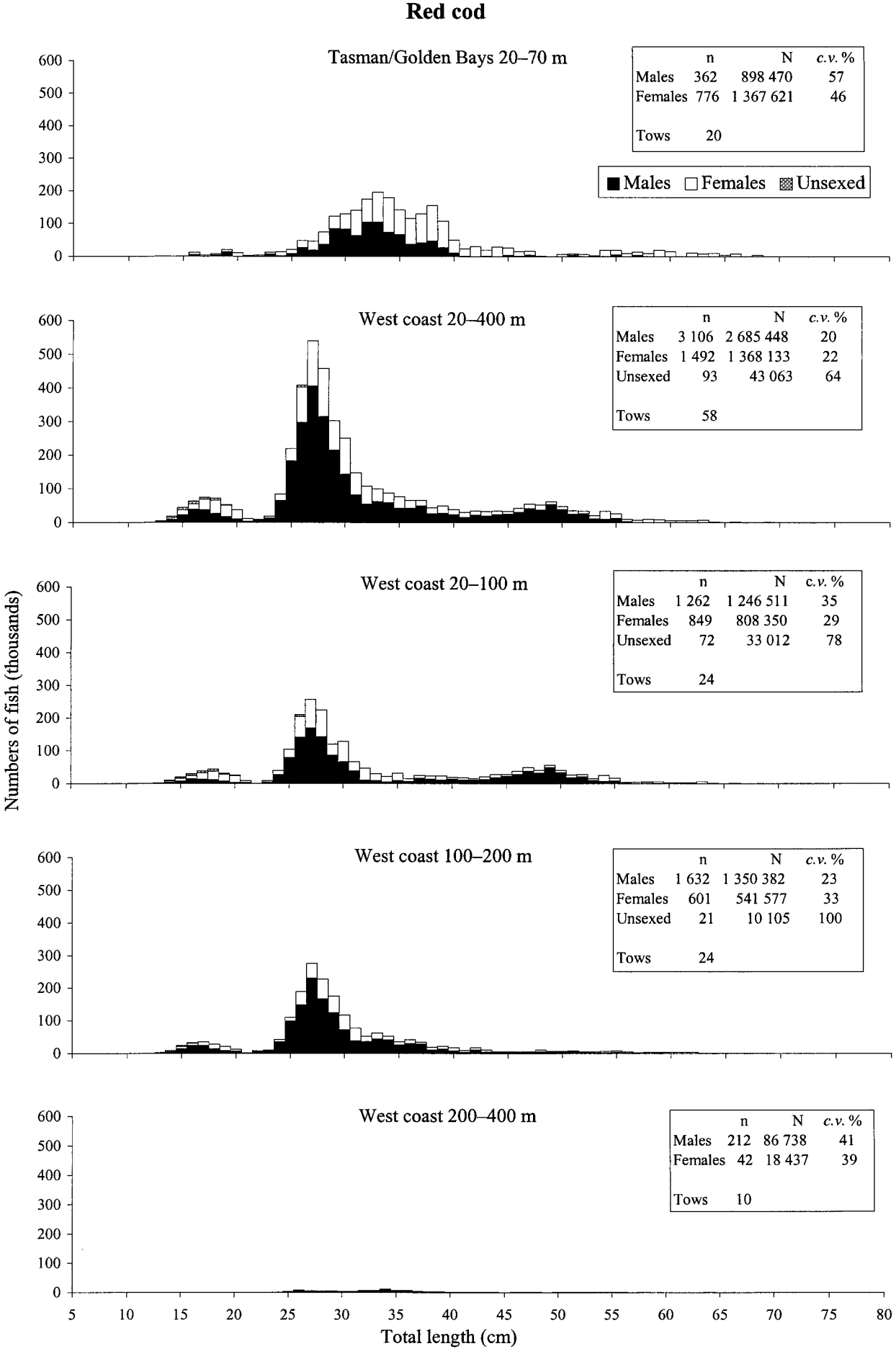
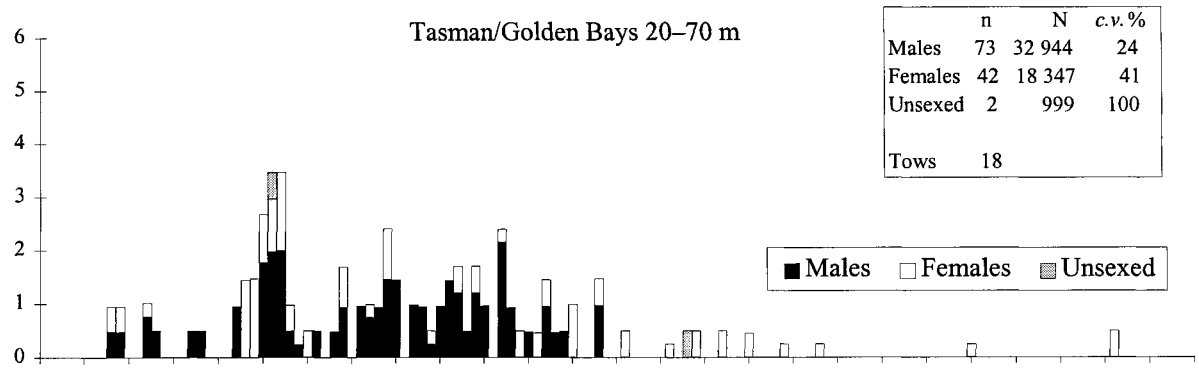
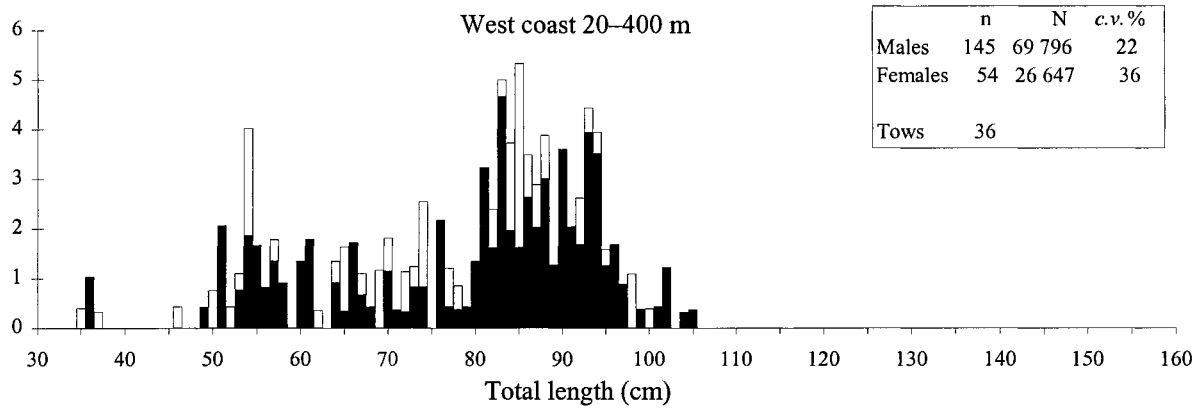


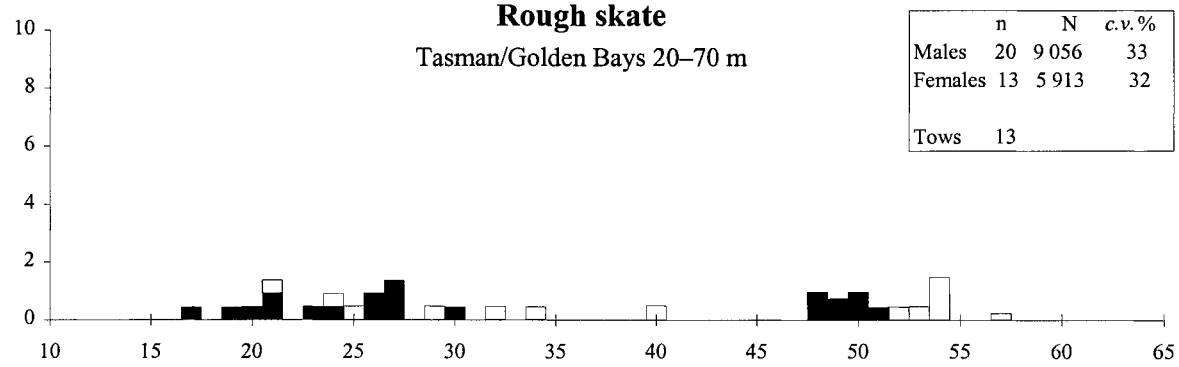
Figure 4—*continued*

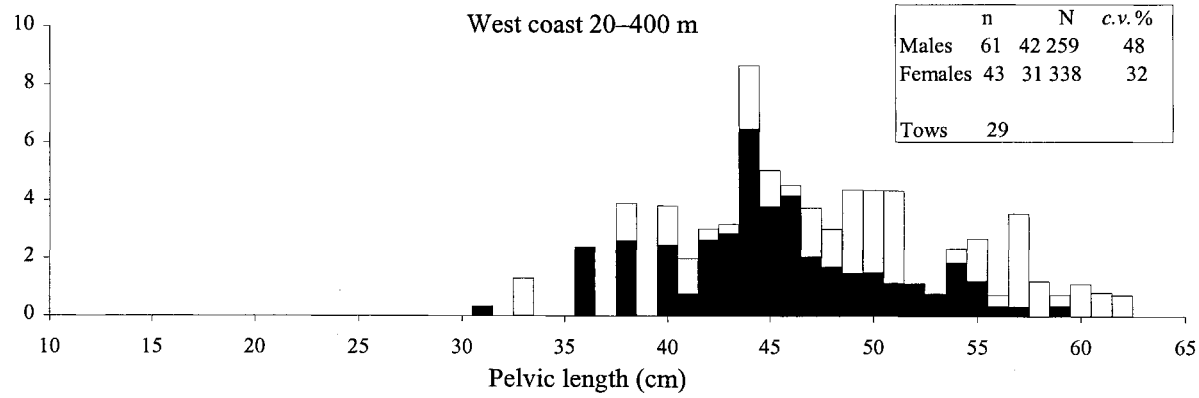
Rig





Rough skate





Numbers of fish (thousands)

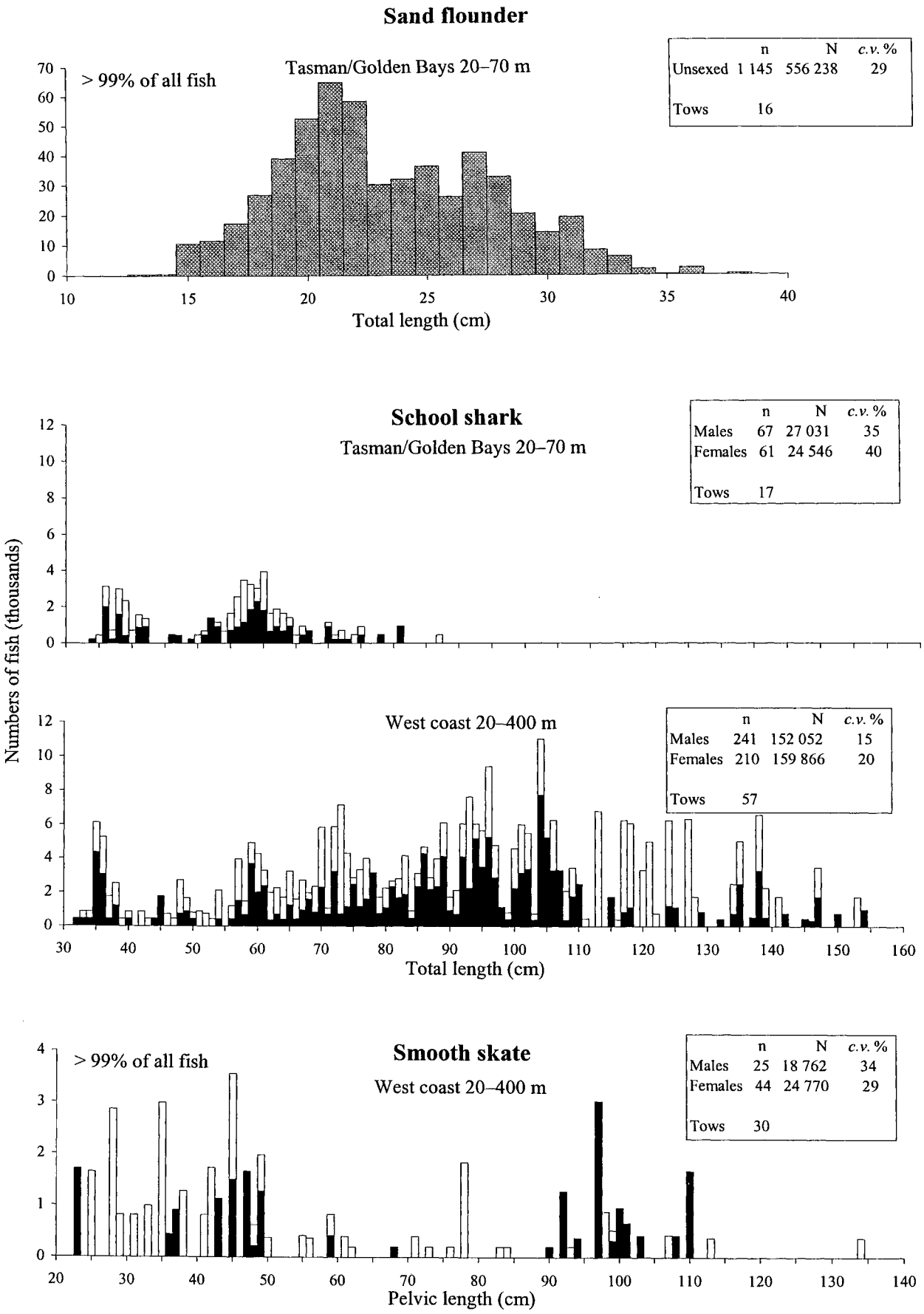
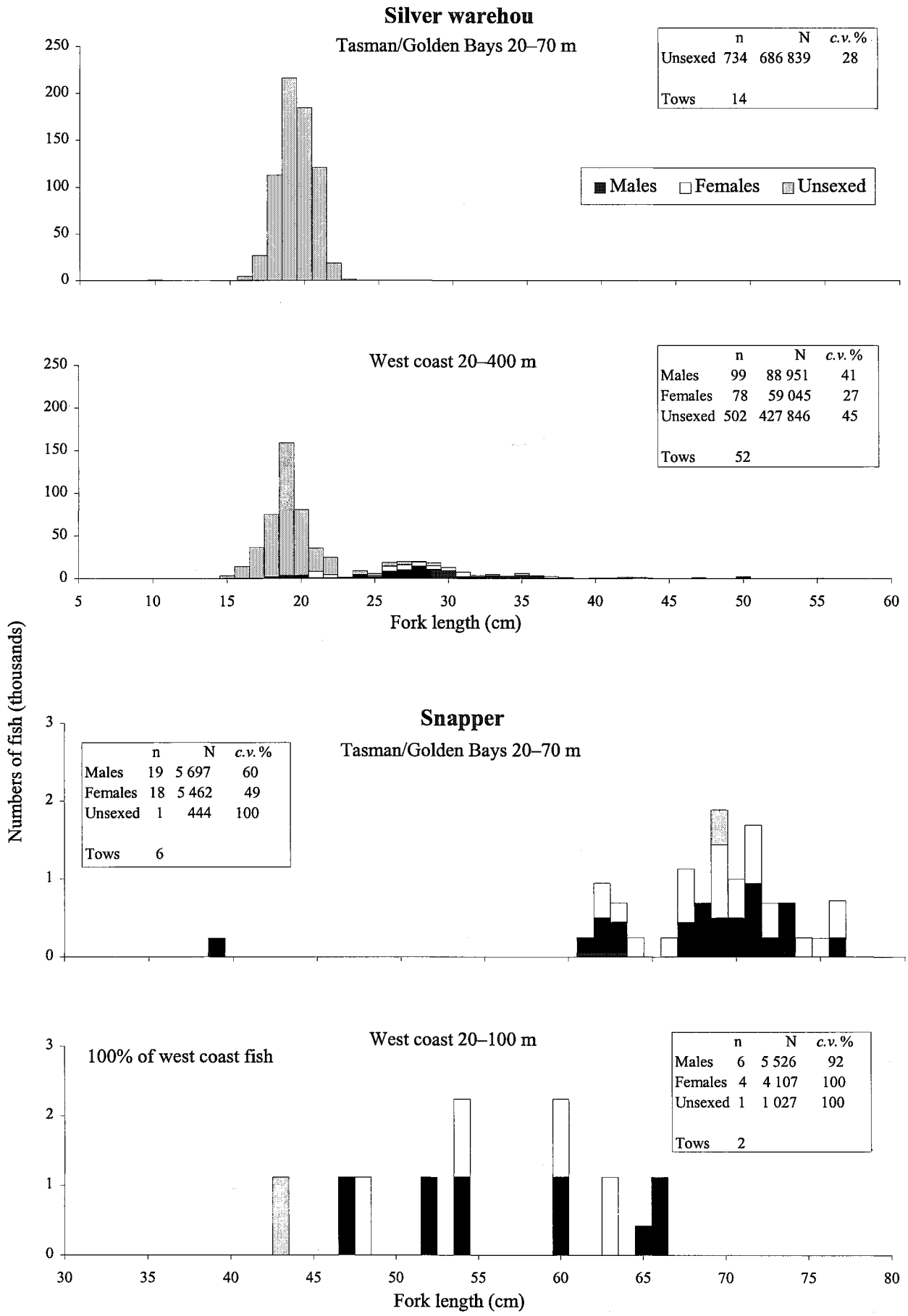


Figure 4—*continued*


Silver warehou
Tasman/Golden Bays 20–70 m
n N c.v. %
Unsexed 734 686 839 28
Tows 14
Males Females Unsexed
West coast 20–400 m
n N c.v. %
Males 99 88 951 41
Females 78 59 045 27
Unsexed 502 427 846 45
Tows 52
Fork length (cm)
Numbers of fish (thousands)
Snapper
Tasman/Golden Bays 20–70 m
n N c.v. %
Males 19 5 697 60
Females 18 5 462 49
Unsexed 1 444 100
Tows 6
West coast 20–100 m
100% of west coast fish
n N c.v. %
Males 6 5 526 92
Females 4 4 107 100
Unsexed 1 1 027 100
Tows 2
Fork length (cm)

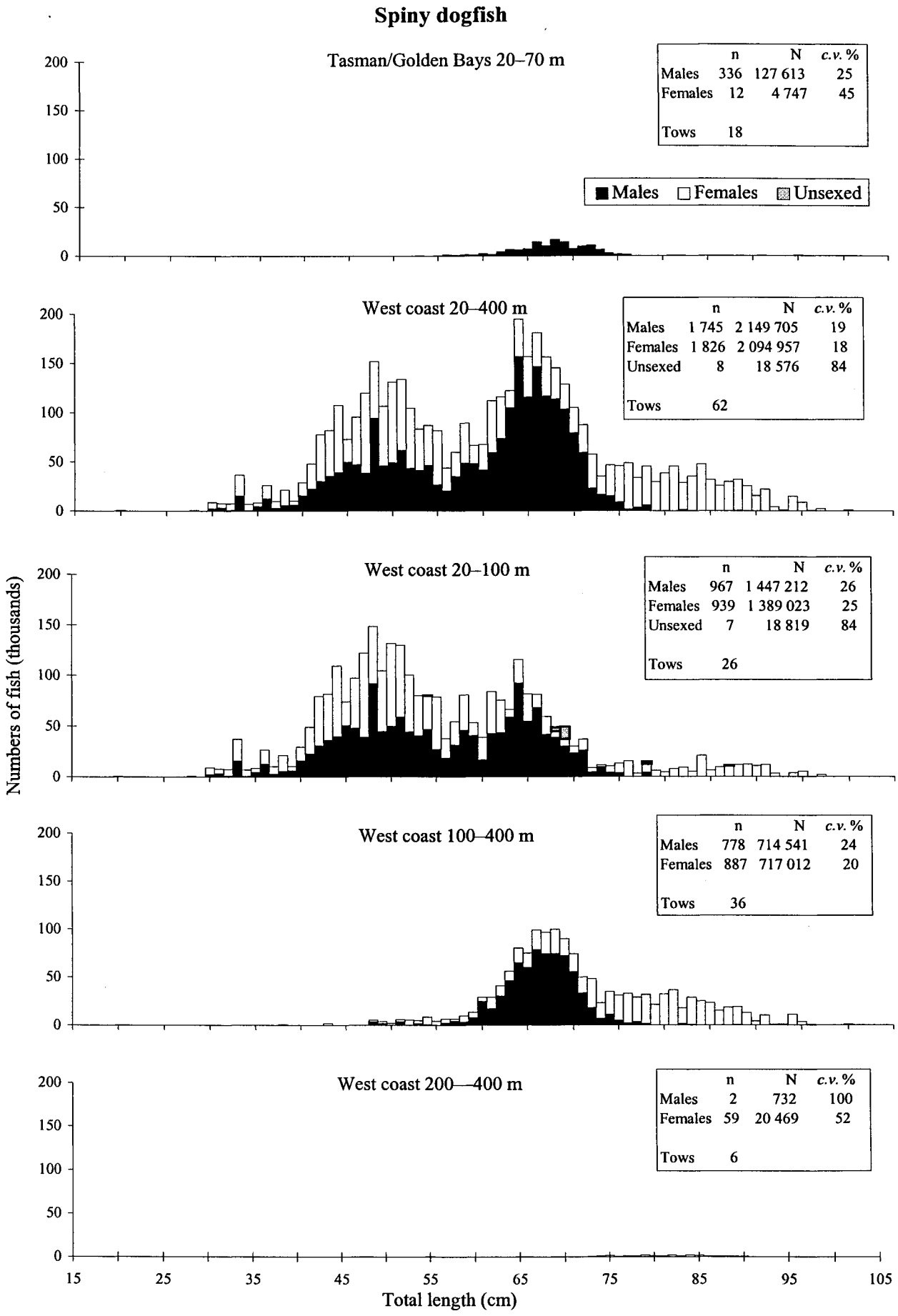
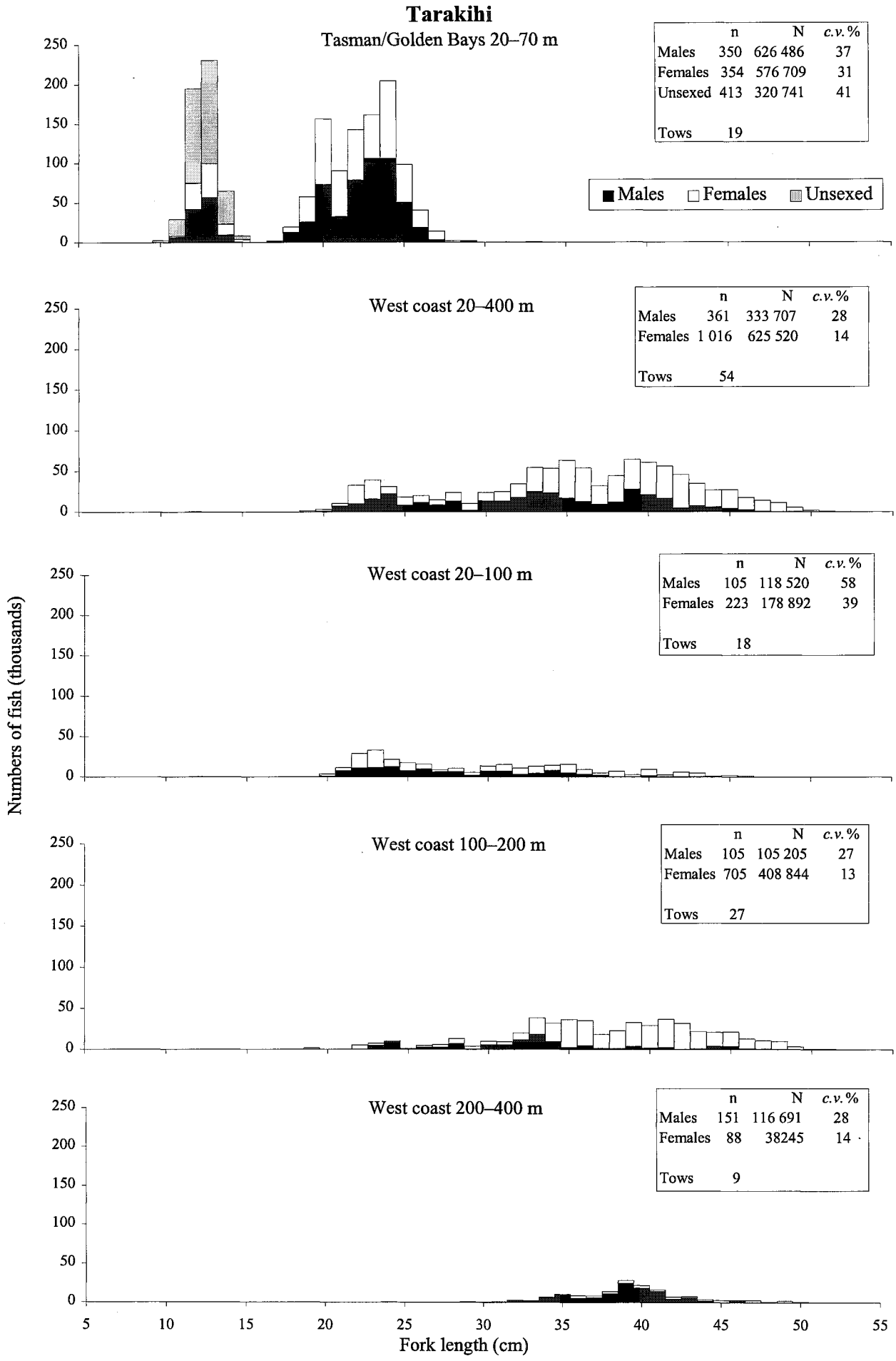


Figure 4—*continued*


Tarakihi
Tasman/Golden Bays 20–70 m
n N c.v.%
Males 350 626 486 37
Females 354 576 709 31
Unsexed 413 320 741 41
Tows 19
Males Females Unsexed
West coast 20–400 m
n N c.v.%
Males 361 333 707 28
Females 1 016 625 520 14
Tows 54
West coast 20–100 m
n N c.v.%
Males 105 118 520 58
Females 223 178 892 39
Tows 18
West coast 100–200 m
n N c.v.%
Males 105 105 205 27
Females 705 408 844 13
Tows 27
West coast 200–400 m
n N c.v.%
Males 151 116 691 28
Females 88 38245 14
Tows 9
Numbers of fish (thousands)
0 50 100 150 200 250
5 10 15 20 25 30 35 40 45 50 55
Fork length (cm)

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

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

Species	*a*	*b*	n	Range Min.	Range Max.	Data source
Barracouta	0.0052	2.98	919	15	96	DB, TAN9502
Blue cod	0.0122	3.07	2 137	12	47	DB, LHR9501
Blue warehou	0.0144	3.10	338	27.4	69.6	DB, TAN9604
Dark ghost shark	0.0018	3.30	525	30	74	DB, TAN9601
Elephantfish	0.0049	3.17	378	13.4	91	DB, KAH9618
Gemfish	0.0021	3.29	257	55	97	DB, TAN9301
Giant stargazer	0.0119	3.11	662	13	78	This survey
Hake	0.0020	3.29	420	37	123	DB, TAN9301
Hoki	0.0046	2.90	1 714	28	115	DB, TAN9209
Jack mackerel						
(*Trachurus declivis*)	0.0165	2.93	200	15	53	DB, COR9001
(*T. murphyi*)	0.0171	3.27	488	30.7	62	DB, TAN9502
(*T. novaezelandiae*)	0.0163	2.92	200	15	40	DB, COR9001
Lemon sole	0.0027	3.47	107	15	42	DB, KAH9608
Ling	0.0011	3.41	482	32	162	DB, TAN9501
New Zealand sole	0.0059	3.13	60	8	50	DB, James (1969)
Red cod	0.0124	2.91	1 327	14	69	This survey
Red gurnard	0.0053	3.19	780	19	51	This survey
Rig	0.0033	3.05	134	17	135	This survey
Rough skate	0.0346	2.87	134	17	62	This survey
Sand flounder	0.0125	3.02	–	–	–	DB, IKA8003
School shark	0.0042	3.03	523	32	154	This survey
Sea perch	0.0262	2.92	210	7	42	DB, KAH9618
Silver warehou	0.0047	3.37	427	16	58	DB, TAN9301
Smooth skate	0.0292	2.90	70	23	134	This survey
Snapper	0.0314	2.90	401	29	66	DB, KAH9602
Spiny dogfish	0.0007	3.45	1 052	43.4	104.4	DB, TAN9501
Tarakihi	0.0129	3.10	1 127	10	52	This survey

Group B: $W = aL^bL^{c(\ln L)}$

	a	*b*	*c*	n	Range (cm)	Data source
Arrow squid	0.2777	1.41	0.2605	2 792	3–45	DB, *James Cook*, east coast South Island 1982–83

Appendix 2: Summary of station data

			Start of tow			End of tow		Gear depth (m)		Distance trawled	Headline	Doorspread	Surface temp	Bottom temp
Station	Stratum	Date	Time	° ' S	° ' E	° ' S	° ' E	Min.	Max.	(n. miles)	height (m)	(m)	(°C)	(°C)
1	18	21-Mar-97	614	41 09.14	173 15.07	41 07.78	173 11.76	23	24	2.85	4.8	73.4	17.5	17.7
2	18	21-Mar-97	750	41 06.07	173 14.82	41 04.62	173 11.25	30	32	3.06	4.9	74.6	17.7	17.8
3	18	21-Mar-97	943	40 58.38	173 11.65	40 59.77	173 15.18	36	38	3.00	4.8	74.3	17.6	15.8
4	19	21-Mar-97	1310	40 59.56	173 31.10	41 01.57	173 27.82	41	46	3.19	4.8	76.0	17.9	16.8
5	1	22-Mar-97	642	40 33.54	172 17.85	40 32.13	172 21.55	88	91	3.15	4.6	83.2	16.3	13.8
6	1	22-Mar-97	924	40 42.66	172 14.88	40 41.29	172 18.15	40	41	2.84	4.7	77.6	14.9	14.0
7	2	22-Mar-97	1248	40 34.97	171 54.59	40 37.21	171 51.90	164	166	3.03	4.7	83.6	17.9	13.2
8	2	22-Mar-97	1427	40 40.31	171 53.63	40 42.90	171 51.65	138	140	3.00	4.8	80.8	17.4	12.8
9	1	23-Mar-97	629	41 06.93	172 02.51	41 09.93	172 01.73	57	59	3.06	5.4	75.8	15.9	13.4
10	5	23-Mar-97	949	41 24.67	171 43.92	41 27.38	171 41.88	90	94	3.12	4.8	78.9	16.4	12.6
11	5	23-Mar-97	1207	41 34.04	171 40.28	41 36.18	171 37.23	54	57	3.13	4.8	74.5	15.5	13.3
12	5	23-Mar-97	1416	41 40.81	171 25.94	41 43.16	171 23.59	93	96	2.94	5.0	77.2	16.0	12.8
13	7	23-Mar-97	1621	41 48.11	171 20.51	41 50.83	171 19.03	81	81	2.93	4.9	79.0	15.6	12.5
14	16	24-Mar-97	631	43 19.77	169 30.91	43 20.58	169 27.01	302	320	2.96	4.8	95.2	17.3	12.1
15	16	24-Mar-97	858	43 24.33	169 17.34	43 26.45	169 14.61	386	387	2.91	4.7	96.4	16.8	11.0
16	15	24-Mar-97	1130	43 26.35	169 16.81	43 24.98	169 19.29	281	300	2.26	4.7	83.3	16.3	12.0
17	14	24-Mar-97	1358	43 32.74	169 30.21	43 30.49	169 33.02	43	45	3.04	4.6	71.9	16.2	13.7
18	14	24-Mar-97	1533	43 31.03	169 37.94	43 29.19	169 41.35	23	24	3.10	4.8	70.8	14.5	14.2
19	15	25-Mar-97	632	43 29.08	169 24.50	43 31.23	169 21.69	104	117	2.96	5.1	70.6	16.3	12.8
20	15	25-Mar-97	825	43 30.44	169 16.96	43 32.91	169 14.57	135	139	3.02	4.7	76.0	16.6	13.0
21	15	25-Mar-97	1113	43 41.68	169 04.00	43 41.45	169 08.10	125	130	2.99	4.5	70.7	15.1	12.8
22	14	25-Mar-97	1344	43 43.41	169 06.96	43 42.28	169 10.70	88	98	2.94	4.4	71.3	14.4	13.7
23	14	25-Mar-97	1632	43 47.33	169 03.57	43 48.69	168 59.73	43	49	3.10	4.6	78.3	–	14.2
24	15	26-Mar-97	630	43 21.75	169 47.42	43 19.57	169 50.34	104	111	3.05	4.6	71.5	–	13.4
25	16	26-Mar-97	953	43 15.80	169 34.54	43 13.32	169 36.53	353	363	2.87	5.0	88.4	16.9	11.8
26	13	26-Mar-97	1143	43 12.85	169 40.51	43 10.17	169 41.24	261	270	2.74	4.8	86.2	16.7	12.1
27	13	26-Mar-97	1345	43 12.04	169 43.76	43 15.01	169 44.71	213	215	3.05	5.0	79.0	–	12.4
28	12	26-Mar-97	1540	43 13.48	169 49.74	43 16.31	169 48.67	169	175	2.93	5.0	79.0	–	12.3
29	14	27-Mar-97	645	43 20.56	169 51.25	43 18.23	169 53.93	81	84	3.04	5.0	79.3	14.2	13.3
30	15	27-Mar-97	848	43 17.64	169 51.77	43 15.20	169 54.18	126	134	3.01	5.0	81.3	16.3	12.6
31	11	27-Mar-97	1213	43 13.71	169 59.99	43 11.40	170 02.62	70	72	3.00	5.0	75.0	16.4	13.7

Appendix 2—*continued*

Station	Stratum	Start of tow				End of tow		Gear depth (m)		Distance trawled	Headline	Doorspread	Surface temp	Bottom temp
		Date	Time	° ' S	° ' E	° ' S	° ' E	Min.	Max.	(n. miles)	height (m)	(m)	(°C)	(°C)
32	12	27-Mar-97	1430	43 06.17	169 53.20	43 03.49	169 55.35	176	183	3.10	5.0	85.5	17.4	12.4
33	13	27-Mar-97	1648	43 00.27	169 48.41	42 58.46	169 51.33	346	352	2.80	5.0	92.8	17.0	12.2
34	12	28-Mar-97	635	42 59.14	170 01.32	42 56.63	170 03.87	169	172	3.17	5.0	79.6	16.6	12.5
35	12	28-Mar-97	818	42 54.76	170 05.10	42 52.13	170 06.70	173	174	2.88	5.0	75.1	16.8	12.5
36	13	28-Mar-97	1004	42 51.92	170 03.55	42 48.86	170 02.88	201	216	3.09	4.9	75.1	–	12.7
37	13	28-Mar-97	1153	42 46.49	170 04.23	42 49.46	170 03.57	200	203	3.00	5.0	85.9	–	12.6
38	12	28-Mar-97	1341	42 50.60	170 05.74	42 47.99	170 07.52	169	182	2.92	4.7	88.4	–	12.9
39	12	28-Mar-97	1537	42 48.89	170 14.57	42 52.03	170 14.73	129	137	3.14	4.9	79.0	–	12.9
40	12	29-Mar-97	634	42 47.33	170 09.52	42 44.73	170 11.04	152	160	2.83	5.0	77.2	–	12.8
41	12	29-Mar-97	823	42 40.13	170 15.19	42 38.72	170 18.72	144	154	2.96	4.8	80.7	16.0	12.6
42	12	30-Mar-97	635	42 44.22	170 19.61	42 42.20	170 22.57	113	120	2.97	4.9	81.4	16.9	13.0
43	12	30-Mar-97	840	42 41.95	170 22.89	42 39.86	170 25 46	113	132	2.82	4.9	78.2	16.0	13.0
44	11	30-Mar-97	1029	42 42.41	170 25.72	42 41.82	170 29.82	91	100	3.08	4.9	73.1	16.5	13.3
45	11	30-Mar-97	1316	42 43 46	170 39.43	42 40.92	170 37.41	86	97	2.94	4.8	75.8	16.8	13.1
46	13	30-Mar-97	1523	42 33.33	170 41.51	42 30.98	170 43.87	243	268	2.92	4.7	87.7	16.5	13.3
47	11	31-Mar-97	626	43 11.27	170 06.05	43 08.88	170 08.64	32	32	3.05	5.3	74.0	16.2	14.0
48	11	31-Mar-97	757	43 06.36	170 09.22	43 04.31	170 12.30	41	48	3.05	5.4	74.8	16.4	13.7
49	11	31-Mar-97	947	43 00.17	170 19.72	42 58.36	170 23.21	32	35	3.14	5.4	75.2	16.5	14.9
50	11	31-Mar-97	1125	42 57.11	170 21.99	42 54.72	170 24.11	48	51	2.85	5.5	73.4	17.8	14.4
51	11	31-Mar-97	1306	42 54.02	170 25.04	42 51.60	170 27.04	49	49	2.83	5.4	72.6	17.1	14.3
52	11	31-Mar-97	1458	42 48.58	170 35.75	42 48.28	170 39.74	38	41	2.95	5.0	74.8	17.1	13.0
53	11	1-Apr-97	630	42 39.63	170 56.68	42 37.45	170 59.29	29	33	2.91	5.0	73.1	15.2	14.8
54	7	1-Apr-97	856	42 26.72	171 02.61	42 24.17	171 04.59	63	64	2.94	5.3	79.0	15.5	13.6
55	7	1-Apr-97	1025	42 22.06	171 07.40	42 19.20	171 09.08	34	35	3.11	5.3	74.5	15.6	14.0
56	9	2-Apr-97	642	42 04.78	170 32.95	42 01.97	170 33.53	389	401	2.85	5.0	91.6	18.2	11.0
57	9	2-Apr-97	837	42 00.15	170 37.28	41 57.34	170 38.23	291	297	2.90	5.0	88.4	18.2	12.3
58	9	2-Apr-97	1026	41 54.45	170 35.89	41 51.50	170 35.85	385	395	2.95	4.9	94.2	18.4	11.0
59	8	2-Apr-97	1252	41 50.80	170 49.51	41 53.51	170 51.25	188	200	3.01	4.9	78.8	18.3	12.7
60	8	2-Apr-97	1432	41 51.56	170 54.32	41 48.76	170 55.98	170	175	3.05	5.0	83.5	18.5	12.8
61	18	4-Apr-97	1400	41 07.58	173 19.00	41 05.25	173 21.36	27	34	2.93	4.8	77.7	18.4	17.0
62	18	4-Apr-97	1527	41 04.88	173 21.25	41 02.31	173 23.02	36	42	2.95	4.9	78.3	18.6	16.7

Appendix 2—*continued*

Station	Stratum	Start of tow Date	Time	° ' S	° ' E	End of tow ° ' S	° ' E	Gear depth (m) Min.	Max.	Distance trawled (n. miles)	Headline height (m)	Doorspread (m)	Surface temp (°C)	Bottom temp (°C)
63	19	5-Apr-97	625	40 59.80	173 25.24	40 57.24	173 27.29	45	49	3.00	4.8	77.0	17.6	16.2
64	19	5-Apr-97	833	40 50.28	173 33.69	40 48.12	173 30.95	54	58	3.01	5.0	77.2	17.1	15.8
65	19	5-Apr-97	1052	40 51.07	173 18.55	40 49.02	173 15.51	45	46	3.08	4.9	77.6	17.2	15.8
66	17	5-Apr-97	1335	40 41.12	172 5984	40 39.80	172 56.33	33	35	2.98	5.1	75.0	17.4	16.1
67	17	5-Apr-97	1510	40 38.01	172 53.96	40 38.61	172 50.03	29	30	3.05	5.1	75.2	17.5	16.5
68	17	6-Apr-97	633	40 42.74	172 47.05	40 43.74	172 50.87	23	27	3.07	5.0	71.9	17.1	16.5
69	19	6-Apr-97	915	40 45.68	173 09.85	40 47.39	173 13.25	45	47	3.09	4.7	77.6	17.5	16.5
70	19	6-Apr-97	1119	40 45.66	173 24.49	40 47.70	173 27.36	52	53	2.90	4.8	78.0	16.9	15.1
71	19	6-Apr-97	1325	40 49.82	173 28.42	40 52.41	173 30.14	51	51	2.90	5.0	77.8	16.4	15.3
72	19	6-Apr-97	1536	40 52.78	173 19.56	40 55.11	173 22.06	44	47	3.00	5.0	77.9	17.2	15.8
73	2	10-Apr-97	637	41 11.75	171 06.71	41 14.22	171 04.83	185	185	2.85	5.0	84.0	17.5	13.1
74	6	10-Apr-97	837	41 17.08	170 59.29	41 19.70	170 57.34	198	198	3.00	5.0	85.8	17.4	13.2
75	6	10-Apr-97	1053	41 19.97	171 07.87	41 22.98	171 08.11	182	188	3.01	5.1	87.9	17.8	13.0
76	6	10-Apr-97	1305	41 29.89	171 15.36	41 32.88	171 15.39	149	150	2.99	5.0	78.6	16.9	12.6
77	6	10-Apr-97	1455	41 32.46	171 20.93	41 29.38	171 21.62	141	143	3.12	5.0	80.8	16.4	13.3
78	8	11-Apr-97	634	41 44.58	171 09.82	41 46.91	171 07.24	155	155	3.02	4.8	80.2	16.1	12.6
79	8	11-Apr-97	843	41 47.11	171 06.92	41 49.37	171 04.35	158	161	2.97	5.0	82.3	15.9	12.6
80	8	11-Apr-97	1051	41 50.46	171 12.99	41 53.22	171 11.04	143	146	3.12	5.0	78.3	15.9	12.6
81	7	11-Apr-97	1330	41 58.67	171 19.66	42 01.54	171 17.91	49	49	3.16	5.3	78.2	16.6	14.5
82	7	11-Apr-97	1610	42 07.26	171 09.33	42 04.62	171 11.33	84	89	3.02	5.1	80.2	15.7	13.2
83	8	12-Apr-97	644	42 03.88	170 55.30	42 00.97	170 55.31	183	188	2.90	5.1	78.3	17.5	12.7
84	8	12-Apr-97	836	42 01.92	171 02.39	41 59.33	171 04.54	155	158	3.04	5.2	72.1	16.6	12.2
85	19	13-Apr-97	640	40 37.59	173 05.46	40 37.65	173 09.26	42	48	2.89	5.1	73.6	16.6	14.6
86	19	13-Apr-97	934	40 43.89	173 32.03	40 46.55	173 33.84	54	56	2.99	4.9	74.2	16.7	15.5
87	19	13-Apr-97	1139	40 51.92	173 40.44	40 54.34	173 37.78	55	56	3.15	5.0	75.0	17.2	15.9
88	19	13-Apr-97	1316	40 57.45	173 37.42	40 59.55	173 34.52	47	50	3.04	4.9	75.6	16.6	16.0

– No data

Appendix 3: Species caught, total weight, occurrence (Occ.), and depth range of all species caught

Species Code	Common name	Scientific name	Catch (kg)	Occ.	Depth (m) Min.	Depth (m) Max.
ANC	Anchovy	*Engraulis australis*	5.9	9	23	49
BAR	Barracouta	*Thyrsites atun*	5 150.9	79	23	395
BCO	Blue cod	*Parapercis colias*	245.2	18	23	58
BEN	Scabbardfish	*Benthodesmus* spp.	0.2	1	353	363
BNS	Bluenose	*Hyperoglyphe antarctica*	9.0	2	346	401
BRI	Brill	*Colistium guntheri*	4.4	5	23	49
BSQ	Broad squid	*Sepioteuthis australis*	4.5	3	33	56
CAR	Carpet shark	*Cephaloscyllium isabella*	1 309.9	76	23	401
CBI	Two saddle rattail	*Caelorinchus biclinozonalis*	1 490.2	16	41	161
CDO	Capro dory	*Capromimus abbreviatus*	39.4	27	81	401
CON	Conger eel	*Conger* spp.	43.6	7	30	57
CUC	Cucumberfish	*Chlorophthalmus nigripinnis*	112.8	23	81	401
EGR	Eagle ray	*Myliobatis tenuicaudatus*	115.9	8	23	56
ELE	Elephantfish	*Callorhinchus milii*	238.9	9	29	89
EMA	Blue mackerel	*Scomber australasicus*	7.5	3	104	155
ERA	Electric ray	*Torpedo fairchildi*	191.8	14	23	134
ESO	N.Z. sole	*Peltorhamphus novaezelandiae*	118.3	17	23	98
FHD	Deepsea flathead	*Hoplichthys haswelli*	10.5	5	281	401
FRO	Frostfish	*Lepidopus caudatus*	538.0	34	42	401
GSH	Dark ghost shark	*Hydrolagus novaezelandiae*	1 148.8	30	54	401
GUR	Red gurnard	*Chelidonichthys kumu*	989.9	55	23	200
HAG	Hagfish	*Eptatretus cirrhatus*	0.9	1	389	401
HAK	Hake	*Merluccius australis*	1 873.0	42	23	387
HAP	Hapuku	*Polyprion oxygeneios*	44.1	7	91	216
HEP	Sharpsnouted sevengill shark	*Heptranchias perlo*	6.3	1	243	268
HOK	Hoki	*Macruronus novaezelandiae*	2 870.5	45	30	401
JAV	Javelinfish	*Lepidorhynchus denticulatus*	43.8	6	113	401
JDO	John dory	*Zeus faber*	37.1	11	29	175
JMD	N.Z. jack mackerel	*Trachurus declivis*	303.0	45	23	198
JMM	Chilean jack mackerel	*Trachurus murphyi*	109.5	29	29	200
JMN	N.Z. jack mackerel	*Trachurus novaezelandiae*	727.7	27	23	94
KAH	Kahawai	*Arripis trutta*	4.9	2	29	35
KIN	Kingfish	*Seriola lalandi*	42.2	3	43	56
LDO	Lookdown dory	*Cyttus traversi*	17.9	3	346	387
LEA	Leatherjacket	*Parika scaber*	422.1	18	23	58
LIN	Ling	*Genypterus blacodes*	479.9	50	23	387
LSK	Longtailed skate	*Arhynchobatis asperrimus*	5.4	2	385	401
LSO	Lemon sole	*Pelotretis flavilatus*	167.4	47	23	320
MDO	Mirror dory	*Zenopsis nebulosus*	3.5	2	291	352
MOK	Blue moki	*Latridopsis ciliaris*	3.8	1	40	41
MSG	Green-lipped mussel	*Perna canaliculus*	24.9	4	23	34
NSD	Northern spiny dogfish	*Squalus mitsukuri*	119.9	12	40	401
OCT	Octopus	*Octopus maorum*	13.7	12	23	130
OPA	Opalfish	*Hemerocoetes* spp.	0.7	7	41	188
OPE	Orange perch	*Lepidoperca aurantia*	11.9	3	201	401
OYS	Dredge oyster	*Tiostrea chilensis*	0.5	3	23	34
PAD	Paddle crab	*Ovalipes catharus*	0.1	1	32	32
PCO	Ahuru	*Auchenoceros punctatus*	2.5	10	29	64

Appendix 3—*continued*

Species Code	Common name	Scientific name	Catch (kg)	Occ.	Depth (m) Min.	Depth (m) Max.
POP	Porcupine fish	*Allomycterus jaculiferus*	*	1	30	32
GLB+	Globefish	*Contusus richei*	17.3	4	32	48
RAT	Rattails	Macrouridae	7 762.2	47	29	401
RBT	Redbait	*Emmelichthys nitidus*	33.1	12	43	200
RCO	Red cod	*Pseudophycis bachus*	5 235.3	78	23	401
RHY	Common roughy	*Paratrachichthys trailli*	4.5	2	113	352
RMU	Red mullet	*Upeneichthys lineatus*	4.1	4	29	49
RSK	Rough skate	*Raja nasuta*	304.9	42	29	401
SAR	Mantis shrimp	*Squilla armata*	0.2	2	155	155
SCA	Scallop	*Pecten novaezelandiae*	0.1	1	30	32
SCG	Scaly gurnard	*Lepidotrigla brachyoptera*	485.1	64	27	297
SCH	School shark	*Galeorhinus galeus*	1 569.9	74	23	300
SCI	Scampi	*Metanephrops challengeri*	0.2	1	302	320
SCO	Swollenhead conger	*Bassanago bulbeceps*	4.2	1	386	387
SDO	Silver dory	*Cyttus novaezelandiae*	2 490.7	40	43	395
SDR	Spiny seadragon	*Solegnathus spinosissimus*	0.6	5	129	216
SFI	Starfish	Echinodermata	0.2	2	27	155
SFL	Sand flounder	*Rhombosolea plebeia*	249.7	18	23	58
SKI	Gemfish	*Rexea solandri*	1 650.3	7	243	395
SNA	Snapper	*Pagrus auratus*	286.3	8	23	50
SPD	Spiny dogfish	*Squalus acanthias*	9 603.8	81	23	352
SPE	Sea perch	*Helicolenus* spp.	721.6	49	29	401
SPM	Stout sprat	*Sprattus muelleri*	10.8	12	23	137
SPO	Rig	*Mustelus lenticulatus*	671.5	54	23	268
SPR	Sprat	*Sprattus antipodum , S. muelleri*	8.2	13	23	94
SPS	Speckled sole	*Peltorhamphus latus*	0.3	2	23	32
SPZ	Spotted stargazer	*Genyagnus monopterygius*	0.1	1	30	32
SQU	Arrow squid	*Nototodarus sloanii, N. gouldi*	1 224.0	85	23	401
SQP	Sepiolid squid	*Sepioloidea pacifica*	0.1	1	32	35
SSH	Slender smoothhound	*Gollum attenuatus*	61.3	3	353	401
SSI	Silverside	*Argentina elongata*	21.7	38	32	401
SSK	Smooth skate	*Raja innominata*	500.9	31	44	401
STA	Giant stargazer	*Kathetostoma giganteum*	3 242.4	61	29	387
STR	Stingray	*Dasyatis* spp.	31.8	2	36	47
STY	Spotty	*Notolabrus celidotus*	85.2	12	23	50
SWA	Silver warehou	*Seriolella punctata*	324.7	66	23	401
TAR	Tarakihi	*Nemadactylus macropterus*	1 989.7	73	23	401
THR	Thresher shark	*Alopias vulpinus*	40.2	2	34	47
TOD	Dark toadfish	*Neophrynichthys latus*	1.0	6	93	395
TRE	Trevally	*Pseudocaranx dentex*	20.2	2	29	41
TUR	Turbot	*Colistium nudipinnis*	10.9	3	29	41
WAR	Blue warehou	*Seriolella brama*	2 191.7	47	23	183
WIT	Witch	*Arnoglossus scapha*	1 069.1	83	23	401
YBF	Yellowbelly flounder	*Rhombosolea leporina*	15.9	3	23	34
YBO	Yellow boarfish	*Pentaceros decacanthus*	0.4	1	213	215
YEM	Yelloweyed mullet	*Aldrichetta forsteri*	5.8	2	23	32
			61 069.7			

* Counted but not weighed
+ Temporary code

Appendix 4: Catch (kg) by station for the 15 most abundant commercially important species and all species combined. Species codes are given in Appendix 3.

	Species code															
Station	BAR	GUR	HAK	HOK	JMN	RCO	SCH	SDO	SKI	SPD	SPE	SQU	STA	TAR	WAR	All species
1	12.4	13.2	0	0	53.7	3.4	34.1	0	0	0	0	4	0	0.1	2.3	284.6
2	26.1	38.1	0.3	0.1	9	111.7	0.8	0	0	25	0	1.6	0	0.1	5	384.6
3	31.6	21.1	3.7	0	4.2	46	0.4	0	0	90	1.6	9.8	0	30.2	1.5	396.7
4	50.2	52.6	6.2	0.1	1.8	199.8	1.7	0	0	39.9	0	15	0.2	0.1	1.1	518.0
5	2.7	6.4	0	0	0.7	0	39.8	21.7	0	212.2	0	31	0	61.6	0	429.9
6	6.7	7.4	0	0	0	0.2	36.3	0	0	294.1	0	3.5	0	19.5	20	554.2
7	0	0	0	0	0	0	3.3	1.3	0	18.9	0.8	7.6	0	0.0	0	76.4
8	2.1	0	0	0	0	0	51.6	0	0	51.3	1.9	36.8	0	9.5	0	323.2
9	2.8	16.7	100.3	0	61.2	35.7	15	0	0	26.6	0	0.8	0	1.2	0	680.3
10	129.3	10.1	0.9	0	4.9	194.9	0	9.5	0	283.1	0	13.9	0	9.7	0	966.8
11	137.5	25.9	21.2	0	27	25.6	0.9	0	0	56.2	0	0.8	0	0.7	0	414.5
12	15.8	5.2	406.6	0.1	0	66.4	18.7	0	0	70.6	0	0.6	1.4	10.9	0	961.4
13	20.7	3.7	15.5	2.1	0.8	34.7	20.1	0.1	0	25.7	0	4.6	0.9	9.7	0.4	387.7
14	0	0	15.9	93.4	0	3.6	0	0	4.4	26.1	0.3	13	67.6	0.0	0	339.0
15	0	0	2.4	390.8	0	1	0	0	0	0	8	22.1	36	0.0	0	811.2
16	0	0	4.3	498.3	0	27.2	3.4	0.3	4.4	6.7	0.3	9.9	36.4	0.0	0	702.3
17	0.2	17.1	0	0	0	0	0	0	0	15.2	0	4	0	0.1	70.9	196.2
18	70.8	105.7	1.9	0	0	60.9	13.6	0	0	650.2	0	1	0	0.0	39.3	990.8
19	29.2	0	1	19.7	0	38.1	37	0.1	0	112.7	1.1	20.7	21.1	21.0	20.5	467.8
20	83.9	0	0.7	26.6	0	87.5	9.7	1.8	0	58.7	33.5	11.1	85.4	78.4	9.4	625.5
21	58	0	644.6	75.3	0	62	2.3	32.4	0	45.9	0.4	10.4	19.9	51.1	542.8	1 727.1
22	57.6	0	3.1	28.2	0	16.4	4.9	112.8	0	20	0.1	15.3	272.7	19.6	6.1	645.2
23	4.5	8.8	0	0	0	4.2	0	0.1	0	765.4	0	8.4	49	0.0	0	905.9
24	39.7	0.8	22	74.4	0	142.8	39.6	0.1	0	688.8	0.2	28.5	191	22.6	208.5	2 449.0
25	0	0	0	70.8	0	3.1	0	0	10	0	4.2	11.1	39.6	3.7	0	212.7
26	12.4	0	0	0	0	2.8	5.7	6.1	0	0	52.7	32	70.7	125.7	0	586.6
27	6.7	0	0	3.7	0	1.8	9.3	5.4	0	1.8	37.1	17.2	105.7	27.8	0	245.4
28	51.7	0	2.5	160	0	34	12.2	0.7	0	40.4	34.1	24.2	80.9	101.1	28.2	911.4
29	8.5	6.7	11.6	1.5	0	50.2	37.1	0	0	109.2	0	19.3	114.9	17.5	114.6	834.9
30	134.2	0	15.4	452.1	0	51.2	114.8	0.3	0	786.5	7.9	66.9	140.3	36.3	67.7	3 496.5
31	20.7	0.7	11.6	1.8	0	20	15.5	0	0	32.8	0	6.3	45.6	6.3	317.2	676.0

Appendix 4—*continued*

Station	Species code															
	BAR	GUR	HAK	HOK	JMN	RCO	SCH	SDO	SKI	SPD	SPE	SQU	STA	TAR	WAR	All species
32	15.2	0	0	7.8	0	14.3	16.6	0.4	0	37.2	48.8	22.3	94.3	36.1	29.6	643.4
33	0	0	0	44.7	0	7.3	0	0	1 521.4	8.8	14.3	5.3	45.1	31.8	0	1 858.6
34	60.6	0	0	4.1	0	26	9.7	0	0	91.9	13	36.4	49.2	20.5	3.1	534.0
35	45.8	0	0	5	0	44.3	47.8	0.3	0	173.4	42.3	37.7	89.9	35.4	3.8	624.3
36	31.1	0	0	0	0	7.6	11.4	3.5	0	38.2	44.7	11.8	144.8	7.6	0	374.2
37	18.4	0	0	0	0	50.4	11.4	4.2	0	70.5	24.8	27.8	80.4	44.1	0	394.7
38	4.5	0	0	0	0	4.4	33.9	0.4	0	114.8	60.5	25.5	82.5	35.5	0	393.2
39	123.9	0	0	77.2	0	46.1	20.1	0	0	137.4	56	30.6	80.1	21.2	31.7	964.0
40	46.2	0	0	3.1	0	29.1	22	0.1	0	93.6	24.1	24.1	69	51.8	11.7	458.6
41	70.6	0	0	9	0	53.8	5.5	8	0	100.5	16.8	14.2	38.4	82.6	9.3	600.3
42	32.7	0.7	1.1	46	0	19.6	15	3.8	0	71.3	0.6	20.3	41.9	42.4	84.1	1 054.6
43	31.5	0	8.3	153.4	0	37.6	22.6	8.8	0	49.3	0	15.1	70.7	30.6	3.6	1 289.3
44	24	0.7	3.5	235.2	0	63.6	4.7	0.8	0	77.5	0	11.3	77.5	14.6	23.4	2 908.5
45	1377	0	0	0.9	0	22.5	9.6	0.6	0	690.3	0	13.1	335.3	47.9	13.6	2 669.3
46	77.9	0	1.7	220.6	0	27.9	5.5	0	27.9	8.1	0.9	10.5	245.1	51.0	0	824.2
47	0	12.4	2.4	0	0	264.7	10.7	0	0	138.9	0	0	0	0.0	6.3	506.1
48	21.4	15.7	67	0	0	93.7	4	0	0	30.5	0	1.4	0	1.3	30.9	439.3
49	2.4	7.9	12.1	1.4	0.7	213.7	9.8	0	0	644.3	0	0	0	0.0	5.2	981.3
50	34.2	9.7	103.2	0.7	0	60.4	44.7	0	0	79.6	0	2.3	5.8	7.4	22.4	591.9
51	27.7	32.8	81.9	0.1	0	83.9	62.7	0	0	70.9	0	0.3	6.4	14.6	25.6	722.9
52	46.8	0.7	228.4	1.9	0	61.4	0	0	0	446.2	0	0.1	0	0.0	0	926.5
53	53.1	31.6	3.7	0	0	146.1	3.9	0	0	57.7	0	1.1	0	0.0	369.7	773.3
54	70.8	32.3	0.7	0.1	1.1	22.5	0.9	0	0	24.7	0	9.9	0	7.5	14	392.7
55	7.3	32	0.7	0	0	65.7	25.1	0	0	73.9	0	0.3	0	0.0	0.2	352.7
56	0	0	0	13.8	0	2	0	0	0	0	1.1	11.5	0	2.8	0	235.2
57	48.8	0	0	0	0	0	0	74.8	77.7	0	2.8	14.3	0	43.4	0	345.7
58	29.8	0	0	0	0	0	0	0.5	4.5	0	0	54.5	0	0.0	0	181.0
59	1.1	2.2	0	0.5	0	0.3	25.5	294.5	0	17.7	0	12.4	48.3	30.5	0	512.2
60	0	7	0	0	0	0	2.9	375.2	0	231.3	0.2	3.1	30.8	30.0	0	737.1
61	28.7	27.7	0	0	17.4	3.2	0	0	0	17.5	0	2.2	0	0.6	1.3	167.4
62	68.2	17.6	0	0	51.2	0.7	1.1	0	0	24.1	0	4.2	0.6	0.0	0.5	215.8

Appendix 4—*continued*

Station	Species code															
	BAR	GUR	HAK	HOK	JMN	RCO	SCH	SDO	SKI	SPD	SPE	SQU	STA	TAR	WAR	All species
63	100.7	11.5	0	0	28.2	21.7	2.8	0	0	10.9	27.4	8.1	6.3	70.1	13.2	516.5
64	61.5	23.5	0	0	138	8	3.9	0	0	30.5	2	15.1	8	3.1	1.6	403.4
65	110.6	42.7	14.6	0.7	10.1	860.1	2.3	0	0	23.6	13.6	5.4	5.7	74.2	12.6	1 352.1
66	4.1	43.5	0.3	0	8.2	20	4.9	0	0	13.4	14.4	3.1	1.5	17.5	2.3	426.9
67	0.6	40	0	0	4.7	0.7	21.8	0	0	8.6	64.9	2.4	2.1	92.1	5.5	239.0
68	26.9	15.1	0.1	0	116.7	26.9	0	0	0	39.8	0	0.5	0	2.2	1.4	377.7
69	57.6	22.8	0	0	46.6	11	4.8	0	0	4.6	4.3	3.4	0.3	16.4	0	318.2
70	114.4	11.6	5.3	0	15.7	903	3.9	0	0	26.4	0.5	14.7	4.1	137.7	5.2	1 378.1
71	88.8	46.8	0	0	8.9	40.9	0.9	0	0	18.3	0	14.6	2.8	4.8	0	367.9
72	122.8	25.9	1.1	0	39.4	38.7	4.3	0	0	29	4.2	9	4.5	25.2	3.4	529.0
73	9.6	3.5	0	0	0	0	60.3	51.7	0	58.1	3.9	42.5	24.2	7.5	0	347.4
74	119.2	0	0	0	0	0	196.9	0.1	0	3.7	0.4	2.9	0	0.0	0	494.8
75	9.1	0	0	0	0	2.5	35.5	281.4	0	90.8	0.1	17	1.1	14.8	0	598.5
76	53.3	0.8	0	0	0	7	3.5	561.2	0	106.4	0	17.5	2.1	13.3	0	873.3
77	154.3	1.2	0	9.2	0	64.8	16.7	95.8	0	102.2	4.3	13.4	7.7	14.2	0	735.2
78	197.7	0.6	0	78.2	0	19.6	59.1	207.1	0	113.1	1.4	27.9	8	11.3	0	959.6
79	84.2	0	0	6	0	64	45.1	205.2	0	97.5	7.2	52.6	1.1	22.8	0	759.2
80	150.5	0.7	0.5	28.3	0	37.3	47	2.2	0	91.1	5.8	23.5	22.4	15.0	0	516.7
81	0.1	4.6	9.2	1.3	0	182.1	6	0	0	297.2	0	0	0.8	0.0	0.1	664.3
82	1.7	28.8	35.5	12.9	0	14.7	20.2	0	0	21.2	0	2.9	0	6.5	0.9	254.8
83	40.5	2.3	0	0	0	0	9.7	109.2	0	129.5	0.9	29.8	119.9	25.7	0	530.0
84	132	1.4	0	9.4	0	64.7	41.9	8.2	0	67	20.6	20.5	1.6	13.0	0	494.4
85	21.6	39.3	0	0	2.4	12.5	1.8	0	0	12.5	0	6.6	0	0.7	0	165.5
86	38.4	2.4	0	0	19.2	8.9	20.5	0	0	15	10.6	7.6	1.3	44.9	0	487.6
87	13.4	11.3	0	0	19.5	0.9	1.2	0	0	12.2	0	2.6	0.8	0.2	0	169.5
88	21.6	38.4	0	0	36.4	27.3	0	0	0	7.1	0	5.4	0.7	0.8	0	236.0
Total	5 150.9	989.9	1 873.0	2 870.5	727.7	5 235.3	1 569.9	2 490.7	1 650.3	9 603.8	721.6	1 224.0	3 242.4	1 989.7	2 191.7	61 069.7

Appendix 5: Species of invertebrates collected and identified by NIWA, Wellington. Additional identification work remains

Annelida
- Hirudinea (leeches)
  - *?Pontobdella benhami*

Mollusca
- Gastropoda
  - *Alcithoe ostenfeldi*
  - *Charonia capax*
- Bivalvia
  - *Chlamys diefenbachii*
  - *Modiolarca impacta*
  - *Perna canaliculus*
  - *Ostrea lutaria*
- Cephalopoda
  - *Octopus maorum*
  - *Octopus huttoni*
  - *Sepioloidea pacifica*
  - *Sepioteuthis australis*
  - *Nototodarus* sp.
- Opisthobrancia (sea slugs)
  - *Pleurobranchaea maculata*

Actinaria (sea anemones)
- Actinaria (anenome)
- Actinaria (ring anemone)

Pennatulacea (sea pens)
- *Anthoptilum murrayi*
- *Funiculina quadrangularis*

Echinodermata
- Ophiuridea (sea cucumbers)
  - *Amphiura correcta*
  - *Astrothorax waitei*
  - *Ophionereis fasciata*
- Asteroidea (starfish)
  - *Dipsacaster magnificus*

Crustacea (hermit crabs, crabs, prawns, barnacles)
- *Ibacus alticrenatus*
- *Paguristes pilosus*
- *Squilla* sp.
- Parasitic isopod
- *Diacanthurus rubricatus*
- *Balanus decorus*
- *Metanephrops challengeri*
- *Nematocarcinus huttoni*
- *Ovalipes catharus*
- *Chloroticus novaezelandiae*

Miscellaneous taxa
- Chaetopterid tubes (Polychaeta)
- *Cheilonereis* sp. (Polychaeta)
- large worm tubes
- Hydroids
- Pyrosoma (salps)
- solitary ascidians
- sponges
- *Terebratella harakiensis* (brachiopods)

? Identification uncertain