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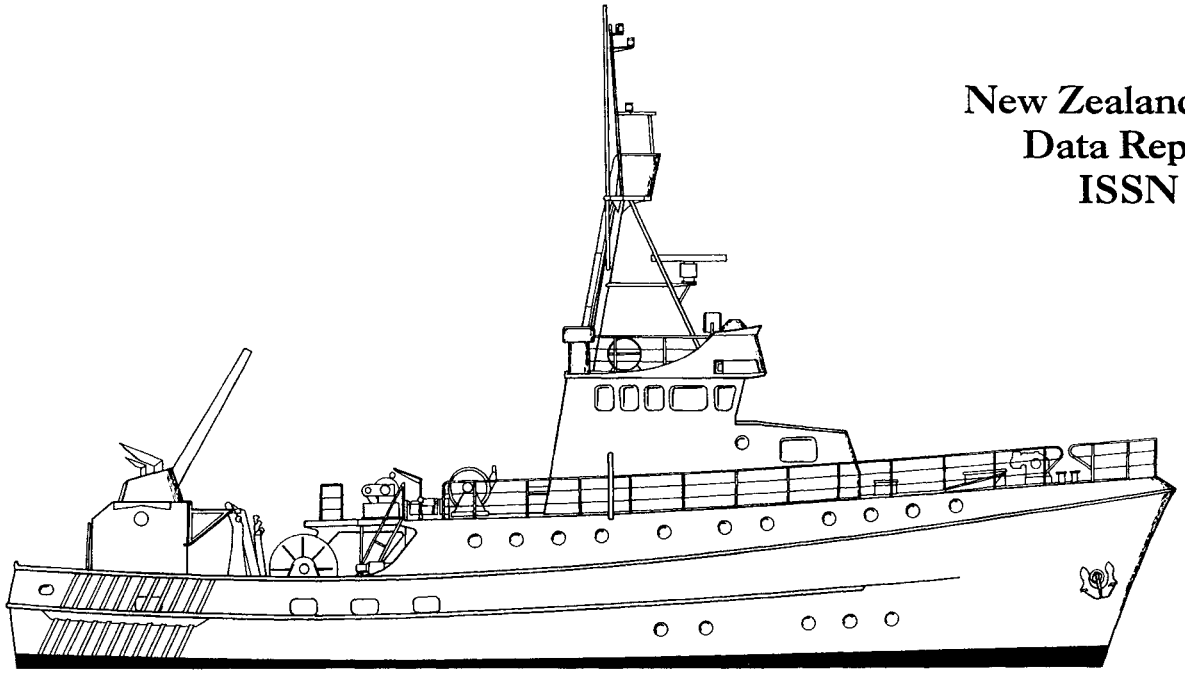
Bottom trawl survey of inshore waters of the east coast North Island, February-March 1996 (KAH9602)

Michael L. Stevenson



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Contents

Introduction

This report presents the results of the fourth of a planned time series of stratified random trawl surveys with RV *Kaharoa* in waters between 20 and 400 m deep off the east coast of the North Island, New Zealand. The first three surveys in this series (March–April 1993, February–March 1994, and February–March 1995) were described by Kirk & Stevenson (1996), Stevenson & Kirk (1996), and Stevenson (1996) respectively.

The principal aim of the time series was to estimate the relative abundance for snapper (*Pagrus auratus*), tarakihi (*Nemadactylus macropterus*), and trevally (*Pseudocaranx dentex*). A standardised index of relative abundance estimates for species from this time series will assist with stock assessment and management strategies.

This report describes the survey design and methods and provides stock assessment data for commercially important Individual Transferable Quota (ITQ) species and non-ITQ species. The survey was carried out using RV *Kaharoa* between 17 February and 18 March 1996.

Following a project review in November 1995, snapper and trevally were discontinued as target species for the series. Trawling by *Kaharoa* does not adequately sample the larger adult size classes of snapper (Drury & Hartill 1993) and trevally (Langley 1994). Although snapper and trevally were dropped as target species for this survey, abundance estimates were calculated to maintain continuity for the project objectives.

Pre-recruit (less than or equal to 65 cm FL) gemfish were included as a target species for this survey because they were caught during the previous surveys in the series and there is a lack of recent information on pre-recruit gemfish from other areas.

Project objectives

The major objectives of this research programme are:
1. to develop a time series of relative abundance indices of adult snapper, tarakihi, and trevally along the east coast of New Zealand between Cape Runaway and Turakirae Head;
2. to determine the distribution of adults of commercially important inshore finfish species along the east coast of New Zealand between Cape Runaway and Turakirae Head; and
3. to determine parameter inputs for the stock assessment of these species by collecting and analysing biological data (length and age frequency, length-weight, reproductive condition, and fecundity).

Survey objectives

The specific objectives of the trawl survey were:
1. to obtain relative biomass data for tarakihi and pre-recruit gemfish sampled by bottom trawl off the east coast of New Zealand between Cape Runaway and Turakirae Head during February–March 1995;
2. to collect data on the length, sex, and reproductive condition of tarakihi and other commercially important species;
3. to collect otoliths of gemfish, snapper, tarakihi, trevally, and red cod;
4. to collect data on the length and sex of all other Quota Management System (ITQ) and selected non-ITQ species; and
5. to tag lively school shark as part of a national study on the growth and movement of this species.

Project and voyage personnel

The project and voyage leader was M. Stevenson. The survey was divided into two parts (17 February–3 March, 4–18 March). Skippers for the voyage were A. Muir and R. Brown.

Methods

Survey area

The survey area covered depths of 20–400 m off the east coast of the North Island from Cape Runaway and Turakirae Head (20–200 m between Tolaga Bay and Cape Kidnappers).

The survey area of 18 576 km^2 (which includes non-trawlable ground) was divided into 15 strata by water depth (20–50, 50–100, 100–200, 200–400 m) and latitude (Table 1, Figure 1). Stratum boundaries used during the 1994 and 1995 surveys were retained.

The trawlable ground within the survey area represented 58% of the total survey area. Of the 7891 km^2 of non-trawlable ground, 3860 km^2 was in strata 9, 11, and 14.

Survey design

The survey used was of a modified two-phase stratified random design (*after* Francis 1984). Because of the difficulty of locating suitable trawl positions (and amount of vessel time spent) during the 1993 survey, stations that were successfully trawled during the 1993, 1994, and 1995 surveys were revisited. Before the survey began, sufficient trawl stations to cover any required additional phase 2 stations within each stratum were randomly generated by the computer program 'rand_stn v2.1' (*see* Vignaux 1994). The locations of new stations were checked to ensure a minimum distance of 5.6 km from any revisited station.

Each tow was 1 h long and in daylight. Non-trawlable ground was identified before the voyage from data collected before the 1993 survey and from the 1993, 1994, and 1995 surveys. The amount of non-trawlable ground in each stratum is given in Table 1.

For the two-phase methodology, pre-recruit gemfish and tarakihi were designated as target species. A total of 80 stations was assigned to phase 1, with a minimum of 3 stations in each stratum. The remaining phase 1 stations were allocated to minimise the variance of the expected catch rates of the target species as described by Stevenson (1996). Phase 2 stations were planned for completion during any remaining survey time to improve the precision of the biomass estimates for the target species and were allocated after phase 1 had been completed. Allocation of phase 2 stations was based on the catch rates of the target species separately with five phase 2 stations reserved for pre-recruit gemfish. Allocation of the remaining phase 2 stations was based on the catch rates for tarakihi only. This procedure was followed because the higher catch rates for tarakihi could have masked the catch rates for pre-recruit gemfish.

Vessel and gear specifications

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 net used was a high-lift, bottom-wing trawl fitted with a codend of 80 mm (inside measurement) mesh. The net was specially designed and constructed for fishing the target species found on the soft substrate off the east coast of the North Island. The design was based on similar nets used by commercial fishers in this area. Gear specifications and details of the net design were given by Kirk & Stevenson (1996). Before the 1995 survey, *Kaharoa* was equipped with new trawl doors based on the design of the old doors but heavier. Comparative details are given in Appendix 1.

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. Doorspread varied from 71.2 to 111 m with a mean of 87.4 m (Appendix 2). Headline height varied between 6.3 and 7.7 m.

Trawling procedure

All trawling was conducted in daylight. Where necessary, upon arrival at the shot location the seafloor along the proposed tow path was surveyed. Once the tow was considered safe, 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 a combination of weather conditions and bottom contours, and secondly by the location of the next tow (to minimise steaming between stations).

If a station occurred in an area of foul or the depth was out of the stratum range, an area within 3.5 n. miles was searched and the station occupied if possible. If no tow was possible, the station was abandoned and replaced with an alternative position from a list of random station positions.

Standard tows were of 1 h at a speed of 3.5 kn. The tow was deemed to have started when the netsonde showed that the net was on the bottom, and completed when hauling began. The length of the tow was measured using a Furuno Navigator GP50 GPS.

A minimum of 200 m of warp was deployed for each trawl. In depths below 100 m a reduced warp to depth ratio of 3 : 1 was used.

Water temperatures

The surface temperature at each station was recorded from a Kainga case Brannan thermometer for stations 1–72. A 10 l bucket was filled with sea water from the port side of the vessel at the start of each tow and the thermometer in its case placed in the bucket. The thermometer was left in the bucket for about 1 min and then the temperature read to the nearest 0.1 °C. After its last calibration on 8 January 1996, the thermometer was found to read 0.2 °C below actual temperature at 10 °C and 0.05 °C below at 17.6 °C. The thermometer was found to be broken in its case at the start of tow 73. A correction of 0.1 °C upwards was made for temperatures below 17.6 °C for this method. For stations 75–98 surface temperatures were taken at the start of each tow from a sensor on the main engine intake. Graduations on the sensor were in 2 °C bands and the sensor was not calibrated, so temperatures for these stations

are uncertain. Bottom temperatures were recorded by the Scanmar netsonde, 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. When possible, tagged school shark were weighed before release. If it was not desirable to weigh a tagged school shark, its weight was estimated from the length-weight coefficients given in Appendix 3b. Weights of some large stingrays were estimated.

Length, to the nearest whole centimetre below the actual length, and sex were recorded for all ITQ species, either for the whole catch or a randomly selected subsample of up to 200 fish per tow. Length measurements were also recorded for some non-ITQ species.

When available, more detailed biological data were collected from a selected subsample of red cod, gemfish, snapper, tarakihi, and trevally. Fish for these analyses were sampled non-randomly to ensure that a full size range of each species was sampled from the catch. For these species individual length and weight to the nearest 10 g were recorded along with sex and state of maturity. Similar biological data were collected for all blue moki (*Latridopsis ciliaris*) and hapuku (*Polyprion oxygeneios*).

Up to four pairs of otoliths per 1 cm size class, per sex, were collected from gemfish, snapper, tarakihi, trevally, and red cod. Otoliths were collected from all blue moki and hapuku.

Sections of vertebrae from just below the dorsal fin were taken from rig and school shark and dorsal spines collected from elephantfish for ageing studies at Greta Point. These samples were also selected non-randomly to ensure that a full size range of the species was represented.

Tagging

Lively school shark were measured, sexed, and tagged using a single dart tag, and released within minutes of being removed from the codend. For each tagged school shark a release factor was assigned on a scale of 1–3, with 1 corresponding to the fish swimming away weakly, 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.

Data analysis

Doorspread relative biomass estimates and scaled length frequency distributions were estimated using the area-swept method described by Francis (1981, 1989) using the Trawlsurvey Analysis Program described by Vignaux (1994).

The following assumptions were made.

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 areas at the time of the survey.
5. Within the survey area, fish were evenly distributed over both trawlable and non-trawlable ground.

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

Length-weight coefficients were determined for gemfish, red cod, snapper, tarakihi, and trevally using the geometric mean functional relationship (Appendix 3a).

Biomass estimates were calculated using data from all stations where gear performance was considered to be satisfactory, i.e., the gear performance code was 1 or 2 (this excluded stations 23 and 68). Biomass estimates were scaled to include non-trawlable ground. All length frequencies were scaled by the percentage of catch sampled, area swept (function of doorspread and distance towed), and stratum area using the Trawlsurvey Analysis Program. Parameters of length-weight relationships used in the Trawlsurvey Analysis Program to calculate length frequencies are given in Appendix 2.

The coefficient of variation (*c.v.*) associated with estimates of biomass was calculated after the method of Vignaux (1994).

Gear trials

To improve estimates of doorspread for the 1993 and 1994 surveys, Scanmar equipment was fitted to the previous trawl gear configuration (including doors), and trials were completed off the east coast of the North Island at the end of this survey. Trials were planned for depth ranges of 0–25, 25–50, 50–75, 75–100, 100–200, 200–300, and 300–400 m to provide adequate data on the total range of depths covered.

Results

Trawl stations

Seventy-eight phase 1 stations and 18 phase 2 stations were successfully completed (*see* Table 1, Figure 1, and Appendix 1). The completed station density ranged between 1 station per 67 km^2 in stratum 4, to 1 station per 933 km^2 in stratum 10, with an overall station density of 1 station per 194 km^2 (*see* Table 1). At least three stations were completed in all 15 strata. The positions of all stations occupied are shown in Figure 2 and individual station data are presented in Appendix 1.

Catch composition

About 69.2 t of fish was caught during the 98 tows at an average of 706 kg per tow (range 34.5 to 13 537.4 kg). The largest catch (station 68) included an estimated 12 t of southern spiky dogfish. During the survey, 105 species were recorded: 1 agnathan, 20 elasmobranchs, 73 teleosts, 6 crustaceans, 3 cephalopods, and 1 bivalve. Several species of crab were caught but not identified. Porcupine fish were not weighed because of their high water content and are not included in the catch weights. A full list of species caught, and the number of stations at which they occurred, is given in Table 2.

The total catch of each target species was tarakihi, 3947 kg and pre-recruit gemfish, 147 kg. Target species made up 4.09 t (5.9%) of the total catch. The total catch and percentage composition by weight for each species recorded is given in Table 2.

Southern spiny dogfish was the most abundant species by weight (16.1 t) while barracouta occurred at more stations (87) than any other species. Five of the seven catches greater than 2 t were made in depths greater than 200 m.

Other species with catches greater than 2 t were barracouta (7.9 t), Murphy's mackerel (5.2 t), hoki (4.9 t), tarakihi (4.1 t), frostfish (3.7 t), horse mackerel (3.5 t), rattails (3.1 t), and red cod (2.3 t) (*see* Table 2). Arrow squid and tarakihi were the only other species to occur at more than 75% of the stations (*see* Table 2).

Catch rates and species distribution

Catch rates and distributions for all species combined and the 17 most abundant commercial finfish species are presented in Figure 2. Catch rates by stratum for the 25 most abundant species are given in Table 3. (Catch rates are given in terms of $kg.km^{-2}$, so a catch rate of 1000 $kg.km^{-2}$ equates to a catch of 510 kg in a standard tow (as it covers 0.51 km^2 on average).)

Biomass estimation

Relative biomass estimates for the 25 most abundant species are given in Table 4. For gemfish, hoki, red cod, and tarakihi, estimates for pre-recruits and recruits are provided. For red cod the processing size limit varies between years (38 cm in 1993, 45 cm in 1994, and 40 cm in 1995 and 1996). The 40 cm size limit is used as the minimum size of recruited red cod in this report, which is consistent with that used for the west coast South Island series (Drummond & Stevenson 1996). The relative biomass estimates by stratum for pre-recruit and recruited gemfish and tarakihi are given in Table 5.

For southern spiny dogfish, the large catch at station 68 could only be estimated, so a range of biomass estimates was calculated (*see* Table 4).

Among the 25 most abundant species, tarakihi (15%), frostfish (17%), kingfish (19%), and trevally (19%) had relative biomass estimates with *c.v.*s of 20% or less.

Water temperatures

Sea surface and bottom water temperatures are included in Appendix 2. Isotherms were not estimated for surface temperatures because of the different methods used to take the temperatures. Isotherms for bottom temperatures were not estimated because phase 2 stations north of Cape Kidnappers (occupied from 10 March to 16 March) were significantly warmer than phase 1 stations (occupied from 17 February to 28 February) (*see* Appendix 2).

School shark tagging

Sixty-three school shark (24 males and 39 females) were tagged and released. They ranged from 73 to 160 cm total length. A previously tagged male school shark (113 cm length) was captured on 23 February and re-released. The fish was originally tagged on 23 February, 1994 at a length of 97 cm and was recaptured 28 km from the original tagging location.

Length frequencies 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 major commercial species are shown in Figure 3. The length frequencies represent the estimated population structure for the survey area as sampled by bottom trawl. The number of fish for the target species sampled at each gonad stage are summarised in Table 7.

Target species

Tarakihi. The estimated biomass was 943 t (*c.v.* = 15%) with 928 t (*c.v.* = 15%) recruited (equal to or greater than 25 cm) (*see* Table 4). In total, 604 t (64%) was north of Tolaga Bay, while 528 t (56%) was in the 100–200 m depth range (*see* Table 5). For all fish the sex ratio (males : females) was 0.88 : 1, but altered significantly with depth where the ratios were 0.92 : 1 in 20–50 m, 0.43 : 1 in 50–100 m, 1.26 : 1 in 100–200 m, and 0.78 : 1 in 200–400 m (*see* Figure 3). All tarakihi less than 20 cm long had immature gonads, but a full range of gonad stages were recorded from larger length classes (*see* Table 7).

Gemfish: Of the total relative biomass estimate of 190 t (*c.v.* = 31 %), 55 t (*c.v.* = 32%) was pre-recruit (less than or equal to 65 cm) biomass. Of the pre-recruit gemfish, 41 t (75%) was in 200–400 m with 40 t (73%) south of Cape Kidnappers (*see* Table 5 & Figure 2). The length frequency distributions of gemfish have clear modes at 46–56 cm, 57–61 cm, and 63–71 cm corresponding to the 3+, 4+, and 5+ cohorts respectively. The mode at 57–61 cm is weak and was weak or missing from the 1994 and 1995 surveys in this series (Stevenson & Kirk 1996, Stevenson 1996). No gemfish had gonads that were in late stages of maturity and only one was spent. The depth range for gemfish extends beyond the maximum for this survey and therefore the length frequency distributions shown in Figure 3 are unlikely to represent the "true" population structure.

Gear trials

Because of poor weather, trials were not completed in the depth ranges of 200–300 m or 300–400 m. A linear regression analysis was run on the trial data to estimate doorspread in 200–300 m and 300–400 m. A linear regression was also run on depth (x) vs. doorspread (y) for the station data from this survey. The equations obtained were:

Gear trials

Old doors: $y = 0.102x + 85.04$, $r^2 = 0.768$

New doors: $y = 0.074x + 74.32$, $r^2 = 0.405$

Station data

New doors: $y = 0.0897x + 75.77$, $r^2 = 0.759$

The results of the trials are summarised in Appendix 4. Adjusted biomass estimates for the 1993 and 1994 surveys are given in Appendix 5. Biomass estimates for 1993 include the area between 200 and 400 m from Tolaga bay to Cape Kidnappers which was excluded following re-stratification for later surveys. The area totals 684 km^2 (3.7% greater than later surveys). Biomass estimates for 1993 are therefore slightly higher for species caught at these depths.

Biomass estimates for both 1993 and 1994 were lower for all species compared to those based on constant doorspread. For 1993 the estimates ranges from 67% (hoki, 65 cm +) to 84% (red gurnard, all fish) of previous estimates and averaged 77% of previous calculations. For 1994, the range was 55% (hoki, all fish) to 90% (hoki, 65 + cm) and the average was 78%.

Discussion

The best precision (*c.v.* = 15%) was associated with the relative biomass estimate for tarakihi. This is the best precision for tarakihi in the series and the only time the *c.v.* was less than 20%. The *c.v.* for gemfish (31%) was also the lowest achieved in this series. Because *Kaharoa* cannot trawl the entire depth range for gemfish the relative biomass index is unlikely to reflect population changes well.

The very large catch of southern spiky dogfish (est. 12 t) at station 68 is the second time this station has yielded a large catch which had to be estimated. In 1994 the net had to be cut away because of deteriorating weather conditions and the estimated 10 t catch could not be safely landed. This year the net tore while trying to land the catch and about one-third of the dogfish were lost overboard. Since the stratum does not yield much of the target species, I recommend this station be permanently replaced to avoid gear damage.

Five days were lost to bad weather, and conditions were marginal on several other days. Returning to known stations was the main reason the survey could be completed within the allotted 32 days.

The biomass estimates and high *c.v.*s for the jack mackerel species (*see* Table 4) are the highest recorded for this series and are the result of two large catches, 6.6 t of *Trachurus declivis* (1.6 t) and *T. murphyi* (5.0 t) at station 36, and a 1.5 t catch of *T. novaezelandiae* at station 53.

Acknowledgments

I thank the masters of *Kaharoa*, Arthur Muir and Roy Brown, and the crews for their willing help throughout the survey. Don Tindale, Ron Blackwell, Kevin Mulligan, Rob Merilees, Kim George, and Michael Coakley worked hard on the survey and helped with data collection. I also thank Dave Gilbert for his 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	
Castlepoint–Turakirae Head						
1	20–50	432	223	3	0	144
2	50–100	568	104	3	0	189
3	100–200	692	321	6	0	115
4	200–400	468	191	3	4	67
Cape Kidnappers–Castlepoint						
5	20–50	422	347	3	0	141
6	50–100	1 011	217	3	0	337
7	100–200	1 590	149	6	0	265
8	200–400	1 362	56	3	0	454
Tolaga Bay–Cape Kidnappers						
9	20–50	2 605	1 345	3	0	868
10	50–100	2 801	857	3	0	933
11	100–200	2 182	1 163	3	12	145
Cape Runaway–Tolaga Bay						
12	20–50	594	506	3	1	149
13	50–100	1 015	302	12	0	85
14	100–200	1 816	1 352	18	2	91
15	200–400	1 018	758	5	0	203
Total (average)		18 576	7 891	77	19	(194)

Table 2: Species caught, total weight, percentage of total catch, and number of stations out of 98 at which species occurred (Occ)

Common name	Scientific name	Code	Catch (kg)	% of total catch	Occ
Southern spiny dogfish	*Squalus acanthias*	SPD	16 079	23	58
Barracouta	*Thyrsites atun*	BAR	7 923	11	87
Murphy's mackerel	*Trachurus murphyi*	JMM	5 158	7	36
Hoki	*Macruronus novaezelandiae*	HOK	4 893	7	34
Tarakihi	*Nemadactylus macropterus*	TAR	3 947	6	74
Frostfish	*Lepidopus caudatus*	FRO	3 699	5	72
Horse mackerel	*Trachurus novaezelandiae*	JMN	3 512	5	72
Rattails	Macrouridae	RAT	3 054	4	27
Red cod	*Pseudophycis bachus*	RCO	2 287	3	65
Jack mackerel	*Trachurus declivis*	JMD	1 910	3	30
Red gurnard	*Chelidonichthys kumu*	GUR	1 410	2	62
Snapper	*Pagrus auratus*	SNA	1 206	2	37
Sea perch	*Helicolenus* spp.	SPE	1 073	2	56
Carpet shark	*Cephaloscyllium isabellum*	CAR	1 003	1	65
Rough skate	*Raja nasuta*	RSK	987.3	1	67
Ling	*Genypterus blacodes*	LIN	924.2	1	64
Kahawai	*Arripis trutta*	KAH	911.2	1	18
Gemfish	*Rexea solandri*	SKI	773.5	1	26
School shark	*Galeorhinus galeus*	SCH	744.1	1	45
Silver dory	*Cyttus novaezelandiae*	SDO	660.4	1	30
Orange perch	*Lepidoperca* sp.	OPE	595.7	1	1
Kingfish	*Seriola lalandi*	KIN	594.4	1	37
Rig	*Mustelus lenticulatus*	SPO	492.4	1	53
Trevally	*Pseudocaranx dentex*	TRE	414.4	1	31
Blue moki	*Latridopsis ciliaris*	MOK	365.0	1	16
Hapuku	*Polyprion oxygeneios*	HAP	360.8	1	30
Arrow squid	*Nototodarus sloanii & N. gouldi*	SQU	344.6	< 1	80
Dark ghost shark	*Hydrolagus novaezelandiae*	GSH	329.2	< 1	9
Electric ray	*Torpedo fairchildi*	ERA	302.4	< 1	35
John dory	*Zeus faber*	JDO	288.8	< 1	40
Smooth skate	*Raja innominata*	SSK	264.2	< 1	28
Seal shark	*Scymnorhinus licha*	BSH	252.7	< 1	3
Giant stargazer	*Kathetostoma giganteum*	STA	220.3	< 1	25
Ruby fish	*Plagiogeneion rubiginosus*	RBY	198.1	< 1	8
Mirror dory	*Zenopsis nebulosus*	MDO	189.8	< 1	24
Stingray	*Dasyatis* spp.	STR	185.3	< 1	7
Alfonsino	*Beryx splendens*	BYS	183.1	< 1	8
Javelinfish	*Lepidorhynchus denticulatus*	JAV	144.1	< 1	9
Bluenose	*Hyperoglyphe antarctica*	BNS	125.7	< 1	3
Lookdown dory	*Cyttus traversi*	LDO	124.8	< 1	18
Lemon sole	*Pelotretis flavilatus*	LSO	119.0	< 1	39
Silver warehou	*Seriolella punctata*	SWA	109.6	< 1	21
Witch	*Arnoglossus scapha*	WIT	104.4	< 1	73
Blue warehou	*Seriolella brama*	WAR	82.1	< 1	8
Brown stargazer	*Gnathagnus innotabilis*	BRZ	74.9	< 1	20
Conger eel	*Conger* spp.	CON	71.1	< 1	5
Elephantfish	*Callorhinchus milii*	ELE	66.5	< 1	10
Silver roughy	*Hoplostethus mediterraneus*	SRH	40.1	< 1	5

Table 2—*continued*

Common name	Scientific name	Code	Catch (kg)	% of total catch	Occ
Broadsnouted sevengill shark	*Notorynchus cepedianus*	SEV	36.8	< 1	1
Northern spiny dogfish	*Squalus blainvillei*	NSD	35.5	< 1	7
Mako shark	*Isurus oxyrinchus*	MAK	27.3	< 1	2
Capro dory	*Capromimus abbreviatus*	CDO	27.0	< 1	23
N.Z. sole, common sole	*Peltorhamphus novaezeelandiae*	ESO	26.0	< 1	7
Common roughy	*Paratrachichthys trailli*	RHY	22.1	< 1	5
Sand flounder	*Rhombosolea plebeia*	SFL	19.7	< 1	6
Octopus	*Octopus maorum*	OCT	19.5	< 1	40
Deepsea flathead	*Hoplichthys haswelli*	FHD	16.5	< 1	6
Sharpsnouted sevengill shark	*Heptranchias perlo*	HEP	15.5	< 1	2
Silverside	*Argentina elongata*	SSI	15.4	< 1	44
Pufferfish	*Sphoeroides pachygaster*	PUF	14.2	< 1	3
Bass	*Polyprion americanus*	BAS	13.6	< 1	2
Thresher shark	*Alopias vulpinus*	THR	12.8	< 1	1
Japanese gurnard	*Pterygotrigla picta*	JGU	12.4	< 1	6
Northern bastard cod	*Pseudophycis breviuscula*	BRC	11.8	< 1	7
Trumpeter	*Latris lineata*	TRU	10.8	< 1	2
Blue mackerel	*Scomber australasicus*	EMA	9.4	< 1	6
Anchovy	*Engraulis australis*	ANC	8.7	< 1	8
Slender smooth-hound	*Gollum attenuatus*	SSH	8.5	< 1	1
Numbfish	*Typhlonarke* spp.	BER	6.1	< 1	3
Turbot	*Colistium nudipinnis*	TUR	5.8	< 1	2
Longfinned boarfish	*Zanclistius elevatus*	LFB	4.9	< 1	3
Parore	*Girella tricuspidata*	PAR	4.6	< 1	1
Ray's bream	*Brama brama*	RBM	4.3	< 1	2
Scampi	*Metanephrops challengeri*	SCI	4.3	< 1	8
Blue cod	*Parapercis colias*	BCO	4.2	< 1	1
Scaly gurnard	*Lepidotrigla brachyoptera*	SCG	4.1	< 1	33
Prawn killer	*Ibacus alticrenatus*	PRK	3.0	< 1	25
Longtailed skate	*Arhynchobatis asperrimus*	LSK	2.8	< 1	2
Unidentified crab	Decapoda	CRB	2.5	< 1	6
Cucumber fish	*Chlorophthalmus nigripinnis*	CUC	2.5	< 1	6
Redbait	*Emmelichthys nitidus*	RBT	2.3	< 1	5
Pigfish	*Congiopodus leucopaecilus*	PIG	1.8	< 1	5
Spiny sea dragon	*Solegnathus spinosissimus*	SDR	1.8	< 1	15
Banded bellowsfish	*Centriscops humerosus*	BBE	1.7	< 1	5
Leatherjacket	*Parika scaber*	LEA	1.6	< 1	6
Packhorse rock lobster	*Jasus verreauxi*	PHC	1.5	< 1	1
Opalfish	*Hemerocoetes* spp.	OPA	1.1	< 1	11
Mantis shrimp	Crustacea	CRU	1.0	< 1	10
Lucifer dogfish	*Etmopterus lucifer*	ETL	1.0	< 1	3
Broad squid	*Sepioteuthis australis*	BSQ	0.7	< 1	4
Rock lobster	*Jasus edwardsii*	CRA	0.5	< 1	1
Ahuru	*Auchenoceros punctatus*	PCO	0.4	< 1	3
Snipefish	*Macrorhamphosus scolopax*	SNI	0.4	< 1	3
Unidentified		UNI	0.4	< 1	4
Paddle crab	*Ovalipes catharus*	PAD	0.3	< 1	1
Sand stargazer	*Crapatalus novaezelandiae*	SAZ	0.3	< 1	1
Sprats	*Sprattus antipodum, S. muelleri*	SPR	0.3	< 1	3

Table 2—*continued*

Common name	Scientific name	Code	Catch (kg)	% of total catch	Occ
Yellow boarfish	*Pentaceros decacanthus*	YBO	0.3	< 1	1
Yelloweyed mullet	*Aldrichetta forsteri*	YEM	0.3	< 1	1
Messmate fish	*Echiodon cryomargarites*	ECR	0.1	< 1	1
Hagfish	*Eptatretus cirrhatus*	HAG	0.1	< 1	1
Dredge oysters	*Tiostrea chilensis*	OYS	0.1	< 1	1
Pilchard	*Sardinops neopilchardus*	PIL	0.1	< 1	1
Porcupinefish*	*Allomycterus jaculiferus*	POP	–		
			69 227		

*Counted but not weighed

Table 3: Catch rates (to the nearest whole kg.km^{-2}) by stratum, for the 25 most abundant species in the catch from stations used for biomass calculations*

QMS species

		Species code														
Stratum	Depth (m)	BAR	JMM	HOK	TAR	JMN	RCO	JMD	GUR	SNA	LIN	SKI	SCH	SPO	TRE	MOK
1	20–50	249	0	0	0	7	0	0	103	4	0	0	0	12	3	70
5	20–50	255	0	6	0	5	99	0	210	0	2	0	0	57	12	10
9	20–50	179	5	5	5	81	481	0	114	30	5	0	17	18	7	11
12	20–50	3	+	0	98	162	4	0	71	232	0	0	20	31	60	2
2	50–100	323	0	16	2	19	1	29	18	0	4	0	0	0	4	57
6	50–100	24	0	0	3	17	1	1	65	0	20	0	10	15	5	5
10	50–100	5	0	0	14	3	0	1	30	4	4	0	3	3	8	7
13	50–100	167	0	4	49	91	31	1	42	67	3	0	3	6	13	2
3	100–200	104	10	86	9	29	11	20	1	0	1	2	8	5	0	14
7	100–200	145	1	27	35	37	49	4	1	0	11	18	12	5	0	0
11	100–200	74	1	1	73	28	12	1	11	24	7	2	24	11	15	0
14	100–200	229	3	10	169	38	34	2	5	7	6	3	16	1	1	0
4	200–400	7	1	650	18	+	98	1	0	0	141	105	9	5	0	0
8	200–400	444	23	700	40	886	40	94	0	0	12	54	3	2	0	0
15	200–400	16	1783	6	186	+	3	563	0	0	9	26	35	6	0	0

Non-QMS species

		Species code									
Stratum	Depth (m)	SPD	FRO	RAT	SPE	CAR	RSK	KAH	SDO	OPE	KIN
1	20–50	113	0	0	0	7	59	4	0	0	5
5	20–50	276	0	0	0	7	193	8	0	0	25
9	20–50	13	0	0	0	0	5	460	0	0	0
12	20–50	0	0	0	0	0	0	83	0	0	13
2	50–100	57	0	0	0	61	8	0	0	0	22
6	50–100	52	+	0	0	93	64	0	0	0	8
10	50–100	7	7	0	+	35	13	0	0	0	7
13	50–100	2	18	0	+	4	18	6	0	0	9
3	100–200	37	106	117	14	8	1	0	10	0	18
7	100–200	28	11	22	14	24	6	0	+	0	4
11	100–200	264	54	0	2	35	13	2	+	0	23
14	100–200	3	211	2	1	17	11	+	+	0	8
4	200–400	66	87	551	184	1	6	0	156	159	0
8	200–400	29	1	75	68	0	0	0	1	0	0
15	200–400	0	19	11	2	9	1	0	9	0	3

* Species codes are given in Table 2

+ < 0.5

Table 4: Relative biomass estimates* (to the nearest tonne) and coefficients of variation (*c.v.* %) for the 25 most abundant species in the catch

Common name	Lower 95% confidence interval	Biomass (t)	Upper 95% confidence interval	*c.v.* %
Southern spiny dogfish				
Excluding station 68	0	1 026	2 068	51
Station 68 catch = 9 t	0	3 121	7 441	69
Station 68 catch = 12 t	0	3 824	9 517	74
Station 68 catch = 15 t	0	4 527	11 606	78
Barracouta	1 366	2 495	3 624	23
Murphy's mackerel	0	1 881	5 514	97
Hoki (all)	0	1 413	2 830	50
Hoki (< 65 cm)	4	33	63	45
Hoki (65 + cm)	0	1 380	2 799	51
Tarakihi (all)	661	943	1 225	15
Tarakihi (< 25 cm)	1	15	30	47
Tarakihi (25 + cm)	648	927	1 207	15
Frostfish	455	693	931	17
Jack mackerel (*Trachurus novaezelandiae*)	0	1 854	4 291	66
Rattails	220	491	762	28
Red cod all	0	1 608	4 046	76
Red cod (< 40 cm)	0	666	1691	77
Red cod (40 + cm)	0	942	2358	75
Jack mackerel (*T. declivis*)	0	748	1 917	78
Red gurnard	301	709	1 117	29
Snapper	191	362	533	24
Sea perch	49	219	390	39
Carpet shark	214	396	578	23
Rough skate	157	307	457	24
Ling	109	185	261	21
Kahawai	0	1 262	3 408	85
Gemfish (all)	73	190	308	31
Gemfish (< 66 cm)	20	55	91	32
Gemfish (66 + cm)	44	135	226	34
School shark	121	228	335	23
Silver dory	0	91	234	78
Orange perch	0	74	222	100
Kingfish	97	157	217	19
Rig	93	172	250	23
Trevally	85	137	189	19
Blue moki	33	134	236	38

* Doorspread estimates with vulnerability set at 1.0, using stations with gear performance of 1 or 2 (96 stations). Estimates above a given size are recruited biomass

Table 5: Biomass (to the nearest tonne) by stratum for target species

		Biomass estimate (t)					
		Tarakihi			Gemfish		
Stratum	Depth (m)	< 25 cm	25 cm +	all	< 65 cm	65 cm +	all
1	20–50	0	0	0	0	0	0
2	50–100	0	1	1	0	0	0
3	100–200	0	6	6	1	0	1
4	200–400	+	8	8	18	31	49
5	20–50	+	0	+	0	0	0
6	50–100	+	3	3	0	0	0
7	100–200	1	54	55	10	19	28
8	200–400	0	54	54	11	63	74
9	20–50	1	12	12	0	0	0
10	50–100	1	37	38	0	0	0
11	100–200	4	156	160	1	4	5
12	20–50	7	51	58	0	0	0
13	50–100	+	50	50	0	0	0
14	100–200	1	306	307	2	4	6
15	200–400	0	189	189	12	15	27

+ < 0.5

Table 6: Numbers of length frequency and biological samples collected (species codes are given in Table 2)

	Length frequency data		Biological data	
Common name	No. of samples	No. of fish	No. of samples	No. of fish
Alfonsino	8	348	0	0
Barracouta	86	4 347	0	0
Bass	2	2	2	2
Blue cod	1	4	0	0
Blue mackerel	4	11	0	0
Blue moki	16	92	16	92
Blue warehou	8	118	0	0
Bluenose	3	35	0	0
Brown stargazer	20	57	0	0
Dark ghost shark	9	285	0	0
Elephantfish	10	32	0	0
Gemfish	26	382	26	225
Giant stargazer	25	65	0	0
Hapuku	30	74	30	74
Hoki	34	1 357	2	21
Jack mackerel (*Trachurus declivis*)	30	771	0	0
Jack mackerel (*T. murphyi*)	36	309	0	0
Jack mackerel (*T. novaezelandiae*)	71	3 709	0	0
Japanese gurnard	6	20	0	0
John dory	40	206	0	0
Kahawai	18	419	0	0
Kingfish	37	96	0	0
Lemon sole	38	307	0	0
Ling	64	586	0	0
Longfinned boarfish	3	8	0	0
Lookdown dory	6	139	0	0
Mako shark	2	2	0	0
Mirror dory	23	477	0	0
New Zealand sole	7	62	0	0
Northern bastard cod	7	15	0	0
Parore	1	1	0	0
Ray's bream	2	2	0	0
Red cod	64	2 085	52	716
Red gurnard	62	2 116	0	0
Rig	52	157	0	0
Rough skate	66	420	0	0
Rubyfish	8	139	0	0
Sand flounder	6	28	0	0
Sand stargazer	1	1	0	0
Scampi	1	9	0	0
School shark	44	111	0	0
Silver dory	2	5	0	0
Silver warehou	19	96	0	0
Smooth skate	28	70	0	0
Snapper	37	850	37	401
Tarakihi	74	4 448	73	1 185
Trevally	31	295	31	248
Trumpeter	2	2	1	1
Turbot	2	3	0	0

Table 7: Numbers of the target species sampled at each reproductive stage

	Males					Females					
	Gonad stage					Gonad stage					
Fork length (cm)	1	2	3	4	5	1	2	3	4	5	
Gemfish											
31–40	0	0	0	0	0	1	0	0	0	0	
41–50	13	1	0	0	0	10	1	0	0	0	
51–60	31	6	0	0	0	37	0	0	0	0	
61–70	34	12	0	0	0	35	0	0	0	0	
71–80	5	6	0	0	0	11	1	0	0	1	
81–90	0	9	0	0	0	3	1	0	0	0	
91–100	0	0	1	0	0	2	2	0	0	0	
101–110	0	0	0	0	0	2	0	0	0	0	
Total	83	34	1	0	0	101	5	0	0	1	225
Tarakihi											
10–20	23	0	0	0	0	16	0	0	0	0	
21–30	98	44	7	5	0	122	8	0	0	1	
31–40	41	124	49	37	2	187	228	10	1	2	
41–50	1	5	13	5	0	16	136	2	0	0	
51–60	0	0	0	0	0	0	1	0	0	0	
Total	163	173	69	47	2	341	373	12	1	3	1184

Gonad stages used were: 1, immature or resting; 2 maturing (oocytes visible in female fish); 3, mature (hyaline oocytes in female fish, milt expressible in male fish); 4 running ripe (eggs and milt free flowing); 5, spent.

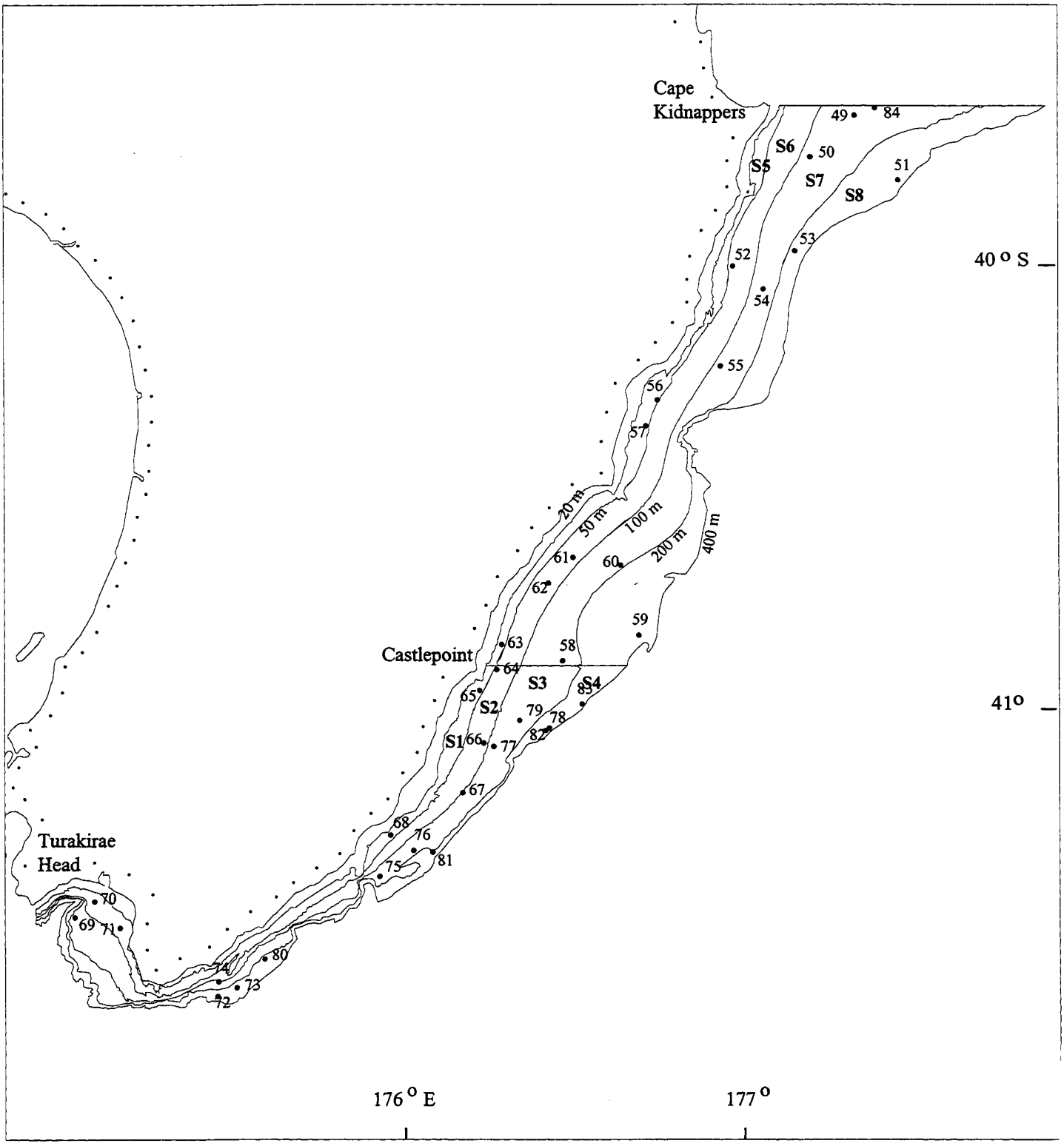


Figure 1a: Stratum boundaries (south of Cape Kidnappers) with station positions and numbers.

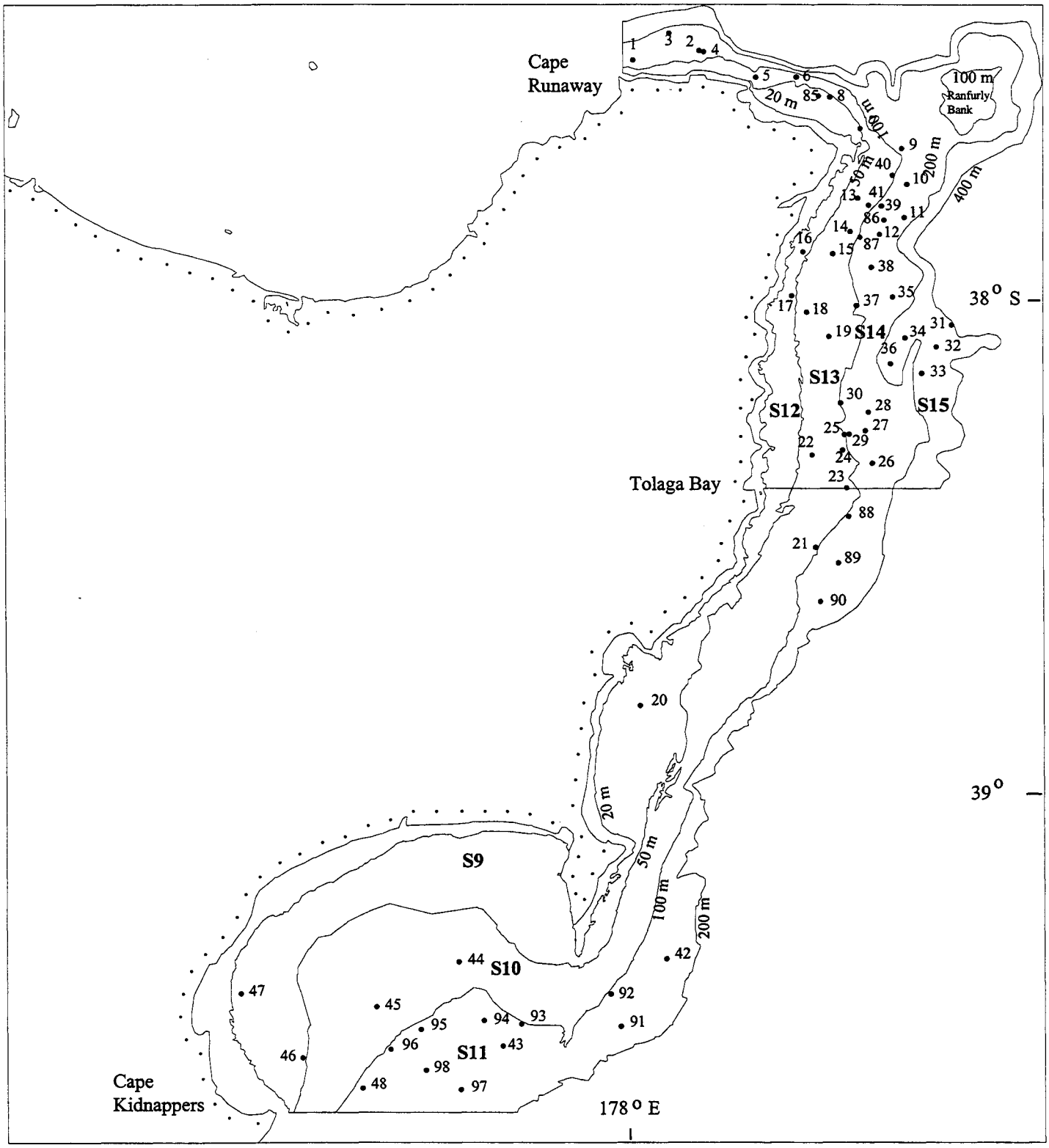


Figure 1b: Stratum boundaries (north of Cape Kidnappers) with station positions and numbers.

All species combined

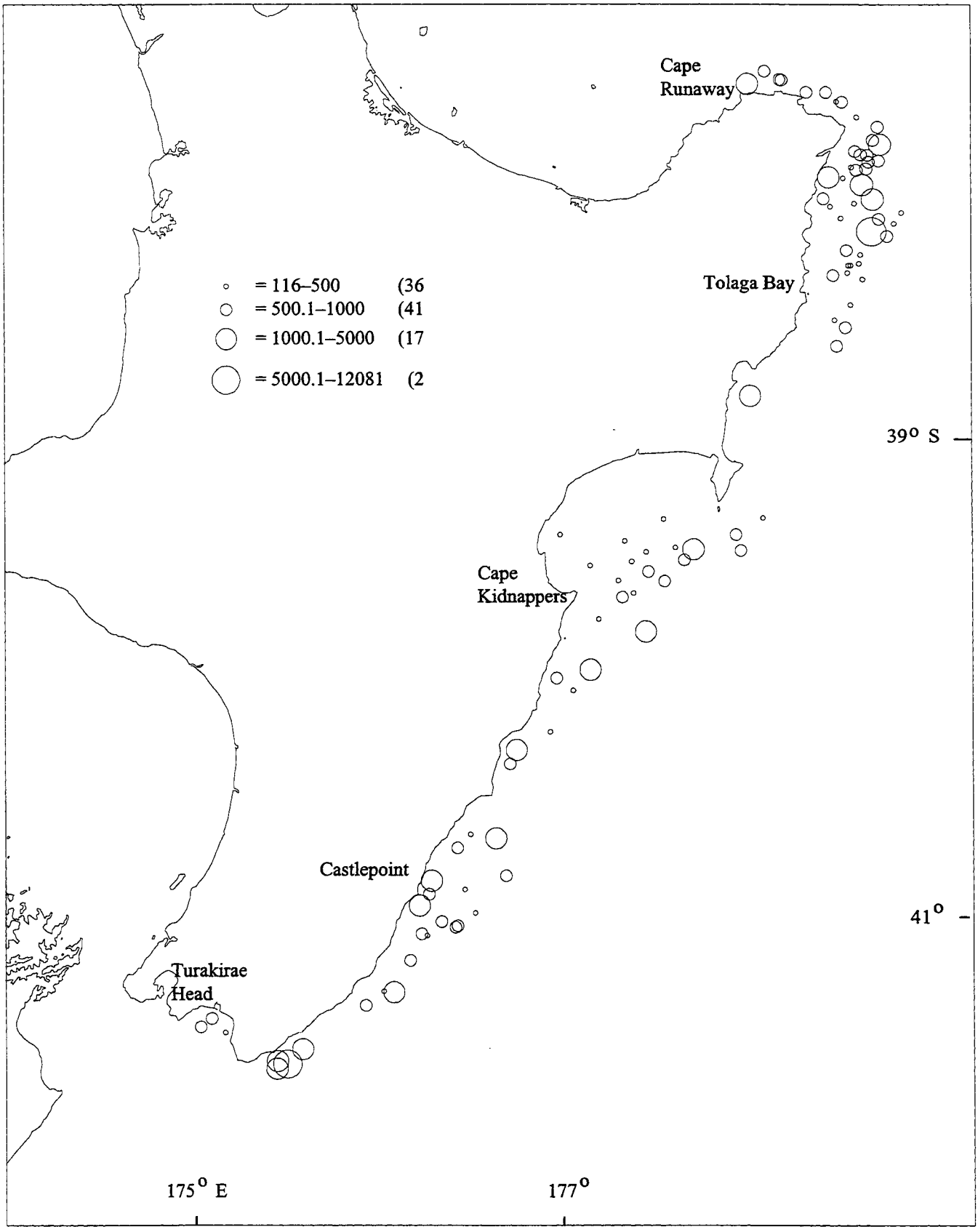


Figure 2: Catch rates (kg.km^{-2}) for all species combined and the 16 most abundant commercial finfish species for stations used for biomass calculations (numbers in parentheses are the number of stations at the given catch rate).

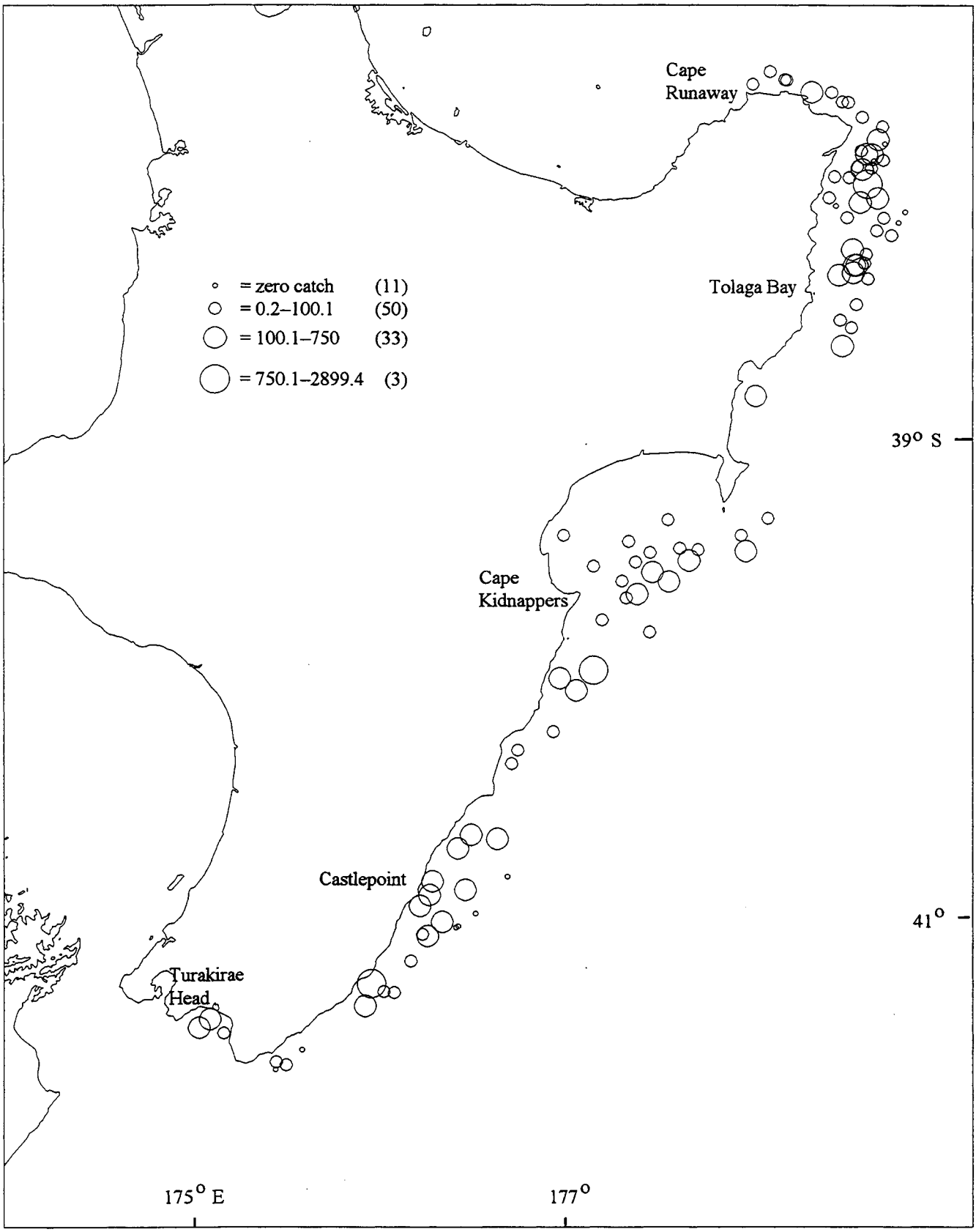


Figure 2—*continued*

Frostfish

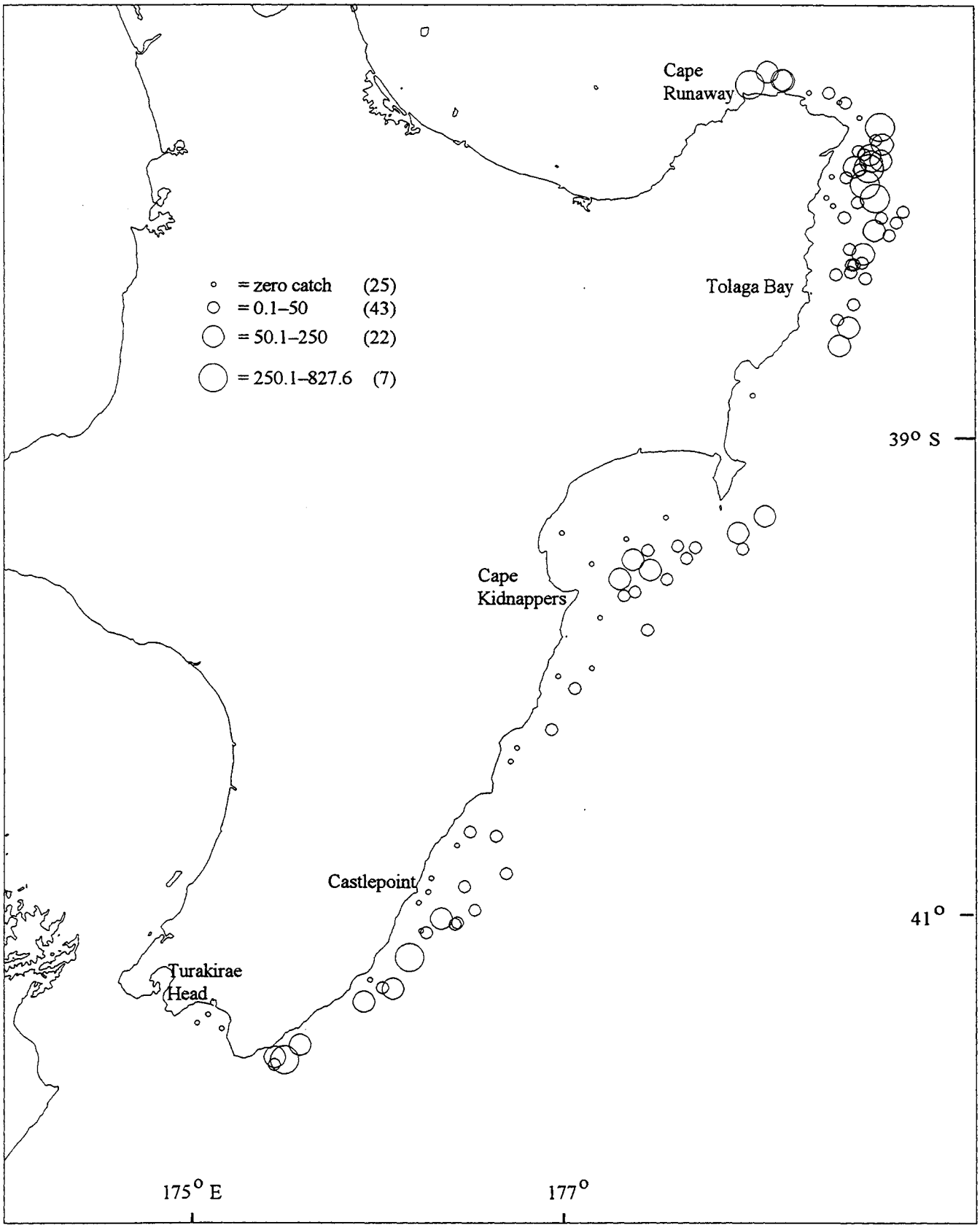


Figure 2—*continued*

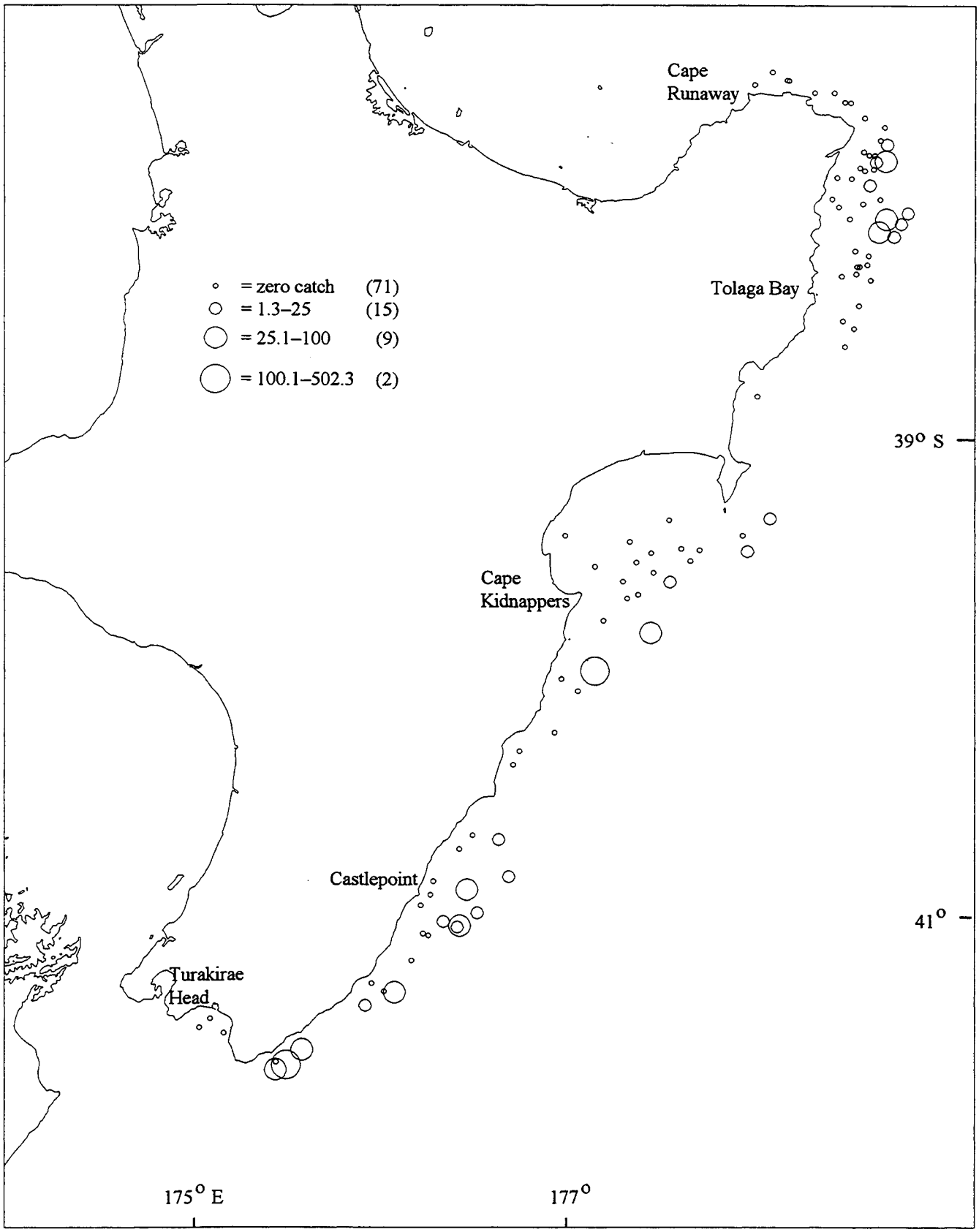


Figure 2—*continued*

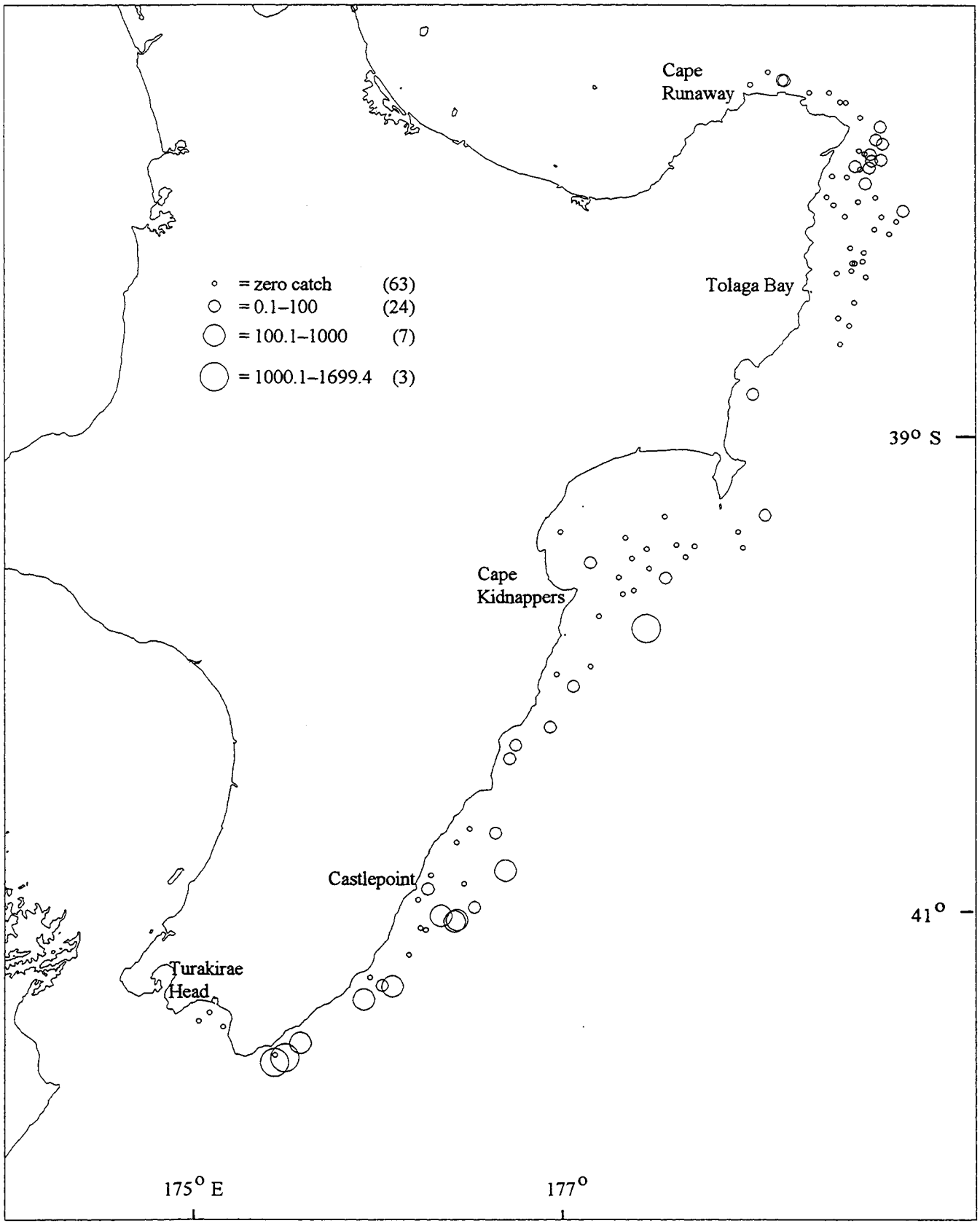


Figure 2—*continued*

Jack mackerel

Trachurus declivis

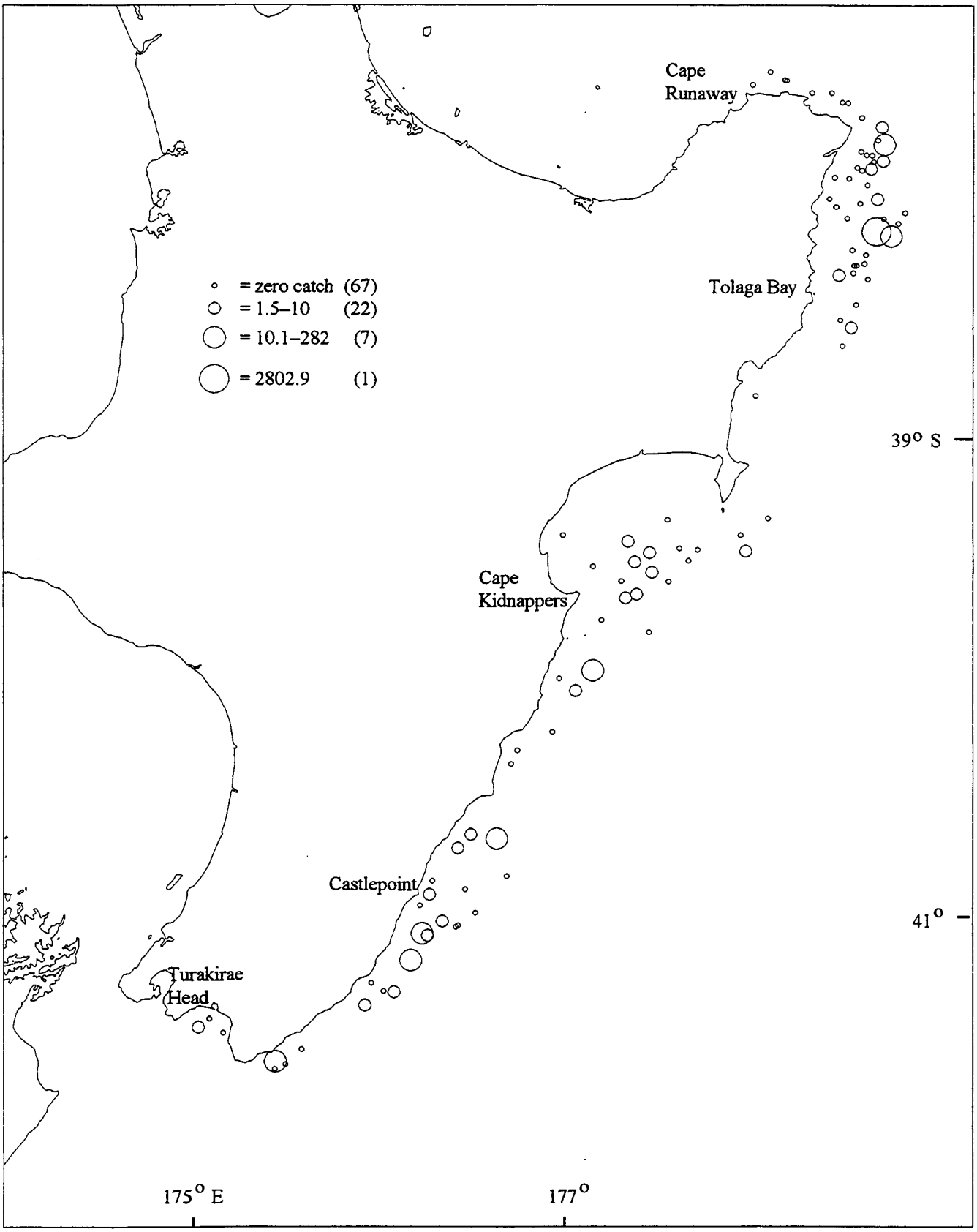


Figure 2—*continued*

Jack mackerel

Trachurus murphyi

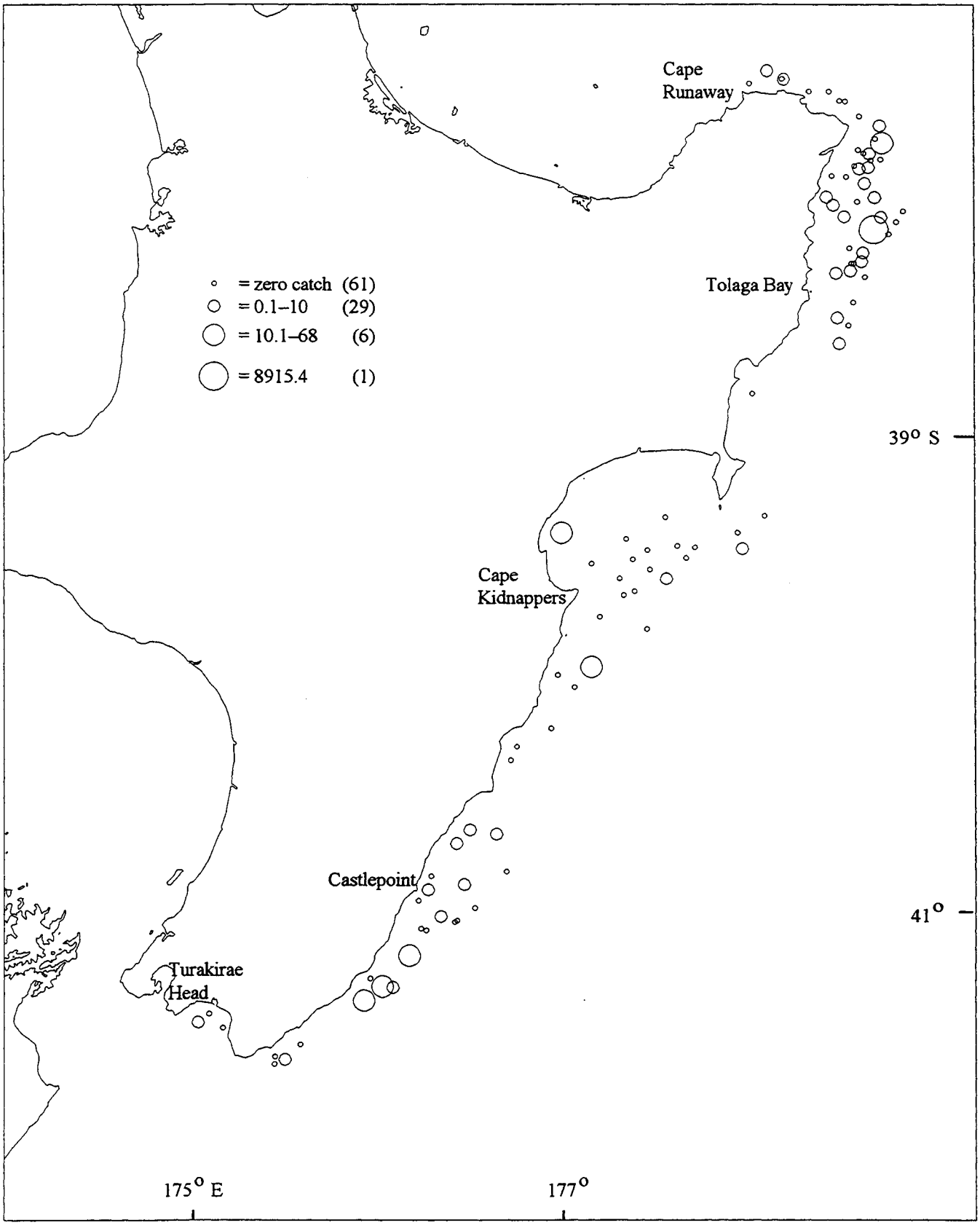


Figure 2—*continued*

Jack mackerel

Trachurus novaezelandiae

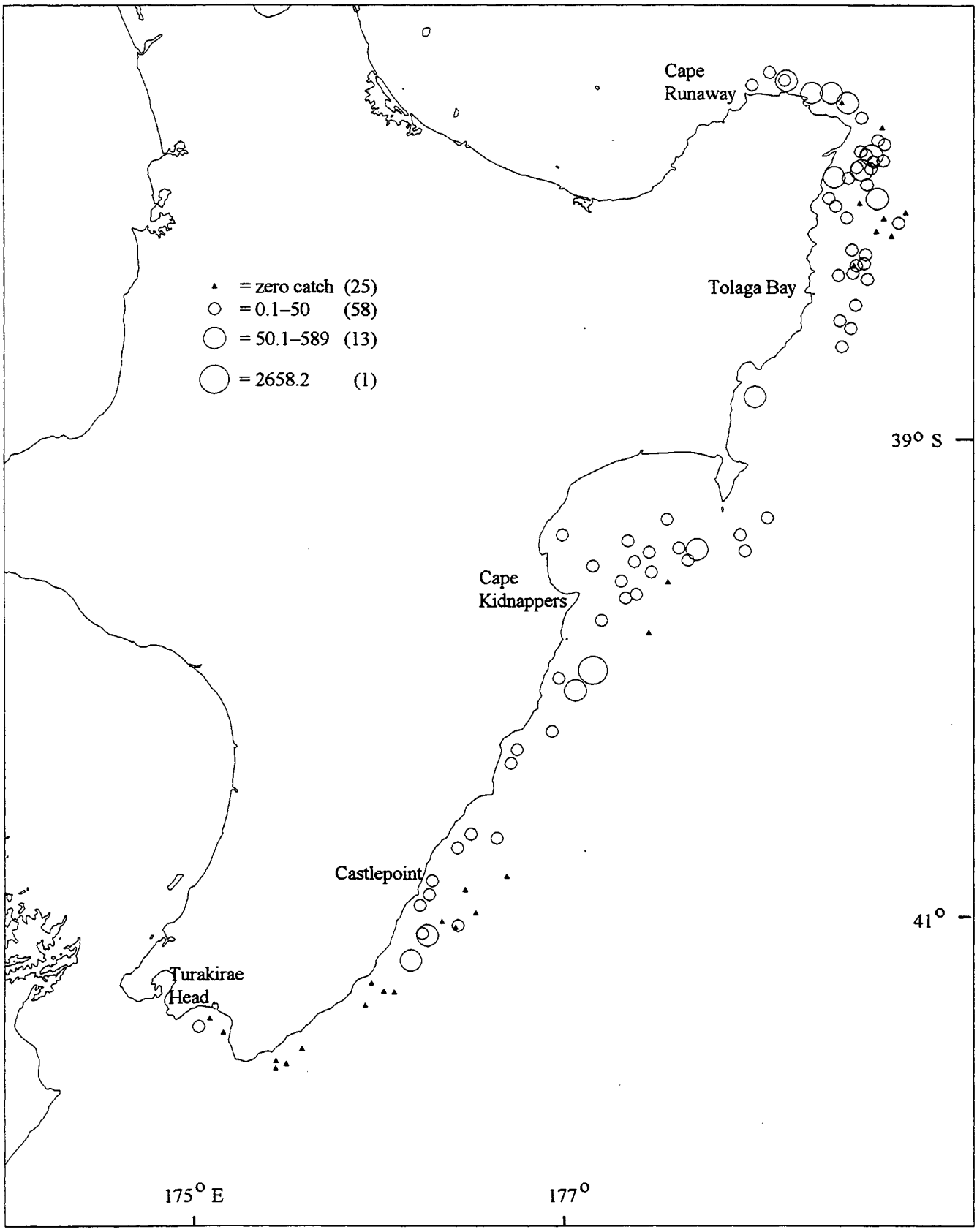


Figure 2—*continued*

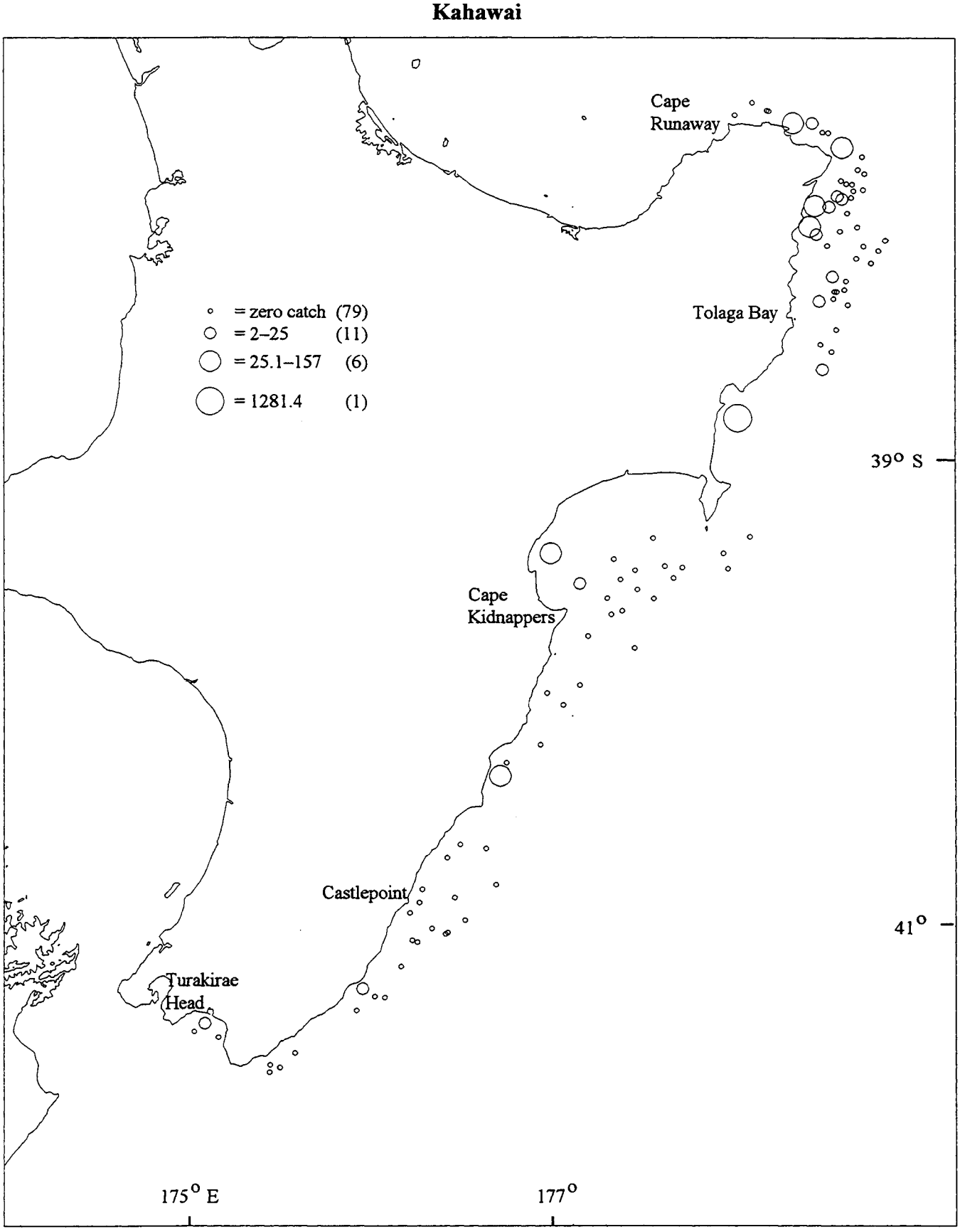


Figure 2—*continued*

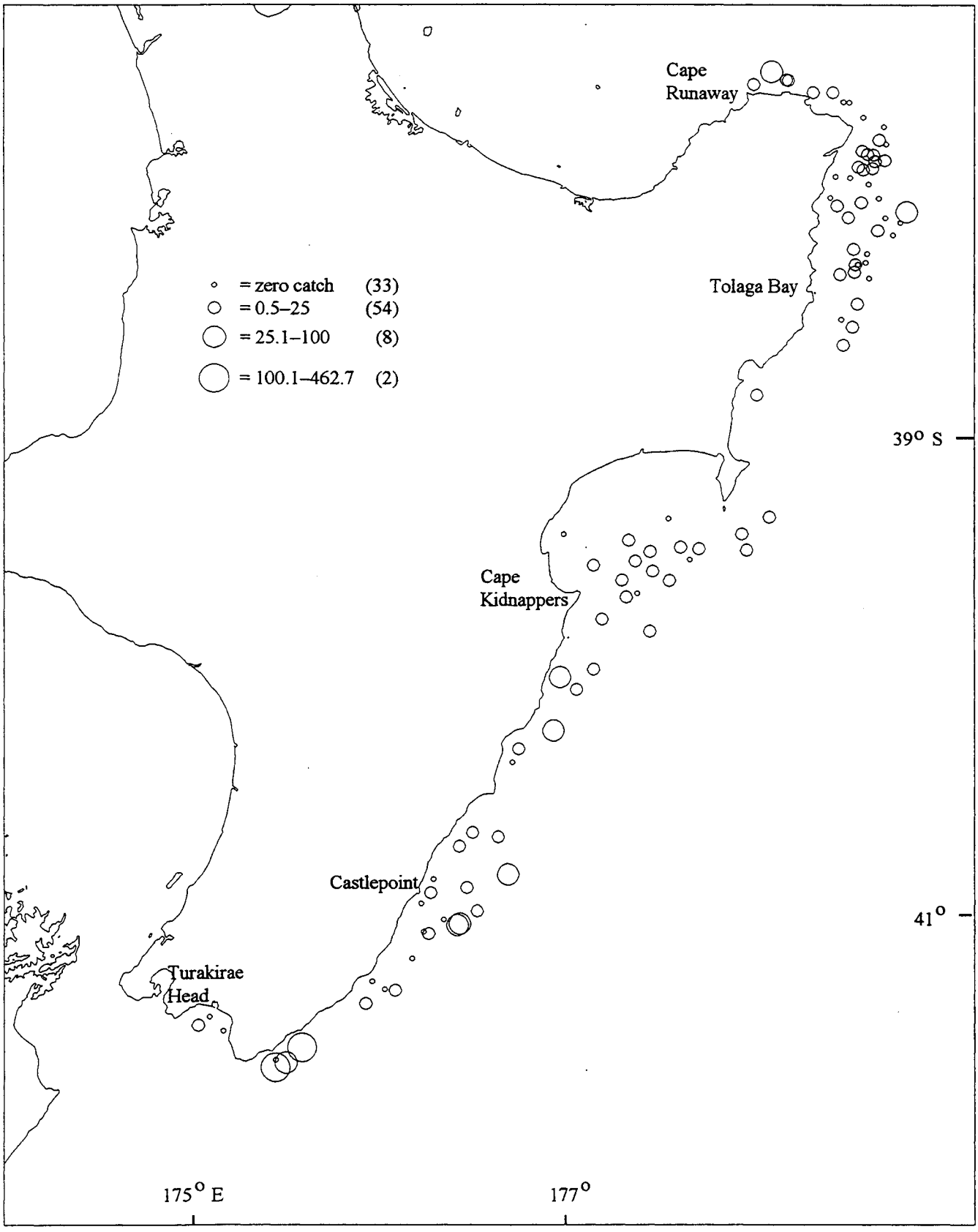


Figure 2—*continued*

Red cod

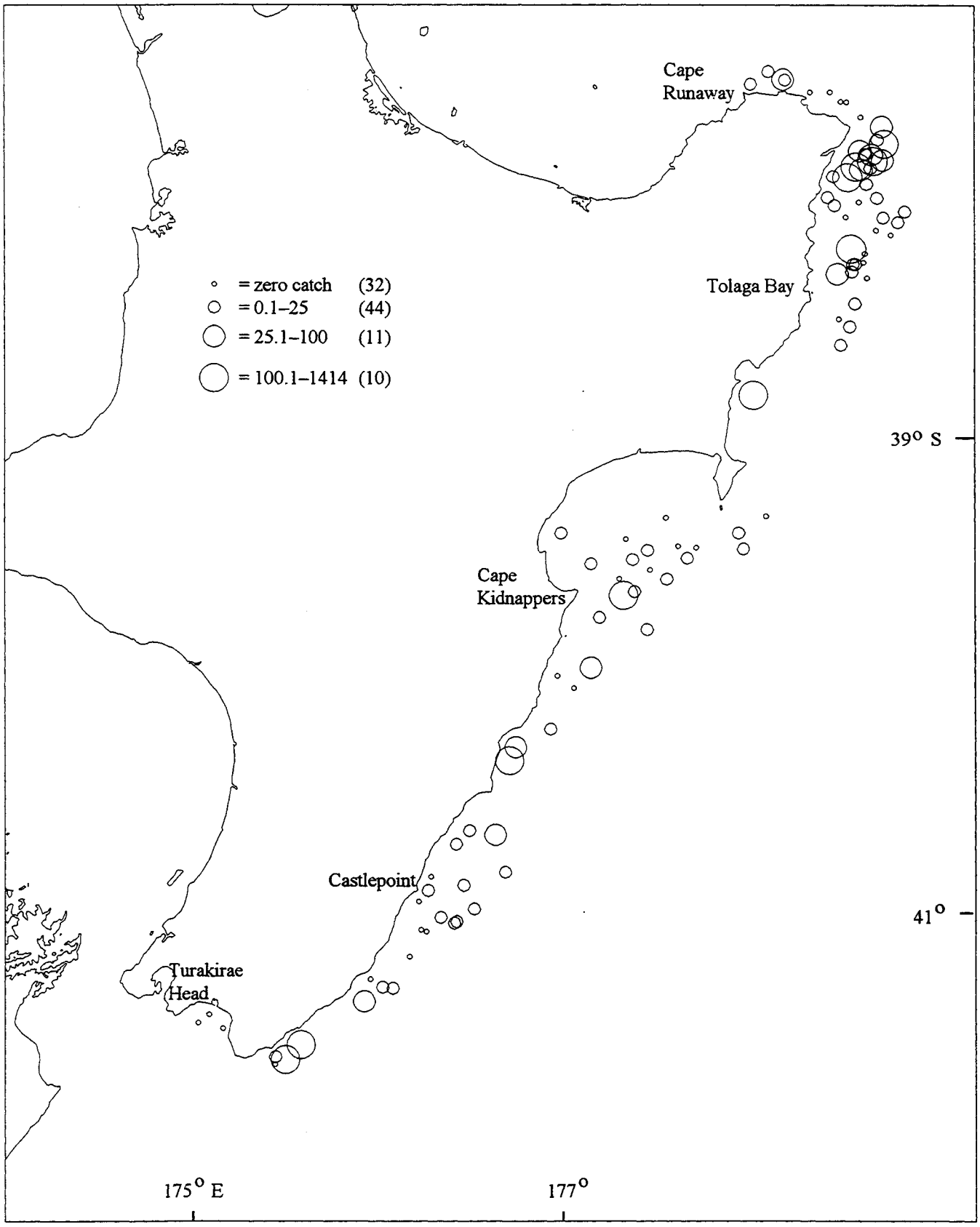


Figure 2—*continued*

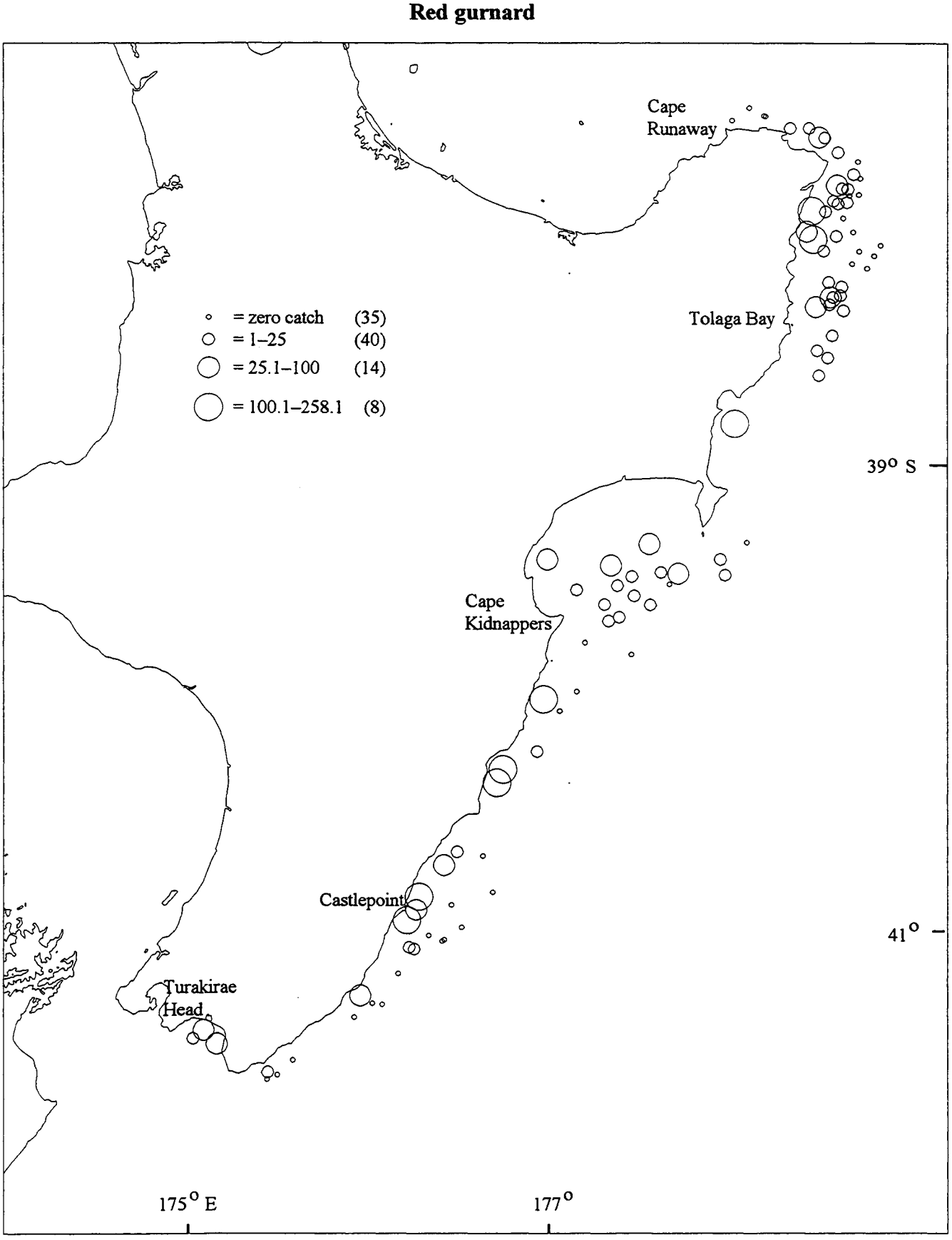


Figure 2—*continued*

School shark

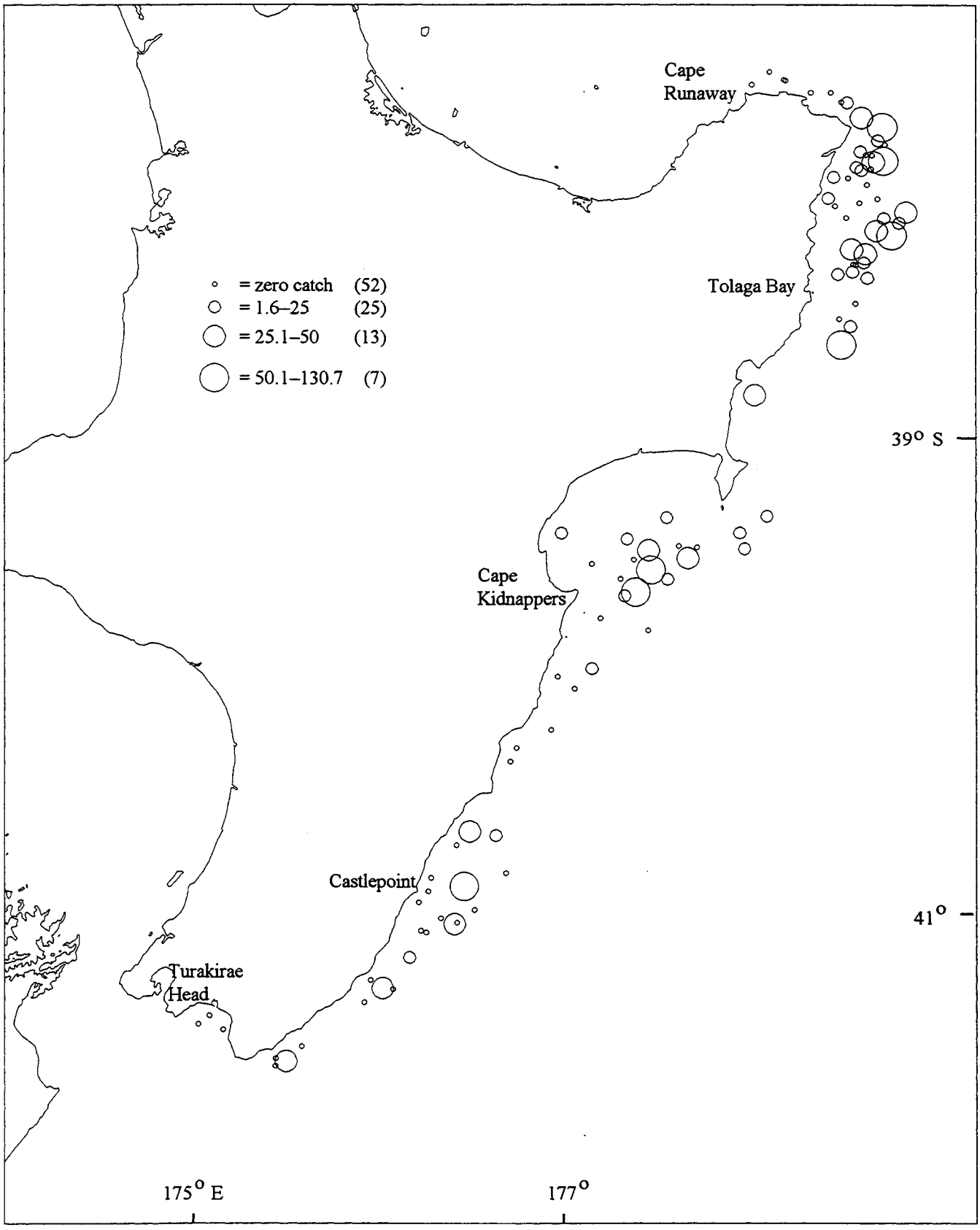


Figure 2—*continued*

Sea perch

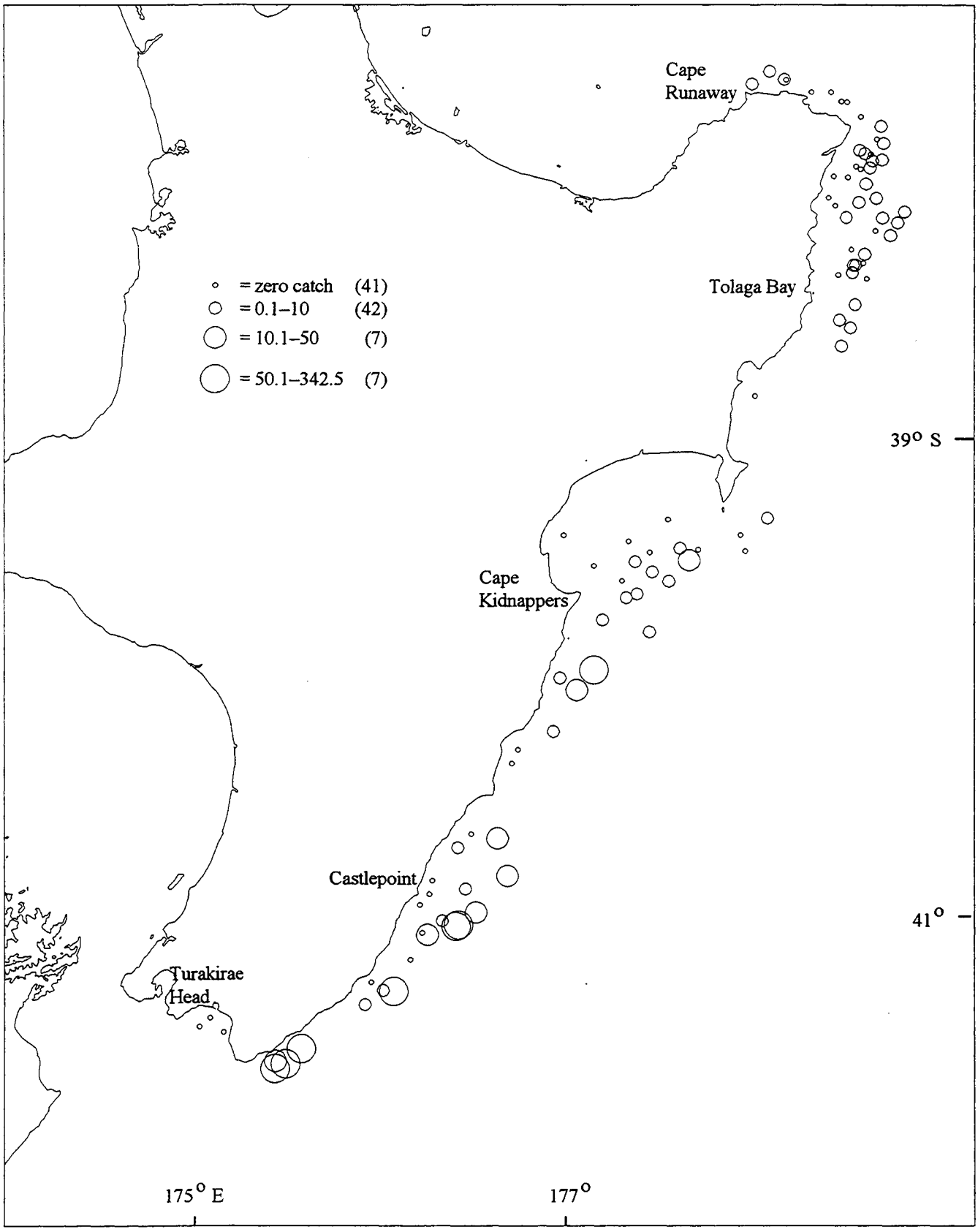


Figure 2—*continued*

Snapper

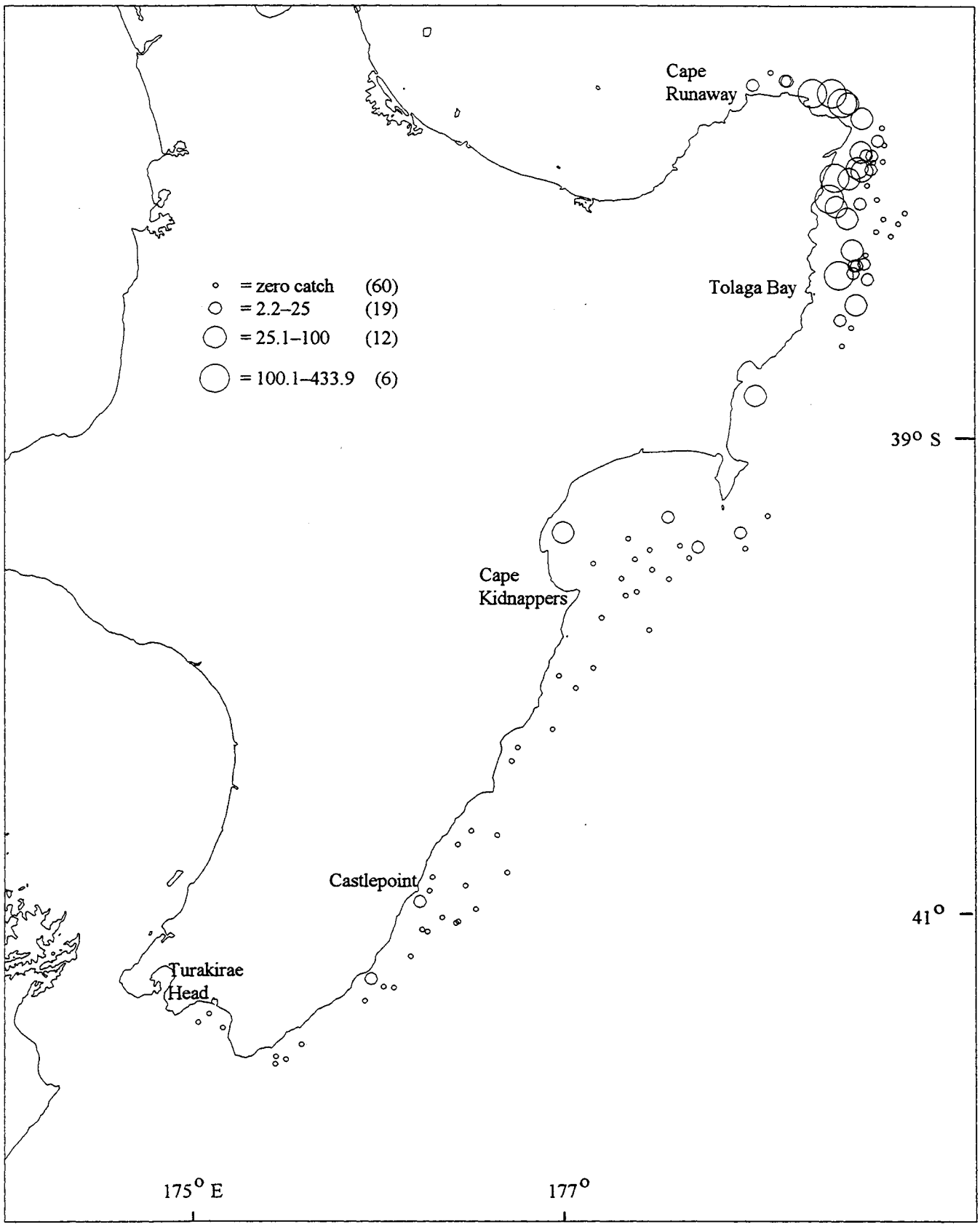


Figure 2—*continued*

Southern spiky dogfish

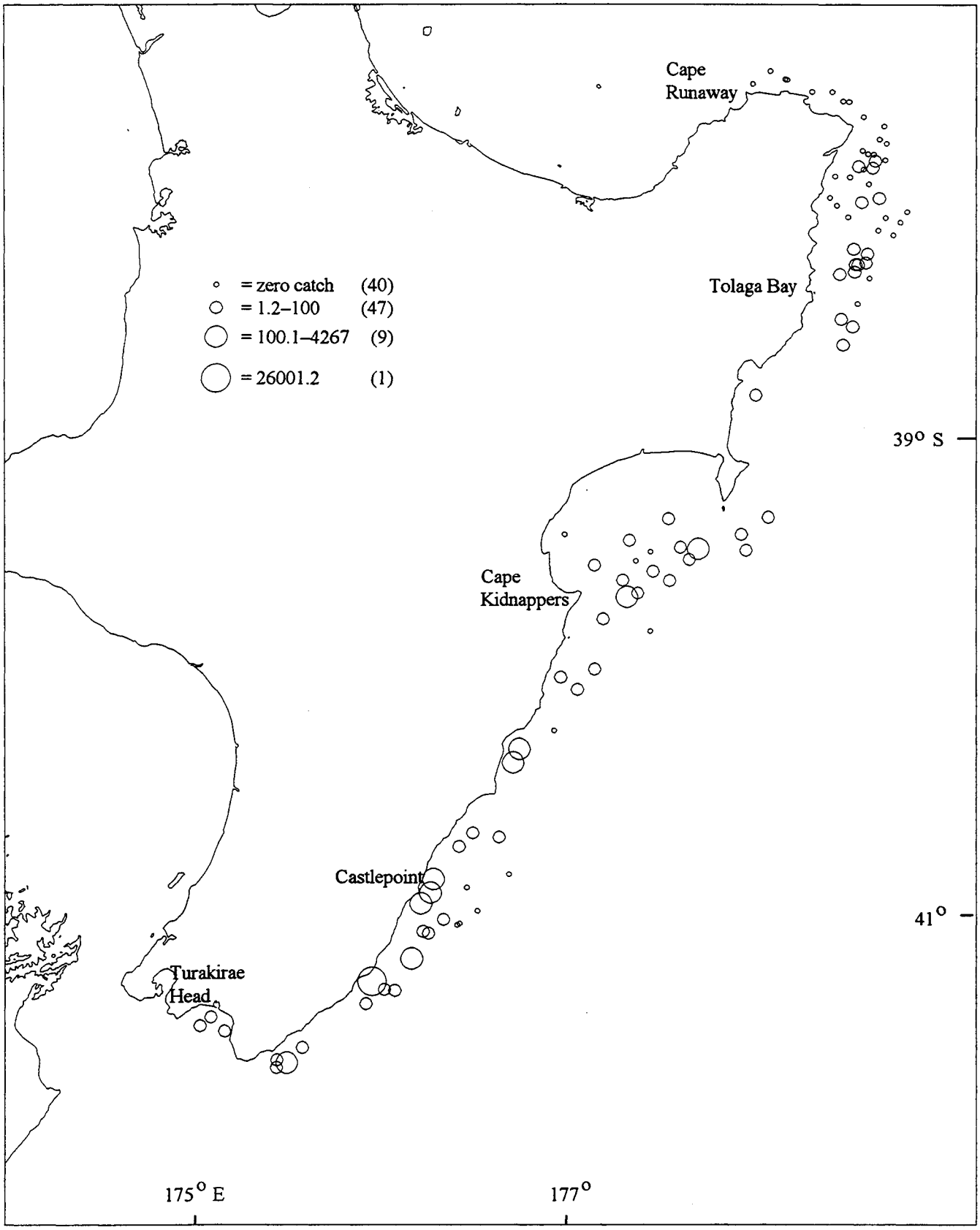


Figure 2—*continued*

Tarakihi

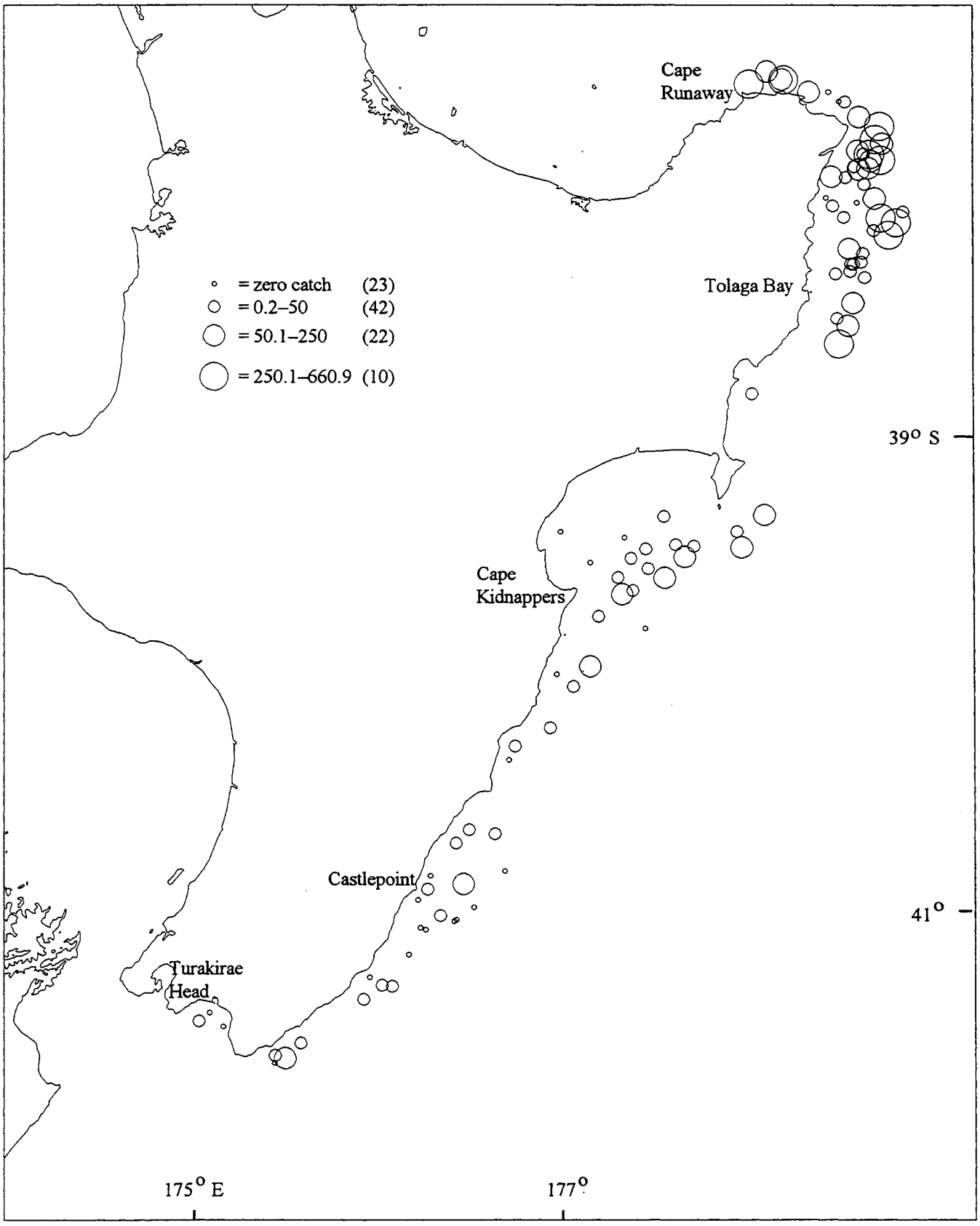


Figure 2—*continued*

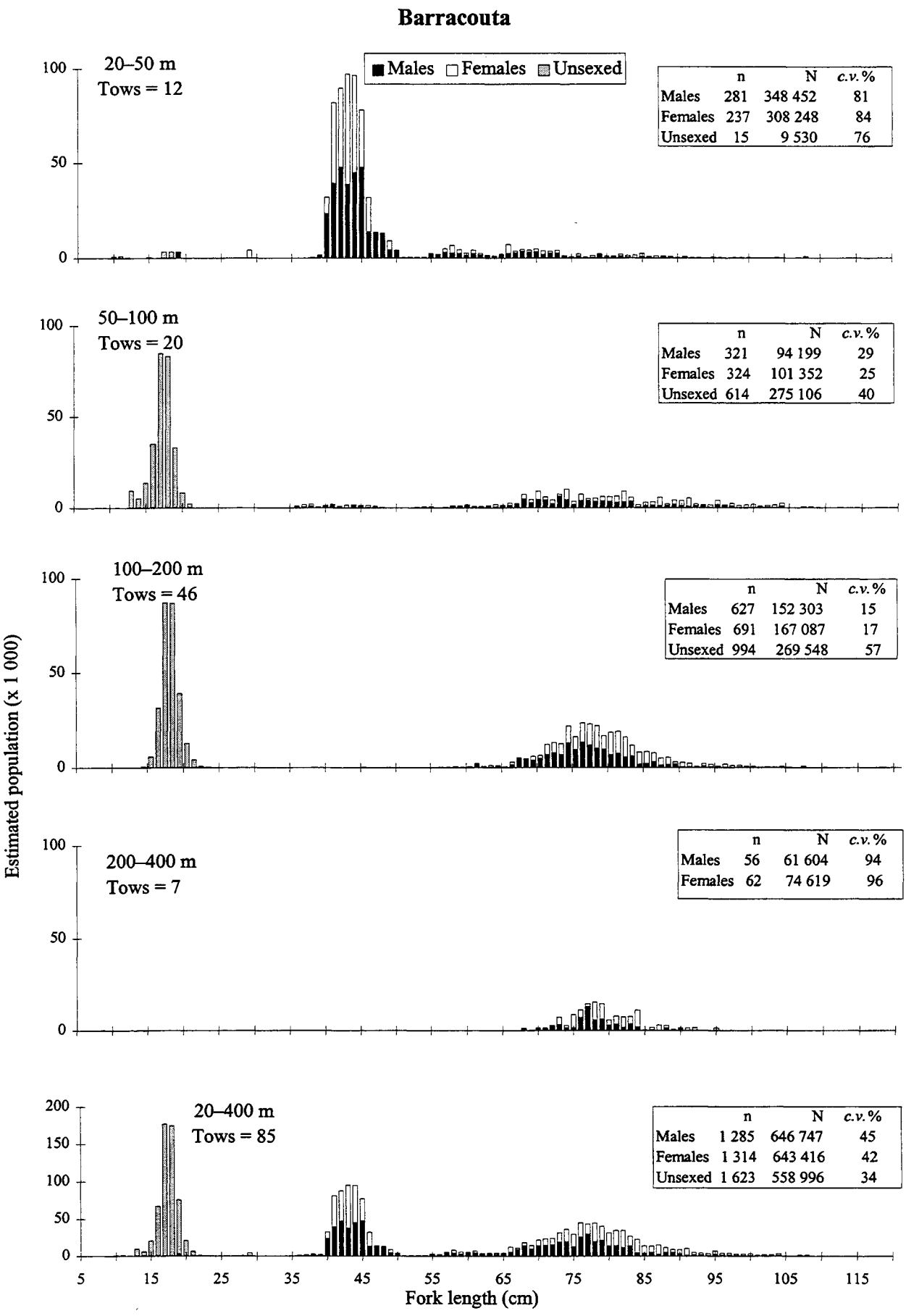


Figure 3: Length frequency distributions for the 17 most abundant ITQ species and selected non-ITQ species (n, number of fish measured; N, estimated population; Tows, number of ssamples; c.v., coefficient of variation).

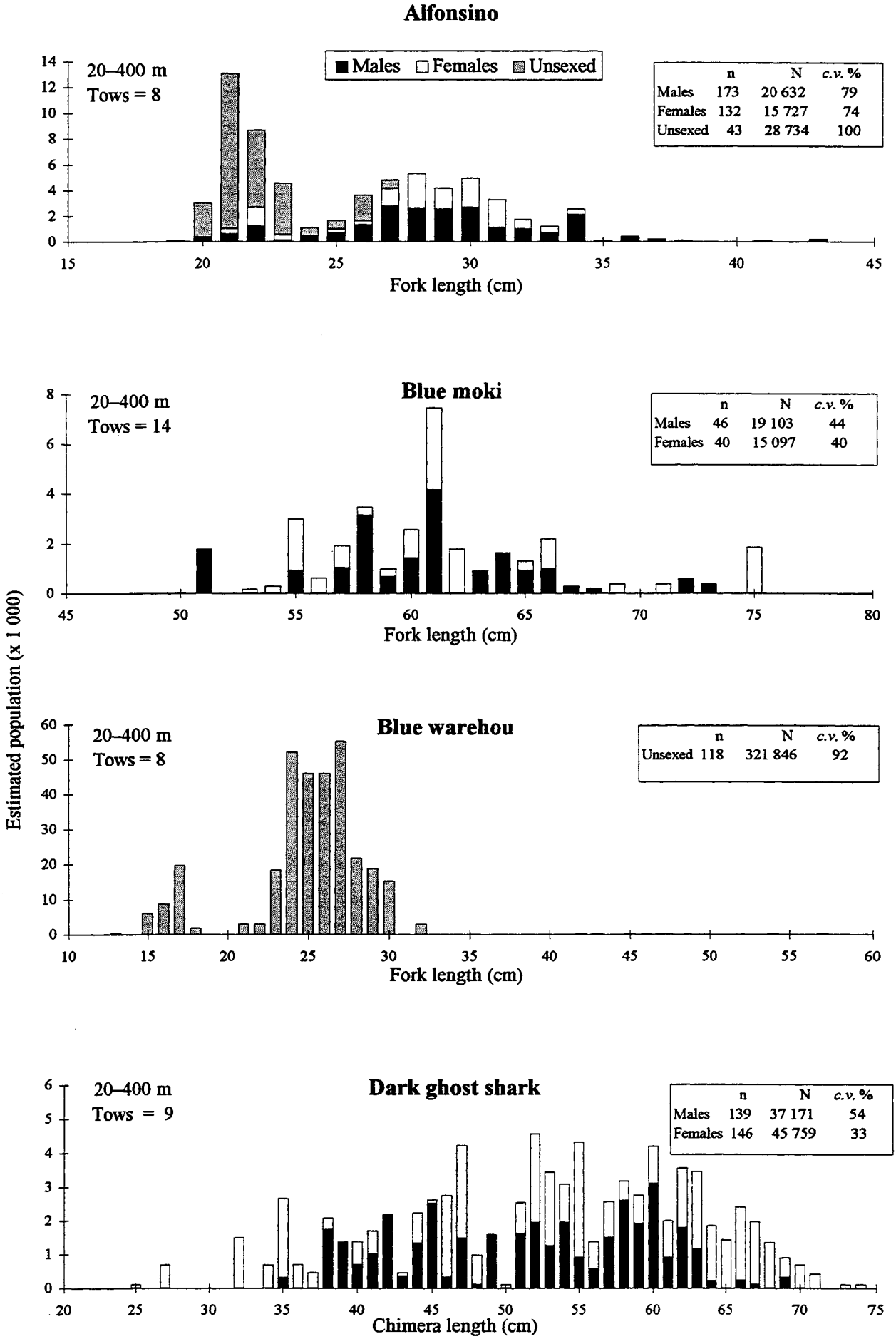


Figure 3—*continued*

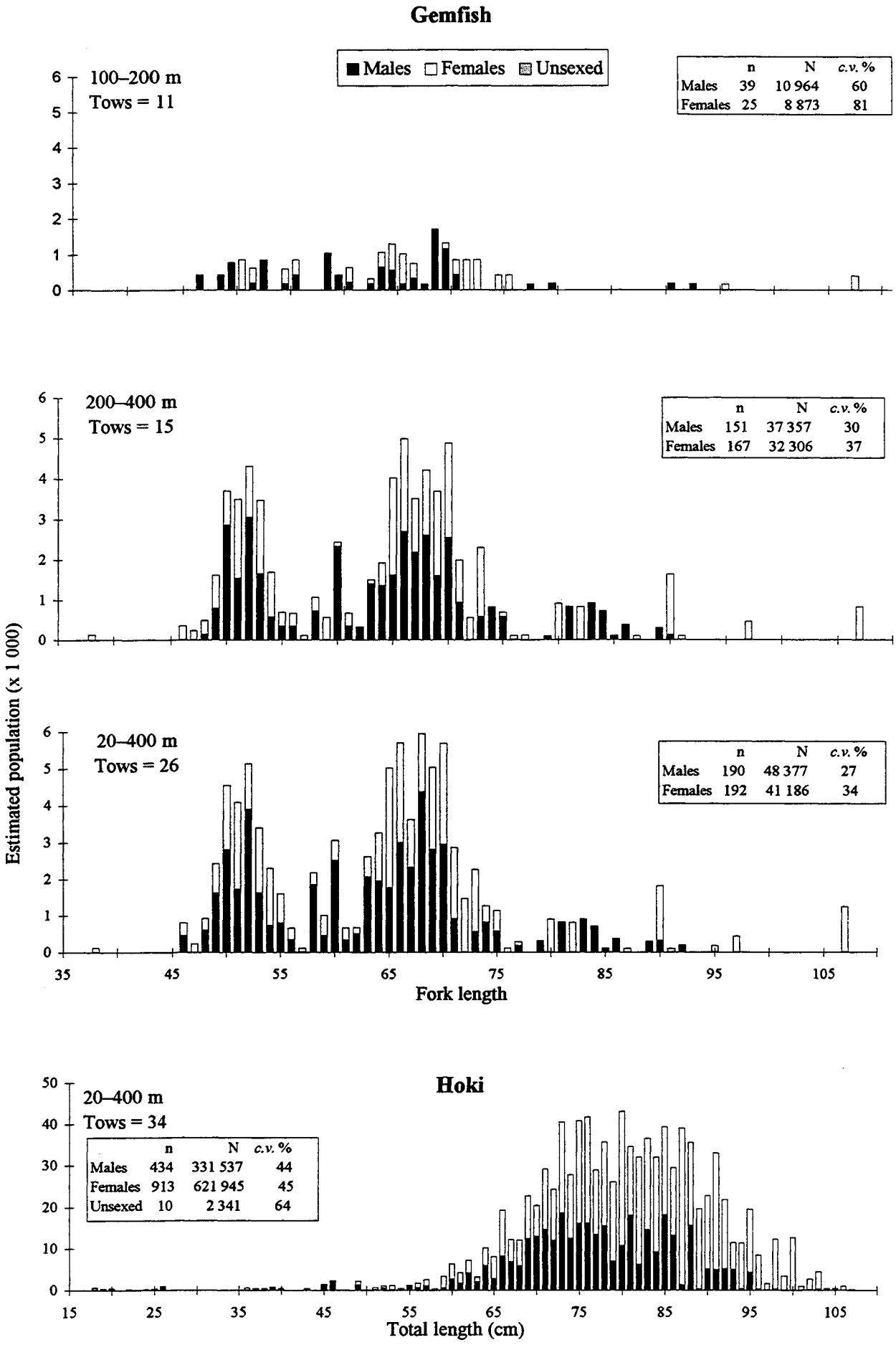


Figure 3—*continued*

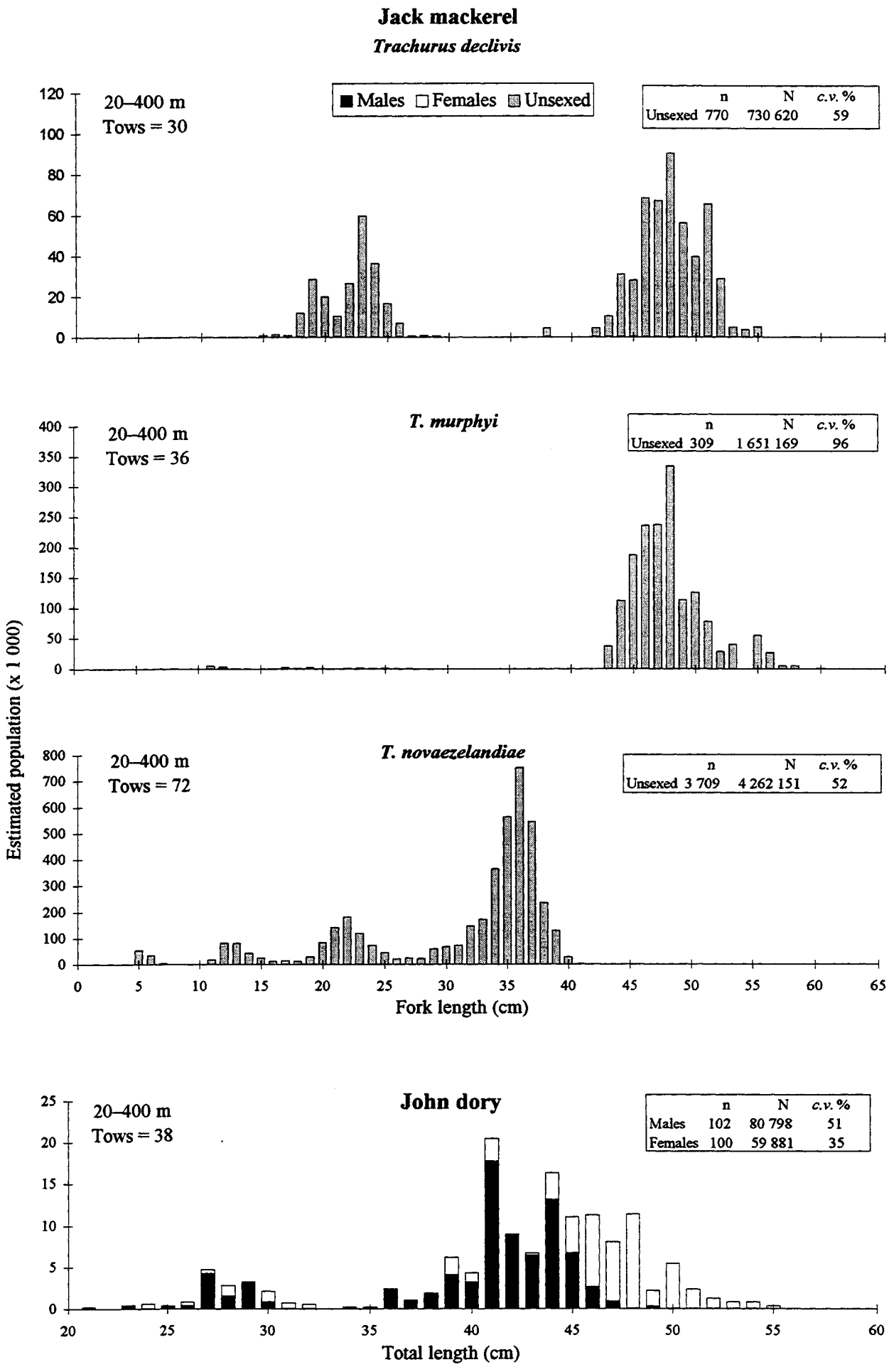


Figure 3—*continued*

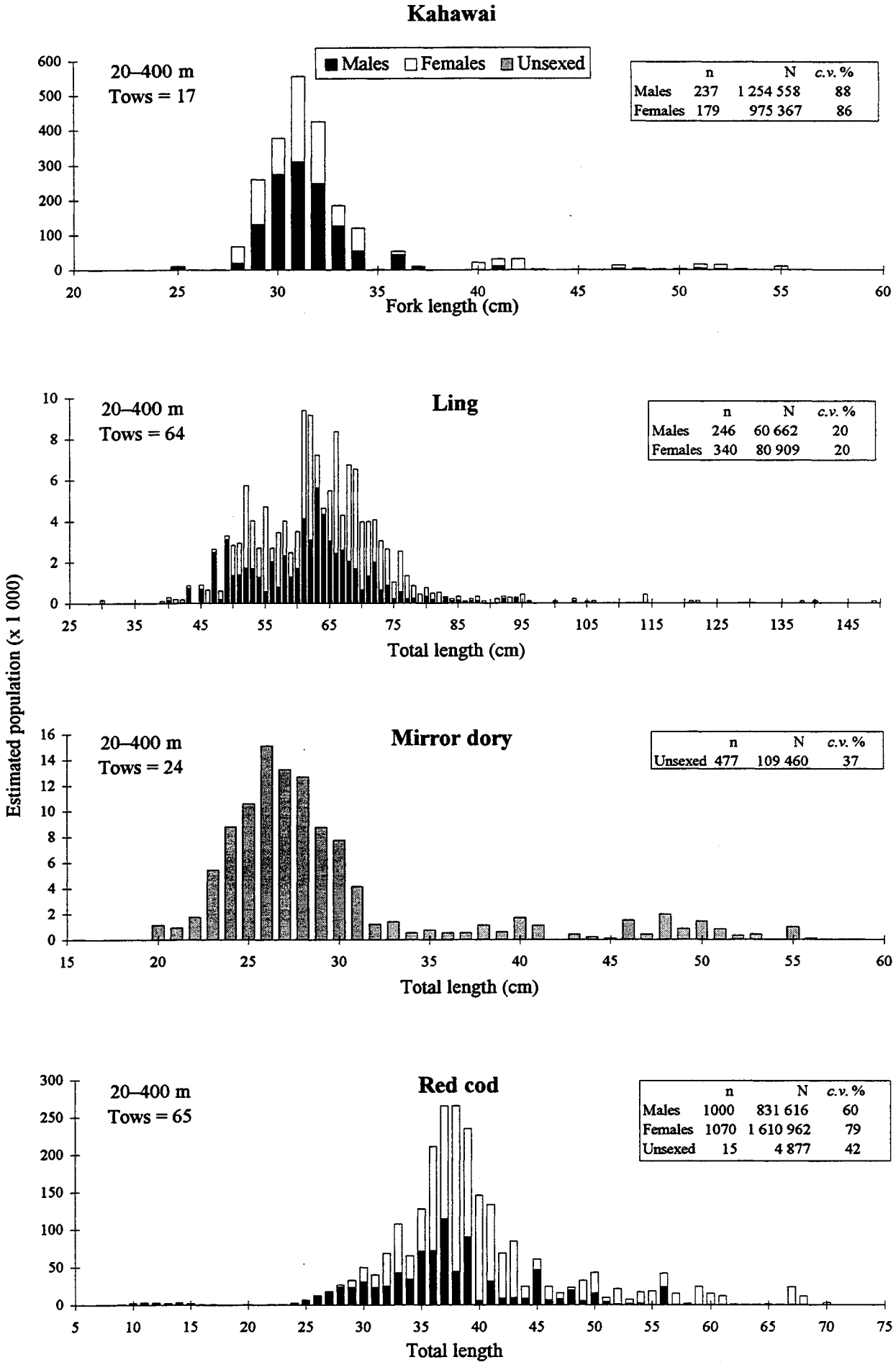


Figure 3—*continued*

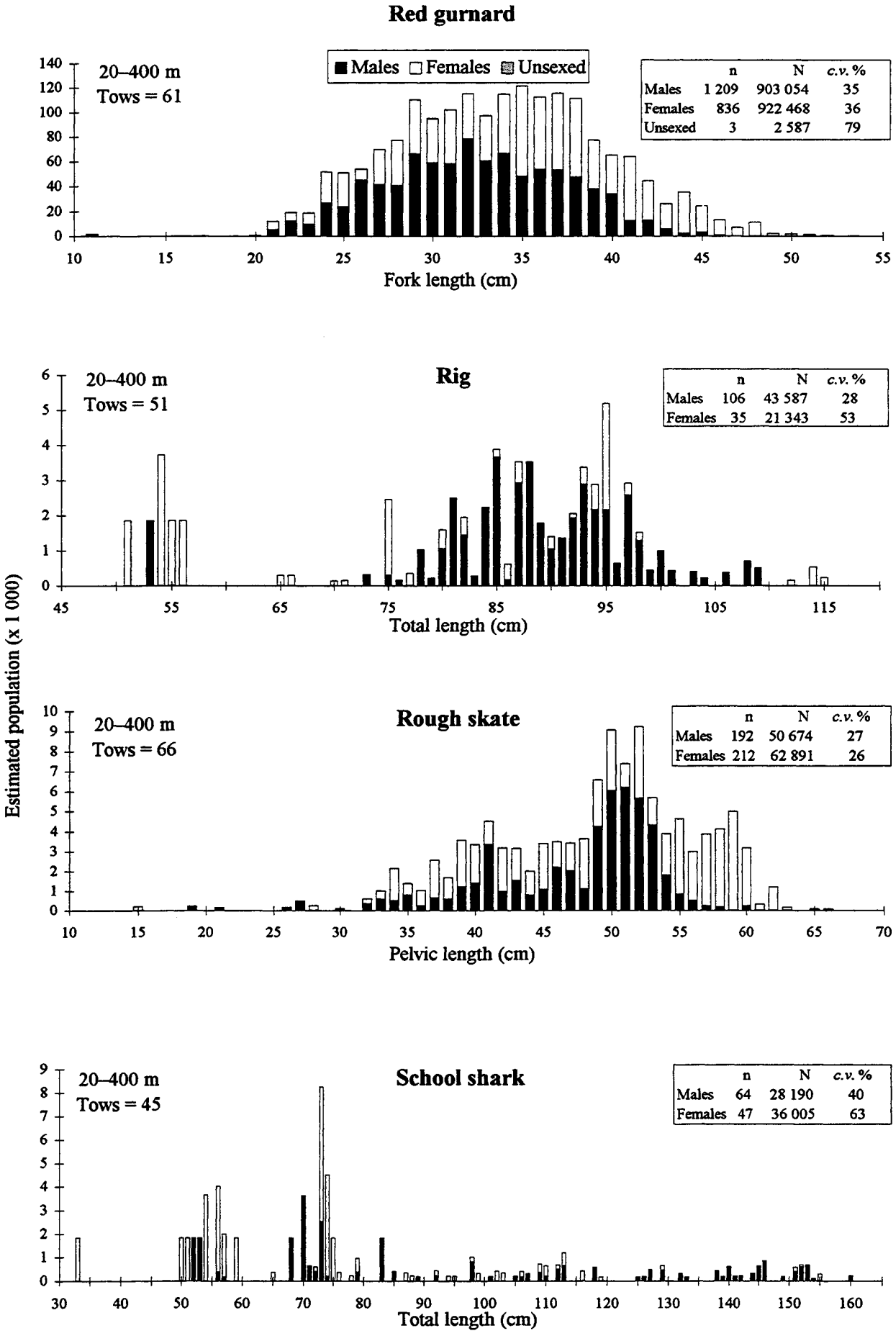


Figure 3—*continued*

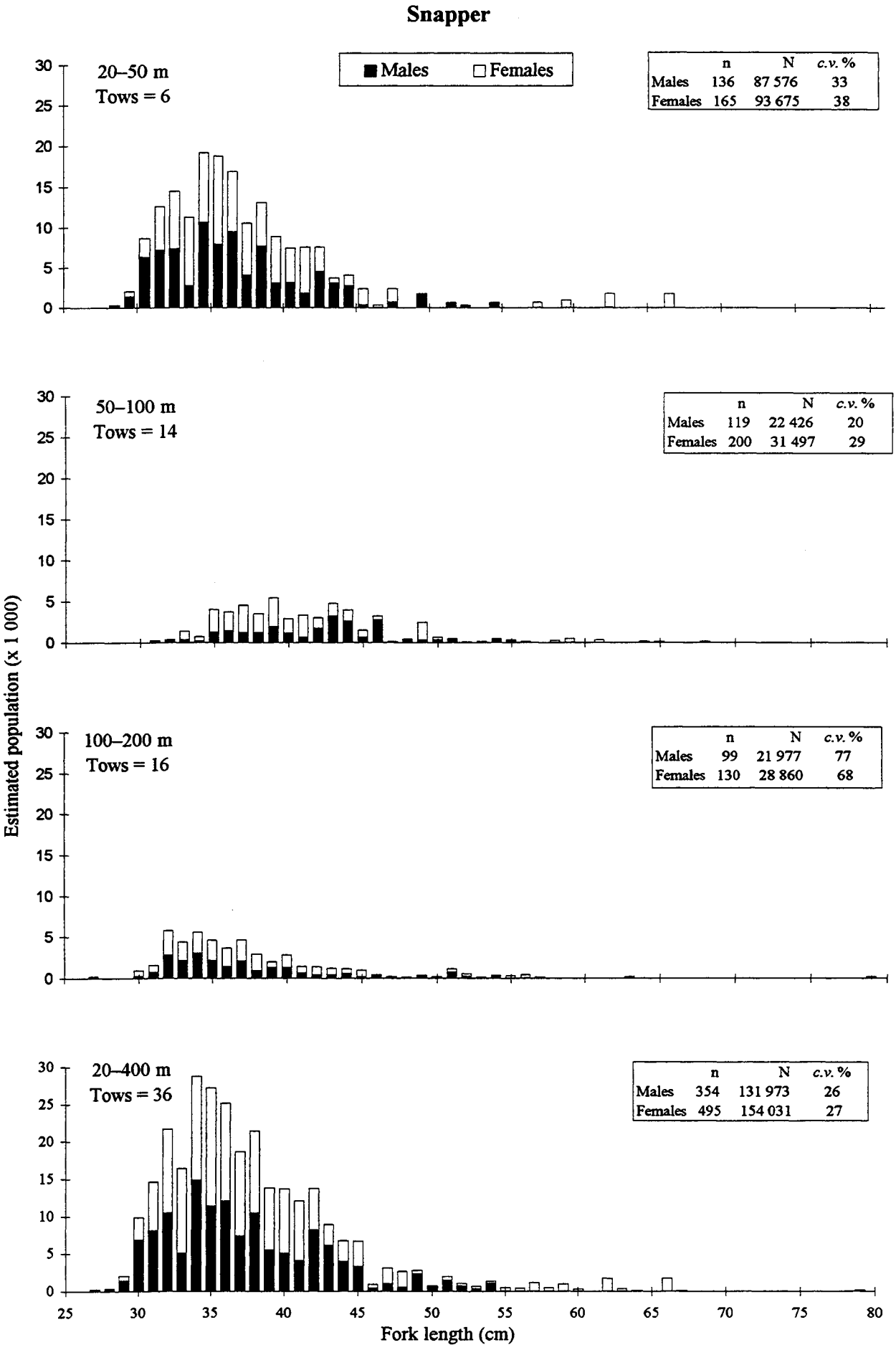


Figure 3—*continued*

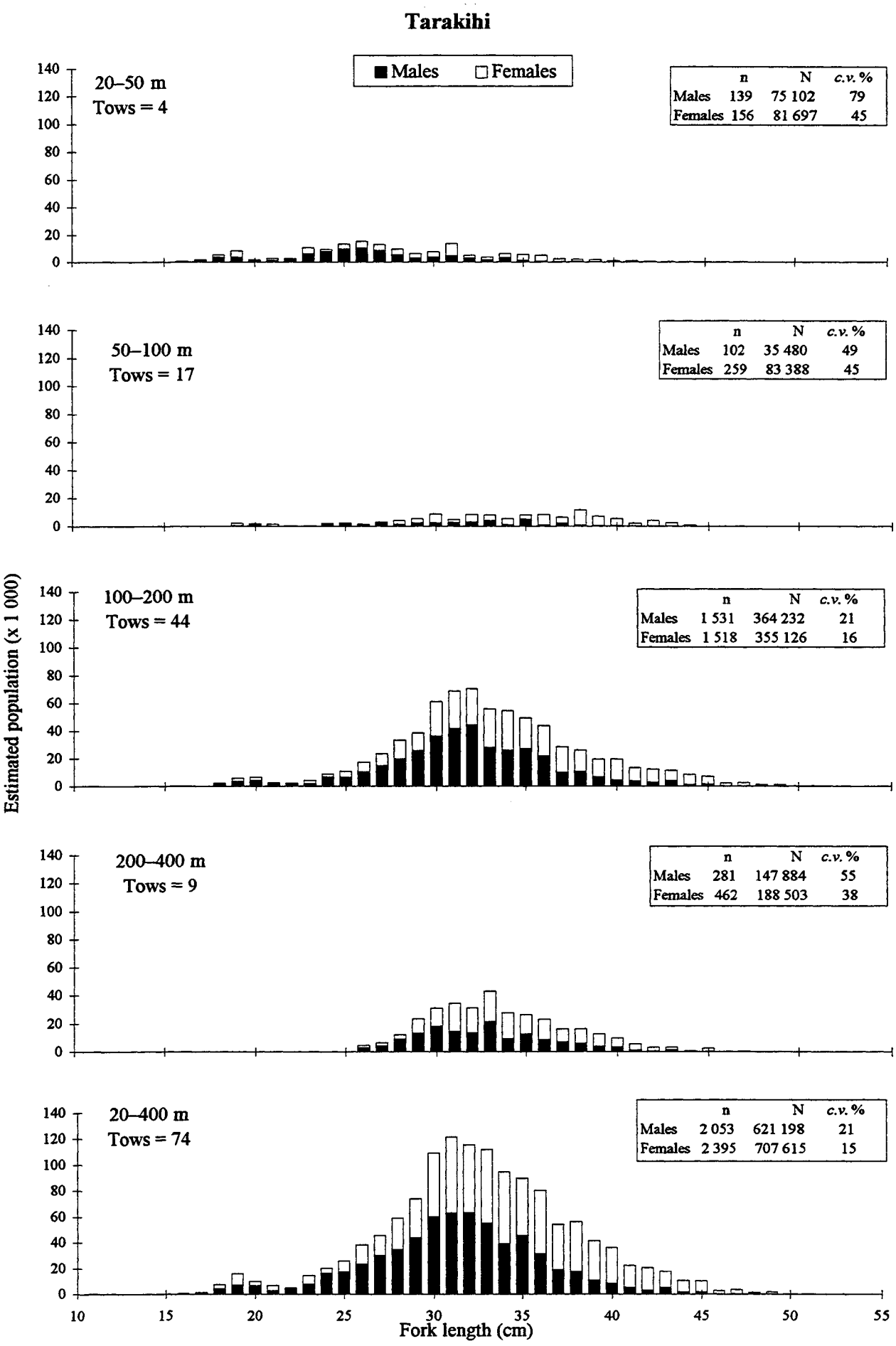


Figure 3—*continued*

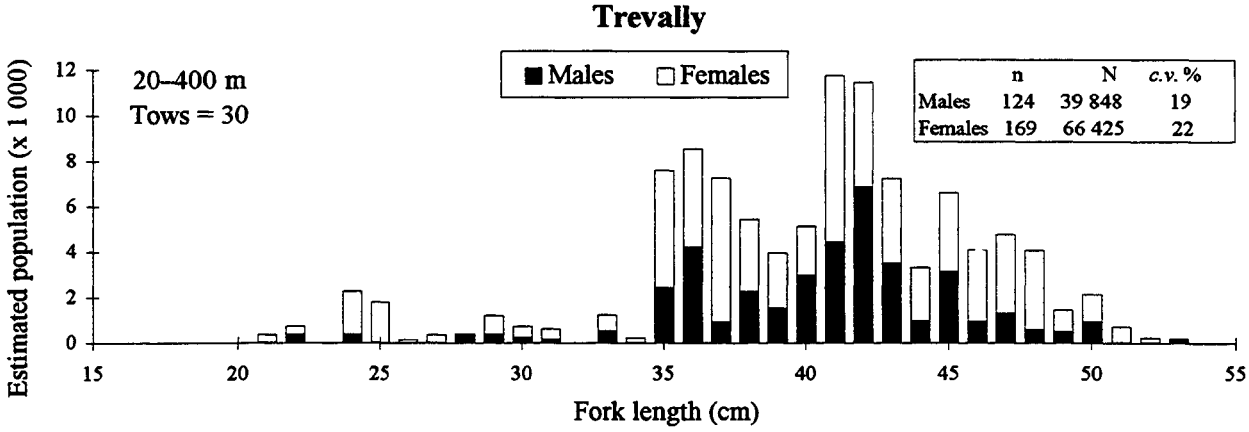
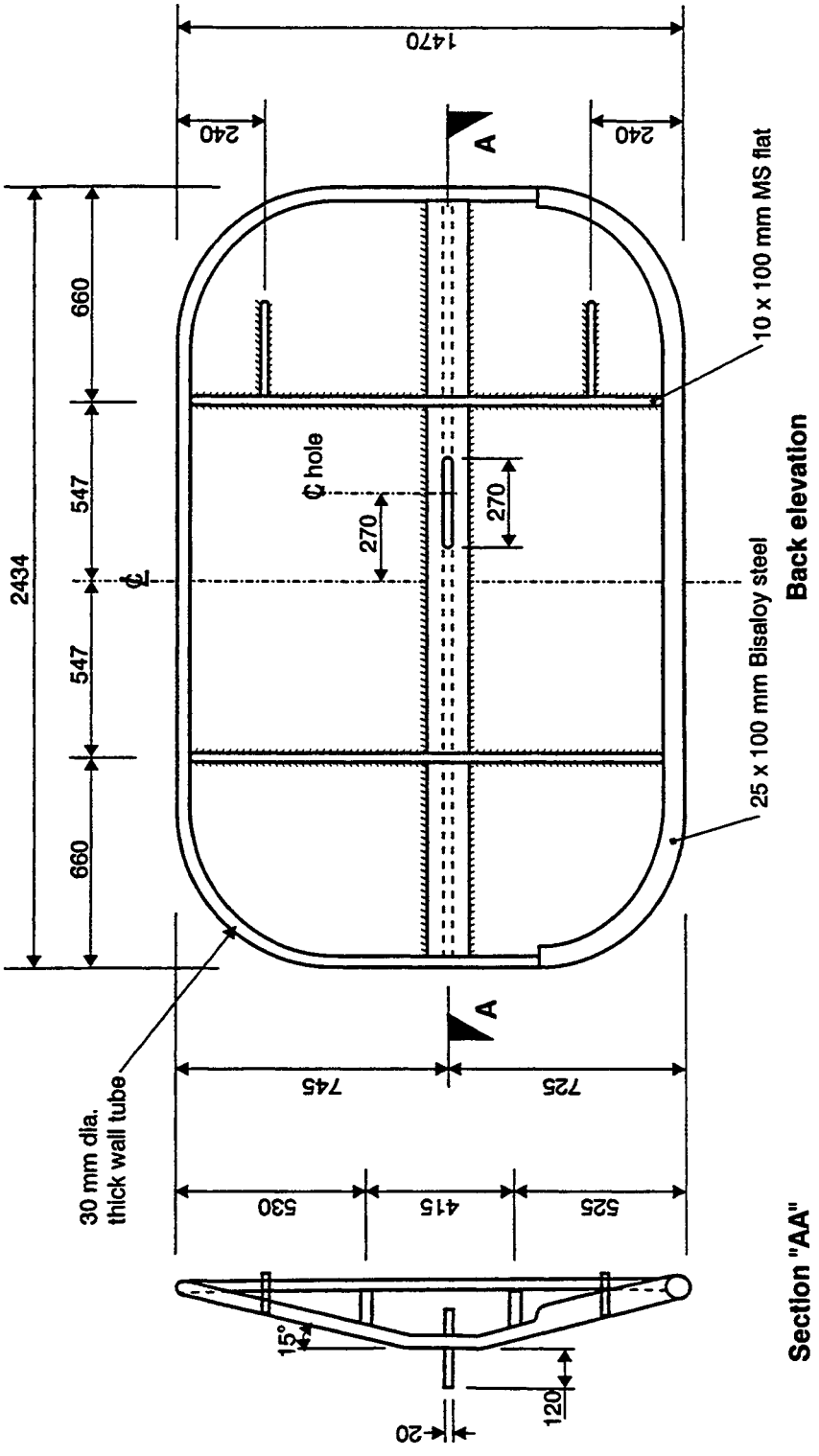


Figure 3—*continued*

Appendix 1: Specifications for the old (used during 1993 and 1994) and new (1995 and 1996) trawl doors

Attribute	Old	New
Aspect ratio (area/span^2)	Low	Low
Surface area	3.2 m^2	3.2 m^2
Shape	Rectangular "V"	Rectangular "V"
Scanmar brackets fitted	No	Yes
Weight	500 kg (with weighted shoes)	630 kg (dispersed over entire door)

Back elevation and side section of new doors



Appendix 2: Summary of station data

Station	Stratum	Date	Start of tow			End of tow		Gear depth (m)		Distance trawled	Doorspread	Surface temp.	Bottom temp.
			Time	° ' S	° ' E	° ' S	° ' E	Min.	Max.	(n. miles)	(m)	(°C)	(°C)
1	14	17-Feb-96	551	37 30.64	178 00.99	37 30.86	178 05.61	108	131	3.67	85.6	21.6	15.8
2	14	17-Feb-96	753	37 29.50	178 11.38	37 29.20	178 07.23	115	130	3.31	88.3	21.4	14.4
3	14	17-Feb-96	934	37 27.44	178 06.67	37 28.18	178 10.92	141	164	3.45	89.7	21.4	14.4
4	14	17-Feb-96	1117	37 29.65	178 12.08	37 29.65	178 16.69	110	130	3.67	83.5	21.4	17.5
5	13	17-Feb-96	1306	37 32.73	178 20.21	37 32.54	178 25.04	81	95	3.83	91.1	21.4	19.7
6	13	17-Feb-96	1441	37 32.71	178 26.47	37 34.00	178 30.61	65	84	3.54	83.8	21.8	18.0
7	12	18-Feb-96	531	37 38.94	178 36.24	37 37.73	178 31.67	39	58	3.82	83.5	20.4	20.0
8	13	18-Feb-96	716	37 35.13	178 31.64	37 37.08	178 35.68	51	80	3.76	78.4	20.2	–
9	14	18-Feb-96	912	37 41.36	178 42.65	37 43.04	178 46.86	124	126	3.73	89.2	20.2	13.5
10	14	18-Feb-96	1154	37 45.72	178 43.41	37 49.12	178 43.15	122	160	3.39	82.7	20.8	14.2
11	14	18-Feb-96	1347	37 49.79	178 42.99	37 53.06	178 41.95	172	185	3.36	96.1	20.8	11.6
12	14	18-Feb-96	1534	37 51.81	178 39.16	37 48.35	178 37.93	102	145	3.58	88.6	21.2	13.7
13	13	19-Feb-96	535	37 47.42	178 35.81	37 50.80	178 34.55	76	86	3.52	76.7	21.0	16.2
14	13	19-Feb-96	703	37 51.47	178 34.63	37 54.95	178 32.93	89	91	3.72	80.2	21.1	14.8
15	13	19-Feb-96	838	37 54.18	178 32.01	37 57.62	178 30.40	74	80	3.66	84.3	21.2	15.0
16	12	19-Feb-96	1029	37 53.96	178 27.38	37 57.31	178 25.43	44	46	3.67	82.5	21.2	20.6
17	12	19-Feb-96	1208	37 59.30	178 25.68	38 02.85	178 25.79	46	50	3.55	85.3	21.2	20.2
18	13	19-Feb-96	1347	38 01.29	178 27.92	38 04.81	178 27.74	59	61	3.51	85.0	21.6	18.0
19	13	19-Feb-96	1524	38 04.26	178 31.36	38 07.68	178 31.60	76	83	3.42	80.5	21.7	15.4
20	9	20-Feb-96	1042	38 49.20	178 01.85	38 52.42	177 59.82	42	49	3.57	75.2	21.6	17.7
21	10	20-Feb-96	1505	38 30.01	178 29.26	38 26.45	178 29.31	83	97	3.55	89.4	21.4	14.2
22	13	21-Feb-96	541	38 18.71	178 28.76	38 21.85	178 30.48	74	82	3.41	80.4	20.9	15.5
23 *	13	21-Feb-96	723	38 22.72	178 34.03	38 22.00	178 34.05	89	97	0.75	85.1	21.2	15.0
24	13	22-Feb-96	645	38 18.10	178 33.43	38 14.99	178 30.98	88	100	3.65	88.0	20.0	15.5
25	14	22-Feb-96	830	38 16.18	178 33.70	38 19.18	178 35.96	107	114	3.47	91.0	19.8	15.5
26	14	22-Feb-96	1010	38 19.70	178 38.01	38 16.39	178 36.48	125	128	3.51	87.3	20.4	14.1
27	14	22-Feb-96	1146	38 15.73	178 36.93	38 12.56	178 38.60	118	133	3.45	91.7	20.6	13.8
28	14	22-Feb-96	1323	38 13.45	178 37.40	38 16.41	178 34.93	115	134	3.54	85.6	20.0	13.9
29	14	22-Feb-96	1454	38 16.17	178 34.42	38 12.63	178 34.14	111	117	3.54	90.2	20.4	14.3

Appendix 2—*continued*

			Start of tow			End of tow		Gear depth (m)		Distance trawled	Doorspread	Surface temp.	Bottom temp.
Station	Stratum	Date	Time	° ' S	° ' E	° ' S	° ' E	Min.	Max.	(n. miles)	(m)	(°C)	(°C)
30	14	22-Feb-96	1621	38 12.32	178 33.14	38 08.72	178 33.31	99	106	3.59	85.7	20.3	15.3
31	15	23-Feb-96	534	38 02.80	178 50.08	38 06.16	178 50.01	344	377	3.66	103.6	20.4	11.0
32	15	23-Feb-96	728	38 05.53	178 47.81	38 08.62	178 46.06	246	273	3.38	97.8	20.7	11.6
33	15	23-Feb-96	912	38 08.72	178 45.61	38 05.23	178 45.14	205	216	3.5	95.6	20.2	12.8
34	15	23-Feb-96	1157	38 04.42	178 43.09	38 00.89	178 43.12	195	239	3.52	95.6	20.2	12.6
35	14	23-Feb-96	1339	37 59.45	178 41.16	37 56.23	178 38.87	141	143	3.69	87.1	19.9	13.5
36	15	26-Feb-96	530	38 07.57	178 40.85	38 04.19	178 40.50	207	210	3.39	89.6	20.0	13.6
37	14	26-Feb-96	845	38 00.48	178 35.60	37 57.09	178 36.20	104	115	3.42	90.5	19.9	14.9
38	14	26-Feb-96	1020	37 55.82	178 37.91	37 52.30	178 37.67	130	132	3.53	84.8	20.0	14.0
39	14	26-Feb-96	1207	37 48.40	178 39.47	37 45.09	178 41.15	102	117	3.56	90.0	19.7	14.0
40	13	26-Feb-96	1345	37 44.62	178 41.17	37 47.37	178 38.34	96	100	3.55	93.7	19.9	15.0
41	13	26-Feb-96	1523	37 48.29	178 37.52	37 50.93	178 34.83	90	97	3.39	91.5	19.6	15.5
42	11	27-Feb-96	535	39 19.93	178 05.87	39 22.72	178 03.14	134	144	3.5	96.4	20.2	13.5
43	11	27-Feb-96	852	39 30.54	177 40.28	39 32.88	177 36.86	123	140	3.53	85.8	19.2	13.3
44	10	27-Feb-96	1134	39 20.26	177 33.50	39 18.72	177 29.34	72	81	3.57	83.0	19.0	14.5
45	10	27-Feb-96	1351	39 25.74	177 20.74	39 25.93	177 16.49	68	73	3.35	82.7	18.5	14.6
46	9	27-Feb-96	1557	39 31.98	177 09.31	39 34.29	177 06.14	31	47	3.36	80.1	18.7	17.7
47	9	28-Feb-96	542	39 24.11	176 59.66	39 20.71	177 01.01	25	26	3.56	75.8	18.9	18.6
48	11	28-Feb-96	916	39 35.72	177 18.58	39 38.03	177 15.43	101	106	3.35	85.3	19.2	13.6
49	7	28-Feb-96	1114	39 39.98	177 19.93	39 41.24	177 15.68	123	139	3.42	91.2	19.6	13.6
50	7	28-Feb-96	1309	39 45.51	177 12.07	39 48.65	177 10.04	119	125	3.5	85.4	19.8	13.6
51	8	28-Feb-96	1609	39 48.65	177 27.57	39 46.00	177 30.88	341	354	3.67	102.9	19.8	11.0
52	6	29-Feb-96	532	40 00.26	176 58.38	39 57.85	177 01.42	60	84	3.35	81.2	19.2	14.2
53	8	29-Feb-96	743	39 58.18	177 09.39	40 01.26	177 07.90	227	229	3.28	95.9	19.3	11.4
54	7	29-Feb-96	954	40 03.31	177 03.77	40 06.64	177 03.51	147	170	3.33	90.3	19.8	12.3
55	7	29-Feb-96	1209	40 13.74	176 56.22	40 15.91	176 52.97	102	121	3.3	84.8	19.5	13.0
56	5	29-Feb-96	1406	40 18.29	176 44.98	40 21.37	176 43.16	43	50	3.38	79.0	19.0	15.5
57	5	29-Feb-96	1535	40 21.76	176 42.87	40 25.16	176 41.55	37	41	3.54	79.3	19.0	16.0
58	7	1-Mar-96	544	40 53.41	176 27.98	40 50.22	176 29.14	170	180	3.4	96.1	18.4	12.5

Appendix 2—*continued*

Station	Stratum	Date	Start of tow			End of tow		Gear depth (m)		Distance trawled	Doorspread	Surface temp.	Bottom temp.
			Time	° ' S	° ' E	° ' S	° ' E	Min.	Max.	(n. miles)	(m)	(°C)	(°C)
59	8	1-Mar-96	839	40 50.01	176 41.49	40 46.69	176 42.48	340	351	3.4	105.4	18.7	9.6
60	7	1-Mar-96	1100	40 40.55	176 38.28	40 37.00	176 38.33	130	194	3.53	98.2	18.3	12.2
61	6	1-Mar-96	1304	40 39.52	176 29.87	40 42.44	176 27.56	84	93	3.44	79.8	18.2	13.2
62	6	1-Mar-96	1435	40 42.97	176 25.54	40 45.78	176 23.31	78	78	3.4	77.5	17.8	13.3
63	5	2-Mar-96	543	40 51.23	176 17.19	40 54.67	176 15.63	38	51	3.62	78.2	17.5	14.8
64	2	2-Mar-96	726	40 54.62	176 16.30	40 57.87	176 14.57	59	64	3.48	77.8	17.5	13.0
65	1	2-Mar-96	859	40 57.43	176 13.24	41 00.38	176 10.99	37	41	3.42	74.1	16.6	13.3
66	2	2-Mar-96	1046	41 04.52	176 13.93	41 07.46	176 11.62	82	92	3.4	80.1	17.1	12.3
67	3	2-Mar-96	1226	41 11.19	176 10.23	41 13.77	176 07.49	101	110	3.45	78.2	17.5	13.4
68 *	1	2-Mar-96	1437	41 16.89	175 57.43	41 19.70	175 54.57	35	45	3.5	71.2	16.1	14.4
69	2	6-Mar-96	743	41 27.92	175 01.71	41 30.79	175 03.02	69	79	3.03	85.3	14.9	13.4
70	1	6-Mar-96	1347	41 25.80	175 05.22	41 28.37	175 08.21	28	31	3.41	76.8	15.9	14.2
71	1	6-Mar-96	1522	41 29.32	175 09.72	41 26.30	175 06.69	24	32	3.77	74.7	16.0	15.0
72	4	7-Mar-96	542	41 38.50	175 26.61	41 38.16	175 30.39	320	420	2.87	111.0	15.3	9.1
73	4	7-Mar-96	909	41 37.33	175 29.99	41 37.69	175 25.57	191	264	3.33	102.3	–	8.4
74	3	7-Mar-96	1337	41 36.53	175 26.78	41 35.55	175 31.08	114	157	3.37	89.6	–	11.6
75	3	8-Mar-96	543	41 22.46	175 55.53	41 20.28	175 59.31	157	161	3.58	81.4	14.5	12.2
76	3	8-Mar-96	723	41 18.93	176 01.49	41 16.50	176 05.00	150	163	3.59	85.1	14.5	13.0
77	3	8-Mar-96	1015	41 04.97	176 15.74	41 02.70	176 19.19	112	136	3.46	88.5	15.0	12.8
78	4	8-Mar-96	1222	41 02.51	176 25.64	41 00.42	176 29.13	314	334	3.36	105.5	16.0	9.6
79	3	8-Mar-96	1450	41 01.45	176 20.37	40 57.84	176 21.14	126	140	3.65	88.6	16.5	12.3
80	4	9-Mar-96	542	41 33.51	175 34.96	41 31.58	175 39.10	197	222	3.64	97.6	14.0	11.5
81	4	9-Mar-96	934	41 19.16	176 04.87	41 17.31	176 07.72	200	360	2.91	99.6	14.5	11.0
82	4	9-Mar-96	1303	41 02.85	176 24.97	41 00.25	176 28.45	271	330	3.74	104.1	16.5	10.1
83	4	9-Mar-96	1509	40 59.25	176 31.38	40 56.41	176 34.19	324	380	3.56	104.3	15.5	10.6
84	11	10-Mar-96	1554	39 39.00	177 23.57	39 35.86	177 25.65	133	143	3.49	95.4	18.0	13.9
85	11	11-Mar-96	646	37 35.02	178 29.87	37 33.47	178 25.93	40	50	3.55	79.6	17.7	17.2
86	11	13-Mar-96	535	37 50.08	178 39.86	37 53.64	178 40.62	136	166	3.61	91.0	17.8	18.6
87	11	13-Mar-96	725	37 52.17	178 36.15	37 55.43	178 34.80	102	105	3.42	86.7	17.0	18.9

Appendix 2—*continued*

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.	Distance trawled (n. miles)	Doorspread (m)	Surface temp. (°C)	Bottom temp. (°C)
88	11	13-Mar-96	1202	38 26.19	178 34.31	38 29.27	178 31.68	107	108	3.68	77.5	18.0	16.6
89	11	13-Mar-96	1342	38 31.92	178 32.73	38 34.93	178 29.73	119	126	3.8	77.5	17.5	15.6
90	11	13-Mar-96	1517	38 36.58	178 29.92	38 39.29	178 27.01	111	127	3.51	80.3	18.0	15.6
91	11	14-Mar-96	534	39 28.15	177 58.64	39 24.69	178 00.68	124	139	3.8	90.3	17.0	13.7
92	11	14-Mar-96	715	39 24.18	177 57.09	39 27.03	177 54.37	100	111	3.6	85.4	17.0	14.8
93	11	14-Mar-96	926	39 27.85	177 43.24	39 27.37	177 38.66	98	107	3.58	85.4	17.5	14.5
94	11	14-Mar-96	1126	39 27.43	177 37.34	39 27.27	177 32.84	109	115	3.49	85.4	17.0	14.2
95	11	14-Mar-96	1327	39 28.52	177 27.69	39 30.26	177 23.68	101	106	3.56	85.4	17.5	15.6
96	11	14-Mar-96	1506	39 30.95	177 2.295	39 34.28	177 21.16	103	112	3.6	85.4	17.0	15.8
97	11	15-Mar-96	626	39 35.90	177 33.79	39 34.97	177 29.14	139	146	3.69	85.7	16.5	13.7
98	11	15-Mar-96	804	39 33.52	177 28.45	39 29.96	177 27.62	113	136	3.6	90.3	17.0	14.1

* Denotes station note used for biomass calculations

– No data

Appendix 3a: **Length-weight coefficients *a* and *b* calculated using the geometric mean functional relationship from data collected during this survey, and used to scale length frequencies and calculate biomass for length intervals***

	a	*b*	*N*	Range (cm)
Gemfish	0.0020	3.30	225	38–107
Red cod	0.0087	3.02	714	10–70
Snapper	0.0314	2.90	401	29–66
Tarakihi	0.0140	3.09	1185	11–51
Trevally	0.0173	3.02	248	21–53

Appendix 3b: **Additional length-weight coefficients *a* and *b* used to scale length frequencies and calculate biomass for length intervals ***

	a	*b*	Source	*N*	Range (cm)
Alfonsino	0.0167	3.11	TAN9301	183	19–52
Barracouta	0.0091	2.88	TAN9301	919	15–96
Blue moki	0.0547	2.71	M. Francis (1979)	188	17–80
Blue warehou	0.0191	3.03	TAN9301	281	29–67
Dark ghost shark	0.0022	3.25	TAN9501	299	23–81
Hoki	0.0046	2.88	SHI8301	525	22–110
John dory	0.0480	2.70	IKA8003	–	–
Kahawai	0.0236	2.89	Wood	170	5–60
Ling	0.0010	3.36	SHI8302	398	45–135
Red gurnard	0.0017	3.48	KAH9008 KAH9105 KAH9205	227	19–54
Rig	0.0005	3.47	Francis (unpub.)	120	65–137
Rough skate	0.0438	2.825	TAN9601 TAN9604	288	29–87
School shark	0.0070	2.91	Seabrook-Davidson (unpub.)	804	30–166
Trachurus declivis	0.0165	2.93	COR9001	200	15–53
T. murphyi	0.0255	2.77	TAN9301	90	44–62
T. novaezelandiae	0.0163	2.92	COR9001	200	15–40

* Determined from $W = aL^b$, where W = weight (g), L = length (cm); N = sample size.

Appendix 4a: Results of gear trials undertaken off the east coast of the North Island in March 1996 (KAH9506) comparing the trawl gear configurations used in 1995 (KAH9504) with those used in 1993 (KAH9304) and 1994 (KAH9402)

Objective: To compare efficiency and spread of the old *Kaharoa* trawl doors with those of the new doors at selected depths using the standard warp to depth ratios used on past surveys.

Depth range (m)	Target depth (m)
0–25	20
25–50	40
50–75	60
75–100	90
100–200	150
200–300	250
300–400	350

At each target depth the aim was to complete one tow with the tide and prevailing weather and one tow in the opposite direction. During each tow doorspread was recorded at about 5 min intervals until three to six measurements were obtained. These measurements were averaged to obtain a mean doorspread for each depth range. The first series of tows was done in all depth ranges with the new doors. The old doors were then fitted and the tows repeated.

	New doors				Old doors			
Depth range (m)	Mean depth (m)	Number of recordings	Mean doorspread (m)	Standard deviation	Mean depth (m)	Number of recordings	Mean doorspread (m)	Standard deviation
0–25	21	12	77.8	2.49	23	12	86.8	1.35
25–50	38	12	75.7	1.68	45	12	86.8	2.08
50–75	61	12	81.6	2.50	61	12	95.4	0.78
75–100	93	12	75.4	3.21	97	12	95.1	1.34
100–200	151	12	88.1	2.53	161	12	100.6	1.92
200–300*	250	0	92.8#		250	0	110.5#	
300–400*	350	0	100.2#		350	0	120.7#	

* No trials in this depth range
\# Calculated from linear regression

Appendix 4b: Optimum wing end spread and optimum sweep angles for the South Island bottom trawl net (see Kirk & Stevenson 1996 for specifications)

Optimum wingspread (Prado 1990)
= 0.5 * headline length
= 0.5 * 29.75 m
= 14.88 m

Optimum doorspread (Prado 1990)
= 2 sin(sweep angle) * net length + optimum wingspread
Where net length = 118 m

Doorspread (m)	Sweep angles (°)
72.0	14
76.0	15
79.9	16
83.9	17
87.8	18
91.7	19

Appendix 5: Adjusted relative biomass estimates for the 20 most abundant species from the 1993* (KAH9304) and 1994 (KAH9402) inshore trawl surveys of the east coast North Island

	1993		1994	
	Biomass (t)	*c.v.* %	Biomass (t)	*c.v.* %
Barracouta	2 159	15	7 083	33
Southern spiny dogfish	964	78	988	47
Tarakihi (all)	819	27	1 052	20
Tarakihi (25 + cm)	810	28	1 046	20
Hoki (all)	646	23	2 792	47
Hoki (65 + cm)	625	24	2 169	49
Frostfish	560	39	1 079	40
Red cod (all)	271	49	1 242	50
Red cod (40 + cm)	181	65	686	51
Gemfish	380	33	225	33
School shark	354	16	235	23
Blue moki	119	45	—	—
Trevally	331	35	202	24
Rattails	91	39	430	32
Dark ghost shark	29	56	—	—
Giant stargazer	129	22	—	—
Red gurnard (all)	439	44	871	16
Red gurnard (30 + cm)	387	43	701	13
Snapper	540	32	317	21
Jack mackerel (*T. nz*)	243	24	462	32
John dory	265	17	268	31
Hapuku	110	17	—	—
Carpet shark	145	24	205	22
Rig	143	26	185	13
Arrow squid	—	—	302	34
Ling	—	—	172	31
Murphy's mackerel	—	—	98	31
Bluenose	—	—	316	72

Estimates above a given size are recruited biomass. These estimates update those given in Kirk & Stevenson (1996) and Stevenson & Kirk (1996).

* North Island strata (7–18) only

— Not a top 20 species for that year

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