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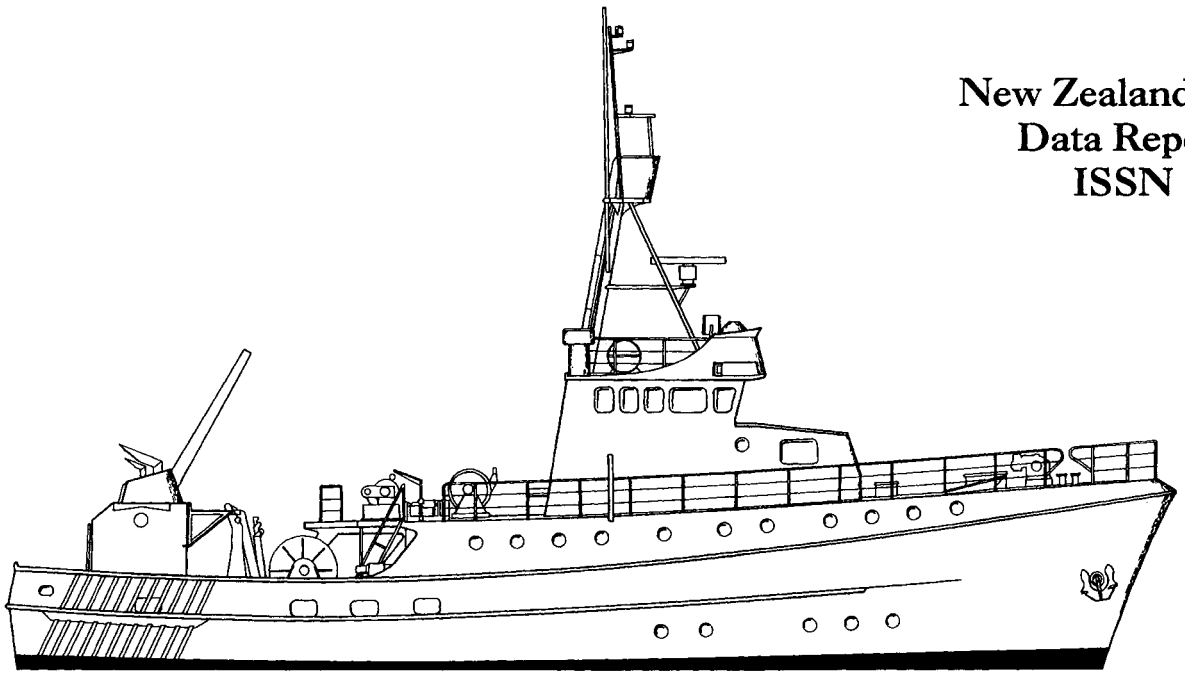
Bottom trawl survey of inshore waters of the east coast North Island, February-March 1995 (KAH9502)

Michael L. Stevenson



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Contents

Introduction

This report presents the results of the third in a time series of stratified random trawl surveys in depths between 20 and 400 m off the east coast of the North Island, New Zealand. The first two surveys in this series (March–April 1993 and February–March 1994) were described by Kirk & Stevenson (1996) and Stevenson & Kirk (1996) respectively. March–April was originally chosen for this series because it was planned to alternate with the west coast South Island survey to make best use of *Kaharoa*'s time. In addition, snapper are more dispersed in autumn than in summer and a survey during this period is less likely to encounter spawning schools which could increase the risk of biased biomass estimates. The surveys were moved forward 1 month in 1994 because of conflicts in the vessel's schedule.

The principal aim of the time series is to estimate the relative abundance of snapper (*Pagrus auratus*), tarakihi (*Nemadactylus macropterus*), and trevally (*Pseudocaranx dentex*). A standardised index of relative abundance estimates for these 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.

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/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 snapper, tarakihi, and trevally 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 snapper, tarakihi, trevally, and other commercially important species;
3. to collect otoliths of kahawai, snapper, stargazer, tarakihi, and trevally;
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 leader was M. Stevenson assisted by P. Kirk. The survey was divided into two parts (5–28 February and 1–9 March). M. Stevenson was the voyage leader and R. Brown the skipper during the first leg and K. Drummond was the voyage leader and A. Muir the skipper for the second leg.

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 total survey area of 19 127 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 survey were retained.

The trawlable ground within the survey area represented 56% of the survey area. Of the 8491 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 1993 and 1994 were revisited. Most of the phase 1 stations for the 1995 survey were therefore the same as for 1994.

Before the survey began, sufficient trawl stations to cover any required additional phase 1 stations and all 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 and 1994 surveys. The amount of non-trawlable ground in each stratum is given in Table 1.

For the two-phase methodology, snapper, tarakihi, and trevally 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 sum of the expected catch rates of the target species using the following procedure:

A_i = area of stratum i

N_i = number of stations allocated to stratum i

M_i = sum of the mean catch rates of the target species in stratum i

Step 1: The "weight" of stratum i was calculated as

$$W_i = (A_i M_i / k)\,(A_i M_i / k)$$

for each stratum. The quantity $A_i M_i$ is proportional to the number of stations that would ideally be allocated to stratum i for the whole survey. k is an arbitrary constant (the same for all strata) set to make W_i a manageable size, usually 10 000 or 100 000.

Step 2: The relative gain, G_i, was calculated as $G_i = W_i/(N_i(N_i+1))$ for each stratum.

Step 3: One station was allocated to the stratum with the highest G_i and values for N_i and G_i were updated.

Step 3 was repeated as many times as required until the desired number of phase 1 stations was allocated.

The expected catch rates were the combined catch rates from the 1994 survey. 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 combined catch rates of the target species from phase 1 stations, as recommended by Francis (1984).

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 during this survey was a high-lift, bottom-wing trawl fitted with a codend constructed 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 the commercial industry fishing in this area (Kirk & Stevenson 1996).

Before the 1995 survey, *Kaharoa* was equipped with new trawl doors based on the design of the old doors, but heavier. In both the surface area was 3.2 m^2 and the shape a rectangular "V". The old doors had a total weight of 500 kg each with weighted shoes and the new doors weighed 630 kg each with the weight distributed over the entire door. The changes were made to improve bottom contact throughout the tow. Comparative details were given by Drummond & Stevenson (1996). Doorspread and headline height measurements were read off Scanmar monitoring equipment with an average of five readings during each tow. Doorspread varied from 77.5 to 113 m (Appendix 1). Headline height varied between 6.9 and 8.9 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 Magnavox GPS.

A minimum of 200 m of warp was deployed for each trawl. In depths below 60 m, a reduced warp to depth ratio was used, starting at 4 : 1 and dropping to 3 : 1 for depths below 150 m.

Water temperatures

The surface temperature at each station was recorded from a hull-mounted sensor. The calibration of the sensor was uncertain, so surface temperatures are only relative. Bottom temperatures were recorded from 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. The weight of tagged school shark was estimated from the length-weight coefficients given in Appendix 2b. Weights of some large sharks and rays 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 20 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.

Up to four pairs of otoliths per 1 cm size class, per sex, were collected from snapper, tarakihi, trevally, and red cod.

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

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 area sampled 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) and Stevenson & Kirk (1996).

Length-weight coefficients were determined for snapper, tarakihi, and trevally using the geometric mean functional relationship.

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. 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. Length-weight coefficients used in the scaling are given in Appendix 2.

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

Results

Trawl stations

Seventy-eight phase 1 stations and 39 phase 2 stations were successfully completed (*see* Table 1, Figure 1, Appendix 1). Stations 7, 54, and 104 were excluded from biomass analysis because of poor gear performance. The completed station density ranged from 1 station per 44 km^2 in stratum 13 to 1 station per 454 km^2 in stratum 8, with an overall station density of 1 station per 159 km^2 (*see* Table 1). At least three stations were completed in each stratum. The positions of all stations occupied are shown in Figure 1 and individual station data are presented in Appendix 1.

Catch composition

A total of 38.8 t of fish was caught during the 120 tows at an average of 323.2 kg per tow (range 8.4–2782 kg). Ninety-two species were recorded during the survey: 21 elasmobranchs, 64 teleosts, 3 crustaceans, 3 cephalopods, and 1 mammal. Porcupine fish were not weighed because of their high water content and are not included in the catch weights.

The total catch of each target species was tarakihi, 5144 kg; snapper, 2341 kg; and trevally, 907 kg. Target species made up 8.4 t (21.6 %) of the total catch. The total catch and percentage composition by weight for each species is given in Table 2.

Hoki was the most abundant species by weight (7.0 t) and barracouta occurred at more stations (101) than any other species. Three of the four catches greater than 2 t were made south of Castlepoint in depths of less than 100 m.

Other species with catches greater than 2 t were barracouta (6.2 t), tarakihi (5.1 t), snapper (2.3 t), and frostfish (2.2 t) (*see* Table 2). Arrow squid was 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 shown in Figure 2. (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).) Seven of the 10 total catch rates over 1000 $kg.km^{-2}$ occurred south of Cape Turnagain.

The catch rates by stratum for the 20 most abundant species are given in Table 3.

Biomass estimation

Relative biomass estimates for the 20 most abundant species are given in Table 4. For red cod and hoki, estimates above a given size 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). The 40 cm size limit is used as the minimum size of recruited red cod in this report. The relative biomass estimates by stratum for the target species are given in Table 5.

Snapper (13.2%), John dory (17.5%), and kingfish (19.2%) 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 estimated from the station data are shown in Figure 3.

School shark tagging

Thirty school shark (22 males and 8 females) were tagged and released. They ranged from 88 to 157 cm total length.

Length frequencies and biological data

The numbers of length frequency and biological samples taken during the survey are given in Table 6. Scaled length frequency distributions of the major commercial species are shown in Figure 4. The length frequency histograms represent the estimated population structure for the survey area. The numbers of the target species sampled at each gonad stage are summarised in Table 7.

Target species

Snapper. All of the relative biomass estimate of 298 t (*c.v.* = 13.2%) was from north of Cape Kidnappers and 95% was in depths less than 100 m (*see* Table 5). The sex ratios (males : females) were 0.70 : 1 inside 50 m, 1.76 : 1 in 50–100 m, and 0.72 : 1 overall (*see* Figure 4). Of the 304 males sampled, 163 had immature or resting gonads, 132 maturing, 5 running ripe, and 4 spent. Of the 358 females sampled, 266 had immature or resting gonads, 80 maturing, and 12 spent (*see* Table 7).

Tarakihi. Of the total biomass estimate of 791 t (*c.v.* = 22.6%), 606 t (77%) was caught north of Tolaga Bay (*see* Table 5, Figure 2) and 393 t (50%) was in the 100–200 m depth range. For all fish the sex ratio was 0.60 : 1, but this altered significantly with depth where the ratios were 0.33 : 1 in 50–100 m, 0.72 : 1 in 100–200 m, and 0.81 : 1 in 200–400 m (*see* Figure 4). Almost no tarakihi were caught in depths less than 50 m (*see* Table 3, Figure 2). All tarakihi less than 20 cm long had immature gonads, but a full range of gonad stages was recorded from larger fish (*see* Table 7).

Trevally. Of the total relative biomass estimate of 215 t (*c.v.* = 26.4%), 201 t (93%) was caught inside 100 m with 185 t (86%) caught north of Cape Kidnappers (*see* Table 5, Figure 2). The sex ratios by depth were 1.28 : 1 in 20–50 m, 1.05 : 1 in 50–100 m, and 0.32 : 1 in 100–200 m, and the ratio for all fish was 1.15 : 1 (*see* Figure 4). Of the 329 trevally sampled, 15 had immature or resting gonads, 229 maturing, 83 running ripe, and 2 spent.

Discussion

Changing the *Kaharoa*'s trawl doors between the 1994 and 1995 surveys means that some of the differences between the surveys may be due to the heavier doors used in the 1995 survey. Although the trawl doors used were essentially of the same design, the difference in weight may have increased performance during 1995 by better maintaining bottom contact throughout the tow.

Previous successful stations were revisited whenever possible. The coefficient of variation of the biomass estimates for tarakihi and trevally were up slightly from 1994 (22.6% vs. 19.7% and 26.4% vs. 24.9% respectively). The *c.v.* for snapper was down significantly to 13.2% from 20.5 %

in 1994. This is probably due to the increased number of stations where snapper was caught (68 in 1995, 38 in 1994).

The survey finished 4 days early primarily because of lower catches than in 1994. The total catch of 38.8 t was down significantly from the 78.2 t caught in 1994. The greatest decreases were for barracouta (6986 kg vs. 21 562 kg), southern spiny dogfish (1963 kg vs. 8359 kg) and frostfish (2176 kg vs. 5888 kg). Although barracouta were caught at more stations than any other species, the variability in the catches resulted in a moderate *c.v.* of 28.6%.

Separate biomass estimates for all fish and for recruited fish for the target species and red gurnard have not been included in this report because pre-recruits of these species were poorly sampled and the two estimates are virtually identical.

Snapper and trevally should be dropped as target species in future surveys. Trawl sampling by *Kaharoa* is biased toward small adult snapper length classes (Drury & Hartill 1993). The snapper relative biomass estimates derived from this series are therefore unlikely to reflect the "true" adult population biomass. Langley (1994) compared trevally length frequencies from the 1982–93 *Kaharoa* trawl survey programme in the Auckland Fishery Management Area with those from the commercial catch and found that *Kaharoa* did not adequately sample the larger (over 40 cm F.L.) length classes.

With only tarakihi remaining as a target species, the series sampling only the adult population, and the commercial catch for TAR 2 remaining relatively stable at near the TACC the need for this series should be reviewed.

For the 1995 survey, trawl performance monitoring was improved by using Scanmar equipment. During previous surveys doorspread was estimated by the method of Koyama (1974), and relative biomass estimates assumed a constant doorspread. Improved doorspread information from the 1995 survey also enabled sweep angles to be calculated and compared to optimal angles (Prado 1990). To achieve the desired sweep angles of 15–19°, a doorspread of 76.0–91.7 m was required. At the start of the survey the observed doorspreads were generally above this and some modifications to trawl gear configurations were made, including altering the point of attachment of the warp to the doors and adjusting warp to depth ratios.

To improve the relative biomass estimates of doorspread for the 1993 and 1994 surveys, Scanmar equipment is to be fitted to the previous trawl gear configuration (including doors), and trials are planned off the east coast of the North Island in March 1996. Revised biomass estimates, incorporating the updated doorspread information, for the top 20 species from each of the previous two surveys should be incorporated in a future report.

Acknowledgments

I thank the masters of *Kaharoa*, Arthur Muir and Roy Brown, and the crew for their willing help throughout the survey. Kim Drummond provided invaluable help and suggestions on optimum doorspread. Kevin Mackay resolved any difficulties I had with using the trawl research database. Special thanks to referees Martin Cryer and Adrian Colman, whose comments significantly improved this report. I also thank John Hadfield, Phil Kirk, Toby Cantwell, Ron Blackwell, Paul Cresswell, Kevin Mulligan, and Michael Coakley for their help with data collection.

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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	3	0	230
4	200–400	468	191	3	0	156
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	4	0	398
8	200–400	1 362	56	3	0	454
Tolaga Bay–Cape Kidnappers						
9	20–50	2 605	1 345	5	11	163
10	50–100	2 801	857	4	4	350
11	100–200	2 182	1 163	11	0	198
Cape Runaway–Tolaga Bay						
12	20–50	594	506	8	2	59
13	50–100	1 015	302	8	15	44
14	100–200	1 816	1 352	13	7	91
15	200–400	1 018	758	4	0	255
Total (average)		18 576	7 891	78	39	(159)

Table 2: Species caught, total weight, percentage of total catch, and occurrence (Occ)

Common name	Scientific name	Code	Catch (kg)	% of total catch	Occ
Hoki	*Macruronus novaezelandiae*	HOK	6 986	18	32
Barracouta	*Thyrsites atun*	BAR	6 236	16	101
Tarakihi	*Nemadactylus macropterus*	TAR	5 144	13	67
Snapper	*Pagrus auratus*	SNA	2 341	6	63
Frostfish	*Lepidopus caudatus*	FRO	2 176	6	80
Southern spiny dogfish	*Squalus acanthias*	SPD	1 963	5	39
Horse mackerel	*Trachurus novaezelandiae*	JMN	1 732	4	87
Red cod	*Pseudophycis bachus*	RCO	1 441	4	72
Arrow squid	*Nototodarus sloanii, N. gouldi*	SQU	1 068	3	100
Trevally	*Pseudocaranx dentex*	TRE	907	2	59
Rattails	Macrouridae	RAT	790	2	25
Red gurnard	*Chelidonichthys kumu*	GUR	723	2	73
Gemfish	*Rexea solandri*	SKI	704	2	16
Blue moki	*Latridopsis ciliaris*	MOK	619	2	21
School shark	*Galeorhinus galeus*	SCH	534	1	32
John dory	*Zeus faber*	JDO	494	1	64
Murphy's mackerel	*Trachurus murphyi*	JMM	394	1	27
Kingfish	*Seriola lalandi*	KIN	348	1	37
Carpet shark	*Cephaloscyllium isabellum*	CAR	328	1	44
Alfonsino	*Beryx splendens*	BYS	325	1	3
Silver warehou	*Seriolella punctata*	SWA	319	1	15
Mirror dory	*Zenopsis nebulosus*	MDO	298	1	20
Rig	*Mustelus lenticulatus*	SPO	282	1	38
Sea perch	*Helicolenus* spp.	SPE	260	1	36
Rough skate	*Raja nasuta*	RSK	250	1	46
Bigeyed thresher shark	*Alopias superciliosis*	BET	230	1	1
Ling	*Genypterus blacodes*	LIN	223	1	43
Hapuku	*Polyprion oxygeneios*	HAP	222	1	26
Jack mackerel	*Trachurus declivis*	JMD	194	< 1	45
Electric ray	*Torpedo fairchildi*	ERA	189	< 1	30
Giant stargazer	*Kathetostoma giganteum*	STA	120	< 1	15
Kahawai	*Arripis trutta*	KAH	110	< 1	16
Common dolphin	*Delphinus delphis*	CDD	100	< 1	1
Broadsnouted sevengill shark	*Notorynchus cepedianus*	SEV	100	< 1	3
Silver dory	*Cyttus novaezelandiae*	SDO	74	< 1	23
Bluenose	*Hyperoglyphe antarctica*	Fswa	70	< 1	2
Smooth skate	*Raja innominata*	SSK	57	< 1	9
Dark ghost shark	*Hydrolagus novaezelandiae*	GSH	45	< 1	6
Trumpeter	*Latris lineata*	TRU	36	< 1	6
Seal shark	*Scymnorhinus licha*	BSH	33	< 1	3
Lookdown dory	*Cyttus traversi*	LDO	31	< 1	6
Eagle ray	*Myliobatis tenuicaudatus*	EGR	30	< 1	4
Brown stargazer	*Gnathagnus innotabilis*	BRZ	26	< 1	10
Mako shark	*Isurus oxyrinchus*	MAK	21	< 1	1
Thresher shark	*Alopias vulpinus*	THR	21	< 1	3
Oilfish	*Ruvettus pretiosus*	OFH	17	< 1	1
Leatherjacket	*Parika scaber*	LEA	17	< 1	9
Javelinfish	*Lepidorhynchus denticulatus*	JAV	17	< 1	7
Stingray	*Dasyatis* spp.	STR	15	< 1	2

Table 2—*continued*

Blue warehou	*Seriolella brama*	WAR	14	< 1	4
Sharpsnouted sevengill shark	*Heptranchias perlo*	HEP	12	< 1	2
Elephantfish	*Callorhinchus milii*	ELE	11	< 1	3
Witch	*Arnoglossus scapha*	WIT	9	< 1	25
Ruby fish	*Plagiogeneion rubiginosus*	RBY	7	< 1	2
Lemon sole	*Pelotretis flavilatus*	LSO	6	< 1	14
Octopus	*Octopus maorum*	OCT	6	< 1	10
Northern spiny dogfish	*Squalus blainvillei*	NSD	6	< 1	2
Deepsea flathead	*Hoplichthys haswelli*	FHD	6	< 1	3
Capro dory	*Capromimus abbreviatus*	CDO	4	< 1	17
Sand flounder	*Rhombosolea plebeia*	SFL	4	< 1	4
Japanese gurnard	*Pterygotrigla picta*	JGU	4	< 1	2
Lucifer dogfish	*Etmopterus lucifer*	ETL	3	< 1	3
Pale ghost shark	*Hydrolagus* spp.	GSP	3	< 1	1
Cucumberfish	*Chlorophthalmus nigripinnis*	CUC	2	< 1	5
Blue mackerel	*Scomber australasicus*	EMA	2	< 1	2
Silverside	*Arentina elongata*	SSI	2	< 1	21
N.Z. sole, common sole	*Peltorhamphus novaezeelandiae*	ESO	2	< 1	4
Orange perch	*Lepidoperca* sp.	OPE	2	< 1	2
Longtailed skate	*Arhynchobatis asperrimus*	LSK	2	< 1	1
Common roughy	*Paratrachichthys trailli*	RHY	2	< 1	3
Northern bastard cod	*Pseudophycis breviuscula*	BRC	2	< 1	2
Scaly gurnard	*Lepidotrigla brachyoptera*	SCG	1	< 1	9
Spiny sea dragon	*Solegnathus spinosissimus*	SDR	1	< 1	3
Ray's bream	*Brama brama*	RBM	1	< 1	1
Anchovy	*Engraulis australis*	ANC	1	< 1	6
Hake	*Merluccius australis*	HAK	1	< 1	1
Pilchard	*Sardinops neopilchardus*	PIL	1	< 1	5
Prawn killer	*Ibacus alticrenatus*	PRK	1	< 1	7
Scampi	*Metanephrops challengeri*	SCI	1	< 1	3
Blue cod	*Parapercis colias*	BCO	1	< 1	1
Pale toadfish	*Neophrynichthys angustus*	TOP	1	< 1	1
Sand stargazer	*Crapatalus novaezelandiae*	SAZ	1	< 1	1
Southern igfish	*Congiopodus leucopaecilus*	PIG	< 0.5	< 1	1
Unidentified crab	Decapoda	CRB	< 0.5	< 1	2
Lanternfish	Myctophidae	LAN	< 0.5	< 1	1
Snipefish	*Macrorhamphosus scolopax*	SNI	< 0.5	< 1	2
Bluebanded bellowsfish	*Centriscops obliquus*	BLB	< 0.5	< 1	1
Broad squid	*Sepioteuthis australis*	BSQ	< 0.5	< 1	1
Paddle crab	*Ovalipes catharus*	PAD	< 0.5	< 1	1
Pufferfish	*Sphoeroides pachygaster*	PUF	< 0.5	< 1	3
Redbait	*Emmelichthys nitidus*	RBT	< 0.5	< 1	1
Sprats	*Sprattus antipodum, S. muelleri*	SPR	< 0.5	< 1	1
Porcupinefish	*Allomycterus jaculiferus*	POP	*		21
		Total	38 786		

* Counted but not weighed

Table 3: Catch rates (to the nearest whole kg.km^{-2}) by stratum, for the 20 most abundant species in the catch*

QMS species

		Species code															
Stratum	Depth (m)	HOK	BAR	TAR	SNA	JMN	RCO	SQU	TRE	GUR	SKI	MOK	SCH	JDO	JMM	BYS	SWA
1	20–50	0	1176	0	0	1	1	1	6	9	0	29	0	7	0	0	0
5	20–50	0	136	1	0	12	15	5	17	43	0	0	1	32	0	0	0
9	20–50	0	17	0	30	7	4	1	35	18	0	9	1	5	0	0	0
12	20–50	0	4	0	235	13	1	0	34	18	0	2	0	2	0	0	0
2	50–100	6	333	32	0	29	150	50	1	3	0	202	0	6	48	0	9
6	50–100	11	142	5	0	35	79	6	20	13	0	57	9	19	0	0	0
10	50–100	0	33	2	6	19	67	18	17	21	0	4	4	28	1	0	0
13	50–100	19	35	208	45	22	22	2	11	15	0	2	2	6	0	0	0
3	100–200	1 041	487	45	0	1	2	204	0	0	145	0	0	0	30	0	4
7	100–200	874	243	49	0	17	6	44	0	0	12	0	0	0	16	0	0
11	100–200	3	35	21	3	31	5	13	3	2	1	0	10	14	4	0	0
14	100–200	12	20	132	5	62	20	8	5	3	0	0	5	1	1	0	0
4	200–400	226	1	0	0	0	15	1	0	0	1	0	0	0	1	145	11
8	200–400	431	141	2	0	0	8	12	0	0	14	0	8	0	3	7	6
15	200–400	73	1	152	0	0	1	33	0	0	95	0	79	0	51	0	0

Non-QMS species

		Species code			
Stratum	Depth (m)	FRO	SPD	RAT	KIN
1	20–50	0	101	0	12
5	20–50	0	63	0	14
9	20–50	0	2	0	3
12	20–50	3	0	0	10
2	50–100	1	20	1	3
6	50–100	2	0	0	5
10	50–100	1	4	0	3
13	50–100	25	2	0	12
3	100–200	53	407	33	0
7	100–200	44	31	127	0
11	100–200	27	99	0	2
14	100–200	88	2	7	1
4	200–400	0	0	97	0
8	200–400	68	6	10	0
15	200–400	41	0	14	0

* Species codes are given in Table 2

Table 4: Estimated relative biomass* (to the nearest tonne) for the 20 most abundant species in the catch

Common name	Lower 95% confidence interval	Biomass (t)	Upper 95% confidence interval	*c.v.* (%)
Hoki (all)	445	2 937	5 429	42.4
Hoki (65 + cm)	334	2 642	4 950	43.7
Barracouta	899	2 103	3 307	28.6
Tarakihi	434	791	1 149	22.6
Snapper	219	298	376	13.2
Frostfish	275	493	711	22.1
Southern spiny dogfish	325	658	990	25.3
Jack mackerel (*T.nz*)	147	366	586	30.0
Red cod all	133	470	806	35.8
Red cod (40 + cm)	99	423	747	38.3
Arrow squid	217	398	578	22.7
Trevally	101	215	328	26.4
Rattails	0	312	696	61.6
Gurnard	86	178	270	25.8
Gemfish	62	237	411	36.8
Moki	30	224	418	43.3
School shark	77	148	219	23.9
John dory	111	170	230	17.5
Murphy's mackerel	18	141	264	43.7
Kingfish	36	58	80	19.2
Alfonsino	0	77	214	88.3

* Doorspread estimates with vulnerability set at 1.0, using stations with gear performance of 1 or 2 (117 stations).

Estimates above a given size are recruited biomass

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

Stratum	Depth (m)	Biomass estimate (t)		
		Snapper	Tarakihi	Trevally
1	20–50	0	0	3
2	50–100	0	18	1
3	100–200	0	31	0
4	200–400	0	0	0
5	20–50	0	0	7
6	50–100	0	5	20
7	100–200	0	77	0
8	200–400	0	2	0
9	20–50	79	0	90
10	50–100	18	5	49
11	100–200	6	45	6
12	20–50	140	0	20
13	50–100	46	211	11
14	100–200	9	240	9
15	200–400	0	155	0

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

Common name	Length frequency data		Biological data	
	No. of samples	No. of fish	No. of samples	No. of fish
Alfonsino	4	244		
Arrow squid	9	129		
Barracouta	101	3 494		
Bigeyed thresher shark	1	1		
Blue cod	1	1		
Blue mackerel	2	2		
Blue moki	22	172		
Blue warehou	4	4		
Bluenose	3	17		
Broadsnouted sevengill shark	2	2		
Brown stargazer	11	19		
Common dolphin	1	1		
Dark ghost shark	7	34		
Elephantfish	3	3		
Gemfish	17	316		
Giant stargazer	16	32		
Hake	1	1		
Hapuku	27	58		
Hoki	33	2 194		
Jack mackerel (*Trachurus declivis*)	46	421		
Jack mackerel (*T. murphyi*)	28	381		
Jack mackerel (*T. novaezelandiae*)	87	2 147		
Japanese gurnard	3	4		
John dory	65	320		
Kahawai	17	56		
Kingfish	37	55		
Leatherjacket	1	1		
Lemon sole	13	15		
Ling	44	147		
Lookdown dory	6	39		
Mako shark	1	1		
Mirror dory	15	294		
New Zealand sole	5	7		
Oil fish	1	1		
Pale ghost shark	1	1		
Pilchard	2	2		
Ray's bream	1	1		
Red cod	73	1 270		
Red gurnard	73	1 262		
Rig	39	117		
Rubyfish	3	4		
Sand flounder	5	6		
Sand stargazer	2	2		
School shark	32	89		
Sharpsnouted sevengill shark	1	1		
Silver warehou	16	153		
Snapper	64	1 573	63	664
Tarakihi	67	2 681	67	848
Thresher shark	3	3		
Trevally	60	704	59	329
Trumpeter	7	8		

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

	Males					Females					
	Gonad stage					Gonad stage					
Fork length (cm)	1	2	3	4	5	1	2	3	4	5	
Snapper											
21–30	10	5	0	1	0	10	2	0	0	0	
31–40	108	57	12	2	2	166	37	1	0	4	
41–50	42	23	13	1	0	71	22	6	0	2	
51–60	2	10	7	0	2	13	8	0	0	5	
61–70	1	3	2	1	0	6	3	1	0	1	
71–80						0	0	2	0	0	
Total	163	98	34	5	4	266	72	8	0	12	662
Tarakihi											
10–20	2	0	0	0	0	3	0	0	0	0	
21–30	37	2	1	3	0	30	4	1	0	0	
31–40	35	49	27	87	32	118	169	46	4	15	
41–50	1	2	14	6	1	9	116	24	3	4	
51–60	0	0	0	0	0	0	1	0	0	0	
Total	75	53	42	96	33	160	289	71	7	19	845
Trevally											
21–30	2	0	0	0	0	2	0	0	0	0	
31–40	3	9	24	40	0	2	43	9	5	0	
41–50	4	8	32	32	1	1	73	16	4	1	
51–60	1	1	1	2	0	0	10	3	0	0	
Total	10	18	57	74	1	5	126	28	9	1	329

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.

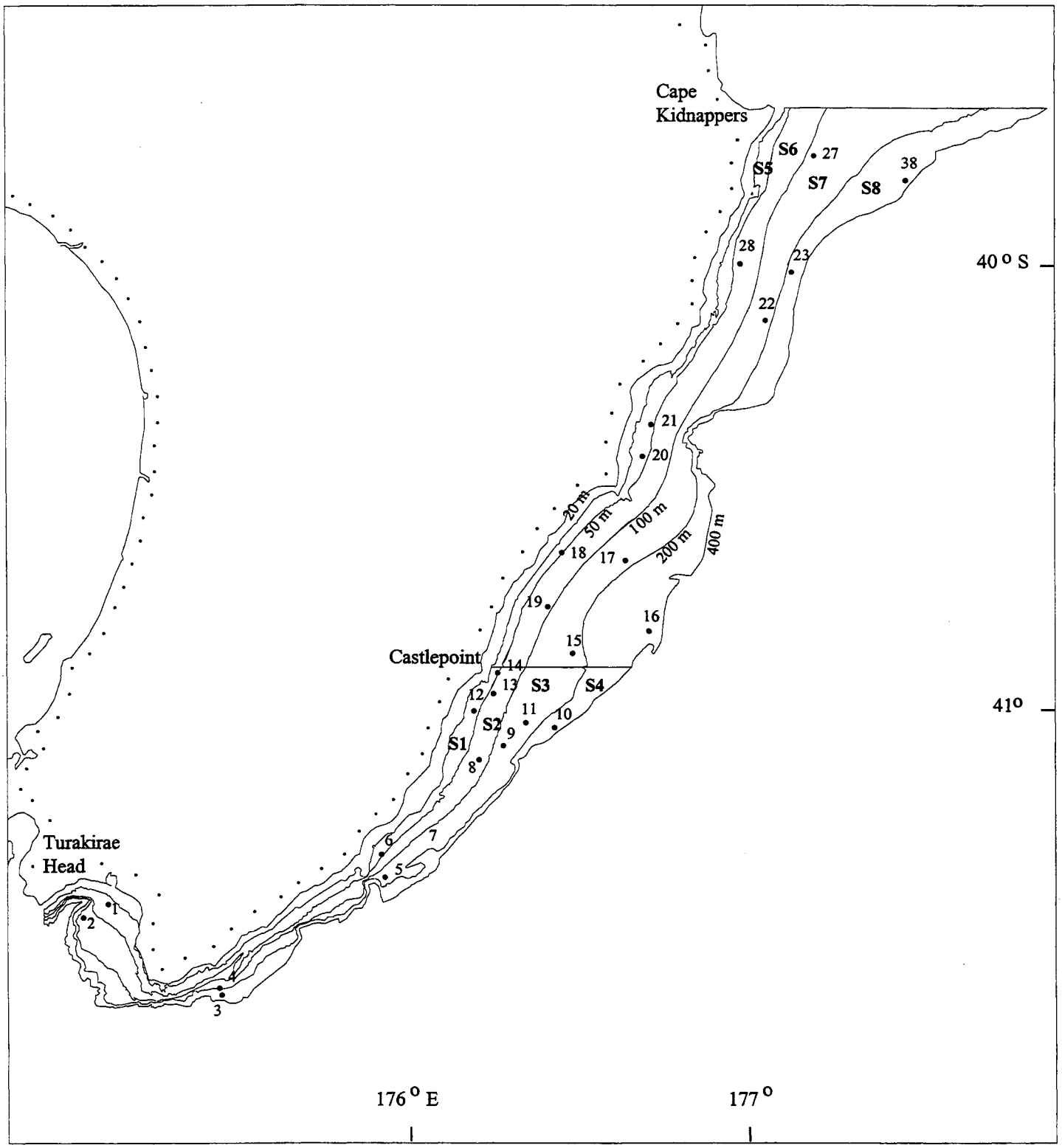

Figure 1a: Stratum boundaries (south of Cape Kidnappers) with station positions and numbers.

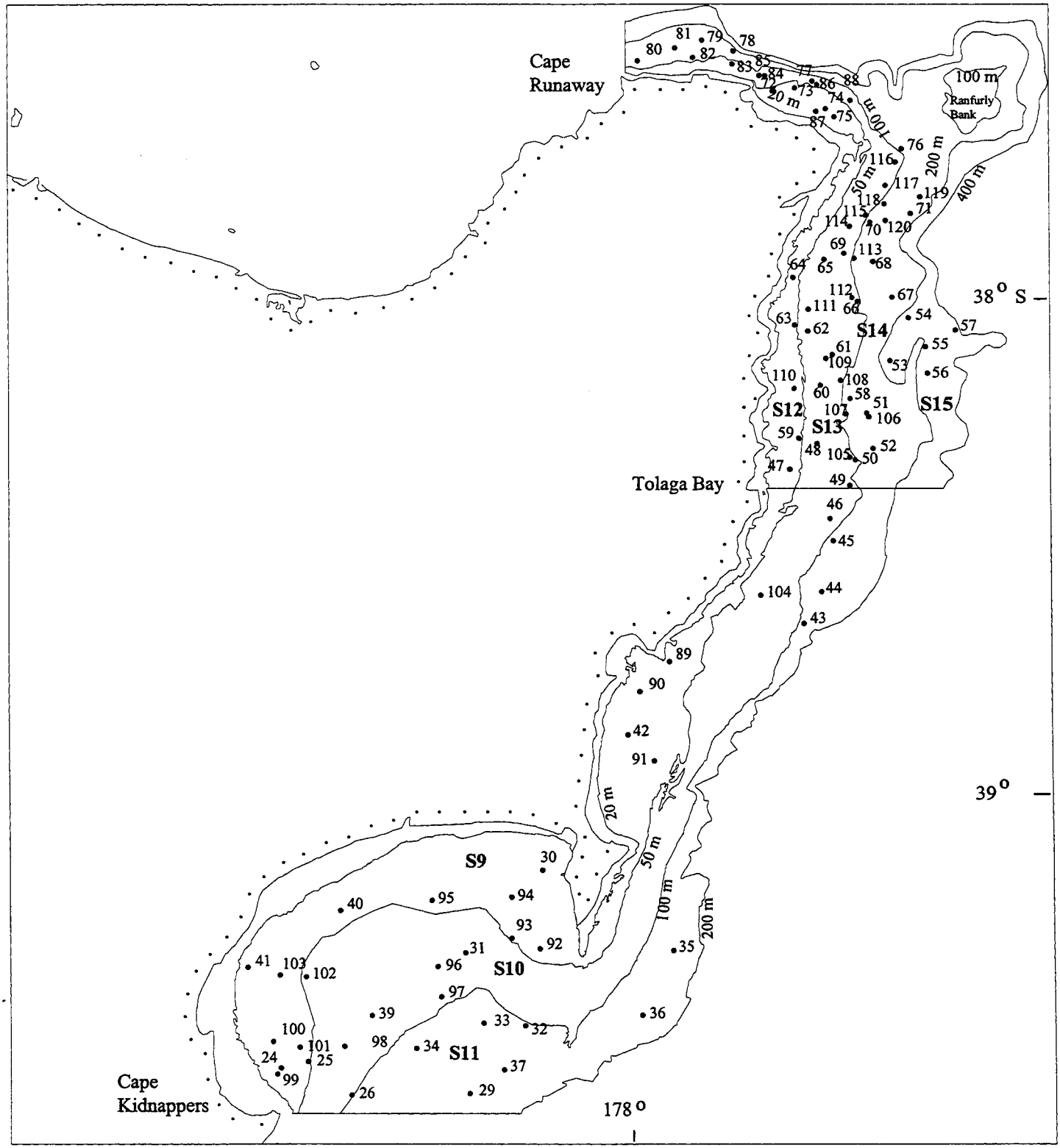

Figure 1b: Stratum boundaries (north of Cape Kidnappers) with station positions and numbers.

All species combined

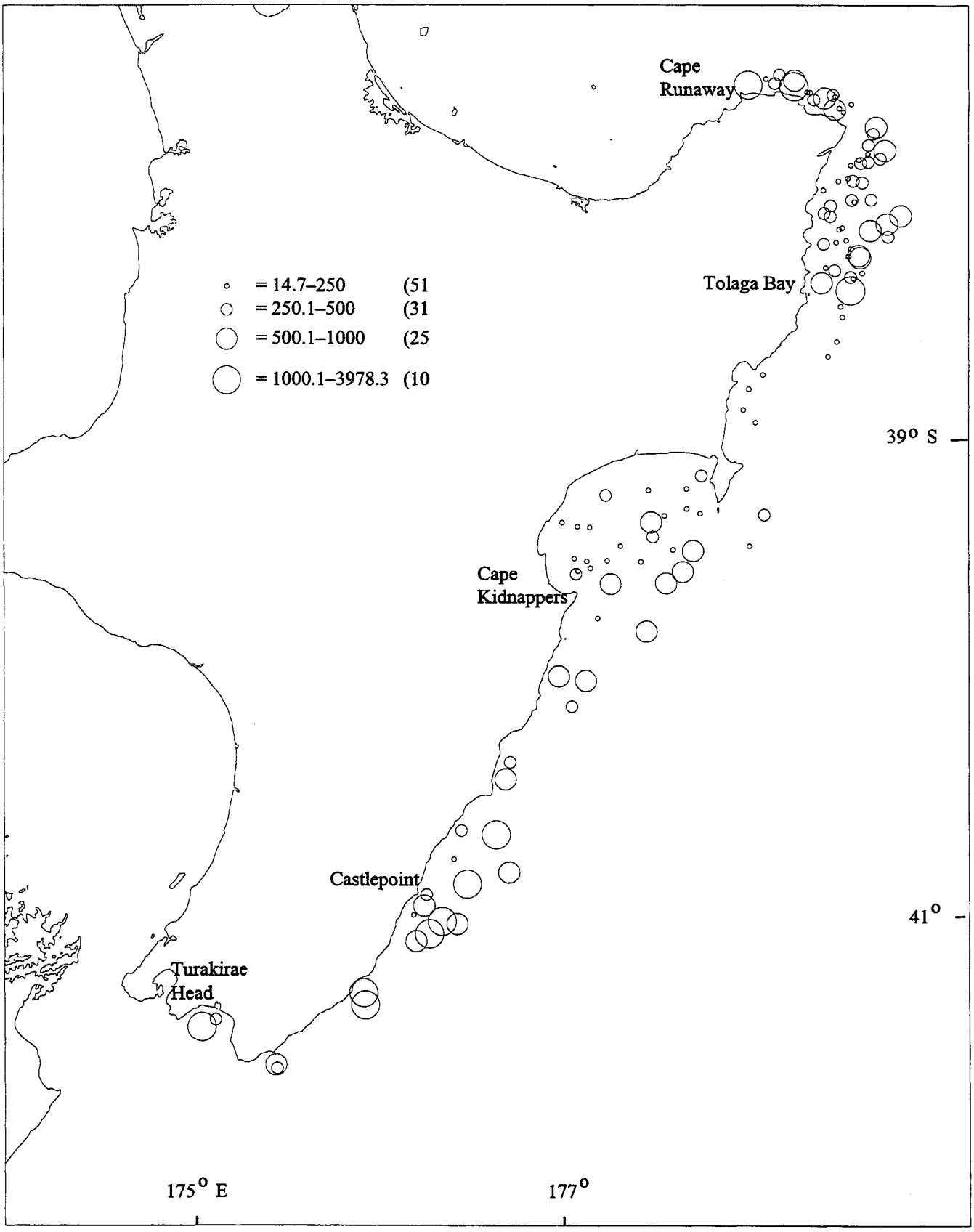

Figure 2: Catch rates (kg.km^{-2}) for all species combined and the 17 most abundant commercial finfish species for stations used for biomass calculations (numbers in parentheses are the number of stations at the given catch rate).

Alfonsino

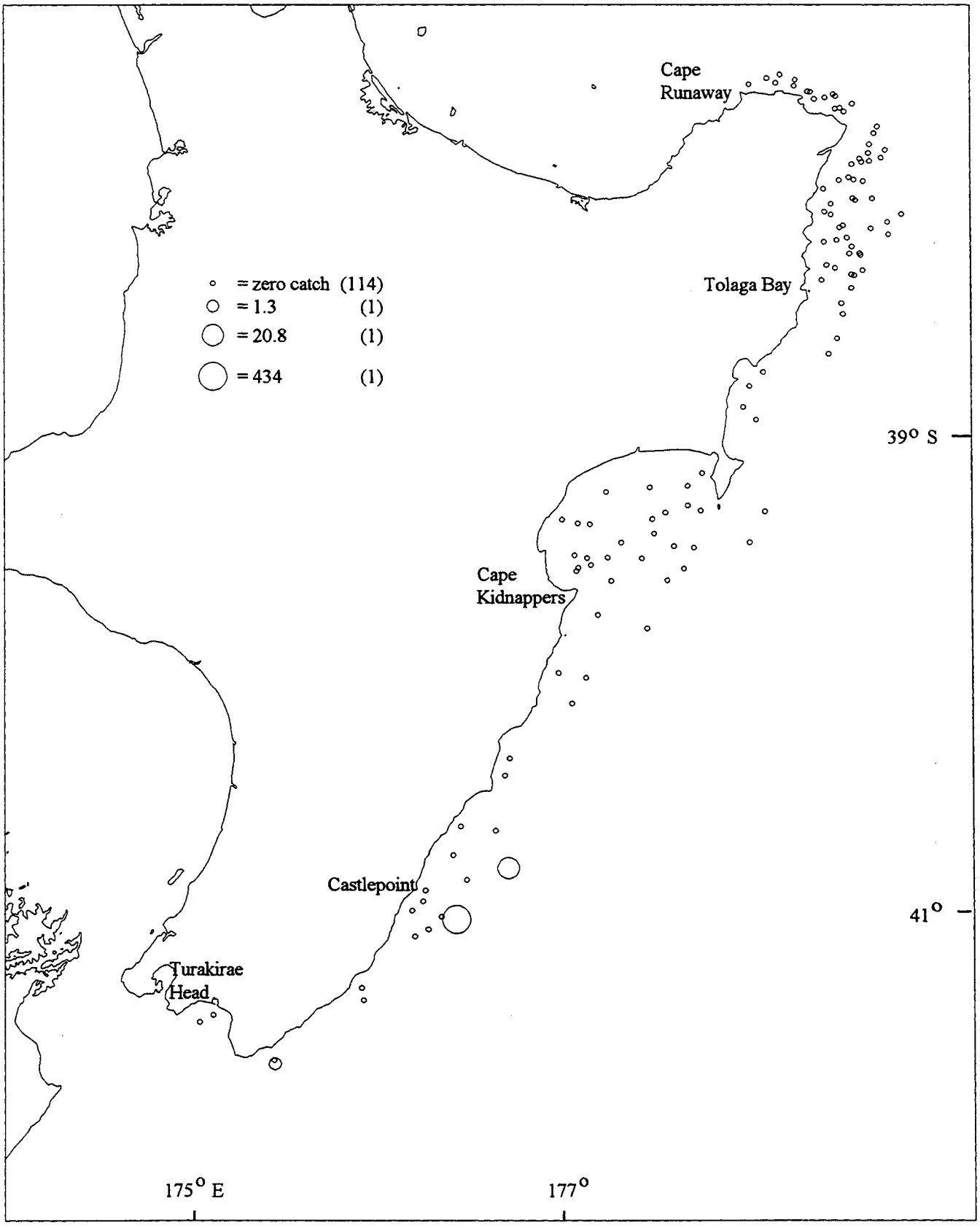

Figure 2—*continued*

Barracouta

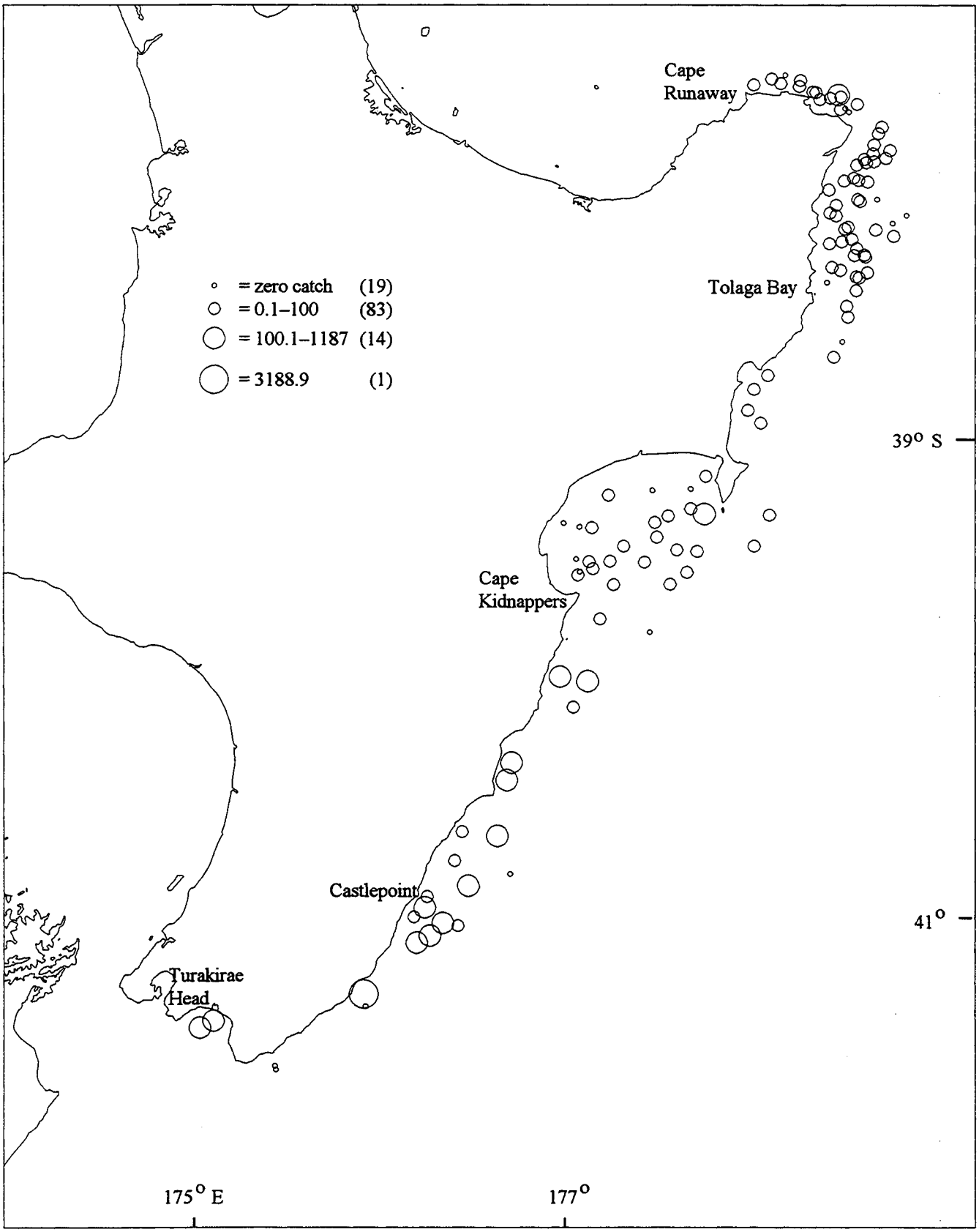

Figure 2—*continued*

Blue moki

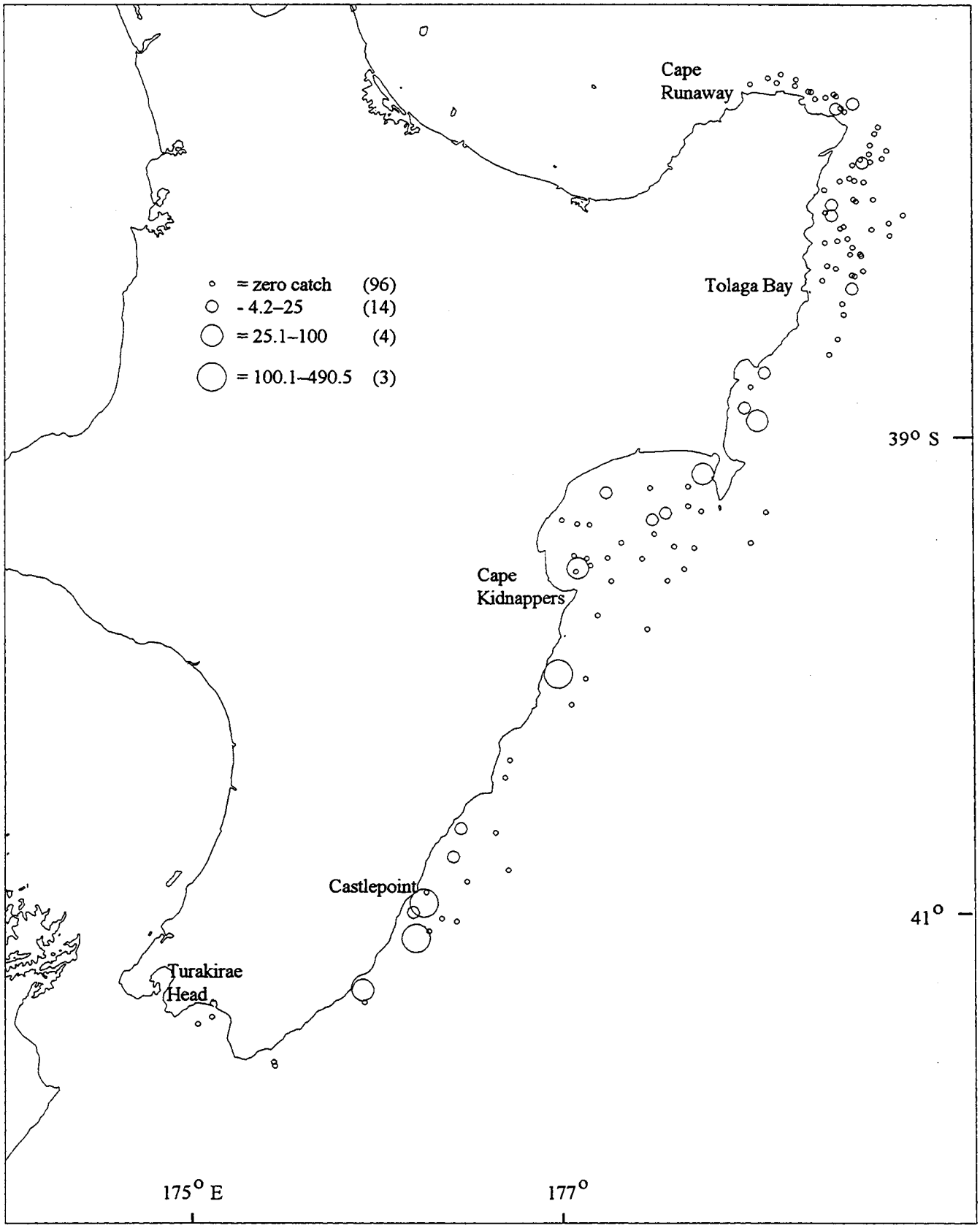

Figure 2—*continued*

Frostfish

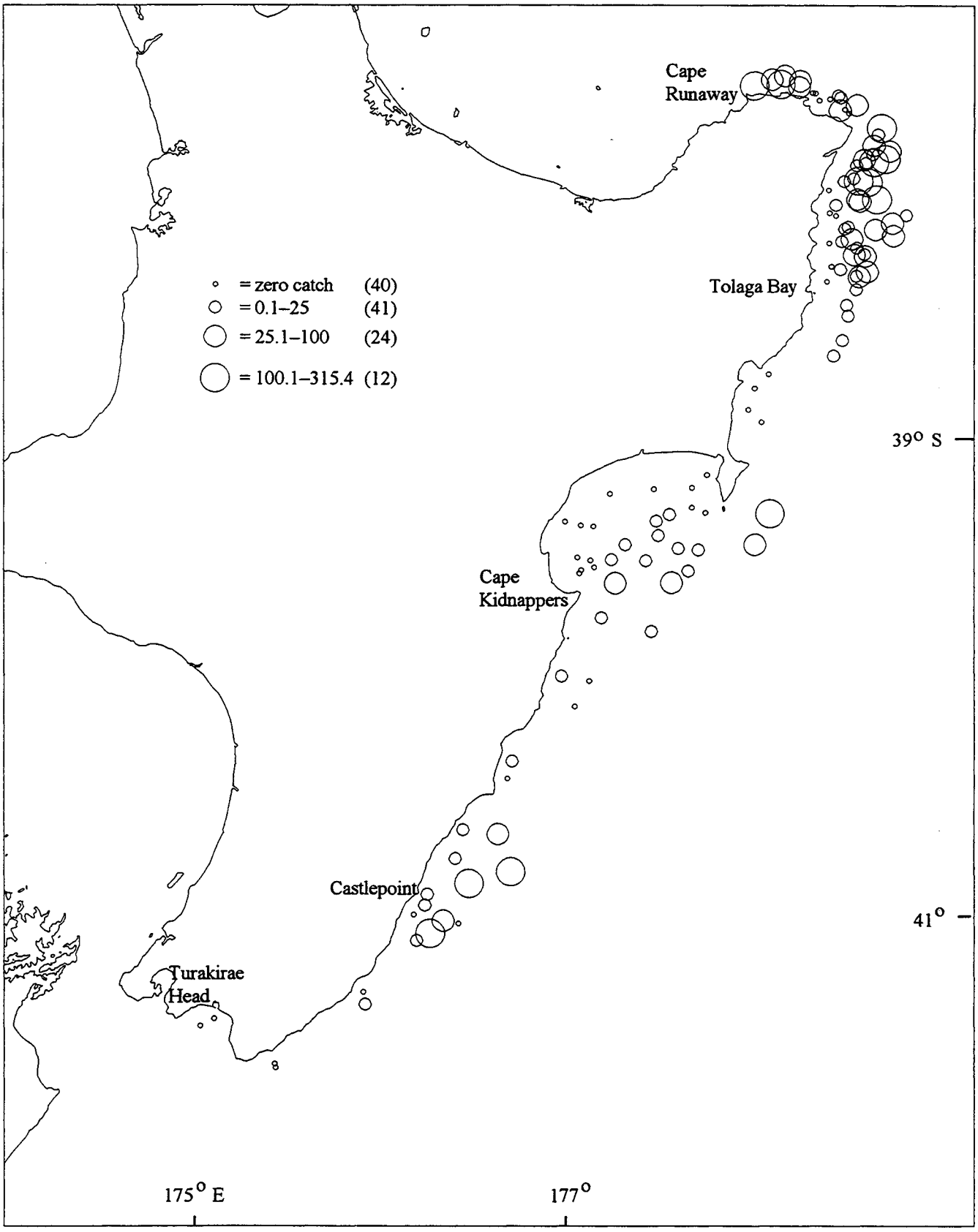

Figure 2—*continued*

Gemfish

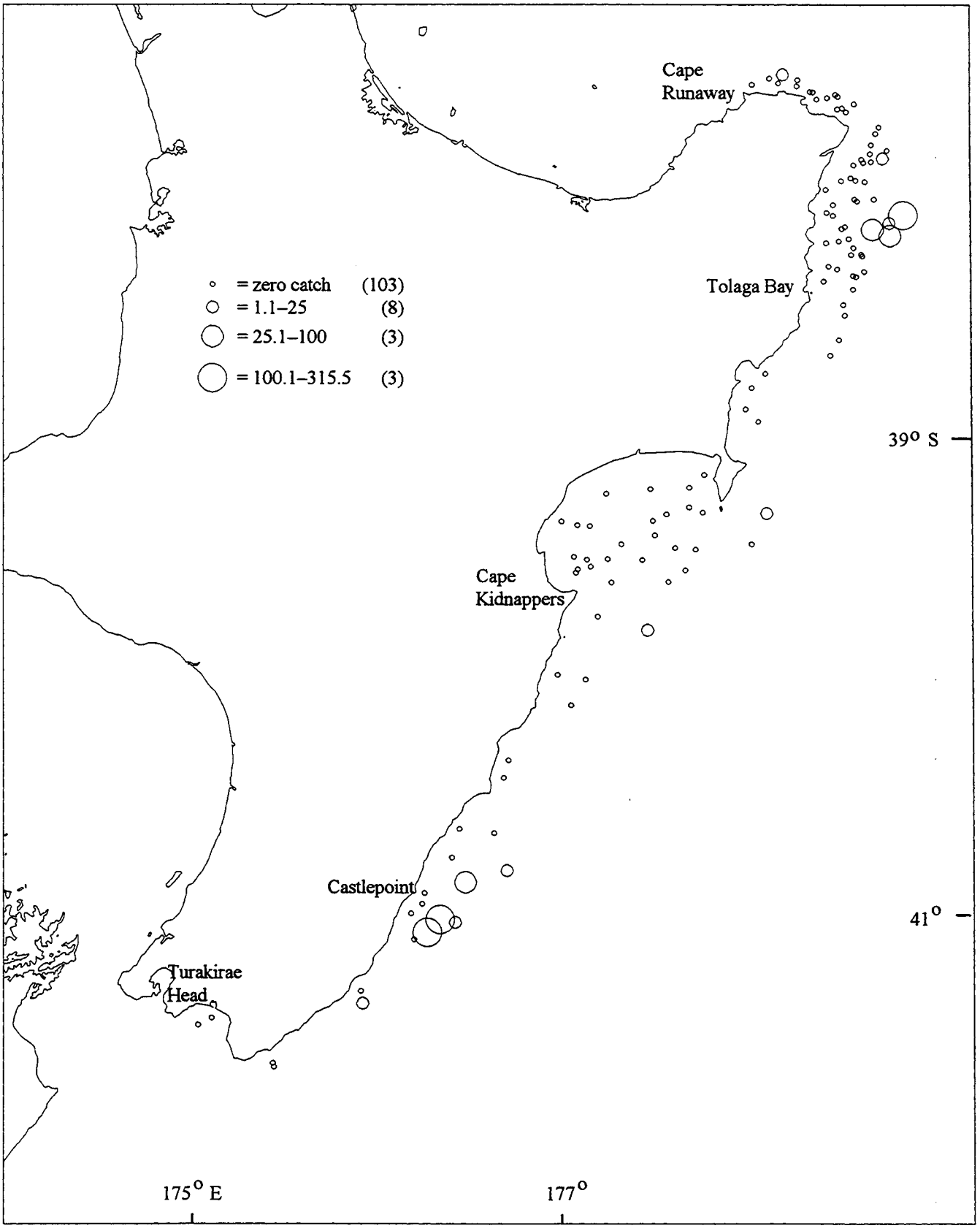

Figure 2—*continued*

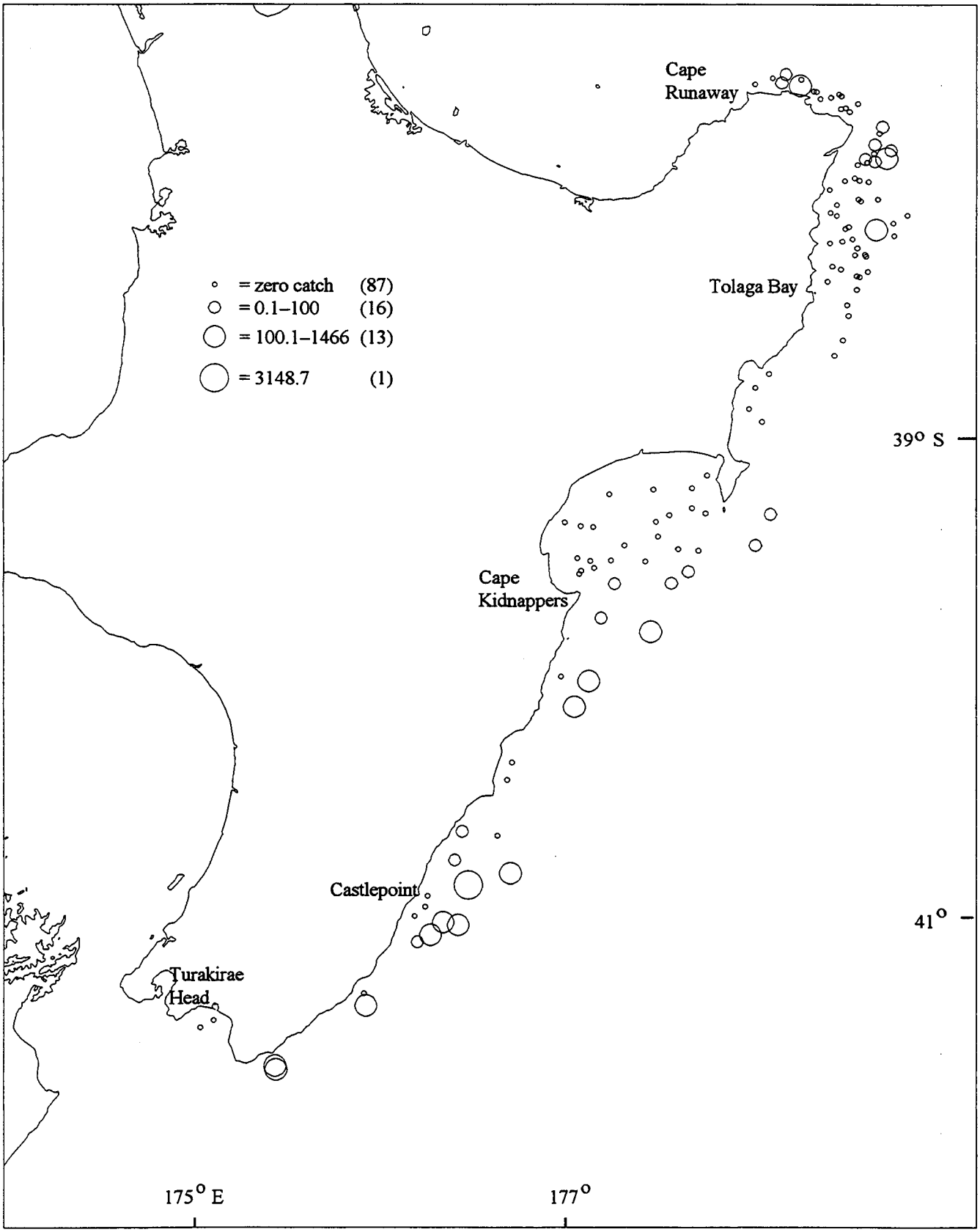

Figure 2—*continued*

Jack mackerel

Trachurus murphyi

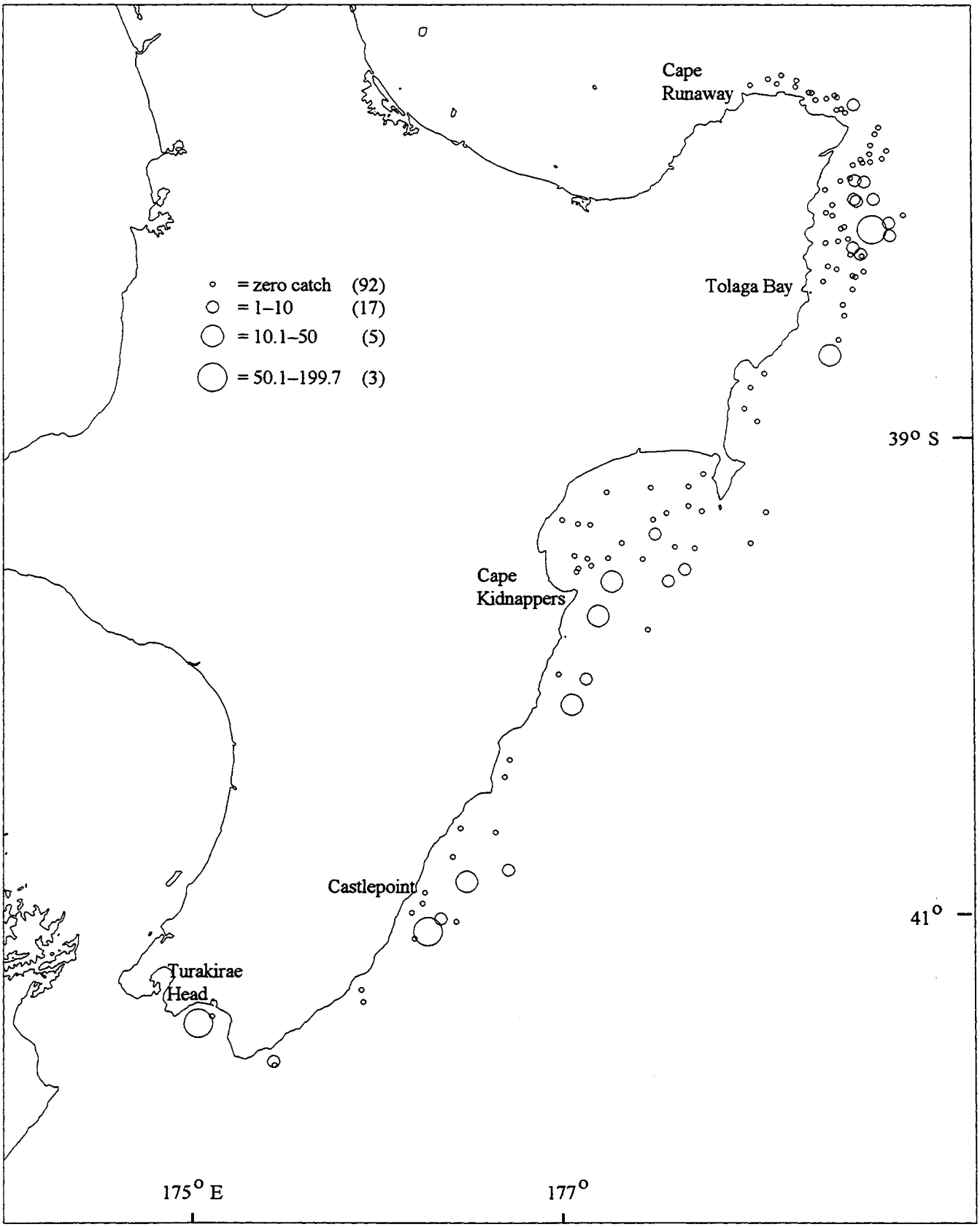

Figure 2—*continued*

Jack mackerel

Trachurus novaezelandiae

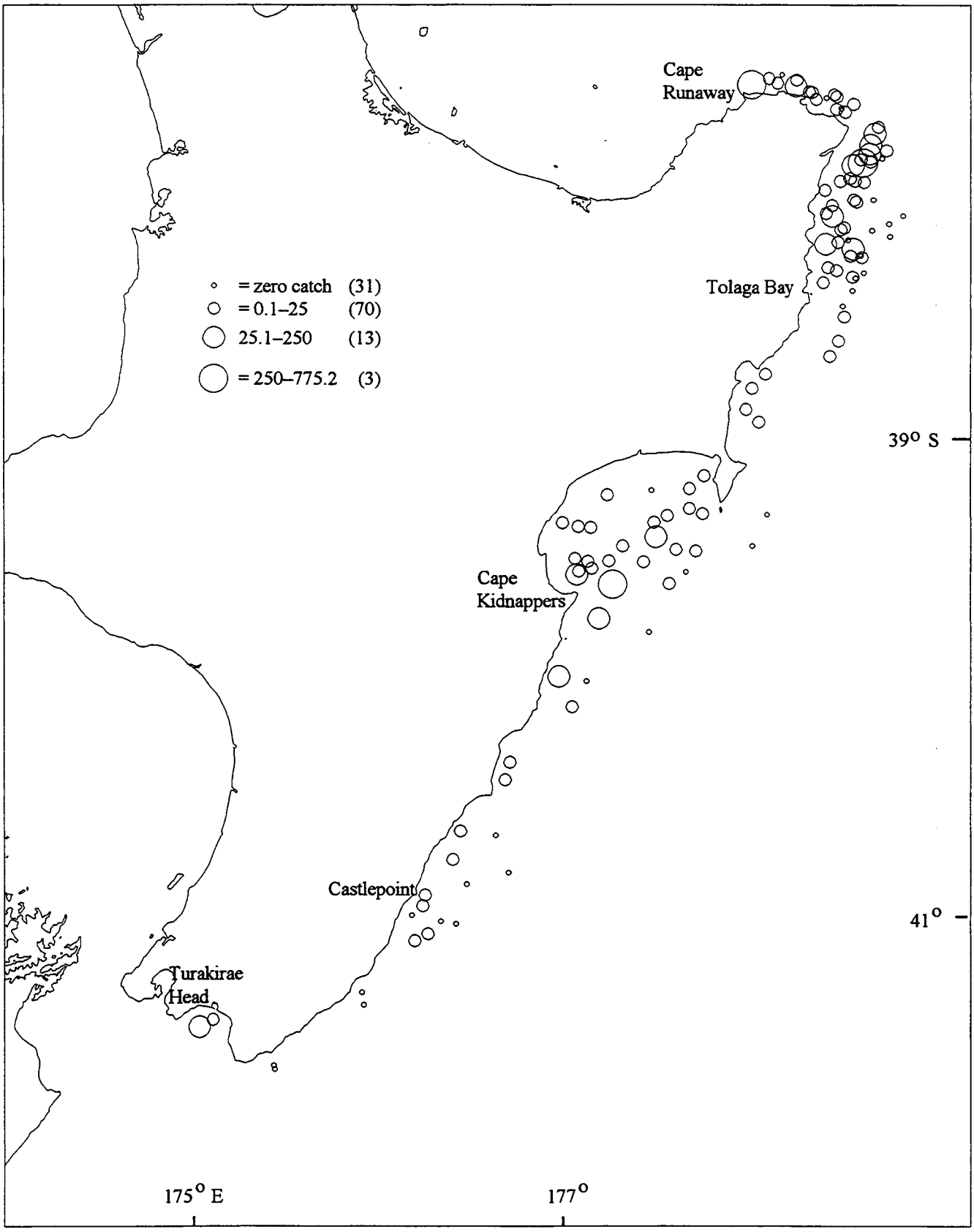

Figure 2—*continued*

John dory

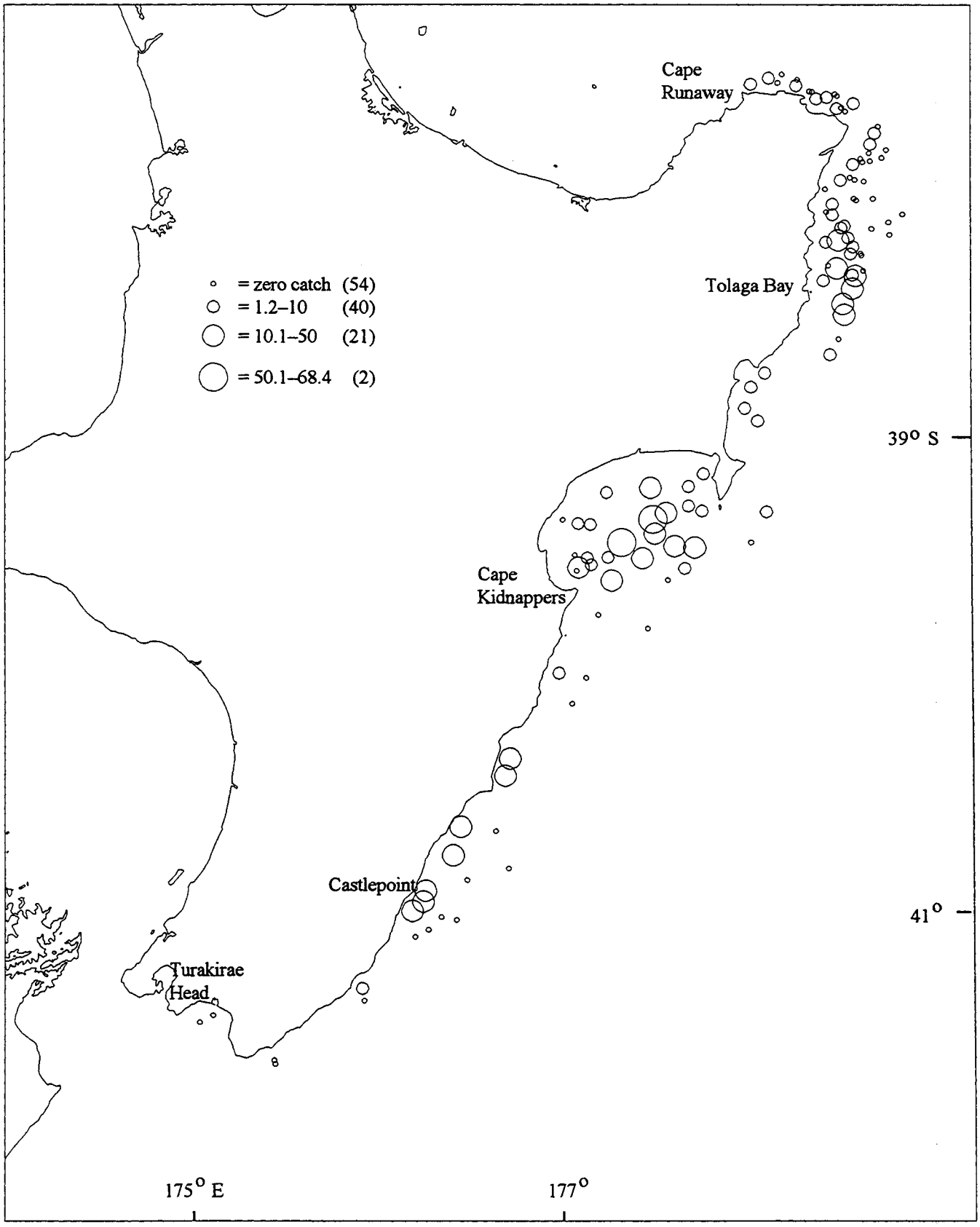

Figure 2—*continued*

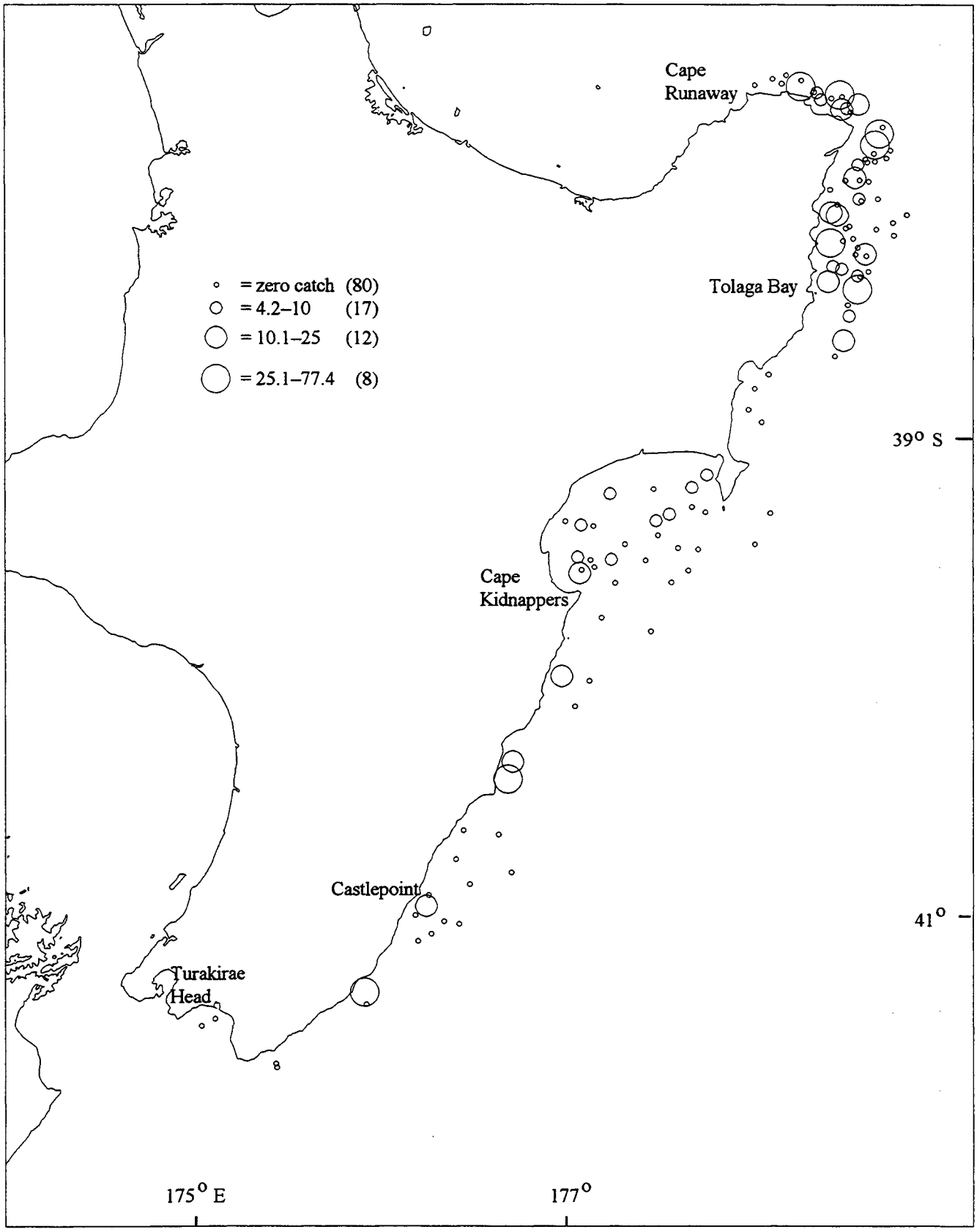

Figure 2—*continued*

Red cod

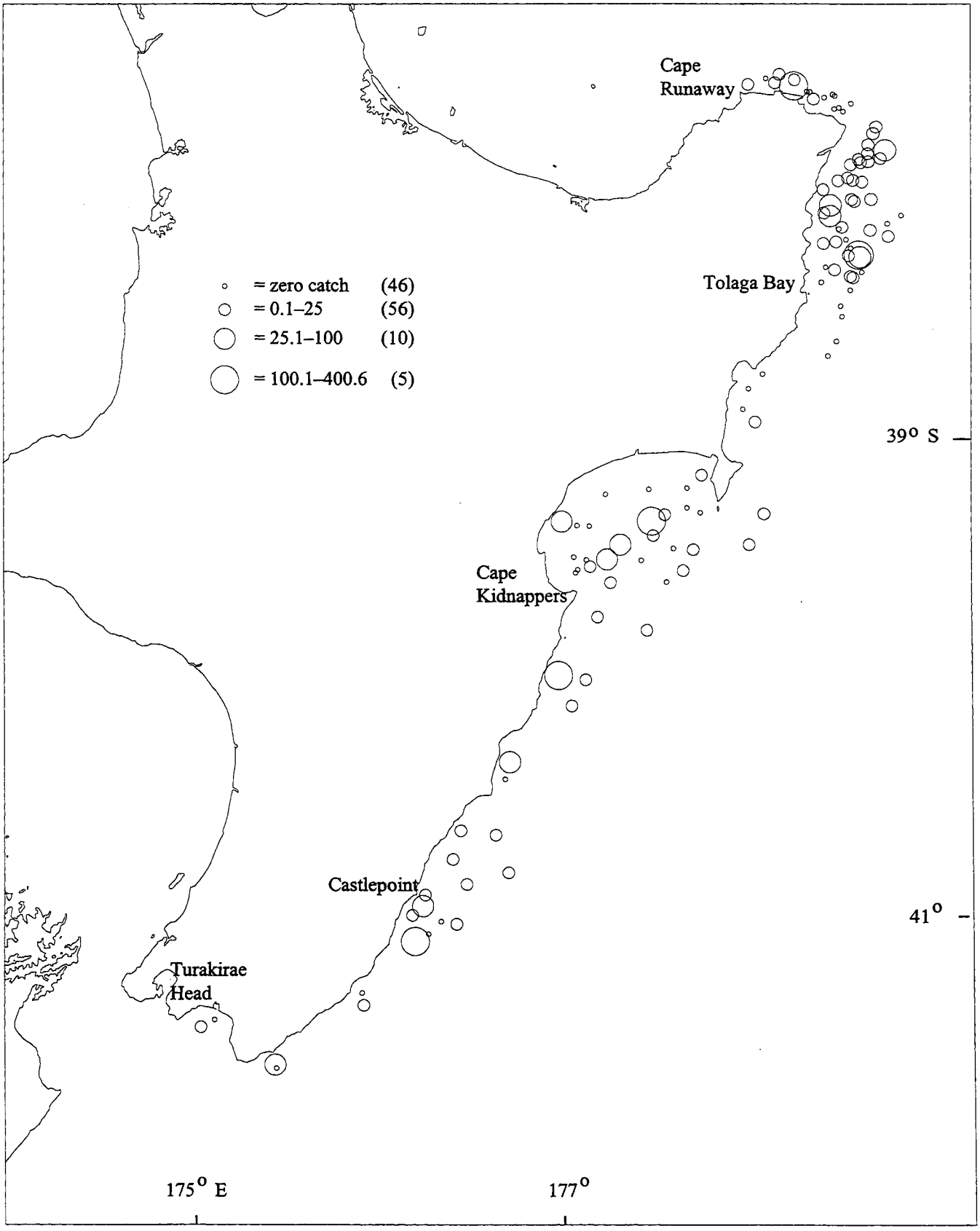

Figure 2—*continued*

Red gurnard

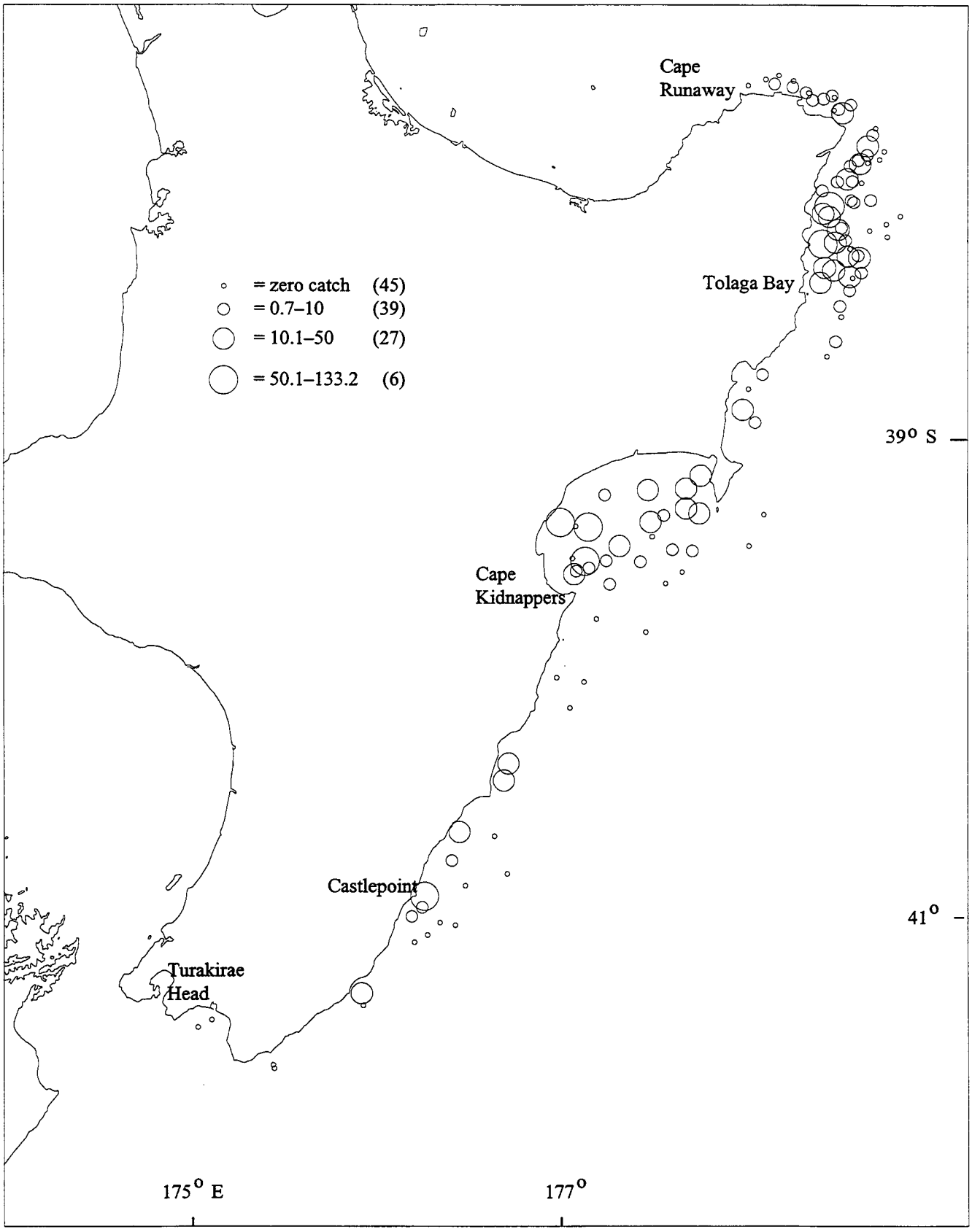

Figure 2—*continued*

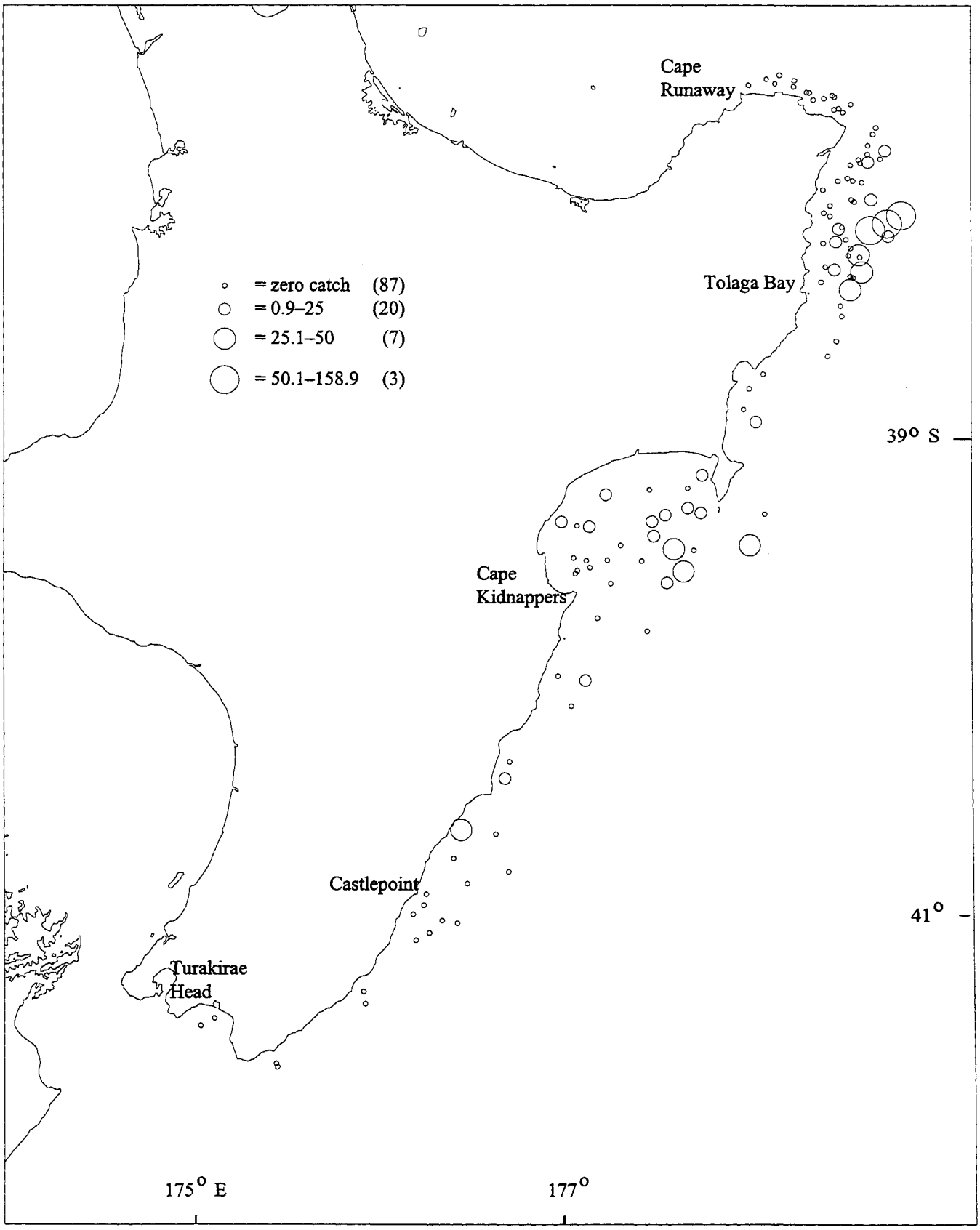

Figure 2—*continued*

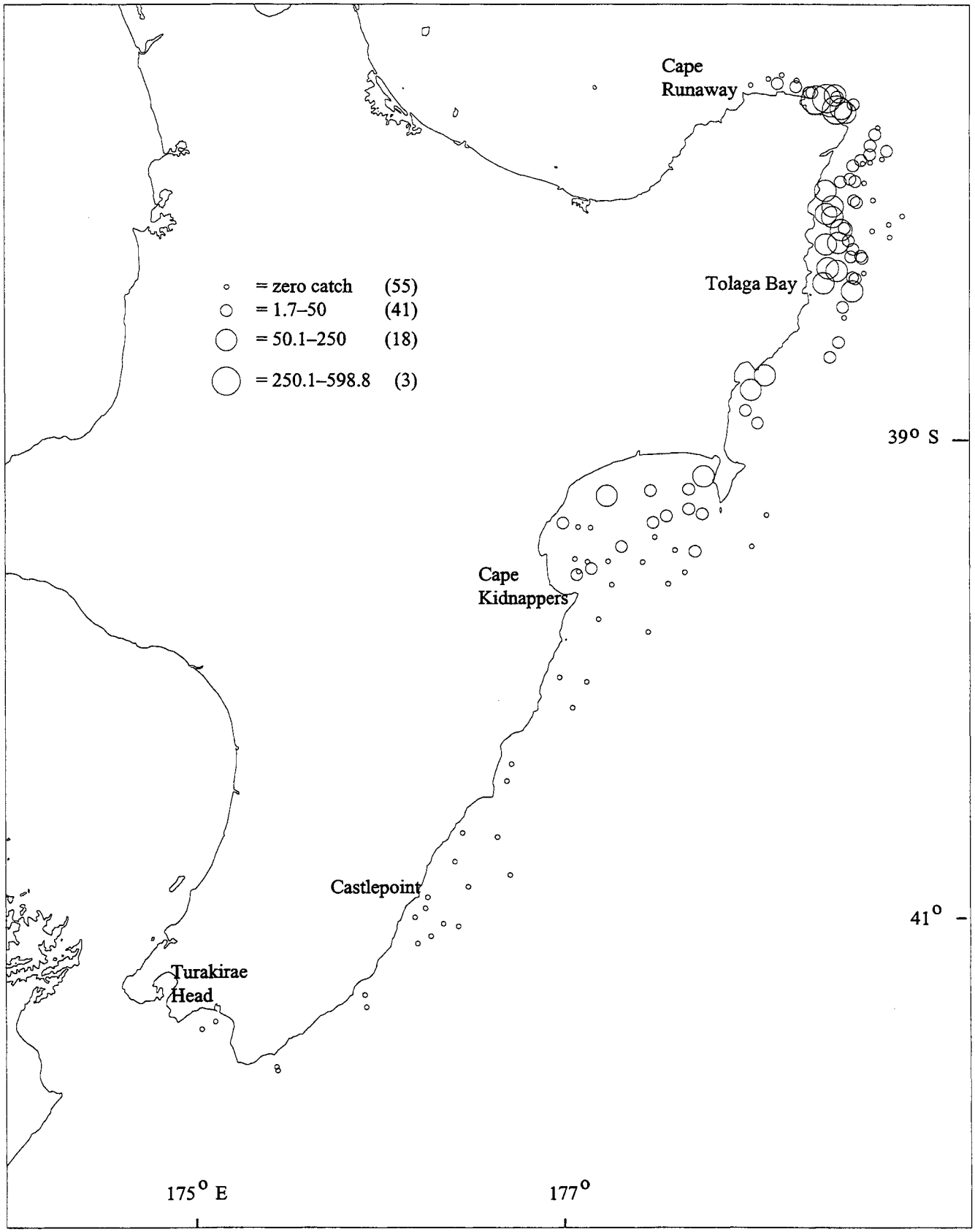

Figure 2—*continued*

Southern spiky dogfish

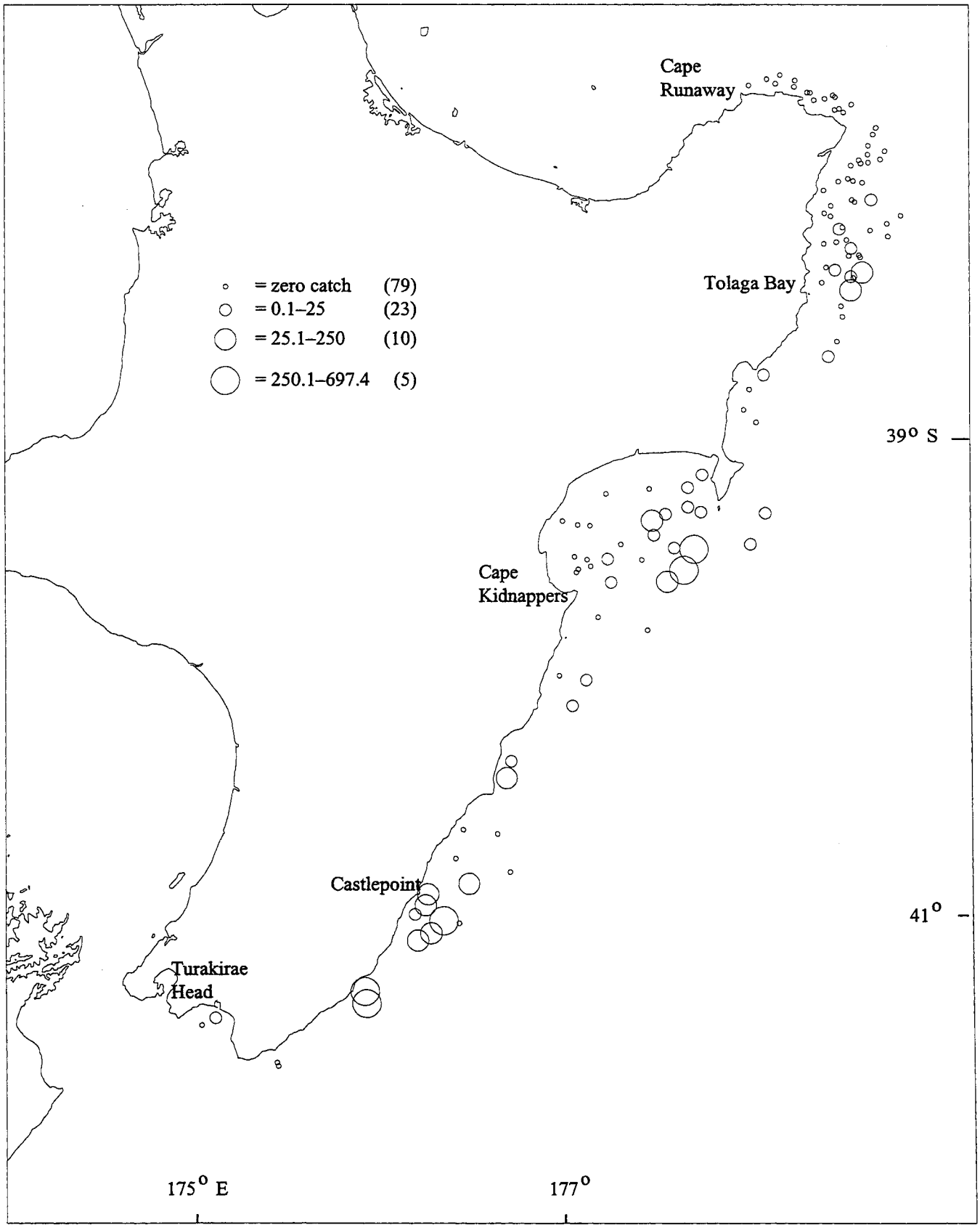

Figure 2—*continued*

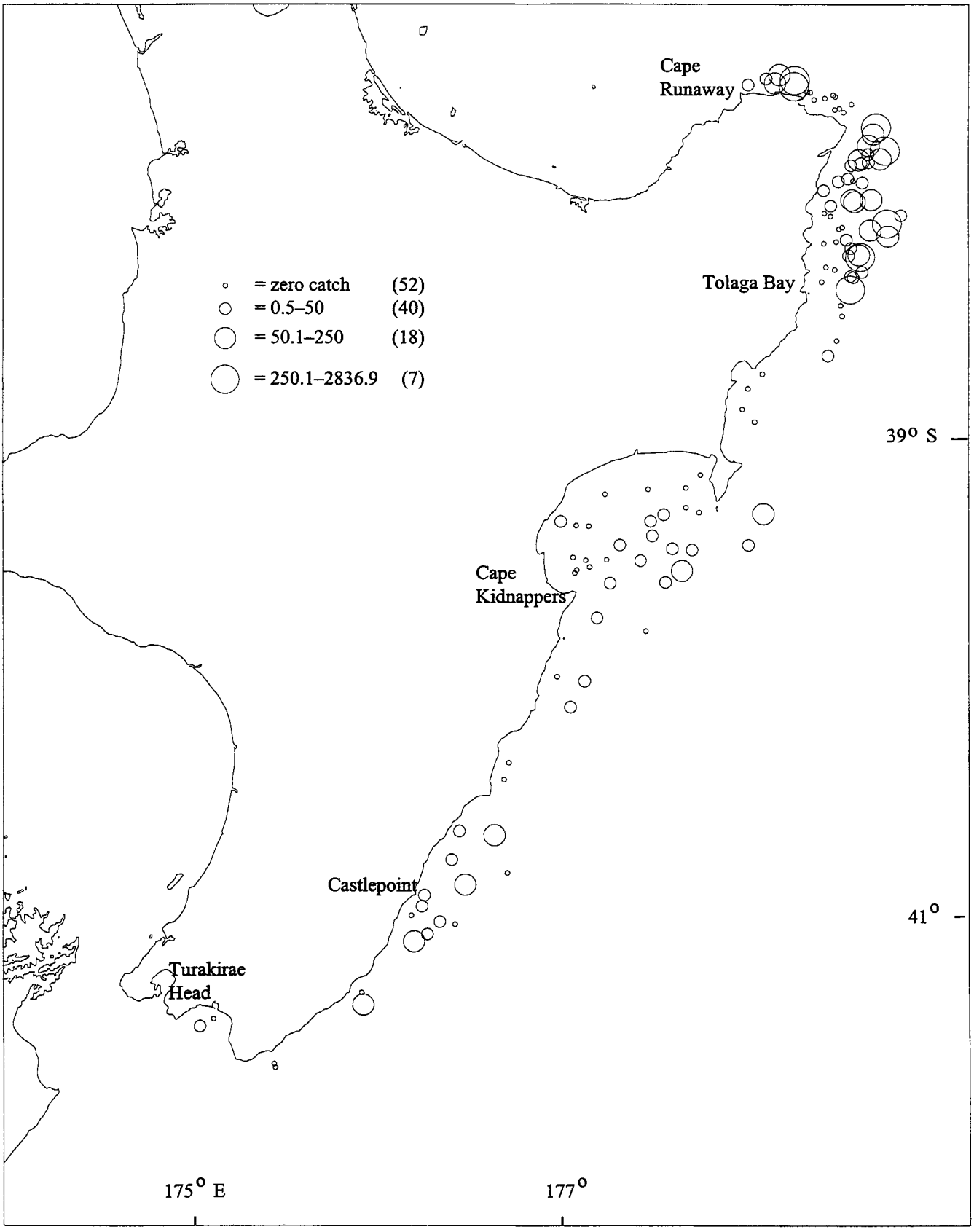

Figure 2—*continued*

Trevally

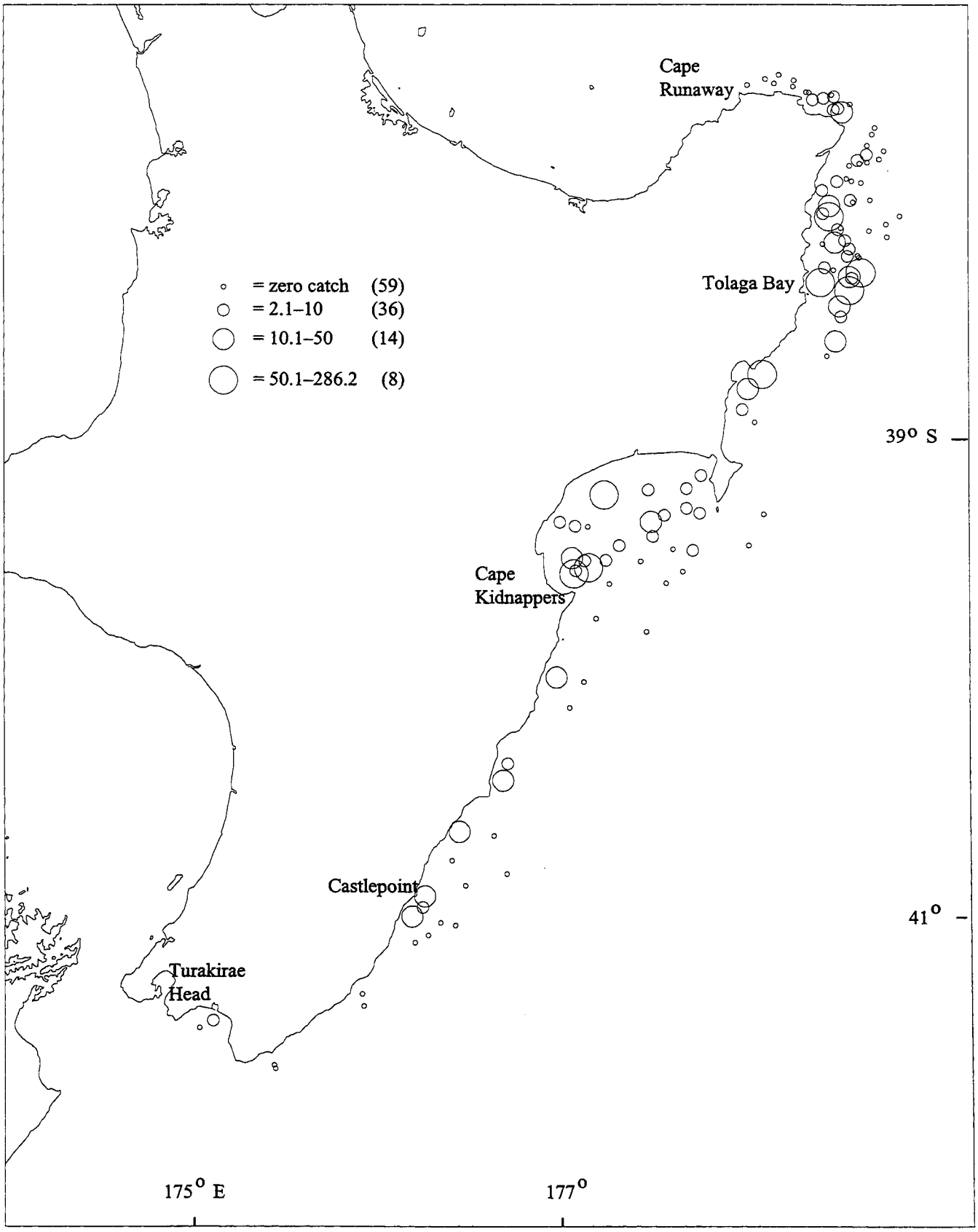

Figure 2—*continued*

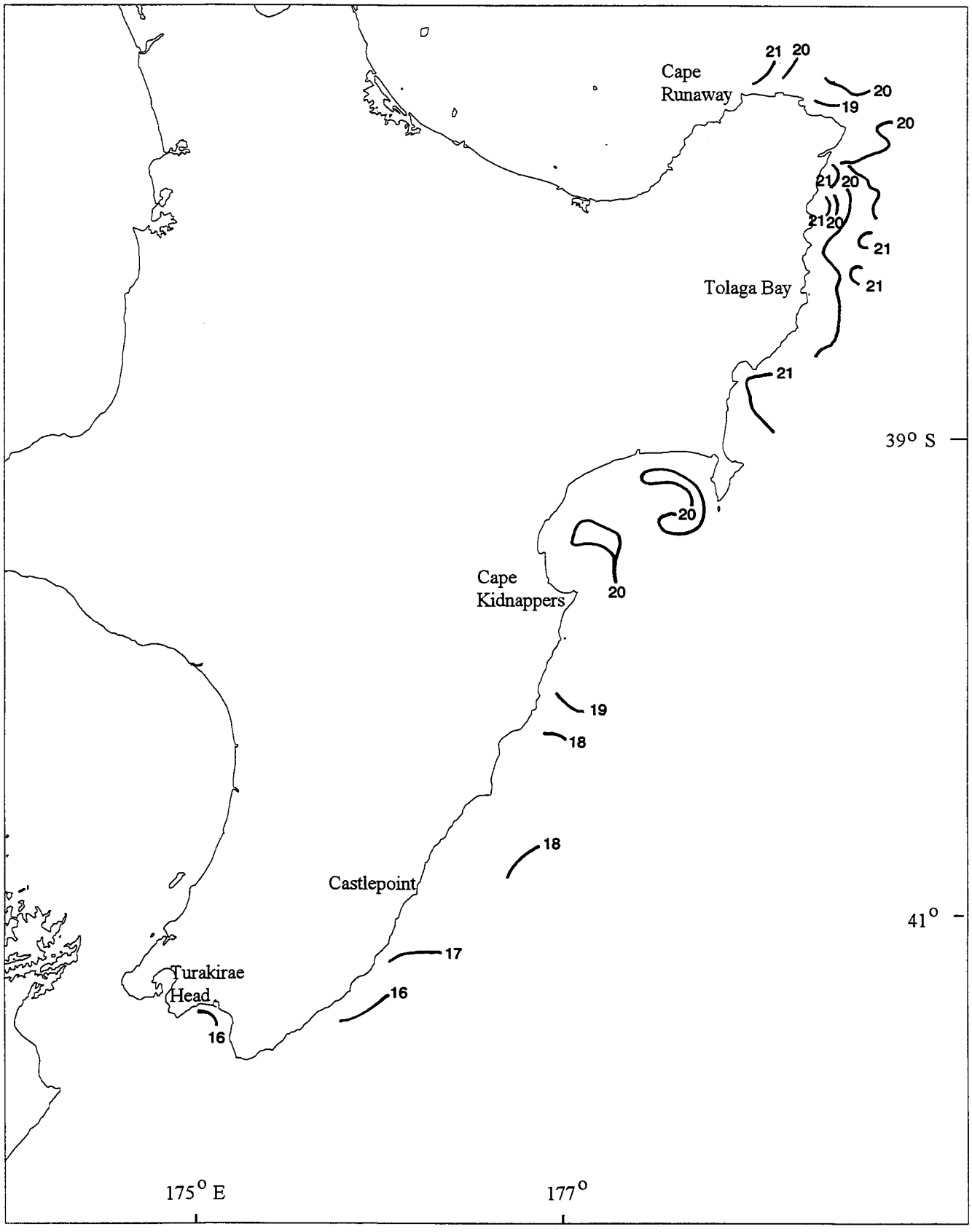

Figure 3a: Surface isotherms estimated from station data.

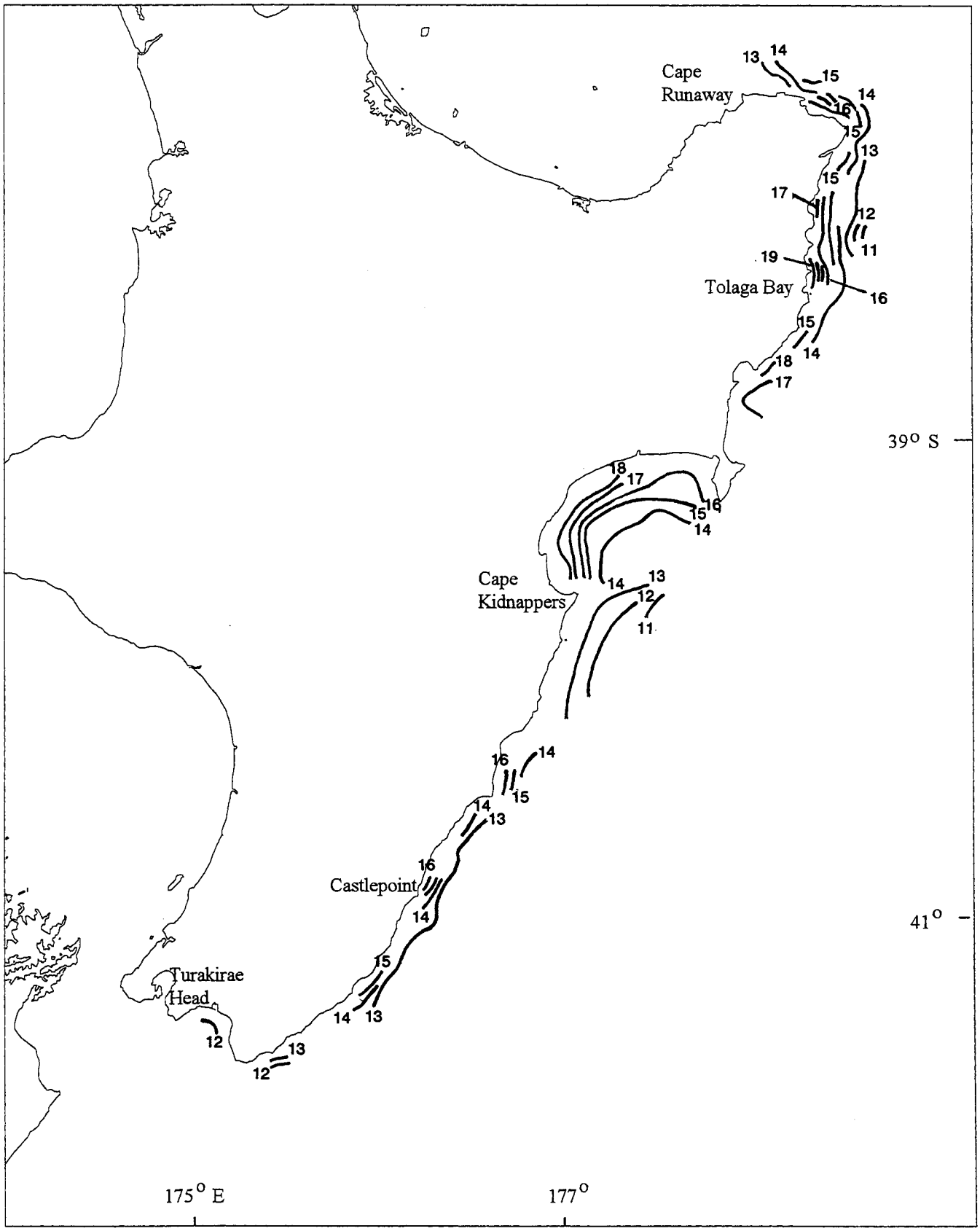

Figure 3b: Bottom isotherms estimated from station data.

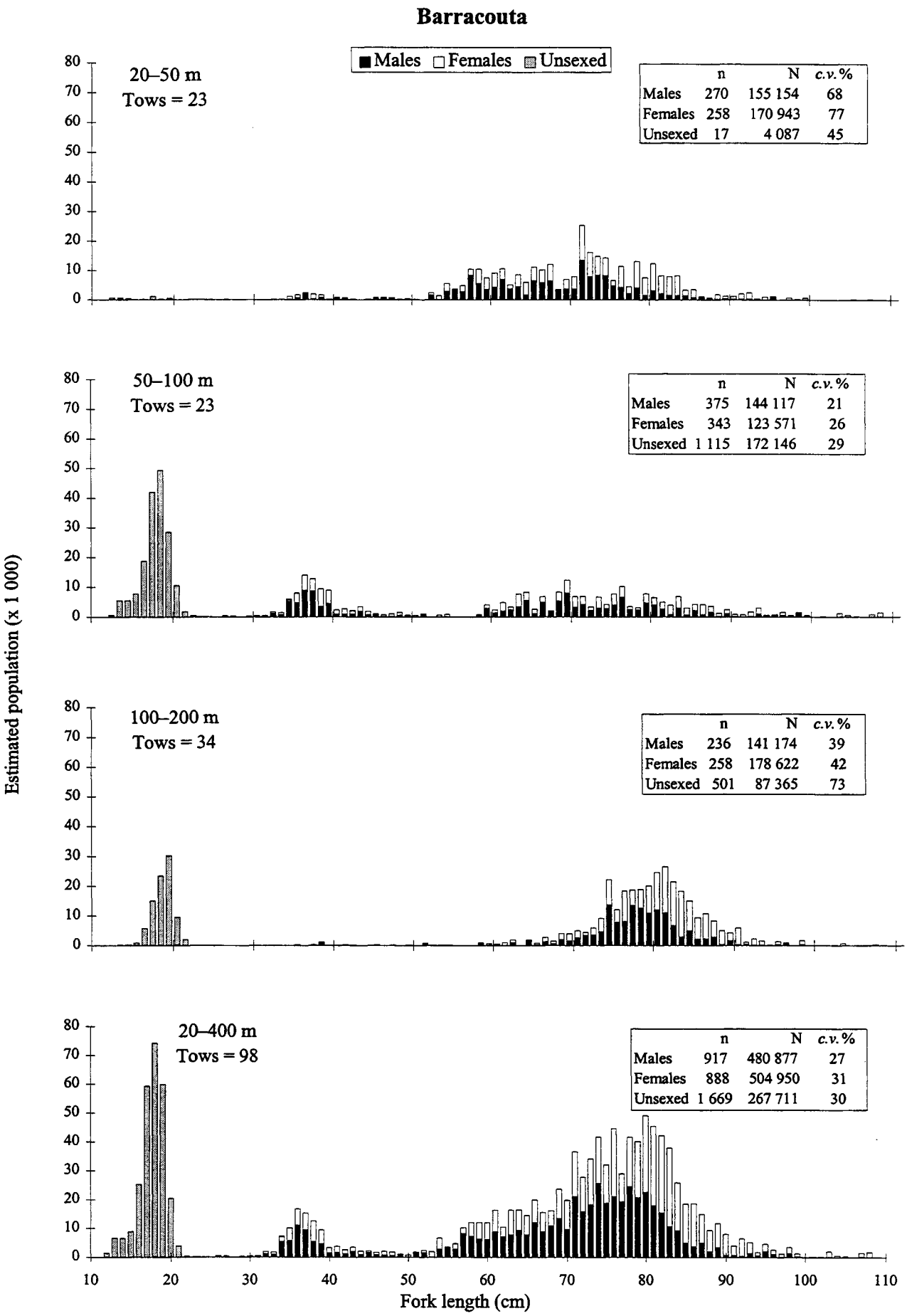

Figure 4: Scaled length frequency distributions for the 14 most abundant ITQ finfish species (n, number of fish measured; N, estimated population; Tows, number of stations at which species was caught).

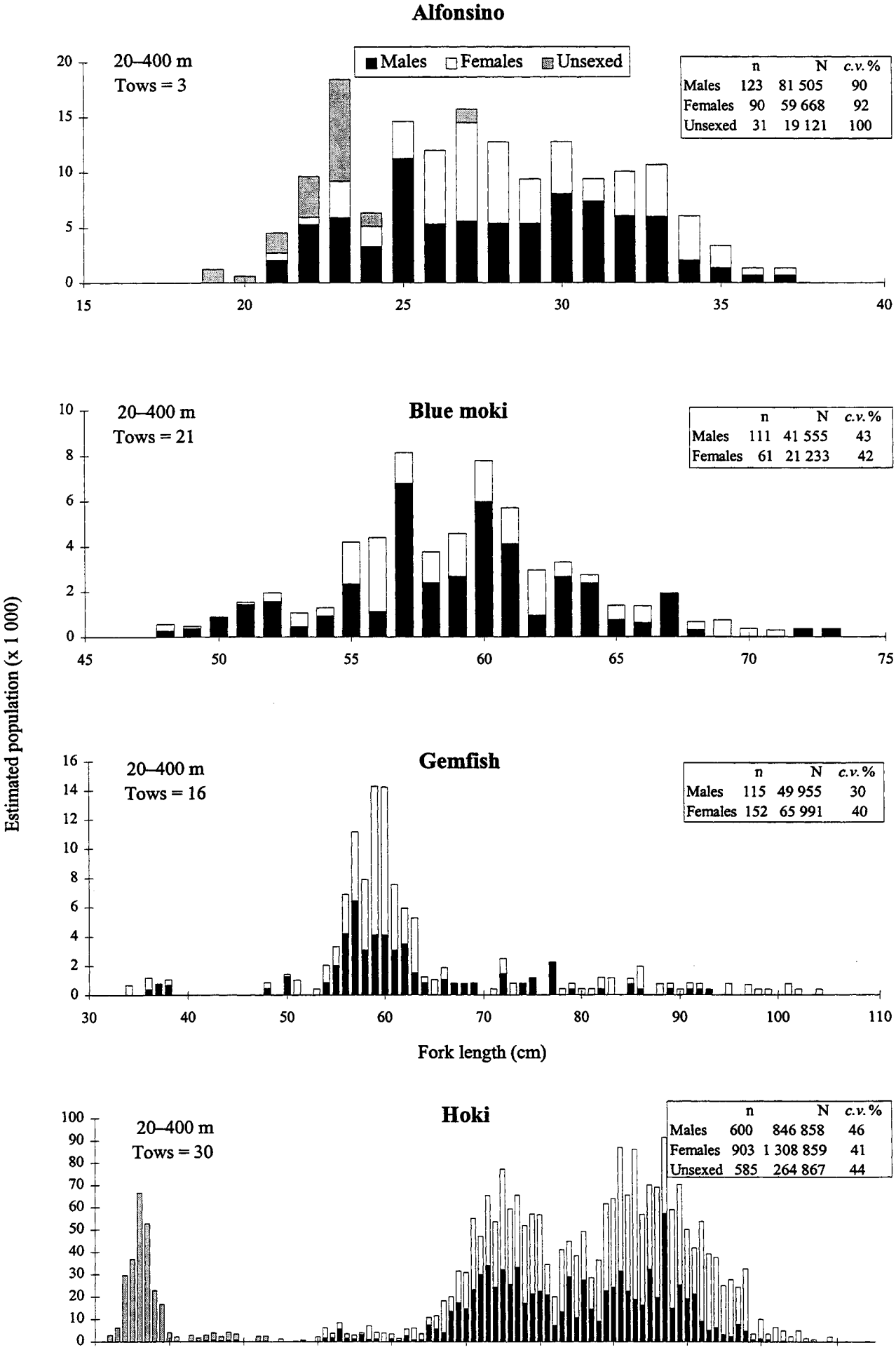

Figure 4—*continued*

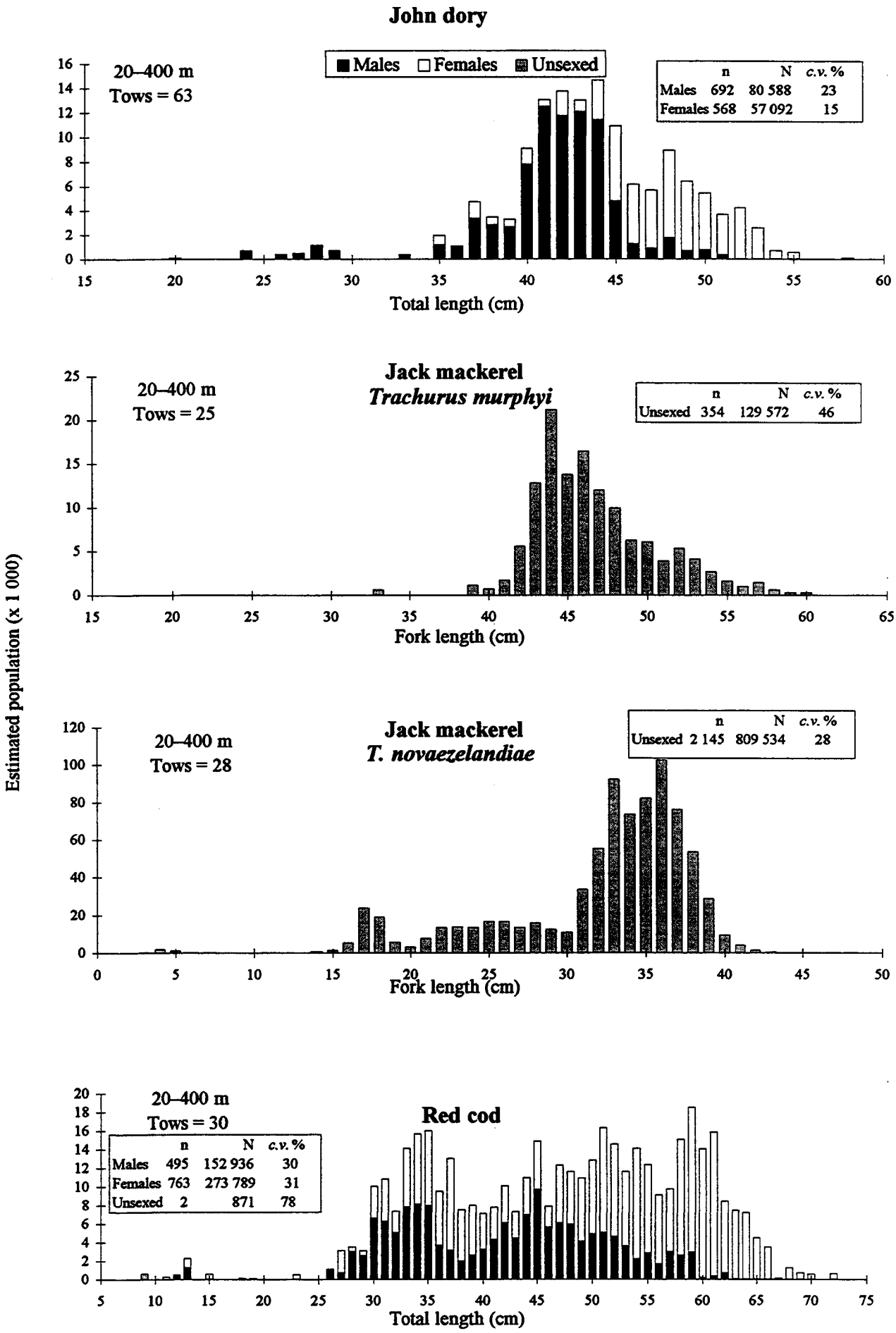

Figure 4—*continued*

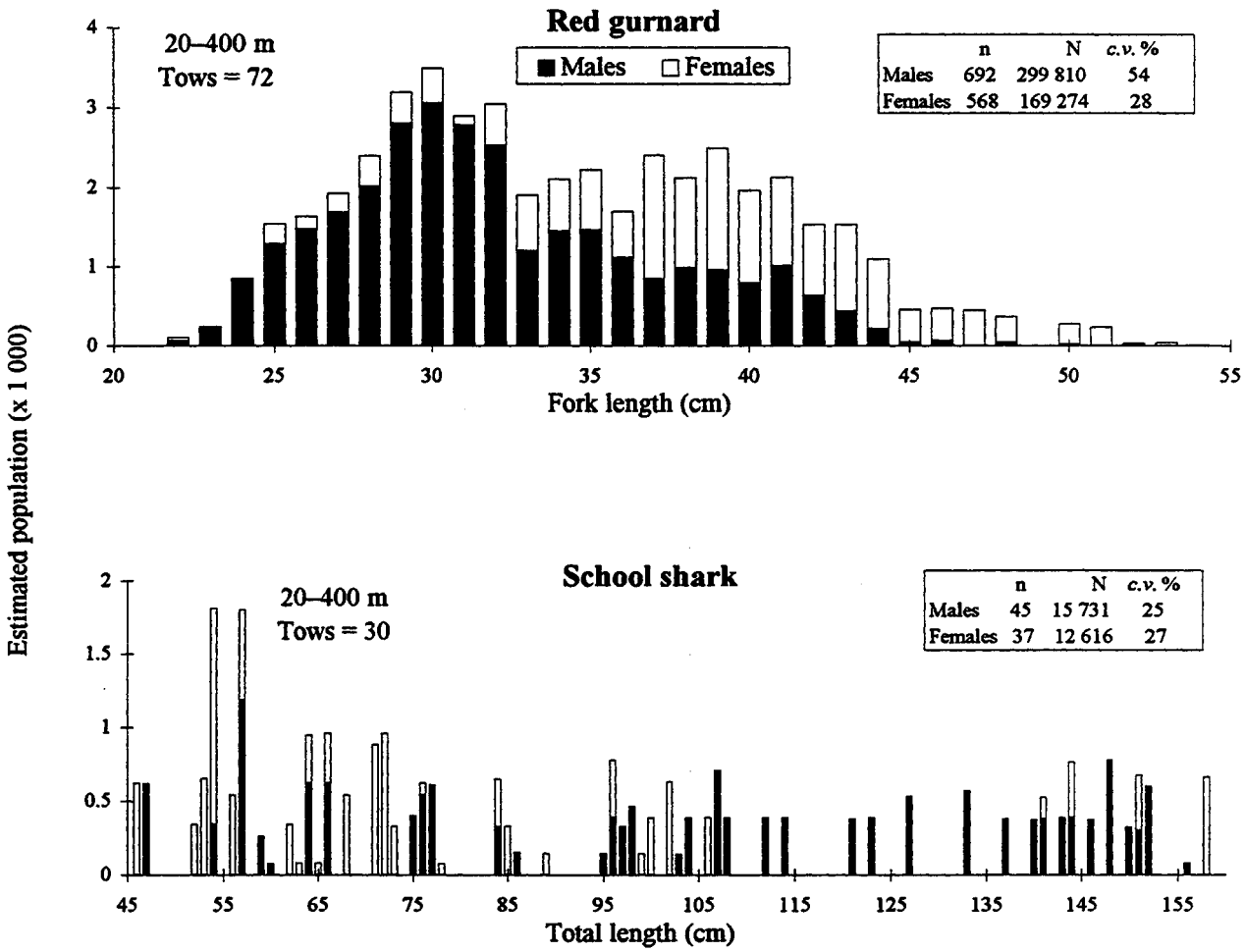

Figure 4—*continued*

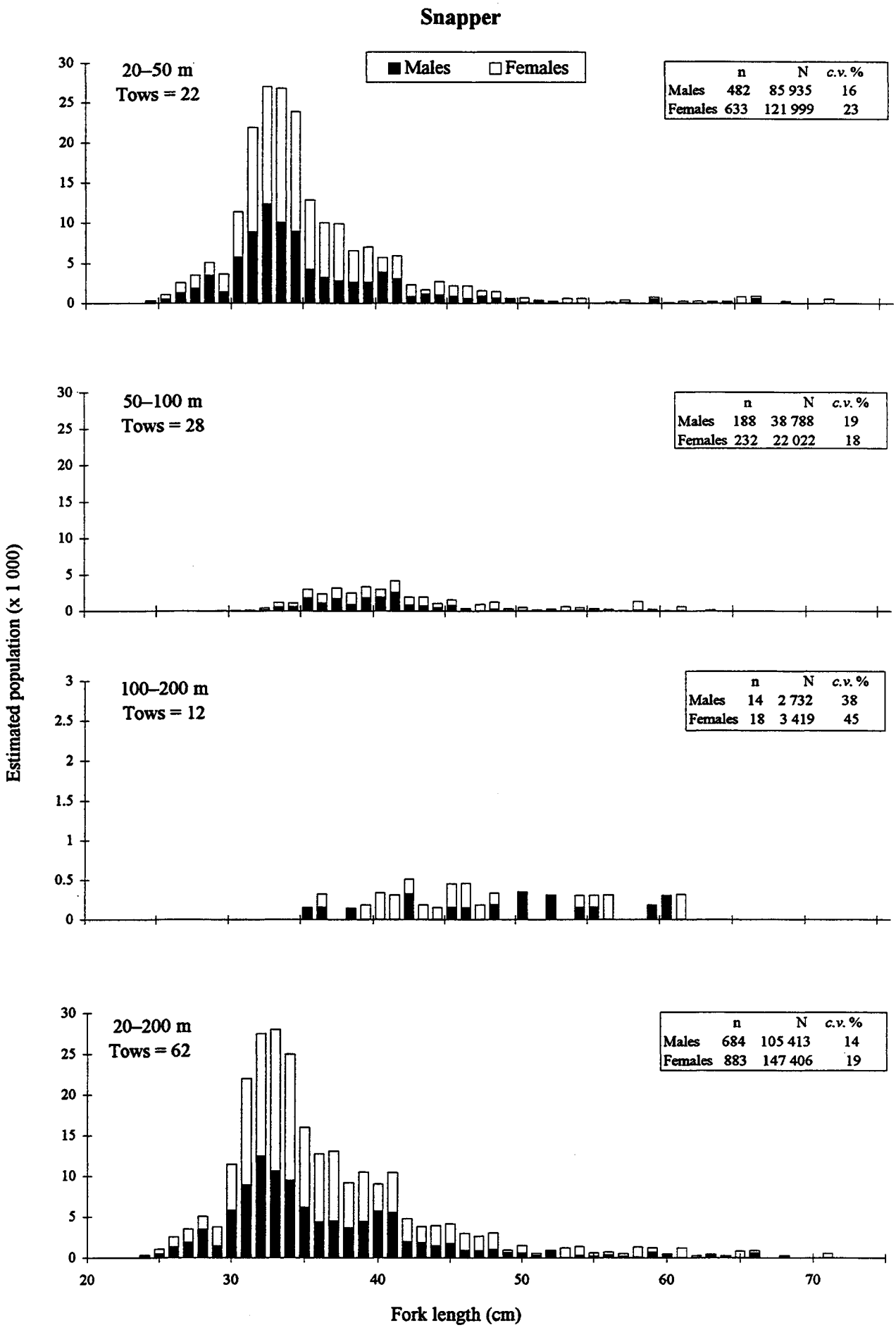

Figure 4—*continued*

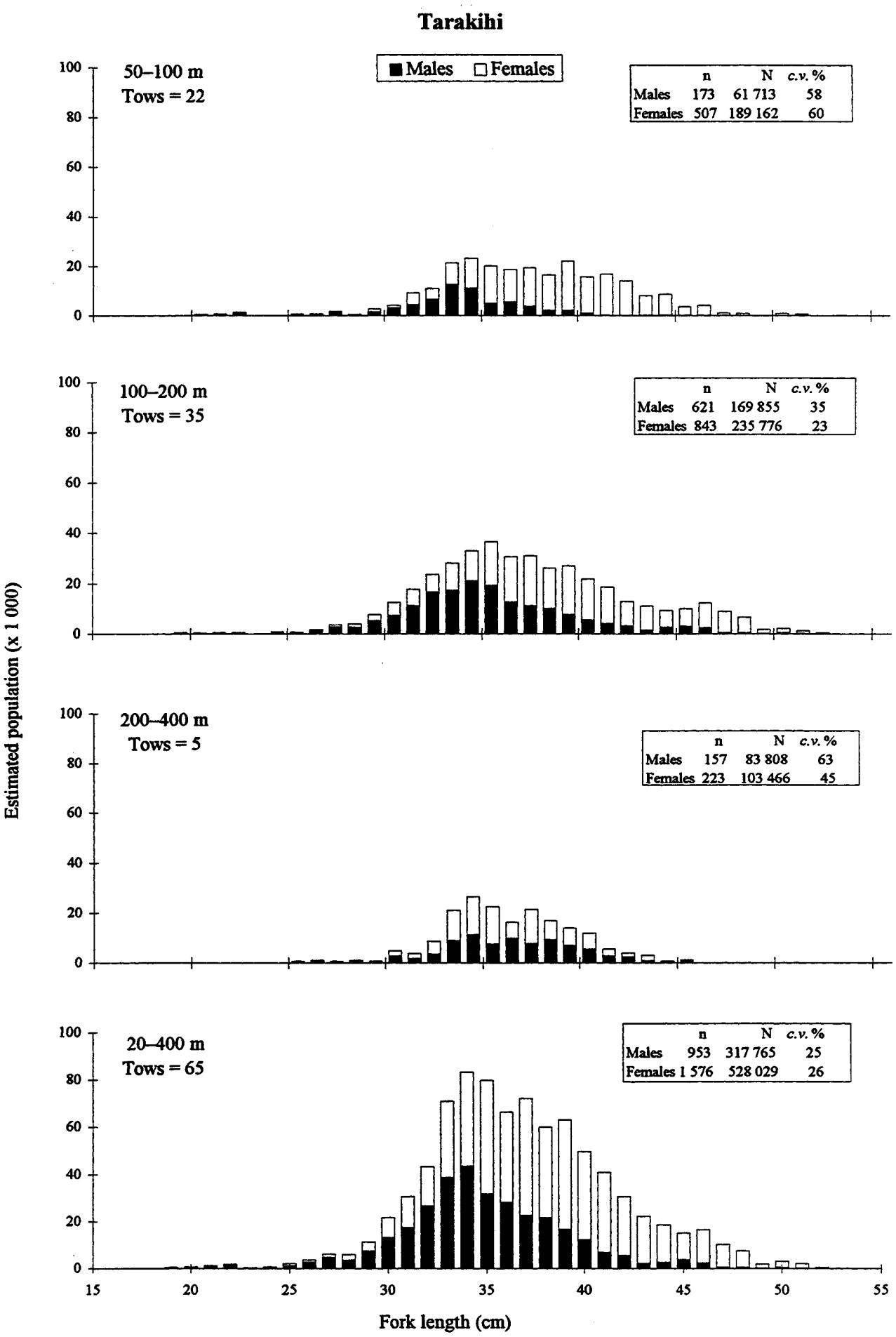

Figure 4—*continued*

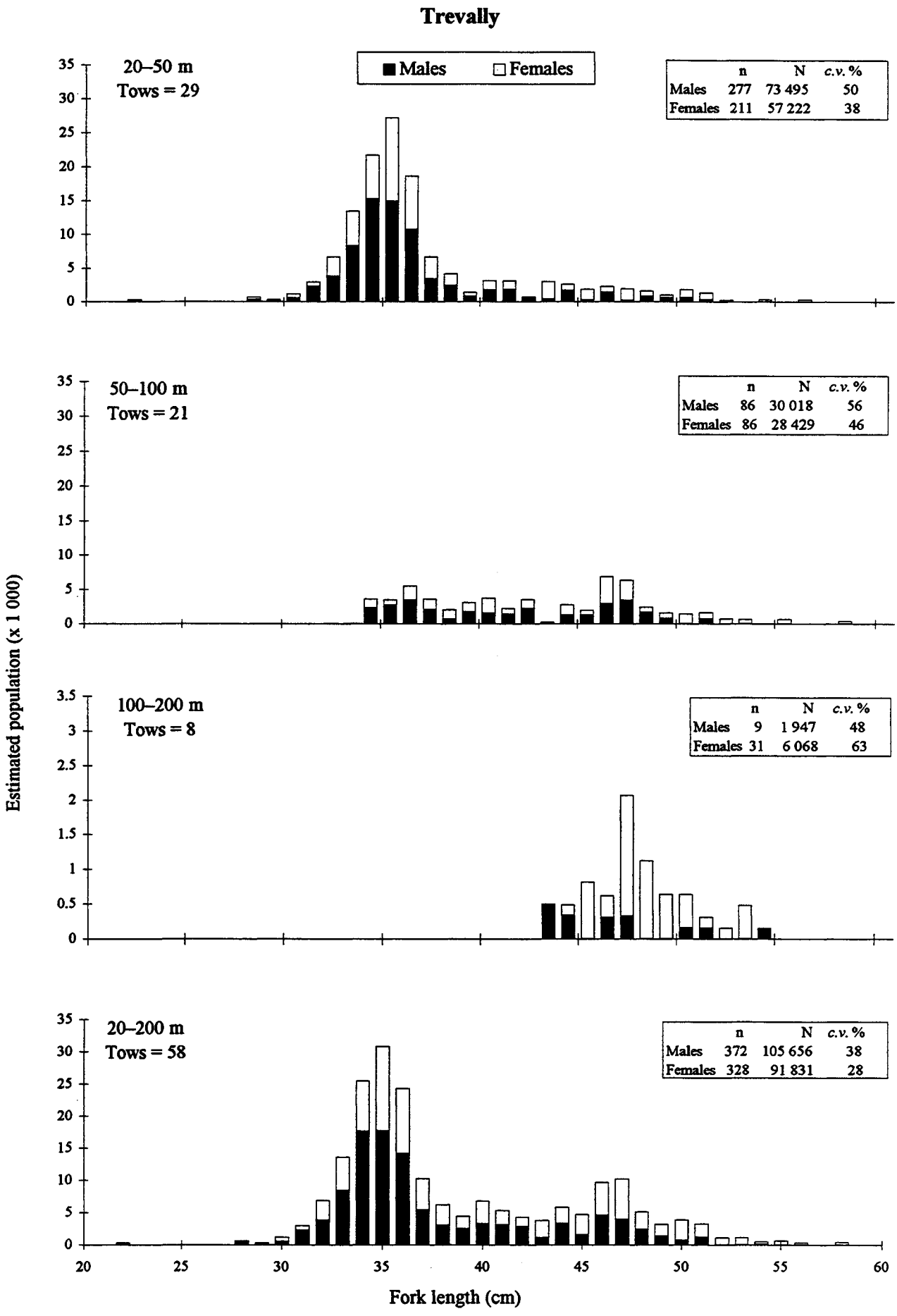

Figure 4—*continued*

Appendix 1: 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	1	5-Feb-95	0520	41 26.10	175 06.39	41 28.82	175 09.47	28	33	3.56	82.8	15.6	–
2	2	5-Feb-95	0718	41 27.95	175 01.91	41 31.31	175 04.04	69	86	3.71	83.5	16.3	12.0
3	4	5-Feb-95	1038	41 38.40	175 26.63	41 37.98	175 30.18	318	400	2.69	113	15.0	11.5
4	4	5-Feb-95	1244	41 37.46	175 26.22	41 36.48	175 30.83	196	238	3.58	105	15.3	13.0
5	3	6-Feb-95	0522	41 22.51	175 55.50	41 20.57	175 59.00	165	167	3.33	88.5	16.4	13.3
6	1	6-Feb-95	0746	41 19.42	175 54.90	41 16.54	175 57.80	36	47	3.60	83.5	16.7	15.1
7 *	3	6-Feb-95	1034	41 18.54	176 02.21	41 16.16	176 05.36	156	174	3.35	95.5	16.3	13.5
8	2	6-Feb-95	1607	41 06.56	176 12.15	41 03.44	176 14.82	83	96	3.70	94.5	17.5	14.0
9	3	7-Feb-95	0536	41 04.70	176 16.46	41 02.26	176 19.96	123	145	3.59	89.5	17.6	12.7
10	4	7-Feb-95	0803	41 02.25	176 25.59	40 59.98	176 29.11	294	317	3.50	110	16.6	11.4
11	3	7-Feb-95	1042	41 01.59	176 20.54	40 58.14	176 21.09	130	149	3.46	97.8	17.4	12.7
12	1	7-Feb-95	1306	40 59.99	176 11.26	40 57.17	176 13.73	41	46	3.38	78.3	17.9	14.1
13	2	7-Feb-95	1442	40 57.66	176 14.72	40 54.48	176 16.44	60	65	3.43	81.5	17.1	13.8
14	5	8-Feb-95	0521	40 54.87	176 15.49	40 51.52	176 17.05	33	50	3.54	80	17.6	16.3
15	7	8-Feb-95	0741	40 52.21	176 28.83	40 49.00	176 27.50	152	177	3.74	99	17.0	12.9
16	8	8-Feb-95	1035	40 49.27	176 42.46	40 46.70	176 38.80	321	369	3.77	102	18.0	12.9
17	7	8-Feb-95	1242	40 39.76	176 38.34	40 36.00	176 38.82	122	181	3.75	102	17.8	12.5
18	6	8-Feb-95	1531	40 38.69	176 26.95	40 41.80	176 29.56	53	112	3.68	85.5	17.5	14.6
19	6	9-Feb-95	0532	40 45.93	176 24.43	40 42.23	176 25.00	66	91	3.72	91.5	17.5	12.9
20	5	9-Feb-95	0850	40 25.75	176 41.43	40 22.32	176 42.81	39	44	3.59	84.5	17.4	16.5
21	5	9-Feb-95	1023	40 21.47	176 42.95	40 18.29	176 44.91	41	51	3.51	86.3	17.4	14.2
22	7	9-Feb-95	1332	40 07.47	177 03.29	40 03.85	177 03.64	150	176	3.63	106	19.4	12.2
23	8	9-Feb-95	1527	40 00.92	177 07.88	39 57.68	177 09.69	224	231	3.52	110	19.5	12.0
24	9	11-Feb-95	0552	39 33.16	177 05.30	39 36.43	177 06.74	29	32	3.45	–	19.1	17.2
25	10	11-Feb-95	0754	39 32.39	177 09.50	39 35.96	177 10.00	49	59	3.58	80	19.6	15.8
26	11	11-Feb-95	0959	39 36.45	177 16.23	39 39.94	177 15.95	99	116	3.47	87.5	20.0	13.2
27	7	11-Feb-95	1216	39 45.15	177 11.84	39 48.11	177 09.46	116	116	3.47	97.7	19.8	12.5
28	6	11-Feb-95	1524	39 59.80	176 58.91	39 57.18	177 02.63	67	96	3.87	96.5	19.2	13.7
29	11	12-Feb-95	0611	3936.28	177 34.57	39 34.58	177 30.55	150	154	3.55	77.5	19.1	13.1

Appendix 1—*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)
30	9	13-Feb-95	0516	39 09.18	177 46.05	39 12.01	177 42.86	34	38	3.76	88.3	19.3	16.3
31	10	13-Feb-95	0749	39 19.17	177 34.04	39 19.77	177 29.32	71	77	3.70	98.6	19.0	14.6
32	11	13-Feb-95	1100	39 28.06	177 43.29	39 26.27	177 39.42	102	102	3.49	100	19.6	13.8
33	11	13-Feb-95	1253	39 27.73	177 36.80	39 26.70	177 32.17	110	114	3.73	101	19.6	13.6
34	11	13-Feb-95	1508	39 30.80	177 26.30	39 27.36	177 26.87	100	120	3.47	97.5	19.6	13.3
35	11	14-Feb-95	0521	39 18.92	178 06.34	39 1..991	178 01.90	110	144	3.58	94	19.3	13.1
36	11	14-Feb-95	0748	39 26.79	178 01.46	39 27.83	177 56.85	126	148	3.60	94	19.2	13.2
37	11	14-Feb-95	1035	39 33.38	177 39.94	39 31.52	177 35.71	134	136	3.76	91.9	19.5	13.4
38	8	14-Feb-95	1433	39 48.47	177 28.06	39 45.68	177 31.00	344	351	3.58	102	19.6	10.3
39	10	15-Feb-95	0514	39 26.79	177 19.51	39 23.30	177 18.80	68	75	3.52	93.2	19.2	–
40	9	15-Feb-95	0747	39 14.03	177 14.60	39 15.54	177 10.37	38	39	3.61	87.5	19.0	18.3
41	9	15-Feb-95	1001	39 20.92	177 00.18	39 24.52	177 00.47	24	26	3.60	84.5	19.2	18.2
42	9	16-Feb-95	0531	38 52.63	177 59.45	38 49.54	178 01.73	44	50	3.56	88	20.1	16.4
43	11	16-Feb-95	0910	38 39.16	178 26.95	38 36.57	178 30.00	115	132	3.53	101	20.0	13.2
44	11	16-Feb-95	1041	38 35.33	178 29.68	38 32.47	178 32.36	123	126	3.55	101	20.0	13.4
45	11	16-Feb-95	1226	38 29.16	178 31.50	38 26.49	178 34.45	109	114	3.53	95.8	20.1	13.6
46	10	16-Feb-95	1403	38 26.45	178 31.02	38 28.53	178 27.55	83	90	3.43	100	20.1	14.2
47	12	17-Feb-95	0508	38 20.47	178 24.86	38 16.74	178 25.42	40	43	3.75	88.9	19.5	19.2
48	13	17-Feb-95	0649	38 17.37	178 29.07	38 20.90	178 29.43	75	77	3.54	92.3	20.0	15.4
49	13	17-Feb-95	0847	38 22.45	178 34.12	38 19.02	178 34.04	93	96	3.43	88	20.1	14.4
50	14	17-Feb-95	1037	38 19.30	178 35.02	38 15.87	178 33.94	104	108	3.53	97.5	20.6	14.2
51	14	17-Feb-95	1226	38 13.67	178 36.81	38 17.07	178 38.04	132	133	3.53	95.5	21.0	13.4
52	14	17-Feb-95	1403	38 17.96	178 37.77	38 21.51	178 37.52	123	128	3.55	98.1	21.3	13.3
53	15	18-Feb-95	0513	38 07.37	178 40.39	38 03.81	178 40.55	209	209	3.55	104	20.0	12.5
54 *	15	18-Feb-95	0710	38 02.14	178 43.17	38 04.77	178 44.56	180	228	2.85	105	20.0	–
55	15	18-Feb-95	0858	38 05.70	178 45.70	38 09.23	178 45.89	225	226	3.53	107	20.1	–
56	15	18-Feb-95	1047	38 08.89	178 46.01	38 05.63	178 47.92	247	276	3.59	95.5	20.2	11.6
57	15	18-Feb-95	1308	38 03.64	178 50.12	38 07.18	178 50.12	337	376	3.53	108	20.4	10.3
58	14	18-Feb-95	1557	38 11.95	178 34.25	38 15.70	178 34.37	113	120	3.74	97.2	21.1	13.0

Appendix 1—*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)
59	12	19-Feb-95	0517	38 16.73	178 26.27	38 13.20	178 25.07	40	48	3.64	88.7	20.5	16.6
60	13	19-Feb-95	0710	38 10.34	178 29.60	38 06.83	178 30.10	74	74	3.53	92.6	20.6	14.6
61	13	19-Feb-95	0848	38 06.65	178 31.48	38 03.20	178 32.10	80	81	3.47	100	20.7	14.7
62	13	19-Feb-95	1037	38 03.80	178 27.71	38 00.34	178 28.22	59	63	3.48	92.4	20.4	16.5
63	12	19-Feb-95	1222	38 03.04	178 25.70	37 59.45	178 25.70	46	50	3.58	84.3	21.4	18.2
64	12	19-Feb-95	1404	37 57.25	178 25.46	37 54.08	178 27.39	45	46	3.50	87.6	21.6	17.4
65	13	19-Feb-95	1535	37 55.03	178 30.26	37 58.60	178 31.13	69	79	3.62	102	21.8	13.6
66	14	21-Feb-95	0511	38 00.15	178 35.41	37 56.69	178 36.30	102	116	3.53	98.2	20.4	–
67	14	21-Feb-95	0719	37 59.64	178 40.72	37 56.26	178 39.46	146	147	3.51	102	20.2	13.2
68	14	21-Feb-95	0853	37 55.28	178 37.91	37 51.63	178 37.94	132	133	3.65	105	20.2	13.3
69	13	21-Feb-95	1055	37 54.28	178 33.36	37 50.91	178 34.90	91	91	3.55	103	20.3	13.9
70	14	21-Feb-95	1243	37 50.44	178 37.43	37 46.96	178 38.84	96	120	3.65	96.4	20.2	13.5
71	14	21-Feb-95	1449	37 49.36	178 43.54	37 51.24	178 39.59	149	172	3.65	100	20.2	12.0
72	12	22-Feb-95	0527	37 34.49	178 22.41	37 35.63	178 26.48	44	52	3.60	88.7	19.2	18.2
73	12	22-Feb-95	0701	37 34.11	178 25.84	37 35.15	178 30.07	43	48	3.52	85.7	19.8	16.7
74	12	22-Feb-95	0829	37 36.64	178 30.57	37 37.77	178 34.48	40	41	3.30	81.5	19.4	19.8
75	12	22-Feb-95	1005	37 37.62	178 31.89	37 38.82	178 35.85	38	48	3.36	82.1	19.2	18.5
76	14	22-Feb-95	1233	37 41.47	178 42.26	37 42.81	178 46.10	121	126	3.32	101	19.6	13.9
77	13	22-Feb-95	1532	37 33.28	178 28.53	37 32.49	178 23.84	62	73	3.81	92.3	20.0	15.4
78	14	23-Feb-95	0539	37 29.62	178 16.24	37 29.38	178 12.09	113	119	3.31	106	19.3	14.6
79	14	23-Feb-95	0741	37 28.28	178 11.37	37 27.59	178 07.24	137	158	3.36	102	20.8	14.0
80	14	24-Feb-95	0753	37 30.81	178 01.33	37 30.77	178 05.98	106	120	3.69	99.3	21.3	12.2
81	14	24-Feb-95	1013	37 29.25	178 07.12	37 28.33	178 12.09	130	139	4.05	96.5	21.5	12.2
82	13	24-Feb-95	1212	37 30.41	178 09.95	37 30.59	178 14.30	94	108	3.47	103	20.9	12.6
83	13	24-Feb-95	1345	37 31.19	178 16.06	37 32.78	178 19.79	87	100	3.37	85.5	19.3	13.4
84	13	24-Feb-95	1542	37 32.62	178 21.19	37 33.73	178 25.64	51	76	3.71	94.1	19.0	14.0
85	13	25-Feb-95	0540	37 32.58	178 20.29	37 32.83	178 24.56	66	95	3.40	79	18.5	15.4
86	13	25-Feb-95	0720	37 33.72	178 29.23	37 35.67	178 33.15	52	55	3.67	91.8	17.8	14.9
87	12	25-Feb-95	0904	37 36.97	178 29.10	37 35.76	178 24.88	41	42	3.56	87.5	18.7	15.2

Appendix 1—*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)
88	13	25-Feb-95	1108	37 35.61	178 34.41	37 38.57	178 37.08	77	101	3.63	85.5	20.0	14.3
89	9	26-Feb-95	1133	38 43.76	178 05.93	38 46.40	178 03.01	33	33	3.48	84.3	20.5	18.5
90	9	26-Feb-95	1300	38 47.39	178 01.36	38 49.52	177 57.82	34	39	3.49	85.9	21.4	17.5
91	9	26-Feb-95	1502	38 55.83	178 03.49	38 58.67	178 00.76	46	49	3.55	86.3	21.7	17.5
92	9	27-Feb-95	0541	39 18.67	177 45.59	39 16.31	177 48.95	39	45	3.51	86	20.0	16.0
93	9	27-Feb-95	0735	39 17.42	177 41.25	39 13.84	177 40.85	41	48	3.59	91.6	19.9	15.1
94	9	27-Feb-95	0906	39 12.44	177 41.26	39 10.13	177 37.75	35	39	3.58	88.6	20.0	15.6
95	9	27-Feb-95	1104	39 12.82	177 28.87	39 12.70	177 24.28	38	47	3.56	80.5	20.1	15.7
96	10	27-Feb-95	1317	39 20.85	177 29.74	39 22.16	177 25.41	73	76	3.60	89.9	19.8	13.9
97	10	27-Feb-95	1508	39 24.53	177 30.27	39 22.70	177 34.21	93	94	3.55	89.9	20.1	13.6
98	10	28-Feb-95	0530	39 30.53	177 15.13	39 33.14	177 11.70	63	72	3.72	92.5	20.0	13.8
99	9	28-Feb-95	0727	39 33.92	177 04.74	39 30.47	177 03.82	27	27	3.52	86.3	19.7	18.8
100	9	28-Feb-95	0853	39 29.97	177 04.09	39 26.21	177 03.66	28	31	3.76	88	20.0	18.7
101	9	28-Feb-95	1053	39 30.66	177 08.22	39 27.10	177 08.10	40	44	3.55	90.6	19.7	17.1
102	10	28-Feb-95	1251	39 22.08	177 09.26	39 19.04	177 11.57	52	54	3.52	90.1	19.8	14.5
103	9	28-Feb-95	1454	39 21.88	177 05.18	39 25.26	177 03.55	33	42	3.60	85.5	20.0	16.2
104 *	10	3-Mar-95	0439	38 35.75	178 20.23	38 32.57	178 22.27	74	77	3.56	97.9	20.0	15.1
105	13	3-Mar-95	0757	38 19.01	178 34.18	38 16.00	178 31.81	92	99	3.52	86.5	21.0	14.2
106	14	3-Mar-95	0949	38 14.14	178 37.17	38 12.72	178 37.81	116	135	1.50	96	20.7	13.7
107	14	3-Mar-95	1133	38 13.79	178 33.58	38 10.35	178 33.50	109	110	3.42	89.1	20.0	13.9
108	13	3-Mar-95	1309	38 09.77	178 32.77	38 06.19	178 32.71	86	97	3.57	86.2	19.5	14.1
109	13	3-Mar-95	1436	38 07.09	178 30.46	38 10.16	178 28.30	63	75	3.50	86.6	19.8	15.5
110	12	4-Mar-95	0504	38 10.75	178 25.56	38 07.24	178 25.06	44	44	3.52	80.9	19.7	17.5
111	13	4-Mar-95	0700	38 01.13	178 27.78	37 59.46	178 31.68	61	83	3.49	84	19.7	15.4
112	13	4-Mar-95	0838	37 59.70	178 34.58	37 56.22	178 33.88	98	99	3.52	85.3	19.8	14.2
113	14	4-Mar-95	1017	37 54.91	178 34.95	37 51.76	178 36.31	107	111	3.40	80.7	20.0	14.1
114	13	4-Mar-95	1150	37 50.97	178 34.25	37 47.57	178 35.74	75	82	3.57	80.1	19.6	14.1
115	13	5-Mar-95	1340	37 49.61	178 36.79	37 46.10	178 37.92	83	101	3.60	89.6	19.7	15.0
116	13	5-Mar-95	0506	37 43.09	178 41.32	37 46.53	178 39.73	97	101	3.66	85.9	20.0	14.7

Appendix 1—*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)
117	13	5-Mar-95	0652	37 45.95	178 39.81	37 49.02	178 36.95	97	100	3.81	83.7	19.7	14.0
118	14	5-Mar-95	0840	37 48.18	178 39.62	37 44.83	178 41.11	104	117	3.54	92.6	19.3	14.4
119	14	5-Mar-95	1047	37 47.32	178 45.01	37 49.68	178 41.78	159	179	3.48	95	20.2	13.4
120	14	5-Mar-95	1235	37 50.24	178 39.82	37 53.77	178 40.58	142	161	3.57	98	20.2	13.1

* Denotes station note used for biomass calculations

– No data

Appendix 2a: **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 above a minimum size***

	a	*b*	*N*	Range (cm)
Snapper	0.0369	2.85	226	23-73
Tarakihi	0.0111	3.15	847	19-52
Trevally	0.0387	2.79	329	22-58

Appendix 2b: **Additional length-weight coefficients *a* and *b* used to scale length frequencies and calculate biomass above a minimum size***

	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
Gemfish	0.0018	3.34	KAH9204	168	32-106
Hoki	0.0046	2.88	SHI8301	525	22-110
John dory	0.0480	2.70	IKA8003	-	-
Red cod	0.0055	3.14	KAH9008 KAH9105 KAH9205	1187	13-72
Red gurnard	0.0017	3.48	KAH9008 KAH9105 KAH9205	227	19-54
School shark	0.0070	2.91	Seabrook-Davidson (unpub.)	804	30-166
Trachurus 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.

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