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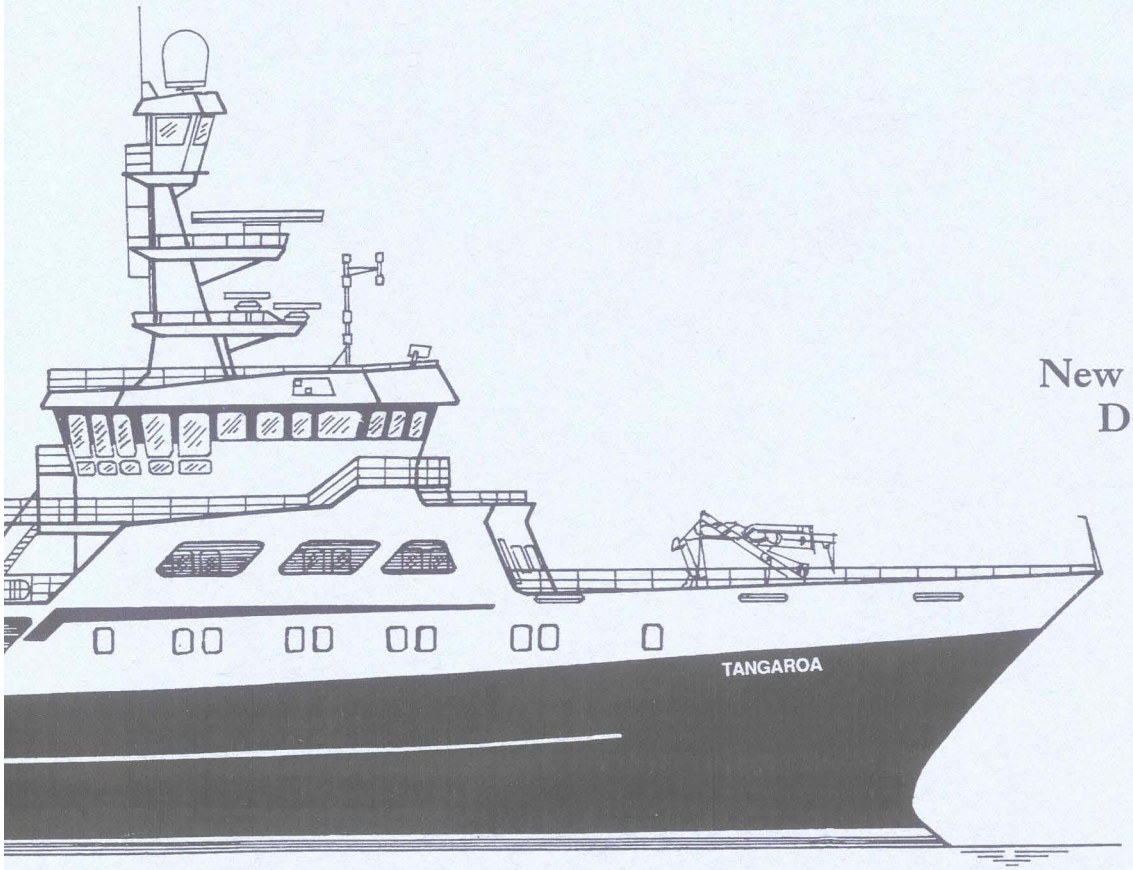
Taihoro Nukurangi

Trawl survey of middle depth and inshore bottom species off Southland, February-March 1995 (TAN9502)

N. W. Bagley
R. J. Hurst



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Contents

Introduction

This report presents results from the third in a time series of trawl surveys of inshore and middle depths (30–600 m) finfish species off Southland, New Zealand. The combined annual catch of these species usually exceeds 20 000 t and, for six of the main commercial species (barracouta, blue warehou, gemfish, ling, school shark, and stargazer), the Southland area is (or has been) of major importance.

The background to the development of this time series and previous research in the area were described by Hurst & Bagley (1994). The second survey report (Bagley & Hurst 1995) detailed changes to the stratification of the survey area along the eastern edge of the shelf in an attempt to increase the intensity of sampling and precision of the biomass estimates for warehou species. The main development for the third survey was the optimisation of station allocation for key species, based on the results of the first two surveys. The survey is primarily designed to obtain relative abundance indices and biological data for key species, but also provides the opportunity to carry out a range of work for other research projects.

Project objectives

1. To develop for stock assessment a time series of relative biomass estimates for the major commercial middle depth and inshore species on the Southland shelf, i.e., banded stargazer, giant stargazer, barracouta, blue warehou, silver warehou, gemfish, hapuku, ling, school shark, and (perhaps) jack mackerels.
2. To develop a time series of prerecruit biomass indices for middle depth and inshore species (as appropriate) on the Southland shelf for stock modelling.
3. To determine growth rates, productivity, and stock relationships of the main middle depth and inshore species from biological data.

Voyage objectives

1. To conduct the third survey in the time series.
2. To record the catch weights of all species or items caught.
3. To collect length, sex, gonad state, stomach contents data, and otoliths of selected commercial species.
4. To survey areas of untrawlable foul ground and record bathymetric data to better define survey depths and stratum boundaries.
5. To define major water mass characteristics within the survey area by recording bottom and surface temperatures and making one conductivity, temperature, and depth (CTD) drop a day during the first phase.
6. To tag school shark to determine the extent and direction of their movements.
7. To collect vertebrae and spines from school shark, rig, and elephantfish for age validation studies (by M. Francis, NIWA).
8. To collect a range of inshore and middle depth species for observer training and for fillet identification (by P. Smith, NIWA).

9. To collect fish samples as requested for the Museum of New Zealand Te Papa Tongarewa.
10. To collect ling flesh and liver samples for stock identification (P. Smith, NIWA).

Timetable and personnel

The voyage was divided into two parts: the first started from Wellington on 11 February and ended in Dunedin on 24 February; the second started from Dunedin on 24 February and finished in Wellington on 12 March.

R. Hurst was the project leader and voyage leader for part 1, N. Bagley was voyage leader for part 2 and responsible for final database editing. The skipper was R. Goodison.

Methods

Survey area and design

The survey was of a two-phase stratified random design (*after* Francis 1984). The rationale for the area, depths, and strata were given by Hurst & Bagley (1994) and strata alterations to optimise for warehou species by Bagley & Hurst (1995). Changes made to the strata for this survey were the combination of strata 7a and 7b into one stratum (7) because of problems locating sufficient trawlable bottom in stratum 7a.

The resulting survey area (Figure 1) was divided into 22 strata by area and depth (30–100, 100–200, 200–400, and 400–600 m). A total of 106 tows was planned for phase 1 and up to 40 stations were anticipated for phase 2. The allocation of stations in phase 1 was designed to optimise the sampling strategy for 11 of the main species — barracouta, blue warehou, gemfish, hapuku, ling, school shark, silver warehou, spiny dogfish, giant stargazer, banded stargazer, and tarakihi — using results from the two previous *Tangaroa* surveys and the procedure outlined by Hurst & Bagley (1994).

Stratum areas and planned station densities for phase 1 are given in Table 1. In phase 2, extra computer-generated stations were allocated to strata providing high catch rates of the main species with relatively high coefficients of variation (Francis 1984).

Standardised procedures for gear set-up and deployment, sampling, data analysis, and data reporting followed guidelines developed and documented for hoki/middle depth trawl surveys (Hurst *et al.* 1992).

Vessel specifications

RV *Tangaroa* is a purpose-built research stern trawler with the following specifications: length overall, 70 m; beam, 14 m; gross tonnage, 2280 t; power, 3000 kW. It is equipped with Simrad EK500 and Kaijo Denki echo sounders, Magnavox and Furuno GPS, Scanmar trawl monitoring (doorspread, wingspread, temperature, and trawl-eye) equipment, and Kaijo Denki and Furuno net monitors.

Net features

The eight-seam hoki bottom trawl used was described by Hurst & Bagley (1994). Variable parameters such as headline height and speed were averaged for each tow from records taken at 5 min intervals. A summary of the variation in gear parameters by depth is given in Table 2. Tow speed data were recorded on all tows and headline height on all but one tow. Doorspread was recorded on only 16 tows because of battery problems and the loss of a trawl door and sensor on tow 36. Doorspread was calculated for other tows using data for the appropriate depth range from the previous two surveys.

Trawling procedure

Procedures for deployment of the hoki bottom trawl were established from gear trials as described by Hurst *et al.* (1992) and Hurst & Bagley (1994). These procedures aim to minimise the variation in gear parameters on the survey.

Other procedures were as recommended by Hurst *et al.* (1992), i.e., daylight tows of 3 n. miles (timed from the gear reaching the bottom to the start of hauling) at 3.5 kn (speed over the ground), either following the bottom contour or in the direction of the next tow if time was limiting. If foul ground was encountered, a search was made within a 5 n. mile radius for suitable ground. If the ground was still unsuitable, the next alternative from the random stations list was chosen.

Catch size recording

All items in the catch were sorted and weighed for every tow using Seaway motion-compensating scales. Finfish, squids, and crustaceans were classified by species, other benthic fauna by family, and rubbish items by general categories. Three methods were used to estimate large catches of spiny dogfish: 30 cases were weighed from each large catch, the remaining fish were cased, and the total number of cases was multiplied by the mean case weight; or, dogfish were counted on the conveyor and the weight was estimated from the mean weight of fish in the length frequency sample; or, in respect of large catches (usually over 5 t) the catch was estimated by the number of full beckets on the codend. Weights from all school shark tagged were calculated using length-weight data from the two previous surveys as scales were not available on the trawl deck.

Biomass estimation

Doorspread biomass was estimated for finfish and squid species (*after* Francis 1981, 1989). The coefficient of variation (*c.v.*), a measure of the precision of the biomass estimate, was calculated by:

$$c.v. = S_B / B \times 100$$

where S_B is the standard error of the biomass, B.

The following assumptions were made.

1. The effective seabed area swept was the distance between the trawl doors multiplied by the distance towed.
2. The catchability coefficient for doorspread estimates was 1.0. This assumes that:
   i. the vulnerability of all fish in the area swept by the doors was 100%;
   ii. vertical availability was 100%;
   iii. areal availability was 100% in the survey area, as defined in Table 1, which includes areas of flat foul ground which were untrawlable but similar in appearance to surrounding trawlable ground. Areas of rough foul ground, significantly different from surrounding trawlable areas, were excluded as fish density and species composition could not be expected to be the same as on surrounding trawlable ground.

Biological measurements

Details of the species, numbers sampled, data collected, and measurement methods are given in Table 3. For all commercially important fish and arrow squid, up to 200 individuals of each species were randomly selected from each tow (for recommendations on sample sizes, *see* appendix 3 of Hurst *et al.* 1992). Length was measured to the nearest centimetre below. All species measured were sexed, except for leatherjacket and flatfish. The spawning condition of most commercial species was recorded.

Individual fish weights were collected from the more common species measured to enable length-weight relationships to be determined for scaling length frequency data. In addition, one or more of gonad stage and weight, stomach contents and state of digestion, and otoliths were collected from selected commercial species. Samples were usually of up to 20 fish per tow, except for gonad stages which were often recorded for every fish in the length frequency sample.

Vertebrae and spines were collected from school shark, rig, and elephantfish for other studies not reported on here.

Hydrological observations

Sea surface temperatures were recorded at each station from water entering a vessel intake pipe at a depth of about 2 m. Bottom temperatures were recorded from the Furuno net monitor. One CTD drop was completed at the end of the day on most days during phase 1 of the survey.

Results

Survey area and design

Station positions are shown in Figure 2; individual station data are given in Appendix 1. A total of 150 successful tows was completed, 106 in phase 1 (stations 1–114) and 44 in phase 2 (stations 115–155). Unsuccessful tows not included in biomass calculations were 2, 32, 36, 49, 70, and 74. Tows near known foul ground to the south of the survey area were reduced to 2 n. miles. Large hauls of spiny dogfish caused problems so tows with heavy dogfish marks were also shortened to 2 n. miles, except for tow 69 which was reduced to 1 n. mile. These tows have been included as successful for biomass calculations.

Phase 2 stations were allocated to target species which had coefficients of variation on the biomass estimates of over 30% after phase 1 of the survey, i.e., blue warehou (76%), ling (40%), and banded stargazer (40%). This improved the precision of the biomass estimates for blue warehou (37%), ling (24%), banded stargazer (29%), and many of the other species. Inclusion of extra phase 2 stations in this survey was made difficult by the unusual concentrations of spiny dogfish in the same strata as blue warehou, resulting in large catches which took considerable time to deal with.

Catch composition, distribution, and biomass

Eighty-six species were recorded: 58 teleosts, 18 elasmobranchs, 3 cephalopods, 1 other mollusc, and 6 crustaceans. Other benthic and pelagic organisms and rubbish items were recorded in broader groupings (Appendix 2). Table 4 shows the total catch and biomass for the 20 most abundant and other commercially important species and the number of stations at which they occurred. Two-thirds of the total catch (185 t) and of the total biomass was made up of spiny dogfish. The distribution of catch rates for the 15 major species of interest (i.e., those most abundant in the 1993 survey) is shown in Figure 3, and the biomass by stratum in Table 5.

Biological data

Details of the number of samples and total sample size are given in Table 3; length-weight relationships used to scale length frequencies are given in Appendix 3.

Length frequency data for the 15 major species of interest are shown in Figure 4, by depth range where significant depth differences were apparent. Data for dark ghost shark and red cod are also given as the sample sizes measured were reasonable (over 500 fish) and the survey encompassed a significant part of the distribution of these species. All length frequencies have been scaled by the percentage of fish sampled per tow, the area swept by the trawl doors, and stratum area.

Prerecruit modal groups which it may be possible to monitor over time were determined from length frequency data for six species. The numbers of fish, biomass, and associated *c.v.* for these modal groups are given in Table 6.

A summary of stomach contents data for 10 species is given in Table 7. The percentage

A summary of stomach contents data for 10 species is given in Table 7. The percentage of fish at each gonad stage by sex are given in Table 8 for 16 species. Otoliths were collected from barracouta, banded stargazer, giant stargazer, blue warehou, hapuku, and gemfish and have yet to be processed. Silver warehou otoliths collected have been used to validate ageing techniques by the New Zealand Fishing Industry Board staff under guidance from the NIWA ageing group (Horn & Sutton 1995).

Ninety school shark in lively condition were measured, sexed, tagged using Floy lock-on and dart tags, and released.

Temperature data

Surface temperatures were recorded from the bridge readout on 153 tows, of which 111 records were in phase 1. Bottom temperatures were recorded during 141 tows, of which 101 records were in phase 1. Phase 1 data are shown in Figure 5. Phase 2 records are not presented because the time elapsed between sampling phases 1 and 2 led to occasional temperature differences. CTD data were collected on 15 stations during phase 1 and are not included in Figure 5.

Discussion and conclusions

Gear damage continued to be a problem, as in previous surveys, but was minimised by increasing knowledge and experience and approaches outlined by Bagley & Hurst (1995).

For most of the key species we are interested in monitoring over time (*see* project objective 1), the *c.v.*s of the biomass estimates continued to be acceptable (i.e., under 20%) and should allow us to monitor biomass changes over time. Biomass estimates for spiny dogfish, tarakihi, rough skate, and smooth skate may also be useful for future stock assessment. The *c.v.* for blue warehou was again larger than desirable (37%), despite improved optimisation and extra phase 2 stations. Improvements in the precision of the biomass estimate for this species may be possible in future surveys, although considerably more targeted effort, both in terms of phase 1 optimisation and phase 2 allocation, may be required. The *c.v.*s for silver warehou and Peruvian jack mackerel were again over 40% and it is unlikely that priority will be given to improving the precision of these estimates in future surveys. Other commercial species were either out of their main areas or depth ranges and the time series will probably not be meaningful for them.

Acknowledgments

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Table 1: Stratum areas, numbers of stations, and station densities.

Stratum	Depth range (m)	Total area (km^2)	Foul area (km^2)	No. of stations: Phase 1 Planned	Phase 1 Actual	Phase 2 Actual	Station density (1 : km^2)
1	30–100	2 360	0	6	6	10	1 : 147
2	30–100	2 137	0	5	5	0	1 : 427
3	30–100	2 317	130	5	5	0	1 : 463
4a	100–200	1 095	0	3	3	4	1 : 156
4b	100–200	1 058	0	3	3	0	1 : 353
5a	100–200	3 832	0	4	4	2	1 : 639
5b	100–200	1 417	0	6	6	0	1 : 236
6a	100–200	4 321	928	5	5	17	1 : 196
6b	100–200	1 230	0	4	4	0	1 : 308
7	100–200	4 009	1 915	8	8	0	1 : 501
8a	100–200	3 049	1 516	3	3	1	1 : 762
8b	100–200	351	0	3	3	0	1 : 117
9	100–200	4 071	692	7	7	0	1 : 582
10a	100–200	2 882	230	7	7	4	1 : 262
10b	100–200	3 089	174	5	5	3	1 : 386
11	100–200	2 577	66	6	6	2	1 : 322
12	100–200	1 003	0	3	3	3	1 : 167
13	200–400	876	0	3	3	0	1 : 292
16	200–400	2 320	0	5	5	0	1 : 464
17	400–600	1 820	0	3	3	2	1 : 364
18	200–600	1 750	0	7	7	0	1 : 250
20	400–600	2 103	0	5	5	0	1 : 421
Total (average)		49 667	5 651	106	106	44	(1 : 331)

* The foul area has been included in the stratum areas for biomass calculations except for strata 3 where the ground is rough and probably has a different species composition.
Station density is given as a proportion of the total stratum area used for biomass calculation.

Table 2: Gear and tow parameters (recorded values only) by depth range (*n* = number of tows)

	Depth range (m)												
	30–100			100–200			200–400			400–600			Total
	n	Mean	*s.d.*	*n*	Mean	*s.d.*	*n*	Mean	*s.d.*	*n*	Mean	*s.d.*	*n*
Headline height (m)	26	6.9	0.32	98	6.9	0.34	9	68	0.66	16	6.9	0.57	149
Tow speed (kts)	26	3.6	0.27	99	3.6	0.17	9	3.5	0.07	16	3.5	0.13	150
Doorspread (m)	1	81.0	–	14	94.5	5.4	1	100.1	–	–	–	–	16

Table 3: Species and numbers of fish and squid measured*

Species code	Measurement method	Length frequencies: No. of tows sampled	No. of fish	No. of males	No. of females	Biological data: No. of tows sampled	No. of fish	No. of males	No. of females	No. of otoliths
BAR‡	1	90	3 501	1 593	1 906	65	1 164	498	666	826
BCO	2	40	402	253	149	31	329	196	133	–
BGZ‡	2	34	160	90	68	29	143	80	63	137
BNS	1	1	1	–	1	1	1	–	1	–
ELE	2	8	68	43	25	8	68	43	25	–
EMA	1	1	1	–	–	–	–	–	–	–
GSH	5	10	374	169	205	9	342	152	190	–
GSP	5	11	70	39	31	7	51	32	19	–
GUR	2	24	400	228	170	13	239	139	98	–
HAK	2	15	97	32	65	14	90	29	61	–
HAP‡	2	95	390	199	190	73	297	151	146	94
HOK‡	2	22	2 287	1 196	1 087	–	–	–	–	–
JMD	1	28	80	38	42	8	35	14	21	–
JMM‡	1	73	1 307	870	433	20	488	301	183	–
LDO	2	14	92	53	39	11	83	50	33	–
LEA	2	1	50	–	–	–	–	–	–	–
LIN‡	2	100	1 267	560	707	53	570	259	311	–
LSO	2	18	417	1	12	–	–	–	–	–
MOK	1	5	8	5	3	4	7	4	3	–
NOS‡	4	137	5 664	2 260	2 783	32	1 121	457	531	–
OPE	1	1	1	0	1	–	–	–	–	–
RBM	1	6	8	5	3	3	5	2	3	–
RCO‡	2	30	922	478	443	19	565	294	271	–
RIB	2	10	25	5	20	9	23	5	18	–
SCH‡	2	69	211	123	86	66	125	70	55	–
SKI‡	1	44	206	118	88	43	205	118	87	205
SPD‡	2	133	6 765	3 816	2 948	30	1 052	503	548	–
SPE‡	2	49	625	336	285	19	287	144	141	–
SPO	2	5	9	4	5	3	6	2	4	–
STA‡	2	126	1 251	692	556	96	779	423	354	570
SWA‡	1	36	621	311	308	22	262	131	129	154
TAR‡	1	52	1 848	908	896	24	1 043	484	557	–
TRU	1	8	19	11	8	5	15	8	7	–
WAR‡	1	21	449	216	233	21	209	111	98	169
WWA	1	2	4	3	1	2	4	3	1	–

* Species codes are given in Appendix 2.
Measurement methods: 1, fork length; 2, total length; 4, mantle length; 5, total length excluding tail filament.
Biological data include one or more of the following: fish weight, gonad stage, gonad weight, stomach contents and state of digestion, otoliths.

‡ Length frequency data are presented in Figure 5.

– no data.

Table 4: Total catch, number of stations at which each species occurred (Occ.), and estimated doorspread biomass and coefficients of variation (*c.v.*) of the 20 most abundant and other commercially important species*

	Catch			Biomass		
	Weight (kg)	% of total	Occ.	Weight (t)	*c.v.* (%)	% of total
Spiny dogfish	122 753	66.5	135	91 364	29	71.8
Barracouta	8 699	4.7	90	4 539	17	3.6
Ling	6 190	3.4	101	2 897	24	2.3
Arrow squid	5 946	3.2	138	3 451	23	2.7
Trachurus murphyi	5 276	2.9	74	2 776	40	2.2
Hoki	4 723	2.6	22	2 893	33	2.3
Red Cod	4 363	2.4	30	2 554	49	2.0
Giant stargazer	3 735	2.0	126	2 452	11	1.9
Silver warehou	3 303	1.8	36	3 372	86	2.7
Tarakihi	3 151	1.7	52	1 570	24	1.2
Blue warehou	2 206	1.2	21	1 110	37	0.9
School shark	1 877	1.0	69	1 012	13	0.8
Hapuku	1 552	0.8	95	892	11	0.7
Rough skate	1 219	0.7	89	800	8	0.6
Dark ghost shark	1 162	0.6	10	787	71	0.6
Gemfish	996	0.5	44	539	25	0.4
Carpet shark	835	0.5	71	485	15	0.4
Blue cod	715	0.4	40	370	23	0.3
Sea perch	679	0.4	49	450	27	0.4
Banded stargazer	619	0.3	34	316	29	0.3
Smooth skate	610	0.3	38	336	19	0.3
Hake	567	0.3	15	296	25	0.2
Red gurnard	265	0.1	24	221	27	0.2
Elephant fish	195	0.1	8	66	49	<0.1
Lemon sole	177	0.1	18	68	38	<0.1
Jack mackerel *(T. declivis)*	147	<0.1	29	71	42	<0.1
Shovelnosed dogfish	143	<0.1	5	106	45	<0.1
Pale ghost shark	121	<0.1	11	64	19	<0.1
Lookdown dory	109	<0.1	14	64	32	<0.1
Spotted dogfish	47	<0.1	5	17	43	<0.1
Ribaldo	42	<0.1	10	23	32	<0.1
Blue moki	32	<0.1	5	17	61	<0.1
Leather jacket	32	<0.1	1	33	100	<0.1
Trumpeter	29	<0.1	8	21	51	<0.1
Bluenose	10	<0.1	1	10	100	<0.1
Other species	2 149	1.2				
All species	184 644 #		150	127 179	21	

* Includes all species for which more than 10 kg were caught. Catch details of other species are given in Appendix 2.

\# Excludes all sponges, salps, corals, and rubbish.

Table 5: Estimated biomass (t) and coefficient of variation (*c.v.*, in parentheses) by stratum for the 15 major species*

Stratum	Species code														
	BAR	BGZ	HAP	HOK	JMM	LIN	NOS	SCH	SKI	SPD	SPE	STA	SWA	TAR	WAR
1	1 267	0	148	0	229	905	801	129	0	5 574	85	26	25	572	20
	(39)		(31)		(67)	(63)	(44)	(34)		(41)	(78)	(27)	(76)	(42)	(49)
2	50	0	78	0	61	138	22	0	2	29 496	0	83	28	292	70
	(78)		(65)		(37)	(97)	(20)		(100)	(69)		(47)	(61)	(61)	(100)
3	12	0	13	0	151	42	160	10	0	2 722	0	328	6	45	0
	(69)		(77)		(79)	(39)	(85)	(61)		(56)		(31)	(67)	(94)	
4a	20	0	12	0	11	17	28	25	6	106	34	22	0	20	0
	(59)		(28)		(86)	(53)	(25)	(100)	(100)	(67)	(98)	(44)		(81)	
4b	8	0	12	0	3	33	266	14	1	13	5	21	2	0	0
	(68)		(100)		(50)	(43)	(94)	(100)	(100)	(25)	(100)	(67)	(100)		
5a	75	0	19	0	24	128	64	26	9	20 207	0	153	1	6	0
	(39)		(45)		(73)	(33)	(66)	(46)	(100)	(67)		(26)	(100)	(100)	
5b	4	6	19	0	11	9	48	1	0	60	0	23	77	0	3
	(66)	(66)	(47)		(77)	(29)	(50)	(100)		(79)		(31)	(89)		(100)
6a	399	3	105	0	735	604	28	188	256	25 264	40	92	10	36	902
	(37)	(100)	(20)		(86)	(58)	(20)	(36)	(46)	(27)	(24)	(12)	(37)	(54)	(45)
6b	2	11	4	0	0	1	7	5	5	115	12	8	1	0	0
	(100)	(18)	(100)			(100)	(56)	(67)	(100)	(54)	(77)	(18)	(100)		
7	8	13	90	0	0	80	60	8	32	484	23	69	2 874	0	0
	(100)	(66)	(51)			(49)	(46)	100)	(66)	(90)	(34)	(58)	(100)		
8a	591	4	67	0	8	13	307	0	0	313	169	29	0	0	0
	(56)	(100)	(29)		(100)	(100)	(85)			(86)	(50)	(56)			
8b	1	1	0	0	0	0	17	0	0	0	0	2	0	0	0
	(50)	(100)					(93)					(50)			
9	281	7	45	0	358	88	97	181	37	157	0	39	0	1	0
	(66)	(65)	35)		(87)	(55)	(36)	(32)	(48)	(30)		(34)		(100)	
10a	765	109	85	0	961	269	81	122	104	673	18	124	0	84	4
	(45)	(38)	(30)		(86)	(34)	(36)	(26)	(45)	(37)	(92)	(23)		(61)	(100)
10b	317	96	56	0	64	76	191	108	32	5 433	0	59	+	4	0
	(49)	(82)	(21)		(49)	(23)	(26)	(36)	(49)	(99)		(42)	(100)	(100)	
11	646	6	94	0	146	9	317	84	2	324	53	1 218	27	468	111
	(32)	(46)	(28)		(51)	(76)	(86)	(45)	(100)	(34)	(67)	(18)	(79)	(43)	(69)
12	55	58	23	0	11	0	155	66	23	113	5	12	1	3	0
	(67)	(37)	(50)		(87)		(57)	(37)	(54)	(39)	(73)	(35)	(64)	(73)	
13	0	0	3	279	0	51	7	0	0	55	0	19	307	0	0
			(100)	(100)		(56)	(75)			(100)		(46)	(99)		

Table 5 — *continued*

Stratum	BAR	BGZ	HAP	HOK	JMM	LIN	NOS	SCH	SKI	SPD	SPE	STA	SWA	TAR	WAR
															Species code
16	39	4	18	668	0	42	660	46	29	129	0	87	3	40	0
	(100)	(100)	(62)	(83)		(25)	(76)	(72)	(49)	(32)		(56)	(100)	(100)	
17	1	0	0	793	3	117	6	0	0	41	0	17	8	0	0
	(100)			(67)	(100)	(25)	(58)			(63)		(91)	(100)		
18	0	0	0	104	0	138	14	0	0	57	2	16	3	0	0
				(34)		(21)	(82)			(30)	(92)	(41)	(100)		
20	0	0	0	1 048	0	137	116	0	0	28	4	5	0	0	0
				(49)		(46)	(32)			(63)	(100)	(65)			

* Species codes are given in Appendix 2.

\+ less than 0.5 t.

Table 6: Estimated number of fish, biomass, and coefficients of variation (*c.v.*) for prerecruit modal groups evident from length frequency data *

	Estimated year class	Modal length range (cm)	No. of fish (scaled)	Biomass (t)	Biomass *c.v.* (%)
Barracouta	1992	28–38	91 304	15	56
	1991	39–48	30 298	11	69
	1990	49–60	217 448	156	75
Blue warehou	1993?	30–39	832	1	69
Hoki	1993	30–45	3 433 080	641	53
	1992	46–58	2 312 363	1 041	36
Red cod	1993	20–38	104 553	84	83
Silver warehou	1994	15–23	58 374	7	50
	1993	24–35	183 604	84	40
Tarakihi	1994	14–21	178 900	18	41
	1993	22–25	299 014	58	38

* Number of fish scaled by percentage sampled, area swept, and area surveyed.

Table 7: Percentage occurrence of food items in teleost stomachs *

	No. of items	Crustacean		Fish	Salps	Mollusc		Unidentified	Other
		Euphausiid	Other			Squid	Other		
Banded stargazer	178	0	4	57	8	96	11	2	0
Barracouta	300	161	29	17	5	88	0	0	0
Blue warehou	157	0	1	0	156	0	0	0	0
Gemfish	118	0	0	51	0	66	0	1	0
Giant stargazer	598	1	74	138	49	264	48	17	7
Hapuku	53	0	16	19	0	13	4	1	0
Jack mackerel (*T. murphyii*)	45	4	18	1	12	0	0	10	0
Ling	66	0	35	29	0	1	1	0	0
Red cod	32	0	25	2	0	4	0	1	0
Silver warehou	110	0	0	0	110	0	0	0	0

* Unidentified includes unidentifiable because digested.

Table 8: Reproductive state of teleost species*

Species code	Sex	No. of fish	Percentage of fish at each gonad stage						
			1	2	3	4	5	6	7
BAR	M	695	8	25	1	4	1	24	37
	F	916	7	70	4	3	0	7	8
BCO	M	117	1	21	35	21	4	15	3
	F	67	2	19	25	37	6	7	3
BGZ	M	82	9	90	1	0	0	0	0
	F	63	5	54	3	2	0	19	17
GUR	M	155	1	65	5	25	3	0	2
	F	102	0	7	5	84	6	0	0
HAK	M	24	8	17	4	8	63	0	0
	F	51	8	39	29	0	0	8	16
HAP	M	80	68	30	1	0	0	0	1
	F	76	28	70	3	0	0	0	0
JMD	M	14	0	21	7	0	0	7	64
	F	21	5	24	5	0	0	0	67
JMM	M	207	1	90	0	0	0	1	8
	F	114	0	86	8	0	0	0	6
LDO	M	33	12	88	0	0	0	0	0
	F	21	33	48	19	0	0	0	0
LIN	M	163	19	41	13	27	0	0	0
	F	180	8	85	5	1	0	0	1
RCO	M	239	2	56	50	23	9	4	0
	F	203	1	84	1	5	1	7	2
SKI	M	117	0	92	4	0	0	1	3
	F	87	0	94	0	0	0	0	6
STA	M	384	12	81	7	1	0	0	1
	F	335	6	48	15	3	0	8	21
SWA	M	193	33	64	0	0	0	0	3
	F	199	22	74	0	0	0	0	4
TAR	M	405	51	23	9	11	5	2	0
	F	425	15	62	11	1	1	10	0
WAR	M	110	0	36	4	28	6	21	6
	F	95	2	55	7	13	2	13	8

* Species codes are given in Appendix 2.
Gonad stages: 1, immature; 2, resting; 3, maturing (oocytes visible in females); 4, mature (hyaline oocytes in females, milt expressible in males); 5, running ripe (eggs and milt free flowing); 6, partially spent; 7, spent.

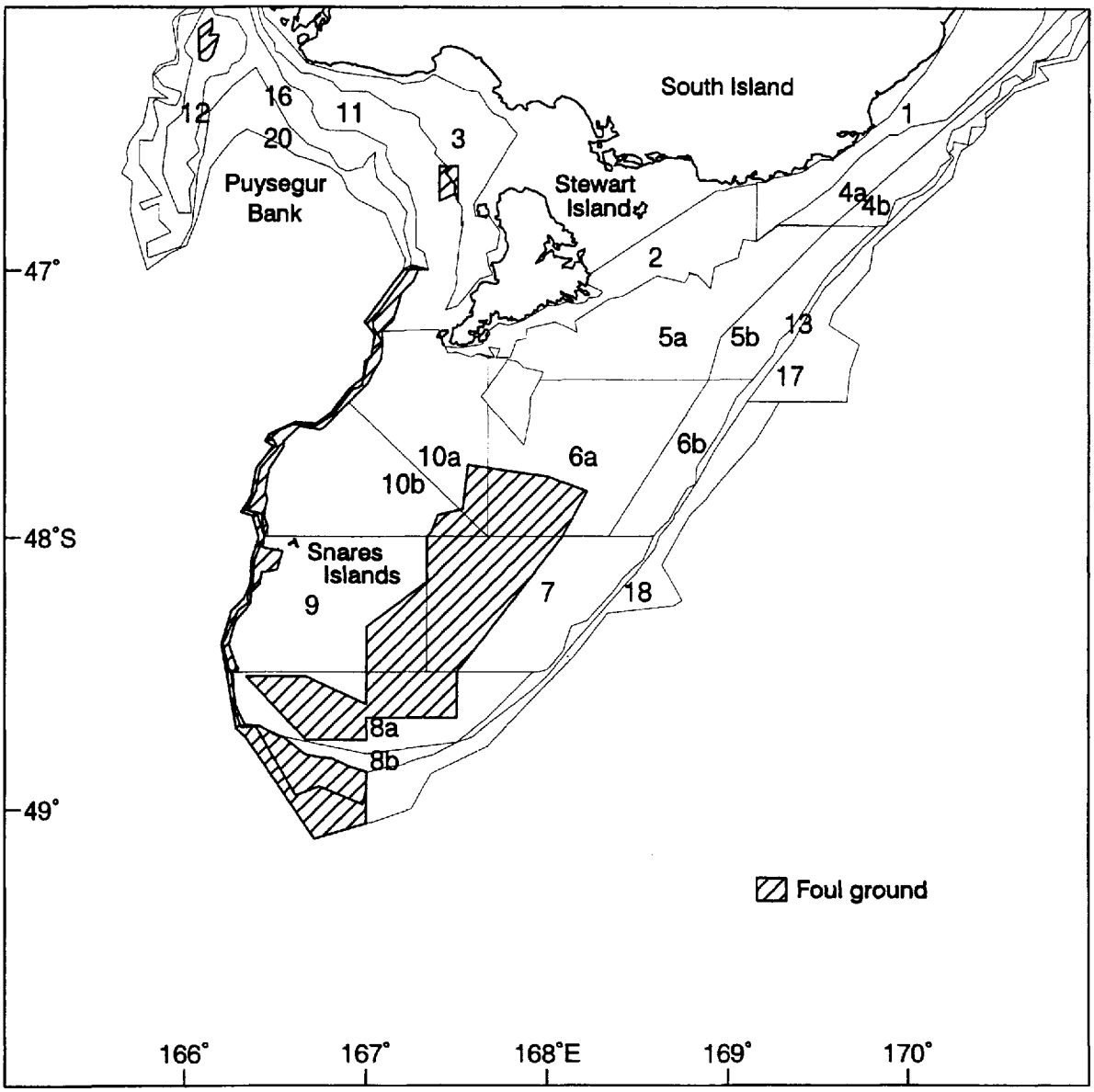


Figure 1: Survey area showing strata boundaries and numbers and foul ground.

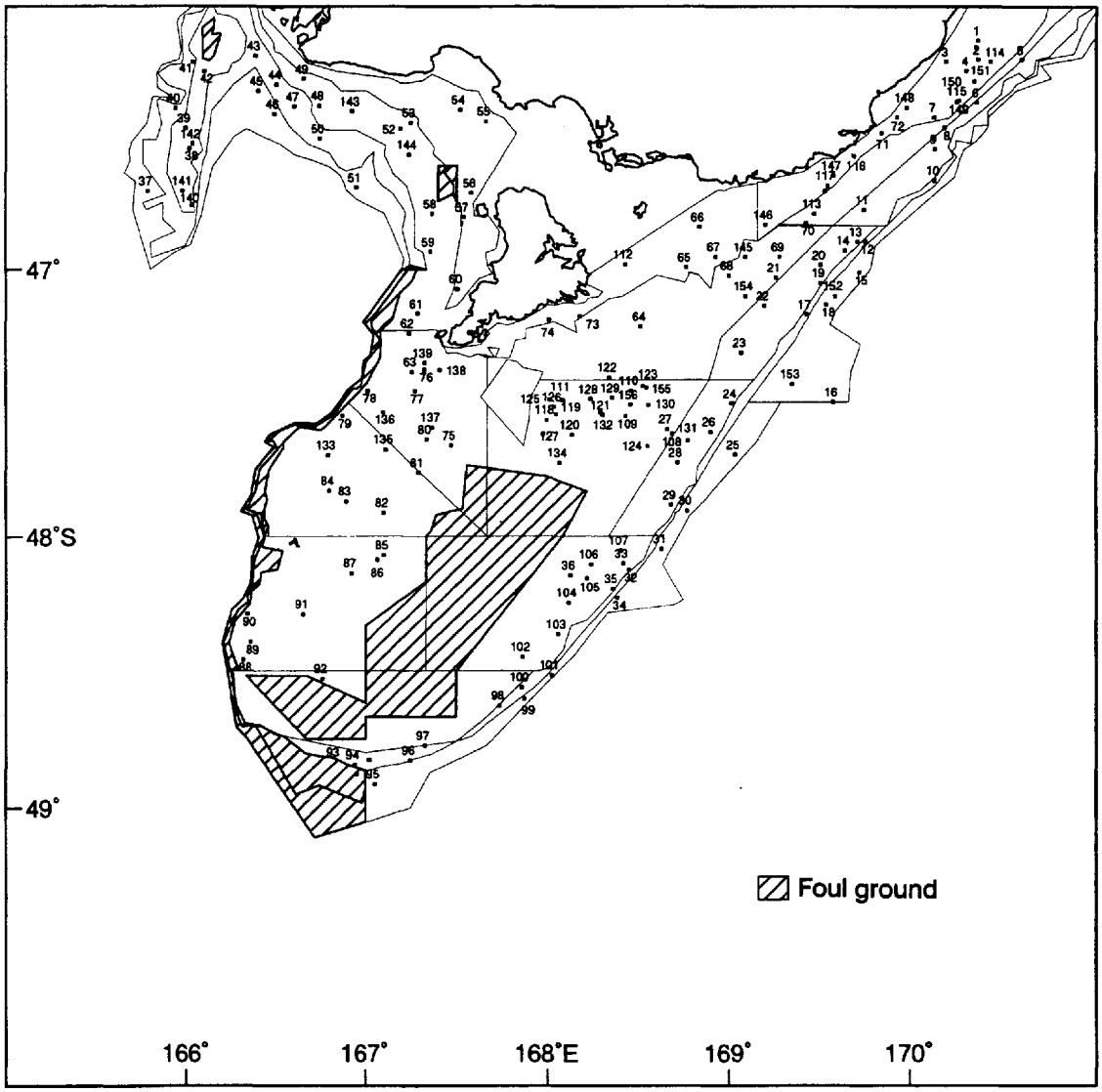


Figure 2: Station positions and numbers.

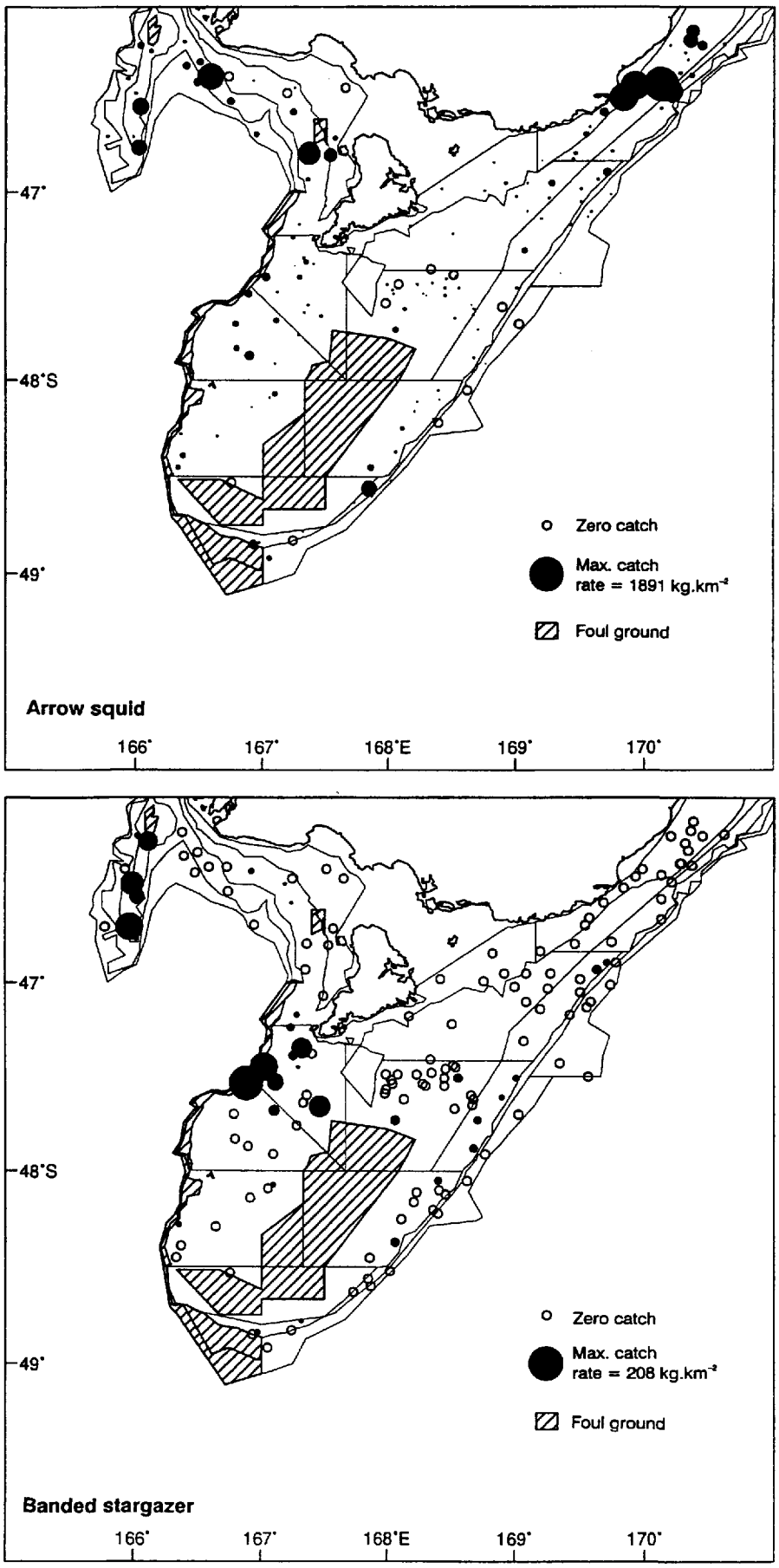
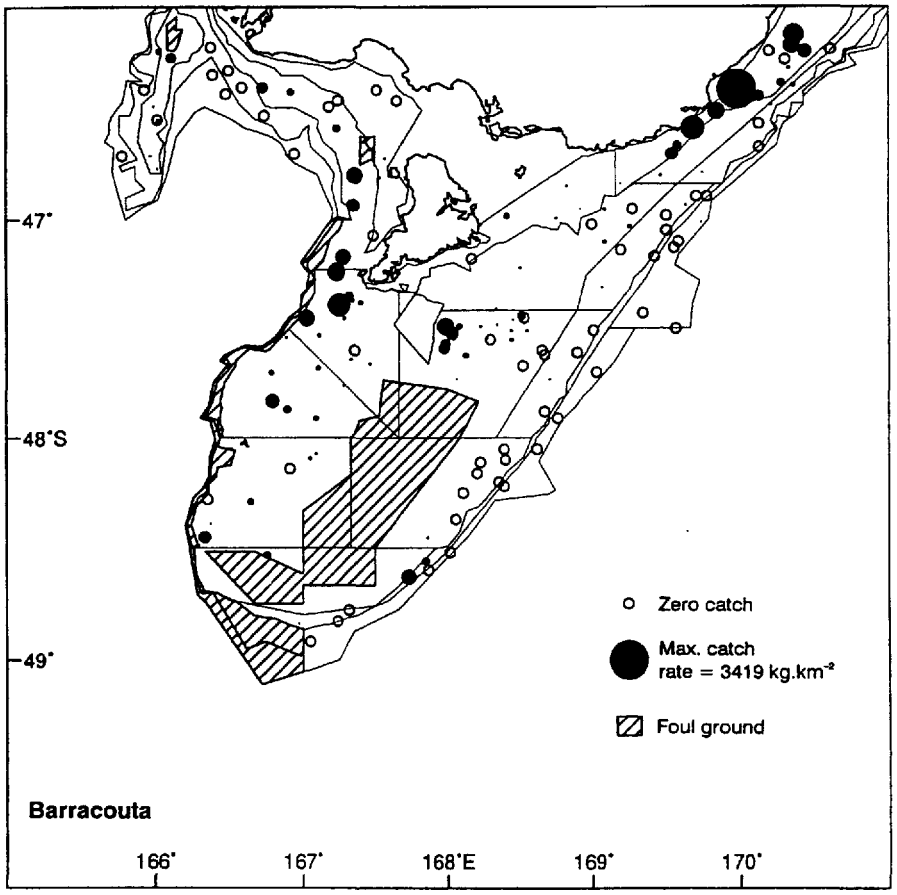


Figure 3: Catch rates of major commercial species. Circle area is proportional to catch rate.



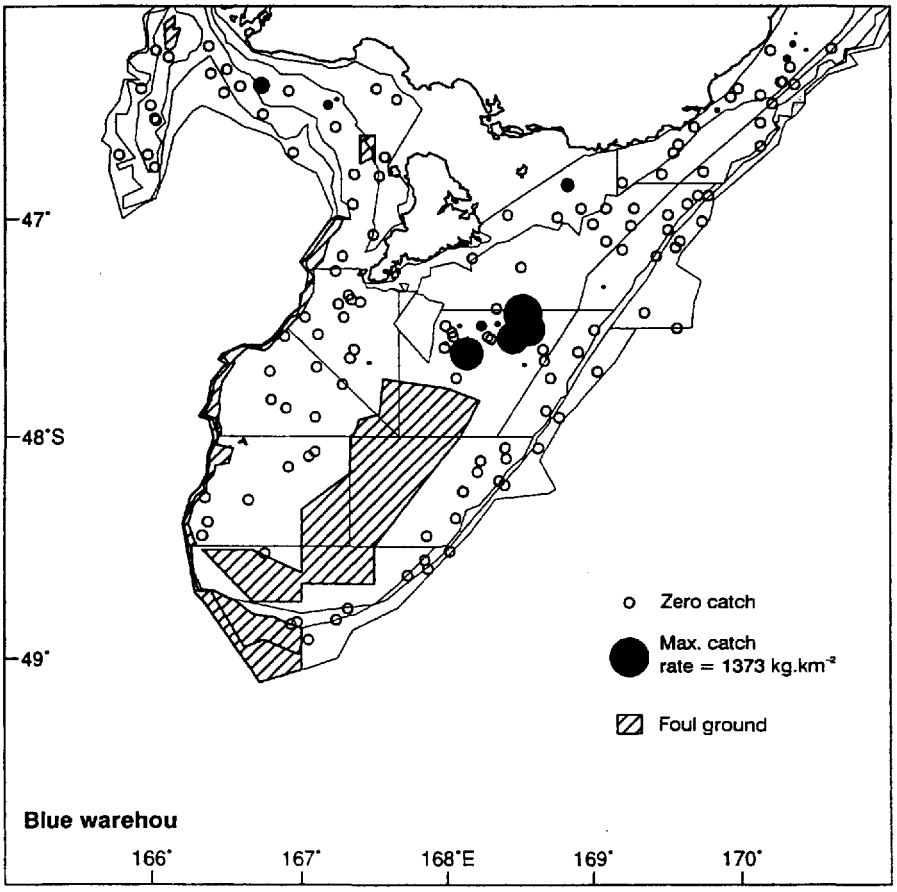
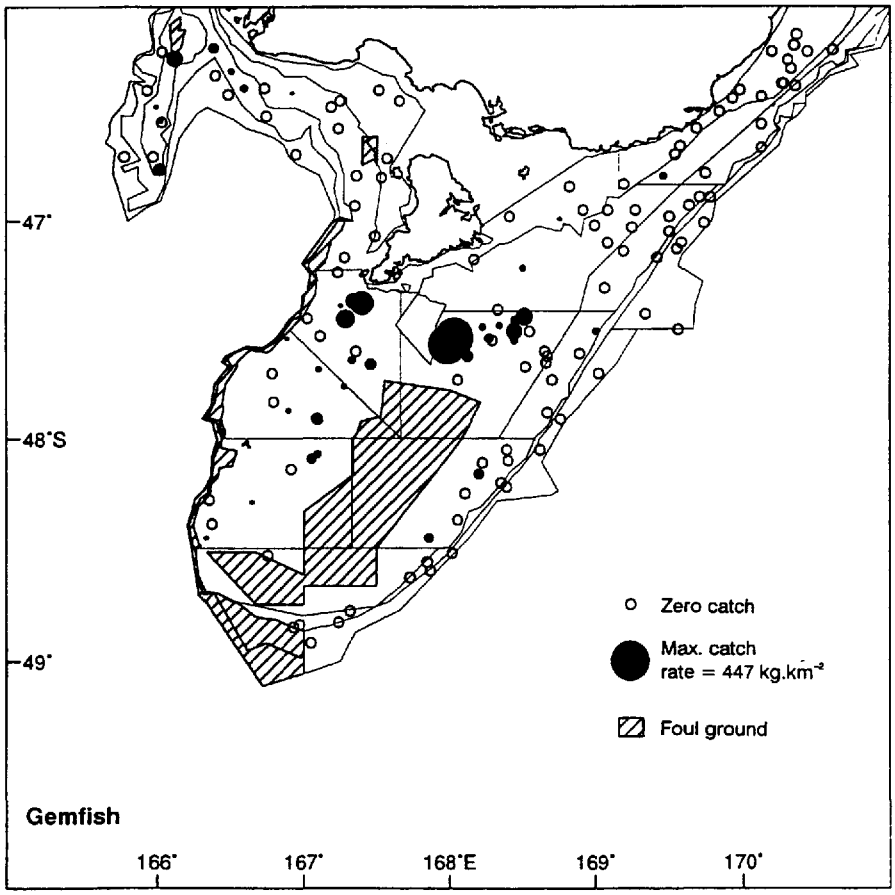


Figure 3—*continued*



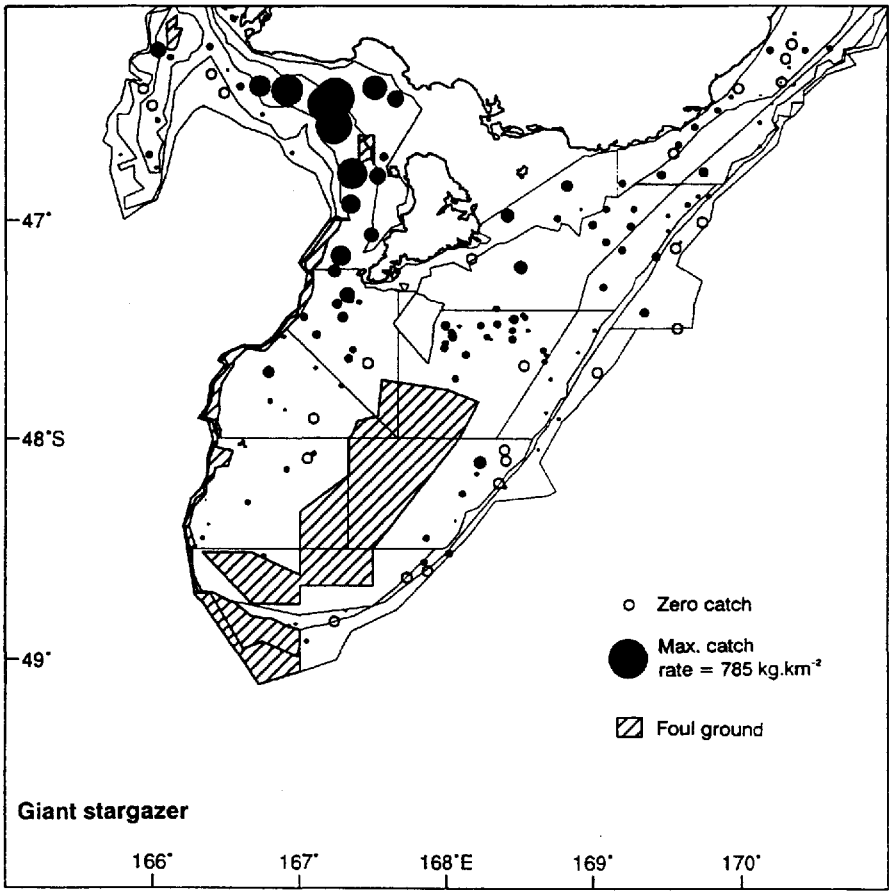
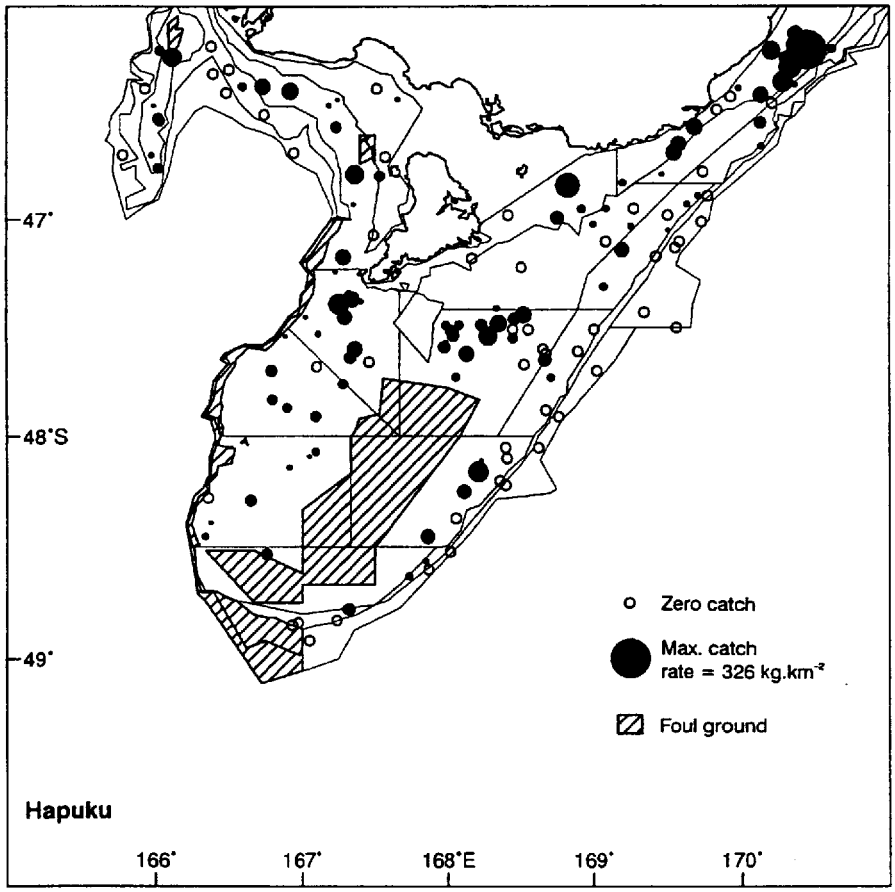


Figure 3—*continued*



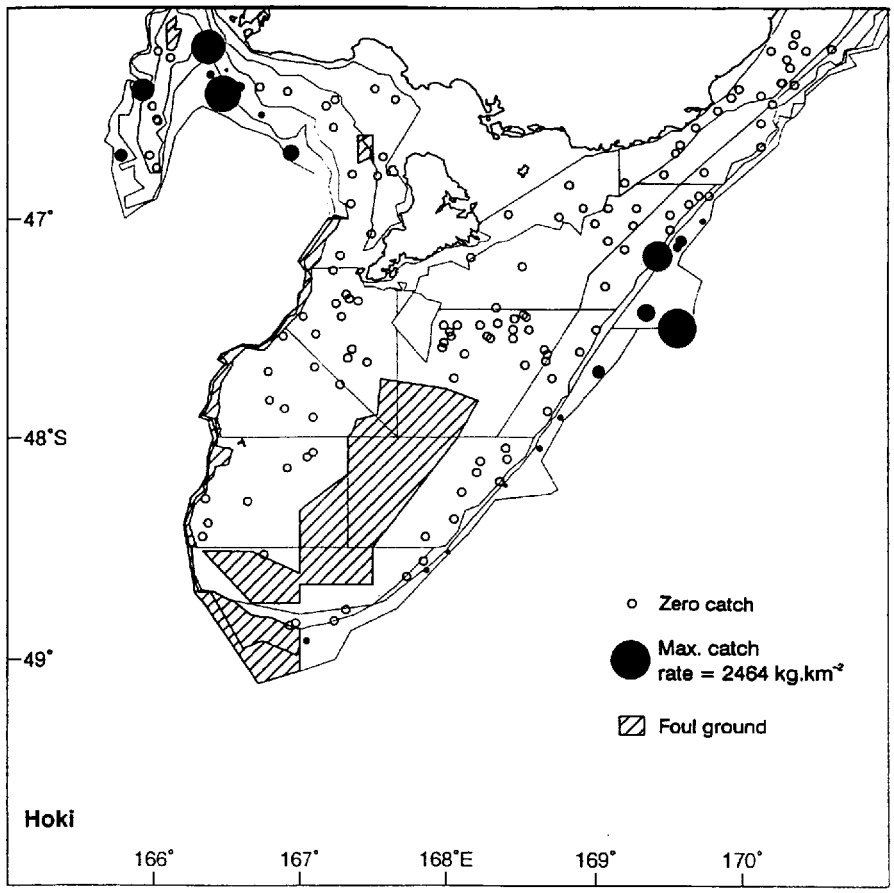
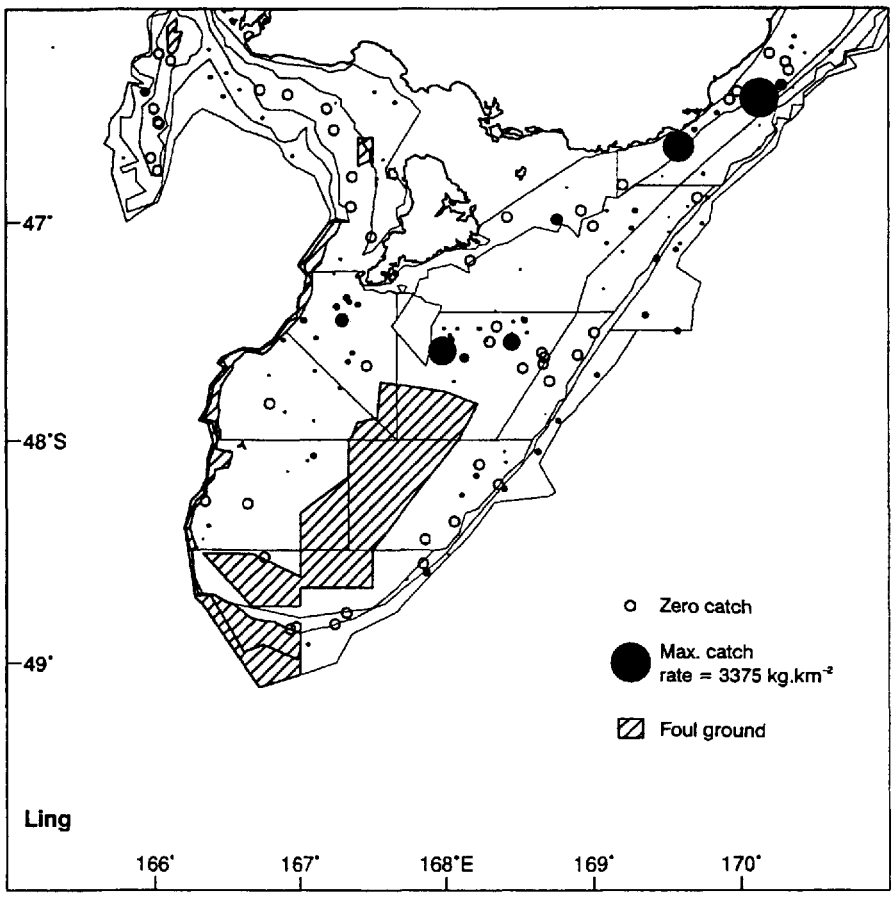


Figure 3—*continued*



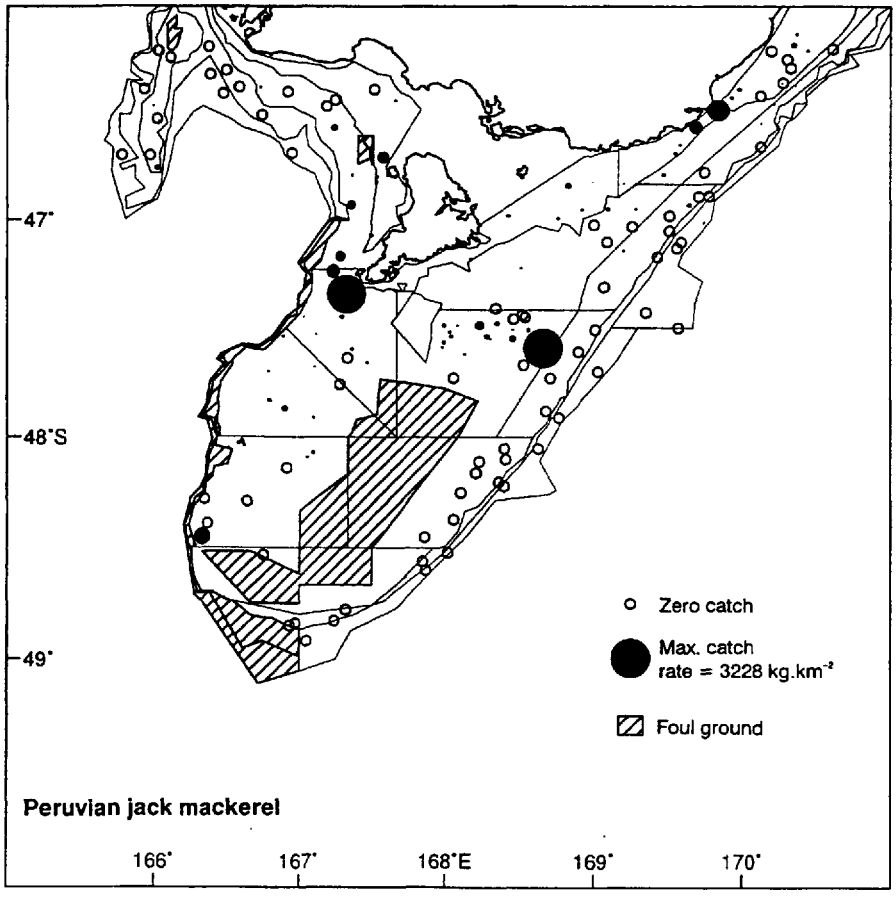
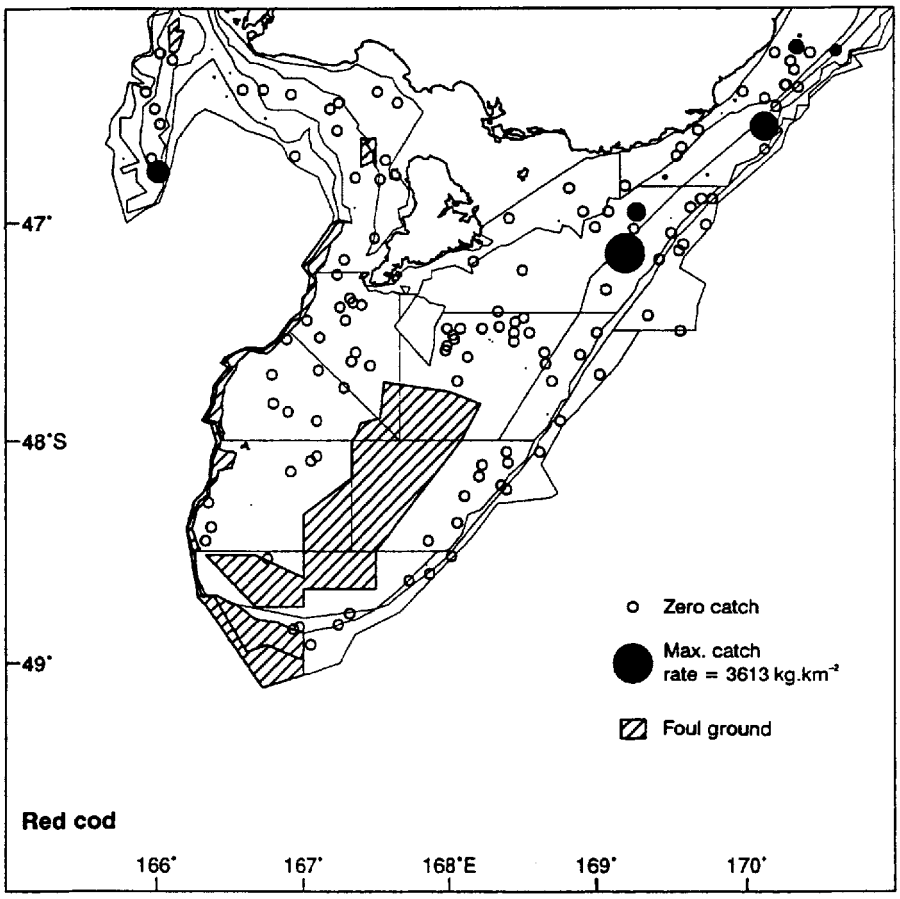


Figure 3—*continued*



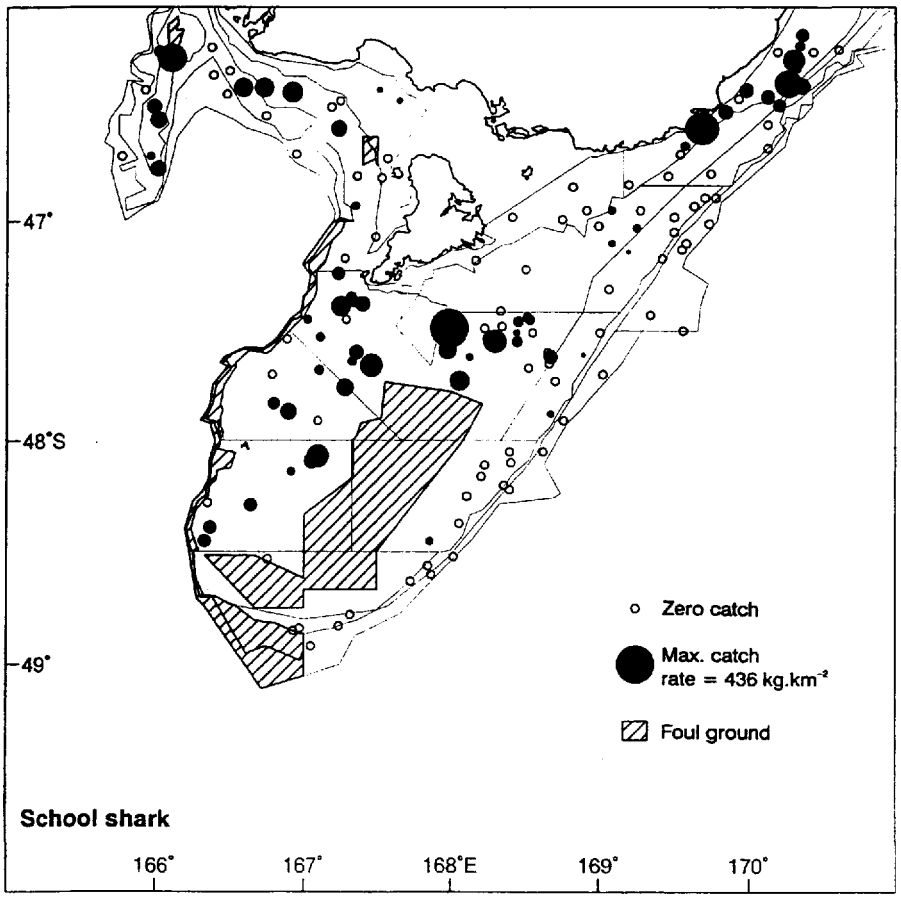
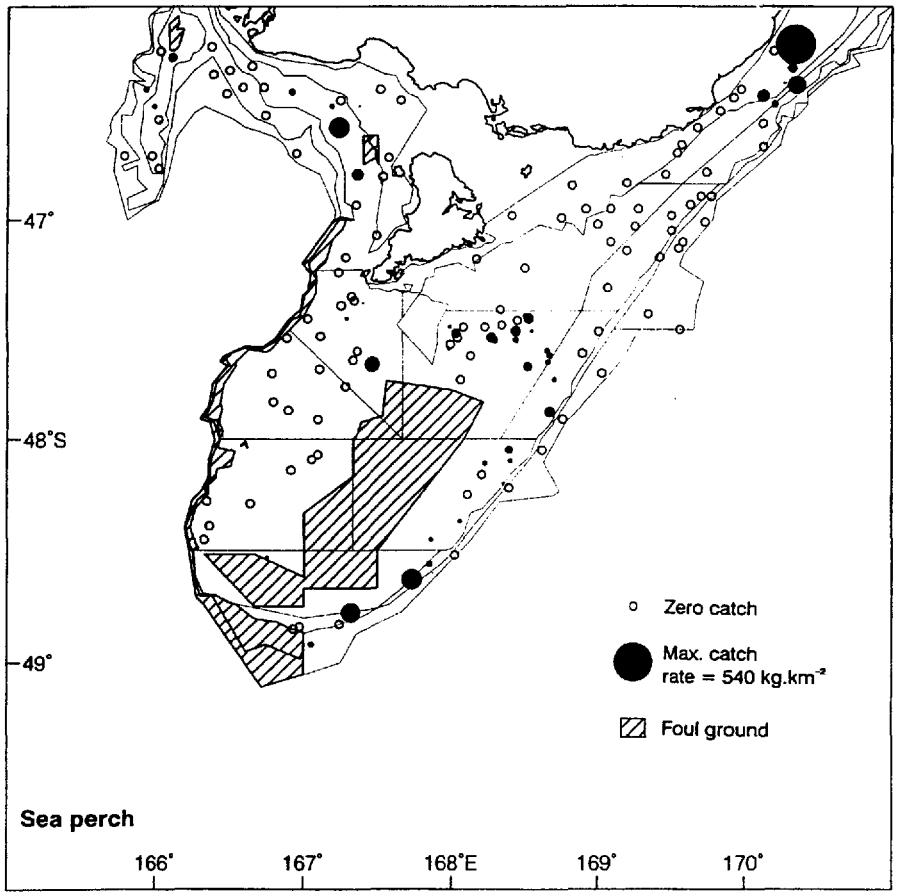


Figure 3—*continued*



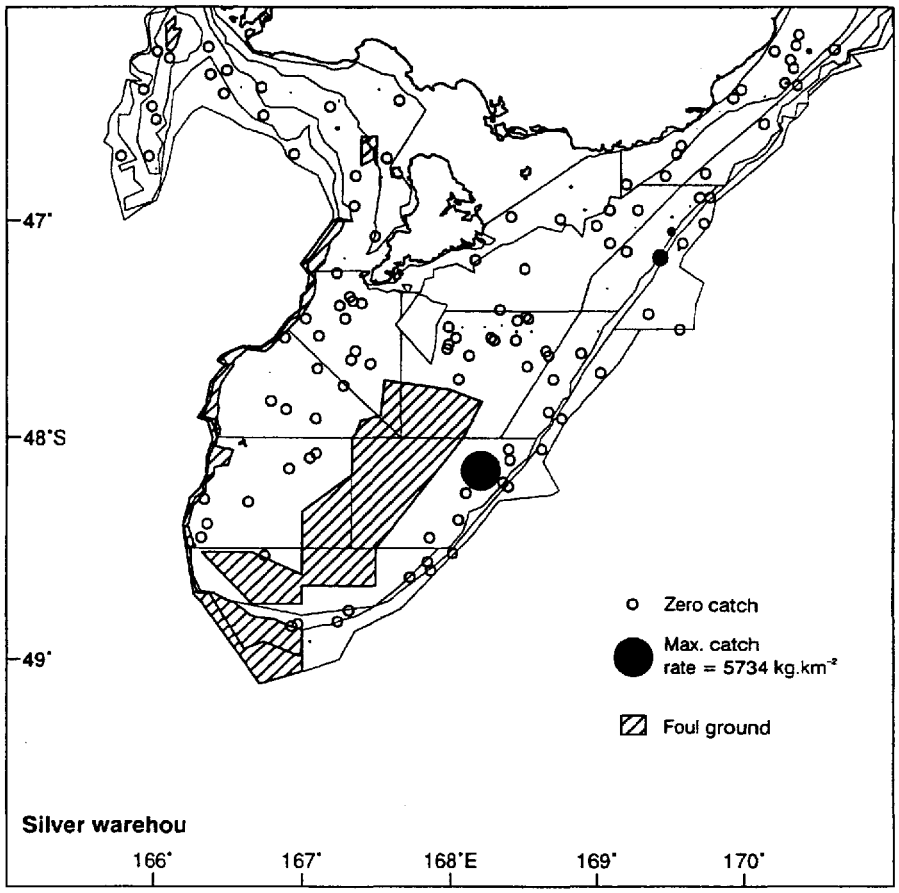
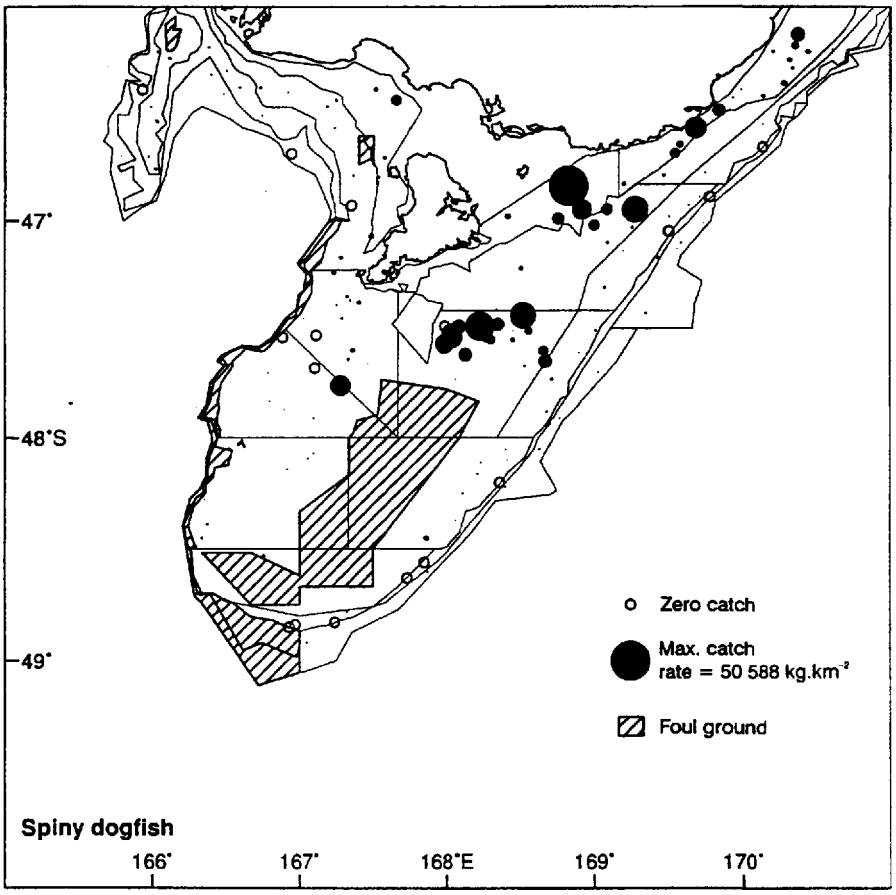


Figure 3—*continued*



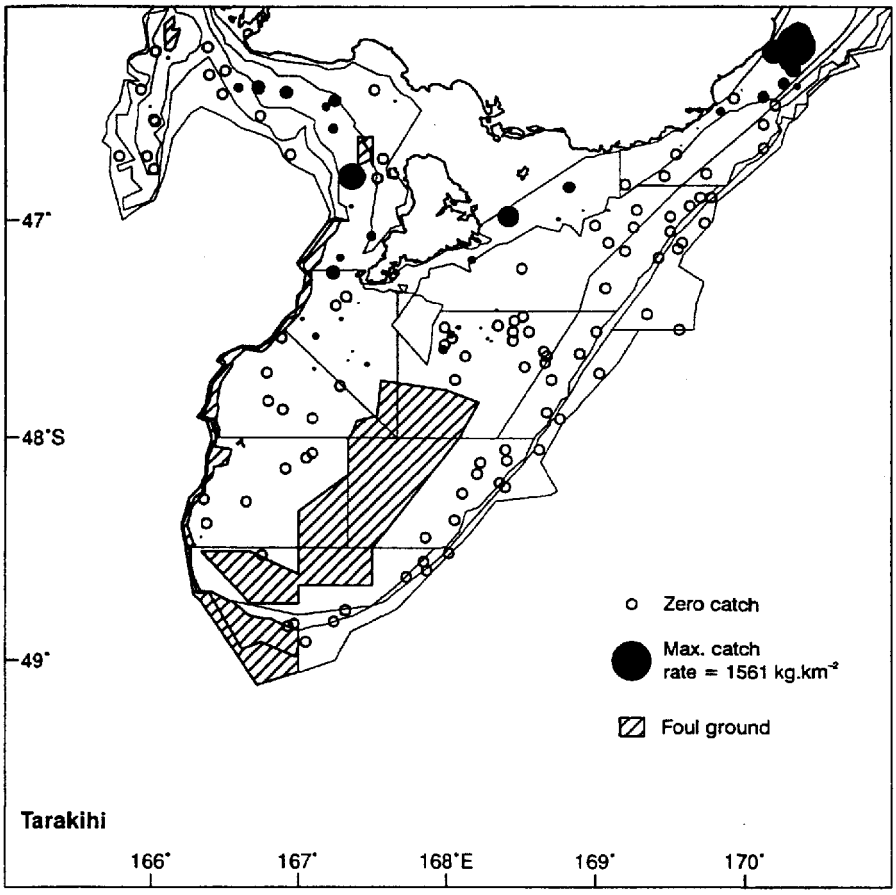


Figure 3—*continued*

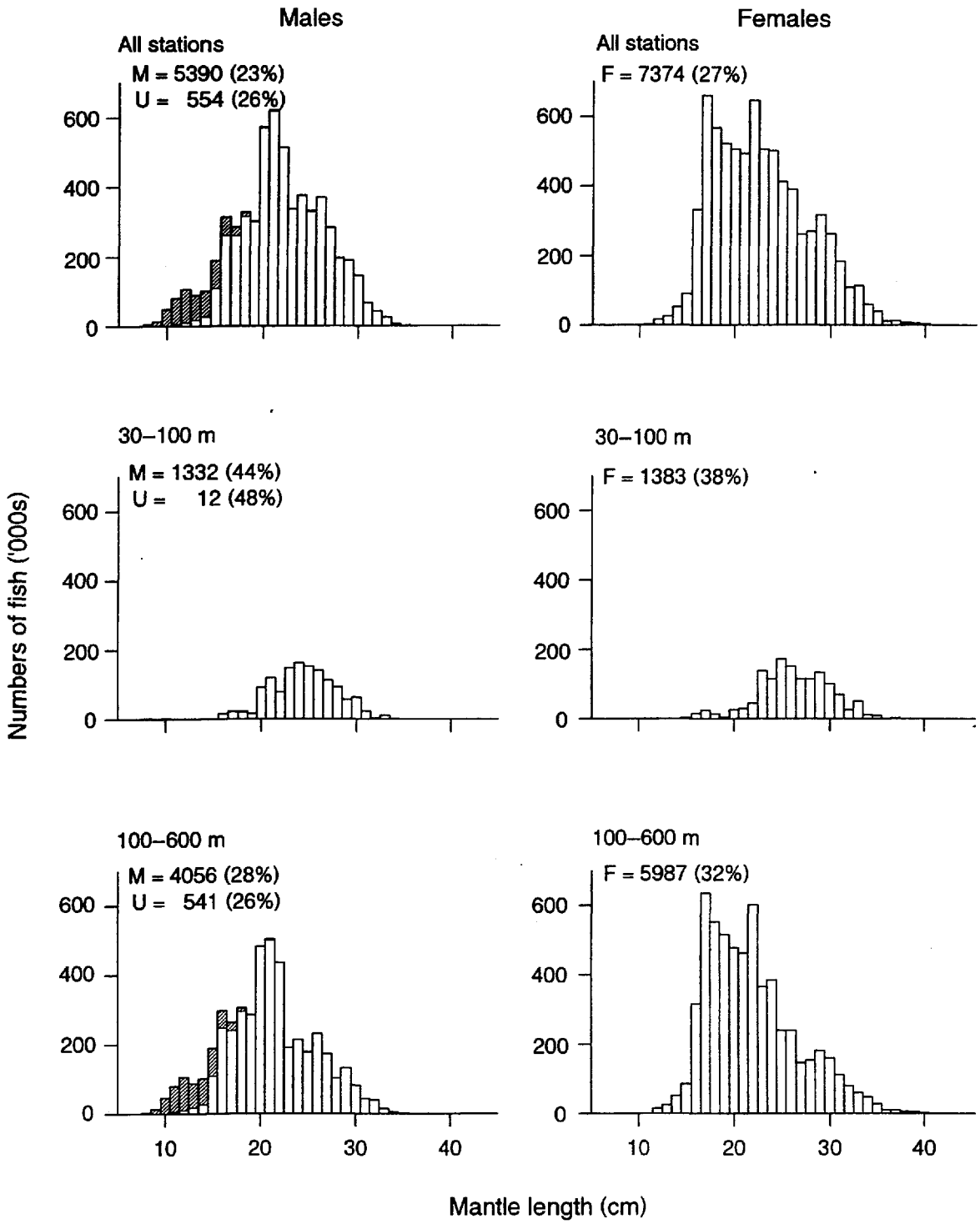


Figure 4: Length frequencies of major commercial species, by depth where appropriate. (M, males; F, females; U, unsexed; numbers are scaled to represent the estimated population size; coefficients of variation in parentheses.)
Arrow squid

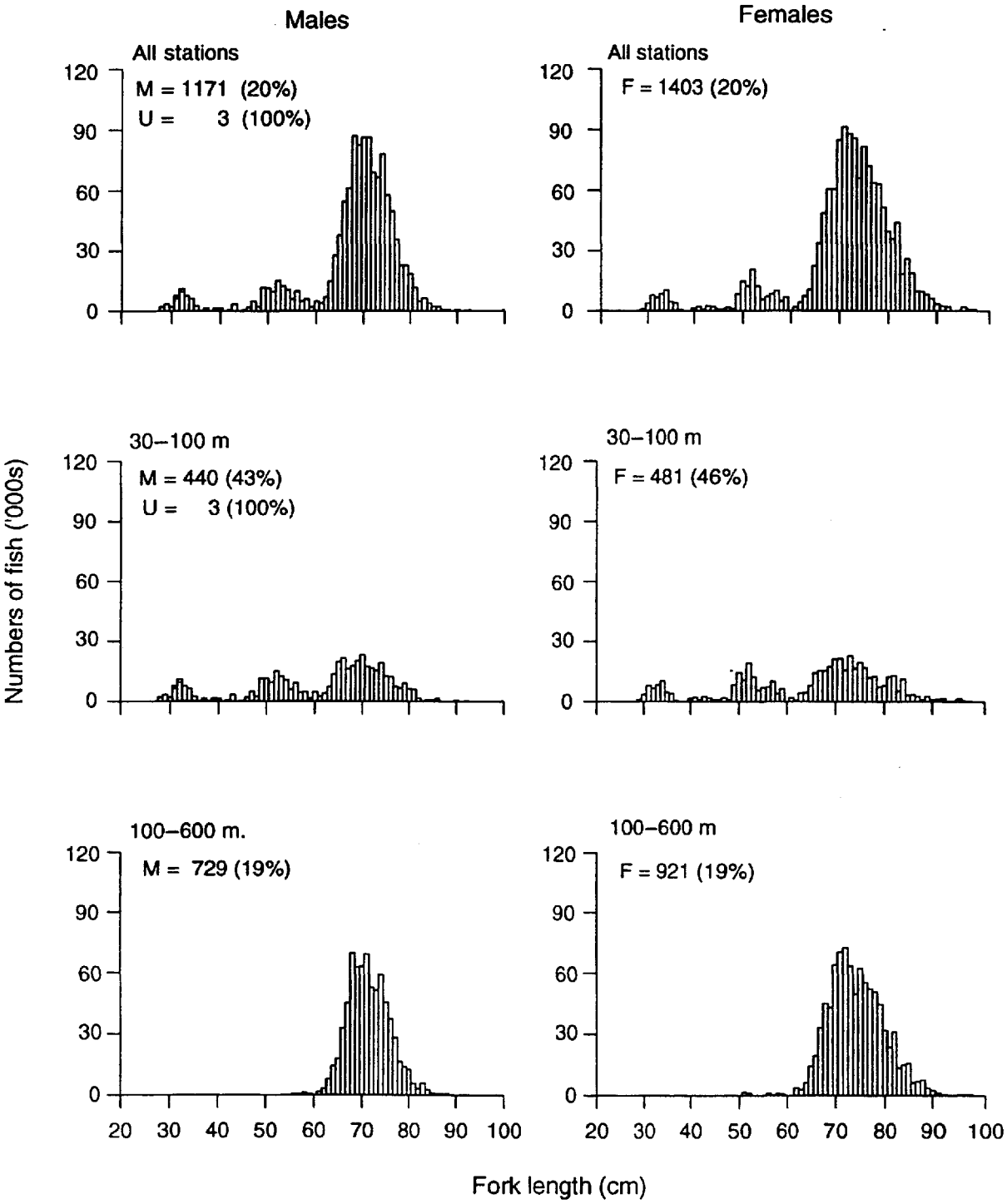


Figure 4—*continued*: Barracouta

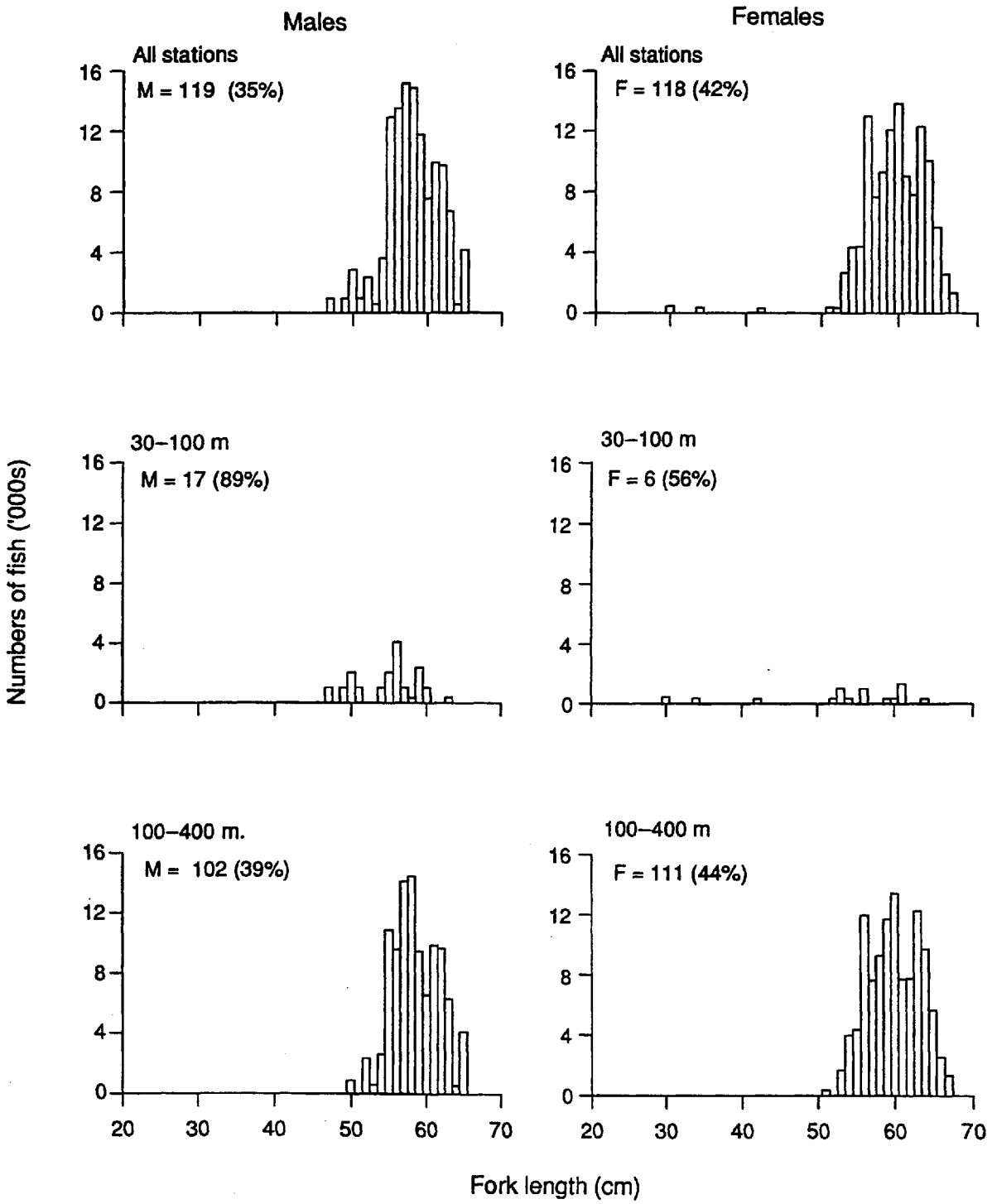


Figure 4—*continued*: Blue warehou

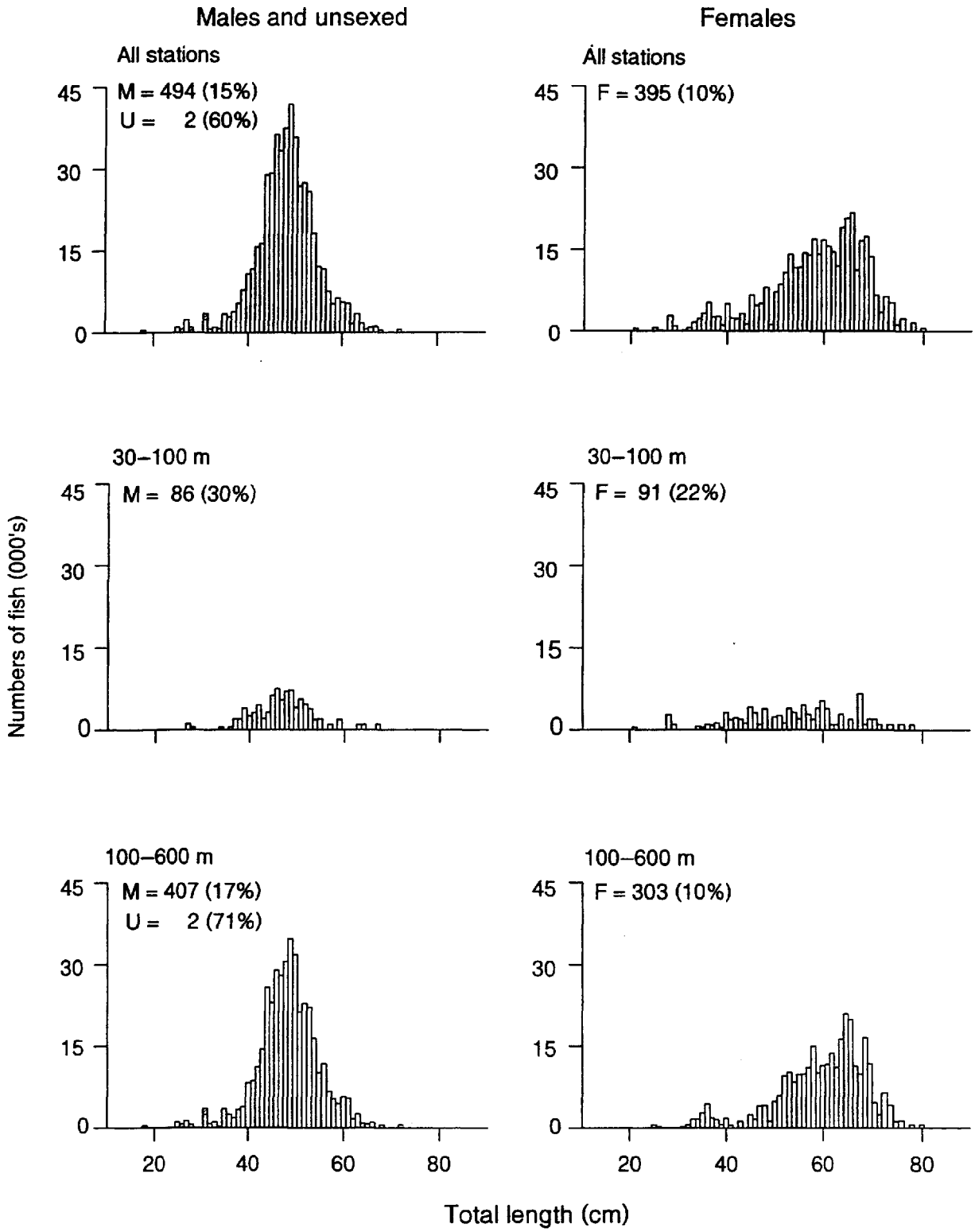


Figure 4—*continued*: Giant stargazer

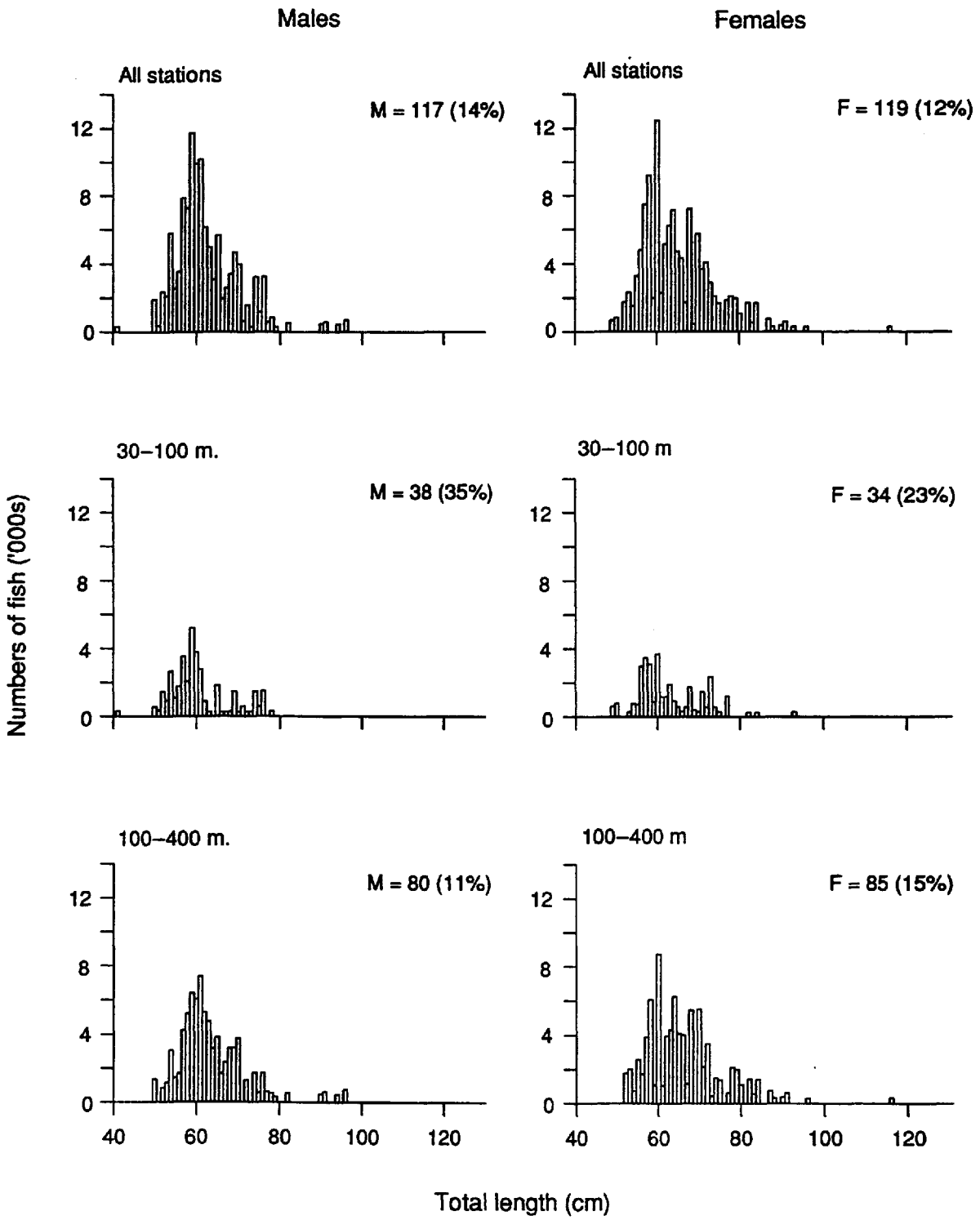


Figure 4—*continued*: Hapuku

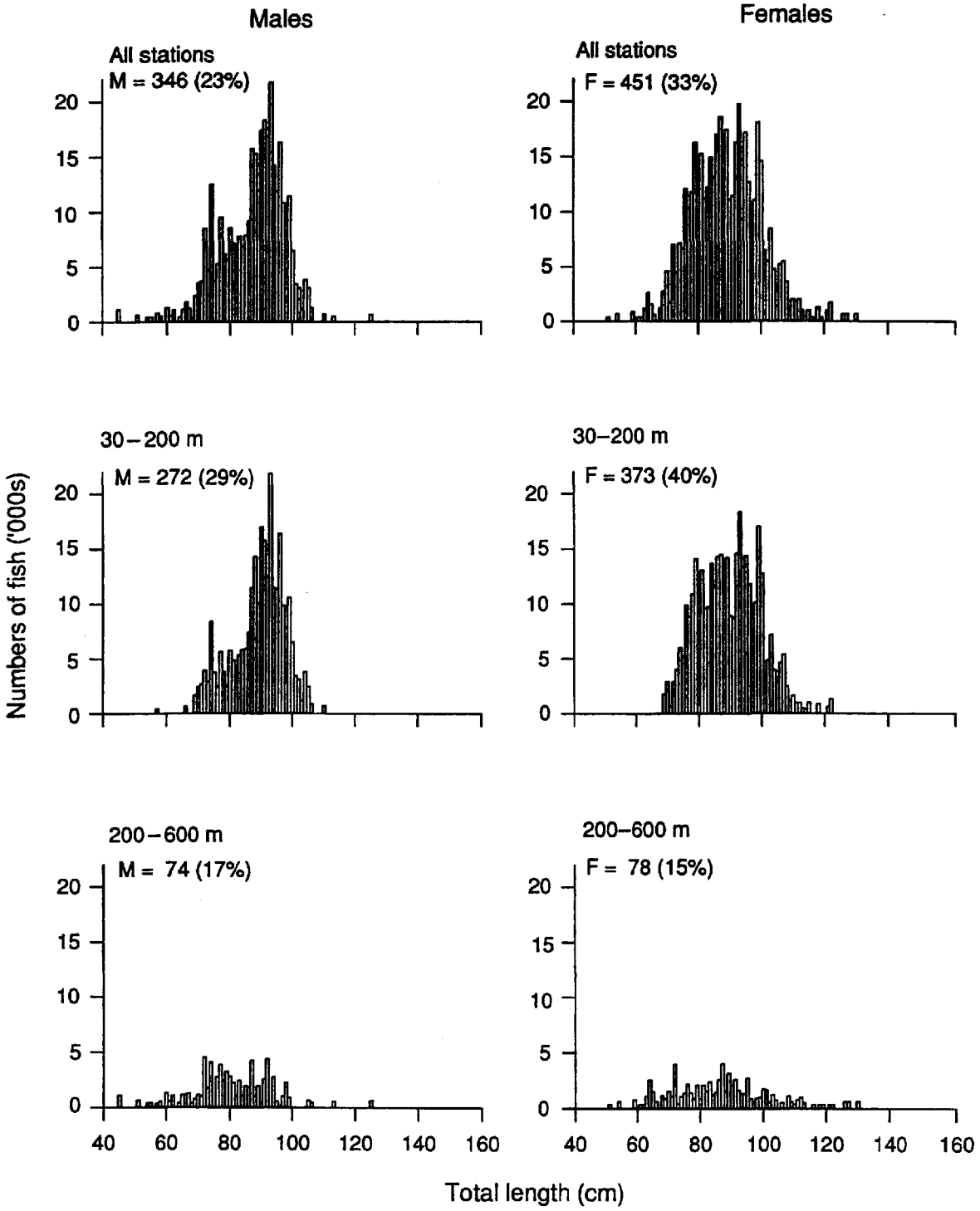


Figure 4—*continued*: Ling

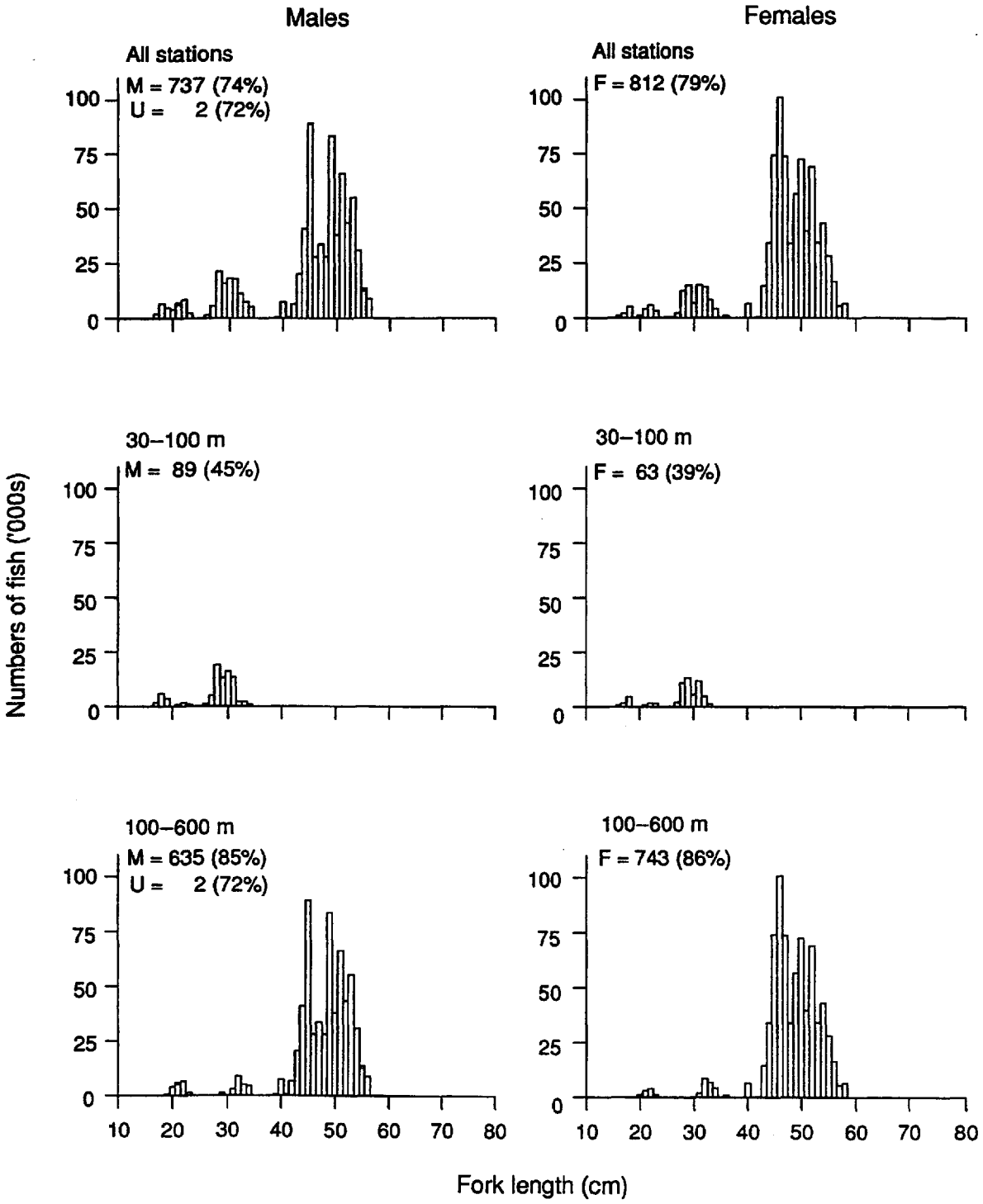


Figure 4—*continued*: Silver warehou

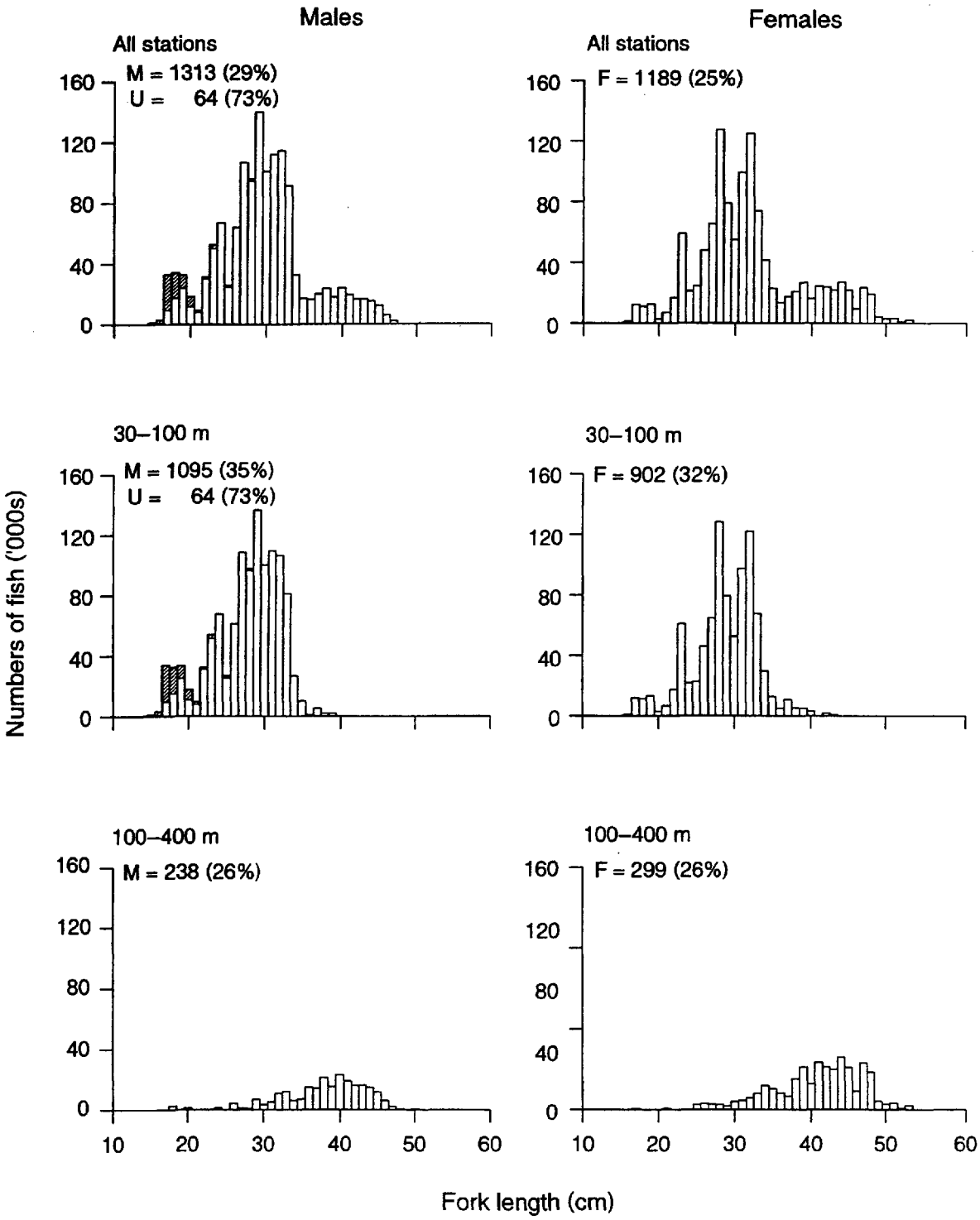


Figure 4—*continued*: Tarakihi

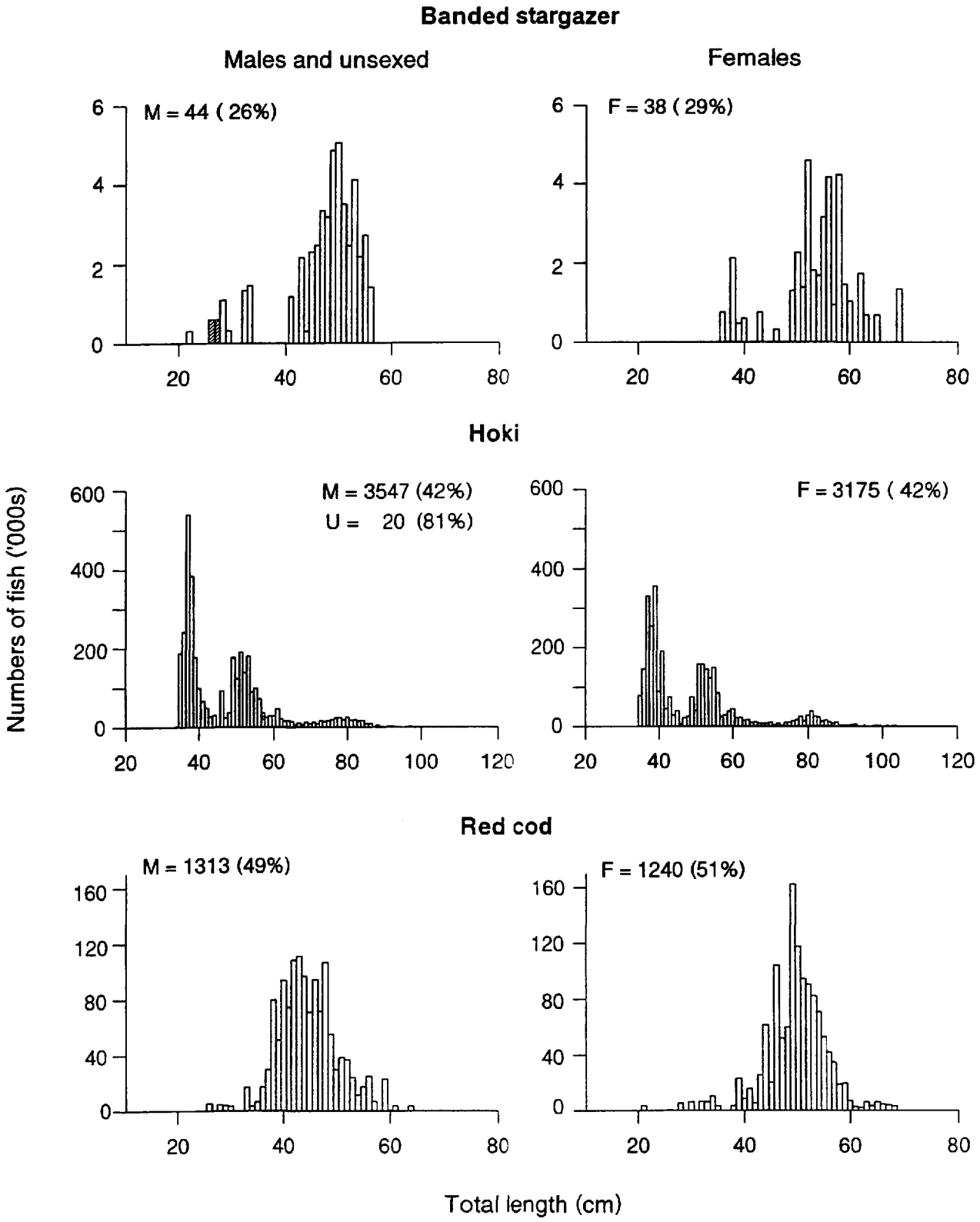


Figure 4—*continued*: Other species

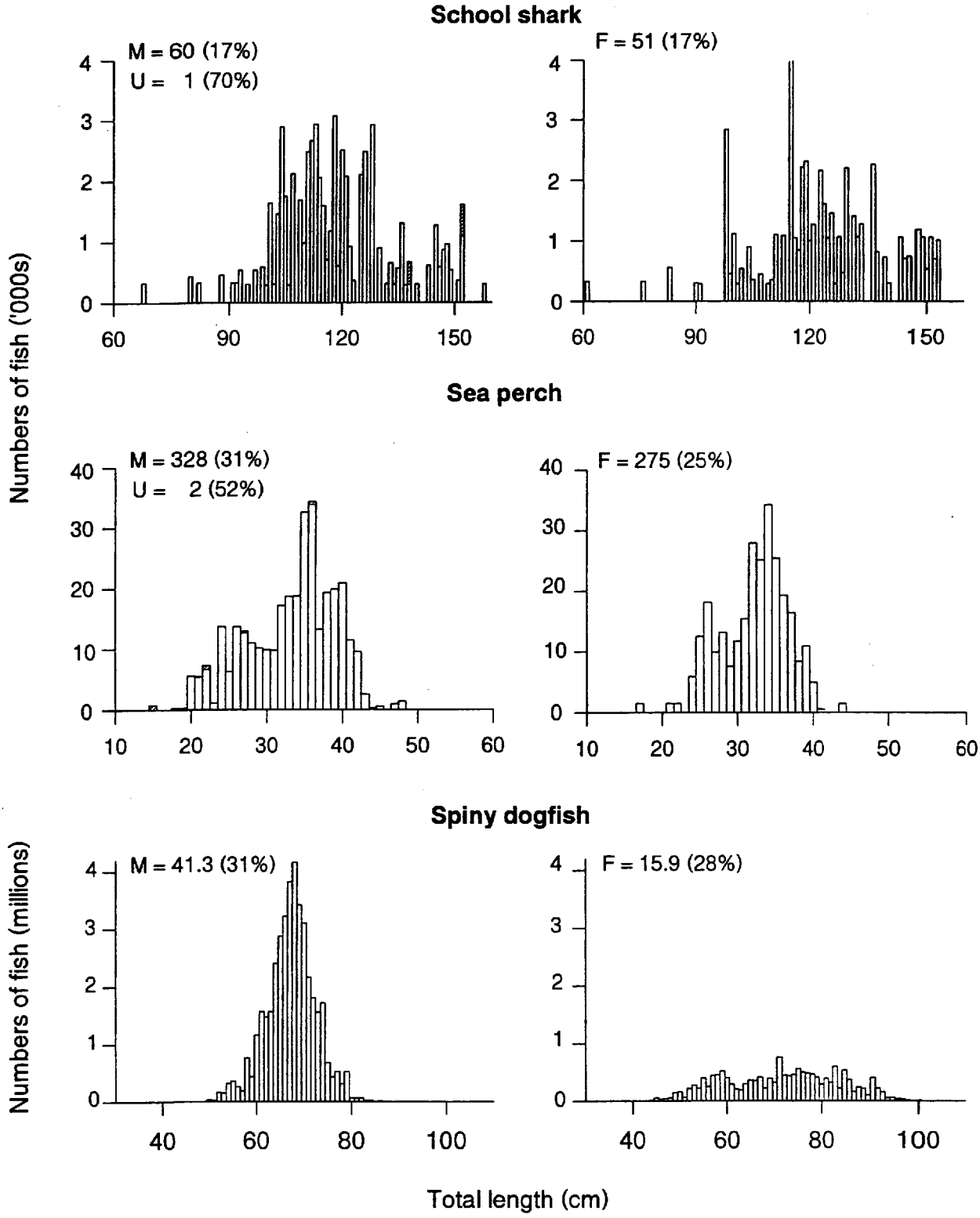


Figure 4—*continued*: Other species

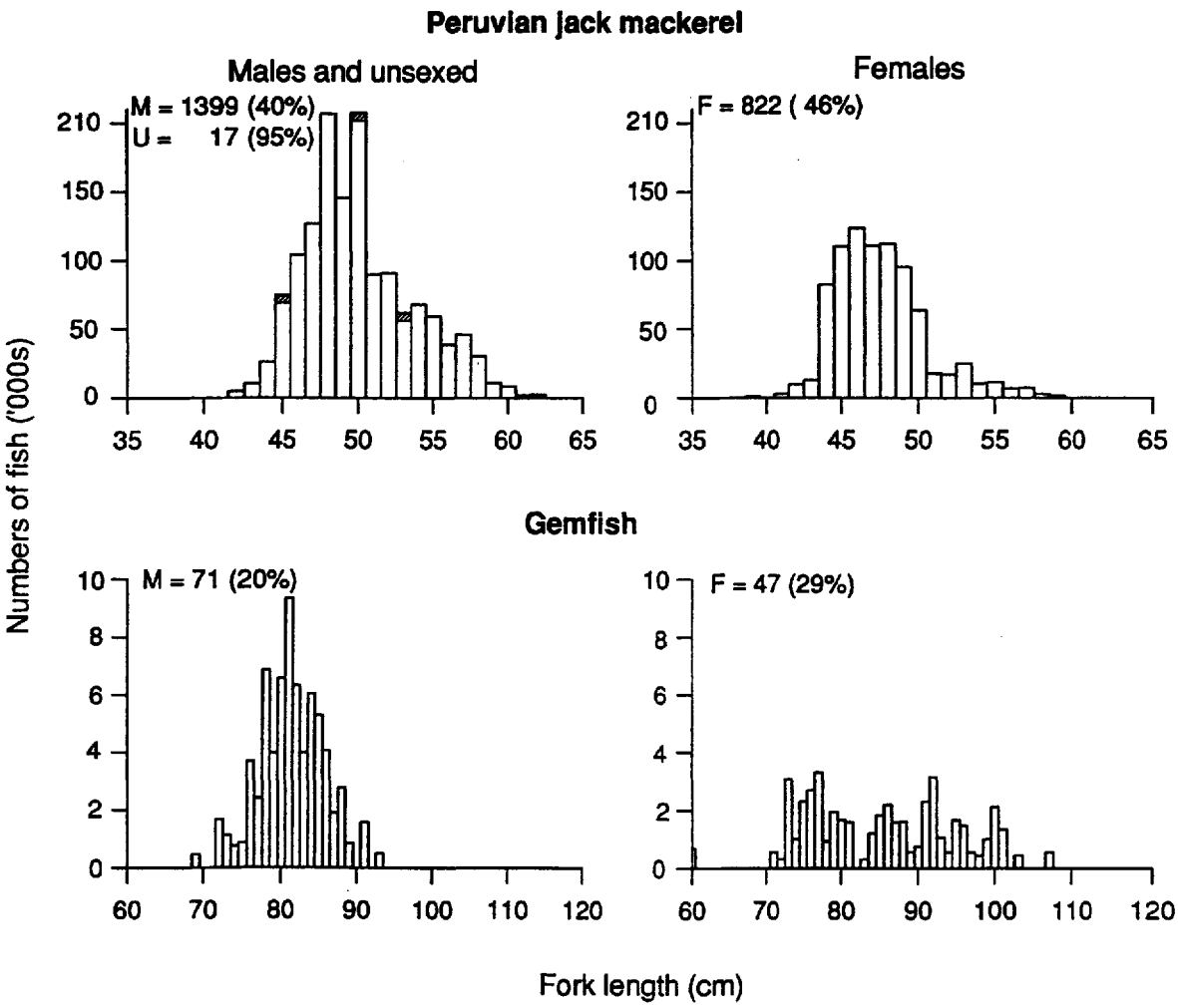


Figure 4—*continued*: Other species

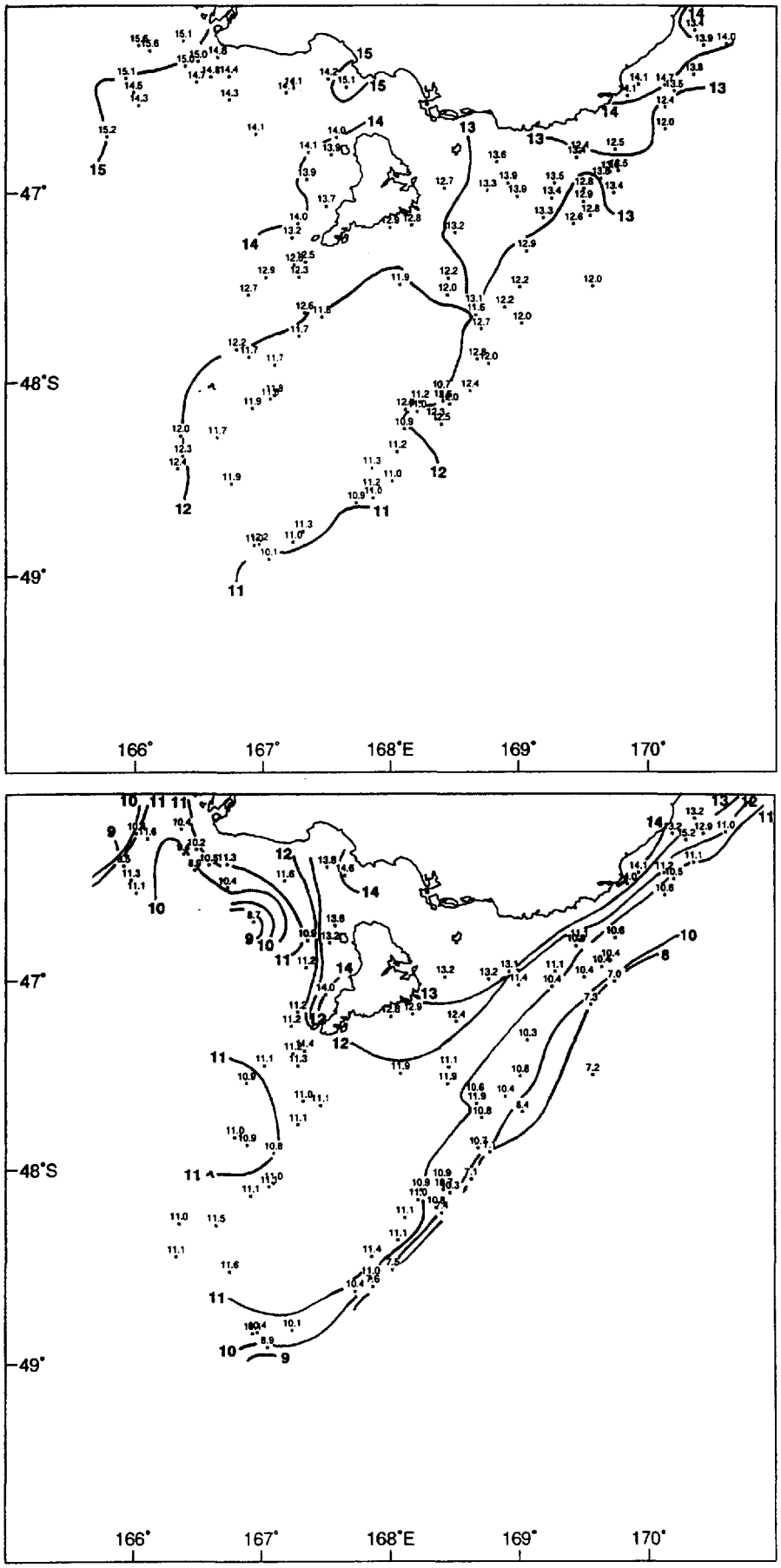


Figure 5: Surface (*above*) and bottom (*below*) water temperatures.

Appendix 1: Individual station data: phase 1, stations 1–114; phase 2, 115–156

Station	Stratum	Date	Time	Start of tow Latitude ° 'S	Start of tow Longitude ° 'E	Start of tow Depth (m)	Tow distance (n. mile)	Door spread (m)
1	1	13 Feb 95	0549	46 07.88	170 22.22	53	3.00	88.3
F 2	1	13 Feb 95	0750	46 12.22	170 22.21	59		88.3
3	1	13 Feb 95	1027	46 12.73	170 11.82	41	3.00	*81.0
4	1	13 Feb 95	1212	46 14.87	170 18.44	64	2.74	88.3
5	4A	13 Feb 95	1427	46 12.17	170 36.72	108	3.00	*97.7
6	4A	13 Feb 95	1638	46 22.08	170 21.80	108	2.99	*90.2
7	1	13 Feb 95	1828	46 25.48	170 07.81	87	2.80	90.4
8	4B	14 Feb 95	0549	46 27.52	170 12.48	103	3.07	*94.6
9	4B	14 Feb 95	0721	46 32.79	170 07.96	119	3.01	*93.0
10	13	14 Feb 95	0909	46 39.81	170 08.05	245	3.05	*100.1
11	4B	14 Feb 95	1138	46 46.50	169 44.80	118	3.02	*98.9
12	13	14 Feb 95	1346	46 53.24	169 46.51	308	3.02	113.3
13	5B	14 Feb 95	1529	46 53.68	169 42.60	122	3.02	98.6
14	5B	14 Feb 95	1700	46 55.73	169 38.50	122	2.87	*96.9
15	17	14 Feb 95	1900	47 00.40	169 44.44	574	3.00	115.0
16	17	15 Feb 95	0558	47 30.05	169 34.38	548	3.00	115.0
17	13	15 Feb 95	0917	47 10.27	169 25.60	366	3.05	113.3
18	17	15 Feb 95	1111	47 07.68	169 33.53	550	3.01	115.0
19	5B	15 Feb 95	1322	47 03.19	169 30.33	123	3.01	*101.0
20	5B	15 Feb 95	1454	46 59.06	169 30.47	121	3.00	*93.8
21	5A	15 Feb 95	1658	47 02.00	169 15.53	117	2.99	*98.6
22	5B	15 Feb 95	1835	47 08.31	169 11.79	119	3.00	*97.5
23	5B	16 Feb 95	0551	47 18.85	169 04.00	118	3.00	*81.9
24	6B	16 Feb 95	0749	47 30.31	169 00.88	125	2.99	*87.3
25	18	16 Feb 95	1002	47 41.79	169 01.72	571	2.98	115.0
26	6B	16 Feb 95	1216	47 36.72	168 53.71	131	3.01	98.6
27	6A	16 Feb 95	1423	47 36.14	168 39.52	127	3.00	98.6
28	6B	16 Feb 95	1618	47 43.60	168 42.73	133	3.01	98.6
29	6B	16 Feb 95	1811	47 53.09	168 40.77	138	3.00	98.6
30	18	17 Feb 95	0601	47 54.40	168 46.05	528	3.03	115.0
31	18	17 Feb 95	0809	48 02.93	168 37.57	557	3.02	115.0
F 32	7	17 Feb 95	0955	48 07.10	168 27.75	137	1.34	98.6
33	7	17 Feb 95	1409	48 06.12	168 24.78	136	3.02	*100.0
34	18	17 Feb 95	1601	48 13.34	168 23.91	543	3.01	115.0
35	7	17 Feb 95	1814	48 11.78	168 21.36	139	3.02	*91.5
F 36	7	18 Feb 95	0553	48 08.76	168 07.11	132	1.96	98.6
37	20	19 Feb 95	0617	46 42.18	165 46.21	468	3.01	115.4
38	12	19 Feb 95	0858	46 32.18	166 01.01	145	3.00	98.6
39	12	19 Feb 95	1050	46 28.04	165 58.53	143	3.01	98.6
40	20	19 Feb 95	1303	46 23.40	165 55.02	551	2.99	115.0
41	16	19 Feb 95	1538	46 12.86	166 00.98	241	3.01	119.7
42	12	19 Feb 95	1719	46 14.50	166 06.12	145	3.00	98.6
43	16	20 Feb 95	0607	46 11.42	166 22.20	356	3.01	113.3
44	16	20 Feb 95	0814	46 17.96	166 29.28	355	3.02	113.3
45	20	20 Feb 95	1038	46 19.48	166 23.08	433	2.98	115.4
46	20	20 Feb 95	1227	46 24.76	166 28.44	443	3.02	115.4
47	16	20 Feb 95	1443	46 23.00	166 35.07	331	3.01	113.3
48	11	20 Feb 95	1641	46 22.82	166 43.42	137	3.00	98.6
F 49	11	20 Feb 95	1824	46 16.70	166 38.13	125	1.87	98.6
50	16	21 Feb 95	0607	46 30.37	166 43.76	316	3.00	113.3
51	20	21 Feb 95	0824	46 41.41	166 56.18	528	2.11	115.0
52	11	21 Feb 95	1108	46 28.18	167 10.86	119	3.01	98.6

Station	Stratum	Date	Time	Start of tow Latitude ° 'S	Longitude ° 'E	Depth (m)	Tow distance (n. mile)	Door spread (m)
53	11	21 Feb 95	1245	46 26.64	167 14.27	103	2.99	98.6
54	3	21 Feb 95	1448	46 23.68	167 30.44	51	3.00	88.3
55	3	21 Feb 95	1620	46 26.38	167 38.87	48	3.00	81.2
56	3	21 Feb 95	1855	46 42.61	167 34.34	65	3.06	88.3
57	3	22 Feb 95	0605	46 48.10	167 31.82	76	3.00	90.4
58	11	22 Feb 95	0818	46 47.35	167 21.32	138	3.02	98.6
59	11	22 Feb 95	1002	46 55.90	167 20.82	137	3.00	98.6
60	3	22 Feb 95	1208	47 04.49	167 29.67	86	3.03	90.4
61	11	22 Feb 95	1442	47 10.00	167 16.65	127	3.00	98.6
62	10A	22 Feb 95	1615	47 14.50	167 13.84	142	2.54	98.6
63	10A	22 Feb 95	1744	47 23.15	167 14.77	152	3.00	103.3
64	5A	23 Feb 95	0559	47 12.96	168 30.56	104	3.00	98.6
65	2	23 Feb 95	0818	46 59.60	168 45.68	89	3.06	90.4
66	2	23 Feb 95	1039	46 50.41	168 50.07	76	2.97	90.4
67	2	23 Feb 95	1447	46 57.15	168 55.41	83	1.99	90.4
68	5A	23 Feb 95	1629	47 01.49	168 59.92	107	2.00	98.6
69	5A	23 Feb 95	1812	46 57.21	169 16.92	113	1.00	98.6
F 70	4A	23 Feb 95	1930	46 49.07	169 26.76	112	.97	98.6
71	1	24 Feb 95	0602	46 29.25	169 50.57	56	1.99	88.3
72	1	24 Feb 95	0712	46 25.51	169 55.63	37	2.00	81.2
73	2	25 Feb 95	1035	47 10.64	168 10.26	89	2.07	90.4
F 74	2	27 Feb 95	0850	47 11.38	168 00.16	89	1.84	90.4
75	10A	27 Feb 95	1411	47 39.67	167 27.62	140	1.95	98.6
76	10A	27 Feb 95	1642	47 22.26	167 20.23	149	3.00	98.6
77	10A	27 Feb 95	1926	47 27.06	167 17.10	150	2.00	103.3
78	10A	28 Feb 95	0606	47 27.00	167 01.18	160	3.01	103.3
79	10B	28 Feb 95	0745	47 32.64	166 52.92	177	3.03	103.3
80	10A	28 Feb 95	1032	47 38.30	167 19.70	142	3.04	98.6
81	10B	28 Feb 95	1232	47 45.75	167 17.09	141	3.01	98.6
82	10B	28 Feb 95	1537	47 54.83	167 05.49	143	3.03	98.6
83	10B	28 Feb 95	1736	47 52.29	166 53.10	149	3.00	98.6
84	10B	28 Feb 94	1923	47 49.83	166 47.32	162	2.02	103.3
85	9	01 Mar 95	0610	48 04.27	167 05.43	145	3.00	98.6
86	9	01 Mar 95	0800	48 05.36	167 03.28	146	3.01	98.6
87	9	01 Mar 95	0946	48 08.20	166 54.76	146	3.00	98.6
88	9	02 Mar 95	0615	48 27.10	166 19.80	156	3.02	103.3
89	9	02 Mar 95	0759	48 23.13	166 22.33	153	3.00	103.3
90	9	02 Mar 95	0930	48 16.88	166 21.15	162	3.02	103.3
91	9	02 Mar 95	1128	48 17.37	166 38.53	143	3.00	98.6
92	8A	02 Mar 95	1417	48 31.71	166 45.06	139	2.01	98.6
93	8B	02 Mar 95	1733	48 50.41	166 58.03	180	3.00	103.3
94	8B	02 Mar 95	1920	48 50.81	166 55.71	188	2.55	103.3
95	18	03 Mar 95	0622	48 55.02	167 02.75	349	2.98	113.3
96	8B	03 Mar 95	0824	48 49.77	167 14.37	194	3.02	103.3
97	8A	03 Mar 95	0958	48 46.53	167 19.20	137	2.02	98.6
98	8A	03 Mar 95	1217	48 37.72	167 43.88	136	3.01	98.6
99	18	03 Mar 95	1431	48 36.20	167 52.06	498	3.00	115.4
100	8A	03 Mar 95	1728	48 33.61	167 51.07	138	2.00	98.6
101	18	03 Mar 95	1917	48 30.99	168 01.05	555	2.62	115.0
102	7	04 Mar 95	0617	48 26.90	167 51.47	131	2.00	98.6
103	7	04 Mar 95	0813	48 21.90	168 03.31	137	2.02	98.6
104	7	04 Mar 95	1001	48 14.90	168 06.55	131	2.01	98.6
105	7	04 Mar 95	1157	48 09.35	168 12.69	131	2.13	98.6
106	7	04 Mar 95	1329	48 06.36	168 13.98	132	1.99	98.6

Station	Stratum	Date	Time	Start of tow Latitude ° 'S	Start of tow Longitude ° 'E	Start of tow Depth (m)	Tow distance (n. mile)	Door spread (m)
107	7	04 Mar 95	1443	48 03.21	168 23.91	135	2.00	98.6
108	6A	04 Mar 95	1820	47 39.04	168 40.16	130	2.09	98.6
109	6A	05 Mar 95	0615	47 32.72	168 26.78	122	3.02	98.6
110	6A	05 Mar 95	0749	47 27.42	168 27.48	118	3.01	98.6
111	6A	05 Mar 95	1004	47 29.45	168 04.71	114	3.01	98.6
112	2	05 Mar 95	1429	46 58.88	168 25.41	71	2.00	88.3
113	4A	05 Mar 95	1849	46 47.48	169 28.28	110	3.01	98.6
114	1	06 Mar 95	0611	46 12.77	170 26.36	63	3.06	88.3
115	1	06 Mar 95	0810	46 21.74	170 15.93	84	3.02	90.4
116	1	06 Mar 95	1156	46 34.29	169 41.29	70	2.99	88.3
117	1	06 Mar 95	1417	46 41.11	169 32.76	80	2.02	90.4
118	6A	07 Mar 95	0617	47 33.99	167 59.36	127	2.50	98.6
119	6A	07 Mar 95	0749	47 32.69	168 02.40	120	2.01	98.6
120	6A	07 Mar 95	1000	47 37.29	168 07.70	130	2.03	98.6
121	6A	07 Mar 95	1152	47 32.91	168 17.94	121	3.00	98.6
122	6A	07 Mar 95	1352	47 24.47	168 20.23	112	3.03	98.6
123	6A	07 Mar 95	1522	47 26.40	168 31.16	118	2.00	98.6
124	6A	07 Mar 95	1838	47 40.03	168 31.52	129	2.99	98.6
125	6A	08 Mar 95	0613	47 29.68	167 59.15	111	2.00	98.6
126	6A	08 Mar 95	0729	47 31.08	168 01.73	111	2.01	98.6
127	6A	08 Mar 95	0920	47 35.43	167 59.07	143	2.00	98.6
128	6A	08 Mar 95	1109	47 29.27	168 13.94	117	2.01	98.6
129	6A	08 Mar 95	1301	47 29.03	168 21.03	116	2.04	98.6
130	6A	08 Mar 95	1426	47 30.66	168 33.39	122	2.02	98.6
131	6A	08 Mar 95	1551	47 37.09	168 40.89	127	2.07	98.6
132	6A	08 Mar 95	1832	47 32.30	168 17.02	122	2.00	98.6
133	10B	09 Mar 95	0624	47 41.89	166 46.83	170	3.01	103.3
134	10B	09 Mar 95	0818	47 43.60	168 03.58	149	2.92	98.6
135	10B	09 Mar 95	1024	47 40.57	167 06.09	148	3.00	98.6
136	10A	09 Mar 95	1217	47 31.78	167 06.34	152	3.02	103.3
137	10A	09 Mar 95	1421	47 35.70	167 21.77	139	3.00	98.6
138	10A	09 Mar 95	1713	47 22.77	167 23.99	150	3.00	103.3
139	10A	09 Mar 95	1906	47 21.17	167 19.09	159	2.41	103.3
140	12	10 Mar 95	0827	46 45.50	166 00.65	175	3.02	103.3
141	12	10 Mar 95	0950	46 42.14	165 57.53	181	2.99	103.3
142	12	10 Mar 95	1143	46 31.61	166 00.72	144	2.27	98.6
143	11	10 Mar 95	1544	46 24.11	166 54.53	125	3.02	98.6
144	11	10 Mar 95	1810	46 33.91	167 13.74	132	3.01	98.6
145	5A	11 Mar 95	0617	46 57.26	169 05.34	104	3.02	98.6
146	1	11 Mar 95	0755	46 49.93	169 12.02	82	3.03	90.4
147	1	11 Mar 95	1009	46 38.83	169 34.68	89	2.62	90.4
148	1	11 Mar 95	1239	46 23.21	169 58.85	37	2.99	81.2
149	1	11 Mar 95	1555	46 21.51	170 16.54	80	2.99	90.4
150	1	11 Mar 95	1710	46 17.41	170 19.70	67	2.99	88.3
151	1	11 Mar 95	1904	46 10.96	170 20.90	56	2.51	88.3
152	17	12 Mar 95	0625	47 06.13	169 35.18	547	3.02	115.0
153	17	12 Mar 95	1044	47 26.01	169 21.03	496	3.02	115.4
154	5A	12 Mar 95	1409	47 06.14	169 05.32	115	3.02	98.6
155	6A	12 Mar 95	1733	47 26.85	168 32.61	119	3.00	98.6
156	6A	12 Mar 95	1848	47 30.56	168 27.12	121	3.01	98.6

F Fouled trawl shots.
* Doorspread values from Scanmar.

Appendix 2: Total catch, number of stations at which caught (Occ.), species code, and depth range of all species caught.

Species code	Common name	Scientific name	Catch (kg)	Occ.	Depth (m) Min.	Depth (m) Max.
ANT	anemones	*Anthozoa*	7.8	7	71	566
BAR	barracouta	*Thyrsites atun*	8 699.3	90	37	575
BCO	blue cod	*Parapercis colias*	715.2	40	44	160
BGZ	banded giant stargazer	*Kathetostoma* spp.	619.6	34	109	282
BNS	bluenose	*Hyperoglyphe antarctica*	10.3	1	528	566
BPE	butterfly perch	*Caesioperca lepidoptera*	26.4	2	124	134
BSH	seal shark	*Scymnorhinus licha*	4.3	3	456	566
CAR	carpet shark	*Cephaloscyllium isabella*	835.3	71	37	160
CAS	oblique banded rattail	*Caelorinchus aspercephalus*	30.0	15	245	572
CBE	crested bellowsfish	*Notopogon lilliei*	3.0	5	71	143
CBI	two saddle rattail	*Caelorinchus biclinozonalis*	15.2	4	308	566
CBO	Bollon's rattail	*C. bollonsi*	153.5	15	443	575
CCX	small banded rattail	*Caelorinchus parvifasciatus*	0.5	1	456	494
CFA	banded rattail	*Caelorinchus fasciatus*	11.5	9	483	575
CNI	black swallower	*Chiasmodon niger*	0.3	1	443	455
COL	Oliver's rattail	*Caelorinchus oliverianus*	11.6	9	523	575
CON	conger eel	*Conger* spp.	9.0	1	144	145
COU	coral (unspecified)		58.8	5	63	143
CRB	crab		309.7	40	63	334
CSQ	leafscaled gulper shark	*Centrophorus squamosus*	278.4	4	145	566
ECH	Echinodermata		0.4	1	61	64
ELE	elephantfish	*Callorhynchus milii*	195.6	8	37	79
EMA	blue mackerel	*Scomber australasicus*	1.2	1	71	73
EPT	deepsea cardinalfish	*Epigonus telescopus*	0.9	1	528	566
ERA	electric ray	*Torpedo fairchildi*	18.5	1	37	37
ETB	Baxter's dogfish	*Etmopterus baxteri*	28.1	6	472	572
ETL	Lucifer dogfish	*E. lucifer*	7.0	11	456	575
GPF	girdled wrasse	*Notolabrus cinctus*	2.3	4	65	143
GSC	giant spider crab	*Jacquinotia edwardsii*	94.5	5	117	336
GSH	dark ghost shark	*Hydrolagus novaezealandiae*	1 162.0	10	102	455
GSP	pale ghost shark	*Hydrolagus* sp.	121.7	11	483	575
GUR	red gurnard	*Chelidonichthys kumu*	264.5	24	37	118
HAK	hake	*Merluccius australis*	566.9	15	138	575
HAP	hapuku	*Polyprion oxygeneios*	1 551.6	95	37	350
HCO	hairy conger	*Bassanago hirsutus*	8.7	3	443	566
HOK	hoki	*Macruronus novaezelandiae*	4 723.7	22	308	575
JAV	javelin fish	*Lepidorhynchus denticulatus*	124.5	18	123	575
JFI	jellyfish		183.0	24	63	164
JMD	jack mackerel	*Trachurus declivis*	147.3	29	37	334
JMM	Peruvian jack mackerel	*T. murphyi*	5 276.6	74	37	575
LCH	longnosed chimaera	*Harriotta raleighana*	9.0	3	542	575
LDO	lookdown dory	*Cyttus traversi*	109.2	14	432	575
LEA	leatherjacket	*Parika scaber*	31.9	1	44	47
LIN	ling	*Genypterus blacodes*	6 189.9	101	43	575
LSO	lemon sole	*Pelotretis flavilatus*	176.9	18	37	194
MDO	mirror dory	*Zenopsis nebulosus*	0.4	1	87	87
MOK	moki	*Latridopsis ciliaris*	32.1	5	61	150
NNA		*Nezumia namatahi*	0.3	1	541	560
NOS	arrow squid	*Nototodarus sloanii*	5 946.9	138	37	575
OCT	octopus	*Octopus maorum*	65.1	13	63	555
ONG	sponges	*Porifera*	835.0	50	37	570
OPE	orange perch	*Lepidoperca aurantia*	24.6	4	131	336

Species code	Common name	Scientific name	Catch (kg)	Occ.	Depth (m) Min.	Max.
PAD	paddle crab	*Ovalipes catharus*	3.9	3	131	146
PIG	pigfish	*Congiopodus leucopaecilus*	6.7	15	52	140
POS	porbeagle shark	*Lamina nasus*	240.0	2	127	382
QSC	queen scallop	*Chlamys delicatula*	4.5	12	87	575
RBM	Ray's bream	*Brama brama*	9.5	6	356	575
RBT	redbait	*Emmelichthys nitidus*	6.8	10	71	282
RCO	red cod	*Pseudophycis bachus*	4 362.5	30	37	494
RIB	ribaldo	*Mora moro*	41.7	10	472	575
RSK	rough skate	*Raja nasuta*	1 218.9	89	37	555
RUD	rudderfish	*Centrolophus niger*	183.4	6	527	575
SAL	salps		207.0	16	76	572
SBK	spineback	*Notacanthus sexspinis*	16.2	7	523	575
SCC	sea cucumber	*Stichopus mollis*	19.1	21	56	158
SCG	scaly gurnard	*Lepidotrigla brachyoptera*	26.7	16	37	138
SCH	school shark	*Galeorhinus galeus*	1 876.6	69	37	334
SCI	scampi	*Metanephrops challengeri*	0.4	1	432	437
SCO	swollenhead conger	*Bassanago bulbiceps*	27.5	3	472	560
SDO	silver dory	*Cyttus novaezealandiae*	6.9	13	65	391
SFI	starfish		17.5	23	37	455
SKI	gemfish	*Rexea solandri*	995.5	44	82	391
SND	shovelnosed spiny dogfish	*Deania calcea*	143.1	5	443	566
SPD	southern spiny dogfish	*Squalus acanthias*	122 753.1	135	37	575
SPE	sea perch	*Helicolenus* sp.	679.9	49	52	560
SPF	scarlet wrasse	*Pseudolabrus miles*	2.0	5	56	145
SPO	rig	*Mustelus lenticulatus*	47.1	5	52	130
SSH	slender smoothhound	*Gollum attenuatus*	2.7	1	130	131
SSI	silverside	*Argentina elongata*	2.7	13	71	555
SSK	smooth skate	*Raja innominata*	610.8	38	44	575
STA	giant stargazer	*Kathetostoma giganteum*	3 735.2	126	37	572
SWA	silver warehou	*Seriolella punctata*	3 303.4	36	43	552
TAR	tarakihi	*Nemadactylus macropterus*	3 150.9	52	37	334
TOD	dark toadfish	*Neophrynichthys latus*	0.7	2	80	112
TOP	pale toadfish	*N. angustus*	6.5	2	143	570
TRU	trumpeter	*Latris lineata*	28.9	8	44	147
WAR	common warehou	*Seriolella brama*	2 206.2	21	52	140
WIT	witch	*Arnoglossus scapha*	31.7	55	43	391
WLP	wavy line perch	*Lepidoperca* sp. B	0.3	1	143	145
WSQ	warty squid	*Moroteuthis ingens*	19.8	8	356	575
WWA	white warehou	*Seriolella caerulea*	4.0	3	127	382
YCO	yellow cod	*Parapercis gilliesi*	2.3	6	109	152
ZFM	rubbish: fishing metals		9.0	1	120	121
ZFP	rubbish: fishing plastic		0.1	1	146	148
ZHP	rubbish: household plastic		0.6	1	574	575

Appendix 3: Length-weight relationships used to scale length frequencies (derived from TAN9502 data unless indicated)*

Species code	Sex	*a*	*b*	*r*(%)	Number of fish	Length (cm) Min.	Max.
BAR	All	0.0045	3.02	98.8	1 164	28.5	96.1
	M	0.0049	3.01	98.7	498	28.5	88.3
	F	0.0043	3.04	98.9	666	29.3	96.1
BCO	All	0.0052	3.30	99.2	329	18.4	61.5
	M	0.0054	3.29	99.0	196	26.0	61.5
	F	0.0040	3.38	99.3	133	18.4	58.7
BGZ	All	0.0103	3.25	97.4	143	22.2	69.4
	M	0.0173	3.11	97.4	80	22.2	56.8
	F	0.0067	3.36	96.1	63	36.4	69.4
ELE	All	0.0176	2.87	96.4	68	52.4	88.4
GSH	All	0.0009	3.48	98.5	342	26.1	71.5
GSP	All	0.1746	2.19	87.3	51	52.5	84.0
GUR	All	0.0049	3.19	98.1	239	29.1	52.5
	M	0.0077	3.06	97.7	139	29.1	46.7
	F	0.0062	3.13	97.4	98	31.4	52.5
HAK	All	0.0015	3.36	98.3	90	63.9	120.5
	M	0.0073	3.00	92.3	29	66.6	96.0
	F	0.0011	3.42	98.7	61	63.9	120.5
HAP	All	0.0044	3.27	98.7	297	41.4	116.7
	M	0.0047	3.25	98.5	151	41.4	96.4
	F	0.0043	3.28	98.9	146	49.9	116.7
JMM	All	0.0171	2.87	91.6	488	30.7	62.0
	M	0.0129	2.94	92.7	301	30.7	61.0
	F	0.0054	3.18	92.1	183	39.8	59.9
LIN	All	0.0013	3.30	97.9	570	45.0	130.1
	M	0.0014	3.27	97.6	259	45.0	125.4
	F	0.0012	3.31	98.1	311	51.8	130.1
NOS	All	0.0160	3.08	98.8	1 121	9.4	39.9
	M	0.0092	3.27	98.4	457	11.1	35.1
	F	0.0124	3.15	98.9	531	11.6	39.9
RCO	All	0.0258	2.73	96.0	565	25.1	67.5
	M	0.0348	2.64	95.3	294	28.0	60.1
	F	0.0255	2.73	95.9	271	25.1	67.5
SKI	All	0.0004	3.67	94.9	205	60.0	107.3
	M	0.0017	3.35	88.8	118	69.3	93.5
	F	0.0003	3.76	96.2	87	60.0	107.3
SPD	All	0.0007	3.45	97.9	1 052	43.4	104.4
	M	0.0039	3.02	94.1	503	44.9	86.8
	F	0.0010	3.37	98.5	548	43.4	104.4

Species code	Sex	*a*	*b*	*r*(%)	Number of fish	Length (cm) Min.	Max.
SPE	All	0.0115	3.15	99.0	287	15.0	48.6
STA	All	0.0118	3.09	98.7	779	18.8	78.5
	M	0.0171	2.99	97.7	423	18.8	68.0
	F	0.0137	3.05	98.7	354	21.9	78.5
SWA	All	0.0048	3.38	99.9	262	16.6	57.8
	M	0.0047	3.39	99.9	131	17.2	56.4
	F	0.0049	3.38	99.8	129	16.6	57.8
TAR	All	0.0161	3.04	99.2	1 043	15.9	53.8
	M	0.0177	3.01	99.2	484	15.9	50.2
	F	0.0170	3.03	99.4	557	16.4	53.8
WAR	All	0.0247	2.98	97.2	209	30.6	67.5
	M	0.0312	2.92	95.4	111	47.8	65.6
	F	0.0241	2.99	97.8	98	30.6	67.5
Other sources:							
TAN9301							
HOK	All	0.0057	2.85	99.6	180	36	86
TAN9301 and TAN9402							
SCH	All	0.0054	2.98	97.8	292	80	162

* Species codes are given in Appendix 2.
$w = aL^b$ where w is weight (g) and L is length (cm).

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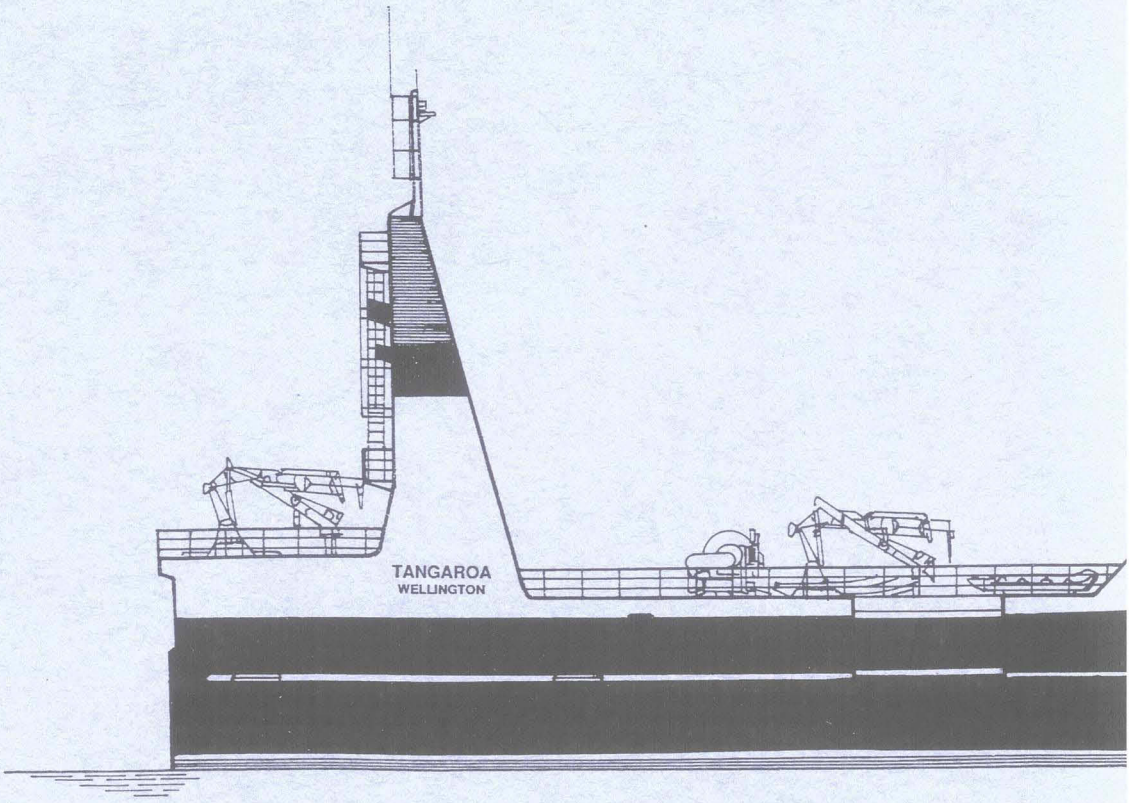
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