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Distribution and abundance of juvenile John dory and juvenile and adult red gurnard from *Kaharoa* trawl surveys around the North Island

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7. Executive Summary

Relative biomass estimates by stratum and catch rates were determined for juvenile (1 year old) John dory (*Zeus faber*), and juvenile (1 year old) and adult (≥ 2 years old) red gurnard (*Chelidonichthys kumu*) by sex from available *Kaharoa* inshore trawl series data from 1983–1997 for the Bay of Plenty, Hauraki Gulf, and/or west coast North Island. Data on distribution and abundance of adult red gurnard and juvenile John dory from a fourth series along the east coast North Island (Cape runaway to Turakirae Head) from 1993–1996 were also analysed.

Juvenile red gurnard were widespread in depths less than 50 m in all three survey areas. Abundance estimates from Bay of Plenty and west coast North Island surveys could be incorporated into models for indices of year class strength however, results from Hauraki Gulf surveys usually had higher and more variable *c.v.*s and should not be used for indices of year class strength for red gurnard.

Data on the distribution and abundance estimates of juvenile John dory suggest the surveys in Bay of Plenty, west coast North Island, and Hauraki Gulf are reliably monitoring the relative abundance of these fish and could be used as indices of year class strength. The east coast North Island survey was less consistent with higher and more variable *c.v.*s and this data would need to be used with caution as indices of year class strength.

Adult red gurnard were often segregated by sex by depth. Females were usually more abundant in depths less than 50 m, while males were usually more abundant in depths greater than 50 m. Sex ratios for adult gurnard were not highly skewed and abundance estimates for adults could also be incorporated into models of the fishery.

8. Introduction

Red gurnard and John dory were caught during all *Kaharoa* trawl surveys around the North Island during 1983–97. Estimates of juvenile (1 year old), adult (≥ 2 years old), and total red gurnard and John dory biomass from each of these surveys were calculated for use as relative indices of year class strength and adult abundance in stock assessment (Hanchet *et al. in press*, Horn *et al. in press*). Members of the Inshore Working Group questioned how well these juvenile indices were monitoring abundance. A more detailed examination of juvenile abundance and distribution was requested before these data were to be used as estimates of year class strength in modelling the fisheries.

Work by Elder (1976) suggested that adult gurnard show marked segregation by sex, with males tending to be deeper than females. Inshore Working Group members considered it also important to examine the distribution and abundance of adult gurnard by sex at the time of the surveys. Although only a portion of red gurnard are sexually mature at age 2 (Hanchet *et al. in press*), for the purposes of this report adult red gurnard have been defined as fish ≥ age 2.

Data on the distribution and abundance of juvenile and adult red gurnard by sex and juvenile John dory were therefore analysed for three areas, Bay of Plenty (BOP), west coast North Island (WCNI), and Hauraki Gulf (HAGU). Data for juvenile John dory and adult red gurnard by sex from a fourth area the east coast of the North Island (ECNI) (Cape Runaway to Turakirae Head), were also analysed. Maximum depth for all surveys was 400 m.

9. Methods

Strata were those used for the respective surveys and were determined by project leaders at the time to optimise for target species. Red gurnard and John dory were not target species for any survey.

For juvenile red gurnard, data were not used from the BOP 1985 (exceptionally low biomass) and 1987 (different time of the year) surveys; from HAGU 1984 survey (28 stations without catch weight or length data); or from the 1986 and 1987 WCNI surveys (biomass estimates only) because of the difficulty in comparing strata.

For adult red gurnard, data were not used from the WCNI 1985 survey; BOP, all surveys except 1992 and 1996 and all HAGU surveys prior to 1990, because no or few fish were sexed.

For juvenile John dory, data were not used from the BOP 1985 (exceptionally low biomass) and 1987 (different time of the year) surveys, or from the HAGU 1984 (38 stations with unweighed and unmeasured catch) and 1985 (no catch weights) surveys.

Analysis parameters described in Appendix 1 of Hanchet *et al.* (*in press)* and Horn *et al.* (*in press*) were used to ensure results were comparable over time and between areas. Note that biomass estimates in this report may differ from those reported in Hanchet *et al.* (*in press*) and Horn *et al.* (*in press*) especially in the WCNI survey data because all strata were included in this report where only comparable strata were included in the other reports.

Estimation of juvenile and adult biomass by strata

Estimates of biomass were determined using TrawlSurvey Analysis Programme (Vignaux 1994) to analyse data on the NIWA *trawl* database.

The size range of 1+ fish was determined for each area from length frequency and ageing data (Hanchet *et al. in press*, Horn *et al. in press*). Maximum lengths of 1+ juvenile John dory used for this analysis to determine biomass estimates and catch were 28 cm for WCNI; 29 cm, HAGU; 32 cm, BOP; and 33 cm, ECNI. The differences reflect the different months of the year of the surveys and the rapid growth of John dory.

For red gurnard juveniles, the cut-off lengths were 19 cm for WCNI and BOP and 18 cm for HAGU (*see* Hanchet *et al. in press*). No analysis of juvenile red gurnard was done for ECNI because too few were caught for analysis.

Both species spawn in summer (Annala *et al.* 1998) so the youngest cohort fish are about one year old as the surveys were carried out between the months of November and April.

Juvenile and adult catch rates

Catch rates were calculated for juveniles and for adults by sex from length frequency data in the *trawl* database. Plots of catch rates were made using MapInfo v2.1. Strata varied between surveys and so, for illustrative purposes, only the strata from the most recent survey of each area are shown.

10. Results

Red gurnard

Bay of Plenty

Strata used for the 1996 BOP trawl survey (KAH9601) are shown in Figure 1. Estimates of juvenile biomass by stratum are shown in Table 1. (Biomass estimates are presented by stratum to more clearly show which sex was more abundant in a given stratum and for ease of comparison of distribution by depth.) The estimates are consistently low, never exceeding 6 t for any one stratum or 15.2 t total. Juveniles

occurred at low levels throughout the survey area in depths less than 50 m in each survey in the series with catch rates seldom exceeding 25 kg.km^2 (Figure 2).

Estimates of adult biomass by sex and stratum are shown in Table 2 and catch rates by sex are shown in Figures 3 & 4. For the two surveys analysed, biomass estimates and catch rates for females were usually higher in depths less than 50 m while estimates for males were usually higher at depths greater than 50 m.

Hauraki Gulf

Strata used for the 1997 survey (KAH9720) are shown in Figure 5.

Estimates of juvenile biomass by stratum are shown in Table 3. The estimates were generally the lowest of the three trawl survey series analysed, never exceeding 2.5 t for any stratum or 3.4 t total. Coefficients of variation (*c.v.*s) were also more variable and generally higher than for other areas. Catch rates for juveniles were low (< 20 kg.km^2) from all strata where depth was less than 50 m (Figure 6).

Adult biomass estimates by sex and stratum are shown in Table 4 and catch rates by sex are shown in Figures 7–11. Biomass estimates for females were usually higher than those for males at all depths.

West coast North Island

Strata used for the 1996 survey (KAH9615) are shown in Figure 12.

Estimates of juvenile biomass by stratum are shown in Table 5. The estimates were the highest of any of the series analysed and juveniles were more common in depths greater than 50 m than in the other areas (Figure 13). Catch rates frequently exceeded 25 kg.km^2 and were as high as 121.9 kg.km^2.

Adult biomass estimates by sex and stratum are given in Table 6 and catch rates by sex are shown in Figures 14–18. Biomass estimates of females were usually greater in depths less than 50 m while biomass estimates of males were usually greater at depths greater than 50 m.

East coast North Island

Strata used for the 1996 survey (KH9602) are shown in Figure 19.

Estimates of biomass by sex and stratum for adult red gurnard are given in Table 7 and catch rates by sex are shown in Figures 20–23. Biomass estimates of females were usually greater in depths less than 50 m while biomass estimates of males were usually greater at depths greater than 50 m.

Sex ratios

Sex ratios (number of males per female) for red gurnard are given in Table 8. Males were almost always more common in the Bay of Plenty and along the east coast, while females were usually more numerous in the Hauraki Gulf and along the west coast.

Juvenile John dory

Bay of Plenty

Biomass estimates by stratum are given in Table 9. Catch rates are shown in Figure 24. Juvenile John dory were widespread in each survey but were most abundant in depths of 25–100 m.

Hauraki Gulf

Biomass estimates by stratum are given in Table 10. Catch rates are shown in Figure 25. Juvenile John dory were widespread in each survey but were most abundant in depths of 50–100 m.

West coast North Island

Biomass estimates by stratum are given in Table 11. Catch rates are shown in Figure 26. Juvenile John dory were widespread in each survey but were most abundant in depths of 50–100 m.

East coast North Island

Biomass estimates by stratum are given in Table 12. Catch rates are shown in Figure 27. Most John dory were caught in depths of 50–100 m north of Cape Kidnappers.

11. Discussion

This work was undertaken to determine whether the estimates of 1 year old John dory and red gurnard and of adult red gurnard derived from trawl surveys of these areas could be used for monitoring abundance.

The catch rate plots and biomass estimates by strata suggest that the BOP and WCNI surveys are reliably monitoring the relative abundance of red gurnard juveniles. In each case the *c.v.*s are reasonable (usually < 30%), and the fish are widespread in depths less than 50 m in the survey areas when abundant, rather than in one or two localised large catches. Biomass in the HAGU surveys tended to be much lower with higher *c.v.*s and areas with high catch rates were less consistent between years. Also, Elder (1976) found that, in his sampling, catch rates of juvenile red gurnard in the Hauraki Gulf were highest from an area between the Coromandel Peninsula and Great Barrier Island. Few juveniles were caught from this area in the research trawl surveys reported here. It is not known if this represents an actual change in distribution or is an artefact of sampling. Further comparison with the age composition of the adult portions of the trawl surveys or commercial catch needs to be made before the HAGU data are used as indices of year class strength.

The catch rate plots and biomass estimates by strata for juvenile John dory suggest that the BOP, WCNI, and HAGU surveys are reliable monitoring the relative abundance of these fish. The *c.v.*s are reasonable (usually < 30%) and the fish were

caught throughout the survey area rather than in one or two localised large catches. Results from ECNI surveys are less consistent, with higher and more variable *c.v.*s and would need to be used with caution as indices of year class strength.

Distribution by sex of adult red gurnard was similar to that found by Elder (1976) in the Hauraki Gulf. Females were usually more abundant at depths less than 50 m, while males were more common in depths greater than 50 m except in the Hauraki Gulf where females were almost always more common at all depths. There is no evidence that the trawl surveys are not adequately sampling either sex because the sex ratios are not highly skewed. It is therefore recommended that adult indices of abundance can also be used in modelling the fishery.

12. Acknowledgments

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Table 1 : **Estimates of biomass (t) (*c.v.* % in brackets) by stratum of 1+ red gurnard from Bay of Plenty trawl surveys (grouped strata are roughly comparable)**

Depth	KAH8303		KAH9004		KAH9202		KAH9601	
range (m)	Stratum	Biomass	Stratum	Biomass	Stratum	Biomass	Stratum	Biomass
10–25	1B	0.6	112	0.9	112	0.1		
10–25	1A	2.2	1185	1.2	1185	0.3	1096	0.6
10–25	2A	0.8	2185	0.2	2185	0		
10–25	2B	0.4	2285	0.1	2285	0.0	2096	0.1
			2385	0.1	2385	0		
10–25	3	2.3	3087	0.1	31SH	0.1		
					32NH	0	32NH	0
25–50	4	1.2	4085	3.0	4085	0.7	4085	2.0
25–50	5	0.8	5187	6.0	5187	0	5187	0.2
			5287	2.7	5287	< 0.1	5287	0.1
50–100	6	0.4	60	0.7	6085	0.1	6085	0
50–100	7	0	70	0.5	7085	0	7085	0.4
100–150	8	0	80	0	8085	0	808C	0
100–150							808E	0
100–150							808N	0
	Total	8.8		15.2		1.3		3.4
		(23)		(34)		(25)		(32)

Table 2 : **Estimated biomass (t) by stratum for adult (>19 cm) red gurnard from Bay of Plenty trawl surveys (bold numbers indicate the sex with the higher biomass for a stratum)**

		KAH9202				KAH9601	
	Depth	Biomass			Depth	Biomass	
Stratum	range (m)	Males	Females	Stratum	range (m)	Males	Females
112	10–25	2.0	**8.1**	1096	10–25	3.8	**23.3**
1185	10–25	0.9	**11.6**				
2185	10–25	0.2	**1.8**				
2285	10–25	0	**1.1**	2096	10–25	2.5	**9.0**
2385	10–25	0.1	**0.8**				
31SH	10–25	1.1	**6.2**				
32NH	10–25	0	**0.2**	32NH	10–25	0.1	**1.0**
4085	25–50	14.2	**28.9**	4085	25–50	**28.5**	24.7
5187	25–50	7.4	**14.3**	5187	25–50	8.1	**13.6**
5287	25–50	12.5	**15.3**	5287	25–50	12.1	**16.0**
6085	50–100	**26.4**	14.7	6085	50–100	**50.6**	12.2
7085	50–100	**53.4**	35.9	7085	50–100	**61.1**	34.8
8085	100–150	**6.8**	4.5	808C	100–150	**4.1**	1.8
		125.0	143.4	808E	100–150	**2.1**	0.0
				808N	100–150	**3.3**	1.4
				909C	150–250	0	**0.9**
				909E	150–250	0	0
				909N	150–250	—	—
						176.3	138.7

—, Insufficient stations to calculate a biomass

Table 3 : **Estimates of biomass (t) (*c.v.* % in brackets) by stratum of juvenile red gurnard from Hauraki Gulf trawl surveys (grouped strata are roughly comparable)**

		KAH8613	KAH8716		KAH8810		KAH8917		KAH9016		KAH9212		KAH311		KAH9411		KAH9720	
Stratum	Depth range (m)	Biomass	Stratum	Biomass	Stratum	Biomass	Stratum	Biomass	Stratum	Biomass	Stratum	Biomass	Stratum	Biomass	Stratum	Biomass	Stratum	Biomass
12	10–25	0	12	< 0.1	12	< 0.1	12	< 0.1	1284	0	1284	< 0.1	1284	0	1284	0.1	1284	< 0.1
13	10–25	0.1	13	< 0.1	13	< 0.1	13	< 0.1	1386	0	1386	< 0.1	1386	—	1386	0.1	1386	0
14	10–25	< 0.1	114	< 0.1	114	< 0.1	114	< 0.1	1148	0	1149	0.1	1149	—	1149	0.1	1149	0.1
			44	0	44	0	44	0	4487	0	4492	0	4492	0	4492	0.1	4492	0
80	10–25	< 0.1	18	0.1	18	0.1	18	0.08	1887	0.2	1887	0.4	1887	0.1	1887	2.0	1887	0.9
26	10–50	0.1	126	0.2	126	0.4	126	< 0.1	1268	0.1	1268	0.3	1268	< 0.1	1268	0.3	1268	0.6
141	10–50	0.2	144	< 0.1	144	0	144	0	1448	0.1	1449	0.1	1449	0	1449	0	1449	0.3
121	25–50	0	121	0	121	0.1	121	0	1218	0	1219	0	1219	0	1219	0.6	1219	0.1
122	10–50	< 0.1	222	0	222	0.1	222	< 0.1	2228	0	2229	0	2229	0	2229	0.1	2229	0.1
151	75–150	0	151	0	151	0	151	0	1518	0	1518	0	1518	0	1518	0	1518	0
											9292	< 0.1	9292	0	9292	0.1	9292	< 0.1
Total		0.4		0.3		0.7		0.2		0.4		1.0		0.1		3.4		2.1
		(57)		(41)		(25)		(49)		(38)		(26)		(71)		(19)		(20)

— Insufficient stations to calculate biomasss

Table 4 : **Estimated biomass (t) by stratum for adult (>18 cm) red gurnard from Hauraki Gulf trawl surveys (grouped strata are roughly comparable)**

		KAH9016			KAH9212		KAH9311		KAH9411		KAH9720	
		Biomass			Biomass		Biomass		Biomass		Biomass	
Depth range (m)	Stratum	Males	Females	Stratum	Males	Females	Males	Females	Males	Females	Males	Females
10–25	1148	0	**< 0.1**	1149	0	**0.1**	NA	NA	0	0	0.2	**0.4**
10–25	1284	< 0.1	**0.2**	1284	1.1	**2.3**	0.2	**0.7**	0.7	**1.5**	0.8	**1.8**
10–25	1386	0	0	1386	< 0.1	**0.6**	NA	NA	0.2	**0.3**	0.1	**0.3**
10–25	1887	0	**0.6**	1887	**0.9**	0.4	< 0.1	**0.4**	0.4	**3.4**	0	**0.4**
10–25				9292	0.4	**1.1**	0.2	**0.3**	**1.4**	0.8	**0.1**	0
10–50	1268	0.4	**1.7**	1449	14.6	**29.7**	2.9	**7.4**	12.2	**19.9**	7.0	**38.6**
10–50	1448	2.1	**10.5**	4492	60.8	**107.1**	31.8	**65.1**	41.8	**52.5**	38.7	**70.8**
10–50	2228	0	**0.2**	1268	1.3	**2.7**	0.5	**1.8**	2.0	**2.3**	0.9	**2.6**
10–75	4487	16.7	**59.0**	2229	1.2	**3.8**	1.6	**3.2**	0.2	**2.2**	2.1	**4.3**
25–50	1218	1.3	**5.2**	1219	22.6	**33.4**	4.7	**14.7**	22.3	**33.2**	8.9	**13.6**
75–150	1518	17.5	**20.4**	1518	5.6	**36.2**	**22.4**	15.3	8.4	**29.4**	2.3	**6.5**

Table 5 : **Estimates of biomass (t) (*c.v.* % in brackets) by stratum of 1+ red gurnard from west coast North Island trawl surveys (grouped strata are roughly comparable)**

KAH8918			KAH9111			KAH9410		KAH9615	
Stratum	Depth range (m)	Biomass	Stratum	Depth range (m)	Biomass	Stratum	Biomass	Stratum	Biomass
GEB1	10–25	0							
GEB2	25–50	0							
WCN3	10–50	0.7	C25	10–25	0.4	C25	1.6	C25	6.9
				25–50		C50	3.6	C50	5.9
WCN2	10–50	0.4	A25	10–25	< 0.1			A25	3.6
			B25	10–25	0.1	B25	0.2	B25	2.8
			A50	25–50	1.0	AA50	1.8	AA50	15.7
			B50	25–50	1.8	BB50	0.6	B50	3.5
WCM3	10–25	0.3	D25	10–25	0.2	D25	0.1	D25	0.6
			E25	10–25	0.2	E25	0	E25	0.1
WCS5	10–25	0.1	F25	10–25	0.2	F25	1	F25	0.2
			G25	10–25	< 0.1	G25	0.2	G25	2.4
WCM2	25–50	0.6	D50	25–50	1.1	DD50	< 0.1	DD50	5.8
WCS3	25–50	0.8	E50	25–50	0.3	E50	8.7	E50	0.8
				25–50		RG50	2.6	RG50	1.3
WCS4		2.6	F50	25–50	0.4	F50	1.8	F50	0.5
WCN1	50–100	1.4	A100	50–100	0.2			A100	17.2
			B100	50–100	3.6	B100	0.8	B100	65.3
WCM1	50–100	5.2	C100	50–100	17.1	C100	6.8	C100	6.9
			E100	50–100	15.2	E100	17.6	E100	8.9
WCS2	50–75	8.2	F100	50–100	7.4	F100	1.2	F100	0
WCS1	75–100	0.6							
			H25	10–25	0				
			I25	10–25	0				
			J25	10–25	0.1				
			G50	25–50	3.6				
			H50	25–50	0.1				
			I50	25–50	< 0.1				
			G100	50–100	0				
			A200	100–200	0			A200	0
			B200	100–200	0			B200	0
			C200	100–200	0			C200	0
			E200	100–200	0			E200	0
			F200	100–200	0			F200	0
Total		20.9			52.7		48.4		148.1
		(25)			(31)		(27)		(21)

Table 6 : **Estimated biomass (t) by stratum for adult (>19 cm) red gurnard from west coast North Island trawl surveys**

KAH8715

Stratum	Depth range (m)	Biomass Males	Biomass Females
34	10–25	5.2	**53.9**
54	10–25	25.1	**164.6**
64	10–25	1.3	**8.7**
74	10–25	3.2	**30.1**
44	10–50	9.7	**37.3**
33	25–50	20.9	**64.6**
43	25–50	5.5	**14.6**
53	25–50	27.8	**131.9**
63	25–50	0.3	**7.6**
73	25–50	44.7	**167.2**
32	50–75	**50.9**	34.8
42	50–75	21.6	**24.5**
52	50–75	160.6	**403.9**
62	50–75	**54.4**	50.6
72	50–75	**80.0**	62.3
31	75–100	**24.4**	5.5
41	75–100	0.2	**0.4**
51	75–100	**13.5**	2.0
61	75–100	**1.2**	0.3
71	75–100	**102.5**	61.2

KAH8918

Stratum	Depth range (m)	Biomass Males	Biomass Females
GEB1	10–25	1.17	**4.7**
WCM3	10–25	14.31	**85.43**
WCS5	10–25	2.08	**38.15**
WCN2	10–50	6.53	**160.19**
WCN3	10–50	10.53	**118.11**
WCM2	25–50	26.08	**269.48**
WCS3	25–50	10.29	**78.68**
WCS4	25–50	41.55	**140.21**
GEB2	25–75	2.22	**4.1**
WCM1	50–100	98.16	**107.56**
WCN1	50–100	88.07	**140.75**
WCS2	50–75	247.68	**260.38**
WCS1	75–100	**49.23**	28.33

KAH9111

Stratum	Depth range (m)	Biomass Males	Biomass Females
A25	10–25	10.4	**78.8**
B25	10–25	1.7	**22.2**
C25	10–25	21.4	**75.5**
D25	10–25	1.4	**12.8**
E25	10–25	4.7	**18.5**
F25	10–25	4.9	**13.7**
G25	10–25	10.5	**81.5**
H25	10–25	0	0
I25	10–25	0	**10.8**
J25	10–25	0.6	**9.0**
A50	25–50	83.3	**366.3**
B50	25–50	27.9	**95.6**
D50	25–50	12.0	**74.7**
E50	25–50	3.6	**48.8**
F50	25–50	4.2	**91.9**
G50	25–50	108.2	**205.3**
H50	25–50	3.6	**14.5**
I50	25–50	0.4	**3.1**
A100	50–100	120.1	**294.2**
B100	50–100	**189.6**	137.8
C100	50–100	**206.1**	116.3
E100	50–100	408.1	**482.2**
F100	50–100	237.8	**366.2**
G100	50–100	**49.4**	26.5
A200	100–200	2.2	**4.3**
B200	100–200	**3.6**	1.9
C200	100–200	**3.5**	3.3
E200	100–200	**12.8**	8.2
F200	100–200	**36.3**	10.1

KAH9410

Stratum	Depth range (m)	Biomass Males	Biomass Females
B25	10–25	1.4	**22.8**
C25	10–25	9.7	**73.3**
D25	10–25	0.2	**4.6**
E25	10–25	0.3	**4.5**
F25	10–25	1.7	**20.3**
G25	10–25	0.4	**16.2**
AA50	25–50	35.5	**211.6**
BB50	25–50	17.0	**87.5**
C50	25–50	29.0	**143.5**
DD50	25–50	0.5	**28.2**
E50	25–50	14.8	**69.2**
F50	25–50	33.7	**173.9**
RG50	25–50	8.9	**81.6**
B100	50–100	**187.0**	80.5
C100	50–100	167.0	**330.8**
E100	50–100	490.1	**736.3**
F100	50–100	**267.1**	188.3

Table 6—continued

		KAH9615	
	Depth	Biomass	
Stratum	range (m)	Males	Females
A25	10–25	12.2	**85.7**
B25	10–25	1.3	**39.5**
C25	10–25	16.1	**118.5**
D25	10–25	4.6	**32.7**
E25	10–25	1.9	**22.7**
F25	10–25	3.8	**30.4**
G25	10–25	27.2	**227.7**
AA50	25–50	39.0	**183.4**
B50	25–50	13.8	**99.0**
C50	25–50	17.4	**109.2**
DD50	25–50	11.6	**82.8**
E50	25–50	2.2	**29.9**
F50	25–50	4.2	**88.5**
RG50	25–50	7.3	**46.8**
A100	50–100	**82.6**	48.6
B100	50–100	**213.0**	208.6
C100	50–100	137.9	**159.8**
E100	50–100	**347.0**	225.1
F100	50–100	**13.6**	5.2
A200	100–200	3.2	**11.6**
B200	100–200	**13.7**	3.3
C200	100–200	**19.8**	7.9
E200	100–200	**5.7**	2.3
F200	100–200	**14.2**	6.6

Table 7: **Estimated biomass (t) by stratum for adult (>19 cm) red gurnard from east coast North Island trawl surveys**

KAH9304

Stratum*	Depth range (m)	Biomass Males	Biomass Females
7	20–50	**25.8**	15.8
11	20–50	8.8	**80.0**
15	20–50	**117.6**	78.6
8	50–100	**4.5**	1.5
12	50–100	**40.9**	8.2
16	50–100	**27.6**	9.9
9	100–200	0.1	**0.4**
13	100–200	6.6	**8.5**
17	100–200	**1.8**	0.5
10	200–400	0	0
14	200–400	0	0
18	200–400	0	0

KAH9402

Stratum	Depth range (m)	Biomass Males	Biomass Females
1	20–50	**53.6**	51.7
5	20–50	**38.1**	26.2
9	20–50	109.0	**197.7**
12	20–50	11.2	**23.8**
2	50–100	**8.2**	6.4
6	50–100	26.1	**26.2**
10	50–100	**126.9**	80.1
13	50–100	**30.4**	12.6
3	100–200	0	0
7	100–200	0	**0.2**
11	100–200	**17.5**	12.9
14	100–200	4.6	**5.7**
4	200–400	0	0
8	200–400	0	0
15	200–400	0	0

KAH9502

Stratum	Depth range (m)	Biomass Males	Biomass Females
1	20–50	**2.7**	1.4
5	20–50	**10.3**	8.0
9	20–50	8.4	**38.5**
12	20–50	1.3	**9.4**
2	50–100	**1.4**	0.5
6	50–100	**7.9**	4.9
10	50–100	**42.4**	15.4
13	50–100	**9.2**	5.6
3	100–200	0	0
7	100–200	0	0
11	100–200	1.6	**3.4**
14	100–200	2.9	**3.0**
4	200–400	0	0
8	200–400	0	0
15	200–400	0	0

KAH9602

Stratum	Depth range (m)	Biomass Males	Biomass Females
1	20–50	**24.9**	17.1
5	20–50	43.0	**45.5**
9	20–50	73.1	**224.5**
12	20–50	6.1	**36.3**
2	50–100	**7.2**	2.8
6	50–100	**37.9**	28.2
10	50–100	**67.8**	16.1
13	50–100	**25.8**	16.4
3	100–200	**0.3**	0.2
7	100–200	0	**0.8**
11	100–200	**16.5**	8.4
14	100–200	**5.3**	3.7
4	200–400	0	0
8	200–400	0	0
15	200–400	0	0

* Strata 1–6 excluded for comparability

Table 8: **Sex ratios (number of males per female) of red gurnard**

Area	Year	1988	1989	1990	1991	1992	1993	1994	1996	1997
Bay of Plenty						1.22			1.91	
Hauraki Gulf				0.77		0.98	0.99	1.32		0.73
West coast North Island		0.83	0.64		1.02			0.93	0.95	
East coast North Island							1.29	1.37	1.77	0.99

Table 9: **Estimates of biomass (t) (*c.v.* % in brackets) by stratum of juvenile John dory from Bay of Plenty trawl surveys (grouped strata are roughly comparable)**

Depth	KAH8303		KAH9004		KAH9202		KAH9601	
range (m)	Stratum	Biomass	Stratum	Biomass	Stratum	Biomass	Stratum	Biomass
10–25	1B	0	112	< 0.1	112	0.1		
10–25	1A	0	1185	< 0.1	1185	0	1096	0.2
10–25	2A	0	2185	0.3	2185	0.13		
10–25	2B	1.6	2285	0.1	2285	1.4	2096	0.6
			2385	0.1	2385	0.37		
10–25	3	0	3087	0.2	31SH	0.6	†	
					32NH	0	32NH	0.2
25–50	4	0	4085	2.8	4085	1.0	4085	1.7
25–50	5	0.8	5187	2.1	5187	9.4	5187	0.6
			5287	5.1	5287	16.7	5287	0.8
50–100	6	3.0	60	2.2	6085	3.1	6085	1.6
50–100	7	12.2	70	20.3	7085	6.32	7085	11.8
100–150	8	0.3	80	3.43	8085	1.5	808C	0
100–150	†		†		†		808E	0
100–150	†		†		†		808N	0.2
	Total	17.9		36.6		40.6		17.7
		(29)		(14)		(28)		(22)

Table 10: **Estimates of biomass (t) (*c.v.* % in brackets) by stratum of juvenile John dory from Hauraki Gulf trawl surveys (adjacent strata are roughly comparable)**

Depth	KAH8613		KAH8716		KAH8810		KAH8917		KAH9016	
range (m)	Stratum	Biomass	Stratum	Biomass	Stratum	Biomass	Stratum	Biomass	Stratum	Biomass
10–25	12	0.2	12	0.3	12	0.1	12	0.1	1284	< 0.1
10–25	13	0.6	13	0.1	13	0.1	13	0.2	1386	0.1
10–25	14	0.2	114	0.5	114	0.1	114	0.1	1148	< 0.1
			44	0	44	1.4	44	1.4	4487	4.8
10–25	80	0.8	18	3.4	18	1.8	18	0.2	1887	0.4
10–50	26	2.7	126	1.4	126	1.6	126	0.4	1268	3.1
10–50	141	10.9	144	0.5	144	0.3	144	0.4	1448	0.4
25–50	121	5.1	121	10.0	121	4.3	121	2.4	1218	1.2
10–50	122	0.9	222	0.9	222	0.5	222	0.2	2228	0.2
75–150	151	2.8	151	0.6	151	0	151	0	1518	7.6
	Total	24.2		17.7		10.3		5.2		17.8
		(28)		(37)		(22)		(32)		(46)

Depth	KAH9212		KAH311		KAH9411		KAH9720	
range (m)	Stratum	Biomass	Stratum	Biomass	Stratum	Biomass	Stratum	Biomass
10–25	1284	0.2	1284	0.2	1284	0.1	1284	0.1
10–25	1386	0.1	1386	0.2	1386	0.2	1386	0.1
10–25	1149	0	1149	< 0.1	1149	0.1	1149	< 0.1
10–75	4492	7.8	4492	8.5	4492	8.0	4492	6.7
10–25	1887	0.5	1887	0.2	1887	0.6	1887	0.3
10–50	1268	0.6	1268	0.5	1268	0.3	1268	0.7
10–50	1449	0.7	1449	0.3	1449	1.66	1449	0.5
25–50	1219	1.5	1219	1.2	1219	3.9	1219	0.4
10–50	2229	0.9	2229	1.8	2229	1.6	2229	1.5
75–150	1518	0	1518	4.5	1518	0	1518	6.2
10–75	9292	< 0.1	9292	0	9292	< 0.1	9292	0.1
	Total	12.6		17.3		16.5		16.5
		(21)		(29)		(13)		(21)

† strata not surveyed

— Insufficient stations to calculate biomasss

Table 11 : **Estimates of biomass (t) (*c.v.* % in brackets) by stratum of juvenile John dory from west coast North Island trawl surveys* (grouped strata are roughly comparable)**

Depth	KAH8612		KAH8715		KAH8918	
range (m)	Stratum	Biomass	Stratum	Biomass	Stratum	Biomass
0–25	G4	0	†		GEB1	0
0–25	H4	0	†			
25–50	G3	0	†		GEB2	0.1
25–50	H3	0	†			
50–75	G2	0	†			
50–75	H2	0	†			
75–100	G1	0	†		†	
75–100	H1	0	†		†	
0–25	C4	0	0044	0	WCN3	0.3
25–50	C3	0	0043	0		
50–75	C2	0	0042	0		
75–100	C1	0	0041	0		
0–25	A4	0.1	0034	0	WCN2	1.3
0–25	B4	0				
25–50	A3	0.5	0033	0.2		
25–50	B3	0				
0–25	D4	0	0054	0	WCM3	0.6
0–25	E4	0	0064	0.1		
0–25	F4	0	0074	0		
0–25	†		†		WCS5	0.2
25–50	D3	0.2	0053	0	WCM2	3.1
25–50	E3	0.4	0063	0.2		
25–50	F3	0.5	0073	0	WCS3	0.3
25–50	†		†		WCS4	0.6
50–75	A2	0.1	0032	0	WCN1	2.3
50–75	B2	0				
75–100	A1	0	0031	0.2		
75–100	B1	0.3				
50–75	D2	2.8	0052	0.2	WCM1	2.6
50–75	E2	0.9	0062	0.3		
75–100	D1	0.3	0051	0.4		
75–100	E1	0.6	0061	0.2		
50–75	F2	1.2	0072	0.3	WCS2	1.8
75–100	F1	0.8	0071	1.2	WCS1	0.5
Total		8.6		3.1		13.2
		(37)		(17)		

† strata not surveyed

Table 11—continued

Depth	KAH9111		KAH9410		KAH9615	
range (m)	Stratum	Biomass	Stratum	Biomass	Stratum	Biomass
10–25	C25	0	C25	0	C25	0.1
25–50	†		C50	0.1	C50	0.3
10–25	A25	0.3	†		A25	0.1
10–25	B25	< 0.1	B25	0	B25	0.1
25–50	A50	2.2	AA50	1.2	AA50	1.4
25–50	B50	0.4	BB50	0.4	B50	0.2
10–25	D25	0	D25	0	D25	0
10–25	E25	0	E25	0	E25	0
10–25	F25	0	F25	0	F25	0
10–25	G25	0.2	G25	0	G25	> 0.1
25–50	D50	0.3	DD50	0	DD50	0
25–50	E50	0	E50	0	E50	0
25–50	†		RG50	0	RG50	0.1
25–50	F50	0	F50	0	F50	0.2
50–100	A100	9.3	†		A100	2.8
50–100	B100	0.0	B100	3.2	B100	1.8
50–100	C100	1.2	C100	3.9	C100	4.2
50–100	E100	10.8	E100	7.3	E100	1.0
50–100	F100	0.4	F100	0.5	F100	0.1
10–25	H25	0	†		†	
10–25	I25	0	†		†	
10–25	J25	0.1	†		†	
25–50	G50	2.7	†		†	
25–50	H50	0.8	†		†	
25–50	I50	0.4	†		†	
50–100	G100	8.5	†		†	
100–200	A200	0	†		A200	0.2
100–200	B200	0	†		B200	0.2
100–200	C200	0.2	†		C200	0.6
100–200	E200	0.8	†		E200	1.7
100–200	F200	1.15	†		F200	0.8
	Total	39.8		48.4		15.8
		(34)		(27)		(15)

† strata not surveyed

Table 12 : **Estimated biomass (t) by stratum for juvenile juvenile John dory from east coast North Island trawl surveys (only strata along the North Island are included)**

KAH9304

Depth range (m)	Stratum	Biomass
20–50	7	0.1
20–50	11	0.5
20–50	15	0
50–100	8	0.2
50–100	12	5.0
50–100	16	1.6
100–200	9	0
100–200	13	0.1
100–200	17	0
200–400	10	0
200–400	14	0
200–400	18	0
Total		7.6
		(20)

KAH9402

Depth range (m)	Stratum	Biomass
20–50	1	0
20–50	5	0
20–50	9	4.3
20–50	12	0.6
50–100	2	0
50–100	6	0
50–100	10	0.5
50–100	13	0.5
100–200	3	0
100–200	7	0
100–200	11	0.1
100–200	14	0
200–400	4	0
200–400	8	0
200–400	15	0
		6.0
		(73)

KAH9502

Depth range (m)	Stratum	Biomass
20–50	1	0
20–50	5	0
20–50	9	0.5
20–50	12	0.1
50–100	2	0
50–100	6	0
50–100	10	0
50–100	13	0.2
100–200	3	0
100–200	7	0
100–200	11	0
100–200	14	0.2
200–400	4	0
200–400	8	0
200–400	15	0
Total		1.0
		(59)

KAH9602

Depth range (m)	Stratum	Biomass
20–50	1	0
20–50	5	0
20–50	9	0
20–50	12	1.5
50–100	2	0
50–100	6	0.3
50–100	10	1.3
50–100	13	1.5
100–200	3	0
100–200	7	0
100–200	11	0.9
100–200	14	0
200–400	4	0
200–400	8	0
200–400	15	0
		5.5
		(31)

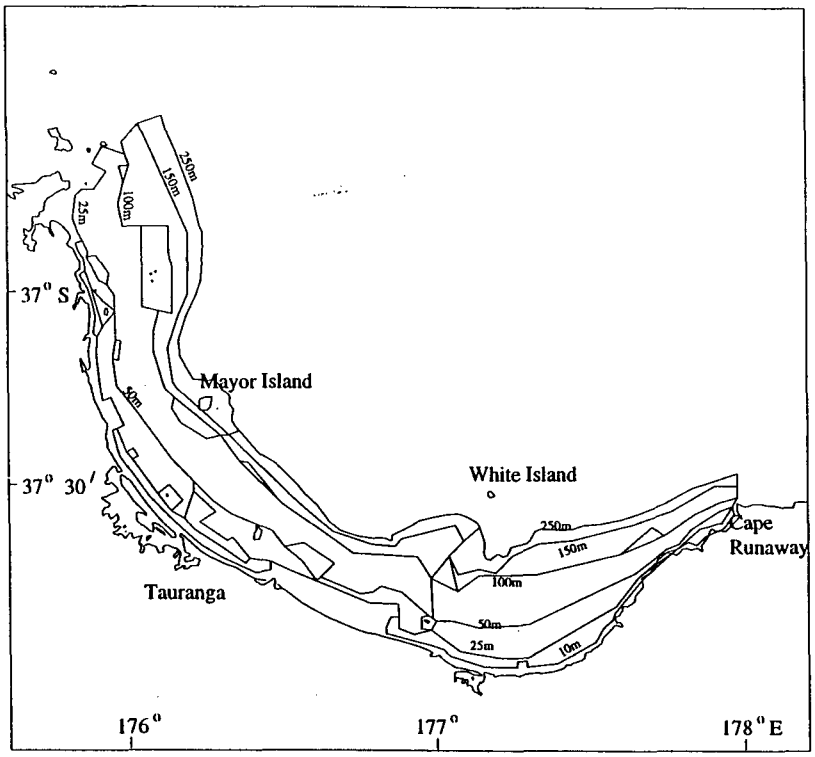


Figure 1: **Stratum boundaries from the 1996 Bay of Plenty trawl survey (KAH9601) (foul ground not shown).**

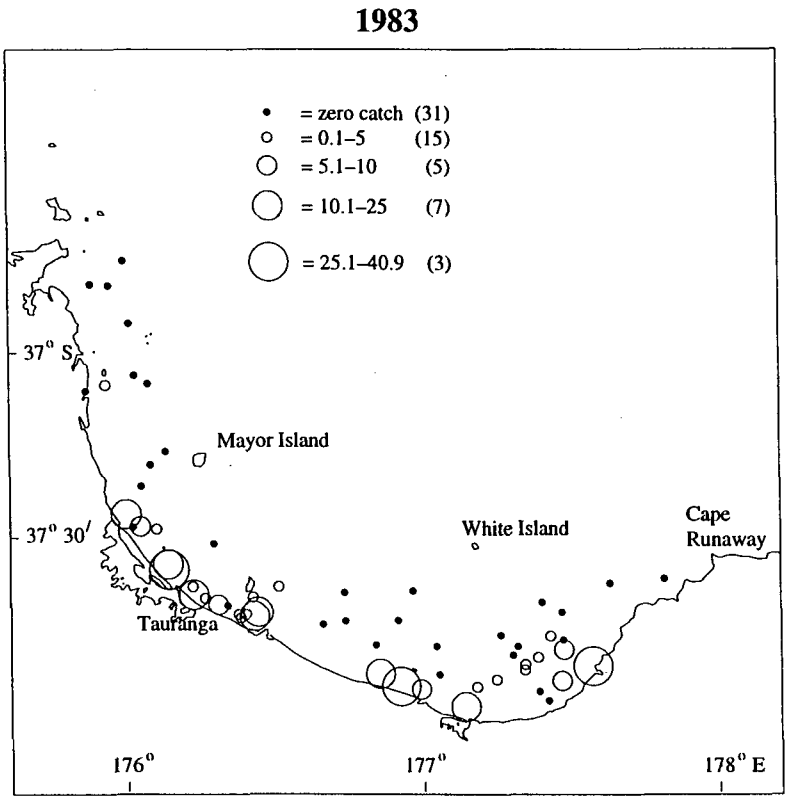
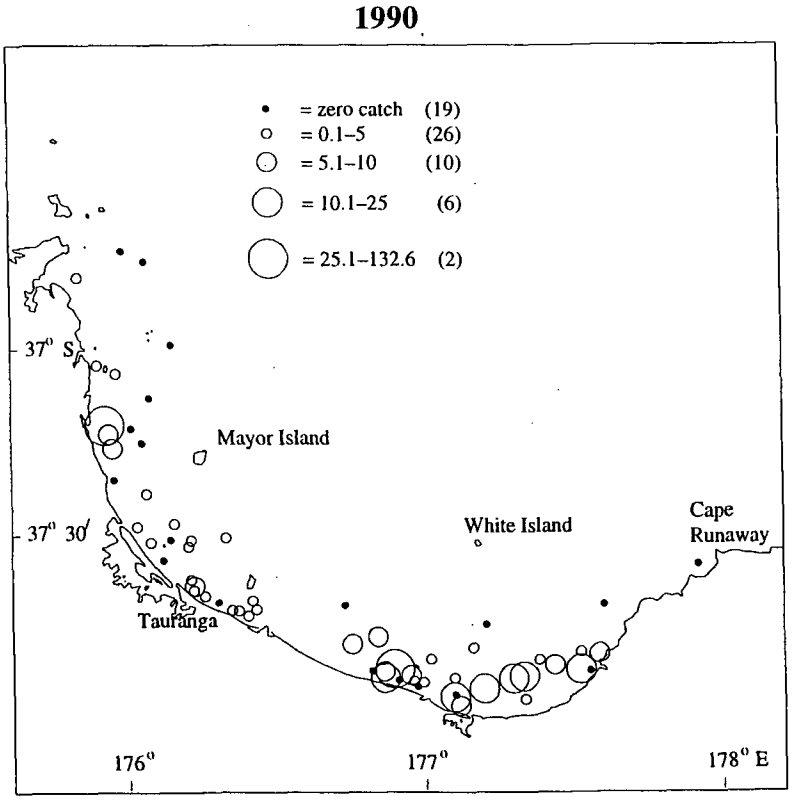


Figure 2: **Catch rates (kg.km^2) for juvenile (<20 cm) red gurnard from Bay of Plenty surveys (numbers in brackets are the number of stations within the given range).**



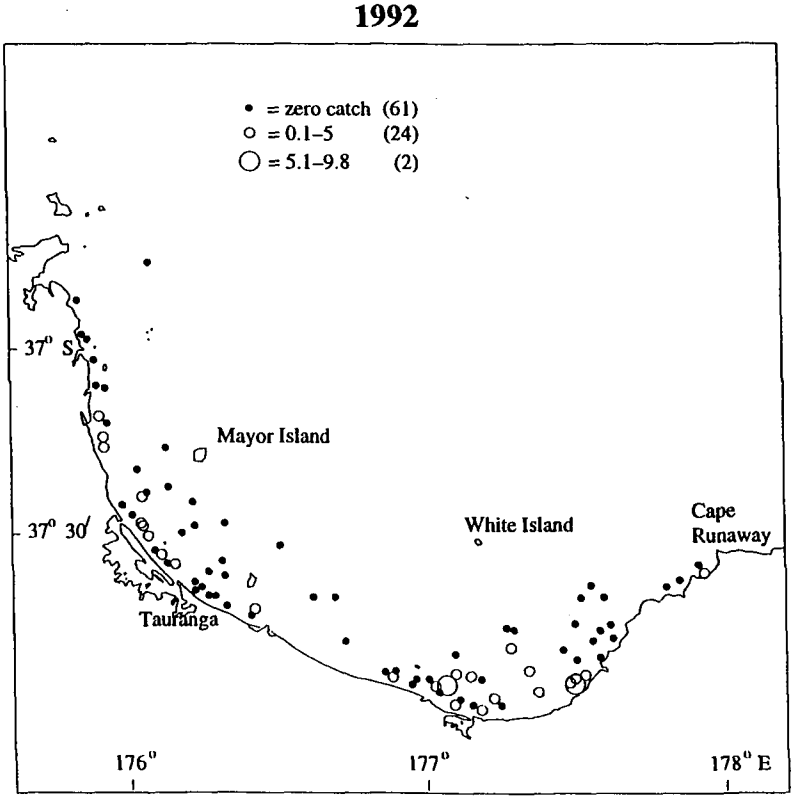


Figure 2–continued

1996

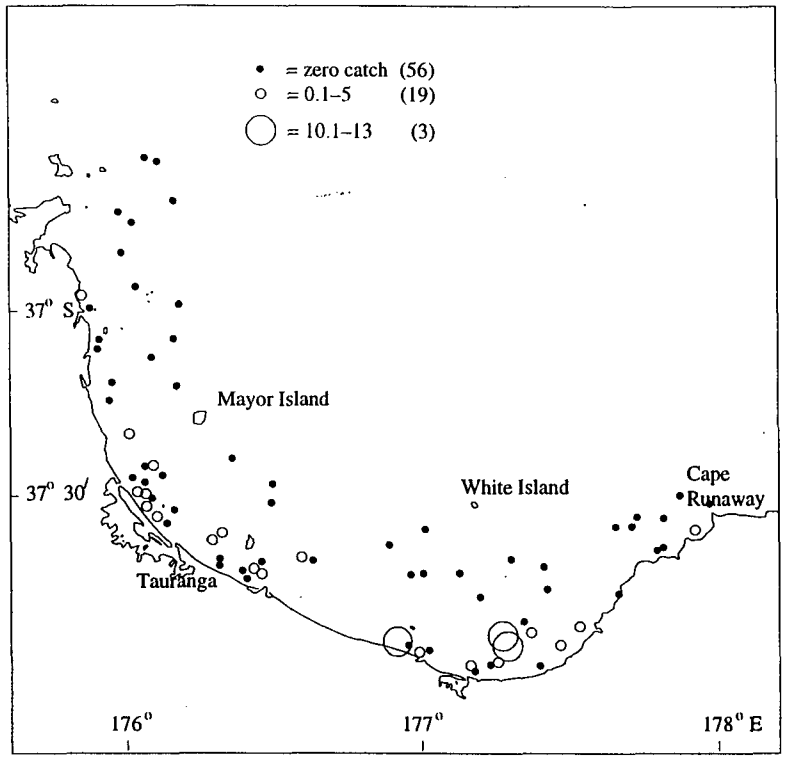
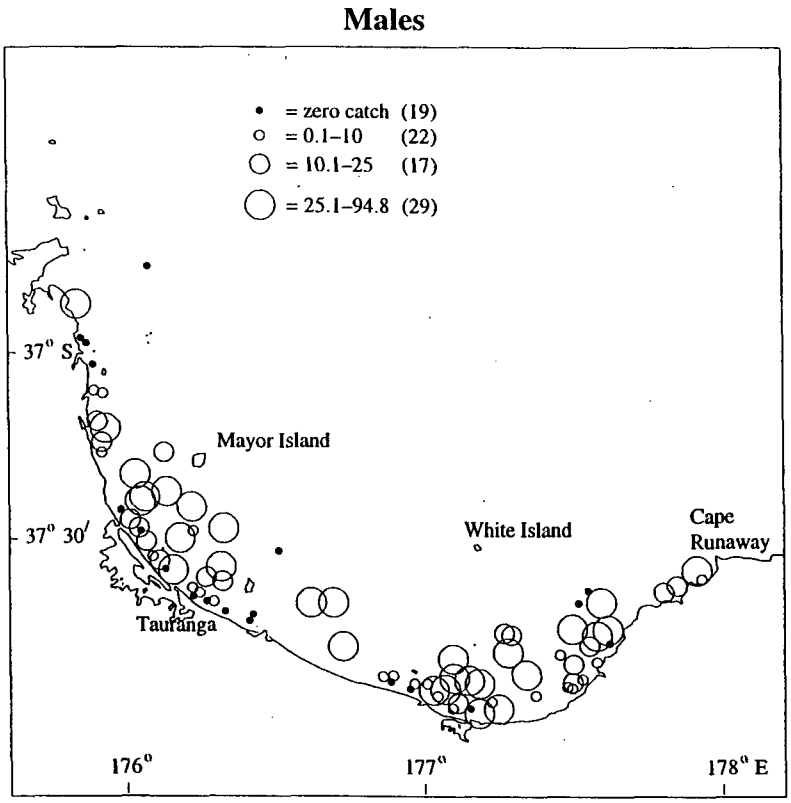


Figure 2—continued



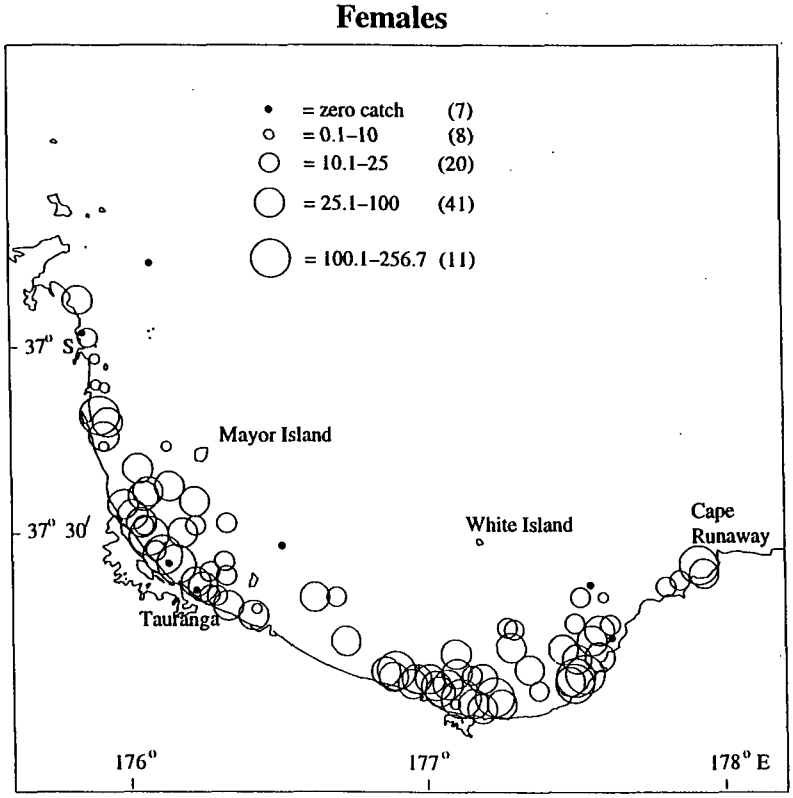
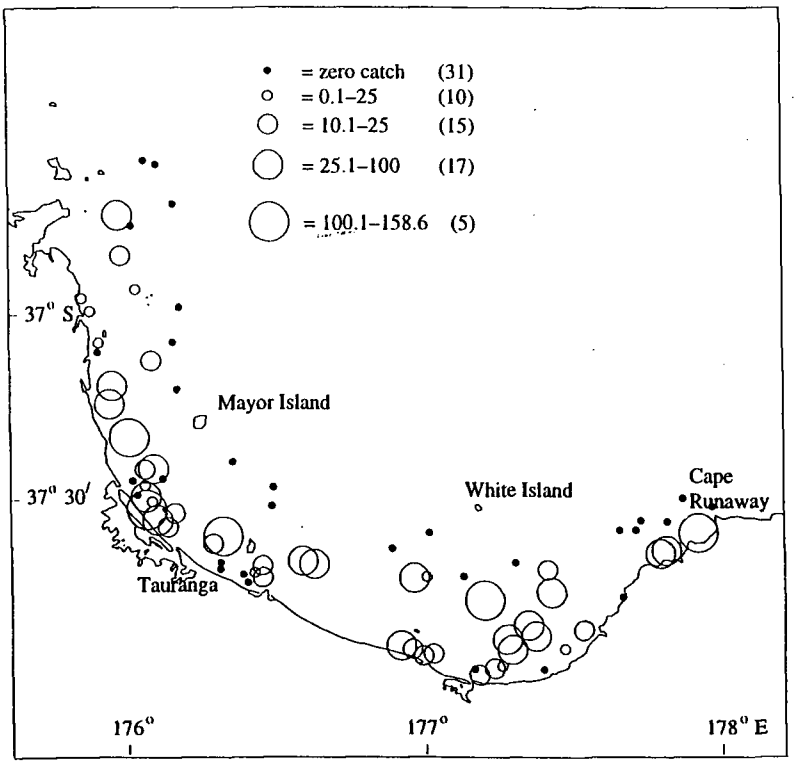


Figure 3 **: Catch rates (kg.km^2) for adult (>19 cm) red gurnard from the 1992 BOP trawl survey (KAH9202) (numbers in brackets are the numbers of stations within the given range).**

Males



Females

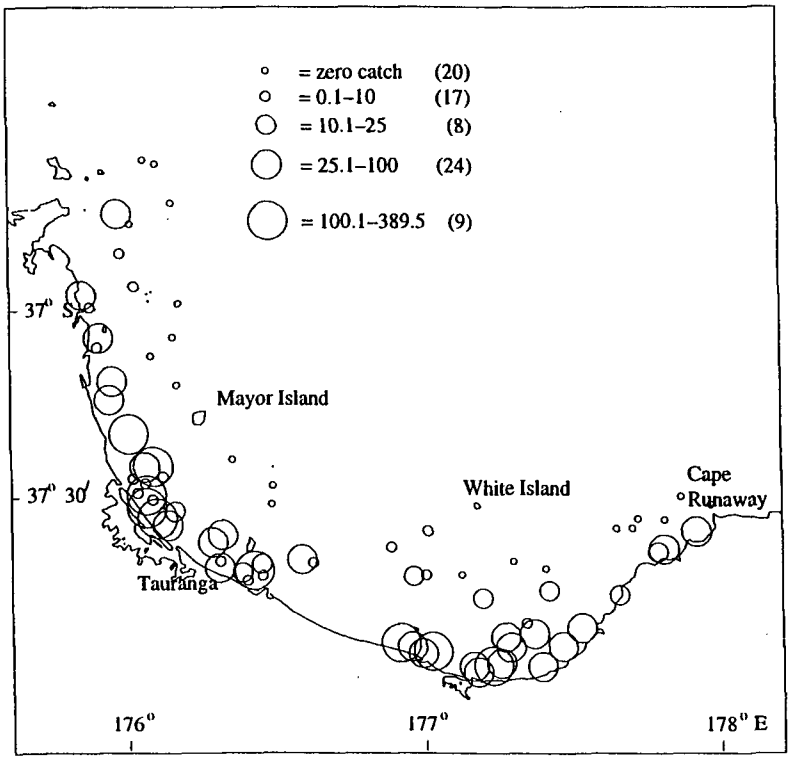


Figure 4 **: Catch rates (kg.km^2) for adult (>19 cm) red gurnard from the 1996 BOP trawl survey (KAH9601) (numbers in brackets are the numbers of stations within the given range).**

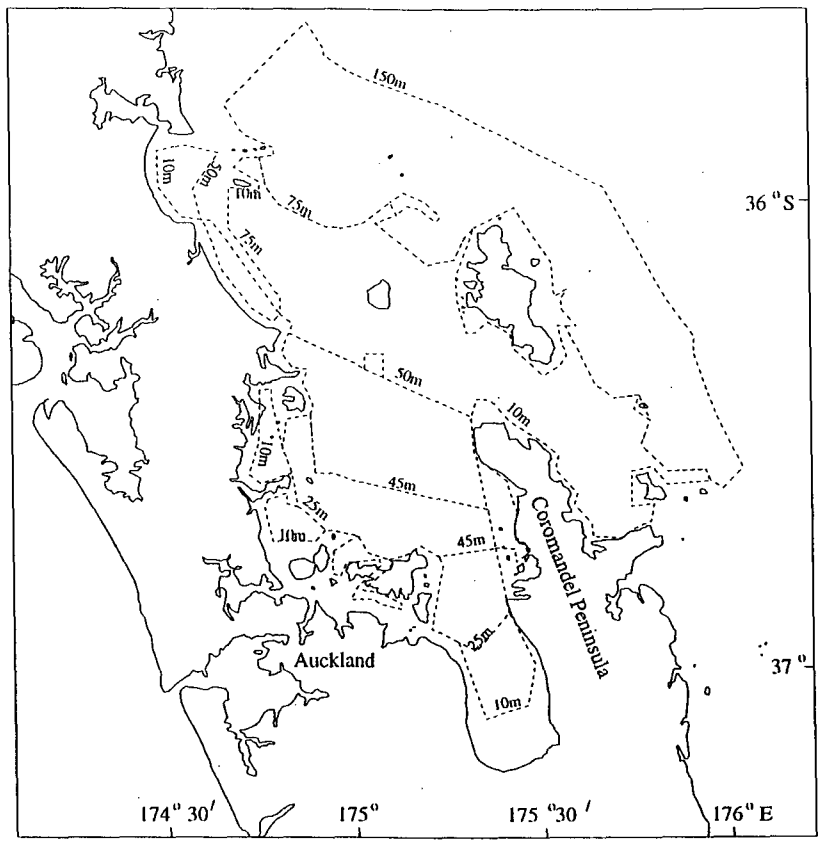


Figure 5: **Stratum boundaries for 1994 Hauraki Gulf trawl survey (KAH9411) (foul ground not shown).**

1986

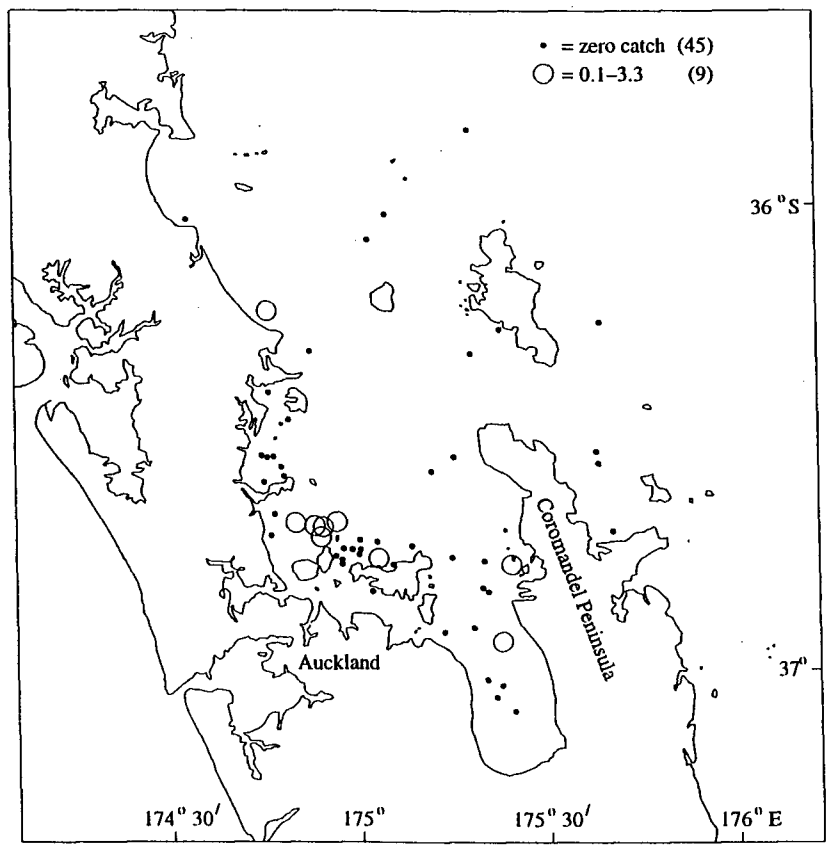
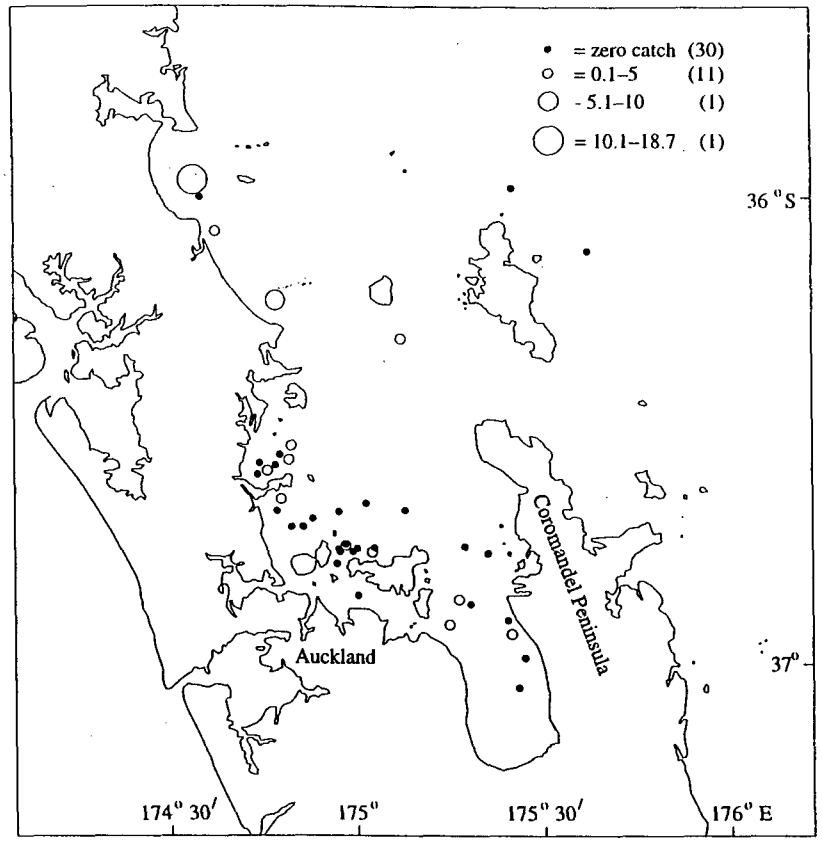


Figure 6: **Catch rates (kg.km^2) for juvenile (<19 cm) red gurnard from Hauraki Gulf surveys (numbers in brackets are the number of stations within the given range).**

1987



1988

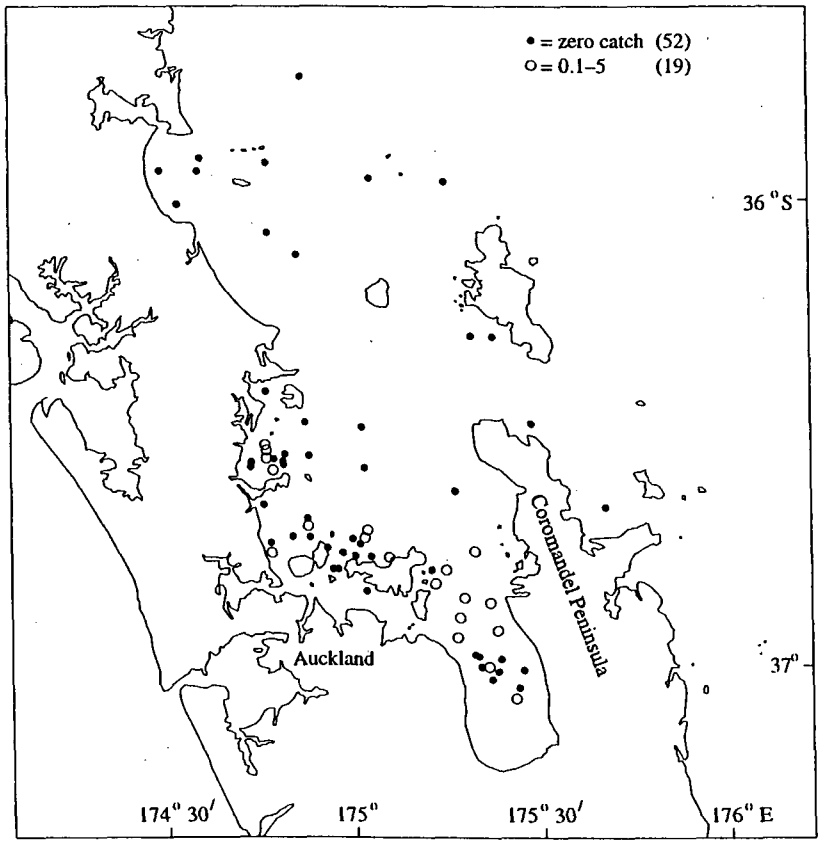
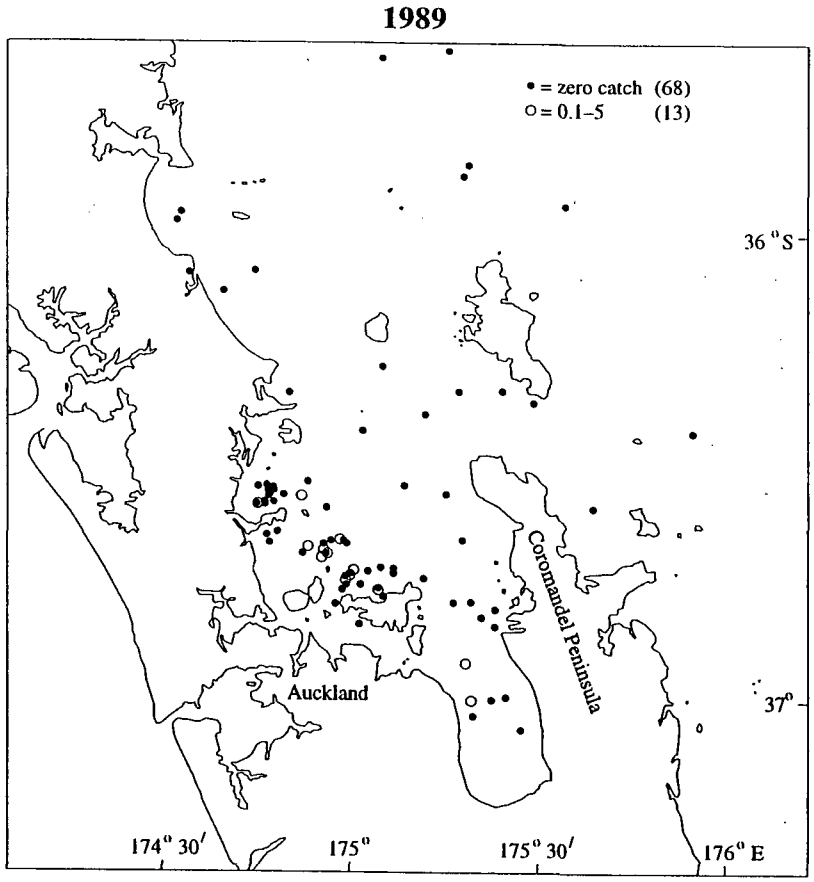


Figure 6—continued



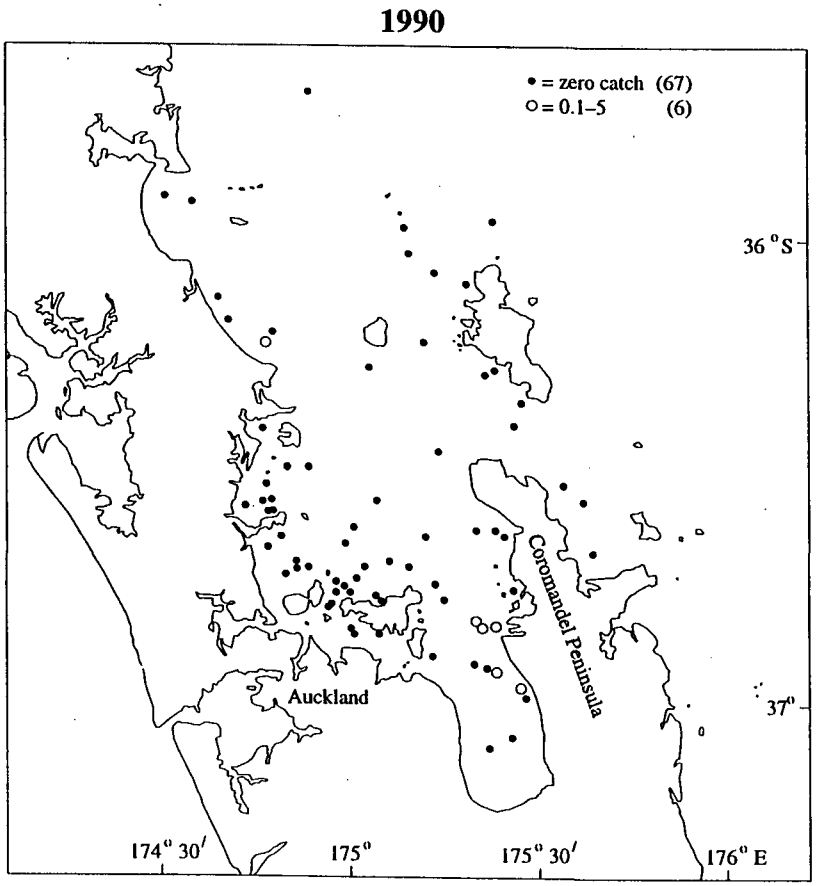
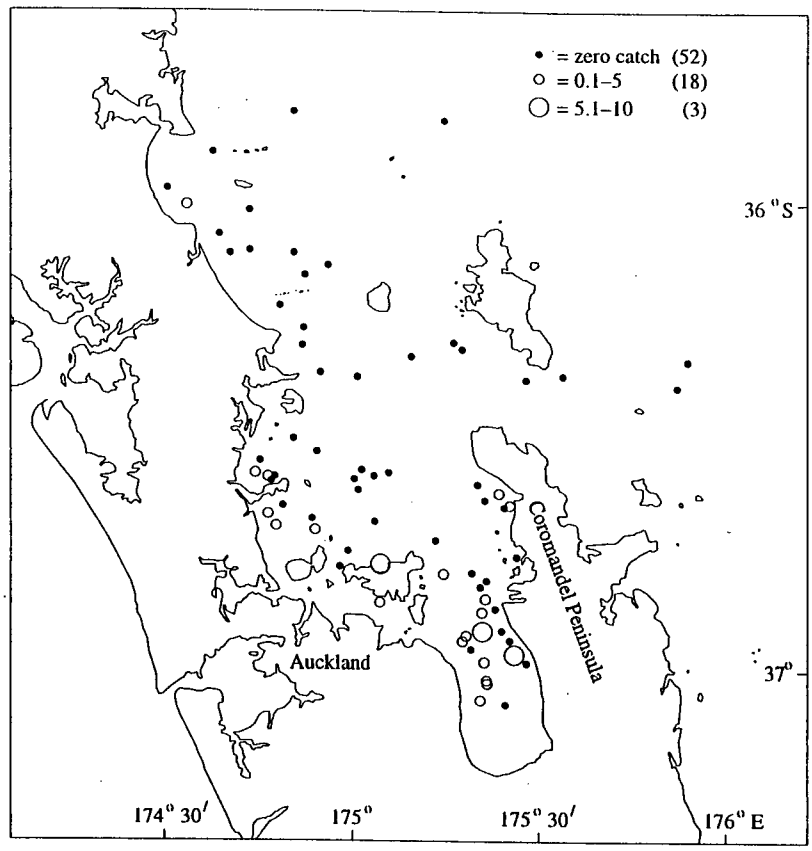
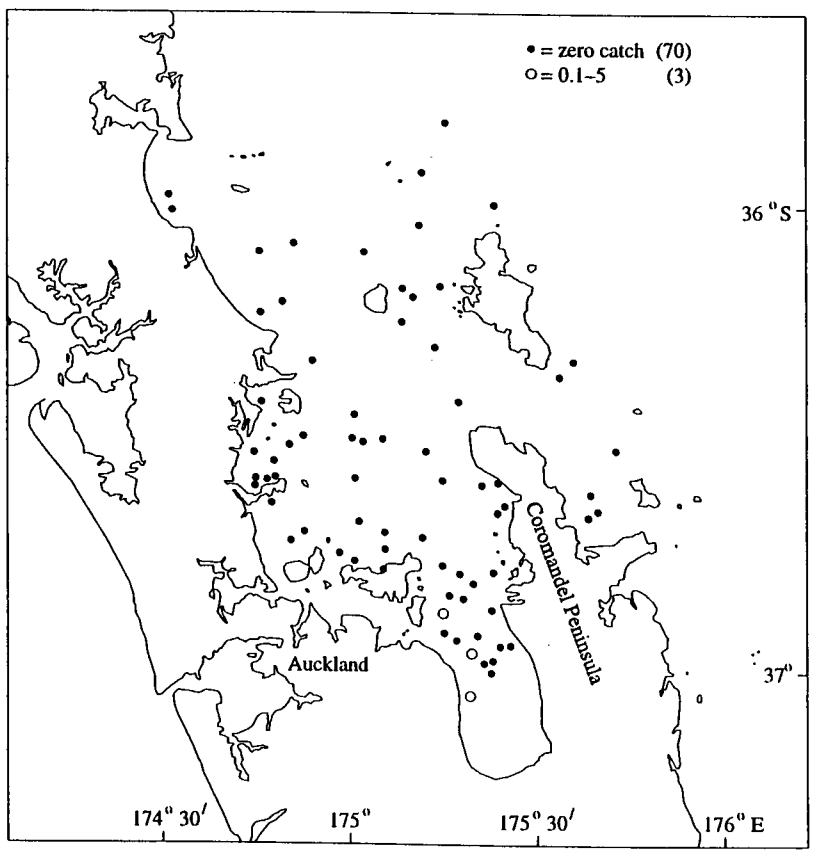


Figure 6—continued

1992



1993



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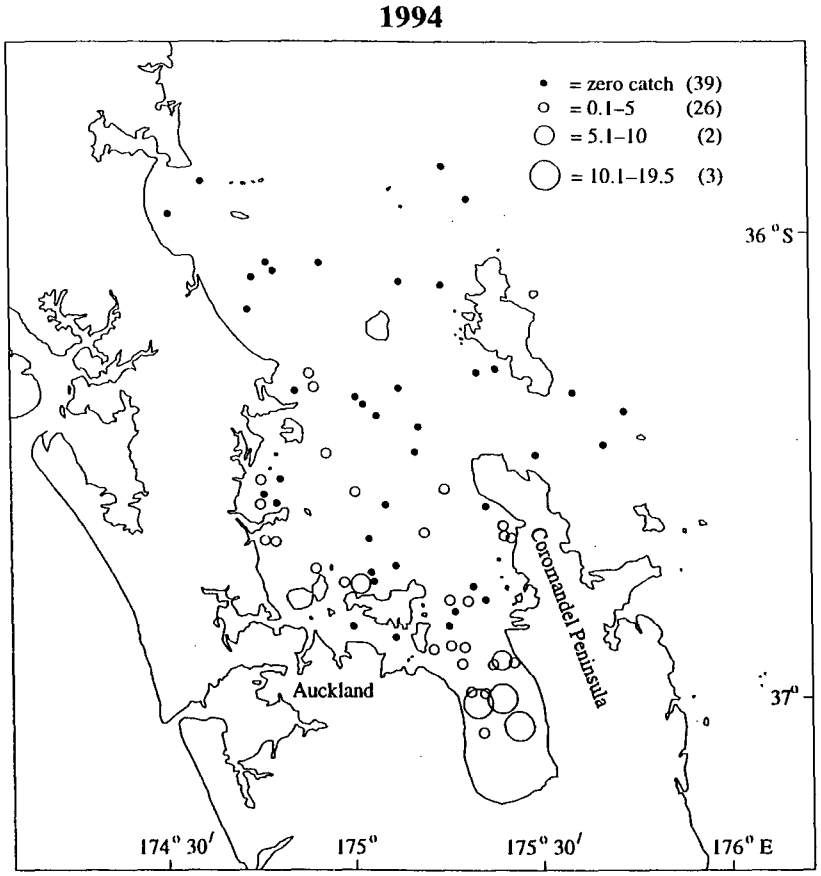

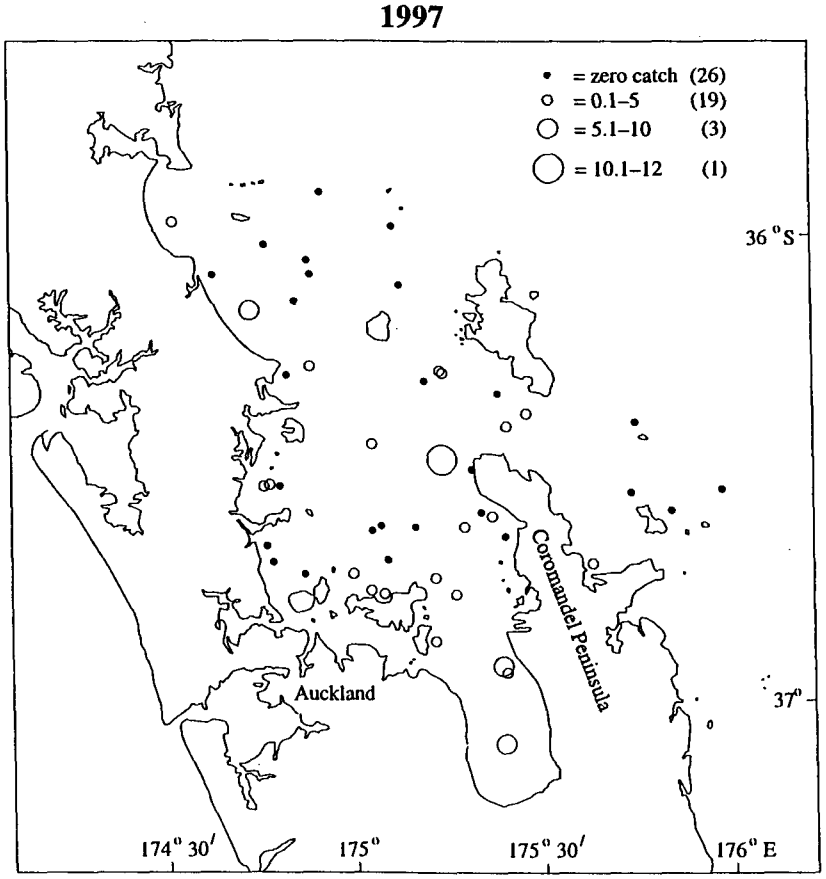

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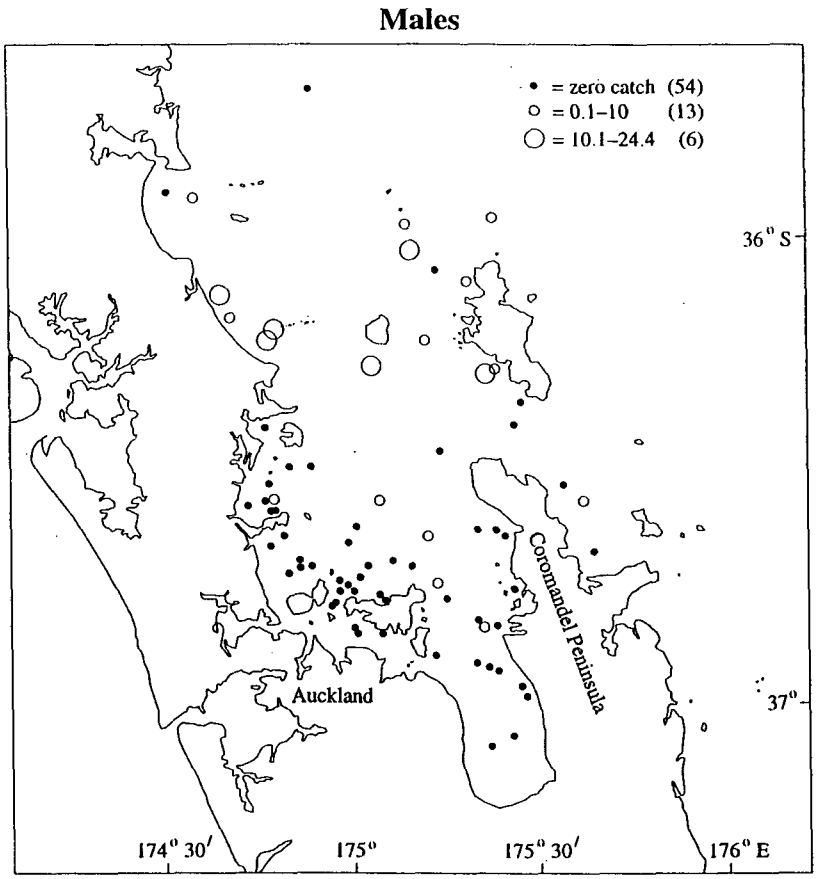


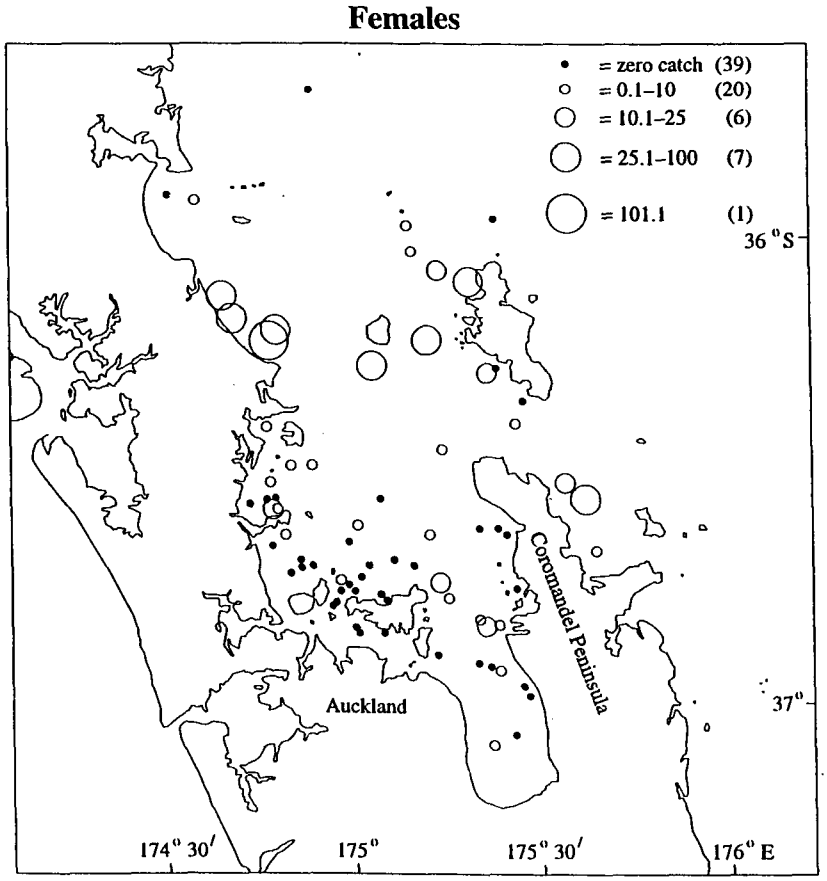


***Figure 7*: Catch rates (kg.km^2) of adult (>18 cm) red gurnard from the 1990 HAGU trawl survey (KAH9016) (numbers in brackets are the number of stations within the given range).**

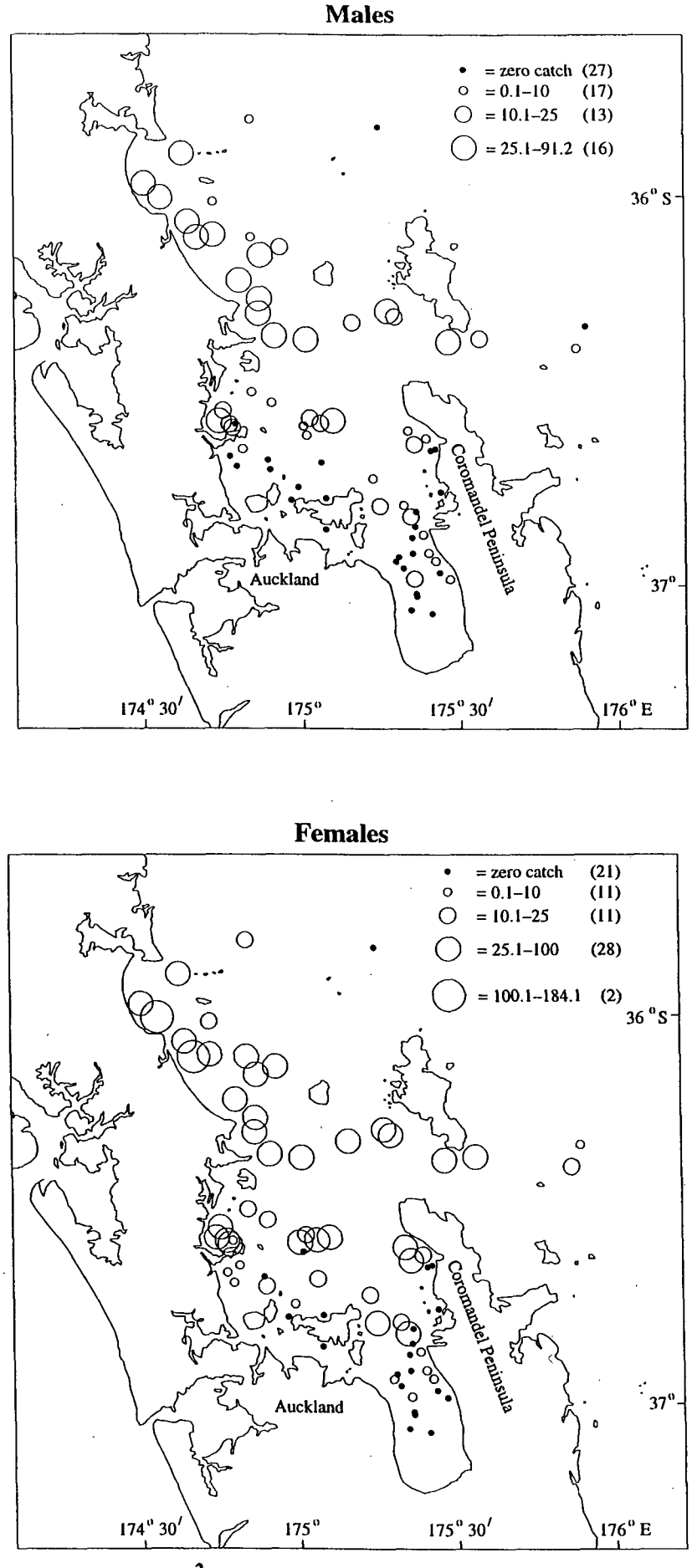
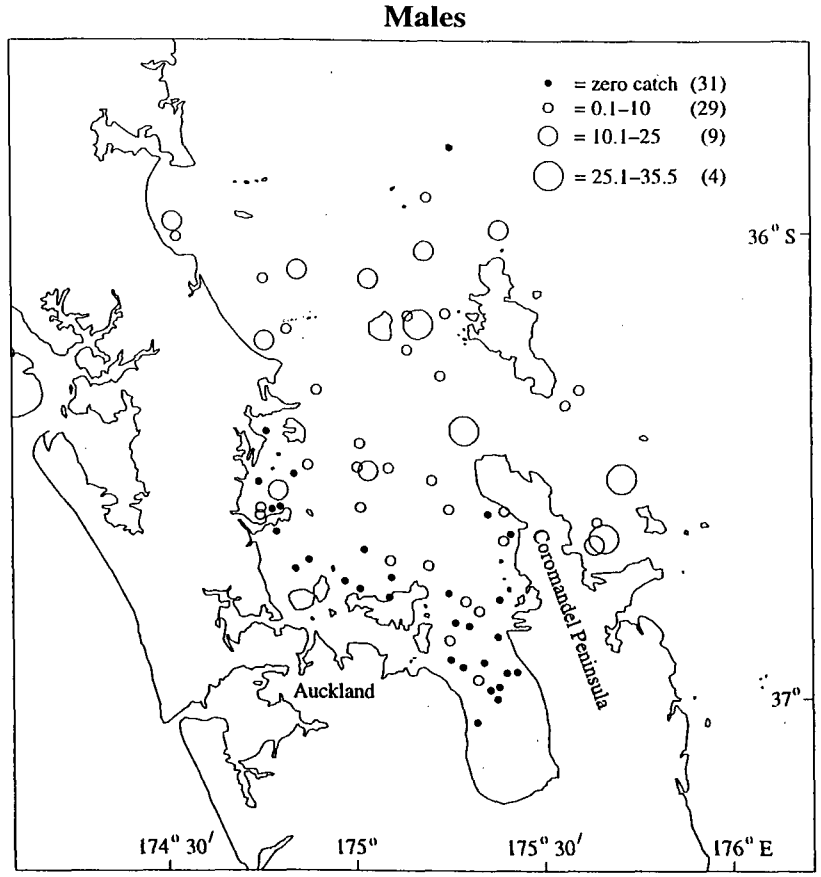


***Figure 8*: Catch rates (kg.km^2) of adult (>18 cm) red gurnard from the 1992 HAGU trawl survey (KAH9212) (numbers in brackets are the number of stations within the given range).**



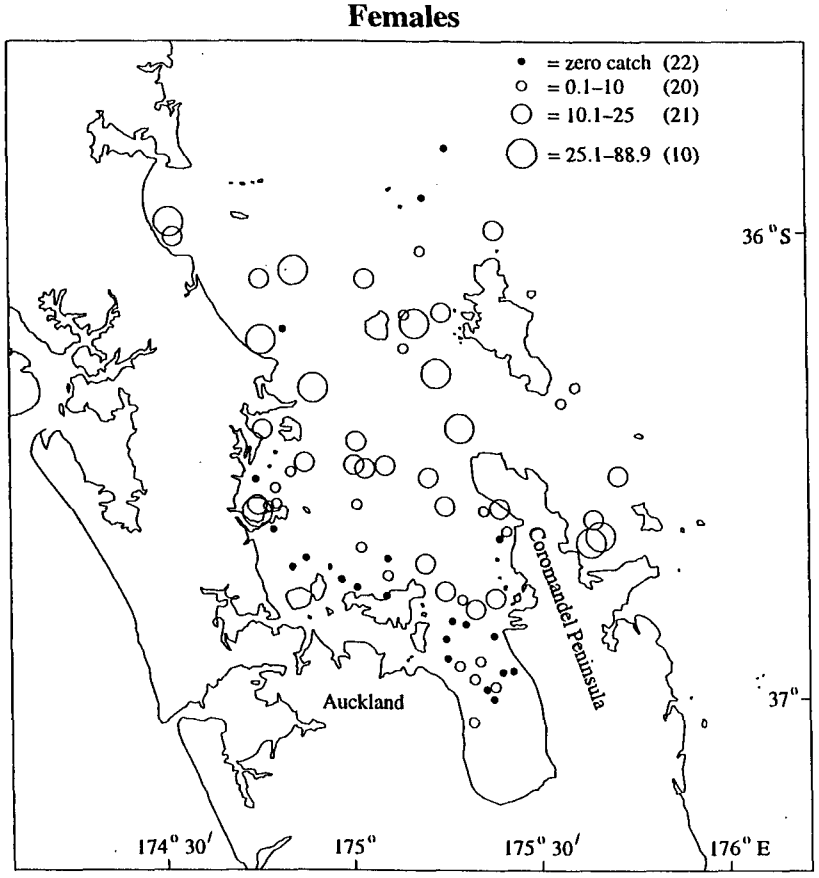


Figure 9: **Catch rates (kg.km^2) of adult (>18 cm) red gurnard from the 1993 HAGU trawl survey (KAH9311) (numbers in brackets are the number of stations within the given range).**

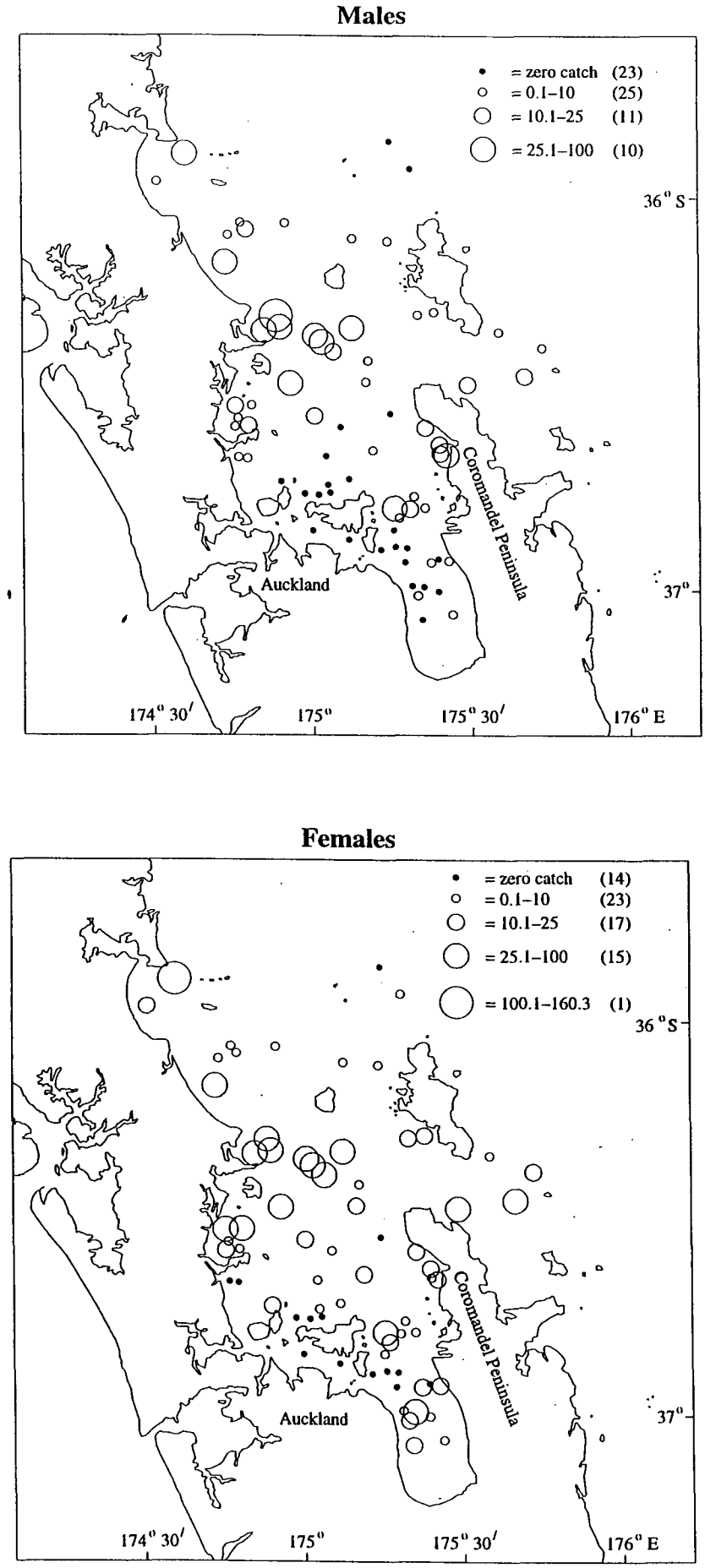
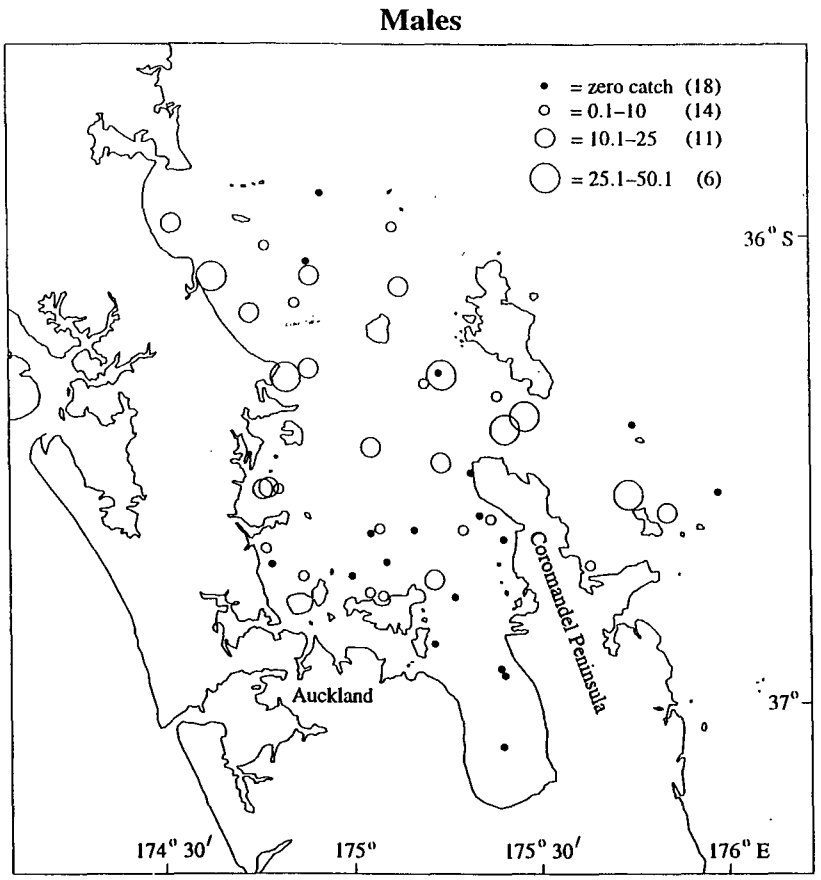


***Figure 10*: Catch rates (kg.km^2) of adult (>18 cm) red gurnard from the 1994 HAGU trawl survey (KAH9411) (numbers in brackets are the number of stations within the given range).**



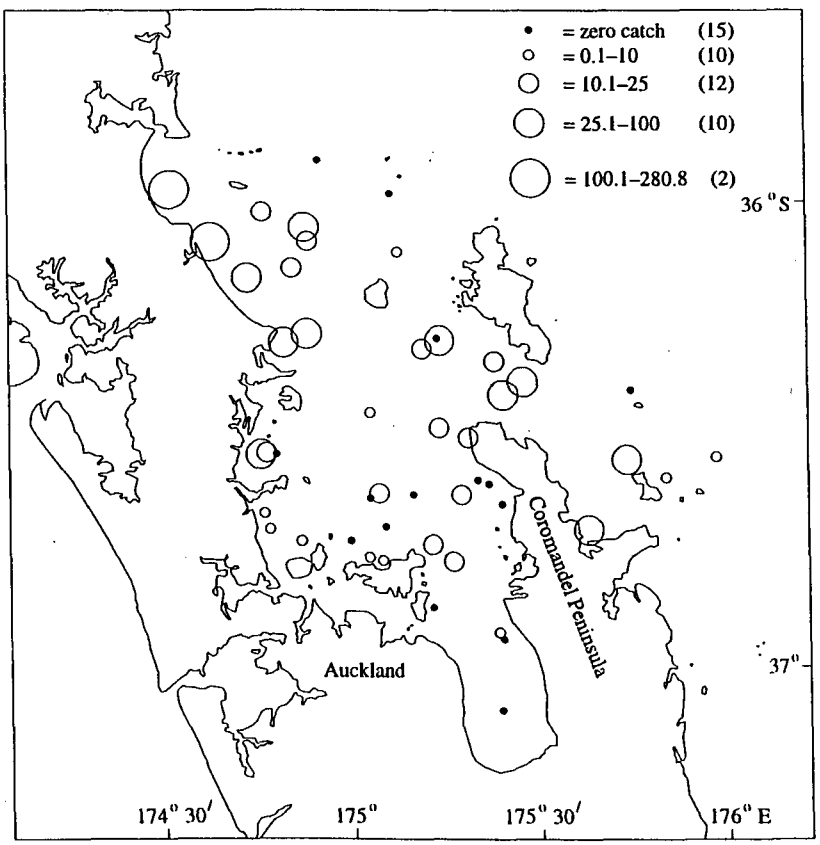


***Figure 11*: Catch rates (kg.km^2) of adult (>18 cm) red gurnard from the 1997 HAGU trawl survey (KAH9720) (numbers in brackets are the number of stations within the given range).**

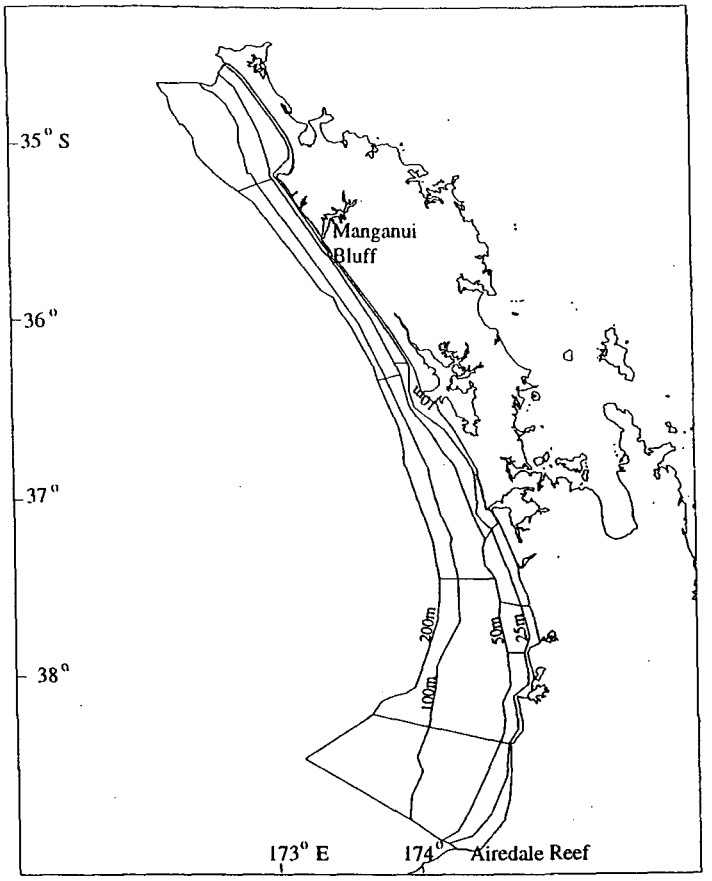


Figure 12: **Strata boundaries for the 1996 west coast North Island trawl survey (KAH9615) (foul ground not shown).**

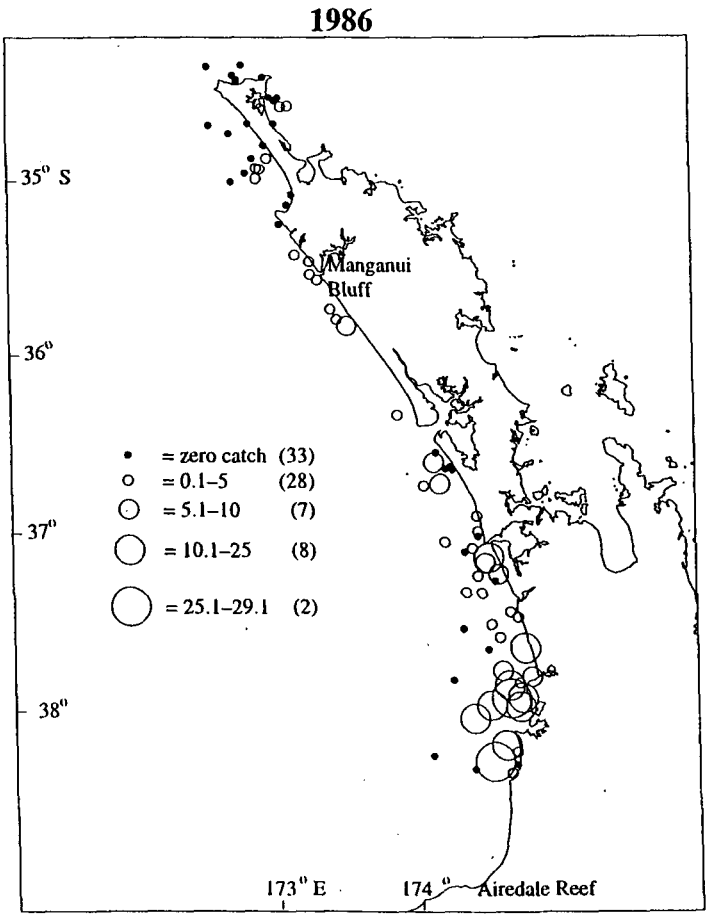
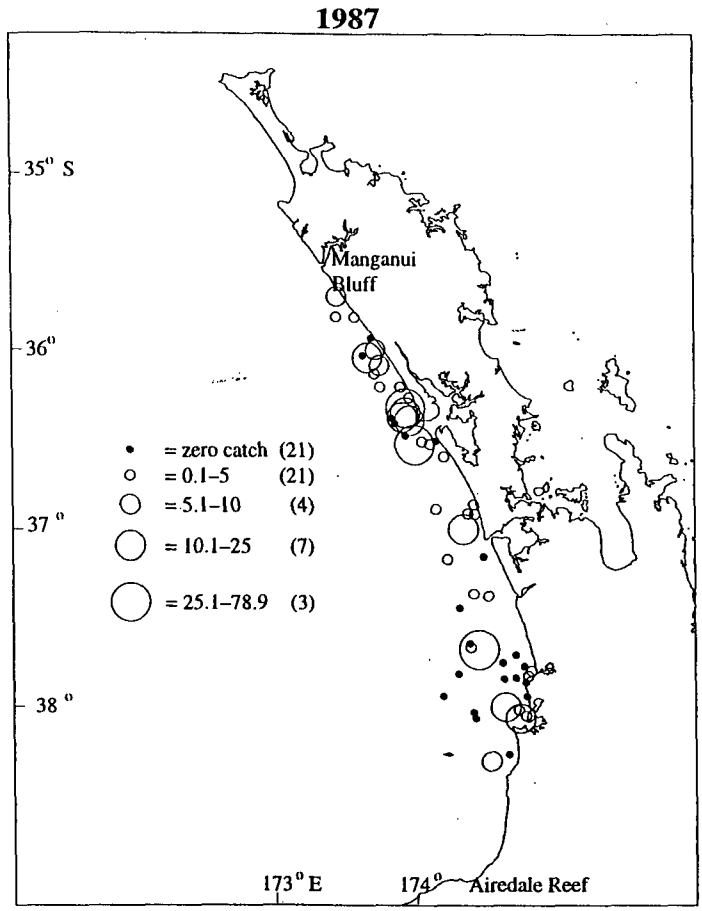


Figure 13: **Catch rates (kg.km^2) for juvenile (<20 cm) red gurnard from WCNI surveys (numbers in brackets are the number of stations within the given range).**



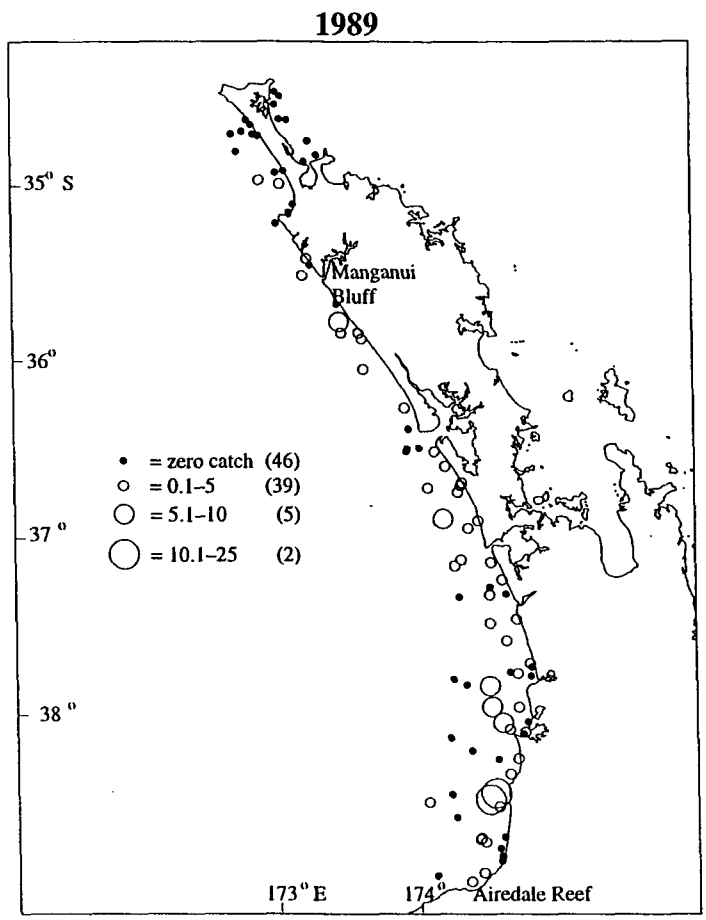
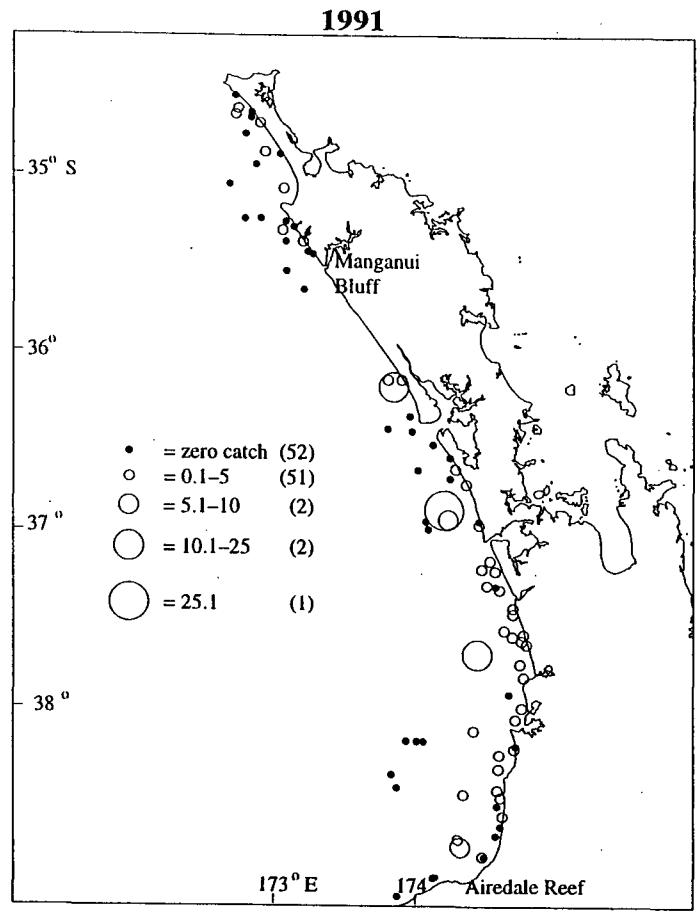


Figure 13—continued



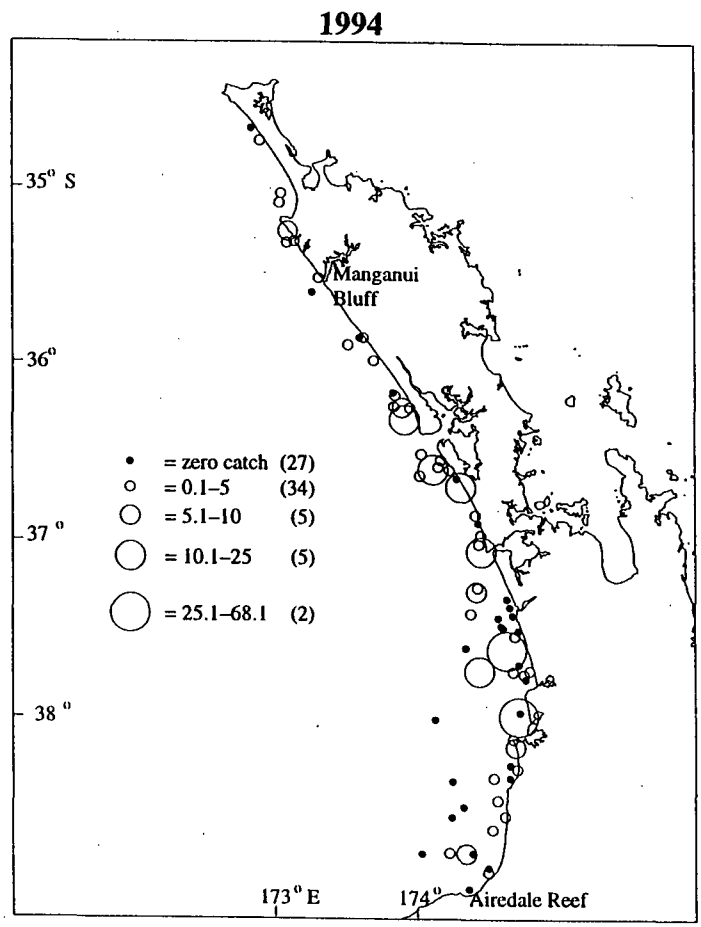


Figure 13—continued

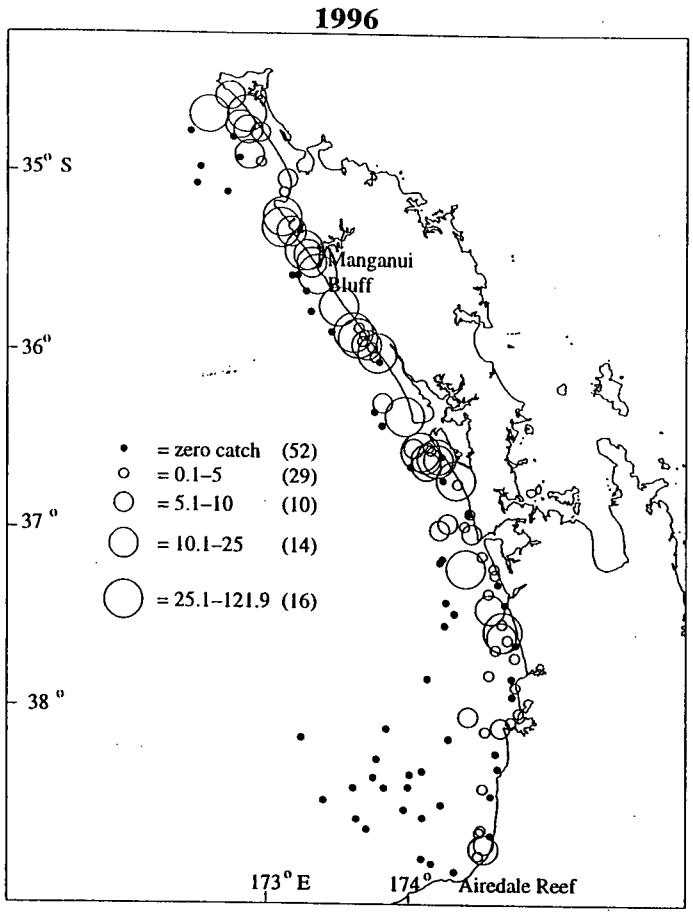


Figure 13—continued

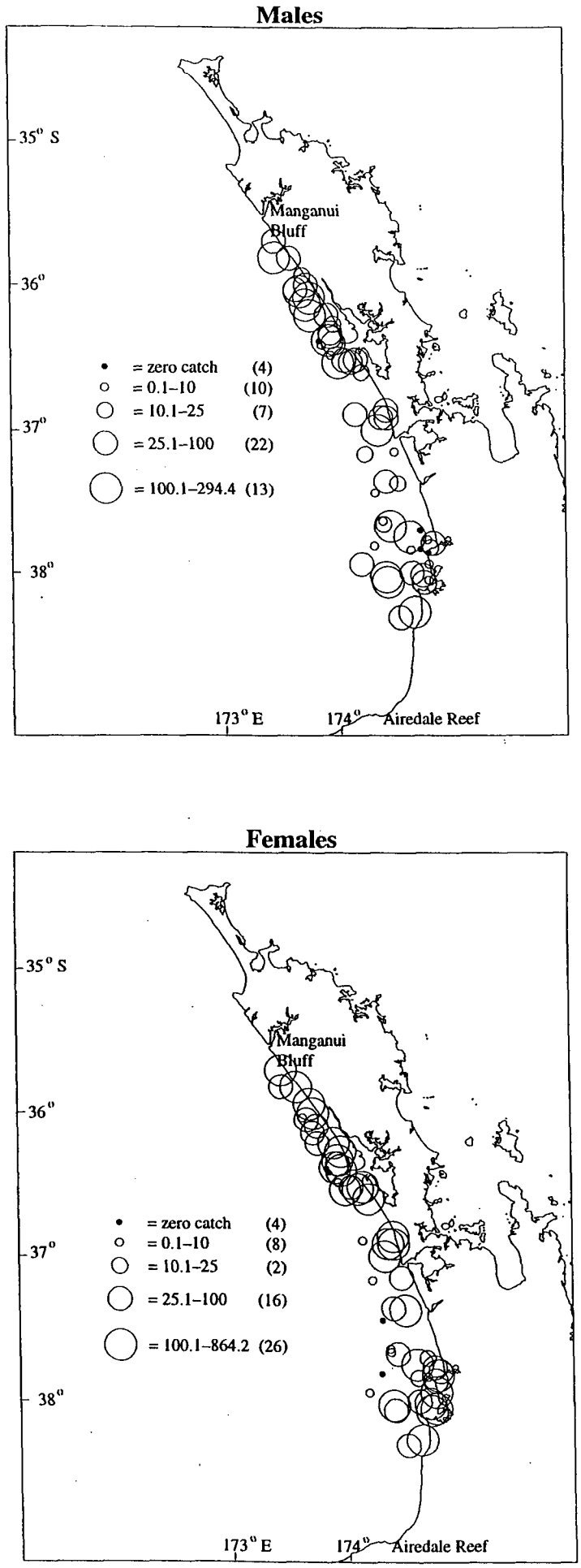
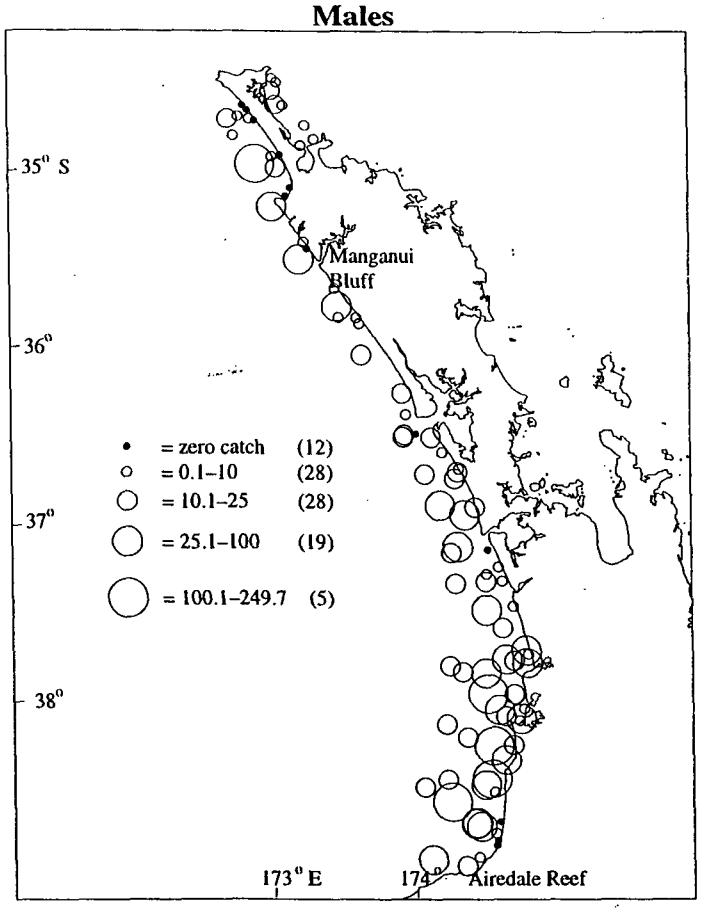


***Figure 14*: Catch rates (kg.km^2) for adult (>19 cm) from the 1987 WCNI survey (KAH8715) (numbers in brackets are the number of stations within the given range).**



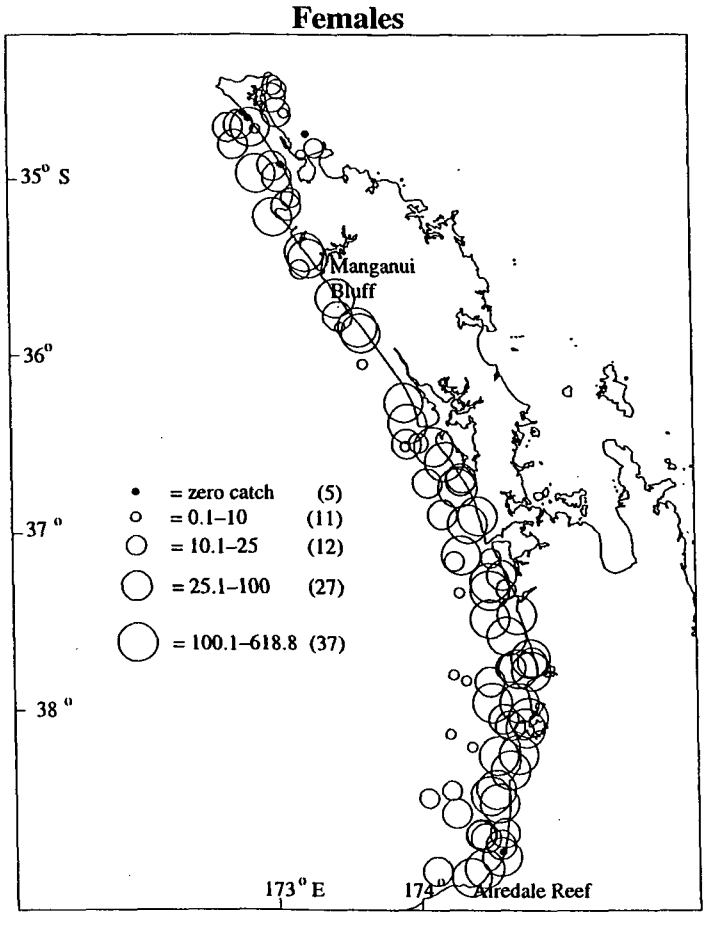
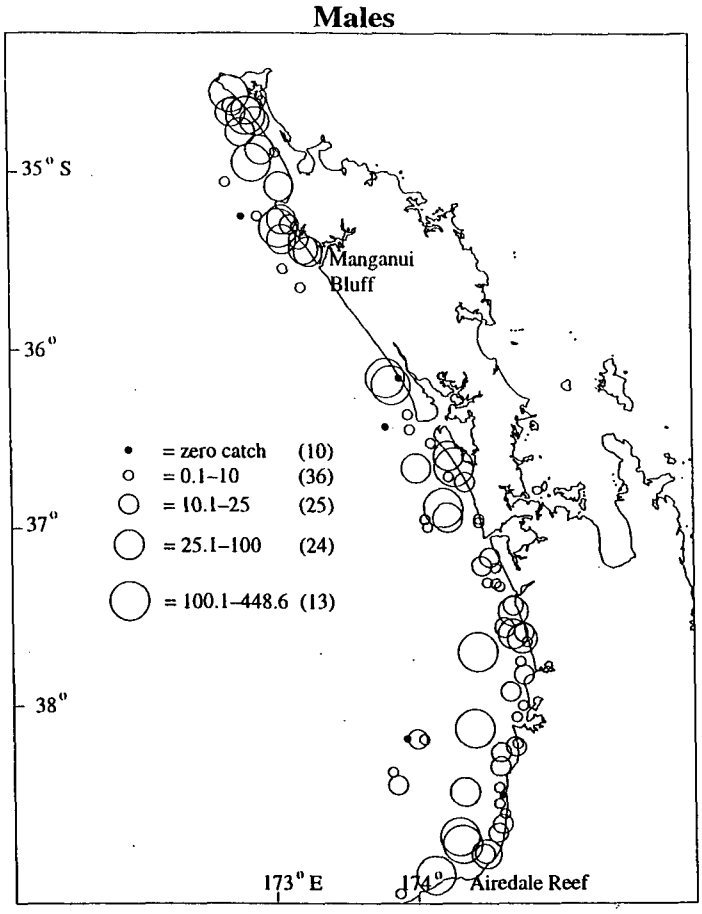


Figure 15: **Catch rates (kg.km^2) for adult (>19 cm) from the 1989 WCNI survey (KAH8918) (numbers in brackets are the number of stations within the given range).**



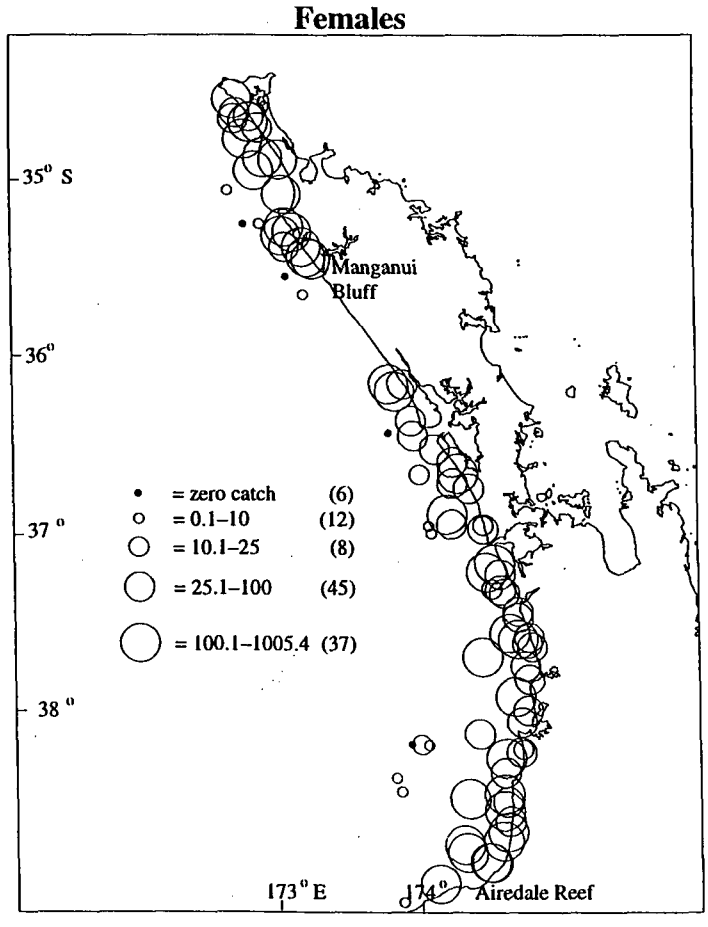
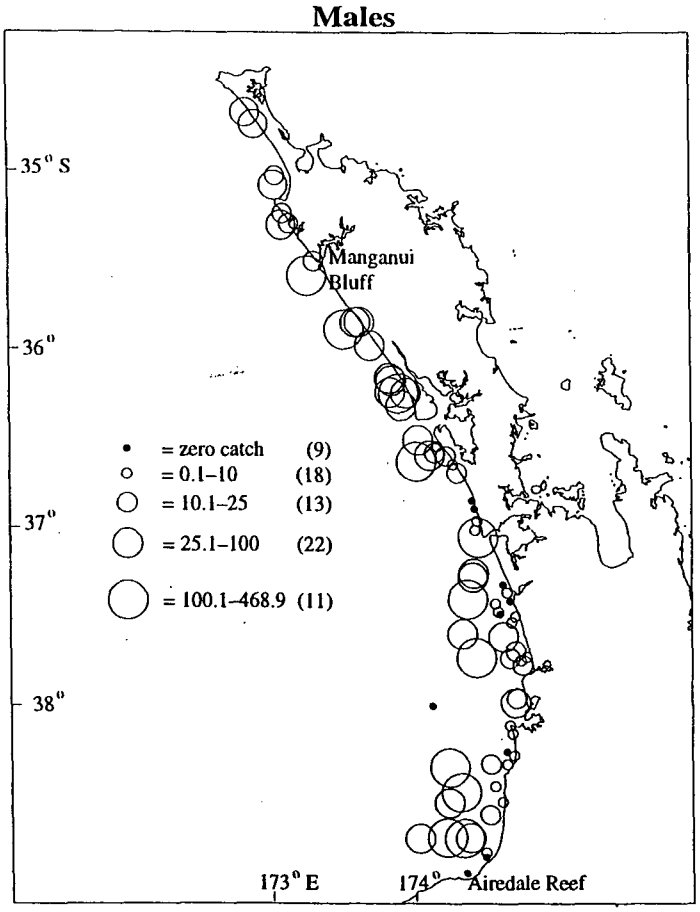


***Figure 16*: Catch rates (kg.km^2) for adult (>19 cm) from the 1991 WCNI survey (KAH9111) (numbers in brackets are the number of stations within the given range).**



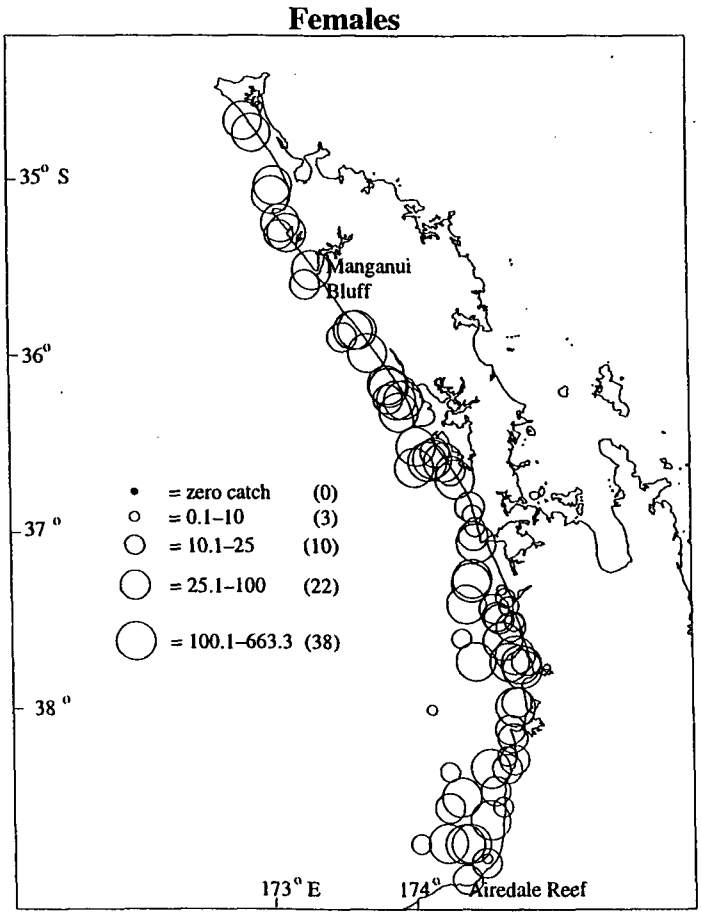
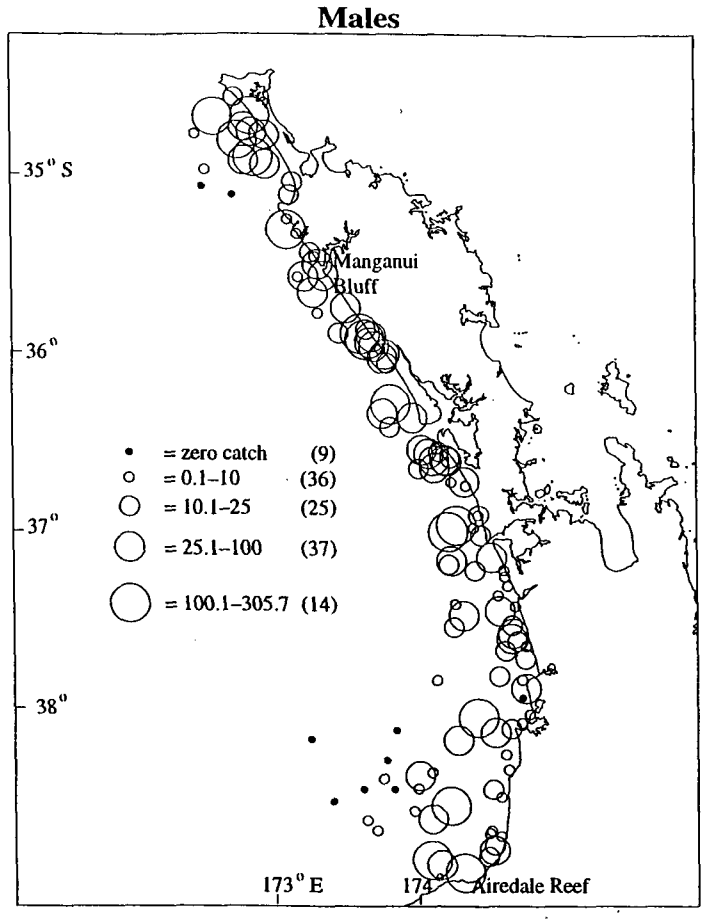


***Figure 17*: Catch rates (kg.km^2) for adult (>19 cm) from the 1994 WCNI survey (KAH9410) (numbers in brackets are the number of stations within the given range).**



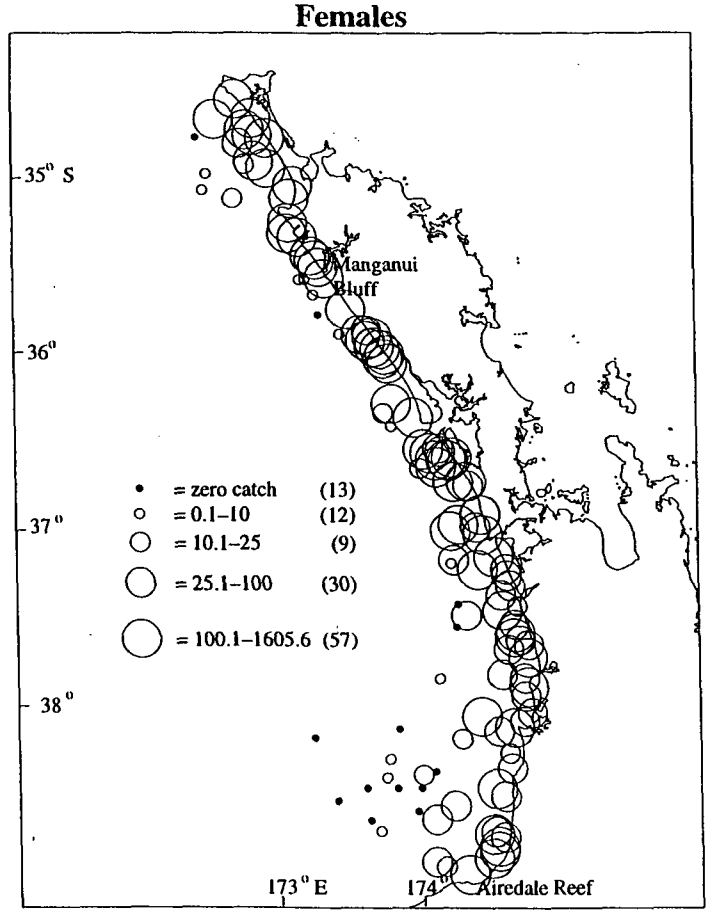


***Figure 18*: Catch rates (kg.km^2) for adult (>19 cm) from the 1996 WCNI survey (KAH9615) (numbers in brackets are the number of stations within the given range).**

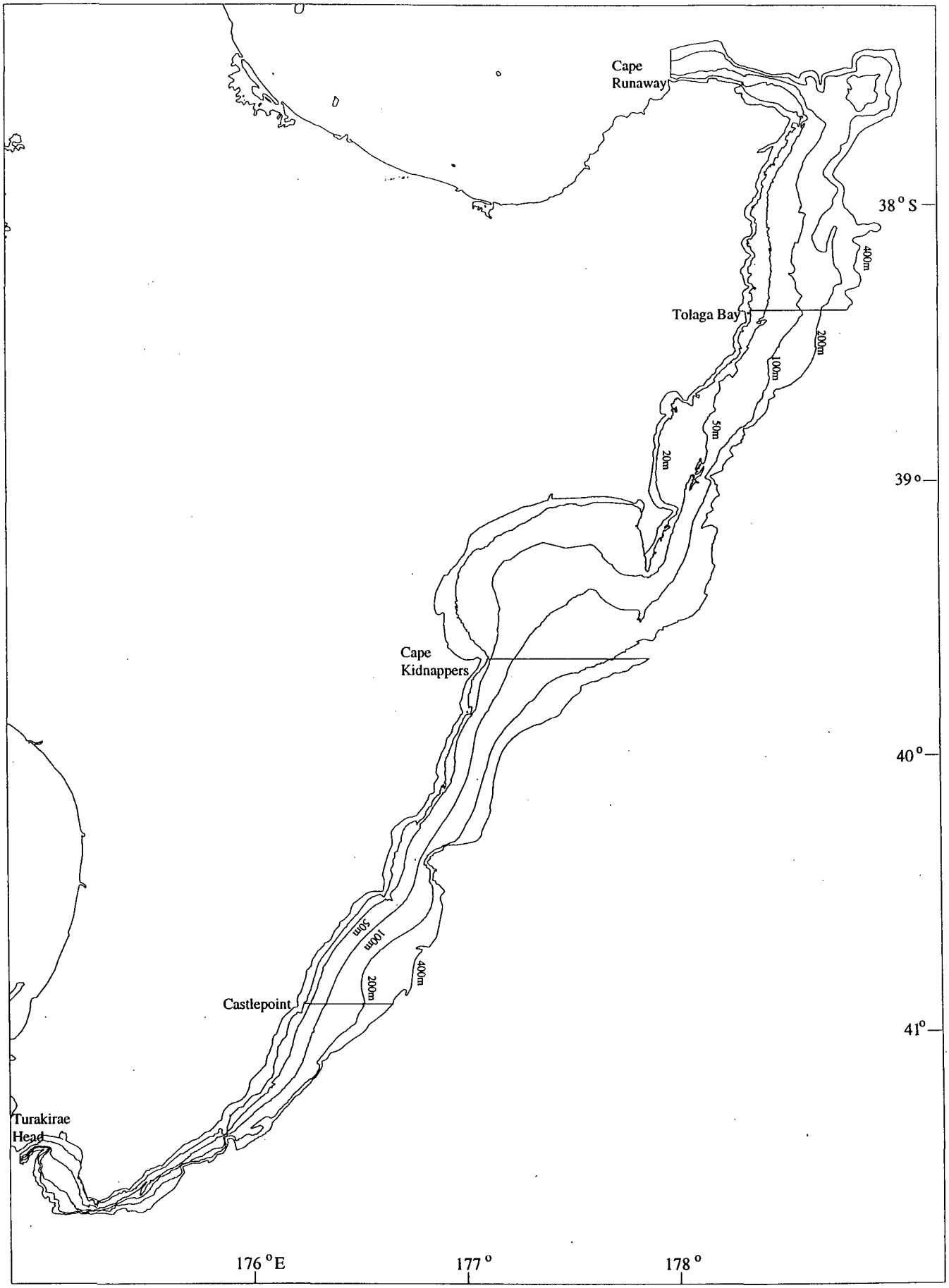
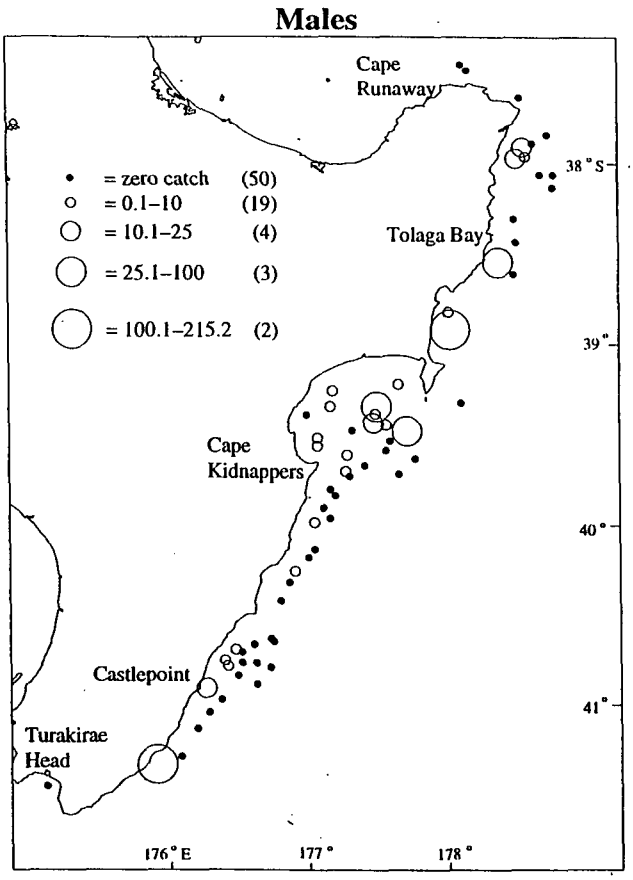


Figure 19 **: Stratum boundaries for the 1996 ECNI trawl survey (KAH9602) (foul ground not shown).**



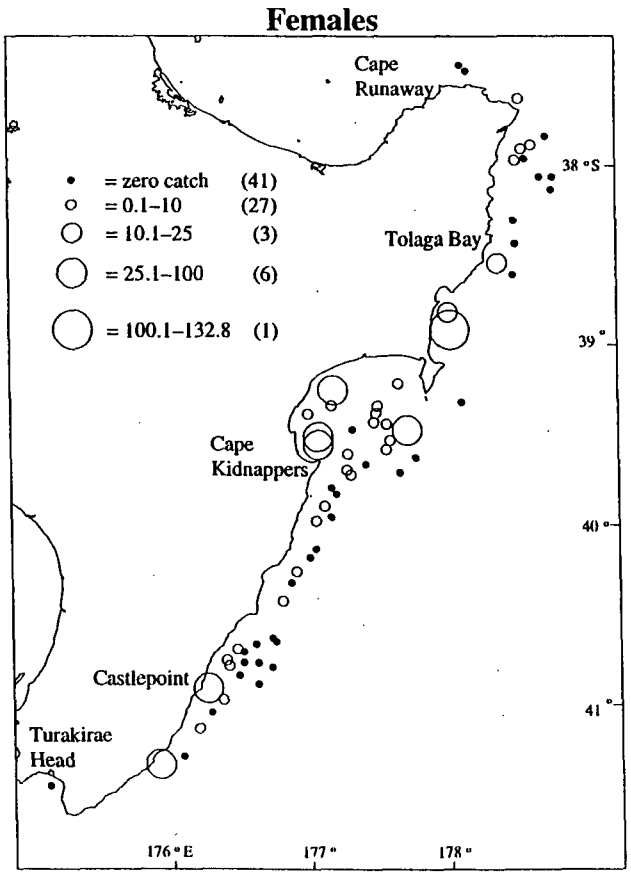
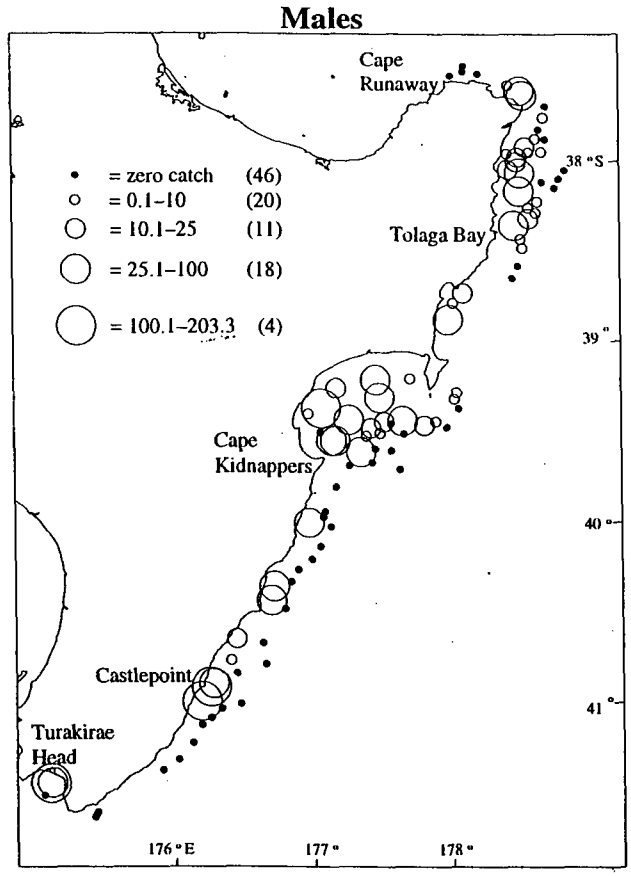


***Figure 20*: Catch rates (kg.km^2) for adult (>19 cm) red gurnard for the 1993 ECNI trawl survey (KAH9304) (numbers in brackets are the numbers of stations within the given range).**



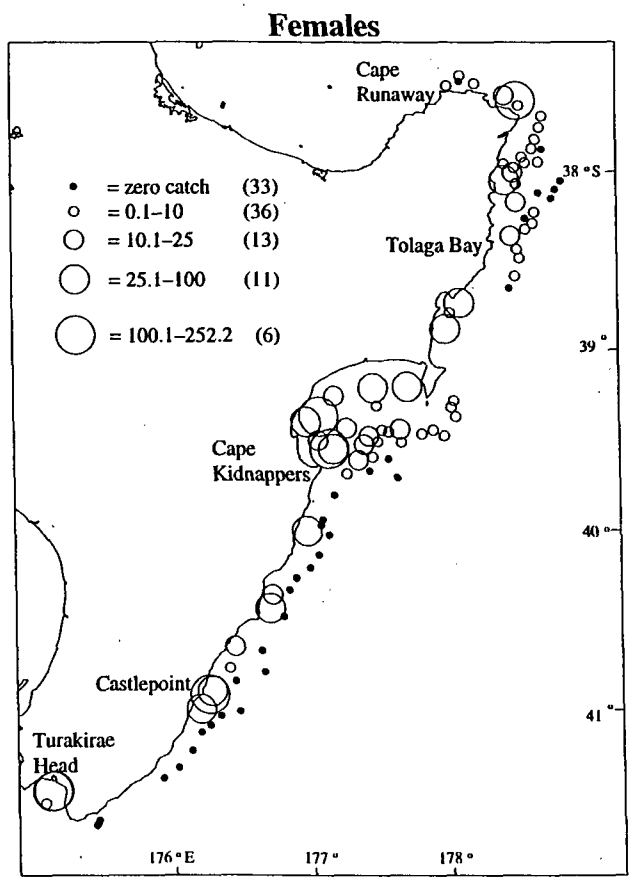
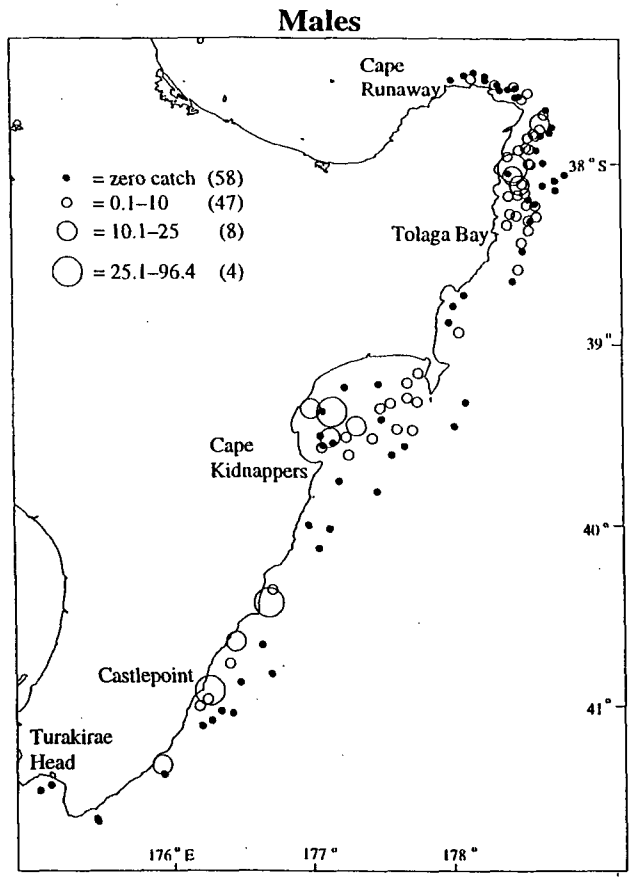


***Figure 21*: Catch rates (kg.km^2) for adult (>19 cm) red gurnard for the 1994 ECNI trawl survey (KAH9402) (numbers in brackets are the numbers of stations within the given range).**



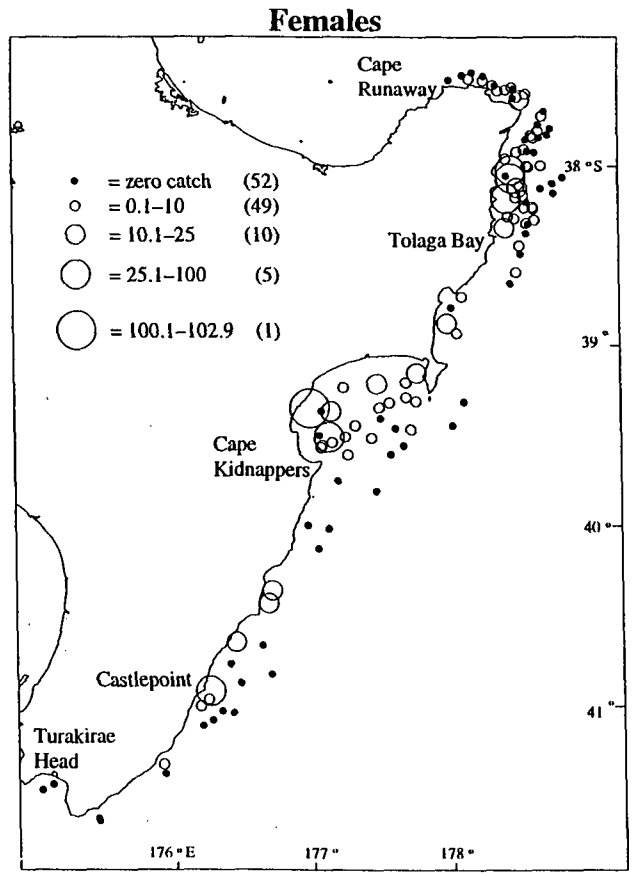
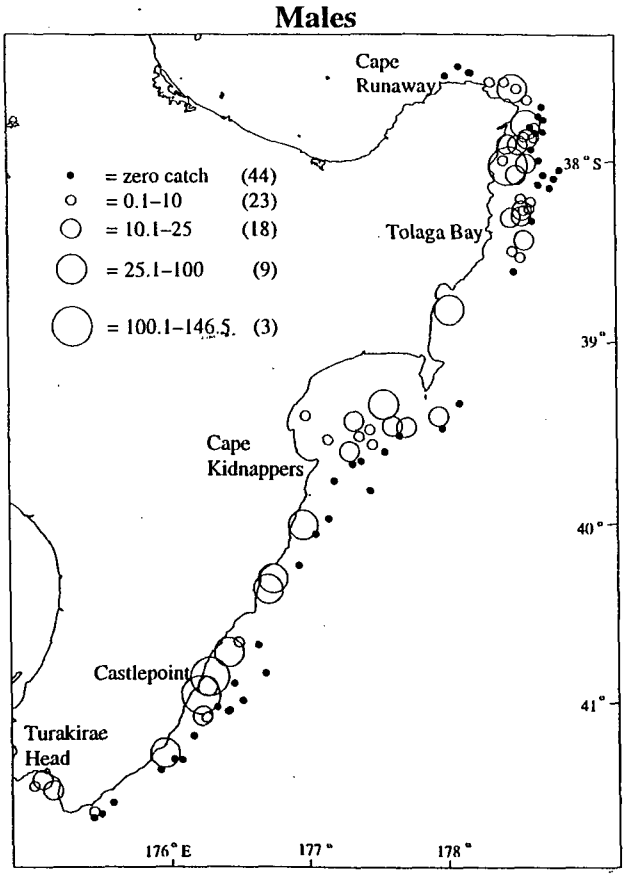


***Figure 22*: Catch rates (kg.km^2) for adult (>19 cm) red gurnard for the 1995 ECNI trawl survey (KAH9502) (numbers in brackets are the numbers of stations within the given range).**



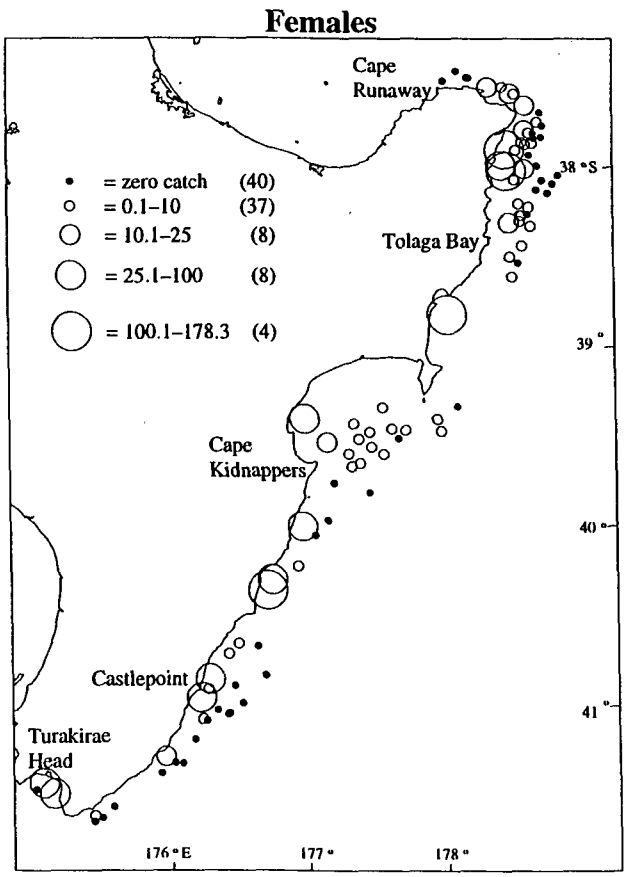
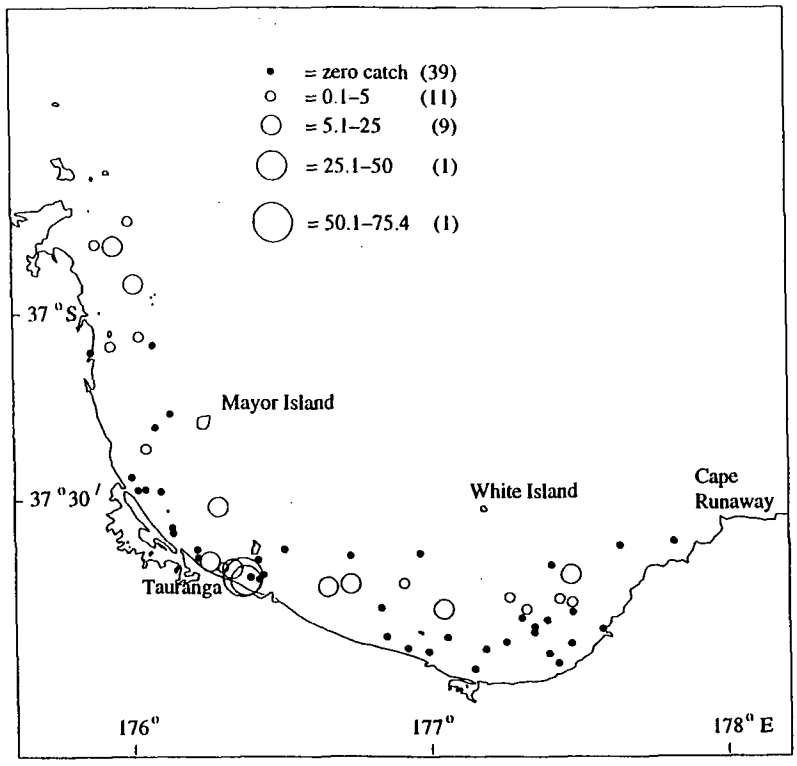


***Figure 23*: Catch rates (kg.km^2) for adult (>19 cm) red gurnard for the 1996 ECNI trawl survey (KAH9602) (numbers in brackets are the numbers of stations within the given range).**

1983



1985

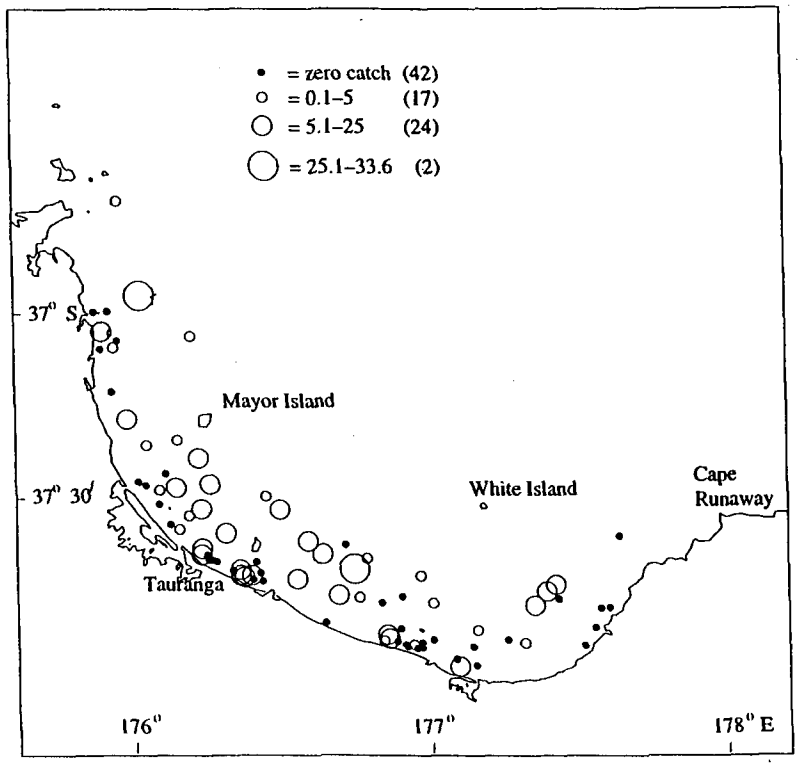
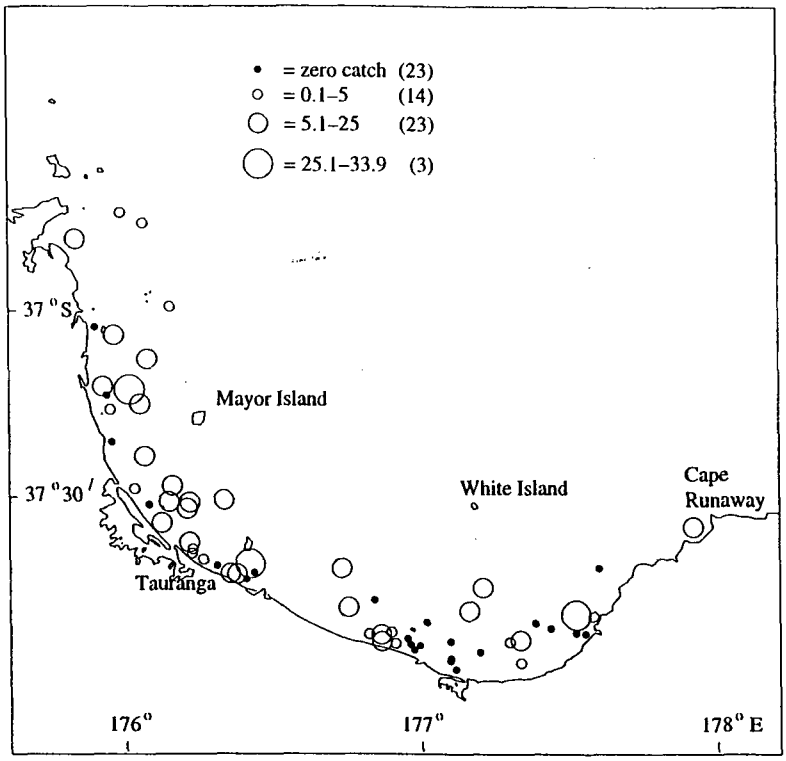


Figure 24 **: Catch rates (kg.km^2) for juvenile (<33 cm) John dory from BOP trawl surveys.**

1990



1992

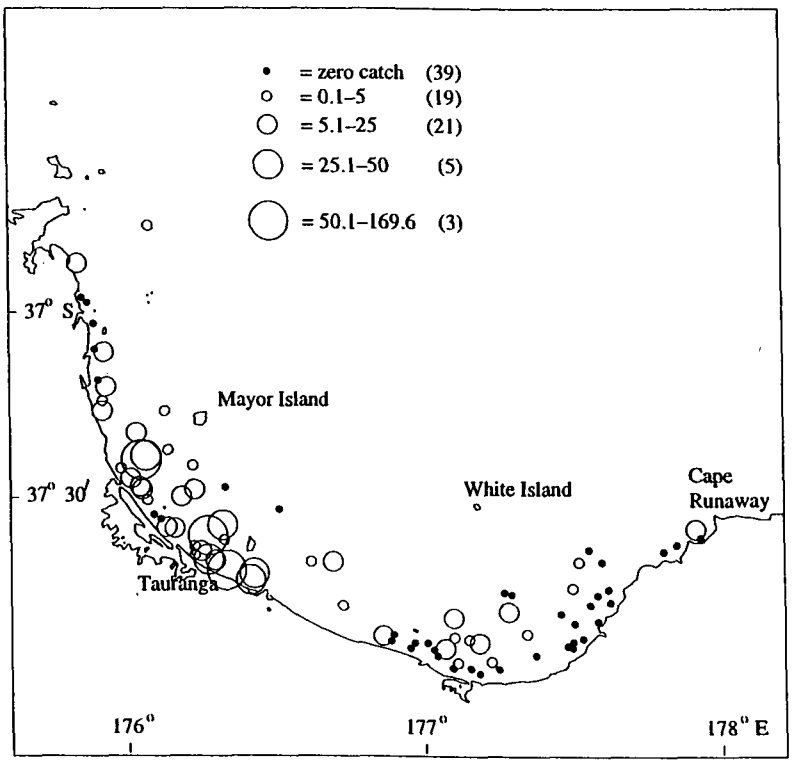


Figure 24—continued

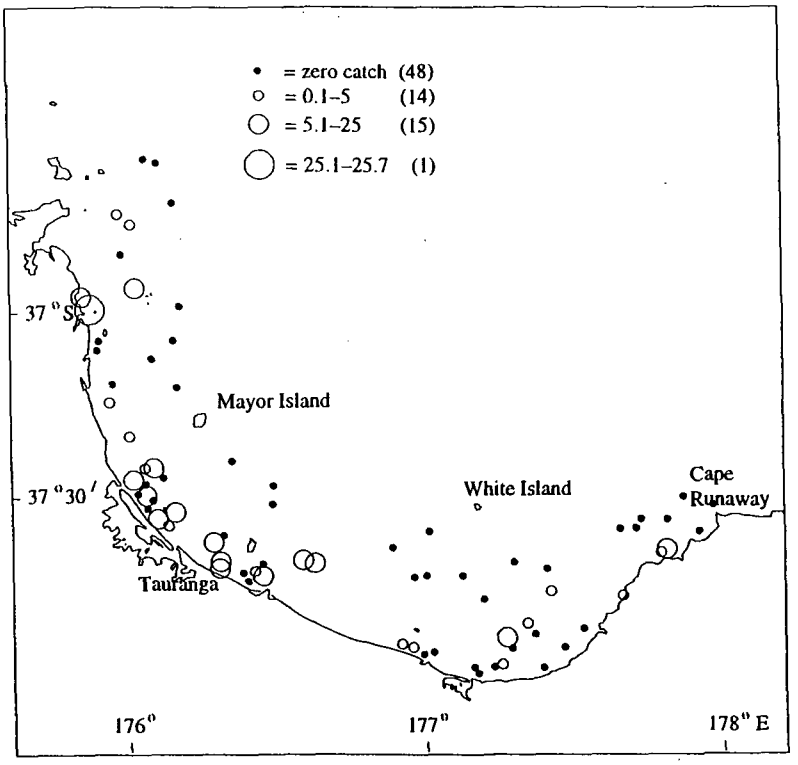


Figure 24—continued

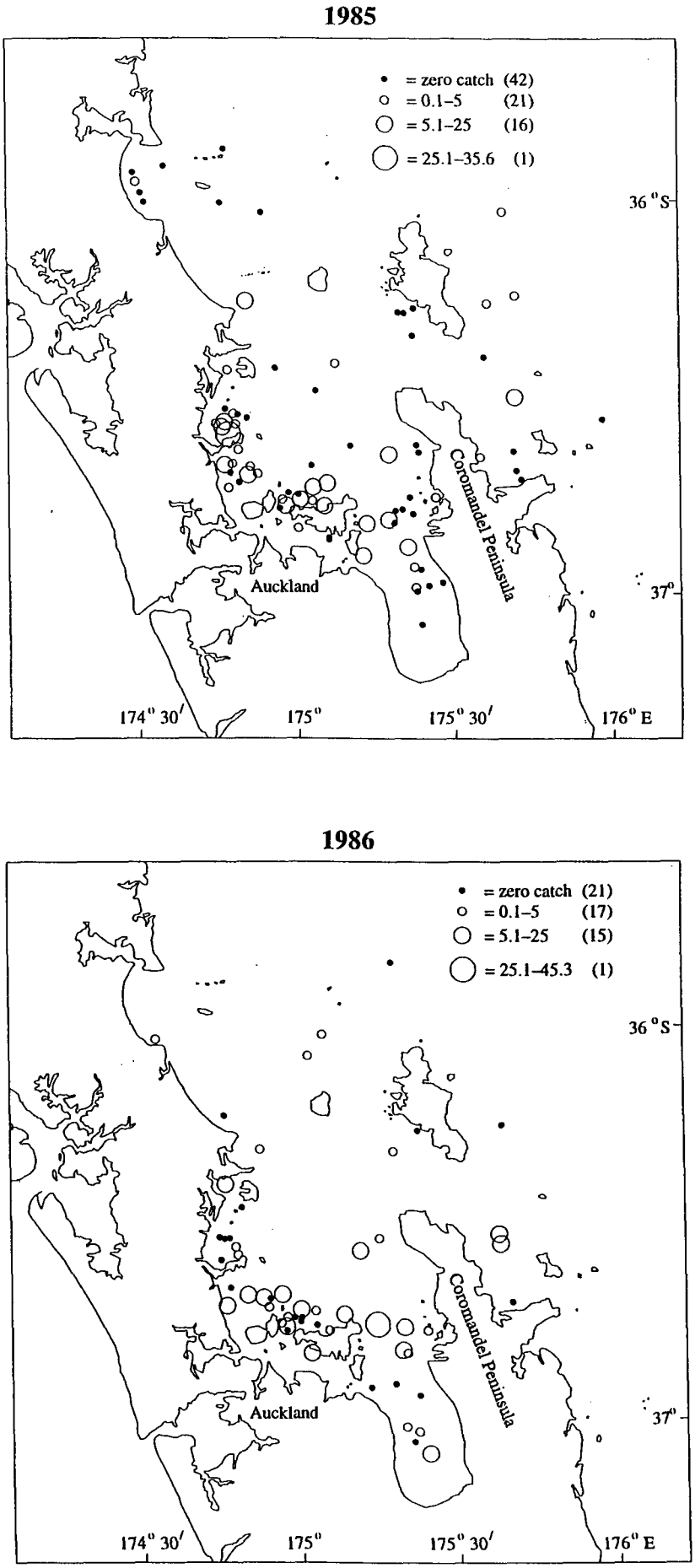
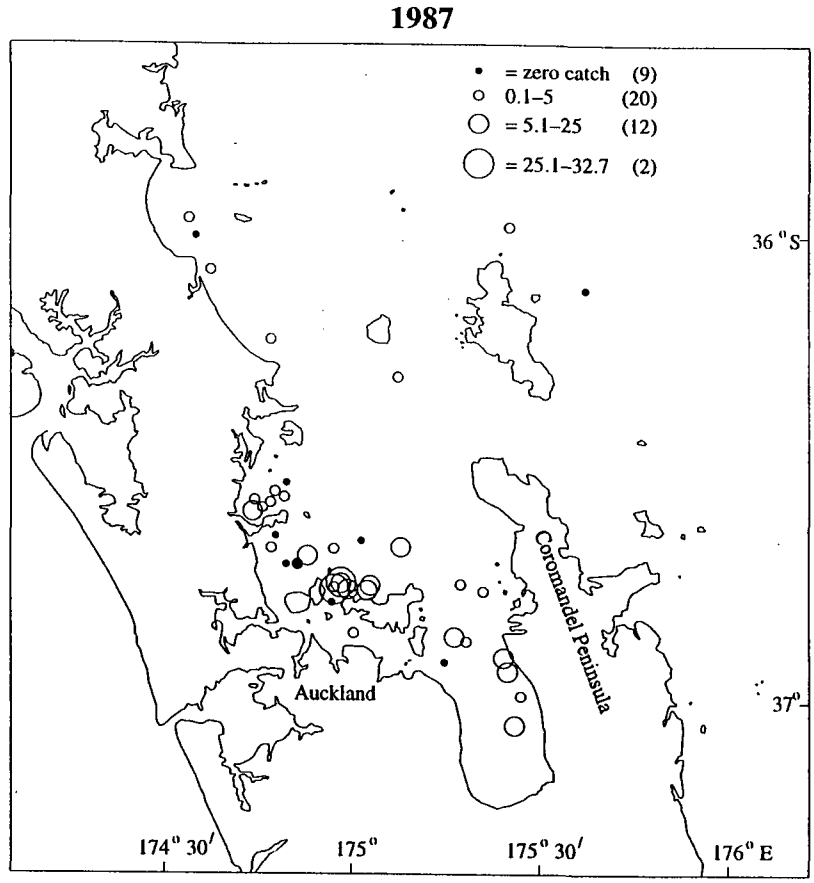


Figure 25: **Catch rates (kg.km^2) for juvenile (< 30 cm) John dory from HAGU trawl surveys**



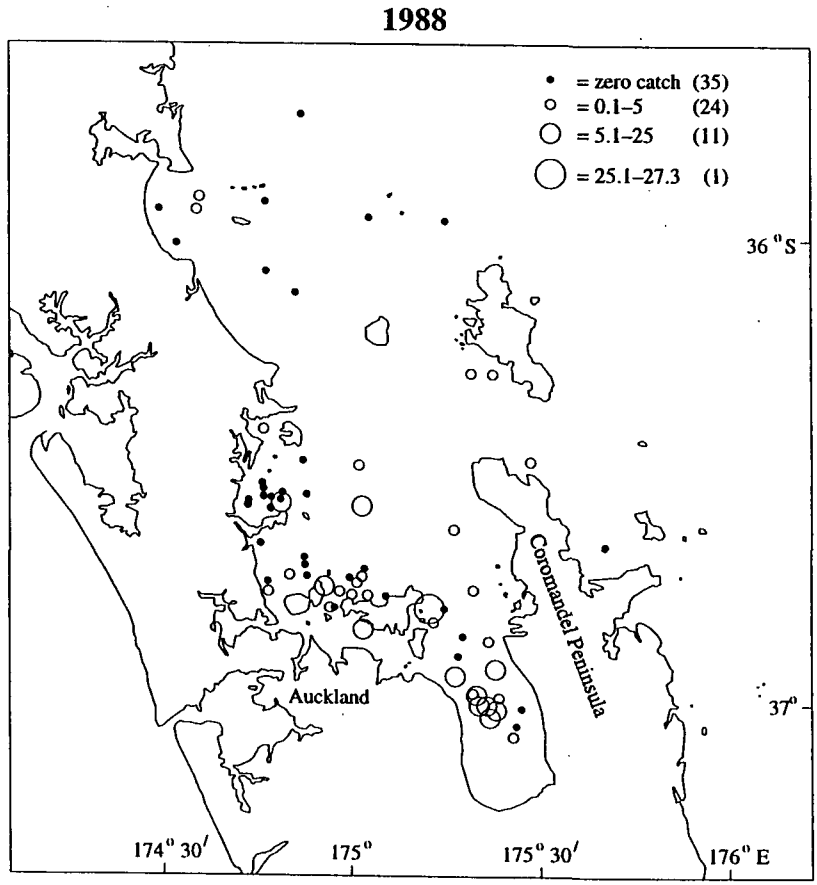
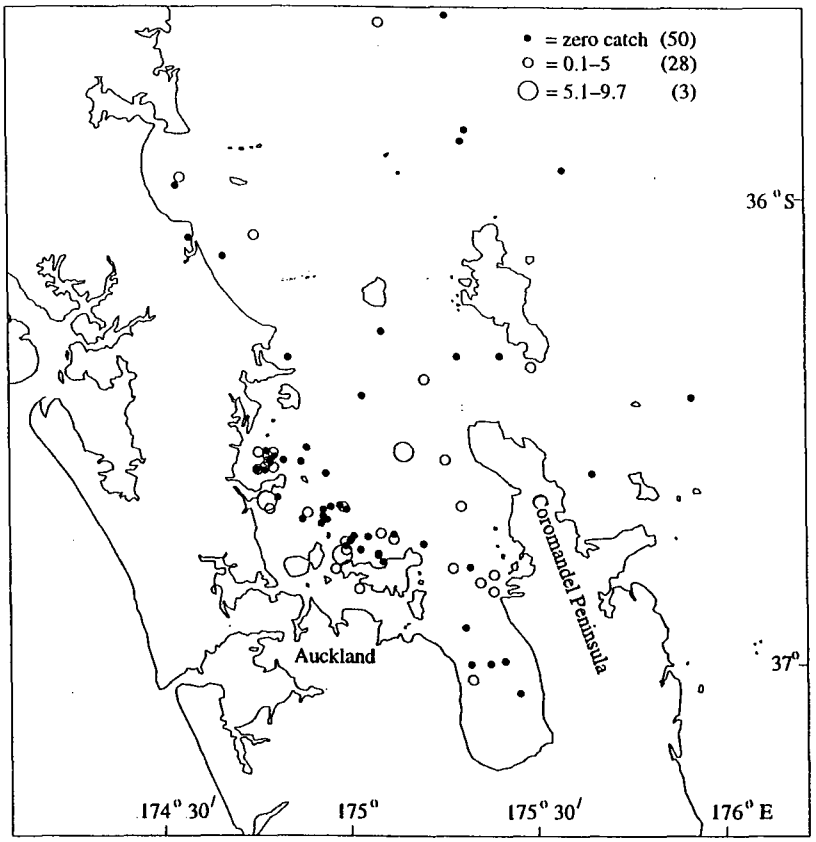


Figure 25—continued

1989



1990

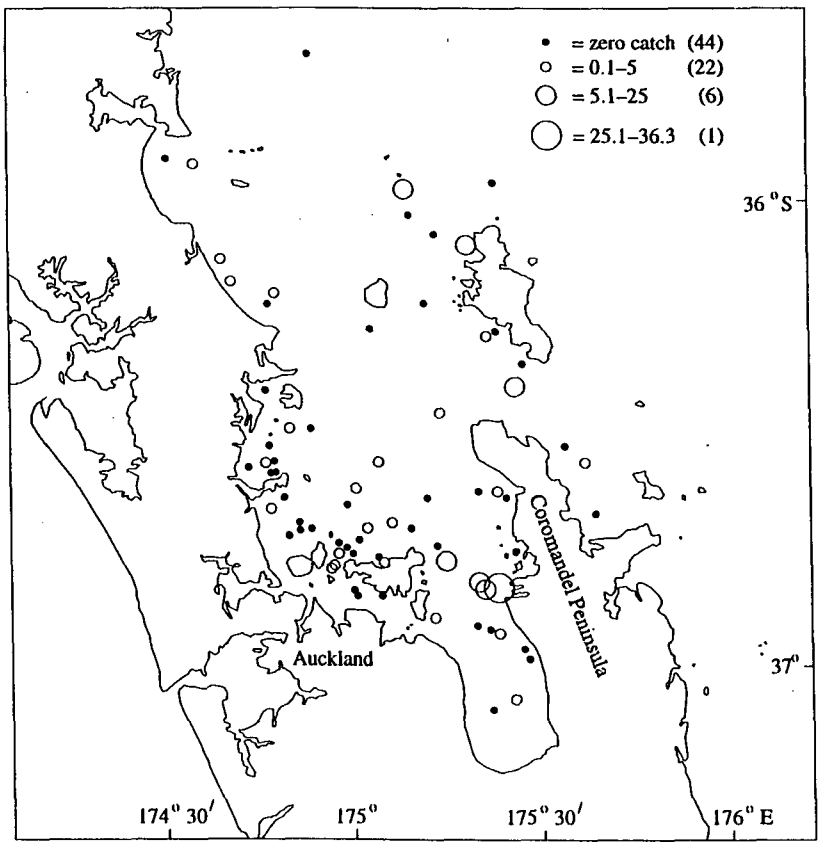
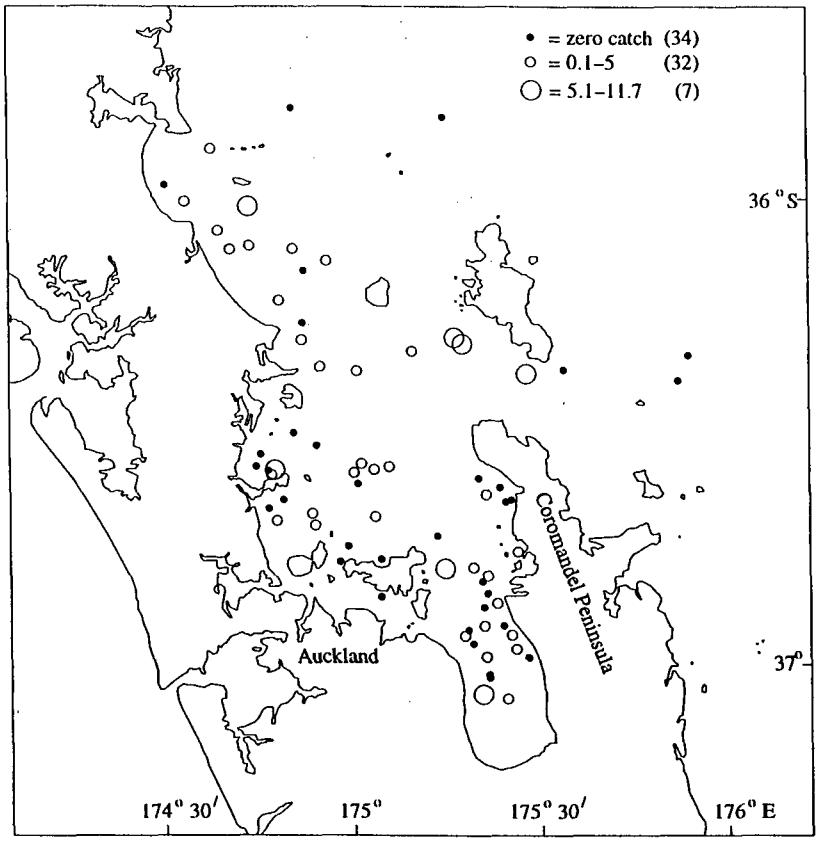


Figure 25—continued

1992



1993

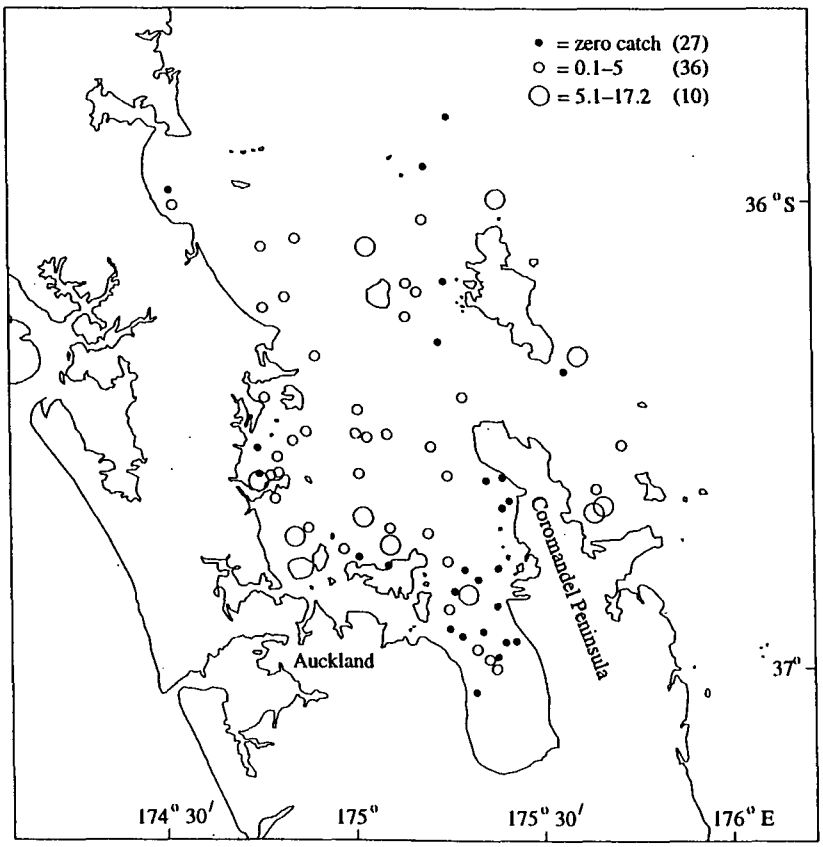
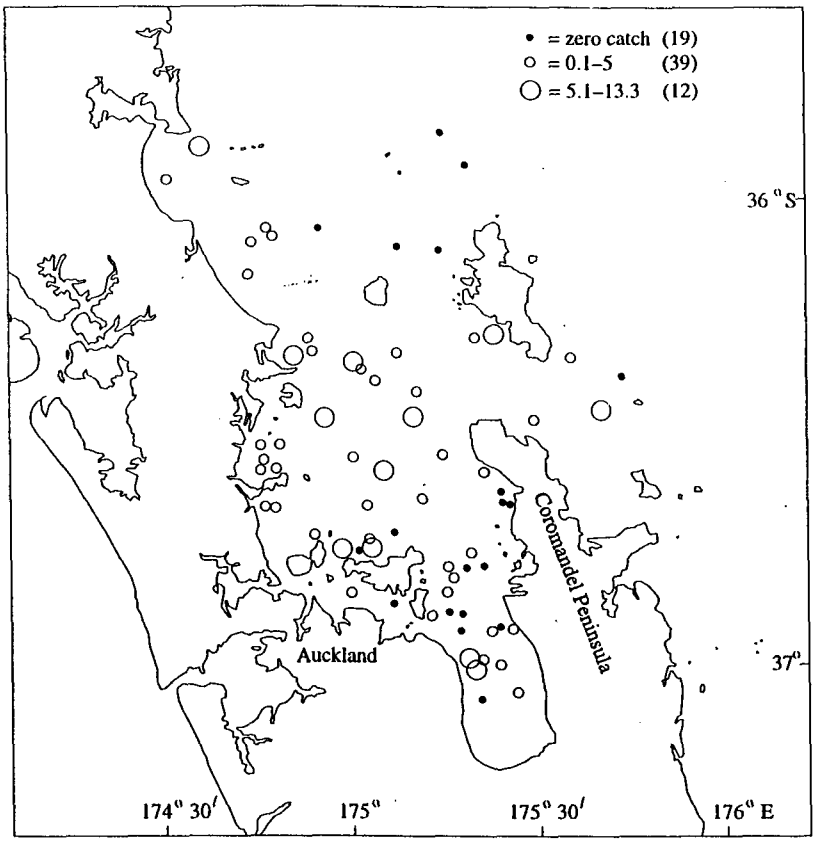


Figure 25—continued

1994



1997

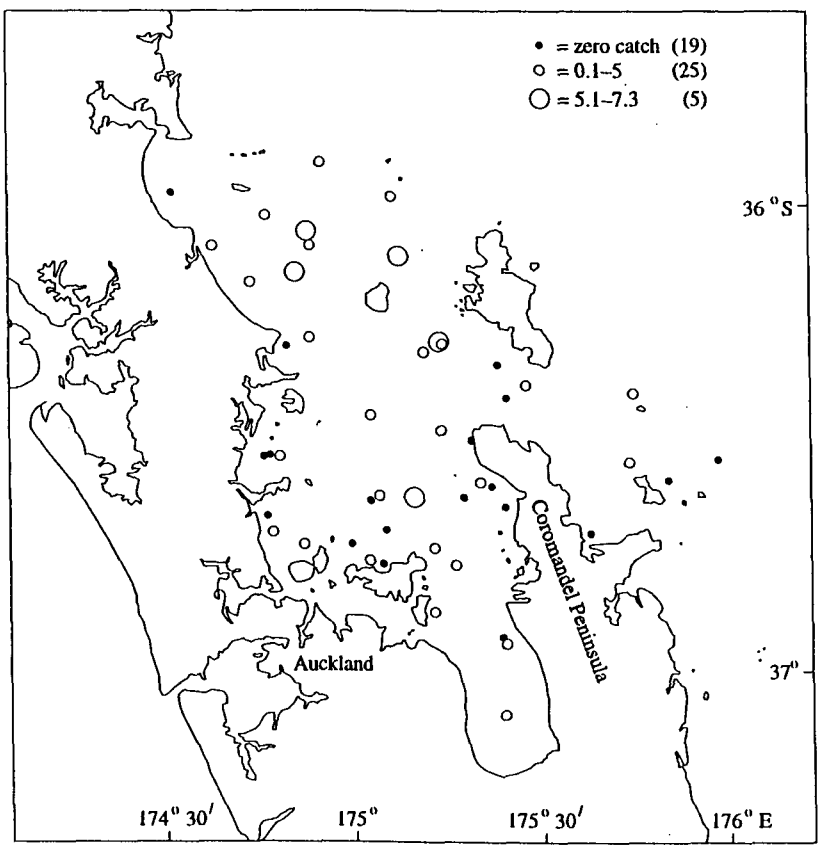
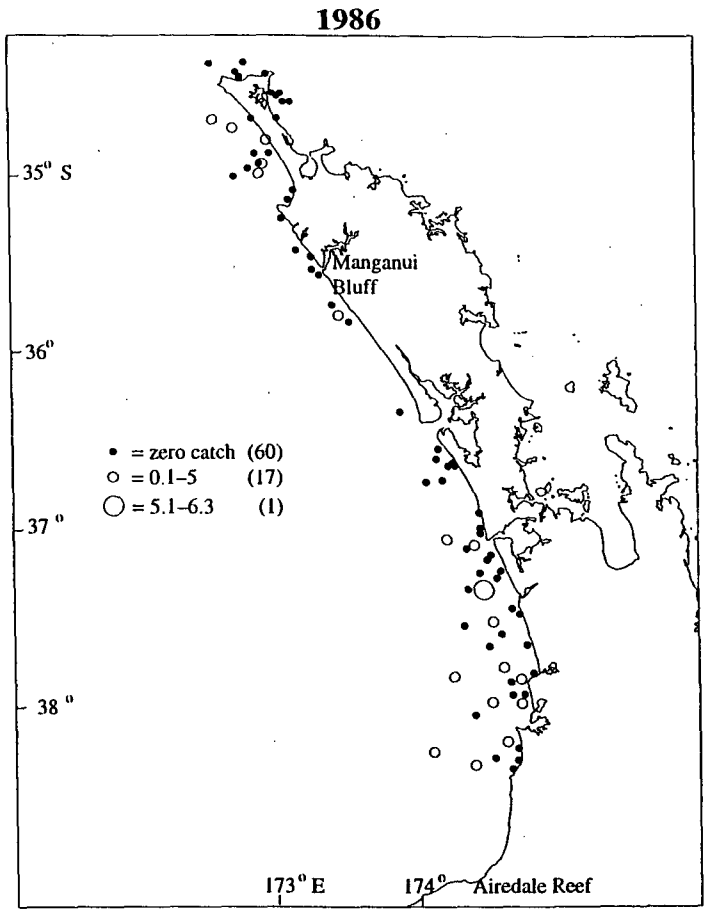


Figure 25—continued



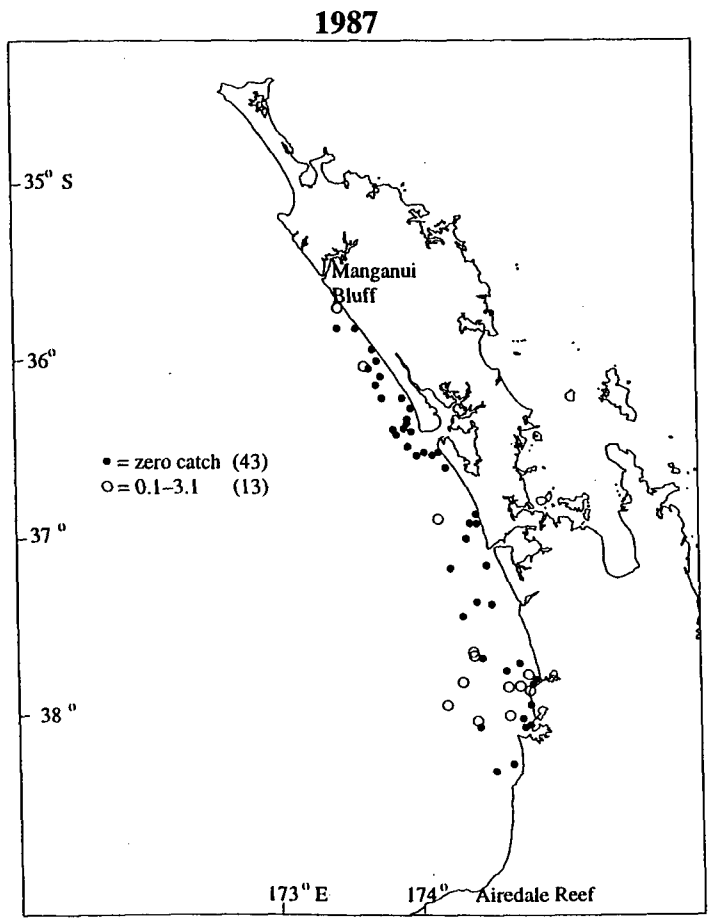
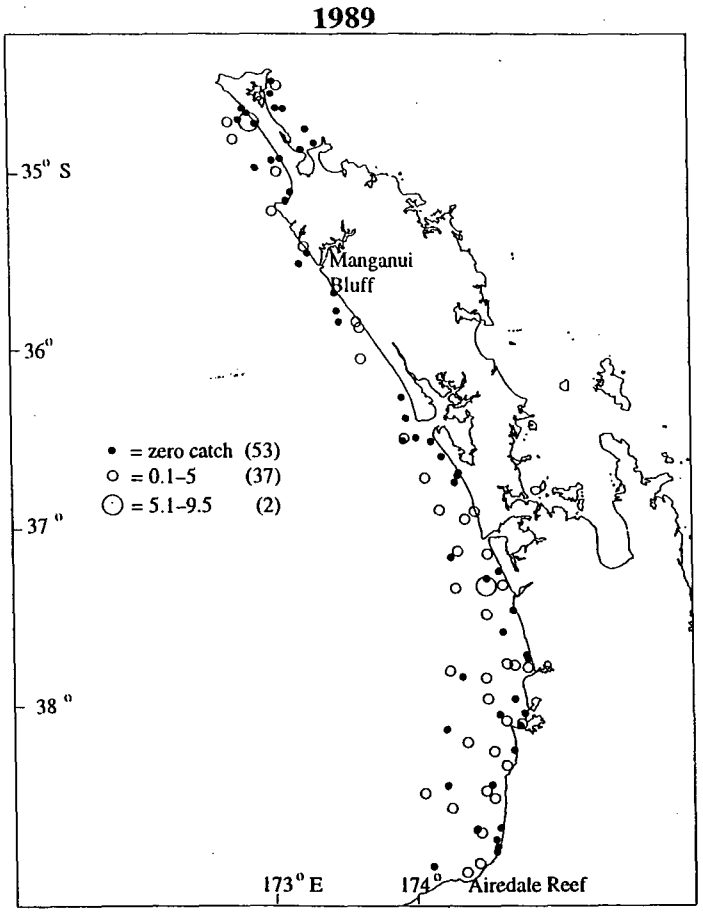


Figure 26 : **Catch rates (kg.km^2) for juvenile (< 29 cm) John dory from WCNI trawl surveys.**



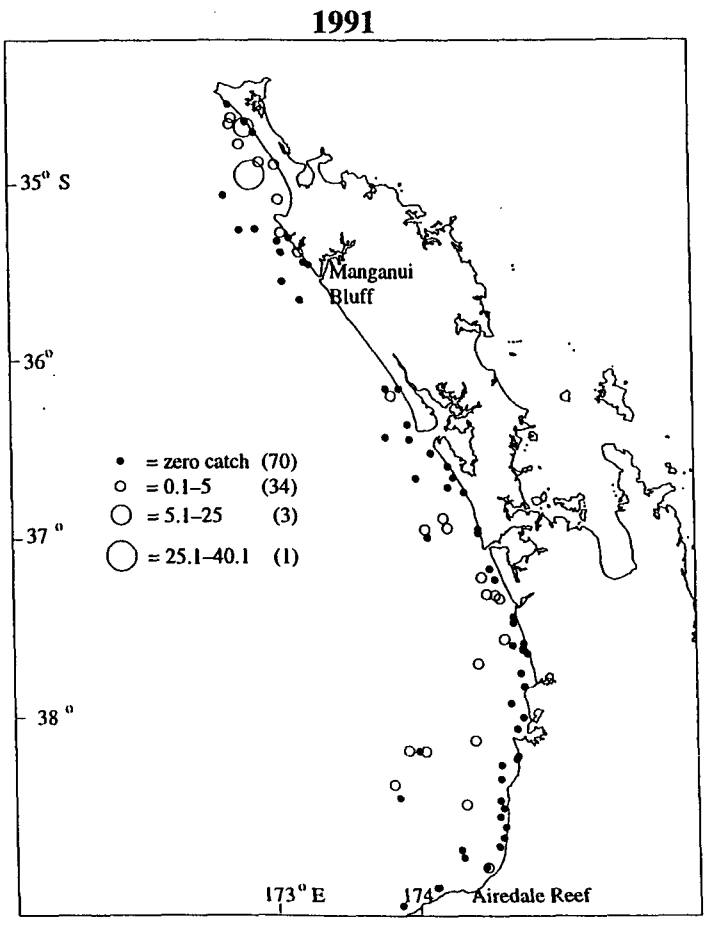
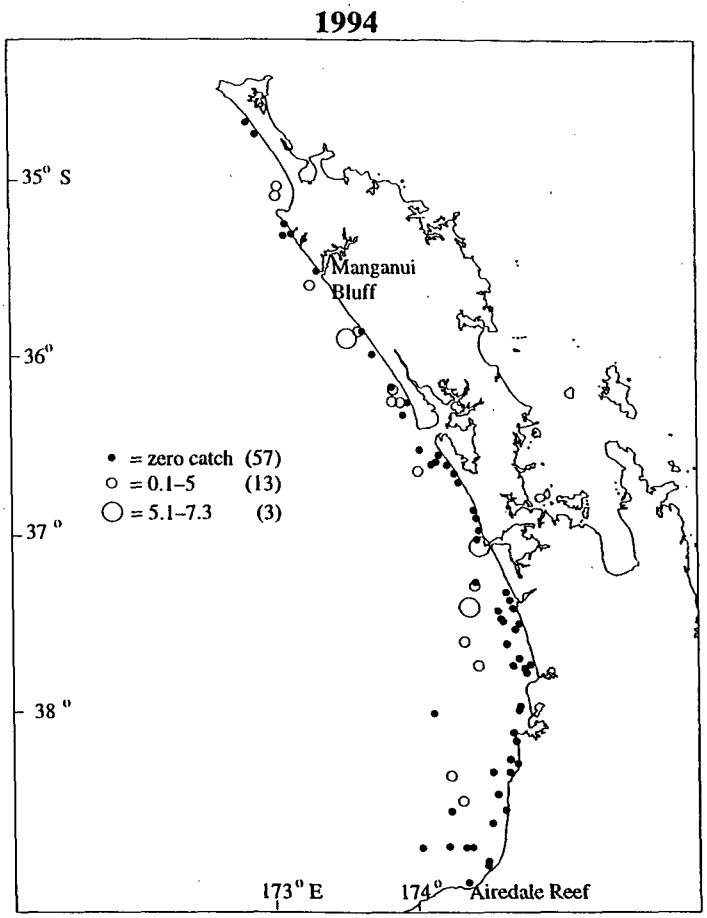


Figure 26—continued



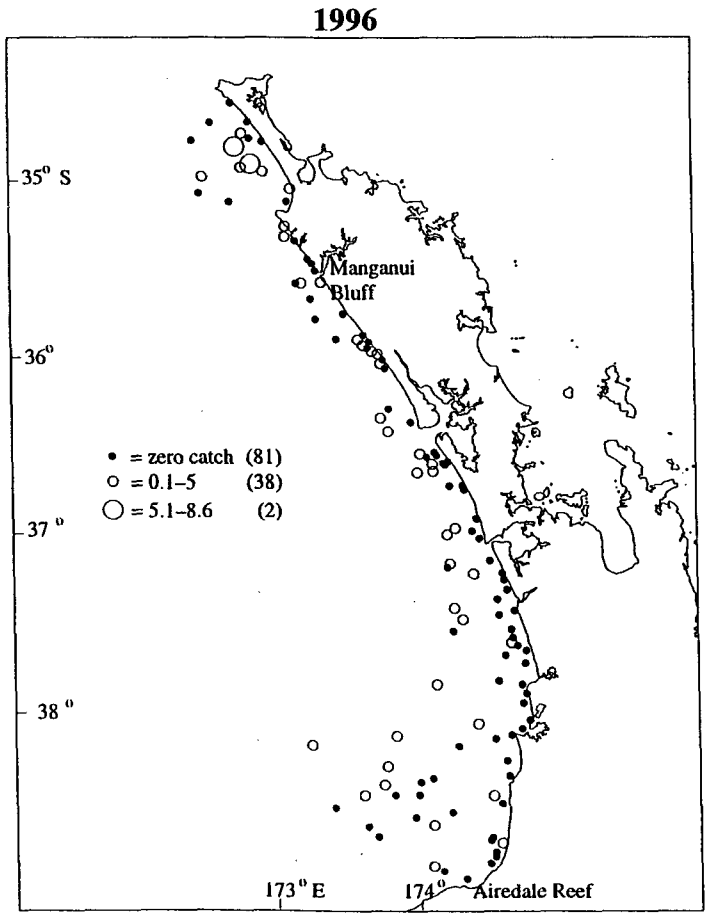


Figure 26—continued

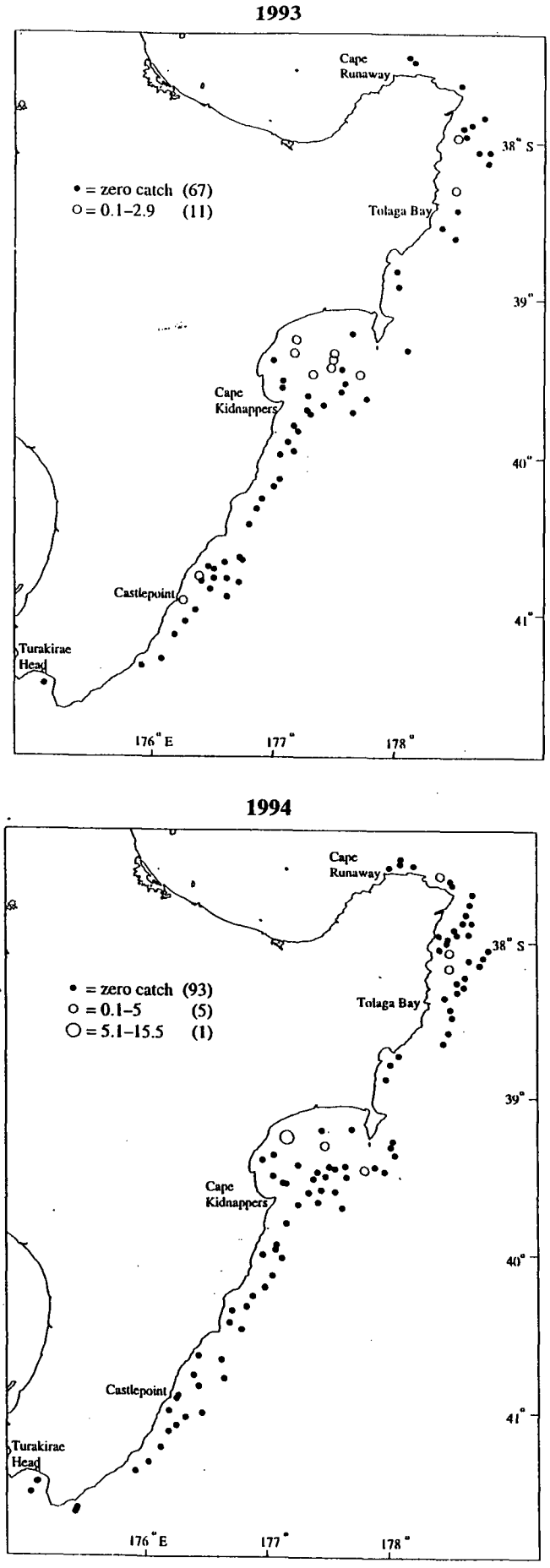
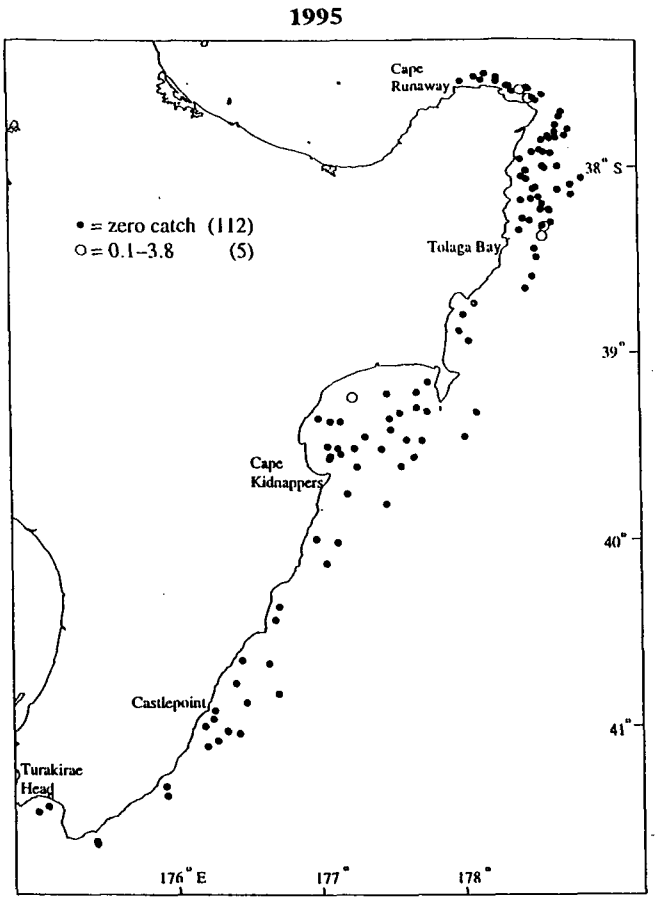


Figure 27: **Catch rates (kg.km^2) for juvenile (< 34 cm) John dory from ECNI trawl surveys.**



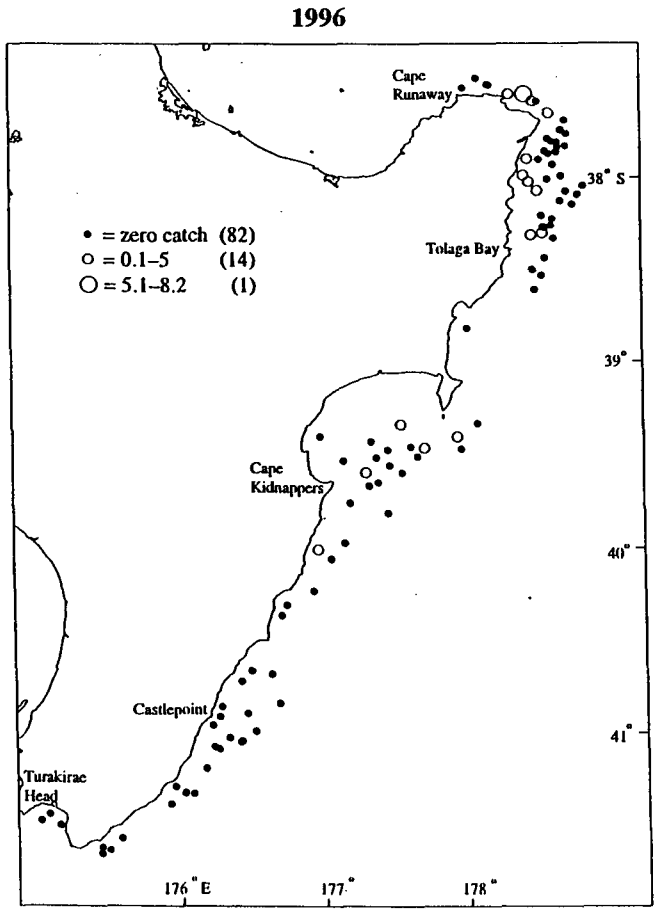


Figure 27—continued