Science Policy

NIWA

Taihoro Nukurangi

Trawl survey of red gurnard, john dory, tarakihi and associated species off the Bay of Plenty, North Island, February 1999 (KAH9902)

M. Morrison, D. Parkinson

Final Research Report for
Ministry of Fisheries Research Project INT9803

National Institute of Water and Atmospheric Research

November 1999

Final Research Report

Report Title: Trawl survey of red gurnard, john dory, terakihi and associated species off the Bay of Plenty, North Island, February 1999 (KAH9902)

Authors: M. Morrison, D. Parkinson

1. Date: 15/10/99

2. Contractor: NIWA

3. Project Title: Estimation of inshore fish abundance in the Bay of Plenty using trawl surveys

4. Project Code: INT9803

5. Project Leader: M. Morrison

6. Duration of Project:

Start Date	1 October 1998
Expected End Date	30 September 1999

7. Executive Summary:

A trawl survey of the Bay of Plenty was successfully completed during February 1999. Seventy eight stations were completed (50 phase 1, 28 phase 2) within 8 depth and area strata. Target *c.v.*s on biomass estimates were 15% for GUR, 20% for JDO, and 30% for TAR; achieved *c.v.*s were 14%, 14%, and 27% respectively. Length and weight information was also collected for all other QMS species in the catch, and for leatherjacket, frostfish, kahawai and kingfish.

Red gurnard were caught throughout the Bay of Plenty, with relatively large individual catches occurring in the 10–100 m depth range. John dory were less common, with scattered larger catches. Relatively few tarakihi were encountered; most of the tows catching these fish were in deeper water in the middle of the survey area. Snapper were found throughout the bay, and most areas had broadly comparable catch rates.

Updated length-weight relationships for red gurnard, john dory, tarakihi and snapper were derived and have been entered onto the TRAWL database. Information on reproductive stages of these four species was also collected.

8. Objectives:

See attached draft technical report.

9. Methods:

See attached draft technical report.

10. Results:

See attached draft technical report.

11. Conclusions:

See attached draft technical report.

12. Publications:

Draft technical report.

13. Data Storage:

All data have been stored in the TRAWL database. Otoliths have been catalogued and stored at Greta Point.

Introduction

Since 1983, trawl surveys have been conducted from R.V. *Kaharoa* in the Bay of Plenty, with a primary objective being the determination of snapper (*Pagrus auratus*) relative abundance, population size structure, and year class strength. However, for the current 1999 survey, snapper was dropped as a target species, and focus re-directed to those species previously assessed as secondary target species; red gurnard (*Chelidodonichthys kumu*) John dory (*Zeus faber*) and, since 1996, tarakihi (*Nemadactlyus macropterus*).

These species support commercial fisheries in the Bay of Plenty, as either target species (tarakihi), or bycatch (red gurnard, John dory), and the trawl survey programme may monitor trends in their relative abundance and population structure.

Tarakihi was specified as a target species for the first time in the 1996 survey; with the depth range of the survey being extended from 150 to 250 m to include its distribution. As a result of the dropping of snapper as a target species, and the inclusion of tarakihi, sampling intensity has shifted overall from the shallower to the deeper strata of the survey area.

Length-weight and reproductive data for the target species and snapper were collected in the present survey; this information has not been collected previously (with the exception of female snapper staging). Otolith collections were also collected and archived for the three target species, and snapper.

Previous trawl surveys have been documented as follows: surveys in 1983, 1985, 1987, no reports; 1990 (Drury & McKenzie 1992); 1992 (Drury & Hartill 1993); 1996 (Morrison 1997). This report presents the results of the Bay of Plenty trawl survey conducted in February 1999. This research was funded by the Ministry of Fisheries through contract INT9803.

Project objectives

The major objective of this research programme is as follows.

1. To determine the relative abundance and distribution of inshore finfish species in the Bay of Plenty; focusing on John dory (*Zeus faber*), red gurnard (*Chelidonichthys kumu*) and tarakihi (*Nemadactylus macropterus*).

Survey objectives

The objectives of the trawl survey for 1999 were as follows.

1. To determine the relative abundance and distribution of John dory, red gurnard, and tarakihi in the Bay of Plenty by carrying out a trawl survey. The target coefficients of variation (c.v.'s) of the biomass estimates for these species were as follows: John dory (20 %); red gurnard (15 %); tarakihi (30 %).

2. To collect the data and to determine the length frequency, length-weight relationship and reproductive condition of John dory, red gurnard, snapper and tarakihi.

3. To collect otoliths from John dory, red gurnard, snapper and tarakihi.

4. To collect the data to determine the length frequencies of all other Quota Management System (QMS) species, and frostfish (*Lepidopus caudatus*), leatherjacket (*Parika scaber*), kahawai (*Arripis trutta*) and kingfish (*Seriola lalandi*).

Timetable

The science staff joined *Kaharoa* at Auckland on 2 February 1999. The vessel sailed in the evening for the Bay of Plenty, and fishing commenced the next morning on the 3 February. A science staff changeover was made off Whakatane on 5 February. A port call was made on 7 February to unload fish and to re-ice, with the vessel sailing again on 8 February. Sampling was completed on the 13 February and a port call made to Tauranga that evening. The catch was unloaded and the science crew disembarked on 14 February.

Methods

Survey area and design

A trawl survey using the research vessel R.V. *Kaharoa* was conducted in an area extending from Mercury Island through to Cape Runaway, in the 10–250 m depth range. The 1996 survey utilised 14 depth and area strata based on the catch rate of pre-recruit snapper (<25 cm fork length (FL)) from previous trawl surveys. Since the current survey did not target juvenile snapper, 10 of these strata were combined into 4 larger strata, reducing the overall number of strata to be surveyed to 8 (Figure 1, Table 1).

A simulation study of precision versus number of stations was undertaken using data from the 1996 survey (the only previous survey with sufficient data for tarakihi biomass estimation) for the three target species. From this, a survey consisting of 78 trawl stations (50 phase 1, 28 phase 2) was chosen as most appropriate for achieving the target *c.v.*s.

The survey was of a two phase stratified random design (*after* Francis 1984), where the second phase involved the allocation of trawl shots to strata so as to maximise the anticipated reduction in the coefficients of variation of the three target species. Trawls were conducted at randomly selected positions (generated within the software RandStat version 1.7), with a minimum of three stations per stratum at least 2 n. miles (3.7 km) apart. Phase 2 stations were allocated on the basis of maximising reductions in the variance estimates of the target species. This was achieved by adding a station iteratively to each of the strata, and using the existing density and variance information to predict the likely improvement in the individual species *c.v.*s, for each possible stratum allocation. The station was then assigned to the stratum giving the greatest improvement across all *c.v.*s, and the process repeated until all stations available had been allocated. A summary of the station allocation is given in Table 1.

Vessel and gear specifications

RV *Kaharoa* is a research stern trawler with an overall length of 28 m, a displacement of 302 t, and a power rating of 522 kW. All trawling was carried out using a high opening bottom trawl (HOBT) with cut away lower wings and a 40 mm codend. Specifications of the trawl gear are given in Appendix 1.

Trawling procedure

All trawls were carried out in daylight, between 0530 and 1700 hours (NZST). Trawls were conducted from the randomly selected start position unless untrawlable ground was encountered, when a search was made for suitable ground within a 2 n. mile (3.7 km) radius of the start position. If no suitable ground was located, the station was abandoned and another random position substituted. Towing speed was between 3.0 and 3.3 knots, and tow direction was generally in a direction that maintained the same water depth throughout the tow. Distance towed was constant at 0.7 n. mile for shallower stations and 1 n. mile for deeper stations, measured using Magnavox GPS. Warp to depth ratios ranged from 13.3 : 1 at the shallowest stations to 2.2 : 1 for the deepest trawls. Trawl door spread was estimated using Scanmar gear. Where the Scanmar gear was not attached to the doors for a particular tow, trawl door spread was estimated using the average from other tows for which door spread was available. A summary of gear parameters is given in Appendix 2.

Catch and biological sampling

The catch from each trawl was sorted by species and weighed to the nearest 0.1 kg on Seaway motion-compensating scales. For all commercially important fish and squid, a sample was taken from each trawl for biological sampling. All specimens were sampled from small catches, but for large catches a random sample was taken, equal to at least 25% of total fish weight (apart from jack mackerel species, for which a smaller percentage was measured).

The length of fish and squid sampled was measured to the nearest cm below the actual length. Red gurnard, John dory, snapper and tarakihi were sexed and staged using appropriate gonad development scales (Clearwater 1992, Hore 1982, Pankhurst *et al.* 1987, Appendices 3–5 respectively). A range of sizes of red gurnard, John dory, tarakihi and snapper were also individually measured and weighed to determine the length-weight relationships for each of these species. To ensure representative samples were collected, up to a maximum of five fish per sex were measured for each 1 cm size interval, haphazardly collected from across the full spatial extent of the survey area.

Otoliths were collected from measured red gurnard, John dory, tarakihi and snapper, (up to a target of 10 otoliths per 1 cm length class, 5 each per sex), and were archived at NIWA, Greta Point, Wellington.

Environmental observations

For most of the trawl stations the following environmental conditions were recorded: sea surface temperature, air temperature, bottom temperature, wind direction and speed, cloud cover, bottom type and contour, barometric pressure, sea condition and colour, and swell height and direction.

Data analysis

Biomass indices and length frequency distributions of the main commercial species were calculated by the area swept method (Francis 1989) using the Trawl Survey Analysis Program (Vignaux 1994). In the calculation of biomass, the following assumptions were made.

1. The area swept was the distance between the doors multiplied by the distance towed.
2. The vertical availability was 1.0. This assumes that all fish within the area swept were below the headline height of the net.
3. The vulnerability was 1.0. This assumes that all fish in the volume swept were caught.
4. The areal availability was 1.0. This assumes that all fish were within the survey area at the time of the survey.

The coefficient of variation (*c.v.*) is a measure of the precision of the biomass estimates and is calculated from

$$c.v.\ (B) = \frac{\sqrt{Var(B)}}{B} \times 100$$

where B is the biomass estimate and $Var\ (B)$ is the variance of the biomass estimate.

Only the length frequencies of the target species are presented.

Results

Eighty stations were completed during the survey, however two were dropped from analysis because of poor gear performance (stations 18 and 77). This left 50 phase 1, and 28 phase 2 successfully completed stations. The areal distribution of trawl shots is shown in Figure 2 and individual station information is given in Appendix 6. Almost all of the phase 2 allocations were made to deeper strata (7085, 808CNE, 909CNE), to reduce the *c.v.* of tarakihi, which was the most variable of the target species.

Catch composition

Sixty-two species were caught during the survey (Table 2). Snapper accounted for 37.5% of the total catch by weight, followed by red gurnard 7.8%, jack mackerel (*Trachurus novaezealandiae*) 7.0%, frostfish 5.7%, jack mackerel (*T. declivis*) 5.3%, trevally 4.6%, and John dory 4.4% (Table 2). Tarakihi accounted for only 2.1% of the catch, even though most

of the second phase sampling was targeted at this species. A summary of catch by station of the more important target species for this survey is given in Appendix 7.

Distribution and catch rates

Red gurnard were caught throughout the Bay of Plenty (Figure 3), with relatively large individual catches occurring in the 10–100 m depth range. John dory were less common, with scattered larger catches (Figure 4). Relatively few tarakihi were encountered; most of the tows catching these fish were in deeper water in the middle of the survey area (Figure 5). Snapper were found throughout the bay, and most areas had broadly comparable catch rates (Figure 6).

Biological data

Biological data collected from the catch are summarised in Table 3. The scaled length frequency distribution of red gurnard showed males and females to have broadly similar population length frequencies, although females reached a larger size and had a lower proportion in the 20–30 cm range (Figure 7). A small mode of juvenile fish was evident in the 12–19 cm range, which probably represented 1+ fish.

Length frequencies for John dory were composed of two size modes, from 20–30 cm, and from 30–45 cm (to 50 cm for females). The smaller size mode is likely to have been composed of 1+ fish. Females displayed a broader size range of fish in the second mode, and were on average larger (Figure 8).

Tarakihi were caught in modest numbers compared to the other target species, and had a dominant mode of fish length at 30–40 cm. No fish less than 19 cm were caught (Figure 9).

Snapper length frequencies were the same for both males and females, with a mode at around 22–27 cm, followed by a descending limb of larger sized fish to 45 cm (Figure 10). The mode at 22–27 cm was likely to be composed of 3–5+ fish, based on previous age-length keys produced for snapper in this area. A modest mode of 1+ snapper were present (11 to 15 cm), and the 2+ cohort (15–21 cm) also appeared to be weak, compared to the 1996 survey.

Individuals of snapper, John dory, and red gurnard were measured, and standard length-weight relationships calculated for each species (Table 4).

Male red gurnard were predominantly in the spermatogenic phase of ovarian development (56%) (Table 5). Female red gurnard were mainly in the regressed (26%), vitellogenic (25%), or spent state (25%). For John dory males, 64% were in a developing-resting state, 20% in a developing state, and 11% in the ripe-spawning state (Table 5). Female John dory were predominately in a maturing virgin state (36%), with the remainder being mainly in developing (12%) developed (17%), or gravid states (17%) (Table 5).

Tarakihi males were predominately in a developing state (50%), with the remainder being in a virgin (24%), developing (15%) or partially spent (9%) state (Table 5). Tarakihi females were mainly in a developing (67%), resting (24%), or advanced developing (15%) state. Snapper males were predominately spermatogenic (58%), with the remainder being mainly immature

(22%), partially spermiated (10%), or spent (8%). Female snapper were predominately regressed (71%), with the remainder being mainly immature (12%), or vitellogenic (14%).

Otoliths collections were made for the three target species and snapper, and a summary of what was collected is given in Appendix 8.

Biomass estimates

Biomass estimates for red gurnard, John dory, tarakihi, snapper, jack mackerel (*T. novaezealandiae*), and trevally are given in Table 6. Coefficients of variation for the three target species were 14.1% for red gurnard, 14.1% for John dory, and 27% for tarakihi, all less than the project objective targets (15% for GUR, 20% for JDO, 30% for TAR). Red gurnard biomass was distributed across most of the shallow to mid-depth strata, but were at low biomass levels in the deepest strata of 150–250 m water depth (909CNE). John dory biomass was concentrated in stratum 7085 (61%), with the bulk of the remaining biomass occurring across both shallower (1096, 6085) and deeper (808CNE) strata. Tarakihi were most abundant in the deepest strata (808CNE, 909CNE) and were not present in strata occupying water depths of less than 50 m.

Snapper were relatively abundant in the shallow to mid depth strata, while jack mackerel (*T. novaezealandiae*) biomass was concentrated in strata 4085 (31%) and 808CNE (33%). Trevally were found mainly in shallow (1096/2096, 4085, 5187/5287) to intermediate depth (7085) strata.

Discussion

This survey is the seventh in the time series of trawl surveys for the Bay of Plenty using the R.V. *Kaharoa*. The present objectives mark a slight departure from previous surveys, with snapper being dropped as a target species, and those species historically ranked as secondary species being re-assigned as primary target species. This resulted in some re-stratification of the area, in particular to improve sampling precision for tarakihi.

All objectives for this programme were successfully met, and the *c.v.*s on biomass estimates were all lower than the specified target *c.v.*s. The *c.v.* for tarakihi, predicted from survey simulations to be the most variable of the target species, was an improvement on the 1996 survey results (the only other survey to include the deeper strata where tarakihi are dominantly found). However, tarakihi biomass was modest at 50 t (*c.v.* of 27%) (*c.f.* 35 t, *c.v.* 46%, 1996), suggesting that the current survey series may not be sampling a large proportion of the tarakihi stock residing within the general region.

*C.v.*s for the other target species were towards the lower end of the range that has been achieved historically (red gurnard current 14%, past range 9–28%; John dory current 14%, past range 12– 44%).

A reasonable *c.v* on snapper biomass was also obtained (18%), although this species is no longer a target species of the surveys. Other commercial species were not particularly abundant.

Acknowledgments

Thanks go to the captain and crew of *Kaharoa*, and the scientific staff during the voyage, Kevin MacKay, Matt Smith, Glen Carbines, Nick Davies, and Jim Drury. Otolith sampling was organised and conducted by Bruce Hartill and Cameron Walsh. Mike Beentjes provided comments on a draft of the report. This work was funded by MFish contract INT9803.

References

Clearwater, S. J. 1992: Reproductive biology and response to capture stress of red gurnard (*Chelidonichthys kumu*) Family Triglidae. Unpublished MSc thesis, University of Auckland. 96 p.

Drury, J., & McKenzie, J. 1992: Summary findings from the 1990 R.V. *Kaharoa* trawl survey of the Bay of Plenty (KAH9004). MAF Fisheries North Internal Report #5. (Draft report held in NIWA library, Wellington).

Drury, J., & Hartill, B.H. 1993: Summary findings from the 1992 R.V. *Kaharoa* trawl survey of the Bay of Plenty (KAH9202). MAF Fisheries North Internal Report #16. (Draft report held in NIWA library, Wellington).

Francis, R.I.C.C. 1984: An adaptive strategy for stratified random trawl surveys. *N.Z. Journal of Marine and Freshwater Research 18*: 59–71.

Francis, R.I.C.C. 1989: A standard approach to biomass estimation from trawl surveys. N.Z. Fisheries Assessment Research Document 89/3 p. (Draft report held in NIWA library, Wellington).

Hore, A. J. 1982: The age, growth and reproduction of the John dory, *Zeus faber*. Unpublished MSc thesis, University of Auckland.

Morrison, M.A. 1997: Trawl survey of snapper and associated species in the Bay of Plenty, February 1996 (KAH9601). NIWA Technical Report 2. 10 p. (Report held in NIWA library, Wellington.)

Pankhurst, N.W., McMillan, P.J., & Tracey, D.M. 1987: Seasonal reproductive cycles in three commercially exploited fishes from the slope waters off New Zealand. *Journal of Fish Biology 30*: 193–211.

Vignaux, M. 1994: Documentation of Trawl Survey Analysis Program. MAF Fisheries Greta Point Internal Report No. 225. 44 p. (Unpublished report held in NIWA library, Wellington.)

Table 1: Stratum descriptions, areas, station allocation, and station densities

Stratum	Description	Depth range	Area (km^2)	No. of Stations		Station density (per km^2)
				Phase 1	Phase 2	
1096/2096	Whale Island – Cape Runaway Waihi – Town Point	10 – 25	432	7	1	1 : 54
5187/5287	Mt Manganui – Whale Island Hot Water Beach – Mt Manganui	25 – 50	629	3		1 : 210
32NH	Te Ororoa – Opoutere	10 – 25	26	3		1 : 9
6085	Whale Island to Cape Runaway	50 – 100	740	3		1 : 25
7085	Mercury Island – Whale Island	50 – 100	1 696	14	11	1 : 68
808CNE	Mercury Island – Cape Runaway	100 – 150	1 304	6	7	1 : 100
909CNE	Mercury Island – Cape Runaway	150 – 250	897	10	9	1 :47
4085	Whale Island – Cape Runaway	25 – 50	486	3		1 : 162
			6 210	50	28	

Table 2: Species caught, total catch, and percentage of stations at which each species occurred (Occ)

Common name	Species code	Scientific name	Total weight (kg)	Percentage of catch by weight	Occ
Snapper	SNA	*Pagrus auratus*	2 358.1	37.5	76.9
Red gurnard	GUR	*Chelidonichthys kumu*	491.9	7.8	74.4
Jack mackerel	JMN	*Trachurus novaezealandiae*	438.3	7.0	50.0
Frostfish	FRO	*Lepidopus caudatus*	357.0	5.7	34.6
Jack mackerel	JMD	*Trachurus declivis*	331.9	5.3	37.2
Trevally	TRE	*Pseudocaranx dentex*	291.2	4.6	38.5
John dory	JDO	*Zeus faber*	276.4	4.4	66.7
Cucumberfish	CUC	*Chlorophthalmus nigripinnis*	161.2	2.6	17.9
Sea perch	SPE	*Helicolenus* spp.	144.5	2.3	35.9
Barracouta	BAR	*Thyrsites atun*	144.0	2.3	32.1
Tarakihi	TAR	*Nemadactylus macropterus*	132.0	2.1	23.1
Silverside	SSI	*Argentina elogata*	131.1	2.1	19.2
Rough skate	RSK	*Raja nasuta*	123.9	2.0	24.4
Leatherjacket	LEA	*Parika scaber*	106.1	1.7	43.6
Snipefish	SNI	*Macrorhamphosus scolopax*	72.0	1.1	14.1
Eagle ray	EGR	*Myliobatus tenuicaudatus*	66.1	1.0	7.7
Stingray	STR	*Allothunnus fallai*	65.7	1.0	6.4
Arrow squid	SQU	*Nototodarus sloanii*	61.1	1.0	34.6
Japanese gurnard	JGU	*Pterygotrigla picta*	60.8	1.0	28.2
Kahawai	KAH	*Arripis trutta*	48.0	0.8	16.7
Thresher shark	THR	*Alopias vulpinus*	45.0	0.7	1.3
Silver dory	SDO	*Cyttus novaezealandiae*	41.7	0.7	15.4
Kingfish	KIN	*Seriola lalandi*	41.1	0.7	9.0
Shorttailed stingray	BRA	*Dasyatis brevicaudatus*	40.0	0.6	1.3
Scaly gurnard	SCG	*Lepidotrigla brachyoptera*	31.5	0.5	35.9
Rig	SPO	*Mustelus lenticulatus*	24.0	0.4	7.7
School shark	SCH	*Galeorhinus australis*	22.1	0.4	3.8
Smooth skate	SSK	*Raja innominata*	21.8	0.3	5.1
Hammerhead shark	HHS	*Sphyrna zygaena*	21.2	0.3	5.1
Mirror dory	MDO	*Zenopsis nebulosus*	20.2	0.3	11.5
Electric ray	ERA	*Torpedo fairchildi*	18.9	0.3	5.1
Jack mackerel	JMM	*Trachurus murphyi*	18.2	0.3	7.7
Red cod	RCO	*Pseudophycis bachus*	11.3	0.2	6.4
Bollons Rattail	CBO	*Caelorinchus bollonsi*	9.9	0.2	1.3
Hapuku	HAP	*Polyprion oxyceneios*	9.3	0.1	3.8
Yellow boarfish	YBO	*Pentaceros decacanthus*	7.3	0.1	2.6
Octopus	OCT	*Octopus* sp.	6.6	0.1	1.3
Sand flounder	SFL	*Rhombosolea plebeia*	5.2	0.1	7.7
Rattail	RAT	Macrouridae	4.8	0.1	3.8
Lemon sole	LSO	*Pelotretis flavilatus*	4.1	0.1	15.4
Witch	WIT	*Arnoglossus scapha*	3.3	0.1	21.8
Southern Boarfish	SBO	*Pseudopentaceros richardsoni*	3.1	0.0	2.6
Brown stargazer	BRZ	*Xenocephalus armatus*	2.7	0.0	3.8
Gemfish	SKI	*Rexea solandri*	2.5	0.0	1.3
Ghost shark	GSH	*Hydrolagus novaezealandiae*	2.3	0.0	2.6
Spotted stargazer	SPZ	*Genyagnus monopterygius*	2.2	0.0	6.4
Blue mackerel	EMA	*Scomber australasicus*	2.1	0.0	3.8
Yellow eyed mullet	YEM	*Aldrichetta forsteri*	2.1	0.0	1.3
Paddle crab	PAD	*Ovalipes catharus*	1.8	0.0	1.3
Northern spiny dogfish	NSD	*Squalus mitsukurii*	1.3	0.0	1.3

Blue cod	BCO	*Parapercis colias*	1.0	0.0	1.3
Conger eel	CON	*Conger* spp.	0.9	0.0	1.3
Ling	LIN	*Genypterus blacodes*	0.8	0.0	1.3
Estuary Stargazer	ESZ	*Leptoscopus macropygus*	0.7	0.0	1.3
Yellow-belly flounder	YBF	*Rhombosolea leporina*	0.7	0.0	1.3
Unidentified	UNI		0.6	0.0	3.8
Prawn killer	PRK	*Ibacus alticrenatus*	0.5	0.0	3.8
Spotty	STY	*Notolabrus celidotus*	0.5	0.0	1.3
Capro Dory	CDO	*Capromimus abbreviatus*	0.4	0.0	3.8
Broad squid	BSQ	*Sepioteuthis australis*	0.3	0.0	1.3
Pipefish	PIP	Syngnathidae	0.2	0.0	2.6
Stargazer	STG		0.2	0.0	1.3
Redbait	RBT	*Emmelichthys nitidus*	0.1	0.0	1.3
		Total	6 295.8		

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

Common name	No. of tows in which species occurred	No. of fish	No. of males	No. of females	No. of unsexed
Snapper	60	3 884	1 633	1 910	341
Red gurnard	58	1 790	696	995	99
John dory	52	380	207	172	2
Jack mackerel (*Trachurus novaezelandiae*)	39	2 576	–	–	
Leatherjacket	34	437	–	1	436
Trevally	30	326	132	193	1
Jack mackerel (*T. declivis*)	29	884	1	–	883
Scaly gurnard	28	48	–	–	48
Sea Perch	28	17	–	–	17
Frostfish	27	550	6	4	540
Arrow squid	27	389	19	13	357
Barracouta	25	266	20	23	223
Japanese gurnard	22	20	–	–	20
Rough Skate	19	8	1	7	0
Tarakihi	18	172	103	69	0
Witch	17	5	–	–	5
Kahawai	13	50	26	16	8
Lemon sole	12	13	1	1	11
Silver dory	12	2	–	2	0
Kingfish	7	8	1	7	0
Eagle ray	6	5	3	2	0
Jack mackerel (*T. murphyii*)	6	16	1	–	15
Sand flounder	6	12	4	1	7
Rig	6	6	3	2	1
Red cod	5	34	1	3	30
Spotted stargazer	5	6	2	2	2
Brown stargazer	3	3	–	1	2
Blue mackerel	3	17	–	–	17
Hapuku	3	3	1	–	2
School shark	3	2	–	2	0
Ghost shark	2	2	–	–	2
Southern Boarfish	2	3	–	–	3
Blue cod	1	1	1	–	0
Broad squid	1	2	–	–	2
Estuary Stargazer	1	2	–	–	2
Ling	1	1	–	–	1
Gemfish	1	2	1	1	0
Yellow-belly flounder	1	2	–	–	2
Yellow eyed mullet	1	11	–	–	11

Table 4: **Length weight coefficients for snapper, John dory, and red gurnard, determined from $W = aL^b$ where W = weight (g) and L = length (mm)**

Species	Sex	n	Length range (cm)	a	b	r
Red gurnard	Male	498	20 – 42	0.0048	3.2075	0.98
	Female	631	14 – 48	0.0031	3.3272	0.96
	All fish	1 184	13 – 48	0.0038	3.2770	0.97
John dory	Male	102	19 – 46	0.0185	2.9531	0.92
	Female	162	20 – 54	0.0084	3.1864	0.96
	All fish	265	19 – 54	0.0067	3.2454	0.95
Tarakihi	Male	101	19 – 46	0.0127	3.0944	0.96
	Female	54	20 – 48	0.0075	3.2414	0.96
	All fish	155	19 – 48	0.0098	3.1665	0.96
Snapper	Male	512	19 – 62	0.0468	2.7655	0.99
	Female	672	15 – 58	0.0426	2.7949	0.98
	All fish	1 222	12 – 62	0.0445	2.7809	0.98

Table 5: **Numbers of male and female red gurnard, John dory, tarakihi and snapper at each reproductive stage**

Species		No. of fish	Gonad stage								
			0	1	2	3	4	5	6	7	8
Red gurnard	Males	504	–	71	283	62	11	76	1	–	–
	Females	633	–	92	163	156	56	10	156	–	–
John dory	Males	186	–	8	119	37	21	1	0	0	0
	Females	163	–	3	59	20	28	28	12	10	3
Tarakihi	Males	100	0	24	50	15	1	1	9	0	–
	Females	54	0	11	36	6	1	0	0	0	–
Snapper	Males	556	–	122	325	53	10	46	0	–	–
	Females	776	–	91	549	105	10	8	13	–	–

–, not applicable

Table 6: **Estimated biomass (t) and coefficient of variation (cv, in parentheses) by stratum and all strata combined, of red gurnard (GUR), John dory (JDO), tarakihi (TAR), snapper (SNA), jack mackerel (JMN, *Trachurus novaezealandiae*), and trevally (TRE)**

	GUR	JDO	TAR	SNA	JMN	TRE
Stratum						
1096/2096	46.1 (25)	10.9 (59)	0.0	463.9 (45)	15.8 (47)	47.2 (28)
32NH	2.9 (35)	0.6 (10)	0.0	31.66 (15)	0.0	2.03 (52)
4085	24.5 (67)	7.9 (80)	0.0	182.1 (29)	114.7 (74)	89.4 (6)
5187/5287	64.2 (34)	7.2 (11)	0.0	360.2 (47)	4.4 (81)	78.4 (84)
6085	40.1 (57)	15.7 (72)	2.3 (52)	166.1 (19)	59.7 (45)	2.90 (100)
7085	150.5 (21)	107.4 (17)	9.1 (85)	404.2 (20)	40.5 (70)	46.31 (40)
808CNE	33.5 (33)	22.6 (29)	13.4 (43)	30.8 (25)	123.6 (64)	0.0
909CNE	1.7 (69)	3.2 (72)	25.6 (38)	6.31 (43)	15.5 (69)	0.0
Total	363.5 (14)	175.5 (14)	50.4 (27)	1 645.4 (18)	374.1 (33)	266.4 (26)

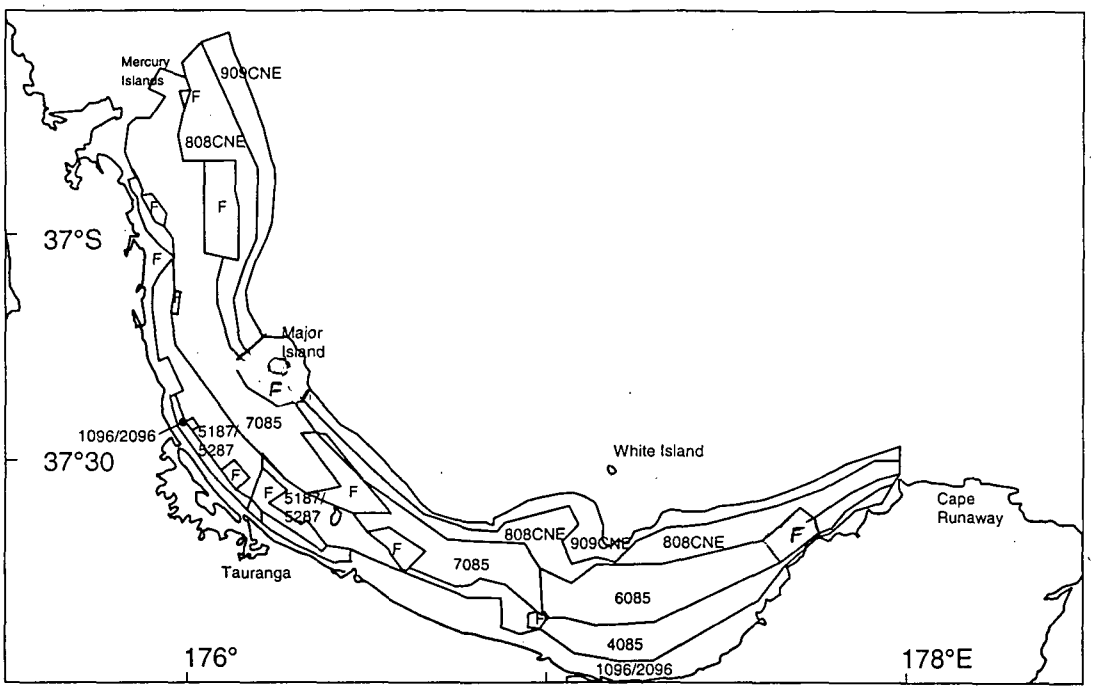

Figure 1: Survey area and stratum boundaries (F = foul ground area). Alphanumeric codes refer to stratum designations.

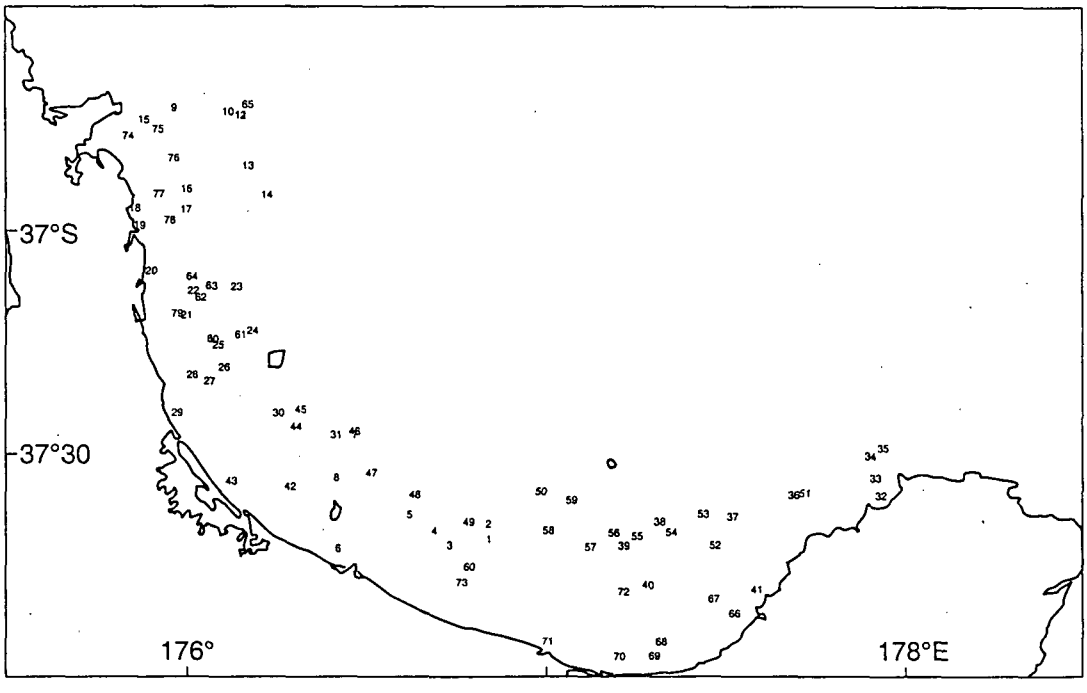

Figure 2: Station position and numbers.

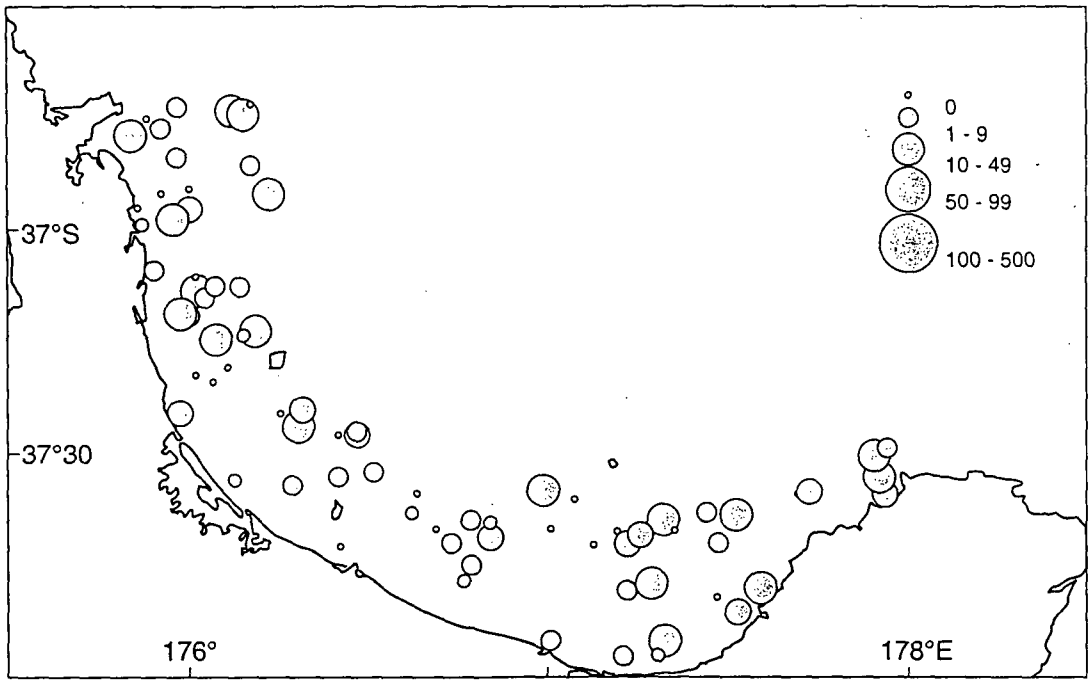

Figure 3: Catch rates (kg.km^{-2}) of red gurnard.

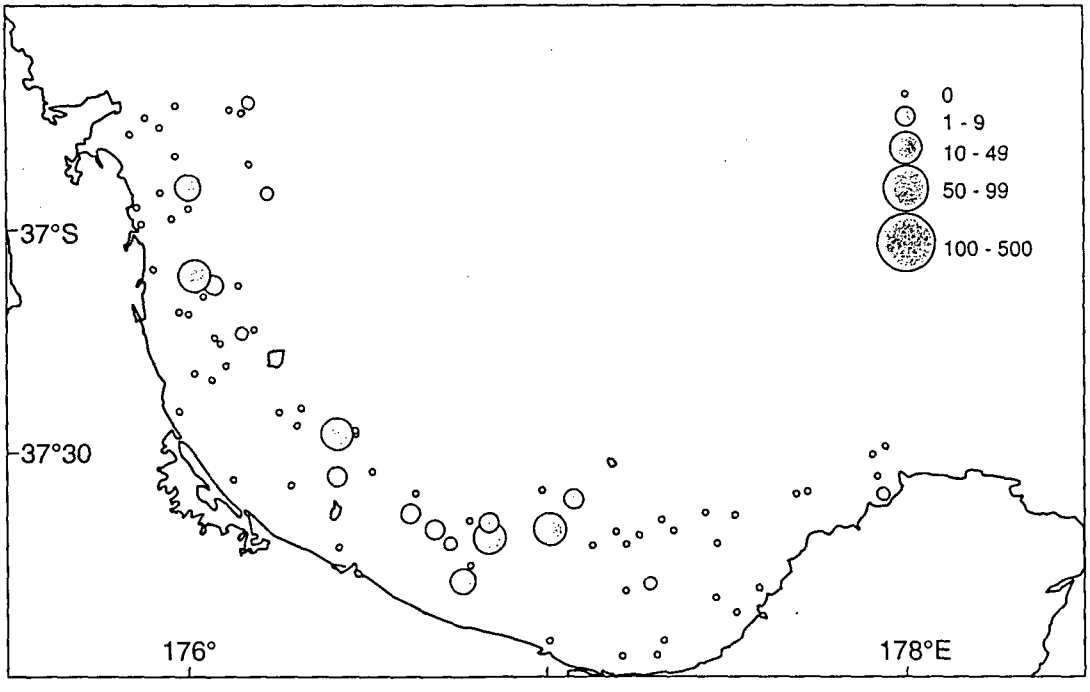

Figure 4: Catch rates (kg.km^{-2}) of john dory.

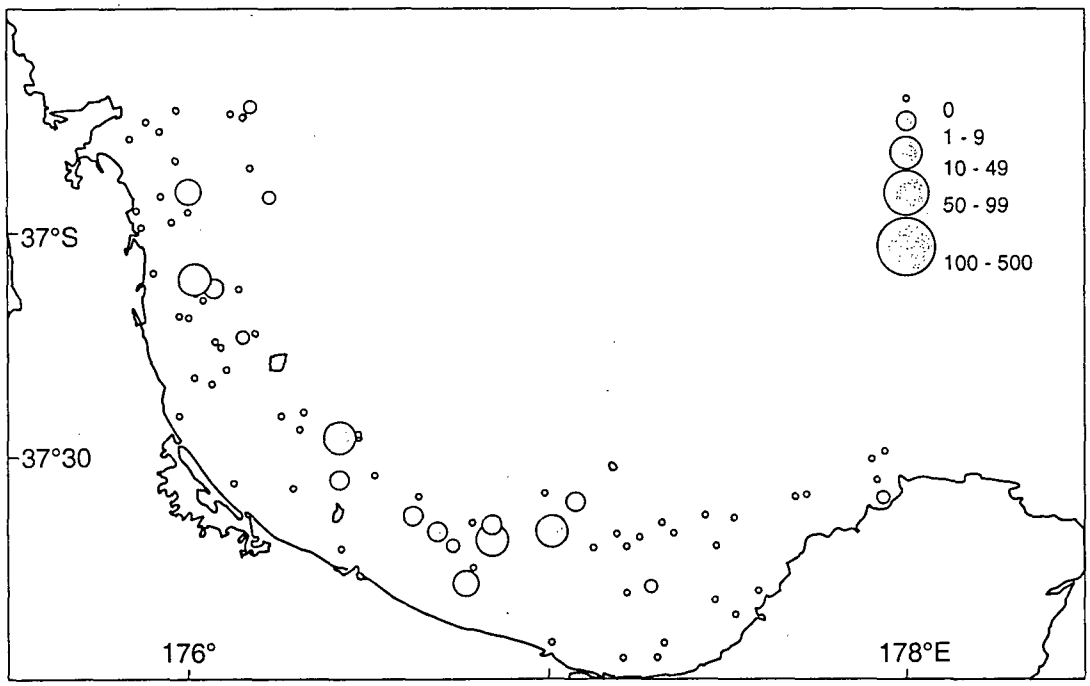

Figure 5: Catch rates (kg.km^{-2}) of tarahiki.

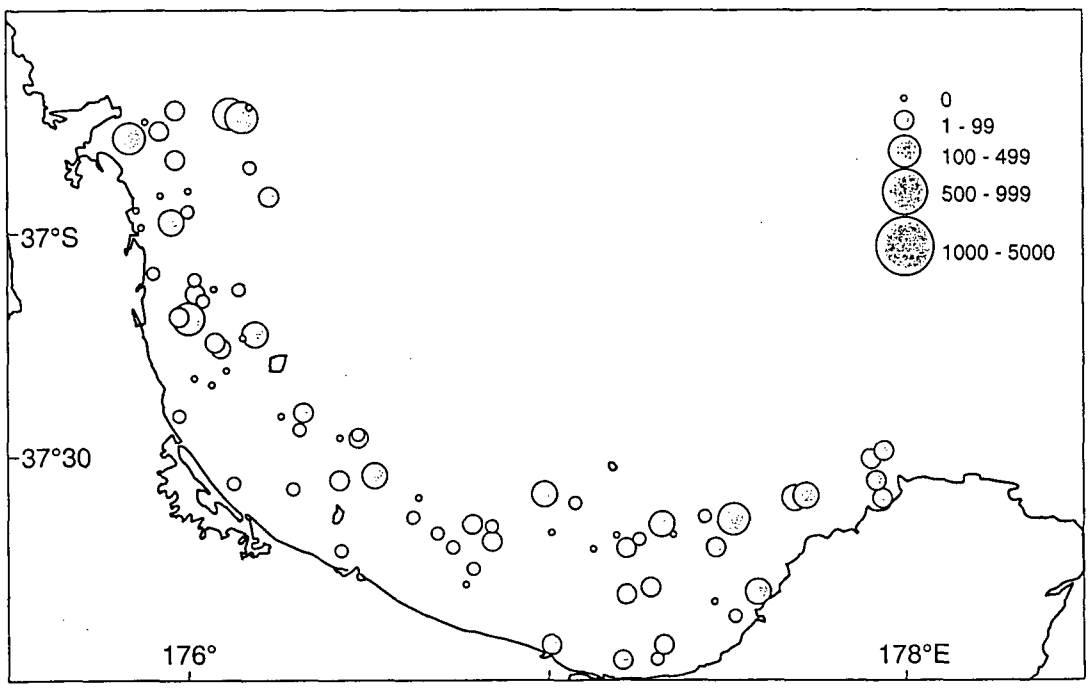

Figure 6: Catch rates (kg.km^{-2}) of snapper.

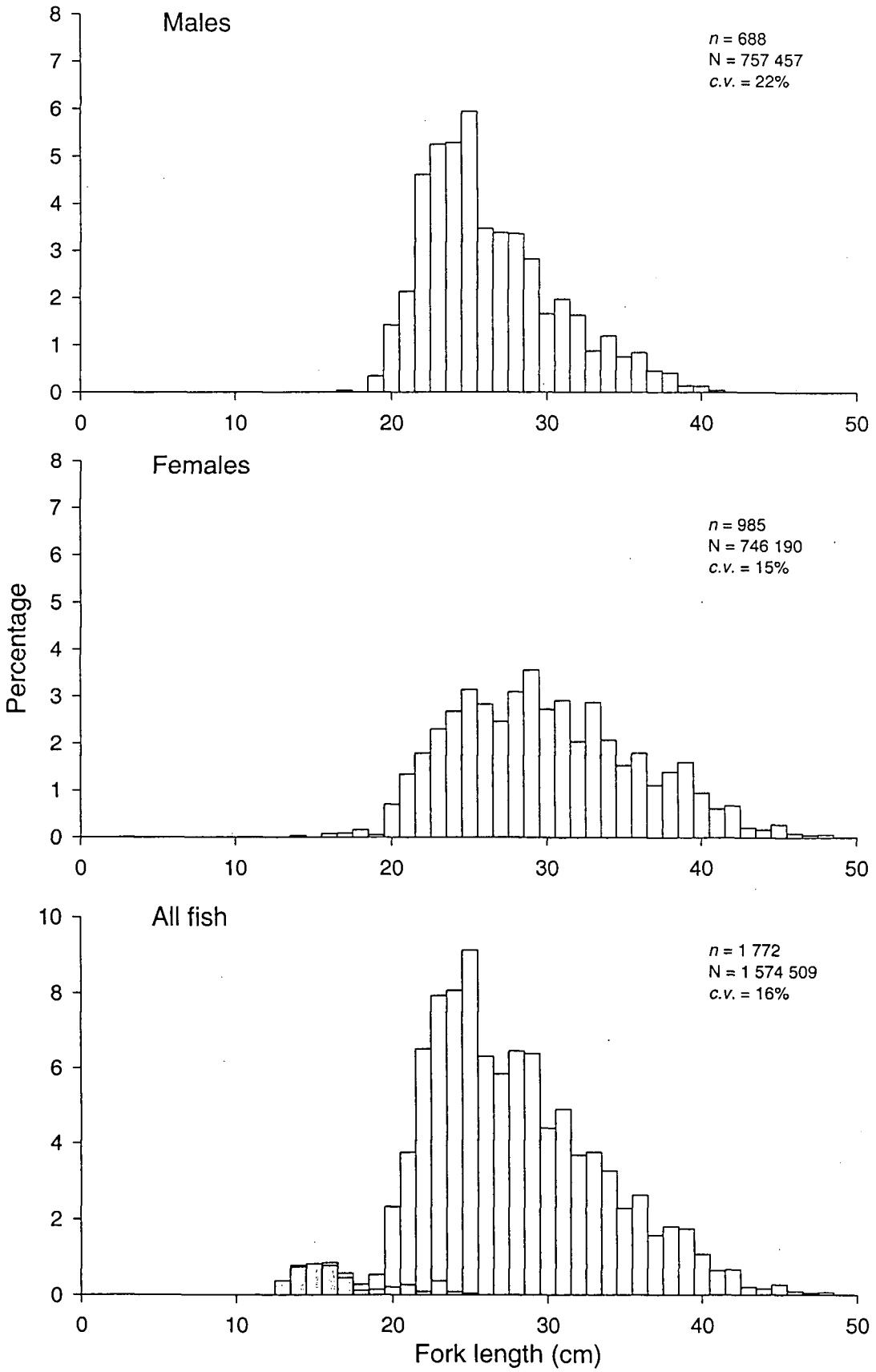

Figure 7 : Scaled length frequency distributions of male, female and all red gurnard. *n* = number of fish measured, N = estimated number of fish in the survey area, and *c.v.* = coefficient of variation of the survey estimate. Unsexed fish are shown as shaded bars.

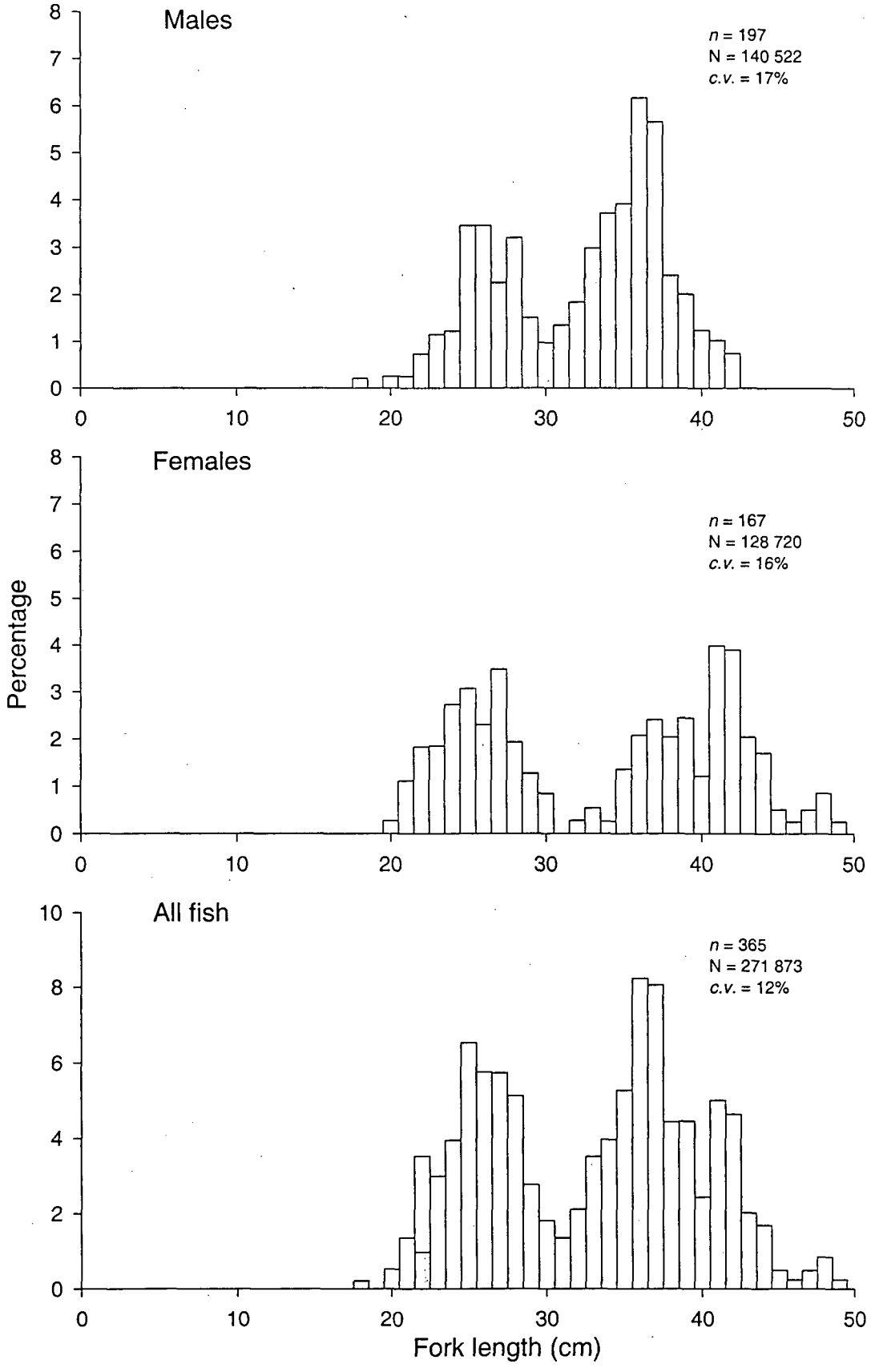

Figure 8 : Scaled length frequency distributions of male, female and all john dory. *n* = number of fish measured, N = estimated number of fish in the survey area, and *c.v.* = coefficient of variation of the survey estimate. Unsexed fish are shown as shaded bars.

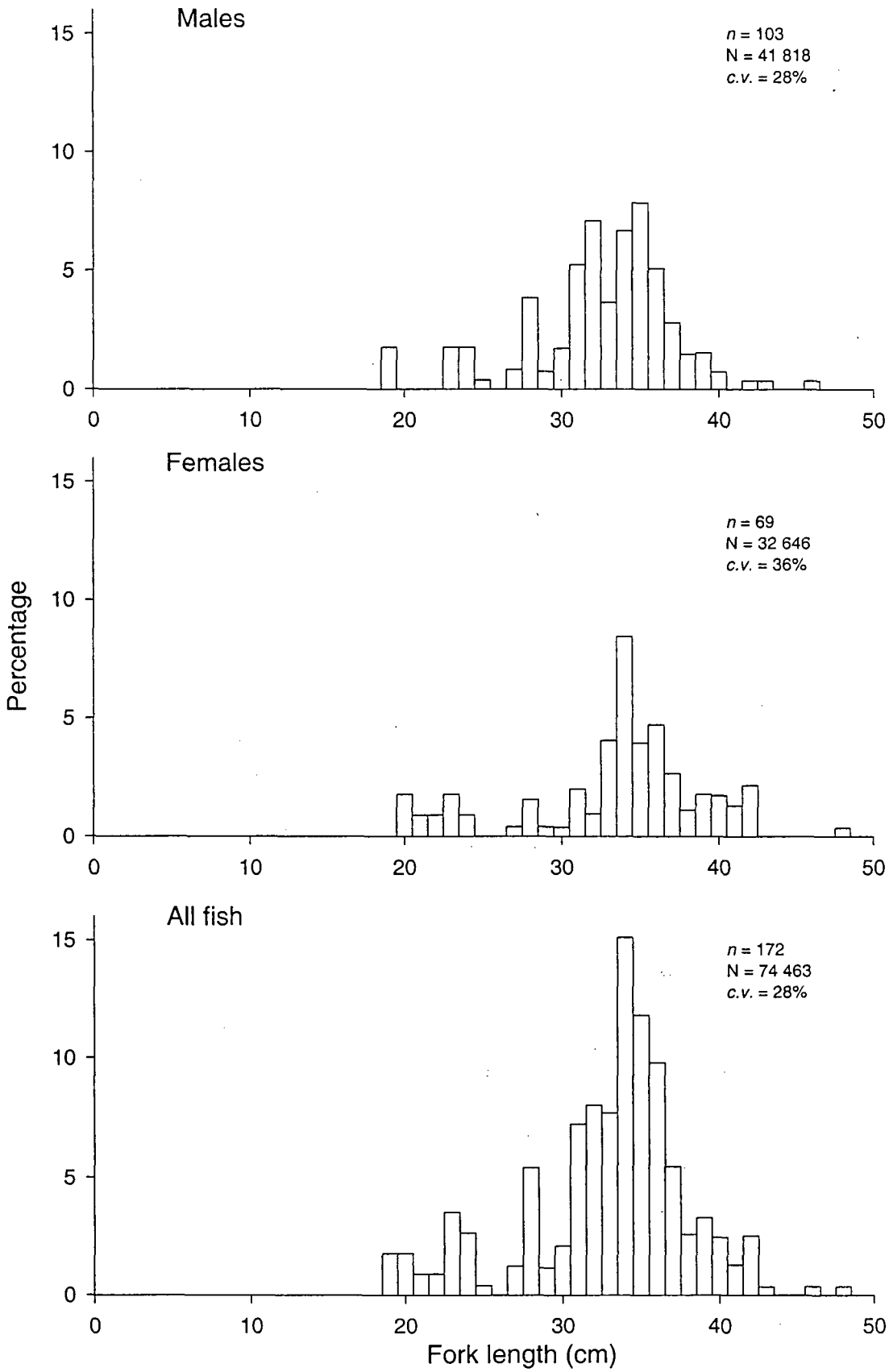

Figure 9 : Scaled length frequency distributions of male, female and all tarakihi. *n* = number of fish measured, N = estimated number of fish in the survey area, and *c.v.* = coefficient of variation of the survey estimate.

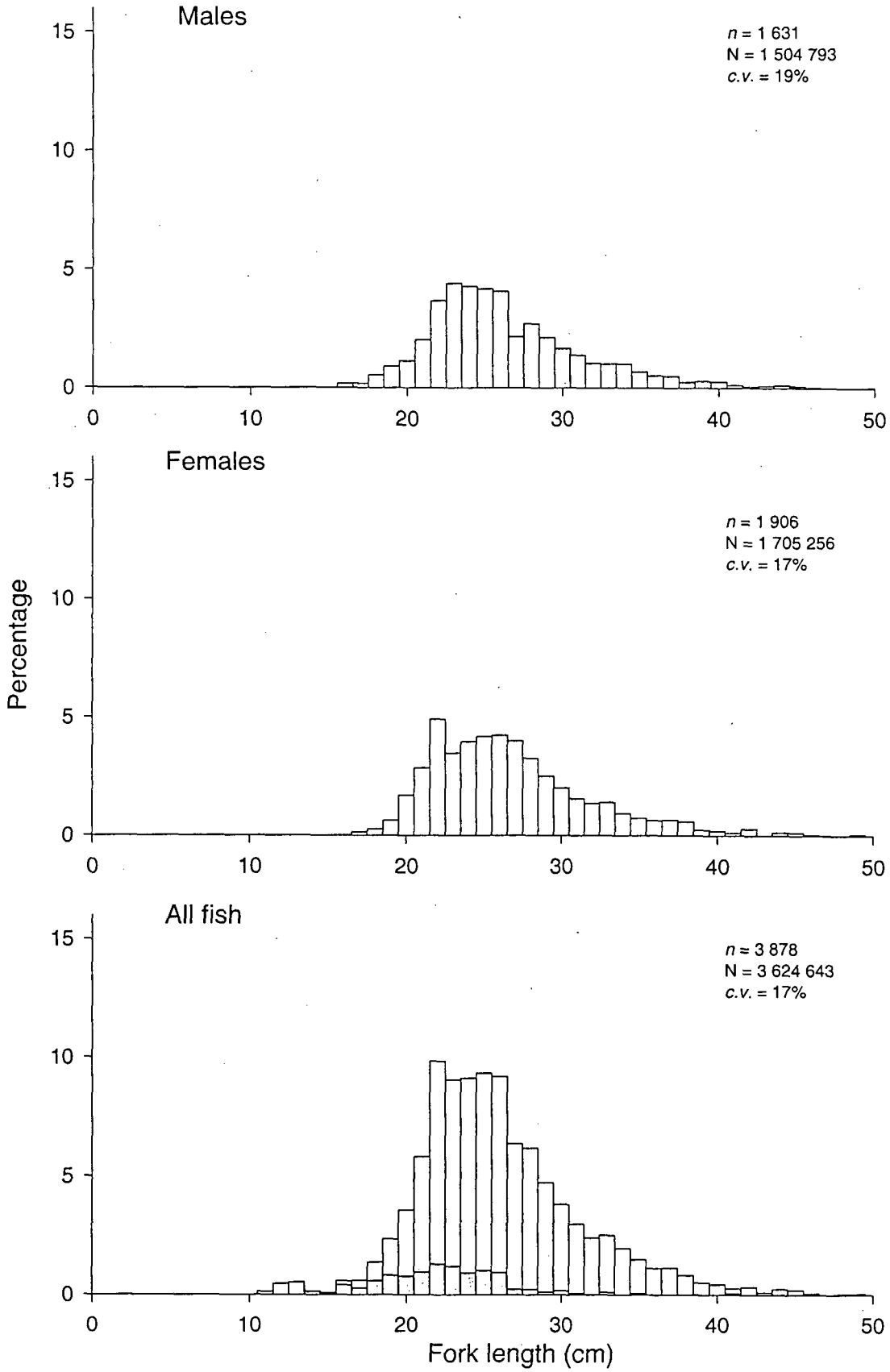

Figure 10 : Scaled length frequency distributions of male, female and all snapper. *n* = number of fish measured, N = estimated number of fish in the survey area, and *c.v.* = coefficient of variation of the survey estimate. Unsexed fish are shown as shaded bars.

Appendix 1: **Trawl gear specifications**

Type :	High opening bottom trawl (HOBT) without lower wings
Doors :	
Type	Rectangular vee
Area	3.4 m^2
Weight	480 kg
Backstrop :	6.6 m
Sweeps :	55 m x 16 mm diam.
Bridles :	
Top	55 m x 12 mm diam.
Bottom	55 m x 16 mm diam.
Headline :	34.5 m
Ground rope :	18.66 m
Ground chains :	2 x 14.5 m x 13 mm diam.
Ground rope weight :	120 kg plus 40 kg
Floats :	60 x 20 cm
Total floatation :	217 kgf
Vertical opening of trawl :	5.7–7.6 m
Codend mesh :	40 mm
Doorspread	73.3–103.0 m

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

	Depth range (m)															Total
	10–50			50–100			100–150			150–200			200–250			
	n	Mean	*s.d.*	*n*	Mean	*s.d.*	*n*	Mean	*s.d.*	*n*	Mean	*s.d.*	*n*	Mean	*s.d.*	*n*
Headline height (m)	17	6.2	0.2	28	6.2	0.3	12	6.4	0.3	14	6.2	0.4	6	6.1	0.2	77
Tow speed (knots)	17	3.1	0.1	28	3.0	0.1	12	3.1	0.1	14	3.0	0.1	6	3.0	0.0	77
Doorspread (DS) (m)	17	80.8	2.4	28	83.8	3.4	12	84.3	5.1	14	91.2	6.5	6	95.6	8.0	77

Appendix 3: **Macroscopic condition stages of gonads of female red gurnard (*after* Clearwater 1992)**

Stage	Macroscopic condition
Males	
1	Immature; testis translucent, angular threads
2	Spermatogenic; testis white, small, no milt in spermaducts
3	Partially spermiated; testis white, viscous milt in spermaducts
4	Mature (fully spermiated); testis white, plump, fluid milt expressable from spermaduct
5	Spent; testis bloody/grey, no milt expressable
Females	
1	Immature; ovaries small, translucent pink, no eggs visible
2	Previtellogenic/regressed; ovaries small, pink-orange granular oocytes may be visible
3	Vitellogenic; ovaries plump, pink-orange or yellow vitellogenic oocytes (~0.6 mm diameter), visible in large numbers
4	Hydrated; ovaries plump, orange red. Clear, hydrated oocytes (~1.2 mm diameter), dispersed evenly amongst vitellogenic oocytes characterising the previous stage
5	Mature; ovulated oocytes expressed from the oviduct when slight pressure applied to the abdomen
6	Spent; ovaries flaccid, often dark red or 'bloody' in colouration. Oocytes if present are unevenly dispersed. Dark brown specks of material sometimes visible

Appendix 4: **Macroscopic condition stages of gonads of male and female John dory (*after* Hore 1982)**

Stage	Macroscopic condition
Males	
1	Virgin; testis thin and ribbon like, pale white in colour with a smooth surface
2	Developing-resting; convoluted surface, grey in colour
3	Developing; convolutions more prominent, network of blood vessels over surface, no milt runs when cut, milky white in colour
4	Ripe-spawning; convolutions of surface marked, firm to touch, pure white, prominent blood vessels, milt runs when testis is cut
5	Spent; flaccid, brown/white in colour, no milt runs when cut
Females	
1	Virgin; ovaries thin, lie along posterior edge of ventral cavity, orange colouration
2	Maturing virgin; ovaries enlarged, no eggs visible to the eye, orange colouration
3	Developing; eggs visible to eye, orange in colour with reddish tinge, network of blood vessels developed
4	Developed; eggs clearly discerbable, some hyaline eggs present. Ovary fills ¼ of ventral cavity, yellow

5	Gravid: ovary fills 1/3 of ventral cavity, some transparent eggs, opaque and small yellow eggs predominate
6	Running ripe; transparent eggs expressed from ovary under slight pressure. Opaque and yellow eggs still present
7	Partly spent; not fully empty, some transparent eggs still present, hyaline and small yellow eggs predominate
8	Fully spent; ovaries flaccid and bloodshot. Some opaque and small yellow eggs visible, ovary walls purple in colour

Appendix 5: **Macroscopic condition stages of gonads of male and female snapper (*after* Pankhurst *et al.* 1987)**

Stage	Macroscopic condition
Males	
1	Immature; testis white threads
2	Spermatogenic; testis firm and ivory white in colour
3	Partially spermiated; testis firm, ivory white in colour with viscous milt in spermduct
4	Fully spermiated; testis firm, ivory white in colour with free flowing milt in spermduct
5	Spent; testis grey and bloody in colour and flaccid
Females	
1	Immature or regressed; ovary clear, no oocytes visible
2	Resting; ovary pink or clear; small clear oocytes visible against the light
3	Developing; opaque orange ovary; oocytes present
4	Ripe; hyaline oocytes present
5	Ovulated; eggs flow freely when light pressure applied to abdomen
6	Spent; ovary flaccid and 'bloody'; residual eggs sometimes present in oviduct

Appendix 6 : Individual station data

Station no.	Stratum	Date	Start time	Start of tow Latitude ° 'S	Start of tow Longitude ° 'E	Start of tow Depth (m)	Tow distance (n. mile)	Warp length (m)	Headline height (m)	Door width (m)
1	7085	3 Feb 99	0549	36 43 91	175 58 16	93	0.67	292	6.8	-
2	808C	3 Feb 99	0717	36 44 90	176 07 21	149	1.00	425	6.5	-
3	909C	3 Feb 99	0921	36 44 75	176 09 47	166	1.00	478	5.7	98.6
4	909C	3 Feb 99	1017	36 44 91	176 09 22	163	1.10	426	5.7	93.4
5	808C	3 Feb 99	1135	36 51 53	176 10 60	145	1.00	350	6.0	89.8
6	909C	3 Feb 99	1247	36 55 33	176 13 76	184	1.00	450	5.8	94.9
7	7085	3 Feb 99	1540	36 45 21	175 53 30	59	0.70	200	6.0	83.1
8	7085	4 Feb 99	0543	36 54 72	176 00 14	80	0.73	225	5.9	84.9
9	7085	4 Feb 99	0648	36 57 28	176 00 16	66	0.71	200	6.2	79.8
10	32NH	4 Feb 99	0818	36 57 40	175 51 85	25	0.69	200	6.3	75.4
11	32NH	4 Feb 99	0956	36 59 46	175 52 47	15	0.70	200	6.0	80.6
12	32NH	4 Feb 99	1139	37 50 63	175 54 35	24	0.70	200	6.5	82.4
13	7085	4 Feb 99	1258	37 11 65	176 00 26	62	0.70	200	6.3	83.3
14	7085	4 Feb 99	1415	37 08 14	176 01 53	73	0.70	225	6.0	85.4
15	909C	4 Feb 99	1551	37 07 91	176 08 89	198	0.94	500	6.7	102.0
16	909C	5 Feb 99	0609	37 13 78	176 11 23	223	1.02	550	5.8	97.8
17	7085	5 Feb 99	0730	37 15 59	176 05 78	79	0.70	250	6.3	81.7
* 18	7085	5 Feb 99	0914	37 18 60	176 06 76	69	0.47	200	6.2	81.2
19	7085	5 Feb 99	1000	37 20 45	176 04 03	52	0.70	200	6.2	77.0
20	5C87	5 Feb 99	1119	37 19 68	176 01 22	46	0.70	200	6.2	79.6
21	096C	5 Feb 99	1218	37 24 83	175 58 87	19	0.70	200	6.0	81.4
22	7085	5 Feb 99	1413	37 24 89	176 15 58	77	0.70	225	6.4	87.8
23	808C	5 Feb 99	1558	37 27 77	176 25 13	125	1.00	300	6.5	86.6
24	096C	6 Feb 99	0530	37 35 98	177 56 12	24	0.69	200	6.2	80.7
25	6085	6 Feb 99	0619	37 33 34	177 55 10	74	0.71	225	7.6	73.3
26	808C	6 Feb 99	0716	37 30 54	177 54 38	149	0.95	350	6.2	88.0
26	808C	6 Feb 99	0716	37 30 54	177 54 38	149	0.95	350	6.2	88.0
27	909C	6 Feb 99	0808	37 29 40	177 56 65	193	0.99	450	5.9	93.4
28	808C	6 Feb 99	1023	37 35 87	177 41 79	145	1.00	350	7.2	74.8
29	808C	6 Feb 99	1147	37 38 61	177 31 39	137	0.99	350	6.9	80.2
30	909C	6 Feb 99	1322	37 39 20	177 19 21	161	0.96	400	6.7	91.9
31	909C	6 Feb 99	1456	37 42 44	177 13 26	184	0.99	500	7.0	83.8
32	6085	6 Feb 99	1627	37 47 89	177 17 36	73	0.69	225	6.9	85.1
33	4085	7 Feb 99	0530	37 48 23	177 35 44	30	0.70	200	5.9	81.1
34	096C	7 Feb 99	0619	37 51 68	177 31 88	22	0.70	200	6.4	80.6
35	4085	7 Feb 99	0713	37 49 71	177 28 13	38	0.69	200	6.2	80.0
36	4085	7 Feb 99	0836	37 55 35	177 19 69	31	0.69	200	6.2	84.4
37	096C	7 Feb 99	0915	37 57 19	177 18 46	25	0.69	200	6.2	79.9
38	096C	7 Feb 99	1007	37 57 40	177 12 82	24	0.69	200	6.6	79.1
39	096C	7 Feb 99	1348	37 55 31	177 00 79	21	0.69	200	6.2	79.9
40	6085	7 Feb 99	1536	37 48 83	177 13 23	68	0.69	220	6.0	80.0
41	5C87	8 Feb 99	0541	37 47 31	176 46 25	46	0.69	200	6.1	82.6
42	7085	8 Feb 99	0657	37 41 59	176 50 96	98	0.75	275	6.2	83.7
43	909C	8 Feb 99	0752	37 39 57	176 50 92	160	0.98	375	6.2	88.9
44	7085	8 Feb 99	0902	37 42 21	176 44 07	87	0.69	250	6.2	85.0
45	7085	8 Feb 99	0948	37 40 40	176 41 85	97	0.69	275	6.2	84.5
46	7085	8 Feb 99	1040	37 38 18	176 37 62	97	0.72	275	6.2	86.0
47	096C	8 Feb 99	1233	37 42 94	176 25 54	20	0.70	200	6.2	85.0
48	909C	8 Feb 99	1448	37 27 79	176 28 38	201	0.99	475	6.2	94.3

49	7085	9 Feb 99	0551	37 33 27	176 25 08	70	0.69	225	6.2	86.0
50	5C87	9 Feb 99	0703	37 34 52	176 17 55	47	0.69	200	6.2	83.4
51	096C	9 Feb 99	0813	37 33 98	176 07 98	21	0.69	200	6.2	77.0
52	7085	10 Feb 99	0630	37 26 58	176 18 67	81	0.70	225	6.2	82.4
53	7085	10 Feb 99	0727	37 24 07	176 19 12	100	0.72	275	6.4	89.1
54	909C	10 Feb 99	0929	37 27 01	176 28 29	220	0.69	525	6.2	80.0
55	808C	10 Feb 99	1141	37 32 86	176 31 00	117	0.99	300	6.5	79.0
56	909C	10 Feb 99	1259	37 35 74	176 38 52	225	1.06	575	6.2	97.5
57	909C	10 Feb 99	1440	37 39 11	176 47 53	206	0.99	450	6.4	89.9
58	909C	10 Feb 99	1624	37 35 07	176 59 60	235	0.98	550	6.0	96.3
59	808C	11 Feb 99	0540	37 35 35	177 43 57	143	1.00	375	6.2	88.4
60	808C	11 Feb 99	0750	37 42 23	177 28 44	102	0.99	300	6.3	81.7
61	808C	11 Feb 99	0904	37 38 04	177 26 54	172	0.99	425	6.7	87.9
62	808C	11 Feb 99	1015	37 40 71	177 21 15	132	1.00	350	6.2	79.1
63	808C	11 Feb 99	1135	37 41 05	177 15 63	133	1.00	350	6.2	88.5
64	909C	11 Feb 99	1237	37 40 95	177 11 87	209	0.99	550	6.4	99.2
65	909C	11 Feb 99	1339	37 42 68	177 07 96	178	0.99	450	6.2	93.0
66	808C	11 Feb 99	1453	37 40 38	177 00 99	119	0.99	325	6.0	87.0
67	909C	11 Feb 99	1611	37 36 36	177 04 85	163	0.99	375	6.4	74.7
68	7085	12 Feb 99	0534	37 45 11	176 47 67	63	0.70	200	6.1	85.0
69	909C	12 Feb 99	1019	37 14 03	176 09 17	154	1.00	400	5.8	90.2
70	7085	12 Feb 99	1135	37 09 03	176 02 96	84	0.70	250	6.0	88.3
71	7085	12 Feb 99	1223	37 07 73	176 04 66	100	0.71	-	6.1	86.8
72	7085	12 Feb 99	1314	37 06 36	176 01 21	73	0.70	225	6.1	88.1
73	909C	12 Feb 99	1614	36 43 23	176 10 70	200	0.99	540	6.1	103.0
74	7085	13 Feb 99	0536	36 47 58	175 50 69	52	0.69	200	6.0	83.1
75	7085	13 Feb 99	0643	36 46 64	175 55 65	86	0.46	250	6.0	85.8
76	7085	13 Feb 99	0738	36 50 43	175 58 20	95	0.69	275	6.0	85.0
* 77	7085	13 Feb 99	0929	36 55 15	175 55 76	63	-	200	-	-
78	7085	13 Feb 99	1009	36 58 95	175 57 58	57	0.69	200	6.4	85.0
79	7085	13 Feb 99	1144	37 11 25	175 58 97	54	0.70	200	6.1	81.8
80	7085	13 Feb 99	1249	37 14 97	176 04 85	79	0.69	250	6.1	85.2

*, fouled or poor performance shot

Appendix 7: Catch (kg) at each station for 7 of the more important commercial species : red gurnard (GUR), john dory (JDO), tarakihi (TAR), snapper (SNA), jack mackerel (*Trachurus novaezelandiae* , JMN; *T. declivis* , JMD), and trevally (TRE)

Station	GUR	JDO	TAR	SNA	JMN	JMD	TRE
1	6.4	2.9	12.1	13.8	0.0	1.0	1.6
2	1.4	0.3	6.7	6.4	14.2	3.0	0.0
3	4.4	0.0	1.7	5.0	7.2	4.6	0.0
4	0.0	0.2	3.4	3.7	2.9	0.5	0.0
5	0.4	0.0	3.7	8.7	1.1	0.1	0.0
6	0.0	0.0	0.0	7.7	0.0	5.0	0.0
7	10.4	13.2	0.0	52.8	0.0	0.0	1.0
8	1.7	11.2	1.2	54.7	0.0	0.0	0.0
9	3.3	11.1	0.0	28.7	0.0	0.0	0.0
10	10.6	1.9	0.0	107.9	0.0	0.0	15.0
11	4.6	2.8	0.0	100.7	0.0	0.4	1.9
12	18.9	2.9	0.0	167.7	0.0	4.4	6.4
13	5.1	1.0	0.0	3.7	0.1	0.0	0.0
14	26.9	3.5	1.1	34.2	0.3	1.3	9.7
15	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16	0.0	0.0	15.0	0.0	42.3	108.3	0.0
17	5.9	12.5	0.0	3.2	0.0	0.0	4.3
18	0.0	0.0	0.0	0.0	0.0	0.0	0.0
19	0.2	1.5	0.0	0.0	0.0	0.3	0.0
20	3.5	1.4	0.0	4.8	0.0	0.1	0.0
21	1.7	12.5	0.0	459.0	0.0	0.0	3.7
22	18.7	13.0	0.0	12.8	0.0	0.0	27.3
23	2.4	1.0	0.0	3.9	0.0	1.9	0.0
24	21.7	0.0	0.0	54.8	0.0	0.0	24.5
25	0.0	0.0	0.0	25.6	2.7	0.0	0.0
26	0.0	0.0	0.0	0.0	0.0	0.0	0.0
27	0.0	0.0	0.0	0.0	0.0	0.0	0.0
28	0.0	0.0	0.0	0.0	110.9	0.0	0.0
29	7.7	6.0	0.0	4.6	0.0	0.0	0.0
30	0.0	0.0	0.0	0.0	0.0	0.1	0.0
31	0.0	0.9	18.6	0.0	0.1	0.0	0.0
32	6.0	1.4	0.6	15.0	6.9	0.0	0.0
33	12.0	0.0	0.0	31.6	1.6	0.0	19.6
34	14.9	0.0	0.0	25.8	4.5	0.0	3.9
35	3.8	0.7	0.0	24.3	11.5	0.0	16.7
36	0.0	4.5	0.0	63.2	62.6	0.0	21.8
37	20.1	5.0	0.0	138.3	14.9	0.0	4.2
38	13.7	3.0	0.0	73.1	2.0	0.0	21.3
39	6.2	0.0	0.0	10.4	1.7	0.0	14.0
40	11.0	5.2	0.4	27.6	15.4	0.0	1.2
41	13.0	1.2	0.0	76.9	1.9	0.0	4.4
42	4.7	3.6	0.0	7.8	43.3	0.0	0.0
43	0.7	1.0	0.0	1.3	0.0	146.9	0.0
44	12.3	12.8	0.0	8.3	0.6	0.0	0.0
45	9.4	8.5	0.0	16.8	0.0	0.4	0.0
46	2.5	2.5	0.0	4.2	0.0	0.5	0.0
47	4.0	0.5	0.0	57.7	1.4	0.0	3.0
48	0.0	0.0	0.0	0.0	2.0	2.7	0.0
49	3.5	9.7	0.0	21.9	0.4	0.4	1.5

	50	15.9	1.0	0.0	100.5	0.3	0.0	35.4
	51	5.5	0.0	0.0	74.8	5.4	0.0	14.6
	52	2.4	0.7	0.0	35.9	0.0	0.0	0.0
	53	1.3	2.0	0.0	5.6	0.0	0.2	0.0
	54	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	55	14.0	2.0	0.0	7.6	0.0	0.0	0.0
	56	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	57	0.0	0.0	0.0	0.0	1.4	0.1	0.0
	58	0.0	0.0	23.2	0.0	0.0	0.0	0.0
	59	0.0	7.2	6.8	0.5	21.6	2.1	0.0
	60	6.2	4.6	0.0	7.3	21.4	0.3	0.0
	61	0.6	0.0	1.2	0.0	0.2	1.5	0.0
	62	4.6	3.0	0.0	4.2	6.2	0.0	0.0
	63	2.8	7.4	3.3	0.0	0.0	0.6	0.0
	64	0.0	0.0	20.9	0.8	0.0	0.0	0.0
	65	0.0	0.0	1.1	0.0	2.3	0.5	0.0
	66	10.4	3.5	0.0	4.1	2.8	0.9	0.0
	67	0.0	0.8	0.0	0.0	0.5	0.0	0.0
	68	12.0	0.0	0.0	14.1	0.5	0.0	0.0
	69	0.4	8.0	0.0	5.1	0.0	1.0	0.0
	70	5.0	14.0	0.0	18.2	0.0	0.0	7.5
	71	4.2	3.4	0.0	14.1	0.0	0.0	3.3
	72	5.3	5.5	0.0	27.2	0.0	0.0	0.0
	73	0.8	0.0	11.0	0.0	1.3	42.8	0.0
	74	15.2	9.1	0.0	112.5	0.6	0.0	13.5
	75	1.4	0.0	0.0	12.1	0.0	0.0	0.9
	76	3.4	8.8	0.0	17.4	0.0	0.0	0.0
	77	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	78	37.3	7.5	0.0	80.0	0.0	0.0	5.7
	79	15.3	5.0	0.0	31.4	21.3	0.0	2.1
	80	34.2	23.5	0.0	16.1	0.0	0.0	1.2
Total		491.9	276.4	132.0	2 358.1	438.3	331.9	291.2

Appendix 8: Summary of otoliths collected, for red gurnard, John dory, tarakihi, and snapper

Size class	Red gurnard			John dory			Tarakihi			Snapper		
	Male	Female	Unsexed	Male	Female	Unsexed	Male	Female	Unsexed	Male	Female	Unsexed
10	-	-	-	-	-	-	-	-	-	-	-	-
11	-	-	-	-	-	-	-	-	-	-	-	3
12	-	-	-	-	-	-	-	-	-	-	-	6
13	-	-	-	-	-	-	-	-	-	-	-	6
14	-	1	2	-	-	-	-	-	-	-	-	4
15	-	-	3	-	-	-	-	-	-	-	1	4
16	-	-	3	-	-	-	-	-	-	-	-	14
17	-	-	5	-	-	-	-	-	-	-	1	7
18	-	-	3	-	-	-	-	-	-	2	2	5
19	1	4	-	1	-	-	2	-	-	4	5	10
20	4	3	-	1	1	-	-	1	-	5	5	1
21	4	4	-	1	2	-	-	1	-	4	6	1
22	6	6	-	4	4	1	-	1	-	5	7	-
23	7	5	1	4	4	-	2	3	-	8	9	-
24	7	6	-	3	5	-	2	1	-	8	8	-
25	5	5	-	6	5	-	-	1	-	12	10	-
26	7	8	-	8	5	-	-	-	-	6	5	-
27	5	8	-	6	7	-	4	1	-	5	8	-
28	6	7	-	6	5	-	1	3	-	6	4	-
29	4	5	-	5	2	-	2	1	-	5	5	1
30	5	5	-	4	4	-	3	2	-	9	6	1
31	5	6	-	5	-	-	7	4	-	5	5	-
32	5	5	-	5	1	-	5	-	-	5	5	-
33	5	6	-	6	2	-	8	2	-	5	5	-
34	5	4	-	6	1	-	9	2	-	5	6	-
35	5	5	-	5	6	-	8	3	-	6	4	-
36	5	5	-	10	6	-	7	6	-	6	5	-
37	6	5	-	8	5	-	5	2	-	5	5	-
38	3	5	-	6	7	-	5	2	-	7	6	-
39	4	7	-	5	4	-	4	3	-	4	4	-
40	2	9	-	3	4	-	1	2	-	6	5	-
41	-	4	-	6	6	-	1	1	-	1	6	-
42	1	6	-	2	7	-	-	1	-	4	7	-
43	-	5	-	-	7	-	1	-	-	3	1	-
44	-	3	-	-	5	-	-	-	-	3	4	-
45	-	7	-	-	2	-	-	-	-	3	1	-
46	-	2	-	-	1	-	1	-	-	3	2	-
47	-	2	-	-	1	-	-	-	-	-	-	-
48	-	1	-	-	3	-	-	1	-	-	2	-
49	-	-	-	-	1	-	-	-	-	-	3	-
50	-	-	-	-	-	-	-	-	-	-	-	-
51	-	-	-	-	1	-	-	-	-	2	-	-
52	-	-	-	-	-	-	-	-	-	-	2	-
53	-	-	-	-	-	-	-	-	-	-	1	-
54	-	-	-	-	1	-	-	-	-	-	-	-
55	-	-	-	-	-	-	-	-	-	-	-	-
56	-	-	-	-	-	-	-	-	-	-	-	-
57	-	-	-	-	-	-	-	-	-	-	1	-
58	-	-	-	-	-	-	-	-	-	-	-	-
59	-	-	-	-	-	-	-	-	-	-	-	-
60	-	-	-	-	-	-	-	-	-	-	-	-
61	-	-	-	-	-	-	-	-	-	-	-	-
62	-	-	-	-	-	-	-	-	-	2	-	-
63	-	-	-	-	-	-	-	-	-	-	-	-
64	-	-	-	-	-	-	-	-	-	-	-	-
65	-	-	-	-	-	-	-	-	-	-	-	-
66	-	-	-	-	-	-	-	-	-	-	-	-
67	-	-	-	-	-	-	-	-	-	-	1	-