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D. M. Tracey, O. F. Anderson, and M. R. Clark

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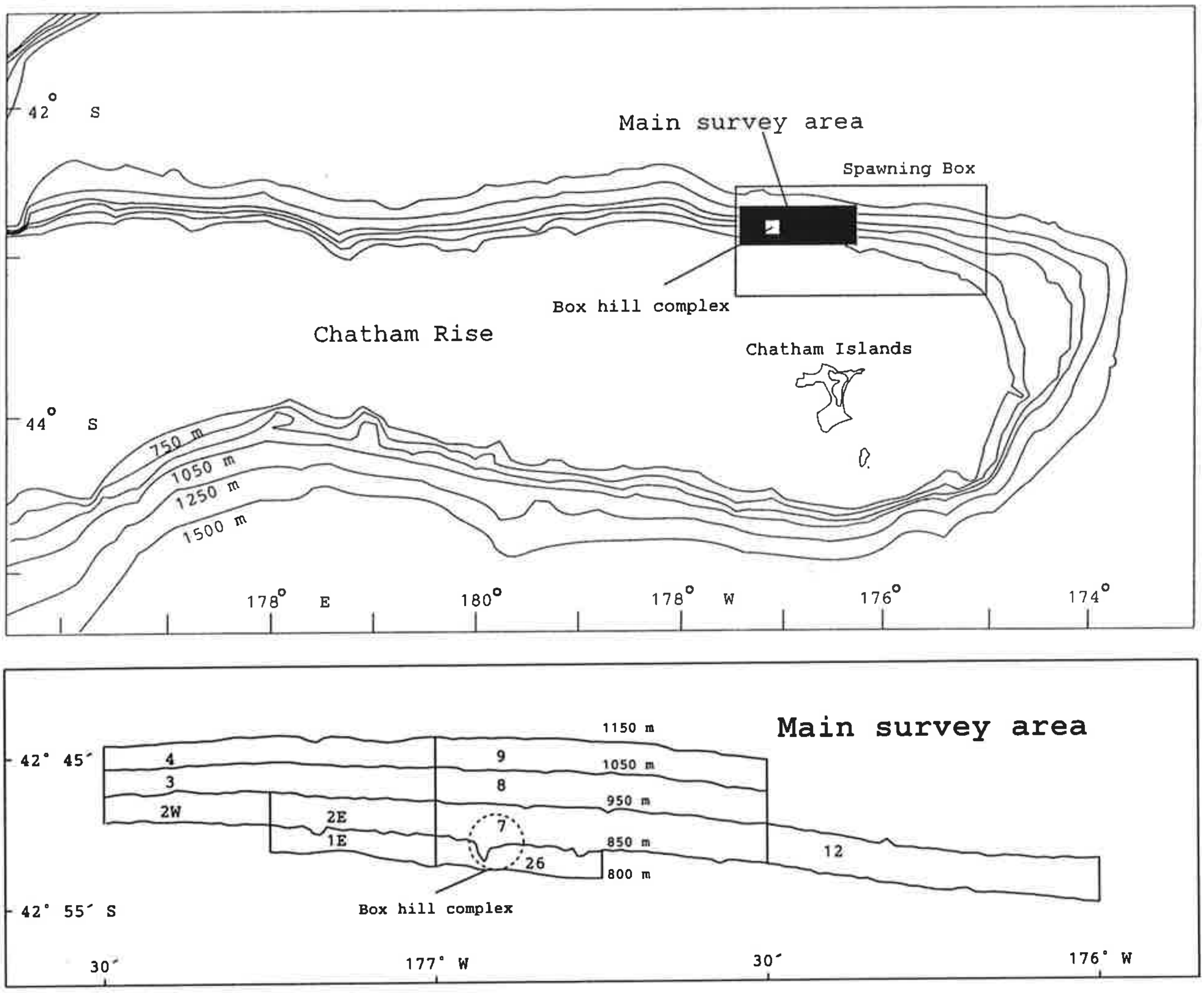


Figure 1: Chatham Rise showing Spawning Box and stratification of the main survey area.

Abstract

Tracey, D. M., Anderson, O. F., & Clark, M. R. 1997: A two-vessel survey of orange roughy in the Chatham Rise "Spawning Box", July-August 1995. *N.Z. Fisheries Technical Report No. 49.* 27 p.

Research surveys of orange roughy were carried out on the north Chatham Rise in July-August 1995 by RV *Tangaroa* and FV *San Waitaki* working cooperatively. The main objectives were to investigate possible reasons for the low fraction of males present and the increasing variance of the biomass index in recent trawl surveys of the "Spawning Box" area.

Four repeat stratified random trawl surveys (snapshots) were carried out in the main spawning area to monitor changes in distribution, catch rates, and biological parameters over the spawning period. Fish distribution centred on a small area of slope where dense plume-like aggregations of orange roughy occurred. Catch rates in this area were high. There was evidence of fish dispersal during the last of the four surveys, with orange roughy moving to the east after spawning had finished. A comparison of catches from parallel tows carried out by the two vessels showed no significant difference in catch rate, but *Tangaroa*'s catches contained more females than those of *San Waitaki*. Sex ratios were highly variable in the area of high fish density, but there was no evidence of sex ratio changes during the survey.

A hill complex in the area which had not been covered in previous surveys was extensively trawled. Catch rate and biological data indicated that spawning aggregations occurred, but catches had an even sex ratio indicating that the area did not act as a refuge for males.

Midwater trawling on marks extending up to 100 m above the seafloor took large catches of orange roughy with the groundrope up to 30 m above the bottom. Sex ratio did not vary with height above the bottom.

The results of a pilot acoustic survey in the main area of orange roughy distribution suggested that the technique has potential to be applied to spawning aggregations to measure abundance.

Introduction

The Chatham Rise (Figure 1) has supported New Zealand's largest and most important orange roughy fishery since 1979. The history of commercial activity and quota allocation since the late 1970s was summarised by Annala (1994), Francis *et al.* (1992), Clark (1995), Grimes (1992), and Tracey & Fenaughty (1997). Initially the main area of commercial fishing was concentrated on the north Rise in the main spawning area termed the "Spawning Box." It then shifted to the northwest and south Chatham Rise and fishing occurred mainly on the flat bottom slopes and on some hills in these areas. In the late 1980s effort shifted to hills on the northeast, east, and southeast Rise and then to a hill complex on the northwest Rise. The Spawning Box was closed to commercial fishing between 1992 and 1995 and reopened in 1996. The 1996–97 (1 October–30 September) catch limit for the Chatham Rise area is 7200 t, of which the Spawning Box contributes 4950 t.

Stock assessment of the Chatham Rise orange roughy fishery has used a time series of biomass indices derived from stratified random bottom trawl surveys in the Spawning Box (Francis *et al.* 1995, Anderson & Fenaughty 1996, Tracey & Fenaughty 1997). The surveys have coincided with the orange roughy spawning season from 1984 to 1994 and have shown a major decline in fish biomass. The area of high fish density has decreased substantially (Clark 1995, Francis *et al.* 1995).

The sequence of station occupation for the Spawning Box trawl surveys remained unchanged until 1992, when sampling design was reviewed and changed to improve the estimate of fish density during the second phase of the trawl survey (Francis 1996). The 1992 and 1994 surveys followed this new design, which placed phase 2 stations closer in time to the phase 1 stations for each stratum. Results produced biomass indices with a low proportion of males in the catch (28% and 14% in 1992 and 1994 respectively). The precision of the indices was poor, with coefficients of variation (*c.v.s*) of 34% and 67% respectively (Francis *et al.* 1995, Tracey & Fenaughty 1997).

A number of hypotheses were put forward to explain the 1992 and 1994 results of low male proportion and high *c.v.s* including the following.

Male orange roughy segregate from the females by aggregating higher in the water column and so are not available to the bottom trawl.

Closure of the Spawning Box in 1992 could have resulted in vertical aggregations undisturbed by fishing, hence different fish behaviour could produce different survey results.

The Box hill complex (a topographical feature comprising a main hill and trench known sometimes as the "crack" or "gap") provides a haven for male orange roughy. This complex was not fished during earlier surveys.

The male population has been fished down more than females, so the results reflect the true status of the fishery.

The sex ratio anomaly and high *c.v.s* are a vessel effect due to different vessels carrying out the surveys.

A change in station sequence, with different areas sampled at different times during the progression of the spawning cycle, affected the results.

A two-vessel programme was designed for the Spawning Box area in 1995, the main objective being to improve our ability to interpret changes in value in the time series of biomass indices, in particular the very low fraction of males and the high *c.v.s*.

The two vessels were RV *Tangaroa* and FV *San Waitaki*. The research was a cooperative venture between NIWA and The Orange Roughy Management Company (a consortium of orange roughy quota holders). Results from this cooperative work are presented in this report.

Survey objectives

Tangaroa

1. To measure or determine catch rates, sexratios, length frequencies, gonad stages, and other standardbiological information on orange roughy and other quota species through the season in the main Spawning Box strata.

2. To test the new acoustic system for orange roughy andconduct a pilot acoustic biomass survey in the main Box strata near the peak of the spawning season.

3. To test for vessel effect on catch rate, catch composition, and sex ratios.

4. To investigate how fishing affects the areal and vertical distribution of orange roughy, in particular looking for any effect on the undisturbed vertical stratificaton by sex, by carrying out intensive trawling in parallel with *San Waitaki.*

5. To collect tissue samples from orange roughy to determine if different genetic groups spawn in the Box over a spawning season.

San Waitaki

6. To measure or determine catch rates, sex ratios, length frequencies, and gonad stages of orange roughy in the Box area.

7. To define the distribution of orange roughy in an area in the Spawning Box known as the Box hill complex.

8. To define the distribution of orange roughy in the water column, and in particular to measure sex ratio with height above the bottom.

9. To identify midwater targets identified during acoustic work by *Tangaroa.*

Methods

Survey area

The survey area for both vessels covered selected strata from the standard Spawning Box slope area sampled since 1984 (*see* Figure 1). These were the eastern part of stratum 1 (stratum 1E) and strata 2, 3, 4, 7, 8, 9, 12, and 26 (Table 1). A line was drawn through stratum 2 to create east and west components (2W and 2E) as historically catches were highest at the eastern side of this stratum. Depths from 800 to 1150 m were covered and the total survey area was 1323 km^2.

In addition, *San Waitaki* sampled the Box hill complex (stratum 30). This feature crosses between strata 7 and 26 and comprises a main hill, three small hills, and a trench area (Figure 2).

Survey design

Tangaroa

Bottom trawling. A series of four replicate stratified random trawl surveys (referred to as snapshots in this report) in 10 strata was carried out during the main part of the spawning season. As each station was sampled on four occasions, monitoring the survey area's temporal changes in sex ratios, catch rates, and biological parameters was theoretically possible. The strata chosen for the survey were those that contributed most to the sex ratio imbalance, and contained most of the biomass, in the 1992 and 1994 surveys (Francis 1996).

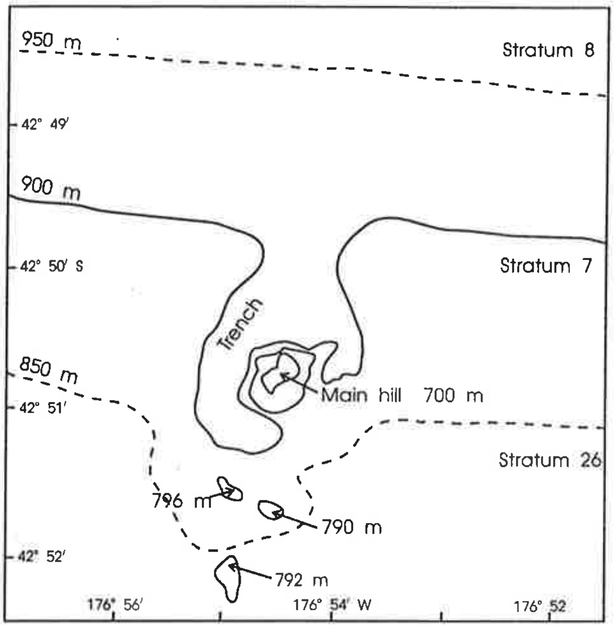


Figure 2: Bathymetry around the Box hill complex, derived from Seaplot data.

Stratification for the snapshots is shown in Figure 1. The eastern side of stratum 1 (1E) was added to the survey area before snapshot 3.

Random stations were allocated to each stratum based on longitude and depth, and the number of tows required for each stratum was weighted by catches in 1992 and 1994 (Francis 1996). Tow length was 1.5 n. mile, except in areas of high fish concentration where tow length was shortened. Where possible, the same tow sequence, position, direction, and tow line were followed for each snapshot.

Parallel trawling. All tows during snapshot 1 were planned to be carried out parallel to *San Waitaki* to see if male and female vulnerability was the same for both vessels and to compare catch rates between vessels. A minimum separation of 0.25 n.mile was maintained between the two vessels during trawling, with *Tangaroa* holding the random tow line.

Acoustics. The acoustic system comprised the surface-based Crest hardware, a 600 m tow cable, and an Edo Western model 6978 transducer, serial number 102 (Coombs 1994).

An acoustic grid survey of transect lines was drawn up to cover all strata, excluding stratum 12. Transect lines were placed randomly north-south across the survey area. A more detailed acoustic survey was carried out in strata 1E and 2E where dense fish marks had been observed by the two vessels during the initial acoustic surveys and trawls. Transect lines in 1E and 2E were placed randomly closer together than in the other areas, and in an east-west direction. The transects in stratum 1E extended south to the 750 m contour.

To determine the absorption coefficient and speed of sound, and to define water mass characteristics in the area, conductivity, temperature, and depth (CTD) probe casts were made at the beginning and end of each acoustic survey.

San Waitaki

Bottom trawling. Initially, the Box hill complex bathymetry was surveyed in detail and the chart of the area updated (*see* Figure 2). Suitable tow lines, both into the trench from the adjacent slope and on the main hill, were then selected for bottom trawling. Trawls into the trench were carried out from the slope at about 850 m down into the bottom of the trench at 900–920 m. Tows on the main hill ran from as near to the top as possible to the base at 920 m. Trawls following the course of "known" commercial fishing tows on the hill and in the trench were also carried out.

Bottom trawls from different directions were targeted on dense orange roughy marks observed in strata 1E and 2E. Trawling time was short and the net was hauled immediately marks were seen on the net monitor.

The random bottom tows were 1.5 n. mile long: the targeted bottom trawls were shorter and varied.

Midwater trawling. Midwater trawling was targeted on fish marks observed on the vessel's echosounder or as directed by *Tangaroa* during the acoustic survey. Various heights above the seabed were fished and the depths varied between tows so that there was no systematic change whereby fish could be driven in one direction. Trawls were carried out up to 100 m from the bottom. During a tow, the net was maintained at a set distance from the bottom. Tow length varied depending on the extent of marks and indications of catch on the monitor.

Tangaroa and *San Waitaki*

Effects of fishing an aggregation. The experiment planned to assess the effects of fishing an aggregation (objective 4) was not carried out as a suitable aggregation could not be found and both vessels were heavily committed to fulfilling other objectives in the available time.

Vessels and gear specifications

Tangaroa is a purpose-built fisheries research vessel owned by the National Institute of Water and Atmospheric Research (NIWA), and *San Waitaki* is a New Zealand stern trawler owned by Sanford Limited. Their main specifications are:

	Tangaroa	*San Waitaki*
Overall length (m)	70	41
Beam (m)	14	11
Gross tonnage	2280	784
Power (kW)	3000	540

The bottom gear used by both vessels was the standard six-panel rough bottom orange roughy trawl with cut away lower wings. There were slight gear differences between the two vessels (Appendix 1). *San Waitaki* used a burst panel at the top of the second codend for much of the survey to restrict catch size to about 40 t. The *Tangaroa* bottom trawl gear (Appendix 1a) was described by McMillan (1996). Details of the *San Waitaki* bottom trawl gear are shown in Appendix 1b. Scanmar 400 systems provided *Tangaroa* with data on doorspread, wingtip, and headline height.

The *San Waitaki* midwater trawl (Appendix 1c) had a net opening 50 m wide by 25 m high and was similar to the nets used by the commercial hoki fleet. The trawl doors used for both the bottom and midwater gear were 5.0 m^2 Super Vs.

Catch and biological sampling

Tangaroa and *San Waitaki*

The catch for each tow in each snapshot was sorted and weighed by species. For catches over 2 t, the total greenweights for orange roughy were back-calculated from a greenweight-to-product weight conversion factor.

Differences in fishing gear between the two vessels were minor and so it was expected that their catching ability would be similar. Catching ability was compared using a paired-samples t-test.

Standard procedure during the survey was to measure the standard length (cm), sex, and gonad stage of a random sample of 200 fish from each station. If a catch was large, at least three samples of 200 orange roughy were taken from different parts of the net and combined to ensure sampling was representative of the catch.

Otoliths were collected on *San Waitaki* for The Orange Roughy Management Company. Over 1000 pairs of otoliths were systematically collected from a full size range of fish.

Tangaroa

Twenty orange roughy (more for large catches) were randomly selected and examined in greater detail. Data were collected on standard length (mm), weight (g), sex, gonad weight (g), gonad stage, as well as stomach fullness, digestion, state, and contents. Otoliths were extracted.

Heart, liver, and muscle tissue samples were collected at approximately weekly intervals from 50 males and 50 females in each snapshot for genetic studies. Tissues from each specimen were stored individually in liquid nitrogen.

Biological analyses

Length frequency distribution. Orange roughy length frequency data obtained from *Tangaroa* trawls were scaled by the percentage of fish sampled per tow, the area swept by the wings, and the biomass calculated from catch weights, in order to accurately represent the population size structure. Length frequencies were also calculated from the *San Waitaki* Box hill complex trawls and midwater trawls. Because of uncertainty regarding vulnerability of orange roughy to the midwater gear and the non-random nature of the midwater stations, length frequencies for these tows were scaled only by the percentage of fish sampled per tow.

Length-weight regression coefficients were calculated for orange roughy from *Tangaroa* data for the continuation of the time series of Chatham Rise length-weight relationships.

Sex ratios. To test several hypotheses, sex ratio data were analysed in detail (using the Mann Whitney test) and compared between snapshots, strata, vessels, and height above the bottom. Sex ratio data were also analysed from trawls in the Box hill complex.

Sex ratio data were analysed between areas, strata, and snapshots to investigate areal and temporal changes and between vessels to test whether *Tangaroa* was less likely to catch males. Sex ratios from *San Waitaki* were also analysed from the Spawning Box hill complex to test the hypothesis that this area was a haven for male orange roughy. Another hypothesis to explain the sex ratio imbalance — that males were higher in the water column and so avoided being caught by bottom trawling — was tested for by analysing the sex ratio data from the midwater trawls carried out by *San Waitaki.*

Reproductive stages. Gonad stages (after Pankhurst *et al.* 1987) are summarised below.

Stage	Female	Male
1	Immature/resting	Immature/resting
2	Early maturation	Early maturation
3	Maturation	Maturation
4	Ripe	Ripe
5	Running ripe	Spent
6	Spent	–
7	Atretic	–
8	Partially spent	Partially spent

The spawning period of orange roughy of both sexes was investigated by applying a distance weighted least squares algorithm (SYSTAT, Wilkinson 1987) to data representing the proportion of fish in each of the "active" reproductive stages (stages 3, 4, 5, 6, and 8) at daily intervals during the survey. The peak of spawning can be defined by the apex of this function when fitted to the proportion of ripe and running ripe fish. A further useful reference point is when the proportion of spent fish reaches 20%. Unscaled data from both vessels and all stations were combined for this analysis.

Feeding. Estimates of stomach state and frequency of occurrence of prey were determined for orange roughy.

Results

Trawl stations

Tangaroa

Bottom trawling. A series of four stratified random bottom trawl snapshots was completed over the main Spawning Box strata. Each snapshot lasted 4–6 days. When extra time was available at the end of any snapshot, additional tows were carried out in the strata where the sex ratio had been most variable, or in strata where there had been high orange roughy catch rates. Dates for each snapshot were: snapshot 1, 9–15 July, snapshot 2, 16–20 July, snapshot 3, 25–28 July, and snapshot 4, 29 July–2 August. Figure 3 shows the standard trawl stations sampled during each snapshot. Stratum 1E was added to the survey area before carrying out snapshots 3 and 4 as high density marks had been observed over this area during the earlier survey work, indicating that the main spawning aggregation had moved into shallower water. Five random stations were allocated and occupied in this stratum. In snapshot 1, 39 tows were completed, (stations 1–39), snapshot 2, 48 tows (stations 40–87), snapshot 3, 45 tows (stations 88–132), and snapshot 4, 45 tows (stations 133–178). A summary of the trawls carried out by *Tangaroa* for each stratum (n = 178) is included in Table 1.

All *Tangaroa* station data (including five experimental tows at the end of the survey to investigate species caught off the bottom as the net was being shot and retrieved) are summarised in Appendix 2.

Parallel trawling. Out of a total of 48 planned parallel trawls, only 28 tows from snapshot 1 and 10 tows from snapshot 3 were carried out. Not all the planned parallel tows in snapshot 1 were possible because of the late arrival of *San Waitaki* in the survey area and also because of the inability of one or other vessel to continue trawling after a large catch or as a result of mechanical problems. The 10 remaining planned parallel tows were carried out as solo trawls. Catching ability and sex ratio comparisons between vessels used all tows in the analysis.

San Waitaki

Trawling. A total of 103 trawls was carried out by *San Waitaki* during the survey. Of these, 50 were random bottom trawls in the Box strata (38 in parallel with *Tangaroa* (Figure 4a), 27 were midwater tows (including using the midwater gear to fish close to as well as off the bottom for mark identification during the *Tangaroa* acoustic survey) (Figure 4b), and 16 were bottom trawls in the Box hill complex (Figure 4c.) The vessel also carried out 8 targeted bottom tows and 2 bottom trawls on marks identified during the acoustic survey (*see* Table 1). After the research survey on *San Waitaki* was completed six targeted commercial trawls were carried out. These tows were not used in any of the analyses of catch except for contributing to the list of all species caught during the survey.

A summary of station data for *San Waitaki* is included in Appendix 2.

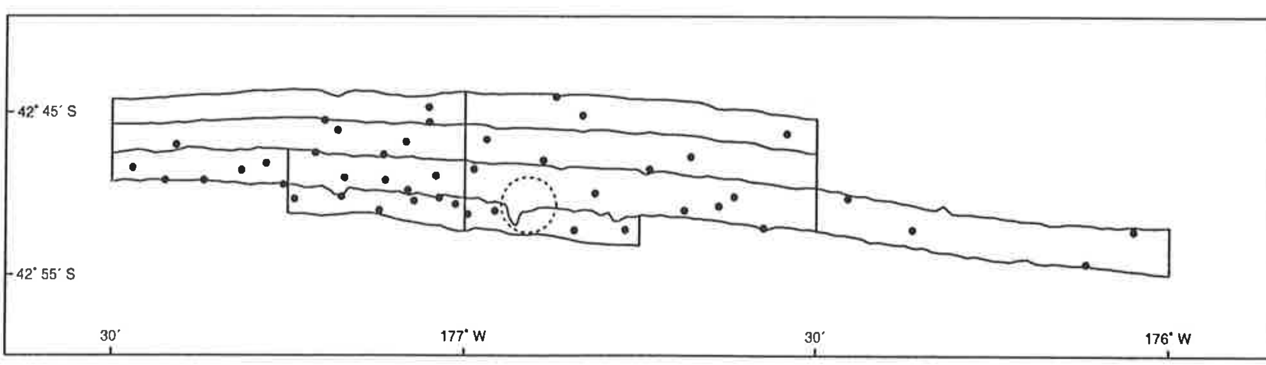
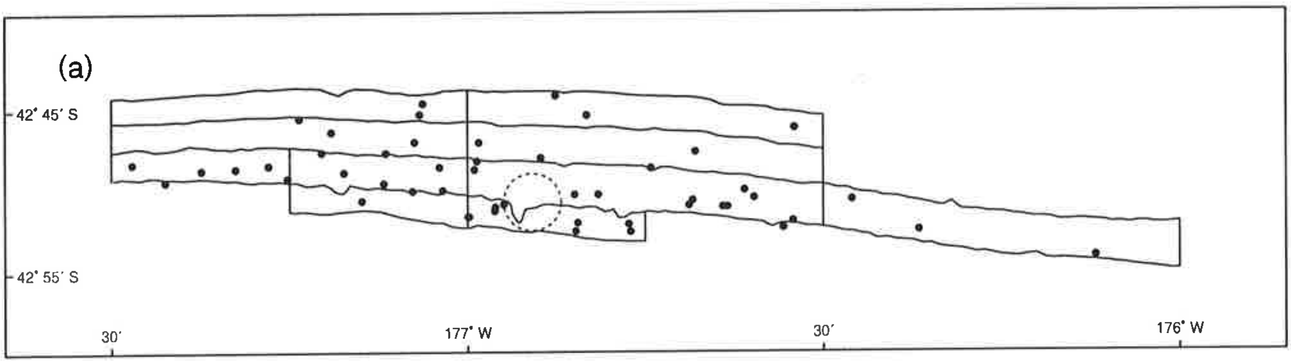


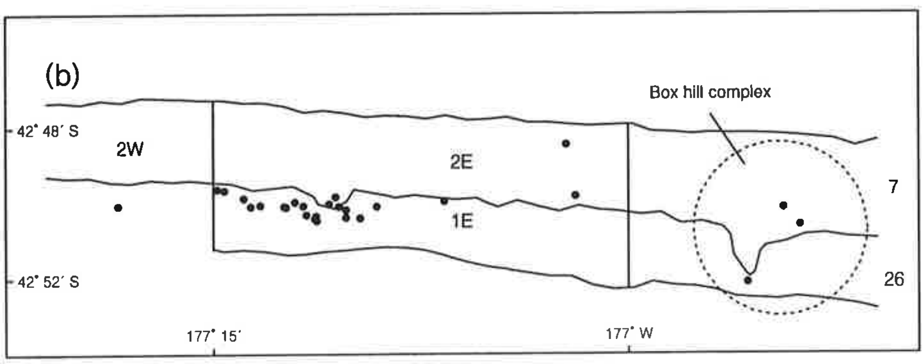
Figure 3: Stratified random trawl survey snapshot station positions for *Tangaroa*.

Table 1: Strata description, number of trawls, and areas for the Spawning Box strata sampled by both vessels

Stratum no.	Area (km²)	Description (longitude and depth (m))	No. of trawls *Tangaroa*	No. of trawls *San Waitaki*
001E	80.0	177 15–177 W, 800–849	9	5
002E	87.0	177 15–177 W, 850–949	27	8
002W	87.0	177 30–177 15 W, 850–949	26	6
0003	139.7	177 30–177 W, 950–1049	16	3
0004	137.6	177 30–177 W, 1050–1149	12	3
0007	207.9	177–176 30 W, 850–949	28	12
0008	181.4	177–176 30 W, 950–1049	17	4
0009	159.3	177–176 30 W, 1050–1149	12	3
0012	209.9	176 30–176 W, 850–949	16	3
0026	71.9	177–176 45 W, 800–849	20	10
0030	(10.3)*	Box hill complex	0	16
Total area	1 322.8			

* Area of Box hill complex included in strata 7 and 26.





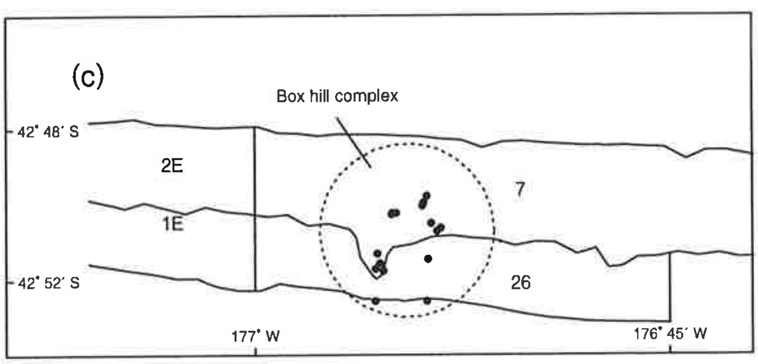


Figure 4: *San Waitaki* station positions for (a) parallel tows with *Tangaroa* (*n* = 50); (b) midwater tows (*n* = 27); (c) Box hill complex tows (*n* = 16).

Table 2a: Catch composition (all tows). Total catch, percentage composition of the total weight, and number of stations where caught of the 10 most abundant species. Includes both vessels and all (non-commercial) stations (*see* Appendix 2 for scientific names)

	Catch (kg)	Percent	No. of stations*
Orange roughy	795 623	96.55	216
Shovelnosed spiny dogfish	3 826	0.46	161
Hoki	3 006	0.36	195
Longnosed velvet dogfish	3 222	0.39	165
Johnson's cod	1 995	0.24	182
Smooth oreo	3 771	0.46	100
Ribaldo	1 965	0.24	144
Baxter's lantern dogfish	1 693	0.21	168
Black cardinalfish	1220	0.15	14
Bigscaled brown slickhead	822	0.10	66
All species	824 045		

* Total number of stations (both vessels), 284.

Table 2b: Catch composition from the Box hill complex. Total catch, percentage composition of the total weight, and number of stations where caught of the 10 most abundant species in the Box hill complex, *San Waitaki* only

	Catch (kg)	Percent	No. of stations*
Orange roughy	81 461	94.27	16
Smooth oreo	2 385	2.76	13
Black cardinalfish	1 156	1.34	8
Ribaldo	323	0.37	16
Shovelnosed spiny dogfish	251	0.29	11
Baxter's lantern dogfish	178	0.21	11
Longnosed velvet dogfish	106	0.12	11
Giant chimaera	76	0.09	5
Hoki	69	0.08	9
Plunket's shark	61	0.07	2
All species	86 066		

* Total number of stations, 16.

Table 2c: Catch composition from midwater tows. Total catch, percentage composition of the total weight, and number of stations where caught of the 10 most abundant species, *San Waitaki* only

	Catch (kg)	Percent	No of stations*
Orange roughy	199 528	99.50	22
Ribaldo	255	0.13	14
Johnson's cod	165	0.08	22
Baxter's lantern dogfish	133	0.07	15
Longnosed velvet dogfish	107	0.05	15
Hoki	88	0.04	19
Shovelnosed spiny dogfish	80	0.04	13
Hake	32	0.02	7
Red squid	11	0.01	7
Salps	29	0.01	10
All species	200 533		

* Total number of stations, 27.

Acoustics

A successful acoustic survey covered the survey area in 3 days. A range of marks was visible, from light "scatter" to a well defined dense mark (with some associated scatter) resembling stacked columns or plumes and defined as "cityscape" marks (*see* Cordue 1996). These high density cityscape marks are often dynamic structures. On this survey they were observed to regularly change shape, size, and position. A cityscape was visible in the high density strata (1E and 2E) and extended from the bottom to heights of 100–130 m. It was measured on acoustic transects positioned over strata 1E and 2E. Background scatter marks were also measured on main acoustic transects over the survey area. Trawling by both vessels on the edge of the cityscape showed that the marks represented tightly aggregated actively spawning orange roughy. Targeted trawling was also carried out by *San Waitaki* on marks away from the high density cityscape plume to identify other fish targets observed during the acoustic survey.

An absolute estimate of orange roughy abundance could be derived from the acoustic survey, but is of limited value until an accurate measure of target strength for this species can be obtained. However it has been estimated that about 50–80% of the biomass was present in the high density cityscape plume (I. J. Doonan, NIWA, Wellington, pers. comm.).

Catch composition

All species caught by both vessels during the survey are listed in Appendix 3. The total catch for *Tangaroa* was 294 t and for *San Waitaki* (excluding commercial tows) 530 t. The catch was predominantly orange roughy, 96.5% by weight of all fish caught (estimated from the combined *Tangaroa* and *San Waitaki* research tows). A higher proportion of bycatch was taken in the smaller orange roughy catches: large catches of orange roughy had little bycatch. For stations where the orange roughy component was greater than 5 t the proportion of the catch which was orange roughy was 99.5% for both vessels combined. For stations where the orange roughy component was less than 5 t, this proportion was 71.6%.

The mean conversion factor for 10 tows on *Tangaroa* was 2.09 (range 2.00–2.17); for 29 tows on *San Waitaki* it was 2.05 (range 1.79–2.23)

Total orange roughy catch for all parallel trawls was compared between vessels. Catches were highly variable and the mean difference in catch (1650 kg in favour of *Tangaroa*) was not significant ($p = 0.152$).

Catch weights of the 10 most abundant species for all tows and for both vessels are given in Table 2a. As with previous Spawning Box surveys (Anderson & Fenaughty 1996, Tracey & Fenaughty 1997) the predominant species caught was orange roughy. The next most common species caught were shovelnosed spiny dogfish (*Deania calcea*) 3.8 t, smooth oreo (*Pseudocyttus maculatus*) 3.8 t, longnosed velvet dogfish (*Centroscymnus crepidater*) 3.2 t, and hoki (*Macruronus novaezelandiae*) 3.0 t.

Table 2b presents the catch composition for the 10 most abundant species caught by *San Waitaki* in the Box hill complex. Black cardinalfish (*Epigonus telescopus*) were relatively more abundant in this area, although bycatch species were a minor component of the catch (less than 6% of the total).

Midwater trawling. A total of 204 t of orange roughy was caught during midwater trawling. Orange roughy were caught in quantity (more than 2 t) only when the groundrope was within 40 m of the bottom and no substantial catches were made with the midwater net when the groundrope was higher than 30 m off the bottom (Figure 5). These larger catches from 30 m and below were at a bottom depth of 820–850 m. Marks seen on the net monitor on some tows extended up to 60 m above the bottom.

Table 2c summarises the catch weights of the 10 most abundant species caught by midwater trawl and shows that the species mix of catch is similar to that of all other trawls during the survey. Orange roughy made up more than 99.5% of the total catch from the midwater tows.

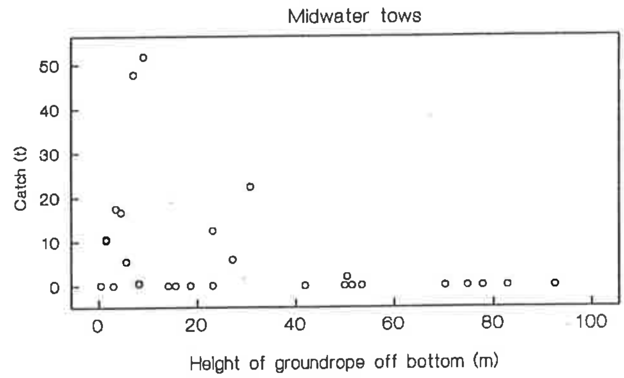


Figure 5: Catch versus groundrope height above the bottom for midwater tows by *San Waitaki*.

Distribution and catch rates

Tangaroa

Catch rates were highly variable between strata (Table 3). Catch rate by station for each snapshot (Figure 6) shows some changes in orange roughy distribution by strata over time. Catch rates were highest in strata 2, 7, and 26 in snapshot 1, and in strata 2, 7, and 12 during snapshot 2. In snapshots 3 and 4, catch rates were highest in the new stratum, 1E, and high also in strata 2, 7, 12, and 26. Snapshots 2 and 3 saw an overall drop in catch rates in the survey area. Overall catch rates were greatest during snapshot 4, when the fish were in what was presumed to be a post-spawning dispersal phase, migrating eastwards from the high density spawning stratum (1E). The highest catch rate (200 600 kg.km^{-1}) occurred during snapshot 4 at station 147 in stratum 1. Generally catch rates were high in a small southwestern area of the Spawning Box where fish were tightly aggregated and forming cityscape plumes. The orange roughy plumes were found initially in stratum 2E and then moved to shallower depths, 82 m, in stratum 1E. Station 171 in snapshot 4 was excluded from analyses of catch rate because of poor gear performance.

San Waitaki

Catch rates during random bottom trawling (carried out in parallel as well as independently) were low over most of the area except in strata 2E and 26 (*see* Figure 6). Maximum catch rates in these areas were 2000 and 4800 kg.km^{-1}.

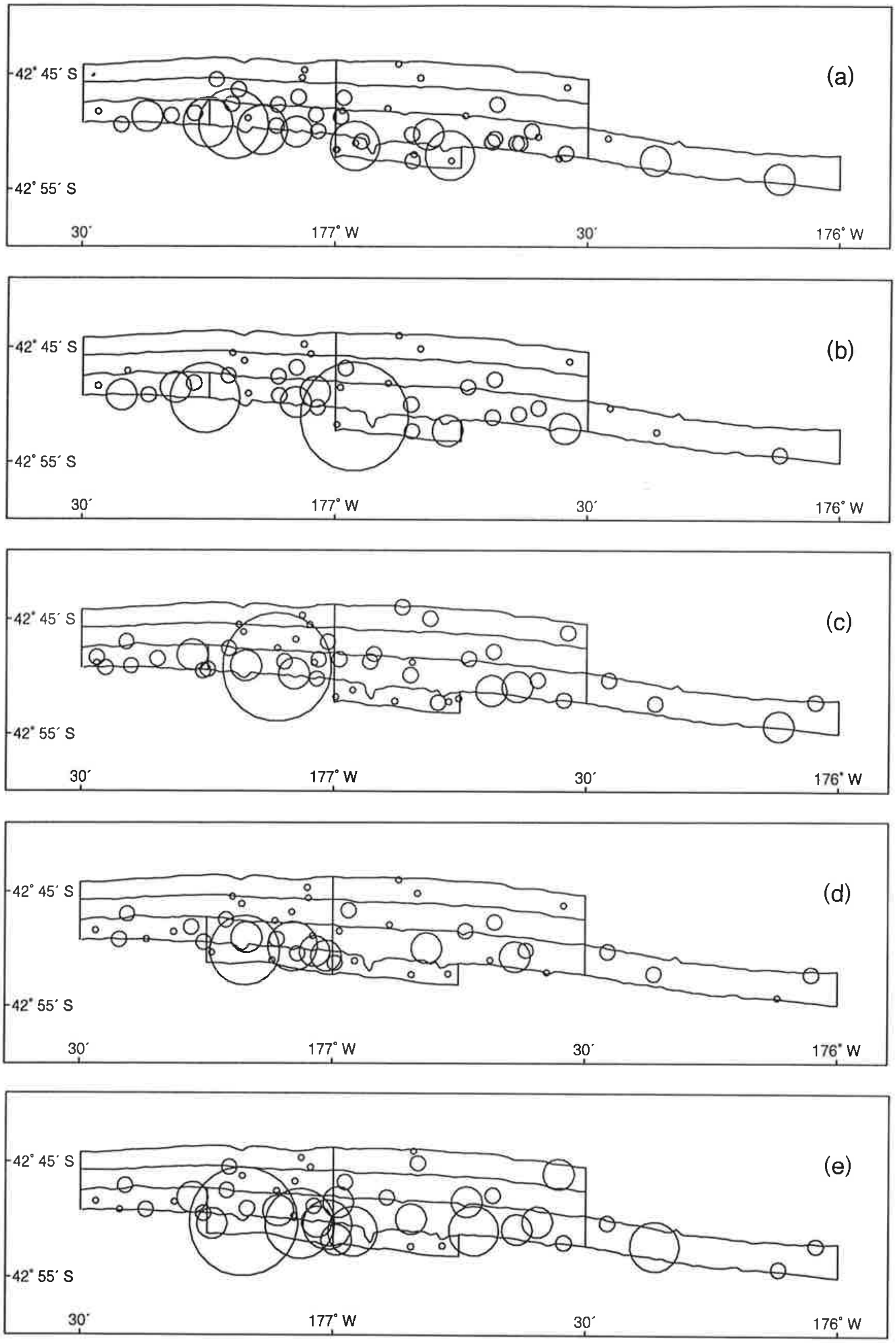
The largest bottom trawl catches in the Box hill complex came off the northwestern side of the main hill. Here catch rates were up to 50 000 kg.km^{-1}. Catch rates were low in the trench area. Bottom trawling was targeted on areas of high fish concentration from different directions and at different times. Catch rates were consistently high during this phase of the survey. The highest catch rate recorded on *San Waitaki* was 56 900 kg.km^{-1} at station 95, a tow targeted on fish marks.

Size structure

Scaled length frequency distributions for orange roughy were calculated for each snapshot and for all snapshots combined, using *Tangaroa* data only (Figure 7), and for *San Waitaki* Box hill complex and midwater tows (Figure 8).

Table 3: Mean catch rates (kg.km^{-1}) of orange roughy by stratum for snapshots1–4, (*n*, number of tows)

	Snapshot 1		Snapshot 2		Snapshot 3		Snapshot 4	
Stratum	*n*	catch rate	*n*	catch rate	*n*	catch rate	*n*	catch rate
1E	–	–	–	–	5	2 217.6	4	7 818.2
2W	6	3 469.9	8	42.3	6	42.1	6	41.2
2E	6	160.0	8	1 280.1	6	382.3	6	61.8
3	4	33.6	4	21.4	4	15.7	4	19.6
4	3	11.4	3	13.3	3	14.1	3	33.4
7	6	81.0	8	66.8	6	88.4	6	614.7
8	4	34.2	4	49.0	4	29.3	4	63.6
9	3	13.0	3	37.7	3	16.9	3	60.8
12	3	32.5	4	65.3	4	40.3	5	635.0
26	4	4 595.5	6	16.3	4	13.3	4	2 124.4



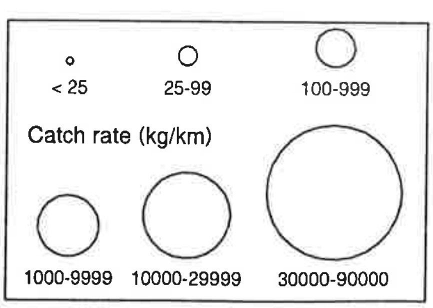


Figure 6: Catch rates (kg.km^{-1}) from all parallel trawls, snapshot 1 (a and b, presented for each vessel separately), and for *Tangaroa* snap shots 2 (c), 3 (d), and 4 (e). Some of the parallel trawls were carried out at separate times and in opposite directions so that some station positions may appear to vary slightly between vessels.

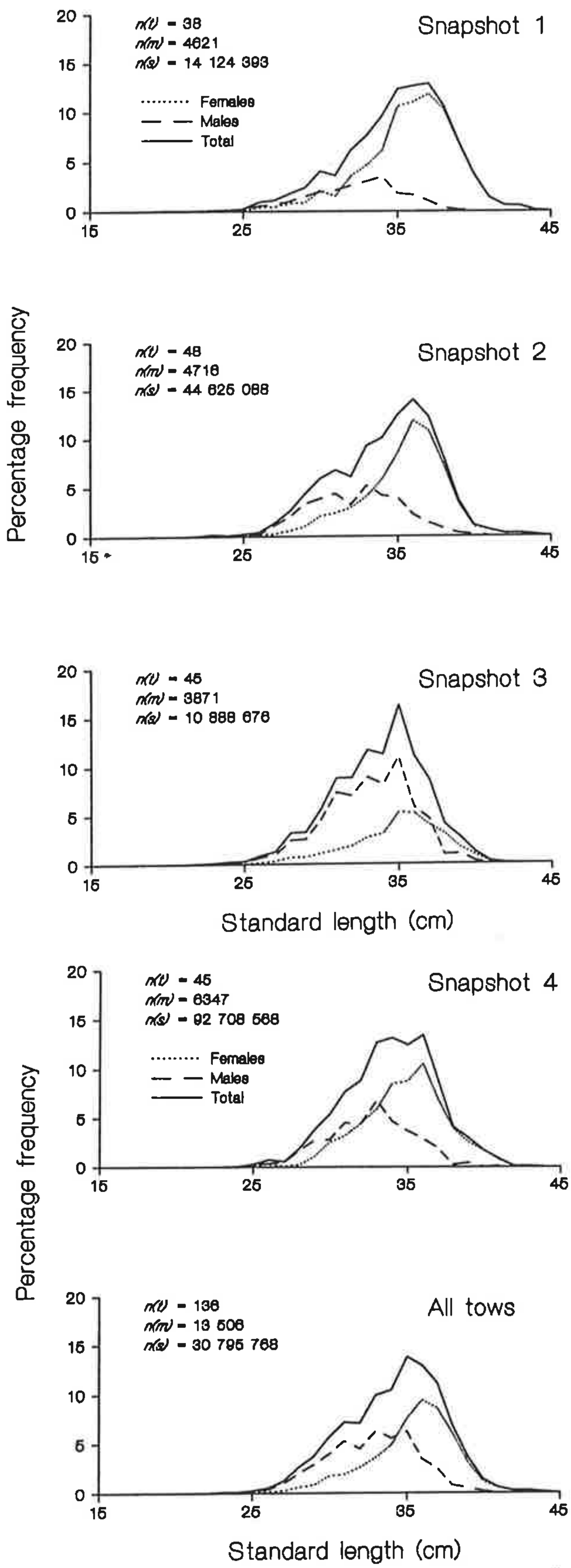


Figure 7: Length frequency distribution of orange roughy in the survey area, overall and for each snapshot separately, from *Tangaroa* samples only, scaled to represent the total population. The percentage frequency refers to the percentage of all fish. *n(t)*, number of tows; *n(m)*, number of fish measured; *n(s)*, scaled total number of fish.

Distributions for the *Tangaroa* data were generally unimodal for both sexes, though there is a suggestion of a second mode at about 30 cm for males in snapshot 2. The size distribution of female orange roughy overall revealed a moderate skew towards larger fish, whereas for male fish the distribution was more symmetrical. Fish ranged in size from 12 to 46 cm standard length (SL) with mean lengths, derived from size distributions scaled to the total population, of 33.2 cm (*s.d.* = 2.9) for males and 35.9 cm (*s.d.* = 2.9) for females.The mean length of female orange roughy was greater than that of males in each snapshot.

The size distribution of fish from the Box hill complex (*see* Figure 8) shows female fish had a broad mode between 34 and 37 cm, and male fish a mode at 34–35 cm. Fish ranged in size from 20 to 44 cm with means of 35.0 (*s.d.* = 2.7) for males and 35.9 cm (*s.d.* = 2.4) for females. The size distribution was tighter than that of the surrounding area, with fewer small fish.

Orange roughy from midwater tows appeared to be slightly smaller than those from bottom tows (Figure 8), with a mode for females at 33–35 cm and for males at 31–34 cm. Mean lengths were 33.2 (*s.d.* = 2.4) for males and 34.9 (*s.d.* = 2.5) for females. The percentage of females calculated from the midwater length frequency distributions was 55.4%.

Length-weight regression coefficients calculated overall and by sex are given in Table 4.

Sex ratios

Tangaroa and *San Waitaki*

Francis (1996) presented the results and discussed the imbalance in sex ratio hypotheses.

In summary, for three of the four snapshots and for all snapshots combined there were more females than males. At the stratum level, there were almost always more females, and for most strata this increased over time. The sex ratio data from the parallel stations (Figure 9a) lend some support to the hypothesis that *Tangaroa* is, for some reason, less likely than *San Waitaki* to catch males because the percentage of males was higher for *San Waitaki* than for *Tangaroa*. However, although this difference was statistically significant for tows taking more than 15 kg (Mann Whitney test, P = 0.04), it was small. The median difference in percentage of males was only 4% (Francis 1996).

Table 4: Length-weight regression coefficients for orange roughy by sex for the *Tangaroa* trawl stations in the Box area

Sex	Coefficients			
	a	*b*	*n*	r^2
Both	0.0857	2.723	3 546	0.93
M	0.1167	2.628	1 351	0.92
F	0.0899	2.713	2 195	0.92

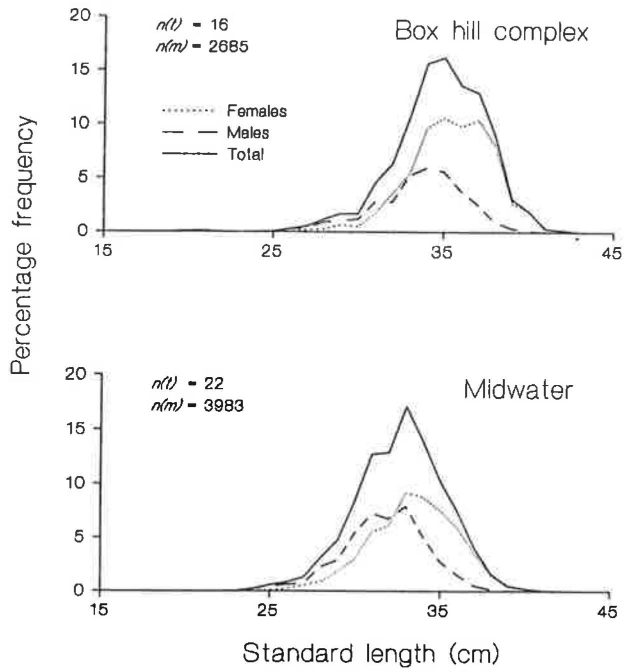


Figure 8: Length frequency distribution of orange roughy in the Box hill complex and from midwater trawling, *San Waitaki* only, scaled by catch. The percentage frequency refers to the percentage of all fish. *n(t)*, number of tows; *n(m)*, number of fish measured.

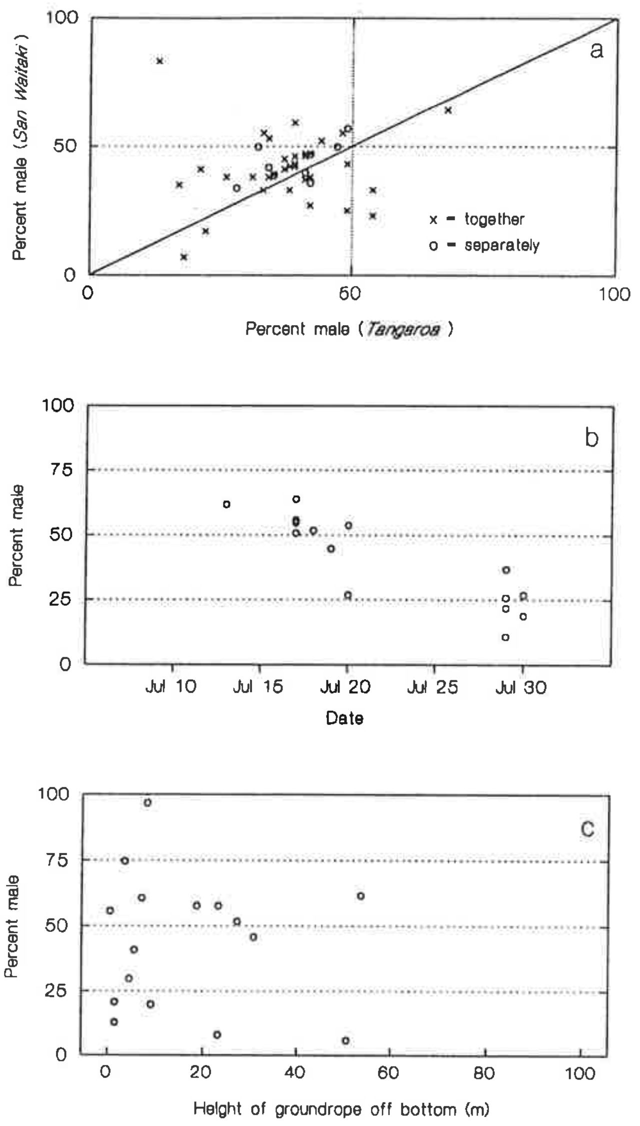


Figure 9: Data used in testing various hypotheses about the imbalance in sex ratios: a, comparison of percent males in catches by *San Waitaki* and *Tangaroa* at the same time (catches less than 15 kg ignored); b, percent male versus date for tows on the Box hill complex; c, percent male versus groundrope height for midwater tows (catches less than 15 kg ignored) (*after* Francis 1996).

Trawling in the Box hill complex confirmed that orange roughy spawn there. However, there was no evidence from the sex ratio data to suggest that this area is a refuge for males (Figure 9b, overall percentage of males, 42.3%).

Data from *San Waitaki* midwater trawls do not show that males were less available to the random trawl surveys than females because they were higher in the water column (Figure 9c). Sex ratios were highly variable, with some tows showing an even ratio and others showing a strong dominance of either males or females.

Reproduction

The changes in gonad condition over the period of the survey are shown in Figure 10. Data from all tows and both vessels were used for this analysis. On 9 July, when the first data were gathered, "active" fish (stages 3, 4, 5, 8) of both sexes were mainly in the maturing stage, with some ripe fish and few spent fish. Ripe fish reached a peak at about 18–19 July for both sexes, after which the number of spent fish steadily increased. The reference point 20% spent fish occurred at about 15 July for males and 17 July for females.

There was evidence of spawning activity in the Box hill complex with about 60% of fish ripe or running ripe when *San Waitaki* began sampling in this area. By late July, 70% of all fish sampled in this area were spent.

Feeding

A total of 3346 stomachs was examined on *Tangaroa*, of which only 13% contained food (Table 5). Prey were identified to major taxon and to family groups where possible (Table 6). Natant decapod crustaceans were the most frequent prey item, followed by fish.

Table 5: Stomach states of orange roughy examined on *Tangaroa*

State	*n*	%
Empty	2 891	86
Trace	132	4
Part-full	262	8
Full	50	1
Everted	11	< 1
n	3 346	

Discussion

Previous trawl surveys on the Chatham Rise have produced biomass estimates for the stock assessment process. The surveys described in this report were not designed to produce biomass estimates of orange roughy to continue the stratified random trawl survey time series, but to address aspects of the results of these previous surveys.

Sampling using the two vessels was designed to answer questions about factors that may have affected the precision of the biomass estimates. Specific questions directed at the extreme sex ratios seen in the 1992 and 1994 surveys were: how do sex ratios and catch rates vary in the main Spawning Box strata through the season; could the vertical distribution of orange roughy explain the anomalous sex ratios; and does the Box hill complex provide a haven for male orange roughy?

The survey area remained more or less the same since 1984, at about 7655 km^2, but the area for this survey was smaller (1323 km^2) and concentrated on strata with previously high catch rates. For the first time the Box hill complex was treated as a separate stratum to ensure the survey included detailed sampling of the pinnacle and trench region of the Spawning Box.

With the Spawning Box closed to commercial fishing since 1992, this was an ideal opportunity to study the undisturbed behaviour of orange roughy during their spawning season. Aggregations of orange roughy are believed to be affected by intensive bottom trawling (Clark & Thomas 1994), which could disrupt school structure and influence catch rates.

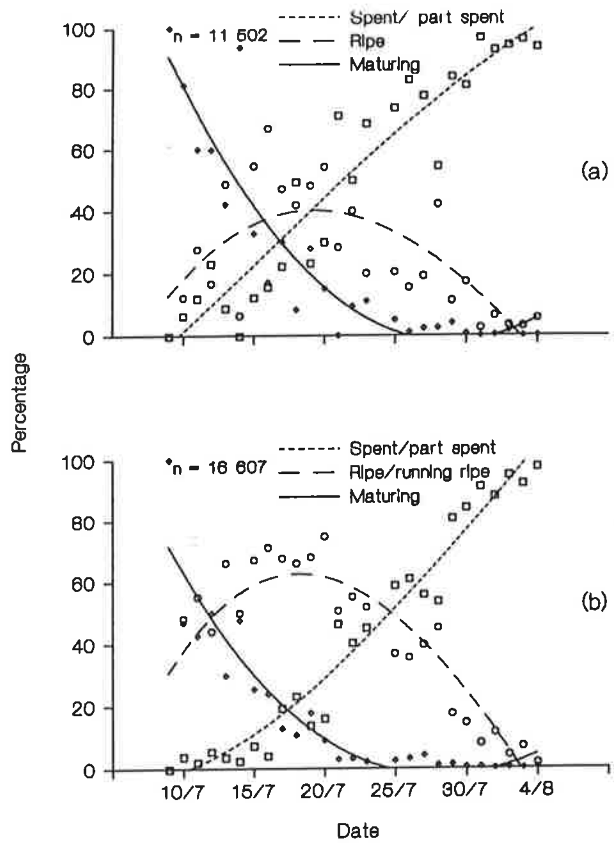


Figure 10: Gonad state of (a) male and (b) female orange roughy during the survey. Data are from all tows where orange roughy were sampled and from both vessels. Percentage refers to percent of mature fish only.

Midwater trawling

The midwater trawling showed that orange roughy congregate in plumes reaching substantial distances off the bottom. One trawl with the groundrope at 30 m off the bottom caught 20 t of orange roughy. The mark on the net monitor for this tow was continuous between the bottom and beyond the 25 m vertical opening of the net, extending a further 10–15 m above the headline of the net. This implies that the fish were at times up to 60–70 m above the bottom. Echosounder marks more than 30–40 m off the bottom, however, were not successfully fished with the midwater gear (*see* Figure 5), suggesting that these higher marks were either smaller fish or plankton not caught by the gear, or were orange roughy which were able to escape the gear by diving beneath it.

No orange roughy were caught in extensive midwater trawling off Tasmania by Australian researchers in support of their orange roughy acoustic programme (Kloser *et al.* 1994). The *San Waitaki* survey is the first documented successful fishing for orange roughy off the bottom by midwater trawling on plumes extending off the seabed.

Repeated trawling to confirm that orange roughy extend well off the bottom during their spawning period is important for stock assessment research as it provides

Table 6: Percentage occurrence of the major prey groups of orange roughy from the survey area (*n*, 312)

Prey group	%
Crustacea	
Amphipoda	2.0
Decapoda Natantia	60.1
Euphausiacea	1.2
Mysidacea	1.7
Crustacean remains	2.9
Cephalopoda	
Decapoda	6.4
Pisces	
Mesopelagic group *	2.1
Other groups †	0.3
Fish remains	22.9
Thaliacea	
Salpidae	0.3
Unidentified	0.3

* Includes families Myctophidae, Chauliodontidae, Idiacanthidae, Stomiidae.

† Includes family Synaphobranchidae.

valuable information for analysis of acoustic survey results. For this reason midwater trawling should be programmed into future surveys to provide further information on vertical distribution, particularly when marks extend to depths greater than 30 m off the bottom.

The midwater work on *San Waitaki* showed that there was no difference in sex ratio higher up the water column.

Biomass and *c.v.*s

Francis (1996) analysed the biomass results from the four snapshots and showed that the values calculated had associated high *c.v.*s and were highly correlated with the maximum catch rate for each snapshot. As a result, even though the estimates varied from less than 50 000 t (snapshot 3) to almost 400 000 t (snapshot 4), there was insufficient evidence to indicate that biomass or sex ratios had changed during the period.

Analysis of the *Tangaroa* catch rate data between strata and over the four time periods showed that the stratified random trawl survey technique continued to produce high *c.v.*s in this area (Francis 1996). Francis compared catch rate data from all Chatham Rise surveys to date and found that although peak catch rates continued to be high, the area in which moderate to high catch rates were obtained had progressively shrunk. This makes the high *c.v.*s almost inevitable.

Distribution and catch rates

Orange roughy plumes were found initially in stratum 2E (840–860 m) and then moved to shallower depths (820 m) in stratum 1E. Having two vessels helped us to observe the movement of the main spawning aggregation and it was apparent that the plume was not static and had moved into shallower depths during snapshot 2.

Catch rates were highest overall for some of the strata in snapshot 4 (*see* Figure 6). At this time fish were considered to be in a dispersal phase, migrating eastwards from the spawning stratum of high fish density (1E). The timing of the migration to the east during snapshot 4 is consistent with the findings of Coburn & Doonan (1994) who described movement of the commercial fleet from the Spawning Box at the end of July eastward after spawning. Analysis of the commercial fleet catch rates showed that after spawning a mass of fish appeared to move out of the area to the east. This is consistent with the survey catch rates during snapshot 4 when high catches were recorded in strata 7 and 12 to the east of the main spawning aggregation in stratum 1E.

Coburn & Doonan (1994) were unable to identify any postspawning migration to the west from the commercial fleet data as generally vessels do not fish there. The survey catch rates during snapshot 4 to the west of the main spawning aggregation after spawning were low (strata 2E, 3, 4), suggesting no outward migration to the west.

Bycatch was higher in tows with a low orange roughy catch rate. Although only 3.5% of the entire research catch of both vessels was not orange roughy (*see* Table 2a), the bycatch proportion was much higher than this for most tows. This effect can be important when comparing catch proportions between areas.

Sex ratios

Information on sex ratio collected during the two vessel survey enabled comparisons based on vessel, area, time of month, and height above the bottom. The shift in orange roughy sex ratios in the Spawning Box was discussed in detail for this survey and the 1992 and 1994 surveys by Francis (1996). The 1995 survey results showed that females predominated in more than 90% of the survey area and that this predominance increased during the survey period. An important finding was that in the area that contained more than half of the biomass (strata 1E and 2E), sex ratios were highly variable and did not favour either sex.

Francis (1996) concluded that altering the survey design was not responsible for the extreme sex ratio results. There was no evidence from the trawling data that males aggregated in the Box hill complex and thus avoided capture during previous surveys.

Data from the midwater trawling did not support the hypothesis that males had been less available to the random trawl surveys because they were higher in the water column. However, no substantial catches were made with the midwater net when the groundrope was more than 40 m off the bottom. Plumes were observed at times to extend 100–150 m above the bottom, so there is still a possibility of some vertical stratification by sex higher in the water column. This again highlights the need for further work on mark composition.

Although *Tangaroa* caught a higher proportion of females than *San Waitaki*, the difference was not sufficient to explain the observed change in sex ratio in recent surveys (Francis 1996).

Francis (1996) concluded that it is likely that the sex ratio of the population has altered in recent years to favour females and that the marked female dominance found in the 1992 and 1994 surveys was not the result of changes or biases in the survey methods.

Size structure

Length frequency distributions in the Spawning Box have remained essentially unimodal over time (Anderson & Fenaughty 1996, Tracey & Fenaughty 1997) and the distributions from this survey are the same. Female mean length remained 1–3 cm greater than that of males, but the mean length of males was less than that calculated from all surveys before 1994 (*see* Francis *et al.* 1995), and the mean length for females was also lower than in most previous surveys.

Large catches of either predominantly males or females strongly influence the distribution of scaled length plots. Females dominated in all distributions calculated for the *Tangaroa* survey results, except for snapshot 3, which was greatly influenced by a single large catch of mostly male orange roughy.

Reproduction

Gonad development in orange roughy followed a pattern similar to that found previously in the Spawning Box. By mid July, during snapshot 2, the incidence of spent fish had increased to 20%. Previous surveys have consistently shown peak spawning to be within a 2 week period between 14 and 27 July (Anderson & Fenaughty 1996).

Spawning was confirmed in the Box hill complex. The general timing of spawning appeared similar to that of aggregations fished on nearby slope strata.

Pilot acoustic survey

A pilot acoustic survey showed that the technique has potential to give reliable estimates of biomass for the Chatham Rise orange roughy Spawning Box fishery. The acoustic system is in continuous development and future surveys will have the benefit of improved signal transfer and fish target strength and target identification information.

Acknowledgments

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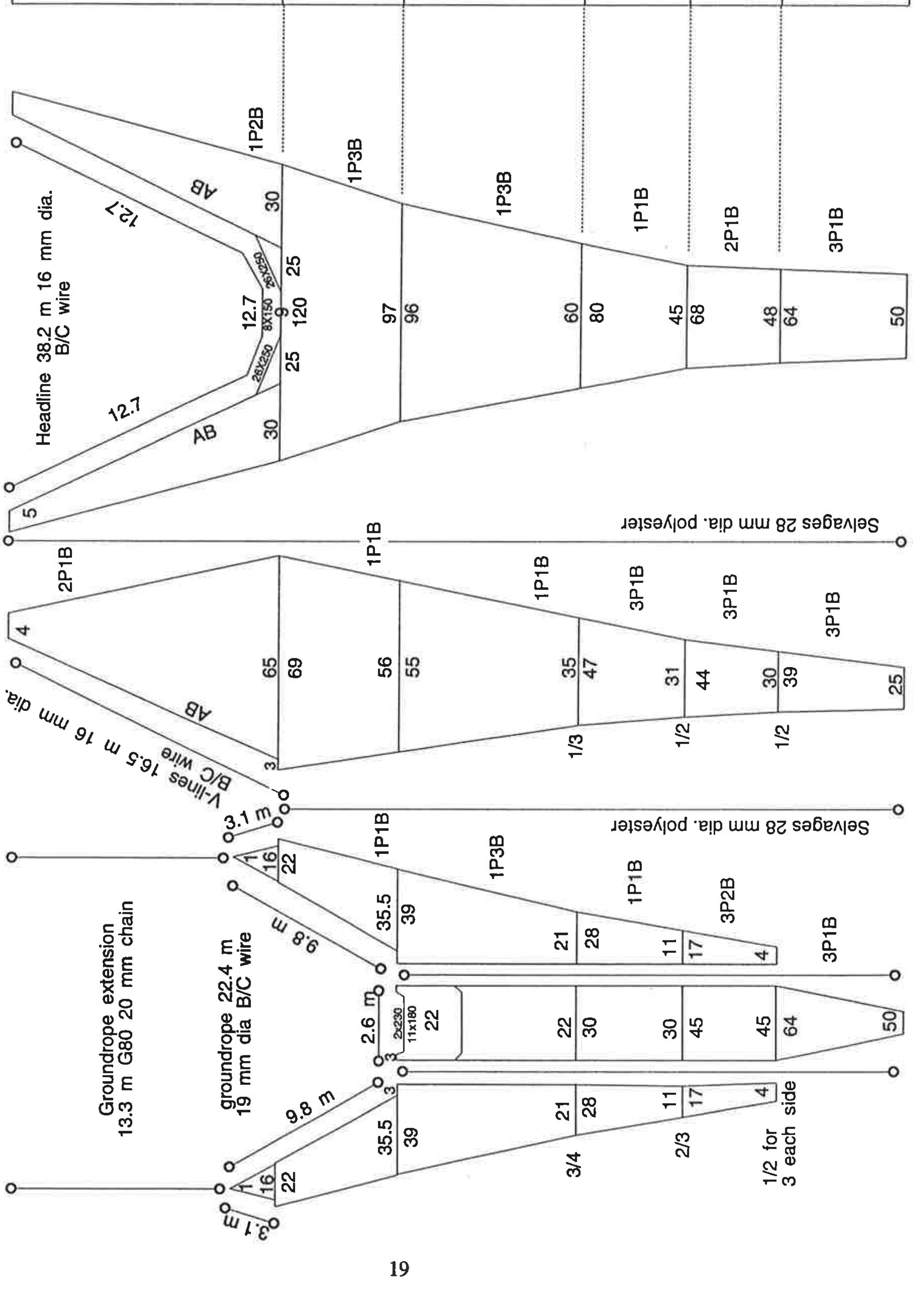
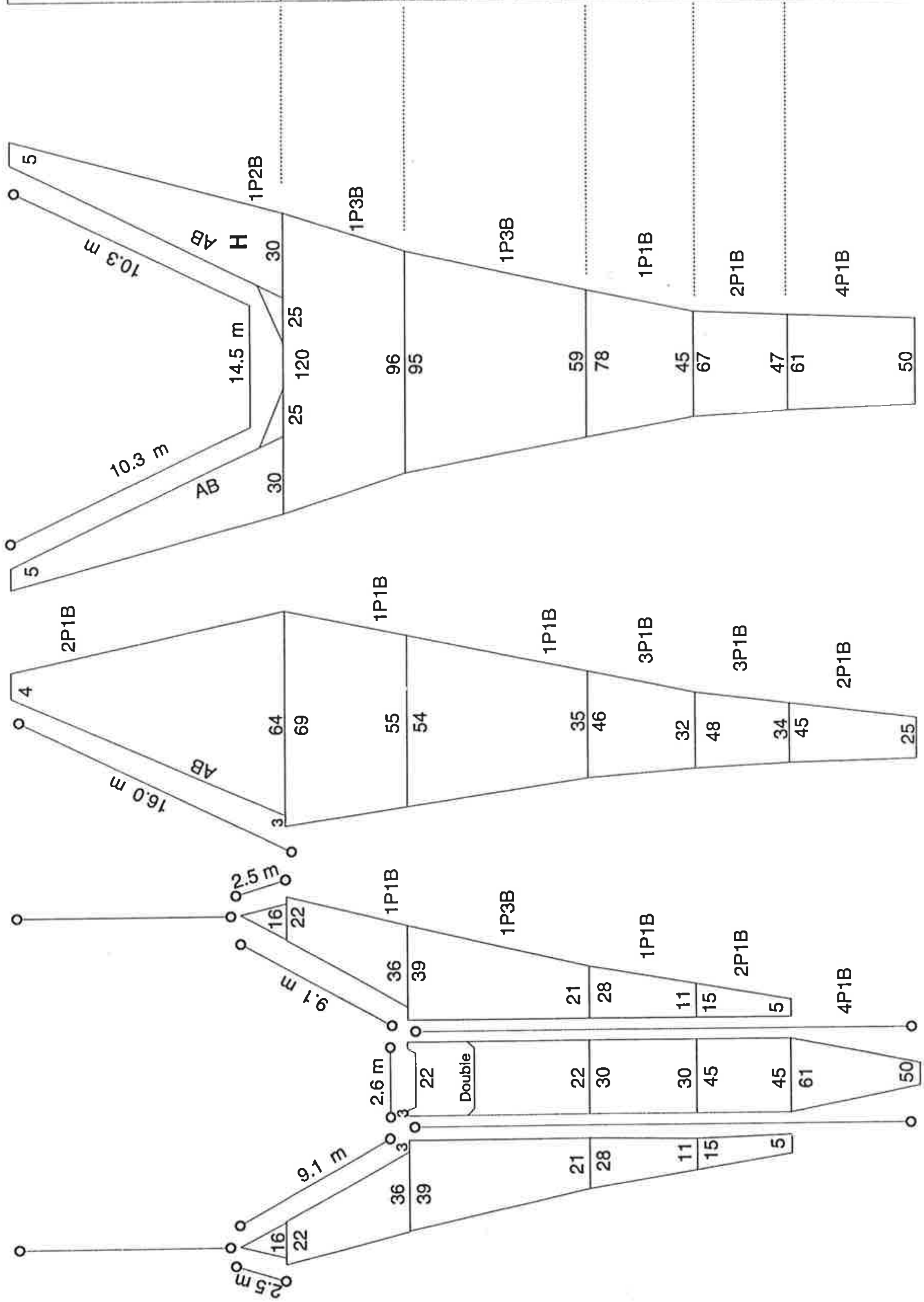
Appendix 1a: ***Tangaroa*** **bottom trawl gear**

Mesh size	12 inch	12 inch	12 inch	9 inch	6 inch	4.5 inch
Twine size	5 mm olivene	5 mm olivene	5 mm olivene	5 mm olivene	5 mm oliv.	5 mm olivene
No. of meshes	50	20	30	50	50.5	50
Double twine	Wing tips 8 meshes deep		9.5 meshes in belly head			



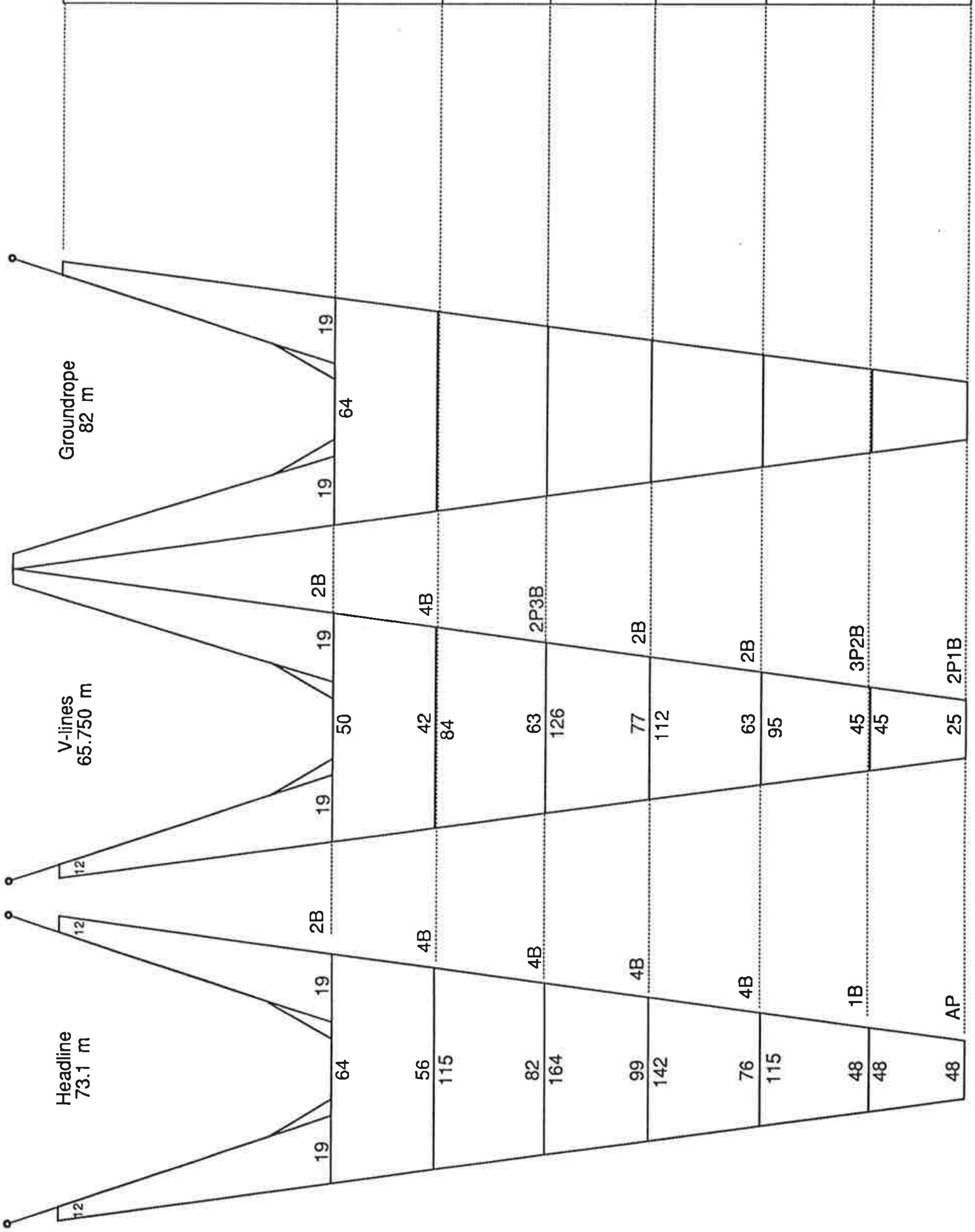
Appendix 1b: *San Waitaki* bottom trawl gear

Mesh size	12 inch	12 inch	12 inch	9 inch	6 inch	4.5 inch
Twine size	5 mm olivene	5 mm olivene	5 mm olivene	5 mm olivene	5 mm oliv.	5 mm olivene
No. of meshes	58	20	30	50	50	50



Appendix 1c: *San Waitaki* midwater trawl gear

No. of meshes	15	7	24.5	49.5	49.5	100.5	50
Mesh size		1800 mm	800 mm	400 mm	200 mm	4 5/8"	



Appendix 2: Summary of station and catch data. Codes are: pt, parallel tows; tm, target on marks; bp, Box hill complex pinnacle; bt, Box hill complex trench; ac, acoustic target; cm, commercial tow; ra, random station; ex, experimental. BT, bottom trawl; MW, midwater trawl

Station no.	Stratum	Date	Net	Code	Distance (n.miles)	Course	Position (start of tow) longitude ° ′ W	latitude ° ′ S	Depth (m)	Total catch (kg)	Orange roughy (kg)
Tangaroa											
1	4	09-Jul	BT	pt	1.49	093	177 12.21	42 45.52	1052–1054	47	13
2	4	10-Jul	BT	pt	1.51	092	177 03.84	42 44.76	1112–1116	93	25
3	4	10-Jul	BT	pt	1.48	274	177 03.01	42 45.58	1063–1069	81	56
4	3	10-Jul	BT	pt	1.51	270	177 04.70	42 46.77	1004–1007	223	185
5	3	10-Jul	BT	pt	1.51	276	177 06.82	42 47.55	962– 969	119	81
6	3	10-Jul	BT	pt	1.51	272	177 10.83	42 46.19	1019–1024	123	65
7	3	10-Jul	BT	pt	1.51	273	177 24.74	42 47.08	971– 973	112	46
8	2	10-Jul	BT	pt	1.53	273	177 16.83	42 48.13	915– 916	340	225
9	2	10-Jul	BT	pt	1.50	272	177 19.0	42 48.51	891– 893	1 404	1 250
10	2	10-Jul	BT	pt	1.50	272	177 22.19	42 49.19	856– 860	329	187
11	2	10-Jul	BT	pt	1.52	267	177 25.41	42 49.19	851– 859	615	395
12	2	10-Jul	BT	pt	1.51	092	177 28.20	42 48.42	901– 911	183	53
13	2	11-Jul	BT	pt	1.50	276	177 06.71	42 49.22	885– 887	225	172
14	2	11-Jul	BT	pt	1.50	280	177 10.34	42 49.04	883– 892	127	42
15	2	11-Jul	BT	pt	1.51	089	177 12.71	42 47.49	950– 962	125	88
16	2	11-Jul	BT	pt	1.49	097	177 15.48	42 49.42	851– 854	56 122	56 085
17	9	12-Jul	BT	pt	1.51	093	176 52.52	42 43.99	1147–1152	98	42
18	9	12-Jul	BT	pt	1.50	095	176 49.90	42 45.13	1096–1097	60	27
19	9	12-Jul	BT	pt	1.49	090	176 32.18	42 46.24	1096–1107	113	39
20	8	12-Jul	BT	pt	1.51	271	176 41.06	42 47.80	992–1003	261	162
21	8	12-Jul	BT	pt	1.45	264	176 44.20	42 48.46	956– 966	151	76
22	8	12-Jul	BT	pt	1.50	272	176 53.72	42 48.14	957– 962	158	53
23	8	12-Jul	BT	pt	1.52	263	176 58.81	42 46.81	1008–1010	193	87
24	26	13-Jul	BT	pt	1.47	272	176 46.62	42 52.25	820– 829	1 452	1 328
25	26	13-Jul	BT	pt	1.50	280	176 50.89	42 52.30	805– 806	301	166
26	26	13-Jul	BT	pt	0.44	263	176 57.77	42 51.03	833– 838	40 339	40 339
27	12	14-Jul	BT	pt	1.04	278	176 07.02	42 54.31	857– 863	429	152
28	12	14-Jul	BT	pt	1.51	272	176 21.77	42 52.35	885– 891	185	52
29	12	14-Jul	BT	pt	1.52	273	176 27.35	42 50.30	941– 949	169	42
30	7	15-Jul	BT	pt	1.51	267	176 32.66	42 52.05	854– 856	921	742
31	7	15-Jul	BT	pt	1.50	277	176 35.80	42 50.28	911– 913	253	122
32	7	15-Jul	BT	pt	1.50	274	176 41.27	42 51.09	867– 868	356	226
33	7	15-Jul	BT	pt	1.50	275	176 59.43	42 48.51	936– 937	149	67
34	26	15-Jul	BT	pt	1.50	273	176 59.82	42 51.75	797– 799	160	6
35	2	15-Jul	BT	pt	1.50	272	177 02.16	42 50.23	848– 856	186	81
36	2	15-Jul	BT	pt	1.50	090	177 02.44	42 48.88	914– 920	1 214	1 100
37	2	15-Jul	BT	pt	1.50	273	177 04.74	42 49.78	863– 888	1 349	1 188
38	7	15-Jul	BT	pt	1.50	092	176 50.99	42 49.98	891– 892	201	90
39	7	15-Jul	BT	pt	1.50	080	176 38.15	42 50.81	883– 898	169	106
40	4	16-Jul	BT	ra	1.50	090	177 11.31	42 45.49	1052–1058	72	26
41	4	16-Jul	BT	ra	1.50	093	177 03.86	42 44.67	1109–1120	81	28
42	4	16-Jul	BT	ra	1.51	268	177 02.98	42 45.50	1068–1076	115	58
43	3	16-Jul	BT	ra	1.50	271	177 04.63	42 46.75	1004–1007	123	55
44	3	17-Jul	BT	ra	1.51	274	177 06.77	42 47.54	965– 967	80	10
45	3	17-Jul	BT	ra	1.50	272	177 10.77	42 46.13	1024–1030	194	59
46	3	17-Jul	BT	ra	1.50	270	177 24.72	42 46.98	974– 980	224	116
47	2	17-Jul	BT	ra	1.50	091	177 28.22	42 48.35	900– 900	186	107
48	2	17-Jul	BT	ra	1.49	085	177 27.19	42 49.24	850– 862	164	77
49	2	17-Jul	BT	ra	1.49	090	177 24.16	42 49.08	858– 863	153	98
50	2	17-Jul	BT	ra	0.85	084	177 20.99	42 48.47	896– 899	102	45
51	2	17-Jul	BT	ra	1.50	272	177 16.86	42 48.12	915– 916	428	319
52	2	17-Jul	BT	ra	0.10	264	177 06.80	42 49.20	885– 887	17 358	17 349
53	2	17-Jul	BT	ra	1.50	087	177 12.49	42 47.57	949– 954	210	120
54	2	17-Jul	BT	ra	1.50	095	177 15.62	42 49.50	851– 853	116	76
55	2	17-Jul	BT	ra	0.20	285	177 10.47	42 49.06	872– 875	288	265
56	2	18-Jul	BT	ra	1.50	274	177 04.82	42 49.75	865– 867	642	465
57	2	18-Jul	BT	ra	1.49	089	177 02.43	42 48.81	916– 921	158	46
58	2	18-Jul	BT	ra	1.50	269	177 02.09	42 50.20	847– 857	221	113
59	9	18-Jul	BT	ra	1.48	099	176 51.93	42 43.94	1134–1153	150	87
60	9	18-Jul	BT	ra	1.49	083	176 48.59	42 44.96	1098–1116	206	135
61	9	18-Jul	BT	ra	1.50	095	176 32.19	42 46.19	1090–1105	191	90
62	26	18-Jul	BT	ra	1.51	271	176 57.80	42 51.18	823– 827	229	45
63	26	18-Jul	BT	ra	1.51	275	176 59.82	42 51.78	795– 797	173	14
64	26	18-Jul	BT	ra	1.50	097	176 52.79	42 52.14	811– 812	192	6
65	26	18-Jul	BT	ra	1.50	272	176 46.32	42 52.18	825– 835	146	11
66	7	19-Jul	BT	ra	1.50	097	176 50.92	42 49.86	892– 896	239	93
67	7	19-Jul	BT	ra	1.50	279	176 59.39	42 48.53	935– 939	202	96
68	8	19-Jul	BT	ra	1.48	081	177 00.79	42 46.96	995–1014	209	115

69	8	19-Jul	BT	ra	1.50	090	176 55.28	42 48.04	957– 966	224	145
70	8	19-Jul	BT	ra	1.50	266	176 43.93	42 48.45	960– 963	307	166
71	8	19-Jul	BT	ra	1.51	273	176 40.99	42 47.83	992– 999	209	117
72	12	19-Jul	BT	ra	1.50	274	176 27.33	42 50.31	940– 943	247	81
73	12	19-Jul	BT	ra	1.50	092	176 02.70	42 52.20	947– 948	308	104
74	12	19-Jul	BT	ra	1.51	277	176 07.0	42 54.31	858– 860	614	360
75	12	19-Jul	BT	ra	1.50	273	176 21.79	42 52.34	887– 888	383	183
76	7	19-Jul	BT	ra	1.50	269	176 32.62	42 52.05	855– 857	249	95
77	7	20-Jul	BT	ra	1.50	279	176 35.73	42 50.32	911– 917	312	134
78	7	20-Jul	BT	ra	1.49	081	176 38.17	42 50.89	876– 895	746	632
79	7	20-Jul	BT	ra	1.50	280	176 41.25	42 51.24	863– 865	435	310
80	2	20-Jul	BT	ra	1.50	284	177 01.88	42 48.52	926– 935	168	94
81	2	20-Jul	BT	ra	1.50	270	177 05.96	42 48.69	900– 918	183	97
82	2	20-Jul	BT	ra	0.25	272	177 15.04	42 49.38	858– 858	65	45
83	2	20-Jul	BT	ra	1.51	279	177 28.21	42 48.82	875– 886	145	24
84	26	20-Jul	BT	ra	1.50	088	176 45.14	42 51.91	833– 835	233	14
85	26	20-Jul	BT	ra	1.50	276	176 47.61	42 52.25	818– 821	297	182
86	7	20-Jul	BT	ra	1.51	276	176 55.72	42 48.71	933– 935	196	87
87	7	20-Jul	BT	ra	1.50	086	176 50.70	42 48.76	935– 945	130	40
88	4	25-Jul	BT	ra	1.48	092	177 11.90	42 45.48	1052–1057	137	32
89	4	25-Jul	BT	ra	1.49	091	177 03.06	42 44.69	1112–1112	124	38
90	4	25-Jul	BT	ra	1.51	277	177 02.96	42 45.60	1060–1072	93	48
91	3	25-Jul	BT	ra	1.51	271	177 04.91	42 46.83	1001–1007	76	20
92	3	25-Jul	BT	ra	1.51	280	177 06.89	42 47.59	956– 964	90	24
93	3	25-Jul	BT	ra	1.49	270	177 10.78	42 46.12	1019–1029	84	35
94	3	25-Jul	BT	ra	1.52	268	177 24.47	42 46.98	977– 980	132	96
95	2	25-Jul	BT	ra	1.49	274	177 16.85	42 48.13	913– 914	230	173
96	2	25-Jul	BT	ra	1.51	276	177 18.91	42 48.56	890– 894	139	64
97	2	25-Jul	BT	ra	1.51	273	177 22.10	42 49.19	852– 859	122	50
98	2	25-Jul	BT	ra	1.50	266	177 25.40	42 49.20	854– 856	215	146
99	2	26-Jul	BT	ra	1.49	093	177 28.19	42 48.41	896– 898	138	59
100	2	26-Jul	BT	ra	1.49	095	177 15.35	42 49.44	854– 854	313	211
101	2	26-Jul	BT	ra	1.46	090	177 12.67	42 47.49	953– 957	222	126
102	1	26-Jul	BT	ra	0.51	090	177 10.46	42 50.17	833– 837	19 024	18 991
103	2	26-Jul	BT	ra	1.50	276	177 06.69	42 49.19	885– 890	186	86
104	1	26-Jul	BT	ra	1.51	271	177 14.40	42 50.34	817– 820	130	2
105	2	26-Jul	BT	ra	0.40	277	177 10.21	42 49.03	882– 885	279	218
106	1	26-Jul	BT	ra	1.50	268	177 07.21	42 51.01	802– 810	196	60
107	2	26-Jul	BT	ra	1.51	273	177 04.79	42 49.80	863– 864	4 800	4 719
108	1	26-Jul	BT	ra	0.44	093	177 04.24	42 50.45	833– 834	55	32
109	2	26-Jul	BT	ra	1.51	089	177 02.42	42 48.90	908– 916	124	57
110	2	26-Jul	BT	ra	1.50	272	177 02.16	42 50.25	848– 849	464	379
111	1	27-Jul	BT	ra	0.74	099	177 00.80	42 50.64	835– 837	305	242
112	9	27-Jul	BT	ra	1.50	090	176 52.17	42 44.03	1151–1156	112	22
113	9	27-Jul	BT	ra	1.50	093	176 49.93	42 45.19	1097–1097	146	57
114	9	27-Jul	BT	ra	1.51	088	176 32.50	42 46.29	1097–1107	142	62
115	8	27-Jul	BT	ra	1.51	268	176 40.72	42 47.73	997–1008	167	70
116	8	27-Jul	BT	ra	1.51	264	176 44.17	42 48.48	951– 962	172	100
117	8	27-Jul	BT	ra	1.50	265	176 53.24	42 47.96	960– 972	166	66
118	8	27-Jul	BT	ra	1.50	261	176 58.11	42 46.70	1004–1029	144	90
119	12	27-Jul	BT	ra	1.49	088	176 03.02	42 52.29	945– 949	305	132
120	12	27-Jul	BT	ra	1.49	278	176 07.01	42 54.31	858– 864	144	39
121	12	28-Jul	BT	ra	1.50	267	176 21.80	42 52.22	881– 889	295	174
122	12	28-Jul	BT	ra	1.50	275	176 27.32	42 50.28	939– 945	178	102
123	7	28-Jul	BT	pt	1.50	088	176 34.47	42 52.09	849– 853	170	31
124	7	28-Jul	BT	pt	1.49	101	176 36.97	42 50.18	912– 915	330	243
125	7	28-Jul	BT	pt	1.51	271	176 41.24	42 51.01	870– 871	259	32
126	7	28-Jul	BT	pt	1.51	093	176 38.28	42 50.75	887– 891	860	689
127	26	28-Jul	BT	pt	1.50	270	176 46.22	42 52.22	822– 827	200	5
128	26	28-Jul	BT	pt	1.50	279	176 50.62	42 52.27	803– 809	145	0
129	7	28-Jul	BT	pt	1.50	271	176 48.81	42 49.98	891– 896	523	425
130	26	28-Jul	BT	pt	1.51	268	176 57.38	42 51.08	823– 829	175	32
131	26	28-Jul	BT	pt	1.50	277	176 59.75	42 51.26	815– 816	230	111
132	7	28-Jul	BT	pt	1.50	276	176 59.21	42 48.51	937– 938	147	57
133	4	29-Jul	BT	ra	1.51	096	177 12.34	42 45.44	1056–1059	787	183
134	4	30-Jul	BT	ra	1.49	096	177 03.87	42 44.61	1108–1119	204	53
135	4	30-Jul	BT	ra	1.51	268	177 02.75	42 45.45	1069–1070	208	44
136	3	30-Jul	BT	ra	1.51	268	177 04.61	42 46.68	1006–1009	146	46
137	3	30-Jul	BT	ra	1.51	273	177 06.77	42 47.51	966– 968	70	20
138	3	30-Jul	BT	ra	1.51	272	177 10.78	42 46.22	1021–1022	130	69
139	3	30-Jul	BT	ra	1.51	273	177 24.75	42 47.08	973– 978	180	85
140	2	30-Jul	BT	ra	1.49	093	177 28.22	42 48.43	895– 904	96	43
141	2	30-Jul	BT	ra	1.50	266	177 25.39	42 49.16	853– 857	121	59
142	2	30-Jul	BT	ra	1.50	271	177 22.24	42 49.13	859– 861	167	72
143	2	30-Jul	BT	ra	1.51	273	177 18.88	42 48.48	891– 896	154	48
144	2	30-Jul	BT	ra	1.51	272	177 16.76	42 48.09	913– 916	372	295
145	2	30-Jul	BT	ra	1.50	096	177 15.46	42 49.45	853– 860	332	172

146	2	30-Jul	BT	ra	1.50	092	177 12.66	42 47.46	955– 959	232	116
147	1	31-Jul	BT	ra	0.12	090	177 10.69	42 50.19	831– 831	44 637	44 602
148	1	31-Jul	BT	ra	1.51	090	177 00.68	42 50.45	842– 849	8 439	8 366
149	2	01-Aug	BT	ra	1.49	087	177 02.35	42 48.81	912– 924	255	121
150	2	01-Aug	BT	ra	1.50	268	177 01.96	42 50.20	846– 863	401	329
151	2	01-Aug	BT	ra	1.09	264	177 04.73	42 49.69	861– 876	223	35
152	1	01-Aug	BT	ra	1.52	269	177 14.42	42 50.35	816– 822	595	443
153	2	01-Aug	BT	ra	1.51	281	177 10.21	42 49.04	873– 893	178	78
154	2	01-Aug	BT	ra	0.53	276	177 06.55	42 49.23	877– 885	321	194
155	1	01-Aug	BT	ra	1.50	259	177 03.95	42 50.34	829– 844	35 675	35 587
156	8	02-Aug	BT	ra	1.51	273	176 41.01	42 47.89	994– 997	231	143
157	8	02-Aug	BT	ra	1.50	264	176 44.07	42 48.47	958– 968	447	331
158	8	02-Aug	BT	ra	1.50	264	176 53.61	42 48.08	955– 964	151	72
159	8	02-Aug	BT	ra	1.51	263	176 58.61	42 46.75	1003–1022	214	164
160	26	02-Aug	BT	ra	1.50	088	176 46.99	42 52.28	819– 826	182	1
161	26	02-Aug	BT	ra	1.50	281	176 50.75	42 52.33	802– 807	95	0
162	26	02-Aug	BT	ra	1.25	265	176 57.67	42 51.03	827– 837	12 380	12 363
163	26	02-Aug	BT	ra	0.41	277	176 59.63	42 51.76	797– 799	113	84
164	7	03-Aug	BT	ra	1.49	275	176 59.41	42 48.49	934– 940	489	342
165	7	03-Aug	BT	ra	1.49	091	176 50.74	42 49.95	892– 893	1 460	1 396
166	7	03-Aug	BT	ra	1.50	095	176 43.25	42 50.97	867– 870	5 898	5 810
167	7	03-Aug	BT	ra	0.91	079	176 38.11	42 50.86	879– 885	459	410
168	12	03-Aug	BT	ra	0.39	090	176 02.56	42 52.23	946– 950	87	64
169	12	03-Aug	BT	ra	1.50	277	176 06.91	42 54.24	861– 866	382	156
170	12	03-Aug	BT	ra	1.50	269	176 21.77	42 52.28	882– 889	5 032	4 793
171	12	03-Aug	BT	ra	0.13	261	176 27.44	42 50.26	949–949	48	36
172	7	03-Aug	BT	ra	1.01	268	176 32.54	42 51.98	859–866	233	118
173	12	03-Aug	BT	ra	1.02	272	176 27.43	42 50.28	942–944	273	180
174	7	03-Aug	BT	ra	1.01	274	176 35.67	42 50.20	915–919	454	370
175	9	04-Aug	BT	ra	1.48	099	176 33.15	42 46.03	1101–1108	425	311
176	9	04-Aug	BT	ra	1.50	274	176 50.48	42 44.04	1150–1154	161	53
177	9	04-Aug	BT	ra	1.48	101	176 49.94	42 45.10	1090–1107	289	139
179	8	04-Aug	BT	ex	0.24	088	176 44.25	42 48.47	945–955	3	2
180	7	04-Aug	BT	ex	0.09	264	176 49.04	42 49.98	840–840	0	0
181	7	04-Aug	BT	ex	0.13	279	176 59.47	42 48.45	904–904	0	0
182	2	04-Aug	BT	ex	0.26	266	177 06.40	42 49.18	855–855	0	0
183	26	04-Aug	BT	ex	0.04	270	176 57.12	42 51.14	789–789	0	0
184	26	04-Aug	BT	ex	0.22	283	176 59.98	42 51.74	769–769	0	0

San Waitaki

1	2	10-Jul	BT	pt	1.53	268	177 22.37	42 48.70	871–883	521	445
2	2	10-Jul	BT	pt	1.55	268	177 25.46	42 49.41	835–850	209	128
3	2	10-Jul	BT	pt	1.51	092	177 28.18	42 48.29	900–904	89	40
4	2	11-Jul	BT	pt	1.51	278	177 07.04	42 49.51	870–875	189	168
5	2	11-Jul	BT	pt	1.49	280	177 10.41	42 48.84	892–895	42	17
6	2	11-Jul	BT	pt	1.25	090	177 12.30	42 47.63	940–946	109	62
7	2	11-Jul	BT	pt	1.50	098	177 15.15	42 49.22	860–865	13 666	13 510
8	3	11-Jul	BT	pt	1.53	274	177 04.47	42 46.98	991–996	104	80
9	3	11-Jul	BT	pt	1.54	274	177 06.88	42 47.67	953–956	183	147
10	3	11-Jul	BT	pt	1.50	270	177 11.51	42 46.34	1013–1014	210	178
11	4	11-Jul	BT	pt	1.53	092	177 14.19	42 45.49	1043–1046	113	74
12	4	11-Jul	BT	pt	1.50	085	177 03.79	42 44.59	1111–1120	101	53
13	4	11-Jul	BT	pt	1.50	267	177 04.04	42 45.27	1072–1080	94	66
14	2	12-Jul	BT	pt	1.50	270	177 16.75	42 48.41	898–901	195	108
15	2	12-Jul	BT	pt	1.54	274	177 19.52	42 48.60	888–892	149	75
16	9	12-Jul	BT	pt	1.53	095	176 52.55	42 44.10	1131–1135	92	49
17	9	12-Jul	BT	pt	1.50	095	176 49.89	42 45.33	1084–1088	102	42
18	9	12-Jul	BT	pt	1.46	089	176 32.47	42 46.13	1091–1106	75	23
19	8	12-Jul	BT	pt	1.48	272	176 40.76	42 47.63	1000–1004	279	180
20	8	12-Jul	BT	pt	1.52	271	176 44.51	42 48.60	954–955	109	54
21	8	12-Jul	BT	pt	1.50	270	176 53.79	42 47.97	962–968	57	31
22	8	12-Jul	BT	pt	1.52	262	176 59.02	42 47.04	988–1000	127	76
23	26	13-Jul	BT	pt	1.50	273	176 46.37	42 52.07	823–845	2 889	2 790
24	26	13-Jul	BT	pt	1.50	278	176 50.81	42 52.51	795–798	227	99
25	26	13-Jul	BT	pt	1.48	263	176 57.67	42 51.25	813–823	5 636	5 495
26	26	13-Jul	BT	pt	1.52	268	176 57.61	42 51.02	825–831	105	35
27	30	13-Jul	BT	bt	4.90	043	176 55.65	42 52.57	762–906	8 645	8 296
28	26	13-Jul	BT	tm	1.48	266	176 57.27	42 51.04	817–835	75 318	75 278
29	12	14-Jul	BT	pt	1.53	270	176 27.60	42 50.56	920–930	60	12
30	7	15-Jul	BT	pt	1.52	269	176 32.57	42 51.89	857–863	189	101
31	7	15-Jul	BT	pt	1.53	275	176 35.85	42 50.45	901–905	125	56
32	7	15-Jul	BT	pt	1.51	273	176 41.33	42 50.91	873–874	241	149
33	7	15-Jul	BT	pt	1.50	273	176 59.37	42 48.70	927–928	160	114
34	26	15-Jul	BT	pt	1.52	272	176 59.82	42 51.58	804–805	54	11
35	2	15-Jul	BT	pt	1.50	264	177 02.09	42 49.98	852–866	232	148

36	2	15-Jul	BT	pt	1.51	100	177 02.38	42 48.52	917–928	288	224
37	2	15-Jul	BT	pt	1.53	275	177 04.65	42 50.01	855–856	395	306
38	7	15-Jul	BT	pt	1.51	094	176 50.90	42 50.25	876–878	181	140
39	7	15-Jul	BT	pt	1.51	083	176 38.03	42 51.01	872–885	218	148
40	12	16-Jul	BT	pt	1.56	286	176 21.94	42 52.48	879–881	381	316
41	12	16-Jul	BT	pt	1.49	269	176 07.09	42 54.09	863–865	812	678
42	30	17-Jul	BT	bt	2.69	02	176 53.78	42 52.57	760–898	684	539
43	30	17-Jul	BT	bp	0.09	025	176 53.77	42 49.78	915–920	3 273	3 212
44	30	17-Jul	BT	bp	0.23	024	176 53.90	42 49.97	805–918	372	337
45	30	17-Jul	BT	bt	1.88	104	176 55.65	42 51.71	817–840	723	605
46	30	18-Jul	BT	bt	2.32	035	176 55.49	42 51.56	824–915	610	501
47	2	18-Jul	BT	tm	1.82	019	177 08.68	42 49.87	821–898	33 080	33 043
48	2	18-Jul	BT	tm	1.30	092	177 12.14	42 49.35	858–863	35 073	35 018
49	30	19-Jul	BT	bp	0.31	032	176 53.94	42 50.05	736–920	6 471	4 237
50	30	20-Jul	BT	bp	0.33	320	176 55.03	42 50.23	700–920	19 408	18 790
51	30	20-Jul	BT	bp	0.42	094	176 53.40	42 50.72	766–902	1 647	1 561
52	–	20-Jul	MW	tm	0.81	081	177 14.87	42 49.62	770–782	5	0
53	–	20-Jul	MW	tm	1.42	091	177 13.90	42 49.86	817–828	63	30
54	–	20-Jul	MW	tm	0.89	097	177 14.60	42 49.67	833–840	551	522
55	–	21-Jul	MW	tm	0.41	084	177 13.65	42 50.09	768–795	1 942	1 937
56	–	21-Jul	MW	tm	4.24	081	177 12.03	42 49.96	809–854	79	29
57	–	22-Jul	MW	tm	1.71	090	177 13.30	42 50.05	820–834	5 476	5 392
58	–	22-Jul	MW	tm	1.57	090	177 12.42	42 50.08	825–834	10 219	10 121
59	–	22-Jul	MW	tm	1.92	090	177 12.34	42 50.10	827–837	10 579	10 435
60	–	22-Jul	MW	ac	1.06	100	177 02.23	42 48.45	921–927	17	3
61	–	22-Jul	MW	ac	1.83	273	177 01.91	42 49.82	863–868	163	117
62	–	22-Jul	MW	ac	0.35	263	177 10.18	42 50.38	821–824	17 218	17 162
63	–	23-Jul	MW	ac	2.16	085	177 11.23	42 50.46	770–784	0	0
64	–	23-Jul	MW	tm	0.46	265	177 09.67	42 50.39	823– 827	16 406	16 353
65	–	23-Jul	MW	ac	1.64	113	177 18.43	42 50.06	796– 815	36	5
66	–	23-Jul	MW	tm	0.79	091	177 11.29	42 50.42	810– 822	46 792	46 778
67	–	25-Jul	MW	tm	1.40	083	177 11.60	42 50.31	800– 810	5 816	5 784
68	–	25-Jul	MW	tm	2.28	080	177 11.26	42 50.35	772– 787	67	29
69	–	25-Jul	MW	tm	2.06	094	177 10.55	42 49.83	836– 838	50 749	50 691
70	–	26-Jul	MW	tm	3.95	270	177 06.62	42 49.95	795– 817	56	2
71	–	26-Jul	MW	tm	2.09	087	177 10.79	42 50.03	746– 770	22	0
72	–	26-Jul	MW	tm	1.42	272	177 09.08	42 50.09	808– 814	21 912	21 900
73	–	26-Jul	MW	ac	0.31	084	176 53.77	42 50.58	683– 750	10	1
74	–	26-Jul	MW	ac	0.27	344	176 54.36	42 50.12	689– 780	8	2
75	30	26-Jul	MW	ac	0.12	280	176 55.66	42 52.12	712– 735	14	0
76	–	27-Jul	MW	ac	2.70	090	177 11.72	42 50.07	817– 825	54	0
77	–	27-Jul	MW	tm	2.52	089	177 10.19	42 50.17	738– 768	36	3
78	–	27-Jul	MW	tm	1.03	092	177 10.45	42 50.09	810– 820	12 278	12 232
79	7	28-Jul	BT	pt	1.53	088	176 33.37	42 52.33	837– 845	57	17
80	7	28-Jul	BT	pt	1.65	106	176 36.63	42 49.97	913– 918	195	162
81	7	28-Jul	BT	pt	1.51	267	176 41.01	42 50.61	881– 887	236	134
82	7	28-Jul	BT	pt	1.54	095	176 38.44	42 51.0	878– 882	348	237
83	26	28-Jul	BT	pt	1.50	273	176 46.17	42 52.54	804– 815	210	0
84	26	28-Jul	BT	pt	1.50	280	176 50.63	42 51.99	813– 818	123	2
85	7	28-Jul	BT	pt	1.51	270	176 48.90	42 50.24	879– 886	511	464
86	26	28-Jul	BT	pt	1.54	276	176 56.89	42 50.85	836– 842	153	72
87	26	28-Jul	BT	pt	1.51	280	176 59.93	42 51.58	800– 810	120	19
88	7	28-Jul	BT	pt	1.52	274	176 59.19	42 48.17	944– 947	108	56
89	30	29-Jul	BT	bp	0.22	074	176 53.26	42 50.62	841– 912	7 900	7 845
90	30	29-Jul	BT	bp	0.34	070	176 53.63	42 50.50	710– 937	2 353	2 183
91	30	29-Jul	BT	bt	2.66	049	176 55.57	42 51.31	812– 909	470	373
92	30	29-Jul	BT	bt	1.42	012	176 53.73	42 51.44	804– 863	99	32
93	–	29-Jul	BT	ac	1.51	092	177 06.58	42 52.58	745– 753	109	0
94	–	29-Jul	BT	ac	1.50	088	177 01.55	42 52.88	750– 755	62	0
95	–	30-Jul	BT	tm	0.29	029	177 10.98	42 49.94	813– 822	30 682	30 597
96	–	30-Jul	BT	tm	0.41	104	177 11.18	42 50.08	834– 836	2 095	2 000
97	30	30-Jul	BT	bt	1.70	107	176 55.35	42 51.76	815– 880	810	750
98	30	30-Jul	BT	bp	0.20	312	176 55.07	42 50.27	748– 845	18 069	17 652
99	30	30-Jul	BT	bp	0.24	282	176 54.89	42 50.24	783– 828	14 884	14 548
100	1	01-Aug	BT	tm	0.89	045	177 10.04	42 49.79	822– 850	14 940	14 904
101	1	01-Aug	BT	tm	0.66	055	177 10.06	42 49.74	829– 850	14 956	14 956
102	1	01-Aug	BT	tm	0.28	060	177 11.62	42 49.64	831– 839	6 000	6 000
103	1	02-Aug	BT	cm	0.32	045	177 13.44	42 50.25	793– 810	31 792	31 780
104	1	02-Aug	BT	pt	1.50	100	177 08.89	42 50.61	811– 813	241	156
105	–	02-Aug	BT	cm	0.93	040	177 10.14	42 49.76	825– 859	31 410	31 410
106	–	03-Aug	BT	cm	4.60	269	177 07.51	42 49.99	837– 852	7 611	7 000
107	–	03-Aug	BT	cm	2.09	324	177 09.56	42 50.18	810– 880	13 580	13 518
108	–	03-Aug	BT	cm	2.05	090	177 11.62	42 50.0	829– 835	15 561	15 510
109	–	04-Aug	BT	cm	0.95	095	177 12.82	42 49.38	848– 852	13 764	13 750

Appendix 3: Species caught (includes catches from both vessels as well as commercial stations). Total number of stations, 292

Species	Number of occurrences
Porifera	
Lissodendoryx sp.	1
other sponges	3
Cnidaria	
Echinodermata	
Anthozoa	
sea anemones	9
Araeosoma spp. (Tam-o-shanter urchin)	7
other echinoids (sea urchins)	1
Asteroidea (starfish)	2
Holothuroidea (sea cucumbers)	23
Urochordata	
Pyrosoma atlanticum	5
other salps	11
Crustacea	
Ibacus alticrenatus (prawn killer)	1
Leptomithrax australis (giant masking crab)	1
Lipkius holthuisi (omega prawn)	52
Lithodes murrayi (southern stone crab)	1
Oplophorus novaezeelandiae	5
Pasiphaea spp.	1
P. barnardi	10
Plesiopenaeus edwardsianus (scarlet prawn)	1
Sergestes spp.	3
Cephalopoda	
Cranchiidae (cranchiid squid)	16
Graneledone spp. (deepwater octopus)	9
Histioteuthis spp. (violet squid)	17
Moroteuthis ingens or *M. robsoni* (warty squid)	29
M.ingens (warty squid)	169
M. robsoni (warty squid)	16
squid (unidentified)	4
Todarodes filippovae	18
Chondrichthyes	
Selachiformes	
Apristurus spp. (catsharks)	20
Centrophorus squamosus (leafscaled gulper shark)	15
Centroscymnus coelolepis	14
C. crepidater (longnosed velvet dogfish)	215
C. owstoni (smooth skin dogfish)	80
Deania calcea (shovelnosed spiny dogfish)	208
Etmopterus baxteri (Baxter's lantern dogfish)	215
E. lucifer (Lucifer dogfish)	1
E. pusillus	1
Galeorhinus galeus (school shark)	4
Scymnodon plunketi (Plunket's shark)	14
Scymnorhinus licha (seal shark)	27
Rajiformes	
Bathyraja sp. (bluntnose skate)	1
B. shuntovi (longnosed deepsea skate)	2
Raja innominata (smooth skate)	1
Torpedo fairchildi (electric ray)	3
Chimaeriformes	
Chimaera sp. (purple chimaera)	7
Chimaera sp. (giant chimaera)	5
Harriotta raleighana (longnosed chimaera)	73
Hydrolagus sp. A (black hydrolagus)	1
Hydrolagus sp. B (pale ghost shark)	65
Rhinochimaera pacifica (widenosed chimaera)	75
Osteichthyes	
Notacanthiformes	
Halosaurus pectoralis (common halosaur)	2
Notocanthus sexspinis (spineback eel)	17
Anguilliformes	
Avocettina spp. (black snipe eel)	1
Bassanago bulbiceps (swollenhead conger)	15
B. hirsutus (hairy conger)	5
Diastobranchus capensis (basketwork eel)	131
Serrivomer sp. (sawtooth eel)	2
Salmoniformes	
Alepocephalus sp. (bigscaled brown slickhead)	86
Bathylagus spp. (deepsea smelt)	7
Persparsia kopua (tubeshoulder)	3
Xenodermichthys sp. (black slickhead)	94
Stomiiformes	
Astronesthidae (snaggletooths)	2
Chauliodus sloani (viper fish)	19
Idiacanthus spp.	5
Malacosteidae (loosejaws)	2
Malacosteus niger (loosejaw)	1
Photichthys argenteus (lighthouse fish)	5
Stomias spp.	1
Aulopiformes	
Alepisaurus brevirostris (shorptnouted lancetfish)	2
Paralepididae (barracudinas)	2
Scopelarchus sp.	2
Myctophiformes	
Myctophidae (lanternfishes)	5
Benthosema suborbitale	1
Diaphus spp.	2
Gymnoscopelus spp.	4
Lampadena spp.	3
Lampanyctus spp.	6
Symbolophorus spp.	1
Gadiformes	
Antimora rostrata (violet cod)	6
Caelorinchus acanthiger (spottyfaced rattail)	20
C. bollonsi (Bollons' rattail)	5
C. fasciatus (banded rattail)	50
C. innotabilis (notable rattail)	214
C. kaiyomaru (Kaiyomaru rattail)	2
C. matamua (Mahia rattail)	100
C. mycterismus (upturned snout rattail)	6
Coryphaenoides sp. B (long barbel rattail)	46
C. mcmillani	3
C. murrayi (abyssal rattail)	4
C. serrulatus (serrulate rattail)	205
C. subserrulatus (four-rayed rattail)	203
Halargyreus johnsoni (Johnson's cod)	238
Lepidion microcephalus (smallheaded cod)	35
Lepidorhynchus denticulatus (javelinfish)	148
Lyconus spp.	4
Macrourus carinatus (ridgescaled rattail)	29
Macruronus novaezelandiae (hoki)	253
Melanonus gracilis	1
Merluccius australis (hake)	113
Mesobius antipodum (black javelinfish)	5
Mora moro (ribaldo)	176
Trachyrincus aphyodes (unicorn rattail)	139
Trachyrincus longirostris (white rattail)	4
Ventrifossa nigromaculata (blackspot rattail)	1
Ophidiiformes	
Brotulotaenia crassa (blue cusk eel)	1
Echiodon cryomargarites (messmate fish)	2
Genypterus blacodes (ling)	5
Lophiiformes	
Lynophyrynidae (black anglerfish)	3
Chaunax pictus (pink frogmouth)	1
Gigantactis paxtoni (slender anglerfish)	1
Lampriformes	
Trachipterus jacksonensis (dealfish)	1
T. trachypterus (dealfish)	6
Beryciformes	
Beryx splendens (alfonsino)	18
Diretmus argenteus (discfish)	1
Hoplostethus atlanticus (orange roughy)	278
H. mediterraneus (silver roughy)	1
Melamphaidae (bigscale fishes)	1
Zeiformes	
Allocyttus niger (black oreo)	16
A. verrucosus (warty oreo)	4
Cyttus traversi (lookdown dory)	19

Species	Number of occurrences
Neocyttus rhomboidalis (spiky oreo)	53
Pseudocyttus maculatus (smooth oreo)	
Scorpaeniformes	
Helicolenus sp. (sea perch)	9
Neophrynichthys angustus (pale toadfish)	5
Psychrolutes sp. (blobfish)	1
Trachyscorpia capensis (Cape scorpionfish)	3
Perciformes	
Brama brama (Ray's bream)	9
Centrolophus niger (rudderfish)	3
Chiasmodon niger (black swallower)	2
Cubiceps spp. (cubehead)	1
Epigonus lenimen (bigeyed cardinalfish)	10
E. robustus (robust cardinalfish)	15
E. telescopus (black cardinalfish)	17
Icichthys australis (ragfish)	1
Plagiogeneion rubiginosus (rubyfish)	1
Rosenblattia robusta	1
Schedophilus sp.	3
Tubbia tasmanica	4
Pleuronectiformes	
Neoachiropsetta milfordi (finless flounder)	6

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