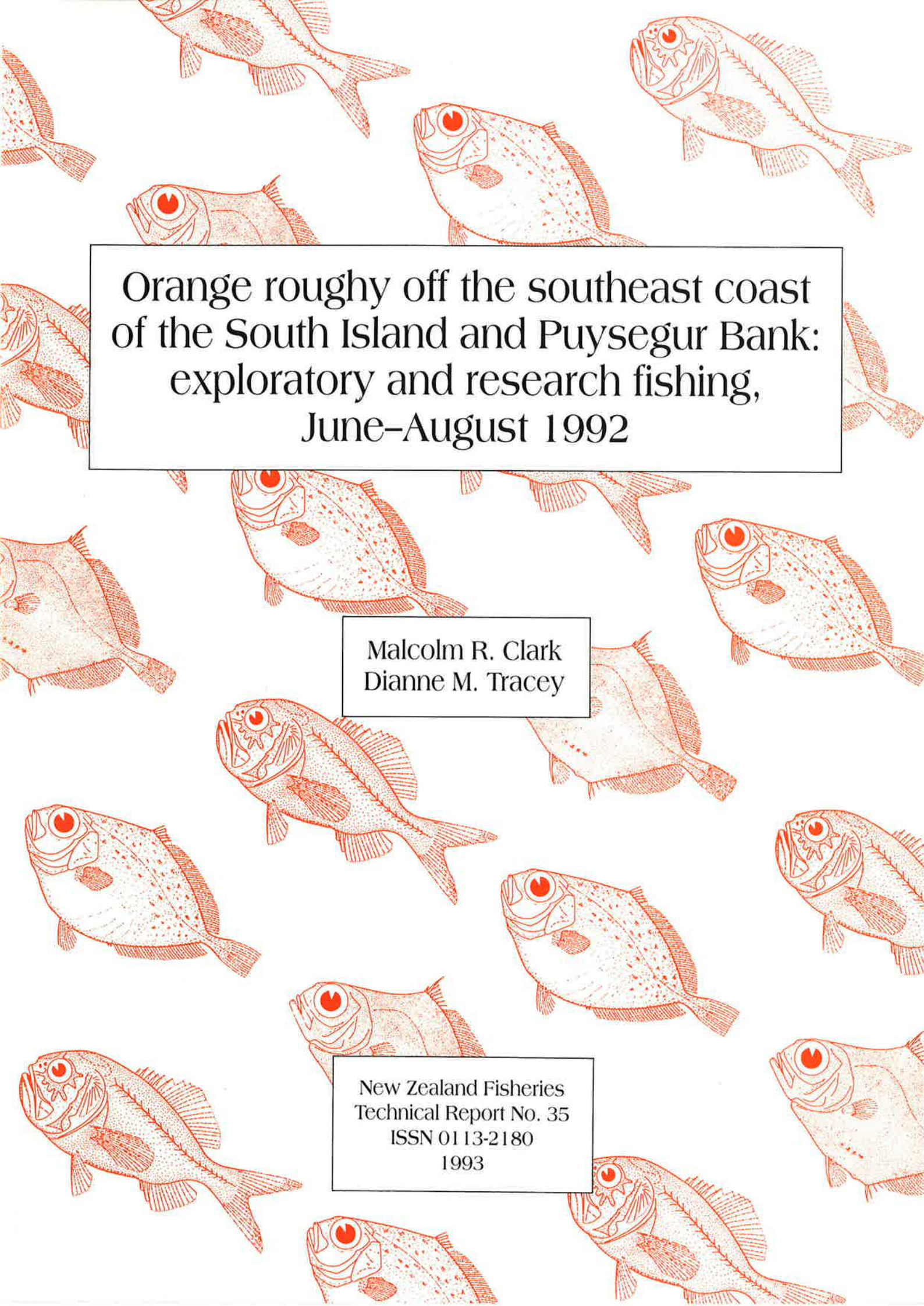

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New Zealand Fisheries
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Abstract

Clark, M. R. & Tracey, D. M. 1993: Orange roughy off the southeast coast of the South Island and Puysegur Bank: exploratory and research fishing, June–August 1992. *N.Z. Fisheries Technical Report No. 35.* 30 p.

Exploratory and research fishing for orange roughy was carried out off the east and south coasts of the South Island in June–August 1992 by FV *Giljanes*. The main objectives were to assess commercial prospects for orange roughy and other deepwater species off the southeast coast of the South Island and around the Bounty Islands, and to conduct a research trawl survey in the Puysegur Bank area.

Exploratory fishing and searching in June extended from the southwestern corner of the Chatham Rise to the Molyneux Sea Valley. Catch rates of orange roughy were low over most of the area, but several large catches were taken at the Waitaki Canyon, and a stratified random trawl survey was subsequently carried out. This survey, in late July, confirmed that spawning aggregations occur, but the distribution of fish was very localised and catch rates were highly variable. There appears to be limited commercial potential for orange roughy.

Catch rates of orange roughy around the Bounty Islands were very low, though several relatively large catches of smooth oreo were taken.

A two-phase stratified random trawl survey was carried out in the Puysegur Bank area. General survey design and area were similar to that of a survey in July 1991. A total of 79 tows gave information on distribution, abundance, and biology of orange roughy, smooth oreo, and black oreo.

Orange roughy were most abundant on the western side of Puysegur Bank, where high catch rates were recorded on several hills and an area of undulating slope in the northwest. The relative biomass index was estimated at 11 500 t (95% confidence interval 4100–18 800 t). Data on size structure, reproduction, and feeding are also presented.

Results are compared with those from the 1991 survey. There were differences in the distribution of orange roughy, smooth oreo, and black oreo; indications that biomasses of orange roughy and black oreo have declined; and differences in length frequency distributions of smooth oreo and black oreo.

Introduction

Commercial fisheries for orange roughy (*Hoplostethus atlanticus*) in Quota Management Area ORH 3B have historically centred on the Chatham Rise. The fishery developed in 1979–80 on the northern slopes of the Rise, where fish form large aggregations for spawning in winter. In recent years an increasing proportion of the quota has been taken outside winter on hills of the southern and eastern slopes of the Rise (Table 1). Stock assessment by MAF Fisheries has shown that the population in the main spawning area on the north Chatham Rise has declined markedly since the fishery developed (*see* Francis *et al.* 1992), and the Total Allowable Catch (TAC) has been reduced in recent years.

In 1991 all ORH 3B quota holders combined to form The Exploratory Fishing Company (ORH 3B) Ltd. The company chartered FV *Will Watch*, which, in a joint programme with MAF Fisheries, undertook an exploratory survey for orange roughy in southern areas of ORH 3B, from Puysegur Bank south down the Macquarie Ridge and western side of the Campbell Plateau. Spawning aggregations of orange roughy were located on Puysegur Bank, and a research trawl survey was carried out (Clark & Tracey 1992). This survey produced extensive data on the distribution, abundance, and biology of orange roughy (and the main bycatch species of black oreo (*Allocyttus niger*) and smooth oreo (*Pseudocyttus maculatus*)). However, because it was

the first survey in a new area, there were no estimates of absolute biomass for use in stock assessment.

In 1991 the Minister of Fisheries maintained the TAC of orange roughy in ORH 3B for 1991–92 at its previous level of 23 787 t, with agreement from the fishing industry to several conditions:

1. to take at least 5000 t of the TAC from the southern area of ORH 3B;
2. to reduce catches from the north Chatham Rise "spawning box";
3. to carry out another research survey in 1992 to further study the orange roughy stocks in the Puysegur Bank area and search for other stocks in the southern areas of ORH 3B.

As a result of the third condition, The Exploratory Fishing Company (ORH 3B) Ltd. chartered FV *Giljanes* for 8 weeks during June–August 1992 to repeat the Puysegur Bank survey and undertake further exploratory fishing. The southeast coast of the South Island was identified as the main area for exploration. Bathymetry in this region is dominated by a series of canyons between the Chatham Rise and northern slopes of the Pukaki Rise. Substantial catches of orange roughy were taken in part of this area near the Waitaki Canyon in late 1991 and early 1992 (Table 2). The voyage was planned and carried out as a cooperative venture between the company and MAF Fisheries.

Objectives

There were seven objectives defined in the cruise programme:

1. to survey parts of the ORH 3B Quota Management Area for commercial prospects for orange roughy fishing;
2. to carry out exploratory trawl fishing to define the distribution and to measure catch rates of orange roughy and bycatch species;
3. to map the distribution and abundance of orange roughy aggregations, and to assess the relative biomass on new grounds where appropriate;
4. to map the distribution and measure the relative biomass of the orange roughy spawning population in the Puysegur Bank area to enable comparison with the biomass estimate from the 1991 Puysegur survey;
5. to measure size structure and reproductive status of orange roughy for determination of pre-recruit/recruited biomass and the development and timing of spawning;
6. to update and map the fisheries bathymetry in these areas;
7. to identify and assess bycatch species;

This report describes the methods and results of four phases of the cruise:

1. exploratory fishing off the east coast of the South Island;
2. research trawl survey of Puysegur Bank;
3. research trawl survey of the Waitaki Canyon;
4. exploratory fishing around the Bounty Islands.

Table 2: Reported monthly catches of orange roughy from the Waitaki Canyon area in 1991–92

	Catch (t)
1991	
Oct	6
Nov	136
Dec	138
1992	
Jan	80
Feb	0
Mar	13
Apr	51
May	4
Jun	1

Table 1: Catches (t)* of orange roughy by area and percent of total ORH 3B catch for 1978–79 to 1990–91 (*modified from* Francis *et al.* 1992)

	Northwest		South		Spawning box		Northeast		Puysegur	
Season	Catch	%	Catch	%	Catch	%	Catch	%	Catch	%
1978–79	0	0	0	0	11 500	98	300	2	0	0
1979–80	1 200	4	800	3	27 900	90	1 200	4	0	0
1980–81	8 400	30	3 700	13	16 000	57	100	0	0	0
1981–82	7 000	28	500	2	16 600	67	800	3	0	0
1982–83	5 400	35	4 800	31	4 600	30	600	4	0	0
1983–84	3 300	13	5 100	21	15 000	61	1 500	6	0	0
1984–85	1 800	6	7 900	27	18 400	63	1 100	4	0	0
1985–86	3 700	12	5 300	18	17 000	56	4 100	13	0	0
1986–87	3 200	10	4 900	16	20 200	66	2 400	8	0	0
1987–88	1 600	7	6 800	28	13 500	56	2 300	10	0	0
1988–89	3 800	12	9 200	28	16 700	51	3 100	9	0	0
1989–90	3 300	11	11 100	35	16 100	51	1 000	3	100	0
1990–91	1 500	7	7 000	33	6 200	29	6 100	28	600	3

* To the nearest 100 t.

Methods

Vessel and gear

Giljanes is a New Zealand factory trawler owned by South Island Deepwater Fisheries Ltd. and based in Timaru. It has the following specifications: overall length, 86.9 m; beam, 13.6 m; depth, 5.9 m; gross registered tonnage, 1594 t; horsepower, 4250 (3130 kW).

The set-up of the trawl gear and the net used were fairly standard for rough bottom orange roughy fishing and, where possible, kept identical to that of *Will Watch* in 1991 (*see* Clark & Tracey 1992): doors, high-aspect Super Vee, 7 m^2, 1800 kg; sweep length, 45 m; bridle length, 45 m; net type, 6 panel bottom trawl, with cutaway lower wings; layback, 0; headline length 36 m; groundrope length, 22.4 m; headline floats 20 x 360 mm (about 300 kg buoyancy) rated to 1500 m; bobbin rig, 3 x 6 m sections, 18 x steel 440 mm; two lengtheners, 3 codend sections, codend mesh 100 mm.

Gear spread parameters, based on flume tank trials, are estimated at 20 m for wingend spread and 75 m for doorspread (J. Greening, Sealord Products Ltd. pers. comm.). Average headline height was about 7 m at trawling speeds of 2.5–3.5 kn.

Exploratory fishing

Exploratory fishing and searching covered depths of 800–1200 m off the east coast of the South Island from the southwestern corner of the Chatham Rise south to the Molyneux Sea Valley, as well as some of the Bounty Platform (Figure 1). Effort focused initially on areas where orange roughy had been caught previously (especially the Waitaki Canyon), and then on chartered features such as canyons, hills, and banks. Much of the searching relied on detecting promising marks or features on the colour echosounder, and trawls were carried out in likely areas of fish abundance, or where marks were seen. Parallel transects about 1 n. mile apart were often followed to enable detailed charting of the bathymetry and to search for fish concentrations. Detailed charts were compiled on board using "SEAPLOT" navigational software and the "HYDRO" computer contouring package.

Waitaki Canyon research survey

Survey area

The survey area covered the region around the Waitaki Canyon: a boot-shaped ridge feature on the outside, the canyon itself, and areas of slope to the north and south bounded by 45° 10.0° S and 45° 30.0° S respectively (Figure 2). Depths fished were 800–1200 m, and the total area was about 645 km^2.

Survey design

A two-phase stratified random survey design was applied (*after* Francis 1984). The survey area was divided into six strata on the basis of catches and bathymetry recorded during exploratory fishing.

Within each stratum, random station positions were generated by computer to define the gear position at the start of the tow. Several methods of specifying tow position and direction were used, depending on the bottom characteristics of the strata:

1. random latitude and longitude, tow direction parallel to depth contour (strata 4, 5, 6);
2. random latitude, random direction off the top of the ridge (stratum 2);
3. random longitude, random direction off the top of the ridge (stratum 1);
4. random latitude and longitude, random direction as a guide to tow directly down steep slope (stratum 3).

The number of stations allocated per stratum in the first phase was based on experience during the exploratory phase, constrained by the total number thought possible in 5 days. There was a minimum of three stations per stratum.

Trawling details

The vessel operated continuously, trawling both day and night. A standard trawl length of 1.5 n. miles was used wherever possible. Towing speed was kept at about 3.0 kn over the ground (determined from GPS position).

Treatment of catch

The catch at each station was sorted into species and weighed on motion-compensating electronic scales to the nearest 0.1 kg. When the large size of a catch made it impractical to weigh, total weights of orange roughy, black oreo, and smooth oreo were backcalculated from processed weight by use of conversion factors and block weights measured on board. Average conversion factor values of processed weight to greenweight were: orange roughy, 2.20; black oreo, 2.40; smooth oreo, 2.20.

Samples of orange roughy, black oreo, and smooth oreo were taken for more detailed study. Samples of 100–200 fish of each species were

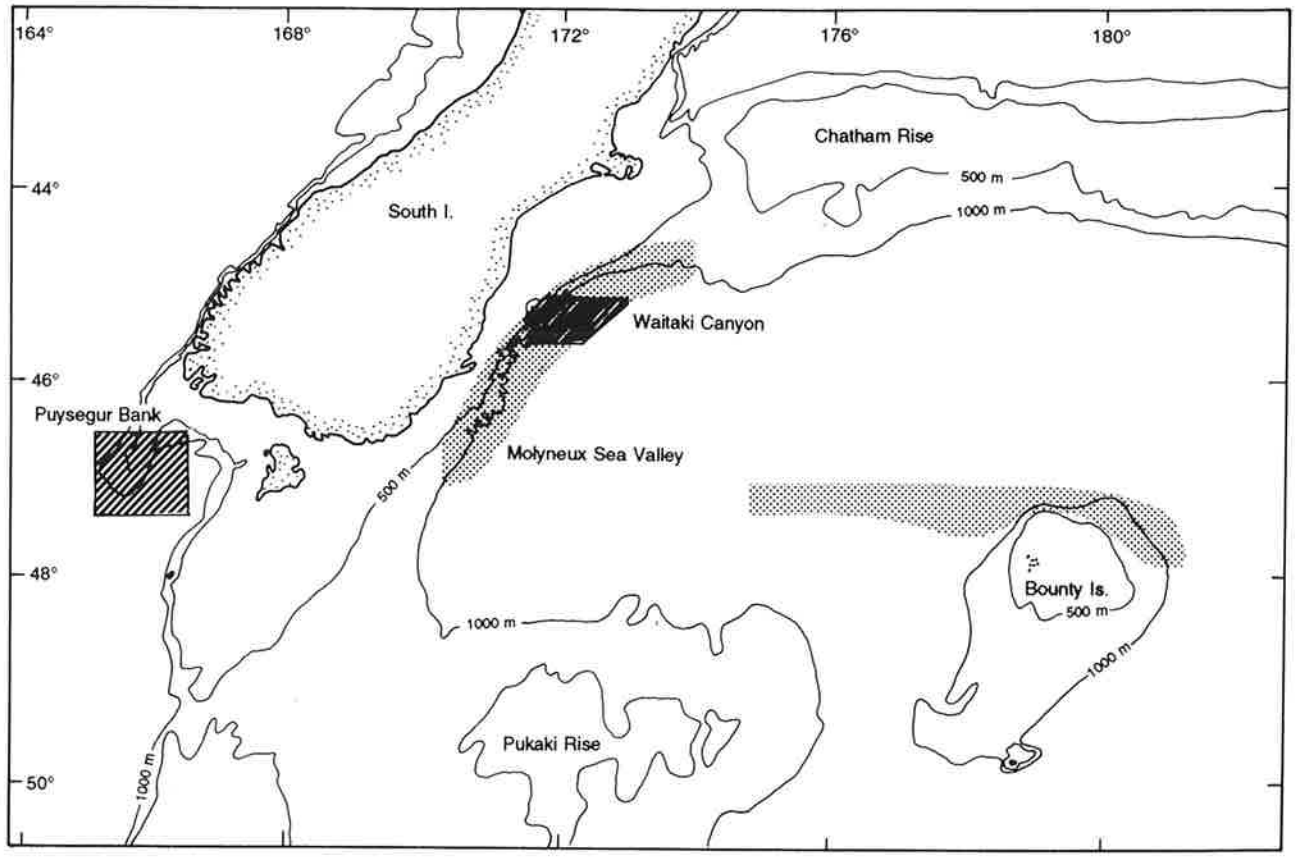

Figure 1: The survey area showing the location of exploratory fishing phases (stippled) and the areas covered in more detail by research trawl surveys (striped).

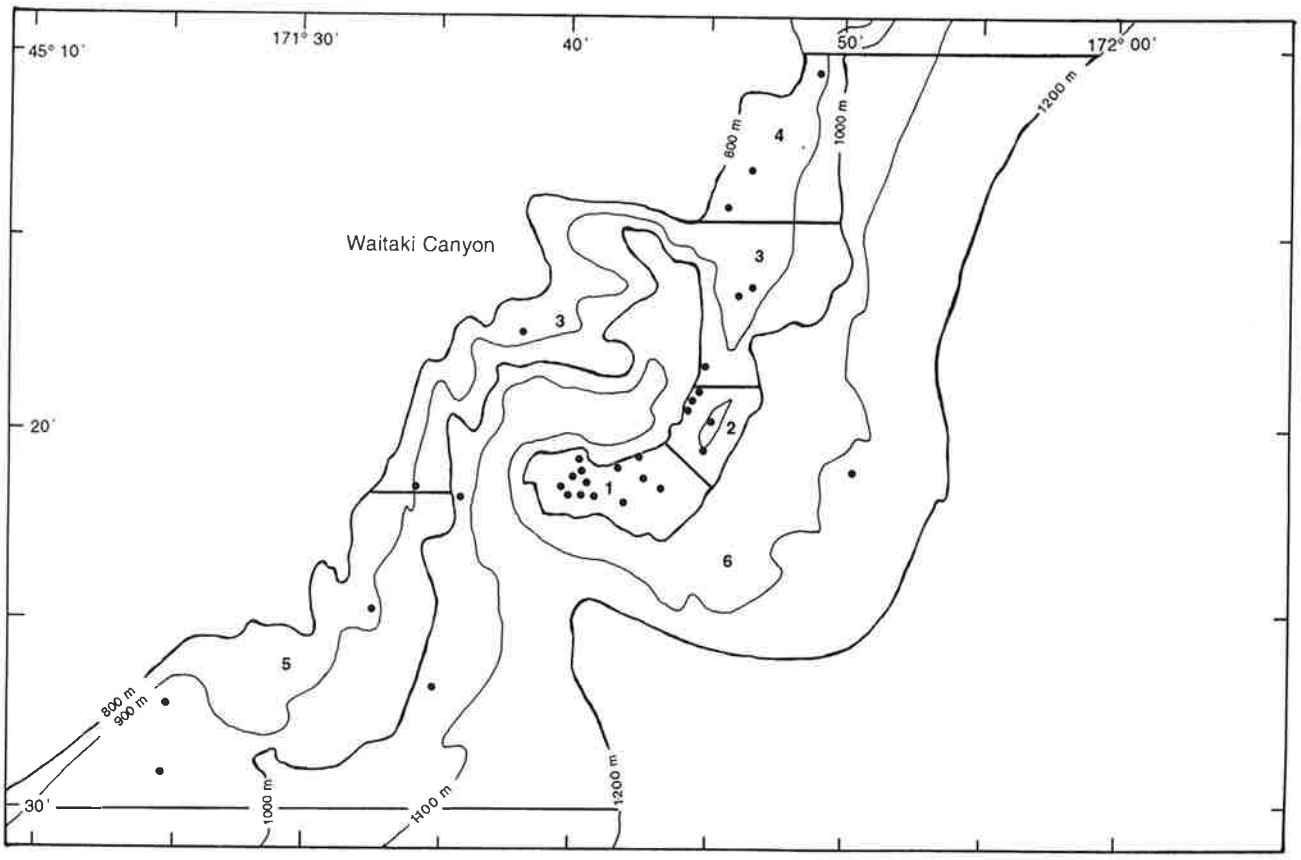

Figure 2: The Waitaki Canyon research survey area showing strata boundaries and trawl positions (*see* Table 6 for stratum area).

routinely measured and sexed. If a catch was large, several samples were taken from different parts of the net and combined. This makes the total sample more representative than a single one because sex ratios and size can vary in different parts of the catch (Clark & Tracey 1989).

From the sample at each tow 10–20 additional fish of each species were taken at random and examined in greater detail: length, weight, sex, gonad weight, gonad stage, stomach fullness, degree of digestion of stomach contents, and prey items were recorded. Otoliths were collected for ageing, and samples of ripe gonads were collected for genetic studies.

Biomass index estimation

Biomass indices were calculated by use of the area swept method as described by Francis (1981). Biomass, and its standard error, were calculated from the following formulae:

$$B = \sum (X_i a_i)/cb$$

$$S_B = \sqrt{\sum S_i^2 a_i^2 / c^2 b^2}$$

where B is biomass (t), X_i is the mean catch rate (kg.km^{-1}) in stratum i, a_i is the area of stratum i (km^2), b is the width swept by the gear (doorspread, m), c is the catchability coefficient (an estimate of the proportion of fish available to be caught by the net), S_B is the standard error of the biomass, S_i is the standard error of X_i.

Approximate 95% confidence limits (CL) were calculated as:

$$CL = B \pm 2S_B$$

The coefficient of variation is a measure of the precision of the biomass estimate, and is calculated by:

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

The catchability coefficient, c, is the product of vulnerability, vertical availability, and areal availability, as defined by Francis (1989). In the absence of information on the effect of trawl gear on orange roughy schools, the effective width of the gear was taken to be the wingend spread; thus, the vulnerability was set equal to the wingend spread divided by the doorspread (0.27). Vertical availability was assigned the value of 1.0, because no fish marks were observed above the headline of the net throughout the survey. Areal availability was taken as 1.0, because the estimated biomass was intended to apply only to the area surveyed.

Biological analyses

1. Length frequency distribution

Length frequency data have been scaled by percentage sampled to represent each catch, and then further scaled by stratum biomass to represent the total population size distribution.

2. Reproductive stages

Gonad stages follow Pankhurst *et al.* (1987):

Stage	Female	Male
1	Immature/regressed	Immature/regressed
2	Early maturation	Early maturation
3	Maturation	Maturation
4	Ripe	Ripe
5	Running ripe	Spent
6	Spent	–

A gonadosomatic index (GSI) was calculated for each gonad stage and for all mature fish (involved in spawning this year):

GSI = gonad weight x 100 / body weight (inclusive of gonads)

3. Feeding analyses

Data on frequency of occurrence and volume of prey have been combined into a single index (IV) to assess relative importance (Vesin *et al.* 1981).

$$IV = \sqrt{(\%\ \text{frequency})(\%\ \text{volume})}$$

where frequency = the number of stomachs in which a food item occurs, expressed as a proportion of the total number of stomachs containing food; and volume = the proportion for a food type of the total volume of stomach contents (relative volume was estimated by eye, each stomach assigned a value of 100%).

Puysegur Bank research survey

Methodology for the Puysegur Bank survey was essentially the same as that described above.

Survey area

The survey area covered the southern Puysegur Bank, from 46° 45.0° S to 47° 25.0° S, and between 165° 20.0° E and 166° 15.0° E. A hill complex 10 n. miles south of the Bank was included (Figure 3). This was the same area as that surveyed in 1991 (Clark & Tracey 1992), except that the 1991 survey included a hill further south. Depths from 800 m (750 m on some hills) to 1200 m were fished, and the total survey area was about 830 km^2.

Survey design

The survey followed two-phase stratified random methodology (*after* Francis 1984). The survey area was divided into 15 strata on the basis of the 1991 survey results, distribution of commercial catches in 1991–92, and bathymetry. Most strata boundaries were unchanged, but the 1991 stratum 3 (West

Puysegur Bank slope 1000–1200 m) was subdivided into three separate strata, and stratum 5 (West Puysegur, 3 hills) was divided into two.

Within each stratum, random station positions were generated by computer to define the gear position at the start of the tow. Several methods of specifying tow position and direction were used, depending on the bottom characteristics of the strata:

1. random latitude and longitude, tow direction parallel to depth contours (strata 1, 2, 31, 32, 7, 8, 9);
2. random tow direction from the top of the hill (strata 4 (2 peaks), 51, 52, 6, 11, 12);
3. random latitude, tow directly down slope (stratum 10);
4. random latitude or longitude, random direction as a guide to general tow direction down steep or undulating slope (stratum 33, part of 52).

The number of stations initially allocated per stratum was based on examination of 1991 results. It differed substantially from 1991 in an attempt to minimise the duration of the survey, yet improve the precision of the biomass estimate. A minimum of three tows per stratum was planned.

The technique applied in this survey differed from the standard design for surveys on flat bottom sea bed. The survey area contained several hills, each of which was treated as a separate stratum. The limits of each hill were determined from the depth contour at which the hill flattened out into the surrounding slope. In contrast to the use of random positions on flat bottom, direction of tow was the main random element on the hills. In addition, because fish distribution often varies between sides of a hill, and because fish may be hard down or off the bottom at various times of the day, hill strata were fished on several occasions throughout the survey. Therefore, fishing was spread out over several days and over a range of times during the day. This meant that the design had a temporal and geographic mixture of trawls in an attempt to represent average fish distribution and abundance.

Results

Trip schedule

The vessel sailed from Timaru on 18 June and began fishing around the Waitaki Canyon on 19 June. Four days were spent fishing and searching around the Waitaki Canyon. The vessel then proceeded south, covering Moeraki, Karitane, Taiaroa, Saunders, Hoopers, and Taieri Canyons to the Molyneux Sea Valley, before returning to the Waitaki Canyon area on 29 June. Fishing continued around the Waitaki Canyon and on the southwest Chatham Rise until 4 July, when the vessel steamed for Puysegur Bank.

Three days were spent with engine problems in Foveaux Strait, and the research survey of Puysegur Bank began on 9 July. The survey continued until 25 July. A further research survey was carried out in the Waitaki Canyon area during 27–31 July. The vessel undertook further exploratory fishing around the Bounty Islands during 2–8 August and returned to Timaru via the Waitaki Canyon on 10 August.

Exploratory fishing

East coast South Island

Exploratory fishing during the first 2 weeks covered a wide area from the southwestern corner of the Chatham Rise to the Molyneux Sea Valley (Figure 4). Detailed station and summarised catch data from the 54 trawls are given in Appendix 1. The catch of fish, shark, squid, and crustacean species combined was 137 330 kg. The main species caught were smooth oreo (76 579 kg, 56% of total catch), black oreo (31 002 kg, 23%), and orange roughy (21 823 kg, 16%). All species caught are listed in Appendix 2. Catch weights of the 10 most abundant species are given in Table 3.

Catch rates of orange roughy were low (< 100 kg.km^{-1}) throughout most of the area explored. However, two tows on the outside of the Waitaki Canyon had catch rates of

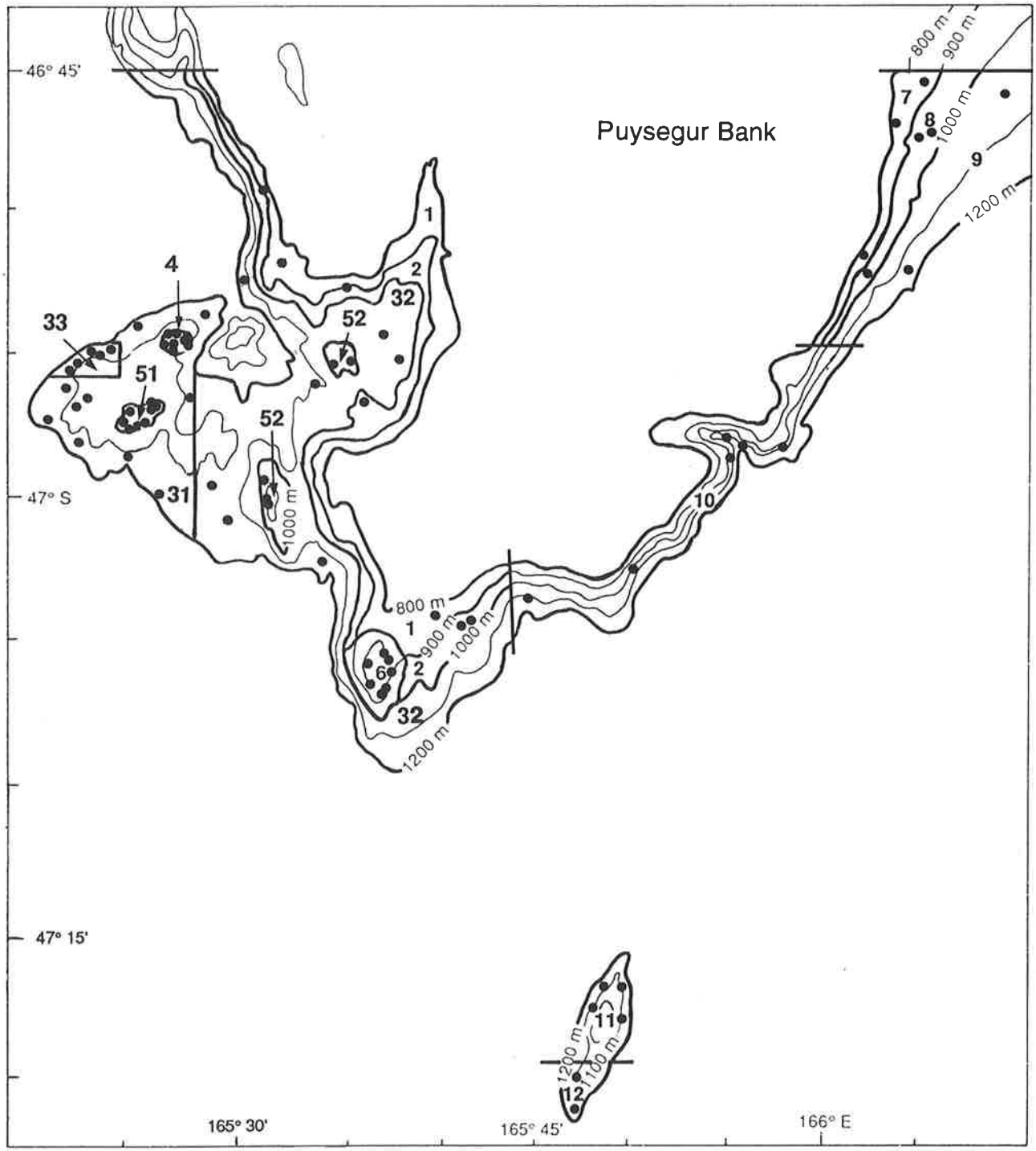

Figure 3: The Puysegur Bank research survey area showing strata boundaries and trawl station positions (*see* Table 13 for stratum area).

10 000–12 000 kg.km^{-1}, and this area was the focus of the research survey carried out later.

Catch rates of smooth oreo were generally higher than for orange roughy, and were frequently 2000–5000 kg.km^{-1} around Waitaki and Moeraki Canyons. Highest catch rates (10 000–12 000 kg.km^{-1}) occurred in the same tows as the high catch rates of orange roughy.

Catch rates of black oreo were relatively low in areas away from the Waitaki Canyon. Around the Waitaki Canyon catch rates were often 1000–2000 kg.km^{-1}, with a maximum of 11 000 kg.km^{-1}.

The Bounty Islands

The final week of the voyage was spent searching and fishing around the Bounty Islands. Fourteen trawls were carried out (Figure 5). The total catch of all species was 27 015 kg. Smooth oreo was the main species caught (26 377 kg), constituting 98% of the catch (Table 3). Few black oreo and orange roughy were caught.

Catch rates at most stations were low, though two tows due north of the Bounty Islands recorded relatively high catch rates of smooth oreo (2000 and 9600 kg.km^{-1}).

Waitaki Canyon research survey

Thirty-two tows were successfully completed during the trawl survey. Phase I comprised 29 tows, with an additional 3 Phase II tows allocated to stratum 1.

Catch composition

Sixty-four species of fish, shark, skate, squid, and crustacean were caught, with a total weight of 120 904 kg. Orange roughy (65 814 kg) constituted 54% of this; the other major species being smooth oreo (35%) and black oreo (7%) (Table 4).

Distribution and catch rates

Orange roughy occurred in most tows around the canyon, but catch rates were high in only two tows in stratum 1 (34 500 kg.km^{-1}, 5000 kg.km^{-1}) (Figure 6). Catches were small at all other stations.

Smooth oreo were more widely distributed on the outside of the canyon. Catch rates over 1000 kg.km^{-1} were frequently recorded, with a maximum of 10 100 kg.km^{-1} (Figure 7).

Black oreo were also caught in most trawls. Catch rates were often over 100 kg.km^{-1}, but exceeded 1000 kg.km^{-1} in only one trawl in stratum 1 (1150 kg.km^{-1}) (Figure 8).

Biomass indices

The relative biomass of orange roughy was estimated at about 9300 t, but with a high 95% confidence interval ranging from 0 to 25 000 t (Table 5). Recruited fish (≥ 32 cm) accounted for 95% of the total biomass. The biomass of orange roughy was concentrated in stratum 1, which contributed 98% of the total (Table 6).

Biomass index estimates for smooth oreo and black oreo were 9100 t and 2350 t respectively. Smooth oreo biomass was predominantly in stratum 1 (53%) and stratum 3 (39%). Stratum 3 accounted for 47% of black oreo biomass, but in general biomass was more evenly distributed between strata than with orange roughy or smooth oreo.

Size structure

The weighted length frequency distribution of orange roughy is given in Figure 9. Fish ranged in size from 11 cm to 45 cm. There was a strong unimodal distribution, with the peak at 35–37 cm. There was a relatively high proportion of orange roughy between 38 cm and 40 cm. The mean length of males was 35.0 cm (*s.d.* = 3.6) and of females was 37.0 cm (*s.d.* = 5.5). The sex ratio was uneven, with males accounting for 64% of fish sampled and females 36% (though most samples came from only two tows).

Table 3: Total catch and percent composition by weight of the 10 most abundant species caught during exploratory fishing on the east coast of the South Island, and the main species near the Bounty Islands

Species*	Catch (kg)	% of total
East coast South Island		
Smooth oreo	76 579	55.8
Black oreo	31 002	22.6
Orange roughy	21 823	15.9
Baxter's lantern dogfish	4 686	3.4
Widenosed chimaera	422	0.4
Hoki	361	0.3
Smallscaled brown slickhead	343	0.3
Fourrayed rattail	338	0.3
Ridgescaled rattail	286	0.2
Pale ghost shark	242	0.2
All species	137 330	
Bounty Islands		
Smooth oreo	26 377	97.6
Rattails (all species)	475	1.7
Black oreo	65	0.2
Orange roughy	15	< 0.1
Warty squid	8	< 0.1
All species	27 015	

* Scientific names are given in Appendix 2.

Table 4: Total catch and percent composition by weight of the 10 most abundant species taken during the Waitaki Canyon research survey

Species	Catch (kg)	% of total
Orange roughy	65 814	54.4
Smooth oreo	42 815	35.4
Black oreo	8 735	7.2
Baxter's lantern dogfish	1 882	1.5
Longnosed velvet dogfish	246	0.2
Purple chimaera	200	0.2
Pale ghost shark	155	0.1
Basket eel	140	0.1
Hoki	124	0.1
Ridgescaled rattail	105	0.1
All species	120 904	

* Scientific names are given in Appendix 2.

Table 5: Biomass of orange roughy, smooth oreo, and black oreo in the Waitaki Canyon survey area

Species	Biomass (t)	95% range	*c.v.* (%)
Orange roughy			
All fish	9 276	0–25 153	85
1–30 cm	458	0–1 062	66
30–50 cm	8 813	0–24 100	86
Smooth oreo			
All fish	9 104	1 312–16 896	43
Black oreo			
All fish	2 348	644–4 053	46

Table 6: Catch rates and biomass of orange roughy (all fish) by stratum in the Waitaki Canyon survey area

Stratum	Area (km^2)	No. of tows	Mean catch rate (kg.km^{-1})	*s.d.*	Biomass (t)	Biomass (%)
1	60.0	13	3 038.0	9 540.6	9114	98.2
2	21.0	5	0.2	0.3	< 1	< 0.1
3	121.0	5	8.4	10.0	51	0.5
4	42.0	3	1.2	1.4	3	< 0.1
5	148.0	3	14.1	14.7	104	1.1
6	253.0	3	0.3	0.6	4	< 0.1

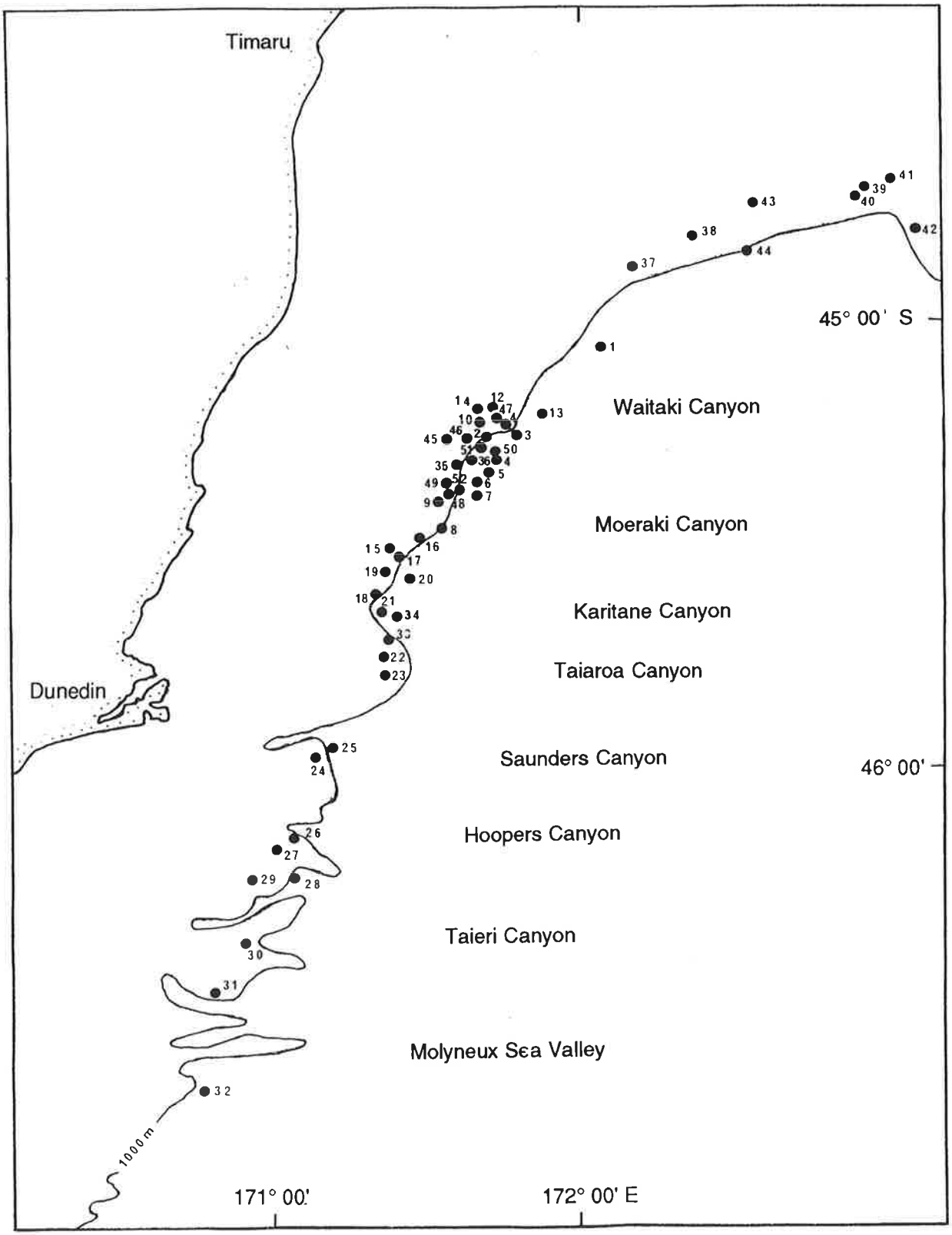

Figure 4: Trawl station positions during exploratory fishing off the east coast of the South Island.

Smooth oreo ranged in size from 15 cm to 47 cm total length (Figure 10). They had a bimodal distribution, with peaks at 24–26 cm and at 33–37 cm. The sex ratio was about even (male 53%, female 47%).

The length frequency distribution of black oreo was unimodal, with a peak at 25 cm, but was skewed (Figure 11). Fish size ranged from 21 cm to 49 cm total length. The sex ratio was about even (male 55%, female 45%).

Length-weight regression equations for orange roughy, smooth oreo, and black oreo are given in Table 7.

Reproduction

Most mature fish caught near the Waitaki Canyon during exploratory fishing in June were maturing (males and females combined 80%) (Table 8). Gonad stages had advanced by the time of the research survey, when most mature fish were ripe (45%) or spent (23%). This confirms that orange roughy spawn in the area in July.

Gonadosomatic index (*GSI*) values by gonad stage for females are given in Table 9. Values show an increase in relative gonad weight from early maturation (stage 2) through to ripe to running ripe (stages 4–5), before dropping after spawning (stage 6). The mean *GSI* of all fish in the 1992 spawning (stages 3–6) was similar for both exploratory and research phases. However, the overall values represent a different gonad stage balance between the two phases: dominance of maturing fish at first, and a mixture of ripe or running ripe and spent fish in the later phase.

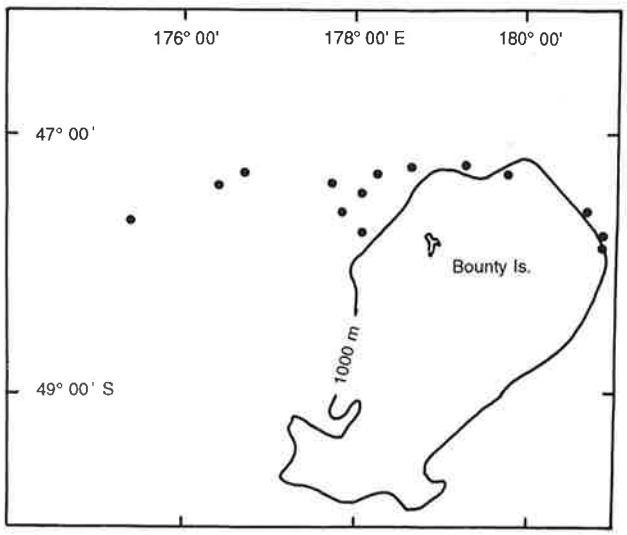

Figure 5: Trawl station positions during exploratory fishing around the Bounty Islands.

Table 7: Length-weight regression equations* for orange roughy, smooth oreo, and black oreo by sex for the Waitaki Canyon survey area

Species	Sex	Regression	*n*	r^2
Orange roughy	Both	$W = 3.8 \times 10^{-2} L^{2.98}$	569	0.98
	M	$W = 4.3 \times 10^{-2} L^{2.93}$	350	0.98
	F	$W = 3.4 \times 10^{-2} L^{3.03}$	219	0.98
Black oreo	Both	$W = 1.7 \times 10^{-2} L^{3.04}$	190	0.94
	M	$W = 2.7 \times 10^{-2} L^{2.91}$	107	0.94
	F	$W = 1.1 \times 10^{-2} L^{3.19}$	83	0.94
Smooth oreo	Both	$W = 1.3 \times 10^{-2} L^{3.14}$	230	0.96
	M	$W = 1.4 \times 10^{-2} L^{3.12}$	116	0.95
	F	$W = 1.3 \times 10^{-2} L^{3.13}$	114	0.97

* L = cm; W = g; n = sample size; r^2 = regression coefficient.

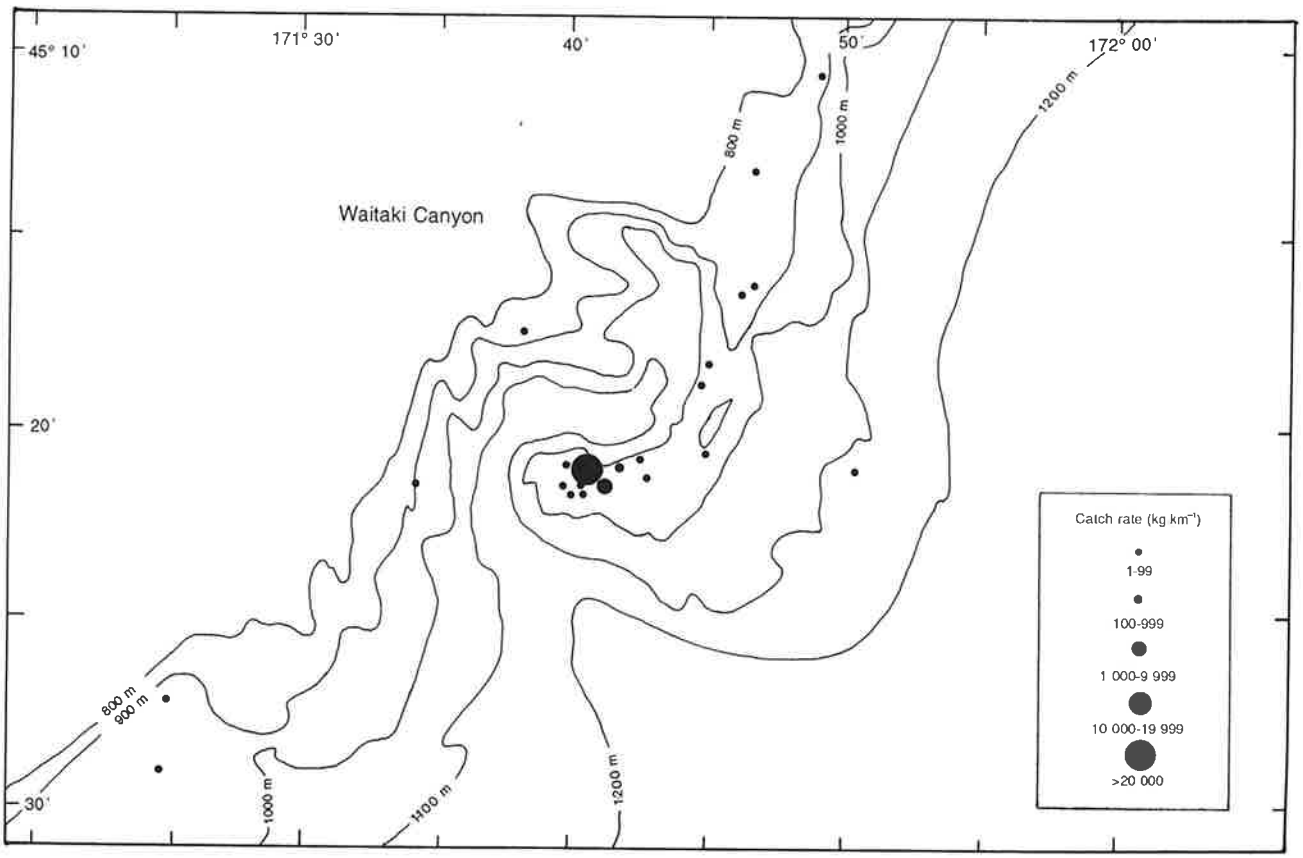

Figure 6: Catch rates (kg.km^{-1}) of orange roughy in research survey tows around the Waitaki Canyon.

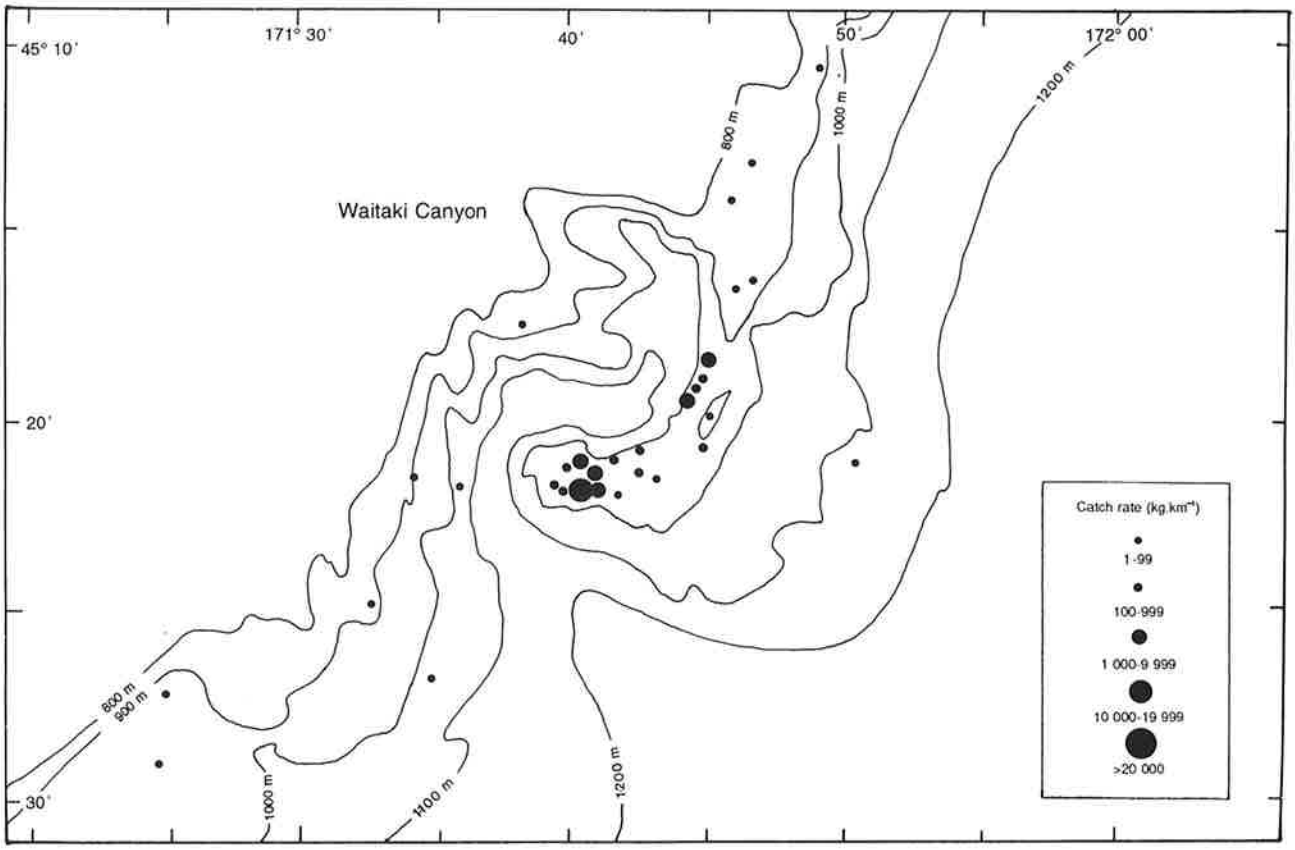

Figure 7: Catch rates (kg.km^{-1}) of smooth oreo in research survey tows around the Waitaki Canyon.

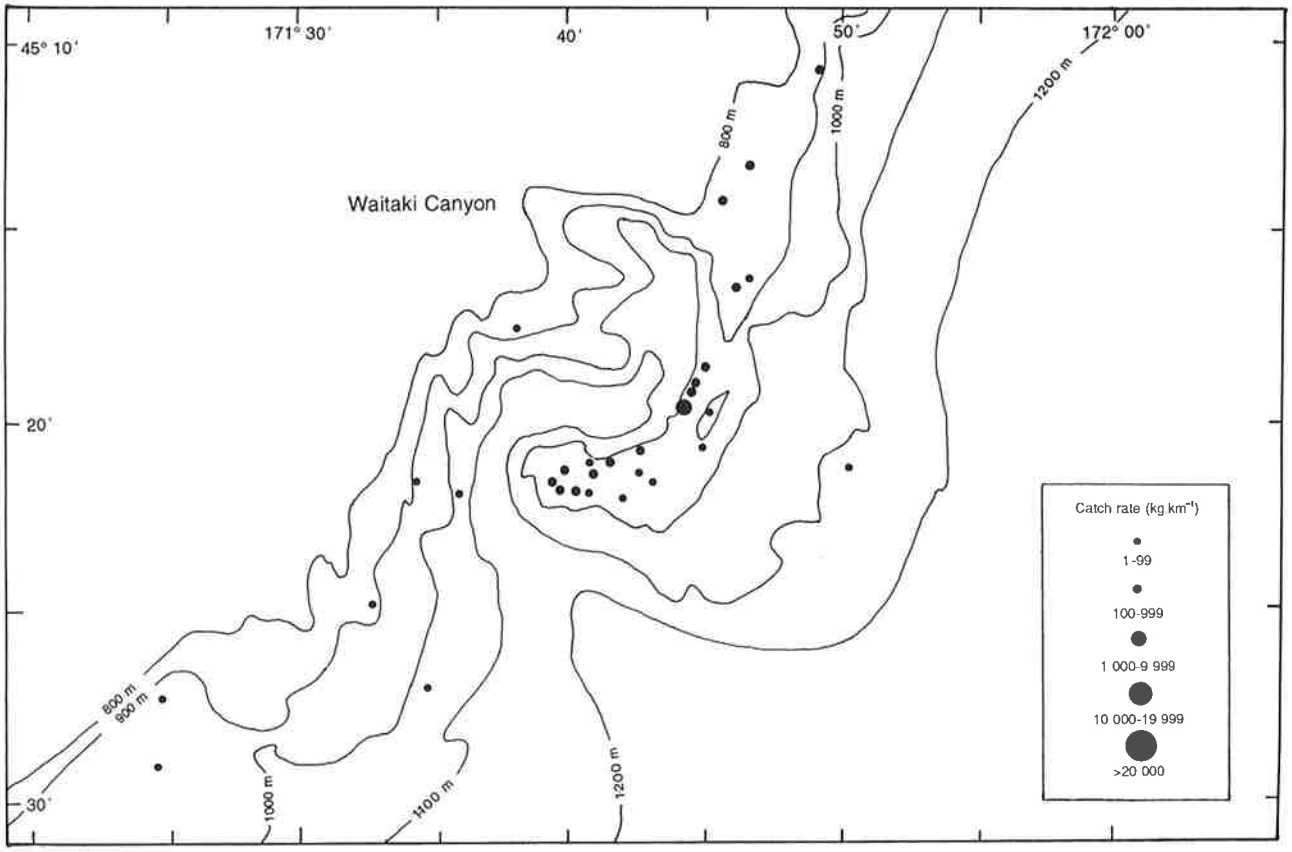

Figure 8: Catch rates (kg.km^{-1}) of black oreo in research survey tows around the Waitaki Canyon.

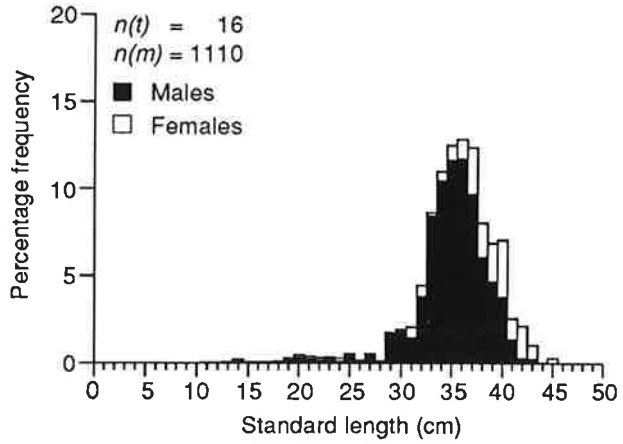

Figure 9: Length frequency distribution of orange roughy from the Waitaki Canyon survey area (scaled to represent the total population, *n(t)* = number of trawls with samples, *n(m)* = number of fish measured).

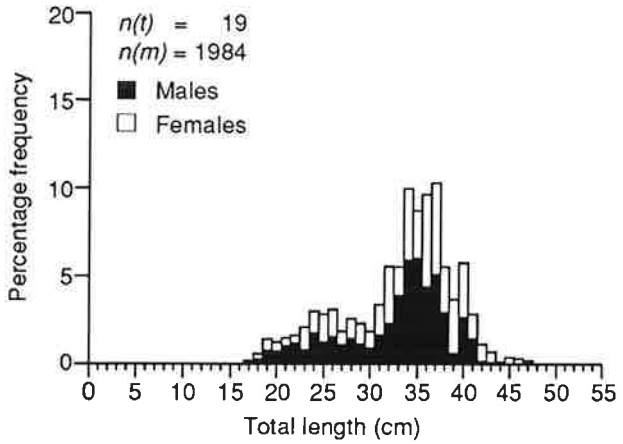

Figure 10: Length frequency distribution of smooth oreo from the Waitaki Canyon survey area (scaled to represent the total population, *n(t)* = number of trawls with samples, *n(m)* = number of fish measured).

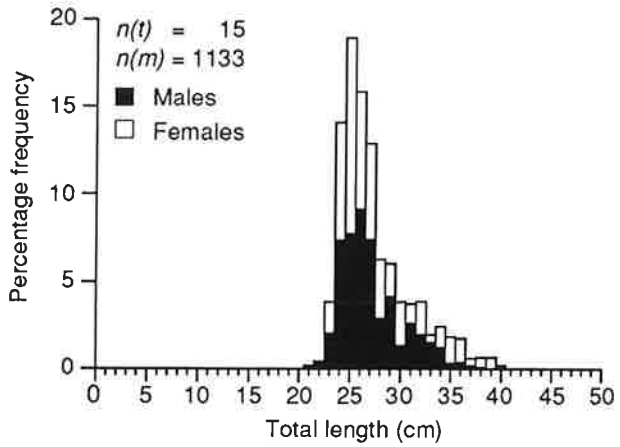

Figure 11: Length frequency distribution of black oreo from the Waitaki Canyon survey area (scaled to represent the total population, *n(t)* = number of trawls with samples, *n(m)* = number of fish measured).

Black and smooth oreo gonads were predominantly in early stages of maturation. No ripe gonads were recorded.

Feeding

A total of 575 orange roughy stomachs was examined from the Waitaki Canyon area (including exploratory tows). Of these, 44% contained food (55% were empty, 1% trace or everted). The most important components of the diet were natant decapod crustaceans and fish (Table 10). The most common crustacean species were *Pasiphaea* sp., *P. barnardi*, and *Sergestes arcticus*.

Puysegur Bank research survey

Seventy-nine trawl stations were successfully completed during the research survey of the Puysegur Bank area. Phase I consisted of 75 tows, and there were 4 Phase II tows.

Catch composition

The catch comprised 69 species of crustaceans, squid, shark, skate, and fish. The total catch was 323 522 kg. Orange roughy was the main species (47%), with black oreo (29%) and smooth oreo (17%) (Table 11).

Distribution and catch rates

Orange roughy were distributed throughout the survey area, but were most abundant on the western side of Puysegur Bank (Figure 12). Catch rates greater than 1000 kg.km^{-1} were regularly recorded on two hills (strata 4 ("Godiva") and 51 ("Goomzy Hill")) and an area of slope in the northwest (stratum 33 ("Alistairs")). Maximum catch rates in these strata were 12 900 kg.km^{-1}, 9900 kg.km^{-1}, and 32 900 kg.km^{-1} respectively. Moderate catch rates were occasionally recorded in a small area of slope on the eastern side of the Bank (stratum 10) and on a hill complex to the south (stratum 11).

Smooth oreo were also caught in most trawls, and were abundant in areas similar to those where orange roughy were taken (Figure 13). Catch rates of 1000–10 000 kg.km^{-1} were recorded in strata 4 and 33 on the western side of Puysegur Bank and on the two southern hills (strata 11 and 12). The highest catch rate was 10 500 kg.km^{-1} on the stratum 4 hill.

Black oreo distribution was similar to that of smooth oreo and orange roughy (Figure 14). Catch rates were high on the west Puysegur hills (strata 4 and 51) and slope (stratum 33) and on hills south of the Bank (strata 11 and 12). In these areas, catch rates were regularly 2000–10 500 kg.km^{-1}, with maximum rates of 12 000–15 000 kg.km^{-1}.

Biomass indices

The biomass of orange roughy from all survey tows was estimated at 11 470 t, with a *c.v.* of 32% (Table 12). Recruited fish ($\geq$ 30 cm) constituted 93% of the estimated biomass.

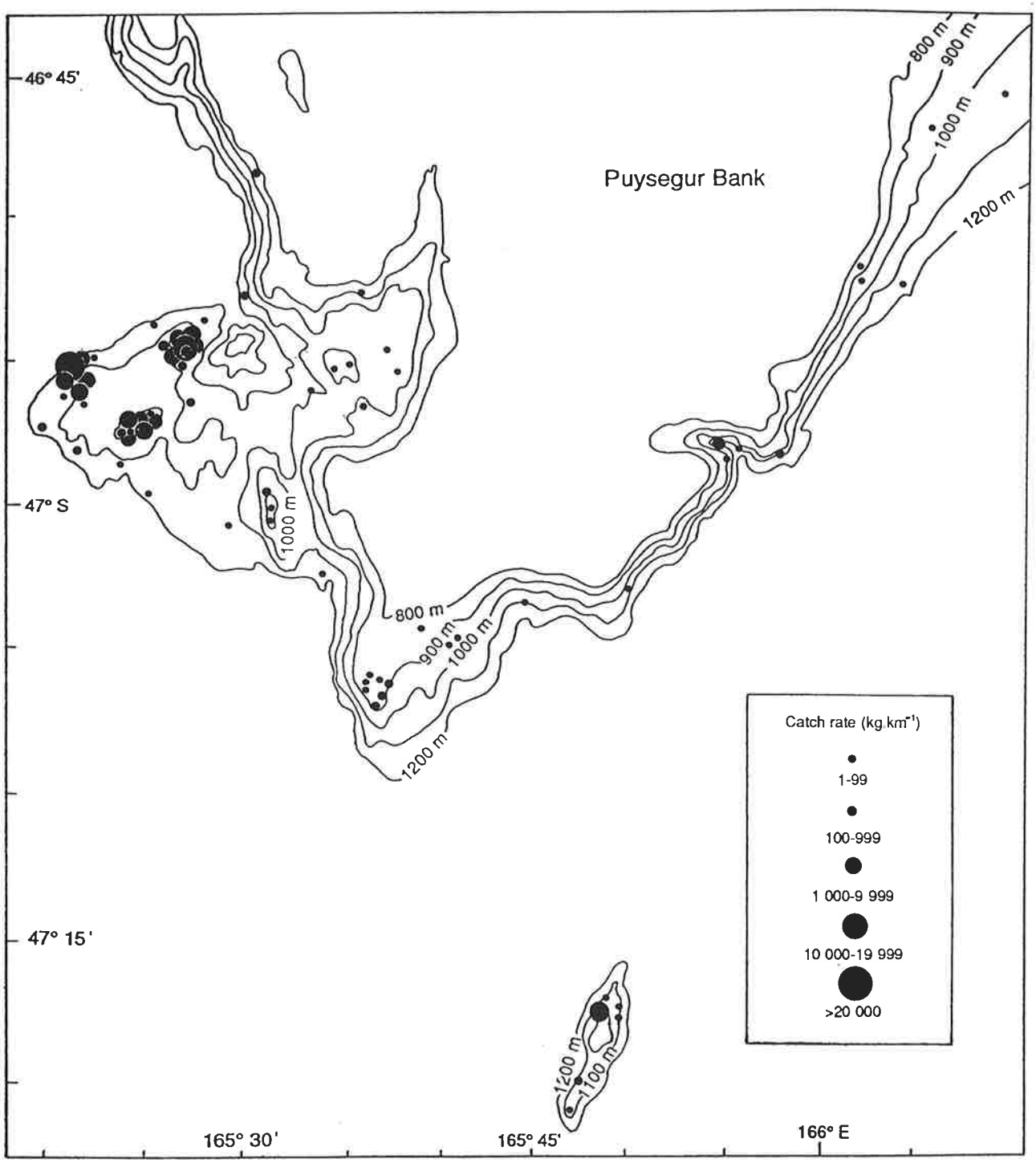

Figure 12: Catch rates (kg.km^{-1}) of orange roughy in research survey tows in the Puysegur Bank area.

Four strata accounted for most of the biomass (Table 13): strata 33 ("Alistairs"), 10 (steep slope around "Seal Cove"), 51 ("Goomzy Hill"), and 11 ("Mt Duncan"). High catch rates were recorded in stratum 4, but this hill did not feature in the overall biomass because of its small area.

Biomass estimates are given in Table 12 for smooth and black oreo: 5648 t and 8888 t respectively. The *c.v.* of these estimates is relatively low considering the survey design and station distribution was optimised to assess orange roughy biomass.

Size structure

The length frequency distribution of all orange roughy sampled from the Puysegur Bank is shown in Figure 15. Fish ranged in size from 13 cm to 49 cm standard length. The distribution is unimodal, with the peak at 34–37 cm. The peak of the male length frequency was at 34 cm (mean length = 31.9 cm, *s.d.* = 4.5), and that for females was at 36–37 cm (mean length = 34.5 cm, *s.d.* = 3.7). The overall sex ratio was about even (45% male, 55% female), though it varied substantially between individual trawls.

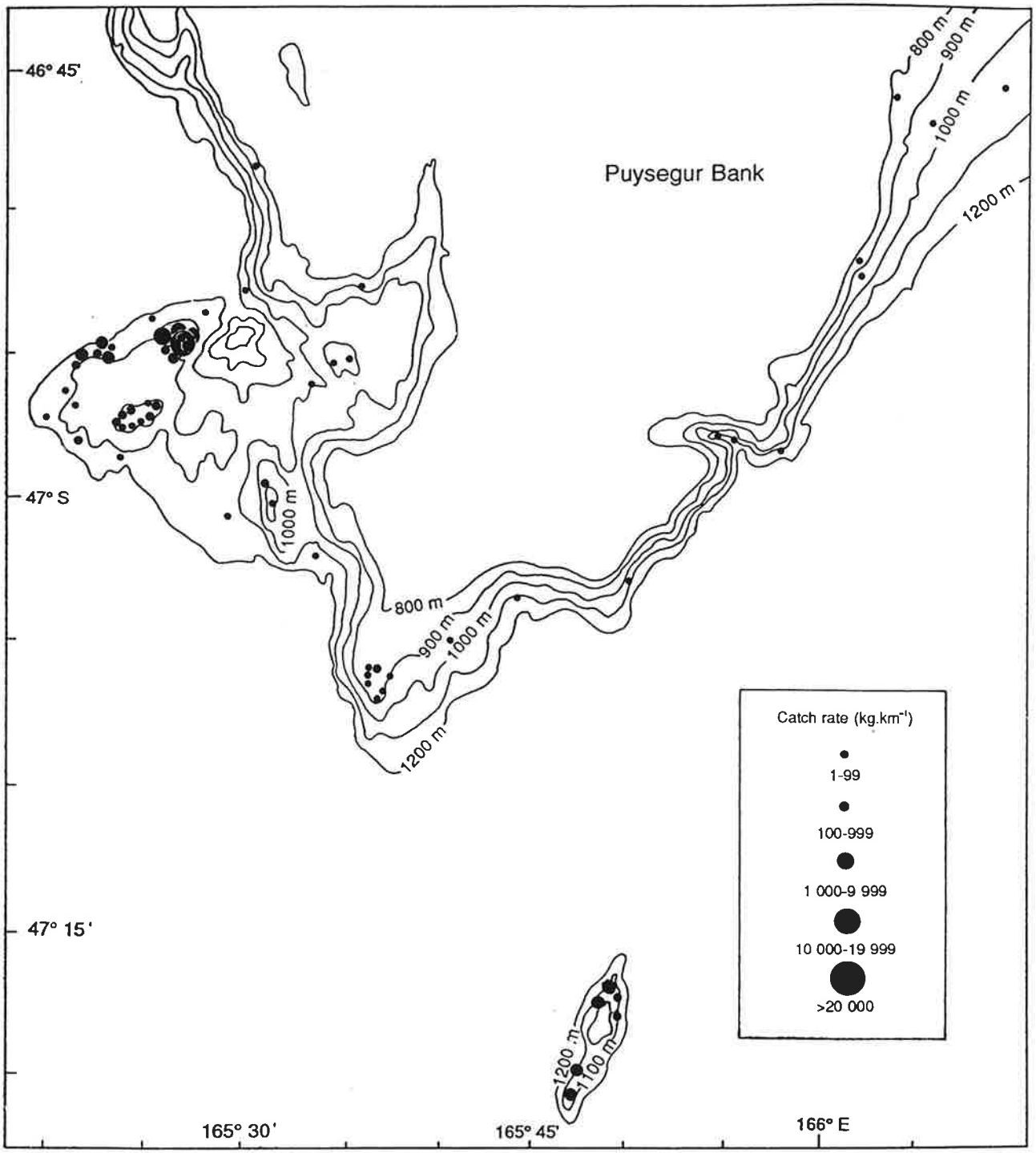

Figure 13: Catch rates (kg.km^{-1}) of smooth oreo in research survey tows in the Puysegur Bank area.

Smooth oreo ranged from 16 cm to 54 cm total length (Figure 16). There was a strongly bimodal distribution, with even peaks at 23–24 cm and 39–41 cm. Most smooth oreo over about 40 cm were female. The overall sex ratio was even (52% male, 48% female).

Black oreo also showed a strong bimodal distribution (Figure 17), with peaks at 28–29 cm and 34–35 cm total length. Size range was from 20 cm to 42 cm. The sex ratio was about even (55% male, 45% female).

Length-weight regression equations for orange roughy, smooth oreo, and black oreo are given in Table 14.

Reproduction

The overall proportions of individual gonad stages for orange roughy are given in Table 15.

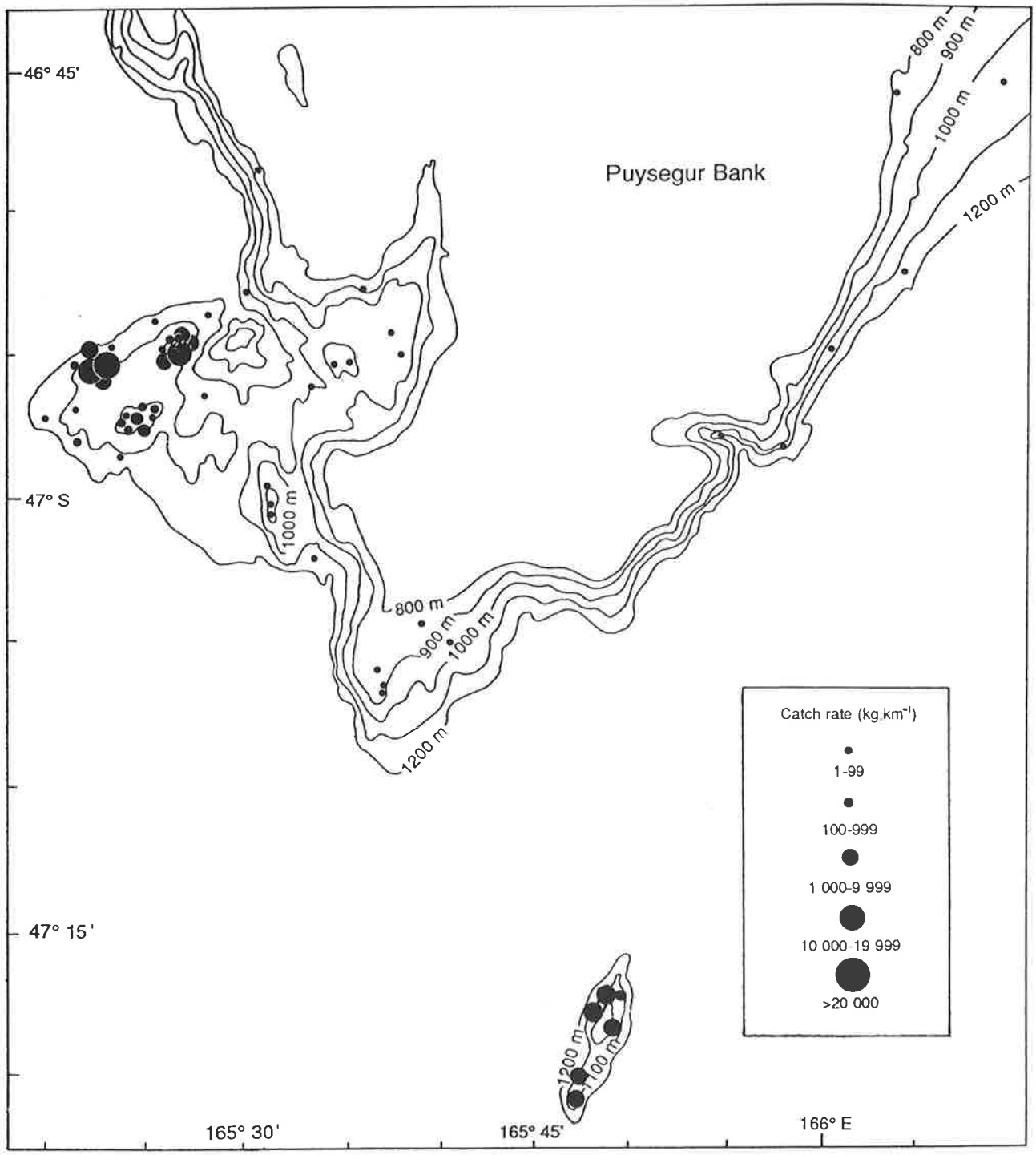

Figure 14: Catch rates (kg.km^{-1}) of black oreo in research survey tows in the Puysegur Bank area.

Spent (stage 6 female, 5 male), ripe (stage 4), early maturation (stage 2), and immature or regressed (stage 1) fish were common, constituting 32%, 23%, 18%, and 22% of combined male and female samples. Most of the fish with immature or regressed or early maturing gonads were less than 30 cm (the approximate mean length at maturity). However, 11.5% of females sampled and 13.5% of males greater than 30 cm had gonads at stage 1 or 2, and would not therefore spawn this year, despite being of mature size.

Gonadal development of mature orange roughy was monitored throughout the survey. Proportions of gonad stages by sex by day in the survey area are shown in Figure 18. Data have been smoothed by applying a 5-day running median. The trends are similar for both male and female. Initially there were relatively high levels of maturing and ripe fish. The proportion of maturing fish declined to 0 by the middle of July, while ripe fish increased. In the second half of July there were decreasing levels of ripe fish and increasing numbers of spent fish. This

Table 8: Gonad stage frequency of orange roughy from the Waitaki Canyon area during exploratory (19 Jun–4 Jul) and research survey (27–31 Jul) phases

	Exploratory				Research			
	Male		Female		Male		Female	
Stage	*n*	%	*n*	%	*n*	%	*n*	%
1	6	5.8	0	0	29	22.0	29	29.3
2	12	11.5	4	8.0	5	3.8	9	9.1
3	79	76.0	44	88.0	0	0	1	1.0
4	7	6.7	1	2.0	66	50.0	32	32.3
5	0	0	0	0	32	24.2	7	7.1
6			1	2.0			21	21.2

Table 9: Female orange roughy gonadosomatic indices* from the Waitaki Canyon exploratory (19 Jun–4 Jul) and research phases (27–31 Jul)

	Exploratory			Research		
Stage	$\bar{x}$	*s.d.*	*n*	$\bar{x}$	*s.d.*	*n*
1	0	0	0	0.35	0.14	29
2	1.22	0.42	4	0.87	0.49	9
3	11.23	1.80	41	11.14	–	1
4	6.40	–	1	12.38	4.26	32
5	0	0	0	13.31	4.43	7
6	1.38	–	1	5.16	2.07	21
3–6	10.89	2.42	43	9.98	5.03	61

* $\bar{x}$ = mean; *s.d.* = standard deviation; *n* = sample size.

Table 10: Major prey groups of orange roughy from the Waitaki Canyon area*

	Frequency		Volume		*IV* index	
Prey group	*n*	%	*v*	%	*IV*	%
Crustacea						
Amphipoda	2	0.8	70	0.3	0.5	0.5
Decapoda Natantia	168	66.7	13 850	54.9	60.5	55.1
Euphausiacea	24	9.5	1 430	5.7	7.3	6.6
Crustacean remains	4	1.6	300	1.2	1.4	1.3
Mollusca						
Cephalopoda Decapoda	3	1.2	300	1.2	1.2	1.1
Pisces						
Macrouridae	7	2.8	580	2.3	2.5	2.3
Mesopelagic group†	15	5.9	1 400	5.5	5.7	5.2
Other groups‡	5	2.0	470	1.9	1.9	1.7
Fish remains	76	30.1	6 600	26.1	28.0	25.5
Unidentified	2	0.8	200	0.8	0.8	0.7

*n = number of fish; v = volume; number of stomachs with food = 252.
† Includes families Myctophidae, Paralepididae, Photichthyidae, Melamphaidae.
‡ Includes families Bathylagidae, Alepocephalidae, Moridae.

Table 11: Total catch and percentage composition by weight of the 10 most abundant species caught in the Puysegur Bank survey

Species	Catch (kg)	% of total
Orange roughy	151 830	46.9
Black oreo	94 182	29.1
Smooth oreo	55 918	17.3
Baxter's lantern dogfish	9 139	2.8
Black cardinalfish	4 878	1.5
Smallscaled brown slickhead	1 508	0.5
Plunket's shark	1 235	0.4
Owston's spiny dogfish	1 030	0.3
Hoki	821	0.3
Longnosed velvet dogfish	662	0.2
All species	323 522	

Table 12: Biomass (t) of orange roughy, smooth oreo, and black oreo in the Puysegur Bank survey area

Species	Biomass	95% range	*c.v.* (%)
Orange roughy			
All fish	11 450	4 100–18 810	32
1–30 cm	750	120– 1 390	42
30–50 cm	10 690	3 660–17 720	33
Smooth oreo			
All fish	5 620	3 330– 7 920	20
Black oreo			
All fish	8 880	4 280–13 480	26

Table 13: Catch rates and biomass of orange roughy (all fish) by stratum in the Puysegur Bank survey area

Stratum	Area (km^2)	No. of tows	Mean catch rate ($kg.km^{-1}$)	*s.d.*	Biomass (t)	Biomass (%)
1	71	3	2.0	1.8	7	< 0.1
2	62	4	18.3	16.5	57	0.5
31	102	10	89.7	178.9	458	4.0
32	257	7	42.9	95.6	551	4.8
33	10	5	10 061.4	12 996.8	5 031	43.9
4	2	8	3 618.7	4 881.5	362	3.2
51	8	9	3 058.6	3 892.0	1 223	10.7
52	15	5	184.8	365.0	139	1.2
6	21	7	107.1	85.3	112	1.0
7	20	3	1.2	2.1	1	< 0.1
8	28	3	1.1	1.7	2	< 0.1
9	122	2	4.3	5.6	26	0.2
10	78	7	612.9	1 282.0	2 390	20.9
11	26	4	809.1	1 483.0	1 052	9.2
12	8	2	91.3	14.9	36	0.3

Table 14: Length-weight regression equations* for orange roughy, smooth oreo, and black oreo by sex for the Puysegur Bank survey area

Species	Sex	Regression	*n*	r^2
Orange roughy	Both	$W = 5.0 \times 10^{-2} L^{2.88}$	1 231	0.97
	M	$W = 6.0 \times 10^{-2} L^{2.82}$	546	0.98
	F	$W = 4.6 \times 10^{-2} L^{2.91}$	685	0.97
Black oreo	Both	$W = 6.9 \times 10^{-3} L^{3.30}$	162	0.91
	M	$W = 1.2 \times 10^{-2} L^{3.15}$	84	0.91
	F	$W = 5.2 \times 10^{-3} L^{3.39}$	78	0.91
Smooth oreo	Both	$W = 9.3 \times 10^{-3} L^{3.21}$	90	0.94
	M	$W = 6.3 \times 10^{-3} L^{3.32}$	38	0.94
	F	$W = 9.8 \times 10^{-3} L^{3.20}$	52	0.92

* L = cm; W = g; n = sample size; r^2 = regression coefficient.

indicates the survey covered most of the period of peak spawning.

Gonadosomatic indices by gonad stage for female orange roughy are given in Table 16. The index increased through maturing stages to peak at spawning and then decreased in the spent stage.

Black and smooth oreo were generally in the early to mid-stages of gonad maturation, and there was no spawning activity.

Feeding

A total of 1231 orange roughy stomachs was examined during the Puysegur survey, of which 38% contained prey (57% were empty, 4% had trace contents, and 1% were everted). Fish were the most important prey (Table 17), accounting for about 53% of *IV* values. Most fish prey were broken or too digested for specific identification. Crustacean groups collectively totalled about 37%, of which natant decapod crustaceans were the most important. Squid were also frequent prey.

Table 15: Gonad stage frequency of orange roughy from the Puysegur Bank survey area (*n* = 546 for males, 685 for females)

	Male		Female	
Stage	*n*	%	*n*	%
1	197	36.1	75	10.9
2	54	9.9	165	24.1
3	23	4.2	30	4.4
4	118	21.6	150	21.9
5	154	28.2	21	3.1
6			244	35.6

Table 16: Female orange roughy gonadosomatic indices* from the Puysegur Bank survey

Gonad stage	$\bar{x}$	*s.d.*	*n*
1	0.46	0.19	75
2	1.05	0.54	165
3	7.49	3.12	30
4	10.70	4.46	150
5	8.54	4.09	21
6	2.18	1.51	244
3–6	5.71	5.02	445

* $\bar{x}$ = mean; *s.d.* = standard deviation; *n* = sample size.

Table 17: Major prey groups of orange roughy from Puysegur Bank*

	Frequency		Volume		*IV* index	
Prey group	*n*	%	*v*	%	*IV*	%
Crustacea						
Amphipoda	59	12.10	2 875	6.2	8.7	7.7
Decapoda Natantia	74	16.0	5 770	12.5	14.1	12.5
Euphausiacea	49	10.6	2 640	5.7	7.8	6.9
Mysidacea	19	4.1	1 420	3.1	3.6	3.2
Crustacean remains	38	8.2	2 610	5.6	6.8	6.0
Mollusca						
Cephalopoda Decapoda	59	12.7	4 590	9.9	11.2	9.9
Pisces						
Macrouridae	15	3.2	1 450	3.1	3.1	2.7
Mesopelagic group†	28	6.0	2 675	5.8	5.9	5.2
Other groups‡	5	1.1	400	0.9	1.0	0.9
Fish remains	243	52.5	20 960	45.3	48.8	43.2
Other groups	10	2.1	910	2.0	2.0	1.8

* *n* = number of fish; *v* = volume; number of stomachs with food = 463.
† Includes families Myctophidae, Malacosteidae, Stomiatidae, Chauliodontidae, Gonostomatidae, Astronesthidae, Melamphaidae, Photochthyidae, Sternoptychidae.
‡ Includes families Bathylagidae, Alepocephalidae.

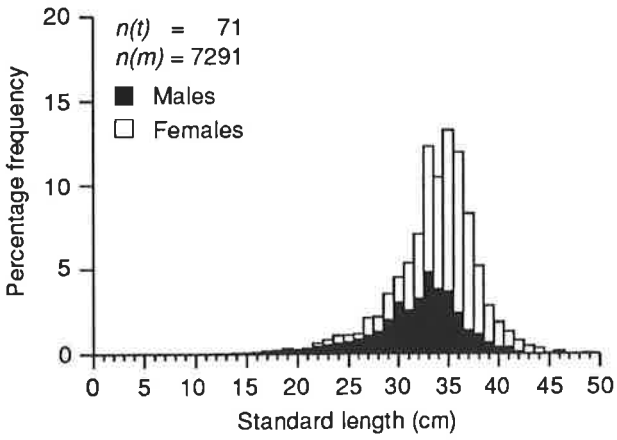

Figure 15: Length frequency distribution of orange roughy from the Puysegur Bank survey area (scaled to represent the total population, *n(t)* = number of trawls with samples, *n(m)* = number of fish measured).

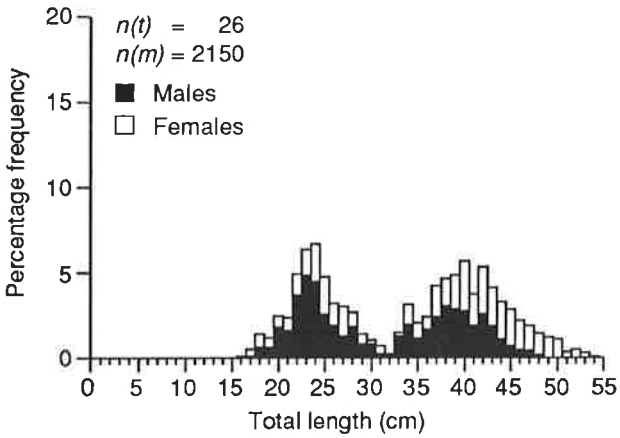

Figure 16: Length frequency distribution of smooth oreo from the Puysegur Bank survey area (scaled to represent the total population, *n(t)* = number of trawls with samples, *n(m)* = number of fish measured).

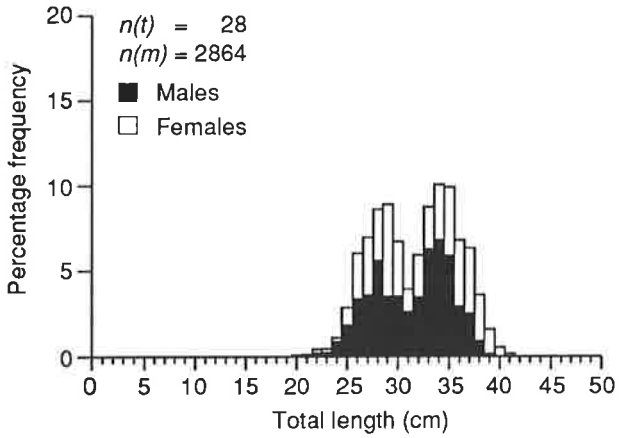

Figure 17: Length frequency distribution of black oreo from the Puysegur Bank survey area (scaled to represent the total population, *n(t)* = number of trawls with samples, *n(m)* = number of fish measured).

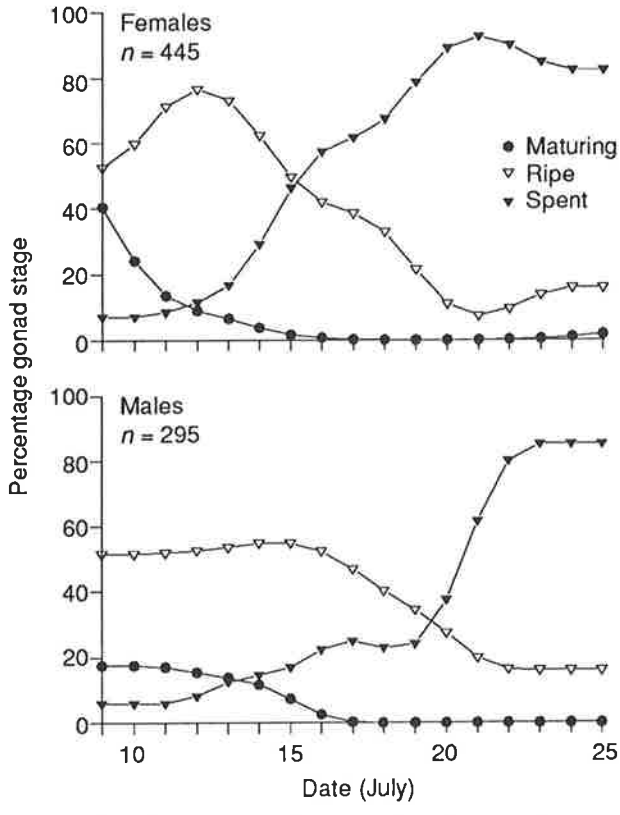

Figure 18: Daily changes in the proportion of gonad stages of orange roughy in the Puysegur Bank survey area (maturing = stage 3; ripe = female stages 4 and 5, male 4; spent = female 6, male 5).

Discussion

The trip had extensive and complex objectives combining exploratory fishing and research surveys. Exploratory phases covered a wide area on the east coast of the South Island and eastwards to the Bounty Islands. In between this exploratory work trawl surveys were carried out in the Puysegur Bank and Waitaki Canyon areas. The major objectives were successfully completed.

Exploratory fishing

Exploratory fishing activities focused initially on the area of the Waitaki Canyon, where significant commercial catches had been taken in late 1991 to early 1992. However, in the first 2 weeks catches of orange roughy were small, fish size was generally small, and some of the larger fish that were caught had spent gonads. Hence, it seemed that orange roughy might have moved elsewhere for spawning, but extensive searching and fishing southwards as far as the Molyneux Sea Valley, and northeastwards on to the Chatham Rise revealed little. Several good catches at the end of the exploratory period, and during the subsequent research survey, confirmed that spawning occurs at the Waitaki Canyon, but the fish were very localised.

Catches of orange roughy around the Bounty Islands were small. Orange roughy eggs have been caught in plankton tows on the eastern side of the Bounty Platform (D. A. Robertson, MAF Fisheries, pers. comm.), but there have been no reports of significant catches of orange roughy in the area. However, the margins of the Bounty Platform at depths of over 800 m cover a large area, and only the northern region was explored in the time available. Several good catches of smooth oreo were taken, so there could be commercial potential for deepwater species in the area.

Research trawl surveys

The trawl surveys carried out on the Puysegur Bank and around the Waitaki Canyon provided extensive information on distribution, abundance, and biology of orange roughy and oreos. A central objective of the surveys was estimation of biomass, and it is important to emphasise that **the biomass values presented in this report are not absolute tonnages of fish, but are relative biomass indices.** There are uncertainties about the effective area swept by the trawl gear, herding by the gear, and escapement of fish (which may depend on their vertical distribution and behaviour) (*see* Clark & Tracey 1992).

Waitaki Canyon survey

The trawl survey of Waitaki Canyon focused on a small area defined from the results of exploratory fishing and reported locations of commercial catches. Time limited the number of tows that could be carried out. Nevertheless, the survey results reflect the particular characteristics of distribution and abundance of orange roughy in this area. High catch rates of orange roughy occurred in only one stratum (the "boot" of the outside margin of the canyon), but catches were highly variable in this stratum. Catches ranged from 3 kg to 45 300 kg, and 5 of the 10 tows on the "boot" caught less than 10 kg of orange roughy. The patchiness of the distribution was more extreme than in the other spawning grounds around New Zealand, and the very low "background" catch rates in surrounding strata were also unusual. Results indicate that the stock is very small and localised, with limited potential to support a target fishery for orange roughy.

Puysegur Bank survey

The design of the Puysegur Bank survey was modified from that of 1991, with some changes to stratification and distribution of tows between strata. The precision of the biomass estimate (*c.v.* = 32%) in this survey was improved over that for 1991 (*c.v.* = 53%).

The distribution of orange roughy was fairly consistent with the 1991 survey and the location of commercial catches in 1991 and 1992. However, comparatively good catch rates were recorded in two areas (stratum 52, "Labrador Bank"; stratum 10, "Seal Cove") which had not previously provided good catches. Orange roughy in both these strata were spawning. Most spawning activity centred on the western hills (stratum 4, "Godiva"; stratum 51, "Goomzy Hill"), with smaller pockets in strata 52, 10, 6 ("Malcolm's Monument"), and 11 ("Mt Duncan").

Puysegur Bank survey comparison, 1991 and 92

The survey in 1991 was carried out from *Will Watch*, which is a smaller and less powerful vessel than *Giljanes*. This resulted in some differences in trawling procedure because of the increased windage and drift with *Giljanes*: there was a slightly

higher towing speed (3.1 kn v. 2.9 kn) and more warp was used (depth:warp ratio of 1:1.65 v. 1:1.55) than with *Will Watch*. However, general fishing techniques and trawl gear were kept as similar as possible, and the survey results can be used to give an indication of changes in the stocks.

Orange roughy

Data from the *Will Watch* survey have been re-analysed using the 1992 stratification. This is acceptable because stratification for 1992 was based mainly on commercial catch data for 1991 and 1992 and on updated bathymetric data, and not solely on the results of the 1991 survey. The revised 1991 and 1992 biomass indices for orange roughy are:

1991: 23 810 t, *c.v.* = 35.4%
(95% range = 6950–40 660 t)

1992: 11 450 t, *c.v.* = 32.0%
(95% range = 4100–18 800 t).

The 95% confidence intervals around the survey estimates are wide and overlap considerably. Mean estimates suggest there has been a decline, but the precise extent of change is uncertain, particularly because different vessels were used.

There was a substantial change in the distribution of biomass between strata (Table 18), with a reduction in the importance of stratum 31, and an increase in strata 33 and 10.

Catch rates generally declined from 1991 levels (Table 19). Catch rates in 1992 were lower in most strata, particularly 4, 51, and 31. These strata comprise the two main commercial hills and surrounding slope.

The size structure of the orange roughy population was similar in both years (Figure 19). The female length frequency distributions were almost identical, but there were some small differences for males.

Smooth oreo

There were indications of changes with smooth oreo. Mean biomass estimates were similar, but there were differences in distribution:

1991: 5450 t, *c.v.* = 42%
(95% range = 900–10 000 t)

1992: 5620 t, *c.v.* = 20%
(95% range = 3330– 7920 t).

In 1991 the biomass was concentrated in stratum 31 (39%), but the 1992 biomass was more evenly spread between strata 11, 12, and 33.

The size distribution of smooth oreo differed between the two surveys. In both years there was a similar bimodal distribution, but the relative importance of modes changed (Figure 20). Catches in 1991 were dominated by the mode of large-sized fish at 42–43 cm, but the small-sized fish mode (peak at 24–25 cm) was more prominent in 1992.

Black oreo

There were differences between the 1991 and 1992 results for black oreo. The biomass estimates had a wide range, but mean values indicated a decrease:

1991: 12 340 t, *c.v.* = 52%
(95% range = 0–25 360 t)

1992: 8 880 t, *c.v.* = 26%
(95% range = 4280–13 480 t).

In 1991 the most important stratum for biomass was 33 (which accounted for 50%), with strata 4, 11, and 12 each contributing 10–20%. In 1992 biomass was distributed evenly between strata 11 and 33 (about 40% each).

Length frequency distributions of black oreo in 1992 also differed from those in 1991 (Figure 21). In 1991 there was a bimodal distribution with its main peak at 35–36 cm. In 1992 there was a similar bimodal distribution, but the mode of smaller fish (peak at 27–28 cm) was more prominent.

Table 18: Percentage of total orange roughy biomass by stratum in 1991 and 1992

Stratum	1991	1992
1	< 0.1	< 0.1
2	4.2	0.5
31	26.0	4.0
32	1.7	4.8
33	19.9	43.9
4	9.8	3.2
51	12.8	10.7
52	0.1	1.2
6	11.1	1.0
7	0.1	< 0.1
8	< 0.1	< 0.1
9	0.1	0.2
10	4.5	20.9
11	9.3	9.2
12	0.2	0.3

Table 19: Mean catch rate (kg.km^{-1}) of orange roughy by stratum in 1991 and 1992

Stratum	1991	1992
1	3.7	2.0
2	325.0	18.3
31	1 216.0	89.7
32	31.4	42.9
33	9 479.0	10 061.4
4	23 372.5	3 618.7
51	7 597.5	3 058.6
52	29.0	184.8
6	2 517.6	107.1
7	28.3	1.2
8	2.9	1.1
9	4.7	4.3
10	275.5	612.9
11	1 703.7	809.1
12	114.8	91.3

Concluding remarks

The results of the 1991 and 1992 surveys are not strictly comparable because different vessels were used. However, the results suggest that the Puysegur Bank stocks have been affected by the fishery in the last year. Clark & Tracey (1992) commented that, although there was the basis for an important commercial fishery, there were several indications that the orange roughy population might be fairly small: the small size of the Puysegur spawning area, the absence of heavy marks on the echosounder, and the variable catch composition and catch rates in comparison with other orange roughy spawning grounds. Hence, the level of commercial catches in the 1991–92 fishing year would have had some impact on the size of the fish population. Total reported catches in the 1991–92 year were (catches between trawl surveys are in parentheses):

Orange roughy	6572.0 t	(6081.0 t)
Smooth oreo	571.8 t	(390.8 t)
Black oreo	2068.4 t	(1725.4 t)
Unspecified oreo	189.6 t	(159.1 t)

A catch limit for orange roughy of 5000 t has been set for the area for the 1992–93 fishing year. This level is probably not sustainable beyond 2 or 3 years. A time series of trawl surveys using GRV *Tangaroa* commenced in August-September 1992, but it will be at least 3–4 years before the programme will provide sufficient data to estimate biomass and yields with any confidence. In the meantime the fishery needs to be carefully monitored.

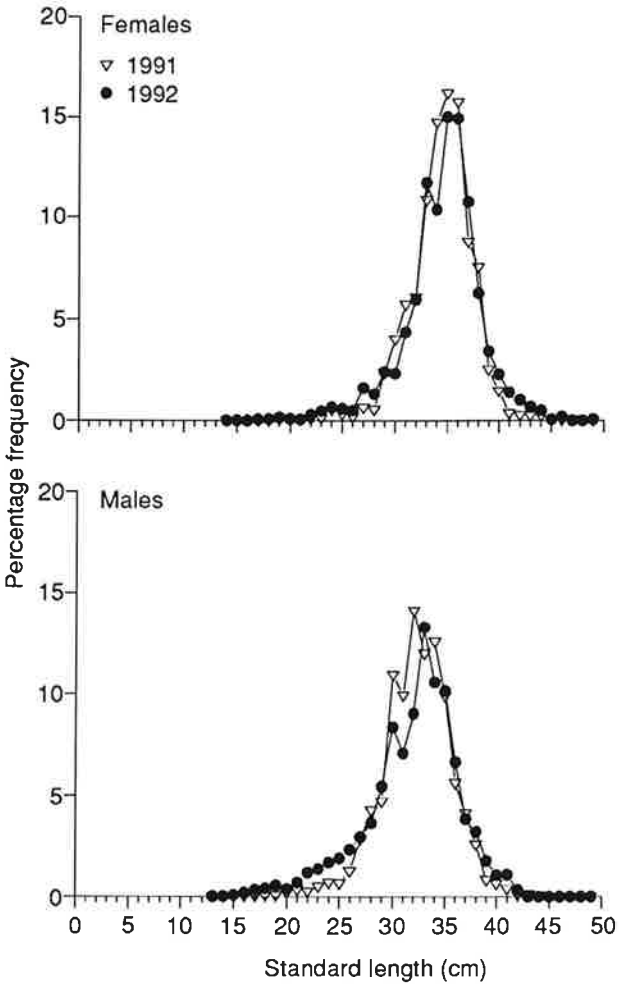

Figure 19: Length frequency distributions of orange roughy by sex from the Puysegur Bank survey area in 1991 and 1992.

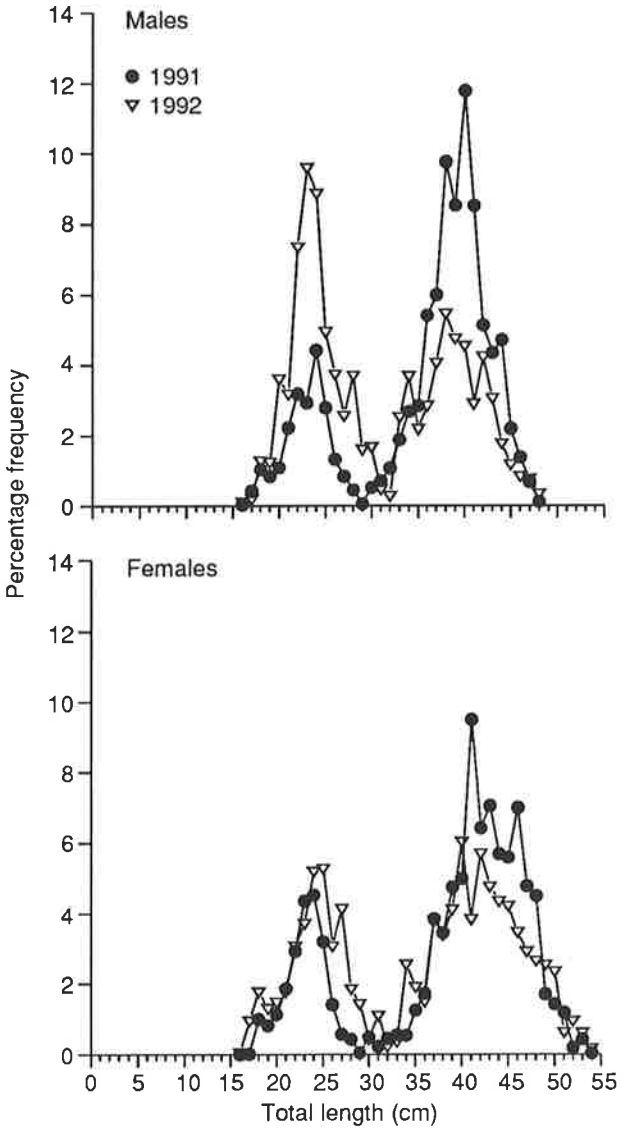

Figure 20: Length frequency distributions of smooth oreo by sex from the Puysegur Bank survey area in 1991 and 1992.

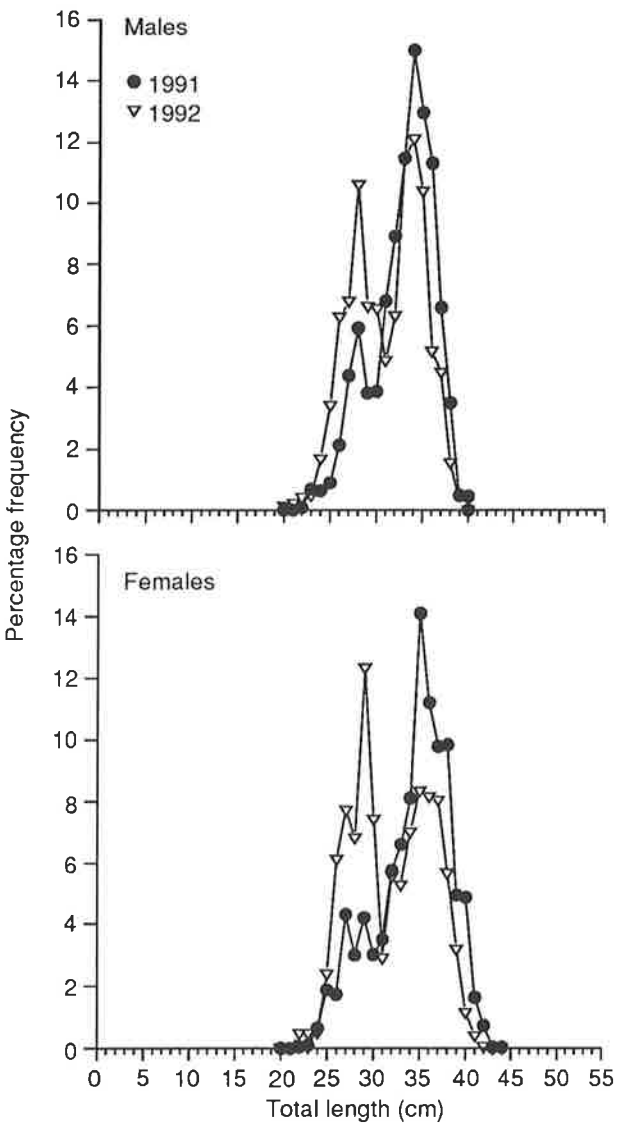

Figure 21: Length frequency distributions of black oreo by sex from the Puysegur Bank survey area in 1991 and 1992.

Acknowledgments

We thank skipper Mike Baker, master Alex Grieve, first mate Chris Carey, and the crew of *Giljanes* for their willing cooperation during the survey; Jenny Shore, Lorraine Thomas, and Joanne Morgan for assistance with sampling and data recording; and Terry Stagg and George Clement for organisation and liaison on shore. Data on exploratory fishing around the Bounty Islands were provided by Eric Prattley and Steven Simpson (Scientific Observer Programme).

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Appendix 1: Station and catch data

Date	Station No.	Station code*	Time	Start of tow Latitude ° 'S	Start of tow Longitude ° 'E	Trawling time (min)	Depth (m) Min.	Depth (m) Max.	Direction of tow °T	Distance towed (n. mile)	Net opening height (m)	Total catch (kg)	Species catch (kg)† ORH	Species catch (kg)† BOE	Species catch (kg)† SSO
19 Jun	001	RE	1055	45 04.05	172 05.02	47	1216	1290	126	2.7	9.0	274	0	0	243
	002	RE	2012	45 17.41	171 44.58	17	868	960	274	0.6	9.0	522	2	146	298
	003	RE	2327	45 17.12	171 49.98	28	995	1073	082	1.2	10.0	111	0	6	69
20 Jun	004	RE	0714	45 20.06	171 45.34	9	926	1012	094	0.4	10.0	941	13	700	87
	005	RE	1320	45 21.36	171 43.29	20	910	950	094	1.1	7.5	8044	0	2000	6000
	006	RE	2222	45 22.49	171 44.21	88	972	1100	088	4.6	8.5	2050	0	500	1500
21 Jun	007	RE	0555	45 23.00	171 44.34	52	983	1125	167	2.2	8.0	239	4	19	84
	008	RE	1029	45 25.46	171 33.05	40	905	1002	088	2.2	10.0	196	8	50	63
	009	RE	1553	45 23.47	171 32.60	41	764	983	089	2.4	10.0	446	2	251	42
	010	RE	2337	45 16.37	171 40.67	57	818	1062	091	2.9	9.5	150	0	50	50
22 Jun	011	RE	0302	45 16.42	171 48.33	40	902	1076	088	2.1	7.5	330	0	18	115
	012	RE	0536	45 16.30	171 45.23	21	825	1060	270	0.9	9.0	4222	11	3000	1000
	013	RE	1135	45 14.05	171 48.84	47	886	1075	121	2.3	10.0	441	3	89	122
23 Jun	014	RE	0408	45 15.82	171 40.00	31	825	1040	012	1.5	10.0	228	62	95	4
	015	RE	1042	45 30.39	171 26.51	57	805	1018	061	3.1	10.0	390	24	50	171
	016	RE	1351	45 27.63	171 30.90	13	878	950	089	0.7	7.0	321	12	100	91
	017	RE	2208	45 31.20	171 28.25	28	936	988	001	1.5	10.0	96	3	15	157
24 Jun	018	RE	0441	45 34.23	171 21.82	56	720	1162	048	3.0	10.0	563	13	217	62
	019	RE	0723	45 31.73	171 25.94	21	826	1111	228	1.0	10.0	498	8	31	302
	020	RE	2136	45 32.89	171 29.58	11	956	980	223	0.6	10.0	5374	3	0	5227
25 Jun	021	RE	0117	45 38.95	171 22.23	20	883	1024	042	1.0	9.0	3133	6	0	3037
	022	RE	0553	45 42.06	171 18.03	30	781	1111	356	1.8	8.0	1165	44	336	445
	023	RE	1242	45 45.05	171 17.95	107	787	1027	094	6.2	7.5	854	9	44	532
	024	RE	2038	45 58.18	171 13.77	55	880	992	002	3.3	8.5	616	4	11	487
	025	RE	2302	45 56.49	171 15.70	36	921	981	180	1.7	8.0	3110	10	100	3000
26 Jun	026	RE	0605	46 08.44	171 05.49	12	810	950	043	0.9	7.0	317	16	218	26
	027	RE	1228	46 11.08	171 01.78	149	762	1119	091	7.9	8.5	719	8	54	411
	028	RE	2234	46 16.86	171 06.96	77	968	1014	203	3.3	7.5	1389	3	30	1112
27 Jun	029	RE	0232	46 15.34	170 54.81	100	811	1051	182	4.7	6.0	257	0	132	0
	030	RE	0939	46 22.88	170 54.65	54	863	985	003	3.6	8.5	154	5	13	36
	031	RE	1728	46 28.74	170 48.46	55	880	1028	032	3.1	8.5	109	3	11	34
28 Jun	032	RE	0326	46 42.86	170 45.23	103	1019	1220	051	5.8	8.0	109	0	34	23
	033	RE	1701	45 41.89	171 18.57	35	790	1110	014	1.9	7.5	520	5	101	17
	034	RE	2029	45 40.00	171 24.31	23	991	1120	028	1.2	7.5	717	5	1	630
29 Jun	035	RE	0257	45 20.25	171 41.56	10	894	1164	020	0.6	8.0	163	11	80	117
	036	RE	0536	45 19.88	171 43.54	19	922	1160	300	0.9	8.0	8897	142	3362	4787
	037	RE	1413	44 53.53	172 15.73	60	780	978	212	3.1	8.0	434	3	157	50
	038	RE	2121	44 49.08	172 27.33	60	798	995	172	2.6	8.0	237	0	64	76
30 Jun	039	RE	0553	44 45.73	172 59.00	2	1010	1067	086	0.2	8.0	260	60	0	191
	040	RE	0753	44 45.97	172 58.92	9	988	1060	074	0.4	7.5	1164	4	28	1078
	041	RE	1053	44 44.38	173 02.19	45	900	935	276	2.0	10.0	3056	0	1916	1084
	042	RE	1657	44 50.09	173 09.60	20	1002	1060	250	0.7	6.0	892	0	86	740
01 Jul	043	RE	0043	44 46.28	172 35.07	80	816	1055	142	3.9	8.0	469	2	40	103
	044	RE	0404	44 53.27	173 34.17	60	1180	1197	235	2.5	8.0	75	0	9	8
	045	RE	1600	45 17.41	171 38.35	57	777	1155	157	2.0	5.5	409	11	130	50
	046	RE	1942	45 17.90	171 41.94	32	943	1040	059	1.7	9.0	810	3	119	602
	047	RE	2152	45 16.07	171 45.58	29	826	1038	274	1.2	7.5	3409	6	2809	551
02 Jul	048	RE	0152	45 21.42	171 40.93	18	894	939	213	0.6	8.0	28384	14044	95	13738
03 Jul	049	RE	0101	45 21.42	171 40.83	9	892	930	219	0.4	8.0	2384	46	110	1973
	050	RE	0318	45 19.97	171 45.35	12	924	1040	91	0.6	8.0	3802	2	532	3010
	051	RE	0553	45 20.09	171 43.82	14	924	1028	271	0.6	9.0	25437	0	12997	12189
04 Jul	052	RE	0552	45 21.59	171 40.88	9	896	940	213	0.4	8.0	12957	7172	10	5723
	053	RE	0810	45 21.08	171 41.27	23	893	921	280	1.4	8.0	4681	25	0	4650
	054	RE	1103	45 21.06	171 41.94	61	893	1000	089	3.2	7.5	491	1	28	380
09 Jul	055	PB	0132	46 46.36	166 07.82	27	905	934	217	1.6	8.0	36	0	0	0
	056	PB	0424	46 50.10	166 08.65	28	1100	1136	217	1.6	7.8	146	24	0	0
	057‡	PB	1027	46 56.72	165 25.39	3	952	970	343	0.1	8.5	932	667	86	15
	058	PB	1514	46 57.05	165 24.21	20	950	1010	320	1.0	8.0	21235	18228	1837	925
10 Jul	059	PB	0117	46 56.84	165 23.06	26	1000	1091	294	1.5	8.0	68	0	26	1
	060	PB	0447	47 00.65	165 26.52	16	1119	1150	186	0.9	8.5	15	1	0	0
	061	PB	0811	46 54.92	165 25.72	17	965	1062	299	0.8	8.5	10294	4459	932	4843
	062	PB	1255	46 56.72	165 31.45	35	1175	1192	051	1.5	8.0	170	91	9	23
	063	PB	1605	46 55.86	165 38.31	32	1015	1059	004	1.6	8.4	61	8	1	0
	064	PB	2001	46 51.98	165 33.24	17	800	850	180	1.0	9.0	0	0	0	0
	065	PB	2256	47 01.33	165 29.84	29	1135	1185	155	1.5	8.0	37	5	0	1
11 Jul	066	PB	0138	47 06.60	165 36.69	28	747	1052	200	1.5	8.4	109	45	0	10
	067	PB	0513	46 55.25	165 27.96	7	967	1118	113	0.3	10.0	2088	120	1858	80

Appendix 1 — *continued*

Date	Station No.	Station code*	Time	Start of tow Latitude ° 'S	Start of tow Longitude ° 'E	Trawling time (min)	Depth (m) Min.	Depth (m) Max.	Direction of tow °T	Distance towed (n. mile)	Net opening height (m)	Total catch (kg)	Species catch (kg)† ORH	Species catch (kg)† BOE	Species catch (kg)† SSO
12 Jul	068	PB	0526	46 46.45	166 05.66	29	816	838	183	1.5	6.5	599	0	5	4
	069‡	PB	0803	46 56.24	166 01.13	3	961	975	090	0.1	10.0	8	0	0	0
	070	PB	1144	47 03.30	165 46.47	31	815	1131	178	1.5	9.4	194	15	0	0
	071	PB	1455	47 05.59	165 37.87	26	736	852	042	1.6	8.5	1391	253	0	837
	072	PB	1749	46 56.90	165 25.38	32	950	1028	004	1.6	8.5	5829	2851	582	355
	073	PB	2001	46 56.33	165 23.20	30	1024	1080	274	1.5	8.5	53	19	0	0
	074	PB	2219	46 56.32	165 24.10	34	985	1060	341	1.5	7.8	35484	27555	5796	1065
13 Jul	075	PB	1110	47 05.02	165 41.83	30	955	990	045	1.5	8.5	283	118	43	2
	076	PB	1254	47 04.39	165 40.61	35	811	850	218	1.6	8.5	243	8	2	0
	077	PB	1704	46 58.50	165 57.64	14	792	1132	209	0.7	8.2	4508	4277	53	53
14 Jul	078	PB	0029	47 18.41	165 49.98	19	894	1070	081	0.9	8.0	6886	78	4188	921
	079	PB	0534	47 18.84	165 47.84	9	870	995	244	0.4	8.0	9774	2191	5043	1685
	080	PB	1209	47 03.22	165 35.53	29	1001	1135	312	1.3	9.0	115	4	41	1
	081	PB	1447	47 00.07	165 31.05	17	857	1061	269	0.9	8.0	2053	1426	10	380
	082	PB	2155	46 56.34	165 22.00	41	1049	1173	298	1.5	6.7	160	16	0	17
15 Jul	083	PB	0014	46 58.04	165 25.41	30	958	1125	157	1.5	8.0	5930	5702	48	58
	084	PB	0311	46 55.00	165 27.80	7	959	1050	075	0.4	8.5	12215	1531	10533	53
	085	PB	0843	46 53.41	165 35.88	23	900	1000	099	1.0	7.5	150	20	36	1
	086	PB	1107	46 55.24	165 22.30	22	1022	1140	314	0.9	6.5	37113	12830	20546	3609
16 Jul	087	PB	1003	46 57.05	165 24.48	19	950	1025	359	0.9	7.4	7056	1663	3884	660
17 Jul	088	PB	0518	46 45.65	166 16.69	29	1130	1150	071	1.5	7.5	82	1	55	1
	089‡	PB	0946	46 55.72	166 01.40	7	856	950	094	0.4	9.0	53	15	1	0
	090	PB	1802	47 06.44	165 38.17	43	751	1050	128	2.2	8.0	5154	950	0	53
	091	PB	2336	46 54.88	165 25.78	10	989	1042	292	0.5	8.5	5346	950	2556	1663
18 Jul	092	PB	0408	46 54.44	165 26.28	14	970	1070	323	0.7	7.6	1257	330	280	530
	093	PB	0629	46 54.45	165 25.13	31	1077	1190	275	1.5	9.0	50	5	26	15
	094	PB	0847	46 58.28	165 25.06	22	941	1095	168	1.1	7.5	1187	132	745	36
	095	PB	1053	46 56.98	165 25.15	29	941	1020	020	1.5	9.0	2118	715	276	940
	096	PB	1345	47 01.16	165 33.40	14	907	1019	089	0.8	9.0	46	11	16	0
	097	PB	1541	47 06.52	165 37.76	26	740	961	152	1.5	8.5	1118	482	17	242
	098	PB	1829	47 21.22	165 48.61	10	922	1175	105	0.4	9.0	5805	64	911	4725
	099	PB	2221	47 18.44	165 50.03	21	871	1140	094	1.1	8.0	2254	136	221	823
19 Jul	100‡	PB	0230	47 21.17	165 46.38	6	963	1060	225	0.3	9.0	363	1	69	275
	101	PB	0817	47 05.66	165 36.37	31	748	1078	313	1.5	8.0	491	206	0	211
	102	PB	1352	46 59.56	165 28.76	28	1077	1100	162	1.5	8.5	27	0	0	0
20 Jul	103	PB	0130	46 54.78	165 39.29	24	1050	1065	177	1.2	7.6	69	8	1	0
	104	PB	0530	46 48.68	165 13.08	20	815	910	158	1.0	9.0	82	6	1	1
	105‡	PB	0809	46 47.09	165 28.55	2	1144	1146	170	0.1	11.0	12	1	0	0
	106	PB	1303	46 56.61	165 27.41	29	1006	1140	104	1.5	7.8	51	2	1	0
	107	PB	1609	46 58.20	165 26.31	12	995	1101	146	0.7	8.8	1309	1214	0	46
	108	PB	1849	46 57.86	165 22.15	30	1065	1134	217	1.5	8.0	3474	1458	442	1356
	109	PB	2117	46 58.79	165 26.51	32	1061	1117	251	1.5	9.0	85	4	16	1
	110	PB	2334	46 54.90	165 36.56	28	876	1044	064	1.5	8.4	199	76	1	15
21 Jul	111	PB	0222	46 54.02	165 28.80	29	1050	1142	054	1.5	8.4	279	150	4	5
	112	PB	0504	46 54.24	165 27.34	14	970	1050	010	0.8	8.0	22171	12852	4757	4514
22 Jul	113	PB	0032	46 49.88	166 05.09	32	835	867	194	1.5	7.9	142	10	0	2
	114	PB	0253	46 50.53	166 05.28	28	900	937	199	1.5	8.0	73	1	0	2
	115	PB	0548	46 58.04	165 56.51	14	895	1201	179	0.7	11.0	95	25	0	0
	116	PB	0921	47 18.54	165 47.75	5	865	995	272	0.3	10.0	1802	53	620	884
	117	PB	1111	47 21.05	165 48.43	10	924	1160	091	0.5	10.0	5054	89	2517	2376
	118	PB	1408	47 06.48	165 38.73	32	915	967	207	1.6	8.5	76	21	26	2
	119	PB	1617	47 05.82	165 37.87	29	750	914	095	1.5	8.0	837	441	4	88
	120	PB	1905	47 00.57	165 33.14	16	864	1017	078	0.8	9.0	178	75	1	8
	121	PB	2114	46 55.05	165 22.47	12	1026	1085	329	0.6	7.3	14529	3142	10336	987
23 Jul	122	PB	0203	46 52.12	165 30.30	32	995	1295	264	1.4	8.3	839	660	22	90
	123	PB	0441	46 55.63	165 34.61	24	890	1110	237	1.2	8.5	136	10	8	4
	124	RE	1025	46 44.17	165 25.58	31	723	1060	237	1.5	10.0	126	1	0	0
	125	PB	1317	46 57.64	165 20.51	23	1060	1159	255	1.1	7.6	1561	607	83	80
	126‡	PB	1625	46 54.84	165 23.14	20	1056	1158	334	0.9	6.7	30	4	7	4
	127	PB	2044	46 57.41	165 37.26	31	940	992	343	1.6	8.5	44	11	0	0
	128	PB	2329	46 55.14	165 25.69	9	968	1048	283	0.4	9.0	75	16	30	1
24 Jul	129	PB	0118	46 54.95	165 28.16	10	987	1050	096	0.5	7.6	22241	11959	640	9610
	130	PB	0625	47 03.45	165 44.01	35	913	963	217	1.6	8.0	557	50	0	0
	131	PB	0947	47 02.73	165 51.96	20	866	1225	126	1.0	10.5	89	10	0	1
	132	PB	1222	46 59.04	165 56.83	14	820	1205	083	0.7	11.0	130	15	0	1
	133	PB	1534	47 47.36	166 07.21	28	919	962	034	1.5	8.5	60	9	0	1
	134	PB	1934	46 45.39	166 07.37	29	846	874	037	1.5	8.5	36	0	0	0
25 Jul	135	PB	0227	46 55.31	165 21.63	24	1042	1204	313	1.0	7.4	5418	2323	1436	1505
	136	PB	0515	46 55.59	165 22.41	22	1040	1061	239	0.9	6.2	21563	9900	6610	5000
	137	PB	1321	46 54.97	165 22.21	7	1025	1056	004	0.3	8.0	26522	16447	5863	4200
	138	PB	1917	46 58.29	165 59.15	25	798	1200	138	1.4	9.5	3491	1980	25	25

Appendix 1 — *continued*

Date	Station No.	Station code*	Time	Start of tow Latitude ° 'S	Start of tow Longitude ° 'E	Trawling time (min)	Depth (m) Min.	Depth (m) Max.	Direction of tow °T	Distance towed (n. mile)	Net opening height (m)	Total catch (kg)	Species catch (kg)† ORH	Species catch (kg)† BOE	Species catch (kg)† SSO
27 Jul	139	WB	0058	45 21.61	171 41.08	30	892	1016	183	1.5	8.5	4409	0	2	4310
	140	WB	0344	45 20.91	171 40.89	16	895	923	283	0.7	8.0	49627	45329	0	4039
	141	WB	1813	45 26.95	171 35.40	31	1026	1037	033	1.5	7.8	42	0	2	3
	142	WB	2228	45 29.34	171 25.40	26	833	923	059	1.3	8.0	167	31	18	6
28 Jul	143	WB	0024	45 27.16	171 25.37	29	815	899	128	1.5	9.5	396	83	46	4
	144	WB	0346	45 20.49	171 42.36	23	913	1185	010	1.1	8.5	2490	4	0	2000
	145	WB	0616	45 18.98	171 44.41	27	932	1145	298	1.2	6.5	1575	1	724	758
	146	WB	1001	45 14.17	171 45.88	30	823	858	036	1.5	7.8	373	0	300	4
	147	WB	1411	45 16.45	171 46.29	43	835	1131	273	1.9	9.0	887	26	407	332
29 Jul	148	WB	0200	45 24.91	171 33.17	29	845	950	136	1.5	9.0	120	0	21	2
	149	WB	0520	45 21.75	171 36.07	18	1000	1135	017	1.0	7.5	99	0	33	8
	150	WB	0756	45 19.17	171 43.88	10	928	1015	296	0.5	8.0	2975	0	1014	1953
	151	WB	1052	45 20.79	171 50.18	29	1080	1135	185	1.5	9.5	107	3	59	19
	152	WB	1321	45 21.02	171 40.44	31	893	1005	272	1.5	7.5	3012	31	480	2380
	153	WB	1601	45 21.57	171 40.71	5	889	935	215	0.2	9.5	4548	3	180	4297
	154	WB	1749	45 21.18	171 42.92	54	912	1050	103	2.7	8.0	1815	4	40	1673
	155	WB	2039	45 21.22	171 40.78	47	900	1020	248	2.2	8.2	32532	20000	536	11900
30 Jul	156	WB	1134	45 21.38	171 34.47	30	871	1065	106	1.6	8.5	447	14	147	153
	157	WB	1352	45 16.23	171 46.88	31	860	909	92	1.5	8.0	509	6	31	339
	158	WB	1615	45 18.33	171 44.04	18	900	1135	265	0.8	8.0	4972	36	988	3685
	159	WB	1920	45 08.00	171 51.04	30	801	1003	106	1.5	9.0	420	3	310	10
	160	WB	2217	45 17.54	171 38.55	29	821	1020	154	1.4	9.5	147	5	51	16
31 Jul	161	WB	0012	45 20.35	171 45.08	31	925	1030	130	1.5	8.5	882	1	116	705
	162	WB	0308	45 21.43	171 43.33	30	920	985	156	1.5	7.4	955	0	109	788
	163	WB	0550	45 21.31	171 39.87	43	930	1052	222	2.0	6.5	1475	8	453	853
	164	WB	0825	45 21.61	171 40.36	40	945	1000	121	2.1	7.8	2141	3	1000	1000
	165	WB	1025	45 21.94	171 42.14	30	945	1028	236	1.5	8.0	285	0	96	87
	166	WB	1213	45 20.71	171 41.80	20	893	1189	027	1.0	9.0	1531	195	279	877
	167	WB	1406	45 19.64	171 45.11	30	925	1033	64	1.6	7.7	397	0	26	268
	168	WB	1631	45 18.99	171 44.29	21	945	1177	278	0.9	7.5	644	0	269	247
	169	WB	1924	45 13.06	171 46.50	26	823	910	37	1.5	8.0	673	8	563	11
	170	WB	2203	45 20.85	171 40.73	22	893	962	289	1.2	8.1	260	22	100	90
02 Aug	171 ‡	RE	1438	47 39.10	175 20.70	4	995	1126	326	0.2	9.0	0	0	0	0
03 Aug	172	RE	0050	47 25.30	176 29.80	31	893	909	256	1.6	9.0	126	1	0	110
	173	RE	0528	47 24.20	176 41.10	28	860	866	086	1.5	9.0	460	4	56	367
04 Aug	174	RE	0054	47 26.60	177 41.90	107	890	976	037	5.2	8.0	215	1	8	25
	175	RE	0737	47 29.90	178 02.80	24	780	805	062	1.5	8.0	18	0	1	1
	176	RE	1300	47 21.20	178 07.40	48	906	1030	006	2.4	9.0	3954	0	0	3939
	177	RE	2247	47 18.00	178 41.20	17	804	804	076	0.8	8.0	18000	5	0	16926
05 Aug	178	RE	0745	47 16.20	179 15.50	26	736	937	015	1.3	8.0	4711	0	0	4696
	179	RE	1638	47 19.30	179 48.30	135	790	1200	040	7.8	8.0	73	1	0	52
07 Aug	180	RE	2318	47 36.60	179 18.60	172	762	1140	053	10.0	8.5	250	1	0	148
	181	RE	1339	47 51.80	179 02.70	14	960	1089	299	0.6	8.0	22	0	0	15
	182	RE	1842	47 55.70	179 09.80	59	808	918	298	3.0	8.0	100	1	0	95
08 Aug	183	RE	1859	47 41.90	178 02.60	61	785	909	235	3.3	8.0	60	1	0	0
09 Aug	184	RE	0013	47 35.20	177 54.30	63	972	1000	244	3.0	8.0	87	0	0	3
10 Aug	185	RE	0455	45 21.30	171 40.80	18	895	966	180	0.8	8.0	6520	1872	246	4457
	186	RE	0712	45 20.90	171 40.30	24	895	1000	275	1.1	8.0	3213	749	620	1693
	187	RE	0918	45 21.10	171 40.70	38	908	1036	247	1.8	8.0	25673	15745	34	9494

* RE = Exploratory; PB = Puysegur biomass; WB = Waitaki biomass.
† Rounded to the nearest kilogram.
‡ Gear damage or fast.

Appendix 2: Species caught

Echinodermata

Holothuroidea (sea cucumber)
Echinoidea (Haggis urchins)
Asteroidea (starfish)

Crustacea

Neolithodes brodiei (southern stone crab)
Lithodes murrayi (southern stone crab)
Pasiphaea barnardi
Gnathophausia ingens (mysid)
Cerathotha sp. (red isopod)

Cephalopoda

Moroteuthis spp. (warty squid)
Histioteuthis spp. (violet squid)
Nototodarus sloanii (arrow squid)
Gonatus sp.
Ommastrephes bartrami (red squid)

Octopoda

Octopoteuthis sp.
Opisthoteuthis spp. (umbrella octopus)

Chondrichthyes

Selachiformes

Centrophorus squamosus (leafscaled gulper shark)
Centroscymnus coelolepis (Portuguese spiny dogfish)
C. crepidater (longnosed velvet dogfish)
C. owstoni (Owston's spiny dogfish)
C. plunketi (Plunket's shark)
Centroscymnus sp. A (roughskinned *Centroscymnus*)
Scymnorhinus licha (seal shark)
Deania calcea (shovelnosed spiny dogfish)
Etmopterus baxteri (Baxter's lantern dogfish)
E. lucifer (Lucifer spiny dogfish)
Squalus acanthias (spiny dogfish)
Mustelus lenticulatus (rig)
Apristurus sp. A (catshark)
Apristurus sp. B (catshark)
Apristurus sp. C (catshark)
Apristurus sp. E (catshark)

Rajiformes

Raja nasuta (rough skate)
Bathyraja sp. (bluntnosed skate)
B. shuntovi (pale longnosed skate)
Pavoraja spp.
P. asperula
P. spinifera

Chimaeriformes

Hydrolagus sp. (black hydrolagus)
Hydrolagus sp. B (pale ghost shark)
Hydrolagus sp. C (purplefinned *Hydrolagus*)
Harriotta raleighana (longnosed chimaera)
Rhinochimaera pacifica (widenosed chimaera)

Osteichthyes

Anguilliformes

Diastobranchus capensis (basketwork eel)
Notacanthus sexspinis (spineback eel)
Nemichthys scolopaceus (slender snipe eel)

Salmoniformes

Bathylagus spp. (deepsea smelt)
Alepocephalus australis (smallscaled brown slickhead)
Alepocephalus sp. (bigscaled brown slickhead)

Stomiiformes

Photichthys argenteus (lighthouse fish)
Chauliodus sloani (viperfish)
Opostomias micripinis (giant black dragonfish)
Stomias spp. (scaly dragonfish)
Melanostomiidae (scaleless black dragonfish)
Idiacanthus spp. (starry dragonfish)
Astronesthes sp. (snaggletooth)

Aulopiformes

Paralepididae (barracudina)

Myctophiformes

Lampanyctus spp. (lantern fish)

Gadiformes

Pseudophycis bachus (red cod)
Mora moro (ribaldo)
Antimora rostrata (violet cod)
Halargyreus johnsoni (Johnson's cod)
Lepidion microcephalus (smallheaded cod)
L. schmidti (giant lepidion)
Austrophycis marginata (dwarf cod)
Tripterophycis gilchristi (grenadier cod)
Merluccius australis (hake)
Macruronus novaezelandiae (hoki)
Lyconus sp.
Trachyrincus spp. (white rattail)
Gadomus aoteanus (filamentous rattail)
Caelorinchus bollonsi (Bollons's rattail)
C. fasciatus (banded rattail)
C. oliverianus (Oliver's rattail)
C. innotabilis (notable rattail)
C. kaiyomaru (Kaiyomaru rattail)
C. matamua (Mahia rattail)
Caelorinchus sp. K2 (spottyfaced rattail)
Coryphaenoides serrulatus (serrulated rattail)
C. subserrulatus (fourrayed rattail)
C. murrayi (Murray's rattail)
Lepidorhynchus denticulatus (javelinfish)
Trachonurus villosus
Macrourus carinatus (ridgescaled rattail)
Nezumia namatahi (squashedfaced rattail)
Nezumia sp. P (false bulbous rattail)
Mesobius antipodum (bathypelagic rattail)

Ophidiiformes

Brotulotaenia crassa (cusk eel)
Genypterus blacodes (ling)

Beryciformes

Melamphaidae (big scale fish)
Hoplostethus atlanticus (orange roughy)

Lophiiformes

Cryptopsaras couesi (sea devil)

Zeiformes

Cyttus traversi (lookdown dory)
Pseudocyttus maculatus (smooth oreo)
Allocyttus niger (black oreo)

Lampridiformes

Trachipterus trachipterus (dealfish)

Scorpaeniformes

Cottunculus nudus (bonyskull toadfish)
Neophrynichthys angustus (pale toadfish)
Psychrolutes sp. (blobfish)

Perciformes

Epigonus lenimen (bigeyed cardinalfish)
E. telescopus (black cardinalfish)
E. robustus (robust cardinalfish)
Brama brama (Ray's bream)
Hyperoglyphe antarctica (bluenose)
Schedophilus huttoni
Tubbia tasmanica
Seriolella caerulea (white warehou)

Pleuronectiformes

Mancopsetta sp. (finless flounder)

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