Exploratory fishing for orange roughy and oreos in regions of the Macquarie Ridge and Pukaki Rise, July 1993

> Malcolm R. Clark Chris D. B. Thomas

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Inquiries to: The Editor, MAF Fisheries Greta Point, PO Box 297, Wellington New Zealand.

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Abstract

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An exploratory survey for orange roughy in southern New Zealand waters was carried out in July 1993 by FV *San Waitaki*. The principal objectives were to map the distribution and abundance of orange roughy and to assess commercial prospects for orange roughy and other deepwater species.

Exploratory fishing and searching covered large sections of the Macquarie Ridge south of 48_ S, as well as areas of slope between the Snares Islands and the Auckland Islands, and in regions of the Pukaki Rise and south Otago coast. Orange roughy, smooth oreo, and black oreo were the main species caught.

Orange roughy were caught throughout the area surveyed. Catches were generally small, except on two hill features near the Snares Islands and Auckland Islands. Spawning aggregations were found, but the distribution of fish was very localised and catch rates on the hills were highly variable. Commercial potential appears limited.

Smooth oreo were widely distributed, with more consistent catches than of orange roughy. Catches were large on several hills of the Macquarie Ridge, and catch rates were moderate off the Otago coast.

Black oreo were concentrated on the hill near the Snares Islands, with small catches elsewhere.

Biological data on size structure, sex ratios, and reproductive condition are presented for orange roughy, smooth oreo, and black oreo.

Introduction

Several exploratory fishing voyages for orange roughy in southern New Zealand waters have been carried out by The Exploratory Fishing Company (ORH 3B) Ltd. (EFC) in association with MAF Fisheries. In 1991 FV Will Watch searched from Puysegur Bank south down the Macquarie Ridge and western side of the Campbell Plateau (Clark & Tracey 1992). Spawning aggregations of orange roughy were located on the western side of Puysegur Bank, and a substantial fishery has since developed. The second survey, by FV Giljanes in July 1992, covered an area off the Otago coast from south of the Chatham Rise, along the northern flank of the Pukaki Rise, and around the Bounty Islands (Clark & Tracey 1993). Spawning was confirmed around the Waitaki Canyon, but the area was small and catch rates highly variable. In both years a research trawl survey of the Puysegur Bank orange roughy stock was conducted.

A further voyage was organised for July 1993, and FV San Waitaki was chartered by the EFC to explore further the Macquarie Ridge and Pukaki Rise regions. The voyage was planned and carried out as a cooperative venture between the EFC and MAF Fisheries, but in contrast to the previous surveys was solely exploratory with no specific research survey component.

Objectives

The main objectives were:

- 1. to undertake exploratory commercial fishing in southern parts of the ORH 3B Quota Management Area to map the distribution and abundance of orange roughy;
- 2. to measure catch rates of orange roughy and bycatch species to assess their commercial potential;
- 3. to map and update the fisheries bathymetry in these areas.



Figure 1: The survey area showing the positions of trawl stations and the regional boundaries. (Regional codes are defined under data analysis, page 8.)

Vessel and gear

San Waitaki is a New Zealand factory trawler owned by Sanford Ltd., Auckland. It has the following specifications: overall length, 42.9 m; beam, 11 m; gross registered tonnage, 784 t; engine power, 1565 kW.

Trawl gear was fairly standard for rough bottom orange roughy and oreo fishing. The net was a standard 6 panel bottom trawl with cutaway lower wings. Gear set up was altered once during the voyage when, from tow number 97, sweep length was increased from 45 to 90 m.

Survey area

The voyage focused on northern areas of the Macquarie Ridge, from a hill feature called "Bob's Gun", where promising catches had been made previously, south to areas off the Auckland Islands. A separate region covering the north side of the Pukaki Rise was also explored (Figure 1).

Fishing methods

Searching and fishing covered depths of 800–1500 m. Effort was initially on charted hill and bank features which seemed promising for orange roughy or oreos. Much of the searching relied on detecting marks and features on the echosounder, and trawls were carried out in likely areas of fish abundance or where marks were seen. Several areas where bathymetry was poorly known were searched, and bathymetric data were collected, when steaming between other features or when processing fish.

Vessel position and depth were recorded manually on "Seaplot" to update files from the 1991 *Will Watch* survey.

Treatment of catch

The catch at each station was estimated by eye or calculated from factory figures of processed catch. In the latter instances, total weights of orange roughy and oreos were backcalculated from processed weight using conversion factors and block weights measured on board. Average conversion factor values of processed weight to greenweight were: orange roughy, 2.05; black oreo, 2.55; smooth oreo, 2.35.

Average tray weights were: orange roughy, 13.5 kg; black oreo, 11.0 kg; smooth oreo, 12.5 kg.

When catches from several tows were mixed, total processed figures were apportioned to tows on the basis of estimated catch ratios.

Emphasis was placed on recording catch weight of orange roughy, smooth oreo, and black oreo. Other species were identified and weighed infrequently, and these catch weights are not analysed in detail.

Samples of orange roughy, black oreo, and smooth oreo were taken for more detailed study. Samples of 100–200 fish of each species were measured (orange roughy, standard length; black oreo and smooth oreo, total length), sexed, and gonad stage was recorded (Table 1). Additional samples were taken for fecundity studies, morphometric/meristic comparisons, and genetic analysis.

Gonad staging was based on the following:

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	न्त्र)
8	Partially spent	Partially spent

Table 1: Origin of biological data collected

Area*	No. of trawls in which caught	No, of trawls sampled	No. of fish measured
Orange roughy	0		
FCSI	3	0	0
PUKR	11	6	47
SNAR	34	11	1 758
MACO	10	2	67
AUCK	13	4	482
Smooth area	10	т	102
	0	0	200
ECSI	9	2	396
PUKR	15	2	152
SNAR	39	2	215
MACQ	22	2	345
AUCK	19	1	176
Black oreo			
ECSI	6	1	181
PUKR	12	1	232
SNAR	39	2	307
MACQ	18	1	146
AUCK	5	0	0

* ECSI, southeast of the Otago coast; PUKR, Pukaki Rise area; SNAR, "Bob's Gun" region; MACQ, "Frazerland" south to "Jacko's" and "Christable"; AUCK, slope and hills ("D.S.W." complex) around the Auckland Islands.

Data analysis

Three main types of analyses are presented in this report.

1. Catch and catch rate

Catch rates (kg.km⁻¹) were determined from estimated catch weights and the calculated distance between start and finish positions.

2. Length frequency distributions

Length frequency data have been scaled by percentage sampled to represent each trawl catch, and by distance towed to standardise between tows.

3. Reproductive stages

Levels of maturing, ripe/running ripe, and spent fish were plotted over the course of the voyage to monitor progression of spawning of orange roughy.

The area covered during the voyage was divided into five regions (*see* Figure 1):

ECSI, southeast of the Otago coast

PUKR, Pukaki Rise area

SNAR, "Bob's Gun" region

MACQ, "Frazerland" south to "Jacko's" and "Christable"

AUCK, slope and hills ("D.S.W." complex) around the Auckland Islands.

Results

Total catch and catch composition

Detailed station data and catch information on orange roughy, smooth oreo, and black oreo are given in Appendix 1 for the 116 trawls completed. Station positions are shown in Figure 1.

The recorded catch for the trip was 751 849 kg. This comprised 17 species of fish (Table 2), though numerous others were caught but not weighed. A list of species caught is given in Appendix 2. The main species were black oreo (310 430 kg) and smooth oreo (286 056 kg) which accounted for 41 and 38%, respectively, of the catch. Orange roughy totalled 152 278 kg (20% of the catch).

Catch distribution and catch rates

Orange roughy

Orange roughy were caught throughout the survey area. Most of the catch (over 141 000 kg: 93% of the orange roughy total) was taken in the SNAR area around "Bob's Gun" (Table 2). Catch rates on "Bob's Gun" were frequently about 10 000 kg.km⁻¹, with a maximum of 16 600 kg.km⁻¹ (Figure 2). High catch rates occurred in only one other region, on a hill complex ("D.S.W.") northwest of the Auckland Islands. Catches were small on southern hills of the Macquarie Ridge and on the Pukaki Rise.

Table 2: Catch (kg) by area of orange roughy, smooth oreo, and black oreo, and total recorded catches of other species

					Area code*	
	SNAR	MACQ	AUCK	PUKR	ECSI	Total
Orange roughy	141 452.3	581.3	10 196.0	46.9	1.3	152 277.8
Smooth oreo	86 865.0	63 680.0	78 313.5	16 386.5	40 811.5	286 056.5
Black oreo	246 190.6	46 834.0	3 030.7	8 713.1	5 661.8	310 430.2
White warehou						120.0
Baxter's dogfish						50.0
Ribaldo						300.0
Hoki						821.0
Ling						7.0
Hake						1 757.5
Basketwork eel						0.7
Paleghost shark						3.0
Purple Hydrolagus						1.0
Javelinfish						6.0
Longnosed chimaera						4.4
Ragfish						1.8
Black javelinfish						5.5
Slickhead						6.0
Total						751 849.4
* Area codes are given in 7	Table 1.					



Figure 2: Catch rates (kg.km⁻¹) of orange roughy. Names refer to major hill features.



Figure 3: Catch rates (kg.km⁻¹) of smooth oreo. Names refer to major hill features.

Smooth oreo

Smooth oreo were widely distributed and relatively abundant (Table 2, Figure 3). There was a more even distribution of catch between areas than with orange roughy. Catches were large on several hills of the Macquarie Ridge. Catch rates of 1000–10 000 kg.km⁻¹ occurred on hills of "Searle City" and "D.S.W.", and over 10 000 kg.km⁻¹ on "Bob's Gun". The maximum catch rate was 26 100 kg.km⁻¹, on the southwesternmost hill of the Ridge ("Jacko's"). Moderate catch rates were also recorded off the Otago coast.

Black oreo

Black oreo were concentrated on "Bob's Gun" (Table 2, Figure 4) and catch rates were up to 20 000 kg.km⁻¹. Smaller catches occurred on southern hills of the Macquarie Ridge, and off the Otago coast. Catch rates off the Auckland Islands and on the Pukaki Rise were relatively low.

Size structure

Orange roughy

Length frequency distributions of orange roughy from the SNAR and AUCK regions are given in Figure 5. Fish from SNAR ("Bob's Gun") overall had a unimodal distribution, with the peak at 35– 37 cm. The female modal peak was at 39 cm and that of the males was at 35 cm.

The number of fish measured and number of trawls sampled were less for the AUCK region. The length frequency distribution was spiky, with peaks at 33 cm (representing the male mode) and at 37 cm (the female peak). Overall, the distribution comprised smaller fish than from the SNAR region.

Sex ratios differed between the areas: there were more males in SNAR (58%) than in the AUCK samples (38%).

Few orange roughy were caught or measured in the other areas, so length frequencies are not given.

Smooth oreo

Length frequency distributions for smooth oreo by region are given in Figure 6. Sample sizes, and the number of trawls sampled, were generally small, so the distributions tend to be spiky. It is uncertain how representative the small samples are, which limits interpretation of modes, but some differences are apparent between areas. Fish from ECSI and PUKR were predominantly male with a unimodal peak at 30–35 cm. Smooth oreo from the southern areas had a more even sex ratio, and the distributions were dominated by fish of 35–45 cm length.

Black oreo

Black oreo length frequency distributions were also constructed from small sample sizes and few tows (Figure 7). Fish in ECSI and PUKR areas were mainly 30–35 cm long, and showed a tight length distribution. The SNAR and MACQ regions had larger fish, with the main modal peak at about 35–36 cm.

Reproductive biology

Orange roughy

A summary of gonad stage proportions by area is given in Table 3. Sample sizes were small for PUKR and MACQ. The former were mainly small fish which showed little gonad development. Maturing and ripe orange roughy were caught in MACQ, but in very small numbers.

There were clear indications of spawning activity in the SNAR and AUCK regions, with 100% and 91% respectively of fish sampled from these areas being classified as spawners in winter 1993. The main hill features in the SNAR ("Bob's Gun") and AUCK ("D.S.W.") regions were sampled several times during the voyage. Plots of maturing, ripe, and spent proportions by date in SNAR indicate peak spawning occurred towards the end of July (Figure 8). There were fewer data for AUCK, but these also indicated late July spawning.

Smooth oreo

Most smooth oreo in the PUKR and MACQ areas were in an early maturation stage (Table 4). No advanced stages were recorded, which is consistent with smooth oreo spawning later in the year.

Black oreo

Black oreo were also in maturing stages (Table 5), but were more advanced than smooth oreo.

Table 3: Gonad stage proportions of orange roughy by area (male and female combined)

			Ar	ea code*
	PUKR	SNAR	MACQ	AUCK
Immature/resting	11.8	0	1.5	0.4
Early maturation	60.8	0	13.4	8.3
Maturing	9.8	55.3	31.3	63.8
Ripe/running ripe	5.9	42.4	53.8	15.4
Spent	11.7	2.3	0	12.1
Sample size	51	1 601	67	480
* Avec codec ave aire	un in Table 1			

* Area codes are given in Table 1.

Table 4: Gonad stage proportions of smooth oreo by area (male and female combined)

Area code*

FCSI	DUIZD
100.	PUKK
0	11.7
91.2	85.4
8.8	2.9
0	0
0	0
102	137
	0 91.2 8.8 0 0 102

* Area codes are given in Table 1.



Figure 4: Catch rates (kg.km⁻¹) of black oreo. Names refer to major hill features.

Table 5: Gonad stage proportions of black oreo by area (male and female combined)

		Area code [*]
	PUKR	MACQ
Immature/resting	5.3	6.9
Early maturation	25.5	34.9
Maturing	69.2	58.2
Ripe/running ripe	0	0
Spent	0	0
Sample size	94	146
* Area codes are given in Table 1.		

14 SNAR ORH N(m) = 1758N(t) = -1112 Total Male 10 Female 8-6-4 Percentage frequency 2-0 14 AUCK ORH N(m) = 482 $\dot{N}(t) =$ 4 12-10-8 6 4-2-0-45 10 15 20 25 30 35 40 50 Standard length (cm)



Figure 5: Length frequency distribution of orange roughy from the SNAR and AUCK regions, scaled to represent total catch. N(m) = number of fish measured; N(t) = number of trawls with samples.

Figure 6: Length frequency distribution of smooth oreo by area, scaled to represent total catch. N(m) = number of fish measured; N(t) = number of trawls with samples.

Discussion

The voyage covered northern parts of the Macquarie Ridge and explored areas of potential identified during previous research and commercial surveys. Additional southern regions were searched where bathymetry was poorly known, and several new hills were discovered. Parts of the Pukaki Rise were also fished, but in less detail than the Macquarie area.

Spawning concentrations of orange roughy were identified in two locations: "Bob's Gun" and "D.S.W." "Bob's Gun" was fished in June and July 1991 during the survey by *Will Watch*, but although several good catches were taken, distribution was patchy. The voyage this year fished the hill intensively over a number of weeks. A part of the ridge on the northern side yielded some high catch rates, and almost all the orange roughy caught during the trip came from this site. However, these catches were very localised and irregular. A more detailed examination of catches on "Bob's Gun" (Figure 9) shows clearly the very tight line of fishing and small area over which high catch rates occurred. Further consideration of catches over time (Figure 10) indicates highly variable catches from tow to tow. Catches were small early in July, but increased and were relatively large over a 2 week period from the middle of July. This could suggest that fish moved on to the hill for spawning. Catches decreased again at the end of July, but with only two tows in that period it is unclear whether this was the result of inherent variability in catches on the hill evident over the entire period, or of fish having migrated away after spawning. Catch rates during the 1991 Will Watch survey were also variable in June-July, and catches were small in August-September 1992 in a survey by Tangaroa. These observations on the extent, variability, and duration of catches on "Bob's Gun" are consistent with there being a small stock of orange roughy which aggregates on a part of the hill for spawning and disperses quickly afterwards. Commercial significance is probably limited.

The "D.S.W." hills appear to have less commercial potential. They are very small features and only two significant catches of orange roughy were taken there (*see* Figure 10). Most trawls caught few fish.

Black oreo and smooth oreo were widely distributed and relatively abundant on hills of the Macquarie Ridge. This voyage confirmed findings of the *Will Watch* survey and other commercial trips that oreos are the more abundant species in the region and orange roughy is effectively a bycatch species.



Figure 7: Length frequency distribution of black oreo by area, scaled to represent total catch. N(m) = number of fish measured; N(t) = number of trawls with samples.

Figure 8: Daily changes in the proportion of gonad stages of orange roughy in the SNAR region (smoothed curves). (Dotted line = maturing; solid line = ripe/running ripe; dashed line = spent.)





Figure 9: Catch rates (kg.km⁻¹) of orange roughy in the "Bob's Gun" area.

The large northern flank of the Pukaki Rise was not explored in much detail with the time available. Few orange roughy were caught, and most were small. Catches of black oreo and smooth oreo were moderate in the western corner, as well as further north in the "Nugget Nook" area. Oreo fisheries have occurred over much of the Pukaki Rise in the past, and the western end is an established fishing ground. The general area may warrant more detailed searching in future.



Figure 10: Catch of orange roughy in individual tows by day in the SNAR and AUCK regions.

Acknowledgments

We thank Steve Jackson and the crew of *San Waitaki* for their willing cooperation during the voyage and George Clement and Simon Gibb for onshore liaison. Special thanks to Chris Carey for helping to collect data and samples during the trip. Di Tracey helped to collate and check data before punching.

References

- Clark, M. R. & Tracey, D. M. 1991: Trawl survey of orange roughy in southern New Zealand waters, June-July 1991. N.Z. Fisheries Technical Report No. 32. 27 p.
- 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.

Appendix 1: Individual station data and catches of orange roughy (ORH), smooth oreo (SSO), and black oreo (BOE)

				Start of tow		Distance					
			Latitude	Longitude	Depth (m)	towed	Course				Catch (kg)
Stn	Area	Start date	°S	°Έ	Min. Max.	(n. mile)	(°T)	Total	ORH	SSO	BOE
1	ECSI	1 Jul 93	46 20.91	170 58.90	923 111	1.48	0	0.0	0.0	0	0.0
2	ECSI	1 Jul 93	46 39.55	170 55 35	142 1 216	1.66	100	20.6	1.3	16.5	2.8
3	SNAR	3 Jul 93	48 00.35	165 10.86	890 1 009	0.49	50	790.7	0.0	117.5	673.2
4	SNAR	3 Jul 93	48 00 50	165 10,60	997 1 120	0.88	107	463.4	2.7	264.4	196.3
5	SNAR	3 Jul 93	48 01.40	165 10.57	926 963	0.74	57	2 279.7	0.0	793.1	1 486.6
6	SNAR	3 Jul 93	48 00.37	165 10.61	877 970	0.29	130	8 762.0	858.0	1 310.0	6 594.0
0	SNAR	3 JUI 93	48 00.24	165 10.60	868 977	0.53	126	2 000.0	0.0	10 744.0	1 400.0
0 0	SNAR	5 101 93	40 09.29	165 10 73	997 1 159	1.33	202	54 435.0 16 425 0	442.0	2 250 0	12 622 0
10	SNAR	5 101 93	48 00.02	165 11 52	1 000 1 275	1.58	206	1 202 0	443.0	2 330.0	1 23/ 0
11	SNAR	6 Jul 93	48 00 17	165 10 72	867 980	0.46	90	3 082 6	968.6	235.0	1 879 0
12	SNAR	6 Jul 93	47 59.56	165 10.82	864 980	0.40	90	4 326.5	0.0	1 586.0	2 740.5
13	MACQ	6 Jul 93	48 58.67	164 33.37	776 1 000	0.42	295	0.0	0.0	0.0	0.0
14	MACQ	7 Jul 93	49 09.53	164 19.28	838 963	0.24	185	1 056.0	4.0	940.0	112.0
15	MACQ	7 Jul 93	49 08.74	164 19.94	807 1 036	0.61	90	1 125.0	0.0	676.0	449.0
16	MACQ	7 Jul 93	49 08.36	164 17.98	821 1 100	0.49	300	804.0	0.0	411.0	393.0
17	MACQ	7 Jul 93	49 08.30	164 18.14	802 1 054	0.59	320	5 700.0	0.0	3 700.0	2 000.0
18	MACQ	7 Jul 93	49 09.06	164 17.77	808 1 007	0.55	265	6 545.0	0.0	45.0	6 500.0
19	MACQ	7 Jul 93	49 09.82	164 18.87	854 1 120	1.14	190	3 435.0	0.0	45.0	3 390.0
20	MACQ	8 Jul 93	50 05.58	163 30.37	1 018 1 183	0.24	88	263.0	0.0	235.0	28.0
21	MACQ	8 Jul 93	50 01.48	163 43.42	958 965	0.14	74	558.5	1.5	529.0	28,0
22	MACQ	8 Jul 93	51 00.08	164 32.73	945 1 075	2.18	271	379.8	27.8	352.0	0.0
23	MACQ	8 Jul 93	51 03.95	164 35.97	950 996	1.86	185	728.0	28.0	350.0	0.0
24	AUCK	9 Jul 93	50 04.54	165 55.17	1008 1230	1.13	44	11 497.0	277.0	11 220.0	0,0
20	AUCK	9 Jul 93	50 03.14	165 57.04	1012 1100	0.87	270	1 520.0	5.0	1 520 0	0.0
20	AUCK	9 Jul 93	50 05.83	165 54.95	990 1 2/1	1 68	225	3 521 0	55.0	3 466 0	0.0
28	ALICK	10 Jul 93	50 04 76	165 56 23	1 012 1 200	0.63	30	3 440 0	0.0	3 440 0	0,0
29	AUCK	10 Jul 93	50 05 18	165 53 77	995 995	0.00	276	18 000 0	0.00	12 000 0	0.0
30	AUCK	10 Jul 93	50 05.23	165 53.84	997 1 252	1.06	270	1 000.0	500.0	500.0	0.0
31	AUCK	10 Jul 93	50 05.05	165 56.11	990 1 144	0.88	100	10 985.0	250.0	10 735.0	0.0
32	MACQ	10 Jul 93	50 07.16	165 59.41	859 1 183	0.94	180	0.0	0.0	0.0	0.0
33	MACQ	11 Jul 93	49 08.28	164 18.35	802 1 050	0.54	315	15 550.0	50.0	7 000.0	8 500.0
34	MACQ	11 Jul 93	49 09.58	164 18.95	833 1 030	0.57	189	8 881.0	60.0	4 867.0	3 954.0
35	MACQ	11 Jul 93	49 08.16	164 1 8.18	828 1 210	0.65	330	7 743.0	250.0	3 818.0	3 675.0
36	MACQ	12 Jul 93	49 08.34	164 18.63	785 920	0.26	326	172.0	0.0	88.0	84.0
37	MACQ	12 Jul 93	49 09.71	164 18.70	828 1 420	0.79	194	10 009.0	0.0	1 145.0	8 864.0
38	MACQ	12 Jul 93	49 08.08	164 18.20	793 1 103	0.44	326	5 282.0	55.0	2 085.0	3 142.0
39		12 JUI 93	48 38.44	164 52.48	860 960	0.89	76	1 582.0	55.0	1 527.0	0.0
40	SNAR	13 JUL 93	47 59.72	165 08.53	852 996	0.39	274	25 000.0	12 000.0	7 000.0	6 000.0
41	SNAR	12 10 02	47 59.64	165 09 61	070 T 040	0.52	200	5 000.0	0.0	2 500.0	2 500.0
42	SNAR	13 Jul 93	47 59.63	165 08 83	870 960	0.55	260	5 005 0	090.0 5.0	1760.0	2 000.0
44	SNAR	13 Jul 93	48 00 14	165 10 70	849 928	0.00	60	16 978 0	4 207 0	2 056 0	10 715 0
45	SNAR	13 Jul 93	47 59 78	165 08 62	866 1 100	0.66	260	25 766 0	12 620.0	2 291 0	10 855 0
46	SNAR	14 Jul 93	47 59.69	165 00.94	941 1 130	0.53	157	3 050.0	50.0	1 500.0	1 500.0
47	SNAR	14 Jul 93	47 59.69	165 08.55	870 1 118	0.63	275	16 800.0	3 300.0	3 500.0	10 000.0
48	SNAR	14 Jul 93	47 58.29	164 58.95	942 1 208	0.34	330	3 290.0	140.0	350.0	2 800.0
49	SNAR	15 Jul 93	47 59.64	165 10.60	872 1 057	0.72	90	20 376.0	498.0	1 470.0	18 288.0
50	SNAR	15 Jul 93	47 59.91	165 10.77	867 1 145	0.95	75	24 734.0	19 540.0	1 940.0	3 254.0
51	SNAR	15 Jul 93	48 00.12	165 10.76	886 1 121	0.92	80	5 556.0	692.0	881.0	3 983.0
52	SNAR	16 Jul 93	47 59,64	165 10.60	896 1 068	0.78	90	7 415.0	2 463.0	352.0	4 600.0
53	SNAR	16 Jul 93	48 00.17	165 08.75	876 1 025	0.62	250	26 787.0	8 170.0	617.0	18 000.0
54	SNAR	16 Jul 93	49 08.77	166 24.45	934 1 079	2.02	205	50.0	20.0	30.0	0,0
55	SNAR	18 Jul 93	48 00.02	165 10.76	863 969	0.30	75	18 400.0	6 310.0	3 700.0	8 390.0
56	SNAR	18 Jul 93	47 59.55	165 10.68	878 1 044	0.46	75	2 033.0	3.0	30.0	2 000.0
57	SNAR	18 Jul 93	47 59.69	165 10.72	864 1 164	1.00	95	1 032.0	2.0	30.0	1 000.0
58	SNAR	18 Jul 93	47 59.97	165 10.72	863 1 106	0.89	85	29 190.0	22 580.0	2 350.0	4 260.0
29	SNAR	21 JUL 93	47 59.86	165 10.80	879 990	0.33	96	2 558.0	62.0	646.0	1 850.0
61	SNAR	21 JUL93	40 00.06	165 01 00	0/0 1 1 18 0/6 1 170	0.84	105	1411.0	94.0	0.180	10 140 0
62	SNAR	21 JUL93	47 59.44	165 09 71	940 11/8 002 1110	0.64	125	40 068.0	300.0	21020.0	10 148.0
62	SNAR	22 JUI 33	47 50 64	165 10 60	202 I I 10 262 I 100	0.73	290	2 020.0	1 090.0	1 000 0	4 020.0
64	SNAR	22 Jul 93	47 50 00	165 10.09	863 1 002	0.97	20	2 UZU.U 11 020 N	20.0 7 603 0	6/6.0	3 500.0
65	SNAR	25 Jul 93	48 00 52	165 10 83	853 1 080	0.87	90	29 186 0	21 920 0	646 0	6 620 0
66	SNAR	25 Jul 93	47 59 80	165 08 59	871 1 064	0.00	269	12 030 0	4 500 0	530.0	7 000 0
67	SNAR	25 Jul 93	48 00.46	165 10.76	863 1 079	0.89	90	6 150.0	90.0	1 000.0	5 060.0
68	AUCK	26 Jul 93	50 04.77	165 56.22	1 003 1 208	0.73	38	7 942.0	16.0	7 870.0	56.0
69	AUCK	28 Jul 93	50 04.84	165 53.67	1 000 1 240	0.95	285	19 395.0	2 800.0	16 595.0	0.0

Appendix 1 – *continued*

				Start of tow			Distance					
			Latitude	Longitude	De	pth (m)	towed	Course			(Catch (kg)
Stn	Area	Start date	° ´S	°Έ	Min.	Max.	(n. mile)	(°T)	Total	ORH	SSO	BOE
70	AUCK	29 Jul 93	50 05.04	165 53.78	1 000	1 231	0.91	270	1 520.0	20.0	1 500.0	0.0
71	AUCK	29 Jul 93	50 02.37	165 59.20	830	832	0.13	35	10.0	4.0	5.0	1.0
72	AUCK	29 Jul 93	49 08.12	164 18.37	804	1 250	0.59	335	5 600.0	100.0	3 000.0	2 500.0
73	AUCK	29 Jul 93	49 08.59	164 17.80	795	1 031	0.41	307	1 001.0	3.0	525.0	473.0
74	SNAR	30 Jul 93	48 00.14	165 10.76	879	1 050	0.67	90	12 700.0	2 700.0	1 000.0	9 000.0
75	SNAR	30 Jul 93	47 59.53	165 10.71	884	1 076	0.66	80	6 917.0	12.0	645.0	6 260.0
76	MACQ	30 Jul 93	48 38.41	164 52.75	860	1 046	0.79	95	4 625.0	50.0	4 525.0	50.0
77	MACQ	30 Jul 93	49 09.78	164 18.73	879	1 128	0.89	188	3 717.0	0.0	1 527.0	2 190.0
78	MACQ	30 Jul 93	49 09.65	164 18.80	821	1 024	0.75	189	3 780.0	0.0	1 705.0	2 075.0
79	MACQ	31 Jul 93	49 27.54	164 07.66	867	1 011	0.29	100	0.0	0.0	0.0	0.0
80	MACQ	31 Jul 93	50 02.22	163 42.41	959	1 102	0.58	185	29 500.0	0.0	28 100.0	1 400.0
81	MACQ	31 Jul 93	50 02.02	163 42.21	940	950	0.14	180	10.0	0.0	10.0	0.0
82	MACQ	31 Jul 93	50 05.11	163 28.14	1 068	1 068	0.03	315	0.0	0.0	0.0	0.0
83	AUCK	1 Aug 93	50 58.03	165 39.22	837	900	0.03	332	2.2	0.0	1.5	0.7
84	AUCK	1 Aug 93	50 58.06	165 39.36	729	857	0.20	359	0.0	0.0	0.0	0.0
85	AUCK	2 Aug 93	50 04. 9 4	165 53.63	1 014	1 263	0.84	272	350.0	0.0	350.0	0.0
86	AUCK	2 Aug 93	50 04.65	165 56.10	1 027	1 254	0.64	33	1 200.0	0.0	1 200.0	0.0
87	AUCK	3 Aug 93	50 05.81	165 54.57	991	1 201	1.40	200	3 133.0	166.0	2 967.0	0.0
88	AUCK	3 Aug 93	50 08.39	165 58.62	961	1 140	0.64	270	587.0	0.0	587.0	0.0
89	MACQ	3 Aug 93	50 05.25	163 27.62	1 071	1 171	0.15	305	0.0	0.0	0.0	0.0
90	MACQ	3 Aug 93	50 03.67	163 37.51	1 006	1 150	0.32	270	0.0	0.0	0.0	0.0
91	MACQ	4 Aug 93	50 01.39	163 48.86	949	949	0.06	90	0.0	0.0	0.0	0.0
92	PUKR	5 Aug 93	48 32.30	170 08.22	906	1 026	8.40	140	403.0	1.0	70.0	14.0
93	PUKR	6 Aug 93	48 35.37	170 27.85	957	1 080	9.71	80	282.0	12.0	100.0	0.0
94	PUKR	6 Aug 93	48 34.66	170 45.22	906	970	9.86	50	358.0	9.0	29.0	112.0
95	PUKR	6 Aug 93	48 36.30	171 09.69	837	885	8.15	90	197.8	6.0	118.0	2.0
96	PUKR	6 Aug 93	48 29.51	172 07.86	905	976	9.09	75	43.6	2.5	6.5	4.5
97	PUKR	6 Aug 93	48 28.90	172 26.76	940	1 076	6.45	90	11.1	0.0	8.0	0.6
98	PUKR	7 Aug 93	48 14.77	172 07.14	1 112	1 1 1 4	12.23	240	3.0	0.0	3.0	0.0
99	PUKR	7 Aug 93	48 11.74	171 17.00	1 165	1 220	9.89	270	5.5	0.0	0.0	0.0
100	PUKR	7 Aug 93	48 34.01	170 25.96	962	1 070	2.38	12	198.3	3.3	15.0	0.0
101	PUKR	8 Aug 93	48 35.39	170 22.52	968	1 068	2.25	270	4.0	4.0	0.0	0.0
102	PUKR	8 Aug 93	48 36.07	170 08.87	908	948	9.36	240	10174.0	0.0	6 460.0	3 450.0
103	PUKR	8 Aug 93	48 32.34	170 11.47	910	919	6.78	185	6 004.0	4.0	4 000.0	1 200.0
104	PUKR	8 Aug 93	48 40.46	170 07.59	925	939	10.91	355	5 840.0	0.0	3870.0	1 / 60.0
105	PUKR	8 Aug 93	48 32.50	170 12.10	935	945	10.17	185	3 278.0	0.0	1 380.0	1 486.0
106	PUKR	9 Aug 93	48 00.46	170 02.64	882	978	10.30	300	312.5	4.5	150.0	56.0
107	PUKR	9 Aug 93	47 51.41	169 52.14	868	1 000	9.51	38	563.7	0.7	147.0	28.0
108	PUKK	9 Aug 93	47 35.88	169 51.98	860	888	3.75	180	1.00	0.0	30.0	1.0
109	EUSI	10 Aug 93	46 55.86	170 20.30	9/4	1023	3.06	90	12 447.0	0.0	12 423.0	0.0
110	ECSI	10 Aug 93	46 56.05	170 20.27	1 011	984	10.54	90	10 840.0	0.0	10 640.0	0.0
111	EUSI	10 Aug 93	46 39.55	170 53.71	1 011	1 1 9 3	3.64	88	120.0 6 420.0	0.0	F 000 0	520.0
112	EUSI	10 Aug 93	40 30.58	170 33.21	1011	1 130	0.99	120	0 430.0	0.0	3 900.0	200.0
113	EUSI	11 Aug 93	40 33.55	170 44.83	00/	000	3.05	130	38.0	0.0	20.0	20.0
114	ECO	11 Aug 93	40 20.29	170 52.00	902	1 001	2.24	100	0.00	0.0	6 550.0	2 000 0
110	ECO	11 Aug 93	40 21.20	170 04.01	307 016	1 0/0	0.00	200	7 100 0	0.0	1 000.0	2 200.0
110	ECOI	11 Aug 93	40 27,48	170 54.01	310	1 049	0.62	223	7 100.0	0.0	4 500.0	2 200.0

Appendix 2: Species caught

Crustacea

Unidentified crab Unidentified prawn

Cephalopoda

Moroteuthis spp. (warty squid) Unidentified octopus

Chondrichthyes

Selachiformes

Scymnorhinus licha (seal shark) Deania calcea (shovelnosed spiny dogfish) Etmopterus baxteri (Baxter's lantern dogfish) Rajiformes

Unidentified skate

Chimaeriformes

Hydrolagus sp. B (pale ghost shark) Hydrolagus sp. C (purple-finned Hydrolagus) Harriotta raleighana (longnosed chimaera) Rhinochimaera pacifica (widenosed chimaera)

Osteichthyes

Salmoniformes Alepocephalus sp. (unspecified brown slickhead)

Aulopiformes Bathysaurus ferox (deepsea lizardfish) Gadiformes Mora moro (ribaldo) Halargyreus johnsonii (Johnson's cod) Merluccius australis (hake) Macruronus novaezelandiae (hoki) Caelorinchus spp. (unspecified rattail) Coryphaenoides subserrulatus (fourrayed rattail) Lepidorhynchus denticulatus (javelin fish) Mesobius antipodum (black javelinfish) Ophidiiformes Genypterus blacodes (ling) Beryciformes Hoplostethus atlanticus (orange roughy) Zeiformes Pseudocyttus maculatus (smooth oreo) Allocyttus niger (black oreo) Scorpaeniformes Neophrynichthys angustus (pale toadfish) Perciformes Schedophilus huttoni Seriolella caerulea (white warehou)

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