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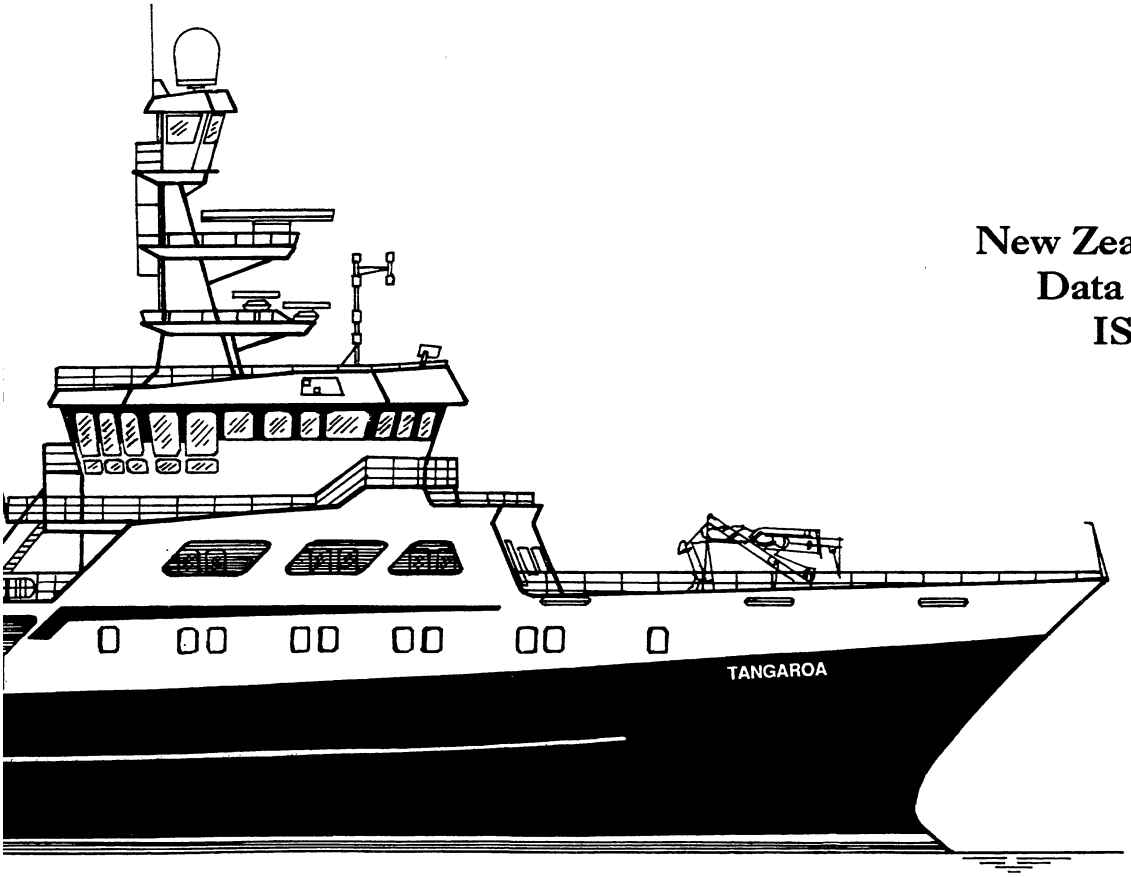

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Introduction

This report describes the second stratified random bottom trawl survey of deepwater fish of the south Chatham Rise carried out using GRV *Tangaroa* between 16 October and 12 November 1992. McMillan & Hart (1994a) described the first (1991) survey.

The principal aim of this time series of trawl surveys is to estimate the relative biomass of black oreo (*Allocyttus niger*), smooth oreo (*Pseudocyttus maculatus*), and orange roughy (*Hoplostethus atlanticus*) on the south Chatham Rise. Relative biomass is required for stock assessment of these species from the area.

The 1992 survey differed from the 1991 survey in two main ways.

1. The survey area was restratified according to the catch rates from the 1991 and 1990 surveys to create strata with more homogeneous catch rates.
2. Some of the hills on the south Chatham Rise known to be fished commercially were sampled. This work was considered as a separate survey and will be referred to as the "hill" survey, whilst the main survey will be referred to as the "standard" survey. The hill survey was designed to estimate the biomass of black oreo, smooth oreo, and orange roughy on some of the fishing hills and was developed because the standard survey did not sample fishing hills. The area east of 180° was chosen because it contains most of the hills that are fished on the south Chatham Rise.

Objectives

1. To estimate the relative biomass and determine the distribution of deepwater species, principally black oreo, smooth oreo, and orange roughy.
2. To determine the size structure of the populations of black oreo, smooth oreo, and orange roughy
3. To determine the spawning condition of the populations of black oreo, smooth oreo, and orange roughy
4. To retain rare or unusual species of fish, molluscs, and crustaceans for the Museum of New Zealand, Wellington.

Methods

Survey area

Standard survey. (Figure 1, Table 1). The 1992 survey area totalled 60 503 km², slightly more than the 1991 survey area of 56 841 km². The similarities to, and differences from, the 1991 survey are as follows.

1. Subarea 1 was the same (172° 30′–174° 30′ E).
2. Subarea 2 was the same (174° 30′–176° E).
3. Subarea 3 was new (176–177° E).
4. Subarea 4 was new and included most of old subarea 3 and part of subarea 4 (177–179° 30′ E).
5. Subarea 5 was new and was part of old 4 (179° 30′ E–178° 20′ W).
6. Subarea 6 was new and included parts of old 4 and 5 (178° 20′ W–175° 10′ W).
7. Subarea 7 was new and was part of old 5 (175° 10′–174° W).

Hill survey. (Figure 1, Table 2). This was carried out on 6 hills east of 180° on the south Chatham Rise which were selected at random from a list of 14 known commercial fishing hills. The area surveyed totalled 17 km^2.

Survey design

Standard survey. A two-phase stratified random bottom trawl survey design (*after* Francis 1981, 1984) was used with 105 stations planned for phase 1 and 45 for phase 2. Areas and depths were chosen to sample black oreo, smooth oreo, and orange roughy.

Hill survey. The survey was of a single-phase random design. It was planned to carry out 3 stations on each of 6 hills (each hill was a stratum) making a total of 18 stations. The survey was designed to sample black oreo, smooth oreo, and orange roughy.

Stratification

Strata details are given in Tables 1 and 2. The principal differences from the 1991 survey were that the 800–900, 900–1000, 1000–1100, and 1100–1200 m intervals in the 1991 survey were combined into 200 m intervals of 800–1000 and 1000–1200 m in subareas 1, 2, 5, and 7 in 1992. This change was made because there were no apparent differences in catch rates between the adjacent 100 m depth intervals. Subarea 3 was reduced to one stratum because the area had low biomass estimates and was considered to warrant only minimal coverage. The 1200–1500 m stratum in subarea 4 was extended to the west because of relatively high catch rates in 1100–1200 m (stratum 14) in 1991.

Station allocation

Standard survey, phase 1. Fewer stations were allocated to subareas 1 and 2 than in 1991 because of the low biomass results from the 1991 (McMillan & Hart 1994a) and 1990 (McMillan & Hart 1994b) surveys. Stations were reduced by randomly selecting stations from the list of 1991 phase 1 stations. Reductions from 1991 were as follows: 800–1000 m, stratum 2, nine stations; 1000–1200 m, stratum 3, six stations; 800–1000 m, stratum 5, five stations. New stations were allocated to subarea 3. For the other new subareas (4–7) the 1991 phase 1 stations were plotted on a map to determine which new subarea they occurred in, and the numbers of stations were either reduced by random selection from the 1991 stations or new stations were allocated.

Standard survey, phase 2. The strata and numbers of stations required to reduce the variability of the biomass estimates were calculated. Emphasis was placed on reducing the coefficient of variation (*c.v.*) of the largest biomass estimate (smooth oreo) to less than 30%.

Hill survey. Only a single phase was carried out and the minimum number of stations (three) was allocated to each hill because of time constraints.

Station position selection

Standard survey. Phase 1 random station positions were taken from the list of 1991 phase 1 stations. New phase 1 station positions (latitude and longitude pairs) were generated before the survey. New random positions (random longitude and depth pairs) were generated on board for phase 2 stations.

Hill survey. Phase 1 station positions were determined as follows. The direction of tow for each station was randomly selected, i.e., a direction from 1 to 360°. The tow path was surveyed by echosounder to determine if it was trawlable. If it was not, then the next random direction was surveyed. The aim at each station was to tow from the top down the side of the hill for as long as possible. In practice we had to limit tow length to about 2 min on the bottom because we could not gauge the amount of fish going into the net from the net monitor picture.

Station execution

Phase 1 stations were carried out using the actual start and finish positions of the 1991 stations. For new phase 1 and 2 positions the station was carried out by towing through the random position. Where this was not possible because of bad trawl ground, an area within 2 n. miles of the position was searched for trawl ground. If a station was still not possible, the position was abandoned and replaced with the next one on the list.

Phase 1 and phase 2 stations for the standard survey were usually 2 n. miles long, but ranged from 0.68 to 2.23 n. miles (n = 146, mean = 1.9 n. miles).

Hill survey stations were 0.08 to 0.75 n. miles long (n = 18, mean = 0.24 n.mile).

Survey timing

The survey was carried out between 16 October and 12 November 1992.

Vessel and gear

Vessel specifications were given by McMillan & Hart (1994a). Trawl gear specifications are given in Appendix 1 where they differ from the 1991 survey.

Biomass estimation

Biomass estimation was carried out using the area-swept method described by Francis (1981). The formulas were summarised by Vignaux (1994).

The assumptions about the effective fishing width of the net are unchanged from the 1991 survey, i.e., the width between the wings of the net was assumed to be the effective fishing width and consequently the vulnerability (V) was assigned a value of 0.239. The distance between the doors was measured at only 10 stations in 1992 (Appendix 1) because of problems with the telemetry gear, so the 1991 survey value of 117 m has been used as the mean 1992 value.

Biomass was calculated with the MAF Fisheries Trawlsurvey Analysis Program held at Greta Point. The combined biomass and length frequency analysis was used and biomass stations were selected from the required strata where gear performance was 1 or 2. Run parameters for the analysis included: recorded distance towed; constant doorspread of 117.0 m; catch data weight as recorded in catch table; length-weight relationship calculated for each species from data collected during the 1992 survey; fish vulnerability, 0.239; vertical availability, 1.0; areal availability, 1.0. Catch rates were expressed as $kg.km^{-1}$.

Biomass estimates for the three main species (black oreo, smooth oreo, and orange roughy) were made for fish of all lengths ("all fish") and also for fish that were considered to have recruited to the fishery ("recruited"). Recruited lengths were 27 cm total length (TL) for black oreo, 34 cm TL for smooth oreo, and 33 cm standard length (SL) for orange roughy.

Separate biomass estimates were made for the standard and the hill surveys.

Data recording and handling

All station data were recorded by hand on to 030 forms and were then entered by hand on to the on board computer. All the catch and biological data were entered directly on to computer in the wet lab using the digitisers. All weights including catch, individual fish, and gonad weights were captured electronically. Data were checked on board by Peter McMillan and Alan Hart and were checked and edited at Greta Point before being loaded on to the database.

Catch sampling

All catches were sorted by species and all bycatch species were weighed and recorded.

Small catches totalling less than about 2000 kg were weighed in full on the Seaway weighers and the data recorded.

For catches over about 2000 kg, the weight of the smooth oreo, black oreo, or orange roughy was back-calculated from the amount of fish processed on board. This required the following information: the conversion factor (from unprocessed to headed and gutted state), estimated for most of the large catches from about 200 kg of unprocessed fish (results of conversion factor tests are given in Appendix 2); the average frozen block (tray) weights estimated from a sample of 10 blocks weighed at the start of the survey (Appendix 2); and the number of frozen blocks of each species produced at each station. The total catch of each species was then calculated from the product of the number of frozen blocks, the conversion factor, and the average block weight. Small specimens of the three main species that could not be processed were sorted out of large catches, weighed, recorded, and then discarded.

Rare or unusual fish, molluscs, and crustaceans were labelled with a station number and frozen for the Museum of New Zealand, Wellington.

Biological sampling

A sample of up to about 200 individuals each of black oreo, smooth oreo, orange roughy (and other quota species when they were caught) was taken at each station to determine the length frequency distribution in different areas and depths. (Length was measured to the nearest centimetre below.) In addition, length (to the nearest millimetre), weight (nearest 10 g), sex, gonad stage, gonad weight (nearest 1 g), and otoliths were collected for up to 20

individual specimens of the above three species at each station. These data were collected for studies of size and age structure (not described in this report), length-weight relationship, and reproductive state of the populations sampled. Reproductive state was assessed by macroscopic gonad staging using the definitions for black oreo, smooth oreo, and orange roughy given in Appendix 3. About 600 otolith pairs for each species were collected. The stomachs of smooth oreo sometimes contained a large amount of water, probably taken in during capture, and consequently the stomach was removed before weighing. Black oreo and orange roughy were weighed intact. Removal of stomachs is considered in the Discussion.

Scaling length data

Length frequency data were scaled or adjusted to represent the population in the survey area using the MAF Fisheries Trawlsurvey Analysis Program. Options selected for running the program were: combined biomass and length frequency; scaled to percent sampled and distance towed; stations were selected from the required strata where gear performance was 1 or 2; length-weight parameters used were obtained from data collected during the 1991 survey (*see* Table 13). The calculations within the program were described by Vignaux (1994).

Water temperatures

The sea surface temperature was recorded at each station from the bridge weather station. Bottom temperatures were not available because the net monitor (Kaijo-Denki) had no temperature sensor.

Results

Trawl stations

Standard survey. A total of 146 stations (103 in phase 1 and 47 in phase 2) were completed and used for biomass estimation (Table 1). Station data are summarised in Appendix 4.

Hill survey. Eighteen stations were completed and used for biomass estimation (Table 2). Station data are summarised in Appendix 4.

Catch and catch rates

A summary of the catch of the 10 most abundant species from all stations from the standard and hill surveys is given in Table 3. Catches of the three main species from all stations are listed in Appendix 5. The species caught during the survey are listed in Appendix 6.

Standard survey. Catch and catch rates of black oreo, smooth oreo, and orange roughy from each stratum and catch from each subarea are presented in Table 4. Catch rates of the three main species are plotted by station in Figures 2–4.

Hill survey. Catch and catch rate data are presented in Table 5.

Biomass estimates

Biomass estimates for all quota species and commercially important non-quota species caught during the standard survey are given in Table 6. Catch and biomass estimates of hoki from the depth intervals 600–800, 800–1000, and 1000–1200 m for all catches made during daylight (0451–1813 hours New Zealand Standard Time) are listed in Table 7. The survey covered only a fraction of the depth range of species such as hoki, hake, ling, ribaldo, and pale ghost shark and was not designed to measure the biomass of these species.

Standard survey. Biomass estimates for all strata, individual strata, and for recruited and fish of all lengths for each of the three main species are presented in Table 8.

Hill survey. Biomass estimates for all strata, individual strata, and for recruited and fish of all lengths for each of the three main species are presented in Table 9.

Biomass estimates for the three main species for fish of all lengths are summarised by subarea in Table 10 and by depth in Table 11.

Biological data

The numbers of length and other biological samples taken during the survey are given in Table 12.

The length distributions of scaled samples of black oreo, smooth oreo, and orange roughy measured during the survey are given in Figure 5.

Scaled length data for black oreo, smooth oreo, and orange roughy from the depth intervals 600–800, 800–1000, and 1000–1200 m are given in Figure 6. Figure 7 presents scaled length data for the same species by three newly defined areas, i.e., 1, 172° 30′–176° E; 2, 176°–179° 30′ E; 3, 179° 30′ E–174° W. These areas were chosen on the assumption that they showed relatively uniform species catch composition during the survey.

Length-weight relationships for the fish sampled are given in Table 13.

The results of macroscopic staging of gonads for the three species sampled throughout the survey are summarised in Table 14. A large proportion of samples of black oreo and smooth oreo were either immature or developing (stages 1–3). Most of the orange roughy were immature or resting (stages 1–2).

Tables 15 and 16 give the incidence of each gonad stage for the three main species by depth interval and subarea, respectively.

Water temperatures

Surface temperatures ranged from 8.4 to 12.6 °C (n = 155). Temperatures were low at the western end and high at the eastern end of the survey area.

Discussion

This discussion is limited to the methods employed in this survey and to methods to consider for future surveys. Comparisons of the results of this survey with others will not be made here.

The strata for the 1992 survey were changed to make catch rates more homogeneous within each stratum, thereby reducing the variability of the biomass estimates. The *c.v.*s from the 1992 survey were slightly higher for black oreo and smooth oreo and considerably higher for orange roughy than in the 1991 survey (McMillan & Hart 1994a), probably because of the high variability of catches from strata 19, 21, and 22 in subarea 6. This subarea needed most of the second phase stations in the 1991 and 1990 surveys, so it is not surprising that the second phase stations in 1992 were also in the area. However, the survey design and stratification appear to be appropriate (*see* Figures 2–4) and we do not recommend any changes to future surveys.

The numbers of stations in subareas 1 and 2 were reduced because of low biomass estimates in 1990 and 1991 and enabled stations to be allocated to the new hill survey. There was some concern about reducing stations in subareas 1 and 2 because there is evidence from previous surveys that the timing of the survey may be important. Surveys in November 1986 and 1987 (Fincham *et al.* 1987, Fenaughty *et al.* 1988) produced about 36 and 29% respectively of the survey biomass of smooth oreo in subareas 1 and 2 compared to 4% in October 1991 and 10% in October 1992.

We stress that the hill survey was intended to provide biomass estimates only for the set of hills that was sampled. It does not provide an index of fish abundance for all hills. It is not currently possible to survey all hills because of limited resources. In 1992 it was possible to sample only commercial fishing hills at the eastern end of the south Chatham Rise. It would be desirable to develop a hill survey for the other major fishing area at the western end of the south Chatham Rise (173–175° E) in a future survey.

The next survey should be as similar to the 1992 survey as possible and continue to refine the biomass estimate of smooth oreo. The main emphasis should be on the standard survey because it is a comprehensive survey which fulfils statistical requirements for random trawl survey design. It is also the longest series of surveys that we have for the area. It has possible deficiencies in not sampling features such as hills. Small hills are unlikely to be selected from a large area of flattish terrain, and it is desirable to continue to attempt to develop ways to obtain unbiased estimates of fish abundance from hills and drop-offs.

Length-weight relationship for smooth oreo

Since 1982, when biological measurements were first made on smooth oreo, the stomach has been removed before the fish is weighed. This is because the stomachs of some individuals are full of sea water, apparently ingested during capture and therefore not of biological interest. The length-weight relationship therefore gives a smaller weight for a given length than if the stomachs were not removed. There are no data to quantify this difference.

Stomach removal is acceptable if the length-weight relationship is used to describe the biology of smooth oreos, or in comparisons with other fish. However, when the length-weight relationship calculated from the biological measurements is used for biomass calculations, it is used to relate lengths from a length frequency distribution to weights of fish in the catch whose stomachs have not been removed, and this may introduce errors.

The length-weight relationship is used to calculate biomass estimates of parts of the population, such as pre-recruited and recruited biomass, and a scaling factor in estimating the numbers of fish in a population.

The effects of a change in the length-weight relationship in the above calculations are as follows.

(i) The weight of each fish in the length frequency sample is calculated from the length-weight relationship. The catch of (for example) recruited fish at a station is calculated from the proportion (by weight) of fish in the length frequency sample that are of recruited size, multiplied by the total catch at that station.

If the length-weight relationship is for fish without stomachs, then the weight of each fish will be too small. However, if the error is the same for both small and large fish, then the calculation of the proportion by weight of recruits will not be affected, so the correct catch will be allocated to the recruits. Plots of the proportion of full stomachs against fish size show no change in the proportion with increasing fish size. Provided the ratio of stomach size to body weight also stays constant, it is therefore reasonable to assume that the catches (and hence the biomass) of recruited fish will be correctly calculated.

(ii) The number of fish at a station is calculated from the number of fish in the length frequency sample divided by the percentage (by weight) of fish that were measured. The number of fish in the population in a stratum is calculated by taking the average catch rate in numbers (number per km^2) in each of the stations in the stratum and multiplying by the stratum area (in km^2). The total weight of this number of fish with a known distribution of lengths can be calculated by multiplying the number of fish of each size by the weight of that fish calculated from the length-weight relationship. This total weight should equal the biomass calculated from the catches alone. If they do not match, the number of fish is rescaled by a calculated scaling factor.

If the length-weight relationship calculates weights without stomachs, then the calculated biomass will be incorrect, and the scaling factor will also be incorrect. The numbers of fish should be calculated without this scaling factor.

Correct values for the scaled numbers of fish can be calculated by dividing the incorrect scaled numbers by the scaling factor or by running the program using the option to obtain catch weights from the length frequency divided by the percentage sampled rather than using the weights recorded in the catch table. Scaled numbers are not presented in this report, so this issue is not a problem, but the details are discussed here for completeness.

The removal of stomachs is thus not a major problem. However, data should be collected to allow the calculation of a length-weight relationship which includes stomach weights to enable comparison to be made with length-weight relationships calculated without stomachs and to verify the assumption of constant proportions.

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References

Fenaughty, J. M., Banks, D. A., Hart, A. C., & McMillan, P. J. 1988: Cruise report: the second stratified random trawl survey of the south Chatham Rise, November 1987. Fisheries Research Centre Internal Report No. 99. 73 p. (Draft report held in MAF Fisheries Greta Point library, Wellington.)

Fincham, D. J., Banks, D. A., & McMillan, P. J. 1987: Cruise report — stratified random bottom trawl survey of the southern Chatham Rise, 600–1200 m, 31 October-7 December 1986. Fisheries Research Centre Internal Report No. 74. 74 p. (Draft report held in MAF Fisheries Greta Point library, Wellington.)

Francis, R. I. C. C. 1981: Stratified random trawl surveys of deepwater fish stocks around New Zealand. *Fisheries Research Division Occasional Publication 32*: 1–28.

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

McMillan, P. J. & Hart, A. C. 1994a: Trawl survey of oreos and orange roughy on the south Chatham Rise, October-November 1991 (TAN9104). *N.Z. Fisheries Data Report No. 50.* 45 p.

McMillan, P. J. & Hart, A. C. 1994b: Trawl survey of oreos and orange roughy on the south Chatham Rise, October-November 1990 (COR9004). *N.Z. Fisheries Data Report No. 49.* 46 p.

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

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

Table 1: Subareas, strata, and numbers of stations

Stratum	Depth (m)	Area (km^2)	No. of stations		
			Phase 1	Phase 2	Total
Subarea 1					
1	600–800	3 630	3		3
2	800–1000	3 167	6		6
3	1000–1200	3 351	6		6
	Subtotal	10 148	15	0	15
Subarea 2					
4	600–800	4 180	3		3
5	800–1000	3 248	3		3
6	1000–1200	3 474	3		3
	Subtotal	10 902	9	0	9
Subarea 3					
7	600–1200	4 875	3		3
Subarea 4					
8	600–800	2 909	3		3
9	800–900	1 376	3		3
10	900–1000	1 361	6	1	7
11	1000–1100	1 580	4		4
12	1100–1200	2 242	6		6
	Subtotal	9 468	22	1	23
Subarea 5					
13	600–800	1 922	3		3
14	800–1000	2 366	3		3
15	1000–1200	2 380	3		3
16	1200–1500	3 990	3		3
	Subtotal	10 658	12		12
Subarea 6					
17	600–800	2 106	3		3
18	800–900	1 295	6		6
19	900–1000	1 039	6	12	18
20	1000–1100	1 159	6		6
21	1100–1200	1 094	6	21	27
22	1200–1500	4 085	3	9	12
	Subtotal	10 778	30	42	72
Subarea 7					
23	600–800	930	3		3
24	800–1000	547	3		3
25	1000–1200	846	3		3
26	1200–1500	1 351	3		3
	Subtotal	3 674	12	0	12
Total		60 503	103	43	146

Table 2: Hill strata and numbers of stations*

Hill	Stratum	Area (km^2)	No. of stations
Trev's pinnacle	30	1	3
Condoms	31	3	3
Mangrove	32	1	3
Charlies	33	2	3
Possum	34	8	3
Cotopaxi	35	2	3
Total		17	18

* Two stations on Condoms and two on Mangrove were aborted and redone.

Table 3: Total catch, percentage catch composition by weight, and number of stations at which the species was caught for the 10 most abundant species from standard and hill survey stations combined

	Total catch (kg)	Percentage composition	No. of stations
Smooth oreo	237 396	70.2	147
Orange roughy	55 307	16.4	100
Black oreo	26 349	7.8	120
Baxter's lantern dogfish	6 030	1.8	134
Shovelnosed dogfish	2 069	0.6	68
Hoki	1 903	0.6	74
Johnson's cod	1 479	0.4	115
Bigscaled brown slickhead	1 018	0.3	74
Smallscaled brown slickhead	911	0.3	89
Black javelinfish	542	0.2	65
All other species	4 960	1.5	–
All species	337 968		164

Table 4: Catch, percentage of total catch, and mean catch rate for black oreo (BOE), smooth oreo (SSO), and orange roughy (ORH) by stratum and subarea from the standard survey

	Catch (kg)				% of total catch			Mean catch rate (kg.km^{-1})		
Stratum	BOE	SSO	ORH	All species	BOE	SSO	ORH	BOE	SSO	ORH
Subarea 1										
1	206	14	0	448	46.0	3.1	0.0	78	5	0
2	991	2 547	0	3 995	24.8	63.8	0.0	189	480	0
3	106	148	0	430	24.7	34.4	0.0	42	28	0
Subtotal	1 303	2 709	0	4 873	26.7	55.6	0.0			
Subarea 2										
4	822	18	0	1 047	78.5	1.7	0.0	360	8	0
5	119	4	1	289	41.1	1.4	0.3	51	2	<0.5
6	1	9	0	133	0.8	6.8	0.0	1	3	0
Subtotal	942	31	1	1 469	64.1	2.1	0.1			
Subarea 3										
7	217	8	1	707	30.7	1.1	0.1	79	3	<0.5
Subtotal	217	8	1	707	30.7	1.1	0.1			
Subarea 4										
8	1164	13	0	1 563	74.5	0.8	0.0	430	5	0
9	338	31	1	533	63.4	5.8	0.2	126	11	<0.5
10	3704	1598	12	5 700	65.0	28.0	0.2	597	257	2
11	310	738	22	1 285	24.1	57.4	1.7	88	210	6
12	6	10	0	224	2.7	4.5	0.0	1	2	0
Subtotal	5 522	2 390	35	9 305	59.3	25.7	0.4			
Subarea 5										
13	995	9	0	1 279	77.8	0.7	0.0	375	3	0
14	149	14	4	456	32.7	3.1	0.9	58	5	2
15	3	11	10	247	1.2	4.5	4.1	1	4	4
16	0	4	0	163	0.0	2.5	0.0	0	2	0
Subtotal	1 147	38	14	2 145	53.4	1.8	0.7			
Subarea 6										
17	22	54	0	1 294	1.7	4.1	0.0	8	20	0
18	356	5 985	57	7 099	5.0	84.3	0.8	70	1 127	11
19	870	65 765	5 561	74 066	1.2	88.8	7.5	74	5 820	516
20	56	2 877	80	3 606	1.6	79.8	2.2	11	654	15
21	49	44 324	501	47 621	0.1	93.1	1.1	2	2 880	22
22	0	6 942	6	8 142	0.0	85.3	0.1	0	647	1
Subtotal	1 353	125 947	6 205	141 828	1.0	88.8	4.4			
Subarea 7										
23	0	9	13	472	0.0	1.9	2.8	0	3	5
24	0	9	28	544	0.0	1.7	5.2	0	4	13
25	1	5	36	274	0.4	1.8	13.1	<0.5	2	14
26	1	1 227	16	1 424	0.1	86.2	1.1	<0.5	466	6
Subtotal	2	1 250	93	2 714	0.0	46.1	3.4			
Total	10 486	132 373	6 349	163 041	6.4	81.2	3.9			

Table 5: Catch, percentage of total catch, and mean catch rate for black oreo (BOE), smooth oreo (SSO), and orange roughy (ORH) by hill stratum

Hill	Stratum	Catch (kg)			All species	% of total catch			Mean catch rate (kg.km^{-1})		
		BOE	SSO	ORH		BOE	SSO	ORH	BOE	SSO	ORH
Trev's pinnacle	30	291	28 455	2 265	31 221	0.9	91.1	7.3	431	42 967	3 358
Condoms	31	528	24 147	22	24 798	2.1	97.4	0.1	1 578	59 596	64
Mangrove	32	362	46 999	3 441	50 969	0.7	92.2	6.8	1 372	162 692	12 454
Charlies	33	9 133	3 271	32 847	49 529	18.4	6.6	66.3	52 932	17 878	189 441
Possum	34	3 485	1 247	5 566	10 434	33.4	11.9	53.3	17 461	7 053	25 870
Cotopaxi	35	2 064	905	4 817	7 972	25.9	11.4	60.4	13 056	6 368	35 336
Total		15 863	105 024	48 958	174 923	9.1	60.0	28.0			

Table 6: Biomass estimates (for fish of all lengths) for all quota species and commercially important non quota species caught during the standard survey*

	Biomass (t)	*c.v.* (%)
Smooth oreo	146 864	25.0
Black oreo	55 725	21.0
Hoki	12 947	32.6
Orange roughy	5 599	78.1
Shovelnosed dogfish	4 676	21.6
Pale ghost shark	2 205	18.7
Ling	781	44.1
Ribaldo	247	36.2
Hake	407	36.9
Total	260 075	15.5

* The total biomass was calculated using the "Biopc" program held on the main computer at Greta Point. The vulnerability value used in that calculation was restricted to two decimal points i.e., 0.24 was used rather than the 0.239 which was used for the rest of the biomass calculations.

Table 7: Catch and biomass of hoki (all lengths) from catches taken during the standard survey between 0451 and 1813 hours NZST

Depth (m)	Catch (kg)	Biomass (t)	*c.v.* (%)	No. of stations where caught
600–800	1 177.1	12 667	47.5	13
800–1000	243.7	1 370	33.9	25
1000–1200	20.8	207	74.1	27

Table 8: Biomass estimates (t) for fish of all lengths (all fish) and for recruited fish for black oreo, smooth oreo, and orange roughy*

Stratum	Area (km^2)	No. of stations	Black oreo				Smooth oreo				Orange roughy			
			All fish	*c.v.* (%)	Recruited	*c.v.* (%)	All fish	*c.v.* (%)	Recruited	*c.v.* (%)	All fish	*c.v.* (%)	Recruited	*c.v.* (%)
Subarea 1														
1	3 630	3	2 425	1	2 274	2	170	89	0		0		0	
2	3 167	6	5 118	53	4 630	55	12 999	93	2 524	98	0		0	
3	3 351	6	1 196	80	1 162	81	800	78	654	83	0		0	
Subarea 2														
4	4 180	3	12 864	59	10 714	57	276	56	199	70	0		0	
5	3 248	3	1 421	21	1 059	25	51	53	33	51	6	100	0	
6	3 474	3	18	100	10	100	99	17	66	6	0		0	
Subarea 3														
7	4 875	3	3 281	43	2 619	49	124	50	66	51	12	100	0	
Subarea 4														
8	2 909	3	10 691	36	9 773	42	116	79	61	100	0		0	
9	1 376	3	1 486	58	1 454	59	135	69	61	49	4	100	0	
10	1 361	7	6 949	89	6 917	89	2 992	73	1 598	66	23	45	14	43
11	1 580	4	1 184	98	1 116	98	2 837	91	2 201	92	87	71	54	68
12	2 242	6	23	34	19	41	37	34	26	41	0		0	
Subarea 5														
13	1 922	3	6 159	59	5 546	65	53	100	8	100	0		0	
14	2 366	3	1 180	62	974	64	111	33	30	100	32	51	13	100
15	2 380	3	22	100	13	100	82	16	65	9	77	53	59	54
16	3 990	3	0		0		52	100	47	100	0		0	
Subarea 6														
17	2 106	3	150	100	88	100	359	100	24	100	0		0	
18	1 295	6	775	52	688	57	12 473	69	2 255	95	121	47	24	76
19	1 039	18	653	48	630	50	51 685	43	31 832	58	4 588	95	3 086	98
20	1 159	6	106	75	92	85	6 474	86	1 500	82	153	41	62	40
21	1 094	27	20	50	16	55	26 930	72	19 148	80	209	26	142	28
22	4 085	12	0		0		22 574	63	19 890	66	18	54	13	52
Subarea 7														
23	930	3	0		0		23	100	17	100	38	100	0	
24	547	3	0		0		17	26	0		62	67	29	100
25	846	3	1	100	0		14	77	6	100	99	70	29	77
26	1 351	3	2	100	2	100	5 381	92	4 716	91	71	59	52	55
Total	60 503	146	55 725		49 797		146 864		87 026		5 599		3 576	
Lower bound †			32 274		28 266		73 497		30 867		0		0	
Upper bound †			79 175		71 328		220 231		143 186		14 344		9 631	
c.v. (%)			21.0		21.6		25.0		32.3		78.1		84.7	

* Recruited size for black oreo is ≥ 27 cm TL, for smooth oreo ≥ 34 cm TL and for orange roughy ≥ 33 cm SL.

† ± 2 standard deviations.

Table 9: Biomass estimates from hill strata for black oreo, smooth oreo, and orange roughy*

Hill	Area (km^2)	No. of stations	Black oreo				Smooth oreo				Orange roughy			
			All fish	*c.v.* (%)	Recruited	*c.v.* (%)	All fish	*c.v.* (%)	Recruited	*c.v.* (%)	All fish	*c.v.* (%)	Recruited	*c.v.* (%)
Trev's pinnacle	1	3	4	47	3	47	367	58	278	57	28	49	25	50
Condoms	3	3	40	55	35	56	1 528	39	1 410	40	2	58	1	70
Mangrove	1	3	12	50	11	50	1 391	82	1 336	82	106	60	93	58
Charlies	2	3	905	74	898	75	306	36	272	36	3 238	71	2 824	72
Possum	8	3	1 194	96	194	79	482	63	417	71	1 769	53	1 373	52
Cotopaxi	2	3	223	47	211	48	109	56	99	56	604	66	491	64
Total	17	18	2 378		1 352		4 183		3 812		5 748		4 807	
Lower bound			0		0		1 497		1 242		735		424	
Upper bound			5 046		2 745		6 868		6 382		10 761		9 190	
c.v. (%)			56.1		51.5		32.1		33.7		43.6		45.6	

* Recruited size for black oreo is ≥ 27 cm TL, for smooth oreo ≥ 34 cm TL, and for orange roughy ≥ 33 cm SL.

Table 10: Biomass estimates for fish of all lengths by subarea for black oreo (BOE), smooth oreo (SSO), and orange roughy for the standard survey subareas and hill survey

Subarea	Area (km²)	% of area	Biomass (t)			% of biomass		
			BOE	SSO	ORH	BOE	SSO	ORH
1	10 148	16.8	8 739	13 969	0	15.7	9.5	0.0
2	10 902	18.0	14 303	426	6	25.7	0.3	0.1
3	4 875	8.1	3 281	124	12	5.9	0.1	0.2
4	9 468	15.6	20 333	6 117	114	36.5	4.2	2.0
5	10 658	17.6	7 361	298	109	13.2	0.2	1.9
6	10 778	17.8	1 704	120 495	5 089	3.1	82.0	90.9
7	3 674	6.1	3	5 435	270	0.0	3.7	4.8
Hills	17	<0.1	2 378	4 183	5 748			
Total	60 503		55 725	146 864	5 599			

NB: totals exclude hill survey data.

Table 11: Biomass estimates for fish of all lengths by depth for black oreo (BOE), smooth oreo (SSO), and orange roughy for the standard survey only

Depth interval	Area (km²)	Biomass (t)			% of biomass		
		BOE	SSO	ORH	BOE	SSO	ORH
600–800	15 677	32 289	997	38	61.6	0.7	0.7
800–1000	14 399	17 582	80 463	4 836	33.5	54.8	86.5
1000–1200	16 126	2 570	37 273	625	4.9	25.4	11.2
1200–1500	9 426	2	28 007	89	0.0	19.1	1.6
All depths	55 628	52 443	146 740	5 588			

NB: excludes subarea 3 (600–1200 m).

Table 12: Number of length and sex and "biological" (i.e., up to 20 fish per station) samples taken from the total survey area

	Length & sex	Biological	Otoliths
Black oreo	8 877	2 902	yes
Smooth oreo	16 017	6 637	yes
Orange roughy	3 711	1 047	yes
Hoki	927	0	no
Hake	17	0	no
Ling	23	0	no

Table 13: Length-weight relationships for oreos and orange roughy

	Weight range (g)	Length range (cm)	*a*	*b*	r^2	*n*
Black oreo	240–1 995	18.0–46.0	0.010	3.21	94.1	1 382
Smooth oreo	75–2 720	16.1–50.8	0.030	2.89	96.1	1 528
Orange roughy	70–2 320	10.4–43.0	0.072	2.77	98.4	850

* $W = a.L^b$. Lengths are total length for oreos, and standard length for orange roughy

Table 9: Biomass estimates from hill strata for black oreo, smooth oreo, and orange roughy*

Hill	Area (km^2)	No. of stations	Black oreo				Smooth oreo				Orange roughy			
			All fish	*c.v.* (%)	Recruited	*c.v.* (%)	All fish	*c.v.* (%)	Recruited	*c.v.* (%)	All fish	*c.v.* (%)	Recruited	*c.v.* (%)
Trev's pinnacle	1	3	4	47	3	47	367	58	278	57	28	49	25	50
Condoms	3	3	40	55	35	56	1 528	39	1 410	40	2	58	1	70
Mangrove	1	3	12	50	11	50	1 391	82	1 336	82	106	60	93	58
Charlies	2	3	905	74	898	75	306	36	272	36	3 238	71	2 824	72
Possum	8	3	1 194	96	194	79	482	63	417	71	1 769	53	1 373	52
Cotopaxi	2	3	223	47	211	48	109	56	99	56	604	66	491	64
Total	17	18	2 378		1 352		4 183		3 812		5 748		4 807	
Lower bound			0		0		1 497		1 242		735		424	
Upper bound			5 046		2 745		6 868		6 382		10 761		9 190	
c.v. (%)			56.1		51.5		32.1		33.7		43.6		45.6	

* Recruited size for black oreo is ≥ 27 cm TL, for smooth oreo ≥ 34 cm TL, and for orange roughy ≥ 33 cm SL.

Table 10: Biomass estimates for fish of all lengths by subarea for black oreo (BOE), smooth oreo (SSO), and orange roughy for the standard survey subareas and hill survey

Subarea	Area (km²)	% of area	Biomass (t) BOE	SSO	ORH	% of biomass BOE	SSO	ORH
1	10 148	16.8	8 739	13 969	0	15.7	9.5	0.0
2	10 902	18.0	14 303	426	6	25.7	0.3	0.1
3	4 875	8.1	3 281	124	12	5.9	0.1	0.2
4	9 468	15.6	20 333	6 117	114	36.5	4.2	2.0
5	10 658	17.6	7 361	298	109	13.2	0.2	1.9
6	10 778	17.8	1 704	120 495	5 089	3.1	82.0	90.9
7	3 674	6.1	3	5 435	270	0.0	3.7	4.8
Hills	17	<0.1	2 378	4 183	5 748			
Total	60 503		55 725	146 864	5 599			

NB: totals exclude hill survey data.

Table 11: Biomass estimates for fish of all lengths by depth for black oreo (BOE), smooth oreo (SSO), and orange roughy for the standard survey only

Depth interval	Area (km²)	Biomass (t) BOE	SSO	ORH	% of biomass BOE	SSO	ORH
600–800	15 677	32 289	997	38	61.6	0.7	0.7
800–1000	14 399	17 582	80 463	4 836	33.5	54.8	86.5
1000–1200	16 126	2 570	37 273	625	4.9	25.4	11.2
1200–1500	9 426	2	28 007	89	0.0	19.1	1.6
All depths	55 628	52 443	146 740	5 588			

NB: excludes subarea 3 (600–1200 m).

Table 12: Number of length and sex and "biological" (i.e., up to 20 fish per station) samples taken from the total survey area

	Length & sex	Biological	Otoliths
Black oreo	8 877	2 902	yes
Smooth oreo	16 017	6 637	yes
Orange roughy	3 711	1 047	yes
Hoki	927	0	no
Hake	17	0	no
Ling	23	0	no

Table 13: Length-weight relationships for oreos and orange roughy

	Weight range (g)	Length range (cm)	*a*	*b*	r^2	*n*
Black oreo	240–1 995	18.0–46.0	0.010	3.21	94.1	1 382
Smooth oreo	75–2 720	16.1–50.8	0.030	2.89	96.1	1 528
Orange roughy	70–2 320	10.4–43.0	0.072	2.77	98.4	850

* $W = a.L^b$. Lengths are total length for oreos, and standard length for orange roughy

Table 9: Biomass estimates from hill strata for black oreo, smooth oreo, and orange roughy*

Hill	Area (km^2)	No. of stations	Black oreo				Smooth oreo				Orange roughy			
			All fish	*c.v.* (%)	Recruited	*c.v.* (%)	All fish	*c.v.* (%)	Recruited	*c.v.* (%)	All fish	*c.v.* (%)	Recruited	*c.v.* (%)
Trev's pinnacle	1	3	4	47	3	47	367	58	278	57	28	49	25	50
Condoms	3	3	40	55	35	56	1 528	39	1 410	40	2	58	1	70
Mangrove	1	3	12	50	11	50	1 391	82	1 336	82	106	60	93	58
Charlies	2	3	905	74	898	75	306	36	272	36	3 238	71	2 824	72
Possum	8	3	1 194	96	194	79	482	63	417	71	1 769	53	1 373	52
Cotopaxi	2	3	223	47	211	48	109	56	99	56	604	66	491	64
Total	17	18	2 378		1 352		4 183		3 812		5 748		4 807	
Lower bound			0		0		1 497		1 242		735		424	
Upper bound			5 046		2 745		6 868		6 382		10 761		9 190	
c.v. (%)			56.1		51.5		32.1		33.7		43.6		45.6	

* Recruited size for black oreo is ≥ 27 cm TL, for smooth oreo ≥ 34 cm TL, and for orange roughy ≥ 33 cm SL.

Table 10: Biomass estimates for fish of all lengths by subarea for black oreo (BOE), smooth oreo (SSO), and orange roughy for the standard survey subareas and hill survey

Subarea	Area (km²)	% of area	Biomass (t)			% of biomass		
			BOE	SSO	ORH	BOE	SSO	ORH
1	10 148	16.8	8 739	13 969	0	15.7	9.5	0.0
2	10 902	18.0	14 303	426	6	25.7	0.3	0.1
3	4 875	8.1	3 281	124	12	5.9	0.1	0.2
4	9 468	15.6	20 333	6 117	114	36.5	4.2	2.0
5	10 658	17.6	7 361	298	109	13.2	0.2	1.9
6	10 778	17.8	1 704	120 495	5 089	3.1	82.0	90.9
7	3 674	6.1	3	5 435	270	0.0	3.7	4.8
Hills	17	<0.1	2 378	4 183	5 748			
Total	60 503		55 725	146 864	5 599			

NB: totals exclude hill survey data.

Table 11: Biomass estimates for fish of all lengths by depth for black oreo (BOE), smooth oreo (SSO), and orange roughy for the standard survey only

Depth interval	Area (km²)	Biomass (t)			% of biomass		
		BOE	SSO	ORH	BOE	SSO	ORH
600–800	15 677	32 289	997	38	61.6	0.7	0.7
800–1000	14 399	17 582	80 463	4 836	33.5	54.8	86.5
1000–1200	16 126	2 570	37 273	625	4.9	25.4	11.2
1200–1500	9 426	2	28 007	89	0.0	19.1	1.6
All depths	55 628	52 443	146 740	5 588			

NB: excludes subarea 3 (600–1200 m).

Table 12: Number of length and sex and "biological" (i.e., up to 20 fish per station) samples taken from the total survey area

	Length & sex	Biological	Otoliths
Black oreo	8 877	2 902	yes
Smooth oreo	16 017	6 637	yes
Orange roughy	3 711	1 047	yes
Hoki	927	0	no
Hake	17	0	no
Ling	23	0	no

Table 13: Length-weight relationships for oreos and orange roughy

	Weight range (g)	Length range (cm)	a	b	r^2	n
Black oreo	240–1 995	18.0–46.0	0.010	3.21	94.1	1 382
Smooth oreo	75–2 720	16.1–50.8	0.030	2.89	96.1	1 528
Orange roughy	70–2 320	10.4–43.0	0.072	2.77	98.4	850

* $W = a.L^b$. Lengths are total length for oreos, and standard length for orange roughy

Table 14: Relative proportions of gonad stages from the total survey area

	Black oreo				Smooth oreo				Orange roughy			
Gonad stage	Male	%	Female	%	Male	%	Female	%	Male	%	Female	%
1	720	49.2	455	31.6	576	17.2	1087	33.1	237	53.4	135	19.9
2	326	22.3	375	26.1	517	15.5	1305	39.7	207	46.6	422	62.1
3	378	25.9	355	24.7	1568	46.9	250	7.6			71	10.4
4	21	1.4	205	14.2	616	18.4	345	10.5				
5	17	1.2	14	1.0	65	1.9	155	4.7				
6			31	2.2			139	4.2			12	1.7
7			4	0.3			3	0.1			40	5.9
All	1462	100.0	1439	100.0	3342	100.0	3284	100.0	444	100.0	680	100.0

Table 15: Percentage of gonads at stage by species by depth range from the standard survey only *

Black oreo

	Males						Females						
Depth range (m)	1	2	3	4	5	*n*	1	2	3	4	5	6	*n*
600–800	70.9	24.4	4.7			127	30.1	49.6	17.3	2.3			133
800–1000	41.0	30.7	25.9	1.7	0.7	691	25.1	28.8	16.3	24.5	1.6	3.3	694
1000–1200	74.8	15.9	6.5		2.8	107	38.9	30.5	22.1	8.4			95
1200–1500	100.0					1							
Total *n*	454	260	192	12	8	926	251	295	157	181	11	23	922

Smooth oreo

	Males						Females						
Depth range (m)	1	2	3	4	5	*n*	1	2	3	4	5	6	*n*
600–800	61.1	9.7	26.4	2.8		72	72.9	16.7	6.3	2.1		2.1	48
800–1000	30.6	16.2	33.3	19.4	0.6	1057	45.8	27.2	5.9	14.4	3.9	2.9	902
1000–1200	24.5	24.5	39.0	11.9	0.1	715	45.4	39.4	5.7	4.9	1.7		861
1200–1500	2.1	5.1	71.5	19.8	1.5	333	13.9	54.7	9.8	8.2			490
Total *n*	549	370	888	358	12	2177	907	860	153	213	76	92	2301

Orange roughy

	Males			Females				
Depth range (m)	1	2	*n*	1	2	3	7	*n*
600–800	91.7	8.3	12	75.0	25.0			8
800–1000	73.2	26.8	168	43.1	41.2	9.3	6.4	204
1000–1200	52.4	47.6	166	13.5	54.1	18.5	13.9	281
1200–1500		100.0	3	23.1	76.9			13
Total *n*	221	128	349	135	248	71	52	506

* Excludes subarea 3.

Table 16: Percentage of gonads at stage by species by subarea

Black oreo

	Males						Females						
Subarea	1	2	3	4	5	*n*	1	2	3	4	5	6	*n*
1	64.0	32.0	4.0			125	34.9	40.3	24.0	0.8			129
2	78.0	20.3	1.7			59	56.3	23.4	20.3				64
3	67.3	32.7				98	52.8	22.2	22.2	2.8			144
4	31.6	47.6	20.8			231	12.8	59.3	21.4	6.6			243
5	85.9	4.7	9.4			64	36.5	42.3	9.6	9.6		1.9	52
6	44.6	21.3	29.6	2.7	1.8	446	27.6	14.3	12.9	36.6	2.5	0.7	434
7						1							0
Hills	45.7	7.8	42.5	2.1	2.1	438	34.3	12.9	44.5	5.4	0.8		373
Total *n*	720	362	378	21	17	1462	455	375	355	205	14	31	1439

Smooth oreo

	Males						Females						
Subarea	1	2	3	4	5	*n*	1	2	3	4	5	6	*n*
1	26.9	16.9	56.2			130	56.3	33.3	9.5	0.8			126
2	26.9	15.4	57.7			26	30.8	38.5	23.1	7.7			13
3	50.0	33.3	16.7			12	83.3	16.7					6
4	27.1	12.7	58.4	1.8		221	36.0	37.9	20.5	5.6			161
5	69.0	9.5	19.0	2.4		42	85.4	9.8	4.9				41
6	22.8	18.2	37.7	20.8	0.5	1651	37.8	37.6	5.6	10.6	3.8	4.5	1850
7	39.3	10.3	38.3	9.3	2.8	107	35.5	47.3		4.5	4.5		110
Hills	1.8	12.4	58.8	22.4	4.6	1153	17.9	45.4	9.9	13.5	8.1	5.1	977
Total *n*	576	517	1568	616	65	3342	1087	1305	250	345	155	141	3284

Orange roughy

	Males			Females				
Subarea	1	2	*n*	1	2	3	7	*n*
1			0					0
2			0		100.0			1
3			0		100.0			1
4	37.5	62.5	8	5.6	52.8	30.6	11.1	36
5	62.5	37.5	8		100.0			7
6	63.0	37.0	284	25.8	48.2	14.5	10.8	415
7	69.4	30.6	49	53.2	46.8			47
Hill strata	16.8	83.2	95		100.0			173
Total *n*	208	133	444	135	422	71	52	680

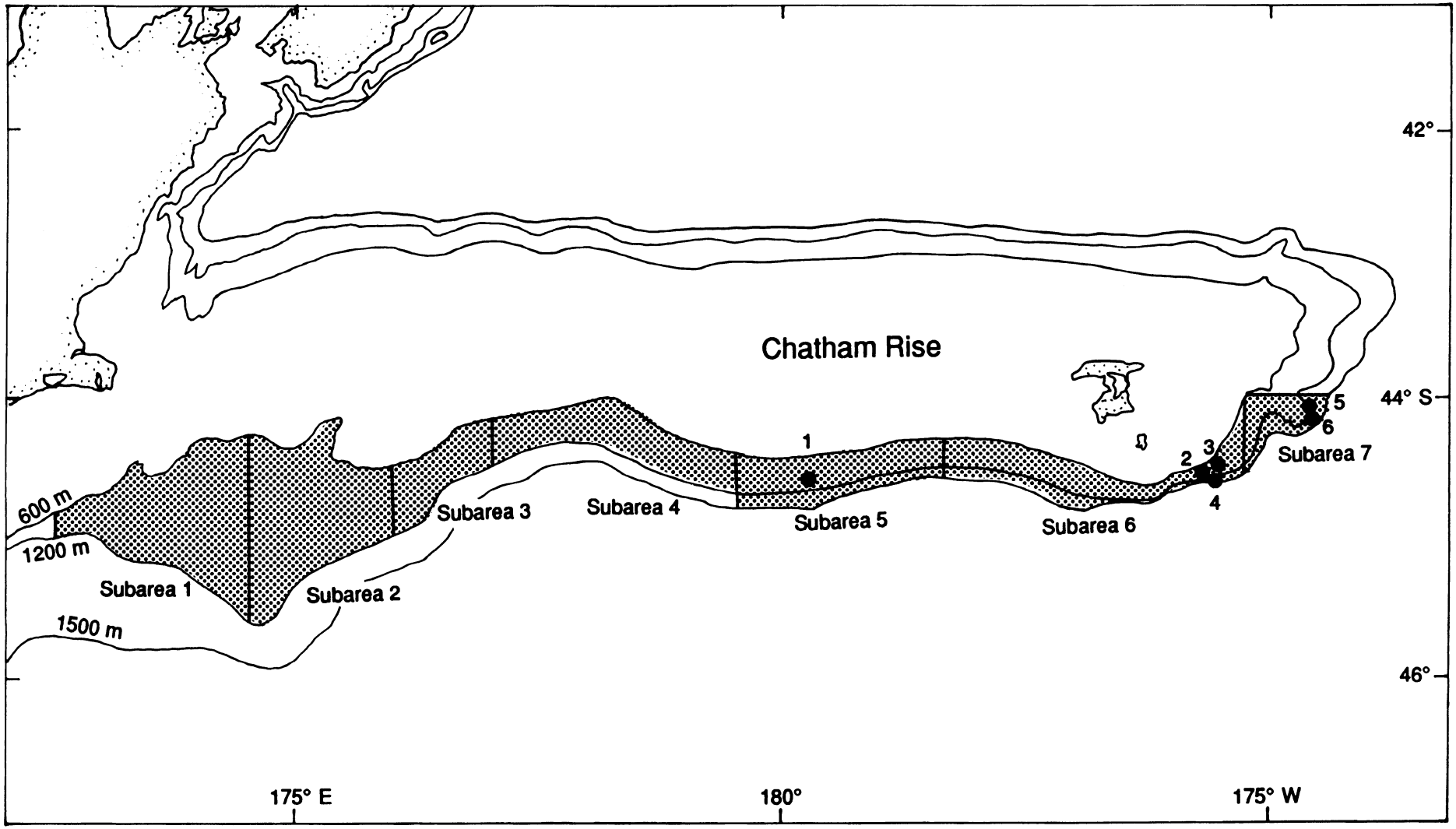

Figure 1: Survey area showing subareas and locations of the hills sampled: 1. Trev's Pinnacle, 2. Condoms, 3. Mangrove, 4. Charlies, 5. Possum, and 6. Cotopaxi.

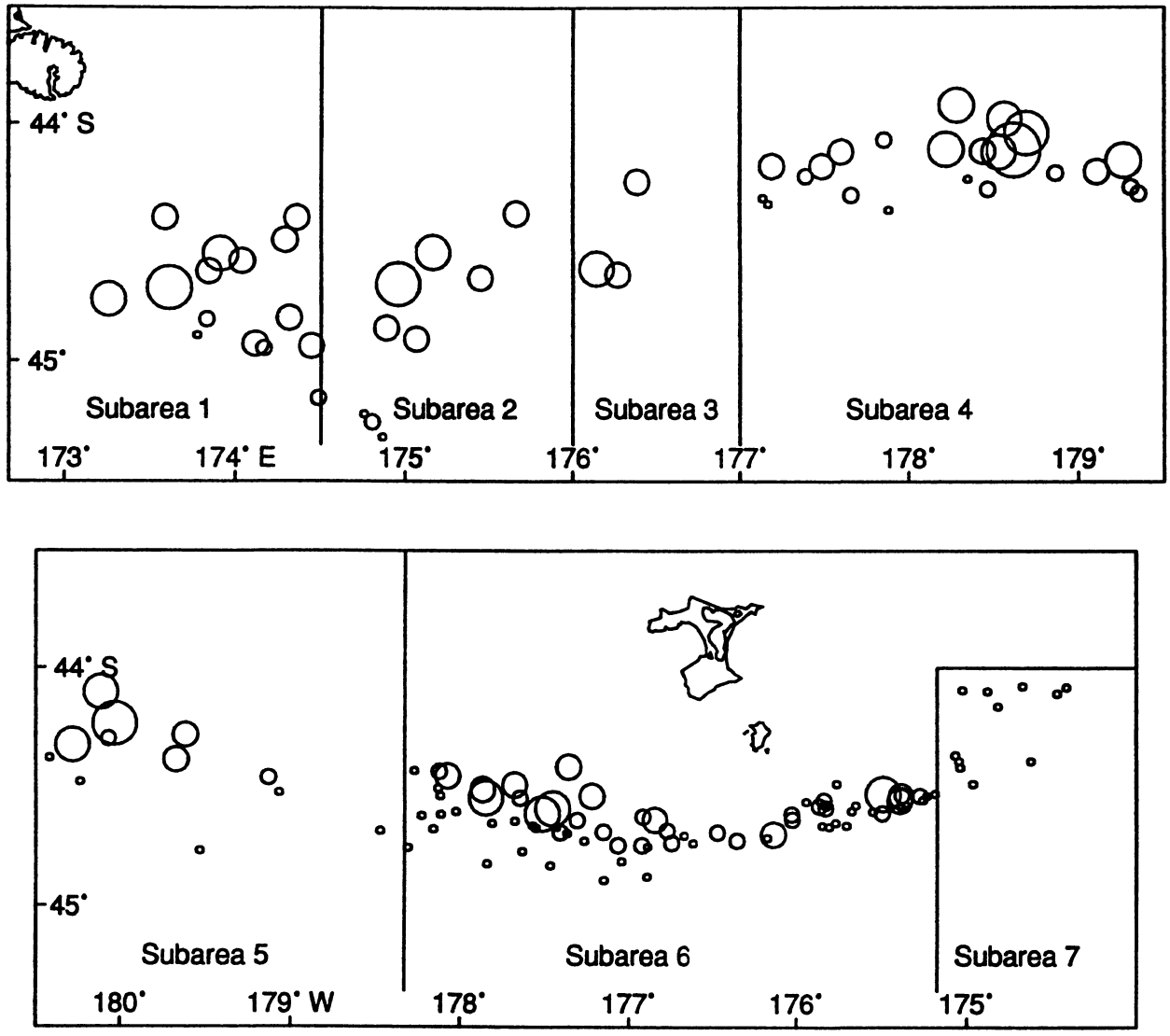

Figure 2: Catch rates (kg.km^{-1}) of black oreo.

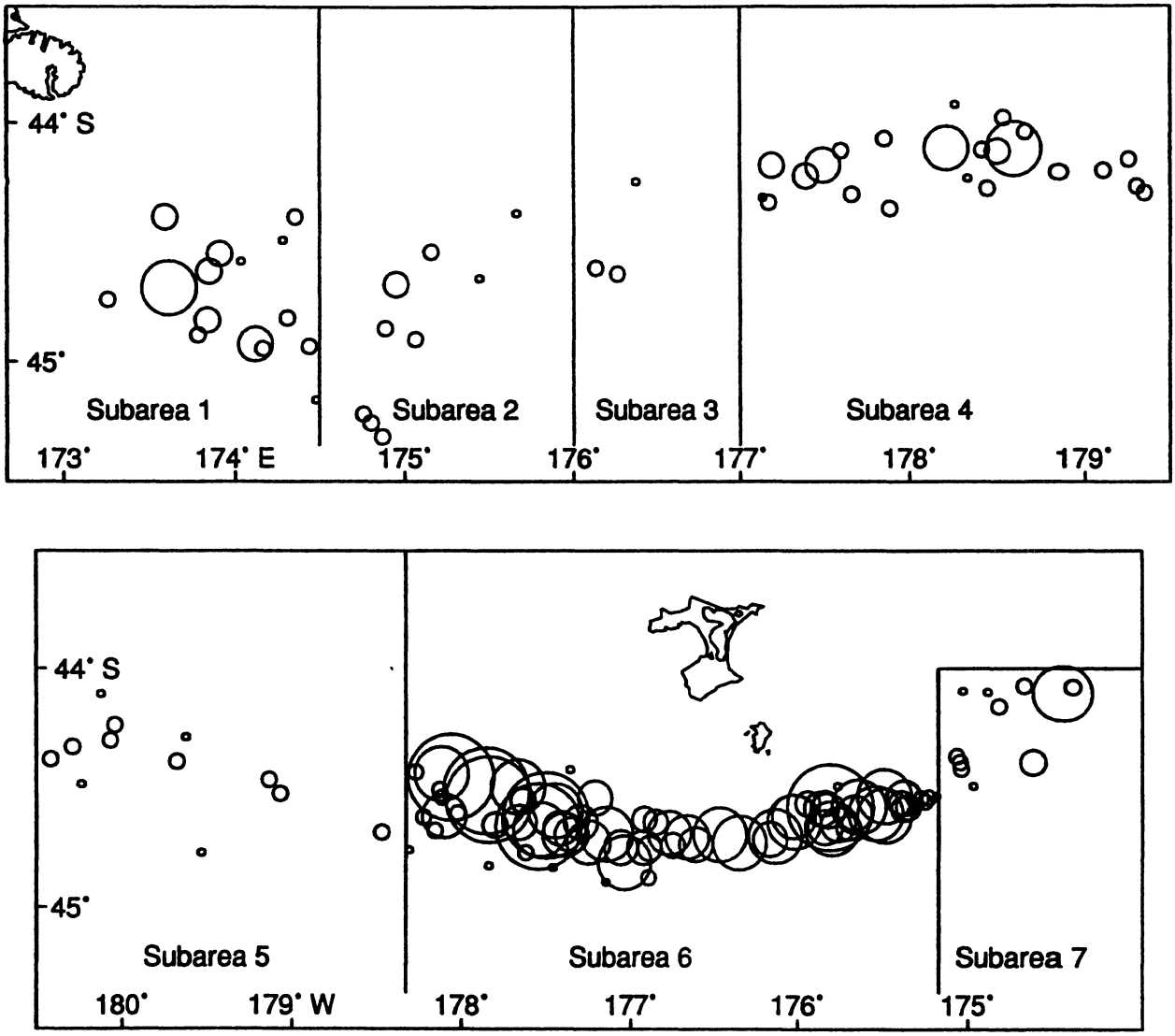

Figure 3: Catch rates ($kg.km^{-1}$) of smooth oreo.

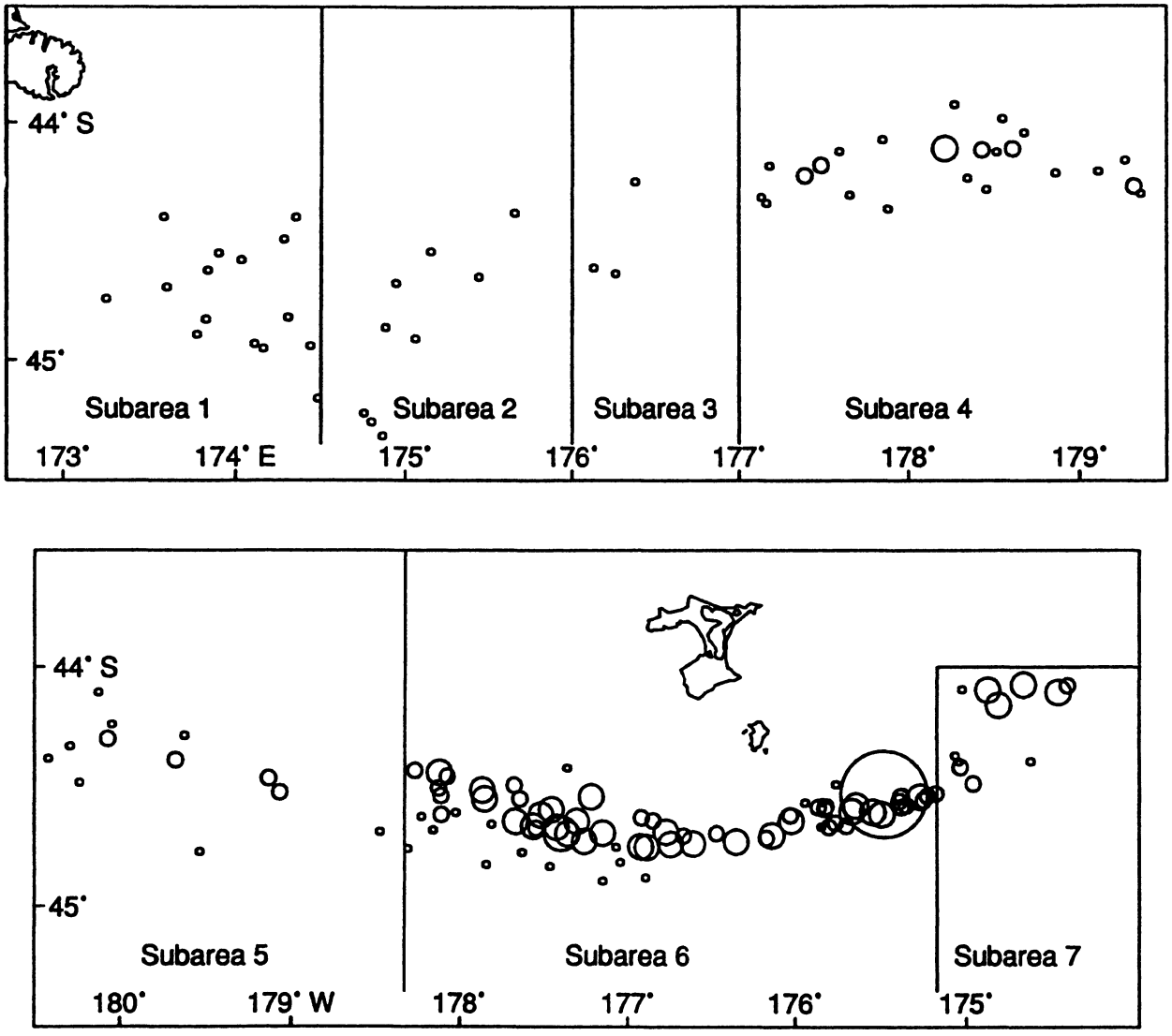

Figure 4: Catch rates (kg.km^{-1}) of orange roughy.

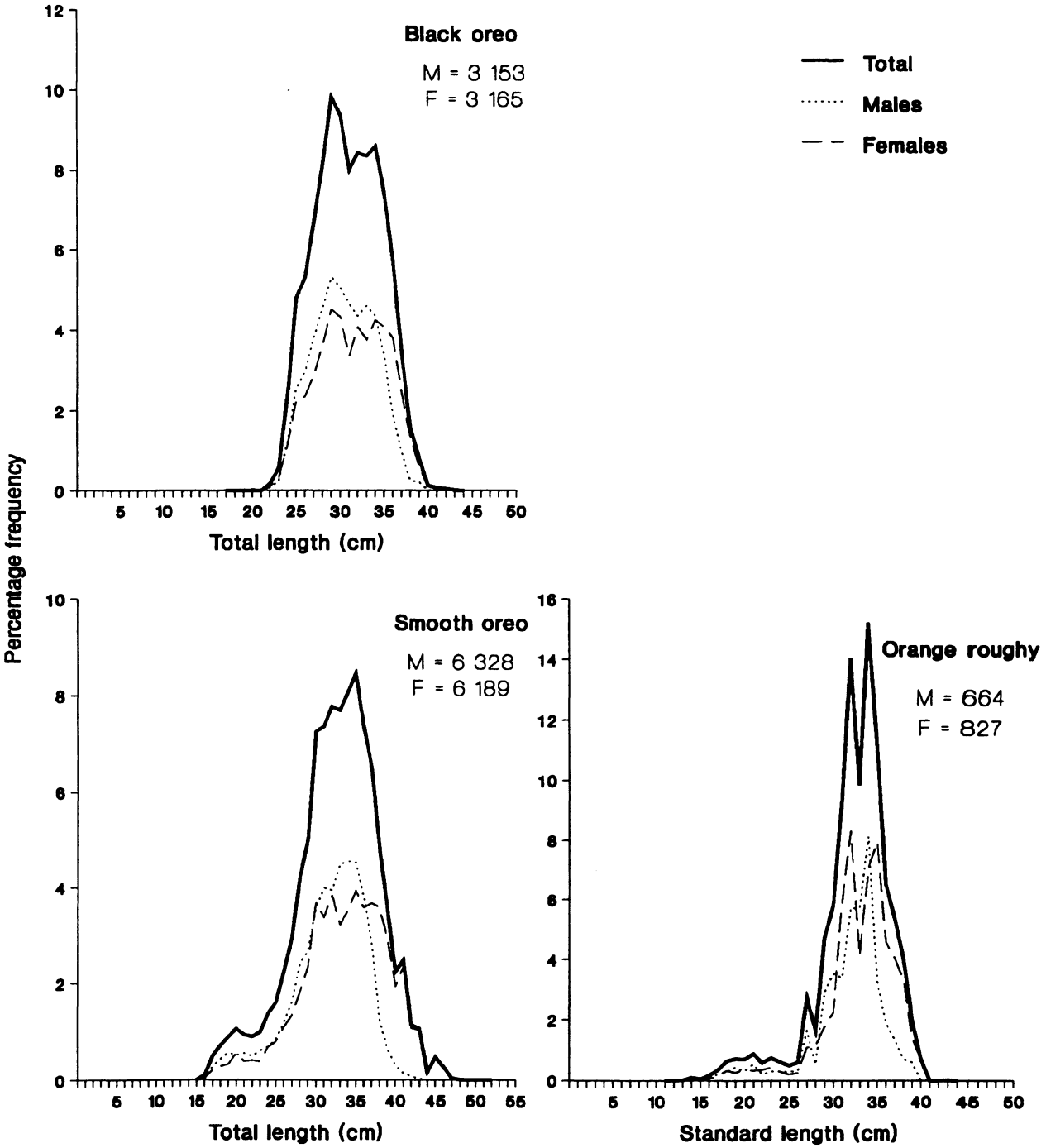

Figure 5: Distribution of scaled black oreo, smooth oreo, and orange roughy length samples for the entire survey area.

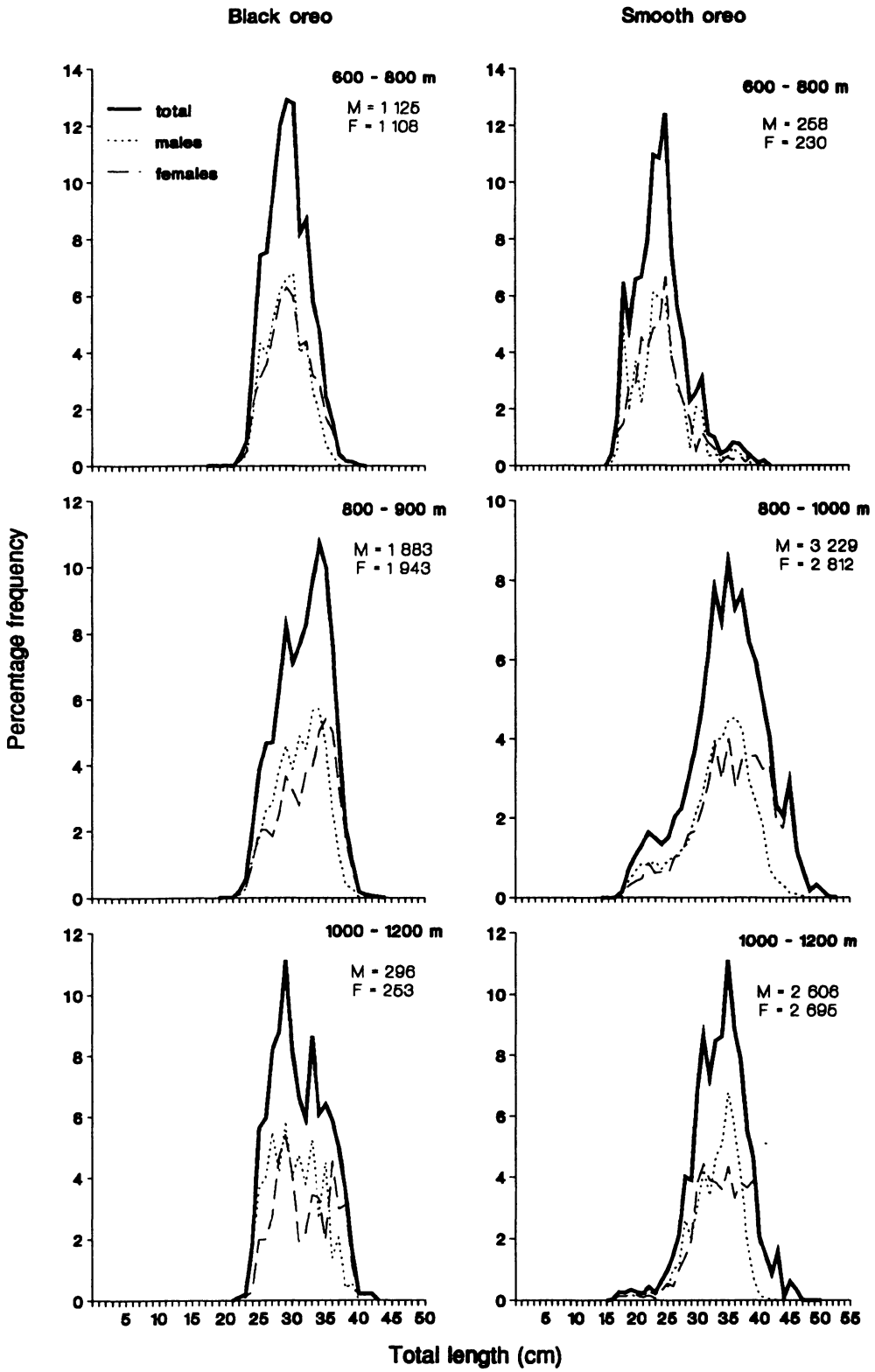

Figure 6: Distribution of scaled length data for black oreo, smooth oreo, and orange roughy by depth interval.

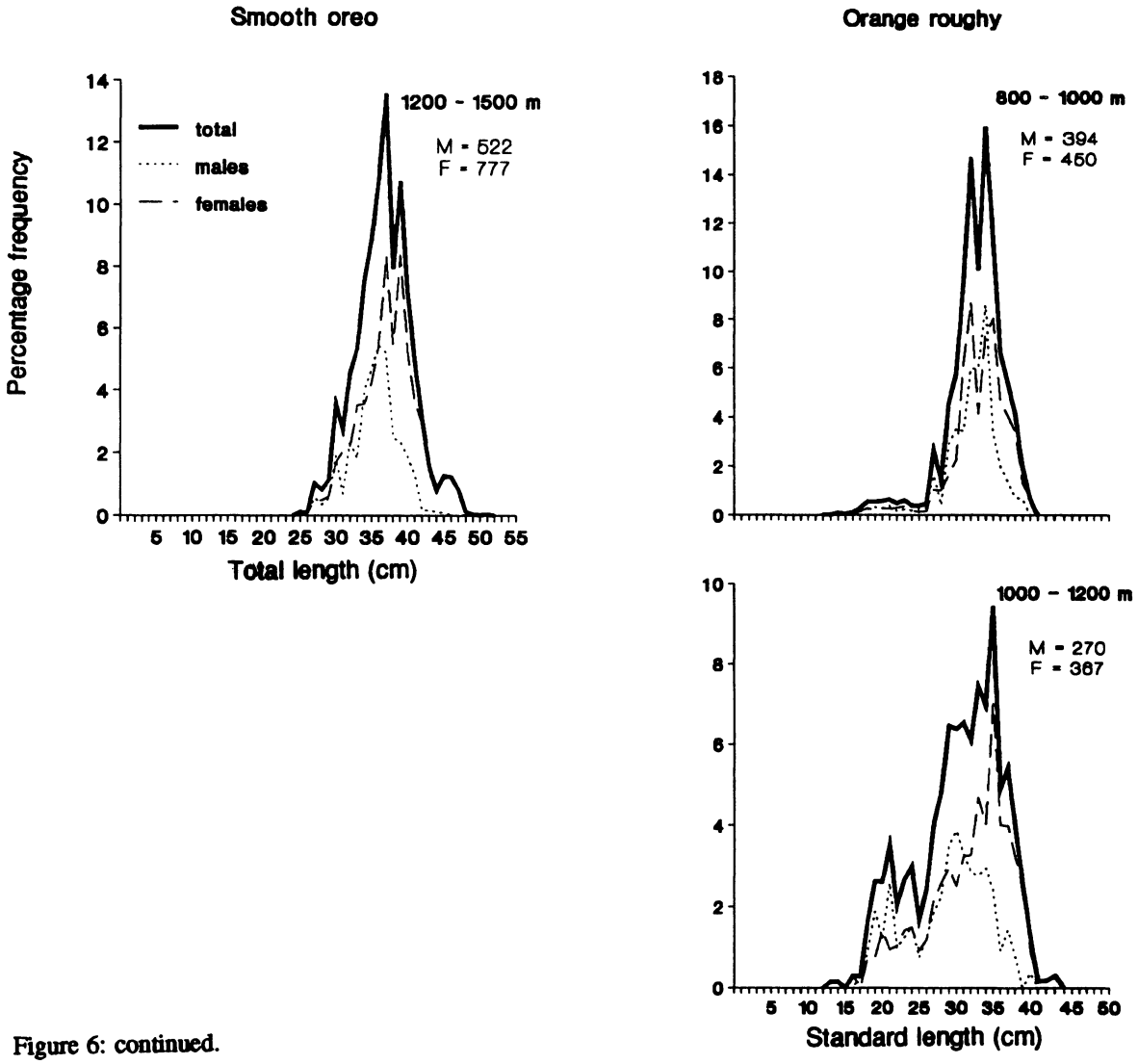

Figure 6: continued.

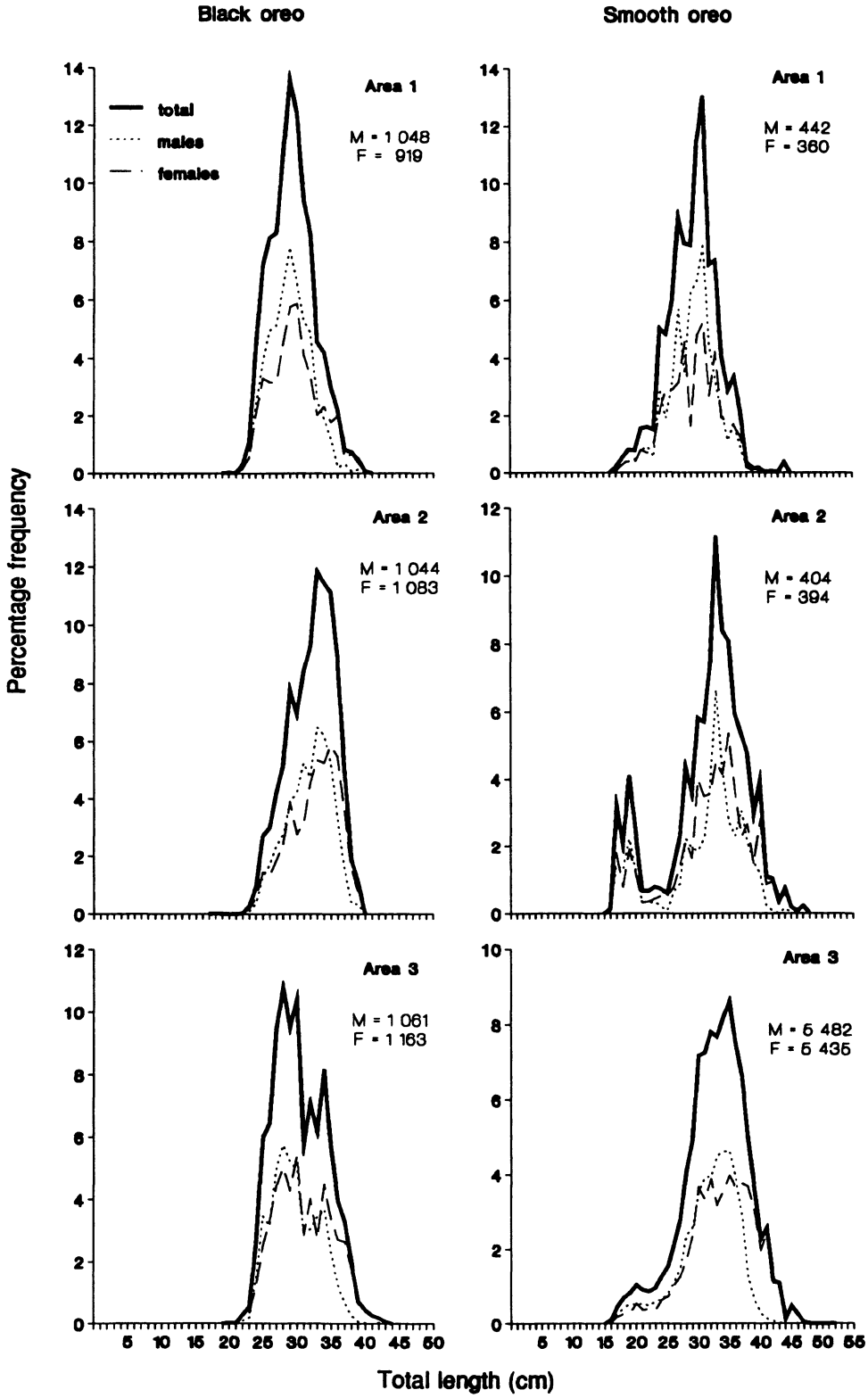

Figure 7: Distribution of scaled length data for black oreo, smooth oreo and orange roughy by area. Area 1 = 172° 30′ to 176° E; area 2 = 176° to 179°30′ E; area 3 179°30′ E to 174°W.

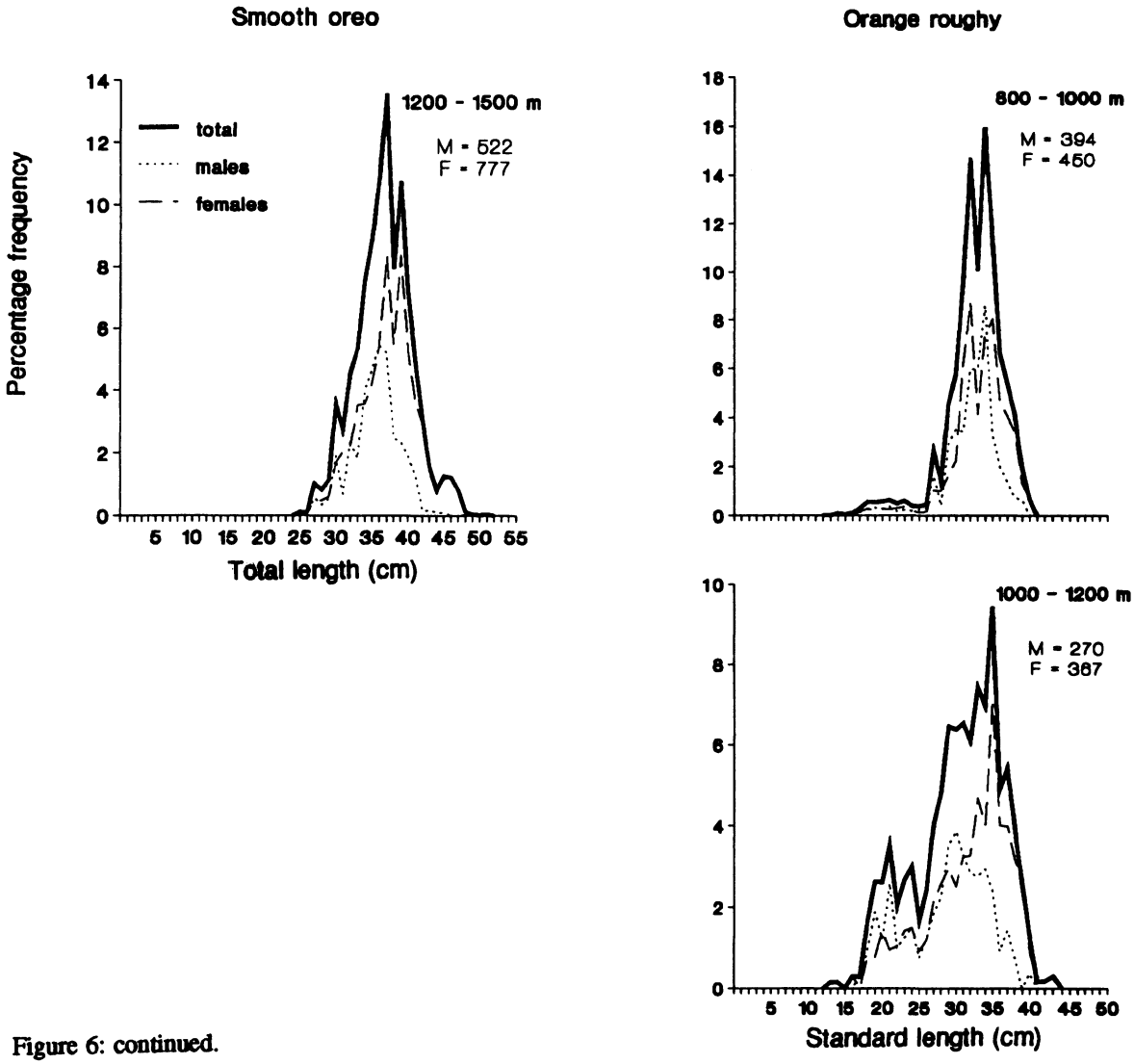

Figure 6: continued.

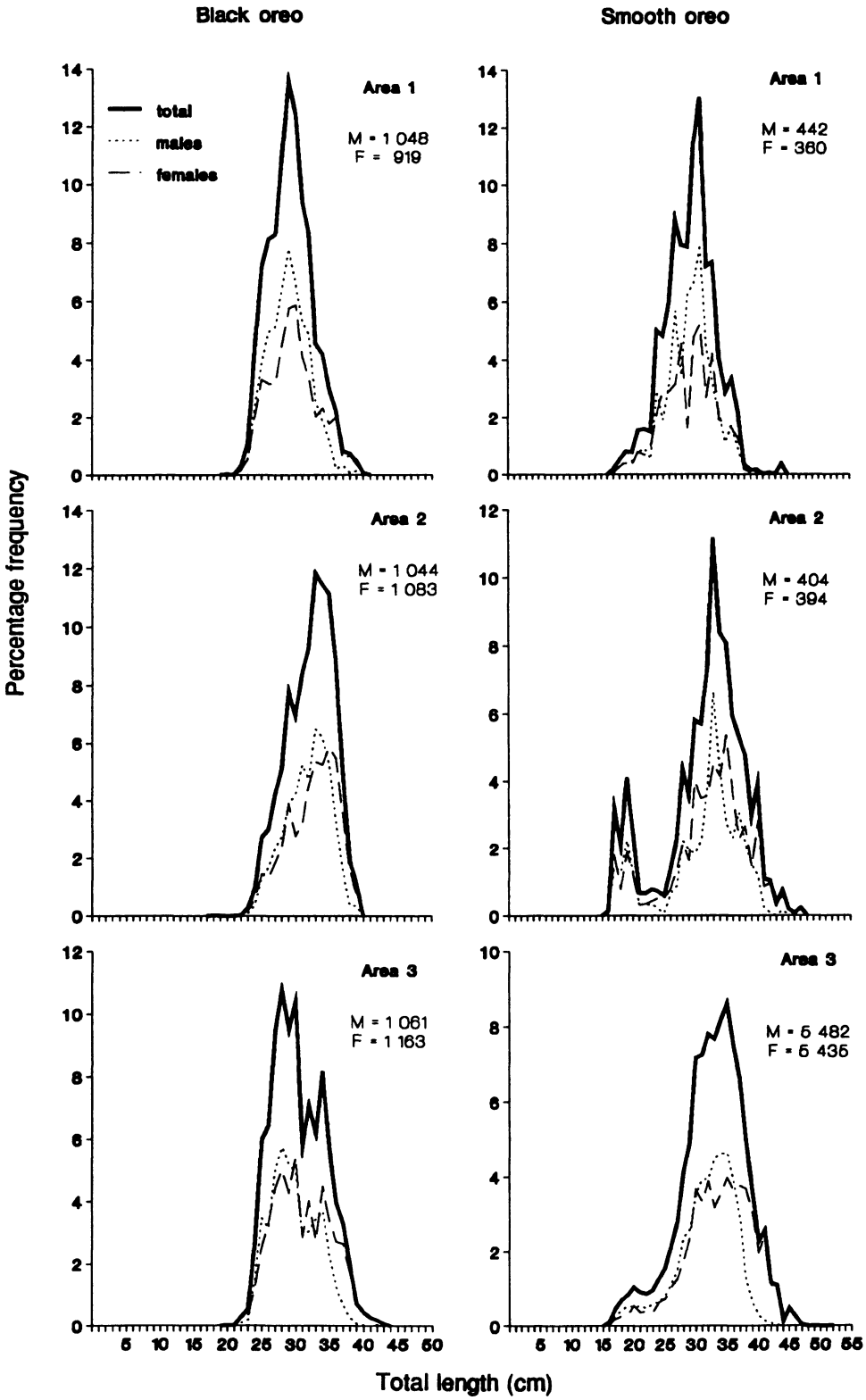

Figure 7: Distribution of scaled length data for black oreo, smooth oreo and orange roughy by area. Area 1 = 172° 30′ to 176° E; area 2 = 176° to 179°30′ E; area 3 179°30′ E to 174°W.

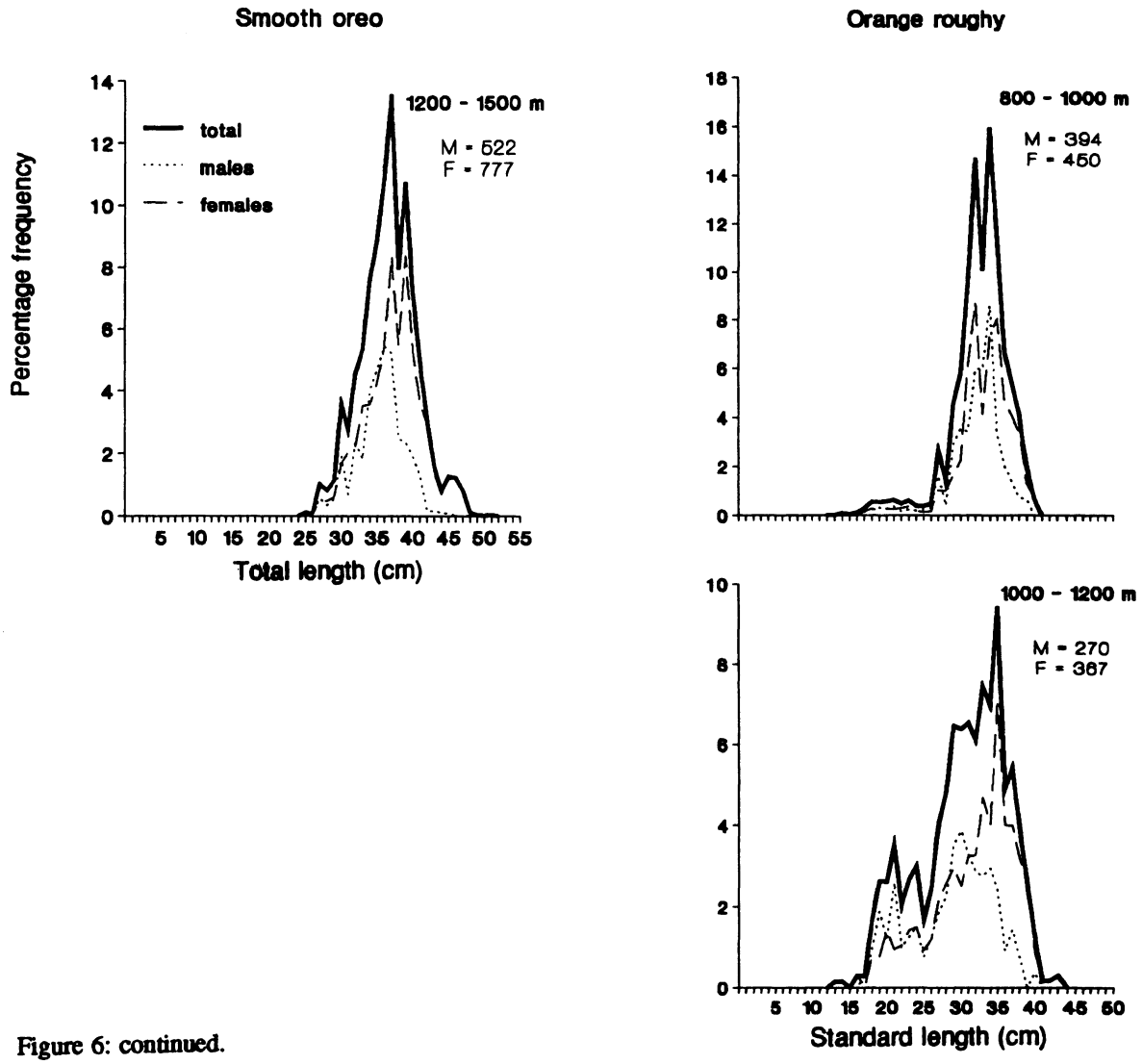

Figure 6: continued.

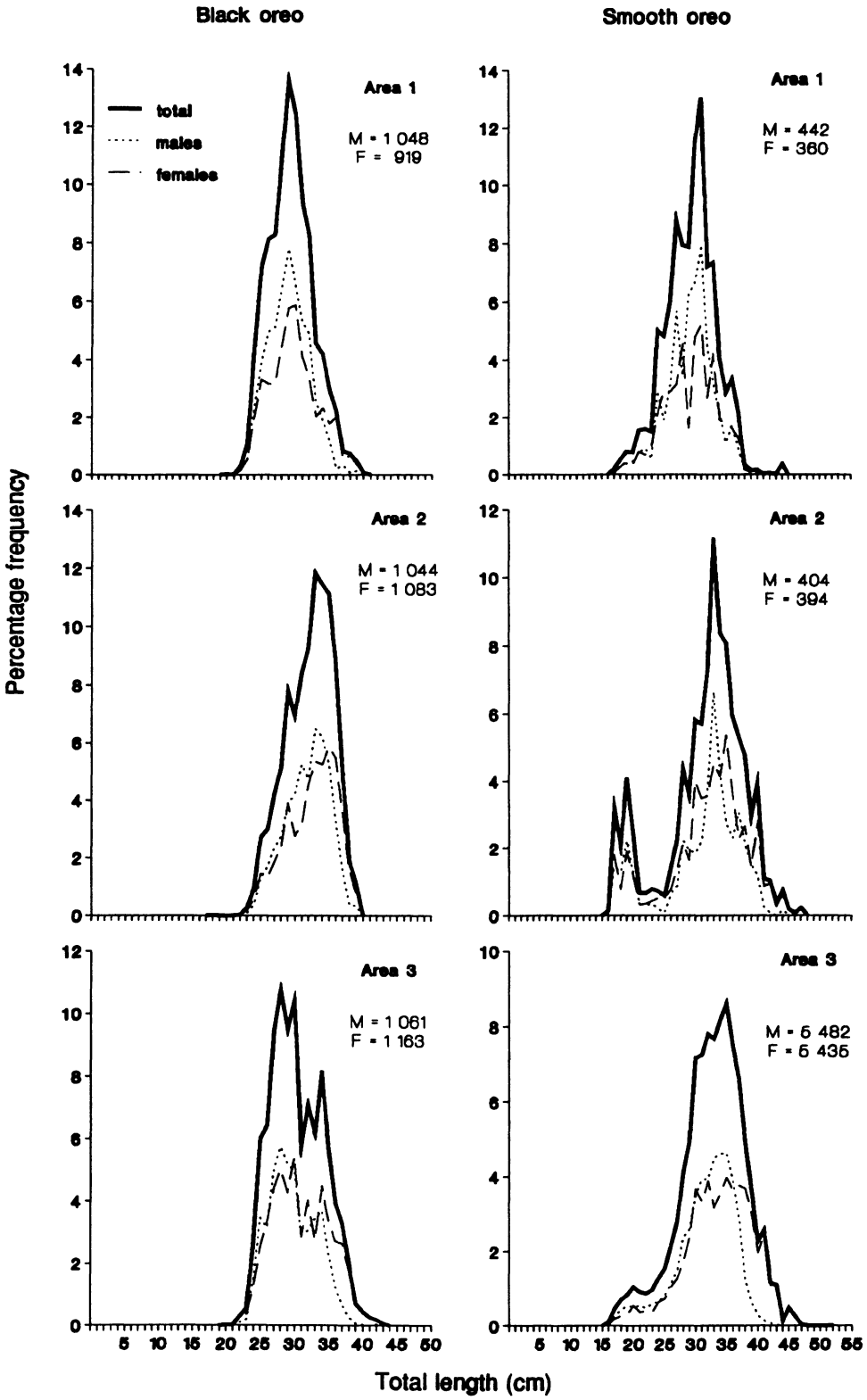

Figure 7: Distribution of scaled length data for black oreo, smooth oreo and orange roughy by area. Area 1 = 172° 30′ to 176° E; area 2 = 176° to 179°30′ E; area 3 179°30′ E to 174°W.

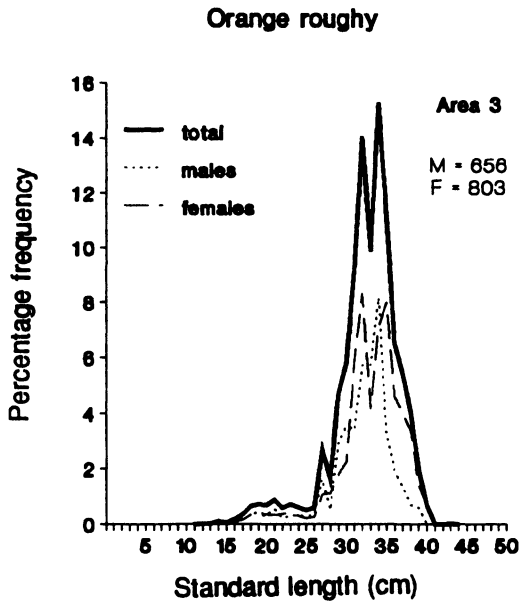

Figure 7: continued.

Appendix 1: Gear specifications for survey TAN9210 where they differ from TAN9104.

Flotation: 26 × 1500 m floats were used on the headline with no floats on the selvages.

Summary of measurements from net monitor (†) and Scanmar net telemetry gear (‡):

	Range (m)	Mean (m)	Median (m)	No. of tows
Headline height †	4.5–10.0	7.0	6.9	163
Distance between doors ‡	114–127	119	118.9	10

Note: At each station a range of values was noted where possible for the measurements of the headline height and the distance between the doors. The value recorded for that station was the one considered to have been in effect for most of the distance towed.

Appendix 2: Conversion factor (C.F.) and block weight measurements used to back-calculate large catches*.

Conversion factor

Station	(kg)	Green weight (kg)	Headed and gutted C.F.
Black oreo			
40	119.5	45.8	2.61
Smooth oreo			
57	217.4	96.6	2.25
71	242.8	104.0	2.33
76	230.0	98.1	2.34
76	183.7	84.6	2.17
84	226.2	104.0	2.17
85	379.5	162.1	2.34
86	335.6	147.5	2.27
Orange roughy			
94	275.9	135.9	2.03

Frozen block weights

Station	No. of blocks	Total weight	Mean block weight
Smooth oreo			
57	12	161.9	13.5
161	22	299.7	13.6

* All weights were measured on a "Seaway" weigher. Green weight is the weight before processing; Headed and gutted is the weight after processing; and C.F. is the conversion factor calculated by dividing the green weight by the headed and gutted weight.

Appendix 3: Black oreo, smooth oreo, and orange roughy gonad stages used during the survey (*from* Pankhurst *et al.* 1987).

Stage	Macroscopic condition	Histological condition
Females		
1	Immature or regressed; ovary clear.	Previtellogenic oocytes only.
2	Ovary pink or clear; small clear oocytes visible against the light.	Endogenous vitellogenesis (yolk globule accumulation).
3	Opaque white (oreos) or orange (orange roughy) oocytes present.	Exogenous vitellogenesis (yolk granule accumulation).
4	Mature ovary; hyaline oocytes present.	Final oocyte maturation; nuclear migration and breakdown; coalescence of yolk material and oil droplet formation.
5	Ovulated; eggs flow freely when light pressure applied to abdomen.	Follicular separation and rupture.
6	Spent; ovary flaccid and "bloody"; residual eggs sometimes present in oviduct.	Post-ovulatory follicles, increased vascularization, follicular atresia.
7	Atresia. Decaying hyaline oocytes.	Resorption of hyaline oocytes.
Males		
1	Immature or regressed; testis threadlike.	Spermatogonia and primary spermatocytes predominate.
2	Testis increased in size but no milt expressible	Secondary spermatocytes and spermatids present, spermatozoa in larger gonads.
3	Partially spermiated; viscous milt expressible.	Spermatozoa predominate.
4	Fully spermiated; hydrated, freely flowing milt.	Spermatozoa predominate.
5	Spent; testis "bloody" or grey; no milt expressible.	Residual spermatozoa, spermatogonia present towards testis margin.

Appendix 4: Summary of station data.

Station	Stratum	Date 1992	Start Latitude ° 'S	Start Longitude ° 'E/W	Finish Latitude ° 'S	Finish Longitude ° 'E/W	Depth (m) Min.	Depth (m) Max.	Distance towed (n. mile)	Warp length (m)
1	2	17 Oct	44 41.70	173 36.32 E	44 39.82	173 35.34 E	831	886	2.00	1 550
2	1	17 Oct	44 23.78	173 35.46 E	44 22.66	173 37.75 E	664	668	1.98	1 150
3	3	17 Oct	44 44.54	173 15.14 E	44 44.25	173 16.11 E	1 008	1 024	0.75	1 780
4	2	17 Oct	44 37.46	173 50.58 E	44 36.17	173 52.68 E	848	886	1.97	1 620
5	2	17 Oct	44 32.96	173 54.28 E	44 31.80	173 56.47 E	814	820	1.94	1 420
6	1	17 Oct	44 23.92	174 21.02 E	44 22.55	174 23.02 E	681	694	1.98	1 280
7	1	17 Oct	44 29.51	174 16.94 E	44 31.46	174 16.26 E	752	771	2.00	1 280
8	2	17 Oct	44 34.81	174 02.18 E	44 35.40	173 59.42 E	872	892	2.05	1 620
9	3	18 Oct	44 49.71	173 50.05 E	44 51.63	173 48.07 E	1 000	1 120	1.90	1 890
10	3	18 Oct	44 53.51	173 46.98 E	44 55.17	173 48.60 E	1 145	1 155	2.02	2 000
11	3	18 Oct	44 55.79	174 06.78 E	44 55.81	174 03.93 E	1 019	1 090	2.02	1 780
12	3	18 Oct	44 56.93	174 09.75 E	44 58.76	174 09.38 E	1 003	1 099	1.85	1 980
13	2	18 Oct	44 49.22	174 18.53 E	44 51.02	174 19.07 E	918	1 000	1.84	1 800
14	2	18 Oct	44 56.44	174 26.30 E	44 58.25	174 25.55 E	953	990	1.89	1 650
15	3	18 Oct	45 09.64	174 28.87 E	45 07.82	174 27.48 E	1 087	1 090	2.07	1 860
16	6	18 Oct	45 15.57	174 48.04 E	45 14.53	174 49.73 E	1 062	1 077	1.58	1 920
17	6	18 Oct	45 19.03	174 52.08 E	45 18.80	174 49.23 E	1 085	1 100	2.02	1 950
18	6	19 Oct	45 13.46	174 45.40 E	45 11.50	174 44.68 E	1 049	1 056	2.02	1 850
19	5	19 Oct	44 54.67	175 03.65 E	44 53.83	175 05.15 E	925	963	1.35	1 650
20	5	19 Oct	44 51.93	174 53.10 E	44 51.98	174 55.95 E	876	888	2.02	1 590
21	4	19 Oct	44 40.82	174 56.63 E	44 39.23	174 56.31 E	784	800	1.61	1 420
22	4	19 Oct	44 32.74	175 09.30 E	44 30.79	175 09.78 E	708	725	1.98	1 920
23	5	19 Oct	44 39.21	175 26.56 E	44 37.15	175 26.62 E	803	821	2.06	1 450
24	4	19 Oct	44 22.88	175 39.61 E	44 21.57	175 37.43 E	689	732	2.04	1 250
25	7	20 Oct	44 36.89	176 07.81 E	44 38.49	176 09.78 E	959	1 023	2.13	1 900
26	7	20 Oct	44 38.22	176 15.53 E	44 38.75	176 12.77 E	1 067	1 092	2.03	1 900
27	7	20 Oct	44 14.87	176 22.59 E	44 13.82	176 25.00 E	619	679	2.02	1 200
28	9	20 Oct	44 10.99	177 11.30 E	44 12.89	177 10.41 E	835	884	2.00	1 550
29	12	20 Oct	44 18.82	177 08.37 E	44 18.82	177 11.13 E	1 091	1 118	1.97	2 050
30	12	20 Oct	44 20.39	177 10.27 E	44 20.45	177 13.09 E	1 127	1 142	2.02	2 050
31	11	20 Oct	44 13.61	177 23.25 E	44 13.28	177 25.55 E	1 007	1 030	1.68	1 800
32	10	21 Oct	44 10.94	177 29.22 E	44 12.89	177 29.95 E	940	1 000	2.02	1 750
33	9	21 Oct	44 07.30	177 35.82 E	44 08.91	177 37.44 E	883	920	1.99	1 680

Station	Stratum	Date 1992	Start Latitude ° 'S	Start Longitude ° 'E/W	Finish Latitude ° 'S	Finish Longitude ° 'E/W	Depth (m) Min.	Depth (m) Max.	Distance towed (n. mile)	Warp length (m)
34	12	21 Oct	44 18.25	177 39.60 E	44 18.49	177 42.17 E	1 100	1 103	1.85	1 930
35	12	21 Oct	44 21.83	177 53.09 E	44 21.89	177 55.87 E	1 139	1 145	1.99	2 030
36	10	21 Oct	44 04.33	177 51.23 E	44 04.78	177 53.96 E	900	977	2.01	1 750
37	8	21 Oct	43 55.40	178 16.24 E	43 55.79	178 19.02 E	639	663	2.04	1 200
38	8	21 Oct	43 58.99	178 33.24 E	43 58.93	178 36.04 E	683	690	2.02	1 250
39	8	21 Oct	44 02.55	178 40.71 E	44 02.88	178 37.90 E	782	790	2.05	1 390
40	10	21 Oct	44 06.75	178 36.42 E	44 05.80	178 33.16 E	912	991	2.00	1 800
41	10	22 Oct	44 07.41	178 31.06 E	44 07.50	178 33.86 E	940	946	2.01	1 700
42	10	22 Oct	44 07.13	178 25.68 E	44 07.87	178 23.08 E	973	1 010	2.01	1 750
43	11	22 Oct	44 06.59	178 12.48 E	44 07.75	178 10.21 E	1 012	1 066	2.00	1 820
44	12	22 Oct	44 14.06	178 20.75 E	44 14.52	178 18.11 E	1 114	1 120	1.95	1 970
45	12	22 Oct	44 16.85	178 27.54 E	44 18.13	178 29.69 E	1 157	1 183	2.00	2 100
46	11	22 Oct	44 12.63	178 51.79 E	44 12.88	178 54.52 E	1 004	1 009	1.97	1 750
47	10	22 Oct	44 12.31	179 06.28 E	44 13.57	179 08.45 E	935	952	2.00	1 610
48	9	22 Oct	44 09.38	179 15.31 E	44 09.36	179 12.50 E	825	831	2.02	1 520
49	10	23 Oct	44 16.28	179 18.21 E	44 17.49	179 20.50 E	979	992	2.04	1 750
50	11	23 Oct	44 17.79	179 20.91 E	44 19.09	179 18.74 E	983	1 038	2.03	1 800
51	16	23 Oct	44 28.96	179 45.80 E	44 29.81	179 48.34 E	1 212	1 215	2.00	2 100
52	14	23 Oct	44 18.25	179 55.71 E	44 19.42	179 57.97 E	922	942	2.00	1 750
53	13	23 Oct	44 14.43	179 57.31 E	44 16.14	179 58.79 E	772	802	2.01	1 410
54	14	23 Oct	44 19.82	179 42.64 E	44 19.84	179 39.83 E	824	831	2.01	1 450
55	14	23 Oct	44 23.54	179 40.56 W	44 25.21	179 40.59 W	926	1 000	1.67	1 820
56	13	23 Oct	44 17.15	179 37.21 W	44 17.51	179 39.97 W	715	750	2.01	1 300
57	30	24 Oct	44 26.26	179 16.95 W	44 25.85	179 17.44 W	885	954	0.54	1 750
58	30	24 Oct	44 26.90	179 17.41 W	44 26.94	179 18.08 W	885	943	0.48	1 630
59	16	24 Oct	44 46.26	179 31.91 W	44 46.43	179 29.05 W	1 303	1 325	2.04	2 250
60	15	24 Oct	44 28.16	179 08.33 W	44 30.10	179 07.67 W	1 009	1 057	2.00	1 800
61	15	24 Oct	44 31.69	179 04.41 W	44 31.63	179 01.56 W	1 113	1 130	2.03	1 960
62	30	24 Oct	44 26.11	179 16.67 W	44 25.84	179 16.99 W	880	952	0.35	1 700
63	16	25 Oct	44 41.31	178 28.51 W	44 41.32	178 25.68 W	1 273	1 279	2.01	2 210
64	19	25 Oct	44 26.22	178 16.33 W	44 26.15	178 13.51 W	960	966	2.02	1 710
65	19	25 Oct	44 26.68	178 07.78 W	44 26.70	178 04.21 W	928	932	2.03	1 640
66	20	25 Oct	44 30.66	178 08.00 W	44 32.65	178 07.44 W	1 005	1 061	2.03	1 770
67	20	25 Oct	44 32.56	178 07.12 W	44 32.80	178 04.30 W	1 041	1 048	2.02	1 820

Station	Stratum	Date 1992	Start Latitude ° 'S	Start Longitude ° 'E/W	Finish Latitude ° 'S	Finish Longitude ° 'E/W	Depth (m) Min.	Depth (m) Max.	Distance towed (n. mile)	Warp length (m)
68	21	25 Oct	44 36.45	178 01.64 W	44 36.48	177 59.74 W	1 100	1 132	1.35	2 000
69	19	25 Oct	44 31.12	177 52.34 W	44 32.93	177 51.16 W	904	985	2.00	1 560
70	18	25 Oct	44 29.84	177 40.71 W	44 29.65	177 37.94 W	808	817	1.98	1 420
71	21	25 Oct	44 40.07	177 34.00 W	44 40.61	177 32.79 W	1 102	1 155	1.02	2 020
72	17	26 Oct	44 25.35	177 21.63 W	44 26.65	177 19.46 W	638	671	2.02	1 200
73	22	26 Oct	44 53.63	177 08.79 W	44 54.76	177 06.42 W	1 450	1 493	2.02	2 500
74	20	26 Oct	44 40.34	177 25.77 W	44 40.87	177 23.03 W	1 064	1 076	2.02	1 890
75	21	26 Oct	44 41.92	177 24.52 W	44 42.09	177 21.70 W	1 144	1 156	2.01	2 040
76	19	27 Oct	44 37.23	177 31.25 W	44 37.02	177 33.18 W	925	943	1.39	1 690
77	18	27 Oct	44 35.87	177 27.55 W	44 36.19	177 30.33 W	857	887	2.01	1 520
78	18	27 Oct	44 32.74	177 13.30 W	44 34.65	177 12.41 W	800	826	2.01	1 360
79	18	27 Oct	44 38.66	176 51.11 W	44 39.41	176 51.16 W	800	878	0.75	1 500
80	21	28 Oct	44 45.15	176 55.69 W	44 46.20	176 58.11 W	1 111	1 175	2.01	2 040
81	21	28 Oct	44 42.37	176 08.51 W	44 44.09	176 09.48 W	1 106	1 200	1.85	2 010
82	20	28 Oct	44 38.75	176 01.68 W	44 39.81	176 03.38 W	1 006	1 021	1.61	1 800
83	31	28 Oct	44 36.97	175 45.84 W	44 37.20	175 46.06 W	861	890	0.28	1 400
84	31	28 Oct	44 36.35	175 45.99 W	44 37.09	175 46.17 W	862	936	0.75	1 660
85	22	29 Oct	44 40.31	175 48.38 W	44 39.74	175 45.65 W	1 336	1 358	2.02	2 350
86	31	29 Oct	44 35.93	175 46.28 W	44 35.80	175 46.63 W	900	972	0.28	1 640
87	18	29 Oct	44 33.85	175 50.32 W	44 33.81	175 53.11 W	838	900	1.99	1 600
88	17	29 Oct	44 33.93	175 56.56 W	44 34.89	175 59.08 W	762	774	2.04	1 350
89	17	29 Oct	44 29.47	175 45.72 W	44 29.70	175 48.55 W	590	603	2.03	1 100
90	31	29 Oct	44 36.53	175 46.42 W	44 36.56	175 46.66 W	875	913	0.17	1 600
91	31	29 Oct	44 36.54	175 46.39 W	44 36.57	175 46.57 W	867	912	0.13	1 680
92	19	30 Oct	44 35.25	175 52.02 W	44 35.50	175 49.36 W	940	990	2.00	1 700
93	20	30 Oct	44 35.69	175 49.80 W	44 35.96	175 46.99 W	1 001	1 063	2.02	1 760
94	33	30 Oct	44 41.43	175 20.70 W	44 41.61	175 20.76 W	965	1 020	0.19	1 773
95	32	30 Oct	44 41.96	175 29.48 W	44 41.96	175 29.53 W	1 003	1 005	0.04	2 000
96	32	30 Oct	44 41.91	175 29.57 W	44 41.89	175 29.80 W	1 008	1 160	0.16	2 047
97	19	30 Oct	44 32.30	175 29.72 W	44 32.62	175 31.53 W	931	960	1.33	1 680
98	20	30 Oct	44 33.85	175 23.68 W	44 34.41	175 26.39 W	1 049	1 054	2.01	1 840
99	32	31 Oct	44 40.92	175 28.64 W	44 40.69	175 28.70 W	1 064	1 200	0.23	2 170
100	21	31 Oct	44 35.25	175 22.86 W	44 35.69	175 19.41 W	1 100	1 172	2.00	2 040
101	19	31 Oct	44 32.64	175 23.15 W	44 32.88	175 25.96 W	983	998	2.02	1 725

Station	Stratum	Date 1992	Start Latitude ° 'S	Start Longitude ° 'E/W	Finish Latitude ° 'S	Finish Longitude ° 'E/W	Depth (m) Min.	Depth (m) Max.	Distance towed (n. mile)	Warp length (m)
102	32	1 Nov	44 41.90	175 29.65 W	44 41.91	175 29.86 W	1 109	1 221	0.15	1 900
103	32	1 Nov	44 41.96	175 29.38 W	44 41.97	175 29.53 W	987	1 040	0.11	1 750
104	33	1 Nov	44 39.86	175 20.16 W	44 39.78	175 20.12 W	945	1 034	0.08	1 731
105	33	1 Nov	44 41.25	175 19.72 W	44 41.36	175 19.64 W	950	1 036	0.12	1 739
106	25	1 Nov	44 31.91	175 10.85 W	44 31.93	175 09.05 W	1 151	1 200	1.29	2 062
107	25	2 Nov	44 29.39	174 57.66 W	44 29.36	174 54.87 W	1 080	1 178	1.99	1 910
108	24	2 Nov	44 25.27	175 02.11 W	44 26.53	174 59.93 W	868	929	2.00	1 600
109	24	2 Nov	44 23.74	175 02.67 W	44 21.84	175 01.73 W	815	855	2.02	1 600
110	23	2 Nov	44 22.26	175 03.84 W	44 20.29	175 02.39 W	771	798	2.23	1 400
111	26	2 Nov	44 23.73	174 37.05 W	44 22.11	174 36.53 W	1 420	1 471	1.66	2 550
112	34	2 Nov	44 12.27	174 28.76 W	44 12.08	174 28.71 W	846	916	0.19	1 700
113	34	2 Nov	44 12.82	174 28.15 W	44 12.72	174 27.99 W	710	732	0.15	1 460
114	26	2 Nov	44 06.46	174 27.88 W	44 06.51	174 25.10 W	1 208	1 233	2.00	2 220
115	34	2 Nov	44 12.36	174 29.21 W	44 12.24	174 29.21 W	850	912	0.12	1 470
116	26	2 Nov	44 04.87	174 24.58 W	44 04.56	174 21.82 W	1 201	1 242	2.01	2 120
117	35	3 Nov	44 10.06	174 28.01 W	44 10.10	174 28.20 W	987	1 106	0.14	NA
118	35	3 Nov	44 10.68	174 26.16 W	44 10.76	174 26.09 W	950	1 020	0.09	1 750
119	35	3 Nov	44 09.46	174 25.53 W	44 09.37	174 25.35 W	1 044	1 134	0.16	1 990
120	25	3 Nov	44 04.49	174 39.84 W	44 04.00	174 37.12 W	1 016	1 070	2.01	1 785
121	24	3 Nov	44 09.64	174 48.71 W	44 10.00	174 46.67 W	931	1 000	1.51	1 660
122	23	3 Nov	44 05.89	174 52.54 W	44 03.89	174 52.38 W	785	796	2.00	1 400
123	23	3 Nov	44 05.58	175 01.30 W	44 03.51	175 01.21 W	748	760	2.07	1 430
124	21	4 Nov	44 32.55	175 13.80 W	44 33.68	175 16.17 W	1 155	1 157	2.03	2 100
125	21	4 Nov	44 32.71	175 16.43 W	44 34.08	175 18.55 W	1 100	1 129	2.04	1 950
126	21	4 Nov	44 33.51	175 15.07 W	44 34.88	175 17.16 W	1 169	1 189	2.02	2 050
127	21	4 Nov	44 34.91	175 21.08 W	44 35.79	175 23.56 W	1 113	1 131	1.97	1 980
128	19	4 Nov	44 32.47	175 22.85 W	44 32.22	175 25.40 W	964	995	1.84	1 700
129	21	4 Nov	44 37.07	175 29.76 W	44 37.20	175 26.98 W	1 161	1 185	1.98	2 070
130	21	4 Nov	44 36.51	175 32.81 W	44 36.78	175 35.60 W	1 140	1 185	2.00	2 050
131	21	4 Nov	44 34.85	175 38.93 W	44 35.55	175 41.57 W	1 111	1 131	2.01	1 960
132	21	5 Nov	44 36.32	175 40.36 W	44 36.44	175 43.17 W	1 172	1 200	2.00	NA
133	22	5 Nov	44 39.26	175 46.10 W	44 39.21	175 43.36 W	1 284	1 371	1.95	2 400
134	22	5 Nov	44 39.97	175 42.05 W	44 41.20	175 44.32 W	1 393	1 436	2.03	2 500
135	22	5 Nov	44 39.99	175 50.81 W	44 41.95	175 51.33 W	1 218	1 355	1.99	2 180

Station	Stratum	Date 1992	Start Latitude ° 'S	Start Longitude ° 'E/W	Finish Latitude ° 'S	Finish Longitude ° 'E/W	Depth (m) Min.	Depth (m) Max.	Distance towed (n. mile)	Warp length (m)
136	19	5 Nov	44 35.20	175 49.26 W	44 35.81	175 50.43 W	978	1 002	1.03	1 750
137	19	5 Nov	44 37.38	176 01.94 W	44 38.69	176 04.10 W	902	930	2.02	1 600
138	21	5 Nov	44 43.05	176 10.34 W	44 42.95	176 07.47 W	1 147	1 197	2.04	2 170
139	21	5 Nov	44 44.02	176 21.22 W	44 44.56	176 23.97 W	1 133	1 176	2.03	2 090
140	19	6 Nov	44 41.97	176 28.31 W	44 41.93	176 27.36 W	951	962	0.68	1 710
141	21	6 Nov	44 44.34	176 36.94 W	44 44.62	176 34.18 W	1 112	1 201	1.98	2 150
142	19	6 Nov	44 42.43	176 40.17 W	44 42.64	176 42.87 W	928	1 000	1.93	1 720
143	19	6 Nov	44 41.52	176 46.58 W	44 40.42	176 44.50 W	934	991	1.84	1 695
144	21	6 Nov	44 44.51	176 44.96 W	44 46.08	176 46.84 W	1 155	1 193	2.06	2 250
145	21	6 Nov	44 45.27	176 53.44 W	44 45.38	176 50.63 W	1 126	1 140	2.00	1 980
146	18	7 Nov	44 37.95	176 55.27 W	44 38.34	176 58.08 W	850	905	2.04	1 530
147	21	7 Nov	44 45.17	177 04.13 W	44 45.17	177 01.36 W	1 189	1 191	1.97	2 150
148	22	7 Nov	44 52.71	176 53.62 W	44 52.10	176 56.40 W	1 377	1 393	2.06	2 400
149	22	7 Nov	44 48.99	177 02.62 W	44 48.98	177 05.51 W	1 318	1 326	2.05	2 320
150	21	7 Nov	44 43.79	177 15.83 W	44 44.15	177 12.98 W	1 170	1 190	2.06	2 100
151	19	7 Nov	44 41.81	177 09.18 W	44 41.84	177 05.51 W	978	1 000	2.00	1 770
152	19	7 Nov	44 38.80	177 18.45 W	44 39.81	177 16.06 W	971	996	1.98	1 750
153	21	7 Nov	44 41.85	177 21.87 W	44 41.85	177 24.04 W	1 116	1 121	1.54	1 950
154	22	8 Nov	44 50.00	177 27.67 W	44 50.43	177 24.93 W	1 412	1 423	1.99	2 500
155	21	8 Nov	44 40.60	177 32.82 W	44 41.96	177 30.79 W	1 138	1 183	1.98	2 000
156	19	8 Nov	44 33.22	177 38.76 W	44 31.94	177 40.95 W	902	953	2.02	1 660
157	21	8 Nov	44 38.82	177 40.24 W	44 39.48	177 37.54 W	1 166	1 200	2.03	2 070
158	22	8 Nov	44 46.43	177 37.70 W	44 45.69	177 40.37 W	1 324	1 332	2.03	2 350
159	22	8 Nov	44 49.54	177 50.51 W	44 50.69	177 48.18 W	1 401	1 438	2.01	2 600
160	21	8 Nov	44 39.44	177 48.59 W	44 39.40	177 51.44 W	1 163	1 178	2.03	2 040
161	19	9 Nov	44 33.22	177 51.39 W	44 33.01	177 49.13 W	933	968	1.62	1 770
162	19	9 Nov	44 27.65	178 04.81 W	44 28.02	178 05.90 W	911	933	0.86	1 650
163	21	9 Nov	44 37.20	178 06.97 W	44 37.74	178 04.19 W	1 158	1 182	2.05	2 030
164	22	9 Nov	44 40.88	178 09.54 W	44 40.99	178 06.72 W	1 238	1 242	2.01	2 250
165	21	9 Nov	44 37.53	178 13.73 W	44 38.13	178 11.05 W	1 172	1 184	2.00	2 150
166	22	9 Nov	44 45.59	178 18.61 W	44 45.95	178 15.89 W	1 328	1 355	1.97	2 400
167	13	10 Nov	44 06.31	179 52.67 E	44 06.90	179 55.29 E	606	607	1.97	1 050
168	15	10 Nov	44 22.98	179 34.88 E	44 23.41	179 37.61 E	1 127	1 134	2.00	2 000

Stations 13, 25, 44, 79, 84, 9: 112 and 143 were gear performance 2.
Stations 83, 90, 95 and 102 were gear performance 3.

Appendix 5: Catch (kg) of black oreo, smooth oreo, and orange roughy at each station

Station	Black oreo	Smooth oreo	Orange roughy
1	556.8	2 408.9	0
2	68.3	13.3	0
3	68.9	0.5	0
4	45.1	71.7	0
5	286.8	59.0	0
6	68.0	1.1	0
7	69.9	0	0
8	39.4	0.4	0
9	8.6	10.5	0
10	1.0	10.2	0
11	20.5	121.7	0
12	3.4	4.0	0
13	47.3	6.1	0
14	15.3	1.2	0
15	4.1	1.1	0
16	1.3	1.7	0
17	0	3.9	0
18	0	2.9	0
19	38.3	1.3	0
20	26.2	3.0	0.6
21	546.4	10.6	0
22	233.4	7.3	0
23	54.9	0	0
24	42.6	0	0
25	120.6	4.1	0
26	12.6	4.1	0.8
27	84.3	0	0
28	59.8	24.1	0.8
29	0.9	0.6	0
30	0.8	4.1	0
31	1.9	32.7	4.8
32	70.8	363.8	2.3
33	34.4	3.9	0
34	2.5	1.8	0
35	0.9	2.1	0
36	3.7	2.3	0
37	179.1	0	0
38	324.5	1.8	0
39	661.2	10.9	0
40	3 344.2	1 185.2	1.2
41	167.2	24.2	0
42	65.8	10.1	6.1
43	304.9	695.4	17.2
44	0	0	0
45	1.1	1.5	0
46	2.0	5.3	0
47	45.4	10.2	1.0
48	243.7	2.5	0
49	6.9	1.8	1.6
50	1.2	4.3	0
51	0	0	0
52	4.9	7.9	1.9
53	694.9	8.6	0
54	113.0	4.0	0
55	31.4	2.2	1.9
56	21.4	0	0
57	171.5	9 863.4	1 155.9

Station	Black oreo	Smooth oreo	Orange roughy
58	113.4	18 517.7	1 097.0
59	0	0	0
60	2.9	4.7	4.1
61	0	3.1	6.1
62	6.3	73.8	11.8
63	0	4.1	0
64	0.9	4.2	9.0
65	1.8	3 843.6	92.2
66	0.8	2.7	9.0
67	0.8	5.0	4.1
68	0	1.9	0
69	43.0	8 498.0	66.2
70	93.3	1 194.9	5.5
71	0	25 383.5	15.9
72	22.4	0	0
73	0	0	0
74	0.9	110.3	41.6
75	3.0	986.8	129.8
76	237.3	27 487.3	26.3
77	209.5	4 357.0	29.9
78	27.2	314.0	14.4
79	9.6	7.4	0.5
80	5.7	208.9	21.8
81	23.2	2 206.4	36.9
82	3.9	2 470.4	10.3
83	14.3	473.3	0.7
84	41.2	13 576.9	9.9
85	0	4 188.2	1.9
86	387.5	4 036.7	3.0
87	9.6	80.8	0.6
88	0	54.0	0
89	0	0	0
90	0	0	0
91	85.4	6 060.2	7.9
92	6.5	153.5	4.1
93	4.8	201.8	7.3
94	2 065.2	1 471.6	8 106.2
95	0	0	0
96	54.1	1 381.0	789.7
97	200.8	2 409.0	5 228.0
98	44.8	86.4	7.8
99	278.4	43 706.7	2 636.0
100	0.4	17.8	7.3
101	12.4	207.8	4.7
102	0	0	0
103	30.0	1 911.3	15.5
104	123.0	240.0	650.7
105	6 945.6	1 559.4	24 091.0
106	0	0	1.3
107	0.4	0.8	5.4
108	0	4.7	7.3
109	0	1.9	0.9
110	0	8.6	0
111	0	53.4	0
112	67.8	258.4	3 918.0
113	3 386.6	143.2	1.0
114	0	1 169.9	11.1
115	30.2	846.1	1 646.6

Station	Black oreo	Smooth oreo	Orange roughy
116	0.4	3.4	5.2
117	1 316.3	383.4	1 614.6
118	670.6	504.9	3 163.0
119	77.4	17.2	39.9
120	0	4.3	29.0
121	0	2.2	20.2
122	0	0	12.7
123	0	0	0
124	0.4	7.7	1.6
125	1.8	6.9	16.9
126	0.9	7.4	4.7
127	0.9	55.1	9.7
128	9.6	139.0	5.7
129	3.1	2 892.7	11.5
130	0.9	2 747.8	25.5
131	0	1 457.7	16.4
132	0	498.0	12.4
133	0	457.8	2.4
134	0	28.7	1.3
135	0	369.5	0
136	0.3	4 111.9	2.9
137	3.0	580.5	4.4
138	0.5	462.9	8.7
139	2.0	2 926.9	36.4
140	0.8	1 312.0	3.2
141	0.8	339.4	29.3
142	0	684.0	4.6
143	2.1	633.7	10.4
144	4.3	53.0	12.4
145	0	42.0	11.2
146	7.0	30.5	6.4
147	1.1	147.3	1.0
148	0	10.9	0
149	0	1 874.1	0
150	0	1 048.7	11.7
151	5.0	3 029.0	24.4
152	1.2	118.6	16.8
153	0	83.4	57.1
154	0	0	0
155	0	1 334.8	7.5
156	1.4	43.6	2.6
157	0	478.3	12.0
158	0	4.9	0
159	0	1.0	0
160	0	24.6	0
161	331.6	8 551.6	52.3
162	12.0	3 958.1	3.2
163	0	899.4	2.8
164	0	7.8	0
165	0	4.7	0.6
166	0	0	0
167	278.8	0	0
168	0	2.9	0

Appendix 6: Species caught.

Species code	Scientific name	Common name
Crustacea		
APE	*Acanthephyra pelagica*	
LHO	*Lipkius holthuisi*	omega prawn
LMU	*Lithodes murrayi*	southern stone crab
NEB	*Neolithodes brodiei*	southern stone crab
PZE	*Paralomis zelandica*	
PBA	*Pasiphaea barnardi*	
Cephalopods		
VSQ	*Histioteuthis* spp.	violet squid
MIQ	*Moroteuthis ingens*	warty squid
MRQ	*M. robsoni*	warty squid
DWO	*Octopus* sp.	deepwater octopus
RSQ	*Ommastrephes bartrami*	red squid
CHQ	Cranchiidae	cranchiid squid
OPI	*Opisthoteuthis sp.*	
Chondrichthyes		
Squalidae		
CSQ	*Centrophorus squamosus*	leafscaled gulper shark
CYP	*Centroscymnus crepidater*	longnosed velvet dogfish
CYO	*C. owstoni*	smooth skinned dogfish
SND	*Deania calcea*	shovelnosed spiny dogfish
ETB	*Etmopterus baxteri*	Baxter's lantern dogfish
ETL	*E. lucifer*	Lucifer dogfish
ETM	*Etmopterus* sp.	
PLS	*Scymnodon plunketi*	Plunket's shark
BSH	*Scymnorhinus licha*	seal shark
SPD	*Squalus acanthias*	spiny dogfish
Chlamydoselachidae		
FRS	*Chlamydoselachus anguineus*	frill shark
Scyliorhinidae		
APR	*Apristurus* spp.	catshark
Rajidae		
PSK	*Bathyraja shuntovi*	longnosed deepsea skate
BTH	*Pavoraja* spp.	bluntnosed skate
SSK	*Raja innominata*	smooth skate
Rhinochimaeridae		
LCH	*Harriotta raleighana*	longnosed chimaera
RCH	*Rhinochimaera pacifica*	widenosed chimera
Chimaeridae		
CHG	*Chimaera* sp. B	giant chimaera
CHP	*Chimaera* sp. C	purple chimaera
HYB	*Hydrolagus* sp. A	black hydrolagus
GSP	*Hydrolagus* sp. B	pale hydrolagus
HYP	*Hydrolagus* sp. C	longnosed blue hydrolagus
SCO	*Bassanago bulbiceps*	swollenhead conger

Teleosts

Notacanthiformes		
Notocanthidae		
SBK	*Notacanthus sexspinis*	spineback eel
Anguilliformes		
Congridae		
Synaphobranchidae		
BEE	*Diastobranchus capensis*	basketwork eel
Salmoniformes		
Argentinidae		
SSI	*Argentina elongata*	silverside
Bathylagidae		
DSS	*Bathylagus* sp.	deepsea smelt
Alepocephalidae		
SSM	*Alepocephalus australis*	smallscaled brown slickhead
SBI	*Alepocephalus* sp.	bigscaled brown slickhead
BSL	*Xenodermichthys copei*	black slickhead
TAL	*Talismania longifilis*	threadfin slickhead
BAT	*Rouleina* sp.	largeheaded slickhead
Stomiiformes		
Photichthyidae		
PHO	*Photichthys argenteus*	lighthouse fish
Chauliodontidae		
CHA	*Chauliodus sloani*	viperfish
Melanostomiidae		
OMI	*Opostomias micripnus*	scaleless black dragonfish
Idiacanthidae		
IDI	*Idiacanthus* spp.	black dragonfishes
Aulopiformes		
Alepisauridae		
ABR	*Alepisaurus brevirostris*	shortsnouted lancetfish
Myctophiformes		
Myctophidae		
LAN	Myctophidae (family)	lanternfish
Gadiformes		
Moridae		
VCO	*Antimora rostrata*	violet cod
HJO	*Halargyreus johnsonii*	Johnson's cod
SMC	*Lepidion microcephalus*	smallheaded cod
LEG	*L. schmidti*	giant lepidion
RIB	*Mora moro*	ribaldo
Melanonidae		
MEL	*Melanonus gracilis*	pelagic cod
Gadidae		
SBW	*Micromesistius australis*	southern blue whiting

Merlucciidae		
LYC	*Lyconus* sp.	blackmouth hake
HOK	*Macruronus novaezelandiae*	hoki
HAK	*Merluccius australis*	hake
Macrouridae		
CKX	*Caelorinchus acanthiger*	spottyfaced rattail
CBO	*C. bollonsi*	Bollon's rattail
CFA	*C. fasciatus*	banded rattail
CIN	*C. innotabilis*	notable rattail
CKA	*C. kaiyomaru*	Kaiyomaru rattail
CMA	*C. matamua*	Mahia rattail
COL	*C. oliverianus*	Oliver's rattail
CMX	*Coryphaenoides mcmillani*	
CMU	*C. murrayi*	abyssal rattail
CSE	*C. serrulatus*	serrulate rattail
CSU	*C. subserrulatus*	fourrayed rattail
CBA	*Coryphaenoides* sp. B	long barbelled rattail
NPU	*Kuronezumia leonis*	
JAV	*Lepidorhynchus denticulatus*	javelinfish
MCA	*Macrourus carinatus*	ridgescaled rattail
BJA	*Mesobius antipodum*	black javelinfish
NNA	*Nezumia namatahi*	squashedfaced rattail
WHR	*Trachyrincus longirostris*	white rattail
WHX	*Trachyrincus* sp.	unicorn rattail
VNI	*Ventrifossa nigromaculata*	blackspot rattail
Ophidiiformes		
Ophidiidae		
BCR	*Brotulotaenia crassa*	blue cusk eel
LIN	*Genypterus blacodes*	ling
Carapidae		
ECR	*Echiodon cryomargarites*	messmate fish
Bythitidae		
CAN	*Cataetyx niki*	brown brotula
Lophiiformes		
Ceratiidae		
SDE	*Cryptopsaras couesi*	seadevil
Himantolophidae		
HIA	*Himantolophus appelii*	prickly anglerfish
Lampriformes		
Trachipteridae		
DEA	*Trachipterus trachypterus*	dealfish
DPO	*Desmodema polystictum*	dealfish
Beryciformes		
Trachichthyidae		
ORH	*Hoplostethus atlanticus*	orange roughy
Diretmidae		
DIS	*Diretmus argenteus*	discfish
Anoplogastridae		
ANO	*Anoplogaster cornuta*	fangtooth roughy

Berycidae		
BYS	*Beryx splendens*	alfonsino
Melamphaidae		
MPH	*Melamphaes* sp.	bigscale fish
Zeiformes		
Zeidae		
LDO	*Cyttus traversi*	lookdown dory
Oreosomatidae		
BOE	*Allocyttus niger*	black oreo
WOE	*A. verrucosus*	warty oreo
SOR	*Neocyttus rhomboidalis*	spiky oreo
SSO	*Pseudocyttus maculatus*	smooth oreo
Syngnathiformes		
Macrorhamphosidae		
BBE	*Centriscops humerosus*	redbanded bellowsfish
Scorpaeniformes		
Scorpaenidae		
TRS	*Trachyscorpia capensis*	cape scorpionfish
Psychrolutidae		
COT	*Cottunculus nudus*	bony skull toadfish
PSY	*Psychrolutes* sp.	blobfish
Perciformes		
Apogonidae		
EPL	*Epigonus lenimen*	bigeyed cardinalfish
EPR	*E. robustus*	robust cardinalfish
EPT	*E. telescopus*	black cardinalfish
Serranidae		
SPE	*Helicolenus* sp.	sea perch
Centrolophidae		
RUD	*Centrolophus niger*	rudderfish
TUB	*Tubbia tasmanica*	
WWA	*Seriolella caerulea*	white warehou
Trichiuridae		
BEN	*Benthodesmus* sp. ?	scabbard fish
Caristiidae		
PLA	*Platyberyx* sp.	

Others

SCC	sea cucumbers
ONG	sponges
COR	red coral
ANT	anemones
ASR	starfish
SCY	jellyfish
SUR	sea urchin

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