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Malcolm Clark
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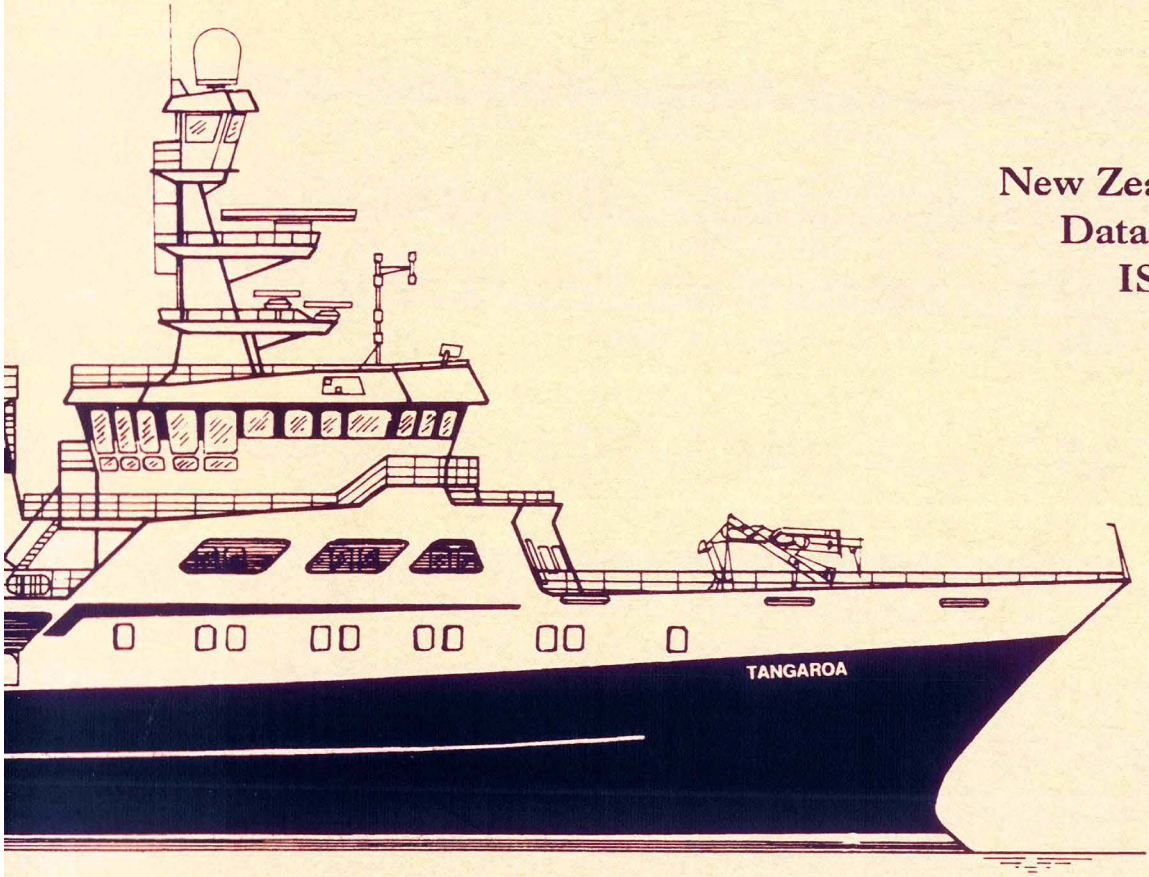

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Contents

Introduction

Commercial fisheries for orange roughy (*Hoplostethus atlanticus*), black oreo (*Allocyttus niger*), and smooth oreo (*Pseudocyttus maculatus*) developed in the Puysegur Bank region in late 1990. Orange roughy were initially caught as a minor bycatch in the oreo fishery.

In June 1991, FV *Will Watch* was chartered by The Exploratory Fishing Company (ORH 3B) Ltd for a 6 week period to explore southern New Zealand waters for new orange roughy fishing grounds. Concentrations of spawning orange roughy were found on the western side of the Puysegur Bank, and a stratified random trawl survey was planned and carried out by MAF Fisheries staff. The survey produced extensive data on distribution, relative abundance, and biology of orange roughy, as well as on the main bycatch species of oreo (Clark & Tracey 1992). This survey was repeated by FV *Giljanes* in July 1992 in a second co-operative venture between MAF Fisheries and industry. This gave further information on the fish stocks in the area, and some insight into the effects of commercial fishing for orange roughy when in 1991–92 about 7000 t of orange roughy and 3000 t of black and smooth oreo were caught (Clark & Tracey 1993). However, the two surveys were inadequate for reliable estimation of population size and yield, and industry expressed reluctance to be involved in further research in the area. Hence, a time series of three or four surveys by GRV *Tangaroa* was planned to collect scientific data for use in stock reduction analyses to estimate biomass and sustainable yield of orange roughy, black oreo, and smooth oreo in the region. This report describes the first of these surveys.

Objectives

1. To describe the distribution and measure the relative biomass of orange roughy, black oreo, and smooth oreo in the region of Puysegur Bank, western Stewart Shelf, and the Macquarie Ridge.
2. To collect biological data on size structure and reproduction for determination of pre-recruit/recruited biomass, gonad development, and timing of spawning.
3. To investigate stock/population structure in the area.
4. To improve knowledge of bathymetry around the Puysegur Bank.

Methods

Survey area

The survey covered the Puysegur Bank, the western Stewart Shelf, and the Macquarie Ridge region from about 46° 30′ to 48° 10′ S and 165° to 167° E (Figure 1). A ridge at 49° 00′ S was also explored. The survey covered 6480 km^2, substantially more than that covered by previous joint industry-MAF Fisheries surveys in 1991 and 1992. This region forms part of ORH 3B and OEO 1 fish stock areas.

Survey design

The survey followed a two-phase random trawl method (*after* Francis 1984). The survey area was divided into 34 strata (Table 1, Figure 1) on the basis of knowledge of fish distribution and bottom bathymetry acquired during previous surveys. Random stations were

generated by computer and there was a minimum of three tows per stratum. Several methods of specifying tow positions were used depending on the bottom characteristics of the strata.

1. Random latitude and longitude, tow direction parallel to depth contour
2. Random latitude, random direction off the top of the hill
3. Random latitude, tow directly down steep slope where it was too steep and rough to follow depth contour.

Hill strata were fished on a number of occasions. Fish distribution may vary between sides of a hill at different times of the day, so tows were spread over a number of days as well as being in random directions down the sides of the hill. Time of day was not specifically randomised, but was not selected, and hence varied. This design gave a temporal and geographic mixture of trawls to represent fish distribution and abundance.

Towing speed was kept at 3.0–3.5 knots, and when possible tow distance was standardised to 1.5 n.mile. When carrying out hill and steep slope tows, however, these two parameters could not be kept constant. The warp to depth ratio varied from 1.6 : 1 to 2.1 : 1 depending on depth and bottom condition.

Vessel specifications

GRV *Tangaroa* has the following specifications: overall length, 70 m; beam, 14 m; gross tonnage, 2280 t; main engine power, 3000 kW.

The gear used was the standard rough bottom orange roughy trawl (*see* Appendix 1) with two lengtheners, three cod-ends, and bobbin rig. The trawl specifications were:

cod-end mesh	100 mm
sweeps	50 m
bridles	50 m
layback	1 m
headline length	38 m
groundrope length	20.8 m
ground chains	12.5 m
headline floats	26 x 1500 m (52–56 x 2000 m for early part of trip)
doors	Super Vee, 6.1 m^2
doorspread	115 m
wingspread	26 m
headline height	6–8 m
bobbin rig	10 steel and 9 rubber bobbins and 2 extra bunt bobbins in front of groundrope

Treatment of catch

The catch for each tow was sorted by species and weighed. If a large catch made weighing impractical, the greenweights of the three main species (orange roughy, smooth oreo, and black oreo) were back-calculated from the factory tray counts. Conversion factors and mean tray weights were obtained from all tows thus handled.

Samples of 100–200 orange roughy, smooth oreo, and black oreo were routinely measured and sexed. If a catch was large, several samples were taken from different parts of the net and combined to ensure sampling was representative of the entire catch.

At each tow a further 20 fish of each of the main species were taken at random and examined in greater detail for length (mm), weight (g), sex, gonad weight (g), gonad stage (following Pankhurst *et al.* 1987), stomach fullness and digestion state, and identification of

prey items. Otoliths were collected as well as tissue samples (heart, liver, and muscle) from 50 large and 50 small orange roughy for genetic studies.

Timetable of events

Tangaroa sailed for the survey grounds on the morning of 16 August: fishing began on the morning of the 18th, and continued until 24 August when it was necessary to steam to Bluff for engine repairs. Fishing resumed on 27 August and the survey was completed on 12 September. The vessel berthed in Port Chalmers on 13 September.

Biomass estimates

Biomass indices were calculated by the area swept method (Francis 1981). Clark & Tracey (1992) described the formulae for calculating biomass and standard error. A constant wingspread measurement figure of 26.0 m (vulnerability of 0.23) and vertical and areal availability assumptions of 1.0 were used to estimate biomass. The recorded distance was used for distance towed.

Biological analyses

1. Length frequency distribution

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

2. Reproductive stages

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

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

3. Feeding analyses

Data on frequency of occurrence and volume of prey have been combined into a single index (*IV*) (Vesin *et al.* 1981) to assess relative importance of prey for orange roughy,smooth oreo, and black oreo:

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

Frequency of occurrence is the number of stomachs in which a prey item was found. Volume was assessed by eye as the proportion of stomach contents, where each stomach totalled 100%.

Note on terminology
In several analyses, data are grouped by sub-area:
Puysegur – the Puysegur Bank region, including strata 110 to 450.
Stewart – the western Stewart Shelf, strata 610 to 750.
Macquarie – the northern Macquarie Ridge, strata 501, 502, 801, and 802.

Results

A total of 135 tows covering the three main sub-areas, Puysegur, Macquarie, and Stewart, was completed, 122 of which were used in the biomass analyses. Thirteen tows were excluded from the biomass analyses. Six were due to poor gear performance (tow numbers 21, 29, 71, 91, 119, and 124). Tows 86 and 87 in stratum 900 were excluded as the minimum number of tows (three) could not be carried out because of rough terrain, and tows 80 to 84 were at exploratory, non-random stations in stratum 1000.

Station positions are shown in Figure 2. Detailed station data with catch information are given in Appendix 2. The catch of all fish, shark, squid, and crustacean species combined was 336 618 kg. A full species list is given in Appendix 3. Catch weights of the 10 most abundant species are given in Table 2. As with previous surveys, the main species caught were orange roughy (37%), black oreo (36%), and smooth oreo (21%). Table 3 shows orange roughy to be most dominant in the Puysegur area, followed by black oreo then smooth oreo. In the Macquarie region a low proportion of orange roughy was trawled compared with larger catches of black and smooth oreo. Small catches of the three main species occurred throughout the Stewart area.

Conversion factor trials were carried out at 11 stations. Processed (headed and gutted) to greenweight values were 2.10 for orange roughy (range 1.90–2.15), 2.25 for smooth oreo (range 2.10–2.40), and 2.35 for black oreo (range 2.30–2.38).

Distribution and catch rates

Orange roughy occurred throughout the survey area: catch rates were relatively low away from the western side of Puysegur (Figure 3). On the Puysegur Bank, catch rates over 1000 kg.km^{-1} were regularly recorded in hill strata 0244 ('Godiva') and 0245 ('Goomzy'), and occasionally in strata 0243 ('Alistairs') and 0247 ('Malcolm's Monument'). Maximum catch rates were 10 000–11 000 kg.km^{-1} in stratum 0244. Catches in deeper water (1200–1500 m) around the bank were small.

Smooth oreo were not as widely distributed as orange roughy (Figure 4). They were generally not caught in trawls on the eastern side of Puysegur or in the northern section of Stewart, but were relatively abundant in similar areas to orange roughy on the western side of Puysegur (strata 0243, 0244, and 0245), and on two hill complexes to the south (strata 0501, 0502 ('Mt Duncan') and 0801, 0802 ('Bob's Gun')). Catch rates in these areas were often over 1000 kg.km^{-1}, with a maximum of 18 500 kg.km^{-1} in stratum 0244 ('Godiva').

The distribution of black oreo was similar to that of smooth oreo (Figure 5). Catch rates over 1000 kg.km^{-1} were frequently recorded in strata 0243, 0244, and 0245 in the western part of Puysegur, and at times over 10 000 kg.km^{-1} on southern hills (strata 0502, 0801, 0802). Catch rates were low in areas of general slope in the Stewart region.

Biomass indices

The biomass of orange roughy from all survey tows (excluding strata 0900 and 1000 for which there were few random stations and/or poor knowledge of bathymetry) was estimated at 5980 t, with a *c.v.* of 27% (Table 4). Biomass indices for smooth and black oreo were 4830 t (*c.v.* = 32%) and 7510 t (*c.v.* = 33%), respectively (Table 4).

The biomass of orange roughy was concentrated in Puysegur in strata 0242 (general plateau area), 0245, and 0247 (Table 5). High catch rates were recorded in stratum 0244, but this hill did not contribute much to the total biomass. Biomass in the Puysegur area was mainly of recruit-sized fish (≥ 30 cm), but the slope areas of Stewart were dominated by small fish.

The biomass of smooth oreo also varied with area (Table 6). Hills of the Macquarie region contributed almost 75% of the total biomass.

Black oreo biomass was also concentrated on these southern hills (Table 7). The southern part of stratum 0802 accounted for about 50% of the biomass.

Size structure

1. Orange roughy

Weighted length frequency distributions for orange roughy were calculated for the three main sub-areas (Figure 6). In the Puysegur area fish ranged in size from 14 to 46 cm standard length with a modal peak at 35–36 cm and a less distinctive mode at 28 cm. The mean length for males was 31.9 cm (*s.d.* = 4.8) and for females 33.3 cm (*s.d.* = 5.1). Macquarie orange roughy were larger with a unimodal peak for males of 35 cm and for females of 35–40 cm. The mean length for males was 35.2 (*s.d.* = 3.7) and for females 37.4 cm (*s.d.* = 4.3). The Stewart area orange roughy were dominated by smaller fish ranging in size from 12 to 39 cm with a unimodal peak at 24–25 cm. The mean length for males was 23.7 cm (*s.d.* = 4.1) and for females 24.3 cm (*s.d.* = 4.4). The sample sizes of orange roughy were considerably smaller in the Macquarie and Stewart areas than on the Puysegur Bank because of lower catch rates. The overall sex ratio was even for each area (51% males).

Length weight relationships for orange roughy, smooth oreo, and black oreo are given in Table 8.

2. Smooth oreo

Length frequency distributions for smooth oreo were compared for the Puysegur and Macquarie areas (Figure 7). Fish ranged in size from 17 to 55 cm, and both areas showed a strongly bimodal distribution with modal peaks at 25–26 cm and at around 40 cm. The mean male length in the Puysegur area was 35.4 cm (*s.d.*= 7.5) and the mean female length was 37.7 cm (*s.d.* = 8.9). In the Macquarie region the mean male length was 37.6 cm (*s.d.* = 6.5). Females over 40 cm dominated in this region with a mean length of 41.2 cm (*s.d.* = 7.5). The overall sex ratio was even (49% males).

3. Black oreo

The Puysegur length frequency distribution was strongly unimodal (Figure 8). Fish ranged in size from 21 to 43 cm with a peak at 36 cm. The mean lengths were 34.1 cm (*s.d.* = 3.9) and 35.3 cm (*s.d.* = 3.2) for males and females, respectively. In the Macquarie area (Figure 8) black oreo were from 25 to 46 cm, with a broad modal peak at 36–39 cm. The mean male length was 36.5 cm (*s.d.* = 2.5) and the mean female length was 38.2 cm (*s.d.* = 3.0). The overall sex ratio was even (50% males).

Reproduction

Gonadal development of orange roughy, smooth oreo, and black oreo was monitored throughout the voyage. Overall gonad proportions for each species by area sampled are shown in Table 9. Most orange roughy gonads were in a post-spawning condition (spent), immature or regressed (stage 1), or in early stages of maturation (stage 2). The high proportion of stage 1 fish in the Stewart area is explained by the small size of orange roughy sampled, most being immature. The two oreo species were predominantly in a maturing state (stage 3).

Feeding

A total of 1632 orange roughy stomachs were examined throughout the survey, of which 54% contained food (Table 10). The major prey groups for the three areas combined were fish (*IV%* = 42), natant decapod crustaceans (*IV%* = 20), squid (*IV%* = 12), and amphipods (*IV%* = 11) (Table 11).

Almost 75% of the 549 smooth oreo stomachs were empty or everted (Table 10). Those stomachs with food present contained predominantly salps (*IV%* = 46) and squid (*IV%* = 30), and fish (*IV%* = 21), (Table 12). A total of 450 black oreo stomachs were also examined and again a high proportion, 70%, were empty or everted (Table 10). The major prey group for this species was fish (*IV%* = 72) (Table 13).

Discussion

This survey is the first in a standardised time series for the Puysegur region. Extensive information and experience from previous cooperative industry and MAF Fisheries surveys, as well as from commercial catch data, meant that the voyage's objectives to measure fish distribution and abundance of orange roughy, smooth oreo, and black oreo were well met. Bathymetry for the area continued to be updated during the voyage, and detailed charts of the area have been compiled.

Eight of the survey strata defined hills (from their peak to about 1000 m at the "base"). The small area of such features, and the large aggregations of fish commonly associated with them, can cause problems with area-swept methodology. However, in this area orange roughy are generally distributed tightly around hills, and do not appear to move between strata. They are also close to the bottom, with no sign of "plumes" or schools extending above the bottom over the headline height of the net. There were also no indications of rapid gear saturation, or the net catching fish while approaching or coming off the bottom, so measurement of distance trawled by the gear adequately described catch per kilometre, even though some tows were relatively short. The use of biomass as relative indices over time also means that any bias in catch rates of such strata should be the same for each survey. Care should be exercised, however, in directly comparing catch rates in flat bottom/slope strata with hill strata.

Stratification in the Puysegur region remained similar to the previous survey in July 1992 by *Giljanes*. Despite the slightly later timing of the *Tangaroa* survey, distribution of the three main commercial species was similar to previous results. However, the total survey area was extended so that a clearer understanding of species distribution by area and depth, especially for oreos, could be obtained. Orange roughy were caught throughout the area, but occurred in high concentrations only around the western side of Puysegur. No major differences in distribution between this and previous surveys in July were evident indicating that post-spawning orange roughy remain in the main spawning area. The oreo species were also

concentrated in similar areas to earlier surveys on the western Puysegur hills and slope region as well as on the two hill features of the Macquarie Ridge.

The size structure of orange roughy in the Puysegur region is similar to the previous surveys in this area. The length frequency distributions for oreos differ, although the significance of this is unclear as the surveys are not directly comparable.

It will be at least 3–4 years before the *Tangaroa* time series provides sufficient data to obtain good size estimates of the orange roughy, smooth oreo, and black oreo populations. In the meantime, further research will result in a better understanding of these fish stocks and the potential sustainable yields.

Acknowledgments

We thank the officers and crew of *Tangaroa* as well as the scientific staff for their excellent cooperation and hard work throughout the voyage. Thanks also to Kevin Mackay for help with "S" plots during report preparation, and to Marianne Vignaux and Kevin Sullivan for constructive comments on the manuscript.

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Table 1: Strata descriptions and areas

Stratum	Area (km^2)	No. of stations	Description
0110	252.0	3	north Puysegur, 600–800
0120	111.5	2	north Puysegur, 800–1000
0140	64.0	1	north Puysegur, 1000–1500
0210	180.0	3	west Puysegur, 600–800
0220	71.0	4	west Puysegur, 800–900
0230	62.0	3	west Puysegur, 900–1000
0241	102.0	7	west Puysegur, 1000–1200 (west)
0242	257.0	6	west Puysegur, 1000–1200 (east)
0243	10.0	6	west Puysegur, 1000–1200 (Alistairs)
0244	2.0	7	west Puysegur hill (Godiva)
0245	8.0	9	west Puysegur hill (Goomzy)
0246	15.0	4	west Puysegur hills (others)
0247	21.0	7	west Puysegur hill (Malcolm's Monument)
0250	461.0	3	west Puysegur, 1200–1500
0320	78.0	5	central Puysegur, 800–1200
0410	79.0	3	east Puysegur, 600–800
0420	46.0	3	east Puysegur, 800–900
0430	79.0	4	east Puysegur, 900–1000
0440	187.0	3	east Puysegur, 1000–1200
0450	193.0	3	east Puysegur, 1200–1500
0501	26.0	4	south Puysegur hill (Mt. Duncan)
0502	8.0	3	south Puysegur hill (Porirua)
0610	567.0	3	north Stewart, 600–800
0620	604.0	3	north Stewart, 800–1000
0640	723.0	3	north Stewart, 1000–1200
0650	372.0	3	north Stewart, 1200–1500
0710	212.0	2	south Stewart, 600–800
0720	375.0	5	south Stewart, 800–1000
0740	585.0	4	south Stewart, 1000–1200
0750	408.0	3	south Stewart, 1200–1500
0801	8.0	5	west Snares hill (north)
0802	14.0	4	west Snares hill (south)
0900*	250.0	2	east Snares slope
1000*	–	5	north Macquarie hill (Checkpoint Charlie)
Total	6 430.0		

* Strata 900 and 1000 were not included in the biomass analyses (*see* text).

Table 2: Total catch and percentage composition by weight of the 10 most abundant species, and of the major ITQ species, caught in the Puysegur Bank survey (*see* Appendix 2 for scientific names)

Species	Catch (kg)	% of total
Orange roughy	123 322	36.6
Black oreo	122 510	36.4
Smooth oreo	69 916	20.8
Baxter's dogfish	6 598	2.0
Smallscaled brownslickhead	3 644	1.1
Longnosed velvet dogfish	1 397	0.4
Leafscaled gulper shark	1 136	0.3
Javelinfish	1 104	0.3
Plunket's shark	927	0.3
Owston's spiny dogfish	857	0.3
Hoki	733	0.2
Ling	277	0.1
Hake	220	0.1
Black cardinalfish	143	< 0.1
All species	336 618	

Table 3: Total catches (kg) of the three main commercial species by area

Species	Puysegur	Macquarie	Stewart
Orange roughy	121 741	1 083	433
Smooth oreo	41 977	27 723	4
Black oreo	73 971	48 083	1

Table 4: Biomass indices (t) for orange roughy, smooth oreo, and black oreo (to nearest 10 t)

Species	Biomass	95% range	*c.v.* (%)
Orange roughy	5 980	2 790–9 180	26.7
All fish	1 370	640–2 100	26.6
1–30 cm	4 610	2 000–7 220	28.3
30–50 cm			
Smooth oreo	4 830	1 700–7 970	32.5
All fish			
Black oreo	7 510	2 530–12 490	33.1
All fish			

Table 5: Catch rates and biomass of orange roughy by stratum*

Stratum	Mean catch rate (kg.km^{-1})	*s.d.*	Biomass (t)	Biomass (%)	Recruit/ prerecruit
0110	15.8	26.9	153.5	2.6	P
0120	14.6	1.8	62.6	1.0	R
0210	0.1	0.2	1.0	–	–
0220	15.2	30.2	41.6	0.7	R
0230	35.3	53.4	84.2	1.4	P = R
0241	115.0	145.6	451.1	7.5	R
0242	151.3	360.3	1 495.4	25.0	R
0243	605.1	982.7	232.7	3.9	R
0244	4 678.6	4 936.1	359.9	6.0	R
0245	2 552.0	3 031.5	785.2	13.1	R
0246	224.9	335.3	129.8	2.2	R
0247	689.9	1 131.0	557.2	9.3	R
0250	7.4	9.1	131.0	2.2	R
0320	74.6	61.3	223.7	3.7	R
0410	0.1	0.1	0.1	–	–
0420	0.4	0.5	0.7	–	–
0430	8.5	14.1	25.9	0.4	P
0440	14.6	15.5	105.3	1.8	R
0450	3.1	3.6	23.3	0.4	R
0501	155.5	153.1	155.5	2.6	R
0502	110.7	116.5	34.1	0.6	R
0610	0.1	0.2	2.4	–	–
0620	4.7	3.3	109.2	1.8	P
0640	2.3	2.3	64.4	1.1	P = R
0650	1.1	0.6	15.9	0.3	R
0710	0.1	0.1	0.8	–	–
0720	4.2	2.5	60.6	1.0	P
0740	21.9	16.4	493.9	8.2	P
0750	5.1	2.9	80.2	1.3	P
0801	36.5	47.5	11.2	0.2	R
0802	167.6	283.1	90.3	1.5	R

* P = biomass predominantly of prerecruit-sized fish (< 30 cm).
R = recruit-sized fish (≥ 30 cm).
– = Negligible.

Table 6: Catch rates and biomass of smooth oreo by stratum*

Stratum	Mean catch rate ($kg.km^{-1}$)	*s.d.*	Biomass (t)	Biomass (%)
0110	0.2	0.2	1.7	–
0120	2.1	2.9	8.9	0.2
0210	0.1	0.2	1.0	–
0220	0.3	0.5	0.7	–
0230	0.1	0.1	0.2	–
0241	70.6	118.4	277.0	5.7
0242	0.6	1.2	5.8	0.1
0243	544.6	751.6	209.5	4.3
0244	4 142.0	7 185.5	318.6	6.6
0245	402.9	233.3	124.0	2.6
0246	204.7	263.9	118.1	2.4
0247	109.1	160.1	88.2	1.8
0250	2.6	4.5	46.4	1.0
0320	9.1	13.2	27.2	0.6
0410	0.3	0.5	0.9	–
0420	0			
0430	0			
0440	0			
0450	0			
0501	606.6	568.1	606.6	12.5
0502	1 581.6	1 548.0	486.7	10.1
0610	0			
0620	0			
0640	0			
0650	0			
0710	0			
0720	0.1	0.2	2.2	–
0740	0.1	0.1	1.6	–
0750	0.1	0.2	1.5	–
0801	1 965.0	3 815.1	604.6	12.5
0802	3 531.7	4 427.6	1 901.7	39.3

– = Negligible.

Table 7: Catch rates and biomass of black oreo by stratum*

Stratum	Mean catch rate (kg.km^{-1})	*s.d.*	Biomass (t)	Biomass (%)
0110	0			
0120	0			
0210	0.9	1.5	6.2	0.1
0220	0			
0230	0.6	0.8	1.4	–
0241	53.6	79.1	210.3	2.8
0242	1.9	3.2	18.4	0.2
0243	1 167.8	1 717.8	449.1	6.0
0244	2 290.0	2 514.2	176.1	2.3
0245	1 871.6	2 265.5	575.9	7.7
0246	2.3	3.7	1.3	–
0247	2.4	5.5	1.9	–
0250	4.5	7.7	79.3	1.0
0320	0.3	0.5	0.8	–
0410	0			
0420	0			
0430	0			
0440	0			
0450	0			
0501	536.7	456.3	536.7	7.1
0502	4 553.2	6 534.9	1 401.0	18.6
0610	0			
0620	0			
0640	0			
0650	0			
0710	0			
0720	0			
0740	0			
0750	0			
0801	1 291.1	1 855.0	397.3	5.3
0802	6 789.8	6 869.6	3 656.0	48.7

– = Negligible.

Table 8: Length-weight regression equations for orange roughy, smooth oreo, and black oreo by sex for the survey area*

Species	Sex	*L-W* regression	*n*	r^2
Orange roughy	Both	$W = 8.0 \times 10^{-2} L^{2.75}$	1 635	0.98
	M	$W = 8.1 \times 10^{-2} L^{2.74}$	788	0.98
	F	$W = 7.9 \times 10^{-2} L^{2.75}$	847	0.98
Black oreo	Both	$W = 7.8 \times 10^{-3} L^{3.26}$	450	0.89
	M	$W = 6.7 \times 10^{-3} L^{3.30}$	235	0.88
	F	$W = 1.1 \times 10^{-2} L^{3.19}$	215	0.90
Smooth oreo	Both	$W = 1.6 \times 10^{-2} L^{3.07}$	549	0.98
	M	$W = 1.8 \times 10^{-2} L^{3.08}$	238	0.97
	F	$W = 1.5 \times 10^{-2} L^{3.08}$	311	0.98

*L = length (cm); W = weight (g); n = sample size; r^2 = correlation coefficient.

Table 9: Gonad stage percentage frequency of orange roughy, smooth oreo, and black oreo from the main survey areas

	Orange roughy					
	Puysegur		Macquarie		Stewart	
Stage	% male	% female	% male	% female	% male	% female
1	29.7	16.0	6.7	9.6	85.5	75.3
2	17.6	25.1	12.0	21.2	6.0	20.0
3	0.2	0.5	1.3	0	0	0
4	0	0	0	1.9	0	0
5	52.5	0.2	80.0	0	8.5	0
6		58.3		67.3		4.7
n	586	630	75	52	117	150

	Smooth oreo				Black oreo			
	Puysegur		Macquarie		Puysegur		Macquarie	
Stage	% male	% female	% male	% female	% male	% female	% male	% female
1	13.1	19.1	24.1	23.9	26.3	19.0	23.5	13.0
2	23.3	37.3	12.1	28.3	34.5	29.9	33.4	21.7
3	63.1	43.5	62.1	47.8	38.0	51.1	43.1	63.8
4	0	0	0	0	0	0	0	0
5	0.5	0	1.7	0	1.2	0	0	0
6	0	0	0	0	0	0	0	1.5
n	176	209	58	92	171	137	51	69

Table 10: Percentage stomach states of orange roughy, smooth oreo, and black oreo examined during the survey

State	Orange roughy		Smooth oreo		Black oreo	
	%	*n*	%	*n*	%	*n*
Empty	46.0	750	57.0	313	30.7	93
Trace	8.5	139	7.8	43	3.1	14
Part-full	36.1	590	16.4	90	20.4	92
Full	9.4	153	2.2	12	4.9	22
Everted	0	0	16.6	91	50.9	229
n		1 632		549		450

Table 11: Major prey groups of orange roughy from the survey area*

Prey group	Frequency		Volume		*IV* index	
	n	%	*v*	%	*IV*	%
Crustacea						
Amphipoda	124	16.7	7 450	10.1	13.0	11.1
Decapoda Natantia	214	28.8	14 785	20.0	24.0	20.4
Euphausiacea	45	6.0	2 725	3.7	4.7	4.0
Mysidacea	26	3.5	1 915	2.6	3.0	2.6
Crustacean remains	83	11.2	5 457	7.4	9.1	7.7
Mollusca						
Cephalopoda Decapoda	120	16.2	8 675	11.7	13.8	11.7
Pisces						
Macrouridae	9	1.2	895	1.2	1.2	1.0
Mesopelagic group†	70	9.4	5 465	7.4	8.3	7.1
Other groups‡	16	2.2	1 365	1.9	2.0	1.7
Fish remains	317	42.7	25 460	34.3	38.3	32.6
Unidentified	1	0.1	40	0.1	0.1	0.1

* *n* = number of fish; *v* = volume; number of stomachs part full or full = 743.

† Includes families Myctophidae, Malacosteidae, Stomiatidae, Chauliodontidae, Gonostomatidae, Astronesthidae, Melamphaidae, Photichthyidae, Sternoptychidae, Idiacanthidae, Melanostomiidae.

‡ Includes families Bathylagidae, Alepocephalidae, Synaphobranchidae, Platytroctidae, Apogonidae.

Table 12: Major prey groups of smooth oreo from the survey area*

Prey group	Frequency		Volume		*IV* index	
	n	%	*v*	%	*IV*	%
Crustacea						
Decapoda Natantia	2	2.0	45	0.4	0.9	0.8
Mollusca						
Cephalopoda Decapoda	44	43.1	2 610	25.6	33.2	30.1
Pisces						
Mesopelagic group†	6	5.9	555	5.4	5.6	5.1
Fish remains	20	17.0	1 790	17.5	17.2	15.6
Thaliacea						
Salpidae	54	52.9	5 000	49.0	50.9	46.2
Unidentified	3	2.9	200	2.0	2.4	2.2

* *n* = number of fish; *v* = volume; number of stomachs part full or full = 102.
† Includes families Stomiatidae, Chauliodontidae, Melamphaidae, Idiacanthidae.

Table 13: Major prey groups of black oreo from the survey area*

Prey group	Frequency		Volume		*IV* index	
	n	%	*v*	%	*IV*	%
Crustacea						
Amphipoda	1	0.9	20	0.2	0.4	0.4
Decapoda Natantia	9	7.9	640	5.6	6.7	6.0
Euphausiacea	1	0.9	10	0.1	0.3	0.3
Mysidacea	3	2.6	230	2.0	2.3	2.1
Crustacean remains	6	5.3	410	3.6	4.4	3.9
Mollusca						
Cephalopoda Decapoda	18	15.8	1 300	11.4	13.4	11.9
Pisces						
Mesopelagic group†	15	13.2	1 200	11.4	12.3	11.0
Other groups‡	3	2.6	240	2.1	2.3	2.1
Fish remains	82	71.9	6 890	60.7	66.1	58.9
Thaliacea						
Salpidae	4	3.5	320	2.8	3.1	2.8
Unidentified	1	0.9	100	0.9	0.9	0.8

* (*n* = number of fish; *v* = volume; number of stomachs part full or full = 114.
† Includes families Myctophidae, Stomiatidae, Chauliodontidae, Gonostomatidae, Melamphaidae, Photichthyidae, Sternoptychidae.
‡ Includes families Alepocephalidae, Platytroctidae, Apogonidae.

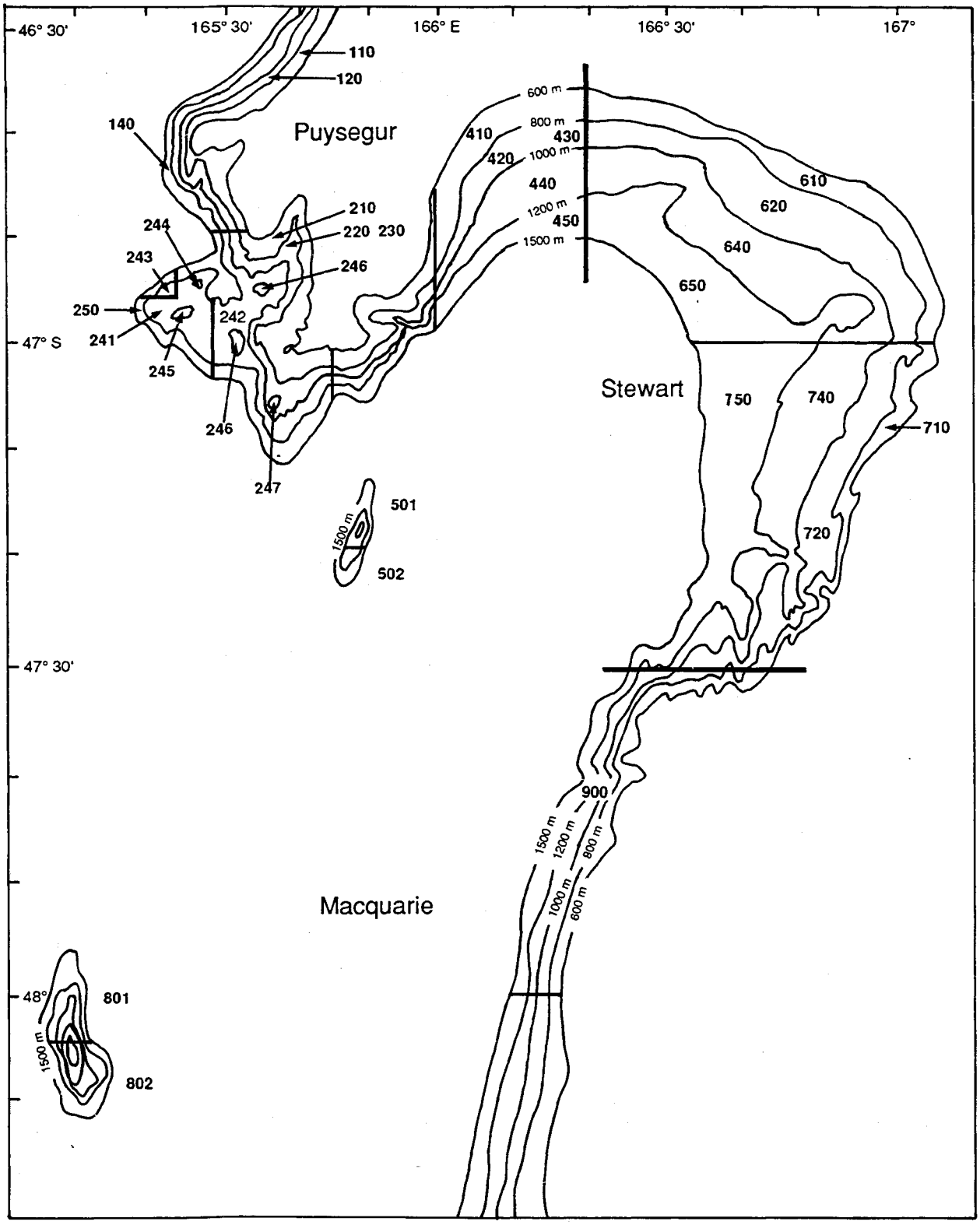


Figure 1: Survey area for TAN9208, showing strata boundaries (*see* Table 1 for strata description and areas; excludes stratum 1000).

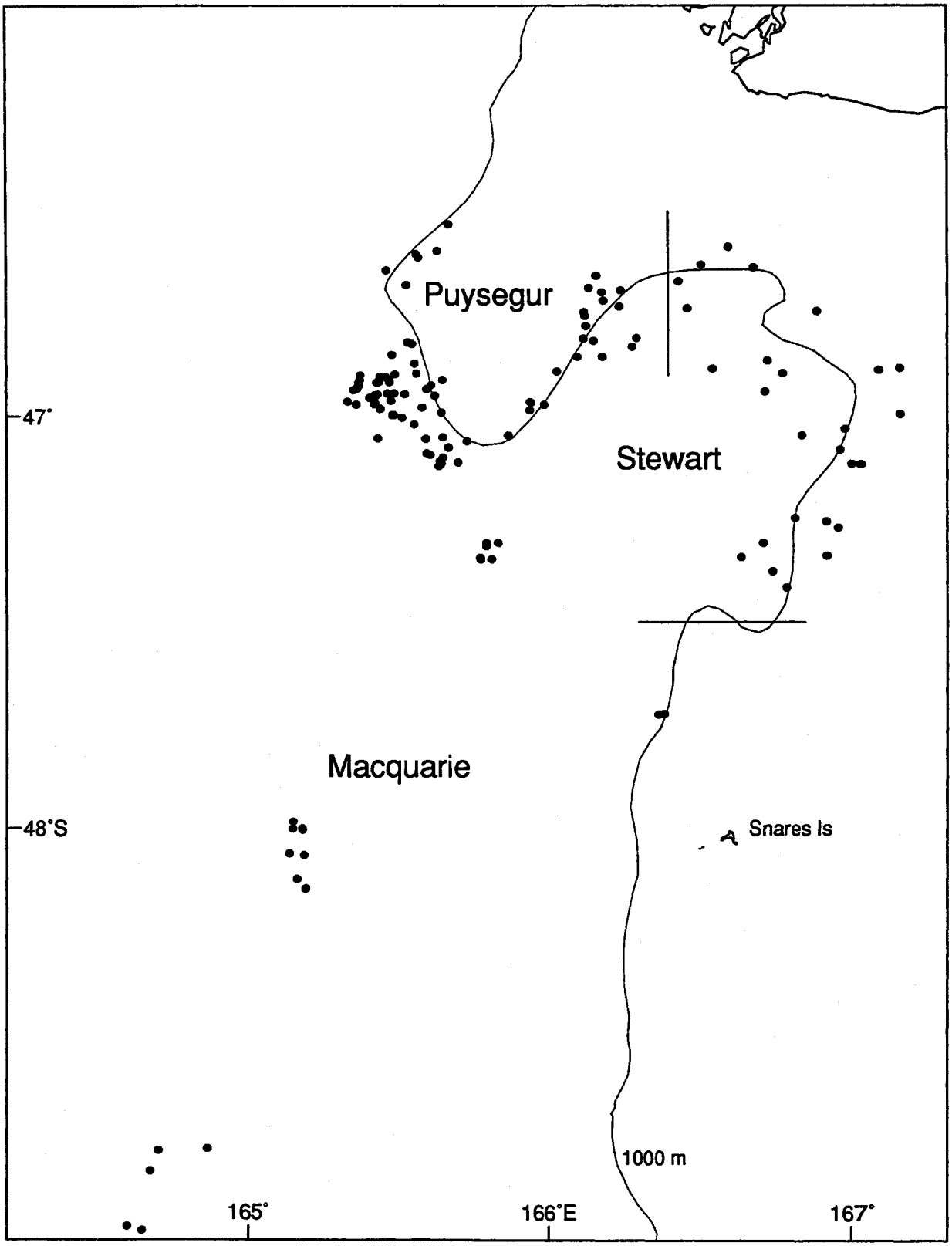


Figure 2: Station positions (vessel position, start of tow).

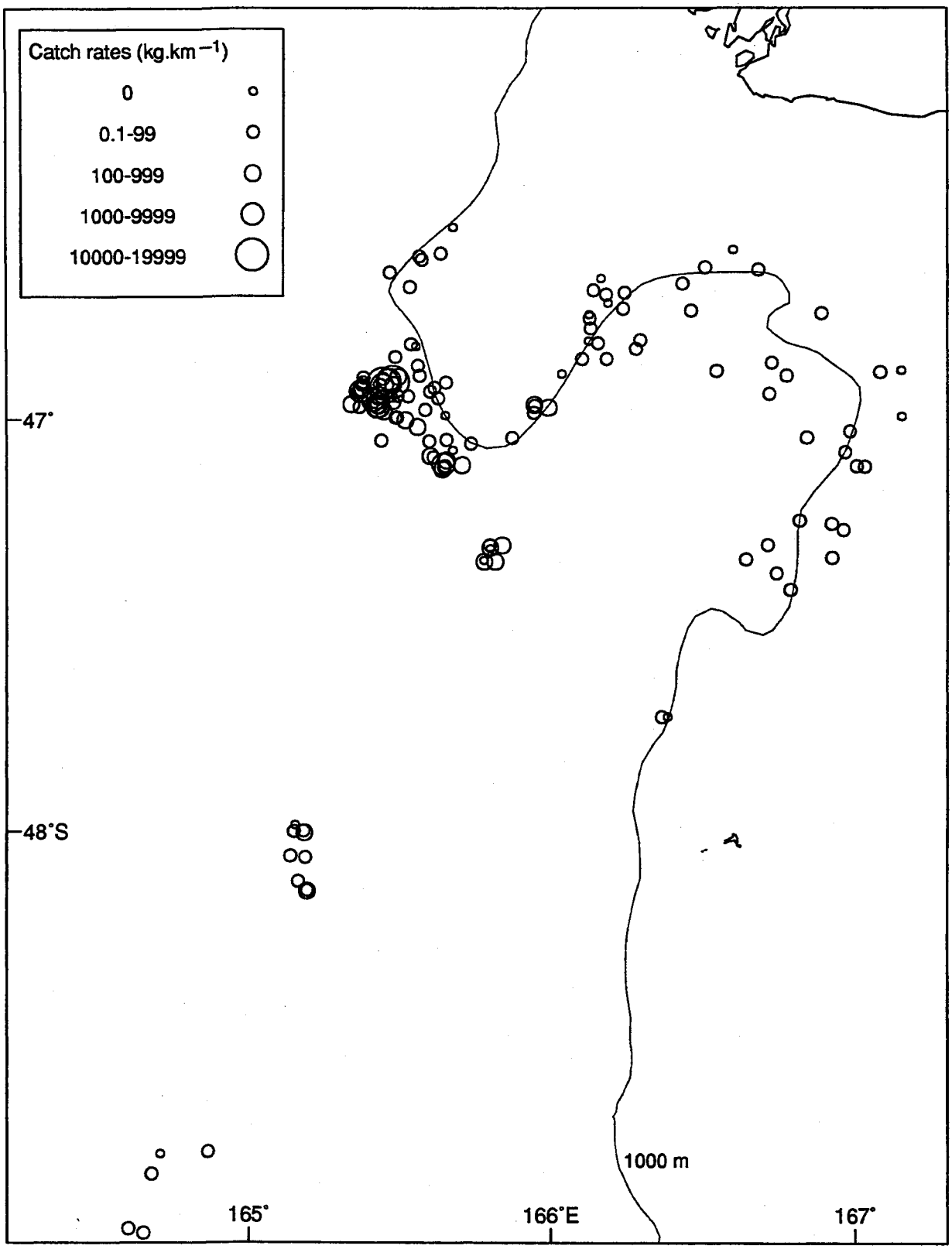


Figure 3: Catch rates (kg.km^{-1}) of orange roughy.

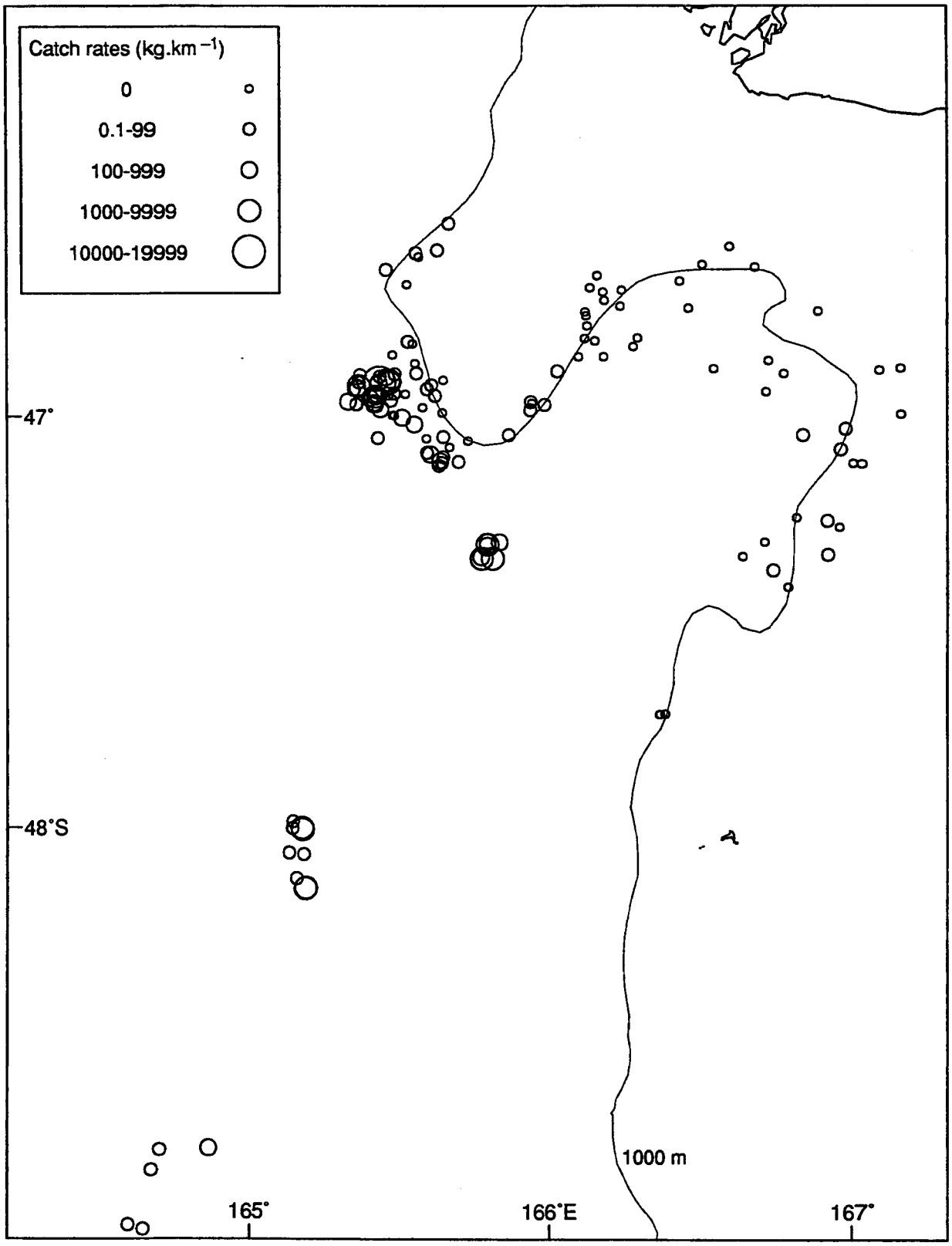


Figure 4: Catch rates (kg.km^{-1}) of smooth oreo.

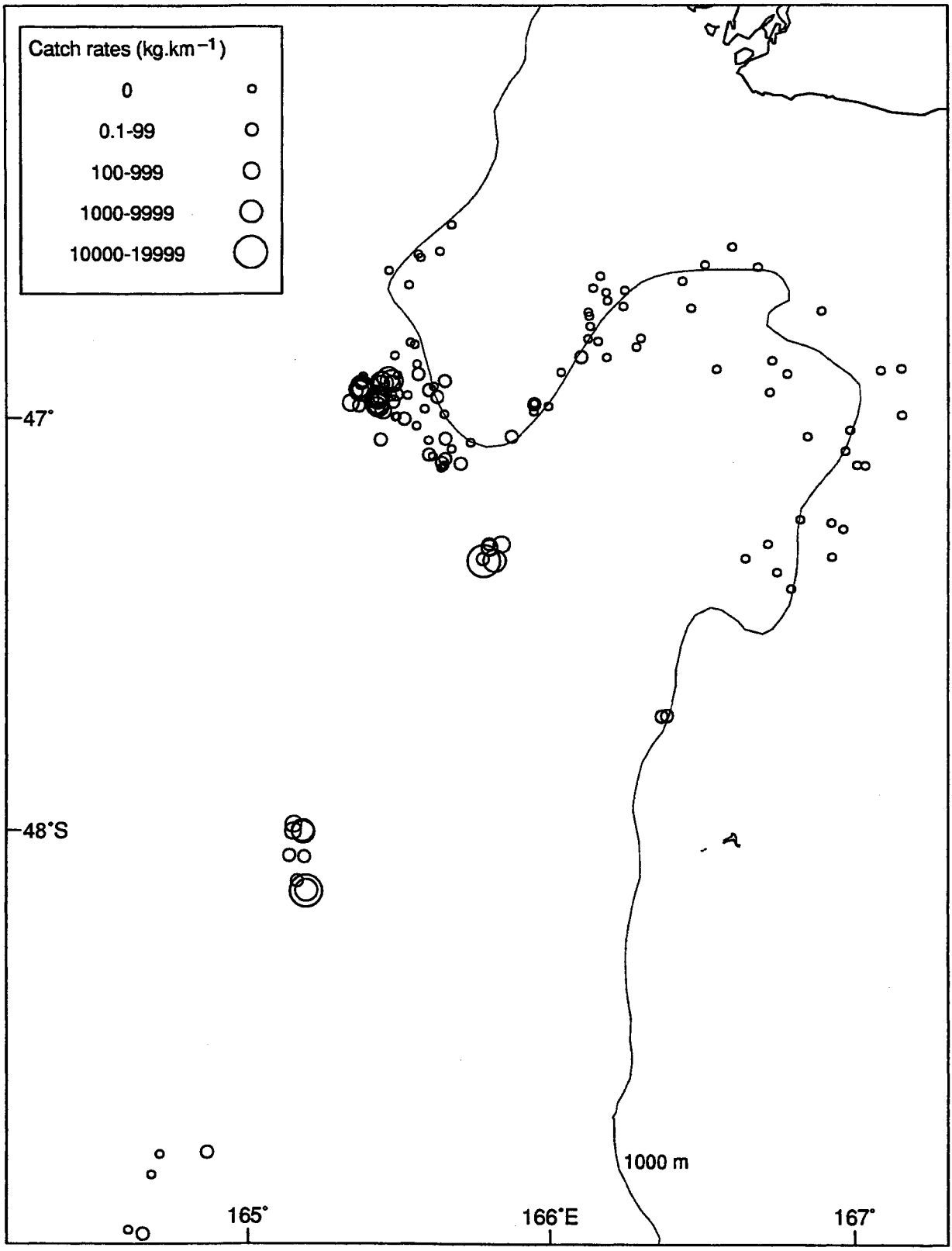


Figure 5: Catch rates (kg.km^{-1}) of black oreo.

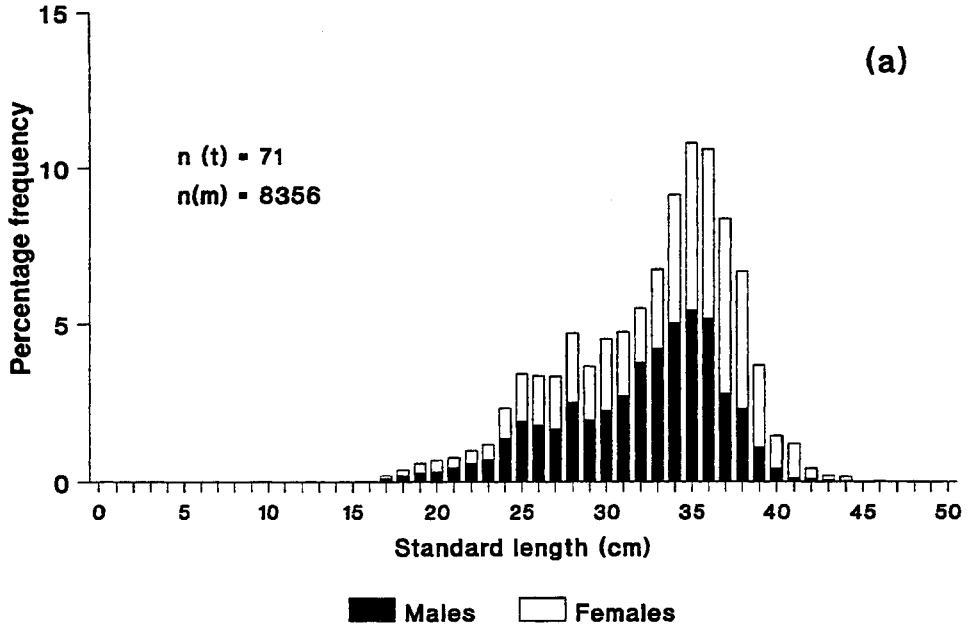


Figure 6: Length frequency distribution of orange roughy by area (a) Puysegur, (b) Macquarie, (c) Stewart (scaled to represent the total population and the percentage frequency refers to the percentage of all fish; n(t), number of trawls with samples; n(m), number of fish actually measured).

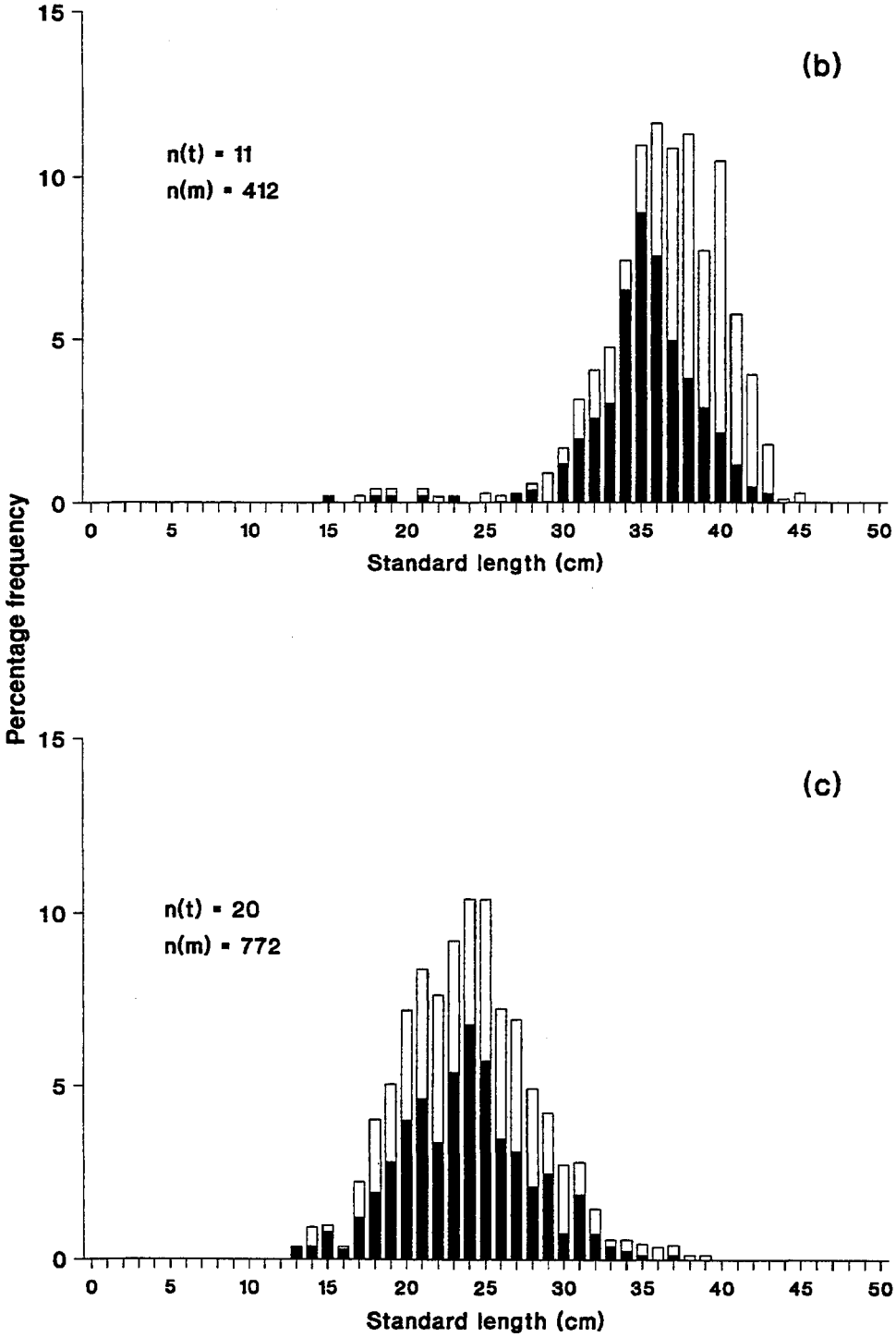


Figure 6—*continued*

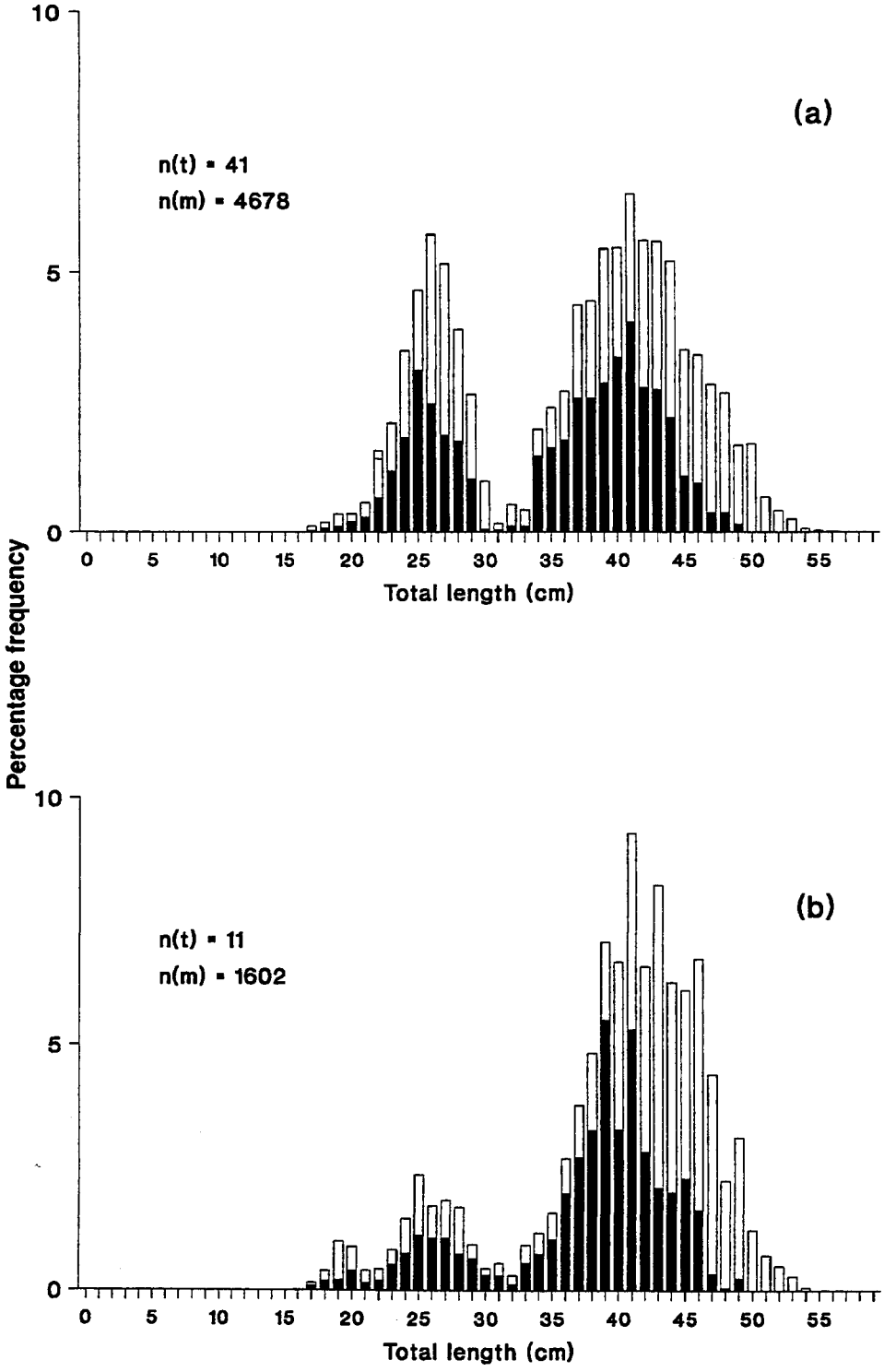


Figure 7: Length frequency distributions of smooth oreo from the (a) Puysegur and (b) Macquarie survey areas (scaled to represent the total population and the percentage frequency refers to the percentage of all fish; n(t), number of trawls with samples; n(m), number of fish actually measured).

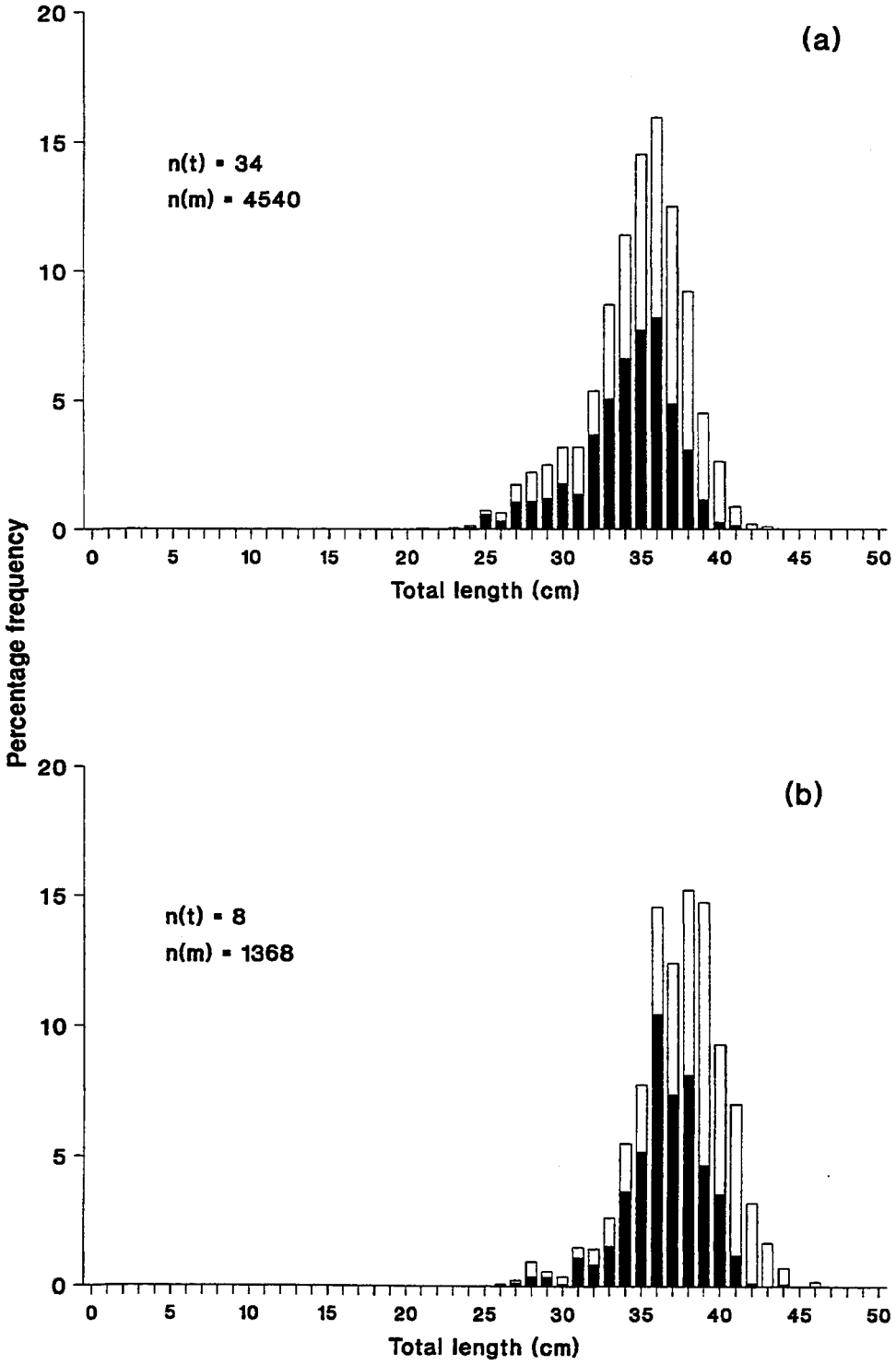
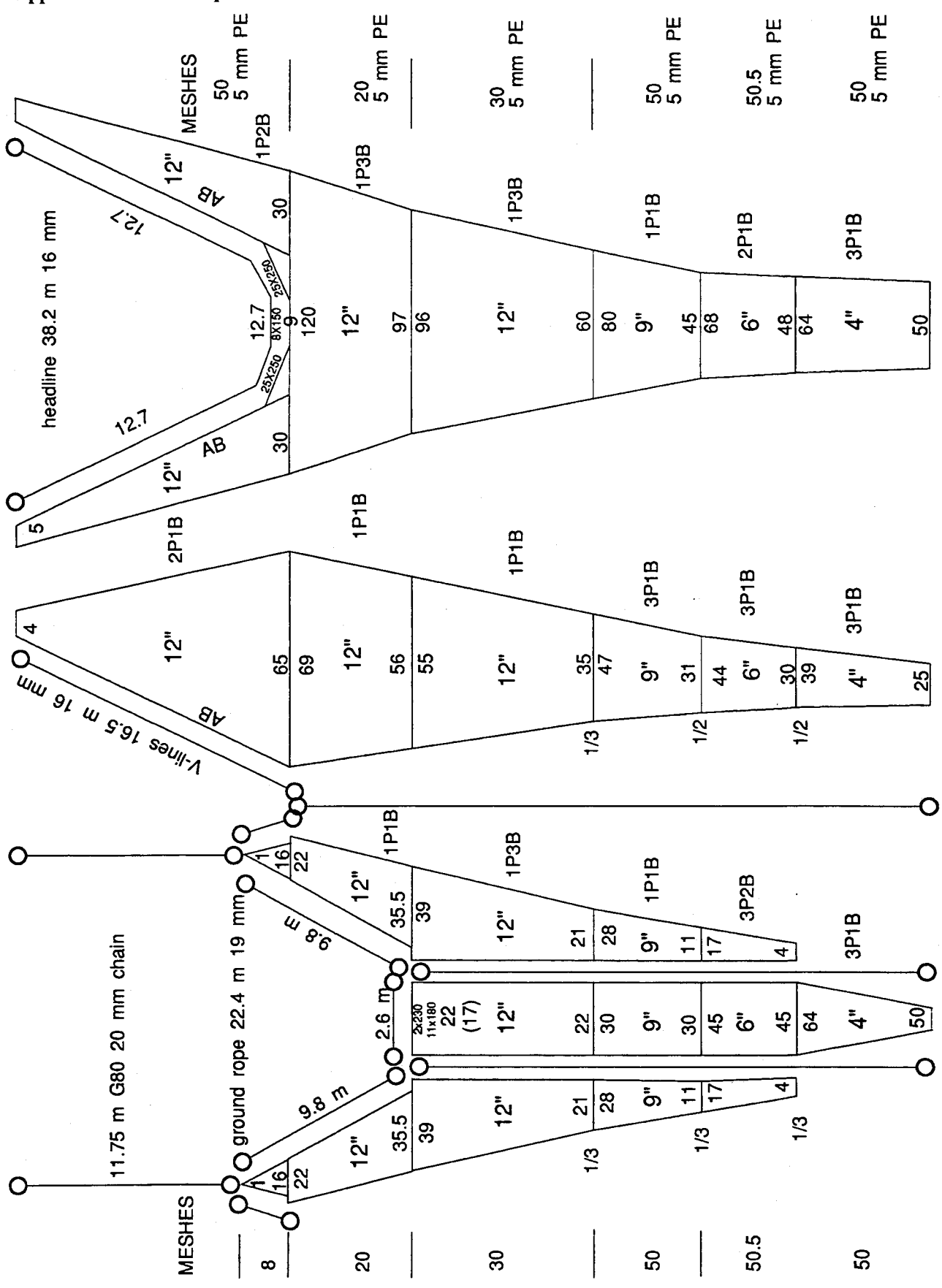


Figure 8: Length frequency distributions of black oreo from the (a) Puysegur and (b) Macquarie survey areas (scaled to represent the total population and the percentage frequency refers to the percentage of all fish; n(t), number of trawls with samples; n(m), number of fish actually measured).

Appendix 1: Trawl net plan



Appendix 2: Individual station and catch data for orange roughy (ORH), smooth oreo (SSO), and black oreo (BOE).

Station	Stratum	Date	Start of tow		Depth (m)		Distance towed (n.mile)	Direction of tow (°T)	Start time	Total catch (kg)	Species catch (kg)		
			Latitude	Longitude	Min.	Max.					ORH	SSO	BOE
1	0110	18 Aug 92	46°31.88'S	165°40.10'E	625	654	1.58	207	535	445.30	0.00	1.30	0.00
2	0120	18 Aug 92	46°36.57'S	165°33.91'E	895	915	1.61	232	918	268.80	47.30	0.00	0.00
3	0140	18 Aug 92	46°36.10'S	165°33.39'E	1 009	1 041	1.53	234	2004	127.00	22.30	0.10	0.00
4	0110	18 Aug 92	46°35.72'S	165°37.78'E	713	728	1.51	32	2354	355.70	131.30	0.20	0.00
5	0120	19 Aug 92	46°38.53'S	165°27.46'E	910	978	1.05	249	1611	106.60	25.90	8.10	0.00
6	0220	19 Aug 92	46°49.00'S	165°31.82'E	824	887	1.34	164	1836	92.10	0.40	2.60	0.00
7	0210	19 Aug 92	46°49.26'S	165°32.63'E	649	712	1.57	349	2137	232.10	0.00	0.00	0.00
8	0230	19 Aug 92	46°53.63'S	165°33.52'E	965	1 005	0.99	124	2345	251.10	177.50	0.10	0.50
9	0242	20 Aug 92	46°56.70'S	165°31.27'E	1 147	1 197	1.56	54	216	127.40	5.10	0.00	0.00
10	0244	20 Aug 92	46°55.04'S	165°25.56'E	970	1 060	0.49	275	425	415.60	9.20	15.60	312.10
11	0244	20 Aug 92	46°54.23'S	165°27.44'E	975	1 100	0.92	22	1037	12 654.70	6 043.50	390.00	6 018.50
12	0250	20 Aug 92	46°50.93'S	165°28.68'E	1 285	1 311	1.52	185	1510	54.30	7.10	0.00	0.00
13	0241	20 Aug 92	46°58.84'S	165°26.38'E	1 071	1 124	1.52	252	2132	3 109.80	1 022.40	520.40	569.20
14	0250	21 Aug 92	47°03.15'S	165°25.83'E	1 385	1408	1.09	144	150	102.20	3.60	15.70	27.10
15	0210	21 Aug 92	47°02.98'S	165°38.93'E	621	743	1.51	161	502	34.60	1.20	1.20	7.50
16	0243	21 Aug 92	46°54.66'S	165°22.26'E	1 060	1 200	0.81	327	801	66.70	2.90	0.00	4.20
17	0243	21 Aug 92	46°56.10'S	165°21.05'E	1 053	1 160	1.12	235	954	469.20	197.70	69.40	184.50
18	0241	21 Aug 92	46°57.76'S	165°19.86'E	1 060	1 200	1.03	255	1426	1 676.50	516.90	555.30	234.60
19	0242	21 Aug 92	46°59.73'S	165°29.06'E	1 097	1 115	1.53	163	1645	37.90	4.70	0.00	0.00
20	0410	21 Aug 92	46°53.39'S	166°01.77'E	635	680	1.46	33	2108	97.10	0.00	2.40	0.00
21	0430	21 Aug 92	46°48.52'S	166°07.17'E	948	995	0.51	18	2340	0.00	0.00	0.00	0.00
22	0440	22 Aug 92	46°51.19'S	166°05.91'E	1 017	1 054	1.49	37	1129	455.50	87.40	0.00	0.30
23	0450	21 Aug 92	46°51.15'S	166°10.89'E	1 204	1 267	1.50	201	1327	213.80	20.40	0.00	0.00
24	0320	22 Aug 92	46°58.26'S	165°59.20'E	809	1 200	1.48	134	1616	597.30	377.40	79.10	0.00
25	0320	22 Aug 92	46°59.11'S	165°56.40'E	810	1 200	1.09	83	1826	179.40	37.70	4.90	0.00
26	0320	22 Aug 92	47°02.72'S	165°52.05'E	810	1 200	0.96	127	2056	174.90	45.40	4.10	1.90
27	0247	22 Aug 92	47°06.52'S	165°38.22'E	744	1 004	1.93	124	2344	12 773.40	11 283.70	1 290.40	0.80
28	0247	23 Aug 92	47°07.02'S	165°38.45'E	803	1 065	2.04	134	350	207.50	107.80	0.00	0.00
29	0247	23 Aug 92	47°05.53'S	165°36.27'E	740	811	0.22	314	548	328.70	4.90	131.90	0.00
30	0245	23 Aug 92	46°56.77'S	165°25.72'E	950	1 010	1.21	27	1216	1 512.80	79.50	547.70	501.10
31	0244	23 Aug 92	46°55.02'S	165°28.22'E	970	1 200	1.11	96	1428	3 882.90	1 039.20	2 218.90	529.80

Appendix 2—(*continued*)

Station	Stratum	Date	Start of tow		Depth (m)		Distance towed (n.mile)	Direction of tow (°T)	Start time	Total catch (kg)	Species catch (kg)		
			Latitude	Longitude	Min.	Max.					ORH	SSO	BOE
32	0243	23 Aug 92	46°55.48′S	165°22.10′E	1 020	1 104	0.86	305	1704	11 467.40	1 489.40	3 091.10	6 823.90
33	0242	23 Aug 92	46°59.75′S	165°28.82′E	1 095	1 100	1.49	160	2131	45.20	5.60	0.00	0.00
34	0220	24 Aug 92	46°58.68′S	165°34.68′E	836	956	1.40	17	136	64.40	0.70	0.00	0.00
35	0210	24 Aug 92	46°59.39′S	165°38.64′E	601	702	1.56	30	402	124.00	0.00	0.00	0.00
36	0241	24 Aug 92	47°03.26′S	165°35.46′E	1 000	1 135	1.29	314	644	58.00	11.50	0.00	0.00
37	0244	24 Aug 92	46°54.92′S	165°26.05′E	965	980	0.26	270	910	17 083.50	5 095.20	8 920.10	3 025.40
38	0610	27 Aug 92	46°35.16′S	166°35.92′E	661	677	1.58	266	811	79.40	0.00	0.00	0.00
39	0620	27 Aug 92	46°37.73′S	166°30.53′E	918	933	1.57	277	1020	135.10	22.60	0.00	0.00
40	0640	27 Aug 92	46°40.13′S	166°26.08′E	1 045	1 070	1.54	103	1404	163.40	14.10	0.00	0.00
41	0410	27 Aug 92	46°39.33′S	166°09.66′E	705	757	1.48	174	1732	331.00	0.00	0.00	0.00
42	0410	27 Aug 92	46°41.11′S	166°08.26′E	728	741	1.50	208	1933	62.00	0.40	0.00	0.00
43	0420	27 Aug 92	46°41.78′S	166°10.84′E	864	877	1.56	217	2200	88.90	1.00	0.00	0.00
44	0430	28 Aug 92	46°42.94′S	166°11.10′E	925	943	1.52	217	111	43.40	0.00	0.00	0.00
45	0440	28 Aug 92	46°43.80′S	166°14.25′E	1 027	1 040	1.52	241	333	143.70	30.90	0.00	0.00
46	0440	28 Aug 92	46°48.83′S	166°09.19′E	1 067	1 116	1.47	174	553	84.20	3.50	0.00	0.00
47	0430	28 Aug 92	46°46.70′S	166°07.63′E	928	940	1.53	36	830	78.40	2.10	0.00	0.00
48	0244	28 Aug 92	46°54.98′S	165°25.97′E	970	1 088	1.37	273	1257	9 384.20	5 817.90	2 512.60	884.30
49	0250	28 Aug 92	46°53.94′S	165°22.36′E	1 200	1 307	1.52	315	2027	136.40	50.30	0.20	0.00
50	0241	28 Aug 92	46°53.78′S	165°29.19′E	1 073	1 171	1.17	55	2320	409.40	251.10	3.90	0.00
51	0241	29 Aug 92	46°56.55′S	165°27.81′E	1 015	1 155	1.55	89	137	305.50	60.00	19.40	114.30
52	0241	29 Aug 92	46°57.68′S	165°28.52′E	1 085	1 112	1.30	205	426	53.10	16.00	5.00	10.60
53	0245	29 Aug 92	46°57.25′S	165°24.24′E	952	1 030	1.54	295	658	9 105.40	7 917.60	512.80	136.10
54	0241	29 Aug 92	46°58.20′S	165°21.59′E	1 062	1 181	1.50	214	914	877.00	62.50	21.40	16.10
55	0245	29 Aug 92	46°58.14′S	165°25.10′E	953	1 100	1.46	178	1212	26 859.70	23 537.00	1 238.50	1 670.10
56	0450	29 Aug 92	46°49.74′S	166°16.83′E	1 273	1 320	1.53	262	2002	45.20	2.00	0.00	0.00
57	0450	29 Aug 92	46°48.45′S	166°17.74′E	1 254	1 261	1.53	50	2247	103.60	3.90	0.00	0.00
58	0420	30 Aug 92	46°44.66′S	166°07.24′E	808	838	1.51	208	214	90.30	0.00	0.00	0.00
59	0420	30 Aug 92	46°45.17′S	166°07.45′E	833	872	1.52	42	404	90.70	2.60	0.00	0.00
60	0430	30 Aug 92	46°41.44′S	166°14.52′E	956	962	1.51	58	535	169.70	69.50	0.00	0.00
61	0620	30 Aug 92	46°38.12′S	166°40.91′E	885	935	1.54	249	856	233.20	14.50	0.00	0.00
62	0610	30 Aug 92	46°44.49′S	166°53.35′E	673	687	1.62	97	1138	212.20	1.00	0.00	0.00
63	0650	30 Aug 92	46°44.07′S	166°27.77′E	1 296	1 320	1.52	257	1617	41.50	3.20	0.00	0.00
64	0650	30 Aug 92	46°52.98′S	166°32.74′E	1 301	1 334	1.49	11	2005	105.40	4.80	0.00	0.00

Appendix 2—(*continued*)

Station	Stratum	Date	Start of tow		Depth (m)		Distance towed (n.mile)	Direction of tow (°T)	Start time	Total catch (kg)	Species catch (kg)		
			Latitude	Longitude	Min.	Max.					ORH	SSO	BOE
65	0640	30 Aug 92	46°51.79′S	166°43.60′E	1 103	1 111	1.54	307	2254	30.20	4.50	0.00	0.00
66	0640	31 Aug 92	46°53.61′S	166°46.58′E	1 138	1 141	1.53	279	149	23.50	1.20	0.00	0.00
67	0650	31 Aug 92	46°56.33′S	166°43.14′E	1 290	1 293	1.51	109	437	30.90	1.30	0.00	0.00
68	0610	31 Aug 92	46°52.88′S	167°09.00′E	645	738	1.53	262	752	203.40	0.00	0.00	0.00
69	0620	31 Aug 92	46°53.16′S	167°04.96′E	829	892	1.51	259	932	337.10	3.50	0.00	0.00
70	0501	31 Aug 92	47°18.41′S	165°50.01′E	870	1 026	0.64	83	1624	2 314.90	134.40	528.10	808.50
71	0501	31 Aug 92	47°18.89′S	165°47.62′E	875	905	0.17	238	1812	104.50	0.00	71.10	33.40
72	0501	31 Aug 92	47°18.78′S	165°47.61′E	861	917	0.12	255	2116	566.80	72.30	275.10	200.60
73	0501	31 Aug 92	47°18.44′S	165°47.61′E	870	1 100	0.58	282	2333	283.40	30.00	146.60	27.40
74	0502	1 Sep 92	47°20.79′S	165°46.46′E	923	934	0.04	270	132	1 150.20	7.40	239.30	892.90
75	0502	1 Sep 92	47°20.59′S	165°46.39′E	940	1 180	0.48	304	409	301.90	0.00	141.50	74.60
76	0502	1 Sep 92	47°20.83′S	165°48.64′E	920	1 165	0.40	76	721	2 367.30	172.00	1 004.10	1 127.90
77	0247	1 Sep 92	47°05.36′S	165°35.67′E	805	1 060	1.06	310	1224	608.40	371.10	66.20	29.00
78	0245	1 Sep 92	46°56.88′S	165°25.19′E	951	1 012	1.41	23	1544	18 155.90	13 713.90	428.40	3 721.80
79	0243	1 Sep 92	46°55.93′S	165°21.77′E	1 035	1 055	0.73	238	1900	7 139.10	3 347.50	921.90	2 786.80
80	1000	2 Sep 92	48°46.84′S	164°51.90′E	602	1 200	1.73	88	908	1 105.60	28.70	978.90	19.40
81	1000	2 Sep 92	48°47.14′S	164°42.20′E	620	1 202	1.18	265	1126	3.10	0.00	1.50	0.00
82	1000	2 Sep 92	48°50.10′S	164°40.54′E	600	1 153	1.57	281	1558	51.70	2.60	20.40	0.00
83	1000	2 Sep 92	48°57.96′S	164°35.97′E	638	1 100	3.00	241	2031	289.50	11.40	229.10	0.00
84	1000	3 Sep 92	48°58.53′S	164°38.87′E	700	1 178	1.25	136	322	96.60	4.00	13.70	4.20
85	0802	3 Sep 92	48°08.80′S	165°11.46′E	910	1 152	1.50	188	1034	24 952.30	17.40	5 714.00	18 368.90
86	0900	4 Sep 92	47°43.39′S	166°23.07′E	625	1 000	1.31	268	733	353.40	0.00	0.00	0.70
87	0900	4 Sep 92	47°43.44′S	166°22.08′E	740	1 092	0.96	263	945	258.00	3.80	0.00	0.40
88	0801	4 Sep 92	48°00.31′S	165°10.75′E	866	985	0.40	114	1545	4 342.50	78.60	763.10	3 351.10
89	0801	4 Sep 92	47°59.18′S	165°08.79′E	868	1 142	0.75	312	1720	456.00	0.00	4.10	251.00
90	0801	4 Sep 92	48°03.70′S	165°08.11′E	616	1 100	2.41	309	1925	251.10	5.90	25.90	181.40
91	0802	4 Sep 92	48°03.92′S	165°11.06′E	669	1 130	0.96	75	2222	34.90	0.60	21.30	9.10
92	0802	5 Sep 92	48°07.44′S	165°09.61′E	635	1 160	1.65	221	322	207.30	6.40	90.90	32.40
93	0801	5 Sep 92	48°00.04′S	165°10.70′E	865	980	0.29	92	642	5 615.80	35.40	4 696.40	600.50
94	0801	5 Sep 92	48°00.09′S	165°08.71′E	865	1 058	0.76	272	815	1 074.80	13.10	58.60	834.10
95	0802	5 Sep 92	48°08.85′S	165°11.28′E	870	1 085	0.96	159	1120	40 669.60	879.30	15 127.50	24 440.00
96	0230	5 Sep 92	47°03.61′S	165°43.80′E	930	971	1.48	216	2113	164.90	0.20	0.00	0.00
97	0220	6 Sep 92	47°04.51′S	165°40.01′E	802	853	1.47	220	213	77.50	0.00	0.00	0.00

Appendix 2—(*continued*)

Station	Stratum	Date	Start of tow		Depth (m)		Distance towed (n.mile)	Direction of tow (°T)	Start time	Total catch (kg)	Species catch (kg)		
			Latitude	Longitude	Min.	Max.					ORH	SSO	BOE
98	0247	6 Sep 92	47°06.81′S	165°38.62′E	935	979	1.48	211	408	416.50	247.20	0.70	0.00
99	0246	6 Sep 92	47°00.10′S	165°30.72′E	857	1 046	0.51	267	640	709.60	117.30	526.40	1.40
100	0245	6 Sep 92	46°57.95′S	165°25.06′E	948	1 104	1.44	154	859	10 849.10	1 648.90	1 304.70	7 087.60
101	0750	6 Sep 92	47°20.50′S	166°38.44′E	1 301	1 319	1.51	357	1843	74.40	20.60	0.00	0.00
102	0720	6 Sep 92	47°24.94′S	166°47.33′E	868	968	1.55	271	2328	49.10	19.70	0.00	0.00
103	0740	7 Sep 92	47°22.56′S	166°44.57′E	1 096	1 102	1.51	31	150	223.10	125.10	0.50	0.00
104	0720	7 Sep 92	47°20.31′S	166°55.35′E	785	1 030	1.66	310	727	71.70	11.60	0.80	0.00
105	0244	7 Sep 92	46°54.63′S	165°28.06′E	980	1 054	0.94	67	1448	32 026.50	19 315.10	6 902.80	5 754.90
106	0750	7 Sep 92	47°18.44′S	166°42.69′E	1 200	1 286	1.54	270	2320	40.50	5.20	0.00	0.00
107	0740	8 Sep 92	47°14.81′S	166°49.01′E	1 102	1 104	1.55	188	216	94.60	44.30	0.00	0.00
108	0720	8 Sep 92	47°15.30′S	166°55.30′E	878	935	1.97	223	524	181.30	24.40	1.90	0.00
109	0710	8 Sep 92	47°16.27′S	166°57.59′E	729	772	1.56	354	859	110.20	0.60	0.00	0.00
110	0720	8 Sep 92	47°06.89′S	167°00.31′E	907	967	1.51	249	1157	64.50	5.00	0.00	0.00
111	0243	8 Sep 92	46°55.03′S	165°22.00′E	1 019	1 182	1.02	316	1910	105.40	35.20	4.30	0.60
112	0243	8 Sep 92	46°55.76′S	165°21.70′E	1 035	1 183	1.38	270	2138	3 354.60	265.40	1 557.10	1 454.10
113	0246	9 Sep 92	46°55.99′S	165°35.69′E	883	1 025	0.99	171	141	112.80	33.90	3.60	14.10
114	0230	9 Sep 92	46°56.95′S	165°37.31′E	946	998	1.70	345	326	163.10	28.40	0.80	4.70
115	0246	9 Sep 92	46°55.44′S	165°36.55′E	878	1 035	1.93	102	551	326.90	121.50	10.20	0.00
116	0244	9 Sep 92	46°54.10′S	165°26.23′E	970	1 145	1.21	325	835	426.10	111.30	142.90	28.10
117	0245	9 Sep 92	46°58.00′S	165°25.34′E	956	1 140	1.72	191	1042	14 162.20	2 988.90	1 776.00	8 578.10
118	0246	9 Sep 92	47°01.14′S	165°33.03′E	870	1 010	1.06	126	1453	2 080.00	1 419.30	503.70	0.00
119	0320	9 Sep 92	46°57.99′S	165°56.53′E	900	1 068	0.40	174	1821	74.00	53.50	0.00	5.10
120	0242	9 Sep 92	47°06.64′S	165°42.00′E	1 020	1 150	1.16	218	2127	2 149.90	1 904.90	6.30	5.10
121	0242	10 Sep 92	46°54.64′S	165°38.81′E	1 055	1 058	1.53	194	252	156.80	42.50	0.00	1.90
122	0220	10 Sep 92	46°52.16′S	165°33.18′E	800	855	0.89	180	532	195.50	99.70	0.00	0.00
123	0110	10 Sep 92	46°40.62′S	165°31.58′E	600	638	1.55	180	930	68.40	1.60	0.00	0.00
124	0245	10 Sep 92	46°57.05′S	165°25.23′E	950	952	0.04	9	1448	245.40	1.80	103.00	95.10
125	0245	10 Sep 92	46°57.05′S	165°25.44′E	944	1 001	1.53	25	1640	2 473.80	186.40	794.70	1 289.80
126	0245	10 Sep 92	46°58.12′S	165°25.32′E	950	1 128	1.52	190	1925	27 655.60	5 701.40	2 391.80	19 291.80
127	0242	11 Sep 92	46°56.57′S	165°29.13′E	1 090	1 190	1.57	19	252	51.90	1.60	1.80	23.70
128	0247	11 Sep 92	47°05.96′S	165°38.89′E	850	968	1.50	169	614	2 531.00	2 440.00	60.00	5.00
129	0247	11 Sep 92	47°07.27′S	165°38.05′E	820	1 018	1.50	144	1126	1 535.30	1 317.70	66.00	0.00
130	0320	11 Sep 92	46°57.89′S	165°56.45′E	720	1 200	0.65	188	1446	470.00	140.10	3.20	0.00

Appendix 2—(*continued*)

Station	Stratum	Date	Start of tow		Depth (m)		Distance towed (n.mile)	Direction of tow (°T)	Start time	Total catch (kg)	Species catch (kg)		
			Latitude	Longitude	Min.	Max.					ORH	SSO	BOE
131	0750	11 Sep 92	47°02.74′S	166°50.45′E	1 215	1 266	1.52	277	1951	138.60	17.30	0.80	0.00
132	0740	11 Sep 92	47°04.86′S	166°57.94′E	1 018	1 069	1.57	307	2232	109.60	62.30	0.20	0.00
133	0720	12 Sep 92	47°06.97′S	167°01.94′E	815	918	1.52	316	141	106.90	5.30	0.00	0.00
134	0710	12 Sep 92	46°59.66′S	167°09.12′E	607	730	1.51	276	451	12.30	0.00	0.00	0.00
135	0740	12 Sep 92	47°01.80′S	166°58.91′E	1 024	1 075	1.52	241	725	52.80	17.50	0.10	0.00

Appendix 3: Species caught.

Echinodermata
Echinoidea (haggis urchins)
Crustacea
Neolithodes brodiei (southern stone crab)
Lithodes murrayi (southern stone crab)
Lipkius holthuisi (omega prawn)
Pasiphaea barnardi
Cephalopoda
Sepioteuthis sp. (sepiolid squid)
Moroteuthis spp. (warty squid)
Histioteuthis spp. (violet squid)
Nototodarus sloanii (arrow squid)
Ommastrephes bartrami (red squid)
Chondrichthyes
Selachiformes
Centrophorus squamosus (leafscaled gulper shark)
Centroscymnus crepidater (longnosed velvet dogfish)
C. owstoni (Owston's spiny dogfish)
C. plunketi (Plunket's shark)
Centroscymnus sp. A (roughskinned *Centroscymnus*)
Scymnorhinus licha (seal shark)
Deania calcea (shovelnosed spiny dogfish)
Etmopterus baxteri (Baxter's lantern dogfish)
E. lucifer (Lucifer spiny dogfish)
Apristurus sp. A (catshark)
Apristurus sp. B (catshark)
Apristurus sp. C (catshark)
Apristurus sp. E (catshark)
Rajiformes
Bathyraja sp. (bluntnosed skate)
B. shuntovi (pale longnosed skate)
Pavoraja asperula
P. spinifera
Chimaeriformes
Hydrolagus sp. B (pale ghost shark)
Harriotta raleighana (longnosed chimaera)
Rhinochimaera pacifica (widenosed chimaera)
Chimaera sp. (purple chimaera)
Chimaera phantasma (giant chimaera)
Osteichthyes
Anguilliformes
Diastobranchus capensis (basketwork eel)
Notacanthus sexspinis (spineback eel)
Bassanago hirsutus (hairy conger)
Salmoniformes
Bathylagus spp. (deepsea smelt)
Alepocephalus australis (smallscaled brown slickhead)
Alepocephalus sp. (bigscaled brown slickhead)
Platytroctidae (tubeshoulder)
Holtbyrnia sp. (tubeshoulder)
Stomiiformes
Chauliodus sloani (viperfish)
Stomias spp. (scaly dragonfish)
Idiacanthus spp. (starry dragonfish)
Astronesthes sp. (snaggletooth)
Sternoptychidae (hachetfish)
Aulopiformes
Evermannella sp. (sabretooth)

Myctophiformes
- *Lampanyctus* spp. (lanternfish)

Gadiformes
- *Pseudophycis bachus* (red cod)
- *Mora moro* (ribaldo)
- *Antimora rostrata* (violet cod)
- *Halargyreus johnsoni* (Johnson's cod)
- *Lepidion microcephalus* (smallheaded cod)
- *L. schmidti* (giant lepidion)
- *Merluccius australis* (hake)
- *Macruronus novaezelandiae* (hoki)
- *Trachyrincus* spp. (white rattail)
- *Gadomus aoteanus* (filamentous rattail)
- *Caelorinchus bollonsi* (Bollons's rattail)
- *C. aspercephalus* (oblique banded rattail)
- *C. cookianus* (Cook's rattail)
- *C. fasciatus* (banded rattail)
- *C. oliverianus* (Oliver's rattail)
- *C. innotabilis* (notable rattail)
- *C. kaiyomaru* (Kaiyomaru rattail)
- *C. matamua* (Mahia rattail)
- *Caelorinchus* sp. K2 (spottyfaced rattail)
- *Coryphaenoides serrulatus* (serrulated rattail)
- *C. subserrulatus* (fourrayed rattail)
- *C. murrayi* (Murray's rattail)
- *Coryphaenoides* sp. B
- *Lepidorhynchus denticulatus* (javelinfish)
- *Macrourus carinatus* (ridgescaled rattail)
- *Odontomacrurus murrayi*
- *Nezumia namatahi* (squashedfaced rattail)
- *Nezumia* sp. P (false bulbous rattail)
- *N. bubonis* (bulbous rattail)
- *Ventrifossa nigromaculata* (blackspot rattail)

Ophidiiformes
- *Genypterus blacodes* (ling)

Beryciformes
- Melamphaidae (big scale fish)
- *Hoplostethus atlanticus* (orange roughy)
- *H. mediterraneus* (silver roughy)
- *Diretmus argenteus* (discfish)

Lophiiformes
- *Cryptopsaras couesi* (sea devil)
- *Chaunax pictus* (pink frogmouth)
- Melanocoetidae (anglerfish)

Zeiformes
- *Cyttus traversi* (lookdown dory)
- *Pseudocyttus maculatus* (smooth oreo)
- *Allocyttus niger* (black oreo)
- *Neocyttus rhomboidalus* (spiky oreo)

Scorpaeniformes
- *Helicolenus* sp. (sea perch)
- *Neophrynichthys angustus* (pale toadfish)
- *Psychrolutes* sp. (blobfish)
- *Trachyscorpia capensis* (Cape scorpionfish)

Perciformes
- *Epigonus lenimen* (bigeyed cardinalfish)
- *E. telescopus* (black cardinalfish)
- *E. robustus* (robust cardinalfish)
- *Brama brama* (Ray's bream)
- *Hyperoglyphe antarctica* (bluenose)
- *Lepidopus caudatus* (frostfish)

Centrolophus niger (rudderfish)
Schedophilus huttoni
Tubbia tasmanica
Seriolella caerulea (white warehou)
S. brama (common warehou)
Kathetostoma giganteum (giant stargazer)
Cubiceps caeruleus (cubehead)
Pleuronectiformes
Mancopsetta sp. (finless flounder)

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