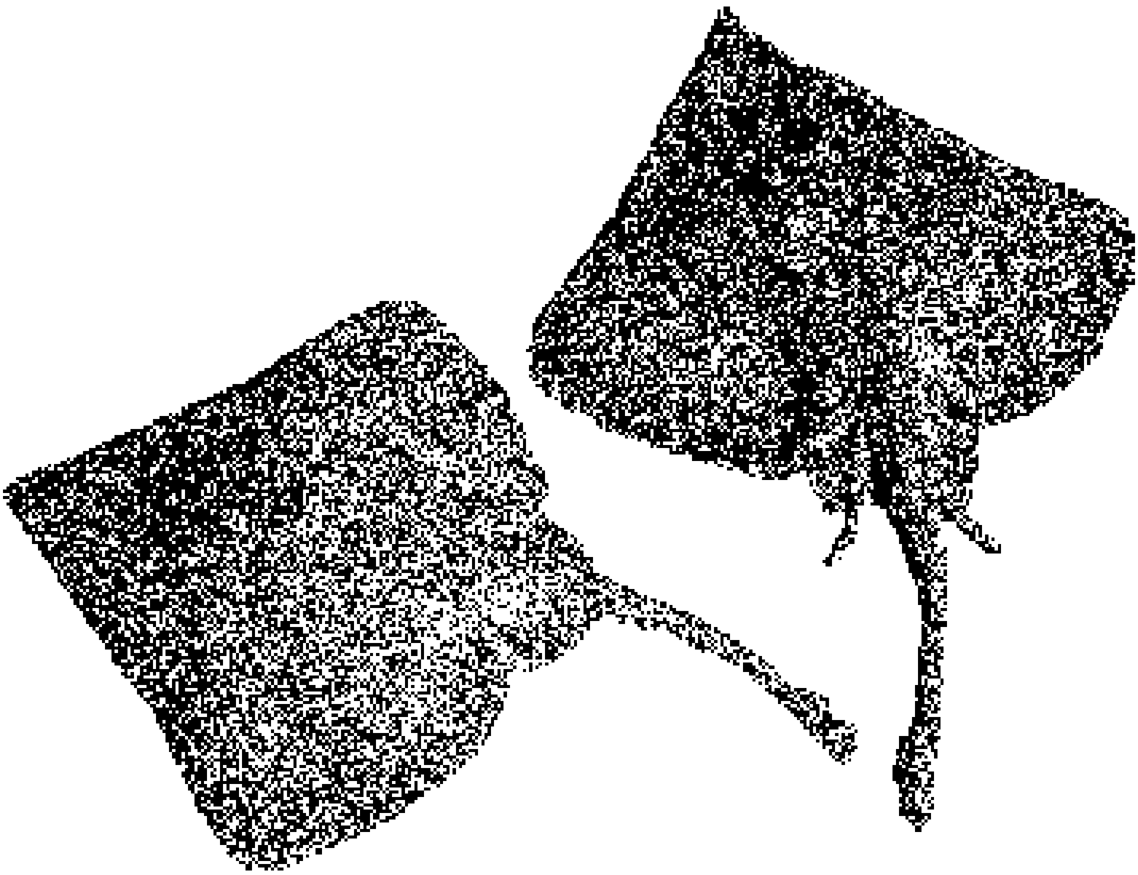
# Scientific Report

# Fisheries Research Cruise ZDLH1-07-2000



**Fisheries Department**

**Falkland Islands Government**

# Scientific Report

# Fisheries Research Cruise

# ZDLH1-07-2000

*FPRV Dorada*

*26 July to 3 August 2000*

**Fisheries Department**

**Falkland Islands Government**

**Stanley**

**Falkland Islands**

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For citation purposes this publication should be referenced as follows:

Falkland Islands Government (2002). Scientific Report, Fisheries Research Cruise ZDLH1-07-2000. Stanley, Falkland Islands Government Fisheries Department.

Printed by the Falkland Islands Government Printing Office, Stanley, Falkland Islands.

# Preface

This report describes the activities and results of the research cruise carried out by the Scientific Section of the Falkland Islands Government Fisheries Department during late July and early August 2000 using the Fisheries Patrol and Research Vessel *Dorada*.

We wish to record our thanks to the master, fishing master, officers and crew of the *Dorada* for their work during the cruise.

## Summary

The research cruise ZDLH1-07-2000 was carried out using the Fisheries Protection & Research Vessel *Dorada* in winter (July-August) 2000, at the beginning of the second season skate/ray fishery. The purpose of the cruise was to carry out a bottom trawl survey of the northern part of the FICZ/FOCZ where the ray/skate commercial fishery operates.

Transects were arranged perpendicular to the slope and trawls carried out at three standard depths. A bottom trawl with tickler chain and polyvalent doors was used at all trawl stations, with a standard trawling distance of 3.5 nm (i.e. approximately 1hr at 3.5 knots).

Bathymetric data collected along the vessel track demonstrated that two data sets commonly used in the illustration of local bathymetry contain inaccuracies, particularly in the south of the region surveyed.

Rays proved quite abundant during the survey with an average catch of 102.3 kg/56 individuals per station providing reasonable sample sizes. Depth was to be the main determinant of ray species composition although there were also some regional differences – in particular the catch composition at the single station on the plateau differed from that at slope top stations of a similar depth.

*Bathyraja albomaculata* was the most ubiquitous species and was present at all stations. *Bathyraja griseocauda* was found at the majority of stations and was the most abundant ray species in terms of catch weight. However its abundance was noticeably lower at the shallow, slope top stations. Several of the ray species showed size-specific differences in distribution. Amphipods, *Serolis* spp., and polychaetes were the numerically dominant prey items in the ray stomachs analysed. Most species showed a change in diet with increasing size. *Bathyraja albomaculata* and *Bathyraja macloviana*, showed especially limited diets dominated by polychaetes and amphipods. In other species the larger animals often progressed to feeding on fish and cephalopods.

Catches of *Loligo gahi* were small, but fairly widespread with the highest abundance at the 250m stations. The maturing squid showed sexual segregation with the proportion of females increased with depth.

Hoki, *Macruronus magellanicus*, were caught widely especially in the north-western part of the survey region. Some spatial segregation of sizes was apparent. Common hake, *Merluccius hubbsi*, were also caught widely – the majority were developing or resting females.

A new sub-species of sepiolid, *Neorossia caroli jeannae* (Nesis et al., 2001), was found at the deepest station sampled.

# 1. Introduction

The research cruise ZDLH1-07-2000 aimed to investigate the skate and ray assemblage to the north of the Falkland Islands in the region that is exploited by the licensed RAY fishery. Although this fishery does not rank as one of the most commercially important of the Falkland's fisheries, it has been recognised that elasmobranch fisheries are generally vulnerable to over-fishing and must be managed appropriately (Agnew *et al.*, 1999). The fishery exploits an assemblage of more than ten ray species of varying sizes and growth rates, which are not differentiated in catch reports from the commercial fleet, thus presenting a challenging fisheries management problem. The species specific information provided by the Fisheries Department's scientific observer program is necessarily restricted to "snapshots" of the catch of a single vessel over relatively short time periods which may not, therefore, be entirely representative of species distributions over the whole region.

This research cruise aimed to investigate the species composition and biological characteristics over a wide part of the slope north of the Falkland Islands. Collection of ray vertebrae and thorn samples for ageing studies was also a priority as these are typically not available from sampling aboard the commercial fleet, where animals are usually frozen whole and undamaged.

## *Cruise plan*

The region to be covered included the northern part of the FICZ and FOCZ; the planned transects are illustrated in Figure 1, and detailed in Table I. Each transect included three 1-hr (3.5nm) bottom trawl hauls at depths of 120-150 m, 200-250 m, and 350-400 m. This spanned the bulk of the fishing depths reported by the commercial fleet (Figure 2). Extra trawls both in deeper water and on the shelf were to be included as time and weather allowed.

**Figure 1.** Planned transects for research cruise ZDLH1-07-2000 with predicted bathymetry from NOAA Southern Ocean Geophysical Data atlas.

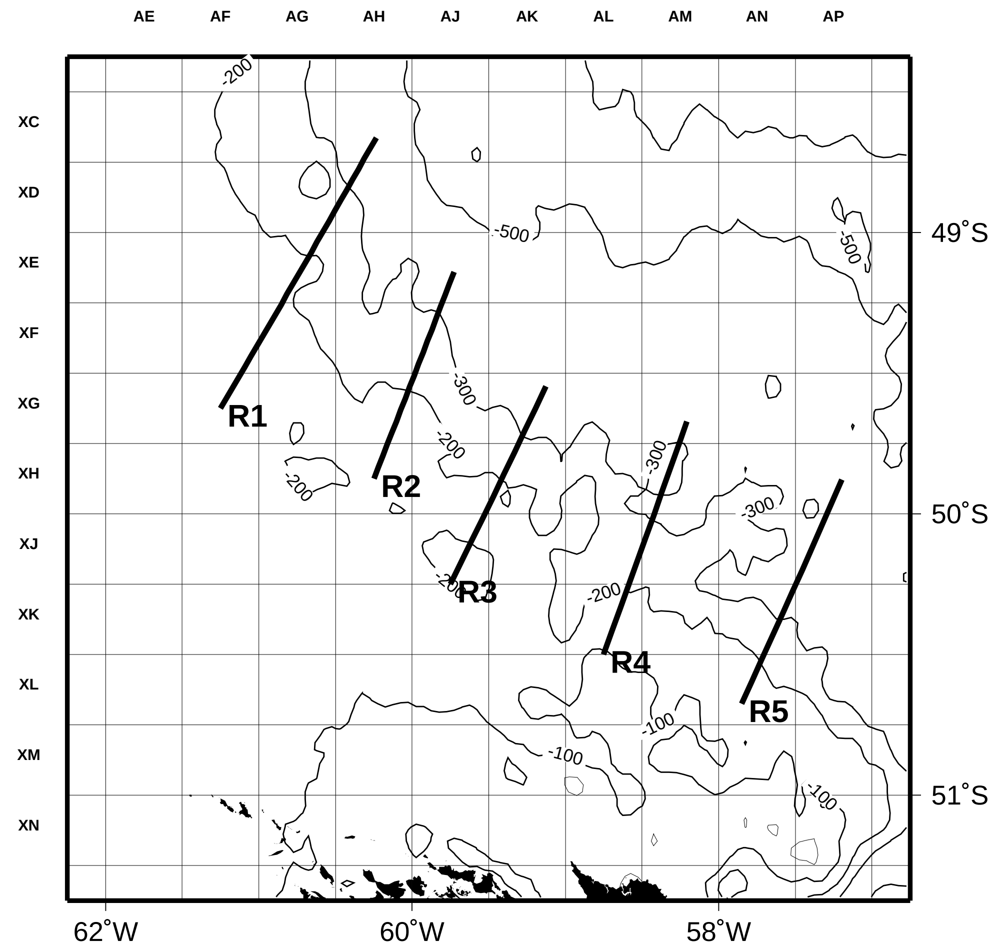


**Figure 2.** Distribution of mean daily fishing depth reported by vessels licensed to target skates and rays.

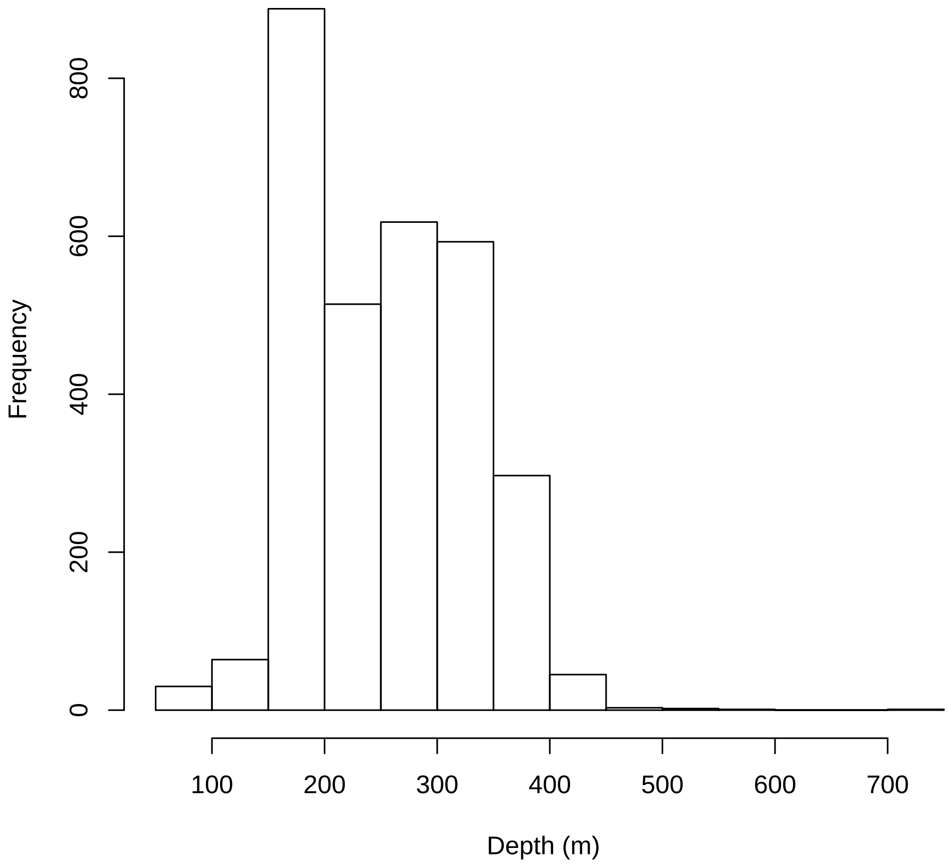



**Table I.** Details of planned transects.

| *Transect* | *Southern position* | *Bearing* |
|---|---|---|
| R1 | 49°37.5'S 61°15.0'W | 35° |
| R2 | 49°52.5'S 60°15.0'W | 25° |
| R3 | 50°15.0'S 59°45.0'W | 30° |
| R4 | 50°30.0'S 58°45.0'W | 23° |
| R5 | 50°40.5'S 57°51.0'W | 28° |

## *Cruise objectives*

1. To carry out a bottom trawl survey in the region of the skate/ray fishery in the FICZ/FOCZ.
2. To investigate the demersal fish assemblage in the northern part of the FICZ/FOCZ.
3. To collect vertebrae and thorns for ray ageing studies.

## *Vessel characteristics*

The cruise was conducted on board the Fishery Patrol/Research Vessel *Dorada* registered in the Falkland Islands.

**Table II.** Characteristics of the Fisheries Protection and Research Vessel, *Dorada***.**

| | |
|---|---|
| Callsign | ZDLH1 |
| Length | 76 m |
| GRT | 2360 t |
| NRT | 708 t |
| Crew | 16 people |

## Equipment

All trawls were carried out using a bottom trawl with a 40-mm cod end liner and 1200kg polyvalent doors. A tickler chain and towing speed of 3 to 3.5 knots were used.

## Personnel and responsibilities

The following FIFD personnel participated in the cruise:

| | |
|---|---|
| David Middleton | Chief cruise scientist |
| Joost Pompert | Trawl survey |
| Paul Brickle | Trawl survey |
| Mark Potter | Trawl survey |
| Matthew Dawkins | Trawl survey |
| Michael Hattersley | Trawl survey |
| Paul Schroeder | Trawl survey |

## 2. Survey execution and bathymetric data

### *Survey execution and station details*

Bad weather prevented fishing on two occasions. As a result the trawls on transect R4, and the deepest station on transect R3, were not completed. A deep (480m) station was carried out between transects R1 and R2 and an additional trawl was made further onto the shelf south of R2. The positions of the completed stations are shown in Figure 3 and station details given in Table III. Figure 4 illustrates the variability in trawling effort across all stations using data from the Simrad ITI trawl instrumentation. The trawl distance over the seabed is calculated here as the great circle distance between the start and end positions of the trawl on the seabed. The lack of gyro compass input to the ITI system creates variability in position fixes, which means that the distance trawled is overestimated if calculated as the sum of position to position distances.

**Table III.** Station details.

| *Station* | *Standard Station Code* | *Activity* | *Date* | *Start Time* | *Seabed Start Latitude* | *Seabed Start Longitude* | *Seabed Finish Latitude* | *Seabed Finish Longitude* | *Modal Depth (m)* | *Duration Start to Finish (mins)* |
|---|---|---|---|---|---|---|---|---|---|---|
| 413 | R1-150 | Trawl | 27/07/00 | 13:25 | 49° 37.66 S | 61° 16.80 W | 49° 36.80 S | 61° 10.60 W | 161 | 106 |
| 414 | R1-200 | Trawl | 27/07/00 | 19:48 | 49° 06.20 S | 60° 42.50 W | 49° 08.90 S | 60° 37.90 W | 200 | 102 |
| 415 | R1-350 | Trawl | 28/07/00 | 07:05 | 48° 40.40 S | 60° 15.20 W | 48° 43.00 S | 60° 10.20 W | 394 | 121 |
| 416 | | Trawl | 28/07/00 | 10:26 | 48° 43.60 S | 59° 48.20 W | 48° 44.20 S | 59° 41.90 W | 478 | 128 |
| 417 | R2-350 | Trawl | 28/07/00 | 18:28 | 49° 09.80 S | 59° 46.20 W | 49° 09.70 S | 59° 40.30 W | 397 | 148 |
| 418 | R2-200 | Trawl | 29/07/00 | 06:40 | 49° 26.60 S | 59° 59.70 W | 49° 30.80 S | 59° 54.60 W | 242 | 108 |
| 419 | R2-150 | Trawl | 29/07/00 | 12:08 | 49° 51.50 S | 60° 15.90 W | 49° 50.10 S | 60° 08.80 W | 165 | 112 |
| 420 | | Trawl | 29/07/00 | 18:09 | 50° 16.50 S | 60° 33.50 W | 50° 16.50 S | 60° 27.30 W | 156 | 102 |
| 421 | R3-150 | Trawl | 30/07/00 | 06:38 | 50° 06.70 S | 59° 39.50 W | 50° 09.60 S | 59° 35.20 W | 157 | 100 |
| 422 | R3-200 | Trawl | 30/07/00 | 12:57 | 49° 46.40 S | 59° 21.80 W | 49° 49.10 S | 59° 17.40 W | 245 | 101 |
| 423 | R5-350 | Trawl | 01/08/00 | 06:56 | 50° 03.80 S | 57° 21.50 W | 50° 07.50 S | 57° 19.10 W | 357 | 106 |
| 424 | R5-200 | Trawl | 01/08/00 | 13:15 | 50° 26.20 S | 57° 40.80 W | 50° 29.20 S | 57° 36.90 W | 239 | 109 |
| 425 | R5-150 | Trawl | 01/08/00 | 16:50 | 50° 39.00 S | 57° 53.40 W | 50° 40.60 S | 57° 47.10 W | 138 | 105 |

**Figure 3.** Trawl stations completed on research cruise ZDLH1-07-2000.

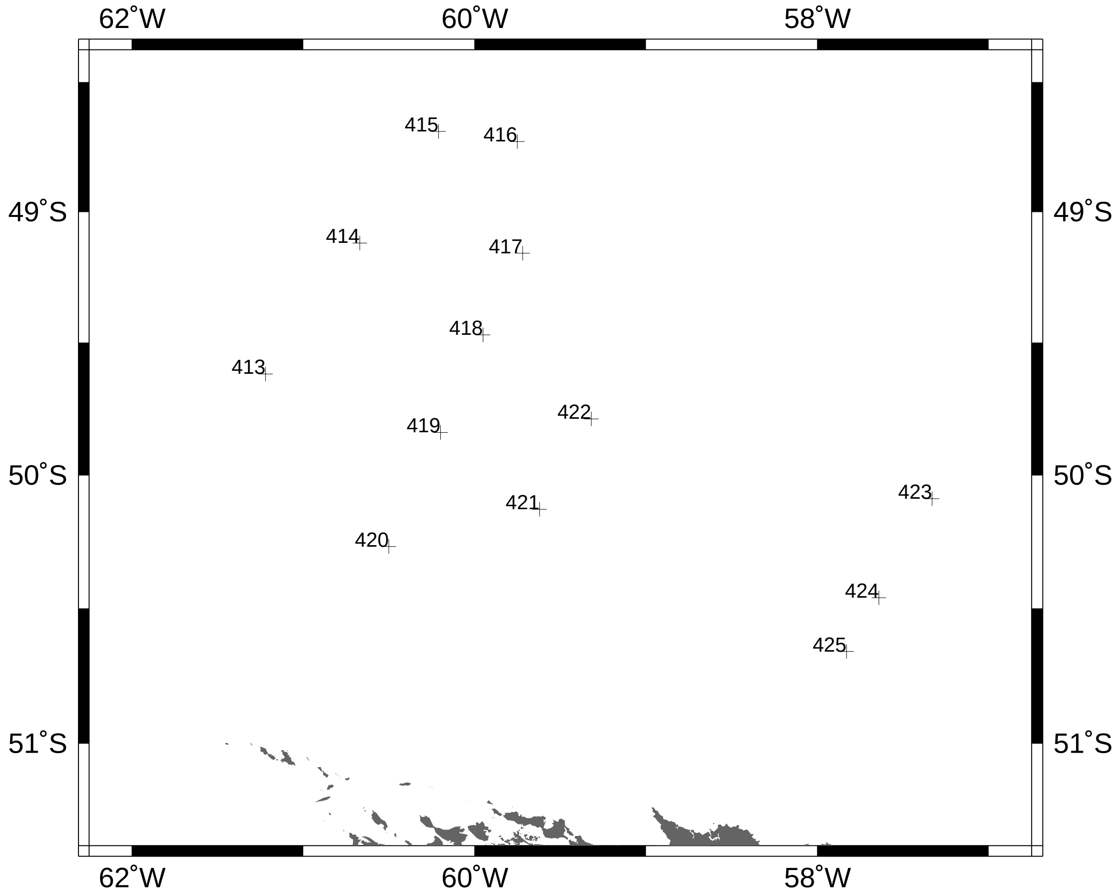
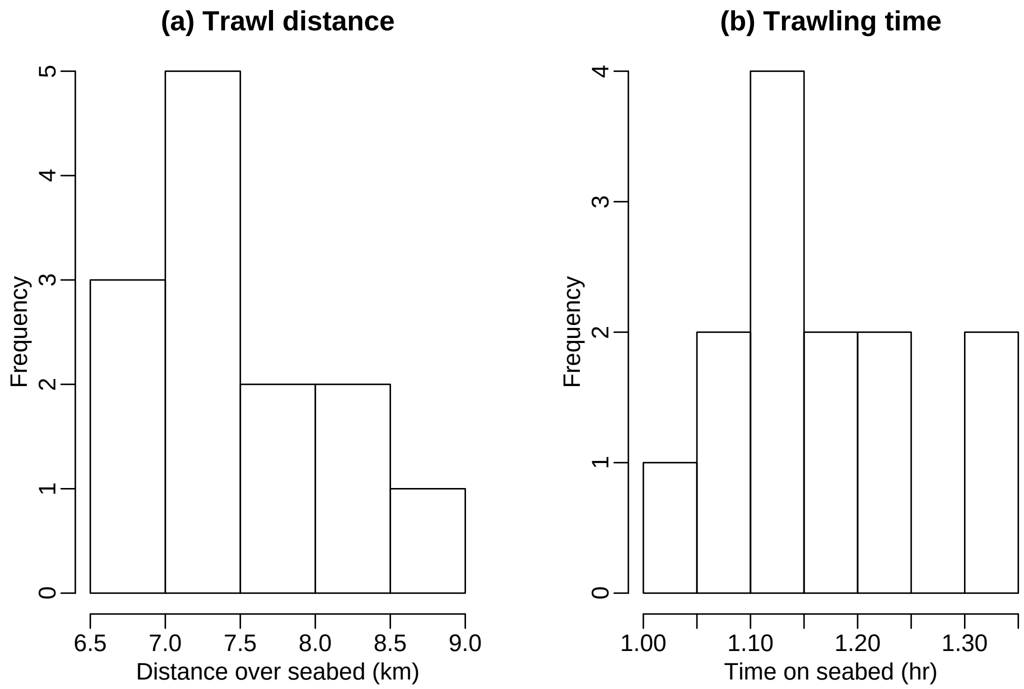



**Figure 4.** Consistency of trawling effort in terms of (a) trawling distance over the seabed, and (b) trawl time on the seabed, from trawl instrumentation data.



## Bathymetric data

It is useful to be able to present catch data in relation to the bathymetry of the survey area. Two global bathymetric datasets are available for this purpose: the GEBCO-97 (General Bathymetric Chart of the Oceans) atlas (NERC, 1997), and predicted sea floor topography from satellite observations such as that by Sandwell and Smith included on the Southern Ocean Geophysical data CDROM (NOAA, 1995). Although these datasets are useful for a general overview of an area's bathymetry they are often inaccurate in detail. The area surveyed in this research cruise was a small part of the slope north of the Falkland Islands. The trawl transects were arranged perpendicular to the slope and so the bathymetric data logged from the ship's echo-sounders presents a useful dataset for comparison with the global datasets.

Figure 5 illustrates the available datasets. The GEBCO data is provided in the form of digitised contours. Unfortunately the different map sheets that make up the GEBCO dataset do not all contain data at the same resolution so contours may be discontinuous at the joins of map sheets. This is apparent in Figure 5(a), which spans the boundary between GEBCO sheets 5.12 (scale of 1:5,737,447 at the equator, coverage to 50°S) and 5.16 (scale of 1 to 10 million at the equator). One solution to this problem is to fit a surface to the contoured data (i.e. treating the digitised contours as real position/depth data) and re-contour using standard algorithms. This use of digitised contour data is known to be a difficult problem computationally. The result of trying this is shown in Figure 5(b). While there is a reasonably good match between the original and computed contours in the north of the area, the fit is poorer in the south.

Figure 5(c) shows a contour map derived from the predicted satellite topography over the same region. While, as expected, the same major features are present in this data as in the GEBCO dataset there are some significant differences (compare the 100m contour for example) and much more "apparent detail" which may or may not represent real sea bottom features.

Data collected along the cruise track is presented in Figure 6. This uses bathymetric data from the RoxAnn bottom profiling system (38kHz Simrad transducer) which has been checked against data logged from the Furuno bridge echo-sounder (28kHz), and spurious data removed. Depths are available frequently along the cruise track, but overall coverage of the area of interest is rather low. Data were converted to a two minute grid, taking the median if a block had multiple readings, and a global surface was fitted. Figure 6 (a) shows contours of this global surface along with (dark grey) the blocks with depth readings (i.e. the ship track). The lighter grey represents a mask, used in Figure 6 (b), to show only contours within 10km of blocks with depth readings (i.e. those areas where confidence in the fitted contours is higher). The contoured surface is compared with the GEBCO data in Figure 6 (c) and the predicted topography data in Figure 6 (d). In the north-west of the plotted region both the GEBCO and satellite predicted datasets match the observed depth data fairly well. The GEBCO data positions the 500m contour more accurately. In the southern part of the region the GEBCO data shows significant deviations from the observed depth readings (this is the area covered by GEBCO sheet 5.16), and unfortunately the satellite predicted topography data does not perform much better.

The contours estimated from the actual depth recordings are used in the remainder of this report to illustrate catch distribution in relation to bathymetry. The ongoing collection of further depth data will provide an improved bathymetric database for research.

**Figure 5.** Illustration of bathymetric information for surveyed area from standard sources: (a) “raw” GEBCO contours from sheets 5.12 and 5.16; (b) gridded and re-contoured GEBCO data using the GMT surface program with a tension of 0.99 (original contours in red) and (c) Sandwell and Smith predicted topography data.

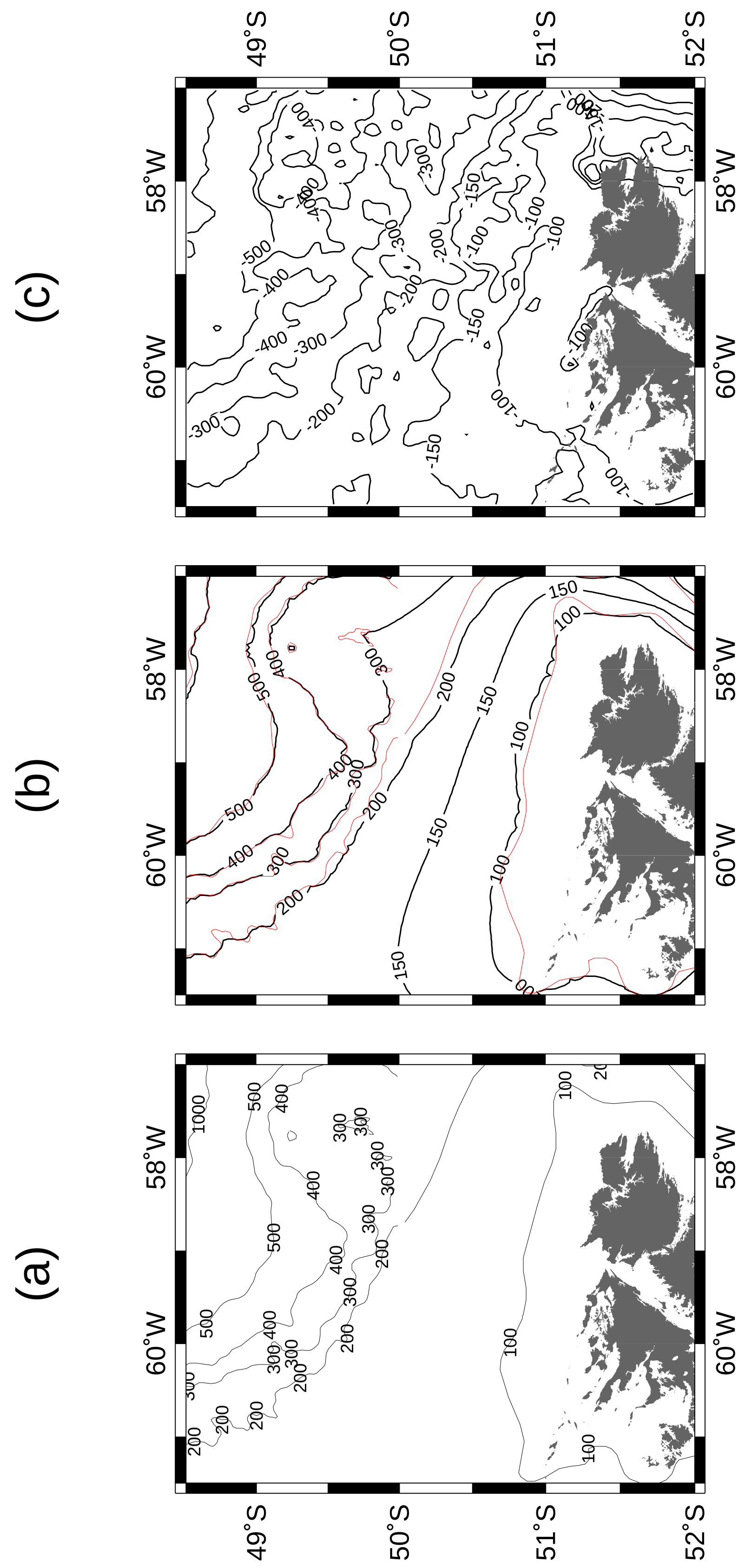
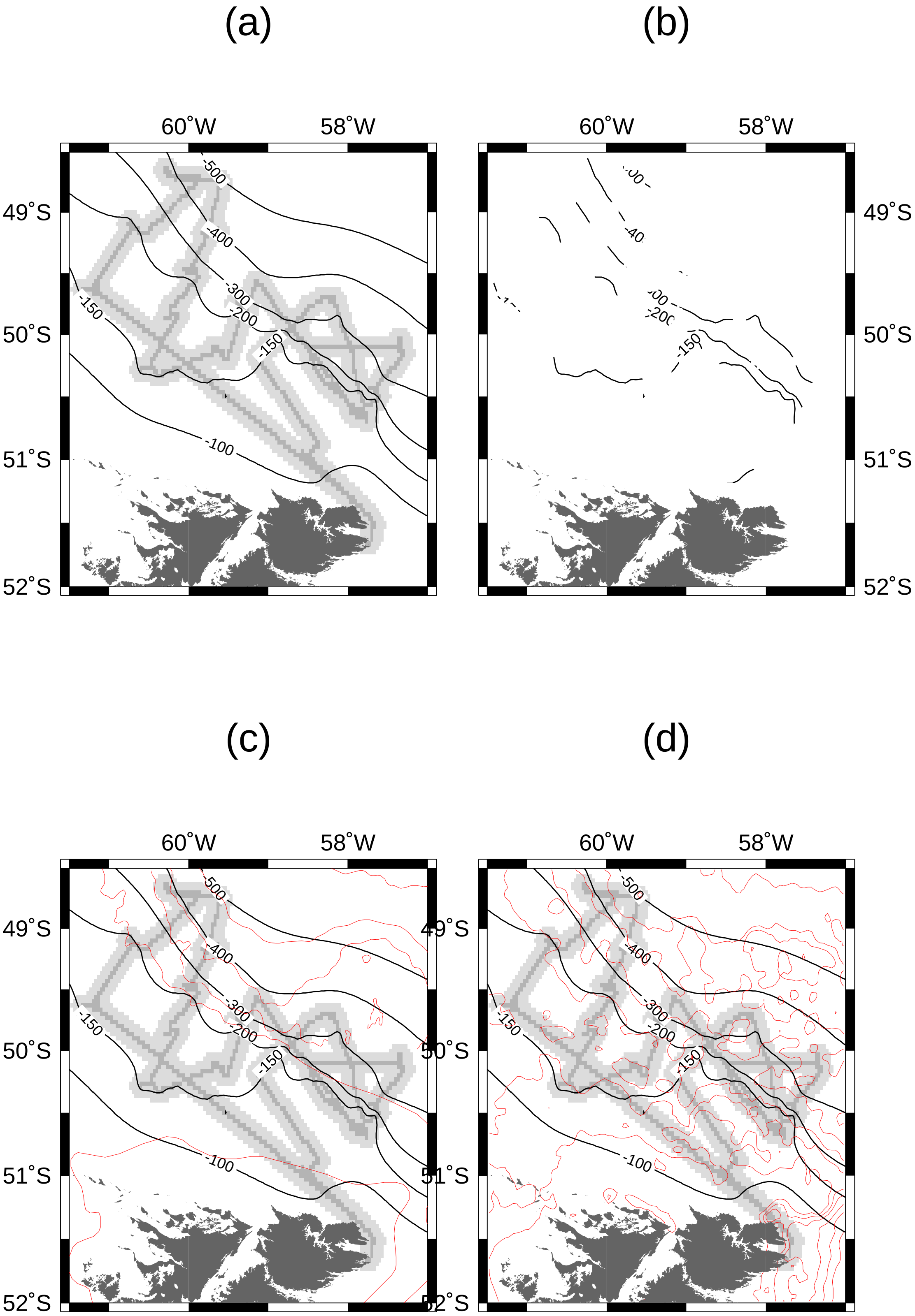


**Figure 6.** Contouring of recorded depth measurements after fitting a smooth surface (tension 0.35) to the data gridded on a two minute grid. (a) contours plotted for the whole region with blocks with data (i.e. along the cruise track) shaded in dark grey and a 10km mask illustrated in lighter grey; (b) application of the mask, illustrated in (a), to show only those contours within 10km of grid blocks with depth readings; (c) comparison of the contoured surface with the GEBCO data; comparison with predicted topography data.



# 3. Biological sampling

Objectives of the biological sampling programme were to:

1. Accurately weigh all catch and by-catch, and identify to species level, where possible.
2. Collect biological parameters like length/frequency and/or size/weight data from the main catch and a wide variety of by-catch species.
3. Analyze the diet of a variety of species, mainly rays/skates, as well as notothenids and dogfish/catsharks
4. Collect vertebrae and dorsal spine samples from all ray species for age analyses.
5. Collect samples of *Loligo gahi* for statolith extraction ashore.
6. Collect diet samples from hake for the Instituto Español de Oceonagrafia and Aberdeen University.
7. Collect parasitological data from rays.

## *3.1 Sampling methods*

The catch from each trawl was identified to species level (where possible) and weighed. Large catches (approx. >35 kg) of individual species were weighed in baskets using a spring balance (max 45-50kg), with smaller catches being weighed using the marine adjusted Scanvaegt balances.  All skate and rays caught were weighed (grams to the nearest 20 g) and measured (disk width and total length to the nearest centimetre below), their sex and maturity stage (Table 4) established, and samples of their vertebrae and thorns were collected for age determination. . Due to the complexities of identifying all *Psammobatis* spp. to species level, this genus was grouped under the code RPX.

**Table 4.** Skate/ray maturity scale.

| *Stage* | *Description* | *Interpretation* |
|---|---|---|
| I | Juvenile | All sexual organs completely undeveloped. |
| II | Adolescent | All sexual organs in very early stages of development. |
| III | Adult, developing | Sexual organs very clearly mostly developed. |
| IV | Adult, mature | Sexual organs fully developed, no egg-cases present in female, no sperm in tip of the clasper of the male. |
| V | Adult, running | As IV with egg cases present or sperm present in tip of clasper. |
| VI | Adult, resting | Females only, no egg cases present.  Oviducts venous and stretched. |

All squid catches were subject to normal length-frequency analysis. For females evidence of sperm in the buccal cavity and/or in the mantle attached near or onto the gills was recorded.   Samples were taken for statolith extraction ashore.   Normal length frequency and length weight samples were taken for commercial finfish species, in particular toothfish, *D. eleginoides*.  Hake and hoki stomach samples were also collected and frozen for later analysis.

### Ray diet analyses

Diet sampling of rajids was carried out at most stations.  The following parameters were recorded: stomach fullness (0=empty, 1=¼ full, 2=½ full, 3=¾ full, and 4=full), prey code (species, genus, or family level where possible), prey particle type (whole, legs, carapaces, beaks, etc.), stage of digestion (undigested through to digested), number of prey and mean length of prey item (in mm). The presence and level of infection with the parasite *Otodistomum plunketi* was also recorded for all animals where the stomach was assessed, in order to try and establish a meaningful correlation between diet and infection

## *3.2 Catch and by-catch*

The thirteen trawls yielded a total catch of 7992 kg. The overall catch by species is given in Table V. The greatest overall catch by weight was of sponges, 1546 kg (80%) of which came from the deepest station 416. Another interesting catch, also from station 416, was a sepiolid since classified as a new sub-species *Neorossia caroli jeannae* (Nesis et al., 2001). Hoki (*Macruronus magellanicus*) and common hake (*Merluccius hubbsi*) were the most abundant commercial species encountered. All trawls yielded good numbers of skates and rays.

**Table V.** Catch summary by species.

| *Species Code* | *Species name* | *Total Catch (kg)* | *Total Sampled (kg)* | *Total Discarded (kg)* |
|---|---|---|---|---|
| SPN | Sponges | 1,924.70 | 0.00 | 1,924.70 |
| PAR | *Patagonotothen ramsayi* | 901.96 | 0.00 | 901.96 |
| WHI | *Macruronus magellanicus* | 771.94 | 326.88 | 669.54 |
| HAK | *Merluccius hubbsi* | 698.00 | 302.48 | 611.00 |
| ANT | Anthozoa | 635.79 | 0.00 | 635.79 |
| LOL | *Loligo gahi* | 329.04 | 56.94 | 292.26 |
| RGR | *Bathyraja griseocauda* | 269.57 | 269.57 | 269.57 |
| RBR | *Bathyraja brachyurops* | 267.42 | 267.42 | 267.42 |
| RFL | *Raja flavirostris* | 264.88 | 264.88 | 264.88 |
| TOO | *Dissostichus eleginoides* | 247.08 | 247.08 | 157.59 |
| GRX | *Coelorhynchus* sp. cf *braueri* | 223.00 | 0.00 | 223.00 |
| RAL | *Bathyraja albomaculata* | 204.06 | 204.06 | 204.06 |
| UCH | Sea urchin | 172.28 | 0.00 | 172.28 |
| RBZ | Undescribed *Bathyraja* sp. #3 | 136.02 | 136.02 | 136.02 |
| RED | *Sebastes oculatus* | 134.98 | 55.60 | 53.38 |
| KIN | *Genypterus blacodes* | 126.74 | 108.22 | 83.08 |
| BAC | *Salilota australis* | 108.18 | 0.00 | 108.18 |
| COT | *Cottunculus granulosus* | 61.18 | 1.20 | 61.18 |
| RMC | *Bathyraja macloviana* | 54.08 | 54.08 | 54.08 |
| AST | Asteroidea | 49.41 | 0.00 | 49.41 |
| RMU | *Bathyraja multispinis* | 40.38 | 40.38 | 40.38 |
| OPH | Ophiuroidea | 38.66 | 0.00 | 38.66 |
| BEE | *Benthoctopus eureka* | 38.40 | 13.70 | 23.70 |
| RDO | *Raja doellojuradoi* | 31.62 | 31.62 | 31.62 |
| RSC | *Bathyraja scaphiops* | 30.66 | 30.66 | 30.66 |
| WLK | Whelks | 30.66 | 0.00 | 30.66 |
| SCA | Scallop | 27.88 | 0.00 | 27.88 |
| BUT | *Stromateus brasiliensis* | 22.50 | 1.50 | 21.00 |
| RPX | *Psammobatis* spp. | 20.24 | 20.24 | 20.24 |
| EEL | *Iluocoetes fimbriatus* | 19.74 | 0.00 | 19.74 |
| ANM | Anemones | 17.86 | 0.00 | 17.86 |
| RTR | *Raja trachyderma* | 11.40 | 11.40 | 11.40 |
| DGH | *Schroederichthys bivius* | 11.12 | 0.00 | 11.12 |
| DGS | *Squalus acanthias* | 10.82 | 0.00 | 10.82 |
| CAS | *Campylonotus semistriatus* | 9.02 | 0.00 | 2.48 |
| ING | *Moroteuthis ingens* | 8.82 | 8.82 | 0.00 |
| THB | *Thymops birsteini* | 7.71 | 0.00 | 0.59 |
| CGO | *Cottoperca gobio* | 5.32 | 0.00 | 5.32 |
| GRF | *Coelorhynchus fasciatus* | 4.50 | 0.00 | 4.50 |
| MMA | *Mancopsetta maculata* | 4.43 | 0.00 | 4.43 |

| | | | | |
|---|---|---|---|---|
| MAM | *Mancopsetta milfordi* | 3.66 | 0.00 | 0.66 |
| PYM | *Physiculus marginatus* | 3.14 | 0.00 | 3.14 |
| PAA | *Pandalopsis ampla* | 2.78 | 0.00 | 0.00 |
| NEM | *Neophyrnichthys marmoratus* | 2.16 | 0.00 | 2.16 |
| MUN | *Munida* spp. | 1.62 | 0.02 | 1.60 |
| SER | *Serolis* spp. | 1.32 | 0.00 | 1.32 |
| MUO | *Muraenolepis orangiensis* | 1.06 | 0.00 | 1.06 |
| ELE | Eledoninae-like octopod | 0.92 | 0.92 | 0.00 |
| BLU | *Micromesistius australis* | 0.88 | 0.00 | 0.88 |
| BEJ | *Benthoctopus* sp.cf.*januarii* | 0.42 | 0.00 | 0.42 |
| NEC | *Neorossia caroli jeannae* | 0.36 | 0.36 | 0.00 |
| GYR | *Gymnoscopelus brauri* | 0.34 | 0.10 | 0.24 |
| PES | *Peltarion spinosulum* | 0.33 | 0.00 | 0.33 |
| MXX | Myctophidae | 0.28 | 0.00 | 0.28 |
| CTE | Ctenophora | 0.26 | 0.00 | 0.26 |
| PAS | *Patagonotothen squamiceps* | 0.22 | 0.00 | 0.22 |
| BRP | Brachiopoda | 0.16 | 0.00 | 0.16 |
| HOL | Holothuroidea | 0.10 | 0.00 | 0.10 |
| LYB | *Lycenchelys bachmanni* | 0.10 | 0.00 | 0.10 |
| OCT | Unidentified octopus | 0.10 | 0.10 | 0.00 |
| LIG | *Libidoculaea granaria* | 0.08 | 0.00 | 0.08 |
| SAS | *Salilota* sp. | 0.06 | 0.00 | 0.06 |
| XXX | Unidentified animal | 0.04 | 0.04 | 0.00 |
| GYM | *Gymnoscopelus* spp. | 0.02 | 0.00 | 0.02 |
| POE | *Pogonolycus elegans* | 0.02 | 0.02 | 0.00 |
| POL | Polychaeta | 0.02 | 0.00 | 0.02 |

## 3.3 Rays & Skates

### 3.3.1 Catch distribution

Skates and rays were caught in reasonable quantities at all trawl stations (Figure 7); total RAY catch ranged from 50kg at station 425 to 192kg at station 420. The shallower stations at the top of the slope tended to have the lowest catches. However station 420, with the highest catch, was also one of the shallower stations, but on the plateau rather than near the slope.

The more abundant species showed some distinctive patterns in their catch distributions. These are illustrated in terms of both catch weight and catch numbers in Figure 8 to Figure 17. Note that the circles representing catch magnitude are scaled to emphasise differences in distribution within a species, so the scales are not directly comparable across species. As trawling effort was reasonably constant across all stations raw catch weights and numbers are plotted.

*Bathyraja griseocauda* was the most abundant ray species overall and found at the majority of stations (Figure 8). Its abundance was noticeably lower at the shallower stations at the slope top. The next most abundant species, *Bathyraja brachyurops* (Figure 9), was much less widely distributed being caught mainly at the shallower stations, and in particular at station 420 on the plateau away from the slope. *Raja flavirostris* was caught at a wider range of depths, with the exception of the deepest station, but was noticeably absent from trawls on transect R5 in the south-east of the area surveyed (Figure 10). *Bathyraja albomaculata* (Figure 11) was present at all stations with no particular pattern in relative abundance. The unidentified ray species #3 (RBZ) was most abundant at the deeper stations (Figure 12).

The undescribed *Bathyraja* sp. #3 was restricted to the deeper stations in the west of the region. *Bathyraja macloviana* was found in small numbers at many stations with the notable exception of the mid-depth (200-250m) stations in the north-west of the survey area (transects R1 to R3, Figure 14). This species was found at this depth on transect R5 in the south-east of the area. *Bathyraja multispinis* showed a similar pattern but was missing from the shallower, slope top, stations in the north-east (Figure 15).

*Raja doellojuradoi* occurred only in small numbers but was most abundant at intermediate (200m) depths and uncommon at the shallower stations. Small numbers of *Bathyraja scaphiops* were found at most stations of 200m and deeper. *Psammobatis* spp. were restricted to the slope top stations.

**Figure 7.** Total catch of all skates and rays (i.e. commercial code RAY) at each station.

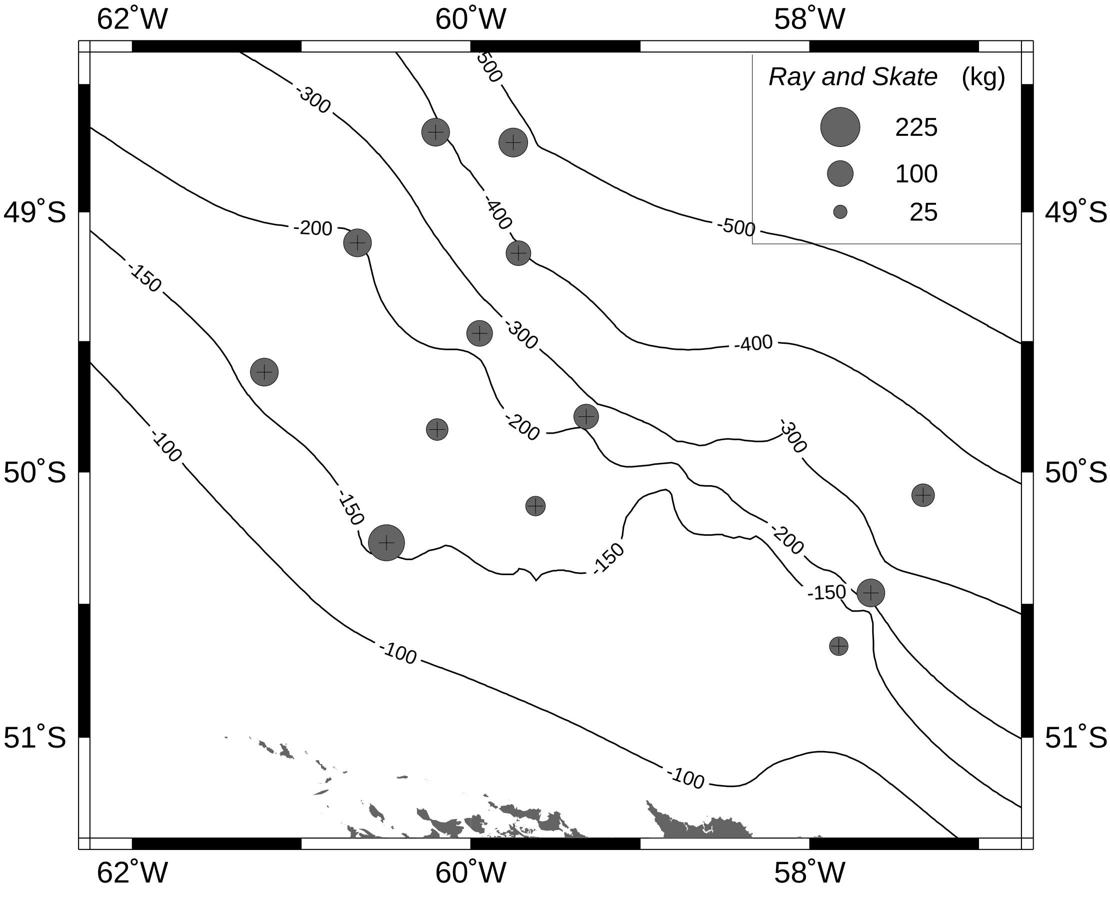



**Figure 8.** Catches of *Bathyraja griseocauda* in terms of weight and number of individuals.

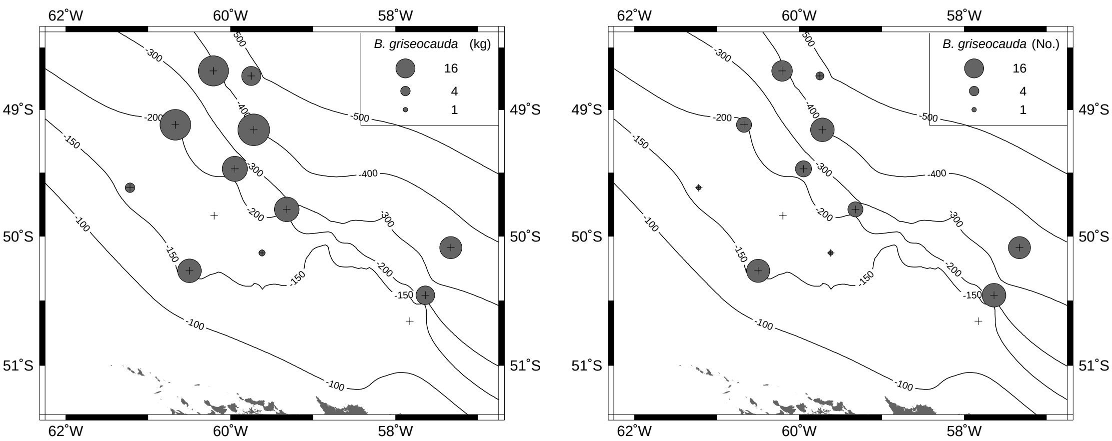


**Figure 9.** Catches of *Bathyraja brachyurops* in terms of weight and number of individuals.

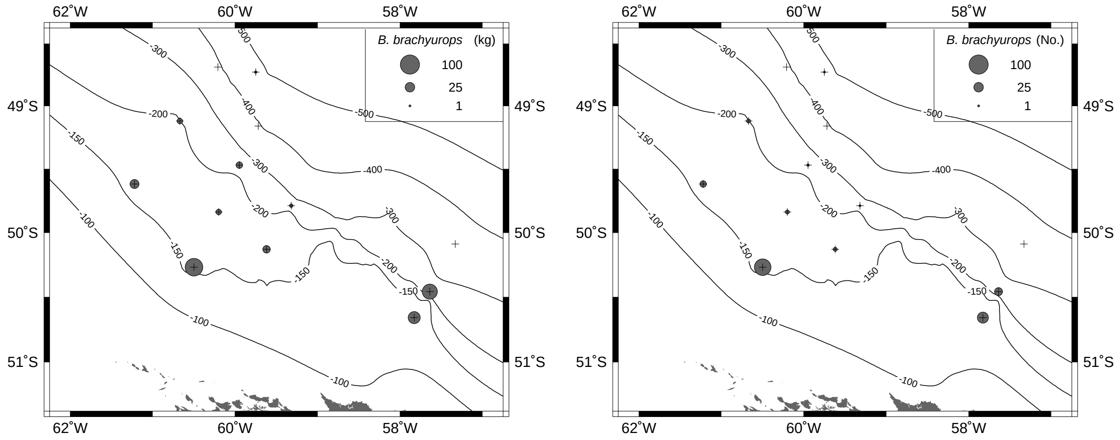



**Figure 10.** Catches of *Raja flavirostris* in terms of weight and number of individuals.

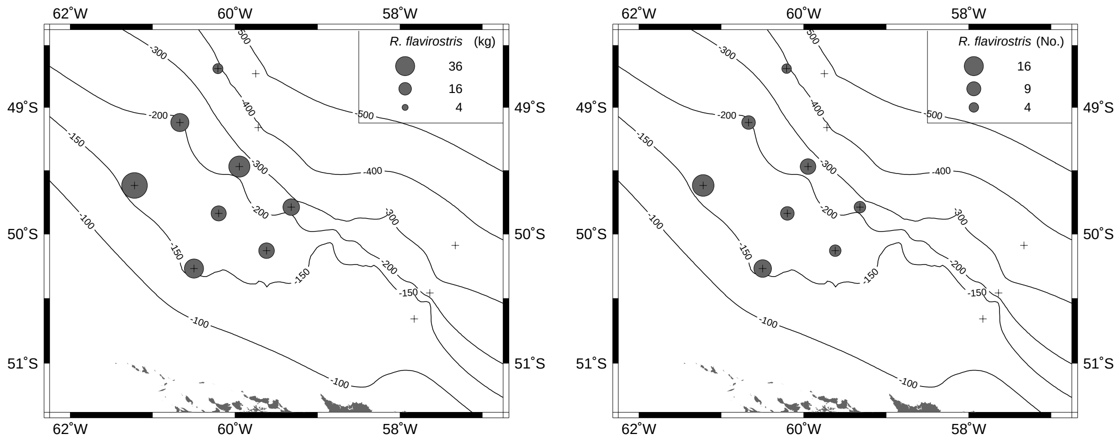



**Figure 11.** Catches of *Bathyraja albomaculata* in terms of weight and number of individuals.

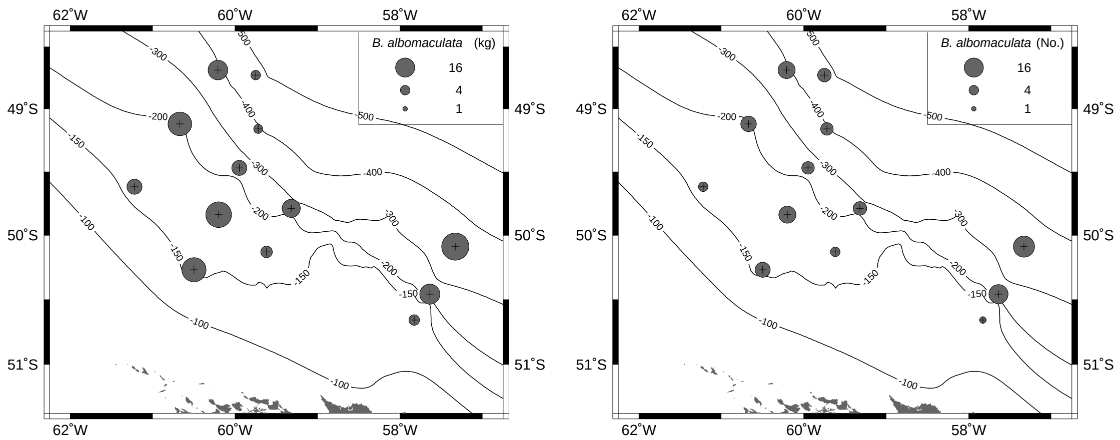


**Figure 12**. Catches of the undescribed *Bathyraja* sp. #3 in terms of weight and number of individuals

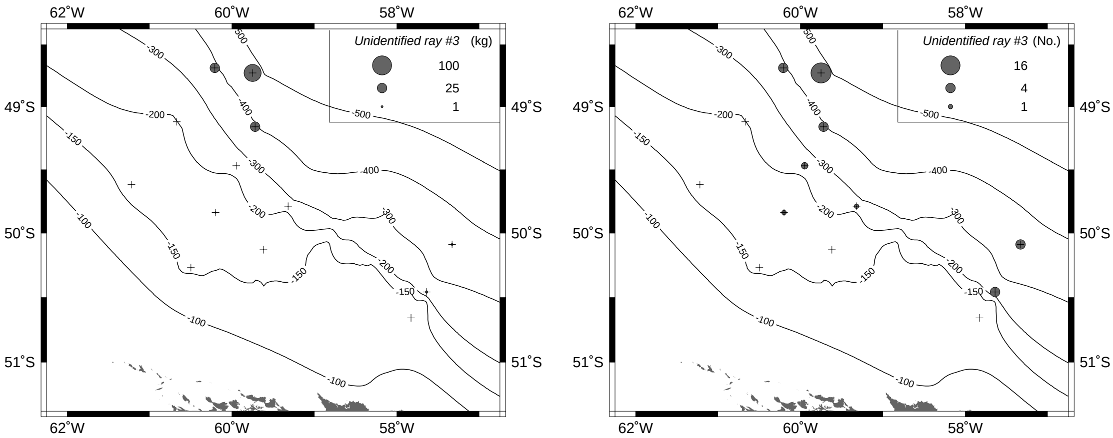



**Figure 13.** Catches of *Bathyraja macloviana* in terms of weight and number of individuals.

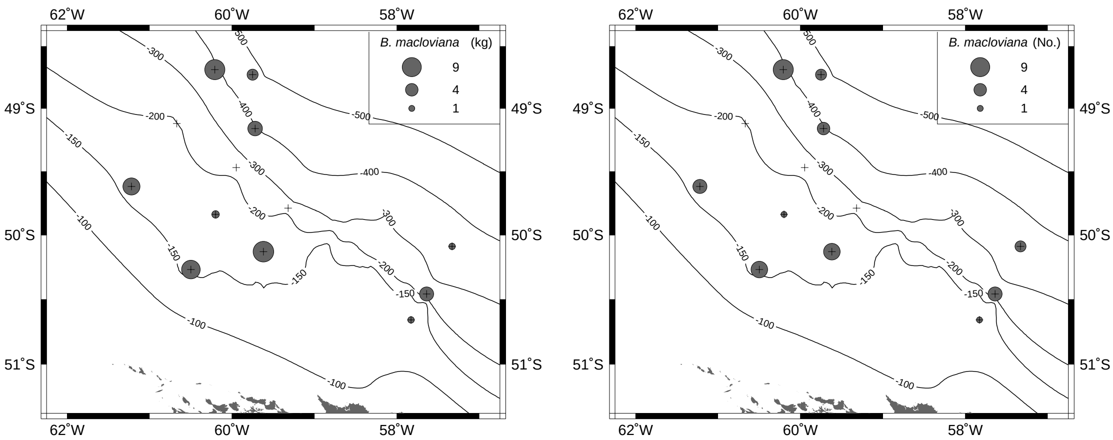



**Figure 14.** Catches of *Bathyraja multispinis* in terms of weight and number of individuals.

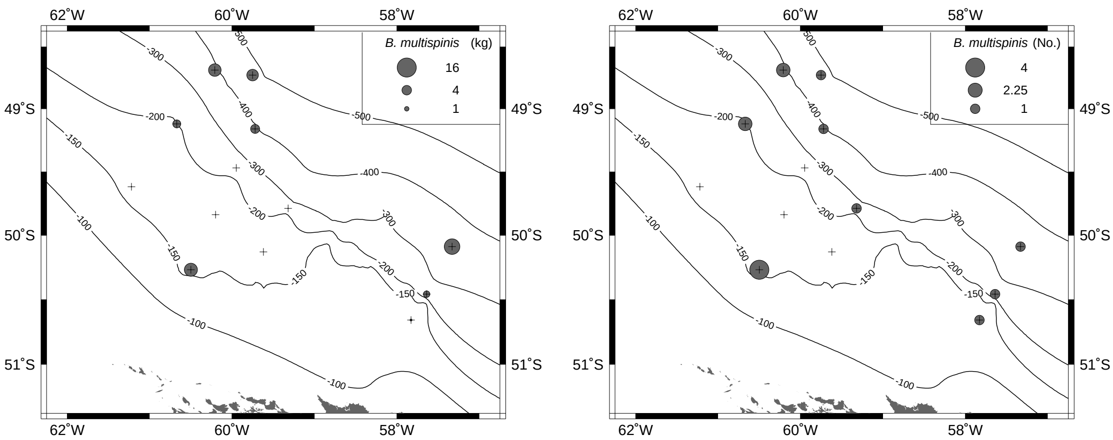


**Figure 15.** Catches of *Raja doellojuradoi* in terms of weight and number of individuals.

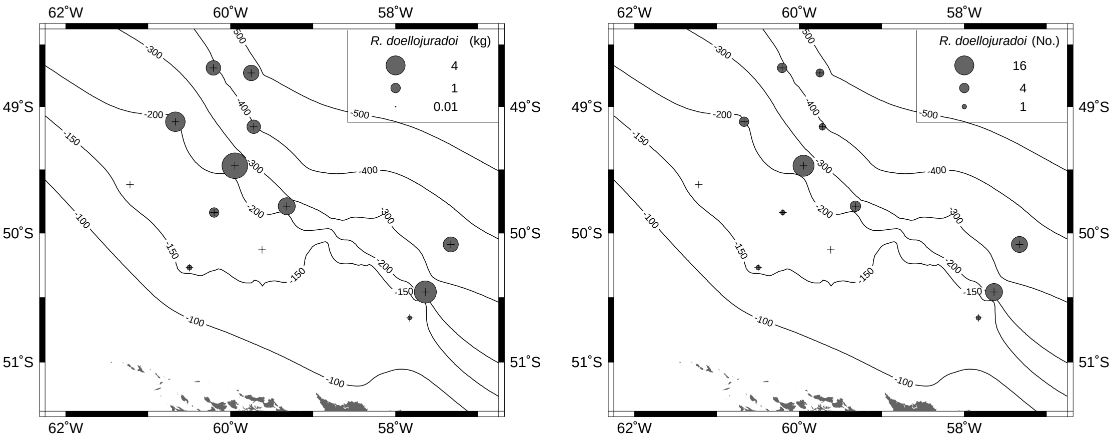



**Figure 16.** Catches of *Bathyraja scaphiops* in terms of weight and number of individuals.

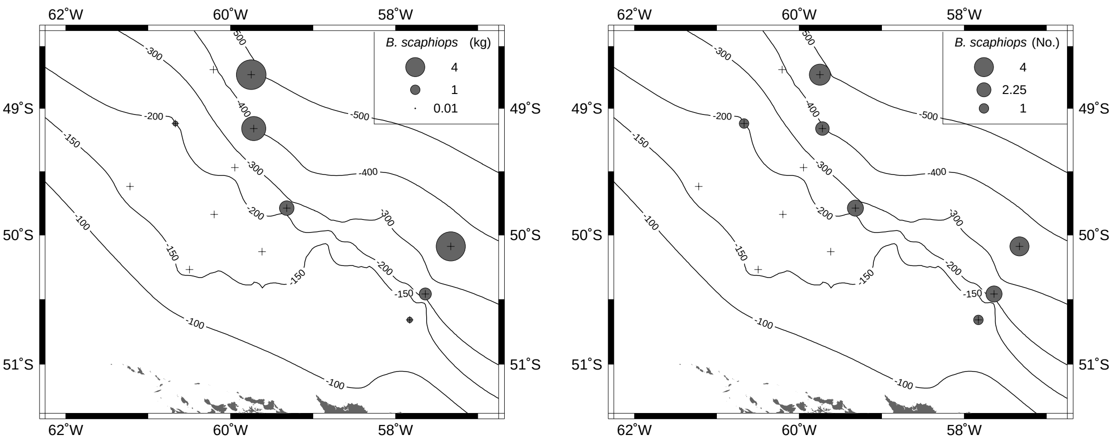
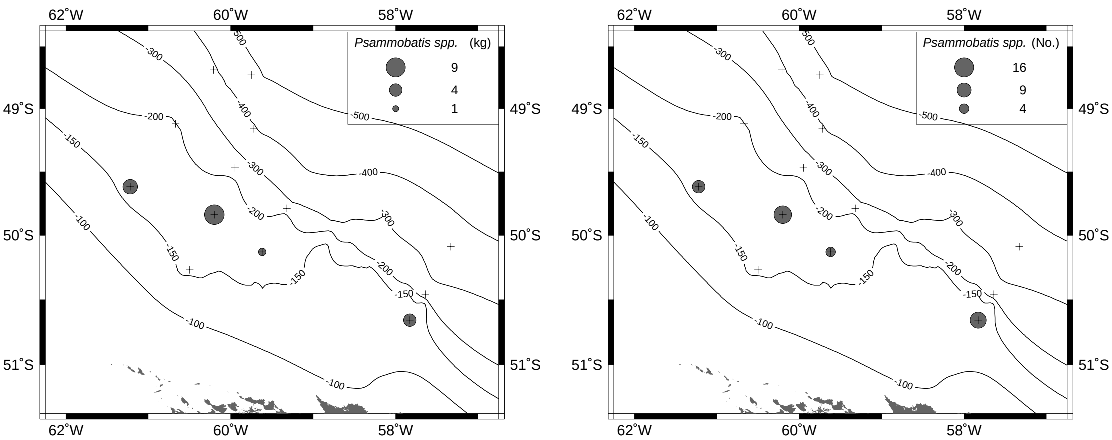



**Figure 17.** Catches of *Psammobatis* spp. in terms of weight and number of individuals.



### 3.3.2 Catch composition

The distribution patterns of individual skate and ray species (Figure 8 to Figure 17) are summarised in this section to illustrate the change in skate/ray catch composition with depth and area. Figure 18 illustrates the proportional catch composition by weight, and Figure 19 the composition by number, of skates and rays at the standard stations (i.e. the three standard depths on transects R1 to R5, where transect R1 is furthest north-west and R5 furthest south-east). The deep station (416) and the additional shallow station (420) further from the slope are not included.

Inspection of Figure 18 and Figure 19 suggests that, at the time of the survey, depth was the main determinant of ray catch composition. However, there are also regional differences the most obvious of which is the absence of *Raja flavirostis*, and proportional increase in *Bathyraja brachyurops*, at 150 and 200 m depths on transect R5.

*Bathyraja albomaculata* was the only species that could be considered to form a reasonably constant proportion of the catch at all stations, irrespective of depth. Within each of the three standard depths, however, catch composition of the major species was reasonably consistent. Comparison with Figure 20 illustrates that region specific differences cannot be ignored: station 420, at 150m on the plateau away from the slope edge, shows a very different catch composition to that seen in the 150m stations on the slope top.

### 3.3.3 Size and maturity

Size (disk width) distributions, coloured according to maturity stage, are shown in Figure 21 to Figure 24 for species where sample sizes were sufficiently large. Males and females are plotted separately and samples have been separated according to depth classes:

150P - ~ 150m on the plateau (station 420)

150S - ~ 150m on the slope top (stations 413, 419, 421 and 425)

200 - ~ 200m (stations 414, 418, 422 and 424)

350 - ~ 350m (stations 415, 417 and 413)

500 - ~ 500m (station 416)

In *Bathyraja griseocauda* (Figure 21) immature animals, some up to 60cm disk width were found at 200m and 350m, and a single immature female was caught at 500m. Maturing animals were caught at all depths. Although few were caught at the top of the slope, 24 maturing animals were taken at the 150m station on the shelf. Larger, mature animals occurred in small numbers at depths of 200m and greater.

With the exception of a single immature female from the deepest station, *Bathyraja brachyurops* was restricted to 200m and shallower (Figure 22). Smaller, maturing animals were common at the 150m stations.

In *Raja flavirostis* (Figure 23) the majority of individuals were developing. Immature animals were restricted to the 150m stations and mature animals to the stations on the slope. Smaller immature and maturing *Bathyraja albomaculata* (Figure 24) were largely restricted to depths of 200m and greater. Larger, mature animals were more widespread but did not occur at the 500m station.

**Figure 18.** Catch composition by weight of ray and skate species at standard stations. The total weight is given in parenthesis beneath the transect number.

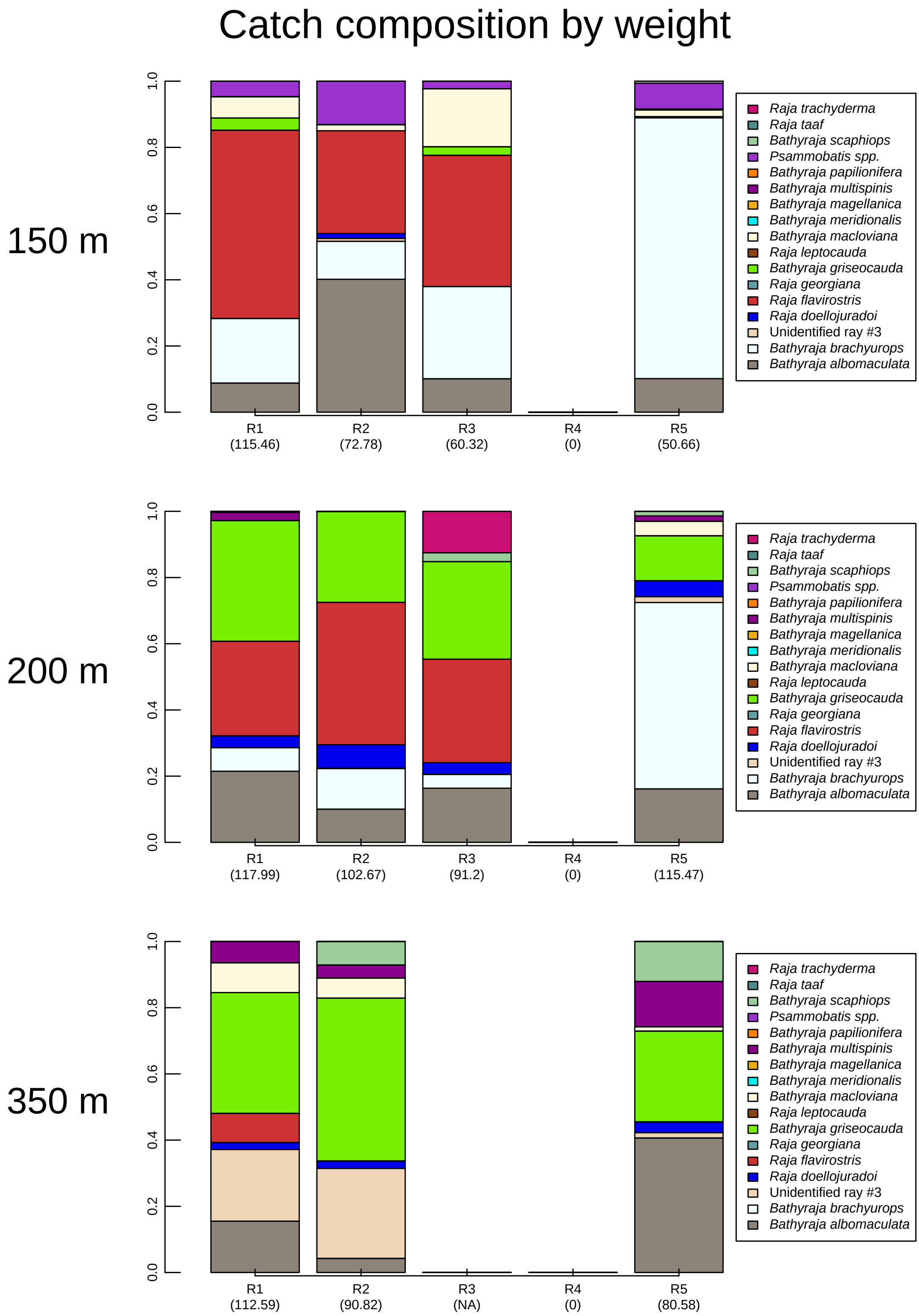


**Figure 19.** Catch composition by number of ray and skate species at standard stations. The total number of individuals is given in parenthesis beneath the transect number.

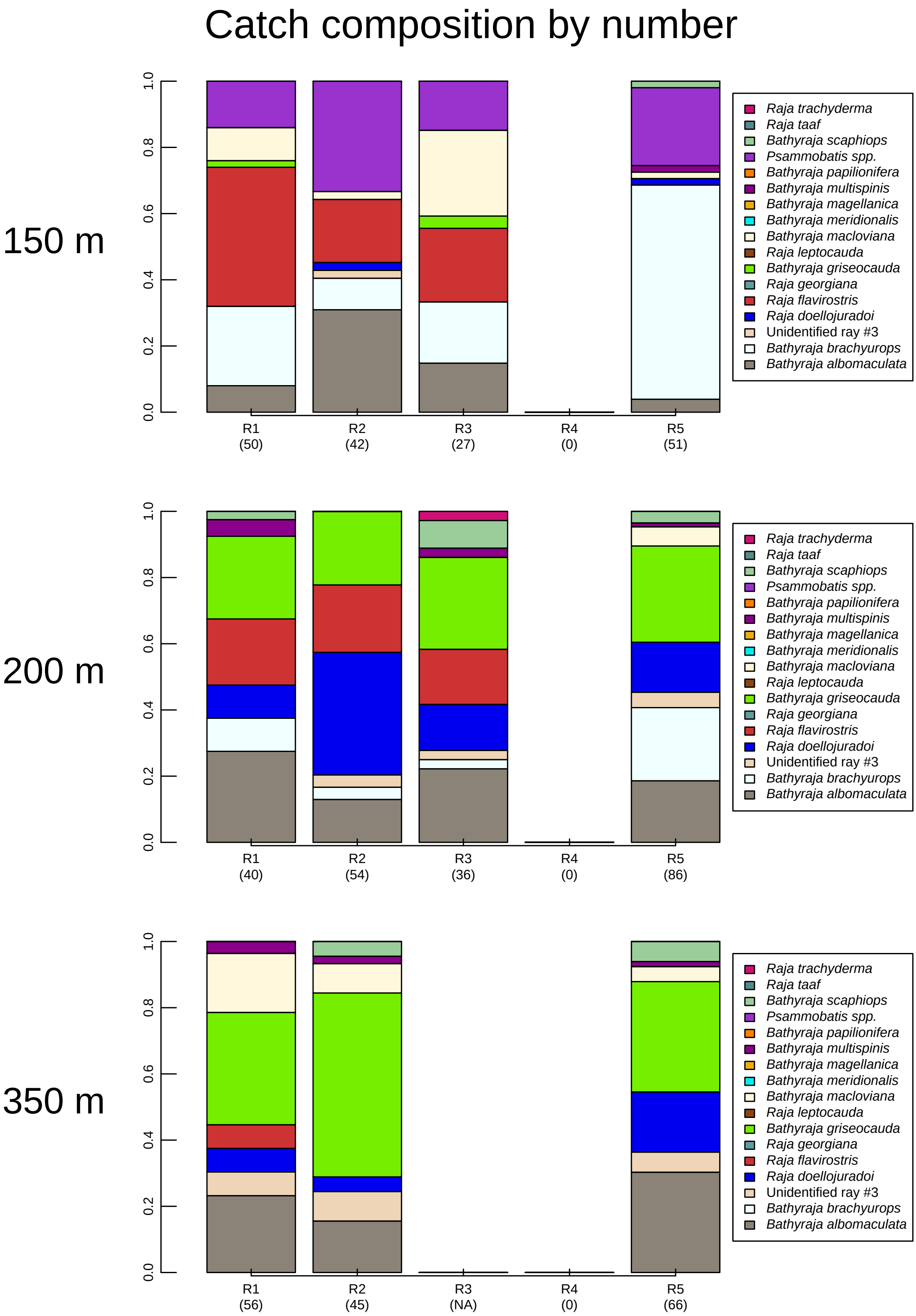


**Figure 20.** Catch composition at the two stations off the standard transects: station 416 at 480m between transects R1 and R2 and station 420 at 150m on the plateau.

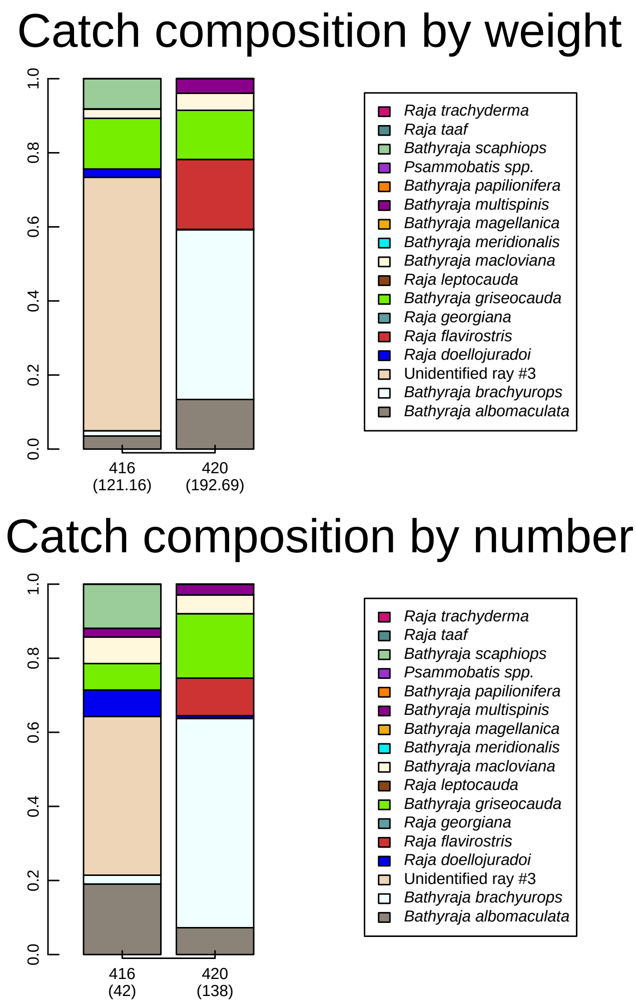


**Figure 21.** Disk-width (3cm groupings labelled with lower size limit of group) frequency distributions for *Bathyraja griseocauda*.

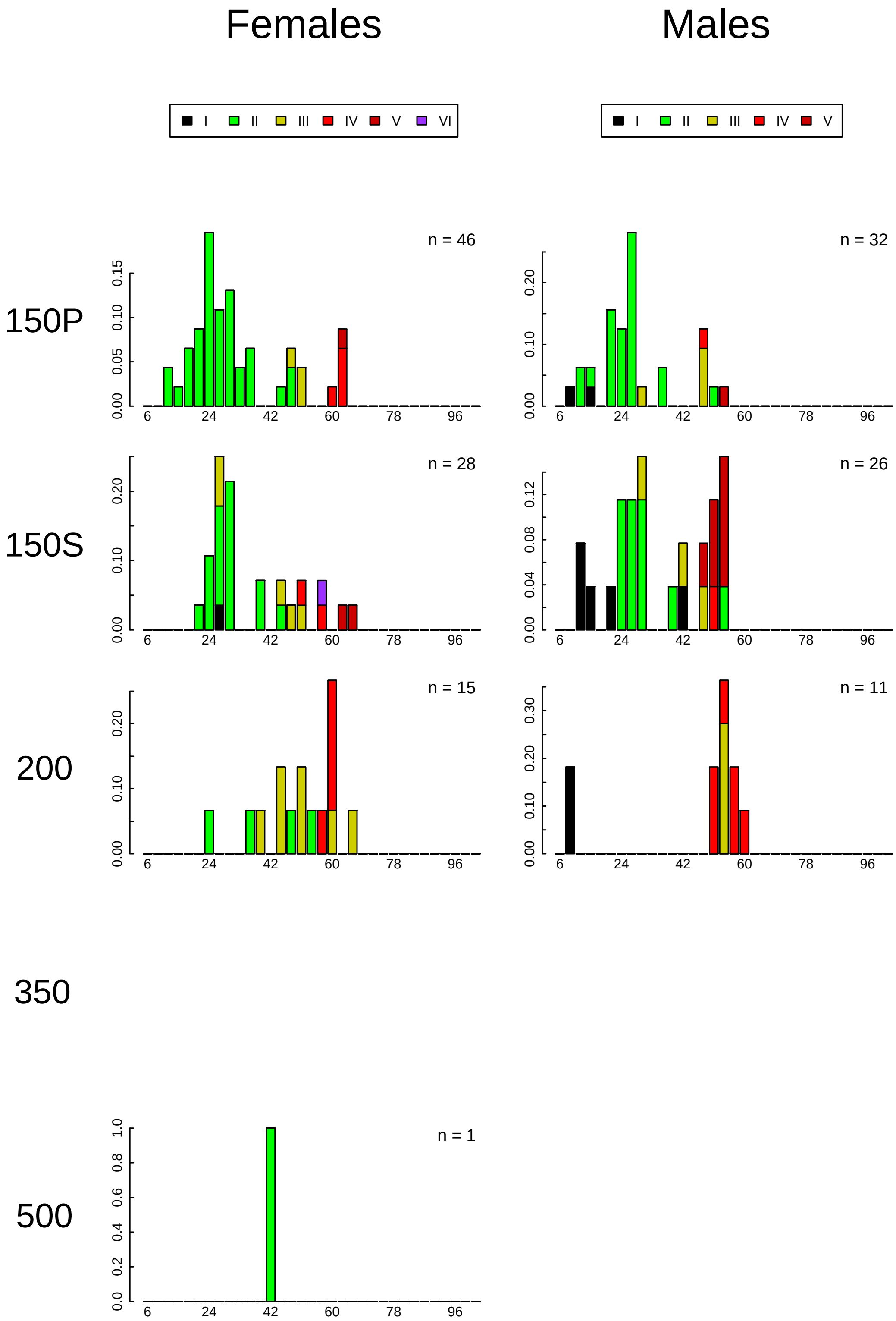


**Figure 22.** Disk-width (3cm groupings labelled with lower size limit of group) frequency distributions for *Bathyraja brachyurops*.

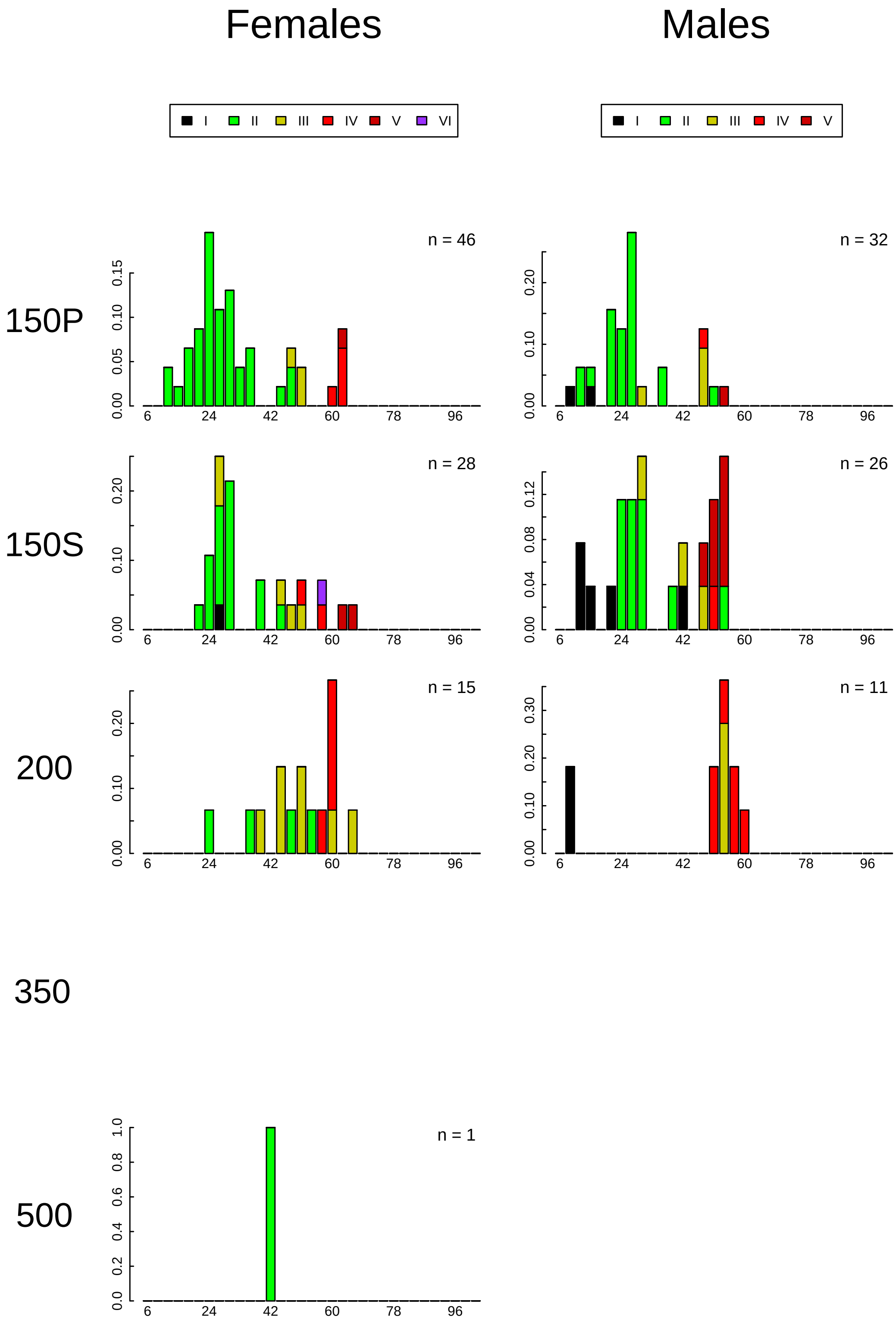


**Figure 23.** Disk-width (3cm groupings labelled with lower size limit of group) frequency distributions for *Raja flavirostris.*

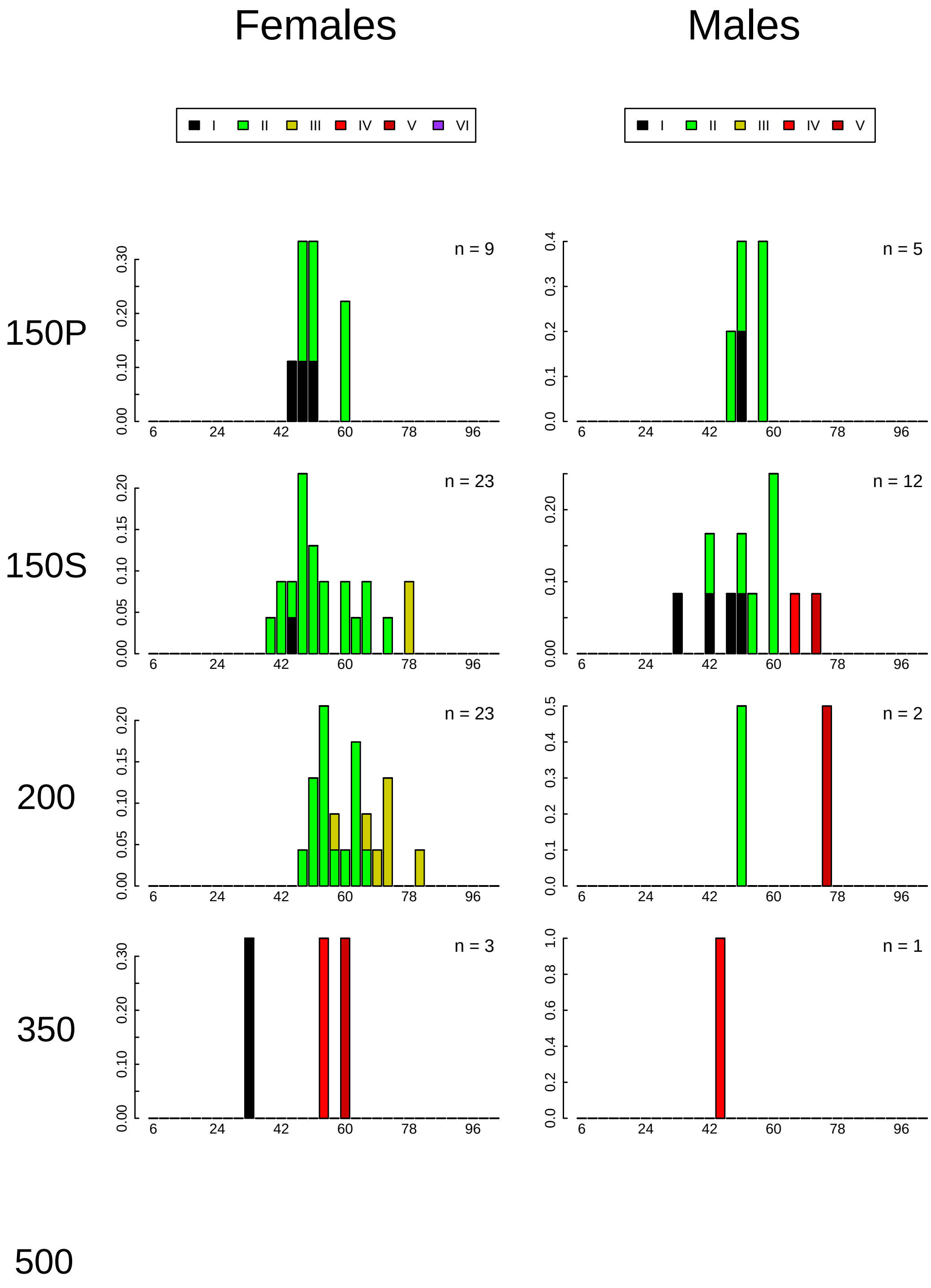
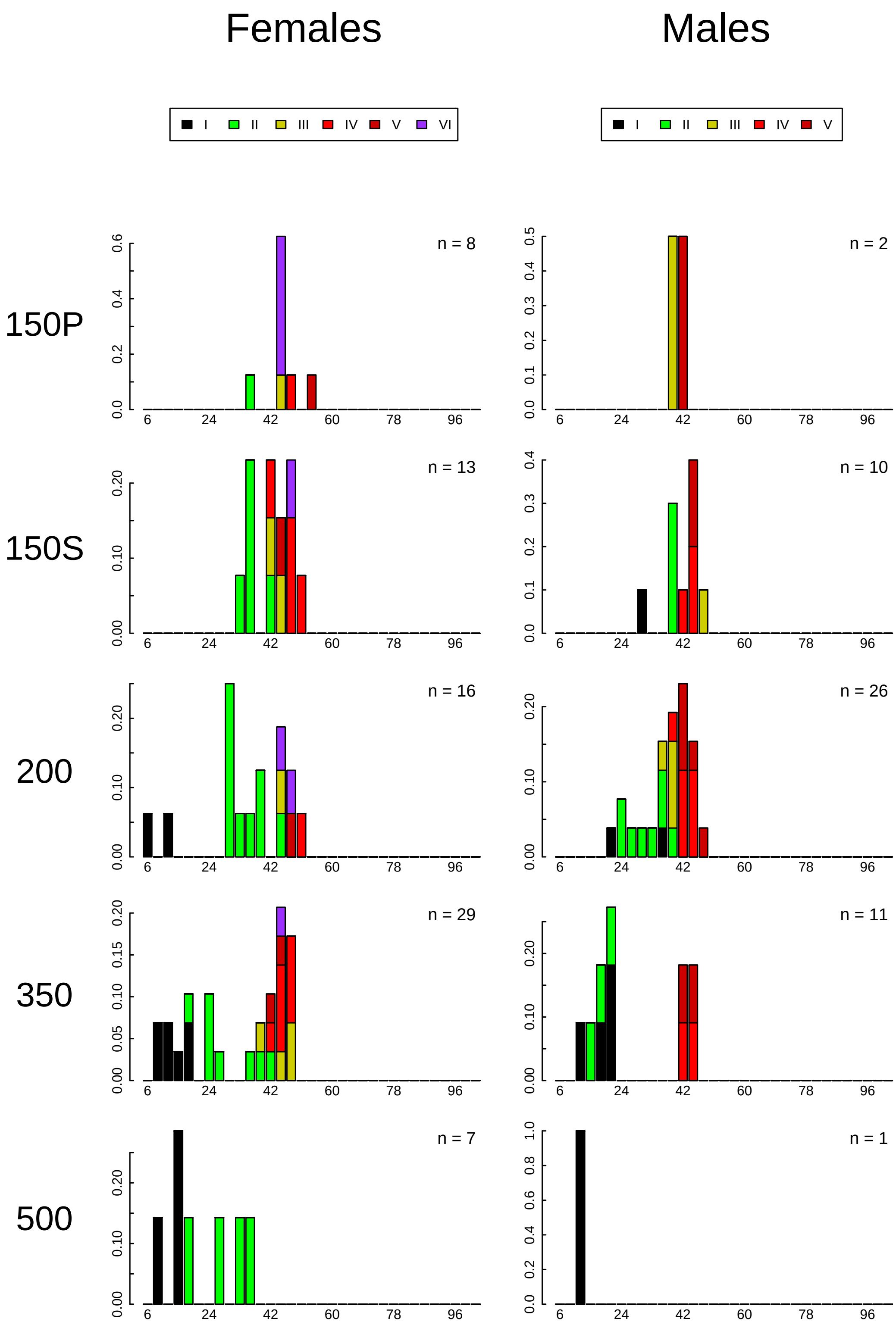


**Figure 24.** Disk-width (3cm groupings labelled with lower size limit of group) frequency distributions for *Bathyraja albomaculata*.



### 3.3.4 Age analyses

A total of 732 samples of vertebrae and thorns for ageing were collected. Once ashore, all samples were cleaned with boiling water, air-dried, and stored in plastic bags.

### 3.3.5 Diet analyses

Of the 732 individual rajids caught during the cruise 454 individuals (62%) were assessed for diet and the presence of *Otodistomum plunketi*. Diet composition was expressed in terms of percentage of the number of food items identified.

*Stomach fullness*
The stomach fullness categories were represented fairly evenly, with a slight predominance of the ¼ full and ½ full categories. Stage 4 (full) was least well represented in all species. Preliminary analyses suggests that in some species (*Bathyraja albomaculata*, *B. brachyurops*, *Raja doellojuradoi*, and to a lesser extent *B. macloviana*) average stomach fullness decreases with increasing specimen size. This may indicate differences in feeding behaviour with size.

*Diet composition*
Grouping the diet data from all specimens sampled 95.4% of prey items identified were from seven categories: Amphipoda 31.3%, *Serolis* spp. 23.3%, Polychaeta 21.8%, *Themisto gaudichaudii* 9.4%, Isopoda 4.8%, finfish 2.7%, and Euphausidae 2.1%. The remaining 4.6% of items was composed of a further 23 prey types.

Amphipods were the dominant prey items identified (31.3%) with overall proportions per species (i.e. proportion of all prey items recovered from all specimens of a species) varying between 18.9% and 78% except in *Raja flavirostris* (1.1%). *Serolis* spp. was the next most common prey type overall (23.3%) but these were not as ubiquitous throughout the species as amphipods. *Serolis* spp. was only common in *Bathyraja griseocauda* (64.6%), *Raja flavirostris* (37.4%), *Psammobatis* spp. (27.1%), *Bathyraja* sp.#3 (24.6%), and *B. multispinis* (18.4%). It was a less common prey item of *Bathyraja brachyurops* (7.2%), *Raja doellojuradoi* (4.1%) and *B. albomaculata* (0.3%) and was not recovered from stomachs of *Bathyraja macloviana* and *Bathyraja scaphiops*.

Proportions of polychaetes varied considerably. The highest overall proportions were in *Bathyraja albomaculata* (54.6%) and *Bathyraja macloviana* (53.8%) with smaller amounts in *Psammobatis* spp. (24.7%) and *Raja doellojuradoi* (21.5%). Polychaetes were an insignificant prey item in all other species.

*Diet composition by species by size class*
For analyses in relation to individual size animals were grouped in 10cm size classes (disk widths of 10 – 19 cm = class 15, 20 – 29 cm = class 25, etc.). Stated sample sizes include individuals with empty stomachs.

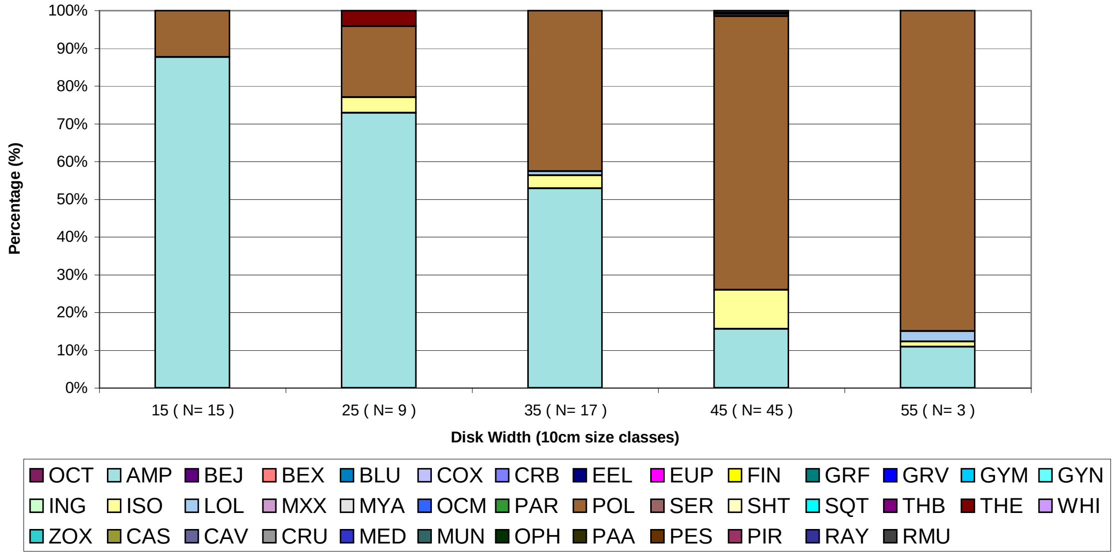
**Table 6.** Codes for identified prey items in ray diet.

| *Code* | *Description* |
|---|---|
| AMP | Amphipoda |
| BLU | *Micromesistius australis* |
| CAS | *Campylonotus semistriatus* |
| CAV | *Campylonotus vagans* |
| COX | Nototheniids |
| CRU | Crustacea |
| EEL | *Iluocoetes fimbriatus* |
| EUP | Euphausiids |
| FIN | Unidentified finfish |
| GYM | *Gymnoscopelus* spp. |
| ISO | Isopoda |
| LOL | *Loligo gahi* |
| MED | Medusae |
| MUN | *Munida* spp. |
| MXX | Myctophids |
| OCM | *Benthoctopus megalocyathus* |
| OCT | Unidentified octopus |
| OPH | Ophiuroidea |
| PAA | *Pandalopsis ampla* |
| PAR | *Patagonotothen ramsayi* |
| PES | *Peltarion spinosulum* |
| PIR | Pirapulida |
| POL | Polychaeta |
| RAY | Rajidae |
| RMU | *Bathyraja multispinis* |
| SER | *Serolis* spp. |
| THB | *Thymops birsteini* |
| THE | *Themisto gaudichaudi* |
| WHI | *Macruronus magellanicus* |
| ZOX | Zoarcids |

### *Bathyraja albomaculata*

The main prey items of *B. albomaculata* were polychaetes (54.6%) and amphipods (37.9%) with isopods comprising a further 6.4% of identified prey items. Proportions of the various prey items in the diet of *B. albomaculata* showed a smooth change with size class (Figure 25). Amphipods comprised 88% of the prey items of the smallest size class but only 11% in the largest size class. Polychaetes became more common prey items in the larger size classes. Isopods were present in small numbers in the stomachs of specimens in size classes 25-55.

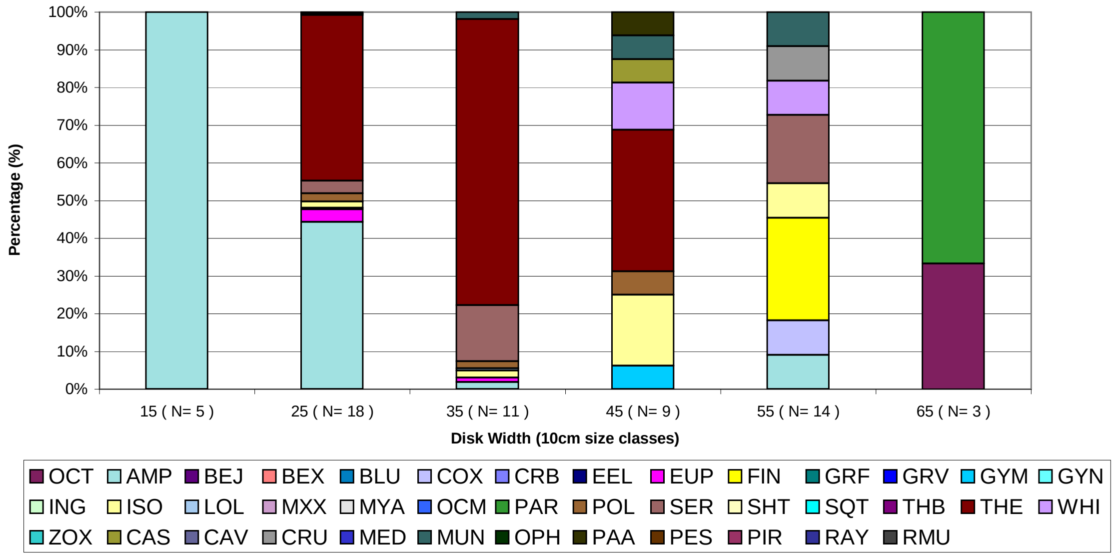
**Figure 25.** Prey item proportions (by number) in the diet of *Bathyraja albomaculata* (RAL) for 10cm size ranges.




### *Bathyraja brachyurops*

*Themisto gaudichaudii* made up 49.8% of the prey items in specimens of *B. brachyurops* and amphipods comprised 31.7%. However, these prey were taken mainly by individuals in the smaller size classes (15 – 45, Figure 26. Diet composition shows a definite trend with size with the smallest individuals feeding exclusively on amphipods, intermediate sized animals shifting their diet to *T. gaudichaudii*, and the larger sizes taking a variety of larger prey.

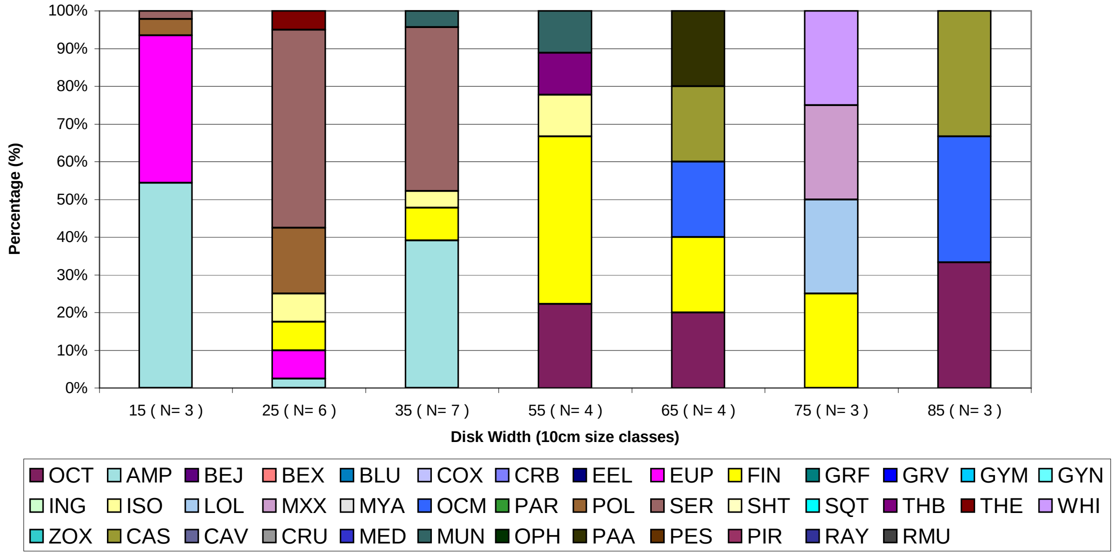
**Figure 26.** Prey item proportions (by number) in the diet of *Bathyraja brachyurops* (RBR) for 10cm size ranges.



### *Bathyraja* sp.#3

In the undescribed *Bathyraja* sp. #3 amphipods comprised 26.9% of prey items, 24.6% were *Serolis* spp. and 16.2% euphausids. Other prey types occuring in smaller proportions were finfish (8.5%), polychaetaes (6.9%), isopods (3.8%), and octopods (3.1%). Individuals in size classes 15 – 35 fed largely on small crustaceans (Figure 27 whereas the larger size classes focused on a variety of larger prey such as finfish and octopods/cephalopods, as well as some shrimps.

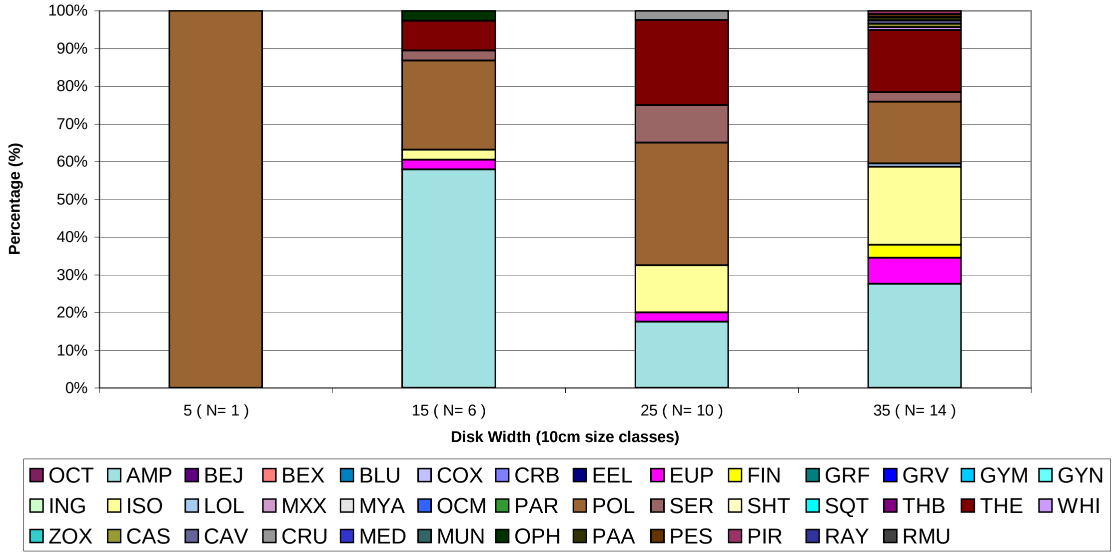
**Figure 27.** Prey item proportions (by number) in the diet of *Bathyraja* sp.#3 (RBZ) for 10cm size ranges.




### *Raja doellojuradoi*

Nearly 85% of the prey items of the sampled *R. doellojuradoi* were amphipods (31.3%), polychaetes (21.5%), *T. gaudichaudii* (15.9%) and isopods (15.4%). A shift in diet is noticeable (Figure 28) as size increases to an increased variety of prey items in the larger size classes.

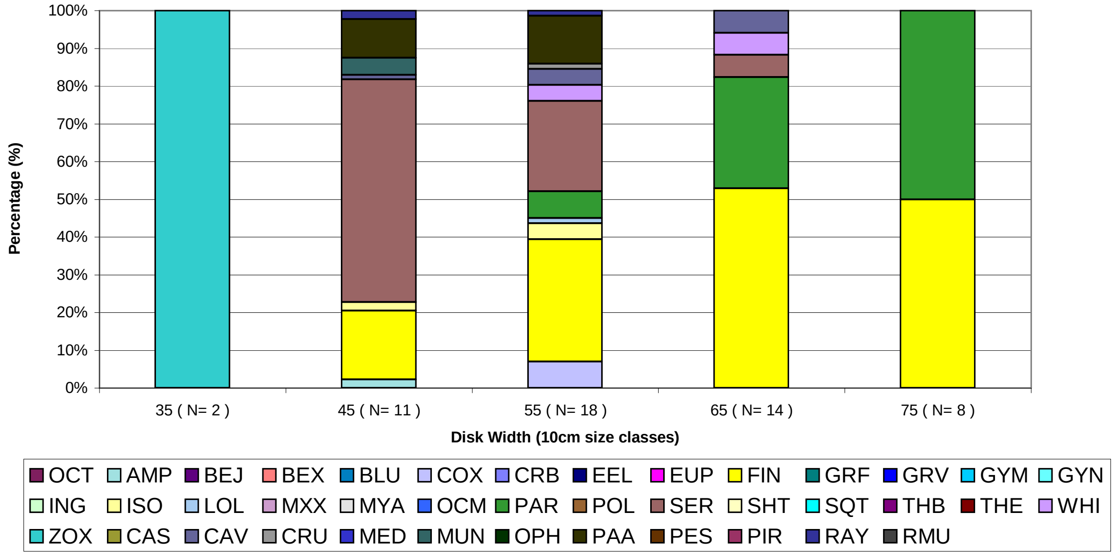
**Figure 28.** Prey item proportions (by number) in the diet of *Raja doellojuradoi* (RDO) for 10cm size ranges.



### *Raja flavirostris*

The bulk (83% of prey items) of the diet of *Raja flavirostris* consisted of *Serolis* spp. (37.4%), unidentified finfish (28.32%), *Pandalopsis ampla* (9.6%), and *Patagonotothen ramsayi* (8.0%). The remainder consisted of a variety of crustaceans and identifiable finfish (hoki and rockcods). Smaller size classes preyed mainly on crustaceans whereas in larger size classes this shifted to a variety of finfish species (Figure 29). The one specimen in size class 35 had been feeding on a zoarchid (probably EEL).

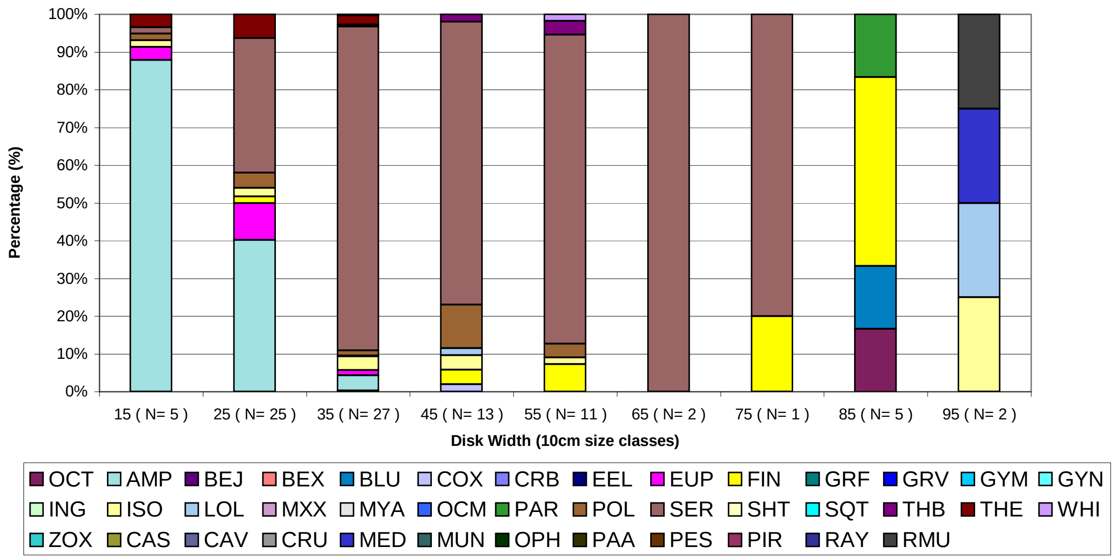
**Figure 29.** Prey item proportions (by number) in the diet of *Raja flavirostris* (RFL) for 10cm size ranges.




### *Bathyraja griseocauda*

In *B. griseocauda* 83.5% of the diet consisted of just two prey types: *Serolis* spp. (64.6%) and amphipods (18.9%). The smallest specimens (class 15) fed primarily on amphipods (88%) but the proportion decreased in the next size class (25) to just 40% with *Serolis* spp. making up 36% of prey items (Figure 30). In size classes 35-75 amphipods disappeared from the diet altogether while *Serolis* spp. comprised more than 80%. In the largest size classes 85 & 95 the diet focused on a variety of finfish species, some cephalopods, and even other rajids.

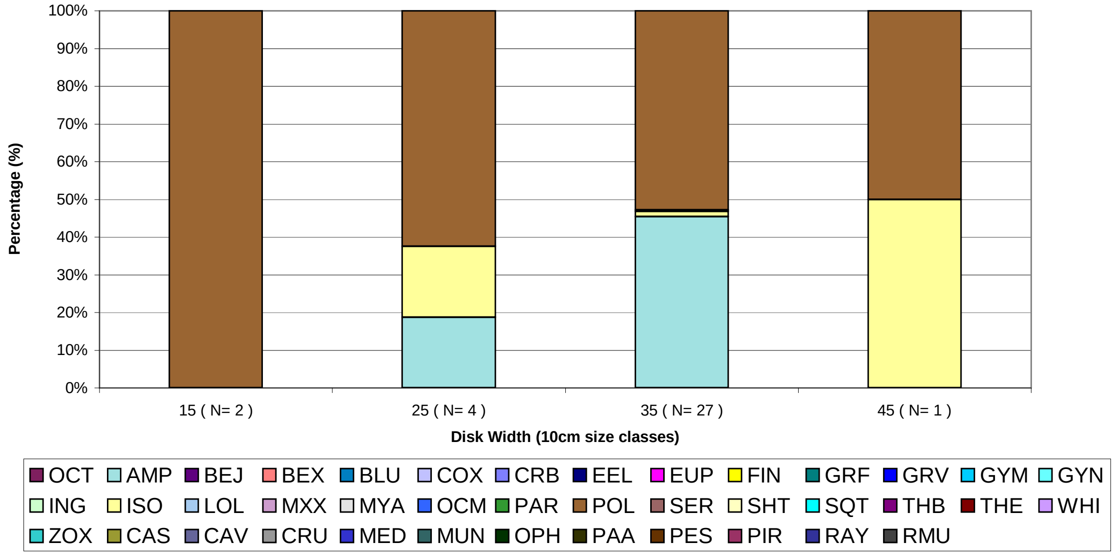
**Figure 30.** Prey item proportions (by number) in the diet of *Bathyraja griseocauda* (RGR) for 10cm size ranges.



### *Bathyraja macloviana*

*Bathyraja maclovinia*, like *B. albomaculata*, had a rather restricted diet. Only four prey types were recorded and the majority of items were in just two categories: polychaetes (53.8%) and amphipods (43%). Sample numbers were low in most size classes (Figure 31) and hence it can only be tentatively concluded that polychaetes decreased in importance as amphipods and isopods became more prevalent in the larger size classes. In contrast to *B. albomaculata* the smallest size classes fed mainly on prey from the substratum (Polychaeta). This remained an important diet in the larger size classes although the diet widened to include isopods and amphipods.

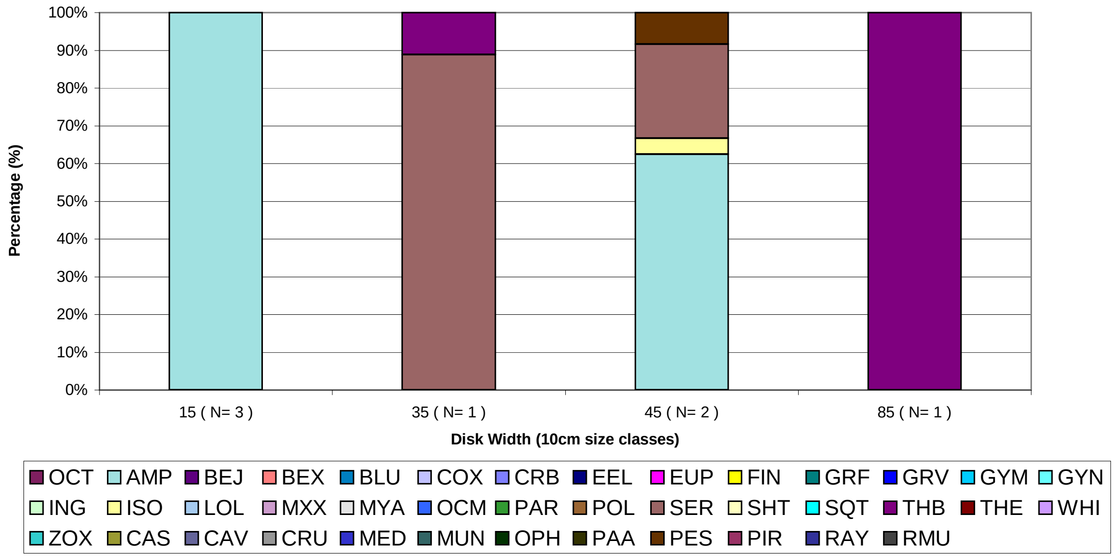
**Figure 31.** Prey item proportions (by number) in the diet of *Bathyraja macloviana* (RMC) for 10cm size ranges.




### *Bathyraja multispinis*

Amphipods were the main prey of the sampled *B. multispinis* comprising 65.8% of items with *Serolis* spp. making up 18.4% and *Thymops birsteini* 11.8%. *Peltarion spinosulum* has been frequently reported from the diet of *B. multispinis* in other regions (FIFD observer data) but was notably low in prevalence (2.6% overall) here where the few specimens sampled had preyed largely on crustaceans.

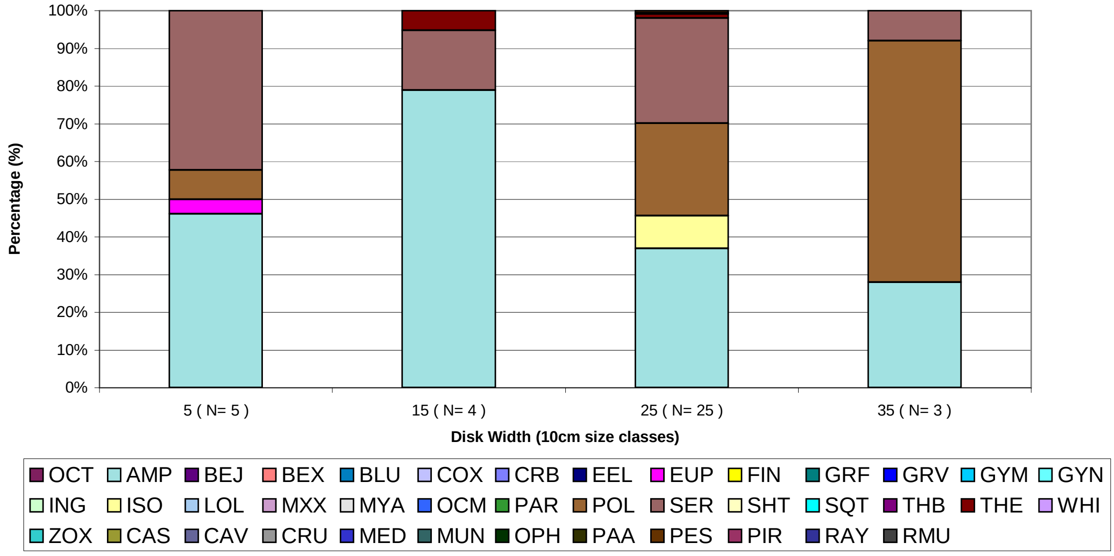
**Figure 32.** Prey item proportions (by number) in the diet of *Bathyraja multispinis* (RMU) for 10cm size ranges.



### *Psammobatis* spp.

In *Psammobatis* spp. 90% of prey diet items were of just three types: amphipods (38.8%), *Serolis* spp. (27.1%) and polychaetes (24.7%). A further 7.3% consisted of isopods. In the larger size classes (Figure 33) the proportion of amphipods decreased while the proportion of polychaetes increased. *Serolis* spp. was a diet component throughout the size classes although the proportion varied.

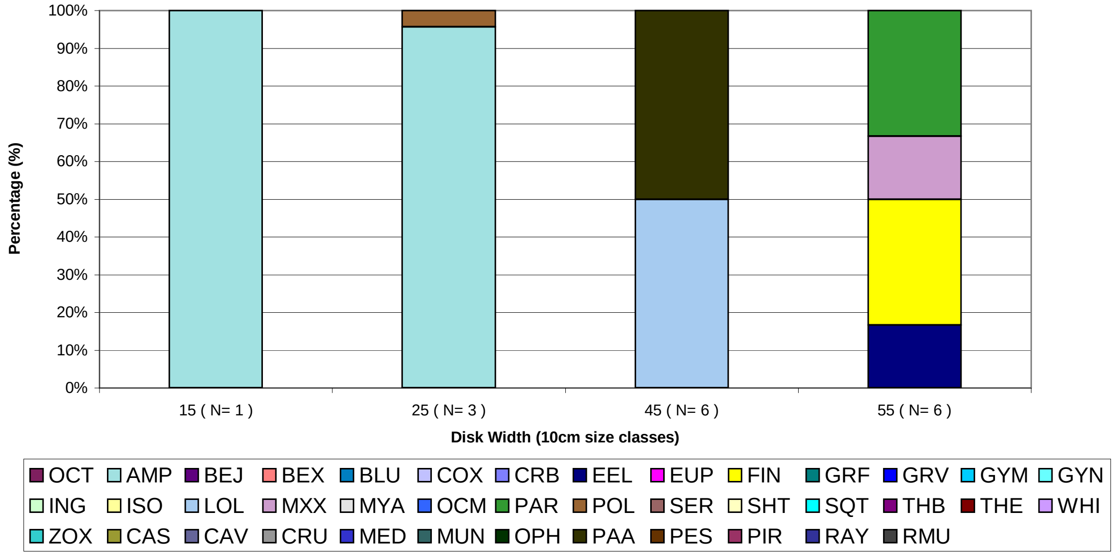
**Figure 33.** Prey item proportions (by number) in the diet of *Psammobatis* spp. (RPX) for 10cm size ranges.




### *Bathyraja scaphiops*

Amphipods were most prevalent with in the diet of *B. scaphiops* making up 78% of items but these all occurred in the stomachs of just three individuals from classes 15 and 25 (Figure 34). The remaining specimens had fed on a variety of finfish, zoarchids, and crustaceans but all in very low numbers. *B. scaphiops* displays a major shift in feeding behaviour from size class 25 on. Larger individuals took larger prey items.

**Figure 34.** Prey item proportions (by number) in the diet of *Bathyraja scaphiops* (RSC) for 10cm size ranges.



### 3.3.6 The occurrence of *Otodistomum plunketi*

*Otodistomum plunketi* Fyfe, 1953, a large digenean trematode found in the abdominal cavity of elasmobranchs, was originally described from *Scymnodon plunketi* off New Zealand by Fyfe (1953), and was reported from *Raja longirostris* off the Pacific coast of the former U.S.S.R. by Skrjabin (Skrjabin and Guschanskaja, 1958). It was also reported from *Centroscymnus coelolepis* in the northwest Atlantic by Harshbarger and Gibson, 1982. The occurrences reported here are all new host records for this parasite species.

During the assessment of skate maturity the organs of the abdominal and pericardial cavities of the skate were examined for *O. plunketi*. Mean abundance was calculated as the number of parasites divided by the number of hosts examined and mean intensity as the number of parasites divided by the number of hosts infected (Bush *et al*., 1997).

The prevalence and mean intensity of *O. plunketi* in all hosts examined was 35.89% and 4.18 respectively. Of the host species examined *Bathyraja albomaculata* had the highest prevalence at 73.33%, a mean intensity of 4.50 and a range of 1-43 parasites. *Raja doellojuradoi* and the single *R. trachyderma* examined were not infected. Table 7 summarises the data for all hosts examined.

**Table 7.** Prevalence, mean infection intensity and mean abundance of *O. plunketi* in skates examined on ZDLH1-07-2000.

| *Species* | *No. examined* | *Prevalence %* | *Mean Intensity (SD)* | *Range* | *Mean Abundance* |
|---|---|---|---|---|---|
| *B. ablbumaculata* | 90 | 73.33 | 4.50 (6.37) | 1-43 | 3.30 |
| *Bathyraja* sp. #3 | 32 | 71.88 | 6.04 (9.44) | 1-33 | 4.34 |
| *B. multispinus* | 9 | 66.67 | 17.50 (20.33) | 2-56 | 11.67 |
| *B. maclovinia* | 34 | 64.71 | 1.73 (0.70) | 1-3 | 1.12 |
| *B. brachyurops* | 60 | 46.67 | 2.82 (1.93) | 1-8 | 1.32 |
| *B. griesiocauda* | 91 | 16.48 | 1.13 (0.35) | 1-2 | 0.16 |
| *B. scaphiops* | 16 | 6.25 | 1.00 | | 0.06 |
| *Psammobatis* spp. | 37 | 5.41 | 4.50 (3.54) | 2-7 | 0.24 |
| *R. flavirostris* | 53 | 1.89 | 1.00 | | 0.02 |
| *R. deollojuradai* | 32 | 0.00 | 0.00 | | 0.00 |
| *R. trachyderma* | 1 | 0.00 | 0.00 | | 0.00 |

## *3.4 Loligo gahi*

### 3.4.1 Distribution

Although this was a short cruise, data on *L. gahi* distribution and abundance are important because they were collected outside the normal squid fishery area (the "*Loligo* box"). Overall *L. gahi* was not abundant during the survey (Figure 35) with a maximum catch of 135 kg at 250 m on transect R3. The highest catches were generally observed at 250 m (mean 67 kg). Squid were much less abundant deeper than 300 m (mean catch 16.2 kg) and the lowest catches were encountered at 130-150-m depths (1.6 kg).

### 3.4.2 Sex ratio

Preliminary analysis showed that sex ratios of *L. gahi* were quite similar at all stations made at the same depth so data were pooled by depth range. The proportion of females increased with depth with the highest proportion (83%) at depths > 350 m (Figure 38).

### 3.4.3 Maturity

The highest proportion of immature squid occurred in shallow water (females > 50%, males ca. 30%), with maturing males (stage 3) being the most abundant (Figure 36) at this depth. At 250 m the majority of both sexes were maturing and some males (up to 5%) were already mature (Figure 37). The most advanced squid were caught in deep water. Among females stage 3 was still the most abundant but about 10% were at stage 4 and some at stage 5. Males were also more mature than at 250 m depths (Figure 38).

### 3.4.4 Length-frequency distribution

In shallow waters small squid (8-10 cm ML) predominated in catches (Figure 36). At 250 m depths squid were larger: their size distribution was unimodal with well-pronounced 10-cm modes in both sexes (Figure 37). The largest squid were caught at the deepwater stations where their mantle length range was the widest. Females had a mode at 13 cm ML whereas the most abundant males were 10-12 cm ML. The largest male (22 cm ML) was captured in deep water (Figure 38).

### 3.4.5 General remarks

The survey was performed during the feeding periods of both the first and second cohorts of *L. gahi* (Hatfield, 1992). Squid of the first cohort would be small and immature, occurring essentially in shallow water (<100 m depth). It was not a surprise, therefore, that their abundance at 'transient' depths (150 m) was very low. Squid of the second cohort had started their maturation while on their deepwater feeding grounds. Females predominated at deepwater stations confirming the recent results on the sexual segregation of the second cohort *L. gahi* during its winter feeding period (Arkhipkin & Middleton, in press). It is notable that the feeding grounds of the cohorts are spatially distinct preventing cannibalism by larger squid of the second cohort on their smaller counterparts in the first cohort.

**Figure 35.** Catch of *Loligo gahi* at bottom trawl stations. Circle size is proportional to the square root of catch weight.

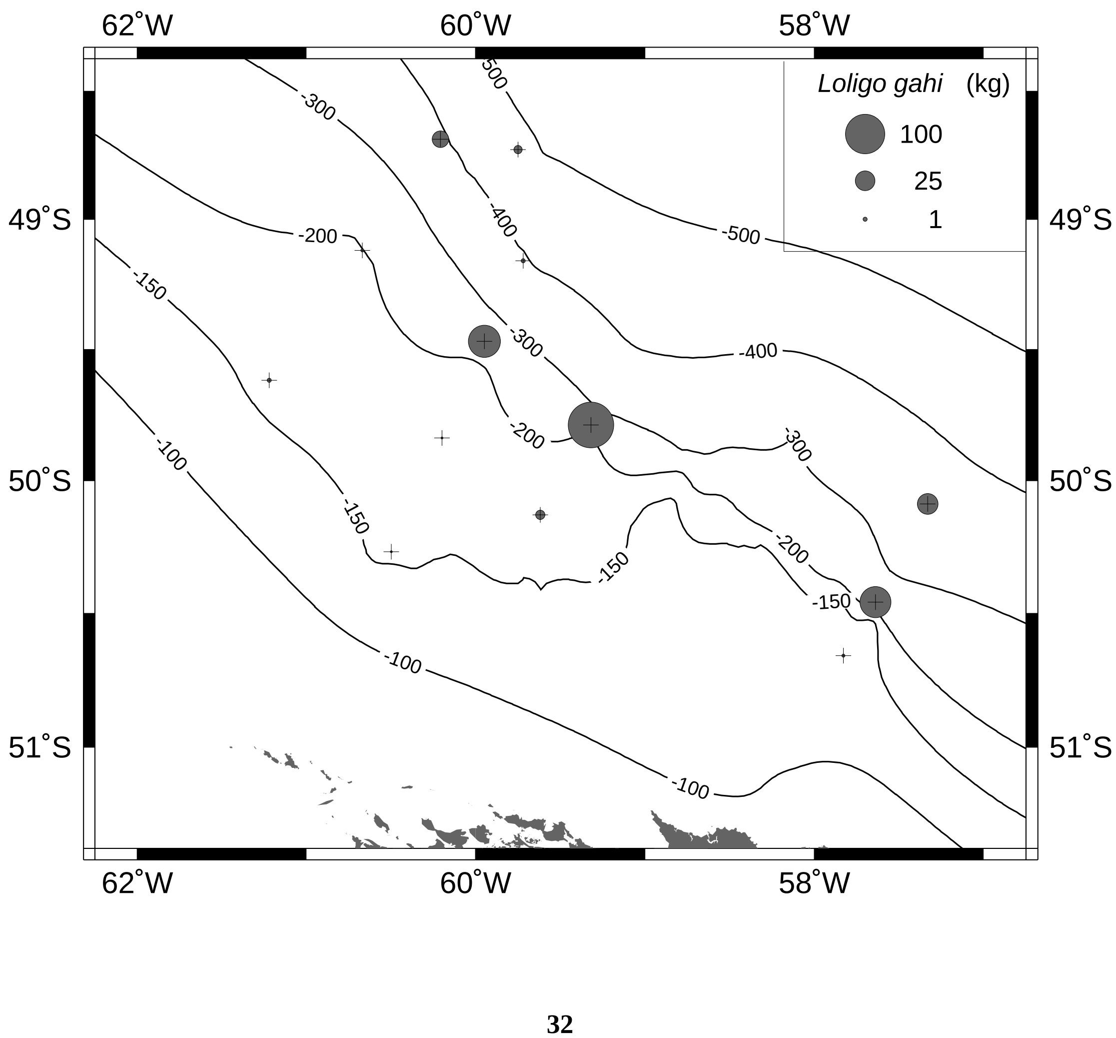


**Figure 36.** Length-frequency distributions by maturity period and proportions of maturity stages for females and males of *Loligo gahi* at 130-150 m depths during the ray survey. Maturity periods: immature (stages 1 and 2), bold line with circles; maturing (stages 3 and 4), dashed line with triangles; mature (stage 5), dotted line with crosses.

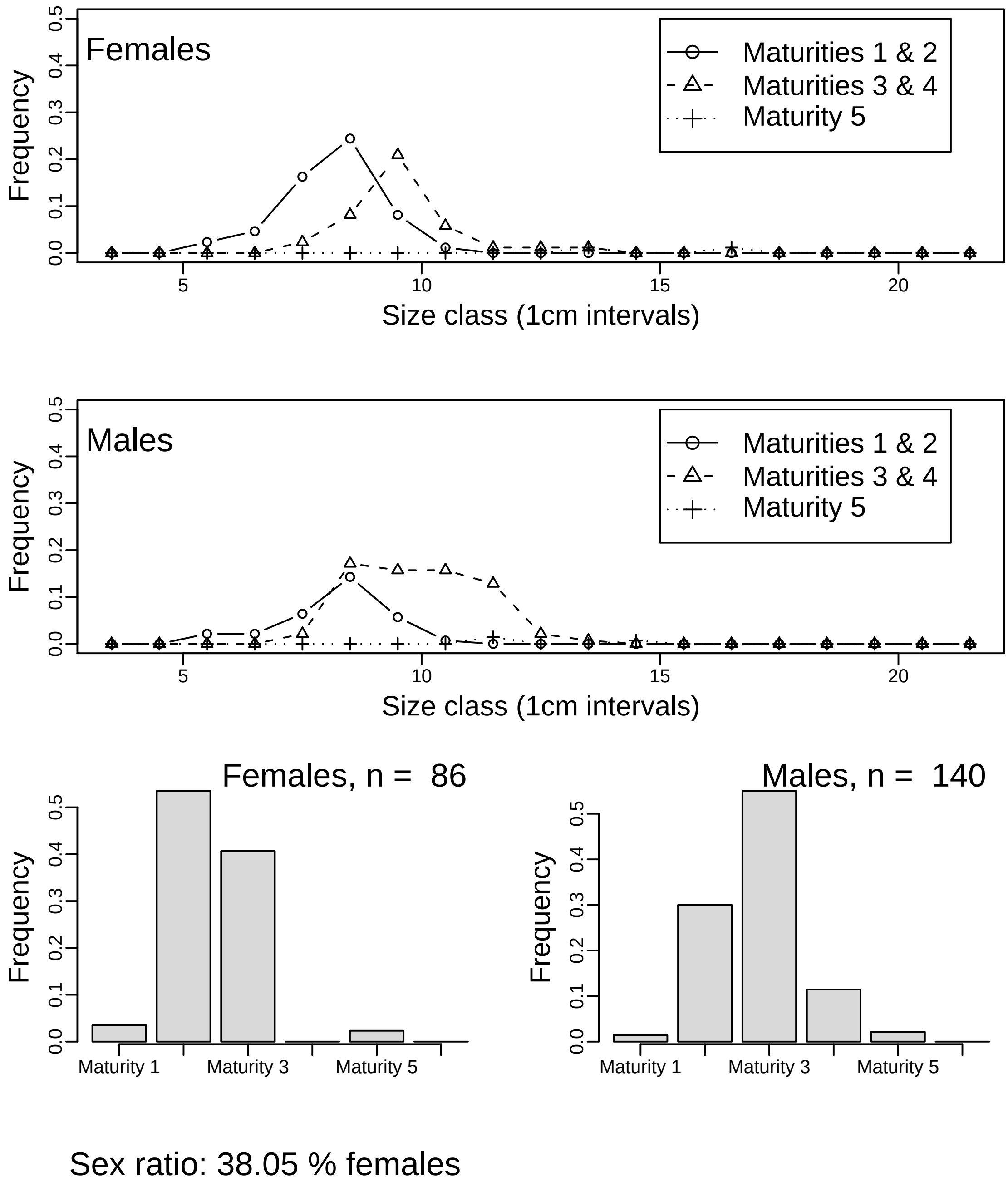


**Figure 37.** Length-frequency distributions by maturity period and proportions of maturity stages for females and males of *Loligo gahi* at 250 m depth during the ray survey.

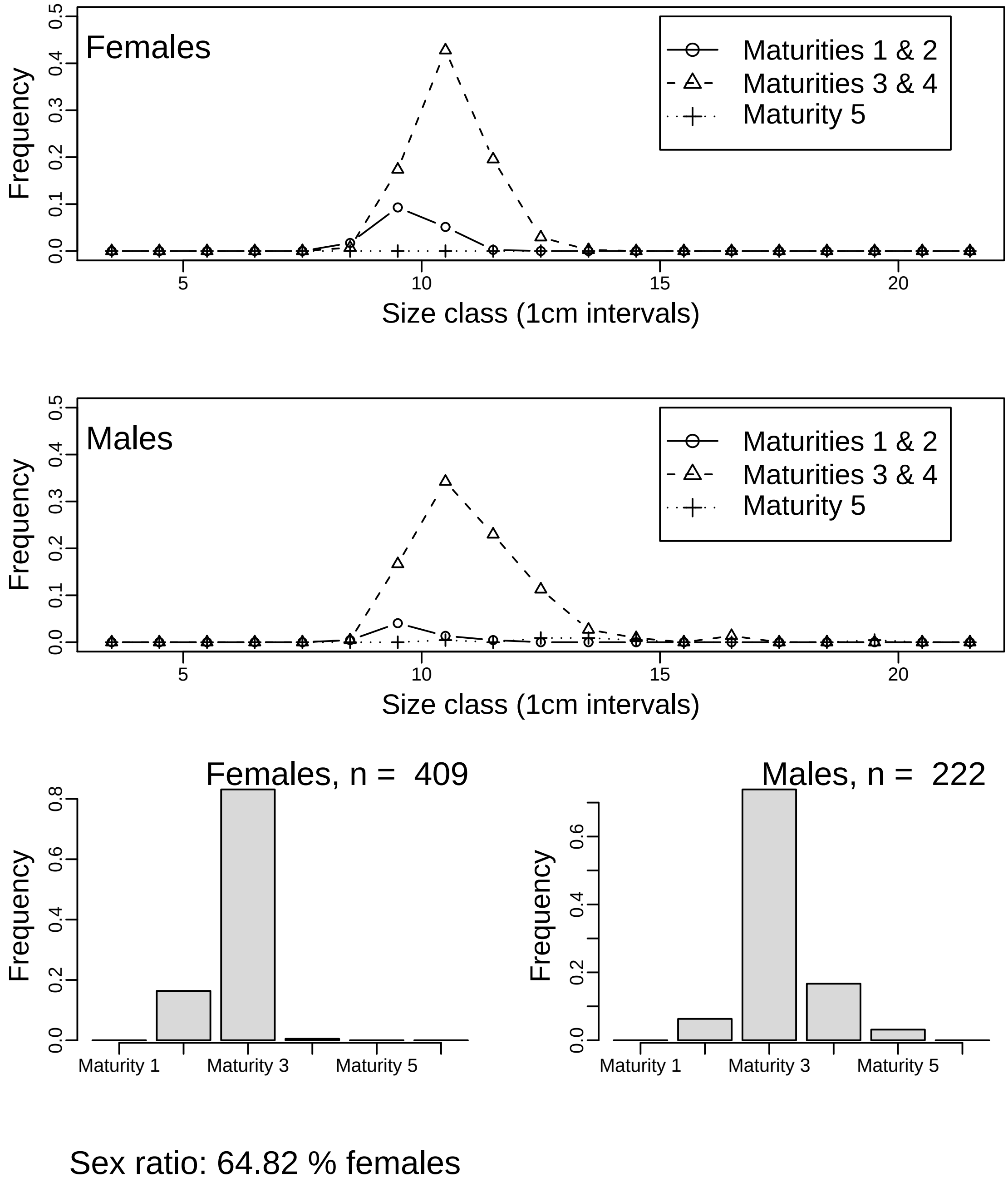
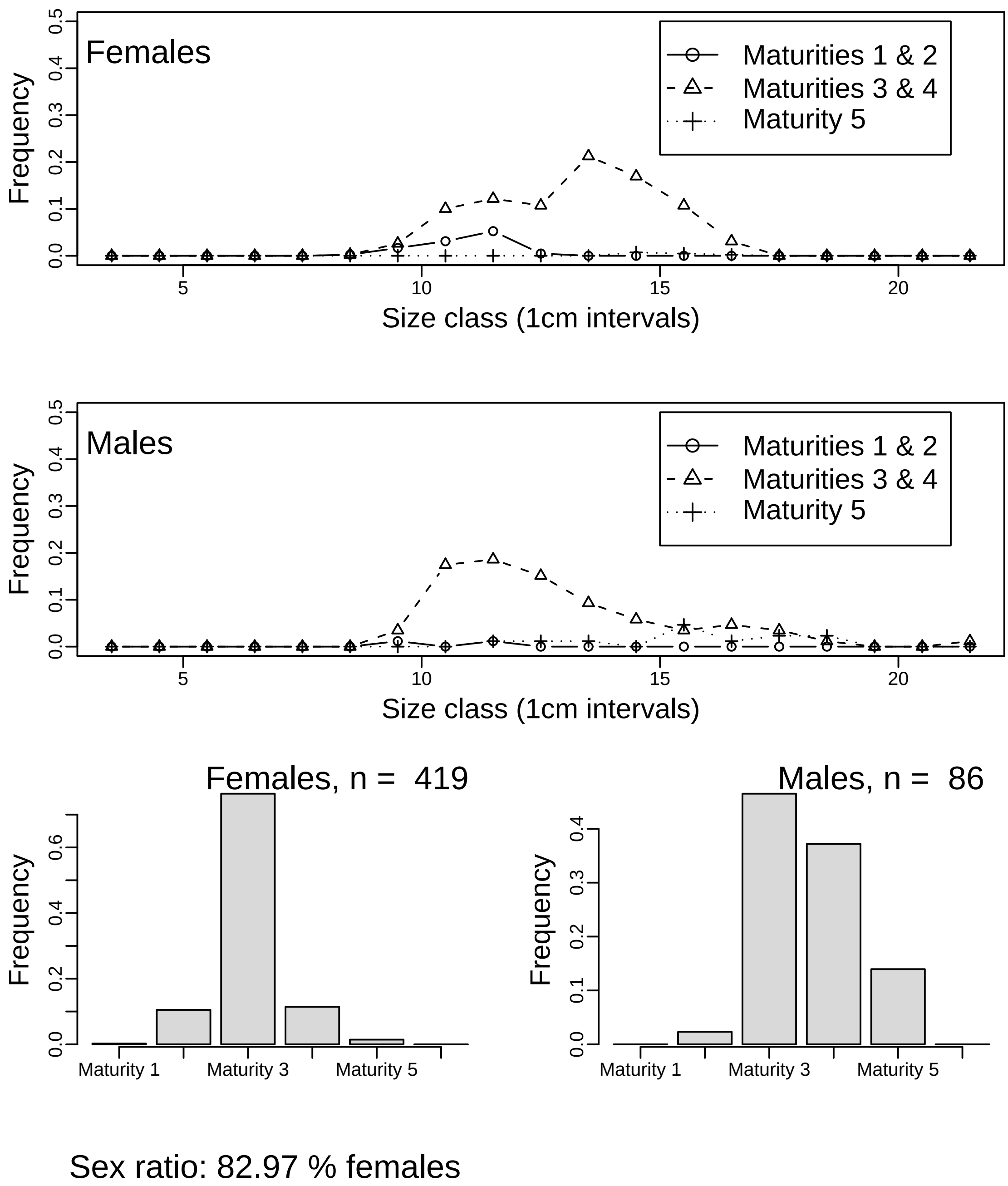


**Figure 38.** Length-frequency distributions by maturity period and proportions of maturity stages for females and males of *Loligo gahi* at depths > 350 m during the ray survey.



## *3.5 Finfish*

### 3.5.1 Catch distributions

A number of finfish species were caught in reasonable quantities; catch distributions are illustrated in Figure 39 to Figure 42. The highest overall catch was of *Patagonotothen ramsayi* with some of the deeper stations yielding the highest catches (Figure 39). The highest catches of hoki, *Macruronus magellanicus*, occurred in the region of 60°W (Figure 40) at both deep and shallow stations. Common hake, *Merluccius hubbsi*, was found over the whole region surveyed though largely restricted to depths shallower than 300m (Figure 41). Toothfish, *Dissostichus eleginoides*, was widespread deeper than 150m (Figure 42).

**Figure 39.** Catches of *Patagonotothen ramsayi*.

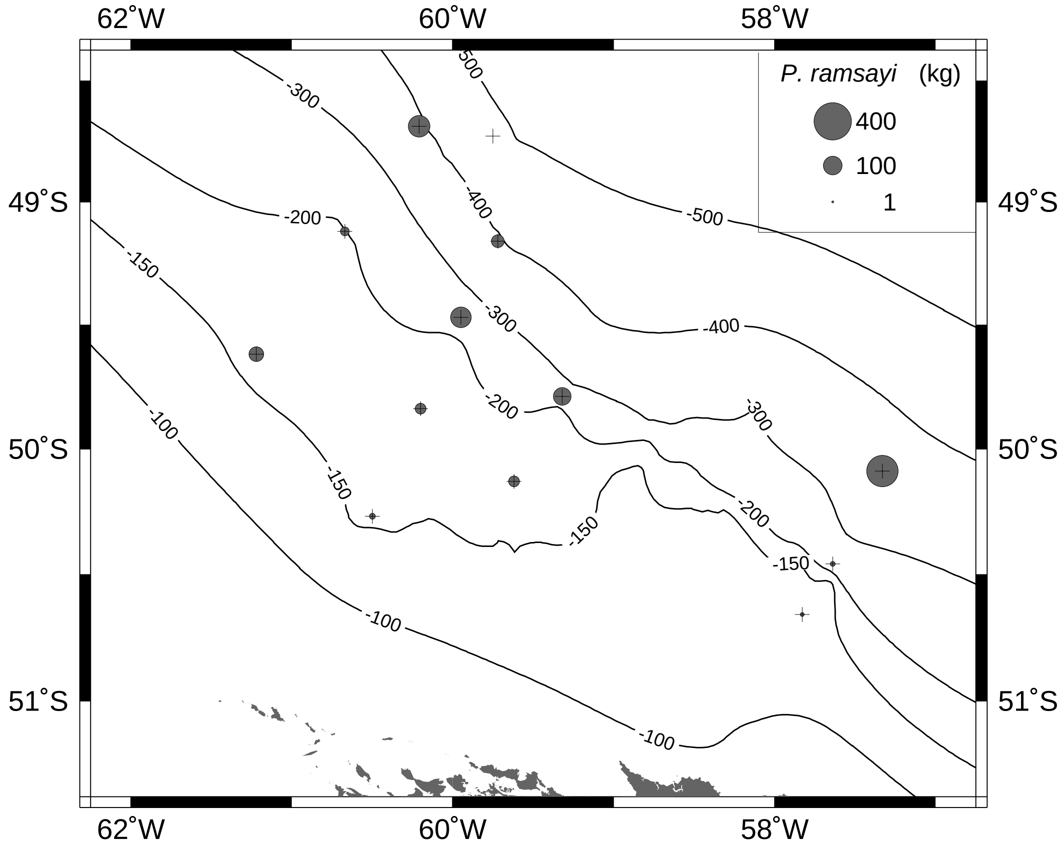


**Figure 40.** Catches of hoki, *Macruronus magellanicus*.

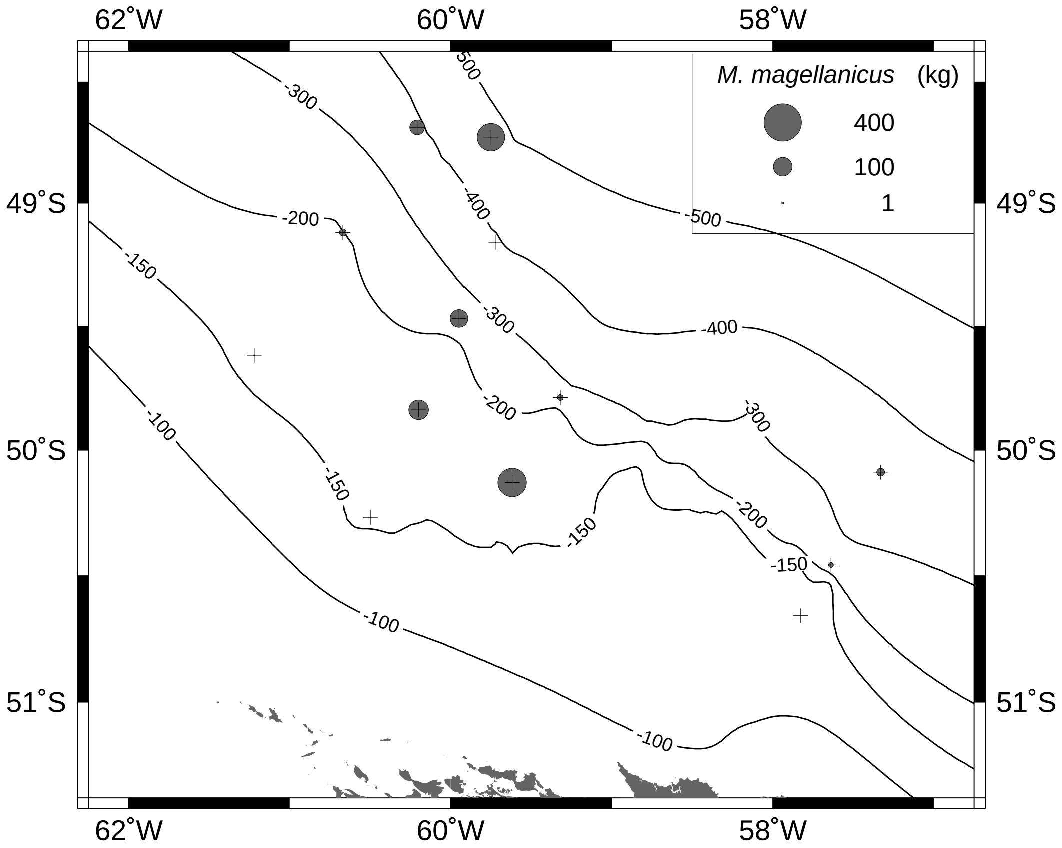



**Figure 41.** Catches of common hake, *Merluccius hubbsi*.

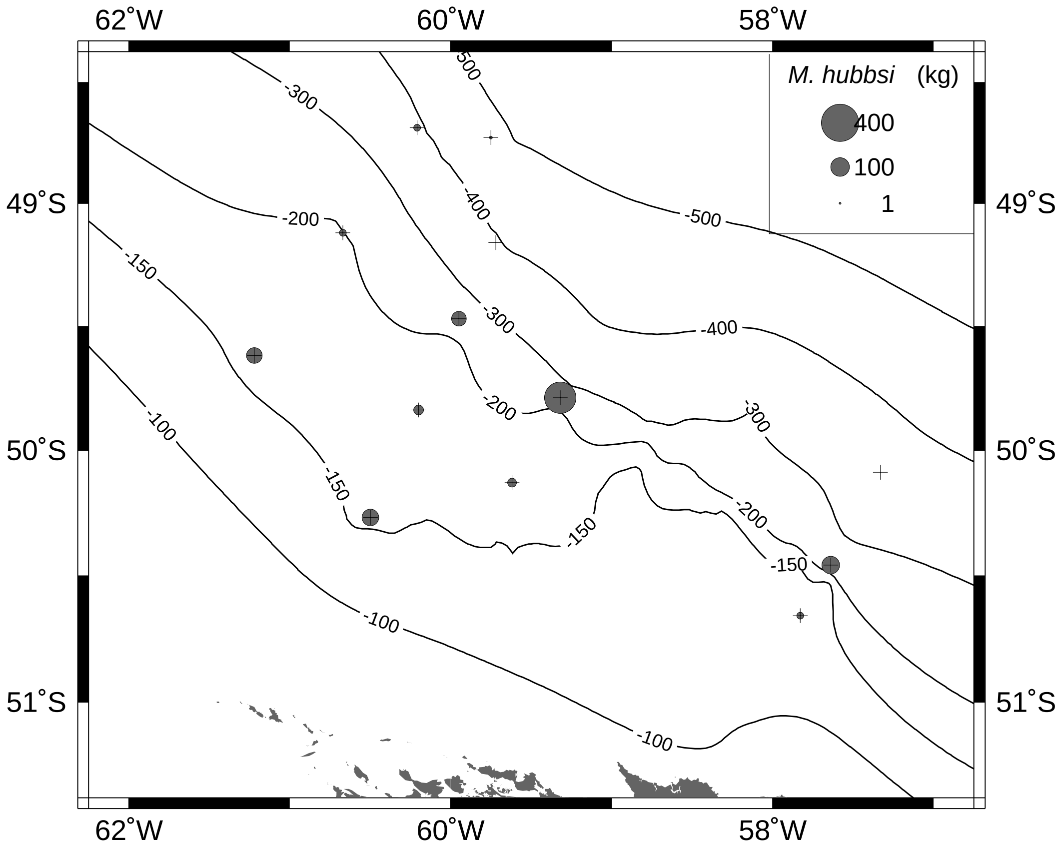
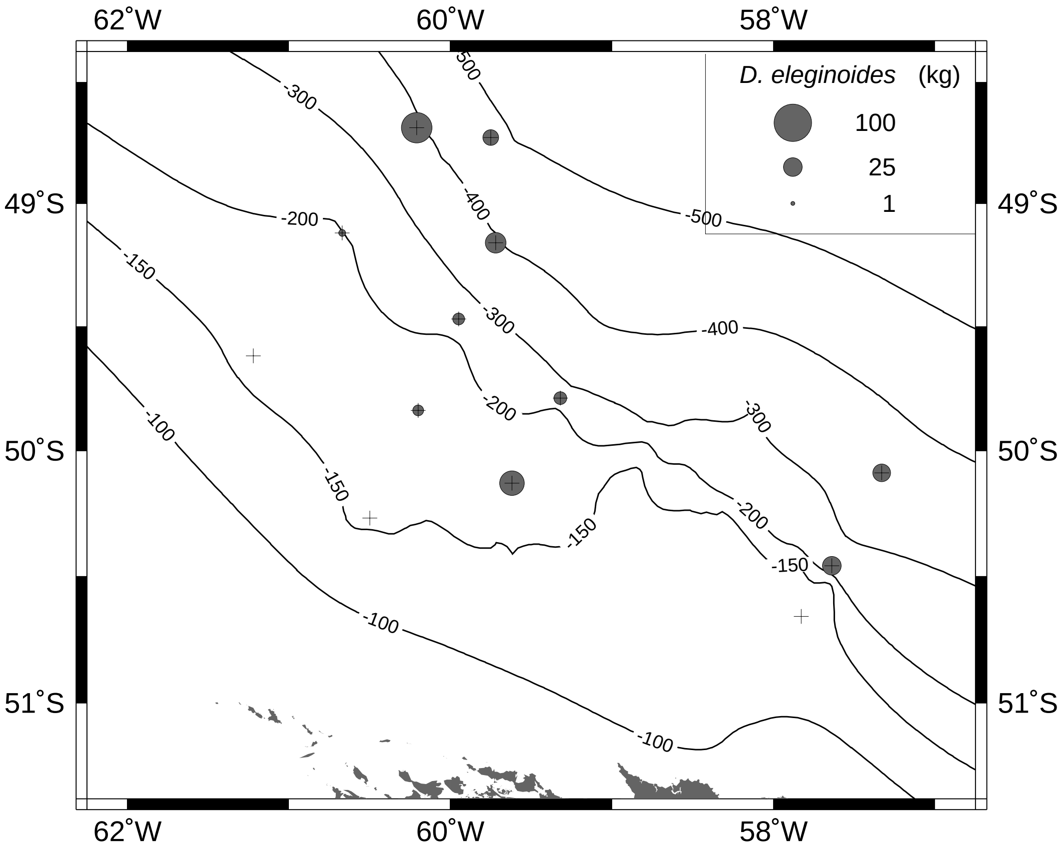


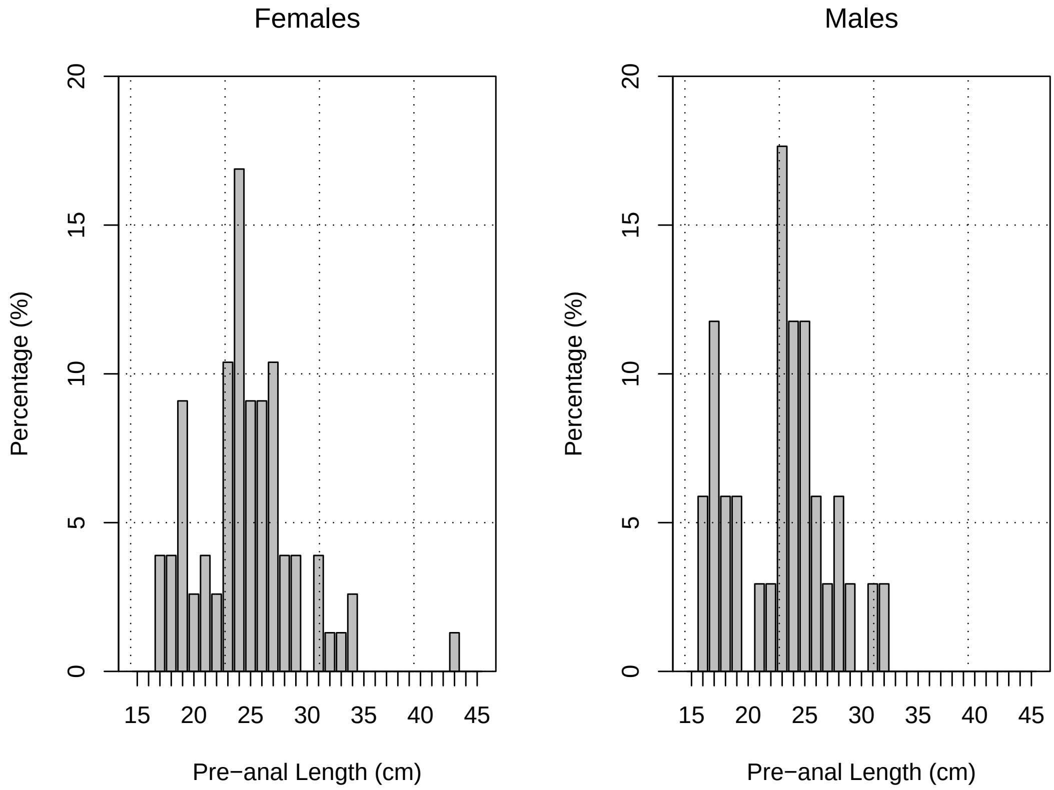
**Figure 42.** Catches of toothfish, *Dissostichus eleginoides*.



### 3.5.2 *Macruronus magellanicus*: biological data

A composite length frequency distribution for *Macruronus magellanicus* from all stations sampled (414, 415, 416, 418, & 421) is shown in Figure 43. However, the size distribution varied from station to station. At stations 418 and 421 an essentially bi-modal distribution was found, comparable to the composite distribution, with the main modes at ~17 and ~25cm pre-anal length. Stations 415 and 416 yielded mainly larger fish (modes 27, 33cm PAL) whilst station 414 (at 200m) consisted of primarily of specimens around the smaller mode.

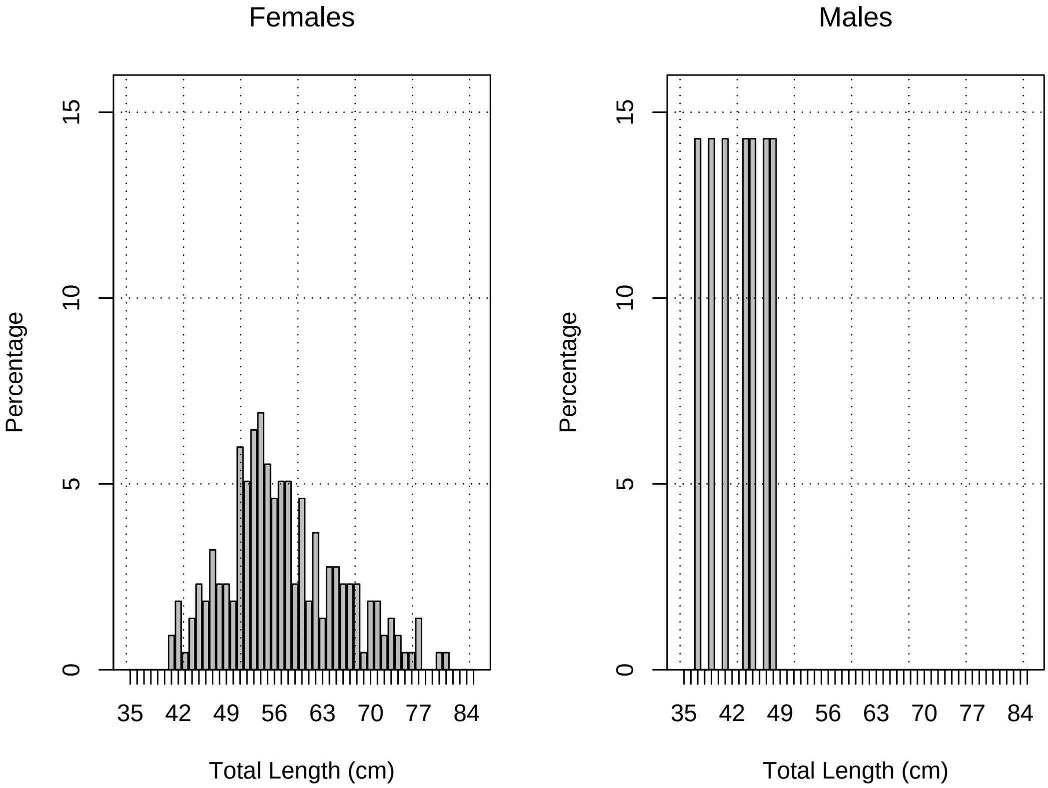
**Figure 43.** Length frequency distribution of female (*n* = 77) and male (*n* = 34) *Macruronus magellanicus* (stations 413-425).



### 3.5.3 *Merluccius hubbsi*: biological data

There were a number of significant catches of *M. hubbsi* most of which were sampled, primarily to collect stomachs samples. Of the six stations with hake catches a total of 224 specimens were sampled. Figure 44 shows the length frequency distribution: the mean length of the females was 59.6cm, whereas for the very small number of males it was 45.0cm. All specimens were at either developing or resting maturity stages.

**Figure 44** Length frequency distribution of female (*n* = 217) and male (*n* = 7) *Merluccius hubbsi* (stations 413-425).




## *3.6 Octopus*

All the octopi caught during the cruise belonged to the species *Benthoctopus eureka* (Robson, 1929) and were caught at depths ranging from 233 to 391 m. Mantle length varied from 5.0 to 13 cm, total length from 24.5 to 52.0 cm, and body weight from 61 to 709 g. The largest animals found were females (TL 48-52 cm, BW 694-709 g). This is unusual for benthic octopods where mature males are usually larger than females. In this case it is probably due to the small sample size with a high proportion of females (70%).

The sampled males were mostly mature with abundant spermatophores in the Needham sac in 9 out of 10 animals, whilst the remaining male was at maturity stage III (well-developed reproductive system, sperm absent from the spermaduct, and no spermatophore were present). Female maturity varied from immature (largest eggs about 2 mm length) to pre-spawning (largest eggs 23 to 27 mm) and one was either spent or ill – oocytes in its ovary were at different stages of resorption. The total number of oocytes was counted in ten females with female fecundity ranging from 95 to 299, being higher in larger animals.

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