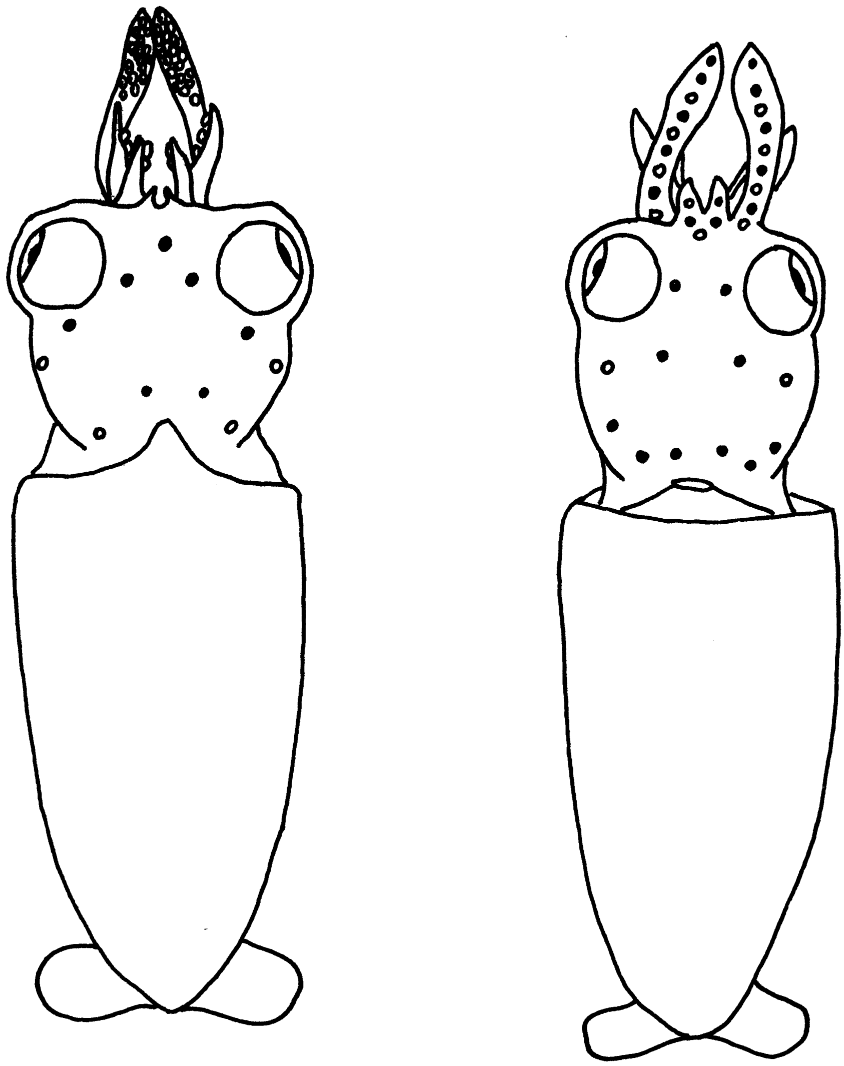
# Scientific Report

# Fisheries Research Cruise ZDLH1-11-1999




**Fisheries Department**

**Falkland Islands Government**

# Scientific Report

# Fisheries Research Cruise

# ZDLH1-11-1999

*FPRV Dorada*

*3 to 24 November 1999*

**Fisheries Department**

**Falkland Islands Government**

**Stanley**

**Falkland Islands**

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# 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 November 1999. This was the second research cruise carried out by the Department using the Fisheries Patrol and Research Vessel *Dorada*.

We wish to record our thanks to the masters, officers and crew of the *Dorada* for their work and enthusiastic participation during both phases of this research cruise.

# Summary

The research cruise ZDLH1-11-1999 was conducted on board the Fisheries Research & Protection Vessel *Dorada* at the end of the austral spring (3-24 November 1999). The main purpose of the cruise was to study the distribution, biological condition and abundance of the second cohort of the squid *Loligo gahi* (Loliginidae) during its spawning period in the inshore waters of the south-eastern and eastern parts of the Falkland Shelf, and to locate possible spawning sites by diving. The distribution and size composition of the main commercial and by-catch finfish and elasmobranchs were also studied. Studies of parasitic worms infecting *Loligo* were continued.

It was found that, during the survey, the *Loligo* box was occupied by cold waters with temperatures in the range 4-6°C. The superficial water layer had started its seasonal warming, forming a weak thermocline at depths of 40-60 m. The thermocline was more pronounced in shallow water than at offshore deepwater stations. On the shelf at depths below the thermocline water temperatures were lower than in winter (5.2-5.5°C).

Acoustic marks during a clean haul of *L. gahi* were comparable with those observed on the previous cruise with mean volume backscattering averaging about 4dB more at 120kHz than 38kHz. Distinctive marks and a large number of single target detections accompanied two catches of the lobster krill *Munida gregaria* in shallow water. The marks have a mean volume backscattering strength that is almost 18dB higher at 38kHz than 120kHz. The difference in single target strength is considerably less than this when all detections at the two frequencies are considered.

In total, at least 98 species of squid, fish, shellfish and other demersal invertebrates were caught, including some deepwater animals from the trawls on the continental slope. Catches of both *L. gahi* and finfish were generally very low. In contrast to June, catches of *L. gahi* were highest at a depth of 100 m on all eastern and northern transects, and in most cases they consisted of mature squid. Mature females were of approximately the same mantle length as those that had been observed in commercial catches in September-October 1999 at 200 m depths. All of them were mated, the majority inside the mantle, indicating that they were ready to spawn. Preliminary analysis of their fecundity has shown that some of them had already spawned.

As in June, *L. gahi* were generally free from parasites. Only about 13% of squid were infected by the trematode *Phyllobothrium* spp., and 2.3% by *Anisakis simplex*. The prevalence of infection increased with size. More than 50% of *L. gahi* greater than 14 cm mantle length were infected by trematodes.

Among finfish, the highest catches were of hoki, *Macruronus magellanicus*, and southern blue whiting, *Micromesistius australis*. Length frequency distributions of the toothfish *Dissostichus eleginoides* showed that larger fish were found at deeper depths. The smallest fish (11 – 15 cm) were found at 200 m on transect P3, while the largest fish were caught in deep water trawls. The total ray catch was about half that caught during the previous research cruise. The two most common species caught were *Bathyraja griseocauda* and unidentified *Bathyraja* sp. # 3. The typical deepwater fish *Macrourus carinatus* and *Antimora rostrata* predominated in catches at deep-water stations. The *M. carinatus* were medium-sized (modal pre-anal length 20 – 24 cm), and most were immature.

During the diving survey, two principal *Loligo s*pawning sites were found in the inshore waters, one between Sea Lion Island and Bleaker Island, and another (more abundant) north of Volunteer Point (Cow Bay and Dutchman's Island). Egg masses occurred at the outer (seaward) edge of the algae beds with ambient water temperature 6.5-9°C and salinity 33.75-33.85‰. They were attached to the stems of the kelp algae *Lessonia* spp. and *Macrocystis pyrifera* from 0.5 m to 2.5 m off the bottom at 12-20 m depths. The overall density of egg masses was low. The egg masses were a bundle of prolong gelatinous translucent capsules with each capsule attached strongly to the kelp by its basal end. The capsules were short (mainly 50-60 mm in length) and contained an average of 70 fertilized eggs inside. Each egg mass consisted of 20-170 capsules and from 138 to 11,531 eggs.

# 1. Introduction

The Patagonian long-finned squid *Loligo gahi* is an important fishery resource within the Falkland Islands Interim Conservation and Management Zone (FICZ) with the annual catch varying from 26,000 to 98,000 tonnes (FIG, 1998). It has been shown that the squid undertake ontogenetic vertical migrations. They move from the inner shelf to the shelf edge and continental slope (mainly down to 200-300 m depths) as juveniles, feed and grow in the deepwater as immature and maturing adults and, upon maturation, return to shallow waters to spawn (Hatfield and Rodhouse, 1994).

Although small quantities of fully mature females have been found in inshore trawl catches, leading to the assumption of shallow water spawning (Hatfield et al., 1990), neither spawning sites nor egg masses of *L. gahi* have yet been described. Local SCUBA divers sometimes indicated the rare presence of egg masses strongly resembling those of loliginids in shallow bays around Eastern Falkland, but they have never been examined (George and Hatfield, 1995). The main purposes of this cruise were to investigate possible patterns of spatial and vertical distribution of the second cohort of *L. gahi* during the spawning period and to locate its inshore spawning sites around East Falkland by diving. Trawl and oceanographic stations were designed to be on the same transects used on previous research cruises.

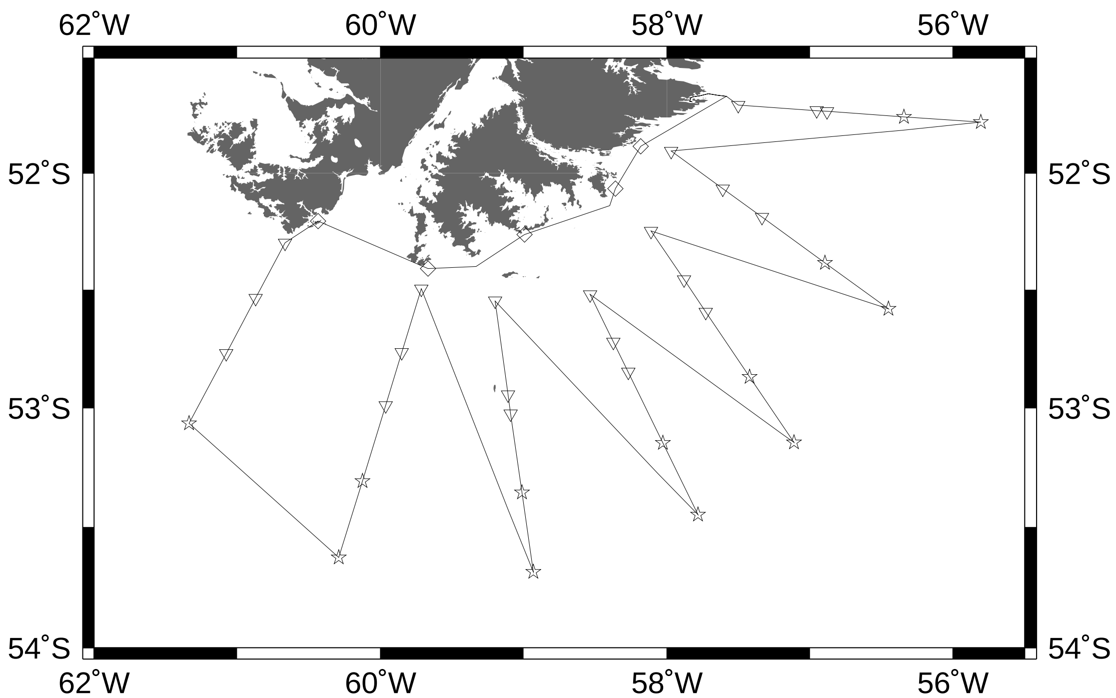
## *Region*

The region surveyed included a segment of the FICZ (eastern and southern parts) known as the "Loligo box". The planned route and station positions are illustrated in Figure 1.

## *Cruise objectives*

1. To study oceanographic conditions within the "*Loligo* box".
2. To make an acoustic survey of the "*Loligo* box" and carry out targeted trawling in conjunction with acoustic surveying with the aim of quantifying *L. gahi* "target strength".
3. To carry out a bottom trawl survey for biological analysis of the second cohort of *L. gahi* during its spawning period
4. To make a diving study of possible *L .gahi* spawning sites

Figure 1. Planned transects and station positions for the main leg of the cruise.



## *Cruise plan*

The cruise consisted of two legs:

Leg 1 (3-16 November 1999): Trawl, oceanographic and acoustic survey of the "*Loligo* box".

Leg 2 (19-24 November 1999): Scientific diving around East Falkland.

The trawl survey consisted of seven short biological transects located within the "*Loligo* box". Each transect included three 0.5-hr bottom trawl hauls at depths <100 m, ~180-200 m and 300 m, and an oceanographic station made before each trawl. All trawls were carried out in the daytime. In addition, on each transect two oceanographic stations were carried out at depths of 500 and 1000 m, mainly at night. Three deep-water trawl hauls (down to 800-900 m) were done on the eastern part of the continental slope.

The diving survey was carried out at locations of possible *L.gahi* spawning sites on the south-east coast of East Falkland during the first part of the cruise, and at several locations around the island during the second part of the cruise.

## *Vessel characteristics*

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

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

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

## *Personnel and responsibilities*

The following FIFD scientific personnel participated in the cruises (alphabetical):

Dr Alexander Arkhipkin — Chief Cruise Scientist

Antony Bishop — Trawl survey

Emma Jones — Trawl survey, diving

Dr Vladimir Laptikhovsky — Trawl survey

Karen Macleod — Trawl survey

Dr David Middleton — Acoustic survey, diving

Mark Potter — Trawl survey

Additionally, Steve Waugh (FIFD Fishery Officer) and David Eynon (SAMS, Stanley) participated in the diving work. Lian Butcher (FIFD) took part in the egg mass analysis during the second part of the cruise.

## *Survey design*

### Leg 1:

The complex survey of the "*Loligo* box" consisted of seven transects running from the shore on fixed bearings as detailed in Table II.

Table II. Details of transects used in Leg 1, during the "*Loligo* box" survey.

| *Transect No* | *Shoreside Lat/long* | *Bearing* |
|---|---|---|
| P1 | 51°42'S 57°38'W | 94° |
| P2 | 51°49'S 58°10'W | 126° |
| P3 | 52°00'S 58°23'W | 146° |
| P4 | 52°15'S 58°45'W | 154° |
| P5 | 52°20'S 59°15'W | 172° |
| P6 | 52°24'S 59°40'W | 197° |
| P7 | 52°18'S 60°40'W | 208° |

### Leg 2:

Diving survey of the near shore waters of East Falkland.

# 2. Hydrographic survey

During the cruise, the hydrographic data were collected in two periods. During the first leg data were collected at 46 oceanographic stations within the "*Loligo* box, before each bottom trawl station and at offshore stations on transects P1-P7 (Figure 2). During the second leg 16 stations were made, offshore in the vicinity of each diving station (Figure 3).

Figure 2. Oceanographic stations and transects, 3-16 November 1999.

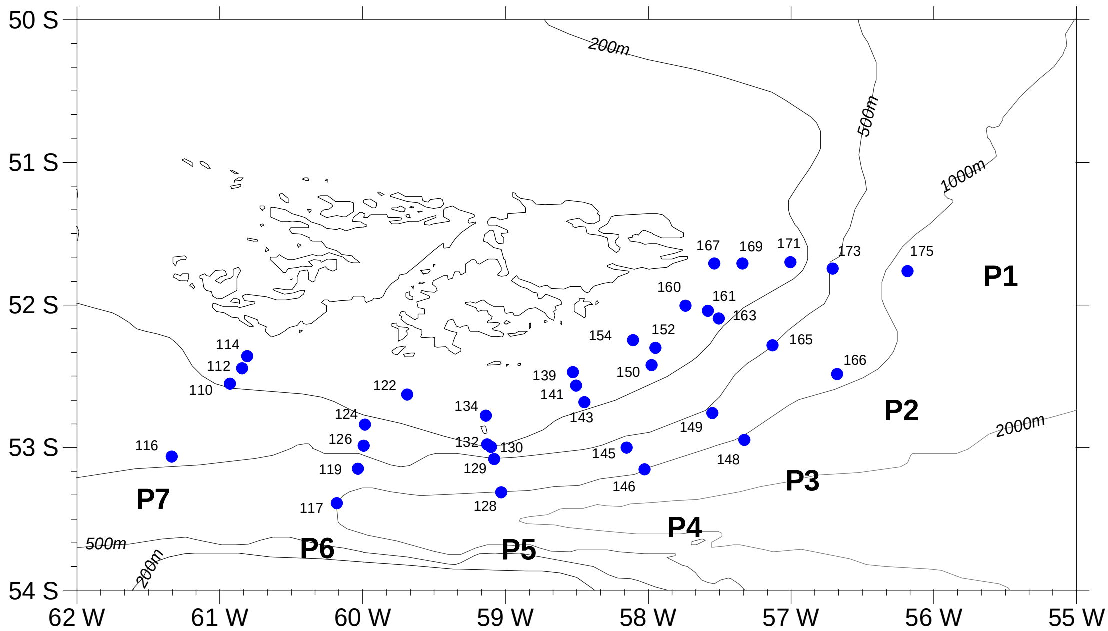
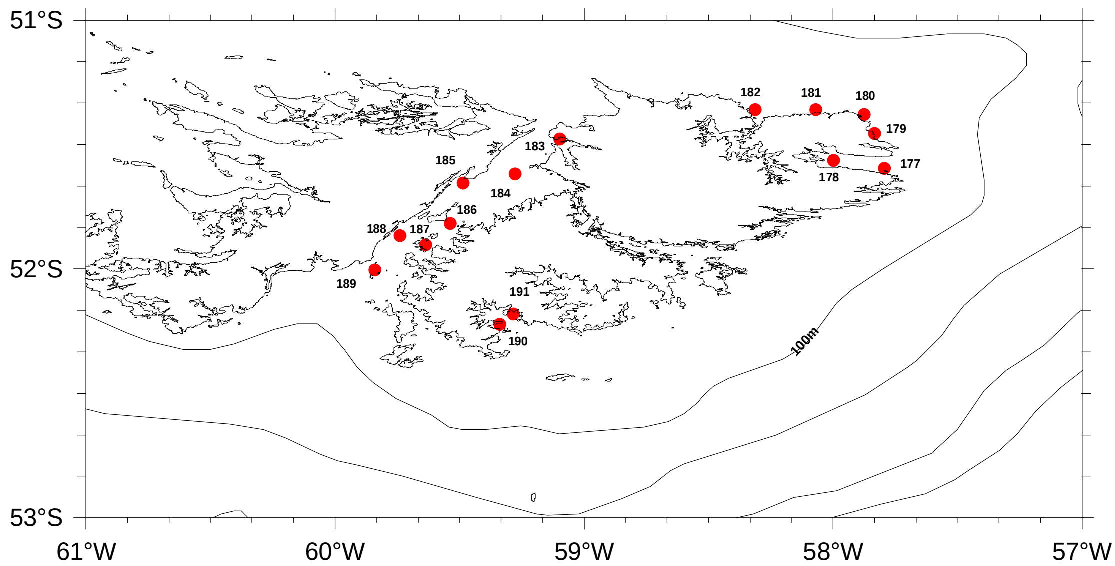



Figure 3. Oceanographic stations during the diving survey, 19-24 November 1999.



## Materials and Methods

A Sealogger SBE25 profiler (Sea-Bird Electronics Inc.) was used to obtain depth (m), temperature (°C), salinity (‰), density (kg $m^{-3}$) and dissolved oxygen (ml $l^{-1}$) data. Speed of deployment was monitored using an electronic wire counter and was approximately 1 m $sec^{-1}$. The CTDO was deployed first for 4 min at 10 m depth to allow polarizing of the oxygen sensor and the pump to start. It was then retrieved to 1 m depth and deployed again either to about 20 m above the bottom (shelf and continental slope complex stations) or down to 1000 m in the open sea. Both down and up-cast measurements were recorded. Temperature was measured directly, whereas other parameters were calculated using the Seasoft v. 4.326 software (Sea-Bird Electronics Inc.) from the following parameters: pressure (dB), conductivity (S/m), oxygen current (μA) and oxygen temperature (°C). Data were recorded at 8 scans per second and retrieved after deployment.

### Data quality

Depth, temperature and salinity sensors of the SBE25 were calibrated in March 1999, and the oxygen sensor was calibrated in October 1999 at Sea-Bird Electronics Inc.

### Data presentation

For each station, profiles of temperature, salinity, oxygen and density were plotted using the Seaplot program of the SEASOFT software. Contour maps were constructed using the Surfer 6.02. On the horizontal axis stations were set according to the distance between them, and the oceanographic parameters calculated for all grid points using kriging.

## Results

In this section, we present a brief description of the main oceanographic conditions encountered during the cruise. A thorough analysis of water masses, geostrophic currents and dynamics will be presented at a later date, in a report commissioned from Dr.P. Glorioso (POL, UK).

During the period of the trawl survey the whole “*Loligo* box” was occupied by cold waters with temperatures in the range 4-6°C. The surface waters had started their seasonal warming, forming a weak thermocline at depths of 40-60 m (Figure 4). This was more pronounced at shallow water stations than at offshore, deep-water stations. On transects P5-P2, the thermocline had developed only in shallow waters (100-300 m); further offshore the surface waters were below 6°C. Below the thermocline, water temperatures were low (5.2-5.5°C). The near-bottom temeratures at 200-300 m depths were higher on the southern transects (P7-P6) than on the eastern transects (P1). The 5° isotherm moved closer to the surface layers in 1000 m depths on P5 and in 500 m depths on P4, indicating a lift of deep waters which was confirmed by an increase in salinity on P4 (Figure 5). Less saline shelf waters occupied the superficial water layers (down to 50-80 m depths) from the shore to depths of 300-400 m on the southern transects (P6 and P7). On the north-eastern transects, these shelf waters were nearer shore, substituted by the more saline waters of the Falkland Current in depths of 300-400 m. The distribution of oxygen was rather uniform on all transects (Figure 6).

The distribution of the oceanographic parameters along the 300 m isobath (the depth of maximum penetration of *L. gahi* from the shelf) also indicated the intrusion of colder and more saline water on the most northerly transect, P1 (Figure 7).

Figure 4. Contoured temperature (°C) profiles for transects P1-P7.

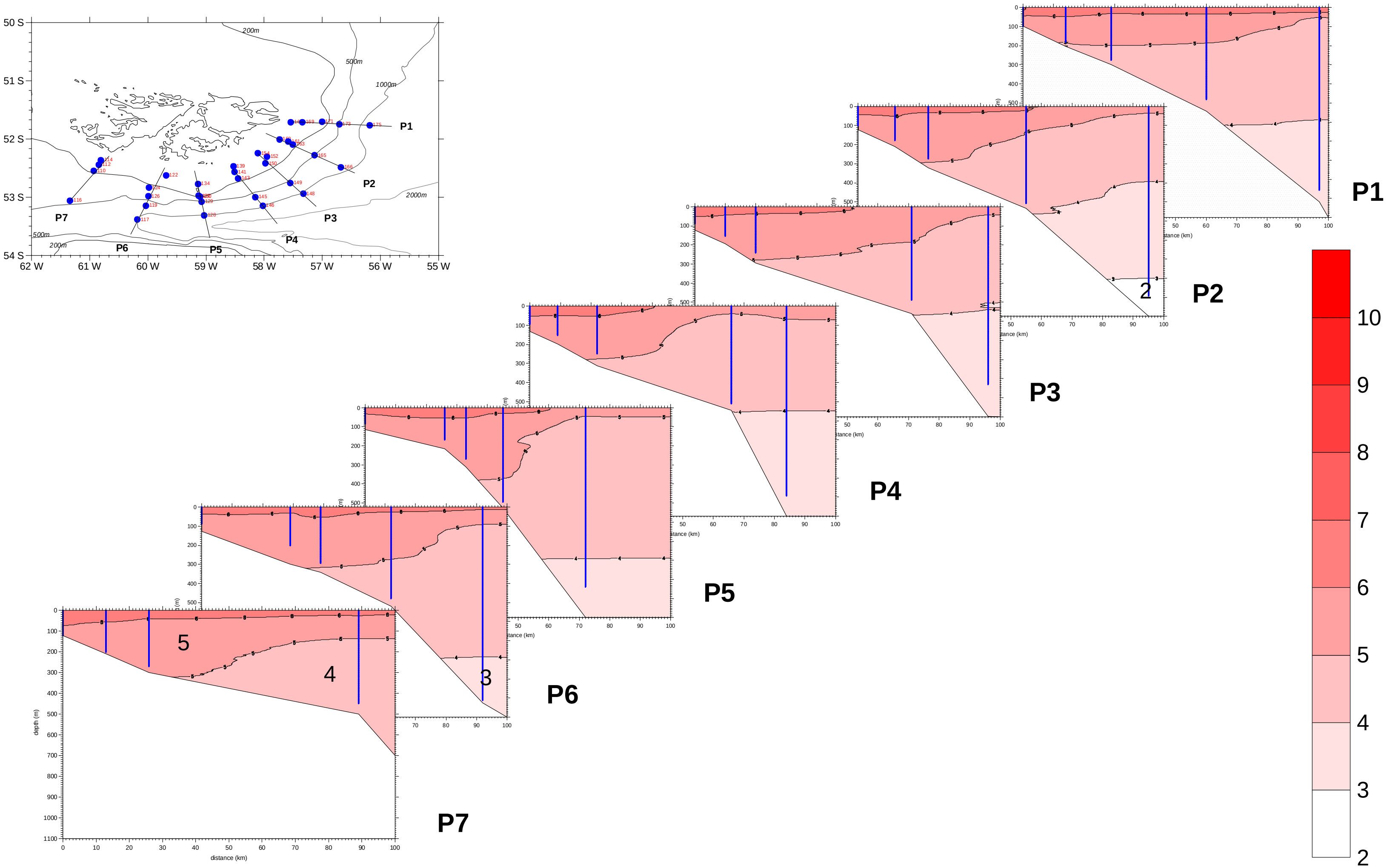


Figure 5. Contoured salinity (‰) profiles for transects P1-P7.

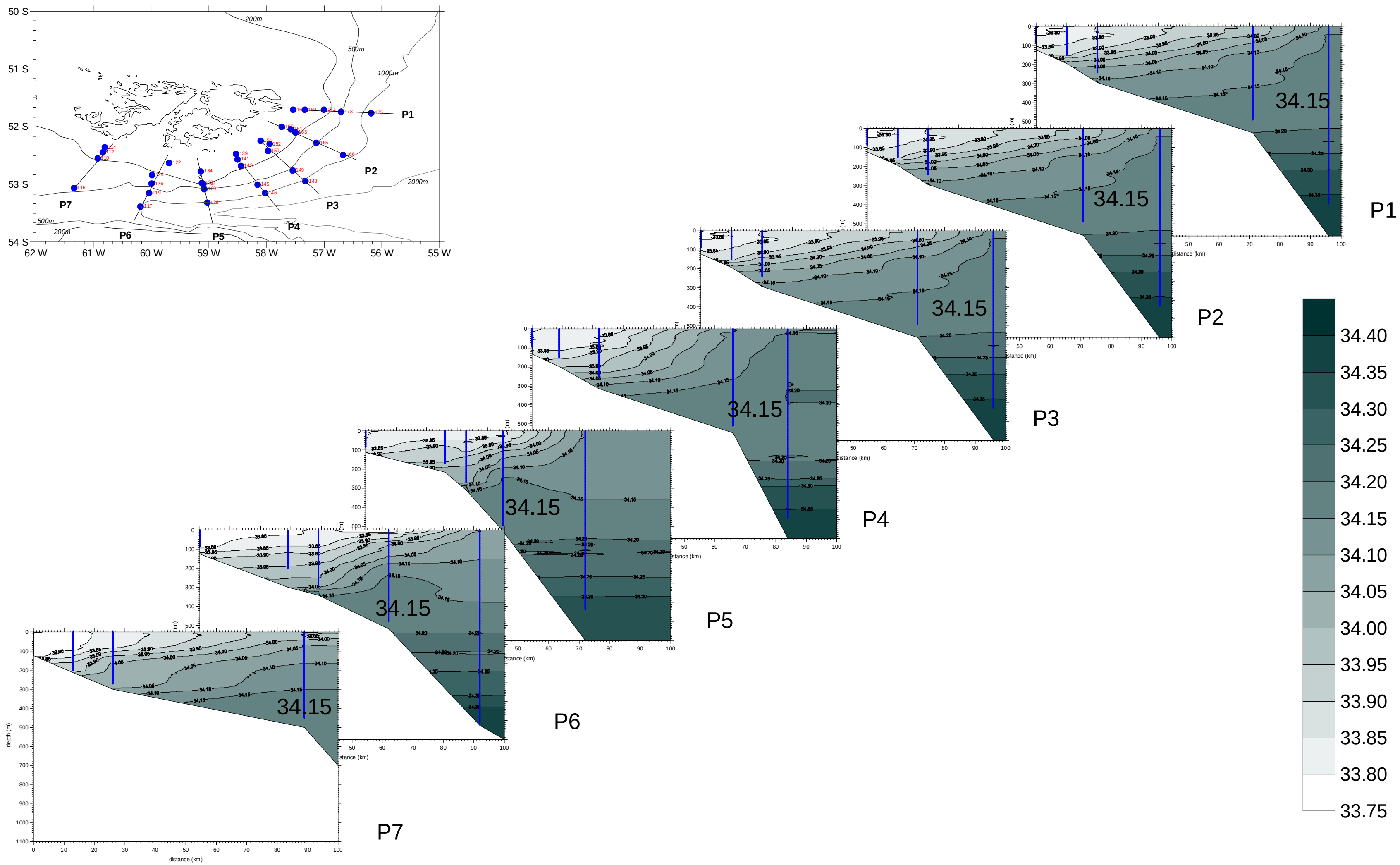


Figure 6. Contoured oxygen concentration (ml/l) profiles for transects P1-P7.

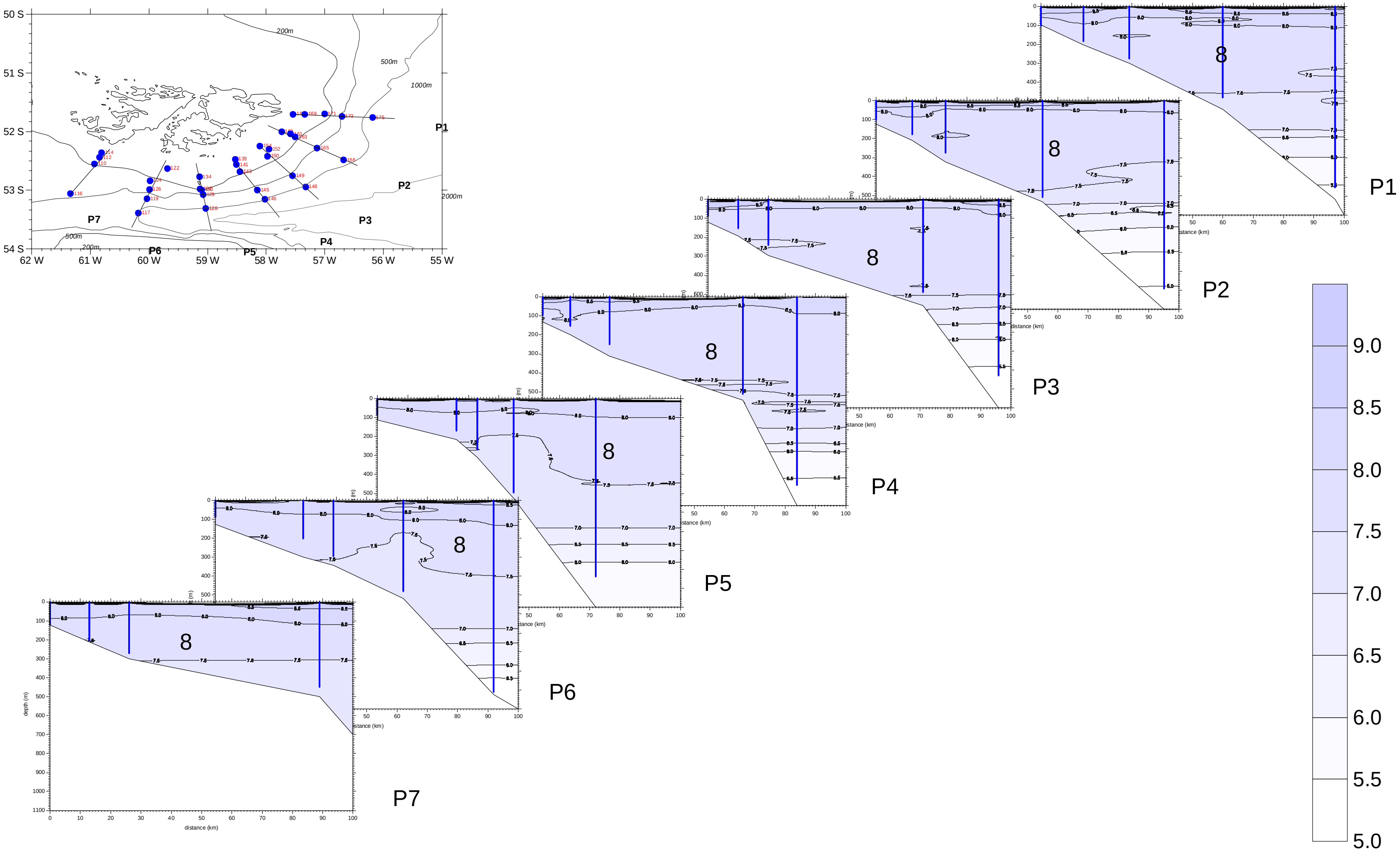
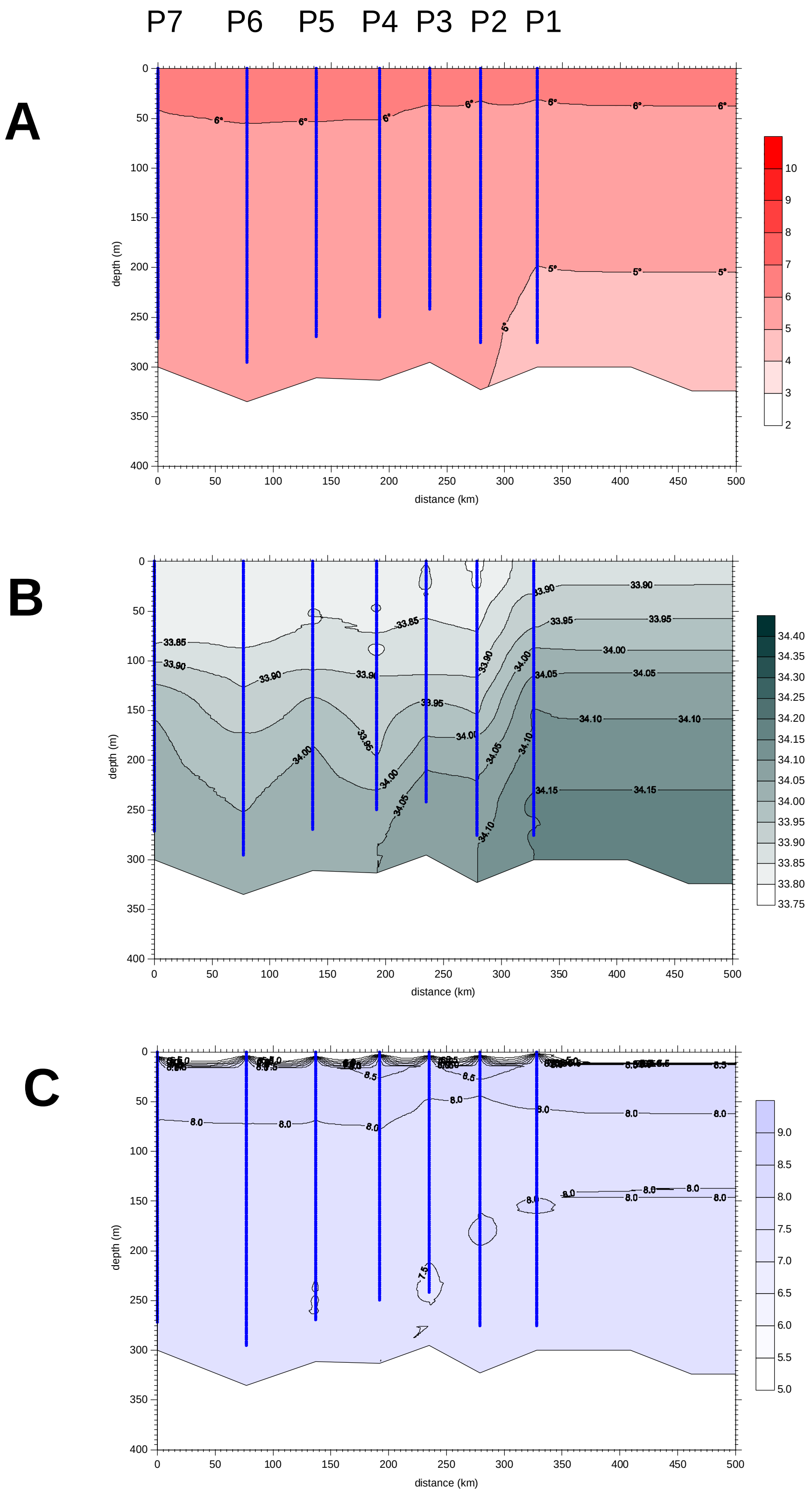


Figure 7. Temperature (A), salinity (B) and oxygen (C) profiles along the 300 m isobath for the transects P1-P7.



# 3. Acoustic surveying

## Introduction

Acoustic data from the EK500 was logged along the entire cruise track. The main objective, however, was comparison of the acoustic data during trawls with the catch with the aim of characterising the acoustic properties of major commercial species, in particular *Loligo gahi*.

## Methods

### Equipment and Software

*Dorada* is equipped with a Simrad EK500 scientific echo sounder with hull mounted split beam transducers operating at 38kHz and 120kHz (Table I).

Table I. Simrad EK500 scientific echo sounder, FPRV *Dorada*: installed transducers

| *EK500 channel number* | *1* | *2* | *3* |
|---|---|---|---|
| Transducer type | ES 38-B | ES 120-7 | None installed |
| Serial number | 22047 | 28907 | |

Equipment details are as given in Appendix 3.1 of FIG (1999), except that more recent versions of SonarData software were used: EchoView 1.51.19, EchoLog_EK 1.50.06, and EchoConfig_EK 1.50.05 beta.

### Interference from other acoustic devices

As noted in FIG (1999) the EK500 system, as originally installed, suffered from interference from other acoustic devices at both the 38kHz and 120kHz frequencies. Cables were therefore run between the bridge and dry lab to allow synchronisation of acoustic equipment.

The bridge echo sounder (Furuno, transceiver unit model ETR-10D1, Echo Sounder FE-881 II and colour display FCV-780/782) operates at 28kHz and interfered with the EK500's 38kHz and 120kHz frequencies. As currently configured the FE-881 II is the master sounder in this arrangement. This model cannot accept an external keying pulse (KP) and so cannot be synchronised to the EK500. However, as an interim measure the EK500 was synchronised to the output KP of the FE-881 sounder. This resolved the problem of interference from this source, at the expense of having to trigger the EK500 with a KP that varied in frequency according to depth. However the EK500 did not transmit in response to every KP if processing of the previous ping had not been completed.

The KP from the FE-881 sounder was also input to the Furuno Doppler sonar current profiler (model CI-30, 130kHz) with the intention of removing the interference caused to the EK500's 120kHz frequency. However it was established that the CI-30 ceases reception, rather than transmission, in response to an external KP so the interference persisted. Work is currently underway to establish whether an output KP from the CI-30 can be utilised.

### Logging of trawl position

The Simrad Integrated Trawl Instrumentation (ITI) system was upgraded prior to the cruise to allow logging of trawl position information via an ethernet interface. This allows more precise comparison of the areas sampled acoustically with the area swept by the trawl.

## Calibration

Calibration of the EK500 using the standard reference targets was carried out at Port Albemarle 52° 12.42' S, 60° 26.22' W on 5 November 1999. The procedures used are as described in FIG (1999, ch.3). The ship anchored at 10:00 local and calibration was completed by 21:00. Calm conditions allowed the calibration to be completed while anchored at the bow only, although increased wind between 15:30 to 17:00 caused the ship to swing thus delaying the calibration of the 120kHz transducer.

A CTDO cast was made so that the sound speed and absorption coefficient could be calculated (see Figure 1). The salinity and temperature from 6 to 20m range were used to calculate average salinity of 33.77‰ and temperature of 6.66°C, which resulted in a sound speed of 1475.9ms$^{-1}$ at 10m depth using Mackenzie's empirical equation (MacLennan & Simmonds, 1992, pp. 43-44).

The results of the calibration are given in Table II.

## Operating procedures

The EK500 and PC logging echogram data were both set to GMT at the beginning of the cruise, and periodic checks were made to ensure that these times remained close. The EK500 allows synchronisation to an external clock and some experiments were made with the EK500 updating its clock from the GPS data on the serial line. However, this was found to produce faulty time stamps on the echo sounder data at times, in particular around midnight, and was abandoned.

Figure 1. Temperature and salinity profiles from CTDO cast at EK500 calibration site. Shaded region denotes depth range over which values were averaged for the calculation of sound speed.

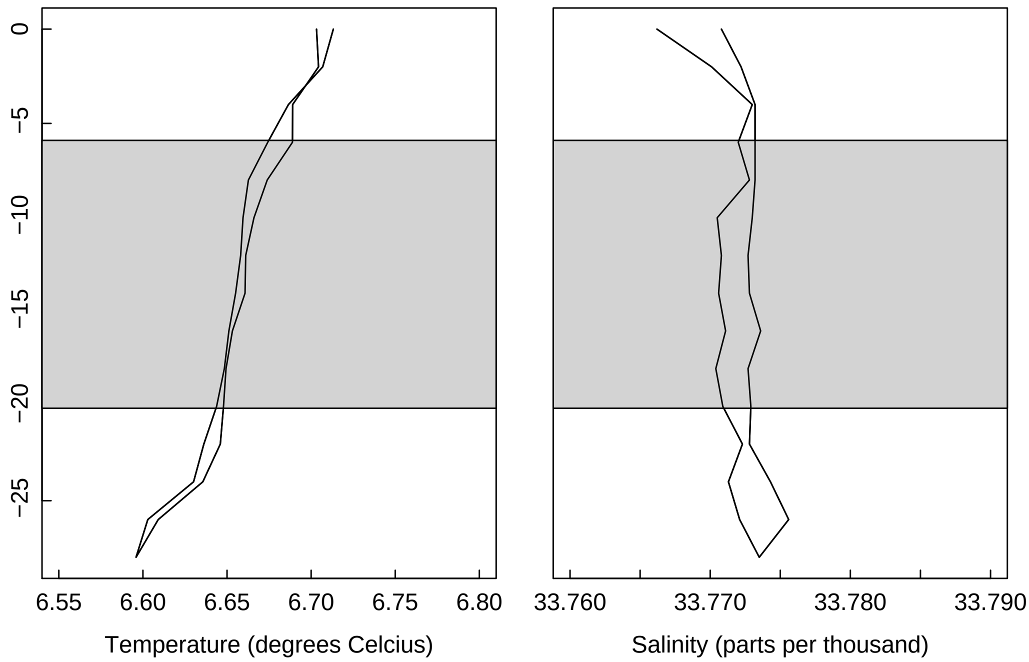


Table II. FPRV *Dorada* EK500 calibration results, 5 November 1999.

| | | |
|---|---|---|
| Date | 05/11/99 | 05/11/99 |
| Time (local) | 15:10 | 18:45 |
| Place | Port Albemarle | Port Albemarle |
| Software version | 5.30 | 5.30 |
| **Frequency** | **38** | **120** |
| Test oscillator | -55.5 | -55.4 |
| Water depth | 38.8 | 38.8 |
| Temperature | 6.66 | 6.66 |
| Salinity | 33.77 | 33.77 |
| Sound speed | 1475.9 | 1475.9 |
| Alpha | 10.24 | 33.4 |
| Angle sensitivity along | 21.9 | 21.0 |
| Angle sensitivity athwart | 21.9 | 21.0 |
| Ping rate | 0.0 | 0.0 |
| Transmit power | normal | normal |
| Max power | 4000 | 1000 |
| Pulse duration | medium 1.0 | long 1.0 |
| Bandwidth | wide | narrow |
| Minimum echo length | 0.8 | 0.8 |
| Maximum echo length | 1.6 | 1.5 |
| Max gain compens. | 1.4 | 1.4 |
| Max phase deviation | 2.0 | 2.0 |
| Sphere TS | -33.62 | -40.28 |
| **Sphere type** | **Cu 60.0** | **Cu 23.0** |
| Old TS gain | 24.95 | 24.89 |
| **Calibrated TS gain** | **24.89** | **25.43** |
| Default 2-way beam | -20.6 | -18.00 |
| Range to sphere | 20.4 | 21.30 |
| Old Sv gain | 24.71 | 25.25 |
| **Calibrated Sv gain** | **24.67** | **25.34** |
| *Lobe results* | | |
| TS gain | 24.97 | 25.40 |
| Alongships beam | 6.95 | 7.31 |
| Athwartships beam | 7.03 | 7.51 |
| Alongships offset | -0.01 | -0.02 |
| Athwartships offset | 0.01 | 0.16 |

Echogram data were logged over the entire cruise track. All data were logged with an expanded bottom echogram of 15m range starting 10m above the detected bottom. The range of the main echogram was adjusted as required to cover the entire water column. The 714 intervals available for logging the echogram data were divided as follows: at 38kHz 150 bottom echogram values and 500 main echogram values; at 120kHz 214 bottom values and 500 main values.
The updated version of the EchoView software used is able to utilize the expanded bottom data to increase echogram resolution near the seabed. It was therefore unnecessary to adjust the range of the main echogram during trawling as was the practice on an earlier cruise (FIG, 1999, ch.3).

An EchoView "ev" file was created for each trawl station with marker regions denoting the position at which the net was believed to have reached and left the seabed. These marker positions were corrected to take account of the fact that the ship passed over a particular position some minutes before the trawl sampled this region. These corrections were calculated assuming that vessel speed, and the distance of the trawl behind the ship, remained constant during the trawl.

Table III shows the constants applied in the processing of logged acoustic data with EchoView. Data collected prior to calibration were collected with the pre-calibration constants but processed with the post-calibration constants. Data collected after calibration were logged and processed with the post-calibration constants.

For each trawling station the echograms at 38kHz and 120kHz were printed for the whole water column, and a region nearer the bottom. The ship's track was exported from the echo sounder logs for comparison with the trawl track from the trawl instrumentation logs.

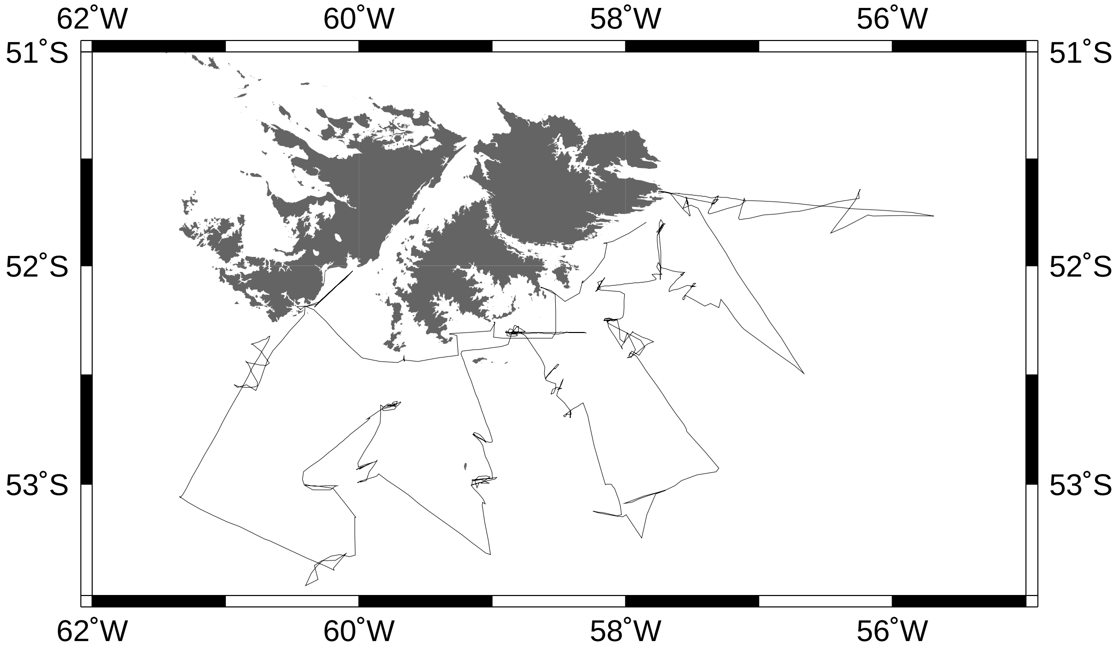
## Results

Figure 2 illustrates the track along which acoustic data were collected. Quantitative analyses of the acoustical data were once again hampered by the interference discussed above. However, comparison of the acoustic data collected during trawls with the trawl catch allows some useful progress in the characterisation of the acoustic properties of several species.

Table III. Constants used in EchoView processing.

| | *Transducer 1* | | *Transducer 2* | |
|---|---|---|---|---|
| | Pre-calibration | Post-calibration | Pre-calibration | Post-calibration |
| Absorption coefficient (dB/m) | 0.0100000 | 0.0102400 | 0.0331200 | 0.0334000 |
| Sound speed (m/sec) | 1474.9 | 1475.90 | 1474.9 | 1475.90 |
| Transmitted power (W) | 4000.0 | 4000.0 | 1000.0 | 1000.0 |
| Equivalent 2-way solid beam angle | -20.60 | -20.60 | -18.00 | -18.00 |
| SV gain (dB) | 24.7100 | 24.7670 | 25.2500 | 25.3400 |
| TS gain (dB) | 24.9600 | 24.8900 | 25.1700 | 25.4300 |
| Wavelength (m) | 0.03881 | 0.03881 | 0.01229 | 0.01229 |
| Transmitted pulse length (ms) | 1.000 | 1.000 | 1.000 | 1.000 |
| Frequency (kHz) | 38 | 38 | 120 | 120 |
| Draft correction (m) | 0 | 0 | 0 | 0 |
| Nominal angle (degrees) | 6.95 | 6.95 | 7.410 | 7.410 |

Figure 2. Track of FPRV *Dorada* from 3 to 16 November 1999 along which acoustic data were collected.




## *Loligo gahi*

Catches of *L.gahi* were small during the entire survey. The highest catch was taken at station 140, where the 18.42kg of *L.gahi* represented 49.9% of the total. The echograms from this trawl (Figure 3) show a number of aggregations near the bottom which are similar to those observed at station 62 during the June survey (FIG, 1999, Figure 20). Figure 4 illustrates that the track trawled at this station closely matched the track of the ship, which represents the track acoustically surveyed.

## *Differences in backscattering strength at 120kHz and 38kHz*

The outlines of the aggregations were defined using the EchoView schools detection module (SonarData, 1999) operating on the relatively interference-free 38kHz data. The integration results within these regions were calculated at both 38kHz and 120kHz and δ dB (the difference in mean volume backscattering, Sv, between 120kHz and 38kHz) was calculated. The distributions of δ dB are illustrated in Figure 5; in addition to the distribution for all regions, separate distributions are plotted for regions with and without contamination of the 120kHz data by interference from the Doppler log. It is apparent that the Doppler noise is responsible for increased variability in the observed δ dB. Mean δ dB for the complete data set is 3.8dB (median 3.7dB), and for those regions without Doppler noise at 120kHz the mean δ dB is 3.7dB (median 4.2dB). This is a smaller difference than found at station 62 in the June 1999 survey (FIG, 1999, Figure 21) where average δ dB was between 4.7 and 5.5dB.

However, plotting a histogram of δ dB for the regions without Doppler noise reveals a bimodal distribution that suggests that two types of aggregations may actually be present (Figure 6). Figure 7 illustrates that the group of aggregations with a higher δ dB tends to be taller aggregations, and further off the seabed than the group with the smaller δ dB.

A small number of single targets were detected by the EK500 in the region trawled (Figure 8), but the number detected is too small for any detailed analysis.

Figure 1. Echograms from the latter part of station 140 at 38kHz (top) and 120kHz (bottom) showing possible *L. gahi* aggregations. The Doppler log was turned off during most of this trawl: interference is visible at 120kHz when the Doppler was turned on towards the end of the trawl. Minimum Sv = -90dB.

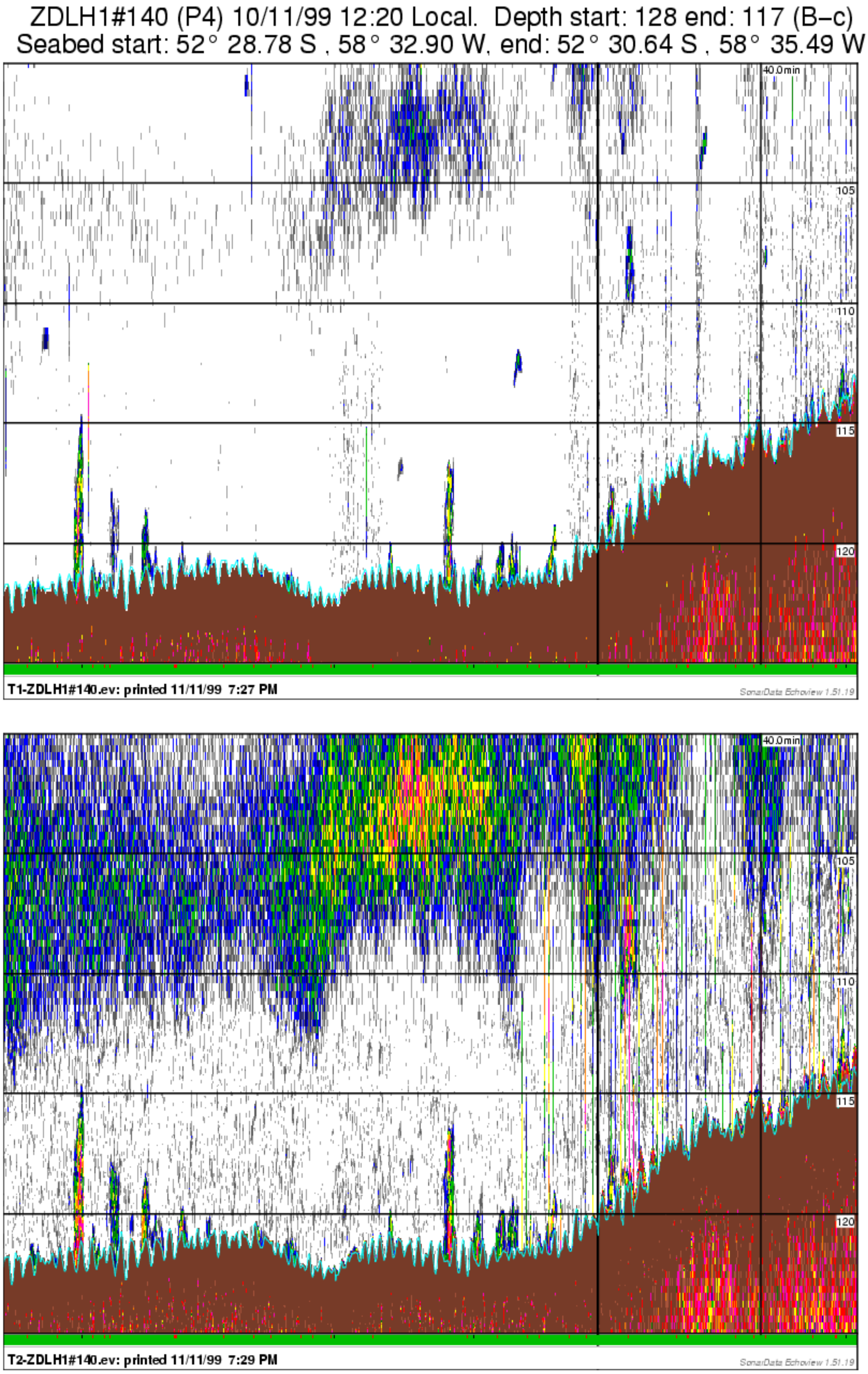


Figure 2. Trawl track at station 140 in comparison with track of ship.

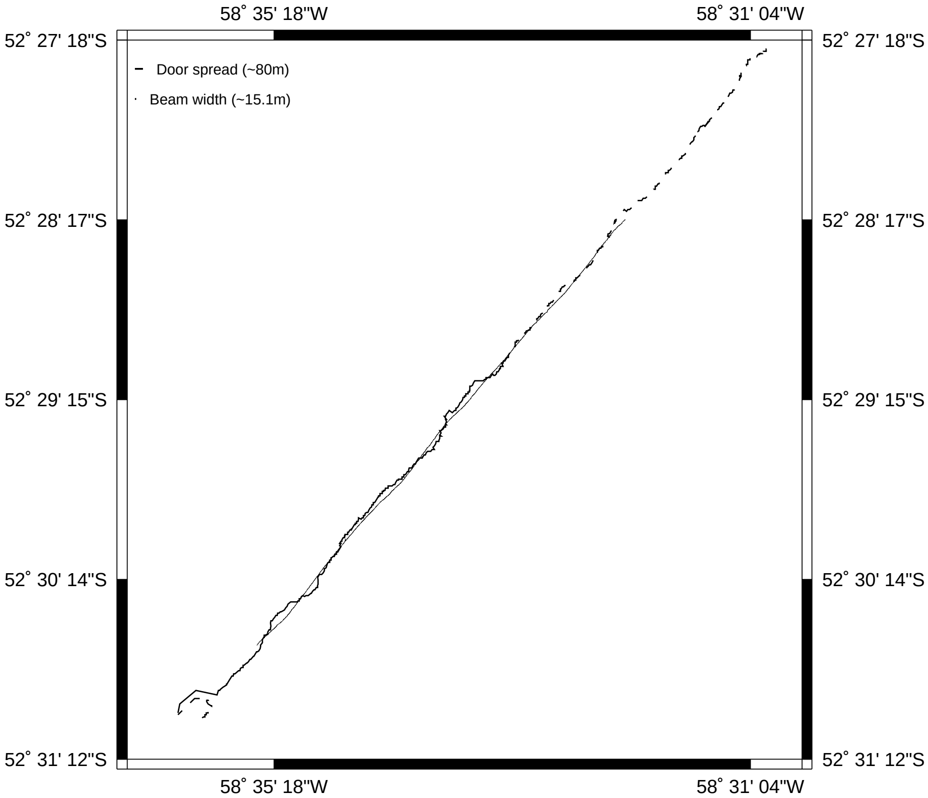



Figure 3. Difference in mean volume backscattering (Sv) at 38kHz and 120kHz for the aggregations visible in the echograms records of station 140. For each region δ dB = mean(Sv at 120kHz) – mean (Sv at 38kHz).

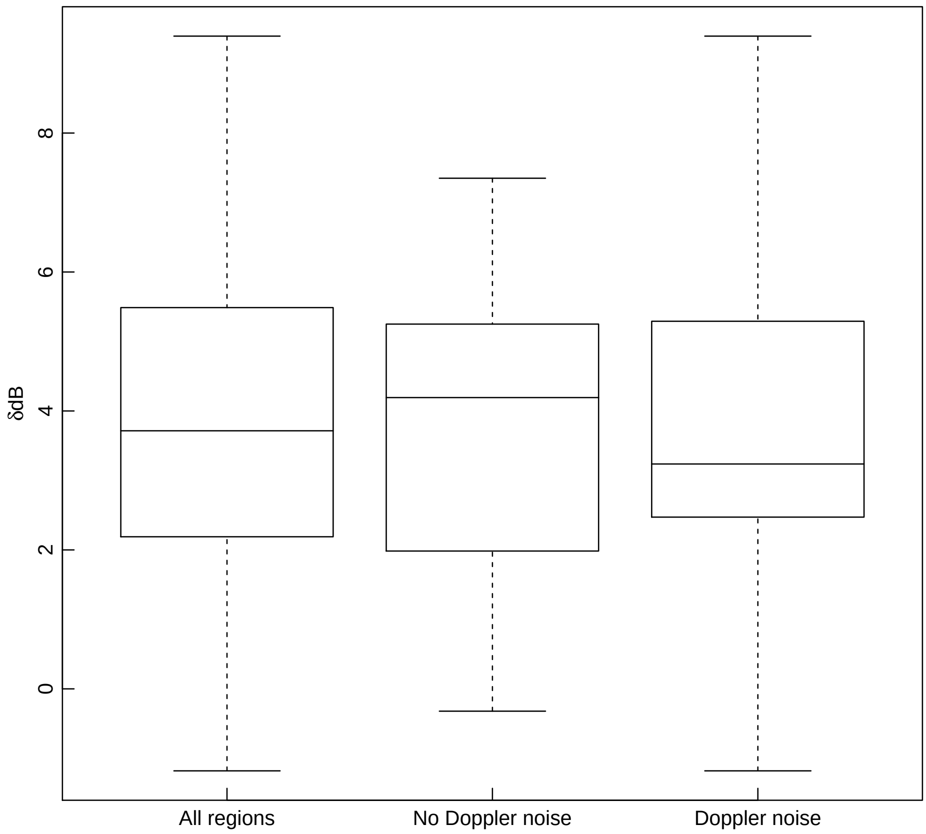


Figure 4. Histogram of δ dB for those aggregations at station 140 where the 120kHz data is not contaminated by interference from the Doppler log.

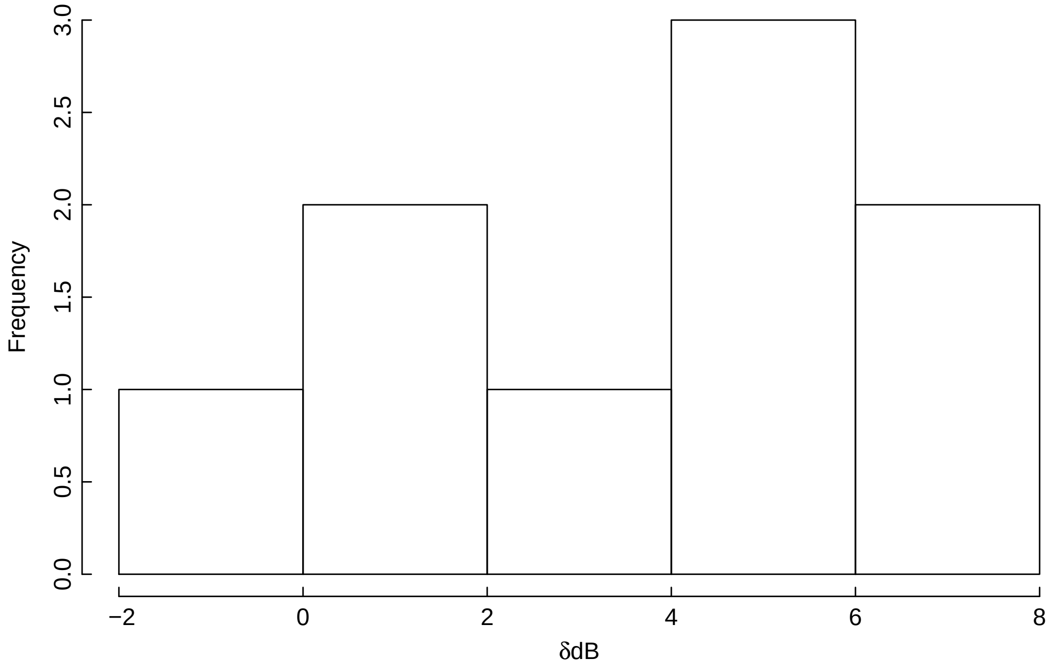



Figure 5. The relationship between δ dB (for those aggregations where the 120kHz data is not contaminated by interference) and (a) aggregation distance off the seabed (b) mean height of the aggregation at station 140.

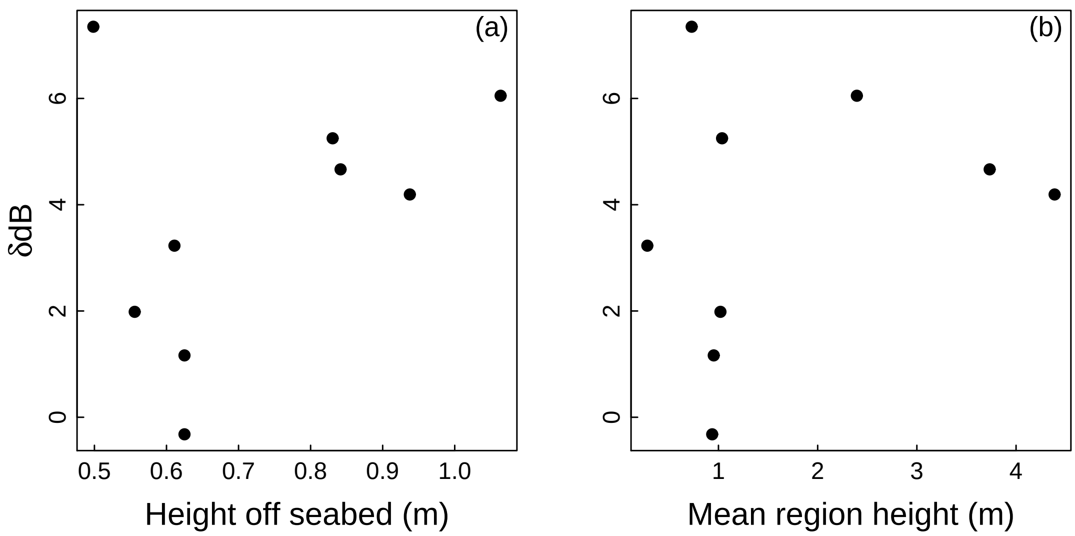
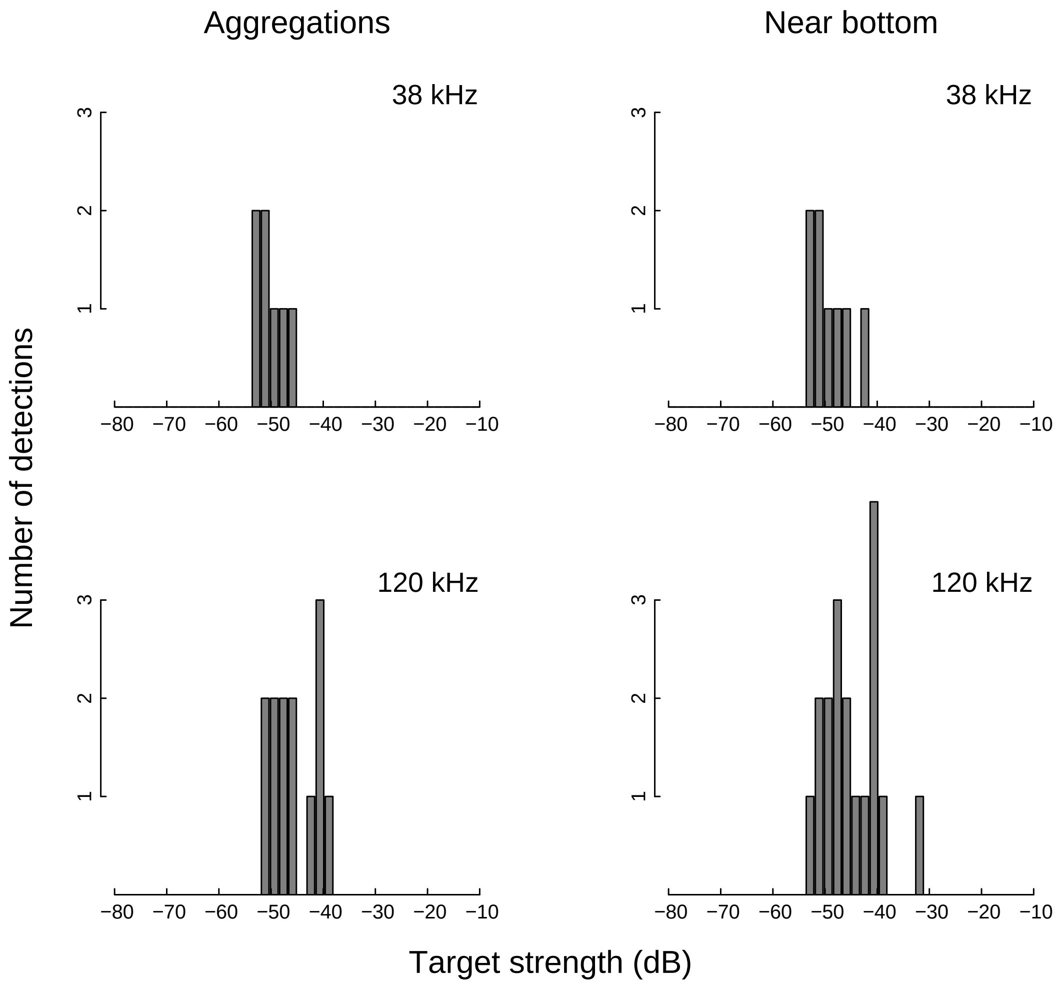


Figure 6. Distributions of target strength of single targets detected over the track trawled at station 140. The left column shows single targets detected in the aggregations identified by the schools detection process, the right column shows all single targets detected within 5m of the seabed.




## *Munida gregaria*

Lobster krill, *Munida gregaria* Fabricius 1793, is abundant in shallow waters around the Falklands. Although small it has a hard carapace that could make it a strong acoustic target. It is therefore important to characterise the acoustic properties of this species to allow it to be distinguished from other acoustic scatterers, especially *L.gahi*, in shallow water echograms.

*M. gregaria* represented a significant proportion of the catch at two shallow water trawl stations off Bleaker Island (station 137, 88.8% of the catch; station 138, 75.7%). During both trawls distinctive marks, particularly strong at 38kHz, were visible (Figure 7). Figure 8 shows the length frequency distribution of *M. gregaria* at these stations along with the distribution of single target strengths from a bottom-referenced layer 4.5m high. The length frequency distributions of *M. gregaria* are rather similar at the two stations. However, the number of single target detections in the bottom layer was much lower (and the mean target strength of detected targets smaller) during station 138. The smaller number of single target detections near the bottom during station 138 correlates well with the echograms which show that the distinctive acoustic marks observed are somewhat sparser, and higher in the water column, during station 138 (a daylight trawl, Figure 10) than during station 137 (a night-time trawl, Figure 7). However the catch of *M. gregaria* at the two stations was rather similar, with 94.5kg taken at station 137 and 69kg at station 138. This suggests that *M. gregaria* were being caught during shooting and hauling as well as when the trawl was on the bottom, with the higher catch during darkness (station 137) reflecting that fact that *M. gregaria* were present closer to the bottom during this trawl. Figure 9 illustrates the distribution of TS of single targets throughout the entire water column.

Figure 7. Echograms from 38kHz (top) and 120kHz (bottom) midway through station 137, a night trawl in ~80m that yielded a rather clean catch of *Munida gregaria*, showing the entire water column. Minimum Sv = -90 dB.

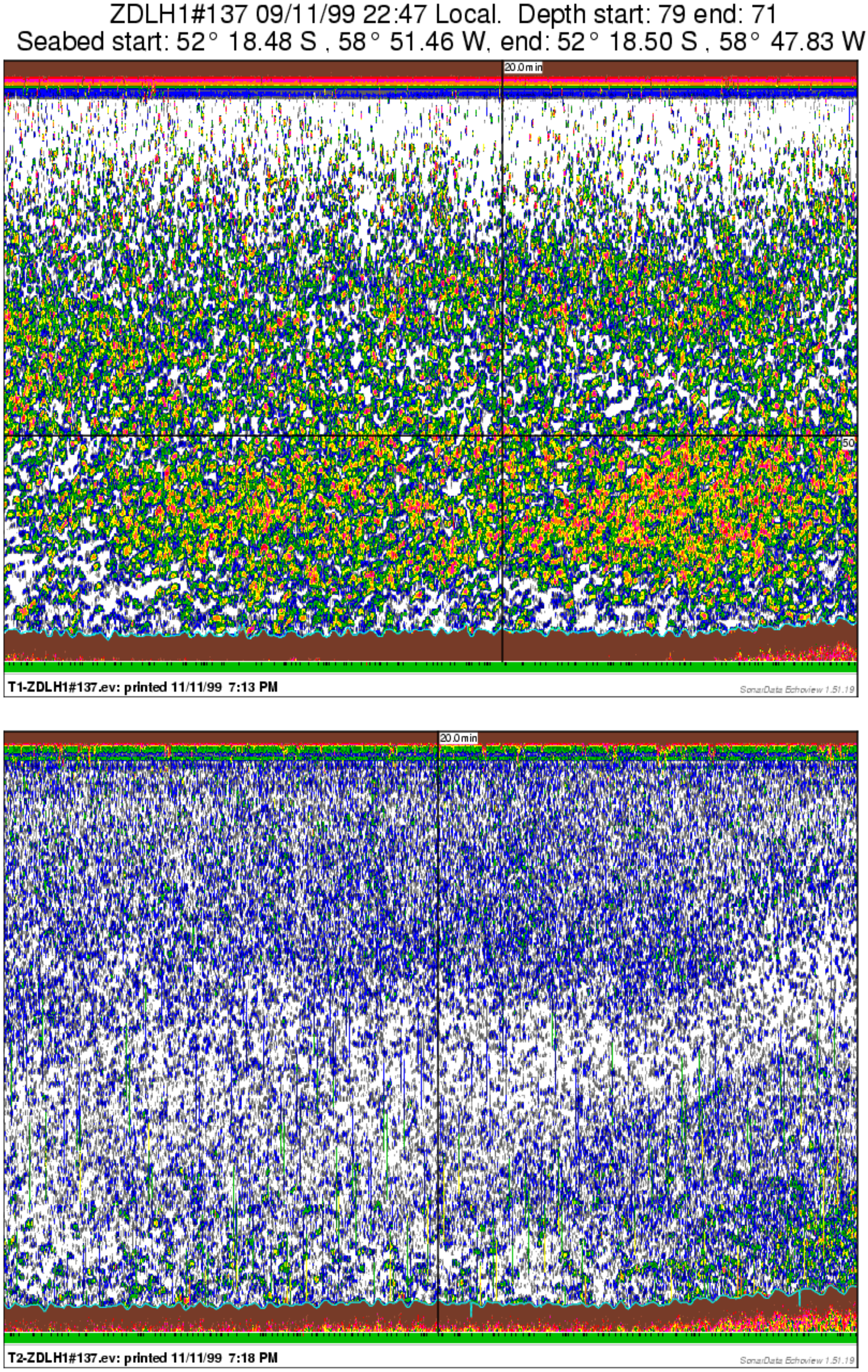


Figure 8. Target strength of single targets detected in the 4.5m layer above the bottom at (a) station 137 and (b) station 138. The third column shows the length-frequency distribution of *Munida gregaria*. (a) $\overline{TS}_{38} = -54.43\text{dB}$, $\overline{TS}_{120} = -54.53\text{dB}$, $\overline{L} = 29.55\text{mm}$; (b) $\overline{TS} = -58.45\text{dB}$, $\overline{TS}_{120} = -62.60\text{dB}$, $\overline{L} = 29.05\text{mm}$. Lines illustrate the kernel density estimate of the probability density.

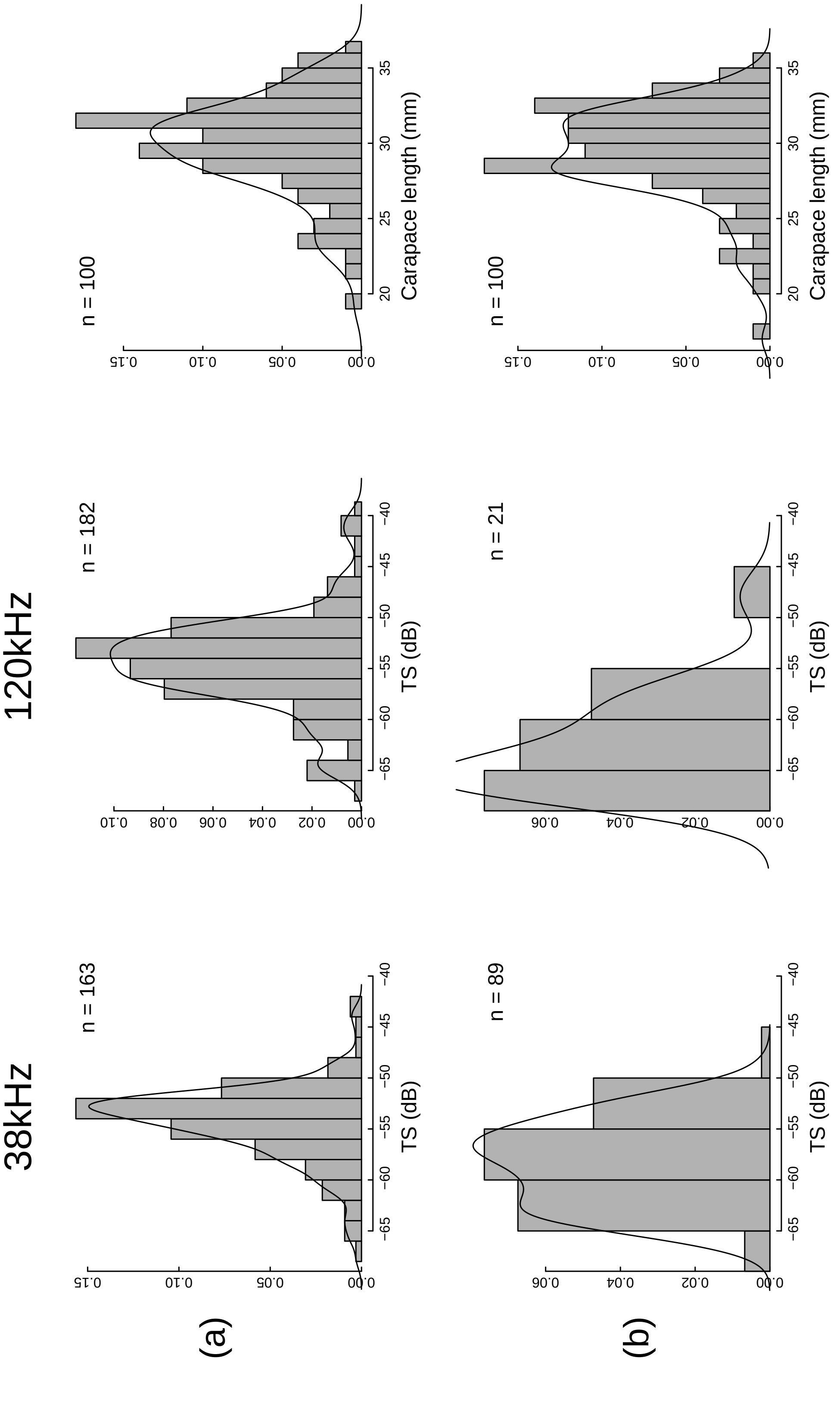
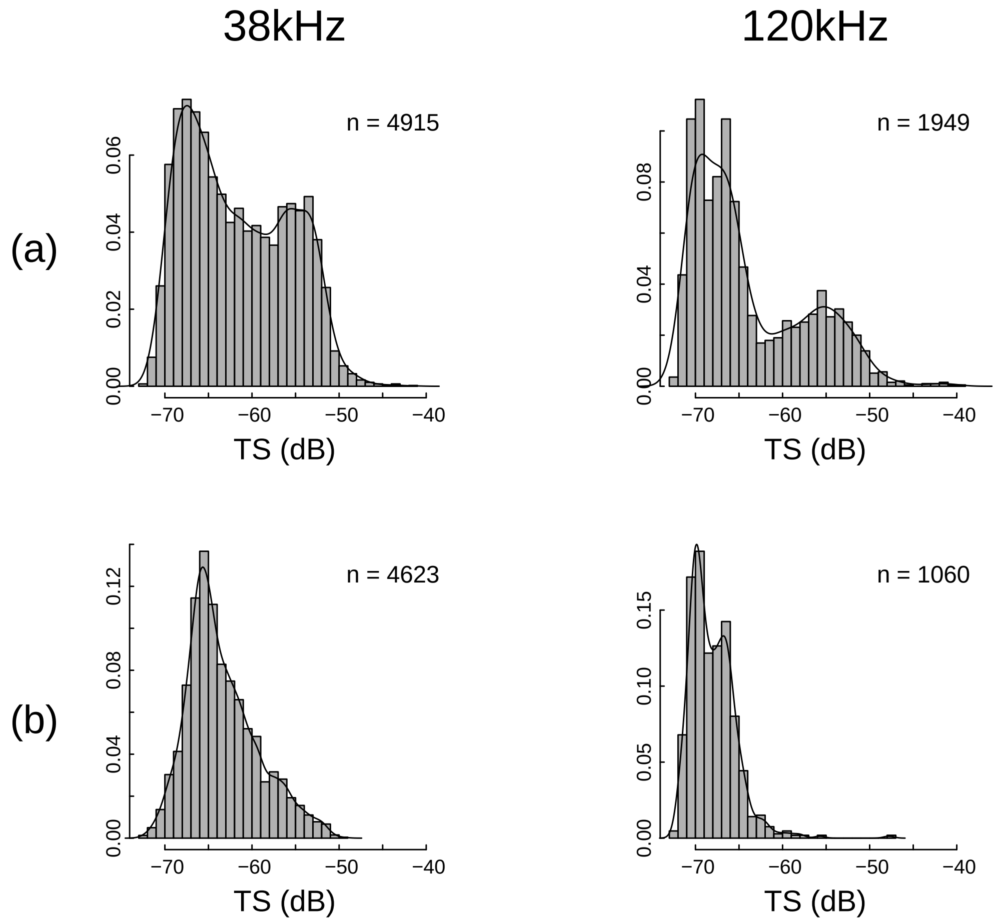


Figure 9. Target strength of single targets detected in the entire water column from 8.5m below the transducer to the bottom (a) station 137, modal $TS_{38} = -67.45\text{dB}$, modal $TS_{120} = -69.24\text{dB}$; (b) station 138, modal $TS_{38} = -65.63\text{dB}$, modal $TS_{120} = -69.87\text{dB}$. Lines illustrate the kernel density estimate of the probability density.




The echograms from both stations 137 and 138 (Figure 7 and Figure 10 respectively) show marks which are clearly stronger at 38kHz than 120kHz. The EchoView schools detection module was again used to outline the individual marks. Despite the rather diffuse pattern of the marks suitable settings allowed the EchoView schools detection module, operating on the clean 38kHz data, to outline the majority of prominent marks. With the large number of individual marks outlined (4385) it was not practical to separate those which, at 120kHz, were contaminated by noise from those that were not. The distribution of difference in mean Sv is unimodal with a mean of –17.7 dB (Figure 11). The average mean volume backscattering over all outlined echo traces was –64.7dB at 38kHz and –82.4dB at 120kHz.

## Discussion

Despite the continued presence of acoustic interference, which makes quantitative studies difficult, the acoustic data gathered during the cruise proved interesting and useful.

Logging of the trawl position data from the Integrated Trawl Instrumentation (ITI) system has proved very useful in the interpretation of acoustic records from trawl stations, in particular it is important in demonstrating whether the acoustic data track matches the track actually trawled.

Figure 10. Whole water-column echograms from 38kHz (top) and 120kHz (bottom) at the start of station 138, a daylight trawl in ~80m that again yielded a clean catch of *Munida gregaria*, though less than that taken at station 137. Minimum Sv = -90 dB.

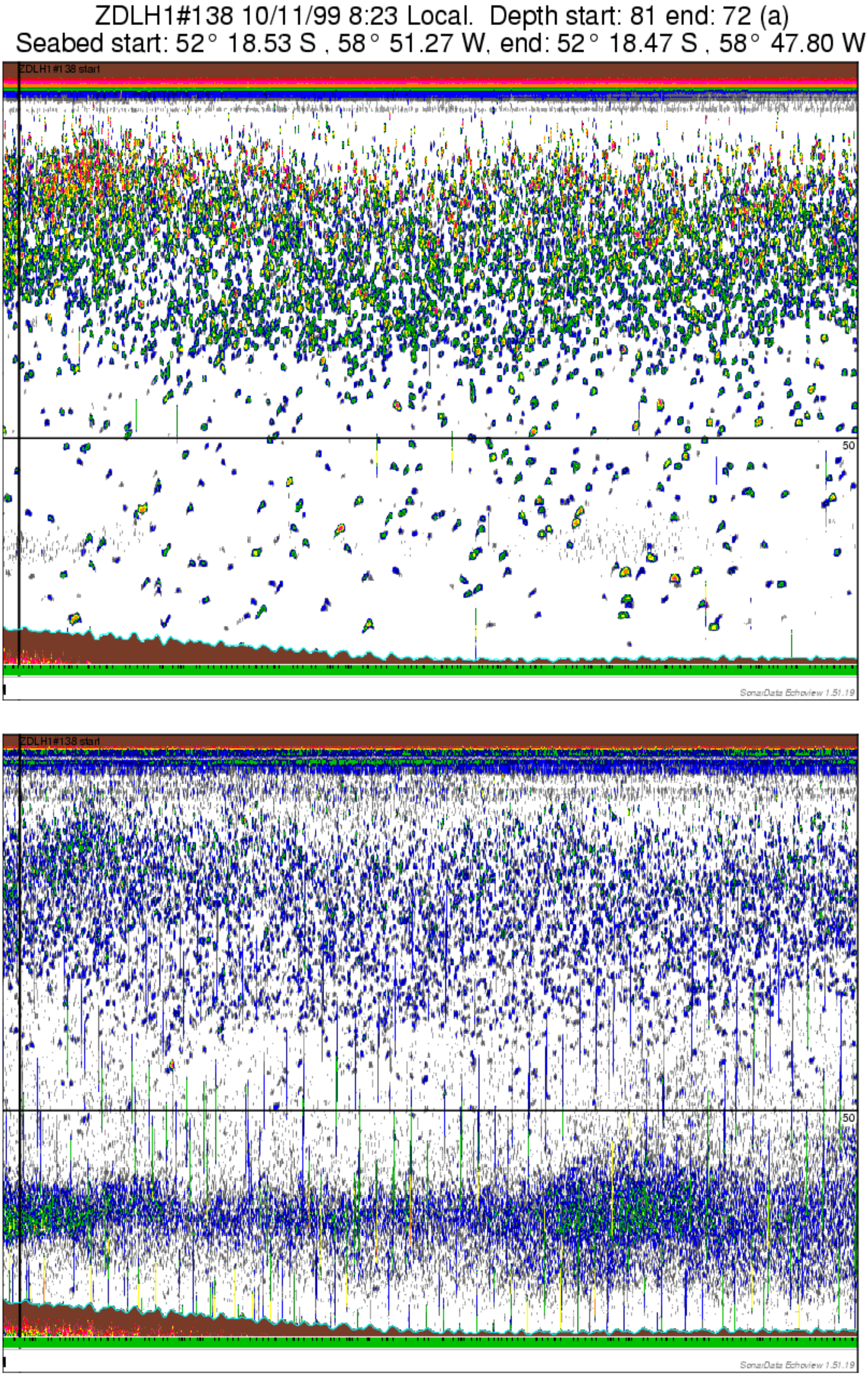
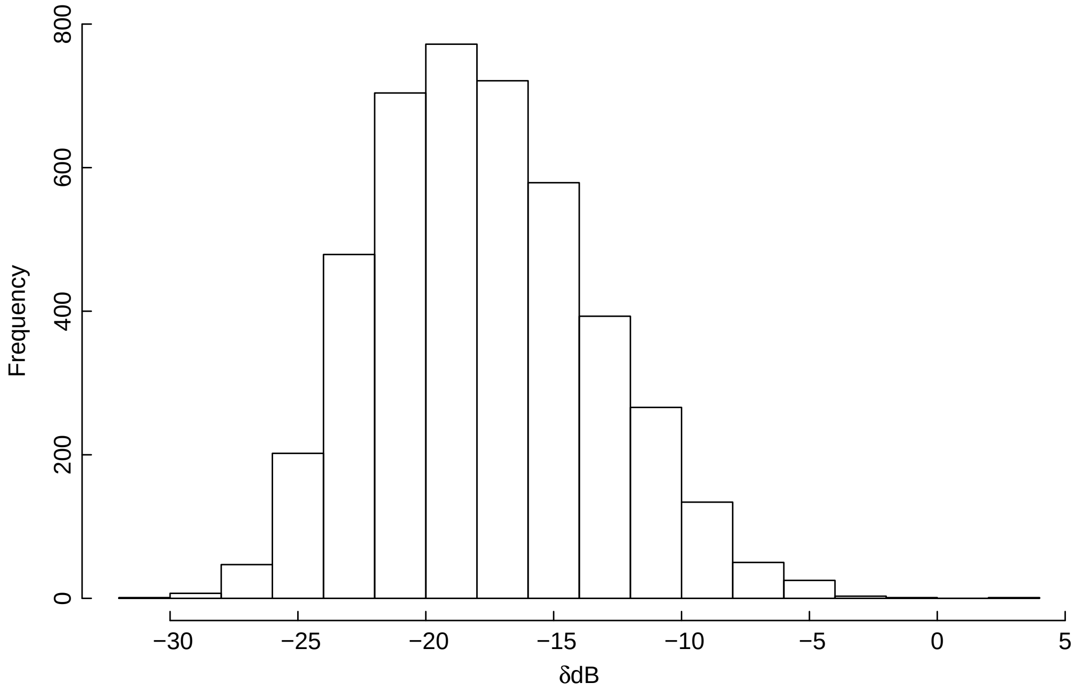


Figure 11. Distribution of difference in mean volume back-scattering strength between 120kHz and 38kHz at station 137. Marks were outlined using the EchoView schools detection module with min. school length set to 2m, min. height 0.8m, min. candidate length 2m, min. candidate height 0.8m, max. vertical linking distance of 1m, max. horizontal linking distance of 2m and min. Sv display threshold set to –72 dB.




The clean catch of *L. gahi* at station 140 was accompanied by marks that were similar to those observed at station 62 during the June survey. The analysis of the properties of automatically detected schools on the echograms from station 140, as discussed above, suggests that a set of criteria for the recognition of "*Loligo* marks" could be defined for use in future acoustic surveying. The acoustic characterisation of other species, both commercial and otherwise, is equally important in this respect and it is therefore useful to have had clean catches of *Munida gregaria* accompanied by distinctive marks and a large number of single target detections. The marks associated with the clean catches of *L. gahi* (station 140, Figure 1) are clearly distinct from those at stations 137 (Figure 7) and 137 (Figure 10). which had clean catches of *M. gregaria*, both in visual appearance and δ Sv (Figure 11).

The difference between the echograms for night and daytime trawls (stations 137 and 138) that were accompanied by high catches of *M. gregaria* raises the question of the extent to which *M. gregaria* were caught in the water column during shooting and hauling of the net. This question also complicates the interpretation of the individual target strength distributions. It is clear from Figure 9 that the group of relatively strong targets at 120kHz (mode around –55dB) that were present during station 137 are absent during station 138. These targets were present only below 50m. Likewise there are fewer strong targets at 38kHz during station 138 than 137. The strong targets at 38kHz are not restricted to the bottom layer. The distributions suggest that there are at least two, and possibly three, groups of targets being identified. At this stage it is not clear which of these is *M. gregaria*, and how these targets combine to produce the large difference in mean backscattering strength observed on the echograms.

Reasonably clean catches of both *Macruronus magellanicus* and *Micromesistius australis* were taken at a number of stations on this research cruise. The accompanying marks have not yet been analysed in detail, but the question of whether the echotraces of these species can be distinguished (other than by trawling) is of particular interest as *Micromesistius australis* is the subject of annual acoustic surveys.

# 4. Biological sampling

Trawling was carried out at 28 stations around East and West Falkland (Figure 21). All trawls were made near the bottom. The bottom trawl used was equipped with polyvalent doors, each weighing 1,200 kg, and a 40 mm cod end liner.

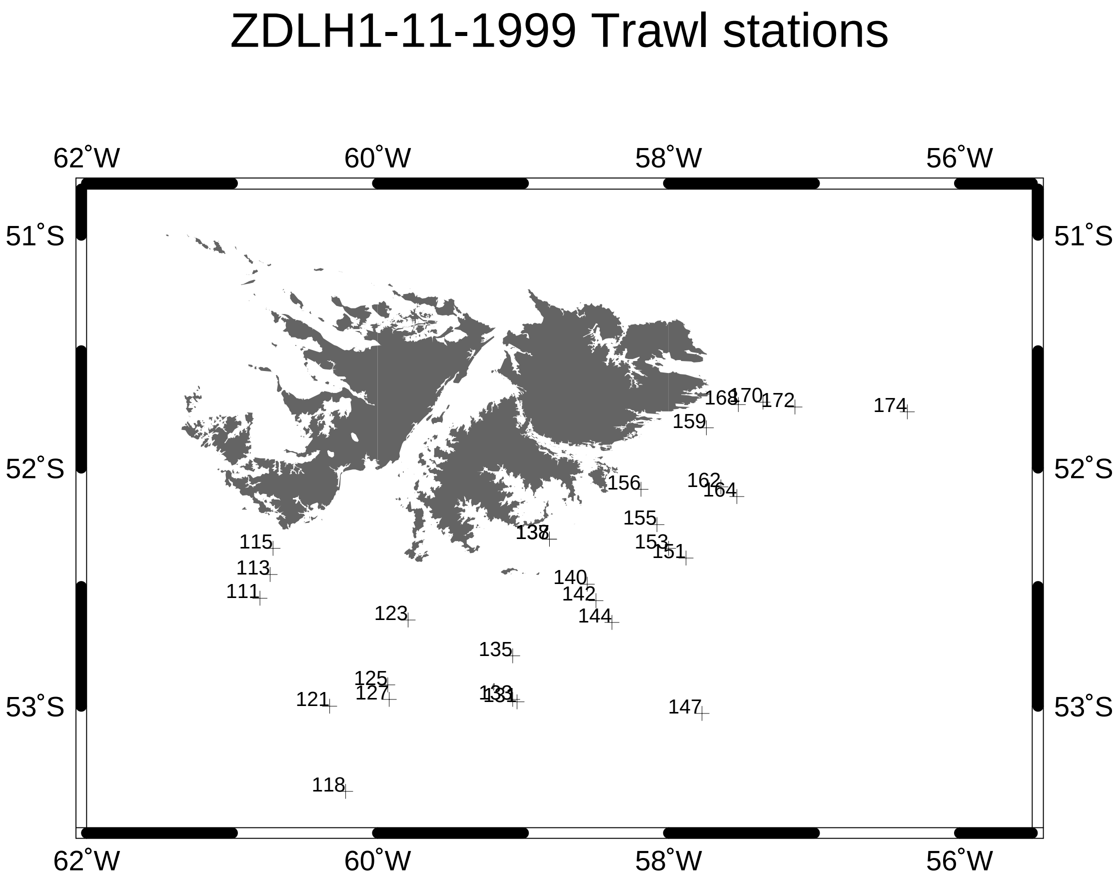
Nineteen stations lay on previously established transects (P1 – P7) where trawling took place at depths of approximately 100 m, 200 m and 300 m. Each of these trawls covered a distance of 3.7 km (2 nautical miles) with an average on-bottom time of 30 minutes. In addition, 3 trawls were carried out at stations of approximately 1000 m, 1 trawl was carried out at 500 m and 3 inshore trawls were carried out at around 70 m. All of these additional trawls had an average on-bottom time of 30 minutes except the deep water trawls at 1000 m which lasted around 200 minutes.

## *4.1 Biological analysis and processing of the catch*

The 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 such as length frequency and/or length weight data from the main catch and a wide variety of by-catch species.
3. Collect parasitological data from *Loligo gahi* and rays.
4. Collect otoliths from juvenile and adult commercial fish species, with an emphasis on the collection of *Dissostichus eleginoides* otoliths.
5. Collect samples of *Loligo gahi* for statolith removal ashore, fecundity studies, DNA analysis and trace element analysis.

Figure 21. Location of trawl stations during the cruise.



## 4.2 Catch and by-catch

Weight and percentage figures (kg & %) are noted in this section without decimals, greater accuracy can be found in Table VII which shows the catch summary by species for the period of the cruise.

A total catch of 26,710 kg was the result of 27 trawled stations. The most predominant species caught was *Macruronus magellanicus* which formed 28 % (7,414 kg) of the total catch. The second most common species caught was *Micromesistius australis* which formed 17 % (4,559 kg) of the total catch. *Macrourus carinatus* almost equalled the *M. australis* catch at 17 % (4,477 kg) of the total catch, but this is probably due to the fact that the majority of *M. carinatus* were caught at the deep water stations which had extended trawl times. This was followed by *Dissostichus eleginoides* which formed 10 % (2,665 kg) of the total catch. Significant catches of *Patagonothen ramsayi*, 2,600 kg (10 % of the total catch) and *Salilota australis*, 2,296 kg (9 % of the total catch) also occurred (Figure 22).

## 4.3 Commercial species

Commercial species caught during the research cruise included *Loligo gahi, Genypterus blacodes, Salilota australis, Merluccius hubbsi, Merluccius asutralis,* Skate and Rays, *Macruronus magellanicus, Micromesistius australis* and *Dissostichus eleginoides*. The latter three finfish species were caught at most stations in large enough quantities to warrant further biological analysis so these species have been discussed in further detail later in this report.

The distribution of commercial species caught and species groups (i.e. those reported to the Fisheries Department in daily catch reports) is illustrated in Figure 22. It can be seen that transects P7, P6 and P5, to the south of the Falkland Islands, gave the greatest yield of commercial species. *S. australis* were particularly abundant at station 115 near Cape Meredith which is a well known fishing ground for this species. Catch weights of *M. hubbsi* and *Merluccius australis* have been combined as this is how they are reported by commercial fishing vessels. These species were not caught in any great quantity with catches only ranging from 0.3 kg to 34 kg. The majority of *Genypterus blacodes* were caught at station 127 with 82 % (198 kg) of their total catch being caught there.

### *Otolith and other sample collection*

At total of 743 otoliths were collected from a number of commercial and by-catch finfish species. Otoliths from the commercial species have joined collection OT99D and will be used for age analysis. The otoliths from the by-catch species will be added to the otolith display board within the department. 462 otoliths were collected from *D. eleginoides* for ageing studies by the Old Dominion University (USA). Other sample collections included a number of finfish in good condition for display within the department as well as a some brachiopods for BAS.

Table VI. Station details.

| ***Station*** | *Standard Station Code* | *Activity* | *Date* | *Time Start* | *Start Seabed Latitude* | *Start Seabed Longitude* | *Finish Seabed Latitude* | *Finish Seabed Longitude* | *Modal Depth (m)* | *Duration Start to Finish (mins)* |
|---|---|---|---|---|---|---|---|---|---|---|
| **103** | | CTD | 03/11/99 | 12:40 | 51° 53.90' S | 58° 09.90' W | 51° 53.90' S | 58° 53.90' W | 42 | 11 |
| **104** | | CTD | 03/11/99 | 15:24 | 52° 04.60' S | 58° 19.70' W | 52° 04.60' S | 58° 19.70' W | 30 | 8 |
| **105** | | CTD | 03/11/99 | 20:11 | 52° 06.00' S | 58° 37.90' W | 52° 06.00' S | 58° 37.90' W | 25 | 5 |
| **106** | | CTD | 04/11/99 | 06:45 | 52° 15.58' S | 58° 59.00' W | 52° 15.58' S | 58° 59.00' W | 30 | 5 |
| **107** | | CTD | 04/11/99 | 09:23 | 52° 18.80' S | 59° 19.50' W | 52° 18.80' S | 59° 19.50' W | 30 | 5 |
| **108** | | CTD | 04/11/99 | 12:52 | 52° 25.05' S | 59° 39.90' W | 52° 25.05' S | 59° 39.90' W | 61 | 7 |
| **109** | | CTD | 05/11/99 | 10:10 | 52° 12.09' S | 60° 26.40' W | 52° 12.09' S | 60° 26.40' W | 41 | 6 |
| **110** | P7-300 | CTD | 06/11/99 | 05:55 | 52° 33.10' S | 60° 55.80' W | 52° 32.80' S | 60° 55.90' W | 303 | 15 |
| **111** | P7-300 | Trawl | 06/11/99 | 06:30 | 52° 33.54' S | 60° 51.28' W | 52° 33.43' S | 60° 46.88' W | 280 | 82 |
| **112** | P7-200 | CTD | 06/11/99 | 08:53 | 52° 26.54' S | 60° 50.65' W | 52° 26.48' S | 60° 50.79' W | 202 | 15 |
| **113** | P7-200 | Trawl | 06/11/99 | 09:24 | 52° 27.08' S | 60° 46.66' W | 52° 27.50' S | 60° 42.95' W | 196 | 69 |
| **114** | P7-100 | CTD | 06/11/99 | 11:39 | 52° 21.68' S | 60° 48.33' W | 52° 21.68' S | 60° 48.41' W | 144 | 11 |
| **115** | P7-100 | Trawl | 06/11/99 | 12:01 | 52° 20.98' S | 60° 45.09' W | 52° 20.24' S | 60° 42.06' W | 126 | 54 |
| **116** | P7-500 | CTD | 06/11/99 | 18:06 | 53° 03.70' S | 61° 20.29' W | 53° 03.70' S | 61° 20.29' W | 483 | 22 |
| **117** | P6-1000 | CTD | 06/11/99 | 23:08 | 53° 23.32' S | 60° 10.91' W | 53° 23.32' S | 60° 10.91' W | 1024 | 48 |
| **118** | | Trawl | 07/11/99 | 05:16 | 53° 23.87' S | 60° 21.33' W | 53° 19.19' S | 60° 05.81' W | 967 | 280 |
| **119** | P6-500 | CTD | 07/11/99 | 11:23 | 53° 08.91' S | 60° 02.08' W | 53° 08.84' S | 60° 01.76' W | 525 | 24 |
| **120** | | CTD | 07/11/99 | 15:34 | 53° 00.35' S | 60° 09.64' W | 53° 00.29' S | 60° 09.30' W | 427 | 21 |
| **121** | | Trawl | 07/11/99 | 16:18 | 53° 00.46' S | 60° 16.69' W | 53° 00.43' S | 60° 23.42' W | 486 | 119 |
| **122** | P6-100 | CTD | 08/11/99 | 05:43 | 52° 37.69' S | 59° 41.15' W | 52° 37.69' S | 59° 41.15' W | 121 | 8 |
| **123** | P6-100 | Trawl | 08/11/99 | 07:06 | 52° 38.52' S | 59° 45.78' W | 52° 39.01' S | 59° 49.06' W | 131 | 74 |
| **124** | P6-200 | CTD | 08/11/99 | 12:08 | 52° 55.39' S | 59° 59.07' W | 52° 55.34' S | 59° 58.94' W | 226 | 12 |
| **125** | P6-200 | Trawl | 08/11/99 | 12:43 | 52° 55.41' S | 59° 58.81' W | 52° 53.93' S | 59° 53.32' W | 199 | 87 |
| **126** | P6-300 | CTD | 08/11/99 | 15:39 | 52° 59.25' S | 59° 59.53' W | 52° 59.09' S | 59° 59.43' W | 328 | 16 |
| **127** | P6-300 | Trawl | 08/11/99 | 16:17 | 52° 58.79' S | 59° 57.19' W | 52° 58.06' S | 59° 53.24' W | 295 | 79 |
| **128** | P5-1000 | CTD | 08/11/99 | 21:35 | 53° 18.89' S | 59° 01.79' W | 53° 18.93' S | 59° 01.30' W | 1007 | 43 |
| **129** | P5-500 | CTD | 08/11/99 | 23:56 | 53° 04.82' S | 59° 04.47' W | 53° 04.92' S | 59° 04.29' W | 524 | 23 |
| **130** | P5-300 | CTD | 09/11/99 | 05:41 | 52° 59.60' S | 59° 06.11' W | 52° 59.64' S | 59° 05.87' W | 294 | 16 |
| **131** | P5-300 | Trawl | 09/11/99 | 06:28 | 52° 59.47' S | 59° 05.31' W | 52° 58.74' S | 59° 00.40' W | 309 | 98 |

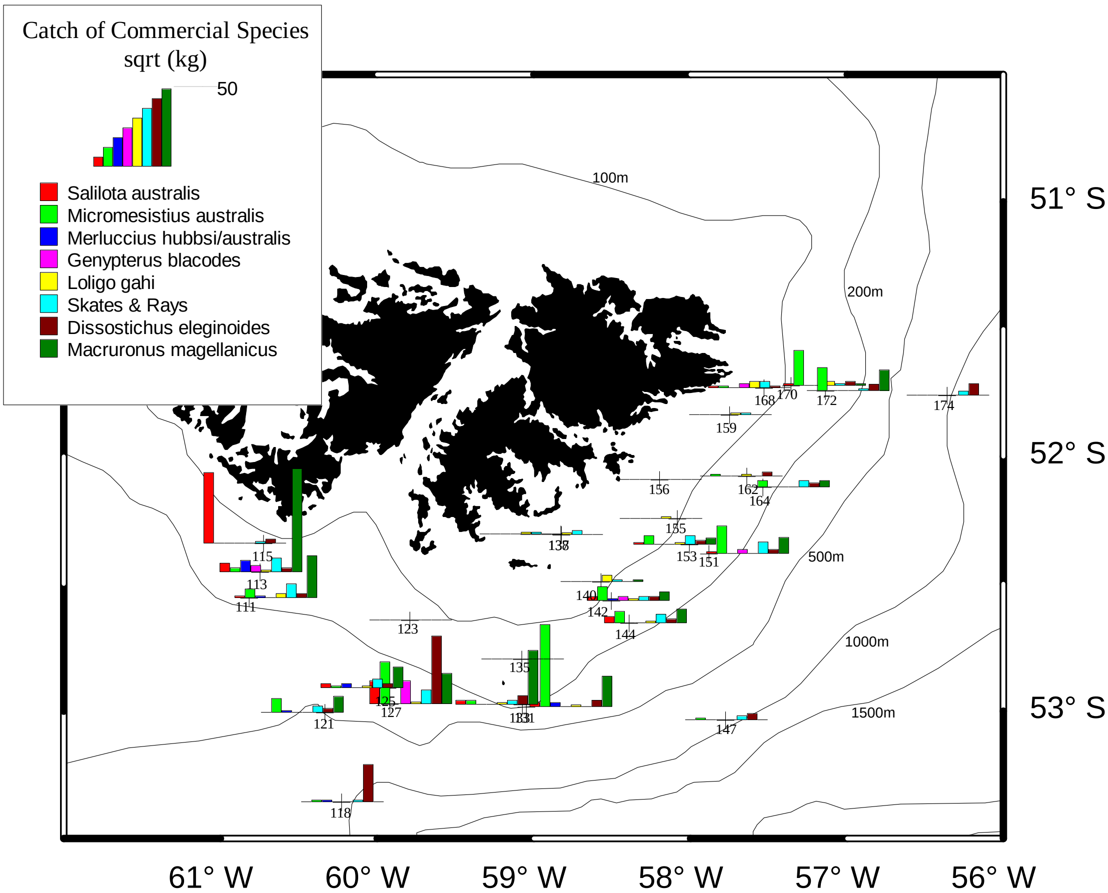
| ***Station*** | *Standard Station Code* | *Activity* | *Date* | *Time Start* | *Start Seabed Latitude* | *Start Seabed Longitude* | *Finish Seabed Latitude* | *Finish Seabed Longitude* | *Modal Depth (m)* | *Duration Start to Finish (mins)* |
|---|---|---|---|---|---|---|---|---|---|---|
| **132** | P5-200 | CTD | 09/11/99 | 09:00 | 52° 58.74' S | 59° 07.33' W | 52° 58.77' S | 59° 07.27' W | 205 | 12 |
| **133** | P5-200 | Trawl | 09/11/99 | 09:37 | 52° 58.81' S | 59° 07.28' W | 52° 58.38' S | 59° 01.45' W | 210 | 90 |
| **134** | P5-100 | CTD | 09/11/99 | 13:52 | 52° 46.44' S | 59° 08.01' W | 52° 46.45' S | 59° 07.94' W | 111 | 8 |
| **135** | P5-100 | Trawl | 09/11/99 | 14:16 | 52° 47.38' S | 59° 06.08' W | 52° 48.34' S | 59° 03.00' W | 114 | 87 |
| **136** | | CTD | 09/11/99 | 22:10 | 52° 18.14' S | 58° 53.10' W | 52° 18.12' S | 58° 53.11' W | 73 | 7 |
| **137** | | Trawl | 09/11/99 | 22:32 | 52° 18.48' S | 58° 51.46' W | 52° 18.50' S | 58° 47.83' W | 75 | 35 |
| **138** | | Trawl | 10/11/99 | 08:08 | 52° 18.53' S | 58° 51.27' W | 52° 18.47' S | 58° 47.80' W | 76 | 62 |
| **139** | P4-100 | CTD | 10/11/99 | 11:13 | 52° 28.31' S | 58° 31.82' W | 52° 28.31' S | 58° 31.84' W | 119 | 9 |
| **140** | P4-100 | Trawl | 10/11/99 | 11:45 | 52° 28.78' S | 58° 32.90' W | 52° 30.64' S | 58° 35.49' W | 123 | 83 |
| **141** | P4-200 | CTD | 10/11/99 | 14:53 | 52° 33.97' S | 58° 30.23' W | 52° 33.97' S | 58° 30.23' W | 185 | 13 |
| **142** | P4-200 | Trawl | 10/11/99 | 15:33 | 52° 33.06' S | 58° 29.51' W | 52° 35.13' S | 58° 30.87' W | 191 | 70 |
| **143** | P4-300 | CTD | 10/11/99 | 18:45 | 52° 40.80' S | 58° 26.60' W | 52° 40.80' S | 58° 26.40' W | 289 | 16 |
| **144** | P4-300 | Trawl | 10/11/99 | 19:29 | 52° 40.32' S | 58° 25.79' W | 52° 38.56' S | 58° 21.25' W | 306 | 98 |
| **145** | P4-500 | CTD | 10/11/99 | 23:22 | 53° 00.02' S | 58° 09.10' W | 52° 59.96' S | 58° 08.81' W | 555 | 24 |
| **146** | P4-1000 | CTD | 11/11/99 | 06:09 | 53° 08.80' S | 58° 01.20' W | 53° 08.57' S | 58° 00.64' W | 1014 | 50 |
| **147** | | Trawl | 11/11/99 | 11:56 | 53° 04.48' S | 57° 55.85' W | 53° 00.05' S | 57° 37.01' W | 884 | 283 |
| **148** | P3-1000 | CTD | 11/11/99 | 17:49 | 52° 56.62' S | 57° 19.42' W | 52° 56.21' S | 57° 18.71' W | 989 | 46 |
| **149** | P3-500 | CTD | 11/11/99 | 20:03 | 52° 45.22' S | 57° 32.92' W | 52° 45.01' S | 57° 32.83' W | 525 | 24 |
| **150** | P3-300 | CTD | 12/11/99 | 05:51 | 52° 25.32' S | 57° 58.65' W | 52° 25.28' S | 57° 58.39' W | 291 | 16 |
| **151** | P3-300 | Trawl | 12/11/99 | 06:27 | 52° 24.44' S | 57° 55.92' W | 52° 21.60' S | 57° 50.07' W | 301 | 123 |
| **152** | P3-200 | CTD | 12/11/99 | 09:35 | 52° 18.15' S | 57° 57.09' W | 52° 18.13' S | 57° 56.96' W | 185 | 11 |
| **153** | P3-200 | Trawl | 12/11/99 | 09:56 | 52° 19.73' S | 57° 58.93' W | 52° 21.86' S | 58° 01.64' W | 212 | 77 |
| **154** | P3-100 | CTD | 12/11/99 | 13:32 | 52° 14.65' S | 58° 06.38' W | 52° 14.65' S | 58° 06.32' W | 114 | 9 |
| **155** | P3-100 | Trawl | 12/11/99 | 15:04 | 52° 14.98' S | 58° 07.03' W | 52° 14.71' S | 58° 02.88' W | 116 | 86 |
| **156** | | Trawl | 12/11/99 | 19:37 | 52° 04.69' S | 58° 10.95' W | 52° 06.55' S | 58° 12.70' W | 60 | 69 |
| **157** | | CTD | 12/11/99 | 21:12 | 52° 05.79' S | 58° 11.49' W | 52° 05.80' S | 58° 11.46' W | 62 | 7 |
| **158** | | CTD | 13/11/99 | 06:55 | 51° 48.81' S | 57° 43.48' W | 51° 48.82' S | 57° 43.47' W | 89 | 8 |
| **159** | | Trawl | 13/11/99 | 07:22 | 51° 49.27' S | 57° 44.15' W | 51° 51.39' S | 57° 45.64' W | 90 | 64 |
| **160** | P2-100 | CTD | 13/11/99 | 09:26 | 52° 00.43' S | 57° 44.13' W | 52° 00.48' S | 57° 44.11' W | 129 | 8 |
| **161** | P2-200 | CTD | 13/11/99 | 10:33 | 52° 02.62' S | 57° 34.80' W | 52° 02.64' S | 57° 34.77' W | 209 | 12 |
| **162** | P2-200 | Trawl | 13/11/99 | 11:02 | 52° 03.77' S | 57° 36.81' W | 52° 05.92' S | 57° 40.00' W | 190 | 90 |

| ***Station*** | *Standard Station Code* | *Activity* | *Date* | *Time Start* | *Start Seabed Latitude* | *Start Seabed Longitude* | *Finish Seabed Latitude* | *Finish Seabed Longitude* | *Modal Depth (m)* | *Duration Start to Finish (mins)* |
|---|---|---|---|---|---|---|---|---|---|---|
| **163** | P2-300 | CTD | 13/11/99 | 14:07 | 52° 05.79' S | 57° 30.18' W | 52° 05.90' S | 57° 30.15' W | 297 | 17 |
| **164** | P2-300 | Trawl | 13/11/99 | 14:50 | 52° 06.01' S | 57° 30.52' W | 52° 08.80' S | 57° 34.16' W | 289 | 75 |
| **165** | | CTD | 13/11/99 | 20:21 | 52° 16.91' S | 57° 07.88' W | 52° 17.06' S | 57° 07.36' W | 592 | 27 |
| **166** | | CTD | 13/11/99 | 22:49 | 52° 29.18' S | 56° 40.52' W | 52° 29.45' S | 56° 40.28' W | 1063 | 45 |
| **167** | P1-100 | CTD | 14/11/99 | 09:36 | 51° 42.49' S | 57° 32.18' W | 51° 42.54' S | 57° 32.12' W | 113 | 9 |
| **168** | P1-100 | Trawl | 14/11/99 | 10:13 | 51° 42.67' S | 57° 32.22' W | 51° 45.35' S | 57° 31.37' W | 119 | 73 |
| **169** | P1-200 | CTD | 15/11/99 | 05:48 | 51° 42.51' S | 57° 20.40' W | 51° 42.51' S | 57° 20.28' W | 201 | 12 |
| **170** | P1-200 | Trawl | 15/11/99 | 06:29 | 51° 42.02' S | 57° 20.35' W | 51° 44.78' S | 57° 22.66' W | 199 | 82 |
| **171** | P1-300 | CTD | 15/11/99 | 09:19 | 51° 42.11' S | 57° 06.26' W | 51° 42.16' S | 57° 06.26' W | 324 | 14 |
| **172** | P1-300 | Trawl | 15/11/99 | 09:50 | 51° 43.05' S | 57° 07.55' W | 51° 46.23' S | 57° 09.08' W | 310 | 97 |
| **173** | P1-500 | CTD | 15/11/99 | 13:00 | 51° 44.76' S | 56° 42.48' W | 51° 44.83' S | 56° 42.28' W | 508 | 24 |
| **174** | P1-1000 | Trawl | 15/11/99 | 16:24 | 51° 41.39' S | 56° 16.48' W | 51° 49.94' S | 56° 26.90' W | 926 | 300 |
| **175** | P1-1000 | CTD | 15/11/99 | 22:32 | 51° 45.83' S | 56° 10.98' W | 51° 45.72' S | 56° 10.70' W | 1008 | 41 |
| **176** | | CTD | 16/11/99 | 13:21 | 51° 39.88' S | 57° 36.05' W | 51° 39.91' S | 57° 36.04' W | 72 | 7 |
| **177** | | CTD | 19/11/99 | 15:11 | 51° 35.73' S | 57° 47.59' W | 51° 35.73' S | 57° 47.59' W | 33 | 5 |
| **178** | | CTD | 19/11/99 | 19:31 | 51° 33.73' S | 57° 59.83' W | 51° 33.73' S | 57° 59.83' W | 24 | 5 |
| **179** | | CTD | 20/11/99 | 09:17 | 51° 27.33' S | 57° 47.68' W | 51° 27.36' S | 57° 47.60' W | 34 | 7 |
| **180** | | CTD | 20/11/99 | 11:26 | 51° 22.96' S | 57° 52.35' W | 51° 22.96' S | 57° 52.35' W | 34 | 6 |
| **181** | | CTD | 20/11/99 | 13:11 | 51° 21.60' S | 58° 04.10' W | 51° 21.60' S | 58° 04.09' W | 32 | 6 |
| **182** | | CTD | 20/11/99 | 16:00 | 51° 21.59' S | 58° 18.15' W | 51° 21.59' S | 58° 18.13' W | 24 | 6 |
| **183** | | CTD | 21/11/99 | 14:05 | 51° 28.74' S | 59° 05.76' W | 51° 28.74' S | 59° 05.76' W | 15 | 6 |
| **184** | | CTD | 21/11/99 | 19:03 | 51° 37.09' S | 59° 16.81' W | 51° 37.07' S | 59° 16.85' W | 56 | 5 |
| **185** | | CTD | 21/11/99 | 20:01 | 51° 39.30' S | 59° 29.21' W | 51° 39.28' S | 59° 29.19' W | 37 | 7 |
| **186** | | CTD | 22/11/99 | 08:39 | 51° 49.30' S | 59° 32.48' W | 51° 49.38' S | 59° 32.53' W | 68 | 8 |
| **187** | | CTD | 22/11/99 | 11:02 | 51° 54.18' S | 59° 38.07' W | 51° 54.17' S | 59° 38.06' W | 22 | 6 |
| **188** | | CTD | 22/11/99 | 12:55 | 51° 52.01' S | 59° 44.30' W | 51° 52.02' S | 59° 44.39' W | 33 | 7 |
| **189** | | CTD | 22/11/99 | 14:40 | 52° 00.25' S | 59° 50.30' W | 52° 00.25' S | 59° 50.28' W | 21 | 6 |
| **190** | | CTD | 23/11/99 | 14:19 | 52° 13.43' S | 59° 20.30' W | 52° 13.43' S | 59° 20.31' W | 23 | 6 |
| **191** | | CTD | 23/11/99 | 18:11 | 52° 10.87' S | 59° 17.94' W | 52° 10.87' S | 59° 17.95' W | 16 | 5 |
| **192** | | CTD | 24/11/99 | 10:41 | 51° 22.97' S | 57° 52.02' W | 51° 22.97' S | 57° 51.98' W | 36 | 6 |

Table VII. Catch summary by species, ZDLH1 6 – 16 November 1999. Percentages are given to two decimal places only.

| | *Species name* | *Species Code* | *Total Catch (kg)* | *Proportion of Total Catch (%)* | *Total Sampled (kg)* | *Total Discarded (kg)* |
|---|---|---|---|---|---|---|
| 1 | MACRURONUS MAGELLANICUS | WHI | 7,413.92 | 27.76% | 895.86 | 7413.92 |
| 2 | MICROMESISTIUS AUSTRALIS | BLU | 4,559.22 | 17.07% | 450.8 | 4559.22 |
| 3 | MACROURUS CARINATUS | GRC | 4,477.64 | 16.76% | 233.14 | 4477.64 |
| 4 | DISSOSTICHUS ELEGINOIDES | TOO | 2,665.42 | 9.98% | 1167.24 | 2654.92 |
| 5 | PATAGONOTOTHEN RAMSAYI | PAR | 2,600.38 | 9.74% | 23.5 | 2600.38 |
| 6 | SALILOTA AUSTRALIS | BAC | 2,296.44 | 8.60% | 137.05 | 2296.44 |
| 7 | COELORHYNCHUS FASCIATUS | GRF | 478.36 | 1.79% | 0 | 478.36 |
| 8 | ANTIMORA ROSTRATA | ANR | 437.5 | 1.64% | 0 | 437.5 |
| 9 | BATHYRAJA GRISEOCAUDA | RGR | 273.94 | 1.03% | 273.94 | 273.94 |
| 10 | GENYPTERUS BLACODES | KIN | 241.5 | 0.90% | 230.5 | 236.5 |
| 11 | MUNIDA GREGARIA | MUN | 172.64 | 0.65% | 1.06 | 172.64 |
| 12 | UNIDENTIFIED RAY #3 | RBZ | 120.88 | 0.45% | 120.76 | 120.88 |
| 13 | MACROURUS HOLOTRACHYS | GRH | 88.9 | 0.33% | 0 | 88.9 |
| 14 | LOLIGO GAHI | LOL | 72.16 | 0.27% | 49.74 | 59.94 |
| 15 | GYMNOSCOPELUS NICHOLSI | GYN | 62.1 | 0.23% | 0.84 | 62.1 |
| 16 | ELEGINOPS MACLOVINUS | MUL | 54.76 | 0.21% | 0 | 54.76 |
| 17 | LAMNA NASUS | POR | 50 | 0.19% | 0 | 50 |
| 18 | SPONGES | SPN | 45.92 | 0.17% | 0 | 45.92 |
| 19 | ILUOCOETES FIMBRIATUS | EEL | 40.68 | 0.15% | 0 | 40.68 |
| 20 | LITHODES ANTARCTICUS | LIA | 39 | 0.15% | 0 | 39 |
| 21 | MERLUCCIUS HUBBSI | HAK | 37.98 | 0.14% | 37.98 | 37.98 |
| 22 | COTTOPERCA GOBIO | CGO | 36.84 | 0.14% | 1.5 | 36.84 |
| 23 | MACROURUS WHITSONI | GRW | 34 | 0.13% | 0 | 34 |
| 24 | ANTHOZOA | ANT | 33.22 | 0.12% | 0 | 33.22 |
| 25 | SPRATTUS FUEGENSIS | SAR | 32.36 | 0.12% | 6.98 | 32.36 |
| 26 | MERLUCCIUS AUSTRALIS | PAT | 25.86 | 0.10% | 25.86 | 25.86 |
| 27 | BATHYRAJA MULTISPINIS | RMU | 24.5 | 0.09% | 24.5 | 24.5 |
| 28 | BATHYRAJA BRACHYUROPS | RBR | 22.94 | 0.09% | 22.94 | 22.94 |
| 29 | BATHYRAJA ALBOMACULATA | RAL | 22.7 | 0.08% | 22.7 | 22.7 |
| 30 | MEDUSAE SP. | MED | 22.02 | 0.08% | 0 | 22.02 |
| 31 | SEA URCHIN | UCH | 21.06 | 0.08% | 0 | 21.06 |
| 32 | ASTEROIDEA | AST | 20.7 | 0.08% | 0 | 20.7 |
| 33 | SCALLOP | SCA | 17.02 | 0.06% | 0 | 5.52 |
| 34 | PSEUDOCYTTUS MACULATUS | PSM | 13.5 | 0.05% | 2.62 | 13.5 |
| 35 | BATHYRAJA MACLOVIANA | RMC | 12.74 | 0.05% | 12.74 | 12.74 |
| 36 | PHYSICULUS MARGINATUS | PYM | 12.22 | 0.05% | 0 | 12.22 |
| 37 | ASCIDIACEA | SQT | 11.34 | 0.04% | 0 | 11.34 |
| 38 | ECHIODON CRYOMARGARITES | ECC | 9.3 | 0.03% | 0 | 9.3 |
| 39 | BATHYRAJA MERIDIONALIS | RME | 9.12 | 0.03% | 0 | 0 |
| 40 | BATHYRAJA SCAPHIOPS | RSC | 9.03 | 0.03% | 9.03 | 9.03 |
| 41 | MURAENOLEPIS ORANGIENSIS | MUO | 6.34 | 0.02% | 6.34 | 6.34 |
| 42 | MOROTEUTHIS INGENS | ING | 6.14 | 0.02% | 0 | 0.38 |
| 43 | SCHROEDERICHTHYS BIVIUS | DGH | 6.1 | 0.02% | 3.66 | 6.1 |
| 44 | ANEMONE | ANM | 5.94 | 0.02% | 0 | 5.94 |
| 45 | BATHYRAJA PAPILIONIFERA | RPA | 5.8 | 0.02% | 0 | 5.8 |
| 46 | RAJA FLAVIROSTRIS | RFL | 5.6 | 0.02% | 5.6 | 5.6 |
| 47 | SEBASTES OCULATUS | RED | 5.5 | 0.02% | 0 | 0 |
| 49 | WHELKS | WLK | 4.05 | 0.02% | 0 | 4.05 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 48 | PATAGONOTOTHEN TESSELLATA | PTE | 4.54 | 0.02% | 0 | 4.54 |
| 50 | BATHYRAJA MAGELLANICA | RMG | 3.85 | 0.01% | 2.27 | 3.85 |
| 51 | NOTACANTHUS SEXSPINIS | NOS | 3.48 | 0.01% | 1.12 | 3.48 |
| 52 | PSAMMOBATIS SCOBINA | RPS | 3.2 | 0.01% | 3.2 | 3.2 |
| 53 | GYMNOSCOPELUS FRASERI | GYF | 2.84 | 0.01% | 0 | 2.84 |
| 54 | RAJA DOELLOJURADOI | RDO | 2.62 | 0.01% | 1.18 | 2.62 |
| 55 | ICICHTHYS AUSTRALIS | ICA | 2.38 | 0.01% | 1.64 | 2.38 |
| 56 | PASIPHAEA ACUTIFRONS | PAC | 2.12 | 0.01% | 0 | 2.12 |
| 57 | CORYPHAENOIDES SUBSERRULATUS | COS | 2.00 | 0.01% | 0 | 2 |
| 58 | ACANTHEPHYRA PELAGICA | ACP | 1.52 | 0.01% | 0 | 1.52 |
| 59 | HALARGYREUS JOHNSONII | HAJ | 1.32 | 0.00% | 0 | 1.32 |
| 60 | OCTOPUS MEGALOCYATHUS | OCM | 1.22 | 0.00% | 0 | 0 |
| 61 | MANCOPSETTA MACULATA | MMA | 1.14 | 0.00% | 0 | 1.14 |
| 62 | CERATIAS TENTACULATUS | CET | 1.06 | 0.00% | 0 | 1.06 |
| 63 | SQUALUS ACANTHIAS | DGS | 1.04 | 0.00% | 0 | 1.04 |
| 64 | MANCOPSETTA SP. | MAN | 1.04 | 0.00% | 0 | 0 |
| 65 | COELORINCHUS CF.FLABELLISPINIS | COF | 0.86 | 0.00% | 0 | 0.86 |
| 66 | BENTHOCTOPUS EUREKA | BEE | 0.80 | 0.00% | 0 | 0.58 |
| 67 | LEPIDION ENSIFERUS | LEE | 0.73 | 0.00% | 0 | 0.73 |
| 68 | STROMATEUS BRASILIENSIS | BUT | 0.72 | 0.00% | 0 | 0.72 |
| 69 | THYMOPS BIRSTEINI | THB | 0.66 | 0.00% | 0 | 0.66 |
| 70 | ALEPOCEPHALUS PRODUCTUS | ALP | 0.60 | 0.00% | 0 | 0.6 |
| 71 | MYXINE AUSTRALIS | MYA | 0.54 | 0.00% | 0 | 0.54 |
| 72 | CAMPYLONOTUS SEMISTRIATUS | CAS | 0.46 | 0.00% | 0 | 0.46 |
| 73 | HOLOTHUROIDEA | HOL | 0.44 | 0.00% | 0 | 0.44 |
| 74 | GYMNOSCOPELUS BRAURI | GYR | 0.39 | 0.00% | 0 | 0.39 |
| 75 | PSAMMOBATIS EXTENTA | REX | 0.38 | 0.00% | 0 | 0.38 |
| 76 | CARISTIUS GROENLANDICUS | CAG | 0.36 | 0.00% | 0 | 0.36 |
| 77 | BRACHIOPOD SPP. | BRP | 0.33 | 0.00% | 0.06 | 0.05 |
| 78 | CRUSTACEA | CRU | 0.32 | 0.00% | 0 | 0.32 |
| 79 | PELTARION SPINOSULUM | PES | 0.32 | 0.00% | 0 | 0.1 |
| 80 | COTTUNCULUS GRANULOSUS | COT | 0.28 | 0.00% | 0 | 0.28 |
| 81 | MYCTOPHID SPP. | MXX | 0.24 | 0.00% | 0 | 0.24 |
| 82 | LAMPINICTUS ACHURUS | LAA | 0.22 | 0.00% | 0 | 0.22 |
| 83 | EPIGONUS ROBUSTUS | EPR | 0.2 | 0.00% | 0 | 0.2 |
| 84 | PSAMMOBATIS SPP. | RPX | 0.18 | 0.00% | 0.18 | 0.18 |
| 85 | HISTIOTEUTHIS SPP. | HIX | 0.16 | 0.00% | 0 | 0 |
| 86 | POLYCHAETA | POL | 0.15 | 0.00% | 0 | 0.15 |
| 87 | GONATUS ANTARCTICUS | GON | 0.13 | 0.00% | 0 | 0.01 |
| 88 | CAMPYLONOTUS VAGANS | CAV | 0.11 | 0.00% | 0 | 0.11 |
| 89 | ANOTOPTERUS PHARAO | ANP | 0.08 | 0.00% | 0 | 0.08 |
| 90 | CHAMPSOCEPHALUS ESOX | CHE | 0.08 | 0.00% | 0 | 0.08 |
| 91 | NUDIBRANCHIA | NUD | 0.08 | 0.00% | 0 | 0.08 |
| 92 | BENTHABELLA ELONGATA | BEL | 0.05 | 0.00% | 0 | 0.05 |
| 93 | LITHODES MURRAYI | LIM | 0.04 | 0.00% | 0 | 0 |
| 94 | CHAULIODUS SPP. | CHX | 0.04 | 0.00% | 0 | 0.04 |
| 95 | SEMIROSSIA PATAGONICA | SRP | 0.02 | 0.00% | 0 | 0.02 |
| 96 | MACRUROPLUS POTRONUS | MAO | 0.02 | 0.00% | 0 | 0.02 |
| 97 | PANDALOPSIS AMPLA | PAA | 0.02 | 0.00% | 0 | 0.02 |
| 98 | PROTOMICTOPHUM CHORIODON | PMC | 0.01 | 0.00% | 0 | 0.01 |
| | **TOTAL** | | **26,710.67** | **100.00%** | **3,776.53** | **26,647.77** |




## *4.4 Loligo gahi*

### Distribution within the "*Loligo* box"

Generally, abundance of *L. gahi* was very low in all parts of the "*Loligo* box", averaging 3.3 kg per trawl (see Figure 23). The highest catches (both in weight and numbers) were observed on transect P4 at depths of 100 m (18.4 kg) and on transect P1 at the same 100 m depth (14.92 kg). With the exception of the southern regions (mainly P7, where the catch was 6.4 kg), squid were practically absent at 300 m depths (average 1.66 kg). At 200-m depths, catches were also very low but twice as high as at 300 m depths (average 2.93 kg), with the only exception of P1 (7.2 kg). The catch was greater with depth on P7, where nothing was caught at 100 m, and the maximum catch was at 300 m. The opposite situation was observed on P4 and P1, where the maximum catches were taken from shallow depths (Figure 23 and Figure 24).

### Sex ratio

The period studied was characterised by the prevalence of females at almost all stations. Maximum proportions of females were observed at 300 m depths (~80%, transects P7-P4). At 200 m depths, females were more abundant in the southern transects and less abundant in the northern transects. At 100 m depths, the proportion of females was slightly higher than 50% on P4 and P3 and ~60% on P2 and P1 (Figure 25). The sex ratios were different however if animals were analysed by maturity stage. Among immature squid, the highest proportion of females was observed on P2 at 200 m depth. However, the total number of squid caught at that station was relatively small which could affect the resulting sex ratio. At 100 m depths, where the immature squid were the most abundant (especially on

P4), the sex ratio was close to 1:1 with a slight predominance of females (Figure 25). Among maturing squid, females tended to be more abundant in the southern parts of the "*Loligo* box". Sex ratios among mature squid varied in different regions. While females were more abundant on the P7-P3 transects both at 300 m and 200 m depths, the sex ratio was practically equal at 200 m on the P4-P1 transects. In shallow waters (100 m depth), males were predominant on P4 (however, again only 20 animals were analysed), but females were more abundant on P2 and P1 (Figure 25). Unfortunately, the small numbers of squid caught at 100 m in the southern part and at 300 m in the eastern part of the "*Loligo* box" prevented proper analysis of sex ratios at these stations.

Figure 23. Catch of *L. gahi* at constant effort bottom trawl stations (kg per 0.5 hr trawling). Circle size is proportional to the square root of catch weight.

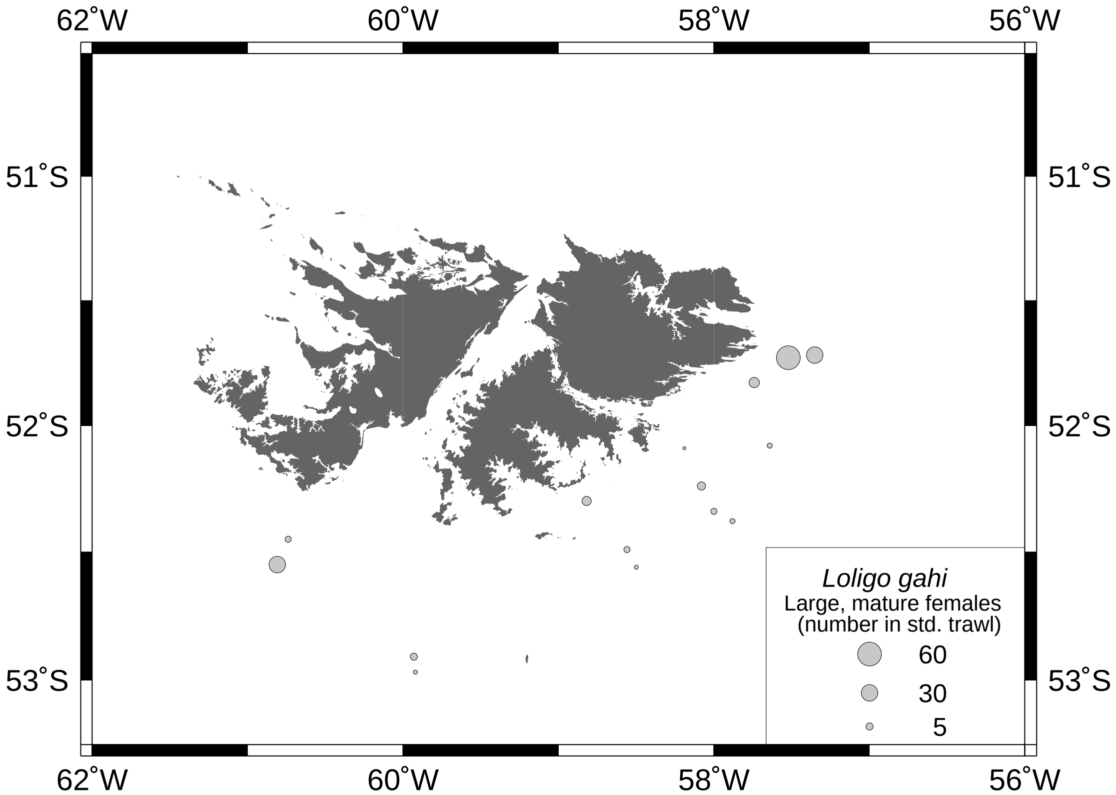



Figure 24. Total catch per trawl of *L. gahi* in weight (A) and in numbers (B). P1 – P7 are the transect numbers of the survey.

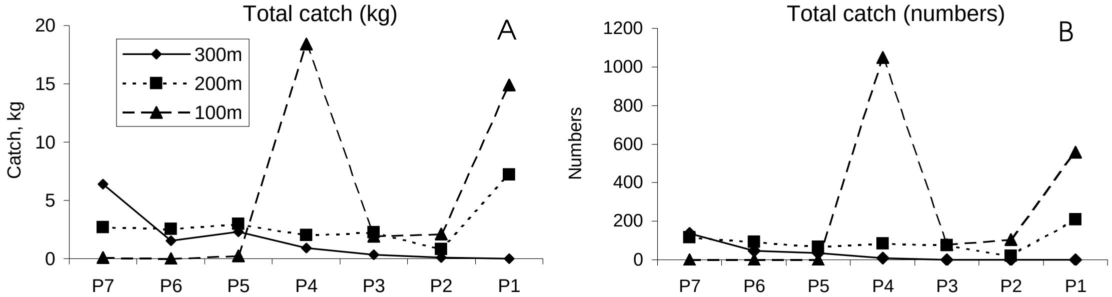
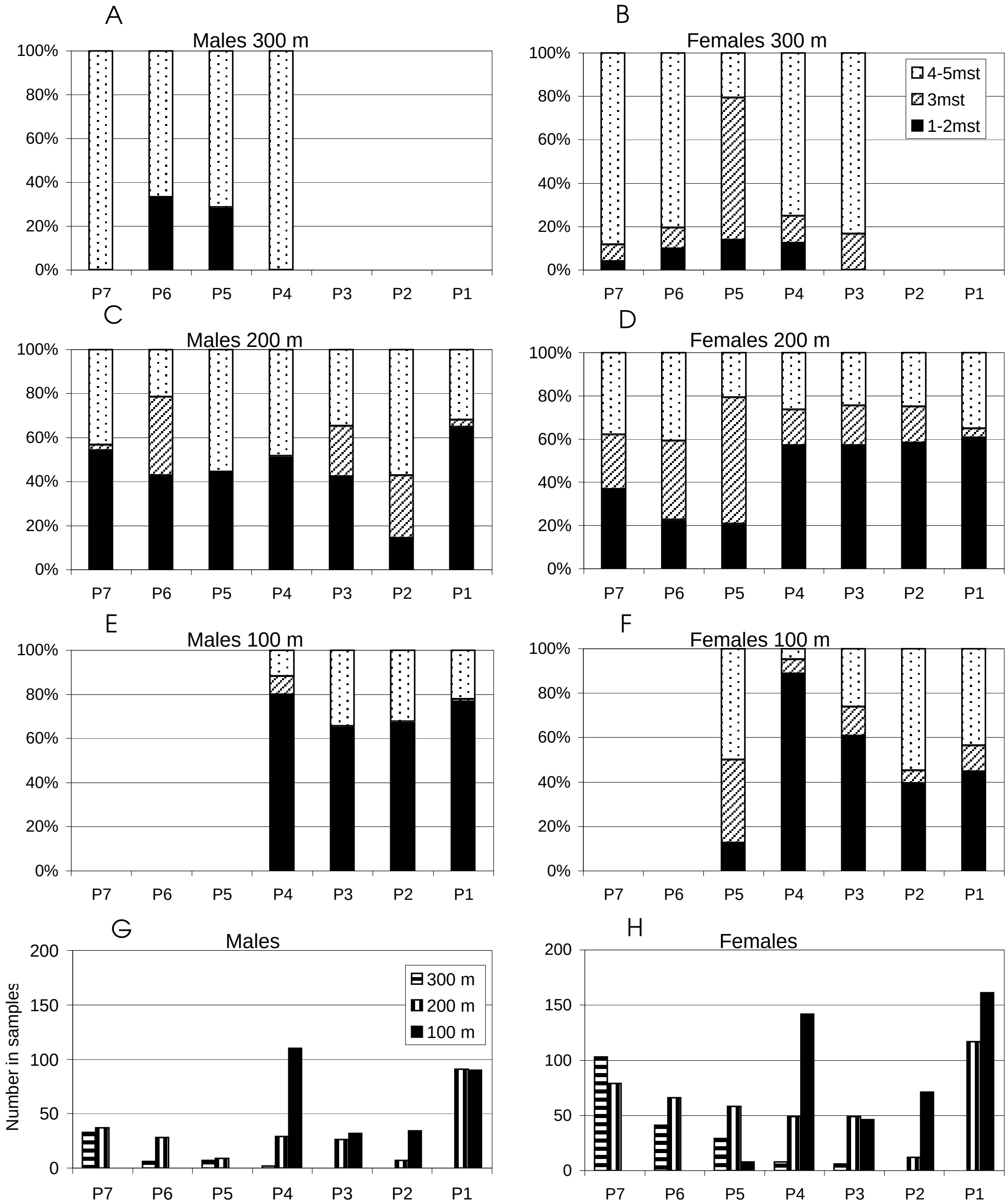


Figure 25. Proportion of *L. gahi* females in catches in all maturity stages pooled (A), immature (stages 1-2), maturing (stage 3) and mature (stages 4-5) squids separately for 100 m, 200 m and 300 m depths.

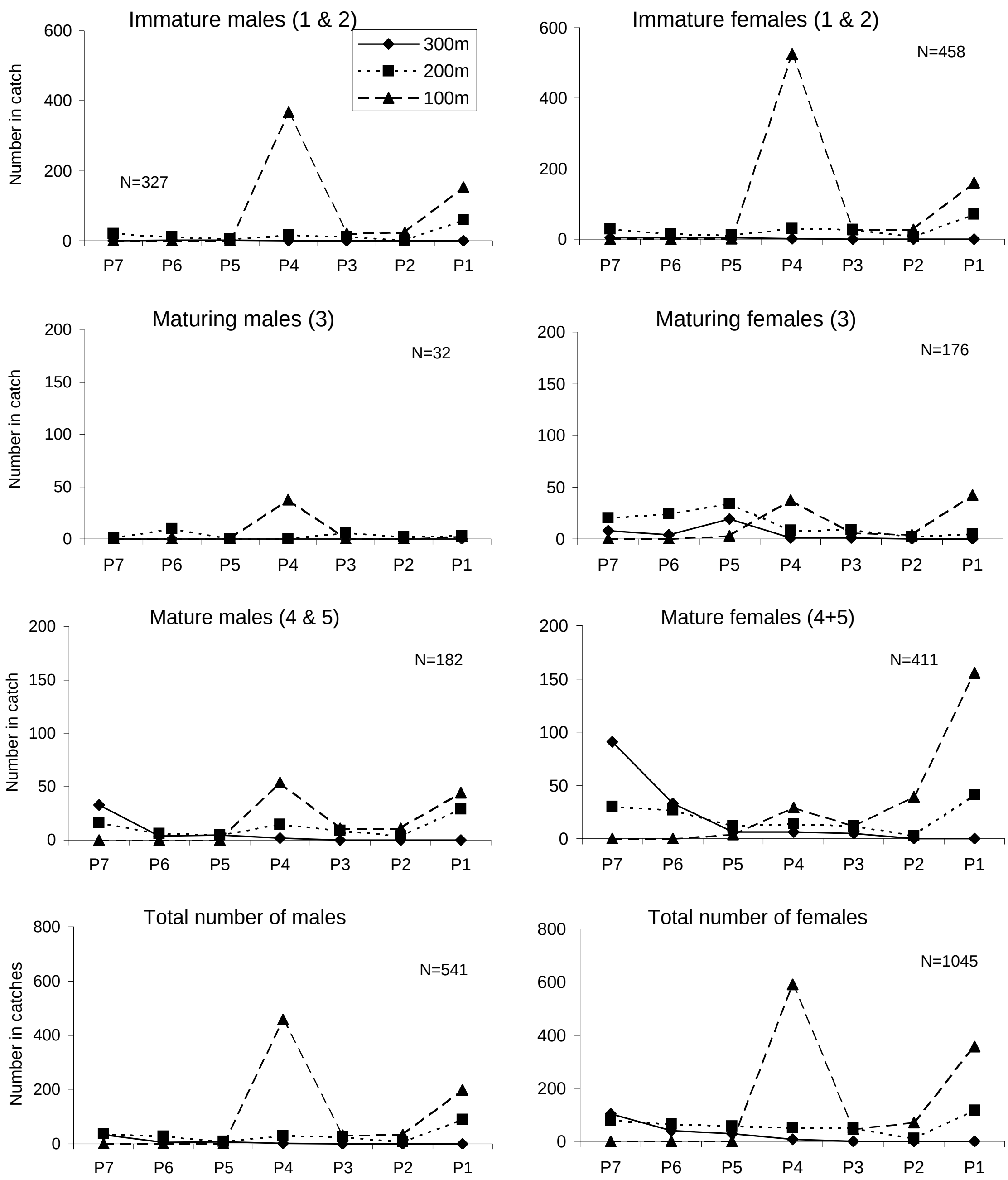



## Maturity

The maturity status of female and male *L. gahi* varied at different depths. The majority of females were mature at 300 m, except on transect P5 where more than half the females were still maturing. The proportion of immature females was small at 300 m depths, and they were completely absent on transect P3 (Figure 26). The proportion of immature females increased at 200 m depths, ranging from 20-35% in the southern transects to 55-60% in the eastern transects. The proportion of mature females was less variable on all transects (20-40%). In shallow waters (100 m depth), both immature and mature females predominated in catches. The maximum proportion of immature females was observed on P4, and that of mature females on transect P2. In general, transect P5 was characterised by the highest prevalence of maturing females at all depths. The greatest quantity of immature females was caught on transect P4 at 100 m depth. Surprisingly, the greatest number of mature females occurred in deep waters on the southern P7 transect, and in shallow waters in the eastern P1 transect (Figure 27).

As was the case for females, mature males predominated in catches at 300 m depths. The proportion of immature males increased at 200 m depths, and was greatest on transect P1 (>60%). Maturing males occurred mainly on transects P6, P3 and P2 at 200 m depths, with the highest number caught on transect P4, despite the fact that their proportion was low (Figure 26, Figure 27). At 100 m depths, immature males predominated in catches. The total number of mature males in catches was greatest at 100 m depths on transects P4 and P1 (Figure 27).

Figure 26. Proportions of males and females at different maturity periods in 300 m trawls (A, B) and 200 m trawls (C, D), and number of animals in each sample (E, F).



## Length-frequency distribution

As in the previous report, length-frequency distributions (LFDs) were analysed separately for each sex, maturity period and depth (Figure 28, Figure 29). Generally, LFDs of immature animals of both sexes were rather narrow at all depths, consisting of four to five 1 cm length intervals. LFDs of maturing and mature squid were broader, and consisted of eight to ten 1 cm intervals. The smallest squid were caught in shallow waters (< 5 cm ML). The largest female occurred at a depth of 200 m (22 cm ML), whereas the largest male was caught at a depth of 300 m (>30 cm ML).

Immature females were rather small during the period studied, with modal sizes ranging from 7 to 8 cm ML. Modal length of immature females was similar at all depths (Figure 28A) except on transect P2 at 100 m, where the immature females were smaller (6-7 cm ML). Maturing females were 1-2 cm larger than immature ones, and their modal sizes were almost the same at all depths (Figure 28B). The strongest variation in sizes was observed in mature females. At 100 m depths, their modal length progressively increased from the south (P5) to the north (P1). Even on the two neighbouring transects, mature females were larger on the northern transect (P2 and P1, respectively). The same tendency was observed at 200 m depths, where females were distinctly larger in the northern part of the *Loligo* box. The small number of squid caught at 300 m depths prevented any comparison of the sizes of mature females between different parts of the region studied. It is notable however that their modal sizes were greater on transect P7 than on transect P6 (Figure 28C).

Modal sizes of immature males were quite similar to those of immature females (7-8 cm ML). Their modal length did not vary among the different transects at depths of 100 m. At 200 m, they were 1-2 cm larger on the northern transects than in the south (Figure 29A). There were only a few maturing males in catches at all depths, so their LFD structure was not investigated (Figure 29B). Mature males were quite small both at 100 and 200 m depths (11-12 cm ML). There were not any significant trends in the size of mature males over the different transects. In general, mature males were either smaller or the same length as females at all stations except at 300 m on P7. Interestingly, large mature males (>16 cm ML) occurred in significant numbers only at that particular station (Figure 23, Figure 29C).

Figure 27. Numbers in catches of males and females at different maturity stages on each transect.

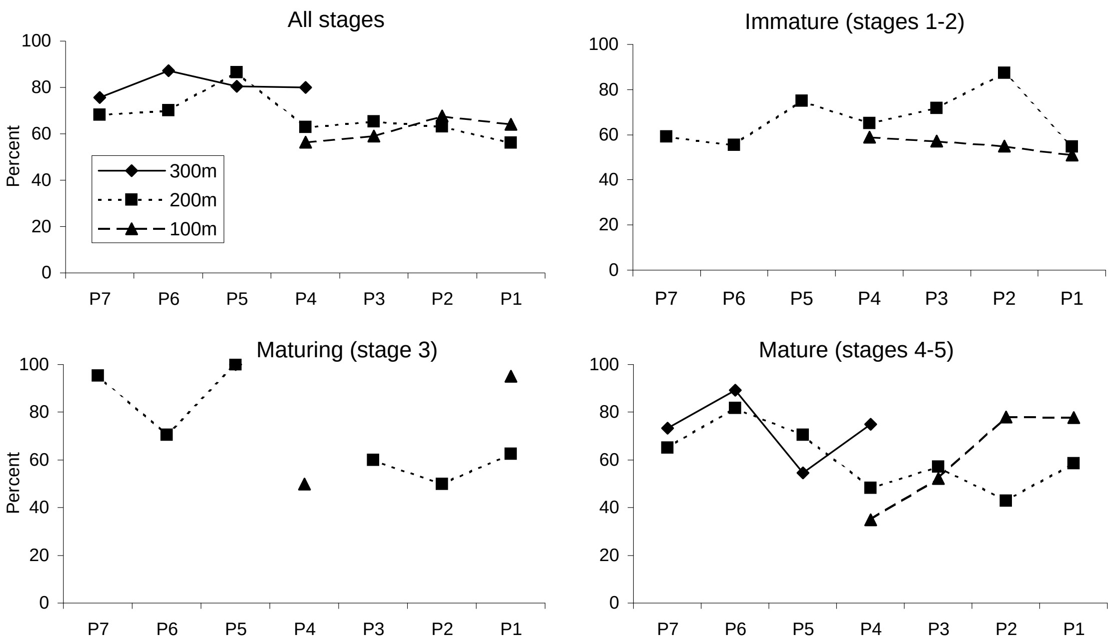


Figure 28. Length-frequency distributions of female *L. gahi* by transect at different depths. A: maturity stages 1 and 2, B: maturity stages 3 and 4. Transects are arranged sequentially from SE to NW. The 1 cm size classes are measured to the nearest centimetre below the actual mantle length (i.e. the 10cm class includes individuals with a dorsal mantle length between 10 and 11 cm). The shade allocated to each size class represents the proportion of individuals, of the total in each depth and maturity stage grouping, that fall in a particular size class. The actual number of individuals used to construct each LFD is given beneath the transect number; these are included to indicate the precision of the LFD rather than the number of individuals present.

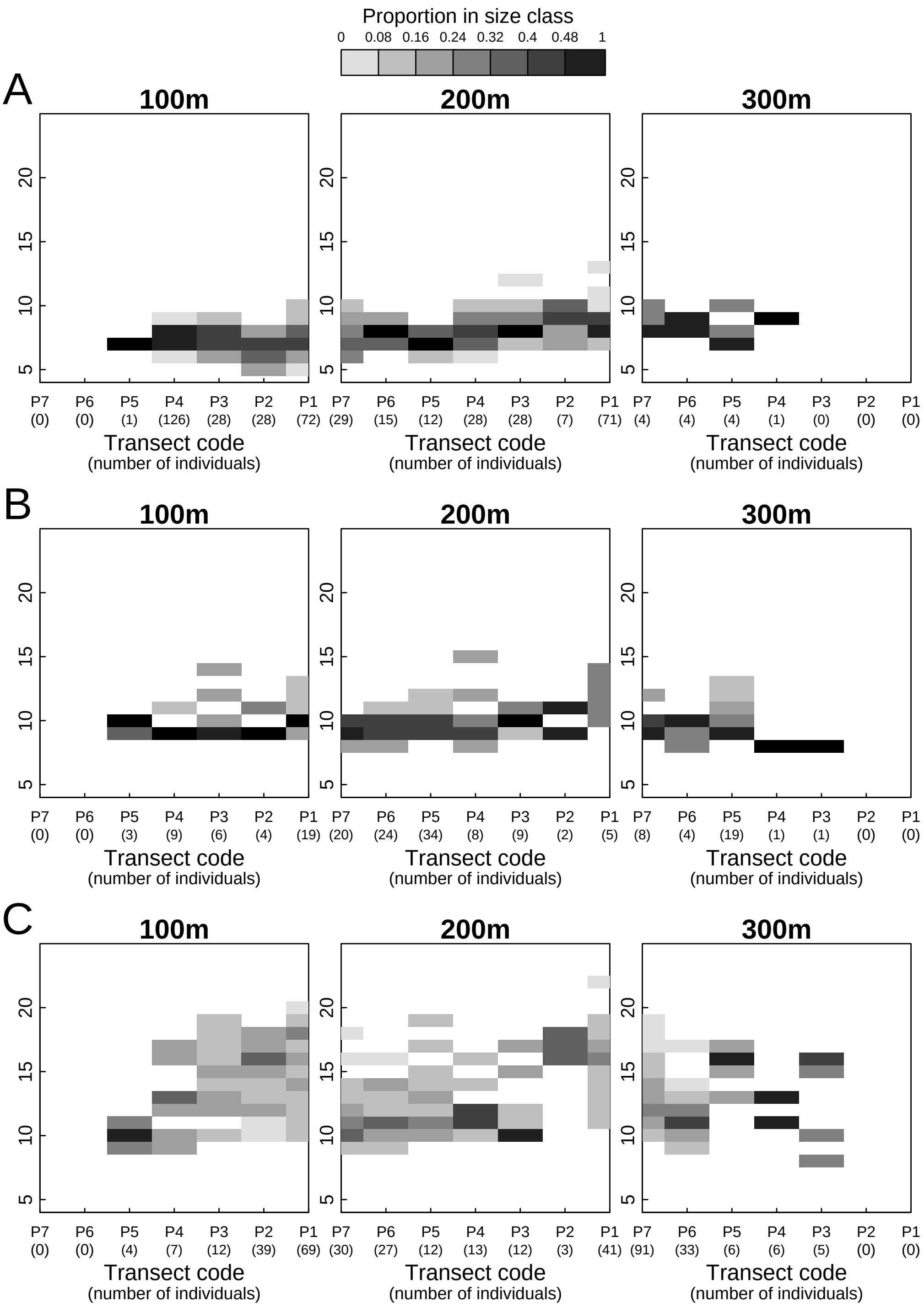
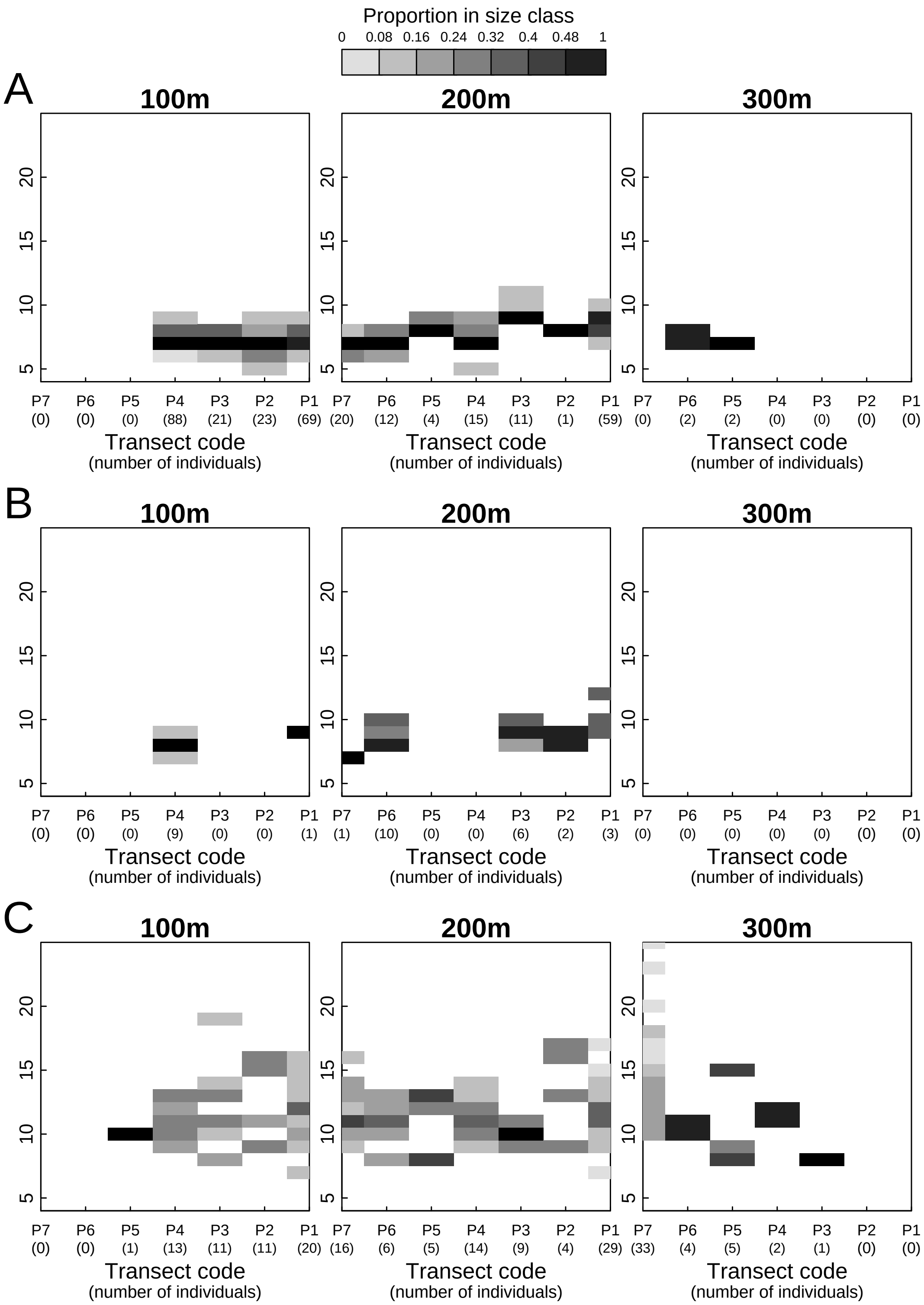


Figure 29. Length-frequency distributions for male *L. gahi* by transect at different depths. A: maturity stages 1 and 2, B: maturity stage 3, C: maturity stages 4 and 5. Transects are arranged sequentially from SE to NW. See Figure 28 for further details. Note that while the size range plotted accounts for the majority of observed individuals, occasional mature males of up to 40cm were found.



## General remarks

The survey was carried out during the spawning period of the second cohort of *L. gahi* (Hatfield, 1992). During this period, it has been assumed that all squid of the second cohort should be mature and that they move to shallow inshore waters to mate and spawn (Hatfield & Rodhouse, 1994). The results of our survey confirmed these assumptions. On all eastern and northern transects (P4-P1), catches of *L. gahi* were highest at 100 m depths and, in most cases (except P4), they consisted of mature squid. Mature females were of approximately the same mantle length as those that had been observed in commercial catches in September-October 1999 at 200 m depths, and are therefore likely to be the same animals. All of them were mated, the majority inside the mantle, indicating that they were ready to spawn. A preliminary analysis of their fecundity has shown that some of them had spawned already. The occurrence of large males (>12-13 cm) in catches was surprisingly low at these depths, as they had been very abundant in September-October catches. They had possibly died after mating or migrated elsewhere, while smaller and less abundant 'sneaker' males (10-12 cm ML) remained in the spawning grounds. This fact is at odds with the well-known pattern of spawning behaviour in other loliginids, where females are present in the spawning grounds together with large males (Hanlon, 1998).

The population structure typical of loliginid spawning grounds was found for *L. gahi* on transect P7 at 300 m. Large mature females and males were simultaneously relatively abundant at that station. As in shallow water, all mature females had a sperm in their buccal sperm reservoir, but only few of them had also mated in the mantle cavity. Thus, the possible occurrence of the deep-water spawning in *L. gahi* should not be neglected.

On transect P4 at 100 m depths young recruits, presumably belonging to the first cohort, started to aggregate in schools before migration to their deeper feeding grounds. Sex ratios in these recruit schools were balanced. As in June 1999, schools of small and large squid were segregated in space despite the fact that they occurred mainly in the same depth range (100 m) during the period studied.

# *4.5* Toothfish *Dissostichus eleginoides*

Although this species was found at most stations in small numbers, the majority were caught at just two stations, station 118 (524 kg) and station 127 (1,877 kg). Catches at all other stations were less than 50 kg. The distribution map for this species (Figure 30A) shows their main abundance to be located to the south of the Falkland Islands and at depths greater than 300 m.

A comparison of the length frequency distributions for the above mentioned stations (Figure 31) shows that larger fish were found at deeper depths. The same seemed to be true for all other transects (Figure 32). The smallest *D. eleginoides* were found at 200 m on transect P3 (P3-200) where the first modal peak was at 11 – 15 cm. The largest fish were caught in deep water trawls (Figure 33). Most catches did not provide enough individuals to create any meaningful length frequency distributions but it appears that smaller individuals tended to be caught on the more northerly transects, while larger individuals tended to be caught in the south.

The sex ratio of female to male *D. eleginoides* varied with transect and depth from 100 % females at P3-300 and P7-100 to 82 % males at P7-300. There was a slight tendency for males to be more common at deeper depths but generally the sex ratio varied around 50:50 (Figure 34). Female *D. eleginoides* exhibited maturity stages I – III and VIII while males exhibited stages I – III, VI and VIII (Figure 35). The most common maturity for females at 200 and 300 m depth was maturity stage II while that for males was maturity stage I. No males were present at P3-300 but females at this station showed an increase in the prevalence of individuals at maturity stage I. Maturity stage I was also more common at 200m depth rather than at 300m depth. This is probably due to the fact mentioned above that shallower depths generally yielded individuals with a shorter total length. At 1000 m, individuals were generally at stage II. The females here also showed a slight increase in maturity stage III.

Figure 30. Distribution of catches by weight of toothfish *Dissostichus eleginoides* (A), southern blue whiting *Micromesistius australis* (B) and hoki *Macruronus magellanicus* (C).

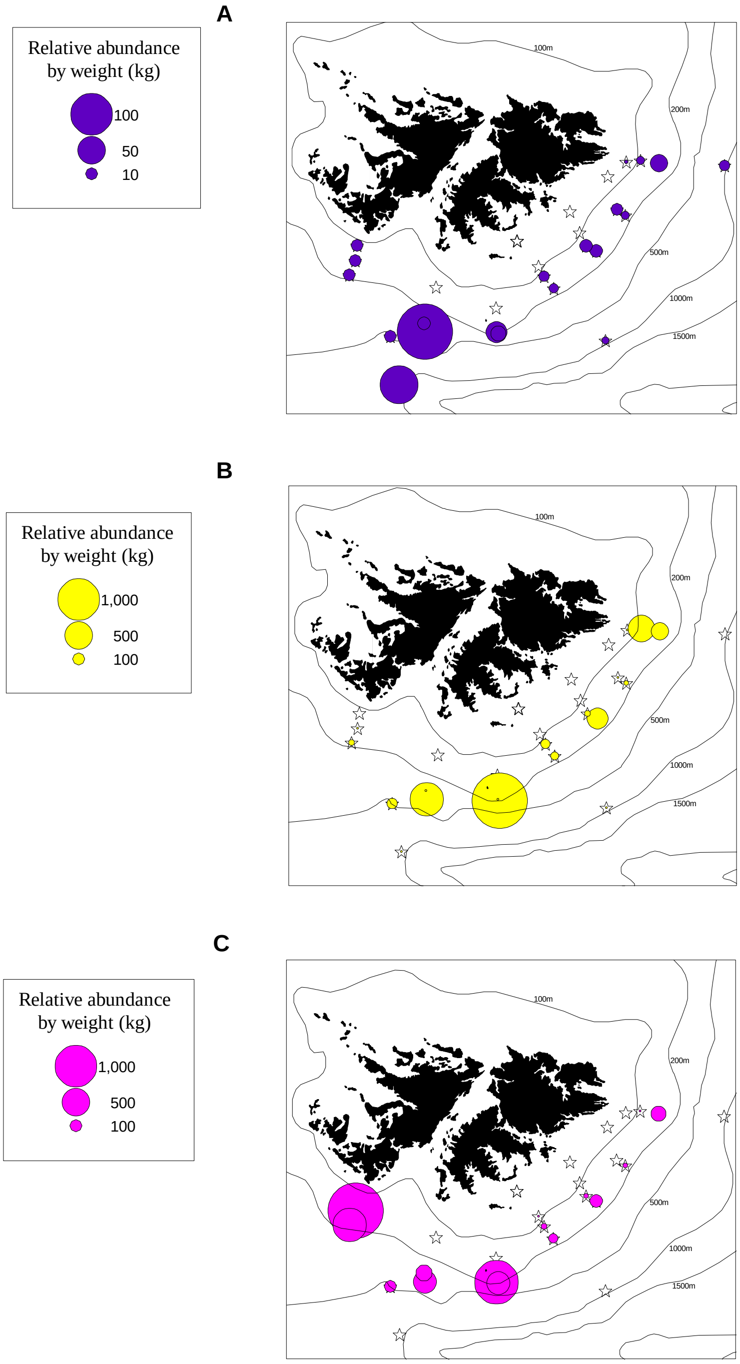


Figure 31. Comparison of length frequency distribution for *D. eleginoides* at Station 127 (depth 300 m ) and station 118 (depth 1000m).

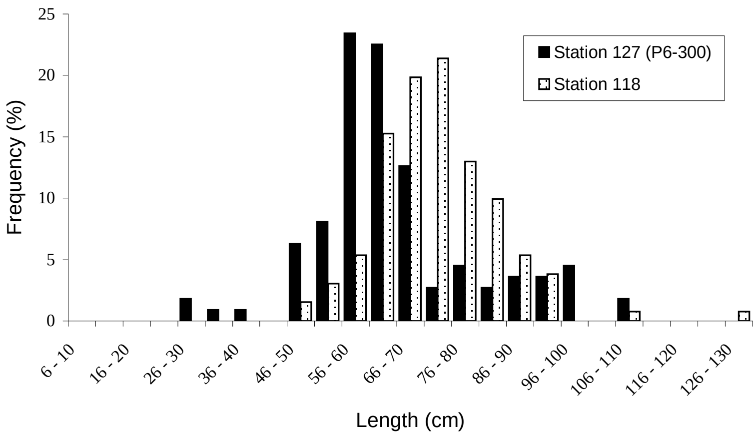



Figure 32. Length frequency distribution of *Dissostichus eleginoides* at 100-300 m depth.

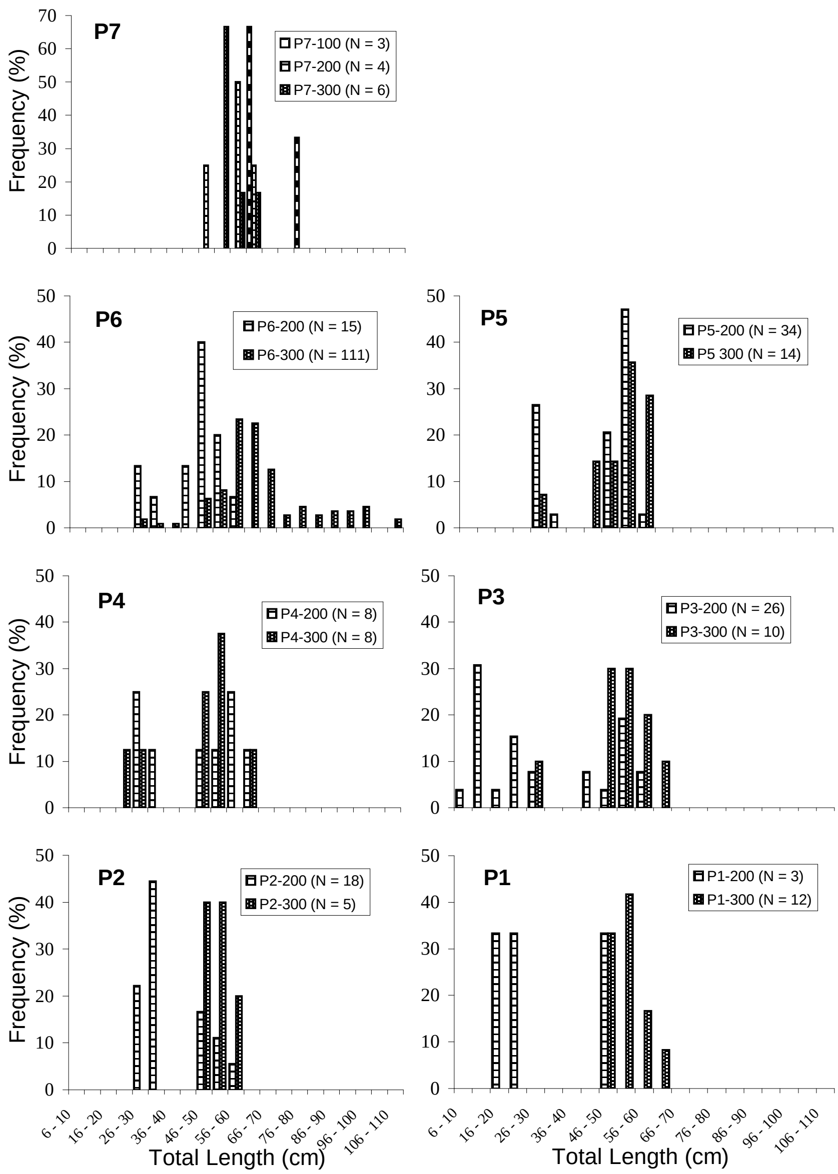


Figure 33. Length frequency distribution for *Dissostichus eleginoides* at 800-950 m depth.

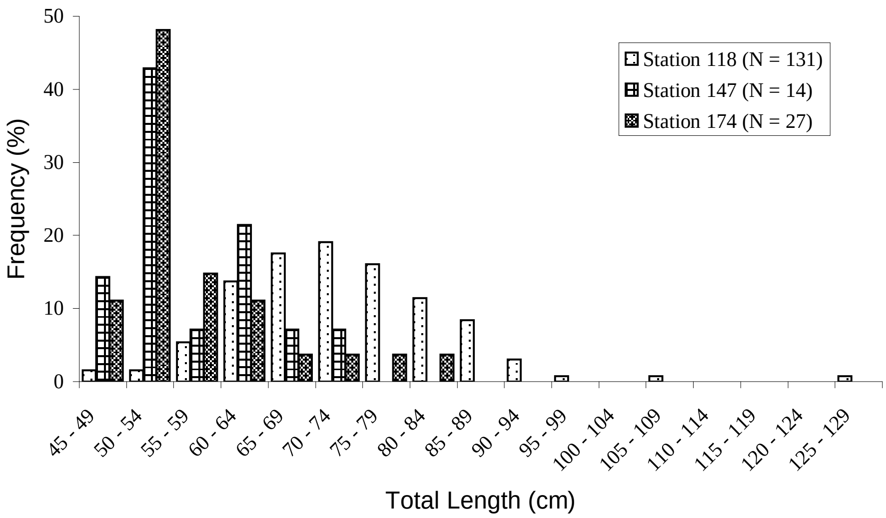



Figure 34. Sex ratios of *Dissostichus eleginoides* at different depths and transects.

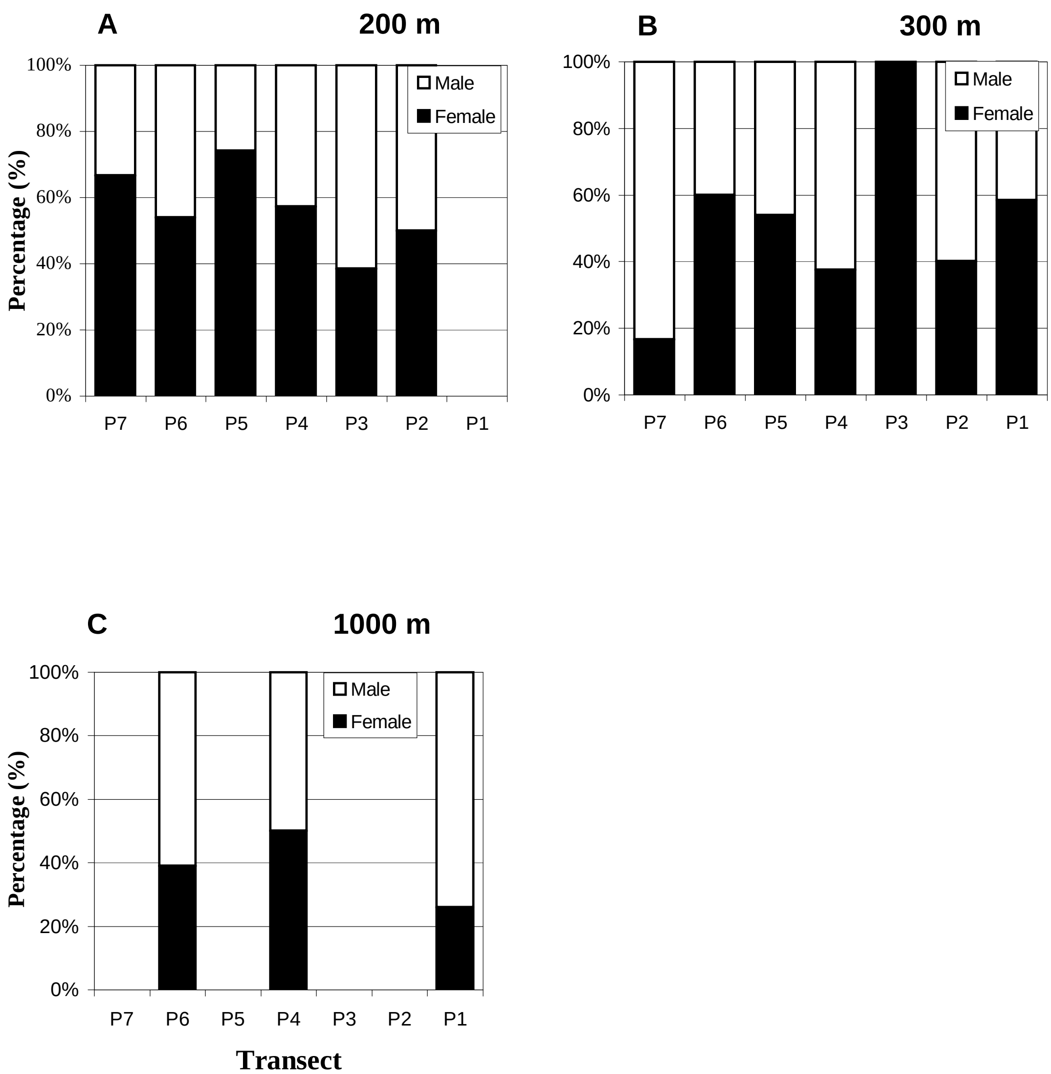
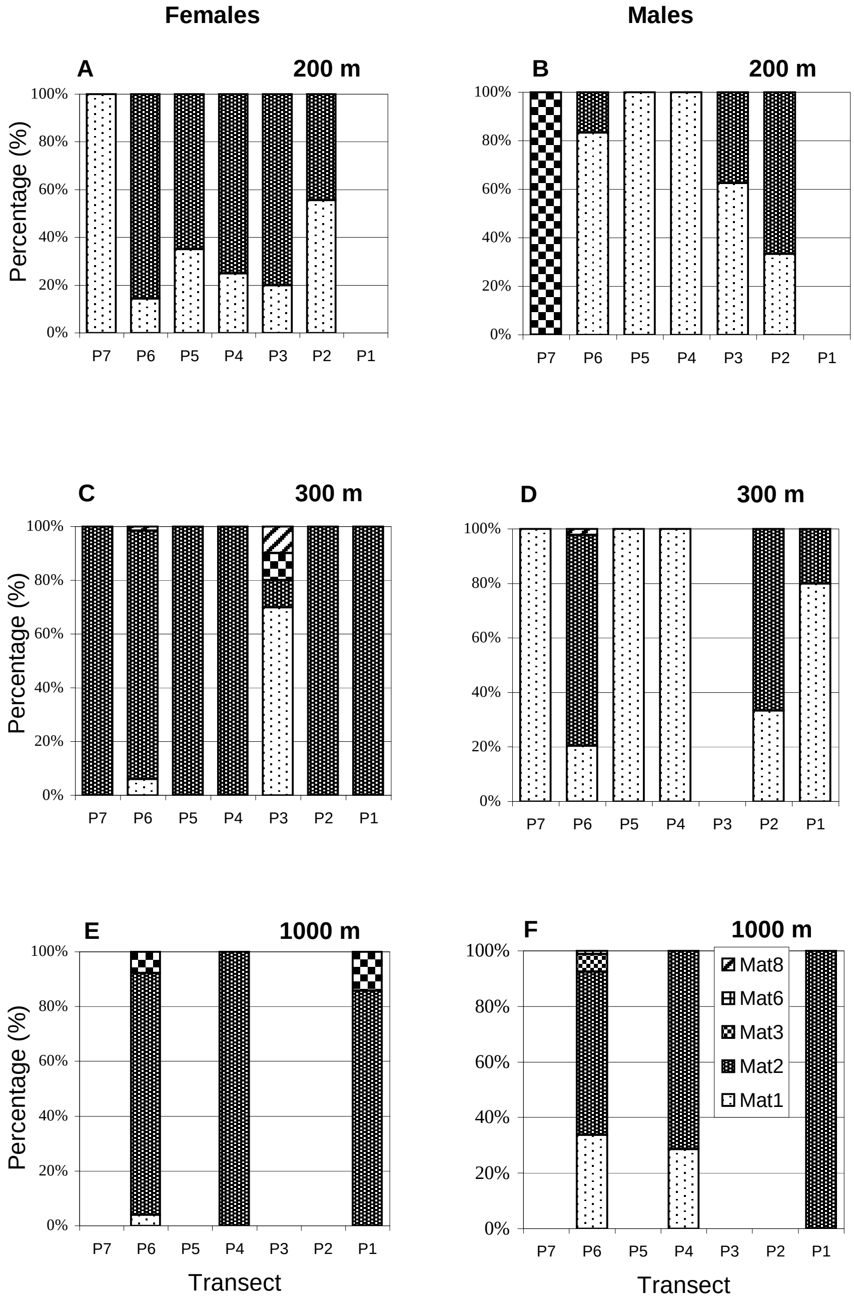


Figure 35. Percentage maturity distributions of *Dissostichus eleginoides* at different depths and transects.



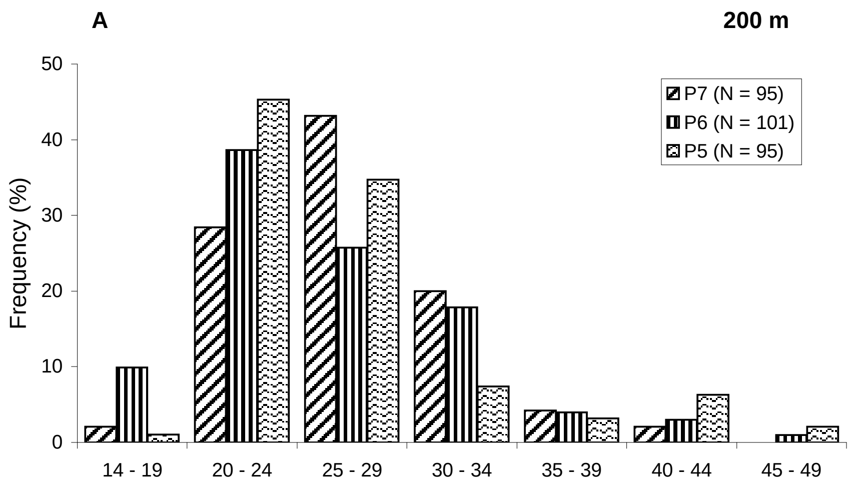

## *4.6* Hoki *Macruronus magellanicus*

The largest catches of this species were at stations 113 (4,176 kg), 133 (1,121), 111 (668 kg), 131 (370 kg) and 127 (364 kg) but as the distribution map for this species (Figure 30C) shows, *M. magellanicus* were fairly common throughout the sampling area between the depths of 100 m and 300 m.

At depths of around 200m, *M. magellanicus* was only caught in sufficient quantity to be sampled on transects P7, P6 and P5. Individuals at all these stations appeared to have a similar length frequency distribution with the modal pre-anal lengths (PAL) for P6-200 and P5-200 both being between 20 – 24 cm. At 300 m, *M. magellanicus* were found on all transects. P2 – P4-300 and P6 – P7-300 all showed very similar length frequency distributions with one modal peak at 20 – 24 cm PAL. The hoki on P5 and P1 were, however, different. P5-300 showed two modal peaks, the first at 20 – 24 cm PAL and the second at 40 – 44 cm PAL while individuals sampled at P1-300 had one modal peak at 35-39 cm PAL (Figure 36).

Females tended to dominate the population with female to male sex ratios ranging from 50:50 to 94:6 at 300 m and staying fairly constant at 65:35 at 200 m (Figure 37E,F). Both males and females exhibited maturity stages I – V and VII – VIII (Figure 37A-D). The most common maturity stage for both males and females was stage II although at stations P3-300 and P2-300 a larger proportion of the sample exhibited maturity stage I. The larger PAL at P5-300 and P1-300 has led to a corresponding increase in maturity with maturity stages VII and VIII becoming more common in both the males and the females.

Figure 36. Percentage length frequency distribution for *Macruronus magellanicus* at (A) 200 m and (B) 300 m depths.



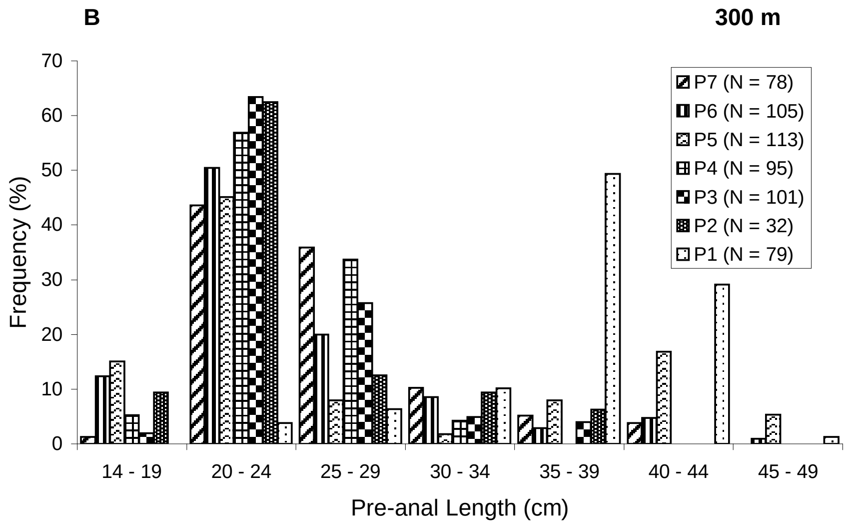
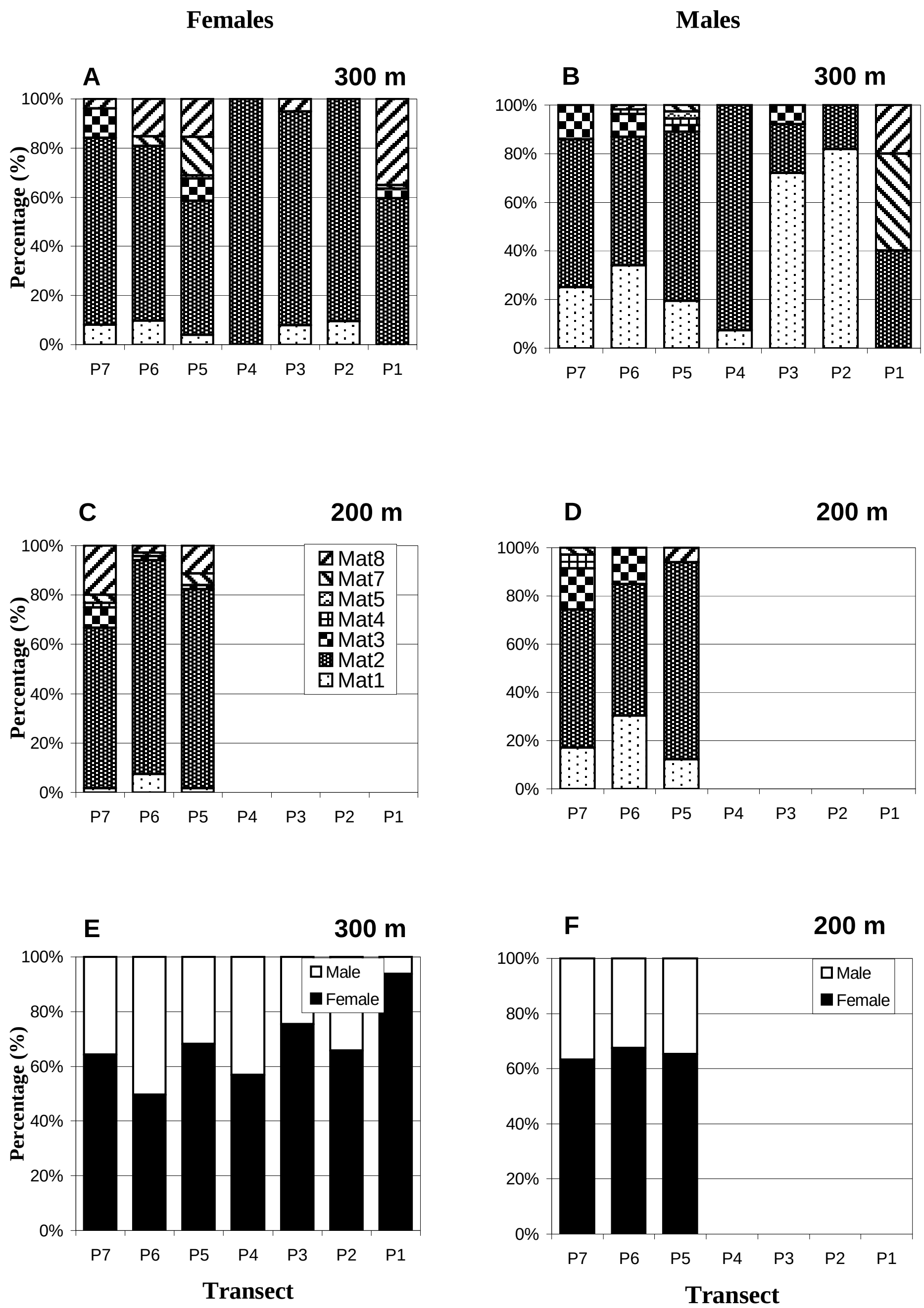



Figure 37. Percentage maturity distributions (A-D) and sex ratios (E-F) of *Macruronus magellanicus* at different depths and transects.




## *4.7* Southern Blue Whiting *Micromesistius australis*

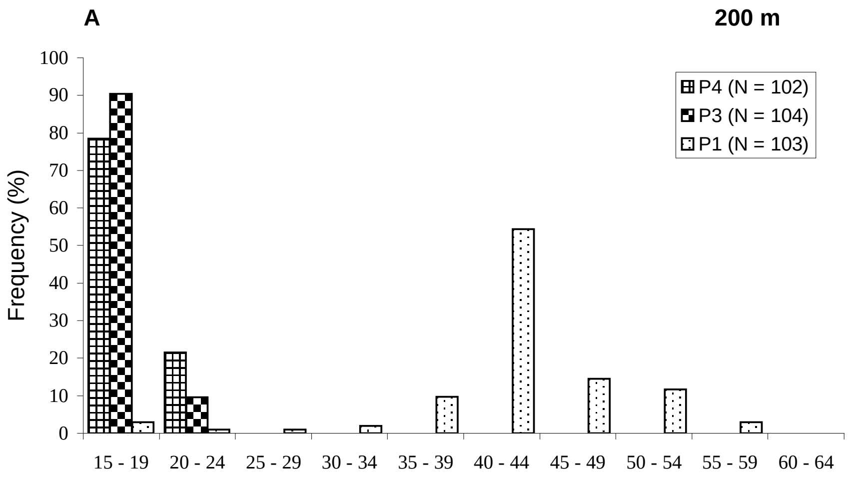
This species was also fairly well distributed throughout the sampling area and both adult and juvenile *M. australis* were found at most stations (Figure 30B). The highest catches of this species were at stations 131 (2,605 kg), 127 (674 kg), 170 (474 kg), 151 (292 kg) and 172 (208 kg).

The length frequency distributions (Figure 38) show that the total length of this species ranged from 15 – 61 cm and that there were two different cohorts present in the sampling area. Juvenile *M. australis* were present, in the majority, at P4-300, P2-300, P4-200 and P3-200. These fish corresponded with modal peaks at 20 – 24 cm total length at 300 m and 15 – 19 cm total length at 200 m. Larger, more mature fish, were present on transects P6-P1 at 300 m and at P1 at 200 m. No *M. australis* were present in trawls undertaken at 100 m.

Adult female *M. australis* exhibited maturity stages II, III, V, and VI – VIII with the most common stages being II and VIII. Adult males exhibited maturity stages II, III, and VI – VIII (Figure 39A-D). Maturity stage III was absent amongst those males sampled at 200 m and the most common maturity stage at 300 m and 200 m was stage VIII.

Males tended to dominate the sampled population and female to male sex ratios ranged from 30:70 to 55:45 at 300 m and from 20:80 to 46:54 at 200 m (Figure 39E,F)

Figure 38. Percentage length frequency distribution for *Micromesistius australis* at (A) 200 m and (B) 300 m depths



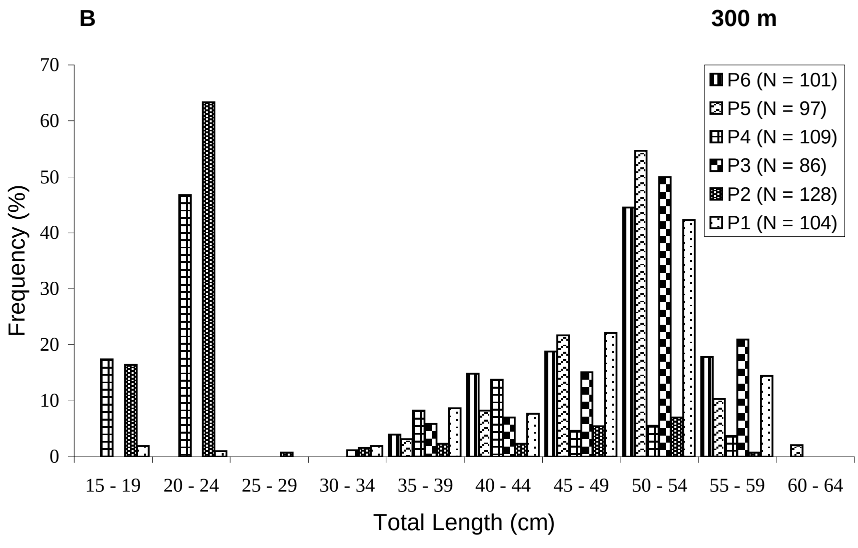
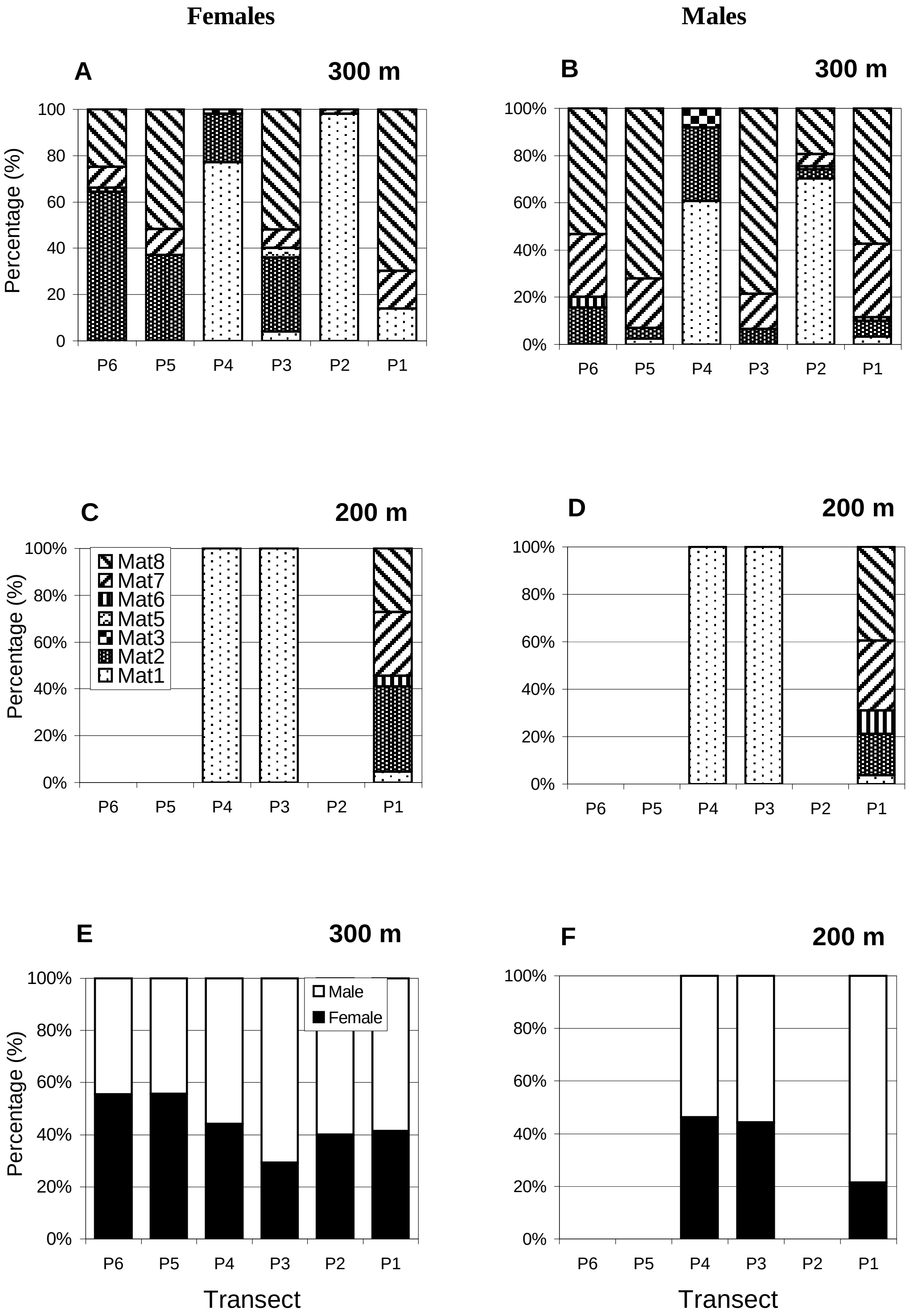



Figure 39. Percentage maturity distributions (A-D) and sex ratios (E-F) of *Micromesistius australis* at different de



## *4.8 Rays and Skates*

Table VIII shows the catch summary of all ray species caught during the research period. The total ray catch was 517 kg (2 % of the total catch) which was about half that caught during the previous research cruise (ZDLH1-06-1999). The two most common species caught were *Bathyraja griseocauda* (273 kg) and Unidentified *Bathyraja* sp. # 3 (121 kg).

All rays caught (with the exception of one *Psammobatis extenta* which was badly damaged) were weighed and assessed for total length, disc width and maturity. Most rays were also assessed for the presence of parastites. No one species of ray occurred in any great number so no further biological analyses were carried out (Figure 40).

The distribution maps (Figure 41) show the rays to be typical of their species with only *Raja doellojuradoi* and *Bathyraja papilionifera* present at the deep water stations (1000 m), and inshore species such as *Psammobatis* spp., *Bathyraja magellanica* and *Bathyraja macloviana* present at the shallower stations (100m or less). Other ray species such as *Bathyraja scaphiops,* unidentified *Bathyraja* sp. and *Bathyraja griseocauda* tended to be found around the 200 – 300 m area.

Table VIII. Ray catch summary by species, ZDLH1-11-1999. Percentages are given to two decimal places only.

| ***Species name*** | *Species Code* | *Total Catch (kg)* | *Proportion of Total Catch (%)* | *Total Sampled (kg)* | *Total Discarded (kg)* |
|---|---|---|---|---|---|
| *BATHYRAJA GRISEOCAUDA* | RGR | 273.94 | 1.03% | 273.94 | 273.94 |
| UNIDENTIFIED *RAY #3* | RBZ | 120.88 | 0.45% | 120.76 | 120.88 |
| *BATHYRAJA MULTISPINIS* | RMU | 24.5 | 0.09% | 24.5 | 24.5 |
| *BATHYRAJA BRACHYUROPS* | RBR | 22.94 | 0.09% | 22.94 | 22.94 |
| *BATHYRAJA ALBOMACULATA* | RAL | 22.7 | 0.08% | 22.7 | 22.7 |
| *BATHYRAJA MACLOVIANA* | RMC | 12.74 | 0.05% | 12.74 | 12.74 |
| *RAY* SPP. | RAY | 9.12 | 0.03% | 9.12 | 9.12 |
| *BATHYRAJA SCAPHIOPS* | RSC | 9.03 | 0.03% | 9.03 | 9.03 |
| *BATHYRAJA PAPILIONIFERA* | RPA | 5.8 | 0.02% | 5.8 | 5.8 |
| *RAJA FLAVIROSTRIS* | RFL | 5.6 | 0.02% | 5.6 | 5.6 |
| *BATHYRAJA MAGELLANICA* | RMG | 3.85 | 0.01% | 2.27 | 3.85 |
| *PSAMMOBATIS SCOBINA* | RPS | 3.2 | 0.01% | 3.2 | 3.2 |
| *RAJA DOELLOJURADOI* | RDO | 2.62 | 0.01% | 1.18 | 2.62 |
| *PSAMMOBATIS EXTENTA* | REX | 0.38 | 0.00% | 0 | 0.38 |
| *PSAMMOBATIS* SPP. | RPX | 0.18 | 0.00% | 0.18 | 0.18 |
| RAY TOTAL CATCH | RAY | 517.48 | 1.94% | 513.96 | 517.48 |
| TOTAL CATCH | | 26710.67 | 100.00% | 3776.53 | 26647.77 |

Figure 40. Catch by number of all Rajidae.

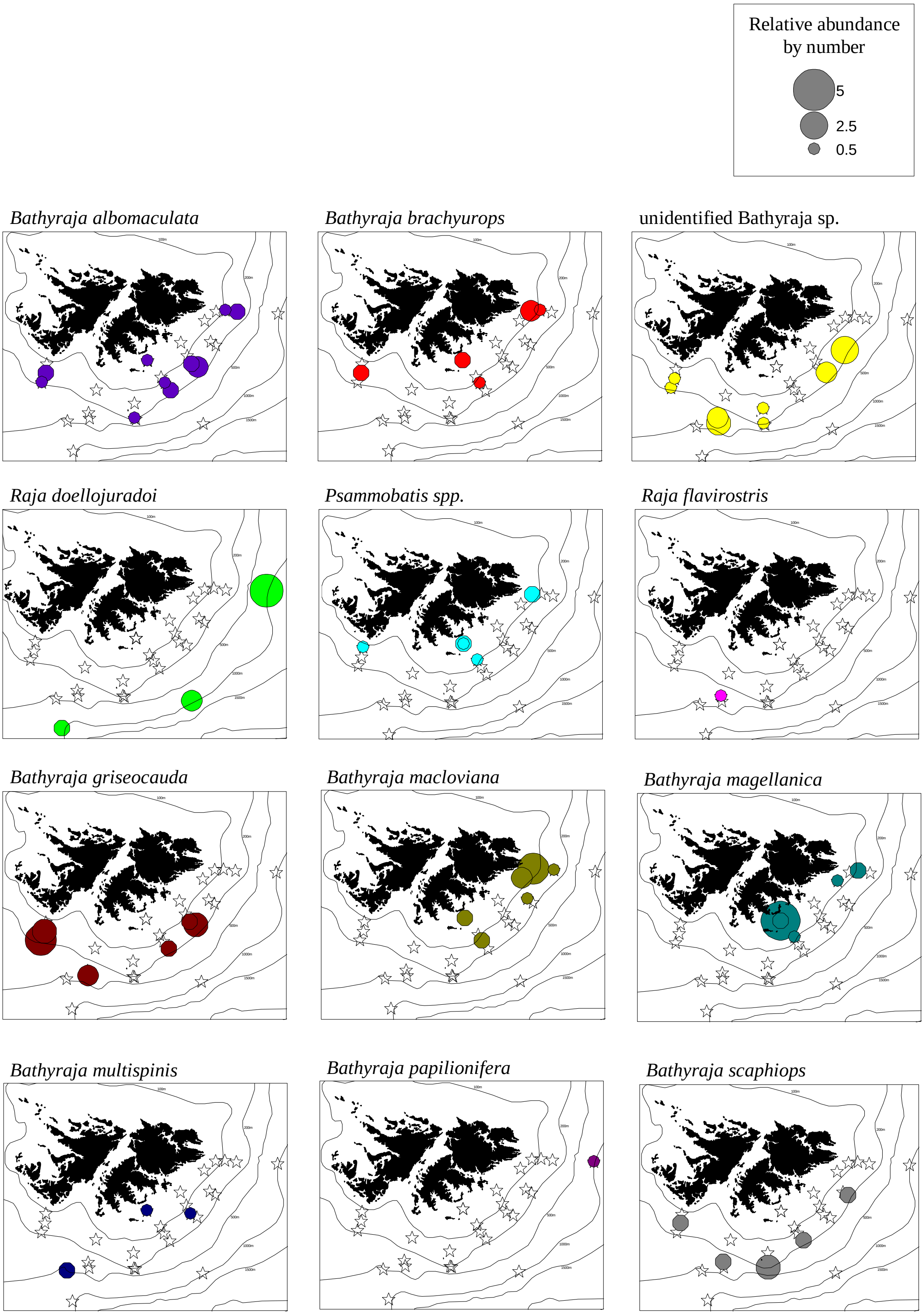
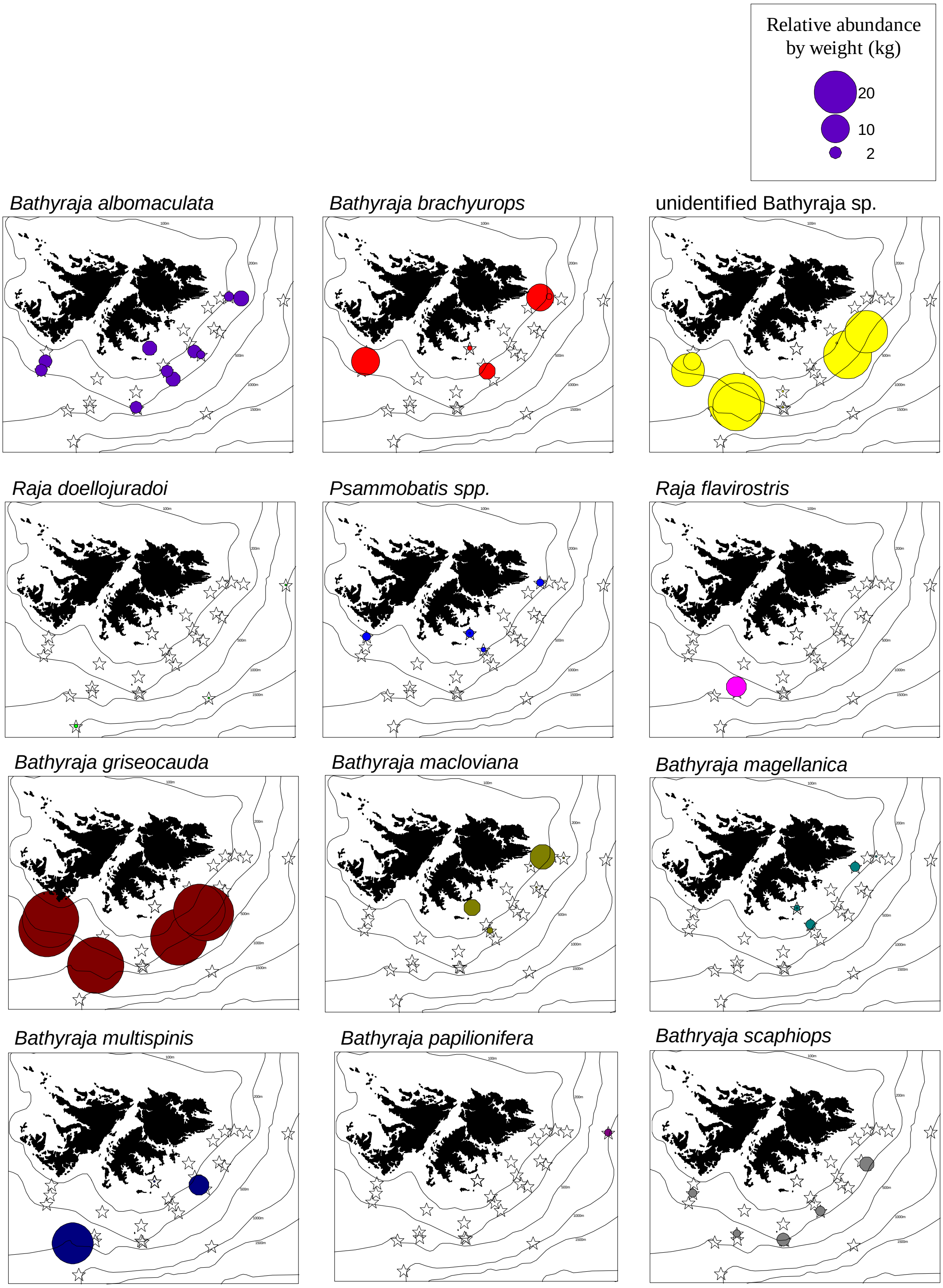


Figure 41. Catch by weight of all Rajidae.



## 4.9 Non-commercial by-catch shelf and slope species

The distribution of the principle non-commercial species caught during the research cruise is illustrated in Figure 42. *P. ramsayi* was the most abundant by-catch species at 10 % (2,600 kg) of the total catch followed by *Coelorhynchus fasciatus* at 2 % (478 kg) of the total catch and *Munida gregaria* which formed 1 % (173 kg) of the total catch. Length frequency measurements of this species were taken for comparison with acoustic data. The length frequency distribution (Figure 43) shows that *Munida gregaria* caught during the sampling period had a positively skewed distribution with the main modal peak between 28 – 31mm. Carapace length ranged from 17mm – 36 mm. The main *M. gregaria* catch was obtained at stations 137 and 138.

Figure 42. Catch of principal by-catch species. Height of bars is proportional to the square root of the catch (in kg). The crosses on the histogram axis mark the trawl positions.

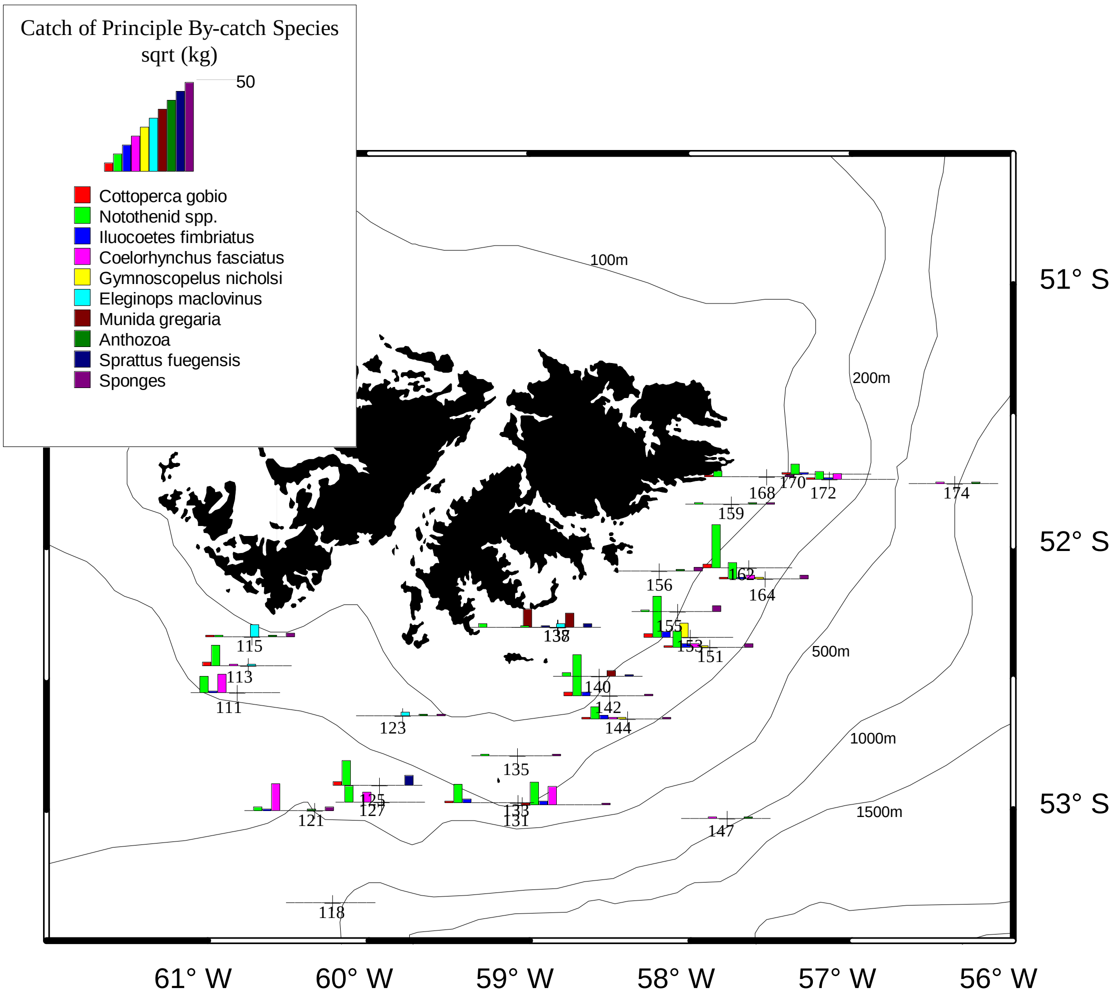
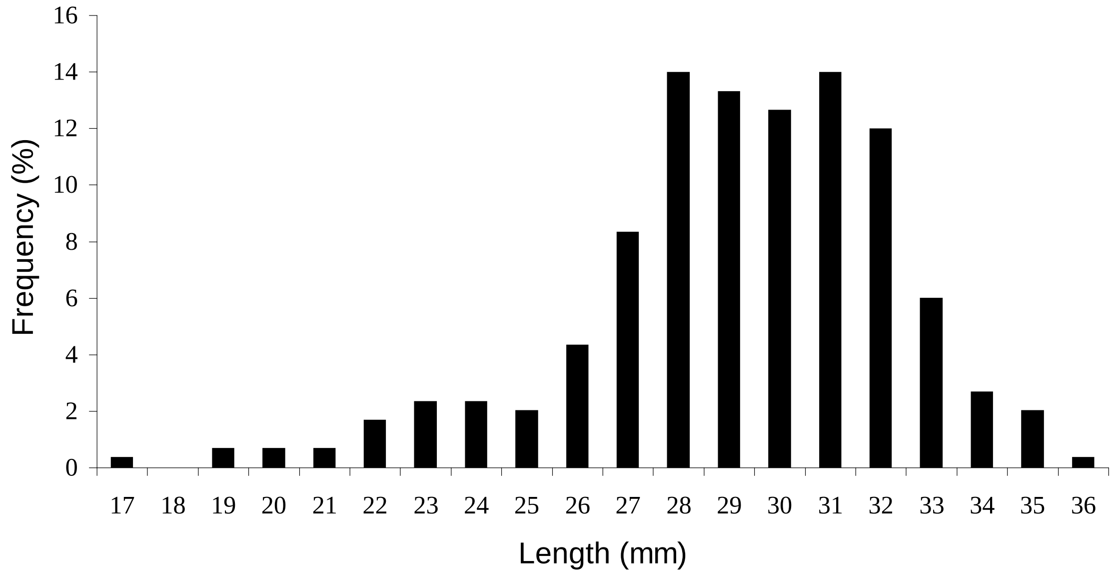


Figure 43. Percentage length frequency distribution of *Munida gregaria* (stations 137 and 138).




## 4.10 Deepwater species

Deep water stations yielded very different fishes and invertebrates to all other trawls with typical deepwater species such as *Macrourus carinatus* and *Antimora rostrata* predominating. The distribution and relative abundance of the principle deep water by-catch species is shown in Figure 44.

The length frequency histogram for *M. carinatus* (Figure 45) shows a very similar pattern for individuals caught at all three deepwater stations. The PAL ranged from 13 – 34 cm and the main modal peak was between 20 – 24 cm. Males exhibited maturity stages I-VI while the females exhibited maturity stages I-V and VII. The majority of males were in maturity stage III while the most common female maturity stage was II – III (Figure 46). Female to male sex ratio was around 50:50 at stations 118 and 174 but males dominated at station 147 with a ratio of 30:70.

Figure 44. Catch of principal deepwater species. Height of bars is proportional to the square root of the catch (in kg). The crosses on the histogram axis mark the trawl positions.

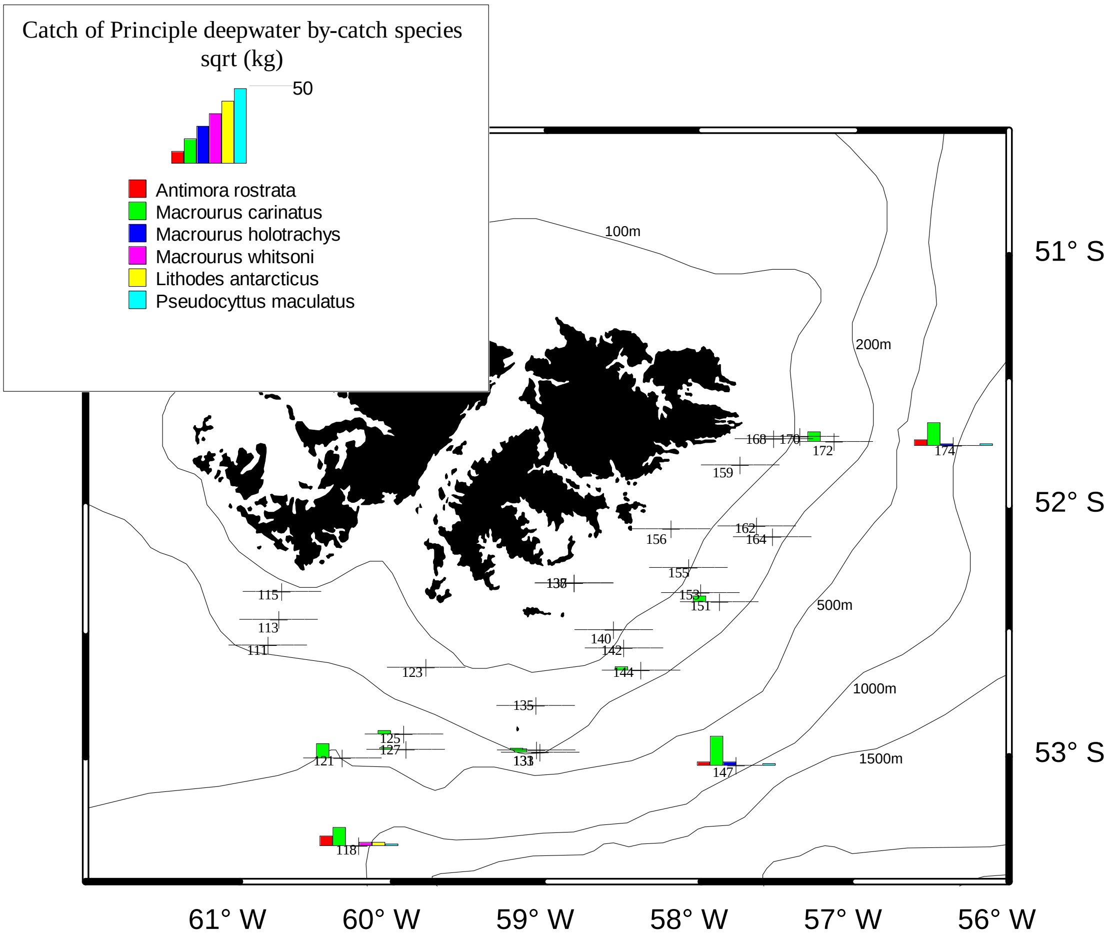



Figure 45. Percentage length frequency distribution of *Macrourus carinatus*.

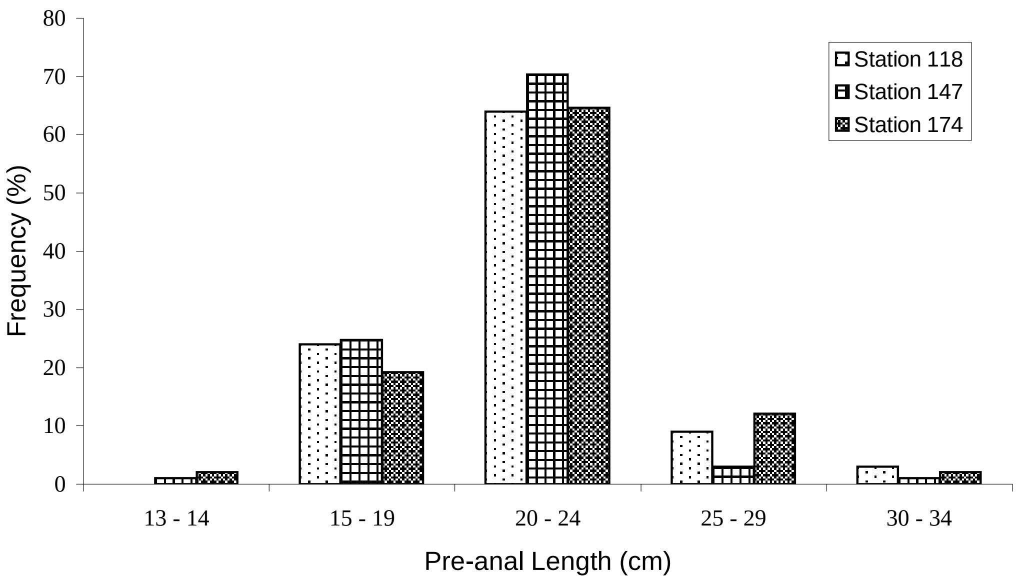
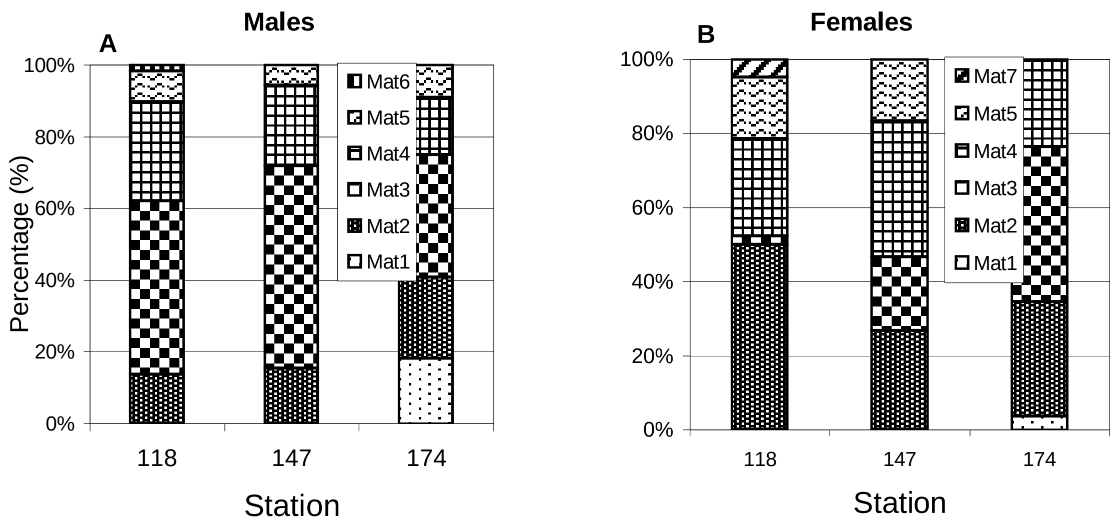


Figure 46. Percentage maturity distributions for males (A) and females (B) of *Macrourus carinatus.*




## *4.11* King crab *Lithodes murrayi*

A good catch (39 kg) of king crab was obtained at station 118 located on the southern slope of the Falkland shelf at 800 m depth (Figure 44). All crabs were males (stage 3) of about 2-3 kg total weight. Our fishing gear was not appropriate for fishing benthic crabs, and their abundance therefore seems to be quite high near that station during the period studied.

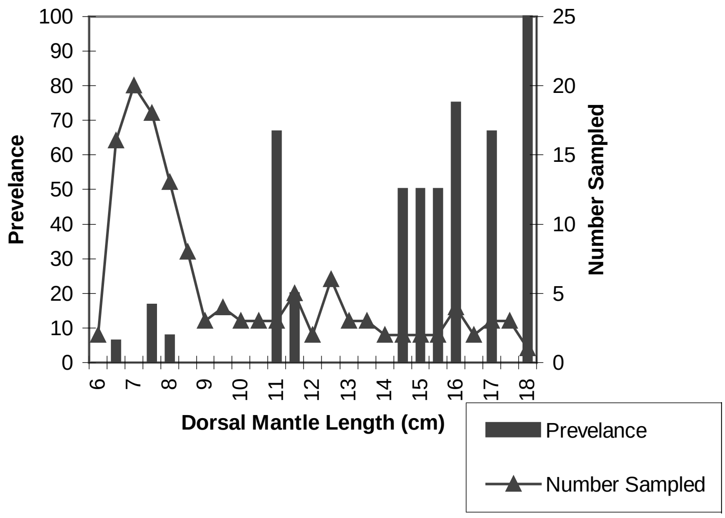
## *4.12* Parasites of *Loligo gahi*

The study on the parasite ecology of *Loligo gahi* during this research cruise was part of an on-going study looking at parasite infection rates over a year. During the research cruise a total of 83 random post recruit *Loligo gahi* were collected and frozen for onshore analysis. Analysis of *L. gahi* during the research cruise was carried out on 50 non random samples. Each individual was opened up longitudinally, with the ceacum, stomach, rectum, gills, and gonads examined under the dissecting microscope. For each individual the position and presence of any parasites was noted along with stomach contents. On shore statoliths were removed from each individual for future age analysis. Of the 133 post recruit *Loligo gahi* examined 19 were infected with parasites (14.29% prevalence), with a mean abundance of 0.19.

Table IX. Parasite occurrence in *Loligo gahi*.

| | Phyllobothrium | *Anisakis sp. larvae* |
|---|---|---|
| Count | 17.00 | 3.00 |
| Sum | 20.00 | 6.00 |
| Min | 1.00 | 1.00 |
| Max | 2.00 | 3.00 |
| Prevalence | 12.78 | 2.26 |
| Mean Intensity | 1.17 | 2.00 |
| SD | 0.39 | 1.00 |
| Mean Abundance | 0.15 | 0.05 |

Figure 47. The prevalence of parasite infection within *L. gahi* in relation to the number sampled per size class.




As can be seen in Table IX the prevalence of *Phyllobothrium* sp. within the sampled *L. gahi* is relatively low with only 12.78% of the sample being infected. This is similar to the prevalence observed in June.

The prevalence of *Anisakis* sp. larvae within the sampled *L. gahi* is much lower than that of *Phyllobothrium* sp. with only 2.26% of the sample being infected. This is much lower than the prevalence observed during June (5.95%).

The data suggests that several pulses of infection of *L. gahi* have occurred, as different size classes show different levels of infection, and squid between 8.5-11cm and 12.5- 14.5cm were not infected. These pulses may be related to food availability at the time of infection, with the primary host for *Phyllobothrium* sp. not being available to the feeding *L. gahi*.

The minimum size of *L. gahi* infected by parasites in November was much smaller than that observed in the June sample, with the smallest infected squid only 6.5cm ML. The smallest infected *L. gahi* in the June sample was 9.5cm ML.

The mean abundance in November was very similar to that in June. On both occasions the maximum number of *Phyllobothrium* sp. found within an individual was two and the maximum number of *Anisakis* sp. larvae was three.

# 5. Diving survey

## Introduction

Loliginid squids are generally shallow water spawners (Hanlon 1998), although their egg have sometimes been found on the bottom as deep as 507 m (*Loligo forbesi,* Lordan and Casey 1999). Loliginids usually form dense spawning aggregations and, in the case of *Loligo vulgaris reynaudii*, their spawning sites have a patchy distribution along the coast (Sauer et al. 1992). Females attach gelatinous capsules containing eggs to different objects on the bottom, sometimes making large concentrations of egg capsules ('egg beds') greater than 3 m in diameter (Sauer et al. 1992). Although small quantities of fully mature females have been found in inshore trawl catches, prompting the assumption of shallow water spawning (Hatfield et al. 1990), neither spawning sites nor egg masses of *L. gahi* have yet been described. Local SCUBA divers have previously reported the rare presence of egg masses, strongly resembling those of loliginids, in shallow bays around East Falkland, but these were never examined (George and Hatfield 1995). A shallow water marine survey around the Falkland Islands recorded the presence of loliginid egg masses at several sites around the Islands (Tingley et al. 1996) but again these were not studied.

The main purposes of this survey were to locate inshore spawning sites of *L. gahi* around East Falkland by diving, and to investigate the morphology of egg masses and egg capsules at various stages of embryonic development.

## Materials and methods

Forty-six egg masses were sampled during the diving survey. Actual dive positions were determined both by weather conditions and an on-site evaluation of kelp bed extents (Figure 48). Divers entered the water at the seaward margin of kelp, as visible from the surface, and the area surveyed was generally restricted to this outer edge. However, at many sites kelp was found to extend beyond the area visible from the surface, while some sites allowed inspection of the seabed deeper than the kelp bed.

Four divers, diving in pairs, participated in the research cruise. Dives generally involved 30 minutes survey time. The divers searched along a linear route either in a single direction or around the perimeter of a rectangular area, depending on the topography of the site. During the dive the number of egg masses observed was recorded, along with the approximate number of capsules in each mass. On dives where egg masses were found, the first egg mass encountered was sampled whole. Capsules were sampled from up to four other egg masses per dive. Between site variability in factors such as visibility, kelp density and egg mass density (and hence time spent sampling), combined with the aim of covering a long coastline in a fairly short period, prevented simple quantification of the area surveyed. Instead egg mass density was expressed as egg masses observed per minute dive time.

At each diving station, temperature and salinity were measured. After sampling, egg masses were kept in seawater in a refrigerator for a maximum of one day after which they were analysed in the laboratory either ashore or on board the ship. Every egg capsule was examined in 29 egg masses. In the remaining egg masses a sample of 2 to 5 capsules was analysed. For each capsule, the total length was measured to the nearest 1 mm under. The total number of eggs within the capsule was counted by squeezing the capsule between two glass slides. Stages of embryonic development were assigned using the scale described for loliginid squid by Arnold (1965). The maximum egg diameter was measured in 20-40 eggs for each embryonic stage observed.

## Results

### Location of spawning sites and egg mass occurrence

The egg mass density encountered around the coast of East Falkland during the period of the research cruise varied considerably (Figure 48). Squid eggs were found around almost the entire coastline of East Falkland with the notable exception of the central part of Falkland Sound. The highest density was found on the north-east coast.

There was considerable local variation in egg mass density. Eggs could be entirely absent from a site within a few kilometres of a site with relatively high densities. Within a site there was also noticeable patchiness in egg mass density. At some sites egg masses would be encountered throughout the dive, whilst at other sites most of the dive could pass without observing any egg masses. All egg masses found during the course of the research cruise were attached to kelp, both *Lessonia* spp. and *Macrocystis pyrifera* (Figure 49). Areas of rock and sand adjacent to kelp beds were checked at several sites, without discovering any egg masses, but sites further offshore were not investigated. Since the research cruise two egg masses have been found loose on the seabed; it is not clear whether either of these had been previously attached to kelp. Egg masses tended to occur on short, solitary kelp strands. This was particularly noticeable in the case of *M. pyrifera* where the majority of the kelp tends to be rooted in dense, "communal" holdfasts (i.e. supporting a mass of fronds). No egg masses were found in such clusters of kelp stems. Typically the *M. pyrifera* stems supporting egg masses had no large frond and extended only two or three metres off the seabed. Clusters on *Lessonia* spp. were generally found on small, frondless stems, although a few clusters were found on healthier looking plants (although the maximum stem diameter on which clusters were attached was about 2cm). Egg masses were attached approximately 0.5m to 2.5m off the seabed.

Underwater some idea of egg mass age and development was visually apparent. Freshly laid, undeveloped, egg masses had a bright white, semi-transparent, appearance. In older egg masses embryos could sometimes be seen, giving the capsules a darker, rust-brown, appearance. Older masses also tended to accumulate a layer of silt, although the extent of this varied considerably from site to site.

Figure 48. Position of dives around the coast of East Falkland during the Falkland Islands Fisheries Department research cruise ZDLH1-11-1999, November 1999 (crosses), and density of *L. gahi* egg masses (expressed as egg masses observed per unit dive time). Circle diameter is proportional to the square root of egg mass density. The rectangle encloses the Stanley/Port William area where additional samples were obtained.

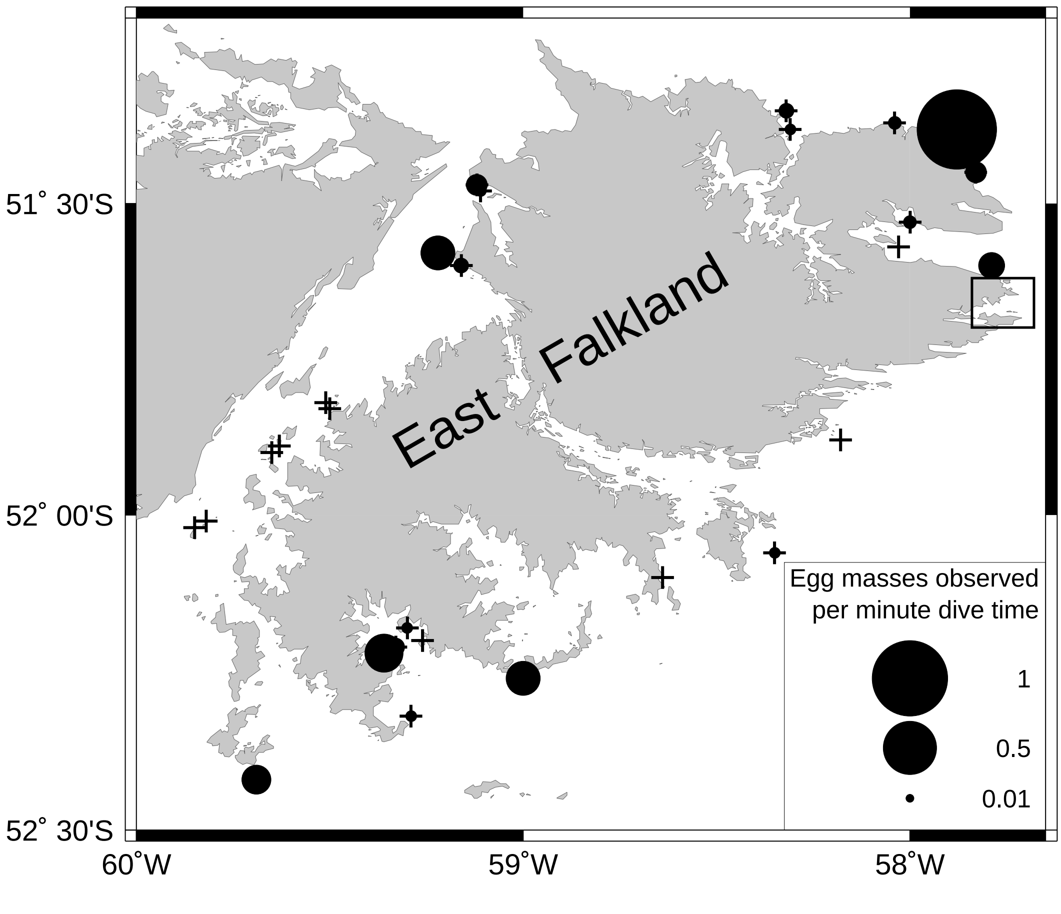
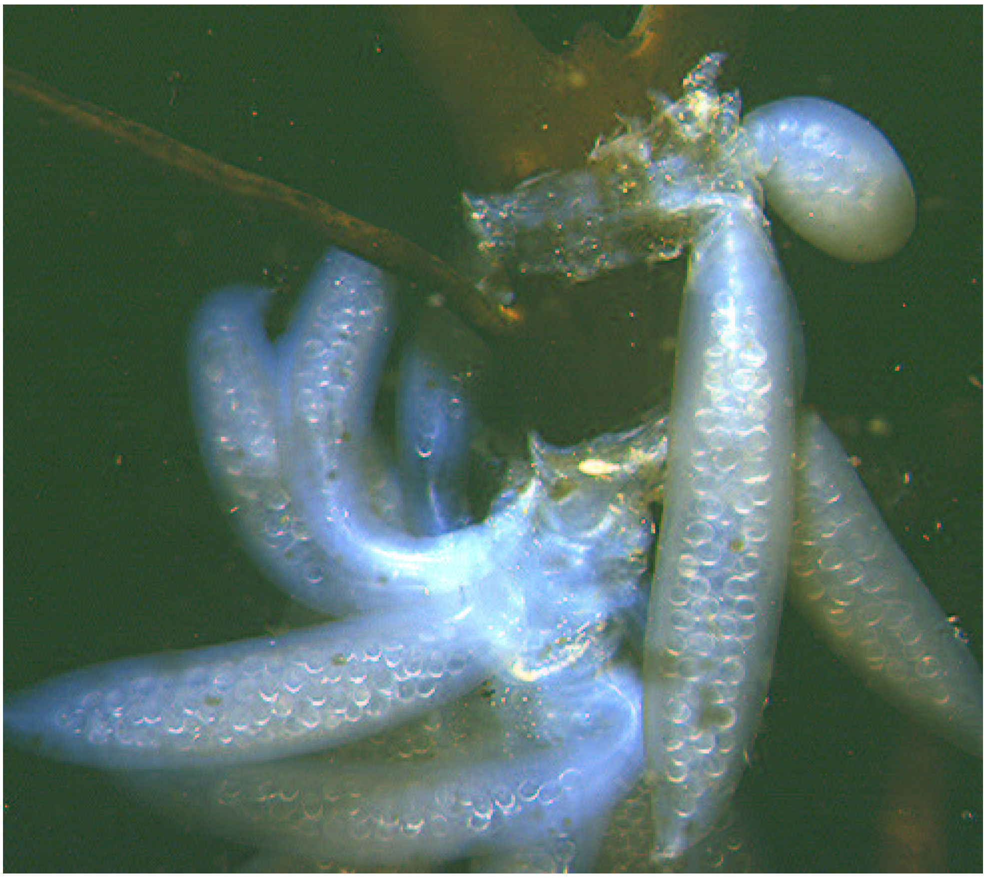


Figure 49. Egg mass attached to stalk of *Lessonia* spp. Photograph by David Eynon, Falkland Images.



The egg masses were not observed undergoing any significant predation despite the fact that a lot of different possible predators (crabs and echinoderms) were observed on the bottom. The only evidence of possible predation on the egg masses was a hermit crab climbing a single *M. pyrifera* stem which supported an egg mass.

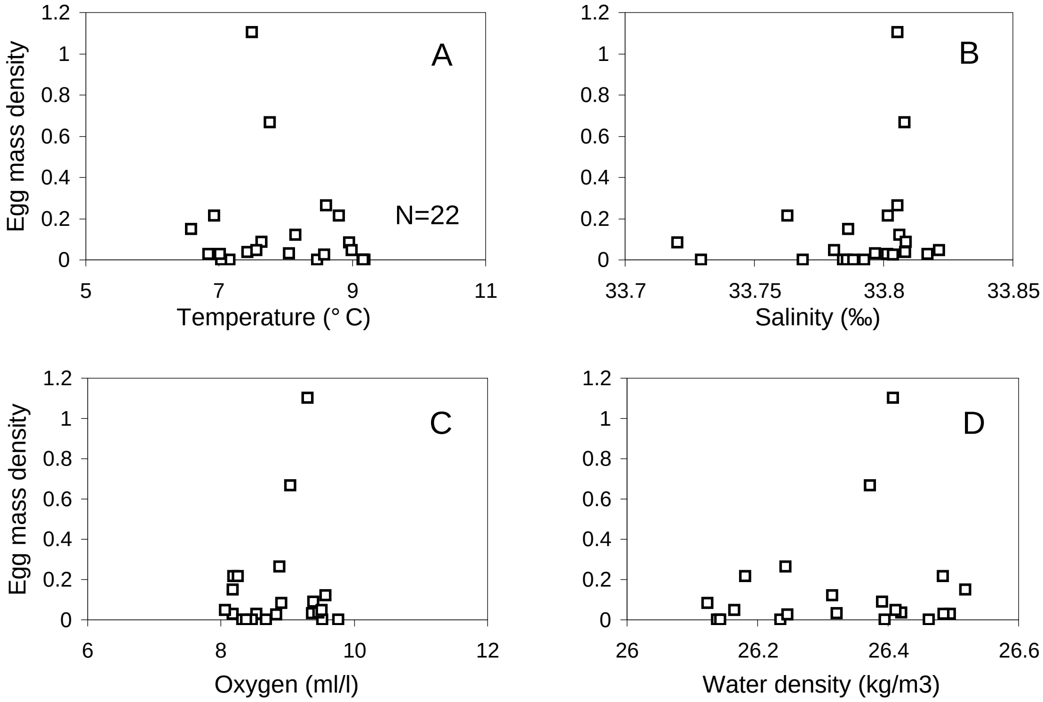
## Environmental conditions

Egg masses occurred in the whole spectrum of hydrological parameters encountered during the study (Figure 50). However, maximum egg masses abundance was found at a water temperature of 7.5-7.8°C, salinity 33.8‰, oxygen concentration 9-9.3 ml/l and water density 26.4 kg/m$^3$.

## Structure of the egg mass

The egg masses look like bundles of elongated balloons (capsules) with each capsule attached strongly to the algal stem at its basal end. The number of capsules in the sampled egg masses varied from 4 to 161. As in other loliginid squid (see Drew, 1911), the egg capsule is spindle-shaped and consists of two gelatinous layers. The outer layer is more resilient and surrounds a more viscous inner layer that contains the eggs. The length of capsules varied from 18 to 86 mm (mean 53.64; SD=10.86) and egg number ranged from 0 to 144 (mean 71.67; SD=22.37). Larger capsules usually contained more eggs. The total number of eggs in the sampled egg masses varied from 138 to 11,487 eggs. Egg masses containing up to 2500 eggs were most frequent.

Figure 50. The relationship of egg mass density (in numbers observed per unit dive time) to temperature, salinity, oxygen concentration, and water density at diving stations around the coast of East Falkland in November 1999.




## Stages of embryonic development

During the period studied, almost all stages of the embryonic development were observed in the egg masses, from fertilized eggs (stage 1-2) to embryos which were ready to hatch (stages 29-30). Each egg capsule contained eggs at a similar stage of embryonic development.

## Multiple maternity of eggs within egg masses

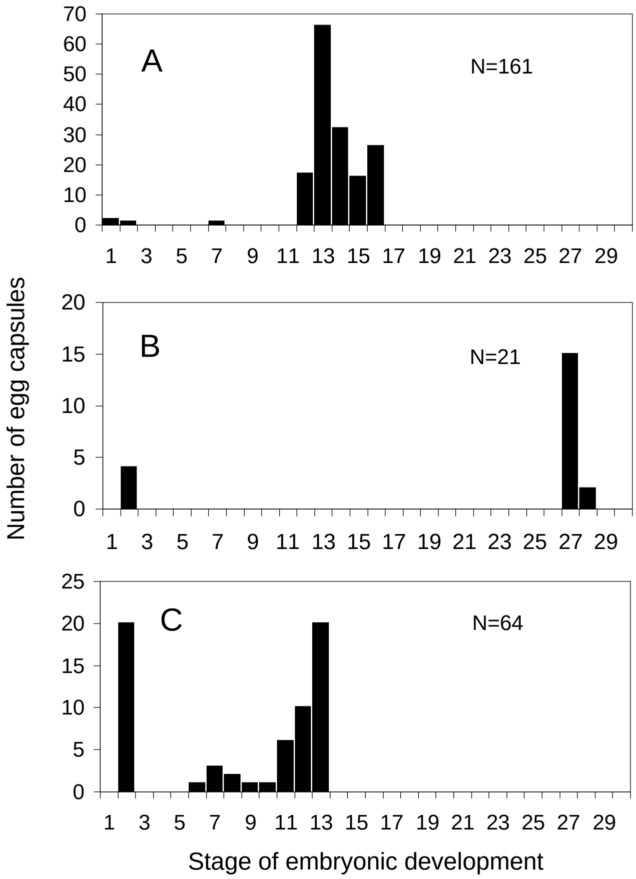
Among 29 fully studied egg masses, 15 contained eggs all at the same point of development (i.e. all eggs within a maximum range of one point on the Arnold scale). The rest of the egg masses examined had capsules with eggs at different (up to 7) stages of embryonic development. Large egg masses usually contained capsules of very variable size with eggs at different stages of development (Figure 51). This probably reflects multiple maternity of the egg clusters within a mass, which is common for loliginid squids (Drew 1911), rather than different rates of egg development in different egg capsules. The simultaneous occurrence of capsules at very different stages of embryonic development (stages 14 and 28, for example) in the same egg mass supports this conclusion.

## Hatching and paralarvae

One egg mass studied contained embryos at development stage 30 (ready to hatch). During its analysis in the laboratory (an hour after its collection), paralarvae started to hatch from the egg mass, probably due to a sudden increase of water temperature in the jar. Each paralarva emerged from the egg and then penetrated easily through the outer gelatinous layer of the egg capsule. After paralarva escapement the hole in the outer layer of the capsule was quickly filled by the surrounding jelly and disappeared, making the capsule appear intact but with an empty egg inside.

The chromatophore arrangement of the paralarva head (Figure 52) was typical for *Loligo* spp. hatchlings (Vecchione and Lipinski 1995), confirming that the egg masses studied belonged to *Loligo* sp. There is only one species of this genus in Falkland's waters: *Loligo gahi.* The mantle length of newly hatched paralarvae varied from 3.1 to 3.4 mm (mean 3.2 mm ML).

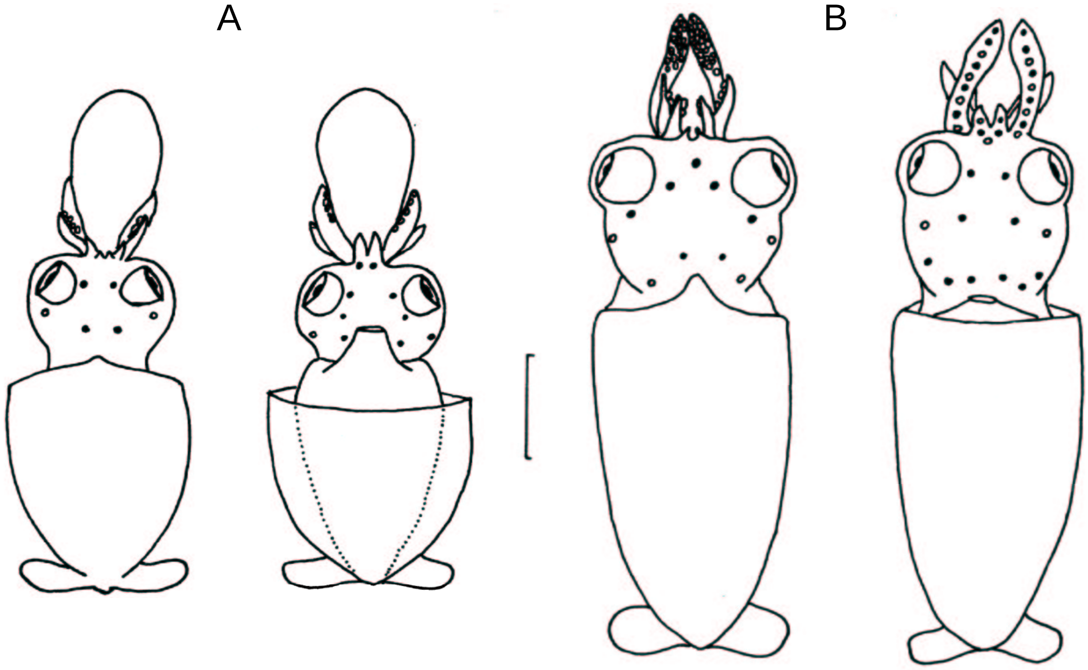
Figure 51. Numbers of egg capsules with embryos at different stages of development in three separate egg masses (A, B and C).




## *Discussion*

Squid of the family Loliginidae are demersal spawners laying their egg masses on different substrates on the bottom (Hanlon 1998). Some species tend to spawn inshore at depths 15-20 m (*L. vulgaris reynaudii*, Sauer et al. 1992), other species prefer to spawn deeper on the shelf and continental slope (*L. forbesi*, Lordan and Casey 1999). The inshore spawning *L. v. reynaudii* is rather flexible in choosing spawning sites, from relatively protected bays to exposed parts of the coast, but always below the energetic turbulent zone (>15 m depth, Sauer et al. 1992). In contrast to the latter species, *L. gahi* almost always chooses rather exposed sites, often on the outer edge of the kelp forest, with significant surge and tidal movements. The spawning substrate of *L. gahi* seems to be unique among loliginid squids, with eggs laid on stalks of algae at shallow depths. Most loliginids studied previously lay their egg capsules one by one on a sandy bottom, anchoring them in the sand by the sticky basal tip of the capsule (*L. opalescens,* McGowan 1954; *L.v. reynaudii*, Sauer and Smale, 1993). They usually form large 'egg beds' several meters in diameter containing as many as 6700 egg capsules (Augustin et al. 1994). Only occasionally do females attach a few egg capsules to different objects on the bottom such as rope moorings, twigs and crab pots (*L. forbesi,* Holme 1974). The reason for the preference of *L. gahi* to spawn onto algal stalks is unclear. In Falkland's waters there are no potential fish predators capable of eating the squid egg capsules such as, for example, the sparid *Spondyliosoma emarginatum* in South Africa which attacked the egg capsules of *L. v. reynaudii*. These attacks, however, were unsuccessful and damaged only the capsule tips (Sauer and Smale 1993). Only benthic invertebrates therefore could potentially feed on squid eggs, such as spider crabs which easily open egg capsules, offered in the laboratory aquarium, using their claws, then take out and eat the eggs (pers. obs.). Thus, laying the egg capsules on smooth algae stalks at some distance above the bottom should protect them from foraging by invertebrates. Continuous movement of the egg masses together with the algae stalks may prevent significant coverage by organic debris and enhance egg respiration. Finally, locating the egg masses on algal stalks may afford protection in the high-energy near-shore environment.

Figure 52. General morphology and head chromatophore arrangement of (A) an embryo at stage 30 (2.8 mm ML) and (B) a paralarvae.




Despite surveying near the end of the spawning period of the abundant second cohort of *L. gahi* (Hatfield and Des Clers 1998), the total density of egg masses found at the edge of the kelp forest was low. It is still possible therefore that the main spawning grounds of *L. gahi* could be located deeper (>50 m depth) where fully mature and spawning females have been frequently caught by trawling (Rasero and Portela 1998; our data). Two facts, however, do not favour possible deepwater spawning. Firstly, we have never observed egg masses of *L.gahi* attached to any substrate other than algal stalks, and this does not occur deeper than 20 m with any great frequency. Secondly, egg masses have not been reported from the bottom trawl fishery for *L. gahi* despite extensive monitoring of the fishery by scientific observers (George and Hatfield 1995). Further investigations are needed to clarify the status of the inshore spawning sites of *L. gahi*.

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