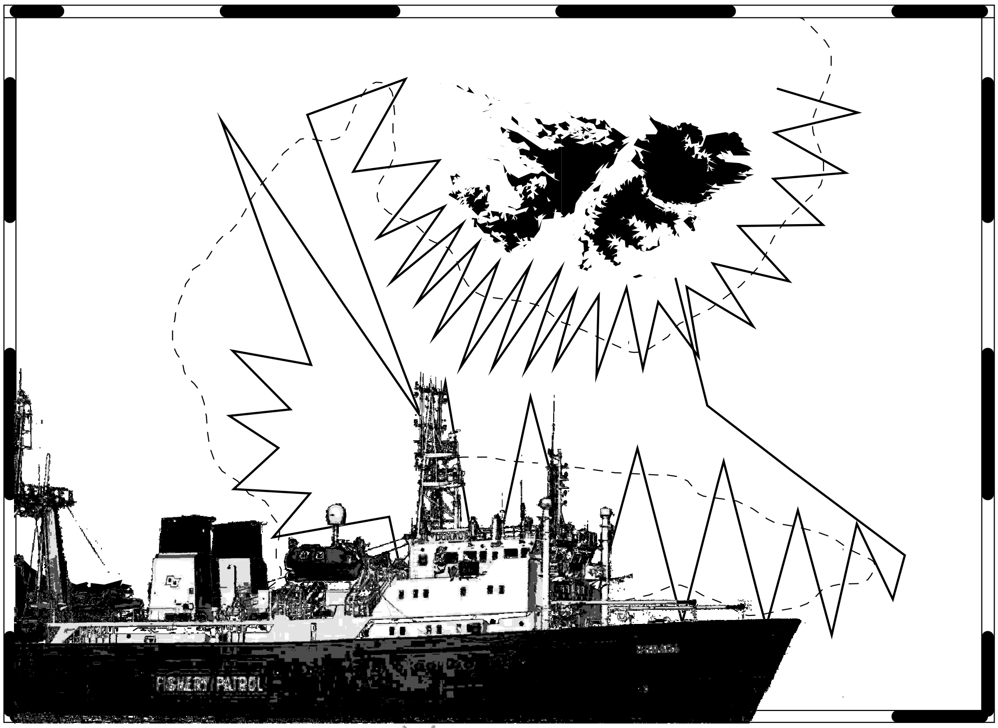
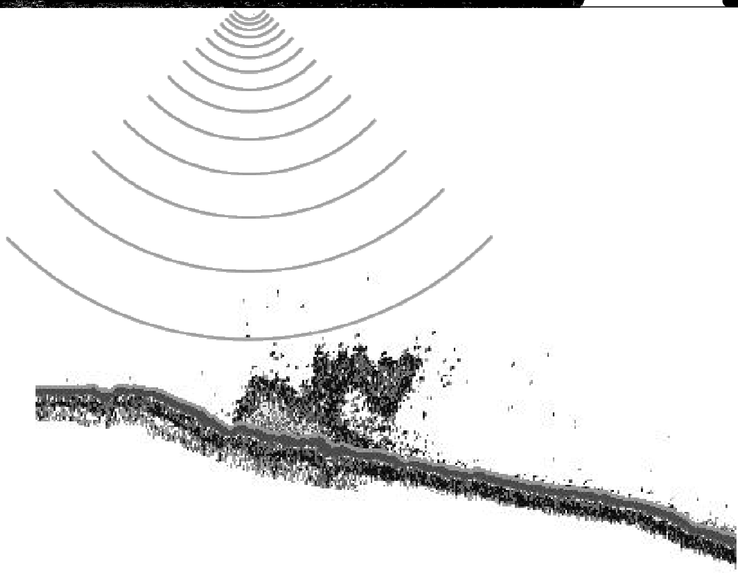
Scientific Report

Fisheries Research Cruise ZDLH1-09-2002





Fisheries Department

Falkland Islands Government

Scientific Report

Fisheries Research Cruise

ZDLH1-09-2002

FPRV Dorada

5 September to 2 October 2002

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 September 2002 using the Fisheries Patrol and Research Vessel *Dorada*. This was the first occasion on which the *Dorada* participated in a joint UK-Argentine research cruise under the auspices of the South Atlantic Fisheries Commission and we welcomed the participation of scientists from INIDEP. We wish to record our thanks to the master, fishing master, officers and crew of the *Dorada* for their work during the cruise.

We are also grateful to the Berntsens at Albemarle Station and Chaters at New Island who, together with FIGAS, assisted in changes of scientific personnel during the survey.

Summary

The research cruise ZDLH1-09-2002 was carried out on board the Fisheries Research and Protection Vessel *Dorada* at the start of the austral spring (September) 2002. This was primarily an acoustic survey of spawning southern blue whiting, *Micromesistius australis australis*, and was the first phase of a joint survey carried out under the auspices of the South Atlantic Fisheries Commission.

The area surveyed included the slope from 100 – 500 m around the east, south and west of the Falkland Islands, the deeper shelf area to the SW of the Falklands, the slope north of Isla de los Estados, and the Burdwood Bank. The principal concentrations of southern blue whiting were found to the south of the Falkland Islands. Two distinct groups were identified in this region: large fish aggregated for spawning, and aggregations of smaller fish of mixed maturity in deeper water to the south of the spawning area. The post-spawning dispersal had not begun and no significant aggregations of blue whiting were found to the east of the Falklands, although a small number of juvenile fish were caught here.

Southern blue whiting was uncommon over the deeper shelf areas but more abundant to the north of Isla de los Estados. Here there was again evidence of two groups of fish: juveniles and larger fish at a mixture of maturity stages, including a small number of spawning fish. Virtually no southern blue whiting were caught on the Burdwood Bank.

Preliminary acoustic estimates of southern blue whiting biomass ranged from 45 to 105 thousand tonnes. The wide range in these estimates was the result of an extremely patchy distribution of spawning southern blue whiting, and further analysis of the distribution is required before a final biomass figure can be derived.

Samples were taken from southern blue whiting for studies of stock discrimination and reproduction.

Hoki, *Macruronus magellanicus*, was abundant to the south east and south west of the Falklands, and north of Isla de los Estados. The majority were at resting (stage II) maturity. Spawning aggregations of Falklands Herring, *Sprattus fuegensis*, were found in the eastern part of the Burdwood Bank. The rockcod *Patagonotothen ramsayi*, was also abundant on the Burdwood Bank and the majority of adults were post-spawning.

Loligo gahi was encountered widely throughout the survey area and samples were taken for genetic analysis.

Three deep water pelagic trawls were carried out at the end of the survey in deep water to the south of the Falklands to investigate the relatively unknown deep-water pelagic ecosystem of the area. These trawls were successful in obtaining the first specimens of mature female squid *Galiteuthis glacialis* and *Gonatus antarcticus*.

1.Introduction

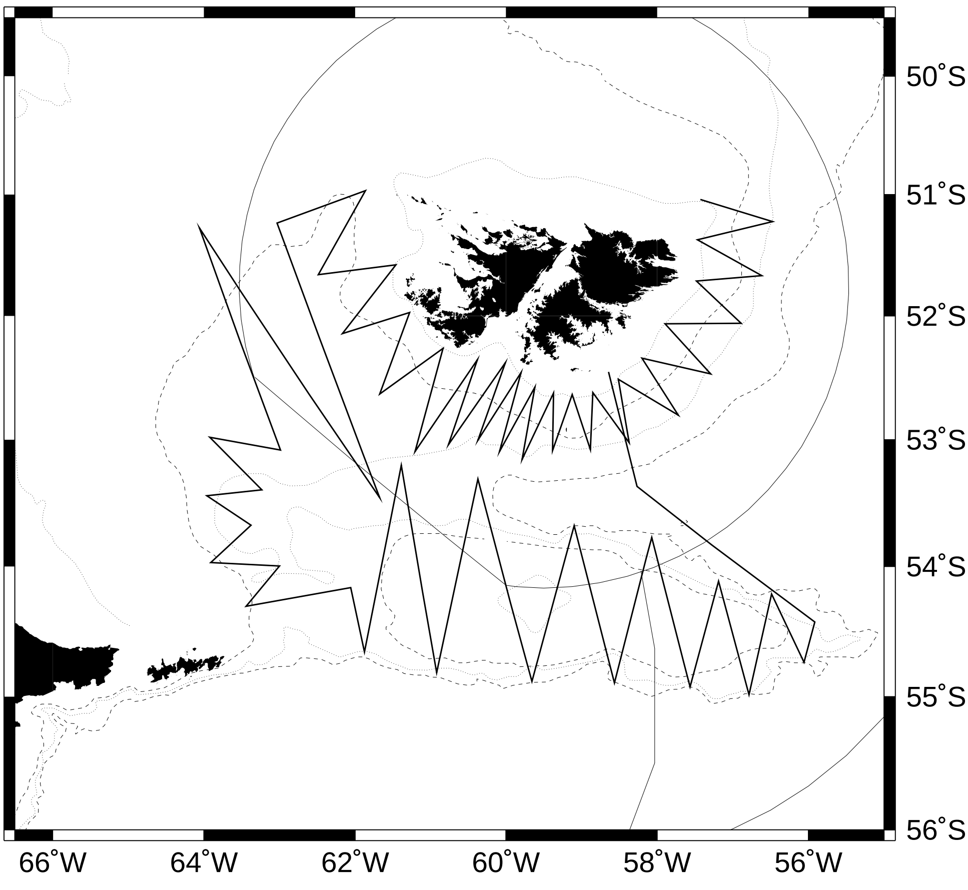
The research cruise ZDLH1-09-2002 was the second acoustic survey of spawning concentrations of *Micromesistius australis australis* (southern blue whiting) carried out by the Fisheries Department onboard the *Dorada*. It was also the first occasion on which the *Dorada* participated in a joint UK-Argentine survey under the auspices of the South Atlantic Fisheries Commission, and three scientists from INIDEP joined the scientific team. The work onboard *Dorada* represented the first phase of the joint survey, with the second phase carried out by the INIDEP vessel *Oca Balda* during October 2002.

Previous joint surveys of Southern Blue Whiting, and the additional survey carried out by FIFD in October 2001 (Falkland Islands Government, 2002), generally missed peak spawning. Although large post-spawning aggregations were encountered on a number of surveys, on these occasions there was also evidence that the fish had begun their post-spawning dispersal. Analysis of data gathered by FIFD observers over the last fourteen years suggested that spawning usually peaked in September. Peak spawning was expected to be the best time at which to carry out an acoustic survey as it was anticipated that the majority of the spawning population would be concentrated in the main spawning area to the south of the Falklands.

1.1. Region

The region surveyed included the slope around the Falkland Islands at depths between 100 and 500 m clockwise from NE of East Falkland to NW of West Falkland, the deeper shelf region in the SW of the FICZ, the slope north of Isla de los Estados, and the Burdwood Bank. Two of these areas (the slope round the Falkland Islands, and north of Isla de los Estados) were surveyed again by the *Oca Balda* during the second phase of the joint survey. The planned cruise track is shown in Figure 1.

Figure 1. Planned cruise track for research cruise ZDLH1-09-2002.



1.2. Cruise objectives

1. To carry out an acoustic and trawl survey to assess the distribution, abundance and biological condition of southern blue whiting, especially on its major spawning grounds south of the Falkland Islands.
2. To study oceanographic conditions over the survey area.
3. To collect routine biological samples and specific samples for studies of stock discrimination and reproduction in *M. a. australis*.
4. To monitor the effects of an experimental bird scaring device (South Atlantic Albatross Saver, SAAS) during trawling.
5. To carry out inter-vessel calibrations with the *Capt. Oca Balda*.
6. If time allowed, to carry out some deep water pelagic trawls south of the Falklands.

1.3. Cruise plan

The main survey was carried out between 5 September and 2 October 2002. Trials of the bird scaring device were carried out during the first ten days of this period, with changes in scientific personnel being carried out at Albemarle on 13 September and New Island on 16 September. The inter-ship comparison was carried out after the main survey period, on 14/15 October, when the *Capt. Oca Balda* arrived in the area.

The planned acoustic survey track (Figure 1) consisted of a "zig-zag" transect pattern, beginning to the NE of East Falkland. Transects were generally up/down slope between 100 and 500 m. Oceanographic stations were carried out at the cruise track vertices and at the middle or every second survey leg. Additional oceanographic stations were carried out on pre-existing oceanographic transects. Acoustic and oceanographic data were collected along the entire cruise track. Regular plankton stations were not included in the cruise plan but were carried out as time allowed.

1.4. Vessel characteristics

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

Table 1. Characteristics of the Fisheries Protection and Research Vessel, *Dorada*.

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

1.5. Personnel and responsibilities

The following FIFD personnel participated in the cruise:

Dr David Middleton	Chief Cruise Scientist/Acoustic survey
Dr Ryszard Grzebielec	Oceanographic survey
Joost Pompert	Trawl survey
Dr Vladimir Laptikhovsky	Trawl survey/Reproductive biology
Andrew Stocks	Trawl survey/SAAS trials
Oliver Yates	Trawl survey

Drs. Adrian Madirolas (Acoustic survey), Marcelo Pájaro (Trawl survey/Reproductive biology), Gustavo Alvarez Colombo (Acoustic survey/Trawl survey) from INIDEP also participated in the survey together with Dr. Ben Sullivan (Falklands Conservation Seabirds at Sea team) who led the SAAS trials.

2.Bathymetry

2.1. Introduction

The bathymetric data available for the survey region from hydrographic charts or standard data sources such as GEBCO-97 (General Bathymetric Chart of the Oceans; NERC, 1997) varies in quality. Depth contours are often inaccurately placed making cruise planning and data interpretation more difficult. The survey pattern designed for the assessment of *Micromesistius australis australis* biomass was also useful for the collection of bathymetric data.

2.2. Methods

Position and water depth were recorded at five minute time intervals along the cruise track. During trawls more frequent position/depth data was logged. This was integrated with previous track log data recorded on *Dorada*. Bathymetric data was compiled for the region from 50.5 to 55.5°S and 55.0 to 66.5°W. This data was gridded using a 0.05° latitude/longitude grid spacing, taking the median value when a grid cell contained multiple depth recordings, and interpolated using splines. Grid cells more than 10 km from a measured depth were masked and the resulting grid was contoured.

2.3. Results

The bathymetry of the region is illustrated in Figure 2. In Figure 3 the dataset is contoured and the 100, 200, 500, 1000 and 1500 bathymetric contours are compared with the data from the GEBCO atlas. It is clear that the GEBCO contours give a reasonable approximation of the regional bathymetry but are most accurately positioned for deeper depths. The actual position of the 100m contour north of the Falklands, and the 200 and 500m contours south and east of the Falklands clearly differs quite significantly from that given in the GEBCO dataset.

Figure 2. Bathymetry of the survey region from data utilising new and historical data. Grid cells from which no data is available are shown in white.

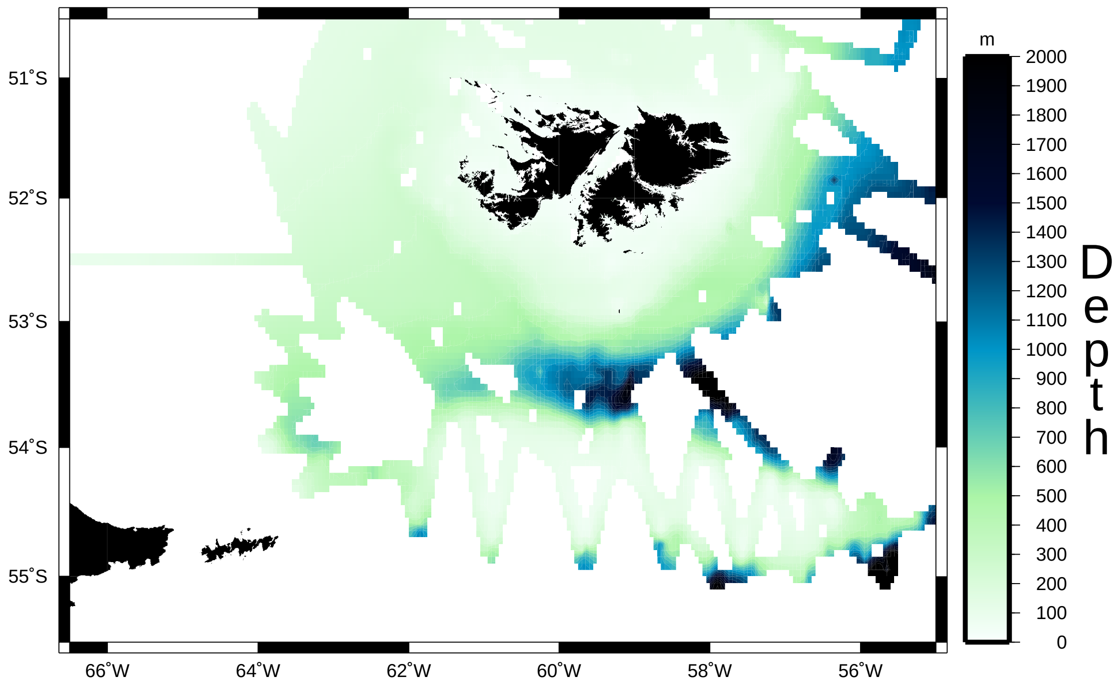
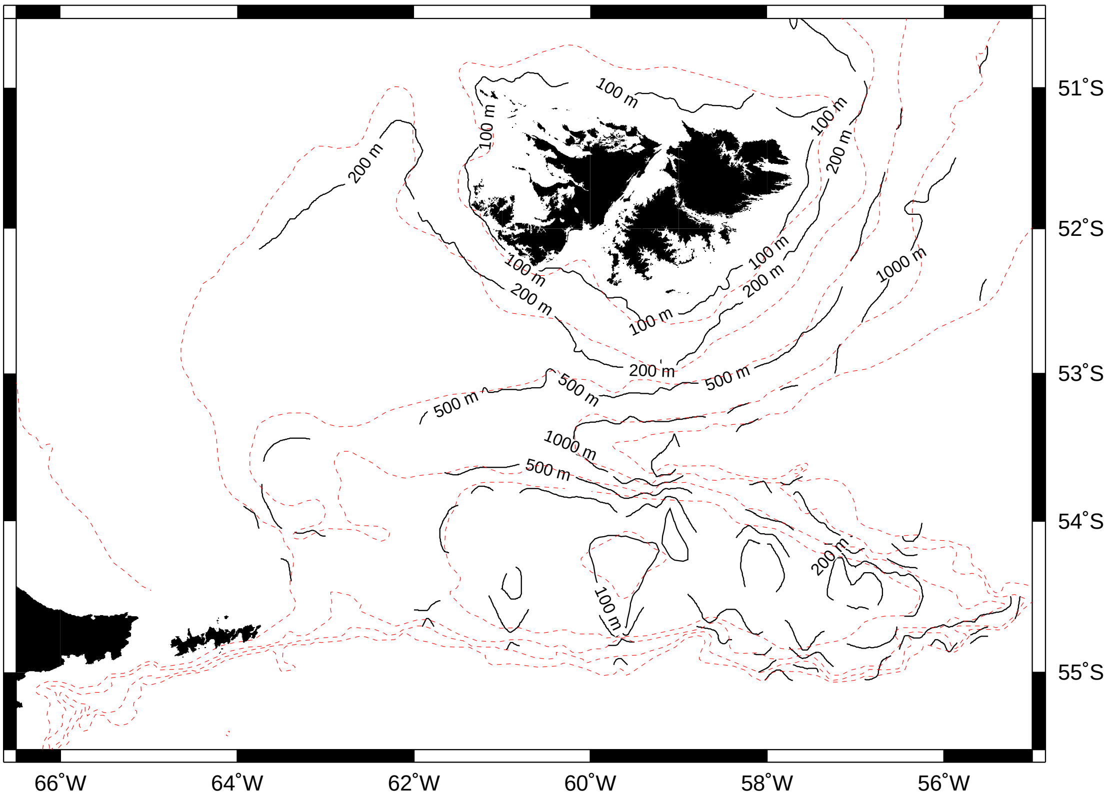


Figure 3. Bathymetric contours at 100, 200, 500, 1000 and 1500m using the same data as Figure 2 (black lines) together with the equivalent contours from the GEBCO atlas (dashed red lines).



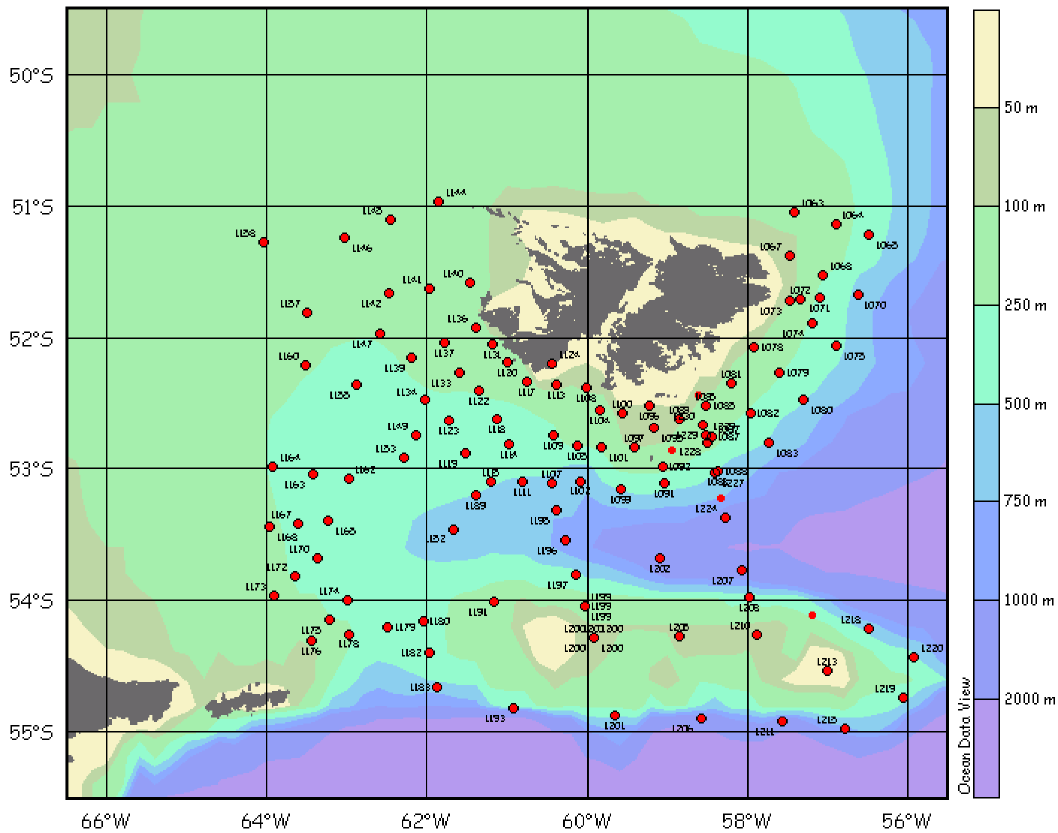
3. *Oceanographic survey*

Hydrographic data were collected at 120 oceanographic stations (Figure 4) during the period 6 September to 1 October 2002. Stations were made at the cruise track vertices and at intermediate positions on every second survey leg. Additional stations were carried out on pre-defined oceanographic transects. Two transects in the south made towards the end of the survey will supplement the pattern of radial oceanographic transects around the Falklands carried out by the *Oca Balda* in the second phase of the joint survey.

3.1. Methods

A logging CTDO profiler (SBE-25, Sea-Bird Electronics Inc., Bellevue, USA) was deployed to obtain depth profiles of temperature (°C), salinity (PSU), and chlorophyll-a (ug l^{-1}). Data on oxygen concentration was also logged but is not considered reliable and so is not discussed further. The CTD was deployed for the first 4 minutes at 10m depth to allow polarizing of the oxygen sensor. It was then retrieved to 1 m depth and deployed again either to a depth about 10-20 m above the bottom (shelf and continental slope) or down to 1100 m in the open sea. The speed of deployment was *c.* 1 m/s and was monitored by use of a wire counter. The CTDO sensors were calibrated in May/June 2002 by Sea-Bird Electronics Inc. Analyses were carried out using Ocean Data View version (mp) 1.2a (Schlitzer 2002).

Figure 4. Location of the CTD stations carried out on research cruise ZDLH1-09-2002 (GEBCO bathymetry).



3.2. Results

The CTD stations covered waters of the eastern and western branch of the Falkland Current near the Falkland Islands, shelf waters over the Patagonian shelf, and waters of the Burdwood Bank and Falkland Trough.

Temperatures ranged from 2.2° to 6.2° C, salinity from 33.3 to 34.3 psu, chlorophyll-a from 0 to 3 [µg/L] and densities ranged from 26.2 to 27.3 kg m^3. The distribution of these parameters for all 120 stations is presented in Figure 5 whilst surfaces fitted to the near bottom and surface data are shown in Figure 6 to Figure 9.

A detailed hydrological analysis of the data obtained will be carried out during the first half of 2003 by oceanographers from AtlantNIRO (Kaliningrad) under contract to FIG.

Figure 5. Distribution of temperature, salinity, chlorophyll a and density for all CTD stations carried out during research cruise ZDLH1-09-2002.

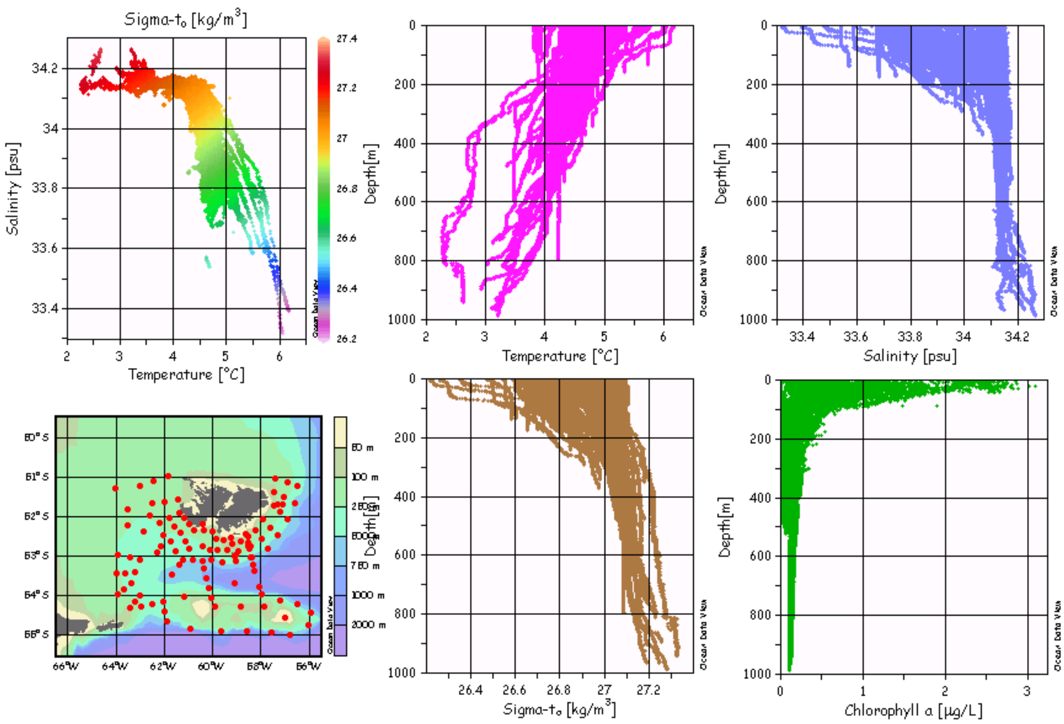


Figure 6. The distribution of surface and near-bottom temperatures using data from all CTD stations carried out during research cruise ZDLH1-09-2002 (5 September to 2 October 2002).

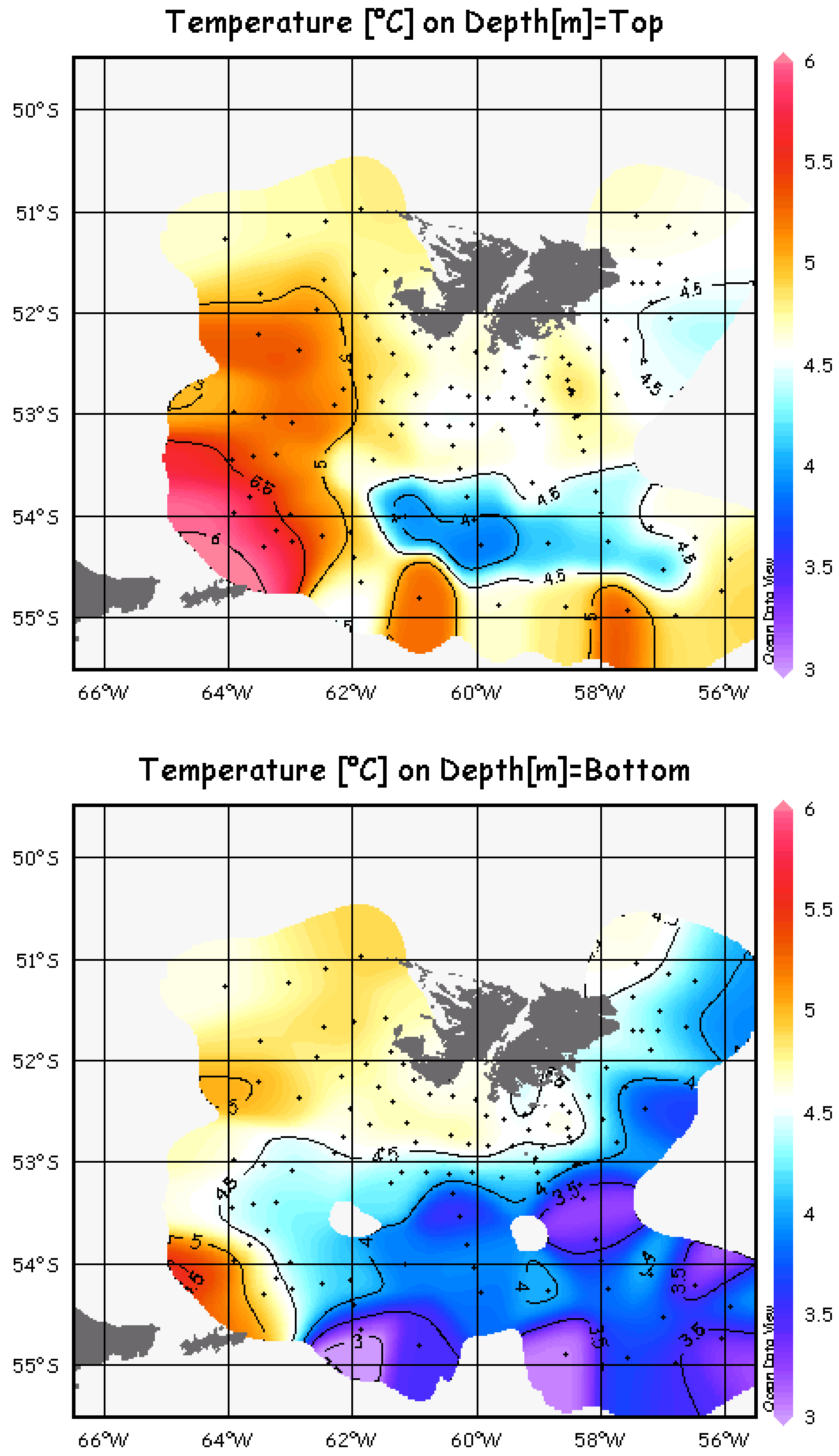


Figure 7. The distribution of surface and near-bottom salinity using data from all CTD stations carried out during research cruise ZDLH1-09-2002 (5 September to 2 October 2002).

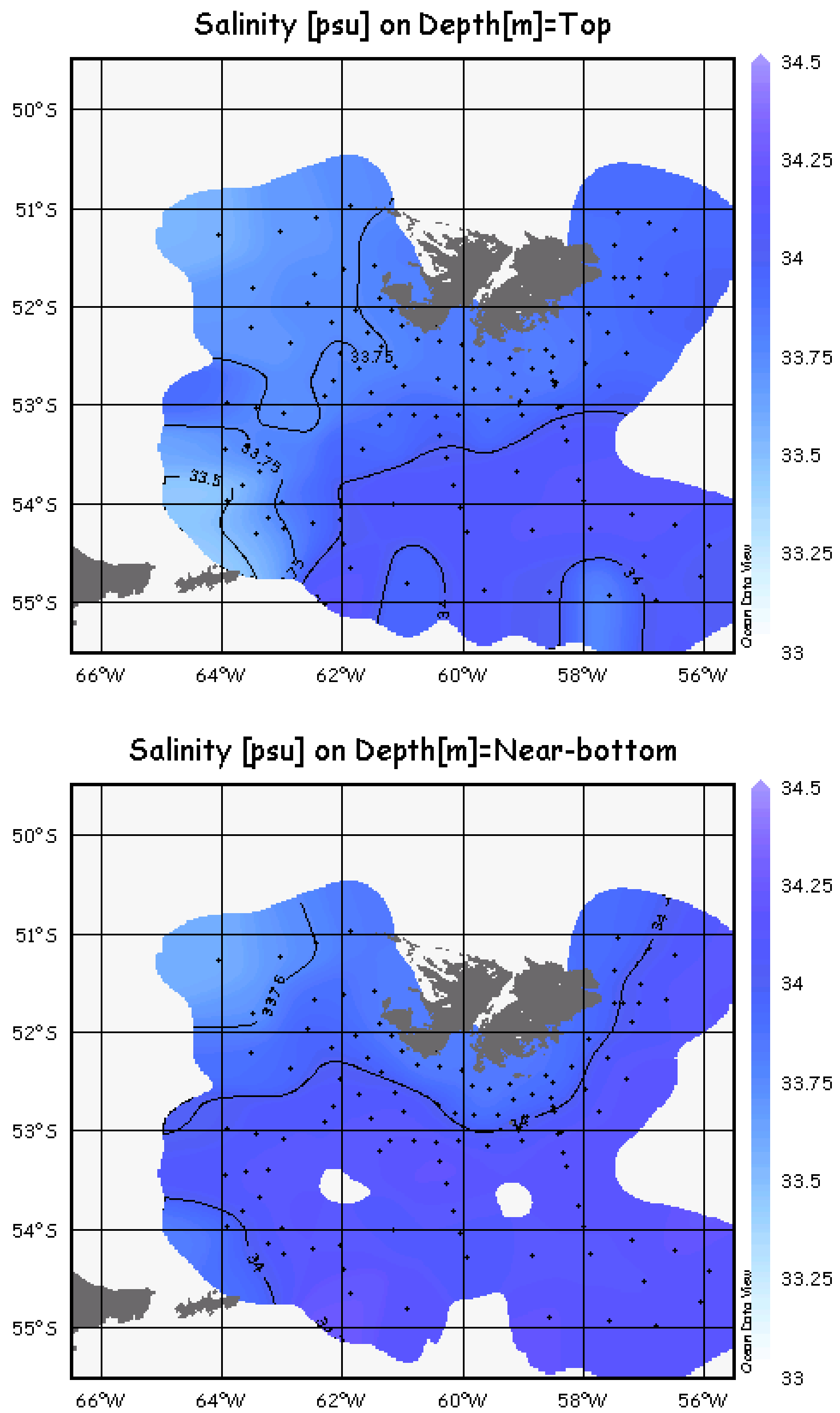


Figure 8. The distribution of surface and near-bottom chlorophyll-a using data from all CTD stations carried out during research cruise ZDLH1-09-2002 (5 September to 2 October 2002).

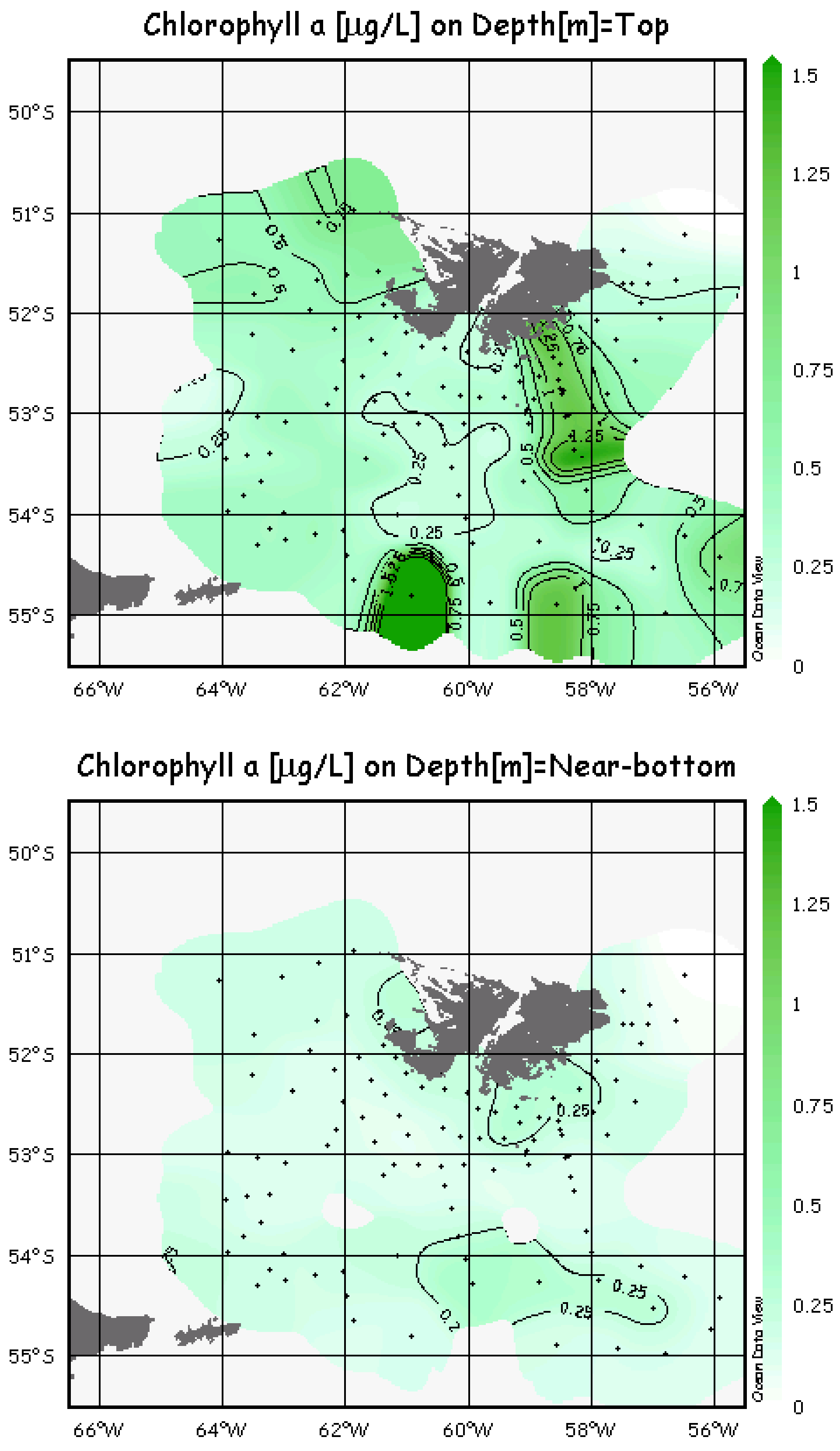
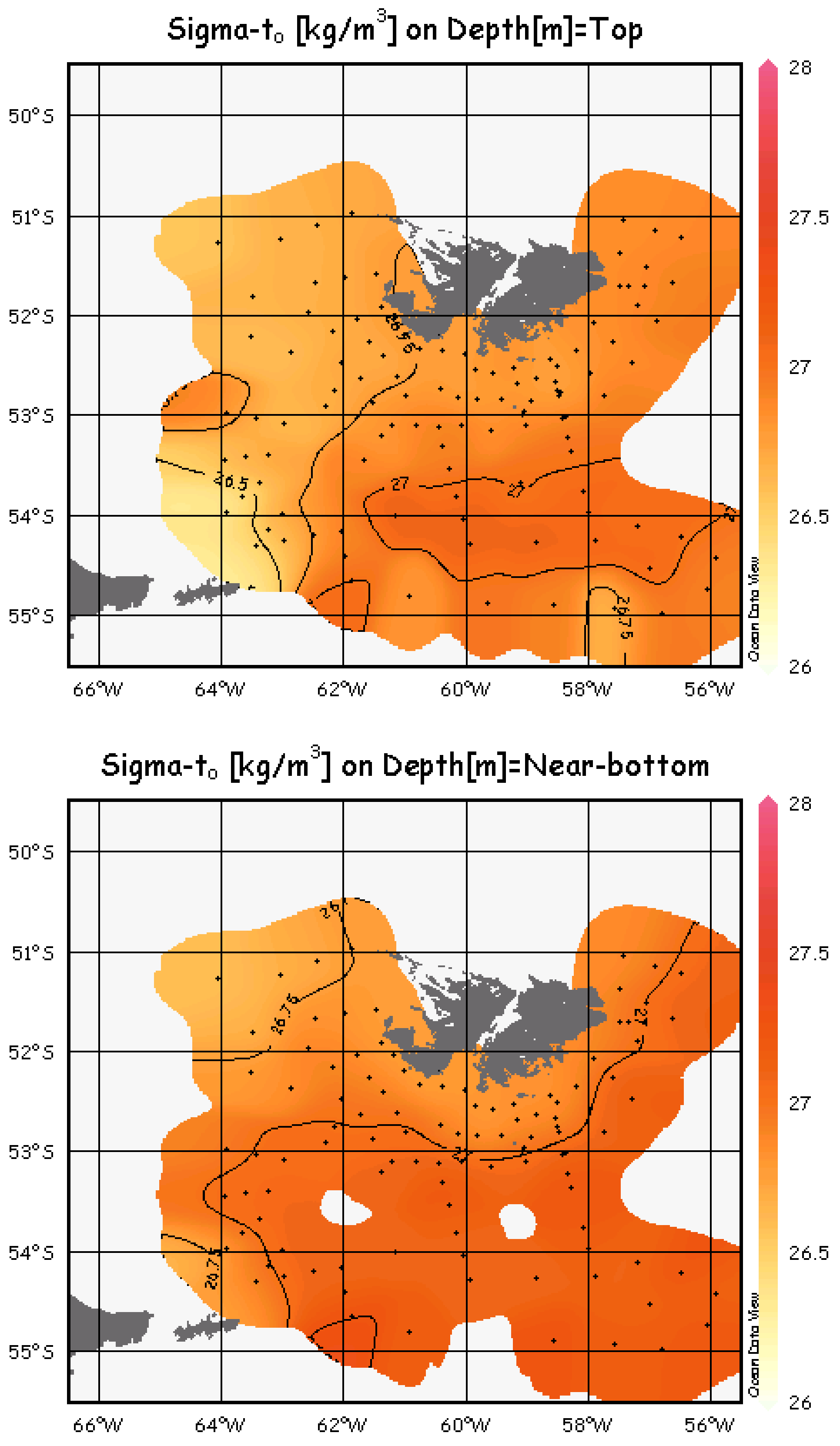


Figure 9. The distribution of surface and near-bottom density using data from all CTD stations carried out during research cruise ZDLH1-09-2002 (5 September to 2 October 2002).



4. Biological sampling

4.1. Trawls

All trawl stations used an ENGEL semi-pelagic trawl with a 40.2 m headline and a 38.7 m footrope equipped with rockhoppers. The mesh size at the cod-end was 95 mm and a 40 mm cod-end liner was used. The doors were Super-V style weighing 1200 kg and with an area of 6 m^2. The trawl was equipped with SIMRAD ITI sensors. The typical vertical opening of the trawl was between 11 and 15 m when fishing semi-pelagically. The towing time at the trawl horizon (usually the seabed) was normally 30 mins but when targeted trawls were carried out this was shortened if necessary to avoid a massive catch (and subsequent discard) of fish. Towing time for the deep-water pelagic trawls was 2 hours at the designated horizon.

4.2. Biological sampling

Objectives of the biological sampling programme were to:

1. Accurately weigh all catch and by-catch, and identify to species level, where possible.
2. Collect biological data including length/frequency and/or size/weight data from the main catch and by-catch species, together with otoliths for ageing finfish.
3. Collect whole fish, otolith, and muscle samples from *Micromesistius australis australis* for stock discrimination studies.
4. Collect gonad samples from *Micromesistius australis australis* for studies of its reproductive biology.
5. Analyse the diet of a variety of species and collect whole stomachs of *Micromesistius australis australis* for analysis ashore.
6. Collect samples of *Loligo gahi* for statolith extraction and muscles samples for genetic analysis.

4.2.1. Catch estimation

The total catch was sorted, identified to species (when possible) and weighed by species using marine balanced scales. Sample/sub-sample weights were also recorded.

4.2.2. Biological analyses

For samples (100 individuals, or the entire catch if less) of commercial fin-fish species the following were recorded: total or pre-anal length to the nearest centimeter below (TL), sex, maturity stage (FIFD eight stage scale), stomach fullness and diet composition. Individual weight was recorded in grams to the nearest gram using a POLS marine balanced scale or to the nearest 20 grams using the Scanvaegt balances.

From all stations where *Loligo gahi* was caught a sample of 200 individuals (or the entire catch if this was less) was analysed for length and weight, with some sub-samples subjected to statolith extraction at sea. Dorsal mantle length (DML) was measured to the nearest half-centimetre below, and sex and maturity stage were recorded. For females, evidence of sperm in the buccal cavity and/or in the mantle attached near or onto the gills was recorded. A stomach fullness index (SFI, range 0-5) and stage of digestion (1-4) was recorded for all specimens.

For rays the following were recorded: species, total length (TL) and disk-width (DW) to the nearest centimeter below, sex, stage of maturity (FIFD scale), weight, diet, and level of *Otodistomum plunketi* infection.

Species codes used for the description of dietary components are given in Table 2.

Table 2. Codes used for dietary components.

Code	*Species name*
ACP	*Acanthephyra pelagica*
AMP	Amphipods
ANM	Anemone
ANT	Anthozoa
BEE	*Benthoctopus eureka*
BEO	*Beroe ovata*
BLU	*Micromesistius australis australis*
CAS	*Campylonotus semistriatus*
CAV	*Campylonotus vagans*
CHA	Chaetognatha
COA	Copepoda
COG	*Patagonotothen guntheri*
COX	Notothenids
CRB	Crab
CRU	Crustacea
CRX	*Cranchiidae* spp.
EUP	Euphausids
FIN	Unidentified finfish
GON	*Gonatus antarcticus*
GRF	*Coelorhynchus fasciatus*
GYM	*Gymnoscopelus* spp.
HOL	Holothuroidea
HYD	Hydrozoa
ISO	Isopods
LOL	*Loligo gahi*
MAR	*Martialia hyadesi*
MED	Medusae
MUN	*Munida* spp.
MXX	Myctophidae
MYS	Mysidacea
NEE	*Nematoscelis megalops*
NUD	Nudibranchia
OPH	Ophiuroidea
PHR	Phronimidae
POL	Polychaeta
SAL	*Salpa* sp.
SER	*Serolis* spp.
STP	*Sternoptyx pseudodiaphana*
WLK	Whelks

4.2.3. *Micromesistius australis australis* ageing samples

Otoliths for ageing were collected by stratified random sampling, randomly sampling 25 fish from each 5cm size interval. The actual sample numbers obtained are detailed in Table 3. Separate ageing otolith collections were made in each of the regions from which stock discrimination samples were collected. Otolith pairs were split and packaged separately with one otolith going to FIFD and the other to INIDEP.

4.2.4. Sampling for *Micromesistius australis australis* stock discrimination studies

Otolith and muscle samples

When available, one hundred adult individuals were randomly sampled from each region shown in Figure 10. When sampling in a region revealed fish belonging to apparently different population groups then one hundred individuals were sampled from each group. Actual sample sumbers obtained are detailed in Table 4.

From each sampled fish two biological samples were taken: (i) otoliths, for trace element studies, and (ii) muscle samples, for genetic studies. Otolith were removed with plastic forceps and pairs were packaged together so that one otolith could be used for trace element analysis and the other for ageing. Half the otolith pairs were collected for INIDEP and half for FIFD.

Two muscles samples (one for FIFD and one for INIDEP) were taken from each fish sampled. Tissue samples were collected by making two parallel cuts with a scalpel blade into the dorsal side of the fish near the dorsal fin several millimetres apart and removing a strip of tissue, no wider than 5mm and not longer than 20mm, with scalpel and forceps. Tissue samples were stored in 96% ethanol. Both scalpel and forceps were rinsed in a separate sea water bath prior to handling a new sample.

Whole fish for parasite studies

Whole fish were collected for the purposes of a parasitological survey to identify potential biological tags for stock discrimination. A random sample of 50 animals was collected from each of the study regions identified in Figure 10 when sufficient fish were caught (Table 5).

Each animal sampled was individually wrapped and frozen within in one hour of capture. The samples were split with 25 per region fish going for examination at INIDEP and 25 at FIFD.

Table 3. Otolith samples taken for ageing.

Length Class (cm)	*E, SE of Islands*	*Main spawning grounds*	*SW of Islands*
15	1	2	
20	3	8	1
25	11		19
30	20		13
35	27	5	25
40	29	17	26
45	6	33	9
50	5	39	6
55		45	3
60	1	10	

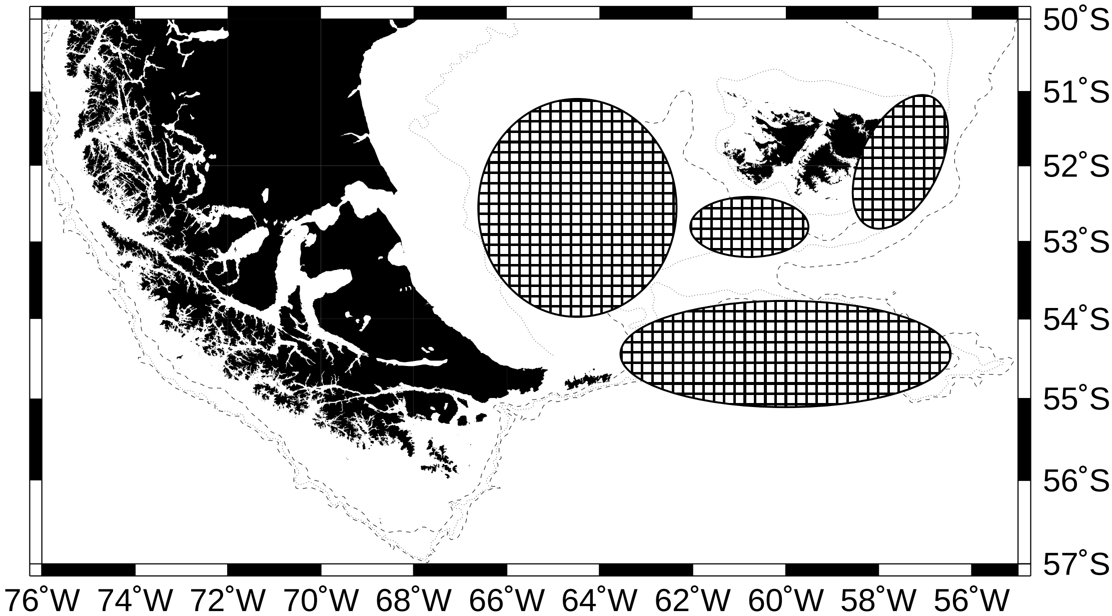
Table 4. Samples for genetic studies and otolith trace element studies.

Region	*Stations*	*Fish sampled*
1. E, SE of Islands	1076, 1084, 1094	124
2. Main spawning grounds	1116, 1186	50
3. SW of Islands	1150, 1151, 1154, 1161, 1166	100
4. Burdwood Bank	1194, 1209	5

Table 5. Samples obtained for parasite analysis.

Region	*Stations*	*Fish sampled*
2. Main spawning grounds	1110, 1186	100
3. SW of Islands	1169	50

Figure 10. Pre-defined regions from which samples of southern blue whiting were collected for stock discrimination studies during the research cruise ZDLH1-09-2002.



4.2.5. Sampling of *Micromesistius australis australis* gonads

Gonads were collected for microscopic histological analysis and were sampled and preserved within two hours of the catch arriving on deck. 30 ovaries of adult females were collected randomly from each trawl where a representative number of *Micromesistius australis australis* was caught for examination at INIDEP, together with extra ovaries at stages IV or V when possible. These were placed individually in plastic bags (40 x 25 cm) which were perforated and preserved in sealable drums of 10% formaldehyde (40-50 gonads per 20 litres of 10% formaldehyde).

Sampling for histological analysis at FIFD aimed to collect a total of 10 female ovaries and 5 male testes from each maturity stage encountered. To estimate female fecundity, a total of 15 ovaries at stage 5 per 1cm size class were collected when available with additional samples collected from spawning aggregations. Gonads were again placed individually in plastic bags which were perforated and preserved in sealable drums of formaldehyde - acetic mixture (15 parts seawater, 5 parts 40% formalehyde and 1 part glacial acetic acid).

4.2.6. Sampling of *Micromesistius australis australis* stomachs

Stomachs were be collected from *Micromesistus australis australis* for diet studies, stratified by size class and region as per the collection of otoliths for ageing. Full stomachs were frozen whole in individual plastic bags.

4.3. Station summary

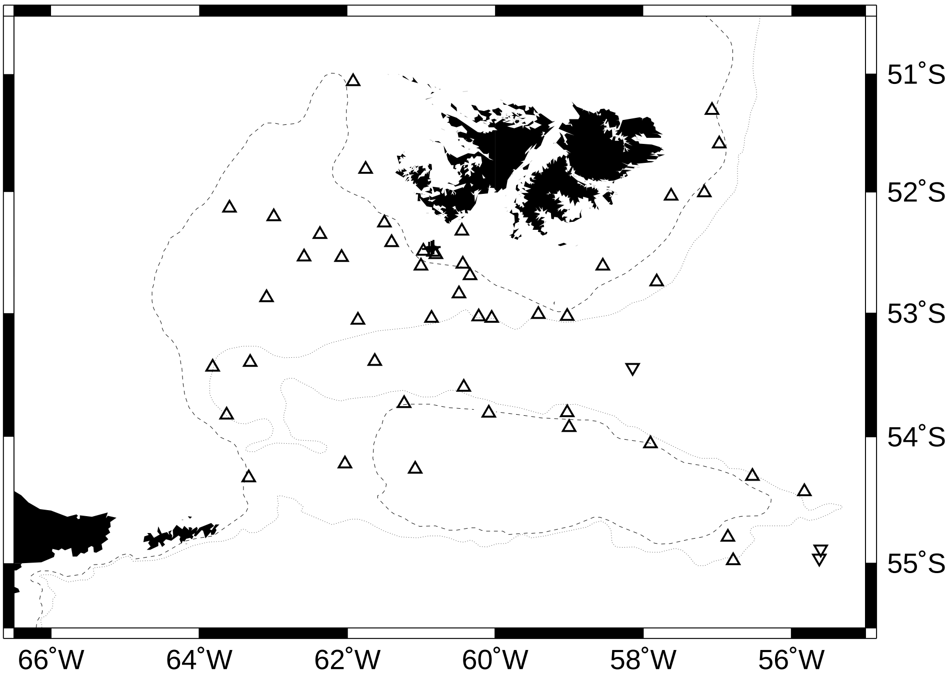
Table 6. Summary station details for research cruise ZDLH1-09-2002.

Stat.	*Activity*	*Date*	*Start Time*	*Seabed Start Latitude*	*Seabed Start Longitude*	*Seabed Finish Latitude*	*Seabed Finish Longitude*	*Modal Depth (m)*	*Durat -ion (mins)*
1063	CTD	06/09/02	00:05	51° 02.40 S	57° 24.90 W	51° 02.30 S	57° 24.70 W	120	7
1064	CTD	06/09/02	02:30	51° 08.50 S	56° 54.00 W	51° 08.00 S	56° 53.60 W	262	14
1065	CTD	06/09/02	04:39	51° 13.30 S	56° 28.70 W	51° 12.60 S	56° 28.60 W	505	21
1066	Semi-pelagic	06/09/02	08:15	51° 19.50 S	57° 05.10 W	51° 17.40 S	57° 03.30 W	249	30
1067	CTD	06/09/02	14:56	51° 22.30 S	57° 28.20 W	51° 22.20 S	57° 28.40 W	102	9
1068	CTD	06/09/02	17:00	51° 31.20 S	57° 03.40 W	51° 30.90 S	57° 03.50 W	298	16
1069	Semi-pelagic	06/09/02	18:16	51° 34.60 S	56° 57.90 W	51° 36.60 S	56° 59.40 W	373	31
1070	CTD	06/09/02	22:05	51° 40.20 S	56° 37.00 W	51° 39.70 S	56° 36.60 W	535	25
1071	CTD	07/09/02	00:39	51° 42.00 S	57° 05.40 W	51° 41.80 S	57° 05.10 W	332	16
1072	CTD	07/09/02	02:25	51° 42.40 S	57° 20.00 W	51° 42.20 S	57° 19.60 W	200	11
1073	CTD	07/09/02	03:21	51° 42.90 S	57° 28.70 W	51° 42.70 S	57° 28.40 W	133	10
1074	CTD	07/09/02	05:19	51° 53.50 S	57° 11.20 W	51° 53.20 S	57° 10.30 W	325	16
1075	CTD	07/09/02	07:20	52° 03.60 S	56° 53.60 W	52° 03.30 S	56° 52.70 W	551	25
1076	Semi-pelagic	07/09/02	09:40	52° 01.60 S	57° 10.90 W	51° 58.70 S	57° 10.20 W	349	30
1077	Semi-pelagic	07/09/02	14:58	52° 03.10 S	57° 38.50 W	52° 00.90 S	57° 36.50 W	164	32
1078	CTD	07/09/02	18:05	52° 04.00 S	57° 54.60 W	52° 03.80 S	57° 54.90 W	95	10
1079	CTD	07/09/02	21:10	52° 16.30 S	57° 35.90 W	52° 16.10 S	57° 35.90 W	342	20
1080	CTD	07/09/02	23:31	52° 28.10 S	57° 17.60 W	52° 27.80 S	57° 17.40 W	423	19
1081	CTD	08/09/02	03:41	52° 20.60 S	58° 12.00 W	52° 20.50 S	58° 12.00 W	144	10
1082	CTD	08/09/02	05:40	52° 34.30 S	57° 57.90 W	52° 33.80 S	57° 57.90 W	425	20
1083	CTD	08/09/02	07:55	52° 48.20 S	57° 43.50 W	52° 47.80 S	57° 43.60 W	482	19
1084	Semi-pelagic	08/09/02	08:33	52° 45.50 S	57° 48.10 W	52° 43.90 S	57° 50.50 W	482	30
1085	CTD	08/09/02	14:38	52° 30.70 S	58° 31.00 W	52° 30.60 S	58° 31.00 W	135	9
1086	Semi-pelagic	08/09/02	15:19	52° 35.90 S	58° 32.40 W	52° 37.80 S	58° 33.20 W	203	29
1087	CTD	08/09/02	18:40	52° 45.70 S	58° 26.80 W	52° 45.60 S	58° 26.70 W	396	10
1088	CTD	08/09/02	20:36	53° 01.20 S	58° 22.30 W	53° 01.20 S	58° 22.50 W	509	24
1089	CTD	09/09/02	00:03	52° 37.40 S	58° 51.30 W	52° 37.30 S	58° 51.20 W	115	9
1090	CTD	09/09/02	01:55	52° 51.80 S	58° 56.60 W	52° 51.80 S	58° 56.40 W	143	9
1091	CTD	09/09/02	03:45	53° 06.50 S	59° 01.90 W	53° 06.10 S	59° 01.40 W	519	23
1092	CTD	09/09/02	05:06	52° 59.40 S	59° 04.00 W	52° 59.40 S	59° 03.50 W	293	14
1093	CTD	09/09/02	06:26	52° 58.10 S	59° 03.70 W	52° 57.90 S	59° 03.30 W	182	14
1094	Semi-pelagic	09/09/02	08:33	53° 01.90 S	59° 02.60 W	53° 01.20 S	59° 00.50 W	428	18
1095	CTD	09/09/02	12:55	52° 41.20 S	59° 10.30 W	52° 41.20 S	59° 10.20 W	121	9
1096	CTD	09/09/02	14:19	52° 31.20 S	59° 13.60 W	52° 31.30 S	59° 13.70 W	58	6
1097	CTD	09/09/02	16:34	52° 50.40 S	59° 24.70 W	52° 50.40 S	59° 24.70 W	133	9
1098	CTD	09/09/02	21:14	53° 09.30 S	59° 35.20 W	53° 09.40 S	59° 35.50 W	539	24
1099	Semi-pelagic	09/09/02	18:05	53° 00.40 S	59° 27.20 W	53° 00.80 S	59° 23.20 W	251	30
1100	CTD	10/09/02	01:20	52° 34.70 S	59° 33.60 W	52° 34.80 S	59° 33.50 W	101	9
1101	CTD	10/09/02	03:31	52° 50.40 S	59° 49.30 W	52° 50.70 S	59° 49.00 W	159	11
1102	CTD	10/09/02	05:52	53° 05.60 S	60° 04.80 W	53° 05.70 S	60° 04.20 W	455	22
1103	Semi-pelagic	10/09/02	07:30	53° 02.50 S	60° 03.20 W	53° 02.60 S	60° 02.70 W	432	5
1104	CTD	10/09/02	12:35	52° 33.10 S	59° 50.00 W	52° 33.20 S	59° 50.00 W	116	9
1105	CTD	10/09/02	14:51	52° 49.80 S	60° 07.20 W	52° 50.00 S	60° 06.90 W	202	12
1106	Semi-pelagic	10/09/02	16:49	53° 01.60 S	60° 14.20 W	53° 02.20 S	60° 12.30 W	478	16
1107	CTD	10/09/02	20:12	53° 06.70 S	60° 25.90 W	53° 06.70 S	60° 25.50 W	534	25
1108	CTD	11/09/02	01:28	52° 22.70 S	60° 00.40 W	52° 22.80 S	60° 00.30 W	89	7
1109	CTD	11/09/02	04:27	52° 44.60 S	60° 24.70 W	52° 44.90 S	60° 24.60 W	276	13
1110	Semi-pelagic	11/09/02	06:37	52° 49.90 S	60° 29.90 W	52° 51.10 S	60° 29.00 W	348	17
1111	CTD	11/09/02	10:55	53° 05.80 S	60° 49.20 W	53° 06.00 S	60° 50.10 W	497	19
1112	Semi-pelagic	11/09/02	14:48	52° 34.90 S	60° 27.60 W	52° 36.70 S	60° 24.70 W	197	33
1113	CTD	11/09/02	18:04	52° 21.30 S	60° 22.70 W	52° 21.20 S	60° 22.60 W	117	10
1114	CTD	11/09/02	21:42	52° 48.60 S	60° 58.40 W	52° 48.70 S	60° 59.00 W	385	18
1115	CTD	12/09/02	00:15	53° 05.70 S	61° 12.50 W	53° 05.80 S	61° 13.10 W	503	21
1116	Semi-pelagic	12/09/02	05:43	52° 30.10 S	60° 51.70 W	52° 29.80 S	60° 48.10 W	236	30
1117	CTD	12/09/02	08:30	52° 19.90 S	60° 45.20 W	52° 20.00 S	60° 45.50 W	127	9
1118	CTD	12/09/02	10:56	52° 37.00 S	61° 08.40 W	52° 37.20 S	61° 08.30 W	370	19
1119	CTD	12/09/02	13:24	52° 52.90 S	61° 31.20 W	52° 53.10 S	61° 31.70 W	363	18

Stat.	*Activity*	*Date*	*Start Time*	*Seabed Start Latitude*	*Seabed Start Longitude*	*Seabed Finish Latitude*	*Seabed Finish Longitude*	*Modal Depth (m)*	*Durat -ion (mins)*
1120	CTD	12/09/02	18:28	52° 11.30 S	61° 00.00 W	52° 11.30 S	60° 59.60 W	116	9
1121	Semi-pelagic	12/09/02	20:27	52° 24.90 S	61° 22.50 W	52° 25.30 S	61° 25.70 W	293	30
1122	CTD	12/09/02	22:31	52° 24.40 S	61° 20.90 W	52° 24.40 S	61° 21.00 W	274	14
1123	CTD	13/09/02	00:46	52° 37.80 S	61° 43.60 W	52° 37.90 S	61° 44.20 W	340	16
1124	CTD	13/09/02	08:43	52° 12.10 S	60° 26.10 W	52° 12.10 S	60° 26.10 W	42	6
1125	Semi-pelagic	14/09/02	10:29	52° 36.20 S	61° 01.60 W	52° 37.50 S	60° 59.10 W	359	30
1126	Semi-pelagic	14/09/02	13:17	52° 31.20 S	60° 49.80 W	52° 31.10 S	60° 46.50 W	245	31
1127	Semi-pelagic	14/09/02	16:21	52° 19.10 S	60° 28.50 W	52° 19.80 S	60° 25.40 W	114	30
1128	IKMT	14/09/02	20:32	52° 28.50 S	60° 53.90 W	52° 28.30 S	60° 53.00 W	223	15
1129	IKMT	14/09/02	21:09	52° 28.10 S	60° 52.10 W	52° 27.80 S	60° 51.40 W	211	15
1130	IKMT	14/09/02	21:38	52° 27.60 S	60° 50.60 W	52° 27.40 S	60° 49.90 W	198	15
1131	CTD	15/09/02	05:39	52° 02.70 S	61° 10.70 W	52° 03.10 S	61° 10.70 W	106	9
1132	Semi-pelagic	15/09/02	08:04	52° 14.30 S	61° 30.30 W	52° 16.60 S	61° 29.70 W	252	30
1133	CTD	15/09/02	10:22	52° 15.70 S	61° 35.70 W	52° 16.10 S	61° 35.80 W	317	15
1134	CTD	15/09/02	12:55	52° 28.60 S	62° 01.90 W	52° 29.00 S	62° 02.00 W	308	15
1135	Semi-pelagic	15/09/02	13:21	52° 31.60 S	62° 03.50 W	52° 33.30 S	62° 05.70 W	312	30
1136	CTD	15/09/02	22:25	51° 55.40 S	61° 23.70 W	51° 55.70 S	61° 23.50 W	111	9
1137	CTD	16/09/02	00:27	52° 02.10 S	61° 47.20 W	52° 02.30 S	61° 46.90 W	212	12
1138	Semi-pelagic	16/09/02	07:00	51° 47.40 S	61° 44.90 W	51° 49.60 S	61° 45.00 W	160	30
1139	CTD	16/09/02	19:39	52° 09.20 S	62° 11.20 W	52° 09.60 S	62° 11.40 W	277	15
1140	CTD	17/09/02	02:04	51° 34.90 S	61° 27.50 W	51° 35.20 S	61° 27.60 W	101	8
1141	CTD	17/09/02	04:21	51° 37.40 S	61° 58.30 W	51° 37.70 S	61° 58.40 W	174	11
1142	CTD	17/09/02	06:47	51° 39.80 S	62° 28.80 W	51° 40.00 S	62° 28.90 W	220	13
1143	Semi-pelagic	17/09/02	15:33	51° 02.80 S	61° 54.60 W	51° 04.90 S	61° 55.50 W	183	31
1144	CTD	17/09/02	18:00	50° 58.00 S	61° 51.60 W	50° 58.20 S	61° 51.60 W	173	10
1145	CTD	17/09/02	20:46	51° 05.90 S	62° 27.20 W	51° 06.10 S	62° 27.20 W	181	8
1146	CTD	17/09/02	23:34	51° 14.20 S	63° 01.70 W	51° 14.40 S	63° 01.40 W	165	11
1147	CTD	18/09/02	04:35	51° 58.50 S	62° 35.20 W	51° 58.70 S	62° 35.10 W	239	13
1148	Semi-pelagic	18/09/02	07:00	52° 19.90 S	62° 22.50 W	52° 22.10 S	62° 21.60 W	284	30
1149	CTD	18/09/02	10:47	52° 44.90 S	62° 08.80 W	52° 45.20 S	62° 07.40 W	332	18
1150	Semi-pelagic	18/09/02	13:49	53° 04.00 S	61° 52.70 W	53° 03.20 S	61° 49.60 W	448	30
1151	Semi-pelagic	18/09/02	19:03	53° 24.00 S	61° 39.30 W	53° 23.20 S	61° 36.10 W	564	30
1152	CTD	18/09/02	21:55	53° 27.50 S	61° 40.50 W	53° 27.60 S	61° 39.30 W	603	26
1153	CTD	19/09/02	07:00	52° 54.70 S	62° 17.30 W	52° 54.50 S	62° 16.90 W	341	16
1154	Semi-pelagic	19/09/02	12:14	52° 32.80 S	62° 36.60 W	52° 32.00 S	62° 33.00 W	291	31
1155	CTD	19/09/02	17:05	52° 21.70 S	62° 52.80 W	52° 21.50 S	62° 52.30 W	262	14
1156	Semi-pelagic	19/09/02	18:40	52° 12.70 S	63° 01.10 W	52° 11.70 S	62° 58.20 W	239	30
1157	CTD	20/09/02	00:03	51° 48.30 S	63° 29.80 W	51° 48.20 S	63° 29.30 W	183	11
1158	CTD	20/09/02	04:28	51° 16.70 S	64° 03.20 W	51° 16.40 S	64° 03.00 W	142	10
1159	Semi-pelagic	20/09/02	10:22	52° 07.00 S	63° 34.90 W	52° 08.80 S	63° 36.00 W	207	30
1160	CTD	20/09/02	13:18	52° 12.50 S	63° 30.80 W	52° 12.40 S	63° 30.50 W	216	12
1161	Semi-pelagic	20/09/02	18:15	52° 52.60 S	63° 06.80 W	52° 52.10 S	63° 03.60 W	323	30
1162	CTD	20/09/02	21:29	53° 04.80 S	62° 59.30 W	53° 04.60 S	62° 59.20 W	357	17
1163	CTD	20/09/02	23:46	53° 02.30 S	63° 25.90 W	53° 02.20 S	63° 25.70 W	349	17
1164	CTD	21/09/02	01:57	52° 58.80 S	63° 55.40 W	52° 58.70 S	63° 55.00 W	312	16
1165	CTD	21/09/02	05:49	53° 23.90 S	63° 14.20 W	53° 23.60 S	63° 14.50 W	482	22
1166	Semi-pelagic	21/09/02	07:05	53° 24.00 S	63° 16.80 W	53° 24.10 S	63° 20.60 W	487	30
1167	CTD	21/09/02	10:40	53° 25.20 S	63° 36.50 W	53° 25.30 S	63° 35.80 W	473	21
1168	CTD	21/09/02	12:27	53° 26.60 S	63° 57.70 W	53° 26.60 S	63° 57.60 W	322	15
1169	Semi-pelagic	21/09/02	13:14	53° 27.20 S	63° 49.80 W	53° 25.60 S	63° 47.90 W	408	30
1170	CTD	21/09/02	17:15	53° 40.50 S	63° 22.60 W	53° 40.60 S	63° 23.20 W	562	24
1171	Semi-pelagic	21/09/02	18:48	53° 48.80 S	63° 37.40 W	53° 50.30 S	63° 38.00 W	570	30
1172	CTD	21/09/02	21:36	53° 49.30 S	63° 39.10 W	53° 48.80 S	63° 39.30 W	551	24
1173	CTD	21/09/02	23:28	53° 58.00 S	63° 54.50 W	53° 58.00 S	63° 54.60 W	137	10
1174	CTD	22/09/02	02:59	53° 59.80 S	62° 59.90 W	53° 59.90 S	62° 59.50 W	577	25
1175	CTD	22/09/02	04:52	54° 08.90 S	63° 13.50 W	54° 08.80 S	63° 13.80 W	360	17
1176	CTD	22/09/02	06:38	54° 18.30 S	63° 26.60 W	54° 18.00 S	63° 26.40 W	162	12
1177	Semi-pelagic	22/09/02	07:29	54° 18.90 S	63° 19.70 W	54° 20.50 S	63° 20.00 W	257	30
1178	CTD	22/09/02	10:35	54° 15.40 S	62° 59.10 W	54° 15.50 S	62° 59.40 W	373	19
1179	CTD	22/09/02	12:48	54° 12.20 S	62° 29.90 W	54° 12.40 S	62° 30.10 W	541	24
1180	CTD	22/09/02	14:56	54° 09.70 S	62° 03.20 W	54° 09.90 S	62° 03.00 W	346	17
1181	Semi-pelagic	22/09/02	15:23	54° 12.20 S	62° 03.00 W	54° 13.80 S	62° 00.80 W	377	30
1182	CTD	22/09/02	19:02	54° 24.20 S	61° 58.30 W	54° 24.10 S	61° 58.50 W	233	14
1183	CTD	22/09/02	20:58	54° 39.40 S	61° 52.30 W	54° 39.70 S	61° 51.10 W	1000	40

Stat.	*Activity*	*Date*	*Start Time*	*Seabed Start Latitude*	*Seabed Start Longitude*	*Seabed Finish Latitude*	*Seabed Finish Longitude*	*Modal Depth (m)*	*Durat -ion (mins)*
1184	CTD	23/09/02	02:33	53° 55.40 S	61° 37.40 W	53° 55.90 S	61° 37.00 W	206	12
1185	CTD	23/09/02	07:19	53° 12.10 S	61° 23.20 W	53° 12.40 S	61° 23.00 W	501	23
1186	Semi-pelagic	23/09/02	19:40	52° 28.80 S	60° 59.60 W	52° 30.20 S	60° 57.30 W	235	30
1187	Semi-pelagic	24/09/02	10:48	53° 02.50 S	60° 50.20 W	53° 02.80 S	60° 53.30 W	451	30
1188	Semi-pelagic	24/09/02	18:20	52° 42.50 S	60° 19.60 W	52° 40.60 S	60° 21.40 W	220	30
1189	CTD	25/09/02	08:51	53° 12.10 S	61° 23.30 W	53° 12.10 S	61° 22.90 W	500	23
1190	Semi-pelagic	25/09/02	12:56	53° 44.30 S	61° 15.50 W	53° 43.90 S	61° 12.00 W	251	30
1191	CTD	25/09/02	16:50	54° 00.50 S	61° 09.70 W	54° 00.60 S	61° 09.20 W	137	9
1192	Semi-pelagic	25/09/02	18:56	54° 16.50 S	61° 04.60 W	54° 14.30 S	61° 05.40 W	136	30
1193	CTD	25/09/02	23:53	54° 49.10 S	60° 55.20 W	54° 49.20 S	60° 54.80 W	646	26
1194	Semi-pelagic	26/09/02	08:35	53° 35.80 S	60° 27.30 W	53° 36.40 S	60° 24.00 W	664	30
1195	CTD	26/09/02	13:01	53° 18.70 S	60° 22.50 W	53° 18.50 S	60° 21.40 W	861	34
1196	CTD	26/09/02	15:20	53° 32.70 S	60° 16.00 W	53° 32.80 S	60° 14.30 W	938	35
1197	CTD	26/09/02	17:53	53° 48.50 S	60° 08.80 W	53° 48.50 S	60° 08.30 W	248	13
1198	Semi-pelagic	26/09/02	18:30	53° 48.60 S	60° 07.20 W	53° 48.90 S	60° 03.30 W	250	30
1199	CTD	26/09/02	22:05	54° 02.80 S	60° 02.10 W	54° 02.80 S	60° 02.00 W	107	9
1200	CTD	26/09/02	23:51	54° 17.00 S	59° 55.30 W	54° 17.10 S	59° 55.20 W	94	8
1201	CTD	27/09/02	03:51	54° 53.00 S	59° 39.40 W	54° 53.40 S	59° 37.50 W	961	37
1202	CTD	27/09/02	12:20	53° 40.80 S	59° 06.10 W	53° 40.70 S	59° 05.10 W	1671	43
1203	Semi-pelagic	27/09/02	14:08	53° 48.20 S	59° 03.40 W	53° 48.70 S	59° 00.20 W	297	30
1204	Semi-pelagic	27/09/02	17:19	53° 56.60 S	58° 59.80 W	53° 54.60 S	59° 00.60 W	159	30
1205	CTD	27/09/02	21:10	54° 16.70 S	58° 51.30 W	54° 16.60 S	58° 51.20 W	106	9
1206	CTD	28/09/02	01:20	54° 53.80 S	58° 34.20 W	54° 53.60 S	58° 33.40 W	881	35
1207	CTD	28/09/02	09:00	53° 46.20 S	58° 04.40 W	53° 46.00 S	58° 03.70 W	735	30
1208	CTD	28/09/02	11:05	53° 58.60 S	57° 58.90 W	53° 58.50 S	57° 58.80 W	513	22
1209	Semi-pelagic	28/09/02	11:49	54° 03.10 S	57° 56.30 W	54° 03.80 S	57° 52.50 W	310	39
1210	CTD	28/09/02	16:19	54° 15.50 S	57° 52.50 W	54° 15.50 S	57° 52.30 W	89	9
1211	CTD	28/09/02	20:47	54° 55.50 S	57° 34.20 W	54° 55.40 S	57° 34.20 W	657	26
1212	CTD	29/09/02	02:18	54° 06.80 S	57° 11.40 W	54° 06.80 S	57° 11.90 W	848	33
1213	CTD	29/09/02	05:36	54° 32.20 S	56° 59.80 W	54° 32.20 S	56° 59.70 W	90	9
1214	Semi-pelagic	29/09/02	07:39	54° 47.80 S	56° 53.50 W	54° 47.80 S	56° 49.80 W	146	30
1215	CTD	29/09/02	10:30	54° 59.00 S	56° 47.10 W	54° 58.70 S	56° 46.60 W	359	17
1216	Semi-pelagic	29/09/02	11:05	54° 58.70 S	56° 45.50 W	54° 58.70 S	56° 49.10 W	360	45
1217	Semi-pelagic	29/09/02	17:55	54° 18.70 S	56° 33.30 W	54° 19.20 S	56° 30.00 W	371	30
1218	CTD	29/09/02	20:23	54° 12.70 S	56° 29.30 W	54° 12.80 S	56° 30.00 W	929	36
1219	CTD	30/09/02	04:19	54° 44.30 S	56° 03.50 W	54° 44.60 S	56° 03.20 W	794	31
1220	CTD	30/09/02	06:58	54° 25.70 S	55° 55.10 W	54° 26.00 S	55° 55.30 W	416	19
1221	Semi-pelagic	30/09/02	08:15	54° 26.40 S	55° 51.10 W	54° 26.20 S	55° 48.00 W	425	30
1222	Pelagic	30/09/02	12:02	54° 50.10 S	55° 35.90 W	54° 56.70 S	55° 36.60 W	900	120
1223	Pelagic	30/09/02	16:32	54° 54.70 S	55° 36.20 W	55° 00.60 S	55° 39.00 W	500	120
1224	CTD	01/10/02	06:29	53° 22.30 S	58° 16.60 W	53° 22.00 S	58° 16.70 W	1000	39
1225	Pelagic	01/10/02	07:23	53° 24.40 S	58° 13.20 W	53° 29.00 S	58° 03.90 W	1000	120
1226	CTD	01/10/02	16:36	53° 13.20 S	58° 19.90 W	53° 13.00 S	58° 19.90 W	975	17
1227	CTD	01/10/02	18:20	53° 01.80 S	58° 24.50 W	53° 01.90 S	58° 24.90 W	502	23
1228	CTD	01/10/02	20:05	52° 47.80 S	58° 29.40 W	52° 47.90 S	58° 29.50 W	406	19
1229	CTD	01/10/02	20:57	52° 44.80 S	58° 30.90 W	52° 44.40 S	58° 31.20 W	305	17
1230	CTD	01/10/02	21:47	52° 39.80 S	58° 32.90 W	52° 39.90 S	58° 33.00 W	201	14
1231	CTD	01/10/02	23:27	52° 26.40 S	58° 36.70 W	52° 26.50 S	58° 36.70 W	96	9

Figure 11. The location of trawl stations carried out by FPRV *Dorada* between 5 September and 2 October 2002 (research cruise ZDLH1-09-2002). Semi-pelagic hauls are indicated by triangles, pelagic hauls by inverted triangles and plankton trawls by crosses.



4.4. Catch summary

Separate catch tables are given for the 47 semi-pelagic trawls that were the primary biological sampling activity carried out on the cruise (Table 7), and the three deep-water pelagic trawls carried out in deep water south of the Falkland Islands at the end of the cruise (Table 8).

The semi-pelagic trawls yielded a total catch of 16,098kg. The greatest overall catch by weight was that of hoki (*Macruronus magellanicus*) with 8,612kg (53.5% of the total), followed by southern blue whiting (*Micromesistius australis australis*) with 4,333kg (26.9%), the grenadier *Macrourus carinatus* with 1,086kg and the Falklands Herring *Sprattus fuegensis* with 614kg (3.8%). These four species comprised over 90% of the entire catch by weight. The 3 pelagic trawls yielded a total of 96kg, of which nearly 74% (71kg) consisted of Medusae.

Table 7. Overall catch and sample weight from all semi-pelagic trawls carried out during research cruise ZDLH1-09-2002.

Species Code	*Species name*	*Total Catch (kg)*	*Total Sampled (kg)*	*Percentage of total*
WHI	*Macruronus magellanicus*	8612.120	475.306	53.50
BLU	*Micromesistius australis australis*	4332.926	609.260	26.92
GRC	*Macrourus carinatus*	1086.313	645.093	06.75
SAR	*Sprattus fuegensis*	613.737	12.756	03.81
PAR	*Patagonotothen ramsayi*	275.978	129.571	01.71
LOL	*Loligo gahi*	158.762	66.244	00.99
GRF	*Coelorhynchus fasciatus*	123.567	45.569	00.77
PAT	*Merluccius australis*	104.350	104.350	00.65
RGR	*Bathyraja griseocauda*	100.325	100.325	00.62
BAC	*Salilota australis*	90.812	90.812	00.56
RBR	*Bathyraja brachyurops*	77.604	77.604	00.48
LAR	*Lampris immaculatus*	71.920	71.920	00.45
TOO	*Dissostichus eleginoides*	51.964	51.964	00.32
HAK	*Merluccius hubbsi*	45.976	45.976	00.29
RFL	*Raja flavirostris*	42.944	42.944	00.27
MED	Medusae	38.754	1.326	00.24

Species Code	*Species name*	*Total Catch (kg)*	*Total Sampled (kg)*	*Percentage of total*
KIN	*Genypterus blacodes*	37.152	37.152	00.23
RBZ	Undescribed bathyrajid #3	37.057	37.057	00.23
SPN	Sponges	33.060	0	00.21
CGO	*Cottoperca gobio*	18.588	18.588	00.12
RAL	*Bathyraja albomaculata*	18.073	18.073	00.11
RMU	*Bathyraja multispinis*	16.660	16.660	00.10
MUL	*Eleginops maclovinus*	16.540	7.540	00.10
ING	*Moroteuthis ingens*	14.247	14.235	00.09
RSC	*Bathyraja scaphiops*	13.250	13.250	00.08
ANT	Anthozoa	8.090	2.000	00.05
PYM	*Physiculus marginatus*	6.666	6.666	00.04
ANM	Anemones	5.359	0	00.03
UCH	Sea urchins	4.916	0	00.03
DGH	*Schroederichthys bivius*	4.480	4.480	00.03
DGS	*Squalus acanthias*	4.250	4.250	00.03
LAM	*Lampanyctus macdonaldi*	4.220	0	00.03
PGR	*Paradiplospinus gracilis*	3.832	3.537	00.02
BEE	*Benthoctopus eureka*	3.173	2.833	00.02
COG	*Patagonotothen guntheri*	2.480	0.453	00.02
COT	*Cottunculus granulosus*	2.115	2.115	00.01
EEL	*Iluocoetes fimbriatus*	1.878	1.591	00.01
GYN	*Gymnoscopelus nicholsi*	1.811	0.046	00.01
MAM	*Mancopsetta milfordi*	1.489	1.489	00.01
OPH	Ophiuroidea	1.382	0	00.01
LEM	*Lepidonotothen macrophthalma*	1.162	1.162	00.01
WLK	Whelks	1.005	0	00.01
RDO	*Raja doellojuradoi*	1.004	1.004	00.01
MGP	*Magnisudis prionosa*	0.981	0.981	00.01
AST	Asteroidea	0.890	0	00.01
MAT	*Achiropsetta tricholepis*	0.723	0.723	<00.01
RPX	*Psammobatis* spp.	0.513	0.513	<00.01
CET	*Ceratias tentaculatus*	0.455	0.455	<00.01
BRY	Bryozoa	0.351	0.295	<00.01
HIE	*Histioteuthis eltarinae*	0.278	0.278	<00.01
MMA	*Mancopsetta maculata*	0.247	0.210	<00.01
NUD	Nudibranchia	0.232	0	<00.01
CAS	*Campylonotus semistriatus*	0.228	0.142	<00.01
GYM	*Gymnoscopelus* spp.	0.218	0	<00.01
NOW	*Paranotothenia magellanica*	0.146	0.146	<00.01
GRH	*Macrourus holotrachys*	0.136	0.136	<00.01
MUO	*Muraenolepis orangiensis*	0.130	0.130	<00.01
MAR	*Martialia hyadesi*	0.120	0.120	<00.01
MKN	*Moroteuthis knipovichi*	0.119	0.119	<00.01
THB	*Thymops birsteini*	0.092	0.089	<00.01
MXX	Myctophids	0.092	0.092	<00.01
BRL	*Brachioteuthis linkovskyi*	0.066	0.066	<00.01
GYB	*Gymnoscopelus bolini*	0.065	0	<00.01
CAM	*Cataetyx messieri*	0.055	0.055	<00.01
BRP	Brachiopods	0.051	0	<00.01
ARR	*Arctozenus risso*	0.046	0.046	<00.01
PMG	*Protomictophum gemmatum*	0.041	0.019	<00.01
EUL	*Eurypodius latreillei*	0.037	0	<00.01
PAC	*Pasiphaea acutifrons*	0.034	0	<00.01
MUG	*Munida gregaria*	0.031	0	<00.01
PMX	*Protomictophum* spp.	0.024	0	<00.01
DIH	*Diaphus hudsoni*	0.024	0	<00.01
SCH	*Scopelosaurus hamiltoni*	0.014	0.014	<00.01
NED	*Neolithodes diomedeae*	0.008	0.007	<00.01

Species Code	Species name	Total Catch (kg)	Total Sampled (kg)	Percentage of total
PMC	*Protomictophum choriodon*	0.008	0.002	<00.01
STX	*Stomias* spp.	0.004	0.004	<00.01
GON	*Gonatus antarcticus*	0.002	0.002	<00.01
STS	*Stereomastis suhmi*	0.001	0.001	<00.01
		16098.453	2769.846	

Table 8. Overall catch and sample weight for the three deep-water pelagic trawls carried out during research cruise ZDLH1-09-2002.

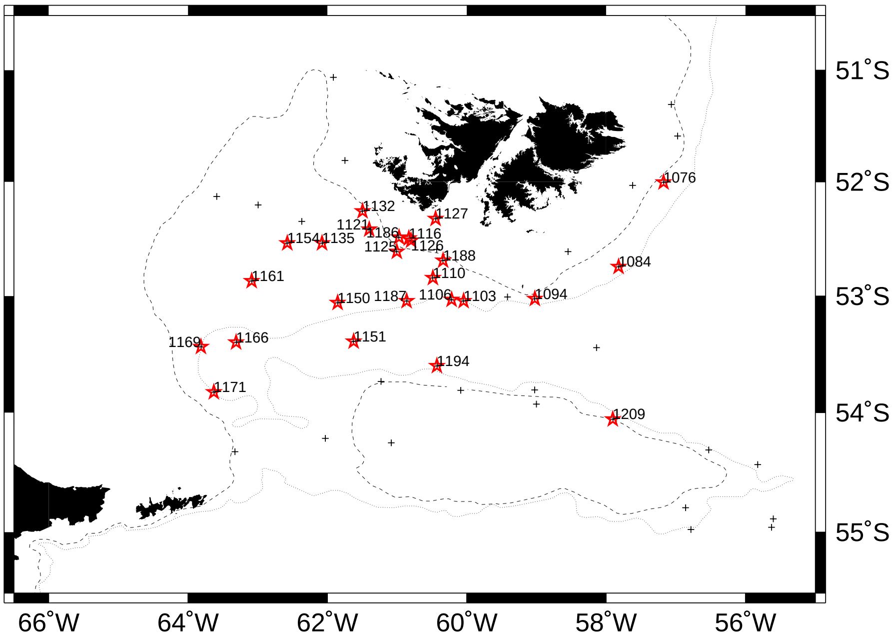
Species Code	Species name	Total Catch (kg)	Total Sampled (kg)	Percentage of total
MED	Medusae	71.160	0	73.99
STG	*Stomias gracilis*	4.612	0.108	04.80
BOA	*Borostomias antarcticus*	3.594	0.126	03.74
LAA	*Lampanyctus achirus*	3.162	2.669	03.29
BAG	*Bathylagus gracilis*	2.058	2.058	02.14
SPN	Sponges	1.850	0	01.92
GRC	*Macrourus carinatus*	1.326	0	01.38
GYB	*Gymnoscopelus bolini*	1.315	0.685	01.37
GAG	*Galiteuthis glacialis*	1.223	1.223	01.27
PGR	*Paradiplospinus gracilis*	0.687	0.041	00.71
ACP	*Acanthephyra pelagica*	0.622	0.622	00.65
BAT	*Bathylagus antarcticus*	0.619	0.619	00.64
GYN	*Gymnoscopelus nicholsi*	0.619	0	00.64
CET	*Ceratias tentaculatus*	0.454	0.454	00.47
BEM	*Benthalbella macrospinna*	0.410	0.142	00.43
SQX	Unidentied squid	0.392	0.392	00.41
PMT	*Protomictophum tenisoni*	0.212	0.013	00.22
PAC	*Pasiphaea acutifrons*	0.185	0.185	00.19
CHS	*Chauliodus sloani*	0.176	0.176	00.18
GON	*Gonatus antarcticus*	0.175	0.175	00.18
SVM	Serrivomeridae	0.164	0.164	00.17
CAG	*Caristius groenlandicus*	0.159	0.159	00.17
LAM	*Lampanyctus macdonaldi*	0.141	0.141	00.15
GYH	*Gymnoscopelus hintonoides*	0.133	0.081	00.14
MGP	*Magnisudis prionosa*	0.101	0.101	00.11
AVI	*Avocettina infans*	0.080	0.059	00.08
ELC	*Electrona carlsbergi*	0.074	0.074	00.08
LEX	*Lestrolepis* spp.	0.058	0.058	00.06
GYO	*Gymnoscopelus opisthopterus*	0.056	0.036	00.06
BEL	*Benthabella elongata*	0.056	0.056	00.06
IDF	*Idiacanthus fasciola*	0.054	0.054	00.06
ALX	Alepocephalidae	0.049	0.049	00.05
PMC	*Protomictophum choriodon*	0.041	0	00.04
BRR	*Brachioteuthis riisei*	0.023	0.023	00.02
BAA	*Bathyteuthis abyssicola*	0.021	0.021	00.02
HIE	*Histioteuthis eltarinae*	0.020	0.020	00.02
STP	*Sternoptyx pseudodiaphana*	0.019	0.019	00.02
HIX	*Histioteuthis* spp.	0.018	0.008	00.02
CRU	Crustacea	0.016	0.016	00.02
NOO	*Notolepis coatsi*	0.013	0.013	00.01
BRX	*Brachioteuthis* sp.	0.009	0.009	00.01
ROR	*Rosenblattia robustus*	0.008	0.008	00.01
CYM	*Cyclothone microdon*	0.008	0.008	00.01
POC	*Poromitra crassiceps*	0.006	0.006	00.01
GIX	*Gigantocypris* spp.	0.003	0.003	<00.01
		96.181	10.874	

4.5. Micromesistius australis australis

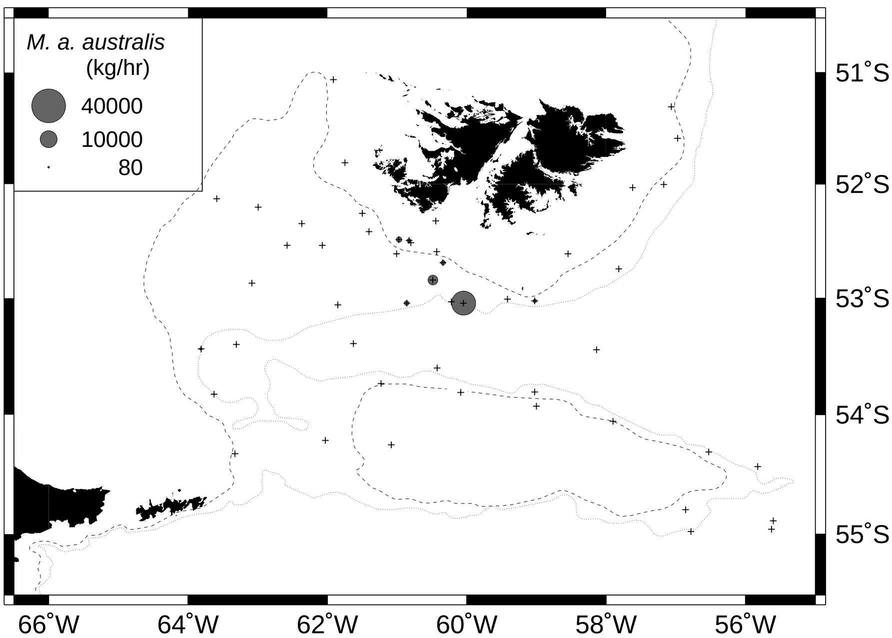
Southern blue whiting occurred widely (Figure 12a) but was most abundant in spawning aggregations found to the south of the Falkland Islands in depths of 250 – 350m (Figure 12b). Very few *M. a. australis* were found to the east and south-east of the Falklands indicating that the post-spawning dispersal had not yet begun. However, mixed aggregations of *M. a. australis* (both juvenile and non-spawning, adult fish) were encountered somewhat further east of the main spawning aggregations in depths of 350 – 550m. Southern blue whiting were also encountered, at rather lower densities, to the north of Isla de los Estados. Very few *M. a. australis* were encountered on the Burdwood Bank.

Figure 12. (a) Presense (red stars) of *M. a. australis* at trawl stations during research cruise ZDLH1-09-2002. **(b)** Catch per unit effort of *M. a. australis*. Circle diameter is proportional to the square root of CPUE (kg/hr). Trawl positions are indicated by black crosses.

(a)



(b)



Between station differences in the length frequency distribution and distribution of maturity at length were investigated using cluster analysis. Clustering on the basis of length alone used the proportion of individuals in each centimetre size class as variables. The combined length frequency distribution at each station, and separate male and female length frequency distributions, were considered. When clustering on the basis of size and maturity the proportion of individuals of each sex and maturity stage in each centimetre length class was used. Agglomerative clustering was carried out using the group averages and euclidean distance. Only the thirteen stations where eight or more individuals were sampled were included. When clustering male and female length frequency distributions only stations where at least eight individuals of that sex were sampled were included.

Clustering on the basis of female size (Figure 13a) suggested the presence of three or four groups of stations, but considerably less structure was evident in the clustering of male length frequency (Figure 13b). Clustering on the basis of combined length frequency (Figure 13c) and frequency of sex at maturity at size (Figure 13d) suggests between 3 and 5 distinct groups of stations.

The station groupings identified in the cluster analysis are fairly clear when the station by station length frequency distributions are considered (Figure 14). Two stations (1076 and 1126) were comprised almost exclusively of small (18 – 23 cm) fish which ageing data suggests will be in the 1+ age class. These were caught only in small numbers. Station 1076 occurred east of the Falklands, but station 1126 was close to the main spawning aggregations to the south of Cape Meredith (Figure 12a).

Station 1166, north of Isla de los Estados, was dominated by fish in the size range 26 – 30 cm. At the nearby station 1169 this size mode was still apparent but the majority of the fish were 35 – 45 cm. Existing otolith data suggests the 26 – 30cm fish are aged 2+. The only other station where fish of this size were present in any significant numbers was station 1187 in deeper water to the south of the main spawning area. However stations in this region (1094, 1103, 1106, 1187 at 400 – 500m and 1151 at 560m) were largely dominated by fish of 35 to 45 cm. All maturity stages were present, with the males being generally more mature than the females.

The main spawning areas, to the south of the Falklands in depths of 220 – 360 m, were represented by stations 1110, 1116, 1186 and 1188. The majority of individuals were in the range 35 to 65cm with at least three size modes occurring within this range. Stations 1186 and 1188 were trawled approximately two weeks after 1110 and 1116 and the progression of female maturity stages in this period is very clear with post-spawning females dominating the latter trawls.

Small numbers of spawning fish were found in deeper water south of the main spawning aggregations and at station 1169 north of Isla de los Estados.

To investigate patterns of maturation in southern blue whiting a total of five gonads per each male maturity stage and ten gonads per each female maturity stage were preserved in the formaline-acetic mixture. A total of 34 ovaries at stage 5 were sampled to estimate both batch and total fecundity.

The standard FIFD macroscopic fish maturity scale has some limitations when investigating the precise sequence and timing of spawning in an intermittent spawner such as the *M. a. australis*. A more detailed scale (Table 2) was therefore applied. This is compatible with the normal FIFD scale but allows a more detailed description of the population reproductive status.

The distribution of maturity stages, and the size of ovaries, in females sampled from the reproductive groups encountered when the main spawning area was first surveyed suggests that they were probably in the middle of the spawning season. Two weeks later when the area was surveyed again most of the females were found to be reaching the end of the spawning season.

Trawls were carried out only during daylight and early evening so it was not possible to find out what time of day egg hydration and spawning occurs. The greatest occurrence of spawning females was at station 1186, which was the latest trawl carried out on the spawning grounds (20.15-20.45). There were no significant numbers of stage 5-6 females in morning and day trawls. Therefore it is likely that the southern blue whiting spawns early in the night.

Spawning animals had not been feeding. The feeding activity of foraging fish outwith the spawning grounds was also low; most stomachs were empty. In those few that contained remnants of food, euphausiids were a common prey item.

Figure 13. Dendograms showing agglomerative clustering of stations from which at least 8 *M. a. australis* were sampled. Clustering is based on (a) female length frequency distribution; (b) male length frequency distribution; (c) combined sex length frequency distribution; and (d) frequency of sex at maturity at size.

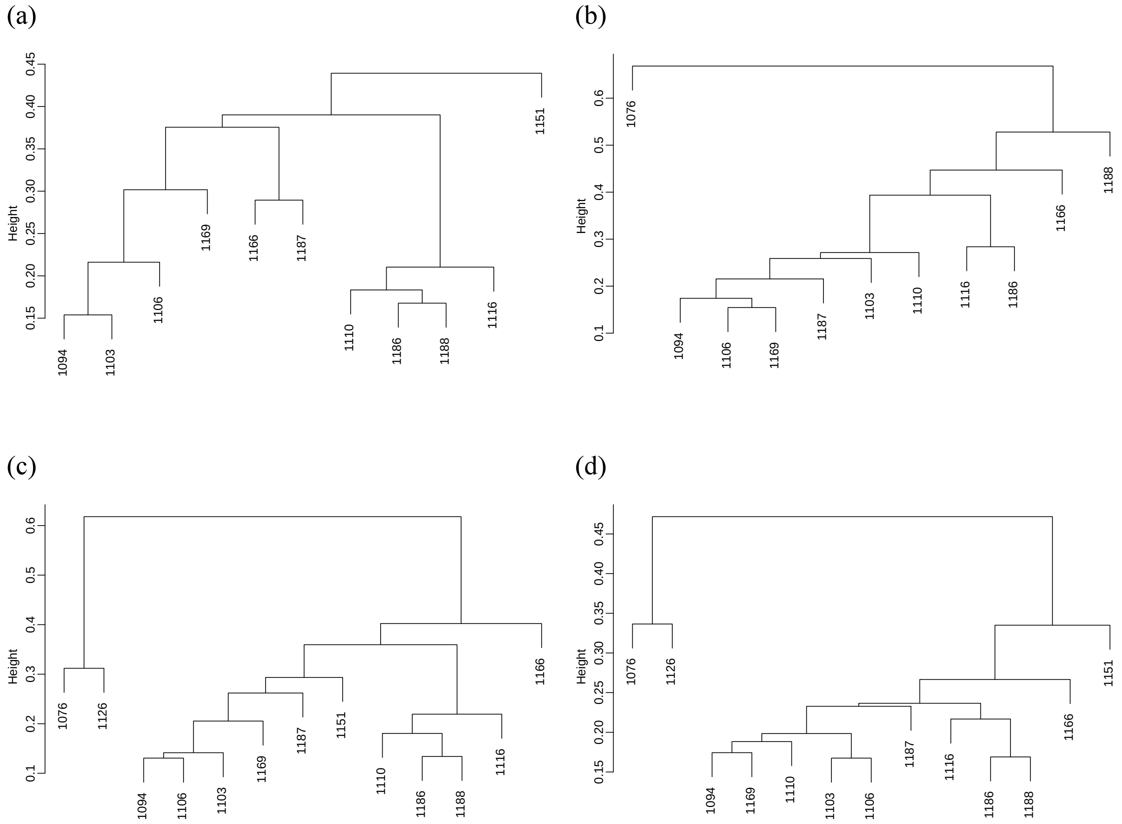


Figure 14. Station by station length frequency distributions of female and male *M. a. australis* for stations where at least individuals were sampled. The plots use 3cm length classes with the histogram bars coloured according to the proportion of each maturity class present.

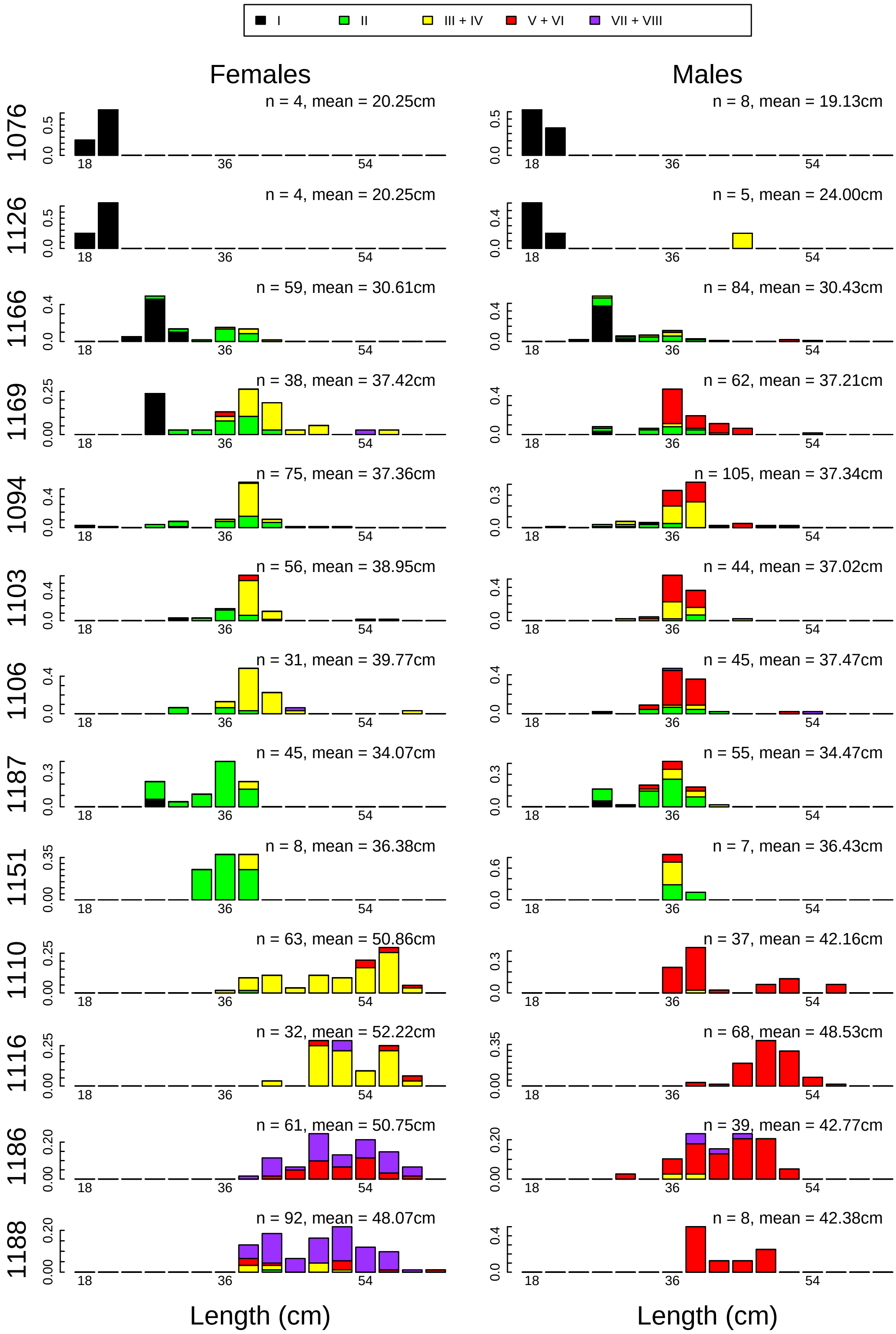


Table 9. Detailed maturity scale.

Standard FIFD maturity stage	*Detailed stage*	*Description*	*Diagnosis*
1	1	Juvenile	As per standard scale
2	2-	Fish has never spawned before (after stage 1)	Differences between stages are quite subjective and should be described for every species if necessary. Generally an ovary at stage 2+ is much larger than at stage 2-. Apply when certain, otherwise just use stage 2.
	2+	Fish did not spawn before in this year (after stage 8). This stage could absent in many species (where stage 3+ follows stage 8).	
3	3-	Fish has never spawned before (after stage 2-)	Differences between stages are quite and are related to the larger volume of the ovary lumen at stage 3+ than at stage 3-. Apply when certain, otherwise assign as stage 3.
	3+	Fish has not spawned before in this year (after stage 8 or stage 2+).	
4	4-	Fish did not spawn before in this season (after both stages 3+ and 3-).	Volume of the ovary lumen is negligible at stage 4- and very large at stage 4+. Stages recognisable only after ovary opened.
	4+	Fish has already released some part of fecundity.	
5	5-	Fish did not spawn before in this season (after stage 4-).	Differences are the same is the same as between 4– and 4+.
	5+	Fish has already released some part of fecundity (after stage 4+).	
6	6		Differences between possible 6- and 6+ are usually barely recognisable and subjective.
7		End of spawning	As per standard scale
8		Spent and resting	As per standard scale

4.6. Macruronus magellanicus

Catches of hoki ranged from 5,641kg at station 1064 to a few hundred grams at others (see Figure 15). Figure 16 shows the combined (male, female and juvenile) length-frequency distributions for selected stations together with the overall distribution for all stations combined. The majority of fish were in the range 17-27cm pre-anal length (PAL) but some stations specimens from outwith this range or displayed an extra size mode (stations 1099, 1169, 1177).

The majority of the population (81%) was at maturity stage 2 with considerably smaller amounts in other stages (2% unsexed and or juveniles, 6% stage 1, 9% stage 3, 2% stage 8).

Stomach fullness and diet components were assessed in all individuals sampled. Feeding was more prevalent in some areas than in others (see Table 10). Diet components were similar to those found previously with the exception of station 1169 where a common component in the diet of hoki was *Physiculus marginatus* (PYM). This species was also only caught in the same general area, SW of the Falklands (stations 1151, 1154, 1166, 1169, and 1171).

Table 10. *M. magellanicus* diet summary table. Codes for dietary components are given in Table 2.

Station	*Feeding proportion*	*Diet Components*
1094	virtually no feeding	
1099	App. 65%,	mainly CHA and THE, some EUP
1103	No feeding	
1106	Only 3%,	some MXX and THE
1121	App. 50%,	THE and EUP
1125	App. 50%	THE and EUP
1132	App. 20%,	THE and EUP
1135	App. 65%,	THE and EUP, some LOL, 1 Brachioteuthis
1138	App. 10%,	EUP and THE, but little amounts
1143	App. 65%,	LOL, SAR, THE and EUP
1148	little	THE and EUP
1154	App. 70%,	THE mainly, few EUP
1159	App. 70%	THE and EUP
1166	Few (20%)	MXX, EUP, THE
1169	30%	Mainly PYM, some BLU, some EUP, few THE, even comb jellies.
1177	juveniles, only 10%	EUP and AMP

Figure 15. Relative abundance of *Macruronus magellanicus.* Circle diameter is proportional to the square root of CPUE (kg/hr). Trawl positions are indicated by black crosses.

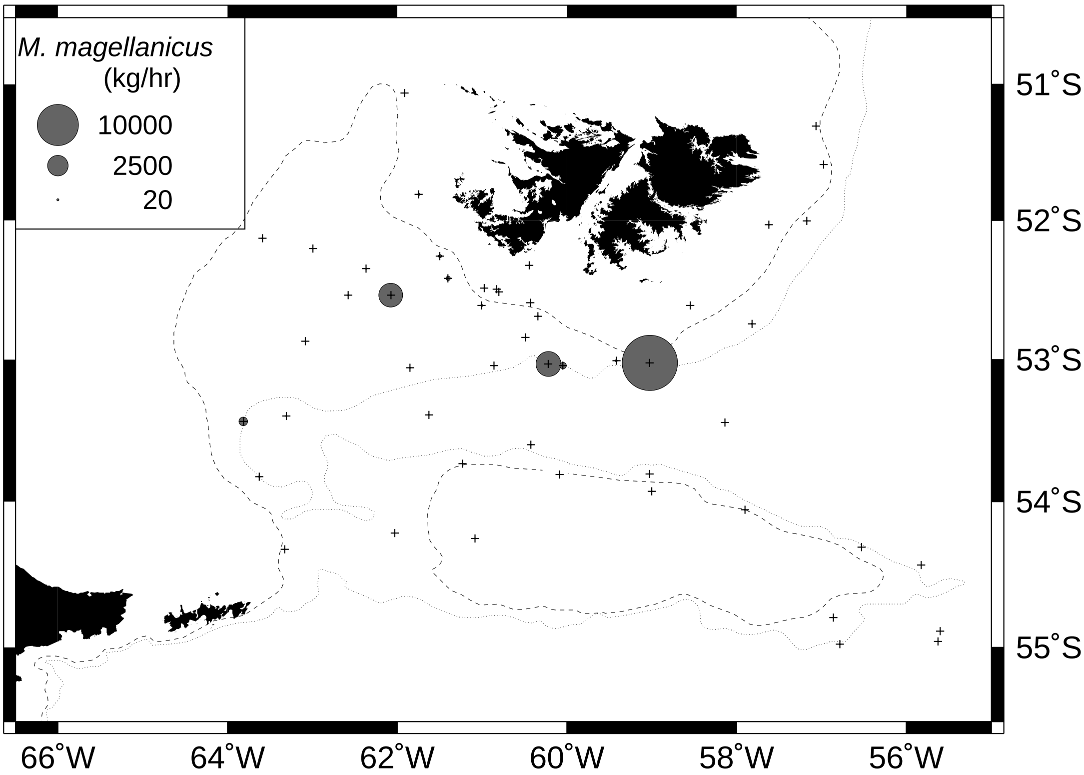
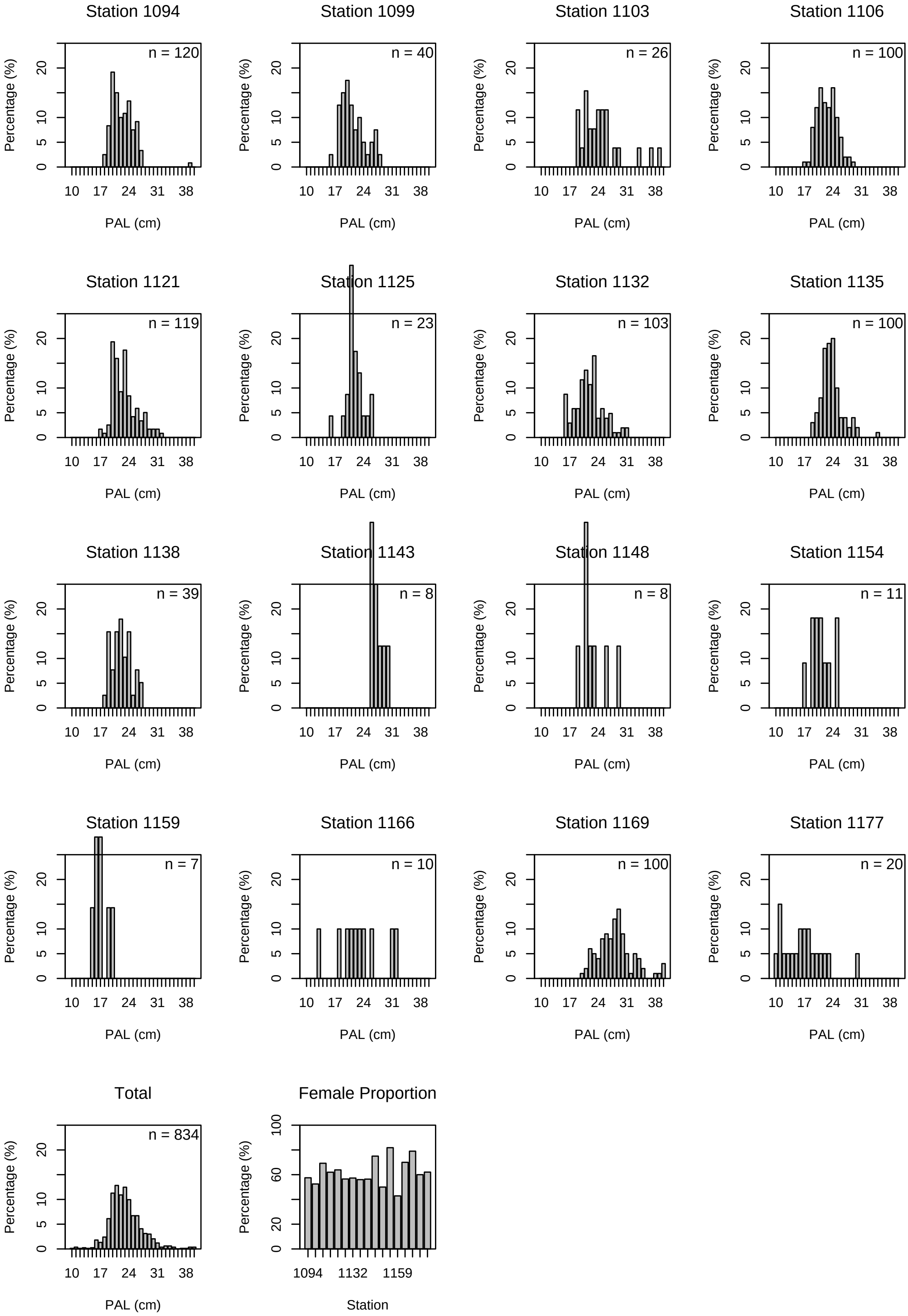


Figure 16. *M. magellanicus* length frequency distribution and sex ratio for selected (number sampled > 5) stations.



4.7. Macrourus carinatus

Catches of the grenadier *Macrourus carinatis* ranged from 558kg at station 1194 at 660m on the northern flank of the Burdwood Bank to a few hundred grams (one specimen) at others. It was widespread, and commonly caught at depths greater than 350m.

Specimens ranged in size from 8cm to 31cm PAL, with males being noticeably smaller (<25cm PAL) than females (up to 32cm PAL, see Figure 18). Females were clearly more abundant comprising 68% of the individuals sampled. The majority of fish sampled were immature or maturing (12% stage 2, 35% stage 3, 10% stage 4, 5% stage 5) but a significant proportion (34%) was already in post-spawning stages 7 (19%) and 8 (15%). No spawning animals were encountered. However, mature and spawning specimens were encountered in the SW of the FICZ during August 2003 by FIFD observers on commercial vessels. The spawning period of *M. carinatus* may, therefore, last for a few months from early August until October.

Figure 17. Relative abundance of *M. carinatus*. Circle diameter is proportional to the square root of CPUE (kg/hr). Trawl positions are indicated by black crosses.

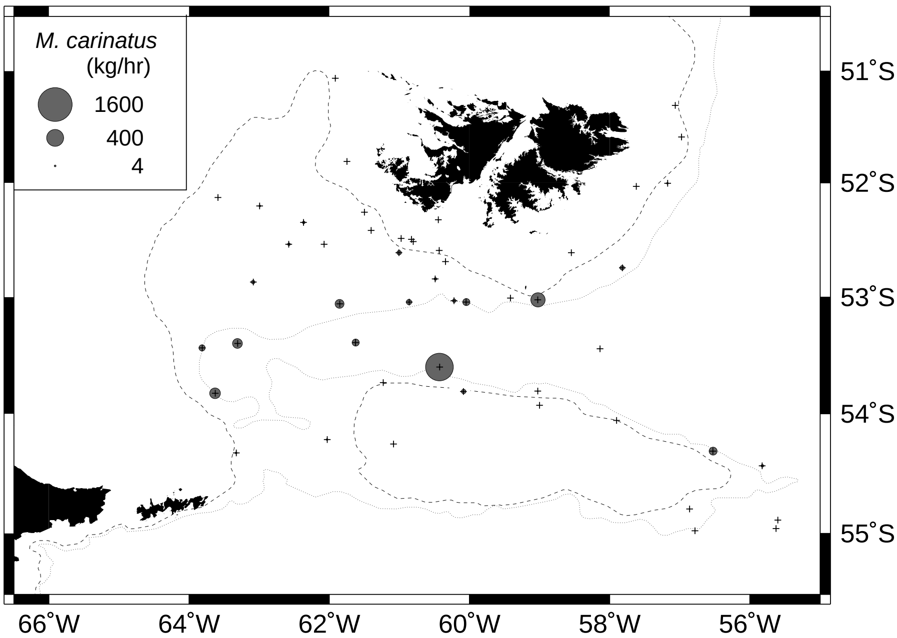
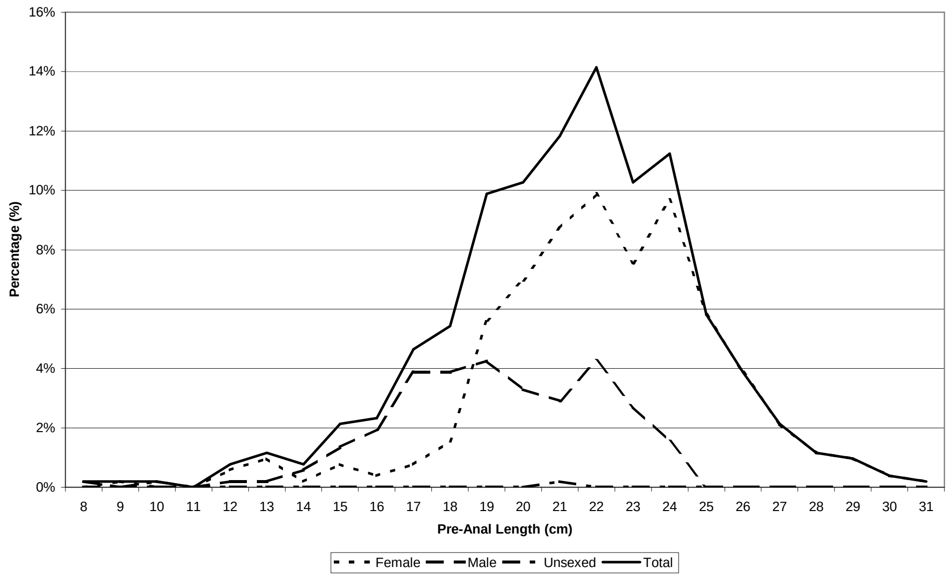


Figure 18. Grouped (all stations) length frequency distribution for *M. carinatus.*



Feeding and diet were examined in all specimens sampled although this was complicated by the tendency of stomachs in this species to become inverted during hauling. The diet of *M. carinatus* was considerably more varied than that of other species (see Table 11), which corresponds with the fact that grenadiers are known to be scavengers. Dietary components are listed roughly in order of importance.

Table 11. Station by station diet summary for *M. carinatus.*

Station	*Feeding proportion*	*Diet Components*
1076	100%	PAR and LOL
1084	30%	PAR and BEE
1094	9%	ANT, GRF, FIN, OPH, AMP, CAS
1103	Nil	
1106	Nil	
1110	Nil	
1125	30%	ANM, WLK, FIN
1135	Nil	
1148	Nil	
1150	8%	WLK, HOL, GRF, PYM
1151	12%	CHA. EUP, SER,
1154	50%	SER, EUP, ISO, MAR, GRV
1156	50%	EUP, THE, AMP, MED
1161	25%	EEL
1166	12%	FIN (PYM?), PYM, ANM, MED
1169	19%	FIN, PAR, MED, GRF, PYM, Comb jellies
1171	7%	FIN, THE, POL, EUP, AMP, Shrimp
1177	Nil	
1181	Nil	
1187	19%	THB, CAS, GRF otolith
1194	11%	FIN
1198	12.5%	ISO, AMP, FIN
1217	20%	PAR and SAR
1221	Nil	
1125	Nil	

4.8. *Sprattus fuegensis*

Falklands Herring was caught exclusively on the Burdwood Bank with the exception of a single specimen at station 1086. The largest catch was 604kg at station 1204 (604kg). Distinctive acoustic traces enables further large catches to be avoided but 8kg was taken at station 1217 (see Figure 19).

Specimens ranged in size from 16cm to 23cm total length (TL), with females being larger and more abundant (70%, see Figure 20). The population was clearly close to or in the process off spawning, with 56% in stage 4, 20% in stage 5, 12% in stage 6, 12% in stage 7, and <1% in stage 8.

Diet and feeding were assessed in all specimens sampled. At station 1204 13% of individuals had been feeding while at station 1217 all specimens had been feeding. In all cases *S. fuegensis* had been feeding on euphausids (EUP).

Figure 19. Relative abundance of *S. fuegensis.* Circle diameter is proportional to the square root of CPUE (kg/hr). Trawl positions are indicated by black crosses.

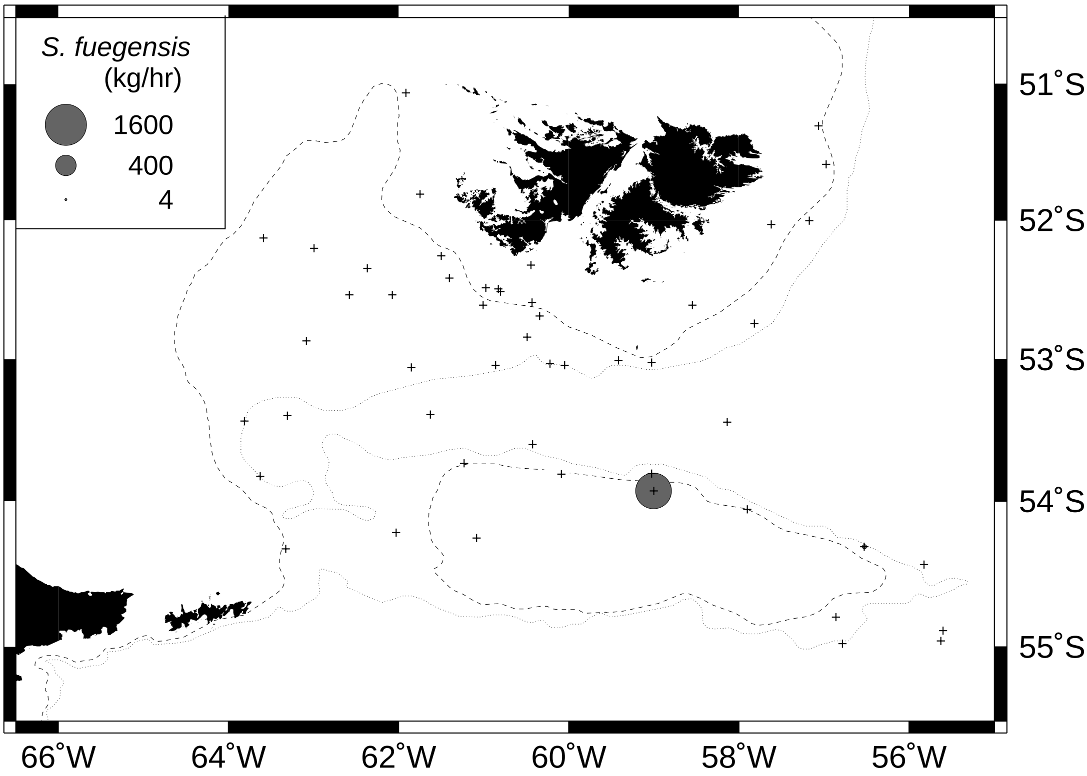
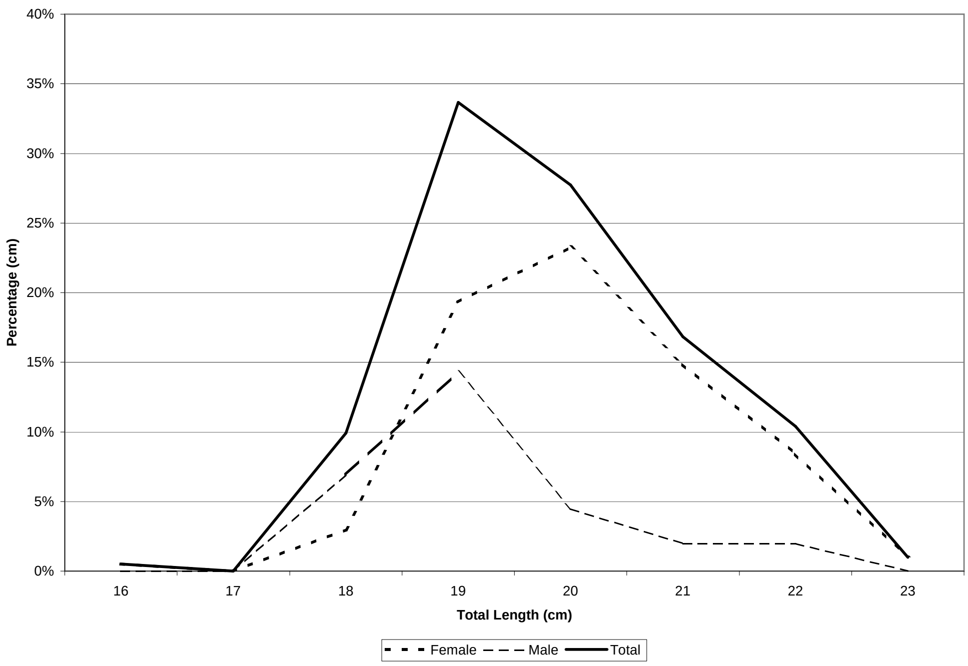


Figure 20. Grouped (all stations) length frequency distribution for *S. fuegensis.*



4.9. *Patagonotothen ramsayi*

Catches of the rockcod *P. ramsayi* occurred throughout the cruise, at a total of 40 stations. The largest catches occurred on the Burdwood Bank with 111kg at station 1190 and 39kg at station 1203.

Specimens ranged in size from 7cm to 41cm TL and females were slightly more abundant (58% females). Specimens larger than 34cm TL were exclusively female but otherwise the size distributions of the sexes were similar. Adults, mainly post-spawning specimens, started to appear in the population at around 20cm TL with the proportion of adults increasing with size (see Figure 22 and Figure 23). Males of adult size were less advanced in maturity than females, with a fair proportion still in stages 5 and 6, whereas in females these stages were absent

It had been observed previously that *P. ramsayi* displays some colour variation and as a result notes were kept on colouration during biological sampling. It was found that mature male specimens had black colouration on their fins, and gill covers that was absent in post-spawning/resting stages (Figure 24).

The diet of *P. ramsayi* was analysed only from station 1166 onwards. Table 12 lists the proportion that had been feeding and dietary components in order of importance. At certain stations (1190 & 1194*) P. ramsayi* fed intensively on the eggs of the euphausid *Nematoscelis megalops*, as well as on the eggs of *M. carinatus* and copepods. On a few occasions *P. ramsayi* fed extensively on both *Serolis* spp. and ophiuridae.

Figure 21. Relative abundance of *P. ramsayi.* Circle diameter is proportional to the square root of CPUE (kg/hr). Trawl positions are indicated by black crosses.

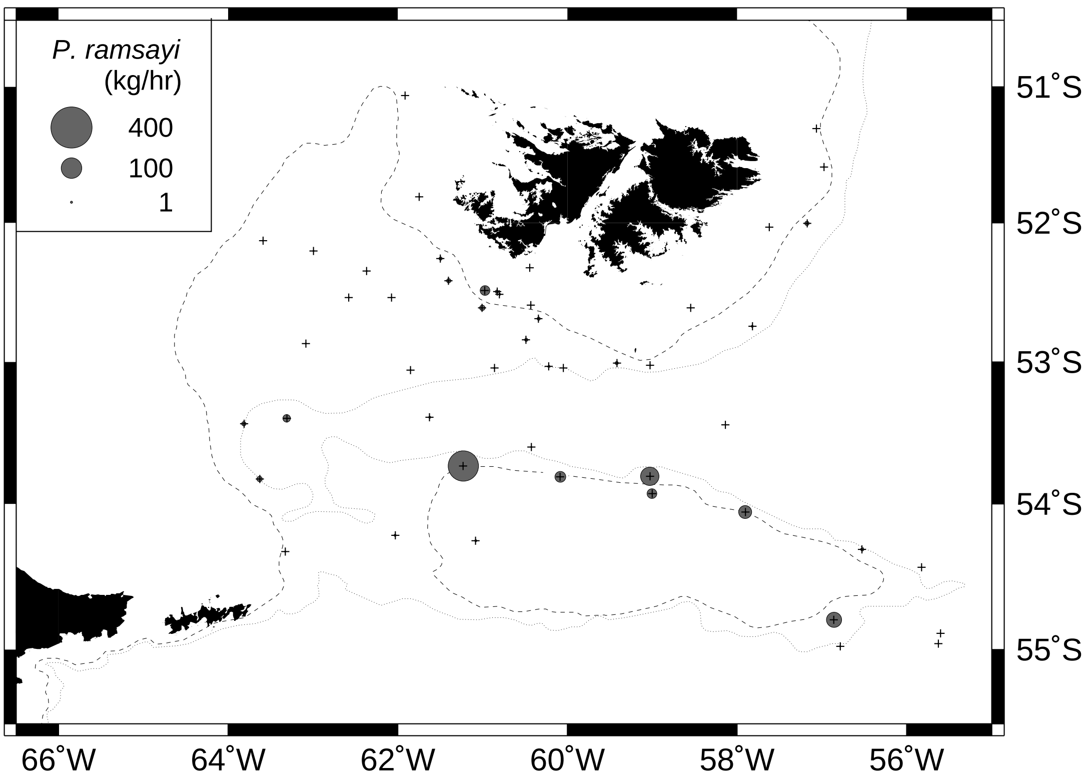


Figure 22. Grouped (all stations) length frequency and maturity distribution for female *P. ramsayi.*

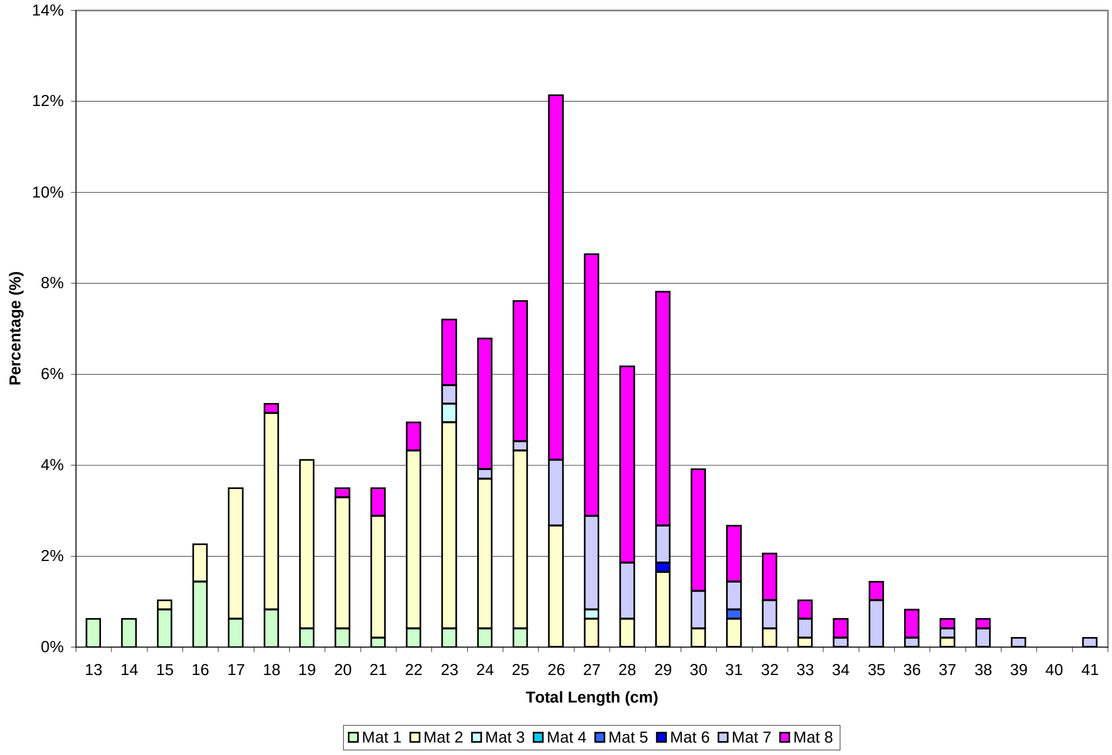


Figure 23. Grouped (all stations) length frequency and maturity distribution for male *P. ramsayi.*

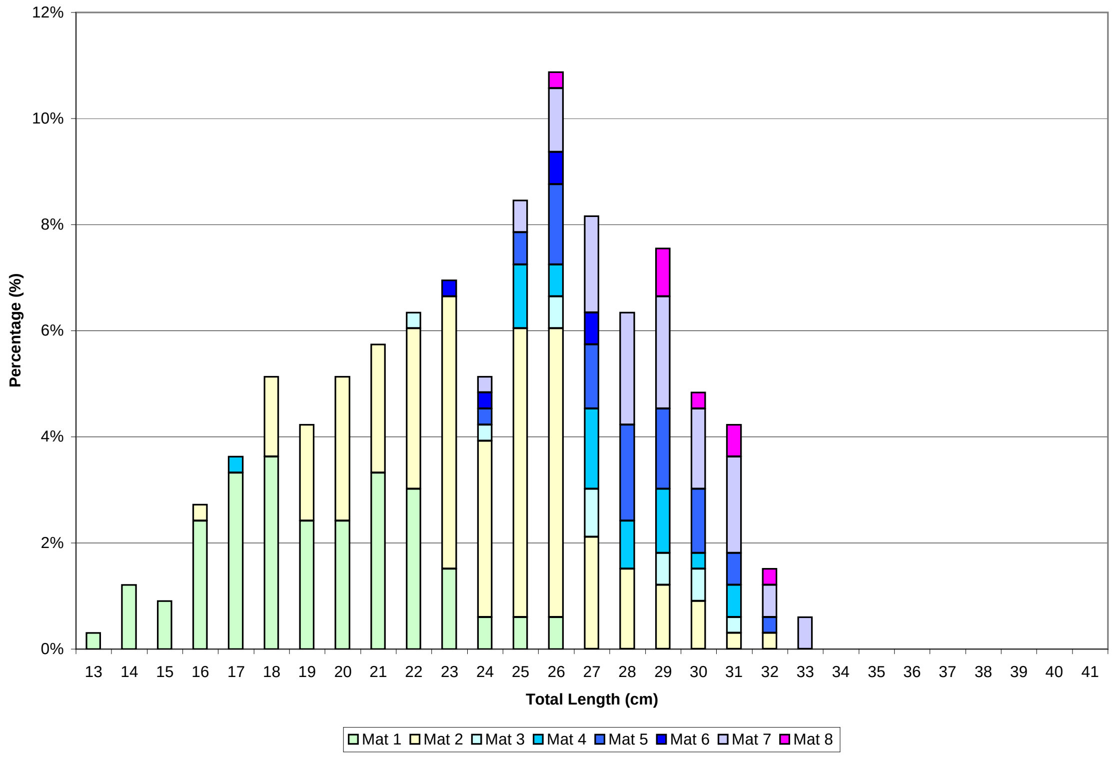


Figure 24. Colouration in mature male *P. ramsayi*.

Table 12. Station by station diet summary for *P. ramsayi*.

Station	*Feeding proportion*	*Diet Components*
1166	37%	SER, CRU, FIN, ANM, ANT, WLK
1169	58%	SER, ANM, Stones
1171	18%	EUP
1177	50%	FIN eggs, AMP
1181	100%	EUP. THE, FIN eggs
1186	17%	OPH, FIN, THE
1187	Nil	
1190	100%	GRC eggs, NEE eggs, NEE, EUP, CHA, COA, AMP, THE
1192	100%	MUN, EUP, SER
1194	100%	NEE, COA, CHA, THE, GRC eggs, NEE eggs
1198	63%	EUP, HYD, MUN, FIN, THE, FIN eggs, POL, CHA
1203	96%	EUP, THE, AMP, POL, MXX, COA
1204	53%	SAR eggs, EUP, MUN, COA, THE, FIN
1209	60%	EUP, THE, COA, MED, OPH, AMP, POL, Salps
1214	40%	COG, SER, eggs unid., EUP
1216	100%	CYM, PMX, CHA, STP, EUP, PAR, POL
1217	44%	BEO, POL, EUP

4.10. Coelorhynchus fasciatus

Catches of the grenadier *Coelorhynchus fasciatus* were generally small with the largest being a total of 90kg at station 1177, which was also the greatest depth at which this species was caught (570m). Otherwise catches varied from a few specimens to just over 7kg. The species was most abundant at depths of 450-550m SW of the Islands (see Figure 25).

Specimens ranged in size from 5cm to 13cm PAL, with females slightly more abundant (59%) than males and noticeably larger (Figure 26). Adult, (pre-)spawning specimens started to appear in the population at around 8cm PAL with the proportion adult increasing with size (Figure 26 and Figure 27). Overall the proportion of mature males was very low, with 92% of males in stages, 1, 2 and 3, and only 8% in stages 4 and 7. In females the situation was quite different, with 27% in stages 1, 2, and 3, 63% in stages 4 (26%), 5 (34%) and 6 (3%), and the remaining 10% in stages 7 and 8.

The diet of *C. fasciatus* was analysed whenever possible, but this was hampered by the tendency for stomachs to invert during hauling. As a result the sample size for diet analysis was small. Dietary components were euphausids, isopods, and *T. gaudichaudi*.

Figure 25. Relative Abundance of *C. fasciatus.* Circle diameter is proportional to the square root of CPUE (kg/hr). Trawl positions are indicated by black crosses.

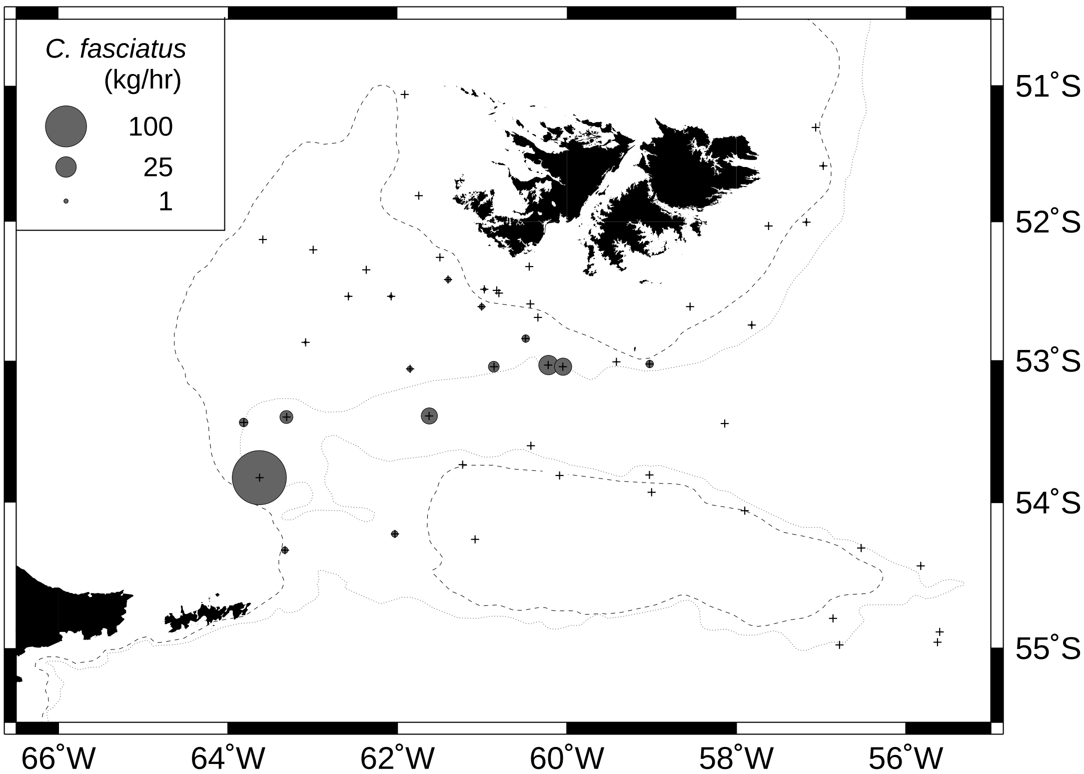


Figure 26. Grouped (all stations) length frequency and maturity distribution for female *C. fasciatus.*

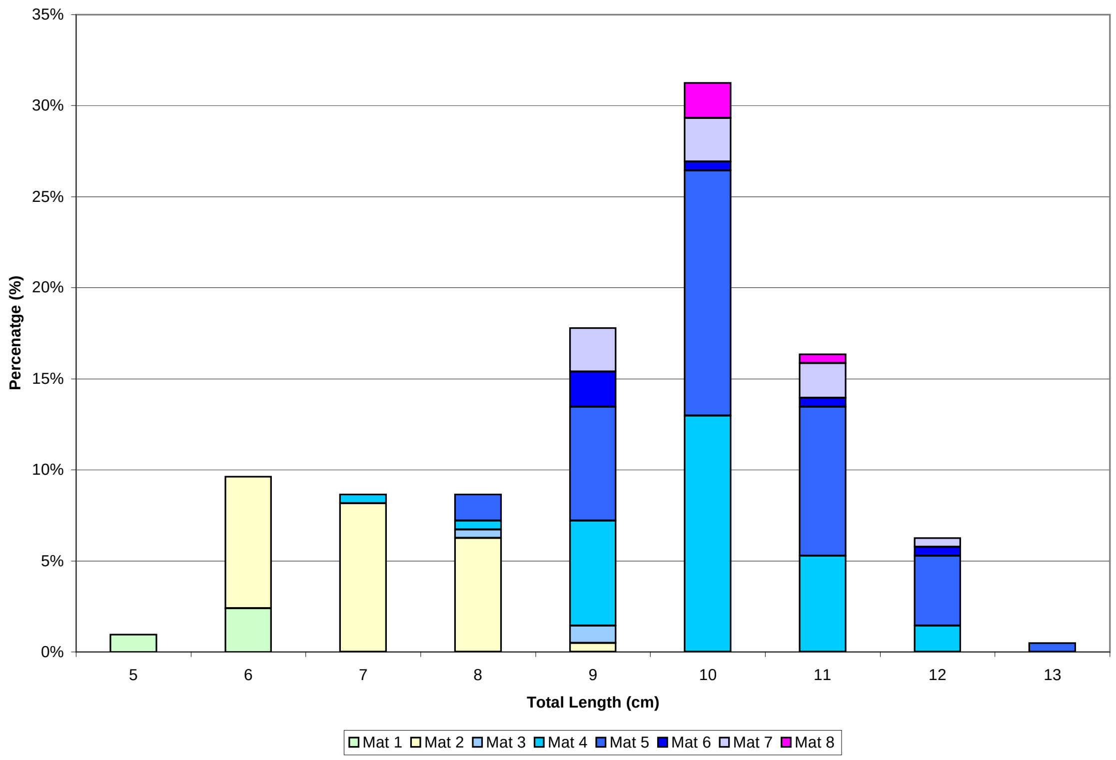
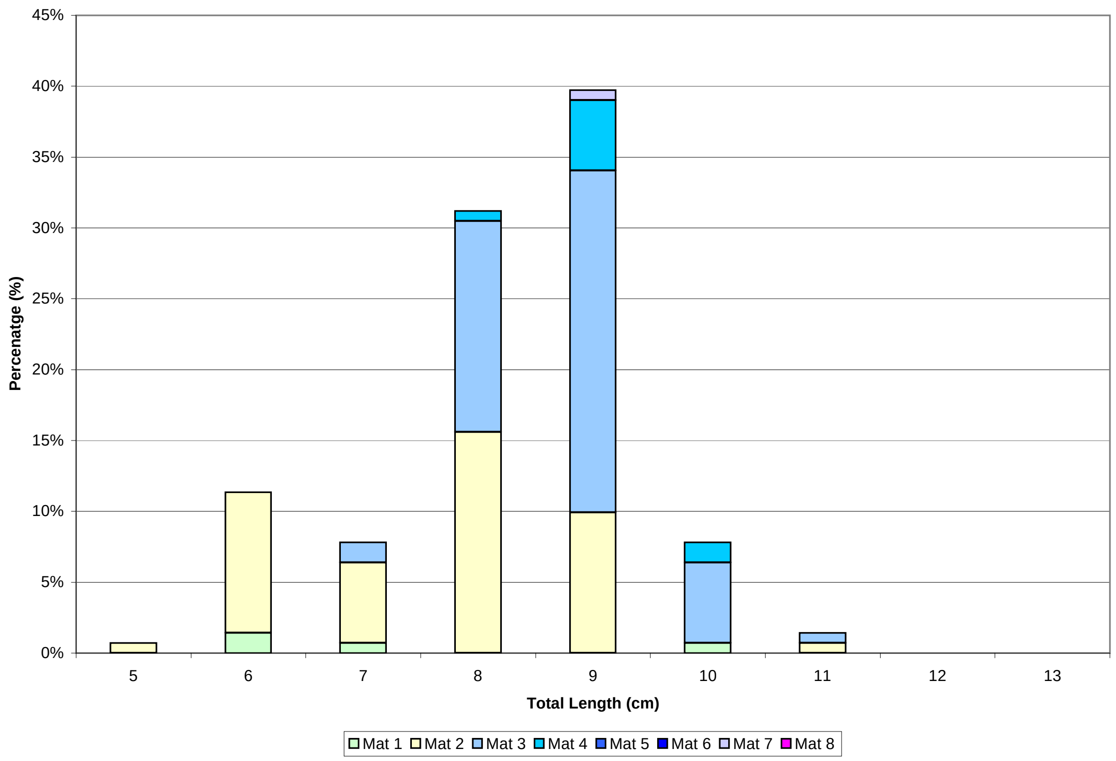


Figure 27. Grouped (all stations) length frequency and maturity distribution for male *C. fasciatus.*



4.11. *Merluccius australis* & *Merluccius hubbsi*

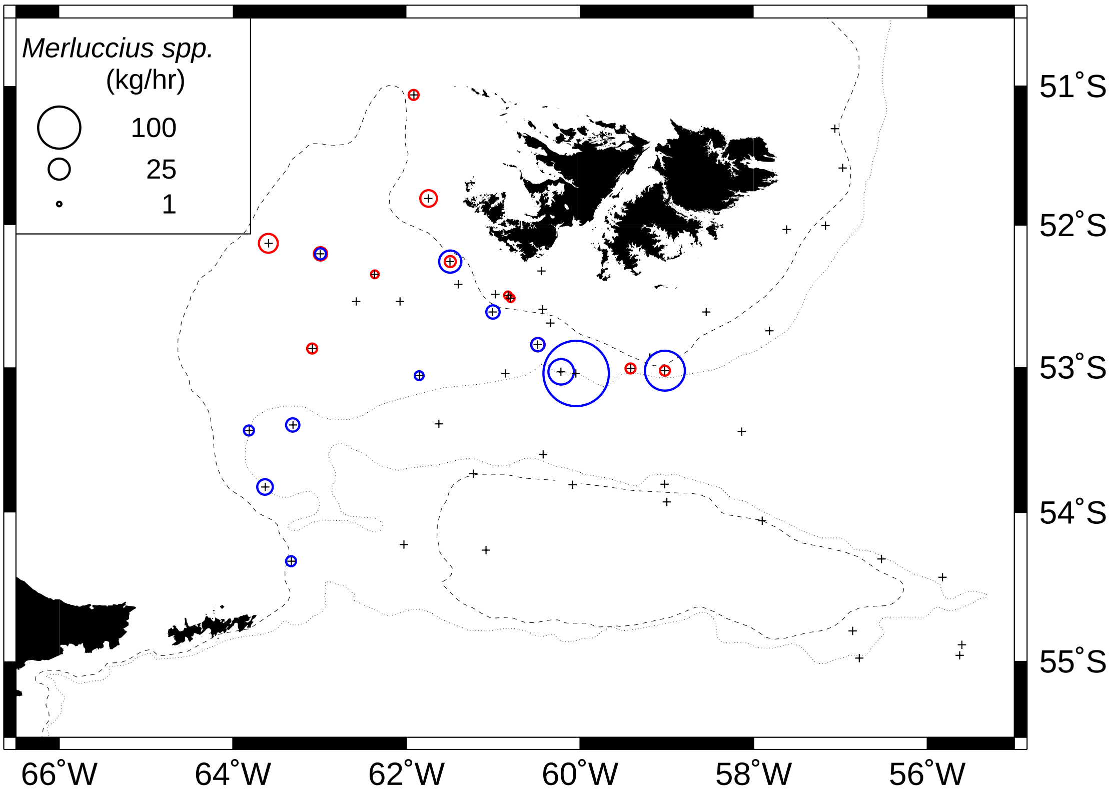
From station 1094 to station 1177 both *M. australis* and *M. hubbsi* appeared frequently in catches, although typically were represented by just a few specimens of each. The largest hake catches (>10kg) occurred at the four stations 1094, 1103, 1106, and 1132, and were all of *M. australis*. The largest *M. hubbsi* catch (just less than 10kg) occurred at station 1159 (Figure 28).

Of the 22 *M. hubbsi* specimens caught and analysed during the cruise all but one were females, which ranged in size from 52-85cm TL (mean 67cm). The solitary male was 71cm TL. Overall 23% were in maturity stage 2, 32% in stage 3 and 45% in stage 8.

Of the 35 specimens of *M. australis* caught and analysed 89% were females. These were in the size range 63-90cm TL (mean 74cm), while the 4 males ranged from 69-80cm (mean 76cm). Overall 80% of specimens were in maturity stages 2 & 3, 9% in stages 4 & 6, and 11% in stages 7 & 8. The specimens in stages 4, 6, and 7 were mainly males (3 out of 4), with one female in stage 4.

The diet of the two hakes was very similar focussing on large finfish, primarily *M. a. australis* and *M. magellanicus*, with the occasional occurrence of other prey such as PYM, GRF, EUP, BAC, LOL, TOO, GON, and MED. Note however that samples sizes were small.

Figure 28. Relative abundance of *M. australis* (blue), and *M. hubbsi* (red). Circle diameter is proportional to the square root of CPUE (kg/hr). Trawl positions are indicated by black crosses.



4.12. *Salilota australis*

Catches of red cod, *S. australis*, ranged from few hundred grams to 17kg (station 1112). Most of the catches occurred to the south and southwest of the Islands (Figure 29). Of the 137 specimens caught and analysed during cruise, 55% were female. These ranged in size from 16 to 77cm TL (mean 37cm, Figure 30). Males ranged from 15-64cm (mean 33cm, Figure 31). The majority (75%) of specimens were in immature stages 1, 2, & 3, 15% were in stages 4 & 5, and the remaining 10% were in the post spawning stages 7 & 8. Specimens smaller than 45cm TL were immature while specimens larger than this size were in adult maturity stages. The fish sampled were generally immature, suggesting that the majority of adults were elsewhere for spawning.

Inverted stomachs made the diet of *S. australis* difficult to study. Some smaller specimens were found with stomach contents which included LOL, AMP, EUP, SER, ISO, POL, COX, and THE.

Figure 29. Relative abundance of *S. australis.* Circle diameter is proportional to the square root of CPUE (kg/hr). Trawl positions are indicated by black crosses.

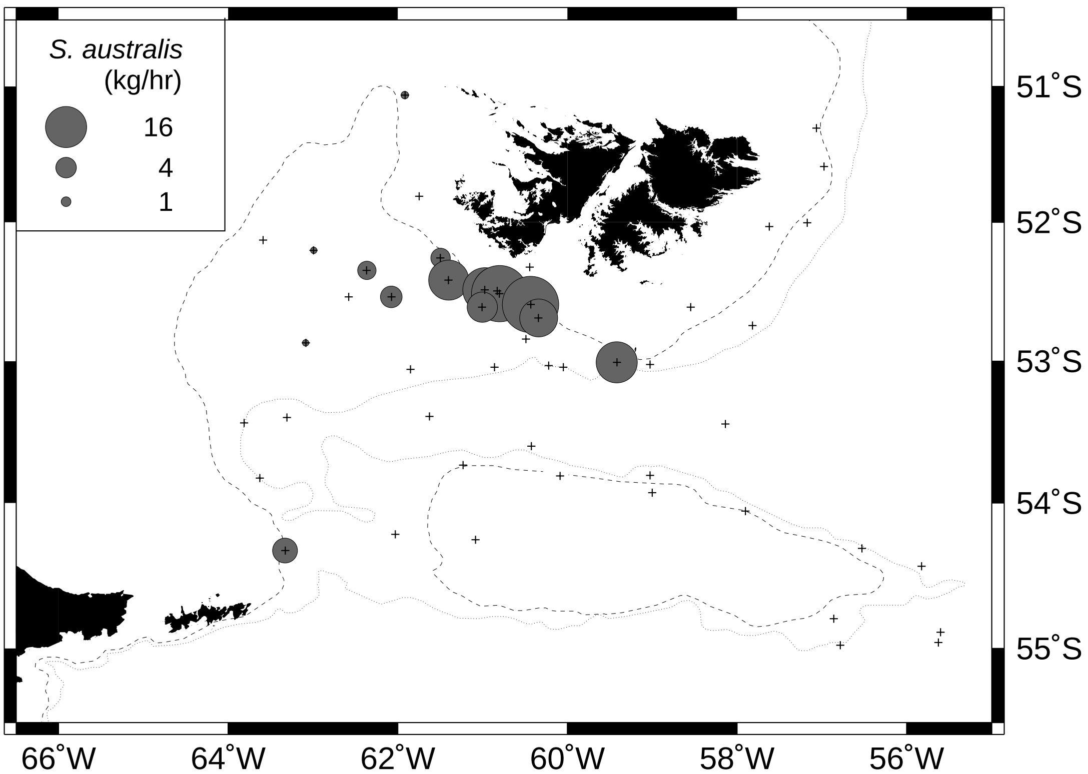


Figure 30. Grouped (all stations) length frequency and maturity distribution for female *S. australis*.

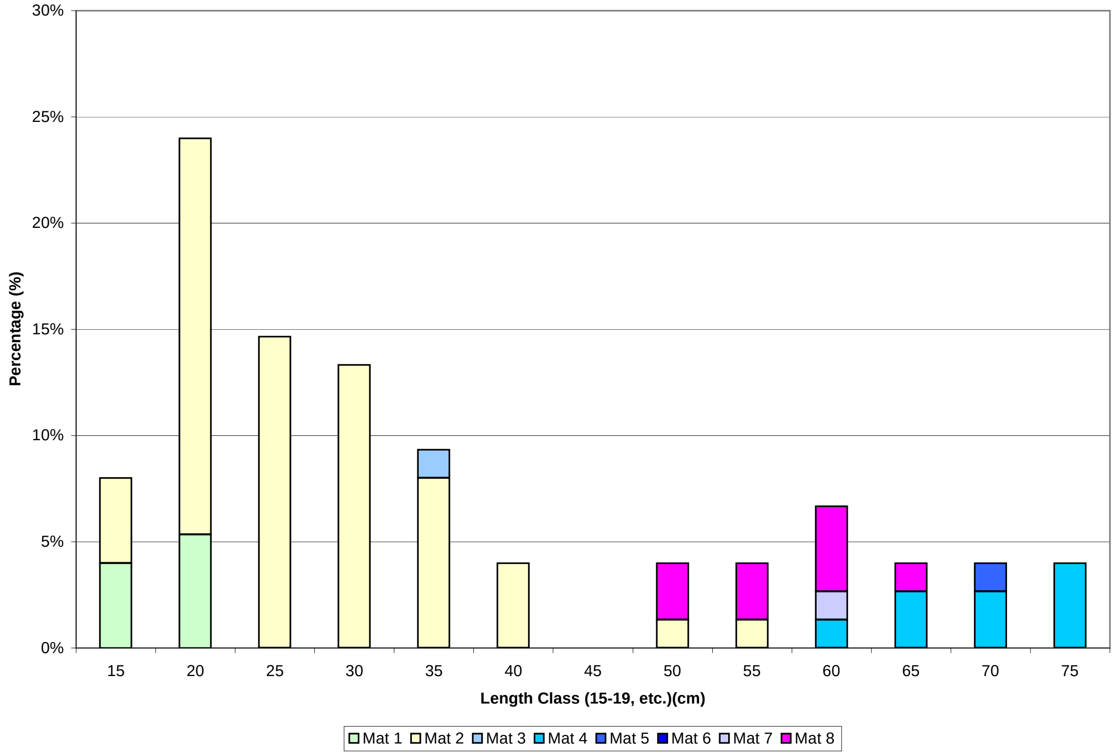
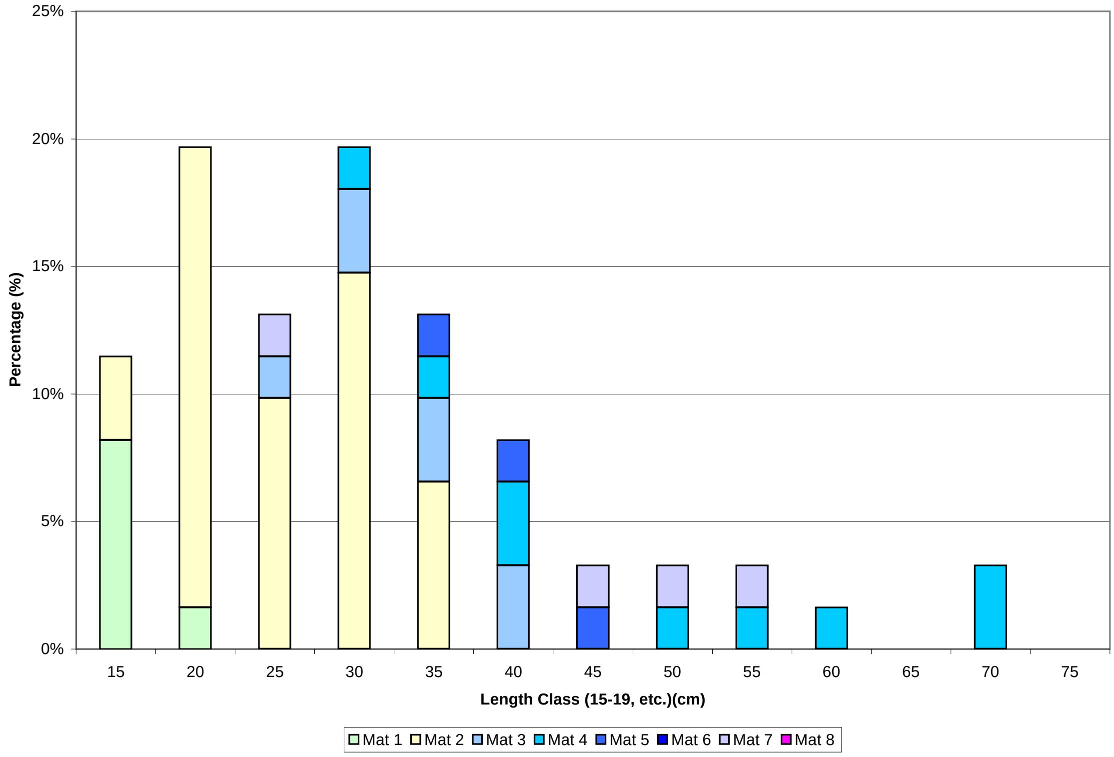


Figure 31. Grouped (all stations) length frequency and maturity distribution for male *S. australis.*

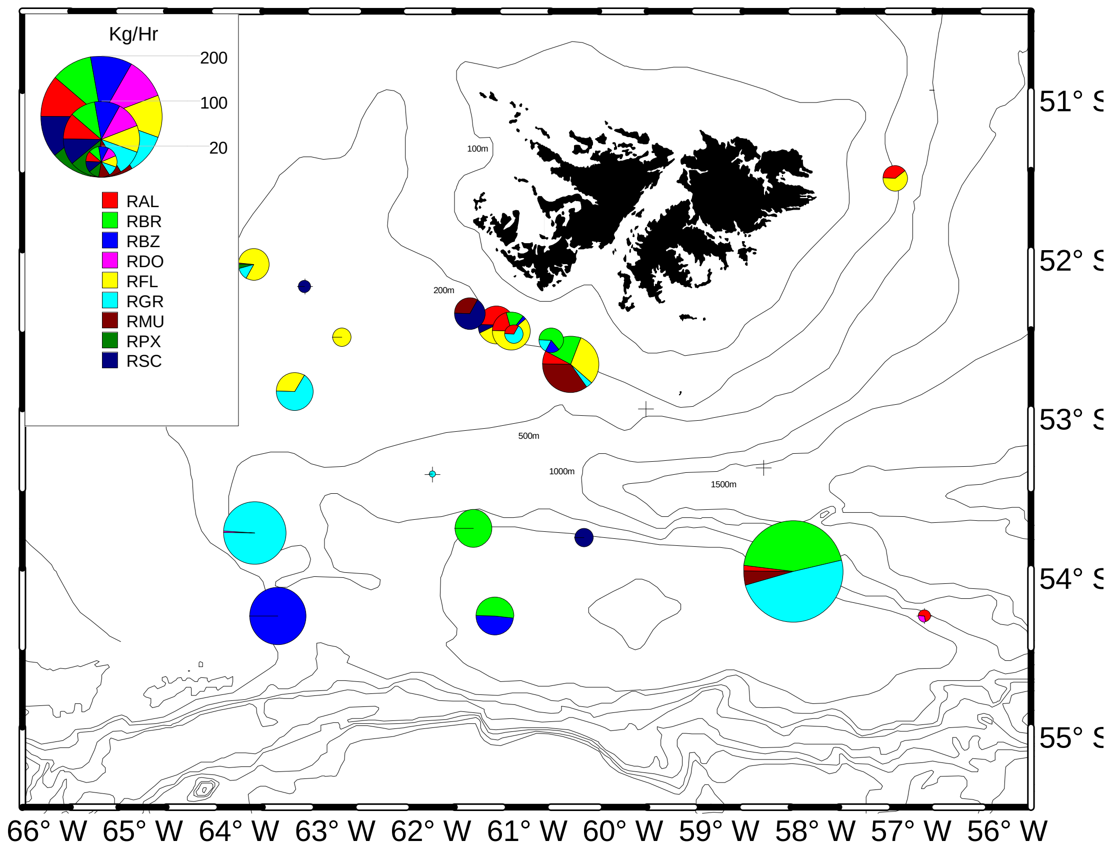


4.13. Rajidae

Catches of rays were relatively low, which is presumably largely due to the type of gear used. At a number of stations, however, some sizeable quantities of particular species were caught, including 28kg of the undescribed *Bathyrajid* #3 at station 1177, 12 and 44kg of *Bathyraja brachyurops* at stations 1190 and 1209 respectively, and 37 and 48kg of *Bathyraja griseocauda* at stations 1171 and 1209 respectively. Table 13 lists the species in order of total catch size, while Figure 32 shows the relative abundance by station and species. Biological data was collected as per usual protocols, but the sample size was limited to relatively few specimens per species.

Table 13. Rajidae catch table.

Species		*Total Catch (kg)*	*Proportion(%)*
RGR	*Bathyraja griseocauda*	100.325	32.63%
RBR	*Bathyraja brachyurops*	77.604	25.24%
RFL	*Raja flavirostris*	42.944	13.97%
RBZ	*Undescribed Bathyrajid #3*	37.057	12.05%
RAL	*Bathyraja albomaculata*	18.073	5.88%
RMU	*Bathyraja multispinis*	16.66	5.42%
RSC	*Bathyraja scaphiops*	13.25	4.31%
RDO	*Raja doellojuradoi*	1.004	0.33%
RPX	*Psammobatis spp.*	0.513	0.17%



4.14. Loligo gahi

Loligo gahi was caught widely throughout the survey region (Figure 33) and to the south and east of the Falklands was locally abundant at depths of 250 – 350 m.

The biological data on *Loligo gahi* suggests division into two major areas: a northeast region, which comprises the slope around the Falklands only, and a southwest region, which included areas in the Argentine EEZ, some adjacent Falklands waters, and the Burdwood Bank. Within each of these regions squid size and maturity also varied with depth.

In the northeast region two major cohorts were present (Figure 34), which presumably corresponded to the spring and autumn-winter spawners. Squid of 8-11 cm ML represented the bulk of the autumn-winter spawners. Females were immature and maturing (stages II-III), males were mostly maturing (stage III predominated) and mature, and there was a small number of still immature squid. This cohort represented the bulk of the population (about 85%) at depths of 100-200 m and predominated (about 65%) at depths between 200 and 300 m.

The spring spawners were represented by maturing females and mostly mature males, though some were still maturing. Squid size was mostly 11-20.5 cm. This group was the only group present in deep waters between 350 and 500 m, where females predominated (91%). On the shelf edge and the upper slope (200-300m) these squid represented about 35% of population by numbers, their relative abundance decreasing to 15% at depths shallower than 200 m.

In the southwest squid size and maturity within the two cohorts was similar to that in the northeast region. There is no reliable data for depths of 100-200 m within this region. The autumn-winter spawners occurred in very low numbers between 200 and 300 m (10% of the population) and were absent deeper than 300 m. This cohort was represented exclusively by females.

Spring spawners occupied the entire depth range between 200 and 500 m. In contrast to the northeast region females did not dominate the deeper waters to such a great extent (61%) suggesting that the spawning migration of males was delayed in these colder waters.

Figure 33. Catch per unit effort of *L.gahi*. Circle diameter is proportional to the square root of CPUE (kg/hr). Trawl positions are indicated by black crosses.

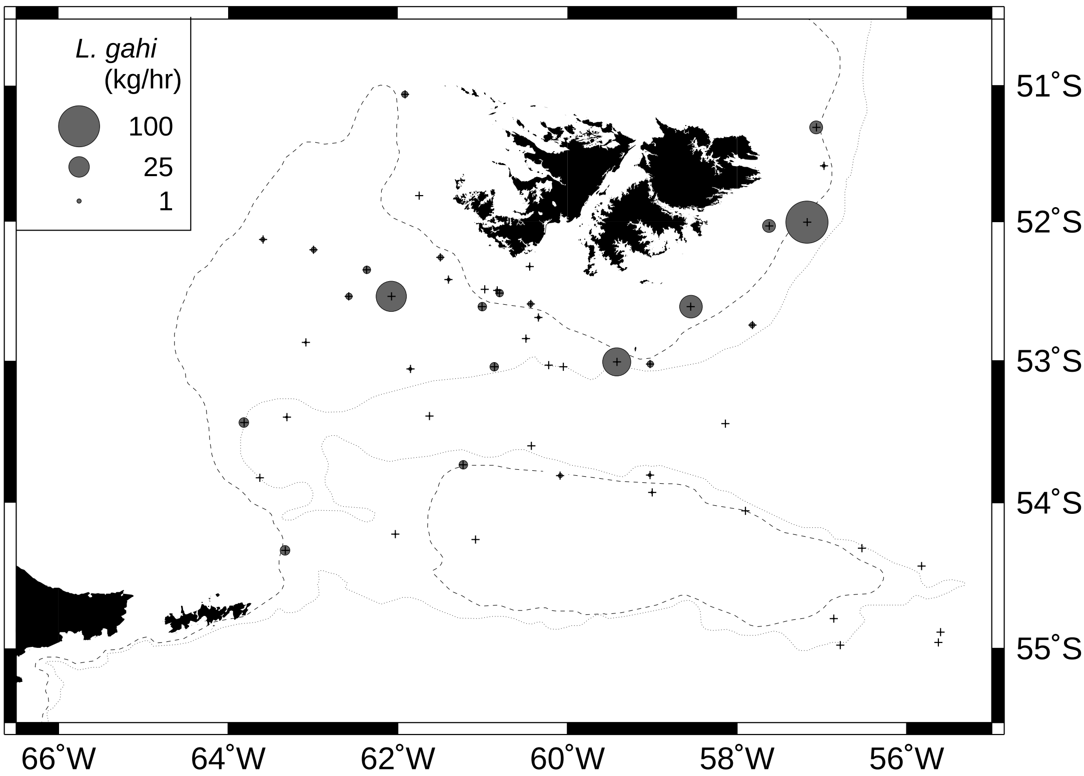
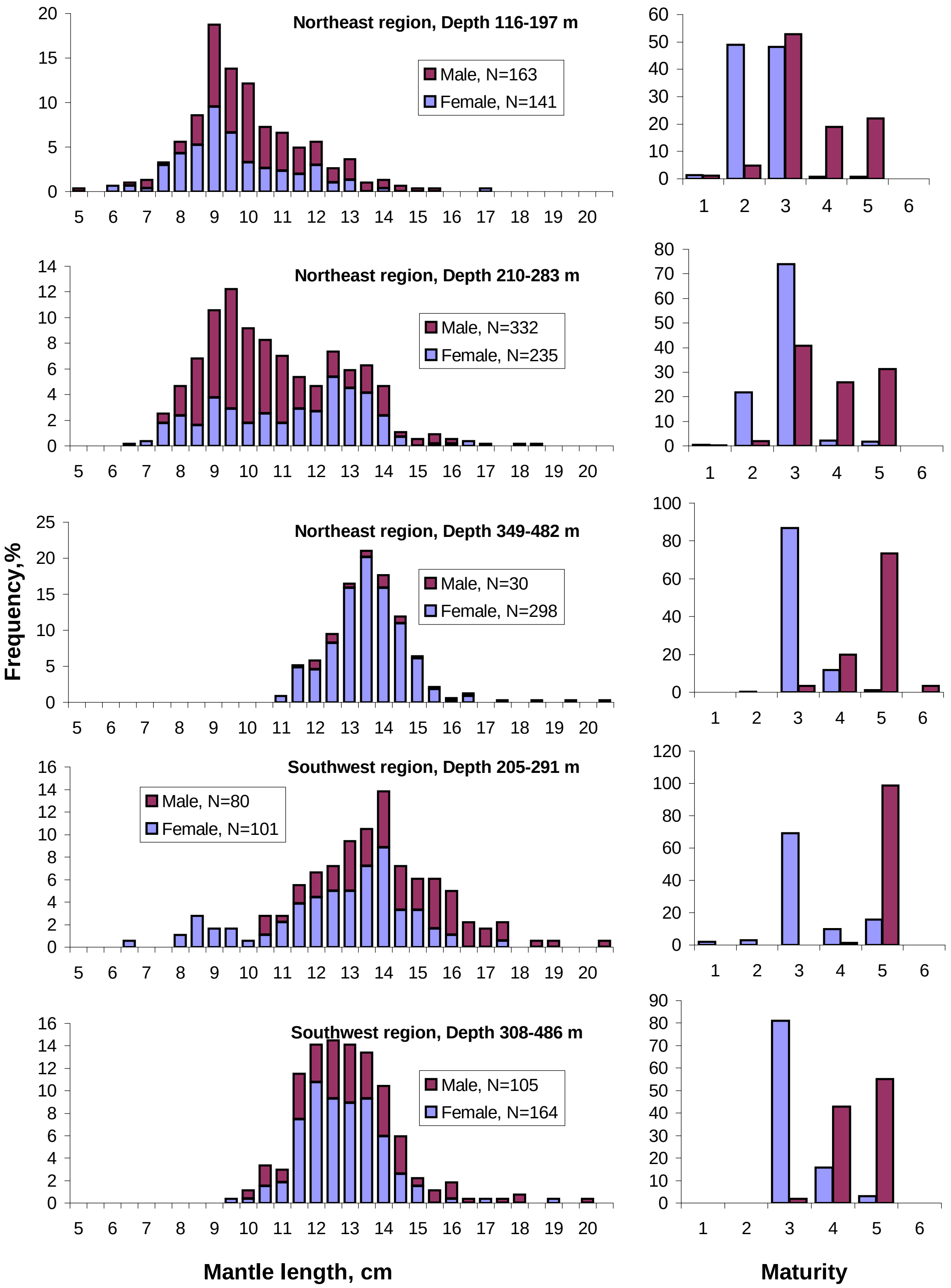


Figure 34. Length frequency and maturity distributions for male and female *L. gahi* at different depths in the northeast and southwest parts of the survey region.



4.15. Plankton

Due to time limitations plankton tows did not form a part of the main cruise plan. However, favourable weather allowed one evening to be devoted to plankton tows in the vicinity of the southern blue whiting spawning aggregations (stations 1128-1130, Figure 11). No commercial species were represented in the plankton tows. (Table 14).

Table 14. Catch in plankton tows carried out on 14/09/02. D - dominating, C - common, R - rare, O-occasional.

Species	*St.1128 (79 g.)*	*St.1129 (47.9 g.)*	*St.1130 (39.3 g.)*
Themisto gaudichaudi	C	C	O
Euphausia lucens	D	D	D
Nematoscelis megalops	R	C	R
Sagitta maxima	C	C	C
Myctophidae	3	8	

4.16. Deep water pelagics

Three pelagic hauls (stations 1222, 1223, 1225) were carried out to the south of the Falklands, with towing horizons of 500 to 1000m over bottom depths of 1848-2900 m, to investigate the fauna and biology of deep-water fish and squid species of the region. The catches were diverse (Table 8) with several species recorded in research trawls for the first time and a number of new and as yet unidentified species retained for further study. In addition to sampling the different myctophid and other deep-sea fish for the general reference collection otoliths were collected to aid in the identification of prey items in diet studies.

Unidentified fish belonging the poorly known family Alepocephalidae were sampled for further investigation of its taxonomy and distribution and two recently described squid species of the family Brachioteuthidae, whose biology is unknown, were sampled for the reference collection.

Catches of the squid *Galiteuthis glacialis* at stations 1222 and 1225 included the first recorded mature female. It had a mantle length of ML 430 mm and its fecundity was estimated as 3,600 eggs with a ripe egg size of 3.0-3.2 x 2.2-2.7 mm. The first recorded collection of adult spent females of the squid *Gonatus antarcticus* were taken at station 1225. Mantle lengths were 380 and 395 mm, their ovaries contained some 22,000 and 25,000 empty follicles, and about 375 and 100 residual yolk oocytes. The second female had nine ripe eggs in her oviduct, their size was 3.2-3.3 x 2.5-2.9 mm.

5. Southern blue whiting acoustic survey

5.1. Introduction

In the Southwest Atlantic southern blue whiting spawn in the productive upwelling waters to the south and south-west of the Falkland Islands (Shubnikov et al., 1969). Spawning is strictly seasonal and usually takes place in September - October although spawning concentrations sometimes start to form in August (Shubnikov et al., 1969; Macchi and Pajaro, 1999). A “snapshot” acoustic survey of the main spawning area may therefore provide a good estimate of the spawning stock biomass in a given year.

Joint Argentine-UK scientific surveys of the southern blue whiting spawning area began in 1994 and since then have taken place annually with the primary aim of estimating spawning stock biomass. However these surveys have generally found post-spawning aggregations. In 2001 the joint survey was carried out by the Argentine research vessel the *Capitan Oca Balda* in August, earlier than in previous years, in an attempt to survey the beginning of the spawning season. However, few fish had aggregated for spawning at this time. In October 2001 the FIFD carried out another survey, utilising the research vessel *Dorada* (Falkland Islands Government, 2002). Post-spawning aggregations of southern blue whiting were located on the southern and south-eastern part of the shelf and continental slope of the Falkland Islands.

Analysis of data from FIFD observers on commercial vessels over the period 1998 – 2001 (Figure 35) suggested that peak spawning was most likely to be encountered in September and the *Dorada*’s survey was planned for this time. In fact the first spawning southern blue whiting reported by an FIFD observer in 2002 were recorded on 28 August 2002.

The final biomass estimate from the joint survey carried out in 2002 will be made after data from both phases of the survey have been analysed and integrated. However, this chapter presents a preliminary biomass estimate which is based on the analysis of the data collected by the *Dorada* only and using the simple grid-square based stratification that was employed in the October 2001 survey.

5.2. Methods

5.2.1. Survey design

The planned survey area (Figure 1) was largely similar to that covered in previous surveys but a zig-zag survey track was adopted with increased allocation of acoustic sampling effort (i.e. closer transect spacing) in the area south of the Falkland Islands where the main post-spawning aggregations were found in previous surveys. Two parts of the track, the slope around the east, south and west of the Islands, and the slope north of Isla de los Estados were repeated in October by the *Capt. Oca Balda* in the second phase of the joint survey. This survey track of the *Dorada* included coverage of the deeper shelf to the south west of the Islands and the Burdwood Bank. Most of the survey legs were up/down slope and aimed to cover depths from 100 to 500 m.

The realised cruise track is shown in Figure 36. The only significant change to the planned track was to maintain the denser transect spacing in the region SW of Cape Meredith. Favourable weather also allowed the addition of additional survey effort in the main spawning areas.

Figure 35. The proportion of individuals at various maturity stages for all trawls where southern blue whiting was sampled by FIFD observers during August – November on an annual basis from 1988 – 2001.

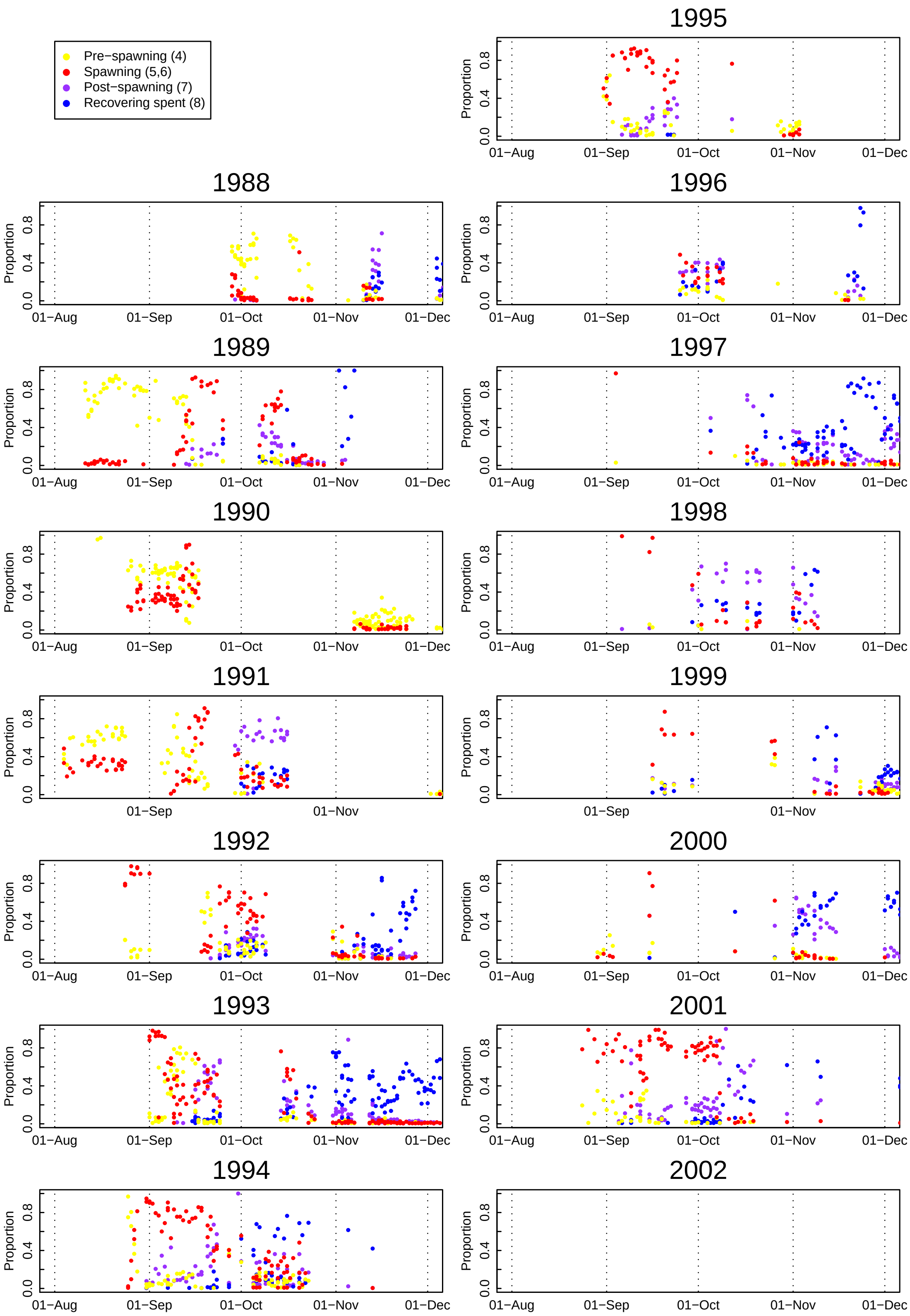
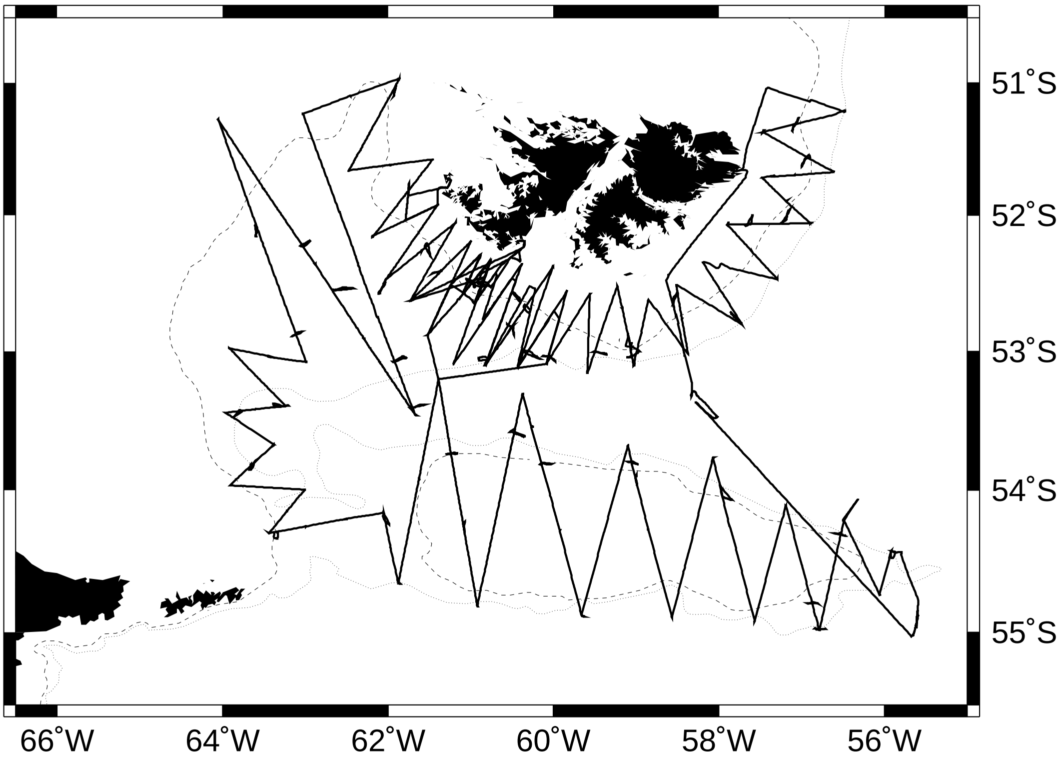


Figure 36. Realised cruise track of FPRV *Dorada* from 5 September to 2 October 2000, research cruise ZDLH1-09-2002. The 200 m (dashed line) and 500 m (dotted line) depth contours are illustrated using data from the GEBCO bathymetric atlas.



5.2.2. Acoustic surveying and analysis

A Simrad EK500 echosounder operating at 38 and 120kHz was used. Settings are given in Table 15. Acoustic data were logged using SonarData Echolog 500 v. 2.25.16. The echosounder was externally triggered with a ping interval of approximately 2 s. Acoustic transects were run at a nominal speed of 10 knots.

The 38kHz data with expanded bottom were used as the primary data for biomass estimation. Acoustic data processing was carried out with SonarData Echoview versions 2.25.88. Each of the 60 survey legs was analysed separately. This was primarily due to PC memory limitations, but also allowed setting of the background noise independently for each leg. Data was logged and processed without use of a draft correction. All depths are therefore, strictly, ranges from the transducer.

The logged acoustic range was automatically set to ensure that data was logged from the entire water column at all times. During targetted trawls on substantial marks the sample Sv and angle data were logged in addition to the normal Q telegram data.

Additional data collected on transit to the calibration site in Port Albemarle on 13/09/02 was also processed.

5.2.2.1. Background noise correction

Background noise correction was performed by subtraction implemented via virtual variables in Echoview. On 08/09/02 the RoxAnn unit connected to the 38kHz transducer was removed leading to a substantial reduction in the amount of electrical noise at this frequency.

The background noise S_V re 1m was estimated for each leg independently. This was done by the standard method of increasing the subtracted noise level until the colour banding pattern disappeared. Estimated noise for each leg is given in Table 16.

5.2.2.2. Calibration

Calibration of the EK500 was undertaken on 13 September 2002 in Port Albemarle. Calibrations were carried out using the standard sphere method (Anon., 1996), with copper spheres of 60mm (38kHz) and 23mm (120kHz) diameter. Calibration parameters are given in Table 17 and Table 18 summarises the calibration settings applied in Echoview.

5.2.2.3. Data quality control

An Echoview "EV" file was constructed for each survey leg. Data from the start or end or the leg, and from mid-leg trawl and CTD stations, was masked using "bad data" regions. Similarily the ping following an echosounder range change was eliminated.

Acoustic "drop-outs" due to sea conditions were eliminated by making use of the observation that the sounder detected bottom was generally broken at these poor quality pings. Echoview virtual variables were used to construct a mask variable that eliminated pings whenever there was a break in the sounder detected bottom.

A surface exclusion layer at a fixed depth of 15m was applied, and data below a line 0.5m above the sounder detected bottom was likewise excluded.

The nautical area scattering coefficient (S_A) values were then inspected using a 0.5nm along transect spacing. High values were scrutinised to ensure that they were not due to erroneous integration of the seabed echo or acoustic noise. When the sounder detected bottom was found to be in error (a particular problem on very steep slopes, such as the boundaries of the Burdwood Bank, when bottom echo was derived from the side lobes of the transducer beam) the bottom line was corrected by hand. Pings found to contain noise pulses were masked.

The Echoview virtual variables used are detailed in Table 19.

5.2.2.4. Delineation of volume backscattering attributed to southern blue whiting.

To distinguish between fish aggregations and plankton backscattering the Echoview schools detection module was applied to automatically identify aggregations. A minimum S_V threshold of –65dB was applied prior to schools detection using the re-sampled data (variable SchoolDetect, Table 19). School detection parameters were set as follows:

Minimum school length:	20m
Minimum school height:	5 m
Minimum connected length:	20m
Minimum connected height:	1.5m
Maximum vertical linking distance:	10m
Maximum horizontal linking distance:	60m

GPS distance was used in schools detection distance calculations.

The regions detected by the school detection algorithm were manually assigned to a fish species based on trawling results and school characteristics. In this initial analysis only schools in the main spawning region and in the area of aggregations of smaller, mixed maturity fish in deeper water to the south of the main spawning areas were partitioned by species.

The boundaries of the detected schools assigned to *M. a. australis* ("BLU") were used to mask the unthresholded, noise free data (38-S-C-BLU, Table 19) prior to echointegration.

Table 15. Survey echosounder settings.

Operation menu		Ping Mode	Ext.Trig
		Ping Auto Start	On
		Ping Interval	0.0 sec
		Transmit Power	Normal
		Noise Margin	0 dB
Transceiver menu	Transceiver-1 Menu	Mode	Active
		Transducer Type	ES38B
		Transd. Sequence	Off
		Transducer Depth	0.00 m
		Absorption Coef.	10 dBkm
		Pulse Length	Medium
		Bandwidth	Wide
		Max. Power	2000 W *
		2-Way Beam Angle	-21.1 dB
		Angle Sens.Along	21.9
		Angle Sens.Athw.	21.9
		3 dB Beamw.Along	6.7 dg
		3 dB Beamw.Athw.	6.7 dg
		Alongship Offset	-0.03 dg
		Athw.ship Offset	-0.19 dg
		Frequency	38 kHz
	Transceiver-2 Menu	Mode	Active
		Transducer Type	ES120-7
		Transd. Sequence	Off
		Transducer Depth	0.00 m
		Absorption Coef.	31 dBkm **
		Pulse Length	Long
		Bandwidth	Narrow
		Max. Power	1000 W
		2-Way Beam Angle	-18.8 dB
		Angle Sens.Along	21.0
		Angle Sens.Athw.	21.0
		3 dB Beamw.Along	8.7 dg
		3 dB Beamw.Athw.	8.7 dg
		Alongship Offset	0.17 dg
		Athw.ship Offset	-0.07 dg
		Frequency	120 kHz
Bottom detection menu	Bottom Detection-1 Menu	Minimum Depth	*varied*
		Maximum Depth	*varied*
		Min. Depth Alarm	0.0 m
		Max. Depth Alarm	0 m
		Bottom Lost Al.	Off
		Minimum Level	-50 dB
	Bottom Detection-2 Menu	Minimum Depth	*varied*
		Maximum Depth	*varied*
		Min. Depth Alarm	0.0 m
		Max. Depth Alarm	0 m
		Bottom Lost Al.	Off
		Minimum Level	-50 dB
Log menu		Mode	Speed
		Ping Interval	100
		Time Interval	120 sec
		Dist. Interval	1.0 nm
		Nm Pulse Rate	200/nm

Layer menu	Super Layer	1	
	Layer-1 Menu	Type	Off
	Layer-2 Menu	Type	Off
	Layer-3 Menu	Type	Off
	Layer-4 Menu	Type	Off
	Layer-5 Menu	Type	Off
	Layer-6 Menu	Type	Off
	Layer-7 Menu	Type	Off
	Layer-8 Menu	Type	Off
	Layer-9 Menu	Type	Off
	Layer-10 Menu	Type	Off
Ts detection menu	TS Detection-1 Menu	Min. Value	-70 dB
		Min. Echo Length	0.8
		Max. Echo Length	1.6
		Max. Gain Comp.	6.0 dB
		Max. Phase Dev.	3.0
	TS Detection-2 Menu	Min. Value	-70 dB
		Min. Echo Length	0.8
		Max. Echo Length	1.6
		Max. Gain Comp.	6.0 dB
		Max. Phase Dev.	3.0
Ethernet com. Menu	Telegram Menu	Remote Control	On
		Sample Range	*varied*
		Status	On
		Parameter	On
		Annotation	Off
		Sound Velocity	Off
		Navigation	On
		Motion Sensor	Off
		Depth	1&2
		Depth NMEA	1
		Echogram	1&2
		Echo-Trace	1&2
		Sv	Off
		Sample Angle	*varied*
		Sample Power	*varied*
		Sample Sv	Off
		Sample TS	Off
		Vessel-Log	On
		Layer	On
		Integrator	Off
		TS Distribution	Off
		Towed Fish	Off
	Echogram-1 Menu	Range	*varied*
		Range Start	0 m
		Auto Range	Off
		Bottom Range	15 m
		Bot. Range Start	10 m
		No. of Main Val.	550
		No. of Bot. Val.	150
		TVG	20 log R
	Echogram-2 Menu	Range	*varied*
		Range Start	0 m
		Auto Range	Off
		Bottom Range	15 m
		Bot. Range Start	10 m
		No. of Main Val.	550
		No. of Bot. Val.	150
		TVG	20 log R

Motion sensor menu		Heave	Off
		Roll	Off
		Pitch	Off
Utility menu		Beeper	Off
		Status Messages	On
		RD Display	Off
		FIFO Output	Off
		External Clock	Off
		Language	English
Test menu		Version	EK500 5.30

* Prior to calibration on 13/09/02 the ES-38B operated with max power set to 4000 W.
** Set to 37 dBkm prior to calibration on 13/09/02.

Table 16. Survey noise measurements (dB). These were set by the standard technique of disappearance of colour banding.

Leg	Noise (S_V re 1m) 38 kHz	Leg	Noise (S_V re 1m) 38 kHz
1	-137	31	-140
2	-137	32	-147
3	-137	33	-143
4	-137	34	-147
5	-137	35	-147
6	-137	36	-140
7	-143	37	-145
8	-137	38	-141
9	-141	39	-141
10	-147	40	-141
11	-147	41	-147
12	-147	42	-143
13	-147	43	-143
14	-141	44	-141
15	-142	45	-142
16	-140	46	-141
17	-141	47	-151.5
18	-143	48	-150.5
19	-143	49	-143
20	-141	50	-141
21	-143	51	-147
22	-141	52	-147
23	-143	53	-150
24	-145	54	-147
25	-139	55	-150
26	-147	56	-150
27	-140	57	-150
28	-143	58	-150
29	-141	59	-150
30	-147	60	-150

Table 17. Simrad EK500 calibration parameters for M/V *Dorada*.

Vessel	FPRV *Dorada*, ZDLH1	
Software version	5.30	
Location	Port Albemarle	
Date	13/09/02	
Water depth (m)	41.2	
Temperature (°C)	4.54	
Salinity (psu)	33.8	
Sound speed (ms^{-1})	1467.4	
Transducer	ES38B	ES120-7
Time (L)	14:10	18:10
Frequency	**38**	**120**
Test oscillator	-55.3	-55.3
Absorption coefficient	10.4	30.82
Angle sensitivity	21.9	21.0
Ping rate	1.0	1.0
Transmit power	normal	normal
Max power	2000	1000
Pulse duration	medium (1 ms)	long (1 ms)
Bandwidth	wide	narrow
Sphere TS	-33.65	-40.32
Sphere type	**Cu 60**	**Cu 23**
Old TS gain	24.92*	25.87
Calibrated TS gain	**26.68**	**24.98**
Default 2-way beam	-21.1	-18.80
Range to sphere	22.2	22.32
Old Sv gain	24.67*	25.78
Calibrated Sv gain	**26.39**	**25.02**
Lobe results		
TS gain	26.69	
Alongship beam	6.94	
Athwartship beam	6.99	
Alongship offset	0.14	
Athwartship offset	-0.1	

* Max power set to 4000W

Table 18. Calibration constants set in Echoview.

	38kHz prior to 13/09/02		38kHz after 13/09/02	
	Logging	Processing	Logging	Processing
Absorption coefficient (dB/m)	0.0100000	0.0100000	0.0100000	0.0100000
Sound speed (m/s)	1486.70	1467.40	1467.40	1467.40
Transmitted power (W)	4000.0	2000.0	2000.0	2000.0
Two-way beam angle (dB re 1)	-20.60	-21.10	-21.10	-21.10
Sv gain (dB)	24.6700	26.3900	26.3900	26.3900
Wavelength (m)	0.0392497	0.0387402	0.0387402	0.0387402
Transmitted pulse length (ms)	1.000	1.000	1.000	1.000
Draft correction (m)		0.0		0.0
Frequency (kHz)		38.00		38.00
Nominal angle (degrees)		6.700		6.700

5.2.2.5. Conversion to areal biomass density

An elementary distance sampling unit (EDSU; MacLennan and Simmonds, 1992) of 0.5 nm was adopted. Following the protocol adopted on the joint surveys (Madirolas, 1999) the target strength relationship for northern blue whiting, *Micromesistius poutassou*, was used in biomass estimation. Individual target strength is given as a function of individual length (in cm) by

$$TS_n = a_n + b_n \log L \quad (1)$$

with a_n = -72.7 and b_n = 21.8.

The length-weight relationship was estimated using samples collected during the cruise from sampled from two groups of fish: those on the main spawning grounds and those in the mixed maturity aggregations to the south of the main spawning grounds (Figure 37). As the two sets of data showed a very similar pattern (with the exception of the lack of larger individuals away from the spawning grounds) the combined data was used to fit a relationship of the form

$$W = a_f L^{b_f} \quad (2)$$

which yielded estimates of a_f = 2.17E-6 and b_f = 3.272, for weight in kg and length in cm.

Following MacLennan and Simmonds (1992, pp. 253-254), eqn. 1 was converted to a target strength per unit weight of fish:

$$TS_w = a_w + b_w \log L \quad (3)$$

with $a_w = a_n - 10 \log a_f$ = -19.91 and $b_w = b_n - 10 b_f$ = -8.38.

Length frequency data from stations on the main spawning grounds (stations 1110, 1116, 1186 and 1188) was treated separately to that from stations on the mixed maturity aggregations in deeper water to the south of the main spawning region (stations 1094, 1103, 1106, 1187). Data from station 1126, which was in the vicinity of the main spawning aggregations but which caught only a small number of 18 – 23 cm TL fish, was excluded as it is believed that the main aggregations identified in this area were of larger spawning fish.

Length frequency distributions (separately for the two groups) were combined to give mean frequencies for each 1 cm length class according to MacLennan and Simmonds (1992) eqn. 8.1. The mean cross section per unit weight (kg), $\langle\sigma\rangle$, was calculated according to eqn. 8.7 of MacLennan and Simmonds (1992) using the target strength relationship of eqn. 3. This yielded $\langle\sigma\rangle = 4.504E-3$ for the spawning area and $\langle\sigma\rangle = 5.962E-2$ for the deeper mixed maturity aggregations.

Integrated backscattering area, S_A (m^2/nm^2), was converted to biomass density, ρ (t/nm^2), using the relationship:

$$\rho = S_A / \left(1000\langle\sigma\rangle\right) \quad (4).$$

As only the aggregations from the area south of the Falklands were assigned to species for this initial estimate a simple north-south division was used top determine the value of $\langle\sigma\rangle$ used in biomass density calculations. The estimate of $\langle\sigma\rangle$ from the spawning area samples was used for areas north of 53°S and the estimate from the samples of the deeper mixed-maturity aggregations was used for areas south of 53°S.

5.3. Results

Acoustic data from the 60 survey legs were analysed according to the methods detailed above. The distribution of the raw nautical area backscattering coefficient (S_A) along the planned transects is shown in Figure 38 and backscattering from regions identified by the schools detection algorithm in Figure 39. Finally, backscattering attributed to southern blue whiting in the area south of the Falklands is shown in Figure 40.

For this initial biomass estimate the same stratification procedure adopted for the October 2001 survey (Falkland Islands Government, 2002) was employed. This uses a grid of 0.5° longitude by 0.25° latitude. Mean biomass density was calculated for each grid square through which the survey track passed. Two separate estimates have been calculated. One uses only the data collected along the 60-pre-planned survey legs, whilst the second incorporates the additional data collected on transit to Port Albemarle on 13/09/02 prior to echosounder calibration.

Grid by grid biomass estimates using the data from the planned survey legs only are given in Table 20; Table 21 gives the grid by grid estimates after incorporation of the date collected en route to Albemarle. Biomass density was scaled by grid area and summed to give an estimated total biomass of 45,849 tonnes for the planned survey legs only and 104,846 tonnes when including the additional data.

5.4. Discussion

The acoustic survey successfully targeted the spawning period of southern blue whiting in the Southwest Atlantic. Aggregations of spawning fish were encountered (Figure 41), together with aggregations of smaller fish at a range of maturity stages (Figure 42). The bulk of the *M. a. australis* encountered were in, or near to, the major spawning area to the south of the Falklands although smaller aggregations, with some indications of spawning, were also encountered north of Isla de los Estados. It appeared that the post spawning migrations of southern blue whiting from the spawning grounds to the eastern part of the Falkland Shelf had not yet begun.

The area surveyed covered a large part of the species' range. The bulk of the fish encountered were on, or close to, the main spawning ground of southern blue whiting in the SW Atlantic. Although the acoustic marks observer north of Isla de los Estados have yet to be partitioned between *M. a. australis* and other species present (principally hoki, *M. magellanicus*) it is clear that the data from this region will contribute rather little additional biomass to the total.

In the south eastern part of the area where the bulk of the southern blue whiting were encountered, at depths of 300 – 500m west of Beauchene Island, large aggregations of hoki were also encountered (Figure 43). The acoustic marks encountered thus had to be partitioned between mixed maturity schools of southern blue whiting, and hoki. Trawls in the area tended to be dominated by a single species so partitioning schools into one species or the other was justified. However there is clearly some potential for schools of southern blue whiting to have been misclassified as hoki and vice versa.

The large difference between the total biomass estimates with and without the inclusion of the extra data collected en route to Albemarle on 13 September 2002 illustrates the most problematic part of the survey analysis. Although commercial vessels were taking large catches of southern blue whiting in the area just south west of Cape Meredith in the days just prior to the acoustic survey, no large spawning aggregations were encountered in this area along the pre-planned survey transects. However, on re-traversing the area prior to echosounder calibration in Port Albemarle a large aggregation was encountered (Figure 44), giving rise to the very different biomass estimate. Resurveying the area after calibration again failed to detect any large aggregations. This suggests that the spawning aggregations are patchy and considerably more mobile than the post-spawning aggregations encountered in previous joint surveys. Further work on the spatial distribution and patchiness in spawning aggregations encountered on the survey will be required before a final biomass estimate can be provided for this first phase of the joint survey.

The spawning aggregations detected on the present survey were, however, generally somewhat higher off the seabed than the post-spawning aggregations detected in October 2001. This leads to fewer concerns about the potential for substantial quantities of fish to be missed due to the effect of the acoustic "deadzone" near the seabed (Ona and Mitson, 1996).

As in previous surveys the target strength relationship for northern blue whiting, *Micromesistius poutassou*, has been employed. The additional sample data collected during this survey should provide the opportunity for a re-examination of this relationship using detections of single fish on the margins of schools.

Table 19. Steps implemented in Echoview 2.25.88. Raw variables: Q1B – 38 kHz raw data with expanded bottom; Q2B – 120 kHz raw data with expanded bottom.

Steps	Virtual Variables				
	Name	Operator	Operand1	Operand2	Other Settings Required
Create mask to exclude pings with no sounder detected bottom	BottomLineBitmap	LineBitmap	Q1B		Start Line: T1-SounderDetectedBottom-orig Start Line: T1-SounderDetectedBottom-0.1 Do check "Invert Output"
Create mask to exclude data off the defined transect and other bad data regions	OnTrack	Region Bitmap	Q1B		Region type: Bad Region classification: All Do check "Invert Output"
Create combined exclusion mask	BadDataMask	And	BottomLineBitmap	OnTrack	
Define included part of water column	SurfaceBottom	Line Bitmap	Q1B		Start Line: SurfaceExlusion Stop line: T1-SounderDetectedBottom-0.5 Do NOT check "Invert Output"
Define data to include	Include	And	BadDataMask	SurfaceBottom	
Mask out excluded data	38-E	Mask	Q1B	Include	Do check "Zero is no data"
Resample data	38-S	Resample by time interval	38-E		Average all pings over a 10s time interval; output 500 datapoints
Generate noise	Noise-38	Data generator	38-S		Use noise S_V 1m from Table 16; set α = 0.010
Subtract noise	38-S-C	Linear Minus	38-S	Noise-38	
Create echogram for school detection	SchoolDetect	Copy	38-S-C		Set minimum threshold to –65dB
Create mask based on school detections attributed to BLU	SchoolMaskBLU	Region Bitmap	38-S-C		Region type: Integration Region classification: BLU
Mask noise free echogram to delineat backscattering attributed to BLU	38-S-C-BLU	Mask	38-S-C	SchoolMaskBLU	Grid = 0.5nm; Do NOT check "Zero is no data"

Figure 37. Length-weight relationship for *Micromesistius australis australis* sampled during research cruise ZDLH1-09-2002 using data from stations in the main spawning area (1110, 1116, 1186, 1188, "+" symbols) and in the mixed maturity aggregations of smaller fish to the south of the main spawning area (stations 1094,1103, 1106, 1187, "x" symbols). The line gives the relationship fitted to the data from both groups.

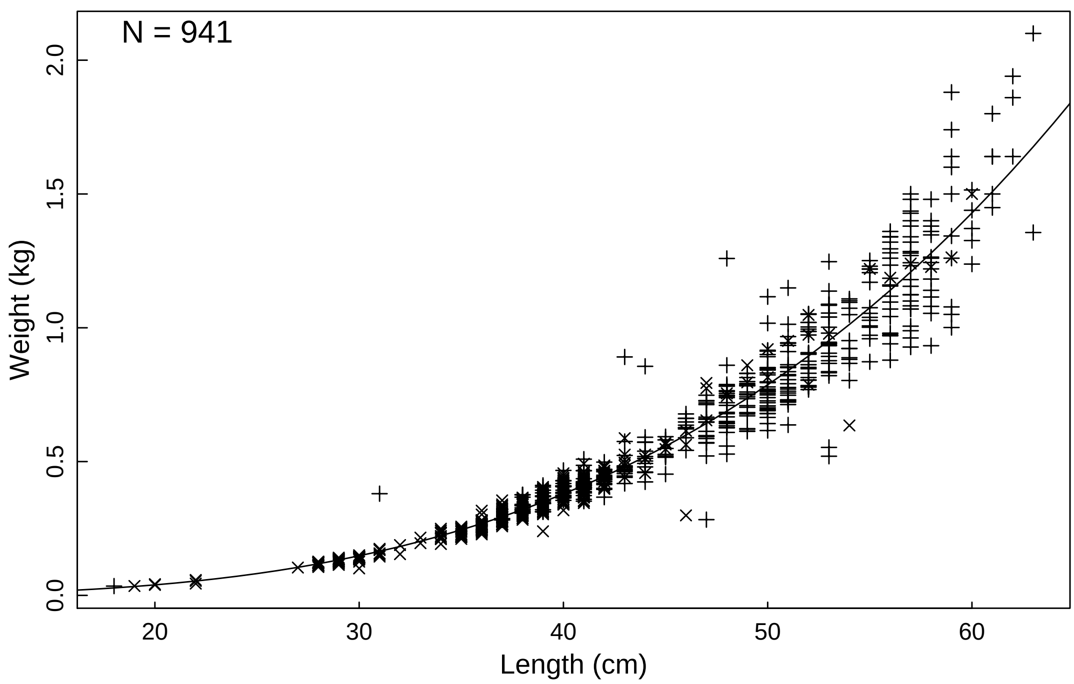


Table 20. Density, area and estimated biomass for all 0.5° longitude by 0.25° latitude grid squares included in the acoustic survey track where biomass was greater than zero, using data collected along the planned survey legs only.

Grid location *(north east corner)* Latitude	Longitude	*Grid area* (nm^2)	*Number of EDSUs in grid*	*Biomass density* *(t/nm^2)*	*Grid biomass (t)*
-53.00	-60.00	281.58	46	56.42	15885.98
-53.00	-60.50	281.58	15	00.59	165.57
-53.00	-61.00	281.58	26	00.25	69.30
-52.75	-60.00	279.96	90	37.87	10602.33
-52.75	-60.50	279.96	83	41.95	11743.14
-52.50	-60.00	278.36	82	00.03	08.39
-52.50	-60.50	278.36	96	03.15	877.74
-52.25	-60.50	276.79	53	23.47	6496.44

Table 21. Density, area and estimated biomass for all 0.5° longitude by 0.25° latitude grid squares included in the acoustic survey track where biomass was greater than zero, using data collected along the planned survey legs and additional data collected en route to Port Albemarle on 13/09/02.

Grid location (north east corner) Latitude	Longitude	*Grid area* (nm^2)	*Number of EDSUs in grid*	*Biomass density (t/nm^2)*	*Grid biomass (t)*
-53.00	-60.00	281.58	46	56.42	15885.98
-53.00	-60.50	281.58	15	00.59	165.57
-53.00	-61.00	281.58	26	00.25	69.30
-52.75	-60.00	279.96	90	37.87	10602.33
-52.75	-60.50	279.96	83	41.95	11743.14
-52.50	-60.00	278.36	82	00.03	08.39
-52.50	-60.50	278.36	96	03.15	877.74
-52.25	-60.50	276.79	94	26.90	7445.41
-52.25	-61.00	276.79	118	209.72	58048.62

Figure 38. Distribution of whole water column S_A along the acoustic survey track. Size of squares is proportional to the square root of S_A calculated over 0.5nm sections of the survey track. Intervals where $S_A < 100$ are not plotted.

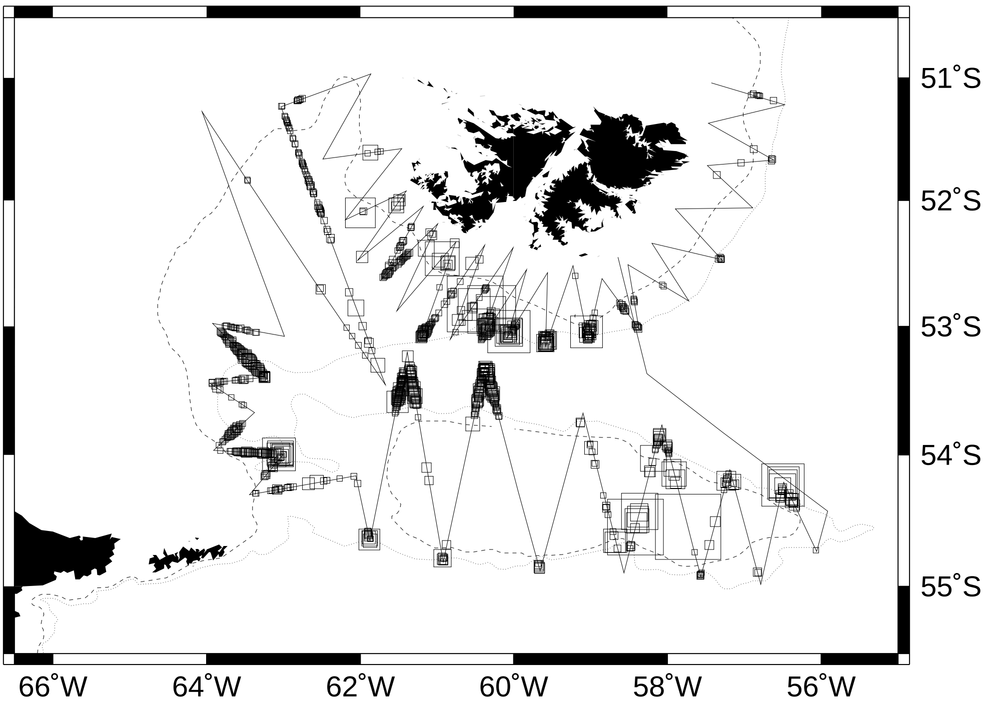


Figure 39. Distribution of S_A in regions identified by the school detection algorithm along the acoustic survey track. Size of squares is proportional to the square root of S_A calculated over 0.5nm sections of the survey track. All intervals where $S_A > 0$ are plotted.

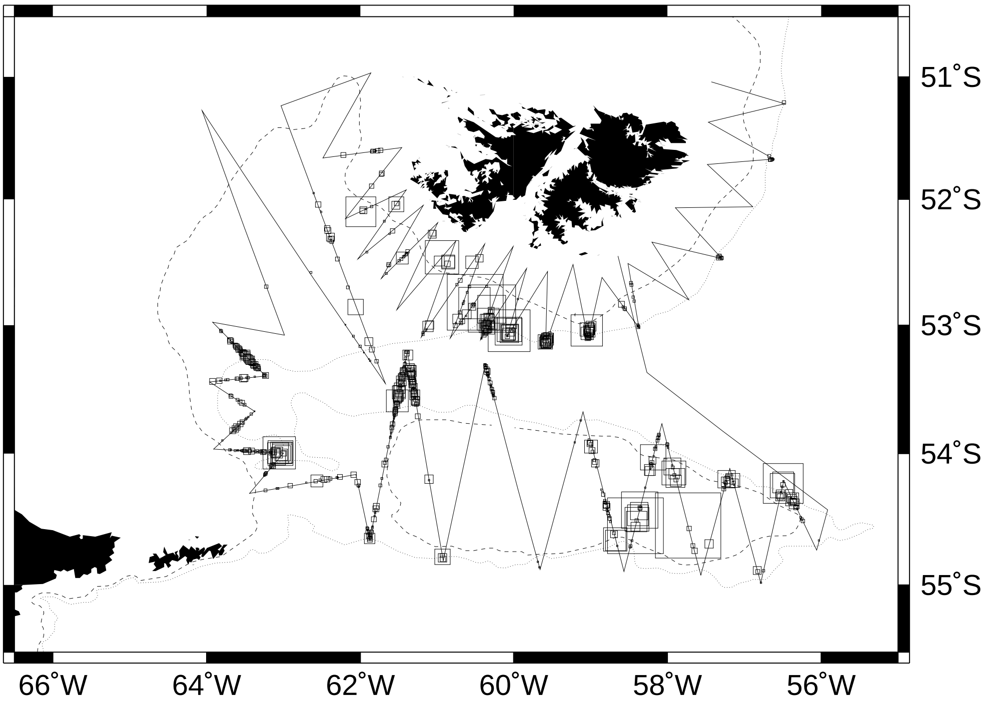


Figure 40. Distribution of S_A along the acoustic survey track from regions identified by the school detection algorithm which were subsequently allocated as southern blue whiting. Size of squares is proportional to the square root of S_A calculated over 0.5nm sections of the survey track. All intervals where $S_A > 0$ are plotted. The grid used for stratification in deriving the initial biomass estimate is also shown. The trackline and squares in black represent data collected along the planned survey track whilst that in red represents the additional data collected en route to Albemarle on 13/09/02.

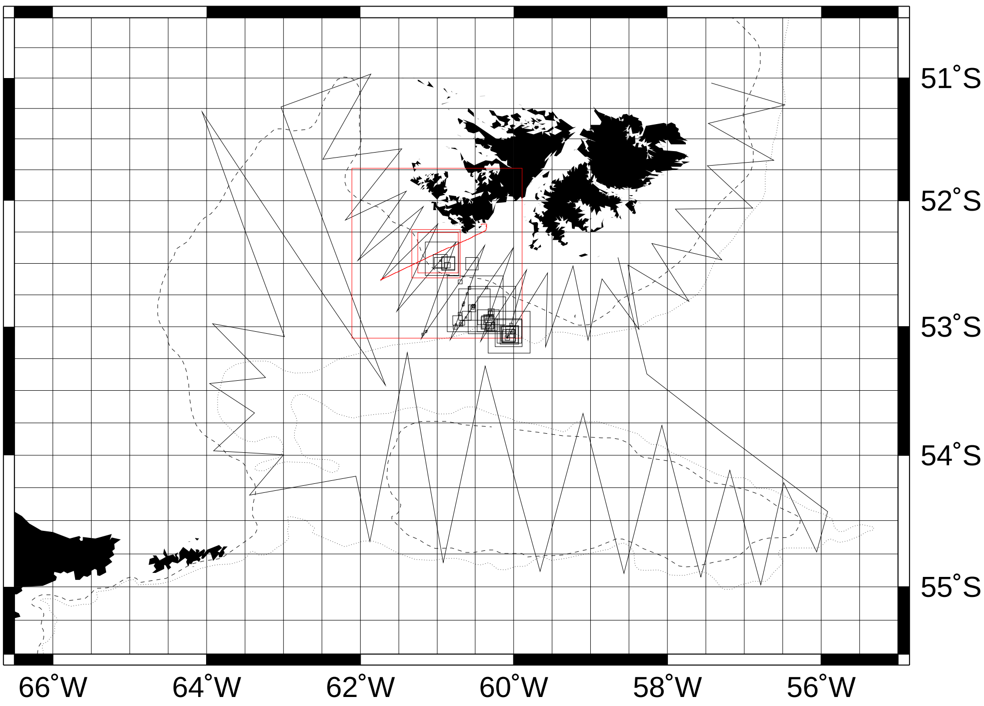


Figure 41. Spawning aggregation of large (35 – 65 cm) southern blue whiting on survey leg 21. Minimum Sv displayed is –80dB.

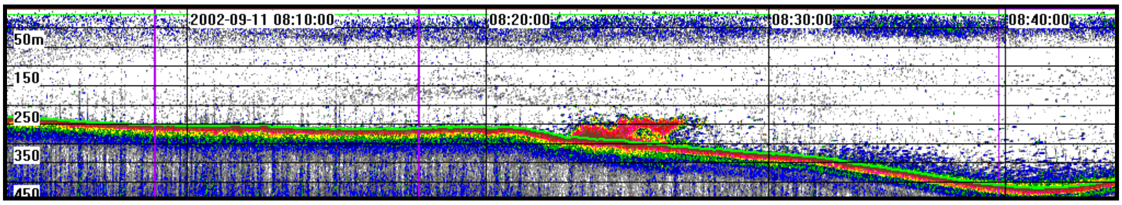


Figure 42. Mixed maturity school of smaller (35 – 45 cm) southern blue whiting on survey leg 17. Minimum Sv displayed is –80dB.

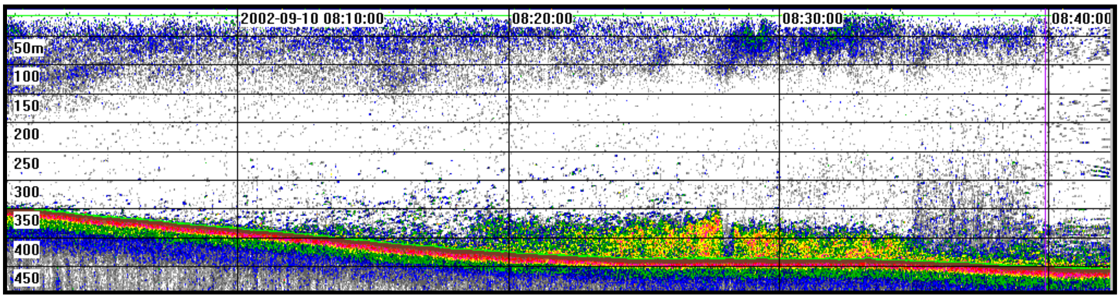


Figure 43. Pelagic school of hoki observed on leg 13. Minimum Sv displayed is –80dB. This school was observed before dawn (times are in GMT) and became hard on the bottom as daylight arrived.

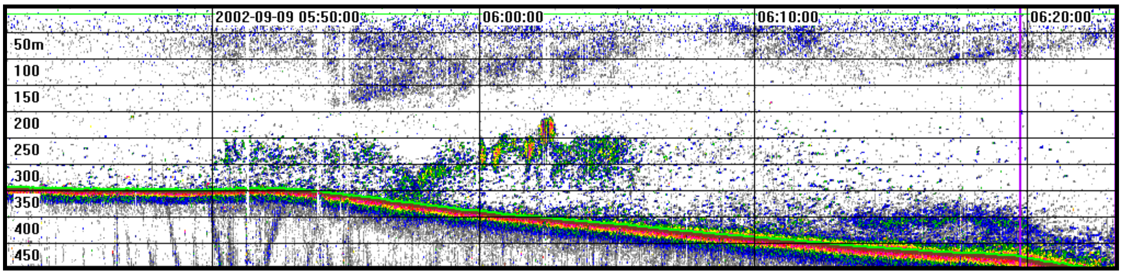
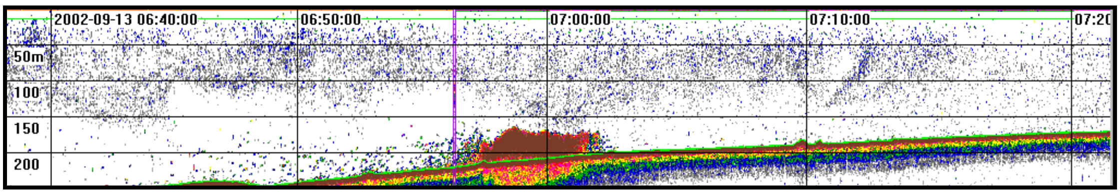


Figure 44. Large southern blue whiting spawning aggregation observed while en route to echosounder for calibration on 13 September 2002. Minimum Sv displayed is –80dB.



6. Seabird scarer trials

6.1. Introduction

In September 2001 and August 2002 the Falklands Conservation Seabirds at Sea Team (SAST) recorded seabird mortality levels of around 1 bird per day on finfish trawlers operating in Falkland Island waters. This is more than double that reported for the Kerguelen region in February/March 1995 when 17 birds were killed on a trawler at a rate of 0.48 birds/day (Weirmerskirch *et al.* 2000). More than 95% of these deaths occurred when birds, feeding on offal discharged near at the stern of the ship, were hit by the trawl warp and dragged under the water, becoming impaled on a splice in the warp cable.

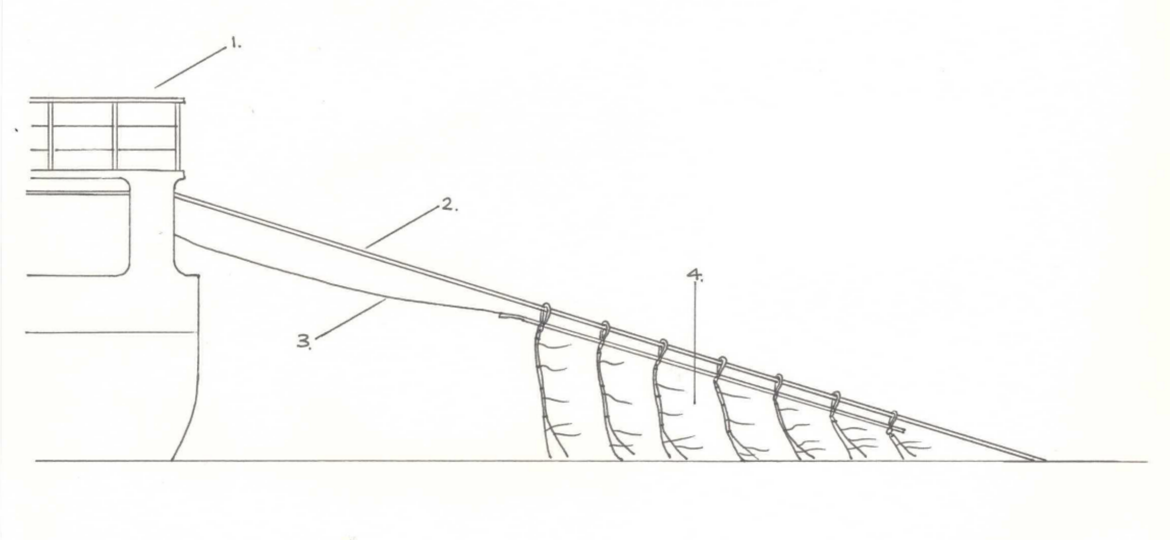
Since the problem was identified SAST and FIFD have been working to develop a bird scarer to keep birds away from the area where the warp enters the water. The device consists of a system of ropes (known as the South Atlantic Albatross Saver, SAAS) that attach to the warp at the stern of the ship. The theory of the device is similar to that of tori lines used on longline vessels, whereby the movement of the ropes as the vessel pitches and rolls scares birds away from the point where the warp enters the water ship so reducing contacts that lead to mortality. The SAAS consists of a series of stainless steel carabiners latched onto the warp cable. These have 14mm diameter ropes attached (with reflective orange tape) that hang to the water. The carabiners and are joined by a 10m long piece of triple-reinforced hydraulic hose; threaded through this is a 3mm diameter piece of rope, which is tied to the stern of the ship (Figure 45). The hose maintains the spacing between carabiners whilst the rope holds the device in position and allows length adjustment in different sea conditions.

SAAS was tested in October 2001 and February 2002 on finfish and *Loligo* trawlers and the results clearly show that SAAS is effective in reducing contacts between the warp and seabirds, especially heavy contacts which lead to incidental mortality (Sullivan and Brickle 2002). A range of interrelated variables potentially influence the frequency of the cable contacting birds, and therefore the probability of a bird being killed. These include:

- The amount and duration of offal discharge, which influences the density of birds attending trawlers).
- The time of year (i.e. season/breeding cycle), which effects the density and foraging behaviour of birds feeding around trawlers.
- The strength and direction of the wind, which influences bird behaviour around vessels.
- Sea state, which influences the force and speed at which the stern of the vessel pitches, and therefore the speed at which the warp pitches.

The primary objective of the trials was to determine the effectiveness of SAAS under different levels of controlled discharge**.**

Figure 45. Illustration of the "South Atlantic Albatross Saver" (SAAS). (1) Observer position; (2) Warp; (3) Lazy line; (4) SAAS.



6.2. Methods

The experimental protocol was designed for the expected 18 trawls that would be conducted between September 6 and 16. Three discharge treatments were chosen, designed to reflect discard levels experienced on finfish trawlers under normal operating conditions: nil, low (10 discharge events every 10 minutes), and high (100 discharge events every 10 minutes). Each individual discharge event represented the discard of an individual fish or part thereof. A random number generator was used to select the nine trawls on which to deploy SAAS and three replicates of each discharge treatment.

All data were collected by a single observer positioned on the stern gantry. For each replicate the abundance of seabirds was estimated from the stern of the vessel in a 500 x 500m sampling area (500m astern and 250m on the starboard and port sides) during all shots and hauls. Species-specific abundance estimates were placed into one of five categories: 1=1-10 birds, 2=11-50, 3=51-200, 4=201-500, and 5 => 500.

All contacts between seabirds and the warp cables were classified and recorded using SAST standard data recording protocols. A range of environmental variables were also recorded for each trawl.

The SAAS device was deployed when shooting was complete and was retrieved prior to hauling. While the device in its current form can remain in place during cable adjustment (e.g. auto trawl), because of the small size of the carabiners used it must be removed to enable a cable splice to pass through.

6.3. Results

Data were analysed using MINITAB. Preliminary data screening indicated that the data set did not break the assumption of equal variance and was therefore suitable for ANOVA. One-way ANOVA indicated that significantly fewer contacts were recorded during trawls with SAAS deployed. No significant difference ($p > 0.05$) was identified for discharge level or sea state.

A one-way ANOVA of black-browed albatross abundance identified two groups (abundance classes 1-3 and 4-5). These data were recoded to form two categories and a subsequent one-way ANOVA between the number of contacts and abundance category demonstrated significantly more contacts when abundance was high ($F_{1,15} = 12.45$; $p<0.003$). However, abundance categories were omitted from subsequent analysis because the relatively small sample size meant that the degrees of freedom were reduced to the point where the confidence in model outcomes was greatly reduced.

An initial generalised linear model (GLM) was run using the following variables: SAAS (On/Off), sea state (2-6), and discharge level (nil, low, high). Sea State was included in the model because it was considered to be the environmental variable most likely to influence the number of contacts with the warp cable, but was found to be non significant ($p > 0.05$) and was removed from the subsequent model. The final model demonstrated significantly less contacts for trawls with SAAS deployed, and a significant relationship between discharge level and the number of contacts. There was no significant interaction identified between SAAS and the level of discharge (Table 1).

Table 22. Variables in final GLM of seabird contacts with warp cables.

Term	*Mean*	*SE Mean*	*F*	*P*
SAAS (Off)	25.99	4.66	14.27	0.003
SAAS (On)	1.33	4.60		
Discharge (Nil)	0.16	5.63	4.32	0.039*
Discharge (Low)	19.26	5.63		
Discharge (High)	21.50	5.63		
SAAS x discharge			3.49	NS
	$F_{1,17}$			

* A *post hoc* Tukey test highlighted a significant difference between the mean number of contacts recorded for trawls with nil discharge and those with low and high discharge levels (t = 2.680, p < 0.05). However, there was no significant difference between the number of contacts recorded for low and high discharge levels (t = 0.293, p > 0.05).

Due to the relatively small sample size, three-way interactions between variables were not investigated because of missing combinations of variables.

6.4. Discussion

The random selection of trawls for the deployment of SAAS resulted in the device being deployed in a wide range of environmental conditions, including up to sea state 6, although higher sea states were generally experienced in the latter stages of the trip. In the latter part of the trip, when sea state increased, some difficulties were experienced with the device twisting around the warp. For the last four days of trials the hydraulic hose was replaced by PVC pipe. Twisting, however, remained a problem. Although it did not greatly reduce the effectiveness of the device it did make it difficult to retrieve and could affect the adjustment of warp length during commercial trawling operations.

The results demonstrate a significant reduction in contacts with the deployment of SAAS and significantly fewer contacts for trawls with no discharge. However, the mean number of contacts recorded during trawls with low and high discharge were not statistically different. This suggests that SAAS works equally well regardless of the level or intensity of discharge.

The trials indicate that SAAS is an effective method for reducing contacts between seabirds and warp cables, which potentially lead to mortality. However, the operational difficulties experienced highlighted a number of areas that require further trials before SAAS is ready for use on commercial finfish trawlers.

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