Scientific Report

Fisheries Research Cruise ZDLH1-06-2007

Fisheries Department
Falkland Islands Government

Scientific Report

Fisheries Research Cruise

ZDLH1-06-2007

FPRV Dorada

26th May – 12th June 2007

Fisheries Department
Falkland Islands Government
Stanley
Falkland Islands

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Summary

A research cruise was undertaken in the northern parts of the Falkland Islands Shelf between the 26th May and 12th June 2007. The objectives of the cruise were to ascertain where and when *Illex argentinus* migrate off the Falkland's shelf at the start of their northerly spawning migration, and to gather oceanographic data on the shelf and shelf break in order to identify features involved in this migratory behaviour. The cruise team consisted of 7 FIFD scientists and one scientist from Falklands Conservation. The FC scientist was on board to try and improve the efficiency of trawler tori lines.

Over the period of the cruise a total of 39 semi-pelagic trawls, 2 pelagic trawls and 46 oceanographic stations were conducted. This coverage enabled us to identify an oceanographic "gateway" that enabled *I. argentinus* to migrate off the shelf into deeper water for their northerly spawning migration. Tests on the buoyancy of different maturity stages of *I. argentinus* helped to explain their depth segregation by maturity. This illustrated that *Illex* used different density waters at differing buoyancy properties (i.e. maturity stages) in order to conserve energy.

The aim of the report is to provide a synopsis of the activities conducted by cruise scientists. Much of the data collected here will be fed into FIFD's scientific programme that will contribute to the knowledge of the biology of many of the species reported here and will also contribute to their stock assessment.

Contents

1.0 Introduction

In May and June 2007, a research cruise was undertaken in the north and north-eastern parts of the Falkland Islands' shelf and shelf break using the Research and Patrol vessel *Dorada.* The primary aim of the cruise was to ascertain where and when *Illex argentinus* migrate off the Falkland Islands' shelf at the start of their northerly spawning migration.

1.1 Cruise Objectives

1. To ascertain where and when *Illex argentinus* migrate off the Falkland Islands Shelf at the start of their northerly spawning migration.
2. To gather oceanographic data on the shelf break in order to identify the features involved in this migratory behaviour.
3. To continue the FIFD skate tagging programme.
4. To conduct tori line trials in order to improve their performance.
5. To conduct an *ad hoc* plankton survey to collect material for international collaborators.

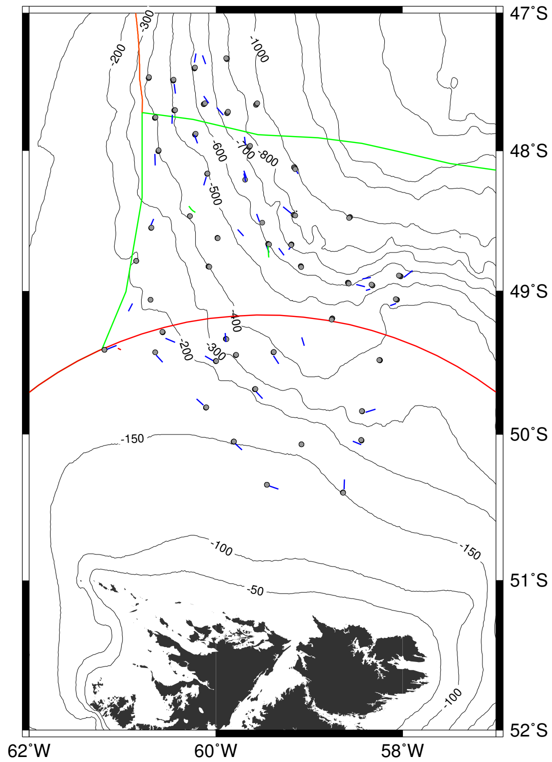


Figure 1: Location of sampling stations undertaken on ZDLH-06-2007 (lines = trawls; circles = CTDs)

1.2 Cruise Plan and Key Dates

The LAN flight had to return to Punta Arenas, with Frankie Hernandez on board, as there was snow on the runway at MPA. At a brief meeting with Len at 1500 we decided to sail without Frankie, complete R4 and return to pick him up on Monday (28^{th} May). This would minimise time loss as most of the navigation would be conducted at night.

The vessel departed Stanley at 1900 on the 26^{th} May and proceeded to the deepest station on R4 (600 m) after conducting a drill in Port William. After finishing a CTD at R4 200 m at 1330 we headed back to Stanley to pick up Frankie after which the remainder of the cruise was spent looking for *I. argentinus* from R3 to R1 and between transects in order to locate dense aggregations. The survey was designed to be flexible in order to map out oceanographic features associated with any large aggregations. We also fished shallower stations on the shelf and shelf slope during the day and at night in deeper waters (~600 – 700 m) as *I. argentinus* behaviour indicated that they were near bottom during these times. They had opposing vertical migrations in deep and in shallow waters.

No days were lost to bad weather; however, strong winds prevented a CTD and a trawl being conducted on 1st of June.

We gained an extra member for the scientific crew when we picked Sam Clarke off the *Kum Wang 102* on the 6th June.

The cruise was completed successfully and the *Dorada* returned to port and was alongside FIPASS at 0800 on the 12th June.

1.3 Vessel Characteristics

The cruise was conducted on the RV *Dorada*, which is registered in the Falkland Islands. The *Dorada's* characteristics are shown in table 1.

Table 1: Vessel characteristics

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

1.4 Personnel and responsibilities

The following staff participated in the cruise:

Dr. Paul Brickle	Chief Scientist
Dr. Vladimir Laptikhovsky	Oceanography/zooplankton/trawl survey
Wetjens Dimmlich	Oceanography/trawl survey
Joost Pompert	Trawl survey/zooplankton survey
Judith Brown	Trawl survey
Anna Schuhbauer	Trawl survey/Data entry
Ester Sancho	Trawl survey/Data entry
Sarah Crofts	Trawl survey/Bird mitigation design

We picked up Sam Clarke off the *Kum Wang 102*, as the vessel was reportedly leaving the zone, on the 6th of June and he became a member of the trawl survey team for the remainder of the cruise.

1.5 Equipment used

1.5.1 Acoustics

The acoustic equipment was similar to that used on previous research cruises and included:

1. Simrad EK500 scientific echo-sounder with hull mounted split transducers at 38 kHz and 120 kHz; and

2. SonarData Echolog_EK v1.50 (data acquisition and Echo View (post processing) software.

The EK500 had a ping interval of approximately 2 seconds. The calibration of the EK500 was not carried out during this research cruise. All data were logged with an expanded bottom echogram of approximately 15 m range, starting at 10 m above the substrate. The range of the echogram was automatically adjusted to cover the entire water column.

1.5.2 Trawling

An ENGEL semi-pelagic trawl with "Super-V" doors was used at all trawl stations. It had a 40.2 m headline and a 38.7 m footrope equipped with rockhoppers. Simrad ITI net monitor sensors had been attached to the upper panel of the trawl. The vertical opening was between 6.9 and 17 m (mean = 11.50 m) and the codend mesh size was 95 mm.

1.5.3 Oceanographu

The oceanographic equipment used on ZDLH1-06-2007 was the same as was used on previous surveys and included.

1. CTD SBE-25 with Sea Tech fluorometer and an oxygen sensor; and
2. Thermosalinometer SBE45.

1.6 Acoustic surveying

During the survey acoustic data were logged over the entire trip. The data were archived in SonarData EK5 format on a PC in the dry lab running the SonarData Echolog 500.

1.7 Trawl stations and biological sampling.

During the ZDLH1-06-2007 research cruise the station numbers ranged from 2831 to 2921 (Table 2). The catches at all stations were weighed using an electronic marine adjusted balance (POLS, min 10 g, and max 80 kg).

Finfish and rajids were measured (L_T, L_{PA} and W_D) to the nearest centimetre below and the sex and stage of maturity were recorded for all specimens sampled. Individual weights were recorded to the nearest gram using a POLS balance or, for larger specimens, to the nearest 20 grams using the Scanvaegt balances.

Cephalopods were analysed for length, sex, maturity and weight, with statoliths extracted from sub samples.

Table 2: Trawl and Oceanographic stations conducted during ZDLH1-06-2007

Station	*Activity*	*Time*	*Date*	*Start Latitude*		*Start Longitude*		*Depth (m)*	*Duration (min)*
2831	C	10.15	27/05/2007	48	53.7	58	1.7	630	24
2832	S	10.59	27/05/2007	48	54.5	58	2.8	609	136
2833	S	15.28	27/05/2007	49	0.3	58	26.3	579	108
2834	C	17.34	27/05/2007	48	57.6	58	19.4	633	25
2835	S	19.15	27/05/2007	49	6.6	58	10.1	410	107
2836	C	21.25	27/05/2007	49	3.7	58	3.5	438	19
2837	C	0.27	28/05/2007	49	29.1	58	14.5	376	16

Station	Activity	Time	Date	Start Latitude		Start Longitude		Depth (m)	Duration (min)
2838	C	7.25	28/05/2007	49	50.4	58	25.9	307	13
2839	S	8.00	28/05/2007	49	50.8	58	26	305	110
2840	S	11.32	28/05/2007	50	2.4	58	33.8	217	108
2841	C	13.44	28/05/2007	50	2.5	58	26.3	248	11
2842	C	7.35	29/05/2007	50	4.1	59	5	145	7
2843	S	9.41	29/05/2007	49	45.9	59	28.4	205	82
2844	C	11.34	29/05/2007	49	44.3	59	34.9	236	11
2845	S	13.00	29/05/2007	49	32	59	17.6	389	83
2846	C	15.01	29/05/2007	49	25.7	59	22.9	377	17
2847	C	16.43	29/05/2007	49	26.9	59	4.1	291	12
2848	S	18.26	29/05/2007	49	26.6	60	8.6	208	104
2849	C	20.24	29/05/2007	49	29.5	60	0	220	11
2850	C	7.31	30/05/2007	49	20.2	59	53.7	300	13
2851	S	7.55	30/05/2007	49	21.8	59	53.7	293	112
2852	S	14.23	30/05/2007	48	44.8	59	25.6	547	116
2853	C	16.36	30/05/2007	48	39.9	59	2.3	588	23
2854	P	18.00	30/05/2007	48	47	59	2.1	534	110
2855	C	23.21	30/05/2007	48	49.6	60	4.7	379	14
2856	C	7.28	31/05/2007	48	12.4	59	41.4	608	23
2857	S	8.01	31/05/2007	48	13.6	59	40.8	605	101
2858	S	9.44	01/06/2007	48	28	60	38.7	267	93
2859	C	11.52	01/06/2007	48	33.1	60	41.6	257	11
2860	S	16.04	01/06/2007	48	16.7	60	8.2	452	121
2861	C	18.31	01/06/2007	48	9.9	60	5.5	486	20
2862	C	8.41	02/06/2007	48	0.1	60	37.1	370	16
2863	S	17.55	02/06/2007	48	6.9	59	42.3	643	141
2864	S	7.55	03/06/2007	48	0.6	60	40.3	360	130
2865	C	13.03	03/06/2007	47	53	60	1.4	516	22
2866	S	13.42	03/06/2007	47	51.5	60	13.2	528	127
2867	S	17.56	03/06/2007	47	51.4	59	41.7	720	138
2868	C	20.37	03/06/2007	47	58.4	59	38.7	725	28
2869	C	7.35	04/06/2007	47	45.8	60	39.3	395	17
2870	S	10.18	04/06/2007	47	50	60	27.7	454	117
2871	C	12.32	04/06/2007	47	42.6	60	2.7	478	19
2872	C	14.06	04/06/2007	47	39.9	60	7.5	605	25
2873	S	18.00	04/06/2007	47	34.4	60	8.7	620	124
2874	S	20.26	04/06/2007	47	39.5	59	59.6	660	128
2875	C	23.02	04/06/2007	47	43.8	59	52.7	687	28
2876	C	0.54	05/06/2007	47	40.1	59	34.2	885	35
2877	C	7.33	05/06/2007	47	28.4	60	43.3	387	16
2878	S	10.06	05/06/2007	47	37.3	60	25.9	496	86
2879	C	12.17	05/06/2007	47	29.6	60	27.4	500	20
2880	C	13.36	05/06/2007	47	24.3	60	13.9	604	26
2881	C	15.19	05/06/2007	47	20.2	59	52.9	754	30
2882	S	17.55	05/06/2007	47	23.4	60	14.6	600	116
2883	S	20.14	05/06/2007	47	16	60	9.2	647	129
2884	C	8.02	06/06/2007	49	3.6	60	42.1	196	9
2885	S	9.45	06/06/2007	49	8.5	60	55.8	170	91
2886	C	13.13	06/06/2007	48	47.2	60	51.1	200	9
2887	S	18.04	06/06/2007	48	40	59	21.6	626	122
2888	S	20.22	06/06/2007	48	45.1	59	14	611	120

Station	Activity	Time	Date	Start Latitude		Start Longitude		Depth (m)	Duration (min)
2889	C	22.45	06/06/2007	48	40.1	59	11.5	648	26
2890	C	1.51	07/06/2007	48	28.5	58	33.8	1000	37
2891	C	7.59	07/06/2007	49	11.5	58	45.2	461	19
2892	S	10.39	07/06/2007	49	23.6	59	3.3	416	100
2893	C	15.36	07/06/2007	48	56.3	58	35.1	600	24
2894	S	17.57	07/06/2007	48	57.9	58	21.4	629	112
2895	S	20.08	07/06/2007	48	55	58	29.8	651	123
2896	C	1.14	08/06/2007	48	49.5	59	5.4	607	23
2897	C	7.51	08/06/2007	48	37.4	59	5.1	440	10
2898	S	10.35	08/06/2007	48	33	59	47.4	501	115
2899	C	13.30	08/06/2007	48	30.9	59	30.3	620	24
2900	S	17.58	08/06/2007	48	32	59	30.5	615	109
2901	S	20.33	08/06/2007	48	22.5	59	20.3	722	125
2902	C	22.54	08/06/2007	48	27.6	59	10	780	35
2903	C	10.31	09/06/2007	48	28	60	16.7	399	15
2904	P	11.34	09/06/2007	48	29.5	60	10.9	422	106
2905	S	17.57	09/06/2007	48	12.5	59	5.3	987	139
2906	C	20.43	09/06/2007	48	7.1	59	9.8	1001	39
2907	C	8.31	10/06/2007	50	23.9	58	38.4	136	6
2908	S	8.44	10/06/2007	50	23.9	58	37.8	137	93
2909	S	12.58	10/06/2007	50	23	59	17.6	142	94
2910	C	14.54	10/06/2007	50	20.1	59	27.1	146	7
2911	S	16.32	10/06/2007	50	7.4	59	41.6	153	98
2912	C	18.32	10/06/2007	50	3	59	48.6	156	8
2913	C	7.28	11/06/2007	49	48.9	60	6.5	160	8
2914	S	7.56	11/06/2007	49	48.5	60	6.5	160	100
2915	S	11.24	11/06/2007	49	30.8	60	33	168	91
2916	C	13.13	11/06/2007	49	25.8	60	39	171	8
2917	S	15.06	11/06/2007	49	22.2	61	1.6	161	98
2918	C	16.57	11/06/2007	49	24.8	61	11.5	159	8
2919	I	19.23	11/06/2007	49	24.7	61	0.8	160	40
2920	C	7.30	12/06/2007	49	17.3	60	34.3	188	9
2921	C	7.50	12/06/2007	49	17.6	60	34.3	189	119

2.0 Oceanography

2.1 Methods

A logging CTDO (SBE-25, Sea-Bird Electronics Inc., Bellevue, USA) was deployed from the surface to 1-20 m above the bottom to obtain profiles of temperature (ºC), salinity (PSU), and dissolved oxygen (ml l^{-1}). The CTD was deployed for the first minute at about 8-10 m depth to allow the polarisation of the oxygen sensor. It was then retrieved to 1 m depth and deployed again either to depth of about 640 m or to approximately 10 m from the bottom, whichever was shallower. The speed of deployment was c. 1m/s and was monitored by the use of wire counter. Temperature was measured directly whereas the other variables were calculated using Seasoft v.4.326 software (Sea-Bird Electronics Inc.) from the following measured parameters: pressure (db), conductivity (S/m), oxygen current (µA) and oxygen temperature (ºC). The CTDO sensors were calibrated annually by Sea-Bird Electronics Inc. For each station, vertical profiles of temperature, salinity and density were constructed using the Seasoft software. Profiles for each transect and iso-surfaces were constructed using the VG griding method including in the Ocean Data View package v. 3.0-2005 (Schlitzer 2005).

2.2 Results

Oceanographic data were collected at 48 oceanographic stations on 27 May – 12 June 2007. These stations were conducted either before or after each trawl. Stations were situated on the northern Falkland shelf between 136 and 1002 m (Figure 2).

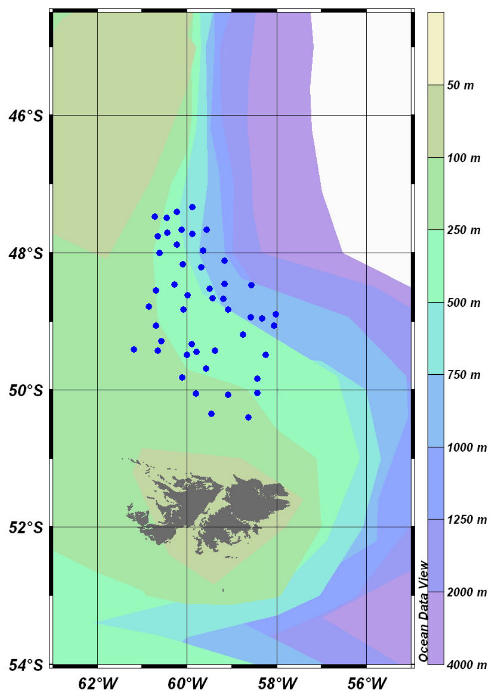


Figure 2: Oceanographic stations conducted during ZDLH1-06-2007

The survey was aimed at assessing the oceanographic situation over the southern part of the shortfin squid, *Illex argentinus* foraging grounds and to reveal environmental factors influencing patterns and timing of its emigration. Surface temperatures ranged from 5.56º to 7.81ºC, surface salinities from 33.69 to 34.08 psu, and surface densities from 26.36 to 26.86 kg/m^3. T-S curves are shown in Figure 3.

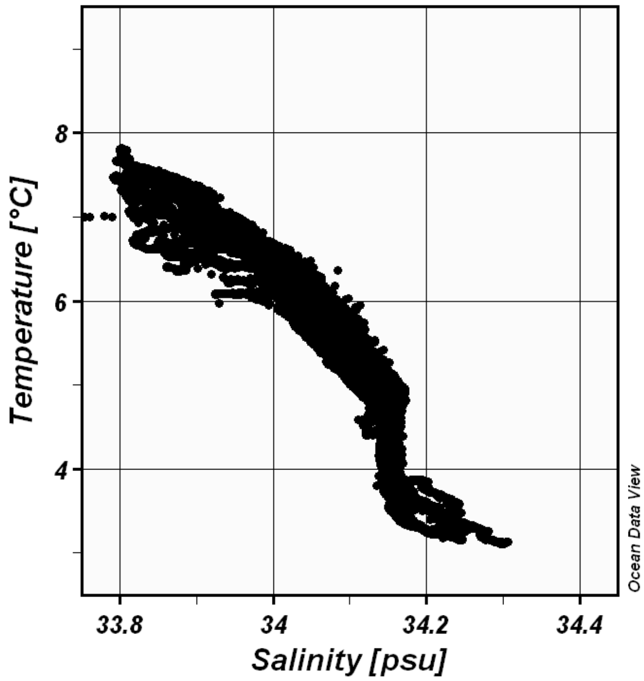


Figure 3: T – S curves of water masses encountered during ZDLH1-06-2007

The study period was characterised by a normal temperature background with neither positive nor negative SST anomalies north of the Falkland Islands (Figure 4).

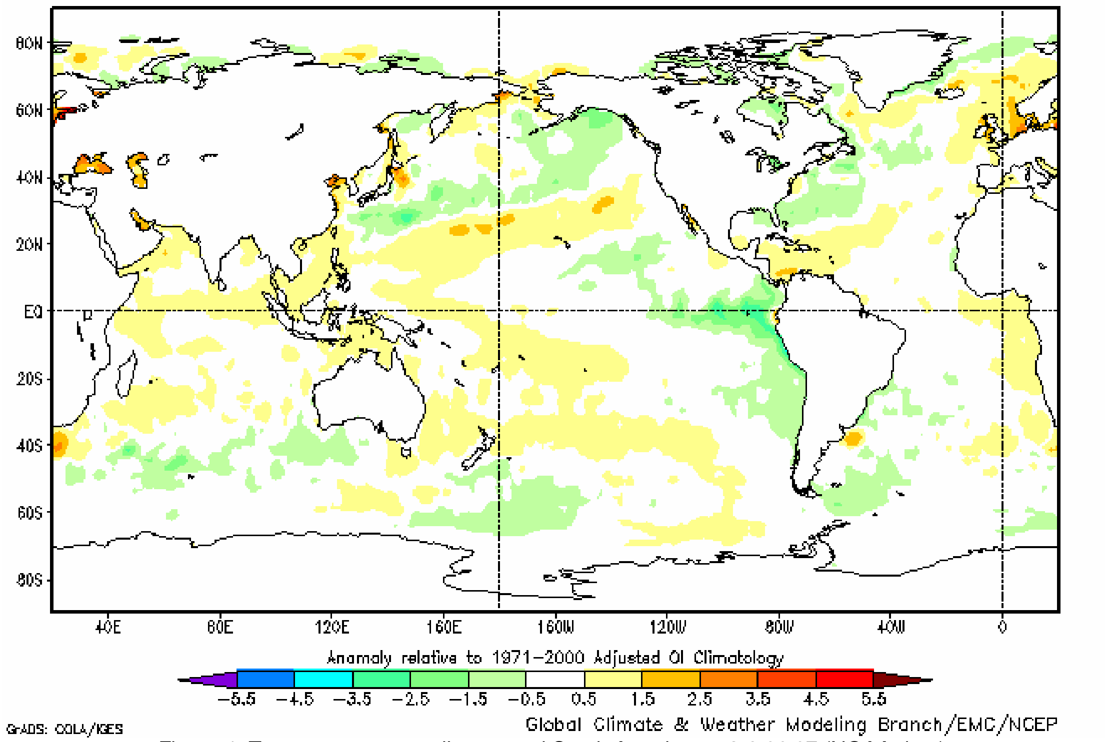


Figure 4: Temperature anomalies around South America on 3-9.06.07 (NOAA data).

Distribution of the surface and bottom temperatures and salinities are shown in Figure 5.

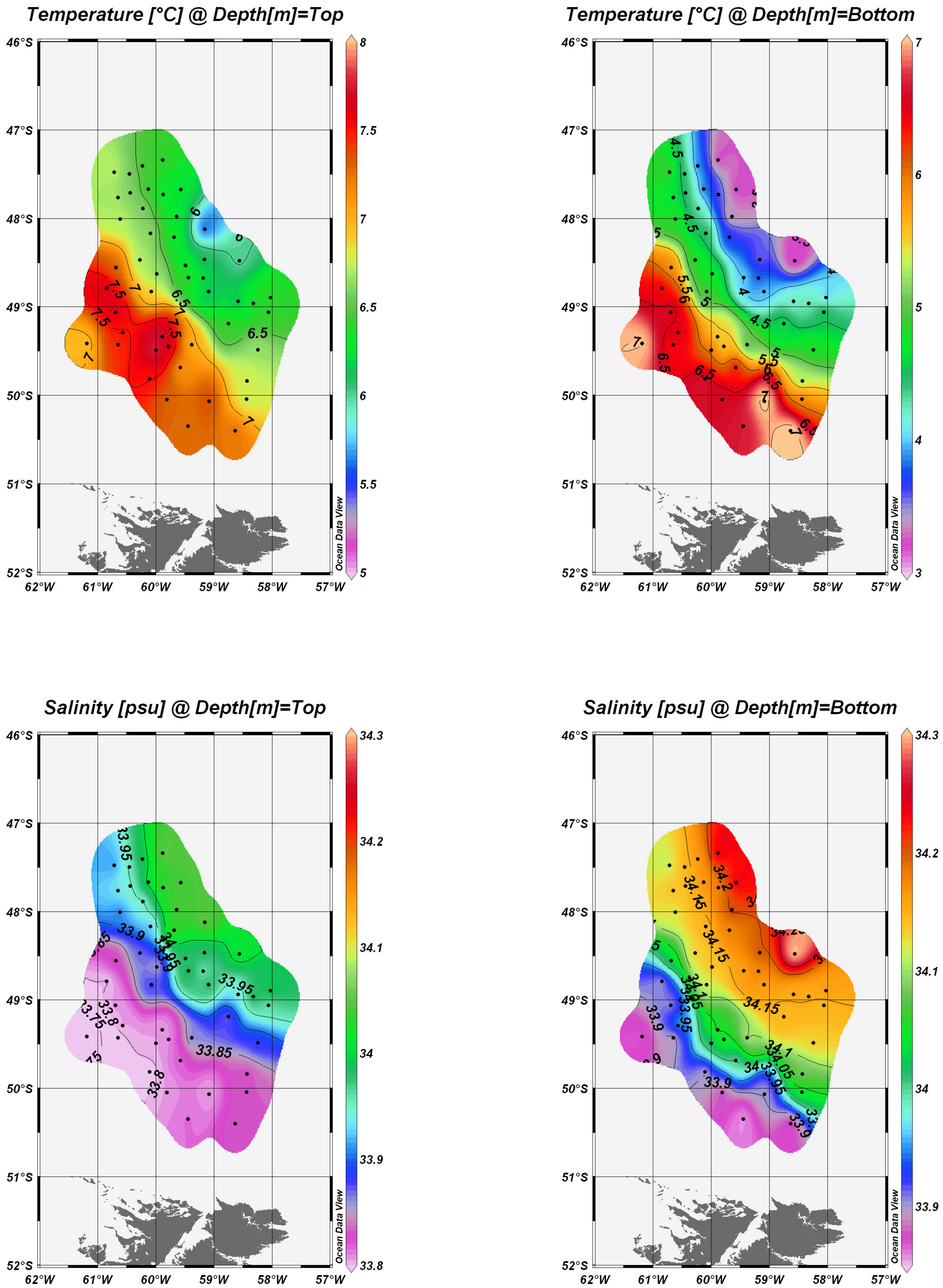


Figure 5: Distribution of temperature and salinity on the northern Falkland shelf in May-June 2007

The analysis of oceanographic features revealed the existence of a strong upwelling above the northern part of the continental slope, where downward migrations of adult squids occured (Figures 6 and 7).

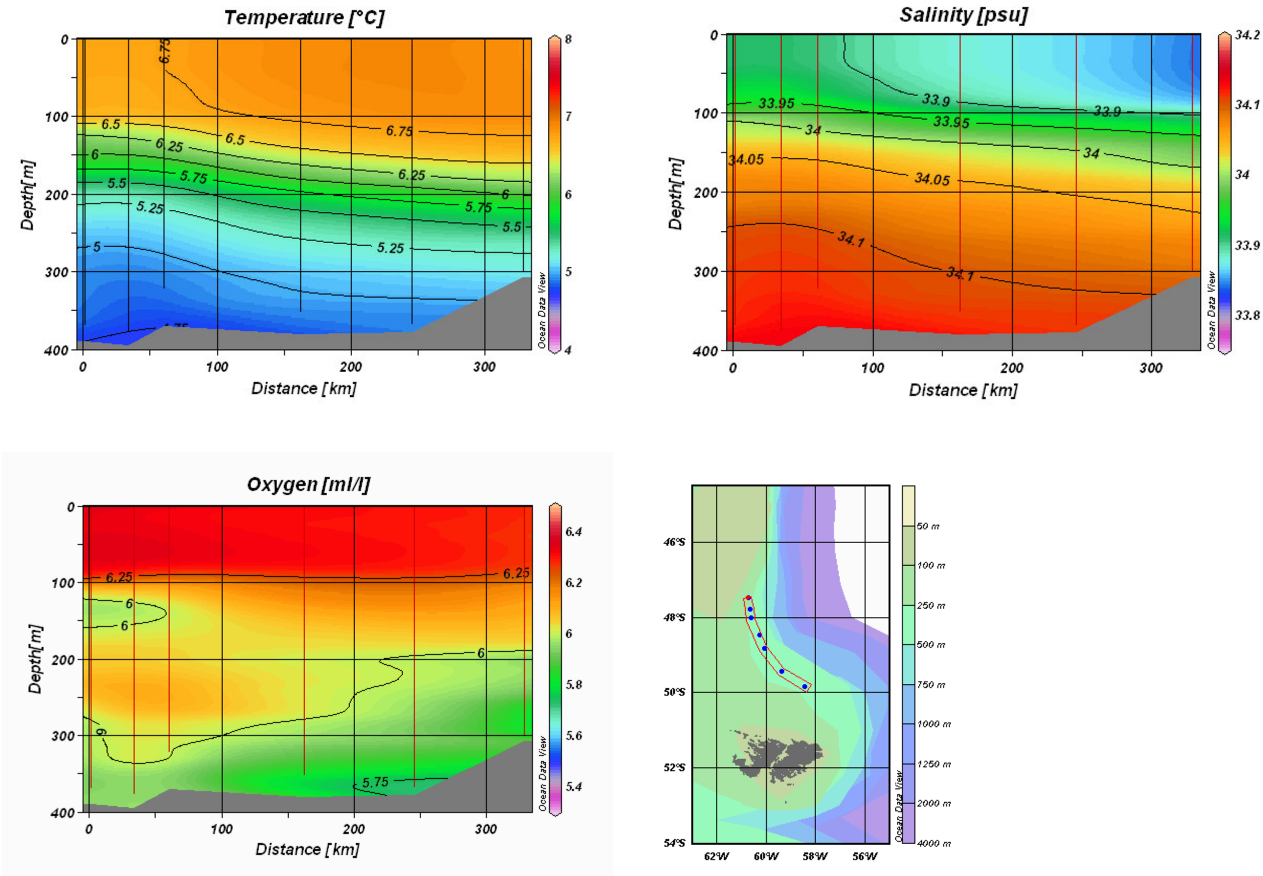


Figure 6: Distribution of temperature, salinity and oxygen along the 400 m isobath

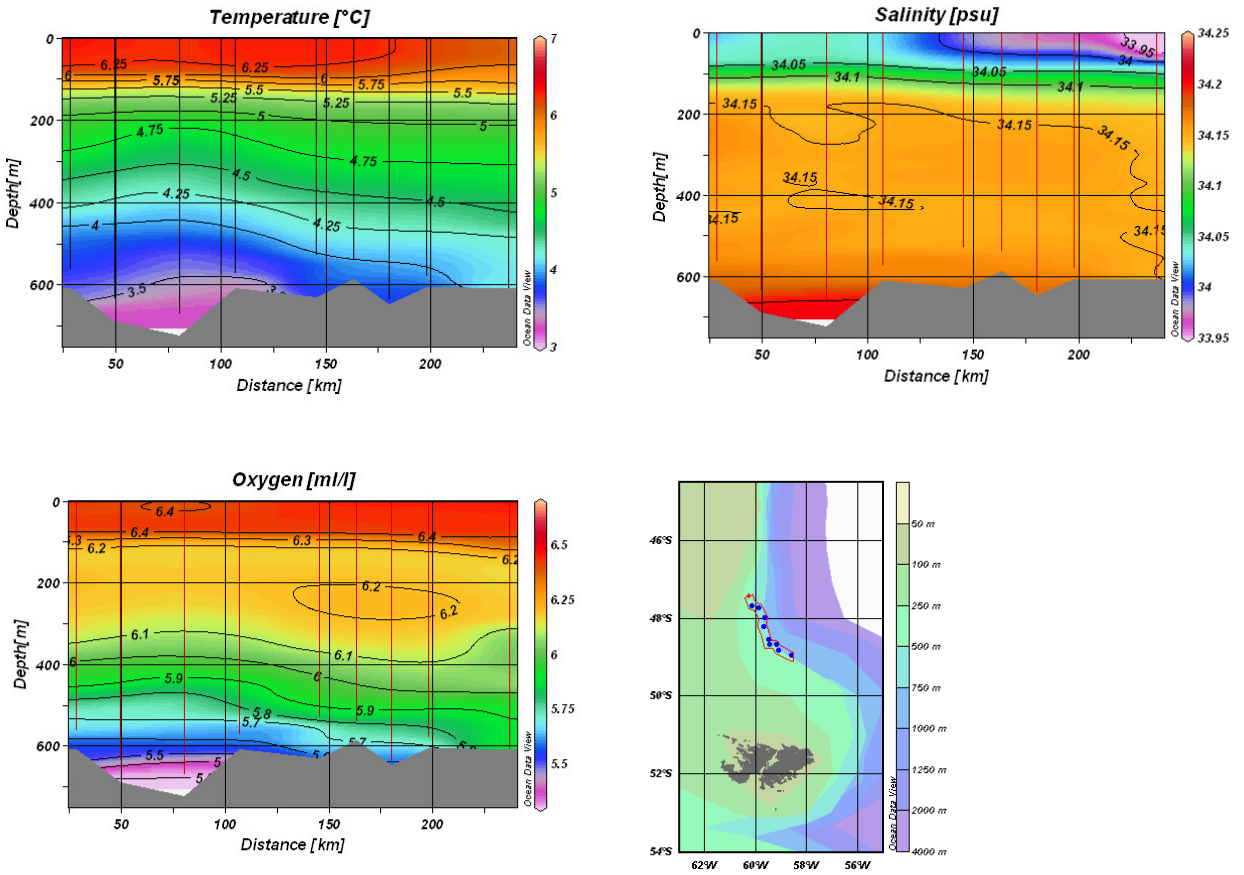


Figure 7: Distribution of temperature, salinity and oxygen along the 600-m isobath

3.0 Biological Sampling

3.1 Catch and by-catch

Trawling was conducted at 41 stations and comprised 2 pelagic stations and 39 semi-pelagic stations. Trawling time on horizon varied between 30 and 79 minutes, with an average time on horizon of 58.56 minutes.

During the cruise a total of 10,732 kg was caught comprising over 110 species (Table 3). In terms of weight, the greatest catches were the Argentine short finned squid (*Illex argentinus*), hoki (*Macruronus magellanicus*), grenadier (*Macrourus carinatus*), jelly fish (Medusae) and the Patagonian long finned squid (*Loligo gahi*).

Table 3: Total catch of all trawl stations during research cruise ZDLH1-06-2007

Species Code	*Species name*	*Total Catch (kg)*	*Total Sampled (kg)*	*Total Discarded (kg)*	*Proportion (%)*
ILL	*Illex argentinus*	3,134.029	985.382	3,114.029	29.20%
WHI	*Macruronus magellanicus*	1,966.270	140.465	81.670	18.32%
GRC	*Macrourus carinatus*	1,147.911	846.336	1,105.831	10.70%
MED	Medusae	1,013.476	0.000	1,013.476	9.44%
LOL	*Loligo gahi*	886.573	113.304	559.903	8.26%
ANT	Anthozoa	611.036	0.000	611.036	5.69%
HAK	*Merluccius hubbsi*	521.115	521.115	149.170	4.86%
SPN	Porifera	408.674	0.000	408.674	3.81%
PAR	*Patagonotothen ramsayi*	287.553	47.013	287.011	2.68%
GYN	*Gymnoscopelus nicholsi*	158.750	3.883	158.749	1.48%
RGR	*Bathyraja griseocauda*	79.884	79.884	79.884	0.74%
ING	*Moroteuthis ingens*	44.033	44.033	44.033	0.41%
KIN	*Genypterus blacodes*	41.385	41.385	0.000	0.39%
RAL	*Bathyraja albomaculata*	34.888	34.888	34.888	0.33%
GYB	*Gymnoscopelus bolini*	33.492	22.968	32.985	0.31%
EGG	Eggmass	27.073	3.206	27.073	0.25%
TOO	*Dissostichus eleginoides*	21.570	17.014	8.006	0.20%
PMC	*Protomictophum choriodon*	20.894	2.107	20.894	0.19%
RBR	*Bathyraja brachyurops*	19.259	19.259	19.259	0.18%
GOC	*Gorgonocephalas chilensis*	18.430	0.000	18.430	0.17%
SAT	*Salpa thomsoni*	17.243	0.000	17.243	0.16%
DGS	*Squalus acanthias*	16.071	1.961	16.071	0.15%
BLU	*Micromesistius australis*	15.760	15.760	15.760	0.15%
UCH	Sea urchin	15.382	0.000	15.382	0.14%
HYD	Hydrozoa	13.727	0.000	13.727	0.13%
RMU	*Bathyraja multispinis*	12.940	12.940	12.940	0.12%
COT	*Cottunculus granulosus*	11.783	9.330	11.783	0.11%
RBZ	*Bathyraja cousseauae*	11.656	11.656	11.656	0.11%
GYM	*Gymnoscopelus spp.*	11.366	0.000	11.366	0.11%
ANM	Anemone	10.574	0.000	10.574	0.10%
BUT	*Stromateus brasiliensis*	9.823	9.823	9.823	0.09%
BAC	*Salilota australis*	9.527	9.527	1.535	0.09%
AST	Asteroidea	8.878	0.000	8.878	0.08%
RED	*Sebastes oculatus*	8.642	8.642	8.642	0.08%
RDO	*Raja doellojuradoi*	8.480	8.480	8.480	0.08%
RSC	*Bathyraja scaphiops*	7.466	7.466	7.466	0.07%

Species Code	*Species name*	*Total Catch (kg)*	*Total Sampled (kg)*	*Total Discarded (kg)*	*Proportion (%)*
BEE	*Benthoctopus eureka*	6.703	3.563	0.240	0.06%
LAA	*Lampinictus achurus*	5.272	1.272	5.272	0.05%
RMC	*Bathyraja macloviana*	5.259	5.259	5.259	0.05%
ANR	*Antimora rostrata*	4.121	4.121	3.720	0.04%
SYB	*Symbolophorus boops*	2.813	2.795	2.095	0.03%
GRN	*Graneledone yamana*	2.771	2.771	1.225	0.03%
PYM	*Physiculus marginatus*	2.433	2.087	2.433	0.02%
EEL	*Iluocoetes fimbriatus*	2.343	2.228	2.343	0.02%
WLK	Whelks	2.312	0.016	2.296	0.02%
GRH	*Macrourus holotrachys*	2.140	2.140	2.140	0.02%
MAR	*Martialia hyadesi*	2.098	1.865	2.073	0.02%
CAS	*Campylonotus semistriatus*	1.957	0.000	0.050	0.02%
CGO	*Cottoperca gobio*	1.690	0.000	1.690	0.02%
MAM	*Mancopsetta milfordi*	1.534	1.534	0.331	0.01%
SQT	Ascidiacea	1.506	0.000	1.506	0.01%
ICA	*Icichthys australis*	1.368	1.143	1.368	0.01%
GYR	*Gymnoscopelus braueri*	1.333	0.848	1.333	0.01%
RPN	*Psammobatis normani*	1.309	1.309	1.309	0.01%
DGH	*Schroederichthys bivius*	1.279	0.595	1.279	0.01%
BAE	*Bathylagus tenuis*	1.268	0.000	1.268	0.01%
MMA	*Mancopsetta maculata*	1.217	1.217	1.063	0.01%
LIA	*Lithodes antarcticus*	1.152	0.000	0.152	0.01%
HIE	*Histioteuthis eltarinae*	1.050	0.974	0.903	0.01%
XXX	Unidentified animal	0.966	0.966	0.000	0.01%
BRY	Bryozoa	0.964	0.000	0.964	0.01%
MUO	*Muraenolepis orangiensis*	0.961	0.961	0.961	0.01%
GYH	*Gymnoscopelus hintonoides*	0.878	0.878	0.878	0.01%
ACP	*Acanthephyra pelagica*	0.809	0.228	0.000	0.01%
SEP	*Seriolella porosa*	0.766	0.000	0.011	0.01%
ELS	*Electrona subaspera*	0.627	0.292	0.627	0.01%
THB	*Thymops birsteini*	0.623	0.238	0.073	0.01%
MKN	*Moroteuthis knipovichi*	0.485	0.485	0.485	<0.01%
GRF	*Coelorhynchus fasciatus*	0.471	0.000	0.471	<0.01%
HAJ	*Halargyreus johnsonii*	0.346	0.346	0.246	<0.01%
AUX	*Austrocidaris sp.*	0.316	0.000	0.000	<0.01%
PGR	*Paradiplospinus gracilis*	0.298	0.000	0.000	<0.01%
BAY	*Bathylagus spp.*	0.253	0.253	0.000	<0.01%
ARR	*Arctozenus risso*	0.253	0.094	0.253	<0.01%
PAC	*Pasiphaea acutifrons*	0.251	0.000	0.006	<0.01%
STE	*Sterechinus sp.*	0.246	0.000	0.000	<0.01%
HOL	Holothuroidea	0.230	0.202	0.028	<0.01%
CET	*Ceratias tentaculatus*	0.210	0.210	0.210	<0.01%
TRM	*Trigonolampa miriceps*	0.203	0.203	0.203	<0.01%
SAP	*Sagitta planctonis*	0.196	0.000	0.196	<0.01%
NUD	Nudibranchia	0.191	0.171	0.020	<0.01%
CAM	*Cataetyx messieri*	0.182	0.182	0.182	<0.01%
BOA	*Borostomias antarcticus*	0.167	0.167	0.167	<0.01%
NOC	*Notacanthus chemnitzi*	0.156	0.156	0.156	<0.01%
ELC	*Electrona carlsbergi*	0.140	0.032	0.140	<0.01%
BEY	*Beroe spp.*	0.136	0.000	0.136	<0.01%
NEM	*Neophyrnichthys marmoratus*	0.076	0.076	0.076	<0.01%

Species Code	***Species name***	***Total Catch (kg)***	***Total Sampled (kg)***	***Total Discarded (kg)***	***Proportion (%)***
LAN	*Lampadena notialis*	0.069	0.069	0.069	<0.01%
CHV	*Chiroteuthis veranyi*	0.060	0.060	0.000	<0.01%
OPH	Ophiuroidea	0.056	0.000	0.056	<0.01%
EUP	Euphausids	0.047	0.001	0.046	<0.01%
SLC	*Slosarczykovia circumantarctic*	0.045	0.045	0.009	<0.01%
MEG	*Melanomus gracilis*	0.034	0.034	0.000	<0.01%
SER	*Serolis spp.*	0.033	0.017	0.016	<0.01%
CHN	*Chiasmodon niger*	0.031	0.031	0.031	<0.01%
PES	*Peltarion spinosulum*	0.031	0.000	0.031	<0.01%
CHS	*Chauliodus sloani*	0.028	0.000	0.028	<0.01%
LYB	*Lycenchelys bachmanni*	0.027	0.027	0.027	<0.01%
POC	*Poromitra crassiceps*	0.023	0.023	0.023	<0.01%
GON	*Gonatus antarcticus*	0.022	0.022	0.000	<0.01%
PAA	*Pandalopsis ampla*	0.015	0.000	0.000	<0.01%
ECC	*Echiodon cryomargarites*	0.014	0.000	0.014	<0.01%
MUN	*Munida spp.*	0.014	0.000	0.014	<0.01%
NEY	*Neoscopelidae*	0.013	0.013	0.000	<0.01%
GYF	*Gymnoscopelus fraseri*	0.009	0.009	0.009	<0.01%
MEV	*Metelectrona ventralis*	0.009	0.009	0.009	<0.01%
MEY	*Melanomidae*	0.007	0.000	0.007	<0.01%
STS	*Stereomastis suhmi*	0.007	0.000	0.007	<0.01%
MUG	*Munida gregaria*	0.006	0.006	0.006	<0.01%
POL	Polychaeta	0.006	0.000	0.006	<0.01%
BRX	*Brachioteuthis sp.*	0.003	0.000	0.003	<0.01%
MAU	*Maurolicus muelleri*	0.001	0.000	0.001	<0.01%
PHS	*Phronima sedentaria*	0.001	0.000	0.001	<0.01%
		10,732.552	**3,060.070**	**8,004.577**	

3.2 Argentine short finned squid – *Illex argentinus*

3.2.1 General patterns

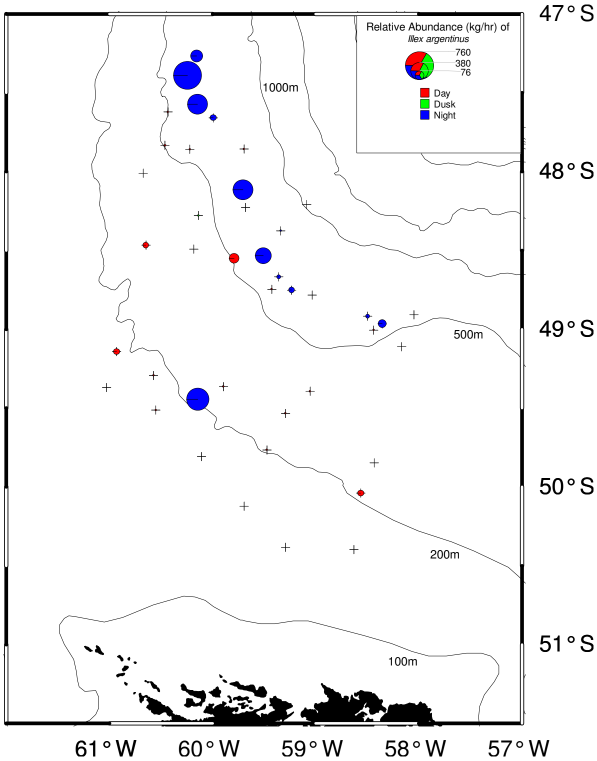


Figure 8: Relative abundance of *Illex argentinus* at each trawl station on ZDLH1-06-2007

Illex argentinus were caught on 34 of the 41 trawl stations and were most abundant in the north of the FICZ/FOCZ between 600 – 650 m at night (Figure 8) and were also the most abundant species caught over the entire cruise. CPUEs ranged from 0.60 to 750.28 kg/hr (mean = 94.47 ± 176.55).

The shallow stations on the shelf and shelf slope during the day and the deeper ones (~600 – 700 m) at night as *I. argentinus* behaviour dictated that they were near the bottom at these times. They have opposing behaviours in both shallow and deep waters. One of the reasons for this is that *I. argentinus* follows the planktonic diurnal vertical migration which rises up to the shallows at night, on the shelf, and returns to near bottom waters during the day. The same behaviour can be seen in deeper water, in the plankton, but the distances are much greater because of the depth. So, in deeper waters *I. argentinus* near the bottom at night and rise off the bottom during the day to meet the plankton as they make their downward migration.

During the cruise a total of 1,313 *I. argentinus* were sampled for length frequency analysis and statoliths and they ranged in length from 10.5 to 36.5 cm L_M (mean = 31.25 ± 2.53). Figure 9 illustrates their length frequency by depth range. The length frequencies are similar with the exception of a greater proportion of males at the 200 – 500 m depth range.

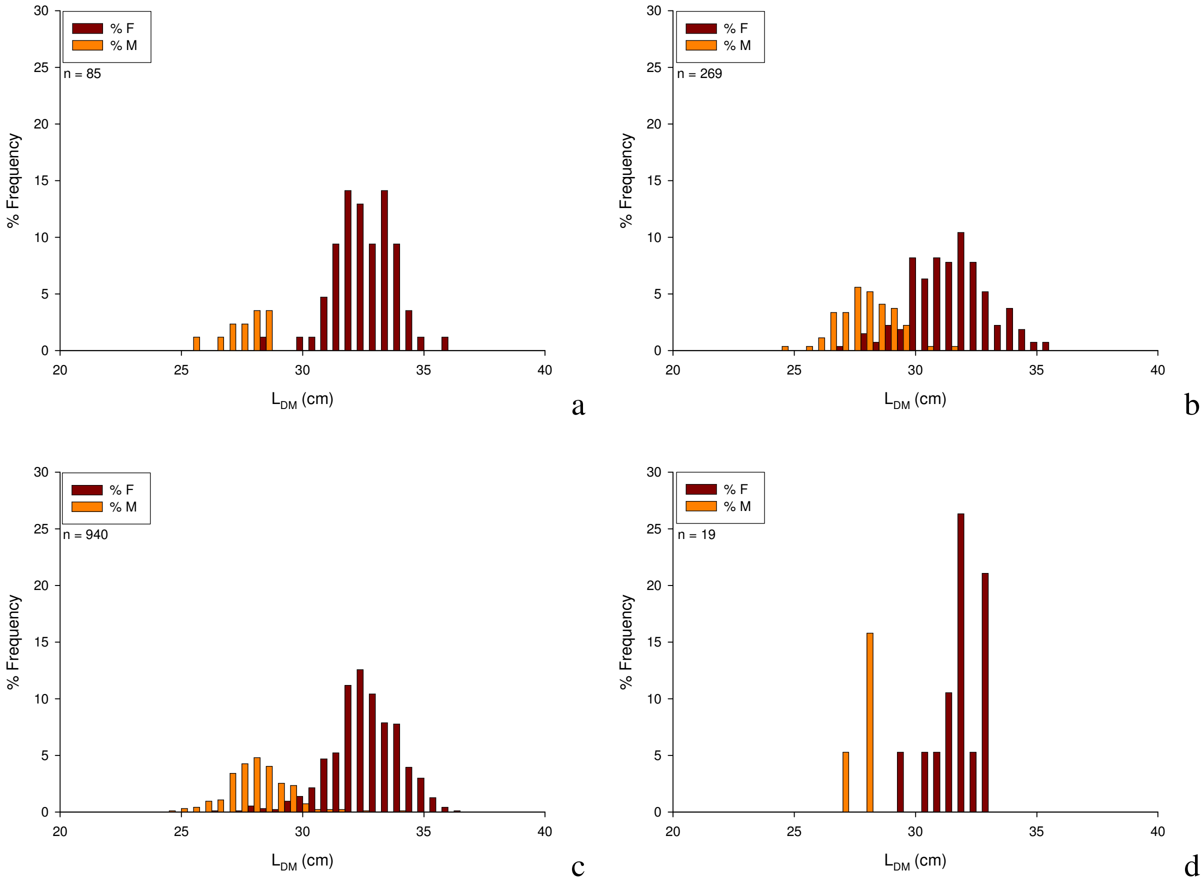


Figure 9: Length frequency distribution of *Illex argentinus* at (a) <200 m, (b) 200 – 500 m, (c) 500 – 700 m, and (d) >700 m

Interestingly the proportions of female at stage V increased with increasing depth with females at stage IV being most common between 200 – 500 m. The sex ratio also had a male bias at the latter depth range and the proportion of males also decreased with increasing depth (Figure 10).

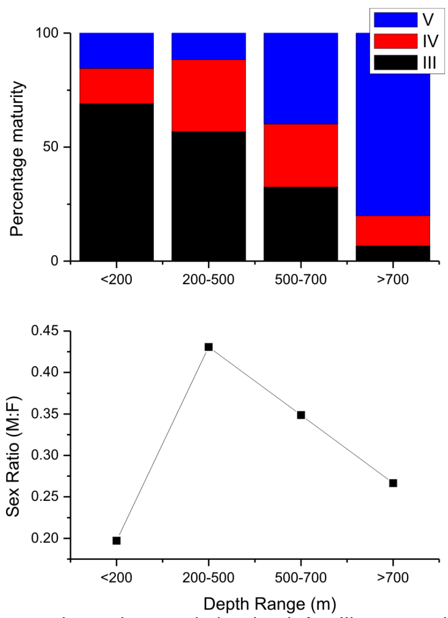


Figure 10: Distribution of female maturity and sex ratio by depth for *Illex argentinus* samples on ZDLH1-06-2007

3.2.2 Buoyancy

One of the questions that struck us while on the cruise was why were female maturities segregated by depth? After some discussion we decided to test the hypothesis that females at stage V were less buoyant as they inhabited deeper and therefore denser waters while female IIIs were more buoyant as they inhabited shallow and therefore less dense waters. Therefore, if the animals were closer to neutral buoyancy in the waters that they inhabited, this would lead to a reduction in energetic costs during their migrations. The next question was how to measure buoyancy on the *Dorada*. We designed a piece of apparatus that allowed us to measure the weight of squid in air and in a large bucket filled with sea water. We assumed that the surface water that went into the bucket was of equal density throughout the experiment. Therefore an index of buoyancy could be calculated by (B) = Wt in air/Wt in water x 100. Neutral buoyancy was considered to be when B < 0.06%. The higher the value the more negatively buoyant the individual.

Figure 11 illustrates the mean buoyancy of *I. argentinus* showing decreasing buoyancy with increasing depth for females and an intermediate buoyancy for male Vs, confirming our hypothesis. Interestingly males were found in intermediate depths (200 – 500 m) and had intermediate buoyancy, as expected.

This feature of *I. argentinus* biology needs to be investigated further.

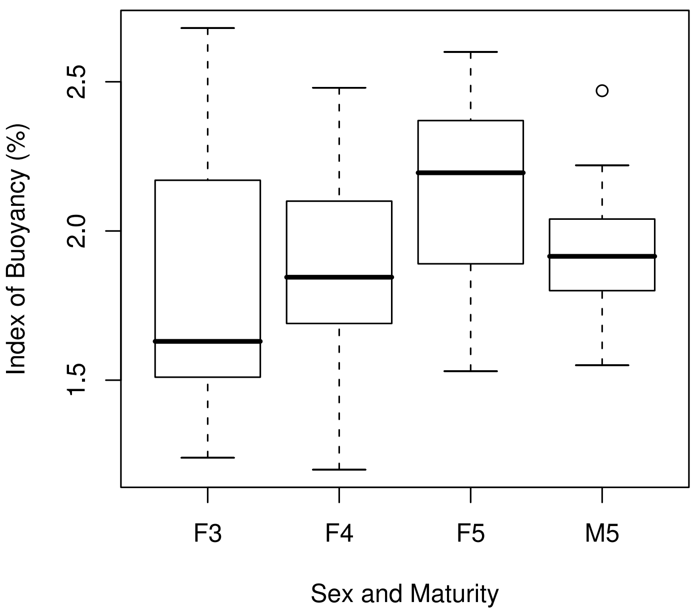


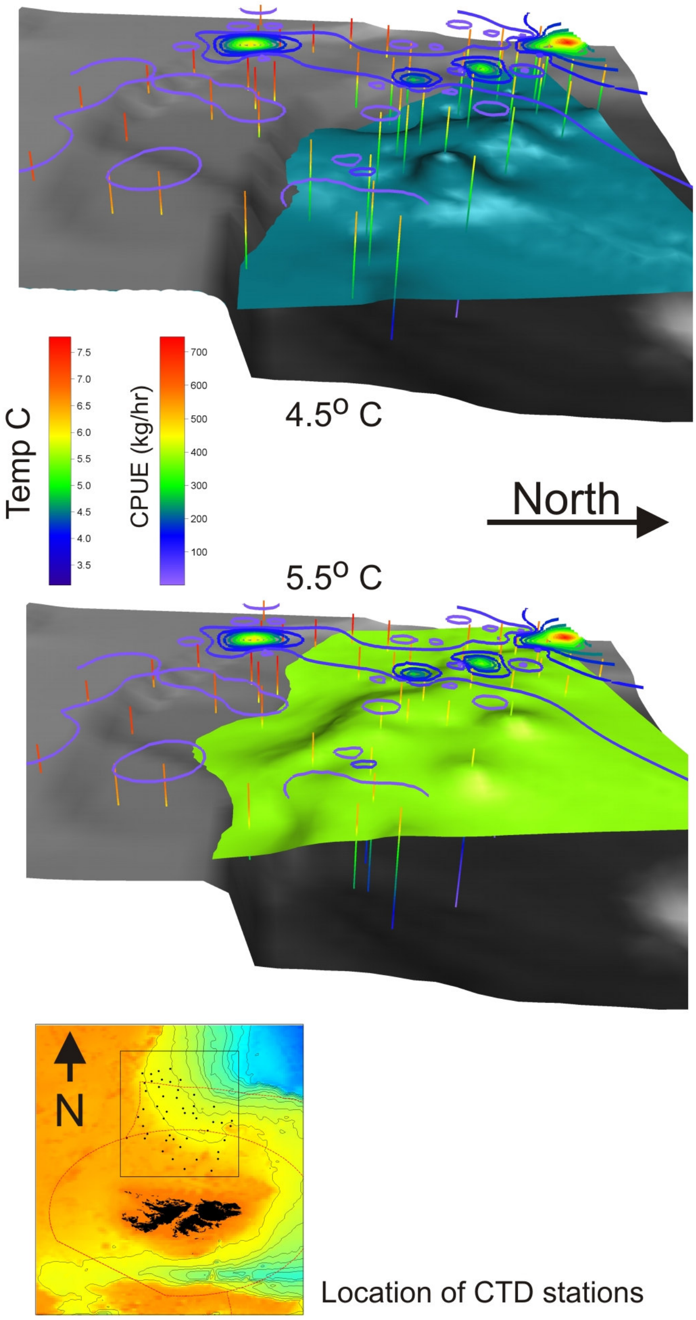
Figure 11: Buoyancy values for *Illex argentinus* of different maturities samples on ZDLH1-06-2007

3.2.3 Oceanographic features enabling migration

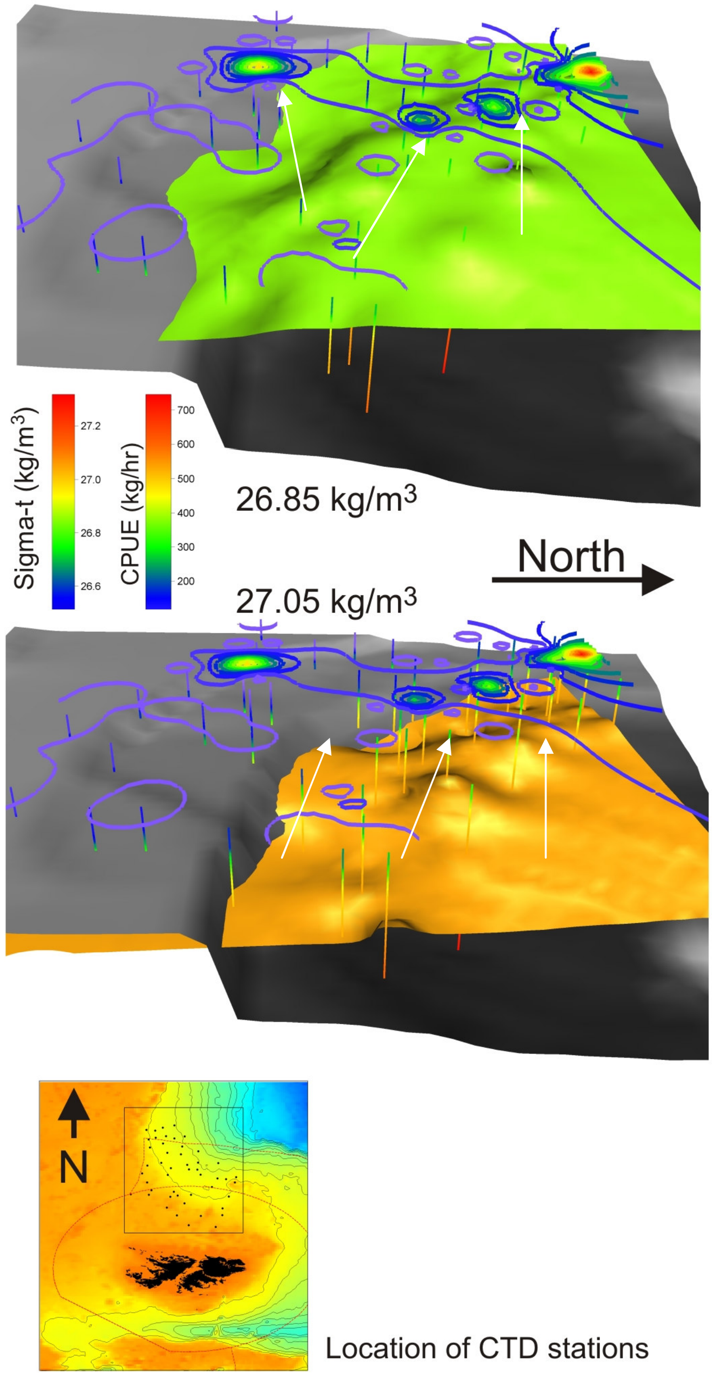
One of the main objectives of the cruise was to try and identify any oceanographic features that could be associated with the migration of *I. argentinus* off the shelf at the beginning of their northerly spawning migration. In order to do this we designed an oceanographic survey that was essentially adaptive and was flexible enough to allow us to “fill in gaps” with stations to highlight particular features. A total of 48 oceanographic stations were conducted during the cruise and the positions of these can be seen in Figure 2.

Higher abundances of *I. argentinus* were associated with a strong upwelling area on the northern part of the continental slope and shelf. This feature was caused by a “meander” of the Falkland’s Current which brought cool nutrient rich waters onto the shelf in this area. It was this feature that *I. argentinus* used as a cue for migrating to deeper water at the beginning of their northerly spawning migration. Figure12 a and b illustrate this feature in terms of iso - temperature and density respectively. The upwelling feature is best illustrated in Figure 12 b and is indicated by the arrows on the figure. Off the shelf *I. argentinus* used this upwelling feature to move north in the Falkland Current and were only found between 600 – 650 m. The density at this depth probably allowed mature squid to optimise their buoyancy in order minimise their energetic expenditure during their northerly migration.

Further investigations should ideally map the northerly and southerly extent of this feature and could be the subject of another research cruise as this is an important part of the life history of *I. argentinus.*



a



b

Figure 12: 3-d representations of depth and CTD positions showing iso-therms (a) and iso-densities (b) with *Illex argentines* CPUEs as contour maps at the surface (arrows depict the upwelling areas

3.3 Patagonian short finned squid – Loligo gahi

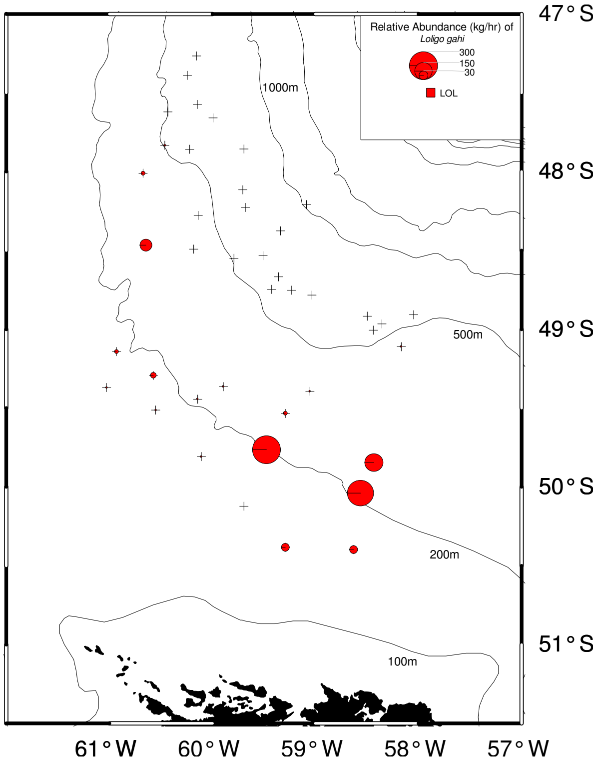


Figure 13: Relative abundance of *Loligo gahi* at each station on ZDLH1-06-2007

Loligo gahi was the 5th most abundant species during the cruise in terms of total weight (886.57 kg – see Table 3). They were most abundany on the shelf and shelf break at about 50°S (Figure 13) and were caught between 137 and 609 m. CPUEs ranged between 0.26 to 286.56 kg/hr (mean = 38.01 ± 79.08).

Loligo gahi comprised late autumn spawning animals with early spring spawning animals. Early spring spawners were characterised by small immature individuals found inshore conversely the late autumn spawners were more mature and found in deeper waters. Figure 14 illustrates the length frequency distributions of the *L. gahi* sampled by depth and sex.

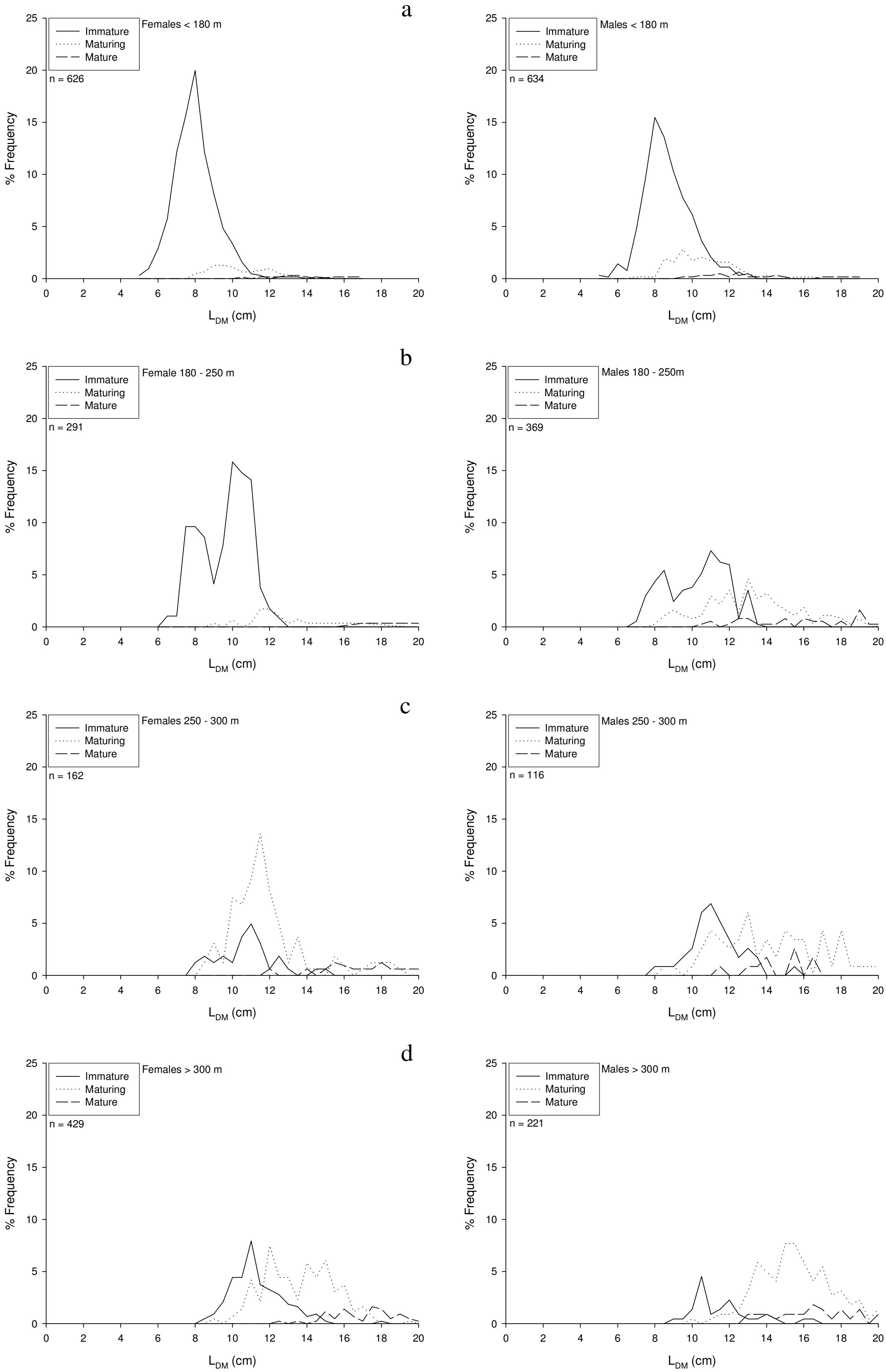


Figure 14: Length frequency distributions of *Loligo gahi* at (a) < 180m, (b) 180 – 250 m, (c) 350 – 300 m and (d) > 300 m

3.4 Hoki – *Macruronus magellanicus*

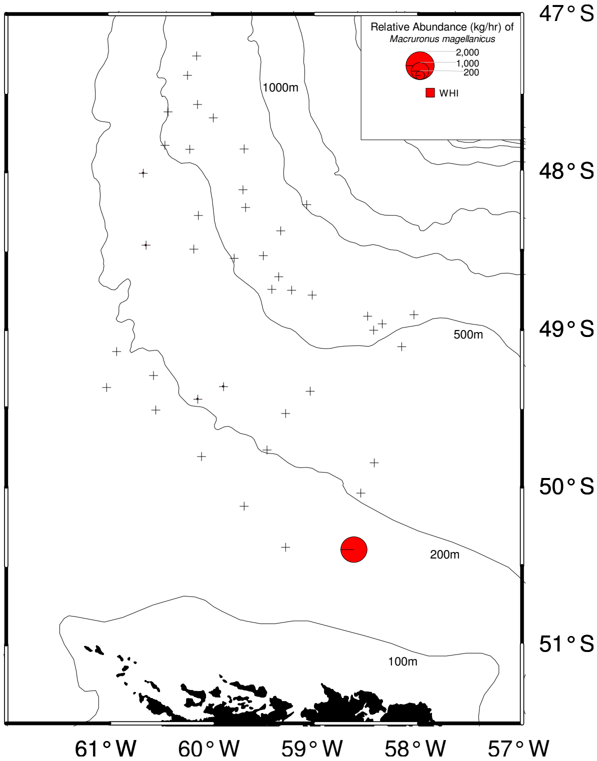


Figure 15: Relative abundance of *Macruronus magellanicus* at each station on ZDLH1-06-2007

Hoki were caught at 10 of the 41 trawl stations conducted on the cruise and were the second most abundant species in terms of total weight (1,966 kg). Catches were low except for a large catch of 1,823 kg caught on the 10th June. CPUEs ranged from 0.44 to 1823.8 kg/hr (mean = 190.51 ± 573.97). Figure 13 illustrates the distribution and relative abundance of hoki caught on the cruise.

A total of 227 individual hoki were sampled for length frequency analysis and for an otolith trace elemental study. oki ranged in length from 14 to 38 cm L_{PA} (mean = 23.40 ± 3.57) and showed two distinct modes at 15 cm and 22 cm L_{PA} (Figure 16).

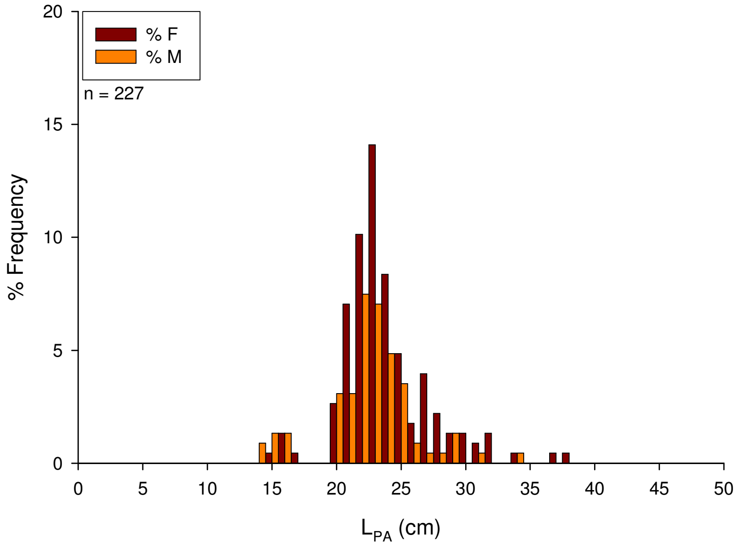


Figure 16: Length frequency distribution for *Macruronus magellanicus* sampled on ZDLH1-06-2007

Maturity stages ranged from I to IV over the cruise with the majority of males and females at stage II, as expected (Figure 17).

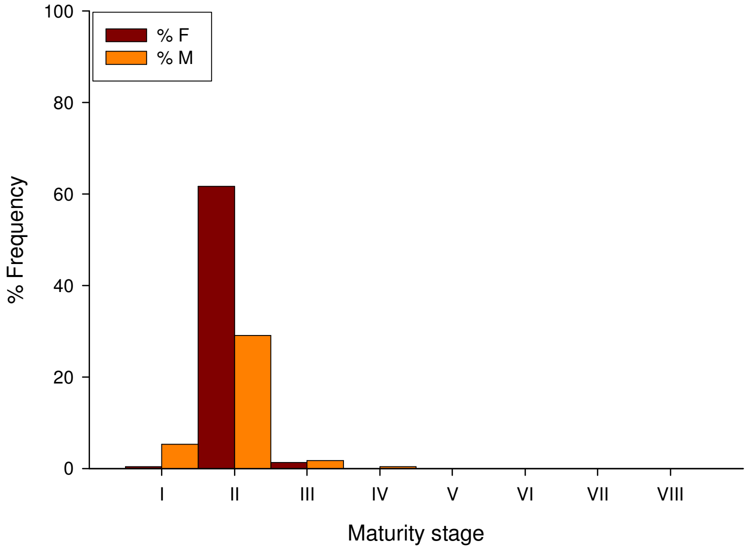


Figure 17: Distribution of maturity stages of *Macruronus magellanicus* encountered on ZDLH1-06-2007

3.5 The grenadiers – Macrourus spp.

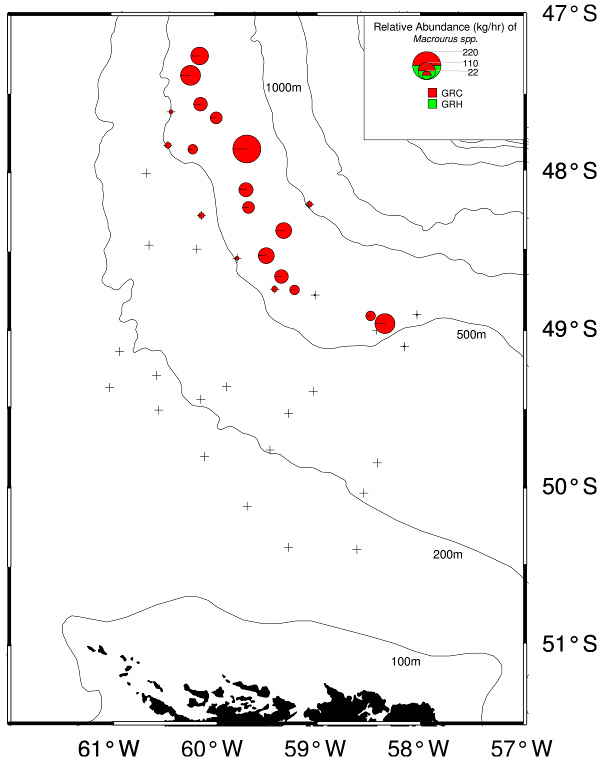


Figure 18: Relative abundance of *Macrourus* spp. at each station on ZDLH1-06-2007

Macrourus carinatus was the third most abundant species in terms of total weight (1,147.9 kg) caught on the cruise. *Macrourus holotrachys*, however, were only caught in small quantities (~2 kg). Figure 18 illustrates the distribution and relative abundance of both. *Macrourus carinatus* was most abundant between 500 and 1,000 m on the northern part of the slope. CPUEs ranged between 1.04 and 210.06 (mean = 50.99 ± 50.19).

A total of 1,300 *M. carinatus* were sampled during the cruise for length frequency analysis and otoliths. *Macrourus carinatus* ranged in size from 4 to 27 cm L_{PA} (mean = 17.14 ± 3.74) (Figure 19).

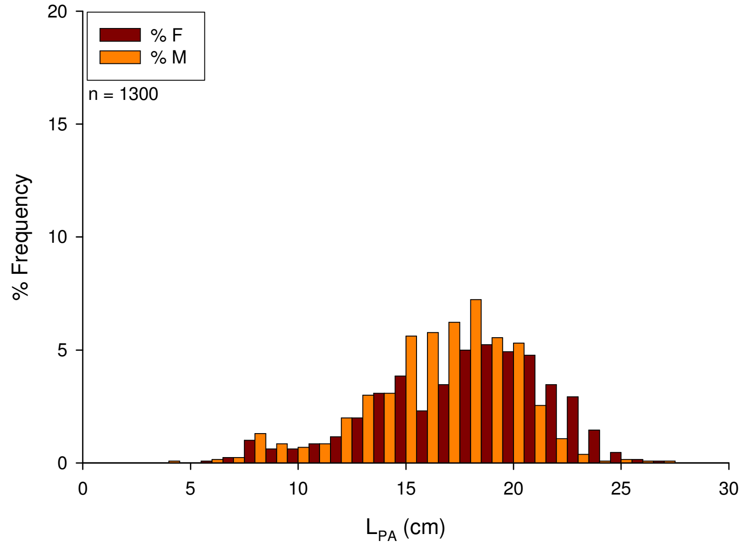


Figure 19: Length frequency distribution for *Macrourus carinatus* sampled on ZDLH1-06-2007

Maturity stages ranged from I through to VIII with the complete absence of VI. However, most of the individuals sampled were in stages I, II and III (Figure 20).

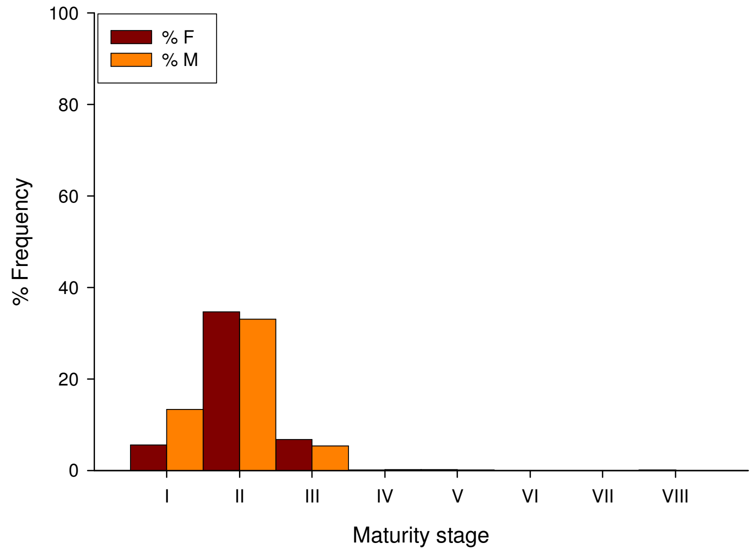


Figure 20: Distribution of maturity stages of *Macrourus carinatus* encountered on ZDLH1-06-2007

3.6 Common hake – *Merluccius hubbsi*

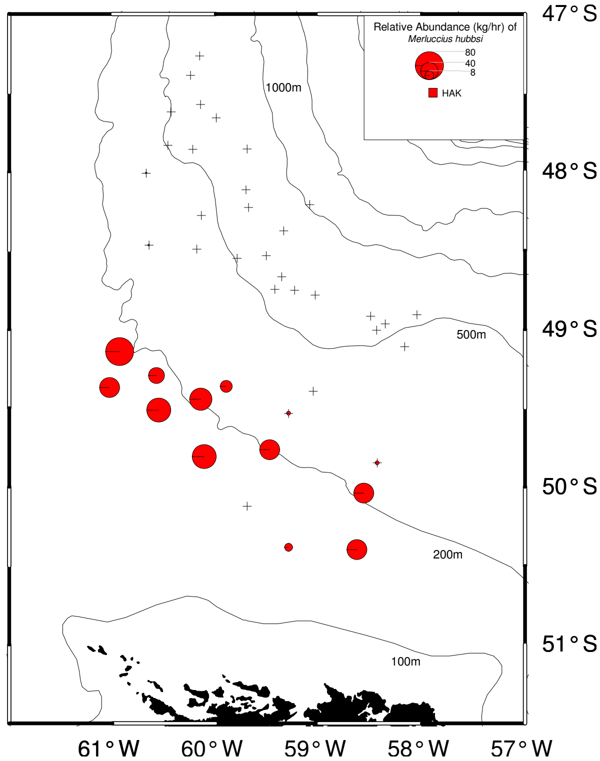


Figure 21: Relative abundance of *Merluccius hubbsi* at each station on ZDLH1-06-2007

Merluccius hubbsi were found to be most abundant on the shelf and shelf break (Figure 21). They were the seventh most abundant species on the cruise in terms of total weight (521.11 kg). CPUEs ranged from 0.70 to 78.43 kg/hr (mean = 33.02 ± 24.97).

Figure 22 illustrates the length frequency distribution of *M. hubbsi* sampled on the cruise showing females to be larger than males. A total of 419 individuals were sampled and they ranged in size from 35 to 87 cm L_T (mean = 54.07 ± 9.36).

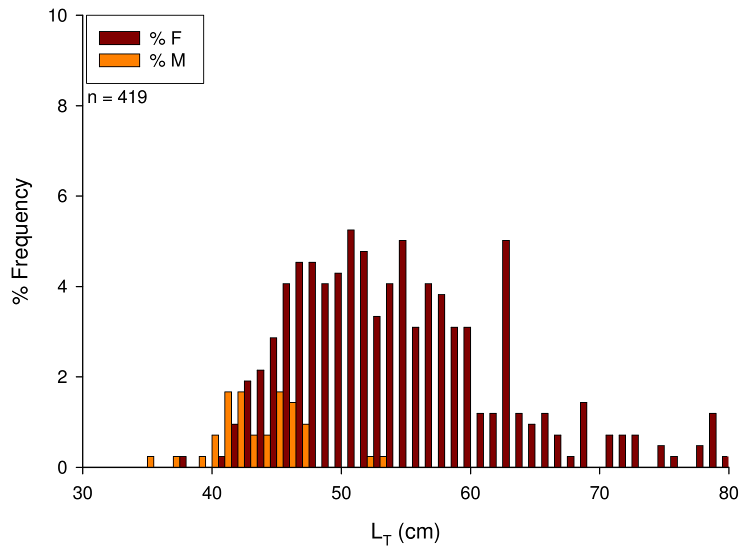


Figure 22: Length frequency distribution for *Merluccius hubbsi* sampled on ZDLH1-06-2007

Most animals were in maturity stages II and III with few numbers in IV, V, VII and VIII. *Merluccius hubbsi* only very occasionally spawns in Falkland Islands waters and we therefore do not often see stages V and VI (Figure 23).

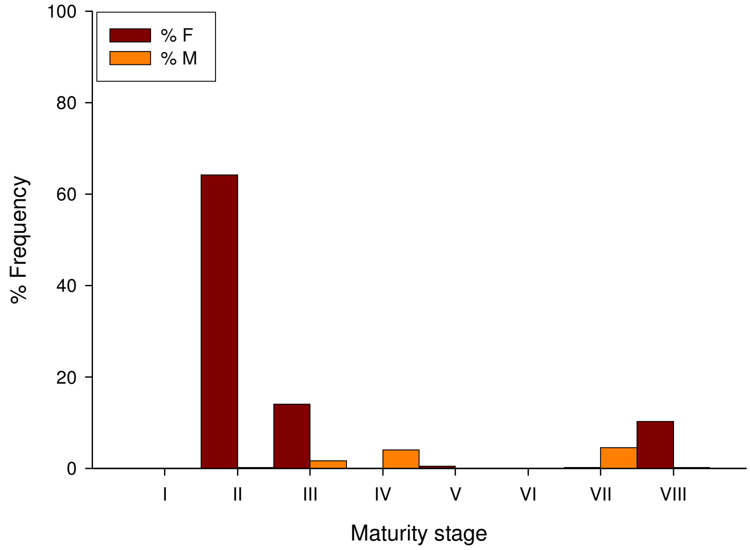


Figure 23: Distribution of maturity stages of *Merluccius hubbsi* encountered on ZDLH1-06-2007

3.7 Lantern fish – Myctophidae

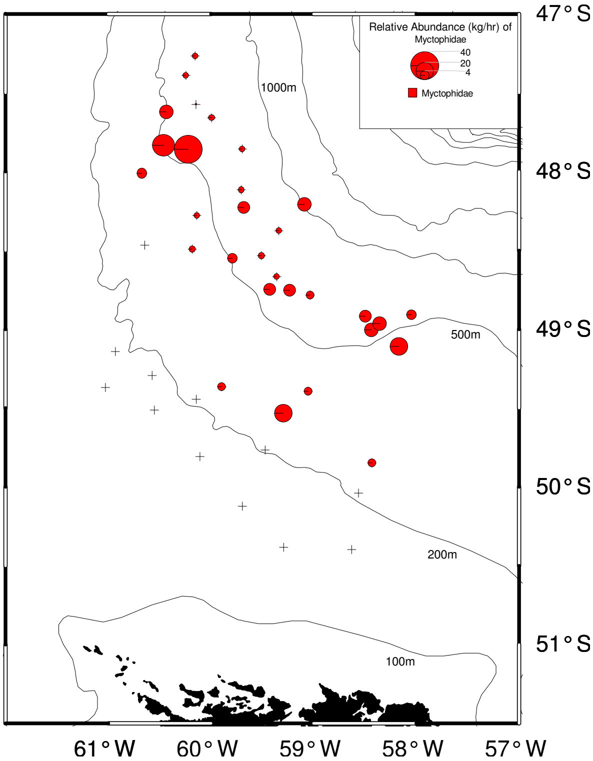


Figure 24: Relative abundance of Myctophidae encountered on ZDLH1-06-2007

Table 4: Catch (kg) and composition of myctophid spp.

Species Code	Species name	Total Catch (kg)	Total Sampled (kg)	Proportion (%)
GYN	*Gymnoscopelus nicholsi*	158.750	3.883	67.37%
GYB	*Gymnoscopelus bolini*	33.492	22.968	14.21%
PMC	*Protomictophum choriodon*	20.894	2.107	8.87%
GYM	*Gymnoscopelus spp.*	11.366	0.000	4.82%
LAA	*Lampanyctus achirus*	5.272	1.272	2.24%
SYB	*Symbolophorus boops*	2.813	2.795	1.19%
GYR	*Gymnoscopelus braueri*	1.333	0.848	0.57%
GYH	*Gymnoscopelus hintonoides*	0.878	0.878	0.37%
ELS	*Electrona subaspera*	0.627	0.292	0.27%
ELC	*Electrona carlsbergi*	0.140	0.032	0.06%
LAN	*Lampadena notialis*	0.069	0.069	0.03%
GYF	*Gymnoscopelus fraseri*	0.009	0.009	0.00%
MEV	*Metelectrona ventralis*	0.009	0.009	0.00%
		235.652	35.162	

Throughout the period myctophids were a regular occurrence in catches on the slope at stations deeper than 300m, with 30 stations (of a total of 41) yielding catches from a few hundred grams to as much as 40 kg at station 2866. The most abundant species was *G. nicholsi*, with a total of 158 kg (or 67% of the total myctophid catch), followed by *G. bolini* with 33 kg (14%), and *P. choriodon* with 21 kg (9%). Figure 24 illustrates the relative abundance for all species combined, with the relative abundance of *G. nicholsi* shown in Figure 25.

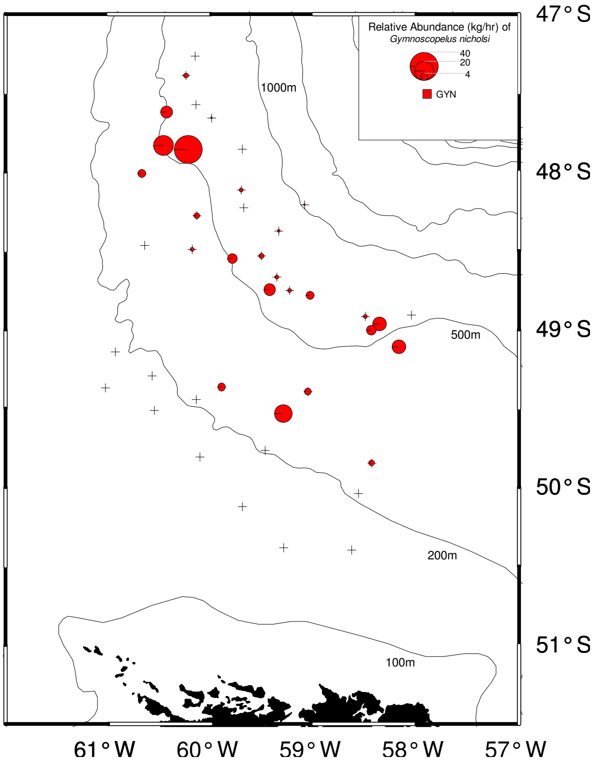


Figure 25: Relative abundance of *Gymnoscopelus nicholsi* encountered on ZDLH1-06-2007

3.7.1 Biological information *Gymnoscopelus nicholsi*

Gymnoscopelus nicholsi appeared to be most common in catches at depths around the 500 m contour, although this species was caught at stations between 305 and 975 m depth. A total number of 517 specimens of this species were sampled at eight stations, and the summarised data shows the specimens ranging in size from 4.5-17.5 cm L_T. The female proportion was 44%. All female specimens were in immature stages I & II (20 & 80% respectively) whereas the males were assessed as slightly more mature, with 31% in stage I, 61% in stage II, and 7% in stage III. The length frequency distribution shows a clear juvenile size mode around 5-7 cm, with possibly a sexually dimorphic growth rate highlighted by a predominantly male dominated size mode at around 10 cm (males twice as common as females) (Figure 26).

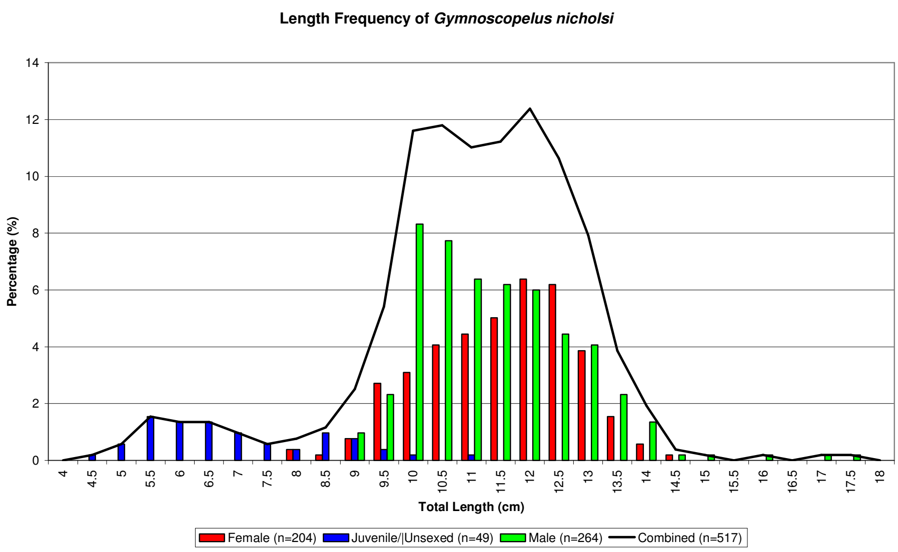


Figure 26: Length frequency distribution for *Gymnoscopelus nicholsi* sampled on ZDLH1-06-2007

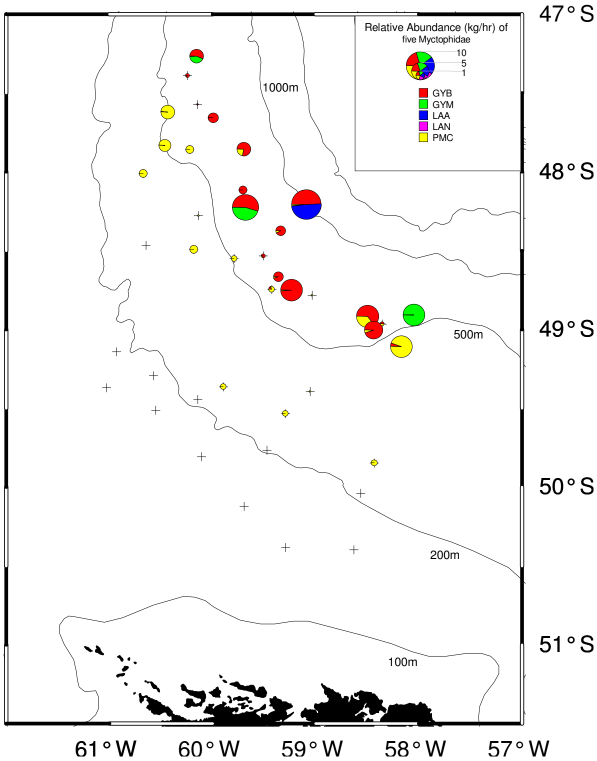


Chart 27: Relative abundance of five Myctophidae: *Gymnoscopelus bolini, Gymnoscopelus spp., Lampanyctus achirus, Lampadena notialis,* and *Protomictophum choriodon* caught on ZDLH1-06-2007

Figure 27 illustrates the abundance of a further five myctophid species of moderate abundance. *Protomictophum choriodon* appears to have a similar distribution to that of *G. nicholsi*, but with a low abundance. The other four species mainly appeared at depths greater than 600 m. Of interest is perhaps *Lampanyctus achirus*, which did only appear at one deep water station at 976m.

3.7.2 Biological information *Gymnoscopelus bolini*

Gymnoscopelus bolini were more common in catches in depths greater than 600 m, with the highest catch at 975 m. A total number of 222 specimens of this species were sampled at thirteen stations, and the summarised data shows the specimens ranging in size from 10.5-33 cm L_T (Figure 28). The female proportion was 59%. Most female specimens were immature at stages I & II (5 & 91% respectively), with small amounts in stage II and IV (3 & 1% respectively). The males were assessed as slightly more mature, with 8% at stage I, 51% in stage II, and 28% in stage III, and 11% in stage 4. The length frequency distribution shows a number of peaks (~17cm, ~23, ~25, ~29cm), but unless further investigations are conducted it would not be possible to say whether these relate to year classes or not.

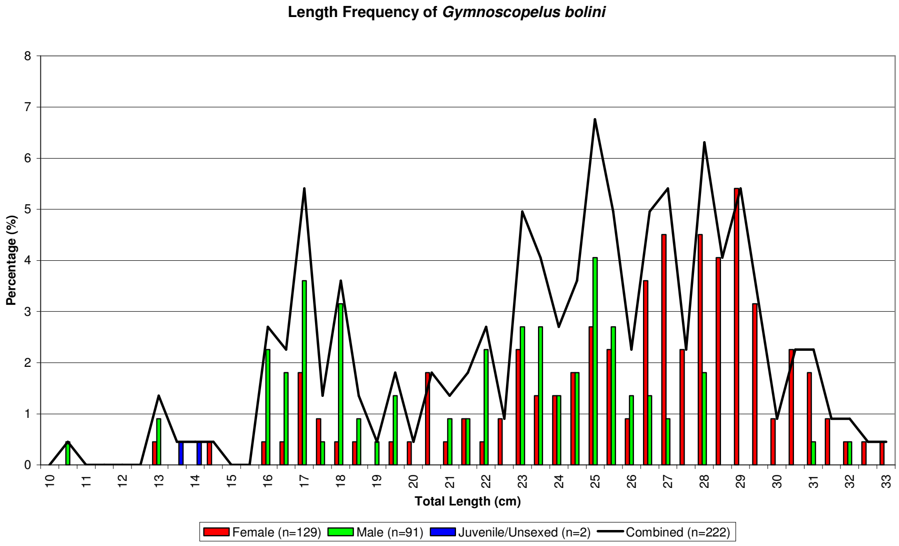


Figure 28: Length frequency distribution for *Gymnoscopelus bolini* sampled on ZDLH1-06-2007

Figure 29 illustrates the distribution and abundance of a further six species. Their abundances were low, and distribution was wide across all stations mentioned in the general distribution of the myctophids.

Both *Gymnoscopelus hintonoides* and *G. braueri* were only caught in the deepwater station at 976m, whereas *Symbolophorus boops* was predominantly caught in the south-easterly stations.

Only one species encountered that was not mapped, *Metelectrona ventralis*, because only one specimen was caught.

Correct identification to species level and regular sampling for biological parameters throughout the year for this family should contribute to a fuller understanding of ecosystem interactions. Their importance in the diet of a number of fish and squid species has been well documented.

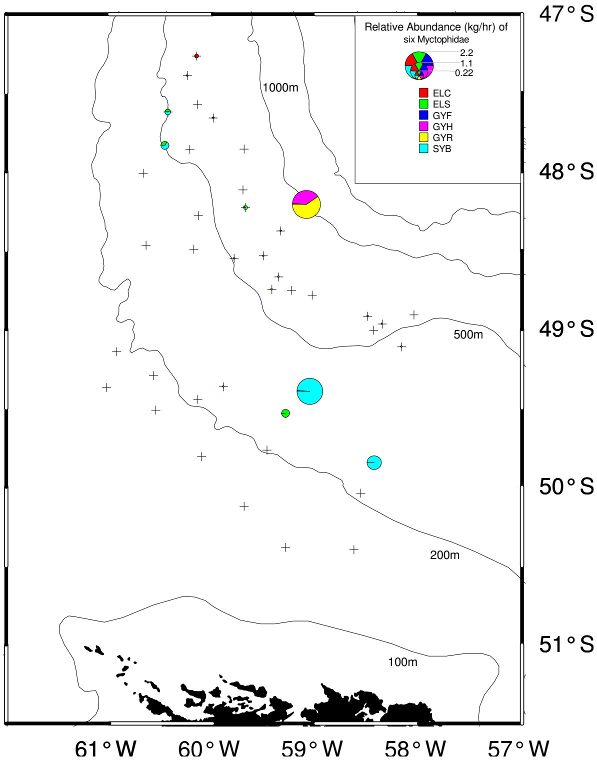


Figure 29: Relative abundance of six Myctophidae: *Electrona carlsbergi, Electrona subaspera, Gymnoscopelus fraseri, Gymnoscopelus hintonoides, Gymnoscopelus braueri,* and *Symbolophorus boops*

3.8 Skates and Rays – Rajidae

This family, of which a total of some 9 species from 3 genera (*Bathyraja, Amblyraja,* and *Psammobatis*) were caught, comprising only 1.68% of the total catch from 39 semi-pelagic trawl stations. Twenty six stations yielded rajid catches, but in small amounts only. The highest skate catch occurred at station 2840 with 26kg, followed by station 2845 with 24kg, and station 2848 with 23kg. Individual catches of less than 20kg occurred in the 23 remaining stations.

The most abundant species were *Bathyraja griseocauda* with 80kg or 44%, *B. albomaculata* with 35kg or 19%, and *B. brachyurops* with 19kg or 11% (see also table 5 and Figure 30).

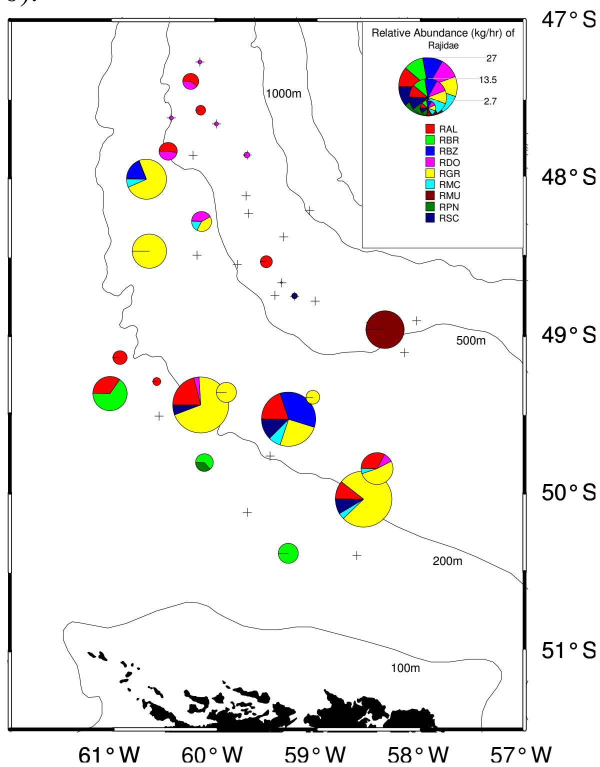


Figure 30: Relative abundance of rajids encountered on ZDLH1-06-2007

This cruise yielded little information on these species, very likely due to the use of the light semi-pelagic net. Apart from the fact that catches appeared concentrated in the stations around the 200 m isobath, very little can be added.

Table 5: Catch (kg) of Rajidae on ZDLH1-06-2007

Species Code	**Species name**	**Total Catch (kg)**	**Total Sampled (kg)**	**Total Discarded (kg)**	**Proportion (%)**
RGR	*Bathyraja griseocauda*	79.884	79.884	79.884	44.10%
RAL	*Bathyraja albomaculata*	34.888	34.888	34.888	19.26%
RBR	*Bathyraja brachyurops*	19.259	19.259	19.259	10.63%
RMU	*Bathyraja multispinis*	12.940	12.940	12.940	7.14%
RBZ	*Bathyraja cousseauae*	11.656	11.656	11.656	6.43%
RDO	*Raja doellojuradoi*	8.480	8.480	8.480	4.68%
RSC	*Bathyraja scaphiops*	7.466	7.466	7.466	4.12%
RMC	*Bathyraja macloviana*	5.259	5.259	5.259	2.90%
RPN	*Psammobatis normani*	1.309	1.309	1.309	0.72%
		181.141	**181.141**	**181.141**	

3.9 Seabird observations and mitigation development

Seabird counts were conducted from the stern gantry and bridge during all daylight fishing operations, all counts were made within a 500 m^2 box extending from the stern of the vessel.

From 23 daylight-trawling operations, a total of 14 species were identified. One possible sighting of a shy albatross was also recorded but not confirmed at 48° south and 60°40 west.

Table 6: Seabird sightings during day light fishing operations

FIFD Code	***Common Name***	***Latin name***	***Average***	***Range***	***Prevalence %***	***Total sightings***
DIM	Black-browed albatross	*Thalassarche melanophrys*	39	1 – 350	96	1993
DAC	Cape petrel	*Daption capense*	26	2 – 150	100	1386
PAX	Prion spp.	*Pachyptilla spp.*	19	1 – 250	39	309
MAG	Southern giant petrel	*Macronectes giganteus*	5	1 – 20	96	222
FUG	Antarctic fulmar	Fulmarus glacialoides	4	1 – 12	91	198
OCO	Wilson's storm petrel	*Oceanites oceanicus*	5	1 – 25	83	167
DIC	Grey-headed albatross	*Thalassarche chrysostoma*	2	1 – 8	87	102
PRO	White-chinned petrel	*Procellaria aequinoctialis*	3	1 – 12	87	92
MAH	Northern giant petrel	*Macronectes halli*	3	1- 8	61	72
DIR	Royal albatross spp.	*Diomedea epomorpha*	2	1 –12	65	77
LAD	Kelp gull	*Larus dominicanus*	1	1	35	8
PEI	Atlantic petrel	*Pterodroma incerta*	1	1-2	13	6
DIX	Wandering albatross	*Diomedea exulans*	1	1	22	6
BUI	Cattle egret	*Bubulcus ibis*	1	1	4	1

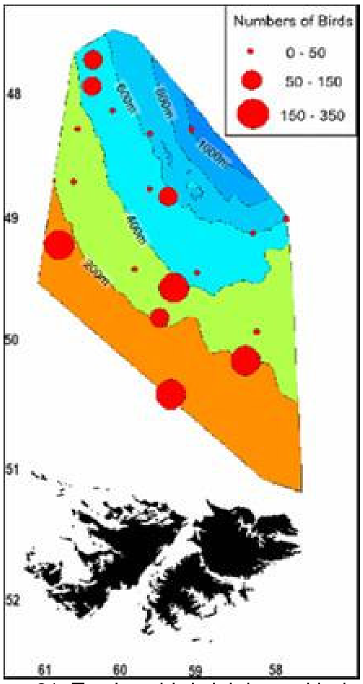


Figure 31. Total seabird sightings with depth.

Species most abundant were black-browed albatrosses and cape petrels, also being the most prevalent birds attending Dorada at fishing operations. Seabird assemblages were found to be typical to those recorded attending fishing trawlers north of the Falkland Islands.

Seabird abundance was correlated to depth ($r^2 = 0.75$: $p<0.05$), although species diversity was not significantly correlated with depth. Highest species diversities according to White *et al*. (2002) were found on the Patagonian shelf waters with many species distributions linked with depth. Generally low densities were encountered in deep water areas.

Observations from fishing vessels do not often reflect true natural at-sea distributions, and they can be influenced by many additional factors, for example seabird numbers will build up after extended periods of fishing and also in relation to discard type and quantity.

During trawling stations *Dorada* did not discharge offal in significant amounts and only intermittently, therefore it was unlikely seabird numbers would build up to any great extent. In addition *Dorada* continually moved to fish in new grounds. Therefore oceanographic and temporal factors may exert a stronger influence on seabird abundances.

3.9.1 Trawler Mitigation Development

Since 2004, tori lines have been employed within the Falkland Island's trawling fleet. These measures were in response to significant seabird mortalities caused by stern trawlers on the warp cables. Tori lines, although hugely successful in reducing seabird mortality could still benefit from improved performance.

Several buoy types were towed behind the tori lines during trawling operations, to assess performance such as line tension and resistance to cross winds and swell.

Modified road cones were tested onboard a commercial trawler during 2006, and although line tension and resistance to lateral deflection was considerably improved practical problems with the "bouncing" nature of the cones compromised performance. During these tests the road cone was modified further by shortening the cone length and increasing the diameter at the nose end. When tested this showed significant improvement with an increased line tension and an almost total reduction in "bounce" through the water. The cone sat just under the surface of the water and was more resistant to deflection by cross wind opposed to a device that sits on the surface, such as the currently used inflated buoy.

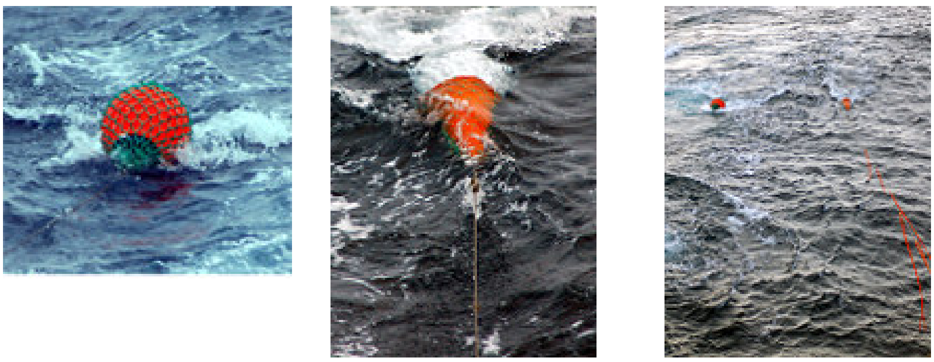


Figure 32: Standard air filled buoy and modified road cone.

Buoy and cones were dragged on 45 m lines. The shorter rope improves line tension with both buoy and cone, and significantly less rope of the distal portions fouled the surface when the lines were at maximum tension. Lines at 50 m with cones had 5 kg weighted lines attached to the 1st and 2nd streamer. Line tension was still sufficient and certainly no worse than the line with the buoy. Therefore with a device that creates more drag, heavier and stronger streamer lines can be incorporated without compromising line tension, as is the case with the current buoys.

The device below was taken from a design used on board a trawler fishing in South Georgia and was made from 2 m sections of rope, folded and bound together. The devise created insufficient drag causing the line to sag and foul the surface. The device sat under the surface of the water at c. 1 m and the last 5m of the distal end was submerged under the water.

Figure 33: Experimental tension devices tested on *Dorada.*