Cruise Report ZDLT1-11-2015

Patagonian toothfish

Juvenile recruitment and larval survey

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Contents

1.0 Introduction

Oceanographic model simulations have suggested that there are two sources or pathways of toothfish larval recruits into the Falklands toothfish fishery; one from southern Chile and the second from the eastern Burdwood Bank (Ashford et al., 2012). The timing of the survey (November) was chosen to coincide with the time period in which toothfish eggs and larvae were predicted to be present within the water column. The Isaacs-Kidd trawl survey stations were chosen to study these two pathways in detail. Studying these two hypothesised pathways was hoped to reveal the distribution of 1+ fish once they move to a predominantly benthic lifestyle. Potential juvenile recruitment areas were also surveyed on the sea bed and in the mid-water column, testing the hypothesis that juvenile toothfish are recruited into the fishery through these two pathways/sources.

The sampled area was designed according to three core regions (Figure 1). A region to the south-west of the Falkland Islands was hypothesised to be the pathway of larval and juvenile toothfish from spawning aggregations off southern Chile to both the north and south of the fishing area (Ashford et al., 2012). A second region to the south east of the Falkland Islands was sampled as the pathway for eggs, larvae and juveniles from spawning aggregations occurring over the Burdwood Bank to the south of the fishing area (Ashford et al., 2012). Sampling was also undertaken over the Burdwood Bank, the spawning area within the FOCZ (Laptikhovsky *et al*., 2006).

1.1 Cruise objectives

1. To examine the distribution of toothfish eggs and larvae in the southern FICZ/FOCZ using the Isaacs-Kidd plankton trawl.
2. To examine the distribution of newly settled toothfish recruits to the shelf using the semi-pelagic trawl.
3. To carry out simultaneous oceanographic measurements at all stations.
4. To collect highest resolution possible bathymetric measurements (EK60)

2.0 Methods

2.1 Cruise vessel and region

The research cruise ZDLT1-11-2015 was conducted onboard the FV Castelo (LOA 67.8 m, GRT 1321) from the 1st until the 13th of November 2015. Embarking and disembarking occurred on the 31st of October and 14th of November respectively.

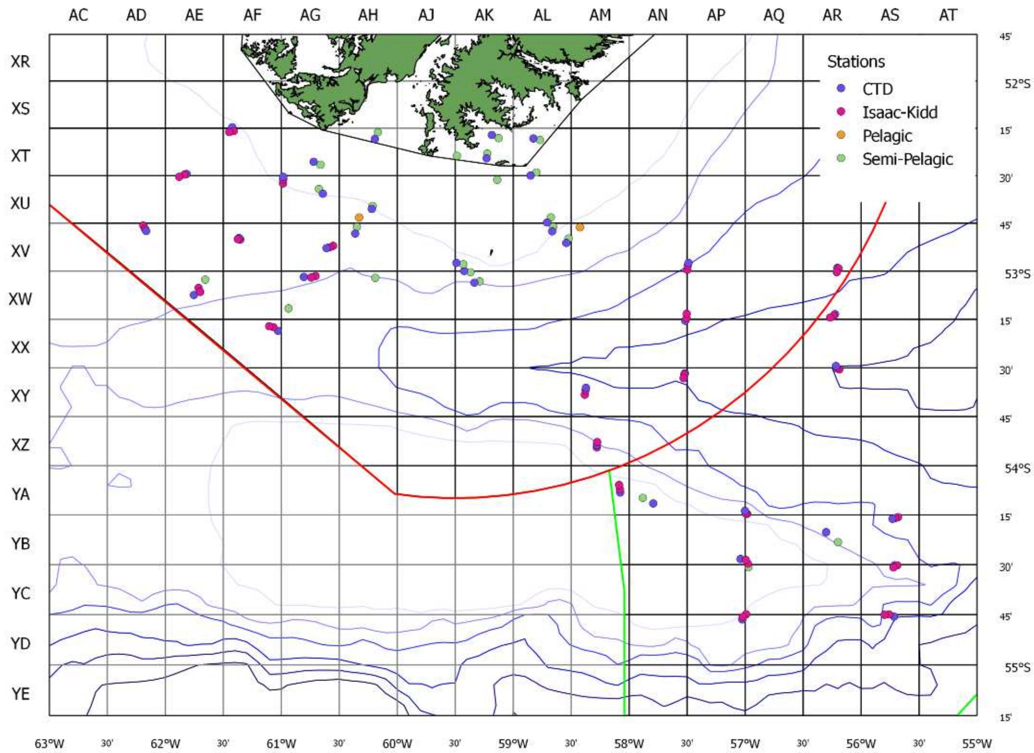

Figure 1: Locations of trawl stations (three types) and associated CTD stations.

Table 1: Trawl stations number, date, geographical coordinates, depth, horizon depth, duration and associated comments. A CTD was also carried out before or after each trawl.

Station	Date	Lat (°S)	Lon (°W)	Modal Depth (m)	Horizon Depth (m)	Duration (min)	Activity	Comments
1787	01/11/2015	52.47	58.78	88		60	S	
1789	01/11/2015	52.70	58.67	187		60	S	
1791	01/11/2015	52.75	58.65	260		60	S	
1793	01/11/2015	52.81	58.51	419		60	S	
1795	01/11/2015	52.82	58.52	419	100	120	P	
1796	02/11/2015	53.05	59.27	403		60	S	
1798	02/11/2015	53.01	59.34	251		60	S	
1800	02/11/2015	52.97	59.39	178		60	S	
1802	02/11/2015	52.54	59.11	81		60	S	
1803	03/11/2015	53.03	60.18	475		60	S	
1804	03/11/2015	52.75	60.34	251		60	S	
1806	03/11/2015	52.78	60.37	227	88	120	P	
1807	03/11/2015	52.62	60.22	186		60	S	
1809	04/11/2015	52.32	58.73	75		60	S	
1811	04/11/2015	52.31	59.09	53		60	S	

1813	04/11/2015	52.36	59.22	62		60	S		
1815	04/11/2015	52.38	59.49	70		60	S		
1816	05/11/2015	52.25	60.16	92		60	S		
1818	05/11/2015	52.45	60.63	177		60	S		
1820	05/11/2015	52.55	60.71	262		60	S		
1823	05/11/2015	52.26	61.40	224	5	30	I		
1824	05/11/2015	52.27	61.44	236	108	30	I		
1826	06/11/2015	52.49	61.82	324	3	30	I		
1827	06/11/2015	52.51	61.87	322	185	30	I		
1828	06/11/2015	52.76	62.20	339	3	30	I		
1829	06/11/2015	52.77	62.18	340	60	30	I		
1831	06/11/2015	53.12	61.72	469	130	120	P		
1833	06/11/2015	53.08	61.72	478	10	30	I		
1834	06/11/2015	53.10	61.71	483	111	30	I		
1835	07/11/2015	52.84	61.35	366	11	30	I		
1837	07/11/2015	52.78	61.37	366	100	30	I		
1838	07/11/2015	52.55	60.99	290	7	30	I		
1839	07/11/2015	52.53	60.98	272	120	30	I		
1841	07/11/2015	53.23	60.99	533		120	S		
1843	07/11/2015	53.29	61.06	567	6	30	I		
1844	07/11/2015	53.29	61.09	560	140	30	I		
1845	08/11/2015	53.02	60.70	461	5	30	I		
1847	08/11/2015	53.03	60.73	462	125	30	I		
1848	08/11/2015	52.87	60.54	486	6	30	I		
1849	08/11/2015	52.88	60.58	456	203	30	I		
1853	08/11/2015	53.53	57.52	2600	10	30	I		
1854	08/11/2015	53.55	57.53	2600	70	30	I		
1855	09/11/2015	53.26	57.51	1710	4	30	I		
1856	09/11/2015	53.23	57.50	1665	164	30	I		
1857	09/11/2015	53.00	57.50	946	7	30	I		
1858	09/11/2015	52.98	57.50	901	82	30	I		
1862	09/11/2015	52.98	56.19	1829	5	30	I		
1863	09/11/2015	53.00	56.21	1850	75	30	I		
1864	09/11/2015	53.23	56.23	2250	8	30	I		
1865	10/11/2015	53.24	56.26	2253	83	30	I		
1866	10/11/2015	53.51	56.18	3000	7	30	I		
1867	10/11/2015	53.51	56.20	3000	130	30	I		
1869	10/11/2015	54.55	56.90	93		120	S		
1872	10/11/2015	54.75	56.98	156	7	30	I		
1873	10/11/2015	54.76	57.01	156	70	30	I		
1874	11/11/2015	54.50	56.97	91	4	30	I		
1875	11/11/2015	54.48	56.99	92	70	30	I		
1876	11/11/2015	54.27	56.98	140	6	30	I		
1877	11/11/2015	54.25	56.99	208	77	30	I		
1880	11/11/2015	54.35	56.27	273		120	S		
1883	11/11/2015	54.75	55.75	750	8	30	I		
1884	11/11/2015	54.75	55.79	794	85	30	I		
1885	12/11/2015	54.50	55.68	486	4	30	I		
1886	12/11/2015	54.51	55.71	476	79	30	I		
1887	12/11/2015	54.26	55.67	1399	7	30	I		
1888	12/11/2015	54.27	55.71	1428	72	30	I		
1891	12/11/2015	54.19	57.82	128		120	S		
1893	12/11/2015	54.13	58.08	134	8	30	I		
1894	12/11/2015	54.11	58.08	137	118	30	I		
1895	12/11/2015	53.91	58.28	498	8	30	I		
1897	13/11/2015	53.89	58.28	572	186	30	I		
1898	13/11/2015	53.65	58.39	1826	4	30	I		
1899	13/11/2015	53.62	58.38	1835	76	30	I		

2.2 Trawl gear

The FIFD Engel semi-pelagic combi trawl with “Super-V” doors was used at all semi-pelagic and pelagic trawl stations. This net has a 40.2 m headline and a 38.7 m footrope equipped with rockhoppers. 115m sweeps were used. A net sensor was attached to the headline, and sensors were fitted on each of the trawldoors. The net vertical opening was between 12.1 and 18.5m for the semi-pelagic, and 10, 13, and 19m for the three pelagic trawls. The codend mesh size was 95 mm, but the codend was fitted with a codend liner with a much finer diamond mesh of ~35mm.

2.3 Plankton gear

The FIFD Nichimo made 6 foot Isaacs-Kidd Mid-water Trawl net (or IKMT) with the following dimensions was used: Top width bar (140cm) and net (143cm), 96cm + 96cm, height 175cm.

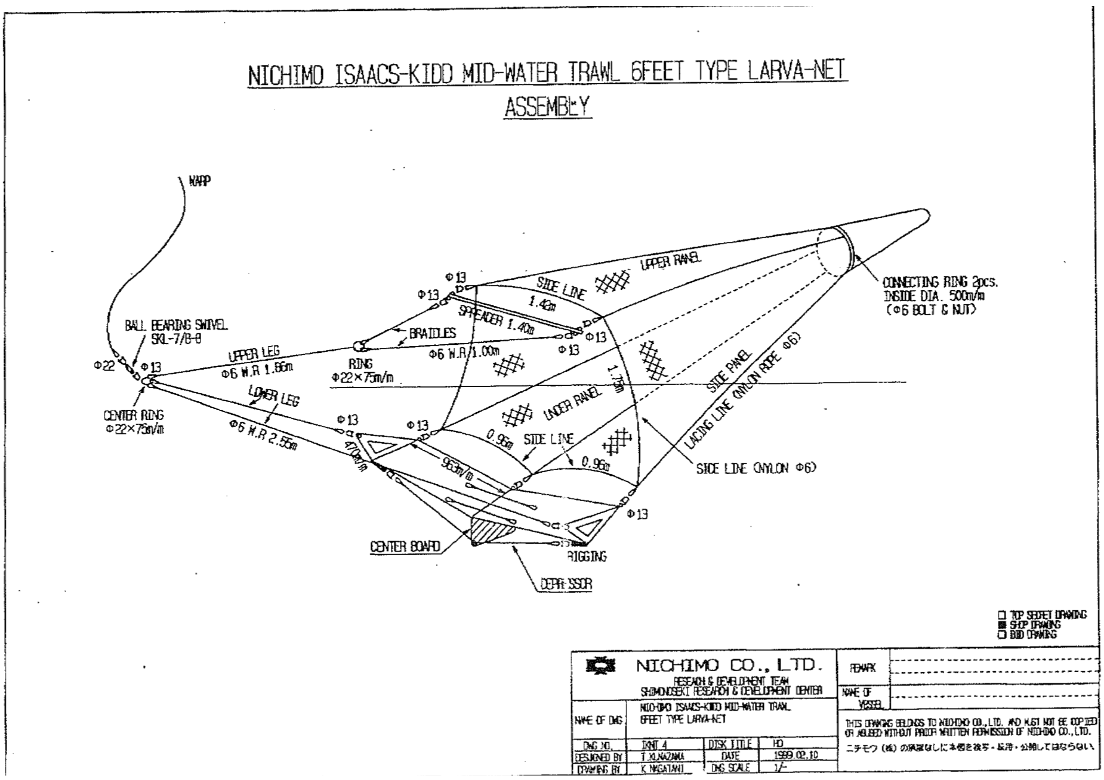

Figure 2: Isaacs Kidd Mid-Water Trawl

The mouth is slightly trapezoid (bottom being wider than the top), resulting in a mouth opening area of approximately 2.9m^2. The mesh of the main net is square mesh with ~4mm across, and ~6mm for the diagonals, covered externally by protective netting. The cod-end holding a 3.3ltr Nalgene sample bottle is fitted to the main net with four carabiners, allowing for a gap of approximately 5cm between the two nets. The square mesh of the cod-end is ~1mm across, ~1.5mm for the diagonals. Protective netting also covers the finer cod-end netting (see also Figure 2). A Valeport flowmeter Model 106 (s/n: 18466) was also fitted in the mouth of the plankton net. This flowmeter records date/time, depth (m), speed (m/s), direction(degrees), pressure (dBar), and temperature (degrees C). Upon return to shore and analyses of the data files, it became clear that on many occasions the values from the pressure and temperature sensors had recorded numerous nonsensical values, and so the depth and temperature values could not be consistently used. Other parameters were not affected. A Marport net monitoring sensors was fitted on the top of the net so that the position and depth of the net could be monitored from the bridge.

2.4 Biological sampling & Plankton sampling

For the trawled stations, the entire catch was weighed by species (for finfish, squids, skates and sharks) or to the lowest taxonomic level (for invertebrates) using the electronic marine adjusted POLS balance. Random samples were taken of all commercial finfish species and Loligo squid, typically 100 specimens in the case of fish or 200 specimens in the case of squid, recording length, sex, and maturity stage for all specimens. However, catches were low, and as such only some catches of finfish yielded over 100 animals. Traditional measuring and scribing methods (using measuring boards and paper forms) were used for all sampling. From all skates both total length and disc width, as well as sex, maturity and weight were recorded. A number of non-commercial fish and crustaceans were also sampled. Subsamples of fish species were taken to extract otoliths at sea. Vertebrae/spine samples were taken from one skate species (*Bathyraja multispinis)*. For all IKMT stations, two trawls were conducted at each location, one at the surface, and one in the backscattering layer (if present). The entire catch was filtered using a 500μm sieve, and weighed using a POLS 13.5kg or MAREL 15kg marine adjusted balance. The contents remaining in the filter were placed in a white plastic tray containing a small amount of seawater, which facilitated easy sorting of the samples. The cod-end was washed thoroughly to ensure all specimens were recorded. Not all the components of the plankton catch were weighed individually, but some of the larger components were if they were dominant and easily separable. In any case, all components were identified to the lowest possible taxon and form (Larva, zoea, fry, adult, juvenile, egg), and assigned an abundance index D(ominant)(30-80%), A(bundant)(5-30%), C(ommon)(1-5%) , O(ccasional)(<1%), R(are)(1-2 specimens). Zooplankton species were predominantly indentified using South Atlantic Zooplankton: Volumes 1 & 2 (ed. Boltovskoy, 1999). Descriptions from fishbase of zooplankton species found on previous research cruises within the FCZ had also been collated into a booklet. This document was used in parallel with species identification guides for accurate identification. Specimens were identified to species level (or as far as possible) using dichotomous keys. Any individuals that could not be identified or could be used as reference material were stored in clearly labelled jars containing 70% ethanol for further analysis onshore. Identification of fish larvae/fry was undertaken using a number of publications which are not referenced in this document.

2.5 Oceanography

A single CTD (SBE-25, Sea-Bird Electronics Inc., Bellevue, USA) instrument was used to collect oceanographic data in the vicinity of all trawl stations, Serial No 0247. However due to damage sustained to the conductivity sensor, sn:2233, was replaced by sensor sn:3131. At all CTD stations the CTD was deployed to a depth of c.10m below surface for a soak time of more than one minute, to allow the pump to start circulating water and flush the system, following this the CTD was raised to a minimum depth of 5 m below surface. The CTD was then lowered toward sea bed at 1m/sec. The CTD collected pressure in dbar, temperature in °C, conductivity in mS/cm, Oxygen Voltage and Fluorescence. The raw hex file was converted and processed using SBE Data Processing Version.7.22.5 using the CON files OldCTD_2013_AUG.xmlcon for data with the original conductivity sensor. When the conductivity sensor was replaced the calibration values were changed to those for the new sensor, and 0247OldCTD_2015_AUGwCond3131.xmlcon was used. Upcast data was filtered out. Depth was derived from pressure using the latitude of each station, with dissolved oxygen in ml/l derived at the same time as depth. Practical Salinity (PSU) and Density as sigma-t (σ-t) were derived following derivation of depth. Further derived variables of conservative temperature (°C) and Absolute Satinity (g/kg) were calculated in Ocean Data View version 4.5.4 (Schlitzer, R., Ocean Data View, http://odv.awi.de, 2013).

3.0 Results

3.1 Catch composition (Semi-pelagic trawls)

Table 2: Catch summary table for Semi-pelagic trawls (n=22)

Species Code	*Species name*	***Total Catch (kg)***	***Total Sampled (kg)***	***Total Discarded (kg)***	***Proportion (%)***
GRC	*Macrourus carinatus*	199.496	199.496	51.286	22.94%
POR	*Lamna nasus*	100.000	0.000	100.000	11.50%
PAR	*Patagonotothen ramsayi*	84.457	37.159	84.457	9.71%
ANG	*Anthoptilum grandiflorum*	82.790	0.000	82.790	9.52%
WHI	*Macruronus magellanicus*	57.420	57.420	0.000	6.60%
BLU	*Micromesistius australis*	49.314	44.788	31.634	5.67%
GRF	*Coelorhynchus fasciatus*	39.640	19.650	39.640	4.56%
GYN	*Gymnoscopelus nicholsi*	36.966	9.788	36.966	4.25%
RGR	*Bathyraja griseocauda*	34.550	34.550	10.650	3.97%
CHR	*Chrysaora cf. plocamia*	33.455	0.000	33.455	3.85%
ALG	Algae	26.596	0.000	26.596	3.06%
SPN	Porifera	21.387	0.000	21.387	2.46%
ING	*Moroteuthis ingens*	19.750	2.492	19.750	2.27%
LOL	*Doryteuthis gahi*	10.564	10.458	10.544	1.21%
WRM	*Chaetopterus variopedatus*	8.766	0.000	8.766	1.01%
RMU	*Bathyraja multispinis*	8.450	8.450	0.000	0.97%
BRY	Bryozoa	7.482	0.000	7.482	0.86%
PYM	*Physiculus marginatus*	4.764	1.300	4.764	0.55%
PAT	*Merluccius australis*	4.590	4.590	0.000	0.53%
MUG	*Munida gregaria*	4.339	1.208	4.339	0.50%
CGO	*Cottoperca gobio*	3.810	3.630	3.810	0.44%
TOO	*Dissostichus eleginoides*	3.338	3.338	0.738	0.38%
SQT	Ascidiacea	3.165	0.000	3.165	0.36%
GOC	*Gorgonocephalus chilensis*	2.632	0.000	2.632	0.30%
RSC	*Bathyraja scaphiops*	2.314	2.314	2.314	0.27%
ANT	Anthozoa	2.180	0.000	2.180	0.25%
RAL	*Bathyraja albomaculata*	1.755	1.755	1.755	0.20%
SHT	Mixed invertebrates	1.518	0.000	1.518	0.17%
COL	*Cosmasterias lurida*	1.500	0.000	1.500	0.17%
BAC	*Salilota australis*	1.344	1.344	1.344	0.15%
MYK	*Myxine knappi*	1.320	0.000	1.320	0.15%
ANM	Anemone	1.316	0.000	1.316	0.15%
ACY	*Armadillogorgia cyathella*	1.202	0.000	1.202	0.14%
DGH	*Schroederichthys bivius*	1.020	1.020	1.020	0.12%
SUN	*Labidaster radiosus*	0.944	0.000	0.944	0.11%
CAS	*Campylonotus semistriatus*	0.696	0.000	0.696	0.08%
EEL	*Iluocoetes fimbriatus*	0.692	0.466	0.692	0.08%
COG	*Patagonotothen guntheri*	0.571	0.571	0.571	0.07%
GYR	*Gymnoscopelus braueri*	0.520	0.000	0.520	0.06%
HOL	Holothuroidea	0.498	0.000	0.498	0.06%
EGG	Eggmass	0.410	0.000	0.410	0.05%
CAZ	*Calyptraster sp.*	0.248	0.000	0.248	0.03%
PEN	Pennatulacea	0.206	0.000	0.206	0.02%
MED	Medusae	0.170	0.000	0.170	0.02%
THO	Thouarellinae	0.164	0.000	0.164	0.02%

MIR	*Mirostenella sp.*	0.158	0.000	0.158	0.02%
STA	*Sterechinus agassizi*	0.126	0.000	0.126	0.01%
MUE	*Muusoctopus eureka*	0.114	0.000	0.114	0.01%
PLU	Primnoellinae	0.085	0.000	0.085	0.01%
PAA	*Pandalopsis ampla*	0.080	0.000	0.080	0.01%
ELC	*Electrona carlsbergi*	0.064	0.064	0.064	0.01%
DPR	*Diplophos rabainsi*	0.064	0.000	0.064	0.01%
FUM	*Fusitriton m. magellanicus*	0.060	0.000	0.060	0.01%
PGR	*Paradiplospinus gracilis*	0.058	0.000	0.058	0.01%
AUC	*Austrocidaris canaliculata*	0.050	0.000	0.050	0.01%
BIV	Bivalve	0.050	0.000	0.050	0.01%
GOR	Gorgonacea	0.050	0.000	0.050	0.01%
POL	Polychaeta	0.048	0.000	0.048	0.01%
ARR	*Arctozenus risso*	0.046	0.000	0.046	0.01%
PTE	*Patagonotothen tessellata*	0.044	0.026	0.044	0.01%
SAR	*Sprattus fuegensis*	0.042	0.000	0.042	<0.01%
AST	Asteroidea	0.036	0.000	0.036	<0.01%
MUU	*Munida subrugosa*	0.032	0.022	0.032	<0.01%
OPH	Ophiuroidea	0.028	0.000	0.028	<0.01%
ASA	*Astrotoma agassizii*	0.025	0.000	0.025	<0.01%
FLX	*Flabellum spp.*	0.025	0.000	0.025	<0.01%
THB	*Thymops birsteini*	0.022	0.000	0.022	<0.01%
ZYP	*Zygochlamys patagonica*	0.018	0.000	0.018	<0.01%
POA	*Porania antarctica*	0.018	0.000	0.018	<0.01%
RMG	*Bathyraja magellanica*	0.016	0.000	0.016	<0.01%
NEH	*Neomenia herwigi*	0.014	0.000	0.014	<0.01%
HYD	Hydrozoa	0.012	0.000	0.012	<0.01%
HIX	*Histioteuthis spp.*	0.010	0.000	0.010	<0.01%
PYX	Pycnogonida	0.007	0.000	0.007	<0.01%
SET	Sertularioidae	0.007	0.000	0.007	<0.01%
STS	*Stereomastis suhmi*	0.006	0.000	0.006	<0.01%
TED	*Terebratella dorsata*	0.006	0.000	0.006	<0.01%
ALC	Alcyoniina	0.004	0.000	0.004	<0.01%
CTA	*Ctenodiscus australis*	0.004	0.000	0.004	<0.01%
NUD	Nudibranchia	0.002	0.000	0.002	<0.01%
OPS	*Ophiactis asperula*	0.002	0.000	0.002	<0.01%
		869.742	**445.899**	**606.872**	

3.2 Catch composition (Pelagic trawls)

Table 3: Catch summary for Pelagic trawls (n=3)

Species Code	*Species name*	***Total Catch (kg)***	***Total Sampled (kg)***	***Total Discarded (kg)***	***Proportion (%)***
GYN	*Gymnoscopelus nicholsi*	16.756	2.086	16.756	96.00%
PAR	*Patagonotothen ramsayi*	0.636	0.636	0.636	3.64%
SYY	*Symbolophorus sp.*	0.036	0.036	0.000	0.21%
ING	*Moroteuthis ingens*	0.026	0.000	0.026	0.15%
		17.454	**2.758**	**17.418**	**100.00%**

3.2.1 Patagonian toothfish catch, distribution, biology

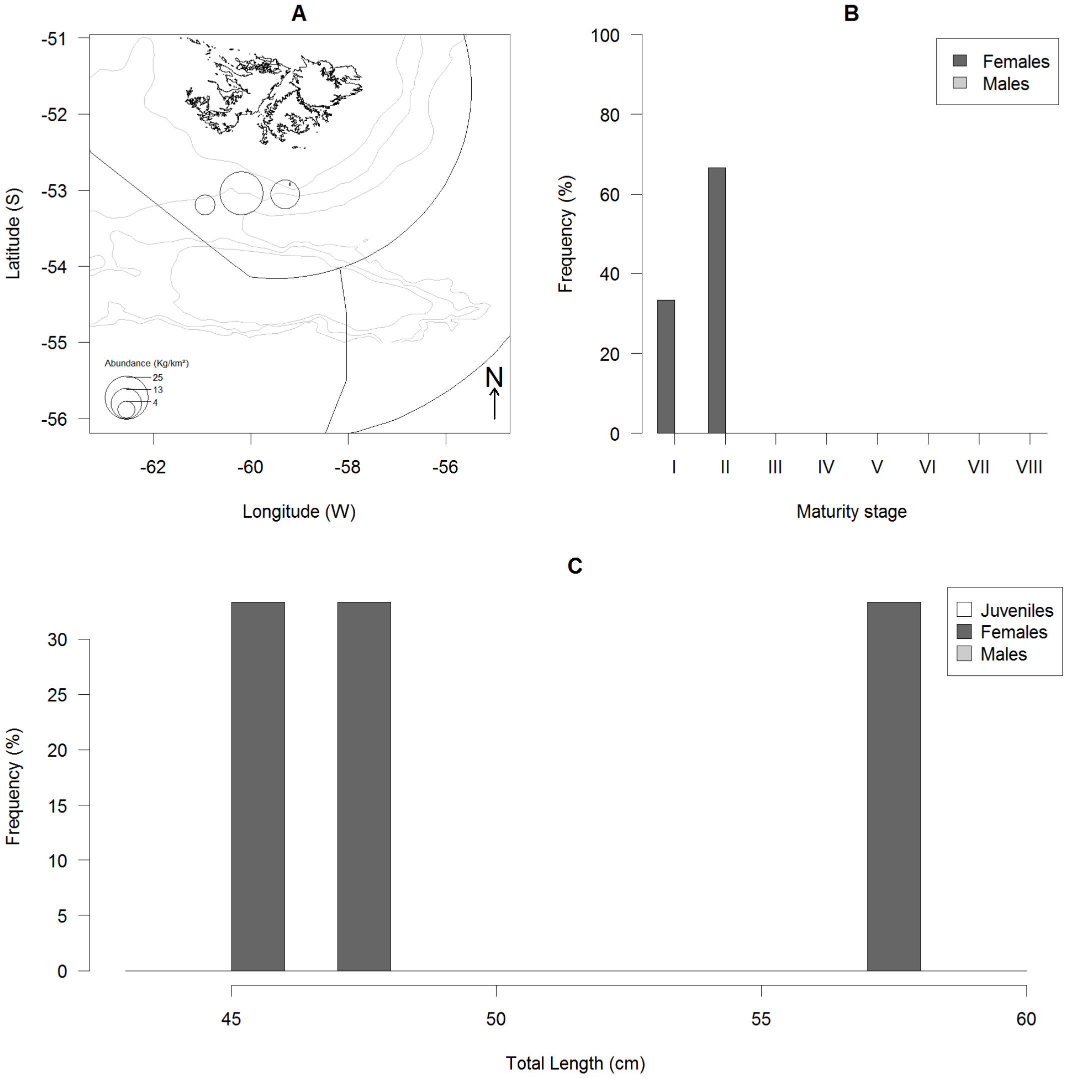

Figure 3: *Dissostichus eleginoides* relative abundance (A), Maturity distribution (B) and size frequency (C)

Only 3.338kg (n=3) of toothfish was caught in Semi-Pelagic trawls. This occurred at three stations with (female maturity stage 1-2) specimens of 45, 57, and 47cm TL respectively caught at depths 403, 475 and 533m (see Figure 3). Although not much can be inferred from these small catches, perhaps the absence of this species in all other stations is more surprising.

3.2.2 Other finfish and squid species catch, distribution, biology

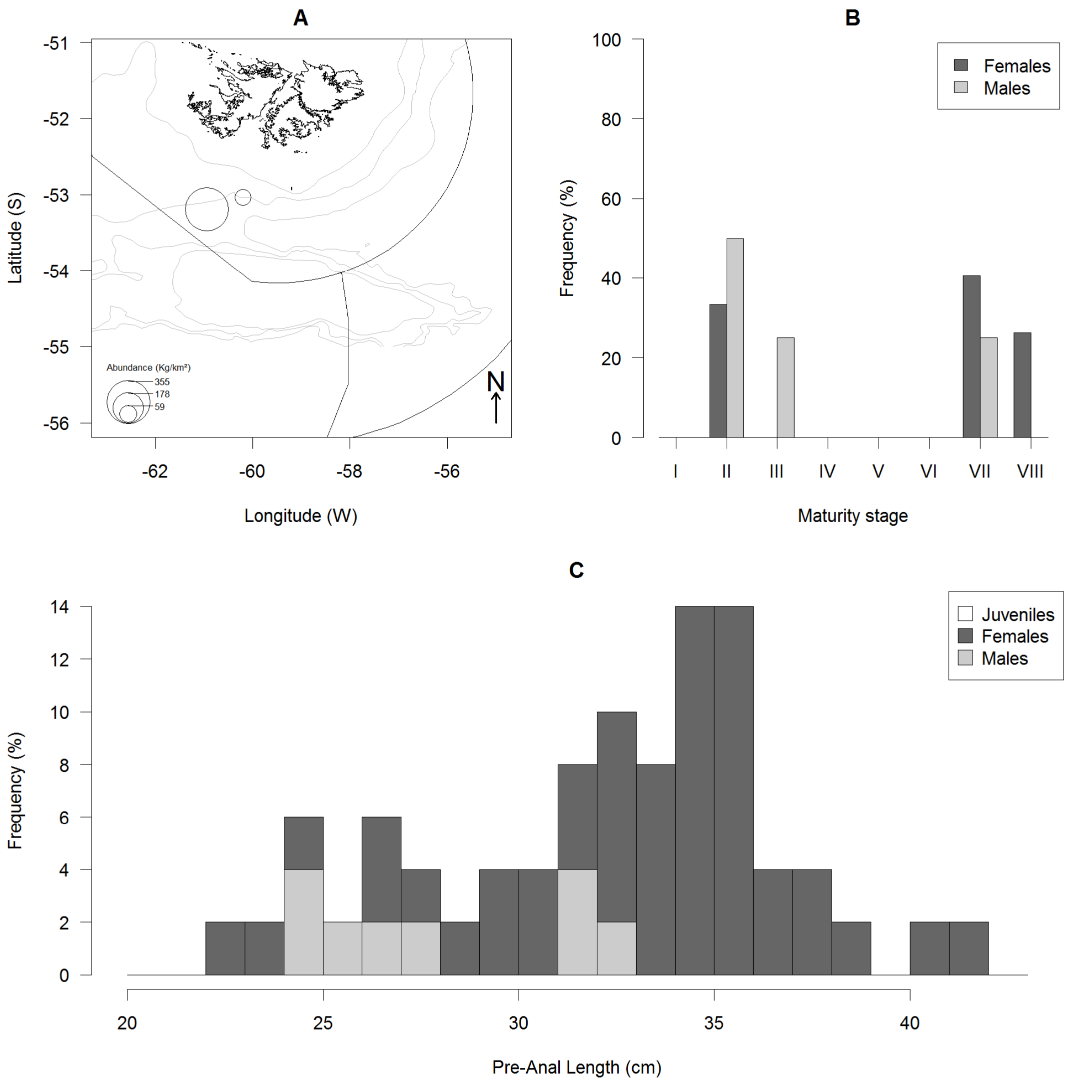

Figure 4: ***Macruronus magellanicus*** **relative abundance (A), Maturity distribution (B) and size frequency (C)**

Macruronus magellanicus

Hoki was caught at two stations, with the entire catch (57.4kg) sampled on both occasions. Females ranged from 22-41cm (x=32.5cm) PAL, males from 24-32cm (x=27.5cm). Figure 4 displays all relevant detail for this species.

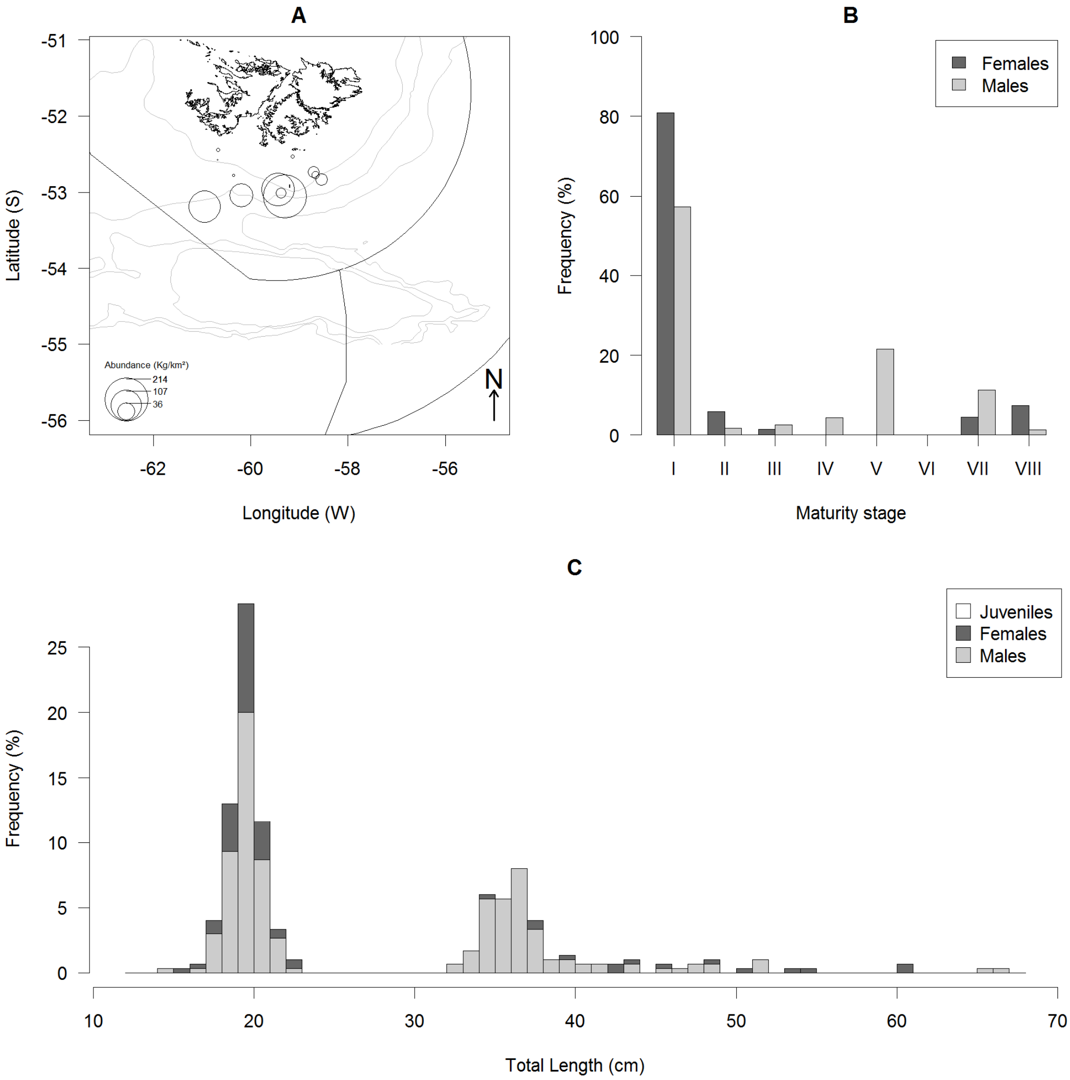

Figure 5: *Micromesistius a. australis* relative abundance (A), Maturity distribution (B) and size frequency (C)

Micromesistius a. australis

Southern blue whiting was caught at 12 stations, with a total catch of 49.3kg Females ranged from 15-60cm (x=24.5cm) TL, males from 14-66cm (x=26.8cm) TL. There was a large male predominance of 77.3%. Figure 5 displays all relevant detail for this species.

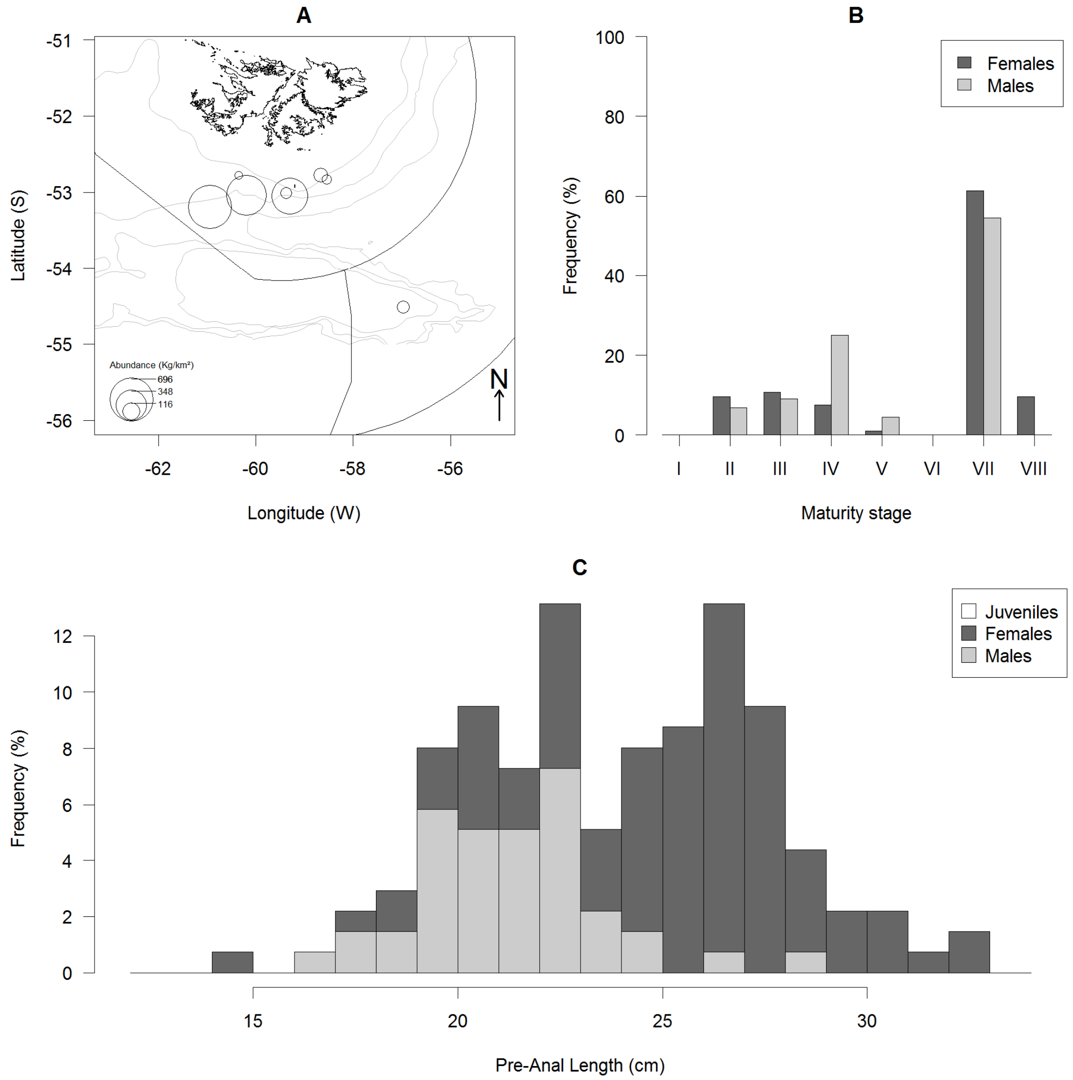

Figure 6: *Macrourus carinatus* relative abundance (A), Maturity distribution (B) and size frequency (C)

Macrourus carinatus

The ridge scaled rattail was caught at 8 stations, with a total catch of 199.5kg. All 137 specimens were assessed, with females ranging from 14-32cm (x=24.7cm) PAL, and males from 16-28cm (x=20.8cm) PAL. There was a female predominance of 67.9%. Figure 6 displays all relevant detail for this species.

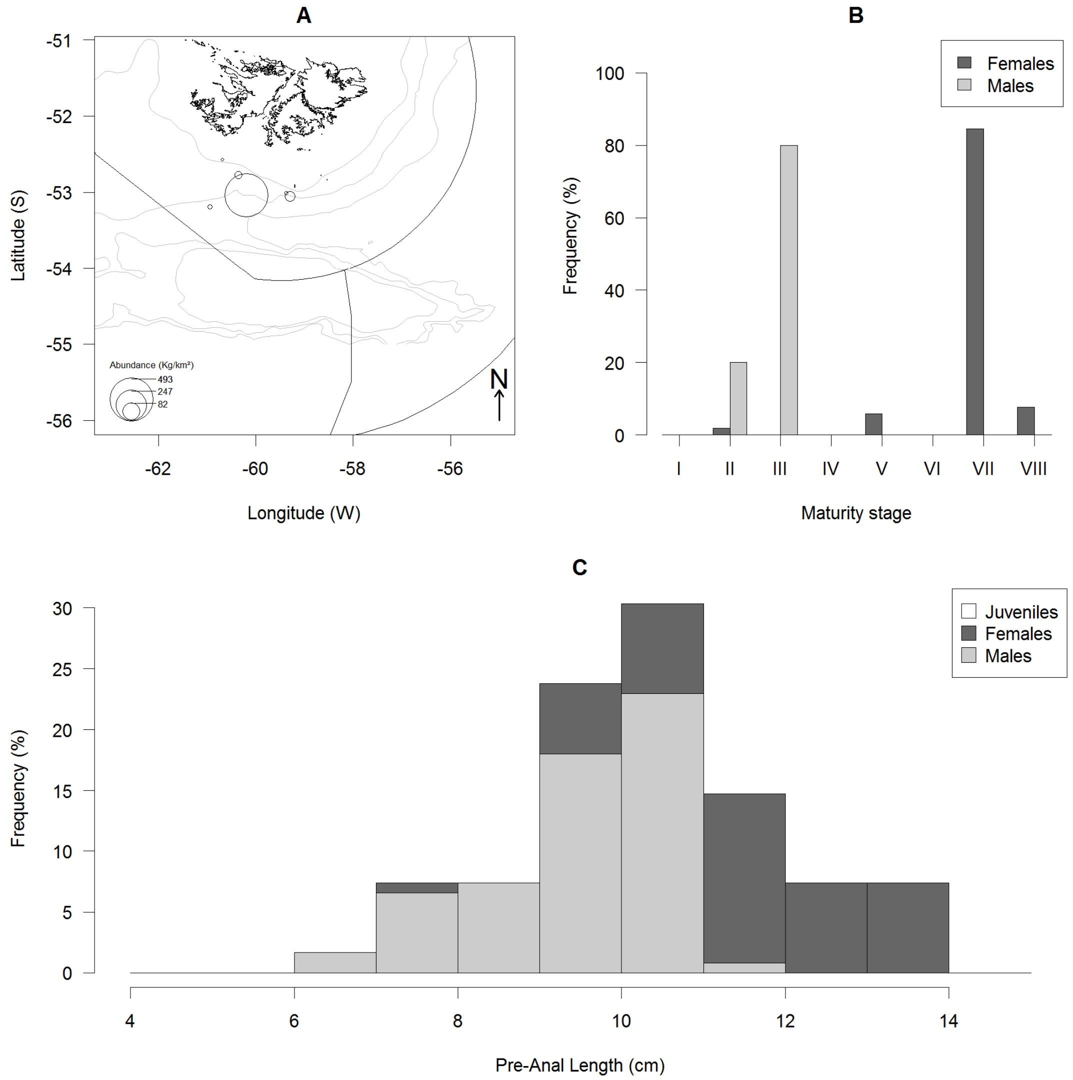

Figure 7: *Coelorhynchus fasciatus* relative abundance (A), Maturity distribution (B) and size frequency (C)

Coelorhynchus fasciatus

The banded whiptail was caught at 8 stations, with a total catch of 39.6kg. All stations were sampled, but of the largest catch (34.8kg at station 1803) only 101 specimens were assessed. In total 122 specimens were assessed, with females ranging from 7-13cm (x=11.0cm) PAL, and males from 6-11cm (x=8.99cm) PAL. There was a male predominance of 57.4%. Figure 7 displays all relevant detail for this species.

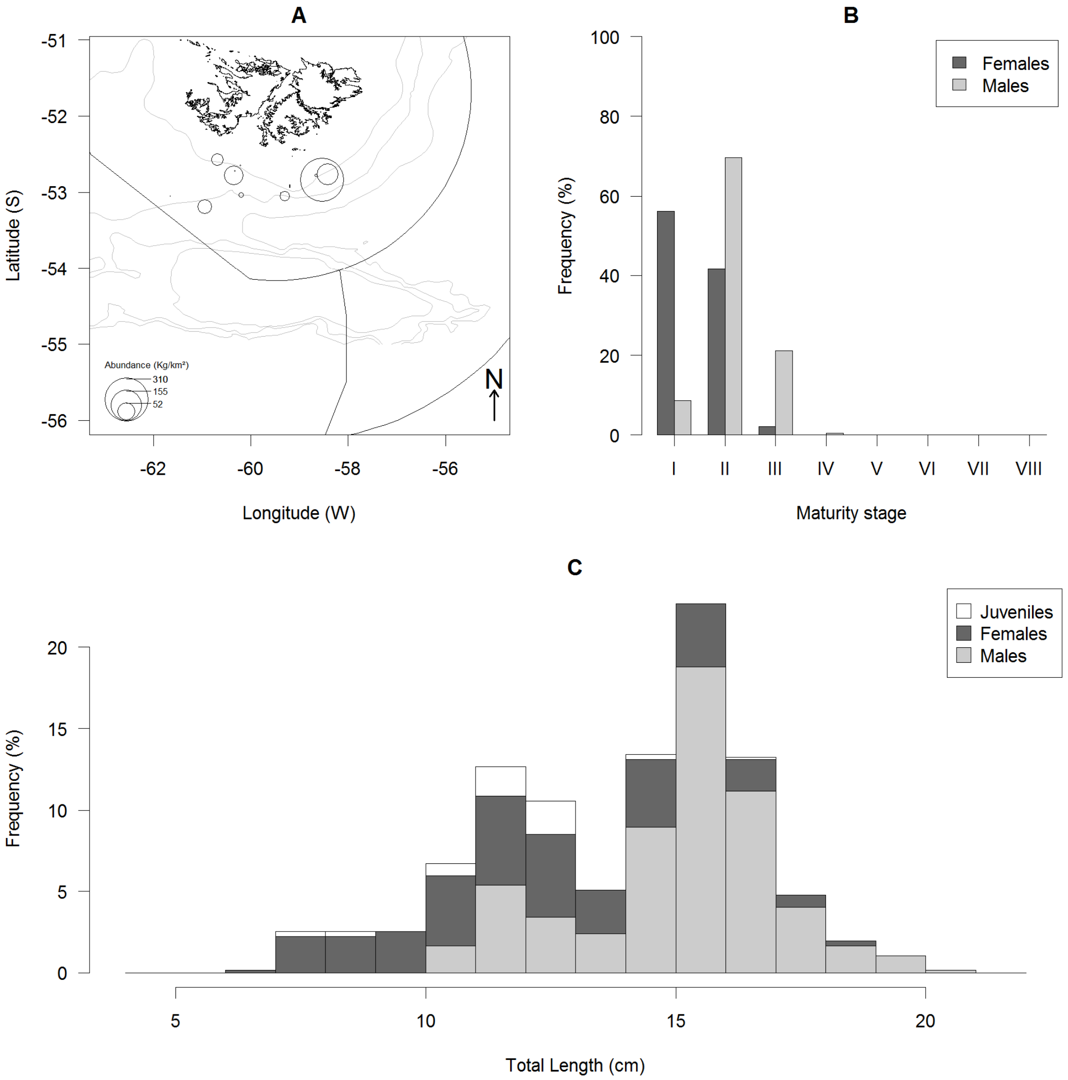

Figure 8: *Gymnoscopelus nicholsi* relative abundance (A), Maturity distribution (B) and size frequency (C)

Gymnoscopelus nicholsi

Nichol's lanternfish was caught at 13 stations, with 37.0kg caught in the semi-pelagic, and 16.8kg in the 2 pelagic trawls. All stations were sampled, but of the largest catch (34.8kg at station 1803) only 101 specimens were assessed. In total 122 specimens were assessed, with females ranging from 7-13cm (x=11.0cm) TL, and males from 6-11cm (x=8.99cm) TL. There was a male predominance of 57.4%. Figure 7 displays all relevant detail for this species.

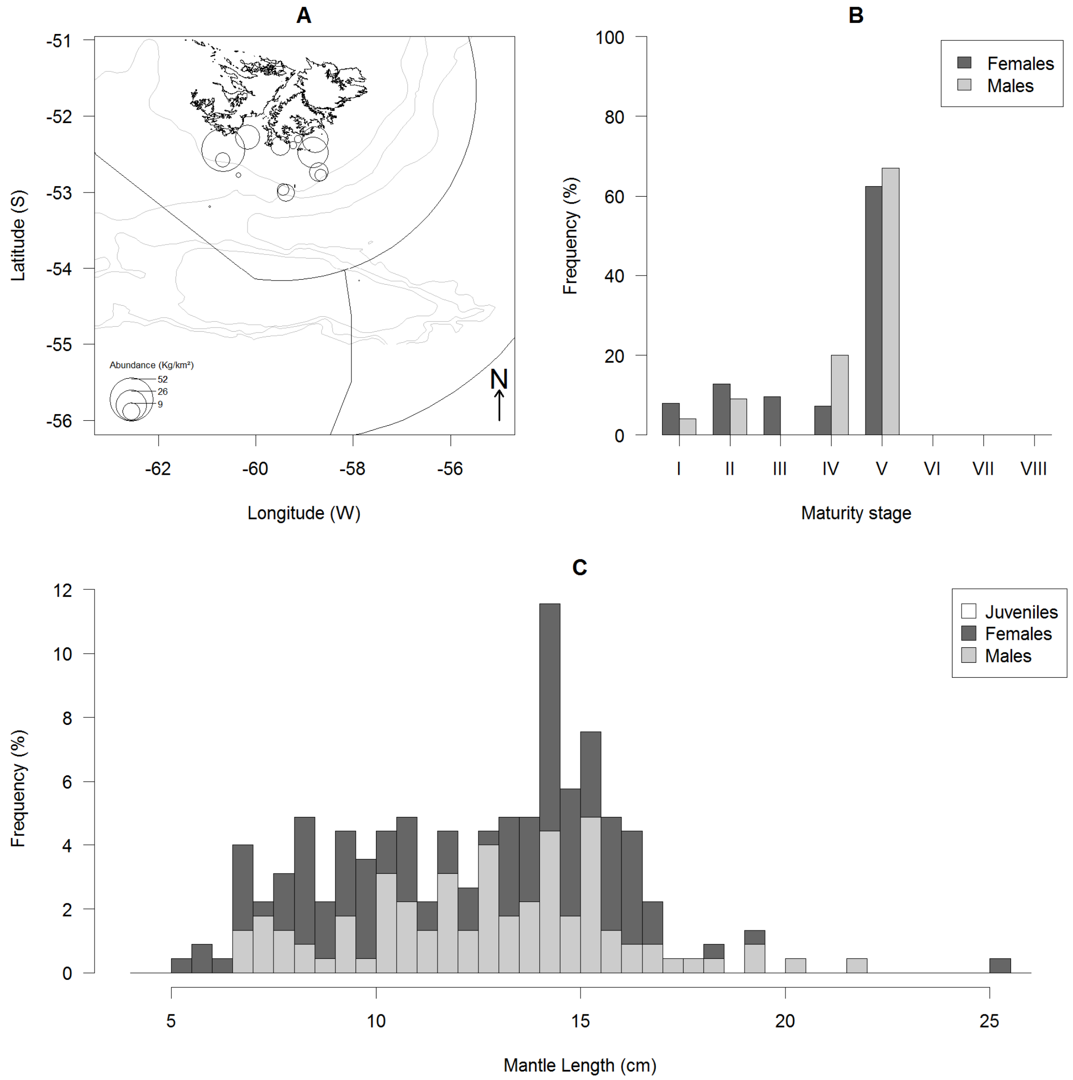

Figure 9: *Doryteuthis gahi* relative abundance (A), Maturity distribution (B) and size frequency (C)

Doryteuthis gahi

Falkland calamari was caught at 15 stations, with 10.6kg caught in the semi-pelagic trawls. 12 stations were sampled. In total 225 specimens were assessed, with females ranging from 5-25cm (x=12.02cm) DML, and males from 6.5-21.5cm (x=12.51cm) DML. There was a female predominance of 55.6%. Figure 9 displays all relevant detail for this species.

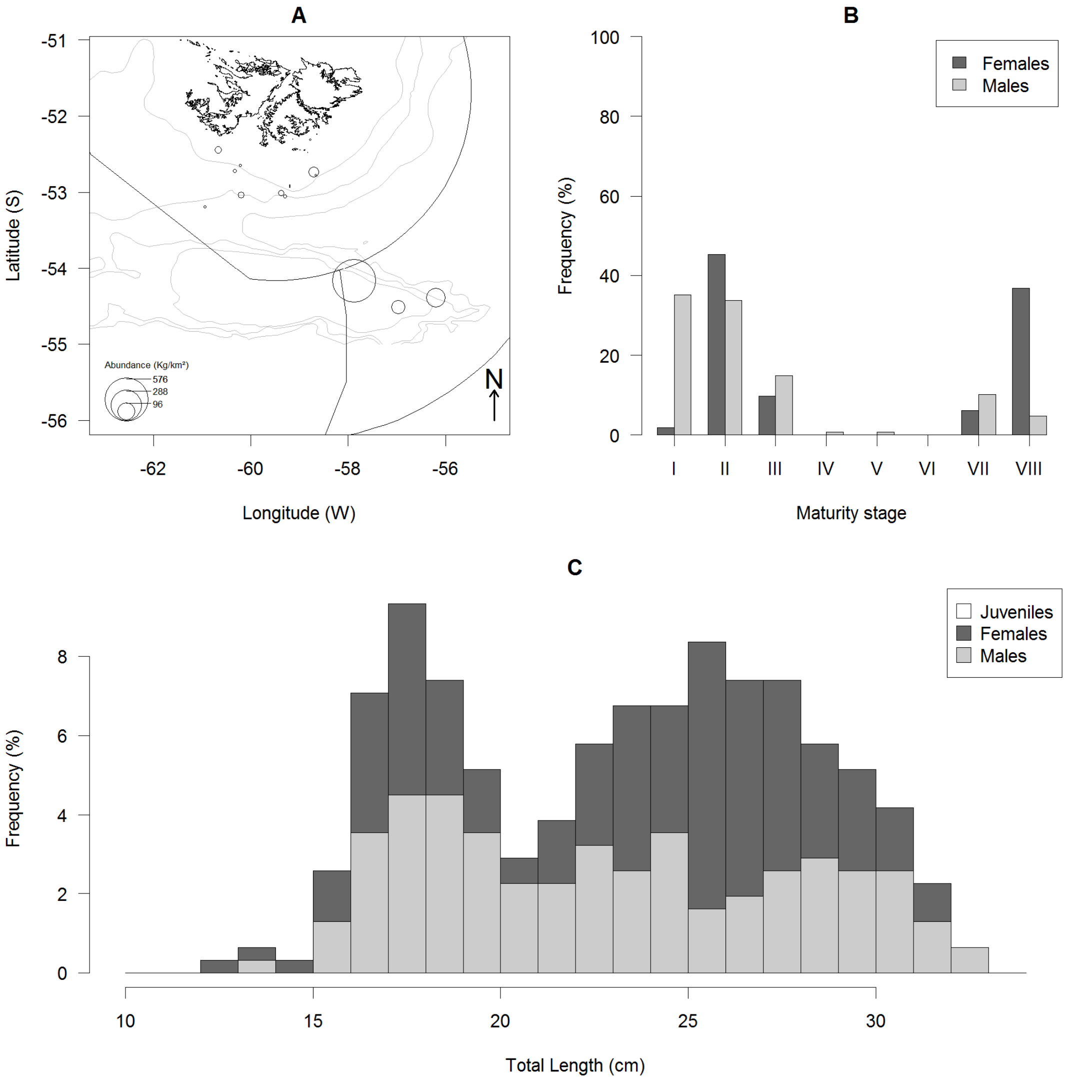

Figure 10: ***Patagonotothen ramsayi*** **relative abundance (A), Maturity distribution (B) and size frequency (C)**

Patagonotothen ramsayi

The common rockcod was caught at 15 stations, with 84.5kg caught in 14 of the semi-pelagic trawls and 0.6kg caught in 1 pelagic trawl. 11 stations were sampled. In total 312 specimens were assessed, with females ranging from 12-38cm (x=23.07cm) TL, and males from 13-32cm (x=22.38cm) TL. There was a very slight female predominance of 52.6%. Figure 10 displays all relevant detail for this species. Biologically the most interesting catch was that of station 1869 where a number of large M7 were caught. A plankton tow in the vicinity yielded a suspected *P. ramsayi* egg mass 70m below the surface (see also section 3.3.1).

3.3 Catch composition (Isaacs-Kidd trawls)

The 48 plankton tows (24 just below the surface, 24 in the backscattering layer if present) yielded a total wet weight of 5,765g (X-120g, range 1-876g). Table 4 summarises all species (or groups) caught grouped by their relative abundance.

Table 4: Catch summary for Isaacs-Kidd Midwater trawls (n=48)

Species code	*Latin Name*	Dominant (30-80%)	Abundant (5-30%)	Common (1-5%)	Occasional (<1%)	Rare (n=1-2)	Total
EUV	*Euphausia vallentini*	24	12	2	2	1	41
THE	*Themisto gaudichaudi*	3	2	6	21	8	40
FIN	Unidentified finfish	1	2	4	7	22	36
COA	Copepoda	2	5	6	6	11	30
PTR	Pteropoda			3	5	14	22
HYM	*Hyperoche medusarum*	1	1			18	20
SAL	*Salpa sp.*	3	2	5	4	6	20
SAM	*Sagitta maxima*	10	3	5	1	1	20
THV	*Thysanoessa vicina*	3	3	3	5	6	20
BEY	*Beroe spp.*			3	9	2	14
GYA	*Gymnosomata*			1	4	9	14
SAH	*Sagitta gazellae*	4	3	4	3		14
DEC	Decapoda				1	12	13
MNL	*Mnemiopsis leidyi*	1	1	1	5	5	13
SQX	Unidentied squid					13	13
PRM	*Prymno macropa*	1				10	11
THM	*Thysanoessa macrura*			1	3	7	11
PHS	*Phronima sedentaria*				1	8	9
ANN	Annelida				1	7	8
CTE	Ctenophora	4			1	1	6
ELU	*Euphausia lucens*		2		1	3	6
BRA	Brachyura					5	5
CHR	*Chrysaora cf. plocamia*	1	1	2	1		5
SAP	*Sagitta planctonis*	2	2	1			5
BEO	*Beroe ovata*			1	3		4
EUG	*Eurythenes gryllus*			1	2	1	4
THR	*Thysanopoda cristata*	1			2	1	4
THY	*Thysanoessa gregaria*		1			3	4
CYG	*Cyllopus magellanicus*					3	3
EUL	*Eurypodius latreillei*					3	3
PMB	*Protomictophum bolini*					3	3
POL	Polychaeta					3	3
SAT	*Salpa thompsoni*		1			2	3
THL	*Thysanoessa longicaudata*		1		1	1	3
VIB	Vibilia			1		2	3
PRA	Prawns				2	1	3
ANM	Anemone					2	2
EUH	*Eukronhia hamata*		1			1	2
MUU	*Munida subrugosa*					2	2
VIA	*Vibilia armata*					2	2
CAZ	*Calyptraster sp.*					1	1
EGG	Eggmass	1					1
EIR	*Eusirus properdentatus*				1		1
EUO	*Eurypodius longirostris*					1	1
GAX	*Galiteuthis sp.*					1	1
LEP	Leptostraca					1	1

MUN	*Munida spp.*					1	1
MXX	*Myctophid spp.*					1	1
NEE	*Nematoscelis megalops*					1	1
PAA	*Pandalopsis ampla*					1	1
PMC	*Protomictophum choriodon*					1	1
SRP	*Semirossia patagonica*					1	1
THB	*Thymops birsteini*	1					1
THC	Thecosomata	1					1
THN	*Thysanopsetta naresi*					1	1
VIU	*Vibilia australis*				1		1

3.3.1 Fish larvae and fry, abundance, distribution & morphology

A total of 501 pelagic larvae and fry were captured with an approximate size range between 5 and 120mm SL. It was possible to identify captured fish larvae to consist of a minimum of 14 species groupings. The abundance of fish (per 1000 m^3) captured at each of the stations have been plotted in Figure 11. The average number of fish captured per station was 10.44, however more than 50 fish larvae/fry were captured in three of the sampled stations (Stations 1848, 1858, 1863), while 0 fish were captured in eight stations. The majority of the fish were captured at the stations targeting the scattering layer (339) compared to those undertaken at the surface (162).

Within the three regions, the majority of larvae were captured in the easterly pathway (256) with 231 fish being captured at the scattering layer and 25 at the surface. Within the westerly pathway, 150 fish were captured (43 at the scattering layer, 107 at the surface) while 95 fish were captured over the Burdwood Bank of which 65 occurred at the scattering layer.

The majority of fish larvae captured were from the family Myctophidae consisting of 248 individuals (Figure 12). These were identified as a result of the laterally pigmented longitudinal gut, a ventrally placed of post-anal pigmentation and the distinguishing shape of the dorsal and anal fins (Figure 20) All the Myctophids were captured within the regions spanning the easterly pathway (203) and the Burdwood Bank (45). Over the Burdwood Bank, the majority of Myctophids were captured at the scattering layer (39), compared to the surface (6). This included a single haul of 22 individuals at station 1884 (Modal water depth of 794m). A total of 203 Myctophid larvae were captured within the eastern pathway including two hauls of 69 and 46 individuals at stations 1858 (Modal depth - 901) and 1863 (Modal depth - 1850). The significant majority of the Myctophids caught were within the scattering layer (201, average 11.2/haul) compared to at the surface (2). An additional 14 juvenile Myctophids were captured (Figure 13), 13 over the easterly pathway and a single specimen over the Burdwood Bank. All of these were captured within the scattering layer. Four individuals of Species 6 (Figure 14, Figure 21) were captured at the surface layer in plankton trawls along the eastern pathway. These individuals appear to potentially Myctophids at a less developed life stage.

The second most abundant grouping of individuals was identified as from the family Nototheniidae, most likely the common rockcod *Patagonotothen ramsayi*) (Arkhipkin et al., 2013). Identifying features included a dense row of melanophores above the urostyle, a lack of head pigmentation and a ventral lateral row of melanophores running along the length of the body (Figure 22). A total of 195 individuals were recorded throughout the sampling period with the majority occurring within the western pathway (134) compared to 41 individuals over the Burdwood Bank and 20 within the eastern pathway (Figure 15). All individuals occurring over the Burdwood Bank and eastern pathway were recorded in shallow waters of <140m apart from 2 individuals recorded in station1895 (modal depth – 497m). In addition an egg mass identified to likely be from rockcod was recorded in station 1873 on the eastern flank of the Burdwood bank in 70m below the surface, depth 156m. All the individuals sampled within the western pathway, including a single haul of 72 individuals at 486 m, occurred at depths <500m (224 – 486 m) apart from one individual captured at 567 m. Throughout the three regions 57 individuals were captured from within the scattering layer compared to 138 at the surface.

Other species of note captured during the cruise included 4 *Cottoperca gobio* occurring in the surface layers of stations 1826 (1 individual), 1874 (2 individuals) and 1893 (1 individual; Figure 16; Arkhipkin *et al*., 2015). Four grenadier larvae were captured in the western pathway in the scattering layer during station 1844 (modal depth – 560 m; Figure 23). Two flatfish specimens were recorded in the eastern pathway during stations 1855 (modal depth – 1710 m) and 1856 (modal depth – 1665 m; Figure 17; Figure 24). Two *Protomictophum bolini* were captured in the scattering layer of two stations (1865 and 1897) occurring along the eastern pathway (Figure 18). Additionally a single *Echiodon cryomargarites* was captured in the western pathway (station 1847) and a *Protomictophum choriodon* in the eastern pathway (1865).

Twelve individuals were captured from an as of yet, unidentified species grouping (Figure 19). These individuals possessed distinctive black pigmentation along the tail (Figure 25). There is a strong likelihood that these individuals may be a mix of a number of species.

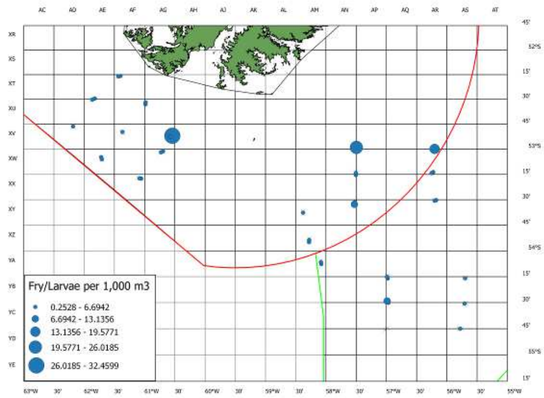

Figure 11: Total rate of abundance

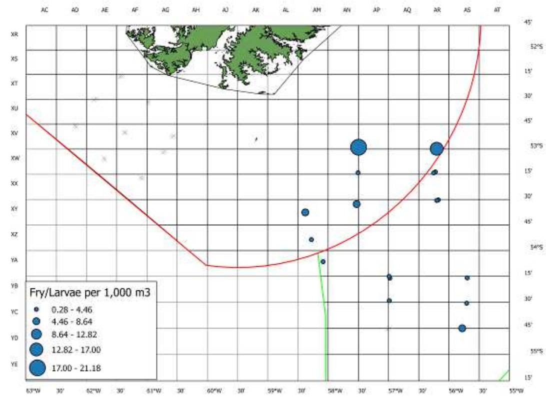

Figure 12: Myctophidae

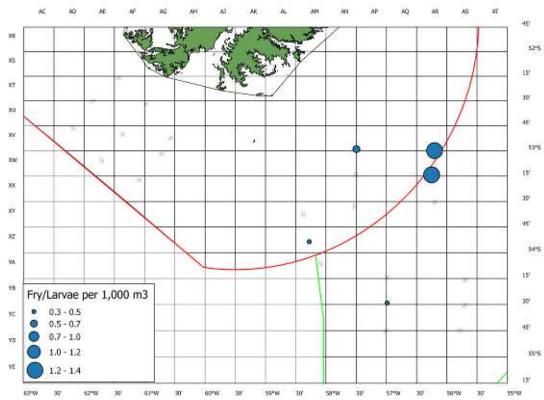

Figure 13: Myctophidae-juvenile

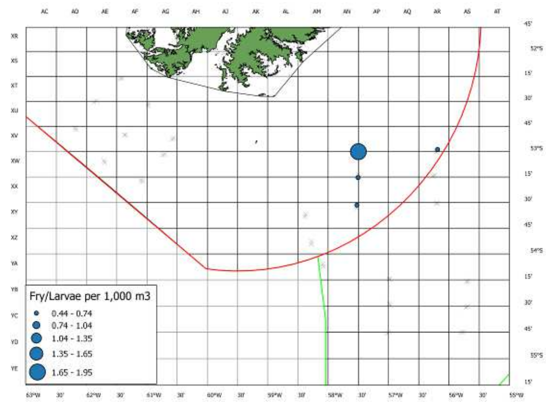

Figure 14: Likely Myctophidae (Sp. 6)

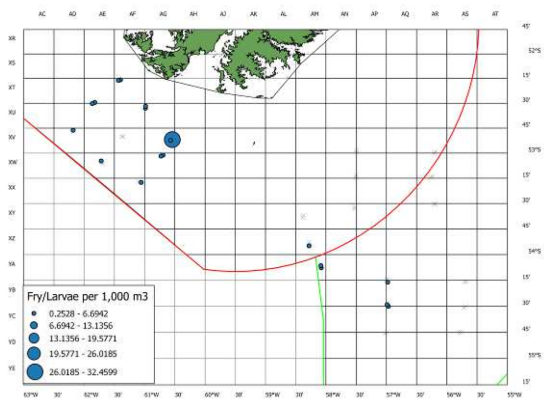

Figure 15: Nototheniidae (*Patagonotothen ramsayi?)*

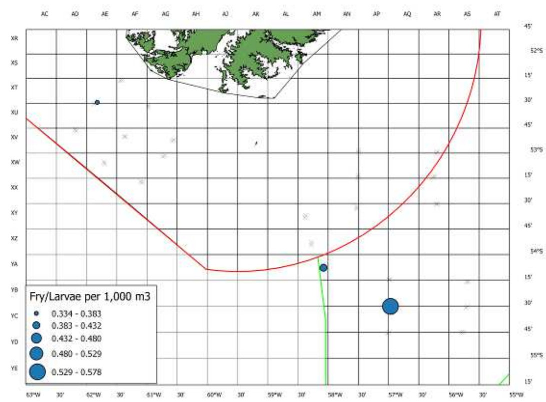

Figure 16: *Cottoperca gobio*

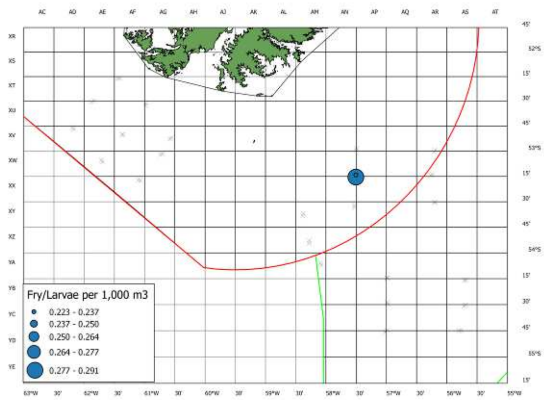

Figure 17: Flatfish

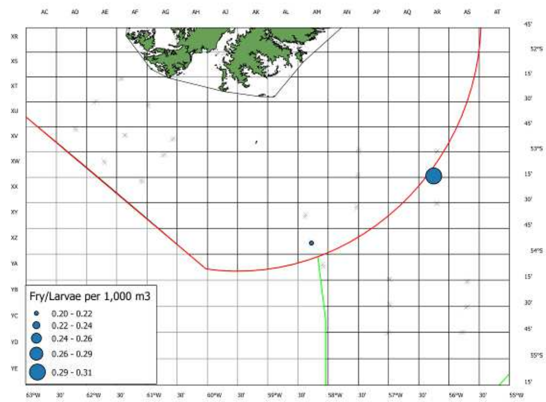

Figure 18: ***Protomictophum bolini***

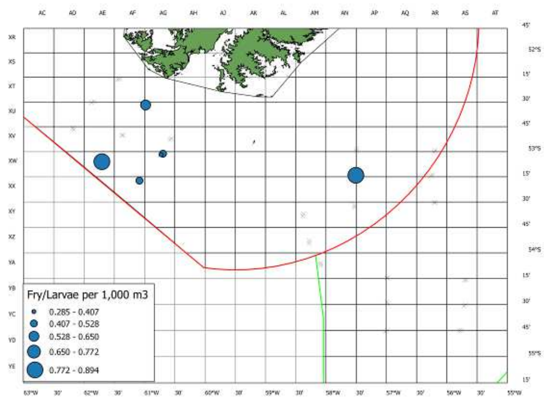

Figure 19: Species 3 (Unknown)

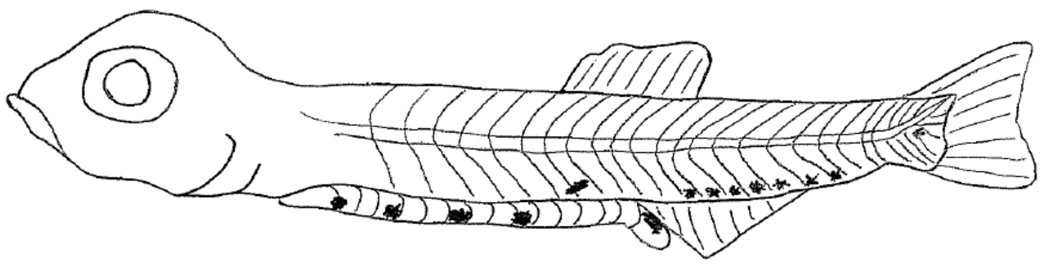

Figure 20: Drawing of sampled Myctophidae of 15 mm SL

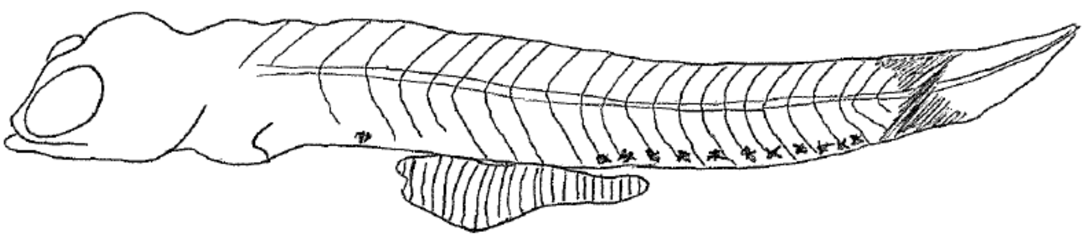

Figure 21: Drawing of sampled Myctophidae of 10 mm SL

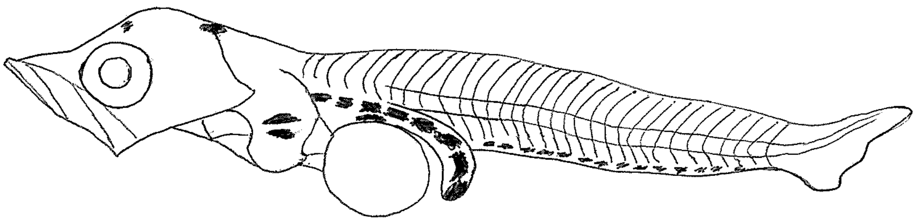

Figure 22: Drawing of sampled Nototheniidae of 14 mm SL

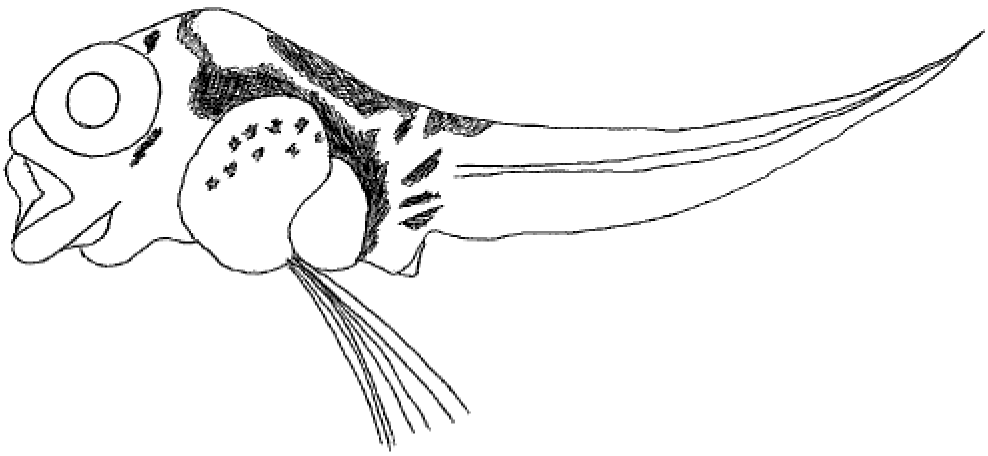

Figure 23: Drawing of sampled grenadier of 13 mm SL

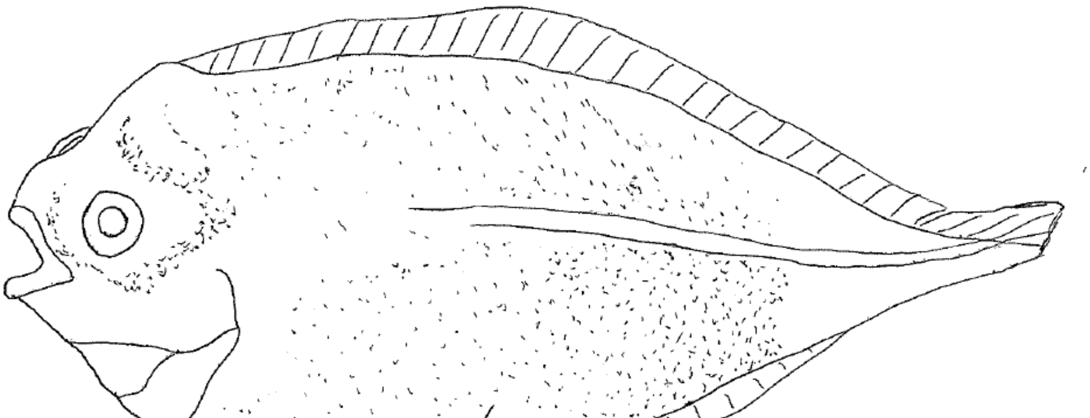

Figure 24: Drawing of sampled flatfish of 18 mm SL

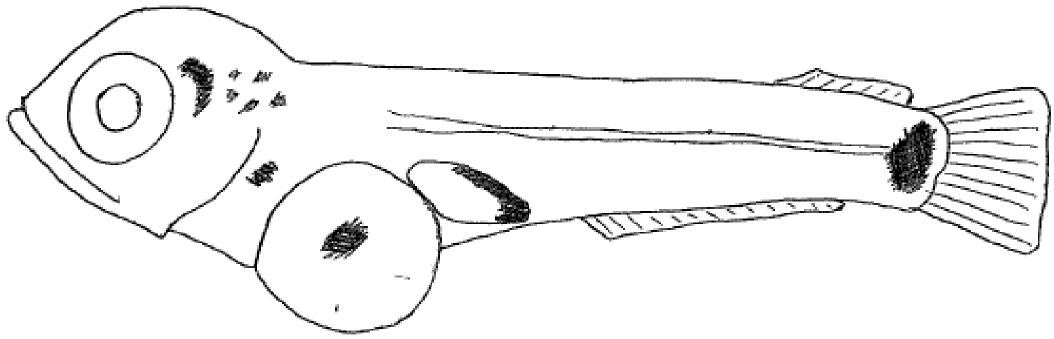

Figure 25: Drawing of unidentified species grouping of 18 mm SL

3.3.2 Zooplankton, abundance & distribution

A list of all zooplankton collected during the research cruise can be found in Table 4. Plankton trawls were conducted at 48 stations, within which 56 different species or species groups were found (including larval fish species and egg masses). Distribution maps for a selection of the most common and notable zooplankton species have been plotted (Figures 26-37). A number of species were found widely throughout samples while others were less common. Macro zooplankton such as SQX occurred on an individual basis. Not one species occurred in all samples.

During the observation period, *Themisto gaudichaudi* (Figure 26) and *Euphausia vallentini* (Figure 27) were the most dominant zooplankton biomass. Copepods were also found in abundance (Figure 29); visual analysis under the dissection microscope identified at least 4 different species of copepod; however these were too small in size to identify to species level on a working vessel. Chaetognatha were a common constituent of the samples and contributed a substantial amount to sample biomass due to their large size (*Sagitta maxima;* Figure 32 and *S. gazellae*; Figure 33 were the most common). The species of Chaetognatha represented in the sample varied spatially with *Sagitta maxima* prevalent in the south easterly stations and *Sagitta gazellae* present in the westerly stations.

Euphausidae and Amphipoda were the most commonly represented groups. There were 8 species of Euphausidae found; two species of the genus *Euphausia* (with *E. lucens* only observed in the most southerly stations; Figure 37) and four species of the genus *Thysanoessa*. The *Thysanoessa* spp. represented in the sample varied spatially with *T. macrura* (Figure 34) and *T. vicina* (Figure 35), the most commonly identified of this genus, found in alternate stations and *T. gregaria* (Figure 36) found solely along the Burdwood bank. There were 9 species of amphipod found; *Hyperoche medusarum* was collected in 20 stations (though were rare in all locations; Figure 30) and there were 3 species of the genus *Vibilia*.

Gelatinous species such as *Salpa thompsoni* were collected in few stations though in high abundance. A total of 8 different species of ctenophores were identified with unidentifiable individuals (due to damage) grouped under Ctenophora (Figure 31). In all the stations that *Phronima* spp. were found, gelatinous species were also present. Stations containing *Hyperoche medusarum* usually contained Ctenophora or *Beroe* spp.

Pteropoda (Figure 28) were a common component of the samples but were often found in low abundance, no more than 5 individuals at a time. They were found both in the sub-order Thecosomata and Gymnosomata. Decapoda larvae were similarly present in many stations though in low abundance, and were most often in the early zoeal stage of development.

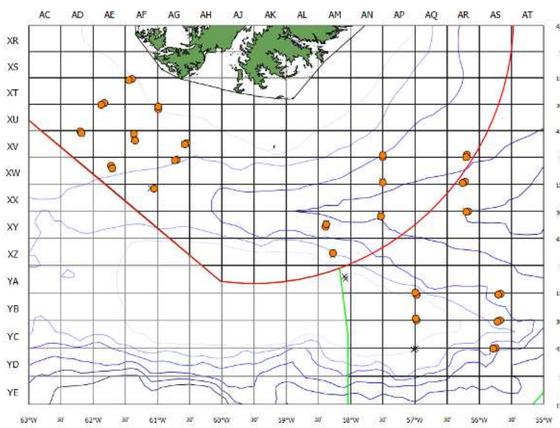

Figure 26: *Themisto gaudichaudi*

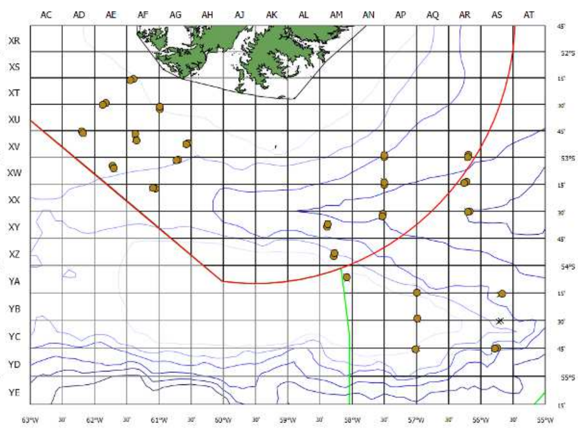

Figure 27: *Euphausia vallentini*

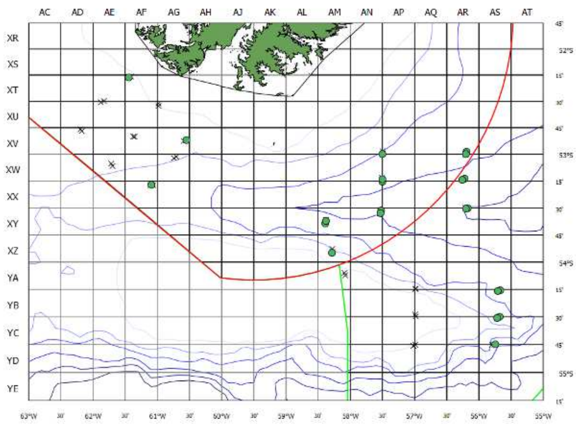

Figure 28: Pteropoda

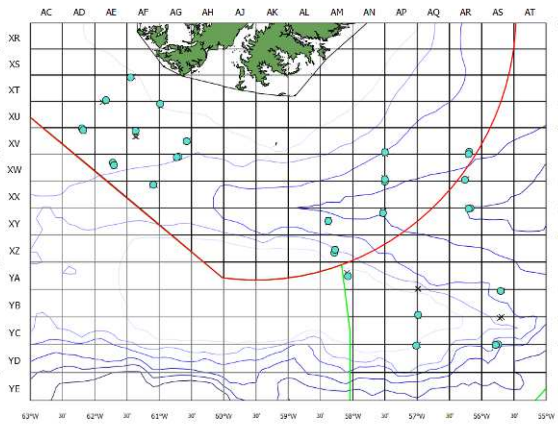

Figure 29: Copepoda

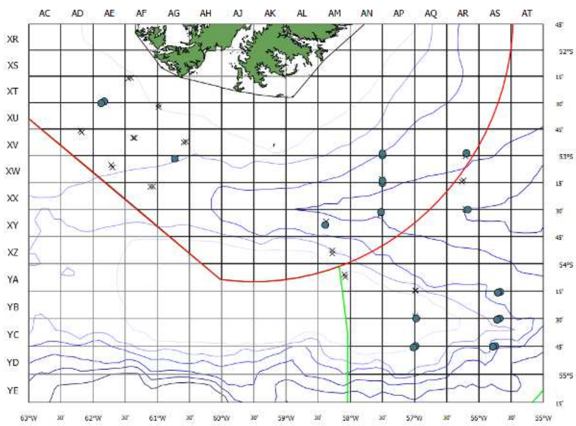

Figure 30: ***Hyperoche medusarum***

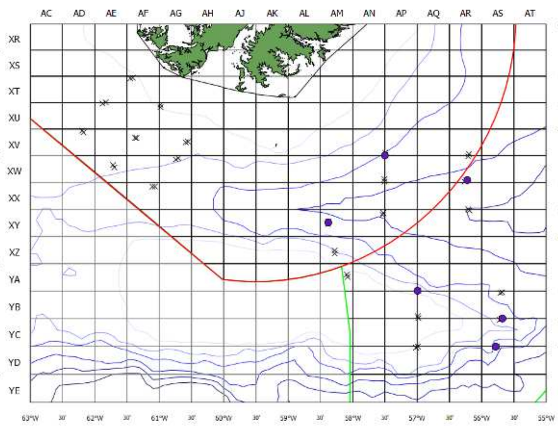

Figure 31: Ctenophora

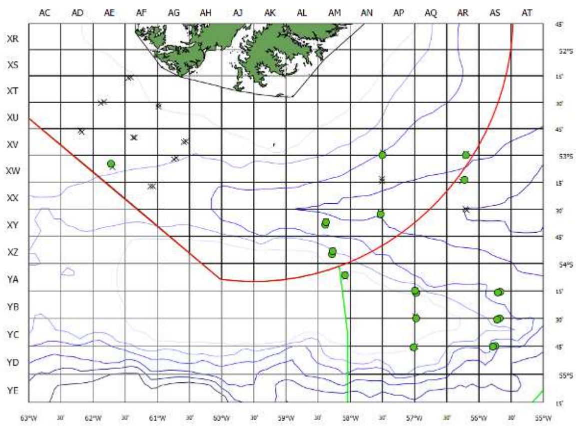

Figure 32: ***Sagitta maxima***

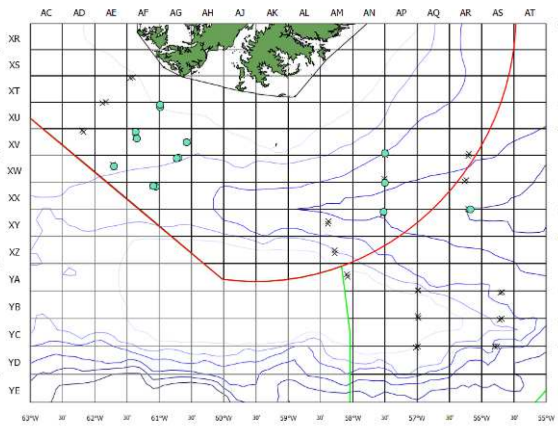

Figure 33: ***Sagitta gazellae***

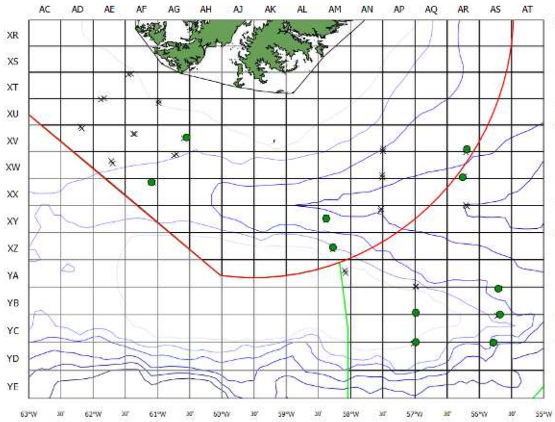

Figure 34: ***Thysanoessa macrura***

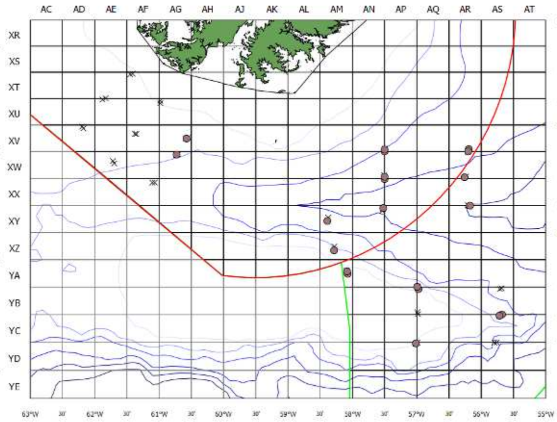

Figure 35: ***Thysanoessa vicina***

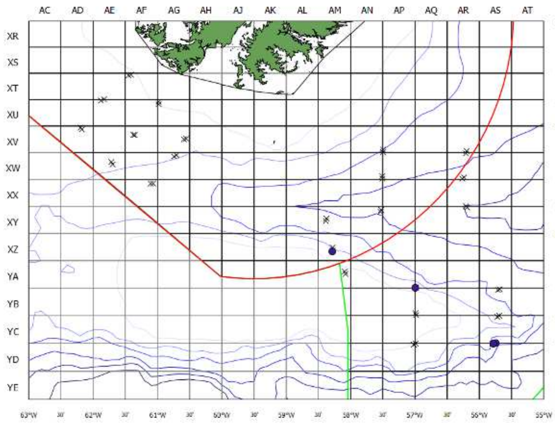

Figure 36: ***Thysanoessa gregaria***

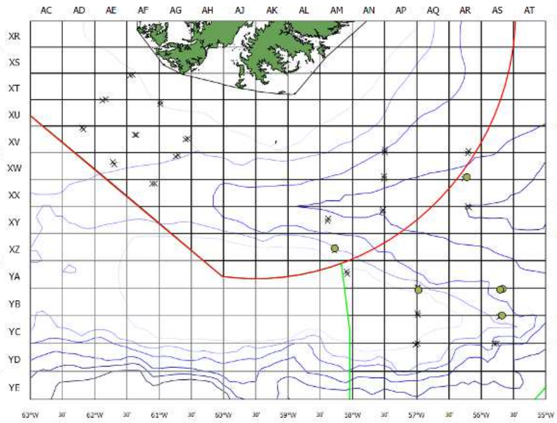

Figure 37: ***Euphausia lucens***

3.7 Oceanography

Oceanographic data were collected at 88 stations. The area covered ranged from 48° 3.13'S to 52° 28.39'S and 56° 53.89'W to 63° 26.45'W. Good data were collected on all the downcasts and so upcast data were removed. The CTD had an issue coping with a strong thermocline with salinity spiking similar to that experienced on the Research Cruise in October and November 2014. Figure 38 below shows the location of the stations.

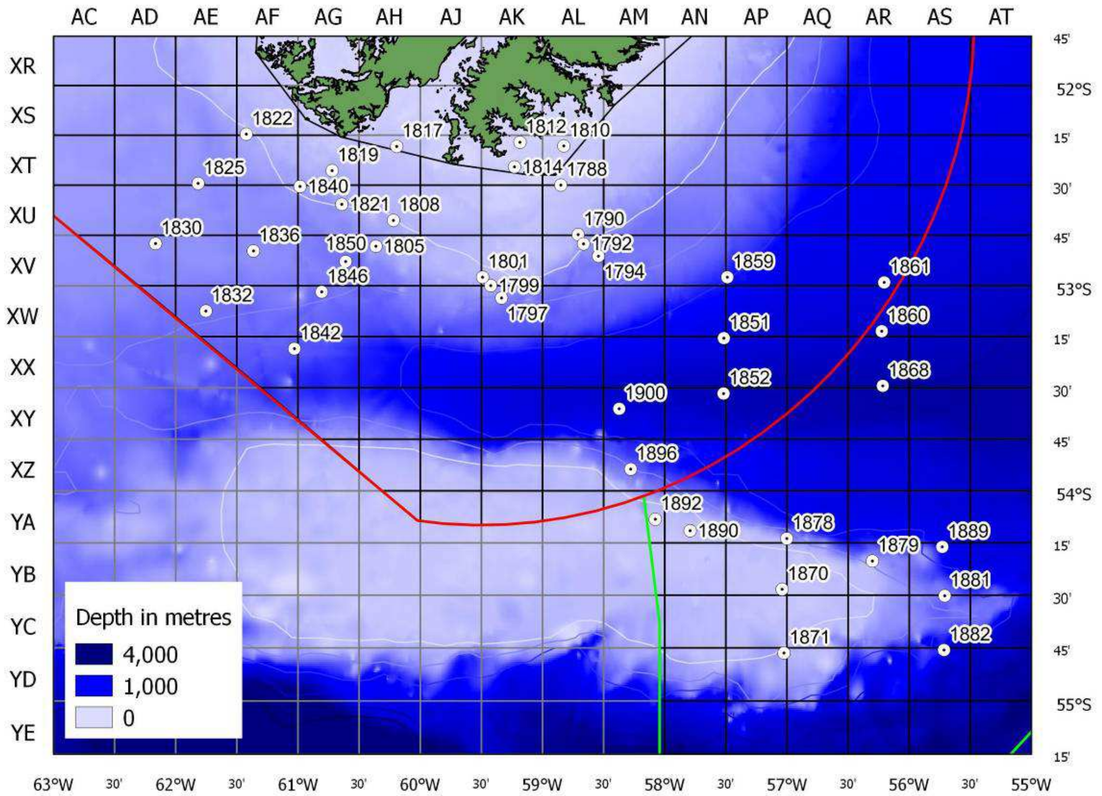

Figure 38: Location and number of CTD stations

Figure 39, Figure 40, and Figure 43 show the temperature, salinity and σ-t density, gridded using ODV4 DIVA[1] gridding algorithm, at depths 10, 50, 100 and 200m. The first layer at 10m is the shallowest depth common to all CTD casts. The surveyed area covered a large depth range, for this reason seabed interpolations largely reflect water depth changes, and do not add to the understanding of the overall environment.

[1] DIVA is a gridding software developed at the University of Liege (http://modb.oce.ulg.ac.be/projects/1/diva)

Generally the maps show warm low salinity water on the shelf around the land mass, with the waters away from the land mass in the trough and over the Burdwood bank being cooler and higher salinity at each depth.

Surface temperature is higher in the north-west and decreases to the south and east. Of interest is the high surface temperature centred near station 1836. Examination of the temperature profile shows this high temperature only occurs in the first 15 metres of station1836 (and so appears on the 10m interpolated surface), at the station 1832 the temperature is similar but the layer disappears above 10m and at 1840 the temp is 0.3°C lower at 10m. The inset below in Figure 39 shows the temperatures at the minimum depth recorded.

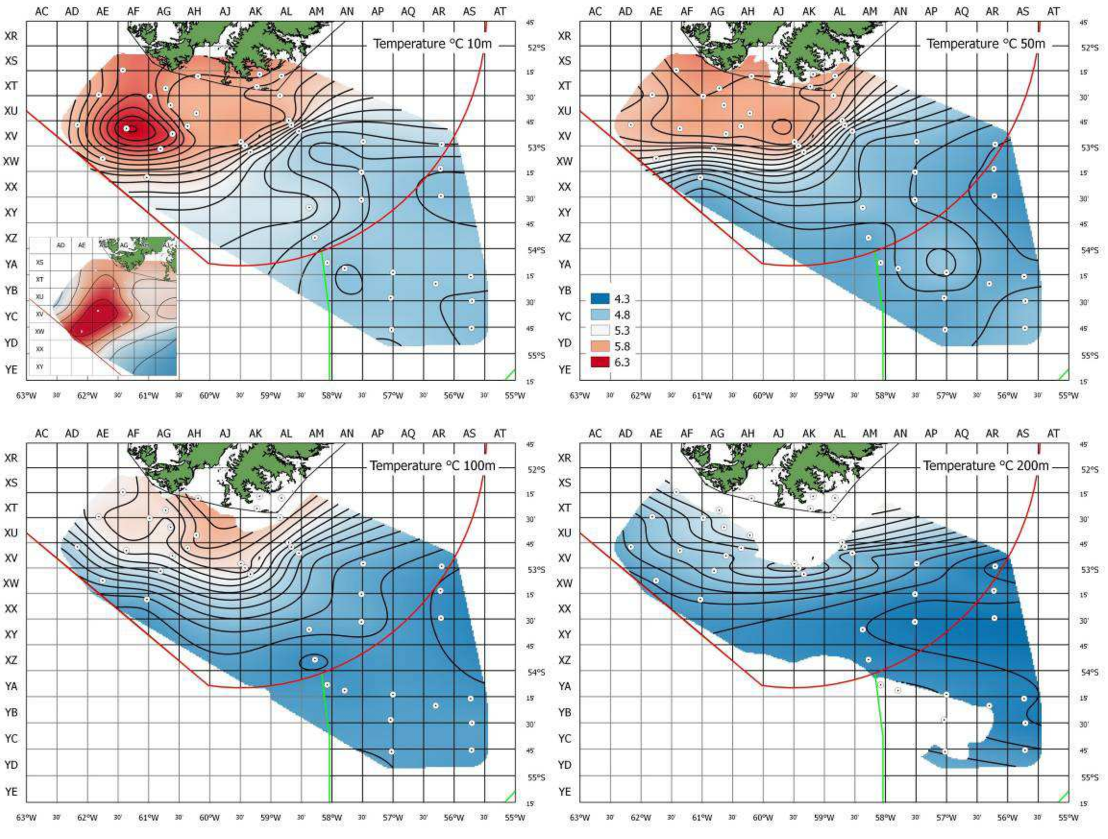

Figure 39: Temperature at 10m, 50m, 100m and 200m (contours at 0.1°C)

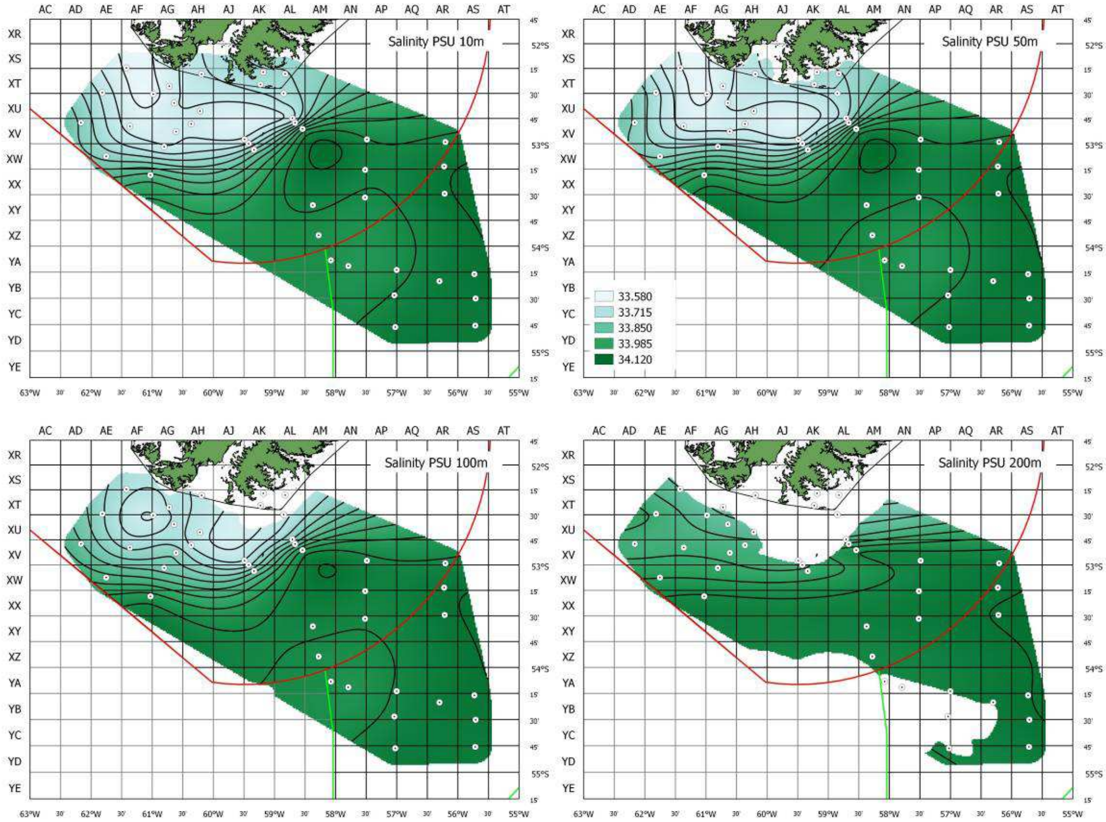

Figure 40: Salinity at 10m, 50m, 100m and 200m (contours at 0.05 PSU)

Figure 40 above shows the salinity over the surveyed area. Generally salinity was lower in the waters on the shelf close to the Falklands, whilst over the Burdwood bank and over the deeper waters the salinity was higher, and fairly uniform.

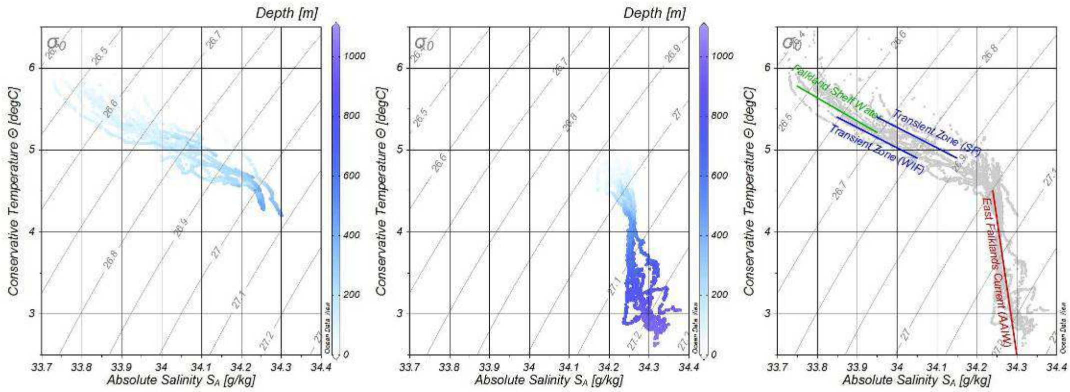

Figure 41: TS plots, stations 1788-1850left and 1851-1900 middle, Water mass profiles right

A plot of conservative temperature against absolute salinity is shown in Figure 41 above, which shows a clear split between the water masses, with 1 potential slight cross over (outlined in red). Stations 1790 to 1850 are at the junction of the Southern Front and the Western Inshore Front. Stations 1851 to 1900 are generally in eastern branch of the Falklands Current, and show the characteristics of the Atlantic-Antarctic intermediate waters that make up the current. (Arkhipkin et al 2013, Arkhipkin et al 2004). The Isopycnal density lines suggest that the water seen at the bottom of the cast (practically seabed) in the deeper stations up to station 1850 is the same water mass that is seen in the 100-200m after station 1851, the 34.2-34.3g/kg salinity, c.4.5°C and 31.6 sigma-t Density. As can be seen in Figure 42 below, the water depth the maximum depth is similar in both areas and varies considerably. However in the northern and western stations the water body is overlain by a considerable quantity of other water, whilst in the south-east these water bodies are generally closer to the surface. Stations 1870 and 1892 were in shallow water, so the water mass reached to the sea floor.

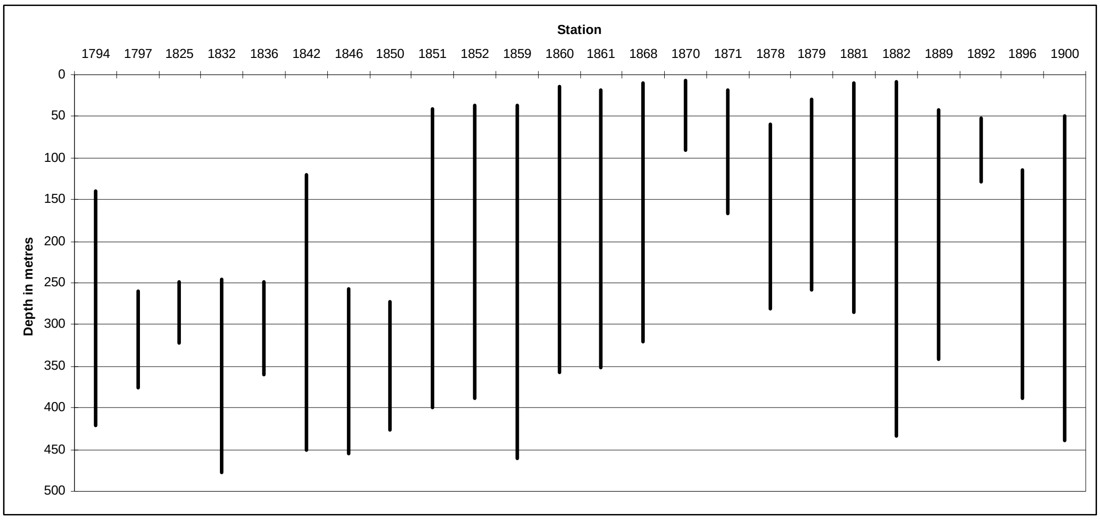

Figure 42: Depth where water in 34.2-34.3g/kg (absolute salinity) and conservative temp 4.2 to 4.8 °C encountered

The density map below shows lower density water at 10 and 50 metres over the shelf near the coast, reflecting the higher temperatures and lower salinity seen in Figure 39 and Figure 40. Away from the coast the higher density water can be seen pushing under the other water masses and at 200m the covers the majority of the area.

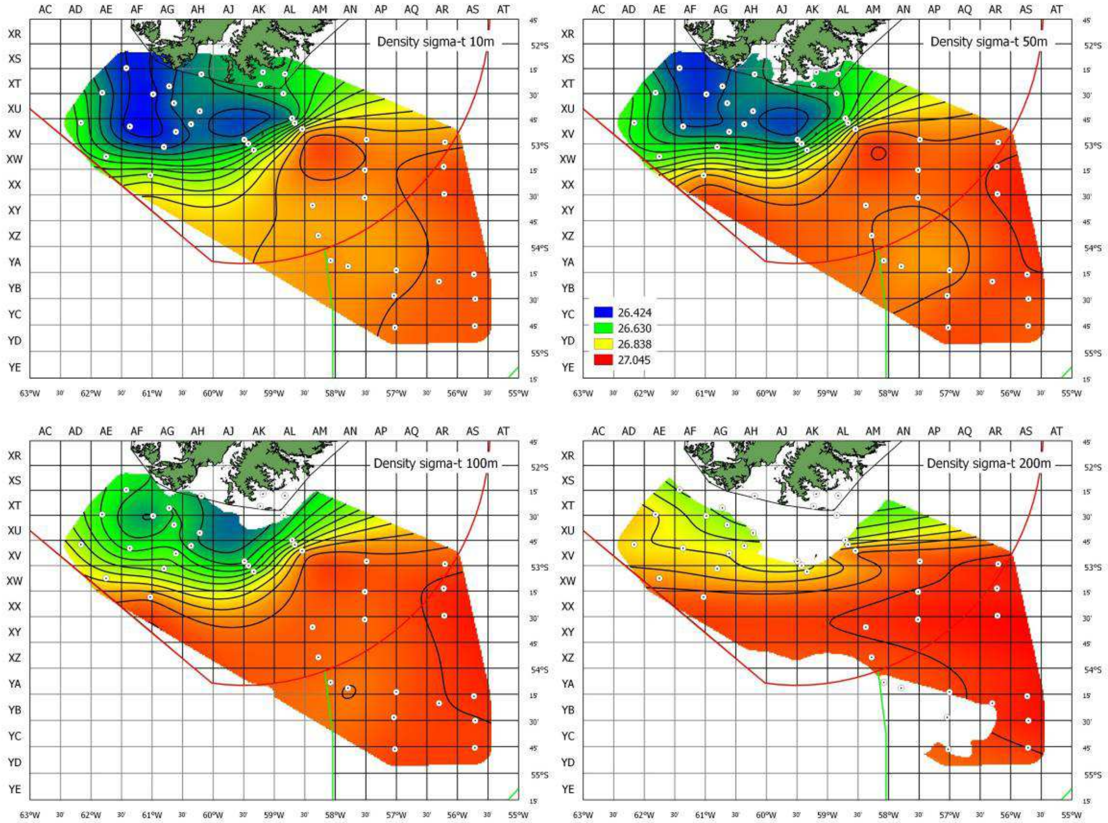

Figure 43: Density at 10m, 50m, 100m and 200m (contours at 0.05 sigma-t)

Figure 44 below shows the oxygen level at 10, 50, 100 and 200 m in ml/l of water. Oxygen concentration is highest at station 1836 at 10m water depth, where the highest temperature water was also seen (Figure 39). Away from this station the level is 0.3-0.5 ml/l lower at 10 metres. At 10m and 50m the higher oxygenation occurs in the north of the surveyed area, but as depth increases oxygenation falls quickly in the north, whilst in the south-east the oxygenation level is consistent over the depth range 10-200m seen in the maps, ranging between 6.83 and 7.27ml/l. Only when the south eastern stations reach there maximum depth does the oxygenation level fall, with the minimum oxygen level of 5.50ml/l.

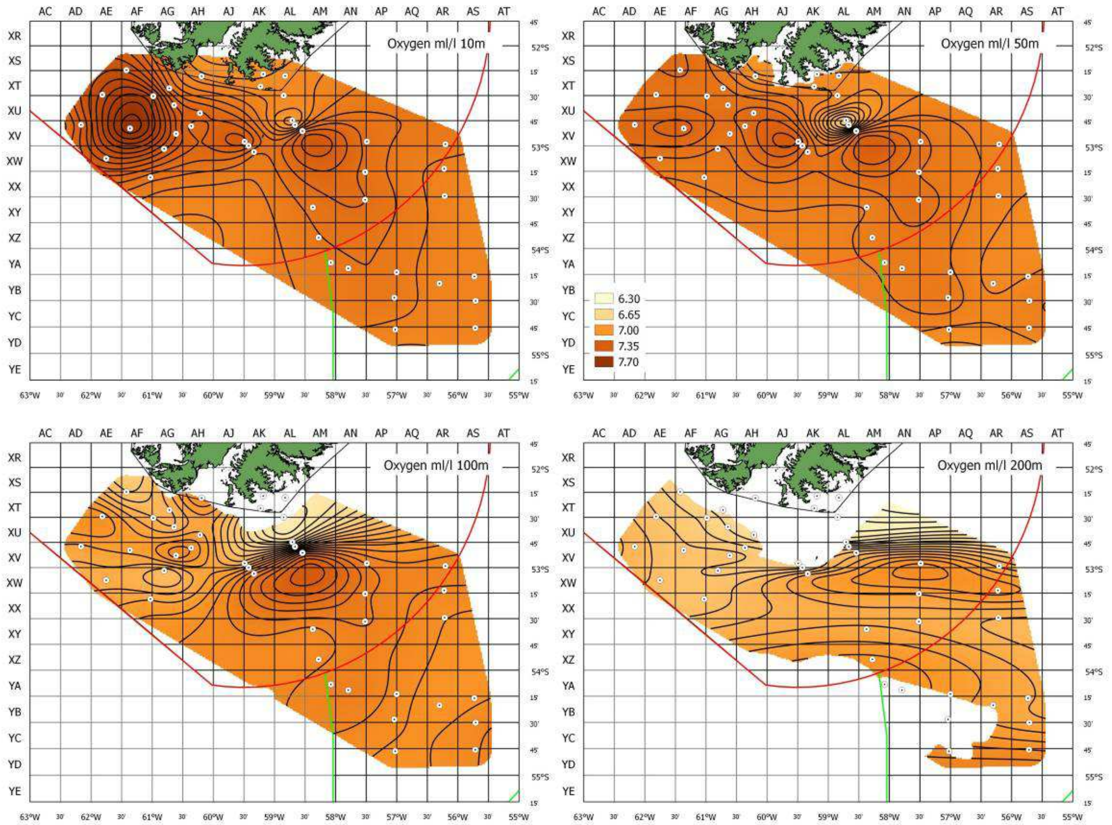

Figure 44: Oxygen at 10m, 50m, 100m and 200m (contours at 0.05 ml/l)

4.0 General conclusions and discussion

The distribution of zooplankton is influenced by many factors; depth, temperature, currents, food and light availability. There are several highly productive meso-scale fronts associated with both branches of the Falkland current system where the sampling was conducted (Arkhipkin *et al.*, 2012), resulting in abundant and diverse plankton and zooplankton communities in this area. This is reflected in the data with large sample wet weights.

The most common species found within this observation period, *E. vallentini* and *T. gaudichaudi,* have been found in previous studies within Falkland Island Waters. These species, as well as *E. lucens* and *T. gregaria* which were also common constituents within the sample, are known to be associated with sub-Antarctic waters and are an important food resource within the area (Philips *et al.,* 2003; Arkhipkin *et al.*, 2012).

The composition of the zooplankton communities varied spatially, with some species more prevalent in the east and others more prevalent in the west, potentially associated with different current systems. Other species often associated with cooler Antarctic waters, such as *E. lucens* and *S. thompsoni* were only found in the most southerly stations. *S. thompsoni* were found in few southerly stations though in high abundance as individuals form chains within the water column.

Two species of amphipod; *Hyperoche medusarum* and *Phronima sedentaria* were only found within stations where ctenophores were present. There are known associations between these species and gelatinous species where amphipods have been reported encased within their ctenophore host (as observed during this research cruise; Brusca 1970).

In future studies, it would be useful to better quantify the abundance of the zooplankton found within samples and their contribution to the total weight of the sample. However, this would involve extensive sorting which may not necessarily be appropriate where time is limited and vessel movement makes sorting of samples challenging.

In the Falkland Islands fishing zones, Patagonian toothfish spawn on and around the Burdwood Bank between July and August (Laptikovsky *et al*., 2006). Although fecundity in the Falkland Islands has not been recorded, this is estimated to range from 48,000 to more than 500,000 eggs varying with fish length (Koch et al., 1985; Evseenko *et al*., 1995). In spite of the high fecundity reported by Patagonian toothfish, catches of eggs and larvae are very sparse (Evseenko *et al*., 1995; North, 2002).

Despite the large number amongst around 15 species of larval fish captured throughout the sampling period, no Patagonian toothfish eggs or larvae/fry were taken during the current cruise. The only recorded capture of Patagonian toothfish larvae in the Falkland Islands occurred during a research cruise undertaken by the British Antarctic Survey on 13 December 1997 (North, 2002). During this cruise three individuals were captured at the surface layer (0 – 3 m depth) over the Burdwood Bank. However, the amount of effort undertaken was not given in the study. At South

Georgia, between 1978 and 2001, only 38 specimens of pelagic early stage Patagonian toothfish were captured during the 15 cruises there in spite of hundreds of thousands of the early stages of other species being captured. Based on eggs and larvae of Patagonian toothfish sampled off South Georgia, incubation is predicted to last three months.

Results from larval surveys around South Georgia indicate that eggs and larvae may be patchily distributed within the surface of the water column meaning that a high amount of effort is required in obtaining erratic abundance of specimens. Another possible reason could be that the survey was undertaken too early in relation to spawning and dispersal of the eggs and larvae along the two pathways.

A clear pattern was evident in the catches of the two most abundant species groups, Myctophids and Notothenids (rockcod). Myctophids were almost exclusively taken along the eastern corridor and around the slope of the Burdwood bank. Specimens were generally captured from within the scattering layer in hauls undertaken over water deeper than 500m. Myctophids are typically mesopelagic with high concentrations of adults known to occur at deep waters during the day, rising in the water column to depths less than 50 m during the night where they feed on phytoplankton in the scattering layer (Pablo Reyes and Mathias Hune, 2012). Juveniles and larvae have been recorded feeding in the upper layers (>50 depth) of waters around South Georgia during the night.

Notothenoid species occurred almost exclusively along the western corridor and over the Burdwood Bank. Despite limited numbers of individuals being sampled along the eastern pathway, these were limited to two sampling sites just to the north of the Burdwood Bank. Evidence suggests that rockcod may be spawning over the Burdwood Bank with post spawning adults being observed during semi-pelagic trawls and an egg mass subsequently being observed in the same location. Although larval Notothenoids were observed in the water column just to the north of the Burdwood Bank, future observations will be required to identify linkage between these spawning individuals and the high abundance of larvae found along the western pathway.

Limited literature is available in order to identify larval fish to the species level within the Falkland Islands, thus further investigation by larval fish experts on retrieved samples needs to be undertaken to further describe and investigate the samples retrieved on a finer scale.

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