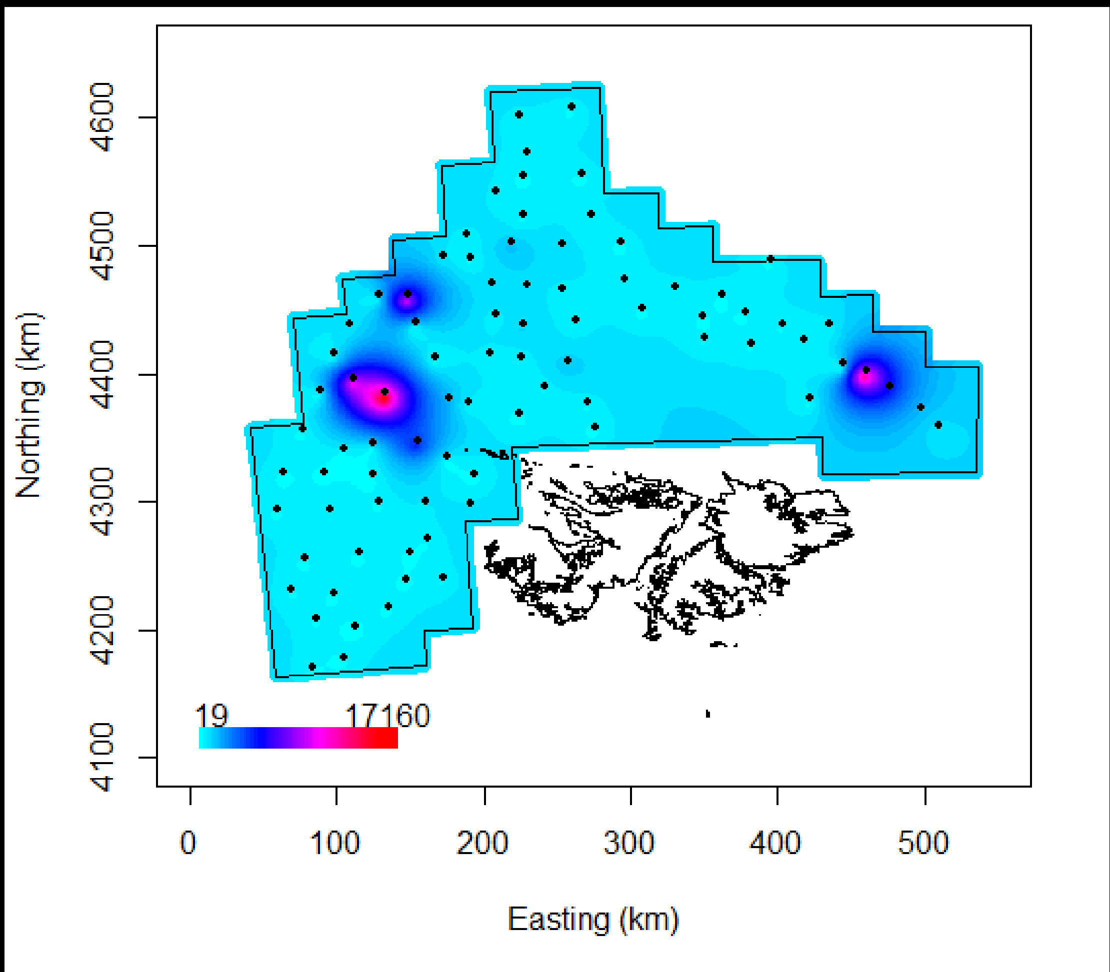
Cruise Report ZDLT1-10-2014

Rockcod Biomass and Biological Survey



Joost Pompert, Michaël Gras, Alex Blake & Eva Visauta

Falkland Islands Government
Directorate of Natural Resources
Fisheries Department
Stanley
Falkland Islands

Participating Scientific Staff

Joost Pompert	Cruise scientist
Dr. Michaël Gras	Rockcod biomass assessment & Trawl Survey
Alex Blake	Oceanography & Trawl Survey
Eva Visauta	Trawl Survey
Brendon Lee	Trawl survey and data handling
Jessica Jones	Trawl Survey and e-board operations
Denise Herrera	Trawl Survey and e-board operations

Acknowledgements
We thank Captain José Vincente Santos Reiriz and officers and crew of the *FV Castelo* for all of their work, assistance and humour.

Report authors
Joost Pompert: Sections 1.0, 1.1, 2.1, 2.2, 2.3, 3.1, 3.1.1, 3.1.2, 3.1.3, 3.1.4, and editor
Dr. Michael Gras: Sections 2.4.1, 3.2, 3.3, 3.4, 3.5, 3.6
Alex Blake: Sections 2.5, 3.7 and maps in sections 3.1, 3.1.1, 3.1.2, 3.1.3, 3.1.4
Eva Visauta: Size frequency graphs in sections 3.1, 3.1.1, 3.1.2, 3.1.3, 3.1.4

For citation purposes this publication should be referenced as follows:

Pompert, J., Gras, M., Blake, A., and Visauta, E. (2014). Scientific Report, Fisheries Cruise ZDLT1-10-2014. Stanley, Fisheries Department, Directorate of Natural Resources, Falkland Islands Government.

Contents

1.0 Introduction

Rockcod has since 2007 been the most abundant finfish species caught in the Falkland Conservation Zones, with total annual amounts (2007-2013) ranging from 30,157t in 2007 to 76,456t in 2010. In the Fisheries licensing advice for 2011 (Paya et al. 2010) a different approach was taken to calculate allowable effort in the general finfish fishery. Prior to 2011, catch and effort data of Southern Blue Whiting (*Micromesistius australis*) formed the basis from which to calculate allowable effort in the finfish fishery. However, a dramatic decline in the SBW stock since 2004 and a concurrent shift in the targeting by the finfish fleet required the FIFD to re-examine its management procedures. It was decided to change the management of the effort allocation in the finfish fishery from one based on Southern Blue Whiting to one based on Rockcod, and in subsequent years' licensing advice this basis has to date been maintained. Two dedicated Rockcod biomass surveys were conducted in February 2010 (Brickle & Laptikhovsky 2010), and February 2011 (Arkhipkin et al. 2011). The February 2010 Rockcod biomass survey on the RV Castelo occurred while at the same time a Loligo pre-recruitment survey took place on the FV Beagle FI. The combined datasets from these two surveys were used to establish a Rockcod biomass (Winter et al. 2010).

Besides these two biomass surveys on the Castelo, a further 6 Rockcod related surveys were conducted, primarily with the aim of arriving at suitable fishing gear advice (Brickle & Winter 2012; Roux et al. 2012a; Roux et al. 2012b; Roux et al. 2013a; Roux et al. 2013b; Roux et al. 2013c). These gear trials have resulted in new mesh regulations, which will come into force in 2015.

A research survey was undertaken by 7 FIFD personnel on board the RV Castelo between 18 October and 8 November 2014. The main aim of the cruise was to estimate the biomass of rock cod present on their feeding grounds in the western, northern and north western parts of the FICZ and to compare the results with those arrived at in the February 2010 and 2011 Castelo surveys.

1.1 Cruise objectives

1. To examine the distribution, biology and biomass of rock cod (*Patagonotothen ramsayi*) on their feeding grounds.
2. To examine the distribution, biomass and biology of other commercial species encountered during the survey.
3. To carry out an oceanographic survey of the study area.

2.0 Methods

2.1 Cruise vessel and region

The Rockcod biomass and biological survey was conducted onboard the FV Castelo (LOA 67.8m, GRT 1,321) between 19 October and 7 November 2014. In February 2010, as well as in February 2011, the same vessel had been used for a Rockcod biomass survey within the FICZ (Arkhipkin et al. 2011; Brickle & Laptikhovsky 2010). In order to have a comparable dataset to those previous two surveys, it was decided to repeat 79 of the trawls conducted in the 2011 survey, and add 4 trawls in the Northern shelf area that falls within the FOCZ. Three non-randomly selected trawls were added in Northern region to try and catch spawning and egg capsule carrying female *Bathyraja griseocauda* (Figure 1).

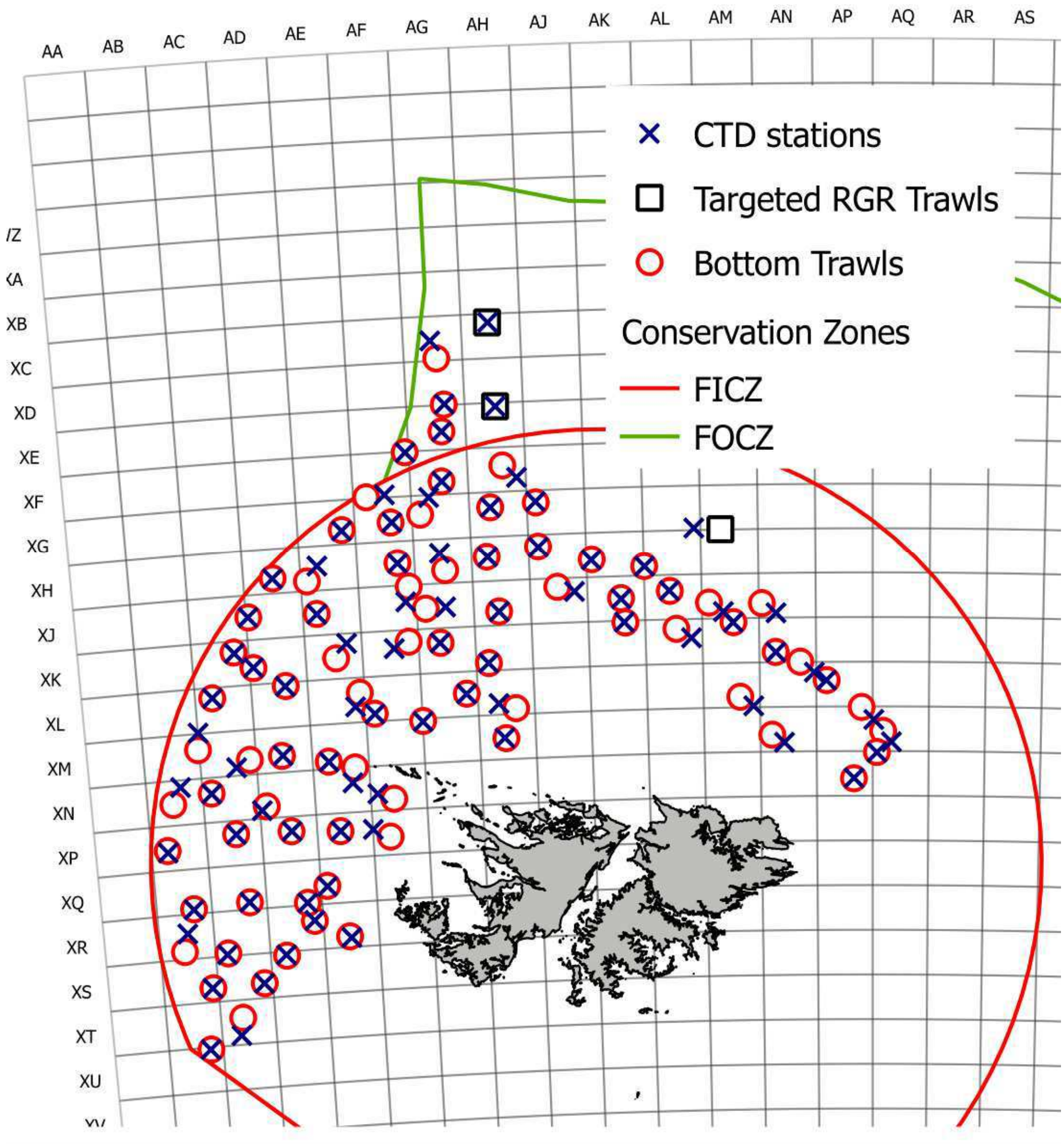


Figure 1: Locations of Bottom Trawls and CTD stations.

Table 1: Trawl station details. CTD's were also conducted at each trawl station.

Station	Date	Lat (°S)	Lon (°W)	Modal Depth	Duration	Activity	Comments
1388	19/10/14	51.92	61.77	174	60	B	
1390	19/10/14	51.86	62.10	259	60	B	
1392	19/10/14	52.04	62.34	269	60	B	
1394	19/10/14	52.18	62.61	259	60	B	
1395	20/10/14	52.37	62.81	276	60	B	
1398	20/10/14	52.49	63.12	269	60	B	
1400	20/10/14	52.15	63.05	235	60	B	
1402	20/10/14	51.97	62.87	224	60	B	
1403	21/10/14	51.94	63.27	204	60	B	
1406	21/10/14	51.71	63.14	194	60	B	
1408	21/10/14	51.70	62.62	215	60	B	
1410	21/10/14	51.72	62.11	198	60	B	
1412	21/10/14	51.64	61.91	170	60	B	
1413	22/10/14	51.39	61.38	140	60	B	
1416	22/10/14	51.35	61.83	196	60	B	
1418	22/10/14	51.33	62.27	203	60	B	
1420	22/10/14	51.34	62.76	180	60	B	
1422	22/10/14	51.37	63.34	161	60	B	
1423	23/10/14	51.12	63.26	152	60	B	
1426	23/10/14	51.09	62.89	169	60	B	
1428	23/10/14	51.17	62.40	191	60	B	
1429	23/10/14	51.02	61.63	150	60	B	
1431	24/10/14	51.18	61.32	133	60	B	
1434	24/10/14	50.94	61.88	176	60	B	
1436	24/10/14	50.91	62.29	186	60	B	
1437	24/10/14	50.92	62.58	169	60	B	
1439	25/10/14	50.82	63.01	151	60	B	
1442	25/10/14	50.55	62.83	149	60	B	
1444	25/10/14	50.30	62.63	147	60	B	
1446	25/10/14	50.42	62.47	153	60	B	
1448	25/10/14	50.54	62.20	165	60	B	
1449	26/10/14	50.60	61.55	163	60	B	
1452	26/10/14	50.69	61.41	147	60	B	
1454	26/10/14	50.77	60.97	130	60	B	
1456	26/10/14	50.89	60.25	132	60	B	
1457	27/10/14	50.71	60.20	143	60	B	
1460	27/10/14	50.61	60.62	147	60	B	
1462	27/10/14	50.44	60.40	152	60	B	
1464	27/10/14	50.34	60.83	153	60	B	
1465	27/10/14	50.33	61.10	156	60	B	
1467	28/10/14	50.37	61.71	160	60	B	
1470	28/10/14	50.12	61.86	158	60	B	
1472	28/10/14	50.11	62.48	147	60	B	
1474	28/10/14	49.90	62.22	144	60	B	
1475	28/10/14	49.93	61.92	155	60	B	
1477	29/10/14	50.03	61.07	159	60	B	
1480	29/10/14	49.86	61.13	163	60	B	
1482	29/10/14	49.65	61.22	161	60	B	
1484	29/10/14	49.66	61.59	157	60	B	
1485	29/10/14	49.49	61.36	159	60	B	
1487	30/10/14	50.14	60.89	158	60	B	
1490	30/10/14	50.16	60.30	161	60	B	Backstrop broke at hauling. Catch not affected.
1492	30/10/14	49.88	60.41	163	60	B	
1493	30/10/14	49.90	60.75	163	60	B	
1495	31/10/14	49.59	60.91	169	60	B	
1498	31/10/14	49.41	60.74	172	60	B	
1500	31/10/14	49.24	61.03	171	60	B	
1502	31/10/14	49.13	60.72	193	60	B	
1504	31/10/14	48.97	60.68	220	60	B	1 DIM mortality
1505	01/11/14	48.71	60.73	242	60	B	
1508	01/11/14	48.57	60.27	389	120	B	Trawl targeting F5 RGR
1510	01/11/14	49.04	60.23	306	120	B	Trawl targeting F5 RGR
1511	02/11/14	49.37	60.17	236	60	B	
1514	02/11/14	49.59	60.35	170	60	B	
1516	02/11/14	49.57	59.90	215	60	B	
1518	02/11/14	49.83	59.89	167	60	B	

1519	03/11/14	50.06	59.73	160	60	B	
1522	03/11/14	49.91	59.41	169	60	B	
1524	03/11/14	50.13	59.18	153	60	B	
1526	03/11/14	50.27	59.15	150	60	B	
1527	03/11/14	50.32	58.70	145	60	B	
1529	04/11/14	49.75	58.36	354	120	B	Trawl targeting F5 RGR
1532	04/11/14	49.96	58.97	164	60	B	
1534	04/11/14	50.10	58.76	155	60	B	
1535	04/11/14	50.17	58.40	181	60	B	
1537	05/11/14	50.18	57.94	278	60	B	
1540	05/11/14	50.29	58.20	146	60	B	
1542	05/11/14	50.46	57.83	147	60	B	
1543	05/11/14	50.70	58.15	135	60	B	
1545	06/11/14	50.51	57.61	204	60	B	
1548	06/11/14	50.62	57.38	226	60	B	
1549	06/11/14	50.77	57.08	253	60	B	
1551	06/11/14	50.89	56.89	241	60	B	
1553	07/11/14	50.92	57.87	132	60	B	
1556	07/11/14	51.03	56.96	120	60	B	
1558	07/11/14	51.17	57.19	109	60	B	

2.2 Trawl gear

The Fisheries Department's owned bottom trawl fitted with rockhopper gear, and the Castelo's Morgère V3 bottom doors (1800kg, 3180 x 2480cm) were used. Although the mesh size in the cod-end was at one time around 90mm it has shrunk over time and is in the region of 80-85mm. Additionally, the cod-end was fitted with a 10-15mm cod-end liner. The trawl doors and net were fitted with sensors for the MarPort Net Monitoring System, transmitting door depth, horizontal spread, angle and tilt, as well as vertical net opening, all of which only door horizontal spread and vertical net opening were recorded. The net horizontal opening (or distance between the wings) was calculated using the formula below:

$$\text{Net Horizontal Opening} = \frac{\text{Door Spread} \times \text{Net Length}}{\text{Bridle Length} + \text{Net Length}}$$

After some discussions with the captain about the gear configuration on this survey, it was confirmed that the 2014 setup was identical to the setup for the February 2011 Rockcod biomass survey (ZDLT1-02-2011). However, in 2010 (ZDLT1-02-2010), although the trawl gear was identical, different trawl doors were used: Morgère Ovalfoil OF12,5 (3400 x 2200cm).

2.3 Biological sampling

For most trawls, the whole catch was weighed by species (or lowest possible taxonomic level in the case of invertebrates) using the electronic marine adjusted POLS balance. At a number of stations where the catch was too large to weigh in its entirety, FIFD conversion factors were used to calculate green weight estimates for the larger amounts. Conversion factors were also ground truthed with data collected onboard.

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. Electronic size/sex/maturity recording using two Fishmeters was practised for all stations, and many species, when random sampling took place. Traditional measuring and scribing methods were used for all non-random and many sub-sampling.
From most skates both total length and disc width, as well as sex, maturity and weight were recorded.

Subsamples of squid species were taken to extract statoliths ashore, whereas subsamples of fish species were taken to extract otoliths at sea. Vertebrae/spine samples were taken from some skate species (mainly *B. multispinis* and large *B. griseocauda*) for ageing ashore.

Subsamples of Kingclip *Genypterus blacodes* were sampled for condition factor, recording liver weight, gonad weight and eviscerated weight, besides their whole weight, length, sex, and maturity,

Specimens from the genus *Psammobatis* were not categorized by species, due to confusion with available identification guides and available literature (i.e. McEachran 1983). It is likely that the most common species found in waters deeper than ~120m is *Psammobatis normani* (slender claspers) whereas in shallower waters the most common species is *Psammobatis rudis* (short and stout claspers). During the survey, only the *Psammobatis cf. normani* was identified.

2.4 Data analyses

2.4.1 Rockcod (and other species) biomass estimates

Biomass estimations using trawl surveys generally generate auto-correlated data. To avoid processing biased data and overestimating the biomass of fish in the survey area, geostatistical methods were developed to first describe and model data autocorrelation and second estimate by kriging unbiased mean of the studied variable and provide interpolated map of the studied variable.

Catches of Rock cod *Patagonotothen ramsayi*, which was the target species of this research cruise, and other demersal species data were processed using geostatistical methods to provide a biomass estimation of the commercial finfish species. In addition to rock cod, this methodology was applied to red cod *Salilota australis* (BAC), hake *Merluccius hubbsi* (HAK), king clip *Genypterus blacodes* (KIN) and Patagonian squid *Doryteuthis gahi*, (LOL).

In a first step, the area swept by the trawl was calculated and used to estimate densities of each species. Then these densities were processed using geostatistics to provide unbiased biomass estimation. The methodology used to process ZDLT1-10-2014 data was based on the R script developed to perform the 2010 rock cod assessment (Winter et al. 2010) using packages rgdal (geographical coordinates projection) and geoR for the geostatistical estimations.

Density estimations using swept area method

The distance covered by the trawl was estimated using the geographical coordinates of the stations. For each station, coordinates of the course start were extracted from the database fields DegS_Start_Seabed, MinS_Start_Seabed, DegW_Start_Seabed, MinW_Start_Seabed and course end from the database fields DegS_Finish_Seabed, MinS_Finish_Seabed, DegW_Finish_Seabed, MinW_Finish_Seabed and transformed first in decimal degrees (deg) and then in radians (rad) as:

$$rad = \frac{\deg \times \pi}{180}$$

Radian coordinates were then used to calculate the distance between the start and end of the courses as:

$$d = a\cos(\sin(latS) \times \sin(latF) + \cos(latS) \times \cos(latF) \times \cos(longF - lonS) \times R$$

where d is the distance covered in km, latS is the start latitude, lonS is the start longitude, latF is the end latitude, lonF is the end longitude and R is the radius of the earth (6371 km). Density of the studied species (D) is finally derived using the catch (C), the distance covered (d) and the horizontal net opening (HNO; see section 2.2 for details)

$$D = \frac{C}{d \times HNO}$$

Densities of stations were then used as input data in the geostatistical procedure to estimate the abundance of each species.

Geographical coordinates

Station's geographical coordinates were collected using the World Geodetic System of 1984 (WGS 84). However, as earth is a sphere and because Falkland Islands are situated at relatively high latitudes (study area in our case ranges from 48 to 52°S), one longitude degree does not have the same length as one latitude degree. It was therefore decided to project coordinates in the Universal Transverse Mercator Coordinate System (zone 21; UTM 21) which keeps the distances between stations both in latitude and longitude. The projection was carried out using the project function (with following argument proj="+proj=utm +zone=21 +south +ellps=WGS84 +towgs84=0,0,0,0,0,0,0 +units=m +no_defs") of the rgdal R package. Previously in the Falkland Islands Fisheries Department, the Easting Northing system was used. A comparison between the UTM 21 projection and Easting Northing system showed no significant differences.

Geostatistic methods

Geostatistic methods must be performed in 4 steps, (i) plotting and (ii) modelling the semi-variogram, (iii) using the variogram model to krige data in order to estimate an unbiased mean of the studied variable, and (iv) mapping the estimated data. The following criteria were used at different steps of the process to take the suitable decision.

- Various numbers of distance classes (from 10 to 50 classes) and 3 lambda parameters of the Box-Cox transformation (0, 0.5 and 1) were tested to obtain a scatter plot describing well the auto-correlation at short distances. The semi-variance values should increase with the distance and reach the sill. The only accepted exception was the pure nugget effect.
- The range must be shorter than the maximum distance observed on the semi-variogram. In the studied dataset, some models can fit quite well log transformed data (lambda=0), however they exhibit a range further than 400 km which is not biologically consistent in our case.
- Exponential, Gaussian and spherical models were fitted in trials to the semi-variogram data and sum of square residuals (SSR) were used as a basis to choose the suitable model. The lowest SSR suggesting the most suitable model.
- Finally the kriging was performed and accepted if the range of estimated biomass was positive and reasonably close to the range of observed values. If not, another variogram model exhibiting higher SSR was tested until estimated and observed values are close enough.

As the protocol was to explore one station per grid square, the kriging area boundaries were defined using the grid squares. The total area was 102,617 km^2.

In the case of rock cod, the biomass estimation was done using data collected in 2010 (ZDLT1-02-2010), in 2011 (ZDLT1-02-2011) and in 2014 (ZDLT1-10-2014) using the same methodology and the same kriging area. For other demersal species, the biomass estimations were only performed using 2014 data.

2.5 Oceanography

A single CTD (SBE-25, Sea-Bird Electronics Inc., Bellevue, USA) instrument, Serial No 0247, was used to collect oceanographic data in the vicinity of all trawl stations. A tandem cast was carried out with instrument 0389 at station 1469, to check an issue with spikes in Salinity. 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 Fluourescence. The raw hex file was converted and processed using SBE Data Processing Version.7.22.5 using the CON files OldCTD_2013_AUG.xmlcon. 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. PSU is a measure of conductivity which normalizes the salinity to KCl parts per thousand of the seawater at 15° C at 1 atmosphere. Sigma-t measures the density of seawater at a given temperature, σ-t is defined as ρ(S,T)-1000 kg m^{-3}, where ρ(S,T) is the density of a sample of seawater at temperature T and salinity S, measured in kg m^{-3}, at standard atmospheric pressure. Further derived variables of conservative temperature (°C) and absolute salinity (g/kg) were calculated in Ocean Data View version 4.5.4 (Schlitzer 2013).

3.0 Results

3.1 Catch composition

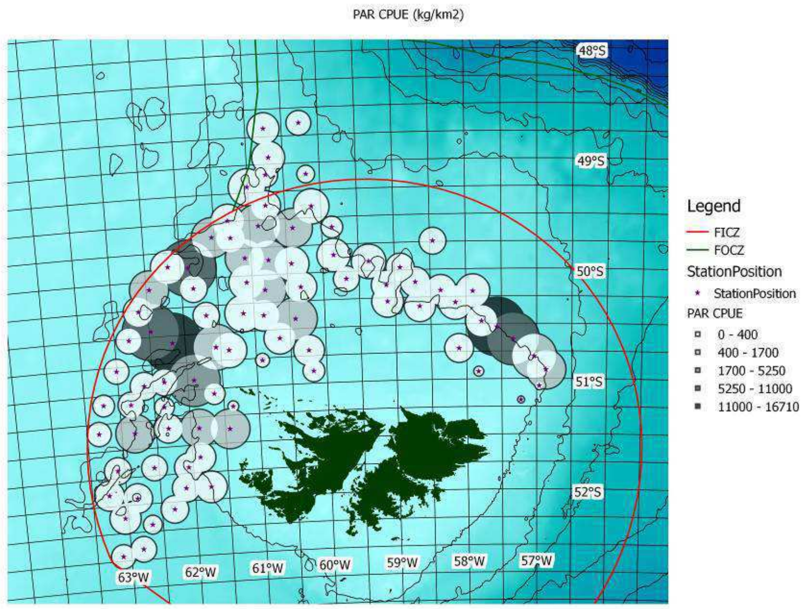
Bottom trawling was conducted at 86 stations as shown in Figure 1 and Table 1. Seabed trawling times during the survey was 60 minutes for 83 of the trawls. Three of the trawls conducted were targeting mature/spawning *Bathyraja griseocauda*, and because of the much greater target depth, the seabed duration of these trawls was doubled to 120 minutes. However, other than the duration, those trawls were identical in to the remaining 83 in every other way, and so they are included in all other calculations.

During the survey a total of 79,516kg of biomass was caught comprising 122 species or taxa (Appendix Table 5). The largest catches by weight, all exceeding 1,000kg in total, were Rockcod (*Patagonotothen ramsayi*), Redcod (*Salilota australis*), Kingclip (*Genypterus blacodes*), Falkland herring (*Sprattus fuegensis*), Falkland calamari (*Doryteuthis gahi*), Southern Blue Whiting (*Micromesistius australis*), and the common hake (*Merluccius hubbsi*), together amounting to 93% of the total catch.

Table 6 in the appendix lists numbers of specimens analysed from randomly collected samples. 448 specimens of two squid species had their statoliths extracted and 2,413 otoliths were extracted from 12 different fish species.

3.1.1 Rockcod (*Patagonotothen ramsayi*) catch, distribution, biology

A total of 37,978kg of Rock cod was caught at all of the 86 stations, with catches ranging from 0.6-6,932kg and CPUEs ranging from 1.3-16,710kg/km^2 or 0.6-6,932kg/hr. The highest catch and CPUEs was at station 1545 to the North, the second highest catch was in the Northwest (st. 1448) with highest CPUE of 16,710kg/km^2 and second highest CPUE of 6,628kg/hr (Figure 2). 9,655 rock cod were sampled from the catch, with sizes ranging from 6-41cm TL. Three distinct size modes at 10-12cm, 16-18cm and ~25cm TL are shown in the total population, but the prominence of these modes varied spatially, as shown in the 5 interim cruise reports as sent from sea. The survey period clearly occurred after the spawning season for Rockcod, which is evidenced by the fact that 60% of females were in early maturity stages I-III, and 39.5% in post spawning stages VII- & VIII. A few pre-spawning and spawning females were also caught. 97% of the males were in early maturity stages, and although a few pre-spawning, spawning and post spawning males were caught, these were generally absent during the survey.



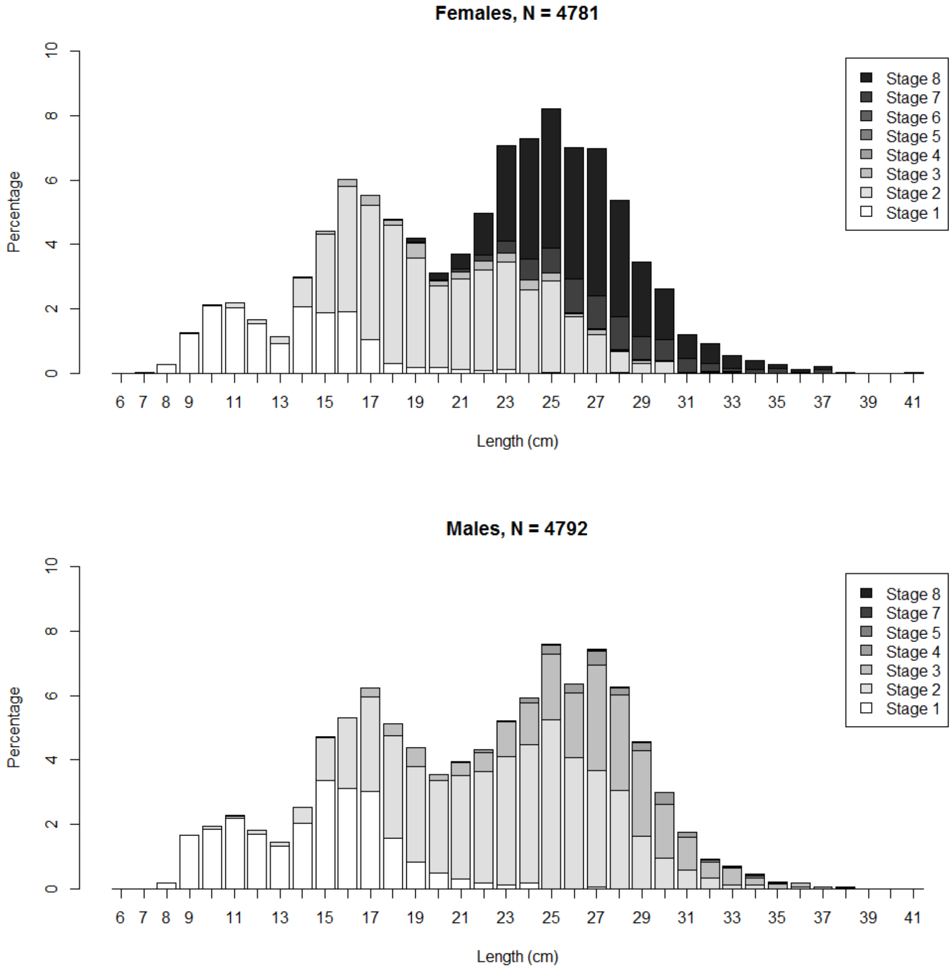


Figure 2: Distribution, CPUE (kg/hr) & length frequency for *Patagonotothen ramsayi*

3.1.2 Commercial finfish and squid species catch, distribution, biology

Commercial finfish and squid species catches are separately listed in Table 2.

Table 2: Commercial finfish and squid catches.

Species Code	Species name	Total Catch (kg)	Total Sampled (kg)	Total Discarded (kg)	Proportion (%)
PAR	*Patagonotothen ramsayi*	37,977.837	1,213.850	13,029.485	47.76%
BAC	*Salilota australis*	15,403.635	1,229.138	882.287	19.37%
KIN	*Genypterus blacodes*	5,929.386	3,022.256	0.000	7.46%
SAR	*Sprattus fuegensis*	5,456.631	27.760	5,052.531	6.86%
LOL	*Doryteuthis gahi*	3,589.363	602.130	40.117	4.51%
BLU	*Micromesistius australis*	2,939.213	181.093	2,939.173	3.70%
HAK	*Merluccius hubbsi*	2,635.954	2,588.814	0.000	3.32%
TOO	*Dissostichus eleginoides*	159.532	159.406	61.052	0.20%
RED	*Sebastes oculatus*	77.570	73.190	5.610	0.10%
GRC	*Macrourus carinatus*	35.250	31.410	35.250	0.04%
WHI	*Macruronus magellanicus*	30.080	27.700	30.080	0.04%
PAT	*Merluccius australis*	5.110	5.110	0.000	0.01%
ILL	*Illex argentinus*	1.201	1.201	0.647	<0.01%
Totals		**74,240.76**	**9,163.06**	**22,076.23**	**93.37%**

3.1.2.1 Red cod (*Salilota australis*)

A total of 15,404kg of red cod was caught at 74 stations throughout the surveyed regions, but primarily in the western region. Although catches were generally low (<75kg/trawl), 9 however were larger than 100kg, with a highest catch of 6,644kg at station 1426. CPUEs ranged from <0.1 to 13,372kg/km^2 or <0.1 to 6,644kg/hr. A total of 3,759 red cod were sampled from 73 stations. Sizes ranged from 9–83cm TL with clear juvenile modes at ~12 and at ~24 cm (Figure 3). Most females and males were in early maturity stages I-III (96% and 93% respectively), but there were a number of animals of both sexes still in pre-spawning, spawning and post-spawning stages IV-VIII.

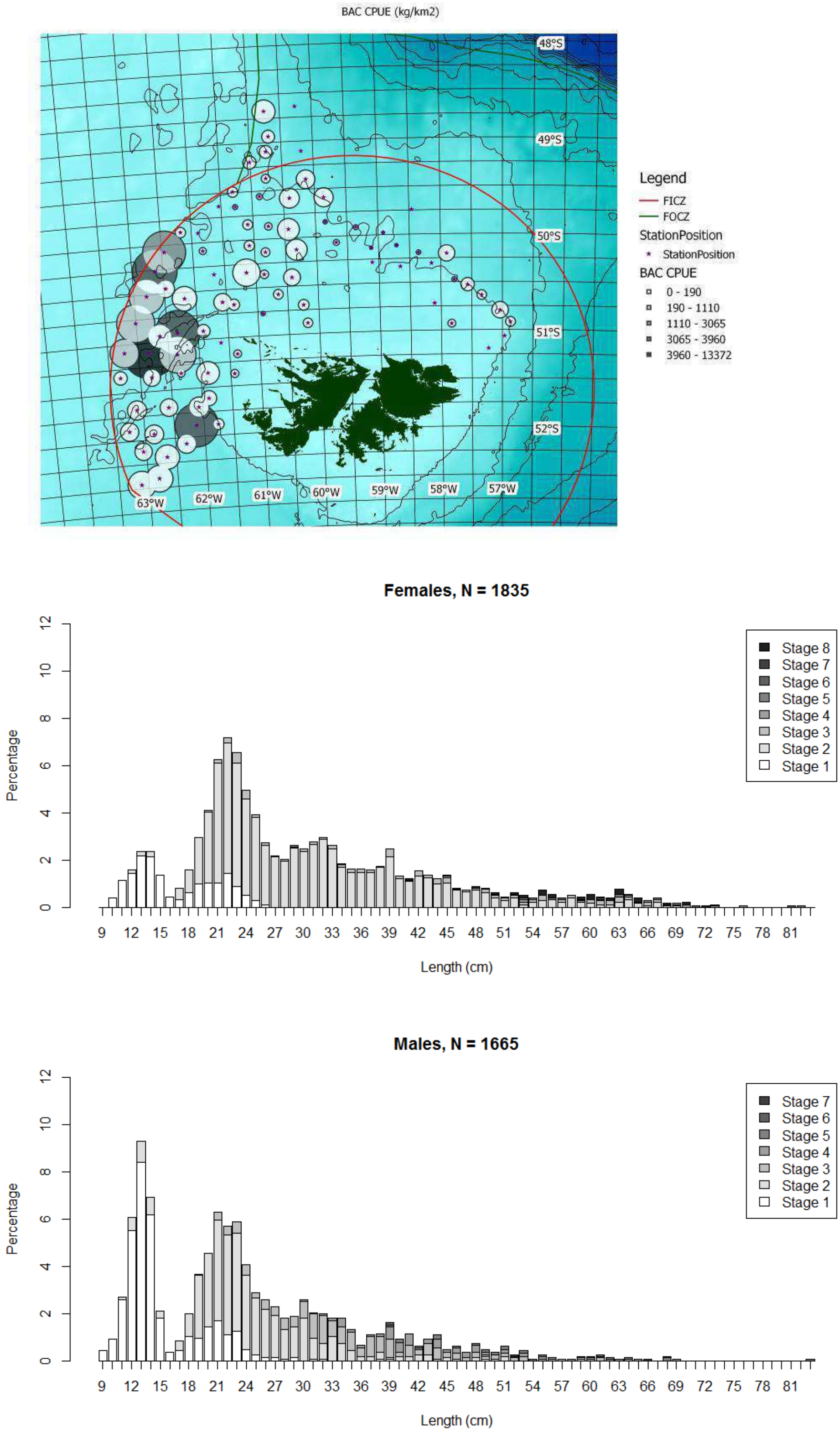
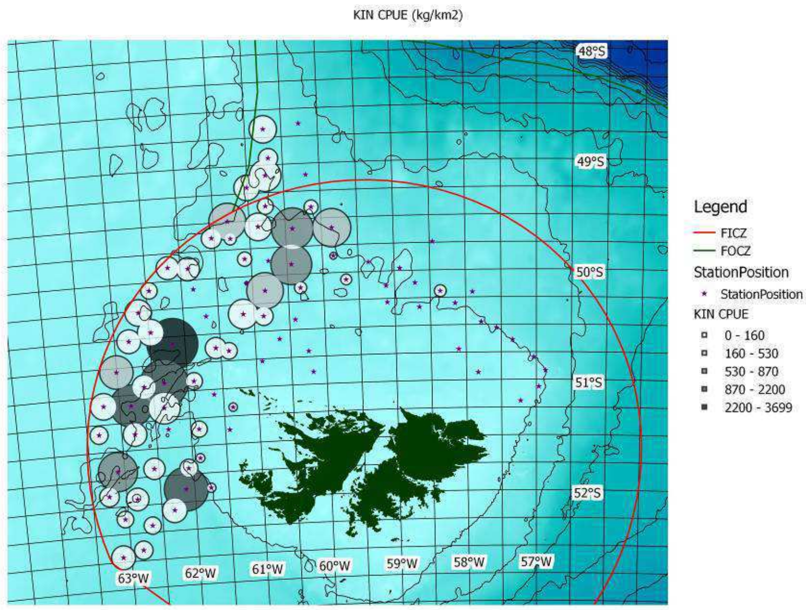
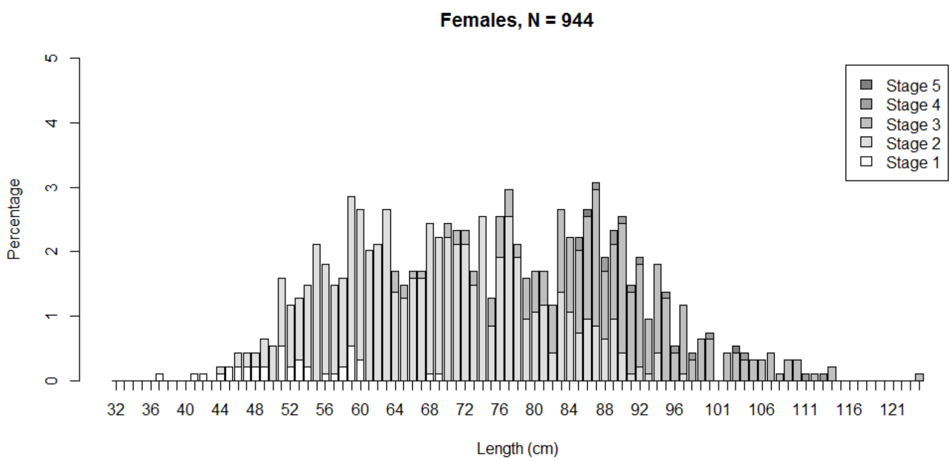


Figure 3: Distribution, CPUE (kg/hr) & length frequency for *Salilota australis*

3.1.2.2 Kingclip (*Genypterus blacodes*)

A total of 5,929kg of Kingclip was caught at 55 stations, primarily in the western and north-western part of the survey area with 8 stations yielding particularly high catch rates ranging between 464-3,699kg/km^2 or 256-1,467kg/hr (Figure 4). 1558 specimens were sampled from the catch, with sizes ranging from 32-124cm total length, modal maturity was Stage II for both females and males (63% and 51% respectively, and 61% females (Figure 4). Two females with hydrated oocytes (stage 5), 1 male with replete testis (stage 5) as well as a post spawning male (stage 7) were also found.





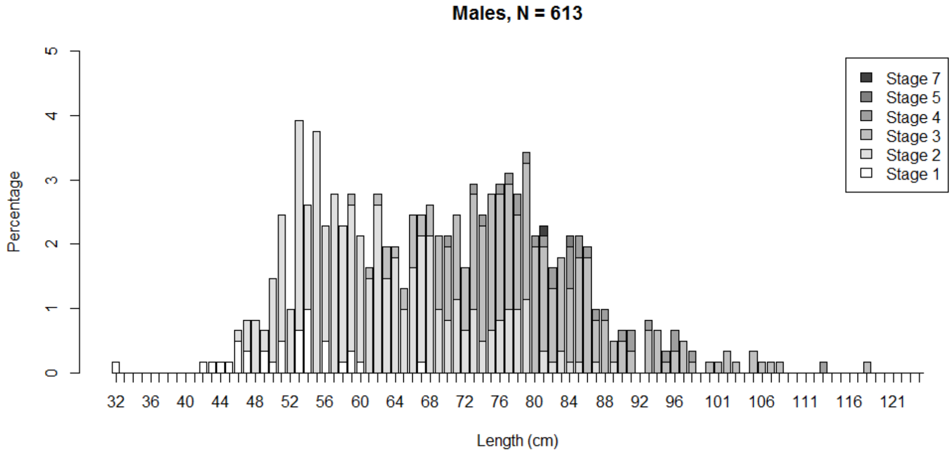
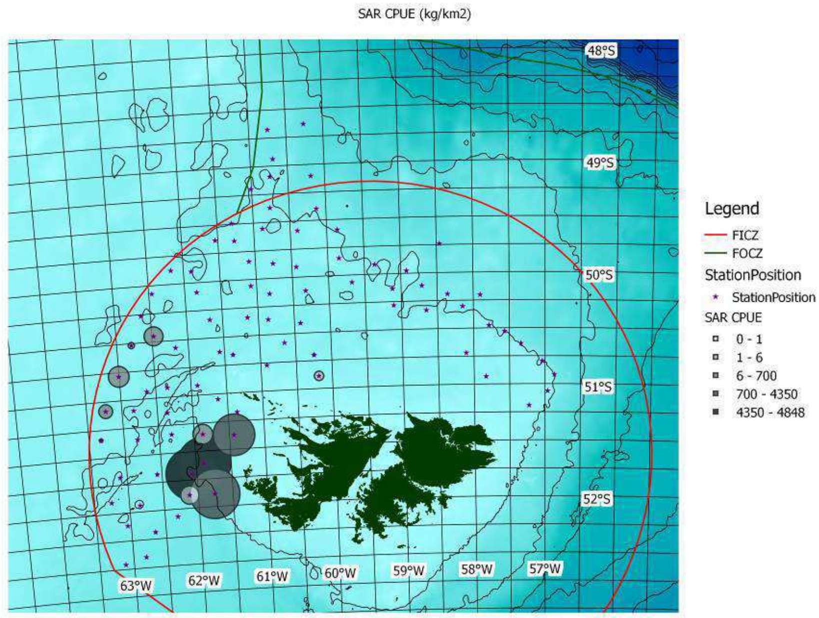


Figure 4: Distribution, CPUE (kg/km^2) & length frequency for *Genypterus blacodes*

3.1.2.3 Falkland herring (*Sprattus fuegensis*)

A total of 5,457kg of Falkland herring was caught at 16 stations, primarily in the west of the survey area. The highest catches were close to islands in the southwest, with four catches ranging from 359-2,037kg, and the remaining 12 catches yielding 10kg or less per trawl. CPUEs for the four dominant stations ranged 715-4,848kg/km^2 or 359-2,037kg/hr. Samples were taken at 6 stations, and of the 692 specimens 47% were female (Figure 5). 96% of the females, and 91% of the males were in pre-spawning stages IV & V, and a single mode at 17-18cm was evident.



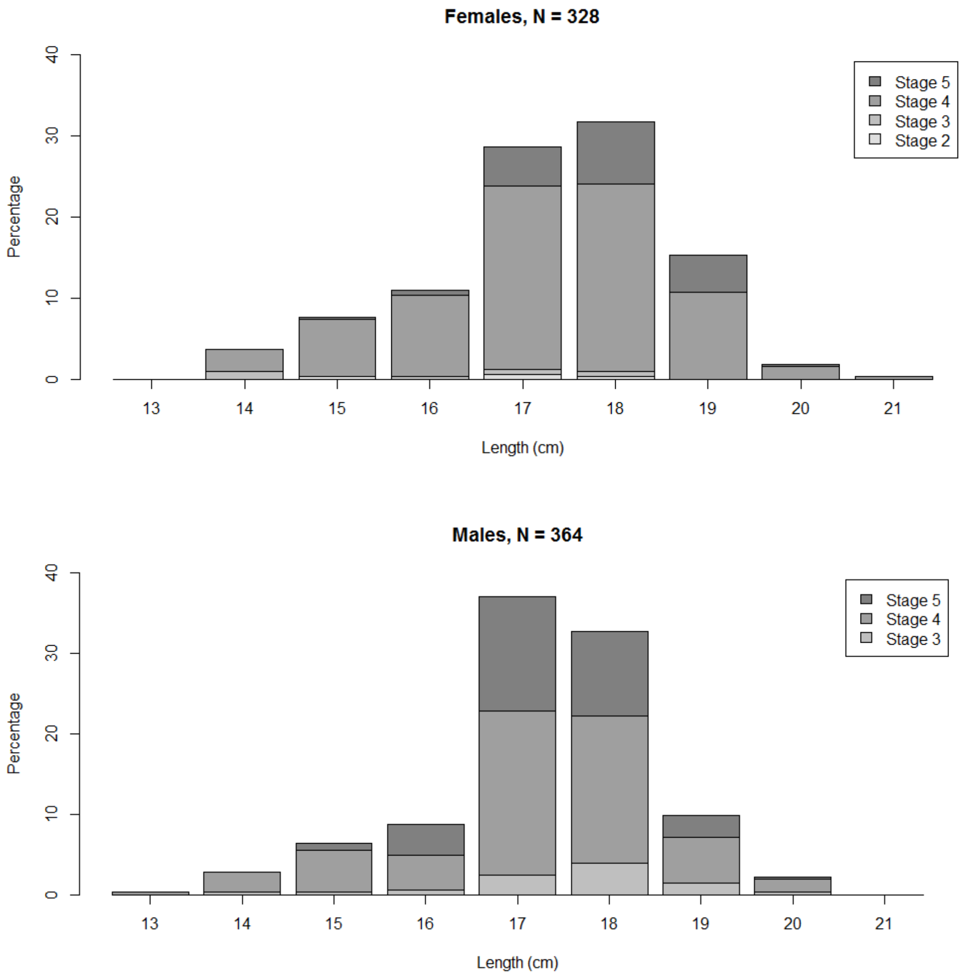


Figure 5: Distribution, CPUE (kg/hr) & length frequency for *Sprattus fuegensis*

3.1.2.4 Southern Blue Whiting (*Micromesistius australis*)

A total of 2,939kg of Southern Blue Whiting was caught at a total of 39 stations primarily on the shelf break to the North and in deeper waters both in the South and North, with catches ranging from <1kg-2,093kg with $^{2}/_{3}$ of the stations yielding less than 5kg each. Maximum CPUEs were 1,974kg/km^2 or 1,047kg/hr. 1,667 specimens were sampled from the catch, with a size range of 16–59cm but a clear dominance in the smaller size classes, (clear modes at 19-21, 27-30, and a weak mode at 37-40cm). All females, except one stage VIII specimen, were in stages I and II. Although nearly 90% of the males were in stages I and II, a noticeable proportion of specimens (5%) were in pre-spawning stages IV and V (Figure 6).

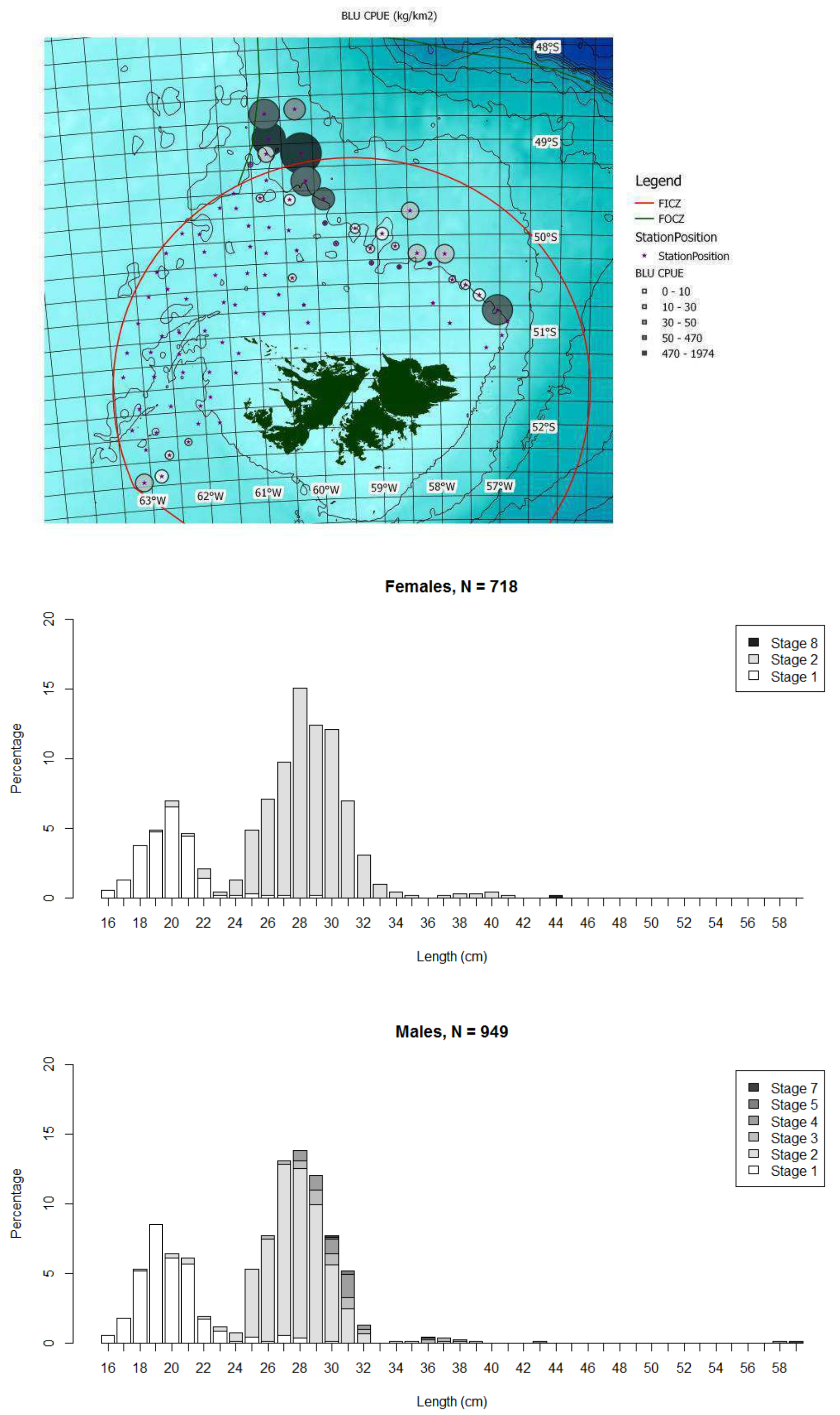
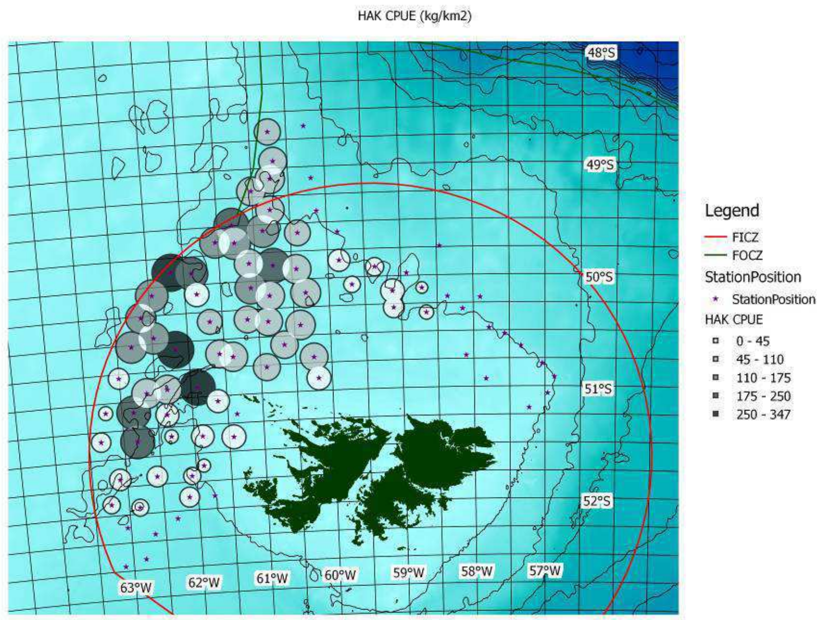


Figure 6: Distribution, CPUE (kg/hr) & length frequency for *Micromesistius australis*

3.1.2.5 Common hake (*Merluccius hubbsi*) & Patagonian hake (*Merluccius australis*)

A total of 2,636 kg of Common hake (*M. hubbsi*) was caught, and it was a consistent component of the catch throughout the survey, but more commonly found in the West and Northwest of the survey area (Figure 7). The mean catch per trawl was 43kg, the maximum 175kg. The mean CPUEs were 86.5kg/km^2 (max=346.7kg/km^2) and 43.2kg/hr (max=174.8kg/hr). All 1,456 specimens were sampled, with sizes ranging from 20-87cm, and 96% were female. 90% of the females were in pre-spawning stages III, IV and V with a small proportion (3%) in post-spawning stages VII and VIII. 67% of the males were in stages III and IV, with 25% in post spawning stages VII and VIII. Three Patagonian hake (*M. australis*) were found at two most southerly stations. The two 52 and 86cm TL females were both in stage VIII and the 66cm TL male was in stage III.



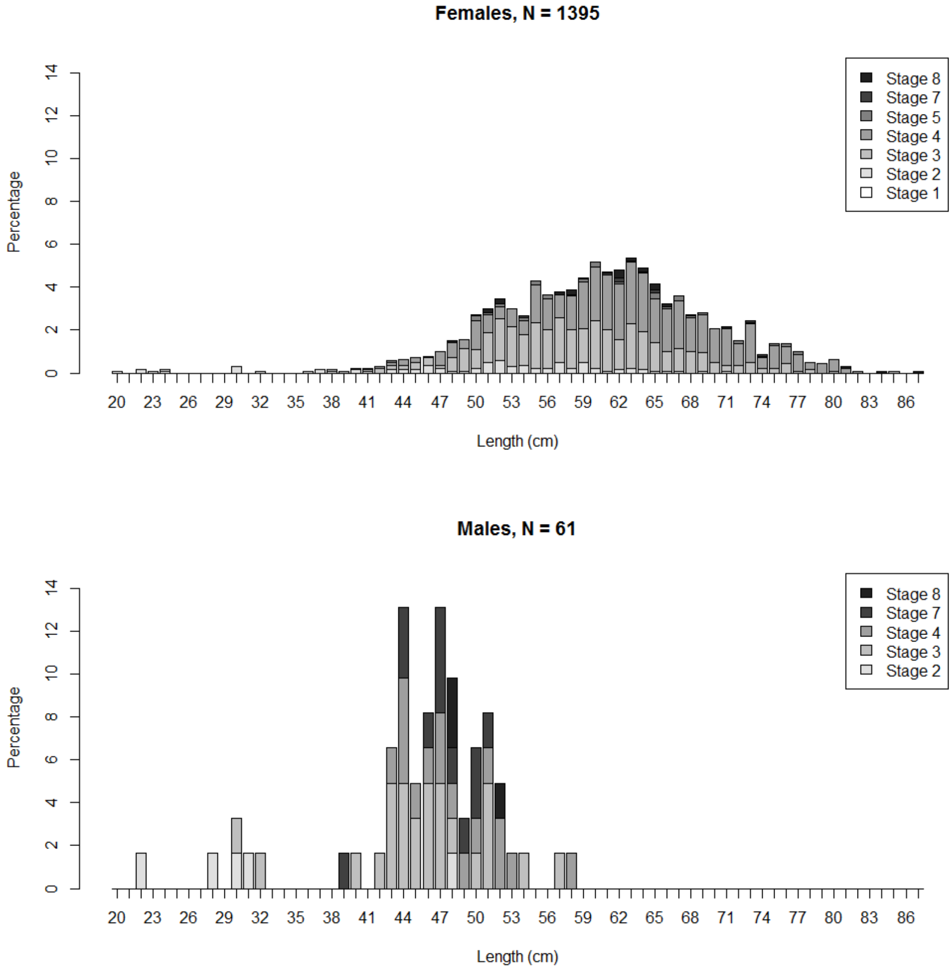


Figure 7: Distribution, CPUE (kg/hr) & length frequency for *Merluccius hubbsi*

3.1.2.6 Toothfish (*Dissostichus eleginoides*)

Toothfish were caught at 27 stations throughout the surveyed regions. Two of these catches were comparatively high (70.9 & 31.8kg), but the remaining catches had a mean of 2.3kg/trawl. Highest CPUEs were 147.2 & 62.9kg/km^2 or 70.9 & 31.8kg/hr. Only two stations (1390 & 1508) yielded some larger specimens >70cm TL, the majority of the trawls yielded 2nd year recruits. A total of 374 toothfish were sampled from the catch, 61% of which were female. Sizes ranged from 24-76cm TL with a clear mode at ~27-29cm (Figure 8). All specimens were in immature stages I & II.

Four stations in the Northeast (st. 1545, 1548, 1549, and 1551) yielded 74% of the total catch by numbers, all of which ranged 24-40cm, with means ranging from 26.5 to 28.6cm. This NE area may be regarded as one where juvenile toothfish recruit onto the shelf.

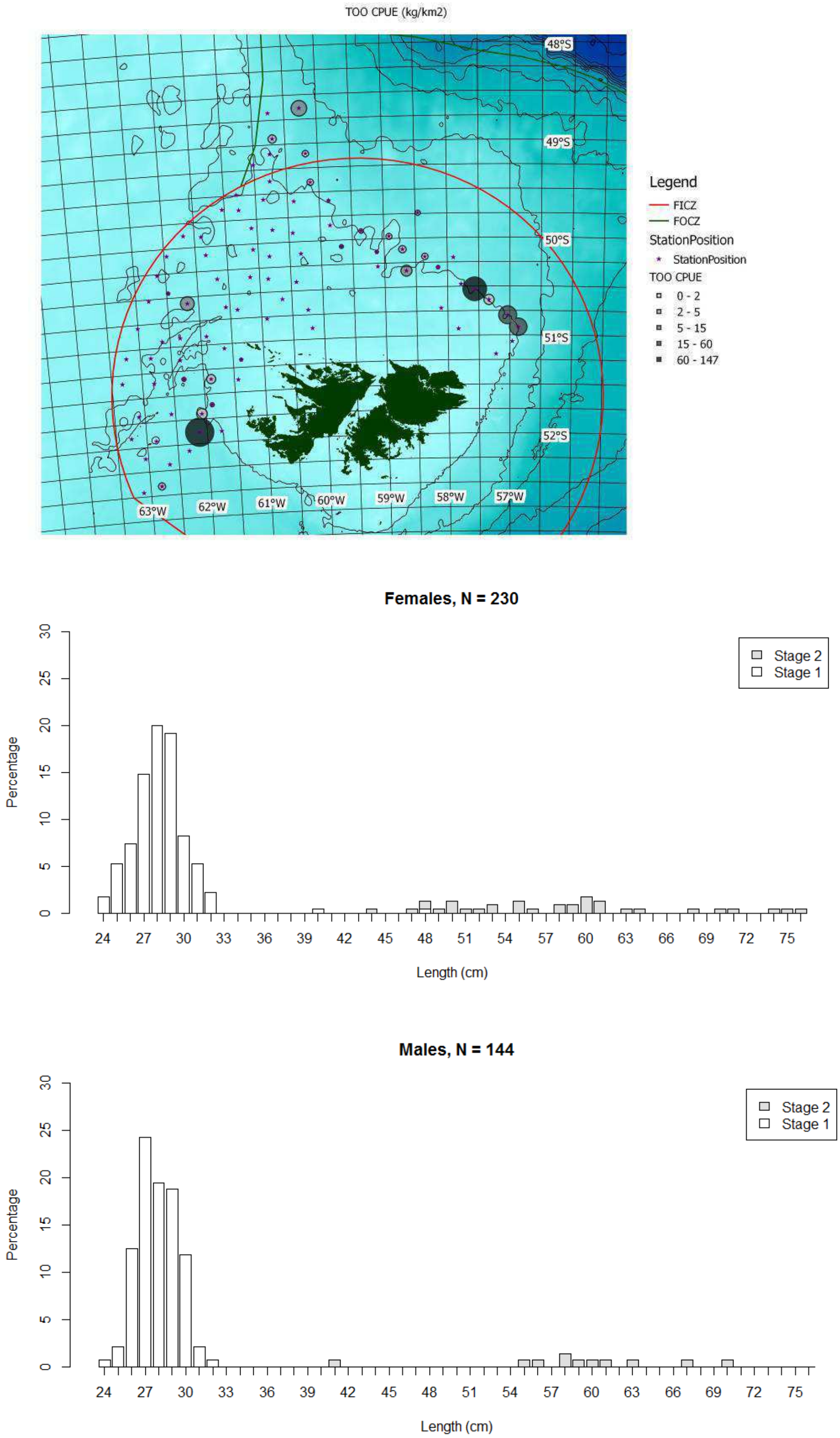
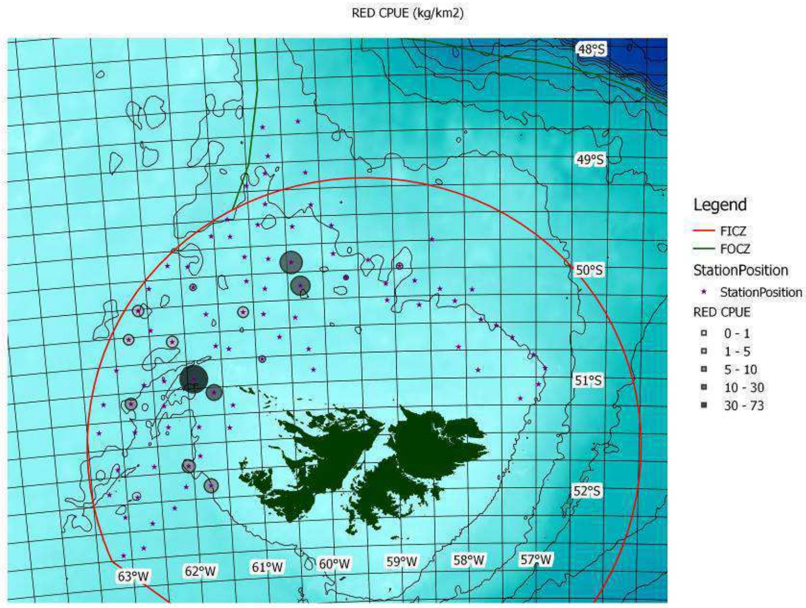
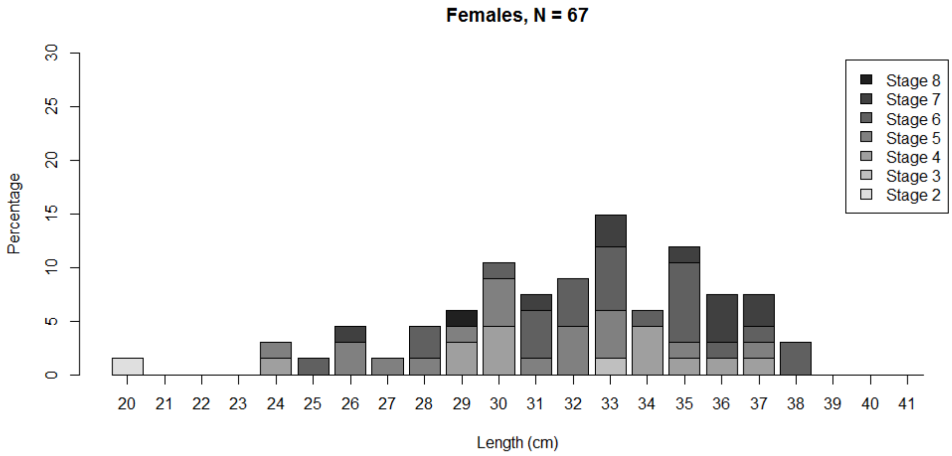


Figure 8: Distribution, CPUE (kg/hr) & length frequency for *Dissostichus eleginoides*

3.1.2.7 Redfish (*Sebastes oculatus*)

A total of 78kg of *Sebastes oculatus* was caught at a total of 15 stations, with the largest catch (32kg) and CPUE (73.3kg/km^2 or 32kg/hr) at station 1434, west of Steeple Jason. 129 specimens (52% Female) were sampled at 13 stations, with sizes ranging from 20-41cm TL. One weak mode was present at around 26cm (Figure 9). Redfish was clearly in their spawning period, as 81% of the females were in stages IV, V, and VI, with 15% in post spawning stage VII. Because this species practises internal fertilization, it was no surprise that 82% of the males were already in post spawning stages VII and VIII.





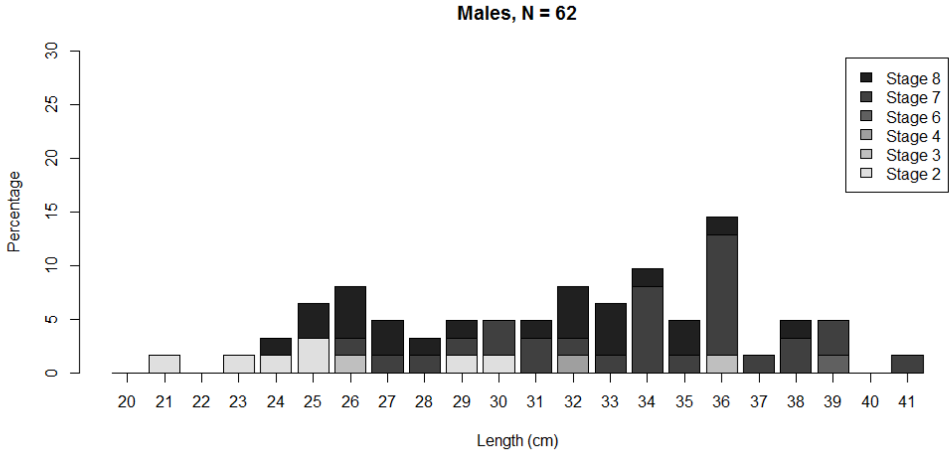
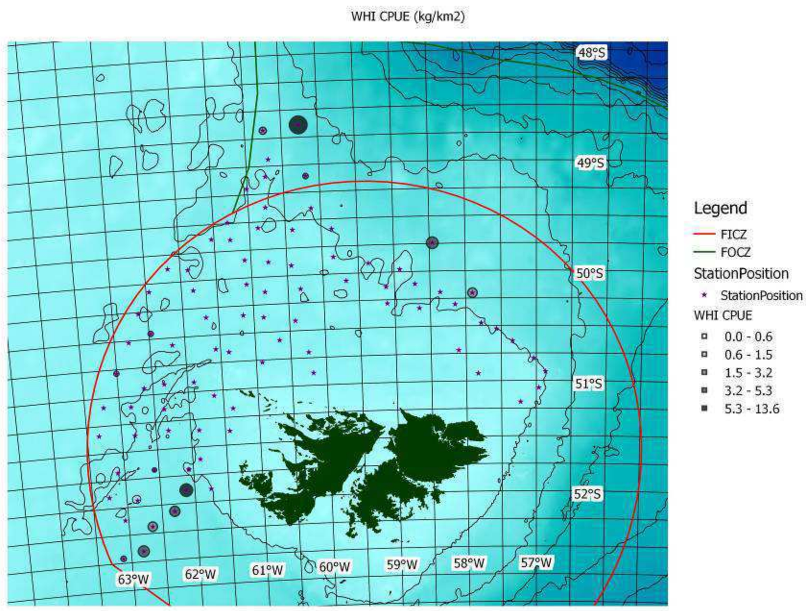


Figure 9: Distribution, CPUE (kg/hr) & length frequency for *Sebastes oculatus*

3.1.2.8 Hoki (*Macruronus magellanicus*)

Only 14 trawls yielded a few insignificant catches in deeper trawls in the southwest and in the north (Figure 10), with catches ranging from 0.34-13.51kg. Maximum CPUEs were correspondingly low: 13.6kg/km^2 or 6.8kg/hr. 50 hoki (64% female) were sampled from the catch, with size ranging from 12-35cm (pre-anal length) with no clear mode. All specimens were either in maturity stage I or II.



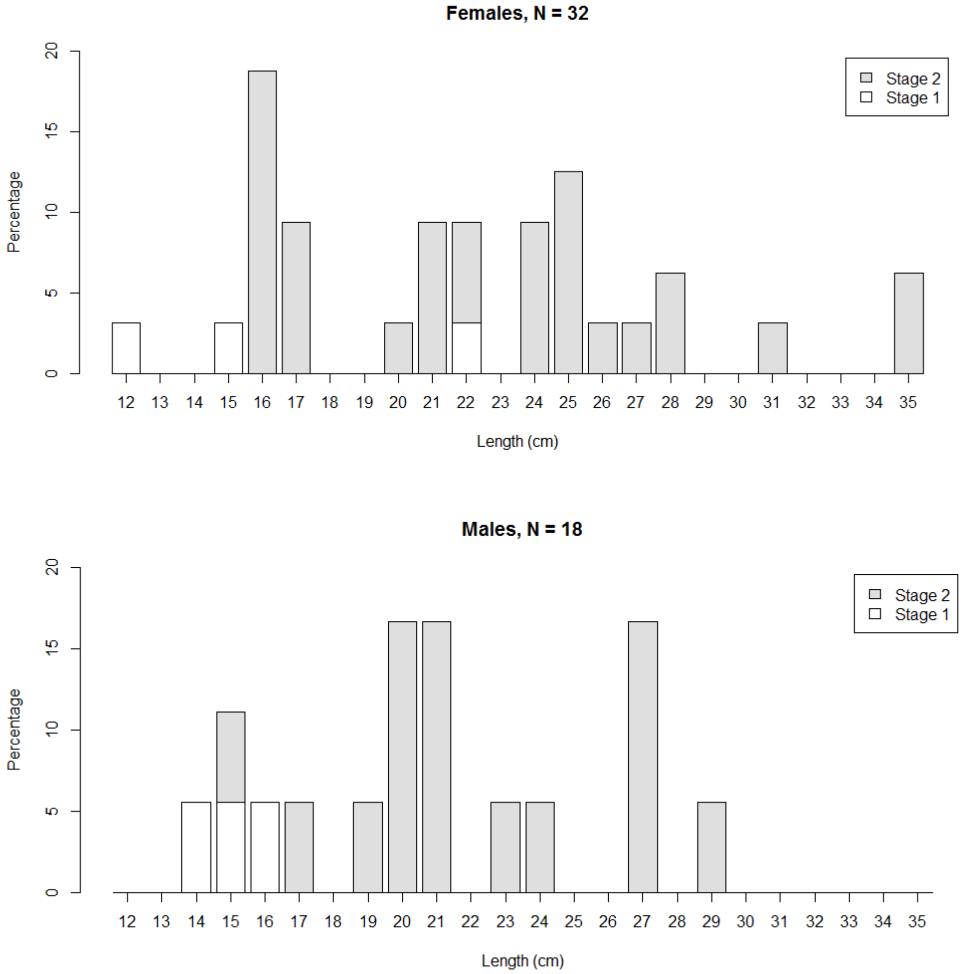
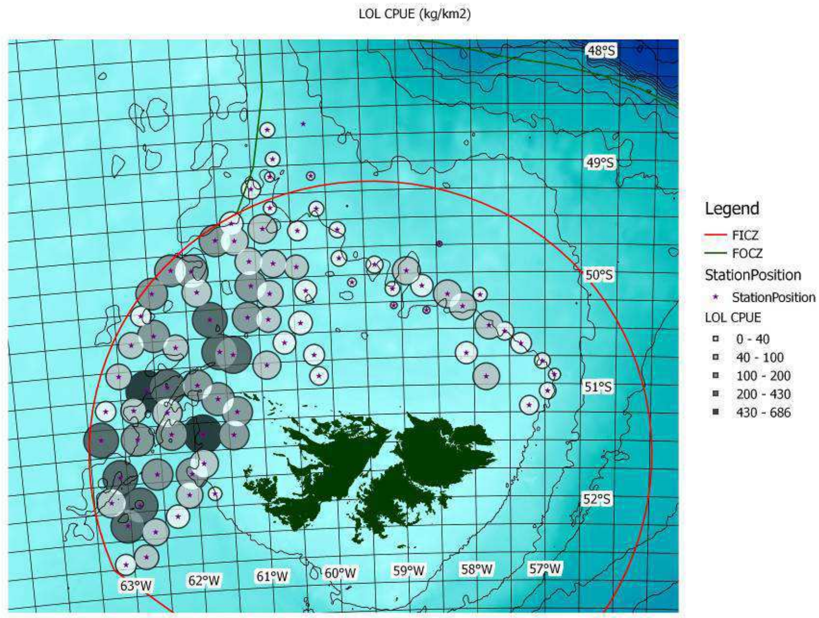
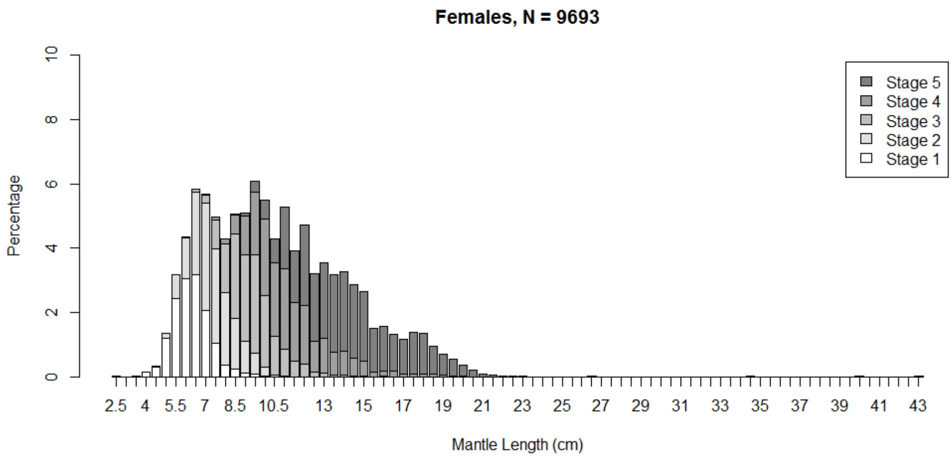


Figure 10: Distribution, CPUE (kg/hr) & length frequency for *Macruronus magellanicus*

3.1.3 Falkland calamari (*Doryteuthis gahi*)

A total of 3,589kg of Falkland calamari was caught, fairly consistently throughout the survey area, although somewhat more dominant in the earlier part of the survey at stations west of longitude 60°30'W. It was recorded at 85 of the 86 stations, and sampled at 83. 26 of the trawls (31%) yielded catches from 51-314kg and CPUEs of 95-686kg/km^2 or 51-314kg/hr. The highest catch was in the south with 159kg, and the remaining catches averaging 11kg per trawl. A total of 16,493 Falkland calamari were sampled from the catch. Size ranged from 2.5-43cm DML, with modes of ~6 and ~9cm ML in the female population, and ~7, ~9, and ~12cm ML for the males. The population was very mature, with 52% of the females and 71% of the males in stages IV and V (Figure 11). At three stations (1429, 1443 & 1434) in the vicinity of Steeple Jason Islands 8 mature females were found with sperm patches attached to the gills close to the oviduct. A further single embedded female stage V was caught at st. 1444.





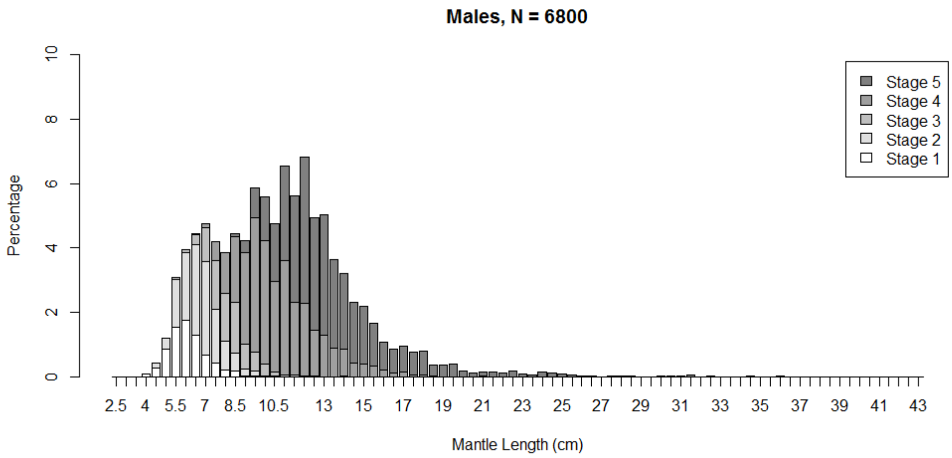


Figure 11: Distribution, CPUE (kg/hr) & length frequency for *Doryteuthis gahi*

3.1.4 Skate catch, distribution and biology

The family Rajidae, of which a total of at least 12 species from 5 genera (*Amblyraja*, *Bathyraja*, *Dipturus*, *Psammobatis* and *Zearaja*) were caught, comprised 3.0% of the total catch from the 86 bottom trawl stations, 78 of which yielded skates, with a mean of 30.5kg/trawl and a mean CPUE of 58.8kg/km^2 or 29.4kg/hr. The four dominant species were *Zearaja chilensis*, *Bathyraja brachyurops*, *Bathyraja griseocauda* and *Bathyraja albomaculata*, their combined catches yielding 2,113kg, or 88.7% of the skate total (Table 3). These are discussed below.

Table 3: Skate Catch (kg)

Species Code	Species name	Total Catch (kg)	Total Sampled (kg)	Total Discarded (kg)	Proportion (%)
RFL	*Zearaja chilensis*	883.370	883.370	2.130	1.11%
RBR	*Bathyraja brachyurops*	718.925	718.925	229.025	0.90%
RGR	*Bathyraja griseocauda*	381.940	381.940	20.330	0.48%
RAL	*Bathyraja albomaculata*	129.055	129.055	32.780	0.16%
RMU	*Bathyraja multispinis*	90.497	90.497	1.490	0.11%
RBZ	*Bathyraja cousseauae*	67.440	67.440	4.380	0.08%
RMC	*Bathyraja macloviana*	49.875	49.875	44.205	0.06%
RDO	*Amblyraja doellojuradoi*	27.310	27.310	27.310	0.03%
RSC	*Bathyraja scaphiops*	18.293	18.293	4.900	0.02%
RPX	*Psammobatis spp.*	8.588	8.566	8.588	0.01%
RMG	*Bathyraja magellanica*	4.330	4.330	4.330	0.01%
RDA	*Dipturus argentinensis*	2.960	2.960	0.000	<0.01%
Totals		**2,382.583**	**2,382.561**	**379.468**	**3.00%**

3.1.4.1 *Dipturus (Zearaja) chilensis*

A total of 883kg was caught in 49 of the 78 stations, comprising 37% of the skate catch. With some exceptions, the species was more commonly caught in stations at the shelf break to the SW and in the NW with the largest catch (175kg) and CPUE (336.7kg/km^2 or 175kg/hr) at station 1498, in the NW of the FICZ. 304 specimens (71% Female) were sampled, with sizes ranging from 35-88cm DW. The majority of the specimens sampled were juveniles or sub-adults, with only 5% of the females in maturity stages IV & VI, and 13% of the males in stages IV and V. No females carried egg capsules (Figure 12).

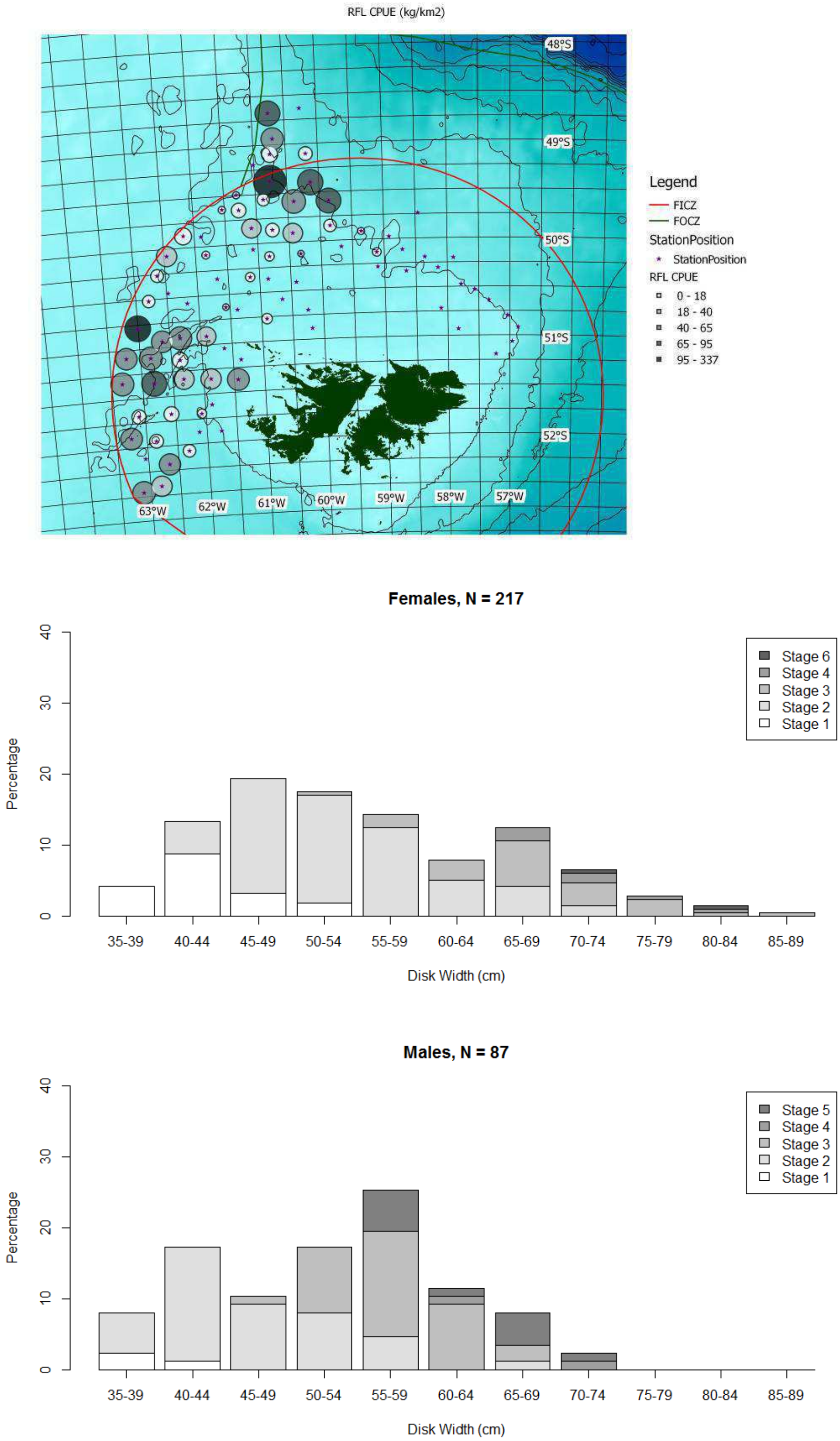


Figure 12: Distribution, CPUE (kg/hr) & size frequency for *Zearaja chilensis*

3.1.4.2 *Bathyraja brachyurops*

A total of 719kg was caught in 59 of the 78 stations, comprising 30% of the skate catch. With some exceptions, the species was more commonly caught in stations at the shelf break to the North of the islands with the largest catch (76kg) and CPUE (136.5kg/km^2 or 76kg/hr) at station 1511, in the NW of the FICZ. All 1291 specimens (51% Female) were sampled, with sizes ranging from 5-69cm DW (Figure 14). The majority of the specimens sampled were juveniles or sub-adults, with only 5% of the females in maturity stages IV & VI, and 13% of the males in stages IV and V. Juveniles were very much abundant in a number of Northern stations as shown in Figure 13 which maps CPUE (number/km^2) as a grey scale, and mean disk width as a relative symbol size. This points to the region around XJAJ as a hatchery/nursery area. Eleven females carrying egg capsules (F5) were encountered, 15% of all females above the L_{dw} at 50% maturity of 45.2cm DW. One senescent female (listed as F8) was also caught.

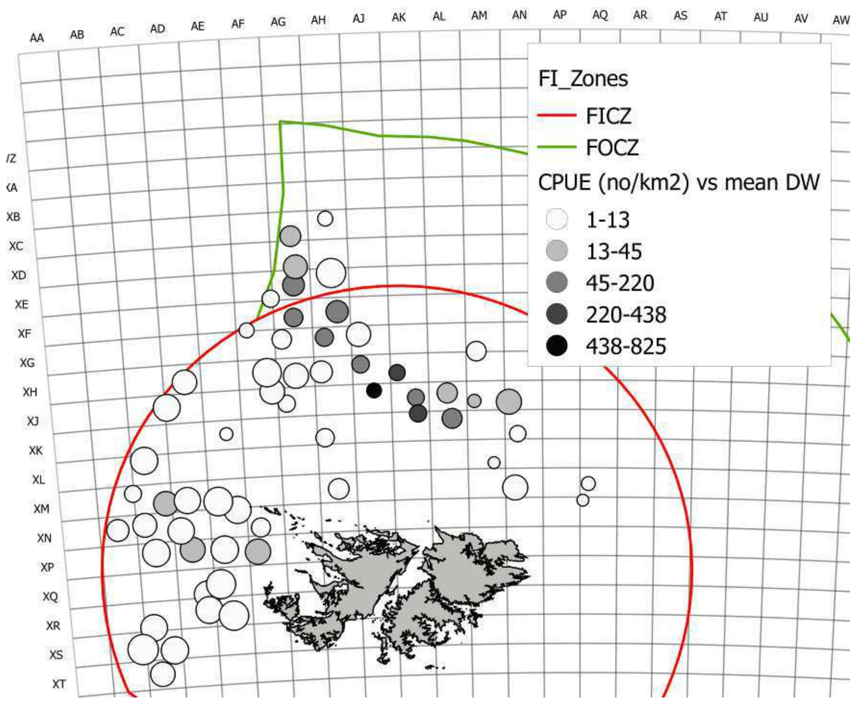
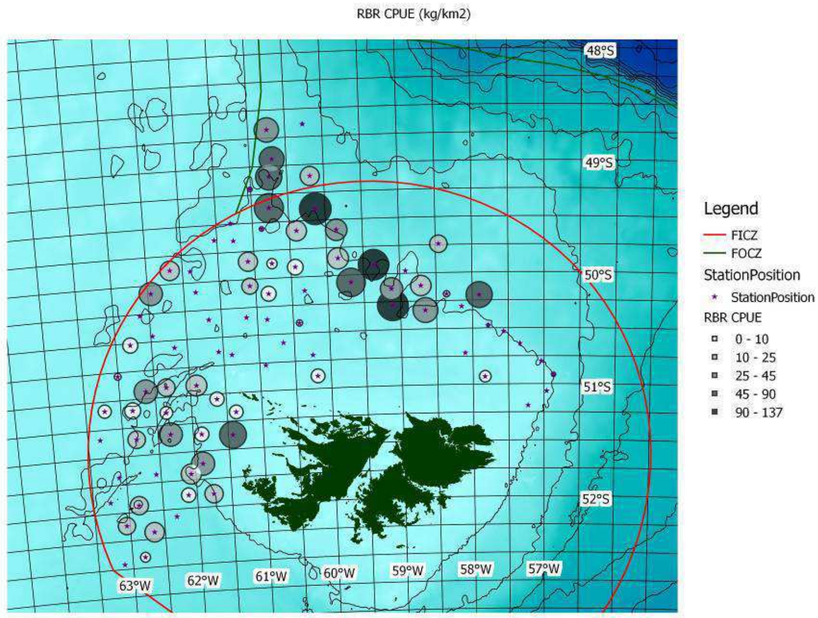
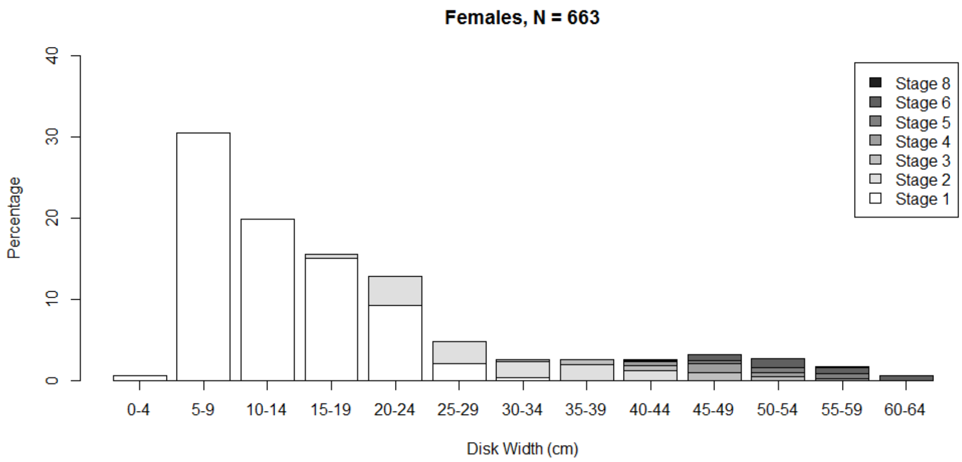


Figure 13: CPUE (no/km^2) and mean disk width (symbol size) of *Bathyraja brachyurops*





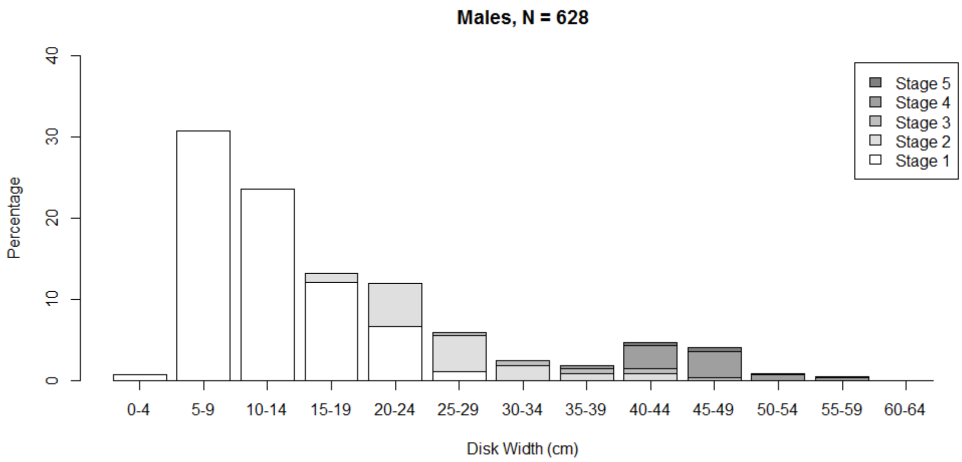
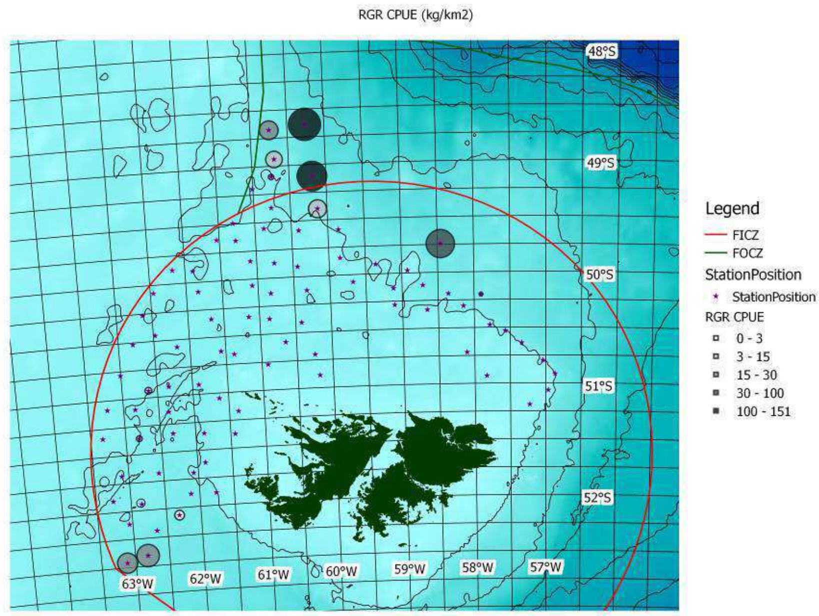


Figure 14: Distribution, CPUE (kg/hr) & size frequency for *Bathyraja brachyurops*

3.1.4.3 *Bathyraja griseocauda*

A total of 382kg was caught in 13 of the 78 stations, comprising 16% of the skate catch. All catches occurred in deeper water over the shelf break both in the South and in the North (Figure 15). The largest three catches (37, 53 and 75kg) all occurred at the three targeted RGR stations 1508, 1510 in the NW of the FOCZ and st. 1529 in North of the FICZ. All 109 specimens (50% Female) were sampled, with sizes ranging from 15-102cm DW (Figure 14). Two of the largest females (96 and 102cm L_{dw}) were encountered carrying egg capsules (F5), 20% of all females above the L_{dw} at 50% maturity of 77.7cm DW. Since capsule carrying females (F5) had previously been encountered at the locations of the targeted RGR stations, they are likely to be spawning areas for this species.



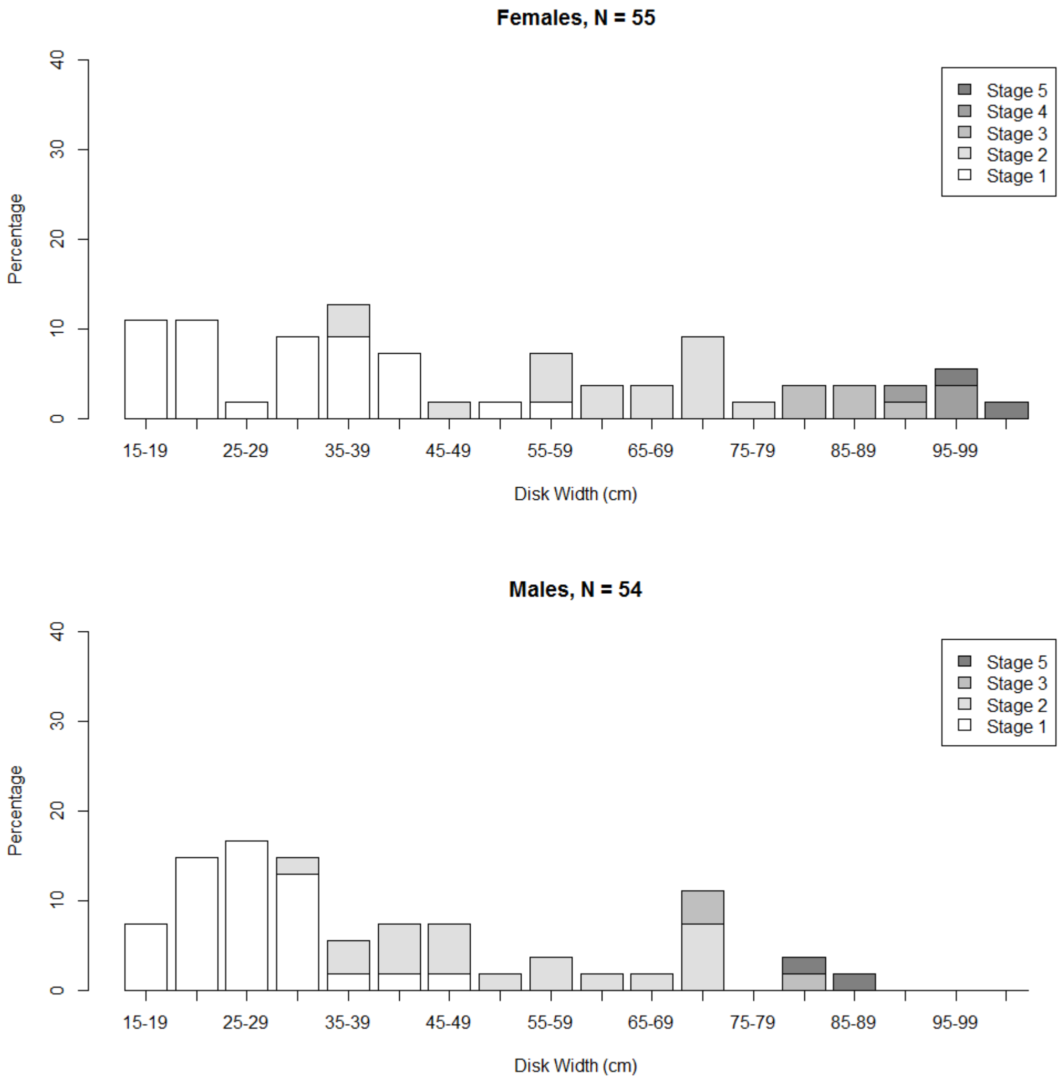


Figure 15: Distribution, CPUE (kg/hr) & size frequency for *Bathyraja griseocauda*

3.1.4.4 *Bathyraja albomaculata*

A total of 129kg of this 4th most abundant species was caught in 17 of the 78 stations, comprising 5.4% of the skate catch. Specimens were caught sporadically throughout the area, with greatest catch and abundance in the northern sector. Of the 88 specimens, 57% were female, sizes ranged from 11-50cm L_{dw}, and only 1 (3.6%) of the 28 females above L_{dw} at 50% maturity of 37.2cm had egg capsules.

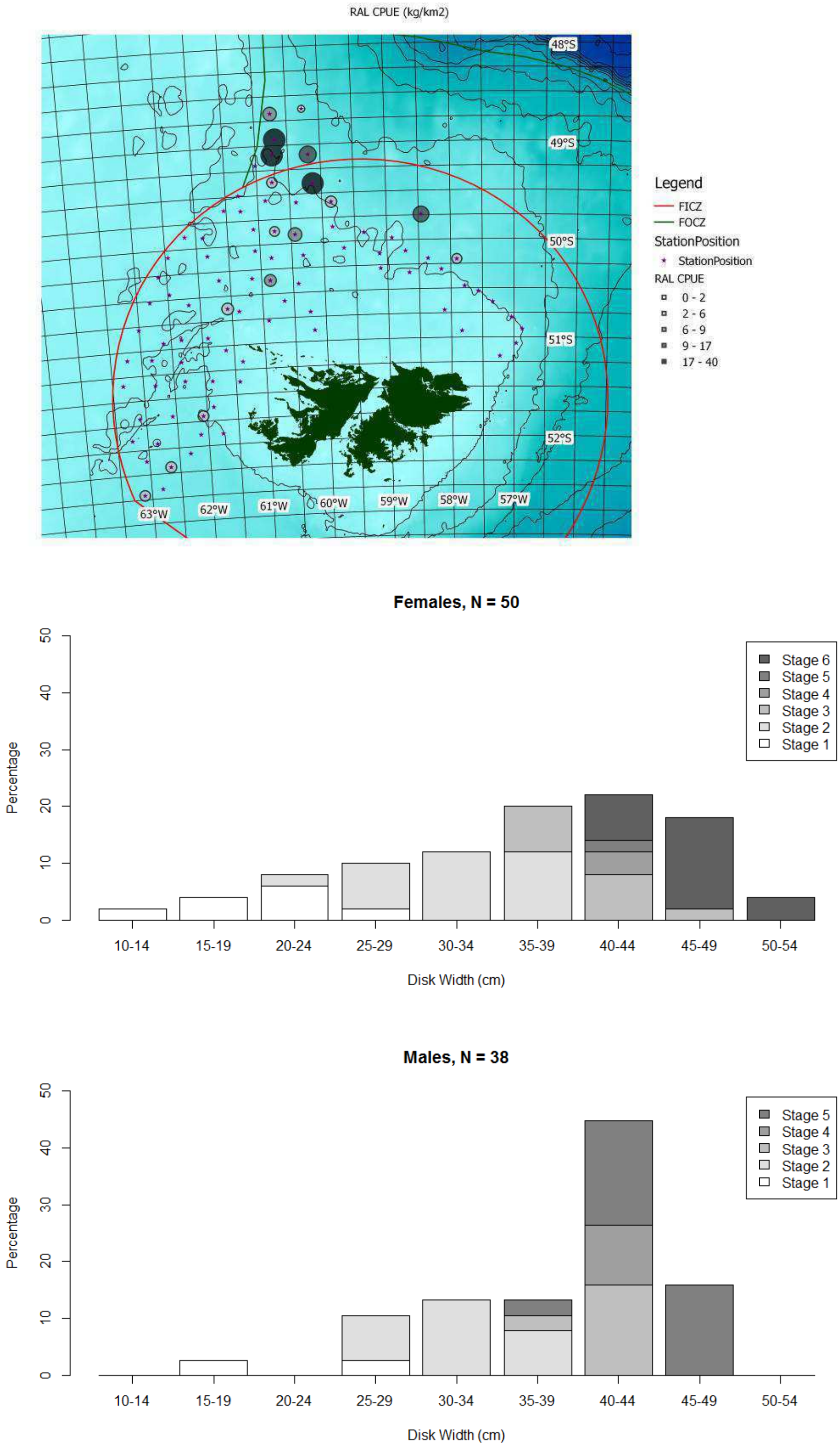


Figure 16: Distribution, CPUE (kg/hr) & size frequency for *Bathyraja albomaculata*

3.2 Rockcod biomass estimates

Using the 2010 data, the only variogram model which fitted the data was the exponential model which reached the sill (4440) at a range of 6.08 km without any nugget effect (Table 4; Figure 17 top left). Rock cod densities varied from 152 kg to 28 t per km^2 (station 433; Figure 17 top right). Highest abundances were generally observed west of West Falkland (stations 373, 391, 407, 416, 426, 416 and 433 had densities >10 $t.km^{-2}$). Three stations (492, 494 and 504) north of East Falkland exhibited densities >10 $t.km^{-2}$. All the other stations exhibited densities <10t.km-2. Total biomass was estimated at 343,124 t for this year.

Using the 2011 data, the lowest SSR was obtained with the Gaussian model, but this model gave unrealistic minimum estimated densities compared to observed densities. The spherical model (with an SSR <1% higher than the Gaussian model) enabled having a range of predicted densities closer to the observed values. With this model, the sill (5030) was reached at the range 93 km with a nugget effect of 210 (Table 4; Figure 17 middle left). Densities ranged from 270 kg to 21.8 t per km^2 (Figure 17 middle right) and total biomass was estimated at 392,053 t (14% increase compared to the previous year). A large patch of high densities was observed northwest of West Falkland. Compared to 2010, high densities seemed to be concentrated in the northwest of the studied area.

In 2014, the lowest SSR was obtained by fitting the spherical model which reached the sill (2330) at a range of 51 km without any nugget effect (Table 4; Figure 17 bottom left). Densities ranged from 9 kg to 16.5 t per km2 (Figure 17 bottom right) and total biomass was estimated at 98,596 t (a 71% decrease compared to 2010 and a 74% decrease compared to 2011). Three hot spots can be identified on the map (two northwest of West Falkland and one north of East Falkland).

With exponential or spherical modelled semi-variances and ranges varying from 6 to 93 km, rock cod densities does not seem to be highly auto-correlated. An improvement of the survey design could be to add some stations northwest of West Falkland where highest densities were observed during the three research cruises to better describe the short distance semi-variance and improve the variogram modelling.

Highest abundances of rock cod are observed northwest of West Falkland where finfish trawlers target this species.

Research cruises for rock cod biomass estimations were first carried out in February (2010 and 2011) and second in October (2014). In Rock cod, the reproduction period takes place between June and August on the shelf break (a significant percentage of specimens were post-spawning in October). The decrease of biomass observed in 2014 is probably due to high densities of rock cod on spawning grounds which are outside the survey area. The migration to the northwest of the FICZ probably occurred after the research cruise.

Table 4: Parameters used to plot the semi-variogram, fit the variogram model and variogram model parameters

	ZDLT1-02-2010	ZDLT1-02-2011	ZDLT1-10-2014
N of distance classes	30	30	30
Lambda	0.5	0.5	0.5
Model	Exponential	Spherical	Spherical
Range (km)	6.08	93	51
Sill	4440	5030	2330
Nugget	0	210	0
Mean estimation (mt)	3344	3821	961
Biomass estimation (mt)	343,124	392,053	98,596

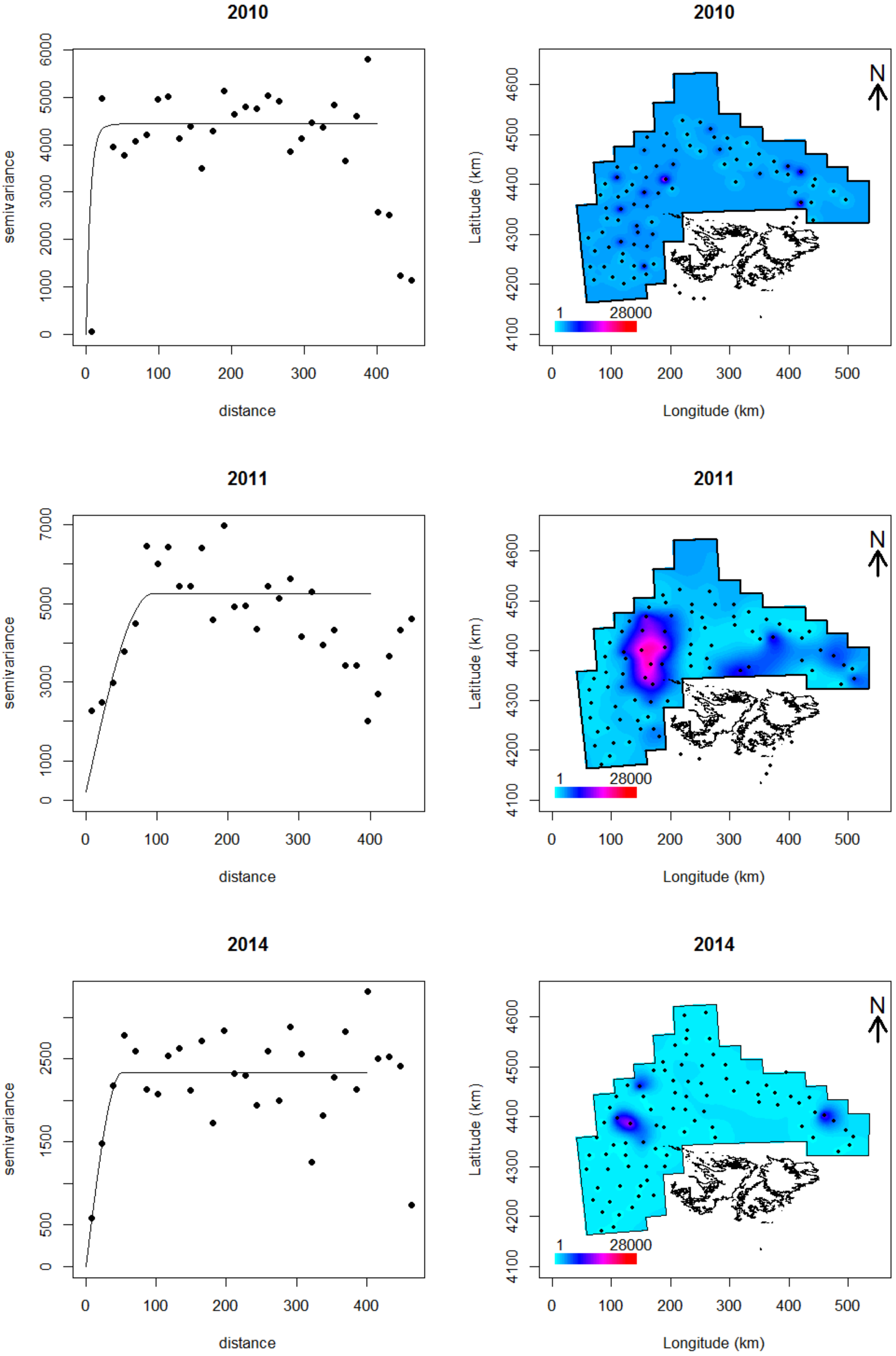


Figure 17: Semi-variogram with variogram model describing the data auto-correlation vs distance between stations (left column) and map of the rock cod density interpolated by kriging (right column) for 2010 (first row), 2011 (second row) and 2014 (third row) data.

3.3 Red cod *Salilota australis* (BAC)

Semi-variogram was plotted using 26 distance classes and a λ=0.5 (Figure 18). The Gaussian model gave the lowest SSR, reaching the sill (1221) at a range of 15.4 km without any nugget effect. Mean density was estimated at 379 kg.km^{-2} and total abundance was 38,909 t. The map of the kriged data (Figure 18) shows densities varying from 1 kg to more than 13 t per km^2. High abundances are observed from northwest to west of West Falkland, the highest being observed in station 1426 (13.4 t per km^2) and stations 1439, 1472, 1390, 1444 and 1436 exhibited densities >1 t per km^2.

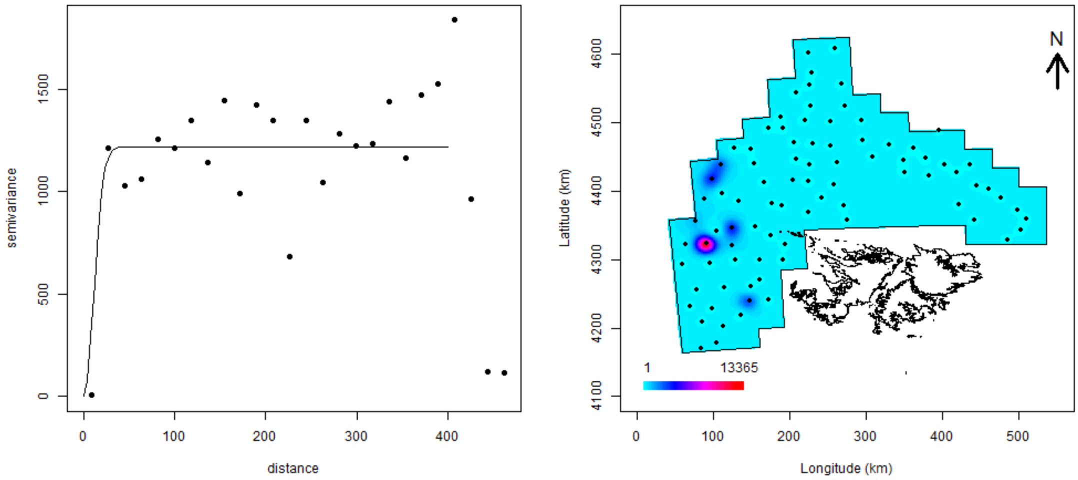


Figure 18: Semi-variogram with variogram model describing the data auto-correlation vs distance between stations (left) and map of the red cod density interpolated by kriging (right).

3.4 Hake *Merluccius hubbsi* (HAK)

Semi-variogram was plotted using 30 distance classes and a λ=0.5 (Figure 19 left). The spherical model gave the lowest SSR, reaching the sill (136) at a range of 305 km without any nugget effect. The semi-variogram shows that hake abundances seem to be highly auto-correlated, unlike the other commercial species studied here. Mean density was estimated at 56 kg.km^{-2} resulting in a total abundance of 5,814 t. Kriged densities (Figure 19 right) vary from 5 to 279 t per km^2. High densities of hake were observed in a large area going from west to north of West Falkland.

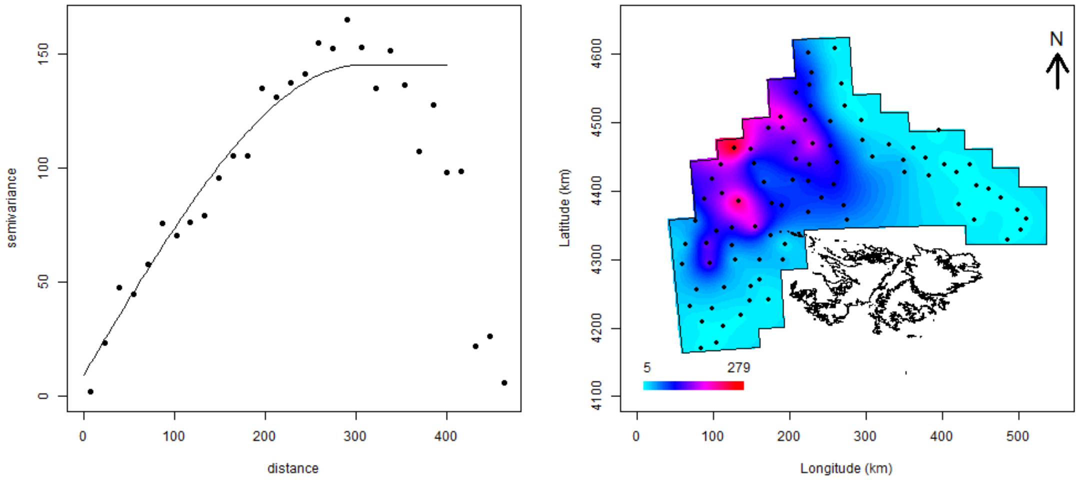


Figure 19: Semi-variogram with variogram model describing the data auto-correlation vs distance between stations (left) and map of the hake density interpolated by kriging (right).

3.5 Kingclip *Genypterus blacodes* (KIN)

Semi-variogram was plotted using 30 distance classes and a λ=0.5 (Figure 20 left). The spherical model gave the lowest SSR, reaching the sill (455) at a range of 34 km without any nugget effect. Kingclip densities range from 2 kg to 3.5 t per km^2. Mean density was estimated at 160 kg.km^{-2} resulting in a total abundance of 16,433 t. Kriged map (Figure 20 right) show that highest density was observed in station 1448 northwest of West Falkland. Stations 1390 and 1436 south of station 1448 exhibited densities >1 t.km^{-2}.

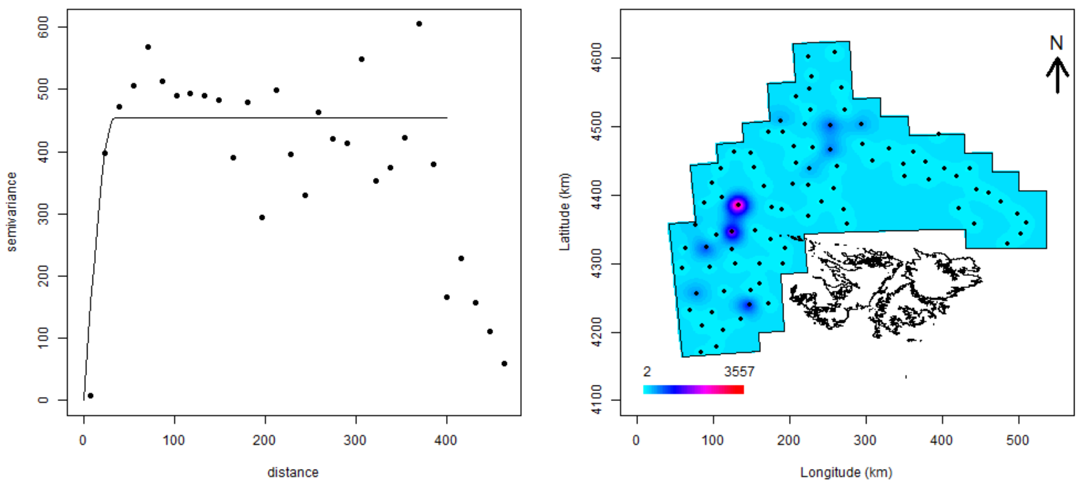


Figure 20: Semi-variogram with variogram model describing the data auto-correlation vs distance between stations (left) and map of the kingclip density interpolated by kriging (right).

3.6 Falkland calamari *Doryteuthis gahi*

In the case of the Falkland calamari and following the criteria described in section 2.4.1, no variogram could have been fitted to the semi-variogram data. Falkland calamari densities could therefore be considered as not auto-correlated and the biomass estimation can be derived by multiplying the mean observed density (86.2 $kg.km^{-2}$) by the surface of the survey resulting in a total biomass of 8848 t. The density map can be visualized in Figure 11.

3.7 Oceanography

Oceanographic data were collected at 86 stations. The area covered ranged from 48° 32.99'S to 52° 30.76'S and 56° 50.03'W to 63° 21.15'W. Good data was collected on all the downcasts and so upcast data was removed. The CTD had an issue coping with a strong thermocline with salinity spiking. This was confirmed as more than a single instrument error by use of the second instrument on the 29th October as part of a tandem cast (Figure 21).

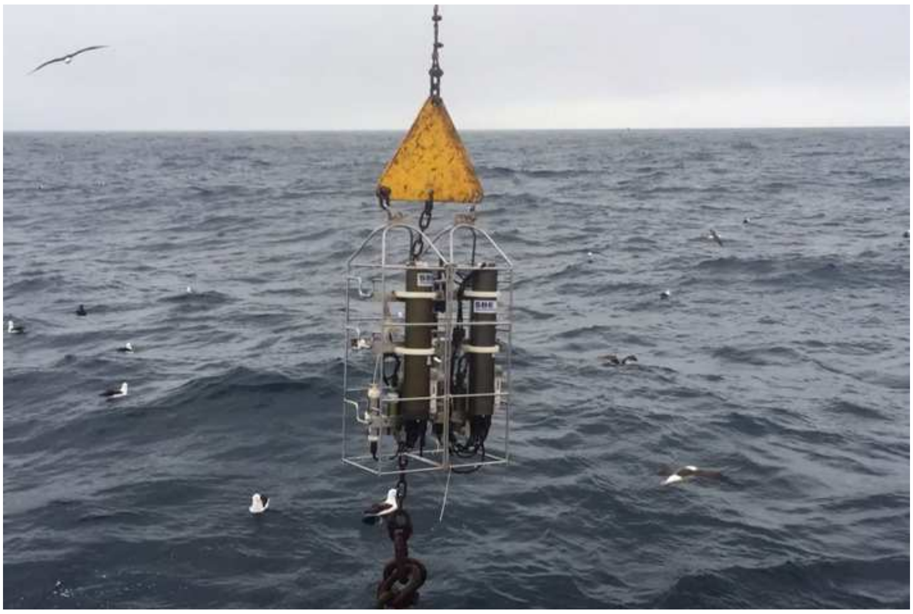


Figure 21 CTD tandem cast setup

The data collected by both instruments was broadly similar, with the slight difference between the data sets caused by the instruments not being synchronized. However both showed similar spiking where large temperature changes occurred.

Figure 22 shows the location of the stations, and the location of the stations that make the ODV temperature section (Figure 26 & Figure 27).

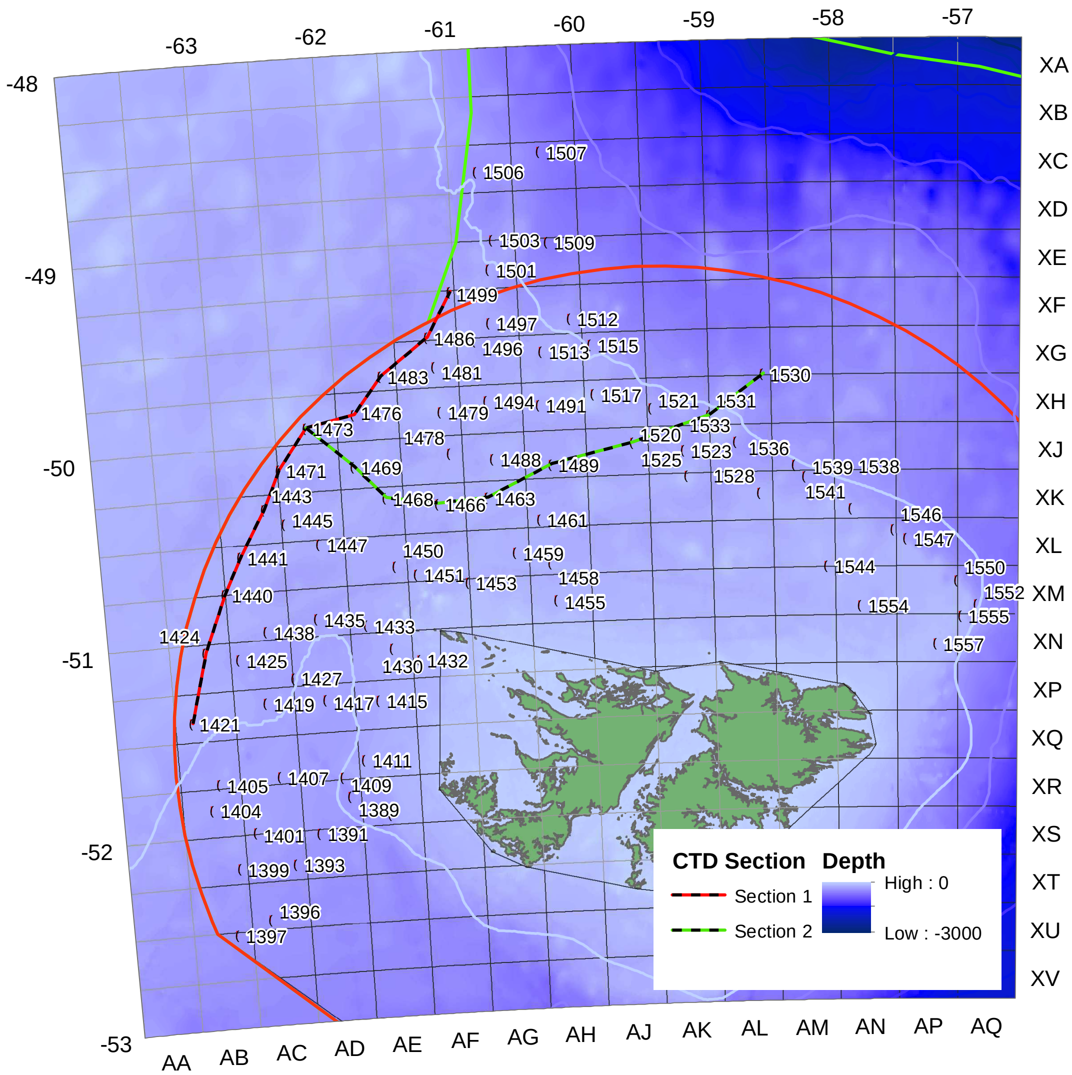


Figure 22 Location and number of CTD stations

Figure 23, Figure 24, and Figure 25 below shows the temperature, salinity and σ-t density, gridded using ODV4 DIVA[1] gridding algorithm. Surface temperature is higher in the north west and decreases to the south and east, this is reflected in the seabed temperature, but this data is skewed by depth, with deeper casts in the south west, north and north east.

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

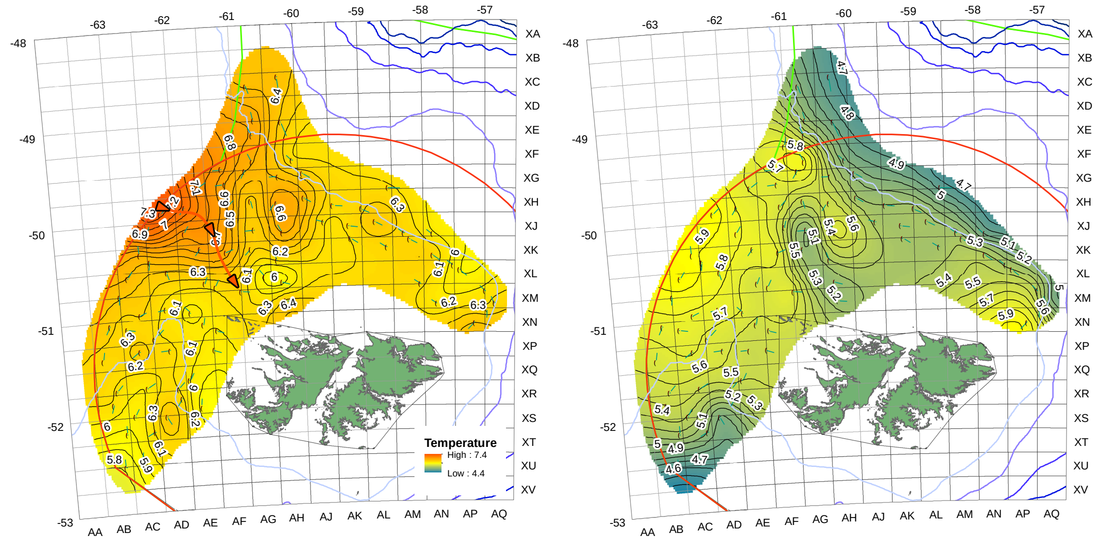


Figure 23 Temperature (Sea surface on the left, Seabed on the right)

Suspected warm water current shown be red arrow and cooler eddy by blue arrow.

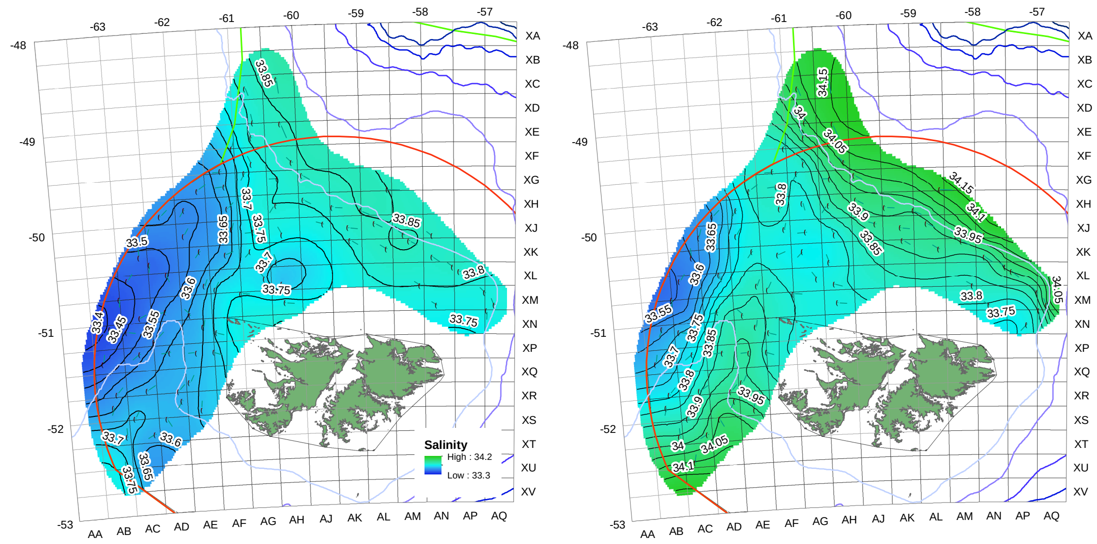


Figure 24 Salinity (Sea surface on the left, Seabed on the right)

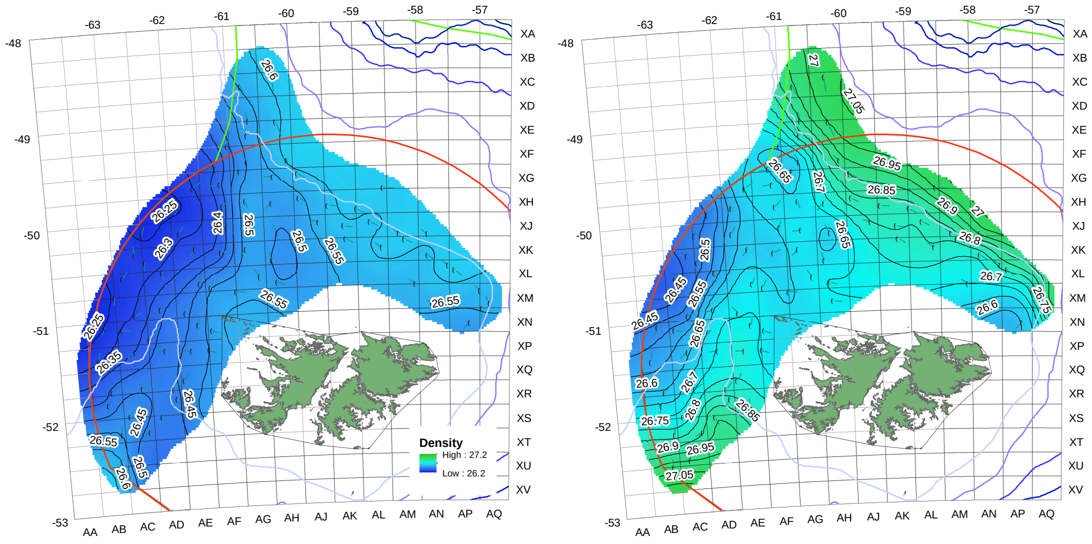


Figure 25. σ-t Density (Sea surface on the left, Seabed on the right)

Temperature plots (Figure 23) show higher temperature water pushing in from the north west, first seen in the cast in XHAD, and pushing west-south-west and then south west when encountering cold water pushing north through grids XMAG, XLAG, XKAG and XJAG. Figure 26 below shows the warm water pushing in to the zone across a 50 km front between stations 1471 and 1476, with the water 0.5°C warmer than the water to the north and c.1° warmer than the water to the south. Deeper than 50 m below the surface the warm stream is absent. Cold water can be seen in the deeper waters to the north and south.

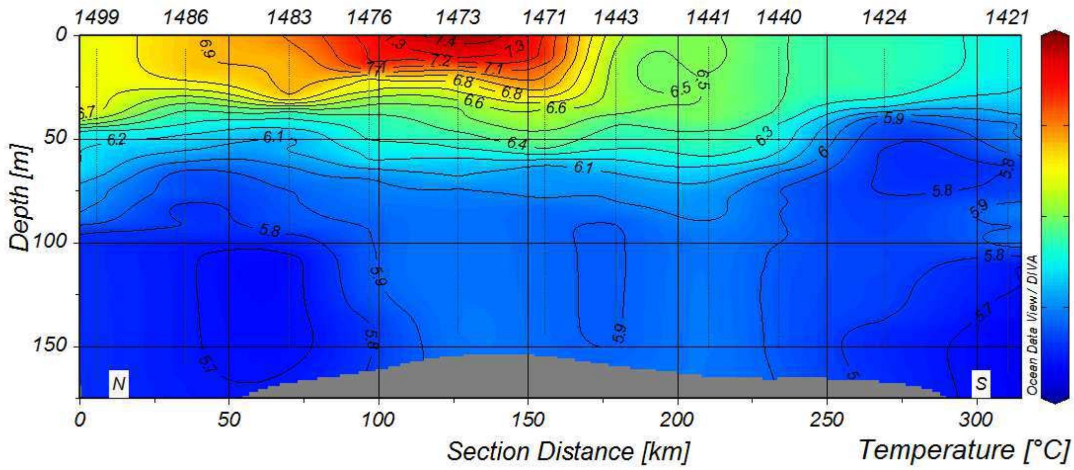


Figure 26 ODV temperature section (Northern stations to left)

A cold water eddy is apparent on both the surface and seabed temperature maps. Cold water was seen at station 1455, 1458, 1459, 1463, 1488 and 1494 (surface). Stations 1461, 1489, 1491 and 1513 provide the warmer water separating the eddy from the colder slope water. The cold water eddy is crossed in the east west section below station 1463 in Figure 27. The section starts at station 1473 in the west seen at the centre of the warmer surface water in Figure 26. In

Figure 27 cold water is also evident pushing in from the north east slope.

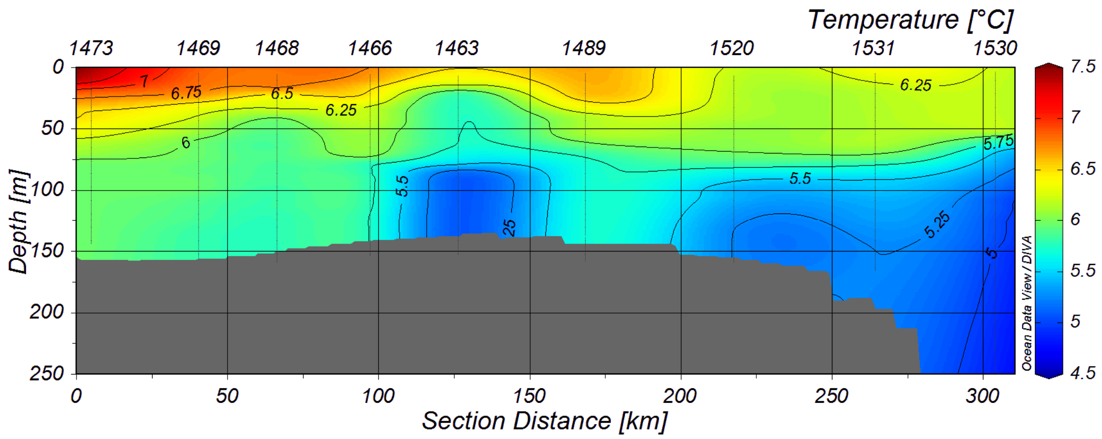


Figure 27 ODV East-West temperature section

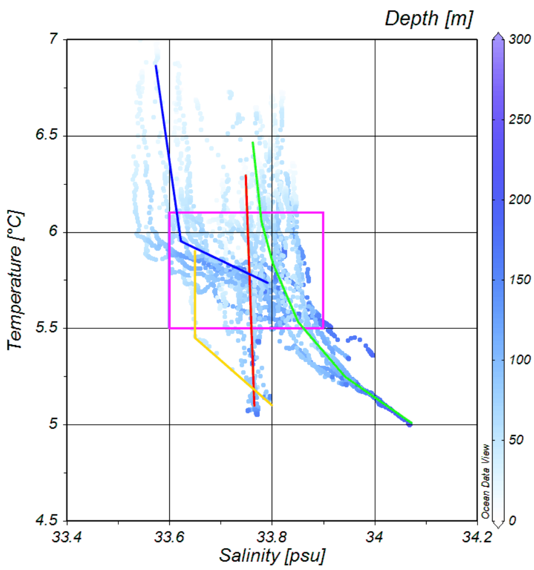


Figure 28 Temperature/Salinity plot north of Falklands area

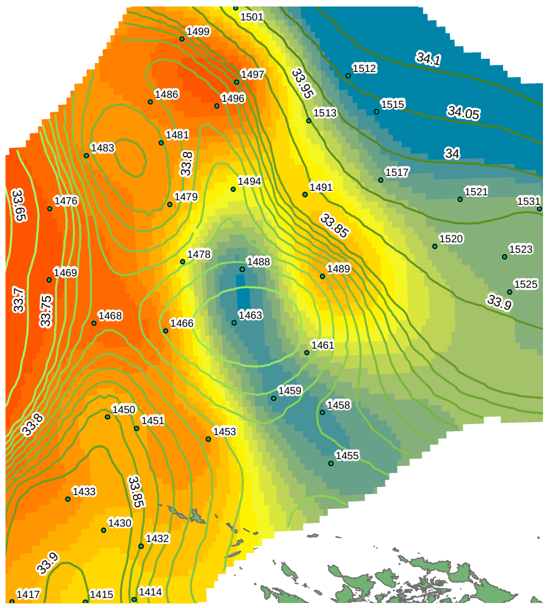


Figure 29 North Falklands water temperature and salinity

A contour map,

Figure 29, with density plotted at 0.01 PSU intervals shows that the water is slightly less saline than the water to the east suggesting the cold water current did not come from that area. The Temperature Salinity plot shows distinct water profiles, for a number of the stations, the easterly stations (1466, 1468, 1469, 1476, 1479 and 1483) show higher temperature and lower salinity at the surface, at the surface. They generally follow the blue line. Station 1455, 1459, 1461, 1463 and 1488 have a uniform salinity with a temperature range of 5.1 to 6.4°C, shown by the red line. The stations on the upper slope (number 1501 and later) upper water is similar to the "red" stations, but as the depth increases, salinity increases and temperature falls represented by the green line. Stations 1496, 1497 and 1498 share the same profile as the other central and western station, but the seabed water occurs before the two water mass profiles diverge. The south westerly stations (of those in Figure 29) profiles show significant mixing with confused profiles, the water mass with the profiles fit within the magenta square. Station 1458 (yellow line in Figure 28) was unique, with no other station in the entire survey exhibiting a similar profile.

Generally surface salinity is lowest in the west and increases to the east of the area surveyed; surface salinity is low in the south where depth increases. Surface salinity increases to the north and east as water depth increases. The seabed salinity is heavily affected by depth, but with in the area where seabed is less than 200m salinity follows a similar pattern to the surface salinity, with the lowest salinity in the west, and higher salinity in the north and east, shown in

Figure 30 below.

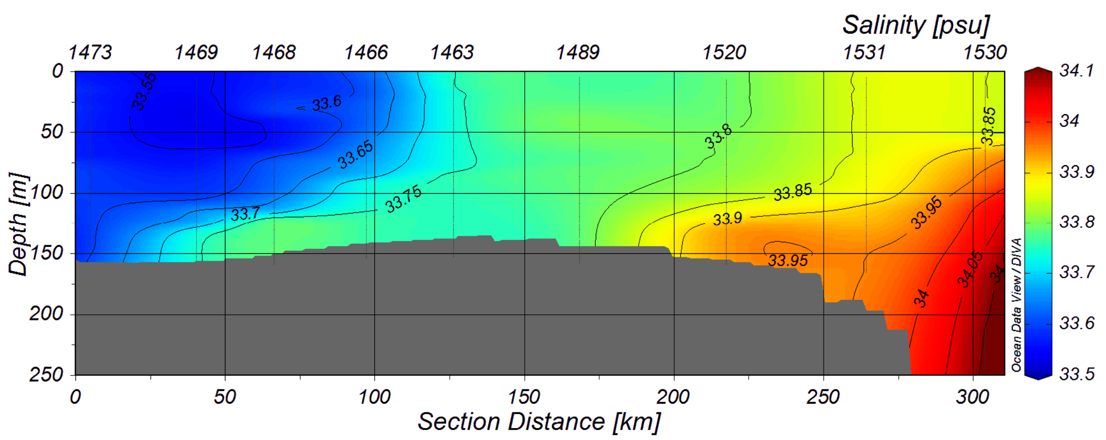


Figure 30 East West salinity section

4.0 General conclusions

The ZDLT1-10-2014 research survey yielded good quality data with very few minor problems.

The Rockcod biomass estimates arrived at through the modelling of the survey data was 98,596 t. This biomass estimate was a 71% decrease compared to the 2010 and a 74% decrease compared to the 2011 Rockcod biomass estimates.

This low 2014 biomass estimate is somewhat surprising, particularly because the 2014 fishery for Rockcod yielded around 56,000t, and there did not seem to be a decline in abundance in the fishery. As such it is likely that underlying biological processes, in particular reproductive and feeding behaviour which may involve significant migration by the species and that are not yet fully understood, may have a much greater influence than previously believed.

The planned February 2015 Rockcod Biomass survey (ZDLT1-02-2015) shall hopefully provide some further insight into these issues.

References

Arkhipkin, A., Bakanev, S. & Laptikhovsky, V. (2011) Cruise Report, ZDLT1-02-2011, Rockcod Biomass survey. FIG Directorate of Natural Resources Fisheries Department: Stanley, Falkland Islands, 1-37.

Brickle, P. & Laptikhovsky, V. (2010) Cruise Report, ZDLT1-02-2010, Rockcod Biomass survey. FIG Directorate of Natural Resources Fisheries Department: Stanley, Falkland Islands, 1-31.

Brickle, P. & Winter, A. (2012) Cruise Report, ZDLT1-11-2011, 1st Cod-end Mesh Size Experiment. FIG Directorate of Natural Resources Fisheries Department: Stanley, Falkland Islands, 1-57.

McEachran, J.D. (1983) Results of the research cruises of FVR "Walther Herwig" to South America, LXI. Revision of the South American skate genus *Psammobatis* Günther, 1870 (Elasmobranchii: Rajiformes, Rajidae). *Archiv für Fischereiwissenschaft*, 34, 23-80.

Paya, I., Brickle, P., Laptikhovsky, V. & Winter, A. (2010) Vessel units, allowable effort, and allowable catch 2011. Technical Document. Fisheries Department Falkland Islands Government.

Roux, M.-J., Brewin, P., Jürgens, E. & Winter, A. (2012a) Cruise Report, ZDLT1-10-2012, 3rd Cod-end Mesh Size Experiment. FIG Directorate of Natural Resources Fisheries Department: Stanley, Falkland Islands, 1-66.

Roux, M.-J., Brewin, P., Jürgens, L., Winter, A. & James, R. (2013a) Cruise Report, ZDLT1-07-2013, Square mesh panel (SMP) trials - 2. FIG Directorate of Natural Resources Fisheries Department: Stanley, Falkland Islands, 1-49.

Roux, M.-J., Laptikhovsky, V., Brewin, P., Arkhipkin, A. & Winter, A. (2012b) Cruise Report, ZDLT1-04-2012, 2nd Cod-end Mesh Size Experiment. FIG Directorate of Natural Resources Fisheries Department: Stanley, Falkland Islands, 1-54.

Roux, M.-J., Laptikhovsky, V., Brewin, P. & Winter, A. (2013b) Cruise Report, ZDLT1-02-2013, Square mesh panel (SMP) trials. FIG Directorate of Natural Resources Fisheries Department: Stanley, Falkland Islands, 1-45.

Roux, M.-J., Winter, A. & James, R. (2013c) Cruise Report, ZDLT1-10-2013, Square mesh panel (SMP) trials - 3. FIG Directorate of Natural Resources Fisheries Department: Stanley, Falkland Islands, 1-53.

Schlitzer, R. (2013) Ocean Data View.

Winter, A., Laptikhovsky, V., Brickle, P. & Arkhipkin, A. (2010) Rock cod (*Patagonotothen ramsayi* (Regan 1913)) stock assessment in the Falkland Islands. Technical Document. Falkland Islands Fisheries Department.

5.0 Appendix

Table 5: Total catch of all trawl stations by species

Species Code	*Species name*	***Total Catch (kg)***	***Total Sampled (kg)***	***Total Discarded (kg)***	***Proportion (%)***
PAR	*Patagonotothen ramsayi*	37,977.837	1,213.850	13,029.485	47.76%
BAC	*Salilota australis*	15,403.635	1,229.138	882.287	19.37%
KIN	*Genypterus blacodes*	5,929.386	3,022.256	0.000	7.46%
SAR	*Sprattus fuegensis*	5,456.631	27.760	5,052.531	6.86%
LOL	*Doryteuthis gahi*	3,589.363	602.130	40.117	4.51%
BLU	*Micromesistius australis*	2,939.213	181.093	2,939.173	3.70%
HAK	*Merluccius hubbsi*	2,635.954	2,588.814	0.000	3.32%
RFL	*Zearaja chilensis*	883.370	883.370	2.130	1.11%
RBR	*Bathyraja brachyurops*	718.925	718.925	229.025	0.90%
DGH	*Schroederichthys bivius*	682.870	0.000	681.870	0.86%
ING	*Moroteuthis ingens*	394.209	56.830	394.209	0.50%
RGR	*Bathyraja griseocauda*	381.940	381.940	20.330	0.48%
CHR	*Chrysaora sp.*	368.648	0.000	368.648	0.46%
CGO	*Cottoperca gobio*	267.544	16.600	267.544	0.34%
GRF	*Coelorhynchus fasciatus*	242.060	31.547	242.060	0.30%
DGS	*Squalus acanthias*	219.100	0.000	219.100	0.28%
SPN	Porifera	187.537	0.000	187.537	0.24%
EEL	*Iluocoetes fimbriatus*	172.714	0.000	172.714	0.22%
TOO	*Dissostichus eleginoides*	159.532	159.406	61.052	0.20%
RAL	*Bathyraja albomaculata*	129.055	129.055	32.780	0.16%
SQT	Ascidiacea	103.409	0.000	103.409	0.13%
RMU	*Bathyraja multispinis*	90.497	90.497	1.490	0.11%
RED	*Sebastes oculatus*	77.570	73.190	5.610	0.10%
RBZ	*Bathyraja cousseauae*	67.440	67.440	4.380	0.08%
MUG	*Munida gregaria*	59.480	0.670	59.480	0.07%
RMC	*Bathyraja macloviana*	49.875	49.875	44.205	0.06%
GRC	*Macrourus carinatus*	35.250	31.410	35.250	0.04%
WHI	*Macruronus magellanicus*	30.080	27.700	30.080	0.04%
RDO	*Amblyraja doellojuradoi*	27.310	27.310	27.310	0.03%
STA	*Sterechinus agassizi*	24.745	0.000	24.745	0.03%
RSC	*Bathyraja scaphiops*	18.293	18.293	4.900	0.02%
COT	*Cottunculus granulosus*	17.990	0.000	17.990	0.02%
WRM	*Chaetopterus variopedatus*	14.305	0.000	14.305	0.02%
ZYP	*Zygochlamys patagonica*	10.571	8.438	3.512	0.01%
ANM	Anemone	9.811	0.000	9.811	0.01%
SER	*Serolis spp.*	9.488	0.000	9.488	0.01%
NEM	*Neophyrnichthys marmoratus*	9.205	0.000	9.205	0.01%
RPX	*Psammobatis spp.*	8.588	8.566	8.588	0.01%
GYM	*Gymnoscopelus spp.*	7.884	0.000	7.884	0.01%
GOC	*Gorgonocephalas chilensis*	7.615	0.000	7.615	0.01%
GYN	*Gymnoscopelus nicholsi*	7.420	0.000	7.420	0.01%
CTA	*Ctenodiscus australis*	6.419	0.000	6.419	0.01%
GYB	*Gymnoscopelus bolini*	5.610	0.000	5.610	0.01%
FUM	*Fusitriton m. magellanicus*	5.205	0.000	5.205	0.01%
PAT	*Merluccius australis*	5.110	5.110	0.000	0.01%
ACS	*Acanthoserolis schythei*	4.794	0.000	4.794	0.01%
SHT	Mixed invertebrates	4.580	0.000	4.580	0.01%
RMG	*Bathyraja magellanica*	4.330	4.330	4.330	0.01%
CAS	*Campylonotus semistriatus*	4.190	0.920	3.270	0.01%

PYM	*Physiculus marginatus*	4.022	2.158	4.022	0.01%
MLA	*Muusoctopus longibrachus akambei*	3.851	0.000	3.851	<0.01%
AUC	*Austrocidaris canaliculata*	3.783	0.000	3.783	<0.01%
PTE	*Patagonotothen tessellata*	3.315	3.310	3.315	<0.01%
MED	Medusae	3.240	0.000	3.240	<0.01%
RDA	*Dipturus argentinensis*	2.960	2.960	0.000	<0.01%
COP	*Congiopodus peruvianus*	2.750	0.000	2.750	<0.01%
CAZ	*Calyptraster sp.*	2.042	0.000	2.042	<0.01%
MUE	*Muusoctopus eureka*	2.013	0.000	2.013	<0.01%
FLX	*Flabellum spp.*	1.865	1.219	0.855	<0.01%
UHH	Heart urchin	1.352	0.000	1.352	<0.01%
BAL	*Bathydomus longisetosus*	1.350	0.000	1.350	<0.01%
ILL	*Illex argentinus*	1.201	1.201	0.647	<0.01%
LOS	*Lophaster stellans*	1.026	0.000	1.026	<0.01%
POA	*Porania antarctica*	0.889	0.000	0.889	<0.01%
CRY	*Crossaster sp.*	0.888	0.000	0.888	<0.01%
ODM	*Odontocymbiola magellanica*	0.861	0.000	0.861	<0.01%
MUU	*Munida subrugosa*	0.811	0.139	0.672	<0.01%
SUN	*Labidaster radiosus*	0.733	0.000	0.733	<0.01%
CAM	*Cataetyx messieri*	0.730	0.000	0.730	<0.01%
PES	*Peltarion spinosulum*	0.674	0.000	0.674	<0.01%
SEP	*Seriolella porosa*	0.670	0.670	0.000	<0.01%
MUO	*Muraenolepis orangiensis*	0.633	0.000	0.623	<0.01%
THB	*Thymops birsteini*	0.629	0.000	0.629	<0.01%
ADA	*Adelomelon ancilla*	0.547	0.000	0.547	<0.01%
OPV	*Ophiacanta vivipara*	0.514	0.010	0.514	<0.01%
NUD	Nudibranchia	0.492	0.280	0.372	<0.01%
OPL	*Ophiuroglypha lymanii*	0.483	0.000	0.483	<0.01%
HEO	*Henricia obesa*	0.480	0.000	0.480	<0.01%
BAO	*Bathybiaster loripes*	0.441	0.000	0.441	<0.01%
COL	*Cosmasterias lurida*	0.410	0.000	0.410	<0.01%
THO	Thouarellinae	0.381	0.000	0.381	<0.01%
PYX	Pycnogonida	0.296	0.000	0.296	<0.01%
ALC	Alcyoniina	0.244	0.088	0.156	<0.01%
BRY	Bryozoa	0.215	0.202	0.169	<0.01%
ZYX	Dead Zygochlamys	0.210	0.000	0.210	<0.01%
ASA	*Astrotoma agassizii*	0.204	0.000	0.204	<0.01%
EUL	*Eurypodius latreillei*	0.184	0.000	0.184	<0.01%
ERR	*Errina sp.*	0.150	0.000	0.150	<0.01%
MMA	*Mancopsetta maculata*	0.140	0.140	0.000	<0.01%
NOW	*Paranotothenia magellanica*	0.140	0.140	0.140	<0.01%
SET	Sertularioidae	0.139	0.000	0.139	<0.01%
CYX	*Cycethra sp.*	0.128	0.000	0.128	<0.01%
SRP	*Semirossia patagonica*	0.117	0.090	0.117	<0.01%
TED	*Terebratella dorsata*	0.116	0.000	0.116	<0.01%
ISO	Isopoda	0.089	0.000	0.089	<0.01%
EGG	Eggmass	0.073	0.000	0.073	<0.01%
MIR	*Mirostenella sp.*	0.073	0.000	0.073	<0.01%
CEX	*Ceramaster sp.*	0.072	0.000	0.072	<0.01%
AST	Asteroidea	0.061	0.000	0.061	<0.01%
POL	Polychaeta	0.059	0.000	0.059	<0.01%
HOL	Holothuroidea	0.053	0.000	0.053	<0.01%
MAV	*Magellania venosa*	0.052	0.000	0.052	<0.01%

XXX	Unidentified animal	0.040	0.040	0.000	<0.01%
OPH	Ophiuroidea	0.038	0.000	0.038	<0.01%
CRI	Crinoidea	0.035	0.000	0.035	<0.01%
EUO	*Eurypodius longirostris*	0.034	0.000	0.034	<0.01%
LEA	*Lepas australis*	0.030	0.000	0.030	<0.01%
ANT	Anthozoa	0.025	0.000	0.025	<0.01%
OPD	*Ophiacantha densispina*	0.024	0.000	0.024	<0.01%
THN	*Thysanopsetta naresi*	0.022	0.000	0.022	<0.01%
HCR	Paguroidea	0.016	0.000	0.016	<0.01%
PRI	Priapulida	0.015	0.000	0.015	<0.01%
OCC	Octocoralia	0.013	0.000	0.013	<0.01%
PLU	Primnoellinae	0.012	0.000	0.012	<0.01%
AGO	*Agonopsis chilensis*	0.010	0.000	0.010	<0.01%
BUC	*Bulbus carcellesi*	0.010	0.000	0.010	<0.01%
ODP	*Odontaster pencillatus*	0.010	0.000	0.010	<0.01%
OPA	*Opisthoteuthis hardyi*	0.010	0.000	0.010	<0.01%
STS	*Stereomastis suhmi*	0.010	0.000	0.010	<0.01%
OPX	*Opisthoteuthis spp.*	0.009	0.000	0.009	<0.01%
SAT	*Salpa thomsoni*	0.005	0.000	0.005	<0.01%
PRX	*Paragorgia sp.*	0.001	0.000	0.001	<0.01%
		79,515.807	**11,669.110**	**25,336.920**	

Table 6: Random sample numbers

Code	Name	Number Sampled	%
LOL	*Doryteuthis gahi*	16,477	42.7%
PAR	*Patagonotothen ramsayi*	9,644	25.0%
BAC	*Salilota australis*	3,654	9.5%
BLU	*Micromesistius australis*	1,642	4.3%
KIN	*Genypterus blacodes*	1,558	4.0%
HAK	*Merluccius hubbsi*	1,456	3.8%
RBR	*Bathyraja brachyurops*	1,291	3.3%
SAR	*Sprattus fuegensis*	692	1.8%
TOO	*Dissostichus eleginoides*	374	1.0%
ING	*Moroteuthis ingens*	349	0.9%
RFL	*Zearaja chilensis*	304	0.8%
GRF	*Coelorhynchus fasciatus*	217	0.6%
RED	*Sebastes oculatus*	129	0.3%
CGO	*Cottoperca gobio*	123	0.3%
RGR	*Bathyraja griseocauda*	109	0.3%
PYM	*Physiculus marginatus*	102	0.3%
RAL	*Bathyraja albomaculata*	88	0.2%
PTE	*Patagonotothen tessellata*	85	0.2%
RMC	*Bathyraja macloviana*	58	0.2%
WHI	*Macruronus magellanicus*	50	0.1%
GRC	*Macrourus carinatus*	38	0.1%
RDO	*Amblyraja doellojuradoi*	37	0.1%
RPX	*Psammobatis spp.*	33	0.1%
RBZ	*Bathyraja cousseauae*	26	0.1%
RMU	*Bathyraja multispinis*	17	0.0%
ILL	*Illex argentinus*	15	0.0%
RSC	*Bathyraja scaphiops*	13	0.0%
PAT	*Merluccius australis*	3	0.0%
RMG	*Bathyraja magellanica*	3	0.0%
NOW	*Paranotothenia magellanica*	1	0.0%
RDA	*Dipturus argentinensis*	1	0.0%
SEP	*Seriolella porosa*	1	0.0%
		38,590	