Cruise Report ZDLT1-02-2017

Ground Fish survey

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1.0 Introduction

The Patagonian shelf large marine ecosystem, where Falkland waters are situated, is one of the most productive zones of the world (Bakun, 1993). In 1987, the Falkland Islands Government declared the Falkland Interim Conservation Zone (FICZ) which was further extended by the Falkland Outer Conservation Zone (FOCZ) in 1990. Every ship fishing in the FICZ/FOCZ has to be licensed by the Directorate of Natural Resources – Fisheries (DNRF). The finfish fishery is currently regulated using a total allowable effort (TAE) which is derived from the 5–year average effort required to reach the catch limit of the main finfish species (FIFD, 2016). The main species was southern blue whiting but after its decrease in abundance, rock cod (*Patagonotothen ramsayi*) took over and became the most abundant finfish species exploited by trawlers in Falkland waters (Laptikhovsky et al., 2013). Annual catch of rock cod have varied between 7,034 and 76,451 t since 2007.

Since 2010, 5 research cruises were conducted to estimate the biomass of the rock cod stock in February 2010 (Brickle and Laptikhovsky, 2010), 2011 (Arkhipkin et al., 2011), October–November 2014 (Pompert et al., 2014), February 2015 (Gras et al., 2015), 2016 (Gras et al., 2016) prior to this survey. From 2011 to 2013, 6 research cruises were also undertaken to test various fishing gears. The objective was to find a new setup for the trawl to fish more efficiently by reducing the bycatch of undersized rock cod and non–commercial species (Brickle and Winter, 2011; Roux et al., 2012a; Roux et al, 2012b; Roux et al, 2013a; Roux et al, 2013b; Roux et al, 2013c). The outcome was the publication of the new regulation in 2014 that came into force on 1 January 2015 to increase the mesh size from 90 to 110 mm in the codend.

The finfish fishery is a mixed fishery and vessels work under licences A, G and W. If rock cod was the primary target species for some years, vessels also targeted or took as a bycatch other finfish species such as common and Patagonian hakes, kingclip, hoki, red cod, southern blue whiting and one species of cephalopod, the Argentine shortfin squid. In recent years, the TAE estimation based on the primary species rock cod has shown its limit, especially in years when rock cod was not the primary targeted stock (2013, 2015 and 2016; FIFD, 2014; 2015; 2016; 2017). It was then advised to not only focus on rock cod but also to collect as much data as possible about all the other species encountered throughout the survey.

In recent years, scientists have shown the importance of studying the trophic relationships between species in marine ecosystems (Bas, 1998). Various types of data could be collected to understand the role of each species in the trophic web (Hyslop, 1980). During this cruise it was decided to collect information about stomach content to describe the diet of each sampled fish during the hours/days prior to their catch. The other objective is now to create a long term data series of stomach content for the species sampled during the ground fish survey to be able to understand how the trophic relationships can change with time.

The primary objective of the survey was to assess the biomass and abundance of demersal commercial species encountered in the survey zone. Biological data (length, sex, maturity, otoliths and stomach contents) were collected for a sample of each species at each station and used to describe the stock in February. In the present report, biological data are presented for all the species that more than 30 specimens were assessed throughout the cruise. Diet data are presented for all the species sampled throughout the cruise. Finally, this report presents the maps of the oceanographic situation based on data collected in the vicinity of each trawl station.

2.0 Material and methods

2.1 Cruise vessel and surveyed area

The ground fish survey ZDLT1–02–2017 was conducted on board the FV Castelo (LOA 67.8 m, GRT 1321) from 4 to 25 February 2017. Embarking and disembarking occurred on 3 and 26 respectively. In order to be able to compare data with previous biomass estimate surveys carried out in 2010 (Brickle and Laptikhovsky, 2010), 2011 (Arkhipkin et al., 2011), 2014 (Pompert et al., 2014), 2015 (Gras et al. 2015) and 2016 (Gras et al., 2016), it was decided to repeat stations already explored in 2011, 2014, 2015 and 2016. In 2015, 3 stations were added in zones where rock cod could be abundant, 2 in the northwest and 1 in the east of the survey area. In 2017, two stations were added in grid squares XNAH and XNAG to sample toothfish of the year (the additional station in XNAH was plotted on Figure 1 but not the other one as the bridle broke after 2 minutes of trawling; Table 1).

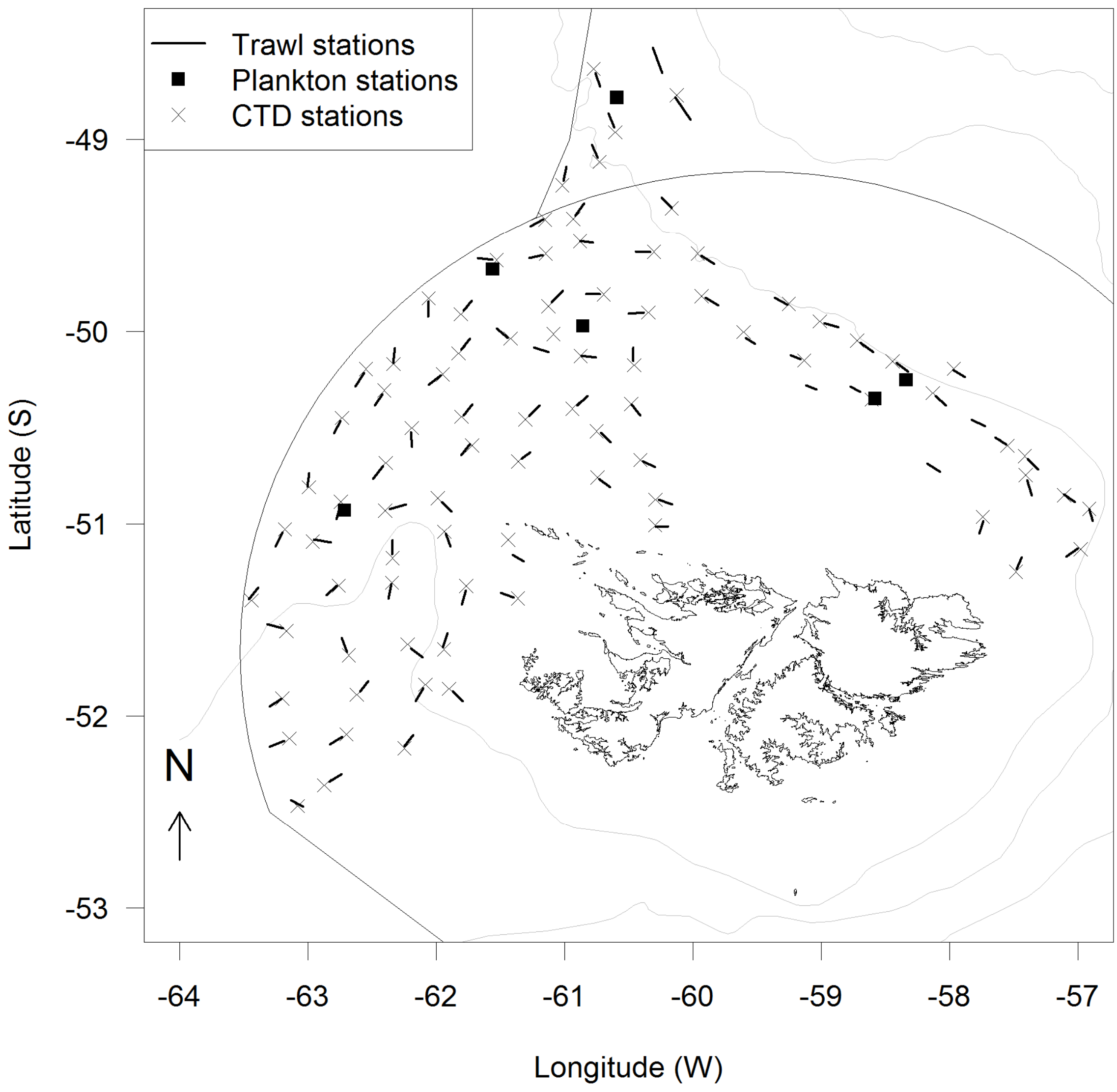

Figure 1: Location of trawl, plankton and CTDO stations

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

Station	Date	Latitude (°S)	Longitude (°W)	Modal Depth	Duration	Activity	Comments
2318	04/02/17	50.81	60.65	132	60	B	
2321	04/02/17	50.53	60.72	147	60	B	
2323	04/02/17	50.68	60.39	143	60	B	
2325	04/02/17	50.88	60.27	132	60	B	
2326	04/02/17	51.01	60.19	90	60	B	
2328	05/02/17	51.02	60.83	79	2	B	trawl failed bridle broken
2330	05/02/17	51.17	61.41	134	60	B	
2332	05/02/17	51.39	61.40	140	60	B	
2334	05/02/17	51.35	61.77	187	60	B	
2335	06/02/17	51.57	61.91	179	60	B	
2338	06/02/17	51.65	62.20	218	60	B	
2340	06/02/17	51.87	61.87	189	60	B	
2342	06/02/17	51.86	62.10	264	60	B	
2343	06/02/17	52.10	62.18	280	60	B	
2345	07/02/17	52.44	63.14	270	60	B	
2348	07/02/17	52.34	62.84	265	60	B	
2350	07/02/17	52.11	62.73	244	60	B	
2352	07/02/17	52.13	63.19	229	60	B	
2353	08/02/17	51.95	63.30	209	60	B	
2356	08/02/17	51.87	62.60	230	60	B	
2358	08/02/17	51.67	62.70	202	60	B	
2360	08/02/17	51.55	63.20	179	60	B	
2361	09/02/17	51.39	62.38	203	60	B	
2364	09/02/17	51.16	62.35	192	60	B	
2366	09/02/17	50.92	62.36	185	60	B	
2368	09/02/17	50.89	61.96	175	60	B	
2370	09/02/17	51.05	61.93	188	60	B	
2371	10/02/17	51.10	62.82	167	60	B	
2374	10/02/17	51.05	63.20	154	60	B	
2375	10/02/17	51.33	63.39	156	60	B	
2377	10/02/17	51.37	62.86	179	60	B	
2379	11/02/17	50.09	62.32	147	60	B	
2382	11/02/17	50.22	62.57	147	60	B	
2384	11/02/17	50.33	62.42	150	60	B	
2386	11/02/17	50.47	62.75	147	60	B	
2387	11/02/17	50.74	62.99	150	60	B	
2389	12/02/17	50.38	61.72	165	60	B	
2392	12/02/17	50.52	62.20	166	60	B	
2394	12/02/17	50.70	62.41	171	60	B	
2396	12/02/17	50.90	62.75	163	60	B	
2397	12/02/17	50.93	62.71	166	15	I	
2398	12/02/17	50.92	62.72	165	30	I	
2399	13/02/17	50.64	61.81	178	60	B	
2402	13/02/17	50.66	61.34	145	60	B	
2404	13/02/17	50.44	61.28	158	60	B	
2406	13/02/17	50.39	60.91	153	60	B	
2407	14/02/17	50.44	60.41	152	60	B	
2410	14/02/17	50.16	60.46	158	60	B	
2412	14/02/17	49.90	60.38	164	60	B	
2414	14/02/17	49.81	60.72	164	60	B	
2415	14/02/17	49.97	60.86	160		I	diagonal profile

2416	14/02/17	49.99	60.87	160		I	diagonal profile
2417	15/02/17	50.14	60.76	158	60	B	
2420	15/02/17	50.11	61.12	158	60	B	
2422	15/02/17	50.04	61.44	157	60	B	
2424	15/02/17	49.85	61.10	163	60	B	
2425	16/02/17	50.28	62.06	157	60	B	
2428	16/02/17	50.10	61.81	158	60	B	
2430	16/02/17	49.89	61.79	157	60	B	
2432	17/02/17	51.24	57.48	95	60	B	
2433	17/02/17	51.17	57.09	128	60	B	
2435	17/02/17	50.99	56.88	118	60	B	
2437	17/02/17	50.89	57.02	126	60	B	
2439	18/02/17	50.31	58.70	148	60	B	
2440	18/02/17	50.30	59.04	149	60	B	
2441	18/02/17	50.15	59.16	156	60	B	
2442	18/02/17	50.07	59.52	160	60	B	
2443	19/02/17	49.54	60.78	169	60	B	
2446	19/02/17	49.60	61.17	161	60	B	
2448	19/02/17	49.63	61.56	157	60	B	
2450	19/02/17	49.85	62.06	147	60	B	
2451	19/02/17	49.68	61.56	157	30	I	
2452	19/02/17	49.67	61.57	155	30	I	
2453	20/02/17	49.45	61.27	163	60	B	
2456	20/02/17	49.40	60.92	172	60	B	
2458	20/02/17	49.22	61.01	172	60	B	
2460	20/02/17	49.10	60.74	196	60	B	
2462	20/02/17	48.94	60.62	237	60	B	
2463	21/02/17	48.90	60.02	388	120	B	
2465	21/02/17	48.66	60.24	390	120	B	
2468	21/02/17	48.66	60.76	241	60	B	
2469	21/02/17	48.79	60.61	260	30	I	
2470	22/02/17	49.30	60.25	240	60	B	
2473	22/02/17	49.59	60.33	170	60	B	
2475	22/02/17	49.61	59.94	187	60	B	
2477	22/02/17	49.83	59.91	166	60	B	
2480	23/02/17	49.83	59.36	202	60	B	
2483	23/02/17	49.96	58.98	166	60	B	
2485	23/02/17	50.06	58.70	162	60	B	
2487	23/02/17	50.17	58.42	180	60	B	
2488	23/02/17	50.21	58.35	181	30	I	
2490	23/02/17	50.35	58.59	142	30	I	
2491	24/02/17	50.24	57.88	271	60	B	
2494	24/02/17	50.34	58.11	139	60	B	
2496	24/02/17	50.46	57.83	158	60	B	
2498	24/02/17	50.73	58.07	136	60	B	
2499	25/02/17	50.55	57.65	138	60	B	
2502	25/02/17	50.66	57.39	133	60	B	
2504	25/02/17	50.77	57.39	130	60	B	
2506	25/02/17	50.99	57.74	123	60	B	

2.2 Trawl gear

The DNR–F owns a bottom trawl fitted with rockhopper gear and used the Castelo's Morgère V3 bottom doors (1800 kg, 3180 x 2480 cm). The cod–end originally had a 90 mm mesh size. However, it seems to have shrunk and is now in the region of 80–85 mm. The cod–end was also fitted with a 10–15 mm cod end liner. The MarPort Net Monitoring System was used to monitor the geometry of the net. Originally sensors were fitted on both the trawl doors to monitor door depth, door horizontal spread, angle and tilt as well as one on the net to monitor vertical net opening. Of these data, only door horizontal spread and vertical net opening were recorded. Until this research cruise, the only information about the horizontal net opening was the wing spread derived as follows:

$$Wing\ spread = \frac{Door\ Spread\ \times Net\ Length}{Bridle\ Length + Net\ Length}$$

In 2016, two additional sensors were bought by the DNRF and attached 2 m behind the trawl wings to monitor the horizontal net opening at the same time as the door spread. Significant differences between calculated and measured values of the horizontal net opening were noted during the research cruise. A method was therefore developed to correct historical geometry net data (Gras, 2016).

During the research cruise ZDLT1–10–2014 (Pompert et al., 2014), a discussion with the captain about the gear configuration revealed that trawl setup was the same as in 2011 (ZDLT1–02–2011) but not as in 2010 (ZDLT1–02–2010) when Morgère Ovalfoil OF12,5 (3400 x 2200 cm) doors were used. According to the captain, the doors used since 2011 opens the trawl a bit more than previously. The trawl setup was asked to be rigorously the same as in 2014 and 2015 and especially the bridle length, which was 115 m. During the ZDLT1–02–2010 and ZDLT1–02–2011 surveys, the bridle length was 100 and 120 m respectively.

2.3 Biological sampling

For most of the trawled stations, the entire catch was weighed by species (for finfish, squids, skates and sharks) or by the lowest taxonomic level (for invertebrates) using the electronic marine adjusted POLS balance. At some stations, when the catch was too large to be weighed, the crew processed the catch. At two red cod catches (stations 2374 and 2420) of these, a sample of the species concerned was taken before factory processing, weighed (green weight; GW), processed by the crew and weighed again (processed weight; PW) to estimate the conversion factor (CF) as:

$$CF = \frac{GW}{PW}$$

The catch (C) for this species was then estimated using the number of filled boxes (BN), the average box weight (BW) and the conversion factor as:

$$C = BN \times BW \times CF$$

At each station, random samples were taken from all finfish species as well as squids *Illex argentinus* and *Doryteuthis gahi*. When it was possible, 100 specimens of each commercial species were randomly taken for all sampled species. Maturity stages were determined for all sampled specimens using an 8 stage maturity scale for finfish (see observer manual), a 6 stage maturity scale for both species of squid (see observer manual) and a 6 stage maturity scale for Chondrichthyans (see observer manual). Length frequencies were recorded using fish measuring board and paper form.

Otolith/statolith extraction was undertaken for 30 finfish species and *I. argentinus* (taken at sea) and statoliths were extracted ashore from *D. gahi* (associated information were length, weight, sex and maturity). Vertebrae/thorn samples were taken from 3 species of skates.

Specimens from the genus *Psammobatis* were not identified to 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 120 m is *Psammobatis normani* (slender claspers) whereas in shallower waters the most common species is *Psammobatis rudis* (short and stout claspers). During the survey there were no shallow stations and all specimens are most likely *Psammobatis normani.*

2.4 Biomass estimation

Biomass estimations using trawl surveys generally generate auto–correlated data (Rivoirard et al., 2000). To avoid processing biased data and overestimating the biomass of fish in the survey area, geostatistical methods were used to firstly describe and model data autocorrelation and secondly to estimate by kriging an unbiased mean of the studied variable and provide an interpolated map of the studied variable.

The variable used in this report is the density of each species of interest (derived from the catch and swept–area). The methodology described below uses R scripts developed to perform the 2010 rock cod assessment (Winter et al. 2010) using packages rgdal (geographical coordinates projection) and geoR (geostatistics).

The distance covered by the trawl was estimated using the geographical coordinates of the stations. For each station, coordinates of the start were extracted from the database fields DegS_Start_Seabed, MinS_Start_Seabed, DegW_Start_Seabed, MinW_Start_Seabed and 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 trawl track as:

$$d = \text{acos}(\sin(latS) \times \sin(latF) + \cos(latS) \times \cos(latF) \times \cos(lonF - lonF) \times R$$

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 (6,371 km). Density of the studied species (D in kg·km^{-2}) was finally derived using the catch (C), the distance covered (d) and the horizontal net opening (HNO; see Gras (2016) for details)

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

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

2.5 Geographical coordinates

Station's geographical coordinates were collected using the World Geodetic System of 1984 (WGS 84). However, as the earth is a sphere and because the Falkland Islands are situated at relatively high latitudes (the study area in our case ranges from 48° to 52°S), one longitude degree does not have the same length as one latitude degree. Data were therefore projected 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.

2.6 Geostatistics 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 fit the right variogram model and estimate a realistic biomass for each species of interest.

- 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 best describing the auto–correlation at short distances. The semivariance values should increase with distance and reach the sill. The only accepted exception is the pure nugget effect.
- The range must be shorter than the maximum distance observed on the semivariogram. In the studied dataset, some models can fit log transformed data (lambda=0) well, however they exhibit a range further than 400 km which is not biologically consistent in our case.
- Exponential, Gaussian and spherical models were fitted to the semivariogram data and sum of square residuals (SSR) were used as a basis to choose the most 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 were close enough.

The kriging area was 106,609 km^2. Biomass estimations for common rock cod, red cod, common hake, toothfish, kingclip, southern blue whiting, Argentine shortfin squid and Falkland calamari were estimated using derived horizontal net opening for data collected in 2010, 2011, 2014 and 2015 (Gras, 2016) and using measured horizontal net opening for 2016 and 2017 datasets and time series displayed for every species.

2.7 Abundance estimation

At each survey station, a random sample of 100 specimens was assessed for total length, sex and maturity. The total number of fish–at–station N_s was estimated using the number of fish in the sample (n_s), the station catch weight (C_s) and the sample weight (W_s) as

$$N_s = \frac{n_s \times C_s}{W_s}$$

The total abundance in the water N_t was estimated using the total biomass B (estimated following protocol of section 2.6)

$$N_t = \frac{B \times \sum N_s}{\sum C_s}$$

The total number of fish–at–length l for each station ($N_{l,s}$) was then estimated using the total number of fish–at–station (N_s) and the number of fish per size class in the sample

$$N_{l,s} = \frac{n_{l,s} \times C_s}{W_s}$$

Finally the total abundance of fish–at–length in the water was estimated using the biomass estimation (B; see section 2.6)

$$N_{l,t} = \frac{B \times \sum N_{l,s}}{\sum C_{l,s}}$$

The numbers–at–length were then presented in histograms to show how the structures of the stocks have changed over the years.

2.8 Diet

A new protocol was set up during the ground fish survey in 2017 to collect diet data. The objective was to assess the diet of some specimens of both commercial and non–commercial species. For each specimen, total (or pre–anal) length, sex, maturity, weight, liver weight, stomach weight, and stomach fullness were collected. The stomach was then opened and the content sorted by the lower taxonomic level identifiable. Specimens were counted, the type of food particle, and stage of digestion recorded. If possible, prey items were measured.

2.9 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 bar 2 trawl stations, an interim station was run between these stations a few days later. 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, this allowed 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 fluorometer was damaged after station 2,461, and the partial dataset is not discussed here. The raw hex file was converted and processed using SBE Data Processing Version.7.22.5 using the CON file 0247OldCTD_2016_May.xmlcon. Up-cast 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 Salinity (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

Bottom trawling was conducted at 91 stations as shown in Figure 1 and Table 1. Seabed trawling times during the survey was 60 minutes for 88 of the trawls, but only 2 mins at station 2328, as one of the bridles snapped and then abandoned. Two of the trawls conducted were partially targeting mature/spawning *Bathyraja griseocauda*, and because of the much greater target depth (~400m), the seabed duration of these trawls was doubled to 120 minutes as in previous surveys. However, other than the duration, those trawls were identical to the remaining 88 in every other way, and so they are included in all other calculations.

During the survey a total of 58,383.684kg of biomass was caught comprising 142 species or taxa (Appendix Table 3). The largest catches by weight, all exceeding 1,000kg in total, were in order of importance: 1) common rock cod (*Patagonotothen ramsayi)*, 2) red cod *(Salilota australis)*, 3) Falkland calamari *(Doryteuthis gahi)*, 4) Falkland herring *(Sprattus fuegensis)*, 5) kingclip *(Genypterus blacodes)*, 6) hoki *(Macruronus magellanicus)*, 7) common hake (*Merluccius hubbsi*), 8) banded whiptail grenadier *(Coelorhynchus fasciatus)*, and 9) Argentine shortfin squid (*Illex argentinus*)*)*, together amounting to 87% of the total catch. Table 4 in the appendix lists numbers of specimens analysed by species and sample type (R, S or N). 213 specimens of two squid species had their statoliths extracted, 1,917 otoliths were extracted from 30 different fish species, and 30 vertebrae and thorns were removed from three skate species and the spiny dogfish.

The finfish component of the catch amounted to 45,254kg which represented 77.5% of the entire catch. The cephalopod component amounted to 7,925kg (13.6%), the elasmobranch component was 2,877kg (4.9%), and the benthos + crustacea component amounted to 2,328kg (4.0%)

3.2 Biological information of finfish species

3.2.1 *Patagonotothen ramsayi* – common rock cod – PAR

The total catch of common rock cod was 14,526 kg. It was caught at all the 90 trawl stations sampled throughout the research cruise (Figure 2). Catches ranged from 0.35 to 1,691 kg. Among the 90 stations, 84 yielded >10 kg, 45 yielded >100 kg, 4 yielded >500 kg and 3 yielded >1 t. Densities ranged from 2.01 to 7,044 kg·km^{-2} (CPUE ranged 0.35–1,691 kg·h^{-1}). Highest densities were observed in the eastern part of the survey zone, especially along the 200 m isobath (mainly young fish). Some high density stations were recorded in the west as well (mainly adults). However, during this survey there was no station with density as high as observed in previous years in the northwest. The number of fish sampled for length frequency was 8,993 (37 juveniles, 4101 females and 4855 males), 13 were sampled for length–weight, 214 for otolith. Total lengths ranged from 5 to 7 cm for juveniles, from 8 to 40 cm for females and from 9 to 38 cm for males. The histogram exhibits 3 different cohorts with modes at 5–6 cm, 14 cm and 23 cm. Females were observed immature (32%), resting (62%), early developing (2%), spent (2%) and recovering spent (1%). Males were immature (35%), resting (65%) and early developing (1%).

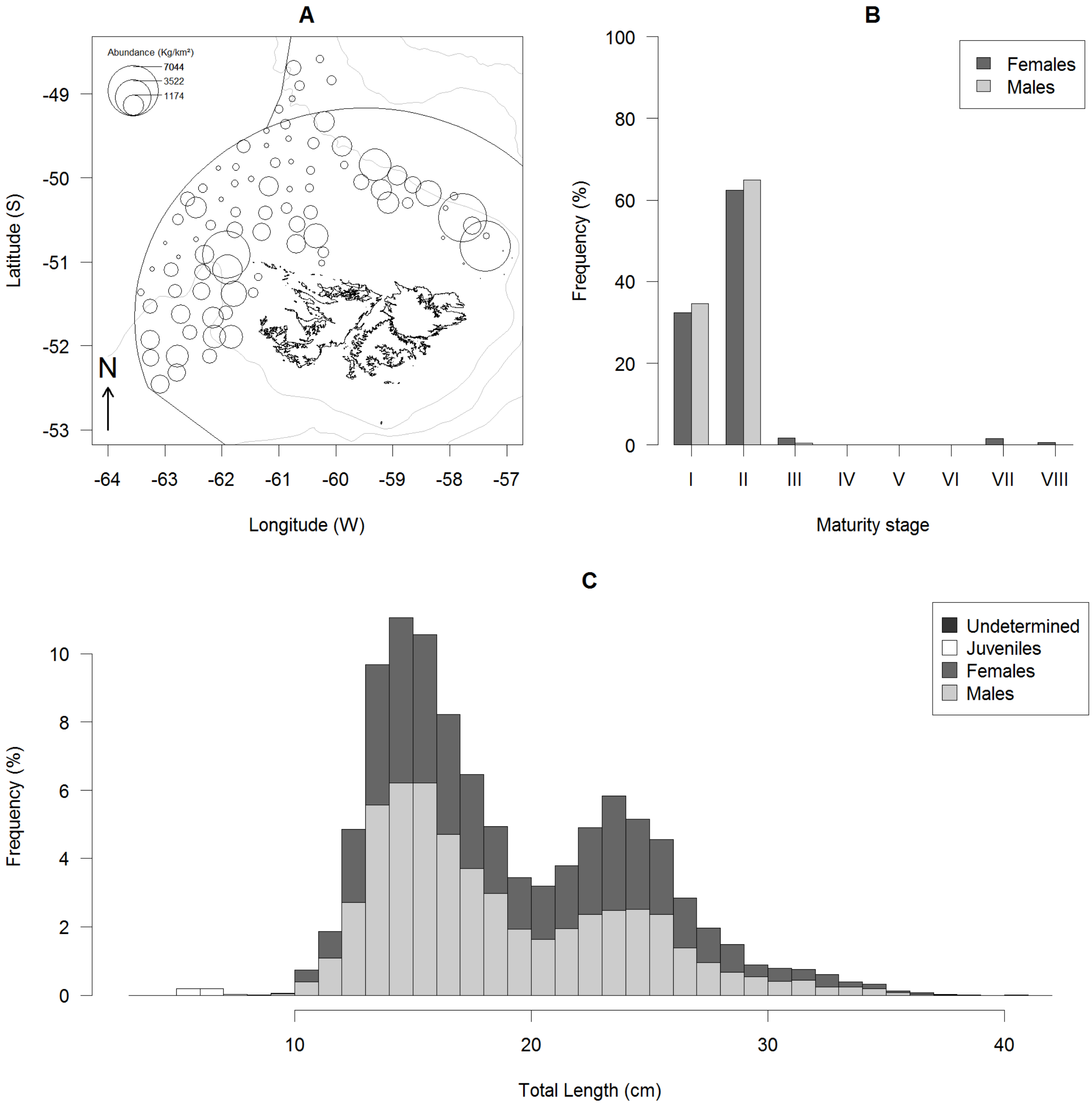

Figure 2: Biological data of *Patagonotothen ramsayi* (common rock cod; PAR), map of the densities in kg·km^{-2} (A), percentage of specimens of each sex per maturity stage (B, immature; II, resting; III, early developing; IV, late developing; V, ripe; VI, running; VII, spent; VIII, recovering spent) and length frequency (in percentage of the total sample assessed) of each sex with 1 cm size class (C; n=8,993).

3.2.2 *Salilota australis* – red cod – BAC

The total catch of red cod was 11,104 kg. It was caught at 83 out of the 90 trawl stations sampled throughout the survey (Figure 3). Catches ranged from 0.04 to 4,411 kg. Among the 83 stations, 33 yielded >10 kg, 11 yielded >100 kg, 3 yielded >1 t. Densities ranged from 0.22 to 22,309 kg·km^{-2} (CPUE ranged 0.04–4,411 kg·h^{-1}). Highest densities were observed in the western part of the survey zone and at one station to the north of the Jason Islands. The number of fish sampled for length frequency was 3,921 (6 juveniles, 2188 females, 1725 males, 1 hermaphrodite and 1 undetermined), 110 were sampled for length–weight, 142 for otolith (including 129 taken randomly). Total lengths ranged from 9 to 15 cm for juveniles, from 11 to 76 cm for females and from 12 to 73 cm for males. The histogram exhibits 2 different cohorts with modes at 16 cm and 23 cm. Beyond 23 cm, cohorts are difficult to identify and otolith–based ageing would be required. Females were immature (20%), resting (75%), early developing (3%), spent (0.5%) and recovering spent (1.5%). Males were immature (33%), resting (38%), early developing (28%) and late developing (1%).

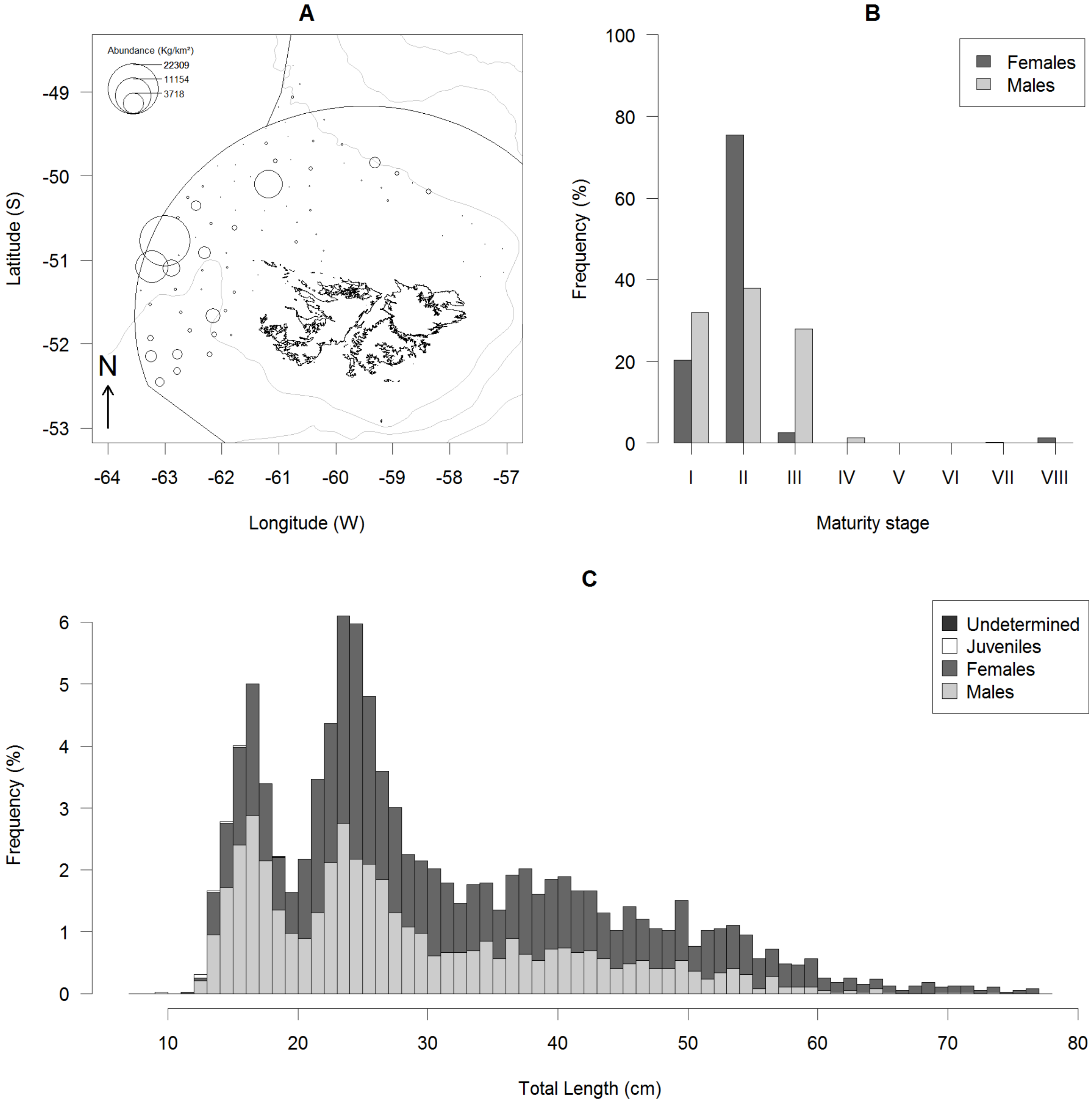

Figure 3: Biological data of *Salilota australis* (red cod; BAC), map of the densities in kg·km^{-2} (A), percentage of specimens of each sex per maturity stage (B, immature; II, resting; III, early developing; IV, late developing; V, ripe; VI, running; VII, spent; VIII, recovering spent) and length frequency (in percentage of the total sample assessed) of each sex with 1 cm size class (C; n=3,921).

3.2.3 *Sprattus fuegensis* – Falkland herring – SAR

The total catch of Falkland herring was 4,272 kg. It was caught at 25 out of the 90 trawl stations sampled throughout the research cruise (Figure 4). Catches ranged from 0.02 to 2,559 kg. Among the 25 stations, 4 yielded >1 kg and 2 yielded >1 t. Densities ranged from 0.09 to 14,242 kg·km^{-2}. (CPUE ranged 0.02–2,559 kg·h^{-1}). Highest densities were observed to the south of the Jason Islands. Herring was also caught in small quantities in the southwest of the survey zone. The number of fish sampled for length frequency was 335 (157 females and 178 males), no sample was taken for length–weight, otolith or diet. Total lengths ranged from 16 to 28 cm for females and from 14 to 22 cm for males. The histogram exhibits 1 cohort with its mode at 18 cm. Females were immature (3%), resting (90%), early developing (6%) and late developing (1%). Males were immature (4%), resting (61%) and early developing (35%).

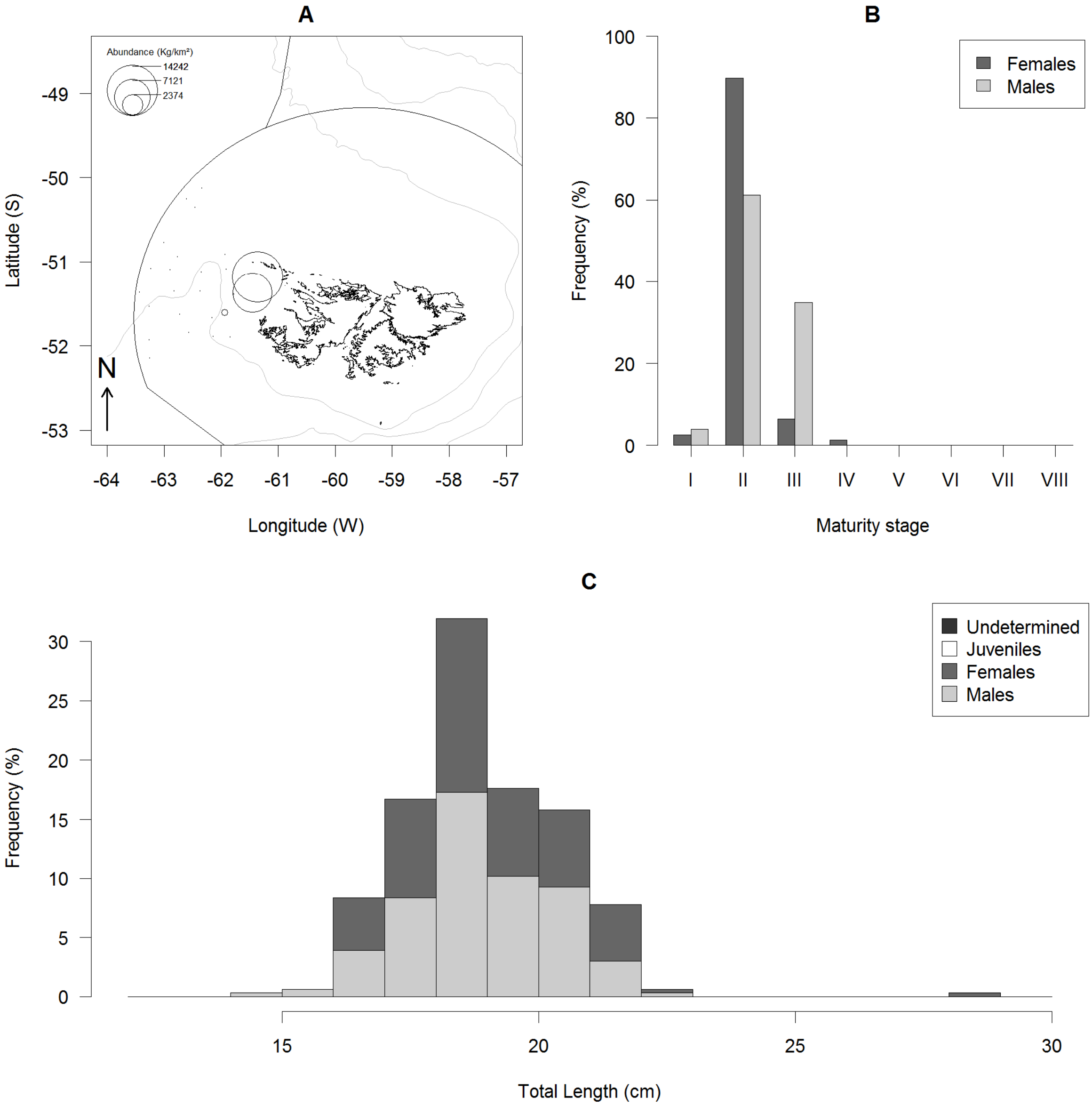

Figure 4: Biological data of *Sprattus fuegensis* (Falkland herring; SAR), map of the densities in kg·km^{-2} (A), percentage of specimens of each sex per maturity stage (B, immature; II, resting; III, early developing; IV, late developing; V, ripe; VI, running; VII, spent; VIII, recovering spent) and length frequency (in percentage of the total sample assessed) of each sex with 1 cm size class (C; n=335).

3.2.4 *Genypterus blacodes* – kingclip – KIN

The total catch of kingclip was 4,156 kg. It was caught at 77 out of the 90 trawl stations sampled throughout the research cruise (Figure 5). Catches ranged from 0.16 to 1,073 kg. Among the 77 stations, 46 yielded >10 kg, 10 yielded >100 kg, 1 yielded >1 t. Densities ranged from 0.81 to 5,186 kg·km^{-2} (CPUE ranged 0.16–1,073 kg·h^{-1}). Most of the kingclip were caught to the west of 59°W. Highest densities were observed in the north of the survey zone and in some stations to the west of the Jason Islands. The number of fish sampled for length frequency was 2,311 (1,346 females 964 males and 1 specimen was undetermined due to the absence of any developed gonad), 7 were sampled for length–weight, 242 for otolith (including 1 non–random). Total lengths ranged from 30 to 136 cm for females and from 28 to 118 cm for males. The histogram exhibits many modes and it is difficult to identify cohorts based on the length frequency. Females were immature (6%), resting (79%), early developing (9%), late developing (6%), ripe (0.1%) and recovering spent (0.1%). Males were immature (15%), resting (70%), early developing (14%) and late developing (1%).

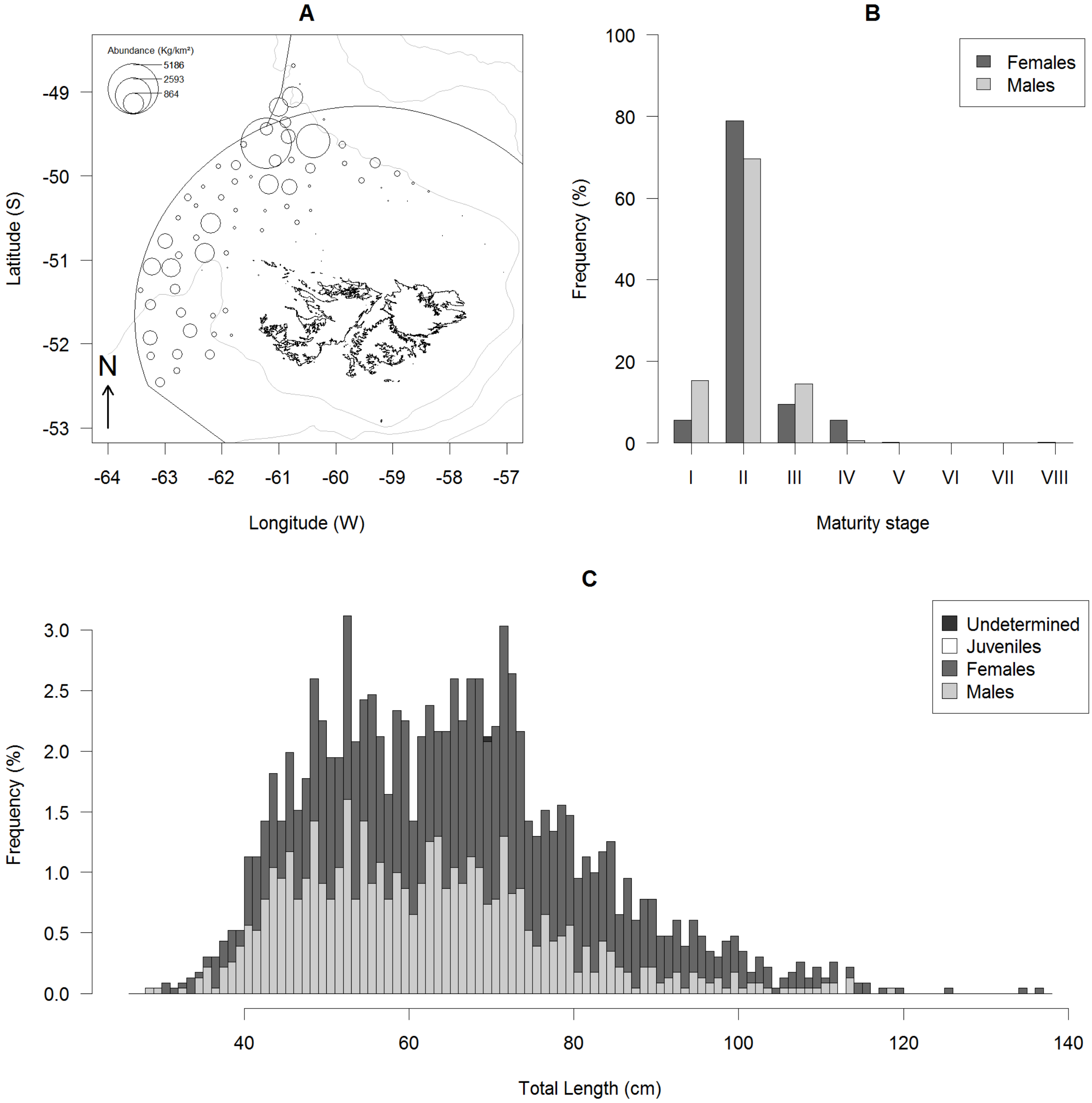

Figure 5: Biological data of *Genypterus blacodes* (kingclip; KIN), map of the densities in kg·km^{-2} (A), percentage of specimens of each sex per maturity stage (B, immature; II, resting; III, early developing; IV, late developing; V, ripe; VI, running; VII, spent; VIII, recovering spent) and length frequency (in percentage of the total sample assessed) of each sex with 1 cm size class (C; n=2,311).

3.2.5 *Macruronus magellanicus* – hoki – WHI

The total catch of hoki was 3,206 kg. It was caught at 33 out of the 90 trawl stations sampled throughout the research cruise (Figure 6). Catches ranged from 0.09 to 982 kg. Among the 33 stations, 13 yielded >10 kg and 10 yielded >100 kg. Densities ranged from 0.45 to 5,338 kg·km^{-2}. (CPUE ranged 0.09–982 kg·h^{-1}). Highest densities were observed in the southwestern part of the survey zone, in deep waters (>200 m). Hoki was also caught in the north of the zone in smaller quantities in stations along the 200 m isobath or deeper. The number of fish sampled for length frequency was 1,234 (727 females and 507 males), 8 were sampled for length–weight, 242 for otolith (including 3 non–random). Pre–anal lengths ranged from 11 to 42 cm for females and from 11 to 39 cm for males. The histogram exhibits 4 different cohorts with modes at 14 cm, 18 cm, 25 cm and 28 cm. Females were immature (11%), resting (74%), early developing (13%), late developing (0.4%), spent (0.1%) and recovering spent (2%). Males were immature (4%), resting (68%), early developing (26%), late developing (0.2%) and recovering spent (1%).

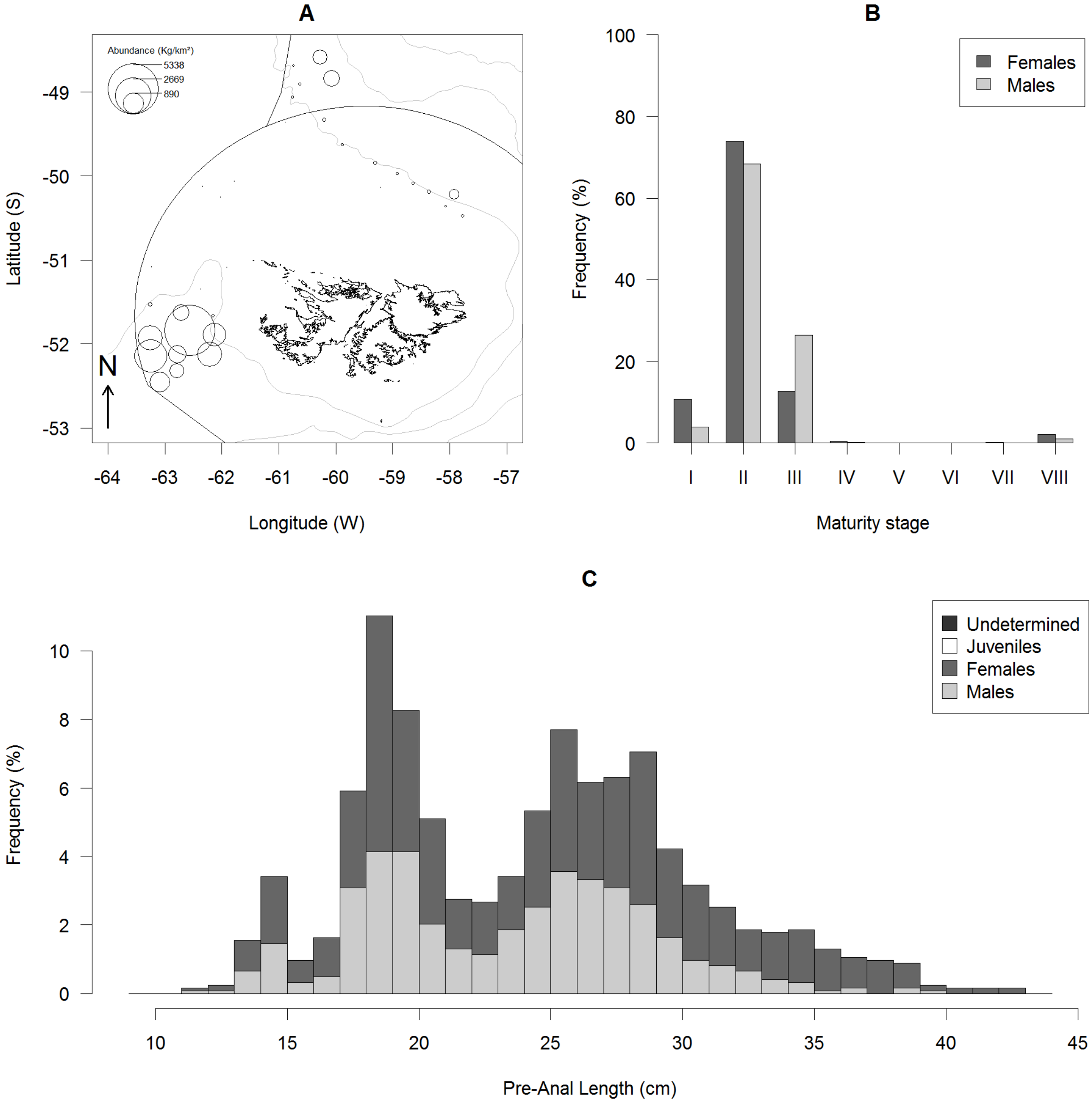

Figure 6: Biological data of *Macruronus magellanicus* (hoki; WHI), map of the densities in kg·km^{-2} (A), percentage of specimens of each sex per maturity stage (B, immature; II, resting; III, early developing; IV, late developing; V, ripe; VI, running; VII, spent; VIII, recovering spent) and length frequency (in percentage of the total sample assessed) of each sex with 1 cm size class (C; n=1,234).

3.2.6 *Merluccius hubbsi* – common hake – HAK

The total catch of common hake was 2,932 kg. It was caught at 63 out of the 90 trawl stations sampled throughout the research cruise (Figure 7). Catches ranged from 0.06 to 241 kg. Among the 90 stations, 41 yielded >10 kg and 11 yielded >100 kg. Densities ranged from 0.26 to 1,322 kg·km^{-2} (CPUE ranged 0.06–241 kg·h^{-1}). Common hake was mainly caught in the northwest quarter of the survey zone, to the west of 60°W and to the north of 51°S. The number of fish sampled for length frequency was 3,020 (1 juvenile, 2,752 females and 265 males and 2 undetermined), 27 were sampled for length–weight, 118 for otolith (including 4 non–random). Total length was 26 cm for the juvenile, ranged from 13 to 80 cm for females and from 13 to 63 cm for males. In Falkland waters, females are more numerous and larger than males, whereas males are more numerous on the high seas to the North of the FOCZ. In the length frequency histogram, cohorts are difficult to distinguish (they probably overlap). Females were immature (0.3%), resting (34%), early developing (55%), late developing (2%), spent (3%) and recovering spent (6%). Males were immature (4%), resting (4%), early developing (15%), late developing (34%), ripe (3%), spent (35%) and recovering spent (5%).

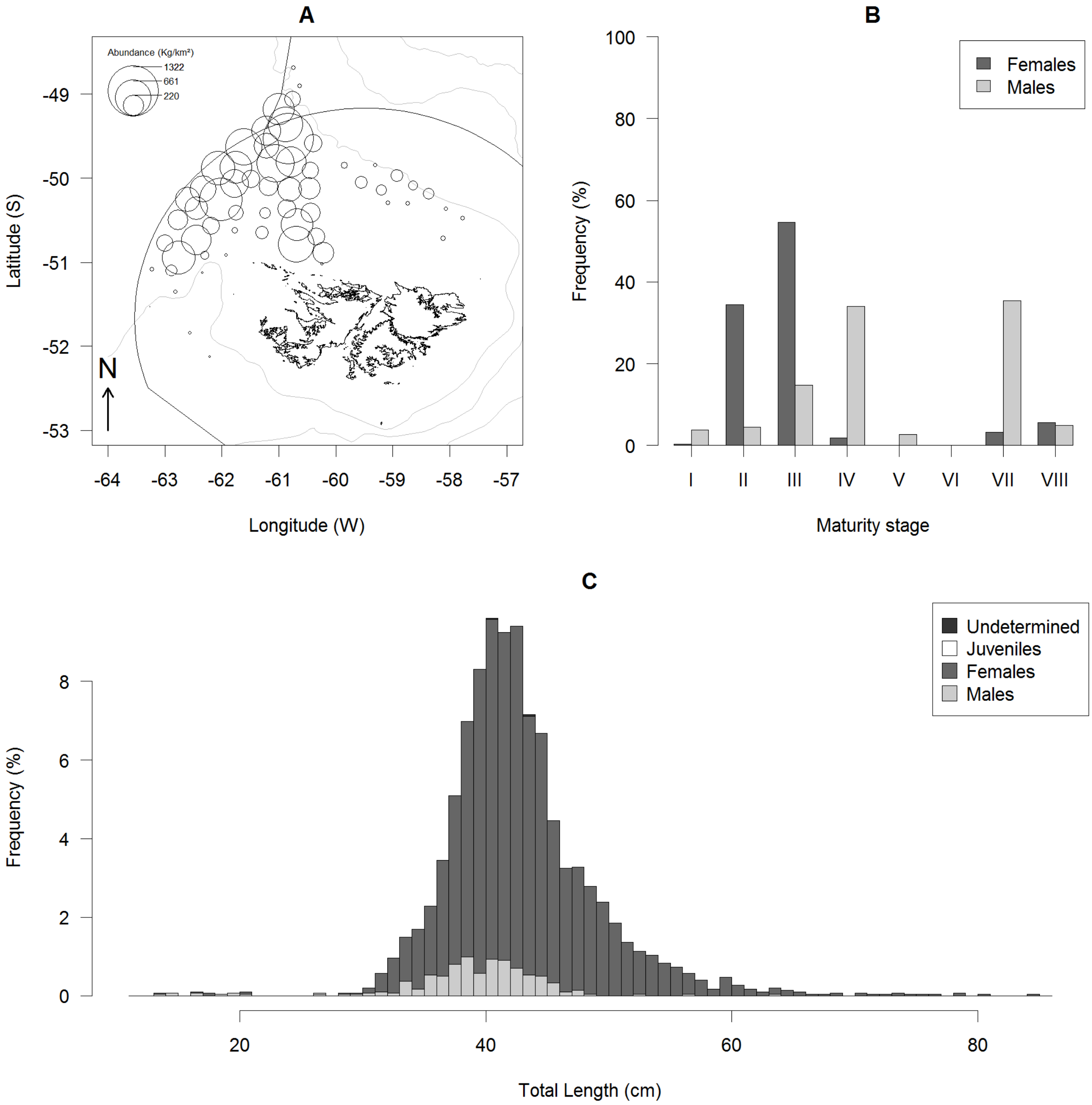

Figure 7: Biological data of *Merluccius hubbsi* (common hake; HAK), map of the densities in kg·km^{-2} (A), percentage of specimens of each sex per maturity stage (B, immature; II, resting; III, early developing; IV, late developing; V, ripe; VI, running; VII, spent; VIII, recovering spent) and length frequency (in percentage of the total sample assessed) of each sex with 1 cm size class (C; n=3,020).

3.2.7 *Coelorhynchus fasciatus* – banded whiptail grenadier – GRF

The total catch of banded whiptail grenadier was 2,538 kg. It was caught at 15 out of the 90 trawl stations sampled throughout the research cruise (Figure 8). Catches ranged from 0.04 to 458 kg. Among the 15 stations, 10 yielded >100 kg. Densities ranged from 0.19 to 2,302 kg·km^{-2} (CPUE ranged 0.04–458 kg·h^{-1}). Highest densities were observed in the southwestern part of the survey zone in waters deeper than 200 m. The number of fish sampled for length frequency was 374 (2 juveniles, 228 females and 144 males). Pre–anal lengths were 2 cm for the 2 juveniles, ranged from 4 to 15 cm for females and from 3 to 12 cm for males. The histogram exhibits perhaps 2 different cohorts with modes at 6 cm and 9 cm. The first one is not obvious and perhaps a more precise measuring gradient is required for this species. Females were immature (2%), resting (47%), early developing (41%), late developing (6%), ripe (3%) and recovering spent (1%). Males were immature (30%), resting (48%) and early developing (22%).

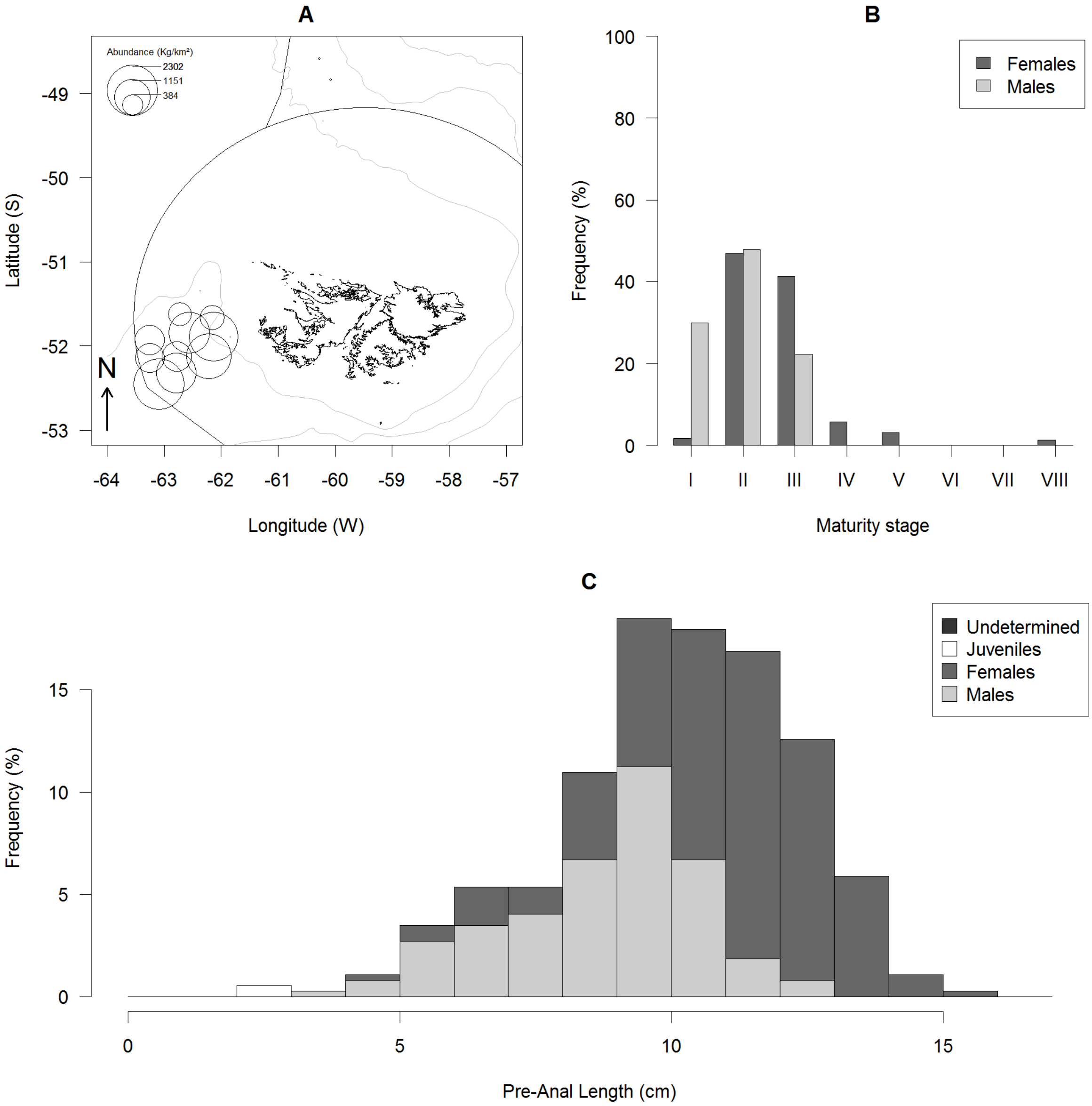

Figure 8: Biological data of *Coelorhynchus fasciatus* (banded whiptail grenadier; GRF), map of the densities in kg·km^{-2} (A), percentage of specimens of each sex per maturity stage (B, immature; II, resting; III, early developing; IV, late developing; V, ripe; VI, running; VII, spent; VIII, recovering spent) and length frequency (in percentage of the total sample assessed) of each sex with 1 cm size class (C; n=374).

3.2.8 *Dissostichus eleginoides* – Patagonian toothfish – TOO

The total catch of Patagonian toothfish was 640 kg. It was caught at 64 out of the 90 trawl stations sampled throughout the research cruise (Figure 9). Catches ranged from 0.015 to 66 kg. Among the 64 stations, 16 yielded >10 kg. Densities ranged from 0.08 to 315 kg·km^{-2}. (CPUE ranged 0.015–66 kg·h^{-1}). Highest densities were observed in the southwest of the survey zone. However, the higher biomass observed in the southwest generally consisted of a few big animals, whereas on the shelf the lower biomass generally consisted of more abundant smaller specimens. The number of fish sampled for length frequency was 822 (83 juveniles, 440 females and 299 males), 46 were sampled for length–weight, 407 for otolith (including 8 non–random). Total lengths ranged from 9 to 30 cm for juveniles, from 25 to 75 cm for females and from 27 to 73 cm for males. The histogram exhibits 3 different cohorts with modes at 12 cm, 33 cm and 47 cm. Beyond 47 cm, cohorts probably overlap and the number of animals caught was too small to identify cohorts. Females were immature (35%) and resting (65%). Males were immature (43%), resting (57%) and late developing (0.3%).

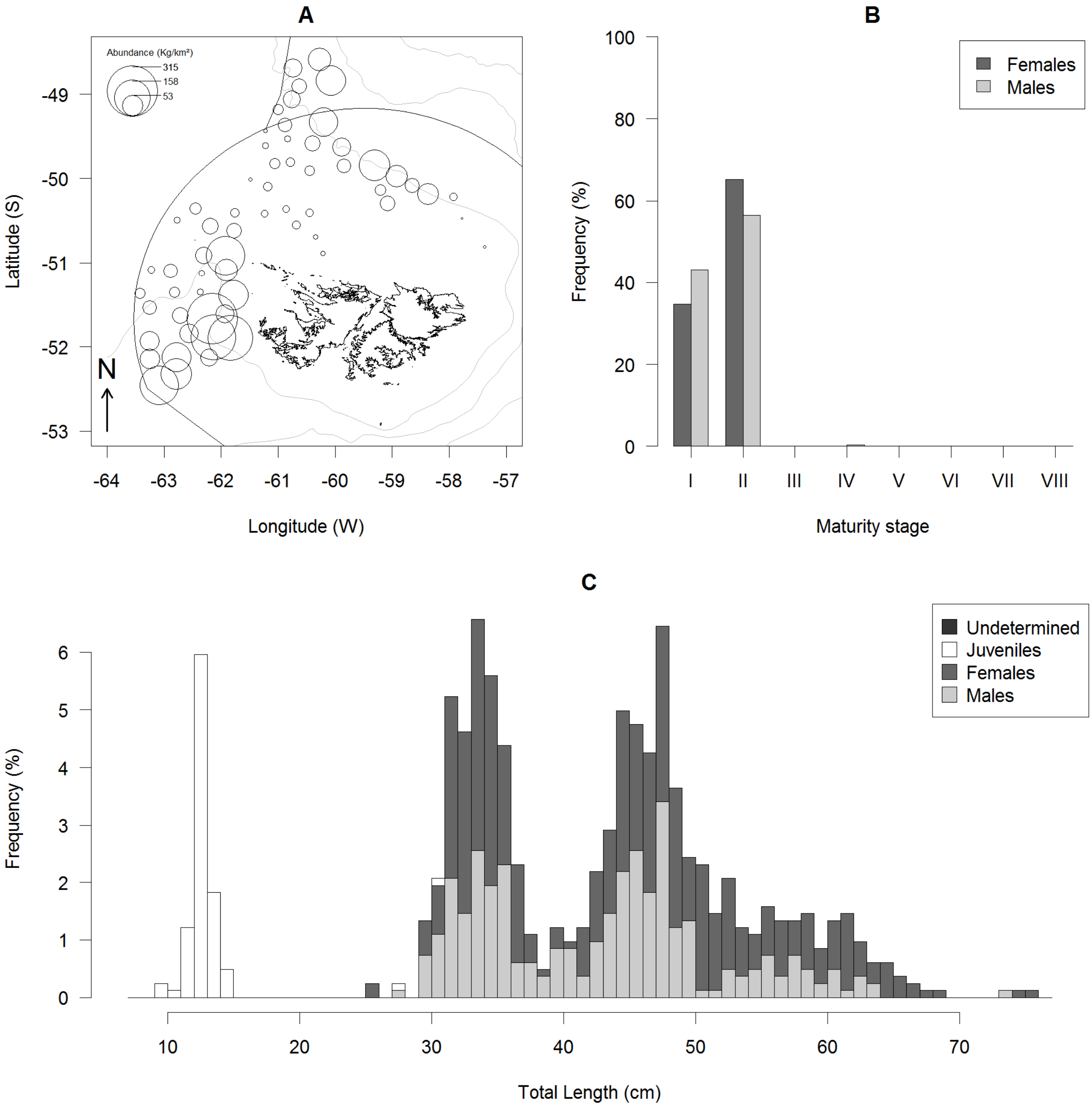

Figure 9: Biological data of *Dissostichus eleginoides* (toothfish; TOO), map of the densities in kg·km^{-2} (A), percentage of specimens of each sex per maturity stage (B, immature; II, resting; III, early developing; IV, late developing; V, ripe; VI, running; VII, spent; VIII, recovering spent) and length frequency (in percentage of the total sample assessed) of each sex with 1 cm size class (C; n=822).

3.2.9 *Cottoperca gobio* – frogmouth – CGO

The total catch of frogmouth was 434 kg. It was caught at 66 out of the 90 trawl stations sampled throughout the research cruise (Figure 10). Catches ranged from 0.05 to 68.2 kg. Among the 66 stations, 11 yielded >10 kg. Densities ranged from 0.28 to 345 kg·km^{-2}. (CPUE ranged 0.05–68 kg·h^{-1}). Highest densities were observed to the west of 61°W in waters shallower than 200 m. Frogmouth was also caught to the east of 61°W and in deep waters (>200 m) but in lower quantities. The number of fish sampled for length frequency was 494 (34 juveniles, 232 females, 227 males and 1 hermaphrodite), 21 were sampled for length–weight (including 5 from the random samples), 5 for otolith. Total lengths ranged from 8 to 18 cm for juveniles, from 9 to 51 cm for females, from 9 to 58 cm for males and the hermaphrodite was 42 cm. Cohorts are difficult to identify on the length frequency histogram. Females were immature (21%), resting (45%), early developing (26%), late developing (6%), ripe (0.5%), spent (1%) and recovering spent (0.5%). Males were immature (47%), resting (43%) and early developing (10%).

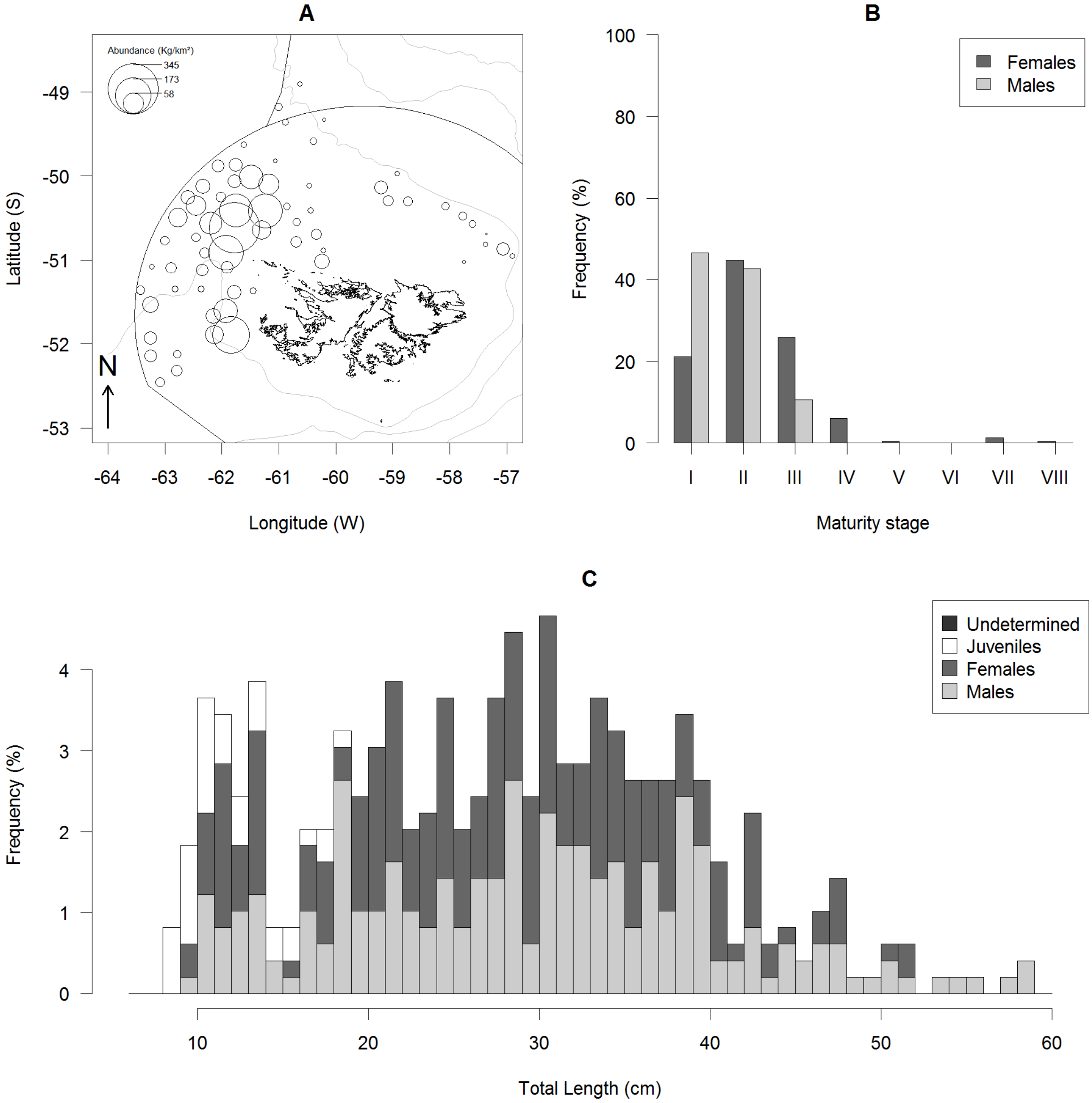

Figure 10: Biological data of *Cottoperca gobio* (frogmouth; CGO), map of the densities in kg·km^{-2} (A), percentage of specimens of each sex per maturity stage (B, immature; II, resting; III, early developing; IV, late developing; V, ripe; VI, running; VII, spent; VIII, recovering spent) and length frequency (in percentage of the total sample assessed) of each sex with 1 cm size class (C; n=494).

3.2.10 *Stromateus brasiliensis* – butterfish – BUT

The total catch of butterfish was 342 kg. It was caught at 28 out of the 90 trawl stations sampled throughout the research cruise (Figure 11). Catches ranged from 0.45 to 80.3 kg. Among the 28 stations, 9 yielded >10 kg. Densities ranged from 2.02 to 402 kg·km^{-2}. (CPUE ranged 0.0.45–80.3 kg·h^{-1}). Highest densities were observed in waters shallower than 200 m and along the western border of the FICZ. Butterfish was also caught at 3 stations to the north of the Jason Islands. The number of fish sampled for length frequency was 408 (348 females and 60 males), 17 were also sampled for otolith. Total lengths ranged from 24 to 37 cm for females and from 22 to 35 cm for males. On the length frequency histogram, one to two cohorts can be identified (modes at 28 and 31 cm), however the second one would need to be confirmed by otolith–based ageing. Females were resting (28%), early developing (71%) and late developing (1%). Males were immature (1.5%), resting (50%), early developing (25%), late developing (22%) and ripe (1.5%).

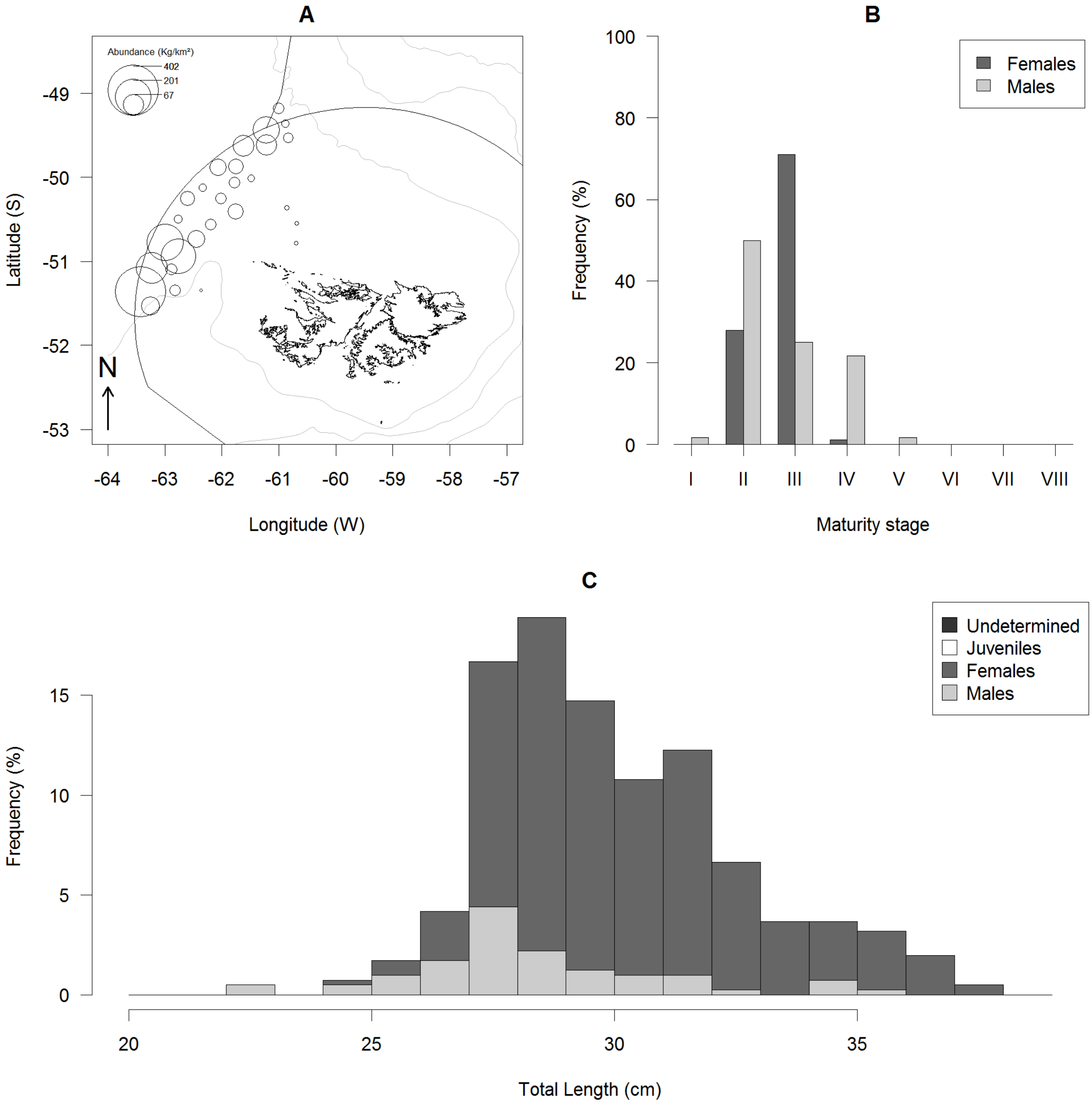

Figure 11: Biological data of *Stromateus brasiliensis* (butterfish; BUT), map of the densities in kg·km^{-2} (A), percentage of specimens of each sex per maturity stage (B, immature; II, resting; III, early developing; IV, late developing; V, ripe; VI, running; VII, spent; VIII, recovering spent) and length frequency (in percentage of the total sample assessed) of each sex with 1 cm size class (C; n=408).

3.2.11 *Patagolycus melastomus* – Black–mouthed eelpout – PAU

The total catch of Black–mouthed eelpout was 296 kg. It was caught at 28 out of the 90 trawl stations sampled throughout the research cruise (Figure 22). Catches ranged from 0.02 to 101 kg. Among the 36 stations, 5 yielded >10 kg and 1 yielded >100 kg. Densities ranged from 0.1 to 455 kg·km^{-2}. (CPUE ranged 0.02–101 kg·h^{-1}). Highest densities were observed in the northern part of the survey zone along the 200 m bathymetric line. The number of fish sampled for length frequency was 336 (168 females and 168 males), 88 for otolith. Total lengths ranged from 15 to 39 cm for females and from 11 to 36 cm for males. Cohorts are difficult to identify on the length frequency histogram. Females were immature (0.5%), resting (54%), early developing (25%), late developing (4%), ripe (15%), running (0.5%), spent (0.5%) and recovering spent (0.5%). Males were immature (12%), resting (72%), early developing (10%), late developing (2%), ripe (1%), spent (1%) and recovering spent (2%).

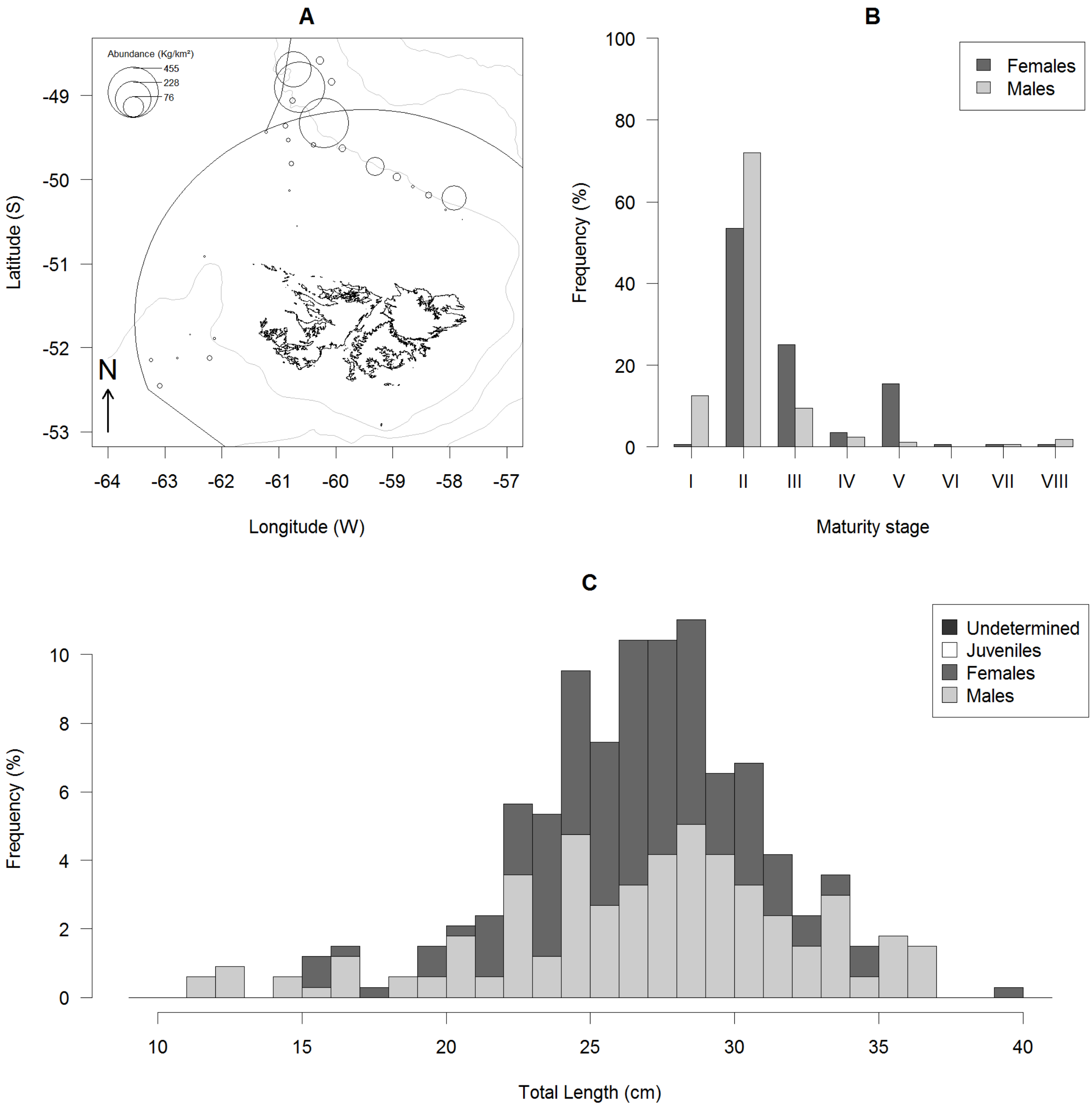

Figure 12: Biological data of *Iluocoetes fimbriatus* (eelpout; ILF), map of the densities in kg·km^{-2} (A), percentage of specimens of each sex per maturity stage (B, immature; II, resting; III, early developing; IV, late developing; V, ripe; VI, running; VII, spent; VIII, recovering spent) and length frequency (in percentage of the total sample assessed) of each sex with 1 cm size class (C; n=336).

3.2.12 *Micromesistius australis* – southern blue whiting – BLU

The total catch of southern blue whiting was 242 kg. It was caught at 30 out of the 90 trawl stations sampled throughout the research cruise (Figure 13). Catches ranged from 0.003 to 113 kg. Among the 30 stations, 4 yielded >10 kg and 1 yielded >100 kg. Densities ranged from 0.01 to 607 kg·km^{-2}. (CPUE ranged 0.003–113 kg·h^{-1}). Highest densities were observed in the southwestern part of the survey zone, in deep waters where southern blue whiting is generally abundant. The number of fish sampled for length frequency was 438 (204 juveniles, 93 females and 141 males), 121 for otolith (including 3 non–random). Total lengths ranged from 7 to 19 cm for juveniles, from 19 to 67 cm for females and from 17 to 64 cm for males. The histogram exhibits 4 different cohorts with modes at 9, 23, 52 and 60 cm. One cohort, represented by only one specimen of 39 cm, seems to be missing but was apparently observed in the *Loligo* box by the pre–recruitment survey conducted from 9 to 24 February 2017 (9-24/2/17?). Females were immature (43%), resting (27%), early developing (4%), spent (1%) and recovering spent (25%). Males were immature (46%), resting (11%), early developing (13%) and recovering spent (30%).

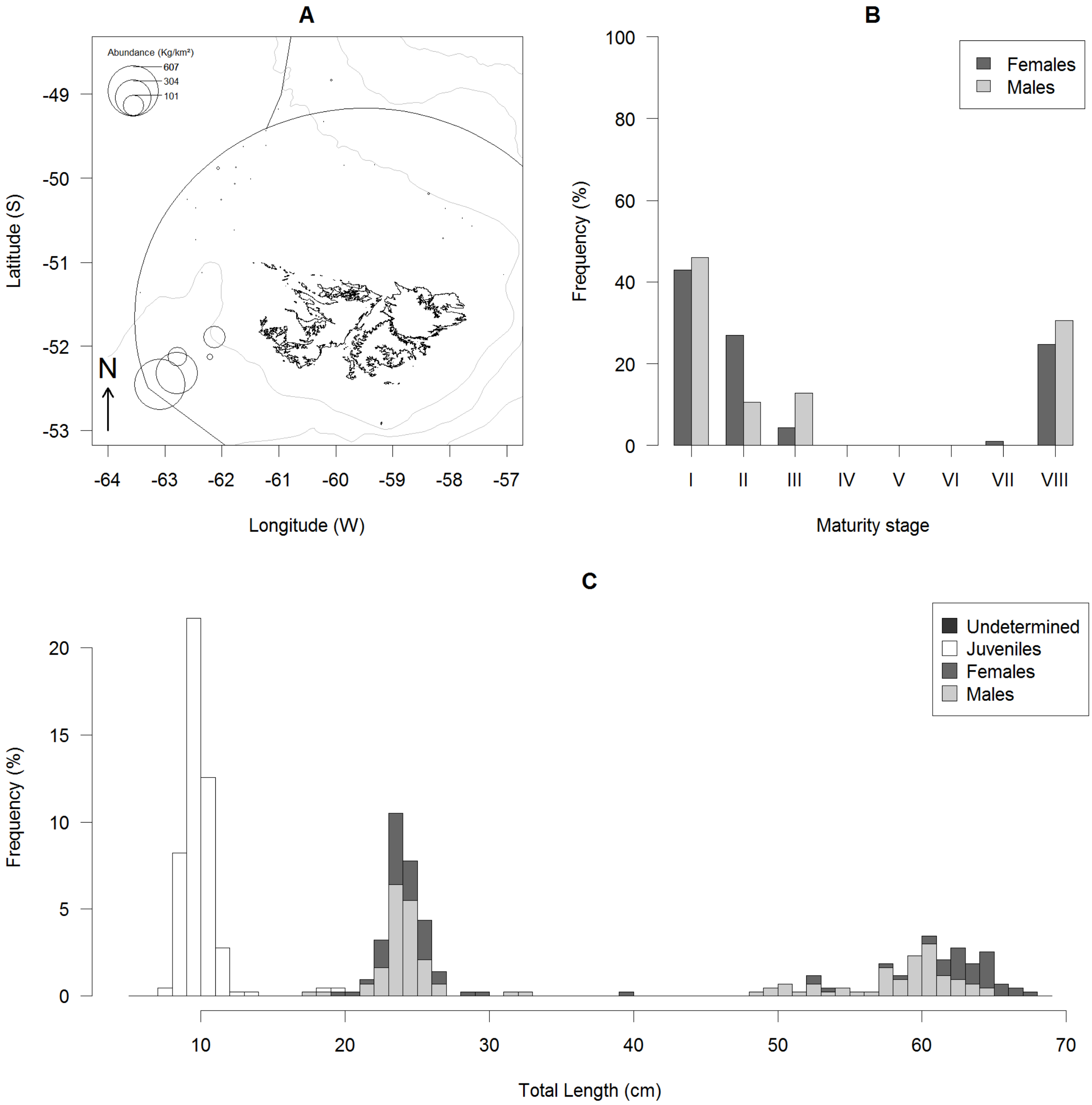

Figure 13: Biological data of *Micromesistius australis* (southern blue whiting; BLU), map of the densities in kg·km^{-2} (A), percentage of specimens of each sex per maturity stage (B, immature; II, resting; III, early developing; IV, late developing; V, ripe; VI, running; VII, spent; VIII, recovering spent) and length frequency (in percentage of the total sample assessed) of each sex with 1 cm size class (C; n=438).

3.2.13 *Merluccius australis* – Patagonian hake – PAT

The total catch of Patagonian hake was 179 kg. It was caught at 12 out of the 90 trawl stations sampled throughout the research cruise (Figure 14). Catches ranged from 0.97 to 51 kg. Among the 12 stations, 8 yielded >10 kg. Densities ranged from 4.03 to 274 kg·km^{-2}. (CPUE ranged 0.97–51 kg·h^{-1}). Highest densities were observed in the southwest of the survey zone, in waters deeper than 200 m and at one station in the north of FOCZ, again in deep waters. The number of fish sampled for length frequency was 71 (60 females and 11 males), 68 for otolith. Total lengths ranged from 44 to 96 cm for females and from 54 to 72 cm for males. Cohorts are difficult to identify on the length frequency histogram due to the low number of fish sampled. Females were resting (58%), early developing (30%) and late developing (2%). Males were immature (55%) and resting (45%).

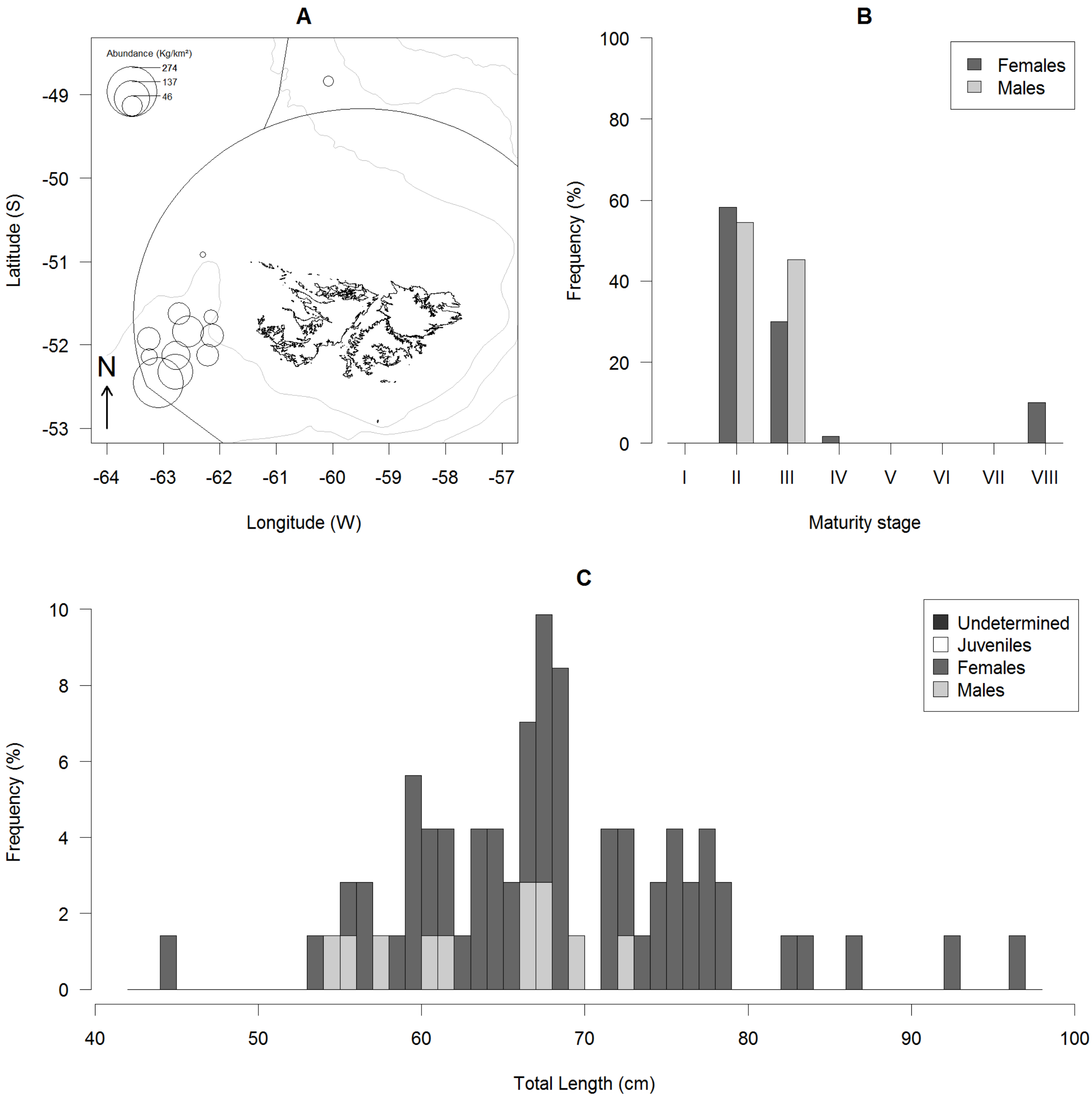

Figure 14: Biological data of *Merluccius australis* (Patagonian hake; PAT), map of the densities in kg·km^{-2} (A), percentage of specimens of each sex per maturity stage (B, immature; II, resting; III, early developing; IV, late developing; V, ripe; VI, running; VII, spent; VIII, recovering spent) and length frequency (in percentage of the total sample assessed) of each sex with 1 cm size class (C; n=71).

3.2.14 *Patagonotothen tessellata* – marbled rock cod – PTE

The total catch of marbled rock cod was 77.8 kg. It was caught at 11 out of the 90 trawl stations sampled throughout the research cruise (Figure 15). Catches ranged from 0.12 to 22.6 kg. Amongst the 11 stations, 2 yielded >10 kg. Densities ranged from 0.67 to 115 kg·km^{-2} (CPUE ranged 0.12–22.6 kg·h^{-1}). Marbled rock cod was exclusively caught in the north–eastern part of the survey zone, in the northern part of the *Loligo* box. The number of fish sampled for length frequency was 805 (1 juvenile, 239 females and 565 males). Total length was 8 cm for the juvenile, ranged from 9 to 20 cm for females and from 9 to 26 cm for males. Cohorts cannot be identified on the length frequency histogram. Females were immature (20%), resting (74%), early developing (5.5%) and spent (0.5%). Males were immature (15%) and resting (85%).

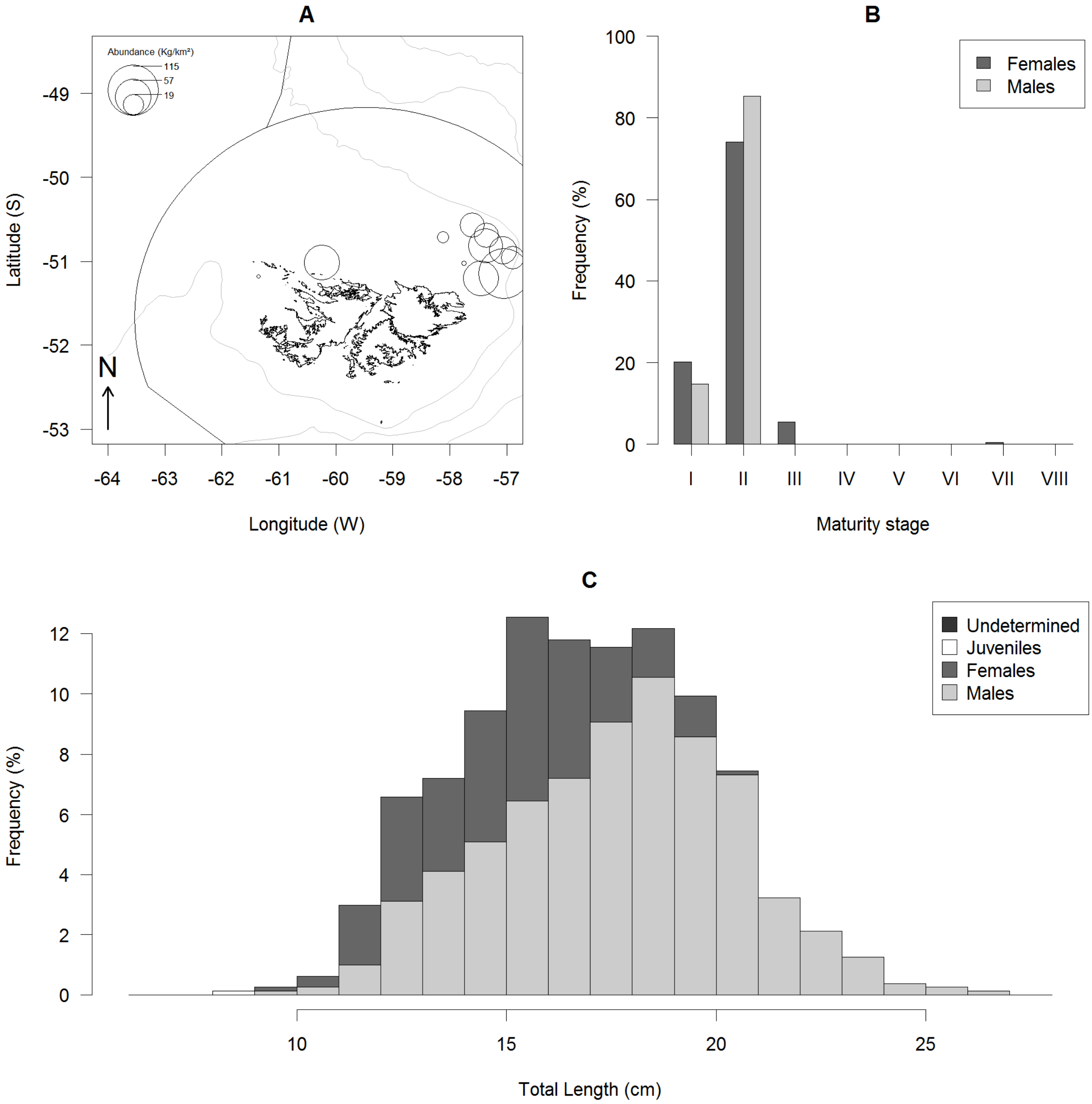

Figure 15: Biological data of *Patagonotothen tessellata* (marbled rock cod; PTE), map of the densities in kg·km^{-2} (A), percentage of specimens of each sex per maturity stage (B, immature; II, resting; III, early developing; IV, late developing; V, ripe; VI, running; VII, spent; VIII, recovering spent) and length frequency (in percentage of the total sample assessed) of each sex with 1 cm size class (C; n=805).

3.2.15 *Gymnoscopelus nicholsi* – Nichol's lanternfish – GYN

The total catch of Nichol's lanternfish was 62 kg. It was caught at 20 out of the 90 trawl stations sampled throughout the research cruise (Figure 16). Catches ranged from 0.005 to 17.7 kg. Among the 20 stations, 3 yielded >10 kg. Densities ranged from 0.02 to 65 kg·km^{-2}. (CPUE ranged 0.005–13.7 kg·h^{-1}). Highest densities were observed in two areas, in deep waters in the northern part of the survey zone and to the north of East Falkland along the 200 m isobath. The number of fish sampled for length frequency was 754. As the fish were too soft to be opened and sexed, all specimens were undetermined. Total length ranged from 6 to 17 cm and it seems that two cohorts were present at 9 and 12 cm, however more thorough assessment would be required to conduct this by sex and maturity.

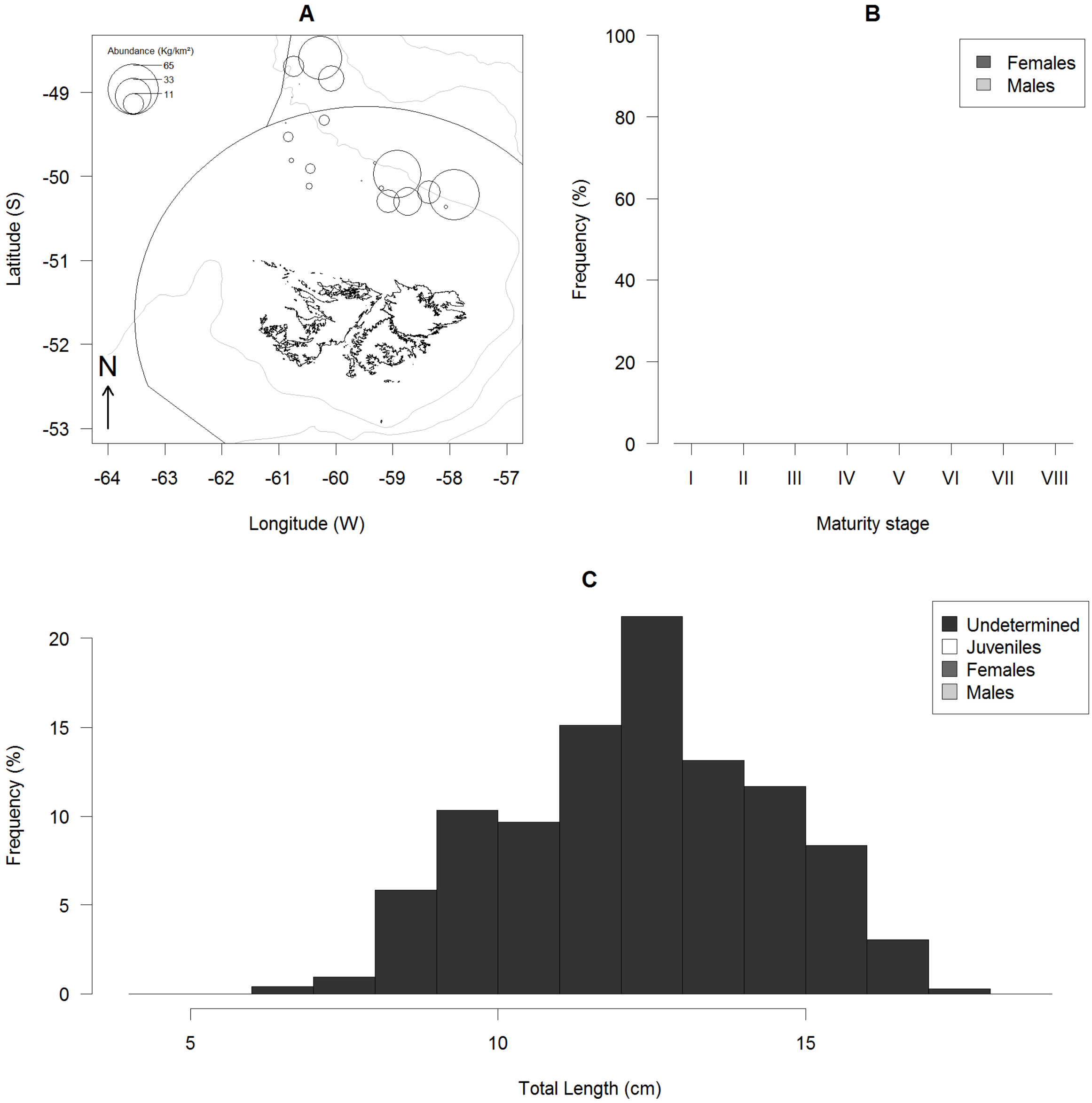

Figure 16: Biological data of *Gymnoscopelus nicholsi* (Nichol's lanternfish; GYN), map of the densities in kg·km^{-2} (A), percentage of specimens of each sex per maturity stage (B, immature; II, resting; III, early developing; IV, late developing; V, ripe; VI, running; VII, spent; VIII, recovering spent) and length frequency (in percentage of the total sample assessed) of each sex with 1 cm size class (C; n=754).

3.2.16 *Champsocephalus esox* – icefish – CHE

The total catch of icefish was 57.4 kg. It was caught at 15 out of the 90 trawl stations sampled throughout the research cruise (Figure 17). Catches ranged from 0.01 to 23.4 kg. Among the 15 stations, 2 yielded >10 kg. Densities ranged from 0.05 to 143 $kg \cdot km^{-2}$. (CPUE ranged 0.01–23.4 $kg \cdot h^{-1}$). Highest densities were observed in two areas, inshore along the north and west coasts of West Falkland and in the northern part of the *Loligo* box. The number of fish sampled for length frequency was 593 (281 females and 312 males), 27 were sampled for length–weight, 18 for otolith. Total lengths ranged from 11 to 34 cm for females and from 12 to 37 cm for males. The histogram exhibits 2 different cohorts with modes at 16 cm and 29 cm. Females were immature (58%) and resting (42%). Males were immature (80%) and resting (20%).

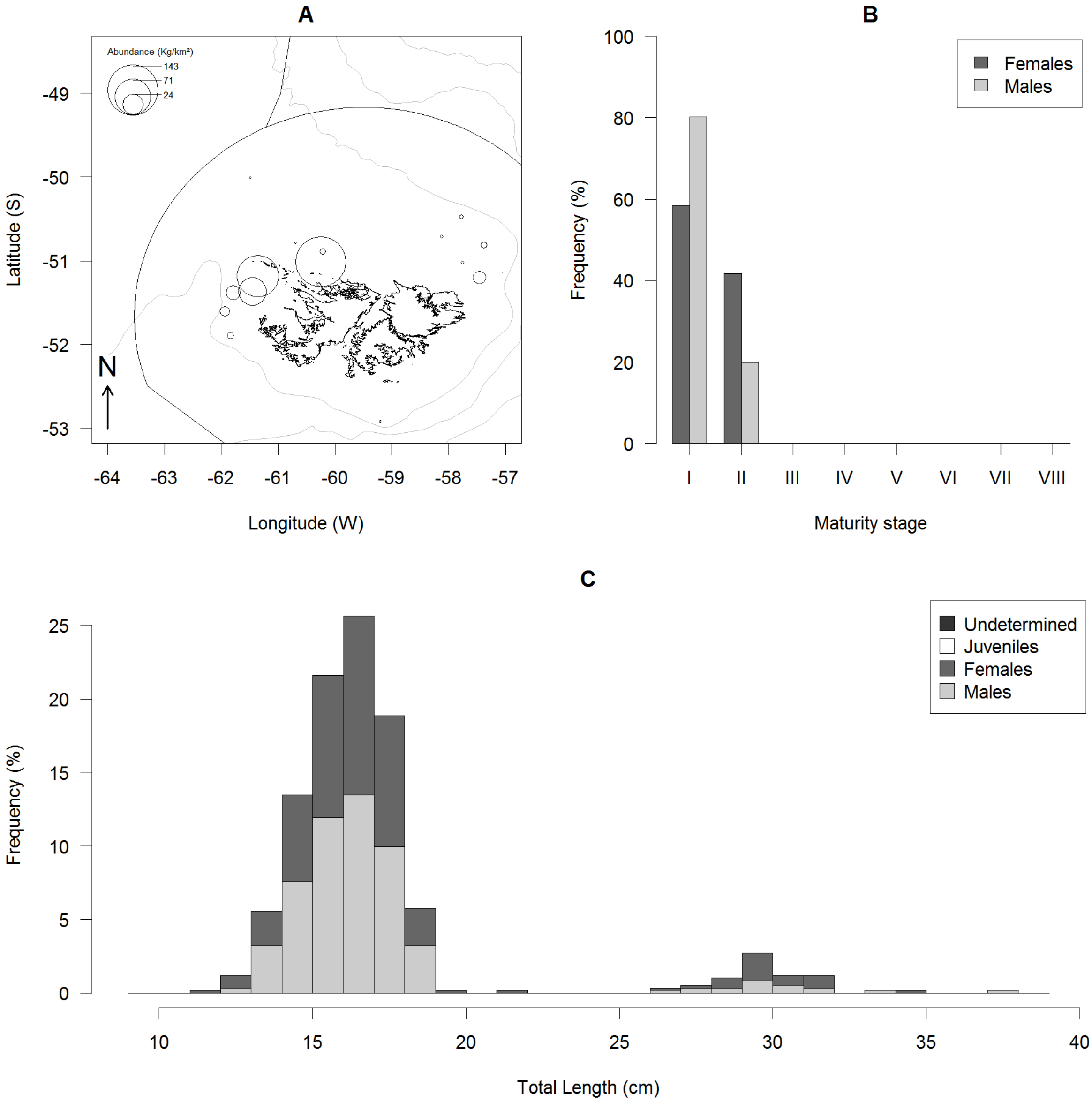

Figure 17: Biological data of *Champsocephalus esox* (icefish; CHE), map of the densities in $kg \cdot km^{-2}$ (A), percentage of specimens of each sex per maturity stage (B, immature; II, resting; III, early developing; IV, late developing; V, ripe; VI, running; VII, spent; VIII, recovering spent) and length frequency (in percentage of the total sample assessed) of each sex with 1 cm size class (C; n=593).

3.2.17 *Physiculus marginatus* – dwarf codling – PYM

The total catch of dwarf codling was 20.5 kg. It was caught at 12 out of the 90 trawl stations sampled throughout the research cruise (Figure 18). Catches ranged from 0.03 to 5.65 kg. Densities ranged from 0.16 to 26.77 kg·km^{-2}. (CPUE ranged 0.03–5.65 kg·h^{-1}). Highest densities were observed in deep waters (>200 m) in the southwest and in the north of the survey zone and at one station to the north of Stanley. The number of fish sampled for length frequency was 270 (130 females and 140 males). Total lengths ranged from 13 to 18 cm for females and from 11 to 18 cm for males. The histogram exhibits 1 cohort with mode at 15 cm and perhaps another one at 11 cm but this one should be confirmed by otolith reading. Females and males were immature (58 and 84% respectively) and resting (42 and 16% respectively).

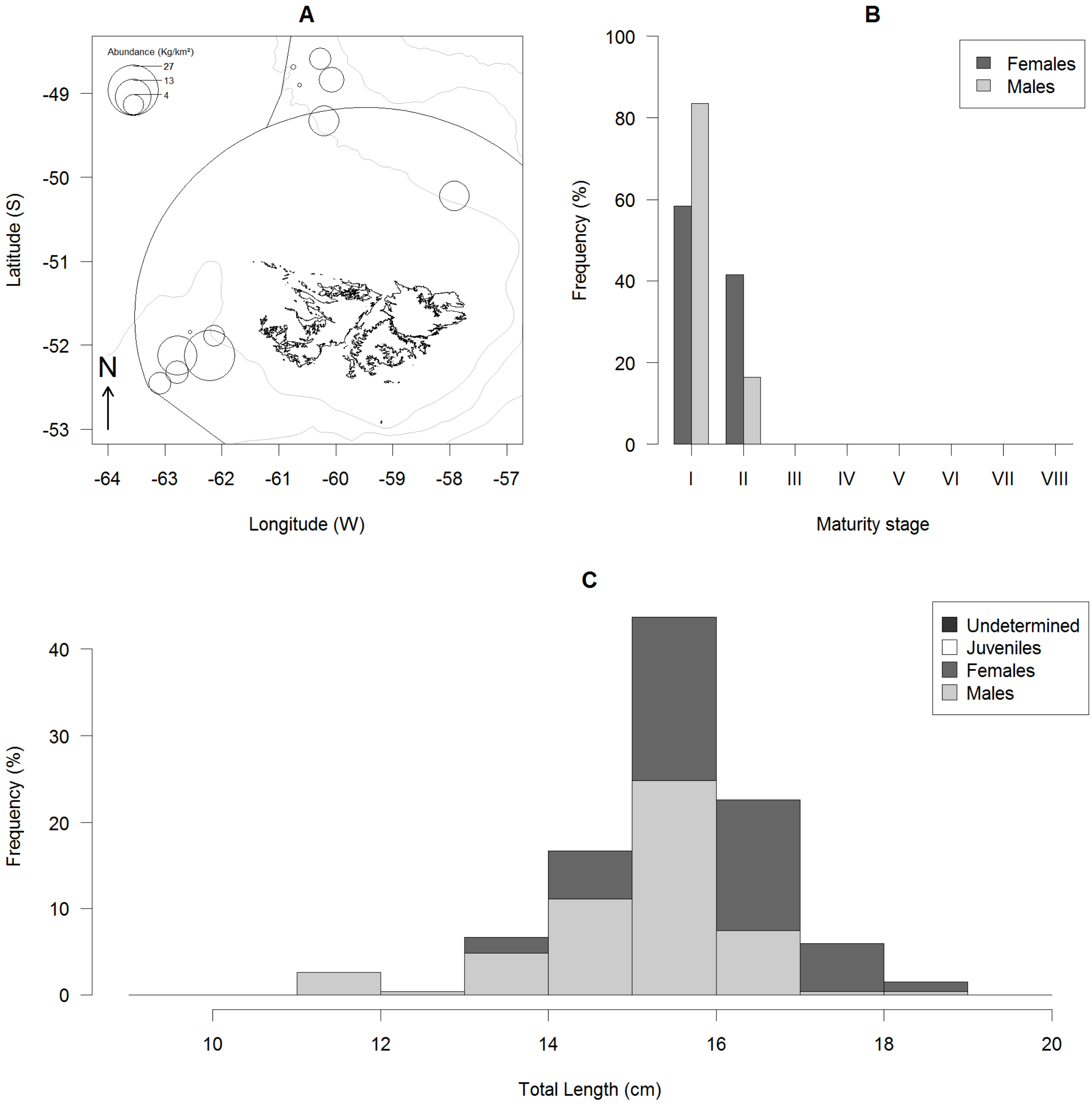

Figure 18: Biological data of *Physiculus marginatus* (dwarf codling; PYM), map of the densities in kg·km^{-2} (A), percentage of specimens of each sex per maturity stage (B, immature; II, resting; III, early developing; IV, late developing; V, ripe; VI, running; VII, spent; VIII, recovering spent) and length frequency (in percentage of the total sample assessed) of each sex with 1 cm size class (C; n=270).

3.2.18 *Sebastes oculatus* – redfish – RED

The total catch of redfish was 53.7 kg. It was caught at 14 out of the 90 trawl stations sampled throughout the research cruise (Figure 19). Catches ranged from 0.22 to 24.55 kg. Among the 14 stations, 2 yielded >10 kg. Densities ranged from 1.46 to 118 kg·km^{-2} (CPUE ranged 0.22–24.55 kg·h^{-1}). Redfish was caught at various stations throughout the survey and the map does not show any particular area where redfish could be more abundant. The number of fish sampled for length frequency was 108 (55 females and 53 males), 75 for otolith. Total lengths ranged from 23 to 44 cm for females and from 17 to 39 cm for males. Several modes can be identified on the length frequency histogram but cohorts are difficult to identify due to the low number of fish sampled. Females were resting (5%), early developing (26%), late developing (36%), ripe (11%), running (4%), spent (4%) and recovering spent (14%). Males were immature (8%), resting (17%) and early developing (75%).

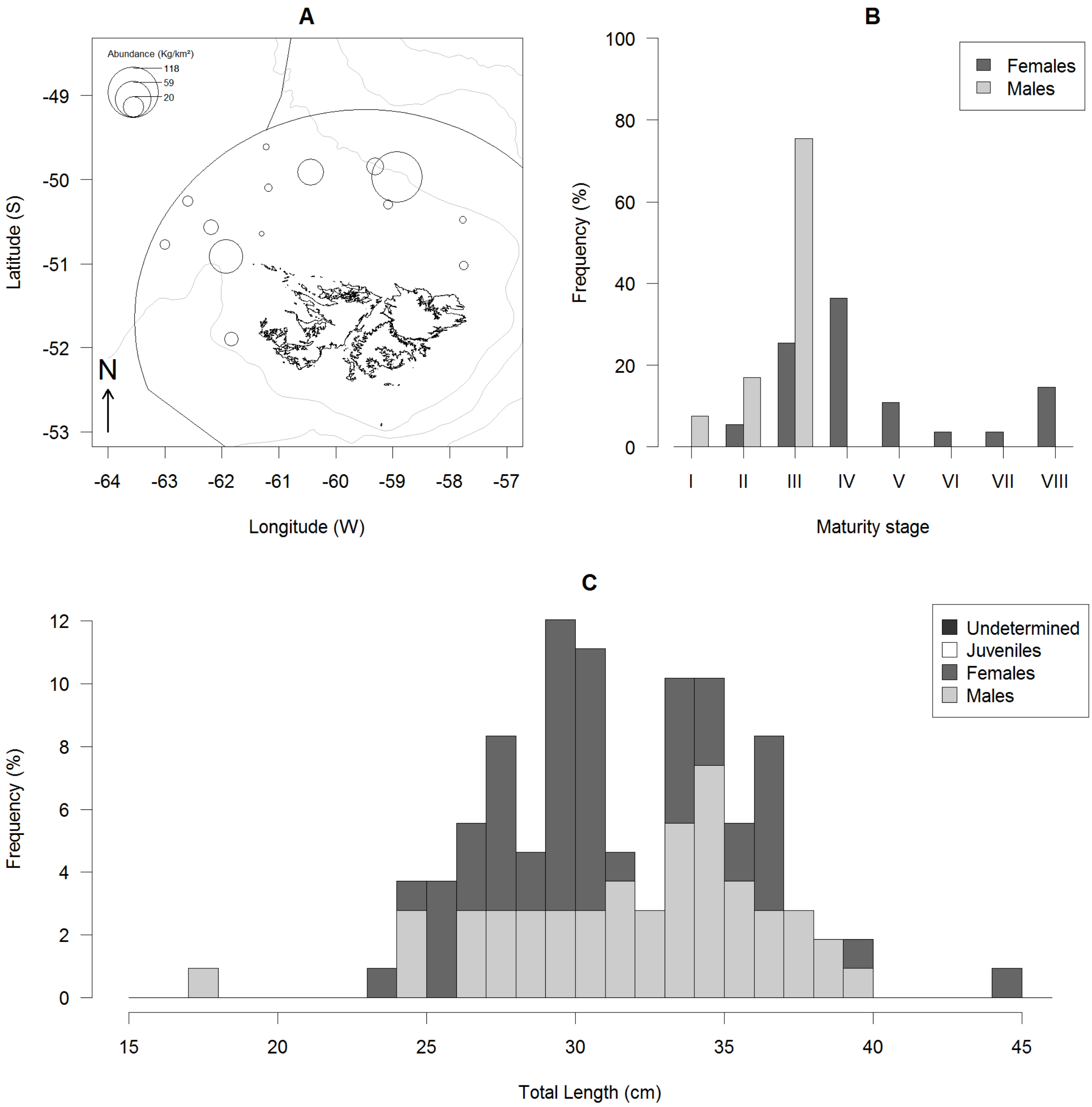

Figure 19: Biological data of *Sebastes oculatus* (redfish; RED), map of the densities in kg·km^{-2} (A), percentage of specimens of each sex per maturity stage (B, immature; II, resting; III, early developing; IV, late developing; V, ripe; VI, running; VII, spent; VIII, recovering spent) and length frequency (in percentage of the total sample assessed) of each sex with 1 cm size class (C; n=108).

3.2.19 *Cottunculus granulosus* – fathead – COT

The total catch of fathead was 11.2 kg. It was caught at 5 out of the 90 trawl stations sampled throughout the research cruise (Figure 20). Catches ranged from 0.01 to 5.59 kg. Densities ranged from 0.05 to 26.5 kg·km^{-2}. (CPUE ranged 0.01–5.59 kg·h^{-1}). Fathead was caught at one station to the north of Stanley, at two deep water stations in the north of the FOCZ and at two deep water stations in the southwestern part of the survey zone. The number of fish sampled for length frequency was 59 (33 females and 26 males). Total lengths ranged from 11 to 30 cm for females and from 8 to 26 cm for males. Several modes can be identified on the length frequency however the small sample size makes it difficult to identify cohorts. Females were immature (3%), resting (55%), early developing (24%), late developing (12%) and ripe (6%). Males were immature (23%), resting (46%), early developing (23%) and late developing (8%).

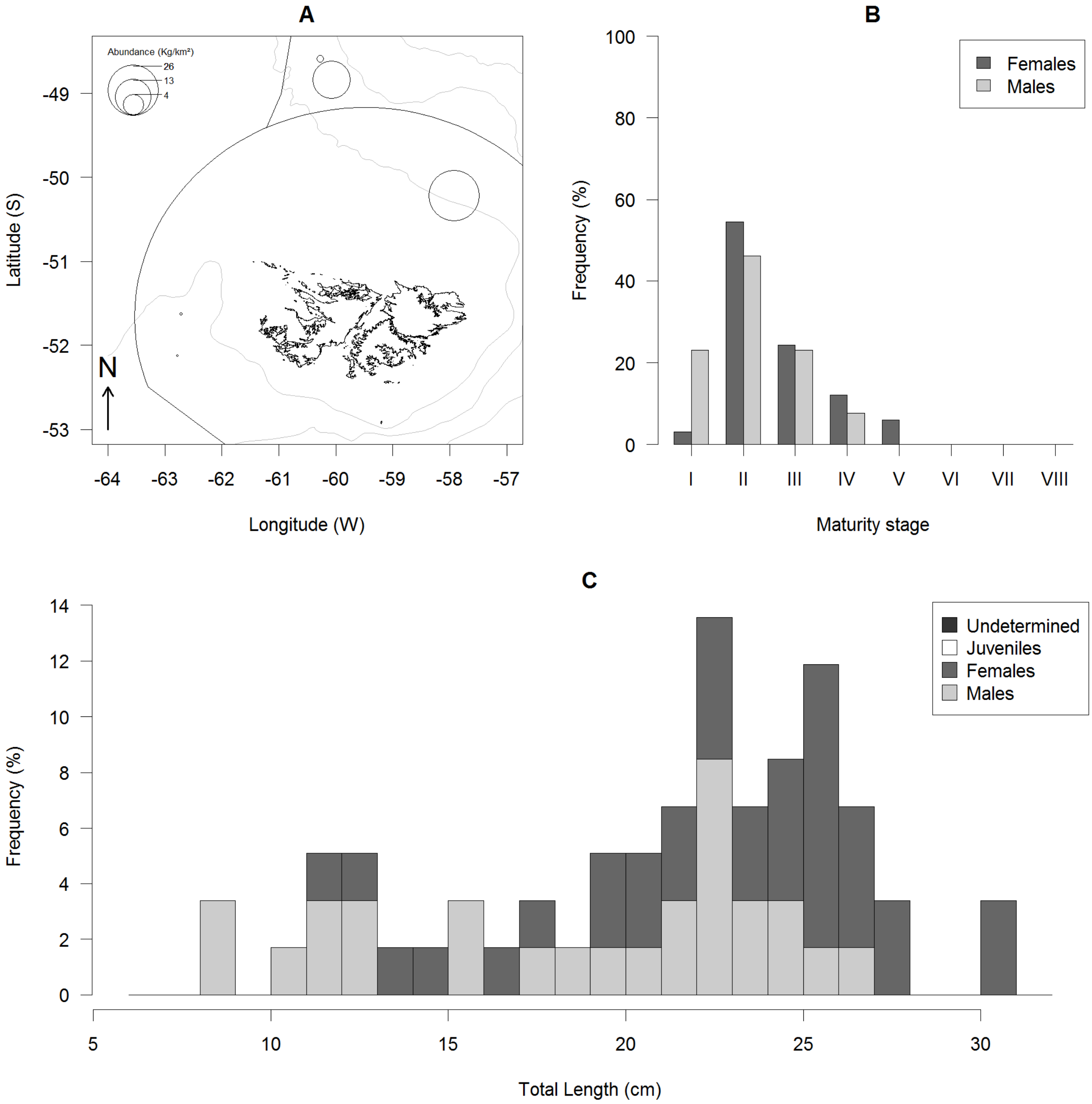

Figure 20: Biological data of *Cottunculus granulosus* (fathead; COT), map of the densities in kg·km^{-2} (A), percentage of specimens of each sex per maturity stage (B, immature; II, resting; III, early developing; IV, late developing; V, ripe; VI, running; VII, spent; VIII, recovering spent) and length frequency (in percentage of the total sample assessed) of each sex with 1 cm size class (C; n=59).

3.2.20 *Protomictophum choriodon* – Gaptooth lanternfish – PMC

The total catch of Gaptooth lantern fish was 4.3 kg. It was caught at 3 out of the 90 trawl stations sampled throughout the research cruise (Figure 21). Catches ranged from 0.25 to 3.17 kg. Densities ranged from 1.13 to 26.3 kg·km^{-2}. (CPUE ranged 0.25–3.17 kg·h^{-1}). Gaptooth lanternfish was caught to the north of East Falkland. The number of fish sampled for length frequency was 85. The samples were not sexed as the fish is too soft to be opened. Total lengths ranged from 7 to 10 cm with mode at 8 cm.

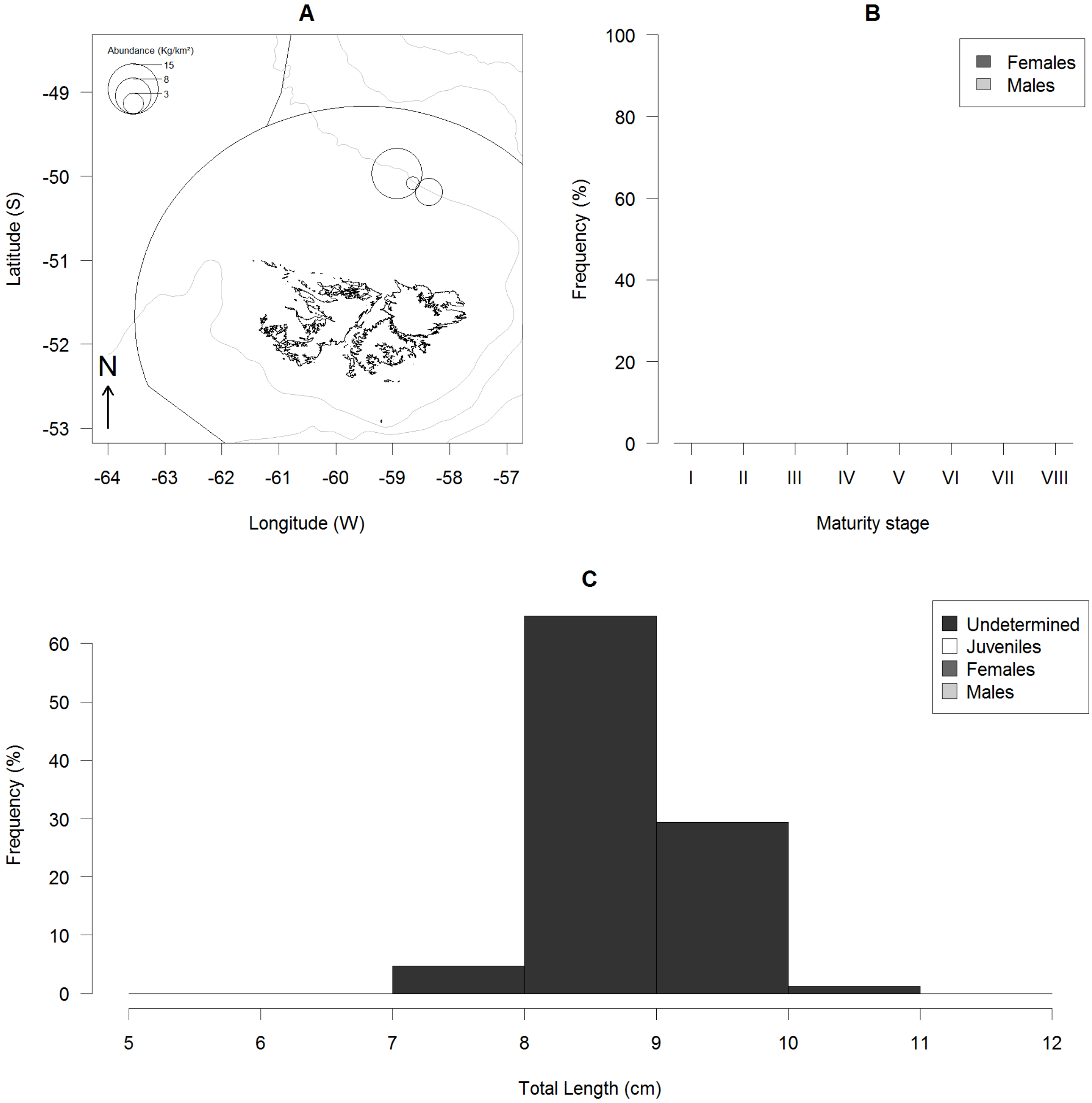

Figure 21: Biological data of *Protomictophum choriodon* (Gaptooth lanternfish; PMC), map of the densities in kg·km^{-2} (A), percentage of specimens of each sex per maturity stage (B, immature; II, resting; III, early developing; IV, late developing; V, ripe; VI, running; VII, spent; VIII, recovering spent) and length frequency (in percentage of the total sample assessed) of each sex with 1 cm size class (C; n=85).

3.2.21 *Iluocoetes fimbriatus* – eelpout – ILF

The total catch of eelpout was 1.1 kg. It was caught at 9 out of the 90 trawl stations sampled throughout the research cruise (Figure 22). Catches ranged from 0.01 to 0.5 kg. Densities ranged from 0.04 to 2.55 kg·km^{-2}. (CPUE ranged 0.01–0.5 kg·h^{-1}). Highest densities were observed at one station in the northern part of the survey zone along the 200 m bathymetric line and to the west of the Jason Islands. The number of fish sampled for length frequency was 26 (15 females and 11 males), all of them for otolith. Total lengths ranged from 11 to 25 cm for females and from 10 to 25 cm for males. Cohorts are difficult to identify on the length frequency histogram. Females were resting (40%), late developing (7%) and ripe (53%). Males were immature (9%), resting (36%), early developing (46%) and recovering spent (9%).

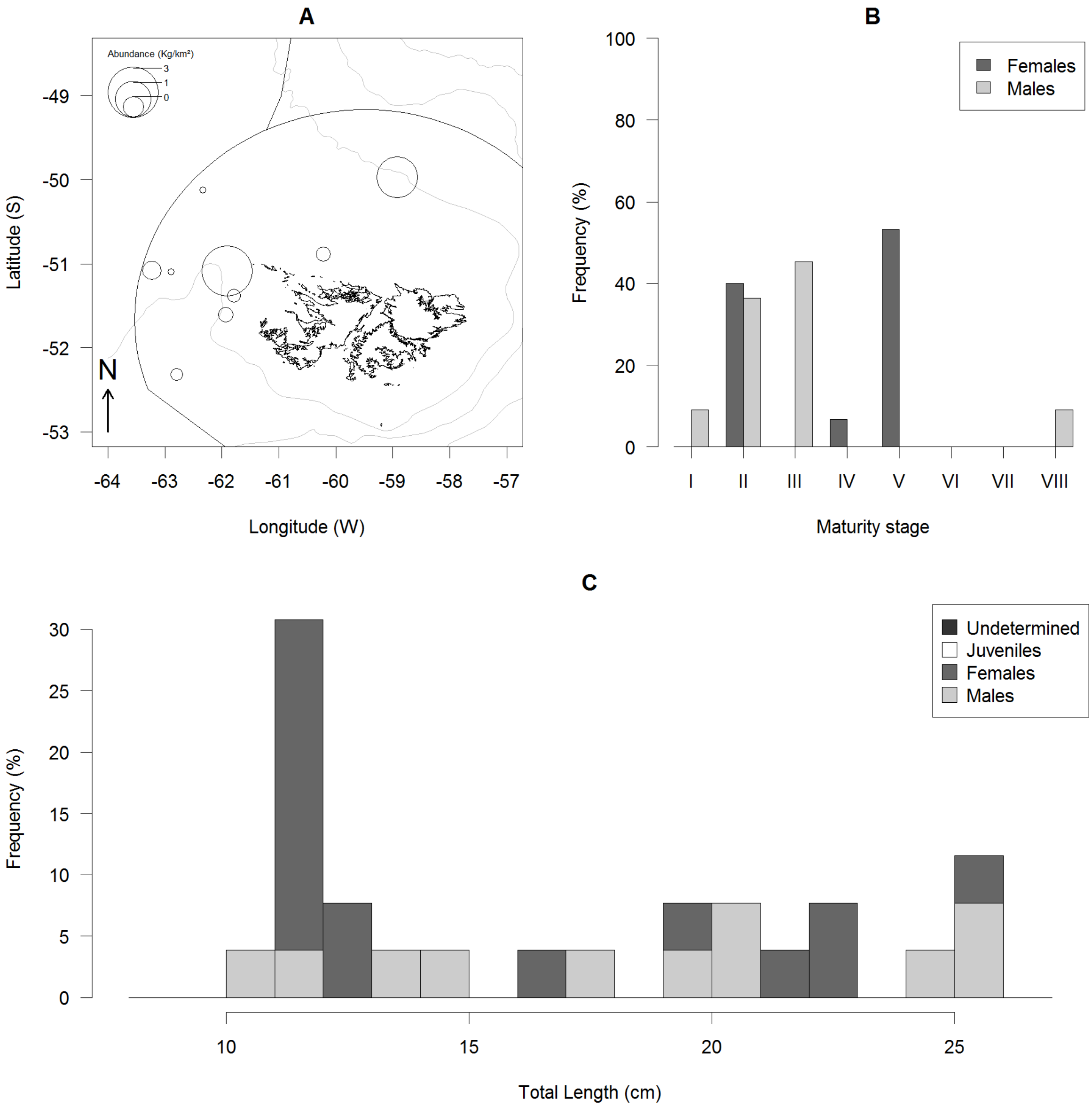

Figure 22: Biological data of *Iluocoetes fimbriatus* (eelpout; ILF), map of the densities in kg·km^{-2} (A), percentage of specimens of each sex per maturity stage (B, immature; II, resting; III, early developing; IV, late developing; V, ripe; VI, running; VII, spent; VIII, recovering spent) and length frequency (in percentage of the total sample assessed) of each sex with 1 cm size class (C; n=26).

3.3 Biological information of squids

3.3.1 *Doryteuthis gahi* (former *Loligo gahi*) – Falkland calamari – LOL

The total catch of Falkland calamari was 5,368 kg. It was caught at 86 out of the 90 trawl stations sampled throughout the research cruise (Figure 2). Catches ranged from 0.25 to 1,343 kg. Among the 86 stations, 59 yielded >10 kg, 11 yielded >100 kg and 1 yielded >1 t. Densities ranged from 1.43 to 6,732 kg·km^{-2}. (CPUE ranged 0.25–1,343 kg·h^{-1}). Falkland calamari was caught throughout the survey and density was significantly higher in the eastern part of the survey zone, in the northern *Loligo* box. The number of squid sampled for dorsal mantle length frequency was 8,229 (1 juvenile, 4,452 females and 3,776 males), 119 were sampled for length–weight and 92 for statolith. Dorsal mantle length was 2.5 cm for the juvenile, ranged from 4.5 to 18 cm for females and from 4 to 22.5 cm for males. One cohort appears on the length frequency histogram (mode at 9 cm). Females were young (12%), immature (78%), preparatory (9%), maturing (0.7%) and mature (0.3%). Males were young (21%), immature (70%), preparatory (5.5%), maturing (3%) and mature (0.5%).

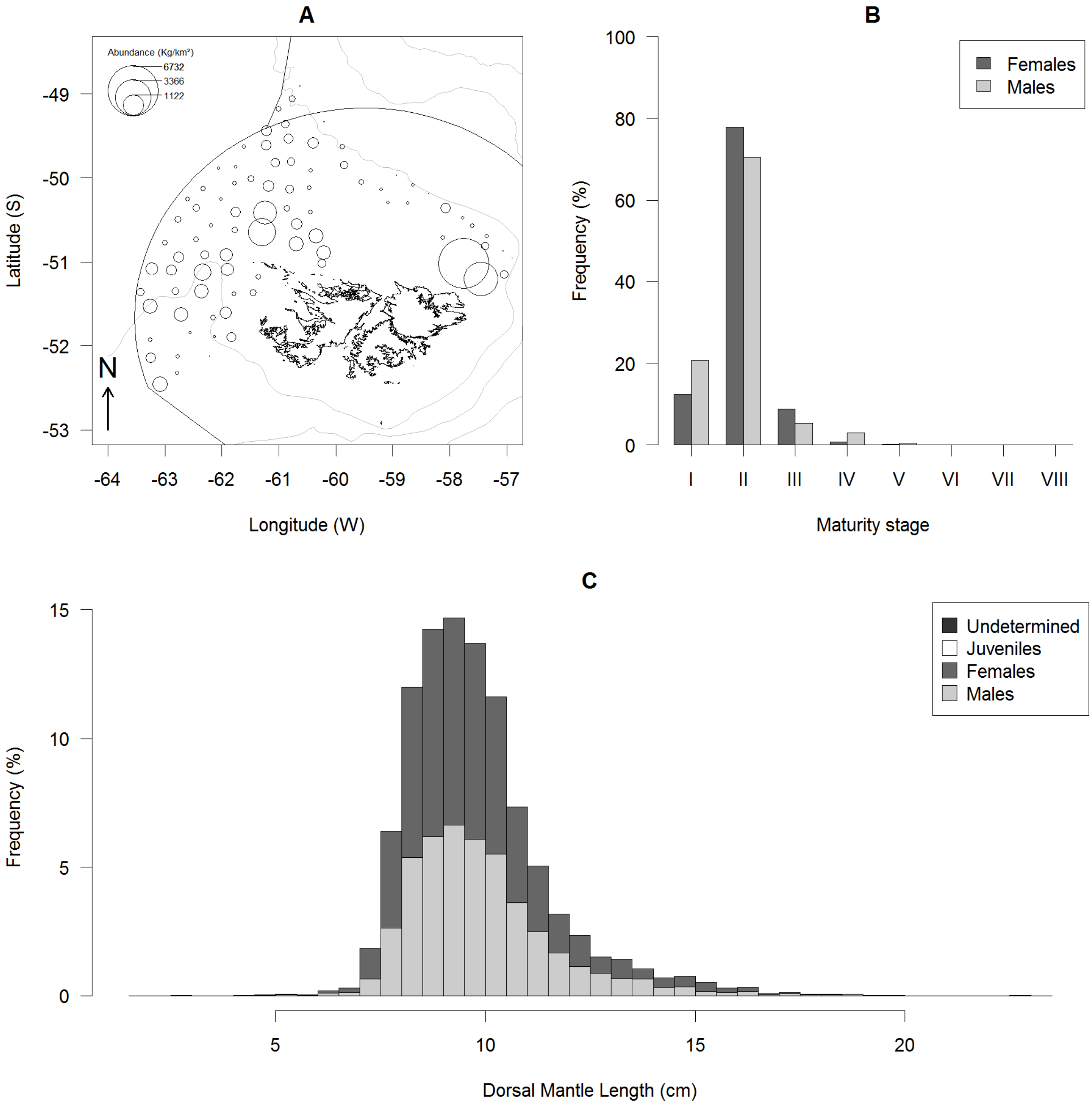

Figure 23: Biological data of *Doryteuthis gahi* (Falkland calamari; LOL), map of the densities in kg·km^{-2} (A), percentage of specimens of each sex per maturity stage (B; I young; II, immature; III, preparatory; IV, maturing; V, mature; VI, spent) and dorsal mantle length frequency (in percentage of the total sample assessed) of each sex with 0.5 cm size class (C; n=8,229).

3.3.2 *Illex argentinus* – Argentine shortfin squid – ILL

The total catch of Argentine shortfin squid was 2,459 kg. It was caught at 77 out of the 90 trawl stations sampled throughout the research cruise (Figure 2). Catches ranged from 0.022 to 334 kg. Among the 77 stations, 22 yielded >10 kg, 9 yielded >100 kg. Densities ranged from 0.1 to 1,661 kg·km^{-2} (CPUE ranged 0.02–334 kg·h^{-1}). Highest densities were observed in the northwest quarter of the survey zone, especially to the west of 59°W and to the north of 51°S. However, Argentine shortfin squid was caught in small quantities at many other stations to the south and to the east of the limits mentioned above. The number of squid sampled for length frequency was 2,934 (1,800 females and 1,134 males), 157 (including 6 non–random) were sampled for length–weight, 121 for statolith (including 22 non–random). Dorsal mantle lengths ranged from 6.5 to 29.5 cm for females and from 5 to 26 cm for males. The histogram exhibits 2 different cohorts with modes at 9 cm and 23 cm. The cohort at 9 cm was also observed in 2016, albeit less abundant. Females were observed young (20%), immature (62%), preparatory (11%), maturing (3%) and mature (4%). Males were young (38%), immature (6%), preparatory (3%), maturing (17%) and mature (36%).

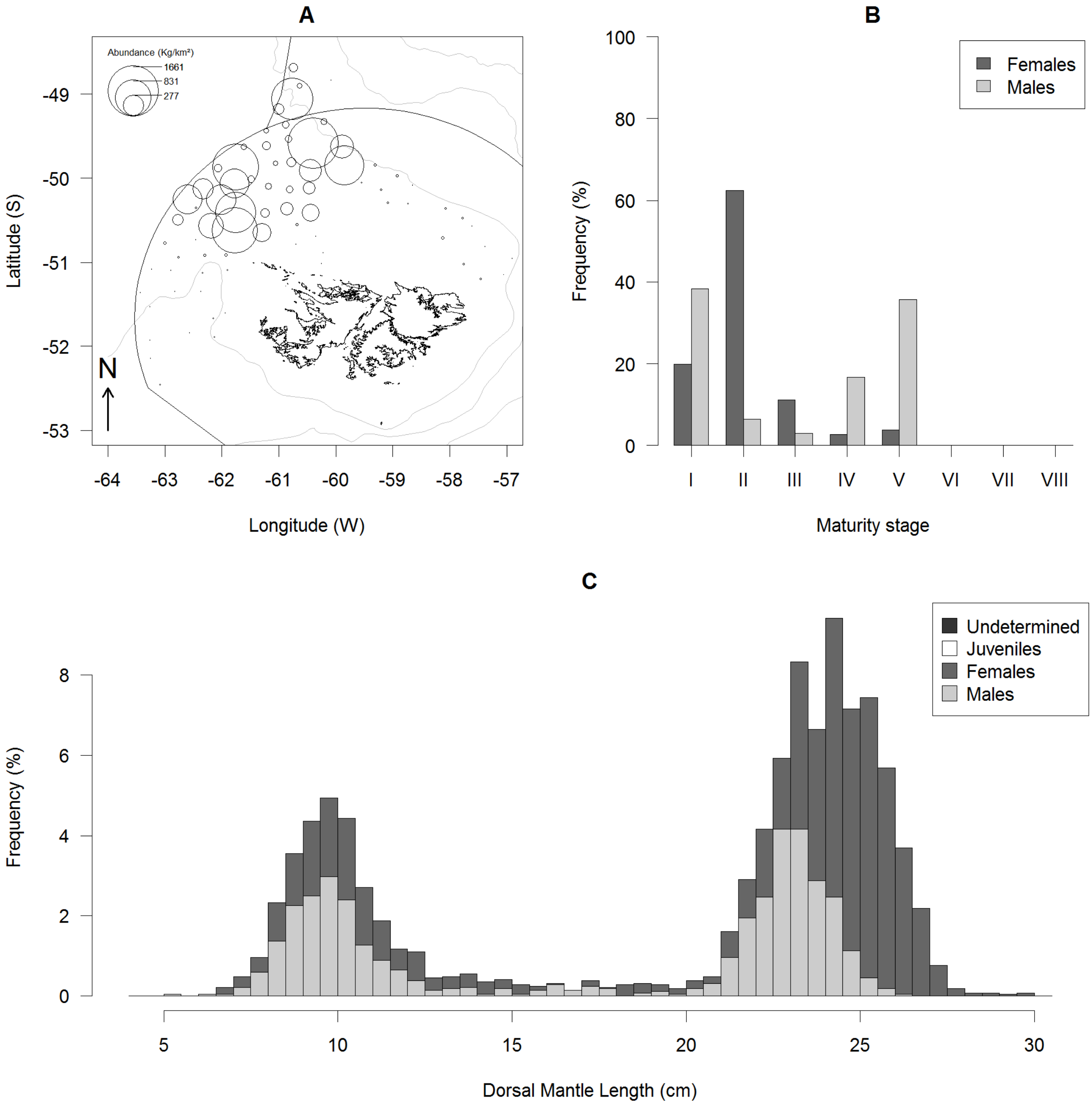

Figure 24: Biological data of *Illex argentinus* (Argentine shortfin squid; ILL), map of the densities in kg·km^{-2} (A), percentage of specimens of each sex per maturity stage (B; I young; II, immature; III, preparatory; IV, maturing; V, mature; VI, spent) and dorsal mantle length frequency (in percentage of the total sample assessed) of each sex with 0.5 cm size class (C; n=2,934).

3.4 Biological information of skates

3.4.1 *Bathyraja brachyurops* – blonde skate – RBR

The total catch of blonde skate was 717kg. It was caught at 70 out of the 90 trawl stations sampled throughout the research cruise (Figure 25). Catches ranged from 0.03 to 196kg. Of the 70 stations, 16 yielded >10 kg, and 1 yielded >100 kg. Densities ranged from 0.17 to 929 kg·km^{-2}. (CPUE ranged 0.03–196 kg·h^{-1}). Highest densities were observed in the NE part of the survey zone. The number of skate sampled for total length, disc–width and weight was 374 (54.5% F). Disc widths ranged from 6 to 75 cm for females and from 9 to 66 cm for males. The histogram exhibits 1 clear juvenile cohort in the 10-14cm size class. Females were observed juvenile (15%), adolescent, maturing (44%), adult, developing (9%), adult, mature (15%), adult, laying (3%) and adult, resting (14%). Males were juvenile (18%), adolescent, maturing (32%), adult, developing (12%), adult, mature (28%), adult, running (9%).

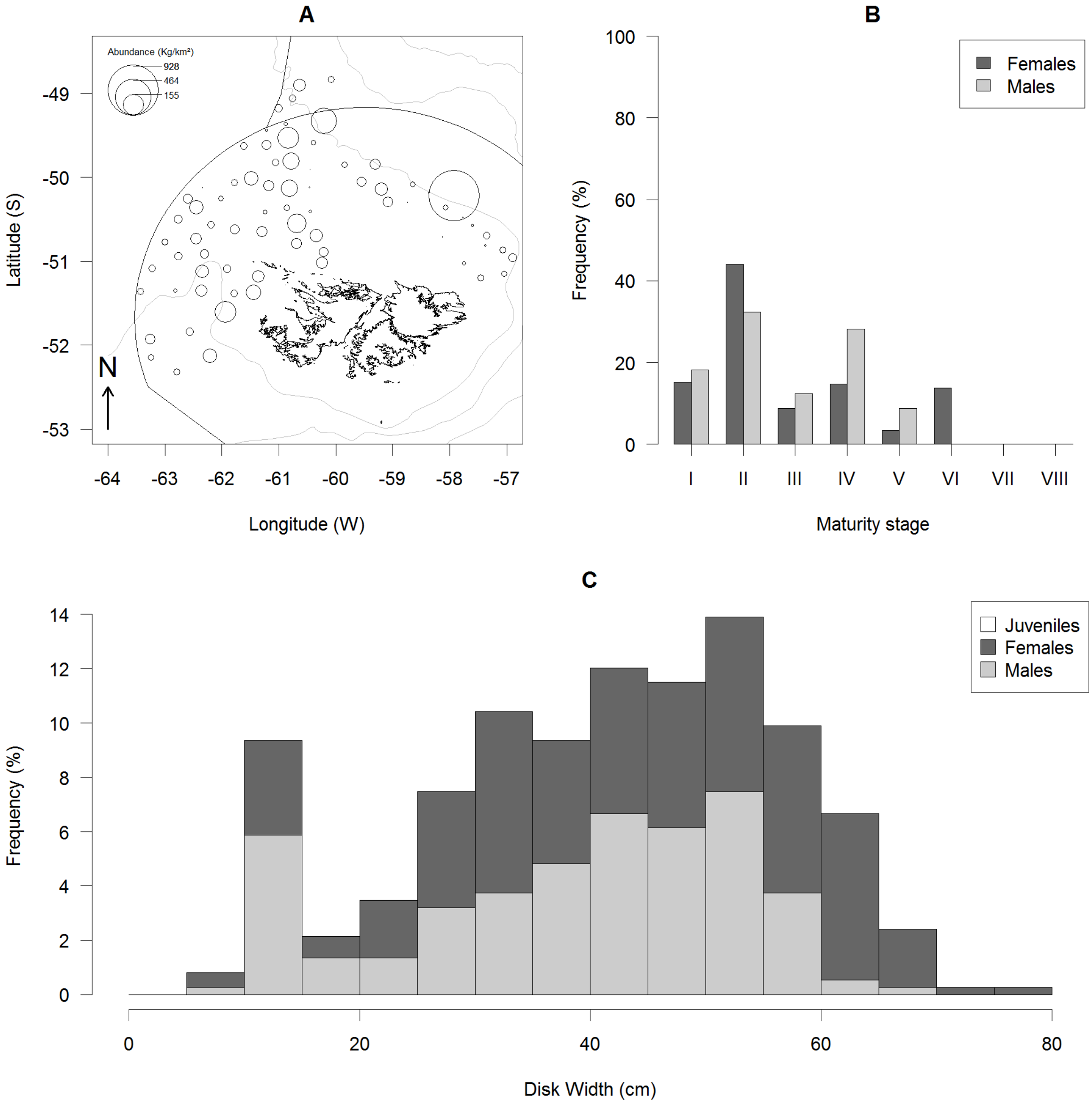

Figure 25: Biological data of *Bathyraja brachyurops* (blonde skate, RBR), map of the densities in kg/km² (A), percentage of specimens of each sex per maturity stage (B; I juvenile; II, adolescent maturing; III, adult, developing; IV, adult, mature; V, adult laying/running; VI, adult resting) and size frequency frequency (in percentage of the total sample assessed) of each sex with 5 cm size classes (C; n=374).

3.4.2 *Zearaja chilensis* – yellow nose skate – RFL

The total catch of yellow nose skate was 666 kg. It was caught at 57 out of the 90 trawl stations sampled throughout the research cruise (Figure 26). Catches ranged from 1.3 to 69 kg. Of the 57 stations, 24 yielded >10 kg. Densities ranged from 6.38 to 418 kg·km^{-2}. (CPUE ranged 1.3–69 kg·h^{-1}). Highest densities were observed in the northern part of the survey zone. The number of skate sampled for total length, disc–width and weight was 244 (82.4% F). Disc width ranged from 34 to 82 cm for females and from 34 to 78 cm for males. The histogram exhibits no clear cohorts. Females were observed juvenile (15%), adolescent, maturing (67%), adult, developing (14%), and adult, resting (4%). Males were adolescent, maturing (63%), adult, developing (21%), adult, mature (5%), adult, running (12%).

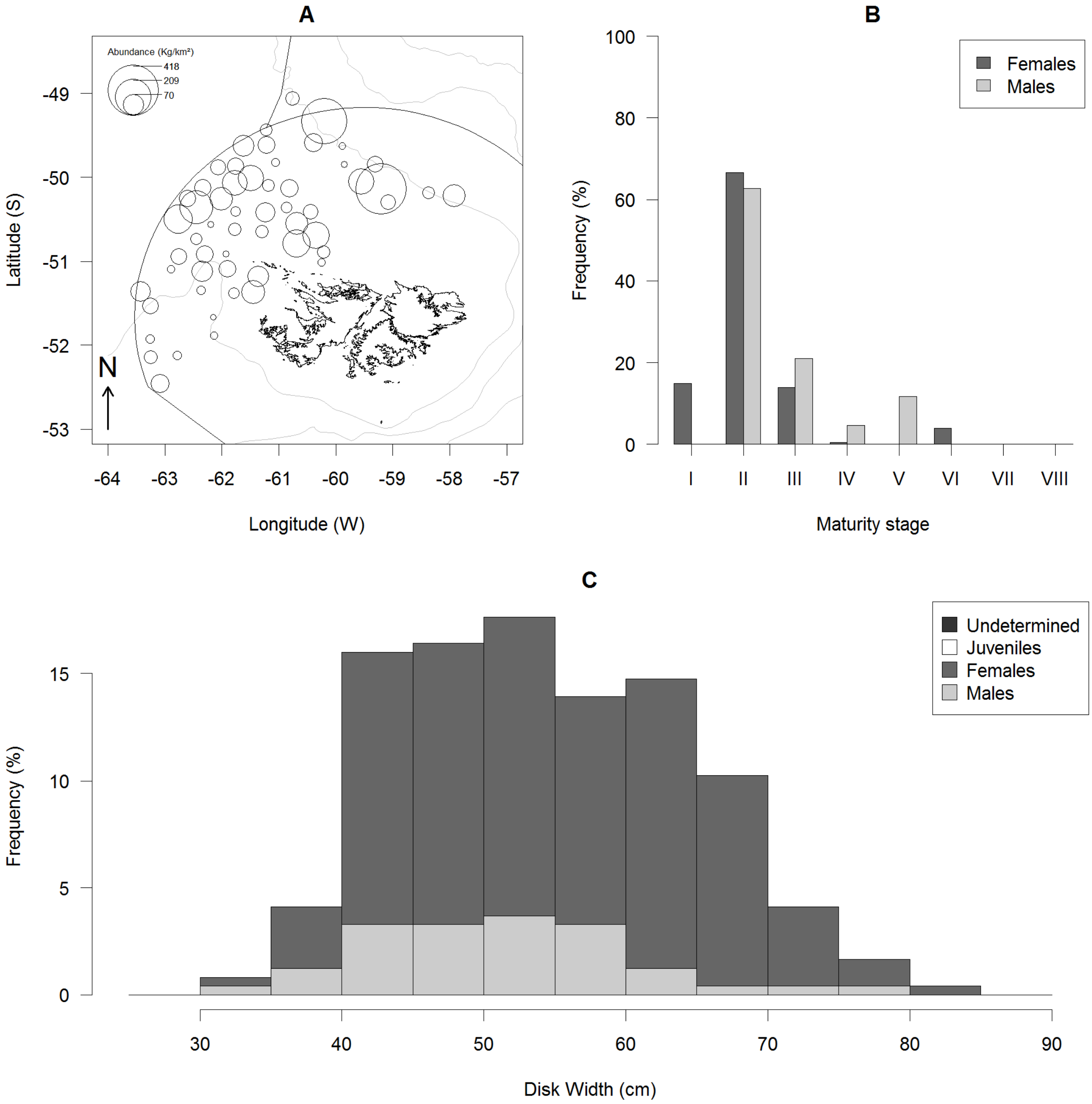

Figure 26: Biological data of *Zearaja chilensis* (yellow nose skate, RFL), map of the densities in kg/km² (A), percentage of specimens of each sex per maturity stage (B; I juvenile; II, adolescent maturing; III, adult, developing; IV, adult, mature; V, adult laying/running; VI, adult resting) and length frequency (in percentage of the total sample assessed) of each sex with 5 cm size class (C; n=244).

3.4.3 *Bathyraja griseocauda* – grey tailed skate – RGR

The total catch of grey tailed skate was 625 kg. It was caught at 18 out of the 90 trawl stations sampled through the research cruise (Figure 27). Catches ranged from 1.71 to 100 kg. Of the 18 stations, 12 yielded >10 kg, and 1 yielded >100 kg. Densities ranged from 7.1 to 440 kg·km^{-2}. (CPUE ranged 1.7–93 kg·h^{-1}). Highest densities were observed in the northern, north-eastern, and south-western part of the survey zone. The number of skate sampled for total length, disc–width and weight was 102 (54% F), and 19 were sampled for vertebrae and thorns. Disc width ranged from 22 to 101 cm for females and from 25 to 94 cm for males. The histogram exhibits no clear cohorts. Females were observed juvenile (31%), adolescent, maturing (49%), adult, developing (9%), adult, mature (5%), adult, laying (4%) and adult, resting (2%). Males were juvenile (17%), adolescent, maturing (47%), adult, developing (13%), adult, mature (6%), and adult, running (17%).

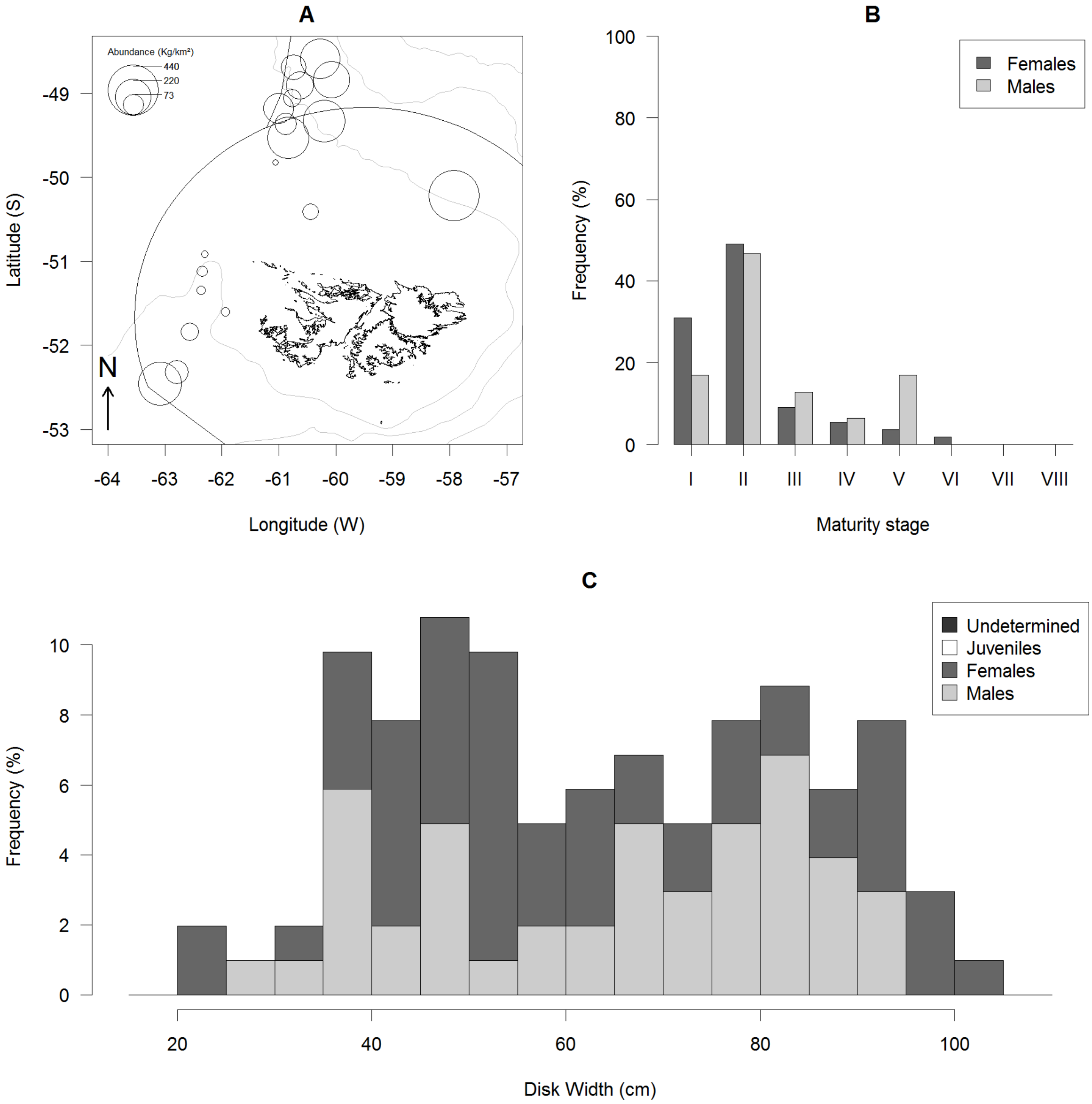

Figure 27: Biological data of *Bathyraja griseocauda* (grey tailed skate, RGR), map of the densities in kg/km² (A), percentage of specimens of each sex per maturity stage (B; I juvenile; II, adolescent maturing; III, adult, developing; IV, adult, mature; V, adult laying/running; VI, adult resting) and length frequency (in percentage of the total sample assessed) of each sex with 5 cm size class (C; n=102).

3.4.4 *Bathyraja cousseauae* – joined–fin skate – RBZ

The total catch of joined-fin skate was 73 kg. It was caught at 4 out of the 90 trawl stations sampled throughout the research cruise (Figure 28). Catches ranged from 8.1 to 28.6 kg. Of the 4 stations, 2 yielded >10 kg. Densities ranged from 38.3 to 76.2 kg·km^{-2}. (CPUE ranged 8.1–14.3 kg·h^{-1}). The number of skate sampled for total length, disc–width and weight was 14 (50% F), and 2 were sampled for vertebrae and thorns. Disc width ranged from 36 to 76 cm for females and from 36 to 73 cm for males. Females were juvenile (14%), adolescent, maturing (29%), adult, developing (14%), and adult, mature (43%). Males were juvenile (43%), adolescent, maturing (14%), adult, developing (14%), adult, mature (14%), and adult, running (14%).

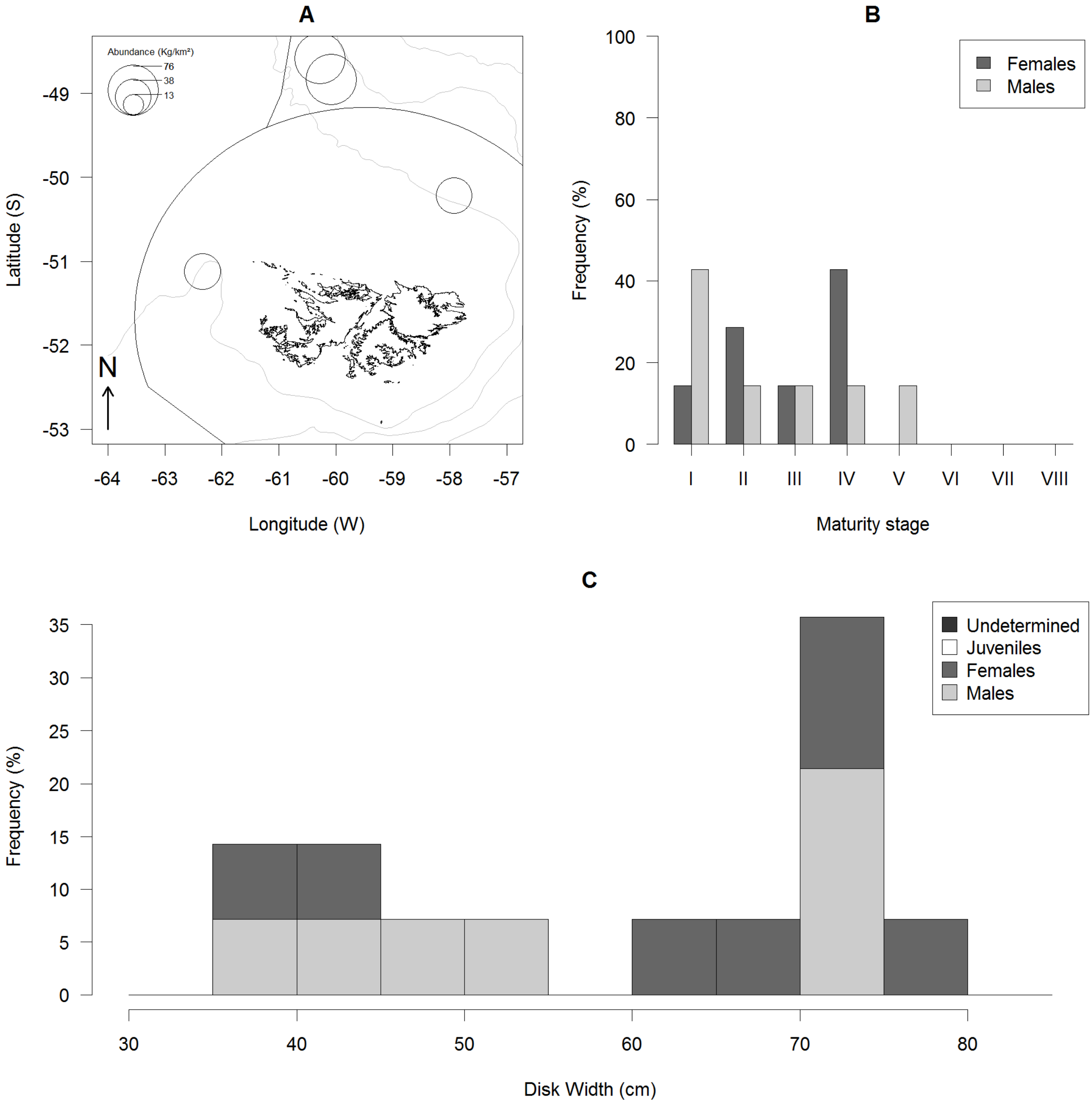

Figure 28: Biological data of *Bathyraja cousseauae* (joined–fin skate, RBZ), map of the densities in kg/km² (A), percentage of specimens of each sex per maturity stage (B; I juvenile; II, adolescent maturing; III, adult, developing; IV, adult, mature; V, adult laying/running; VI, adult resting) and length frequency (in percentage of the total sample assessed) of each sex with 5 cm size class (C; n=14).

3.4.5 *Bathyraja macloviana* – Falkland skate – RMC

The total catch of Falkland skate was 68 kg. It was caught at 38 out of the 90 trawl stations sampled throughout the research cruise (Figure 29). Catches ranged from 0.02 to 10.43 kg. Among the 38 stations, 1 yielded >10 kg. Densities ranged from 0.08 to 69.2 kg·km^{-2}. (CPUE ranged 0.02–10.43 kg·h^{-1}). Highest densities were observed to the NW of the Jason Islands. The number of skate sampled for total length, disc–width and weight was 71 (35% F). Disc width ranged from 8 to 43 cm for females and from 10 to 51 cm for males. The histogram exhibits a juvenile and a sub-adult cohort. Females were juvenile (32%), adolescent, maturing (16%), adult, developing (16%), adult, mature (8%), adult, laying (8%) and adult, resting (20%). Males were juvenile (9%), adolescent, maturing (2%), adult, developing (24%), adult, mature (33%), and adult, running (33%).

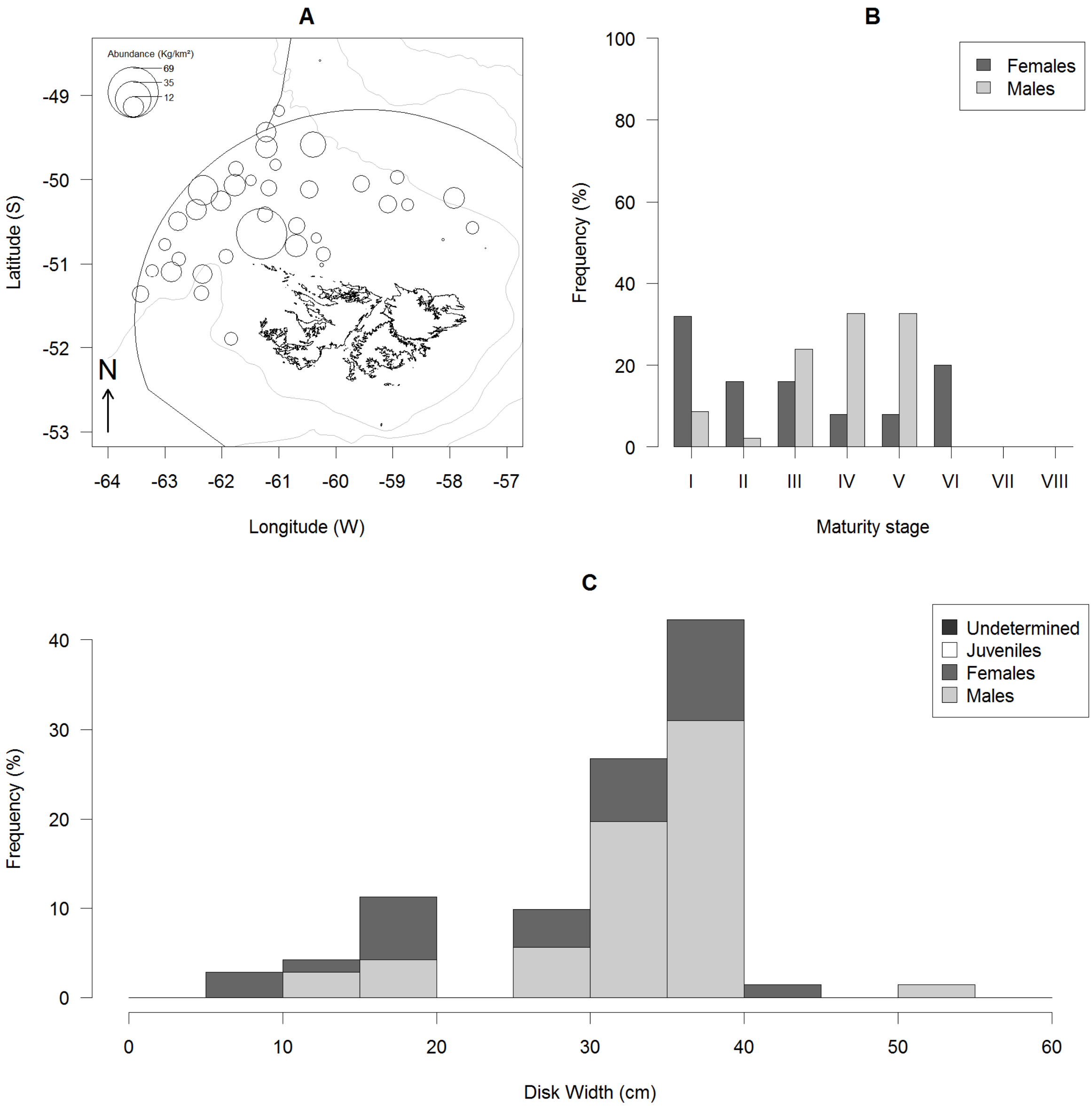

Figure 29: Biological data of *Bathyraja macloviana* (Falkland skate, RMC), map of the densities in kg/km² (A), percentage of specimens of each sex per maturity stage (B; I juvenile; II, adolescent maturing; III, adult, developing; IV, adult, mature; V, adult laying/running; VI, adult resting) and length frequency (in percentage of the total sample assessed) of each sex with 5 cm size class (C; n=71).

3.4.6 *Bathyraja albomaculata* – white spotted skate – RAL

The total catch of white spotted skate was 60.7 kg. It was caught at 17 out of the 90 trawl stations sampled through the research cruise (Figure 30). Catches ranged from 0.57 to 13.1 kg. Of the 17 stations, 2 yielded >10 kg. Densities ranged from 2.7 to 62.1 kg·km^{-2}. (CPUE ranged 0.57–13.1 kg·h^{-1}). Highest densities were observed in the northern part of the survey zone. The number of skate sampled for total length, disc–width and weight was 43 (33% F). Disc width ranged from 8 to 44 cm for females and from 25 to 47 cm for males. The histogram exhibits a juvenile and an adult cohort. Females were juvenile (29%), adolescent, maturing (29%), adult, developing (7%), adult, mature (29%), and adult, resting (7%). Males were juvenile (4%), adolescent, maturing (15%), adult, developing (30%), adult, mature (15%), and adult, running (37%).

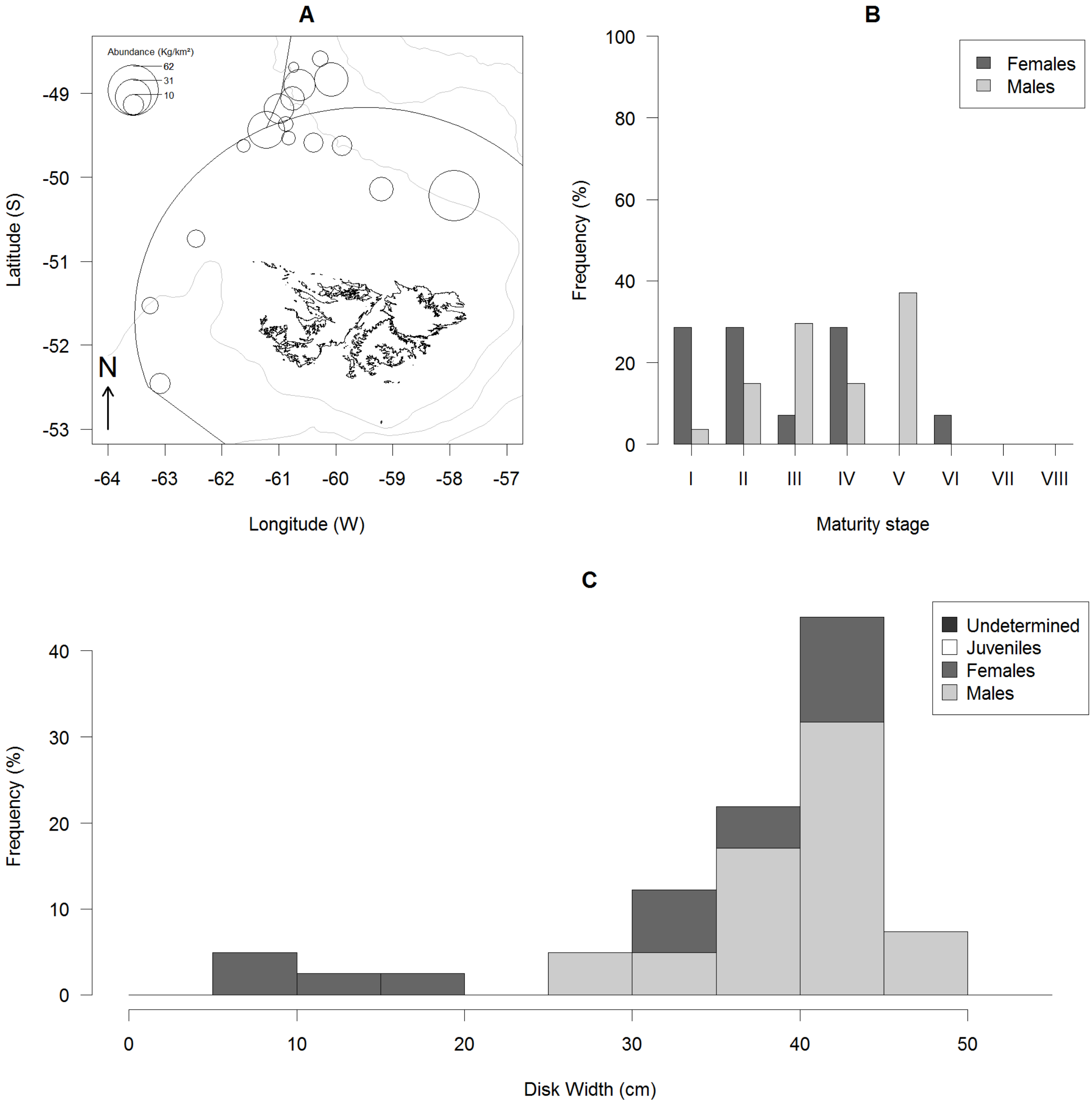

Figure 30: Biological data of *Bathyraja albomaculata* (white spotted skate, RAL), map of the densities in kg/km² (A), percentage of specimens of each sex per maturity stage (B; I juvenile; II, adolescent maturing; III, adult, developing; IV, adult, mature; V, adult laying/running; VI, adult resting) and length frequency (in percentage of the total sample assessed) of each sex with 5 cm size class (C; n=43).

3.4.7 *Bathyraja scaphiops* – cuphead skate – RSC

The total catch of cuphead skate was 60.7 kg. It was caught at 13 out of the 90 trawl stations sampled throughout the research cruise (Figure 31). Catches ranged from 1.58 to 8.5 kg. Densities ranged from 7.5 to 54.1 kg·km^{-2}. (CPUE ranged 1.5–8.5 kg·h^{-1}). Highest densities were observed in the north-eastern part of the survey zone. The number of skate sampled for total length, disc–width and weight was 25 (48% F). Disc width ranged from 28 to 57 cm for females and from 9 to 51 cm for males. The histogram exhibits primarily an adult cohort. Females were observed juvenile (0%), adolescent, maturing (33%), adult, developing (17%), adult, mature (42%), and adult, resting (8%). Males were juvenile (8%), adolescent, maturing (8%), adult, developing (8%), adult, mature (15%), and adult, running (62%).

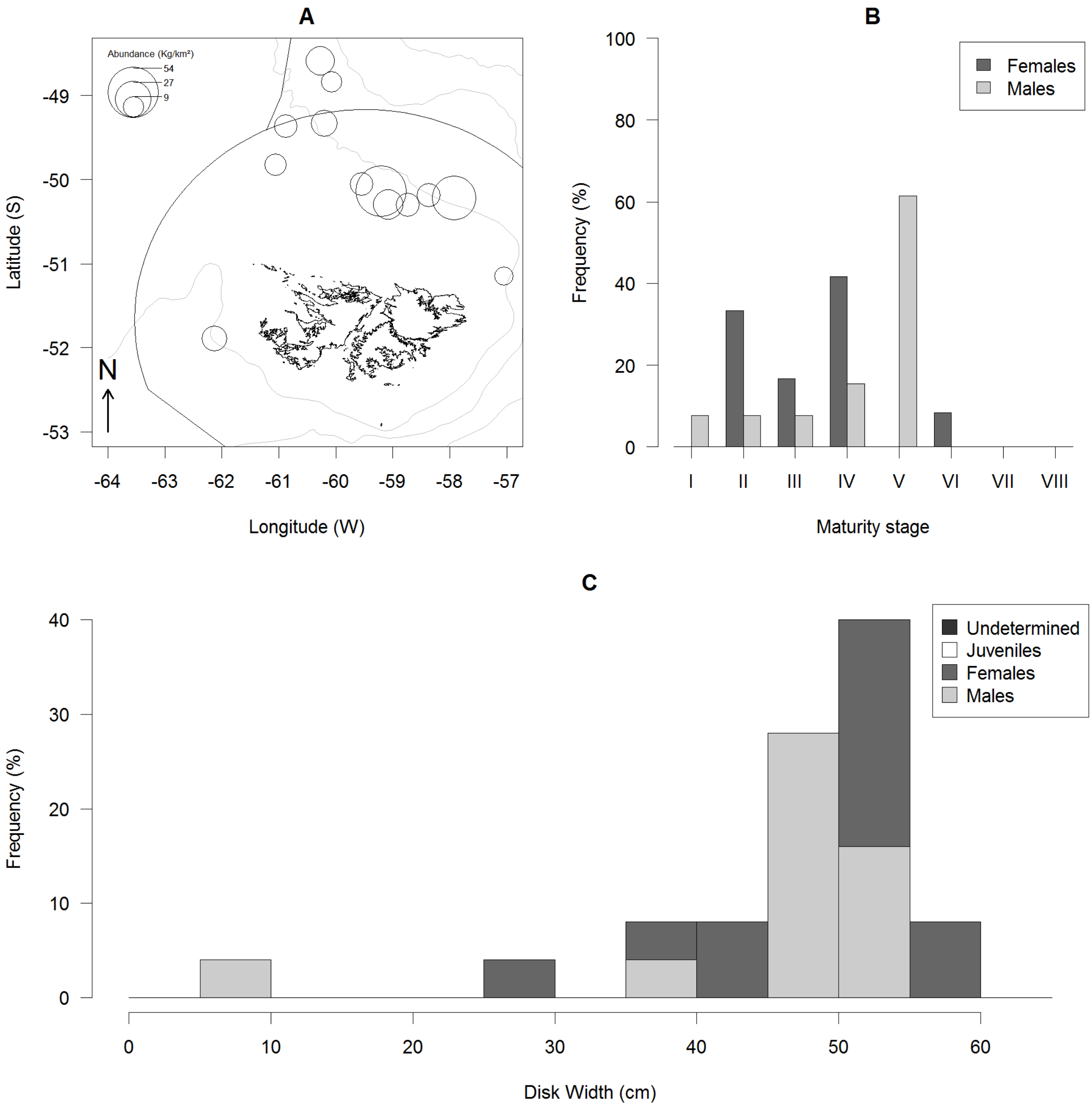

Figure 31: Biological data of *Bathyraja scaphiops* (cuphead skate, RSC), map of the densities in kg/km² (A), percentage of specimens of each sex per maturity stage (B; I juvenile; II, adolescent maturing; III, adult, developing; IV, adult, mature; V, adult laying/running; VI, adult resting) and length frequency (in percentage of the total sample assessed) of each sex with 5 cm size class (C; n=25).

3.4.8 *Bathyraja multispinis* – multispined skate – RMU

The total catch of multispined skate was 42.4 kg. It was caught at 3 out of the 90 trawl stations sampled through the research cruise (Figure 32). Catches ranged from 1.4 to 31.9kg. Of the 3 stations, 1 yielded >10 kg. Densities ranged from 6.7 to 151.2 kg·km^{-2}. (CPUE ranged 1.4–31.9 kg·h^{-1}). Highest densities were observed in the NE part of the survey zone. The number of skate sampled for total length, disc–width and weight was 7 (29% F), 6 of which were sampled for vertebrae and thorns. Disc width ranged from 42 to 87 cm for females and from 44 to 78 cm for males. Females were observed juvenile (50%), and adult, developing (50%). Males were adolescent, maturing (40%) and adult, running (60%).

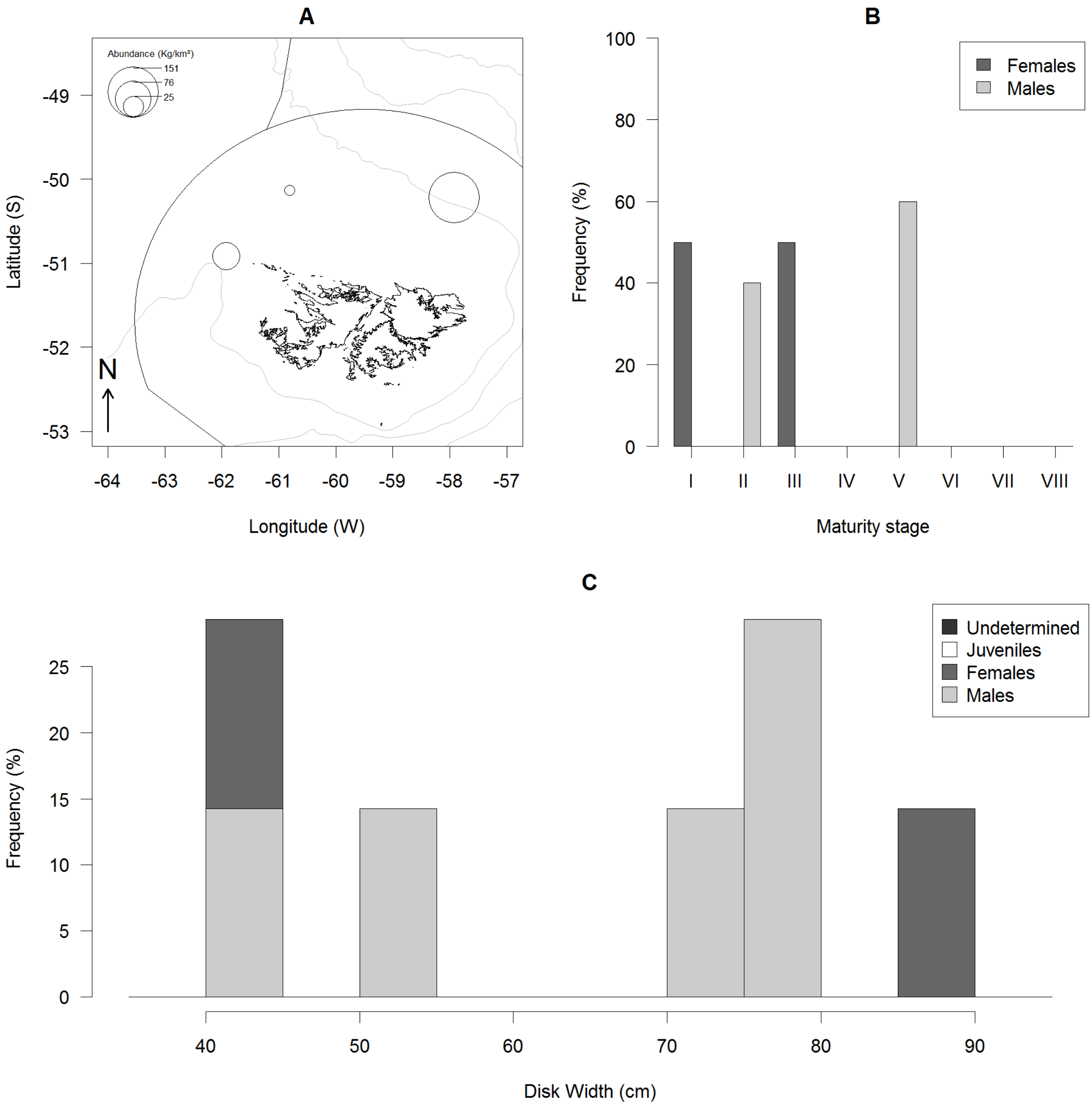

Figure 32: Biological data of *Bathyraja multispinis* (multispined skate, RMU), map of the densities in kg/km² (A), percentage of specimens of each sex per maturity stage (B; I juvenile; II, adolescent maturing; III, adult, developing; IV, adult, mature; V, adult laying/running; VI, adult resting) and length frequency (in percentage of the total sample assessed) of each sex with 5 cm size class (C; n=7).

3.4.9 *Dipturus trachydermus* – Roughskin Skate –RTR

There was one catch of roughskin skate of 32.2 kg. It was caught at 1 out of the 90 trawl stations sampled through the research cruise (Figure 33). Density was 156.8 kg·km^{-2}, and the CPUE was 32.2 kg·h^{-1}). The single adolescent female specimen was taken back to Stanley for detailed analyses.

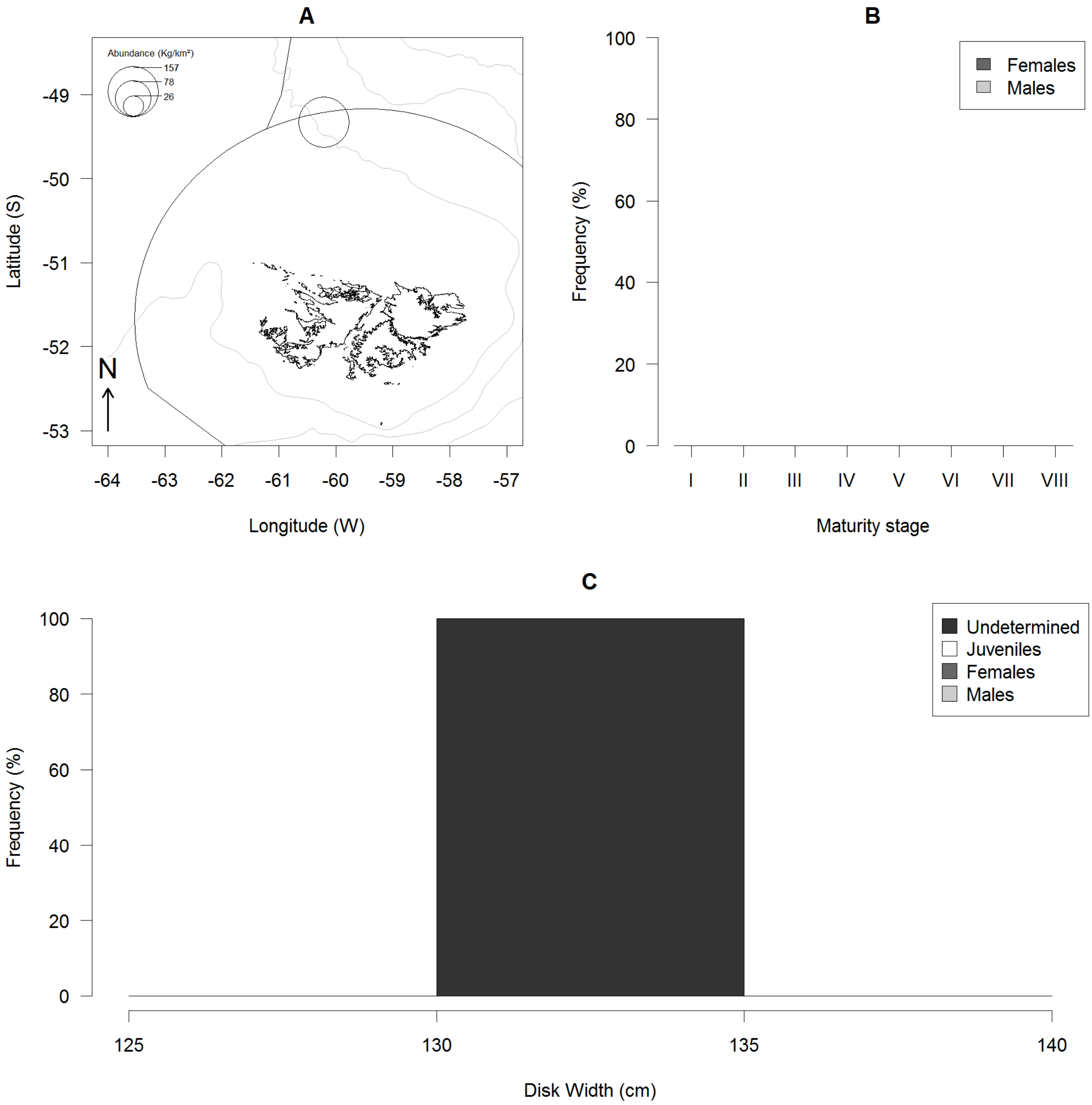

Figure 33: Biological data of *Bathyraja trachydermus* (Roughskin skate, RTR), map of the densities in kg/km² (A), percentage of specimens of each sex per maturity stage (B; I juvenile; II, adolescent maturing; III, adult, developing; IV, adult, mature; V, adult laying/running; VI, adult resting) and length frequency (in percentage of the total sample assessed) of each sex with 5 cm size class (C; n=1).

3.4.10 *Bathyraja magellanica* – Magellanic skate – RMG

The total catch of Magellanic skate was 17.8 kg. It was caught at 4 out of the 90 trawl stations sampled through the research cruise (Figure 34). Catches ranged from 1.7 to 6.9kg. Densities ranged from 7.5 to 38.1 kg·km^{-2}. (CPUE ranged 1.7-6.9 kg·h^{-1}). All catches occurred in the NE of the survey zone in shallower depths. The number of skate sampled for total length, disc–width and weight was 35 (49% F). Disc width ranged from 13 to 40 cm for females and from 10 to 40 cm for males. The histogram exhibits 2 cohorts with modes at 15-19 cm size class, and the 35-39 cm size class. Females were observed juvenile (29%), adolescent, maturing (35%), adult, developing (6%), adult, mature (18%), and adult, resting (12%). Males were juvenile (61%), adolescent, maturing (6%), adult, developing (6%), adult, mature (17%), and adult, running (11%).

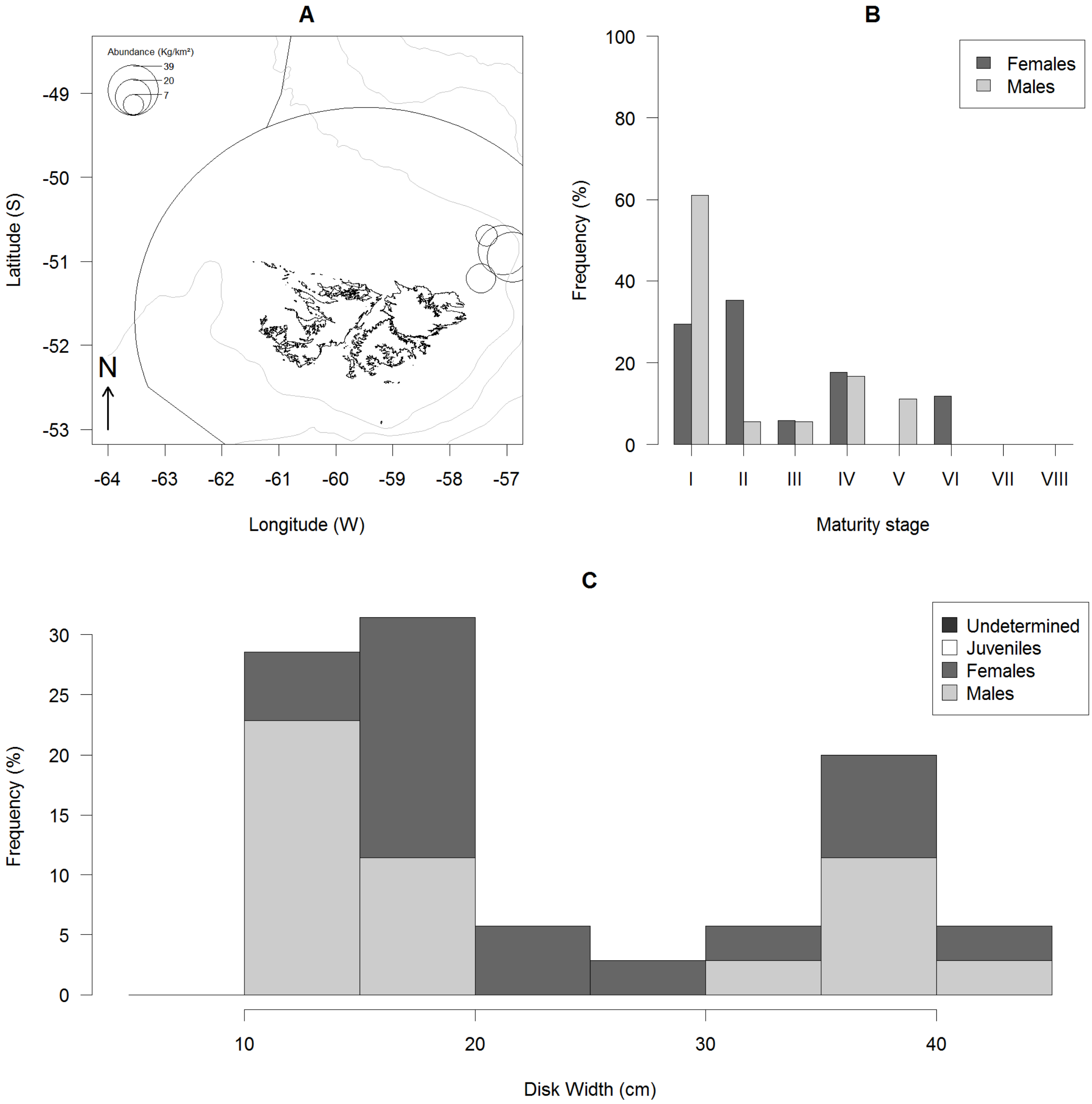

Figure 34: Biological data of *Bathyraja magellanica* (Magellanic skate, RMG), map of the densities in kg/km² (A), percentage of specimens of each sex per maturity stage (B; I juvenile; II, adolescent maturing; III, adult, developing; IV, adult, mature; V, adult laying/running; VI, adult resting) and length frequency (in percentage of the total sample assessed) of each sex with 5 cm size class (C; n=35).

3.4.11 *Pasmmobatis spp*. – Sandray Unidentified – RPX

The total catch of sandrays was 13.7 kg. It was caught at 23 out of the 90 trawl stations sampled through the research cruise (Figure 35). Catches ranged from 0.008 to 2.2 kg. Densities ranged from 0.04 to 10.9 kg·km^{-2}. (CPUE ranged 0.008–2.2 kg·h^{-1}). The number of skate sampled for total length, disc–width and weight was 38 (55% F). Disc width ranged from 5 to 28 cm for females and from 6 to 29 cm for males. Females were observed juvenile (48%), adolescent, maturing (10%), adult, developing (14%), adult, mature (10%), adult, laying (5%) and adult, resting (14%). Males were juvenile (24%), adolescent, maturing (6%), adult, developing (12%), adult, mature (24%), and adult, running (35%).

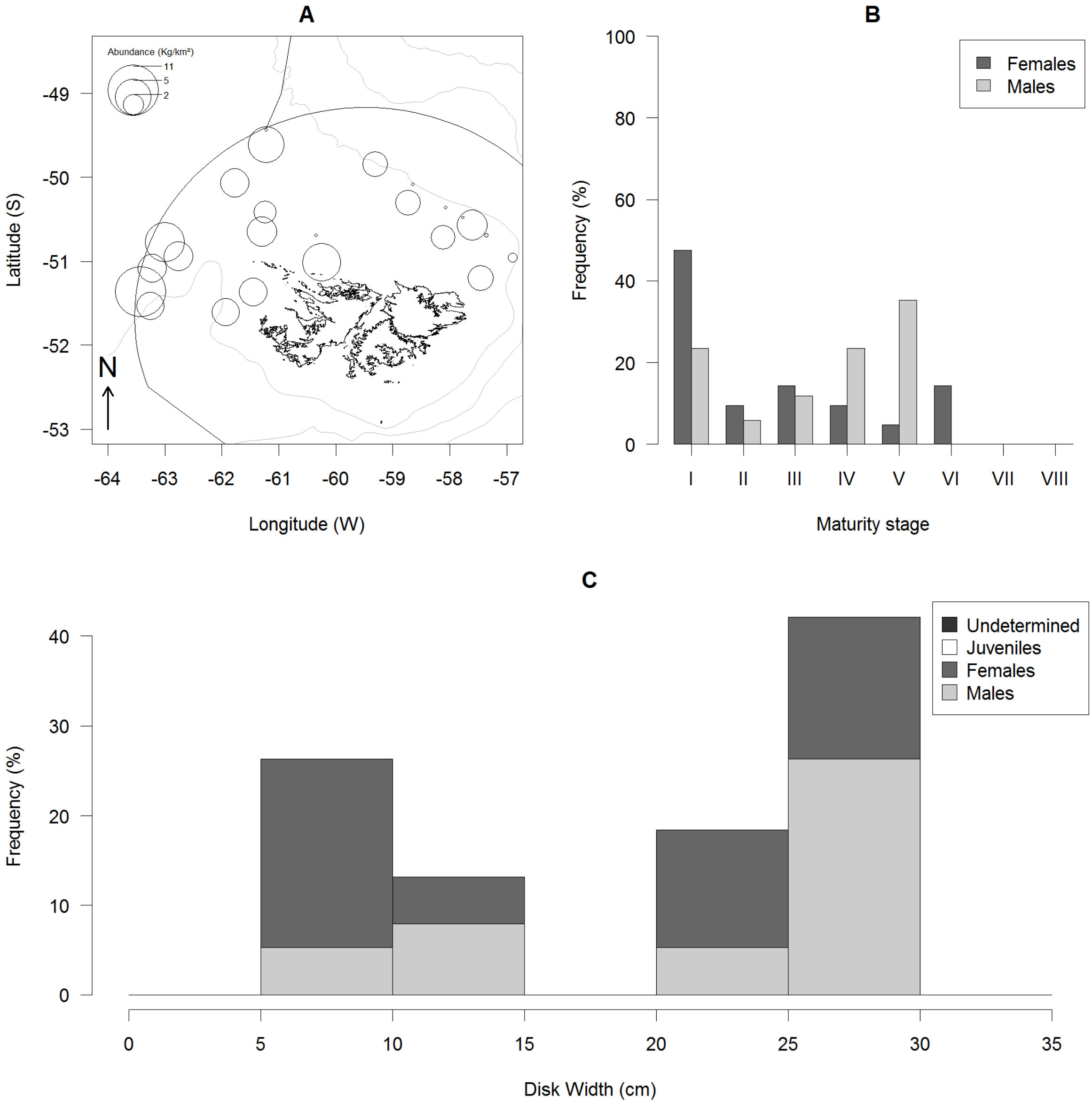

Figure 35: Biological data of *Psammobatis spp*. (Sandray Unidentified, RPX), map of the densities in kg/km² (A), percentage of specimens of each sex per maturity stage (B; I juvenile; II, adolescent maturing; III, adult, developing; IV, adult, mature; V, adult laying/running; VI, adult resting) and length frequency (in percentage of the total sample assessed) of each sex with 5 cm size class (C; n=38).

3.4.12 *Amblyraja doellojuradoi* – Starry Skate – RDO

The total catch of starry skate was 3.0 kg. It was caught at 5 out of the 90 trawl stations sampled through the research cruise (Figure 36). Catches ranged from 0.01 to 1.31 kg. Densities ranged from 0.03 to 5.9 kg·km^{-2}. (CPUE ranged 0.005–1.31 kg·h^{-1}). Highest densities were observed in the northern part of the survey zone in deeper waters. The number of skate sampled for total length, disc–width and weight was 5 (2 F, 3 M). Disc width ranged from 7 to 23 cm for females and from 7 to 40 cm for males. Females were juvenile (50%), and adolescent, maturing (50%). Males were juvenile (33%), and adult, mature (67%).

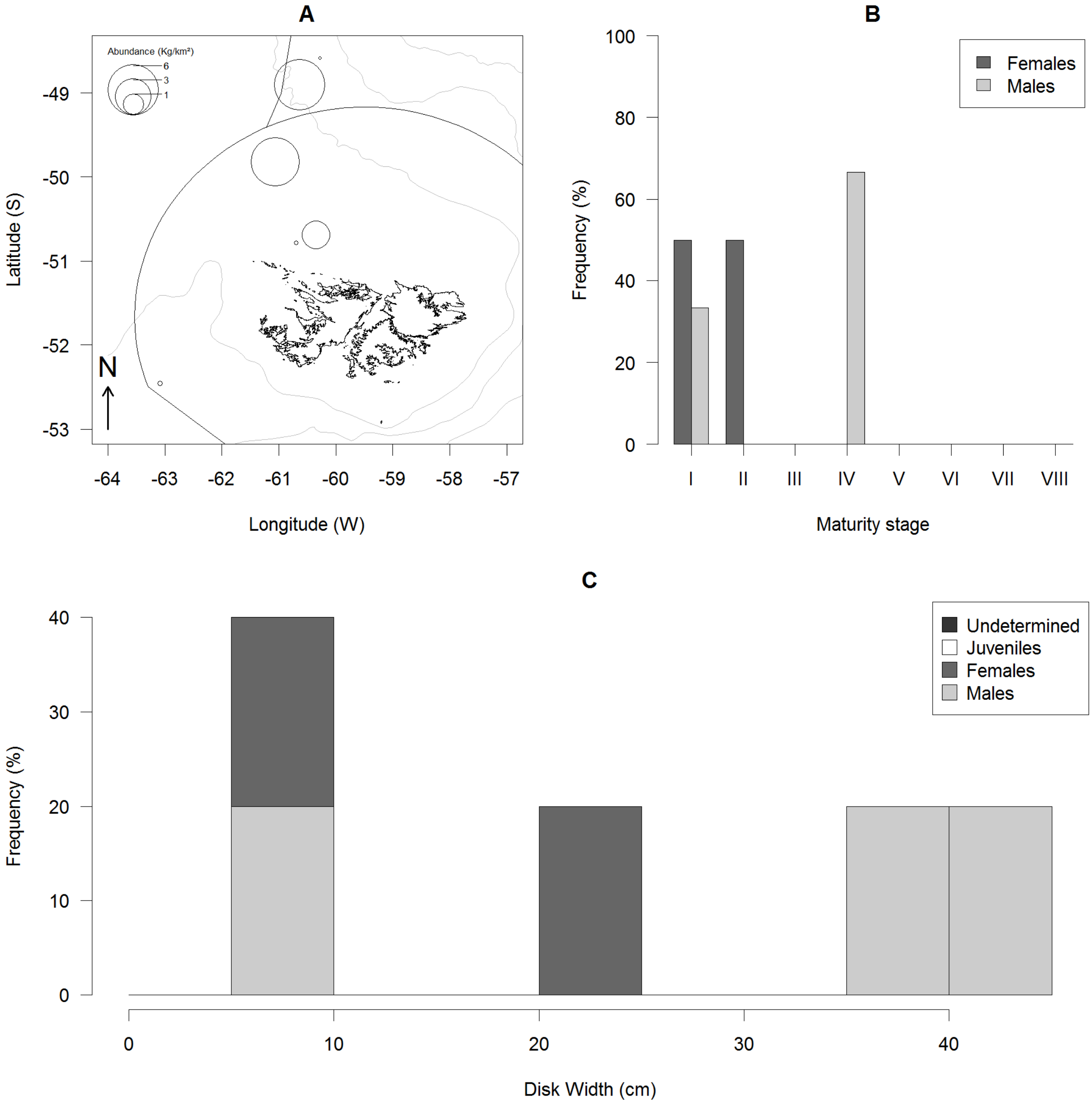

Figure 36: Biological data of *Amblyraja doellojuradoi* (Starry skate, RDO), map of the densities in kg/km² (A), percentage of specimens of each sex per maturity stage (B; I juvenile; II, adolescent maturing; III, adult, developing; IV, adult, mature; V, adult laying/running; VI, adult resting) and length frequency (in percentage of the total sample assessed) of each sex with 5 cm size class (C; n=5).

3.5 Biomass estimation and cohort analysis

3.5.1 Common rock cod

Common rock cod biomass was estimated using density–at–station ranging from 2 kg·km^{-2} to 7,044 kg·km^{-2}. Observed densities were Box–Cox transformed (λ=0.5) and the experimental variogram was plotted with 32 distance classes (Figure 37). The variogram model that best fitted the data was spherical with no nugget effect, a range of 43 km and reached the sill at 981. The average kriged density was 781 kg·km^{-2} and ranged from 4 kg·km^{-2} to 6.8 t·km^{-2}. Finally, the estimated total biomass on the survey zone was 83,342 t. Biomass of rock cod first increased from 2010 to 2011, from 653,039 t to 803,763 t but then decreased significantly to 254,692 t in 2014 (estimated in October). In 2015 and 2016 a non–significant decrease was observed to 195,713 t followed by a significant decrease in 2017 to reach 83,342 t. The estimated number of rock cod in the water also decreased over the period but to a lesser extent. Through the years, the stock consisted of smaller animals as shown in Figure 38 (2014 was not included in this sequence as biomass was estimated in spring).

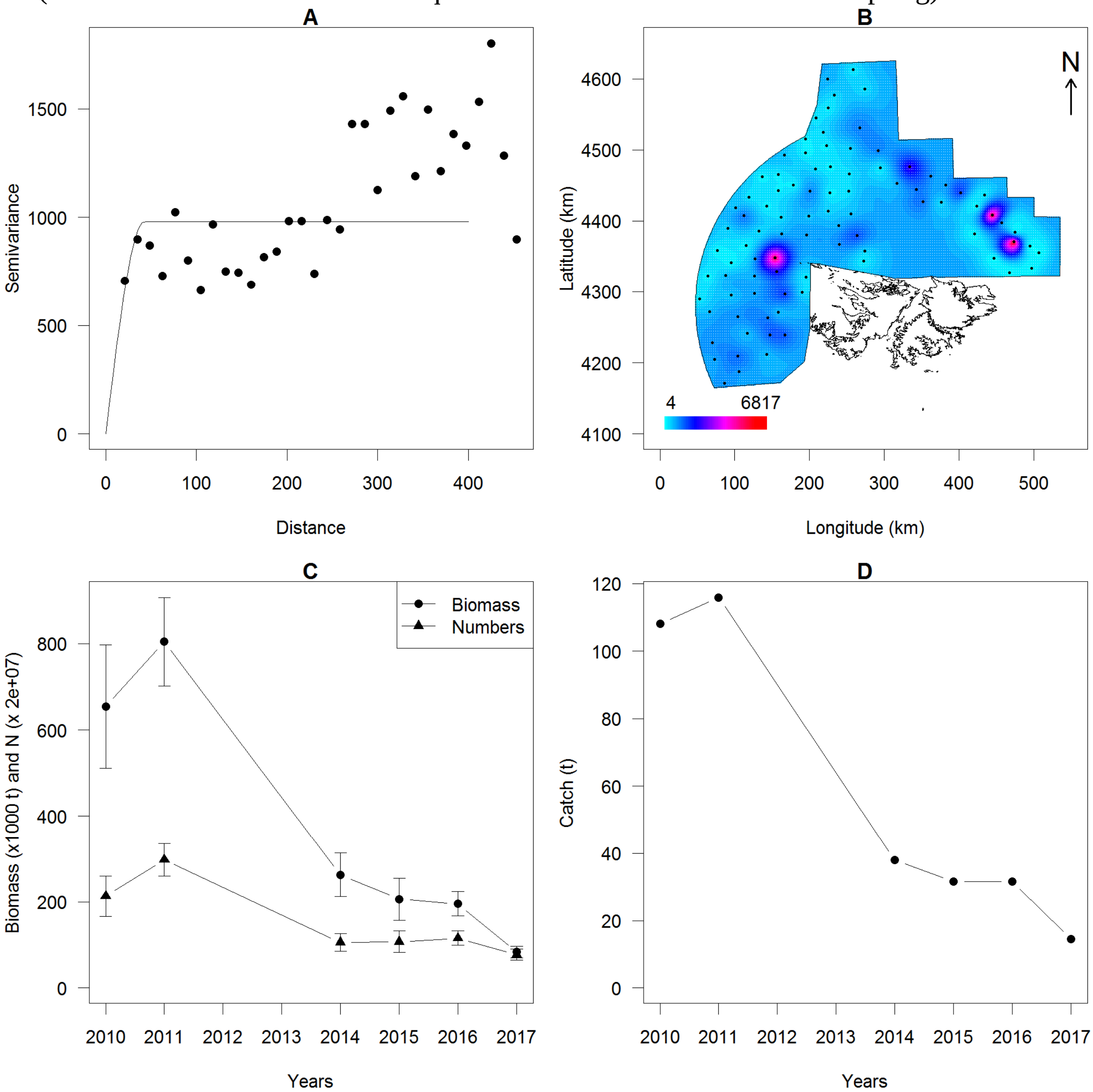

Figure 37: Experimental variogram with spherical model fitted (A), kriged map of common rock cod density (B), time series of estimated biomass and numbers of fish (with associated 95% confidence intervals) using the ground fish survey conducted from 2010 (C) and total catch of each survey (D). Biomass and abundance estimation in 2014 were carried in October–November and are not directly comparable to other years.

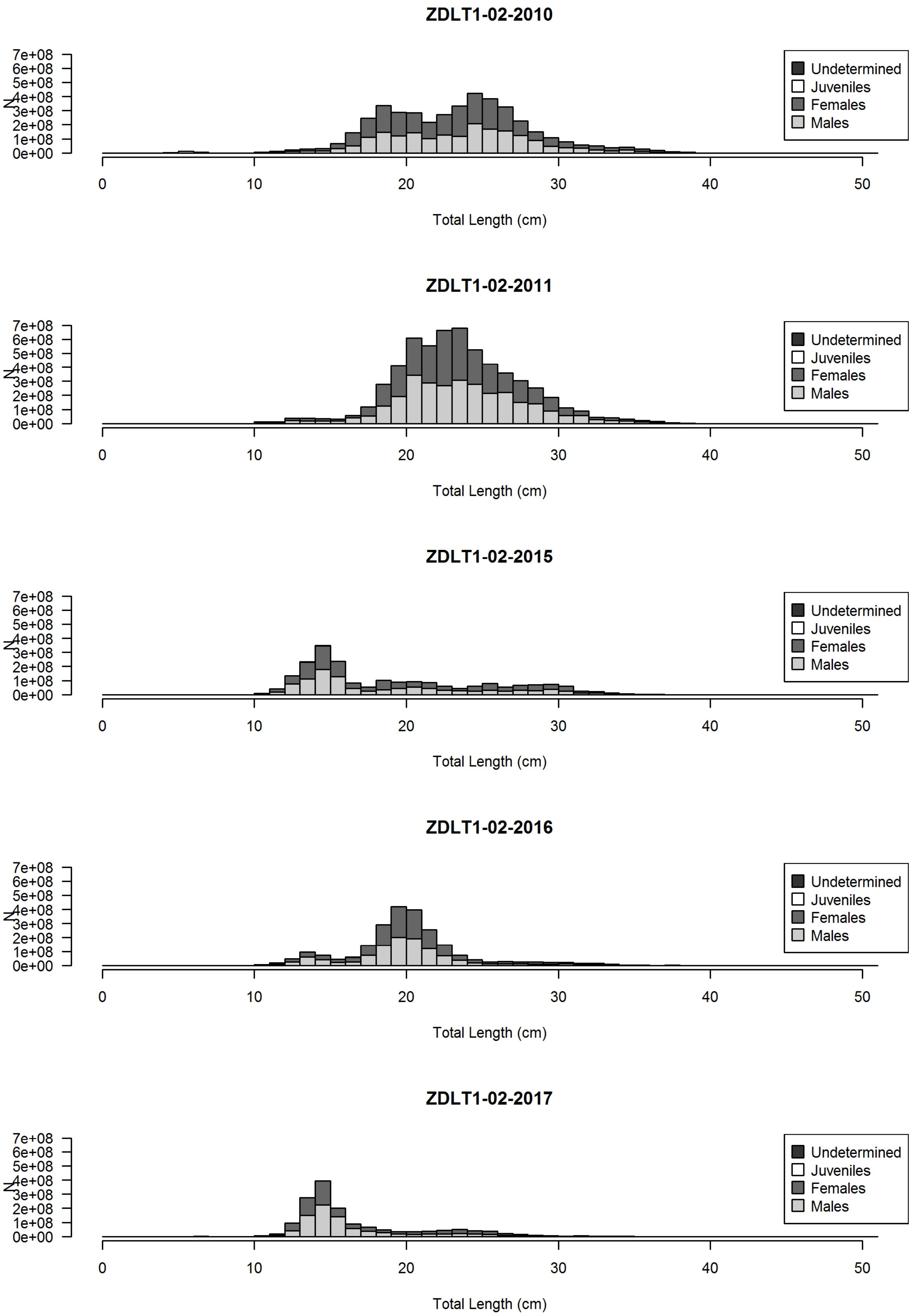

Figure 38: Length frequency histograms of common rock cod extrapolated to the estimated total biomass for years 2010–2011 and 2015–2017.

3.5.2 Red cod

Red cod observed densities ranged from 0.2 kg·km^{-2} to 22.3 t·km^{-2}. These densities were Box–Cox transformed and used to plot the semi–variogram using 30 distance classes (Figure 39). The best variogram model was spherical and reached the sill (1,799) at a range of 52 km. The average kriged density was 589 kg·km^{-2} and the biomass estimation was 62,803 t. Most of the fish was caught to the west of the Jason Islands along the border of the FICZ. Another station to the north of the Jason Islands exhibited higher densities too but to a lesser extent. From 2010 to 2016, red cod biomass varied but was not significantly different between years. However, in 2017, a significant decrease in biomass was observed. The variation of abundance followed the variation of biomass except in 2015–2016 when a non–significant decrease of biomass occurred along with a non–significant increase in abundance. The length frequency actually shows an increasing number of fish below 40 cm for these two years (Figure 40)

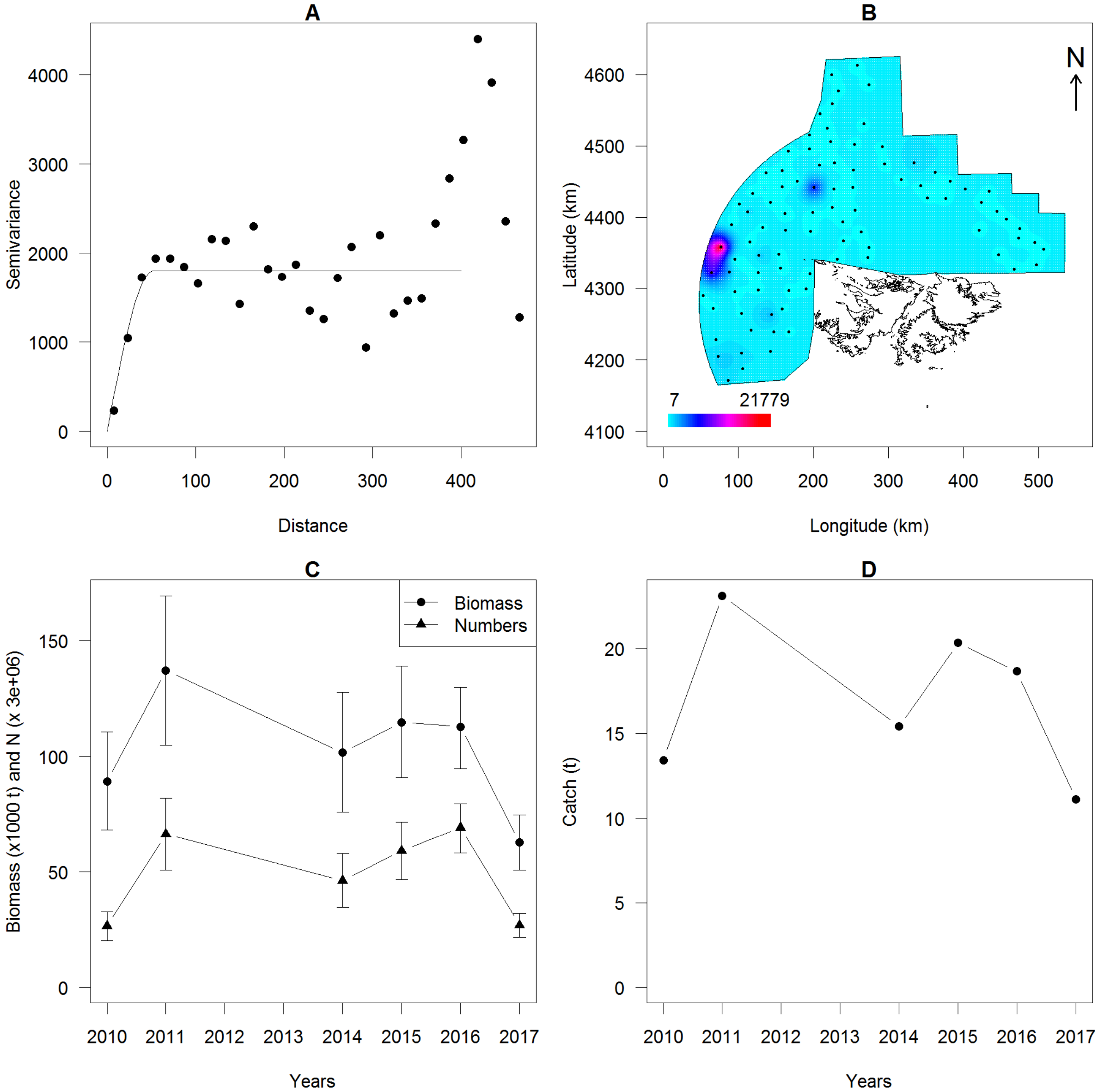

Figure 39: Experimental variogram with spherical model fitted (A), kriged map of red cod density (B), time series of estimated biomass and numbers of fish (with associated 95% confidence intervals) using the ground fish survey conducted from 2010 (C) and total catch of each survey (D). Biomass and abundance estimation in 2014 were carried in October–November and are not directly comparable to other years.

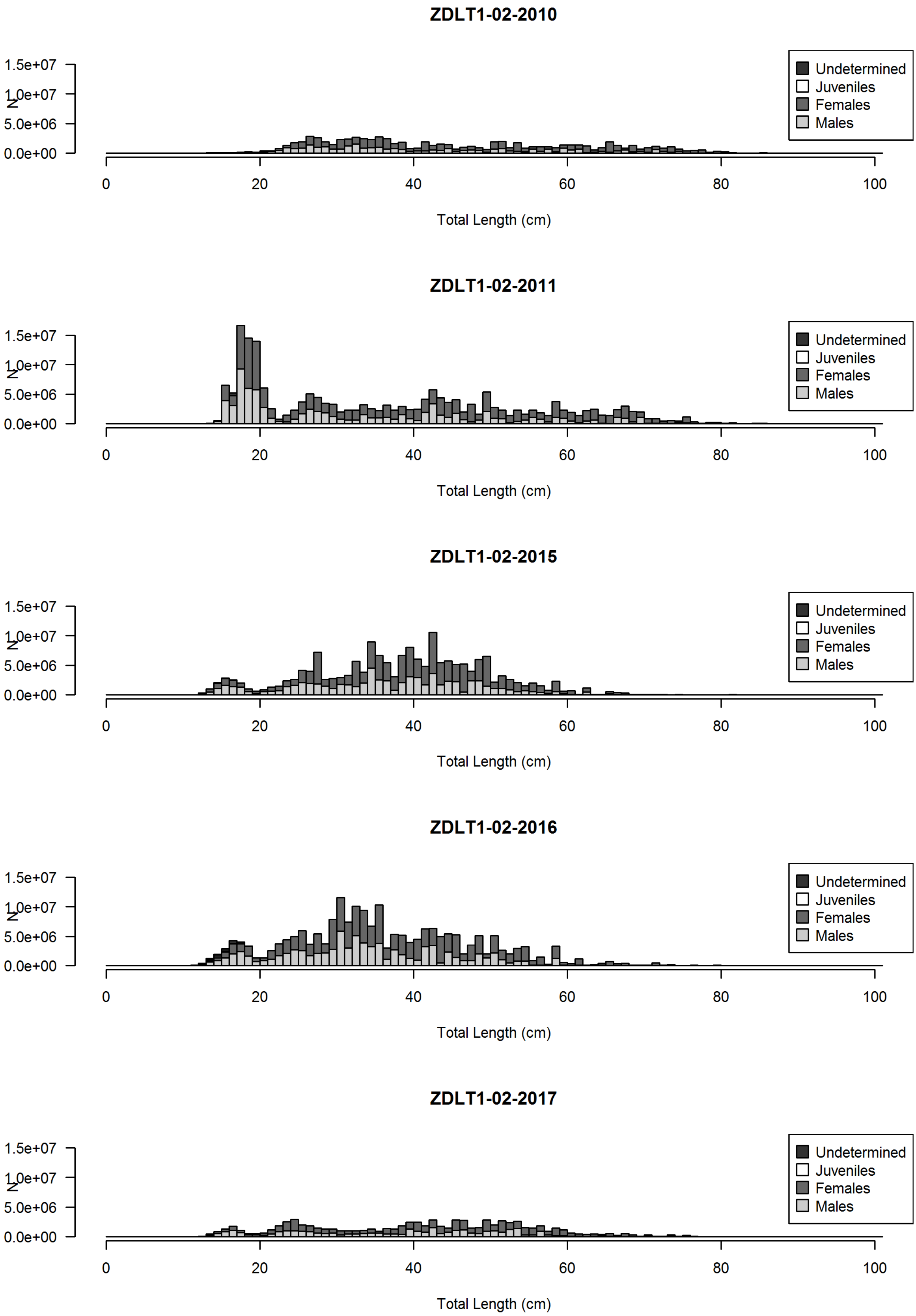

Figure 40: Length frequency histograms of red cod extrapolated to the estimated total biomass for years 2010–2011 and 2015–2017.

3.5.3 Southern blue whiting

Southern blue whiting was caught at a limited number of stations. The observed densities ranged from 0.01 kg·km^{-2} to 607 kg·km^{-2}. Observed densities were used to plot a semi–variogram after Box–Cox transformation (λ=0.5) and using 29 distance classes (Figure 41). The model that best fitted the data was the exponential model without any nugget effect. The variogram was fitted to a maximum distance of 200 km. The model reached the sill (35) at a range of 167 km. The kriged density ranged from 0 to 603 kg·km^{-2}, averaging 10.6 kg·km^{-2}. The biomass estimation was 1,128 t across the survey area. However, southern blue whiting was only caught in the southwest of the surveyed zone and rarely found in shallower waters (<200 m). Southern blue whiting biomass increased from 2010 to 2011 from 27,442 to 30,902 t. From 2014 to 2016 the biomass was significantly lower averaging 16,000 t before the significant decrease observed in 2017. The abundance did not follow the same trajectory as the biomass until 2016, first decreasing and then increasing and finally significantly decreasing. The length frequency histograms highlight a strong recruitment in 2015 leading to this significant increase in abundance (Figure 42).

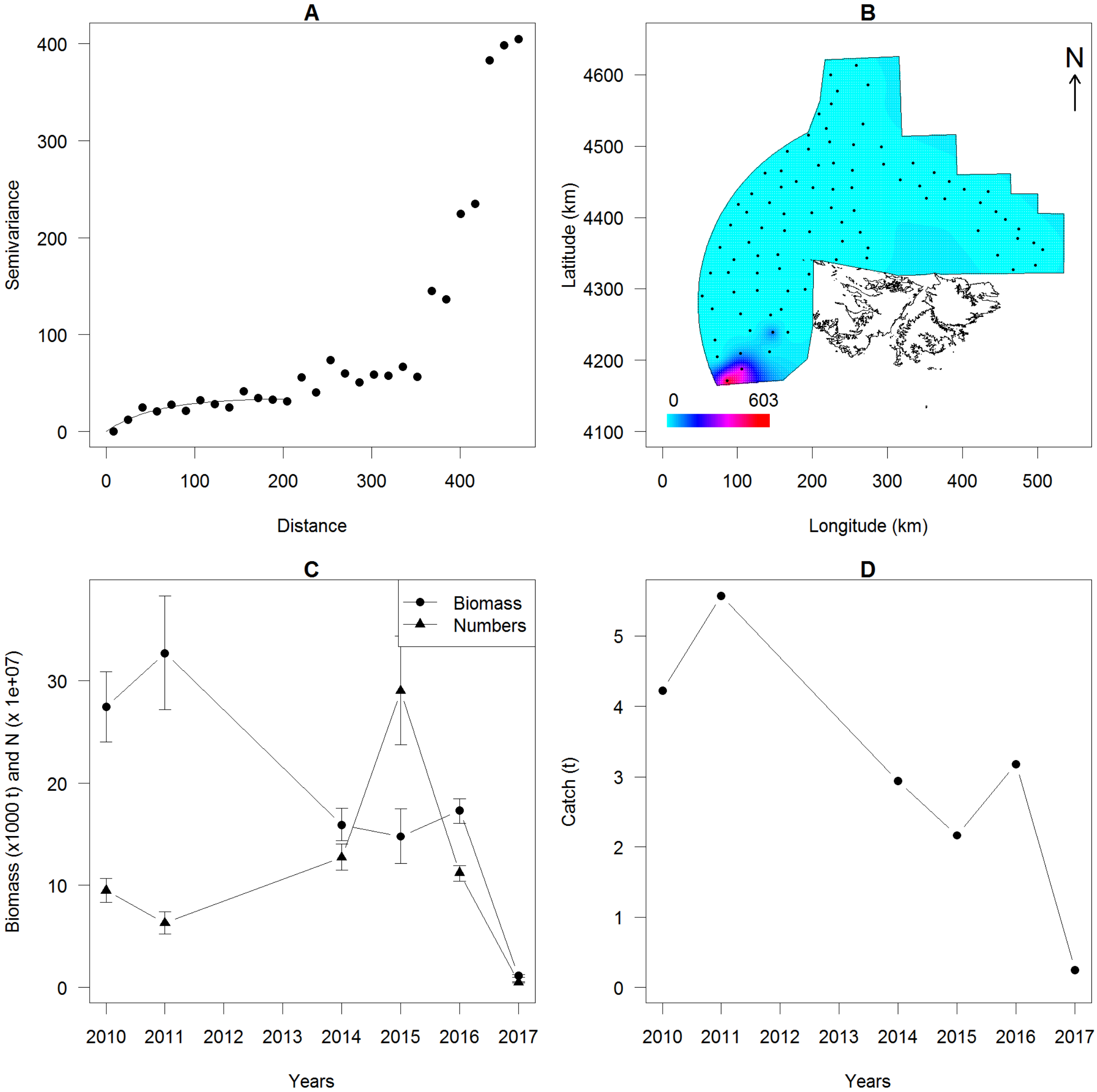

Figure 41: Experimental variogram with spherical model fitted (A), kriged map of southern blue whiting density (B), time series of estimated biomass and numbers of fish (with associated 95% confidence intervals) using the ground fish survey conducted from 2010 (C) and total catch of each survey (D). Biomass and abundance estimation in 2014 were carried in October–November and are not directly comparable to other years.

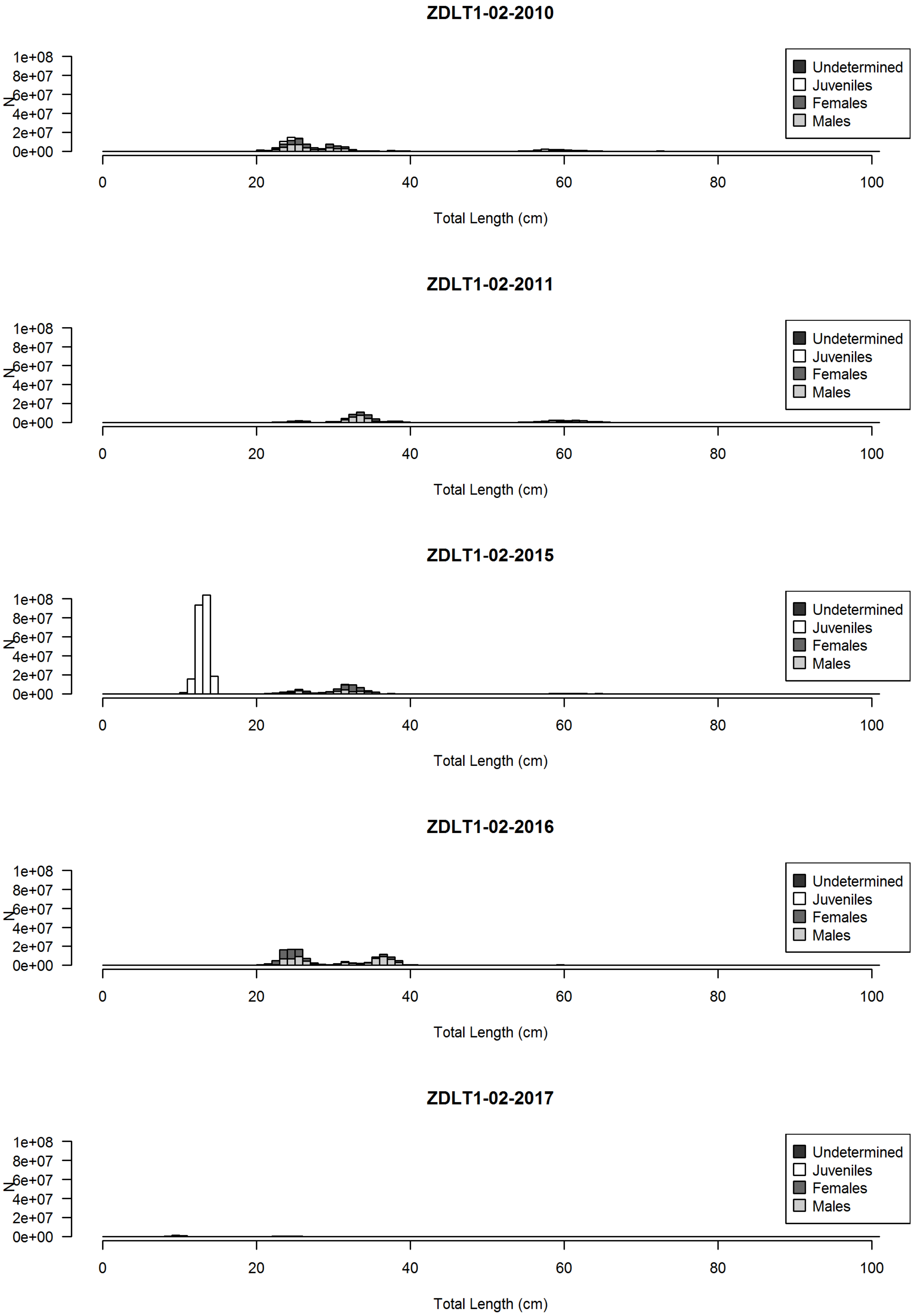

Figure 42: Length frequency histograms of southern blue whiting extrapolated to the estimated total biomass for years 2010–2011 and 2015–2017.

3.5.4 Hake

Hake was observed in higher densities in the northwest of the survey zone. It is generally where hake is abundant in Falkland waters. Observed densities ranged from 0.26 kg·km^{-2} to 1.3 t·km^{-2} and were Box–Cox transformed (λ=0.5). The semi–variogram was plotted with 38 distance classes and a spherical model with no nugget effect fitted to the observed values. The model reached the sill (434) at 238 km. Kriged densities ranged from 11 to 1,022 kg·km^{-2} and averaged 121 kg·km^{-2}. The estimated biomass was 7,487 t. Over the years that the ground fish surveys have been conducted, hake biomass in February increased from 7,477 t in 2010 () to 17,580 t in 2015 (). In 2016, the biomass decreased to 4,075 t and then increased again in 2017 7o 7,487 t. Even if hake is present when the February ground fish survey is conducted, it is not the ideal time to assess this species as this period precedes a period of migration from spawning to feeding grounds which is suspected to occur around April each year. The length frequency histograms show that the number of fish increased between 2010–2011 and 2015–2017. However fish were smaller. In 2016, the year of record catches in the fishery (after 1988), hake was as abundant as in 2010–2011 with a comparable modal size (Figure 44).

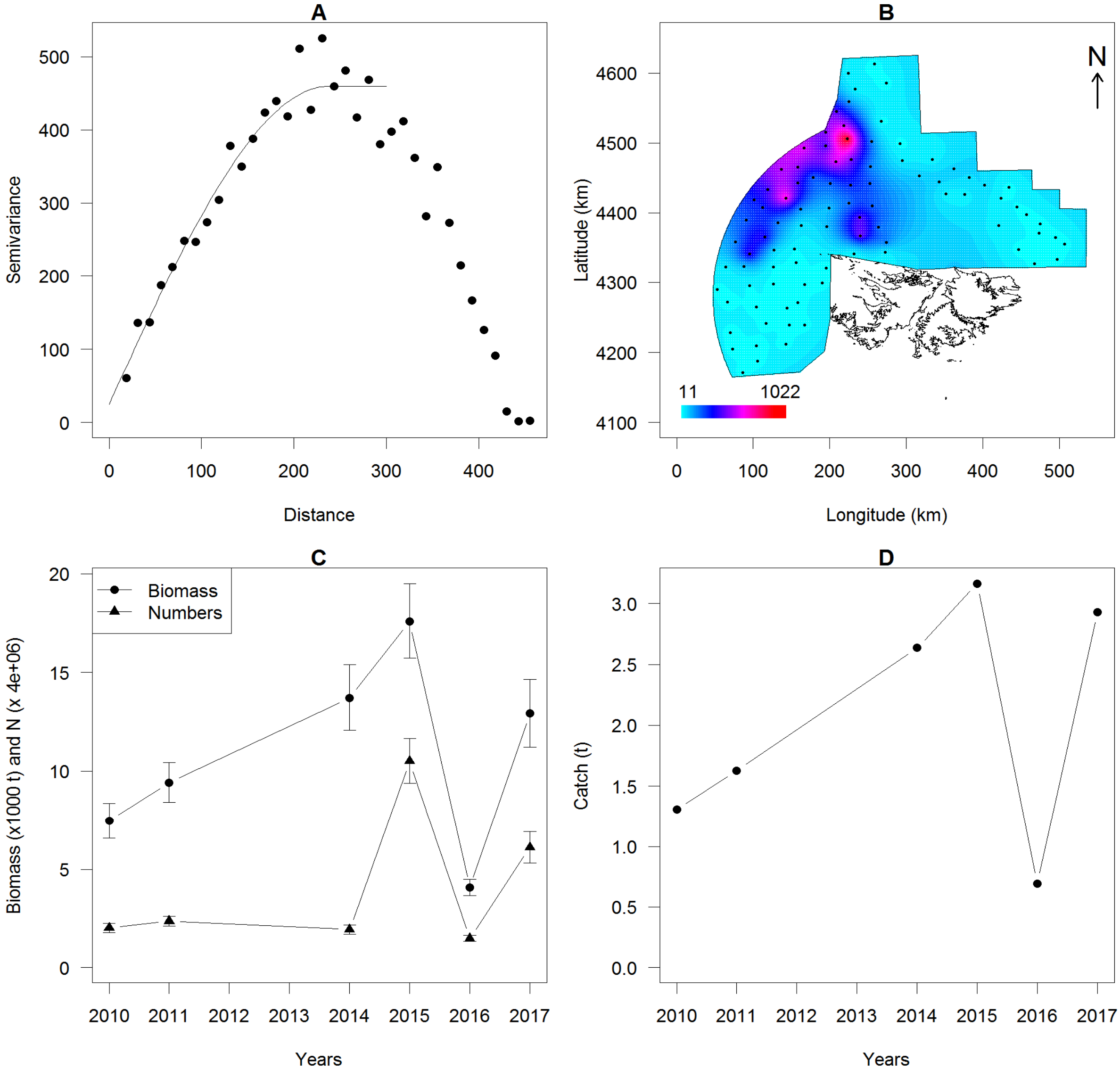

Figure 43: Experimental variogram with spherical model fitted (A), kriged map of red cod density (B), time series of estimated biomass and numbers of fish (with associated 95% confidence intervals) using the ground fish survey conducted from 2010 (C) and total catch of each survey (D). Biomass and abundance estimation in 2014 were carried in October–November and are not directly comparable to other years.

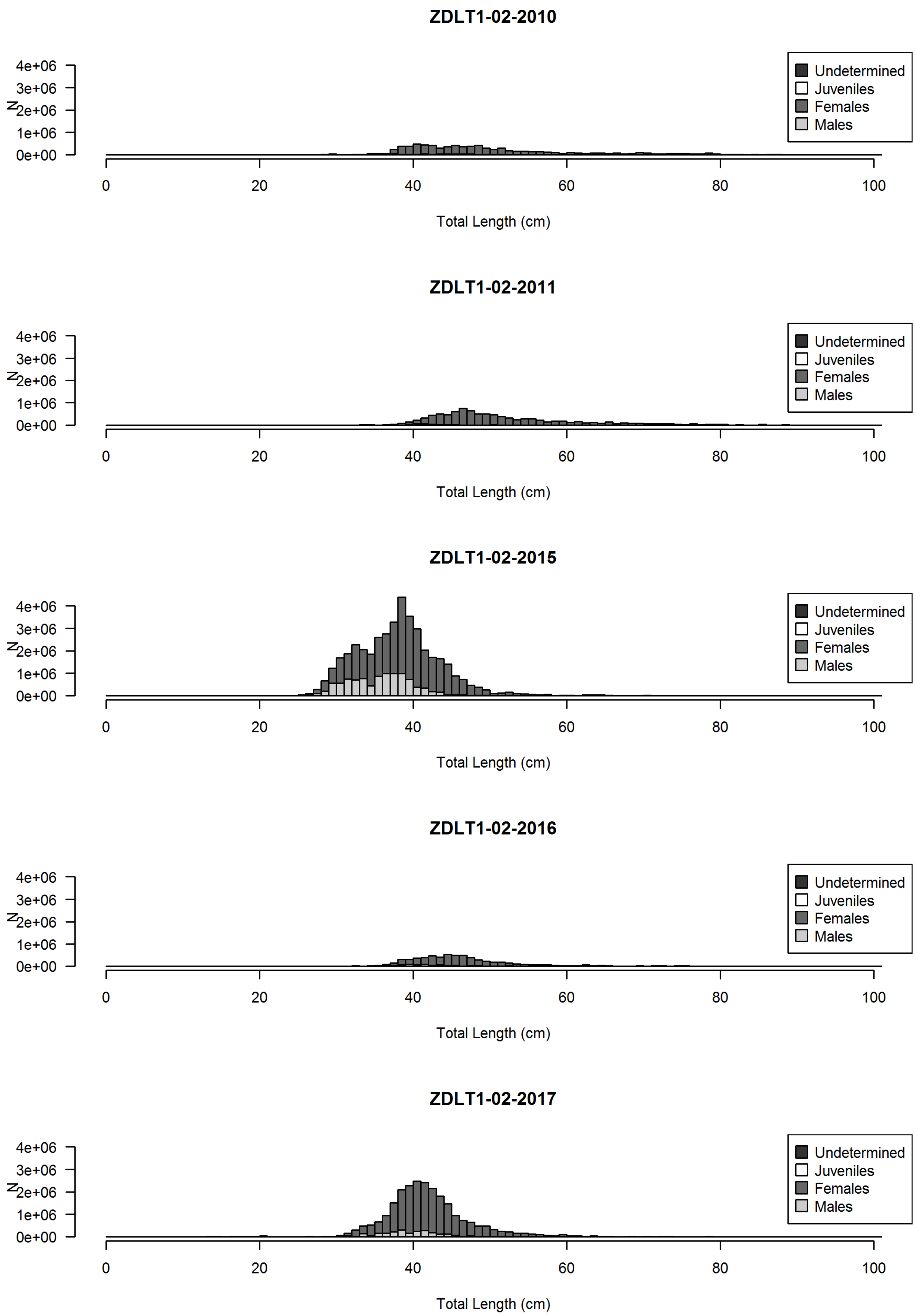

Figure 44: Length frequency histograms of common hake extrapolated to the estimated total biomass for years 2010–2011 and 2015–2017.

3.5.5 Argentine shortfin squid

Observed densities of Argentine short–finned squid ranged from 0.1 kg·km^{-2} to 1.7 t·km^{-2}. The semi–variogram was plotted with 31 distance classes and a spherical model with no nugget effect was fitted (Figure 45). It reached the sill (405) at 84 km. The averaged kriged density was 126.5 kg·km^{-2} ranging from 1 to 1,643 kg·km^{-2}. The total estimated biomass was 13,488 t. This year, two zones exhibited higher densities of short–finned squid, one to the northwest and one to the north of the Jason Islands. Over the years that the ground fish survey has been conducted, *Illex argentinus* biomass ranged from 21 to 13,488 t. The only exception was observed in 2015 when the biomass estimation was 217,371 t prior to the record catch taken in the fishery by jiggers and trawlers. The length frequency histograms reflect that record year (Figure 46). However, in 2015, the modal size was lower than in 2010, 2011 and 2017. In 2016, very low level but widespread catches were observed and the modal size was at 10 cm.

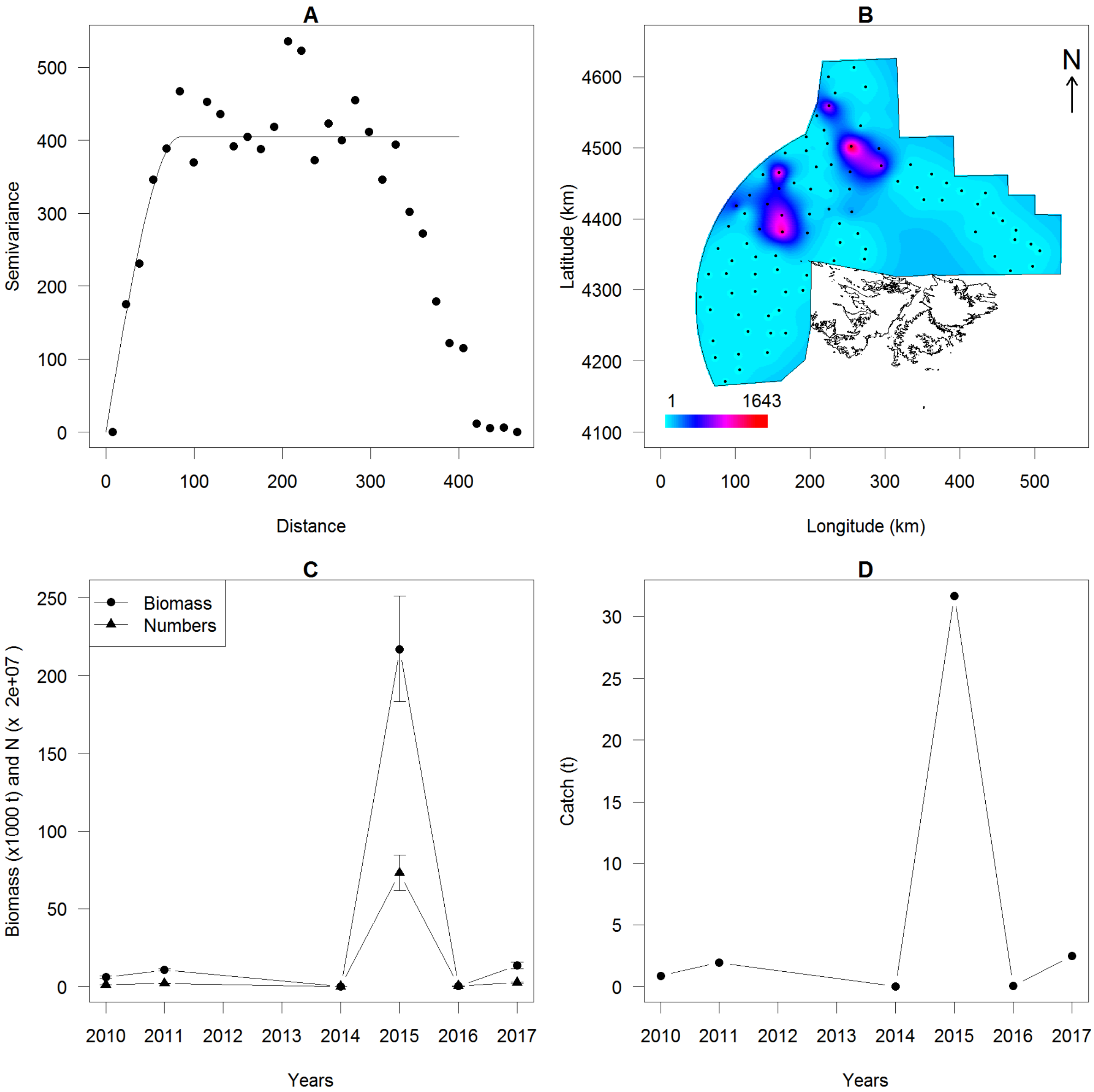

Figure 45: Experimental variogram with spherical model fitted (A), kriged map of common hake density (B) and time series of estimated biomass using the ground fish survey conducted from 2010.

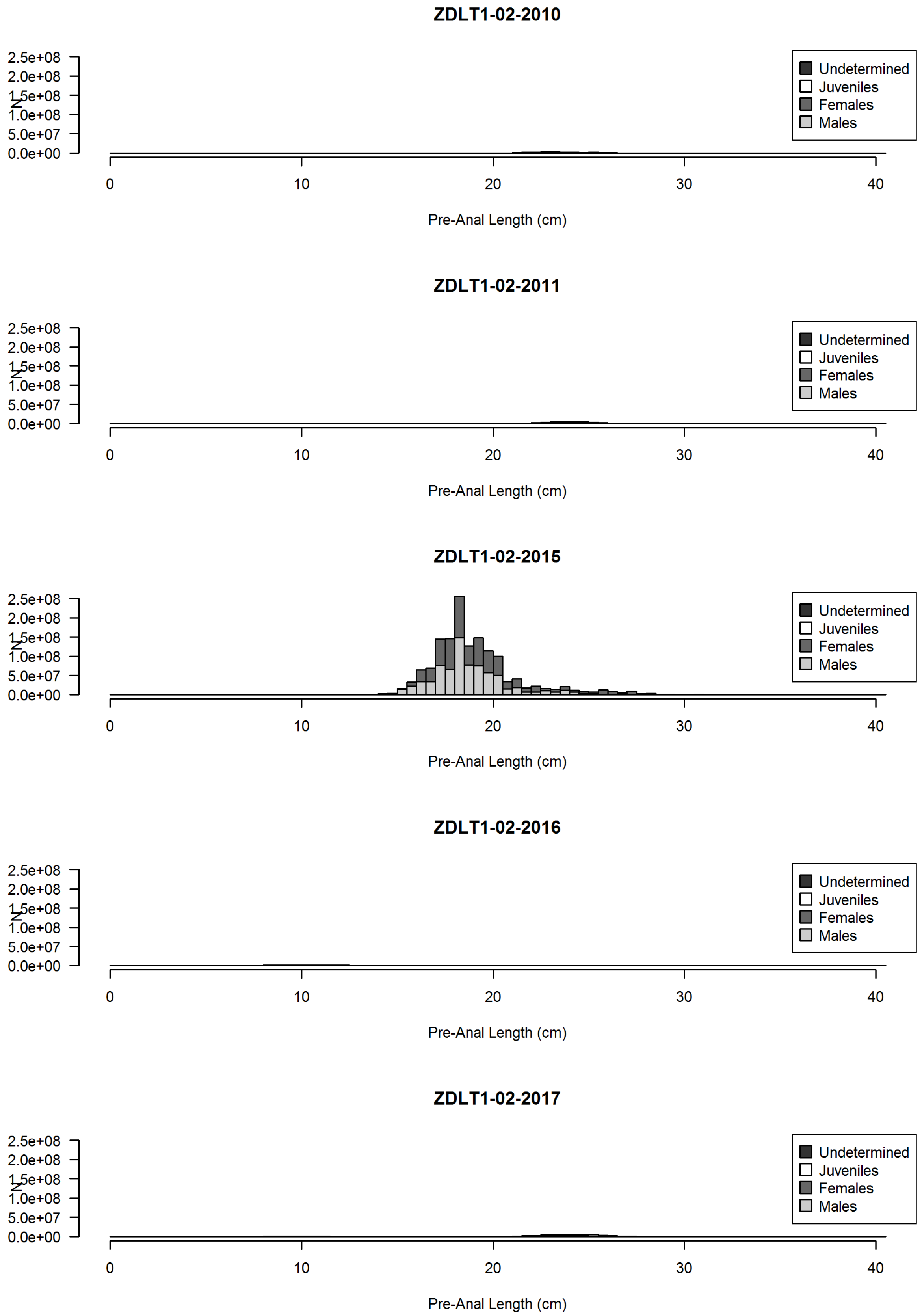

Figure 46: Length frequency histograms of Argentine short–finned squid extrapolated to the estimated total biomass for years 2010–2011 and 2015–2017.

3.5.6 Kingclip

Observed densities for kingclip ranged from 0.8–5,185 kg·km^{-2}. These densities were Box–Cox transformed (λ=0.5) and used to plot a semi–variogram with 27 distance classes. The best model that fitted the data was spherical with no nugget effect. The model reached the sill (508) at 51 km. The kriged densities ranged from 1 kg·km^{-2} to 5.2 t·km^{-2} and averaged 212 kg·km^{-2}. The biomass estimation was 22,648 t. Highest abundance was observed to the north of the Jason Islands in the north of the FICZ, close to the northwest of the FOCZ. Some other stations with higher abundances were observed in the western part of the FICZ, but the abundance was not as high. From a temporal perspective, kingclip abundance increased from 2010 to 2011. In 2015 the highest abundance of the series was observed (99990 t) and the abundances then decreased to the 2017 abundance. The abundance follows the same trajectory as the biomass throughout the time series.

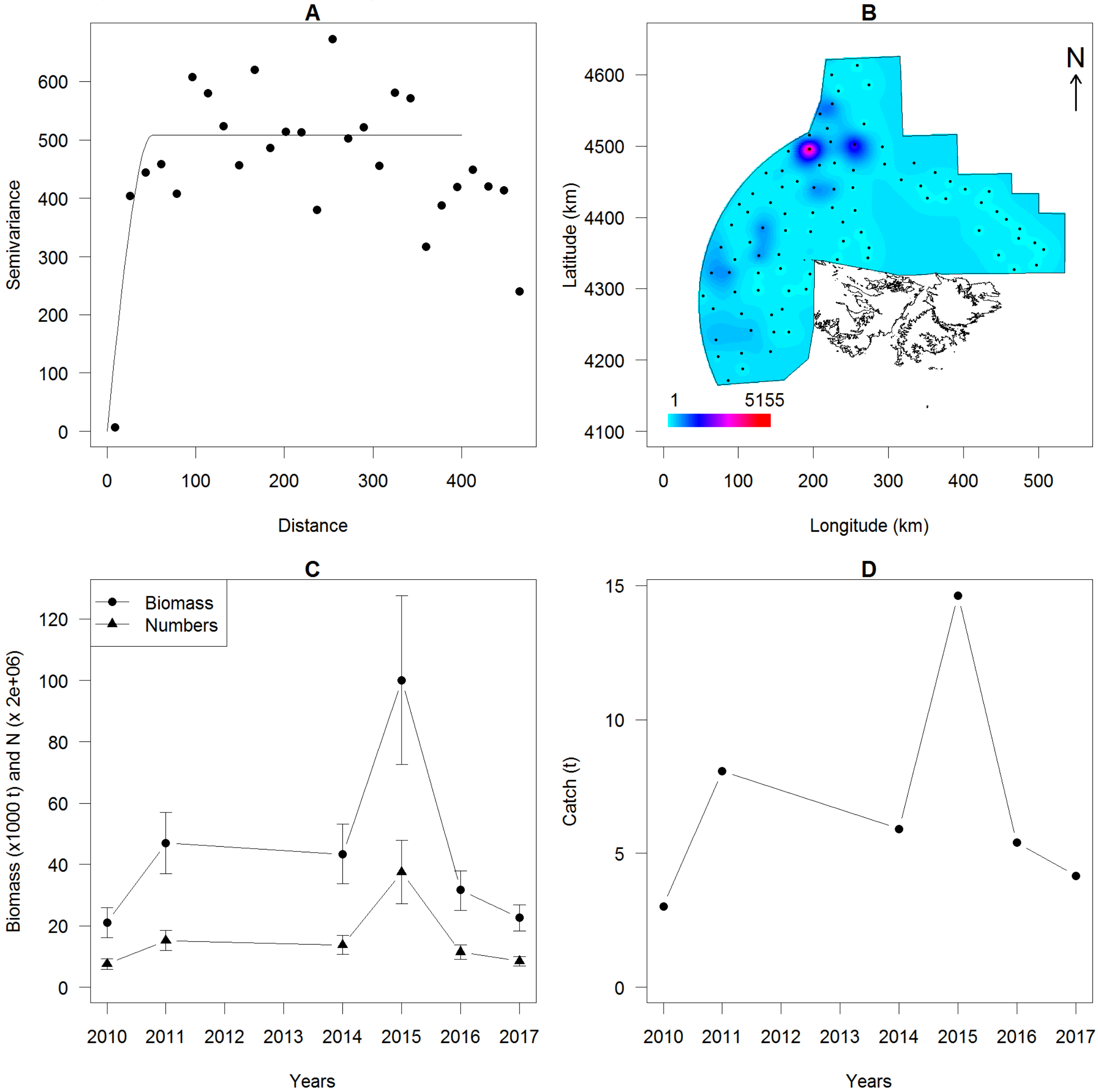

Figure 47: Experimental variogram with spherical model fitted (A), kriged map of kingclip density (B) and time series of estimated biomass using the ground fish survey conducted from 2010.

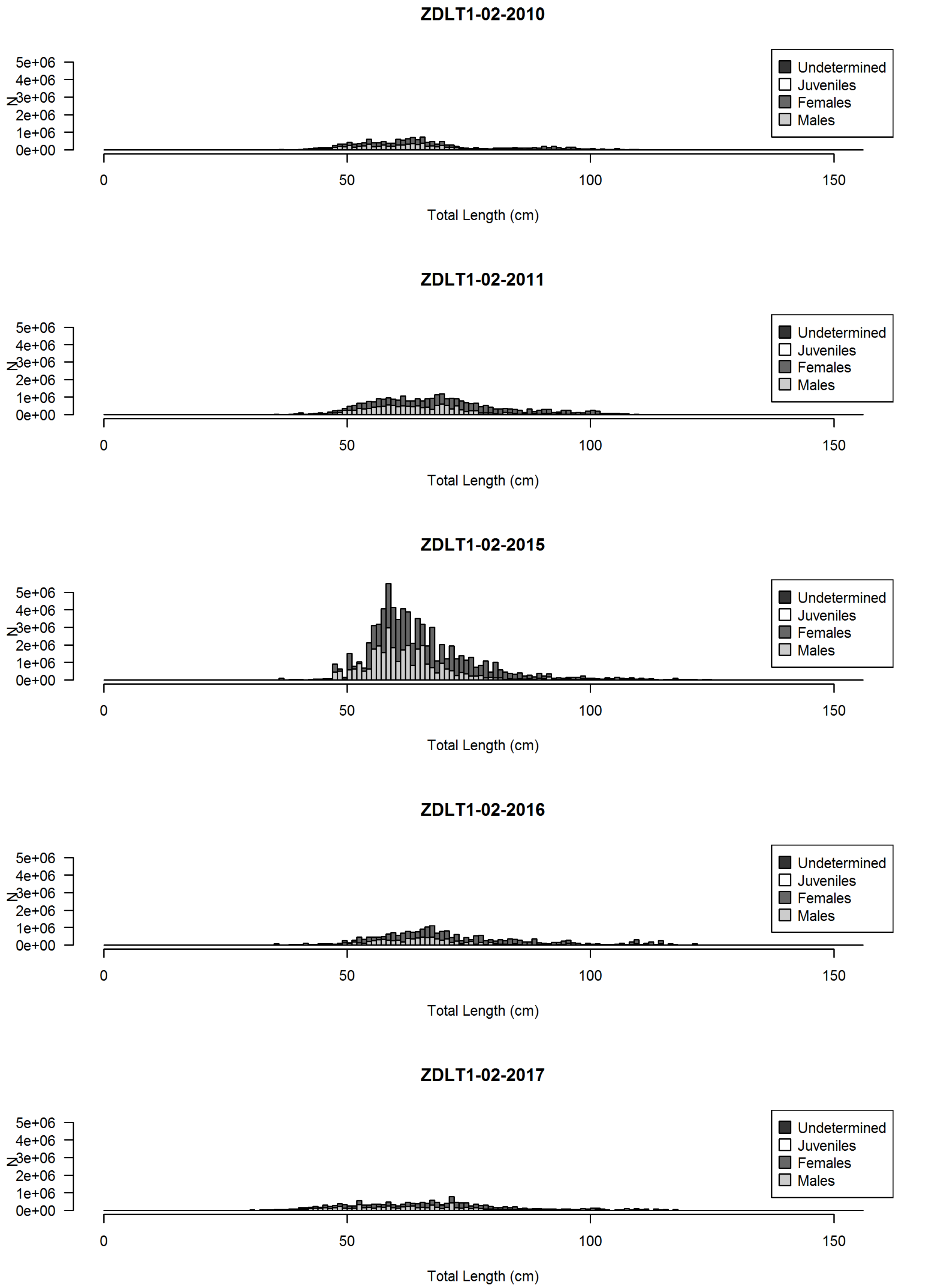

Figure 48: Length frequency histograms of kingclip extrapolated to the estimated total biomass for years 2010–2011 and 2015–2017.

3.5.7 Toothfish

Toothfish observed densities ranged from 0.077–315 kg·km^{-2} and were Box–Cox (λ=0.5) before using them to plot a semi–variogram with 30 distance classes (Figure 49). The model that fitted the best the data was exponential without any nugget effect. It reached the sill (81) at 247 km. Using this variogram model, the kriged density averaged 35.3 kg·km^{-2} ranging from 0 to 312 kg·km^{-2}. The total biomass was estimated to be 3,766 t. Highest biomasses of toothfish were observed in deep waters especially in the southwest of the survey zone. However, the map does not reflect abundances and older toothfish (representing a higher biomass but not necessarily a higher abundance) are generally found deeper than younger toothfish. Biomasses as well as abundance were found to be stable between 2010 and 2011. However a significant reduction of the biomass was observed in 2015 followed by an increase and another decrease in 2016 and 2017 respectively. According to the length frequency histograms, it seems that the population consisted of bigger animals in 2010–2011 (Figure 50).

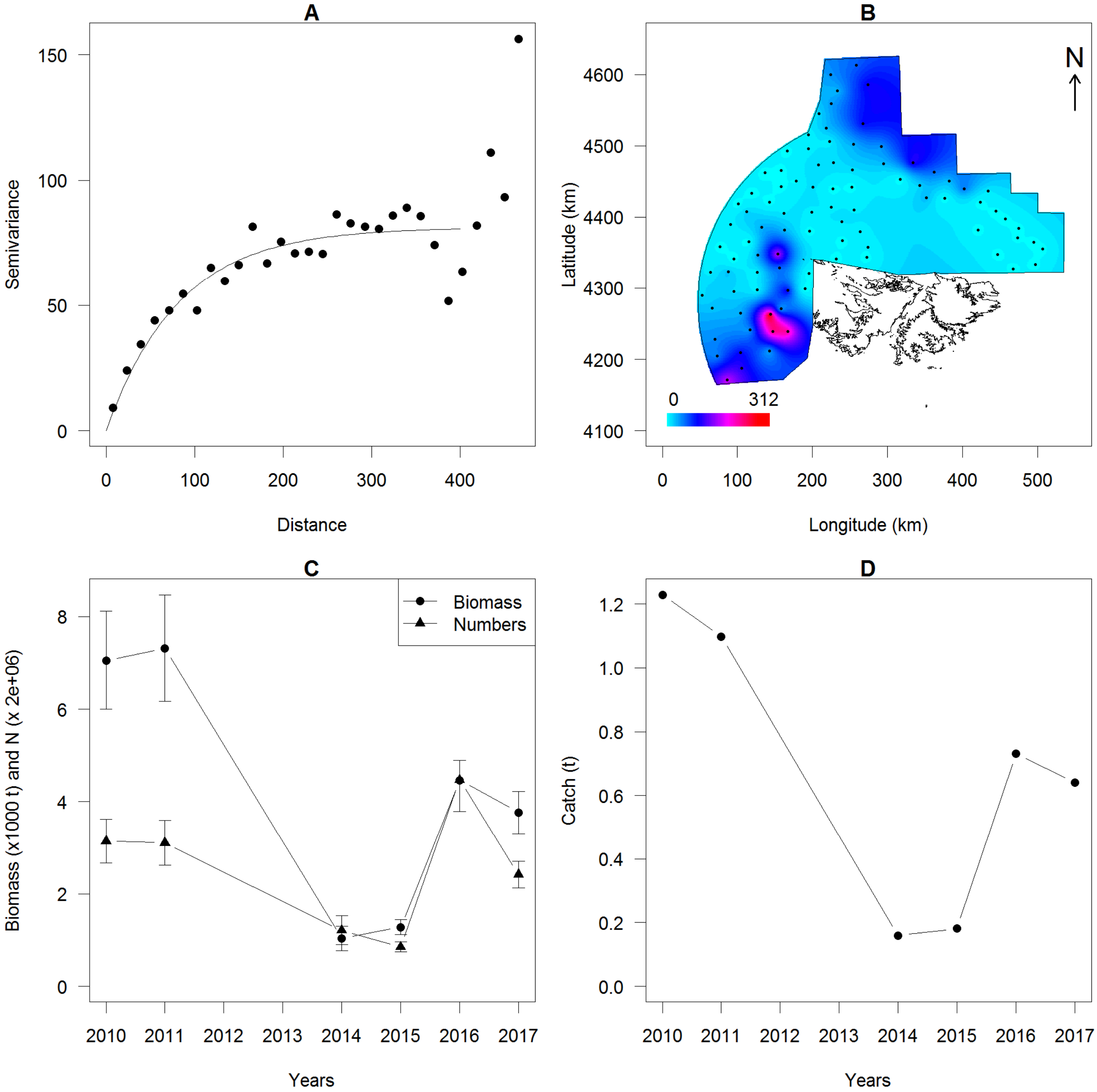

Figure 49: Experimental variogram with spherical model fitted (A), kriged map of toothfish density (B) and time series of estimated biomass using the ground fish survey conducted from 2010.

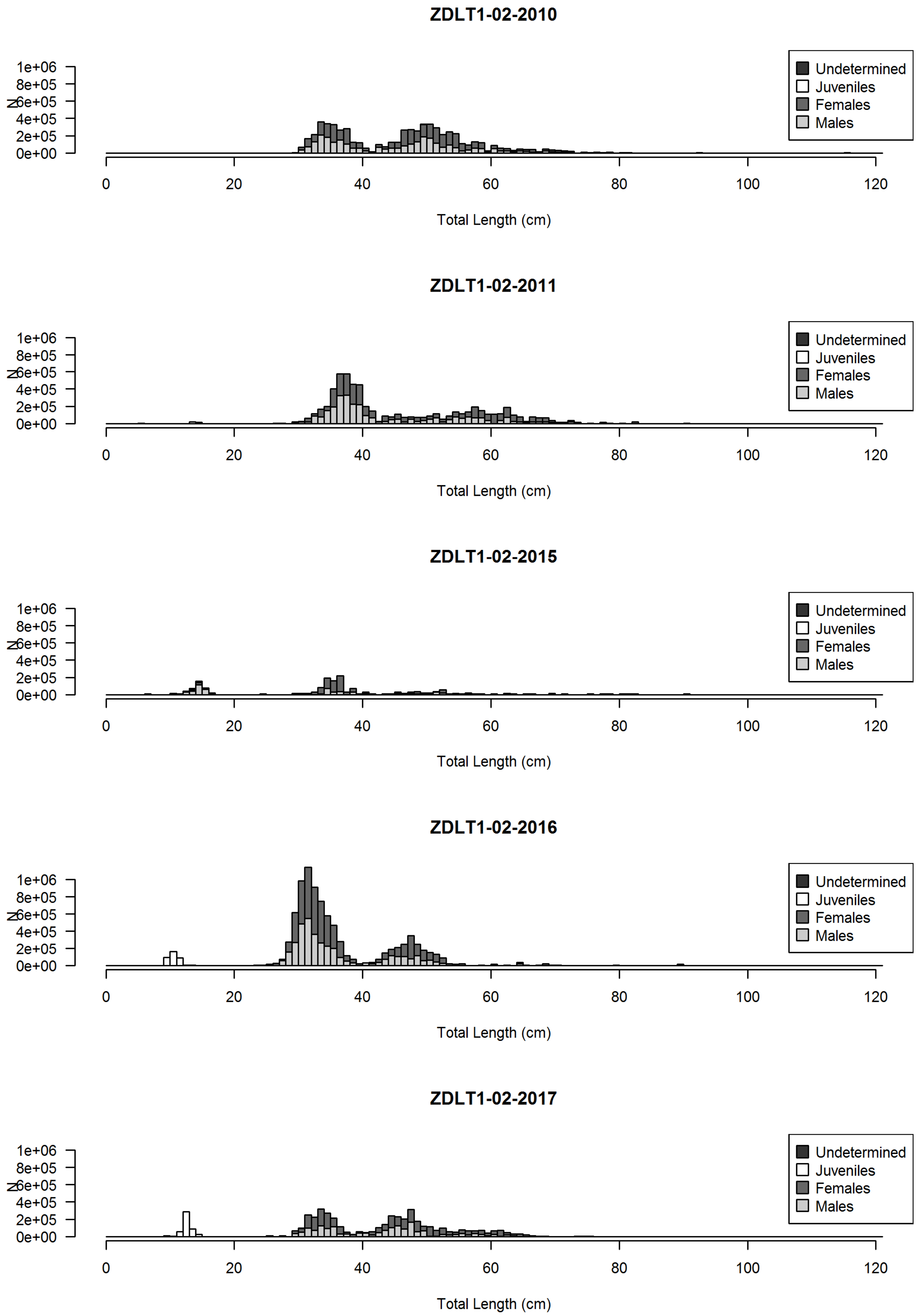

Figure 50: Length frequency histograms of toothfish extrapolated to the estimated total biomass for years 2010–2011 and 2015–2017.

3.5.8 Falkland calamari

Falkland calamari was caught in small quantities throughout the survey area except at one station in the northeast of the survey zone which overlaps with the northern *Loligo* box. Densities ranged from 1.4 kg·km^{-2} to 6.7 t·km^{-2}. After Box–Cox transformation (λ=0.5), observed densities were used to plot the semi–variogram and the best model that fitted the data was spherical (Figure 51). Its sill was 474 and was reached at 56 km. Kriged densities ranged from 2 to 6,615 kg·km^{-2} (average was 310 kg·km^{-2}). The estimated total biomass in the survey area was 33,061 t. Over the years, Falkland calamari biomass appeared to be stable in 2010, 2011 and 2014 at ~18,000 t, decreasing in 2015 to 10,890 t and then following an increasing trend to reach its maximum of the time series in 2017. The time series of length frequency histograms shows that the modal size can vary from year to year (Figure 52). Abundances were stable from 2010 to 2016 and increased in 2017 while biomass decreased in 2015. The length frequency histograms show that Falkland calamari were smaller in 2015 and bigger in 2017 explaining the variation in biomass.

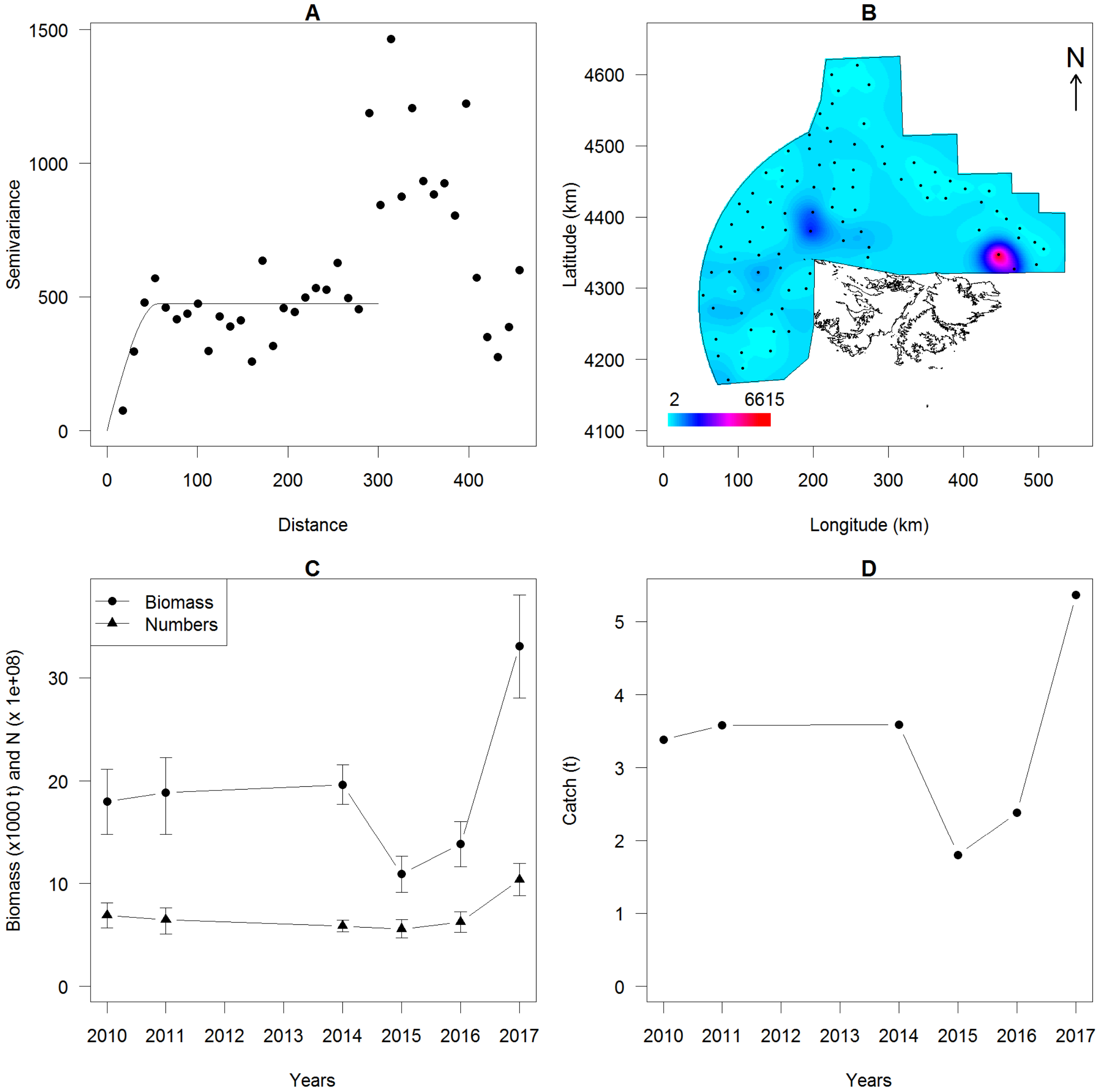

Figure 51: Experimental variogram with spherical model fitted (A), kriged map of Falkland calamari density (B) and time series of estimated biomass using the ground fish survey conducted from 2010.

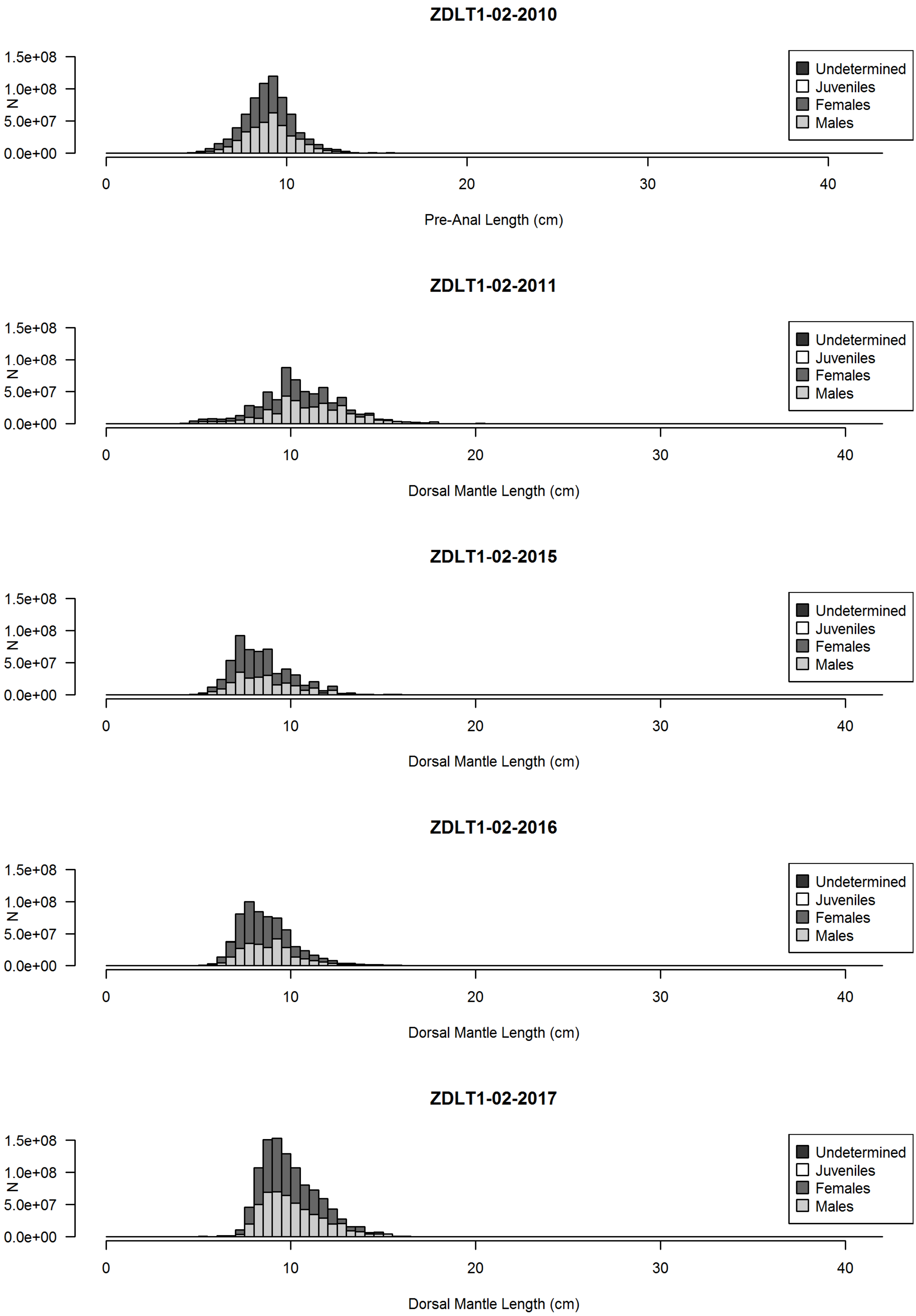

Figure 52: Length frequency histograms of Falkland calamari extrapolated to the estimated total biomass for years 2010–2011 and 2015–2017.

3.5.9 Hoki

Hoki densities varied from 0.45 kg·km^{-2} to 5.3 t·km^{-2}. After Box–Cox transformation with λ=0.5, a semi–variogram was plotted with 33 distance classes and the best model that fitted the data was exponential with no nugget effect (Figure 53). The sill (501) was reached at a distance of 184 km. Taking into account the auto–correlation, the estimated kriged density averaged 177 kg·km^{-2} (ranging from 0 to 5,232 kg·km^{-2}). The total biomass on the survey area was 18,889 t. Most of the hoki was observed in the southwest of the survey zone in deep waters (>200 m) where hoki is normally abundant. Over the years 2010-2017, hoki biomass first decreased, albeit not significantly, between 2010 and 2011 (from 273,377 to 182,440 t). The biomass further decreased in 2015, increased in 2016 and decreased again in 2017. Length frequency histograms show that the number of fish was decreasing from 2010 to 2015 but the length seemed to be stable (Figure 54). However in 2016 and 2017 sampled fish were smaller.

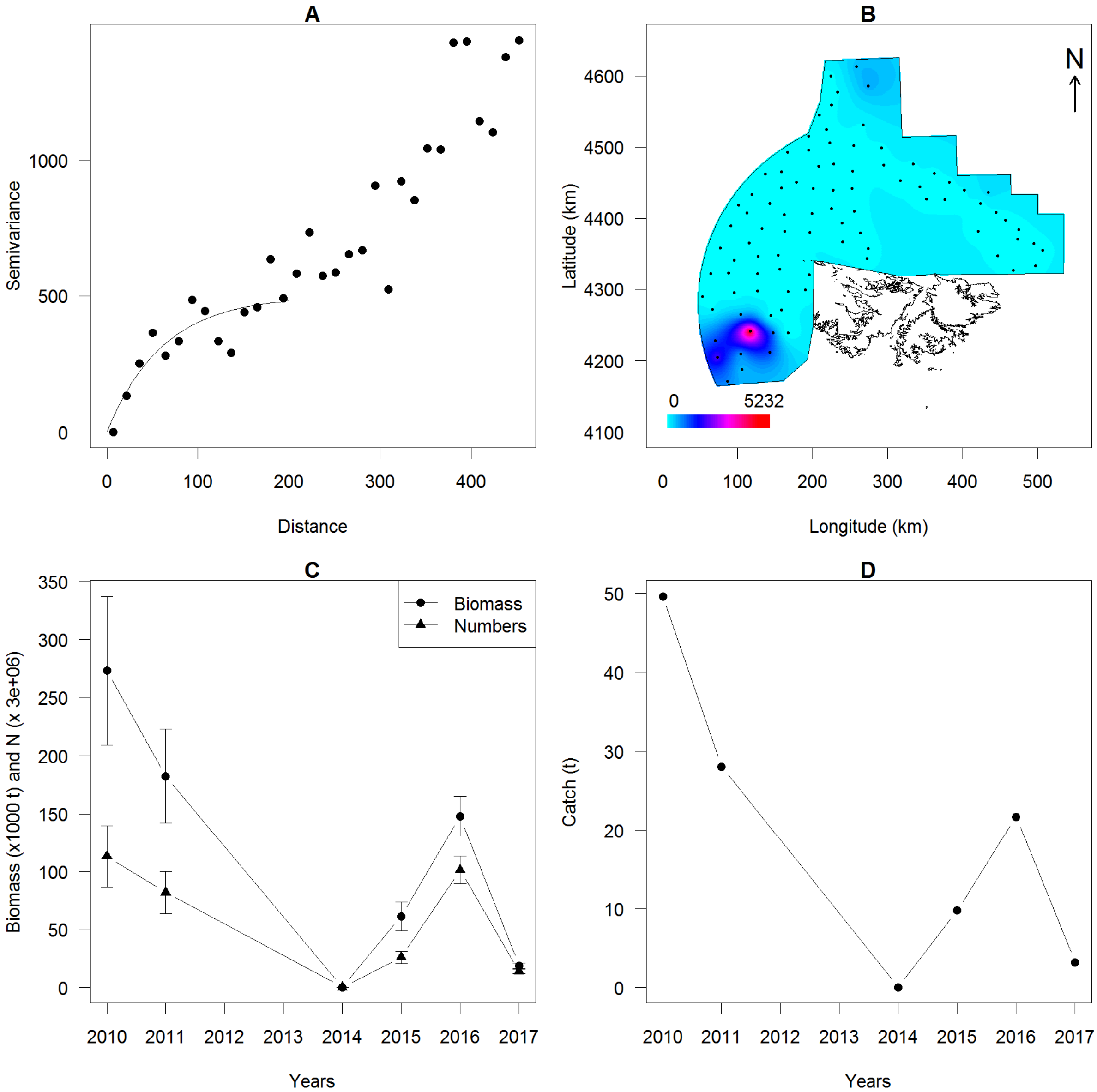

Figure 53: Experimental variogram with spherical model fitted (A), kriged map of hoki density (B) and time series of estimated biomass using the ground fish survey conducted from 2010.

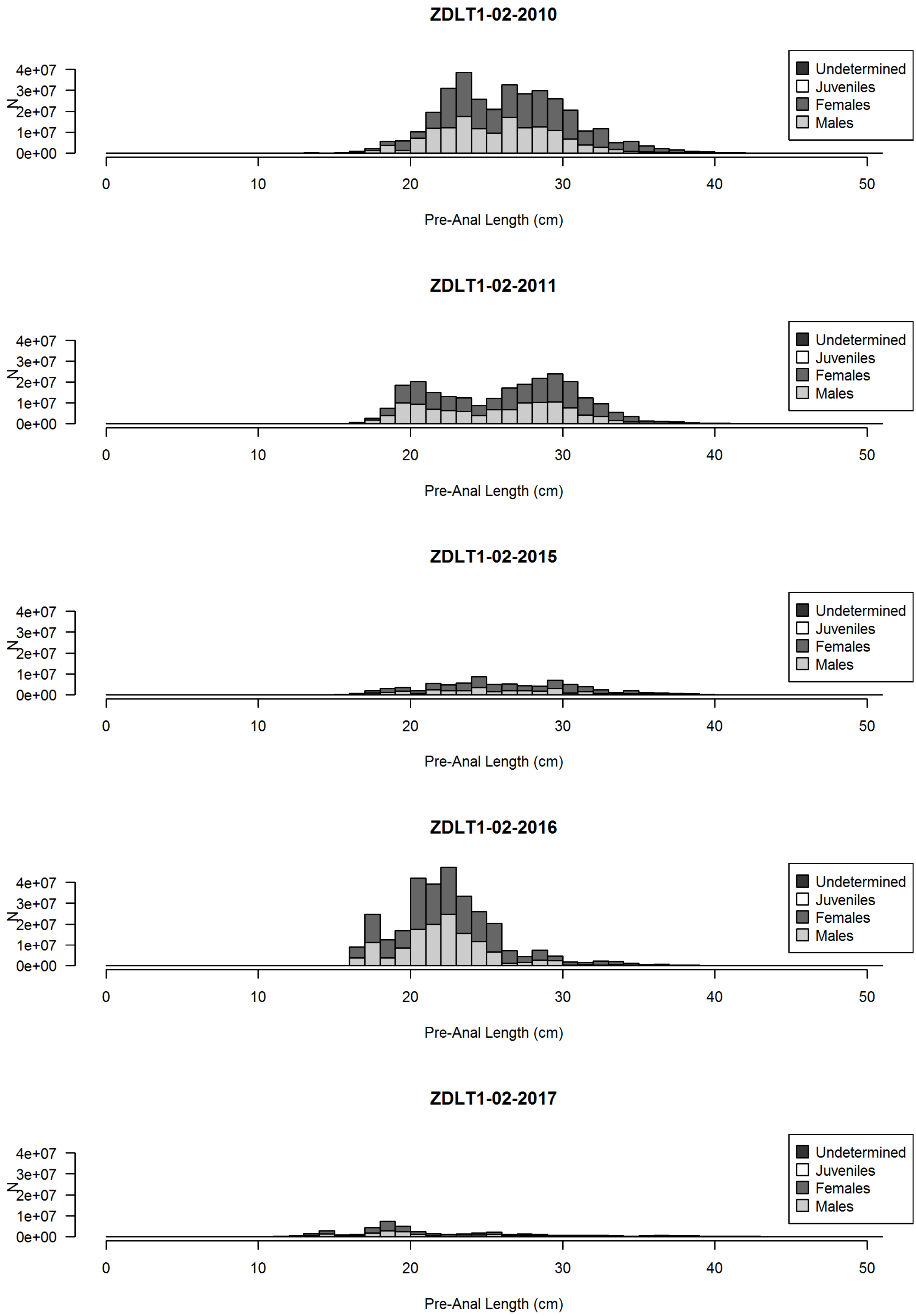

Figure 54: Length frequency histograms of hoki extrapolated to the estimated total biomass for years 2010–2011 and 2015–2017.

3.6 Diet

During the ground fish survey 2017, a new protocol was started to collect diet data at sea on some of the species sampled. Throughout the cruise, 10 species were sampled for diet, common rock cod, common and Patagonian hake, toothfish, hoki, southern blue whiting, red cod, icefish, kingclip and frogmouth. Only common hake and toothfish are presented here as the number of specimens sampled for the other species was too small.

3.6.1 Common hake

The total number of common hake sampled for diet was 55 (49 females and 6 males). Their total length ranged from 19 to 86 cm (Figure 55). A total of 9 taxons were identified in stomach contents. The most abundant prey was common rock cod (44.5%) followed by squat lobster (33%), 12% of the finfish were not identifiable. Other taxons were *Themisto gaudichaudi* (THE), Euphausids (EUP), Falkland calamari (LOL), *Semirossia patagonica* (SRP) and Myctophiid spp (MXX) of which prevalence were all 5% or less.

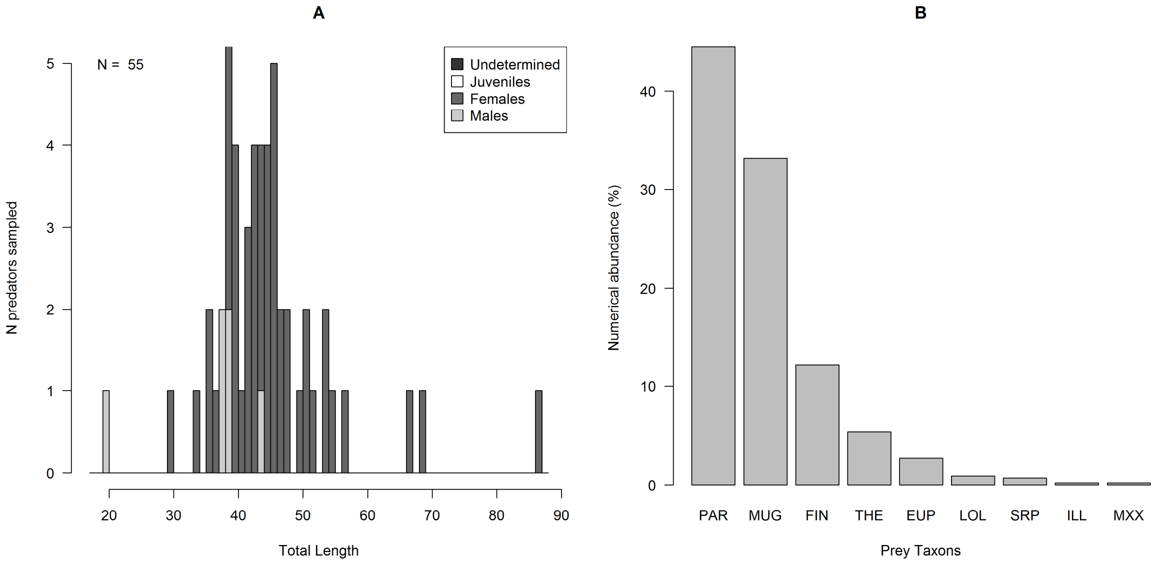

Figure 55: length frequency of common hake sampled for diet analyses (A) and numerical abundance of prey taxon (presented in percentage; B).

3.6.2 Toothfish

The number of toothfish sampled for diet was 82 (14 juveniles, 36 females and 32 males). Their total length ranged from 12 to 66 cm (Figure 56). Five taxons were identified in their stomachs. The most abundant species was rock cod (53%). A significant percentage of finfish were not identified (39%). The rest of the preys consisted of Falkland herring (6%), red cod and small flounder (1% each).

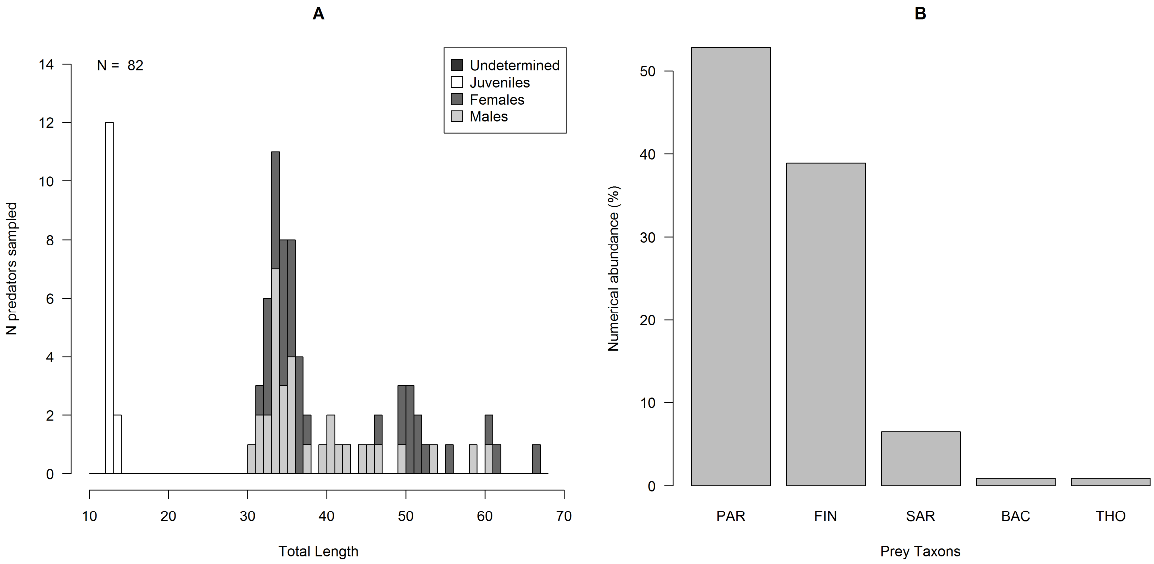

Figure 56: length frequency of toothfish sampled for diet analyses (A) and numerical abundance of prey taxon (presented in percentage; B).

3.7 Oceanography

Oceanographic data were collected at 89 stations (location are shown in Figure 57). The area covered ranged from 48° 31.2'S to 52° 28.1'S and 56° 54.80'W to 63° 26.6'W. Good data were collected on all the down–casts and so up–cast data were removed.
Temperatures, salinities and σ-t densities were gridded using ODV4 DIVA[1] gridding algorithm, at depths 10, 50, 100 and Seabed. The surveyed area covered depth range of 84 to 380 m; however the majority of the stations were on the shelf with all but 15 stations in less than 180 m water.

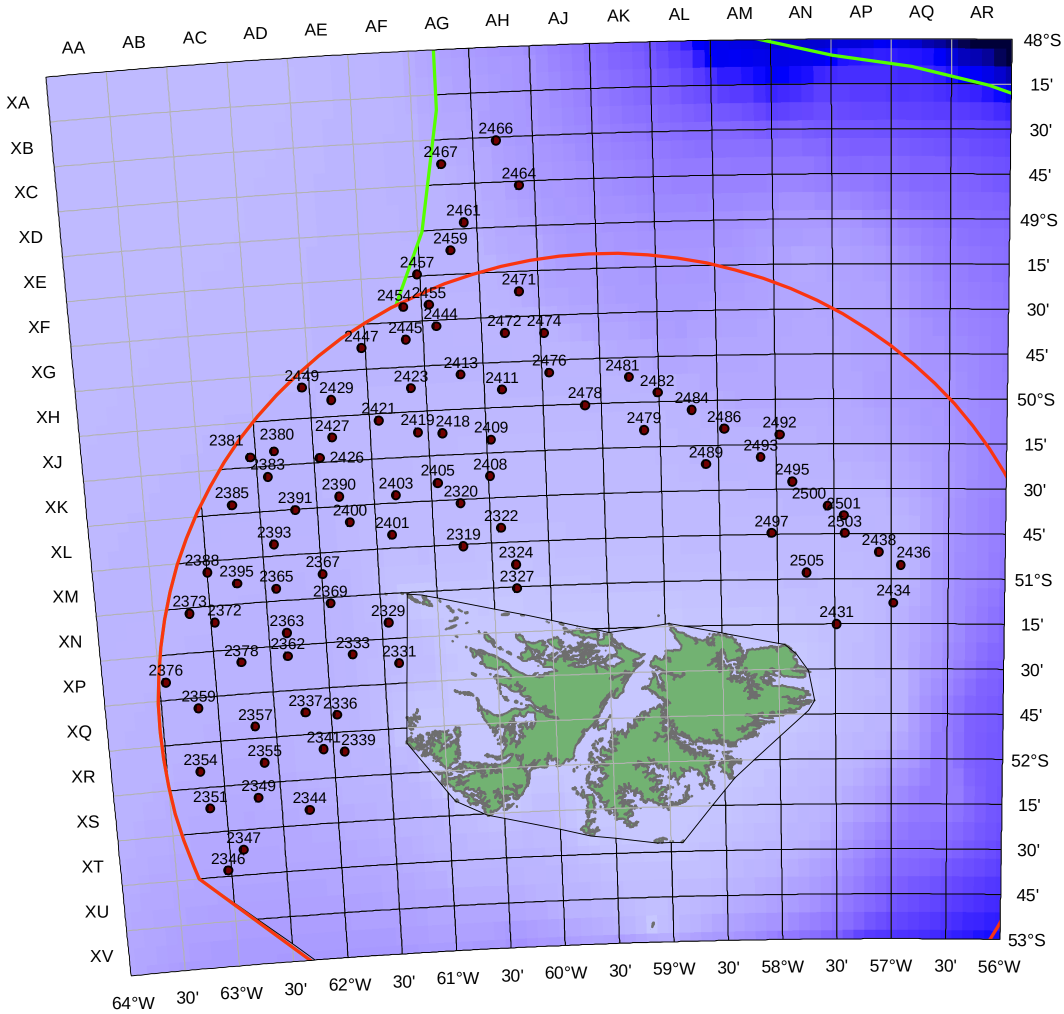

Figure 57 Location and number of CTD stations

The temperature data (Figure 58) showed 2 patterns. Warmer waters were at the surface along the edge of the shelf and cooler waters pushed from the southwest to the north. At 50 m, there was considerable mixing. At 100 m, there was a counter clockwise inflow from the northeast, flowing east along the northern coast of the Falklands. At seabed the western branch of the Falklands current pushed north to meet with the return of the eastern branch of the Falklands Current.

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

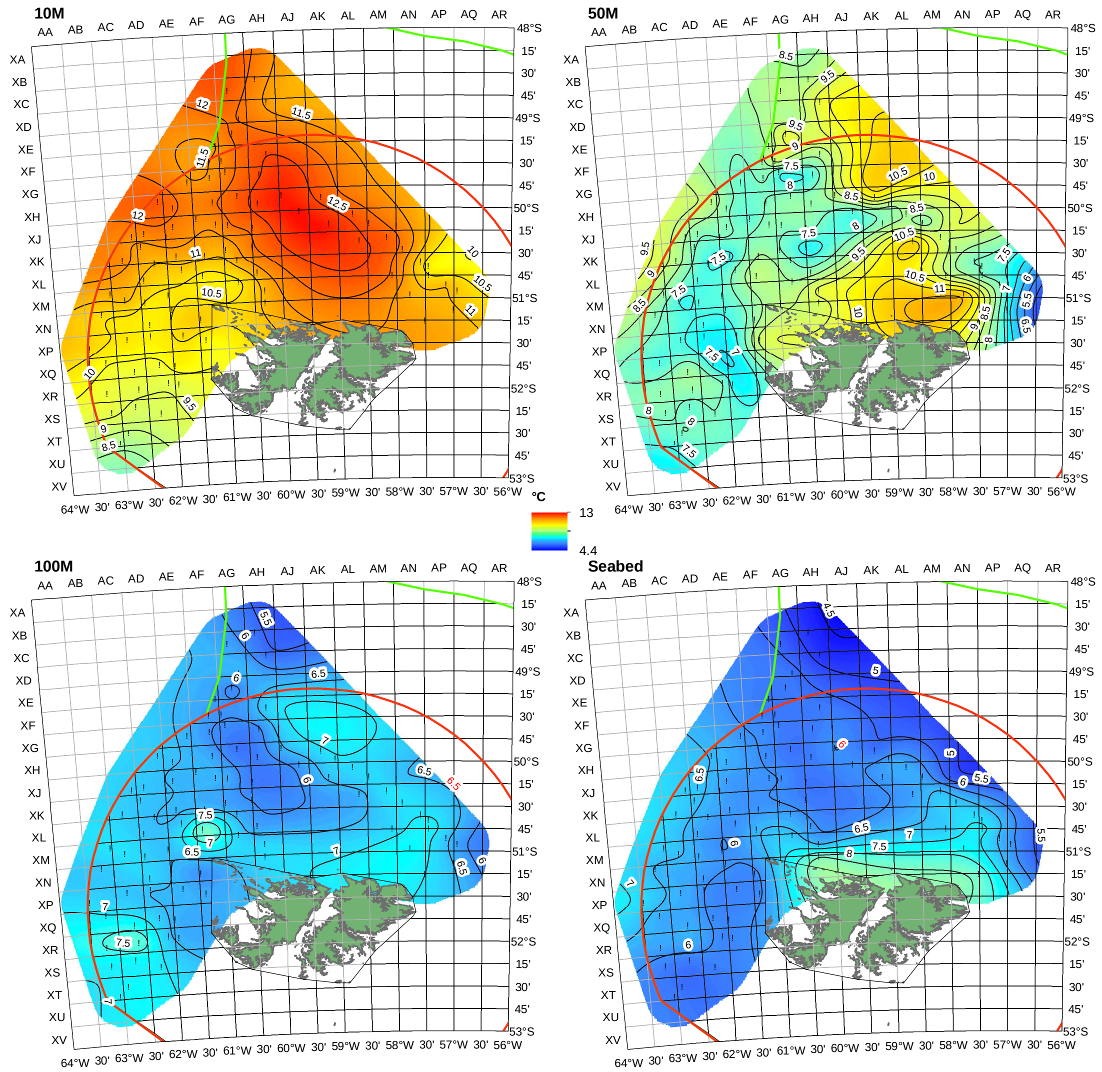

Figure 58 Temperature at 10m, 50m, 100m and seabed (contours at 0.25°C)

Figure 59 shows the change in temperature from 2015 and 2016. At the surface, the water was generally warmer in 2017 than that seen in 2015 and 2016. In the southwest the water was cooler at surface. In the northeast the water was nearly 3°C warmer than in 2015. At the seabed, the waters were generally warmer over the shelf. However, the seabed waters close to the eastern branch of the Falklands current were cooler. The seabed waters are up to 0.5°C warmer than in 2015, and up to 1°C warmer than in 2016.

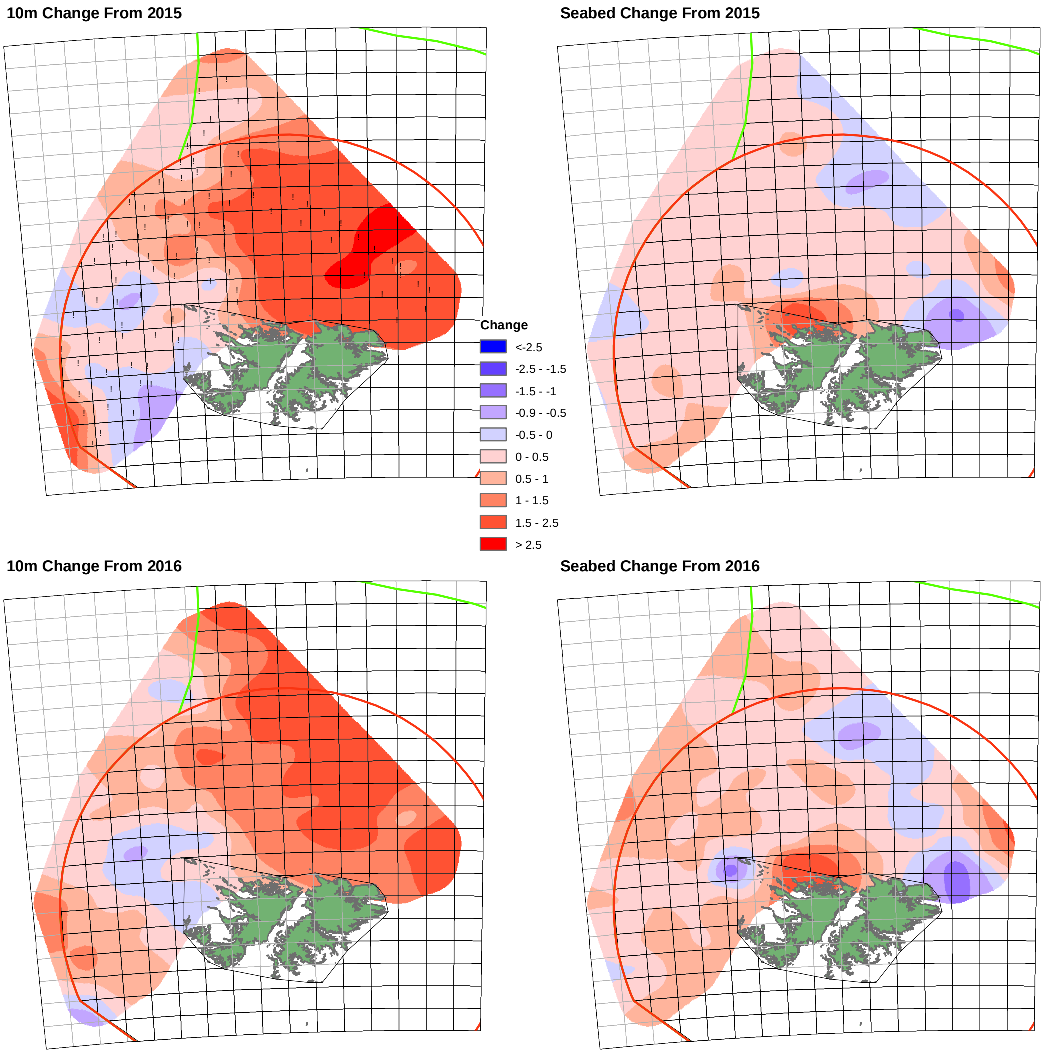

Figure 59 Temperature difference from 2015 at 10 m and seabed

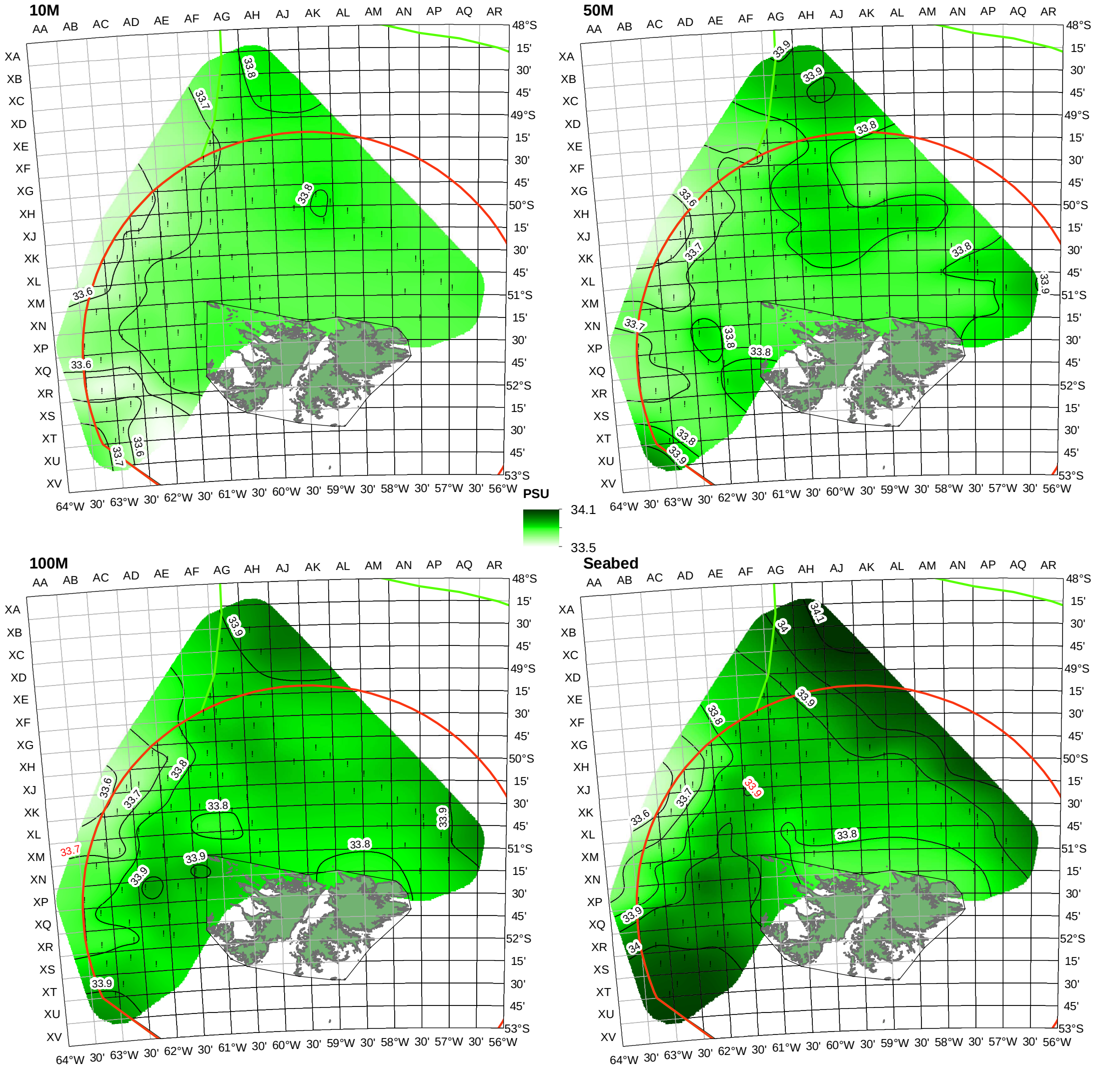

Figure 60 Salinity at 10m, 50m, 100m and seabed (contours at 0.05 PSU)

Figure 60 shows the salinity across the surveyed area. At the surface, the salinity was fairly stable ranging from 33.6 to 33.8 PSU. As depth increases, there is a greater variation, with significant differences at the seabed. At the seabed, water salinity was higher close to the 2 branches of the Falklands Current. The waters to the northeast along the shelf and in the trough to the south west showed measured salinities >34 PSU and interpolated salinity to the north east was >34.1 PSU.

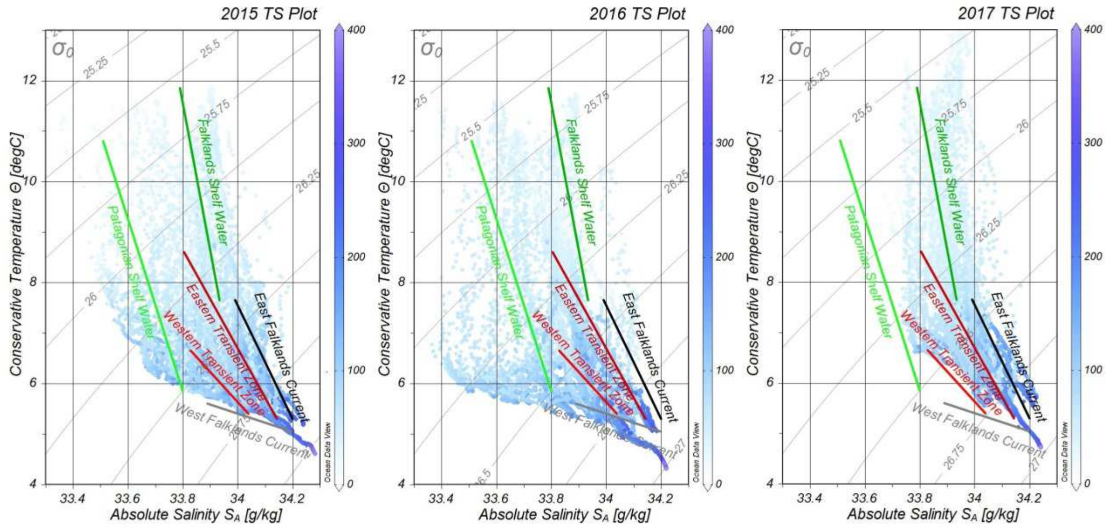

Figure 61 TS plots, 2015 data on the left and 2016 data on the right (water mass terminology Arkhipkin et al. 2013)

A plot of conservative temperature against absolute salinity (Figure 61) was drawn with data collected from February 2015 through to 2017. The TS Plot suggests that the lower salinity Patagonian shelf water was absent in 2017. Shallower waters were dominated by higher salinity over the Falkland shelf. Overall, the salinity range was narrower in 2017 than seen in 2015–2016.

The density map shows that lowest density waters were at 10 m depth over the shelf (Figure 62), reflecting the higher temperatures and lower salinity (Figure 58 and Figure 60). At 50 m, there was more mixing with the denser waters from the West Branch of the Falklands Current moving north and mixing the Falklands Shelf water. At 100 m, away from the deeper layer there is a higher density water mass pushing in through XFAG, XHAG and then moving southeast into XKAJ. The density on the seabed showed this same water mass to the southwest and northeast of the islands in the deep water, below the less dense water seen in the 100 m depth map.

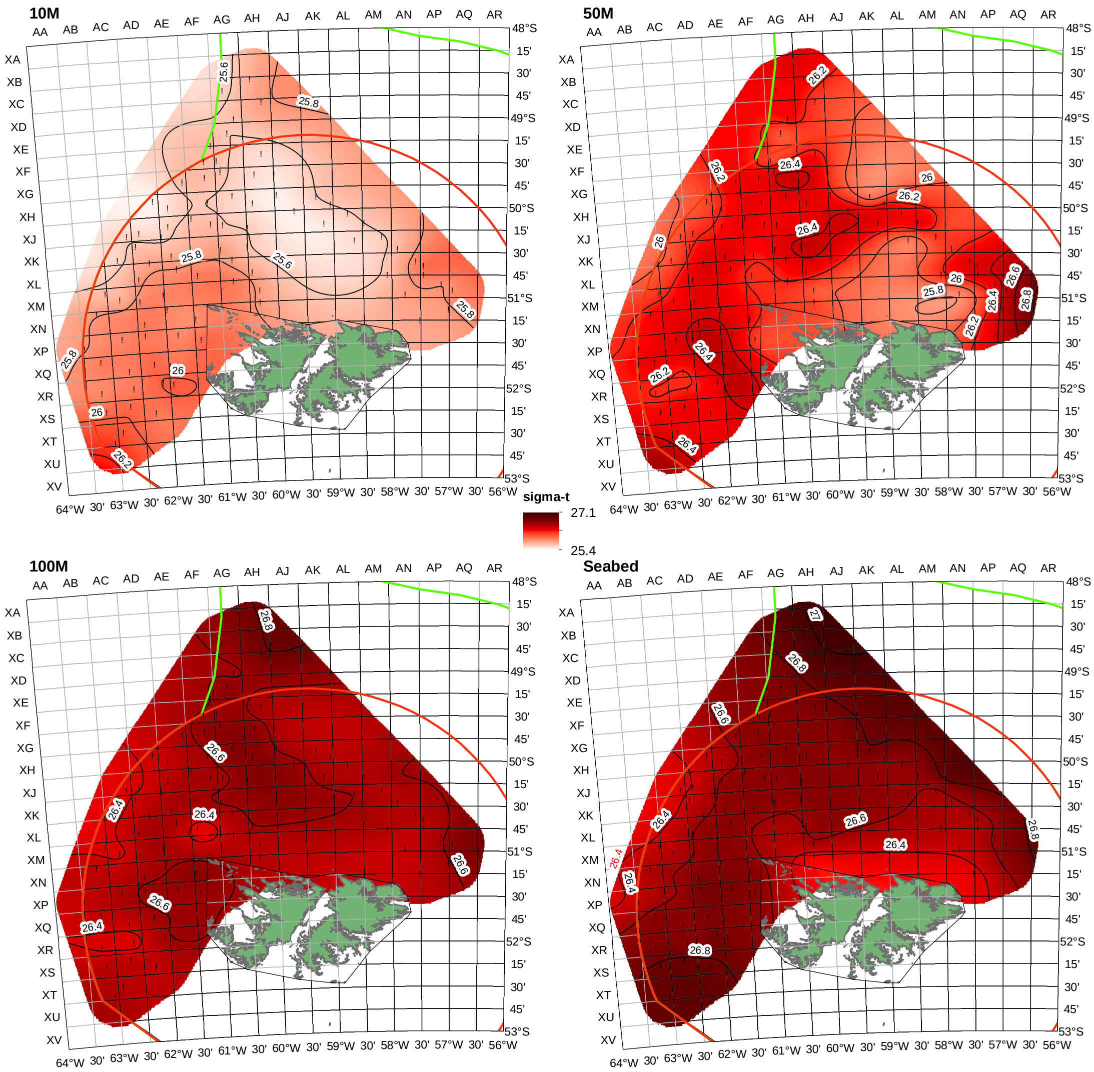

Figure 62 Density at 10m, 50m, 100m and seabed (contours at 0.05 sigma-t)

Oxygen level of water at 10, 50, 100 m depth and at seabed are mapped in Figure 63. Oxygen concentration was highest at the surface, with levels of 6–6.5 ml/l over the majority of the area. Subsurface oxygen concentration was higher at each depth interval over the west branch of the Falklands current. This higher oxygenated water pushes to the north of the Falklands. The eastern branch of the Falklands current and the return gyre did not show higher levels of oxygenation.

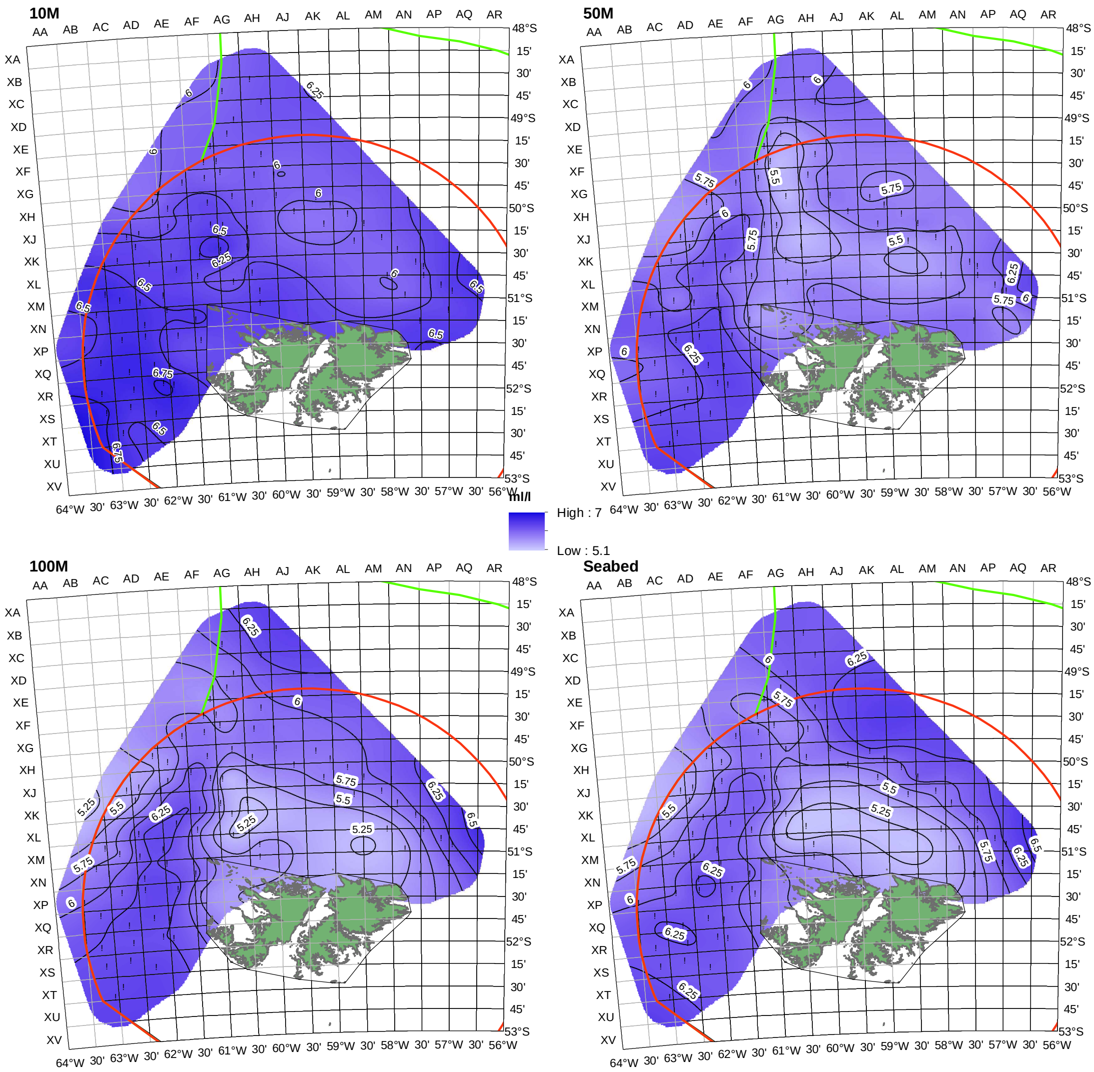

Figure 63 Oxygen at 10m, 50m, 100m and 200m (contours at 0.1ml/l)

3.8 Plankton

The 9 plankton tows (2 just below the surface, 5 in backscattering layers and 2 diagonal profiles) yielded a total wet weight of 8,063g (average 896g, range 60-3,360g). Table 2 summarises all species (or groups) caught grouped by their relative abundance, except for some of the unidentified fish fry.

Table 2: Catch summary for Isaacs-Kidd Midwater trawls (n=9)

Species code	*Latin Name*	Dominant (30-80%)	Abundant (5-30%)	Common (1-5%)	Occasional (<1%)	Rare (n=1-2)	Total
EUP	Euphausids		3	3	2	1	9
THE	*Themisto gaudichaudi*	2	1	3	2	1	9
BEO	*Beroe ovata*	2	1	1		3	7
CHA	Chaetognatha	3	2	1	1		7
FIN	Unidentified finfish				1	6	7
COA	Copepoda			3	1	1	5
MED	Medusae				1	3	4
MUG	*Munida gregaria*	1			1	1	3
PTR	*Pteropoda*					3	3
AMP	Amphipoda					2	2
ISO	Isopoda					2	2
MNL	*Mnemiopsis leidyi*	2					2
PHS	*Phronima sedentaria*					2	2
SAR	*Sprattus fuegensis*					2	2
SER	*Serolis spp.*					2	2
BAC	*Salilota australis*					1	1
CHR	*Chrysaora cf. plocamia*					1	1
MUN	*Munida spp.*					1	1
MXX	*Myctophid spp.*					1	1
PAR	*Patagonotothen ramsayi*					1	1
PHH	*Physophora hydrostatica*					1	1
RED	*Sebastes oculatus*					1	1
SAT	*Salpa thompsoni*	1					1
SQX	Unidentied squid					1	1

4.0 Discussion

For the fifth time since 2010, a biomass survey of the finfish area was carried out in February concurrently to the pre–recruitment survey. The survey was conducted at the same positions as from 2011 and gave a snapshot of the biomass and abundance of demersal species in the finfish box. A total of 189 stations were carried out (91 trawl stations, 89 CTD casts and 9 plankton tows) to gather information on marine fauna, oceanography and plankton.

The total catch of the survey was 58 t which was lower than the total catch recorded in 2015 and 2016 which were 137 and 102 t respectively. It is also a significant decrease compared to 2010 and 2011 surveys during which 207 and 212 t were harvested. It seems that the total demersal biomass in the finfish box has gone downhill since 2011.

Biomass and abundance estimations for rock cod decreased in 2017 compared to 2015–2016, years during which it was stable. In 2017, the biomass was less than half of the biomass observed in 2015–2016 and 10% of what it was in 2011 when the highest biomass of the series was recorded. The rock cod abundance also decreased but not as much as the biomass. This is the result of an increase of the prevalence of small fish in the stock than in years 2010–2011. The rock cod stock in 2017 was made of fish of 1 or 2 years of age which were pre–recruits in the finfish fishery. Analyses of the historical data showed that in 2010–2011, the recruitment was weak and the stock consisted only of recruits. The decrease in biomass and abundance of the rock cod stock could be the consequence of weak recruitments during a series of years. The situation encountered in 2017 with a strong recruitment might be good news for the finfish fishery in the near future. The survey planned in February 2018 will show if this cohort is still in Falkland waters or if it has migrated to other grounds or if it has been predated by another species.

Rock cod was not the only commercial species to have been found on the low side. Red cod, southern blue whiting and kingclip abundances and biomasses decreased over the years 2015–2017. Biomass and abundance of toothfish and hoki were also found to have decreased since 2016. The interpretation of such results should be done with caution for southern blue whiting and hoki. The February survey does not cover the area where the species were the most abundant, *i.e.*in the southwest of the finfish box in deep waters. However, the survey has a good coverage for kingclip and red cod. The only increasing biomasses and abundances were of Argentine shortfin squid and common hake. However, the survey was conducted prior to the migration of these two species to Falkland waters and before concluding about an increase in abundance, more in depth analyses of CPUE data from both Falkland and Argentine waters would be needed. Regarding hake, another survey will be conducted in July 2017 concurrently to the second season *Loligo* pre–recruitment survey and will give an estimation of the biomass and abundance.

The oceanographic survey showed that Falkland waters in the finfish box were warmer in 2017 than in 2015 and 2016. This situation could have created unfavourable conditions for fish which could have experienced higher natural mortality or migrate to other grounds outside Falkland waters. However, more in depth analyses and longer time series on this February survey will be needed to understand the exact effect of temperature on the species.

Regarding the Argentine shortfin squid, it was noted that this species was found to be highly abundant in 2015 when the highest annual commercial catch was recorded and almost absent in 2016 prior to the almost nil catch year. The ground fish survey conducted in February immediately prior to the migration of the Argentine shortfin squid could be a good indicator of the abundance of this species for the following season. However, with only 5 surveys it is difficult to fit a relationship and more in depth analyses could be done in the future to explore that index of abundance.

Diet data showed first interesting results especially on prey diversity for each species. However, the sampling strategy will have to be revisited. With the current strategy, species that are difficult to sample like rock cod were avoided by scientists who tended to concentrate on hake and toothfish. Moreover, the sampling strategy will have to take into account an estimation of the number of empty stomachs that could be used as an indicator of competition (Hyslop, 1980). Weighing the stomach content by taxon could also be carried out in order to have a better estimation of the amount of each taxon in the stomachs. However, it will require having an accurate balance on board (to 0.1 g). Finally, the species identification was found to be difficult from a certain digestion stage, especially for fish. An interesting improvement could be to sample pieces of flesh and determine the species based on DNA samples.

This February survey has shown that most of the species sampled during the survey were on the low side and that a shift has occurred in the ecosystem since 2010 when the survey was carried out for the first time. Results of this survey will be used to make decisions in the framework of the 2018 licence advice and will be considered as the main source of information on biomass and abundance of the species exploited in the survey area (FIFD, 2017).

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Appendix

Table 3: Catch table ZDLT1-02-2017

Species Code	Species name	Total Catch (kg)	Total Sampled (kg)	Total Discarded (kg)	Proportion (%)
PAR	*Patagonotothen ramsayi*	14,525.742	778.454	9,000.090	24.88%
BAC	*Salilota australis*	11,104.460	1,594.240	542.740	19.02%
LOL	*Doryteuthis gahi*	5,434.670	256.300	6.760	9.31%
SAR	*Sprattus fuegensis*	4,271.670	19.930	4,112.930	7.32%
KIN	*Genypterus blacodes*	4,156.340	3,263.030	2.020	7.12%
WHI	*Macruronus magellanicus*	3,206.210	862.830	15.170	5.49%
HAK	*Merluccius hubbsi*	2,931.780	1,724.000	32.980	5.02%
GRF	*Coelorhynchus fasciatus*	2,537.510	55.580	2,537.510	4.35%
ILL	*Illex argentinus*	2,458.798	639.168	344.008	4.21%
RBR	*Bathyraja brachyurops*	717.308	717.308	3.668	1.23%
SPN	Porifera	717.178	0.000	716.962	1.23%
RFL	*Zearaja chilensis*	666.105	666.105	0.000	1.14%
TOO	*Dissostichus eleginoides*	640.275	639.975	0.000	1.10%
RGR	*Bathyraja griseocauda*	625.330	625.330	0.000	1.07%
CGO	*Cottoperca gobio*	433.970	193.340	433.970	0.74%
SQT	Ascidiacea	383.311	0.000	383.311	0.66%
BUT	*Stromateus brasiliensis*	342.402	173.190	298.652	0.59%
DGS	*Squalus acanthias*	299.900	41.280	299.900	0.51%
PAU	*Patagolycus melastomus*	296.516	49.276	247.240	0.51%
BLU	*Micromesistius australis*	242.361	162.044	14.686	0.42%
HYD	Hydrozoa	225.756	0.000	225.756	0.39%
PAT	*Merluccius australis*	178.930	178.930	0.000	0.31%
STA	*Sterechinus agassizi*	168.592	0.000	168.592	0.29%
THO	Thouarellinae	146.630	0.000	146.630	0.25%
DGH	*Schroederichthys bivius*	130.970	0.830	130.140	0.22%
WRM	*Chaetopterus variopedatus*	112.280	0.000	112.280	0.19%
BRY	Bryozoa	100.142	0.000	100.142	0.17%
POR	*Lamna nasus*	80.000	80.000	80.000	0.14%
PTE	*Patagonotothen tessellata*	77.850	44.100	77.730	0.13%
MUN	*Munida spp.*	74.360	0.170	74.190	0.13%
RBZ	*Bathyraja cousseauae*	72.970	72.970	0.000	0.12%
GOC	*Gorgonocephalus chilensis*	72.480	0.000	72.480	0.12%
RMC	*Bathyraja macloviana*	67.950	67.950	2.770	0.12%
GYN	*Gymnoscopelus nicholsi*	61.937	9.282	61.937	0.11%
RAL	*Bathyraja albomaculata*	60.670	60.670	0.000	0.10%
CHE	*Champsocephalus esox*	57.390	16.170	51.580	0.10%
ANM	Anemone	55.172	0.000	55.172	0.09%
RED	*Sebastes oculatus*	53.730	53.730	3.260	0.09%
RSC	*Bathyraja scaphiops*	46.430	46.430	0.000	0.08%
RMU	*Bathyraja multispinis*	42.440	42.440	0.000	0.07%
SEP	*Seriolella porosa*	36.660	36.660	0.000	0.06%
RTR	*Dipturus trachydermus*	32.230	32.230	0.000	0.06%
OPV	*Ophiacanta vivipara*	29.259	0.000	29.259	0.05%
FUM	*Fusitriton m. magellanicus*	28.341	0.000	28.341	0.05%
ALF	*Allothunnus fallai*	27.760	27.760	0.000	0.05%
ING	*Moroteuthis ingens*	26.182	2.390	26.182	0.04%
MUG	*Munida gregaria*	23.998	0.500	23.498	0.04%
ZYP	*Zygochlamys patagonica*	22.146	0.000	14.446	0.04%
ALC	Alcyoniina	20.681	0.000	20.681	0.04%
PYM	*Physiculus marginatus*	20.540	7.156	20.540	0.04%
SUN	*Labidaster radiosus*	20.180	0.000	20.180	0.03%
COP	*Congiopodus peruvianus*	19.910	6.390	19.910	0.03%
RMG	*Bathyraja magellanica*	17.830	17.830	0.020	0.03%
CAZ	*Calyptraster sp.*	17.398	0.000	17.398	0.03%
RPX	*Psammobatis spp.*	13.706	13.686	8.036	0.02%

AUC	*Austrocidaris canaliculata*	13.361	0.000	13.361	0.02%
COT	*Cottunculus granulosus*	11.234	11.210	11.234	0.02%
CIR	Cirripedia	8.910	0.000	8.910	0.02%
CTA	*Ctenodiscus australis*	8.322	0.000	8.322	0.01%
HYP	Hyperiidae	7.400	0.000	7.400	0.01%
NEM	*Neophyrnichthys marmoratus*	6.611	0.000	6.611	0.01%
POA	*Porania antarctica*	5.640	0.000	5.640	0.01%
COL	*Cosmasterias lurida*	5.301	0.000	5.301	0.01%
UHH	Heart urchin	5.130	0.000	5.130	0.01%
ODM	*Odontocymbiola magellanica*	5.128	0.000	5.128	0.01%
SER	*Serolis spp.*	4.395	0.000	4.395	0.01%
PMC	*Protomictophum choriodon*	4.362	0.418	4.362	0.01%
CAS	*Campylonotus semistriatus*	4.241	0.000	0.061	0.01%
OPL	*Ophiuroglypha lymanii*	3.316	0.000	3.316	0.01%
MAV	*Magellania venosa*	3.231	0.000	3.231	0.01%
FLX	*Flabellum spp.*	3.219	0.000	1.599	0.01%
ADA	*Adelomelon ancilla*	2.989	0.000	2.989	0.01%
RDO	*Amblyraja doellojuradoi*	2.980	2.970	1.670	0.01%
MUU	*Munida subrugosa*	2.893	0.000	2.893	<0.01%
ASA	*Astrotoma agassizii*	2.780	0.000	2.780	<0.01%
MUO	*Muraenolepis orangiensis*	2.623	2.393	2.620	<0.01%
PES	*Peltarion spinosulum*	2.409	0.000	2.409	<0.01%
MLA	*Muusoctopus longibrachus akambei*	2.190	0.140	2.050	<0.01%
NUD	Nudibranchia	2.130	0.000	2.130	<0.01%
ANT	Anthozoa	1.920	0.000	1.920	<0.01%
CEX	*Ceramaster sp.*	1.864	0.000	1.864	<0.01%
SEC	*Seriolella caerulea*	1.830	1.830	0.000	<0.01%
EUO	*Eurypodius longirostris*	1.606	0.000	1.606	<0.01%
THB	*Thymops birsteini*	1.578	0.000	0.058	<0.01%
BAL	*Bathydomus longisetosus*	1.467	0.000	1.467	<0.01%
BAO	*Bathybiaster loripes*	1.286	0.000	1.286	<0.01%
SRP	*Semirossia patagonica*	1.225	0.370	1.025	<0.01%
ILF	*Iluocoetes fimbriatus*	1.194	1.194	0.000	<0.01%
OCM	*Octopus megalocyathus*	1.140	0.000	1.140	<0.01%
PLB	Primnoellinae	1.080	0.000	1.080	<0.01%
EUL	*Eurypodius latreillei*	0.960	0.000	0.960	<0.01%
AST	Asteroidea	0.905	0.000	0.905	<0.01%
CYX	*Cycethra sp.*	0.891	0.000	0.891	<0.01%
ODP	*Odontaster pencillatus*	0.815	0.000	0.815	<0.01%
CRY	*Crossaster sp.*	0.780	0.000	0.780	<0.01%
ALG	Algae	0.705	0.000	0.705	<0.01%
TED	*Terebratella dorsata*	0.580	0.000	0.580	<0.01%
MUE	*Muusoctopus eureka*	0.522	0.000	0.522	<0.01%
AUL	*Austrolycus laticinctus*	0.500	0.000	0.500	<0.01%
SOR	*Solaster regularis*	0.415	0.000	0.415	<0.01%
GRN	*Graneledone yamana*	0.410	0.000	0.410	<0.01%
PMX	*Protomictophum spp.*	0.300	0.000	0.300	<0.01%
CAV	*Campylonotus vagans*	0.260	0.000	0.260	<0.01%
LEA	*Lepas australis*	0.250	0.000	0.250	<0.01%
PAG	*Paralomis granulosa*	0.240	0.000	0.240	<0.01%
PYX	Pycnogonida	0.222	0.000	0.222	<0.01%
COG	*Patagonotothen guntheri*	0.213	0.138	0.135	<0.01%
ANC	*Anseropoda antarctica*	0.200	0.000	0.200	<0.01%
MMA	*Mancopsetta maculata*	0.190	0.190	0.190	<0.01%
NEC	*Neorossia caroli*	0.171	0.171	0.000	<0.01%
LOS	*Lophaster stellans*	0.164	0.000	0.164	<0.01%
OCT	Octopus spp.	0.160	0.160	0.000	<0.01%
HCR	Paguroidea	0.145	0.000	0.145	<0.01%
ZOX	Zoarcid sp.	0.130	0.130	0.000	<0.01%

UCH	Sea urchin	0.120	0.000	0.120	<0.01%
COX	Notothenid spp.	0.100	0.100	0.000	<0.01%
NEH	*Neomenia herwigi*	0.100	0.000	0.100	<0.01%
LYB	*Lycenchelys bachmanni*	0.090	0.090	0.000	<0.01%
POE	*Pogonolycus elegans*	0.084	0.084	0.000	<0.01%
THN	*Thysanopsetta naresi*	0.084	0.030	0.084	<0.01%
NUH	*Nuttallochiton hyadesi*	0.070	0.000	0.070	<0.01%
FIN	Unidentified finfish	0.060	0.060	0.000	<0.01%
ISO	Isopoda	0.060	0.015	0.045	<0.01%
ACS	*Acanthoserolis schythei*	0.058	0.000	0.058	<0.01%
OIB	*Oidiphorus brevis*	0.038	0.038	0.000	<0.01%
BIV	Bivalve	0.038	0.000	0.038	<0.01%
PLS	*Plesienchelys stehmanni*	0.036	0.036	0.036	<0.01%
BUC	*Bulbus carcellesi*	0.035	0.000	0.035	<0.01%
OPH	Ophiuroidea	0.031	0.000	0.031	<0.01%
LIA	*Lithodes antarcticus*	0.030	0.000	0.030	<0.01%
MYT	*Myxine tridentiger*	0.030	0.000	0.030	<0.01%
HOL	Holothuroidea	0.030	0.000	0.030	<0.01%
POL	Polychaeta	0.027	0.000	0.027	<0.01%
OCC	Octocoralia	0.026	0.000	0.026	<0.01%
SYB	*Symbolophorus boops*	0.020	0.020	0.020	<0.01%
TRX	*Trophon sp.*	0.020	0.000	0.020	<0.01%
PRX	*Paragorgia sp.*	0.014	0.000	0.014	<0.01%
SQX	Unidentied squid	0.010	0.010	0.000	<0.01%
AGO	*Agonopsis chilensis*	0.010	0.000	0.010	<0.01%
GON	*Gonatus antarcticus*	0.006	0.006	0.000	<0.01%
ALP	*Alepocephalus productus*	0.005	0.000	0.005	<0.01%
PAV	*Patagonotothen brevicauda*	0.003	0.003	0.000	<0.01%
		58,383.684	**13,301.460**	**20,719.153**	

Table 4: Sample numbers by sample type

Code	Species Name	N	R	S	Total	
PAR	*Patagonotothen ramsayi*	82	6,741	2,252	9,075	23.9%
LOL	*Doryteuthis gahi*	1	8,228	103	8,332	22.0%
BAC	*Salilota australis*	13	2,817	1,104	3,934	10.4%
HAK	*Merluccius hubbsi*	4	1,572	1,448	3,024	8.0%
ILL	*Illex argentinus*	30	2,838	96	2,964	7.8%
KIN	*Genypterus blacodes*	1	1,032	1,279	2,312	6.1%
WHI	*Macruronus magellanicus*	3	664	570	1,237	3.3%
TOO	*Dissostichus eleginoides*	8	456	366	830	2.2%
PTE	*Patagonotothen tessellata*		805		805	2.1%
GYN	*Gymnoscopelus nicholsi*		754		754	2.0%
CHE	*Champsocephalus esox*		323	270	593	1.6%
CGO	*Cottoperca gobio*	16	433	61	510	1.3%
BLU	*Micromesistius australis*	3	335	103	441	1.2%
BUT	*Stromateus brasiliensis*		408		408	1.1%
GRF	*Coelorhynchus fasciatus*		271	103	374	1.0%
RBR	*Bathyraja brachyurops*		373	1	374	1.0%
PAU	*Patagolycus melastomus*		62	274	336	0.9%
SAR	*Sprattus fuegensis*		335		335	0.9%
PYM	*Physiculus marginatus*		171	99	270	0.7%
RFL	*Zearaja chilensis*		244		244	0.6%
RED	*Sebastes oculatus*		106	2	108	0.3%
RGR	*Bathyraja griseocauda*		54	48	102	0.3%
PMC	*Protomictophum choriodon*		85		85	0.2%
PAT	*Merluccius australis*		65	6	71	0.2%
RMC	*Bathyraja macloviana*		71		71	0.2%
COT	*Cottunculus granulosus*		59		59	0.2%
RAL	*Bathyraja albomaculata*		41		41	0.1%
RPX	*Psammobatis spp.*		38		38	0.1%
RMG	*Bathyraja magellanica*		32		32	0.1%
ILF	*Iluocoetes fimbriatus*		9	17	26	0.1%
RSC	*Bathyraja scaphiops*		25		25	0.1%
DGS	*Squalus acanthias*		20	2	22	0.1%
SEP	*Seriolella porosa*		19		19	0.1%
COP	*Congiopodus peruvianus*		18		18	<0.01%
RBZ	*Bathyraja cousseauae*		9	5	14	<0.01%
NEC	*Neorossia caroli*		9		9	<0.01%
MUO	*Muraenolepis orangiensis*		8		8	<0.01%
RMU	*Bathyraja multispinis*		2	5	7	<0.01%
LYB	*Lycenchelys bachmanni*		6		6	<0.01%
COG	*Patagonotothen guntheri*		5		5	<0.01%
OIB	*Oidiphorus brevis*		5		5	<0.01%
RDO	*Amblyraja doellojuradoi*		5		5	<0.01%
ALF	*Allothunnus fallai*		3	1	4	<0.01%
MLA	*Muusoctopus longibrachus akambei*		4		4	<0.01%
POE	*Pogonolycus elegans*		4		4	<0.01%
GON	*Gonatus antarcticus*		2		2	<0.01%
PLS	*Plesienchelys stehmanni*		2		2	<0.01%
SEC	*Seriolella caerulea*		2		2	<0.01%
THN	*Thysanopsetta naresi*		2		2	<0.01%
ING	*Moroteuthis ingens*		1		1	<0.01%
MMA	*Mancopsetta maculata*		1		1	<0.01%
PAV	*Patagonotothen brevicauda*	1			1	<0.01%
POR	*Lamna nasus*		1		1	<0.01%
RTR	*Dipturus trachydermus*		1		1	<0.01%
SYB	*Symbolophorus boops*		1		1	<0.01%
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