Cruise Report ZDLT1-02-2016

Finfish and Rock cod Biomass survey

Michaël Gras, Joost Pompert, Alex Blake, Tara Boag, Ashley Grimmer, Verónica Iriarte and Brais Sánchez

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

Participating Scientific Staff

Dr Michaël Gras	Chief scientist
Joost Pompert	Trawl survey supervisor / Plankton survey
Alex Blake	Oceanography and Trawl Survey
Tara Boag	Trawl survey, data handling and e–board operations
Ashley Grimmer	Trawl survey and training
Brais Sánchez	Trawl survey and training
Verónica Iriarte	Trawl survey and training

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1.0 Introduction

Falkland waters are part of the Patagonian Shelf Large Marine Ecosystem, one of the most productive marine ecosystems of the world (Bakun, 1993). Since 1987, and the declaration of the Falklands Interim Conservation Zone (FICZ) by the Falkland Islands Government, every vessel fishing in the FICZ has to be licensed by the Directorate of Natural Resources – Fisheries Department (DNRFD). The fishery is currently regulated using both Total Allowable Catch (TAC) and Total Allowable Effort (TAE). Before 2007, the southern blue whiting (*Micromesistius a. australis*) was the main finfish species exploited in Falkland waters and its biomass used as a basis for TAC and TAE calculation. Since the decrease in southern blue whiting abundance, rock cod (*Patagonotothen ramsayi*) increased in abundance and became one of the most important finfish resources for trawling activity in Falkland waters (Laptikhovsky et al., 2013). Since 2007, rock cod catches have varied between 29,038 and 76,451 t (FIG, 2016). In 2007, as *P. ramsayi* became the primary species in term of catches, it was decided to use this as a basis for the TAC/TAE calculation.

Two research cruises were carried out in February 2010 (Brickle and Laptikhovsky 2010) and 2011 (Arkhipkin et al., 2011) to have a first estimation of the rock cod abundance. From 2011 to 2013, 6 research cruises were undertaken to test various gears in order to improve the rock cod catch by decreasing the bycatch of undersized specimens and non–valuable 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). In 2014, as the new regulations were published to come into force at the beginning of 2015, it was the right time to perform a new biomass estimation. Rock cod biomass estimation was therefore carried out based on data collected between 18 October and 8 November 2014 (research cruise ZDLT1–10–2014; Pompert et al., 2014) and showed that abundance was 98,596 t. In order to have a seasonal comparison, another research cruise was conducted from 2 to 22 February 2015 and concluded that the rock cod biomass was 76,298 t.

The finfish fishery is a mixed fishery and the main species of interest for the fishers are not only rock cod, but also common and Patagonian hakes, kingclip, hoki, red cod, southern blue whiting and Argentine shortfin squid. Although, the finfish fishery is a mixed fishery, the TAC/TAE calculations are only based on rock cod. In the last two years, this system has shown its limits and years when the fleet did not target rock cod were removing to avoid a high increase of the fishing effort. Taking into account more commercial species in the TAC/TAE calculations was suggested as a solution (FIFD, 2014; 2015).

In November 2015, a survey was conducted in the south of FICZ/FOCZ and trawling and plankton towing were carried out in order to catch toothfish juveniles and larvae (Pompert et al., 2015). One of the perspectives was to use the Isaacs–Kidd Mid–water Trawl net (or IKMT) to explore other zones such as the finfish zone where the ZDLT1–02–2016 survey was planned.

The objective of the survey was primarily to gather biological data and estimate the biomass of rock cod and other commercial species of the finfish fishery. In order to have better insight of the ecosystem, biological data of all the species for which more than 30 specimens were assessed are presented in this report. The rock cod/finfish survey was also the opportunity to explore the water column of the finfish zone using a plankton net to catch fish larvae.

2.0 Material and methods

2.1 Cruise vessel and surveyed area

The research cruise ZDLT1–02–2016 was conducted on board the FV Castelo (LOA 67.8 m, GRT 1321) from 2 to 22 February 2016. Embarking and disembarking occurred on 1 and 23 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) and 2015 (Gras et al. 2015), it was decided to repeat stations already explored in 2011, 2014 and 2015. 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.

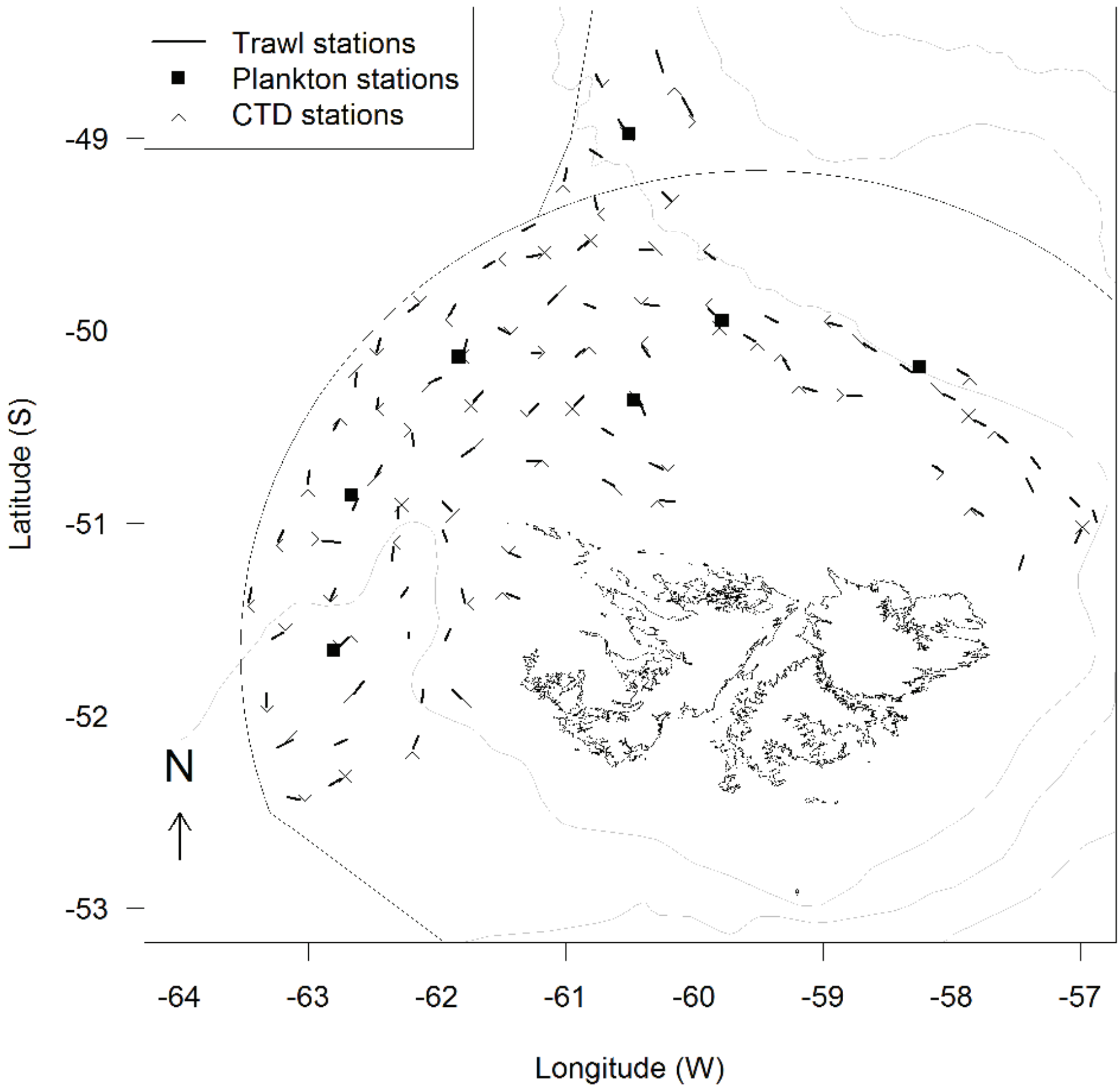


Figure 1: Locations of trawl, plankton and CTD stations.

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	Lat (°S)	Lon (°W)	Modal Depth (m)	Horizon Depth (m)	Duration (min)	Activity	Comments
1901	02/02/2016	50.89	60.15	134		60	B	wing sensors not working
1904	02/02/2016	50.72	60.24	143		60	B	
1905	02/02/2016	50.55	60.63	148		60	B	
1907	02/02/2016	50.77	60.72	133		60	B	
1909	03/02/2016	52.11	62.15	285		60	B	
1912	03/02/2016	52.12	62.70	247		60	B	
1914	03/02/2016	52.32	62.75	272		60	B	
1916	03/02/2016	52.44	63.07	269		60	B	
1917	04/02/2016	52.16	63.25	233		60	B	
1920	04/02/2016	51.95	63.33	199		60	B	
1922	04/02/2016	51.88	62.65	228		60	B	
1924	04/02/2016	51.86	62.11	265		60	B	
1925	05/02/2016	51.87	61.88	193		60	B	
1928	05/02/2016	51.61	61.94	181		60	B	
1930	05/02/2016	51.57	62.22	238		25	B	Hauled early because doors closed: Jellyfish.
1932	05/02/2016	51.59	62.69	202		60	B	
1934	05/02/2016	51.65	62.76	203	1	30	I	
1935	05/02/2016	51.66	62.79	203	70	30	I	
1936	06/02/2016	51.60	63.29	184		60	B	
1939	06/02/2016	51.41	63.47	156		60	B	
1941	06/02/2016	51.10	63.24	152		60	B	
1943	06/02/2016	51.09	62.89	168		60	B	
1944	07/02/2016	51.34	62.79	183		60	B	
1947	07/02/2016	51.39	62.28	218		60	B	
1948	07/02/2016	51.34	61.81	185		60	B	
1951	07/02/2016	51.37	61.46	138		60	B	
1952	07/02/2016	51.18	61.36	136		60	B	
1954	08/02/2016	51.10	61.92	191		60	B	
1957	08/02/2016	50.94	61.89	179		60	B	
1959	08/02/2016	50.92	62.30	187		60	B	
1961	08/02/2016	51.12	62.34	192		60	B	
1962	08/02/2016	50.93	62.66	168		60	B	
1964	08/02/2016	50.84	62.62	167	1	30	I	
1965	08/02/2016	50.85	62.66	166	50	30	I	
1966	09/02/2016	50.70	62.43	169		60	B	
1969	09/02/2016	50.80	63.01	153		60	B	
1971	09/02/2016	50.47	62.77	147		60	B	
1973	09/02/2016	50.22	62.63	145		60	B	
1974	10/02/2016	50.35	62.46	150		60	B	
1977	10/02/2016	50.54	62.20	167		60	B	
1978	10/02/2016	50.65	61.81	179		60	B	
1981	10/02/2016	50.37	61.72	162		60	B	
1983	10/02/2016	50.11	61.80	159		60	B	
1984	10/02/2016	50.10	61.80	158	1	30	I	
1985	10/02/2016	50.13	61.83	159	40	30	I	
1986	11/02/2016	50.25	61.97	157		60	B	
1989	11/02/2016	50.11	62.47	145		60	B	
1990	11/02/2016	49.91	62.23	146		60	B	
1993	11/02/2016	49.92	61.91	155		60	B	
1994	11/02/2016	49.99	61.53	156		60	B	

1996	12/02/2016	50.68	61.30	140		60	B	
1999	12/02/2016	50.43	61.29	160		60	B	
2001	12/02/2016	50.39	60.93	154		60	B	
2003	12/02/2016	50.37	60.43	153		60	B	
2004	12/02/2016	50.36	60.45	154	1	30	I	full of juvenile MUG
2005	12/02/2016	50.37	60.46	154	25	30	I	full of juvenile MUG
2006	13/02/2016	50.14	60.35	161		60	B	
2009	13/02/2016	49.87	60.39	166		60	B	
2011	13/02/2016	50.10	60.85	160		60	B	
2013	13/02/2016	50.11	61.19	158		60	B	
2014	14/02/2016	49.88	60.78	163		60	B	
2017	14/02/2016	49.82	61.07	163		60	B	
2019	14/02/2016	49.61	61.19	162		60	B	
2021	14/02/2016	49.64	61.55	158		60	B	
2022	14/02/2016	49.48	61.34	162		60	B	
2024	15/02/2016	49.58	60.91	168		60	B	
2027	15/02/2016	49.37	60.76	175		60	B	
2029	15/02/2016	49.22	61.02	171		60	B	
2031	15/02/2016	49.10	60.72	198		60	B	
2033	15/02/2016	48.96	60.54	255		60	B	
2034	15/02/2016	48.98	60.51	257	1	30	I	
2035	15/02/2016	48.99	60.51	258	80	30	I	
2037	16/02/2016	48.89	60.02	402		120	B	
2039	16/02/2016	48.66	60.25	385		120	B	
2041	16/02/2016	48.67	60.77	242		60	B	
2043	17/02/2016	49.28	60.25	248		60	B	
2046	17/02/2016	49.59	60.32	172		60	B	
2048	17/02/2016	49.59	59.92	195		60	B	
2050	17/02/2016	49.89	59.89	166		60	B	
2052	17/02/2016	49.98	59.80	162	1	30	I	
2053	17/02/2016	49.96	59.79	164	50	30	I	
2054	18/02/2016	50.02	59.62	161		60	B	
2057	18/02/2016	50.15	59.31	153		60	B	
2059	18/02/2016	50.30	59.16	149		60	B	
2061	18/02/2016	50.34	58.81	145		60	B	
2062	19/02/2016	49.93	59.45	168		60	B	
2065	19/02/2016	49.96	58.96	166		60	B	
2067	19/02/2016	50.07	58.69	162		60	B	
2069	19/02/2016	50.18	58.40	179		60	B	
2071	19/02/2016	50.22	58.29	190	1	30	I	
2072	19/02/2016	50.20	58.26	210	50	30	I	
2073	20/02/2016	50.21	57.96	271		60	B	
2076	20/02/2016	50.33	58.07	169		60	B	
2078	20/02/2016	50.46	57.84	147		60	B	backstrap twisted, trawl was repeated (st. 2081)
2079	20/02/2016	50.70	58.15	135		60	B	
2081	21/02/2016	50.47	57.83	142		60	B	repeat of station 2078
2083	21/02/2016	50.54	57.64	139		60	B	
2085	21/02/2016	50.66	57.38	134		60	B	
2086	21/02/2016	50.77	57.42	130		60	B	
2088	21/02/2016	50.96	57.76	131		60	B	
2090	22/02/2016	50.87	57.08	126		60	B	
2093	22/02/2016	50.93	56.90	119		60	B	
2095	22/02/2016	51.04	56.99	115		60	B	
2097	22/02/2016	51.17	57.44	93		60	B	

2.2 Trawl gear

The FIFD 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 DNRFD 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 the 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 three 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 other stations where no CF sample was collected, the DNRFD stipulated Conversion Factor was used to calculate green weight.

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 except *D. gahi* for which 200 specimens were taken. 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 condrichtyans (see observer manual). Length frequencies were recorded using one electronic fishmeter or fish measuring board and paper form when necessary.

Otolith extraction was undertaken for 20 finfish species (taken at sea) and statoliths were extracted ashore from *I. argentinus* and *D. gahi* (associated information were length, weight, sex and maturity). Vertebrae/thorn samples were taken from 2 species of skates (9 from *Bathyraja brachyurops* and 5 from *Bathyraja multispinis*).

Southern blue whiting, common hake and Patagonian hake, besides collecting the usual data for otolith collection, a piece of tissue for genetic analysis was collected for a maximum of 50 specimens throughout the survey. These samples were provided to Dr. Alexei Orlov from Russian Federal Institute of Fisheries and Oceanography (VNIRO). A piece of flesh from one specimen of *Micromesistius a. australis*, *Illex argentinus*, *Genypterus blacodes*, *Iluocoetes fimbriatus*, *Macruronus magellanicus*, *Salilota australis*, *Champsocephalus esox*, *Patagonotothen ramsayi*, *Sprattus fuegensis*, *Merluccius hubbsi*, *Merluccius australis*, *Dissostichus eleginoides*, *Doryteuthis gahi*, *Moroteuthis ingens* and *Coelorinchus fasciatus* was collected and provided to SAERI for Julie McInnes' project on albatross stomach content analysis. This project is a collaboration between University of Tasmania, SAERI and Falklands Conservation. Samples of *Sprattus fuegensis*, *Macruronus magellanicus*, *Patagonotothen ramsayi*, *Coelorhynchus fasciatus*, *Merluccius hubbsi*, *Doryteuthis gahi*, *Onykia ingens*, *Munida gregaria*, *Salpa thompsoni*, *Mnemiopsis leidyi* and jellyfish (*Chrysaora* sp. and *Desmonema* sp.) were collected for Dr Paulo Catry from ISPA (Portugal) for stable isotope analyses in the framework of a black browed albatross diet study. Themisto were collected for Dr Charlotte Havermans from Alfred Wegener Institute, Germany for agenetic study.

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:

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

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 (6371 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 Geostatistic methods

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

As the protocol was to conduct one station per grid square, the kriging area boundaries were first defined using the grid squares (Pompert et al., 2014; Gras et al., 2015). The kriging area was modified in the framework of this research cruise in order to better take into account the shape of FICZ/FOCZ. The total area increased from 102,617 to 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 and using measured horizontal net opening for 2016 dataset and time series displayed for every species.

2.7 Plankton survey

The DNRFD Nichimo made 6 foot Isaacs–Kidd Mid–water Trawl net (or IKMT) with the following dimensions was used: top width bar (140 cm) and net (143 cm), 96 cm + 96 cm, height 175 cm. The mouth is slightly trapezoid (bottom being wider than the top), resulting in a mouth opening area of approximately 2.9 m^2. The mesh of the main net is square mesh with ~4 mm across, and ~6 mm for the diagonals, covered externally by protective netting. The cod–end holding a 3.3 l Nalgene sample bottle is fitted to the main net with four carabiners, allowing for a gap of approximately 5 cm between the two nets. The square mesh of the cod–end is ~1 mm across, ~1.5 mm for the diagonals. Protective netting also covers the finer cod–end netting. A Valeport flowmeter Model 106 (s/n: 18466) was also fitted in the mouth of the plankton net. This flowmeter records date/time, depth (m), speed (m/s), direction (degrees), pressure (dBar), and temperature (degrees C). As in November 2015, on many occasions the values from the pressure and temperature sensors had recorded numerous nonsensical values, and so the depth and temperature values could not be consistently used. Other parameters such as the speed and date/time were not affected. A Marport net monitoring sensor was fitted on the top of the net so that the position and depth of the net could be monitored from the bridge.

2.8 Oceanography

A single CTD (SBE–25, Sea–Bird Electronics Inc., Bellevue, USA) instrument was used to collect oceanographic data in the vicinity of all trawl stations, Serial No 0247. At all CTD stations the CTD was deployed to a depth of c.10 m below surface for a soak time of more than one minute, to allow the pump to start circulating water and flush the system, following this the CTD was raised to a minimum depth of 5 m below surface. The CTD was then lowered toward sea bed at 1 m.s^{-1}. The CTD collected pressure in dbar, temperature in °C, conductivity in mS/cm, Oxygen Voltage and Fluorescence. The raw hex file was converted and processed using SBE Data Processing Version.7.22.5 using the CON files 0247OldCTD_2016_Jan.xmlcon. Up–cast data was filtered out. Depth was derived from pressure using the latitude of each station, with dissolved oxygen in ml.l^{-1} 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^{-1}) 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 90 stations as shown in Figure 1 and Table 1. Station 2078 was repeated (st. 2081). Seabed trawling times during the survey were 60 minutes for 87 of the trawls, but only 25 mn at st. 1930, as the doors closed due to sudden jellyfish ingress into the net. Two of the trawls conducted were 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. 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 101,560.020 kg of biomass was caught comprising 133 species or taxa (Appendix Table 2). The largest catches by weight, all exceeding 1,000 kg in total, were common rock cod (*Patagonotothen ramsayi*), hoki (*Macruronus magellanicus*), red cod (*Salilota australis*), kingclip (*Genypterus blacodes*), southern blue whiting (*Micromesistius australis*), compass jellyfish (*Chrysaora cf. plocamia*), banded whiptail grenadier (*Coelorhynchus fasciatus*), Falkland herring (*Sprattus fuegensis*), Falkland calamari (*Doryteuthis gahi*), and the brown jellyfish (*Desmonema cf. chierchianum*), together amounting to 92% of the total catch. Table 4 in the appendix lists numbers of specimens analysed from randomly collected samples. 326 specimens of two squid species had their statoliths extracted, 2,951 otoliths were extracted from 15 different fish species, and 14 vertebrae and thorns from two skate species.

3.2 Biological information of finfish species

3.2.1 *Patagonotothen ramsayi* – common rock cod – PAR

A total of 31,648 kg of common rock cod was caught at all the 89 trawl stations sampled (Figure 2). Catches ranged from 0.42 to 5,569 kg. Among the 89 stations, 81 yielded >10 kg of rock cod, 58 yielded >100 kg, 17 yielded >500 kg and 7 stations yielded >1 t. Densities ranged from 2.06 to 30,991 kg.km^{-2} (CPUE ranged 0.42–5,269 kg.h^{-1}). Highest densities were recorded in the northwest and in the northeast of the surveyed zone. Biological data showed that the northwest hot spot consists of big animals while the northeast consists of small animals. A total of 9,341 specimens were assessed (116 juveniles, 4,591 females, 4,633 males and 1 undetermined), 8,917 for length frequency, 1 for length–weight relationship and 423 for otolith collection. Minimum total length regardless of the sex was 9 cm and maximum length was 15, 39 and 38 cm for juveniles, females and males respectively. The length frequency histogram exhibits 3 cohorts (with modes at 13, 20 and 27 cm). Females were observed immature (17%), resting (77%), early developing (2%), late developing (0.1%), ripe (0.1%) spent (0.7%) or recovering spent (2%). Males were immature (21%), resting (77%), early developing (2%) and recovering spent (0.2%).

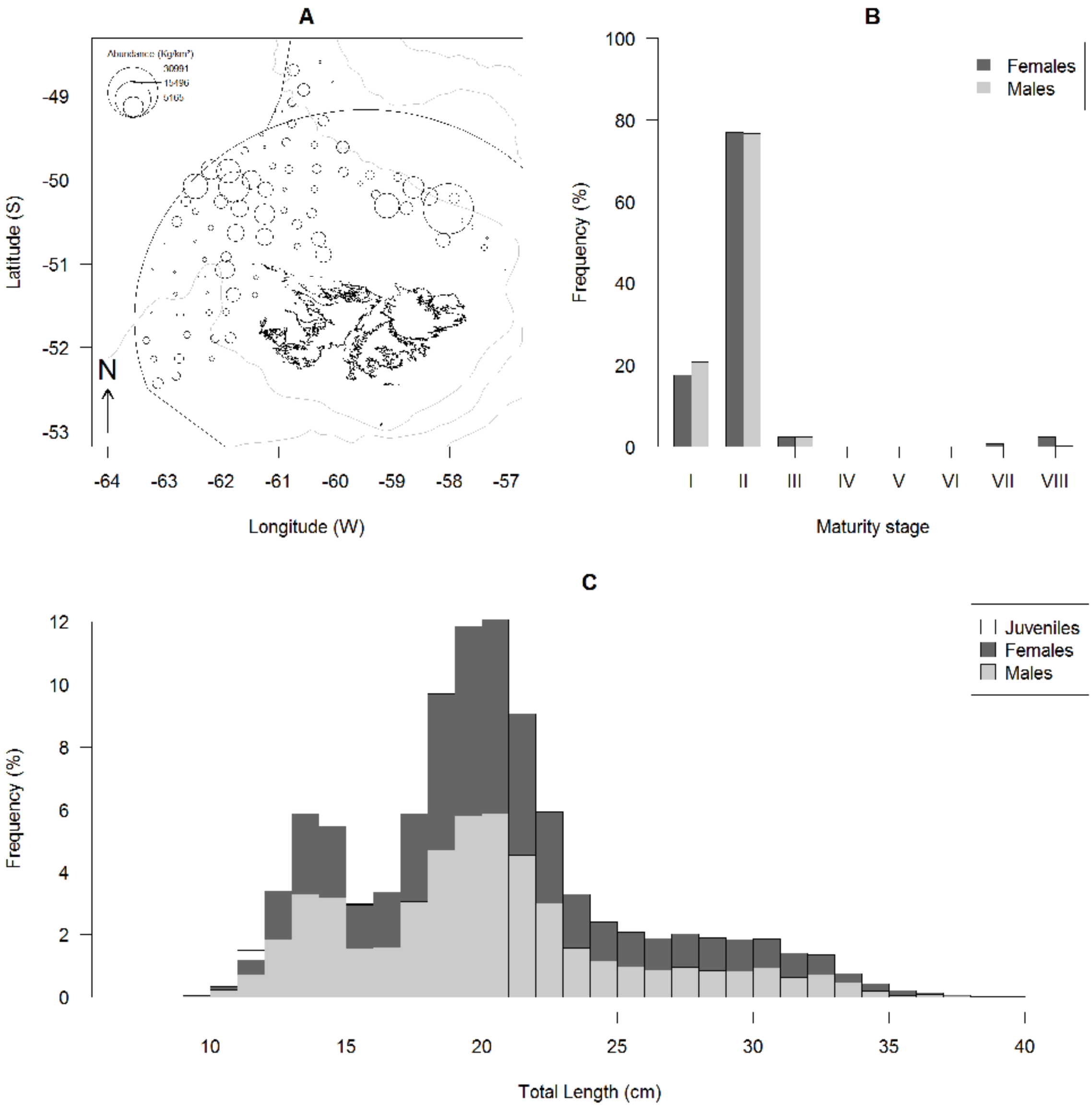


Figure 2: Biological data of *Patagonotothen ramsayi* (common rock cod, PAR), map of the densities in kg.km^{-2} (A), percentage of specimens of each sex per maturity stage (B; I, immature; II, resting; III, early developing; IV, late developing; V, ripe; VI, running; VII, spent; VIII, recovering spent)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

3.2.2 *Macruronus magellanicus* – hoki – WHI

A total of 21,666 kg of hoki was caught at 63 of the 89 trawl stations sampled (Figure 3). Catches ranged from 0.23 to 6,752 kg. Among the 63 stations, 52 yielded >1 kg, 22 yielded >10 kg, 13 yielded >100 kg and 5 yielded >1 t. Densities ranged from 1.09 to 34,997 kg.km^{-2} (CPUE ranged 0.23–6,752 kg.h^{-1}). Hoki was caught throughout the surveyed area, in small quantities in stations shallower than 200 m and in high quantities in the southwest stations deeper than 200 m. A total of 1,950 specimens were assessed (1,177 females and 773 males), 1,629 for length frequency, 4 for length–weight relationship and 317 for otolith collection. Minimum size was 15 cm pre–anal length for both species and maximum size was 43 and 39 cm for females and males respectively. The length frequency histogram exhibits 1 cohort (with mode at 22 cm). Further analyses are required to identify the cohorts. Females were observed immature (0.3%), resting (96%), early developing (2%), spent (0.1%) or recovering spent (1.5%). Males were immature (2%), resting (82%), early developing (14%), late developing (1.5%) or recovering spent (0.5%).

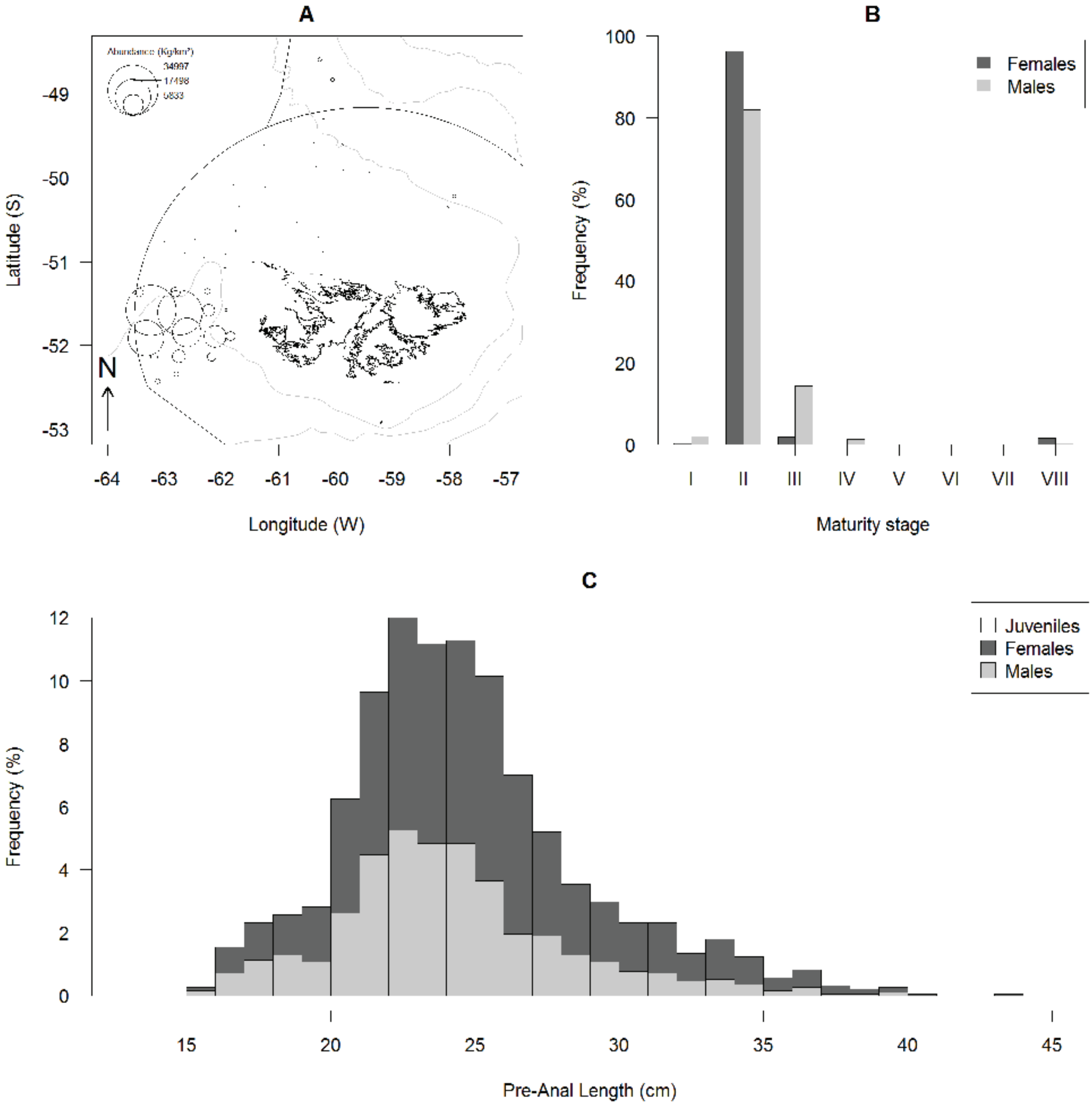


Figure 3: Biological data of *Macruronus magellanicus* (hoki, WHI), map of the densities in kg.km^{-2} (A), percentage of specimens of each sex per maturity stage (B; I, immature; II, resting; III, early developing; IV, late developing; V, ripe; VI, running; VII, spent; VIII, recovering spent) and length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

3.2.3 *Salilota australis* – red cod – BAC

A total of 18,643 kg of red cod was caught at 78 of the 89 trawl stations sampled (Figure 4). Catches ranged from 0.05 to 7,208 kg. Among the 78 stations, 11 yielded >100 kg of red cod and 3 yielded >1 t in the net. Densities ranged from 0.28 to 38,175 kg.km^{-2} (CPUE ranged 0.05–7,208 kg.h^{-1}). Red cod was caught throughout the surveyed area and the highest densities were observed in the northwest of the finfish zone, especially between 51°S and 50°S alongside the FICZ limit. A total of 4,933 specimens were assessed (117 juveniles, 2,468 females, 2,154 males and 194 undetermined), 5 for length–weight relationship and 479 for otolith collection. Juveniles ranged from 10 to 17 cm and males and females ranged from 11 to 80 cm. The length frequency histogram exhibits 3 cohorts (with modes at 17, 24 and 32 cm). Beyond 32 cm, cohorts are hardly identifiable. Females were observed immature (25%), resting (73%), spent or recovering spent (2%). Males were immature (37%), resting (49%) early developing (11%), late developing (3%) and less than 0.5% were spent or recovering spent.

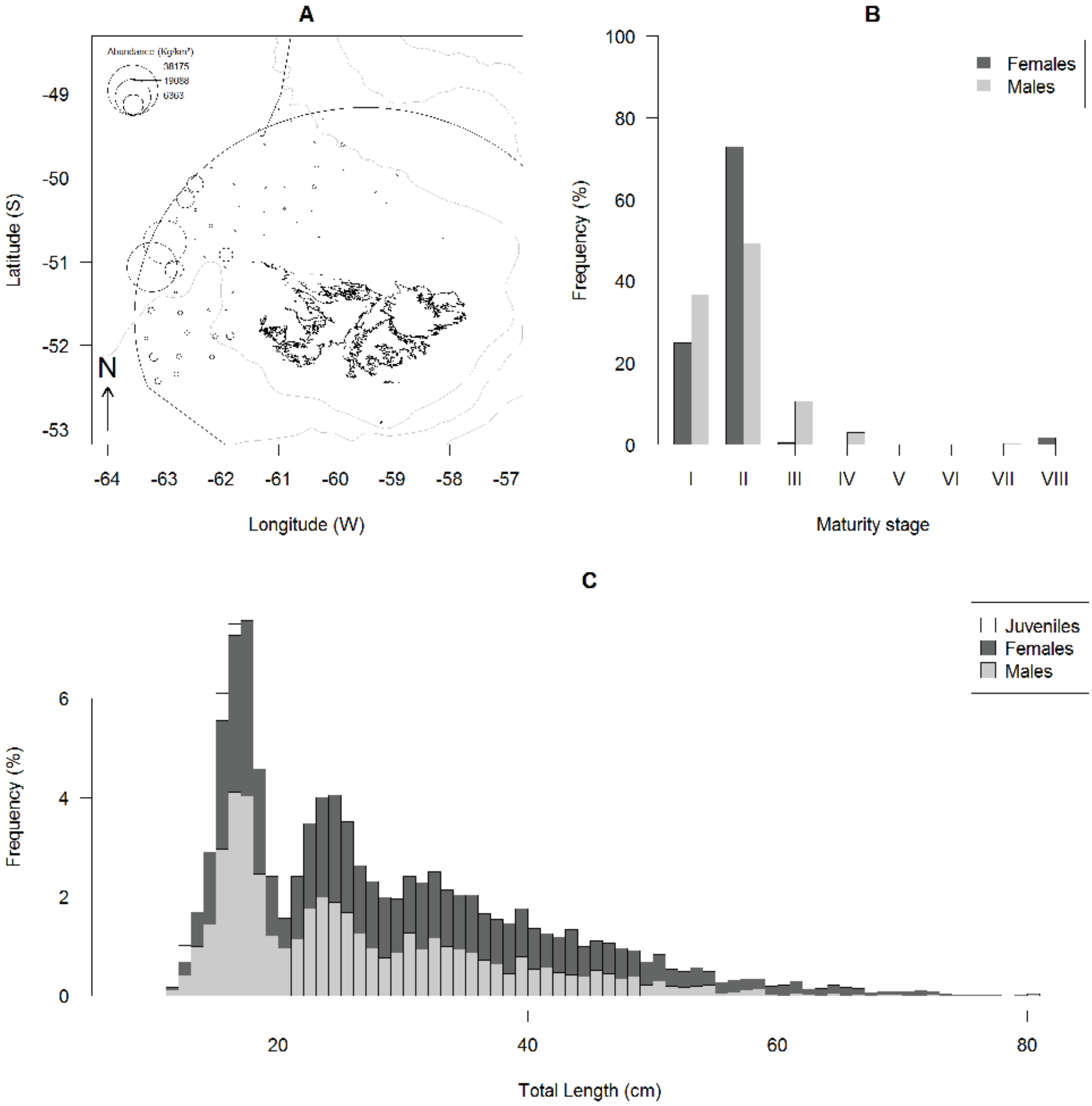


Figure 4: Biological data of *Salilota australis* (red cod, BAC), map of the densities in kg.km^{-2} (A), percentage of specimens of each sex per maturity stage (B; I, immature; II, resting; III, early developing; IV, late developing; V, ripe; VI, running; VII, spent; VIII, recovering spent) and length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

3.2.4 *Genypterus blacodes* – kingclip – KIN

A total of 5,402 kg of kingclip was caught at 67 of the 89 trawl stations sampled (Figure 5). Catches ranged from 0.06 to 1,685 kg. Among the 67 stations, 37 yielded >10 kg of kingclip, 9 yielded >100 kg and 1 yielded >1 t. Densities ranged from 0.29 to 7,971 kg.km^{-2} (CPUE ranged 0.06–1,685 kg.h^{-1}). Catches occurred throughout the surveyed zone in stations shallower than 200 m. A total of 1,767 specimens were assessed (1,084 females and 683 males), 994 for length frequency, 4 for length–weight relationship and 769 for otolith collection. Females ranged from 35 to 129 cm and males ranged from 17 to 117 cm. The length frequency histogram does not exhibit any cohort and a series of mode can be seen on the figure. Females were observed immature (1%), resting (83%), early developing (9%), late developing (4%), ripe (2%) or recovering spent (1%). Males were immature (4%), resting (74%), early developing (14%), late developing (7%), ripe (0.3%) spent (0.1%) or recovering spent (0.6%).

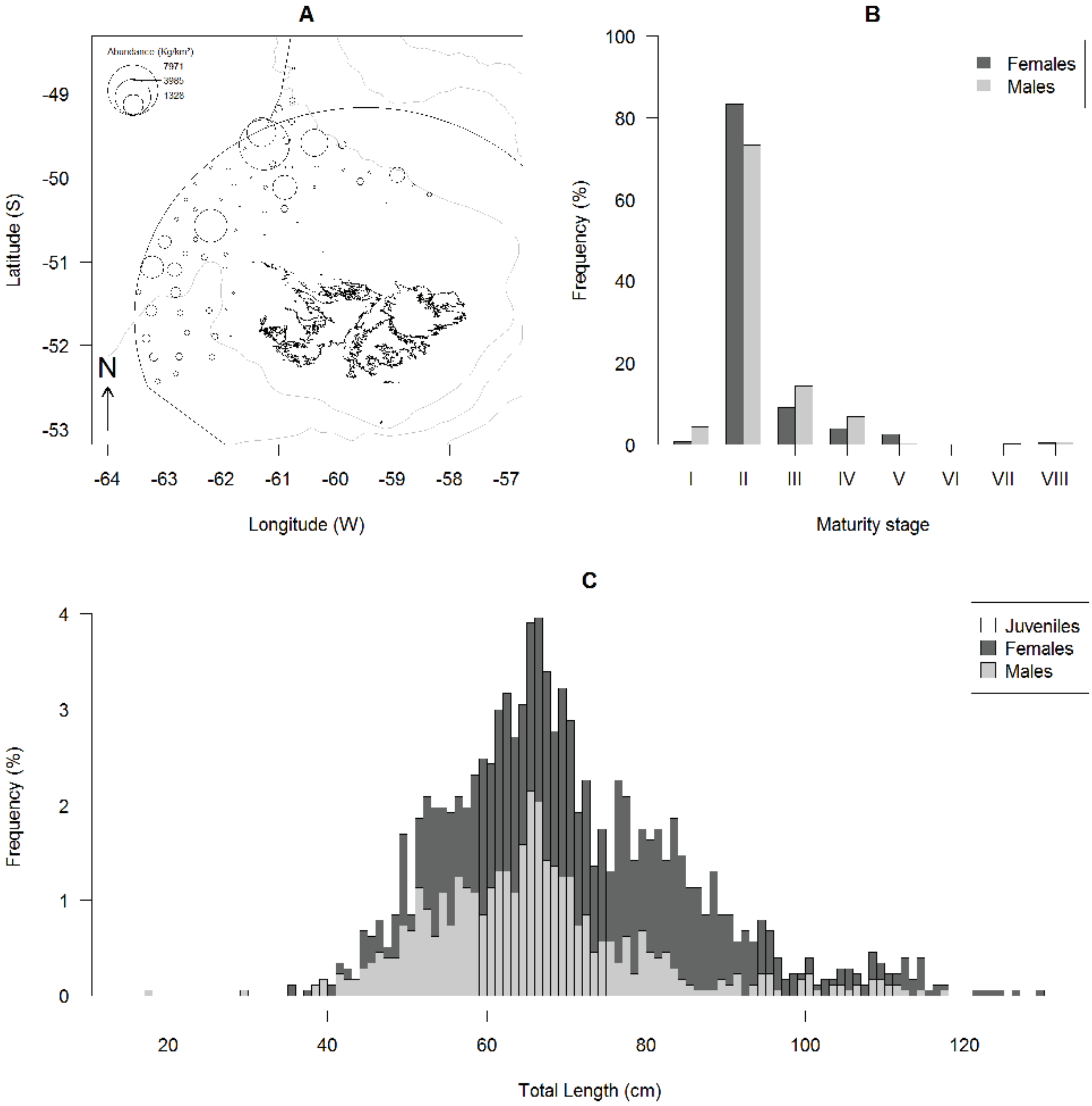


Figure 5: Biological data of *Genypterus blacodes* (kingclip, KIN), map of the densities in kg.km^{-2} (A), percentage of specimens of each sex per maturity stage (B; I, immature; II, resting; III, early developing; IV, late developing; V, ripe; VI, running; VII, spent; VIII, recovering spent) and length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

3.2.5 *Micromesistius a. australis* – Southern blue whiting – BLU

A total of 3,178 kg of southern blue whiting was caught at 28 of the 89 trawl stations sampled (Figure 6). Catches ranged from 0.02 to 976 kg. Among the 28 stations, 10 yielded >10 kg of southern blue whiting and 6 stations yielded >100 kg in the net. Densities ranged from 0.12 to 6,141 kg.km^{-2} (CPUE ranged 0.02–976 kg.h^{-1}). Southern blue whiting was caught during deep stations (>200 m depth), in the southeast and in the north of the surveyed area. A total of 1,025 specimens were sampled (17 juveniles, 403 females and 592 males and 13 undetermined), 900 for length frequency, 1 for length–weight relationship and 124 for otolith collection. Juveniles ranged from 8 to 11 cm, females from 16 to 66 cm and males from 18 to 63 cm. The length frequency histogram exhibits 3 cohorts (with modes at 10, 23 and 36 cm). Females were observed immature (31%), resting (67%) or recovering spent (2%). Males were immature (22%), resting (61%), early developing (11%) or recovering spent (6%). Specimens were mainly at the beginning of the maturation process because reproduction period occurs in winter in the southwest of the finfish zone.

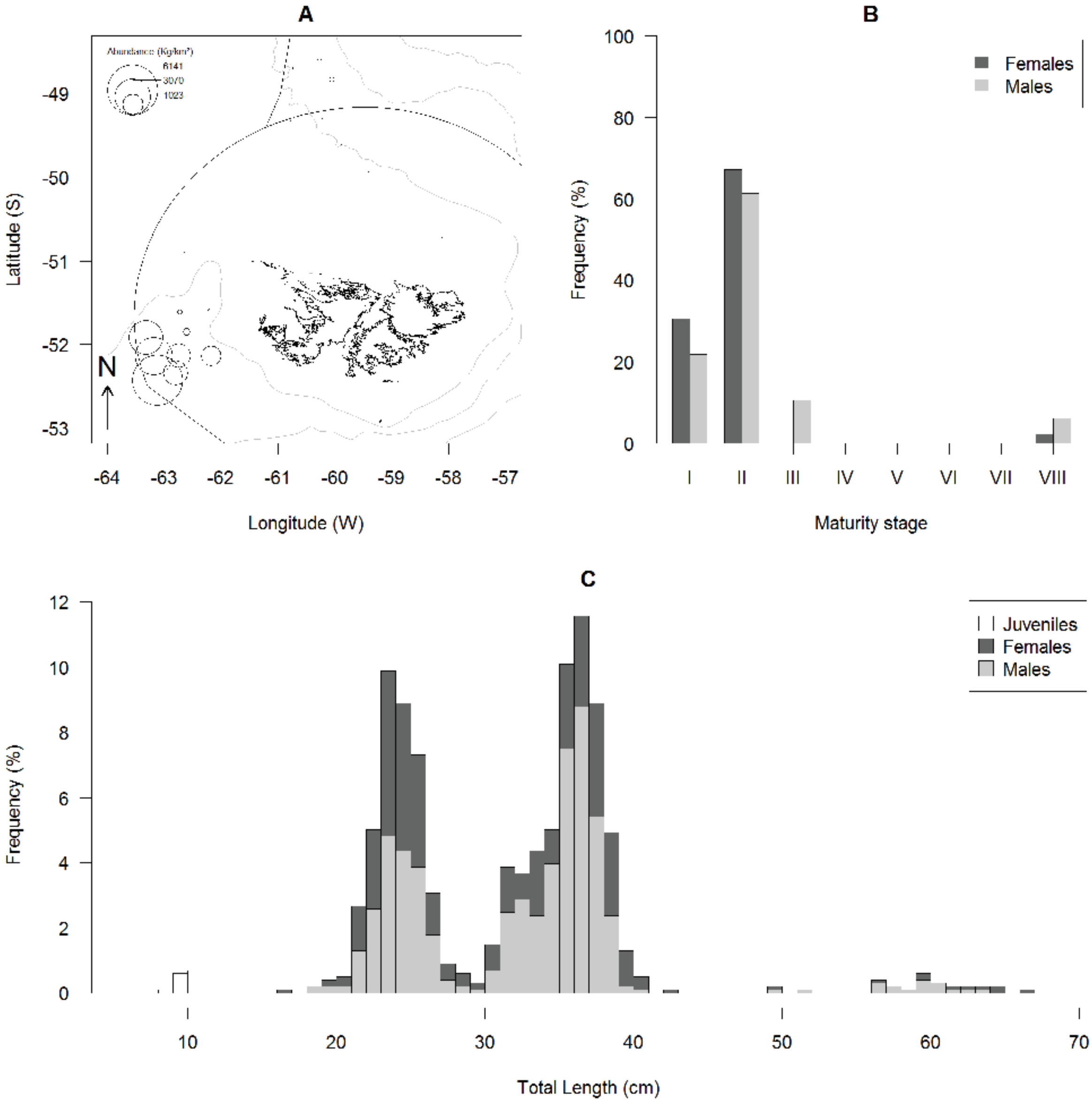


Figure 6: Biological data of *Micromesistius a. australis* (southern blue whiting, BLU), map of the densities in kg.km^{-2} (A), percentage of specimens of each sex per maturity stage (B; I, immature; II, resting; III, early developing; IV, late developing; V, ripe; VI, running; VII, spent; VIII, recovering spent) and length frequency (in percentage of the total sample assessed) of each sex with 1 cm size class (C).

3.2.6 *Coelorinchus fasciatus* – banded whiptail grenadier – GRF

A total of 2,702 kg of banded whiptail grenadier was caught at 13 of the 89 trawl stations sampled (Figure 7). Catches ranged from 1.08 to 874 kg. Among the 13 stations, 8 yielded >100 kg of grenadier and 2 yielded >500 kg. Banded whiptail grenadier was caught in stations deeper than 200 m, especially in the southwest of the surveyed area. Densities ranged from 3.29 to 4,186 kg.km^{-2} (CPUE ranged 0.54–874 kg.h^{-1}). A total of 195 specimens were assessed (112 females and 83 males), all for length frequency. Females ranged from 7 to 12 cm pre–anal length and males ranged from 6 to 11 cm. The length frequency histogram exhibits 1 cohort (with mode at 9 cm). Females were observed immature (3%), resting (32%), early developing (61%) and late developing (4%). Males were immature (1%), resting (66%), early developing (28%) and late developing (5%).

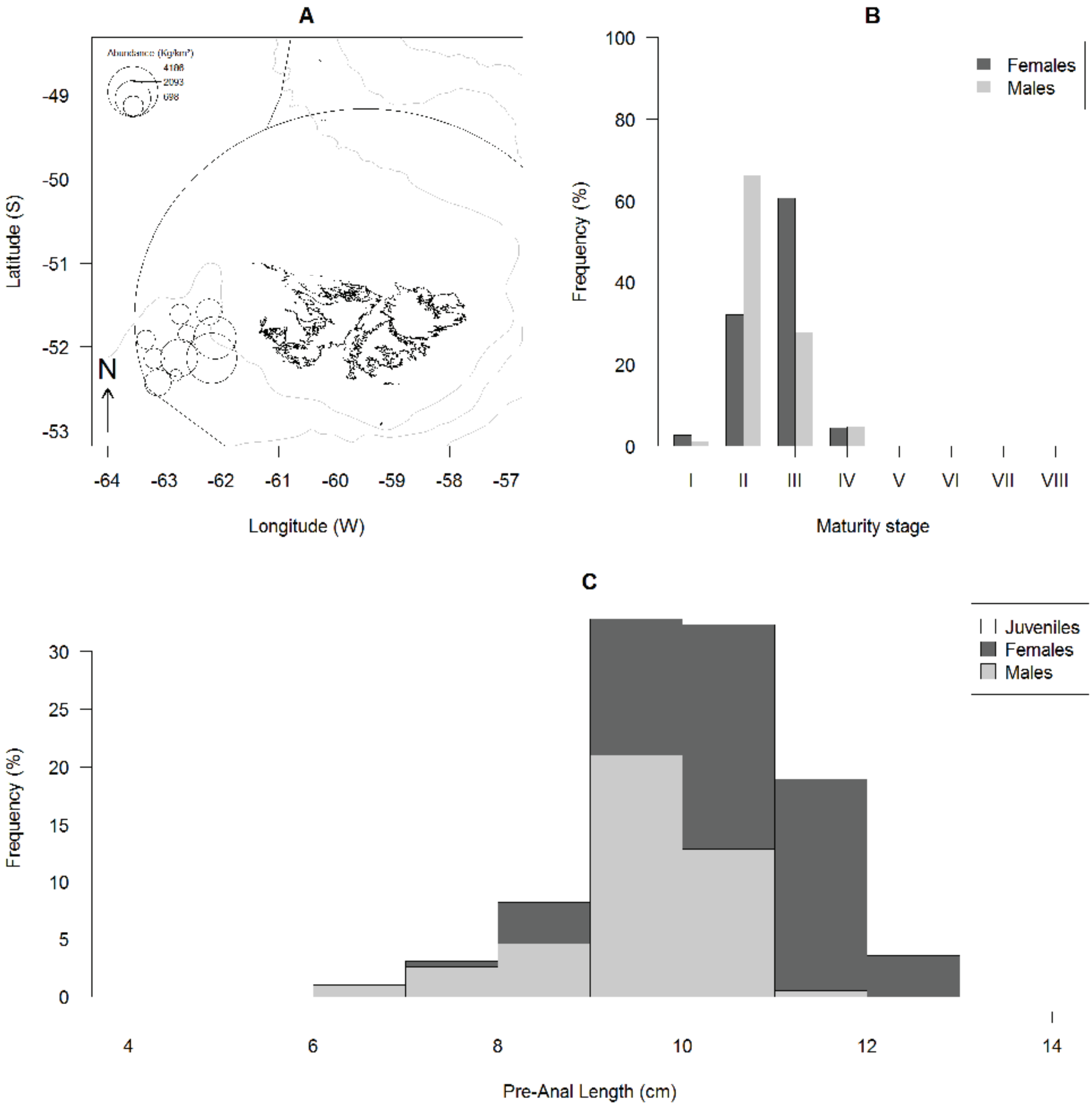
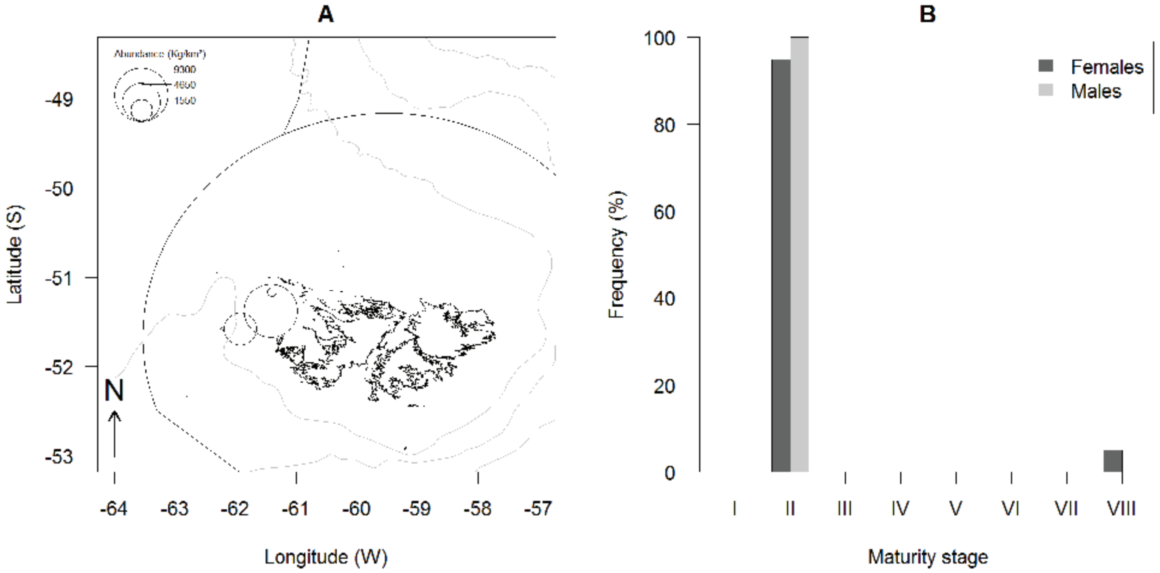


Figure 7: Biological data of *Coelorinchus fasciatus* (banded whiptail grenadier, GRF), map of the densities in kg.km^{-2} (A), percentage of specimens of each sex per maturity stage (B; I, immature; II, resting; III, early developing; IV, late developing; V, ripe; VI, running; VII, spent; VIII, recovering spent) and length frequency (in percentage of the total sample assessed) of each sex with 1 cm size class (C).

3.2.7 *Sprattus fuegensis* – Falkland herring – SAR

A total of 2,421 kg of Falkland herring was caught at 11 of the 89 trawl stations sampled (Figure 8). Catches ranged from 0.005 to 1,732 kg. Among the 11 stations, 4 yielded >1 kg, 2 yielded >500 kg and 1 yielded more than 1,500 kg of Falkland herring. Densities ranged from 0.02 to 9,300 kg.km^{-2} (CPUE ranged 0.005–1,732 kg.h^{-1}). A total of 205 specimens were assessed (99 females and 106 males), all for length frequency. Minimum size was 15 cm for both sexes and maximum size was 21 and 22 cm for females and males respectively. The length frequency histogram exhibits 2 cohorts (with modes at 16 and 19 cm). Females were observed resting (95%) or (5%) and males were all resting.



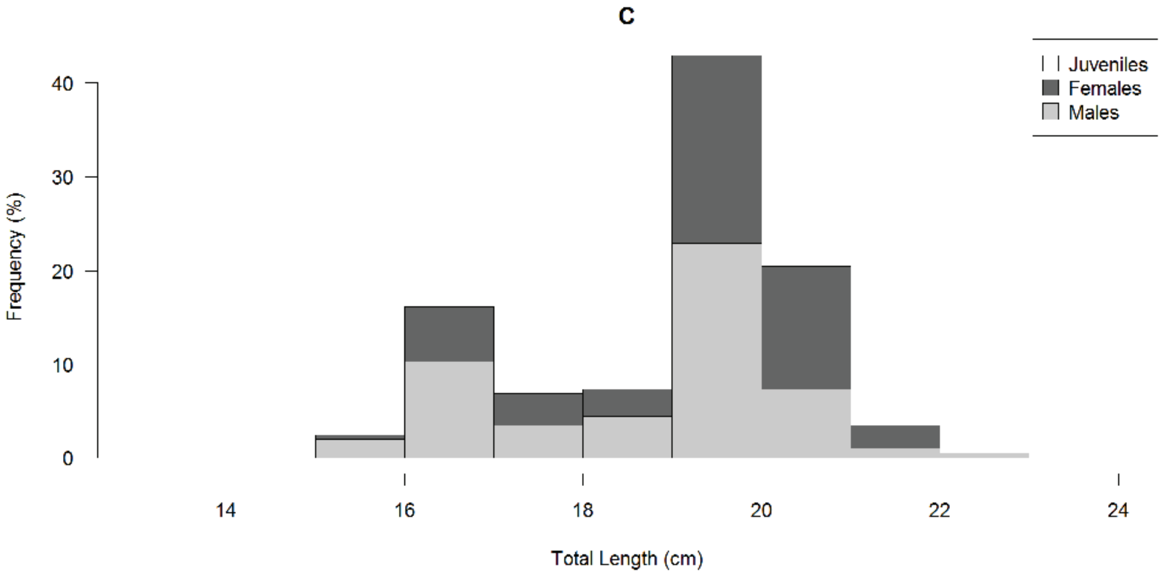


Figure 8: Biological data of *Sprattus fuegensis* (Falkland herring, SAR), map of the densities in kg.km^{-2} (A), percentage of specimens of each sex per maturity stage (B; I, immature; II, resting; III, early developing; IV, late developing; V, ripe; VI, running; VII, spent; VIII, recovering spent) and length frequency (in percentage of the total sample assessed) of each sex with 1 cm size class (C).

3.2.8 *Dissostichus eleginoides* – Patagonian toothfish – TOO

A total of 731 kg of toothfish was caught at 71 of the 89 trawl stations sampled (Figure 9). Catches ranged from 0.01 to 74.2 kg. Among the 71 stations, 57 yielded >1 kg of toothfish, 20 yielded >10 kg. Densities ranged from 0.05 to 467 kg.km^{-2} (CPUE ranged 0.01–74.2 kg.h^{-1}). Catches occurred throughout the surveyed area and was not limited to specific depths. A total of 1,306 specimens were assessed (35 juveniles, 723 females and 548 males), 921 for length frequency, 12 for length–weight relationship and 373 for otolith collection. Juveniles ranged from 9 to 13 cm, females ranged from 23 to 89 cm and males ranged from 24 to 65 cm. The length frequency histogram exhibits 3 cohorts (with modes at 10, 31 and 47 cm). On the Patagonian shelf, catches consist of young animals of the first three cohorts. Females were observed immature (48%), resting (52%) and early developing (0.3%). Males were immature (61%) or resting (39%).

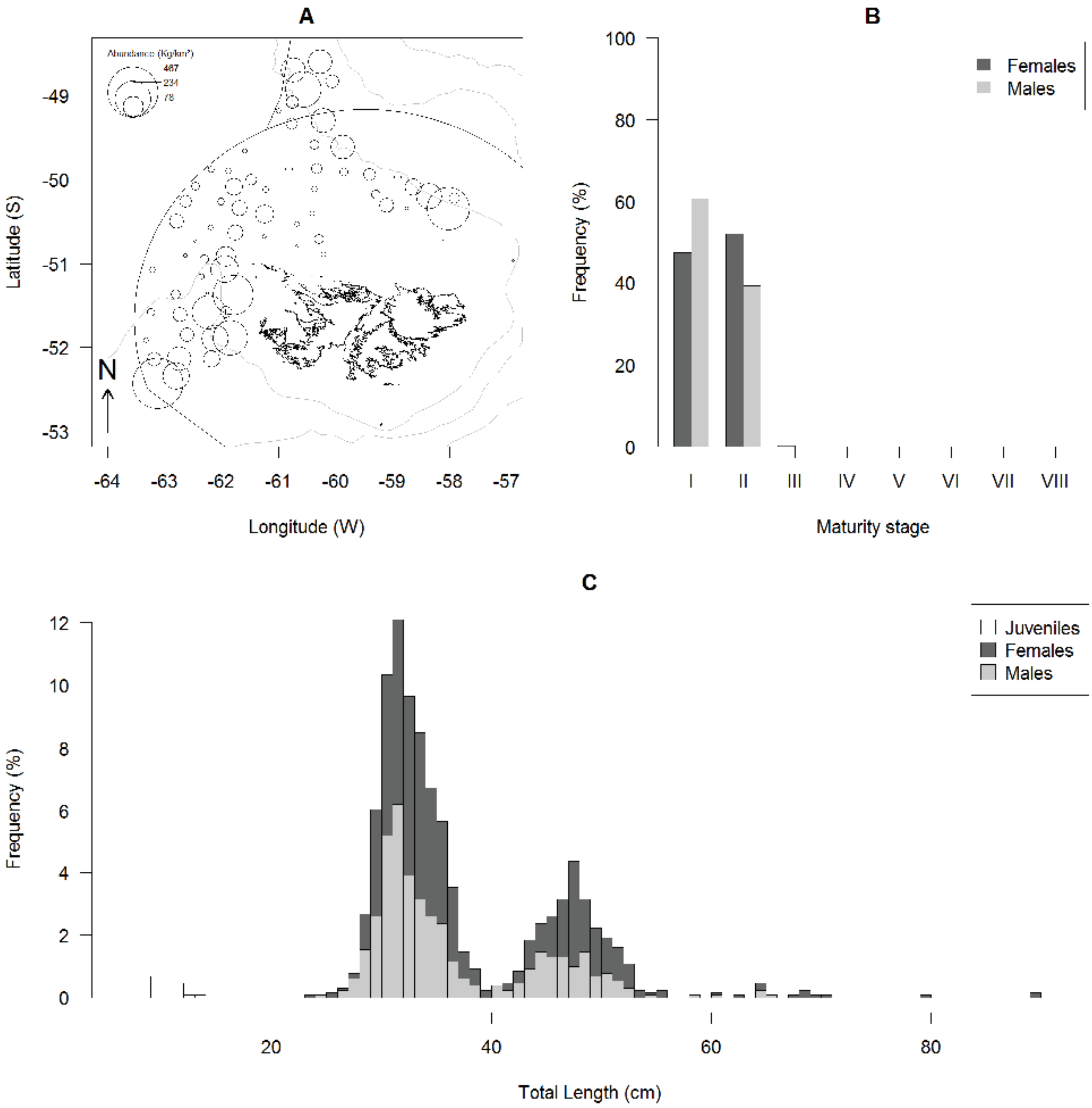


Figure 9: Biological data of *Dissostichus eleginoides* (Patagonian toothfish, TOO), map of the densities in kg.km^{-2} (A), percentage of specimens of each sex per maturity stage (B; I, immature; II, resting; III, early developing; IV, late developing; V, ripe; VI, running; VII, spent; VIII, recovering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

3.2.9 *Merluccius hubbsi* – common hake – HAK

A total of 693 kg of common hake was caught at 54 of the 89 trawl stations sampled (Figure 10). Catches ranged from 0.4 to 50.7 kg. Among the 54 stations, 24 yielded >10 kg and 1 yielded >50 kg in the net. Densities ranged from 2.1 to 245 kg.km^{-2} (CPUE ranged 0.4–50.7 kg.h^{-1}). Catches occurred in the stations shallower than 200 m to the west of 60°W and to the north of 51°N. In February, hake is on the spawning grounds in Argentine waters and migration to Falkland waters where feeding grounds are occur sometime in March–April. A total of 757 specimens were assessed (919 females and 83 males), 757 for length frequency, 4 for length–weight relationship and 241 for otolith collection. Females ranged from 32 to 79 cm and males ranged from 32 to 58 cm. Cohorts are generally difficult to identify on the length frequency histogram but modes can be seen at 42, 44, 62, 64 and 69 cm. Females were observed resting (24%), early developing (36%), late developing (3%), spent (1%) and recovering spent (36%). Males were resting (4%), early developing (8%), late developing (10%), ripe (24%), running (22%), spent (28%) and recovering spent (4%).

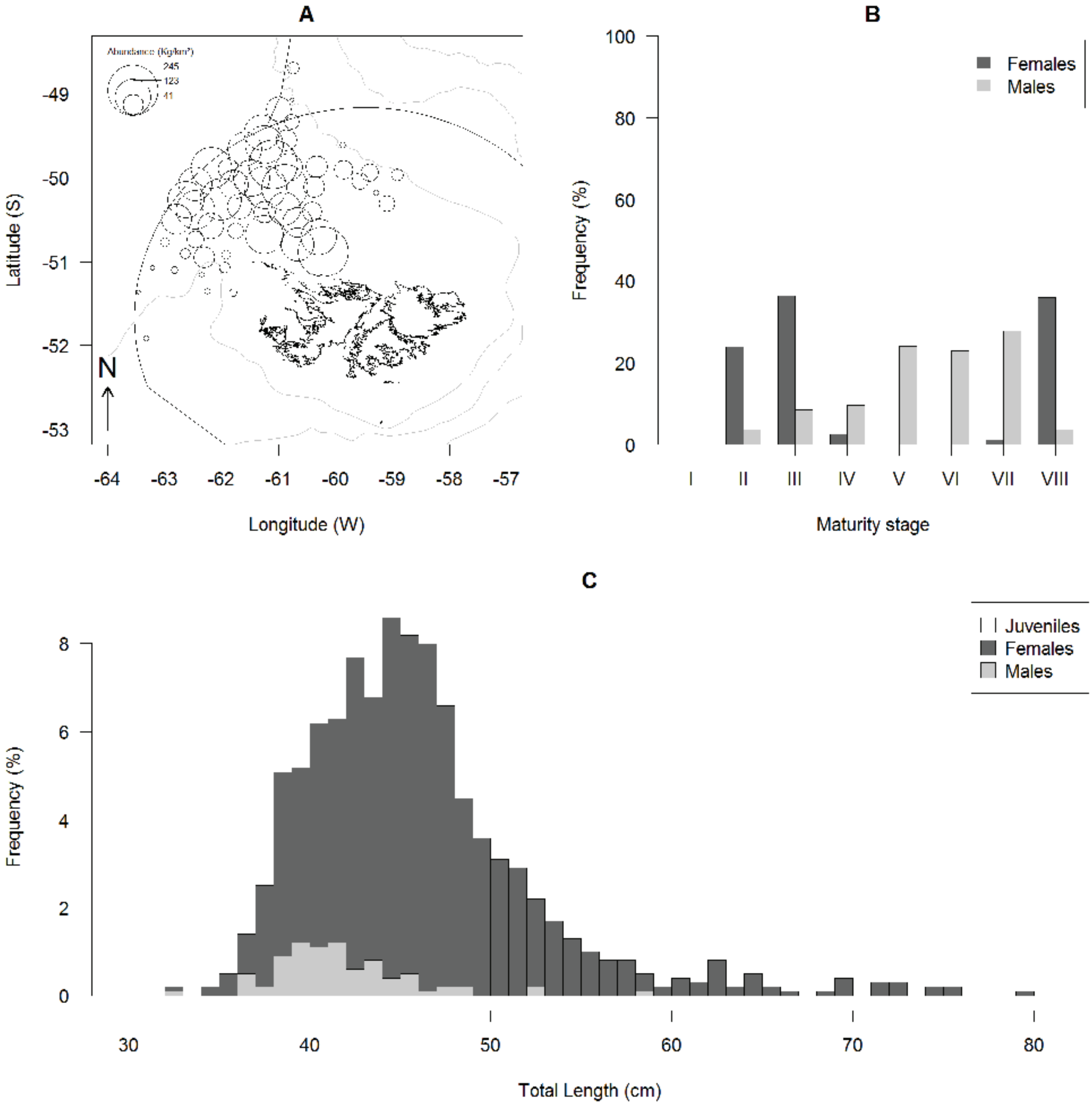


Figure 10: Biological data of *Merluccius hubbsi* (common hake, HAK), map of the densities in kg.km^{-2} (A), percentage of specimens of each sex per maturity stage (B; I, immature; II, resting; III, early developing; IV, late developing; V, ripe; VI, running; VII, spent; VIII, recovering spent) and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

3.2.10 *Cottoperca gobio* – frogmouth – CGO

A total of 542 kg of frogmouth was caught at 64 of the 89 trawl stations sampled (Figure 11). Catches ranged from 0.01 to 65 kg. Among the 64 stations, 17 yielded >10 kg of frogmouth and 2 >50 kg in the net. Densities ranged from 0.05 to 367 kg.km^{-2} (CPUE ranged 0.01–65 kg.h^{-1}). Frogmouth was caught throughout the surveyed area in stations shallower than 200 m. A total of 259 specimens were assessed (118 females and 141 males), all for length–frequency. Minimum size was observed at 9 cm for both sexes and maximum size was 46 and 59 cm for females and males respectively. The length frequency histogram exhibits 5 cohorts (with modes at 10, 17, 28, 33 and 40 cm). There could be other cohorts beyond 40 cm but their identification requires more advanced methods. Females were observed immature (20%), resting (59%), early developing (15%) or ripe (6%). Males were immature (56%), resting (40%) or early developing (4%).

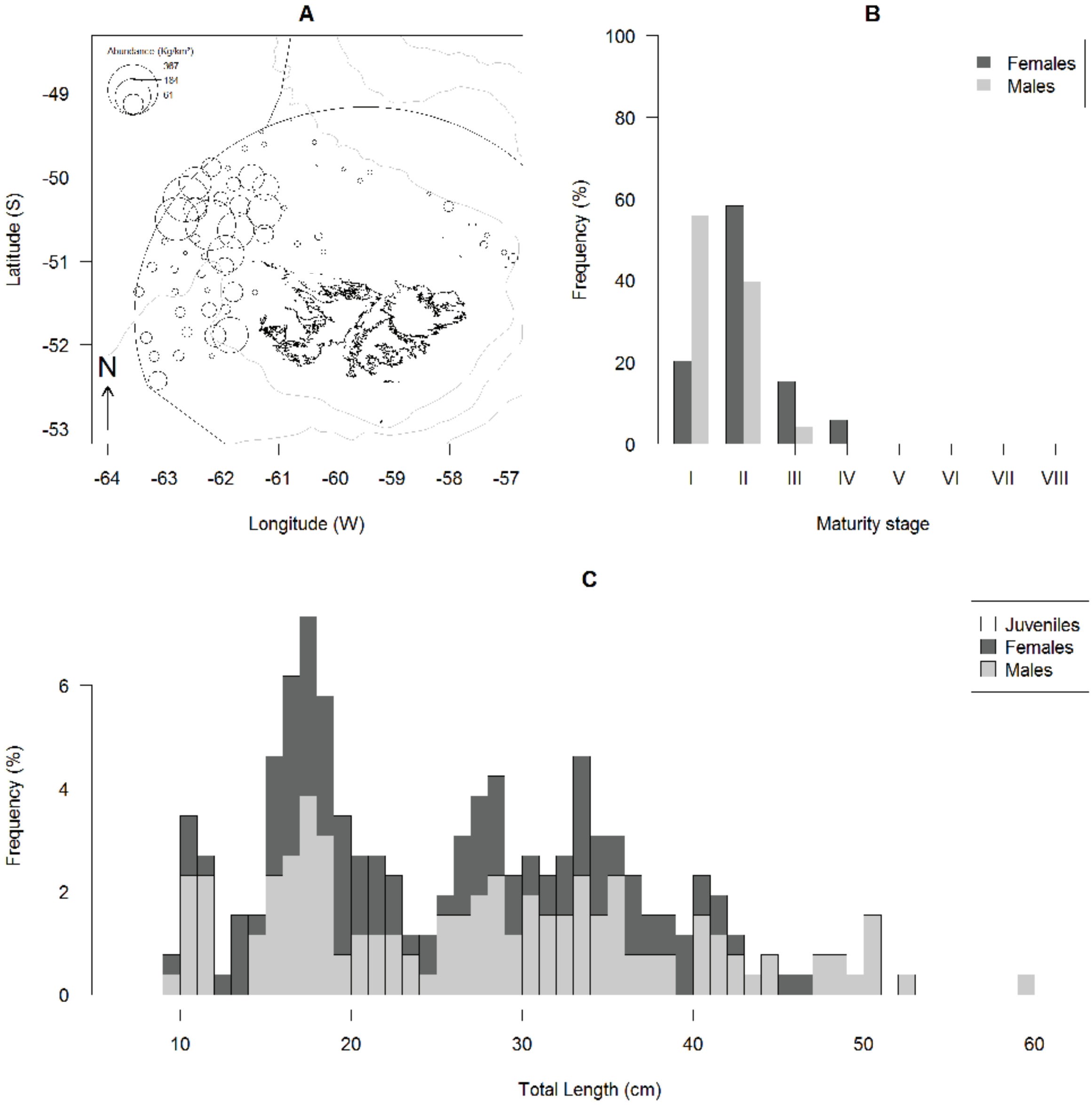


Figure 11: Biological data of *Cottoperca gobio* (frogmouth, CGO), map of the densities in kg.km^{-2} (A), percentage of specimens of each sex per maturity stage (B; I, immature; II, resting; III, early developing; IV, late developing; V, ripe; VI, running; VII, spent; VIII, recovering spent) and length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

3.2.11 *Iluocoetes fimbriatus* – eelpout – EEL

A total of 293 kg of eelpout was caught at 36 of the 89 trawl stations sampled (Figure 12). Catches ranged from 0.05 to 87.2 kg. Among the 36 stations, 6 yielded >10 kg of eelpout, and 2 yielded >50 kg in the net. Densities ranged from 0.25 to 429 $kg.km^{-2}$ (CPUE ranged 0.05–87.22 $kg.h^{-1}$). Some catches occurred in the southwest of the surveyed area in deep sea waters. The highest occurred mainly in the northern part of the finfish zone and highest catches along the 200 m bathymetric line. A total of 611 specimens were assessed (316 females and 295 males), 396 for length frequency, 193 for length–weight relationship and 22 for otolith collection. Females ranged from 16 to 38 cm and males ranged from 18 to 42 cm. The length frequency histogram exhibits 1 cohort with a mode at 27 cm. Three other modes appear at 21, 31 and 38 cm but further analyses would be required to identify the cohorts. Females were observed early developing (68%), late developing (4%) ripe (24%) running (3%) and spent (1%). Males were resting (57%), early developing (31%), late developing (4%), spent (5%) or recovering spent (3%).

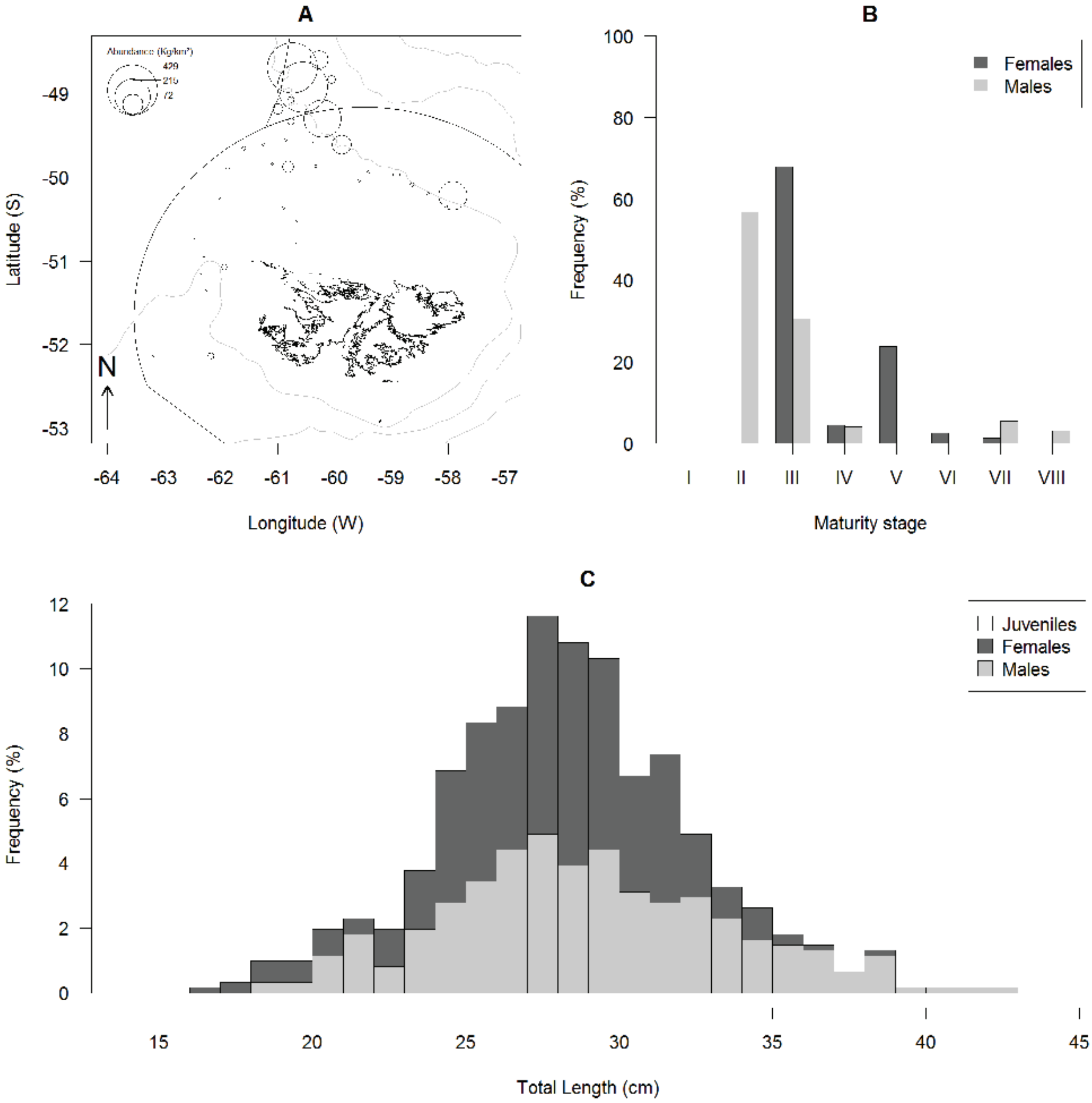


Figure 12: Biological data of *Iluocoetes fimbriatus* (eelpout, EEL), map of the densities in $kg.km^{-2}$ (A), percentage of specimens of each sex per maturity stage (B; I, immature; II, resting; III, early developing; IV, late developing; V, ripe; VI, running; VII, spent; VIII, recovering spent) and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

3.2.12 *Squalus acanthias* – spiny dogfish – DGS

A total of 225 kg of spiny dogfish was caught at 26 of the 89 trawl stations sampled (Figure 13). Catches ranged from 0.25 to 130 kg. Among the 26 stations, 2 yielded >10 kg of dogfish and 1 yielded >100 kg in the net. Densities ranged from 1.2 to 664 kg.km^{-2} (CPUE ranged 0.25–130 kg.h^{-1}). Dogfish was caught in the northwest alongside the border of the FICZ and highest densities were recorded in the north. Catches occurred in stations shallower than 200 m. A total of 108 specimens were assessed (57 females and 51 males), all for length–weight relationship. Females ranged from 50 to 94 cm and males from 56 to 93 cm. Due to the low number of specimens sampled, modes appear at 60, 63, 69, 75 and 81 cm but cohorts are hardly identifiable. Females were observed resting (35%), early developing (39%), late developing (7%), ripe (9%) and running (10%). Males were early developing (2%), late developing (8%) and ripe (90%).

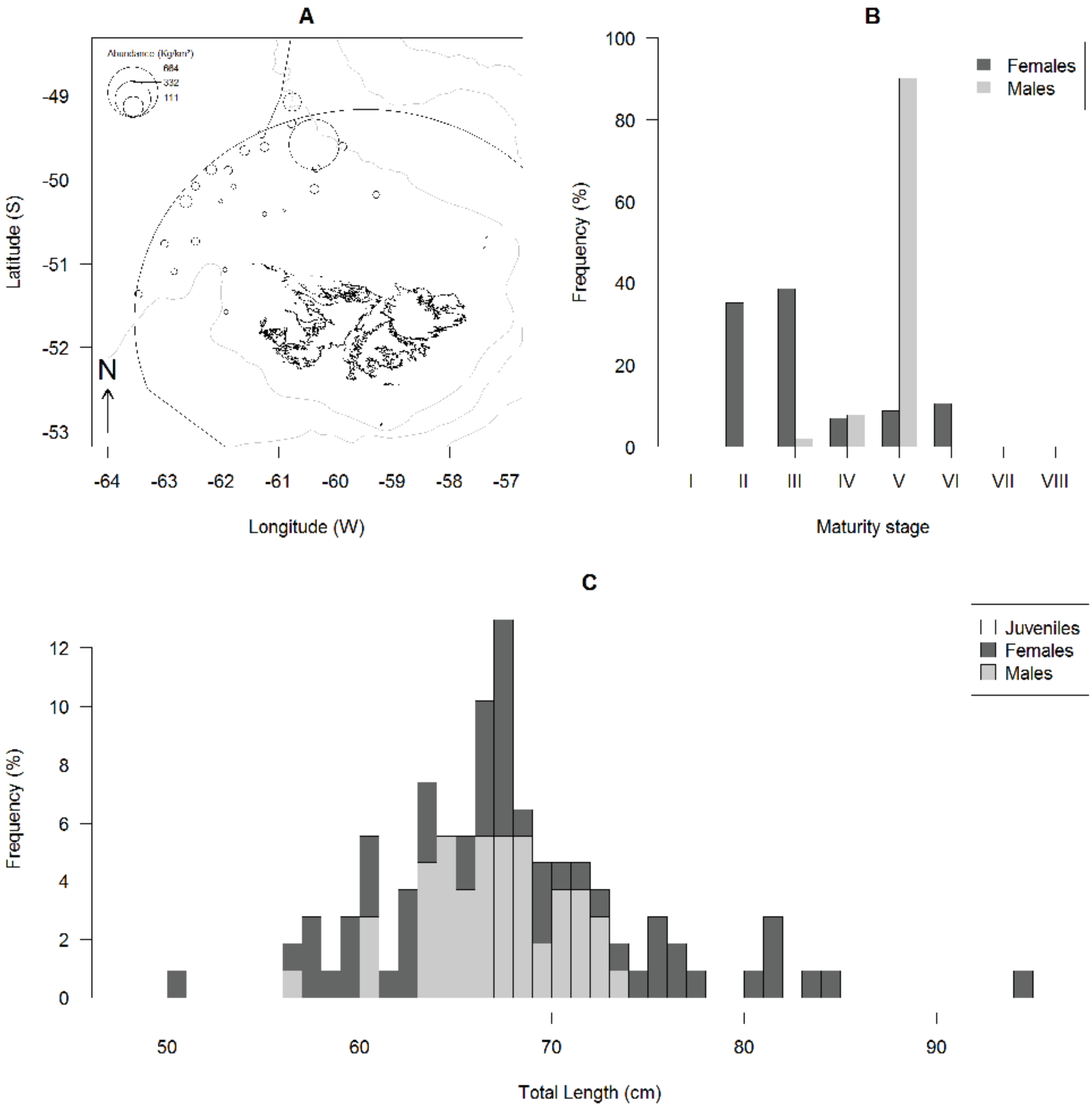


Figure 13: Biological data of *Squalus acanthias* (dogfish, DGS), map of the densities in kg.km^{-2} (A), percentage of specimens of each sex per maturity stage (B; I, immature; II, resting; III, early developing; IV, late developing; V, ripe; VI, running; VII, spent; VIII, recovering spent) and length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

3.2.13 *Merluccius australis* – Patagonian hake – PAT

A total of 215 kg of Patagonian hake was caught at 12 of the 89 trawl sampled (Figure 14). Catches ranged from 0.77 to 38.8 kg. Among the 12 stations, 9 yielded >10 kg of Patagonian hake in the net. Densities ranged from 4.1 to 213 kg.km^{-2} (CPUE ranged 0.77–38.8 kg.h^{-1}). A total of 86 specimens were assessed (78 females and 8 males), 58 for length frequency, 1 for length–weight relationship and 27 for otolith collection as well as genetic samples. Females ranged from 35 to 99 cm and males ranged from 46 to 69 cm. The length frequency histogram does not exhibit any cohort. Females were observed resting (63%), early developing (10%), late developing (9%), spent (1%) and recovering spent (17%). Males were resting (50%), early developing (38%) or recovering spent (12%).

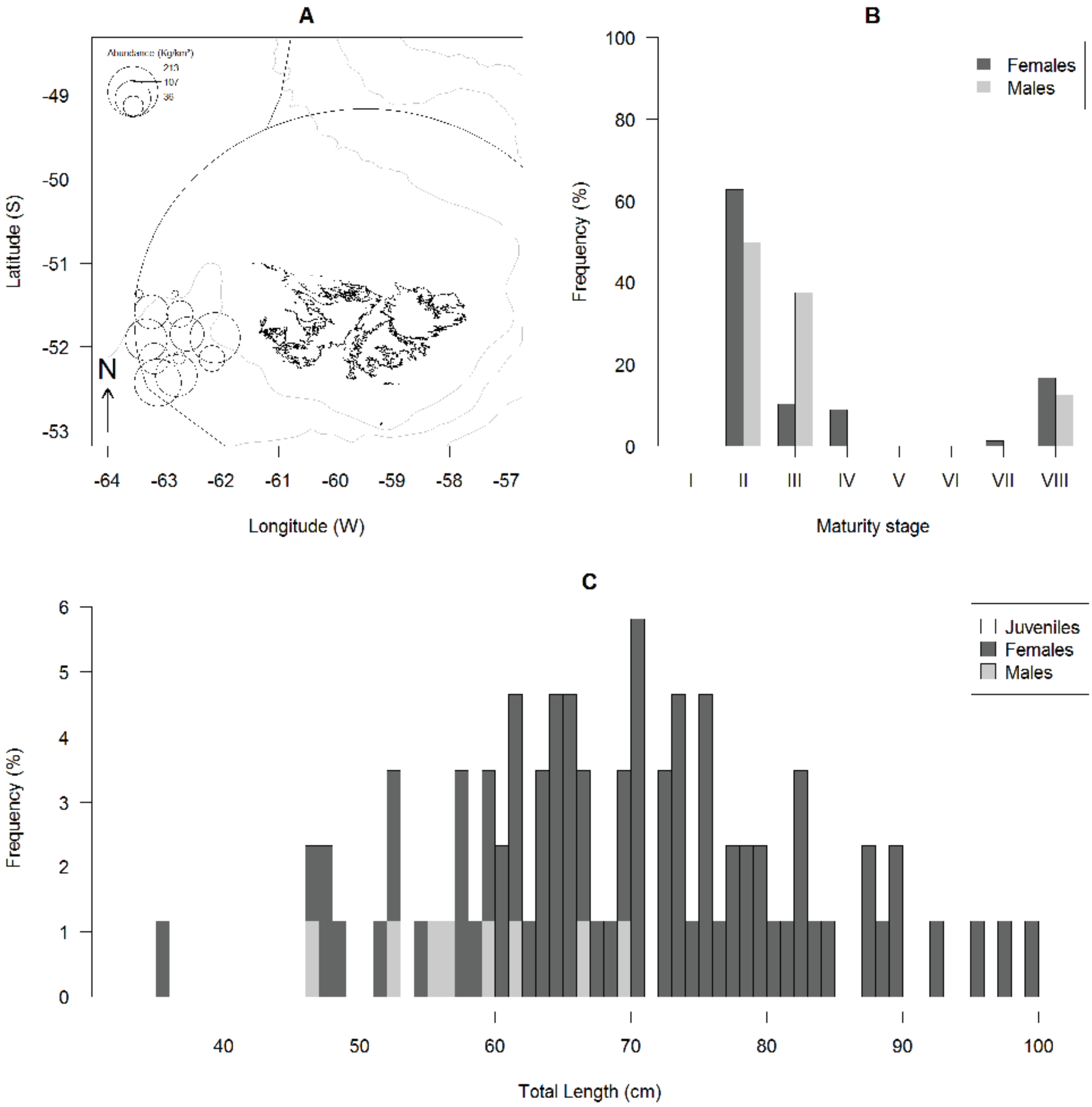


Figure 14: Biological data of *Merluccius australis* (Patagonian hake, PAT), map of the densities in kg.km^{-2} (A), percentage of specimens of each sex per maturity stage (B; I, immature; II, resting; III, early developing; IV, late developing; V, ripe; VI, running; VII, spent; VIII, recovering spent)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

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

A total of 160 kg of Nichol's lanternfish was caught at 12 of the 89 trawl stations sampled (Figure 15). Catches ranged from 0.005 to 76.7 kg. Among the 12 stations, 7 yielded >1 kg and 4 yielded >10 kg. Densities ranged from 0.03 to 398 kg.km^{-2} (CPUE ranged 0.005–76.7 kg.h^{-1}). Catches occurred in the north of the surveyed zone in stations deeper than 200 m. A total of 421 specimens were assessed, just for length frequency and as they were too soft to be assessed for sex and maturity. Specimens ranged from 8 to 17 cm total length and 3 cohorts can be identified on the length frequency graph with modes at 9, 12 and 14 cm.

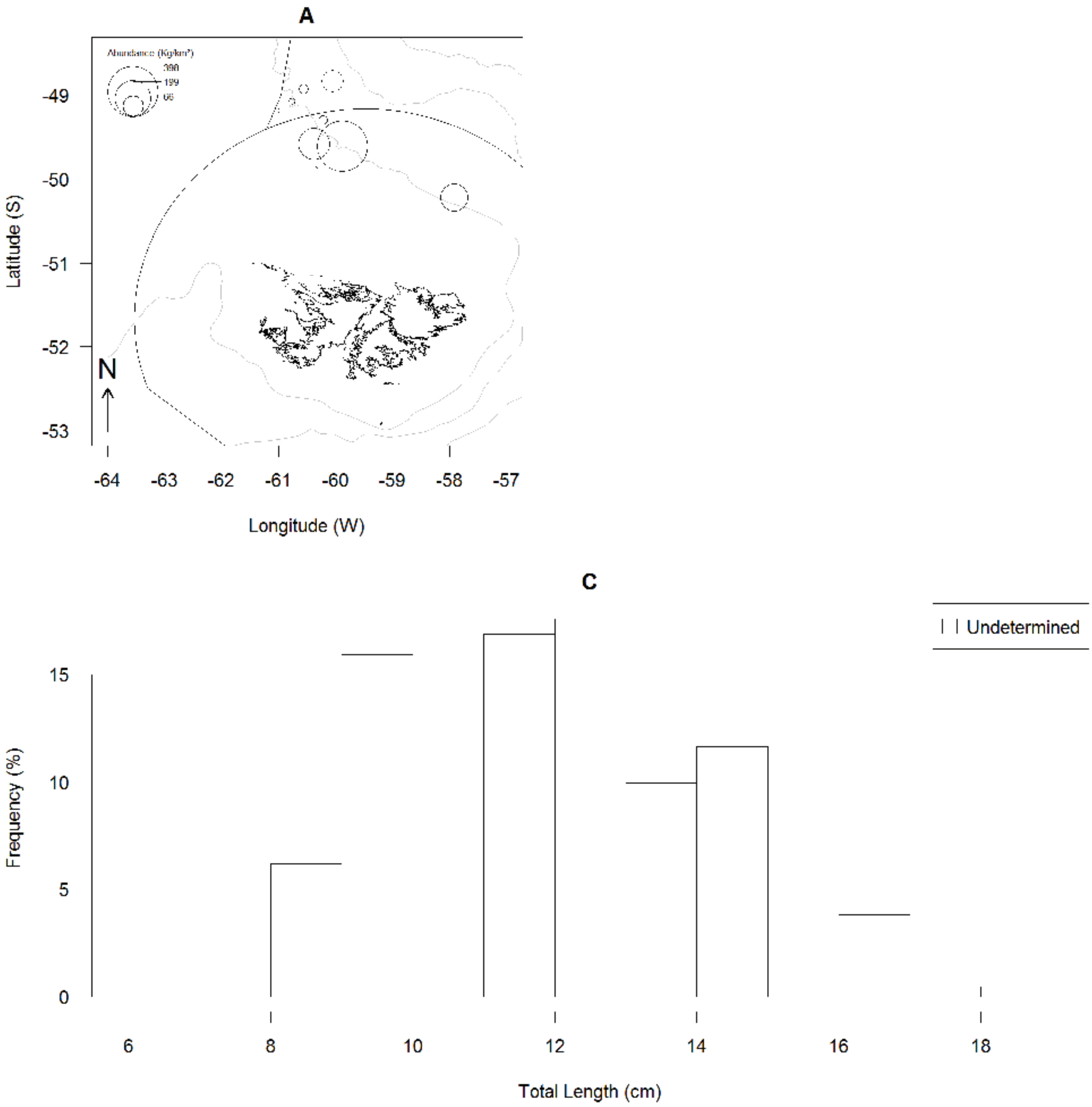


Figure 15: Biological data of *Gymnoscopelus nicholsi* (Nichol's lanternfish, GYN), map of the densities in kg.km^{-2} (A), percentage of specimens of each sex per maturity stage (B; I, immature; II, resting; III, early developing; IV, late developing; V, ripe; VI, running; VII, spent; VIII, recovering spent) and length frequency (in percentage of the total sample assessed) of each sex with 1 cm size class (C).

3.2.15 *Sebastes oculatus* – red fish – RED

A total of 70.4 kg of red fish was caught at 15 of the 89 trawl stations sampled (Figure 16). Catches ranged from 0.02 to 20.3 kg. Among the 15 stations, 10 yielded >1 kg of red fish and 2 stations yielded >10 kg. Densities ranged from 0.1 to 101 kg.km^{-2} (CPUE ranged 0.02–20.3 kg.h^{-1}). Catches occurred in stations shallower than 200 m in different locations throughout the surveyed zone. A total of 116 specimens were assessed (50 females and 66 males), 102 for length frequency, 7 for length–weight relationship and 7 for otolith collection. Minimum sizes were 21 and 13 cm for females and males respectively and maximum size was 40 cm for both species. Cohorts are hardly identifiable on the length frequency histogram and modes appear at 13, 27, 29, 31, 34, 37 and 40 cm. Females were observed resting (34%), early developing (14%), ripe (2%), spent (8%) or recovering spent (36%). Males were immature (3%), resting (21%), early developing (36%), late developing (3%) or recovering spent (37%).

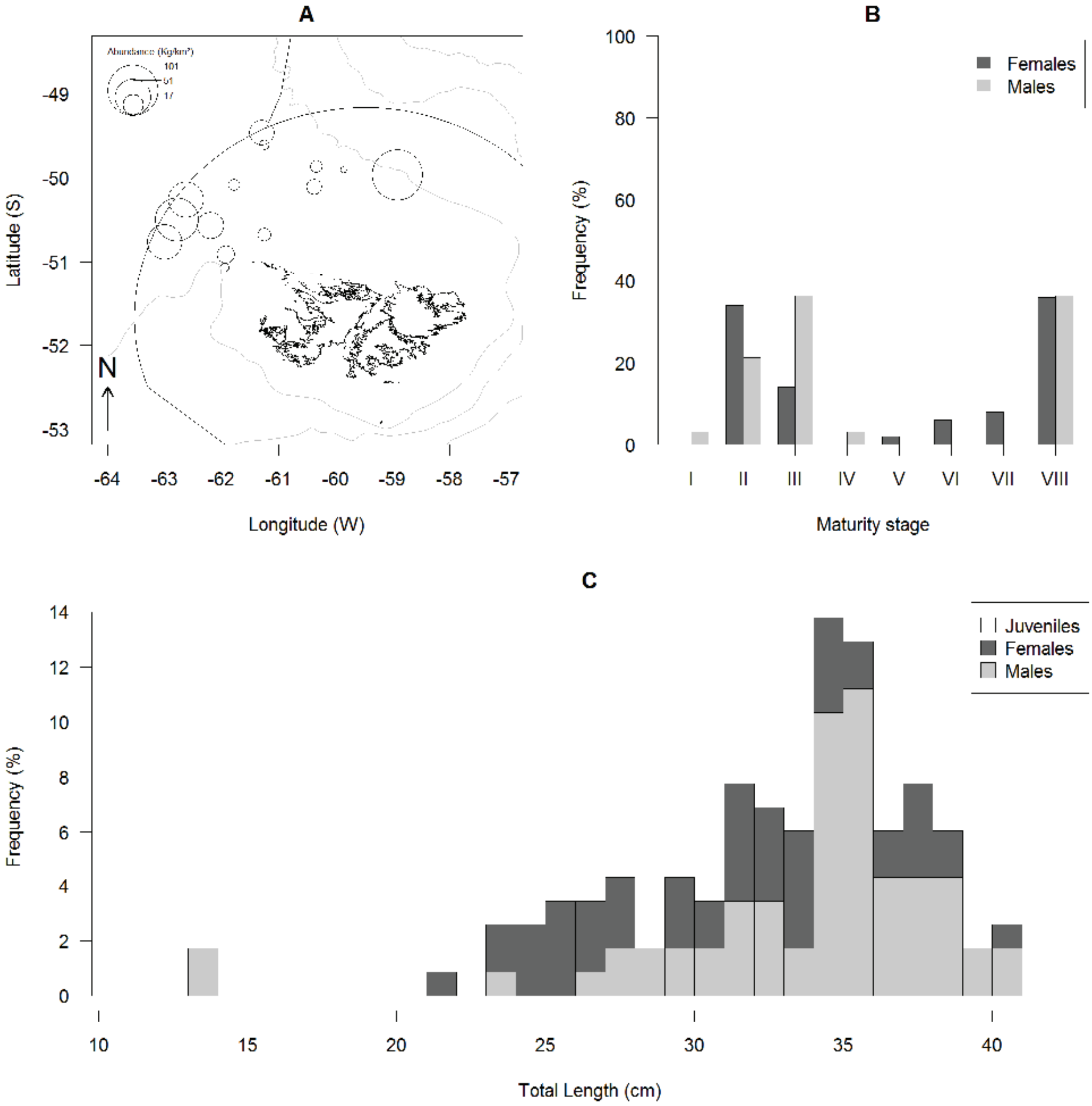


Figure 16: Biological data of *Sebastes oculatus* (red fish, RED), map of the densities in kg.km^{-2} (A), percentage of specimens of each sex per maturity stage (B; I, immature; II, resting; III, early developing; IV, late developing; V, ripe; VI, running; VII, spent; VIII, recovering spent) and length frequency (in percentage of the total sample assessed) of each sex with 1 cm size class (C).

3.2.16 *Congiopodus peruvianus* – Horsefish – COP

A total of 30.7 kg of horsefish was caught at 9 of the 89 trawl stations sampled (Figure 17). Catches ranged from 0.8 to 8 kg. Densities ranged from 4 to 58.6 kg.km^{-2} (CPUE ranged 0.8–8 kg.h^{-1}). Catches occurred to the west and to the northwest of West Falkland where the higher densities were recorded. A total of 60 specimens were assessed (25 females and 35 males), 26 for length frequency and 34 for length–weight relationship. Females ranged from 26 to 34 cm and males from 24 to 31 cm. The length frequency histogram exhibits 2 to 3 cohorts (with modes at 26, 29, 31 and 33–34 cm). Females were late developing (8%), ripe (68%), running (20%) or recovering spent. Males were early developing (29%), late developing (48%), ripe (14%) or running (9%).

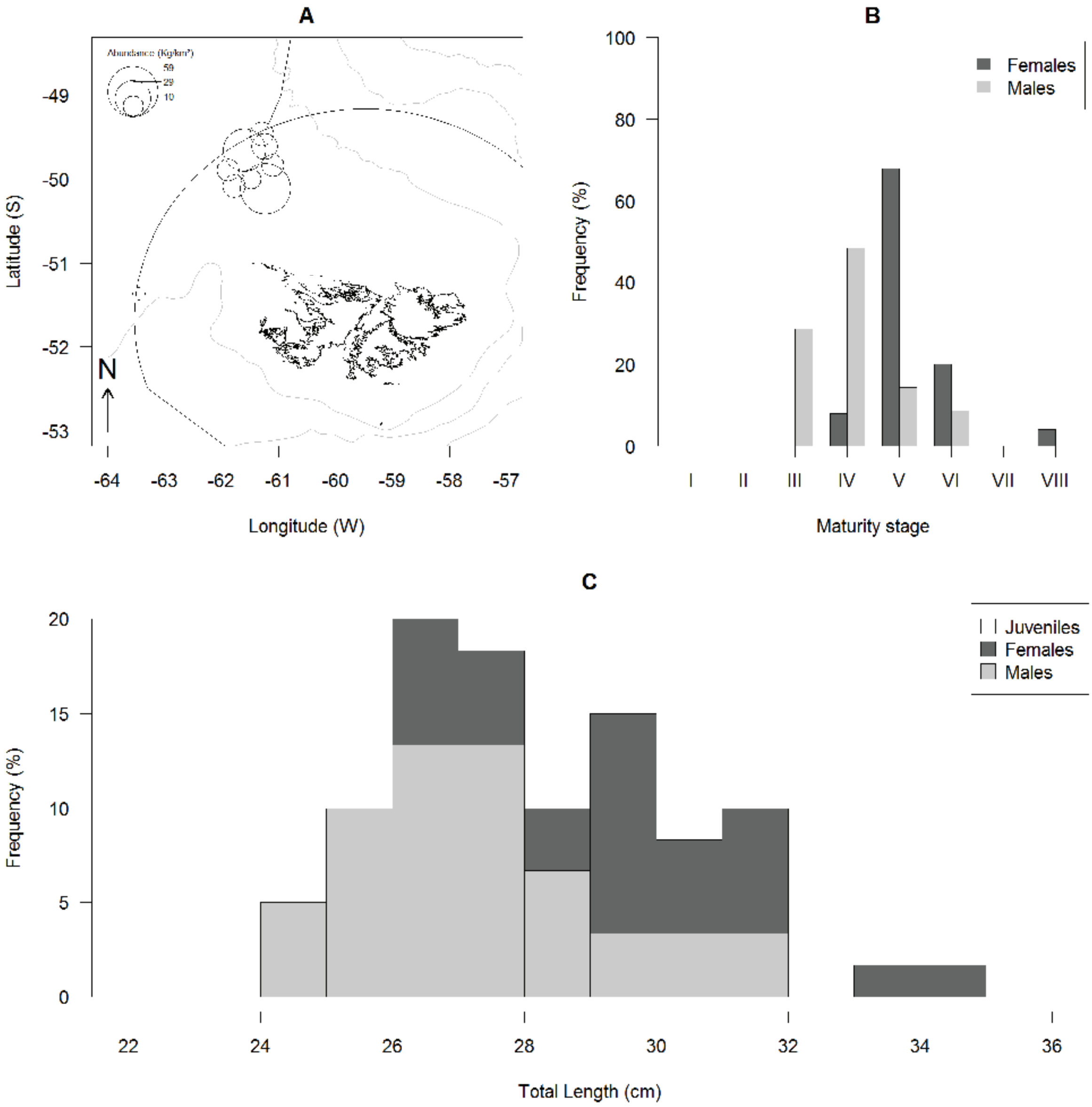


Figure 17: Biological data of *Congiopodus peruvianus* (horsefish, COP), map of the densities in kg.km^{-2} (A), percentage of specimens of each sex per maturity stage (B; I, immature; II, resting; III, early developing; IV, late developing; V, ripe; VI, running; VII, spent; VIII, recovering spent) and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

3.2.17 *Patagonotothen tessellata* – marbled rock cod – PTE

A total of 27.8 kg of marbled rock cod was caught at 10 of the 89 trawl stations sampled (Figure 18). Catches ranged from 0.2 to 15.7 kg. Among the 10 stations, 5 yielded >1 kg of marbled rock cod and 1 station yielded >10 kg. Densities ranged from 1.18 to 86.7 kg.km^{-2} (CPUE ranged 0.2–15.7 kg.h^{-1}). Marbled rock cod was caught in the northern part of the *Loligo* box where highest densities were recorded and in one station to the west of West Falkland. All catches occurred in stations shallower than 200 m. A total of 392 specimens were assessed (165 females and 227 males), all for length frequency. Minimum size was 9 cm for both sexes and maximum total length was 21 and 23 cm for females and males respectively. The length frequency histogram exhibits 2 cohorts (with modes at 11 and 16 cm). Females were observed immature (16%), resting (70%), early developing (11%) or recovering spent (2%). Males were immature (14%), resting (79%), early developing (7%) or spent (0.4%).

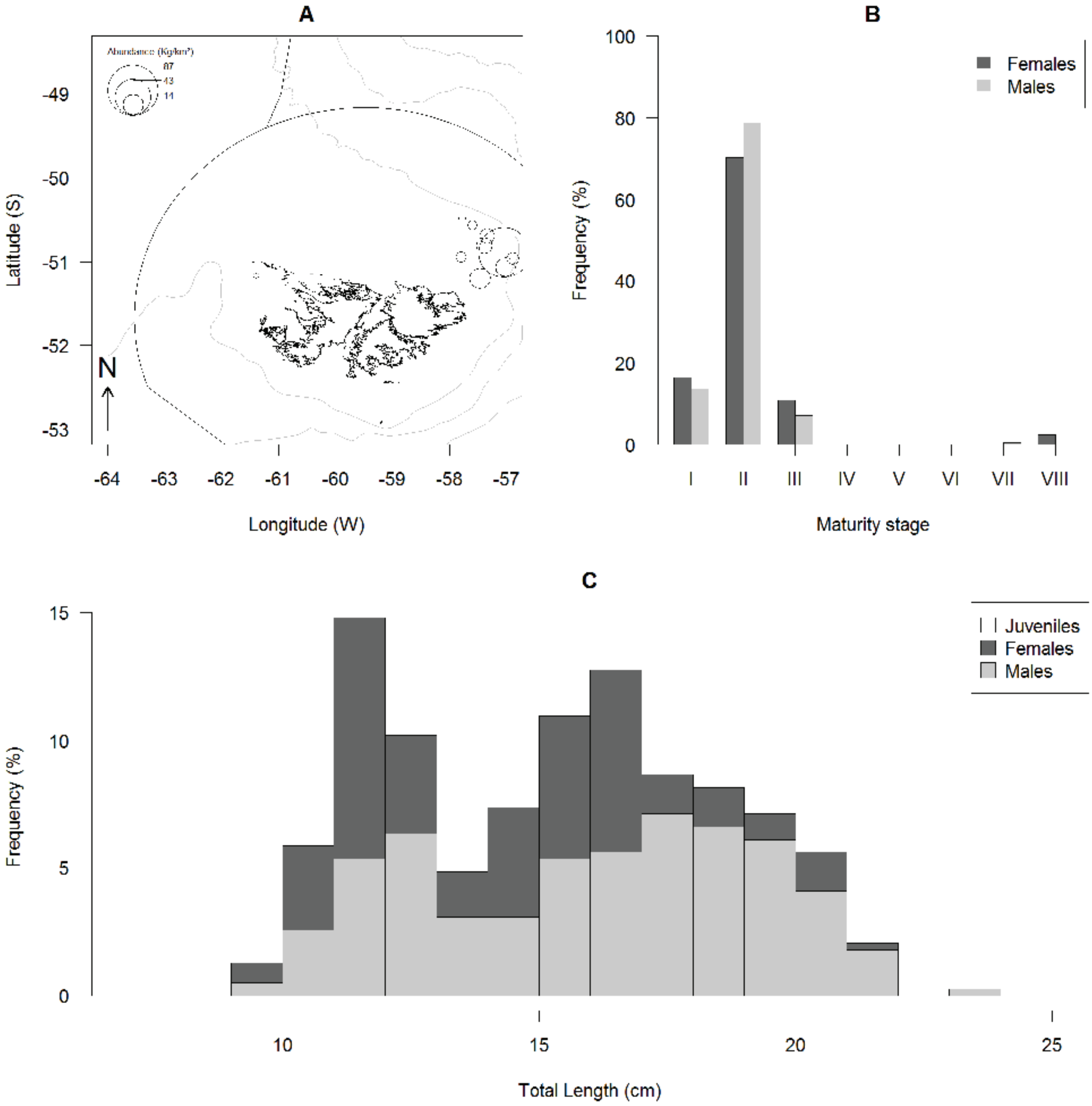


Figure 18: Biological data of *Patagonotothen tessellata* (marbled rock cod, PTE), map of the densities in kg.km^{-2} (A), percentage of specimens of each sex per maturity stage (B; I, immature; II, resting; III, early developing; IV, late developing; V, ripe; VI, running; VII, spent; VIII, recovering spent) and length frequency (in percentage of the total sample assessed) of each sex with 1 cm size class (C).

3.2.18 *Cottunculus granulosus* – Sculpin – COT

A total of 20.4 kg of sculpin was caught at 5 of the 89 trawl stations sampled (Figure 19). Catches ranged from 0.45 to 9 kg. Densities ranged from 2.42 to 27.5 kg.km^{-2} (CPUE ranged 0.45–4.5 kg.h^{-1}). Catches occurred in stations deeper than 200 m in the FOCZ and to the north of East Falkland. A total of 119 specimens were assessed (64 females and 55 males), all for length frequency. Females ranged from 7 to 29 cm and males from 7 to 28 cm. Several modes appear on the length frequency but cohorts identification would require more advanced methods. Females were observed immature (16%), resting (30%), early developing (17%), ripe (11%), spent (20%) and recovering spent (6%). Males were immature (36%), resting (29%), early developing (4%), late developing (18%), spent (4%) or recovering spent (9%).

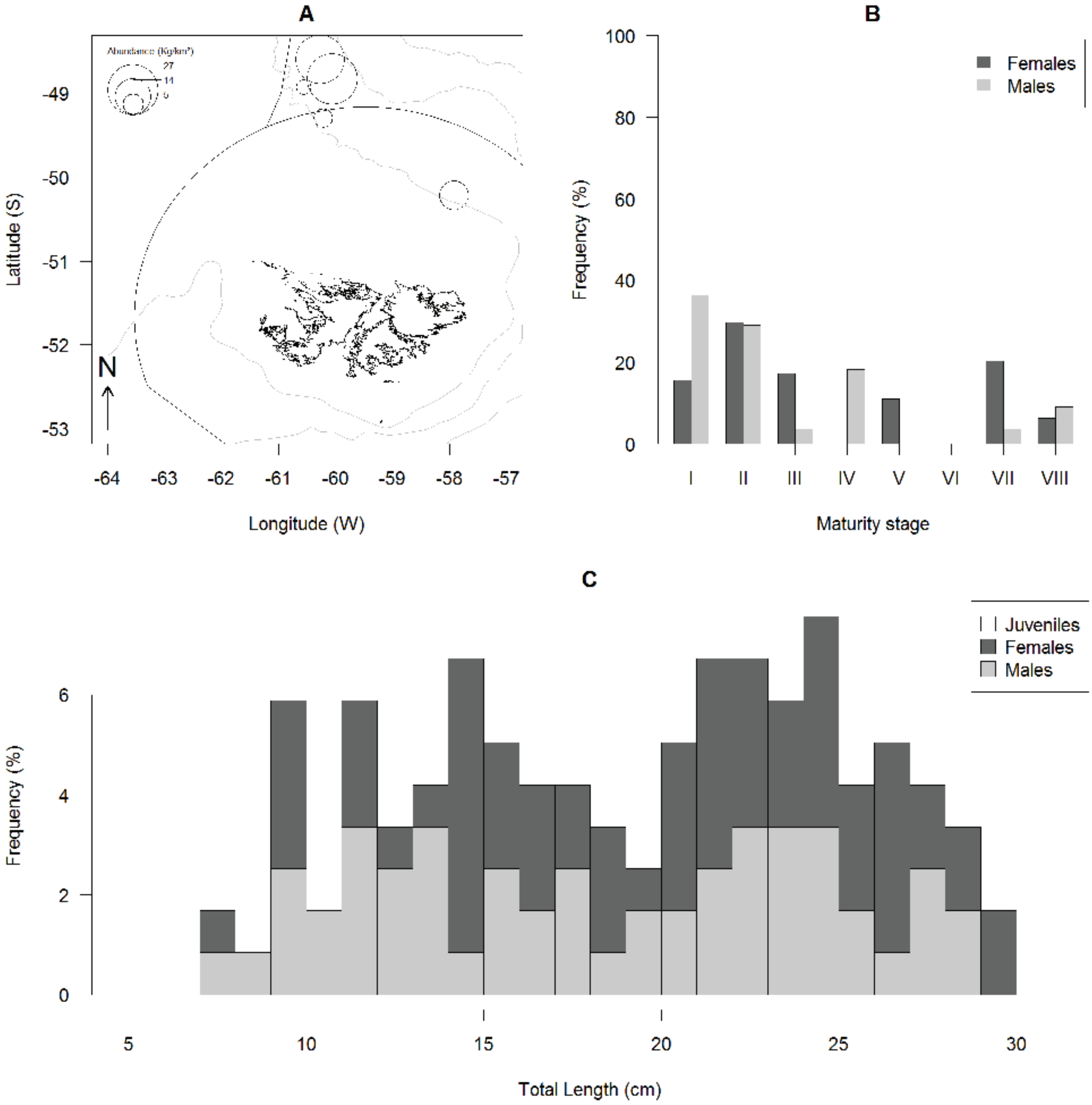


Figure 19: Biological data of *Cottunculus granulosus* (sculpin, COT), map of the densities in kg.km^{-2} (A), percentage of specimens of each sex per maturity stage (B; I, immature; II, resting; III, early developing; IV, late developing; V, ripe; VI, running; VII, spent; VIII, recovering spent) and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

3.2.19 *Champsocephalus esox* – icefish – CHE

A total of 19.5 kg of icefish was caught at 15 of the 89 trawl stations sampled (Figure 20). Catches ranged from 0.01 to 11.4 kg. Among the 15 stations, 4 yielded >1 kg of icefish, and 1 station yielded >10 kg. Densities ranged from 0.06 to 67.6 kg.km^{-2} (CPUE ranged 0.01–11.42 kg.h^{-1}). Catches occurred in shallow waters to the northwest of West Falkland and in the northern part of the *Loligo* box. A total of 127 specimens were assessed (1 juvenile, 70 females and 56 males), 111 for length frequency and 16 for otolith collection. The juvenile specimen was 13 cm, females ranged from 14 to 37 cm and males from 13 to 31 cm. The length frequency histogram exhibits 3 cohorts (with modes at 14–15, 28 and 37 cm). 4% of the females were immature and 96% resting while 11% of the males were immature and 89% resting.

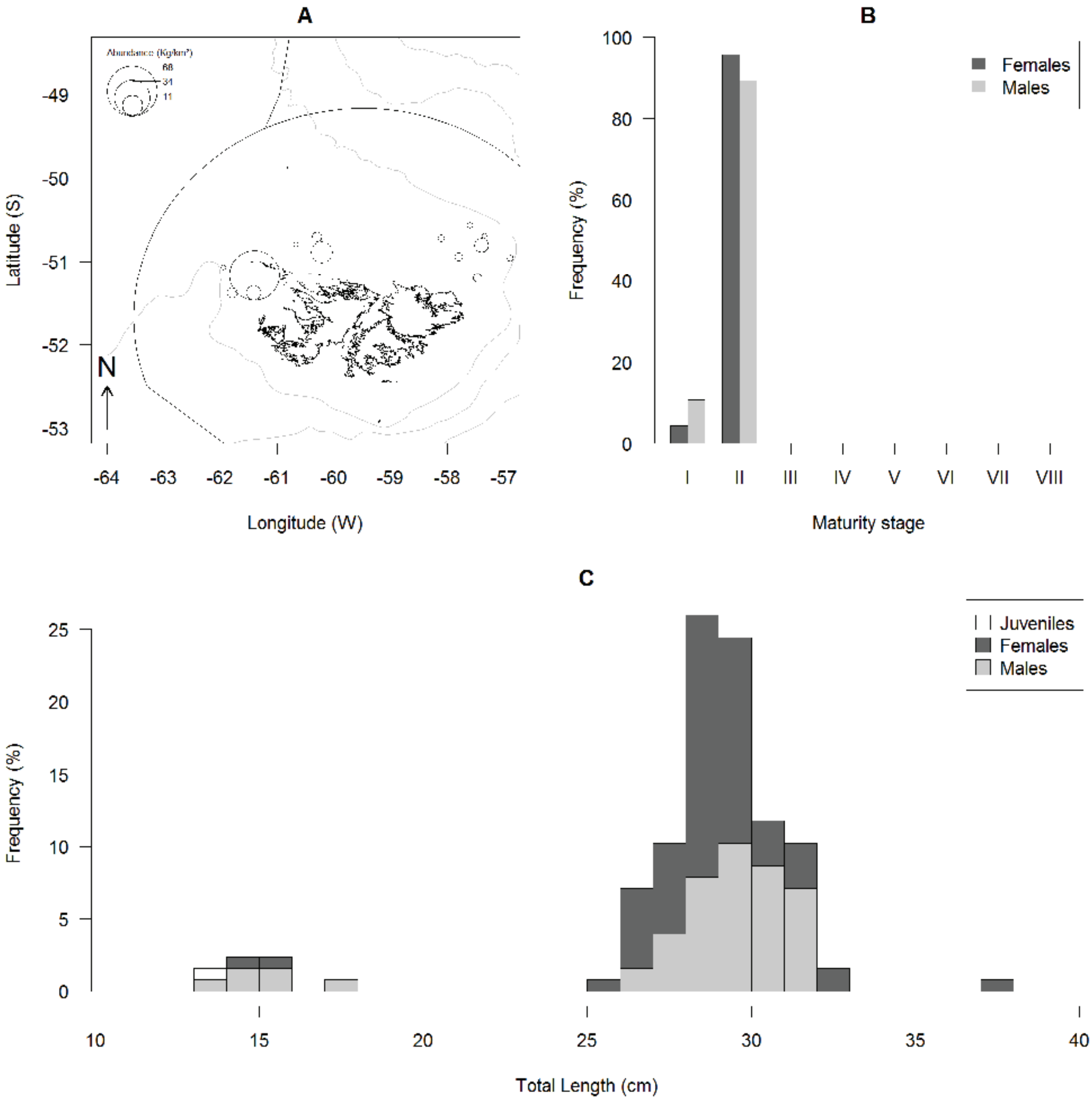


Figure 20: Biological data of *Champsocephalus esox* (icefish, CHE), map of the densities in kg.km^{-2} (A), percentage of specimens of each sex per maturity stage (B; I, immature; II, resting; III, early developing; IV, late developing; V, ripe; VI, running; VII, spent; VIII, recovering spent) and length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

3.2.20 *Physiculus marginatus* – Dwarf codling – PYM

A total of 51.4 kg of dwarf codling was caught at 14 of the 89 trawl stations sampled (Figure 21). Catches ranged from 0.01 to 22 kg. Among the 14 stations, 12 yielded >1 kg of dwarf codling and 1 station yielded >20 kg in the net. Densities ranged from 0.05 to 105 kg.km^{-2} (CPUE ranged 0.01–22 kg.h^{-1}). A total of 91 specimens were assessed (46 females and 45 males), all for length frequency. Minimum size was 11 cm for both sexes and maximum size was 17 and 18 cm for females and males respectively. The length frequency histogram exhibits 1 cohort (with mode at 14 cm). For both sexes, all the specimens were resting.

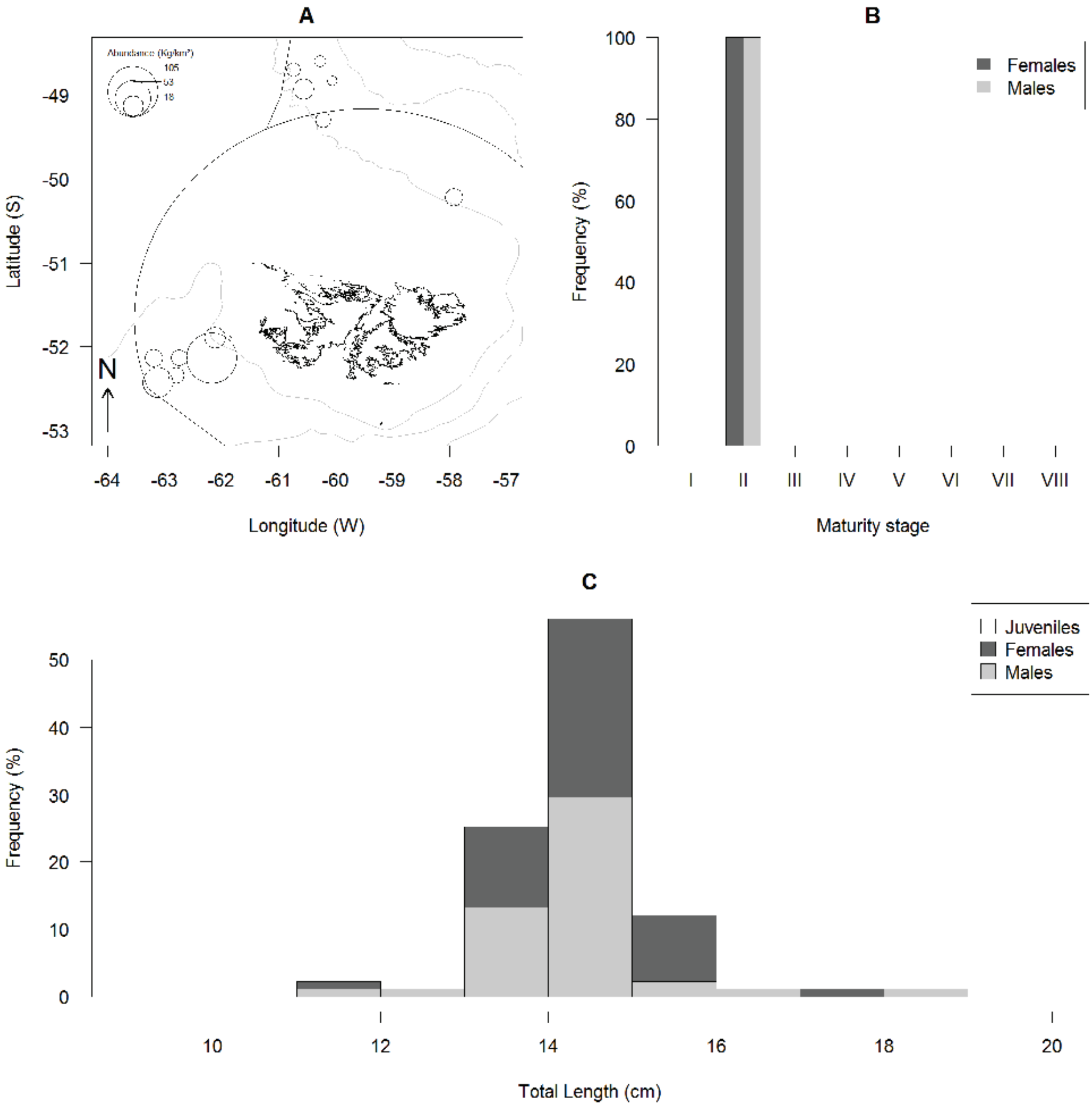


Figure 21: Biological data of *Physiculus marginatus* (Dwarf codling, PYM), map of the densities in kg.km^{-2} (A), percentage of specimens of each sex per maturity stage (B; I, immature; II, resting; III, early developing; IV, late developing; V, ripe; VI, running; VII, spent; VIII, recovering spent)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

3.3 Biological data of squids

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

A total of 2,385 kg of Falkland calamari was caught at 85 of the 89 trawl stations sampled (Figure 22). Catches ranged from 0.02 to 791 kg. Among the 85 stations, 77 yielded >1 kg of Falkland calamari, 53 yielded >10 kg, 7 yielded >50kg and 2 stations yielded >100 kg. Densities ranged from 0.1 to 3,889 kg.km^{-2} (CPUE ranged 0.02–791 kg.h^{-1}). Catches occurred throughout the surveyed zone and high densities were recorded in the north of the *Loligo* box. A total of 14,803 specimens were assessed (16 juveniles, 8,935 females and 5,852 males), 14,161 for length frequency, 375 for length–weight relationship and 267 for statolith collection. Juveniles ranged from 3 to 7.5 cm, females ranged from 3.5 to 17.5 cm and males ranged from 3 to 18.5 cm. The length frequency histogram exhibits 1 cohort with a mode at 7.5 cm. Females were observed immature (59%), resting (39%) early developing (1%), late developing (0.5%) or ripe (0.5%). Males were immature (55%), resting (40%), early developing (3%), late developing (1%) or ripe (1%).

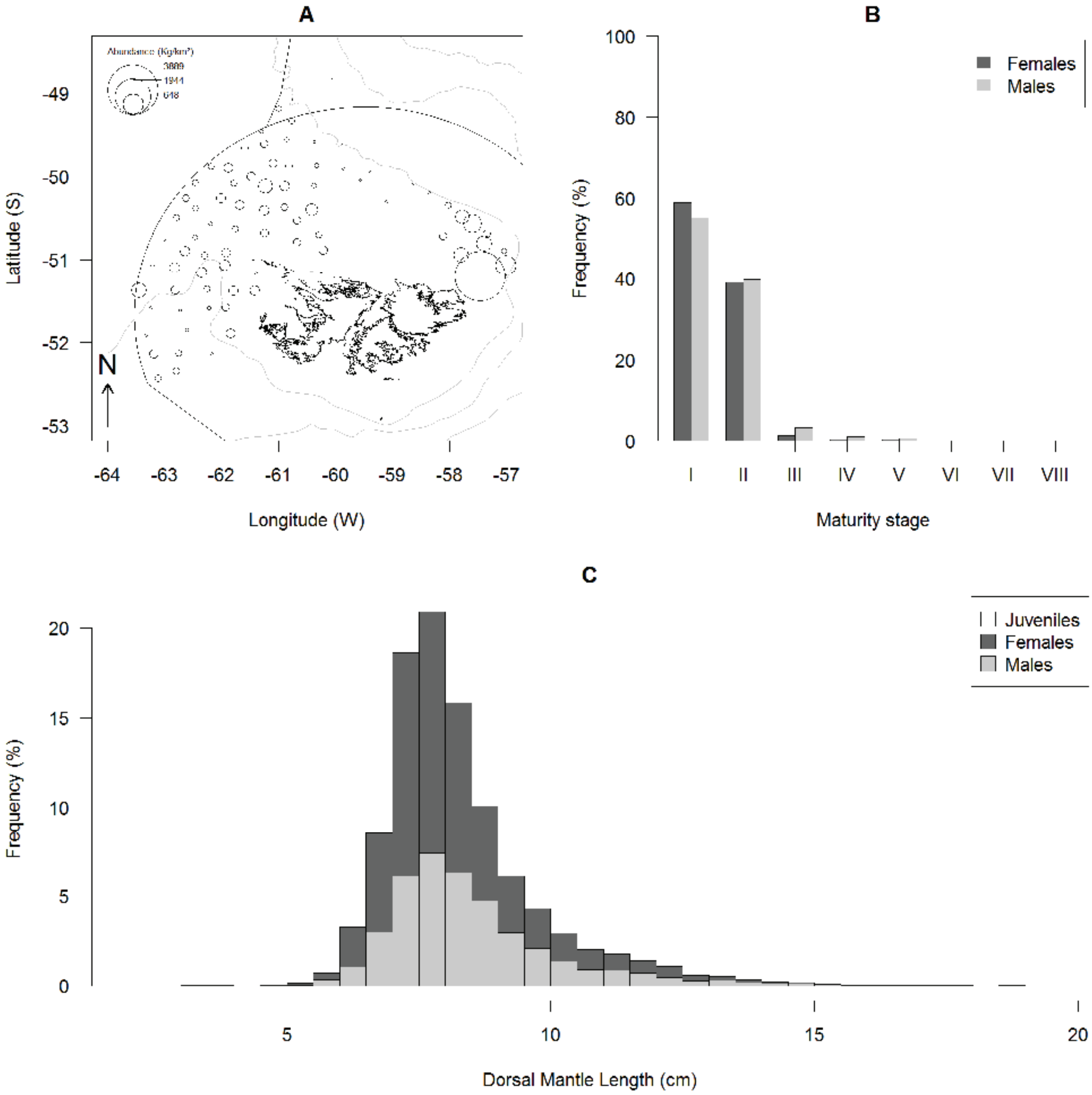


Figure 22: Biological data of *Doryteuthis gahi* (Falkland calamari, LOL), map of the densities in kg.km^{-2} (A), percentage of specimens of each sex per maturity stage (B; I, immature; II, resting; III, early developing; IV, late developing; V, ripe; VI, running; VII, spent; VIII, recovering spent) and length frequency (in percentage of the total sample assessed) of each sex with 0.5 cm size class (C).

3.3.2 *Moroteuthis ingens* – greater hooked squid – ING

A total of 115 kg of greater hooked squid was caught at 59 of the 89 trawl stations sampled (Figure 23). Catches ranged from 0.19 to 10.9 kg. Among the 59 stations, 32 yielded >1 kg of greater hooked squid and 1 yielded >10 kg. Densities ranged from 0.95 to 51.8 kg.km^{-2} (CPUE ranged 0.19–10.9 kg.h^{-1}). Catches occurred throughout the surveyed area with highest densities observed in deep water stations in the southwest and in the north of the *Loligo* box. A total of 90 specimens were assessed (49 females and 41 males), all for length frequency. Females ranged from 11.5 to 27 cm and males ranged from 13.5 to 23 cm. Due to the low number of specimens assessed, cohorts are difficult to identify and modes appear at 14, 16.5, 18, 19, 21.5 and 23 cm. Females were observed resting (96%) or early developing (4%). Males were immature (10%) or resting (90%).

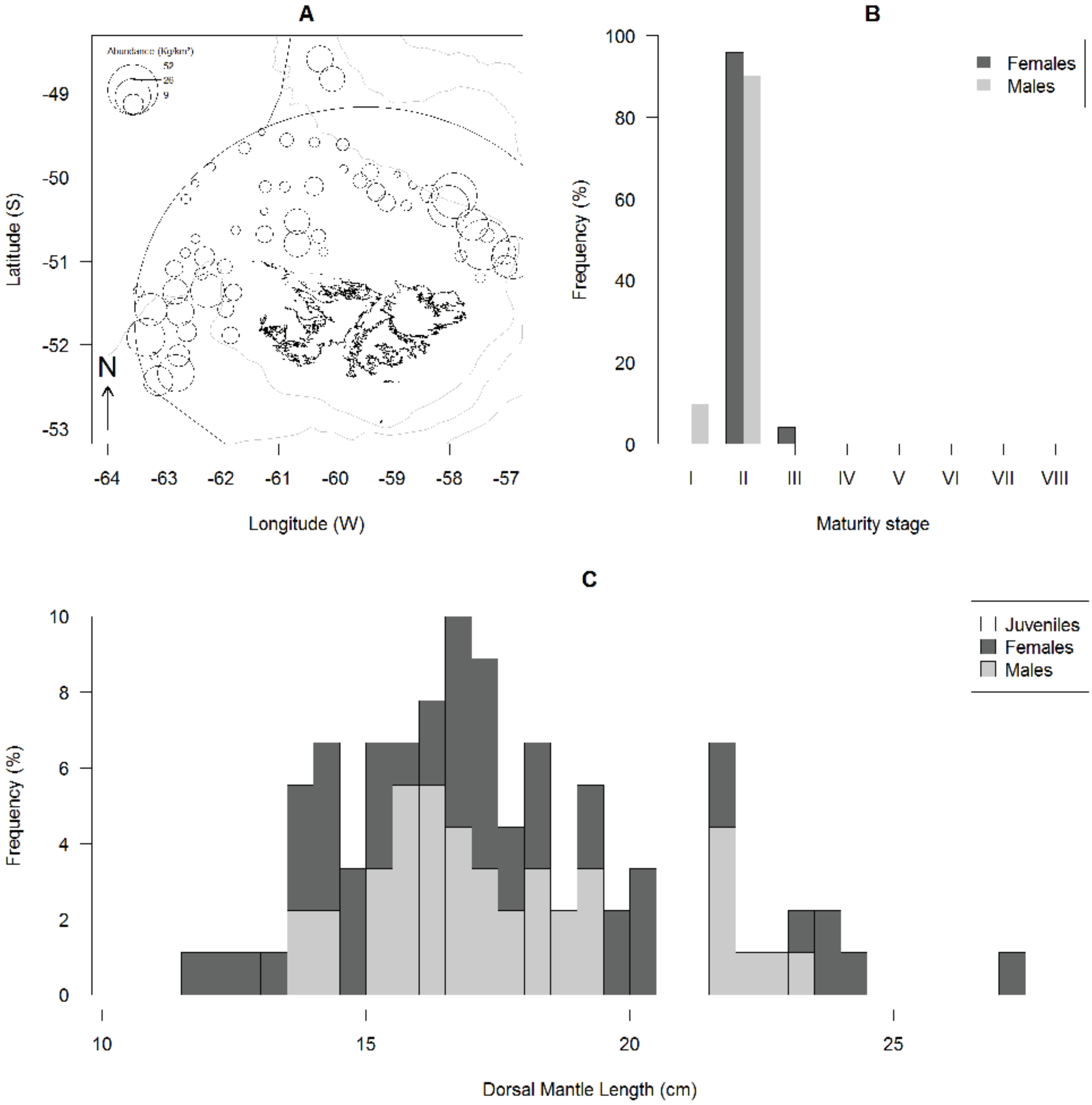


Figure 23: Biological data of *Moroteuthis ingens* (greater hooked squid, ING), map of the densities in kg.km^{-2} (A), percentage of specimens of each sex per maturity stage (B; I, immature; II, resting; III, early developing; IV, late developing; V, ripe; VI, running; VII, spent; VIII, recovering spent) and length frequency (in percentage of the total sample assessed) of each sex with 0.5 cm size class (C).

3.3.3 *Illex argentinus* – Argentine shortfin squid – ILL

A total of 46.4 kg of Argentine shortfin squid was caught at 60 of the 89 trawl stations sampled (Figure 24). Catches ranged from 0.005 to 7.62 kg. Among the 60 stations, 13 yielded >1 kg of Argentine shortfin squid, and 3 yielded >5 kg. Densities ranged from 0.03 to 41 $kg.km^{-2}$ (CPUE ranged 0.005–7.62 $kg.h^{-1}$). Catches occurred throughout the surveyed area, mainly, but not only in stations shallower than 200 m. A zone of high density was recorded in the northwest of the surveyed area and one station in the north of the *Loligo* box exhibited also a high density. A total of 1,124 specimens were assessed (177 juveniles, 462 females, 365 males and 120 undetermined), 988 for length frequency, 96 for length–weight relationship and 40 for statolith collection. Juveniles ranged from 5.5 to 11 cm, females ranged from 7 to 27.5 cm, males ranged from 6.5 to 23.5 cm and undetermined ranged from 7.5 to 14.5 cm. Two cohorts can be identified on the length frequency histogram with modes at 10 and 22 cm. Females were observed immature (87%), resting (10%) or early developing (3%). Males were immature, (92%), resting (4%), early developing (1%), late developing (2%) or ripe (1%).

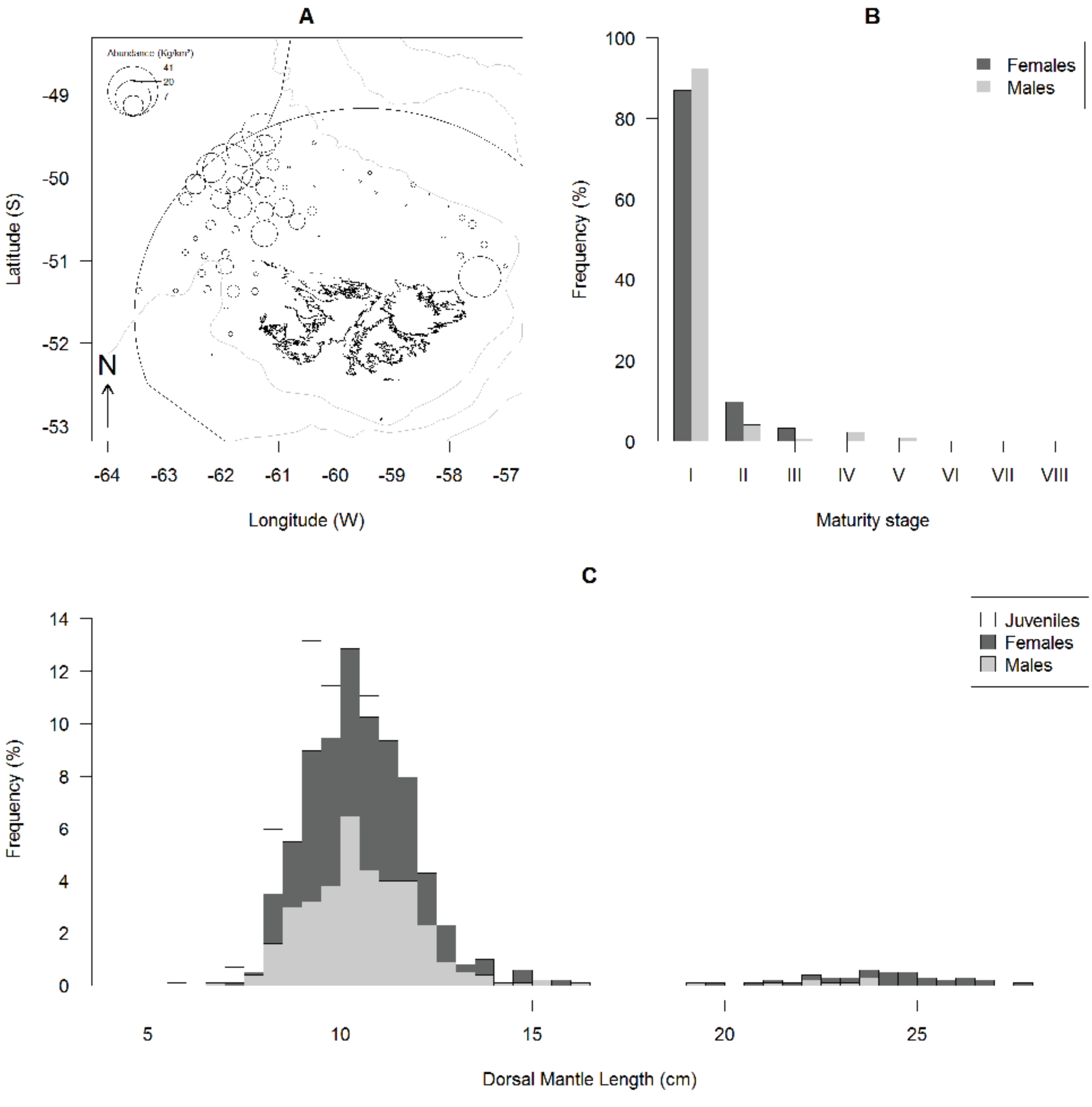


Figure 24: Biological data of *Illex argentinus* (Argentine shortfin squid, ILL), map of the densities in $kg.km^{-2}$ (A), percentage of specimens of each sex per maturity stage (B; I, immature; II, resting; III, early developing; IV, late developing; V, ripe; VI, running; VII, spent; VIII, recovering spent) and length frequency (in percentage of the total sample assessed) of each sex with 0.5 cm size class (C).

3.4 Biological data of skates

3.4.1 *Bathyraja brachyurops* – blonde skate – RBR

A total of 693.14 kg of blonde skate was caught at 76 of the 89 trawl stations sampled (Figure 25). Catches ranged from 0.07 to 47.74 kg. Among the 76 stations, 64 yielded >1 kg, and 24 stations yielded >10 kg. Densities ranged from 0.33 to 371.33 kg.km^{-2} (CPUE ranged 0.07–47.74 kg.h^{-1}). A total of 398 specimens were assessed (193 females and 205 males), all for length/disc–width/weight. Females ranged from 8 to 69 cm and males ranged from 9 to 63 cm DW. The size frequency histogram exhibits 3 cohorts (with modes at 10–15, 25–30 and ~45–55 cm). Females and males were observed in all maturity stages. Ten of the 63 females (15.8%) in stage 4 or above had egg capsules (stage 5).

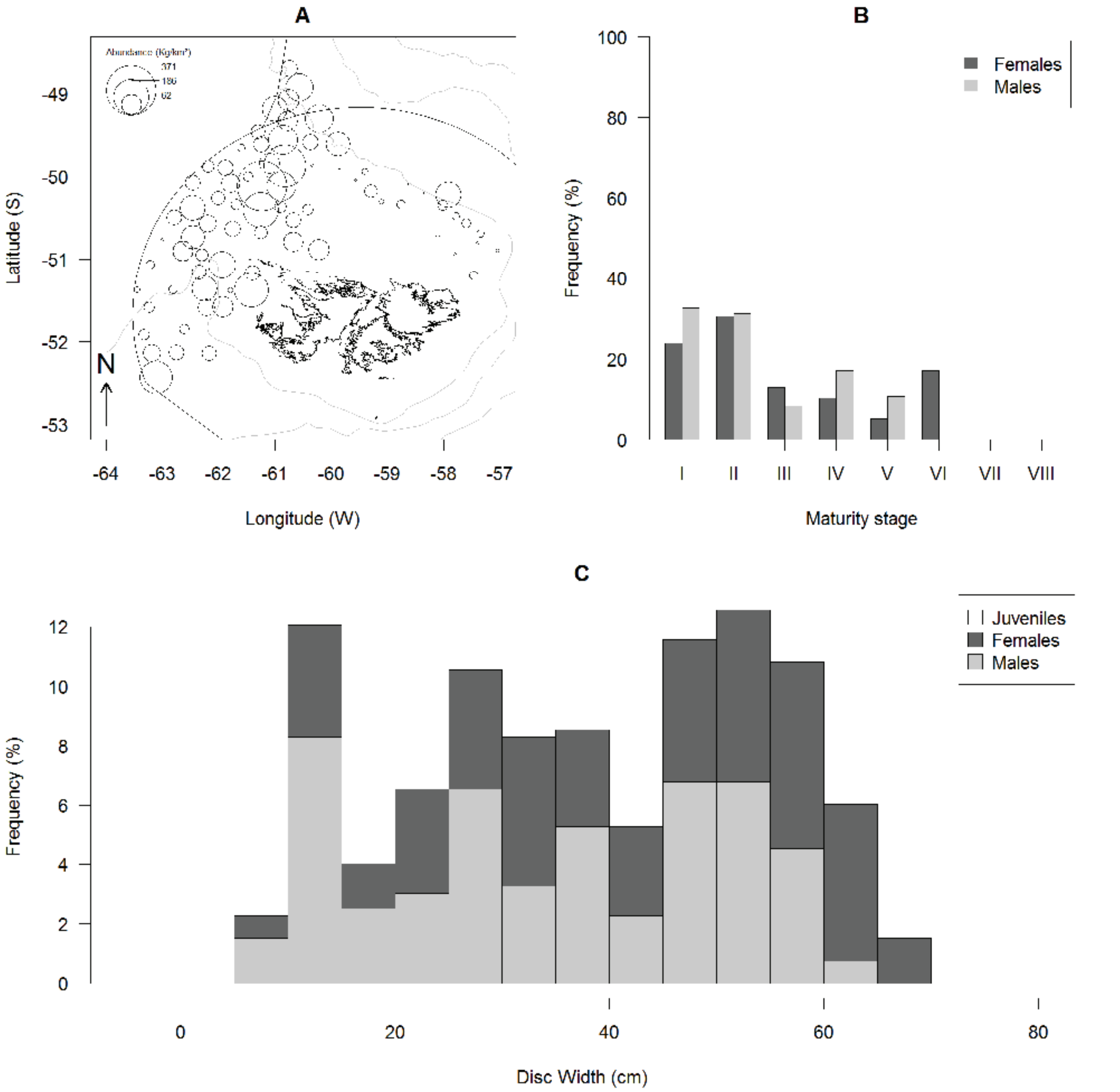


Figure 25: Biological data of *Bathyraja brachyurops* (blonde skate, RBR), map of the densities in kg.km^{-2} (A), percentage of specimens of each sex per maturity stage (B; I, juvenile; II, adolescent, maturing; III, adult, developing; IV, adult, mature; V, adult, laying; VI, adult, resting) and length frequency (in percentage of the total sample assessed) of each sex with 5 cm size class (C).

3.4.2 *Bathyraja griseocauda* – grey tailed skate – RGR

A total of 605.59 kg of grey tailed skate was caught at 21 of the 89 trawl stations sampled (Figure 26). Catches ranged from 0.07 to 152 kg. Among the 21 stations, 18 yielded >1 kg, 11 stations yielded >10 kg, and 2 stations yielded >100 kg. Densities ranged from 0.39 to 817.17 kg.km^{-2} (CPUE ranged 0.07–152 kg.h^{-1}). A total of 106 specimens were assessed (56 females and 50 males), all for length/disc–width/weight, and 9 for vertebrae/thorns. Females ranged from 15 to 99 cm and males ranged from 19 to 88 cm DW. The size frequency histogram exhibits 3 cohorts (with modes at 20–25, 50–60 and 80–90 cm). Females and males were observed in all maturity stages. Two of the 7 females (28.6%) in maturity stage 4–6 had egg capsules (stage 5).

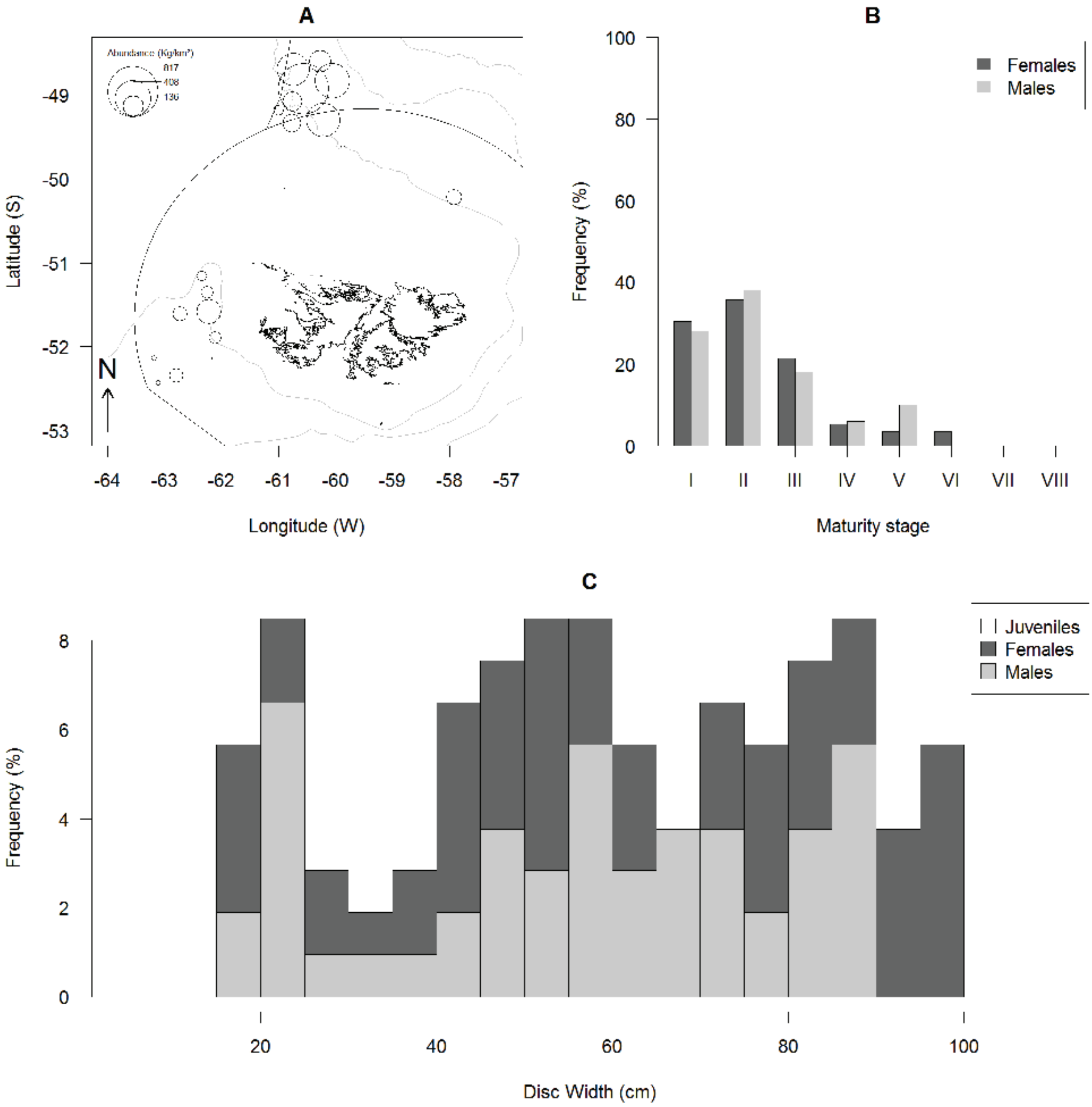


Figure 26: Biological data of *Bathyraja griseocauda* (grey tailed skate, RGR), map of the densities in kg.km^{-2} (A), percentage of specimens of each sex per maturity stage (B; I, juvenile; II, adolescent, maturing; III, adult, developing; IV, adult, mature; V, adult, laying; VI, adult, resting) and length frequency (in percentage of the total sample assessed) of each sex with 5 cm size class (C).

3.4.3 *Zearaja chilensis* – yellow nose skate – RFL

A total of 505.61 kg of yellow nose skate was caught at 48 of the 89 trawl stations sampled (Figure 27). Catches ranged from 0.64 to 69.04 kg. Among the 48 stations, 46 yielded >1 kg, and 14 stations yielded >10 kg. Densities ranged from 3.09 to 349.38 kg.km^{-2} (CPUE ranged 0.64–69.04 kg.h^{-1}). A total of 192 specimens were assessed (151 females and 41 males), all for length/disc–width/weight. Females ranged from 31 to 76 cm and males ranged from 35 to 73 cm DW. The size frequency histogram does not really exhibit any cohorts (with one mode at 55–60 cm). Females and males were observed in nearly all maturity stages, only stage 5 females were absent.

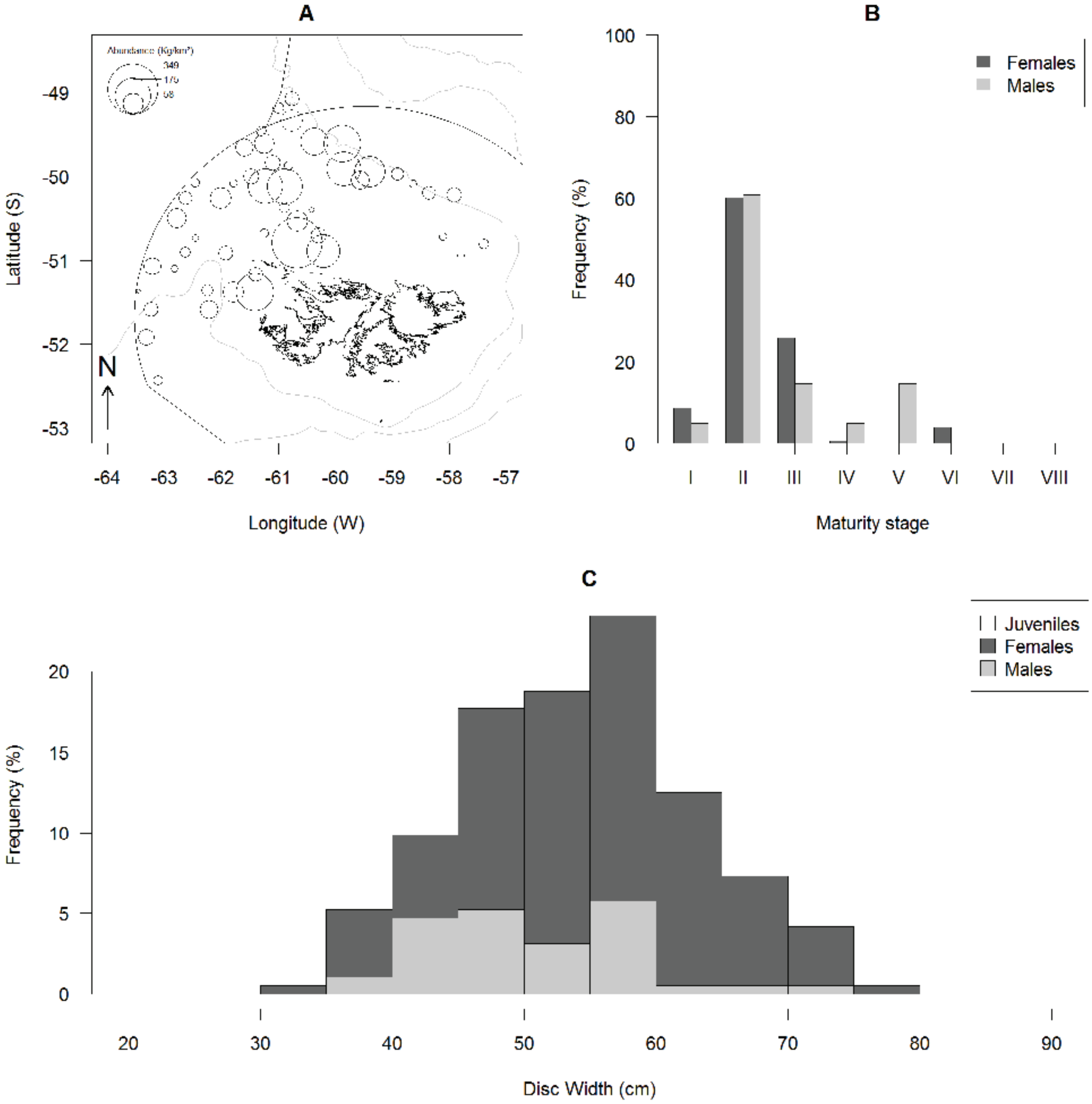


Figure 27: Biological data of *Zearaja chilensis* (yellow nose skate, RFL), map of the densities in kg.km^{-2} (A), percentage of specimens of each sex per maturity stage (B; I, juvenile; II, adolescent, maturing; III, adult, developing; IV, adult, mature; V, adult, laying; VI, adult, resting) and length frequency (in percentage of the total sample assessed) of each sex with 5 cm size class (C).

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

A total of 95.84 kg of joined–fin skate was caught at 4 of the 89 trawl stations sampled (Figure 28). Catches ranged from 0.89 to 46.41 kg. Among the 4 stations, 3 yielded >1 kg, and 2 stations yielded >10 kg. Densities ranged from 4.34 to 140.36 kg.km^{-2} (CPUE ranged 0.89–23.21 kg.h^{-1}). A total of 31 specimens were assessed (18 females and 13 males), all for length/disc–width/weight. Females ranged from 20 to 72 cm and males ranged from 17 to 69 cm DW. The size frequency histogram exhibits 3 cohorts (with modes at 20–25, 40–45 and 55–60 cm). Females and males were observed in maturity stages 1–4, whereas males only in stages 1–3. Only one of the females was in stage 4.

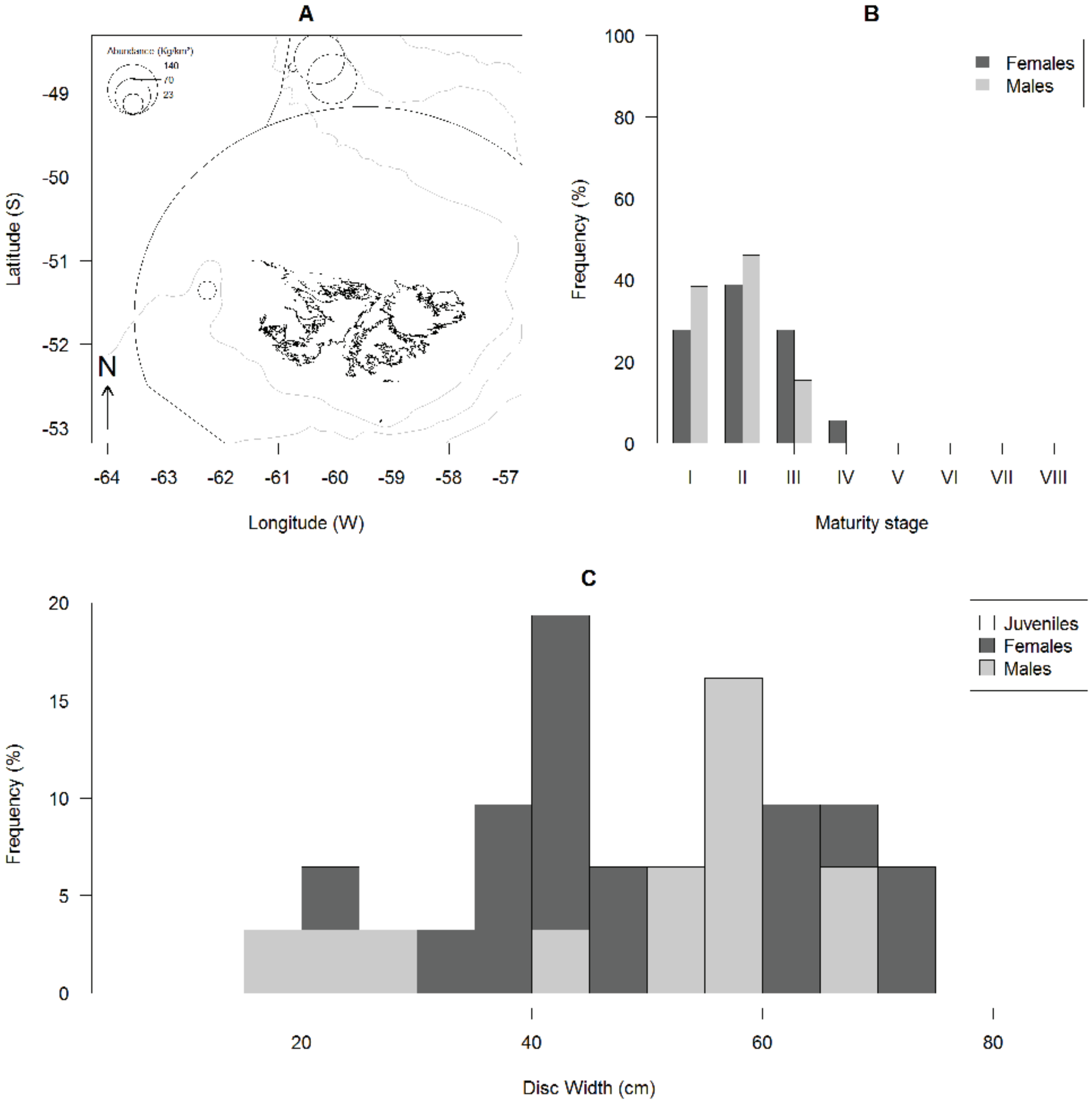


Figure 28: Biological data of *Bathyraja cousseauae* (joined–fin skate, RBZ), map of the densities in kg.km^{-2} (A), percentage of specimens of each sex per maturity stage (B; I, juvenile; II, adolescent, maturing; III, adult, developing; IV, adult, mature; V, adult, laying; VI, adult, resting) and length frequency (in percentage of the total sample assessed) of each sex with 5 cm size class (C).

3.4.5 *Bathyraja albomaculata* – white spotted skate – RAL

A total of 90.23 kg of white spotted skate was caught at 23 of the 89 trawl stations sampled (Figure 29). Catches ranged from 0.34 to 21.73 kg. Among the 23 stations, 21 yielded >1 kg, and 2 stations yielded >10 kg. Densities ranged from 1.66 to 66.20 kg.km^{-2} (CPUE ranged 0.34–10.87 kg.h^{-1}). A total of 56 specimens were assessed (37 females and 19 males), all for length/disc–width/weight. Females ranged from 10 to 51cm and males ranged from 10 to 48 cm DW. The size frequency histogram exhibits 2 cohorts (with modes at 10–15 and 40–45 cm DW). Females and males were observed in all maturity stages. Three of the 16 females (18.8%) in stage 4 or above had egg capsules (stage 5).

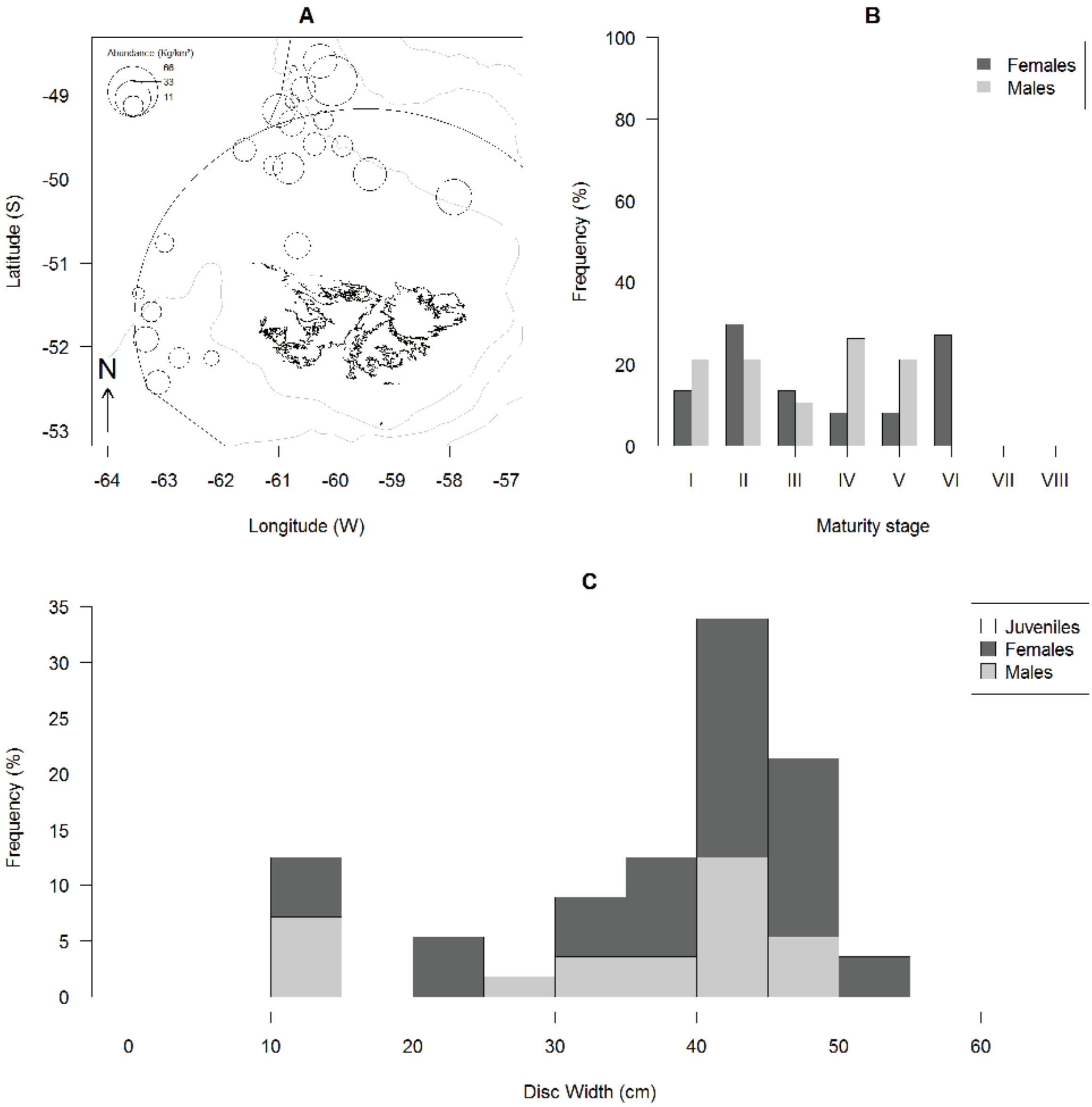


Figure 29: Biological data of *Bathyraja albomaculata* (white spotted skate, RAL), map of the densities in kg.km^{-2} (A), percentage of specimens of each sex per maturity stage (B; I, juvenile; II, adolescent, maturing; III, adult, developing; IV, adult, mature; V, adult, laying; VI, adult, resting) and length frequency (in percentage of the total sample assessed) of each sex with 5 cm size class (C).

3.4.6 *Bathyraja macloviana* – Falkland skate – RMC

A total of 68.64 kg of Falkland skate was caught at 40 of the 89 trawl stations sampled (Figure 30). Catches ranged from 0.01 to 12.45 kg. Among the 40 stations, 24 yielded >1 kg, and only 1 station yielded >10 kg. Densities ranged from 0.05 to 37.65 kg.km^{-2} (CPUE ranged 0.01–6.23 kg.h^{-1}). A total of 72 specimens were assessed (24 females and 48 males), all for length/disc–width/weight. Both females and males ranged from 8 to 41cm DW. The size frequency histogram exhibits 2 cohorts (with modes at 5–15, 35–40 cm). Females and males were observed in most maturity stages, but female stage 5 were absent.

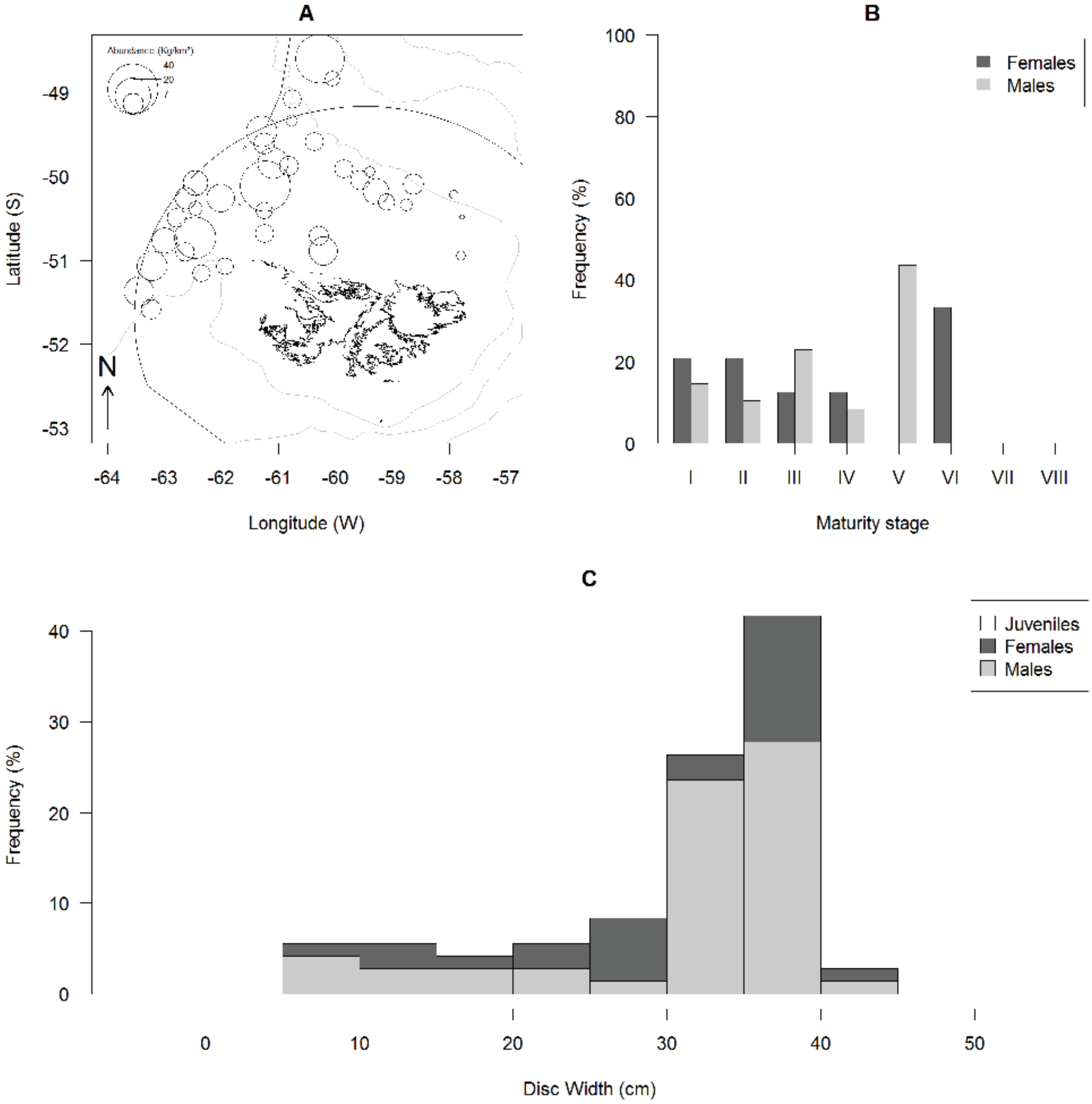


Figure 30: Biological data of *Bathyraja macloviana* (Falkland skate, RMC), map of the densities in kg.km^{-2} (A), percentage of specimens of each sex per maturity stage (B; I, juvenile; II, adolescent, maturing; III, adult, developing; IV, adult, mature; V, adult, laying; VI, adult, resting) and length frequency (in percentage of the total sample assessed) of each sex with 5 cm size class (C).

3.4.7 *Bathyraja multispinis* – multispined skate – RMU

A total of 51.78kg of multispined skate was caught at 3 of the 89 trawl stations sampled (Figure 31). Catches ranged from 7.3 to 36.28 kg. Among the 3 stations, 1 yielded >10 kg. Densities ranged from 22.08 to 191.38 kg.km^{-2} (CPUE ranged 3.65–36.28 kg.h^{-1}). A total of 5 specimens were assessed (3 females and 2 males), all for length/disc–width/weight and vertebrae/thorns. Females ranged from 73–87cm and males ranged from 72–74cm DW. The females were in stages 2, 3 and 6, whereas the males were in stage 3 and 5.

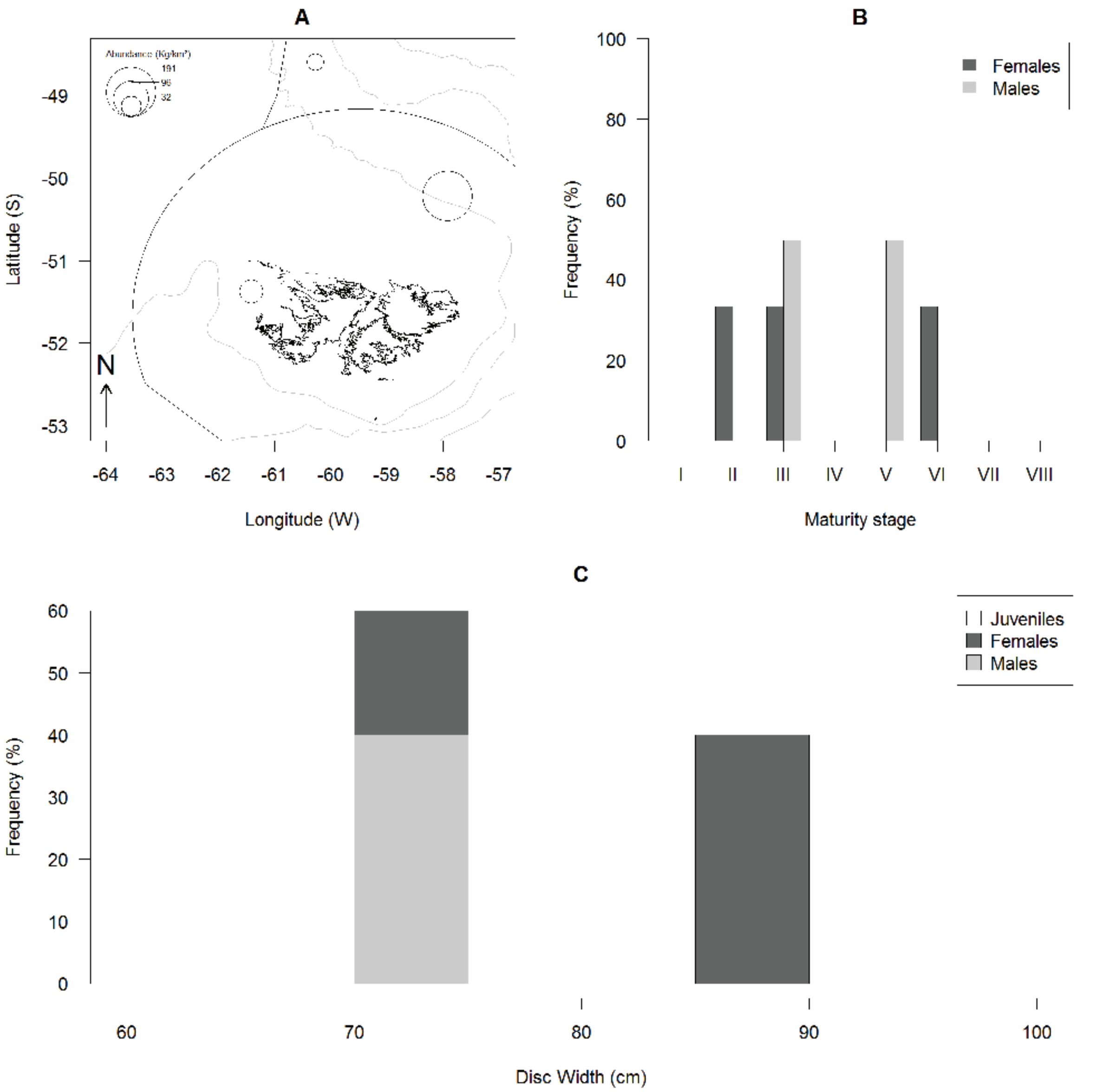


Figure 31: Biological data of *Bathyraja multispinis* (multispined skate, RMU), map of the densities in kg.km^{-2} (A), percentage of specimens of each sex per maturity stage (B; I, juvenile; II, adolescent, maturing; III, adult, developing; IV, adult, mature; V, adult, laying; VI, adult, resting) and length frequency (in percentage of the total sample assessed) of each sex with 5 cm size class (C).

3.4.8 *Psammobatis spp.* – sand ray – RPX

A total of 33.16 kg of sand ray (most likely to all be *Psammobatis normani*, the species with very slender claspers) was caught at 38 of the 89 trawl stations sampled (Figure 32). Catches ranged from 0.01 to 4.62 kg. Among the 38 stations, 10 yielded >1 kg. Densities ranged from 0.05 to 22.32 kg.km^{-2} (CPUE ranged from 0.01 to 4.62 kg.h^{-1}). A total of 66 specimens were assessed (32 females and 34 males), all for length/disc–width/weight. Females ranged from 5–29 cm and males ranged from 6–30cm DW. The size frequency histogram exhibits 2 cohorts (with modes at 10–15 and 25–30 cm). Females and males were found in all maturity stages, and one of the 18 females in stages 4–6 had egg capsules (5.6%).

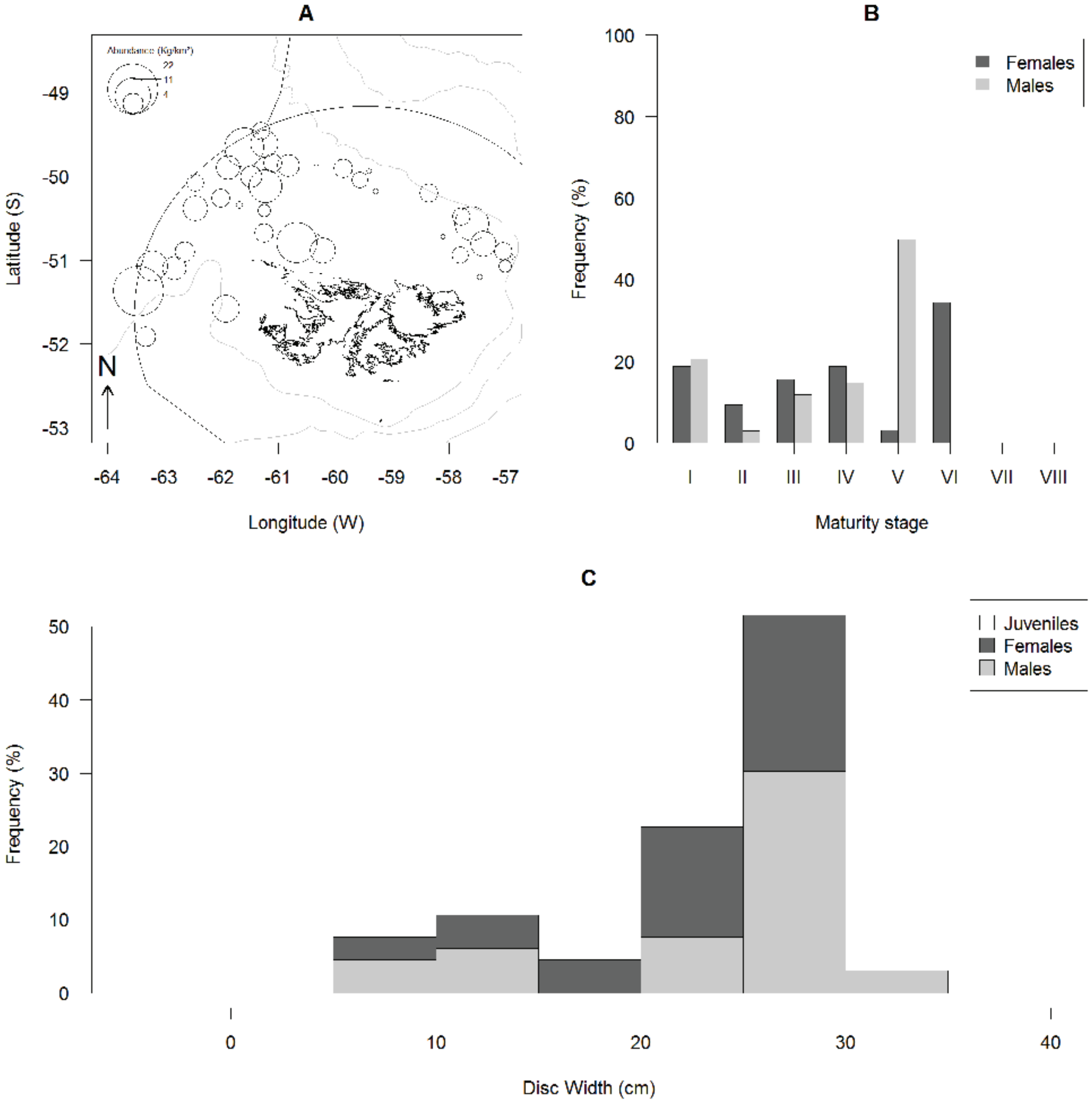


Figure 32: Biological data of *Psammobatis spp.* (sand ray, RPX), map of the densities in kg.km^{-2} (A), percentage of specimens of each sex per maturity stage (B; I, juvenile; II, adolescent, maturing; III, adult, developing; IV, adult, mature; V, adult, laying; VI, adult, resting) and length frequency (in percentage of the total sample assessed) of each sex with 5 cm size class (C).

3.4.9 *Dipturus argentinensis* – Argentine black skate – RDA

A total of 15.44 kg of Argentine black skate was caught at 3 of the 89 trawl stations sampled (Figure 33). Catches ranged from 1.15 to 12.92 kg. Among the 3 stations, 1 stations yielded >10 kg. Densities ranged from 6.47 to 67.12 kg.km^{-2} (CPUE ranged 1.37–12.92 kg.h^{-1}). Three specimens were assessed, all males, for length/disc–width/weight. These ranged from 50 to 98 cm DW. All specimens were juvenile (stage 1).

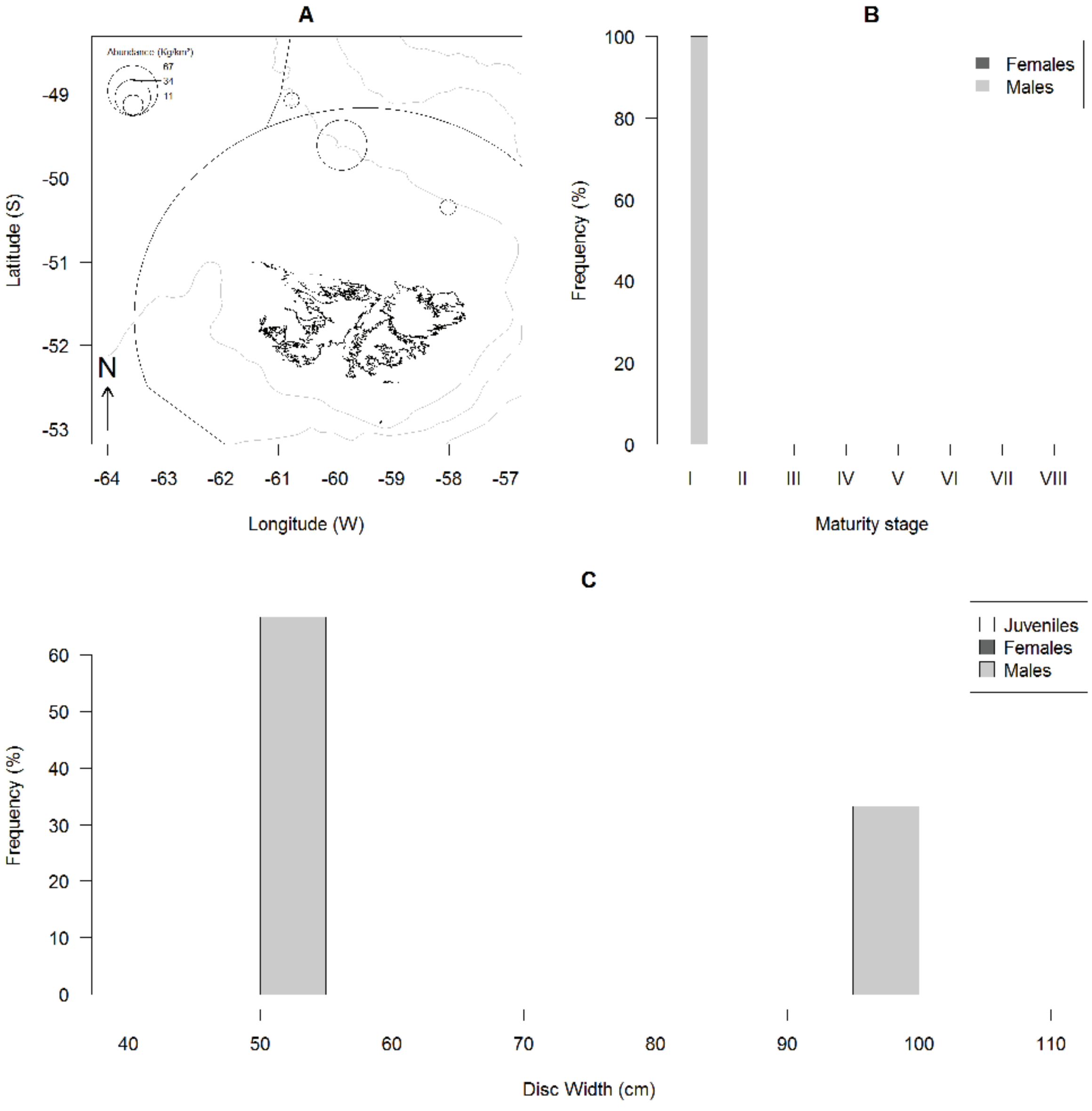


Figure 33: Biological data of *Dipturus argentinensis* (Argentine black skate, RDA), map of the densities in kg.km^{-2} (A), percentage of specimens of each sex per maturity stage (B; I, juvenile; II, adolescent, maturing; III, adult, developing; IV, adult, mature; V, adult, laying; VI, adult, resting) and length frequency (in percentage of the total sample assessed) of each sex with 5 cm size class (C).

3.4.10 *Bathyraja scaphiops* – cuphead skate – RSC

A total of 13.01 kg of cuphead skate was caught at 6 of the 89 trawl stations sampled (Figure 34). Catches ranged from 0.06 to 5.95 kg. Among the 6 stations, 5 yielded >1 kg. Densities ranged from 0.33 to 31.39 kg.km^{-2} (CPUE ranged from 0.06 to 5.95 kg.h^{-1}). A total of 9 specimens were assessed (5 females and 4 males), all for length/disc–width/weight. Females ranged from 28–50 cm and males ranged from 14–49 cm DW. Females were found in all maturity stages except stage 5, whereas for males only one stage 1 and three stage 5 were found.

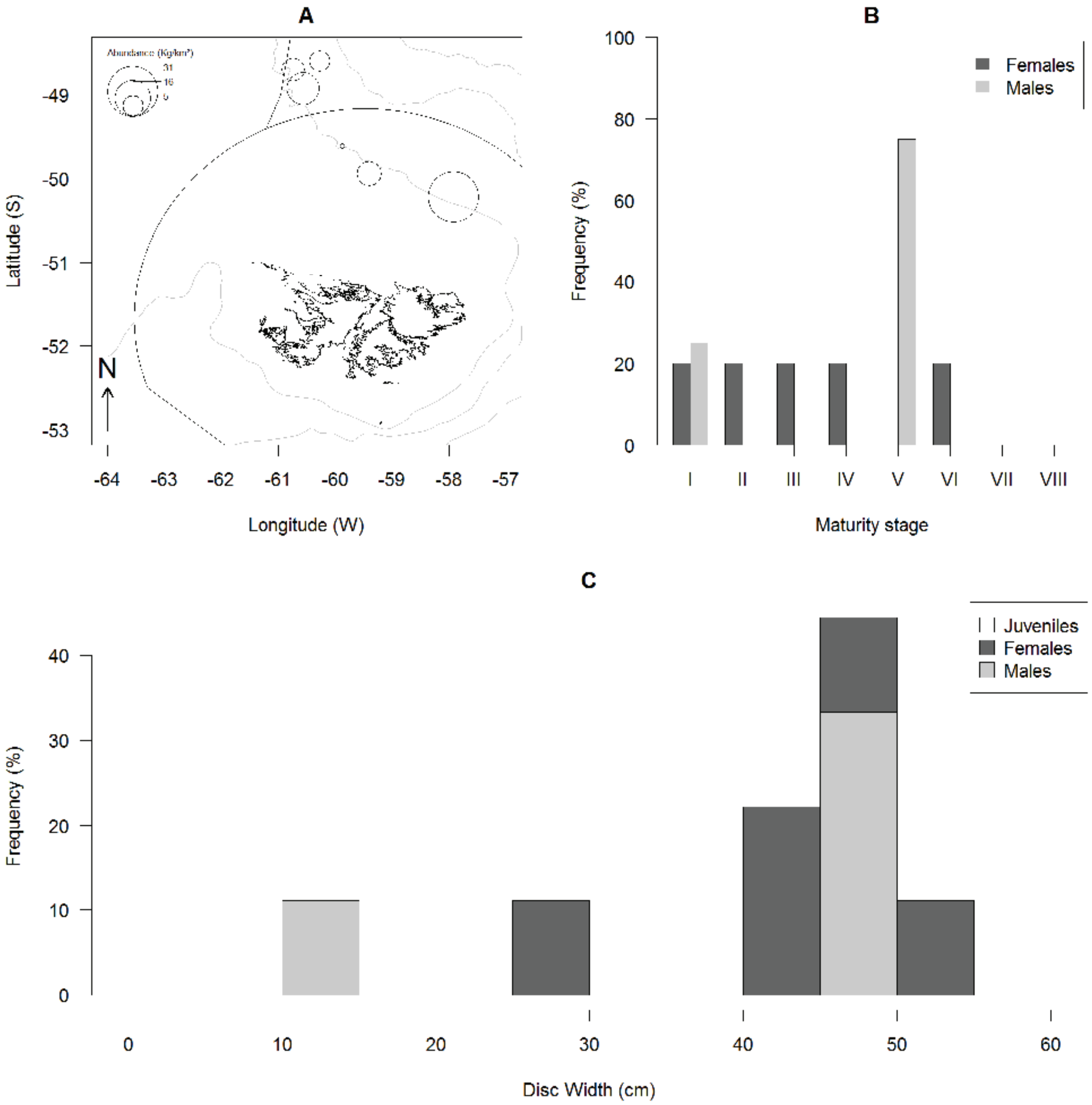


Figure 34: Biological data of *Bathyraja scaphiops* (cuphead skate, RSC), map of the densities in kg.km^{-2} (A), percentage of specimens of each sex per maturity stage (B; I, juvenile; II, adolescent, maturing; III, adult, developing; IV, adult, mature; V, adult, laying; VI, adult, resting) and length frequency (in percentage of the total sample assessed) of each sex with 5 cm size class (C).

3.4.11 *Amblyraja doellojuradoi* – starry skate – RDO

A total of 7.13 kg of starry skate was caught at 5 of the 89 trawl stations sampled (Figure 35). Catches ranged from 0.02 to 4.45 kg. Among the 5 stations, 2 yielded >1 kg. Densities ranged from 0.10 to 28.03 kg.km^{-2} (CPUE ranged 0.02–4.45 kg.h^{-1}). A total of 13 specimens were assessed (6 females and 7 males), all for length/disc–width/weight. Females ranged from 11 to 36 cm and males ranged from 8 to 39 cm DW. Females were observed in maturity stages 1, 2 and 6, whereas males in stages 1, 4 & 5.

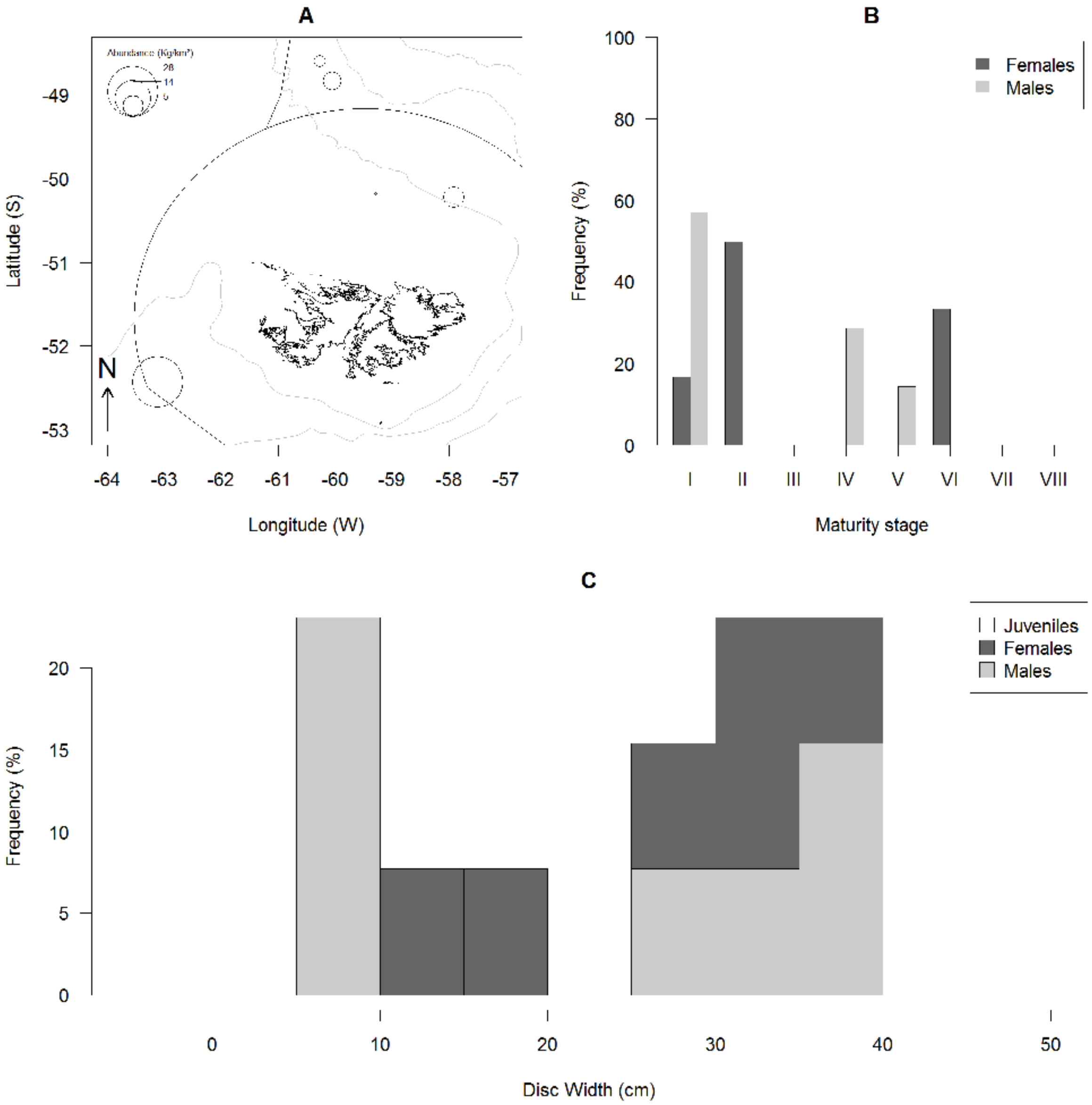


Figure 35: Biological data of *Amblyraja doellojuradoi* (starry skate, RDO), map of the densities in kg.km^{-2} (A), percentage of specimens of each sex per maturity stage (B; I, juvenile; II, adolescent, maturing; III, adult, developing; IV, adult, mature; V, adult, laying; VI, adult, resting) and length frequency (in percentage of the total sample assessed) of each sex with 5 cm size class (C).

3.4.12 *Bathyraja magellanica* – Magellanic skate – RMG

A total of 5.06 kg of Magellanic skate was caught at 5 of the 89 trawl stations sampled (Figure 36). Catches ranged from 0.05 to 3.58 kg. Among the 5 stations, 2 yielded >1 kg. Densities ranged from 0.23 to 17.61 kg.km^{-2} (CPUE ranged 0.05–3.58 kg.h^{-1}). A total of 15 specimens were assessed (7 females and 8 males), all for length/disc–width/weight. Females ranged from 8–18 and males ranged from 10 to 35 cm DW. The size frequency histogram exhibits 2 cohorts (with modes at 10–15 and 30–40 cm). Most females and males were in stages 1–3, except for one mature male (stage 5).

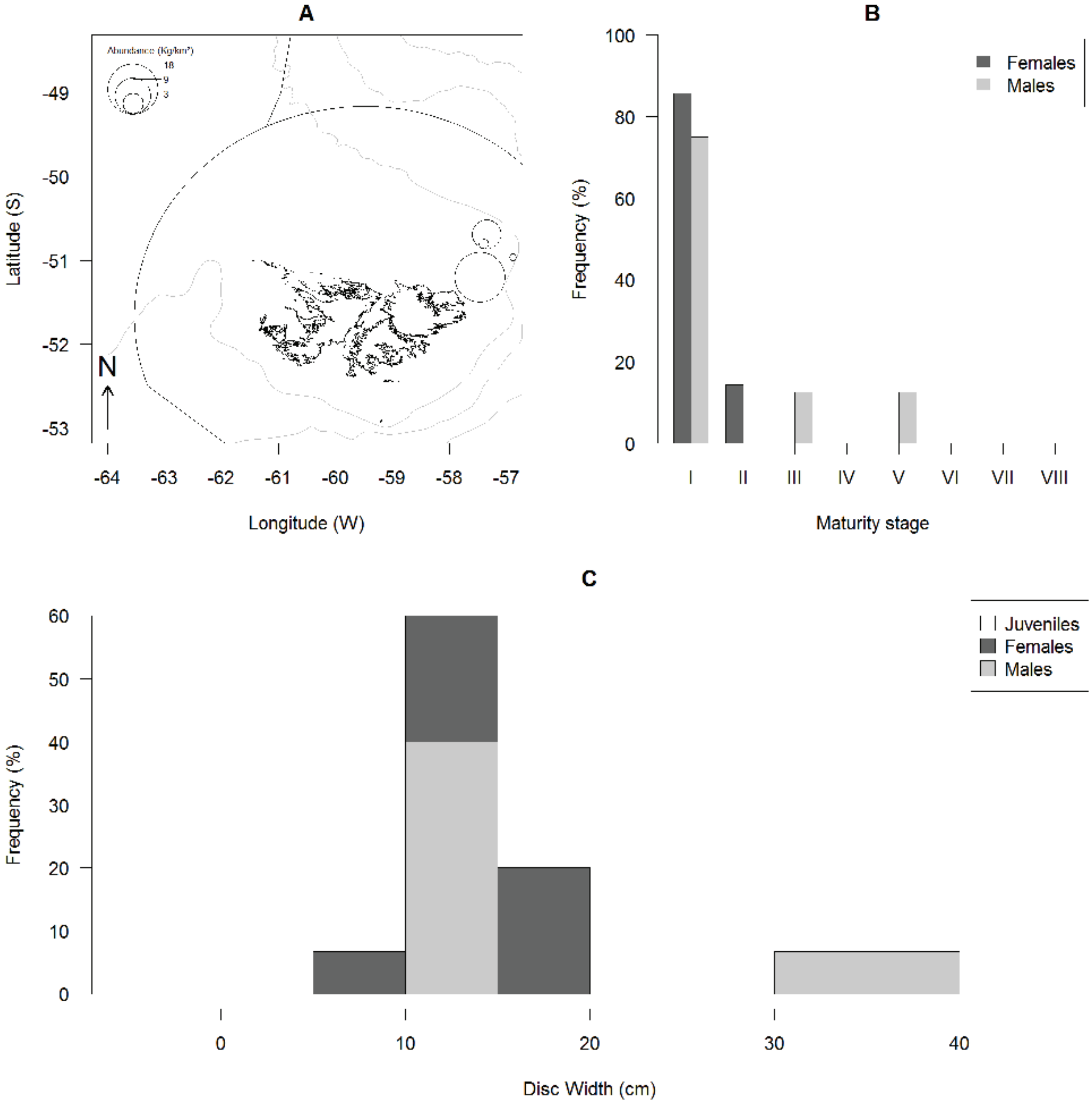


Figure 36: Biological data of *Bathyraja magellanica* (Magellanic skate, RMG), map of the densities in kg.km^{-2} (A), percentage of specimens of each sex per maturity stage (B; I, juvenile; II, adolescent, maturing; III, adult, developing; IV, adult, mature; V, adult, laying; VI, adult, resting) and length frequency (in percentage of the total sample assessed) of each sex with 5 cm size class (C).

3.5 Biomass estimations

Biomass estimations were undertaken for some of the commercial species and for surveys carried out using data collected by rock cod and finfish surveys carried out in February 2010–2011, October 2014 and February 2015–2016 through the finfish area. As the DNRFD bought sensors to measure the horizontal net opening, biomasses were estimated for all the 5 surveys with corrected horizontal net opening (Gras, 2016) to ensure biomass estimations are comparable from year to year. However, one should be cautious when comparing 2014 data with other years as the 2014 survey was conducted in October and not in February.

3.5.1 Common rock cod

For 2010 survey data, horizontal net opening has been derived using the vertical net opening (Gras, 2016). Observed densities ranged from 4.6 kg.km^{-2} to 58.4 t.km^{-2}. Following the steps described in section 2.6, a Box–Cox transformation of the density was carried out using λ=0.5 and the cauchy model was the only model able to fit the experimental variogram plotted with 32 distance classes (Figure 37). The model had no nugget effect, a range of 44 km and reached the sill at 8487. Kriged densities ranged from 60 kg.km^{-2} to 56.9 kg.km^{-2}. On average, density was 6,125 kg.km^{-2} and the total estimated biomass was 653,009 t throughout the surveyed area. Highest densities were observed in the northwest and in the northeast of the surveyed area.

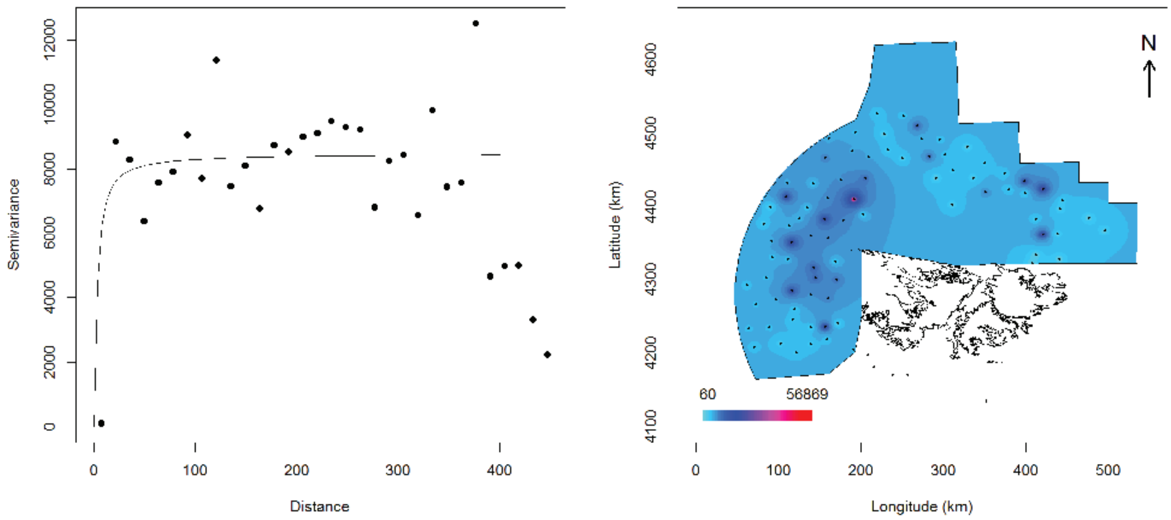


Figure 37: Experimental variogram (dots) and Cauchy variogram model (line) of the ZDLT1–02–2010 survey (left) and kriged map of density with legend in kg.km^{-2} (right).

For 2011 survey, horizontal net opening was also estimated using the vertical net opening (Gras, 2016). Following the steps described in section 2.6, a Box–Cox transformation of the density was carried out using λ=0.5 and the spherical model was found to best fit the experimental variogram plotted with 32 distance classes (exponential and Gaussian models were also tested). The model had no nugget effect, a range of 90 km and reached the sill at 10,157. Observed density ranged from 3.2 kg.km^{-2} to 45.3 t.km^{-2} (Figure 38). On average, kriged density was 7541 kg.km^{-2} ranging from 169 kg.km^{-2} to 45.2 t.km^{-2}. The total biomass was estimated at 803,955 t. Stock structure consisted of two patches of high densities, in the northwest and in the northeast. In the northwest, the patch is larger than observed in 2010 but highest densities were not as high.

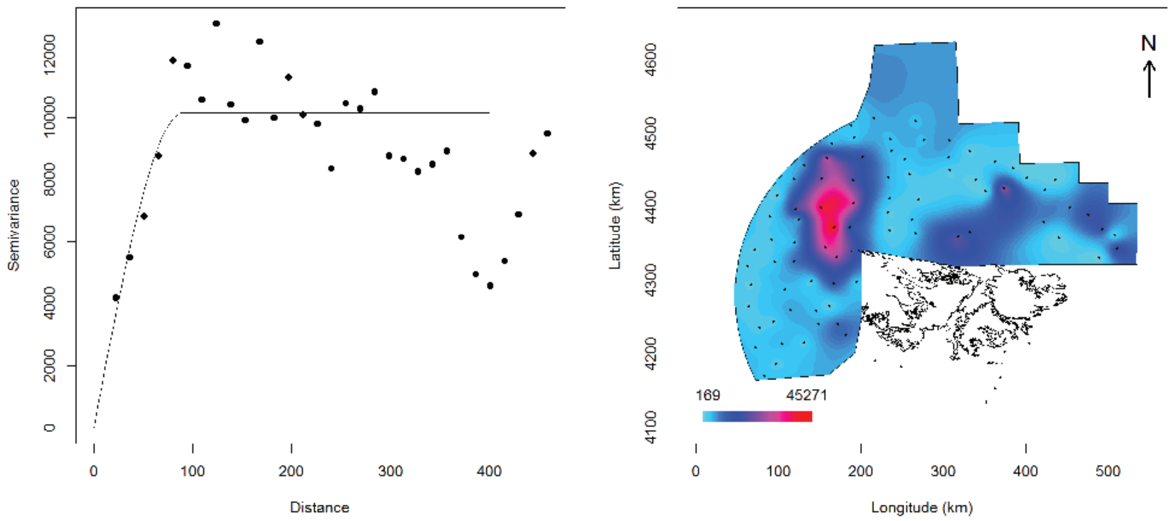


Figure 38: Experimental variogram (dots) and spherical variogram model (line) of the ZDLT1–02–2011 survey (left) and kriged map of density with legend in kg.km^{-2} (right).

For the 2014 survey, horizontal net opening was estimated using both the door spread and the trawl speed (Gras, 2016). Following the steps described in section 2.6, a Box–Cox transformation of the density was carried out using λ=0.5 and the spherical model was found to best fit the experimental variogram plotted with 30 distance classes (exponential and Gaussian models were also tested; Figure 39). The model had no nugget effect, a range of 51 km and reached the sill at 5,938. Observed density ranged from 3.2 kg.km^{-2} to 41.8 t.km^{-2}. On average, kriged density was 2,461 kg.km^{-2} ranging from 24 kg.km^{-2} to 41.3 t.km^{-2}. The total biomass was estimated at 262,415 t. Stock structure consisted of three patches of high densities, two in the northwest and one in the northeast. In the northwest, catches of the two patches consisted of large fish while small fish were caught in the northeast.

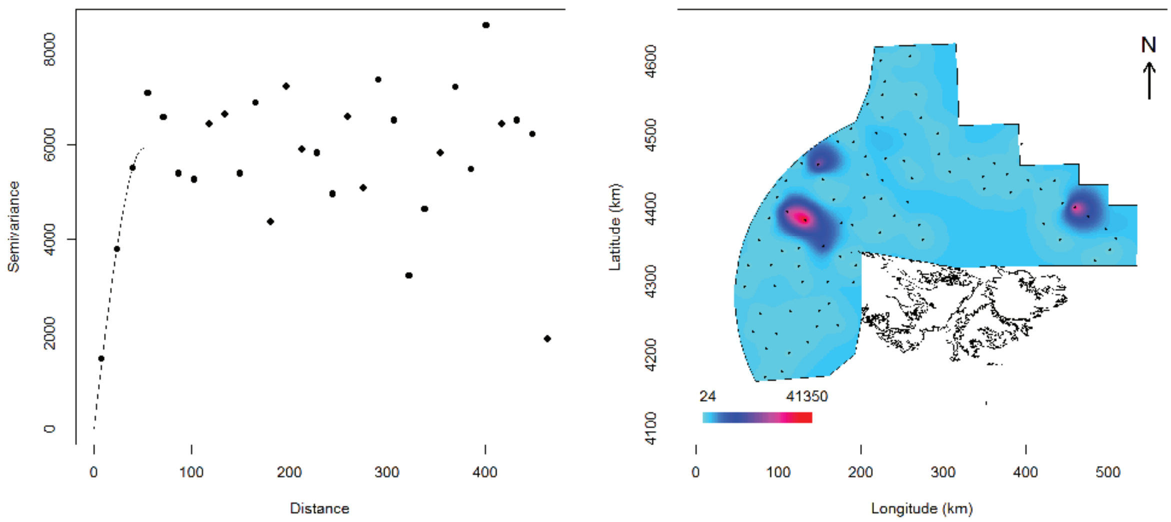


Figure 39: Experimental variogram (dots) and spherical variogram model (line) of the ZDLT1–10–2014 survey (left) and kriged map of density with legend in kg.km^{-2} (right).

For 2015 survey, horizontal net opening was estimated using both the door spread and the trawl speed (Gras, 2016). Following the steps described in section 2.6, a Box–Cox transformation of the density was carried out using λ=0.5 and the spherical model was found to best fit the experimental variogram plotted with 43 distance classes (exponential and Gaussian models were also tested). The model had no nugget effect, a range of 34 km and reached the sill at 3,246 (Figure 40). Observed density ranged from 11.1 kg.km^{-2} to 43.8 t.km^{-2}. On average kriged density was 1,937 kg.km^{-2} ranging from 45 kg.km^{-2} to 43.7 t.km^{-2}. The total biomass was estimated at 206,485 t. Stock structure consisted of one main patch of high density in the northwest of the surveyed area. Two less significant patches appeared, one in the northwest and one in the northeast. The patch in the northwest consist of large fish while in the northeast small fish were taken.

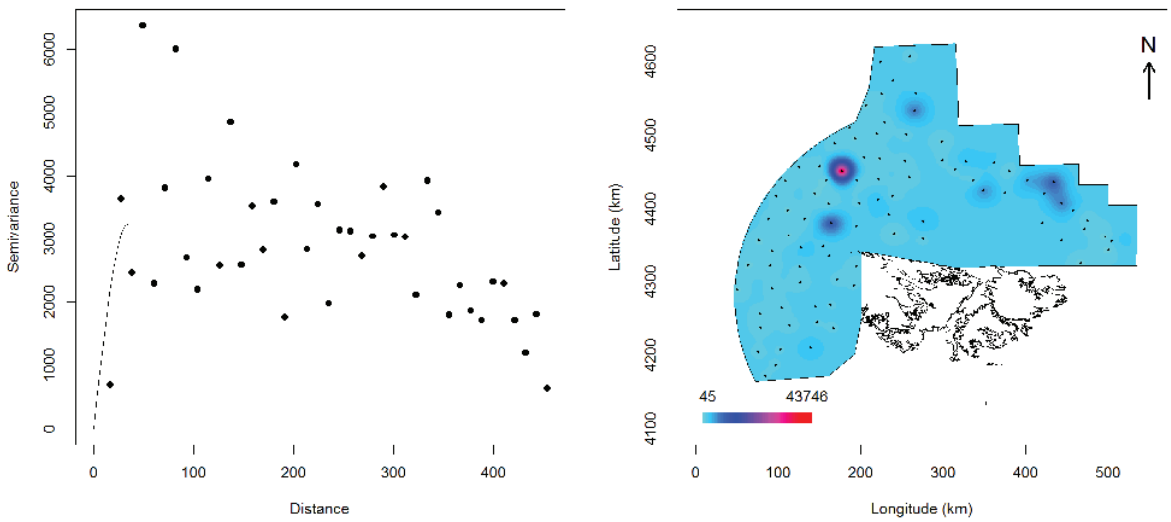


Figure 40: Experimental variogram (dots) and spherical variogram model (line) of the ZDLT1–02–2015 survey (left) and kriged map of density with legend in kg.km^{-2} (right).

For the 2016 survey, horizontal net opening was measured in situ using the sensors bought by the DNRFD. Following the steps described in section 2.6, a Box–Cox transformation of the density was carried out using λ=0.5 and the exponential model was found to best fit the experimental variogram plotted with 33 distance classes (spherical and Gaussian models were also tested; Figure 41). The model had no nugget effect, a range of 146 km and reached the sill at 3,166. Observed density ranged from 2.1 kg.km^{-2} to 31 t.km^{-2}. On average kriged density was 1,836 kg.km^{-2} ranging from 9 kg.km^{-2} to 29.7 t.km^{-2}. The total biomass was estimated at 195,696 t. Stock structure consisted of one main patch of high density in the northeast of the surveyed area and catch there consisted of small specimens. Another patch in the northwest showed lower abundances and consisted of large fish.

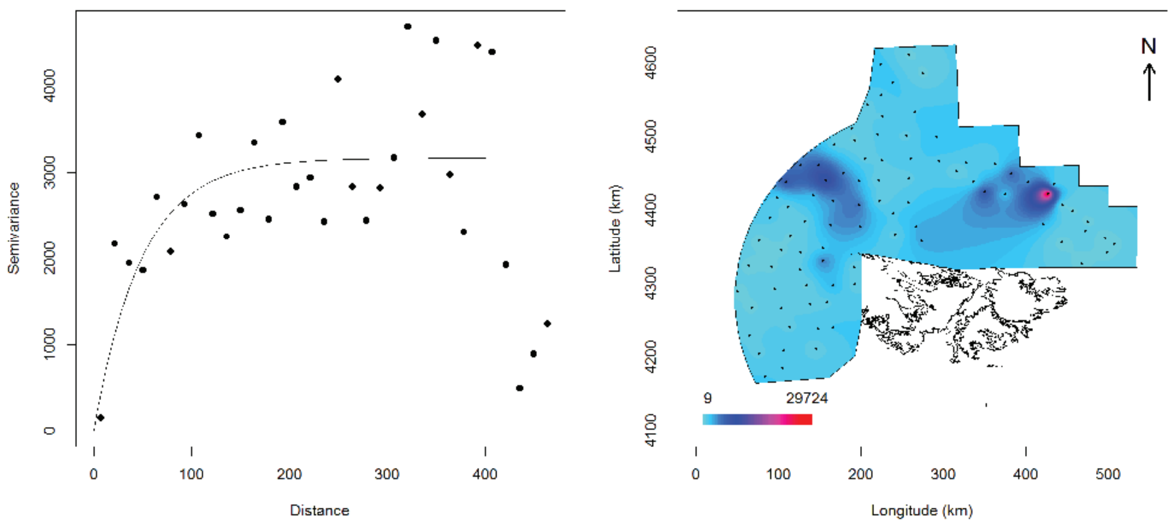


Figure 41: Experimental variogram (dots) and exponential variogram model (line) of the ZDLT1–02–2016 survey (left) and kriged map of density with legend in kg.km^{-2} (right).

The stock structure of rock cod appears to be the same throughout the studied period with high abundances in the northwest and in the northeast. In the northwest, where fishers generally target rock cod, assessed specimens were large, probably adults. The time series of abundance (Figure 42) shows an increase of the biomass from 653,009 t to 803,955 t between the first two surveys. However, in October 2014 the biomass was down to 262,415 t. In February 2015, a decrease of the biomass was again observed (206,485 t) and the last biomass estimation revealed that rock cod was 195,696 t. The maximum density, after decreasing between the first two years, remained relatively stable until 2015. However, in 2016, the northwest patch of large fish did not exhibit an abundance as high as the previous years which is probably the origin of the biomass decrease observed. In the meantime, the hot spot observed in the northeast consisting of small rock cod remains from year to year. This spot could be a nursery for the species. This zone is not exploited by trawlers, a situation that protects this nursery.

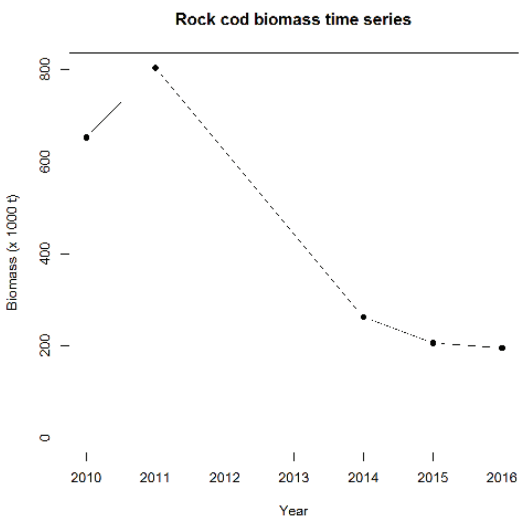


Figure 42: Time series of the rock cod biomass using the finfish survey data collected from 2010.

3.5.2 Red cod

The experimental variogram was plotted using 26 distance classes and data were Box–Cox transformed using λ=0.5 (Figure 43). Spherical model best fitted to the semivariogram with no nugget effect, a range of 74 km and reached the sill at 3,377. Kriged density ranged from 4 kg.km^{-2} to 37.7 t.km^{-2}. Highest abundances were observed in the western part of the FICZ alongside its western limit. Biomass estimations increased from 2010 (89,324 t) to 2011 (137,041 t), decreased to 101,664 t in 2014, slightly increased in 2015 (114,792 t) and remained stable in 2016 (112,882 t).

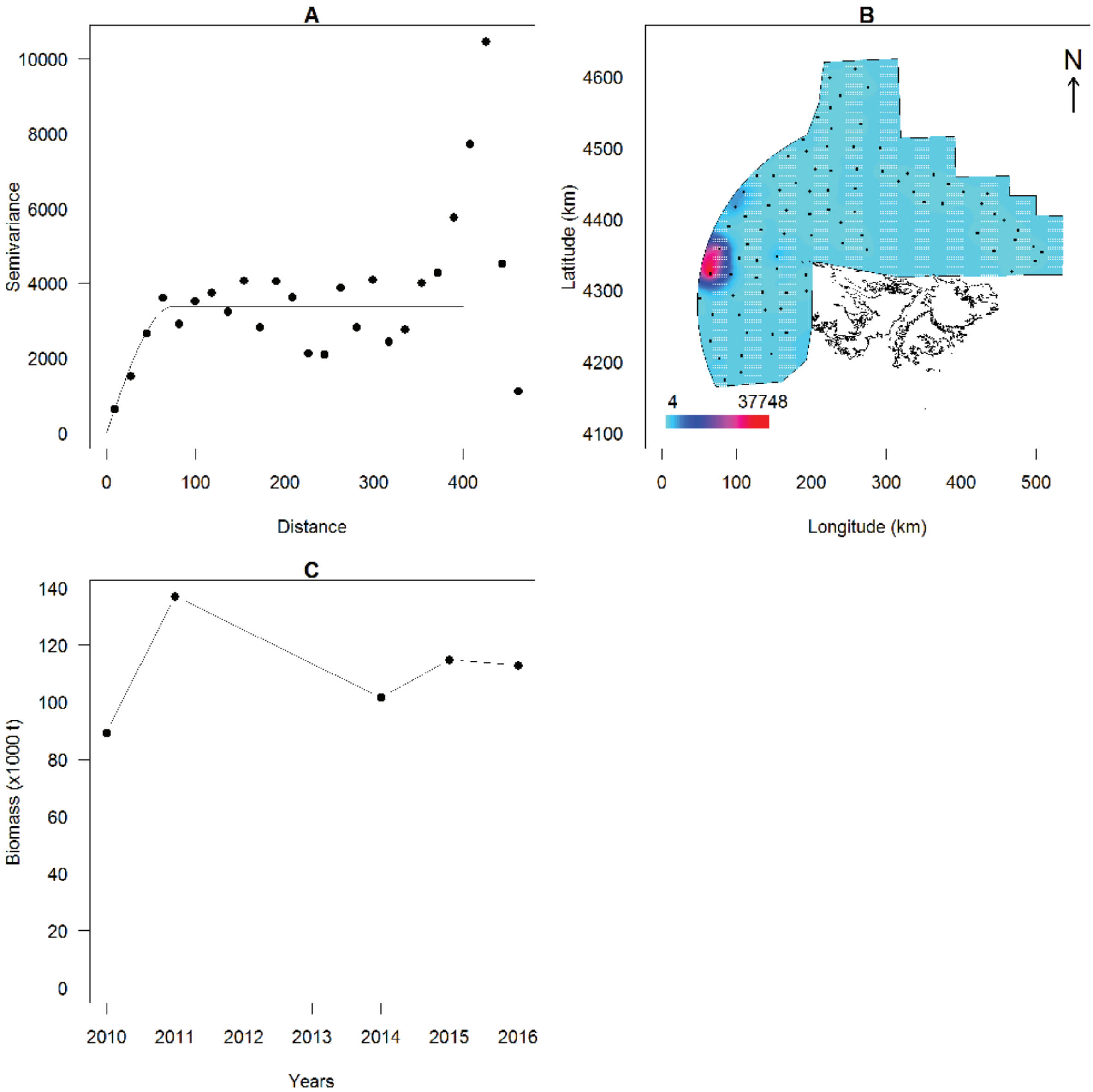


Figure 43: Experimental variogram with spherical model fitted (A), kriged map of red cod density (B) and time series of biomass using the finfish survey data collected from 2010 (C).

3.5.3 Hake

The experimental variogram was plotted using 26 distance classes and data were Box–Cox transformed using λ=0.5 (Figure 44). Spherical model best fitted to the semivariogram with no nugget effect, a range of 228 km and reached the sill at 123. Kriged density ranged from 0 to 244 kg.km^{-2}. Highest abundances were observed to the northwest of West Falkland in two main hot spots, one close to the shore and one close to the northwest border of the FICZ. Biomass estimations increased from 2010 (7,478 t) to 2011 (9,418 t), 2014 (13,707 t) and 2015 (17,580 t) and finally decreased in 2016 (4,075 t). The survey is generally conducted before the migration of hake to Falkland waters for the feeding season (which generally occurs around April) except in 2014 when it was conducted in October, i.e. at the time of emigration of hake to spawning grounds. Biomasses estimated in February and October should not be taken as an indicator of abundance for the following/previous fishing season as time of the migration can vary according to oceanographic conditions.

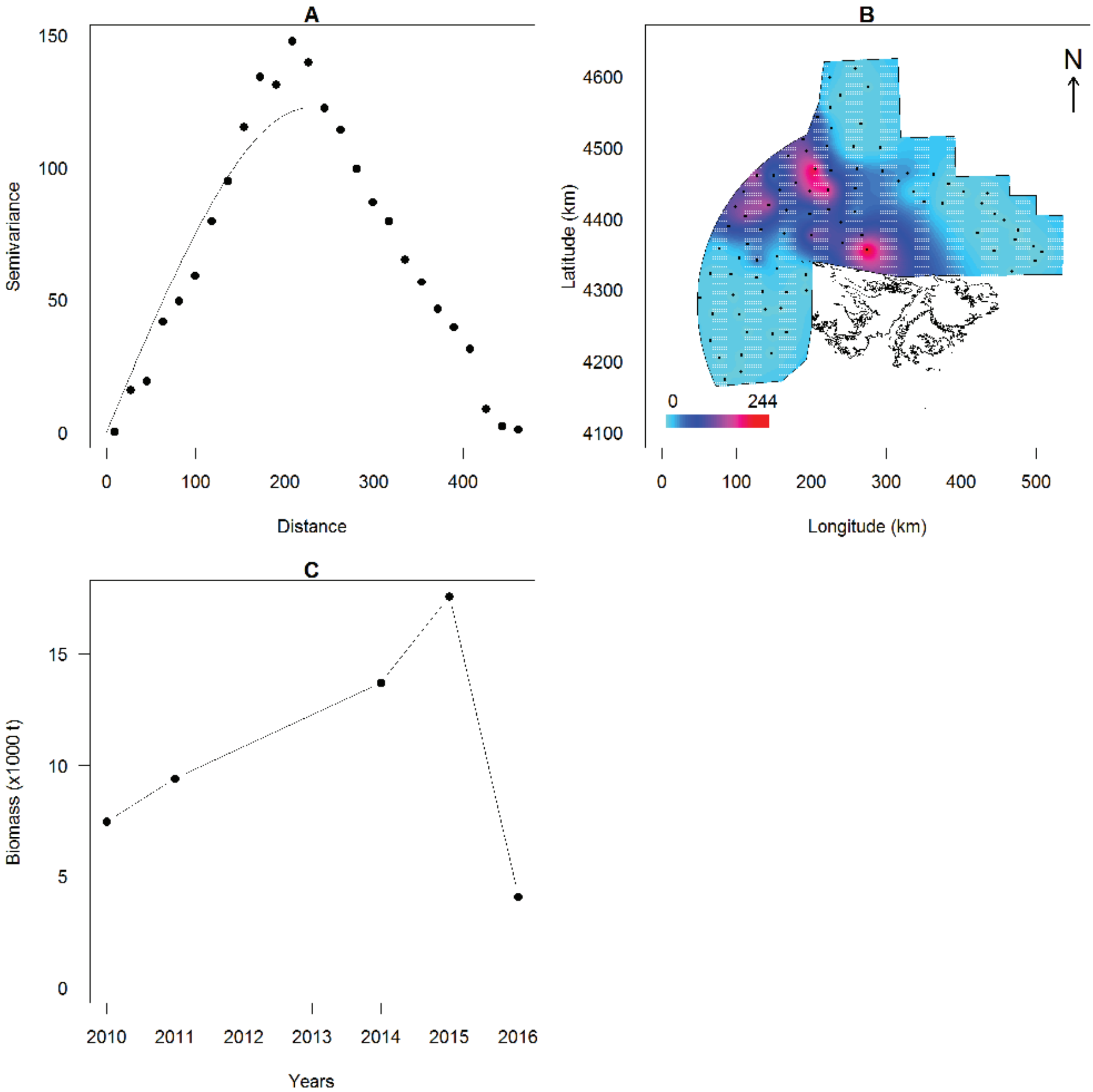


Figure 44: Experimental variogram with spherical model fitted (A), kriged map of hake (B) and time series of biomass using the finfish survey data collected from 2010 (C).

3.5.4 Toothfish

The experimental variogram was plotted using 32 distance classes and data were Box–Cox transformed using λ=0.5 (Figure 45). Exponential model best fitted to the semivariogram with no nugget effect, a range of 265 km and reached the sill at 93. Kriged density ranged from 0 to 458 kg.km^{-2}. Highest abundances were observed in the southwest and in the northeast of the surveyed zone. Biomass estimations slightly increased from 2010 (7,052 t) to 2011 (7,314 t), dropped in 2014 (1,033 t), slightly increased in 2015 (1281 t) and finally increased to 4,464 t in 2016. The toothfish samples consisted mainly of small specimens pre–recruited to the longline fishery. Data from this survey is a good source of information to monitor toothfish pre–recruit abundances, and especially cohorts of the year and probably 1 and 2 year old specimens. Finally, it is also a good opportunity to gather otoliths from young specimens.

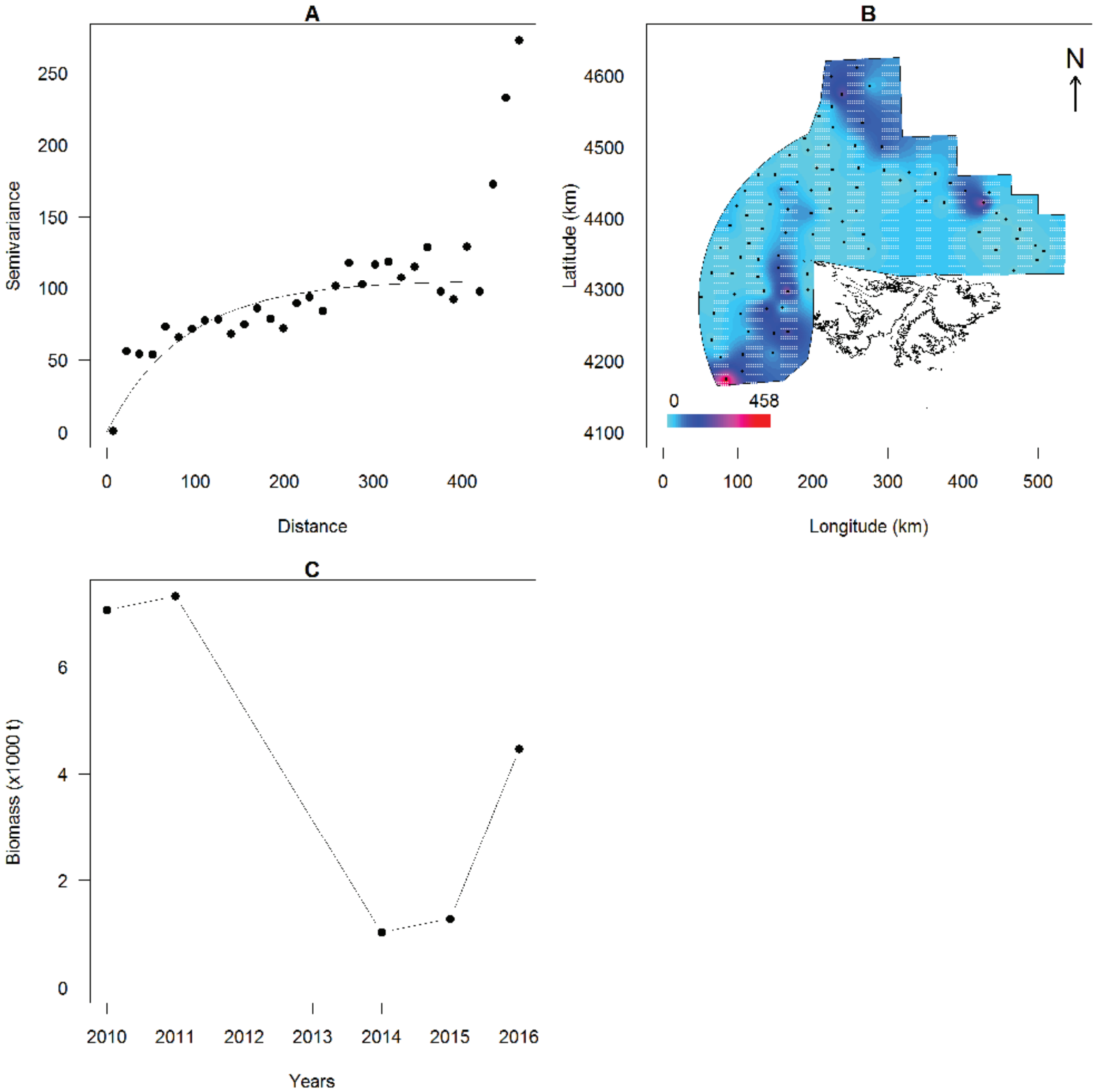


Figure 45: Experimental variogram with exponential model fitted (A), kriged map of toothfish (B) and time series of biomass using the finfish survey data collected from 2010 (C).

3.5.5 Kingclip

The experimental variogram was plotted using 35 distance classes and data were Box–Cox transformed using λ=0.5 (Figure 46). Spherical model best fitted to the semivariogram with no nugget effect, a range of 48 km and reached the sill at 838. Kriged density ranged from 1 kg.km^{-2} to 7.8 t.km^{-2}. Highest abundance was observed in the north of the surveyed area alongside the limit between FICZ and FOCZ. Biomass estimation increased from 2010 (20,968 t) to 2011 (46,988 t), then slightly decreased to 43,343 t in 2014, picked in 2015 (99,991 t) and went back to 31,700 t in 2016.

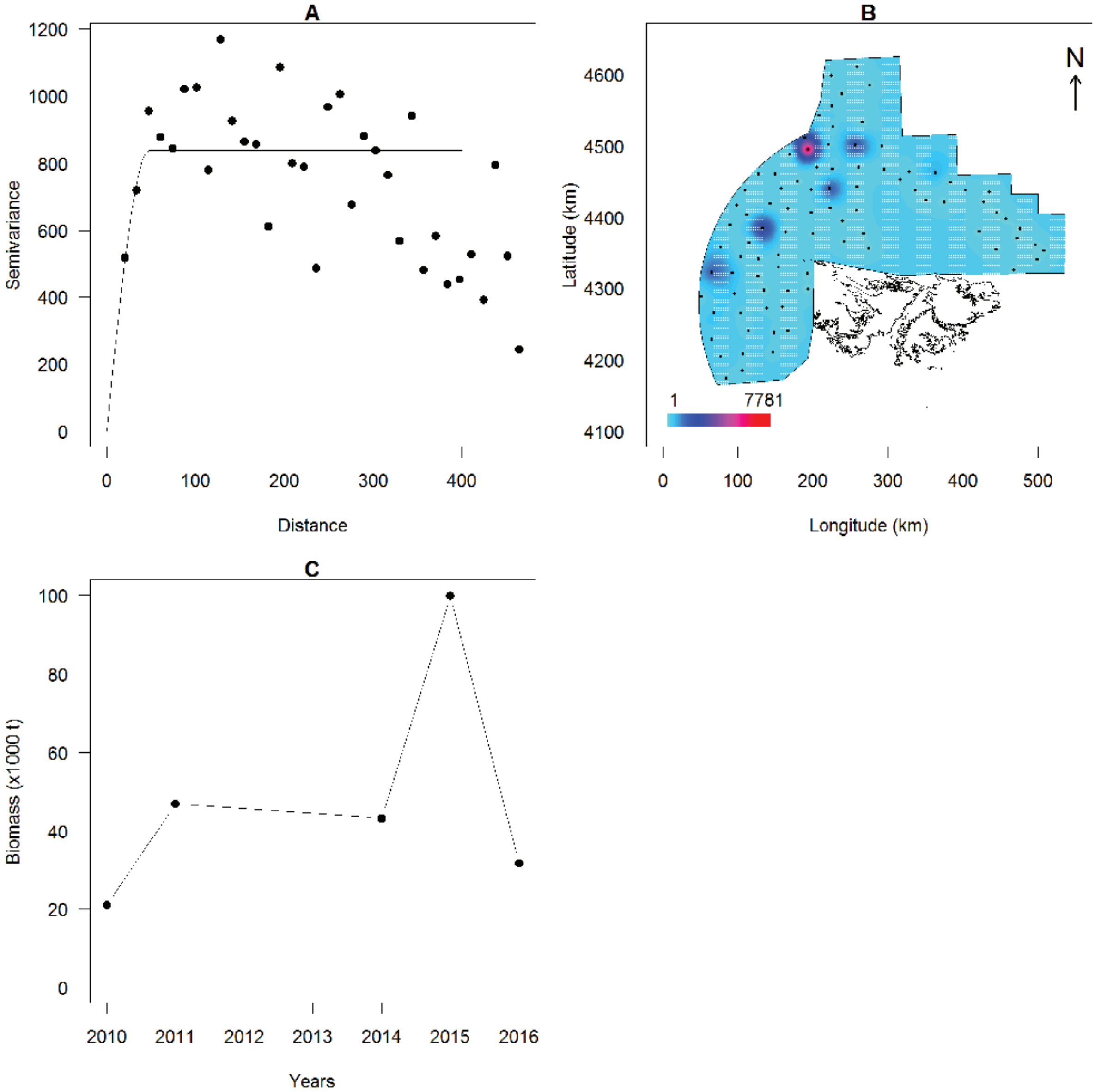


Figure 46: Experimental variogram with spherical model fitted (A), kriged map of kingclip (B) and time series of biomass using the finfish survey data collected from 2010 (C).

3.5.6 Hoki

The experimental variogram was plotted using 23 distance classes and data were Box–Cox transformed using λ=0.5 (Figure 47). Spherical model best fitted to the semivariogram with no nugget effect, a range of 95 km and reached the sill at 3804. Kriged density ranged from 1 kg.km^{-2} to 35 t.km^{-2}. Highest abundance was observed in the southwest of the surveyed zone in deep waters where hoki is generally abundant and where the fishing fleet targets it. Biomass estimation tripled from 2010 (61,836 t) to 2011 (182,440 t) and was almost null in 2014 (182 t). In 2015, biomass increased to 61,425 t and doubled in 2016 (147,857 t).

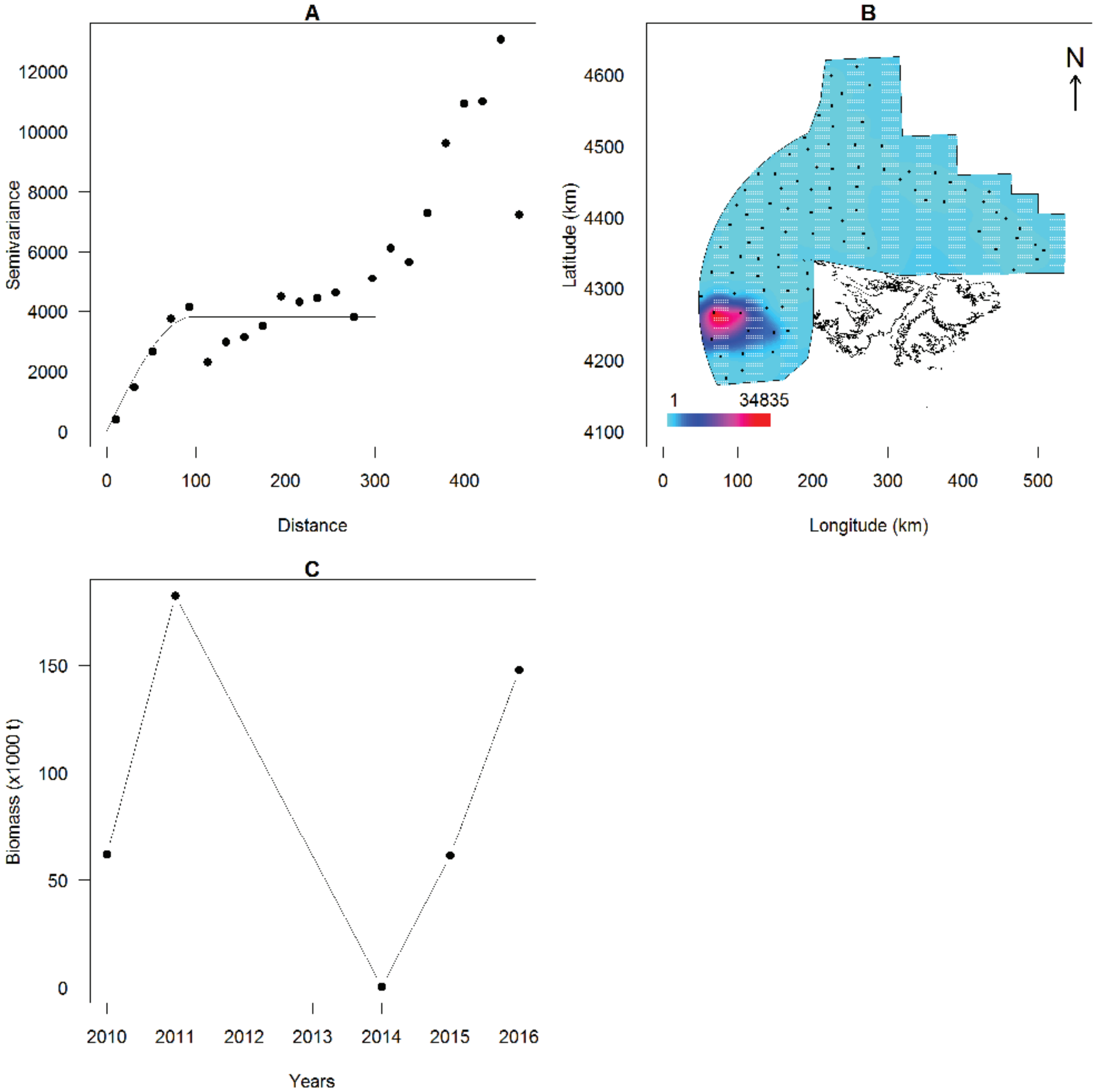


Figure 47: Experimental variogram with spherical model fitted (A), kriged map of hoki (B) and time series of biomass using the finfish survey data collected from 2010 (C).

3.5.7 Southern blue whiting

The experimental variogram was plotted using 34 distance classes and data were Box–Cox transformed using λ=0.5 (Figure 48). Gaussian model best fitted to the semivariogram with no nugget effect, a range of 250 km and reached the sill at 763. Kriged density ranged from 0 kg.km^{-2} to 6.1 t.km^{-2}. Highest abundance was observed in the southwest of the surveyed area in deep waters where southern blue whiting is generally abundant. Biomass estimation slightly increased from 2010 (27,442 t) to 2011 (32,712 t), dropped in 2014 (15,938 t) and was then stable with some variation in 2015 (14,798 t) and 2016 (17,379 t).

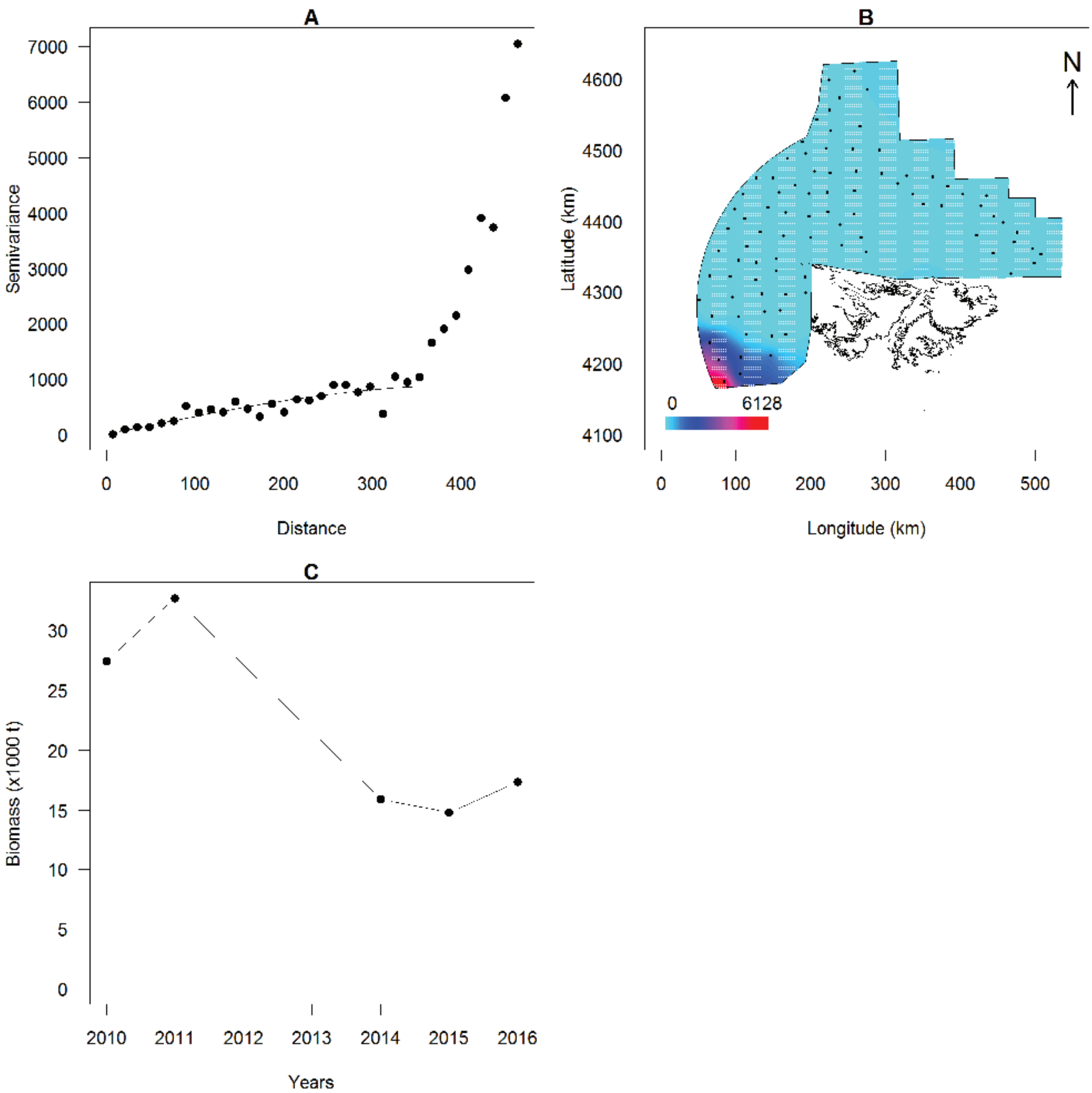


Figure 48: Experimental variogram with Gaussian model fitted (A), kriged map of southern blue whiting (B) and time series of biomass using the finfish survey data collected from 2010 (C).

3.5.8 Argentine short–finned squid

The experimental variogram was plotted using 31 distance classes and data were Box–Cox transformed using λ=0.5 (Figure 49). Spherical model best fitted to the semivariogram with no nugget effect, a range of 134 km and reached the sill at 6.65. Kriged density ranged from 1 kg.km^{-2} to 28 kg.km^{-2}. Highest abundances were observed to the northwest of West Falkland alongside the border of the FICZ and in the eastern part of the surveyed area which is also the north of the *Loligo* box. Biomass estimations almost doubled from 2010 (6,057 t) to 2011 (10,720 t), was almost nil in 2014 (21 t) picked in 2015 (216,921 t) and dropped in 2016 (265 t). Abundance in 2014 was assessed in October when *Illex argentinus* is not yet in Falkland waters.

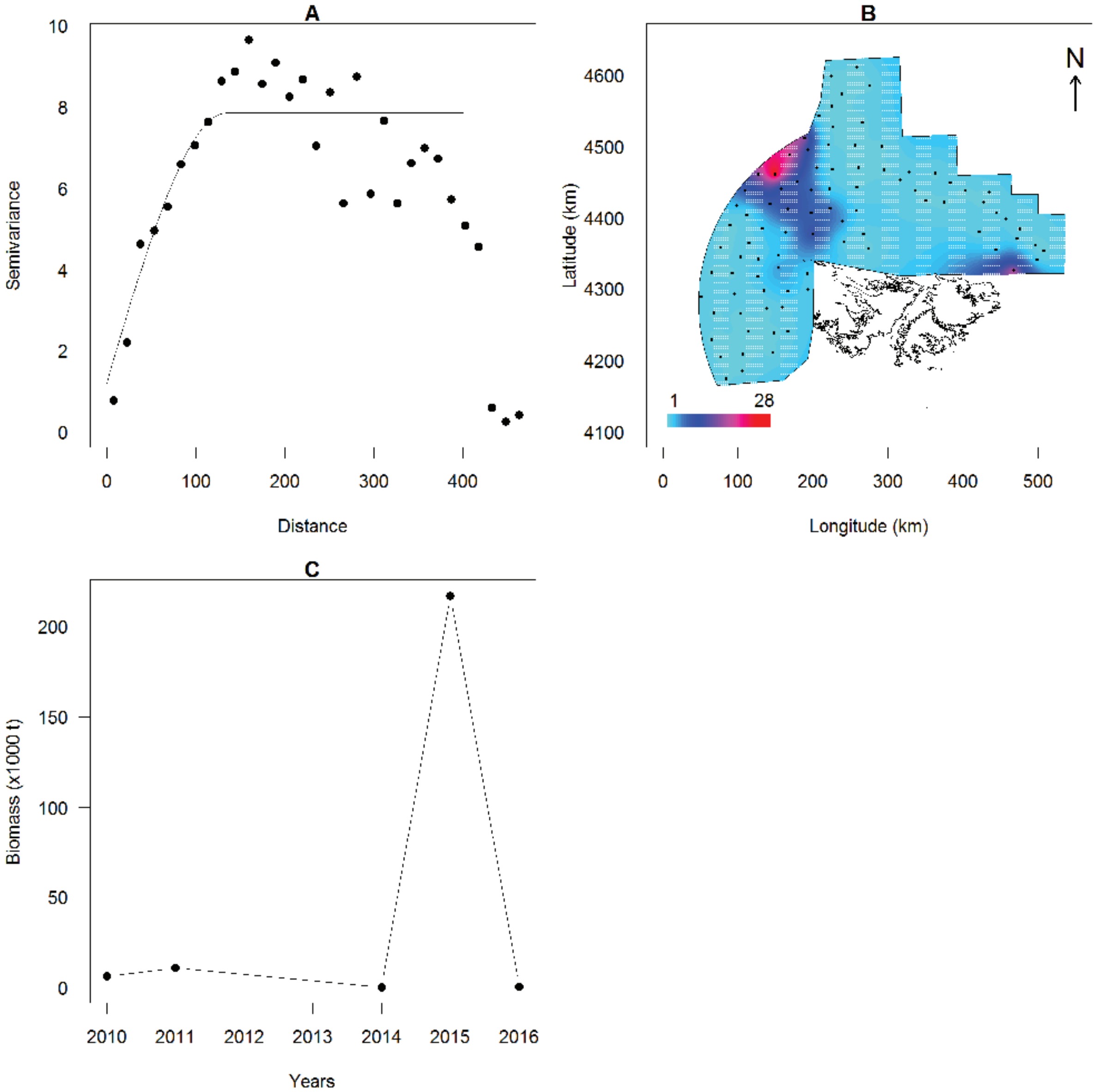


Figure 49: Experimental variogram with spherical model fitted (A), kriged map of Argentine short–finned squid (B) and time series of biomass using the finfish survey data collected from 2010 (C).

3.5.9 Falkland Calamari

The experimental variogram was plotted using 18 distance classes and data were Box–Cox transformed using λ=0.5 (Figure 50). Gaussian model best fitted to the semivariogram with no nugget effect, a range of 23 km and reached the sill at 138. Kriged density ranged from 0 kg.km^{-2} to 3.9 t.km^{-2}. Highest abundance were observed in the southeast of the surveyed which is also the north of the *Loligo* box. Biomass estimations were stable between 2010 (17,953 t) and 2011 (18,831 t) and 2014 (19,598 t). In 2015, biomass decreased to 10,890 and then slightly increased in 2016 (12,252 t).

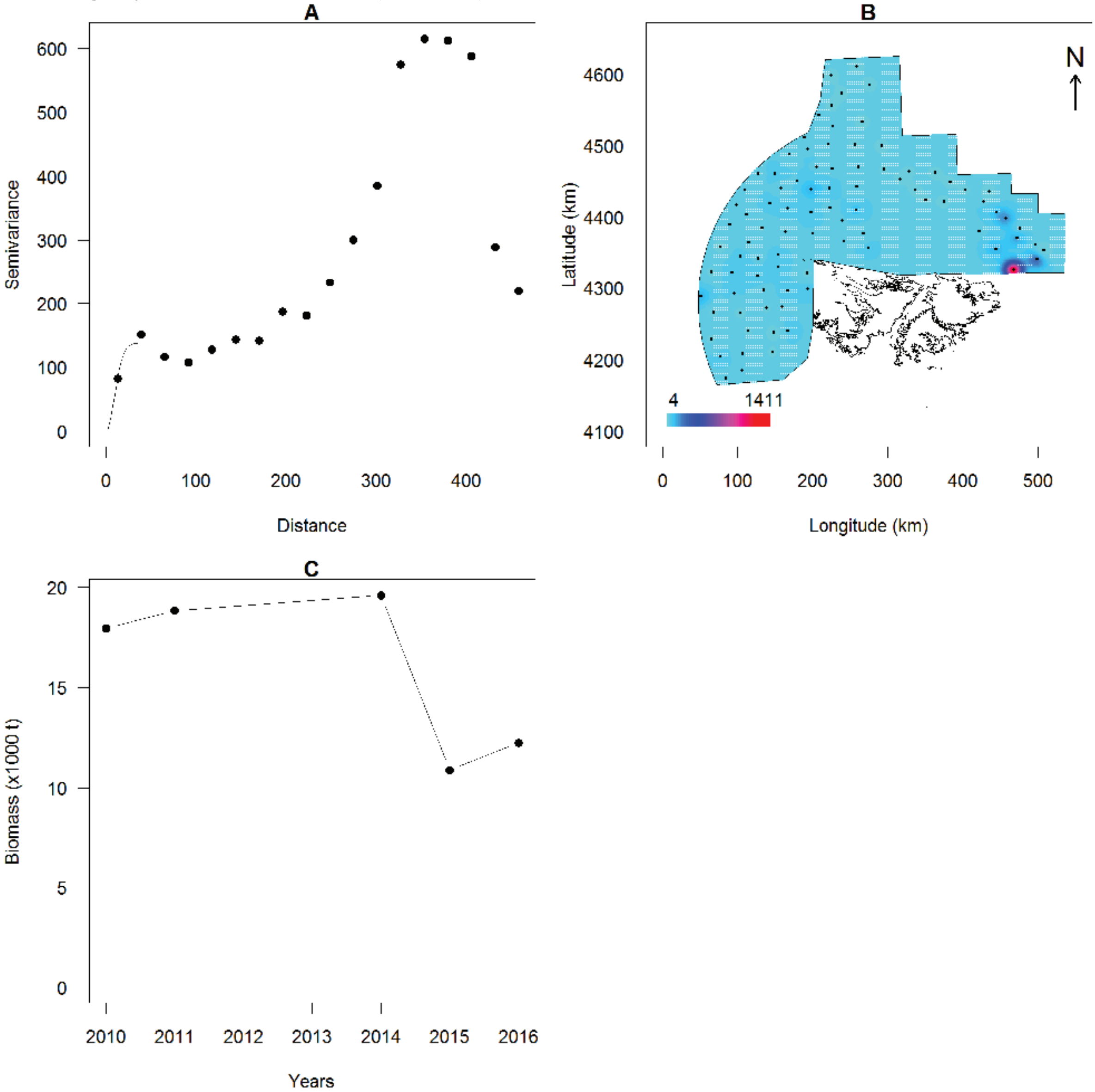


Figure 50: Experimental variogram with Gaussian model fitted (A), kriged map of Falkland calamari (B) and time series of biomass using the finfish survey data collected from 2010 (C).

3.5.10 Catch composition Isaacs Kidd trawl

The 14 plankton tows (7 just below the surface, 7 in the backscattering layer if present) yielded a total wet weight of 11,407 g (X–814g, range 71–2675g). Table 2 summarises all species (or groups) caught grouped by their relative abundance, except for the fish fry, which are discussed below.

Table 2: Catch summary for Isaacs–Kidd Midwater trawls (n=14)

Species code	*Latin Name*	Dominant (30–80%)	Abundant (5–30%)	Common (1–5%)	Occasional (<1%)	Rare (n=1–2)	Total
THE	*Themisto gaudichaudi*	5	3	2	3	2	15
MUG	*Munida gregaria*	2	1	5	1	3	12
CHA	*Chaetognatha*	1	4		2	3	10
BEO	*Beroe ovata*	1		7	1		9
EUP	Euphausids	4	2				6
EUV	*Euphausia vallentini*		3	1	2		6
AMP	Amphipoda					5	5
COA	Copepoda				1	2	3
SAT	*Salpa thompsoni*	2					2
LOL	*Doryteuthis gahi*					2	2
PHS	*Phronima sedentaria*					2	2
ICA	*Icichthys australis*					1	1
MNL	*Mnemiopsis leidyi*				1		1
MUN	*Munida spp.*				1		1
MXX	Myctophidae					1	1
PHH	*Physophora hydrostatica*					1	1
THV	*Thysanoessa vicina*					1	1
THY	*Thysanoessa gregaria*				1		1

3.5.11 Fish larvae and fry, abundance, distribution and morphology

A total of 143 pelagic larvae and fry with an approximate size range between 11 and 51 mm TL were captured at 9 of the 14 stations. It was possible to identify captured fish larvae to consist of a minimum of 7 species groupings. The majority of the specimens (n=108), tentatively identified as *Sprattus fuegensis* (e.g. Figure 51) and measuring ~20 mm TL, were caught at 5 stations. The second most numerous (n=11) were *Sebastes oculatus* (e.g. Figure 52), measuring 11–17 mm TL and caught at 4 stations, and *Salilota australis* (e.g. Figure 53) (n=11), measuring 25–51 mm TL also at 4 stations. Of lesser abundance (n=5) were 5 Myctophidae at 5 stations, and 3 *Cottoperca gobio* (e.g. Figure 54) measuring 22–33 mm TL at one station. Two Notothenoids, two *Patagonotothen ramsayi* of 16 mm TL (e.g. Figure 55) and one 28 mm TL grenadier (Figure 56) were also caught

Figure 51: *Sprattus fuegensis* – st 1985 – 27 mm – TL

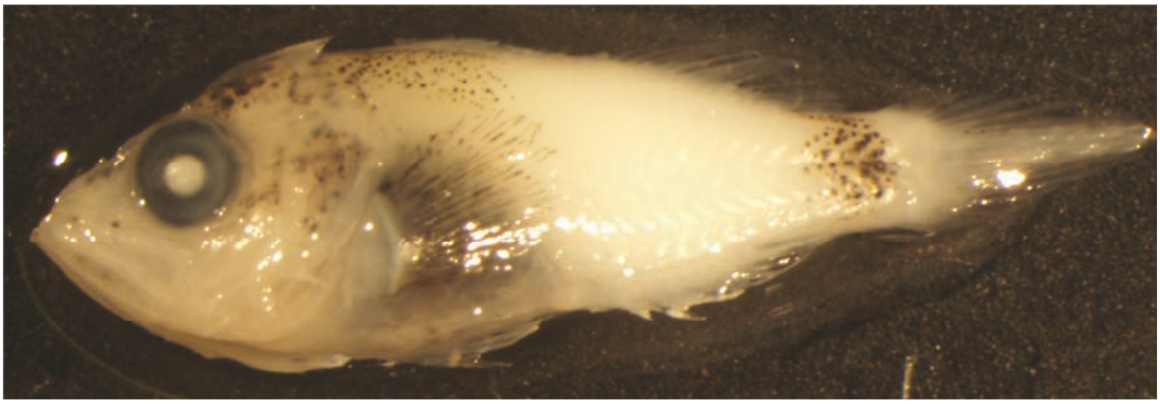


Figure 52: ***Sebastes oculatus*** **– st 2005 – 17 mm – TL**

Figure 53: ***Salilota australis*** **– st 2005 – 35 mm – TL**

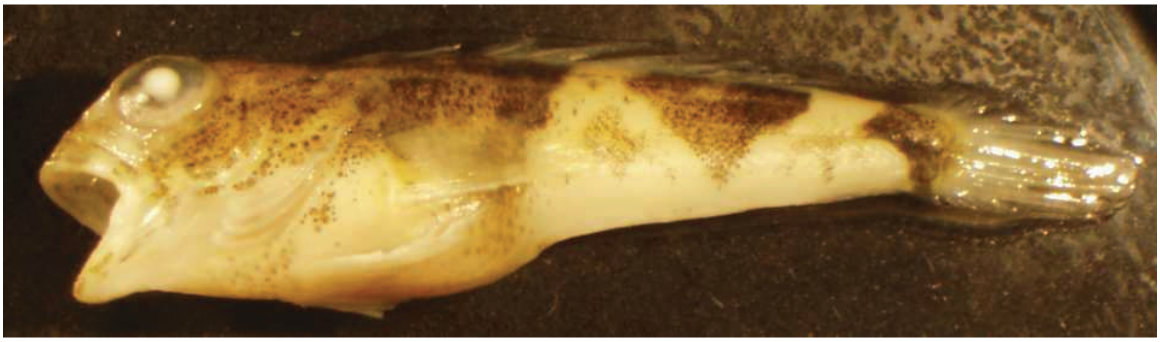


Figure 54: ***Cottoperca gobio*** **– st 2004 – 33 mm – TL**

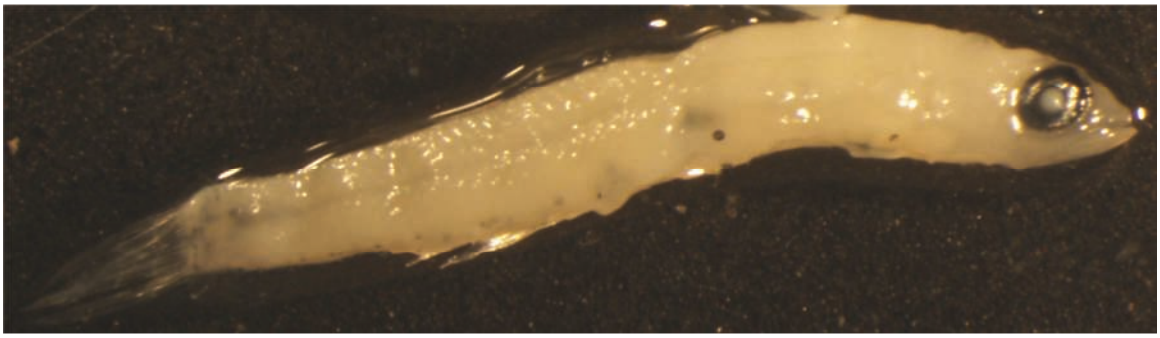


Figure 55: ***Patagonotothen ramsayi*** **– st 2053 – 16 mm – TL**

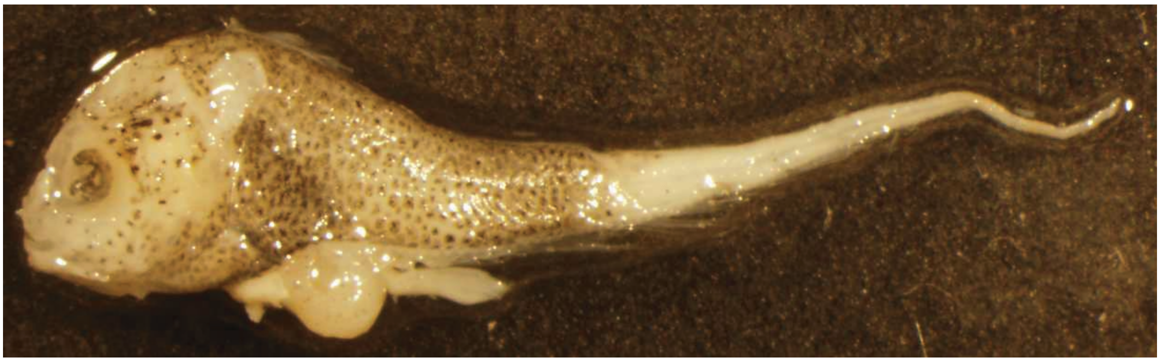


Figure 56: Grenadier – st 2053 – 28 mm – TL

3.6 Oceanography

Oceanographic data were collected at 93 stations (Figure 57). The area covered ranged from 48°32.46'S to 52°26.61'S and 56°53.61'W to 63°28.45'W. No outlier was observed in the down–casts and so up–cast data were removed. Figure 57 below shows the location of the stations.

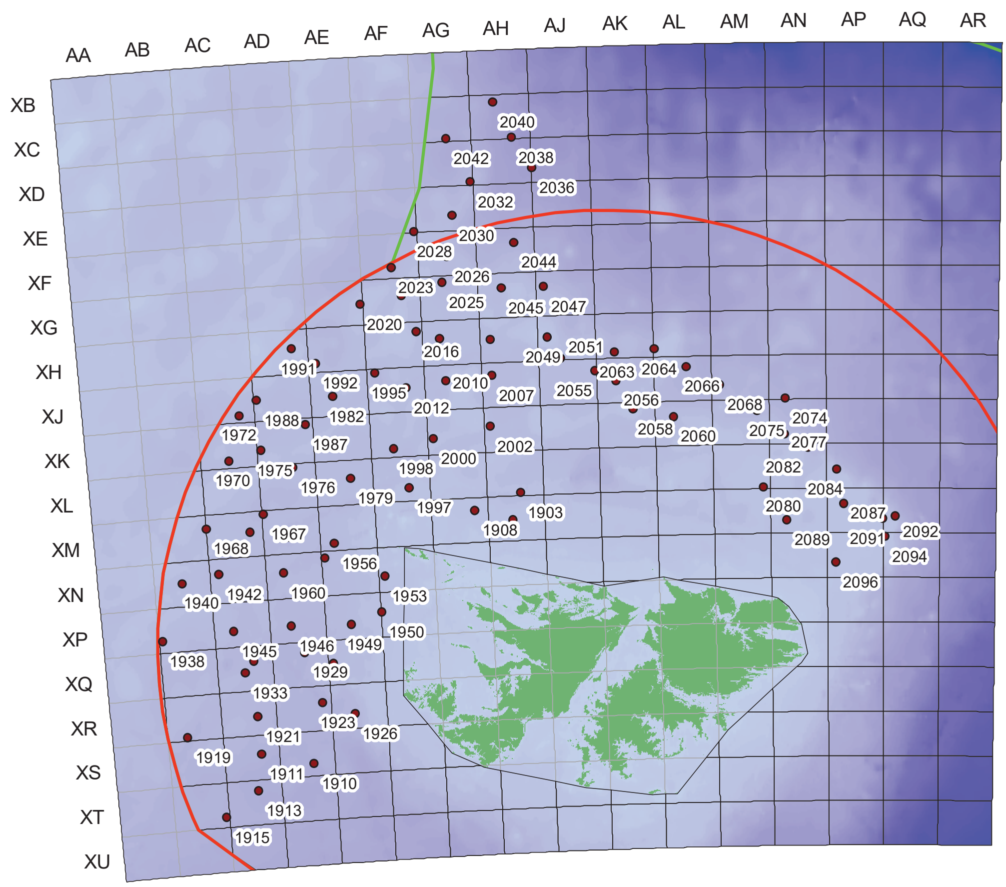


Figure 57: Location and number of CTD stations

Figure 58, Figure 60 and Figure 62 below show the temperature, salinity and σ–t density, gridded using ODV4 DIVA[1] gridding algorithm, at depths 10, 50, 100 m and seabed. The first layer at 10 m is the shallowest depth common to all CTD casts. The surveyed area covered depth range of 84 to 380 m; however the majority of the stations are on the shelf with all bar 15 stations in less than 180 m water.

The temperature data shows 2 patterns, with warm water at the surface in the north west over the shelf, but as depth increases, the water is warmer on the eastern edge of the shelf, in Figure 58 below, the warmer water (than surroundings at that depth) can be seen at the edge of the shelf. The seabed in the north is far deeper than that seen at stations 2047 to 2096, and the depth causes cooler water at 200–400 m.

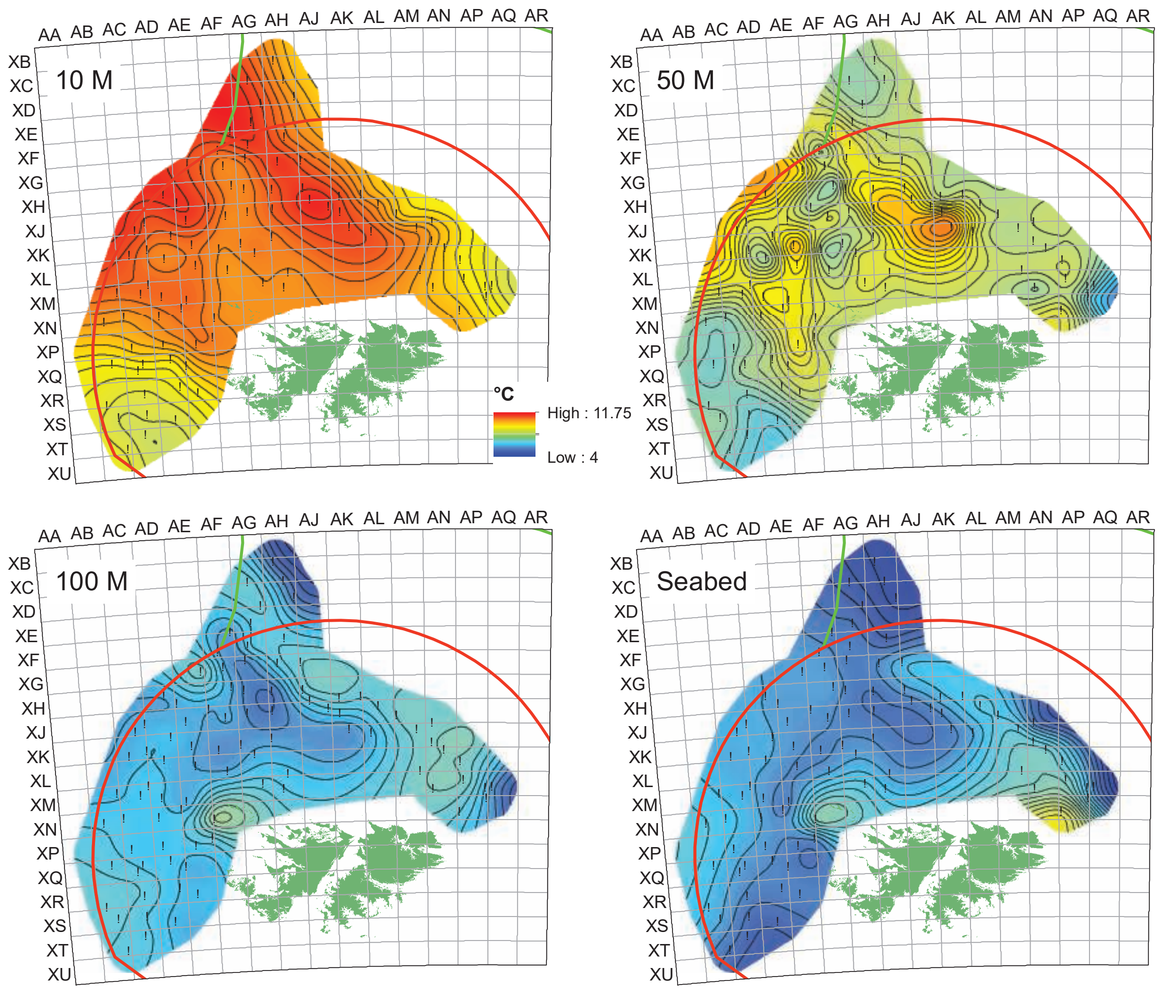


Figure 58: Temperature at 10 m, 50 m, 100 m and seabed (contours at 0.25°C)

Figure 59 shows the change in temperature from 2015 (reds are warmer than 2015, blues are cooler than 2015). At the surface, the water in the north and southwest over the deep water is less than 2015, whilst on the shelf in the east the water was slightly warmer than that surveyed in 2015, on the western shelf the water was slightly cooler.
At the seabed the water was generally cooler, except the eastern branch of the Falklands current which was slightly warmer. The temperature difference was less than that seen at the surface, with only a small area more than 0.25 degrees warmer or cooler.

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

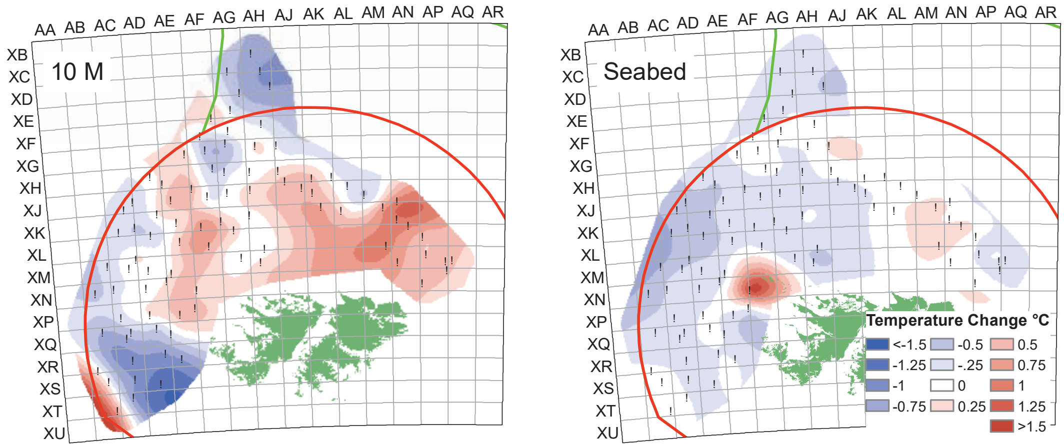


Figure 59: Temperature difference from 2015 at 10 m and seabed

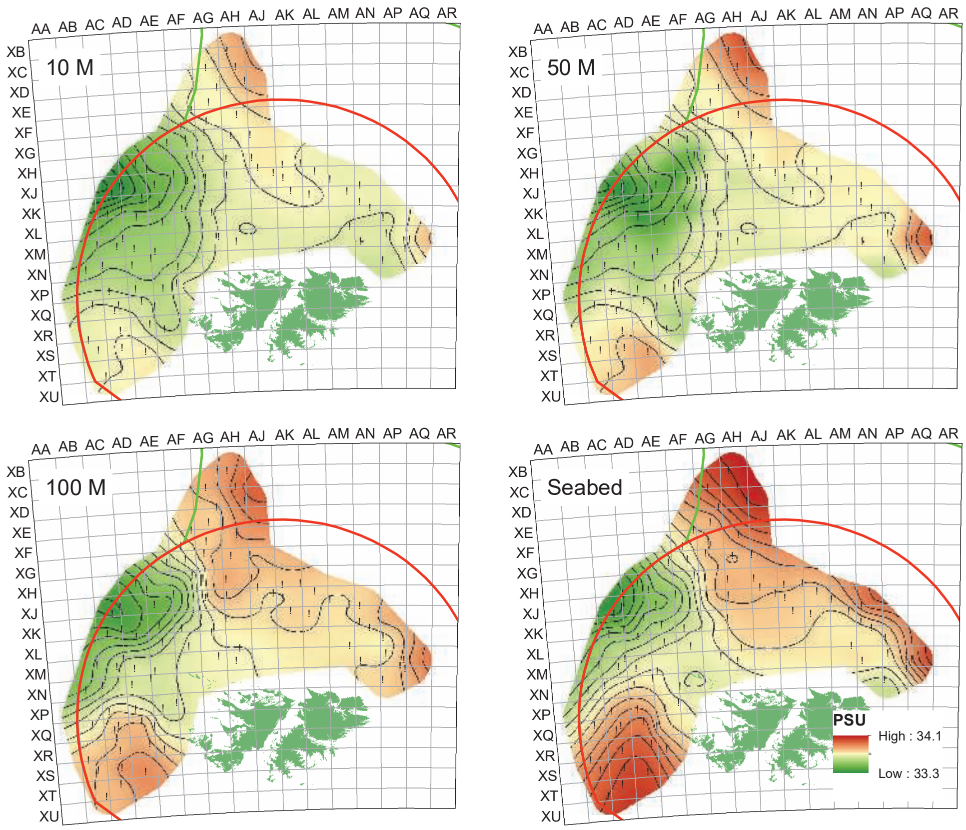


Figure 60: Salinity at 10 m, 50 m, 100 m and seabed (contours at 0.05 PSU)

Figure 60 shows the salinity over the surveyed area. Generally salinity was lower in the waters on the shelf in the northwest and higher in the water close to the 2 branches of the Falklands Current.

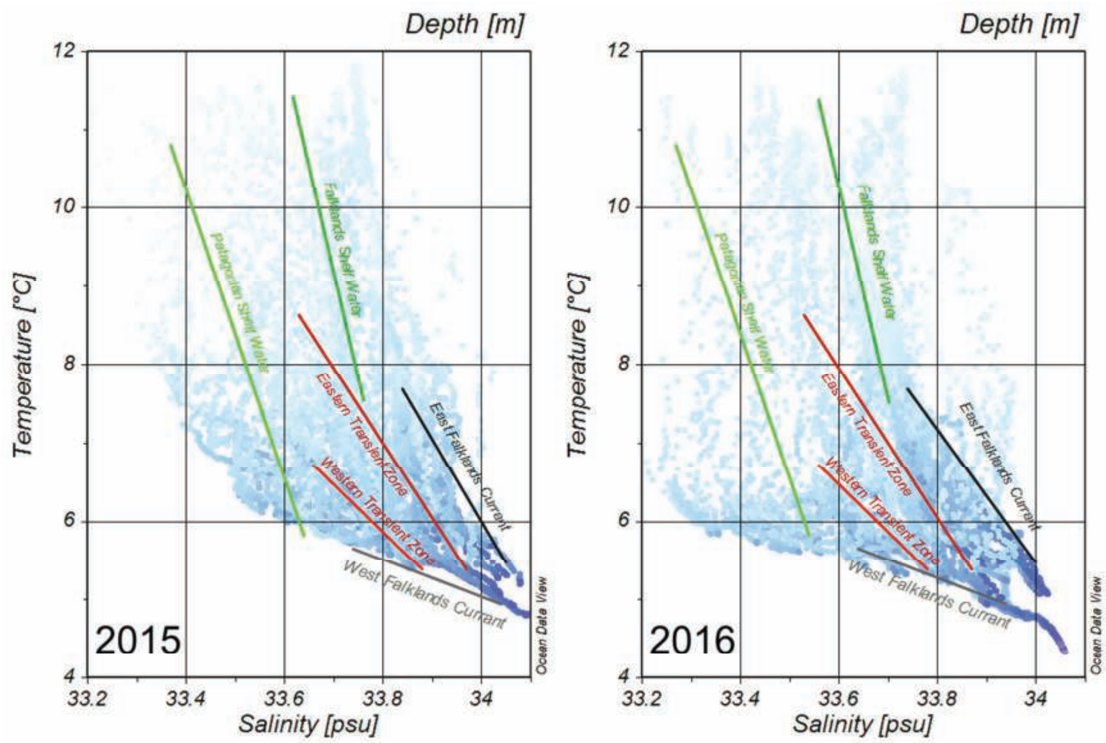


Figure 61: TS plots, 2015 data on the left and 2016 data on the right (water mass terminology Arkhipkin et al., 2013)

A plot of conservative temperature against absolute salinity is shown in Figure 61 with comparison to the survey undertaken in 2015. The water is less saline at temperature than that seen in 2015, particularly at the western shelf stations where salinity was 0.2 ‰ lower in 2016.

The density map (Figure 62) shows lower density water at 10 and 50 m over the shelf, reflecting the higher temperatures and lower salinity seen in Figure 58 and Figure 60. Away from the deeper layer, there is a higher density water mass pushing in through XFAH, XHAH and then moving south east into XKAJ. There is a dense water mass moving north through XTAD up to XMAE.

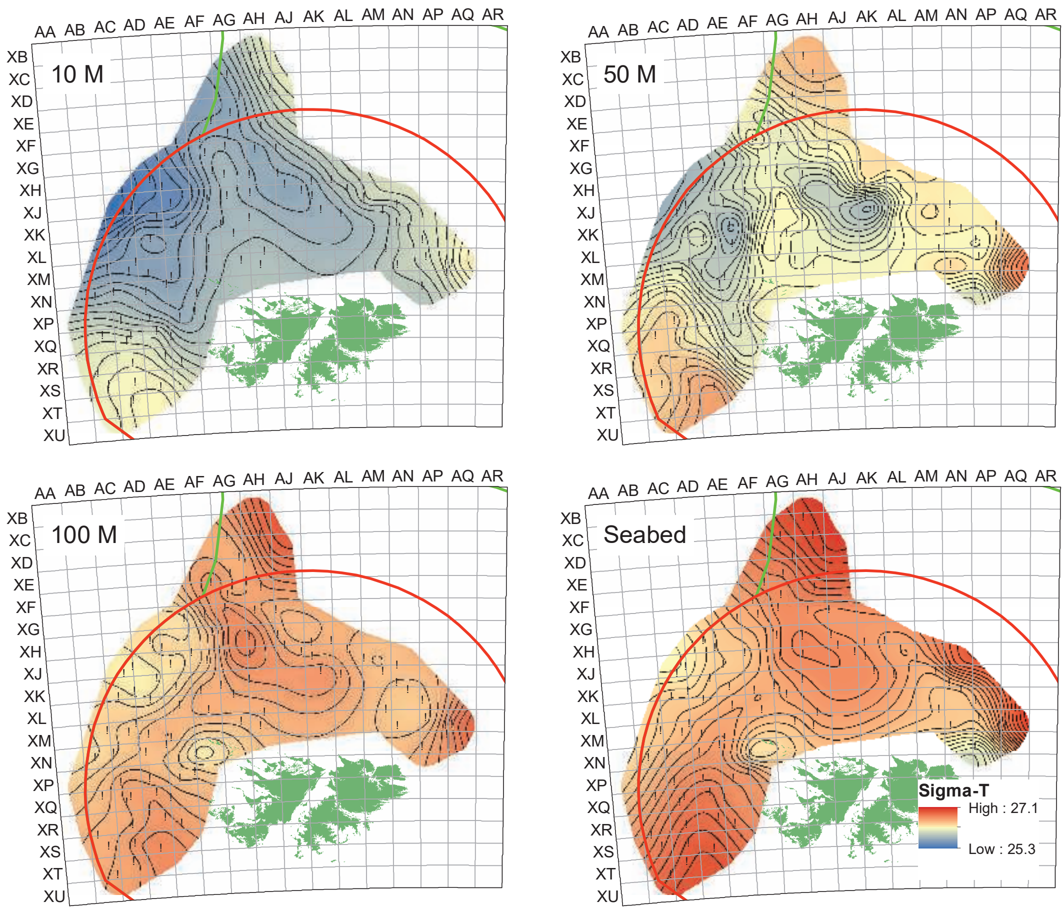


Figure 62: Density at 10 m, 50 m, 100 m and seabed (contours at 0.05 sigma–t)

Figure 63 below shows the oxygen level at 10, 50, 100 m and seabed in ml/l of water. Oxygen concentration is highest at the surface, with levels of 7 ml/l in the southwest over the deeper water and around the north coast of the Falkland Islands. Below the surface oxygen concentration is fairly uniform, with high levels on the edge of the shelf and over the deep water in the southwest, with small variation over the shelf at 50, 100 m and the seabed.

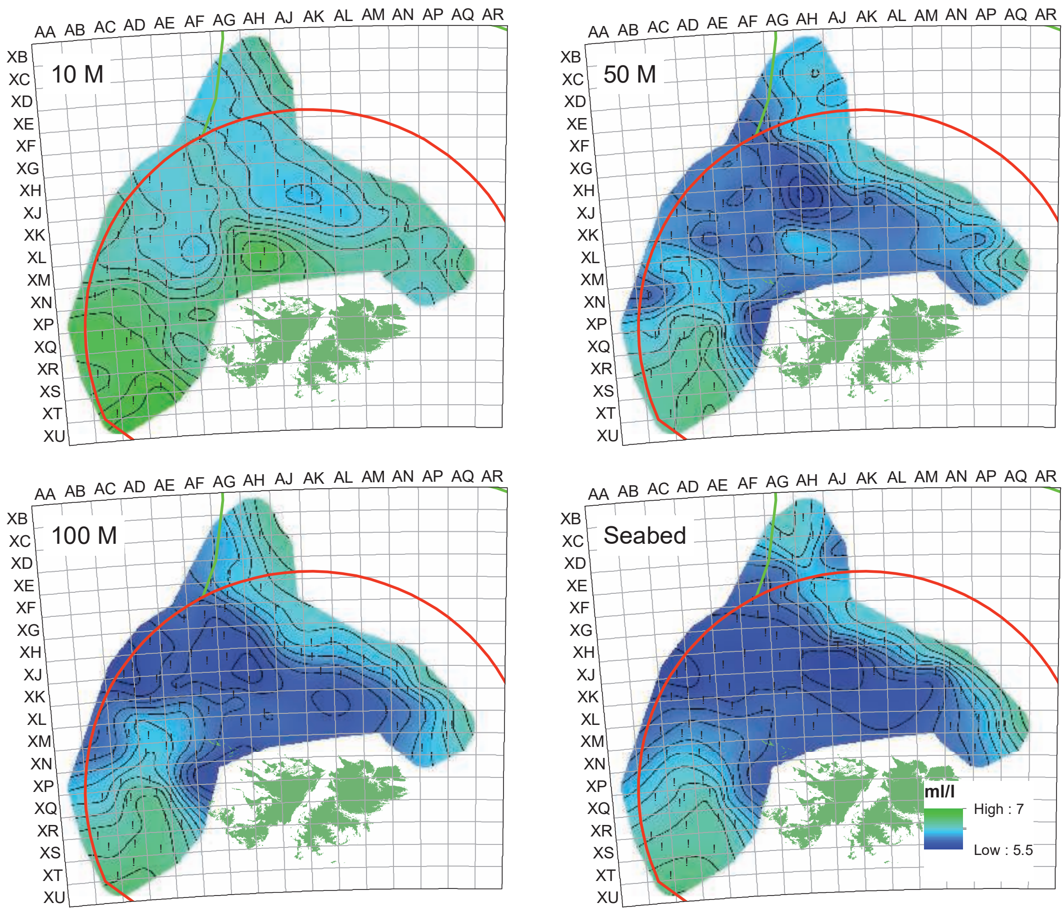


Figure 63: Oxygen at 10m, 50m, 100m and 200m (contours at 0.1ml/l)

4.0 Conclusion

The 2016 rock cod and finfish biomass survey gave a snapshot of the various commercial finfish species present in the finfish area in February. A total of 197 stations were carried out (90 trawl stations, 93 CTD and 14 plankton tow stations) through the 21 days spent at sea. A total of 41390 specimens from 48 species were assessed for sex, maturity and length frequency, 1708 for length–weight relationships and 3296 for otolith or statolith collection. From 2010 to 2016, some of the commercial species exhibited a decreasing abundance like rock cod, toothfish, southern blue whiting and Falkland calamari. At the same time, the majority of commercial species did not show any significant increasing or decreasing trend like red cod, hake, kingclip, hoki and Argentine shortfin squid.

CTD data showed that the SST was warmer over the continental shelf than over the slope. However, the situation was reverted near the sea bottom and temperatures were cooler over the shelf and warmer over the slope. Compared to 2015, SST is generally warmer and sea bottom temperature is generally cooler. Waters of the surveyed area were less saline on the shelf than on the slope. Finally oxygen concentrations appeared to be fairly uniform throughout the area and the water column. Oceanographic conditions, and especially temperatures have probably impacted the distribution of the commercial species in Falkland waters like Argentine shortfin squid which was abundant in 2015 and almost absent in 2016.

A total of 14 plankton stations (7 at the surface and 7 at the backscattering layer) were carried out throughout the survey. A total of 143 pelagic larvae and fry were sampled and identified. Pictures were taken for future identification. Plankton study was not the main objective of the survey, however and even if no toothfish larvae were caught, larvae from other commercial species were assessed.

Results of this survey will be used as a basis for the 2017 licence advice, especially rock cod biomass estimations. It is the intention of the DNRFD to build a time series of biological and oceanographic data by repeating this finfish survey every year at the same time of the year and concurrently with the pre–recruitment survey. For some of the commercial species, results of this survey will be used to fit stock assessment models and use in trials age structured models. If February is the right time to assess some commercial species (rock cod, hoki) it is not the right for other important commercial species like common hake. Finally, data of this survey give a better insight of the ecosystem structure and how it changes throughout the years.

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Appendix

Table 3: Catch table ZDLT1–02–2016

Species Code	*Species name*	***Total Catch (kg)***	***Total Sampled (kg)***	***Total Discarded (kg)***	***Proportion (%)***
PAR	*Patagonotothen ramsayi*	31,656.880	987.771	21,114.900	31.17%
WHI	*Macruronus magellanicus*	21,666.570	1,262.290	93.590	21.33%
BAC	*Salilota australis*	18,644.480	1,570.470	1,646.300	18.36%
KIN	*Genypterus blacodes*	5,401.570	2,992.950	0.000	5.32%
BLU	*Micromesistius australis*	3,178.080	206.660	2,922.270	3.13%
CHR	*Chrysaora cf. plocamia*	3,020.060	0.000	3,020.060	2.97%
GRF	*Coelorhynchus fasciatus*	2,702.100	30.200	2,702.100	2.66%
SAR	*Sprattus fuegensis*	2,420.865	18.100	2,320.865	2.38%
LOL	*Doryteuthis gahi*	2,386.720	302.430	296.710	2.35%
DEH	*Desmonema cf. chierchianum*	1,373.610	0.000	1,343.610	1.35%
MED	Medusae	1,230.240	0.000	1,230.240	1.21%
TOO	*Dissostichus eleginoides*	730.730	692.280	0.040	0.72%
RBR	*Bathyraja brachyurops*	693.140	692.770	10.816	0.68%
HAK	*Merluccius hubbsi*	692.940	692.940	0.000	0.68%
SPN	Porifera	679.129	0.000	679.129	0.67%
RGR	*Bathyraja griseocauda*	605.586	605.586	2.720	0.60%
CGO	*Cottoperca gobio*	542.490	88.430	542.490	0.53%
RFL	*Zearaja chilensis*	505.610	505.610	0.000	0.50%
SQT	Ascidiacea	428.125	0.000	428.125	0.42%
THO	Thouarellinae	365.377	0.000	365.377	0.36%
EEL	*Iluocoetes fimbriatus*	293.340	92.600	292.580	0.29%
DGS	*Squalus acanthias*	224.760	137.330	224.760	0.22%
PAT	*Merluccius australis*	215.410	215.410	0.000	0.21%
POR	*Lamna nasus*	200.000	200.000	200.000	0.20%
GYN	*Gymnoscopelus nicholsi*	160.500	4.710	160.500	0.16%
DGH	*Schroederichthys bivius*	148.740	0.620	148.740	0.15%
STA	*Sterechinus agassizi*	139.460	0.000	139.460	0.14%
ING	*Moroteuthis ingens*	122.950	10.080	121.890	0.12%
RBZ	*Bathyraja cousseauae*	95.840	95.840	0.000	0.09%
RAL	*Bathyraja albomaculata*	90.230	90.230	1.000	0.09%
SER	*Serolis spp.*	82.080	0.000	82.080	0.08%
SHT	Mixed invertebrates	74.080	0.000	74.080	0.07%
RED	*Sebastes oculatus*	70.370	70.060	0.310	0.07%
RMC	*Bathyraja macloviana*	68.641	68.641	39.030	0.07%
RMU	*Bathyraja multispinis*	51.780	51.780	0.000	0.05%
PYM	*Physiculus marginatus*	51.420	1.720	51.420	0.05%
ILL	*Illex argentinus*	46.376	35.786	41.538	0.05%
BUT	*Stromateus brasiliensis*	36.226	10.466	36.226	0.04%
HYD	*Hydrozoa*	34.167	0.000	34.167	0.03%
RPX	*Psammobatis spp.*	33.158	32.568	31.658	0.03%
COP	*Congiopodus peruvianus*	30.670	22.460	30.670	0.03%
ALF	*Allothunnus fallai*	28.600	14.550	0.000	0.03%
PTE	*Patagonotothen tessellata*	27.830	16.210	27.830	0.03%
ANM	Anemone	22.231	0.000	22.231	0.02%
COT	*Cottunculus granulosus*	20.400	19.210	20.400	0.02%
GOC	*Gorgonocephalus chilensis*	20.102	0.000	20.102	0.02%
CHE	*Champsocephalus esox*	19.660	19.140	18.510	0.02%
FUM	*Fusitriton m. magellanicus*	19.653	0.000	19.653	0.02%
MUG	*Munida gregaria*	18.992	0.310	18.682	0.02%

RDA	*Dipturus argentinensis*	15.440	15.440	0.000	0.02%
RSC	*Bathyraja scaphiops*	13.013	13.013	2.513	0.01%
BRY	Bryozoa	11.740	0.000	11.740	0.01%
GYM	*Gymnoscopelus spp.*	10.460	0.100	10.360	0.01%
ZYP	*Zygochlamys patagonica*	9.721	0.000	3.261	0.01%
CTA	*Ctenodiscus australis*	9.660	0.000	9.660	0.01%
AUC	*Austrocidaris canaliculata*	7.951	0.000	7.951	0.01%
NEM	*Neophyrnichthys marmoratus*	7.774	0.000	7.774	0.01%
RDO	*Amblyraja doellojuradoi*	7.130	7.130	6.620	0.01%
CAS	*Campylonotus semistriatus*	6.985	0.000	5.325	0.01%
CAZ	*Calyptraster sp.*	6.095	0.000	6.095	0.01%
AST	Asteroidea	5.410	0.000	3.410	0.01%
MLA	*Muusoctopus longibrachus akambei*	5.270	0.000	5.270	0.01%
RMG	*Bathyraja magellanica*	5.060	5.060	3.850	<0.01%
MUO	*Muraenolepis orangiensis*	4.690	3.900	4.690	<0.01%
OPV	*Ophiacanta vivipara*	4.557	0.000	4.557	<0.01%
POA	*Porania antarctica*	3.817	0.000	3.817	<0.01%
COL	*Cosmasterias lurida*	3.725	0.000	3.725	<0.01%
PMX	*Protomictophum spp.*	3.460	0.010	3.450	<0.01%
UHH	Heart urchin	3.385	0.000	3.385	<0.01%
MUE	*Muusoctopus eureka*	3.180	0.000	3.180	<0.01%
SUN	*Labidaster radiosus*	2.860	0.000	2.860	<0.01%
CEX	*Ceramaster sp.*	2.764	0.000	2.764	<0.01%
MUU	*Munida subrugosa*	2.624	0.050	2.484	<0.01%
ADA	*Adelomelon ancilla*	2.583	0.000	2.583	<0.01%
CAM	*Cataetyx messieri*	1.950	1.950	1.950	<0.01%
ODM	*Odontocymbiola magellanica*	1.800	0.000	1.800	<0.01%
CIR	Cirripedia	1.750	0.000	1.750	<0.01%
PAG	*Paralomis granulosa*	1.710	1.710	0.000	<0.01%
SEC	*Seriolella caerulea*	1.620	0.530	1.620	<0.01%
ZYX	Dead Zygochlamys	1.510	0.000	1.510	<0.01%
BAO	*Bathybiaster loripes*	1.450	0.000	1.450	<0.01%
SRP	*Semirossia patagonica*	1.215	0.590	0.865	<0.01%
BAL	*Bathydomus longisetosus*	1.180	0.000	1.180	<0.01%
THB	*Thymops birsteini*	1.160	0.000	0.890	<0.01%
ASA	*Astrotoma agassizii*	1.062	0.000	1.062	<0.01%
ODP	*Odontaster pencillatus*	1.040	0.000	1.040	<0.01%
CYX	*Cycethra sp.*	1.005	0.000	1.005	<0.01%
MAV	*Magellania venosa*	0.984	0.000	0.984	<0.01%
BDU	*Brama dussumieri*	0.960	0.950	0.010	<0.01%
ALG	*Algae*	0.960	0.000	0.960	<0.01%
FLX	*Flabellum spp.*	0.755	0.000	0.755	<0.01%
OPL	*Ophiuroglypha lymanii*	0.639	0.000	0.639	<0.01%
ALC	Alcyoniina	0.611	0.000	0.611	<0.01%
EUL	*Eurypodius latreillei*	0.609	0.000	0.609	<0.01%
LOS	*Lophaster stellans*	0.520	0.000	0.520	<0.01%
COG	*Patagonotothen guntheri*	0.510	0.490	0.510	<0.01%
EUO	*Eurypodius longirostris*	0.405	0.000	0.405	<0.01%
NEH	*Neomenia herwigi*	0.300	0.000	0.300	<0.01%
WRM	*Chaetopterus variopedatus*	0.280	0.000	0.280	<0.01%
PES	*Peltarion spinosulum*	0.242	0.000	0.242	<0.01%
NUD	Nudibranchia	0.235	0.000	0.235	<0.01%

ZOX	*Zoarcid sp.*	0.224	0.184	0.174	<0.01%
ICA	*Icichthys australis*	0.210	0.000	0.210	<0.01%
ACS	*Acanthoserolis schythei*	0.207	0.000	0.207	<0.01%
PYX	Pycnogonida	0.188	0.000	0.188	<0.01%
LYB	*Lycenchelys bachmanni*	0.180	0.180	0.000	<0.01%
CRY	*Crossaster sp.*	0.165	0.000	0.165	<0.01%
SOR	*Solaster regularis*	0.150	0.000	0.150	<0.01%
OPH	Ophiuroidea	0.100	0.000	0.100	<0.01%
HCR	Paguroidea	0.090	0.000	0.090	<0.01%
AGO	*Agonopsis chilensis*	0.070	0.000	0.070	<0.01%
XXX	Unidentified animal	0.068	0.048	0.048	<0.01%
GYB	*Gymnoscopelus bolini*	0.060	0.000	0.060	<0.01%
POL	Polychaeta	0.052	0.000	0.052	<0.01%
TED	*Terebratella dorsata*	0.050	0.000	0.050	<0.01%
NUH	*Nuttallochiton hyadesi*	0.045	0.000	0.045	<0.01%
THN	*Thysanopsetta naresi*	0.040	0.040	0.040	<0.01%
SYB	*Symbolophorus boops*	0.040	0.000	0.040	<0.01%
OCC	Octocoralia	0.040	0.000	0.040	<0.01%
MOP	*Momonatira paulini*	0.035	0.000	0.035	<0.01%
BIV	Bivalve	0.035	0.000	0.035	<0.01%
MAU	*Maurolicus muelleri*	0.030	0.000	0.030	<0.01%
ISO	Isopoda	0.023	0.000	0.023	<0.01%
AMP	Amphipoda	0.021	0.000	0.021	<0.01%
ANT	Anthozoa	0.020	0.000	0.020	<0.01%
MUN	*Munida spp.*	0.020	0.000	0.020	<0.01%
PMC	*Protomictophum choriodon*	0.020	0.000	0.020	<0.01%
HOL	Holothuroidea	0.015	0.000	0.015	<0.01%
GOR	Gorgonacea	0.011	0.000	0.011	<0.01%
MIR	*Mirostenella sp.*	0.010	0.000	0.010	<0.01%
MUS	Smooth mussel	0.010	0.000	0.010	<0.01%
PLU	Primnoellinae	0.005	0.000	0.005	<0.01%
LEY	*Lepas spp.*	0.002	0.000	0.002	<0.01%
		101,560.020	**11,909.583**	**40,723.351**	

Table 4: Random sample numbers

Code	Name	Number Sampled	
LOL	*Doryteuthis gahi*	14,824	35.9%
PAR	*Patagonotothen ramsayi*	9,341	22.6%
BAC	*Salilota australis*	4,933	12.0%
WHI	*Macruronus magellanicus*	1,950	4.7%
KIN	*Genypterus blacodes*	1,767	4.3%
TOO	*Dissostichus eleginoides*	1,306	3.2%
ILL	*Illex argentinus*	1,171	2.8%
BLU	*Micromesistius australis*	1,025	2.5%
HAK	*Merluccius hubbsi*	1,002	2.4%
EEL	*Iluocoetes fimbriatus*	611	1.5%
GYN	*Gymnoscopelus nicholsi*	421	1.0%
RBR	*Bathyraja brachyurops*	398	1.0%
PTE	*Patagonotothen tessellata*	392	0.9%
CGO	*Cottoperca gobio*	259	0.6%
SAR	*Sprattus fuegensis*	205	0.5%
GRF	*Coelorhynchus fasciatus*	195	0.5%
RFL	*Zearaja chilensis*	192	0.5%
CHE	*Champsocephalus esox*	127	0.3%
COT	*Cottunculus granulosus*	119	0.3%
RED	*Sebastes oculatus*	116	0.3%
DGS	*Squalus acanthias*	108	0.3%
RGR	*Bathyraja griseocauda*	106	0.3%
PYM	*Physiculus marginatus*	91	0.2%
ING	*Moroteuthis ingens*	90	0.2%
PAT	*Merluccius australis*	86	0.2%
RMC	*Bathyraja macloviana*	72	0.2%
RPX	*Psammobatis spp.*	67	0.2%
COP	*Congiopodus peruvianus*	60	0.1%
RAL	*Bathyraja albomaculata*	56	0.1%
RBZ	*Bathyraja cousseauae*	31	0.1%
BUT	*Stromateus brasiliensis*	26	0.1%
COG	*Patagonotothen guntheri*	20	0.0%
RMG	*Bathyraja magellanica*	15	0.0%
CAM	*Cataetyx messieri*	13	0.0%
RDO	*Amblyraja doellojuradoi*	13	0.0%
MUO	*Muraenolepis orangiensis*	12	0.0%
ZOX	*Zoarcid sp.*	11	0.0%
RSC	*Bathyraja scaphiops*	9	0.0%
PAG	*Paralomis granulosa*	5	0.0%
RMU	*Bathyraja multispinis*	5	0.0%
POR	*Lamna nasus*	3	0.0%
RDA	*Dipturus argentinensis*	3	0.0%
ALF	*Allothunnus fallai*	2	0.0%
XXX	*Unidentified animal*	2	0.0%
SEC	*Seriolella caerulea*	1	0.0%
SYB	*Symbolophorus boops*	1	0.0%
THN	*Thysanopsetta naresi*	1	0.0%
BDU	*Brama dussumieri*	1	0.0%
		41,264	