Cruise Report ZDLM3-02-2019

Demersal biomass survey

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Stanley, Falkland Islands

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ZDLM3-02-2019

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1. Introduction

The Patagonian Shelf is the largest marine shelf area in the Southern Hemisphere (approximately 1.2 million km^2) spreading from the Rio de La Plata estuary in the north (38°S) to Tierra del Fuego and Burdwood Bank in the south (54°S), and including the shelf area around the Falkland Islands ~760 km from the mainland coast of South America. This shelf includes the Patagonian large marine ecosystem, one of the most productive areas in the world. Its squid and fish resources have long been exploited by international fishing fleets, with over 1 million tonnes of squid and fish taken annually.

The Patagonian large marine ecosystem comprises a southern temperate ecosystem in the north and a sub-Antarctic ecosystem in the south, partitioned by a boundary running south-west to north-east through the Falkland Islands. The sub-Antarctic ecosystem lies within waters of sub-Antarctic origin. These waters are transported onto the shelf by the cold Falkland Current, which diverges from the main stream of the Antarctic Circumpolar Current in the Drake Passage and turns northwards. At the continental slope south of the Falkland Islands, the Falkland Current splits into a weak branch and a stronger branch that flow around the west and east of the Islands, respectively. The temperate ecosystem lies within waters of subtropical origin, transported onto the shelf by the Brazil Current and mixed with temperate shelf waters. Several productive zones are revealed in this ecosystem, mainly due to the existence of tidal mixing oceanographic fronts, as well as seasonal fronts originating from cold fresh water inflows into the Straits of Magellan.

Within the Patagonian ecosystem, many nektonic fish and squid migrate seasonally to frontal zones for feeding, moving back to the non-frontal zones for spawning, such as short-fin squid *Illex argentinus*, common hake *Merluccius hubbsi* and hoki *Macruronus magellanicus*. The abundance of fish and squid is generally much higher in frontal zones. Intrusions of sub-Antarctic waters onto the shelf favour migrations of deepwater fish like toothfish *Dissostichus eleginoides*, grenadier *Macrourus carinatus* and squid *Onykia ingens*.

Three previous shallow-water surveys have been undertaken to investigate the distribution of juvenile toothfish around the islands. During the first two surveys a nursery ground of juvenile 0+ year class toothfish (10–12 cm total length) was found at depths between 70 and 120 m, extending west from Sea Lion Island (59°W) until the shelf narrows off Weddel Islands to the west (61°W). However, no juvenile toothfish were found in the area during a repeat survey in January 2019, leading to concerns regarding their recruitment of toothfish into the southern shelf waters of the Falkland Islands.

The Falkland Islands Fisheries Department has been carrying out annual two-three weeks demersal surveys since 2010 in order to assess the distribution and abundance of the main commercial squid and fish resources on the shelf. It was revealed that the abundance of some fish, especially rock cod, had decreased dramatically over the last 8 years. Abundance of some other fish like kingclip and red cod also decreased, whereas the abundance of common hake increased (Gras et al., 2018).

The main purpose of the present survey was to carry on the demersal survey of the western, northern and eastern parts of the Falkland Islands Shelf to investigate the abundance, distribution, and biology of demersal species.

1.1. Cruise objectives

1. To examine the abundance, distribution, and biology of demersal fish and squid species in the western, northern and north-eastern parts of the Falkland Shelf.
2. To carry out a one-day survey of juvenile toothfish in the shallow waters to the south of the Falkland Islands.
3. To carry out an oceanographic survey of the studied area.

1.2. Vessel

The cruise was conducted on the F/V *Monteferro* (ZDLM3), registered in the Falkland Islands.

1.3. Personnel and responsibilities

The following personnel participated in the cruise:

Alexander Arkhipkin	(Cruise leader, biological sampling)
Brendon Lee	(Cruise leader, biological sampling)
Ludovic Goyot	(Biological sampling)
Jorge E. Ramos	(Oceanography: CTD. Biological sampling)
Irina Chemshirova	(Biological sampling)
Georgina Roberts	(Biological sampling)
Marina Costa	(Biological sampling)

1.4. Cruise plan and key dates

The vessel departed from Stanley at 6 p.m. on February 1st, 2019 and proceeded overnight to the first station located in the shallow waters to the north of Sea Lion Islands. The first day was dedicated to a toothfish juvenile survey, during which four inshore trawls were conducted within the known recruitment area. The vessel then proceeded to the southwest of FICZ to carry on the demersal survey. Every day, four one-hour trawls were made in adjacent grid squares, each trawl preceded by oceanographic station (Figure 1). On February 9th, 2019 the vessel entered the Falkland Sound (Port San Carlos waters) for a change in scientific crew. Previous Chief Scientist B. Lee disembarked, while A. Arkhipkin joined the vessel to carry on the survey. During the following two weeks, all grid squares in the northern and north-eastern parts of the Falkland Islands Shelf were covered by the survey. A strong south-westerly storm changed the survey plans, and it was decided to do several shallow water trawls on February 21st, 2019 under some protection by the Islands from 40–45 kn south-westerly winds. The last day of the survey was spent in the northern part of the Loligo Box to do north-easternmost stations of the demersal survey. The ship was back in port at 5 a.m. on February 23^{rd,}, 2019. Despite several days of rough weather with strong winds (30–50 kn), the vessel managed to fish with no day lost.

2. Material and Methods

2.1. Trawling

A regular commercial bottom trawl net (120 m horizontal opening) equipped with rectangular Injector Cobra 6.5 m² and 2,600 kg bottom doors was used for the survey. The duration of each trawl was 60 min on the bottom, trawling speed varied between 3.9 and 4.3 kn. The mesh size in the cod-end was 90 mm, and the cod-end had a small mesh liner (40 mm) inside to be able to catch small fish and squid individuals. Usually, up to four trawls were made every day during the survey. However, on two occasions when the navigation time was shorter than usual, the vessel performed five trawls per day.

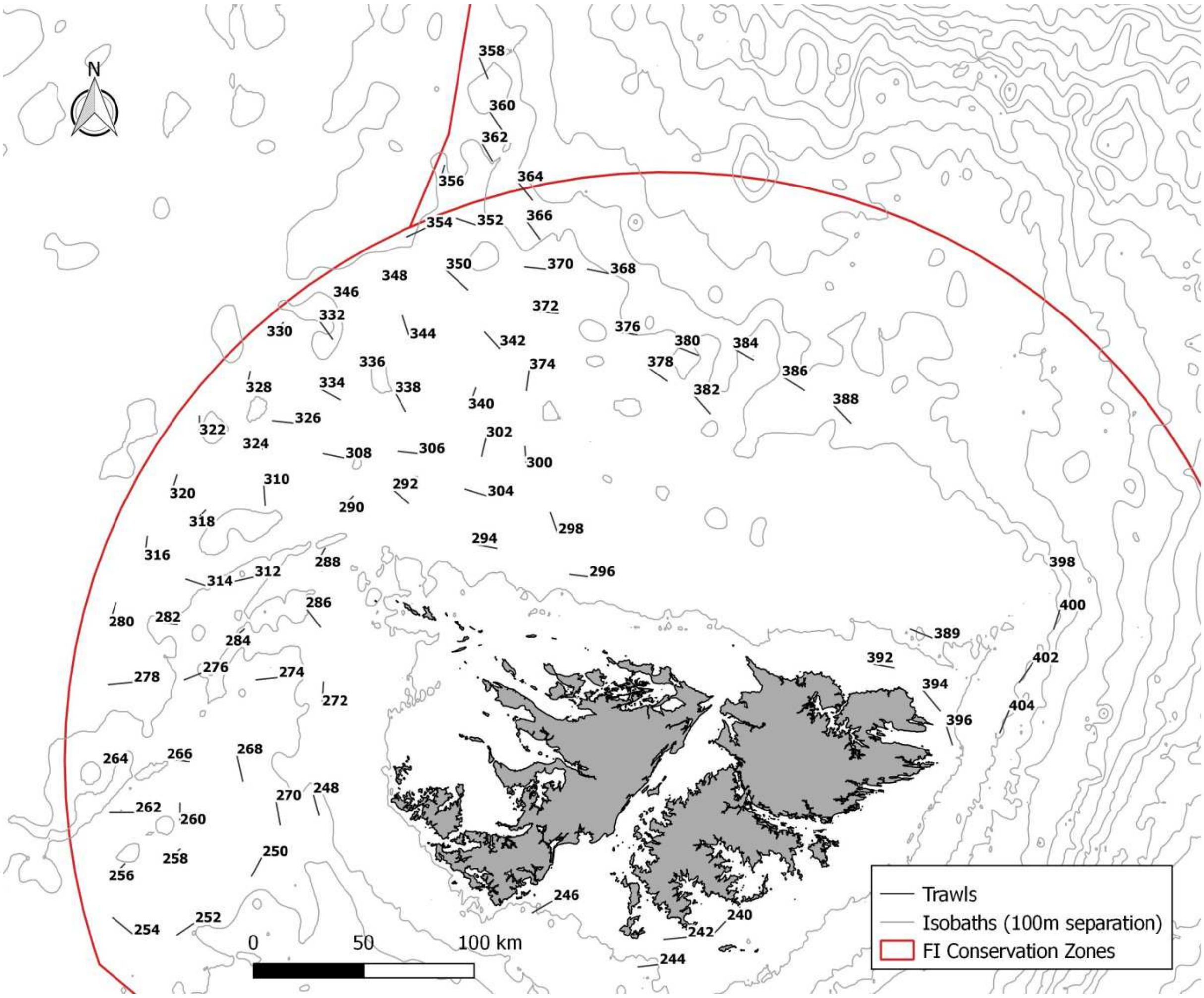

Figure 1. Trawl tracks with station numbers performed during the demersal survey ZDLM3-02-2019 in February 2019.

2.2. Trawl stations and biological sampling

During the ZDLM3-02-2019 demersal survey, a total of 83 trawls were conducted with corresponding station numbers ranging from 240 to 404 (Table I). The total catch of each station was weighed with an electronic Marel balance (80 kg capacity). All species from the catch were sorted - mainly by the factory crew - and weighed. All commercial bycatch species were sampled (random samples of up to 100 individuals); sampling consisted of measurements and identification of sex and maturity stages as of standard biological analyses. From every trawl, all skates were identified, sexed and measured individually (both total length and disc width). Otoliths were taken from large number of fish according to sampling scheme of up to 5 specimens per 1 cm length class and per sex. During otolith collection, individual weights were measured to the nearest gram. Statoliths were not taken during the cruise but samples of both *Illex argentinus* and *Doryteuthis gahi* were frozen to bring ashore for statolith extraction. Some fish and squid specimens were frozen for analysis ashore.

Table I. Station data during the demersal survey ZDLM3-02-2019 in February 2019.

Station	Date	Latitude start	Longitude Start	Latitude finish	Longitude finish	Modal depth
240	02/02/2019	-52.34	-59.12	-52.38	-59.20	60
242	02/02/2019	-52.39	-59.38	-52.40	-59.51	57
244	02/02/2019	-52.50	-59.57	-52.50	-59.68	101
246	02/02/2019	-52.25	-60.28	-52.29	-60.39	94
248	03/02/2019	-51.82	-61.86	-51.89	-61.84	186
250	03/02/2019	-52.07	-62.23	-52.14	-62.29	269
252	03/02/2019	-52.35	-62.69	-52.38	-62.79	266
254	03/02/2019	-52.36	-63.10	-52.32	-63.21	251
256	04/02/2019	-52.14	-63.21	-52.09	-63.14	228
258	04/02/2019	-52.08	-62.85	-52.04	-62.76	237
260	04/02/2019	-51.90	-62.76	-51.84	-62.77	216
262	04/02/2019	-51.88	-63.10	-51.88	-63.23	201
264	05/02/2019	-51.67	-63.24	-51.65	-63.13	187
266	05/02/2019	-51.66	-62.82	-51.67	-62.71	203
268	05/02/2019	-51.66	-62.36	-51.74	-62.34	251
270	05/02/2019	-51.86	-62.13	-51.93	-62.10	260
272	06/02/2019	-51.42	-61.81	-51.35	-61.80	188
274	06/02/2019	-51.32	-62.13	-51.33	-62.25	213
276	06/02/2019	-51.31	-62.64	-51.34	-62.74	184
278	06/02/2019	-51.34	-63.12	-51.35	-63.23	166
280	07/02/2019	-51.09	-63.23	-51.02	-63.19	151
282	07/02/2019	-51.09	-62.90	-51.10	-62.79	167
284	07/02/2019	-51.18	-62.43	-51.13	-62.34	188
286	07/02/2019	-51.05	-61.90	-51.11	-61.83	183
288	08/02/2019	-50.84	-61.85	-50.78	-61.80	167
290	08/02/2019	-50.62	-61.68	-50.56	-61.61	173
292	08/02/2019	-50.54	-61.31	-50.59	-61.24	163
294	08/02/2019	-50.76	-60.77	-50.78	-60.66	132
296	09/02/2019	-50.90	-60.04	-50.89	-60.15	132
298	09/02/2019	-50.70	-60.24	-50.64	-60.29	142
300	10/02/2019	-50.42	-60.45	-50.35	-60.46	151
302	10/02/2019	-50.32	-60.71	-50.39	-60.75	153

Station	Date	Latitude start	Longitude Start	Latitude finish	Longitude finish	Modal depth
304	10/02/2019	-50.55	-60.73	-50.54	-60.84	148
306	10/02/2019	-50.38	-61.19	-50.38	-61.29	155
308	11/02/2019	-50.39	-61.69	-50.39	-61.79	161
310	11/02/2019	-50.52	-62.20	-50.60	-62.19	163
312	11/02/2019	-50.91	-62.29	-50.93	-62.39	186
314	11/02/2019	-50.93	-62.61	-50.92	-62.72	167
316	12/02/2019	-50.81	-63.01	-50.74	-62.99	149
318	12/02/2019	-50.68	-62.68	-50.62	-62.59	156
320	12/02/2019	-50.55	-62.82	-50.48	-62.79	146
322	12/02/2019	-50.29	-62.63	-50.23	-62.64	146
324	13/02/2019	-50.36	-62.32	-50.36	-62.20	153
326	13/02/2019	-50.25	-62.02	-50.25	-62.13	156
328	13/02/2019	-50.11	-62.32	-50.04	-62.30	145
330	13/02/2019	-49.87	-62.16	-49.82	-62.08	145
332	13/02/2019	-49.83	-61.82	-49.89	-61.75	156
334	14/02/2019	-50.11	-61.80	-50.14	-61.70	156
336	14/02/2019	-50.00	-61.53	-49.99	-61.42	155
338	14/02/2019	-50.14	-61.31	-50.20	-61.25	156
340	14/02/2019	-50.17	-60.82	-50.10	-60.78	157
342	15/02/2019	-49.91	-60.65	-49.86	-60.73	162
344	15/02/2019	-49.87	-61.23	-49.80	-61.28	158
346	15/02/2019	-49.70	-61.59	-49.68	-61.71	156
348	15/02/2019	-49.64	-61.39	-49.60	-61.28	157
350	16/02/2019	-49.57	-60.97	-49.50	-60.97	164
352	16/02/2019	-49.40	-60.81	-49.38	-60.91	169
354	16/02/2019	-49.42	-61.14	-49.45	-61.23	162
356	16/02/2019	-49.21	-61.02	-49.14	-60.99	170
358	17/02/2019	-48.69	-60.75	-48.75	-60.71	240
360	17/02/2019	-48.92	-60.67	-48.99	-60.61	230
362	17/02/2019	-49.06	-60.73	-49.12	-60.68	198
364	17/02/2019	-49.23	-60.48	-49.28	-60.40	216
366	17/02/2019	-49.40	-60.42	-49.45	-60.35	191
368	18/02/2019	-49.60	-59.91	-49.59	-60.03	190
370	18/02/2019	-49.59	-60.34	-49.59	-60.45	170
372	18/02/2019	-49.77	-60.35	-49.78	-60.24	166
374	18/02/2019	-50.04	-60.43	-50.11	-60.45	158
376	19/02/2019	-49.86	-59.82	-49.86	-59.71	166
378	19/02/2019	-50.03	-59.60	-50.05	-59.51	158
380	19/02/2019	-49.93	-59.41	-49.96	-59.30	166
382	19/02/2019	-50.15	-59.29	-50.20	-59.22	152
384	20/02/2019	-49.94	-59.03	-49.98	-58.93	168
386	20/02/2019	-50.07	-58.70	-50.11	-58.60	161
388	20/02/2019	-50.19	-58.37	-50.24	-58.29	173
389	21/02/2019	-51.15	-57.75	-51.13	-57.87	110
392	21/02/2019	-51.27	-58.13	-51.28	-58.00	67
394	21/02/2019	-51.39	-57.76	-51.46	-57.68	51
396	21/02/2019	-51.53	-57.63	-51.60	-57.59	70

Station	Date	Latitude start	Longitude Start	Latitude finish	Longitude finish	Modal depth
398	22/02/2019	-50.87	-56.92	-50.93	-56.87	228
400	22/02/2019	-51.06	-56.88	-51.12	-56.91	208
402	22/02/2019	-51.28	-57.07	-51.34	-57.13	205
404	22/02/2019	-51.48	-57.22	-51.54	-57.26	190

2.3. Oceanography

A single CTD (SBE-25, Sea-Bird Electronics Inc., Bellevue, USA) instrument, Serial No 0247, was used to collect oceanographic data in the vicinity of all trawl stations. The CTD was deployed at all CTD stations to a depth of c.10 m below the surface for a soak time of more than one minute, allowing the pump to start circulating water and to flush the system; following this the CTD was raised to a minimum depth of 5 m below the surface. The CTD was then lowered towards the sea bed at 1 $m \cdot s^{-1}$. The CTD collected pressure in dbar, temperature in °C, conductivity in $ms \cdot cm^{-1}$, Oxygen Voltage and Fluorescence. The raw hex file was converted and processed using SBE Data Processing Version.7.22.5, using the CON file 0247_2017_06.xmlcon. Up-cast data was filtered out. Depth was derived from pressure using the latitude of each station, with dissolved oxygen in $mL \cdot L^{-1}$ 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 ($g \cdot kg^{-1}$) were calculated in Ocean Data View version 5.15 (Schlitzer, R., Ocean Data View, http://odv.awi.de, 2013).

3. Results

3.1. Catch composition

Catch volume and composition of squid, finfish, skate and other demersal and pelagic species are presented in Table II. The most abundant species (in terms of catch weight) was Red cod *Salilota australis* (caught mainly in the southwest), followed by the Shortfin squid *Illex argentinus* and Hoki *Macruronus magellanicus*.

Table II. Catch composition and weight of species caught during the demersal survey ZDLM3-02-2019 in February 2019.

Species Code	Latin name	Total caught (kg)	Total sampled (kg)	Total discarded (kg)	%
BAC	*Salilota australis*	10652.87	1815.84	335.21	21.15%
ILL	*Illex argentinus*	9271.00	1355.45	3.89	18.41%
WHI	*Macruronus magellanicus*	7315.40	337.63	1.07	14.52%
LOL	*Doryteuthis gahi*	5745.89	199.30	0.00	11.41%
KIN	*Genypterus blacodes*	4051.22	2994.85	0.18	8.04%
HAK	*Merluccius hubbsi*	2750.53	1470.24	0.00	5.46%
PAR	*Patagonotothen ramsayi*	2550.55	740.61	606.57	5.06%
GRF	*Coelorinchus fasciatus*	2473.94	158.32	2473.94	4.91%
BUT	*Stromateus brasiliensis*	1293.76	529.34	1237.52	2.57%
MUN	*Munida spp.*	649.11	0.00	644.10	1.29%
TOO	*Dissostichus eleginoides*	474.57	472.80	0.00	0.94%
MED	*Medusae*	422.18	0.00	422.04	0.84%
DGS	*Squalus acanthias*	388.91	0.00	385.02	0.77%
SPN	*Porifera*	256.86	0.00	256.84	0.51%
RFL	*Zearaja chilensis*	233.18	233.18	19.61	0.46%
RBR	*Bathyraja brachyurops*	221.57	212.08	28.25	0.44%
DGH	*Schroederichthys bivius*	186.81	0.00	185.61	0.37%
CGO	*Cottoperca gobio*	167.29	1.80	165.47	0.33%
SQT	*Ascidiacea*	159.02	0.00	157.40	0.32%
RGR	*Bathyraja griseocauda*	101.32	86.42	0.30	0.20%
ILF	*Iluocoetes fimbriatus*	78.91	0.00	78.91	0.16%
PYM	*Notophycis marginata*	74.56	3.98	74.56	0.15%
CHE	*Champsocephalus esox*	70.97	3.41	70.12	0.14%
ALF	*Allothunnus fallai*	69.26	48.78	0.00	0.14%
COP	*Congiopodus peruvianus*	60.06	0.00	59.46	0.12%
RMC	*Bathyraja macloviana*	50.64	50.64	8.06	0.10%
BRY	*Bryozoa*	46.78	0.00	46.76	0.09%
ALG	Algae	45.46	0.00	41.99	0.09%
PAT	*Merluccius australis*	41.30	41.30	0.00	0.08%
ING	*Onykia ingens*	38.46	0.00	35.72	0.08%
RED	*Sebastes oculatus*	38.41	38.04	1.17	0.08%
GOC	*Gorgonocephalus chilensis*	30.75	0.00	29.71	0.06%
WRM	*Chaetopterus variopedatus*	28.79	0.00	28.79	0.06%
AUC	*Austrocidaris canaliculata*	26.49	0.00	26.47	0.05%

Species Code	Latin name	Total caught (kg)	Total sampled (kg)	Total discarded (kg)	%
AST	*Asteroidea*	25.39	0.00	24.76	0.05%
RAL	*Bathyraja albomaculata*	19.90	19.90	9.16	0.04%
BLU	*Micromesistius australis*	18.18	8.48	17.76	0.04%
ANM	*Anemone*	17.98	0.00	17.62	0.04%
SUN	*Labidaster radiosus*	17.69	0.00	17.65	0.04%
PAG	*Paralomis granulosa*	16.72	0.00	16.72	0.03%
ANT	*Anthozoa*	15.81	0.00	15.81	0.03%
NEM	*Psychrolutes marmoratus*	14.84	0.00	13.18	0.03%
SEP	*Seriolella porosa*	13.72	0.00	0.64	0.03%
SAL	*Salpa sp.*	13.47	0.00	13.47	0.03%
RMU	*Bathyraja multispinis*	11.48	11.48	0.00	0.02%
RSC	*Bathyraja scaphiops*	10.43	10.43	0.00	0.02%
RPX	*Psammobatis spp.*	9.71	9.02	6.59	0.02%
STA	*Sterechinus agassizii*	8.03	0.00	7.99	0.02%
ZYP	*Zygochlamys patagonica*	6.15	0.00	6.12	0.01%
BEX	*Benthoctopus spp.*	6.09	0.00	4.88	0.01%
PTE	*Patagonotothen tessellata*	6.01	0.00	4.70	0.01%
SHT	Mixed invertebrates	5.25	0.00	5.25	0.01%
LIA	*Lithodes santolla*	4.85	0.00	3.39	0.01%
FUM	*Fusitriton magellanicus*	4.76	0.00	4.76	0.01%
RMG	*Bathyraja magellanica*	4.35	0.00	2.82	0.01%
MUG	*Munida gregaria*	4.04	0.00	3.04	0.01%
SEC	*Seriolella caerulea*	3.72	0.42	1.74	0.01%
XXX	Unidentified animal	3.11	0.01	2.48	0.01%
AUL	*Austrolycus laticinctus*	3.10	0.00	2.52	0.01%
SAR	*Sprattus fuegensis*	3.09	0.51	2.51	0.01%
CIR	*Cirripedia*	2.73	0.00	2.73	0.01%
RDO	*Amblyraja doellojuradoi*	2.66	2.08	1.36	0.01%
CTA	*Ctenodiscus australis*	2.55	0.00	2.55	0.01%
PES	*Peltarion spinulosum*	2.13	0.00	2.03	<0.01%
UCH	Sea urchin	2.07	0.00	1.89	<0.01%
OPV	*Ophiacantha vivipara*	1.96	0.00	1.96	<0.01%
EUL	*Eurypodius latreillii*	1.90	0.00	1.84	<0.01%
UHH	Heart urchin	1.90	0.00	1.89	<0.01%
NUD	*Nudibranchia*	1.63	0.00	1.62	<0.01%
POA	*Glabraster antarctica*	1.34	0.00	1.31	<0.01%
EGG	Eggmass	1.28	0.00	0.39	<0.01%
GOR	*Gorgonacea*	0.82	0.00	0.82	<0.01%
ALC	*Alcyoniina*	0.76	0.00	0.75	<0.01%
CEX	*Ceramaster sp.*	0.67	0.00	0.53	<0.01%
ODM	*Odontocymbiola magellanica*	0.60	0.00	0.60	<0.01%
EUO	*Eurypodius longirostris*	0.49	0.00	0.36	<0.01%
COL	*Cosmasterias lurida*	0.43	0.00	0.43	<0.01%

Species Code	Latin name	Total caught (kg)	Total sampled (kg)	Total discarded (kg)	%
OPL	*Ophiura lymani*	0.38	0.00	0.38	<0.01%
MUU	*Munida subrugosa*	0.38	0.00	0.38	<0.01%
OCT	*Octopus spp.*	0.37	0.00	0.37	<0.01%
NOW	*Paranotothenia magellanica*	0.36	0.00	0.36	<0.01%
MAR	*Martialia hyadesi*	0.35	0.00	0.00	<0.01%
BRA	*Brachyura*	0.33	0.00	0.33	<0.01%
CYX	*Cycethra sp.*	0.31	0.00	0.29	<0.01%
SRP	*Semirossia patagonica*	0.30	0.00	0.23	<0.01%
MAT	*Achiropsetta tricholepis*	0.28	0.00	0.28	<0.01%
CAZ	*Calyptraster sp.*	0.27	0.00	0.18	<0.01%
ANN	*Annelida*	0.24	0.00	0.24	<0.01%
PYX	*Pycnogonida*	0.20	0.00	0.20	<0.01%
RAY	*Rajidae*	0.19	0.00	0.00	<0.01%
LIT	*Lithodes turkayi*	0.19	0.00	0.00	<0.01%
CAV	*Campylonotus vagans*	0.15	0.00	0.15	<0.01%
OPH	*Ophiuroidea*	0.12	0.00	0.12	<0.01%
PAU	*Patagolycus melastomus*	0.12	0.00	0.12	<0.01%
ASA	*Astrotoma agassizii*	0.11	0.00	0.11	<0.01%
THB	*Thymops birsteini*	0.11	0.00	0.11	<0.01%
COG	*Patagonotothen guntheri*	0.10	0.00	0.08	<0.01%
HOL	*Holothuroidea*	0.10	0.00	0.09	<0.01%
OPS	*Ophiactis asperula*	0.07	0.00	0.07	<0.01%
HCR	*Paguroidea*	0.07	0.00	0.06	<0.01%
BRP	*Brachiopod spp.*	0.07	0.00	0.07	<0.01%
ISO	*Isopoda*	0.05	0.00	0.05	<0.01%
BAL	*Americominella longisetosus*	0.05	0.00	0.05	<0.01%
MAV	*Magellania venosa*	0.05	0.00	0.03	<0.01%
ACS	*Acanthoserolis schythei*	0.04	0.00	0.04	<0.01%
CAS	*Campylonotus semistriatus*	0.03	0.00	0.03	<0.01%
PRI	*Priapulida*	0.02	0.00	0.02	<0.01%
NUH	*Nuttallochiton hyadesi*	0.02	0.00	0.01	<0.01%
POL	*Polychaeta*	0.02	0.00	0.02	<0.01%
BAO	*Bathybiaster loripes*	0.02	0.00	0.02	<0.01%
CTE	*Ctenophora*	0.02	0.00	0.02	<0.01%
GAY	*Gastropoda*	0.02	0.00	0.02	<0.01%
PAF	*Paralomis formosa*	0.02	0.00	0.02	<0.01%
LIR	*Limopsis marionensis*	0.01	0.00	0.01	<0.01%
BUC	*Falsilunatia carcellesi*	0.01	0.00	0.01	<0.01%
COT	*Cottunculus granulosus*	0.01	0.00	0.01	<0.01%
EEL	*Iluocoetes/Patagolycus mix*	0.01	0.00	0.01	<0.01%
GAF	*Ganeria falklandica*	0.01	0.00	0.01	<0.01%
GRX	*Coelorinchus braueri*	0.00	0.00	0.00	<0.01%
MXX	*Myctophid spp.*	0.00	0.00	0.00	<0.01%

3.2. Biological information of finfish species

3.2.1. *Salilota australis* – Red cod

The total catch of Red cod was 10,653 kg. This species was caught at 76 of the 83 trawl stations sampled throughout the research cruise; 42 stations yielded <10 kg, 18 yielded ≥10 kg, 13 yielded ≥100 kg, and three stations yielded ≥1 t each. Catches ranged from 0.04 to 2,052 kg, densities were 0.2 to 8,841 kg·km^{-2}, and CPUE ranged from 0.04 to 2,052 kg·h^{-1}. Catches of Red cod occurred mostly along the west and north of the Falkland Islands; minor catches were also observed at the east of East Falkland (Figure 2A). Most females and males were immature (maturity stages ≤ IV) (Figure 2B). Females were 13–85 cm total length, and males were 13–84 cm total length. The overlap of cohorts allowed identifying only two cohorts with length modes at 17–18 cm and at 32 cm total length (Figure 2C).

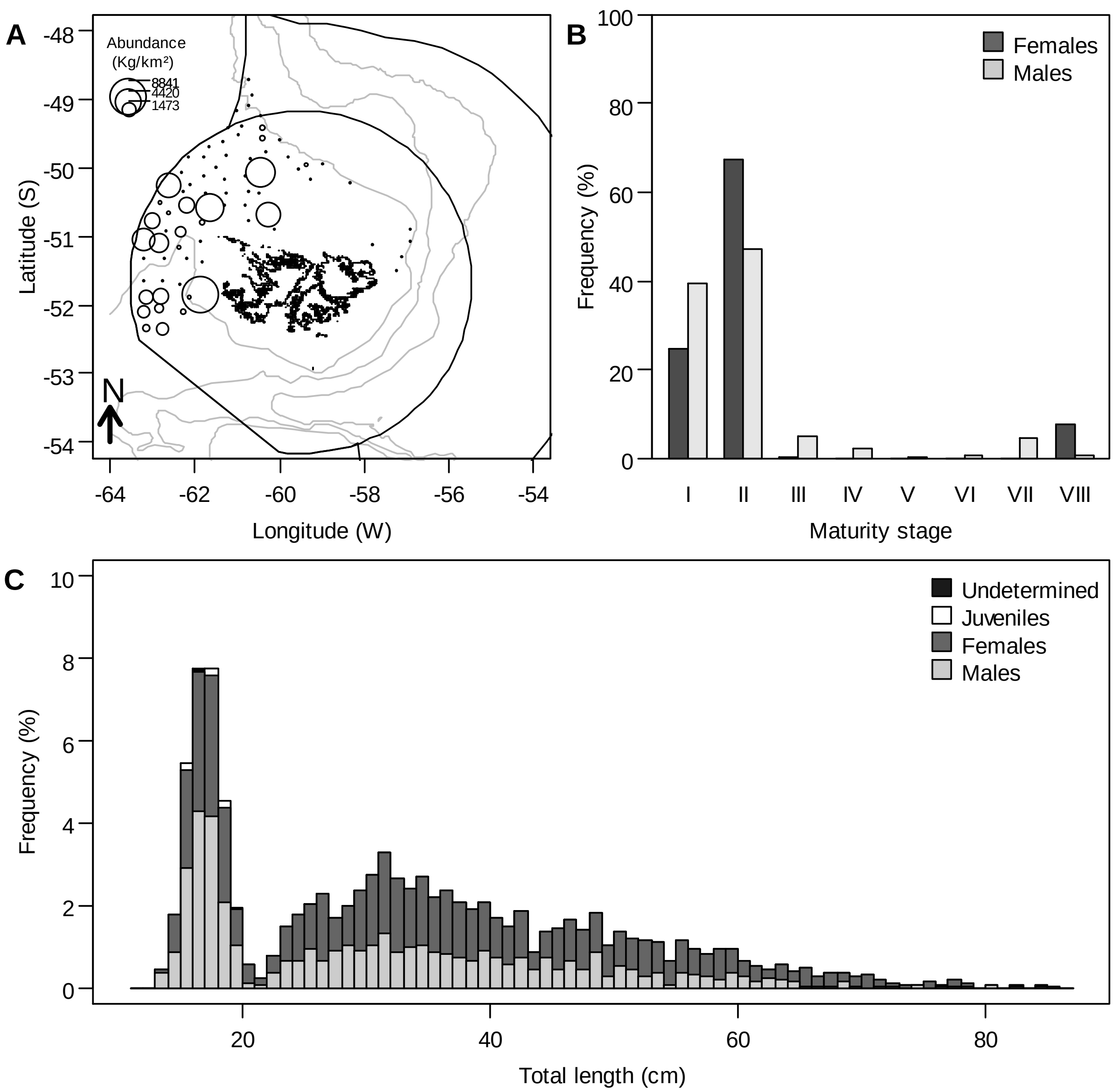

Figure 2. Biological data of *Salilota australis* (Red cod; BAC). A) Map of the densities in kg·km^{-2}; B) percentage of specimens of each sex per maturity stage (I, immature; II, resting; III, early developing; IV, late developing; V, ripe; VI, running; VII, spent; VIII, recovering spent); and C) length frequency (in percentage of the total sample assessed) of each sex with 1 cm size class (n= 3,445).

3.2.2. *Micromesistius australis* – Southern blue whiting

The total catch of Southern blue whiting was 18 kg. This species was caught at 7 of the 83 trawl stations sampled throughout the research cruise. Catches ranged from 0.005 to 8.5 kg, densities ranged from 0.02 to 37 kg·km^{-2}, and CPUE ranged from 0.005–8.5 kg·h^{-1}. Southern blue whiting were caught in the west, approximately at 52°S and 62°W (Figure 3A). A total of 115 fish were sampled for length frequency (44 females, 71 males); 10 individuals were sampled for otoliths. Females and males were immature (100%) (Figure 3B). Females were 21–27 cm total length and males were 20–25 cm total length. One cohort was detected in the length frequency histogram with mode at 23 cm total length (Figure 3C).

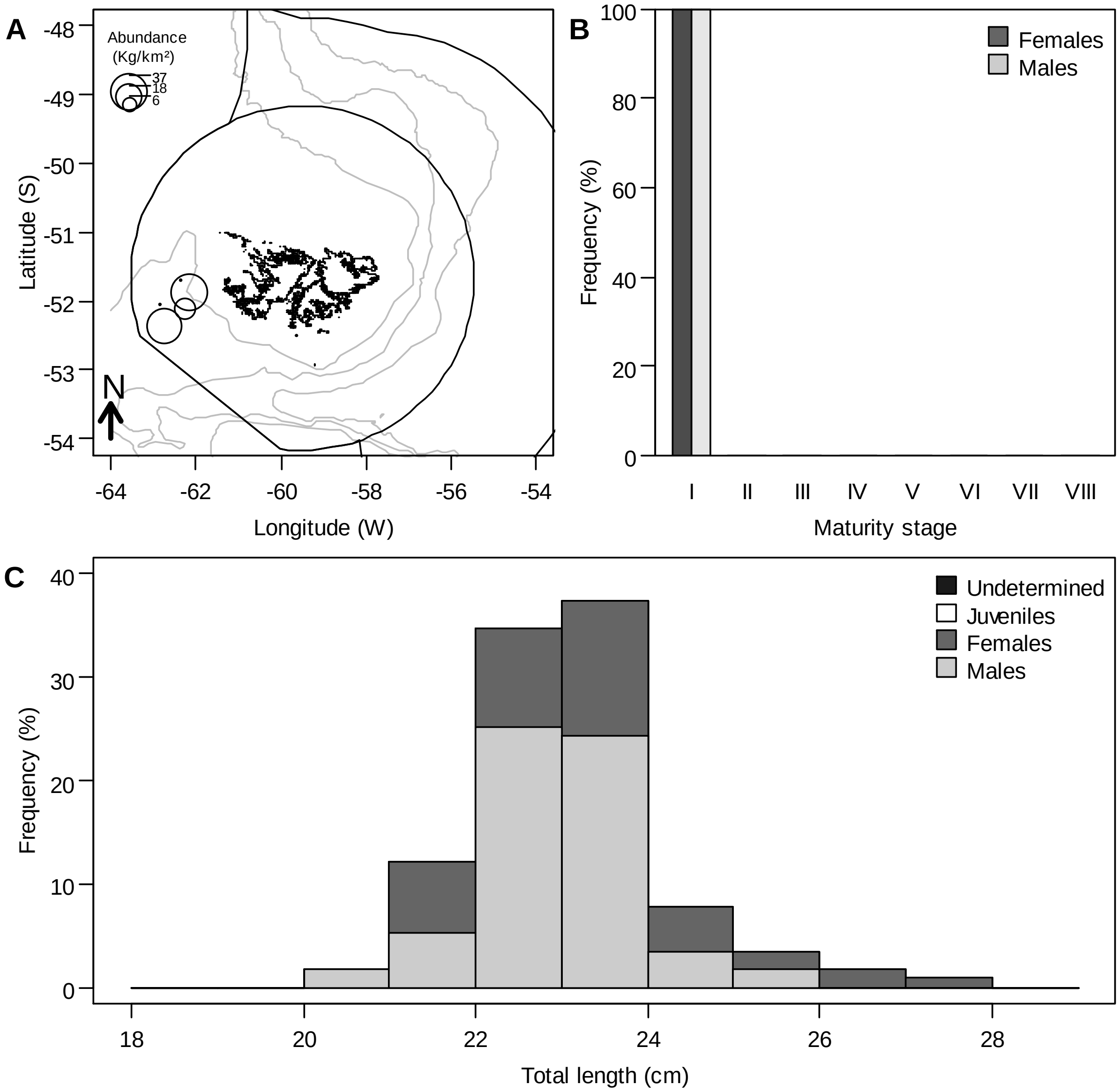

Figure 3. Biological data of *Micromesistius australis* (Southern blue whiting; BLU). A) Map of the densities in kg·km^{-2}; B) percentage of specimens of each sex per maturity stage (I, immature; II, resting; III, early developing; IV, late developing; V, ripe; VI, running; VII, spent; VIII, recovering spent); and C) length frequency (in percentage of the total sample assessed) of each sex with 1 cm size class (n= 115).

3.2.3. *Merluccius hubbsi* – Common hake

The total catch of Common hake was 2,751 kg. This species was caught at 57 of the 83 trawl stations sampled throughout the research cruise. Catches ranged from 0.42 to 227 kg, densities ranged from 1.8 to 1,079 kg·km^{-2}, and CPUE ranged from 0.4 to 227 kg·h^{-1}. Common hake was observed to the west of 60°W and to the north of 51°S, an area where hake has historically been observed at this time of the year (Figure 4A). Most females were immature (maturity stages ≤ IV), whereas most males were mature (maturity stages ≥ V) (Figure 4B). Females were 18–88 cm total length and males were 28–48 cm total length. One cohort was detected on the length-frequency histogram with modal length at 38 cm total length (Figure 4C).

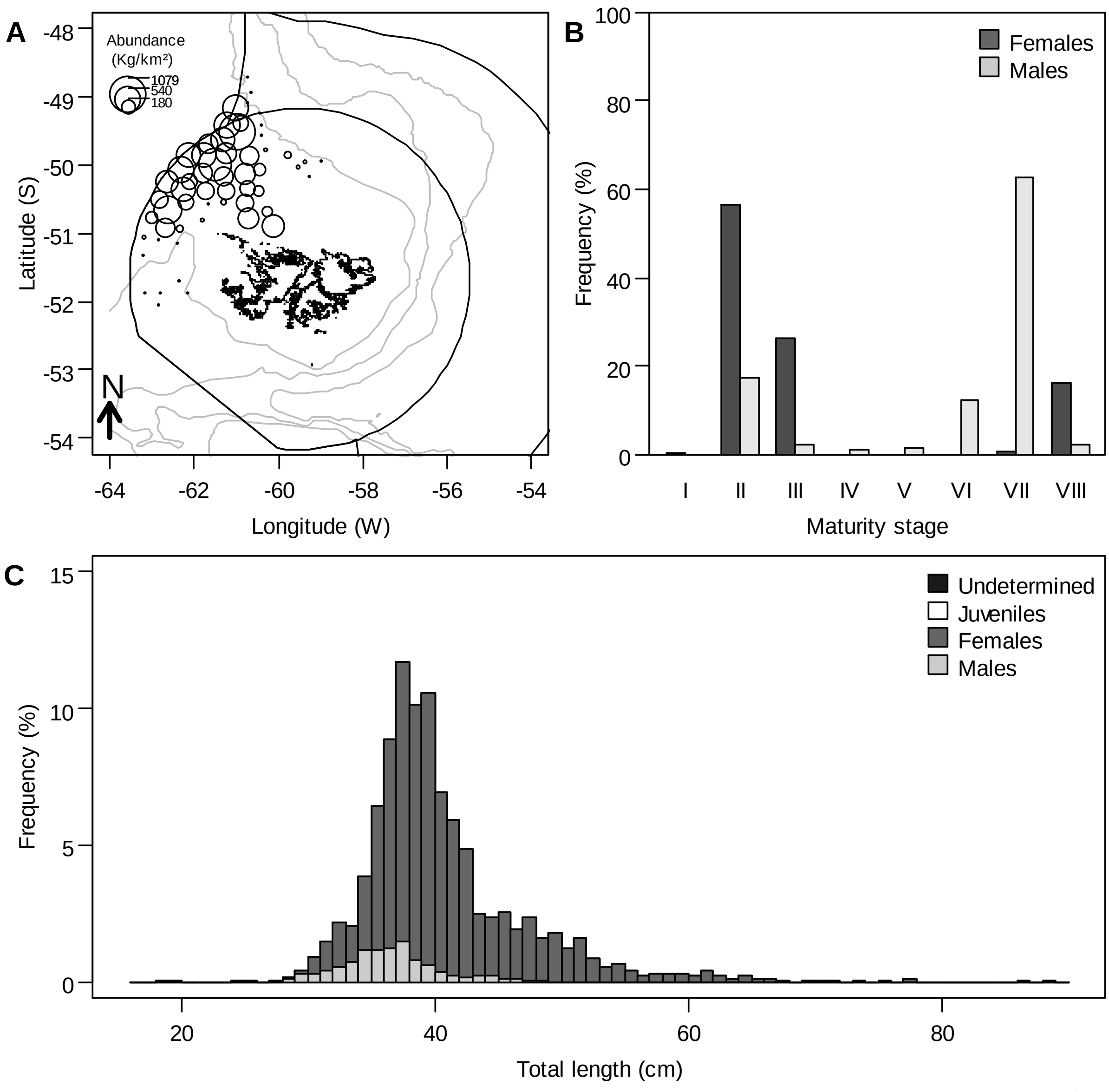

Figure 4. Biological data of *Merluccius hubbsi* (Common hake; HAK). A) Map of the densities in kg·km^{-2}; B) percentage of specimens of each sex per maturity stage (I, immature; II, resting; III, early developing; IV, late developing; V, ripe; VI, running; VII, spent; VIII, recovering spent); and C) length frequency (in percentage of the total sample assessed) of each sex with 1 cm size class (n= 3,023).

3.2.4. *Genypterus blacodes* – Kingclip

The total catch of Kingclip was 4,051 kg. This species was caught at 73 of the 83 trawl stations sampled throughout the research cruise. Catches ranged from 0.2 to 512 kg, densities ranged from 0.8 to 2,407 kg·km^{-2}, and CPUE ranged from 0.2 to 512 kg·h^{-1}. Highest densities were observed along the northwest border of the FICZ; lower densities were observed in the southwest (Figure 5A). Most females and males were immature (maturity stages ≤ IV) (Figure 5B). Females were 32–118 cm total length, and males were 35–115 cm total length. The overlap of sizes allowed identifying only one cohort with modal length at 50 cm total length (Figure 5C); however, more cohorts are likely to have occurred given that individuals from a wide range of sizes were caught.

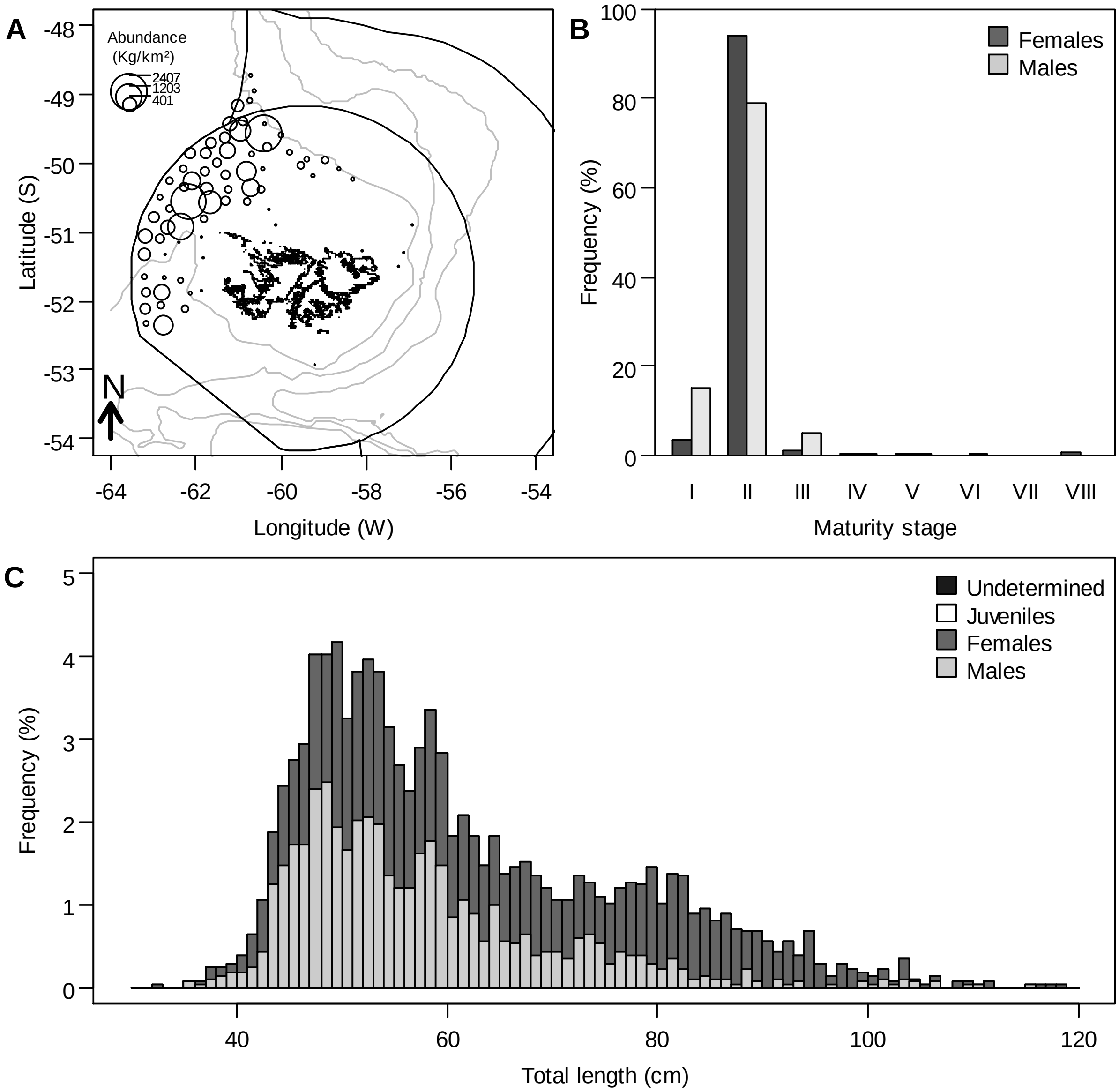

Figure 5. Biological data of *Genypterus blacodes* (Kingclip; KIN). A) Map of densities in kg·km^{-2}; B) percentage of specimens of each sex per maturity stage (I, immature; II, resting; III, early developing; IV, late developing; V, ripe; VI, running; VII, spent; VIII, recovering spent); and C) length frequency (in percentage of the total sample assessed) of each sex with 1 cm size class (n= 2,826).

3.2.5. *Patagonotothen ramsayi* – Common rock cod

The total catch of Rock cod was 2,551 kg. This species was caught practically at every station during the cruise, albeit in small numbers. Catches ranged from 0.03 to 283 kg, densities ranged from 0.11 to 1,280 kg·km^{-2}, and CPUE ranged from 0.03 to 283 kg·h^{-1}. Highest densities were observed to the west and to the north of the Falkland Islands (Figure 6A). Most females and males were immature (maturity stages ≤ IV) (Figure 6B). Juveniles were 4–16 cm total length, females were 9–41 cm total length, and males were 8–42 cm total length. More than two size cohorts may exist but these were not detected because of the overlap of size (Figure 6C).

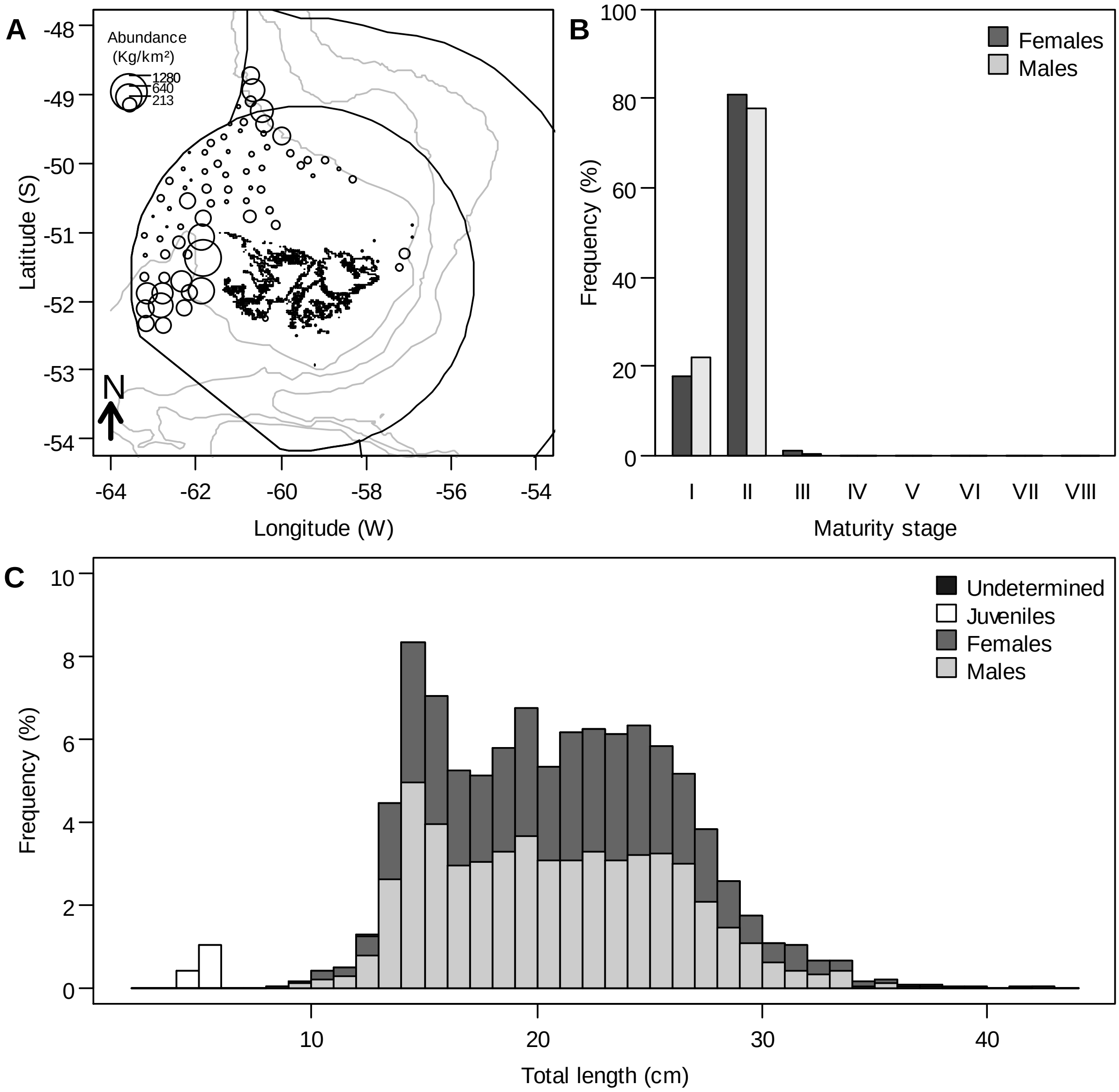

Figure 6. Biological data for *Patagonotothen ramsayi* (Common rock cod; PAR). A) Map of the densities in kg·km^{-2}; B) percentage of specimens of each sex per maturity stage (I, immature; II, resting; III, early developing; IV, late developing; V, ripe; VI, running; VII, spent; VIII, recovering spent); and C) length frequency (in percentage of the total sample assessed) of each sex with 1 cm size class (n= 6,536).

3.2.6. *Merluccius australis* – Patagonian hake

The total catch of Patagonian hake was 41 kg. This species was caught at 7 of the 83 trawl stations sampled throughout the research cruise. Catches ranged from 0.8 to 15 kg, densities ranged from 4 to 62 kg·km^{-2}, and CPUE ranged from 0.8 to 15 kg·h^{-1}. Patagonian hake were observed in the west of the survey zone between the 200 m isobath and near the western edge of the FICZ (Figure 7A). This area is in deeper waters where Patagonian hake are most abundant. All females and males were immature (maturity stages ≤ IV) (Figure 7B). The small number of fish caught and the large size range did not enable identifying cohorts on the length-frequency histogram (Figure 7C).

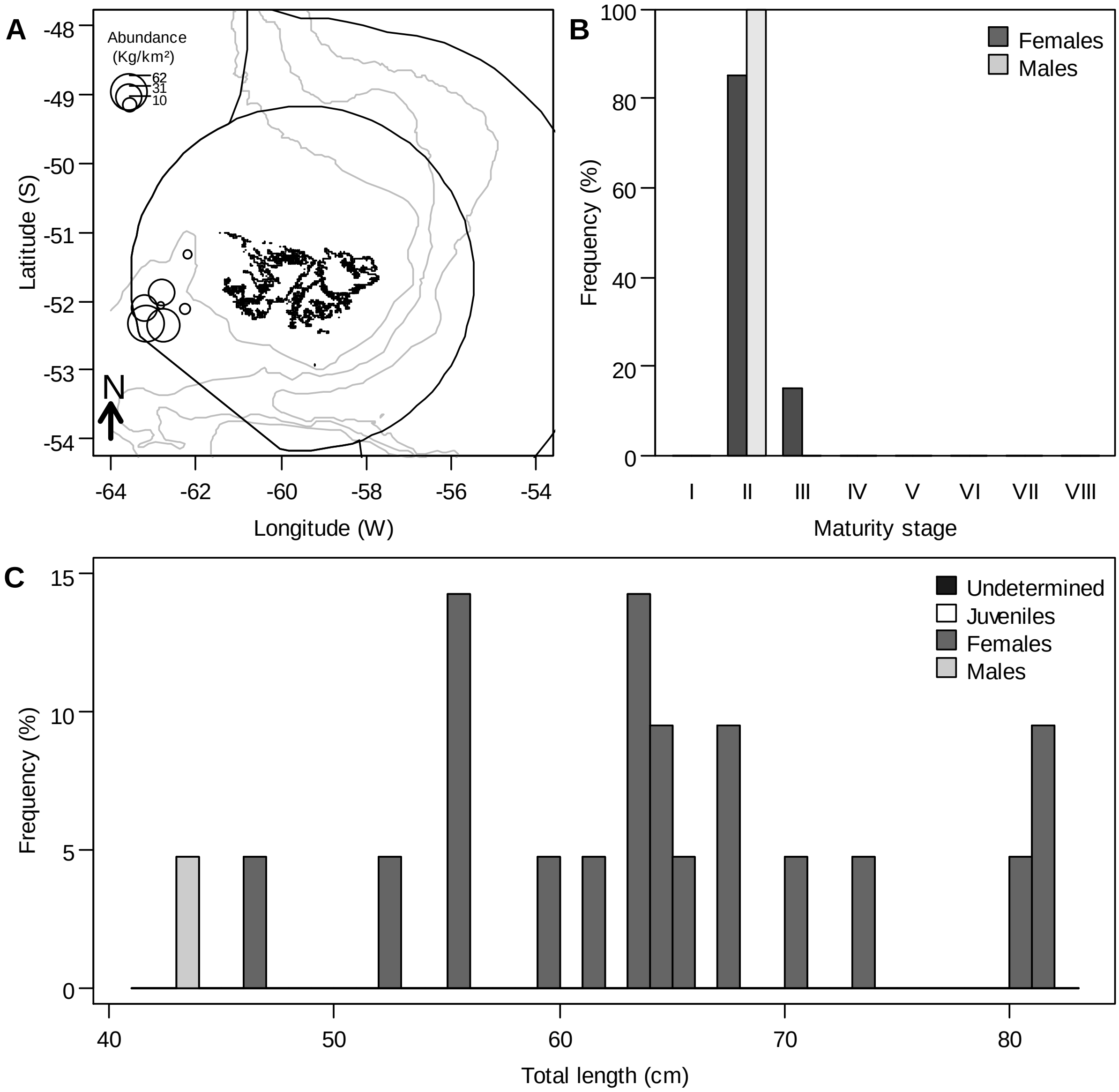

Figure 7. Biological data of *Merluccius australis* (Patagonian hake; PAT). A) Map of the densities in kg·km^{-2}; B) percentage of specimens of each sex per maturity stage (I, immature; II, resting; III, early developing; IV, late developing; V, ripe; VI, running; VII, spent; VIII, recovering spent); C) length frequency (in percentage of the total sample assessed) of each sex with 1 cm size class (n= 21).

3.2.7. *Dissostichus eleginoides* – Patagonian toothfish

The total catch of Patagonian toothfish was 475 kg. This species was caught at 37 of the 83 trawl stations sampled throughout the research cruise. Catches ranged from 0.6 to 115 kg, densities ranged from 3 to 545 kg·km^{-2}, and CPUE ranged from 0.6 to 115 kg·h^{-1}. Highest densities were observed in the southwest of the survey zone at stations deeper than 200 m (Figure 8A). Most females and males were immature (maturity stages ≤ IV) (Figure 8B). Females were 27–86 cm total length, and males were 29–75 cm total length. One cohort was identified with a modal length at 46 cm total length; other cohorts were not clearly detected (Figure 8C).

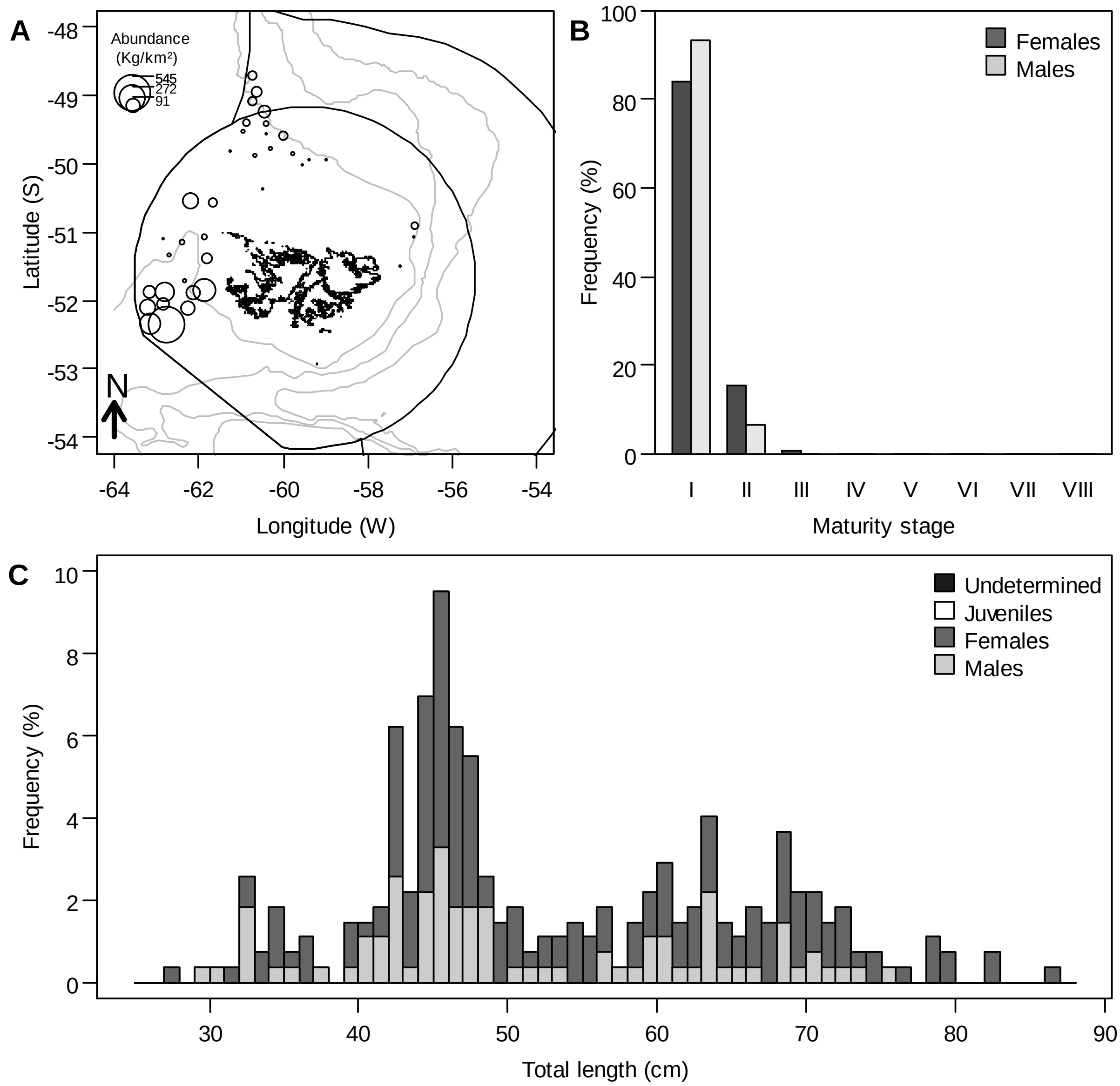

Figure 8. Biological data of *Dissostichus eleginoides* (Patagonian toothfish; TOO). A) Map of the densities in kg·km^{-2}; B) percentage of specimens of each sex per maturity stage (I, immature; II, resting; III, early developing; IV, late developing; V, ripe; VI, running; VII, spent; VIII, recovering spent); and C) length frequency (in percentage of the total sample assessed) of each sex with 1 cm size class (n= 273).

3.2.8. *Macruronus magellanicus* – Hoki

The total catch of Hoki was 7,315 kg, the second most abundant finfish during the cruise. This species was caught at 27 of the 83 stations sampled throughout the research cruise. Catches ranged from 0.1 to 5,872 kg, densities ranged from 0.4 to 24,053 kg·km^{-2}, and CPUE ranged from 0.1 to 5,872 kg·h^{-1}. Highest densities were observed in the southwest of the survey area to the south of 52°S and around 63°W (Figure 9A). Small catches were also observed along the west and northwest of the Falkland Islands. Most females and males were immature (maturity stages ≤ IV) (Figure 9B). Females were 13–42 cm pre-anal length, and males were 13–36 cm pre-anal length. The length frequency histogram exhibits one cohort with modal length at 22 cm pre-anal length (Figure 9C).

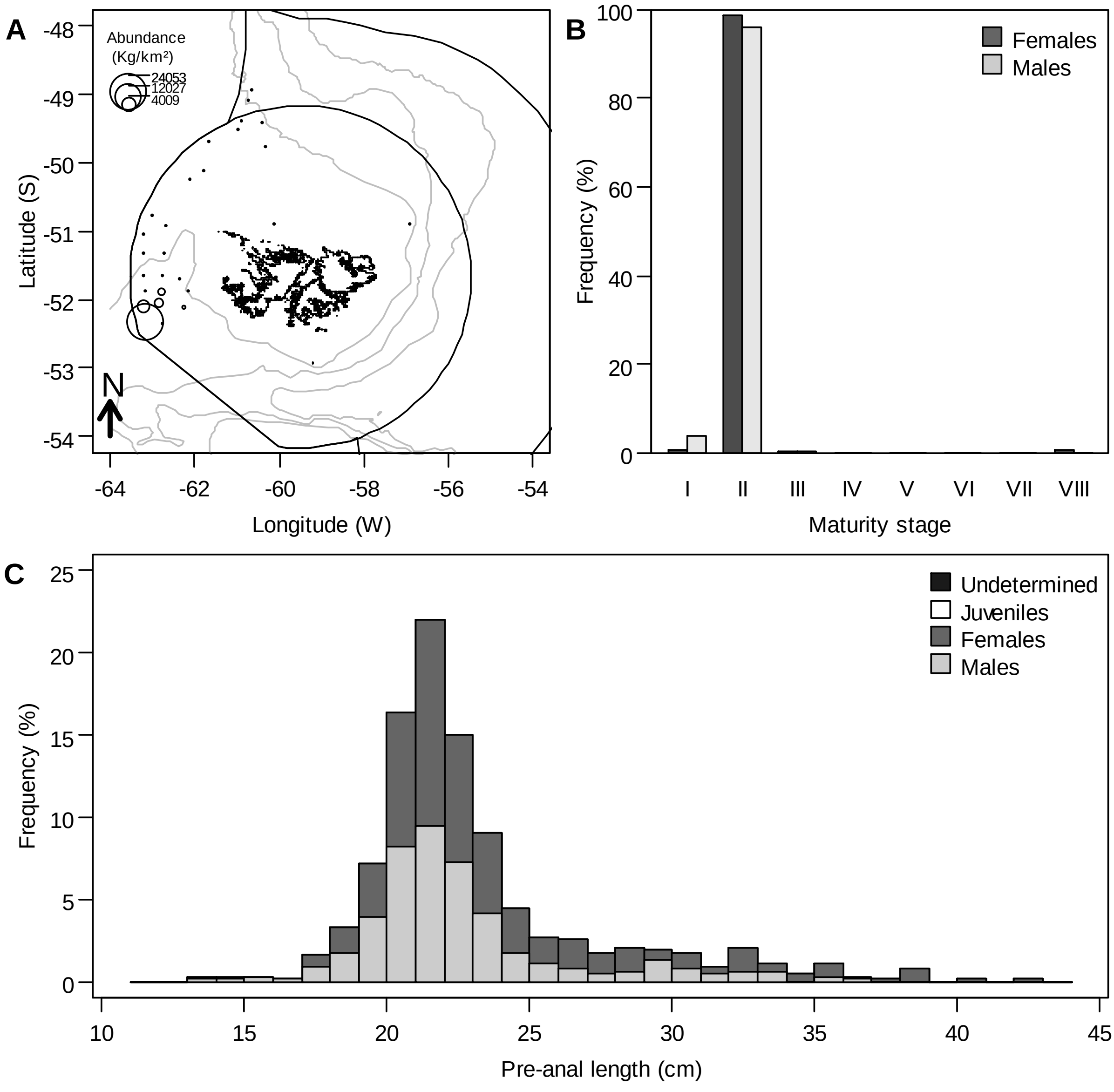

Figure 9. Biological data of *Macruronus magellanicus* (Hoki; WHI). A) Map of the densities in kg·km^{-2}; B) percentage of specimens of each sex per maturity stage (I, immature; II, resting; III, early developing; IV, late developing; V, ripe; VI, running; VII, spent; VIII, recovering spent); and C) pre-anal length frequency (in percentage of the total sample assessed) of each sex with 1 cm size class (n= 631).

3.2.9. *Stromateus brasiliensis* – Butterfish

The total catch of Butterfish was 1,294 kg. This species was caught at 53 of the 83 trawl stations sampled throughout the research cruise. Catches ranged from 0.2 to 127 kg, densities ranged from 0.9 to 555 kg·km^{-2}, and CPUE ranged from 0.2 to 127 kg·h^{-1}. Butterfish was caught in the northwest of West Falkland near the western edge of the FICZ, and in the north of West Falkland at nearshore stations (Figure 10A). Females and males were mostly immature (maturity stages ≤ IV) (Figure 10B). Females were 7–40 cm total length and males were 15–36 cm total length. One cohort was detected with modal length at 26 cm total length; however, more cohorts likely occurred considering the wide range of sizes observed (Figure 10C).

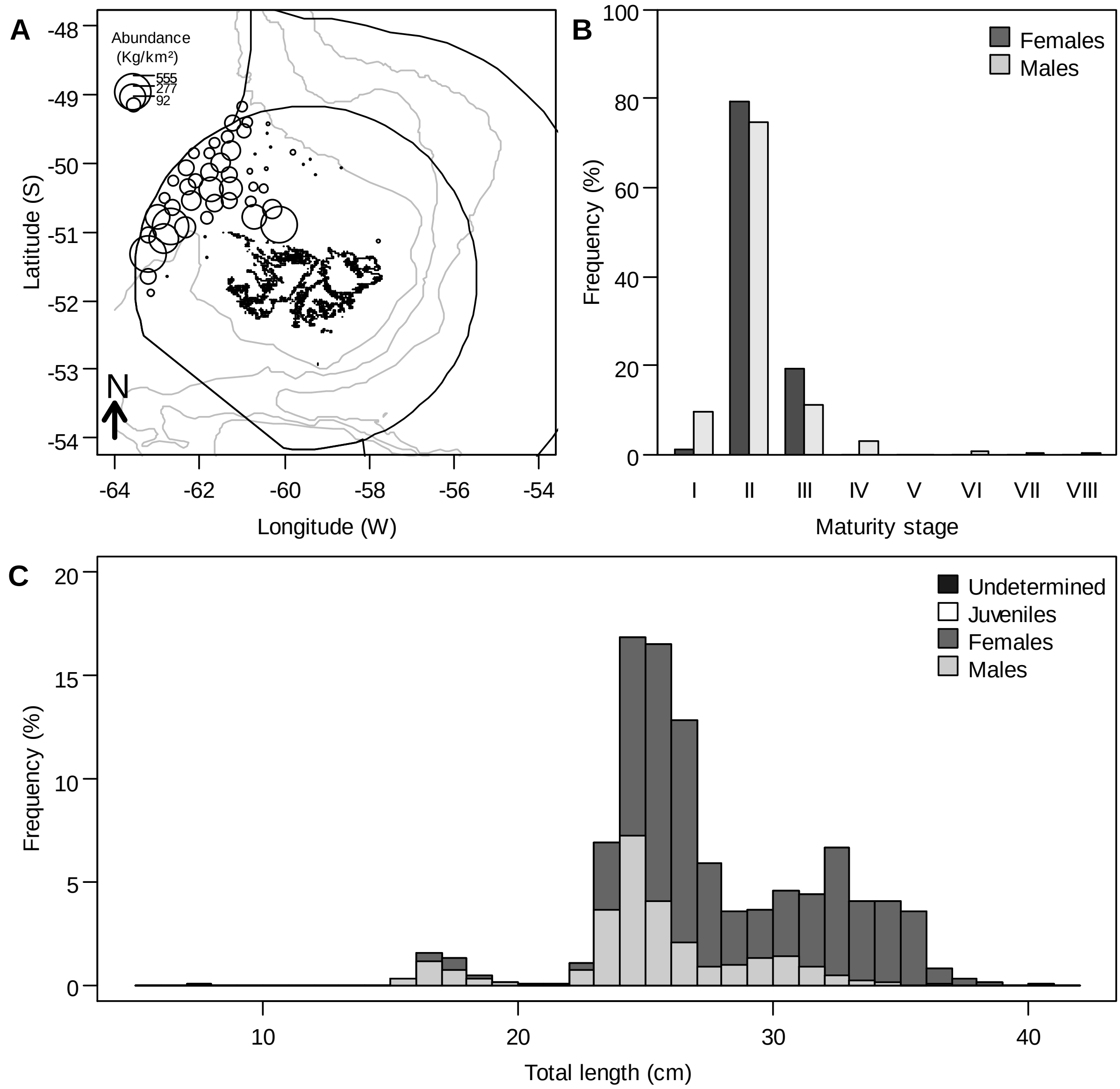

Figure 10. Biological data of *Stromateus brasiliensis* (Butterfish; BUT). A) Map of the densities in kg·km^{-2}; B) percentage of specimens of each sex per maturity stage (I, immature; II, resting; III, early developing; IV, late developing; V, ripe; VI, running; VII, spent; VIII, recovering spent); and C) length frequency (in percentage of the total sample assessed) of each sex with 1 cm size class (n= 1,468).

3.2.10. *Champsocephalus esox* – Icefish

The total catch of Icefish was 71 kg. This species was caught at 10 of the 83 trawl stations sampled throughout the research cruise; only one station yielded ≥10 kg. Catches ranged from 0.01 to 62 kg, densities ranged from 0.1 to 301 kg·km^{-2}, and CPUE ranged from 0.01 to 62 kg·h^{-1}. Icefish were observed to the south of West Falkland, mainly in shallow waters (Figure 11A). A total of 205 fish were sampled for length frequency (93 females, 112 males). Females and males were immature (maturity stages ≤ IV) (Figure 11B). Females were 12–29 cm total length and males were 11–27 cm total length. The length-frequency histogram exhibited one cohort with a modal total length at 14 cm (Figure 11C).

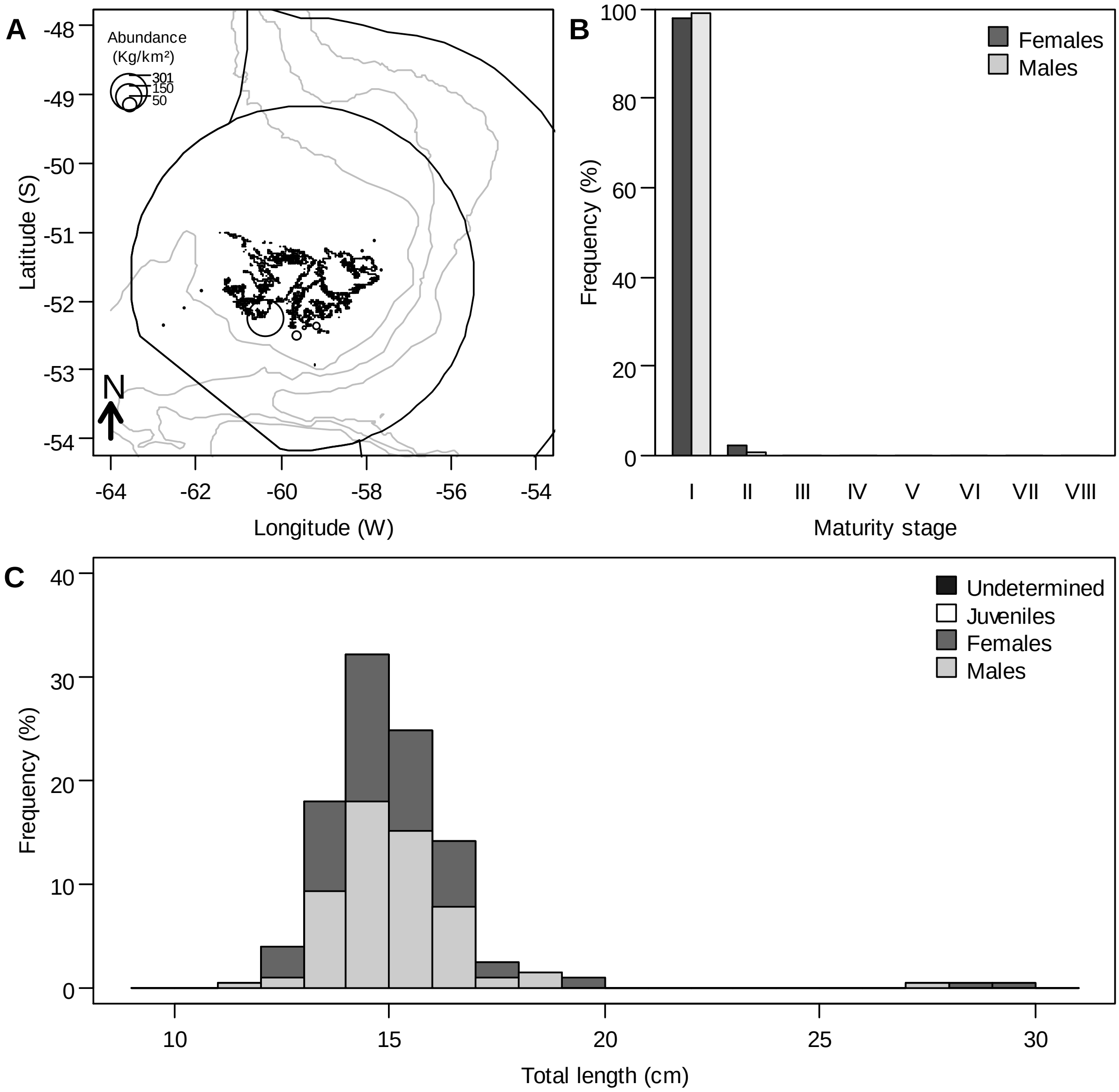

Figure 11. Biological data of *Champsocephalus esox* (Icefish; CHE). A) Map of the densities in kg·km^{-2}; B) percentage of specimens of each sex per maturity stage (I, immature; II, resting; III, early developing; IV, late developing; V, ripe; VI, running; VII, spent; VIII, recovering spent); and C) length frequency (in percentage of the total sample assessed) of each sex with 1 cm size class (n= 205).

3.2.11. *Coelorinchus fasciatus* – Banded whiptail grenadier

The total catch of Banded whiptail grenadier was 2,474 kg. This species was caught at 13 of the 83 trawl stations sampled throughout the research cruise. Catches ranged from 2 to 585 kg, densities ranged from 9 to 2,543 kg·km^{-2}, and CPUE ranged from 2 to 585 kg·h^{-1}. Highest densities were observed in the southwest of the survey zone between the 200 m isobath and the western edge of the FICZ, mainly at stations deeper than 200 m (Figure 12A). Females and males were mostly immature (maturity stages ≤ IV) (Figure 12B). Females were 7–14 cm pre–anal length and males were 7–11 cm pre–anal length. The length-frequency histogram allowed detecting a single cohort with modal length at 11 cm pre–anal length (Figure 12C).

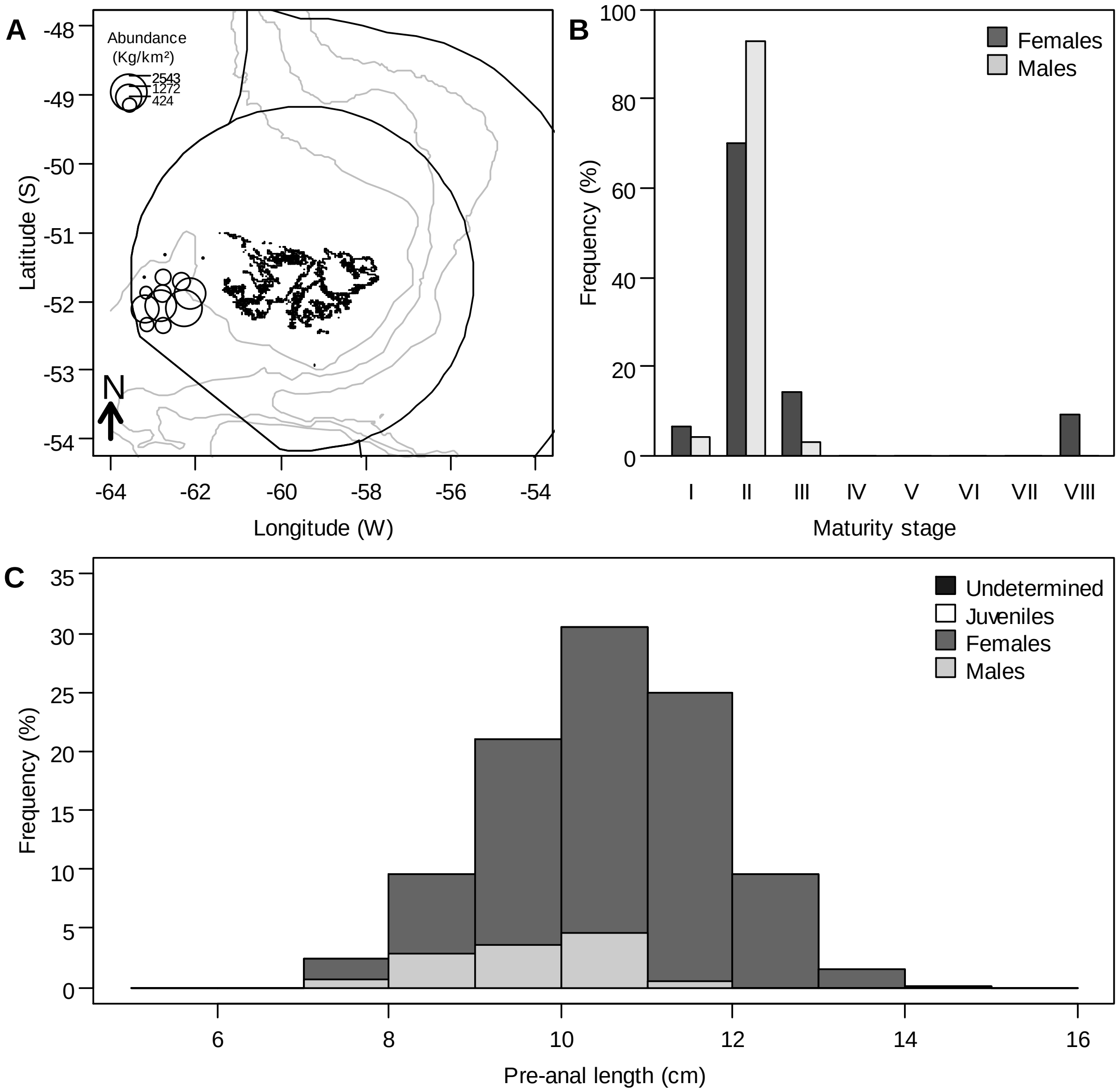

Figure 12. Biological data of *Coelorinchus fasciatus* (Banded whiptail grenadier; GRF). A) Map of the densities in kg·km^{-2}; B) percentage of specimens of each sex per maturity stage (I, immature; II, resting; III, early developing; IV, late developing; V, ripe; VI, running; VII, spent; VIII, recovering spent); and C) pre-anal length frequency (in percentage of the total sample assessed) of each sex with 1 cm size class (n= 811).

3.2.12. *Sebastes oculatus* – Redfish

The total catch of Redfish was 38 kg. This species was caught at 9 of the 83 trawl stations sampled throughout the research cruise; only 2 stations yielded ≥10 kg each. Catches ranged from 0.2 to 14 kg, densities ranged from 0.9 to 67 kg·km^{-2}, and CPUE ranged from 0.2 to 14 kg·h^{-1}. Highest densities were observed to the north and to the northwest of West Falkland (Figure 13A). The proportion of mature (maturity stages > V) and immature (maturity stages ≤ IV) females was relatively similar. In contrast, most males were immature (maturity stages ≤ IV) (Figure 13B). Females were 22–40 cm total length and males were 22–38 cm total length (Figure 13C).

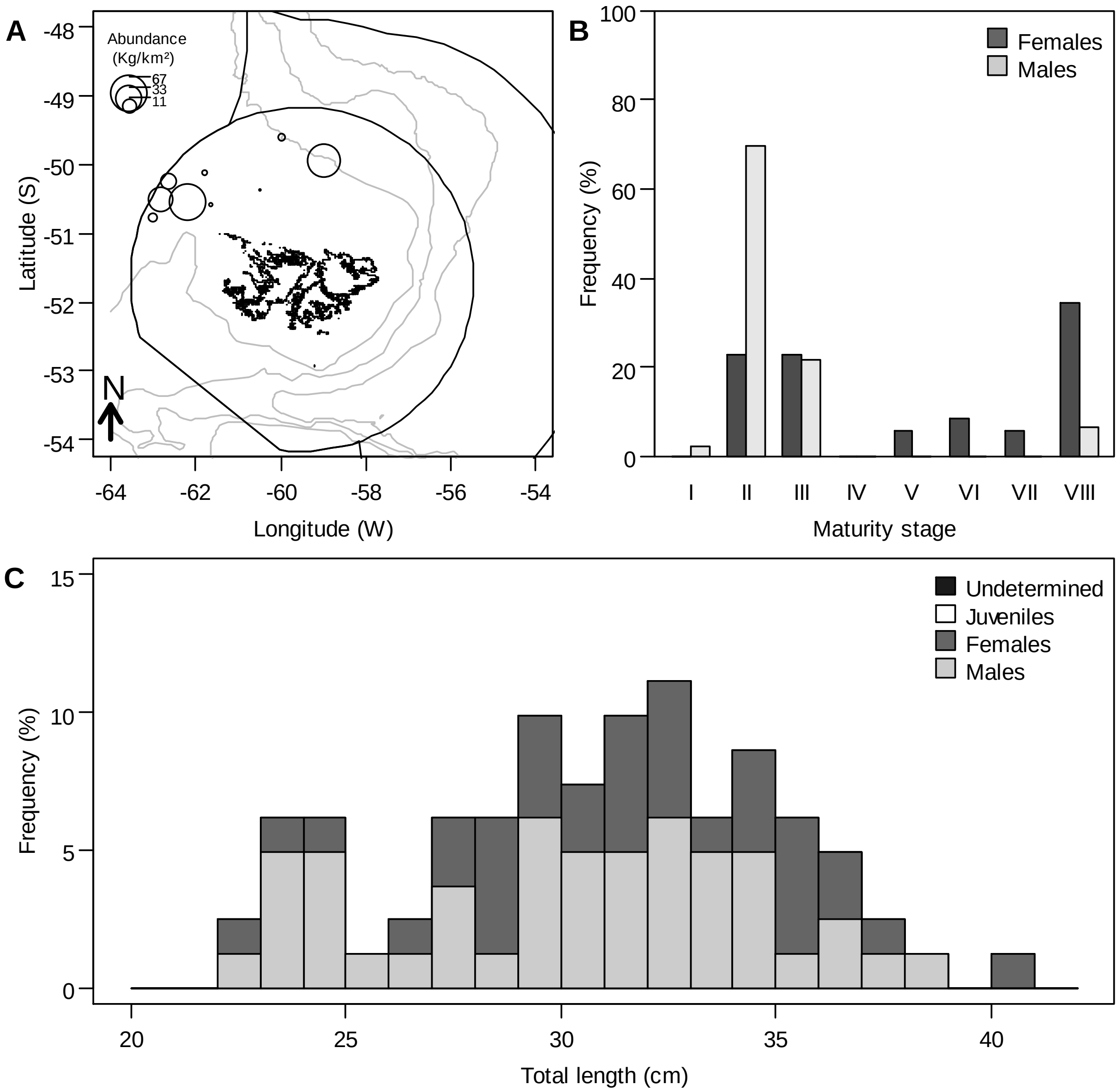

Figure 13. Biological data of *Sebastes oculatus* (Redfish; RED). A) Map of the densities in kg·km^{-2}; B) percentage of specimens of each sex per maturity stage (I, immature; II, resting; III, early developing; IV, late developing; V, ripe; VI, running; VII, spent; VIII, recovering spent); and C) length frequency (in percentage of the total sample assessed) of each sex with 1 cm size class (n= 81).

3.3. Biological information on squids

3.3.1. Illex argentinus – Argentine shortfin squid

The total catch of Argentine shortfin squid was 9,271 kg, the second most abundant species during the cruise in terms of biomass. This species was caught at 75 of the 83 trawl stations sampled throughout the research cruise. Catches ranged from 0.04 to 869 kg, densities ranged from 0.2 to 3,893 kg·km^{-2}, and CPUE ranged 0.04–869 kg·h^{-1}. Highest densities occurred mainly in the northwest of the FICZ (Figure 14A). Most females were immature (maturity stages ≤ III), whereas most males were mature (maturity stages > IV) (Figure 14B). The histogram showed two cohorts with modal dorsal mantle lengths at 13.5 cm and 24.5 cm (Figure 14C).

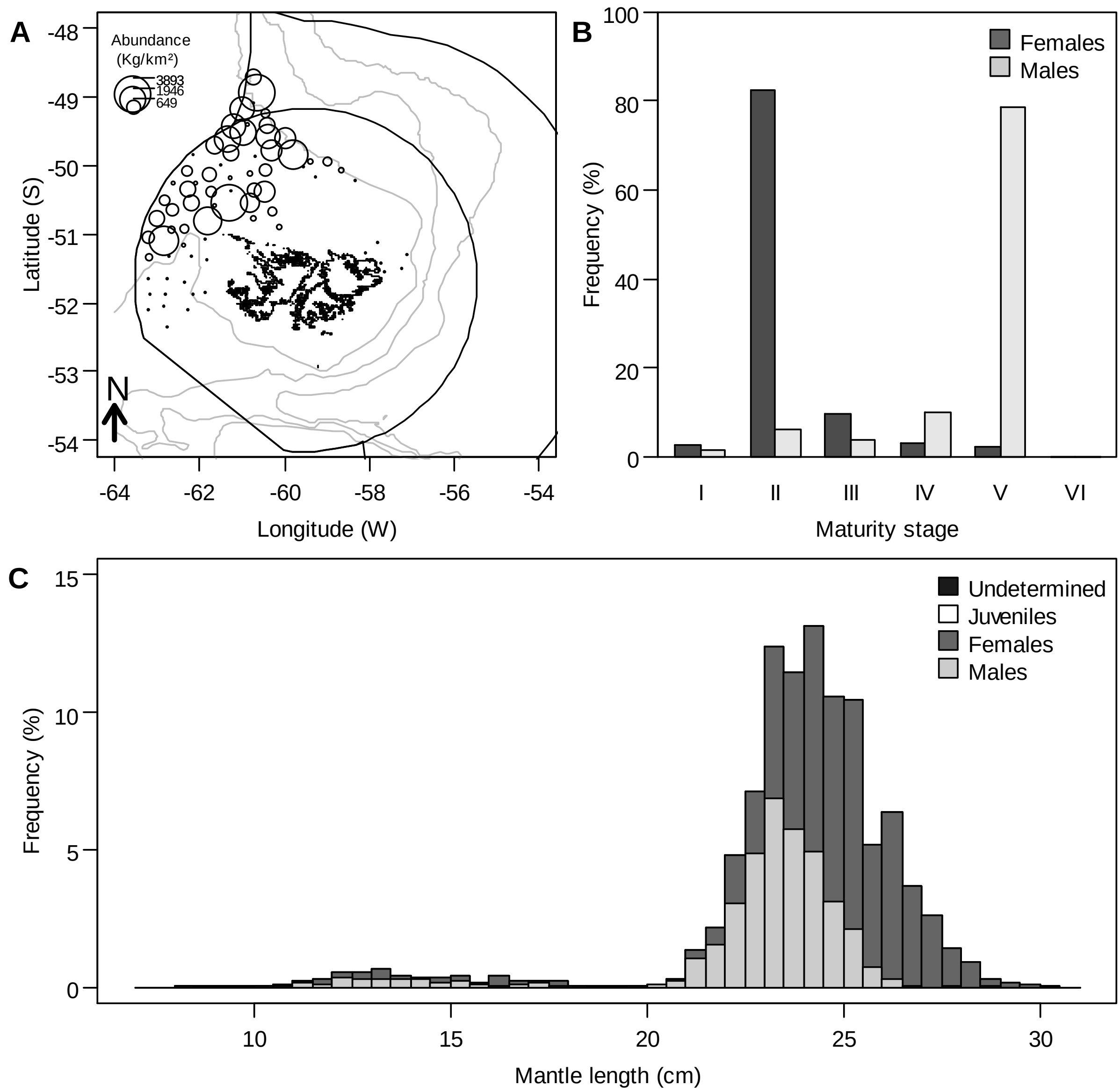

Figure 14. Biological data of *Illex argentinus* (Argentine shortfin squid; ILL). A) Map of the densities in kg·km^{-2}; B) percentage of specimens of each sex per maturity stage (I, young; II, immature; III, preparatory; IV, maturing; V, mature; VI, spent); and C) dorsal mantle length frequency (in percentage of the total sample assessed) of each sex with 0.5 cm size class (n= 4,492).

3.3.2. Onykia ingens – Greater hooked squid

The total catch of Greater hooked squid was 38.5 kg. This species was caught at 27 of the 83 trawl stations sampled throughout the research cruise. Catches ranged from 0.2 to 12 kg, densities ranged from 0.7 to 56 kg·km^{-2}, and CPUE ranged from 0.2 to 12 kg·h^{-1}. Greater hooked squid were caught almost throughout the research cruise. However, higher densities were observed to the northeast of East Falkland and to the west of West Falkland (Figure 15). No biological samples were taken.

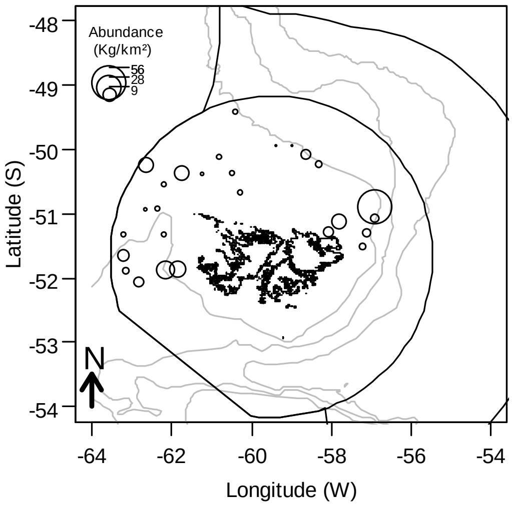

Figure 15. Map of densities of *Onykia ingens* (Greater hooked squid; ING) in kg·km^{-2}.

3.3.3. *Doryteuthis gahi* (former *Loligo gahi*) – Falkland calamari

The total catch of Falkland calamari was 5,746 kg. This species was caught at every station during the cruise. Catches ranged from 0.3 to 322 kg, densities ranged from 2 to 1,337 kg·km^{-2}, and CPUE ranged from 0.3 to 322 kg·h^{-1}. Falkland calamari was caught throughout the survey area but greater densities occurred along the west of the Falkland Islands (Figure 16A). Most females and males were immature (maturity stages ≤ III) (Figure 16B). Juveniles were 5.5–10.5 cm dorsal mantle length, females were 3.5–17.0 cm dorsal mantle length, males were 3.0–19.0 cm dorsal mantle length. One cohort was detected by the dorsal mantle length frequency histogram with mode at 9.5 cm (Figure 16C).

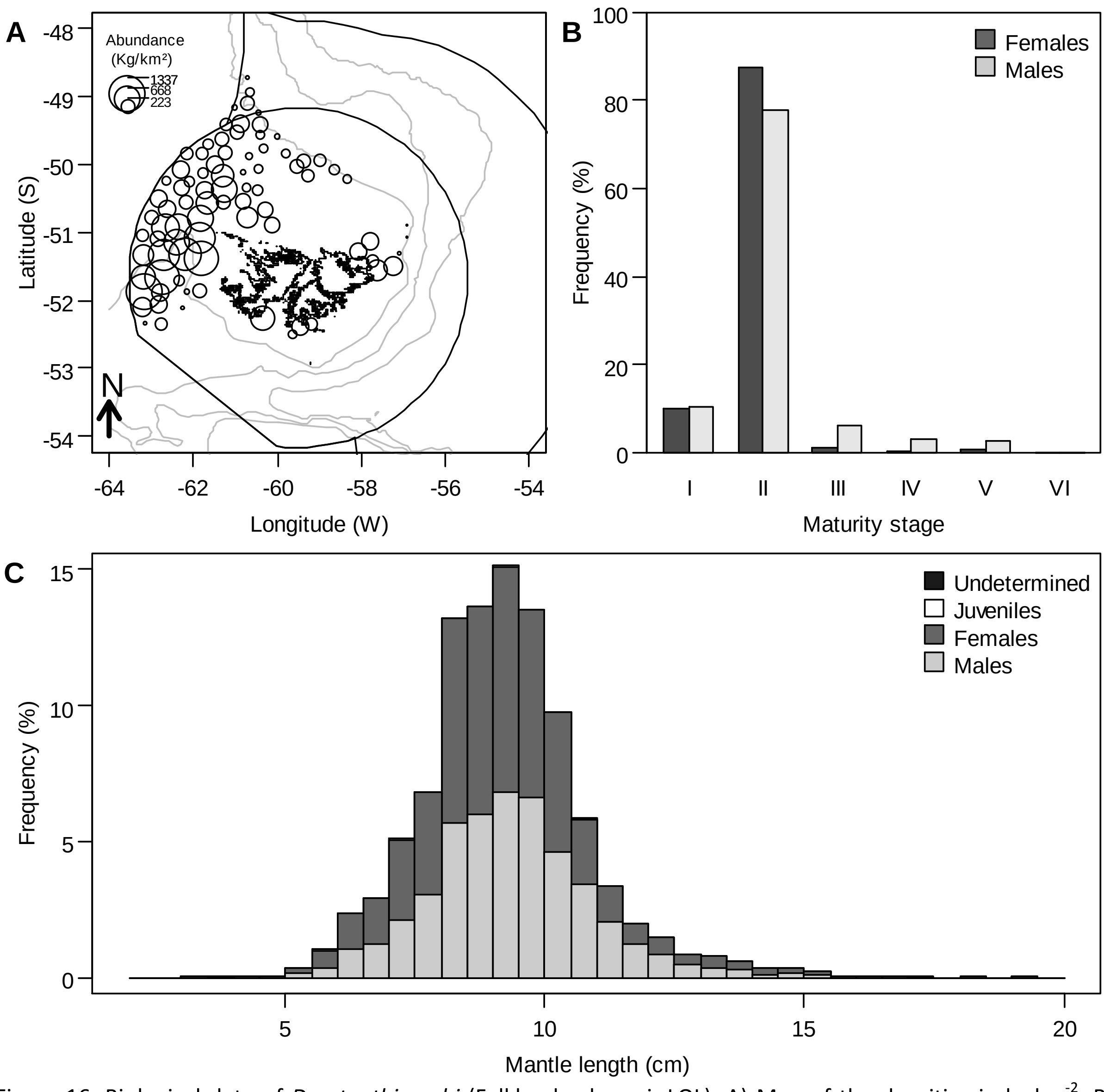

Figure 16. Biological data of *Doryteuthis gahi* (Falkland calamari; LOL). A) Map of the densities in kg·km^{-2}; B) percentage of specimens of each sex per maturity stage (I, young; II, immature; III, preparatory; IV, maturing; V, mature; VI, spent); and C) dorsal mantle length frequency (in percentage of the total sample assessed) of each sex with 0.5 cm size class (n= 7,981).

3.4. Biological information on skates

3.4.1. *Bathyraja albomaculata* – White spotted skate

The total catch of White spotted skate was 20 kg. This species was caught at 9 of the 83 trawl stations sampled through the research cruise; the 9 stations yielded <10 kg each. Catches ranged from 0.7 to 3 kg, densities ranged from 3 to 15 kg·km^{-2}, and CPUE ranged from 0.7 to 3 kg·h^{-1}. Highest densities were observed in the northern and west of the survey zone (Figure 17A). Most females were immature (maturity stages ≤ III), whereas most males were mature (maturity stages ≥ IV) (Figure 17B). Females were 31–48 cm disc width and males were 42–44 cm disc width (Figure 17C).

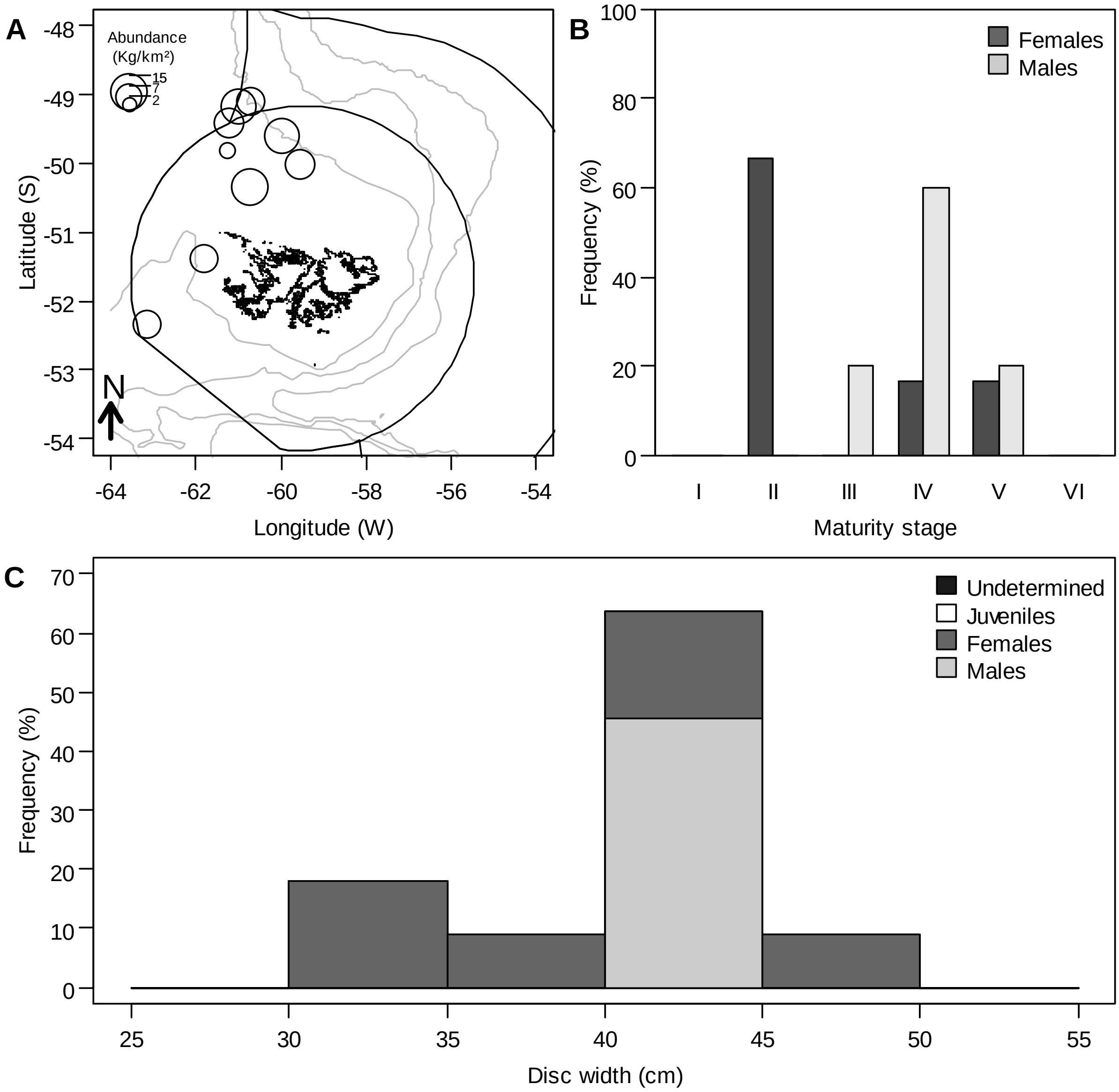

Figure 17. Biological data of *Bathyraja albomaculata* (White spotted skate; RAL). A) Map of the densities in kg·km^{-2}; B) percentage of specimens of each sex per maturity stage (I, juvenile; II, adolescent maturing; III, adult developing; IV, adult mature; V, adult laying/running; VI, adult resting); and C) disc width frequency (in percentage of the total sample assessed) of each sex with 5 cm size class (n= 11).

3.4.2. *Bathyraja brachyurops* – Blonde skate

The total catch of Blonde skate was 222 kg. This species was caught at 45 of the 83 trawl stations sampled through the research cruise. Catches ranged from 0.24 to 23 kg, densities ranged from 1 to 109 kg·km^{-2}, and CPUE ranged from 0.24 to 23 kg·h^{-1}. Highest densities were observed along the west and northwest of West Falkland (Figure 18A). Most females and males were immature (maturity stages ≤ III) (Figure 18B). Females were 21–70 cm disc width and males were 22–63 cm disc width. The length-frequency histogram shows two possible cohorts with modal lengths at 35 cm and at 60 cm disc width; however, the little number of samples does not allow identifying with certainty the presence of more than one cohort (Figure 18C).

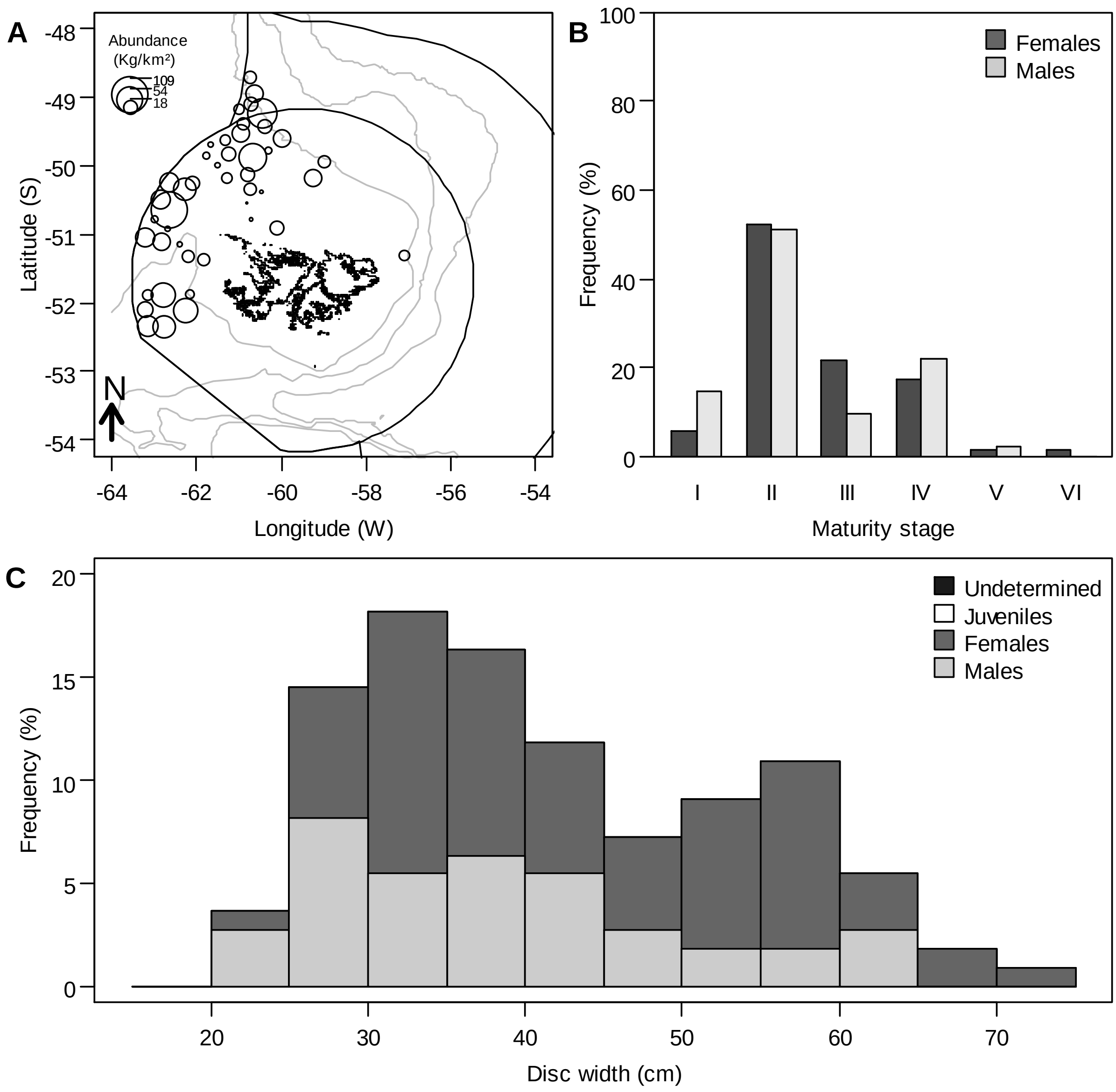

Figure 18. Biological data of *Bathyraja brachyurops* (Blonde skate; RBR). A) Map of the densities in kg·km^{-2}; B) percentage of specimens of each sex per maturity stage (I, juvenile; II, adolescent maturing; III, adult developing; IV, adult mature; V, adult laying/running; VI, adult resting); and C) disc width frequency (in percentage of the total sample assessed) of each sex with 5 cm size class (n= 110).

3.4.3. *Zearaja chilensis* – Yellow nose skate

The total catch of the Yellow nose skate was 233 kg. This species was caught at 41 of the 83 trawl stations sampled through the research cruise. Catches ranged from 1 to 22 kg, densities ranged from 4.3 to 107 kg·km^{-2}, and CPUE ranged from 1 to 22 kg·h^{-1}. Highest densities were observed through the northwest and in one site at the southwest of the survey zone (Figure 19A). Most females and males were immature (maturity stages ≤ III) (Figure 19B). Females were 35–77 cm disc width and males were 41–57 cm disc width (Figure 19C).

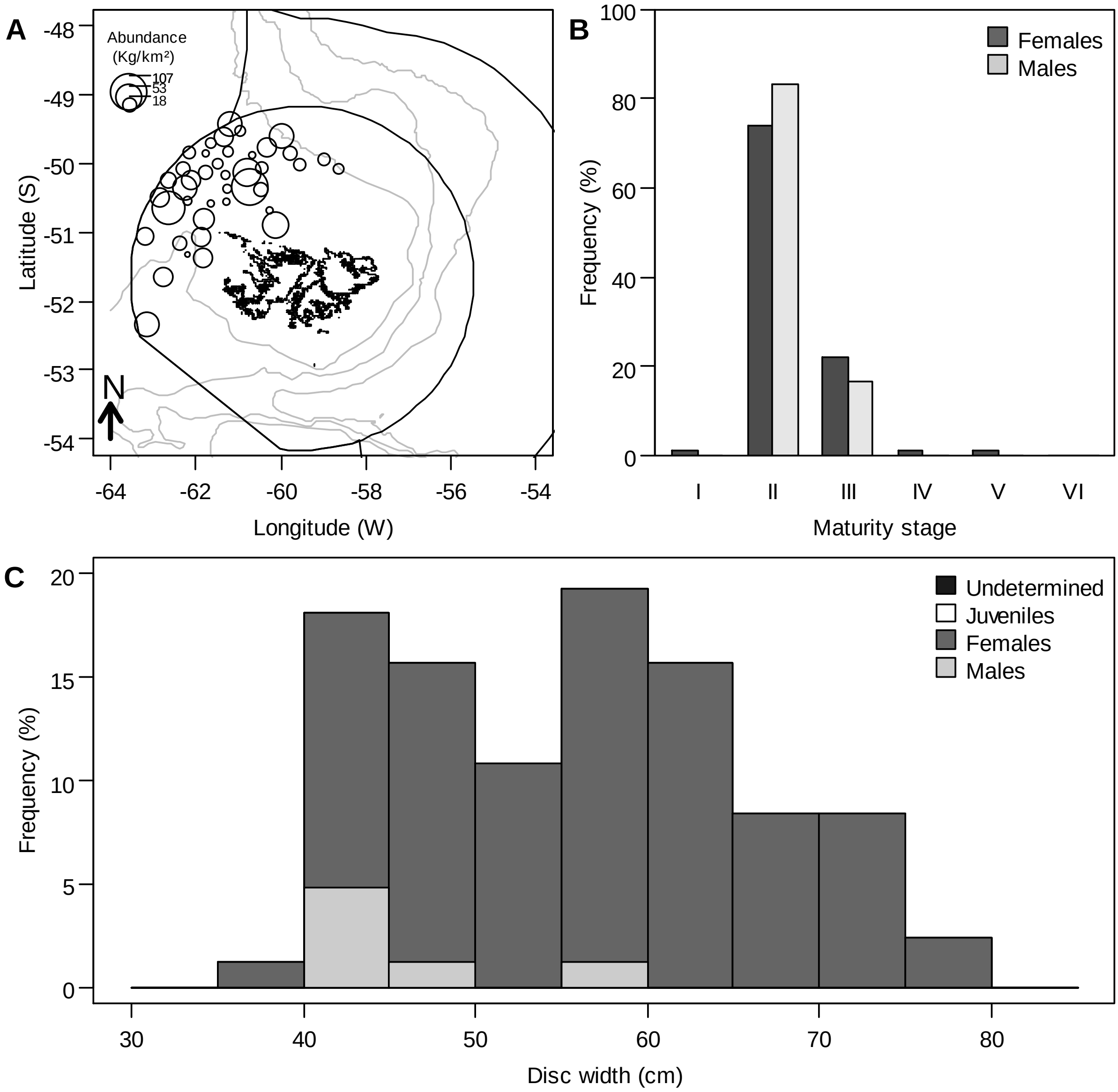

Figure 19. Biological data of *Zearaja chilensis* (Yellow nose skate; RFL). A) Map of the densities in kg·km^{-2}; B) percentage of specimens of each sex per maturity stage (I, juvenile; II, adolescent maturing; III, adult developing; IV, adult mature; V, adult laying/running; VI, adult resting); and C) disc width frequency (in percentage of the total sample assessed) of each sex with 5 cm size class (n= 83).

3.4.4. *Bathyraja griseocauda* – Grey tailed skate

The total catch of the Grey tailed skate was 101 kg. This species was caught at 13 of the 83 trawl stations sampled through the research cruise. Catches ranged from 0.3 to 20 kg, densities ranged from 1 to 87 kg·km^{-2}, and CPUE ranged from 0.3 to 20 kg·h^{-1}. Highest densities were observed at the north, in the limit of the FICZ and the FOCZ, as well as at the west (Figure 20A). A total of 18 individuals (10 females, 8 males) were sampled for total length and disc–width; of which only 9 individuals were weighted. Most females and males were immature (maturity stages ≤ III) (Figure 20B). Females were 24–100 cm disc width and males were 15–76 cm disc width (Figure 20C).

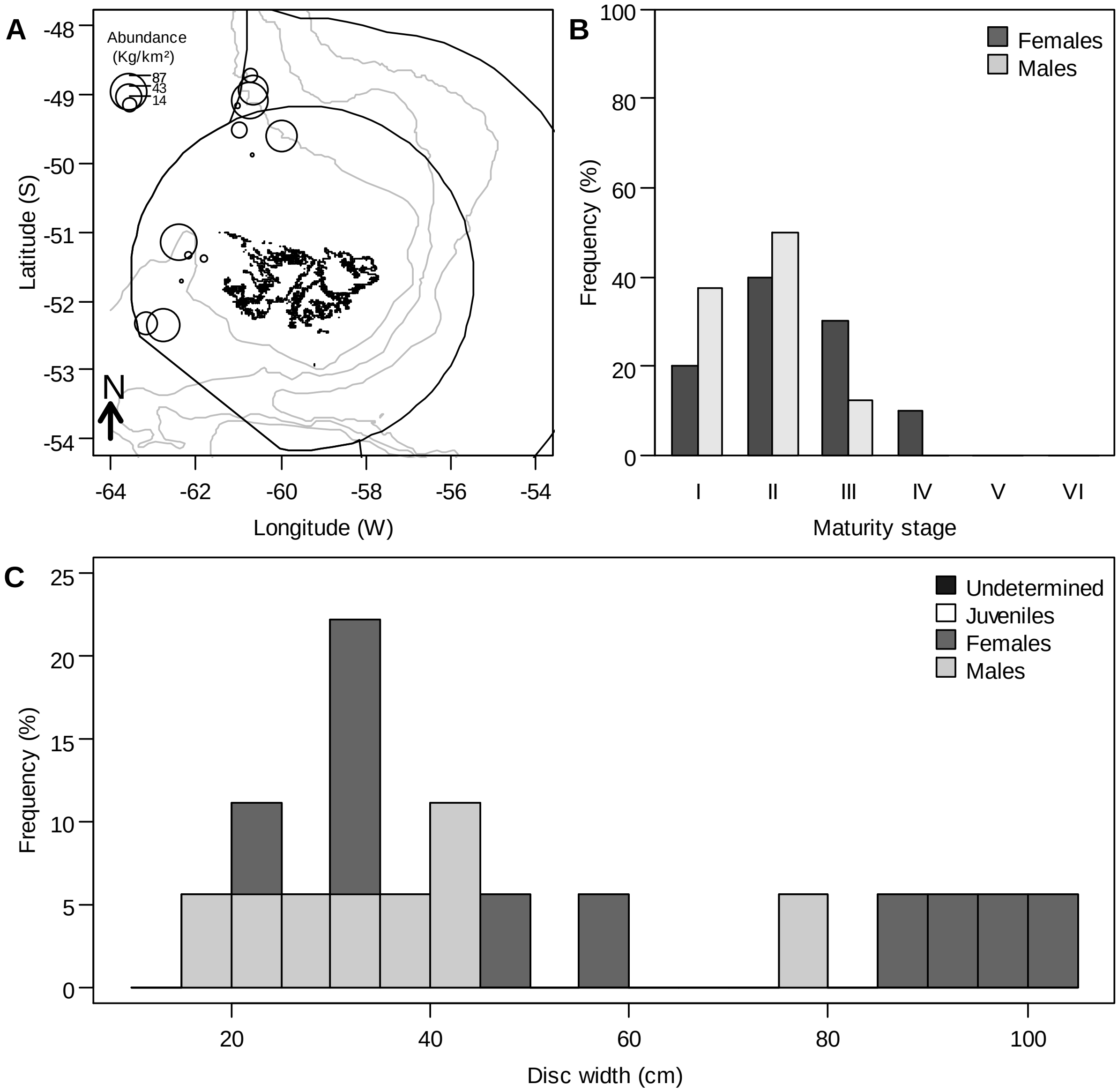

Figure 20. Biological data of *Bathyraja griseocauda* (Grey tailed skate; RGR). A) Map of the densities in kg·km^{-2}; B) percentage of specimens of each sex per maturity stage (I, juvenile; II, adolescent maturing; III, adult developing; IV, adult mature; V, adult laying/running; VI, adult resting); and C) disc width frequency (in percentage of the total sample assessed) of each sex with 5 cm size class (n= 18).

3.4.5. *Bathyraja macloviana* – Falkland skate

The total catch of the Falkland skate was 51 kg. This species was caught at 20 of the 83 trawl stations sampled through the research cruise. Catches ranged from 0.02 to 14 kg, densities ranged from 0.1 to 65 kg·km^{-2}, and CPUE ranged from 0.02 to 14 kg·h^{-1}. Highest densities were observed at the northwest, near the western edge of the FICZ (Figure 21A). Most females and males were mature (maturity stages ≥ IV), although a relatively equal proportion of immature males were also observed (Figure 21B). Females were 25–37 cm disc width and males were 9–40 cm disc width. The length-frequency histogram allowed detecting the modal length at 40 cm disc width (Figure 21C).

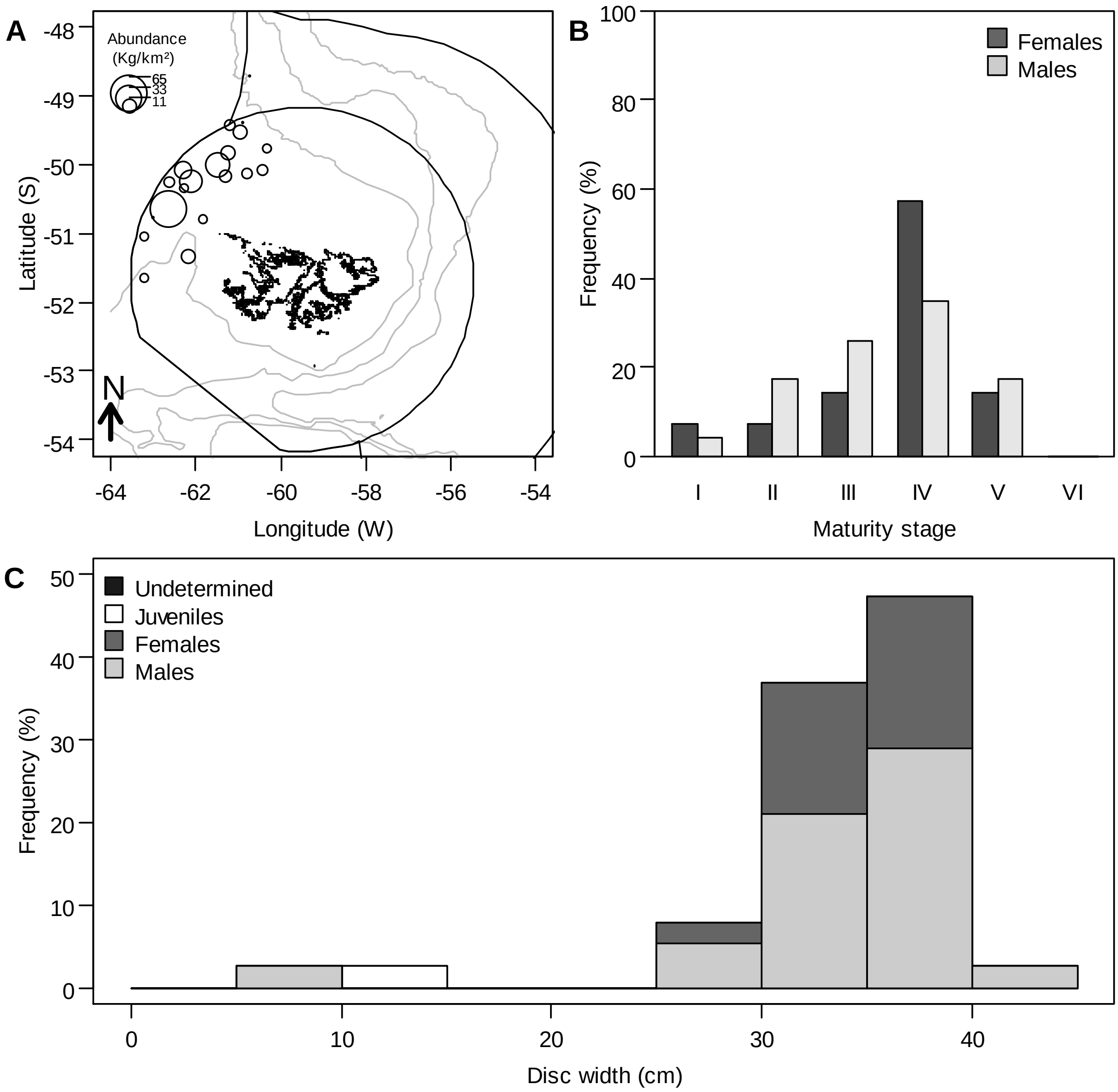

Figure 21. Biological data of *Bathyraja macloviana* (Falkland skate; RMC). A) Map of the densities in kg·km^{-2}; B) percentage of specimens of each sex per maturity stage (I, juvenile; II, adolescent maturing; III, adult developing; IV, adult mature; V, adult laying/running; VI, adult resting); and C) disc width frequency (in percentage of the total sample assessed) of each sex with 5 cm size class (n= 18).

3.5. Biological information on sharks

3.5.1. *Schroederichthys bivius* – Catshark

The total catch of Catshark was 187 kg. This species was caught at 55 of the 83 trawl stations sampled through the research cruise; 51 stations yielded <10 kg and 4 stations yielded ≥10 kg each. Catches ranged from 0.008 to 36 kg, densities ranged from 0.04 to 173 kg·km^{-2}, and CPUE ranged from 0.008 to 35.6 kg·h^{-1}. Catshark were mainly caught at the northwest of the Falkland Islands; highest densities were observed around 50.5°S and 61°W (Figure 22). No biological samples were collected.

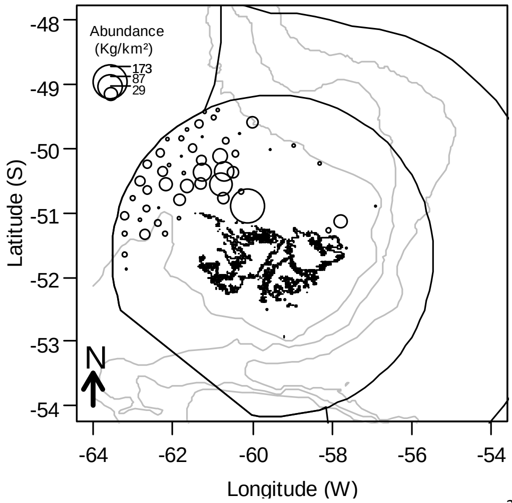

Figure 22. Map of densities of *Schroederichthys bivius* (Catshark; DGH) in kg·km^{-2}.

3.5.2. *Squalus acanthias* – Dogfish

The total catch of Dogfish was 389 kg. This species was caught at 47 of the 83 trawl stations sampled through the research cruise; 41 stations yielded <10 kg and 6 stations yielded ≥10 kg each. Catches ranged from 1 to 96 kg, densities ranged from 4.5 to 451 kg·km^{-2}, and CPUE ranged from 1 to 96 kg·h^{-1}. Dogfish were caught at the northwest of the Falkland Islands; highest densities were observed to the north between the limit of the FICZ and the FOCZ (Figure 23). No biological samples were collected.

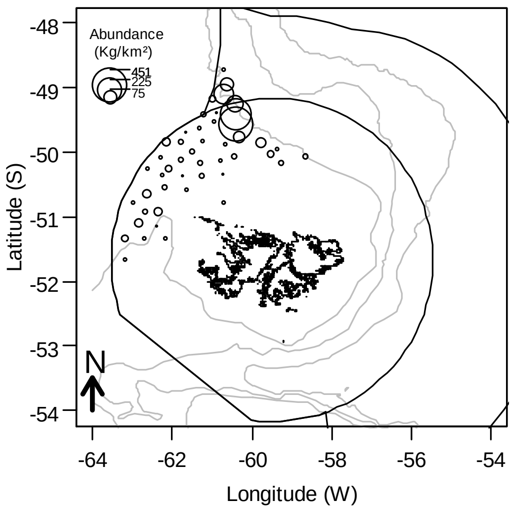

Figure 23. Map of densities of *Squalus acanthias* (Dogfish; DGS) in kg·km^{-2}.

3.6. Inshore survey

A total of 2,038 kg were caught at inshore stations to the south of the Falkland Islands of which 1,077 kg (53%) consisted of benthic and semi-pelagic invertebrates. The majority of the benthos catch (612 kg, 57%) consisted of *Munida* sp. The only other groups that were captured in large quantities were ascidians, consisting of 132 kg (12%) and sponges, which constituted 130 kg (12%) of the catch. Other invertebrates that were captured throughout the inshore region in small quantities included polychaete casings (24 kg, 2%), bryozoans (23 kg, 2%) and Malacostraca (crabs) which constituted 31 kg (3%) of the catch.

A total of 961 kg (47%) of the catch consisted of fish and squid species. The most abundant species in the catch was *D. gahi* (245 kg, 25% of the fish and squid species). Catches within the inshore regions ranged from 20 kg off Cape Meredith to 120 kg in the Falkland Sound. Of the sample, 54% were males compared to 46% females. The majority of both the males (92%) and females (92%) were immature (< maturity stage III). The length frequency distribution appeared to be bimodal with peaks occurring at 6 and 9 cm dorsal mantle length (Figure 24A).

A total of 9 kg (1% of the fish and squid species) of rock cod (*P. ramsayi*), were captured during the inshore trawl stations. Although small quantities of rock cod were present in all the trawls, the majority of these were captured in the station to the south of the Falkland Sound (8 kg). The rock cod catch largely consisted of newly recruited individuals that were likely spawned during the previous winter (<1 year old). Of the sampled catch of rock cod, 49% consisted of juvenile fish newly recruited to the fishery for which sex could not yet be determined. Of the remaining sampled catch, 19% were females and 32% were males, all of which were immature or in a resting state of reproductive development. The newly recruited juvenile rock cod can be clearly seen in the length frequency distribution with a mode at 5 cm, while a second 1+ year old cohort can be seen with a mode at 10 cm (Figure 24B).

Although a total of 70 kg (7% of the fish and squid species) of the catch consisted of icefish (*C. esox*), 88% (62 kg) of this occurred in a single trawl to the south of the Falkland Sound. The sampled catch consisted of 55% males and 45% females of which all the animals were immature (stage I). Importantly, there was no evidence of new recruitment (<1 year old fish, <10 cm fish) evident in the catch, and all the individuals in the length frequency distribution were from the previous year's cohort (Figure 24C). Evidence from previous inshore trawl surveys have shown how newly recruited juvenile icefish generally occurs within the same areas, and at the same depth as that of newly recruited juvenile toothfish. The fact that juvenile recruits from both species were not captured in the inshore trawl stations provides evidence of poor or delayed recruitment of both species which share similar early life-history characteristics.

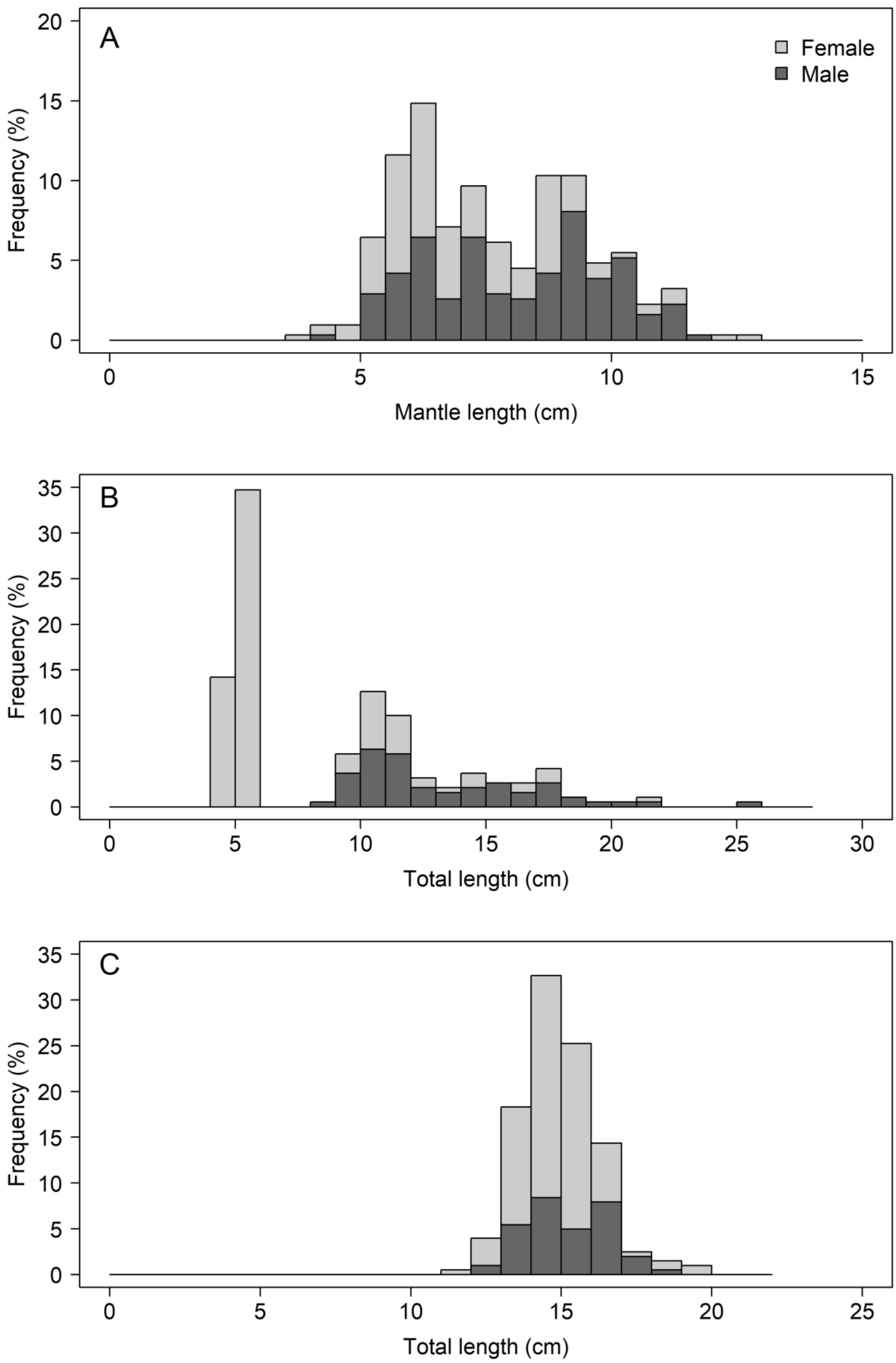

Figure 24. Length frequency distribution for A) *Doryteuthus gahi* (n= 310), B) *Patagonotothen ramsayi* (n= 190), and C) *Champsocephalus esox* (n= 202), captured at inshore stations to the south of the Falkland Islands.

3.7. Oceanography

Oceanographic data were collected at 83 stations (Figure 25). The area covered ranged from 48° 39.5'S to 52° 29.8'S and 56° 52.1'W to 63° 16.7'W. Good data were collected at all but one station, all the downcasts at these stations were good, and so up-cast data were removed.

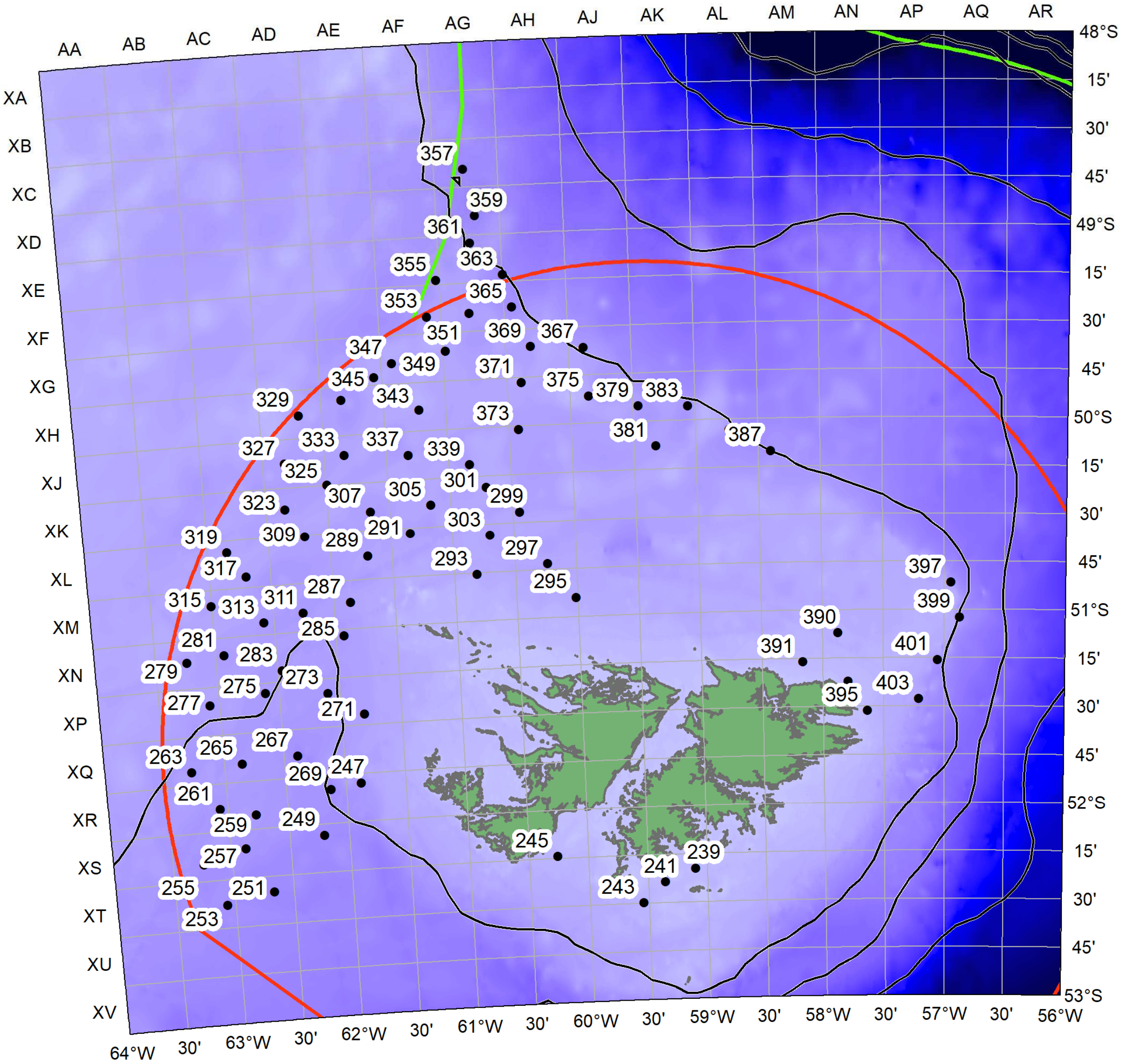

Figure 25. Location and number of CTD stations.

Figures 26, 27 and 28 show the temperature, salinity and σ-t density, gridded using ODV4 DIVA[1] gridding algorithm, at depths 16, 50, 100 and Seabed. The first layer at 16m is the shallowest depth common to all CTD casts. In previous years the depth has been 10 m, but this year there were multiple casts where the depth after the soak was more than 10 m. The surveyed area covered depth range of 50 to 274 m.

The temperature data (Figure 26) shows 2 patterns, with warm water at the surface along the edge of the shelf, and cooler water pushing north from the south-west. As depth increases there is considerable mixing at 50 m. At the seabed it is possible to see the western branch of the Falklands current pushes north, however the return of then eastern branch of the Falklands Current is absent. This pattern is also repeated in the salinity maps.

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

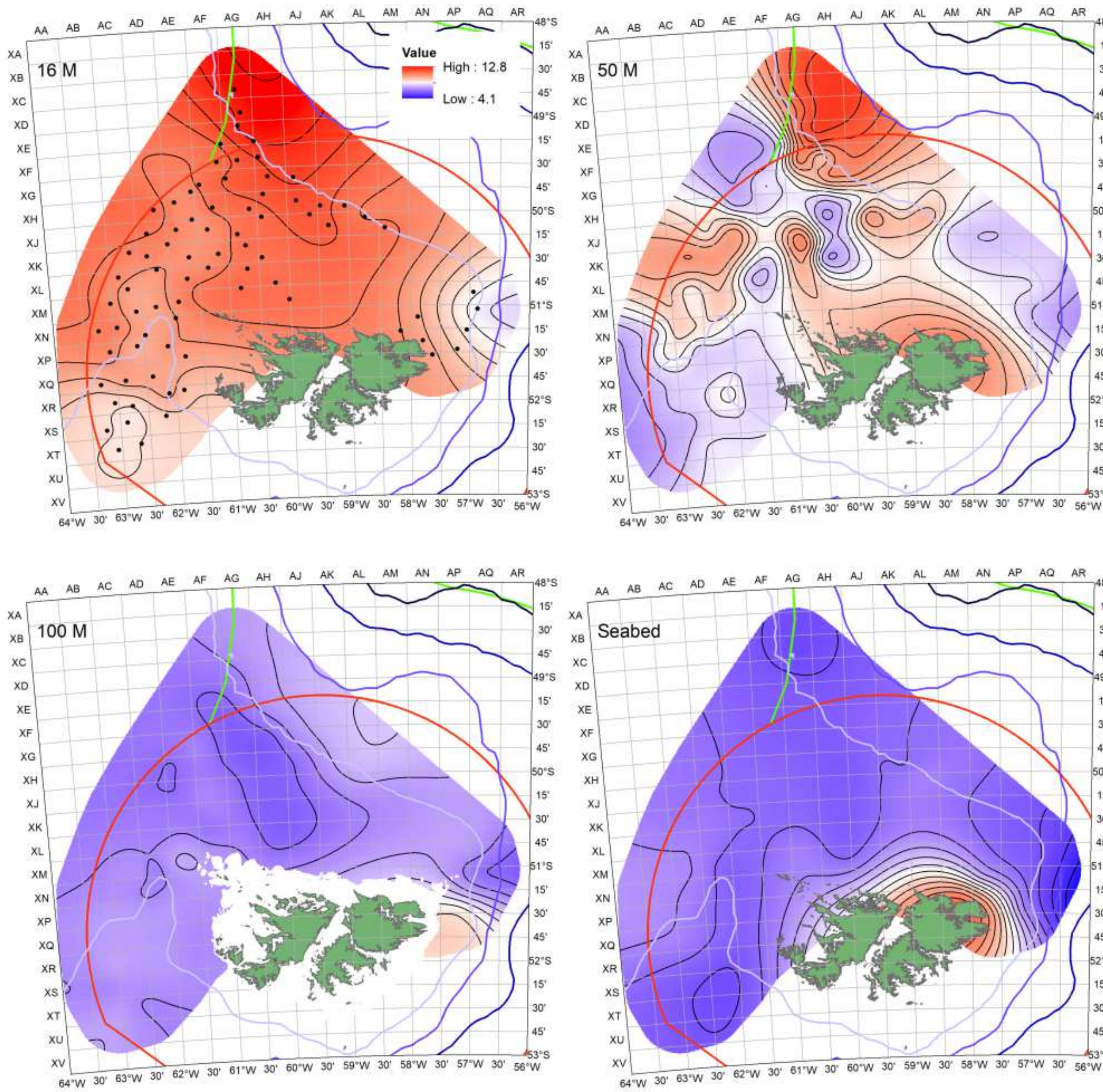

Figure 26. Temperature at 16m, 50m, 100m and seabed (contours at 0.25°C) during the demersal survey ZDLM3-02-2019 in February 2019.

Surface water was generally warmer (red gradient) in 2019 than that seen in 2015 and 2016 to the north of the islands, whilst it was cooler (blue gradient) than the temperature seen to the south west (2015) and west (2016). Surface temperature in 2019 was cooler than surface temperature in 2017 and 2018, particularly to the north of the Falklands. Seabed water was generally warmer in 2019 than in 2015 and 2016, although the change was less significant; in contrast, seabed water was cooler in 2019 than in 2017 and 2018 (Figure 27).

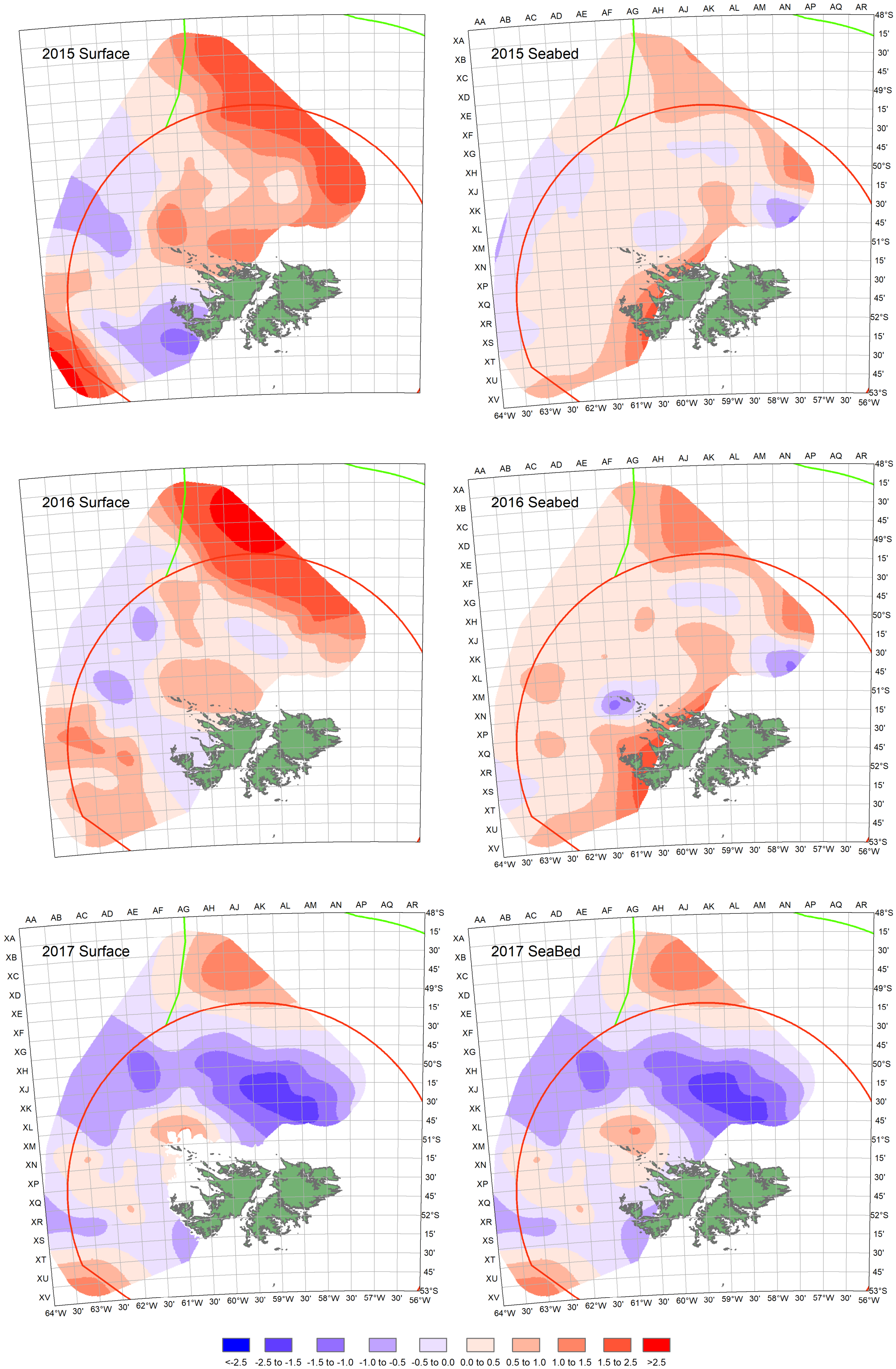

Figure 27. *continues in the next page*

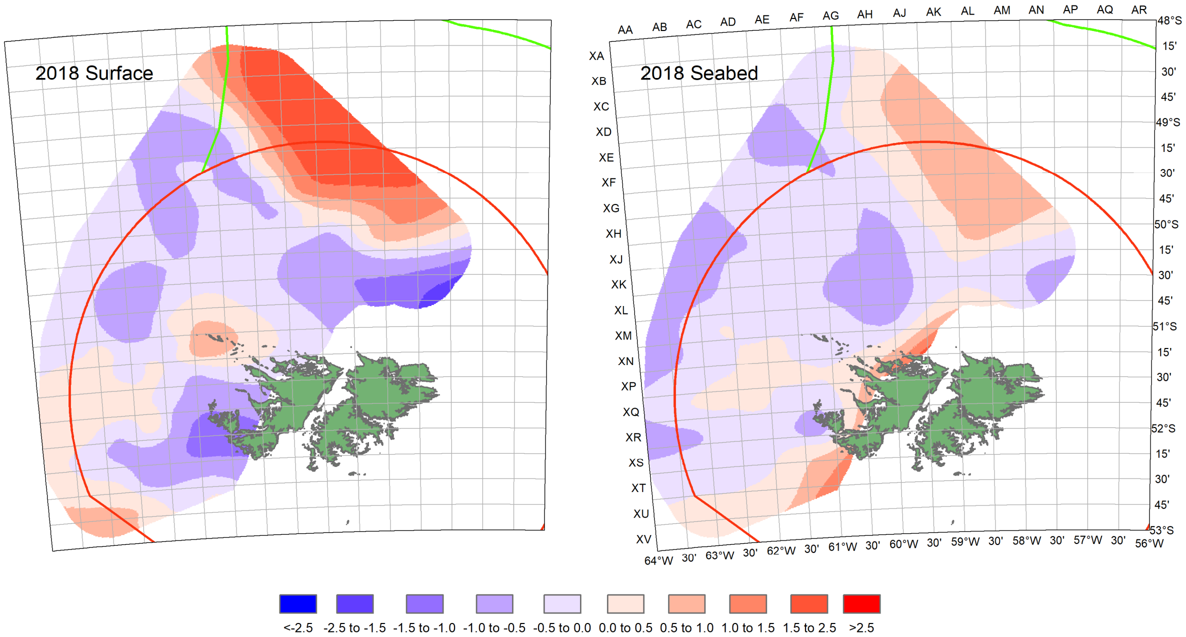

Figure 27. Temperature difference at 10 m and seabed from the years 2015, 2016, 2017 and 2018.

Salinity at the surface is fairly stable (33.5 and 33.8 PSU); as depth increases there is a greater variation, with significant differences at the seabed. Salinity at the seabed is higher than the water close to the 2 branches of the Falklands Current. Salinities greater than 34.0 PSU were recorded in waters to the north east along the shelf edge and in the trough to the south west (Figure 28).

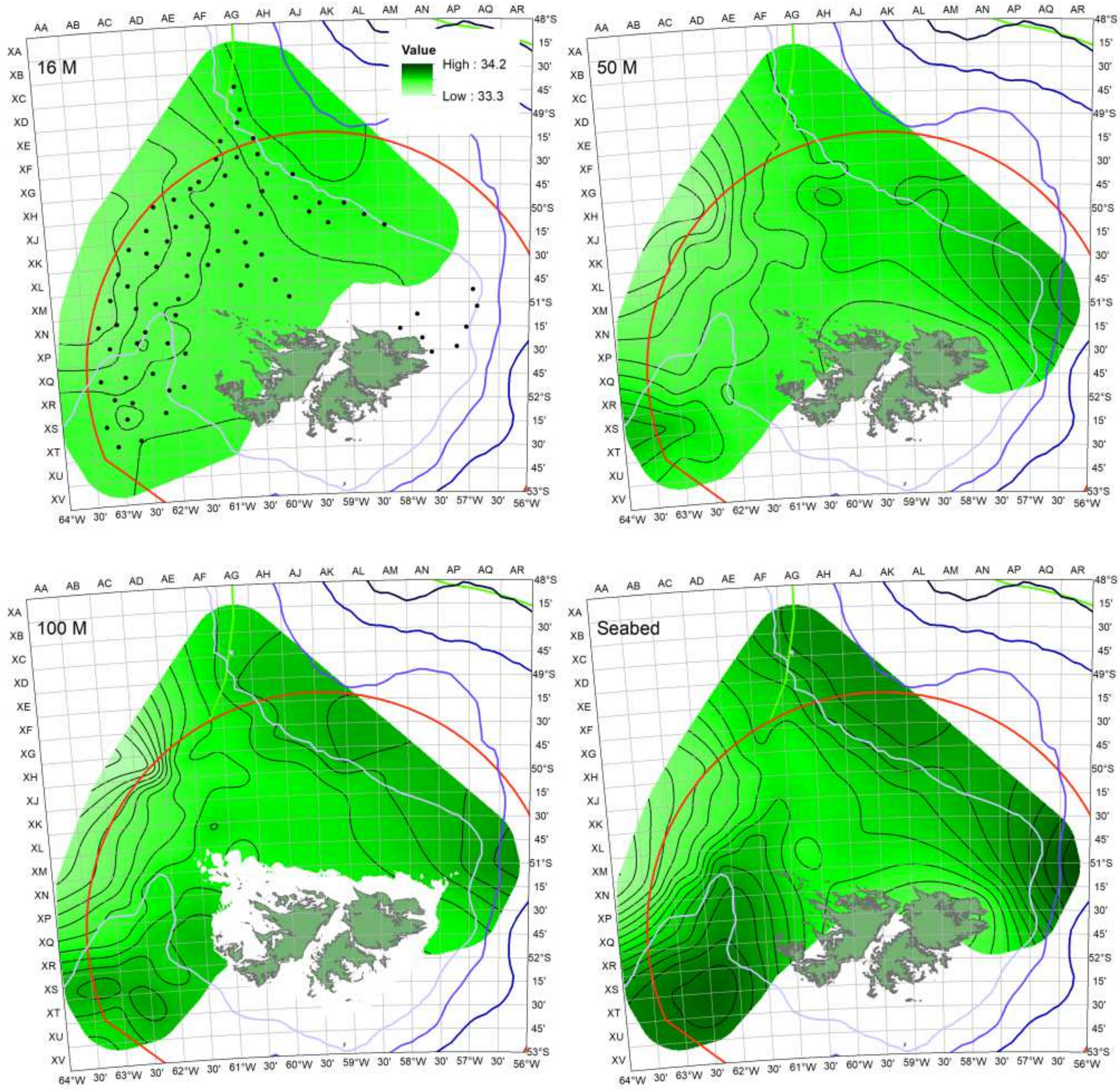

Figure 28. Salinity at 16m, 50m, 100m and seabed (contours at 0.05 PSU) during the demersal survey ZDLM3-02-2019 in February 2019.

Salinity range was limited in 2017, whereas the 2019 data shows very similar characteristics to the 2018 data without the high salinity cold water in the south west, although slightly cooler at the same salinity (Figure 29).

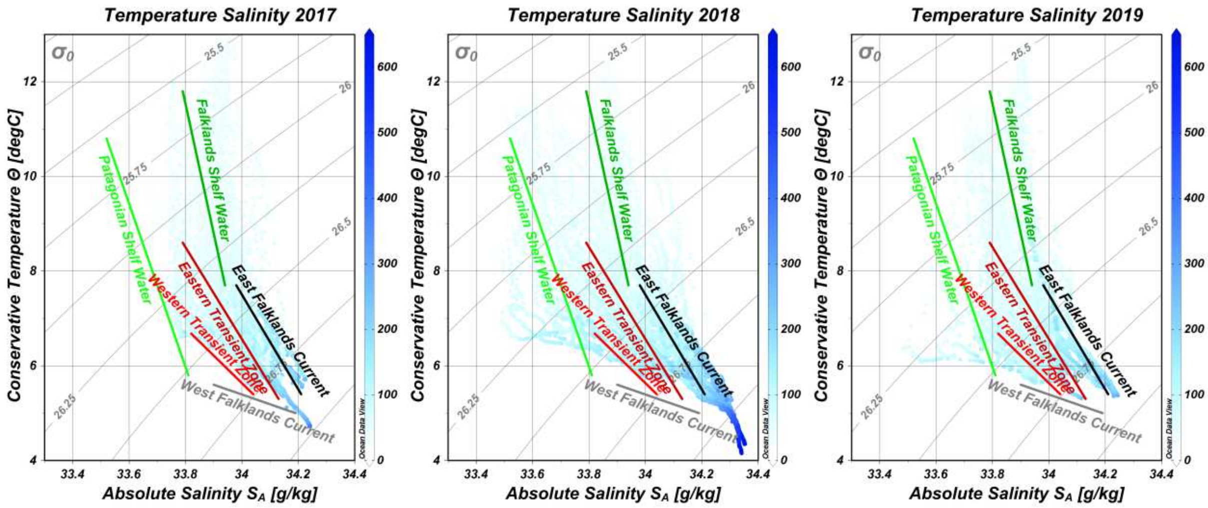

Figure 29. TS plots for 2017, 2018, and 2019 data (from left to right; water mass terminology following Arkhipkin *et al*., 2013).

The lowest density water was detected at 16 metres over the shelf (Figure 30), reflecting the higher temperatures and lower salinity (see Figures 26–28). At 50 m depth there is more mixing with the denser water from the West Branch of the Falklands Current moving north and mixing the Falklands Shelf water. Away from the Falklands in the seabed layer there is a higher density water mass pushing from the south west up the west of the Falklands, which joins the eastern branch of the Falklands Current denser water at the northern most part of the survey.

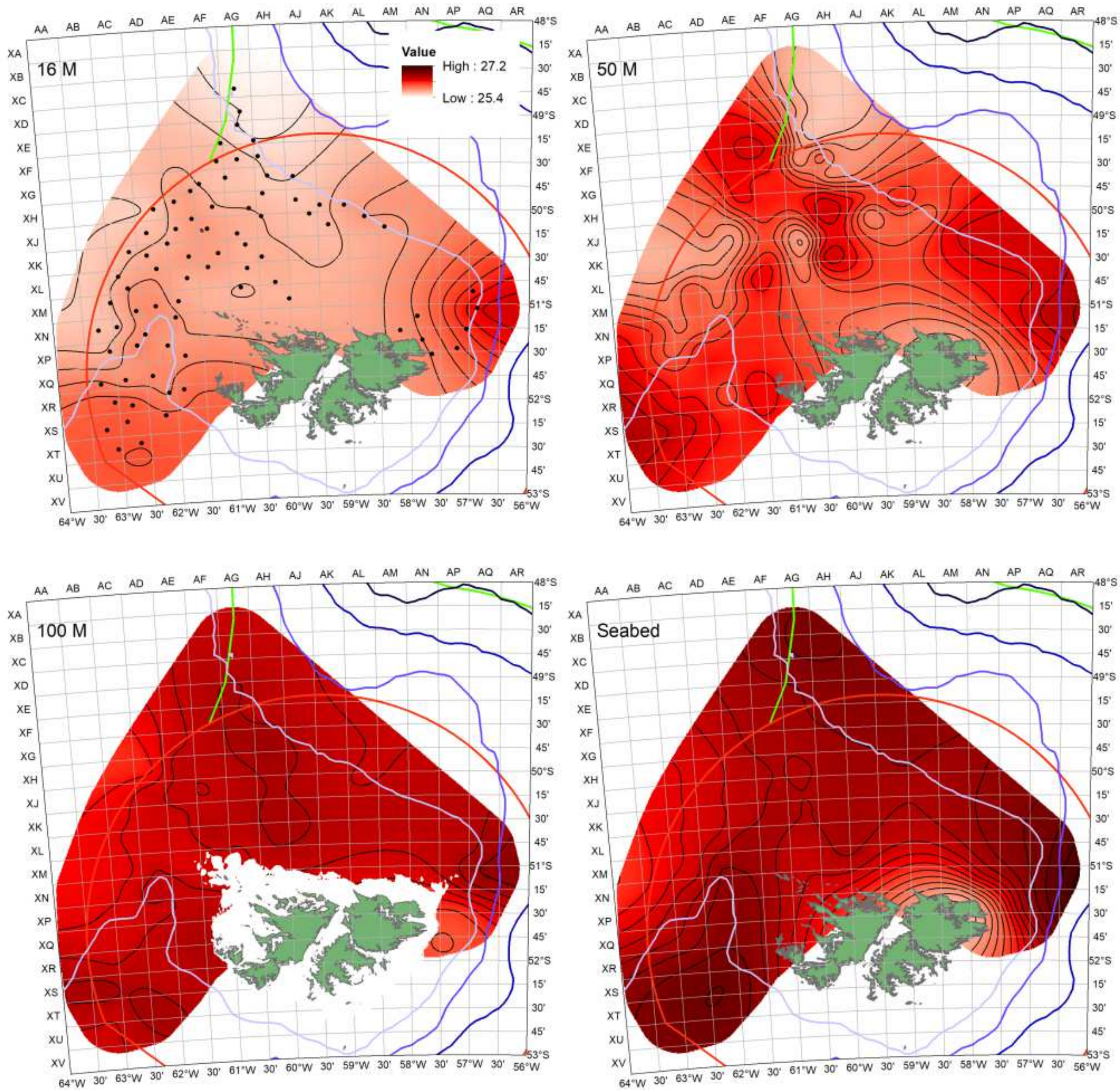

Figure 30. Density at 16m, 50m, 100m and seabed (contours at 0.05 sigma-t) during the demersal survey ZDLM3-02-2019 in February 2019.

Oxygen concentration was highest at the surface, with levels of 6–6.9 mL·L^{-1}. At 50 metres the mixing layer was obvious with a high variation of oxygen levels, ranging from 5.2 to 6.4 mL·L^{-1}. At 100 metres and seabed, oxygen concentration was highest at each depth interval over the west branch of the Falklands current. This higher oxygenated water pushes to the north of the Falklands. The higher oxygenation of the eastern branch of the Falklands current was only seen at the seabed (Figure 31).

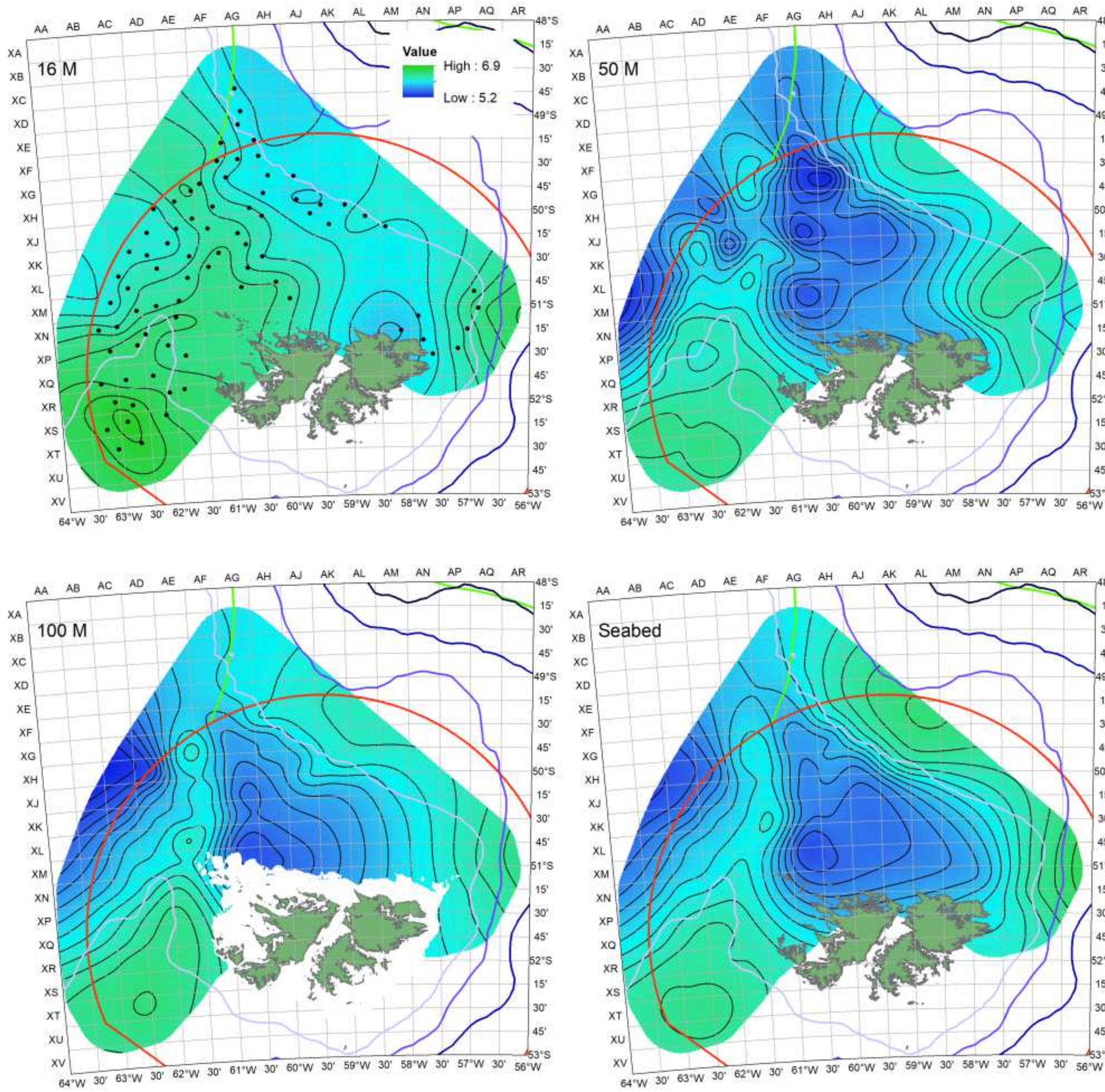

Figure 31. Oxygen at 16m, 50m, 100m and 200m (contours at 0.1 mL·L^{-1}) during the demersal survey ZDLM3-02-2019 in February 2019.

Levels of chlorophyll are insignificant below 50 metres (Figure 32). When comparing chlorophyll to other oceanographic data and bathymetry, high levels of nutrients were evident where the western branch of the Falklands current is lifted by the bathymetry to the south west of the islands and enters the turbulent layer to the northwest and north of West Falkland.

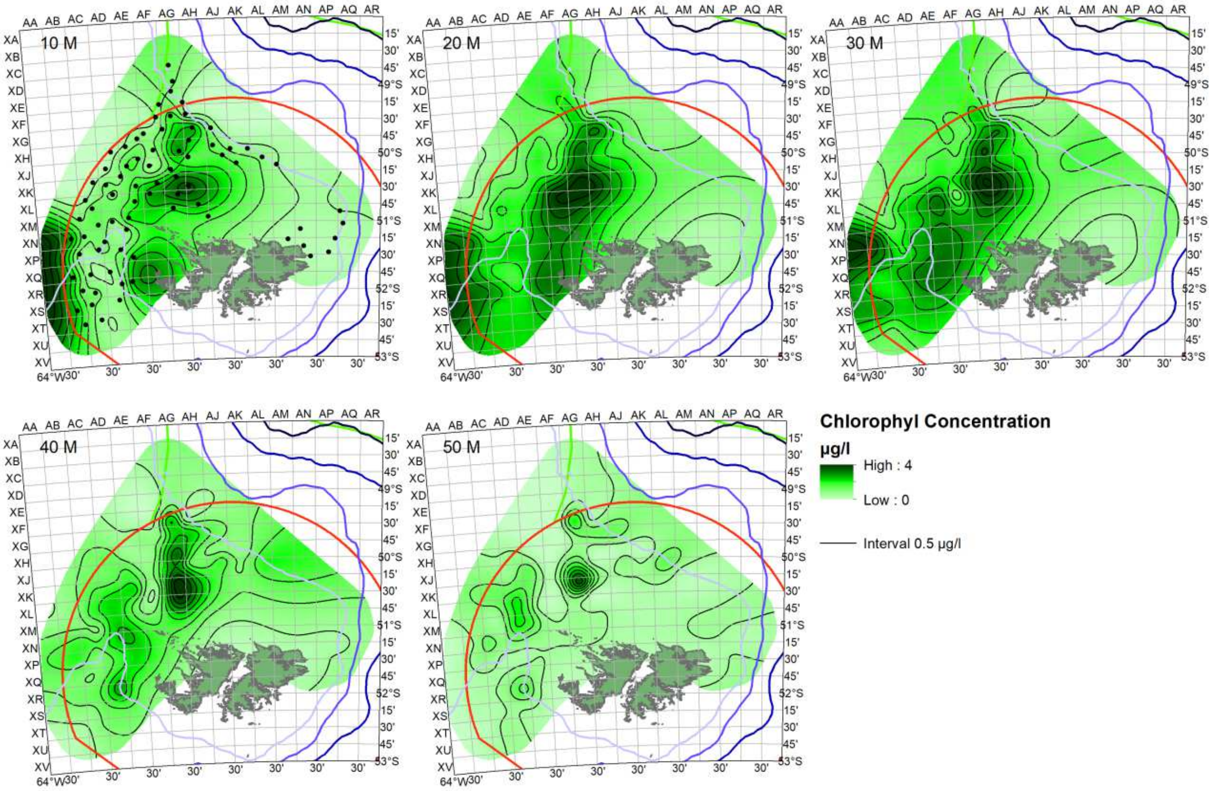

Figure 32. Chlorophyll concentration at 10 to 50 metres during the demersal survey ZDLM3-02-2019 in February 2019.

4. Discussion and Conclusions

1. This year sees the early migration of the squid *Illex argentinus* to the north-western part of FICZ. Despite slightly cooler temperatures at the surface compared to the previous 4 years, squid were already quite large (modal size 23–24 cm), at advanced maturity stages (some females were mature at stage V). Early migration could lead to the earlier concentration of squid at the shelf edge in the northeast of FICZ, and also earlier than usual migration of the Early maturing South Patagonian Stock from Falkland waters.
2. Another squid, *Doryteuthis gahi*, was quite abundant everywhere on the shelf; however it did not yet concentrate near productive zones in the north-eastern part of FICZ. Sizes (mode of 9 cm ML) and maturities (mainly stage II) of *D. gahi* corresponded well to the average values characteristic to this time of the year. All squid belonged to the Autumn Spawning Cohort (ASC).
3. Dense aggregations of hoki were found to the southwest of the Falkland Islands. The fish was quite small (modal pre-anal length of 22 cm), practically all of them were immature (maturity stage II).
4. Red cod was abundant in the area of the Argentine inflow in the northwest of FICZ. Length-frequency of this fish showed significant amounts of adults (mainly post-spawning). It was one clear mode of 1+ fish at 17–18 cm TL.
5. Hakes started to migrate to the Falkland waters with the Argentine inflow. The fish was much smaller than usual (modal lengths of 37–39 cm TL); large specimens were rare. The majority of fish came to the Falkland waters straight after spawning, with adult males being mainly at stage VII, and adult females at stages III and VIII.
6. Kingclip was also smaller than usual, with modal sizes decreased to 47–53 cm TL. The majority of animals were immature.
7. Rock cod occurred practically everywhere on the shelf, with denser concentrations in the northern and southwestern parts of FICZ. The abundance of this fish was however very low, not exceeding 1.2 $t{\cdot}km^{-2}$. Size distribution of this fish was close to normal observed during the last several years, with one abundant mode of 15 cm fish (1+ year old), and significant amounts of adults at 25–30 cm TL. Two fish caught (41 and 42 cm TL) were close to the maximum sizes of this fish observed in FICZ.
8. Toothfish juveniles and young adults (subadults) were quite abundant in deeper areas of the shelf (southwest and north of FICZ). However, there was no small recruitment of toothfish in shallow waters this year. Does it mean that it has been a recruitment failure in 2018 (which was also noted during another research cruise in December 2018)? This requires further examination.
9. This year the abundance of butterfish *Stromateus brasiliensis* was higher than usual. This fish also migrated with temperate waters of the Argentine inflow (together with common hakes and *Illex* squid). Migratory schools consisted mainly of adult fish with modal length of 25–26 cm; some fish attained 40 cm TL.

5. Recommendations

1. The lack of small juveniles of toothfish in their common feeding grounds in shallow waters of the Falkland Islands needs to be monitored. It is possible that toothfish might have a recruitment failure in 2018 spawning season.

2. Simultaneous presence of large *I. argentinus* (22–28 cm ML) together with small juveniles of 12–18 cm ML needs to be investigated further using trace element analysis of their statoliths. Significant amount of statoliths were collected for this project during the cruise.

3. Significant decrease in size of kingclip, hake and hoki, among other species needs to be analysed. Otoliths were collected both from small and large individuals to check whether there is any difference in growth rates comparing with previous years.

4. Biomass estimations of main commercial species during the survey will be done later and included as a special report into Licensing Advice 2019.

6. References

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