Cruise Report ZDLT1-2021-02

Demersal survey

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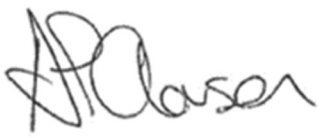

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1. Introduction

The Falkland Islands shelf is located within the Patagonian large marine ecosystem, one of the most productive areas in the world (Arkhipkin et al. 2012). The Patagonian large marine ecosystem is comprised of a southern temperate ecosystem in the north and a sub-Antarctic ecosystem in the south, divided by a boundary that runs from the south-west to the north-east through the Falkland Islands (Boltovskoy 1999). 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 Strait of Magellan. The sub-Antarctic ecosystem lies within waters of sub-Antarctic origin transported onto the shelf by the Falkland Current (Peterson & Whitworth 1989). The Falkland Current diverges from the main stream of the Antarctic Circumpolar Current in the Drake Passage and turns northwards. The Falkland Current splits at the continental slope south of the Falkland Islands into a weak branch and a stronger branch that flow around the west and east of the Islands, respectively (Bianchi et al. 1982). These oceanographic features affect the distribution and abundance of marine species; for instance, Argentine shortfin squid (*Illex argentinus*) and hoki (*Macruronus magellanicus*) migrate to frontal zones for feeding and back to non-frontal zones for spawning (Agnew 2002). In contrast, migrations of deep water fish such as toothfish (*Dissostichus eleginoides*) into the shelf are favoured by intrusions of sub-Antarctic waters (Laptikhovsky et al. 2008; Arkhipkin & Laptikhovsky 2010).
Since 2010, the Falkland Islands Fisheries Department (FIFD) has been carrying out annual demersal surveys. Eight surveys have been conducted consistently in February 2010, 2011, and 2015–2021 to estimate the biomass of the index species, i.e. rock cod, along the west and north of Falkland Islands waters. In recent years, the aim of the February demersal survey extended to other commercial and bycatch species. Biomass estimates from demersal surveys conducted in parallel with calamari pre-season surveys in the *'Loligo Box'* revealed the decrease in abundance of rock cod, red cod, Argentine hake, and toothfish over the last decade (Ramos & Winter 2021).

The distribution and abundance of juvenile toothfish in nursery grounds is poorly understood. In addition, the small number of juveniles (0+) collected during the 2017 and 2018 juvenile toothfish surveys (Arkhipkin et al. 2017; unpublished data), as well as during the 2019 and 2020 demersal surveys (Arkhipkin et al. 2019; Randhawa et al. 2020) suggest that recruitment has failed over the last few years. In this sense, the February demersal survey provides a window of opportunity to continue monitoring juvenile toothfish.

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.
4. To carry out plankton sampling using the Isaacs-Kidd mid-water plankton net.

1.2. Vessel

The survey was conducted aboard the F/V *Castelo* (ZDLT1), registered in the Falkland Islands.

1.3. Personnel and responsibilities

The following personnel participated in the cruise:

Toni Trevizan	(Chief scientist, biological sampling, text)
Jordan Brewin	(Factory coordinator, biological sampling)
Alex Blake	(Oceanography: CTD. Biological sampling, text, graphs)
Jorge E. Ramos	(Biological sampling, text, graphs)
Tobias Buring	(Biological sampling)
Dale Evans	(Biological sampling)
Jolien Claes	(Biological sampling)

1.4. Cruise plan and key dates

The vessel departed from Stanley at 19:00 on February 2nd, and proceeded overnight to the first station located to the north of East Falkland in order to start fishing early in the morning. Every day, four to five one-hour trawls were conducted in adjacent grid squares; each trawl was preceded or succeeded by oceanographic station (Figure 1). On February 18th, due to large catch and concern of breaking the net, one station was shortened to 20 minutes (station 3362) but was considered a valid trawl. All the planned stations were conducted despite a couple of days of rough weather with strong winds (35+ knots). The last day was dedicated to the toothfish juvenile survey, during which four inshore trawls were conducted within the known recruitment area (Arkhipkin et al. 2017). Results from these four trawl stations are presented in a separate section (Section 3.6). The ship was back in port at 01:00 on February 23rd.

2. Material and Methods

2.1. Trawling

A bottom trawl net owned by the FIFD was used; the net is equipped with rockhopper gear fitted with Morgère V3 (1800 kg, 3180 cm x 2480 cm) bottom doors. The duration of each trawl was 60 min on the bottom, except for one trawl with large catch that was hauled after 20 minutes (station 3362). Trawling speed varied between 3.8 and 4.5 knots. The cod-end had a 90 mm mesh size fitted with a 40 mm cod end liner. The MarPort Net Monitoring System was used to monitor the net geometry. The system was not able to provide data on net horizontal opening for 44 stations. All readings from other measurements were successfully obtained for all stations. Four or five trawls were made every day during the survey. However, three trawls were performed on one occasion due to bad weather. Three pelagic trawls were conducted with the Isaacs-Kidd mid-water plankton net to collect plankton. Two out of the three pelagic trawls were conducted successfully for 15 minutes at the depth of the backscatter layer. The desired depth was not reached during one of the three pelagic trawls but the sample was taken. Plankton samples will be processed at a future date.

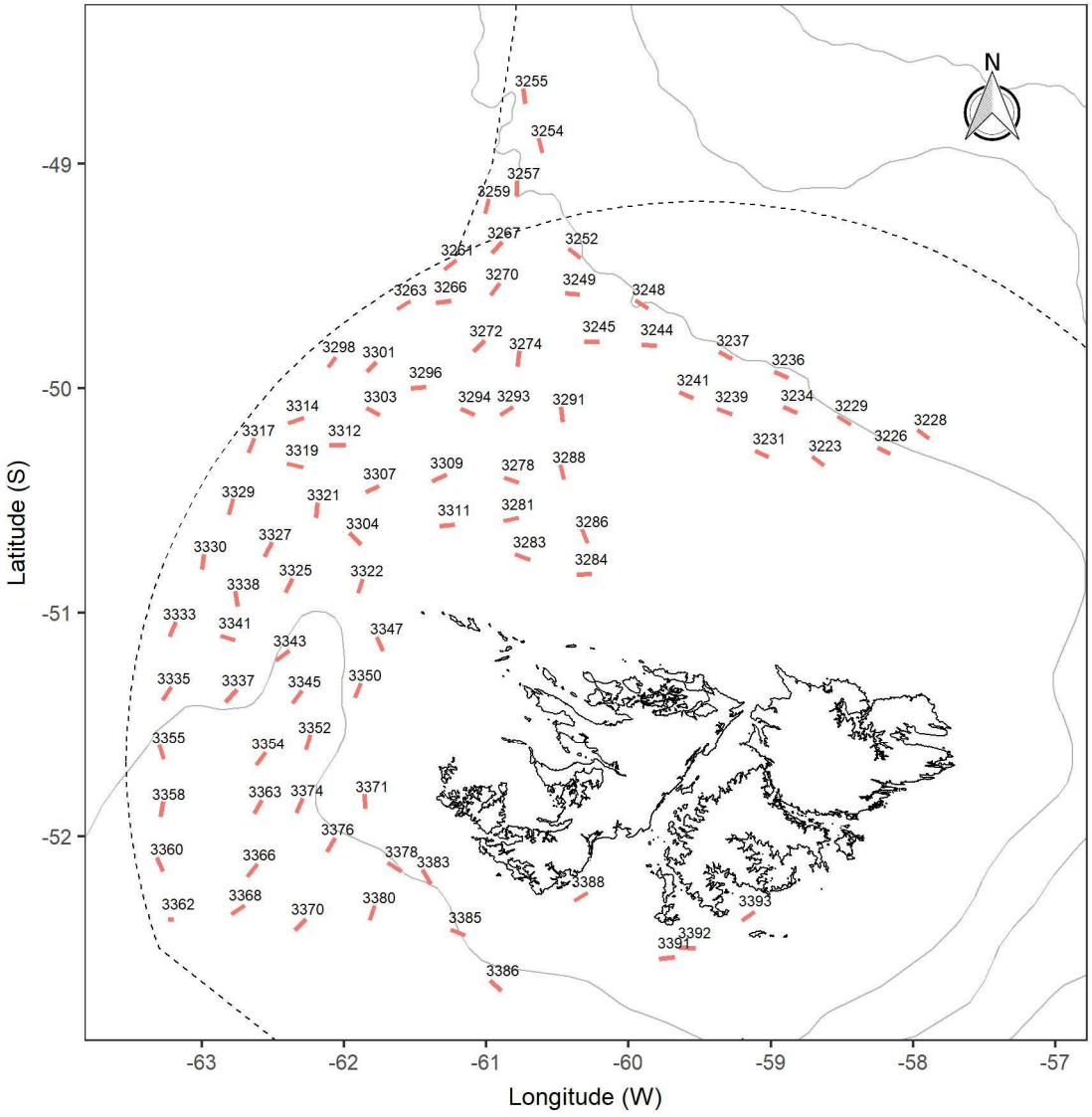

Figure 1. Trawl tracks with station numbers performed during the demersal survey ZDLT1-02-2021 in February 2021.

2.2. Trawl stations and biological sampling

During the ZDLT1-02-2021 demersal survey, a total of 84 trawls were conducted with corresponding station numbers ranging from 3223 to 3393 (Table I). At each station, all species from the catch were sorted and the total catch was weighed by species with an electronic Marel balance (80 kg capacity). All commercial species, and most of the bycatch species, were sampled (random samples of up to 100 individuals). Biological sampling of finfish included measurement of total or pre-anal length to the lower cm, as well as assignation of sex and maturity (eight-stage maturity scale). For skates, disc width was measured to the lower cm, whereas total length (to the lower cm) was measured in some instances; weight, sex, and maturity (six-stage maturity scale). For squid, the sampling included measurement of dorsal mantle length to the lower 0.5 cm, sex and maturity (six-stage maturity scale). Otoliths were taken from large number of fish according to sampling scheme of 2 to 5 specimens per 1 cm length class and per sex. During otolith collection, individual total body weights were measured to the nearest gram. Statoliths were not taken during the cruise but samples of *I. argentinus* and *Doryteuthis gahi* were frozen for statolith extraction at the FIFD laboratory. In addition, a number of fish and squid specimens were frozen for further analysis ashore. Skate thorns of *Bathyraja griseocauda* were collected during this cruise.

Table I. Station data during the demersal survey ZDLT1-02-2021 in February 2021. Stations highlighted in grey correspond to the shallow inshore stations for juvenile toothfish, which data are presented separately (Section 3.6).

Station	Date	Latitude start	Longitude start	Latitude finish	Longitude finish	Mean depth
3223	03/02/2021	-50.31	-58.71	-50.34	-58.63	144
3226	03/02/2021	-50.26	-58.25	-50.29	-58.16	165
3228	03/02/2021	-50.23	-57.89	-50.19	-57.98	276
3229	03/02/2021	-50.16	-58.44	-50.13	-58.53	169
3231	04/02/2021	-50.31	-59.02	-50.28	-59.11	150
3234	04/02/2021	-50.11	-58.82	-50.08	-58.91	155
3236	04/02/2021	-49.96	-58.88	-49.93	-58.98	191
3237	04/02/2021	-49.87	-59.27	-49.84	-59.37	190
3239	04/02/2021	-50.09	-59.38	-50.12	-59.27	158
3241	05/02/2021	-50.05	-59.55	-50.02	-59.64	161
3244	05/02/2021	-49.81	-59.80	-49.81	-59.91	168
3245	05/02/2021	-49.79	-60.20	-49.79	-60.31	167
3248	05/02/2021	-49.61	-59.95	-49.65	-59.86	187
3249	06/02/2021	-49.58	-60.34	-49.58	-60.45	173
3252	06/02/2021	-49.42	-60.34	-49.38	-60.42	197
3254	06/02/2021	-48.95	-60.60	-48.89	-60.63	240
3255	06/02/2021	-48.73	-60.73	-48.66	-60.74	242
3257	07/02/2021	-49.08	-60.79	-49.15	-60.78	188
3259	07/02/2021	-49.16	-60.98	-49.22	-61.01	173
3261	07/02/2021	-49.43	-61.21	-49.47	-61.30	162
3263	07/02/2021	-49.61	-61.53	-49.65	-61.63	158
3266	07/02/2021	-49.62	-61.35	-49.61	-61.25	160
3267	08/02/2021	-49.35	-60.89	-49.40	-60.96	168
3270	08/02/2021	-49.53	-60.91	-49.58	-60.97	166
3272	08/02/2021	-49.79	-61.01	-49.83	-61.09	163

Station	Date	Latitude start	Longitude start	Latitude finish	Longitude finish	Mean depth
3274	08/02/2021	-49.83	-60.77	-49.90	-60.78	163
3278	09/02/2021	-50.40	-60.88	-50.42	-60.77	153
3281	09/02/2021	-50.58	-60.77	-50.59	-60.88	151
3283	09/02/2021	-50.74	-60.80	-50.77	-60.69	133
3284	09/02/2021	-50.83	-60.36	-50.83	-60.26	135
3286	09/02/2021	-50.69	-60.29	-50.63	-60.33	144
3288	10/02/2021	-50.41	-60.45	-50.34	-60.48	155
3291	10/02/2021	-50.15	-60.46	-50.08	-60.48	159
3293	10/02/2021	-50.08	-60.81	-50.12	-60.90	159
3294	10/02/2021	-50.12	-61.08	-50.09	-61.18	159
3296	10/02/2021	-49.99	-61.42	-50.00	-61.53	157
3298	11/02/2021	-49.91	-62.11	-49.86	-62.06	148
3301	11/02/2021	-49.93	-61.84	-49.88	-61.77	157
3303	11/02/2021	-50.12	-61.75	-50.09	-61.84	157
3304	12/02/2021	-50.70	-61.88	-50.65	-61.96	184
3307	12/02/2021	-50.46	-61.85	-50.43	-61.75	168
3309	12/02/2021	-50.41	-61.38	-50.38	-61.28	161
3311	12/02/2021	-50.61	-61.22	-50.61	-61.33	151
3312	13/02/2021	-50.25	-61.99	-50.25	-62.10	158
3314	13/02/2021	-50.13	-62.28	-50.16	-62.39	148
3317	13/02/2021	-50.22	-62.63	-50.29	-62.67	148
3319	13/02/2021	-50.34	-62.40	-50.35	-62.29	154
3321	13/02/2021	-50.51	-62.19	-50.58	-62.20	163
3322	14/02/2021	-50.85	-61.87	-50.91	-61.90	172
3325	14/02/2021	-50.91	-62.41	-50.85	-62.36	184
3327	14/02/2021	-50.75	-62.56	-50.69	-62.51	166
3329	14/02/2021	-50.56	-62.81	-50.49	-62.78	148
3330	15/02/2021	-50.74	-62.99	-50.81	-63.00	150
3333	15/02/2021	-51.04	-63.18	-51.11	-63.23	154
3335	15/02/2021	-51.33	-63.21	-51.39	-63.28	167
3337	15/02/2021	-51.40	-62.83	-51.34	-62.75	184
3338	16/02/2021	-50.90	-62.76	-50.97	-62.75	164
3341	16/02/2021	-51.10	-62.87	-51.12	-62.77	170
3343	16/02/2021	-51.17	-62.39	-51.21	-62.48	190
3345	16/02/2021	-51.35	-62.30	-51.40	-62.36	212
3347	17/02/2021	-51.11	-61.77	-51.17	-61.73	181
3350	17/02/2021	-51.31	-61.88	-51.38	-61.92	199
3352	17/02/2021	-51.54	-62.24	-51.61	-62.27	249
3354	17/02/2021	-51.63	-62.55	-51.68	-62.62	212
3355	18/02/2021	-51.59	-63.30	-51.66	-63.27	184
3358	18/02/2021	-51.84	-63.27	-51.91	-63.29	203
3360	18/02/2021	-52.09	-63.32	-52.16	-63.27	225
3362	18/02/2021	-52.37	-63.24	-52.37	-63.20	257
3363	19/02/2021	-51.84	-62.58	-51.90	-62.63	230
3366	19/02/2021	-52.12	-62.61	-52.18	-62.68	255

Station	Date	Latitude start	Longitude start	Latitude finish	Longitude finish	Mean depth
3368	19/02/2021	-52.31	-62.70	-52.35	-62.79	270
3370	19/02/2021	-52.42	-62.35	-52.37	-62.27	296
3371	20/02/2021	-51.88	-61.85	-51.81	-61.86	189
3374	20/02/2021	-51.83	-62.29	-51.90	-62.33	263
3376	20/02/2021	-52.01	-62.06	-52.07	-62.12	286
3378	20/02/2021	-52.12	-61.69	-52.16	-61.60	253
3380	21/02/2021	-52.37	-61.82	-52.31	-61.78	321
3383	21/02/2021	-52.15	-61.45	-52.21	-61.39	188
3385	21/02/2021	-52.42	-61.25	-52.44	-61.15	273
3386	21/02/2021	-52.64	-60.98	-52.69	-60.89	379
3388	22/02/2021	-52.25	-60.29	-52.29	-60.38	100
3391	22/02/2021	-52.55	-59.79	-52.54	-59.67	112
3392	22/02/2021	-52.50	-59.64	-52.50	-59.53	100
3393	22/02/2021	-52.38	-59.21	-52.34	-59.12	63

2.3. Oceanography

A single CTD (SBE-25, Sea-Bird Electronics Inc., Bellevue, USA) instrument, Serial No 0369, was used to collect oceanographic data in the vicinity of all bar 1 bottom trawl stations. On The final day 2 stations were very close together, (and very close to the monthly P5 Station 1 cast) so only 1 CTD was conducted in the area.

At the first 2 stations the CTD cable was not seated correctly on the measuring pulley and as a result the measured depth was over reported. The CTD was well above the seabed at maximum depth.

At all CTD stations the CTD was deployed to a depth of c.10m below surface for a soak time of two minutes, this allowed the pump to start circulating water and flush the system, following this the CTD was raised to a maximum depth of 5 m below surface. The CTD was then lowered toward sea bed at 1m/sec. The CTD collected pressure in dbar, temperature in °C, conductivity in mS/cm, Oxygen Voltage and Fluorescence. The raw hex file was converted and processed using SBE Data Processing Version.7.22.5 using the CON file 0247_2019_09.xmlcon with the instruments calibrated in July 2019. Up-cast data was filtered out. Depth was derived from pressure using the latitude of each station, with dissolved oxygen in ml/l derived at the same time as depth. Practical Salinity (PSU) and Density as sigma-t (σ-t) were derived following derivation of depth. Further derived variables of conservative temperature (°C) and Absolute Salinity (g/kg) were calculated in Ocean Data View version 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 hoki *M. magellanicus,* followed by shortfin squid *I. argentinus*, and common hake *Merluccius hubbsi*.

Table II. Catch composition and weight of species caught during the demersal survey ZDLT1-02-2021 in February 2021.

Species Code	Latin name	Total caught (kg)	Total sampled (kg)	Total discarded (kg)	%
WHI	*Macruronus magellanicus*	30,457.984	861.496	3.740	37.192
ILL	*Illex argentinus*	9,614.183	1,373.276	0.000	11.740
HAK	*Merluccius hubbsi*	8,145.435	1,986.128	1.562	9.946
GRF	*Coelorinchus fasciatus*	6,360.041	277.894	5,976.255	7.766
BAC	*Salilota australis*	5,681.467	1,931.626	75.951	6.938
LOL	*Doryteuthis gahi*	5,329.454	177.156	184.860	6.508
KIN	*Genypterus blacodes*	4,348.598	2,577.278	2.160	5.310
PAR	*Patagonotothen ramsayi*	3,807.517	673.176	3,193.807	4.649
BUT	*Stromateus brasiliensis*	1,163.108	962.800	1,090.328	1.420
SEP	*Seriolella porosa*	882.080	746.980	0.000	1.077
MED	*Medusa* sp.	659.503	0.000	659.503	0.805
PYM	*Notophycis marginata*	508.999	0.000	508.999	0.622
RGR	*Bathyraja griseocauda*	461.716	458.836	0.600	0.564
GRC	*Macrourus carinatus*	391.320	186.300	0.000	0.478
DGS	*Squalus acanthias*	388.590	388.550	388.590	0.475
SPN	Porifera	373.824	0.000	373.824	0.456
TOO	*Dissostichus eleginoides*	343.866	343.852	0.000	0.420
BLU	*Micromesistius australis*	338.081	86.082	237.979	0.413
RBR	*Bathyraja brachyurops*	289.502	287.242	0.000	0.354
PAT	*Merluccius australis*	240.125	240.125	0.000	0.293
DGH	*Schroederichthys bivius*	187.832	181.820	187.832	0.229
ALG	Algae	186.448	0.000	186.448	0.228
RFL	*Zearaja chilensis*	177.260	174.860	0.000	0.216
CGO	*Cottoperca gobio*	157.493	140.780	157.493	0.192
EEL	*Iluocoetes/Patagolycus* mix	126.033	0.000	126.033	0.154
SHT	Mixed invertebrates	109.294	0.000	109.294	0.133
SQT	Ascidiacea	98.968	0.000	98.968	0.121
POR	*Lamna nasus*	91.000	91.000	91.000	0.111
COP	*Congiopodus peruvianus*	82.400	0.000	82.400	0.101
RTR	*Dipturus trachyderma*	81.160	81.160	0.000	0.099
RMC	*Bathyraja macloviana*	75.640	69.940	74.120	0.092
RMU	*Bathyraja multispinis*	75.384	75.384	2.404	0.092
RAL	*Bathyraja albomaculata*	72.440	72.440	5.600	0.088
HYD	Hydrozoa	62.103	0.000	62.103	0.076
ING	*Onykia ingens*	46.912	25.603	46.912	0.057

Species Code	Latin name	Total caught (kg)	Total sampled (kg)	Total discarded (kg)	%
STA	*Sterechinus agassizii*	34.445	0.000	34.445	0.042
OPV	*Ophiacantha vivipara*	29.126	0.000	29.126	0.036
RBZ	*Bathyraja cousseauae*	28.160	27.300	0.000	0.034
RED	*Sebastes oculatus*	26.140	26.140	0.580	0.032
BRY	Bryozoa	22.701	0.000	22.701	0.028
MUG	*Munida gregaria*	21.291	0.000	21.291	0.026
RPX	*Psammobatis* spp.	20.948	20.948	20.948	0.026
NEM	*Psychrolutes marmoratus*	19.752	4.742	19.752	0.024
CTA	*Ctenodiscus australis*	19.121	0.000	19.121	0.023
RDO	*Amblyraja doellojuradoi*	18.002	17.992	17.802	0.022
GOC	*Gorgonocephalus chilensis*	17.757	0.000	17.757	0.022
ANM	Anemone	17.429	0.000	17.429	0.021
PAG	*Paralomis granulosa*	14.478	13.960	14.478	0.018
RSC	*Bathyraja scaphiops*	14.220	14.220	0.500	0.017
FUM	*Fusitriton m. magellanicus*	13.966	0.000	13.966	0.017
ILF	*Iluocoetes fimbriatus*	13.002	0.000	13.002	0.016
CIR	Cirripedia	12.483	0.000	12.483	0.015
OCM	*Enteroctopus megalocyathus*	11.275	7.530	3.745	0.014
MLA	*Muusoctopus longibrachus akambei*	10.672	0.000	10.672	0.013
GYN	*Gymnoscopelus nicholsi*	8.149	0.000	8.149	0.010
MUE	*Muusoctopus eureka*	7.712	0.000	7.532	0.009
RDA	*Zearaja argentinensis*	6.925	6.925	0.000	0.008
CAZ	*Calyptraster* sp.	6.804	0.000	6.804	0.008
TRP	*Tripylaster philippi*	5.887	0.000	5.887	0.007
PMC	*Protomyctophum choriodon*	5.804	0.000	5.804	0.007
ZYP	*Zygochlamys patagonica*	5.197	0.000	5.197	0.006
DIM	*Dissostichus mawsoni*	4.760	0.000	4.760	0.006
AUC	*Austrocidaris canaliculata*	4.248	0.000	4.248	0.005
SUN	*Labidiaster radiosus*	3.805	0.000	3.805	0.005
POA	*Glabraster antarctica*	3.028	0.000	3.028	0.004
FLX	*Flabellum* spp.	2.981	0.000	2.981	0.004
COL	*Cosmasterias lurida*	2.585	0.000	2.585	0.003
EGG	Eggmass	2.515	0.000	2.515	0.003
BRM	*Brucerolis macdonnellae*	2.509	0.000	2.509	0.003
THO	Thouarellinae	2.481	0.000	2.481	0.003
SAR	*Sprattus fuegensis*	2.312	0.260	2.312	0.003
BAO	*Bathybiaster loripes*	2.216	0.000	2.216	0.003
ADA	*Adelomelon ancilla*	2.165	0.000	2.165	0.003
MUN	*Munida* spp.	2.066	0.000	2.066	0.003
SRP	*Semirossia patagonica*	1.913	0.000	1.913	0.002
OPL	*Ophiura lymani*	1.662	0.000	1.662	0.002
ASA	*Astrotoma agassizii*	1.650	0.000	1.650	0.002
CEX	*Ceramaster* sp.	1.348	0.000	1.348	0.002
COT	*Cottunculus granulosus*	1.184	1.184	1.184	0.001

Species Code	Latin name	Total caught (kg)	Total sampled (kg)	Total discarded (kg)	%
ALC	Alcyoniina	1.066	0.000	1.066	0.001
MUU	*Munida subrugosa*	1.065	0.000	1.065	0.001
PMB	*Protomyctophum bolini*	1.061	0.000	1.061	0.001
PAU	*Patagolycus melastomus*	0.990	0.000	0.990	0.001
AUL	*Austrolycus laticinctus*	0.984	0.000	0.984	0.001
PES	*Peltarion spinulosum*	0.910	0.000	0.910	0.001
DDT	*Desmophyllum dianthus*	0.888	0.000	0.888	0.001
POL	Polychaeta	0.862	0.000	0.862	0.001
AST	Asteroidea	0.790	0.000	0.790	0.001
MAV	*Magellania venosa*	0.786	0.000	0.786	0.001
PYX	*Pycnogonida*	0.742	0.000	0.742	0.001
ODM	*Odontocymbiola magellanica*	0.676	0.000	0.676	0.001
PRM	*Primno macropa*	0.646	0.000	0.646	0.001
MAR	*Martialia hyadesi*	0.598	0.598	0.598	0.001
EUL	*Eurypodius latreillii*	0.597	0.000	0.597	0.001
MIR	*Mirostenella* sp.	0.466	0.000	0.466	0.001
CYX	*Cycethra* sp.	0.460	0.000	0.460	0.001
CTE	Ctenophora	0.420	0.000	0.420	0.001
CHE	*Champsocephalus esox*	0.410	0.380	0.210	0.001
MEV	*Metelectrona ventralis*	0.364	0.000	0.364	<0.001
THN	*Thysanopsetta naresi*	0.338	0.000	0.338	<0.001
THB	*Thymops birsteini*	0.323	0.000	0.323	<0.001
BAL	*Americominella longisetosus*	0.296	0.000	0.296	<0.001
ANT	Anthozoa	0.208	0.000	0.208	<0.001
OPI	*Ophioplocus incipiens*	0.200	0.000	0.200	<0.001
TED	*Terebratella dorsata*	0.190	0.000	0.190	<0.001
COG	*Patagonotothen guntheri*	0.182	0.182	0.182	<0.001
WRM	*Chaetopterus variopedatus*	0.178	0.000	0.178	<0.001
DIA	*Diaulula* spp.	0.176	0.000	0.176	<0.001
HOL	*Holothuroidea*	0.159	0.000	0.159	<0.001
CAS	*Campylonotus semistriatus*	0.145	0.000	0.145	<0.001
LOS	*Lophaster stellans*	0.142	0.000	0.142	<0.001
LIR	*Limopsis marionensis*	0.141	0.000	0.141	<0.001
ACS	*Acanthoserolis schythei*	0.132	0.000	0.132	<0.001
ERR	*Errina* sp.	0.120	0.000	0.120	<0.001
SOR	*Solaster regularis*	0.110	0.000	0.110	<0.001
NUD	*Nudibranchia*	0.107	0.000	0.107	<0.001
LIS	*Lithodes santolla*	0.098	0.000	0.098	<0.001
OPD	*Ophiacantha densispina*	0.092	0.000	0.092	<0.001
HEX	*Henricia* sp.	0.088	0.000	0.088	<0.001
CRY	*Crossaster* sp.	0.083	0.000	0.083	<0.001
HCR	Paguroidea	0.082	0.000	0.082	<0.001
HEO	*Henricia obesa*	0.080	0.000	0.080	<0.001
POX	*Chaetopterus variopedatus*	0.080	0.000	0.080	<0.001

Species Code	Latin name	Total caught (kg)	Total sampled (kg)	Total discarded (kg)	%
LAP	*Lamellaria patagonica*	0.074	0.000	0.074	<0.001
PSX	Psolidae	0.073	0.000	0.073	<0.001
CAV	*Campylonotus vagans*	0.070	0.000	0.070	<0.001
GYB	*Gymnoscopelus bolini*	0.065	0.000	0.065	<0.001
ICA	*Icichthys australis*	0.064	0.025	0.039	<0.001
SYD	*Sympagurus dimorphus*	0.060	0.000	0.060	<0.001
NUH	*Nuttallochiton hyadesi*	0.058	0.000	0.058	<0.001
ODP	*Odontaster pencillatus*	0.054	0.000	0.054	<0.001
ISO	Isopoda	0.052	0.000	0.052	<0.001
NER	Nemertea	0.046	0.000	0.046	<0.001
OIB	*Oidiphorus brevis*	0.042	0.042	0.000	<0.001
ISI	Isididae	0.040	0.000	0.040	<0.001
LAR	*Lampris immaculatus*	0.036	0.000	0.000	<0.001
ASF	*Asterina fimbriata*	0.030	0.000	0.030	<0.001
BER	*Berthella* spp.	0.030	0.000	0.030	<0.001
MUB	*Muusoctopus bizikovi*	0.030	0.000	0.030	<0.001
PAO	*Patagonotothen cornucola*	0.026	0.000	0.026	<0.001
PRD	Primnoidae	0.026	0.000	0.026	<0.001
ALP	*Alepocephalus productus*	0.022	0.000	0.022	<0.001
OCT	*Octopus* spp.	0.020	0.000	0.020	<0.001
PRI	Priapulida	0.020	0.000	0.020	<0.001
SAP	*Solidosagitta planctonis*	0.020	0.000	0.020	<0.001
EUO	*Eurypodius longirostris*	0.015	0.000	0.015	<0.001
OPA	*Opisthoteuthis hardyi*	0.012	0.000	0.012	<0.001
PAM	*Pagurus comptus*	0.010	0.000	0.010	<0.001
PLU	Primnoidae	0.010	0.000	0.010	<0.001
ANX	*Anasteria* sp.	0.008	0.000	0.008	<0.001
BUC	*Falsilunatia carcellesi*	0.006	0.000	0.006	<0.001
HED	*Helicolenus dactylopterus*	0.004	0.000	0.004	<0.001
SAL	*Salpa* sp.	0.004	0.000	0.004	<0.001
LEA	*Lepas australis*	0.002	0.000	0.002	<0.001
MXX	*Myctophidae* spp.	0.002	0.000	0.002	<0.001
OPH	Ophiuroidea	0.002	0.000	0.002	<0.001
CRI	Crinoidea	0.001	0.000	0.001	<0.001
OCC	*Octocorallia* sp.	0.001	0.000	0.001	<0.001
OPS	*Ophiactis asperula*	0.001	0.000	0.001	<0.001

3.2. Biological information of finfish species

3.2.1. *Salilota australis* – Red cod

The total catch of red cod was 5,681 kg. This species was caught at 68 of the 80 trawl stations sampled throughout the research cruise. Catches ranged from 0.06 to 1,042 kg, densities were 0.3 to 4,848 kg/km^2, and CPUE ranged from 0.06 to 1,042 kg/h. Catches of red cod occurred mostly along the west and north of the Falkland Islands (Figure 2A). Most females and males were immature (maturity stage II), with minor frequencies of spent individuals (maturity stages ≥ VII; Figure 2B). Females were 14–78 cm total length, and males were 16–73 cm total length. The length frequency histogram allowed identifying three cohorts for females, one cohort with modal length at 18 cm, the second cohort at 31 cm, and the third cohort at 43 cm total length (Figure 2C). Modal lengths of males were identified at 18 cm, 25 cm, and 43 cm total length (Figure 2D). Overlap of lengths does not allow identifying all the cohorts present.

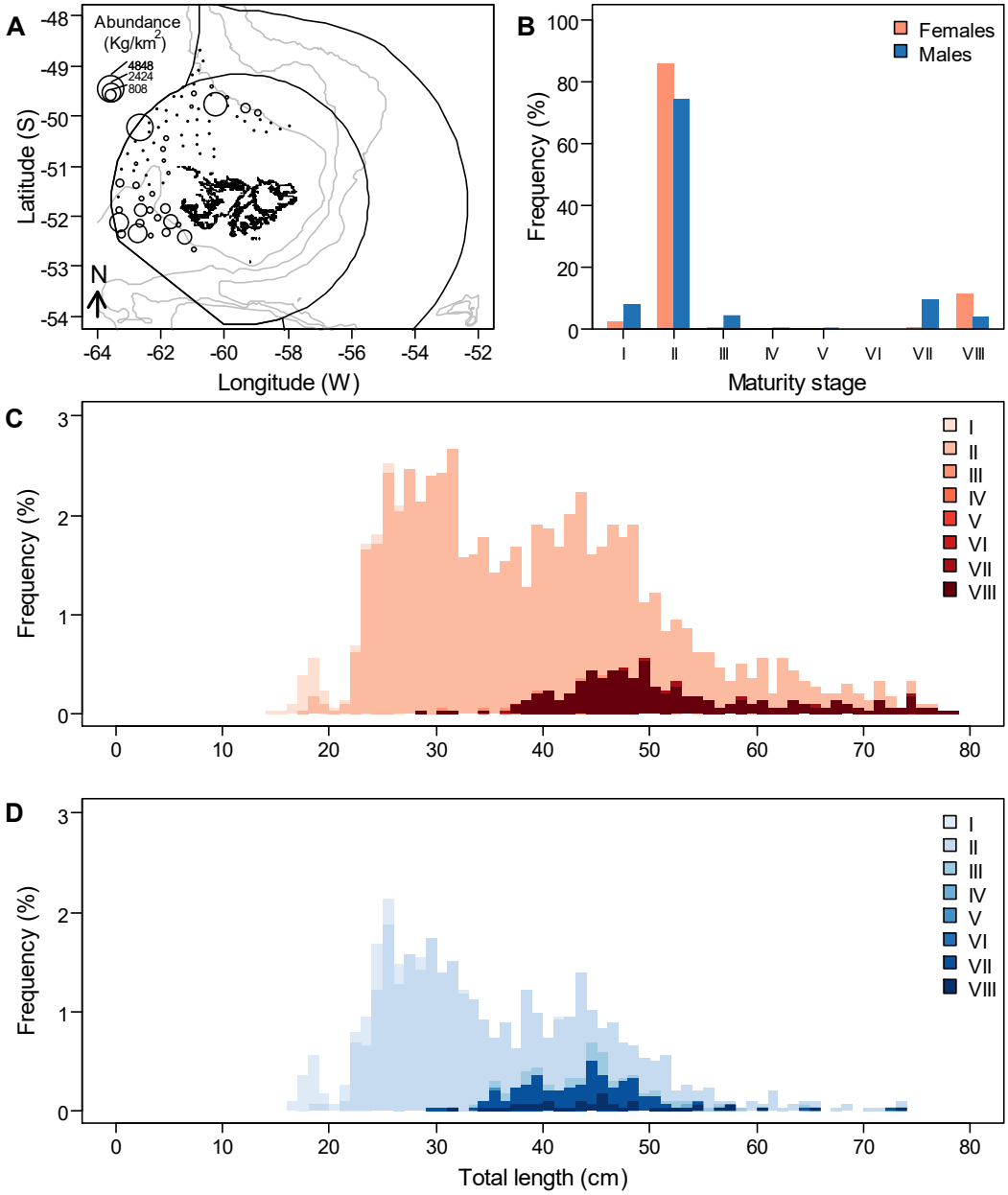

Figure 2. Biological data of *Salilota australis* (Red cod; BAC). A) Map of the densities in kg/km^2; B) relative frequency (%) of specimens of each sex per maturity stage (I, immature; II, resting; III, early developing; IV, late developing; V, ripe; VI, running; VII, spent; VIII, recovering spent); length frequencies (%) of C) females (n = 1,956) and D) males (n = 1,087) with 1 cm size class.

3.2.2. *Micromesistius australis* – Southern blue whiting

The total catch of southern blue whiting was 338 kg. This species was caught at 31 of the 80 trawl stations sampled throughout the research cruise. Catches ranged from 0.01 to 182 kg, densities ranged from 0.02 to 685 kg/km^2, and CPUE ranged from 0.01–182 kg/h. Southern blue whiting were caught in the south-west (Figure 3A). A total of 590 fish were sampled for length frequency (203 females, 387 males). Individuals were mainly immature or resting, with only a few spent individuals (Figure 3B). Females were 20–63 cm total length (Figure 3C) and males were 18–58 cm total length (Figure 3D). The limited number of individuals caught during the survey allowed identifying one cohort with mode at 24 cm total length, for both females and males. There may be more cohorts with modal lengths > 35 cm.

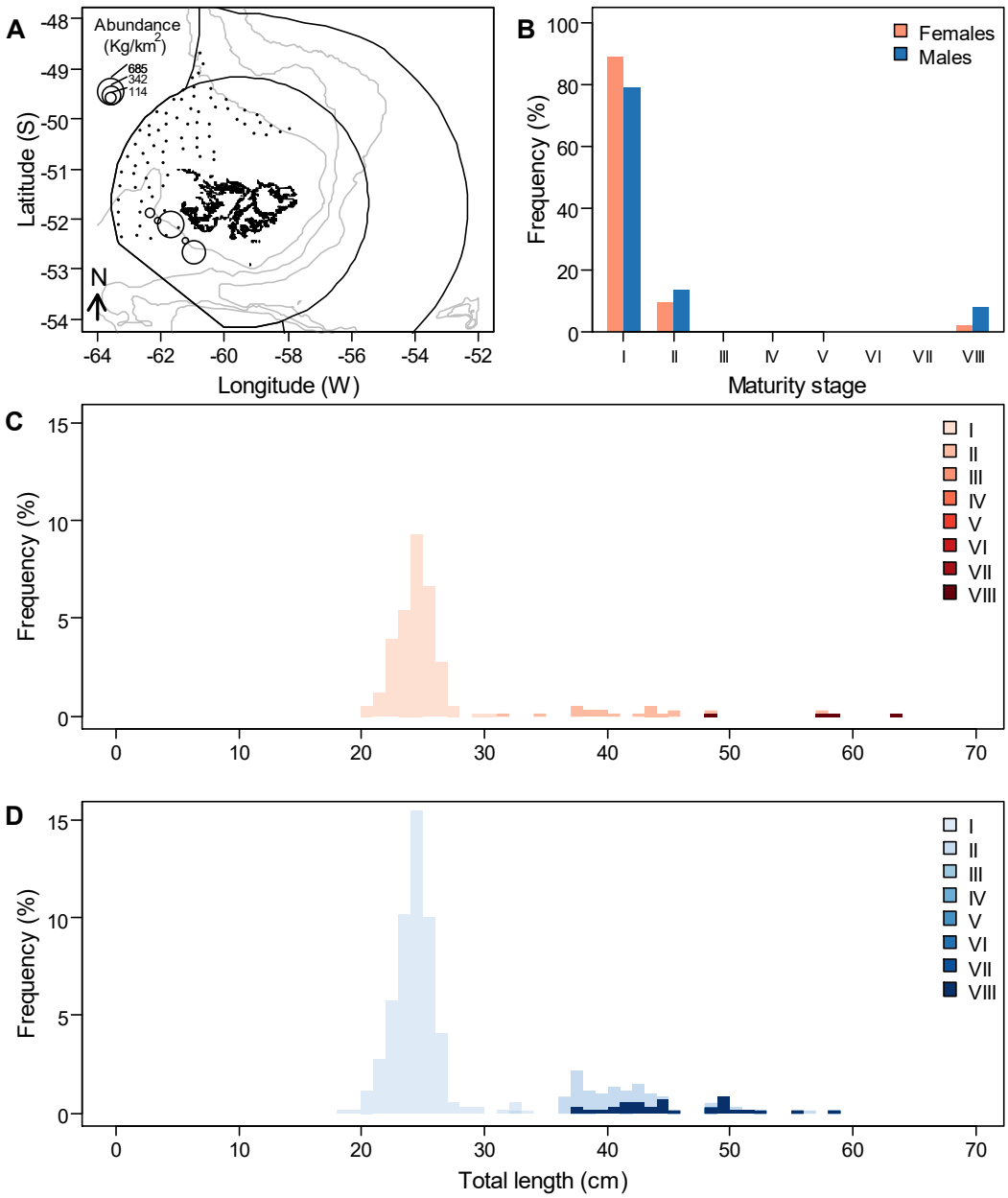

Figure 3. Biological data of *Micromesistius australis* (Southern blue whiting; BLU). A) Map of the densities in kg/km^2; B) relative frequency (%) of specimens of each sex per maturity stage (I, immature; II, resting; III, early developing; IV, late developing; V, ripe; VI, running; VII, spent; VIII, recovering spent); length frequencies (%) of C) females (n = 203) and D) males (n = 387) with 1 cm size class.

3.2.3. *Merluccius hubbsi* – Common hake

The total catch of common hake was 8,145 kg. This species was caught at 57 of the 80 trawl stations sampled throughout the research cruise. Catches ranged from 0.46 to 722 kg, densities ranged from 1.9 to 3,393 kg/km^2, and CPUE ranged from 0.46 to 722 kg/h. Common hake was observed to the north-west near the limit of the FICZ, an area where hake has historically been observed during February (Figure 4A). Most females were spent or recovering spent (maturity stages ≥ VII), or resting (maturity stage II). Most males were spent (maturity stage VII) or resting (Figure 4B). Females were 27–79 cm total length and males were 27–66 cm total length. One cohort was detected with modal lengths at 39 cm total length for females (Figure 4C) and 37 cm total length for males (Figure 4D).

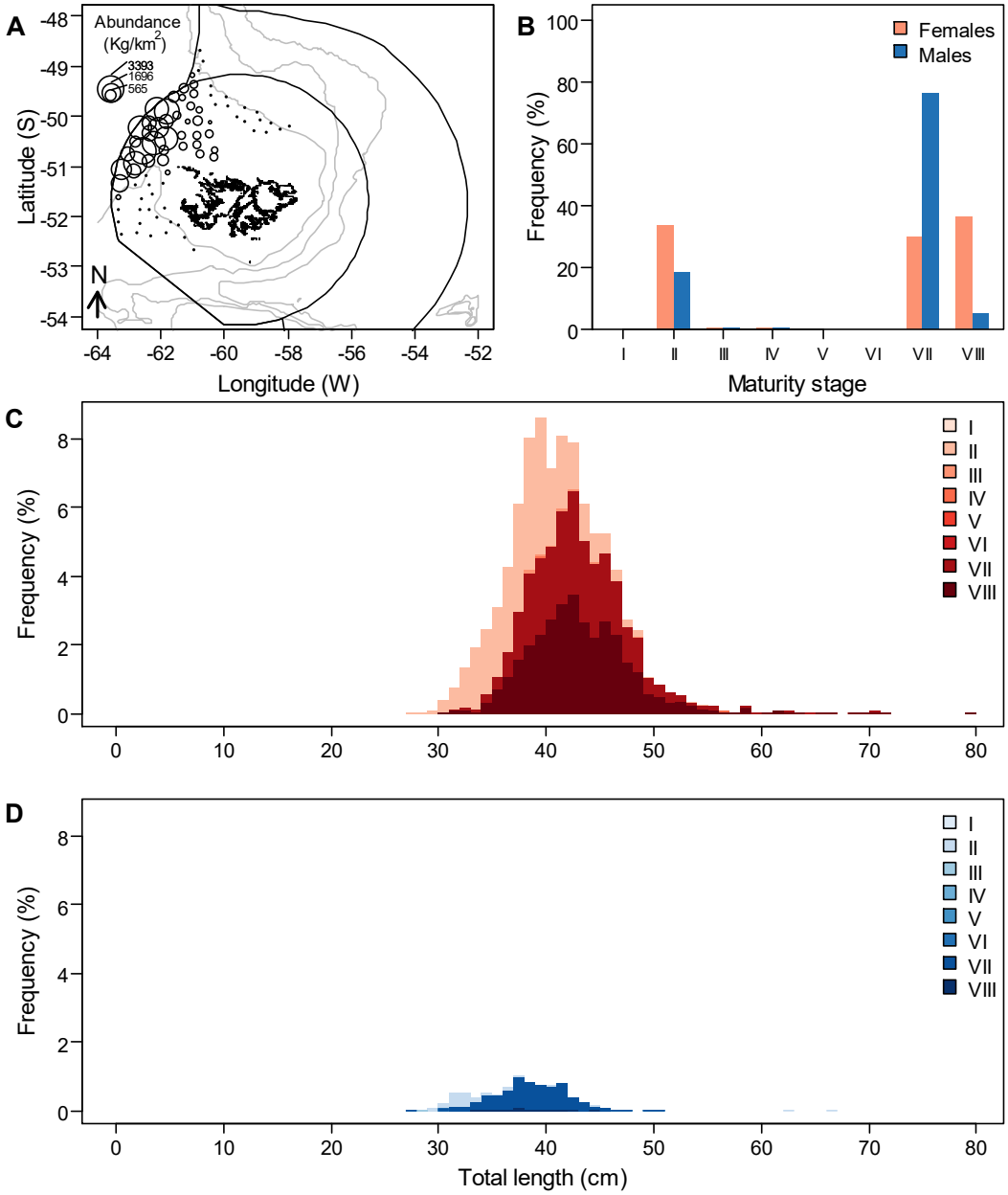

Figure 4. Biological data of *Merluccius hubbsi* (Common hake; HAK). A) Map of the densities in kg/km^2; B) relative frequency (%) of specimens of each sex per maturity stage (I, immature; II, resting; III, early developing; IV, late developing; V, ripe; VI, running; VII, spent; VIII, recovering spent); length frequencies (%) of C) females (n = 3,675) and D) males (n = 359) with 1 cm size class.

3.2.4. *Genypterus blacodes* – Kingclip

The total catch of kingclip was 4,349 kg. This species was caught at 72 of the 80 trawl stations sampled throughout the research cruise. Catches ranged from 0.24 to 718 kg, densities ranged from 1 to 3,923 kg/km^2, and CPUE ranged from 0.24 to 718 kg/h. Catches occurred along the west, with highest densities to the north-west and to the south-west (Figure 5A). Most females and males were at resting maturity stage (maturity stage II) (Figure 5B). Females were 36–121 cm total length, and males were 33–118 cm total length. The overlap of sizes allowed identifying only one cohort with modal lengths at 65 cm total length for females and at 61 cm total length for males (Figure 5C); however, more cohorts are likely to have occurred given the wide range of sizes.

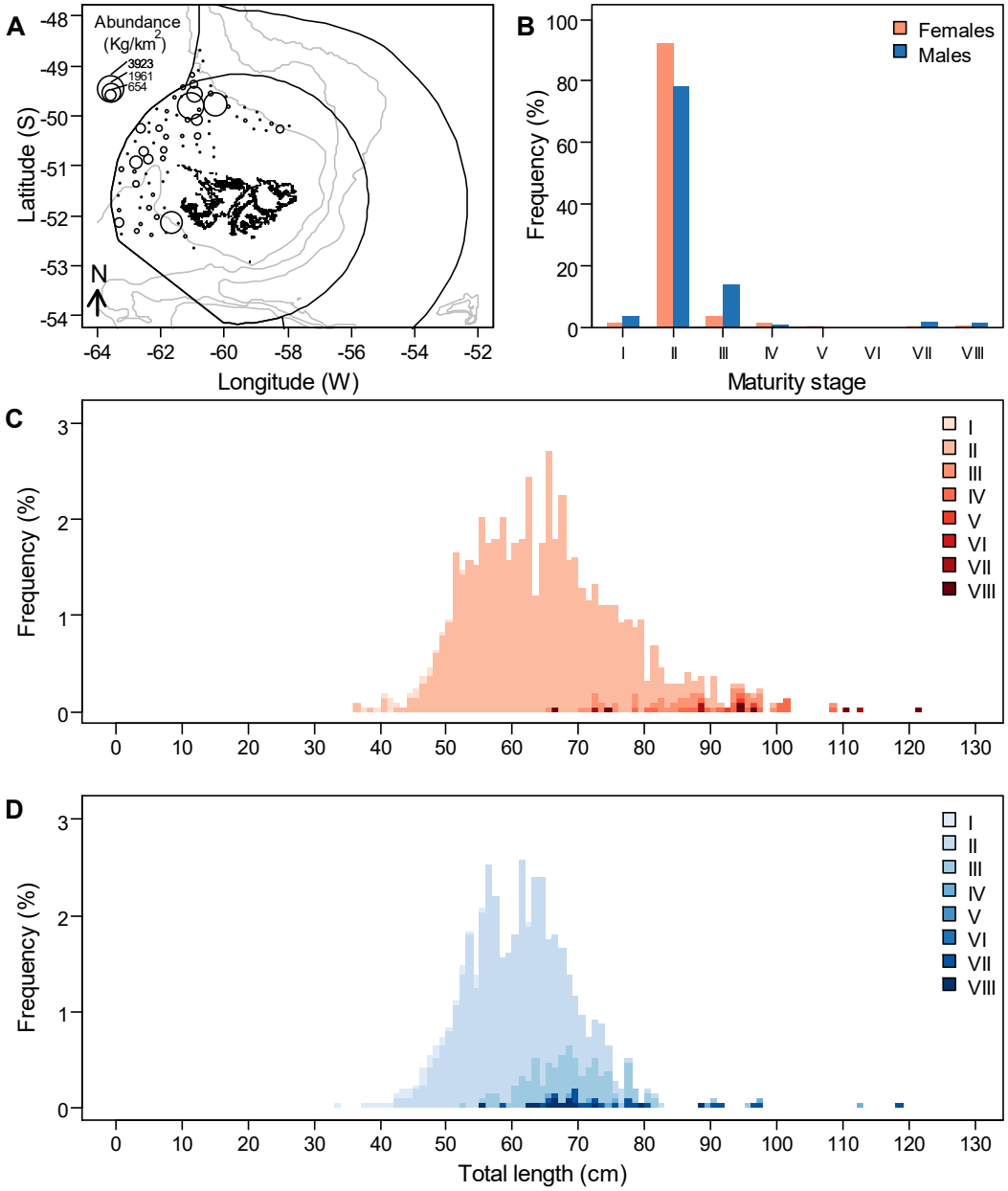

Figure 5. Biological data of *Genypterus blacodes* (Kingclip; KIN). A) Map of densities in kg/km^2; B) relative frequency (%) of specimens of each sex per maturity stage (I, immature; II, resting; III, early developing; IV, late developing; V, ripe; VI, running; VII, spent; VIII, recovering spent); length frequencies (%) of C) females (n = 1,199) and D) males (n = 978) with 1 cm size class.

3.2.5. *Patagonotothen ramsayi* – Common rock cod

The total catch of rock cod was 3,808 kg. This species was caught at every station with catches ranging from 1.6 to 287 kg, densities ranged from 7.8 to 1,347 kg/km^2, and CPUE ranged from 1.6 to 287 kg/h. Highest densities were observed along the west and to the north of the Falkland Islands (Figure 6A). Most females and males were immature (maturity stages ≤ III), with resting individuals being predominant (Figure 6B). Juveniles were 5–16 cm total length, females were 10–38 cm total length, and males were 9–36 cm total length; the sex of six individuals was not determined and their sizes ranged from 11 to 14 cm total length. More than two size cohorts may exist but these were not detected because of the overlap of size. Modal lengths of females were detected at 15 cm and at 22 cm total length (Figure 6C), whereas modal lengths of males were detected at 15 cm and at 23 cm total length (Figure 6D).

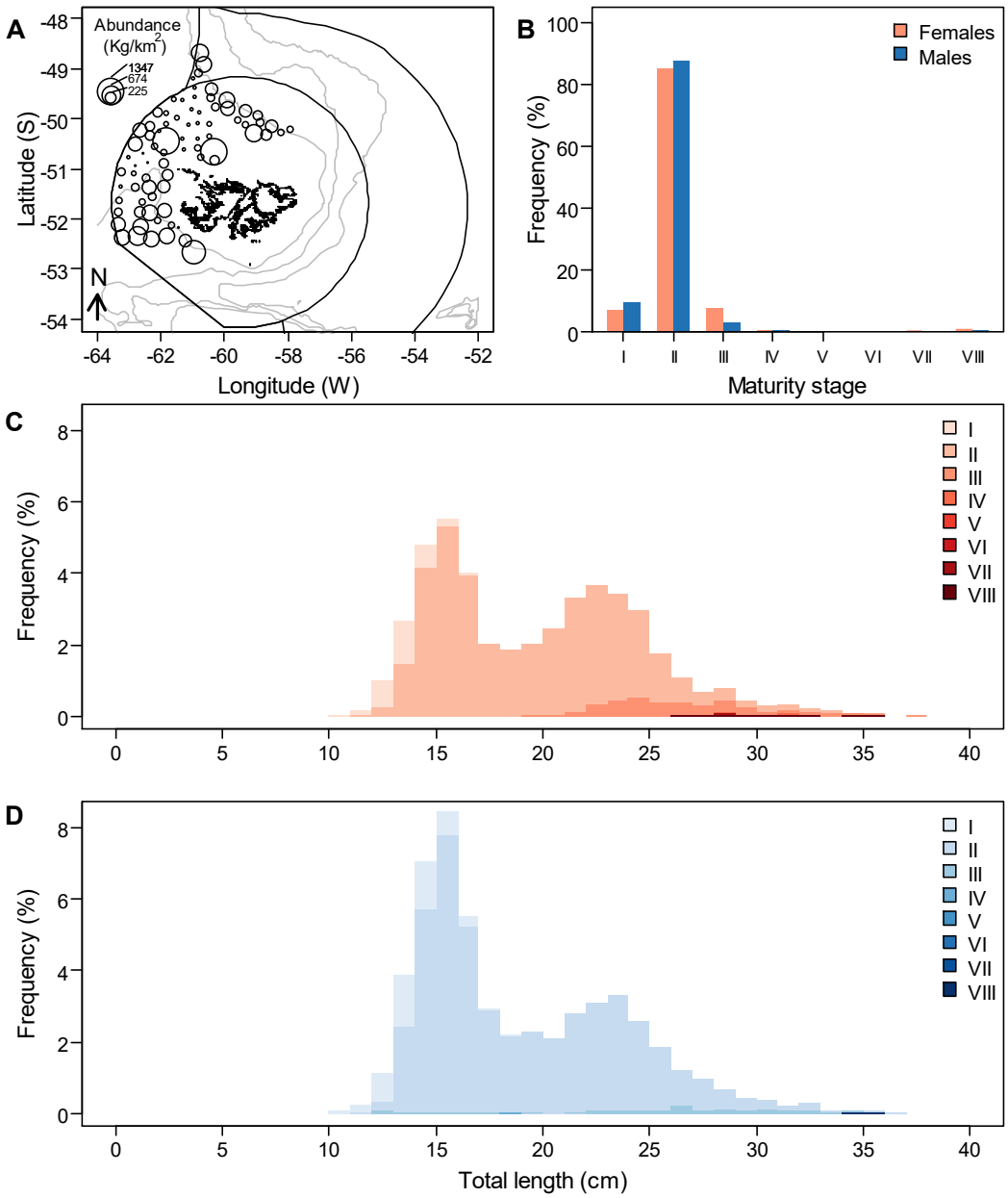

Figure 6. Biological data for *Patagonotothen ramsayi* (Common rock cod; PAR). A) Map of the densities in kg/km^2; B) relative frequency (%)of specimens of each sex per maturity stage (I, immature; II, resting; III, early developing; IV, late developing; V, ripe; VI, running; VII, spent; VIII, recovering spent); length frequencies (%) of C) females (n = 3,572) and D) males (n = 4,210) with 1 cm size class.

3.2.6. *Merluccius australis* – Patagonian hake

The total catch of Patagonian hake was 240 kg. This species was caught at 14 of the 80 trawl stations sampled throughout the research cruise. Catches ranged from 1.3 to 64 kg, densities ranged from 8.5 to 828 kg/km^2, and CPUE ranged from 1.3 to 169 kg/h. Patagonian hake were observed to the south-west of the survey zone near the limit of the FICZ (Figure 7A); this area is in deeper waters where patagonian hake are most abundant. Most females were resting (maturity stage II), recovering spent (maturity stage VIII) or spent (maturity stage VII), whereas most males were resting (Figure 7B). The small number of Patagonian hake caught and the wide range of sizes did not enable identifying cohorts on the length-frequency histograms (Figures 7C–7D), although there seems to be a cohort with modal length at 71 cm total length for females (Figure 7C).

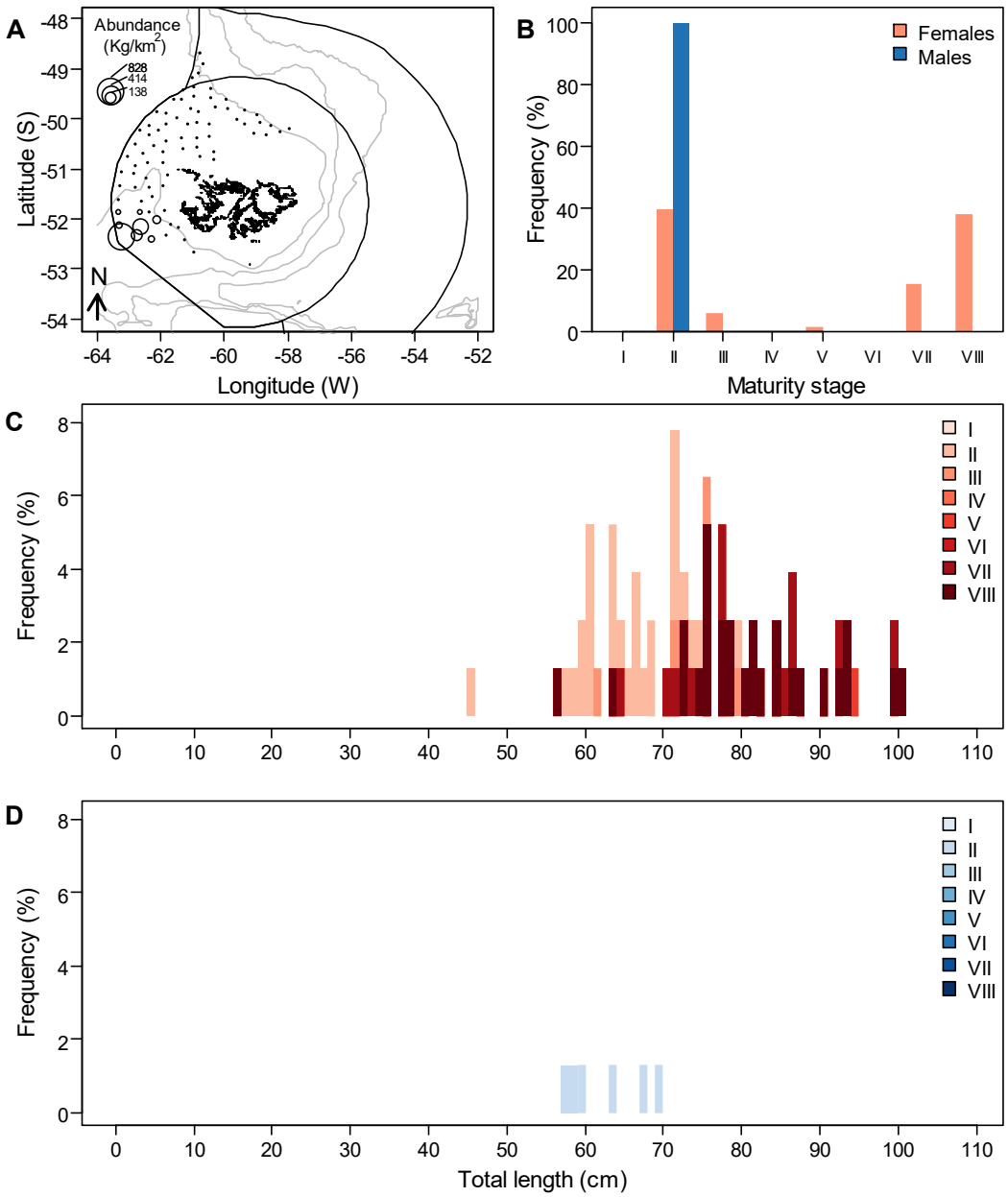

Figure 7. Biological data of *Merluccius australis* (Patagonian hake; PAT). A) Map of the densities in kg/km^2; B) relative frequency (%) of specimens of each sex per maturity stage (I, immature; II, resting; III, early developing; IV, late developing; V, ripe; VI, running; VII, spent; VIII, recovering spent); length frequencies (%) of C) females (n = 71) and D) males (n = 6) with 1 cm size class.

3.2.7. *Dissostichus eleginoides* – Patagonian toothfish

The total catch of Patagonian toothfish was 344 kg. This species was caught at 38 of the 80 trawl stations sampled throughout the research cruise. Catches ranged from 0.01 to 41 kg, densities ranged from 0.06 to 233 kg/km^2, and CPUE ranged from 0.01 to 48 kg/h. Highest densities were observed in the south-west of the survey zone at stations deeper than 200 m (Figure 8A). Most individuals were immature or resting (maturity stages ≤ II) (Figure 8B). Females were 34–89 cm, males were 34–70 cm, and two juveniles were 9 and 10 cm total length. One cohort was identified with a modal length at 48 cm total length for females (Figure 8C) and at 50–51 cm total length for males (Figure 8D). A smaller cohort was detected and it was comprised by the two individual juveniles.

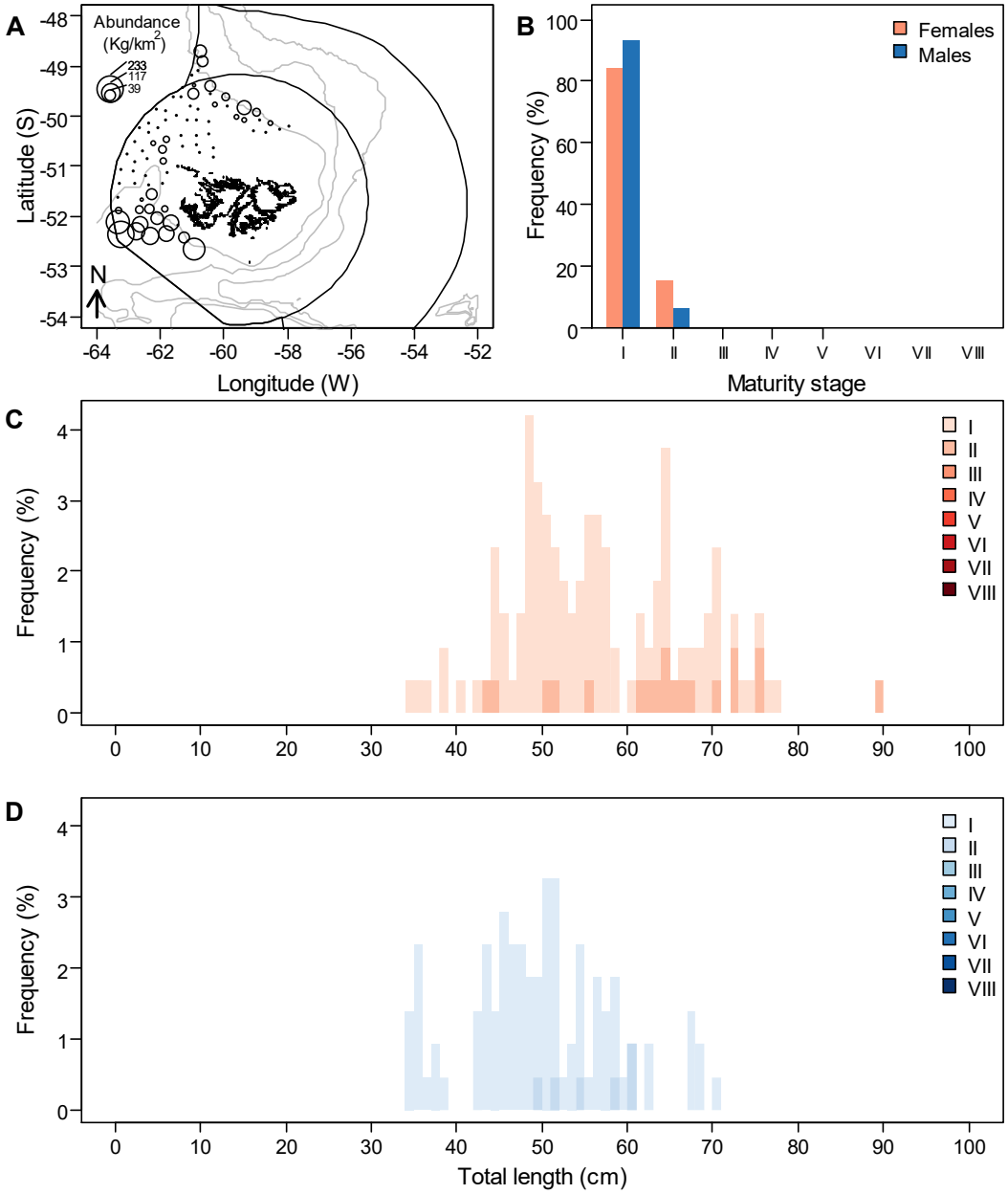

Figure 8. Biological data of *Dissostichus eleginoides* (Patagonian toothfish; TOO). A) Map of the densities in kg/km^2; B) relative frequency (%) of specimens of each sex per maturity stage (I, immature; II, resting; III, early developing; IV, late developing; V, ripe; VI, running; VII, spent; VIII, recovering spent); length frequencies (%) of C) females (n = 121) and D) males (n = 92) with 1 cm size class.

3.2.8. *Macruronus magellanicus* – Hoki

The total catch of hoki was 30,458 kg, the most abundant finfish during the cruise. This species was caught at 24 of the 80 stations sampled throughout the research cruise. Catches ranged from 0.2 to 9,939 kg, densities ranged from 0.95 to 146,193 kg/km^2, and CPUE ranged from 0.2 to 29,817 kg/h. Highest densities were observed in the south-west of the survey area near the limit of the FICZ (Figure 9A), with nearly one third of the total hoki catch caught in one single station (station 3362). Most females and males were immature, resting or early developing (maturity stages ≤ III). A minor proportion of individuals were spent or recovering spent (maturity stages > VII; Figure 9B). Females were 13–43 cm pre-anal length (Figure 9C), and males were 14–37 cm pre-anal length (Figure 9D). The length frequency histograms exhibit one cohort with modal length at 23 cm pre-anal length for females and males.

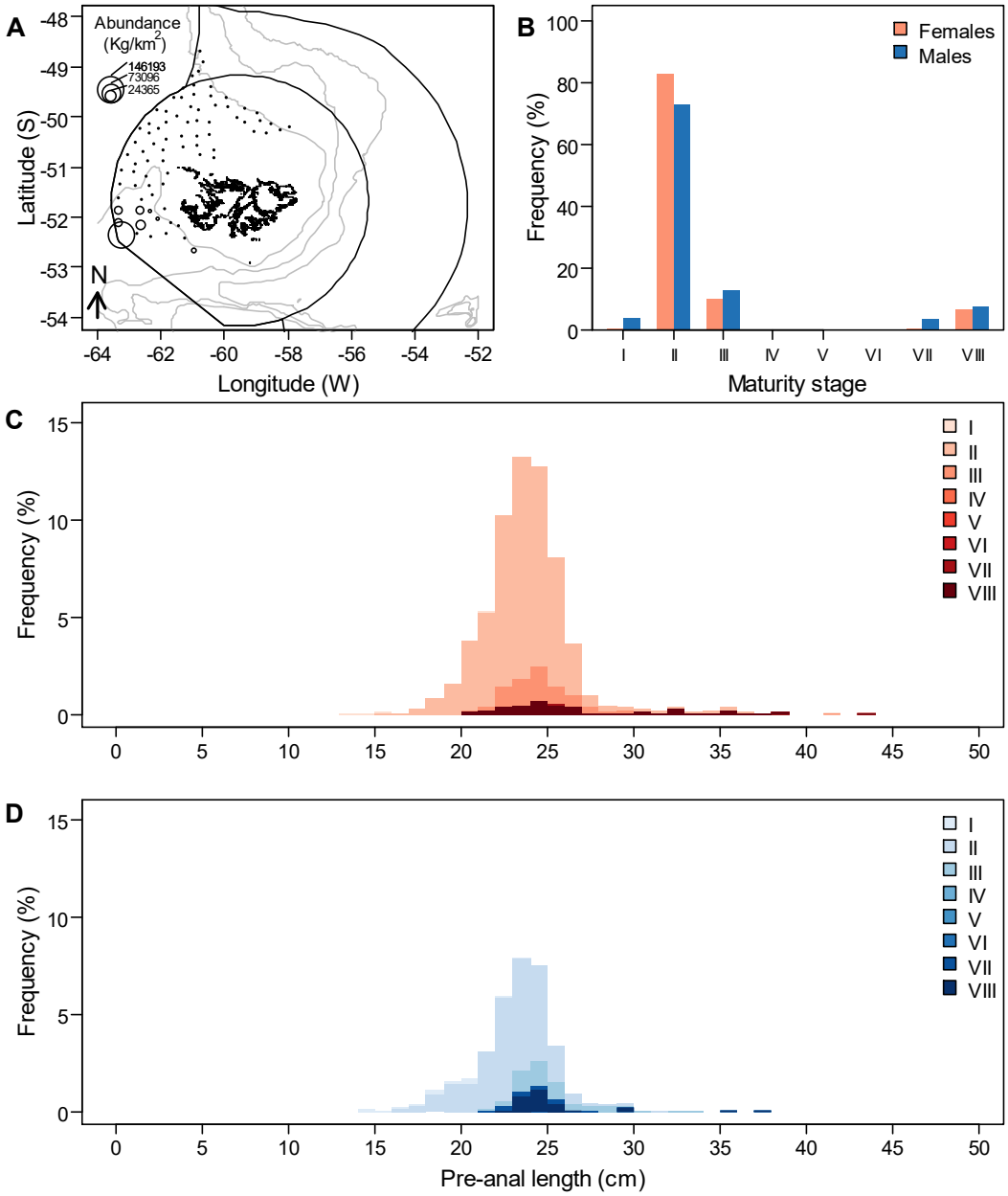

Figure 9. Biological data of *Macruronus magellanicus* (Hoki; WHI). A) Map of the densities in kg/km^2; B) relative frequency (%) of specimens of each sex per maturity stage (I, immature; II, resting; III, early developing; IV, late developing; V, ripe; VI, running; VII, spent; VIII, recovering spent); length frequencies (%) of C) females (n = 925) and D) males (n = 518) with 1 cm size class.

3.2.9. *Stromateus brasiliensis* – Butterfish

The total catch of Butterfish was 1,163 kg. This species was caught at 50 of the 80 trawl stations sampled throughout the research cruise. Catches ranged from 0.2 to 64 kg, densities ranged from 0.8 to 379 kg/km^2, and CPUE ranged from 0.2 to 64 kg/h. Butterfish was caught along the north-west, mainly near the limit of the FICZ, and in the north of West Falkland at nearshore stations (Figure 10A). Females were mostly early developing (maturity stage III) whereas males were mainly resting (maturity stage II); few individuals were spent (maturity stages ≥ VII; Figure 10B). Females were 21–40 cm total length and males were 21–38 cm total length. One cohort was detected with modal lengths at 28 cm total length for females (Figure 10C) and at 26 cm total length for males (Figure 10D).

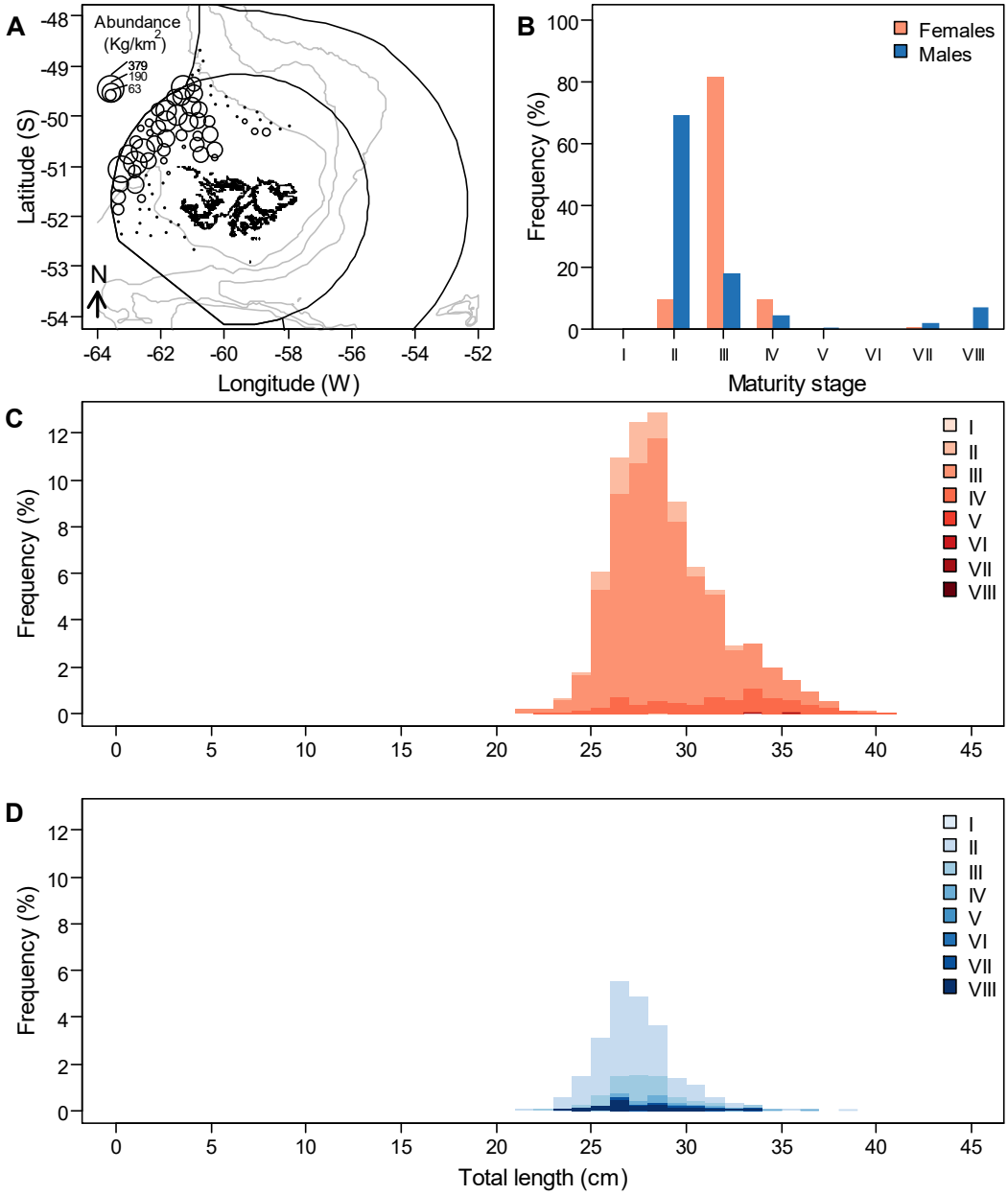

Figure 10. Biological data of *Stromateus brasiliensis* (Butterfish; BUT). A) Map of the densities in kg/km^2; B) relative frequency (%) of specimens of each sex per maturity stage (I, immature; II, resting; III, early developing; IV, late developing; V, ripe; VI, running; VII, spent; VIII, recovering spent); length frequencies (%) of C) females (n = 2,344) and D) males (n = 706) with 1 cm size class.

3.2.10. *Coelorinchus fasciatus* – Banded whiptail grenadier

The total catch of banded whiptail grenadier was 6,360 kg. This species was caught at 19 of the 80 trawl stations sampled throughout the research cruise. Catches ranged from 0.2 to 1,035 kg, densities ranged from 1.1 to 5,267 kg/km^2, and CPUE ranged from 0.2 to 1,035 kg/h. Highest densities were observed in the south-west 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 resting or developing (maturity stages ≤ IV); smaller proportions of spent or recovering spent individuals were also observed (maturity stages ≥ VII; Figure 12B). Females were 5–14 cm pre–anal length; males were 5–11 cm pre–anal length, a few sampled juveniles were about 4 cm pre-anal length (n = 4). The length-frequency histogram allowed detecting a single cohort with modal lengths at 10 cm pre–anal length for females (Figure 12C) and at 9 cm pre-anal length for males (Figure 12D).

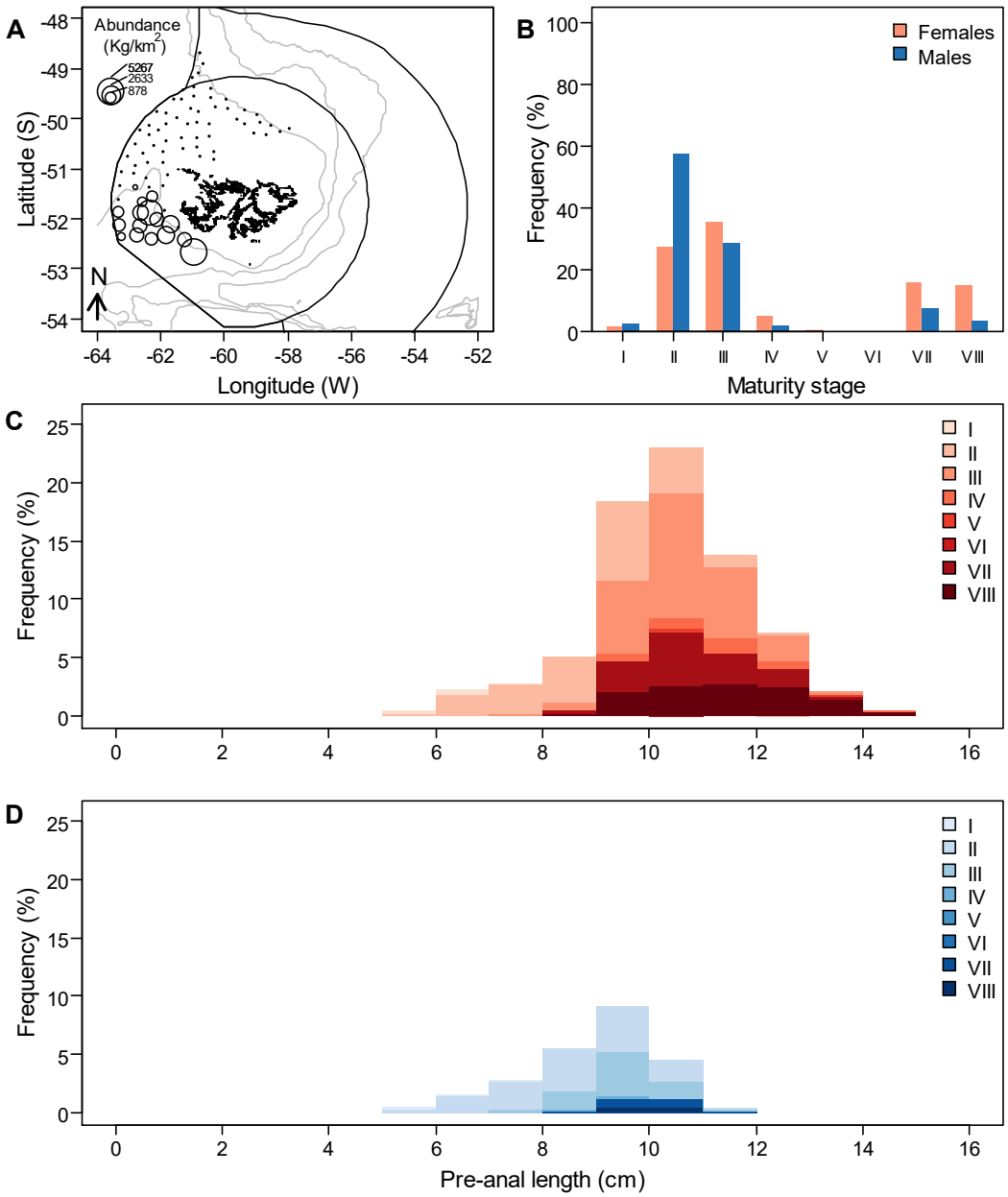

Figure 12. Biological data of *Coelorinchus fasciatus* (Banded whiptail grenadier; GRF). A) Map of the densities in kg/km^2; B) relative frequency (%) of specimens of each sex per maturity stage (I, immature; II, resting; III, early developing; IV, late developing; V, ripe; VI, running; VII, spent; VIII, recovering spent); length frequencies (%) of C) females (n = 1,252) and D) males (n = 408) with 1 cm size class.

3.2.11. *Seriolella porosa* – Driftfish

The total catch of driftfish was 882 kg. This species was caught at 11 of the 80 trawl stations sampled throughout the research cruise. Catches ranged from 2.3 to 364 kg, densities ranged from 8.9 to 1,513 kg/km^2, and CPUE ranged from 2.3 to 364 kg/h. Highest densities were observed to the south-west in the FICZ (Figure 14A). Females were mainly spent or recovering spent (maturity stages ≥ VII); males were mostly recovering spent (maturity stage VIII) (Figure 14B). Females were 34–59 cm total length and males were 39–58 cm total length. Modal lengths were detected at 55 cm total length for females (Figure 14C), and at 52 cm total length for males (Figure 14D).

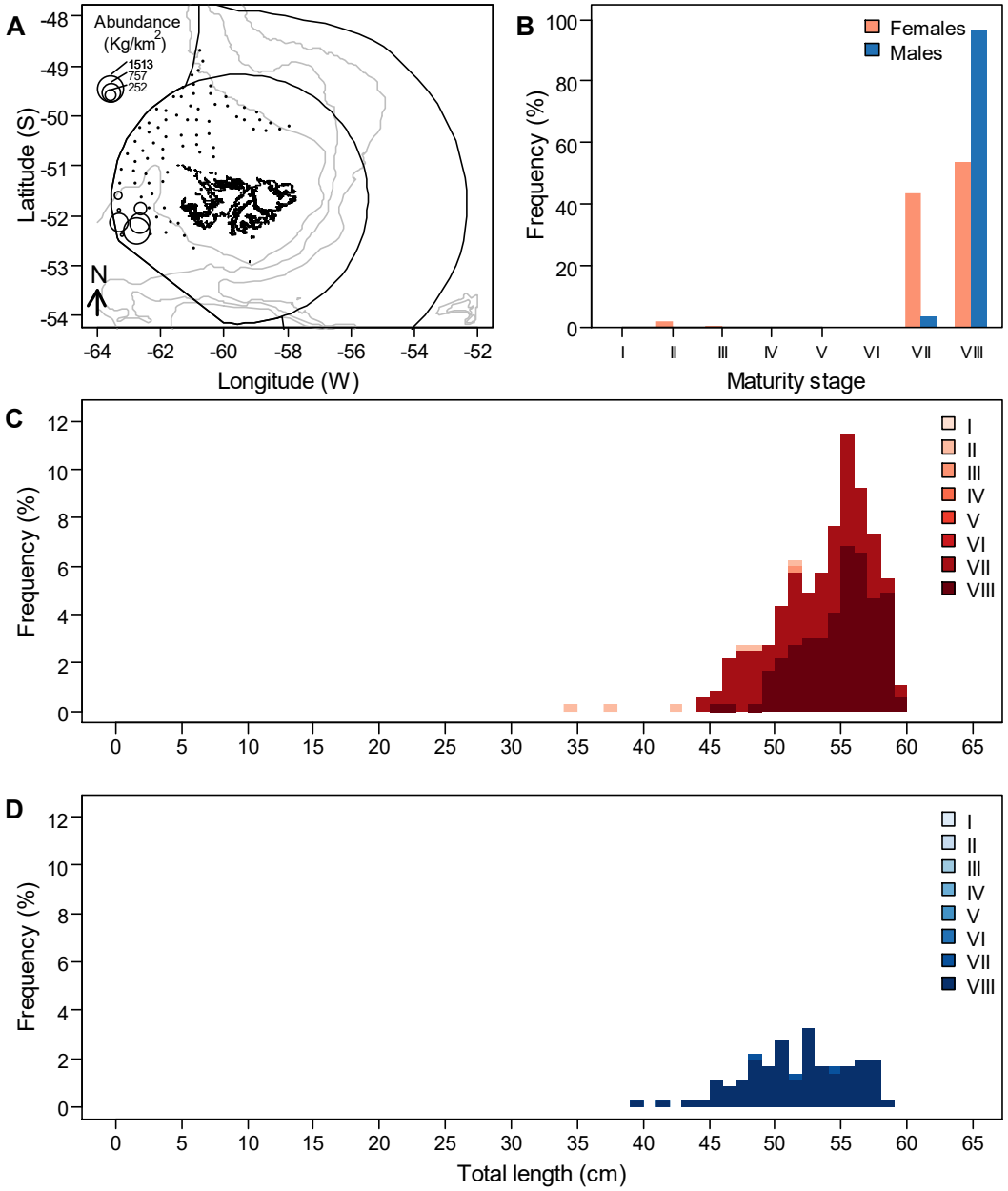

Figure 14. Biological data of *Seriolella porosa* (Driftfish; SEP). A) Map of the densities in kg/km^2; B) relative frequency (%) of specimens of each sex per maturity stage (I, immature; II, resting; III, early developing; IV, late developing; V, ripe; VI, running; VII, spent; VIII, recovering spent); length frequencies (%) of C) females (n = 279) and D) males (n = 89) with 1 cm size class.

3.2.12. *Notophycis marginata* – Dwarf codling

The total catch of dwarf codling was 509 kg. This species was caught at 14 of the 80 trawl stations sampled throughout the research cruise. Catches ranged from 0.06 to 212 kg, densities ranged from 0.22 to 1,088 kg/km^2, and CPUE ranged from 0.06 to 212 kg/h. Highest densities were observed to the south-west in the FICZ (Figure 15). No biological samples of the dwarf codling were processed during the survey.

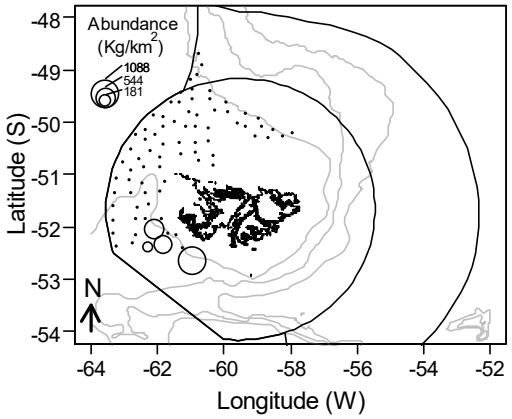

Figure 15. Map of the densities of *Notophycis marginata* (Dwarf codling; PYM) in kg/km^2.

3.2.13. *Macrourus carinatus* – Ridge scaled grenadier

The total catch of ridge scaled grenadier was 391 kg. This species was caught at 3 of the 80 trawl stations sampled throughout the research cruise. Catches ranged from 2.5 to 383 kg, densities ranged from 11.9 to 1,966 kg/km^2, and CPUE ranged from 2.5 to 383 kg/h. Highest densities were observed to the south of West Falkland (Figure 16A). Females were mainly late developing (maturity stage IV) or spent (maturity stages VII); males were mostly developing (maturity stages III and IV; Figure 16B). Females were 19–31 cm pre-anal length and males were 16–23 cm pre-anal length. Modal lengths were detected at 24 cm pre-anal length for females (Figure 16C), and at 21 cm pre-anal length for males (Figure 16D); however, the small number of males collected (n = 10) does not allow identifying the modal length with certainty.

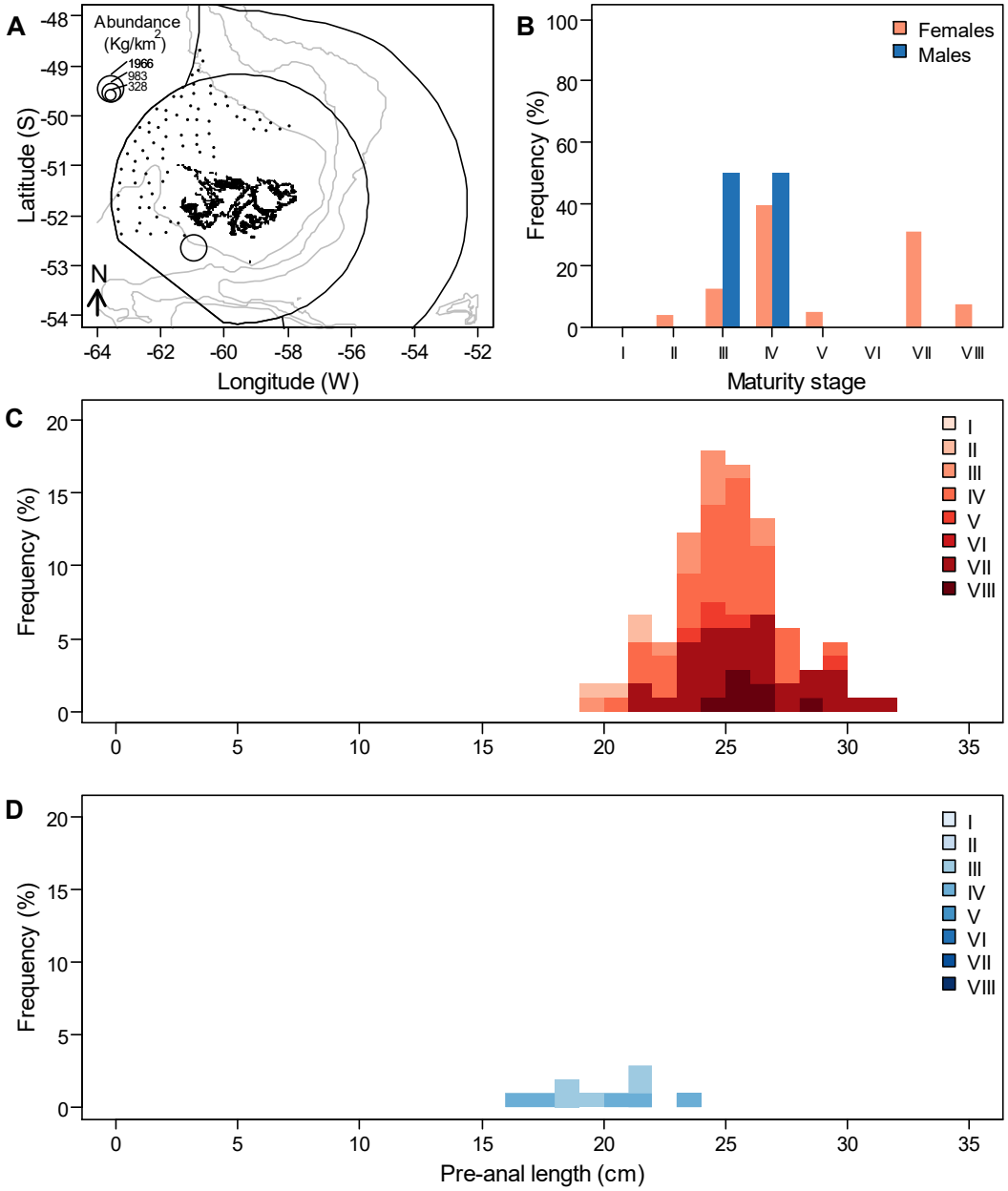

Figure 16. Biological data of *Macrourus carinatus* (Ridge scaled grenadier; GRC). A) Map of the densities in kg/km^2; B) relative frequency (%) of specimens of each sex per maturity stage (I, immature; II, resting; III, early developing; IV, late developing; V, ripe; VI, running; VII, spent; VIII, recovering spent); length frequencies (%) of C) females (n = 96) and D) males (n = 10) with 1 cm size class.

3.3. Biological information of squid species

3.3.1. Illex argentinus – Argentine shortfin squid

The total catch of Argentine shortfin squid was 9,614 kg, the second most abundant species during the cruise. This species was caught at 79 of the 80 trawl stations sampled throughout the research cruise. Catches ranged from 0.02 to 2,774 kg, densities ranged from 0.1 to 13,273 kg/km^2, and CPUE ranged from 0.02 to 2,774 kg/h. Highest densities occurred mainly in the north-west of the FICZ (Figure 17A). Most females were immature (maturity stages ≤ II). Most males were maturing or mature (maturity stages ≥ IV), or immature (maturity stage I; Figure 17B). Females size ranged between 7.5 cm and 35.5 cm dorsal mantle length, with modes at 10.0 cm and at 25 cm dorsal mantle length (Figure 17C). Males size ranged between 7.5 cm and 28 cm dorsal mantle length, with modes at 11.5–12.5 cm and at 23 cm dorsal mantle length (Figure 17D).

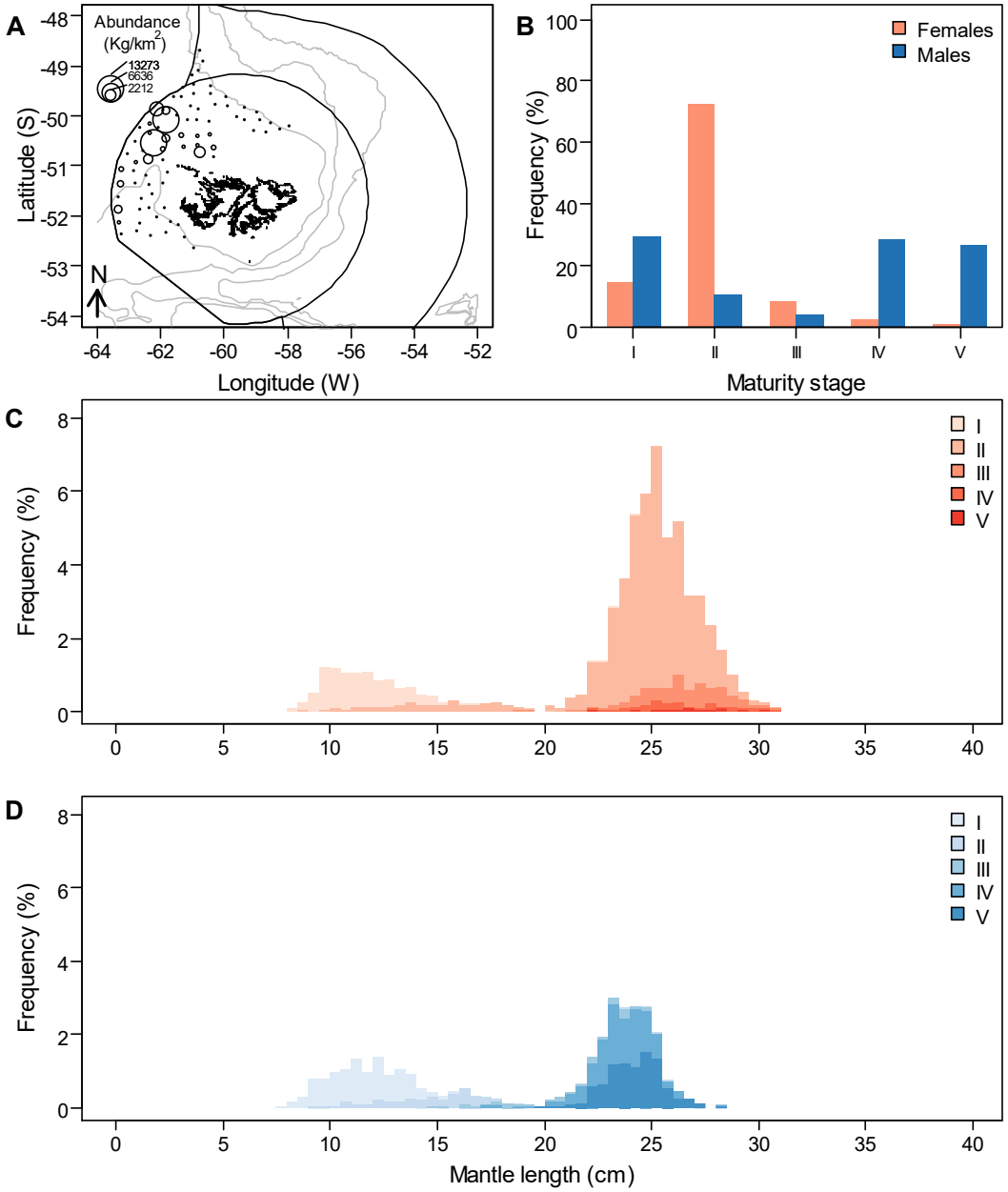

Figure 17. Biological data of *Illex argentinus* (Argentine shortfin squid; ILL). A) Map of the densities in kg/km^2; B) relative frequency (%) of specimens of each sex per maturity stage (I, immature; II, resting; III, early developing; IV, late developing; V, ripe; VI, running; VII, spent; VIII, recovering spent); length frequencies (%) of C) females (n = 3,205) and D) males (n = 1,702) with 0.5 cm size class.

3.3.2. *Doryteuthis gahi* – Falkland calamari

The total catch of Falkland calamari was 5,329 kg. This species was caught at 77 of the 80 trawl stations sampled throughout the research cruise. Catches ranged from 0.04 to 916 kg, densities ranged from 0.2 to 4,701 kg/km^2, and CPUE ranged from 0.04 to 916 kg/h. Falkland calamari were caught throughout the survey area but greater densities occurred along the south-west of West Falkland (Figure 19A). Most females and males were immature (maturity stage II) (Figure 19B). Juveniles were 5–8 cm dorsal mantle length, females were 5.5–21 cm dorsal mantle length (Figure 19C), and males were 5–23 cm dorsal mantle length (Figure 19D). One cohort was detected, with modal length of females and males at 8 cm dorsal mantle length, respectively.

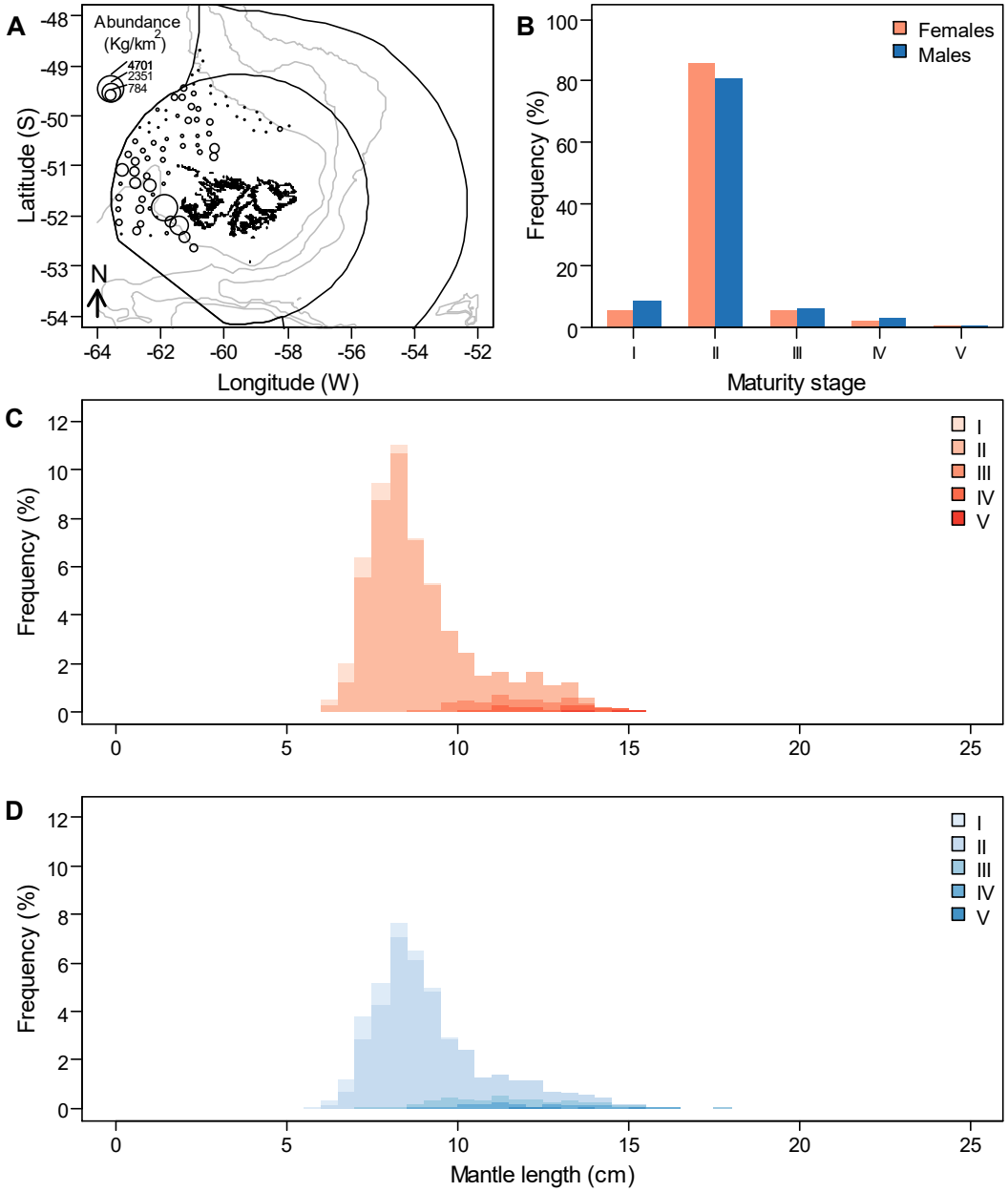

Figure 19. Biological data of *Doryteuthis gahi* (Falkland calamari; LOL). A) Map of the densities in kg/km²; B) relative frequency (%) of specimens of each sex per maturity stage (I, immature; II, resting; III, early developing; IV, late developing; V, ripe; VI, running; VII, spent; VIII, recovering spent); length frequencies (%) of C) females (n = 4,091) and D) males (n = 3,056) with 0.5 cm size class.

3.4. Biological information of skate species

3.4.1. *Bathyraja albomaculata* – White spotted skate

The total catch of white spotted skate was 72 kg. This species was caught at 22 of the 80 trawl stations sampled through the research cruise. Catches ranged from 0.7 to 7 kg, densities ranged from 3.3 to 38 kg/km^2, and CPUE ranged from 0.7 to 7 kg/h. Highest densities were observed in the north and south-west of the survey zone (Figure 20A). Most females were maturing or developing (maturity stages II and III), and there were smaller proportions of mature and running females (maturity stages ≥ IV). Running males were more common (maturity stage V), followed by maturing individuals (maturity stage II; Figure 20B). Females were 26–48 cm disc width with modal disc width at 40 cm (Figure 20C). Males were 26–51 cm disc width, with modal disc width at 43 cm (Figure 20D).

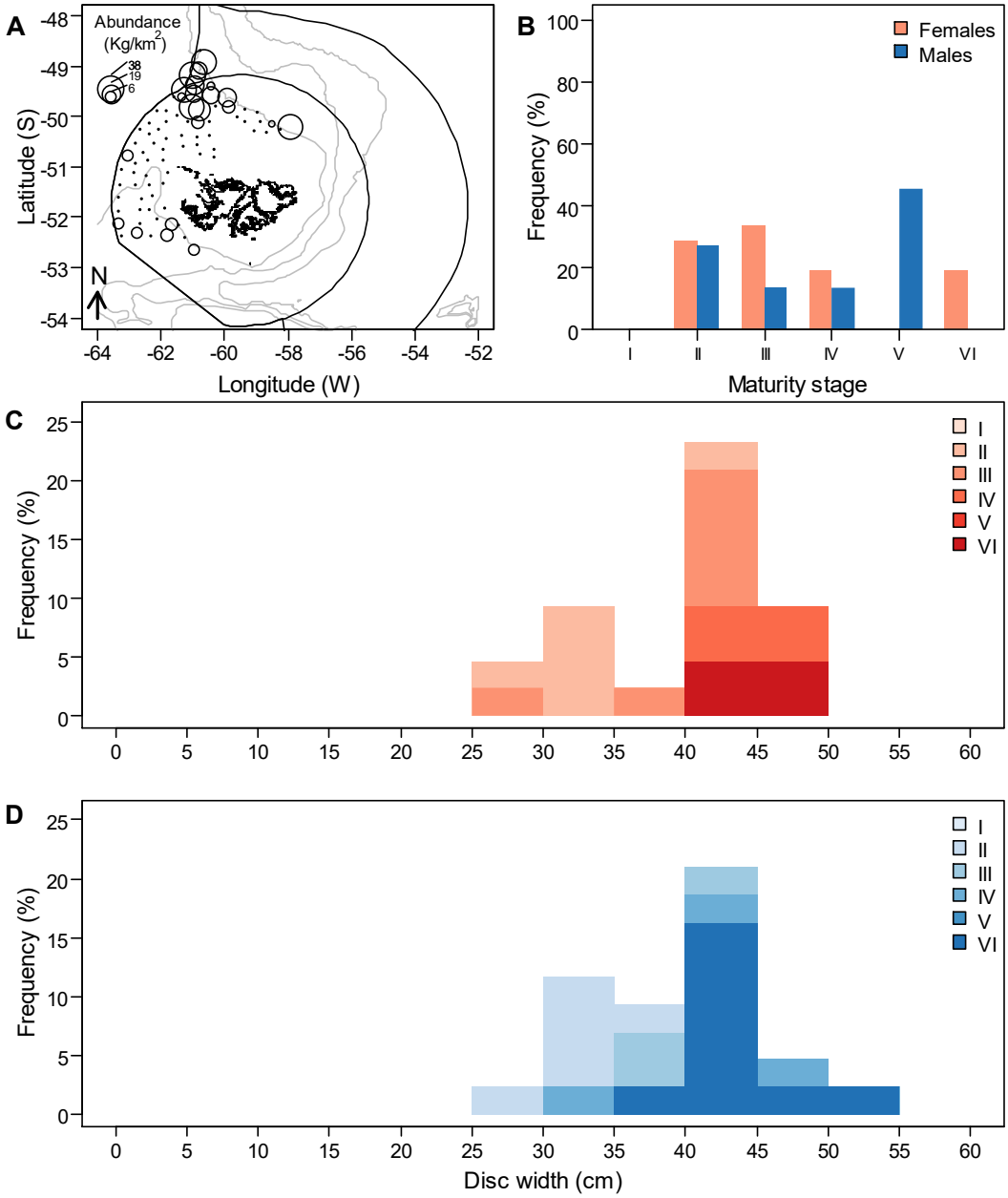

Figure 20. Biological data of *Bathyraja albomaculata* (White spotted skate; RAL). A) Map of the densities in kg/km^2; B) relative frequency (%) of specimens of each sex per maturity stage (I, juvenile; II, adolescent maturing; III, adult developing; IV, adult mature; V, adult laying/running; VI, adult resting); length frequencies (%) of C) females (n = 21) and D) males (n = 22) with 5 cm size class.

3.4.2. *Bathyraja brachyurops* – Blonde skate

The total catch of blonde skate was 290 kg. This species was caught at 52 of the 80 trawl stations sampled through the research cruise. Catches ranged from 0.02 to 25 kg, densities ranged from 0.1 to 123 kg/km^2, and CPUE ranged from 0.02 to 25 kg/h. Highest densities were observed along the north and smaller catches occurred along the west of West Falkland (Figure 21A). Most females and males were maturing (maturity stage II), although all maturity stages were present (Figure 21B). Females were 10–73 cm disc width and males were 7–67 cm disc width. The length-frequency histograms show two possible cohorts with modal lengths of females at 31 cm and at 55–59 cm and 60–64 cm disc width size classes (Figure 21C), and modal lengths of males at 32 cm, and at 50 cm disc width (Figure 21D).

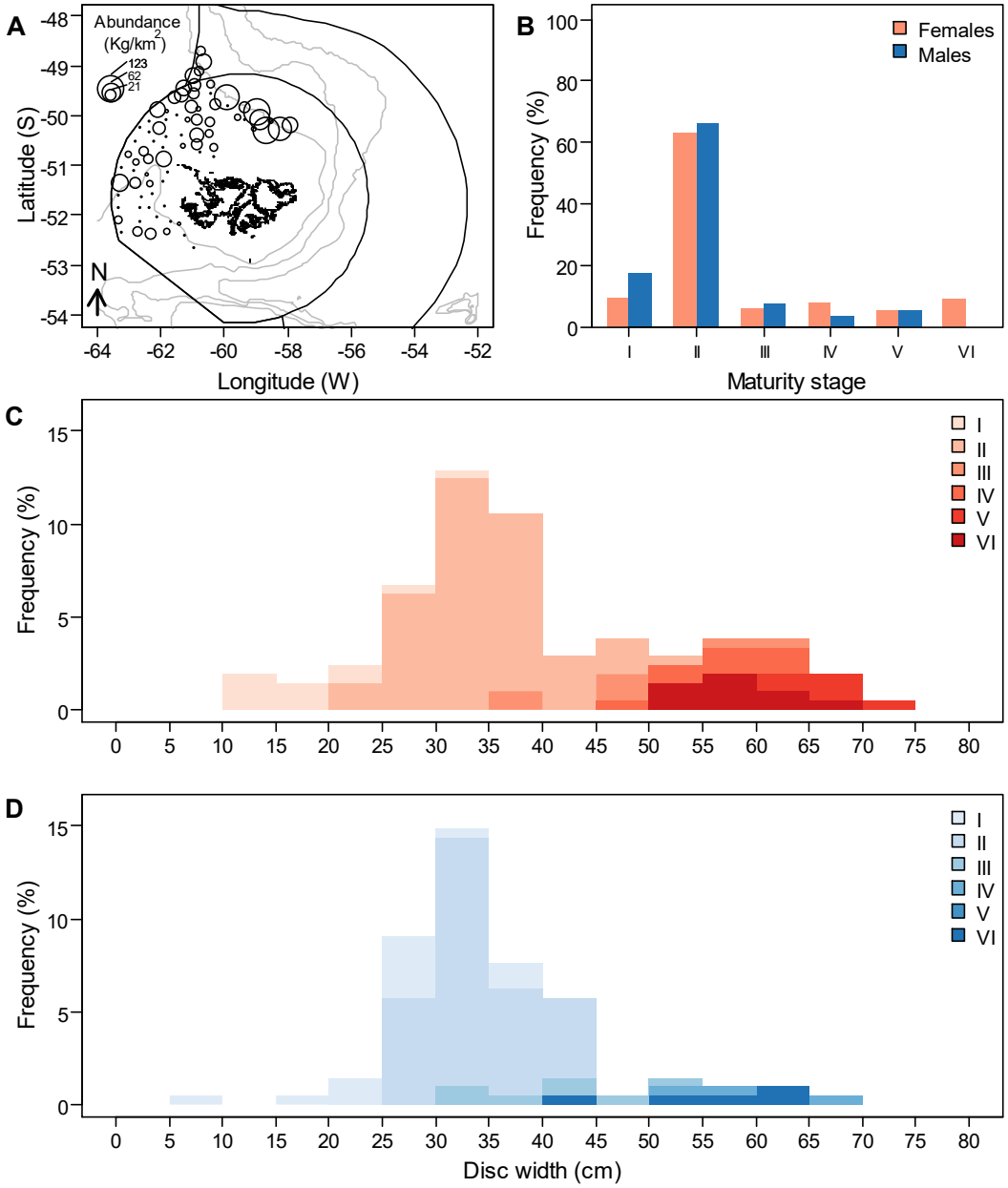

Figure 21. Biological data of *Bathyraja brachyurops* (Blonde skate; RBR). A) Map of the densities in kg/km^2; B) relative frequency (%) of specimens of each sex per maturity stage (I, juvenile; II, adolescent maturing; III, adult developing; IV, adult mature; V, adult laying/running; VI, adult resting); length frequencies (%) of C) females (n = 116) and D) males (n = 92) with 5 cm size class.

3.4.3. *Zearaja chilensis* – Yellow nose skate

The total catch of the yellow nose skate was 177 kg. This species was caught at 31 of the 80 trawl stations sampled through the research cruise. Catches ranged from 0.9 to 22 kg, densities ranged from 4 to 111 kg/km^2, and CPUE ranged from 0.9 to 22 kg/h. Highest densities were observed to the north and to the west of the FICZ (Figure 22A). Most females and males were maturing (maturity stage II), with smaller proportion of developing adults (maturity stage III; Figure 22B). Females were 25–71 cm disc width and modal disc width was identified at the 55–59 cm size class (Figure 22C). Males were 43–55 cm disc width; the small number of males sampled does not allow identifying the modal length of male individuals (Figure 22D).

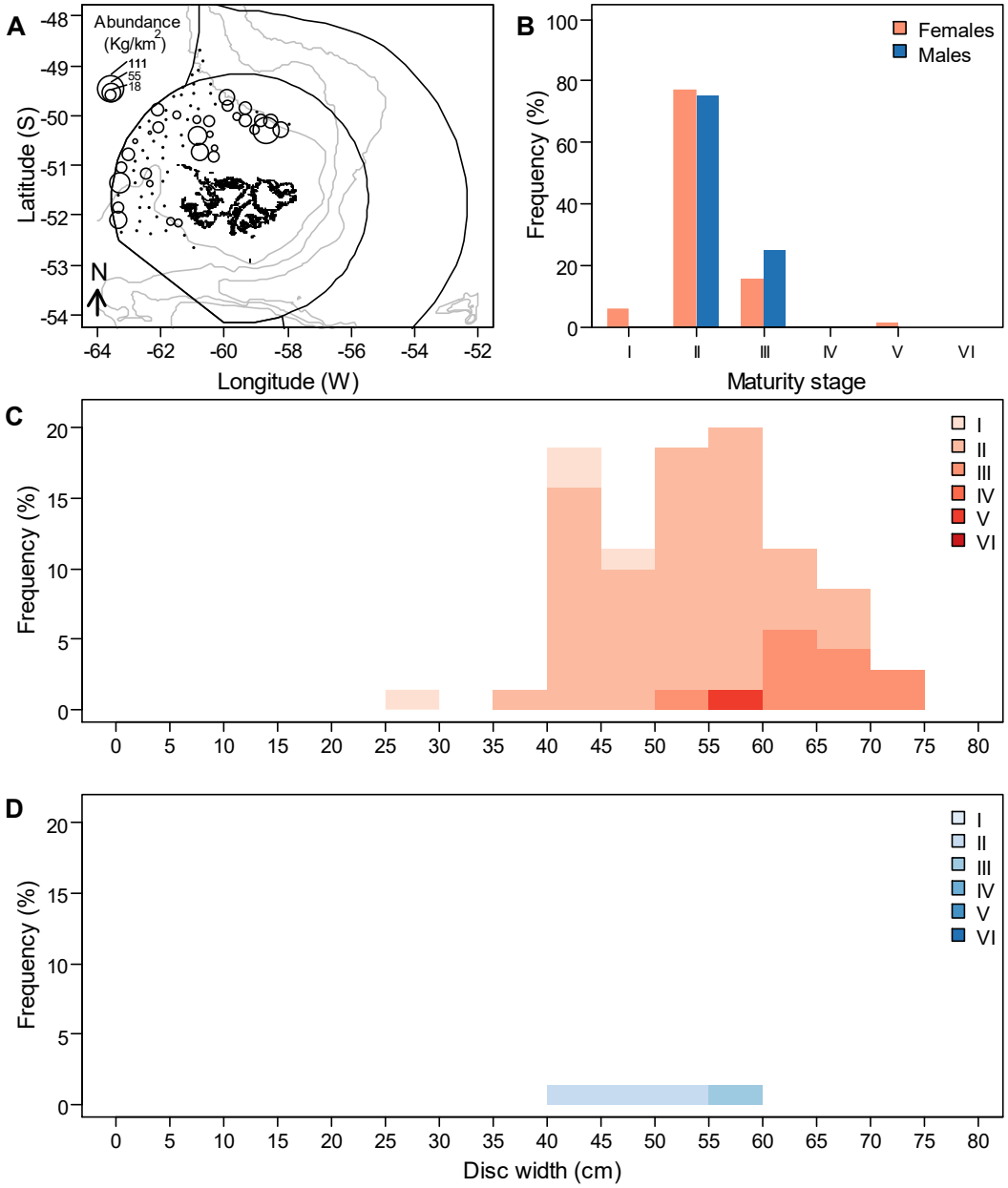

Figure 22. Biological data of *Zearaja chilensis* (Yellow nose skate; RFL). A) Map of the densities in kg/km²; B) relative frequency (%) of specimens of each sex per maturity stage (I, juvenile; II, adolescent maturing; III, adult developing; IV, adult mature; V, adult laying/running; VI, adult resting); length frequencies (%) of C) females (n = 66) and D) males (n = 4) with 5 cm size class.

3.4.4. *Bathyraja griseocauda* – Grey tailed skate

The total catch of the grey tailed skate was 462 kg. This species was caught at 23 of the 80 trawl stations sampled through the research cruise. Catches ranged from 0.2 to 219 kg, densities ranged from 0.9 to 1,004 kg/km^2, and CPUE ranged from 0.2 to 219 kg/h. Highest densities were observed to the north-east and to the south-west of the FICZ (Figure 23A). A total of 83 individuals (45 females, 38 males) were sampled; most females were maturing (maturity stage II) or juveniles (maturity stage I), whereas males were mainly juveniles (maturity stage I) followed by maturing individuals (maturity stage II). However, females and males of all maturity stages were present (Figure 23B). The size of females ranged between 21 cm and 97 cm disc width (Figure 23C). Males size ranged between 16 cm and 91 cm disc width (Figure 23D).

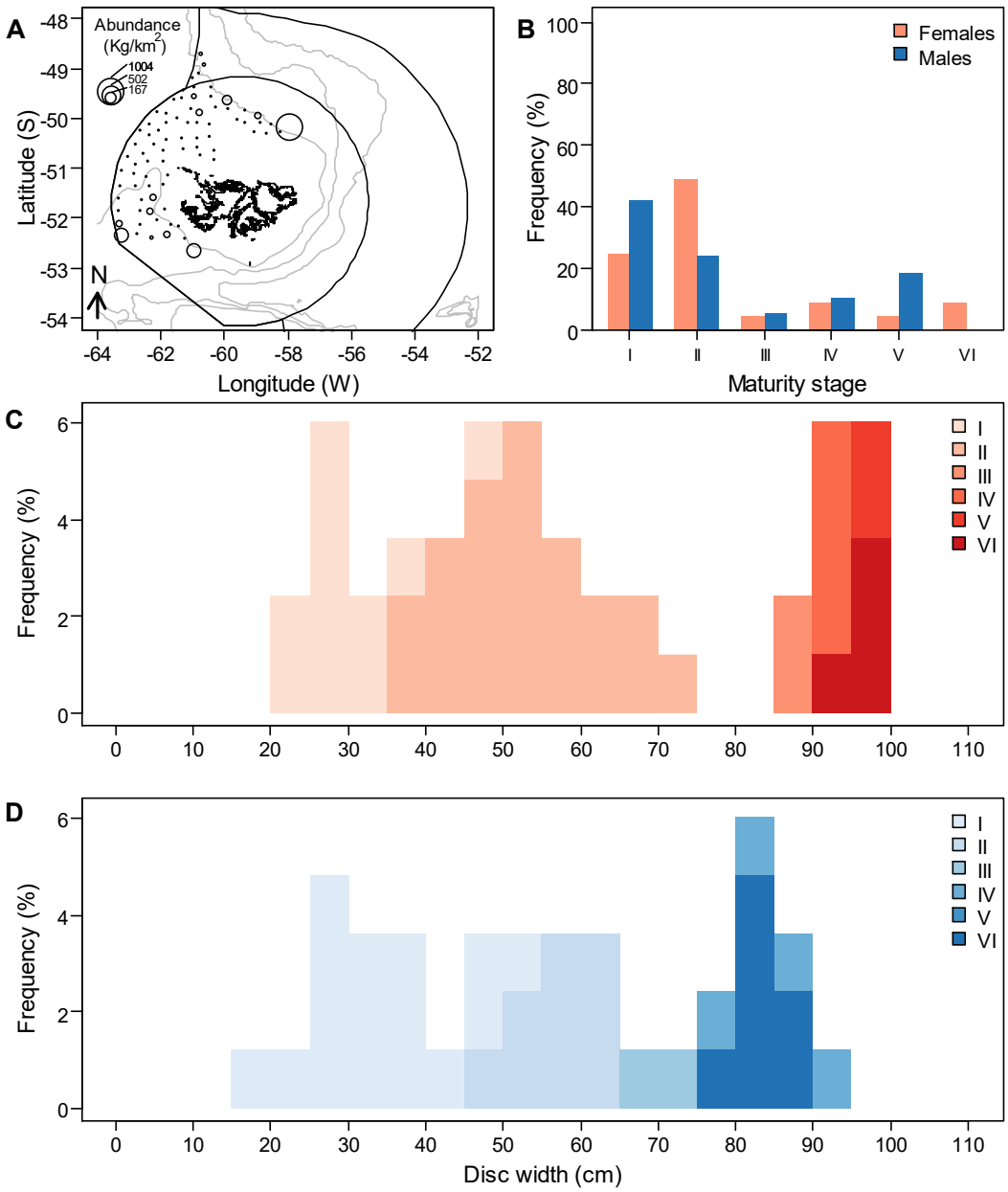

Figure 23. Biological data of *Bathyraja griseocauda* (Grey tailed skate; RGR). A) Map of the densities in kg/km^2; B) relative frequency (%) of specimens of each sex per maturity stage (I, juvenile; II, adolescent maturing; III, adult developing; IV, adult mature; V, adult laying/running; VI, adult resting); length frequencies (%) of C) females (n = 45) and D) males (n = 38) with 5 cm size class.

3.4.5. *Bathyraja macloviana* – Falkland skate

The total catch of the Falkland skate was 76 kg. This species was caught at 39 of the 80 trawl stations sampled through the research cruise. Catches ranged from 0.02 to 7 kg, densities ranged from 0.1 to 31 kg/km^2, and CPUE ranged from 0.02 to 7 kg/h. Highest densities were observed to the north and to the west of the FICZ (Figure 24A). Most females were maturing (maturity stage II), and most males were running (maturity stages V), although a relatively equal proportion of maturing (maturity stage III), developing (maturity stage IV), and mature (maturity stage IV) males were also observed (Figure 24B). Females were 8–41 cm disc width (Figure 24C), and males were 10–38 cm disc width (Figure 24D).

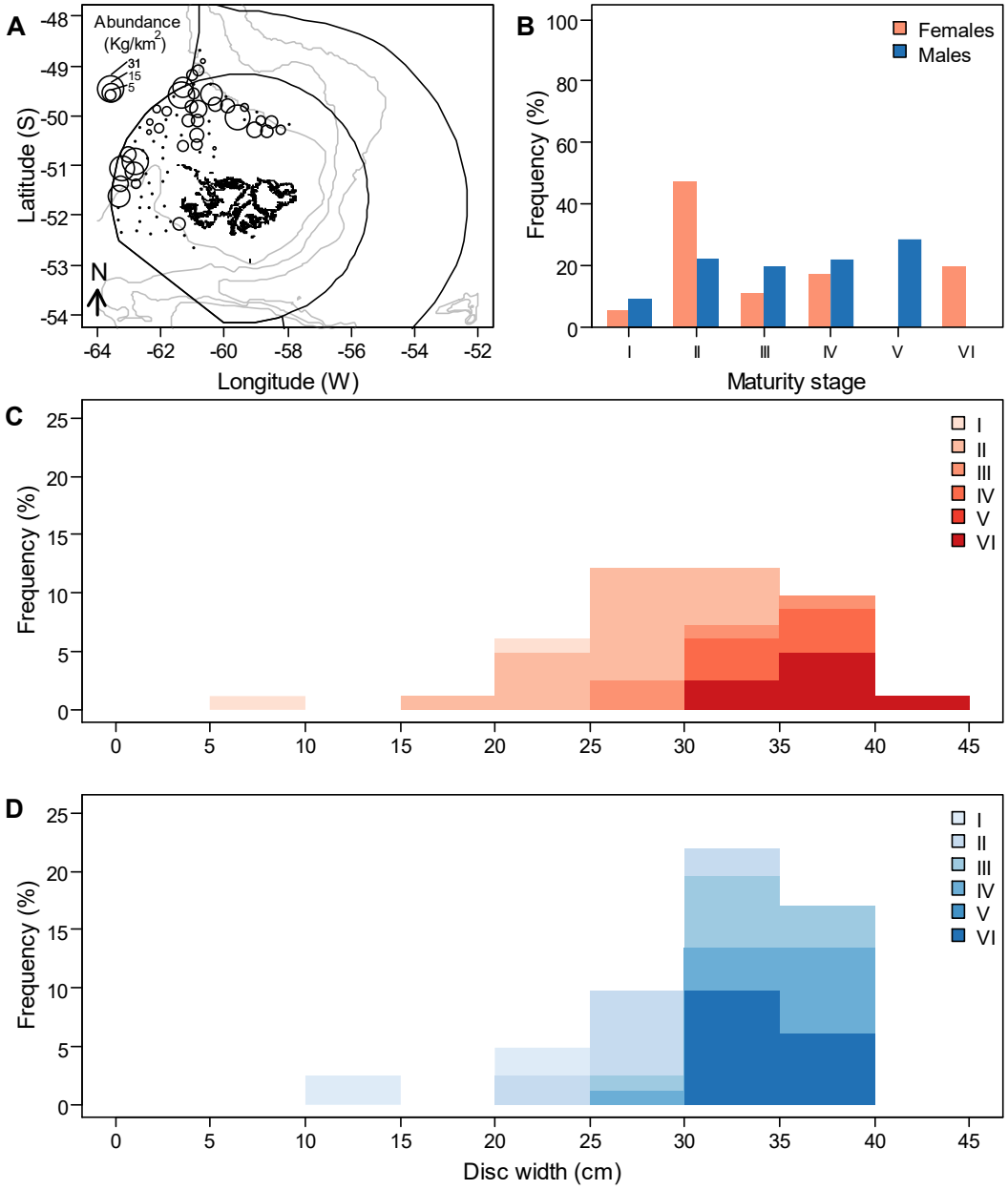

Figure 24. Biological data of *Bathyraja macloviana* (Falkland skate; RMC). A) Map of the densities in kg/km^2; B) relative frequency (%) of specimens of each sex per maturity stage (I, juvenile; II, adolescent maturing; III, adult developing; IV, adult mature; V, adult laying/running; VI, adult resting); length frequencies (%) of C) females (n = 36) and D) males (n = 46) with 5 cm size class.

3.5. Biological information of sharks species

3.5.1. *Schroederichthys bivius* – Catshark

The total catch of catshark was 188 kg. This species was caught at 53 of the 80 trawl stations sampled through the research cruise. Catches ranged from 0.13 to 31 kg, densities ranged from 0.6 to 141 kg/km^2, and CPUE ranged from 0.13 to 31 kg/h. High densities were observed to the north-west near West Falkland (Figure 25A). Relatively similar proportions of maturity stages were found for females, with most individuals at resting (maturity stage II) or mature (maturity stage IV). Most males were juvenile or maturing (maturity stages ≤ II), or mature (maturity stage IV; Figure 25B). Females were 21–65 cm total length, with modal length at 51 cm total length (Figure 25C). Males were 18–74 cm total length, with modal length at 66 cm total length (Figure 25D).

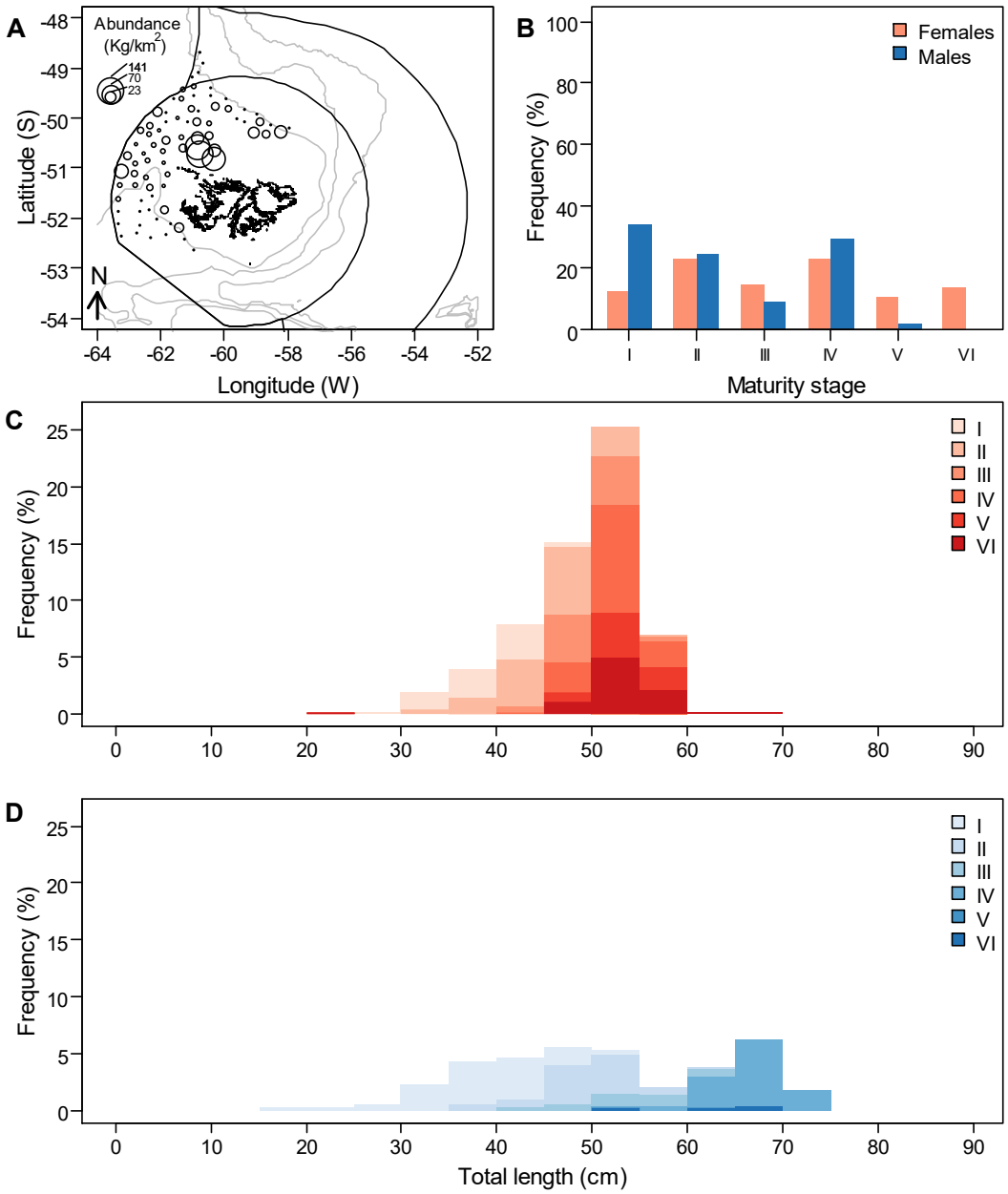

Figure 25. Biological data of *Schroederichthys bivius* (Catshark; DGH); A) Map of the densities in kg/km^2; B) relative frequency (%) of specimens of each sex per maturity stage (I, juvenile; II, adolescent maturing; III, adult developing; IV, adult mature; V, adult laying/running; VI, adult resting); length frequencies (%) of C) females (n = 335) and D) males (n = 194) with 5 cm size class.

3.5.2. *Squalus acanthias* – Dogfish

The total catch of dogfish was 389 kg. This species was caught at 50 of the 80 trawl stations sampled through the research cruise. Catches ranged from 1 to 21 kg, densities ranged from 4.7 to 107 kg/km^2, and CPUE ranged from 1 to 21 kg/h. High densities were observed to the north and north-west (Figure 26A). Most females were maturing (maturity stage II) or developing (maturity stage III). Most males were mature (maturity stage IV) or running (maturity stage V; Figure 26B). Females were 42–89 cm total length, with modal length at about 64–67 cm total length (Figure 26C). Males were 55–78 cm total length, with modal length at 66 cm total length (Figure 26D).

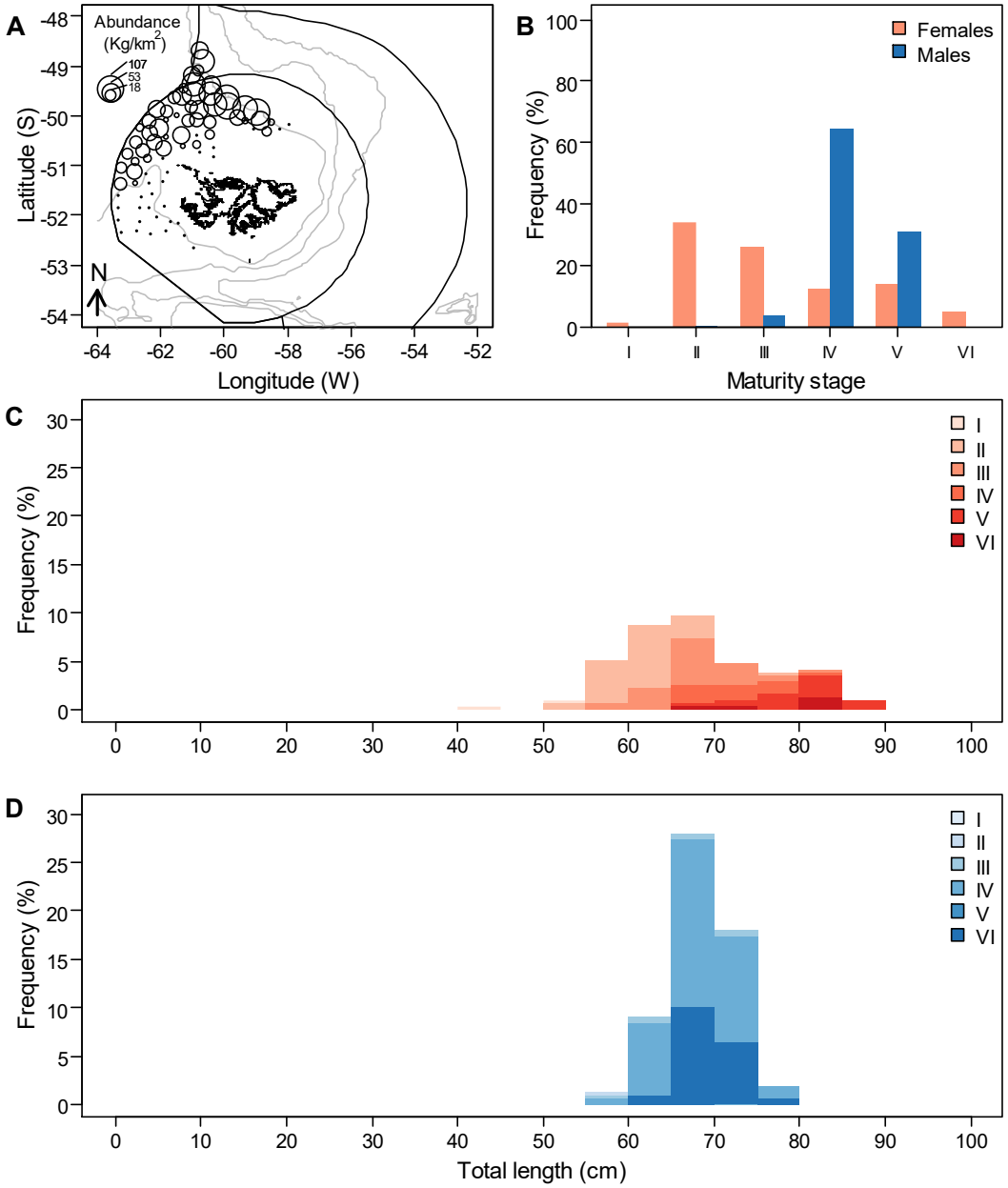

Figure 26. Biological data of *Squalus acanthias* (Dogfish; DGS); A) Map of the densities in kg/km^2; B) relative frequency (%) of specimens of each sex per maturity stage (I, juvenile; II, adolescent maturing; III, adult developing; IV, adult mature; V, adult laying/running; VI, adult resting); length frequencies (%) of C) females (n = 130) and D) males (n = 181) with 5 cm size class.

3.6. Inshore survey

Inshore stations are usually conducted at the beginning of the demersal survey, i.e. February 2019 and 2020 demersal surveys. However, those stations were re-scheduled for the end of the February 2021 demersal survey due to bad weather in the south of Falkland Islands waters during early February.
A total of 4,072 kg were caught at the four inshore stations to the south of the Falkland Islands of which 3,209 kg (79%) consisted of fish and squid species. The most abundant species in the catch was *D. gahi* (3,009 kg, 94% of the fish and squid species). Most of the sampled animals were immature (maturity stage II) but higher frequency of later maturity stages were recorded in comparison with 2020 survey. A total of 19 juvenile toothfish were found in one station (station 3392) to the south of East Falkland. *Notothenia* spp. constituted 3% of the fish and squid species.
Total weight of benthic and semi-pelagic invertebrates was 862 kg. The majority of the benthos catch (679 kg, 79%) consisted of *Munida* sp. The only other groups that were captured in large quantities were Ophiuroidea (basket stars), consisting of 64 kg (7%) and Malacostraca (crabs), which constituted 41 kg (5%) of the catch.

3.6.1. *Dissostichus eleginoides* – Patagonian toothfish

The total catch of Patagonian toothfish was 1.3 kg. This species was caught at 2 of the 4 inshore trawl stations. Catches ranged from 0.4 to 0.9 kg, densities ranged from 0.2 to 5.1 kg/km^2, and CPUE ranged from 0.4 to 0.9 kg/h. The highest density was observed in the station in Falkland Sound to the south-east of West Falkland (Figure 24). A total of 19 juveniles were collected in inshore station, with sizes ranging between 11 and 14 cm total length, and modal length at 13 cm total length.

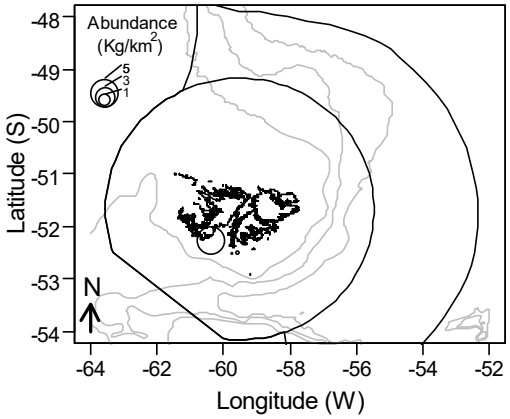

Figure 24. Map of the densities of *Dissostichus eleginoides* (Patagonian toothfish; TOO) in kg/km^2.

3.6.2. *Doryteuthis gahi* – Falkland calamari

The total catch of Falkland calamari in the inshore stations was 3,009 kg. This species was caught at 4 of the 4 inshore trawl stations. Catches ranged from 279 to 1,392 kg and CPUE ranged from 279 to 1,392 kg/h. Greater densities occurred in the Falkland Sound station to the south of West Falkland (Figure 25A). Most females and males were immature (maturity stage II; Figure 25B). Females were 6–16 cm dorsal mantle length (Figure 25C), and males were 6.5–24.0 cm dorsal mantle length (Figure 25D). Modal lengths were detected at 10.5 cm dorsal mantle length for females and at 12 cm dorsal mantle length for males.

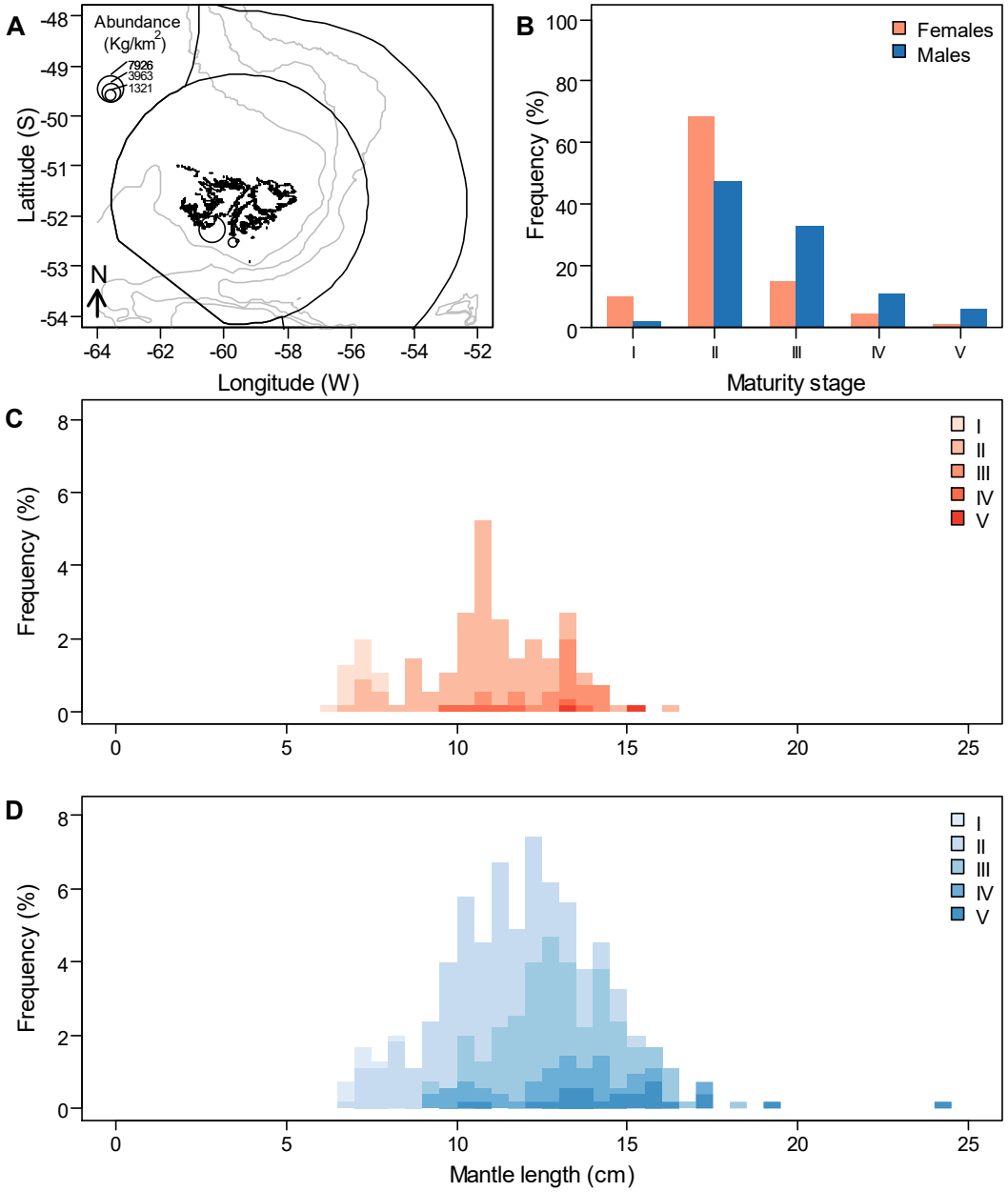

Figure 25. Biological data of *Doryteuthis gahi* (Falkland calamari; LOL) in inshore stations. A) Map of the densities in kg/km^2; B) relative frequency (%) of specimens of each sex per maturity stage (I, immature; II, resting; III, early developing; IV, late developing; V, ripe; VI, running; VII, spent; VIII, recovering spent); length frequencies (%) of C) females (n = 156) and D) males (n = 397) with 0.5 cm size class.

3.6.3. *Champsocephalus esox* – Icefish

The total catch of icefish in the inshore stations was 68 kg. This species was caught at 4 of the 4 inshore trawl stations. Catches ranged from 5 to 51 kg and CPUE ranged from 5 to 51 kg/h. Greater densities occurred to the south-west of East Falkland (Figure 26A). Most females and males were immature or resting (maturity stages ≤ II; Figure 26B). Females were 13–32 cm total length (Figure 26C), and males were 13–33 cm total length (Figure 26D). Modal lengths were detected at 16 cm and at 28 cm total length for females and at 16–17 cm and at 29 cm total length form males.

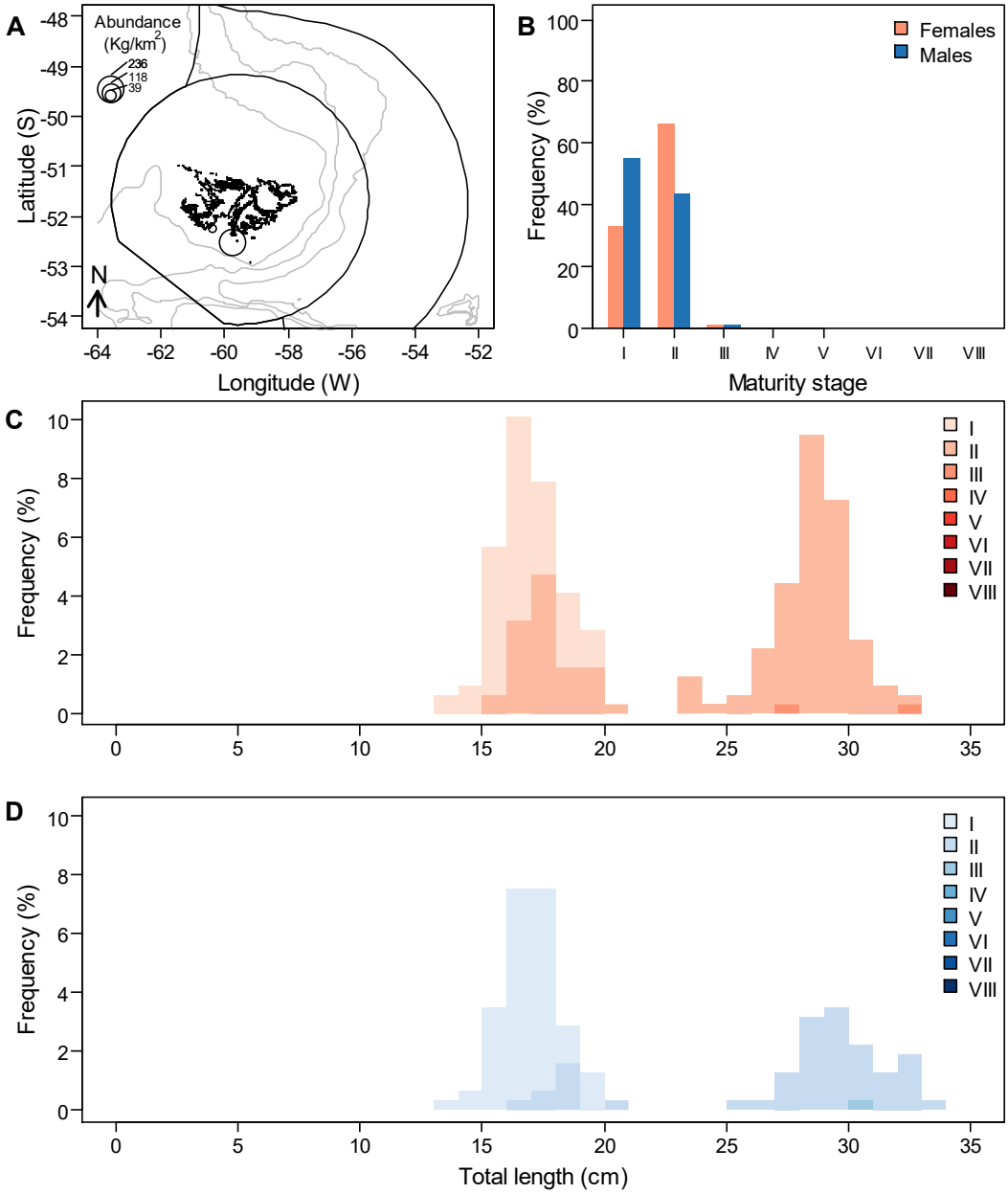

Figure 26. Biological data of *Champsocephalus esox* (Icefish; CHE). A) Map of the densities in kg/km^2; B) relative frequency (%) of specimens of each sex per maturity stage (I, immature; II, resting; III, early developing; IV, late developing; V, ripe; VI, running; VII, spent; VIII, recovering spent); length frequencies (%) of C) females (n = 197) and D) males (n = 121) with 1 cm size class.

3.7. Oceanography

Oceanographic data were collected at 83 stations. The area covered ranged from 48° 39.4'S to 52° 41.9'S and 57° 51.1'W to 63° 19.9'W. Good data were collected at all stations, all the downcasts at these stations were good, and so up-cast data were removed.

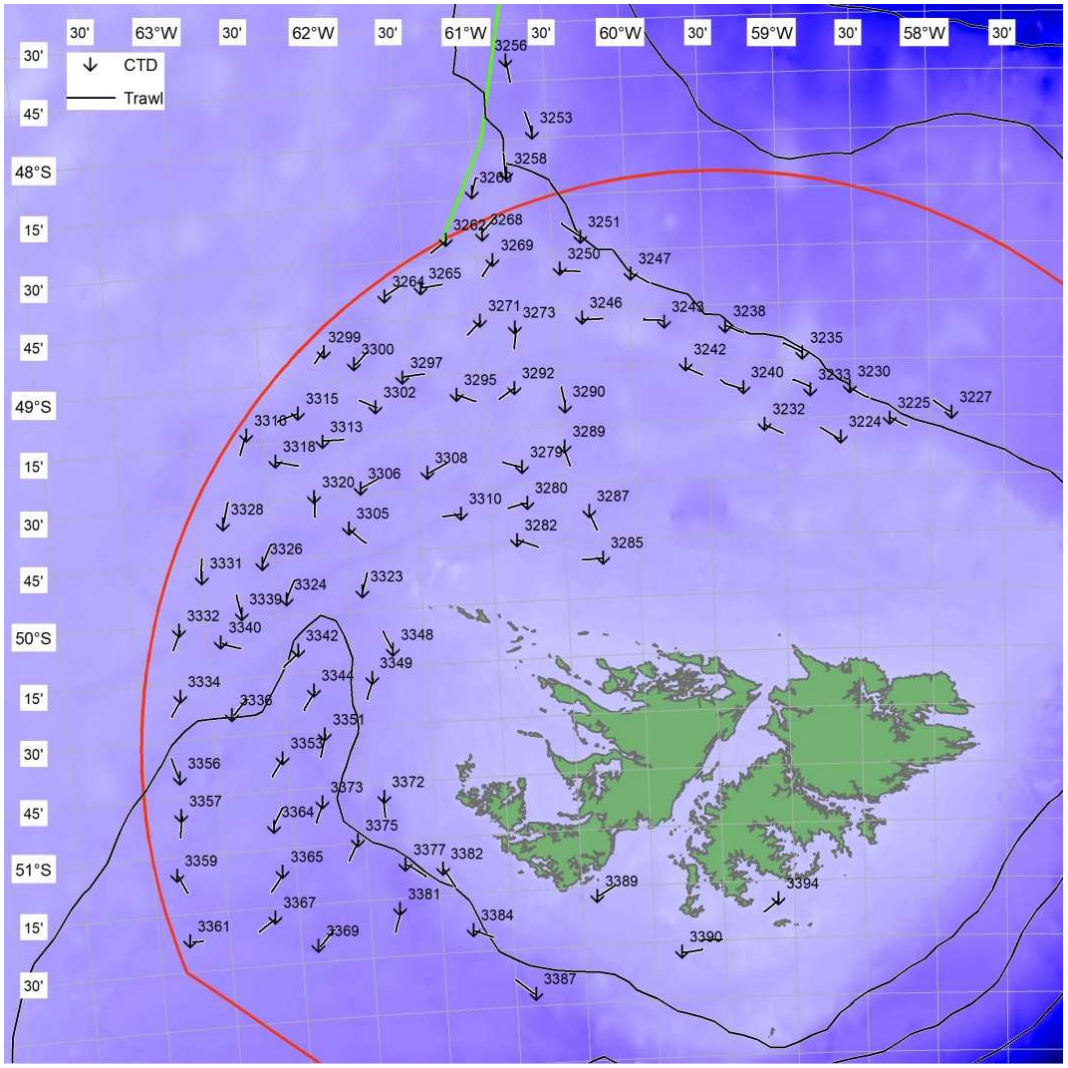

Figure 27. Location and number of CTD stations

Figure 18, Figure and Figure 33 below show the temperature, salinity and σ-t density, gridded using ODV4 DIVA1 gridding algorithm, at depths 10m, 50m, 100m and seabed. The first layer at 10m is the shallowest depth common to all CTD casts. The surveyed area covered depth range of 63 to 368 m.
The temperature data (in Figure 1) 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 to meet the return from the eastern branch, with warmer water on the western edge of the FICZ and around the Falklands.

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

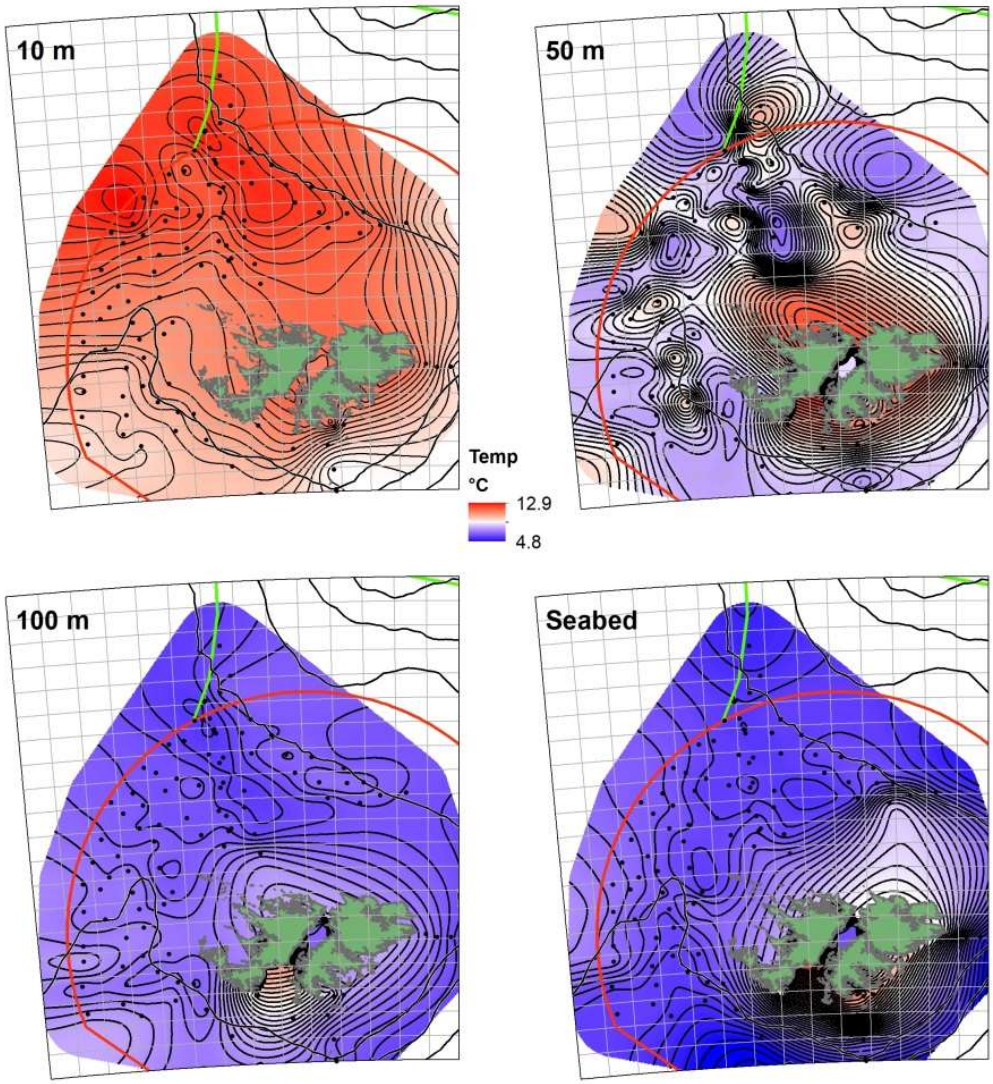

Figure 18. Temperature at 10m, 50m, 100m and seabed (contours at 0.25°C)

Figure and Figure below shows the change in temperature from 2015 to 2020 (reds are warmer in 2020; blues are cooler in 2020 than the previous data sets). The comparison has been undertaken where the 2020 survey overlapped the previous surveys. For 2015-2017 the February CTD transect was used (in 2018 then January data were used as there was no P5 data in February 2018) to compare data in the shallow area to the south surveyed in 2019 and 2020.

At the surface the water is warmer in 2021 than that seen in previous surveys, with the greatest difference seen from that of 2015 and 2016, with the 2021 survey surface warmer across the entire shelf. In 2017 surface was warmer than 2021 in the north-east, with 2021 slightly warmer to the northwest and south west. In 2018 the water was slightly cooler than 2021, apart from the area near the first 3 stations. In 2019 the waters were cooler across the shelf, with only shelf edge warmer in 2019 than 2021. The temperatures were similar (0.5°) in 2020 and 2021 with the west slightly cooler in 2021, and the north slightly warmer. This could be a timing factor with the entire survey conducted in reverse, starting in the north in 2021, and the south in 2020.

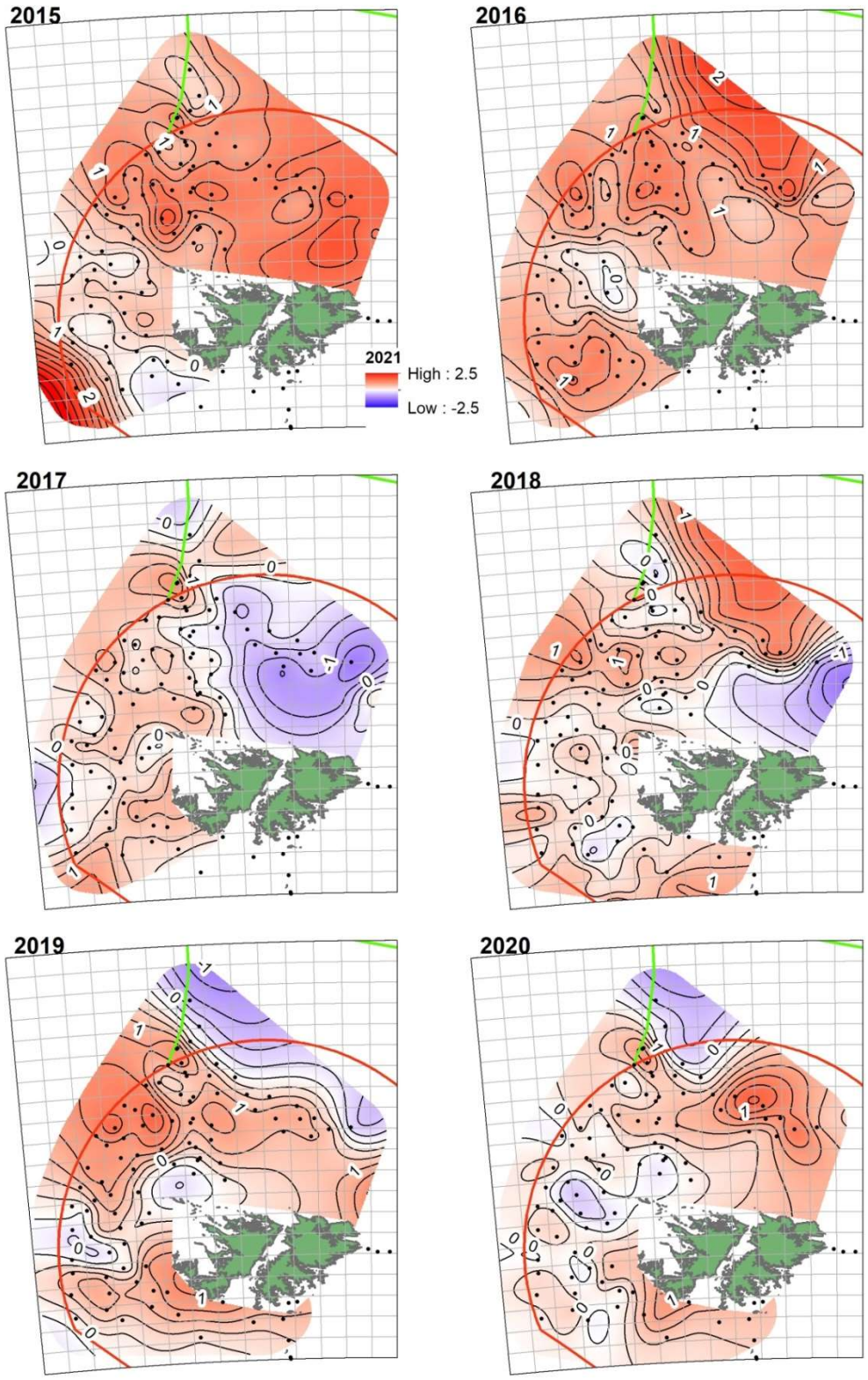

Figure 29. Temperature difference from 2015, 2016, 2017, 2018, 2019 and 2020 at 10 m depth (blues are cooler in 2021, reds are warmer in 2021)

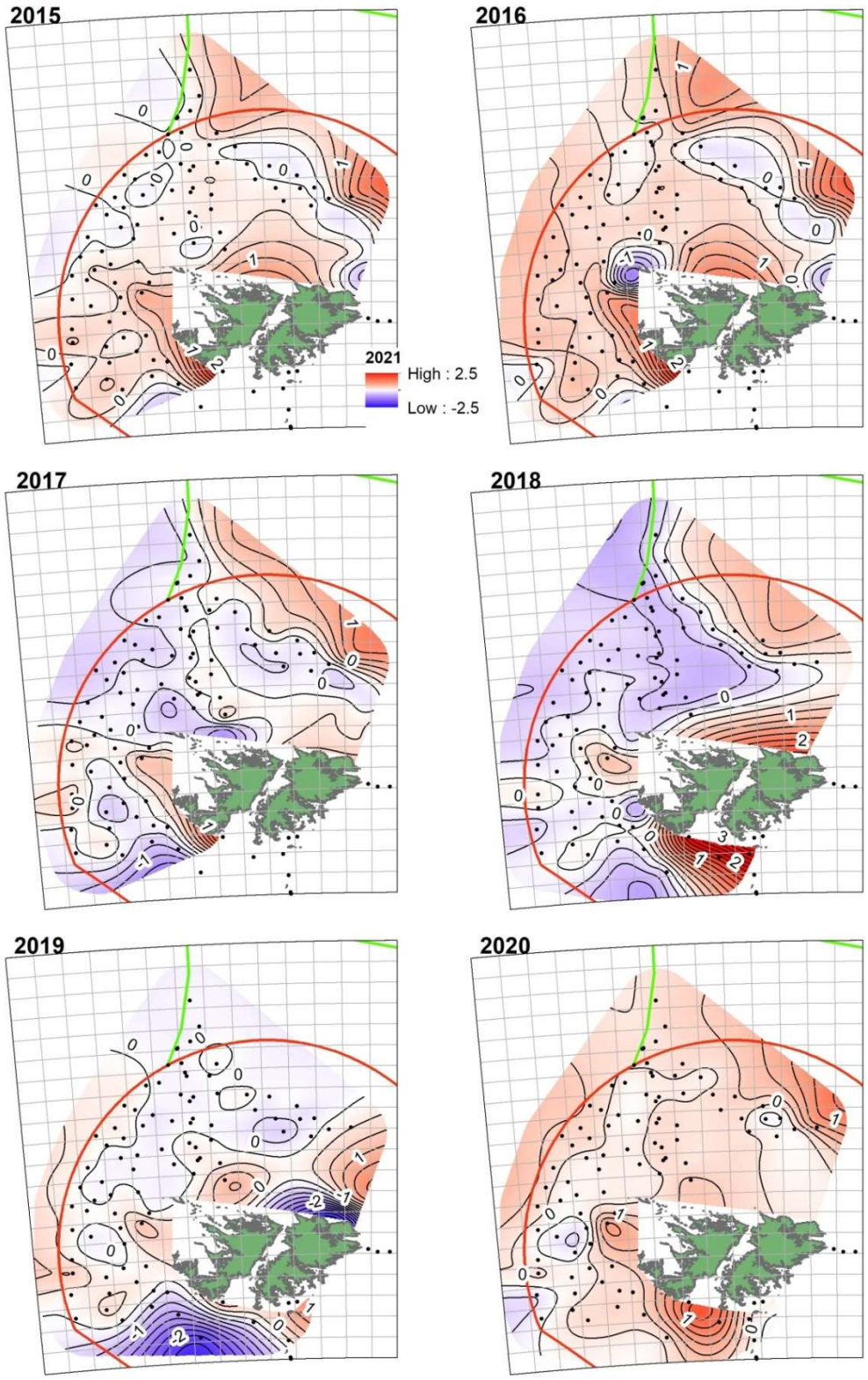

Figure 30. Temperature differences from 2015, 2016, 2017, 2018, 2019 and 2020 at seabed (blues are cooler in 2021, reds are warmer in 2021)

The temperatures at seabed were warmer generally than those in 2015, by up to 1°C, except for the shelf edge/eastern branch of the Falklands Current, , where the temperatures were slightly cooler. The difference is greater in the comparison to 2016, although the pattern is similar with the eastern branch of the Falkland's current slightly cooler in 2021. In 2021 the temperature at seabed is cooler than 2017 and 2018 over the majority of the survey area. In 2019 the temperature at seabed is very similar (less

than 0.5°C warmer) to 2021, with only the most southerly stations being cooler in 2019. In 2020 the majority of the shelf was cooler than in 2021 although the western branch of the Falklands Current is less than 0.5°C warmer in 2021.

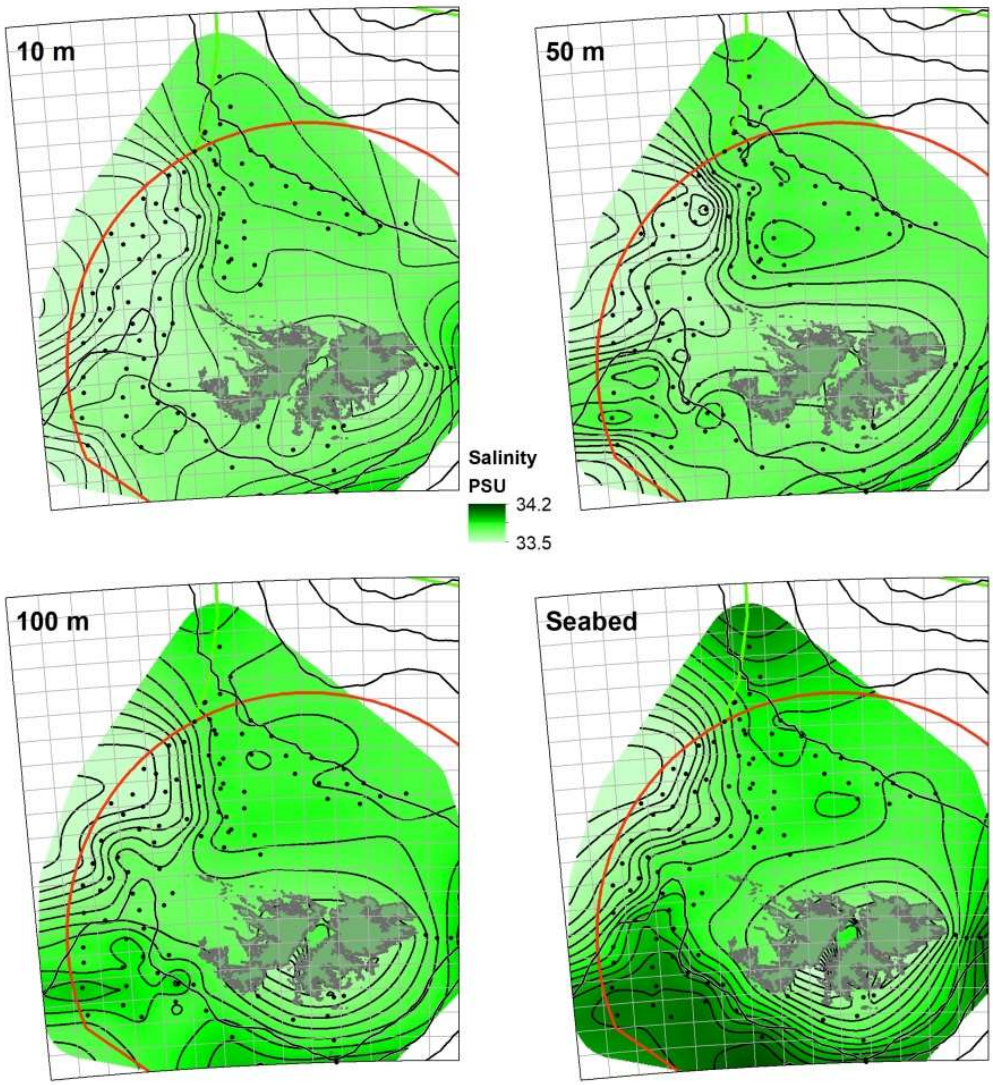

Figure 31. Salinity at 10m, 50m, 100m and seabed (contours at 0.05 PSU)

Figure 31 above shows the salinity over the surveyed area. At surface the salinity is between 33.3 and 33.8 PSU with the lowest salinity in the west, and the highest salinity over the edge of the shelf to the north. As depth increases there is a greater variation, with significant differences at the seabed. In the west the water is less saline increasing in salinity towards the east and over the deeper water at all mapped levels. At seabed salinity is higher the water close to the western branch of the Falklands Current. The waters to the north and in the trough to the south west show measured salinity greater than 34.0 PSU. On the shelf to the west of the Falklands salinity was above 33.8 PSU, with higher salinity water in a stream towards the north east

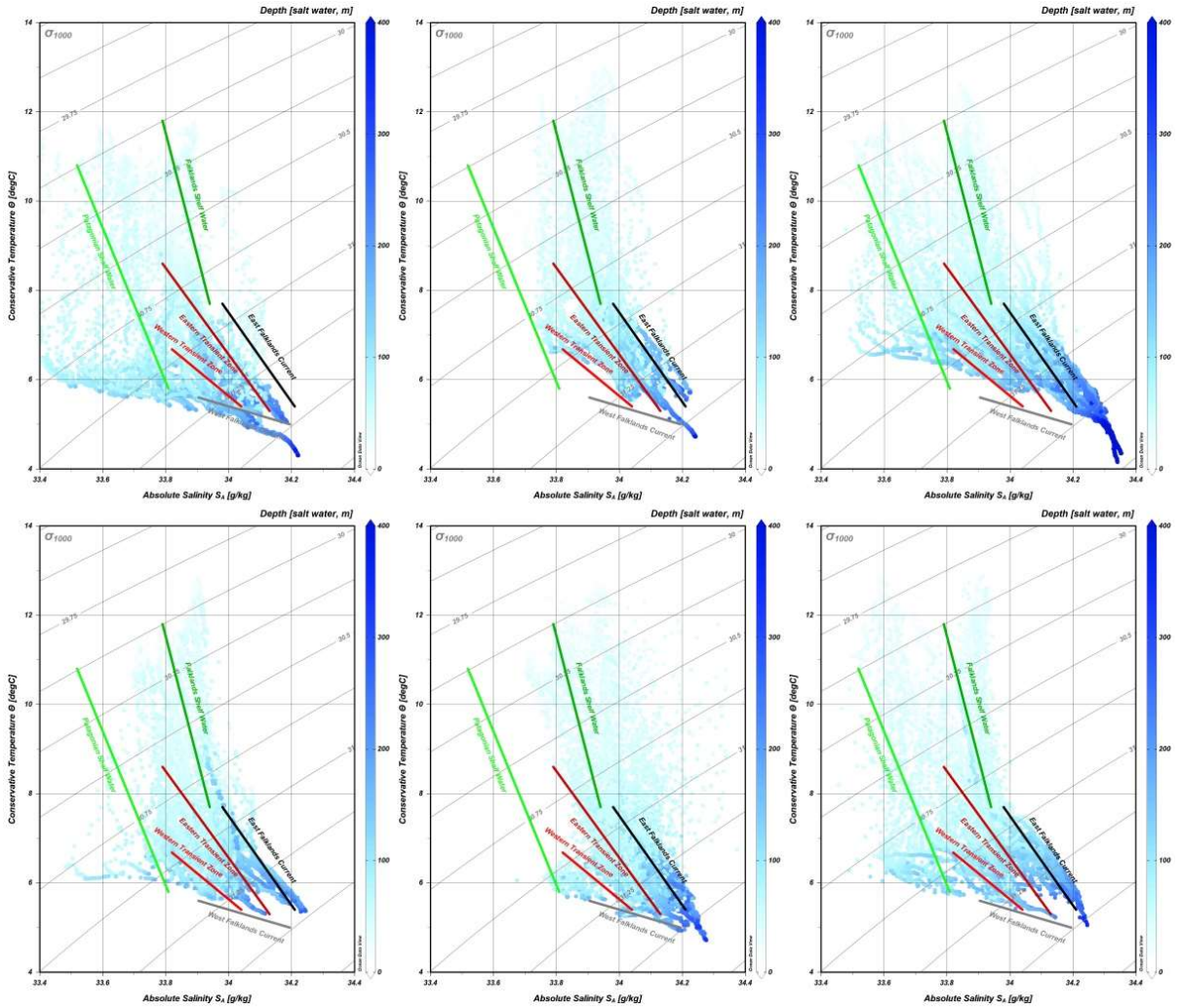

Figure 32. TS plots, 2016 -2021, Top left to bottom right (water mass terminology Arkhipkin et al 2013)

A plot of conservative temperature against absolute salinity is shown in Figure 32 above with comparison to the survey undertaken in February 2016 to 2021. The survey in 2017 and 2020 are lacking in any quantity of Patagonian shelf water, with the shallower water dominated by the Falklands Shelf water. Deeper water is always dominated by the Falklands Current, both the east and west branch.

The density map, Figure 33, below shows lowest density water at 10 metres in the north-west of the zone, reflecting the less dense water of the argentine current with the higher temperatures and lower salinity (seen in Figure 18 and Figure 31). The 50m layer cuts through the mixing layer. At 100 m the Falklands Current is visible 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 to join the gyre formed by eastern branch of the Falklands Current.

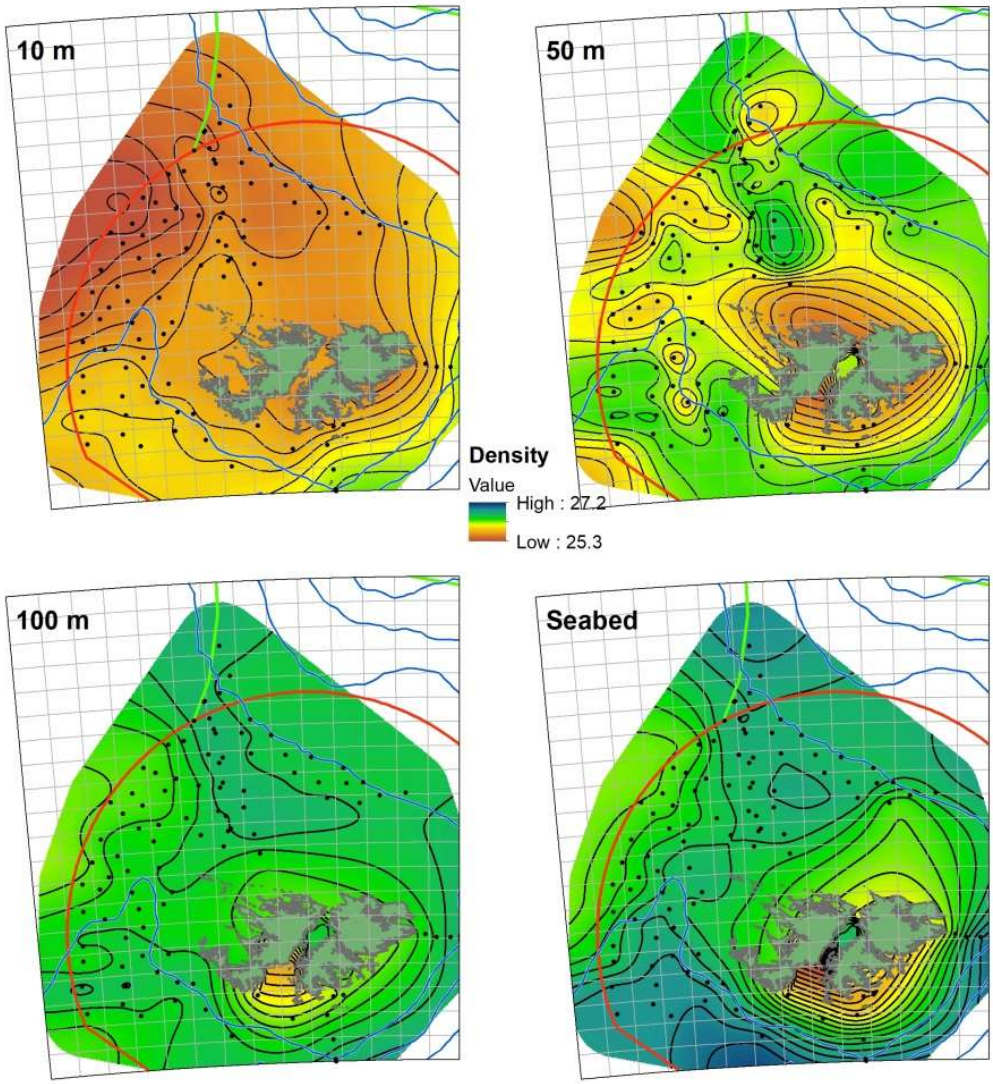

Figure 33. Density at 10m, 50m, 100m and seabed (contours at 0.05 sigma-t)

Figure 34 below shows the oxygen level at 10, 50, 100 and seabed in ml/l of water. Oxygen concentration is highest at the surface, with levels of 6-6.9 ml/l. As water depth increases the oxygen levels fall quickly over the shelf, however in the deeper water to the north and south west the oxygen level levels do not vary greatly, with the southernmost stations only showing a very small decrease in O2 at seabed.

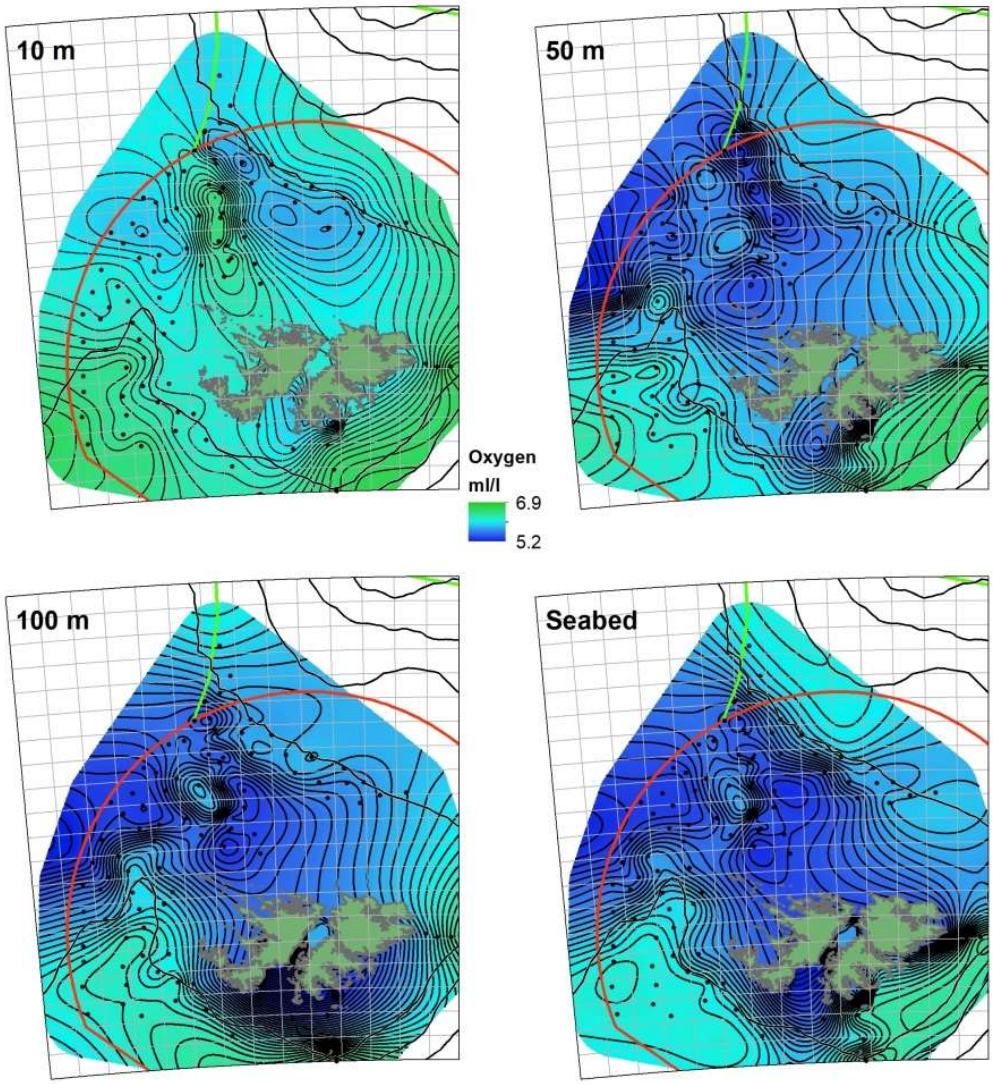

Figure 34. Oxygen at 10m, 50m, 100m and seabed (contours at 0.1ml/l)

Figure 35 below shows the chlorophyll concentration in 10 m intervals to 50 m. Below 50 metres levels of chlorophyll are insignificant. When comparing the chlorophyll to other oceanographic data and the bathymetry it is clear to see the high levels of nutrients 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 west and northwest of West Falkland meeting the warmer less dense surface water from the Argentine current.

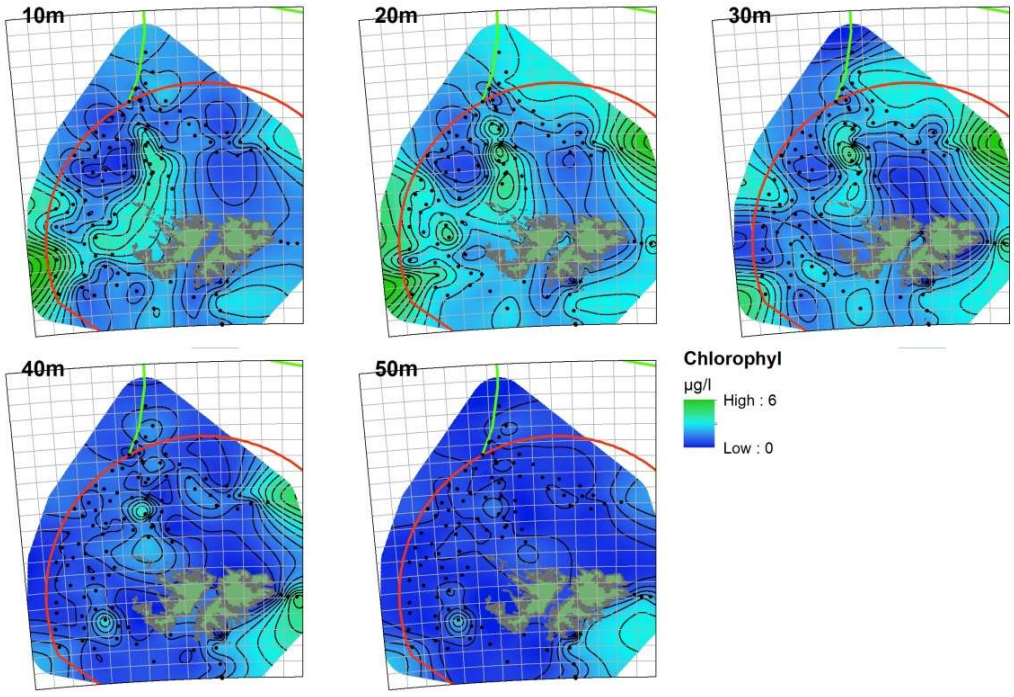

Figure 35. Chlorophyll concentration at 10 to 50 metres

4. Discussion and Conclusions

1. This year sees the early migration of the squid *Illex argentinus* to the north-west of the FICZ. The February 2021 demersal survey had the fourth highest catch (9.6 t) of this species since 2010. Relatively high catches of this species occurred in recent demersal surveys (i.e. since 2018), and the highest catch was reported in 2015. The pattern of the catch is consistent with biomass estimates from February research surveys (including demersal and calamari pre-season surveys). In February 2021, a total of 43,310 t of *I. argentinus* were estimated in Falkland Islands waters (Ramos & Winter 2021). Two cohorts were detected, squids were quite large and mainly at advanced maturity stages.
2. Falkland calamari (*Doryteuthis gahi*) was quite abundant everywhere on the shelf, with largest densities to the south-east of the FICZ. The February 2021 demersal survey had the third highest catch (5.3 t) of *D. gahi* since 2010, whereas the highest catch was reported in 2019 (5.7 t). Sizes (mode at 8 cm mantle length) and sexual maturity (mainly stage II) corresponded to the average values characteristic for this species at this time of the year. All squid belonged to the Autumn Spawning Cohort (ASC).
3. Dense aggregations of hoki (*Macruronus magellanicus*) were found to the south-west of the Falkland Islands at depths deeper than 200 m. This was the second highest catch of hoki (30.5 t) in February demersal surveys since 2010. However, the February 2021 demersal survey had the highest hoki biomass estimate (312,118 t) since 2010, attributed to the high catch of this species in one single station, i.e. station 3362 with 9.9 t of hoki caught (Ramos & Winter 2021). Hoki were small (modal pre-anal length at 23 cm); most of them were immature (maturity stage II) while fewer bigger animals from different cohort were spent or recovering spent stage (VII and VIII). Low numbers of small (13–20 cm pre-anal length) fish were sampled in the February 2021 demersal survey compared with the 2018 and 2020 surveys.
4. Red cod (*Salilota australis*) was abundant in the area of the Argentine inflow in the south-west and north-west of the FICZ. Since 2010, the second lowest catch of red cod was reported for the February 2021 demersal survey (5.7 t), only after the 2020 survey. Accordingly, this is the second lowest biomass estimated for this species (34,341 t) from February demersal and calamari pre-season surveys since 2010 (Ramos & Winter 2021). Low numbers of small (15–20 cm total length) fish were found, which may suggest that recruitment in 2019 was weak.
5. Common hake (*Merluccius hubbsi*) started to migrate to Falkland Islands waters with the Argentine inflow. The catch (8.1 t) of common hake in the February 2021 demersal survey was the highest of any other February demersal survey since 2010, with previous surveys having as much as 3.1 t caught. This is consistent with the highest biomass estimated (33,688 t) from join February demersal and calamari pre-season surveys since 2010 (Ramos & Winter 2021). Accordingly, commercial catches of common hake have increased considerably in Falkland Islands waters during 2019 and 2020 (53,474 t and 43,375 t, respectively) compared with 2010 (nearly 13,000 t) (Falkland Islands Government 2021). Fish were smaller than usual (modal lengths of 37–39 cm total length); large specimens were rare. The majority of fish migrated to the Falkland Islands waters straight after spawning, as suggested by the higher frequency of adult males at maturity stages VII and VIII, and adult females at maturity stages II, VII and VIII.
6. Highest densities of kingclip (*Genypterus blacodes*) occurred to the north-west of the FICZ. Catches of kingclip have been relatively consistent at February demersal surveys, between 3 t and 5 t each survey, except for 2015 with a total catch of 14.6 t. Biomasses estimated from parallel demersal and calamari pre-season surveys have also been relatively stable since 2010, within a range of 14,465 in 2018 to 41,590 t in 2011, except for 2015 with 79,129 t; in February 2021, a total of 20,977 t were estimated (Ramos & Winter 2021). Likewise, commercial catches of kingclip in Falkland Islands waters had little variation and ranged from 1,612 t in 2016 to 3,867 t in 2011 (Falkland Islands Government 2021). Kingclip modal length was at 65 cm total

length for females and at 61 cm total length for males. Modal lengths are higher than those reported during the February 2018–2020 demersal surveys.

7. Rock cod (*Patagonotothen ramsayi*) occurred throughout the entire shelf, with denser concentrations in the northern and south-western parts of the FICZ. However, the abundance of this fish was low and did not exceed 1.3 t/km^2. This year had the third lowest catch (3.8 t) of rock cod at any February survey since 2010, and catches have been lower in recent years. The biomass of rock cod was also the third lowest (59,109 t) since 2010, as estimated from parallel demersal and calamari pre-season surveys; having a declining trend in the last decade (Ramos & Winter 2021). Small sized rock cod (5–6 cm total length) were sampled to the west of the FICZ (station 3355) at a depth of 183 m. Of the three cohorts detected, the medium sized cohort (modal length at 15 cm total length) was more abundant than the larger sized cohort (modal length at 22–23 cm total length).
8. Catch of southern blue whiting (*Micromesistius australis*) in the February 2021 demersal survey was the fourth lowest (338 kg) since 2010, with the lowest catches in recent years. Commercial catches also were the lowest in recent years since 2010, in part due to restrictions on spawning grounds and lack of fishing effort on this species in recent years (Falkland Islands Government 2021). However, biomasses estimated from parallel February demersal and calamari pre-season surveys show that 2021 had the third lowest biomass (22,809 t) since 2010 (Ramos & Winter 2021). Greater abundances of relatively small and immature individuals (modal length at 24 cm total length) were detected to the south-west of the FICZ. Juvenile individuals were scarce during the February 2021 survey, as well as in previous years, suggesting poor recruitment (Ramos & Winter 2021).
9. Adult toothfish (*Dissostichus eleginoides*) are caught mainly in the longline fishery; therefore, the information provided in this report is not representative of the adult portion of the toothfish population. Catches of toothfish in February demersal surveys are usually low (1.4 t), and this year had the second lowest catch (344 kg) since 2010. Juvenile and subadult toothfish were more abundant in deeper areas of the shelf (south-west and north of the FICZ). During the four shallow trawls to the south of the Falkland Islands, 19 juvenile toothfish (11–14 cm total length) were sampled in one single station. Two more juvenile animals were recorded north of East Falkland at 165 m depth. There were no juvenile toothfish sampled during the February 2019 and 2020 demersal surveys. It is important to note that inshore stations were conducted at the end of the February 2021 demersal survey, unlike previous years when these stations were sampled at the beginning of the survey. The presence of juvenile toothfish in nursing areas to the south of the Falkland Islands requires further examination.
10. The catch (6.3 t) of banded whiptail grenadier (*Coelorinchus fasciatus*) was the third highest in the February 2021 demersal survey compared with previous surveys. This is consistent with biomass estimates from parallel February demersal and calamari pre-season surveys, which saw the third highest biomass estimate in February 2021 (66,298 t), whereas the highest biomass was reported in 2010 (86,113 t) (Ramos & Winter 2021). This seems to be a relatively stable stock which length frequencies have remained stable since 2010 (modal length at 9–10 cm pre-anal length; Ramos & Winter 2021).
11. Abundance of butterfish (*Stromateus brasiliensis*) was higher than usual. Catches were recorded in 50 stations, mostly in the north-west part of FICZ. February 2021 sees the fourth highest catch (1.2 t) of butterfish in any February demersal survey since 2010. The highest catches of this species have occurred since 2019. Accordingly, the biomass estimated from the February 2021 demersal and calamari pre-season surveys is the third highest (5,343 t) since 2010 (unpublished data). Migratory schools consisted mainly of adult fish with modal length at 26–28 cm total length; some fish attained 40 cm total length.
12. The highest catch (882 kg) of driftfish (*Seriolella porosa*) was reported in the February 2021 demersal survey relative to previous February demersal surveys since 2010. While in previous demersal surveys driftfish did not exceed 0.03% of the total catch, this year it constituted over 1% of the total catch. All the catches were recorded to the south-west of the FICZ. Higher

catches of driftfish this year could be due to the sampling in the south-west area taking place 10–15 days later in February than in previous years. However, further research on the migratory pattern of this species is required. Migratory schools consisted mainly of adult fish with modal total length at 52–55 cm.

5. Recommendations

1. The number of stations should be consistent across demersal surveys. The inclusion or omission of stations from one year to the next may bias biomass estimates and prevent examination of biomass trends through time.
2. Intrusion of driftfish (*S. porosa*) and butterfish (*S. brasiliensis*) into the FICZ should be further investigated in upcoming years. Collection of samples should be continued in order to understand their role in the Falkland Islands marine ecosystem.
3. Increase in size of kingclip needs to be analysed. Otoliths were collected in order to check whether there is any difference in growth rates comparing with previous years.
4. The MarPort Net Monitoring system did not provide the data for horizontal opening of the net on more than half (n = 44) of the trawls. This issue should be investigated and corrected for upcoming surveys.

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