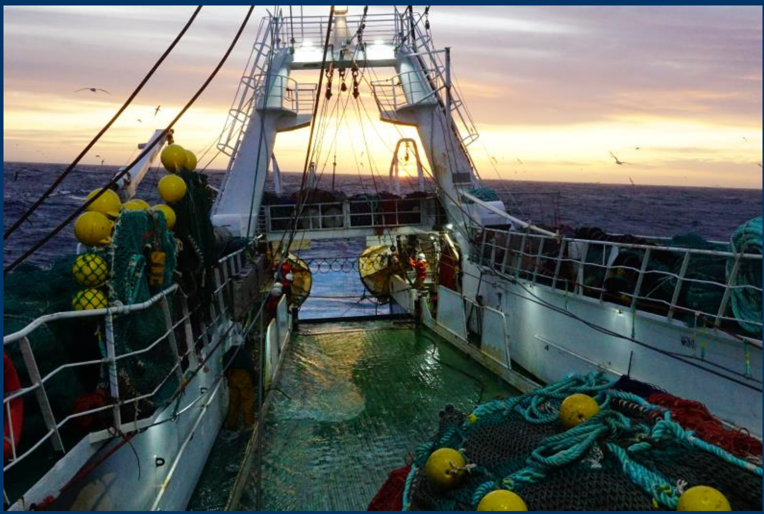
Cruise Report

ZDLT1-07-2022

Demersal Hake Survey



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Stanley, Falkland Islands

ZDLT1-07-2022

DESIRE THE RIGHT

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1. Introduction

In 1986, the Falkland Interim Conservation Zone (FICZ) was declared by the Falkland Islands Government (FIG) and was further extended by the Falkland Outer Conservation Zone (FOCZ) in 1990. The Falkland Shelf lies in the Patagonian large marine ecosystem, one of the most productive regions of the world (Song *et al.*, 2016). The upper-level of circulation is dominated by the opposing flows of the Brazil and Falklands Currents (Agnew, 2002; Croxall and Wood, 2002). The Falkland Current is a north-flowing branch of the Antarctic Circumpolar Current (ACC) that divides into two streams, passing to the west (Patagonian Current) and east (Falklands Current) of the Falkland Islands. These oceanographic features carry cold, productive waters along the continental shelf-break to the south and east of the Falkland Islands (Croxall and Wood, 2002; Arkhipkin, Brickle and Laptikhovsky, 2013). The south-flowing Brazil Current is characterised by the variable formation of warm core eddies and is mainly influential in the northern part of the shelf system (Croxall and Wood, 2002).

High densities of macroplanktonic euphausiid and hyperiid amphipods occur in frontal zones around the Falkland Islands, attracting and sustaining important fish and squid resources (Agnew, 2002; Arkhipkin, Brickle and Laptikhovsky, 2013), taken by multinational fishing fleets operating in the region. Commercial species that inhabit and reproduce in Falkland waters include Patagonian squid *Doryteuthis gahi*, southern blue whiting, *Micromesistius australis*, red cod, *Salilota australis*, Patagonian toothfish, *Dissostichus eleginoides*, rock cod, *Patagonotothen ramsayi*, and a diversity of skate species (Agnew, 2002; Arkhipkin, Brickle and Laptikhovsky, 2013; Laptikhovsky, Arkhipkin and Brickle, 2013). However, some of the most important commercial stocks consist of seasonal foraging migrants such as short-fin squid *Illex argentinus*, hoki *Macruronus magellanicus*, kingclip *Genypterus blacodes* the Patagonian hake *M. australis* and common hake *Merluccius hubbsi* (Arkhipkin *et al.*, 2012; Laptikhovsky, Arkhipkin and Brickle, 2013).

Common hake (hereafter referred to as hake) is a demersal-pelagic species distributed in the southwest Atlantic from 21°S to 55°S, occurring at depths between 50 and 500 m (Vaz-dos-Santos and Rossi-Wongtschowski, 2007). Three regional stocks have been identified, with the Patagonian stock (41°S to 55°S) spawning in Argentinian waters during spring and summer, with a main peak in January (Belleggia *et al.*, 2022). Following the spawning period, adult fish undertake a southerly feeding migration from April into deeper waters on the Falkland Shelf (Agnew, 2002; Arkhipkin *et al.*, 2012). Hake catches were as high as 51,489 t during the early years of the fishery, precipitously declining over the next 6-years to 1,413 t between 1988 and

1994. Catches in the Falkland Islands remained below 4,224 t per year over the next 12 years, during which the commercial fisheries predominantly targeted blue whiting. Following the decline of blue whiting in 2004-2007 (Laptikhovsky, Arkhipkin and Brickle, 2013), hake catches and CPUE began to steadily increase, surpassing rock cod as the primary target of finfish fisheries since 2015.

Since 2010, 10 fisheries independent research surveys were conducted to estimate the biomass, catch composition and demographic structure of demersal fish stocks on the Falkland Shelf. Even though this is the area where hake are generally abundant, all previous surveys were conducted during the late summer months (February), when many seasonal straddling stocks, such as hake, are in Argentine waters for their spawning periods. As such, none of these previous surveys could reliably be used to monitor the population structure of seasonally important species such as hake, and their resultant interactions with other species across the Falkland Shelf. Based on increasing importance of hake on the Falkland Shelf, one previous winter survey was undertaken during July in 2017 (ZDLT1-07-2017; Gras *et al.*, 2017). A hake demography survey was also undertaken during July 2020 (ZDLT1-07-2020; Randhawa *et al.*, 2020).

1.1. Cruise objectives

The main objective of this research cruise was to collect abundance and biological data (length, sex, maturity, otoliths) for common hake during its peak in abundance on the Falkland Shelf. Secondary objectives included: (1) collect abundance and catch compositional and biological data of other commercial and bycatch species; and (2) conduct an oceanographic survey (pressure, temperature, conductivity, oxygen, fluorescence) of the study area.

2. Material and Methods

2.1. Cruise plan and key dates

Scientific surveys are key data sources in fisheries ecology, benefitting from a standardised sampling plan and constant catchability (Hilborn and Walters, 1992; Alglave *et al.*, 2022; Gallo *et al.*, 2022). The Falkland Islands Fisheries Department (FIFD) have carried out annual fisheries independent bottom trawl surveys during Summer (2010, 2011, 2015-2022) and Winter (2017). During these surveys, 84 fixed stations are replicated for each year according to a systematic transect design based on the division of the shelf area (100 – 300 m) into 0.5

longitude by 0.25 latitude decimal degree grid squares. Each station is allocated to an individual grid square to ensure coverage of the entire study area. Additionally, up to 18 floating stations are undertaken each year to broaden the spatial area or cover additional areas of interest in deeper (>300 m) or shallower (<100 m) waters of the shelf. Typically, 84 to 102 trawl stations of 60 minutes take place over a 21-day sampling period during each fishery independent survey.

The survey ZDLT1-07-2022 was conducted aboard the F/V *Castelo* (ZDLT1), registered in the Falkland Islands (LOA 67.8 m, GT 1321). Embarking and disembarking occurred on 6 and 26 July respectively. The cruise was shortened by two days as a result of the earlier start of the X-License fishing season. However, as the number of days of fishing was limited to 19, the survey plan was restricted to cover a minimum of 65 of the statutory 84 trawl stations across the finfish zone, including an additional three deep-water (300 – 400 m) stations to the south-west and one station to the north-east. The retained stations were arranged to cover the full survey area (Figure 1). The vessel departed from Stanley at 20:00 on July 6th and proceeded overnight to the first station located to the southwest of west Falkland. The ship was back in port at 07:00 on July 26th.

2.2. Trawling

A bottom trawl owned by the FIFD was used; the net was 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 that was hauled after 24 minutes (station 3526) due to rough ground. Trawling speed varied between 3.1 and 4.7 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 the net horizontal openings for 27 of the 63 trawl stations.

Three trawls were undertaken during the first four days due to longer setting and hauling times in deeper waters and long steaming periods between stations. Four trawls were undertaken per day thereafter, except for days 13 (3-trawls), 14 (0-trawls), 15 (2-trawls) and 16 (2-trawls) as a result of adverse weather conditions. All stations were preceded or succeeded by an oceanographic station. Despite the loss of sampling days (2 as a result of scheduling and 9 trawls due to weather), 63 out of the minimum targeted 65 trawl stations were completed, with corresponding station numbers ranging from 3522 to 3646 (Table 1).

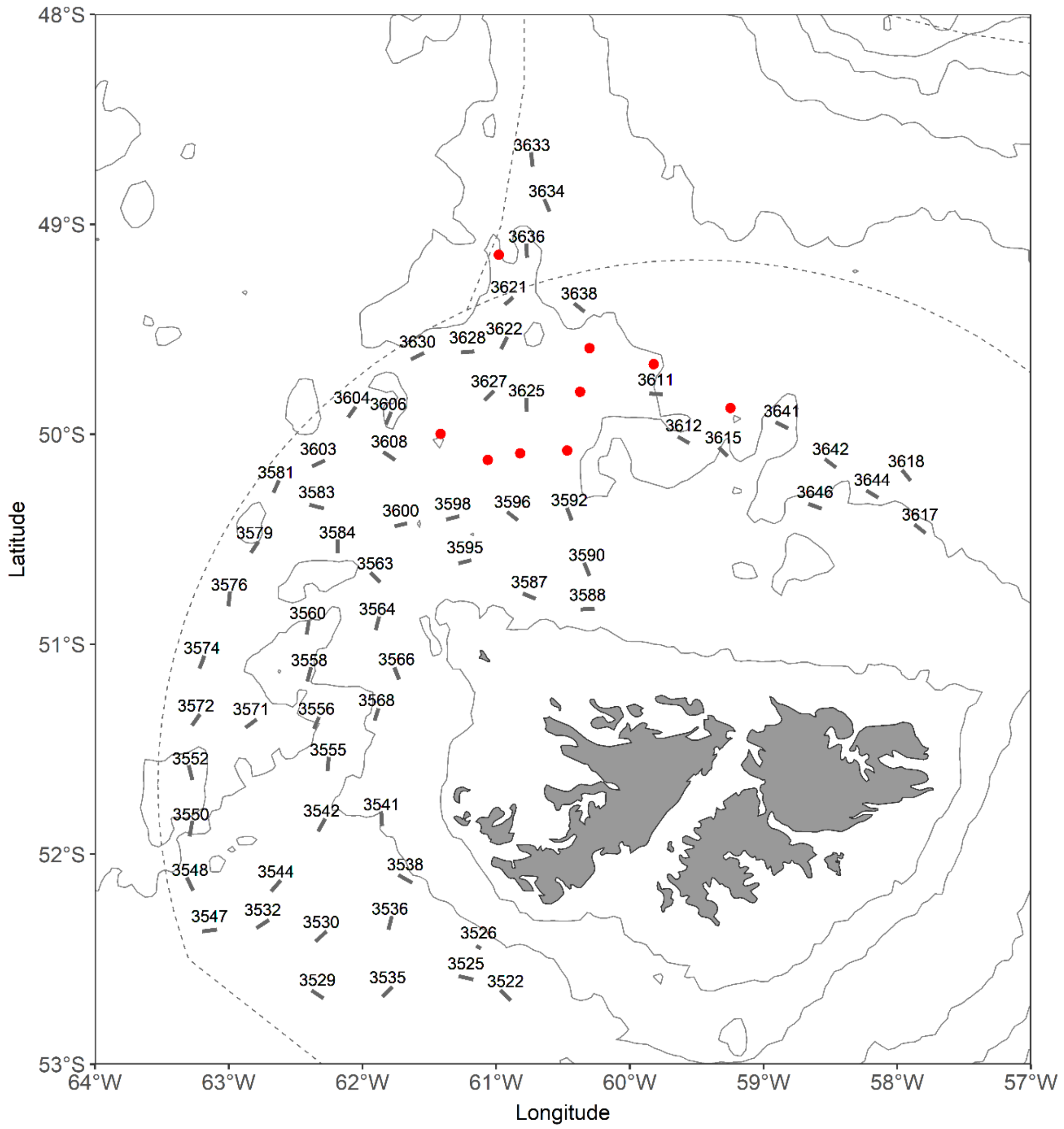


Figure 1: Trawl tracks with station numbers performed during the demersal survey ZDLT1-07-2022 in July 2022. Red dots indicate the nine stations that were excluded from the survey as a result of adverse weather conditions.

2.3. Biological sampling

At each station, all species from the catch were sorted and the total catch was weighed by species with an electronic Marel (150 kg capacity) or Pols (80 kg capacity) balance. All commercial species and most of the bycatch species were sampled (random samples of between 100 and 200 individuals). Biological sampling of finfish included measurement of total or pre-anal length to the lower cm, as well as the macroscopic assessment of sex and maturity according to an eight-stage maturity scale (Nikolsky, 1963). For skates, in addition to total length, disc width was measured to the lower cm; weight, sex, and maturity according to a six-stage maturity scale. For squid, the sampling included the measurement of dorsal mantle length to the lower 0.5 cm, sex and maturity (six-stage maturity scale).

Otoliths were taken from fish according to a combined fixed (FOS) and random (ROS) otolith sampling strategy. For the FOS, otoliths were extracted from 2 to 5 individuals for each 1 cm length bin per sex. Otoliths from an additional 5 to 10 individuals (hake, rock cod, red cod, toothfish and kingclip) were also randomly extracted per station as part of the ROS strategy. During otolith collection, individual total body weights were measured to the nearest gram. Statoliths were not taken during the cruise but samples of *Illex argentinus* and *Doryteuthis gahi* were frozen for statolith extraction at the FIFD laboratory. In addition, several fish and squid specimens were frozen for further analysis ashore.

Table 1: Station data during the demersal survey ZDLT1-07-2022 in July 2022.

Station	Date	Latitude Start	Longitude Start	Latitude Finish	Longitude Finish	Median Depth
3522	07/07/2022	-52.6962	-60.8918	-52.647	-60.9688	377
3525	07/07/2022	-52.5963	-61.1697	-52.5797	-61.282	336
3526	07/07/2022	-52.4492	-61.1142	-52.4352	-61.1495	251
3529	08/07/2022	-52.6858	-62.2918	-52.6478	-62.3818	323
3530	08/07/2022	-52.4152	-62.3508	-52.3663	-62.268	328
3532	08/07/2022	-52.3125	-62.7002	-52.3518	-62.7948	299
3535	09/07/2022	-52.6778	-61.8498	-52.631	-61.7752	335
3536	09/07/2022	-52.3592	-61.8068	-52.2935	-61.7803	309
3538	09/07/2022	-52.1358	-61.6272	-52.0982	-61.7328	277
3541	10/07/2022	-51.866	-61.854	-51.7952	-61.8612	204
3542	10/07/2022	-51.8297	-62.2792	-51.8915	-62.3322	245
3544	10/07/2022	-52.1242	-62.6107	-52.176	-62.6832	287
3547	11/07/2022	-52.3583	-63.0885	-52.3668	-63.1997	258
3548	11/07/2022	-52.1732	-63.2673	-52.1107	-63.3138	248
3550	11/07/2022	-51.915	-63.2932	-51.8393	-63.273	193
3552	11/07/2022	-51.6465	-63.273	-51.5758	-63.3005	214
3555	12/07/2022	-51.6027	-62.261	-51.5362	-62.2537	221
3556	12/07/2022	-51.4023	-62.3633	-51.3462	-62.3247	200
3558	12/07/2022	-51.1772	-62.413	-51.1088	-62.3847	203
3560	12/07/2022	-50.9528	-62.4182	-50.8857	-62.4015	221
3563	13/07/2022	-50.6587	-61.9425	-50.7053	-61.8663	181
3564	13/07/2022	-50.8673	-61.876	-50.932	-61.9022	177

3566	13/07/2022	-51.1097	-61.7632	-51.1675	-61.7257	172
3568	13/07/2022	-51.3053	-61.8805	-51.3633	-61.9102	196
3571	14/07/2022	-51.3572	-62.791	-51.3968	-62.8753	167
3572	14/07/2022	-51.3875	-63.275	-51.3322	-63.2158	176
3574	14/07/2022	-51.1158	-63.2192	-51.054	-63.183	152
3576	14/07/2022	-50.8192	-63.0028	-50.7478	-62.9905	173
3579	15/07/2022	-50.5638	-62.8352	-50.511	-62.7783	105
3581	15/07/2022	-50.2785	-62.6667	-50.2187	-62.6258	149
3583	15/07/2022	-50.3355	-62.3978	-50.3525	-62.289	169
3584	15/07/2022	-50.5022	-62.1883	-50.5663	-62.1877	183
3587	16/07/2022	-50.7573	-60.8013	-50.7828	-60.7038	121
3588	16/07/2022	-50.8333	-60.3693	-50.8307	-60.2635	136
3590	16/07/2022	-50.6737	-60.3017	-50.6107	-60.342	149
3592	16/07/2022	-50.4105	-60.4362	-50.3495	-60.471	169
3595	17/07/2022	-50.614	-61.2827	-50.5993	-61.1863	132
3596	17/07/2022	-50.409	-60.8383	-50.3688	-60.9187	152
3598	17/07/2022	-50.3902	-61.2752	-50.4055	-61.3748	165
3600	17/07/2022	-50.4232	-61.6667	-50.4377	-61.7605	181
3603	18/07/2022	-50.1523	-62.3787	-50.1237	-62.2817	177
3604	18/07/2022	-49.9187	-62.1077	-49.8673	-62.0502	137
3606	18/07/2022	-49.892	-61.7858	-49.9542	-61.8267	208
3608	18/07/2022	-50.0832	-61.8447	-50.1222	-61.756	164
3611	19/07/2022	-49.806	-59.8553	-49.8088	-59.7547	190
3612	19/07/2022	-50.0107	-59.6415	-50.0425	-59.5548	218
3615	19/07/2022	-50.1032	-59.2687	-50.062	-59.3363	198
3617	21/07/2022	-50.4702	-57.7885	-50.4292	-57.871	166
3618	21/07/2022	-50.2215	-57.9	-50.1695	-57.9655	284
3621	22/07/2022	-49.347	-60.8735	-49.383	-60.9367	172
3622	22/07/2022	-49.5362	-60.9173	-49.5937	-60.963	166
3625	23/07/2022	-49.8918	-60.7718	-49.8265	-60.7743	163
3627	23/07/2022	-49.7913	-61.0167	-49.838	-61.0882	142
3628	23/07/2022	-49.6047	-61.1638	-49.6097	-61.2655	156
3630	23/07/2022	-49.6118	-61.5397	-49.6432	-61.6377	154
3633	24/07/2022	-48.6565	-60.739	-48.7248	-60.7273	274
3634	24/07/2022	-48.8792	-60.642	-48.9387	-60.6007	259
3636	24/07/2022	-49.0922	-60.7743	-49.159	-60.7697	191
3638	24/07/2022	-49.3763	-60.4188	-49.4167	-60.3392	262
3641	25/07/2022	-49.9417	-58.9105	-49.9718	-58.8148	123
3642	25/07/2022	-50.1168	-58.5428	-50.1587	-58.4568	269
3644	25/07/2022	-50.2663	-58.232	-50.3013	-58.1427	228

3646	25/07/2022	-50.3538	-58.566	-50.331	-58.6658	154

3. Results

3.1. Catch composition

Catch volume and composition of squid, finfish, skate and other demersal and pelagic species are presented in Table 2. The most abundant species (in terms of catch weight) were common hake *Merluccius hubbsi*, Patagonian squid *Doryteuthis gahi*, rock cod *Patagonotothen ramsayi,* red cod *Salilota australis*, and kingclip *Genypterus blacodes*. Hake constituted nearly 75% of the total catch by weight.

Seven fur seal were caught during station 3571 on the 14th July. Four of the individuals were able to recover, while three did not survive. Two of the fur seals that did not survive appear to have become stuck in the net during shooting, while the third occurred during hauling. Another fur seal was recorded as a mortality during station 3621 on the 22nd of July.

Table 2: Catch composition and weight of species caught, sampled and discarded during the demersal survey ZDLT1-07-2022 undertaken during July 2022.

Species Code	Latin Name	Catch (kg)	Sample	Discards / Galley / Frozen sample	Percent
HAK	*Merluccius hubbsi*	61410.27	3850.83	0	74.367
LOL	*Doryteuthis gahi*	6401.39	186.076	179.376	7.752
PAR	*Patagonotothen ramsayi*	6262.494	408.142	6262.494	7.584
BAC	*Salilota australis*	2208.086	557.466	56.442	2.674
KIN	*Genypterus blacodes*	1724.692	1414.532	0	2.089
GRF	*Coelorinchus fasciatus*	920.96	71.2	920.96	1.115
DGH	*Schroederichthys bivius*	852.225	696.325	852.225	1.032
RFL	*Dipturus lamillai*	462.93	462.93	1.5	0.561
HYD	Hydrozoa	462.821	0	462.821	0.56
MED	*Medusa sp*	282.46	0	282.46	0.342
SPN	Porifera	224.205	0	224.205	0.272
WHI	*Macruronus magellanicus*	203.34	125.7	8.8	0.246
CGO	*Cottoperca trigloides*	155.227	153.447	155.227	0.188
RBR	*Bathyraja brachyurops*	123.572	120.572	5.372	0.15
DGS	*Squalus acanthias*	114.577	114.577	114.577	0.139

TOO	*Dissostichus eleginoides*	104.836	104.836	0	0.127
RGR	*Bathyraja griseocauda*	82.884	82.884	16.104	0.1
SQT	Ascidiacea	59.718	0	59.718	0.072
COP	*Congiopodus peruvianus*	56.186	56.186	56.186	0.068
POR	*Lamna nasus*	45	45	45	0.054
ING	*Onykia ingens*	43.229	8.595	43.229	0.052
RMU	*Bathyraja multispinis*	36.51	36.51	0	0.044
ALG	Algae	29.789	0	29.789	0.036
RAL	*Bathyraja albomaculata*	25.898	25.898	0	0.031
GRC	*Macrourus carinatus*	25.6	25.6	9.28	0.031
BLU	*Micromesistius australis*	22.968	22.66	22.968	0.028
BRY	Bryozoa	21.271	0	21.271	0.026
THO	Thouarellinae	19.924	0	19.924	0.024
RMC	*Bathyraja macloviana*	18.61	18.61	13.36	0.023
RAY	Rajiformes	15	0	0	0.018
MUN	*Munida spp.*	14.406	0	14.406	0.017
RBZ	*Bathyraja cousseauae*	11.81	11.81	0.19	0.014
RED	*Sebastes oculatus*	11.714	11.714	11.714	0.014
PYM	*Notophycis marginata*	11.098	0	11.098	0.013
ALF	*Allothunnus fallai*	10.42	10.42	10.42	0.013
PAT	*Merluccius australis*	9.84	9.84	0.66	0.012
PAG	*Paralomis granulosa*	7.452	0	7.452	0.009
RPX	*Psammobatis spp.*	6.932	6.932	6.932	0.008
ILL	*Illex argentinus*	6.245	6.121	4.259	0.008
ZYP	*Zygochlamys patagonica*	5.742	0	5.742	0.007
RDO	*Amblyraja doellojuradoi*	5.498	5.478	5.498	0.007
STA	*Sterechinus agassizii*	4.908	0	4.908	0.006
ANM	Anemonia	4.833	0	4.833	0.006
GOC	*Gorgonocephalus chilensis*	4.4	0	4.4	0.005
MUL	*Eleginops maclovinus*	4.11	4.11	4.11	0.005
MLA	*Muusoctopus longibrachus akambei*	3.78	3.32	3.78	0.005
MUE	*Muusoctopus eureka*	3.25	3.25	1.26	0.004
EEL	*Iluocoetes/Patagolycus mix*	2.754	0	2.754	0.003
MIR	*Mirostenella sp.*	2.248	0	2.248	0.003
FUM	*Fusitriton m. magellanicus*	1.897	0	1.897	0.002
OPV	*Ophiacantha vivipara*	1.673	0	1.673	0.002
BUT	*Stromateus brasiliensis*	1.66	1.66	1.66	0.002
OCM	*Enteroctopus megalocyathus*	1.528	1.528	1.528	0.002
CAZ	*Calyptraster sp.*	1.459	0	1.459	0.002

ASA	*Astrotoma agassizii*	1.366	0	1.366	0.002
CIR	Cirripedia	1.356	0	1.356	0.002
SEP	*Seriolella porosa*	1.34	1.34	1.34	0.002
RSC	*Bathyraja scaphiops*	1.24	1.24	1.24	0.002
PAU	*Patagolycus melastomus*	1.19	0	1.19	0.001
FLX	*Flabellum spp.*	1.01	0	1.01	0.001
COT	*Cottunculus granulosus*	1	0.4	1	0.001
CAS	*Campylonotus semistriatus*	0.982	0	0.682	0.001
AUC	*Austrocidaris canaliculata*	0.945	0	0.945	0.001
OCC	*Octocorallia sp*	0.941	0	0.941	0.001
CEX	*Ceramaster sp.*	0.839	0	0.839	0.001
POA	*Glabraster antarctica*	0.795	0	0.795	0.001
CTA	*Ctenodiscus australis*	0.738	0	0.738	0.001
COG	*Patagonotothen guntheri*	0.716	0	0.716	0.001
NEM	*Psychrolutes marmoratus*	0.66	0.66	0.66	0.001
COL	*Cosmasterias lurida*	0.52	0	0.52	0.001
SUN	*Labidiaster radiosus*	0.446	0	0.446	0.001
THB	*Thymops birsteini*	0.41	0	0.41	0
ADA	*Adelomelon ancilla*	0.386	0	0.386	0
EGG	Eggmass	0.355	0	0.355	0
BAO	*Bathybiaster loripes*	0.354	0	0.354	0
PSX	Psolidae	0.282	0	0.282	0
OPL	*Ophiura lymani*	0.267	0	0.267	0
MAM	*Neoachiropsetta milfordi*	0.26	0.26	0.26	0
MAV	*Magellania venosa*	0.23	0	0.23	0
BRM	*Brucerolis macdonnellae*	0.227	0	0.227	0
SAL	*Salpa sp.*	0.224	0	0.224	0
AST	Asteroidea	0.186	0	0.186	0
MUG	*Munida gregaria*	0.145	0	0.145	0
TRP	*Tripylaster philippi*	0.144	0	0.144	0
EUL	*Eurypodius latreillii*	0.14	0	0.14	0
WRM		0.137	0	0.137	0
ANT	Anthozoa	0.135	0	0.135	0
ALC	Alcyoniina	0.106	0	0.106	0
HEX	*Henricia sp.*	0.101	0	0.101	0
NUD	Nudibranchia	0.094	0	0.094	0
PES	*Peltarion spinulosum*	0.093	0	0.093	0
PYX	Pycnogonida	0.085	0	0.085	0
SAR	*Sprattus fuegensis*	0.084	0.084	0.084	0
CHO	*Chondrocladia sp.*	0.074	0	0.074	0

CYX	*Cycethra sp.*	0.065	0	0.065	0
ERR	*Errina sp.*	0.064	0	0.064	0
EUO	*Eurypodius longirostris*	0.06	0	0.06	0
UCH	Echinoidea	0.06	0	0.06	0
THN	*Thysanopsetta naresi*	0.058	0.058	0	0
PRX	*Paragorgia sp.*	0.054	0	0.054	0
ACS	*Acanthoserolis schythei*	0.05	0	0.05	0
DIA	*Diaulula spp.*	0.048	0	0.048	0
POL	Polychaeta	0.047	0	0.047	0
ODP	*Odontaster pencillatus*	0.04	0	0.04	0
BAL	*Americominella longisetosus*	0.034	0	0.034	0
LIR	*Limopsis marionensis*	0.028	0	0.028	0
ANN	Annelida	0.024	0	0.024	0
GYN	*Gymnoscopelus nicholsi*	0.024	0	0.024	0
OPH	Ophiuroidea	0.024	0	0.024	0
SRP	*Semirossia patagonica*	0.022	0	0.022	0
GAY	Gastropoda	0.02	0	0.02	0
LOS	*Lophaster stellans*	0.016	0	0.016	0
BER	*Berthella spp.*	0.014	0	0.014	0
TED	*Terebratella dorsata*	0.012	0	0.012	0
GOR	Gorgonacea	0.01	0	0.01	0
HCR	Paguroidea	0.007	0	0.007	0
AGO	*Agonopsis chiloensis*	0.006	0.006	0.006	0
ISO	Isopoda	0.006	0	0.006	0
PAE	*Patagonotothen elegans*	0.006	0.006	0.006	0
STS	*Stereomastis suhmi*	0.006	0	0.006	0
SET	Sertulariidae	0.005	0	0.005	0
TRX	*Trophon sp.*	0.004	0	0.004	0
OIB	*Oidiphorus brevis*	0.003	0.003	0.003	0
BIV	Bivalvia	0.002	0	0.002	0
NUH	*Nuttallochiton hyadesi*	0.002	0	0.002	0
PLU	Primnoidae	0.002	0	0.002	0
PRD	Primnoidae	0.002	0	0.002	0
PRI	Priapulida	0.002	0	0.002	0
HOL	Holothuroidea	0.001	0	0.001	0
OPS	*Ophiactis asperula*	0.001	0	0.001	0

3.2. Biological information of finfish species

3.2.1. Merluccius hubbsi – Common hake

The total catch of common hake was 61,410 kg. This species was caught at all 63 trawl stations. Catches ranged from 7.6 to 7,681 kg, and densities ranged from 36.7 to 36,390 kg/km^2. While hake were observed across the study area, the densest aggregations occurred to the north and northwest adjacent to the 200 m depth contour and near the limit of the FICZ (Figure 2). Most of the females were spent, recovering spent (maturity stages ≥ VII) or resting (maturity stage II). Most males were spent or recovering spent (maturity stages ≥ VII). Females were 30–85 cm total length, and males were 30–49 cm total length. The length frequency distribution showed unimodal patterns with modal lengths of 42 cm total length for females (Figure 4C) and 38 cm total length for males. The female length distribution was skewed to the right indicating a greater proportion of larger individuals compared to males.

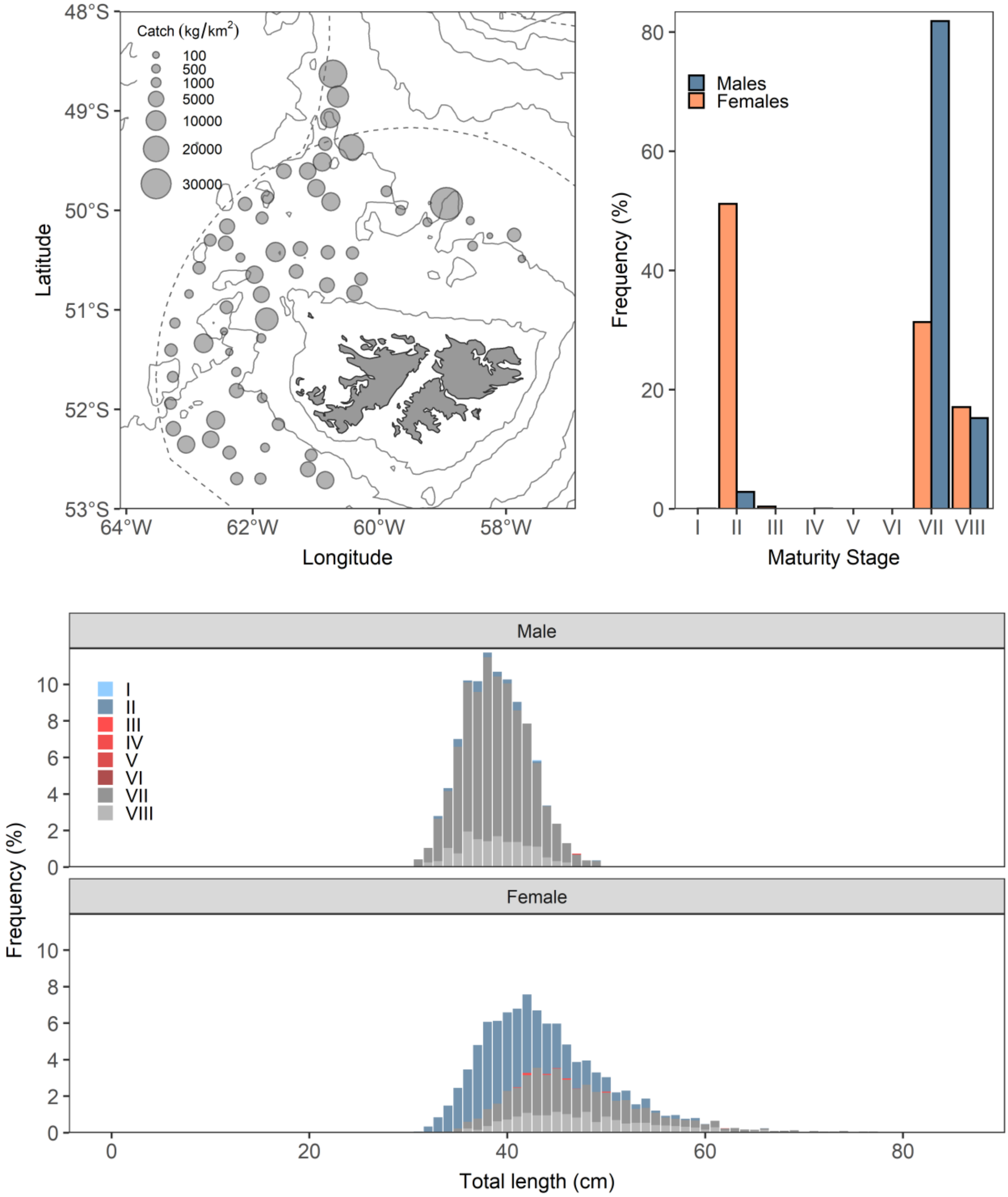
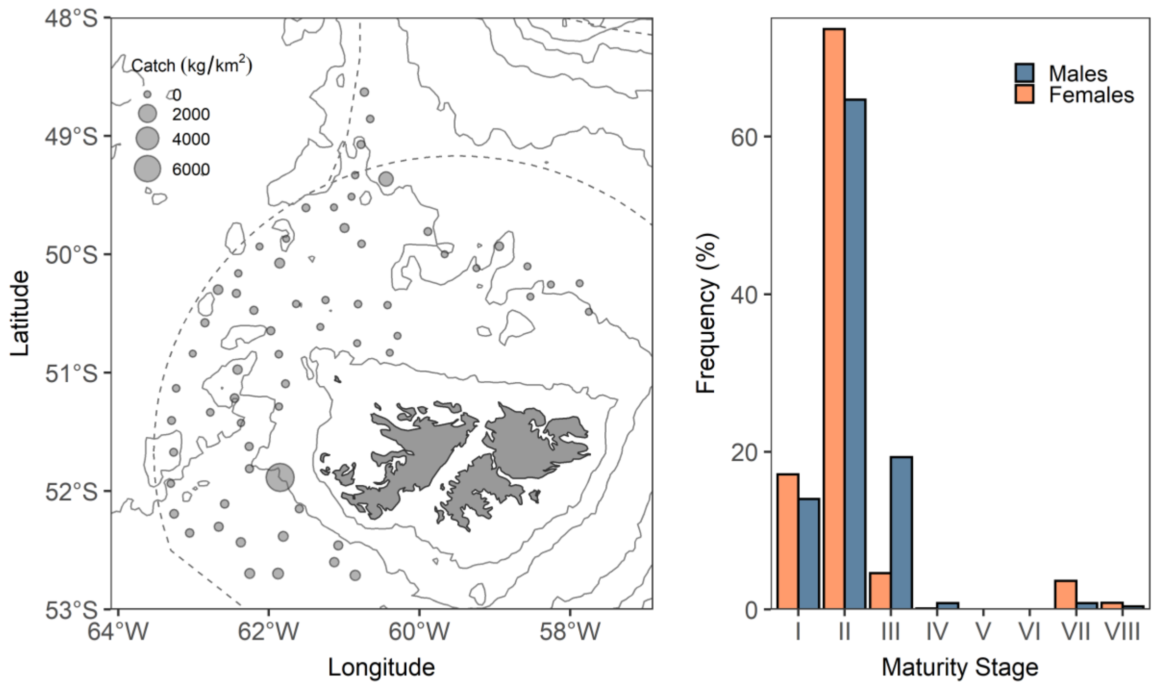


Figure 2: Biological data of *Merluccius hubbsi* (Common hake; HAK). A) Map of the densities in kg/km2; B) relative frequency (%) of specimens of each sex per maturity stage (I, immature; II, resting; III, early developing; IV, late developing; V, ripe; VI, running; VII, spent; VIII, recovering spent); length frequencies (%) of C) females (n = 4330) and D) males (n = 1899) with 1 cm size class.

3.2.2. *Salilota australis* – Red cod

The total catch of red cod was 2,208 kg. This species was caught at 50 of the 63 trawl stations (79%) sampled throughout the research cruise. Catches ranged from 0.036 to 1,587 kg, densities were 0.178 to 7,174 kg/km^2. A single large catch of red cod occurred on the 200 m depth contour to the west, while smaller quantities were also captured to the north of the Falkland Islands (Figure 3). Most females and males were resting (maturity stage II), with minor frequencies of spent (maturity stages ≥ VII) and immature (maturity stage I) individuals. Females were 9-81 cm total length, and males were 12-83 cm total length. Distinct multimodal cohorts were visible in the length frequency distributions for male and female fish at 22, 27 and 31 cm. Distributions appeared to reflect a balanced population with a strong stable decline from smaller, immature and resting individuals (Stage I and II) to larger length classes reflective of consistent recruitment and moderate rates of mortality among successive age classes.



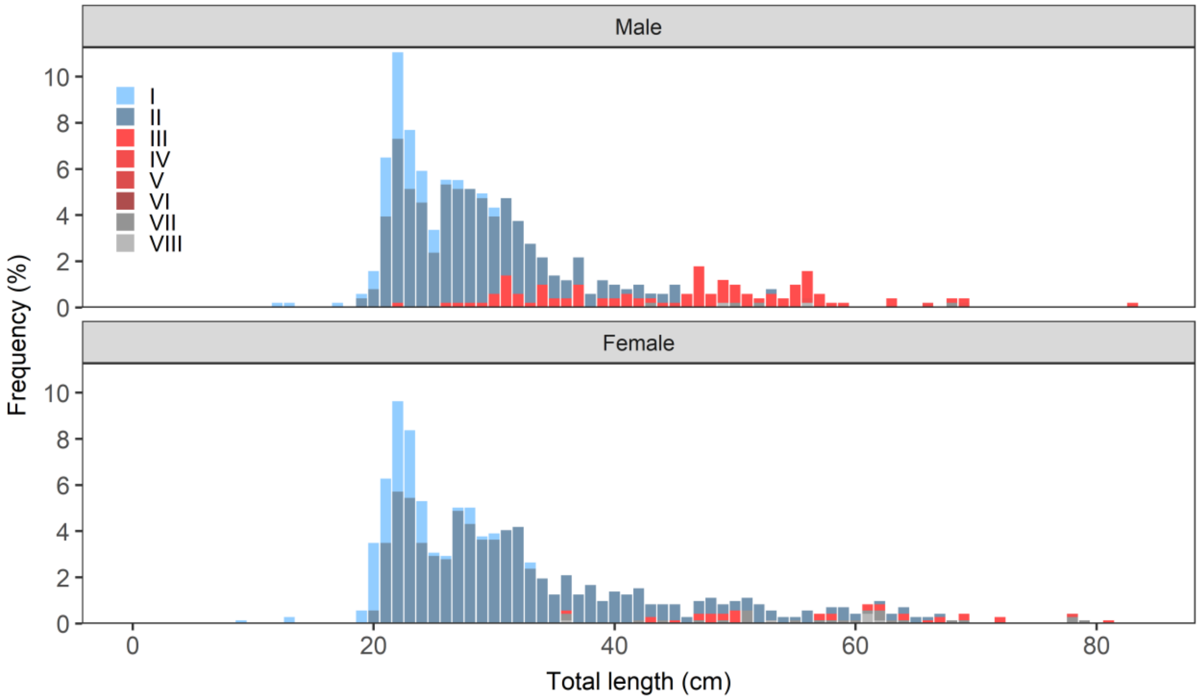


Figure 3: Biological data of *Salilota australis* (Red cod; BAC). Map of the densities in kg/km^2; relative frequency (%) of specimens of each sex per maturity stage (I, immature; II, resting; III, early developing; IV, late developing; V, ripe; VI, running; VII, spent; VIII, recovering spent); length frequencies (%) of females (n = 717) and males (n = 507) with 1 cm size class.

3.2.3. Micromesistius australis – Southern blue whiting

The total catch of Southern blue whiting was 23 kg. This species was caught at 19 of the 63 trawl stations (30%) sampled throughout the research cruise. Catches ranged from 0.01 to 7.3 kg, and densities ranged from 0.05 to 35 kg/km^2. Southern blue whiting was caught to the southwest of West Falkland (Figure 4). A total of 408 fish were sampled for length frequency (96 females, 312 males), the majority of which were immature (stage I). Females ranged from 15–51 cm, and males were 16–52 cm total length. A single distinct modal peak was evident in the length frequency distributions for both sexes (17 cm), consisting of immature individuals around age-1.

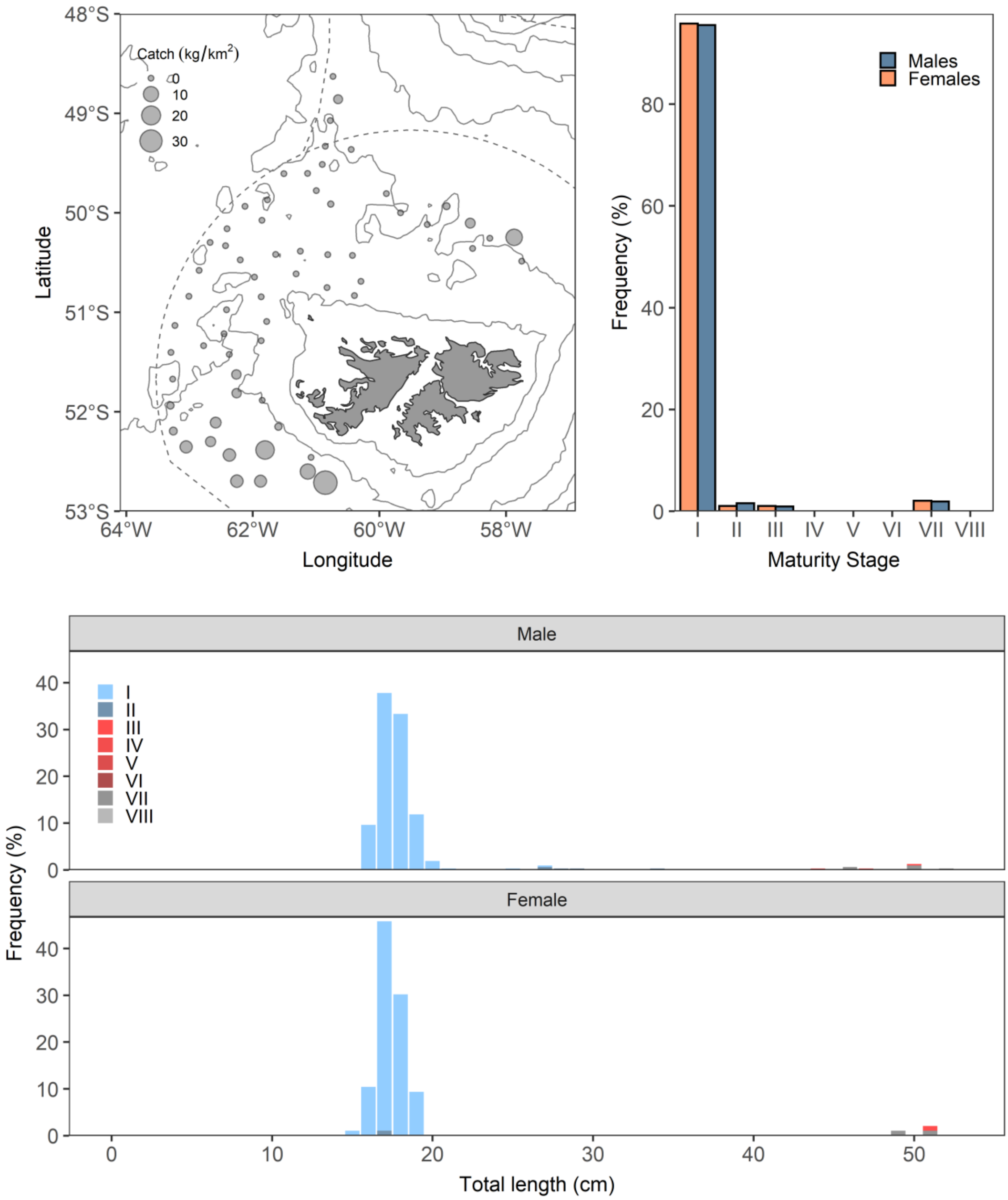
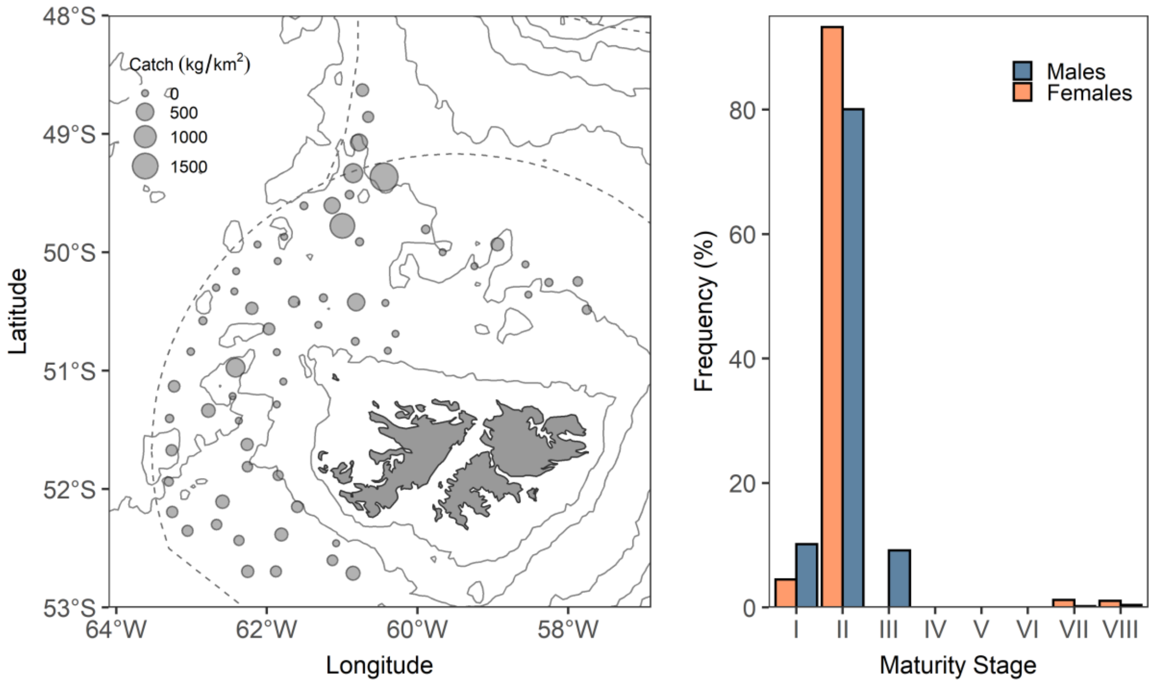


Figure 4: Biological data of *Micromesistius australis* (Southern blue whiting; BLU). Map of the densities in kg/km2; relative frequency (%) of specimens of each sex per maturity stage (I, immature; II, resting; III, early developing; IV, late developing; V, ripe; VI, running; VII, spent; VIII, recovering spent); length frequencies (%) of females (n = 96) and males (n = 312) with 1 cm size class.

3.2.4. Genypterus blacodes – Kingclip

The total catch of kingclip was 1,725 kg. This species was caught at 44 of the 63 trawl stations (70%) sampled throughout the research cruise. Catches ranged from 0.24 to 387 kg, and densities ranged from 1.2 to 1,895 kg/km^2. Catches occurred across the study area, with the highest densities in deeper waters to the southwest and the northwest in the FICZ, extending into the FOCZ to the north (Figure 5). Most females and males were at resting maturity stage (maturity stage II). Females were 36–119 cm total length, and males were 39–98 cm total length. Length frequency distributions were multimodal and interrupted, with many individuals bounded by length groups with fewer individuals. If the strong and weak interruptions correspond to age groups, this may reflect unbalanced year-class strength across the exploited population.



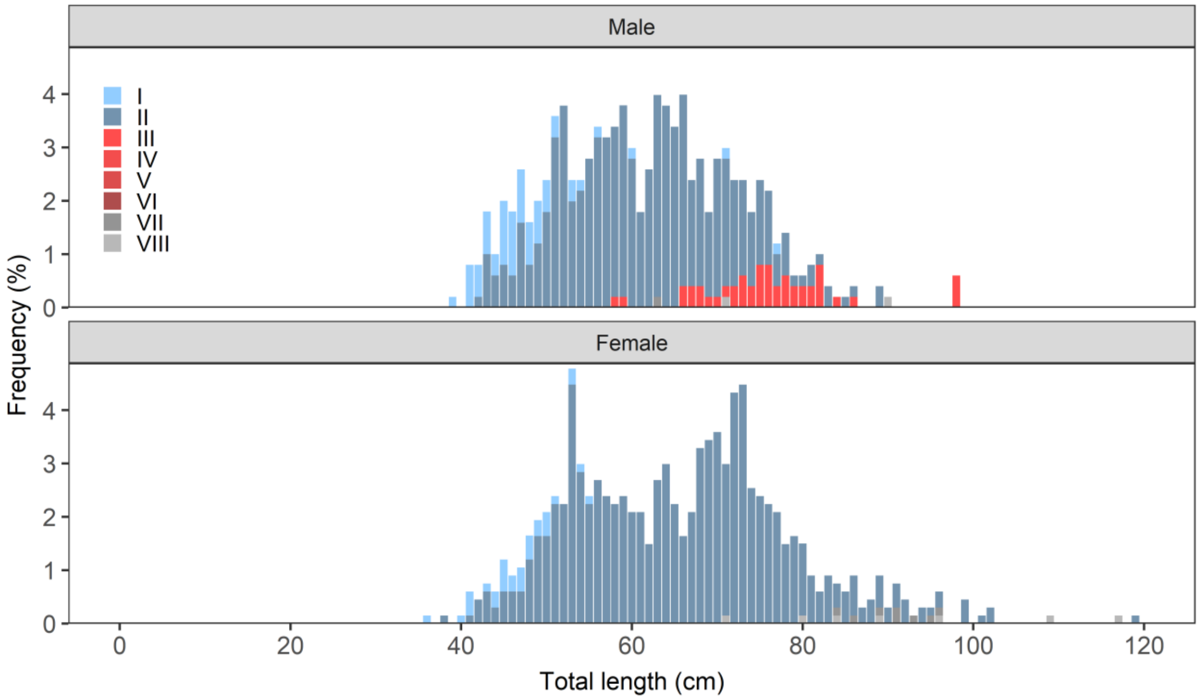


Figure 5: Biological data of *Genypterus blacodes* (Kingclip; KIN). Map of densities in kg/km2; relative frequency (%) of specimens of each sex per maturity stage (I, immature; II, resting; III, early developing; IV, late developing; V, ripe; VI, running; VII, spent; VIII, recovering spent); length frequencies (%) of females (n = 669) and males (n = 502) with 1 cm size class.

3.2.5. Patagonotothen ramsayi – Common rock cod

The total catch of rock cod was 6,262 kg. This species was caught at every station, with catches ranging from 0.06 to 2,365 kg and densities ranging from 0.3 to 11,090 kg/km^2. Higher densities were observed inshore of the 200 m depth contour in a narrow strip running from the west to northwest of the Falkland Islands, largely consisting of aggregations of mature individuals prior to spawning (Figure 6). Both male and female rock cod consisted of immature (maturity stages I and II) and mature individuals (maturity stages III and IV). Females were 7-37 cm total length, and males were 9-35 cm total length. Two length groups could be identified for both male (15 and 23 cm) and female (14 and 23 cm) fish, showing distinct structuring according to maturity level. The first length group (<19 cm) consisted of immature fish, with larger fish consisting of mature individuals. Multiple age groups are likely to exist in the larger length group, but these were not detected because of the overlap of sizes.

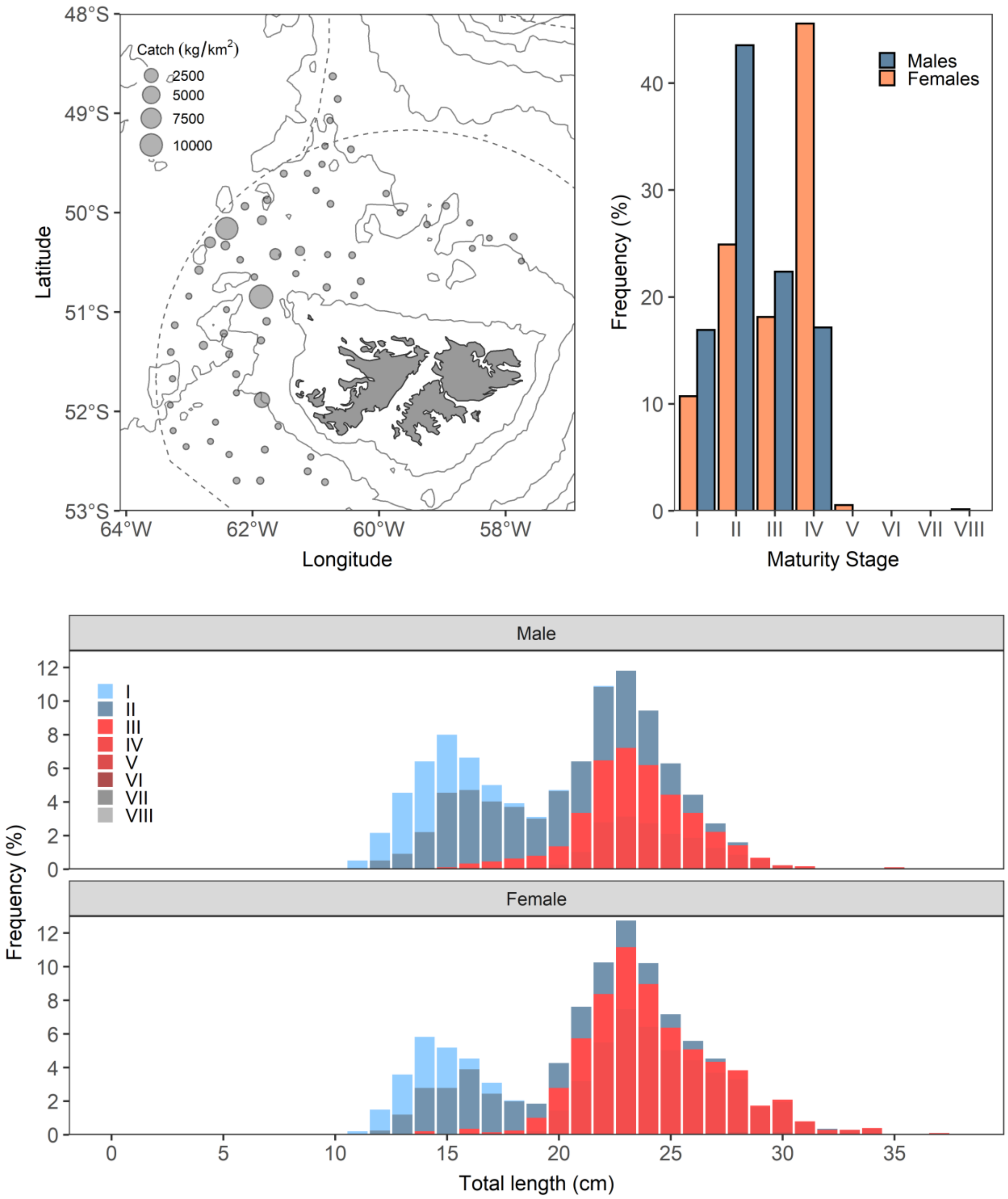


Figure 6: Biological data for *Patagonotothen ramsayi* (Common rock cod; PAR). Map of the densities in kg/km2; relative frequency (%)of specimens of each sex per maturity stage (I, immature; II, resting; III, early developing; IV, late developing; V, ripe; VI, running; VII, spent; VIII, recovering spent); length frequencies (%) of females (n = 2008) and males (n = 1761) with 1 cm size class.

3.2.6. Dissostichus eleginoides – Patagonian toothfish

The total catch of Patagonian toothfish was 105 kg. This species was caught at 17 of the 63 trawl stations (27%) sampled throughout the research cruise. Catches ranged from 0.4 to 14 kg, and densities ranged from 2.0 to 65.8 kg/km^2. The highest densities were observed in the southwest of the survey zone at stations deeper than 200 m (Figure 7). All individuals were immature or resting (maturity stages ≤ II). Females were 40-80 cm total length, and males were 36-72 cm total length. No new recruits (10-25 cm fish) and no distinct cohorts were evident in the length frequency distribution.

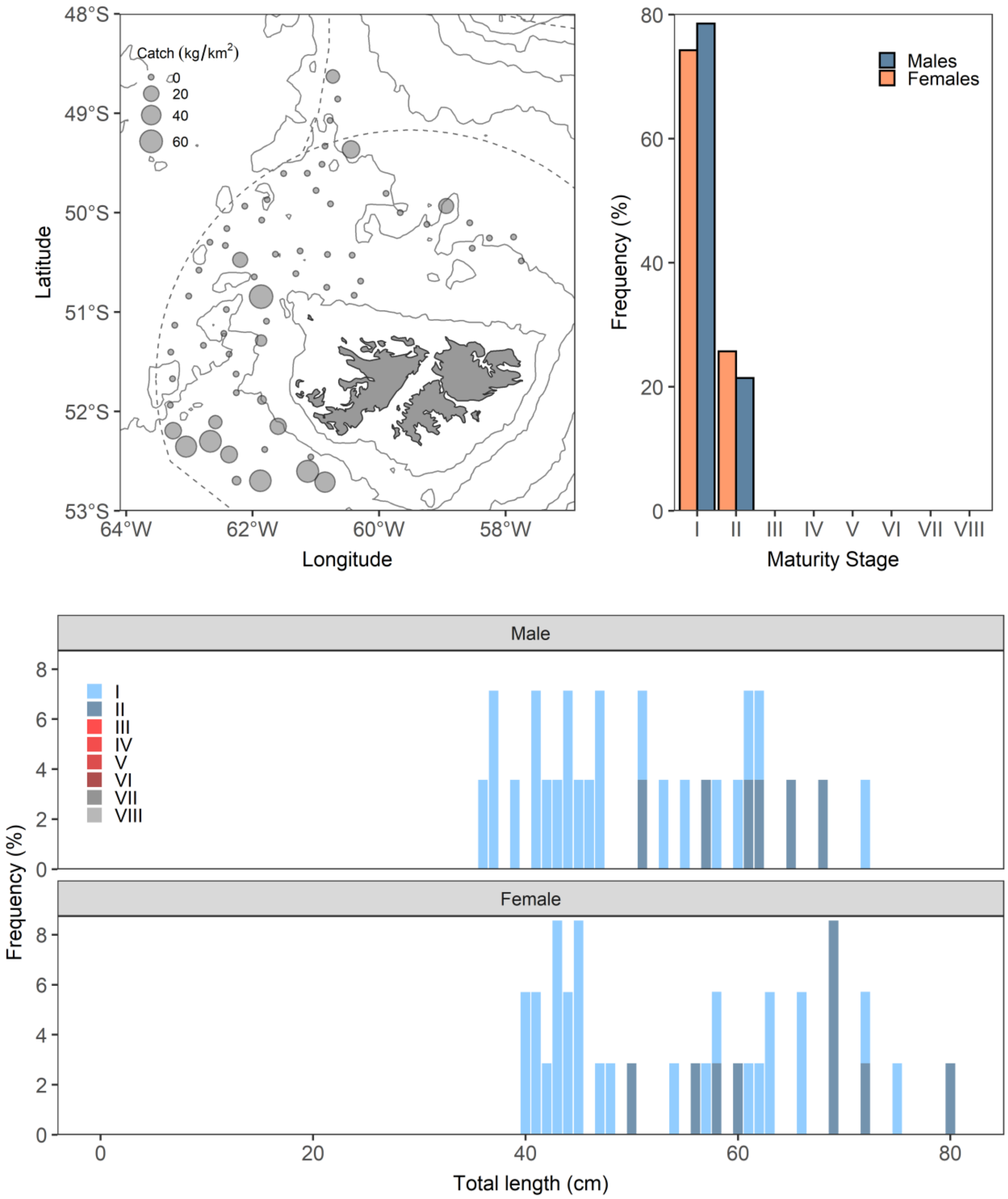
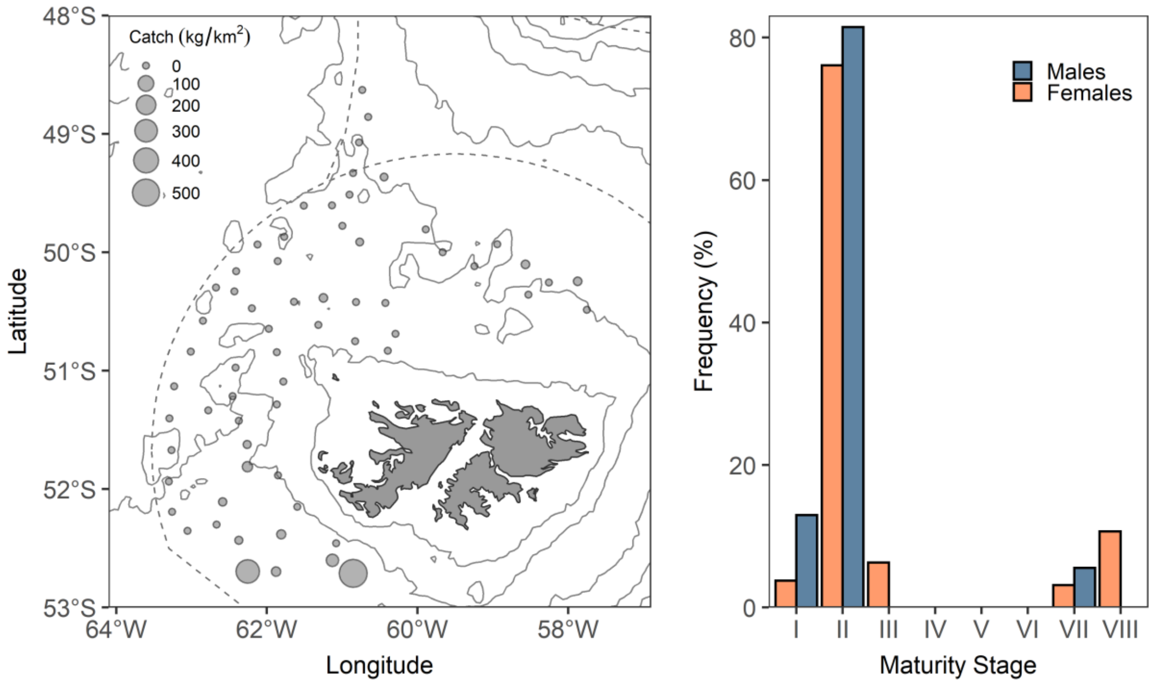


Figure 7: Biological data of *Dissostichus eleginoides* (Patagonian toothfish; TOO). A) Map of the densities in kg/km2; B) relative frequency (%) of specimens of each sex per maturity stage (I, immature; II, resting; III, early developing; IV, late developing; V, ripe; VI, running; VII, spent; VIII, recovering spent); length frequencies (%) of C) females (n = 35) and D) males (n = 28) with 1 cm size class.

3.2.7. Macruronus magellanicus – Hoki

The total catch of hoki was 203 kg. This species was caught at 14 of the 63 stations sampled (22%) throughout the survey period. Catches ranged from 0.2 to 113 kg, and densities ranged from 1.0 to 544.0 kg/km^2. The highest densities were observed in the southwest of the survey area near the limit of the FICZ (Figure 8). Most females and males were immature, resting (maturity stages ≤ III), spent, or recovering spent (maturity stages ≥ VII). Females were 14–30 cm pre-anal length, and males were 12–29 cm pre-anal length. The length frequency histograms exhibited at least three length-groups for female (16, 21, 24 cm) and male (15, 20, 24 cm) fish. These length groups were potentially interrupted by strong and weak overlapping cohorts. The majority of smaller length classes were immature-resting, while larger individuals were spent or recovering spent.



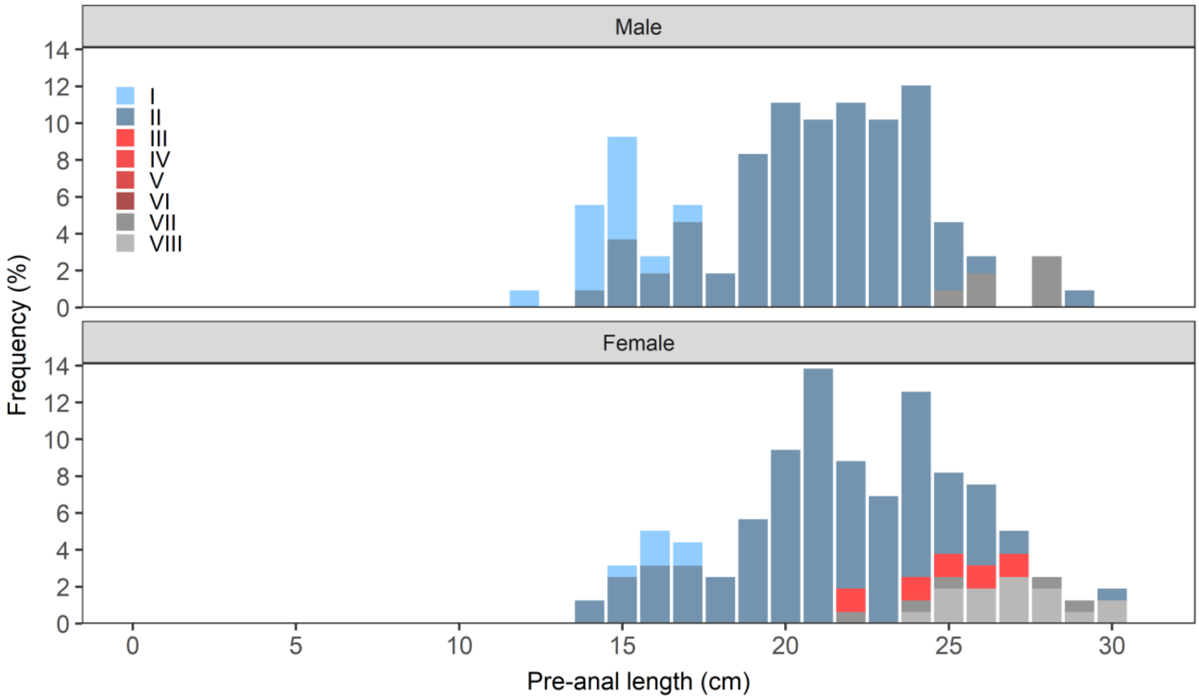


Figure 8: Biological data of *Macruronus magellanicus* (Hoki; WHI). Map of the densities in kg/km2; relative frequency (%) of specimens of each sex per maturity stage (I, immature; II, resting; III, early developing; IV, late developing; V, ripe; VI, running; VII, spent; VIII, recovering spent); length frequencies (%) of females (n = 159) and males (n = 108) with 1 cm size class.

3.2.8. Coelorinchus fasciatus – Banded whiptail grenadier

The total catch of banded whiptail grenadier was 921 kg. This species was caught at 15 of the 63 trawl stations (24%) sampled throughout the research cruise. Catches ranged from 0.1 to 386 kg, and densities ranged from 0.4 to 1,854 kg/km^2. The highest densities were observed in the southwest of the FICZ (Figure 9). Both males and females were mostly resting (maturity stage II) or developing (maturity stages ≤ II), with smaller proportions of females spent (maturity stage VII). Females were 4-13 cm pre–anal length; males were 4-10 cm pre–anal length, three sampled juveniles were 3-4 cm pre-anal length. The length-frequency distribution was unimodal for both female (7 cm) and male (8 cm) fish.

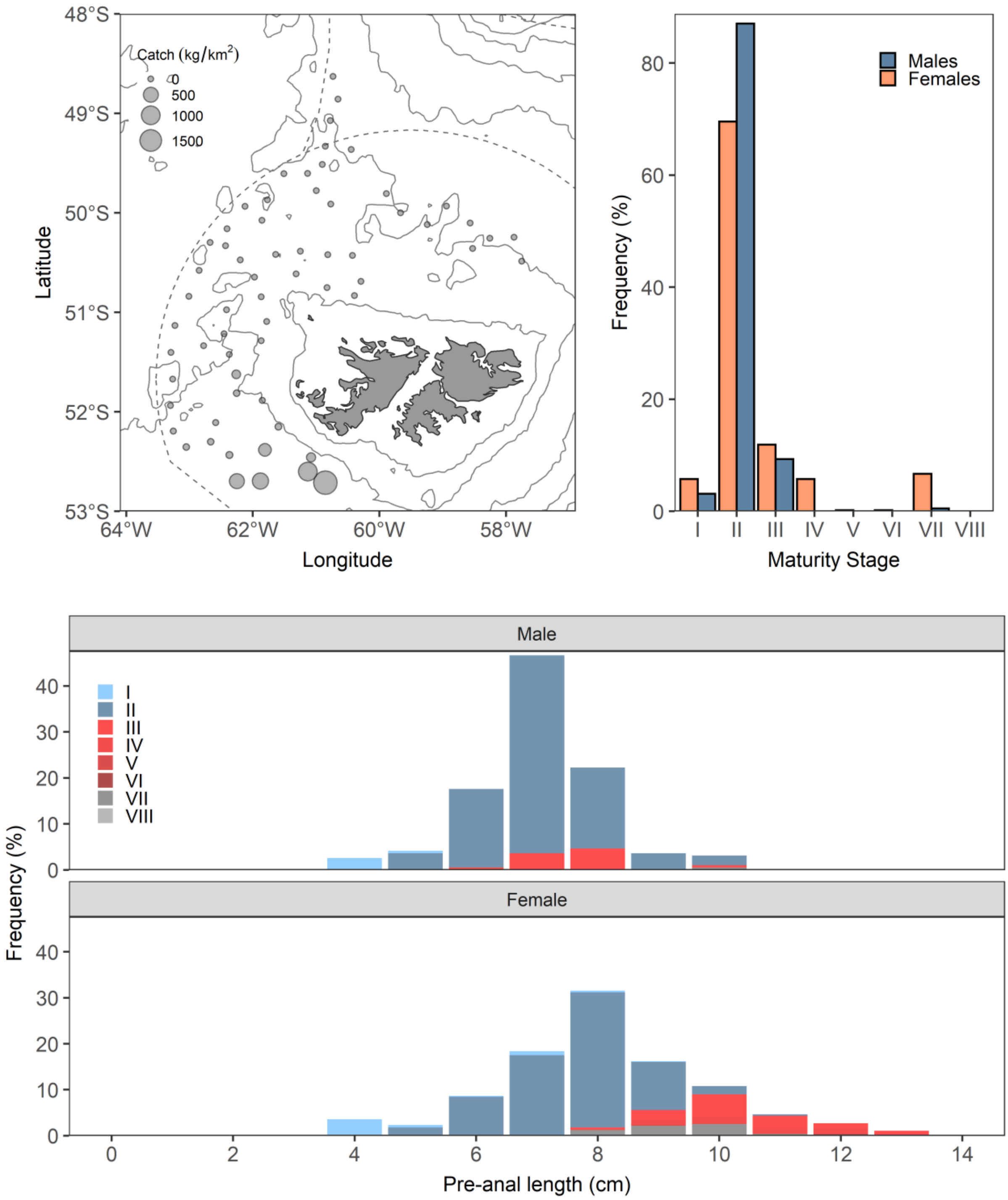
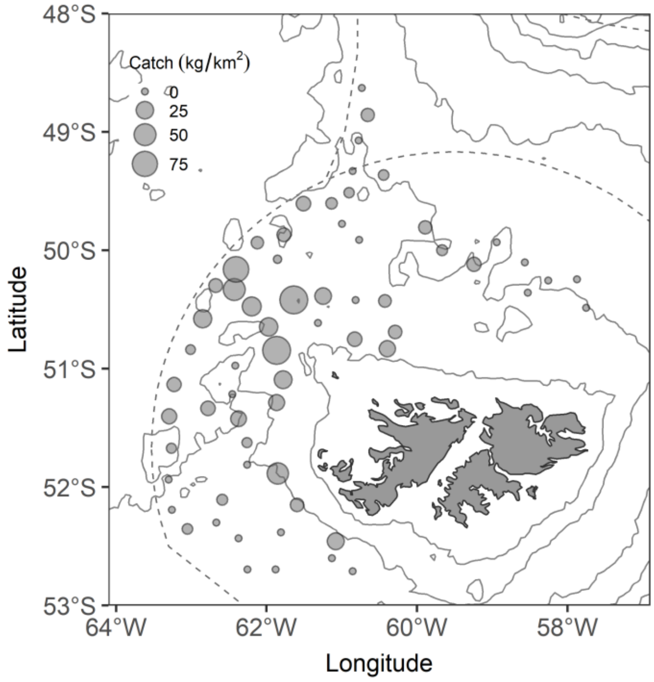
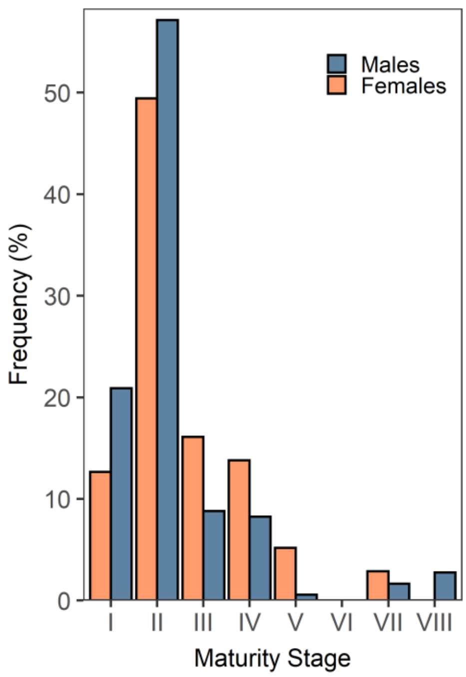


Figure 9: Biological data of *Coelorinchus fasciatus* (Banded whiptail grenadier; GRF). Map of the densities in kg/km2; B) relative frequency (%) of specimens of each sex per maturity stage (I, immature; II, resting; III, early developing; IV, late developing; V, ripe; VI, running; VII, spent; VIII, recovering spent); length frequencies (%) of females (n = 555) and males (n = 193) with 1 cm size class.

3.2.9. Cottoperca trigloides - channel bull blenny

The total catch of the channel bull blenny was 155 kg. This species was caught at 38 of the 63 trawl stations (60%) sampled throughout the research cruise. Catches ranged from 0.1 to 20.7 kg, and densities ranged from 0.6 to 97.3 kg/km^2. Highest densities were observed in waters shallower than 200 m to the west and northwest of the Falkland Islands, suggesting coexistence with rock cod spawning aggregations (Figure 10). Both females and males were predominantly resting (maturity stage II), although large numbers of immature (stage I), developing (stage III), mature (stage IV) and spent (stage VII) individuals also occurred. Females were 11-48 cm total length and males were 13-55 cm total length. The length frequency distributions for both male and female fish showed multiple peaks across samples.





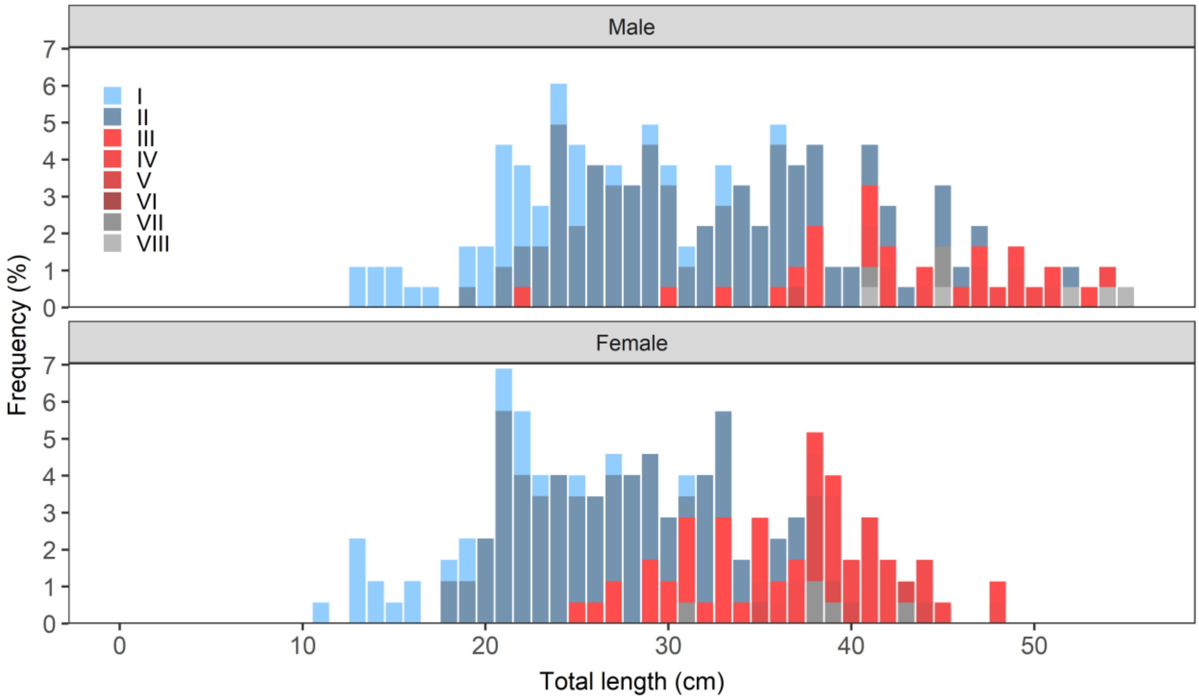
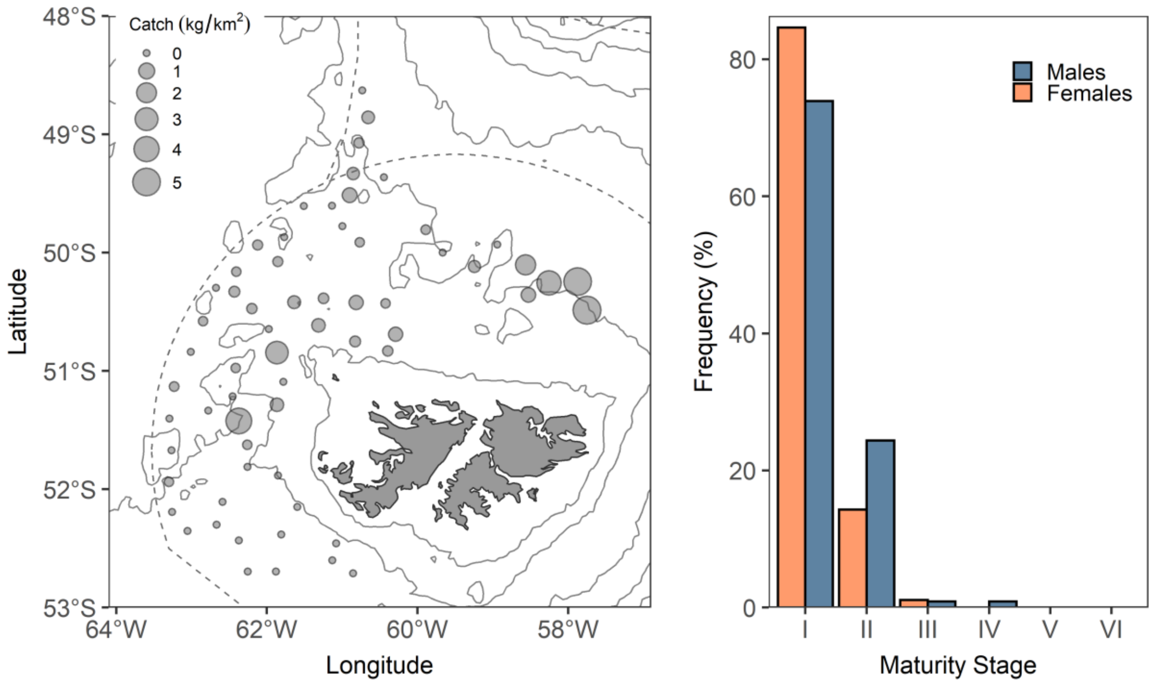


Figure 10: Biological data of *Cottoperca trigloides* (Channel bull blenny; CGO). Map of the densities in kg/km2; B) relative frequency (%) of specimens of each sex per maturity stage (I, immature; II, resting; III, early developing; IV, late developing; V, ripe; VI, running; VII, spent; VIII, recovering spent); length frequencies (%) of females (n = 174) and males (n = 182) 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 6.24 kg. This species was caught at 33 of the 63 trawl stations (52%) sampled throughout the research cruise. Catches ranged from 0.02 to 1.1 kg, and densities ranged from 0.1 to 5.2 kg/km^2. Densities were low across the zone, although these were highest in the northeast of the FICZ (Figure 11). Most females and males were immature (maturity stages ≤ II). Female sizes ranged between 6 cm and 26.5 cm dorsal mantle length, with a modal length of 10.0 cm dorsal mantle length. Male sizes ranged between 7.0 cm and 16.5 cm, with modes at 10.0 cm and 11.0 cm dorsal mantle length.



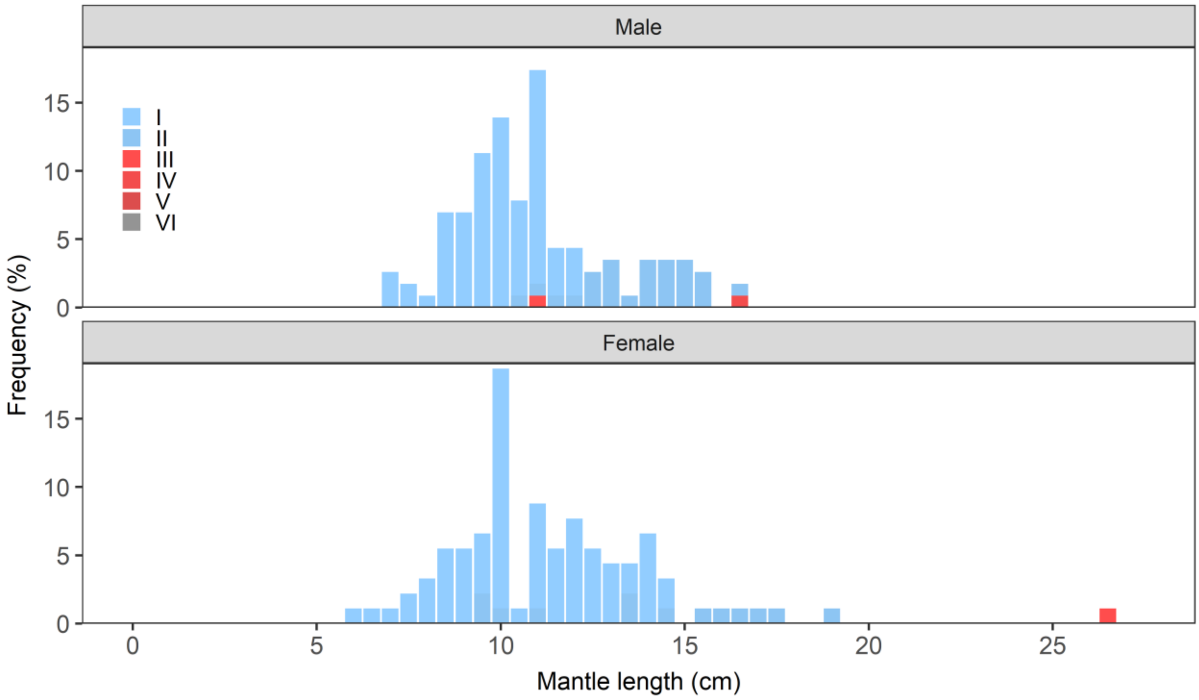


Figure 11: Biological data of Illex argentinus (Argentine shortfin squid; ILL). Map of the densities in kg/km2; relative frequency (%) of specimens of each sex per maturity stage (I, immature; II, resting; III, early developing; IV, late developing; V, ripe; VI, running; VII, spent; VIII, recovering spent); length frequencies (%) of females (n = 91) and males (n = 115) with 0.5 cm size class.

3.3.2. Doryteuthis gahi – Falkland calamari

The total catch of Falkland calamari was 6,401 kg. This species was caught at all 63 of the trawl stations sampled throughout the research cruise. Catches ranged from 8.5 to 794 kg, and densities ranged from 41 to 4,292 kg/km^2. Falkland calamari were caught across the zone with greater densities to the northeast and west of the Falkland Islands (Figure 12). Most females were immature (maturity stage II) although smaller numbers were also in a developing (maturity stage III) and fully developed or spawning state (maturity stage IV and V). Males were generally at a later developmental stage, with the majority at a developing stage of reproductive development (maturity stage III). Females were 4-23.5 cm dorsal mantle length, and males were 4.5-23 cm dorsal mantle length. A single length group was detected, with modal length of females at 9.5 and males at 10.0 cm dorsal mantle length, respectively.

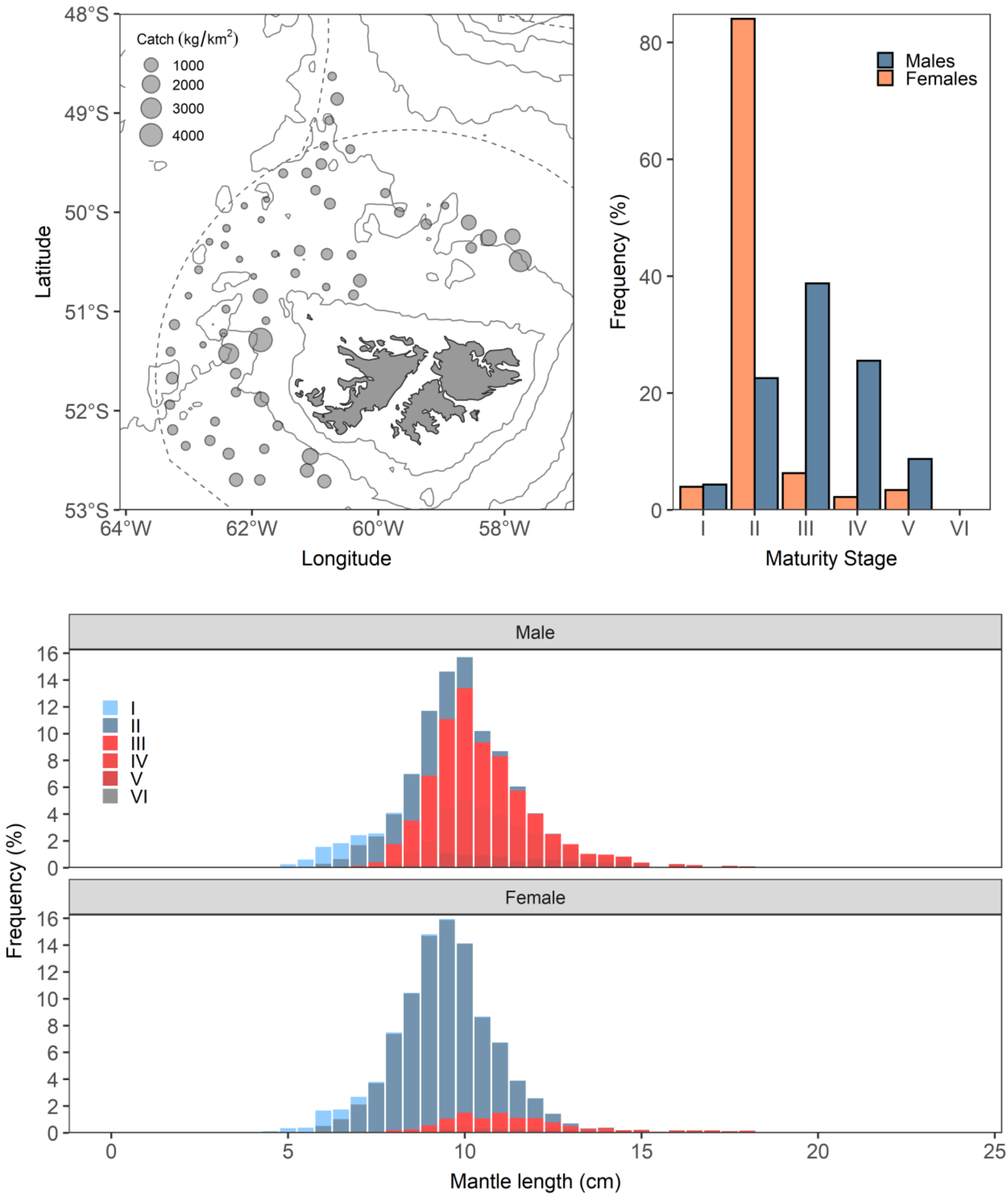
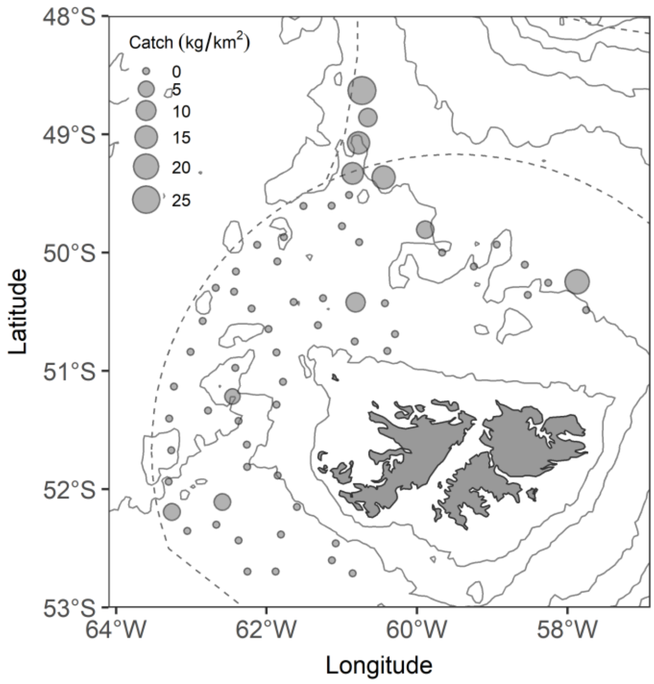


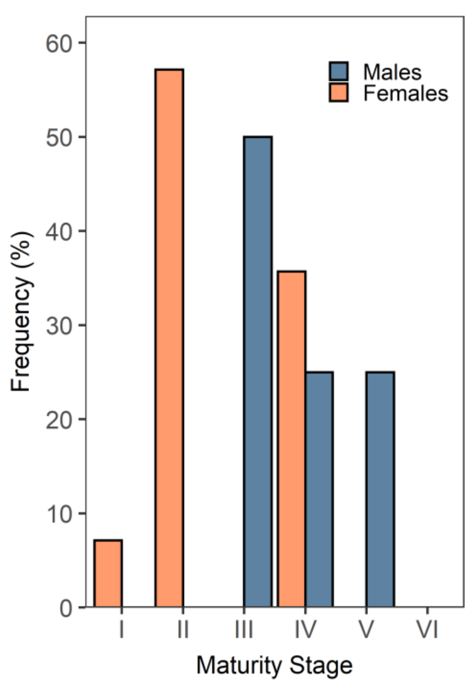
Figure 12: Biological data of *Doryteuthis gahi* (Falkland calamari; LOL). Map of the densities in kg/km2; relative frequency (%) of specimens of each sex per maturity stage (I, immature; II, resting; III, early developing; IV, late developing; V, ripe; VI, running; VII, spent; VIII, recovering spent); length frequencies (%) of females (n = 3845) and males (n = 2786) 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 25.9 kg. This species was caught at 11 of the 63 trawl stations (17%) sampled through the research cruise. Catches ranged from 1 to 5.6 kg, and densities ranged from 4.6 to 26.2 kg/km^2. Higher densities were observed in the north and northwest of the survey zone (Figure 13). Most females were immature-resting (maturity stages II), although mature (maturity stage IV) individuals were also reported. Developing males were the most common (maturity stage III), followed by mature (stage IV) and running (stage V) individuals. Females were 25-44 and males 36-39 cm disc width.





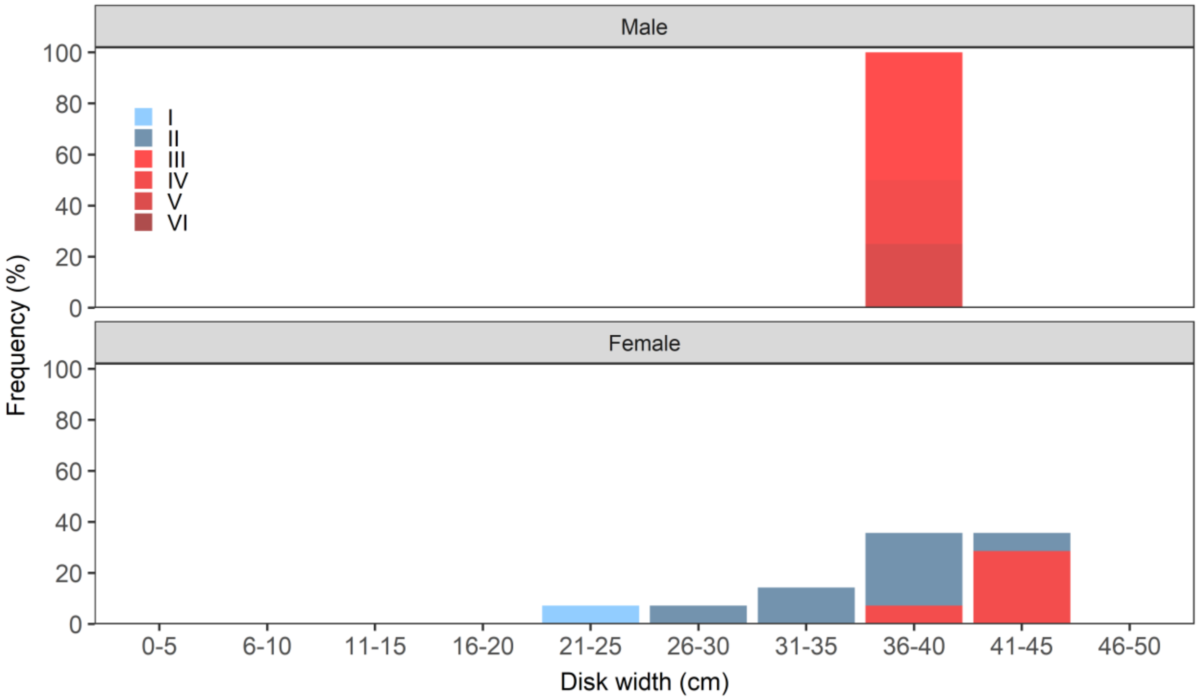


Figure 13: Biological data of *Bathyraja albomaculata* (White spotted skate; RAL). Map of the densities in kg/km2; relative frequency (%) of specimens of each sex per maturity stage (I, juvenile; II, adolescent maturing; III, adult developing; IV, adult mature; V, adult laying/running; VI, adult resting); length frequencies (%) of females (n = 14) and males (n = 4) with 5 cm size class.

3.4.2. Bathyraja brachyurops – Blonde skate

The total catch of blonde skate was 121 kg. This species was caught at 35 of the 63 trawl stations (56%) sampled during the research survey. Catches ranged from 0.004 to 15.4 kg, and densities ranged from 0.02 to 75 kg/km^2. Catches were distributed across the zone, although the highest densities were observed along the north, west and southwest of West Falkland (Figure 14). Most females and males were immature-resting (maturity stage II), although larger individuals were developing (stage III) or mature (stage IV). Females were 10-63 cm disc width, and males were 5-61 cm disc width. The length-frequency histograms show a spread of individuals from 26 to 65 cm disc width, with modal peaks of 31-35 (male and females), 41-45 (male) and 46-50 (female) cm disc width.

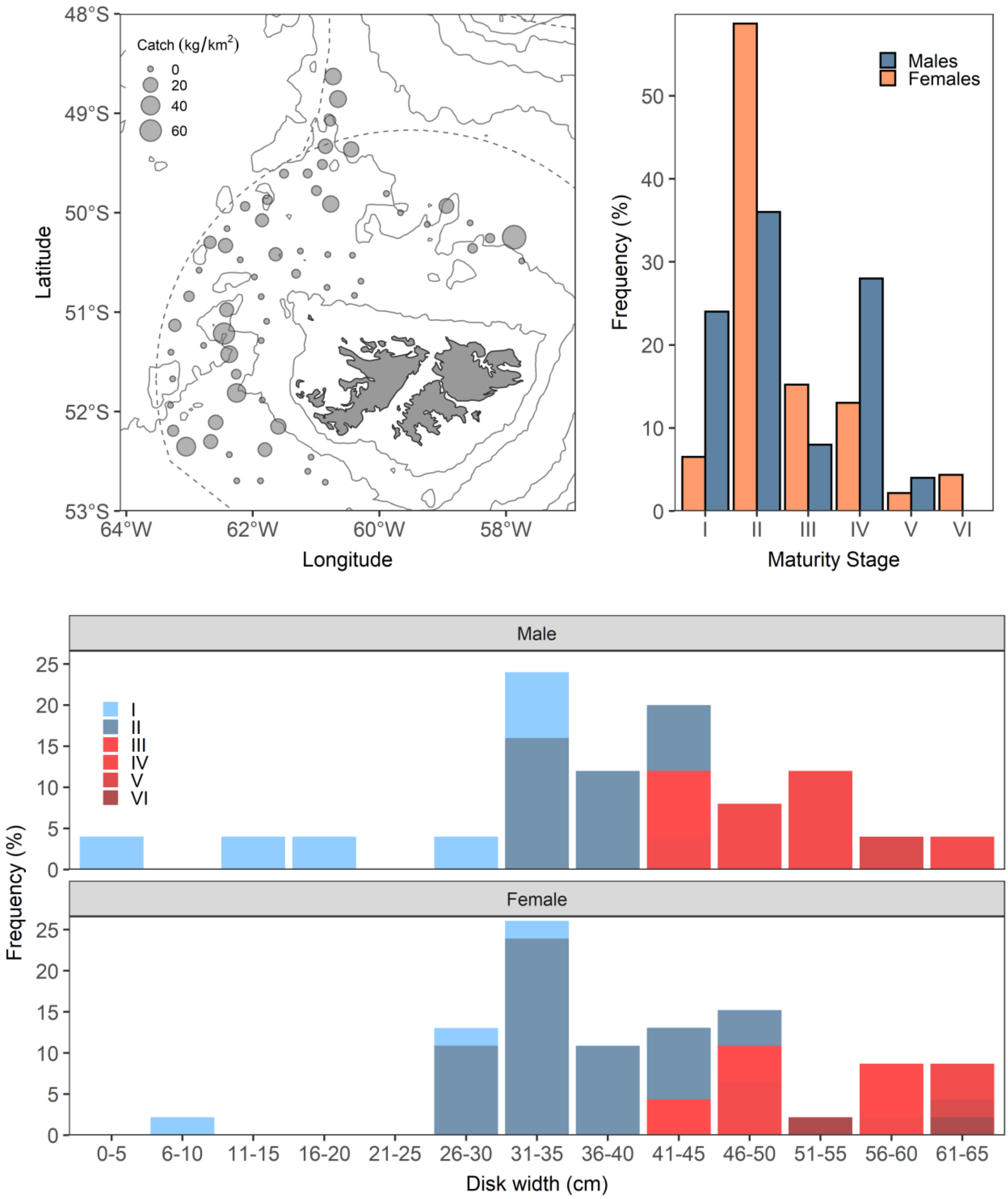
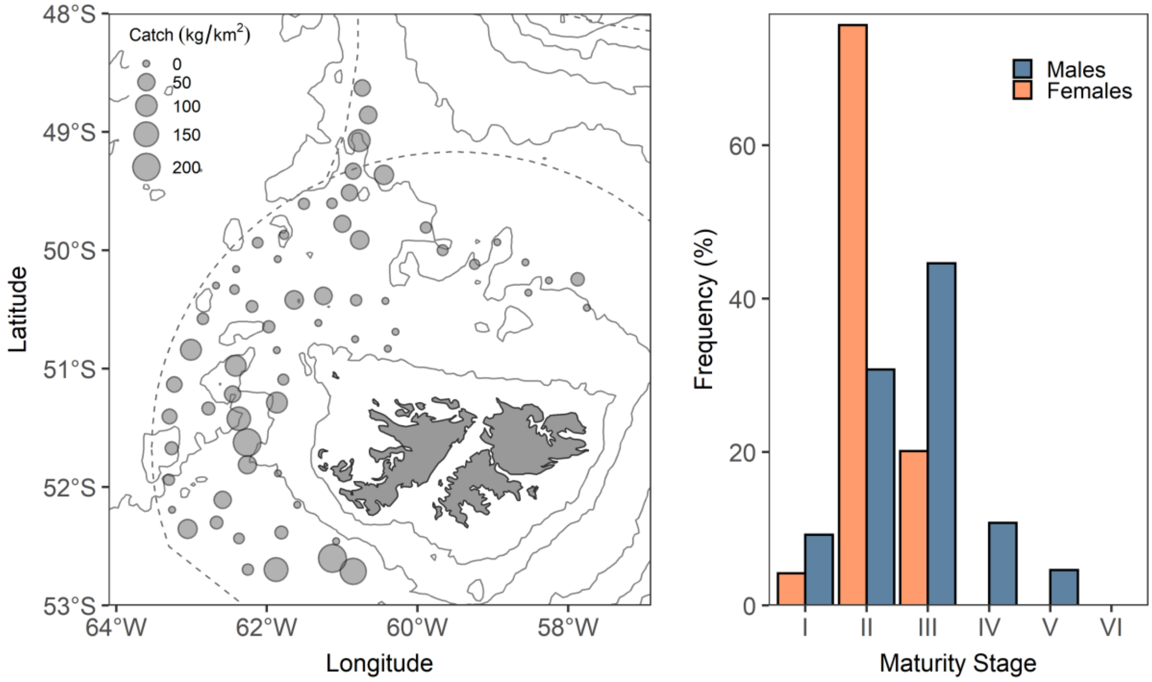


Figure 14: Biological data of *Bathyraja brachyurops* (Blonde skate; RBR). Map of the densities in kg/km2; relative frequency (%) of specimens of each sex per maturity stage (I, juvenile; II, adolescent maturing; III, adult developing; IV, adult mature; V, adult laying/running; VI, adult resting); length frequencies (%) of females (n = 46) and males (n = 25) with 5 cm size class.

3.4.3. *Dipturus lamillai – Yellow nose skate*

The total catch of the yellow nose skate was 463 kg. This species was caught at 45 of the 63 trawl stations (71%) sampled through the research cruise. Catches ranged from 0.53 to 45.2 kg, and densities ranged from 2.6 to 209 kg/km². Higher densities were observed to the southwest, west and northwest of the FICZ (Figure 15). Most females were immature-resting (maturity stage II) or maturing (stage III). While males were also predominantly immature-resting (stage II) or maturing (stage III), mature (stage IV) and running (stage V) individuals were also present in the catch. Females were 32-74 cm disc width and modal disc width was identified at the 56-60 cm size class. Males were 34-76 cm disc width with a distinct modal disc width of 51-55 cm.



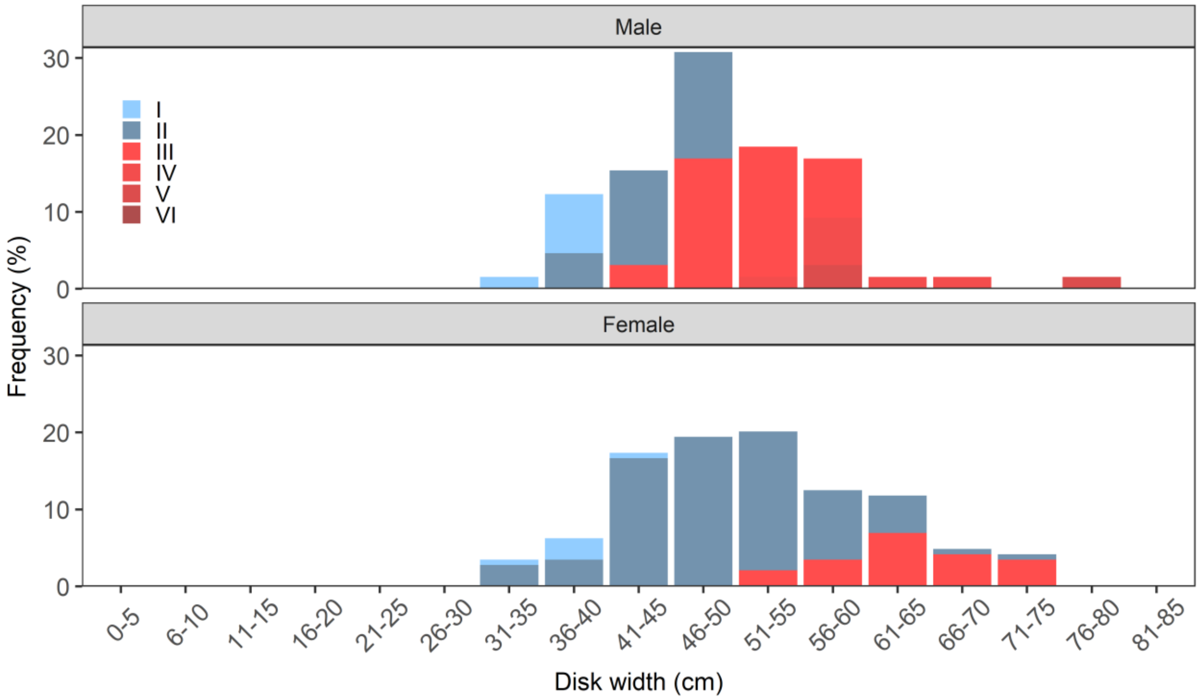


Figure 15: Biological data of *Dipturus lamillai* (Yellow nose skate; RFL). Map of the densities in kg/km2; relative frequency (%) of specimens of each sex per maturity stage (I, juvenile; II, adolescent maturing; III, adult developing; IV, adult mature; V, adult laying/running; VI, adult resting); length frequencies (%) of females (n = 144) and males (n = 65) with 5 cm size class.

3.4.4. Bathyraja griseocauda – Grey tailed skate

The total catch of the grey tailed skate was 82.9 kg. This species was caught at 12 of the 63 trawl stations (19%) undertaken during the research cruise. Catches ranged from 0.1 to 44.9 kg, and densities ranged from 0.4 to 212 kg/km^2. Highest densities were observed in the most southerly and northerly stations sampled (Figure 16). A total of 47 individuals (21 females, 26 males) were sampled. The majority of the individuals sampled were juveniles (maturity stage I), although large numbers of immature resting females were also found (maturity stage II). The size of females ranged between 16 cm and 103 cm disc width. Male sizes ranged between 16 cm and 83 cm disc width.

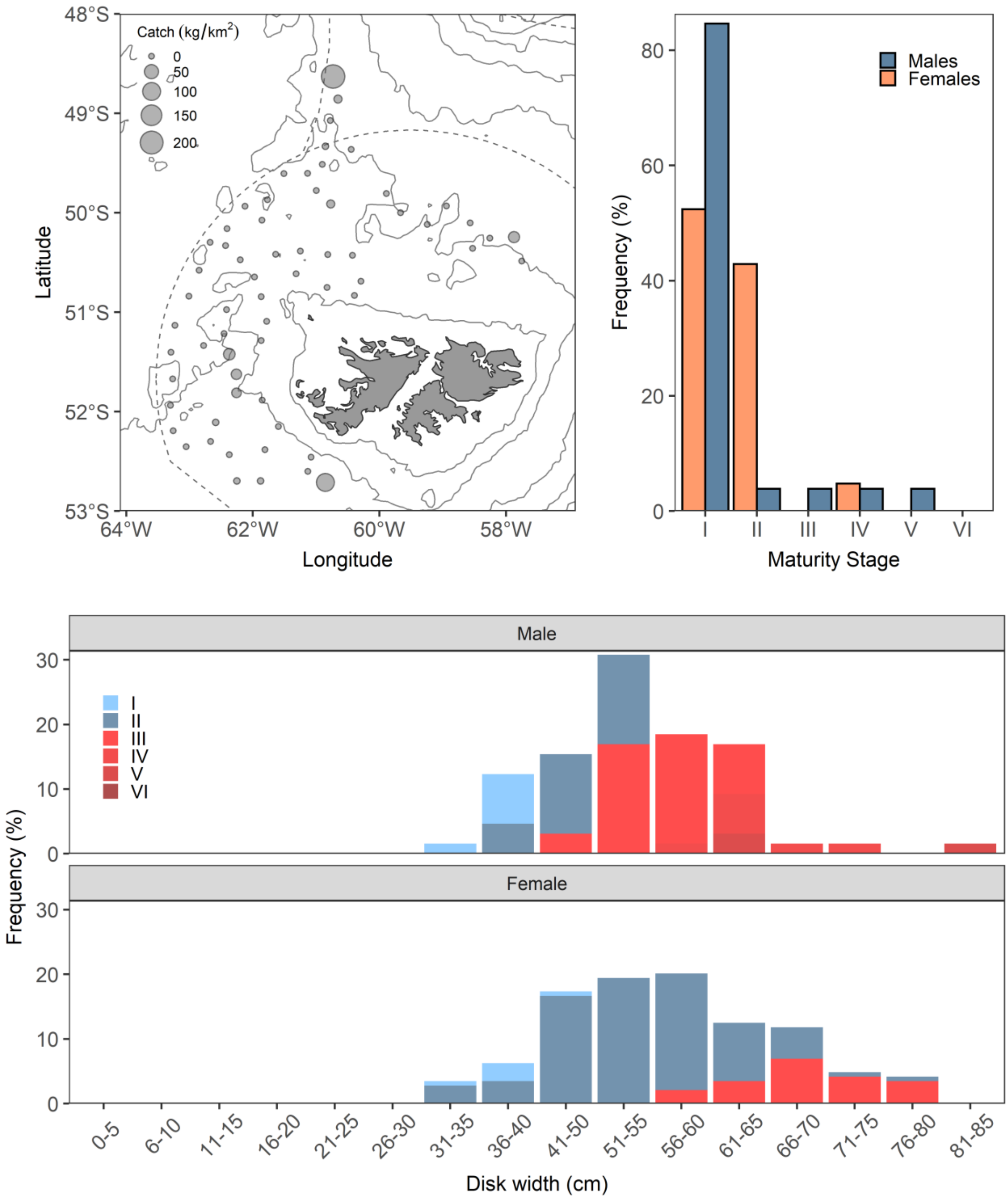
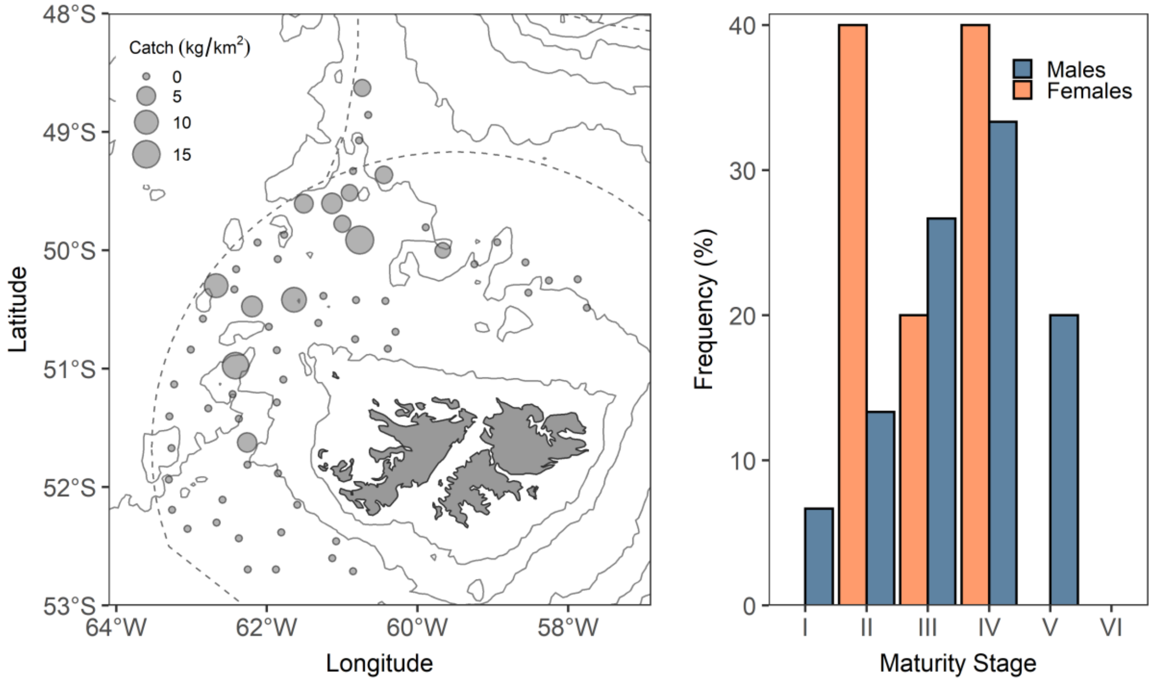


Figure 16: Biological data of *Bathyraja griseocauda* (Grey tailed skate; RGR). Map of the densities in kg/km2; relative frequency (%) of specimens of each sex per maturity stage (I, juvenile; II, adolescent maturing; III, adult developing; IV, adult mature; V, adult laying/running; VI, adult resting); length frequencies (%) of females (n = 21) and males (n = 26) with 5 cm size class.

3.4.5. Bathyraja macloviana – Falkland skate

The total catch of the Falkland skate was 18.6 kg. This species was caught at 13 of the 63 trawl stations (21%) sampled through the research cruise. Catches ranged from 0.5 to 3.1 kg, and densities ranged from 2.6 to 15.6 kg/km^2. Highest densities were observed to the northwest of the FICZ (Figure 17). Most females were immature-maturing (maturity stage II) and mature (maturity stage IV), and most males were mature (maturity stages IV). Females were 30-36 cm disc width, and males were 25-37 cm disc width (Figure 19D).



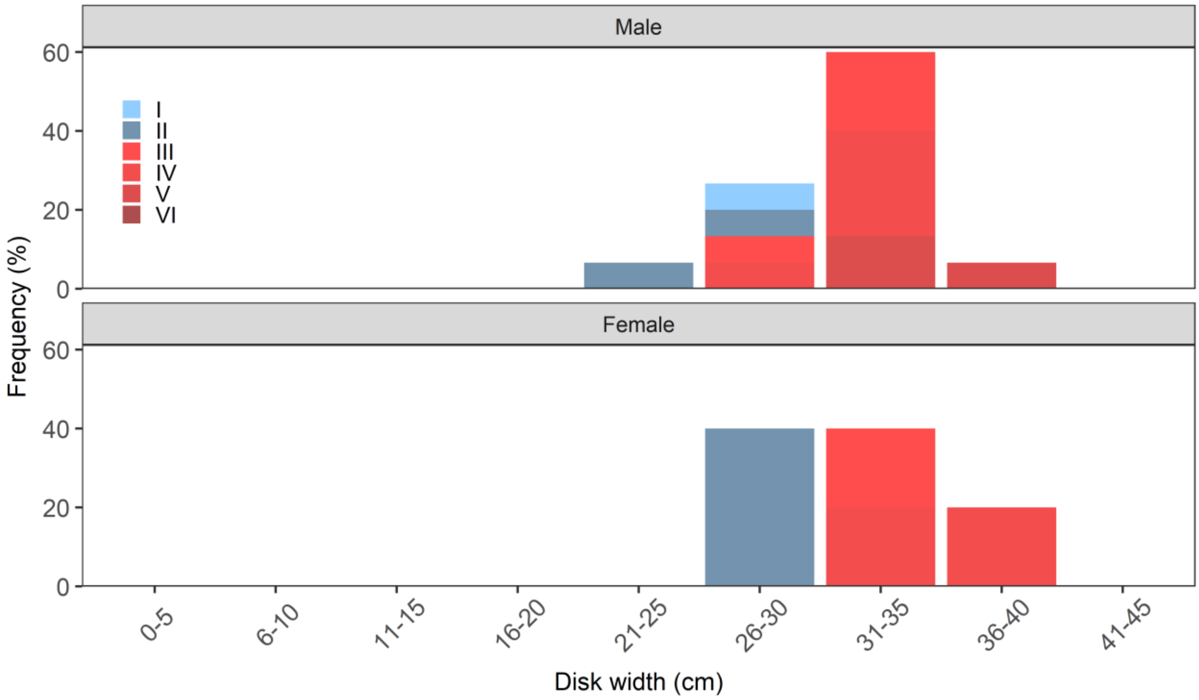


Figure 17: Biological data of *Bathyraja macloviana* (Falkland skate; RMC). Map of the densities in kg/km2; relative frequency (%) of specimens of each sex per maturity stage (I, juvenile; II, adolescent maturing; III, adult developing; IV, adult mature; V, adult laying/running; VI, adult resting); length frequencies (%) of females (n = 5) and males (n = 15) with 5 cm size class.

3.5. Biological information of shark species

3.5.1. Schroederichthys bivius – Catshark

The total catch of catshark was 852 kg. This species was caught at 52 of the 63 trawl stations (83%) sampled through the research cruise. Catches ranged from 0.3 to 76.2 kg, and densities ranged from 1.5 to 379 kg/km^2. High densities were observed across the west and northwest in waters inshore of the 200 m depth contour (Figure 18). Most females found alive were released as soon as possible without assessing maturity stages, and their maturity stage was recorded as X. Males were sampled across juvenile (stage I), immature-developing (stage II), mature-developing (stage III) and mature (stage IV) stages. Females were 19-73 cm total length. Males were 19-80 cm total length.

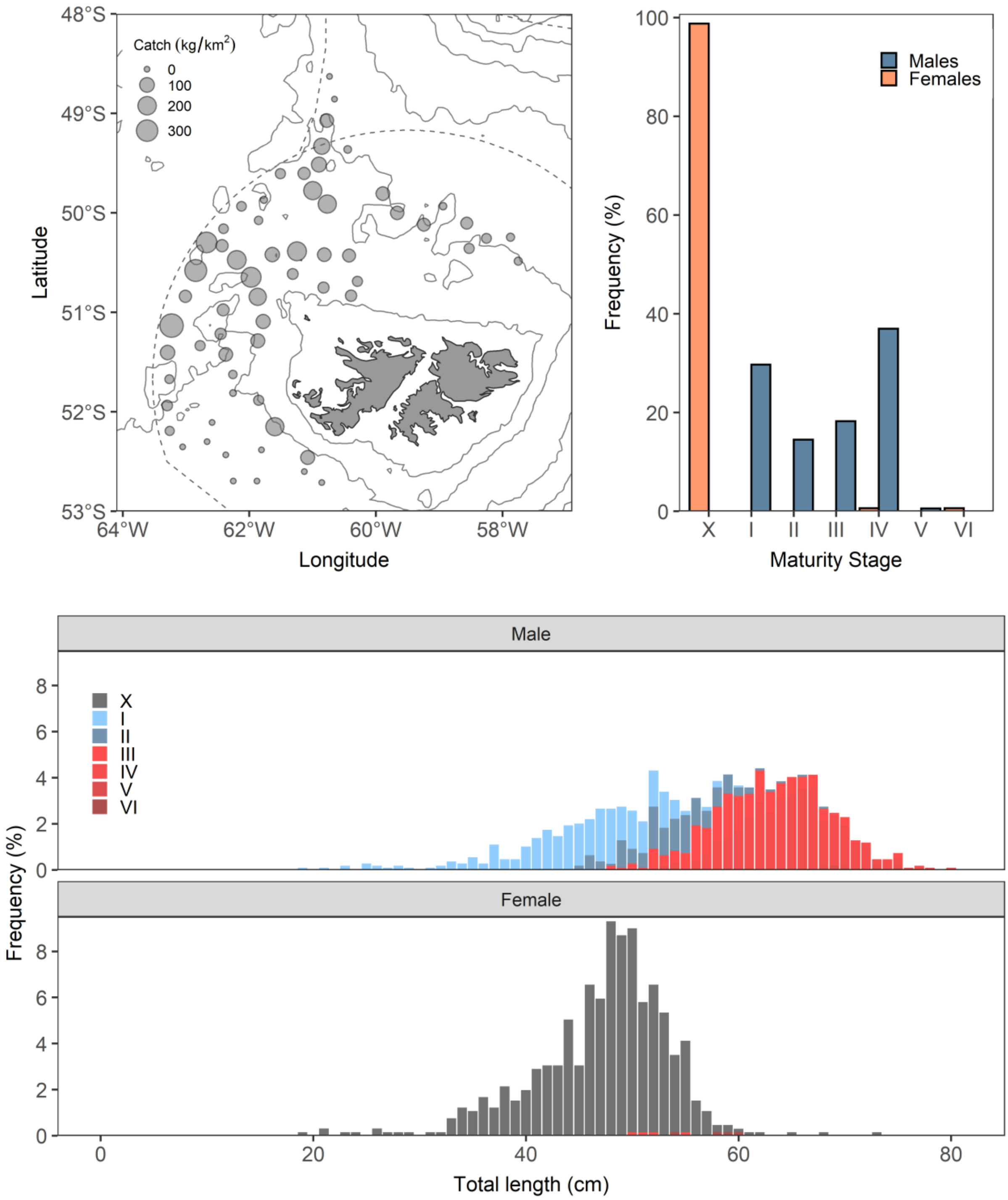
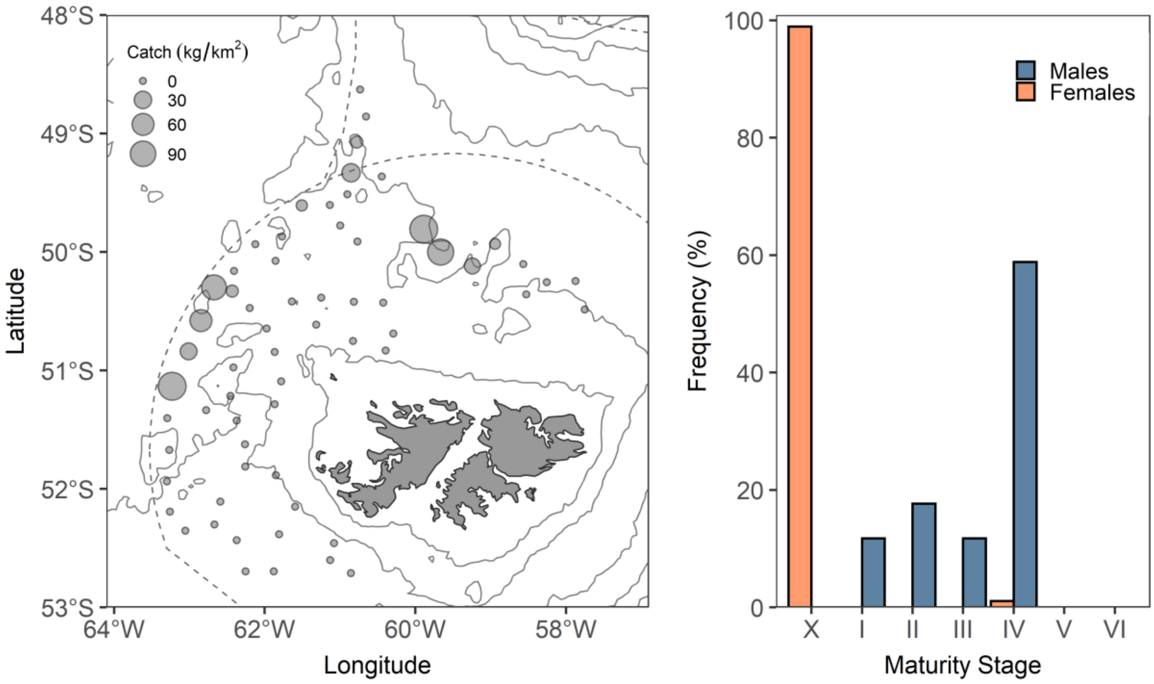


Figure 18: Biological data of *Schroederichthys bivius* (Catshark; DGH); Map of the densities in kg/km2; relative frequency (%) of specimens of each sex per maturity stage (I, juvenile; II, adolescent maturing; III, adult developing; IV, adult mature; V, adult laying/running; VI, adult resting); length frequencies (%) of females (n = 655) and males (n = 1090) with 1 cm size class.

3.5.2. Squalus acanthias – Spiny Dogfish

The total catch of spiny dogfish was 115 kg. This species was caught at 12 of the 63 trawl stations (19%) sampled through the research cruise. Catches ranged from 1 to 22.9 kg, and densities ranged from 4.6 to 114 kg/km^2. High densities were observed to the north and west of the FICZ (Figure 19). Most females found alive were released as soon as possible without assessing maturity stages, and their maturity stage was recorded as X. Most males were mature (maturity stage IV). Females were 49-83 cm total length, with modal length at 57 cm total length. Males were 52–73 cm total length.



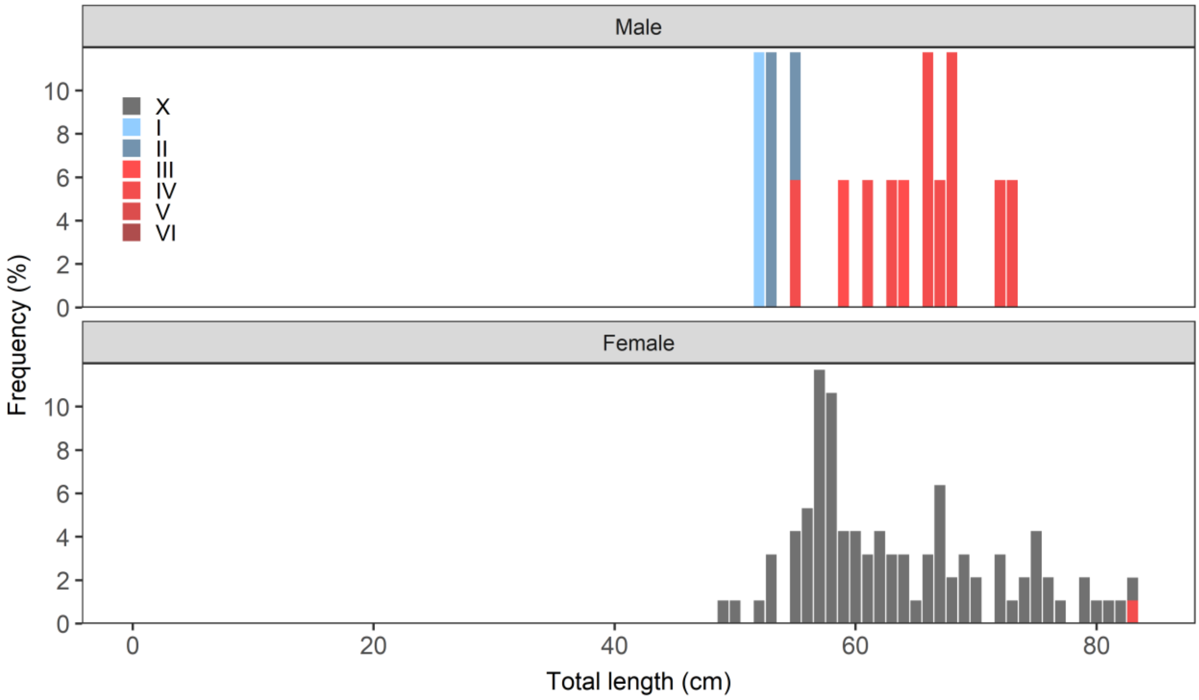


Figure 19: Biological data of *Squalus acanthias* (Spiny dogfish; DGS); Map of the densities in kg/km2; relative frequency (%) of specimens of each sex per maturity stage (I, juvenile; II, adolescent maturing; III, adult developing; IV, adult mature; V, adult laying/running; VI, adult resting); length frequencies (%) of females (n = 94) and males (n = 17) with 1 cm size class.

3.6. Oceanography

Due to memory/storage issues with the CTD at the start of the trip data was lost for stations; 3559, 3561, 3562. Reliable data were recorded for all stations thereafter. These data were processed and can be used as part of the historical dataset.

4. Discussion

The survey conducted from 9 to 26 July 2022 was the 2nd winter groundfish survey undertaken within the FICZ and FOCZ, the previous one taking place during July 2017 (Gras *et al.*, 2017). These surveys were aligned and thus comparable with the summer demersal surveys undertaken during February 2010, 2011, and from 2015 to 2022. In this context, these surveys provide essential data to be utilised for the monitoring of seasonal fish stocks, and the identification of research objectives for the provision of new insights into the Falkland Islands marine ecosystem (Hilborn and Walters, 1992). In particular, data collected from these surveys can be utilised for improving our understanding of spatial and temporal (seasonal and annual) changes in species composition, biomass and demographic patterns (length, sex and maturity) in response to environmental, ecological and anthropogenic drivers across the region. A hake demography survey was also undertaken during July 2020 (Randhawa *et al.*, 2020). Data during this survey was not collected according to the standardised FIFD fisheries independent survey design (see section 2.1), and direct comparisons should therefore be undertaken with caution.

The species of primary interest during this survey was the common hake *Merluccius hubbsi* consisting of 74% of the total catch. Hake was abundant across the zone, with mean densities (4756 kg/km^2) substantially larger compared to the 2017 (1157 kg/km^2) and 2020 (mean = 2371 kg/km^2) surveys. The maturity stage of hake entering the zone (males = stage VII and VIII; females = stage II, VII and VIII) are indicative of a post-spawning feeding migration into Falkland Islands waters (Agnew, 2002; Arkhipkin *et al.*, 2012). The length structure during the current survey was characterised by a unimodal distribution (modal length = 38 cm in males; 42 cm in females), with the female distribution skewed towards larger individuals, compared to the distinct normal patterns evident for male fish. The current survey lacked the presence of a cohort of smaller, newly recruited fish (modal length = 26 cm) that was evident in both the 2017 and 2020 surveys (Gras *et al.*, 2017; Randhawa *et al.*, 2020). The increased densities of migratory contingents and demographic structure of hake in the region requires further investigation.

Observed spatial patterns for hake indicated a distinct abundance hotspot to the north, as well as inshore of the 200 m depth contour to the northwest of the Falkland Islands. These abundance hotspots were consistent with those observed during both the 2017 and 2020 hake demersal surveys. In the prior surveys, the northern hotspot occurred in a narrow strip that straddled the 200 m depth contour, while in the current survey, bad weather resulted in missed stations forming a gap in the west-east extent, as well as along the southern extent of this abundance hotspot. In the current survey, aggregations were also present to the south and southwest, occurring in deeper waters adjacent to the 200 m depth contour. While there were no clear indications of these occurring in the 2017 survey, only a limited number of deep-water stations were undertaken in the southwest, as this area was not extensively explored. There is evidence of a similar hotspot occurring during the 2020 survey, although stations in this region were sparse. This reinforces the need for a standardised sampling design across surveys. The complete coverage of the areas of increased densities should be prioritised in future surveys.

Observed data obtained from other demersal finfish species showed distinct patterns. Rock cod *Patagonotothen ramsayi* consisted of 7.7% of the total catch and showed substantially higher mean densities (471 kg/km^2) compared to the 2017 (133 kg/km^2) and 2020 (81.9 kg/km^2) surveys. Clear differences were also evident in the length frequency distributions. During the 2022 survey, there were increases in the proportion of larger (21-30 cm) mature (stage IV) individuals relative to the smaller (12-21 cm), immature (stage I and II) size classes that dominated the length frequency distribution during the 2017 and 2020 surveys. Distinct spawning aggregations were also identified inshore of 200 m to the west and at the edge of the FICZ to the northwest of the Jason Islands. Such aggregations were not identified during the 2017 survey. The increased densities, combined with the occurrence of spawning aggregations are important for this species that has experienced dramatic increases and declines over the last 15 years, and which is thought to play a key role in the trophodynamics of the area (Laptikhovsky, Arkhipkin and Brickle, 2013; Riccialdelli *et al.*, 2020).

Kingclip *Genypterus blacodes* occurrence was stable during the 2017 (77%), 2020 (69%) and the 2022 (70%) surveys. When captured, densities were lower (193 kg/km^2) compared to both the 2017 (356 kg/km^2) and 2020 (296 kg/km^2) research surveys. The prominence of larger individuals (>60 cm TL) was identified in the length frequency distribution during the 2022 survey compared to previous surveys undertaken in 2017 and 2020. The occurrence and densities of red cod *Salilota australis* in the catch showed minor fluctuations across the three surveys undertaken. They occurred in higher proportions during 2017 (86%) compared to the 2020 (67%) and 2022 (79%) surveys. Densities of red cod when present, showed the opposite trend to the occurrence data and were lower during 2017 (134 kg/km^2), and higher during 2020 (351 kg/km^2) compared to 2022 (204 kg/km^2). The length frequency distribution and the areas of high red cod densities were consistent across all surveys.

Strong differences were present in the Patagonian toothfish *Dissostichus eleginoides* catches across the 2017, 2020 and 2022 demersal surveys. The occurrence of a strong recruitment cohort (Age-1+; 17-26 cm) to the west of the Falkland Islands dominated the toothfish catches during the 2017 survey (Lee, Arkhipkin and Randhawa, 2021). This cohort was still evident in the catch, as larger fish during the 2020 survey in deeper waters to the southwest of the Falkland Islands. The ontogenetic movement of this cohort into deeper waters outside of the survey area, and the absence of any strong recruitment pulses since 2017 was evident in the catches of the 2022 survey, which were characterised by low occurrence (27%), densities (29 kg/km^2) and the thinly spread length distribution covering a wide age structure.

Differences in the occurrence and densities of blue whiting *Micromesistius australis* and hoki *Macruronus magellanicus* among the three winter surveys were not directly comparable as a result of differences in the location of stations. The spatial design of demersal surveys does not include consideration for blue whiting or hoki distribution which is more associated with the deeper waters of the shelf edge than the shelf itself (Agnew, 2002). Furthermore, the bottom trawl used in the survey has a limited horizontal opening (3-4 m). Both blue whiting and hoki are assumed to be associated with the bottom during different stages of their life-history but may occupy a significantly larger proportion of the water column (Alemany, Iribarne and Acha, 2018; Post, Fock and Jansen, 2019; Busbridge *et al.*, 2020; Gorini *et al.*, 2021). Care should be taken in using survey results as an index of abundance for these species. There are other surveys which measure abundance of blue whiting in Falkland Islands waters using acoustic methods but these have consisted of individual specialist surveys and are of limited benefit in terms of generating a time series covering an extended period.

During the 2022 survey, blue whiting occurred primarily to the southwest and northeast of the zone (30%). While the occurrence of blue whiting during 2017 was lower (22%), none of the deep-water stations to the southwest were undertaken during this survey. Similarly, the high occurrence (67%) and zero-inflated densities (107 kg/km^2) of blue whiting during the 2020 survey were generally a result of stations undertaken in deep-water to the southwest, not undertaken during either the 2017 or 2022 surveys. The occurrence and zero-inflated densities of hoki in the catch steadily decreased over the three survey years from 68% in 2017 (622 kg/km^2), 51% in 2020 (51 kg/km^2), to only 22% in 2022 (70 kg/km^2). Further, catches of hoki in the 2022 survey only occurred in the most southerly stations which were not undertaken during 2017.

While not species of commercial importance, the banded whiptail grenadier *Coelorinchus fasciatus*, channel bull blenny *Cottoperca trigloides*, catshark *Schroederichthys bivius* and spiny dogfish *Squalus acanthias* possess important ecological roles as both predators (e.g. of *Doryteuthis gahi* and *Patagonotothen ramsayi*) and prey (e.g. of *Merluccius hubbsi* and *Dissostichus eleginoides*) within the inshore Patagonian shelf ecosystem (Arkhipkin *et al.*, 2012, 2022; Lattuca *et al.*, 2020). In addition, these species also form a substantial bycatch component of local and regional fisheries. The occurrence (60-61%) and zero-inflated densities (16-20 kg/km^2) of the channel bull blenny remained stable across the 2017 and 2022 surveys. The lower occurrence of the species during the 2020 survey (47%) occurred as a result of the greater proportion of stations outside of their depth distribution. Similarly, the catshark showed stable occurrence (60-82%) and densities (82-127 kg/km^2) across all surveys. In contrast, the occurrence and density of spiny dogfish appears to be substantially lowered in 2022 (19%; 48 kg/km^2) compared to 2017 (47%; 183 kg/km^2). The banded whiptail grenadier generally occurs in deeper waters to the southwest of the Falkland Islands. The variable spatial structure of the three surveys in this region means that the 2022 survey occurrence (24%) and mean densities (297 kg/km^2) are not directly comparable with the 2017 (limited deeper stations in the south-west) and 2020 (extra deep-water stations in the south-west) surveys.

Falkland calamari *Doryteuthis gahi* were present across all stations, with the largest densities (4292 kg/km^2) along the narrow shelf to the southwest and northeast of the Falkland Islands. These areas were spatially consistent, but in greater densities compared with observations during the 2017 demersal survey (up to 2797 kg/km^2) and 2020 hake survey (up to 3286 kg/km^2). The Argentine shortfin squid occurred in low densities (1 kg/km^2) in 52% of the stations, primarily to the northeast and west of the Falkland Islands. The majority of these consisted of small (10 cm) immature (stage I) individuals, consistent with observations (65%; 1.8 kg/km^2; 12.5 cm) during the 2017 survey. While squid occurred in far greater densities (933 kg/km^2) during the 2020 survey, these occurred predominantly in the high seas north of FICZ and FOCZ.

The two predominant skate species historically targeted in the FICZ showed evidence of declines. The blonde skate *Bathyraja brachyurops* showed declines both in occurrence and mean densities between 2017 (61%; mean zero-inflated density = 35 kg/km^2) and 2022 (35%; mean zero-inflated density = 17 kg/km^2). Further, the length frequency distributions in 2022 were unbalanced and lacked the distinct cohorts evident during 2017. Similar declines were evident in the yellow nose skate *Dipterus lamillai*, occurring in 80% of trawls (zero-inflated mean density = 80 kg/km^2) in 2017 compared to 71% (zero-inflated mean density = 50 kg/km^2) in 2022. Declines in the occurrence (35-21%) were also identified in Falkland skate, although zero-inflated densities remained stable (7.1 kg/km^2) Research into the skate assemblage, their biology and vulnerabilities to fisheries requires further research.

There is an increasing need for sustained ocean time series, particularly for the monitoring of commercial fisheries resources and bycatch species in the presence of climate change. These can ensure the detection of early signs of unanticipated changes, provide a more holistic understanding of ecosystem responses, and prompt faster management actions. For this reason, fisheries-related surveys that collect fisheries-independent data are considered a key pillar of sustainable fisheries management (Gallo *et al.*, 2022). Data gathered during the current survey, and indeed all other surveys conducted since February 2010, will be of importance to provide scientifically robust advice that will assist in the provision of evidence-based recommendations for improved fisheries management.

5. Recommendations

1. The number and alignment of stations should be consistent across demersal surveys. The inclusion or omission of stations from one year to the next may reduce the spatial and temporal resolution, bias results and complicate the analysis of trends over time. The loss of two fishing days due to scheduling and the subsequent days lost to bad weather resulted in an inability to meet the station target and gaps in the spatial resolution of the data. The complete coverage of the area of interest should be considered a priority for future surveys. Contingency measures should be considered for when such circumstances arise (e.g. an extension of survey period).
2. Similar to both the 2021 and February 2022 surveys, the MarPort Net Monitoring system did not provide net horizontal opening data on 43% (n = 27) of the trawls. This information is essential to calculate biomass; failure to acquire net data may bias biomass estimates and affect the examination of biomass trends through time. This issue should be investigated and corrected immediately after first notice during the surveys.
3. The July survey was a second snapshot of our understanding of the marine ecosystem around the Islands in the winter. Even though the spatial nature and structure of the various stocks were described, limited comparable information is currently available on the inter–annual variability. It is therefore recommended to repeat this survey in July 2023 to further study the annual variability of both the biological and oceanographic components.
4. Increased abundance of hake in FICZ requires further investigation. Key research objectives should focus on (a) improving our understanding of migratory patterns, (b) defining demographic characteristics of the stock in the FICZ, and (c) estimating the ecological impact that increased hake abundance and migratory behaviour may have on other finfish species (e.g. rock cod, red cod, kingclip) in the region.
5. The continued absence of recruitment pulses of Patagonian toothfish remains a concern. Further research should be undertaken to identify the extent that variable recruitment is influenced by environmental or fisheries-related pressures. The continuation of a July demersal survey is important for monitoring toothfish recruitment in the waters of the Falkland Islands.

6. Apparent declines in the occurrence and zero-inflated mean densities of skate species require further investigation. Future research objectives should be identified to improve our understanding of the spatial-temporal interactions of species assemblages as well as describing aspects of their biology, ecology and susceptibility to fisheries exploitation.

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