Cruise Report ZDLT1-01-2017

Juvenile toothfish survey

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Arkhipkin et al. (2017). Scientific Report, Fisheries Cruise ZDLT1-01-2017. Stanley, Fisheries Department, Directorate of Natural Resources, Falkland Islands Government.

Introduction

Knowledge of toothfish dispersal from their spawning grounds on the Burdwood Bank and areas of early recruitment is paramount for studies on the life cycle and demography of this fish in waters around the Falkland Islands. From literature, it is known that toothfish spawns pelagically with eggs and larvae occurring in upper pelagic layers over the continental slope. After a period of intensive growth, young juveniles settle on the shelf, where they carry on feeding and grow rapidly for about 3-4 years before moving back to the continental slope. Locations and pathways of juvenile dispersal have yet to be found in the Falkland Islands.

The first plankton toothfish research survey (November 2015) did not find any small juvenile toothfish over the southern shelf and slope. It was suggested that the main reason for this was the time of the survey being too early after winter spawning. The present survey was shifted to January, giving at least 4 months for larvae and early juveniles to grow after spawning.

Cruise objectives

1. To locate and study the distribution of small juvenile toothfish in the southern FICZ/FOCZ by Isaac-Kidd Plankton Trawl.
2. To locate and investigate the distribution of young toothfish recruitment in shelf areas by semi-pelagic and bottom trawls.
3. To carry out oceanographic survey of the area studied.

Vessel

The cruise was conducted on the F/V *Castelo*, registered in the Falkland Islands and chartered to do research cruises by the Fisheries Department.

Personnel and responsibilities

The following FIFD personnel participated in the cruise:

Dr Alexander Arkhipkin	Chief Scientist
Denise Herrera	Oceanographic survey
Brendon Lee	Trawl survey
Tara Boag	Trawl survey
Kirsty Bradley	Trawl survey
Kate Cockcroft	Trawl survey

Cruise plan and key dates

The vessel departed from Stanley at 7 p.m. on the 19th of January and proceeded overnight to the first station located at 200 m depth in the north-eastern part of the Patagonian Shelf. During the next four days, the vessel moved south west along the shelf and carried out four semi-pelagic trawls daily, two at the 50 to 100 m horizon over 150-200 m depths, and two near bottom tows. Each evening, three IKMT were performed, at horizons of 5 m, 25 m and 50 m over bottom depths of 100-150 m. As the catch of fish and squid was very small during semi-pelagic tows, it was decided to call in to Stanley and change the net to bottom trawl. Over the next nine days of the survey, the vessel proceeded further west around the Falkland Islands, doing four bottom trawls daily from shallow waters (~70 m) to 150 m depth, and IKMTs in the evenings. The cruise was successfully finished on the 3rd of February 2017. Despite two days of rough weather with strong winds (30-50 knots) and high seas, the vessel managed to fish with no days lost due to bad weather.

Equipment used

Trawling

An ENGEL semi-pelagic trawl with "Super-V" doors was used during the first four days of the survey. It had a 40.2 m headline and a 38.7 m footrope equipped with rockhoppers. Net monitor sensors were attached to the upper panel of the trawl. The vertical opening was between 7 and 12 m and the codend mesh size was 95 mm.

A regular bottom net equipped with two 1800 kg Oval-Foil doors (OF-14) was used for the remainder of the survey.

Oceanographic

A CTD SBE 25 was deployed to collect profiles of temperature and salinity during oceanographic stations.

Sampling

Trawl stations and biological sampling

During the ZDLT1-01-2017 research cruise station numbers ranged from 2191 to 2310. The catch at all trawl stations was weighed using an electronic marine adjusted balance (POLS, min 10 g, and max 80 kg). All finfish and skate were weighed by species. Lobster krill catch weights were estimated when in excess of 1.5 tonnes. Random samples (100-200 individuals) of commercially important species were measured (LT, LPA, LDW) to the nearest cm below and sex and stage of maturity were recorded for all specimens sampled. During length-weight sampling (mainly otolith collection), individual weights were measured to the nearest gram.

Oceanography

Methods

A single CTD (SBE-25, Sea-Bird Electronics Inc., Bellevue, USA) instrument was used to collect oceanographic data prior to all trawl stations, Serial Number 0247. This CTD was equipped with a temperature sensor (Serial Number 2680), a conductivity sensor (Serial Number 2273), a Seapoint fluorometer (Serial Number 2510), an SBE 43 dissolved oxygen sensor (Serial Number 0376) and a pH sensor (Serial Number 0223).

At all CTD stations the CTD was lowered to a depth of approximately 10 m below the surface for a soak time of one minute, allowing the pump to start circulating water and flush the system. Following this the CTD was raised to a minimum of 5 m again to begin the main profile and being lowered to the seabed at a rate of $1ms^{-1}$. Pressure was collected in dbar, temperature in ˚C, conductivity in mS/cm, Oxygen Voltage and Fluorescence as µg/L.

The raw hexadecimal file was converted to a Seabird CNV file using SBE Data Processing (version: 7.25.0) with the CON file “0247OldCTD_2016_May.xmlcon”. The initial surface soak and upcast data was filtered out. Depth was derived using the latitude of each station, oxygen in ml/L was derived at the same time. Practical salinity as well as density as sigma-t (σ-t) were derived following derivation of depth. Variables of conservative temperature (˚C) and Absolute Salinity (g/kg) were calculated in Ocean Data View version 4.7.8 (Schlitzer, R., Ocean Data View, http://odv.awi.de). Visual outputs were produced using Ocean Data View as well.

Results

Oceanographic data was collected at 49 stations covering an area from 51˚ 15.9’ S to 53˚ 2.2’ S and from 57˚ 19’ W to 61˚ 14.5’ W. As data was good on all downcasts, the upcasts were subsequently filtered out. Figure 1 below shows the location of stations.

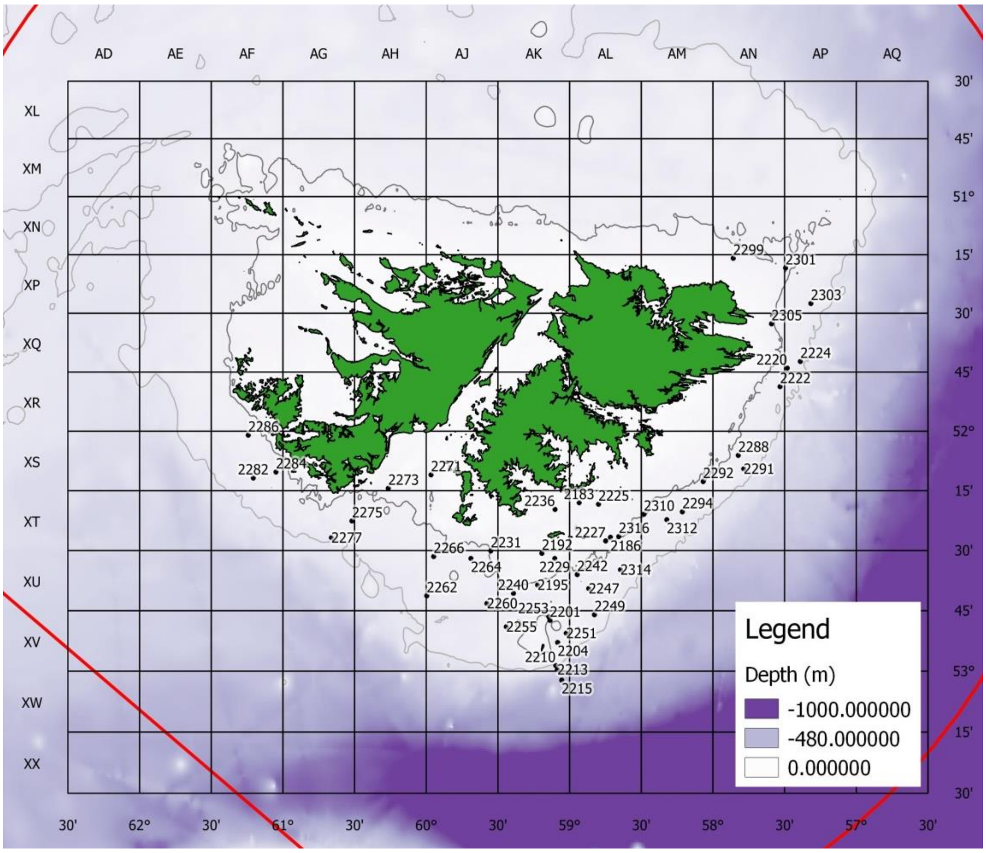

Figure 1: Location of stations

Figures 1 to 5 below show gridded results at both 10 and 50 m of temperature, salinity, σ-t density, dissolved oxygen concentration in mL/L and Chlorophyll a concentration in µg/L. These were gridded using ODV4 DIVA algorithm[i]. The first layer at 10 m is the first depth in common for all CTD casts and as such given as the surface layer. All CTDs reached a depth at least of 50 m.

In general, water temperatures at the surface were warmest further west and inshore, with a stronger temperature variation visible to the east of the islands (Figure 2). Temperature varied at 10 m from 8.98° C (at St. 2213) to 10.88° C (at St. 2305) and at 50 m from 6.91° C (at St. 2251) to 10.74° C (at St. 2305). In the areas around Beauchene Island, eddying is visible resulting in the upwelling of cooler waters to shallower depths. This is particularly visible at 50 m, where cooler waters were observed at St.2201, 2204, 2210, 2213, 2215, 2251 and 2253.

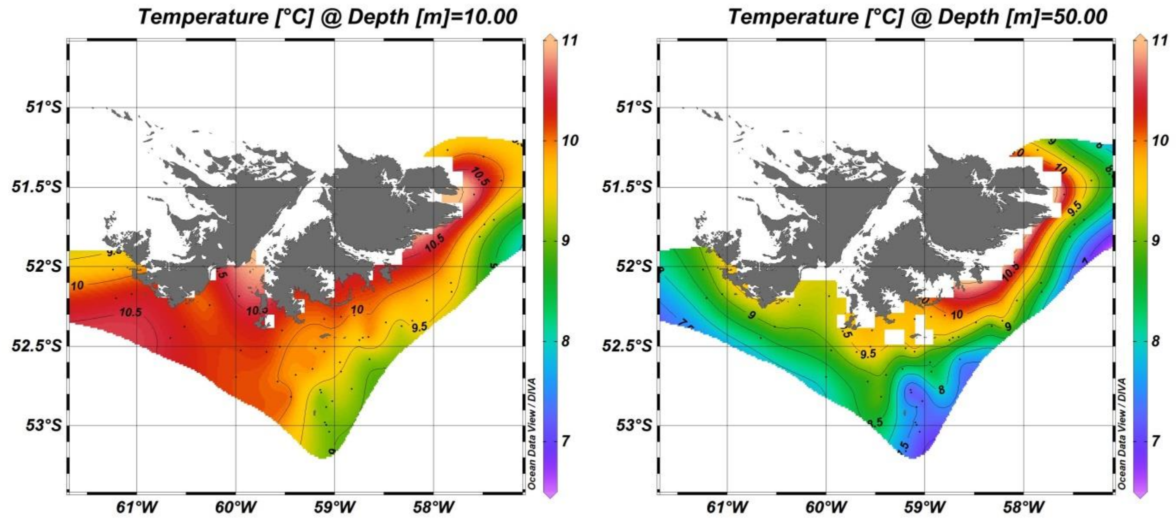

Figure 2: Temperature variation at 10 and 50 m.

Salinity varied from 33.65 to 33.9 across the sample area. Less saline areas were found at the surface further inshore near the East Falkland and further offshore near the West Falkland (Figure 3). Most saline waters were found close to Beauchene Island. At 50m, less saline water were again found closer to the land and more saline further offshore close to Beauchene Island. However, a protruding area of less saline waters is observed off Berkeley Sound at St. 2224 and St. 2305.

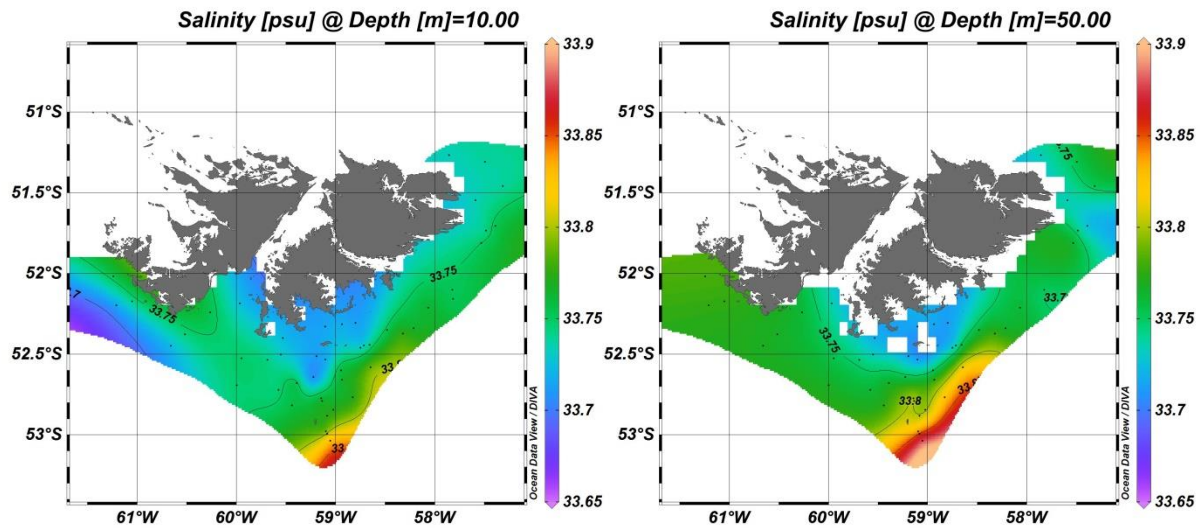

Figure 3: Salinity variation at 10 and 50 m.

Near Beauchene Island (Figure 4), an upwelling of denser water at 50 m was observed that also matched temperature profiles. On a TS plot (Figure 5) a clear mixing of transient zone water with warmer and less saline Falkland Shelf Water was observed. Transient zone water is a mixture of Shelf Water and Sub-Antarctic Superficial Water (SASW) below 100 m (Arkhipkin *et al.*, 2004).

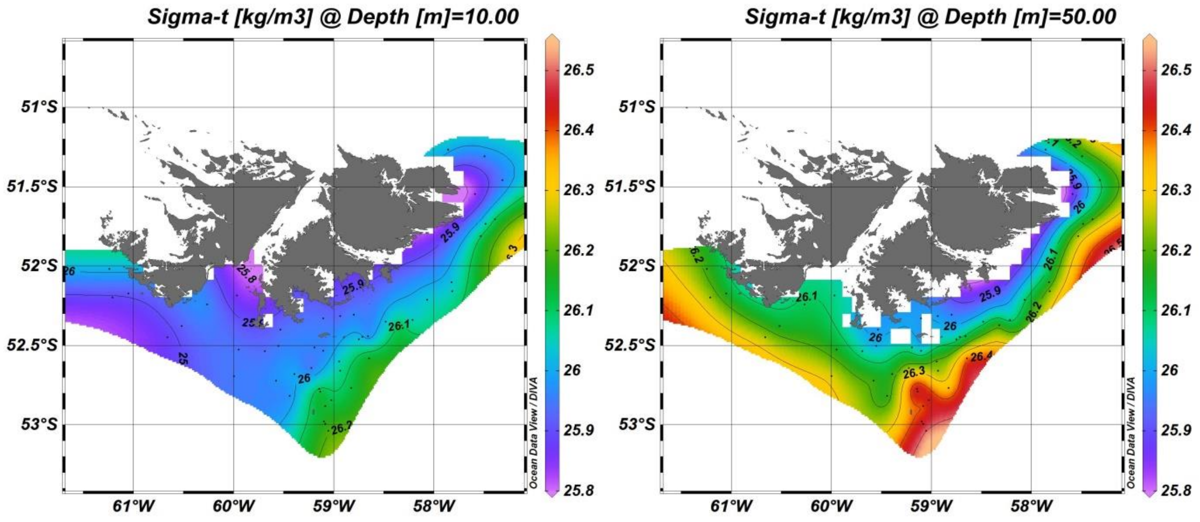

Figure 4: Density variation at 10 and 50 m.

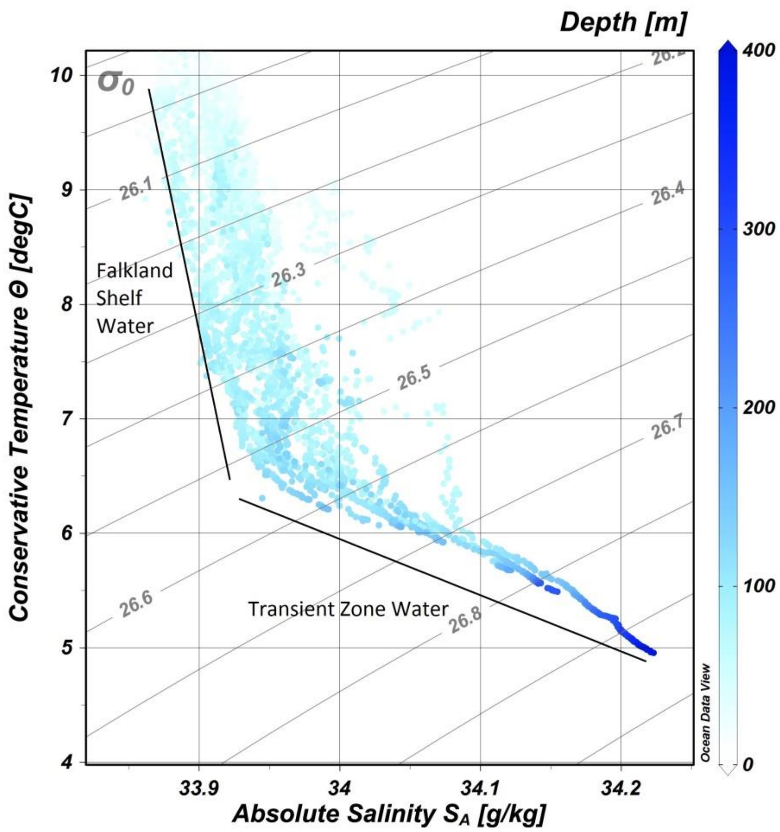

Figure 5: T-S Plot showing Water masses for all profiles.

Chlorophyll a concentration varied greatly throughout the study area, ranging from 0 to 3.5 µg/L. At depths of 10 m, areas of higher chlorophyll a concentration were observed near Beauchene and further offshore associated with the upwelling of cooler waters. Only at some stations closer to land higher concentrations of chlorophyll a were observed. This overall patchiness was likely a result of tidal mixing and small scale surface currents.

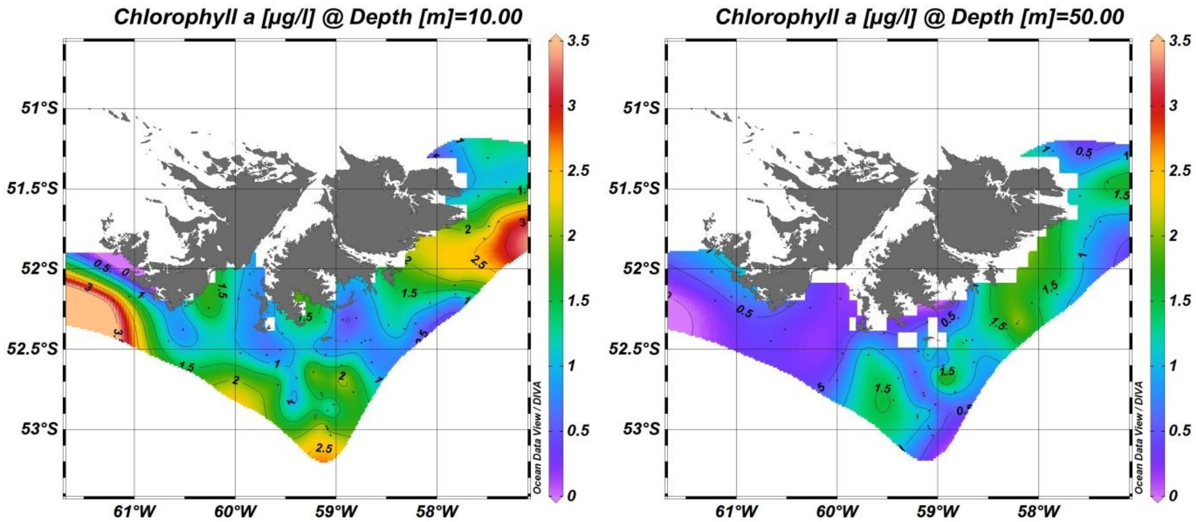

Figure 6: Chlorophyll A concentrations at 10 and 50 m.

Oxygen too varied across the survey area from 5.6 mL/L to 6.65 mL/L. At 10 m lower oxygen values were found further inshore than offshore. Oxygen values at 50 m were lower and patchier, in concurrence with chlorophyll variation. The greatest concentration of dissolved oxygen was found south of Beauchene Island.

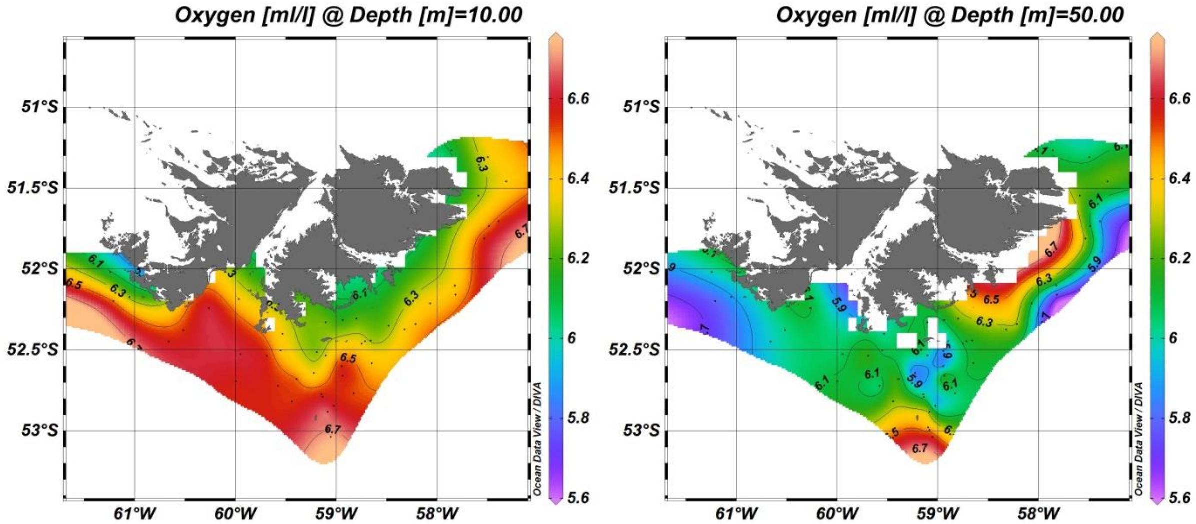

Figure 7: Dissolved oxygen concentrations at 10 and 50 m.

Overall, the oceanographic conditions varied very little across the survey area with only small variations in salinity, chlorophyll a concentration and dissolved oxygen concentration. Falkland Shelf waters were visible across the survey areas most identifiable by warmer temperatures. Cooler waters were also slightly more saline and constituted transition zone water. The greatest areas of mixing were found around and extending northwards from Beauchene Island to Sea Lion Island. Not only stronger inflow of upwelled denser water was visible there but also associated patchiness of chlorophyll A concentration at 10 m and 50 m depths.

Biological Sampling

Bottom trawl catch

Bottom trawling was conducted at 44 stations (Figure 8). Seabed trawling times during the survey was 60 minutes.

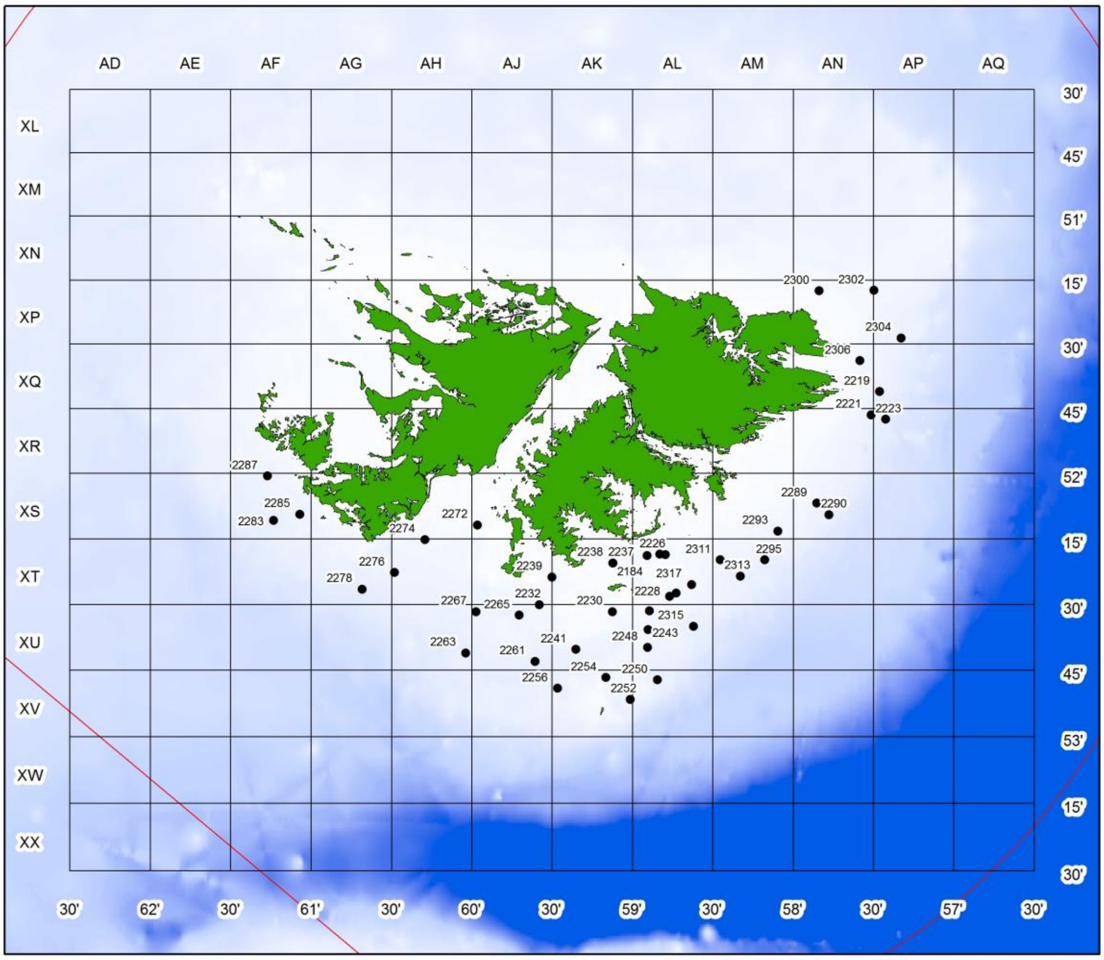

Figure 8. Location of biological stations made by bottom trawl during the survey.

During the cruise a total of 41,261 kg of various animals was caught at 44 bottom trawl stations belonging to about 100 species or taxa (Table 1). The largest catches by weight were lobster krill (*Munida gregaria*) followed by Patagonian longfin squid (*Doryteuthis gahi*) and common rock cod (*Patagonotothen ramsayi*).

Table 1: Total catches of various species by bottom trawl during the cruise.

Species Code	Species Name	Total Catch (kg)	Total Sampled (kg)	Total Discarded (kg)	Proportion (%)
MUG	*Munida gregaria*	20584.26	26.838	20584.26	49.88%
LOL	*Doryteuthis gahi*	7225.509	204.489	0	17.51%
PAR	*Patagonotothen ramsayi*	5465.189	125.388	4726.236	13.24%

SAR	*Sprattus fuegensis*	2883.598	7.26	2883.598	6.99%
CHE	*Champsocephalus esox*	2019.925	134.602	1759.115	4.90%
SHT	*Mixed invertebrates*	446.182	0	446.182	1.08%
BAC	*Salilota australis*	276.864	0.62	103.864	0.67%
BRY	Bryozoa	274.394	0	274.394	0.66%
GOC	*Gorgonocephalus chilensis*	252.264	0	252.264	0.61%
SPN	Porifera	179.614	0	179.614	0.44%
WRM	*Chaetopterus variopedatus*	158.523	0	158.523	0.38%
SAL	Salpa sp.	147.572	0	147.572	0.36%
PTE	*Patagonotothen tessellata*	145.89	0.063	145.89	0.35%
CGO	*Cottoperca gobio*	131.199	0.162	131.199	0.32%
DGH	*Schroederichthys bivius*	126.459	0.098	126.459	0.31%
SQT	Ascidiacea	108.753	0	108.753	0.26%
TOO	*Dissostichus eleginoides*	85.359	68.426	25.871	0.21%
ZYP	*Zygochlamys patagonica*	76.502	0	76.502	0.19%
STA	*Sterechinus agassizi*	69.794	0	69.794	0.17%
ANM	Anemone	63.116	0	63.116	0.15%
RMG	*Bathyraja magellanica*	62.8	5.547	26.89	0.15%
ALF	*Allothunnus fallai*	60.02	60.02	0	0.15%
ALG	Algae	31.492	0	31.492	0.08%
MUU	*Munida subrugosa*	29.947	1.522	29.947	0.07%
COL	*Cosmasterias lurida*	29.808	0	29.808	0.07%
RBR	*Bathyraja brachyurops*	25.088	0	12.988	0.06%
UCH	Sea urchin	22.012	0	22.012	0.05%
COG	*Patagonotothen guntheri*	17.045	0.094	17.045	0.04%
ILL	*Illex argentinus*	16.853	15.615	16.853	0.04%
LIX	Lithodidae	16.128	0	16.128	0.04%
FUM	*Fusitriton m. magellanicus*	12.497	0	12.497	0.03%
ODM	*Odontocymbiola magellanica*	11.979	0	11.979	0.03%
RED	*Sebastes oculatus*	11.904	7.76	2.704	0.03%
RPX	Psammobatis spp.	11.864	1.258	11.864	0.03%
AST	Asteroidea	11.584	0	11.584	0.03%
SUN	*Labidaster radiosus*	11.006	0	11.006	0.03%
THO	Thouarellinae	10.815	0	10.815	0.03%
ALC	Alcyoniina	10.432	0	10.432	0.03%
AUC	*Austrocidaris canaliculata*	9.771	0	9.771	0.02%
RFL	Zearaja chilensis	9.16	5.49	9.16	0.02%
CAZ	Calyptraster sp.	9.022	0	9.022	0.02%
LIS	*Lithodes santolla*	7.258	4.448	5.31	0.02%
LIY	Liparid spp.	6.85	0	6.85	0.02%
COX	Notothenid spp.	6.845	0	6.845	0.02%
POA	*Porania antarctica*	6.759	0	6.759	0.02%
PES	*Peltarion spinosulum*	6.471	0	6.471	0.02%
NED	*Neolithodes diomedeae*	6.46	0	6.46	0.02%
RMC	*Bathyraja macloviana*	5.637	3.716	5.637	0.01%

GOR	Gorgonacea	5.046	0	5.046	0.01%
EUO	*Eurypodius longirostris*	4.959	0	4.959	0.01%
ING	*Moroteuthis ingens*	4.03	0	4.03	0.01%
KIN	*Genypterus blacodes*	3.98	0	3.98	0.01%
OCM	*Octopus megalocyathus*	3.609	0	3.609	0.01%
CRY	Crossaster sp.	3.492	0	3.492	0.01%
WHI	Macruronus magellanicus	3.365	1.95	3.365	0.01%
NEM	Neophyrnichthys marmoratus	3.157	0	3.157	0.01%
CIR	Cirripedia	2.6	0	2.6	0.01%
BLU	*Micromesistius australis*	2.378	0.089	2.378	0.01%
RBZ	*Bathyraja cousseauae*	2.12	0	2.12	0.01%
RAL	*Bathyraja albomaculata*	2.106	0	2.106	0.01%
TRP	*Tripilaster philippi*	2.076	0	2.076	0.01%
RSC	*Bathyraja scaphiops*	2.03	2.03	2.03	<0.01%
NUD	Nudibranchia	1.699	0	1.699	<0.01%
MAV	*Magellania venosa*	1.515	0	1.515	<0.01%
SOR	*Solaster regularis*	1.416	0	1.416	<0.01%
CEX	Ceramaster sp.	1.31	0	1.31	<0.01%
BAL	*Bathydomus longisetosus*	1.16	0	1.16	<0.01%
BRA	Brachyura	1.046	0	1.046	<0.01%
CYX	Cycethra sp.	0.947	0	0.947	<0.01%
RGE	*Amblyraja cf. georgiana*	0.852	0	0.852	<0.01%
HAK	*Merluccius hubbsi*	0.818	0	0	<0.01%
ASA	*Astrotoma agassizii*	0.806	0	0.806	<0.01%
CHR	*Chrysaora cf. plocamia*	0.682	0	0.682	<0.01%
EUL	*Eurypodius latreillei*	0.665	0	0.665	<0.01%
SER	Serolis spp.	0.59	0	0.59	<0.01%
MUO	*Muraenolepis orangiensis*	0.536	0	0.536	<0.01%
OCC	Octocoralia	0.417	0	0.417	<0.01%
MUE	*Muusoctopus eureka*	0.386	0	0.386	<0.01%
CTA	*Ctenodiscus australis*	0.372	0	0.372	<0.01%
LOS	*Lophaster stellans*	0.324	0	0.324	<0.01%
EEL	*Iluocoetes fimbriatus*	0.285	0.055	0.058	<0.01%
NOW	*Paranotothenia magellanica*	0.272	0	0.272	<0.01%
FAN	Metafannyella sp.	0.22	0	0.22	<0.01%
OPH	Ophiuroidea	0.2	0	0.2	<0.01%
POL	Polychaeta	0.194	0	0.194	<0.01%
AUL	*Austrolycus laticinctus*	0.188	0	0.188	<0.01%
BAO	*Bathybiaster loripes*	0.182	0	0.182	<0.01%
SRP	*Semirossia patagonica*	0.156	0	0.156	<0.01%
HYD	Hydrozoa	0.148	0	0.148	<0.01%
EGG	Eggmass	0.13	0	0.13	<0.01%
CAV	*Campylonotus vagans*	0.104	0	0.104	<0.01%
ACS	Acanthoserolis schythei	0.101	0	0.101	<0.01%
THN	*Thysanopsetta naresi*	0.101	0.101	0.101	<0.01%

OPV	*Ophiacanta vivipara*	0.092	0	0.092	<0.01%
OCT	Octopus spp.	0.054	0	0.054	<0.01%
PLU	Primnoellinae	0.05	0	0.05	<0.01%
ACA	*Acesta patagonica*	0.05	0	0.05	<0.01%
NUH	*Nuttallochiton hyadesi*	0.05	0	0.05	<0.01%
AGO	*Agonopsis chilensis*	0.028	0	0.028	<0.01%
PYX	Pycnogonida	0.015	0	0.015	<0.01%
CRI	Crinoidea	0.01	0	0.01	<0.01%
PLB	Primnoellinae	0.01	0	0.01	<0.01%
MED	Medusae	0.001	0	0.001	<0.01%
		41261.603	**677.641**	**32683.62**	

Semi-pelagic trawl catch

Semi-pelagic trawling was conducted at 11 stations (Figure 9). Trawling time during the survey was 120 minutes.

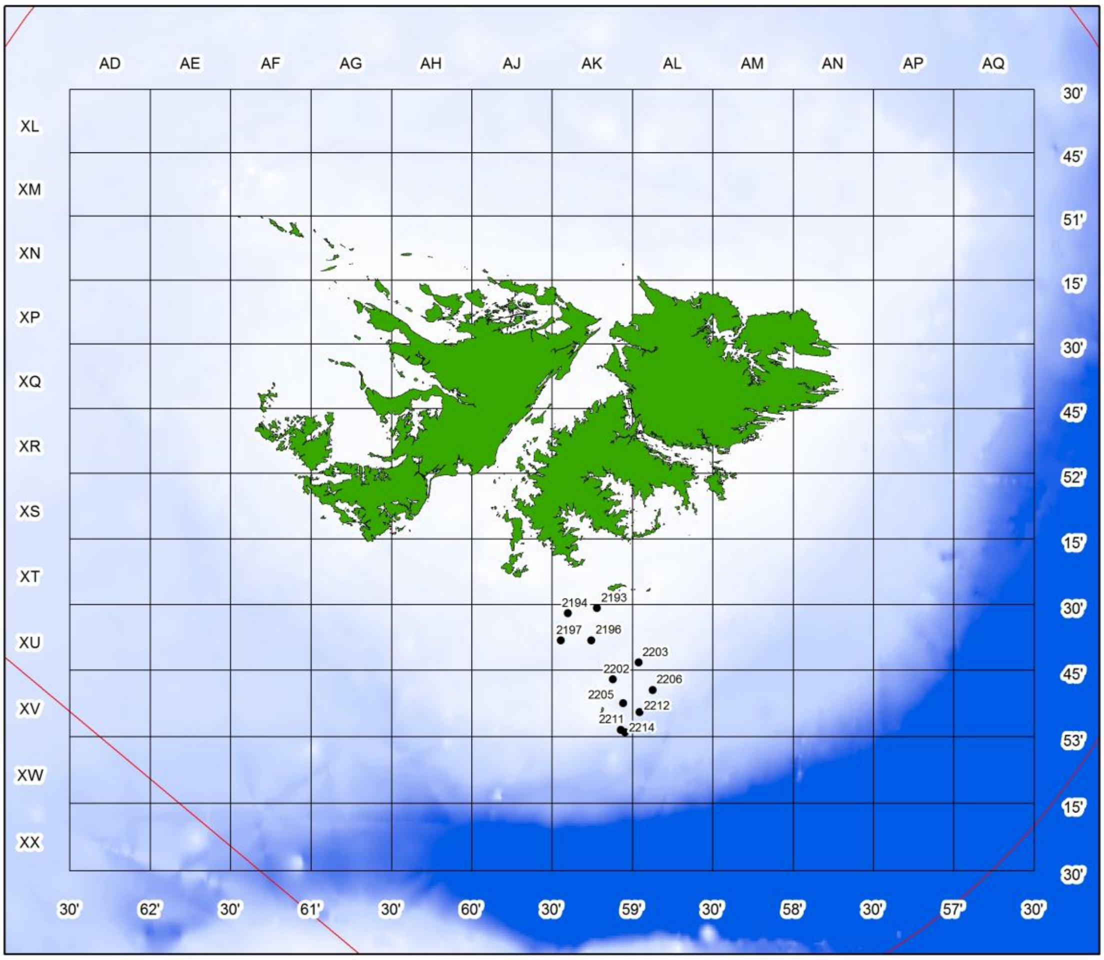

Figure 9. Location of biological stations made by semipelagic trawl during the survey.

During the cruise a total of 1,309 kg of various animals was caught at 11 semipelagic trawl stations belonging to about 60 species or taxa (Table 2). The largest catches by weight were those of grenadier (*Macrourus carinatus*) followed by common rock cod (*Patagonotothen ramsayi*) and southern blue whiting (*Micromesistius australis*).

Table 2: Total catches of various species by semipelagic trawl during the cruise.

Species	Species Name	Total Catch (kg)	Total Sampled (kg)	Total Discarded (kg)	Proportion (%)
GRC	*Macrourus carinatus*	284.24	207.439	0	21.71%
PAR	*Patagonotothen ramsayi*	267.921	17.819	15.401	20.46%
BLU	*Micromesistius australis*	242.167	51.075	0.007	18.50%
LOL	*Doryteuthis gahi*	198.392	15.511	1.288	15.15%
MUG	*Munida gregaria*	99.679	0.726	99.679	7.61%
WHI	*Macruronus magellanicus*	37.48	37.48	0	2.86%
CHE	*Champsocephalus esox*	37.338	2.907	37.338	2.85%
GRF	Coelorhynchus fasciatus	30.14	13.85	30.14	2.30%
SHT	*Mixed invertebrates*	17.986	0	17.986	1.37%
CGO	Cottoperca gobio	14.394	2.624	14.394	1.10%
TOO	*Dissostichus eleginoides*	13.639	13.635	0.045	1.04%
PAT	Merluccius australis	12.4	12.4	0	0.95%
RFL	*Zearaja chilensis*	8.1	8.1	0	0.62%
COX	*Notothenid spp.*	7.462	0.002	7.462	0.57%
PAU	*Patagolycus melastomus*	6.83	2.35	0	0.52%
ALF	Allothunnus fallai	6.3	6.3	0	0.48%
ING	*Moroteuthis ingens*	5.09	0	5.09	0.39%
BAC	*Salilota australis*	3.06	3.06	3.06	0.23%
SPN	*Porifera*	2.681	0	2.681	0.20%
SQT	Ascidiacea	2.454	0	2.454	0.19%
GYM	*Gymnoscopelus spp.*	2.268	0	2.268	0.17%
HAK	*Merluccius hubbsi*	1.38	1.38	0	0.11%
AST	Asteroidea	1.088	0	1.088	0.08%
ALG	*Algae*	0.946	0	0.946	0.07%
ZYP	*Zygochlamys patagonica*	0.857	0	0.857	0.07%
WRM	*Chaetopterus variopedatus*	0.797	0	0.797	0.06%
PTE	Patagonotothen tessellata	0.704	0.704	0.704	0.05%
MED	*Medusae*	0.703	0	0.703	0.05%
COT	*Cottunculus granulosus*	0.472	0	0.472	0.04%
ANM	Anemone	0.412	0	0.412	0.03%
PYM	*Physiculus marginatus*	0.34	0	0.34	0.03%
HYD	*Hydrozoa*	0.288	0	0.288	0.02%
COL	*Cosmasterias lurida*	0.275	0	0.275	0.02%
CHR	Chrysaora cf. plocamia	0.178	0	0.178	0.01%
SUN	Labidaster radiosus	0.159	0	0.159	0.01%
ODM	*Odontocymbiola magellanica*	0.14	0	0.14	0.01%
MUE	Muusoctopus eureka	0.12	0	0.12	0.01%
POA	Porania antarctica	0.1	0	0.1	0.01%

ACS	*Acanthoserolis schythei*	0.062	0	0.062	<0.01%
CYX	Cycethra sp.	0.062	0	0.062	<0.01%
GOC	Gorgonocephalus chilensis	0.042	0	0.042	<0.01%
CAZ	*Calyptraster sp.*	0.03	0	0.03	<0.01%
OCC	Octocoralia	0.024	0	0.024	<0.01%
BAO	Bathybiaster loripes	0.024	0	0.024	<0.01%
AUC	*Austrocidaris canaliculata*	0.021	0	0.021	<0.01%
BRY	*Bryozoa*	0.016	0	0.016	<0.01%
STA	*Sterechinus agassizi*	0.016	0	0.016	<0.01%
PAS	*Patagonotothen squamiceps*	0.015	0	0	<0.01%
THO	Thouarellinae	0.014	0	0.014	<0.01%
EUL	*Eurypodius latreillei*	0.013	0	0.013	<0.01%
XXX	*Unidentified animal*	0.01	0.01	0.01	<0.01%
BRA	*Brachyura*	0.01	0	0.01	<0.01%
CTA	*Ctenodiscus australis*	0.01	0	0.01	<0.01%
NUD	Nudibranchia	0.006	0	0.006	<0.01%
PYX	Pycnogonida	0.003	0	0.003	<0.01%
OPH	Ophiuroidea	0.002	0	0.002	<0.01%
MUU	Munida subrugosa	0.001	0	0.001	<0.01%
SAL	*Salpa sp.*	0.001	0	0.001	<0.01%
POL	*Polychaeta*	0.001	0	0.001	<0.01%
CRI	*Crinoidea*	0.001	0	0.001	<0.01%
		1309.364	**397.372**	**247.241**	

Plankton catch

Plankton trawling was conducted by Isaacs-Kidd midwater trawl at 33 stations (Figure 10). Trawling time of each tow during the survey was 15 minutes.

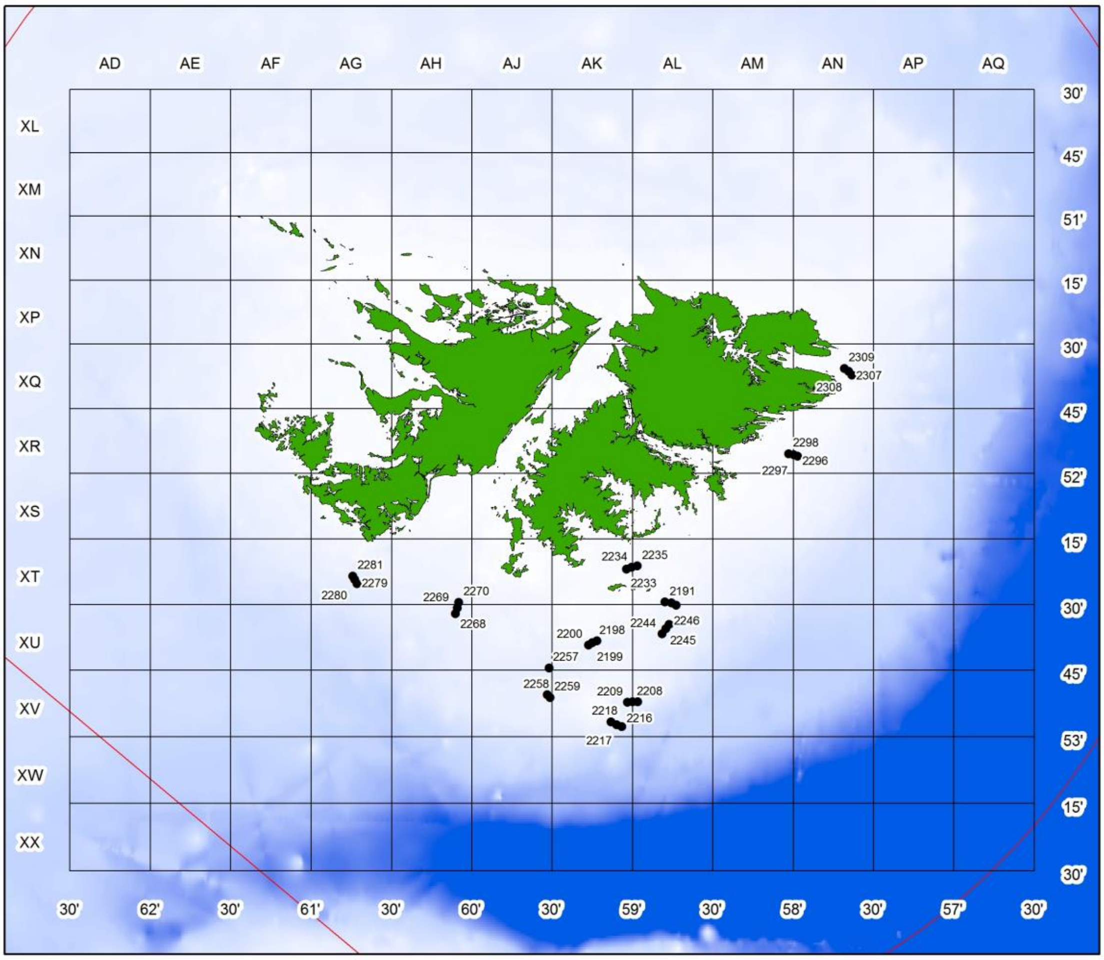

Figure 10. Location of biological stations made by plankton IKMT trawl during the survey.

Table 3: Total catches of various species by plankton IKMT trawl during the cruise.

Species	Name	Abundant (5-30%)	Common (1-5%)	Dominant (30-80%)	Occasional (<1%)	(1-2 specimens)	Total
EUV	*Euphausia vallentini*	14	6	8	5		33
THE	*Themisto gaudichaudi*	8	10	3	7	5	33
FIN	Unidentified finfish	3	7	2	18	2	32
MUG	*Munida gregaria*	4	5	13	5	2	29
CHA	Chaetognatha	8	1	9	3	3	24
THV	*Thysanoessa vicina*	2	3		4	3	12
MYC	*Mysidopsis acuta*		1		4	3	8
COA	Copepoda	2			5		7
LOL	*Doryteuthis gahi*		1		3		4
MED	Medusae sp.		1	3			4
OCM	*Enteroctopus Megalocyathus*		1		1		2
AGO	*Agonopsis chiloensis*		1				1
AMP	Amphipods				1		1
HYX	Hyperia spp.				1		1
MNL	*Mnemiopsis leidyi*				1		1
MUU	*Munida subrugosa*				1		1
PHR	Phronimidae				1		1
PHX	Phrosina spp.					1	1
PTR	Pteropoda				1		1

Results

Patagonian toothfish

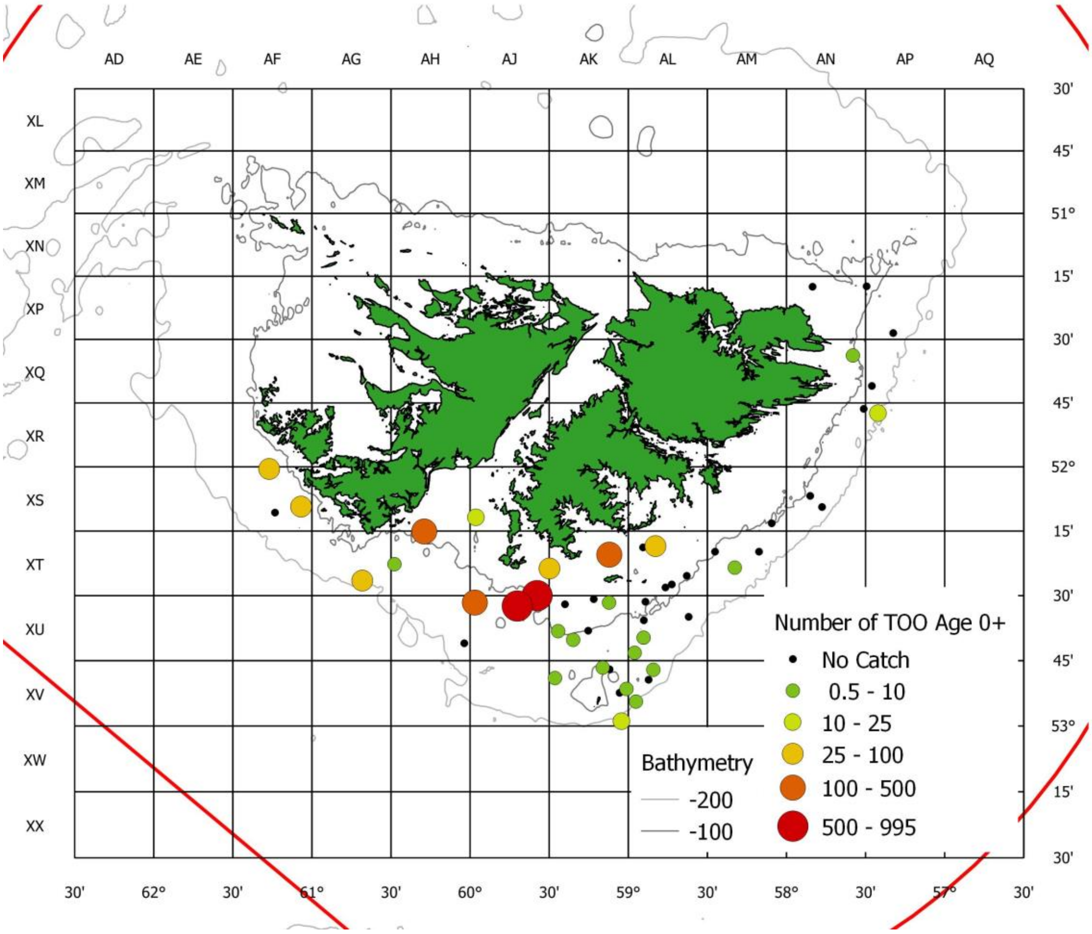

Figure 11. Distribution and abundance (in numbers) of 0+ toothfish during the survey.

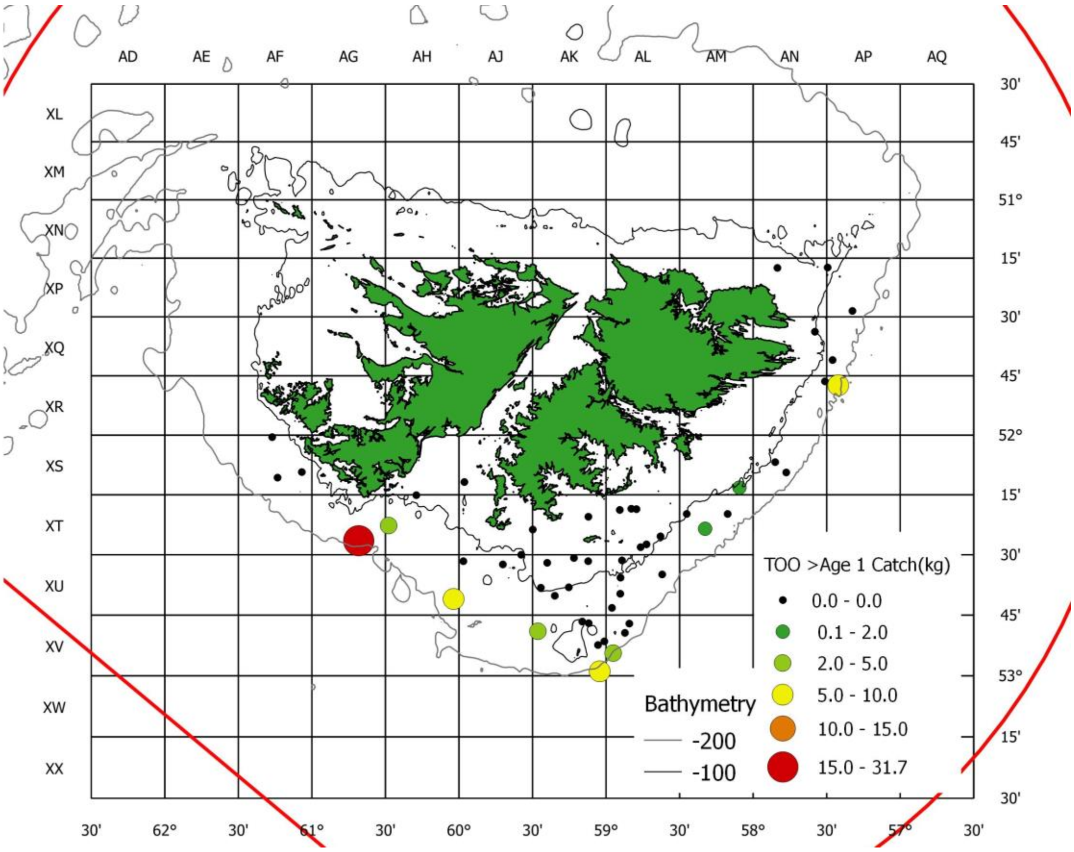

Figure 12. Distribution and abundance (in weight) of >1+ toothfish during the survey.

A total of 1,226 Patagonian toothfish and 4,366 icefish were sampled during the research survey. Patagonian toothfish ranged in length from 6 to 63 cm TL while icefish ranged from 10 to 42 cm TL.

Small juvenile 0+ toothfish were abundant in shallow waters to the south of the Falkland Islands, which have to be considered as their nursery grounds. They were especially abundant at two shallow water stations to the south of Speedwell Island, with the total catch being around 1,000 specimens in 1 hr trawl (Figure 11). Older fish of 1+ year class occurred deeper, almost never co-inhabiting nursery grounds of small juveniles (Figure 12). Therefore, the intra-specific competition of older and larger fish by predation upon younger and smaller fish was avoided by spatial separation of their habitats.

The length frequency distributions of toothfish differed according to depth with larger fish increasingly occurring at the greater depth. At shallow depths (<130 m), the length frequency distribution of Patagonian toothfish displayed a single major modal peak at 12 cm (6 – 14 cm TL) consisting almost entirely of juvenile 0+ fish (**Error! Reference source not found.**4A). This juvenile cohort extended into greater depths of up to 154 m, although larger immature toothfish were also present in the catch (**Error! Reference source not found.**4B). Although no juvenile toothfish were present at depths greater than 170 m, two cohorts consisting of larger immature male and females were evident at 34 cm (26 – 42 cm TL, 1+ fish) and 48 cm (42 – 60 cm TL, 2-3 years old fish, **Error! Reference source not found.**4C).

Figure 13. Juvenile 0+ toothfish and its rock cod prey.

Juveniles of Patagonian toothfish of 0+ year class fed mainly on small 0+ rock cod (4-5 cm TL). Almost exclusively, one large item of prey, bent in half, was found in their stomachs (Figure 13).

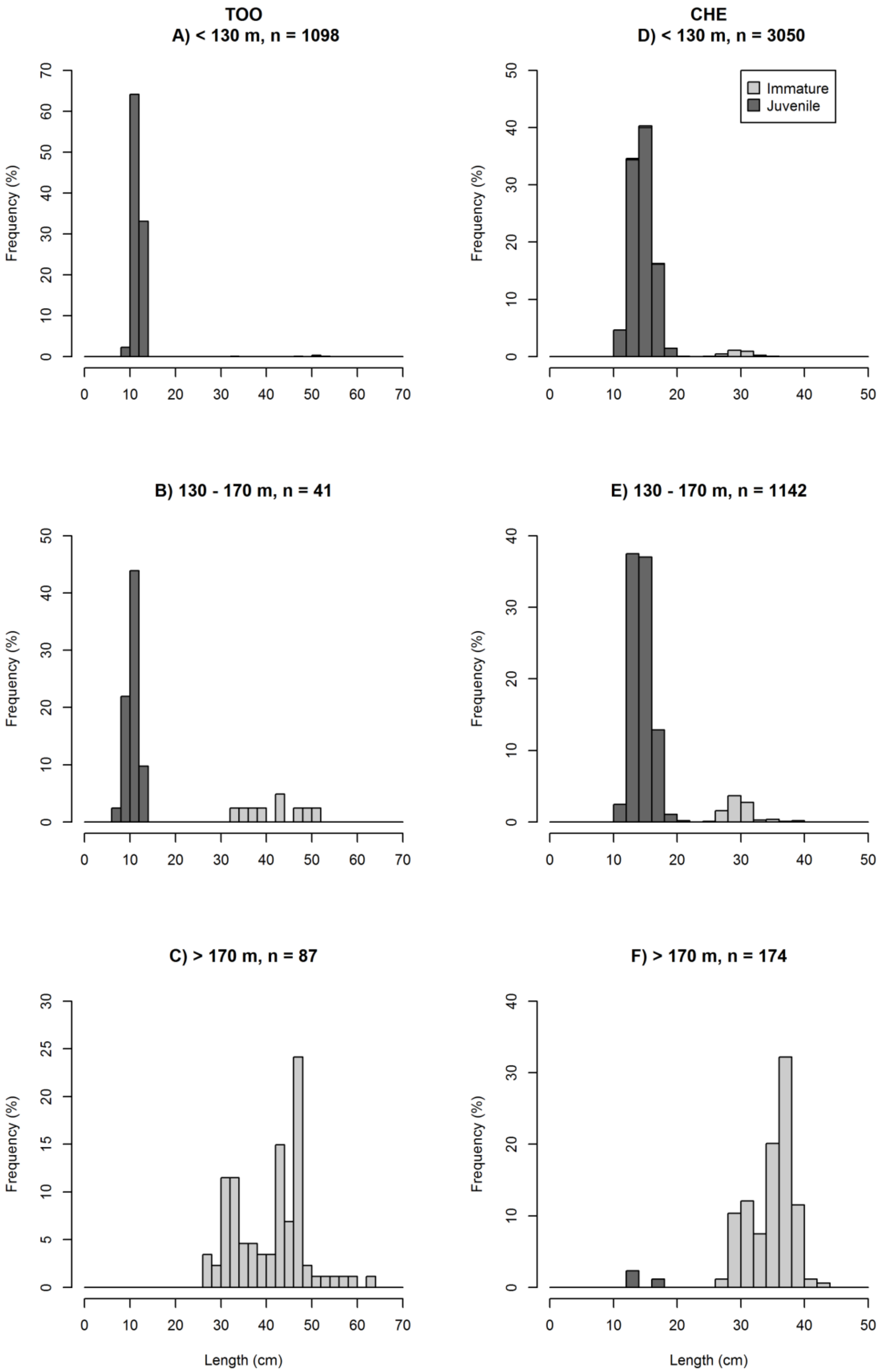

Figure 14. Length frequency distributions at different depths for (A - C) Patagonian toothfish and (D - F) icefish sampled during the research survey.

Icefish

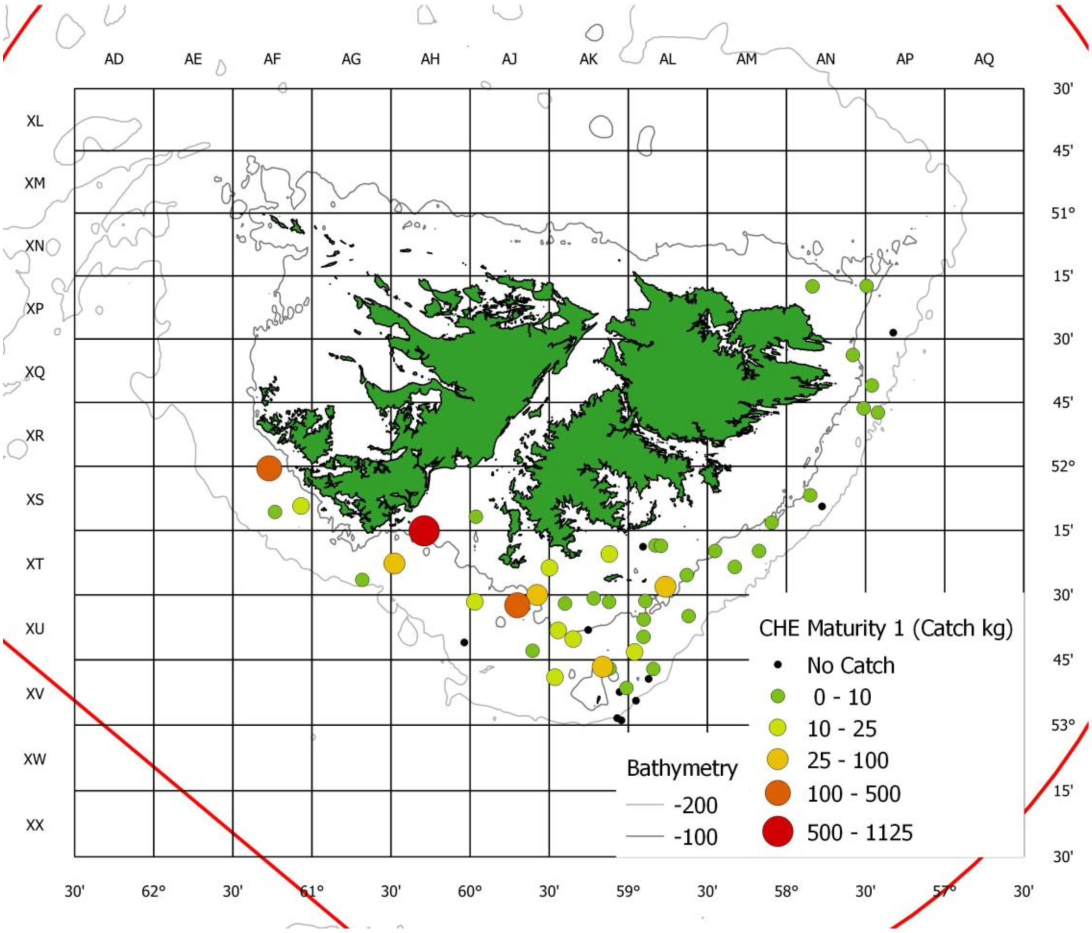

Figure 15. Distribution and abundance (in weight) of juvenile icefish during the survey.

Icefish *C. esox* was mainly caught in shallow water stations of the survey, however in much larger numbers than Patagonian toothfish. In Falkland Sound, the abundance of icefish was about 1,000 times more than that of toothfish, making it one of the dominant predators.

Similarly to toothfish, the highest concentrations of icefish occurred in shallow water stations in the southern parts of the survey (Figures 15-16), with smaller fish of 0+ year class occurring shallower (<100 m) than older fishes (>=1+).

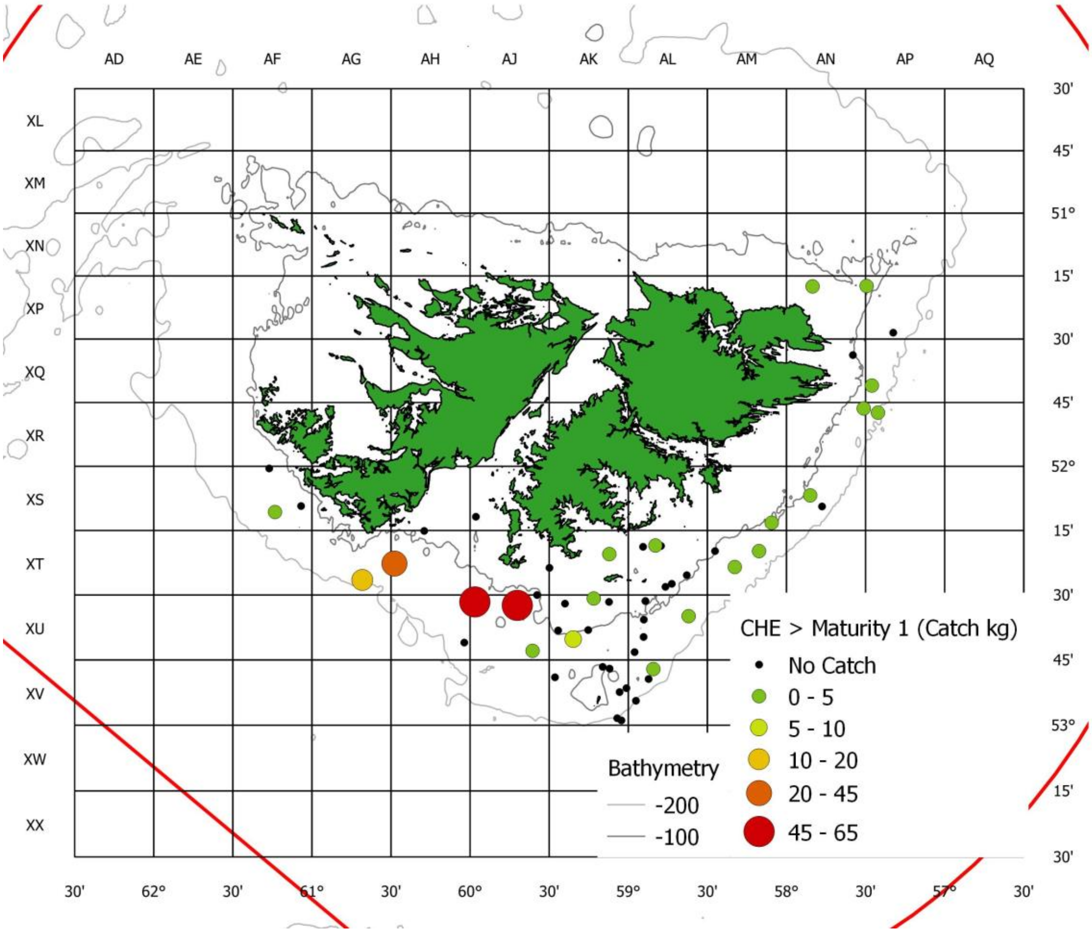

Figure 16. Distribution and abundance (in weight) of adult icefish during the survey.

Similar to Patagonian toothfish, the length frequency distribution of icefish differed according to depth. At shallow depths (<130 m) a major modal peak was evident between 10 and 20 cm TL with a minor modal peak occurring at 26 to 34 cm TL (**Error! Reference source not found.**4D). Although the juvenile cohort (0+) was still prominent at intermediate depths (130 – 170 m), a higher proportion of the second modal length was also present in the catch (**Error! Reference source not found.**4E). Very few juvenile icefish were present in the catch at depths greater than 170 m, with the majority of animals occurring in two modal peaks occurring at 32 cm TL (26 – 34 cm TL) and 36 cm TL (34 – 44 cm TL, **Error! Reference source not found.**4F).

Icefish was also predating on small 0+ rockcod, similarly to juvenile toothfish (Figure 17).

Figure 17. Juvenile 0+ icefish and its rock cod prey.

Lobster krill

Figure 18. Colour forms of lobster krill; common reddish colour of recently settled form, and unusual blue-purple colour of demersal form.

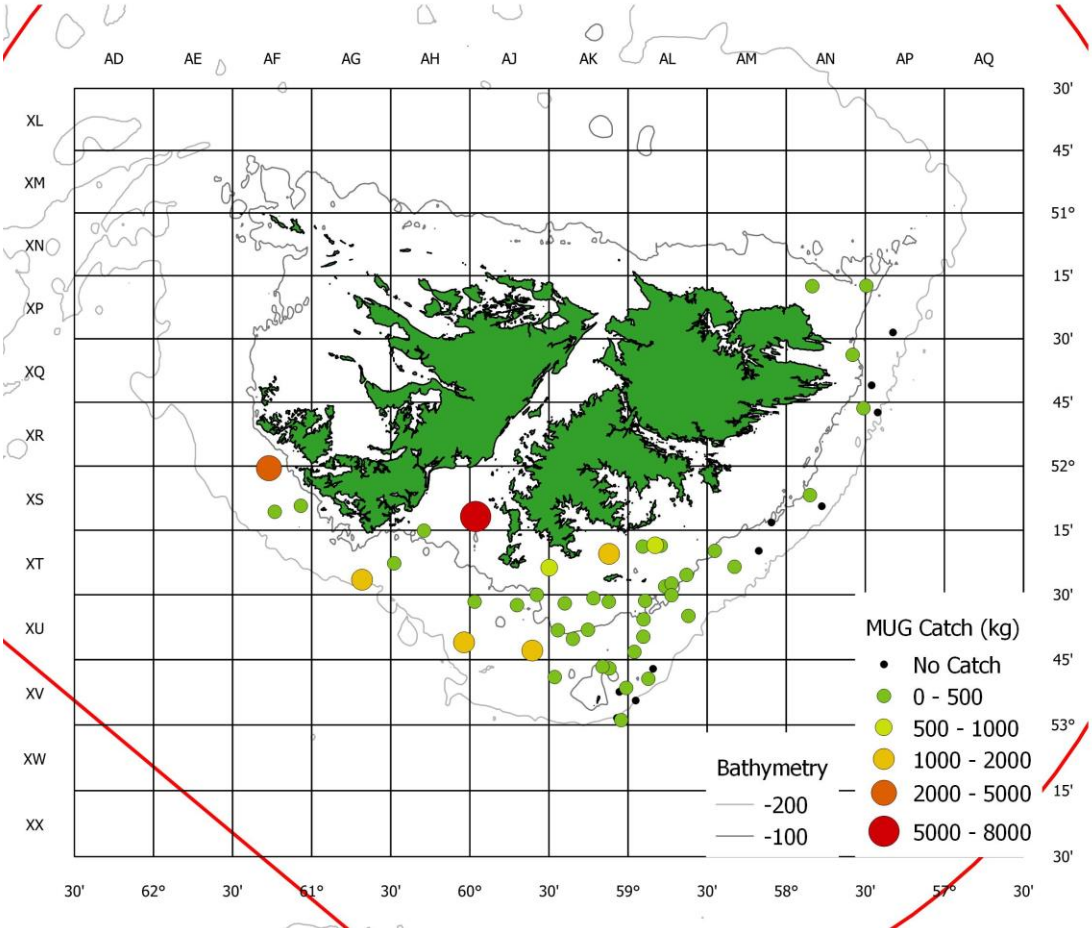

Figure 19. Distribution and abundance (in weight) of lobster krill during the survey.

A total of 2,215 *M. gregaria* were sampled during the research survey ranging in length from 1.1 to 2.6 cm carapace length, CL. The largest catches of lobster krill were observed in shallow waters of Falkland Sound, and near Beaver Island (Fig. 19). Strangely, among the majority of common red-coloured lobster krill encountered small quantities of almost blue animals were also observed (Figure 18).

No clear trends in the length frequency distribution of *M. gregaria* according to depth (**Error! Reference source not found.**0). The length frequency distributions were all unimodal with an average length of 1.9 cm CL (1.1 – 2.6 cm CL) at depths <130 m. As depth increased the mean length of *M. gregaria* increased slightly to 2.1 cm (1.5 – 2.5 cm CL) although fewer animals were present in the catch. At depths greater than 170 m, the mean length of *M. gregaria* decreased again to 1.8 cm CL (1.4 – 2.1 cm CL).

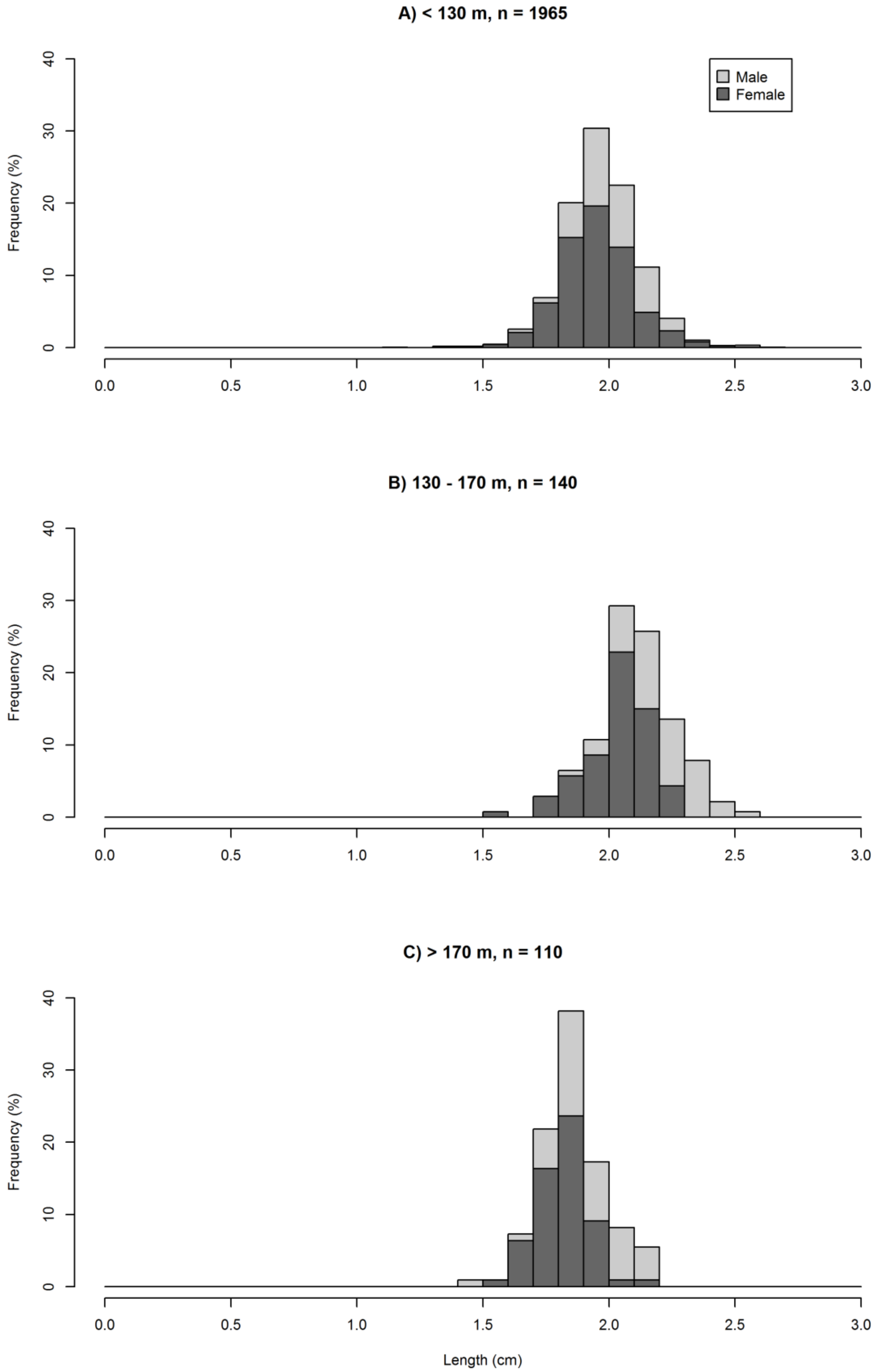

Figure 20. Length frequency distributions at different depths of Munidae gregaria sampled during the research survey

Rock cod

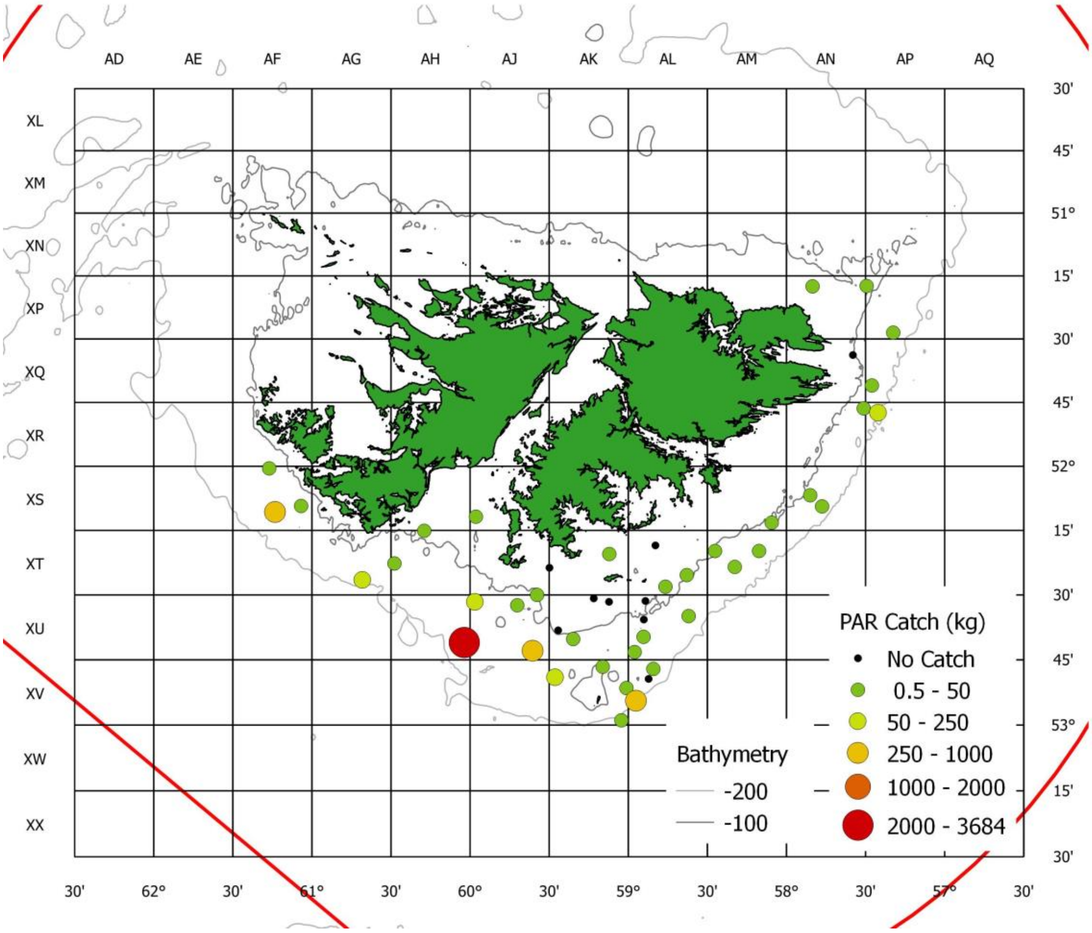

Figure 21. Distribution and abundance (in weight) of rock cod during the survey.

Small 0+ rock cod was very abundant in its nursery shallow water grounds in the southern, south-eastern and eastern parts of the Falkland Shelf (Figure 21). Catches of larger (2+) fish were highest in deeper waters (> 170 m) in the southern part of the survey, to the south of Falkland Sound and near Beaver Island.

Length frequency distributions changed with fishing depths (Figure 22). In shallow water stations (< 130 m) two year classes were the most abundant – 0+ of 5-6 cm TL, and 1+ of 14 cm TL. At intermediate depths, 1+ fish were the most abundant, whereas in deeper waters (> 170 m) fish were much larger with prevalence of 2+ fish of 17-18 cm TL.

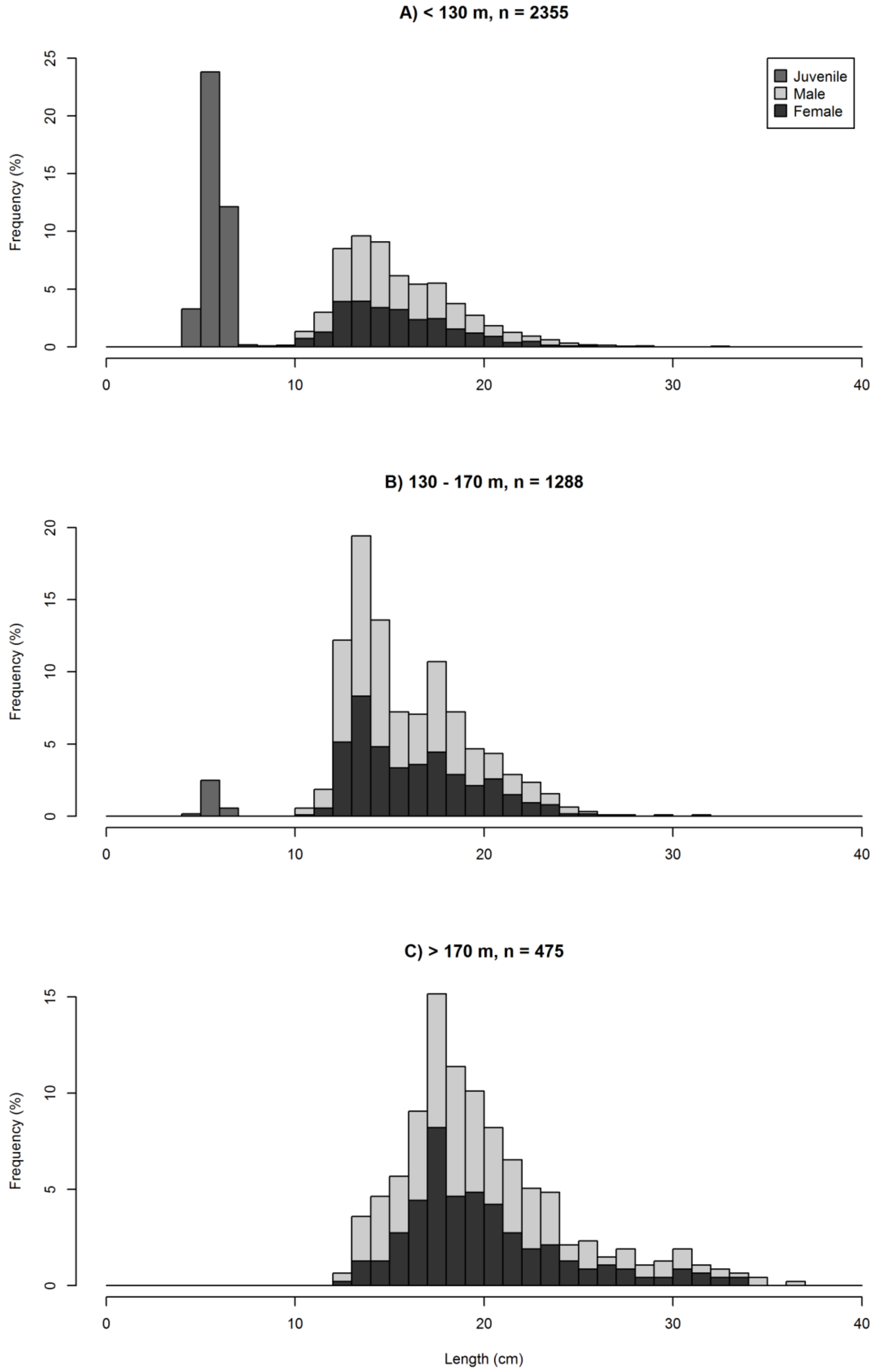

Figure 22. Length frequency distributions at different depths of rock cod sampled during the research survey

Patagonian squid

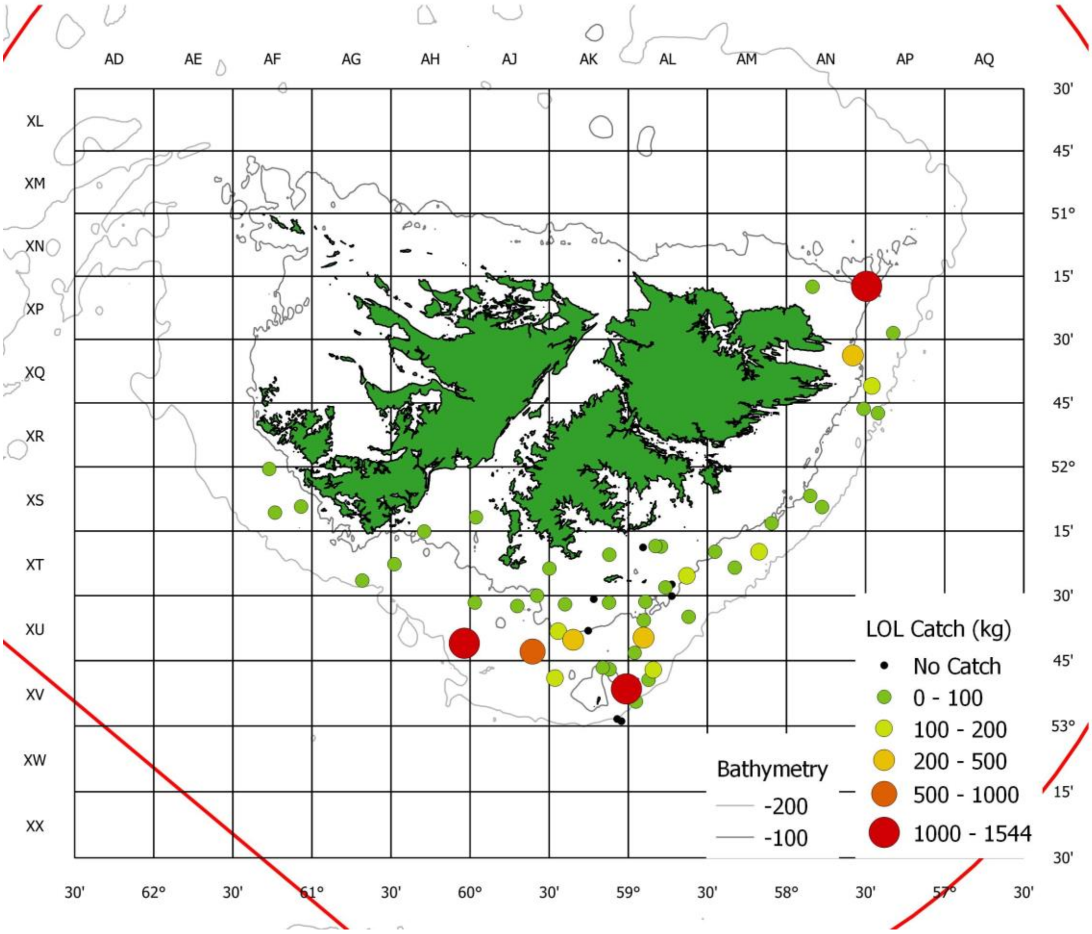

Figure 23. Distribution and abundance (in weight) of Patagonian squid during the survey.

Patagonian squid *Doryteuthis gahi* occurred throughout the majority of the survey area, being the most abundant at 120-150 m depths in the southern part of the Loligo Box (north and west of Beauchene Island), and to the north-east off McBride Head in the northern part of the Box (Figure 23). In shallow waters (<130 m), the widest range in squid size was observed, from small recruitment of the SSC cohort (3.5-5 cm ML) to mature squid >14 cm TL of late spawning SSC cohort. The majority of squid observed > 130 m (immature males and females of 11-12 cm TL) belonged to the ASC cohort that constitutes a bulk of *D. gahi* catch during the first commercial season in March-April. Modal sizes of squid at deepwater stations (12-12.5 cm ML) were slightly larger than those at intermediate depths (11-11.5 cm ML, Figure 24).

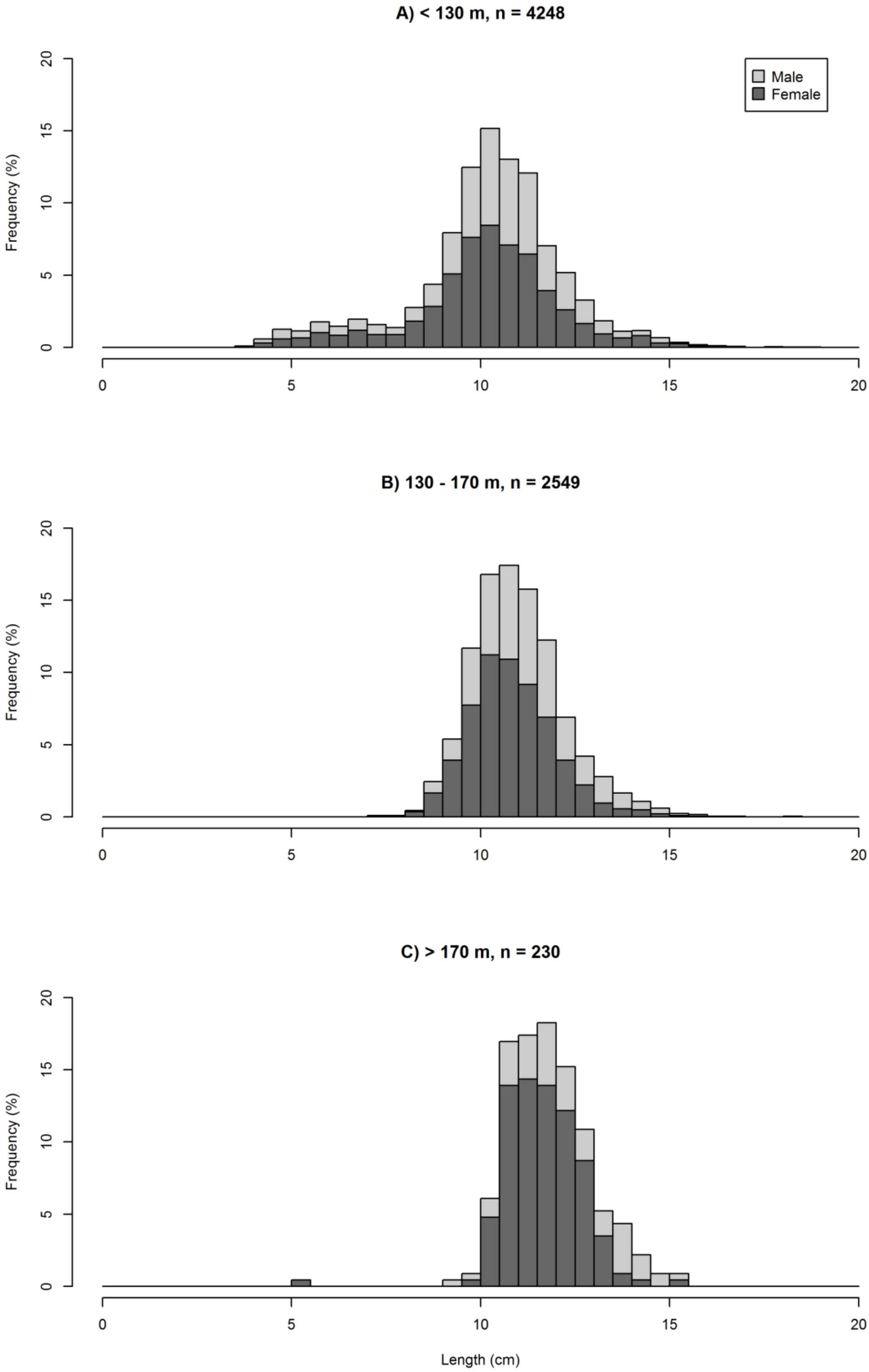

Figure 24. Length frequency distributions at different depths of Patagonian squid sampled during the research survey

Southern king crab

Figure 25. Southern king crab, a new potential fishery resource in the Falkland Islands.

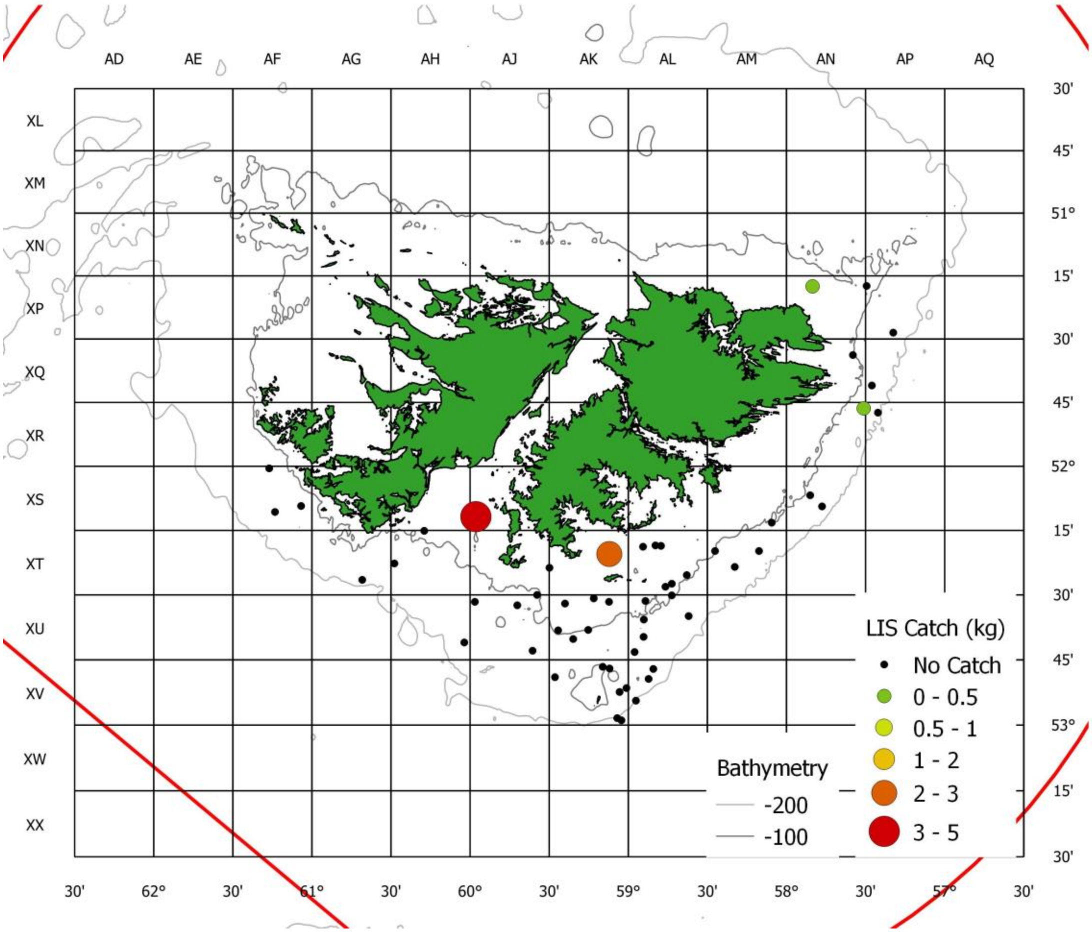

Figure 26. Distribution and abundance (in weight) of southern king crab during the survey.

For the first time during the research surveys, quite a few of large southern king crab (body weight varying between 2.5 and 4.5 kgs) were caught in shallow water bottom tows mostly in the southern part of the survey, to the north of Sea Lion Island and Falkland Sound. Several crabs were also caught in the northern part of the Loligo Box (Figure 26). These animals have not been seen in the Falklands for a long time, and may be relatively new migrants from the southern part of Patagonia. The size and taste of these crabs has the potential of making them a highly valued potential commercial fishery resource in the Falkland Islands.

Conclusions

1. Quasi-stationary cyclonic eddy causing upwelling of transient zone waters was found to the north of Beauchene Island. Same eddy forces the shelf waters further offshore to the east of Beauchene Island.
2. A nursery ground of juvenile 0+ year class toothfish was found to the south of the Falkland Islands, at depths between 70 and 120 m. In most abundant spots, the density of juvenile toothfish reached >1000 specimens by 1 hr trawl. At their nursery grounds, juvenile toothfish feeds predominantly on 0+ year class of rock cod (4-6 cm TL).
3. Habitats of 0+ and 1+ year classes of toothfish do not coincide with larger cohort occurring deeper. That provides necessary separation of both cohorts and prevents cannibalism.
4. At juvenile toothfish nursery grounds, juvenile icefish of almost the same length occurs, feeding and possibly competing on the same prey (0+ rock cod). Larger icefish occur deeper at this time period that prevents their preying upon small toothfish.
5. Recent appearance of large king crabs *Lithodes santolla* in shallow waters around the Falkland Islands represents a new potentially commercial resource for the Falkland fishery.