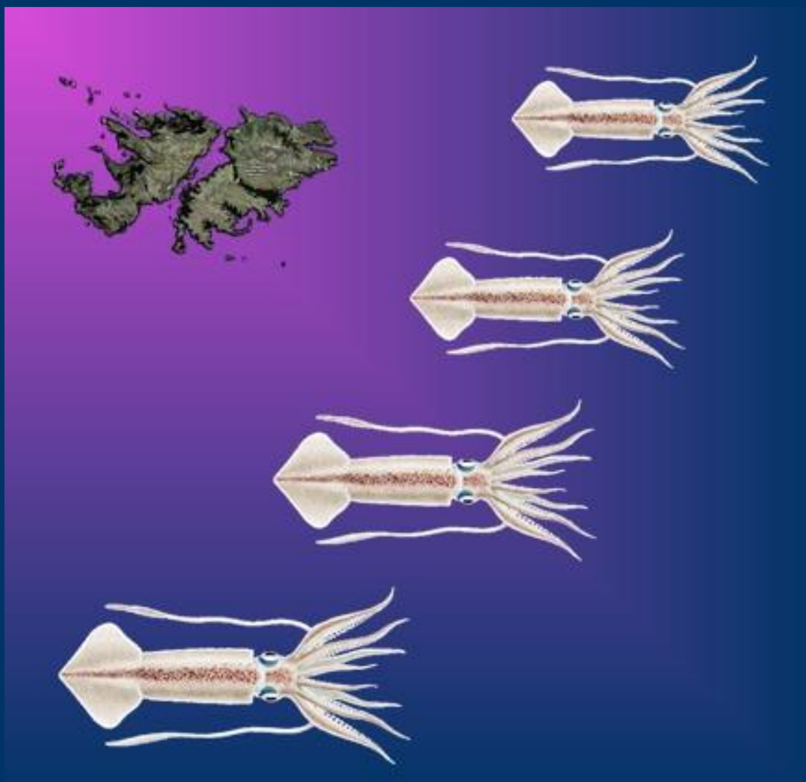
2023 2nd Pre-Season Assessment Survey

Falkland calamari

(*Doryteuthis gahi*)



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Summary

1) A stock assessment survey for *Doryteuthis gahi* (Falkland calamari) was conducted in the Loligo Box from 13th to 27th July 2023. A total of 56 scientific trawls were performed during the survey; 39 fixed-station trawls and 17 adaptive-station trawls. The scientific catch of the survey was 294.65 tonnes *D. gahi*.
2) An estimate of 19,859 tonnes *D. gahi* (95% confidence interval: 15,156 to 27,648 t) was calculated for the fishing zone by inverse distance weighting. The biomass estimate was the lowest for 2nd pre-seasons since 2008. Of the total, 4,956 tonnes were estimated north of 52 ºS, and 14,944 tonnes were estimated south of 52˚S. The proportion north (24.9%) was the lowest for a 2nd pre-season survey estimate since 2017.
3) *D. gahi* had significantly greater average mantle length and maturities of males south of 52˚S compared with individuals north of 52˚S. No significant difference in mantle length of females was found between north and south. Males north: mean mantle length 11.05 cm; mean maturity stage 3.4, south: mantle length 11.16 cm; maturity 3.8. Females north: mantle length 10.44 cm; maturity 2.27 south: mantle length 10.41 cm; maturity 2.2. Mantle length distributions suggested that some immigration continued throughout the survey.
4) A total of 113 taxa were identified in the catches. *D. gahi* was the largest species group at 76.7% of total catch by weight; lowest percentage for a 2nd pre-season since 2017 (64%). The second most abundant species by weight was common hake at 14.7%. Jellyfish contributed 4.4%, whereas blue whiting (0.5%) and rock cod (1.2%) were the only remaining taxa comprising ≥0.5% of total survey catch. Biological measurements and samples were taken from *D. gahi*, rock cod, toothfish, kingclip, hoki, southern blue whiting, common hake, southern hake, and several non-commercial species.

Introduction

A stock assessment survey for *Doryteuthis gahi* (Falkland calamari – Patagonian longfin squid – colloquially *Loligo*) was carried out by the FIFD on-board the fishing vessel *Montelourido* from the 13th to 27th July 2023; experimental license FK048E23. This survey continues the series of surveys that have, since February 2006, been conducted immediately prior to season openings to estimate *D. gahi* stock available to commercial fishing at the start of the season, and to initiate the in-season management model based on depletion time series of the stock.

Objectives of the survey were to:

1) Estimate the biomass and spatial distribution of *D. gahi* on the fishing grounds at the onset of the 2nd fishing season, 2023.
2) Estimate the biomass and distribution of common rock cod (*Patagonotothen ramsayi*) and other commercial species in the 'Loligo Box', for continued monitoring of these stocks in parallel to the finfish research survey.
3) Estimate the bycatch of toothfish (*Dissostichus eleginoides*) in *D. gahi* trawls.
4) Collect biological information on *D. gahi*, rock cod, toothfish and opportunistically other fish and invertebrates taken in the trawls.
5) Deploy SED net camera to obtain footage of seals on behalf of Megan Shapiro (Darwin Plus Project, SAERI).

The survey was designed to cover the 'Loligo Box' fishing zone (Arkhipkin et al. 2008, 2013) that extends along the shelf break across the southern and eastern part of the Falkland

Islands Interim Conservation Zone, plus two grids directly to the north. The delineation of the Loligo Box (Figure 1) represents an area of approximately 31,517.9 km^2, subtracting the 3-nautical mile exclusion zone around Beauchêne Island.

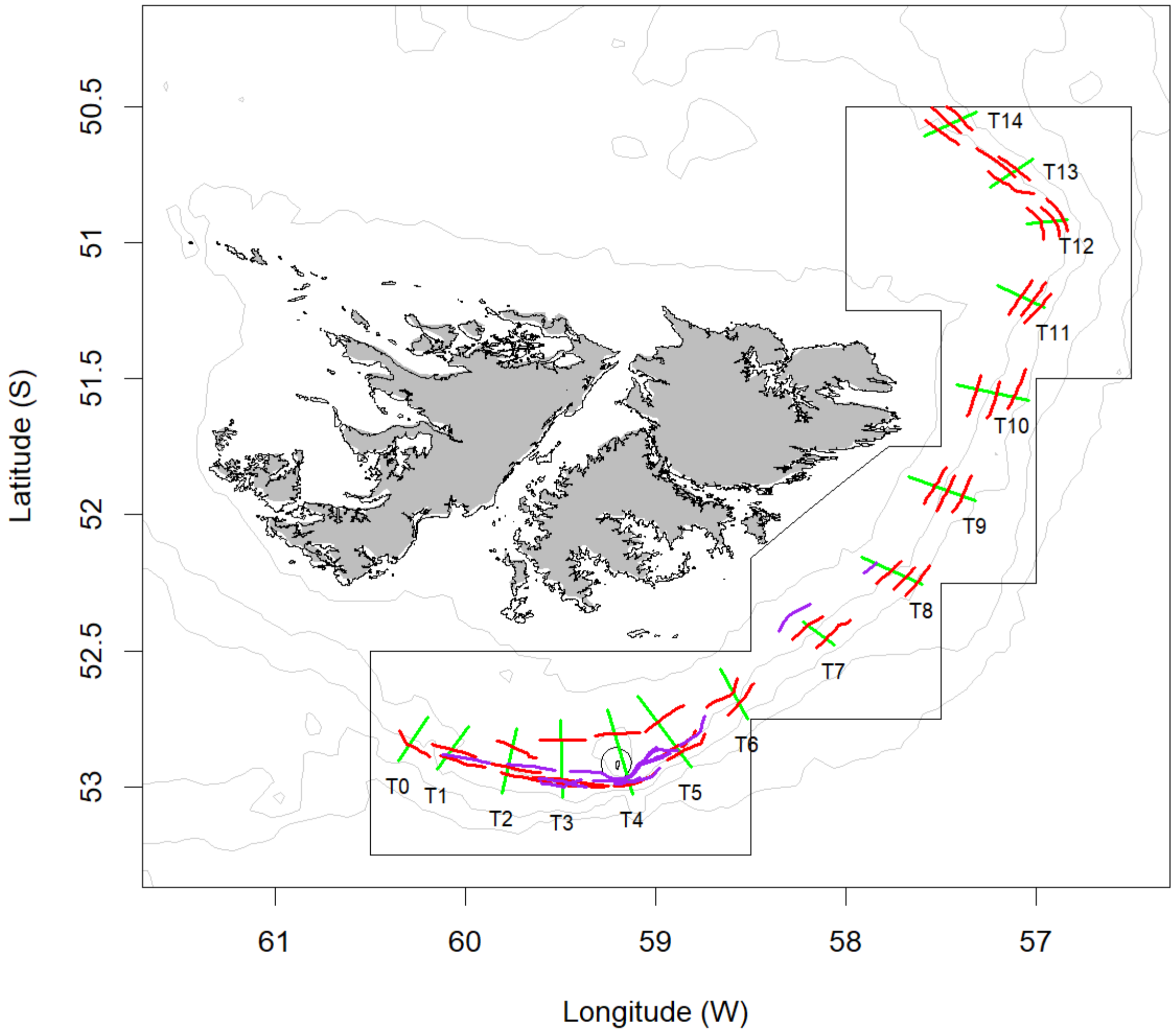

Figure 1. Survey transects (green lines), fixed-station trawls (red), adaptive-station trawls (purple). Boundaries of the ‘Loligo Box’ and Beauchêne Island exclusion zone are in black.

F/V *Montelourido* is a Falkland Islands - registered stern trawler of 68 m length, 1499 gt, and 4050 main engine bhp. Like all vessels employed for pre-season surveys, *Montelourido* operates regularly in the Falkland Islands calamari fisheries, and used its commercial trawl gear for the survey catches. This is the first time the *Montelourido* has been employed for a pre-season survey by the FIFD. The following FIFD personnel participated in the 2nd pre-season 2023 survey:

Role	Name
Survey lead scientist	Irina Chemshirova
Fishery scientist	Rebecca Nicholls
Fishery scientist	Peter Hoyer

Methods

Sampling procedures

The regular survey plan included 39 fixed-station trawls located on a series of 15 transects perpendicular to the shelf break around the Loligo Box (Figure 1), followed by 21 adaptive-station trawls selected to increase the precision of *D. gahi* biomass estimates in high-density or high-variability locations. This dual approach ensures that the scientific requirements of randomization and repeatability are met (via fixed stations) and the spatio-temporal variability of the *D. gahi* population is captured (via adaptive stations) (Gawarkiewicz and Malek Mercer 2018). All trawl tracks were designed for an expected duration of two hours each. All trawls were bottom (demersal) trawls. During the progress of each trawl, GPS latitude, GPS longitude, bottom depth, bottom temperature, net height, cable length, trawl door spread, and trawl speed were recorded on the ship's bridge in 15-minute intervals, and the quantity and quality of acoustic marks observed on the net-sounder were scored visually on a scale from 0 to 10. Following the procedure described in Roa-Ureta and Arkhipkin (2007), the acoustic marks were used to apportion the *D. gahi* catch of each trawl to the 15-minute intervals and thereby increase spatial resolution of the catches. For small catches acoustic apportioning cannot be assessed with accuracy, and any *D. gahi* amounts <100 kg were iteratively aggregated by adjacent intervals. For example, if the total *D. gahi* catch in a trawl was <100 kg it was assigned to one interval; the middle one.

Catch estimation

The catch of every trawl was processed by the factory crew and retained catch weight of *D. gahi*, by size category, was calculated from the number of standard-weight blocks of frozen squid recorded by the factory supervisor. Catch weights of commercially valued fish species were also recorded from the number of blocks of frozen product, but without size categorization. Processed product weights were scaled to whole weights using standard conversion factors (FIG 2016). Total catch composition per trawl, including commercially unvalued species, damaged fish, and undersized fish, was estimated using a combination of visual assessment and basket sample data. Baskets (30 – 35 kg capacity) were hand-sorted by FIFD survey personnel, and species weighed separately. The aggregate quantities of bycatch species in baskets were proportioned to the *D. gahi* catch of the whole trawl. Scarce bycatch species, and all toothfish, were collected and weighed entirely from each trawl. Non-commercial bycatch weights were then added to the factory production weights (as applicable) to give total catch weights of all fish and squid.

Biomass calculation

Biomass density estimates of *D. gahi* per trawl were calculated as catch weight divided by swept area. The calculation of biomass density thus assumes a catchability coefficient = 1, as commonly used in fishery surveys (Somerton et al. 1999)[a]. Swept area equals the product of trawl distance × trawl width, and trawl distance was defined as the sum of distance measurements from the start GPS position to the end GPS position of each 15-minute interval[b]. Trawl width was derived from the distance between trawl doors (determined per interval) according to the equation (Seafish 2010):

[a] Albeit more likely to underestimate than overestimate true density (Harley and Myers 2001); thus conservative.
[b] At the end of any trawl the net may continue to 'fish' for some distance as it is being hauled. Swept-area bias caused by this factor cannot be quantified but is unlikely to be substantial.

trawl width = (door distance × footrope length) / (footrope length + bridle + sweep)

Measurements of *Montelourido*'s trawl, provided by the vessel master, were as follows: footrope = 180 m, sweep = 25 m, bridle = 140 m.

Biomass density estimates were extrapolated to the fish stock area[c] using an inverse distance weighting algorithm (Ramos and Winter 2022). As previously, the fish stock area was delineated to 20,062.8 km^2, partitioned for analysis into 800 area units of 5×5 km. Forty area units with average depth either <90 m or >400 m, where calamari trawlers do not work, were assumed for this analysis to comprise zero *D. gahi*. Biomass densities from all 800 area units were averaged and multiplied by the total fish stock area for total biomass, as well as separately north and south of 52 ºS; the standard sub-area demarcation (Winter and Arkhipkin 2015).

Uncertainty of the biomass density extrapolation was estimated by hierarchical bootstrapping. For 30,000 iterations a number of survey trawls equivalent to the total number were randomly selected with replacement, and within each selected survey trawl its 15-minute intervals were randomly selected with replacement. The trawl's catch was re-proportioned according to the selected intervals' acoustic scores, thus varying the spatial distribution of the catch over that trawl track. When applicable, the aggregation of *D. gahi* amounts <100 kg (see Sampling procedures) was summed to an interval of the trawl also chosen randomly; not necessarily the middle interval. At each of the 30,000 iterations, the inverse distance weighting algorithm was re-calculated over the 5 × 5 km area units.

Biological analyses

Random samples of *D. gahi* (target n = 150, as far as available) were collected from the factory at all trawl stations. Biological analysis at sea included measurements of the dorsal mantle length rounded down to the nearest half-centimetre, sex, and maturity stage scored by inspection of the gonads. Statistical significance of sex ratio departures from 50/50, in total and by station, was evaluated with randomized re-sampling. Statistical significance of differences in mantle length and maturity stage distributions were evaluated with Kruskal-Wallis tests, non-parametric one-way analysis of variance (Kruskal and Wallis 1952).

Additional specimens of *D. gahi* were collected opportunistically according to area stratification (north, central, south) and depth (shallow, medium, deep), and frozen for statolith extraction and age analysis (Arkhipkin 2005), as well as calculation of the length-weight relationship $W = \alpha \cdot L^{\beta}$ (Froese 2006). A sample of 100 rock cod was taken at every trawl station, as far as available. All catches of toothfish were collected from all trawl stations to maximize the time series catch and biological information base for juvenile toothfish. Otoliths were taken from toothfish that corresponded to required size categories, and other fish species as available; usually the predominant fish bycatch in any trawl.

[c] The (approximate) area occupied by the fishable stock of *D. gahi*. This is largely overlapping, but not exactly equal, to the Loligo Box, which is the area that is legally open to *D. gahi* trawling.

Results

Catch rates and distribution

The survey started with fixed-station trawls in the north part of the Loligo box and proceeded southward throughout the Loligo Box in the usual pattern. A schedule of 4 scientific trawls per day was maintained every day except the 20th July[d] (Table A1), resulting in 56 scientific trawls total recorded during the survey: 39 fixed station trawls catching 91.92 tonnes *D. gahi*, and 17 adaptive-station trawls catching 202.73 tonnes *D. gahi*. A total of 13 optional trawls (directed by the vessel master, after survey hours) yielded an additional 203.15 t *D. gahi*, bringing the total catch for the survey to 497.80 t. The scientific survey catch of 294.65 tonnes *D. gahi* is the lowest on record for a 2nd pre-season since 2016 (Table 1).

Table 1. *D. gahi* pre-season survey scientific catches and biomass estimates (in metric tonnes). Before 2006, surveys were not conducted immediately prior to season opening.

Year	First season			Second season		
	No. trawls	Catch	Biomass	No. trawls	Catch	Biomass
2006	70	376	10213	52	240	22632
2007	65	100	2684	52	131	19198
2008	60	130	8709	52	123	14453
2009	59	187	21636	51	113	22830
2010	55	361	60500	57	123	51754
2011	59	50	16095	59	276	51562
2012	56	128	30706	59	178	28998
2013	60	52	5333	54	164	36283
2014	60	124	34673	58	207	40090
2015	57	184	36424	53	137	25422
2016	57	65	21729	58	225	43580
2017	59	180	48785	63[A]	314	56807
2018	59[A]	115	32194	53	510	183593
2019	55	382	49618	51	298	50880
2020	59	268	27991	55	575	92194
2021	55	280	31770	59	534	77526
2022	60	421	47058	59	441	63348
2023	61[B]	549	44015	56	294	19859

[A] Includes four juvenile toothfish transect trawls.
[B] Includes four extra trawls north of the Loligo Box.

Average *D. gahi* catch density (Figure 2) among fixed-station trawls north of 52º S was 0.71 t km^{-2}; the lowest for 2nd pre-season since 2012 (0.94 t km^{-2}). Average *D. gahi* catch density among fixed-station trawls south of 52ºS was 2.26 t km^{-2}; the lowest on record for a 2nd season since 2015 (1.75 t km^{-2}). Average *D. gahi* catch density among adaptive-station trawls south of 52º S was 8.65 t km^{-2}; lower than the last three 2nd pre-seasons.

[d] During the first trawl on this day, a concern regarding a fouled propeller arose and the vessel returned to Stanley to attempt repair; therefore, the first trawl of the day was not sampled for the survey. A seal carcass was found and removed the same day; the survey resumed the subsequent day.

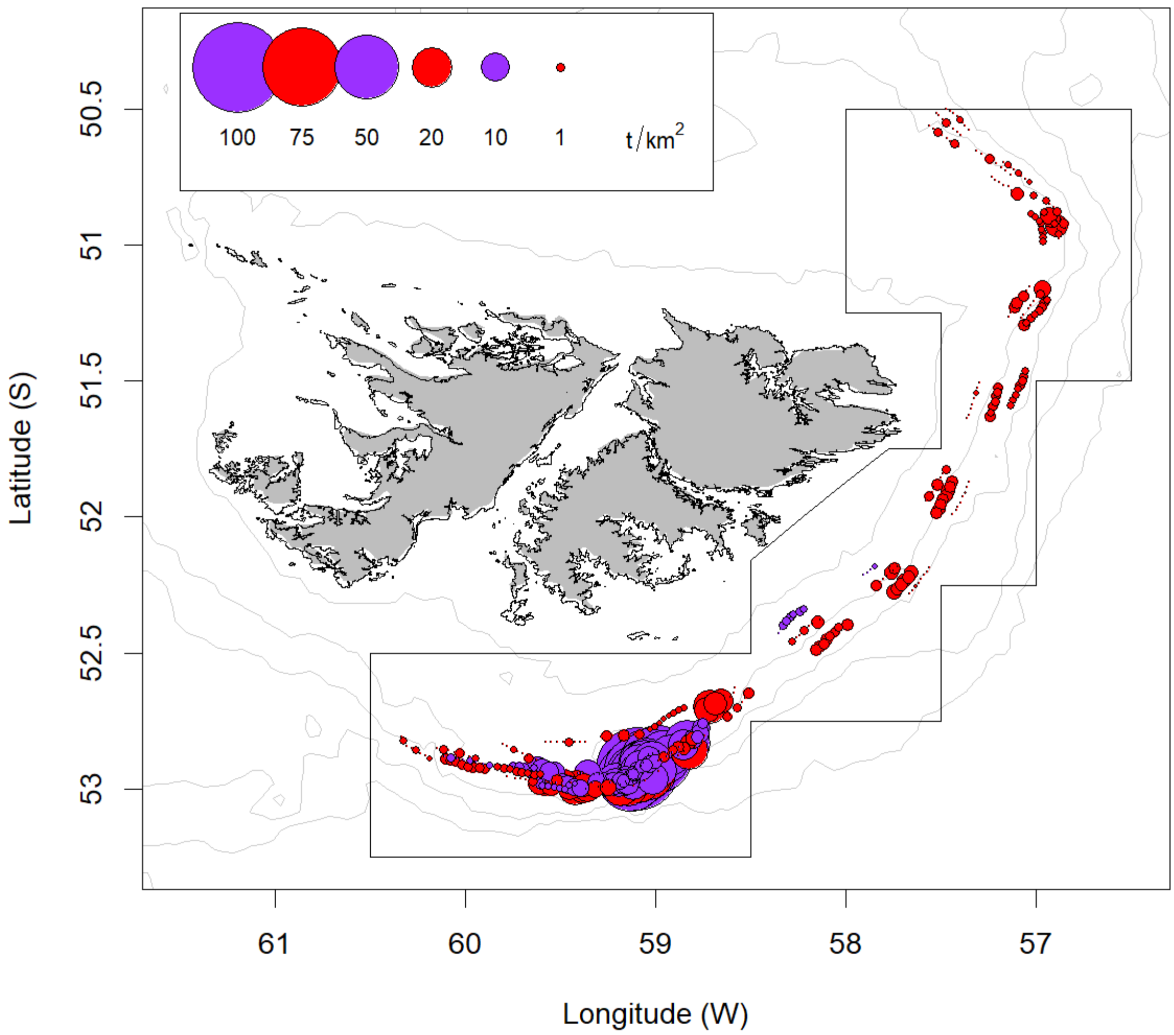

Figure 2. *D. gahi* CPUE (t km^{-2}) of fixed-station (red), adaptive-station (purple) trawls per 15-minute trawl interval. Boundaries of the 'Loligo Box' fishing zone and the Beauchêne Island exclusion zone (mostly hidden) are traced in black.

Biomass estimation

Total *D. gahi* biomass in the fish stock area was estimated at 19,859 tonnes, with a 95% confidence interval of [15,156 to 27,648 t]. The total biomass estimate was the lowest for 2nd pre-seasons since 2008 (Table 1). Partition of the estimated biomass was 4,956 tonnes north [3,647 to 7,230 t] compared with 14,913 tonnes south [10,230 to 22,040 t]. The biomass proportion north (24.9%) was the second lowest for a 2nd pre-season since 2017. Within the north sub-area 50% of *D. gahi* density was aggregated in 72 of 368 5×5 km area units, and 95% of density was aggregated in 196 of the 368 5×5 km area units (Figure 3). Within the south sub-area 50% of *D. gahi* density was aggregated in 34 of 392 5×5 km area units, and 95% of density was aggregated in 194 of the 392 5×5 km area units (Figure 3).

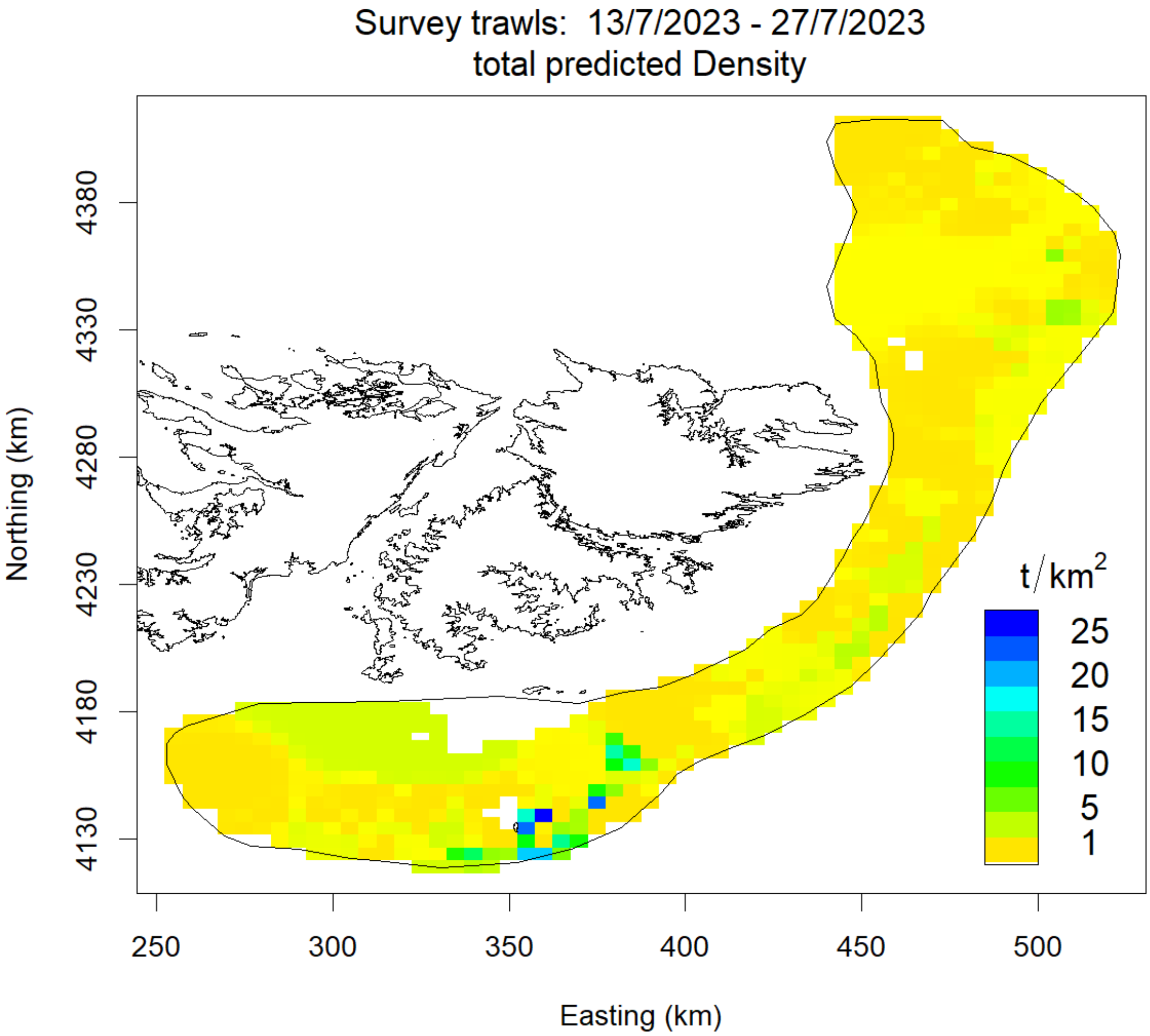

Figure 3. *D. gahi* predicted density estimates per 5 km^2 area units. Blank area units within the perimeter are either <90 or >400 m average depth. Coordinates were converted to WGS 84 projection in UTM sector 21F using the R library rgdal (proj.maptools.org).

Biological data

A total of 113 taxa were identified in the survey catches (Appendix Table A2). *D. gahi* was the predominant catch with 76.7% of the total (Table A2); the lowest percentage of 2nd pre-season catches since 2017 (64%). Second-highest catch species was common hake with 14.7% of the total; the highest catch percentage in a 2nd pre-season survey and the second highest catch per trawl since 2020 at 1008.64 kg per trawl (Figure 4; Left). Hake bycatch was significantly correlated with depth (GAM; edf = 1.8; p<0.001), as 96% of the hake caught was in 24 stations at depth of 200 m or more (Figure 4; Right). Third-highest catch was jellyfish (unspecified Medusae) with 4.4%. Rock cod and blue whiting were only other species that made up ≥0.5% of the total catch at 1.2 and 0.5%, respectively.

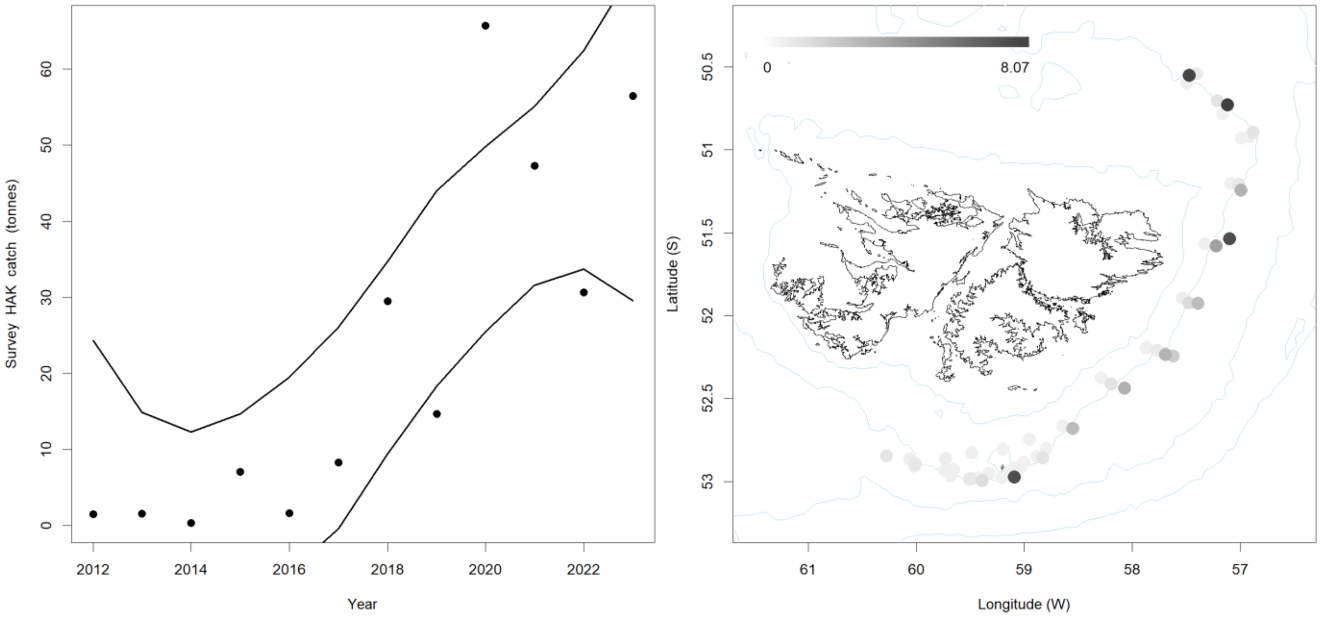

Figure 4. Left: Common hake total catches in 2nd pre-season surveys from 2012 until 2023. Black lines indicate 95% confidence intervals of LOESS smoother (degree=2, span = 1). Right: Catches of common hake (tonnes) per survey station. Blue lines indicate depth of 100, 200, 300 and 1000 m.

During the survey 9355 *D. gahi* were measured for length and maturity (5030 males, 4325 females, from all 56 trawl stations). The total sex ratio was significantly ($p < 0.0001$) majority male. A total of 9 individual trawls had a significant preponderance of females, and 26 individual trawls had a significant preponderance of males.

D. gahi mantle length and maturity distributions north and south of 52° S are plotted in Figure 5. For males north: mean mantle length 11.05 cm; mean maturity stage 3.4 (on a scale of 1 to 6, Lipinski 1979), males south: mean mantle length 11.16 cm; mean maturity stage 3.8. Females north: mean mantle length 10.44 cm; mean maturity stage 2.27, females south: 10.41 cm; stage 2.2. Mean mantle lengths of males and females were below median since 2015; only males in the north were larger than their counterparts from the 2nd season in 2022. No significant difference was identified for mantle lengths of females between north and south (Kruskal-Wallis test, p=0.25), whereas maturities significantly differed (Kruskal-Wallis test, p<0.001). Conversely, mantle length and maturities of males were found to be significantly different in the two areas (Kruskal Wallis test, p<0.05).

Mantle lengths of males and females showed significantly decreasing trends with chronological sampling day throughout varying extents of the survey time span, standardized for latitude/longitude (GAM; edf= 8.85; $p < 0.001$), suggesting that some immigration continued throughout the survey.

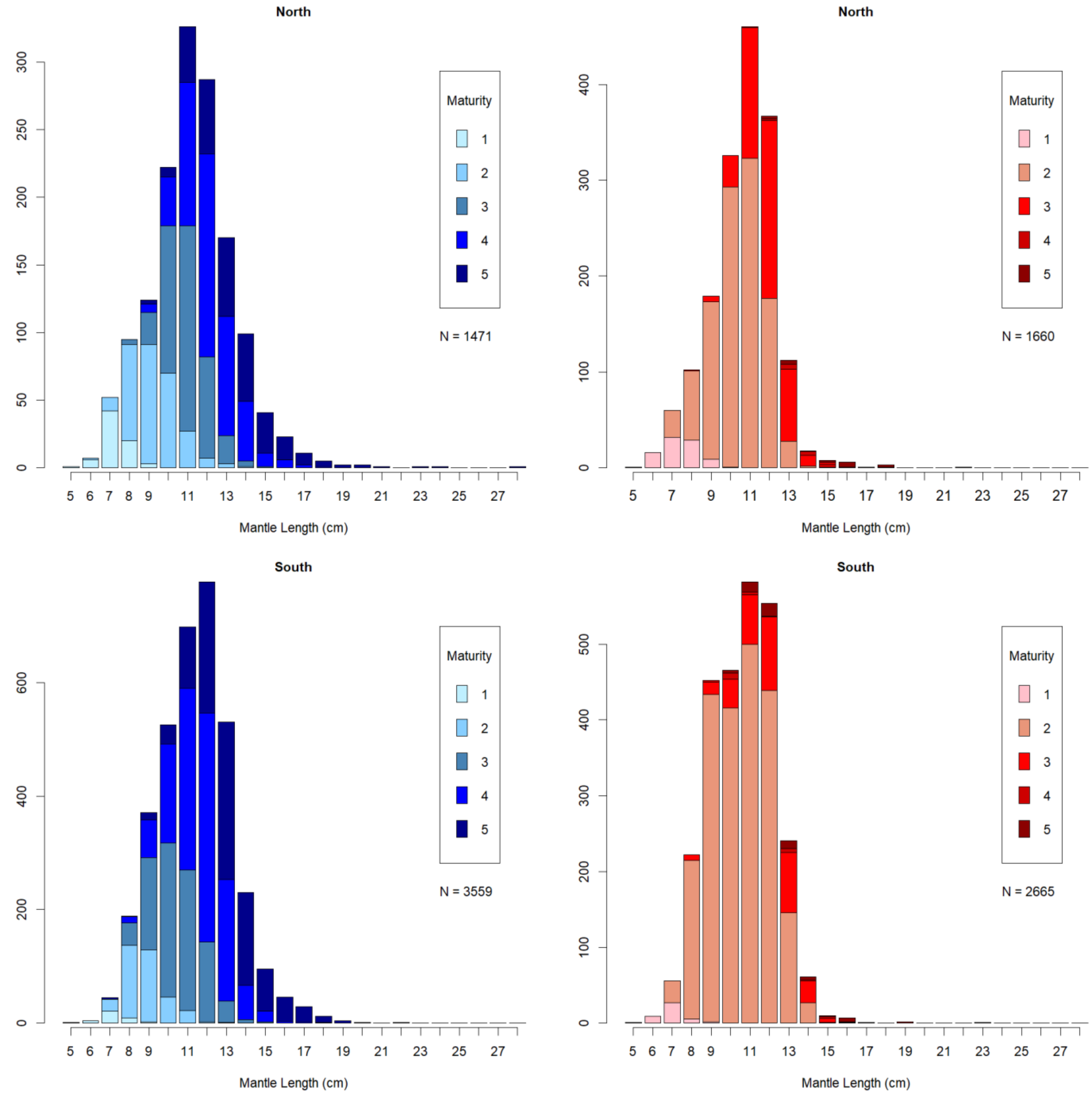

Figure 5. Length-frequency distributions by maturity stage of male (blue) and female (red) *D. gahi* from trawls north (top) and south (bottom) of latitude 52 ºS.

Otoliths taken during the survey are summarized in Table A3.

Pinniped and seabird monitoring

The 2nd pre-season survey 2023 was conducted with seal exclusion devices (SED) in all trawls, to align with compulsory SED use in the following commercial X-licence fishery. Pinniped monitoring was carried out by Neda Matosevic (RBC Compliance Officer) for the duration of the survey. No pinnipeds were brought onboard in the trawl net, as the master waited for them to escape prior to hauling on deck. The carcass of one pinniped was found in the propeller of the vessel. A total of four South American fur seals (*Arctocephalus australis*) live escapes from the SED were observed over the duration of the survey. No incidents with birds were observed.

Netview camera work

The SED net camera was deployed a total of 7 days for the duration of the scientific trawls of the survey. The camera was deployed every other day in order to allow for ample charging time and to review the footage from the preceding day to determine if any adjustments in position were required. The F/V *Montelourido* uses an SED type “A”. Net cameras had previously not been attached to a net that uses this type of SED. Therefore, some experimentation with the positioning of the camera was required. Generally, the camera was attached in the region shown in Figure 6, on the net extension mesh panel to allow for a clear view of the SED escape hatch. A total of 13 hours of footage was collected for the duration of the survey. The camera remained onboard for the observer to continue sampling during their bird observation days on the X-licence fishery. Figure 7 shows an example of the footage obtained.

Figure 6. Camera placement on net extension to monitor SED escape hatch, location marked with red ellipse.

Figure 7. Footage from Netview camera showing *D. gahi* entering the net.

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Appendix

Table A1. Survey stations with total *Doryteuthis gahi* catch. Time: Stanley FI time. Latitude: °S, longitude: °W. Transects labelled A were adaptive-station trawls.

Transect -Station	Data Station	Date	Start			End			Depth (m)	*D. gahi* (kg)
			Time	Lat	Lon	Time	Lat	Lon		
14-37	51	13/07/2023	07:15	50.55	57.59	09:15	50.64	57.41	137	380
13-34	52	13/07/2023	10:20	50.74	57.25	12:20	50.82	57.02	131	928
12-32	53	13/07/2023	13:15	50.87	56.98	15:15	50.98	56.88	128	2 650
11-29	54	13/07/2023	16:35	51.15	56.96	18:35	51.27	57.08	140	1 008
14-39	55	14/07/2023	06:50	50.59	57.34	08:50	50.50	57.48	284	117
14-38	56	14/07/2023	10:00	50.51	57.55	12:00	50.60	57.40	248	214
13-36	57	14/07/2023	13:20	50.68	57.20	15:20	50.77	57.04	276	407
13-35	58	14/07/2023	16:15	50.76	57.11	18:15	50.66	57.31	252	386
12-33	59	15/07/2023	06:50	50.96	56.84	08:50	50.84	56.95	249	613
12-31	60	15/07/2023	10:05	50.87	57.05	12:05	50.99	56.96	125	1 069
11-28	61	15/07/2023	13:15	51.14	57.02	15:15	51.26	57.14	129	1 051
10-25	62	15/07/2023	16:45	51.49	57.29	18:45	51.64	57.36	141	89
11-30	63	16/07/2023	07:10	51.19	56.92	09:10	51.30	57.06	283	1 739
10-26	64	16/07/2023	10:45	51.51	57.20	12:45	51.65	57.26	224	1 825
10-27	65	16/07/2023	13:40	51.61	57.15	15:40	51.46	57.06	287	1 790
9-24	66	16/07/2023	18:15	51.86	57.34	20:15	51.99	57.44	280	27
9-22	67	17/07/2023	06:30	51.96	57.59	08:30	51.83	57.48	155	735
9-23	68	17/07/2023	09:10	51.85	57.43	11:10	51.99	57.53	212	3 360
8-19	69	17/07/2023	12:25	52.17	57.71	14:25	52.25	57.84	202	695
7-17	70	17/07/2023	15:45	52.38	58.13	17:45	52.46	58.28	204	640
0-1	71	18/07/2023	06:45	52.79	60.35	08:45	52.89	60.19	252	474
1-3	72	18/07/2023	09:35	52.89	60.14	11:35	52.93	59.90	205	2 397
2-6	73	18/07/2023	12:40	52.95	59.82	14:40	52.99	59.55	225	4 852
3-9	74	18/07/2023	15:30	52.99	59.52	17:30	52.99	59.25	217	11 661
1-2	75	19/07/2023	06:45	52.84	60.18	08:45	52.89	59.95	211	652
2-5	76	19/07/2023	09:35	52.91	59.86	11:35	52.95	59.60	177	1 628
3-8	77	19/07/2023	12:25	52.96	59.65	14:25	52.99	59.27	184	7 276
4-11	78	19/07/2023	15:25	53.00	59.22	17:25	52.93	58.99	260	22 327

Transect -Station	Data Station	Date	Start			End			Depth (m)	*D. gahi* (kg)
			Time	Lat	Lon	Time	Lat	Lon		
8-21	79	21/07/2023	06:30	52.30	57.69	08:30	52.19	57.56	317	50
8-20	80[e]	21/07/2023	09:30	52.19	57.64	11:00	52.16	57.45	264	2 934
7-18	81	21/07/2023	12:30	52.38	57.98	14:30	52.49	58.16	258	2 656
6-16	82	21/07/2023	16:05	52.62	58.48	18:05	52.74	58.62	247	756
2-4	83	22/07/2023	06:30	52.83	59.84	08:30	52.89	59.63	164	267
A-1	84	22/07/2023	09:35	52.97	59.61	11:35	53.00	59.36	201	3 572
A-2	85	22/07/2023	12:45	52.99	59.22	14:45	52.93	58.98	207	10 942
5-14	86	22/07/2023	15:45	52.90	58.94	17:45	52.80	58.74	206	2 494
5-12	87	23/07/2023	06:30	52.80	59.06	08:30	52.70	58.86	112	808
5-13	88	23/07/2023	09:30	52.79	58.79	11:30	52.90	58.98	147	2 650
A-3	89	23/07/2023	12:40	52.96	59.08	14:40	52.98	59.33	165	3 591
A-4	90	23/07/2023	15:45	52.97	59.39	17:45	52.98	59.60	179	1 068
3-7	91	24/07/2023	06:30	52.83	59.61	08:30	52.83	59.37	154	191
4-10	92	24/07/2023	09:00	52.81	59.32	11:00	52.80	59.09	114	768
A-5	93	24/07/2023	12:00	52.90	59.05	14:00	52.96	59.25	140	5 691
A-6	94	24/07/2023	15:00	52.96	59.14	17:00	52.88	58.93	163	46 931
A-7	95	25/07/2023	09:10	52.96	59.13	11:10	52.87	58.92	160	28 831
A-8	96	25/07/2023	12:15	52.90	59.02	14:15	52.97	59.23	141	21 626
A-9	97	25/07/2023	15:15	52.98	59.23	17:15	52.88	59.04	169	28 836
A-10	98	25/07/2023	18:20	52.86	59.00	20:20	52.97	59.15	138	18 021
A-11	99	26/07/2023	06:30	52.88	60.12	08:30	52.91	59.88	196	550
A-12	100	26/07/2023	09:15	52.92	59.78	11:15	52.94	59.53	166	5 452
A-13	101	26/07/2023	12:15	52.94	59.45	14:15	52.97	59.21	159	3 916
A-14	102	26/07/2023	15:15	52.93	59.10	17:15	52.87	58.89	155	11 401
A-15	103[f]	27/07/2023	06:30	52.18	57.84	07:30	52.12	57.54	136	27
A-16	104	27/07/2023	09:00	52.33	58.19	11:00	52.43	58.35	140	1 128
6-15	105	27/07/2023	12:30	52.60	58.58	14:30	52.71	58.73	165	7 357
A-17	106	27/07/2023	15:30	52.74	58.74	17:30	52.85	58.87	149	11 142

[e] This was a valid trawl that was hauled earlier due to rocks in the SED causing it to be dragged down to the bottom.
[f] This was a valid trawl that was hauled earlier due to large quantity of jellyfish being caught.

Table A2. Empirical estimates of survey total catches by species / taxon.

Species Code	Species/Taxon	Total catch (kg)	Total catch (%)	Sample (kg)	Discard (kg)
LOL	*Doryteuthis gahi*	294 646	76.7	343	542
HAK	*Merluccius hubbsi*	56 484	14.7	2 177	50
MED	Medusa sp	16 785	4.4	0	16 785
PAR	*Patagonotothen ramsayi*	4 551	1.2	228	3 609
BLU	*Micromesistius australis*	1 805	0.5	1	1 805
ZYP	*Zygochlamys patagonica*	1 395	0.4	0	1 395
STA	*Sterechinus agassizii*	1 244	0.3	0	1 244
CGO	*Cottoperca gobio*	1 128	0.3	0	1 128
GOC	*Gorgonocephalus chilensis*	862	0.2	0	862
DGH	*Schroederichthys bivius*	850	0.2	7	850
RAY	Rajiformes	528	0.1	0	184
BAC	*Salilota australis*	409	0.1	0	62
LIS	*Lithodes santolla*	308	0.1	0	2
SPN	Porifera	299	0.1	0	299
KIN	*Genypterus blacodes*	288	0.1	0	0
RBR	*Bathyraja brachyurops*	284	0.1	0	51
TOO	*Dissostichus eleginoides*	251	0.1	149	1
PTE	*Patagonotothen tessellata*	242	0.1	0	242
ALG	Algae	237	0.1	0	237
AST	Asteroidea	235	0.1	0	235
RFL	*Dipturus lamillai*	123	<0.1	0	2
ING	*Onykia ingens*	116	<0.1	0	116
SQT	Ascidiacea	103	<0.1	0	103
UCH	Echinoidea	92	<0.1	0	92
MUL	*Eleginops maclovinus*	67	<0.1	3	38

WHI	*Macruronus magellanicus*	66	<0.1	0	66
RDO	*Amblyraja doellojuradoi*	61	<0.1	0	61
GAY	Gastropoda	55	<0.1	0	55
SAR	*Sprattus fuegensis*	39	<0.1	0	28
ODM	*Odontocymbiola magellanica*	32	<0.1	0	32
GRF	*Coelorinchus fasciatus*	31	<0.1	0	31
GRC	*Macrourus carinatus*	31	<0.1	9	11
OCT	Octopus spp.	30	<0.1	0	30
POA	*Glabraster antarctica*	29	<0.1	0	29
RSC	*Bathyraja scaphiops*	25	<0.1	0	0
FUM	*Fusitriton m. magellanicus*	25	<0.1	0	25
OPL	*Ophiura lymani*	24	<0.1	0	24
OPV	*Ophiacantha vivipara*	23	<0.1	0	23
CAZ	Calyptraster sp.	23	<0.1	0	23
RGR	*Bathyraja griseocauda*	21	<0.1	0	0
OCM	*Enteroctopus megalocyathus*	21	<0.1	0	21
HYD	Hydrozoa	21	<0.1	0	21
RAL	*Bathyraja albomaculata*	20	<0.1	0	1
SUN	*Labidiaster radiosus*	19	<0.1	0	19
PAU	*Patagolycus melastomus*	19	<0.1	1	19
ANM	Anemonia	16	<0.1	0	16
RPX	Psammobatis spp.	15	<0.1	0	15
RMC	*Bathyraja macloviana*	14	<0.1	0	9
RBZ	*Bathyraja cousseauae*	14	<0.1	0	10
CHE	*Champsocephalus esox*	14	<0.1	1	0
SAL	Salpa sp.	12	<0.1	0	12
NEM	*Psychrolutes marmoratus*	9	<0.1	0	9

MLA	*Muusoctopus longibrachus akambei*	9	<0.1	0	9
ILL	*Illex argentinus*	8	<0.1	1	8
WRM	Worm casings	7	<0.1	0	7
THO	Thouarellinae	7	<0.1	0	7
ILF	*Iluocoetes fimbriatus*	6	<0.1	0	6
RMG	*Bathyraja magellanica*	5	<0.1	0	4
EUL	*Eurypodius latreillii*	5	<0.1	0	5
BRY	Bryozoa	4	<0.1	0	4
BDU	*Brama australis*	4	<0.1	0	0
OPH	Ophiuroidea	3	<0.1	0	3
MUE	*Muusoctopus eureka*	3	<0.1	0	2
MAV	*Magellania venosa*	3	<0.1	0	3
CRB	Crab	3	<0.1	0	3
CEX	Ceramaster sp.	3	<0.1	0	3
PEN	Pennatulacea	2	<0.1	0	2
PAT	*Merluccius australis*	2	<0.1	2	0
MIR	Mirostenella sp.	2	<0.1	0	2
GYM	Gymnoscopelus spp.	2	<0.1	0	2
AUC	*Austrocidaris canaliculata*	2	<0.1	0	2
ASA	*Astrotoma agassizii*	2	<0.1	0	2
PES	*Peltarion spinulosum*	1	<0.1	0	1
NUD	Nudibranchia	1	<0.1	0	1
NOW	*Paranotothenia magellanica*	1	<0.1	1	1
MAT	*Achiropsetta tricholepis*	1	<0.1	0	1
MAM	*Neoachiropsetta milfordi*	1	<0.1	0	1
FLX	Flabellum spp.	1	<0.1	0	1
EGG	Egg mass	1	<0.1	0	1

EEL	Iluocoetes/Patagolycus mix	1	<0.1	0	1
CRI	Crinoidea	1	<0.1	0	1
COT	*Cottunculus granulosus*	1	<0.1	0	1
CAS	*Campylonotus semistriatus*	1	<0.1	0	1
AGO	*Agonopsis chiloensis*	1	<0.1	0	1
ACS	*Acanthoserolis schythei*	1	<0.1	0	1
XXX	Unidentified animal	<1	<0.1	0	0
TRP	*Tripylaster philippi*	<1	<0.1	0	0
TED	*Terebratella dorsata*	<1	<0.1	0	0
RMU	*Bathyraja multispinis*	<1	<0.1	0	0
RED	*Sebastes oculatus*	<1	<0.1	0	0
PYX	Pycnogonida	<1	<0.1	0	0
PRX	Paragorgia sp.	<1	<0.1	0	0
POL	Polychaeta	<1	<0.1	0	0
PMC	*Protomyctophum choriodon*	<1	<0.1	0	0
PLB	Primnoidae	<1	<0.1	0	0
PAE	*Patagonotothen elegans*	<1	<0.1	0	0
MYX	Myxine spp.	<1	<0.1	0	0
MUN	Munida spp.	<1	<0.1	0	0
ISO	Isopoda	<1	<0.1	0	0
ICA	*Icichthys australis*	<1	<0.1	0	0
HOL	Holothuroidea	<1	<0.1	0	0
HEX	Henricia sp.	<1	<0.1	0	0
GYN	*Gymnoscopelus nicholsi*	<1	<0.1	0	0
GYB	*Gymnoscopelus bolini*	<1	<0.1	0	0
EUO	*Eurypodius longirostris*	<1	<0.1	0	0
ERR	Errina sp.	<1	<0.1	0	0

CUB	*Cubiceps caeruleus*	<1	<0.1	0	0
CTA	*Ctenodiscus australis*	<1	<0.1	0	0
CRY	Crossaster sp.	<1	<0.1	0	0
CAV	*Campylonotus vagans*	<1	<0.1	0	0
BRM	*Brucerolis macdonnellae*	<1	<0.1	0	0
BAL	*Americominella longisetosus*	<1	<0.1	0	0
AUL	*Austrolycus laticinctus*	<1	<0.1	0	0

Table A3. Summary of otolith sample numbers by species by sex taken during the survey.

Species			No. of otolith pairs	
			M	F
PAR	Common Rockcod	*Patagonotothen ramsayi*	85	96
TOO	Patagonian Toothfish	*Dissostichus eleginoides*	75	105
HAK	Common Hake	*Merluccius hubbsi*	30	138
CHE	Icefish	*Champsocephalus esox*	5	8
BLU	Southern Blue Whiting	*Micromesistius australis*	7	3
GRC	Grenadier-Ridge Scaled Rattail	*Macrourus carinatus*	3	4
SAR	Falkland sprat	*Sprattus fuegensis*	2	2
RED	Patagonian Redfish	*Sebastes oculatus*	2	2
NOW	Yellowbelly	*Paranotothenia magellanica*	2	1
MUL	Falkland Mullet	*Eleginops maclovinus*	2	1
WHI	Whiptail Hake, Hoki	*Macruronus magellanicus*	2	0
ICA	Southern Driftfish	*Icichthys australis*	2	0
AGO	Crocodile Fish	*Agonopsis chiloensis*	1	1
PAT	Patagonian Hake	*Merluccius australis*	0	1
CUB	Blue Flathead	*Cubiceps caeruleus*	1	0
COT	Fathead	*Cottunculus granulosus*	0	1
BAC	Redcod	*Salilota australis*	1	0