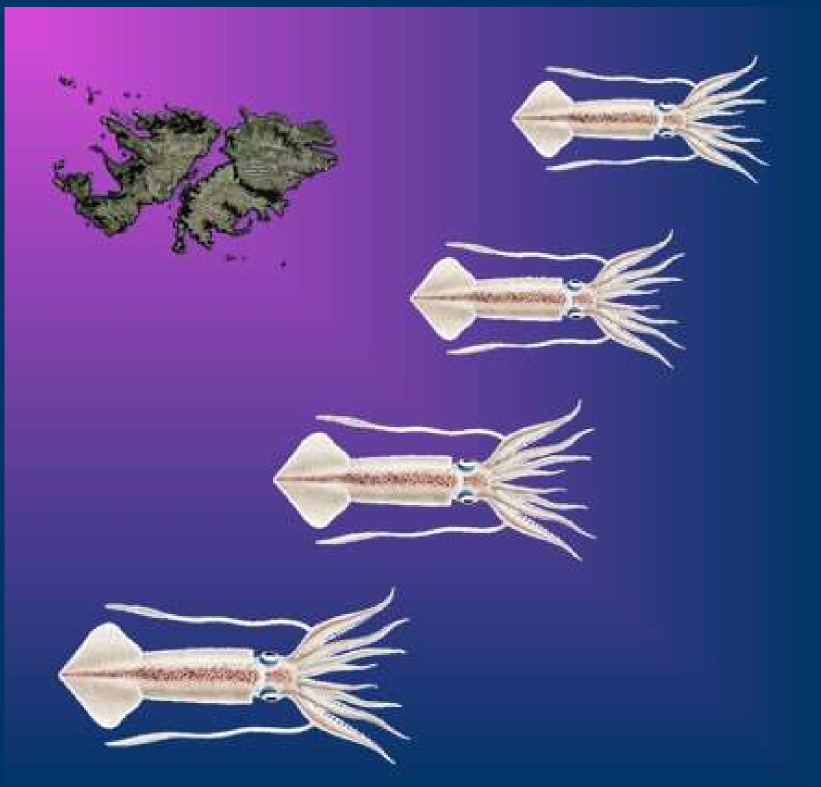
2023 1st Pre-Season Assessment Survey

Falkland calamari

(*Doryteuthis gahi*)



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Index

Summary

1) A stock assessment survey for *Doryteuthis gahi* (Falkland calamari) was conducted in the Loligo Box from 6th to 21st February 2023. Sixty-one scientific trawls were taken during the survey; 39 fixed-station trawls, 18 adaptive-station trawls, and 4 extra trawls north of the Loligo Box. The scientific catch of the survey was 549.12 tonnes *D. gahi*. The extra stations north had higher average *D. gahi* biomass density than stations within the north, and lower than stations within the south.
2) An estimate of 44,015 tonnes *D. gahi* (95% confidence interval: 37,656 to 84,887 t) was calculated for the fishing zone by inverse distance weighting. The biomass estimate was median for 1st pre-seasons of the last five years. Of the total, 17,340 tonnes were estimated north of 52 ºS, and 26,675 tonnes were estimated south of 52 ºS. The proportion north (39.4%) was the highest for a 1st pre-season since at least 2015.
3) *D. gahi* had significantly greater average mantle lengths and maturities north than south of 52 ºS. Males north: mean mantle length 11.93 cm; mean maturity stage 2.31, south: mantle length 11.71 cm; maturity 2.17. Females north: mantle length 11.58 cm; maturity 2.14, south: mantle length 11.10 cm; maturity 2.05. Mantle length distributions suggested that some immigration continued throughout the survey.
4) 78 taxa were identified in the catches. *D. gahi* was the largest species group at 88.6% of total catch by weight; median percentage among the past five 1st pre-seasons. Blue whiting (5.0%) and rock cod (4.2%) were the only other 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 *Igueldo* from the 6th to 21st February 2023; experimental license FK003E23. 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 1st 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.

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.

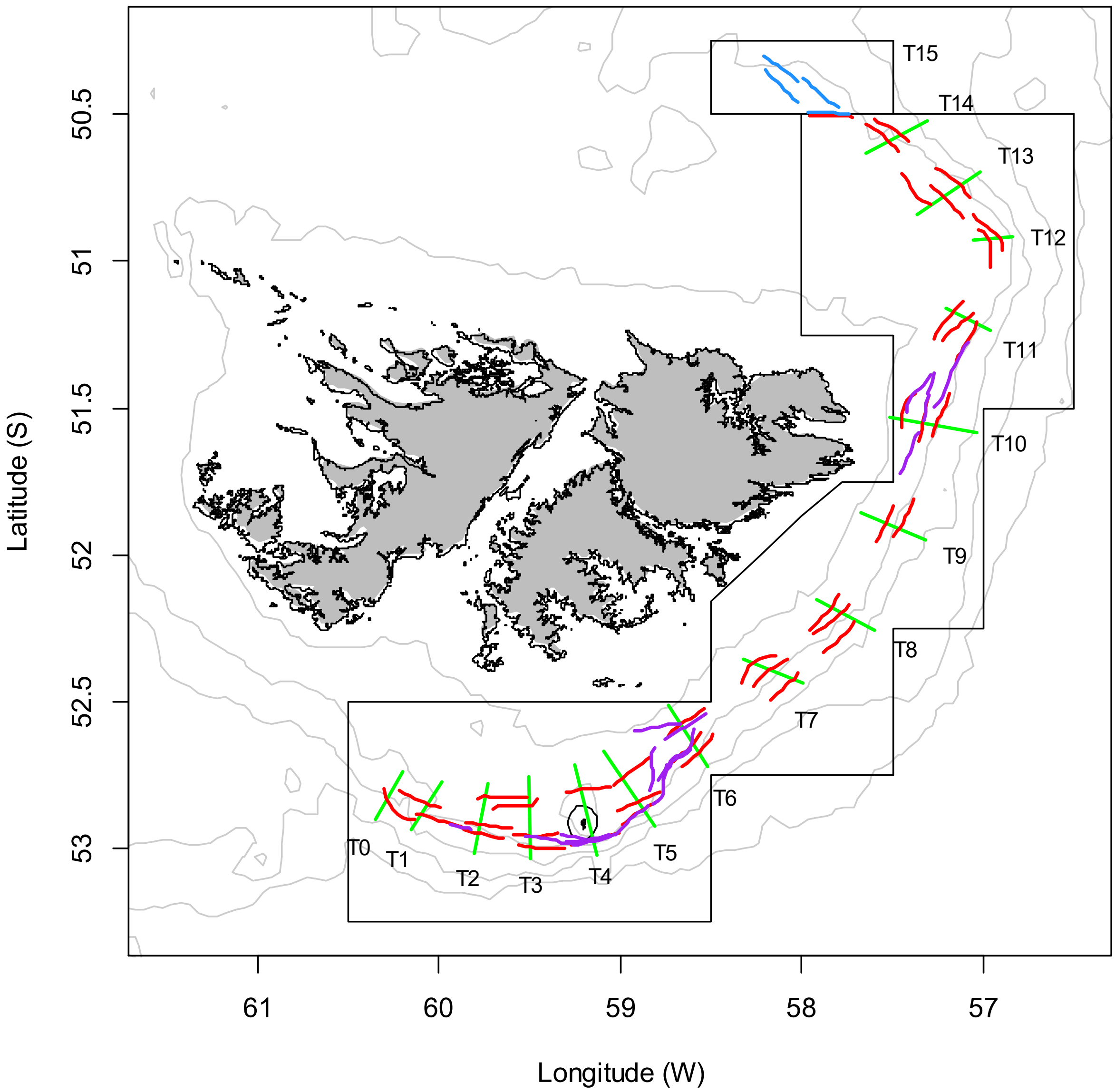

Figure 1. Survey transects (green lines), fixed-station trawls (red), adaptive-station trawls (purple), and extra north station trawls (blue) sampled during the 1st pre-season 2023 survey. Boundaries of the 'Loligo Box', Beauchêne Island exclusion zone, and extra grids north XKAM and XKAN, are in black.

F/V *Igueldo* is a Falkland Islands - registered stern trawler of 83.4 m length, 2305 gt, and 5222 main engine bhp. Like all vessels employed for pre-season surveys, *Igueldo* operates regularly in the Falkland Islands calamari fisheries, and used its commercial trawl gear for the survey catches. *Igueldo* was previously employed for the 2nd pre-season surveys in 2011 and 2017 (Winter et al. 2011; 2017) and for a trawl comparison study in 2012 (Arkhipkin et al. 2012a). The following FIFD personnel participated in the 1st pre-season 2023 survey:

Andreas Winter	lead scientist
Michal Raczynski	fisheries observer
Mariano Peruzzo	fisheries observer

The survey was joined by SAERI scientist Megan Shapiro to test SED cameras.

Methods

Sampling procedures

The regular survey plan includes 39 fixed-station trawls located on a series of 15 transects perpendicular to the shelf break around the Loligo Box (Figure 1), followed by up to 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). For the 2023 1st pre-season survey, one day was added by agreement with the Loligo Producers Group to trawl four tracks in grids XKAM and XKAN and evaluate potential fishable biomass just north of the Loligo Box (>50.5 ºS) (Figure 1). Unlike the other fixed-station trawls, these four tracks were not prescribed as no precedent information was available about the most suitable locations. The additional day north of the Loligo Box was scheduled on the last day of the survey to allow maximum time for *D. gahi* to aggregate. 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 a visual score was assessed of the quantity and quality of acoustic marks observed on the net-sounder. 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 (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 the 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 bycatches 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

[a] Albeit more likely to underestimate than overestimate true density (Harley and Myers 2001); thus conservative.

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 (recorded per interval) according to the equation (Seafish 2010):

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

Measurements of *Igueldo'*s trawl, provided by the vessel master, were: footrope = 181.2 m, sweep = 125 m, bridle = 40 m. *Igueldo* used two identical trawl nets shot alternatingly from port and starboard net drums on deck.

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[d], 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.

Comparison with the extra north

Biomass density estimates of survey trawls were compared between the south (<52 ºS), north (>52 & <50.5 ºS) and extra north (>50.5 ºS) for *D. gahi* and commercially important species shortfin squid *Illex argentinus*, blue whiting *Micromesistius australis*, rock cod, common hake *Merluccius hubbsi*, and toothfish. Comparisons were calculated with Kruskal-Wallis tests: non-parametric one-way analysis of variance, followed by Dunn's test for identifying significant differences (Kruskal and Wallis 1952, Dunn 1964).

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.

[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.

[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.

[d] For this survey the fish stock area was not adjusted from previous surveys because of the addition of trawls just north of the Loligo Box.

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.

Results

Catch rates and distribution

The survey started with fixed-station trawls near the centre of the Loligo Box, to avoid a heavier sea state in the north, then proceeded north on the second day followed by southward throughout the Loligo Box in the usual pattern. A schedule of 4 scientific trawls per day was maintained every day except the 17th and 19th February[e] (Table A1), resulting in 61 scientific trawls total recorded during the survey: 39 fixed station trawls catching 178.55 tonnes *D. gahi*, 18 adaptive-station trawls catching 335.48 t *D. gahi*, and 4 extra north station trawls catching 35.09 t *D. gahi*. Sixteen optional trawls (directed by the vessel master, after survey hours) yielded an additional 207.44 t *D. gahi*, bringing the total catch for the survey to 756.56 t. The scientific survey catch of 549.12 tonnes *D. gahi* is the highest on record for a 1st pre-season (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			

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

[e] High catches on these two days limited survey trawling to 2 and 3 stations respectively, to ensure that nets could be emptied into factory bins separately by station.

Average *D. gahi* catch density (Figure 2) among fixed-station trawls north of 52º S was 2.03 t km^{-2}; the highest for 1st pre-seasons since at least 2011. Average *D. gahi* catch density among fixed-station trawls south of 52º S was 3.52 t km^{-2}; the third-highest on record after 2022 (4.10 t km^{-2}) and 2015 (3.70 t km^{-2}). Average *D. gahi* catch density among adaptive-station trawls north of 52º S was 4.81 t km^{-2}; slightly lower than last year (5.00 t km^{-2}) but thereby the second-highest since 2014. Average *D. gahi* catch density among adaptive-station trawls south of 52º S was 15.78 t km^{-2}; highest on record for 1st pre-seasons. Average *D. gahi* catch density of the extra north station trawls was 5.82 t km^{-2}; higher than either the fixed or adaptive stations north but lower than the adaptive stations south.

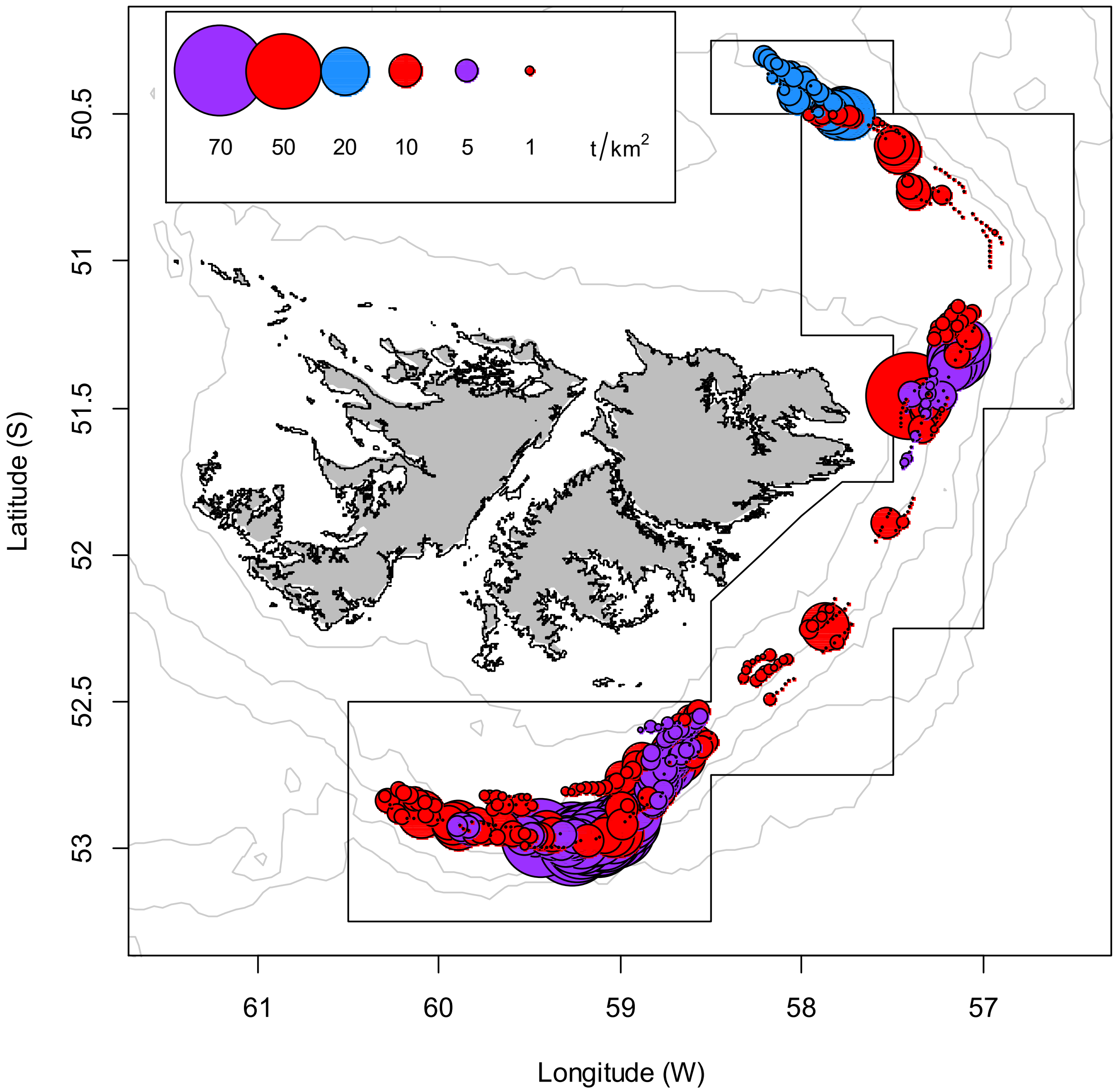

Figure 2. *D. gahi* CPUE (t km^{-2}) of fixed-station (red), adaptive-station (purple) and extra north station (blue) trawls per 15-minute trawl interval. Boundaries of the 'Loligo Box' fishing zone, extra grids north, and the Beauchêne Island exclusion zone (mostly hidden) are traced in black.

Biomass estimation

Total *D. gahi* biomass in the fish stock area was estimated at 44,015 tonnes, with a 95% confidence interval of [37,656 to 84,887 t]. The total biomass estimate was median of the last five years for 1st pre-seasons: lower than 2019 and 2022; higher than 2020 and 2021, and thereby above the long-term median (Table 1). Partition of the estimated biomass was 17,340 tonnes north [7663 to 40,301 t] vs. 26,675 tonnes south [24,725 to 60,815 t]. The biomass proportion north (39.4%) was the highest for a 1st pre-season since at least 2015. Within the north sub-area 50% of *D. gahi* density was aggregated in 15 of 368 5×5 km area units, and 95% of density was aggregated in 123 of the 368 5×5 km area units (Figure 3). Within the south sub-area 50% of *D. gahi* density was aggregated in 35 of 392 5×5 km area units, and 95% of density was aggregated in 230 of the 392 5×5 km area units (Figure 3).

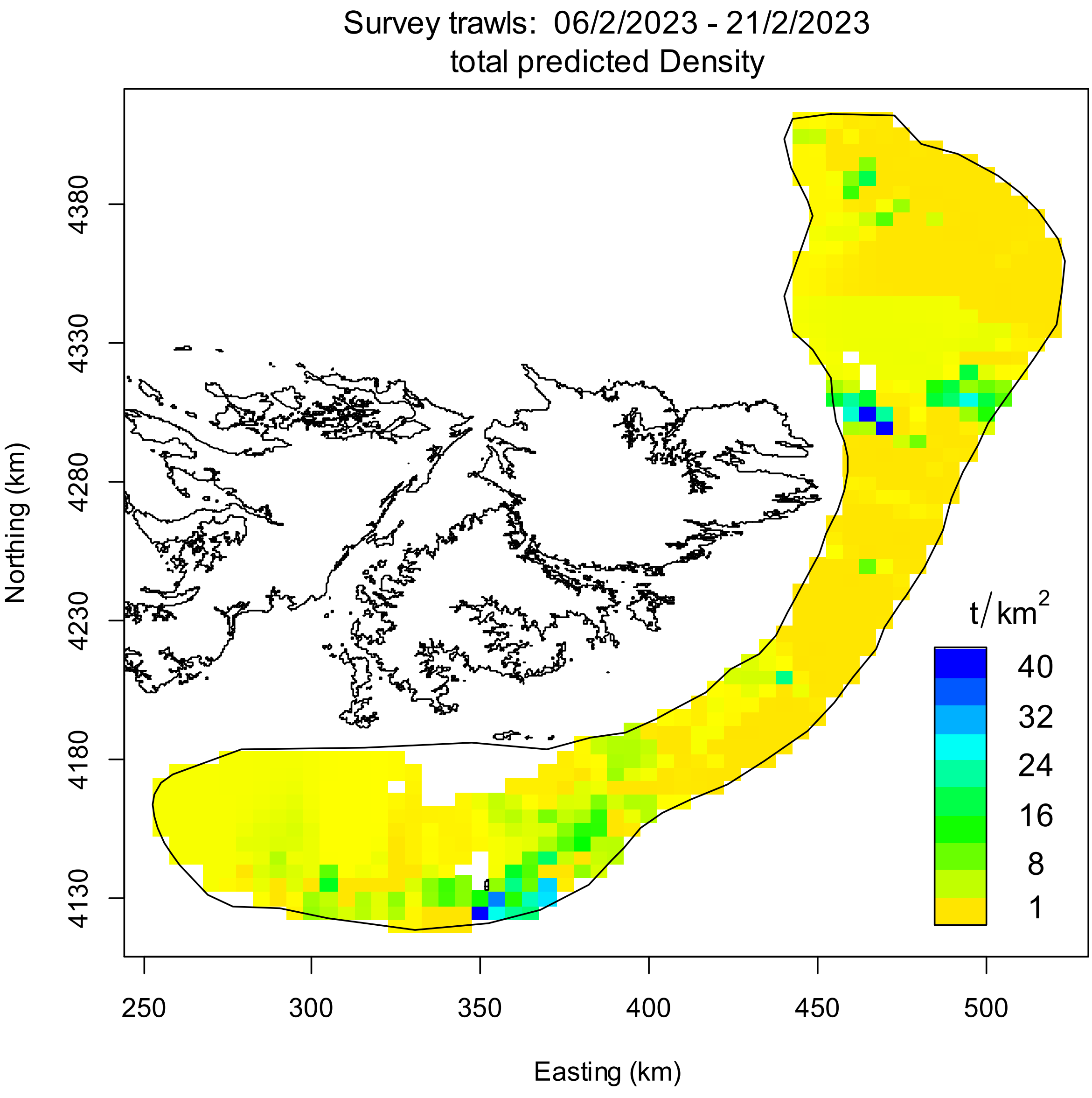

Figure 3. *D. gahi* predicted density estimates per 5 km^2 area units. Blank area units within the perimeter are either <90 or >400 m average depth. Coordinates were converted to WGS 84 projection in UTM sector 21F using the R library rgdal (proj.maptools.org).

Comparison with the extra north

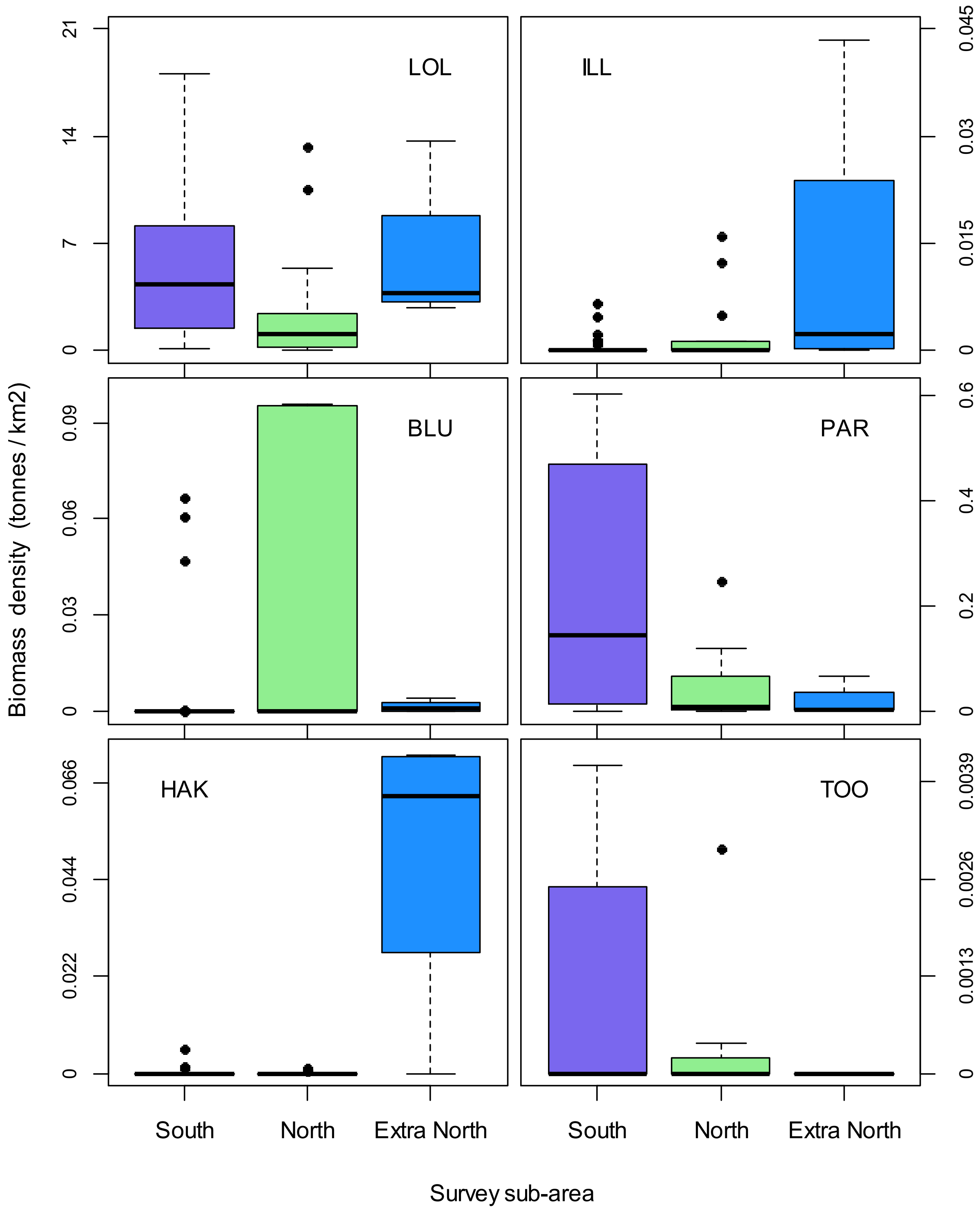

Figure 4. Boxplots of survey biomass densities of important commercial species south (n = 37 survey trawls), north (n = 20) and extra north (n = 4) from the 1st pre-season 2023 survey. For visualization most outliers (black circles) were excluded from these plots.

Average biomass density of *D. gahi* in the four trawls north of the Loligo Box was intermediate: non-significantly lower than in the south and non-significantly higher than in the north[f], while the difference between south and north was statistically significant (Figure 4, Table 2)[g]. Among other commercially important species, trawls north of the Loligo Box (extra north) had the highest average biomass density of *I. argentinus*: non-significantly higher than within the north and significantly higher than the south, and the highest average biomass density of common hake: significantly higher than both within the north and the south (Figure 4, Table 2). However, abundance of common hake is seasonally low overall in Falkland Islands waters during the time of 1st pre-season surveys (Arkhipkin et al. 2012b).

Results of the extra north trawl comparisons in this survey will be amalgamated with further data, e.g., from in-season and previous seasons, to develop a comprehensive overview of the practicality and impact of commercially fishing *D. gahi* in these grids.

Table 2. Average biomass densities of important commercial species from survey trawls in the south, north, and extra north of the Loligo Box during the 1st pre-season 2023 survey. Numbers of trawl stations in parentheses. Jointly overlined sub-areas S (south), N (north) and X (extra north) are not significantly different from each other.

Species	Survey catch density (tonnes km^{-2})			Significant difference
	South (37)	North (20)	Extra North (4)	($p < 0.05$)
D. gahi	8.218	2.479	6.007	$\overline{\mathrm{S} > \overline{\mathrm{X}}}\overline{> \mathrm{N}}$
I. argentinus	0.001	0.007	0.012	$\mathrm{S} < \overline{\mathrm{N} < \mathrm{X}}$
Blue whiting	0.059	0.862	0.002	$\overline{\mathrm{N} > \mathrm{S} > \mathrm{X}}$
Rock cod	0.431	0.084	0.020	$\mathrm{S} > \overline{\mathrm{N} > \mathrm{X}}$
Common hake	0.001	0.001	0.050	$\overline{\mathrm{N} < \mathrm{S}} < \mathrm{X}$
Toothfish	0.015	0.006	0.000	$\overline{\mathrm{S} > \mathrm{N} > \mathrm{X}}$

Biological data

Seventy-eight taxa were identified in the survey catches (Appendix Table A2). *D. gahi* was the predominant catch with 88.6% of the total (Table A2); the median percentage among the last five years' 1st pre-season catches. Second-highest catch species was blue whiting with 5.0% of the total; the highest catch percentage in a 1st pre-season survey since 2018 and the highest average catch per trawl (508.9 kg) since 2016. 80.5% of all blue whiting catch came from a single trawl (station 1133), showing typical high aggregation, in the general area north where most blue whiting bycatch was taken in the last 1st season (Winter and Skeljo 2022). Third-highest catch species was rock cod with 4.2%, the second-lowest percentage (after 2020) in a 1st pre-season survey since at least 2012. No other species group accounted for ≥0.5% of total catch but toothfish, a highly restricted bycatch, had the highest average catch rate for a 1st pre-season since 2017 at 17.1 kg per trawl. Over half of total toothfish survey catch was taken in the one station (1161) that was furthest west, and third-deepest (Table A1). Average sizes of toothfish showed that nearly all were older than recruits.

During the survey 8949 *D. gahi* were measured for length and maturity (3454 males, 5495 females), from 56 of the 61 trawl stations. Five trawl stations with *D. gahi* catches <500 kg were not included, as their sparse quantities would compromise collecting a sample

[f] Reminding that the four trawls north of the Loligo Box were intentionally set to the last day of the survey.

[g] Note that with uneven sample sizes (37, 20, 4), this analysis has relatively limited statistical power (Oldfield and Haig 2016).

randomly. The total sex ratio was significantly ($p < 0.0001$) majority female. Thirty-seven individual trawl stations had a significant preponderance of females, and seven individual trawl stations had a significant preponderance of males. Six of the seven northernmost trawl stations had no sex preponderance.

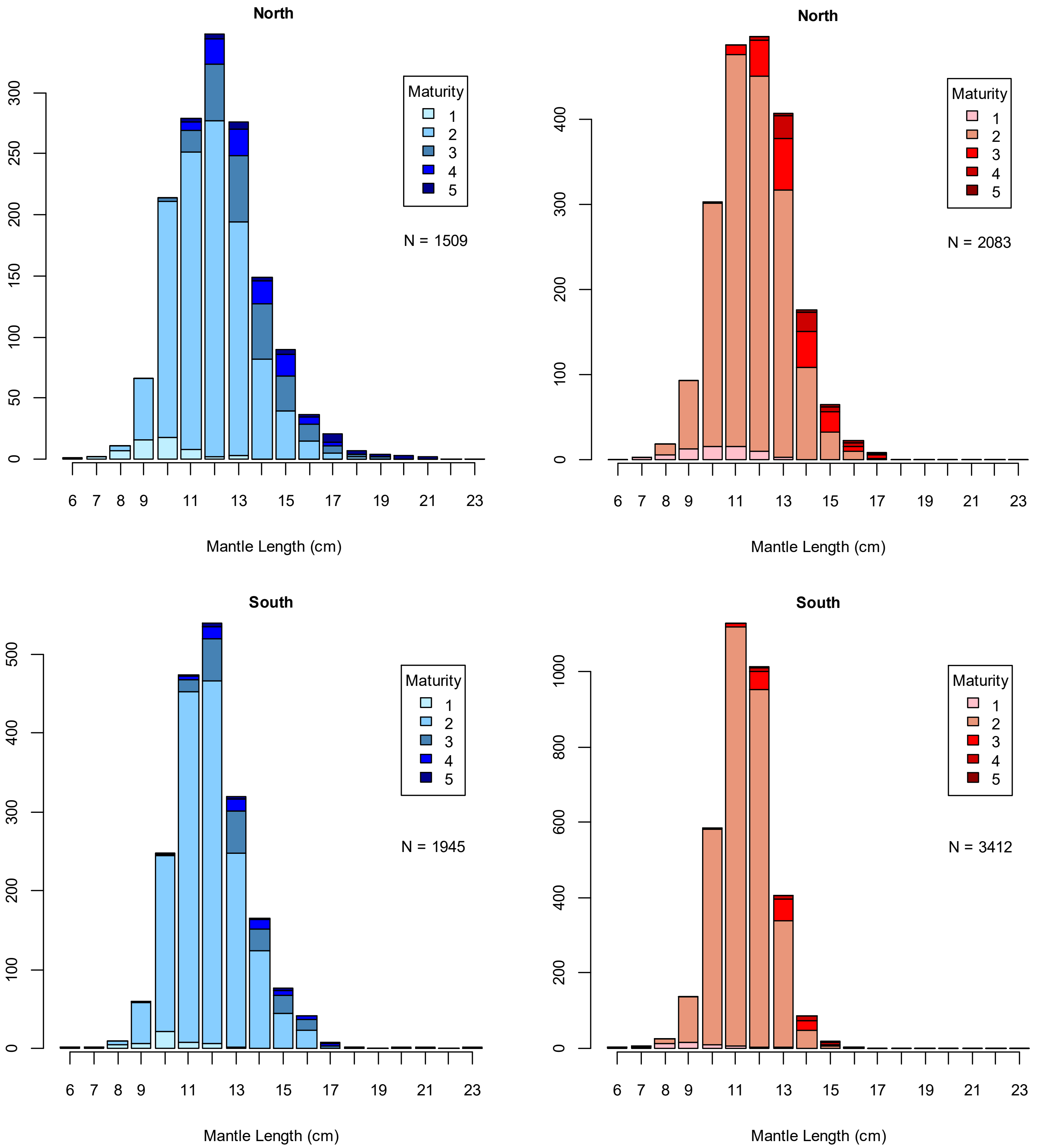

Figure 5 [previous page]. Length-frequency distributions by maturity stage of male (blue) and female (red) *D. gahi* from trawls north (top) and south (bottom) of latitude 52 ºS.

D. gahi mantle length and maturity distributions north and south of 52° S are plotted in Figure 5. For males north: mean mantle length 11.93 cm; mean maturity stage 2.31 (on a scale of 1 to 6, Lipinski 1979), males south: mean mantle length 11.71 cm; mean maturity stage 2.17. Females north: mean mantle length 11.58 cm; mean maturity stage 2.14, females south: 11.10 cm; stage 2.05. Mean mantle lengths of males as well as females were above median since 2015; bigger than 1st pre-season last year 2022 but smaller than 1st pre-season 2021. Mantle length distributions and maturities were significantly different between north and south, for both males and females (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; $p < 0.05$), suggesting that some immigration continued throughout the survey.

Otoliths taken during the survey are summarized in Table A3.

Pinniped and seabird monitoring

The 1st pre-season survey 2023 was conducted with seal exclusion devices (SED) in all trawls, to align with compulsory SED use in the following commercial C-licence fishery. Shooting and hauling of survey trawls was monitored from the bridge by the lead scientist. Pinnipeds were sighted near the stern of the vessel at the shoot and/or haul of five survey trawls (one tentatively identified as southern sea lion *Otaria flavescens*), but none were caught in fishing gear. In three hauls a black-browed albatross (*Thalassarche melanophris*) was retrieved on deck; two alive and one dead.

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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; transects labelled X were extra stations north.

Transect / Trawl	Data Station	Date	Start			End			Depth (m)	*D. gahi* (kg)
			Time	Lat	Lon	Time	Lat	Lon		
9 - 24	1124	06/02/2023	07:00	51.83	57.50	09:00	51.95	57.59	162	1585
9 - 25	1125	06/02/2023	09:40	51.94	57.49	11:40	51.81	57.39	217	349
10 - 27	1126	06/02/2023	12:50	51.61	57.36	14:50	51.46	57.30	142	8959
10 - 26	1127	06/02/2023	15:30	51.45	57.37	17:30	51.56	57.45	126	13843
14 - 37	1128	07/02/2023	06:25	50.50	57.94	08:25	50.51	57.72	137	5949
14 - 38	1129	07/02/2023	09:00	50.53	57.65	11:00	50.62	57.47	136	6903
14 - 39	1130	07/02/2023	11:45	50.59	57.41	13:45	50.52	57.60	222	349
13 - 34	1131	07/02/2023	15:00	50.70	57.45	17:00	50.80	57.29	131	3305
12 - 33	1132	08/02/2023	06:15	50.96	56.90	08:13	50.84	57.06	121	74
13 - 36	1133	08/02/2023	08:50	50.78	57.08	10:49	50.68	57.26	246	0
13 - 35	1134	08/02/2023	11:30	50.74	57.29	13:30	50.85	57.11	130	698
12 - 32	1135	08/02/2023	14:05	50.89	57.03	16:05	51.02	56.96	111	42
11 - 29	1136	09/02/2023	06:10	51.14	57.11	08:10	51.26	57.27	114	3511
11 - 30	1137	09/02/2023	08:45	51.27	57.23	10:45	51.17	57.06	126	3286
11 - 31	1138	09/02/2023	11:20	51.21	57.04	13:20	51.34	57.15	139	2644
10 - 27	1139	09/02/2023	14:15	51.45	57.19	16:15	51.59	57.28	200	202
8 - 21	1140	10/02/2023	06:05	52.14	57.80	08:05	52.26	57.96	136	2147
8 - 22	1141	10/02/2023	08:45	52.27	57.94	10:45	52.17	57.74	187	5797
8 - 23	1142	10/02/2023	11:25	52.23	57.72	13:25	52.33	57.88	257	404
7 - 18	1143	10/02/2023	14:30	52.34	58.15	16:30	52.44	58.33	145	1340
7 - 19	1144	11/02/2023	06:10	52.45	58.27	08:10	52.36	58.08	182	1983
7 - 20	1145 [A]	11/02/2023	08:55	52.40	58.02	10:35	52.49	58.17	245	183
6 - 16	1146	11/02/2023	12:10	52.61	58.56	14:10	52.71	58.72	153	18121
6 - 17	1147	11/02/2023	14:45	52.72	58.66	16:45	52.61	58.49	219	3268
6 - 15	1148	12/02/2023	06:05	52.53	58.54	08:05	52.62	58.74	134	6537
5 - 12	1149	12/02/2023	08:50	52.69	58.83	10:50	52.79	59.04	123	9253
5 - 13	1150	12/02/2023	11:40	52.88	59.02	13:40	52.81	58.78	144	13257
5 - 14	1151	12/02/2023	14:20	52.84	58.79	16:20	52.92	58.99	159	2901
4 - 10	1152	13/02/2023	06:00	52.79	59.06	08:00	52.81	59.30	109	2112
3 - 8	1153	13/02/2023	09:00	52.95	59.35	11:00	52.95	59.59	172	11003
3 - 9	1154	13/02/2023	11:45	52.99	59.56	13:45	53.00	59.30	229	202
4 - 11	1155	13/02/2023	14:20	52.99	59.27	16:20	52.95	59.01	164	13586
2 - 4	1156	14/02/2023	06:05	52.83	59.79	08:05	52.83	59.51	156	1762
3 - 7	1157	14/02/2023	08:45	52.84	59.46	10:45	52.87	59.70	147	2405
2 - 5	1158	14/02/2023	11:45	52.92	59.85	13:45	52.93	59.59	166	4185
2 - 6	1159	14/02/2023	14:25	52.97	59.65	16:25	52.93	59.88	216	3488
1 - 2	1160	15/02/2023	06:05	52.86	59.99	08:05	52.80	60.22	198	4938
0 - 1	1161	15/02/2023	08:55	52.80	60.30	10:55	52.90	60.13	246	2405
1 - 3	1162	15/02/2023	11:35	52.88	60.13	13:35	52.93	59.88	198	15569
A - 1	1163 [B]	15/02/2023	14:25	52.92	59.93	15:15	52.94	59.82	205	4039
A - 2	1164	16/02/2023	06:05	52.54	58.52	08:05	52.63	58.76	137	5067
A - 3	1165	16/02/2023	08:45	52.66	58.81	10:45	52.80	58.84	136	10048
A - 4	1166	16/02/2023	11:25	52.77	58.79	13:25	52.66	58.61	145	11970
A - 5	1167	16/02/2023	14:05	52.66	58.62	16:05	52.77	58.76	156	10980
A - 6	1168	17/02/2023	06:05	52.99	59.28	08:05	52.95	59.03	164	64536

A - 7	1169	17/02/2023	09:00	52.96	59.06	11:00	52.98	59.30	159	40576
A - 8	1170	18/02/2023	06:10	52.60	58.92	08:10	52.58	58.67	118	807
A - 9	1171	18/02/2023	08:50	52.59	58.60	10:50	52.71	58.73	145	10397
A - 10	1172	18/02/2023	11:30	52.72	58.74	13:30	52.85	58.82	148	8941
A - 11	1173	18/02/2023	14:15	52.86	58.85	16:15	52.95	59.02	156	41824
A - 12	1175[C,D]	19/02/2023	06:05	52.96	59.05	07:45	52.99	59.26	169	57963
A - 13	1176	19/02/2023	12:55	52.98	59.29	14:55	52.96	59.52	175	25905
A - 14	1177[E]	19/02/2023	17:20	52.97	59.19	18:25	52.95	59.33	164	8684
A - 15	1178	20/02/2023	06:05	51.72	57.46	08:05	51.58	57.36	138	661
A - 16	1179	20/02/2023	08:40	51.54	57.33	10:40	51.38	57.27	137	1909
A - 17	1180	20/02/2023	11:20	51.39	57.29	13:20	51.51	57.42	129	1322
A - 18	1181[F]	20/02/2023	14:10	51.49	57.27	17:35	51.27	57.09	146	29852
X - 1	1182	21/02/2023	06:00	50.49	57.97	08:00	50.50	57.74	135	19168
X - 2	1183	21/02/2023	08:40	50.48	57.80	10:40	50.38	57.99	140	5880
X - 3	1184	21/02/2023	11:15	50.39	58.02	13:15	50.30	58.21	136	5655
X - 4	1185	21/02/2023	13:55	50.35	58.20	15:55	50.46	58.02	135	4388

[A]: Trawl stopped after a high concentration of acoustic sign was detected, which was blue whiting.
[B]: Trawl stopped early because of a broken cable ring.
[C]: Note that the station number skips from previous station 1173. Through a miscommunication, a catch composition sample was taken from the previous evening's optional trawl. In order to not waste that sample, it was assigned as regular observer station 1174 and added to the database, but is not considered part of this survey.
[D]: Trawl stopped early to prevent excess catch volume.
[E]: Trawl shortened because of late start, and to avoid over-filling factory.
[F]: Trawl hauled because of broken cable, then re-set immediately on the same track for 2 more hours.

Table A2. Empirical estimates of survey total catches by species / taxon. Note that sample weight refers to all samples brought from board, some of which may subsequently not be included in the FIFD database.

Species Code	Species / Taxon	Total catch (kg)	Total catch (%)	Sample (kg)	Discard (kg)
LOL	*Doryteuthis gahi*	549117	88.6	447	0
BLU	*Micromesistius australis*	31045	5.0	37	31045
PAR	*Patagonotothen ramsayi*	25970	4.2	115	25970
BAC	*Salilota australis*	2367	0.4	3	4
BUT	*Stromateus brasiliensis*	1186	0.2	36	1186
CGO	*Cottoperca gobio*	1141	0.2	3	1141
TOO	*Dissostichus eleginoides*	1041	0.2	733	0
SPN	Porifera	768	0.1	0	768
KIN	*Genypterus blacodes*	661	0.1	3	0
ZYP	*Zygochlamys patagonica*	576	0.1	0	576
CHE	*Champsocephalus esox*	560	0.1	37	524
DGS	*Squalus acanthias*	530	0.1	0	530
MED	*Medusa* sp	478	0.1	0	478
PTE	*Patagonotothen tessellata*	440	0.1	8	433
RFL	*Dipturus lamillai*	388	0.1	0	386
GOC	*Gorgonocephalus chilensis*	334	0.1	0	334
ILL	*Illex argentinus*	309	<0.1	0	309
HAK	*Merluccius hubbsi*	308	<0.1	5	1
GRC	*Macrourus carinatus*	278	<0.1	0	278
SHT	Mixed invertebrates	263	<0.1	0	263
DGH	*Schroederichthys bivius*	251	<0.1	0	251

RMC	*Bathyraja macloviana*	242	<0.1	0	242
SQT	Ascidiacea	238	<0.1	0	238
RAL	*Bathyraja albomaculata*	165	<0.1	3	165
RBR	*Bathyraja brachyurops*	161	<0.1	1	161
STA	*Sterechinus agassizii*	159	<0.1	0	159
ING	*Onykia ingens*	153	<0.1	0	153
ALG	Algae	130	<0.1	0	130
GRF	*Coelorinchus fasciatus*	112	<0.1	0	112
EGG	Eggmass	87	<0.1	0	87
CAZ	*Calyptraster* sp.	82	<0.1	0	82
EEL	I*luocoetes*/*Patagolycus* mix	80	<0.1	6	73
ANM	Anemonia	76	<0.1	0	76
AST	Asteroidea	64	<0.1	0	64
FUM	*Fusitriton m. magellanicus*	28	<0.1	0	28
SUN	*Labidiaster radiosus*	22	<0.1	0	22
ODM	*Odontocymbiola magellanica*	22	<0.1	0	22
NEM	*Psychrolutes marmoratus*	17	<0.1	1	17
ALF	*Allothunnus fallai*	14	<0.1	14	0
MXX	Myctophidae spp.	12	<0.1	0	12
LIS	*Lithodes santolla*	12	<0.1	0	4
EUL	*Eurypodius latreillii*	11	<0.1	0	11
RGR	*Bathyraja griseocauda*	10	<0.1	0	10
CRY	*Crossaster* sp.	10	<0.1	0	10
WRM	Worm cases	9	<0.1	0	9
FLX	*Flabellum* spp.	9	<0.1	0	9
CTA	*Ctenodiscus australis*	9	<0.1	0	9
TRP	*Tripylaster philippi*	8	<0.1	0	8
THO	Thouarellinae	6	<0.1	0	6
RSC	*Bathyraja scaphiops*	6	<0.1	0	6
PES	*Peltarion spinulosum*	6	<0.1	0	6
PAT	*Merluccius australis*	6	<0.1	6	0
CEX	*Ceramaster* sp.	6	<0.1	0	6
ALC	Alcyoniina	6	<0.1	0	6
WHI	*Macruronus magellanicus*	5	<0.1	3	5
RPX	*Psammobatis* spp.	3	<0.1	0	3
OCM	*Enteroctopus megalocyathus*	3	<0.1	0	3
EUO	*Eurypodius longirostris*	3	<0.1	0	3
RBZ	*Bathyraja cousseauae*	2	<0.1	0	2
OPV	*Ophiacantha vivipara*	2	<0.1	0	2
OPL	*Ophiura lymani*	2	<0.1	0	2
MLA	*Muusoctopus longibrachus akambei*	2	<0.1	0	1
BRY	Bryozoa	2	<0.1	0	2
PRX	*Paragorgia* sp.	1	<0.1	0	1
MIR	*Mirostenella* sp.	1	<0.1	0	1
DIA	*Diaulula* spp.	1	<0.1	0	1
BRP	Brachiopoda spp.	1	<0.1	0	1
SAR	*Sprattus fuegensis*	<1	<0.1	0	0
RED	*Sebastes oculatus*	<1	<0.1	0	0
POL	Polychaeta	<1	<0.1	0	0
NUD	Nudibranchia	<1	<0.1	0	0
NOW	*Paranotothenia magellanica*	<1	<0.1	0	0
MAV	*Magellania venosa*	<1	<0.1	0	0
CYX	*Cycethra* sp.	<1	<0.1	0	0
CUB	*Cubiceps caeruleus*	<1	<0.1	0	0
CIR	Cirripedia	<1	<0.1	0	0
AUC	*Austrocidaris canaliculata*	<1	<0.1	0	0
AGO	*Agonopsis chiloensis*	<1	<0.1	0	0
		620,021		1,460	66,451

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

Species		N otolith pairs	
		M	F
Toothfish	*Dissostichus eleginoides*	109	144
Common Rock cod	*Patagonotothen ramsayi*	86	86
Southern Blue Whiting	*Micromesistius australis*	10	0
Butterfish	*Stromateus brasiliensis*	4	5
Hoki	*Macruronus magellanicus*	0	3
Common Hake	*Merluccius hubbsi*	0	3
Frogmouth	*Cottoperca gobio*	1	2
Black southern rock cod	*Patagonotothen tessellata*	0	2
Patagonian Hake	*Merluccius australis*	1	1
Slender Tuna	*Allothunnus fallai*	2	0
Falkland sprat	*Sprattus fuegensis*	1	0
Patagonian Redfish	*Sebastes oculatus*	0	1
Fathead	*Psychrolutes marmoratus*	1	0
Kingclip	*Genypterus blacodes*	0	1
Icefish	*Champsocephalus esox*	0	1
Red cod	*Salilota australis*	0	1