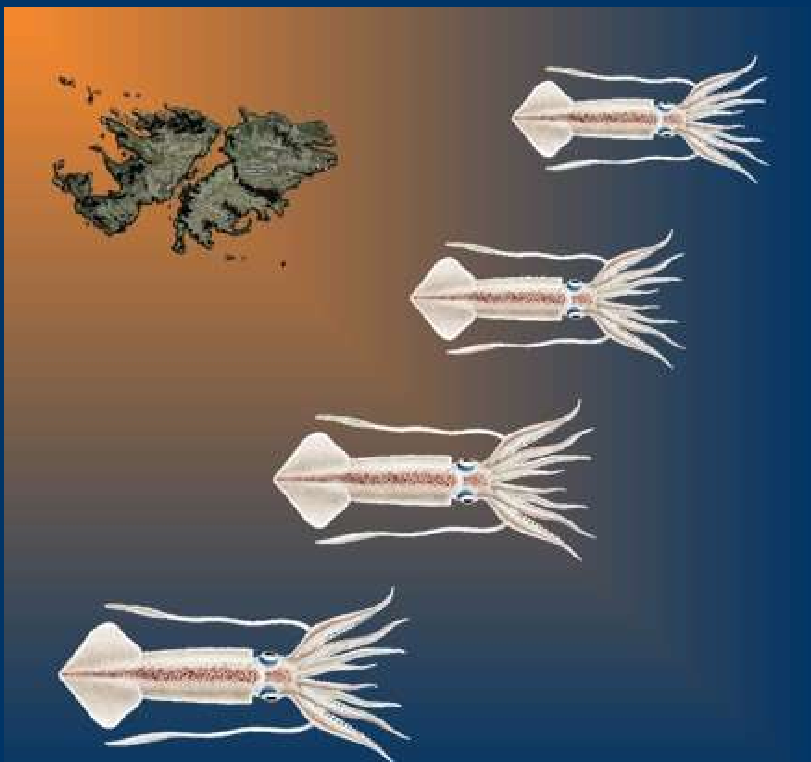
2022 2nd Pre-Season Assessment Survey

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 12th to 26th July 2022. Fifty-nine scientific trawls were taken during the survey; 39 fixed-station and 20 adaptive-station trawls. The scientific catch of the survey was 440.77 tonnes *D. gahi*.
2) An estimate of 63,348 tonnes *D. gahi* (95% confidence interval: 46,149 to 83,140 t) was calculated for the fishing zone by inverse distance weighting. The biomass estimate was the lowest for a 2nd pre-season since 2019, but above the long-term median. Of the total, 28,395 tonnes were estimated north of 52 ºS, and 34,952 tonnes were estimated south of 52 ºS.
3) *D. gahi* had significantly greater average mantle length south than north of 52 ºS. Males had significantly greater average maturity south, and females had significantly greater average maturity north. Males north: mean mantle length 10.85 cm; mean maturity stage 3.00, south: mean mantle length 11.53 cm; mean maturity stage 3.38. Females north: mean mantle length 10.67 cm; mean maturity stage 2.02, south: mean mantle length 11.33 cm; mean maturity stage 2.01. Sizes were smallest for a 2nd pre-season since at least 2015, particularly in the north.
4) 84 taxa were identified in the catches. *D. gahi* was the largest species group at 89.3% of total catch by weight; lower than last year but median among the past five 2nd pre-seasons. Common hake (6.2%) and rock cod (2.8%) were the only other taxa comprising >1% of total survey catch. Biological measurements and samples were taken from *D. gahi*, rock cod, toothfish, kingclip, grenadier, hoki, red cod, southern blue whiting, common 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 *Argos Pereira* from the 12th to 26th July 2022; experimental license FK042E22. 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, 2022.
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.
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. 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.

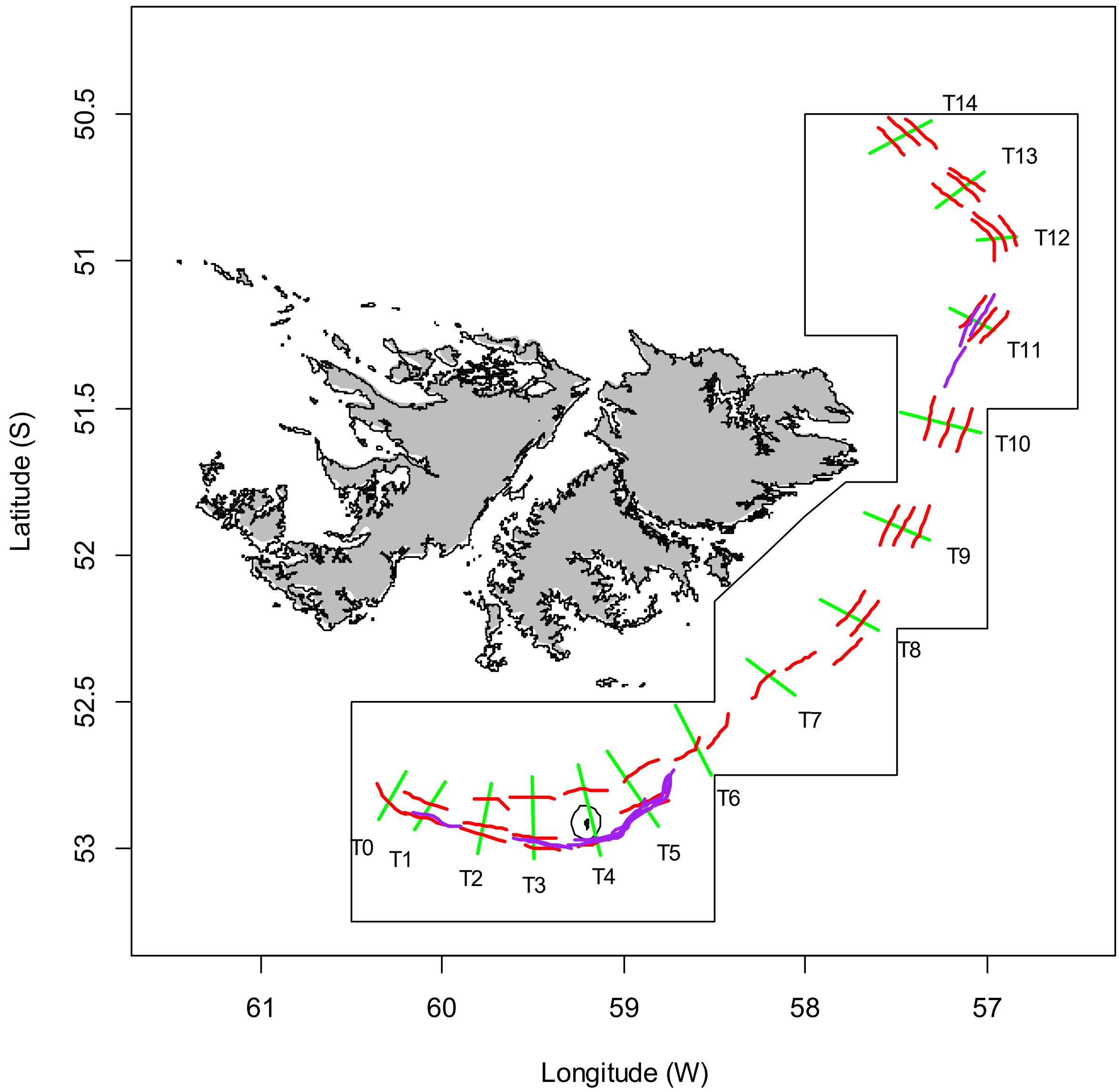


Figure 1. Survey transects (green lines), fixed-station trawls (red lines), and adaptive-station trawls (purple lines) sampled during the 2nd pre-season 2022 survey. Boundaries of the 'Loligo Box' fishing zone and the Beauchêne Island exclusion zone are in black.

F/V *Argos Pereira* is a Falkland Islands - registered stern trawler of 83.5 m length, 2335 gross tonnage, and 3000 main engine bhp. Like all vessels employed for these pre-season surveys, *Argos Pereira* operates regularly in the Falkland Islands calamari fisheries, and used its commercial trawl gear for the survey catches. It was noted that Argos Pereira used rectangular trawl doors during this survey, rather than oval doors that have been more usual in this fishery. *Argos Pereira* has previously been employed for a seabird and pinniped bycatch mitigation assessment (Iriarte 2019). The following FIFD personnel participated in the 2nd pre-season 2022 survey:

Alexander Arkhipkin	lead scientist
Neda Matošević	scientific observer
Lily Copping	scientific observer

Methods

Sampling procedures

The 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 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). 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.

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 data. Baskets 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], and variations in catchability are assumed to be independent of other trawl factors[b]. Swept area is 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[c]. Trawl width was derived from the distance between trawl doors (determined per interval) according to the equation (Seafish 2010):

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

[a] Albeit more likely to underestimate than overestimate true density (Harley and Myers 2001); thus conservative.
[b] This assumption is examined in the current report, see Appendix – Trawl factors.
[c] At the end of any trawl the net will 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.

Measurements of *Argos Pereira's* trawl, provided by the vessel master, were: footrope = 130.04 m, sweep = 110 m, bridle = 20 m in bad weather and 25 m in good weather. The bridles evidently functioned on a self-adjusting flex system and were therefore averaged to 22.5 m.

Biomass density estimates were extrapolated to the fishing area using an inverse distance weighting algorithm (Ramos and Winter 2022). As previously, the fishing 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 fishing 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 tests. Statistical significance of differences in mantle length and maturity stage distributions were evaluated with non-parametric Kruskal-Wallis tests.

Additional specimens of *D. gahi* were collected 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 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 commercial fish species as available.

Results

Catch rates and distribution

The survey started as usual[d] with fixed-station trawls in the north and proceeded throughout the Loligo Box. A schedule of 4 scientific trawls per day was maintained every day except the last day[e] (Table A1), resulting in 59 scientific trawls total recorded during the survey: 39 fixed station trawls catching 145.05 t *D. gahi*, and 20 adaptive-station trawls catching 295.72 t *D. gahi*. Twelve optional trawls (directed by the vessel master, after survey hours) yielded an

[d] Since at least 2010 (Arkhipkin et al. 2010).

[e] A rendezvous to re-fuel the vessel required ending the survey earlier that day.

additional 200.99 t *D. gahi*, bringing the total catch for the survey to 641.76 t. The scientific survey catch of 440.77 t is the lowest for a 2nd pre-season since 2019 (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*	314	56807
2018	59*	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

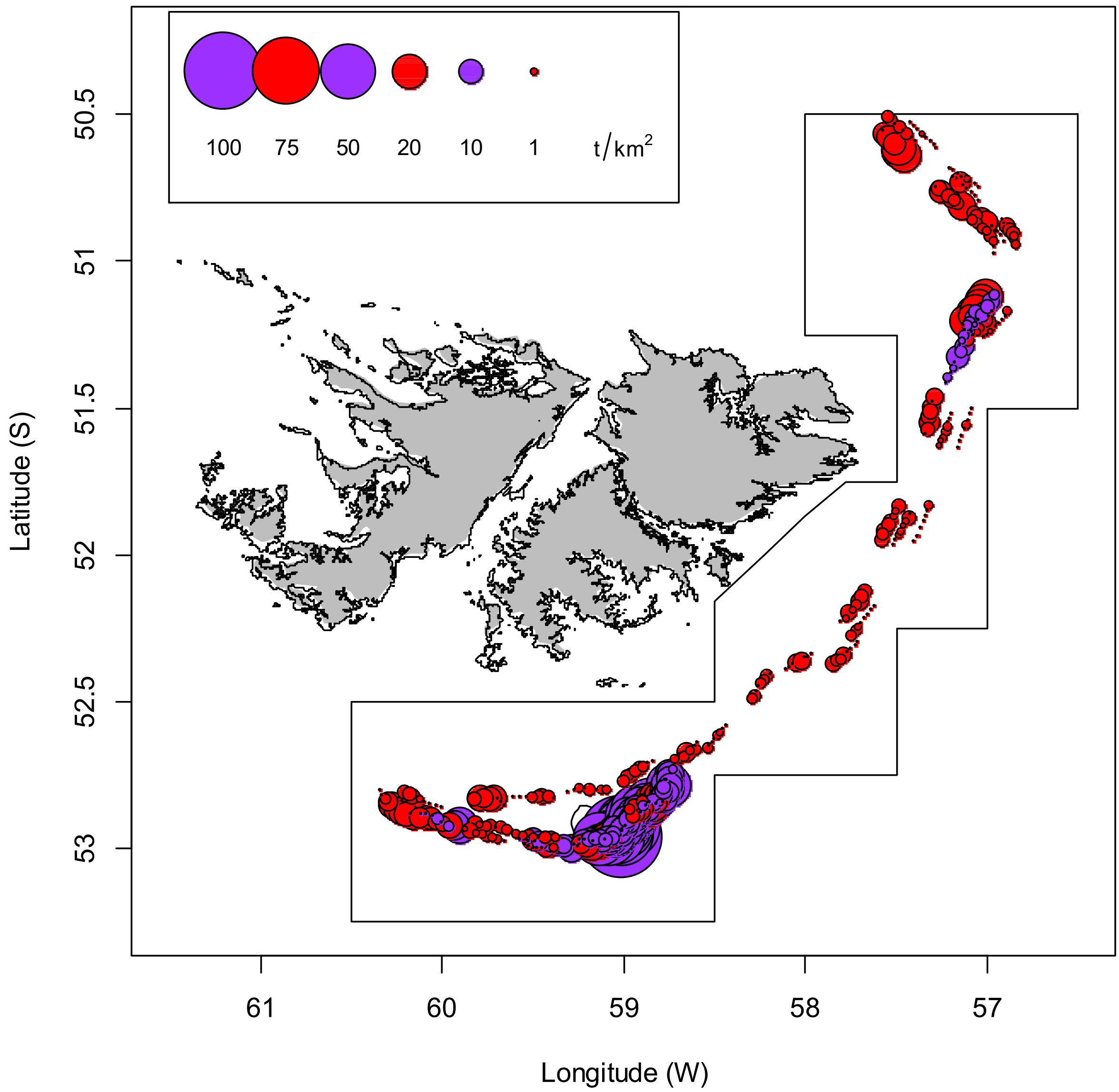
* Includes four juvenile toothfish transect trawls.

Average *D. gahi* catch density (Figure 2) among fixed-station trawls north of 52º S was 2.64 t km^{-2}; the lowest for 2nd pre-seasons since 2017, albeit by a small margin: 2.67 t km^{-2} in 2019, and 2.70 t km^{-2} in 2021. Average *D. gahi* catch density among fixed-station trawls south of 52º S was 3.29 t km^{-2}; median for 2nd pre-seasons among the last five years. Average *D. gahi* catch density among adaptive-station trawls north of 52º S was 2.40 t km^{-2}; the lowest for 2nd pre-seasons since 2015. Average *D. gahi* catch density among adaptive-station trawls south of 52º S was 13.09 t km^{-2}; highest for 2nd pre-seasons since 2018.

Biomass estimation

Total *D. gahi* biomass in the fishing area was estimated at 63,348 tonnes, with a 95% confidence interval of [46,149 to 83,140 t]. The total was the lowest 2nd pre-season estimate since 2019, although well above the long-term median (Table 1). Partition of the estimated biomass was 28,395 tonnes north [13,553 to 38,992 t] vs. 34,952 tonnes south [26,750 to 52,206 t]. The biomass proportion north (44.8%) was also the lowest for a 2nd pre-season since 2019. 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 251 of the 368 5×5 km area units (Figure 3). Within the south sub-area 50% of *D. gahi* density was aggregated in 48 of 392 5×5 km area units, and 95% of density was aggregated in 260 of the 392 5×5 km area units (Figure 3).

Figure 2 [next page]. *D. gahi* CPUE (t km^{-2}) of fixed-station (red) and 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.



Biological data

Eighty-four taxa were identified in the survey catches (Appendix Table A2). *D. gahi* was the predominant catch with 89.3% of the total (Table A2); lower than 2nd pre-season last year but median among the last five years.

The second-highest catch species was common hake *Merluccius hubbsi*, for the fourth time in the last five 2nd pre-season surveys[f], with 6.2% of the total. The percentage was actually a decrease from the 2020 and 2021 2nd pre-season surveys, but continued to present an increasing time series trend (Figure 4 – left) consistent with increasing hake catches overall in Falkland Islands fisheries (FIG 2021). Hake bycatch was significantly correlated with depth, as 88.5% of hake was taken in the 21 stations deeper than 200 m (Figure 4 – right).

Rock cod *Patagonotothen ramsayi* bycatch was the highest total and the highest percentage (2.8%) for a 2nd season since 2017, showing an increasing trend since 2019 (Figure

[f] In 2019 hake was third-highest behind red cod (Goyot et al 2019).

5 – left). The single trawl station furthest south-west accounted for 46.2% of the survey's rock cod bycatch (Figure 5 – right).

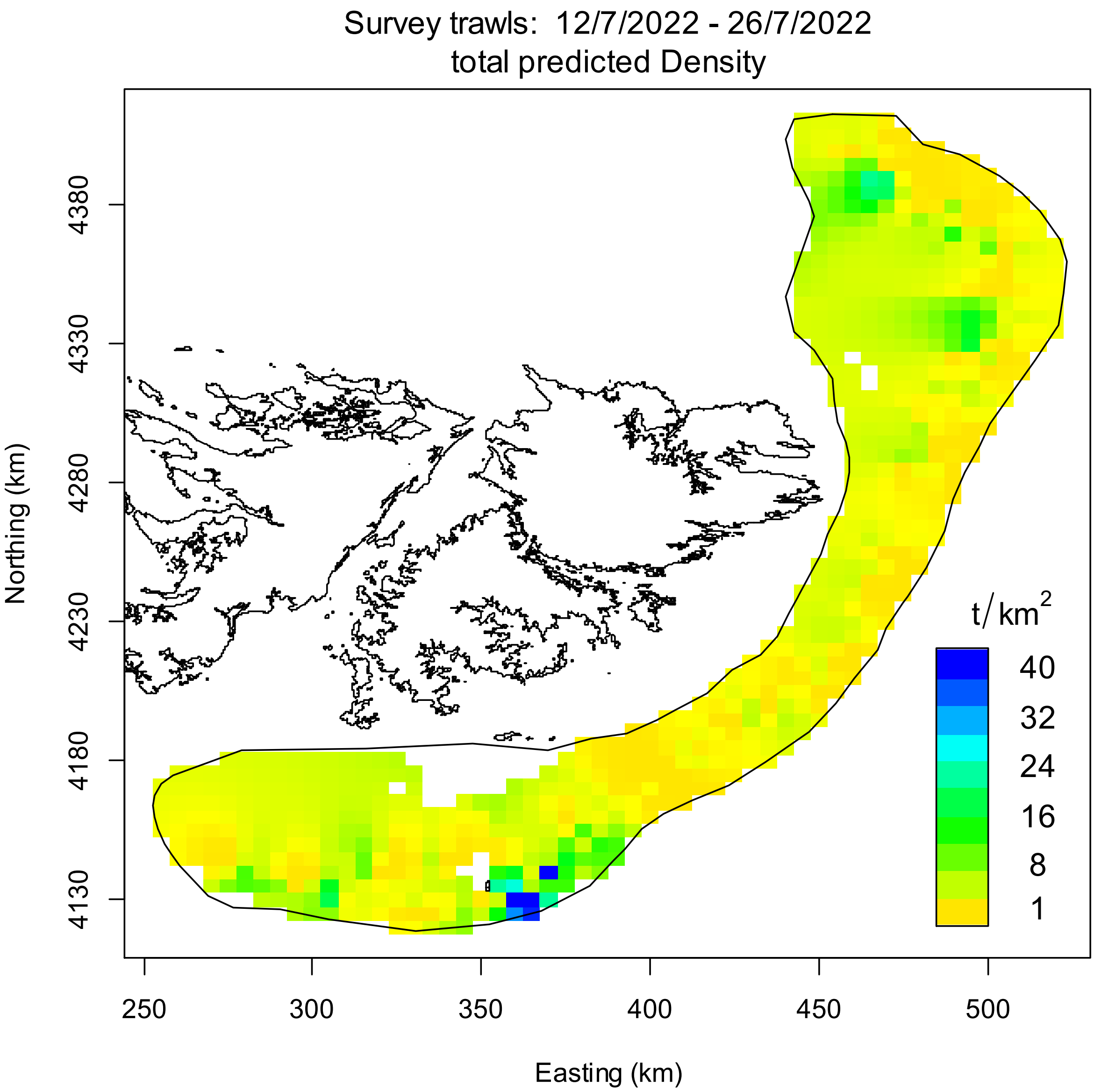
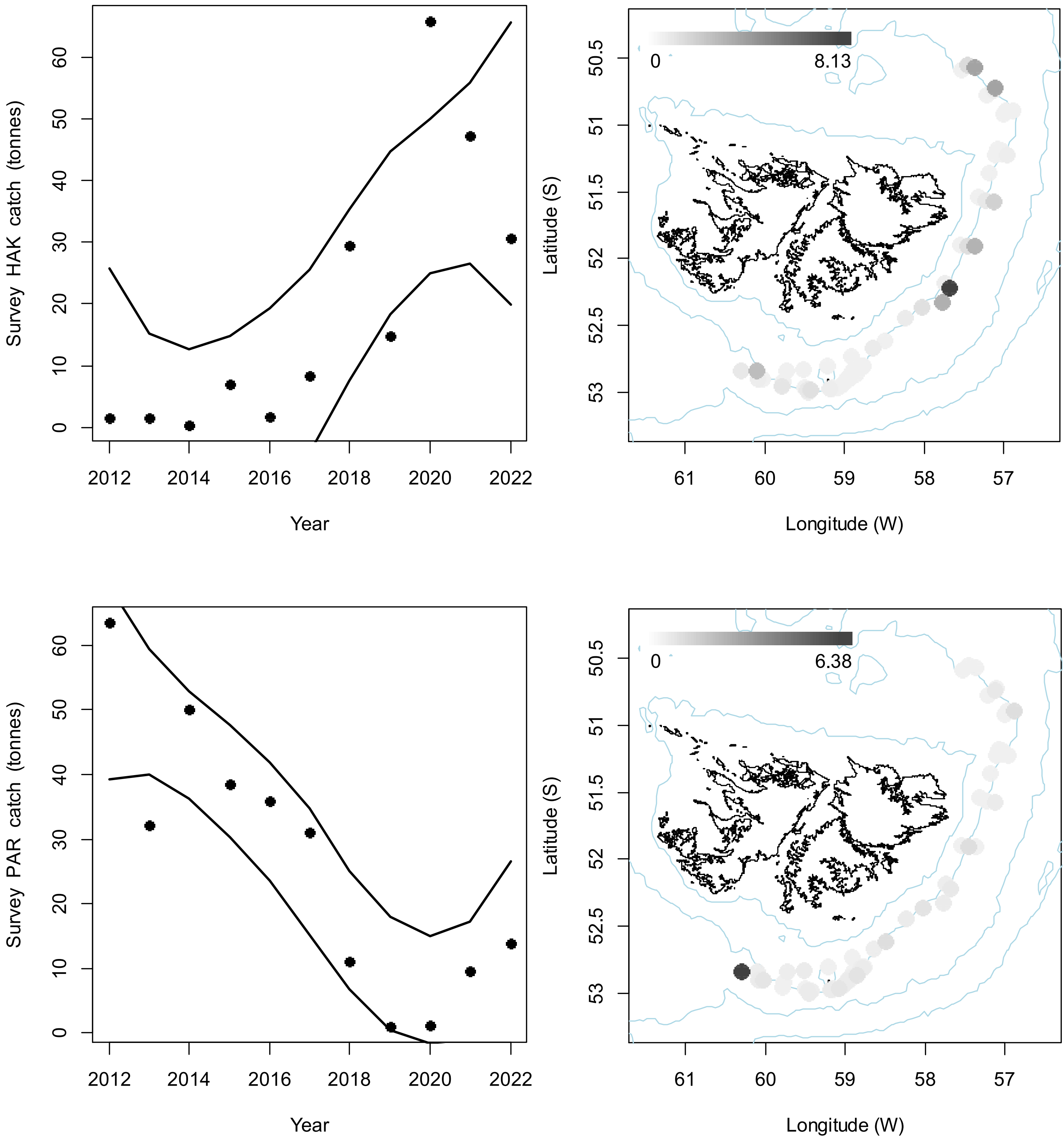


Figure 3. *D. gahi* predicted density estimates per 5 km^2 area units. Blank area units within the perimeter are either <90 or >400 m average depth. Coordinates were converted to WGS 84 projection in UTM sector 21F using the R library rgdal (proj.maptools.org).

Figure 4 [next page – top]. Left: Common hake total catches in 2nd pre-season surveys, 2012 to 2022. Black lines: 95% confidence interval of LOESS smooth (degree = 2, span = 1). Right: Catches of common hake (tonnes) per survey trawl station. Blue lines: bathymetry 100 m, 200 m, 500 m, 1000 m.

Figure 5 [next page – bottom]. Left: Rock cod total catches in 2nd pre-season surveys, 2012 to 2022. Black lines: 95% confidence interval of LOESS smooth (degree = 2, span = 1). Right: Catches of rock cod (tonnes) per survey trawl station. Blue lines: bathymetry 100 m, 200 m, 500 m, 1000 m.



D. gahi were collected and frozen from 9 stations for statolith sampling ashore. During the survey 9382 *D. gahi* were measured for length and maturity (4109 males, 5273 females, from among all 59 trawls). The total sex ratio was significantly ($p < 0.0001$) majority female.

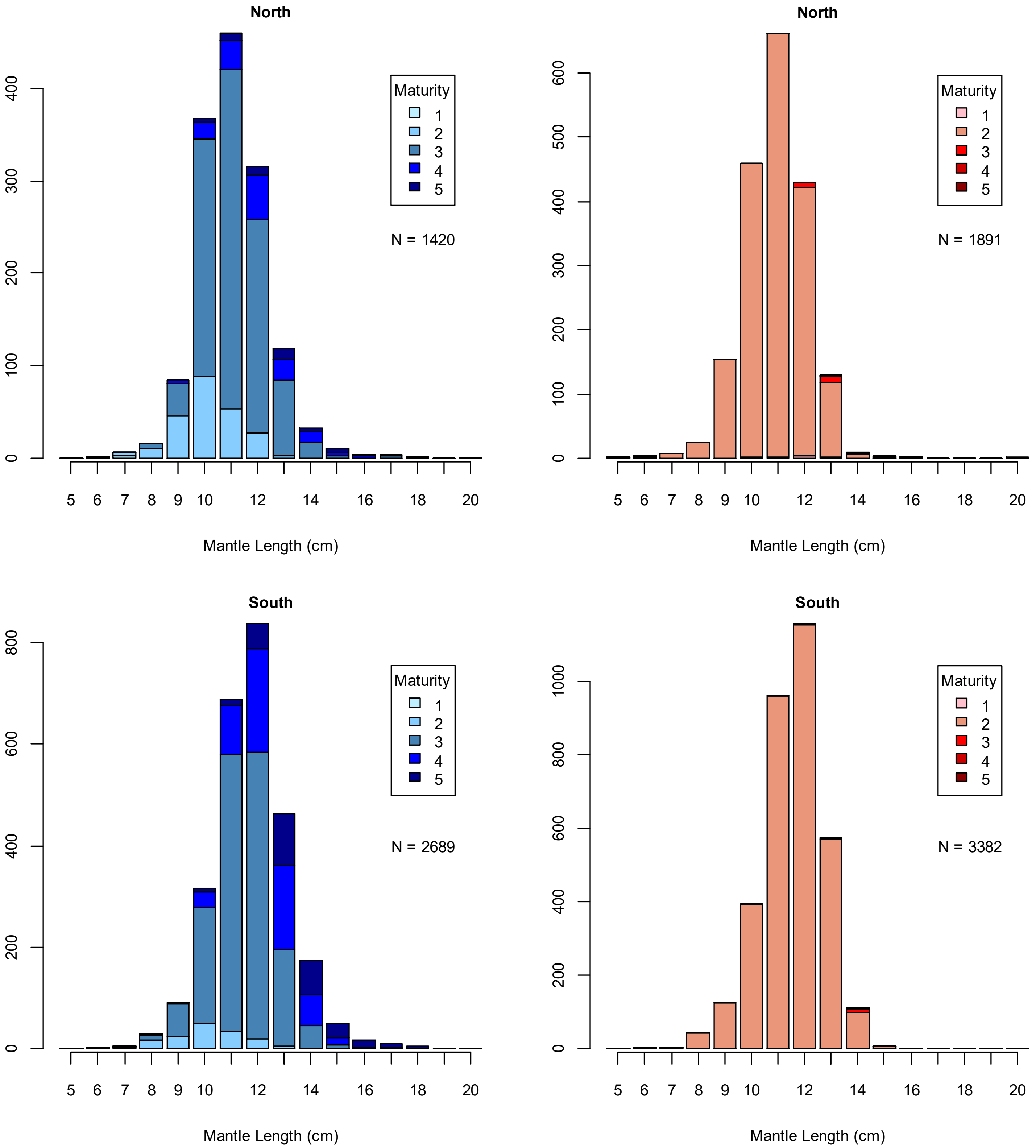


Figure 6. Length-frequency distributions by maturity stage of male (blue) and female (red) *D. gahi* from trawls north (top) and south (bottom) of latitude 52 ºS.

Thirty individual trawls had a significant preponderance of females, including all nine of the northernmost trawls. Seven individual trawls had a significant preponderance of males, dispersed throughout the shallower parts of the survey area. Preponderance of females had a significant positive correlation with depth ($p < 0.02$), concurring with earlier studies that have found females move deeper (Hatfield et al. 1990, Arkhipkin and Middleton 2002).

D. gahi mantle length and maturity distributions north and south of 52° S are plotted in Figure 6. For males north: mean mantle length 10.85 cm; mean maturity stage 3.00 (on a scale of 1 to 6, Lipinski 1979), males south: mean mantle length 11.53 cm; mean maturity stage 3.38. Females north: mean mantle length 10.67 cm; mean maturity stage 2.02, females south: 11.33 cm; stage 2.01. Mean mantle lengths of males as well as females were the smallest for a 2nd pre-season since at least 2015. Mantle length distributions were significantly different between north and south for both males and females (Kruskal-Wallis test, $p < 0.05$). Maturity distributions were also significantly different between north and south for both males and females ($p < 0.05$), presenting the contrast that females were larger but younger in the south. Maturities of males were positively correlated with the sampling day but maturities of females were negatively correlated with the sampling day ($p < 0.05$), suggesting that some immigration continued throughout the survey.

Otoliths taken during the survey are summarized in Table A3.

Pinniped and seabird monitoring

The 2nd pre-season survey 2022 was conducted with seal exclusion devices (SED) in the trawls from the beginning of the survey. Specific pinniped and seabird monitoring were not carried out during the survey. Dozens of fur seals (*Arctocephalus australis*) were present at each trawl station in the southern sub-area, but no seal mortalities were recorded. Three live escapees were observed when trawling near Beauchene Island on 24 July 2022. One black-browed albatross (*Thalassarche melanophris*) was released alive from deck, but no seabird mortalities were recorded.

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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 / Trawl	Data Station	Date	Start			End			Depth (m)	*D. gahi* (kg)
			Time	Lat	Lon	Time	Lat	Lon		
14 - 37	592	12/07/2022	07:40	50.52	57.45	0.41	50.61	57.28	294	102
14 - 38	593	12/07/2022	10:20	50.60	57.38	0.51	50.51	57.55	251	1898
14 - 39	594	12/07/2022	13:05	50.54	57.60	0.63	50.64	57.46	139	12679
13 - 34	595	12/07/2022	16:10	50.74	57.30	0.76	50.81	57.14	133	5473
13 - 36	596	13/07/2022	07:35	50.76	57.02	0.40	50.68	57.21	295	164
13 - 35	597	13/07/2022	10:15	50.70	57.22	0.51	50.79	57.05	253	979
12 - 33	598	13/07/2022	13:15	50.85	56.94	0.64	50.94	56.84	252	2246
12 - 32	599	13/07/2022	16:05	50.97	56.90	0.75	50.83	57.08	124	4224
11 - 30	600	14/07/2022	07:35	51.27	57.04	0.40	51.17	56.88	283	257
11 - 29	601	14/07/2022	10:15	51.16	56.95	0.51	51.27	57.10	152	2903
11 - 28	602	14/07/2022	13:00	51.22	57.15	0.63	51.12	57.01	128	16137
12 - 31	603	14/07/2022	16:05	50.99	56.97	0.75	50.86	57.08	118	2328
9 - 24	604	15/07/2022	07:20	51.98	57.42	0.39	51.83	57.32	288	288
10 - 27	605	15/07/2022	10:40	51.65	57.17	0.53	51.50	57.09	287	240
10 - 26	606	15/07/2022	13:20	51.50	57.19	0.64	51.63	57.26	226	913
10 - 25	607	15/07/2022	16:05	51.61	57.34	0.75	51.46	57.30	148	4786
8 - 21	608	16/07/2022	07:25	52.16	57.60	0.39	52.27	57.75	264	873
8 - 20	609	16/07/2022	10:20	52.24	57.83	0.51	52.12	57.67	196	3506
9 - 22	610	16/07/2022	13:40	51.97	57.59	0.65	51.83	57.49	160	3821
9 - 23	611	16/07/2022	16:20	51.84	57.41	0.76	51.97	57.52	218	1105
1 - 2	612	17/07/2022	07:35	52.87	59.98	0.40	52.81	60.21	199	2178
0 - 1	613	17/07/2022	10:40	52.78	60.36	0.53	52.89	60.20	246	8243
1 - 3	614	17/07/2022	13:30	52.88	60.21	0.65	52.92	59.96	229	10100
2 - 6	615	17/07/2022	16:20	52.93	59.90	0.76	52.98	59.66	237	2439
2 - 4	616	18/07/2022	07:30	52.87	59.64	0.40	52.83	59.82	160	5195
2 - 5	617	18/07/2022	10:35	52.91	59.88	0.52	52.94	59.64	173	2471
3 - 8	618	18/07/2022	13:15	52.95	59.61	0.64	52.97	59.37	181	2403
3 - 9	619	18/07/2022	16:00	53.01	59.35	0.75	52.99	59.54	237	1770
3 - 7	620	19/07/2022	07:35	52.83	59.63	0.40	52.83	59.38	149	1873
4 - 10	621	19/07/2022	10:15	52.82	59.33	0.51	52.80	59.09	111	1177
5 - 13	622	19/07/2022	13:20	52.88	59.01	0.64	52.81	58.77	147	11033
5 - 14	623	19/07/2022	16:25	52.84	58.76	0.77	52.89	58.95	175	8072
8 - 19	624	20/07/2022	07:35	52.28	57.69	0.40	52.38	57.85	308	1864
7 - 18	625	20/07/2022	10:35	52.34	57.94	0.52	52.39	58.11	220	1556
7 - 17	626	20/07/2022	13:20	52.40	58.17	0.64	52.49	58.29	179	1479
6 - 16	627	20/07/2022	16:35	52.54	58.42	0.77	52.66	58.54	238	534
6 - 15	628	21/07/2022	07:25	52.62	58.59	0.39	52.70	58.71	150	1842
5 - 12	629	21/07/2022	10:15	52.70	58.81	0.51	52.77	59.00	130	2691
A - 1	630	21/07/2022	13:20	52.84	58.88	0.64	52.95	59.01	152	13706
4 - 11	631	21/07/2022	16:25	52.96	59.04	0.77	53.00	59.26	204	13208
A - 2	632	22/07/2022	07:50	52.99	59.31	0.41	52.96	59.06	174	11820
A - 3	633	22/07/2022	10:35	52.95	59.06	0.52	52.87	58.88	153	11772
A - 4	634	22/07/2022	13:20	52.85	58.84	0.64	52.75	58.74	157	16717
A - 5	635	22/07/2022	16:10	52.75	58.75	0.76	52.85	58.86	149	9695
A - 6	636	23/07/2022	07:50	52.98	59.27	0.41	52.95	59.02	166	5938
A - 7	637	23/07/2022	10:40	52.96	59.02	0.53	52.86	58.85	160	12260

A - 8	638	23/07/2022	13:30	52.86	58.83	0.65	52.73	58.73	163	10518
A - 9	639	23/07/2022	16:15	52.76	58.77	0.76	52.85	58.88	148	4598
A - 10	640	24/07/2022	07:45	52.98	59.55	0.41	53.00	59.29	200	7699
A - 11	641	24/07/2022	10:45	52.98	59.15	0.53	52.89	58.93	167	21656
A - 12	642	24/07/2022	13:35	52.87	58.88	0.65	52.97	59.08	160	52913
A - 13	643	24/07/2022	16:55	52.97	59.09	0.79	52.87	58.93	164	32000
A - 14	644	25/07/2022	08:05	52.88	60.16	0.42	52.93	59.90	210	7711
A - 15	645	25/07/2022	11:25	52.97	59.60	0.56	52.99	59.32	194	8554
A - 16	646	25/07/2022	14:20	52.98	59.20	0.68	52.92	58.98	178	37592
A - 17	647	25/07/2022	17:20	52.95	59.03	0.81	52.84	58.86	152	21338
A - 18	648	26/07/2022	07:40	51.43	57.24	0.40	51.30	57.12	139	3536
A - 19	649	26/07/2022	10:20	51.26	57.10	0.51	51.12	56.96	134	3088
A - 20	650	26/07/2022	13:10	51.16	57.05	0.63	51.29	57.15	132	2612

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*	440773	89.3	396	1052
HAK	*Merluccius hubbsi*	30647	6.2	1141	514
PAR	*Patagonotothen ramsayi*	13828	2.8	220	13753
BAC	*Salilota australis*	2290	0.5	10	2125
ZYP	*Zygochlamys patagonica*	1286	0.3	0	1286
CGO	*Cottoperca gobio*	1218	0.2	0	1218
DGH	*Schroederichthys bivius*	417	0.1	0	417
RBR	*Bathyraja brachyurops*	353	0.1	0	320
PTE	*Patagonotothen tessellata*	331	0.1	0	331
BLU	*Micromesistius australis*	331	0.1	8	331
STA	*Sterechinus agassizii*	301	0.1	0	301
MED	Medusa sp.	204	<0.1	0	204
TOO	*Dissostichus eleginoides*	182	<0.1	132	40
ING	*Onykia ingens*	182	<0.1	0	182
KIN	*Genypterus blacodes*	180	<0.1	6	0
GOC	*Gorgonocephalus chilensis*	168	<0.1	0	168
SPN	Porifera	160	<0.1	0	160
ALG	Algae	91	<0.1	0	91
RMC	*Bathyraja macloviana*	84	<0.1	0	84
LIS	*Lithodes santolla*	74	<0.1	55	74
PAU	*Patagolycus melastomus*	64	<0.1	13	64
RSC	*Bathyraja scaphiops*	58	<0.1	0	57
RPX	*Psammobatis* spp.	45	<0.1	0	45
SQT	Ascidiacea	44	<0.1	0	44
RDO	*Amblyraja doellojuradoi*	39	<0.1	0	39
WHI	*Macruronus magellanicus*	34	<0.1	3	9
OCM	*Enteroctopus megalocyathus*	22	<0.1	0	22
RGR	*Bathyraja griseocauda*	21	<0.1	0	21
RFL	*Dipturus lamillai*	20	<0.1	0	20
POA	*Glabraster antarctica*	19	<0.1	0	19
GRC	*Macrourus carinatus*	18	<0.1	18	18
RAL	*Bathyraja albomaculata*	16	<0.1	0	16
HYD	Hydrozoa	16	<0.1	0	16
SAL	*Salpa* sp.	15	<0.1	0	15
MUL	*Eleginops maclovinus*	13	<0.1	12	13
CAZ	*Calyptraster* sp.	13	<0.1	0	13
RBZ	*Bathyraja cousseauae*	11	<0.1	0	11
NEM	*Psychrolutes marmoratus*	11	<0.1	0	11

ILL	*Illex argentinus*	10	<0.1	0	8
GRF	*Coelorinchus fasciatus*	9	<0.1	1	9
FUM	*Fusitriton m. magellanicus*	9	<0.1	0	9
BAL	*Americominella longisetosus*	8	<0.1	0	8
ANM	Anemonia	7	<0.1	0	7
SUN	*Labidiaster radiosus*	6	<0.1	0	6
OPV	*Ophiacantha vivipara*	6	<0.1	0	6
OPL	*Ophiura lymani*	5	<0.1	0	5
LIT	*Lithodes turkayi*	5	<0.1	4	5
MIR	*Mirostenella* sp.	4	<0.1	0	4
AST	Asteroidea	4	<0.1	0	4
THO	Thouarellinae	3	<0.1	0	3
MAV	*Magellania venosa*	3	<0.1	0	3
EUL	*Eurypodius latreillii*	3	<0.1	0	3
BRY	Bryozoa	3	<0.1	0	3
WRM	Worm cases	2	<0.1	0	2
SHT	Mixed invertebrates	2	<0.1	0	2
ODM	*Odontocymbiola magellanica*	2	<0.1	0	2
MYX	*Myxine* spp.	2	<0.1	0	2
MLA	*Muusoctopus longibrachus akambei*	2	<0.1	0	2
COT	*Cottunculus granulosus*	2	<0.1	0	2
CEX	*Ceramaster* sp.	2	<0.1	0	2
RMG	*Bathyraja magellanica*	1	<0.1	0	1
NOW	*Paranotothenia magellanica*	1	<0.1	0	1
EGG	Eggmass	1	<0.1	0	1
CTA	*Ctenodiscus australis*	1	<0.1	0	1
AUC	*Austrocidaris canaliculata*	1	<0.1	0	1
ADA	*Adelomelon ancilla*	1	<0.1	0	1
XXX	Unidentified animal	<1	<0.1	0	0
SRP	*Semirossia patagonica*	<1	<0.1	0	0
RED	*Sebastes oculatus*	<1	<0.1	0	0
PYX	Pycnogonida	<1	<0.1	0	0
PES	*Peltarion spinulosum*	<1	<0.1	0	0
PEN	Pennatulacea	<1	<0.1	0	0
PAS	*Patagonotothen squamiceps*	<1	<0.1	0	0
PAF	*Paralomis formosa*	<1	<0.1	0	0
OPS	*Ophiactis asperula*	<1	<0.1	0	0
NUH	*Nuttallochiton hyadesi*	<1	<0.1	0	0
NUD	Nudibranchia	<1	<0.1	0	0
MAA	*Echinoteuthis atlantica*	<1	<0.1	0	0
ISO	Isopoda	<1	<0.1	0	0
HEX	*Henricia* sp.	<1	<0.1	0	0
CYX	*Cycethra* sp.	<1	<0.1	0	0
CRY	*Crossaster* sp.	<1	<0.1	0	0
AGO	*Agonopsis chiloensis*	<1	<0.1	0	0
ACS	*Acanthoserolis schythei*	<1	<0.1	0	0
		493,681		2,019	23,203

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

Species		N otoliths	
		M	F
Common Hake	*Merluccius hubbsi*	10	172
Common Rock cod	*Patagonotothen ramsayi*	56	61
Patagonian Toothfish	*Dissostichus eleginoides*	36	56
Grenadier-Ridge Scaled Rattail	*Macrourus carinatus*	4	13

Falkland Mullet	*Eleginops maclovinus*	8	3
Southern Blue Whiting	*Micromesistius australis*	9	2
Hoki	*Macruronus magellanicus*	2	6
Red cod	*Salilota australis*	0	3
Kingclip	*Genypterus blacodes*	0	2
Grenadier-Banded Whiptail	*Coelorinchus fasciatus*	1	1
Yellowbelly	*Paranotothenia magellanica*	1	0
Fathead	*Cottunculus granulosus*	1	0

Trawl factors

Studies have shown that catchability of demersal species decreases with increasing trawl width, as more individuals may escape under the footrope pulled tauter and lifting more off the bottom, or over the headrope pulled lower as the net expands horizontally (von Szalay and Somerton 2005). Trawl width itself correlates positively with trawl depth, as the longer warp cables deployed in deeper water facilitate more net spread (Godø and Engås 1989, von Szalay and Somerton 2005). Trawl width correlates negatively with catch weight, as a heavier filled net drags more and pulls the doors inward (Weinberg and Kotwicki 2008).

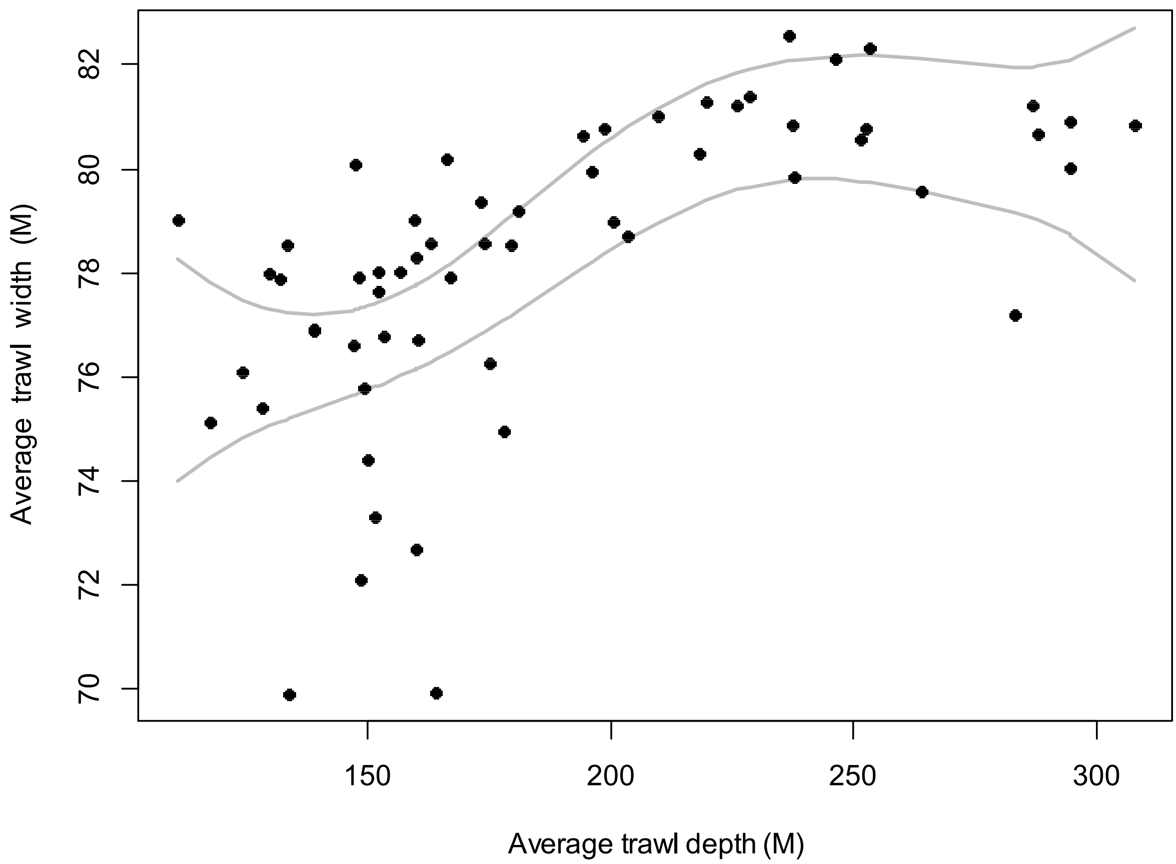

Figure A1. Average (mean) trawl depth vs. average (mean) trawl width of the 59 scientific survey stations. Grey lines: GAM 95% confidence intervals. Note that the GAM was calculated on the whole trawls, not on the 15-minute intervals recorded per trawl, because the acoustic marks corresponding to each 15-minute interval cannot be explicitly quantified as entering the net or not.

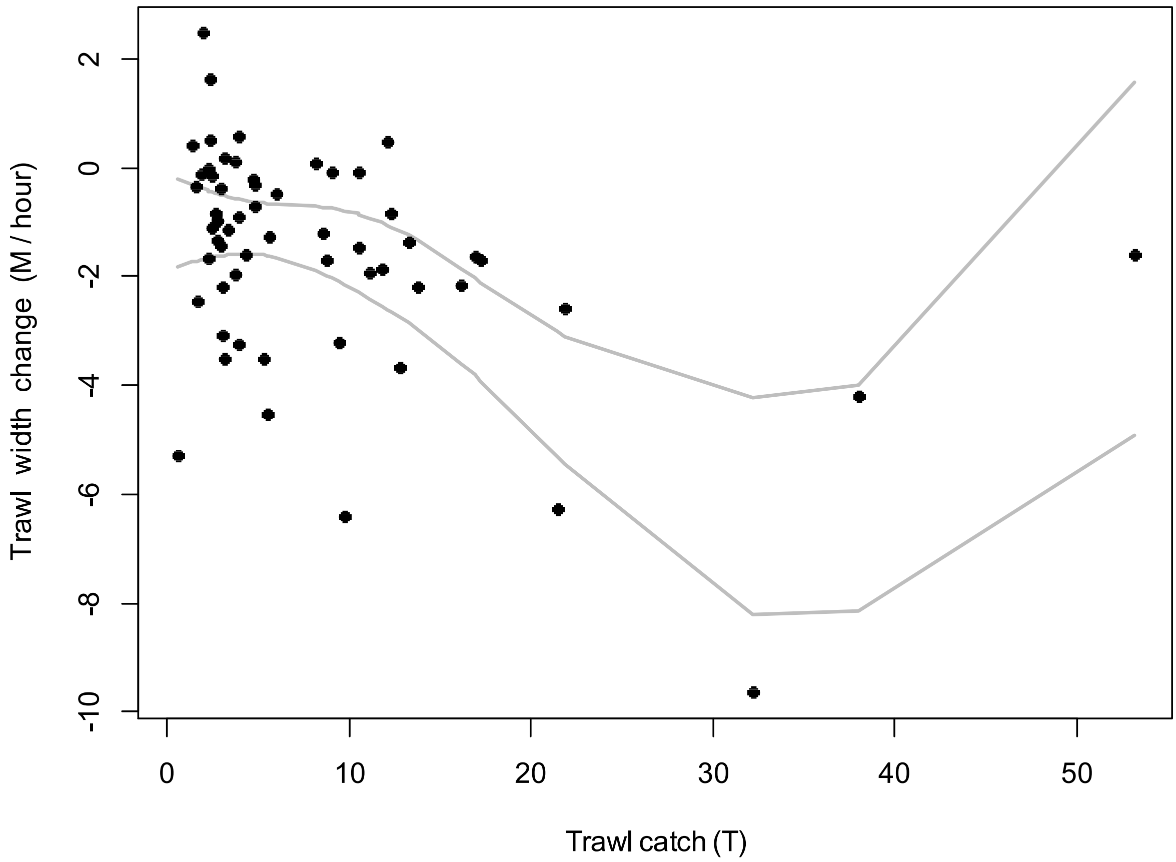

Figure A2. Trawl catch (tonnes) vs. trawl width change (metres per hour) of the 59 scientific survey stations. Trawl width change was calculated as the linear regression of trawl width vs. 15-min interval times recorded for each trawl. Grey lines: GAM 95% confidence intervals.

In this survey, positive correlation between trawl width and trawl depth, and negative correlation between trawl width change and catch weight, were confirmed by generalized additive models (GAM); respectively $p < 0.0001$, Figure A1, and $p < 0.0002$, Figure A2. Adjusting catchability for a depth factor would, however, be confounded by potential direct influence of depth on the abundance of any species (von Szalay and Somerton 2005). Adjusting catchability by catch weight would present a difficult to resolve autocorrelation. Based on the inference that various trawl factors are likely to counteract each other, adjustment to catchability was not implemented.