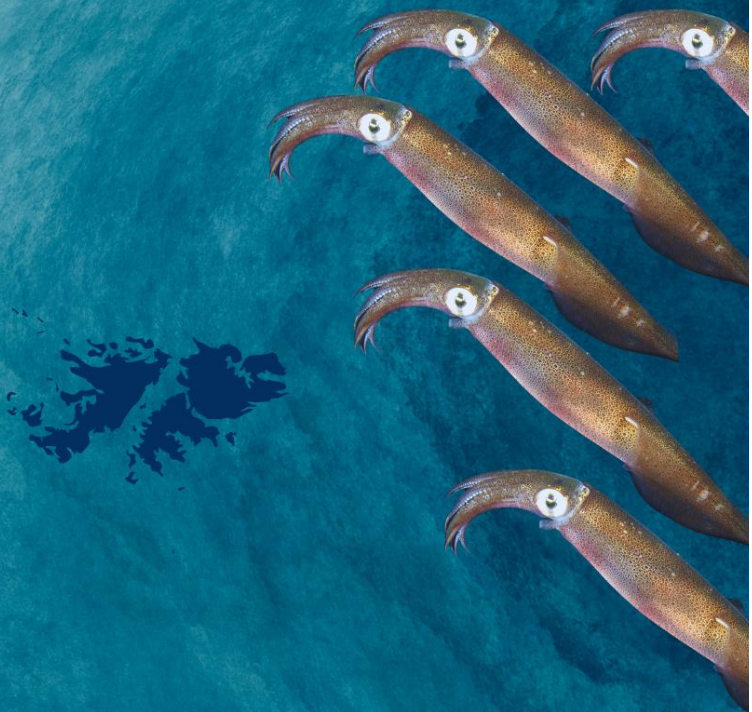
2024 1st Pre-Season Assessment Survey

Falkland calamari
(*Doryteuthis gahi*)



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Natural Resources - Fisheries
Falkland Islands Government

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2024 – S1 – ZDLF2

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Summary

1) A stock assessment survey for *Doryteuthis gahi* (Falkland calamari) was conducted in the Loligo Box from 7th to 22nd February 2024. A total of 64 scientific trawls were performed during the survey; 39 fixed-station trawls and 17 adaptive-station trawls. The scientific catch of the survey was 675.31 tonnes *D. gahi*.
2) An estimate of 70, 335 tonnes *D. gahi* (95% confidence interval: 57, 676 to 98, 016 tonnes) was calculated for the fishing zone by inverse distance weighting. The biomass estimate was the highest for a 1st pre-season since 2006. Of the total, 7, 655 tonnes were estimated north of 52 ºS, and 62, 679 tonnes were estimated south of 52ºS. The proportion north (10.9%) was the lowest for a 1st pre-season survey estimate since 2019.
3) *D. gahi* had significantly greater average mantle lengths and maturities north of 52˚S compared with individuals south of 52ºS. Males north: mean mantle length 10.52 cm; mean maturity stage 2.1, south: mantle length 10.49 cm; maturity 2.03. Females north: mantle length 10.69 cm; maturity 2.01, south: mantle length 10.37 cm; maturity 1.99. Mantle length distributions suggested that some immigration continued throughout the survey.
4) A total of 88 taxa were identified in the catches. *D. gahi* was the largest species group at 69.2% of total catch by weight; median percentage among the past five 1st pre-seasons. Rock cod (15.8%), southern blue whiting (12.1%) and hoki (1.6%) were the only other taxa comprising ≥0.5% of total survey catch. Biological measurements and samples were taken from *D. gahi*, rock cod, toothfish, 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 *New Polar* from the 7th to 22nd February 2024; experimental license FK0021E24. 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, 2024.
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 and identify if any juvenile toothfish were present in the 'Loligo Box'.
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.

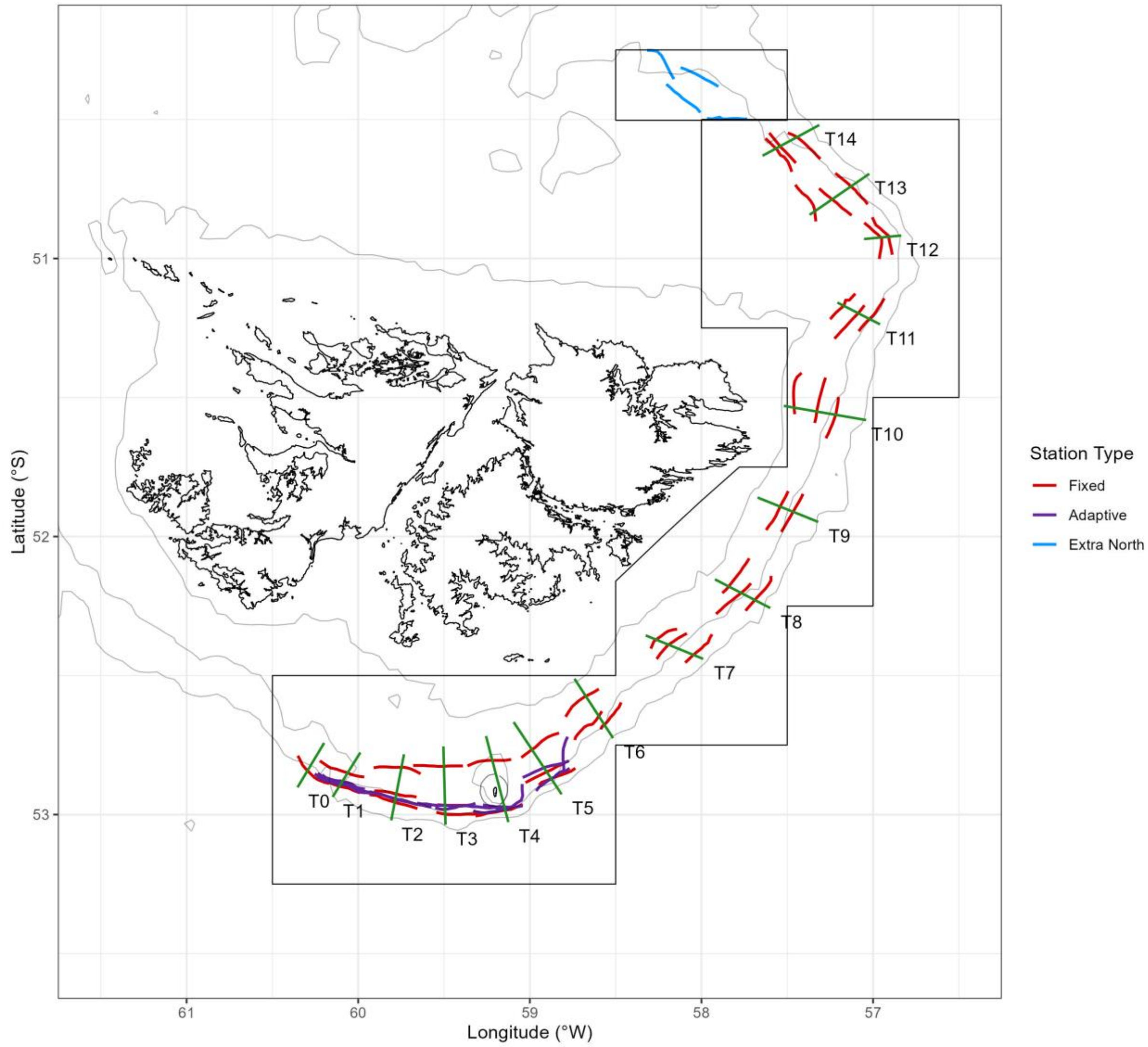

Figure 1. Survey transects (green lines), fixed-station trawls (red), adaptive-station trawls (purple), and extra north station trawls (blue) sampled during the 1st pre-season 2024 survey. Boundaries of the 'Loligo Box', Beauchêne Island exclusion zone, and extra grids north XKAM and XKAN, are in black.

F/V *New Polar* is a Falkland Islands - registered stern trawler of 75.5 m length, 2334 gt, and 4000 main engine bhp. Like all vessels employed for pre-season surveys, *New Polar* operates regularly in the Falkland Islands calamari fisheries, and used its commercial trawl gear for the survey catches. *New Polar* was previously employed for the 2nd pre-season surveys in 2006 and 2019 (Payá et al. 2006; Goyot et al. 2019). The following FIFD personnel participated in the 1st pre-season 2024 survey:

Role	Name
Survey lead scientist	Irina Chemshirova
Fishery scientist	Michal Raczynski
Fishery scientist	Frederick Ongoro

Methods

Sampling procedures

The regular survey plan included 39 fixed-station trawls located on a series of 16 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). For the 2024 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. 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].

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[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 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)

Measurements of *New Polar'*s trawl, provided by the vessel master, were as follows: footrope = 160 m, sweep = 40 m, bridle = 130 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[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, 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,

[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.

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 additional day north of the Loligo Box was used by the vessel on the first day of the survey. The survey then proceeded with fixed-station trawls in the north part of the Loligo box and continued southward throughout the Loligo Box in the usual pattern. A schedule of 4 scientific trawls per day was maintained every day (Table A1), resulting in 64 scientific trawls total recorded during the survey: 39 fixed station trawls catching 211.20 tonnes *D. gahi*, 21 adaptive-station trawls catching 464.08 tonnes *D. gahi*, and 4 extra north station trawls catching 0.047 tonnes *D. gahi*. A total of 15 optional trawls (directed by the vessel master, after survey hours) yielded an additional 315.08 tonnes *D. gahi*, bringing the total catch for the survey to 990.41 tonnes. The scientific survey catch of 675.31 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	56	294	19859
2024	64	675	70334			

[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 52° S was 0.67 t km^{-2}; the lowest for 1st pre-seasons since 2020. Average *D. gahi* catch density among fixed-station trawls south of 52° S was 6.11 t km^{-2}; the highest since at least 2011. Average *D. gahi* catch density among adaptive-station trawls south of 52° S was 16.8 t km^{-2}; highest on record for 1st pre-seasons. Average *D. gahi* catch density of the extra north station trawls was 0.009 t km^{-2}, lower than fixed and adaptive stations for this pre-season survey.

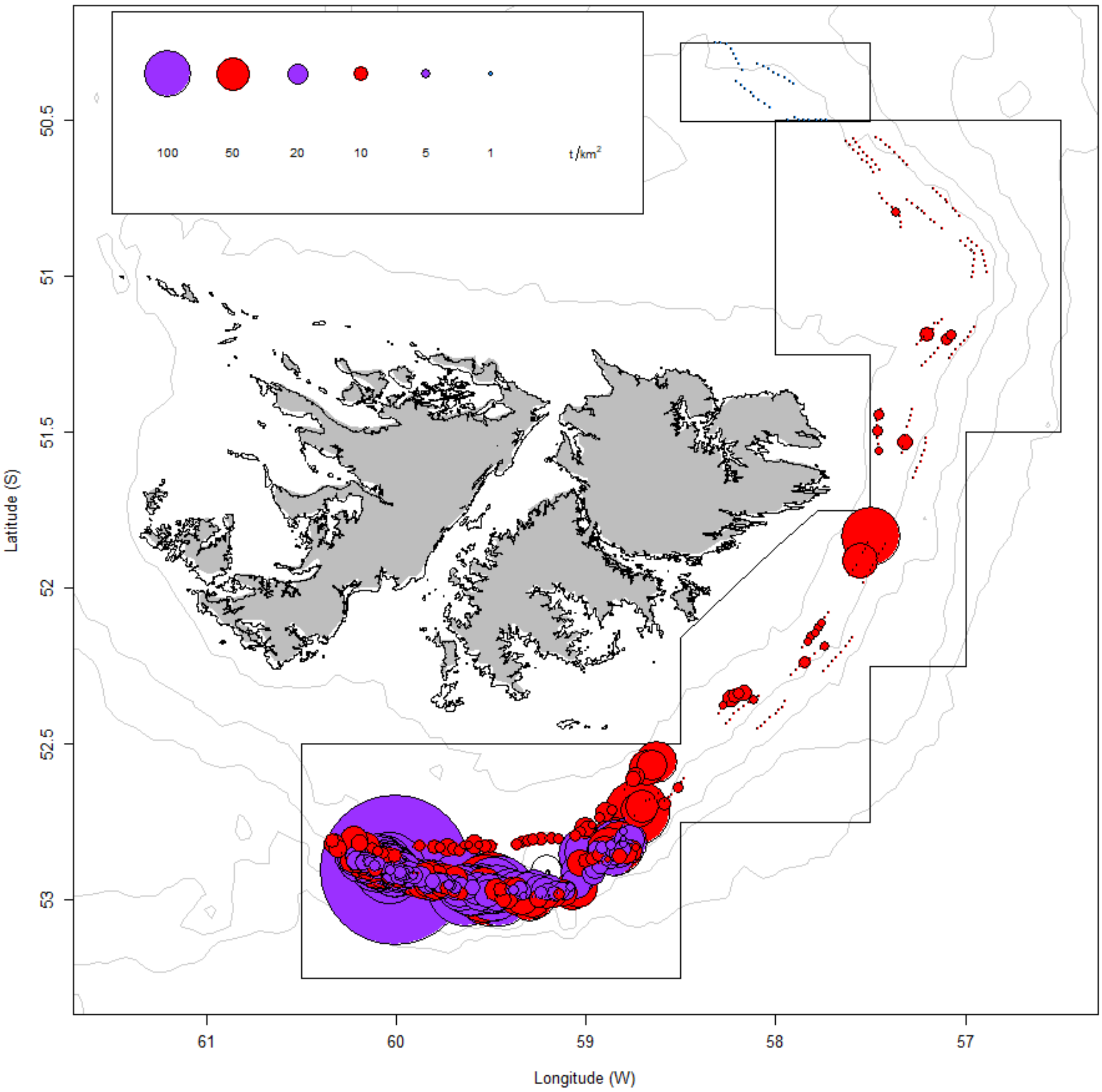

Figure 2. *D. gahi* CPUE (t km^{-2}) of fixed-station (red), adaptive-station (purple) and extra north station (blue) trawls per 15-minute trawl interval. Boundaries of the 'Loligo Box' fishing zone and the Beauchêne Island exclusion zone (mostly hidden) are traced in black.

Biomass estimation

Total *D. gahi* biomass in the fish stock area was estimated at 70, 335[e] tonnes, with a 95% confidence interval of [57, 676 to 98, 017 tonnes]. The total biomass estimate was the highest for a 1st pre-season (Table 1). Partition of the estimated biomass was 7, 655 tonnes north [824

[e] The estimate and associated confidence intervals are different to the initial estimate provided, as it was noted that in Station 637, the vessel did not report any *D. gahi* catch, whereas the scientific staff weighed the entire catch and found that there were 22 kg caught at this station.

to 16, 072 tonnes] vs. 62, 679 tonnes south [53, 273 to 88, 314 tonnes]. The biomass proportion north (10.9%) was the lowest for a 1st pre-season since 2019. Within the north sub-area 50% of *D. gahi* density was aggregated in 8 of 368 5×5 km area units, and 95% of density was aggregated in 104 of the 368 5×5 km area units (Figure 3). Within the south sub-area 50% of *D. gahi* density was aggregated in 83 of 392 5×5 km area units, and 95% of density was aggregated in 241 of the 392 5×5 km area units (Figure 3).

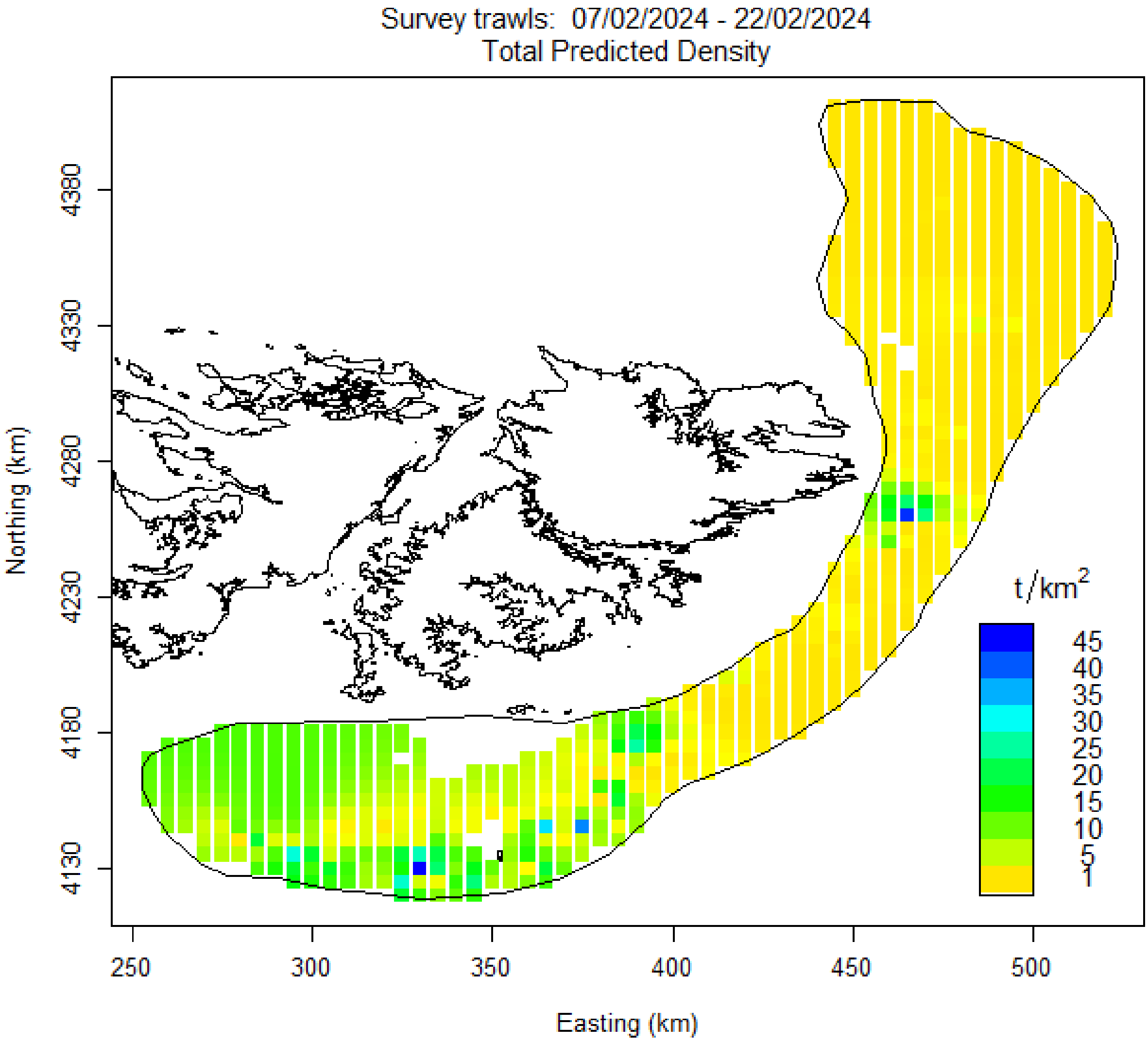

Figure 3. *D. gahi* predicted density estimates per 5 km^2 area units. Blank area units within the perimeter are either <90 or >400 m average depth. Coordinates were converted to WGS 84 projection in UTM sector 21F using the R library rgdal (proj.maptools.org).

Comparison with the extra north

Average biomass density of *D. gahi* in the four trawls north of the Loligo Box was low: significantly lower than in the south and non-significantly lower than in the north, while the difference between south and north was statistically significant (Table 2)[f]. Among other commercially important species, trawls north of the Loligo Box (extra north) had the lowest

[f] Note that with uneven sample sizes (44, 16, 4), this analysis has relatively limited statistical power (Oldfield and Haig 2016).

average biomass density of *I. argentinus*: no significant differences were found between the different areas. The highest average biomass density of common hake was found in the trawls north of the Loligo Box. The average density of common hake was significantly higher in the north compared with the south (Table 2, Figure 4). 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).

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 ($p < 0.05$)
	South (44)	North (16)	Extra North (4)	
D. gahi	10.235	0.660	0.004	$S > \overline{N > X}$
I. argentinus	0.001	0.015	0.0008	$\overline{N > S > X}$
Blue whiting	0.653	3.168	0.244	$\overline{N > S > X}$
Rock cod	2.071	0.891	0.067	$S > \overline{N > X}$
Common hake	0.0001	0.001	0.002	$S < \overline{N < X}$
Toothfish	0.012	0.017	0.002	$\overline{N > S > X}$

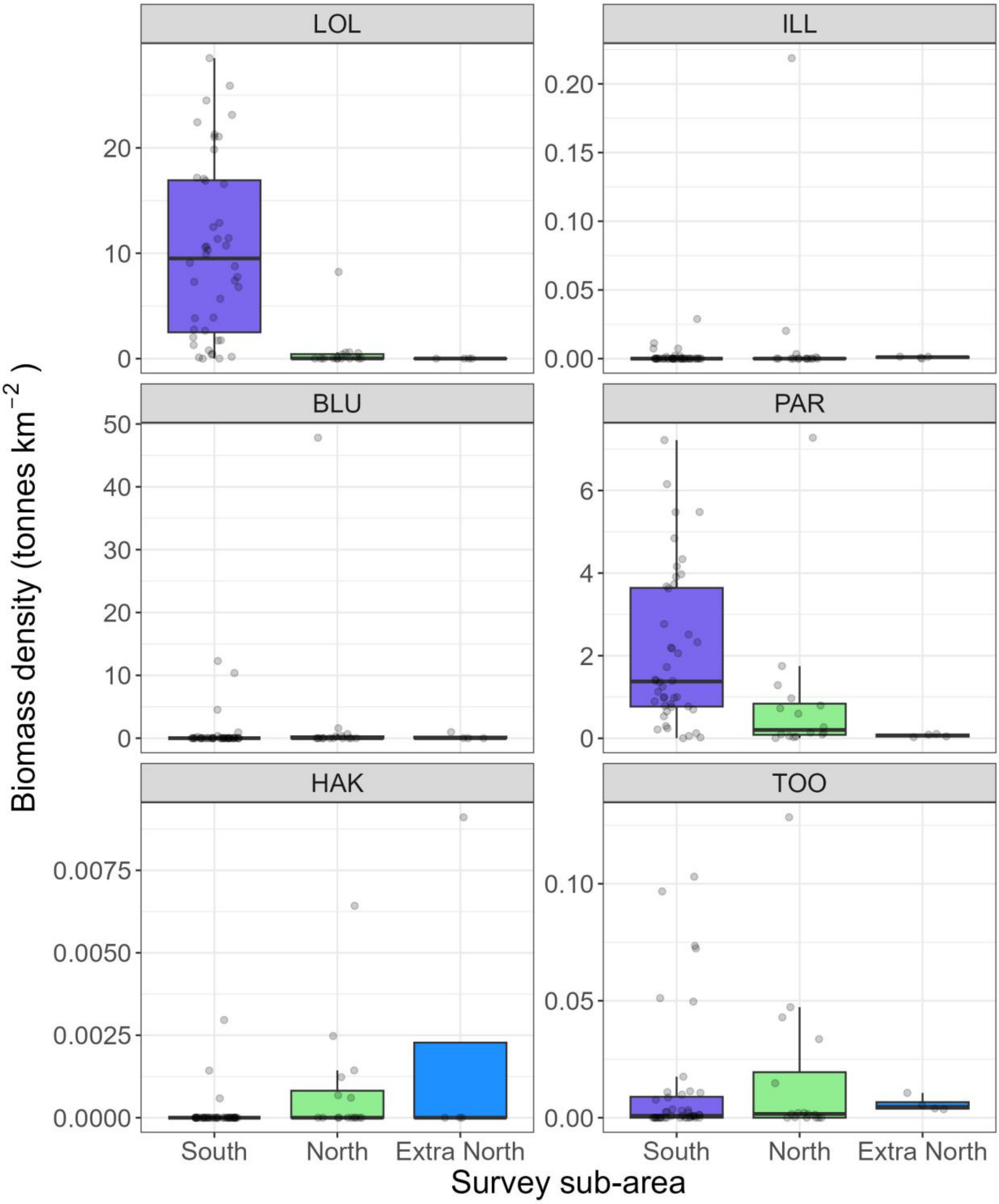

Figure 4. Boxplots of survey biomass densities of important commercial species south (n = 44 survey trawls), north (n = 16) and extra north (n = 4) from the 1st pre-season 2024 survey.

Biological data

A total of 88 taxa were identified in the survey catches (Appendix Table A2). *D. gahi* was the predominant catch with 69.2% of the total (Table A2); the lowest percentage of 1st pre-season catches since 2018 (33.5%). Second-highest catch species was rock cod with 15.8% of the total; the highest catch percentage in a 1st pre-season survey since 2014 and the highest average catch per trawl (2,409 kg/trawl) since 2015 (2,922 kg/trawl). Third-highest catch species was blue whiting with 12.1%, the fourth-highest percentage in a 1st pre-season survey since 2014 (17.3%). This can be largely attributed to a single trawl (Station 644; Figure 4), where 59.1% of the blue whiting was caught, in the northernmost Transect 14 in the Loligo Box. It is of note that there were two more trawls with large bycatch of blue whiting (>10,000 kg), both south of 52°S (16.9%; T8; Station 651; and 11.8%; T5, Station 659). No other species group accounted for ≥0.5% of total catch but hoki, which made up 1.6% of the total survey catch. This can be attributed to two stations, which also had the highest blue whiting catch (see above). Toothfish, a highly restricted bycatch, had the highest average catch rate for a 1st pre-season since 2017 at 19.42 kg per trawl.

Overall, less than half of the total toothfish survey catch was taken in four stations (St 644; 662; 651; 653). It is of note, that only one was north of 52°S (St 644) and accounted for 15.1% of the total toothfish catch. Additionally, upon investigation of the length-frequency of sampled individuals the range sampled was between 30 and 70 cm in total length, indicating that the high catch weight can be attributed to large individuals. Over the course of the survey, no juvenile toothfish were found.

During the survey 9680 *D. gahi* were measured for length and maturity (4056 males, 5624 females, from 60 trawl stations). The total sex ratio was significantly majority female ($p<0.0001$). A total of 31 individual trawls had a significant preponderance of females, and 29 individual trawls had no sex preponderance.

D. gahi mantle length and maturity distributions north and south of 52° S are presented in Figure 5. For males north: mean mantle length 10.52 cm; mean maturity stage 2.1 (on a scale of 1 to 6, Lipinski 1979), males south: mean mantle length 10.49 cm; mean maturity stage 2.03. Females north: mean mantle length 10.69 cm; mean maturity stage 2.01, females south: 10.37 cm; stage 1.99. Mean mantle lengths of males and females were smaller than the mean for both areas compared with the 1st pre-season last year. Mantle lengths were significantly different between north and south, for females (Kruskal-Wallis test, $p<0.05$), whereas no significant difference was found for males (KW test, $p=0.58$). No significant difference was found in the maturity of females between north and south (KW test, $p=0.86$), whereas a significant difference was found between the two areas for the maturities of males (KW 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 (GAM; edf=3.92; $p<0.01$), standardized for latitude/longitude (GAM; edf=27.4; $p<0.001$), suggesting that some immigration continued throughout the survey.

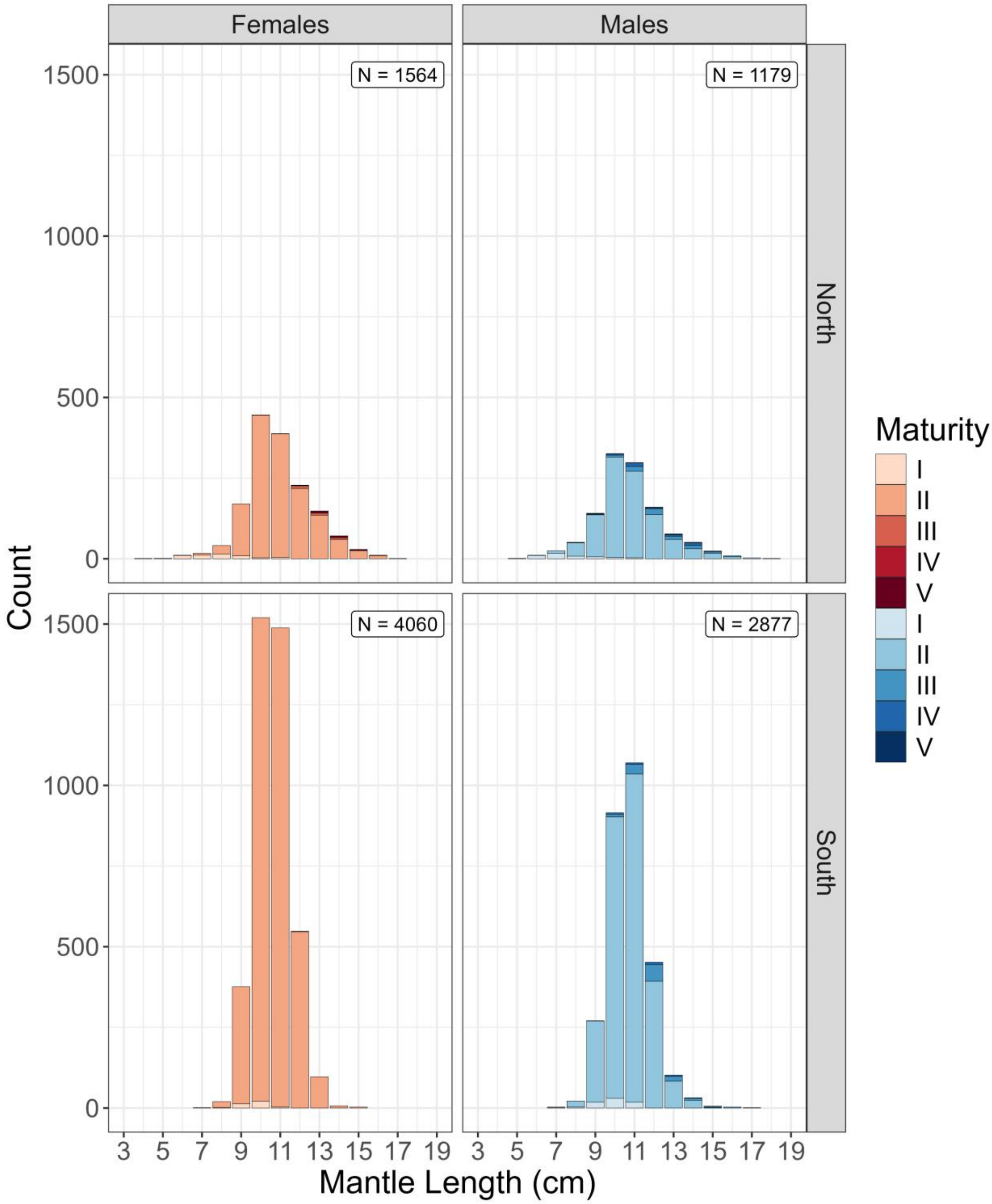

Figure 5. Length-frequency distributions by maturity stage of female (red) and male (blue) *D. gahi* from trawls north (top) and south (bottom) of latitude 52 ºS.

Otoliths taken during the survey are summarized in Table A3.

Pinniped and seabird monitoring

The 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 the survey, but none were caught in fishing gear. In three hauls a black-browed albatross (*Thalassarche melanophris*) was retrieved on deck; two alive (one in the net and another on top of the net), and one dead.

References

Arkhipkin, A.I. 2005. Statoliths as 'black boxes' (life recorders) in squid. Marine and Freshwater Research 56: 573-583.

Arkhipkin, A.I., Middleton, D.A., Barton, J. 2008. Management and conservation of a short-lived fishery-resource: *Loligo gahi* around the Falkland Islands. American Fisheries Societies Symposium 49:1243-1252.

Arkhipkin, A., Laptikhovsky, V., McKenna, J. 2012a. *Loligo gahi* trawl configuration survey, second season 2012. Technical Document, FIG Fisheries Department. 23 p.

Arkhipkin, A., Brickle, P., Laptikhovsky, V., Winter, A. 2012b. Dining hall at sea: feeding migrations of nektonic predators to the eastern Patagonian Shelf. Journal of Fish Biology 81: 882-902.

Arkhipkin, A., Barton, J., Wallace, S., Winter, A. 2013. Close cooperation between science, management and industry benefits sustainable exploitation of the Falkland Islands squid fisheries. Journal of Fish Biology 83: 905-920.

Dunn, J.O. 1964. Multiple comparisons using rank sums. Technometrics 6: 241-252.

FIG. 2016. Conversion factors 2017. Fisheries Dept., Directorate of Natural Resources, Falkland Islands Government, 2 p.

Froese, R. 2006. Cube law, condition factor and weight–length relationships: history, meta-analysis and recommendations. Journal of Applied Ichthyology 22:241-253.

Gawarkiewicz, G., Malek Mercer, A. 2018. Partnering with fishing fleets to monitor ocean conditions. Annual Review of Marine Science 11: 6.1-6.21.

Goyot, L., Derbyshire, C., Jones, J., Tutjavi, V., Winter, A. 2019. *Doryteuthis gahi* stock assessment survey, 2nd season 2019. Technical Document, FIG Fisheries Department. 20 p.

Harley, S.J., Myers, R.A. 2001. Hierarchical Bayesian models of length-specific catchability of research trawl surveys. Canadian Journal of Fisheries and Aquatic Sciences 58: 1569-1584.

Kruskal, W.H., Wallis, W.A. 1952. Use of ranks in one-criterion variance analysis. Journal of the American Statistical Association 47: 583-621.

Lipinski, M. R. 1979. Universal maturity scale for the commercially important squid (Cephalopoda: Teuthoidea). The results of maturity classifications of the *Illex illecebrosus* (LeSueur, 1821) populations for the years 1973–1977. ICNAF Research Document 79/II/38. 40 p.

Oldfield, M., Haig, E. 2016. Unequal sample sizes and the use of larger control groups pertaining to power of a study. DSTL 1:1.

Paya, I., Pritchard, M., 2006. *Loligo gahi* stock assessment survey, second season 2006. Technical Document, FIG Fisheries Department. 19 p.

Ramos, J.E., Winter, A. 2022. February trawl survey biomasses of fishery species in Falkland Islands waters, 2010–2022. SA–2022–05. Technical Document, FIG Fisheries Department. 86 p.

Roa-Ureta, R., Arkhipkin, A.I. 2007. Short-term stock assessment of *Loligo gahi* at the Falkland Islands: sequential use of stochastic biomass projection and stock depletion models. ICES Journal of Marine Science 64:3-17.

Seafish. 2010. Bridle angle and wing end spread calculations. Research and development catching sector fact sheet. www.seafish.org/Publications/FS40_01_10_BridleAngleandWingEndSpread.pdf.

Somerton, D., Ianelli, J., Walsh, S., Smith, S., Godø, O.R., Ramm, D. 1999. Incorporating experimentally derived estimates of survey trawl efficiency into the stock assessment process: a discussion. ICES Journal of Marine Science 56: 299-302.

Winter, A., Arkhipkin, A. 2015. Environmental impacts on recruitment migrations of Patagonian longfin squid (*Doryteuthis gahi*) in the Falkland Islands with reference to stock assessment. Fisheries Research 172: 85-95.

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 E were trawls in the Extra North.

			Start			End				
Transect - Station	Data Station	Date	Time	Lat	Lon	Time	Lat	Lon	Depth (m)	*D. gahi* (kg)
E15-40	634	07/02/2024	06:15	50.48	58.01	08:15	50.37	58.20	137	4
E15-41	635	07/02/2024	09:00	50.35	58.16	11:00	50.25	58.32	139	13
E16-42	636	07/02/2024	11:55	50.31	58.12	13:55	50.38	57.90	146	8
E16-43	637	07/02/2024	14:45	50.50	57.97	16:45	50.50	57.73	135	22
14-38	638	08/02/2024	06:00	50.55	57.60	08:00	50.66	57.45	139	10
13-35	639	08/02/2024	08:45	50.75	57.31	10:45	50.84	57.12	130	44
12-32	640	08/02/2024	11:15	50.87	57.05	13:15	51.00	56.96	124	33
11-29	641	08/02/2024	14:30	51.13	57.10	16:30	51.22	57.25	113	735
13-34	642	09/02/2024	06:00	50.87	57.33	08:00	50.74	57.45	126	210
14-37	643	09/02/2024	08:30	50.69	57.47	10:30	50.57	57.63	133	21
14-39	644	09/02/2024	11:15	50.55	57.50	13:15	50.64	57.31	232	0
13-36	645	09/02/2024	15:45	50.69	57.22	17:45	50.80	57.03	247	0
12-33	646	10/02/2024	06:00	50.85	57.01	08:00	50.99	56.89	126	2
11-31	647	10/02/2024	09:00	51.14	56.94	11:00	51.26	57.08	201	2
11-30	648	10/02/2024	11:55	51.17	57.05	13:55	51.29	57.23	128	798
10-28	649	10/02/2024	15:15	51.50	57.20	17:15	51.65	57.27	218	10
9-25	650	11/02/2024	06:00	51.85	57.41	08:00	51.98	57.53	223	19
8-23	651	11/02/2024	09:00	52.14	57.59	11:00	52.27	57.74	265	0
8-22	652	11/02/2024	12:00	52.17	57.71	14:00	52.28	57.92	197	714
7-20	653	11/02/2024	14:30	52.35	57.94	16:30	52.45	58.09	247	14
7-19	654	12/02/2024	06:00	52.44	58.26	08:00	52.35	58.08	183	252
7-18	655	12/02/2024	08:30	52.33	58.14	10:30	52.40	58.30	150	1,785
6-17	656	12/02/2024	12:40	52.60	58.47	14:40	52.69	58.59	247	462
6-16	657	12/02/2024	15:45	52.63	58.58	17:45	52.73	58.74	146	11,634
4-11	658	13/02/2024	06:15	53.01	59.32	08:15	52.96	59.04	220	20,532
5-14	659	13/02/2024	09:00	52.89	58.95	11:00	52.83	58.74	150	3,717
5-13	660	13/02/2024	11:45	52.81	58.79	13:45	52.88	59.02	146	23,788
A1	661	13/02/2024	15:15	52.87	59.04	17:15	52.81	58.77	137	32,502
0-1	662	14/02/2024	06:00	52.79	60.35	08:00	52.89	60.17	252	6,048
1-3	663	14/02/2024	09:15	52.88	60.21	11:15	52.92	59.99	225	18,144
2-6	664	14/02/2024	12:15	52.93	59.94	14:15	52.98	59.66	230	18,280
2-5	665	14/02/2024	15:00	52.94	59.66	17:00	52.92	59.91	170	10,962
3-8	666	15/02/2024	06:15	52.97	59.33	08:15	52.97	59.54	174	29,400
2-4	667	15/02/2024	09:10	52.85	59.64	11:10	52.83	59.91	159	3,444
1-2	668	15/02/2024	11:45	52.87	59.97	13:45	52.81	60.22	177	9,261
A2	669	15/02/2024	14:45	52.86	60.24	16:45	52.91	59.96	201	18,068
3-9	670	16/02/2024	06:00	52.99	59.55	08:00	53.00	59.26	242	17,451
4-10	671	16/02/2024	09:30	52.80	59.11	11:30	52.83	59.36	104	2,331
3-7	672	16/02/2024	12:00	52.83	59.39	14:00	52.82	59.68	139	1,827
A3	673	16/02/2024	15:30	52.91	60.00	17:30	52.95	59.74	196	15,569
6-15	674	17/02/2024	06:00	52.55	58.60	08:00	52.65	58.79	135	10,710
5-12	675	17/02/2024	08:50	52.71	58.83	10:50	52.80	59.05	135	3,990
A4	676	17/02/2024	11:40	52.89	59.05	13:40	52.98	59.20	139	11,298
A5	677	17/02/2024	14:45	52.97	59.20	16:45	52.97	59.47	165	26,202
A6	678	18/02/2024	06:15	52.86	60.23	08:15	52.92	59.97	199	32,201

A7	679	18/02/2024	09:15	52.92	59.90	11:15	52.89	60.12	187	14,994
A8	680	18/02/2024	12:45	52.85	60.24	14:45	52.91	59.98	192	27,879
A9	681	18/02/2024	15:45	52.92	59.93	17:45	52.88	60.16	196	17,018
A10	682	19/02/2024	06:00	52.97	59.04	08:00	52.97	59.27	192	12,096
A11	683	19/02/2024	08:45	52.96	59.32	10:45	52.98	59.55	170	14,994
A12	684	19/02/2024	11:40	52.97	59.57	13:40	52.94	59.81	203	30,189
A13	685	19/02/2024	15:00	52.93	59.87	17:00	52.97	59.59	190	27,832
A14	686	20/02/2024	06:00	52.72	58.78	08:00	52.86	58.85	143	6,027
A15	687	20/02/2024	09:15	52.83	58.77	11:15	52.92	58.96	155	9,303
A16	688	20/02/2024	12:30	52.98	59.12	14:30	52.99	59.33	214	147
A17	689	20/02/2024	15:15	52.97	59.43	17:15	52.96	59.66	185	35,043
A18	690	21/02/2024	05:50	52.85	60.25	07:50	52.91	60.00	201	41,340
A19	691	21/02/2024	09:00	52.92	59.98	11:00	52.86	60.21	205	30,114
A20	692	21/02/2024	12:10	52.88	60.16	14:10	52.92	59.91	194	32,139
A21	693	21/02/2024	15:15	52.92	59.92	17:15	52.88	60.15	203	29,122
8-21	694	22/02/2024	06:00	52.20	57.88	08:00	52.08	57.72	137	1,071
9-24	695	22/02/2024	09:00	51.98	57.62	11:00	51.84	57.49	141	12,096
10-27	696	22/02/2024	12:45	51.59	57.34	14:45	51.43	57.28	154	630
10-28	697	22/02/2024	15:45	51.41	57.42	17:45	51.56	57.46	123	777

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*	675,328	69.2	331	422
PAR	*Patagonotothen ramsayi*	154,223	15.8	302	154,223
BLU	*Micromesistius australis*	118,345	12.1	260	102,918
WHI	*Macruronus magellanicus*	15,295	1.6	113	15,147
CGO	*Cottoperca gobio*	1,833	0.2	0	1,833
TOO	*Dissostichus eleginoides*	1,243	0.1	383	827
ZYP	*Zygochlamys patagonica*	1,111	0.1	0	1,111
KIN	*Genypterus blacodes*	1,060	0.1	0	264
SQT	Ascidiacea	1,025	0.1	0	1,025
PTE	*Patagonotothen tessellata*	977	0.1	0	977
CHE	*Champsocephalus esox*	965	0.1	0	965
BAC	*Salilota australis*	632	0.1	4	312
ILL	*Illex argentinus*	487	<0.1	1	484
GRC	*Macrourus carinatus*	486	<0.1	0	486
DGH	*Schroederichthys bivius*	367	<0.1	0	367
RAY	Rajiformes	356	<0.1	0	346
RFL	*Dipturus lamillai*	310	<0.1	0	145
ING	*Moroteuthopsis ingens*	289	<0.1	0	289
GRF	*Coelorinchus fasciatus*	246	<0.1	0	246
SPN	Porifera	219	<0.1	0	219
DGS	*Squalus acanthias*	214	<0.1	0	214
GOC	*Gorgonocephalus chilensis*	201	<0.1	0	201
RBR	*Bathyraja brachyurops*	193	<0.1	0	113
STA	*Sterechinus agassizii*	128	<0.1	0	128
LIS	*Lithodes santolla*	82	<0.1	0	19
ILF	*Iluocoetes fimbriatus*	56	<0.1	0	56
RMC	*Bathyraja macloviana*	56	<0.1	0	56
ALG	Algae	54	<0.1	0	54
AST	Asteroidea	53	<0.1	0	53
PAT	*Merluccius australis*	51	<0.1	5	43
HAK	*Merluccius hubbsi*	39	<0.1	9	22
FUM	*Fusitriton magellanicus*	37	<0.1	0	37
BUT	*Stromateus brasiliensis*	35	<0.1	0	35
PYM	*Notophycis marginata*	35	<0.1	0	35
ACY	*Armadillogorgia cyathella*	29	<0.1	0	29
RAL	*Bathyraja albomaculata*	29	<0.1	0	10
TRP	*Tripylaster philippii*	29	<0.1	0	29
ALF	*Allothunnus fallai*	24	<0.1	0	18
NEM	*Psychrolutes marmoratus*	22	<0.1	0	22
RPX	*Psammobatis spp.*	19	<0.1	0	19
ANM	Anemone	18	<0.1	0	18
POA	*Glabraster antarctica*	18	<0.1	0	18
OPV	*Ophiosabine vivipara*	16	<0.1	0	16
SHT	Mixed invertebrates	15	<0.1	0	15
OPL	*Ophiuroglypha lymani*	14	<0.1	0	14
RED	*Sebastes oculatus*	13	<0.1	4	12
WRM	Worm casings	13	<0.1	0	13
CTA	*Ctenodiscus australis*	12	<0.1	0	12
EUL	*Eurypodius latreillii*	9	<0.1	0	9
SUN	*Labidiaster radiosus*	9	<0.1	0	9
RSC	*Bathyraja scaphiops*	8	<0.1	0	2
RDO	*Amblyraja doellojuradoi*	7	<0.1	0	7
ALC	Alcyoniina	6	<0.1	0	6

BRY	Bryozoa	5	<0.1	0	5
CAZ	*Calyptraster sp.*	5	<0.1	0	5
FLX	*Flabellum spp.*	5	<0.1	0	5
NUD	*Nudibranchia*	5	<0.1	0	5
RMG	*Bathyraja magellanica*	5	<0.1	1	5
SAR	*Sprattus fuegensis*	5	<0.1	0	5
HOL	Holothuroidea	4	<0.1	0	4
OCT	Octopus spp.	4	<0.1	0	4
MAV	*Magellania venosa*	3	<0.1	0	3
AUC	*Austrocidaris canaliculata*	2	<0.1	0	2
MLA	*Muusoctopus longibrachus akambei*	2	<0.1	0	2
OPH	Ophiuroidea	2	<0.1	0	2
PAU	*Patagolycus melastomus*	2	<0.1	0	2
PYX	Pycnogonida	2	<0.1	0	2
SRP	*Semirossia patagonica*	2	<0.1	0	2
ACS	*Acanthoserolis schythei*	1	<0.1	0	1
AGO	*Agonopsis chiloensis*	1	<0.1	0	1
CEX	*Ceramaster sp.*	1	<0.1	0	1
COP	*Congiopodus peruvianus*	1	<0.1	0	1
EGG	Eggmass	1	<0.1	0	1
MUN	*Grimothea gregaria*	1	<0.1	0	1
MYX	*Myxine spp.*	1	<0.1	0	1
PES	*Peltarion spinulosum*	1	<0.1	0	1
THO	*Thouarella*	1	<0.1	0	1
ASA	*Astrotoma agassizii*	<1	<0.1	0	0
CRI	Crinoidea	<1	<0.1	0	0
CRY	*Crossaster sp.*	<1	<0.1	0	0
HYD	Hydrozoa	<1	<0.1	0	0
MAM	*Neoachiropsetta milfordi*	<1	<0.1	0	0
MIR	*Mirostenella sp.*	<1	<0.1	0	0
NUH	*Nuttallochiton hyadesi*	<1	<0.1	0	0
ODM	*Odontocymbiola magellanica*	<1	<0.1	0	0
SEP	*Seriolella porosa*	<1	<0.1	0	0
TED	*Terebratella dorsata*	<1	<0.1	0	0
ZOA	Azoanthidae	<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 Rock cod	*Patagonotothen ramsayi*	97	98
TOO	Patagonian Toothfish	*Dissostichus eleginoides*	79	93
BLU	Southern Blue Whiting	*Micromesistius australis*	23	10
WHI	Whiptail Hake, Hoki	*Macruronus magellanicus*	4	8
RED	Patagonian Redfish	*Sebastes oculatus*	5	2
HAK	Common Hake	*Merluccius hubbsi*	0	4
CHE	Icefish	*Champsocephalus esox*	1	1
PAT	Patagonian Hake	*Merluccius australis*	0	1
BAC	Red cod	*Salilota australis*	0	1