FALKLAND ISLANDS FISHERIES DEPARTMENT

Doryteuthis gahi Stock Assessment Survey, 2nd Season 2019

Vessel	**New Polar (ZDLF2)** **Falkland Islands**
Dates	**14/07/2019 – 27/07/2019**
Survey Team	**Ludovic Goyot** **Cian Derbyshire** **Jessica Jones** **Vasana Tutjavi** **Andreas Winter**

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Summary

1) A stock assessment survey for *Doryteuthis gahi* (Falkland calamari) was conducted in the 'Loligo Box' from 14th to 27th July 2019. Fifty-one scientific trawls were taken during the survey; 39 fixed station and 12 adaptive trawls. The scientific catch of the survey was 297.96 tonnes *D. gahi*.
2) An estimate of 50,880 tonnes *D. gahi* (95% confidence interval: 39,974 to 71,103 t) was calculated for the fishing zone by inverse distance weighting. This estimate is comparable to the one of the first season of 2019, but significantly less than the biomass estimate of the previous second season, in 2018.
3) Male and female *D. gahi* had significantly greater average mantle lengths and maturity stages south of 52 ºS than north of 52 ºS. Males north: mean mantle length 11.67 cm; mean maturity stage 3.32, males south: mean mantle length 12.26 cm; mean maturity stage 3.71. Females north: mean mantle length 11.16 cm; mean maturity stage 2.11, females south: mean mantle length 11.59 cm; mean maturity stage 2.17.
4) 98 taxa were identified in the catches. *D. gahi* was the most abundant species at 84.54% of the total catch by weight, followed by red cod (8.01%) and common hake (4.17%). Biological measurements and samples were systematically taken from *D. gahi*, rock cod, Patagonian toothfish, and opportunistically for other teleost / elasmobranch species.
5) Pinniped and bird abundance, behaviour and interactions were recorded for 38 of the 51 survey trawls. Only one light contact was recorded between a black-browed albatross and the fixed aerial array of the vessel – resulting in no apparent damage – and three South American fur seals were captured and released alive. As no mortality was recorded, the use of SED was not enforced before the start of the fishing season.

Introduction

A stock assessment survey for *Doryteuthis gahi* (Falkland calamari – Patagonian longfin squid – colloquially *Loligo*) was carried out by FIFD personnel on the F/V *New Polar* ZDLF2, under E-licence # FK042E19. The survey lasted from July 14th to July 27th 2019 included, during which 51 stations were sampled. The objectives of the survey were as follows:

1) Estimate the biomass and spatial distribution of *D. gahi* on the fishing grounds at the onset of the 2nd fishing season, 2019.
2) Estimate the biomass and distribution of common rock cod (*Patagonotothen ramsayi*) in the 'Loligo Box', for continued monitoring of this stock.
3) Estimate the bycatch of other species of commercial interest (Patagonian toothfish *Dissostichus eleginoides* TOO, southern hake *Merluccius hubbsi* HAK, kingclip *Genypterus blacodes* KIN, red cod *Salilota australis* BAC and various skate species RAY). Collect biological information on *D. gahi*, rock cod, toothfish, and other commercially important fish and squid taken in the trawls.
4) Collect detailed catch information on other fish species of non-commercial interest and benthic communities
6) Monitor pinniped and seabird abundance, behaviour and interactions with the fishing gear and vessel.

The survey strategy was identical to those of previous seasons and was designed to cover the 'Loligo Box' fishing zone (Arkhipkin et al. 2008, 2013) that extends across the southern and eastern part of the Falkland Islands Interim Conservation Zone (Figure 1). The delineation of the Loligo Box represents an area of approximately 31,517.9 km^2, subtracting the exclusion zone around Beauchêne Island.

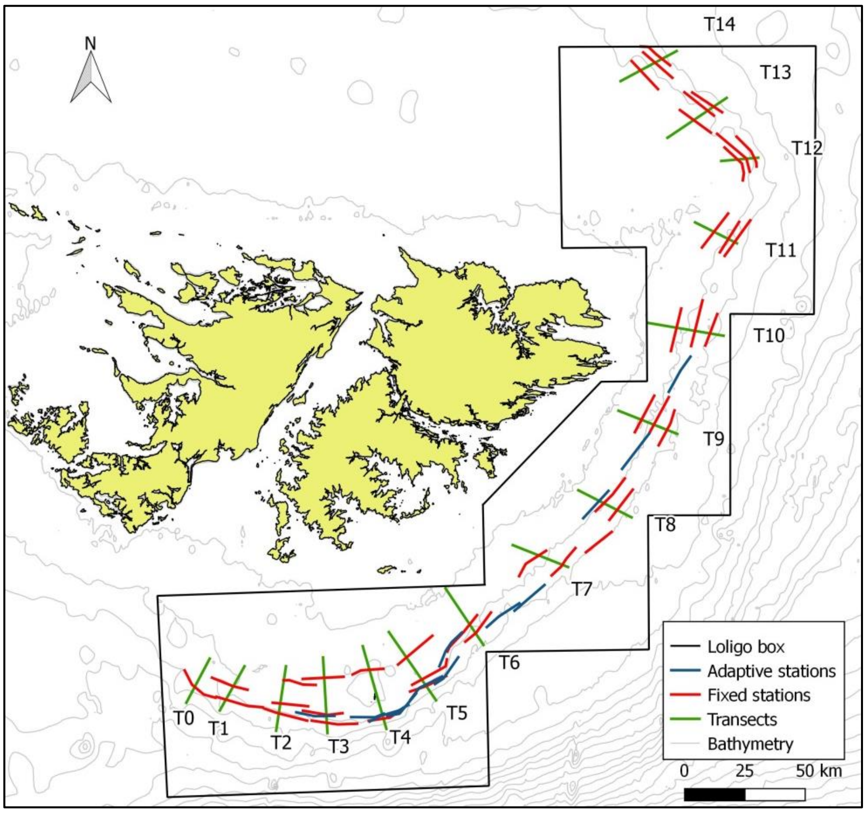

Figure 1. Survey transects (green lines), fixed station trawls (red lines), and adaptive station trawls (blue lines) sampled during the 2nd pre-season 2019 survey. Some fixed-station trawls have deviations to adapt to the terrain. Boundaries of the 'Loligo Box' fishing zone are in black.

The F/V *New Polar* is a Falkland Islands registered stern trawler of 75.50 m length, 1794 gross tonnage / 672 net tonnage, and 4000 main engine bhp. It is equipped with two separate fish bins, each able to hold approximately 20 tonnes. It is the second time that this vessel is employed for a pre-season survey. Like all vessels employed for pre-season surveys, *New Polar* operates regularly in the *D. gahi* fishery and used its commercial trawl gear for the survey catches. The following personnel from the FIFD participated in the 2nd pre-season 2019 survey:

Ludovic Goyot	lead scientist
Cian Derbyshire	fisheries observer
Jessica Jones	fisheries scientist
Vasana Tutjavi	fisheries observer

Methods

1. 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 12 adaptive station trawls selected to increase the precision of *D. gahi* biomass estimates in high-density or high-variability locations – mainly around Beauchene Island. This dual approach ensures that the scientific requirements of randomization and repeatability are met (via fixed stations) and the spatiotemporal 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 2 hours each, and ranged in distance from 13.2 to 21.5 km (median 16.7 km). All trawls were bottom trawls. On one occasion (station 571), the net had to be hauled before the end of the two hours -due to damage. During the progress of each trawl, GPS latitude, GPS longitude, bottom depth, bottom temperature, net height, trawl door spread, trawl speed, wind direction and wind velocity were recorded on the ship's bridge in 15-minute intervals, and a visual score was assessed of the quantity and intensity 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 smaller than 100 kg were iteratively aggregated by adjacent intervals. On one occasion, the total *D. gahi* catch was less than 100 kg and it was assigned to the middle interval of the trawl.

2. Catch estimation

The catch of every trawl was processed separately by the factory crew and retained catch weight of *D. gahi*, by size category, was estimated from the number of standard-weight blocks of frozen squid recorded by the factory supervisor. The catch weights of all the other bycatch species were estimated by the FIFD personnel in the factory and compared to the vessel logbook records. Total catch composition per trawl, including non-commercially valuable species, damaged fish, and undersized fish, was estimated using a combination of visual assessment and weighed samples per species. For consistency with previous survey methods, one to three baskets of unsorted catch were also collected at intervals from most survey trawls, depending on their volume and the sampling schedule. These baskets were hand-sorted by the FIFD survey personnel and each species was weighed separately. An FIFD survey employee remained at the sorting belt for at least one hour and up to the whole duration of the station processing, estimating the total bycatch biomass by extrapolating data collected during the monitored period to the total processing time. This allowed a more accurate estimate of rarer species that would potentially not be collected in the baskets - scarce bycatch species were collected and weighed entirely from each trawl, with the help of the crew. Non-commercial bycatch weights were then added to the factory production weights (where applicable) to give total catch weights of all fish and squid.

3. Biomass calculations

Biomass density estimates of *D. gahi* per trawl were calculated as catch weight divided by swept-area, which is the product of trawl distance × trawl width. 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. 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 + sweep + bridle)

Two different net were used during the survey; however these nets were very similar in their measurements. The main difference between the two nets was that the number of floaters was higher in one net compared to the other, augmenting its floatability (i.e. its vertical opening) but reducing its horizontal opening (i.e. the door spread) Measurements of *New Polar*'s trawl dimensions, provided by the vessel master, were: sweep = 125 m, bridle = 40 m and footropes = 159 m.

Biomass density estimates were extrapolated to the fishing area using an inverse distance weighting algorithm (Winter et al. 2018, 2019). The algorithm was slightly modified from the two previous surveys, following the calculations described in Ramos and Winter (2019). As previously (e.g., Winter et al. 2018), the fishing area was delineated at 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 fish, 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 – i.e. the standard sub-area demarcation (Winter and Arkhipkin 2015).

Uncertainty of the biomass density extrapolation was estimated by hierarchical bootstrapping. For 25,000 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 25,000 iterations, the inverse distance weighting algorithm was re-calculated over the 5 × 5 km area units.

4. Biological analyses

Random samples of *D. gahi* (target n = 150) were collected 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. At some stations, when the sea state allowed accurate records, weight of each individual was also collected to establish a relationship between the length and the weight of the species according to the equation $W = \alpha \cdot L^{\beta}$ (Froese 2006). Additional specimens of *D. gahi* (LOL) 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. A sample of 100 rock cod *Patagonotothen ramsayi* (PAR) was taken at every trawl station, as far as available. Length, sex and maturity were systematically recorded, and weight and otoliths were also collected both randomly and non-randomly, depending on the size of individuals missing from the otolith collection. All catches of toothfish *Dissostichus eleginoides* (TOO) were collected from trawl stations to maximize the time series catch and biological information base for juvenile toothfish. Other information on species of commercial interest, such as *Merluccius hubbsi* (HAK), *Genypterus blacodes* (KIN) *Salilota australis* (BAC), *Schroederichthys bivius* (DGH) and various species of skates (RAY), were also collected. A total of 587 fish were sampled for otoliths and 1296 for length-weight relationship – including 1054 *D. gahi*, for which an additional 319 individuals were collected for statoliths.

For each sex of *D. gahi*, depending on their location – north of south of the Loligo box – the mantle size variance and the maturity stage distribution were assessed using Kruskal-Wallis test and χ^2 test respectively.

5. Pinniped and seabird monitoring

The abundance of seabird and pinniped species and their interactions with the vessel and the fishing gear where monitored from the gantry as often as the environmental conditions and logistical constraints would allow – i.e. during day light and adequate weather. For each sampled haul and shoot, the number of pinnipeds and their interaction with the net was recorded. Just before shooting and hauling, seabird abundance was estimated per species via a categorized count of each species (categories: <10; 11-50; 51-200; 201-500; 501+) in a 200 m perimeter around the vessel. Then, every 10 minutes, a count of individuals per species within 40 m around the vessel was undertaken. All contacts but net feeding were recorded and pooled according to these 10-minute periods.

Results

1. Catch rates and distribution

As it is often the case, the survey started with fixed station trawls in the north and was carried on towards the south-west end of the Loligo Box. As the largest *D. gahi* concentrations appeared to be located to the south-east of Beauchene Island, the majority of the adaptive stations were set in this area, to delineate the limit of this hotspot of biomass. Different depths were also explored. From July 14th to July 21st included, four survey trawls were carried out per day, followed by one commercial trawl at night. During this first week, the vessel crew were able to quickly process the full catches that were fairly low. On the 22nd, the commercial catch exceeded 50 tonnes and therefore delayed the whole survey, resulting in only 2 trawls being carried out this day – which was compensated by five survey trawls the next day. Larger catches combined with the limited processing capacity of the vessel led to the decrease to three survey trawl per day + 1 commercial trawl overnight for the remaining time of the survey.

The 39 fixed stations yielded a total of 177,225 kg of *D. gahi* and the 12 adaptive stations added another 120,733 kg to this amount. When combined with the catches of the 12 commercial trawls that were carried overnight (319,752 kg), the total biomass of *D. gahi* that were caught within the 14 days of this survey reaches 617,710 kg.
The survey total catches reached a total of 352,434 kg, of which 84.54 % were *D. gahi* (Table A2) – the remaining part being mainly due to one station, on July 26th, that yielded 25 tonnes of red cod *Salilota australis* (BAC).

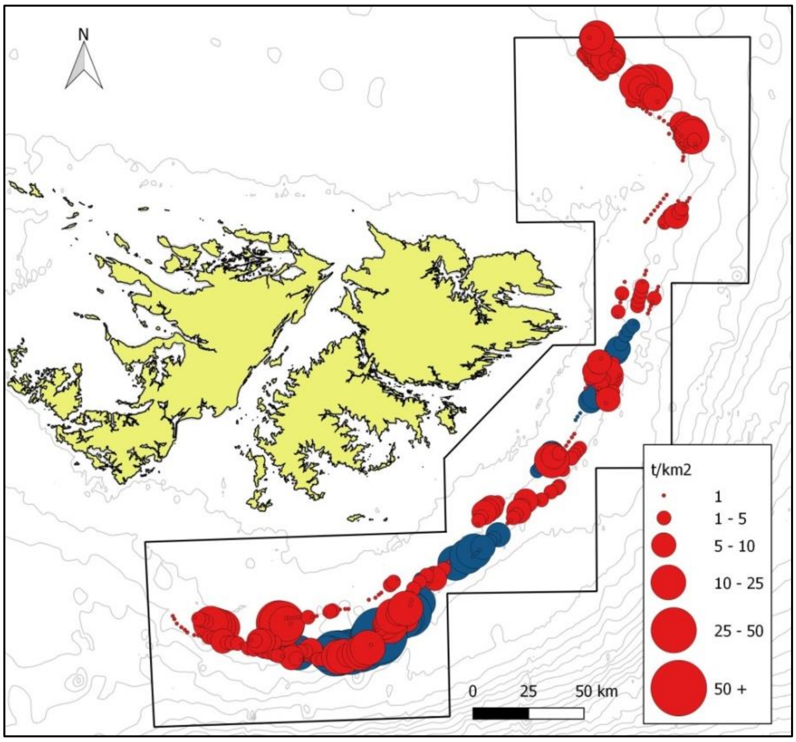

Figure 2. *D. gahi* CPUE (t km^{-2}) of fixed-station (red) and adaptive (blue) trawls per 15-minute trawl interval. Boundaries of the 'Loligo Box' fishing zone are delineated by black lines.

The average catch density of *D. gahi* was of 2.67 t/km^2 in the north and 3.22 t/km^2 south of 52° S for the fixed stations. For the adaptive stations, there was an average catch density of 4.04 t/km^2 in the north and 8.08 t/km^2 in the south, as shown on Figure 2

The fixed stations showed a marked distribution in concentration with one dominant hotspot located around Beauchene Island, and another smaller yet noticeable hotspot in the north of the Loligo box.

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

* Includes four juvenile toothfish transect trawls.

2. Biomass estimation

Total *D. gahi* biomass in the fishing area was estimated at 50,880 tonnes, with a 95% confidence interval of [39,974 to 71,103 t]. Both the north and the south of the zone were estimated to host a high biomass of *D. gahi* with 18,516 tonnes CI95 [11,465 - 20,394 t] in the north, and 32,364 CI95 [28,509 – 50,709 t] in the south (Figure 3).
These estimated numbers are consistent with those calculated for the first season of 2019, but markedly lower than the exceptional biomass estimate of 2018 – S2 which reached 183,593 tonnes.

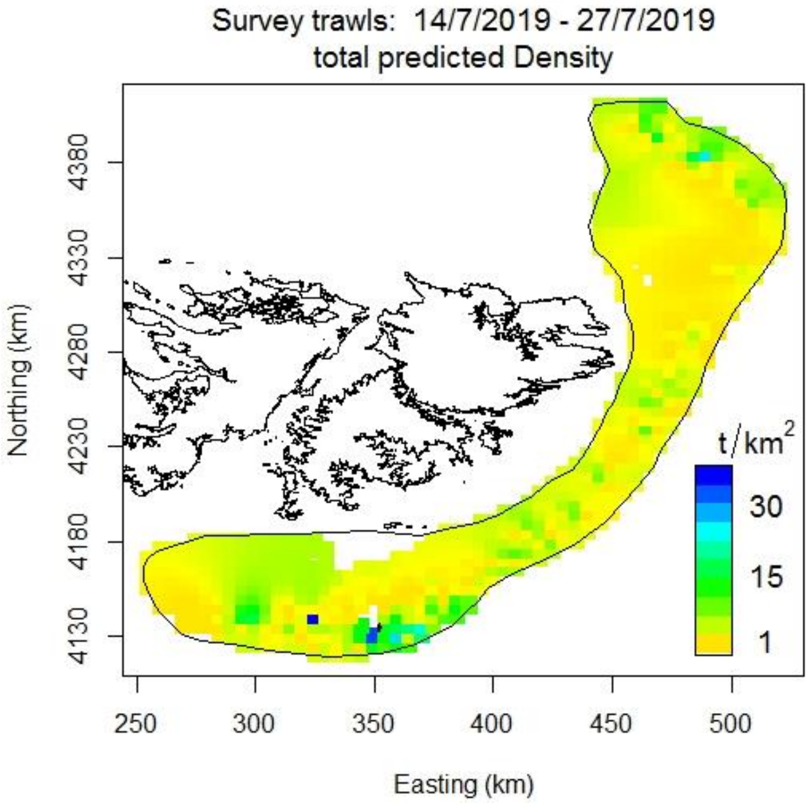

Figure 3. *Doryteuthis gahi* predicted density estimates per 5 km^2 area units. Blank area units within the perimeter are either <90 or >400 m average depth. Coordinates were converted to WGS 84 projection in UTM sector 21F using the R library rgdal (proj.maptools.org).

3. Biological data

A total of 98 taxa were identified, for a total catch of 352,434.56 kg. As stated above, *D. gahi* constituted 84.5% of the total catch followed by *S. australis* (BAC - 8.0%). *M. hubbsi* (HAK) was present in 40 of the 51 stations with a biomass that varied from less than 3 kg to 5 tonnes per trawl. The total catch of HAK was 14.7 tonnes.
Rock cod *P. ramsayi* (PAR) was present in all stations but in very low quantity (total catch of 1,012 kg), which marks a sharp decline from what has been observed during the first season of 2019 where 25,820 kg of PAR were recorded. In 2018 – S2, the PAR catches reached 10,992 kg.
The total catch of Patagonian toothfish *D. eleginoides* (TOO) was of 858 kg, which appears to be consistent with those of the previous seasons. Of all the individuals caught, some were smaller than 30 cm, indicating the presence of juvenile toothfish in the zone.

D. gahi mantle length and maturity distributions north and south of 52° S are plotted in Figure 5. A total of 8,789 individuals were measured, including 319 individuals that were collected for statoliths and 1,054 for the length-weight relationship. 55% of the total individuals appeared to be males and 45% females. The length-weight measurements allowed the calculation of the parameters α and β of the equation

$$W = \alpha \cdot L^{\beta}$$

with $\alpha = 0.13381$ and $\beta = 2.28322$, with $r^2 = 0.887$ – see Figure 4

For both males and females, size distributions were significantly different between the north and the south of 52° S (Kruskal-Wallis test, $p < 0.05$ in all cases). Maturity distributions were also significantly different between the north and the south of 52° S for males and females (χ^2, $p < 0.05$). For males north: mean mantle length 11.67 cm; mean maturity stage 3.32 (on a scale of 1 to 5), males south: mean mantle length 12.26 cm; mean maturity stage 3.71. The significant difference is explained by a higher proportion of male stages 4 and 5 in the south and male stages 2 and 3 in the north (Table 2).

The data for the females are as follows: females north: mean mantle length 11.16 cm; mean maturity stage 2.11 Females south: mean mantle length 11.59 cm; mean maturity stage 2.17. Although the mean maturity stage appears very similar in the north and in the south, the significant difference between these two areas is explained by a higher proportion of female stage 2 in the north, whilst the distribution among other stages is slightly wider in the south (Figure 4).

Table 2. Proportion of individuals per sex and maturity stages to the north and the south of 52° S.

Maturity	1	2	3	4	5
Female					
North	0.00%	92.25%	5.80%	0.18%	1.77%
South	0.43%	87.98%	8.12%	0.43%	3.04%
Male					
North	0.00%	5.28%	63.74%	24.30%	6.68%
South	0.14%	2.01%	39.99%	42.24%	15.62%

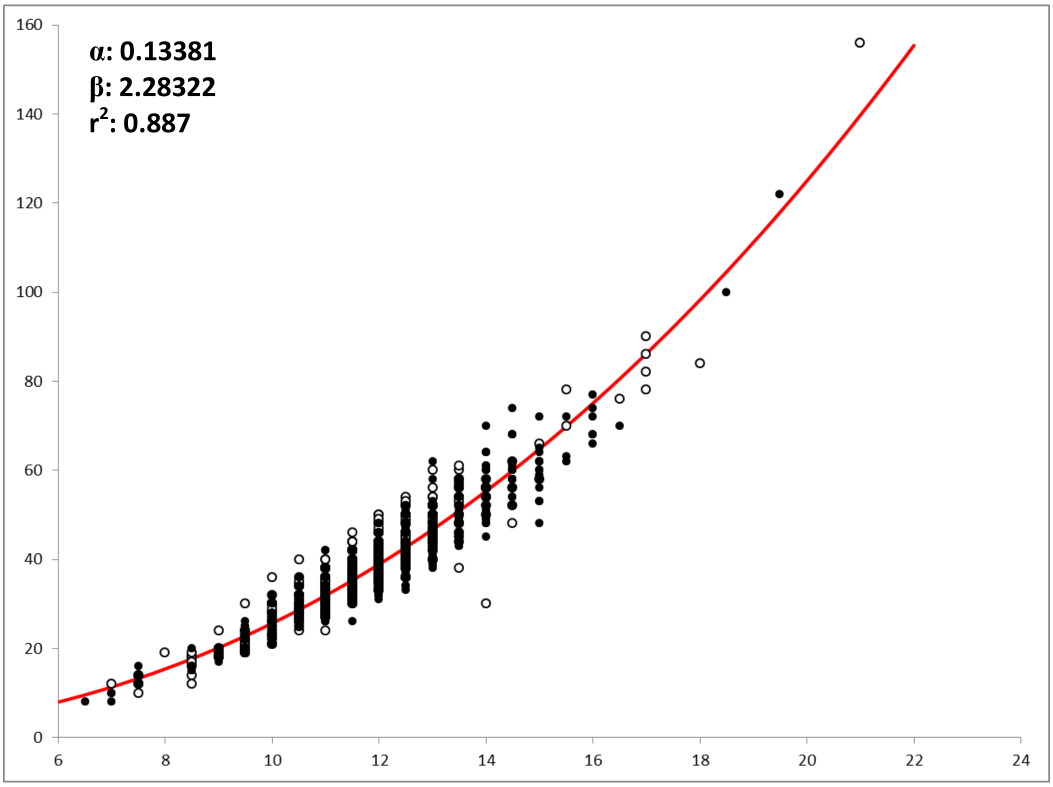

Figure 4. Length-weight relationship of Falkland calamari sampled during the survey. Black points: male, white: female. Parameters refer to the combined sexes' length-weight relationship.

4. Pinniped and seabird abundance and interaction

A total of 38 stations out of the 51 were observed for interactions. The initial estimates of seabird abundance prior to the beginning of a fishing operation (hauling or shooting) are pooled in 5 classes of abundance hence they only allow a bracket estimate of the real abundance per species. 6 taxa of seabird were recorded, with a large dominance of black-browed albatross *Thalassarche melanophris* (7160 – 19300 individuals, 80.62 – 88.98% of the total observed). The giant petrels, *Macronectes sp*, were the second most dominant species with counts ranging between 400 and 1940 (4.97 – 8.10%). Cape petrels, *Daption capense*, were also present in high numbers – 250 to 1290 individuals, 3.11 to 5.39%. The other taxa, i.e. in decreasing order kelp gulls *Larus domenicanus*, giant albatrosses *Diomeda spp* and grey-headed albatrosses *Thalassarche chrysostoma*, were all accounting for less than 5% of the total abundance.

One record of a light contact of a *T. melanophris* with the streamer of the fixed aerial area was recorded at station 593, and it was the only contact noticed for the whole duration of the survey. The bird did not appear to be damaged by this contact.
Pinnipeds were present in 25 of the 38 stations observed, for a total of 123 counts of South American fur seals *Arctocephalus australis*, and 11 counts of Southern sea lion *Otaria flavescens*. On three occasions the number of pinnipeds around the vessel exceeded 15, which resulted twice in individuals being caught in the net: in station 584, one *A. australis* was caught in the net, brought on deck and released alive; in station 588, two *A. australis* were caught in the same net and also brought on deck and released alive.

As no mortality occurred during the survey, the use of a seal exclusion device was not mandated for the vessel.

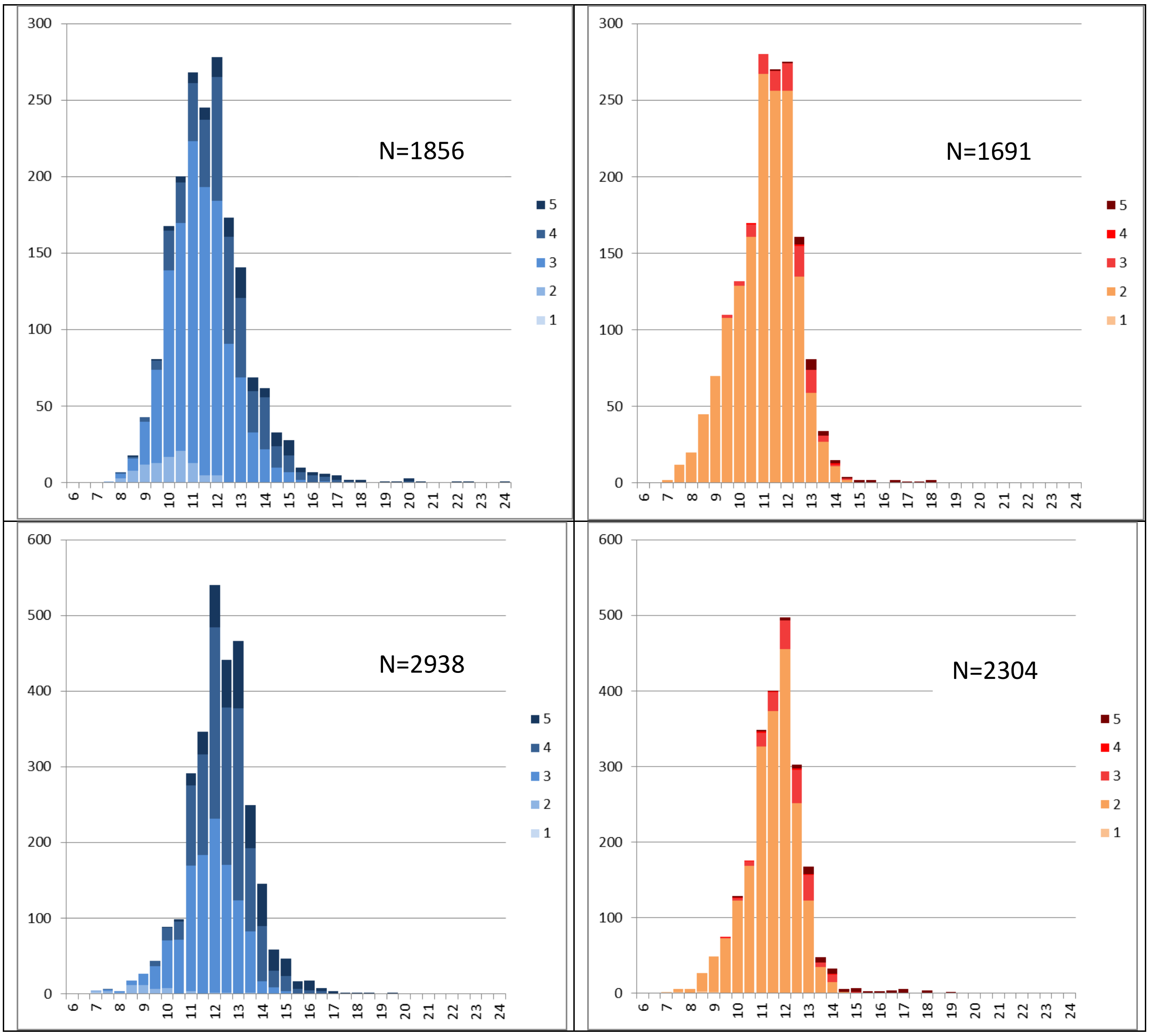

Figure 5. Length-frequency distributions by maturity stage of male (blue) and female (red) *D. gahi* from survey trawls north (top) and south (bottom) of latitude 52 ºS.

Conclusion

298 tonnes of *D. gahi* (84.5% of the total biomass) were caught within the 51 scientific trawls that were carried out during this survey. This resulted in an estimated abundance of 50,880 tonnes of *D. gahi* in the zone, with 18,516 tonnes in the north and 32,364 tonnes in the south. This high abundance is in accordance with what has been previously monitored in the past three years, with a wide distribution of the biomass in the zone with two hotspots – one in the very north of the Loligo box, and the other one around Beauchene Island. The individuals, regardless of their sex, tended to be bigger and more mature in the south than they were in the north, as is typically the case in the second fishing season.

This year, the most abundant bycatch was not *P. ramsayi* (for which biomass appeared to be very low, just above one tonne in the scientific survey), but was composed of *S. australis* – although mainly in one station – and *M. hubbsi*, widely distributed in the fishing zone.

The mortalities of seabird and pinnipeds in previous seasons have led to an increase in monitoring time of interactions and abundance of such megafauna. Nothing abnormal was observed on that matter, as no mortality and very few contacts occurred during the survey. As a consequence, the fleet was allowed to start the fishing season without the use of Seal Exclusion Device.

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Appendix

Table A1. Survey stations with total *D. gahi* catch. Time: Stanley time, latitude: °S, longitude: °W. Transects labelled A were adaptive trawls.

Transect section	Obs Code	Date	Start			End			Depth (m)	*D. gahi* (kg)
			Time	Lat	Lon	Time	Lat	Lon		
13 - 34	543	14/07/2019	07:15	50.82	57.12	09:15	50.74	57.29	131	357
14 - 37	544	14/07/2019	10:10	50.66	57.43	12:10	50.56	57.58	136	2520
14 - 38	545	14/07/2019	12:50	50.52	57.51	14:50	50.62	57.34	252	17283
14 - 39	546	14/07/2019	15:30	50.58	57.35	17:30	50.5	57.52	280	6048
13 - 36	547	15/07/2019	07:05	50.76	57.04	09:05	50.67	57.22	288	7371
13 - 35	548	15/07/2019	10:05	50.67	57.27	12:05	50.76	57.09	248	8463
12 - 33	549	15/07/2019	13:15	50.84	56.96	15:15	50.95	56.85	246	8967
12 - 32	550	15/07/2019	15:55	50.97	56.89	17:55	50.83	57.08	123	987
12 - 31	551	16/07/2019	07:00	50.88	57.03	09:00	51.00	56.93	122	168
11 - 29	552	16/07/2019	10:15	51.16	56.94	12:15	51.27	57.06	206	1029
11 - 30	553	16/07/2019	13:10	51.28	57.03	15:10	51.16	56.89	275	2688
11 - 28	554	16/07/2019	16:00	51.13	57.01	18:00	51.25	57.17	127	84
10 - 27	555	17/07/2019	06:50	51.50	57.08	08:50	51.62	57.15	286	630
10 - 26	556	17/07/2019	09:45	51.62	57.24	11:45	51.45	57.17	225	4473
10 - 25	557	17/07/2019	12:40	51.49	57.29	14:40	51.64	57.36	150	630
9 - 23	558	17/07/2019	15:55	51.81	57.37	17:55	51.94	57.49	222	6846
9 - 22	559	18/07/2019	06:30	51.94	57.58	08:30	51.80	57.46	164	4473
9 - 24	560	18/07/2019	09:40	51.86	57.34	11:40	51.99	57.43	282	1281
8 - 20	561	18/07/2019	13:10	52.15	57.59	15:10	52.26	57.73	263	2604
8 - 19	562	18/07/2019	16:05	52.23	57.82	18:05	52.11	57.64	199	4620
8 - 21	563	19/07/2019	07:00	52.31	57.72	09:00	52.39	57.88	302	1155
7 - 18	564	19/07/2019	10:10	52.37	57.94	12:10	52.47	58.09	262	3969
7 - 17	565	19/07/2019	13:20	52.38	58.12	15:20	52.47	58.29	174	5376
6 - 16	566	19/07/2019	16:45	52.6	58.47	18:45	52.71	58.63	233	1365
5 - 12	567	20/07/2019	07:00	52.79	59.04	09:00	52.69	58.83	124	567
6 - 15	568	20/07/2019	10:20	52.62	58.56	12:20	52.74	58.74	155	1743
5 - 14	569	20/07/2019	13:20	52.84	58.75	15:20	52.89	58.97	182	7287
5 - 13	570	20/07/2019	16:00	52.87	58.96	18:00	52.77	58.74	149	8190
4 - 10	571	21/07/2019	07:00	52.8	59.13	08:45	52.82	59.32	114	441
3 - 8	572	21/07/2019	10:10	52.96	59.40	12:10	52.95	59.64	179	2751
3 - 9	573	21/07/2019	12:55	52.99	59.59	14:55	53.00	59.31	236	4389
4 - 11	574	21/07/2019	15:55	53.01	59.29	17:55	52.95	59.02	222	22491
2 - 4	575	22/07/2019	07:25	52.83	59.75	09:25	52.86	59.55	156	12096
1 - 2	576	22/07/2019	12:55	52.86	59.97	15:55	52.81	60.19	194	12495
0 - 1	577	23/07/2019	06:05	52.78	60.36	08:05	52.89	60.17	242	6.48
1 - 3	578	23/07/2019	09:35	52.89	60.13	11:35	52.93	59.89	224	4473
2 - 6	579	23/07/2019	12:30	52.94	59.87	14:30	52.99	59.62	236	3528
2 - 5	580	23/07/2019	15:15	52.93	59.61	17:15	52.92	59.82	166	2940

3 - 4	581	23/07/2019	18:25	52.83	59.62	20:25	52.83	59.38	145	441
A - T-1	582	24/07/2019	07:00	53.00	59.23	09:00	52.93	58.98	170	28224
A - T-2	583	24/07/2019	11:25	52.93	58.98	13:25	52.84	58.77	155	1155
A - T-3	584	24/07/2019	14:45	52.77	58.67	16:45	52.86	58.82	235	14973
A - T-4	585	25/07/2019	07:05	52.97	59.14	09:05	52.98	59.34	168	20160
A - T-5	586	25/07/2019	10:10	52.97	59.44	12:10	52.96	59.68	190	8064
A - T-6	587	25/07/2019	14:25	52.98	59.12	16:25	52.9	58.94	216	20160
A - T-7	588	26/07/2019	07:20	52.8	58.79	09:20	52.68	58.64	148	586
A - T-8	589	26/07/2019	10:40	52.66	58.49	12:40	52.57	58.29	278	8054
A - T-9	590	26/07/2019	14:40	52.51	58.14	16:40	52.6	58.32	292	4032
A - T-10	591	27/07/2019	06:00	52.28	57.91	08:00	52.16	57.74	166	3516
A - T-11	592	27/07/2019	09:00	52.08	57.66	11:00	51.95	57.49	188	5532
A - T-12	593	27/07/2019	12:15	51.8	57.37	14:15	51.66	57.24	203	6277

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*	297,958.48	84.54%	344.17	0.00
BAC	*Salilota australis*	28,215.42	8.01%	69.67	27971.42
HAK	*Merluccius hubbsi*	14,696.08	4.17%	442.04	3944.34
KIN	*Genypterus blacodes*	2,414.57	0.69%	34.06	780.21
MUN	*Munida* spp.	1,252.61	0.36%	0.00	1252.61
PAR	*Patagonotothen ramsayi*	1,011.70	0.29%	254.23	950.69
ALG	Algae	1,007.35	0.29%	0.00	1007.35
TOO	*Dissostichus eleginoides*	858.38	0.24%	724.00	370.13
SQT	Ascidiacea	839.06	0.24%	0.00	839.06
MED	Medusa sp	578.164	0.16%	0.00	578.16
CGO	*Cottoperca gobio*	515.438	0.15%	22.96	515.44
RBR	*Bathyraja brachyurops*	436.54	0.12%	104.01	422.48
DGH	*Schroederichthys bivius*	415.84	0.12%	23.85	415.84
SPN	Porifera	371.548	0.11%	0.00	371.55
RAL	*Bathyraja albomaculata*	181.09	0.05%	23.38	181.09
POR	*Lamna nasus*	180	0.05%	180.00	180.00
RFL	*Zearaja chilensis*	176.82	0.05%	38.39	157.08
STA	*Sterechinus agassizii*	174.881	0.05%	0.00	174.88
RMC	*Bathyraja macloviana*	127.372	<0.05	25.24	127.37
RSC	*Bathyraja scaphiops*	103.861	<0.05	17.48	96.86
GRF	*Coelorinchus fasciatus*	100.43	<0.05	10.03	100.43
RDO	*Amblyraja doellojuradoi*	53.526	<0.05	7.99	53.53
HYD	Hydrozoa	48.859	<0.05	0.00	48.86
RBZ	*Bathyraja cousseauae*	48.722	<0.05	1.76	38.72
WHI	*Macruronus magellanicus*	47.696	<0.05	14.42	40.70
PTE	*Patagonotothen tessellata*	41.33	<0.05	11.84	41.33
GOC	*Gorgonocephalus chilensis*	39.469	<0.05	0.00	39.47
ZYP	*Zygochlamys patagonica*	39.462	<0.05	0.00	36.46

ANM	Anemonia	37.305	<0.05	0.00	37.31
RAY	Rajidae	36	<0.05	0.00	36.00
RMU	*Bathyraja multispinis*	34.52	<0.05	16.70	1.20
RGR	*Bathyraja griseocauda*	32.8	<0.05	21.98	10.82
COT	*Cottunculus granulosus*	31.93	<0.05	0.00	31.93
RPX	*Psammobatis spp.*	31.737	<0.05	7.16	31.74
ING	*Onykia ingens*	30.505	<0.05	0.00	30.51
GRC	*Macrourus carinatus*	29.846	<0.05	14.85	23.25
NEM	*Psychrolutes marmoratus*	29.645	<0.05	0.00	28.41
OCT	Octopus spp.	28.25	<0.05	0.00	28.25
LAR	*Lampris immaculatus*	24	<0.05	0.00	0.00
PAU	*Patagolycus melastomus*	23.413	<0.05	0.00	23.41
LIS	*Lithodes santolla*	15.536	<0.05	0.00	9.01
MUL	*Eleginops maclovinus*	12.347	<0.05	12.35	12.35
ILL	*Illex argentinus*	7.934	<0.05	0.00	7.91
ILF	*Iluocoetes fimbriatus*	7.164	<0.05	0.00	7.13
OPV	*Ophiacantha vivipara*	6.589	<0.05	0.00	6.59
OCC	Octocorallia sp	6.528	<0.05	0.00	6.53
LIA	*Lithodes santolla*	5.62	<0.05	0.00	5.62
CAZ	*Calyptraster* sp.	5.381	<0.05	0.00	5.38
COL	*Cosmasterias lurida*	5.363	<0.05	0.00	5.36
SUN	*Labidiaster radiosus*	5.12	<0.05	0.00	5.12
SEP	*Seriolella porosa*	4.92	<0.05	3.48	4.92
ODM	*Odontocymbiola magellanica*	4.838	<0.05	0.00	4.84
POA	*Glabraster antarctica*	4.61	<0.05	0.00	4.61
FUM	*Fusitriton m. magellanicus*	4.315	<0.05	0.00	4.32
PAT	*Merluccius australis*	4	<0.05	0.00	4.00
ANT	Anthozoa	3.78	<0.05	0.00	3.78
CTA	*Ctenodiscus australis*	2.354	<0.05	0.00	2.35
EEL	*Iluocoetes/Patagolycus* mix	2.235	<0.05	0.00	2.24
AUC	*Austrocidaris canaliculata*	1.955	<0.05	0.00	1.96
MYX	*Myxine* spp.	1.85	<0.05	0.00	1.85
OPL	*Ophiura lymani*	1.603	<0.05	0.00	1.60
CEX	*Ceramaster* sp.	1.537	<0.05	0.00	1.54
MAN	*Mancopsetta* sp.	1.48	<0.05	0.00	1.48
EUL	*Eurypodius latreillii*	1.072	<0.05	0.00	1.07
MXX	*Myctophidae* spp.	1.025	<0.05	0.00	1.03
ASA	*Astrotoma agassizii*	0.727	<0.05	0.00	0.73
EGG	Eggmass	0.693	<0.05	0.00	0.69
WRM	*Chaetopterus variopedatus*	0.652	<0.05	0.00	0.65
PYR	Pyrosome	0.59	<0.05	0.00	0.59
BLU	*Micromesistius australis*	0.596	<0.05	0.30	0.34
CRY	*Crossaster* sp.	0.554	<0.05	0.00	0.55
AST	Asteroidea	0.309	<0.05	0.00	0.31
SEC	*Seriolella caerulea*	0.28	<0.05	0.00	0.28
CYX	*Cycethra* sp.	0.262	<0.05	0.00	0.26

NOW	*Paranotothenia magellanica*	0.23	<0.05	0.13	0.13
BOA	*Borostomias antarcticus*	0.225	<0.05	0.00	0.23
BIV	Bivalvia	0.22	<0.05	0.00	0.22
PES	*Peltarion spinulosum*	0.212	<0.05	0.00	0.21
ACP	*Acanthephyra pelagica*	0.205	<0.05	0.00	0.21
ALC	Alcyoniina	0.201	<0.05	0.00	0.20
PYX	Pycnogonida	0.164	<0.05	0.00	0.16
MAV	*Magellania venosa*	0.156	<0.05	0.00	0.13
RED	*Sebastes oculatus*	0.09	<0.05	0.08	0.08
NUD	Nudibranchia	0.077	<0.05	0.00	0.08
ODP	*Odontaster pencillatus*	0.075	<0.05	0.00	0.08
EUO	*Eurypodius longirostris*	0.073	<0.05	0.00	0.07
POL	Polychaeta	0.072	<0.05	0.00	0.07
HOL	Holothuroidea	0.06	<0.05	0.00	0.06
SAR	*Sprattus fuegensis*	0.04	<0.05	0.00	0.04
BAO	*Bathybiaster loripes*	0.025	<0.05	0.00	0.03
BRY	Bryozoa	0.022	<0.05	0.00	0.02
UHH	*Tripilaster* sp	0.02	<0.05	0.00	0.02
OPH	Ophiuroidea	0.02	<0.05	0.00	0.02
ISO	Isopoda	0.011	<0.05	0.00	0.01
SER	*Serolis* spp.	0.009	<0.05	0.00	0.01
NUH	*Nuttallochiton hyadesi*	0.008	<0.05	0.00	0.01
CRI	Crinoidea	0.002	<0.05	0.00	0.00
Total		**352,431**		**2426.50**	**41,138**