FALKLAND ISLANDS FISHERIES DEPARTMENT

Doryteuthis gahi Stock Assessment Survey, 1st Season 2019

Vessel	**Argos Cíes (ZDLS3)**
	Falkland Islands
Dates	**08/02/2019 – 22/02/2019**
Survey Team	**Andreas Winter** **Tomasz Zawadowski** **Vasana Tutjavi**

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Summary

1) A stock assessment survey for *Doryteuthis gahi* (Falkland calamari) was conducted in the 'Loligo Box' from 8th to 22nd February 2019. Fifty-five scientific trawls were taken during the survey; 39 fixed-station and 16 adaptive trawls. The scientific catch of the survey was 381.54 tonnes *D. gahi*.
2) An estimate of 49,618 tonnes *D. gahi* (95% confidence interval: 40,650 to 66,556 t) was calculated for the fishing zone by inverse distance weighting. This estimate represents the highest 1st-season survey biomass since 2010. Of the total, 4620 t were estimated north of 52 ºS, and 44,998 t were estimated south of 52 ºS.
3) Male, but not female, *D. gahi* had significantly greater average mantle lengths south of 52 ºS than north of 52 ºS. Maturities were not significantly different between north and south. Males north: mean mantle length 10.54 cm; mean maturity stage 2.13, males south: mean mantle length 10.71 cm; mean maturity stage 2.14. Females north: mean mantle length 10.32 cm; mean maturity stage 2.04, females south: mean mantle length 10.44 cm; mean maturity stage 2.04.
4) 70 taxa were identified in the catches. *D. gahi* was the largest species group at 88.1% of total catch by weight, followed by rock cod (6.0%), blue whiting (3.2%), and red cod (1.1%). Toothfish had the lowest first-season survey catch since 2014, but included specimens larger than usual in calamari trawling. Biological measurements and samples were taken from *D. gahi*, rock cod, toothfish, and kingclip.

Introduction

A stock assessment survey for *Doryteuthis gahi* (Falkland calamari – Patagonian longfin squid – colloquially *Loligo*) was carried out by FIFD personnel on-board the fishing vessel *Argos Cíes* from the 8th to 22nd February 2019; experimental license FK026E19. This survey continues the series of surveys that have, since February 2006, been conducted immediately prior to season openings to estimate the *D. gahi* stock available to commercial fishing at the start of the season, and to initiate the in-season management model based on depletion 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, 2019.
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 being conducted on the F/V Monteferro.
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 (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.

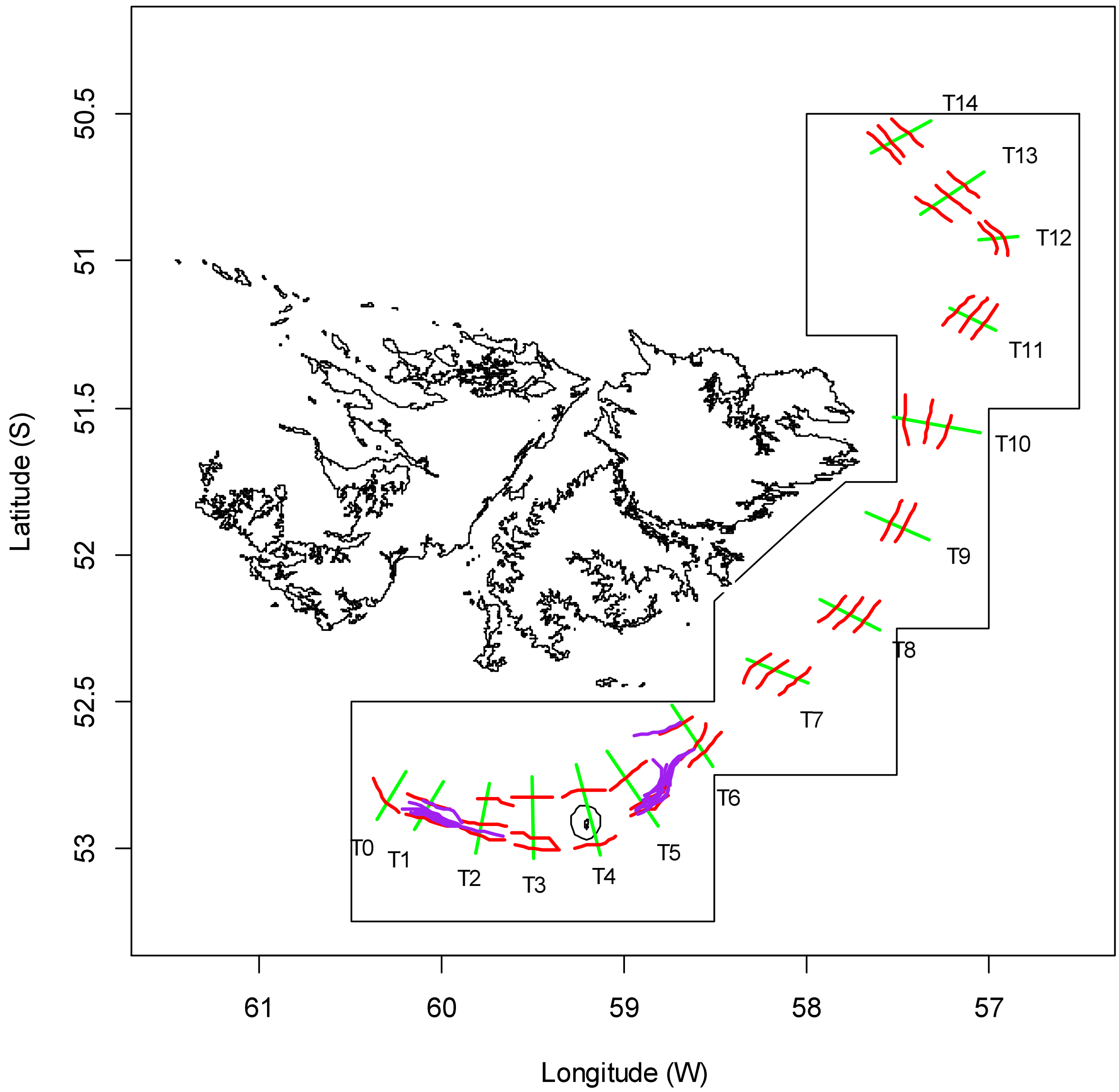


Figure 1. Survey transects (green lines), fixed-station trawls (red lines), and adaptive-station trawls (purple lines) sampled during the 1st pre-season 2019 survey. Boundaries of the 'Loligo Box' fishing zone and the Beauchêne Island exclusion zone are in black.

The F/V *Argos Cíes* is a Falkland Islands - registered stern trawler of 75 m length, 1999 gross tonnage, and 3000 main engine bhp. *Argos Cíes* is a new entrant in the Falkland Islands calamari fishery (FiskerForum 2018), and like all vessels employed for pre-season surveys, used its commercial trawl gear for the survey catches. The following personnel from the FIFD participated in the 1st pre-season 2019 survey:

Andreas Winter	lead scientist
Tomasz Zawadowski	fisheries observer
Vasana Tutjavi	fisheries observer

Much of the survey sampling work was also assisted by Argos compliance officer Jano van Heerden.

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. Trawl tracks were designed for an expected duration of 2 hours each, and ranged in distance from 12.2 to 17.6 km (median 15.9 km). All trawls were bottom trawls. During the progress of each trawl, GPS latitude, GPS longitude, bottom depth, bottom temperature, net height, 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 increase spatial resolution of the catches. For small catches acoustic apportioning cannot be assessed with accuracy, and any *D. gahi* amounts <100 kg were iteratively aggregated by adjacent intervals (if the total *D. gahi* catch in a trawl was <100 kg it was assigned to one interval; the middle one).

Catch estimation

The catch of every trawl was processed by the factory crew and retained catch weight of *D. gahi*, by size category, was calculated from the number of standard-weight blocks of frozen squid recorded by the factory supervisor. On several days of heavy catch, adjacent trawls were proportioned from deck volume estimates of the full trawl codends. 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. One to four observer baskets of unsorted catch were collected at intervals from most survey trawls[1], depending on their volume and the sampling schedule. These 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 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):

[1] Trawls were not basket-sampled if visual inspection showed almost pure squid catch, or if the catches were very small.

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

The bridle length of *Argos Cíes*' trawl, provided by the vessel master, was 170 m. The trawl net was switched three times for repairs between a 4 Caras net (footrope length = 130 m) and a 6 Caras net (footrope length = 160 m): 4 Caras – observer stations 1 to 25 and 30 to 37, 6 Caras observer stations 26 to 29 and ≥38 (Appendix Table A1).

Biomass density estimates were extrapolated to the fishing area using an inverse distance weighting algorithm (Winter et al. 2018b). As previously, 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 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 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.

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. 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 with fixed-station trawls in the north and proceeded throughout the Loligo Box. Adaptive trawls were concentrated in the south as this corresponded to the indications of *D. gahi* biomass distribution (Figures 1 and 2). A schedule of 4 survey trawls per day was maintained except for February 17th, when completion of the last three fixed-station trawls was followed by re-location to a different part of the Loligo Box, February 21st, when rough seas incited the decision to take three longer trawls rather than four 2-hour trawls; reducing deck time for the crew, and February 22nd, when the comparatively large first trawl in the morning (Table A1) precluded further catches that would not have been finished processing in time for the vessel's scheduled return to port. In total 55 scientific trawls were recorded during the survey: 39 fixed station trawls catching 113.26 t *D. gahi*, and 16 adaptive trawls catching 268.28 t *D. gahi*. Fourteen optional trawls (made after survey hours) yielded an additional 238.69 t *D. gahi*, bringing the total catch for the survey to 620.23 t. The scientific survey catch of 381.54 t is the highest for a 1st season since at least 2006 (Table 1).

Average *D. gahi* catch density among fixed-station trawls was 0.36 t km^{-2} north of 52° S and 3.45 t km^{-2} south of 52° S. The north density was the second-highest of the past 9 years for a first season following 2016, and the south density was the second-highest following 2015. Average *D. gahi* catch density among adaptive-station trawls was 10.51 t km^{-2} south of 52° S, the highest for a first season since at least 2011. No adaptive-station trawls were taken in the north sub-area.

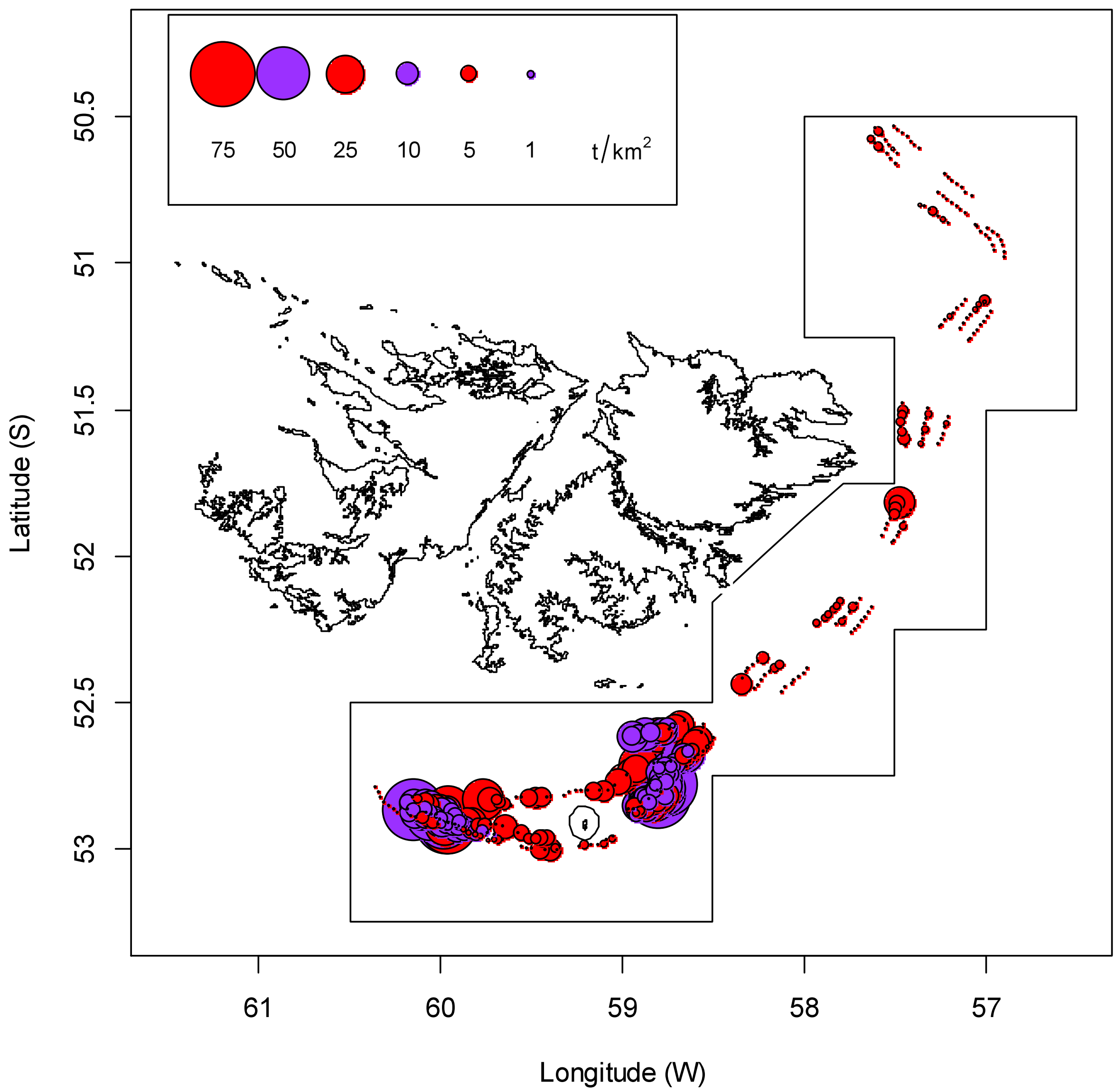


Figure 2. *D. gahi* CPUE (t km^{-2}) of fixed-station (red) and adaptive (purple) trawls per 15-minute trawl interval. Boundaries of the 'Loligo Box' fishing zone and the Beauchêne Island exclusion zone are traced in black.

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			

* Includes four juvenile toothfish transect trawls.

Biomass estimation

Total *D. gahi* biomass in the fishing area was estimated at 49,618 tonnes, with a 95% confidence interval of [40,650 to 66,556 t]. Distribution of the estimated biomass was preponderant towards the south: 44,998 tonnes with a 95% c.i. of [36,031 to 58,993 t], vs. the north: 4620 tonnes with a 95% c.i. of [4619 to 7563 t]. Thus 9.3% of the biomass was north, a less one-sided distribution than first season 2018 (Winter et al. 2018a) or 2017 (Winter et al. 2017). However, within the south sub-area *D. gahi* distribution was highly concentrated, with 50% of aggregate density in 65 of 392 5×5 km area units[2], and 95% of aggregate density in 221 of the 392 5×5 km area units (Figure 3). The total estimate of 49,618 t was the highest for a first season since 2010[3] (Table 1; Arkhipkin et al. 2010).

Biological data

Seventy taxa were identified in the survey catches (Appendix Table A2). *D. gahi* was the predominant catch with the highest proportion for a first season since at least 2011 (88.1% - Table A2). Second-highest catch was rock cod, with a slightly greater total than last first season (25,820 vs. 25,468 t, Table A2; Winter et al. 2018a), but lower than any other year 2012 to 2017. The third species was blue whiting *Micromesistius australis*, with 13659 t the lowest first-season survey total since 2012 except for 2017 (Winter et al. 2017). Toothfish, at 470 t, had the lowest first-season survey catch since 2014 (Winter and Jürgens 2014), but included a number of large specimens. Southern king crabs (*Lithodes santolla*) were caught in two trawls and individually weighed (Table A3). One blue fathead (*Cubiceps caeruleus*) was found in the fourth trawl on February 8th; only the second specimen of this species identified in Falkland Islands fishery catches (the first having been in 2018).

[2] Excluding depths <90 m or >400 m.
[3] However, note that biomass estimates from previous years may not be explicitly equivalent because the definition of the fishing area over which the geostatistic algorithm is applied has been revised several times.

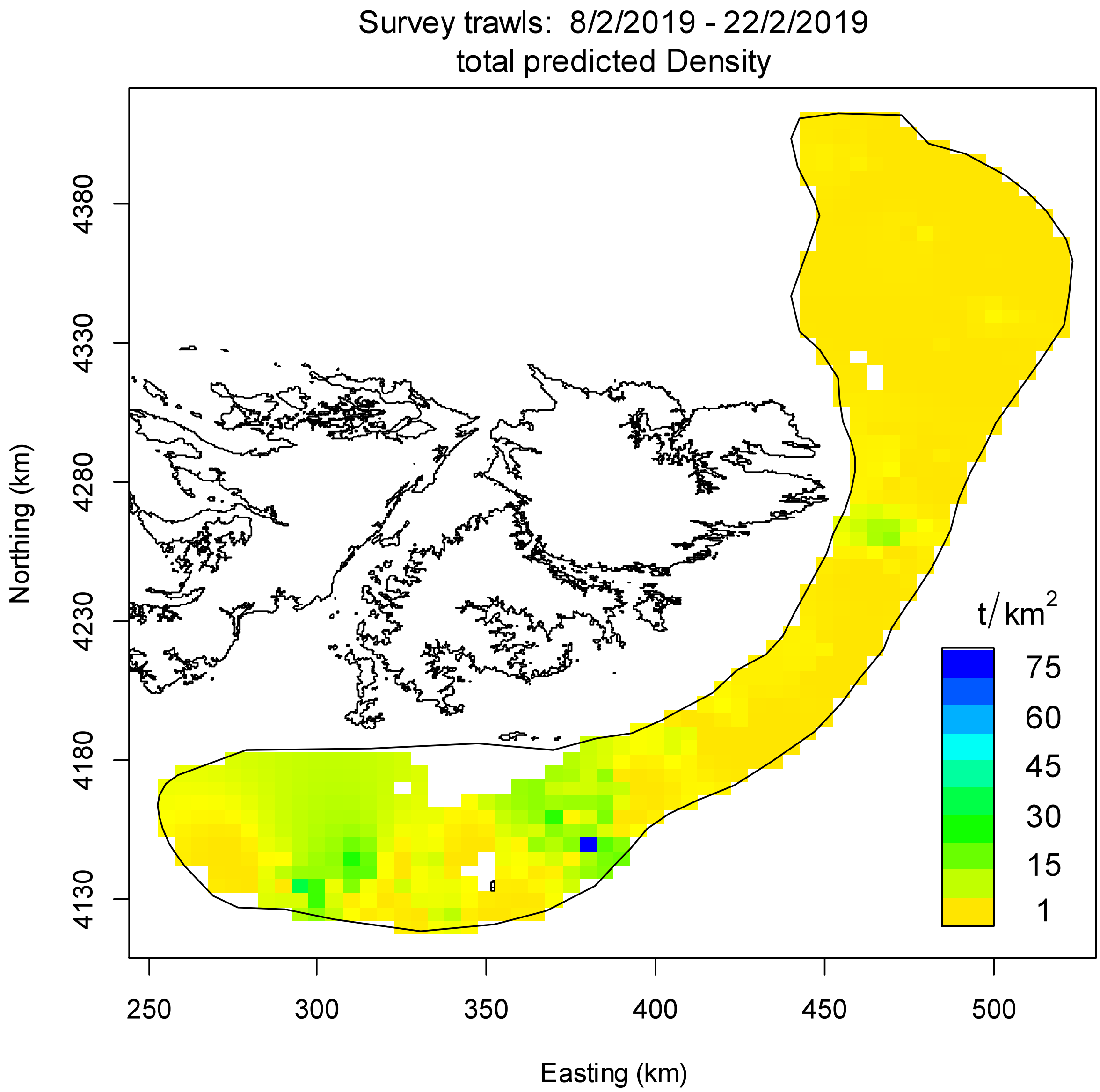
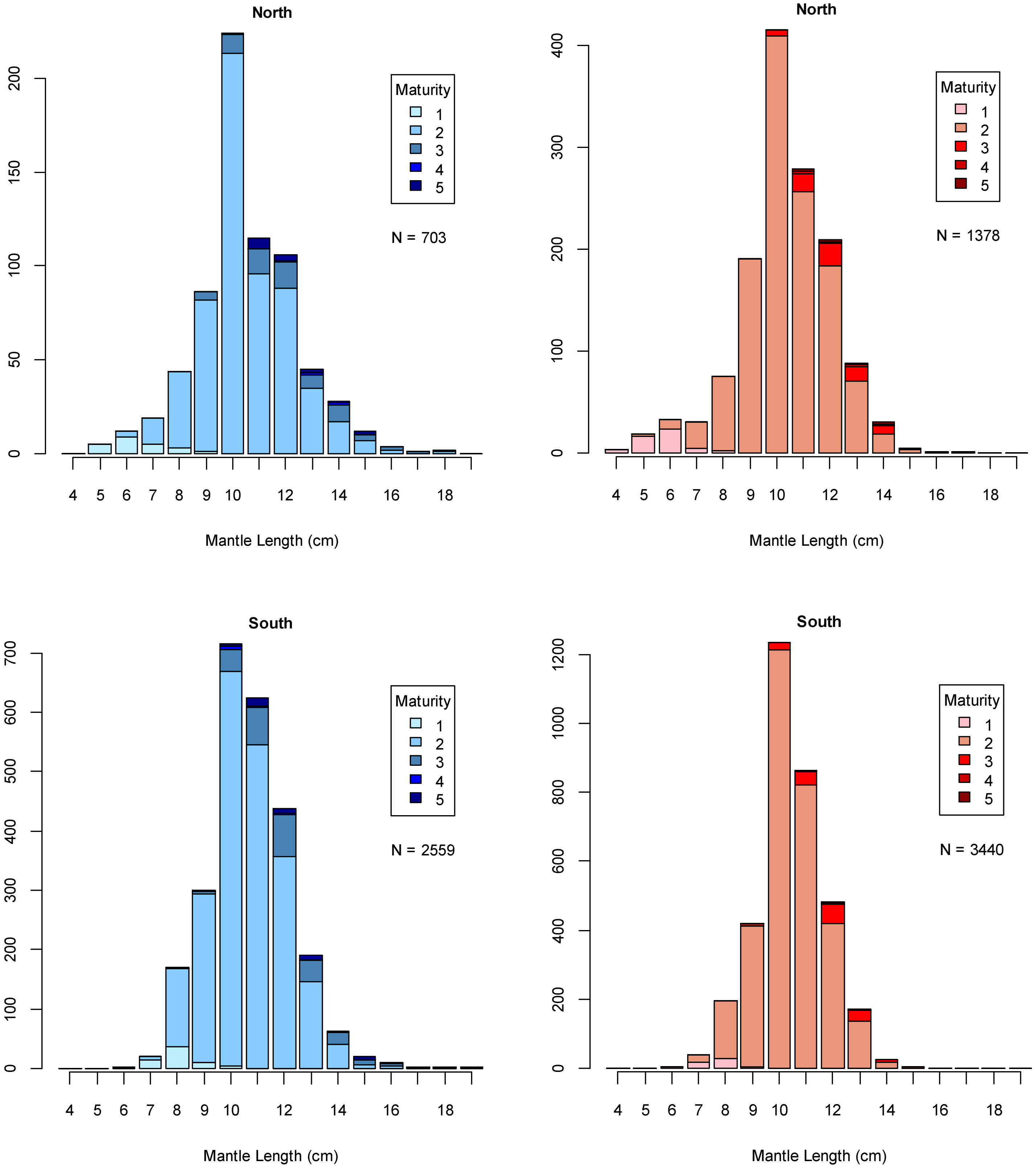


Figure 3. *Doryteuthis gahi* predicted density estimates per 5 km^2 area units. Blank area units within the perimeter are either <90 or >400 m average depth. Coordinates were converted to WGS 84 projection in UTM sector 21F using the R library rgdal (proj.maptools.org).

No pinnipeds were sighted by the FIFD survey team, and no pinniped interactions or incidental catches occurred. Correspondingly, no seal exclusion device (SED) was used in the trawl gear throughout the survey.

8080 *D. gahi* were measured for length and maturity in the survey (3262 males, 4818 females, from 52 of the trawls). The total sex ratio was significantly ($p < 0.001$) majority female. Thirty-five individual trawls had a significant preponderance of females, but two trawls in the south, between longitude 58.95 °W and 58.69 °W, had a significant preponderance of males.

Figure 4 [next page]. Length-frequency distributions by maturity stage of male (blue) and female (red) *D. gahi* from trawls north (top) and south (bottom) of latitude 52 °S.



D. gahi mantle length and maturity distributions north and south of 52° S are plotted in Figure 4. For males, size distributions were significantly different between north and south (Kruskal-Wallis test, $p < 0.01$). For females, size distributions were not significantly different between north and south ($p > 0.10$). Gonad maturity distributions were not significantly different between north and south for either males or females ($p > 0.10$). For males north: mean mantle length 10.54 cm; mean maturity stage 2.13 (on a scale of 1 to 5), males south: mean mantle length 10.71 cm; mean maturity stage 2.14. Females north: mean mantle length 10.32 cm; mean maturity stage 2.04, females south: mean mantle length 10.44 cm; mean maturity stage 2.04.

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Appendix

Table A1. Survey stations with total *D. gahi* catch. Time: Stanley F.I. time. The vessel's clock was 1 hour later. Latitude: °S, longitude: °W. Transects labelled A were adaptive trawls.

Transect Station	Obs Code	Date	Start			End			Depth (m)	*D. gahi* (kg)
			Time	Lat	Lon	Time	Lat	Lon		
14 - 39	9	08/02/2019	06:10	50.52	57.52	07:55	50.61	57.36	249	0
14 - 38	10	08/02/2019	08:45	50.64	57.47	10:30	50.54	57.61	141	396
14 - 37	11	08/02/2019	11:10	50.56	57.66	13:10	50.66	57.49	135	455
13 - 34	12	08/02/2019	14:00	50.78	57.40	15:45	50.87	57.20	127	455
13 - 36	13	09/02/2019	06:00	50.78	57.05	07:45	50.69	57.22	249	3
13 - 35	14	09/02/2019	08:40	50.74	57.29	10:30	50.83	57.10	130	24
12 - 33	15	09/02/2019	11:15	50.87	57.01	13:00	50.98	56.89	120	19
12 - 32	16	09/02/2019	13:45	50.98	56.96	15:20	50.87	57.05	115	24
11 - 31	17	10/02/2019	06:00	51.15	56.95	07:50	51.26	57.09	143	45
11 - 30	18	10/02/2019	08:30	51.24	57.16	10:20	51.12	57.01	127	495
11 - 29	19	10/02/2019	11:00	51.12	57.08	12:50	51.22	57.25	114	105
10 - 26	20	10/02/2019	14:30	51.46	57.45	16:30	51.62	57.44	126	1754
6 - 17	21	11/02/2019	06:00	52.61	58.47	08:00	52.72	58.65	231	64
6 - 16	22	11/02/2019	08:45	52.70	58.69	10:40	52.58	58.55	163	8058
6 - 15	23	11/02/2019	11:30	52.55	58.62	13:00	52.61	58.80	134	8891
5 - 12	24	11/02/2019	14:05	52.71	58.88	16:10	52.80	59.07	121	11160
8 - 23	25	12/02/2019	06:00	52.16	57.59	07:40	52.26	57.74	262	[A] 5
8 - 22	26	12/02/2019	08:45	52.25	57.85	10:30	52.15	57.69	198	549
8 - 21	27	12/02/2019	11:15	52.14	57.78	12:50	52.23	57.93	138	1463
7 - 18	28	12/02/2019	14:10	52.34	58.19	15:55	52.44	58.34	143	1906
0 - 1	29	13/02/2019	06:00	52.76	60.37	07:40	52.88	60.23	250	[B] 15
1 - 3	30	13/02/2019	08:40	52.88	60.20	10:30	52.92	59.95	225	12270
2 - 5	31	13/02/2019	11:15	52.91	59.88	13:05	52.92	59.65	167	6717
3 - 8	32	13/02/2019	13:45	52.95	59.62	15:40	53.00	59.37	177	3633
1 - 2	33	14/02/2019	06:00	52.81	60.19	07:55	52.87	59.95	192	11893
2 - 4	34	14/02/2019	08:40	52.83	59.80	10:10	52.85	59.61	158	8036
3 - 7	35	14/02/2019	10:55	52.83	59.62	12:35	52.83	59.39	146	3537
4 - 10	36	14/02/2019	13:15	52.83	59.34	15:15	52.80	59.10	108	1563
2 - 6	37	15/02/2019	06:00	52.93	59.90	07:55	52.97	59.66	233	[A] 1003
3 - 9	38	15/02/2019	08:55	52.99	59.59	10:40	53.01	59.36	240	3616
4 - 11	39	15/02/2019	11:25	53.00	59.27	13:10	52.96	59.05	218	683
5 - 14	40	15/02/2019	14:00	52.89	58.96	15:45	52.82	58.75	152	9783
9 - 25	41	16/02/2019	06:00	51.83	57.39	07:50	51.96	57.51	218	214
9 - 24	42	16/02/2019	08:40	51.95	57.58	10:30	51.82	57.48	160	2920
10 - 28	43	16/02/2019	11:50	51.64	57.27	13:20	51.53	57.20	220	146
10 - 27	44	16/02/2019	14:40	51.48	57.30	16:45	51.62	57.35	147	421
7 - 20	45	17/02/2019	06:00	52.48	58.15	07:45	52.39	57.98	247	8
7 - 19	46	17/02/2019	08:40	52.37	58.10	10:25	52.45	58.27	186	736
5 - 13	47	17/02/2019	13:00	52.78	58.77	14:45	52.87	58.97	145	10195
A - 1	48	18/02/2019	06:00	52.66	58.61	08:00	52.78	58.75	150	14880
A - 2	49	18/02/2019	08:40	52.79	58.75	10:40	52.88	58.92	151	14975
A - 3	50	18/02/2019	11:25	52.88	58.93	12:55	52.80	58.78	145	24955
A - 4	51	18/02/2019	14:15	52.78	58.77	16:00	52.67	58.65	146	17923
A - 5	52	19/02/2019	06:05	52.84	60.10	08:15	52.92	59.89	182	12828
A - 6	53	19/02/2019	09:05	52.93	59.92	11:05	52.88	60.17	213	13674
A - 7	54	19/02/2019	11:55	52.88	60.15	13:55	52.93	59.89	201	18186

A - 8	55	19/02/2019	14:40	52.92	59.93	16:40	52.87	60.15	191	24822
A - 9	56	20/02/2019	06:05	52.57	58.69	08:10	52.62	58.95	121	12542
A - 10	57	20/02/2019	09:00	52.70	58.84	11:00	52.83	58.87	143	13144
A - 11	58	20/02/2019	11:45	52.84	58.89	13:45	52.72	58.76	147	14655
A - 12	59	20/02/2019	14:35	52.76	58.77	16:35	52.87	58.94	146	25021
A - 13	60	21/02/2019	06:20	52.96	59.66	08:35	52.91	59.96	194	12414
A - 14	61	21/02/2019	10:00	52.92	59.91	12:20	52.84	60.17	189	10891
A - 15	62	21/02/2019	13:15	52.87	60.21	15:40	52.92	59.90	193	13937
A - 16	63	22/02/2019	07:35	52.70	58.71	09:48	52.85	58.85	148	23432

A: Net broken.
B: Net broken on haul. Visual estimate of 8 tonnes fish (mostly blue whiting) lost.

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*	381538	88.1	325	763
PAR	*Patagonotothen ramsayi*	25820	6.0	143	21911
BLU	*Micromesistius australis*	13659	3.2	38	12
BAC	*Salilota australis*	4809	1.1	0	26
SAR	*Sprattus fuegensis*	1674	0.4	0	1524
MUN	*Munida* spp.	979	0.2	0	978
RAY	Rajidae	737	0.2	0	148
TOO	*Dissostichus eleginoides*	470	0.1	397	7
KIN	*Genypterus blacodes*	402	0.1	1	15
GRC	*Macrourus carinatus*	363	0.1	0	29
CGO	*Cottoperca gobio*	359	0.1	0	339
ZYP	*Zygochlamys patagonica*	318	0.1	0	318
ING	*Moroteuthis ingens*	257	0.1	0	257
WHI	*Macruronus magellanicus*	254	0.1	0	32
DGH	*Schroederichthys bivius*	177	<0.1	1	177
PTE	*Patagonotothen tessellata*	166	<0.1	0	166
ILL	*Illex argentinus*	138	<0.1	3	138
GRF	*Coelorinchus fasciatus*	136	<0.1	0	116
SQT	Ascidiacea	122	<0.1	0	122
SPN	Porifera	107	<0.1	0	107
AST	Asteroidea	54	<0.1	0	54
EEL	*Iluocoetes*/*Patagolycus* mix	46	<0.1	0	46
BUT	*Stromateus brasiliensis*	46	<0.1	0	26
GOC	*Gorgonocephalus chilensis*	43	<0.1	0	43
NEM	*Neophyrnichthys marmoratus*	42	<0.1	0	42
RBR	*Bathyraja brachyurops*	40	<0.1	0	11
ALG	Algae	35	<0.1	0	35
STA	*Sterechinus agassizi*	34	<0.1	0	34
MED	Medusae	24	<0.1	0	24
ANM	Anemone	24	<0.1	0	24
CHE	*Champsocephalus esox*	20	<0.1	0	20
GOR	Gorgonacea	18	<0.1	0	18
OCC	Octocoralia	15	<0.1	0	15
RMC	*Bathyraja macloviana*	14	<0.1	0	12
LIS	*Lithodes santolla*	14	<0.1	0	14

PAT	*Merluccius australis*	10	<0.1	0	10
ODM	*Odontocymbiola magellanica*	10	<0.1	0	10
SAL	*Salpa* sp.	6	<0.1	0	6
HAK	*Merluccius hubbsi*	5	<0.1	0	2
FUM	*Fusitriton m. magellanicus*	5	<0.1	0	5
POA	*Porania antarctica*	4	<0.1	0	4
MUE	*Muusoctopus eureka*	4	<0.1	0	4
ILF	*Iluocoetes fimbriatus*	3	<0.1	0	3
SHT	Mixed invertebrates	2	<0.1	0	2
RAL	*Bathyraja albomaculata*	2	<0.1	0	2
PAO	*Patagonotothen cornucola*	2	<0.1	0	2
GRV	*Macrourus* spp.	2	<0.1	0	2
ARD	*Arbacia dufresni*	2	<0.1	0	2
MYX	*Myxine* spp.	1	<0.1	0	1
MYA	*Myxine australis*	1	<0.1	0	1
EGG	Eggmass	1	<0.1	0	1
COT	*Cottunculus granulosus*	1	<0.1	0	1
CEX	*Ceramaster* sp.	1	<0.1	0	1
CAZ	*Calyptraster* sp.	1	<0.1	0	1
WRM	*Chaetopterus variopedatus*	<1	<0.1	0	0
SUN	*Labidaster radiosus*	<1	<0.1	0	0
RPX	*Psammobatis* spp.	<1	<0.1	0	0
PYX	Pycnogonida	<1	<0.1	0	0
PES	*Peltarion spinosulum*	<1	<0.1	0	0
OPV	*Ophiacanta vivipara*	<1	<0.1	0	0
OPS	*Ophiactis asperula*	<1	<0.1	0	0
MUG	*Munida gregaria*	<1	<0.1	0	0
EUO	*Eurypodius longirostris*	<1	<0.1	0	0
EUL	*Eurypodius latreillei*	<1	<0.1	0	0
CTA	*Ctenodiscus australis*	<1	<0.1	0	0
COP	*Congiopodus peruvianus*	<1	<0.1	0	0
CHR	*Chrysaora* cf. *plocamia*	<1	<0.1	0	0
BOA	*Borostomias antarcticus*	<1	<0.1	0	0
BAL	*Bathydomus longisetosus*	<1	<0.1	0	0
AGO	*Agonopsis chilensis*	<1	<0.1	0	0
		433,020		907	27,666

Table A3. Southern king crabs *Lithodes santolla* caught during the survey. Observer station codes correspond to Table A1.

Observer Code	Sex	Eggs	Weight (kg)
17	M		0.84
17	F	Yes	0.83
36	M		2.10
36	M		1.83
36	F	Yes	1.21
36	M		2.11
36	M		1.90
36	M		2.99
36	M		1.79
36	F	Yes	1.09
36	F	Yes	1.33
36	M		2.36

Table A4. Basket samples per station, with minor species summarized in the 'other' (OTH) species code category.

Species Code	Station / Basket	Catch	Station / Basket	Catch	Station / Basket	Catch	Station / Basket	Catch
LOL	10 - 1	26.61	10 - 2	6.23	11 - 1	23.79	11 - 2	26.62
PAR		0.22		0.56		0.02		0.05
RBR		0.10		2.98		1.31		5.00
RFL						6.15		1.50
RMC						0.69		
RDO						0.42		
RAL						0.75		
WHI				0.80				
BLU		0.06		13.13				0.56
CGO		0.03		0.06				
ILL						0.12		0.15
KIN				5.59		0.45		1.52
OTH	ING ODM EEL CTA CAZ MUN ZYP EYC SHT	1.53	BUT DGH ING SAR ZYP STA ALG GOC MUN	3.38	ING ZYP AST SHT BUT DGH	3.55	DGH ING SPN ODM AST SHT	1.68
LOL	12 - 1	24.33	12 - 2	21.86	13 - 1	0.39	13 - 2	
PAR		0.50		0.34		2.31		5.34
TOO						11.71		12.06
RBR				2.02				3.97
RFL				0.89		2.30		
RMC								3.03
RAL								1.00
RPX				0.39				
RSC								1.67
BAC						1.79		0.36
WHI						5.56		6.25
BLU						0.51		
CGO		0.40		0.13				0.30
ILL				0.15				
KIN		0.44		1.10		2.58		1.02
OTH	NEM ING PTE SHT	2.73	PTE GOC ING AST SPN SHT MED	2.45	ING EEL	0.51	EEL ING NOW SHT	0.84
LOL	14 - 1	14.98	14 - 2	6.82	16 - 1	2.38	16 - 2	3.15
PAR				2.79		0.11		0.04
TOO		0.67		0.44				
RBR		7.81				14.81		15.25
RFL		0.90						
RMC		0.95				5.56		0.78
RAL								0.22
RPX								0.22
BAC		2.64		0.52				
WHI		2.30		7.39				
BLU		0.55						
CGO		0.67		2.20		0.51		
ILL		0.40		0.45				
KIN		2.90		1.18				

OTH	DGH PTE ALG AST OCC OPR SHT	2.71	PTE ALG DGH ING SAR EEL AST SHT	8.78	PTE ING SHT DGH	5.74	PTE ING SHT	1.54
LOL	17 - 1	1.22	18 - 1	27.34	19 - 1	15.22		
PAR		1.53		0.03		0.10		
RBR						2.09		
RMC		0.63				1.41		
RDO		0.83						
BAC		0.15						
WHI		0.49						
CGO		2.42						
ILL				0.01				
OTH	LIM SHT OCT SPN AST ALG ING DGH CHE CG0 SAR PTE EEL	14.11	EEL SPN PTE ING ANM ALG AST SAR ZYP DGH SQT EUO SHT	0.54	PTE SPN SQT EUO SHT	8.94		
LOL	20 - 1	10.17	20 - 2	2.55	21 - 1	0.67	21 - 2	0.79
PAR		0.04		0.01		27.02		26.21
RBR		0.85						
RMC				0.04				
BAC						0.93		0.11
WHI						0.30		
CGO						0.47		
OTH	SAR ODM PTE SHT	14.18	SAR ALG ODM CHE SHT PTE STA SPN	30.98	EEL GRV SAR ZYP SHT	1.42	NEM EEL SAR ZYP SHT	SAR ALG ODM CHE SHT PTE STA SPN
LOL	23 - 1	26.2	23 - 2	32.72	23 - 3	29.25		
RMC						0.02		
MUN		0.71		0.46		0.35		
OTH	SPN STAR ZYP SHT	0.19	SAR PTE	0.13	ALG	0.01		
LOL	24 - 1	27.84	24 - 2	26.77	24 - 3	29.02		
ILL				0.05				
MUN		0.55		0.38				
OTH	ZYP SPN GOC ALG	0.13	PTE ZYP SHT	0.38	PTE SAR ANM ZYP SHT	0.68		
LOL	26 - 1	15.90	26 - 2	10.17	27 - 1	23.07	27 - 2	22.57
PAR		14.75		16.86		0.17		0.19
RPX						0.41		
WHI		0.24		0.43				
BLU		0.65		0.64				
CGO				1.17				
OTH	ING EEL CHE DGH GOC SHT	1.22	SAR EEL STA SUT	0.61	PTE GOC ZYP SPN SHT	1.41	GOC SAR ZYP PTE ALG SPN EUL SHT	1.04
LOL	28 - 1	19.62	28 - 2	16.72				
PAR		0.11		0.08				
RMC		1.57						
RPX		0.36		0.38				
OTH	PTE GOC ZYP SHT	1.33	PTE GOC ZYP SPN ALG SHT	1.94				
LOL	29 - 1	0.03	29 - 2	0.03	29 - 3	0.24		

PAR		1.03		1.18		0.33		
BAC		11.38		2.76		4.51		
BLU		12.53		19.35		26.98		
CGO				0.46				
OTH			GRV	1.32	GRV	0.39		
LOL	30 - 1	24.38	30 - 2	20.6	30 - 3	26.93	30 - 4	24.41
PAR		0.93		0.86		0.91		0.74
WHI				0.44				0.32
CGO						1.51		
ILL						0.42		
OTH					GRV ING	4.57	GRC	1.07
LOL	31 - 1	18.39	31 - 2	21.69	31 - 3	25.58		
PAR		2.90		2.36		2.73		
ILL				0.11		0.07		
MUN		0.62		0.53		0.42		
OTH			GOC SAR	0.12	ZYP OCC	0.06		
LOL	32 - 1	25.67	32 - 2	26.38				
PAR		0.70		0.38				
ILL		0.07						
MUN		0.56		0.38				
OTH	PTE EUL ZYP	0.50	ING ALG	0.41				
LOL	33 - 1	20.29	33 - 2	22.70	33 - 3	24.29	33 - 4	20.03
PAR		8.88		1.45		2.86		2.55
BAC						0.05		
ILL				0.07				
OTH					CHE ZYP FUM	0.23	GOR	0.01
LOL	34 - 1	27.99	34 - 2	27.85	35 - 1	32.73	35 - 2	32.64
PAR		0.47		0.63		0.29		0.23
CGO		0.08				0.08		
ILL						0.19		
MUN		0.01				0.29		0.45
OTH			STA ZYP	0.09	PTE ZYP SHT	0.14	CHE AST PES ZYP SHT	0.62
LOL	36 - 1	20.19	36 - 2	19.30	37 - 1	22.17	37 - 2	16.40
PAR		0.01		0.07		4.68		4.39
RAL						0.22		0.97
RPX		0.56						
HAK								1.46
BAC						0.22		0.46
WHI						0.68		0.40
CGO				0.09				
ILL				0.17				
KIN						3.27		
MUN		0.28		0.26				
OTH	ZYP SQT PTE EUL POA ANM SHT	7.37	SAT SQT ZYP SHT	3.57	ZYP GOC	0.12	GRC DGH ING SHT	4.83
LOL	38 - 1	19.89	38 - 2	26.77	39 - 1	5.10	39 - 2	5.12
PAR		4.09		4.71		21.55		21.99
RFL		1.63						
BAC				0.15				

WHI						0.62		0.78
CGO		2.36		1.14				
ILL		0.07						
OTH	EEL GRC ING SHT	3.97	ING EEL SHT	1.34	ING EEL OPL	0.55	ING AST	0.73
LOL	40 - 1	28.54	40 - 2	29.85	40 - 3	30.30	40 - 4	27.95
PAR				0.04		0.02		
ILL		0.07				0.04		
MUN		0.01						
OTH							SAR AST	0.07
LOL	41 - 1	17.82	41 - 2	15.45	42 - 1	25.30	42 - 2	28.95
PAR		6.02		5.25		0.08		0.46
RMC						0.73		
BAC								0.05
WHI				0.28				
CGO		0.82		0.63		0.19		
ILL						0.05		0.05
OTH	EEL STA SHT	0.87	EEL SAR SHT	0.72	STA SPN ZYP SHT	0.36	EEL SHT	0.53
LOL	43 - 1	10.21	43 - 2	9.06	44 - 1	16.00	44 - 2	19.38
PAR		9.51		10.54		3.00		2.99
RAL				2.25				
RBR						1.85		
HAK						3.25		
BAC		0.26		0.04		0.22		
WHI		0.40		0.45				
CGO				0.22		0.19		0.24
ILL				0.14		0.14		0.05
KIN								0.34
OTH	ING SAR EEL STA AST SHT	3.70	STA ING SAR SHT	3.26	STA ING SAR SHT	1.28	CHE STA ING PTE SHT DGH	2.92
LOL	45 - 1	0.04	45 - 2	0.09	46 - 1	5.57	46 - 2	6.97
PAR		8.81		3.18		15.76		17.43
TOO		0.35		2.14				
RMC		0.50						
BAC		16.34		18.05		1.28		2.19
BLU				1.06				
CGO				0.42		0.60		0.49
ILL						0.04		
OTH	SHT GRF EEL	0.62	GRV SHT	1.26	UCH ZYP AST SHT	0.83	ZYP CHE GRF SAR SHT	1.43
LOL	47 - 1	32.64	47 - 2	31.78	47 - 3	26.11	47 - 4	25.25
PAR		0.03		0.06		0.02		
ILL		0.07		0.07		0.04		0.07
OTH					SHT	0.03	ZYP	0.03
LOL	48 - 1	29.37	48 - 2	25.37	48 - 3	25.15	48 - 4	27.58
PAR		0.74		0.50		0.97		2.16
OTH			NEM	0.58	AST GAY	0.07	ZYP	0.01
LOL	49 - 1	29.74	49 - 2	32.00	49 - 3	28.27	49 - 4	30.05
PAR						0.28		0.03
ILL				0.09				
LOL	50 - 1	36.90	50 - 2	38.38	51 - 1	34.28	51 - 2	36.04

PAR						0.19		0.29
ILL				0.18		0.08		
MUN						0.03		
OTH					PTE ZYP SHT	0.10	SHT	0.01
LOL	52 - 1	29.23	52 - 2	24.69	53 - 1	23.41	53 - 2	27.24
PAR		1.95		1.95		1.14		2.68
CGO				0.44				
MUN				0.01				
OTH	SHT	0.01	CRB MED ALC	0.09	ALC	0.04	ALC	0.02
LOL	54 - 1	34.84	54 - 2	36.80	55 - 1	29.66	55 - 2	29.31
PAR		0.41		0.65		0.18		0.53
WHI		0.38						
LOL	56 - 1	29.84	56 - 2	34.04	57 - 1	33.37	57 - 2	31.10
PAR						0.19		0.11
MUN		0.04		0.06		0.48		0.44
OTH	PTE	0.03	SAR PTE	0.11	ZYP STA	0.12	ALG ZYP	0.13
LOL	58 - 1	29.60	58 - 2	34.72	59 - 1	31.76	59 - 2	26.20
PAR		0.30		0.53		0.09		0.11
ILL						0.05		0.06
MUN		0.08		0.04				
OTH	PTE SHT	0.16	SHT	0.07			DGH ZYP	0.54
LOL	60 - 1	28.46	60 - 2	8.91	61 - 1	20.63	61 - 2	18.42
PAR		3.14		1.47		14.22		17.87
MUN						0.01		0.02
OTH							AST	0.01
LOL	62 - 1	27.07	62 - 2	27.35				
PAR		4.45		4.86				
OTH			SAR	0.05				
LOL	63 - 1	30.45	63 - 2	27.25	63 - 3	32.89	63 - 4	30.34
PAR		0.03		0.02		0.12		
ILL						0.08		
OTH					SHT	0.01	ZYP	0.01