FALKLAND ISLANDS FISHERIES DEPARTMENT

Loligo Stock Assessment Survey, 2nd Season 2013

Vessel	Golden Chicha (ZDLC1), Falkland Islands
Dates	30/06/2013 - 14/07/2013
Scientific Crew	A. Winter, A. Blake, F. Sobrado

Summary

1) A stock assessment survey for *Loligo* squid was conducted in the 'Loligo Box' from 30th June to 14th July 2013. Fifty-six scientific trawls were taken during the survey, catching 163.66 tonnes of *Loligo*.
2) A geostatistical estimate of 36,283 tonnes *Loligo* (95% confidence interval: 31,359 to 41,162 t) was calculated for the fishing zone. This represents the third-highest 2nd-season survey estimate since 2006, inclusively. Of the total, 11,740 t were estimated north of 52 ºS, and 24,544 t were estimated south of 52 ºS.
3) Female *Loligo* had higher modal mantle lengths (12 cm) and maturity (81% stage ≥ 3) south of 52 ºS than north (10 cm and 28% stage ≥ 3). Males were unimodal (12 cm) and predominantly (55%) stage 3 in the south, while males had a bimodal length distribution (10 and 14 cm) predominated by stages 2 (36%) and 4 (33%) in the north.
4) Thirty-nine taxa were identified in the catches, of which *Loligo* made up 71.7% by weight. Biological measurements and samples were taken from *Patagonotothen ramsayi*, *Patagonotothen tessellata*, *Eleginops maclovinus*, and *Neophrynichthys marmoratus* in addition to *Loligo*. CTD data were recorded from 49 trawls.

Introduction

A stock assessment survey for *Loligo* (*Doryteuthis gahi* - Patagonian squid) was carried out by FIFD personnel onboard the fishing vessel *Golden Chicha* from 30th June to 14th July 2012. This survey continues the series of surveys that have, since February 2006, been conducted immediately prior to *Loligo* season openings to estimate the *Loligo* 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.

The survey 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 current delineation of the Loligo Box represents an area of approximately 31,118 km^2.

Objectives of the survey were to:

1) Estimate the biomass and spatial distribution of *Loligo* on the fishing grounds at the onset of the 2nd fishing season, 2013.
2) Provide data for comparative estimates of rock cod (*Patagonotothen ramsayi*) bycatch in *Loligo* trawls.
3) Collect biological information on *Loligo*, rock cod, and opportunistically other fish and squid taken in the trawls.

The F/V *Golden Chicha* is a Stanley, Falkland Islands - registered stern trawler of 69.8 m length, 1345 t gross registered tonnage, and 2200 main engine bhp. Like all vessels employed for these pre-season surveys, *Golden Chicha* operates regularly in the commercial *Loligo* fishery and used its commercial trawl gear for the survey catches. *Golden Chicha* was also used for the 1st pre-season survey in 2008 (Payá, 2008) and the 2nd pre-season survey in 2010 (Winter et al., 2010).

The following personnel from FIFD participated in this survey:

Andreas Winter	survey chief scientist
Alex Blake	fisheries scientist, lead observer
Francisco Sobrado	fisheries observer

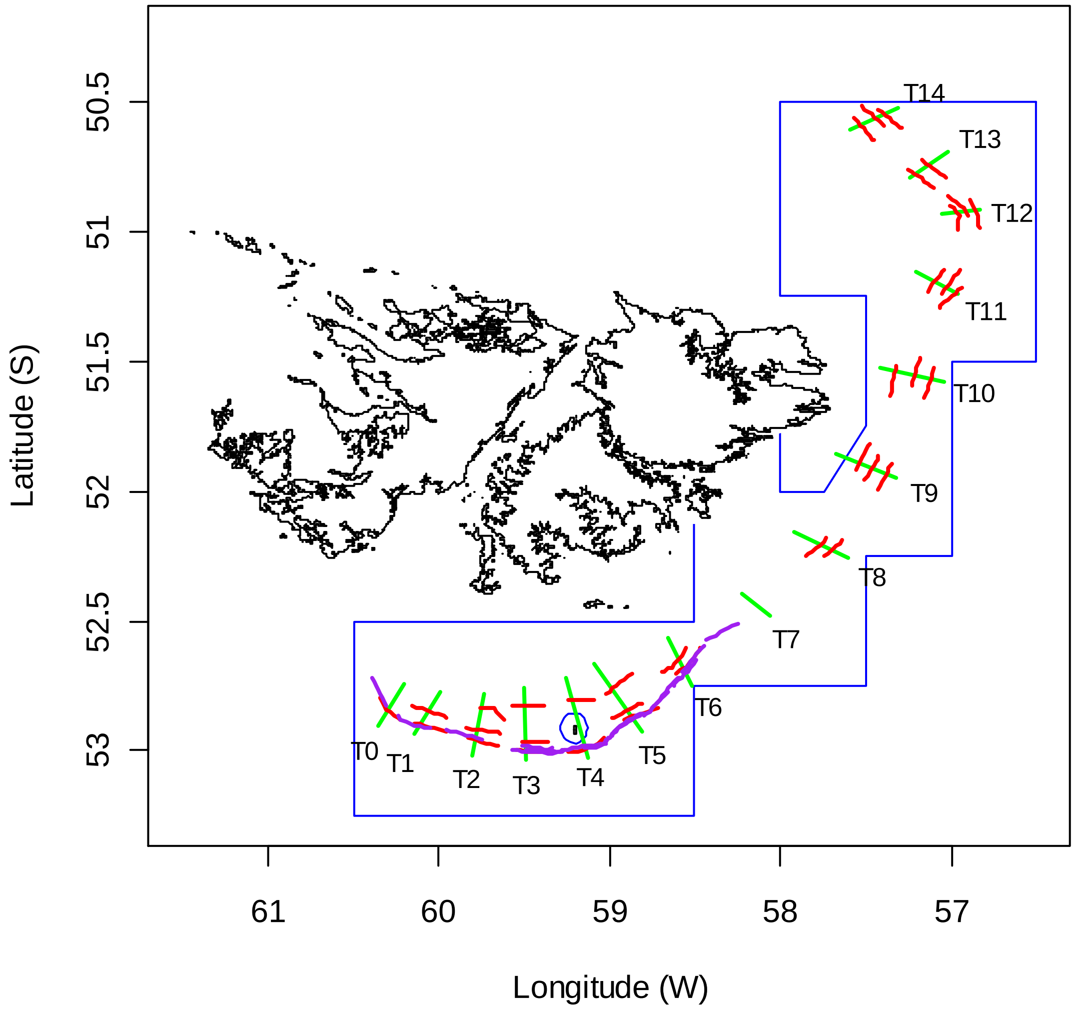


Figure 1. Transects (green lines), fixed-station trawls (red lines), and adaptive-station trawls (purple lines) sampled during the pre-season 2 2013 survey. Boundaries of the 'Loligo Box' fishing zone and the Beauchêne Island exclusion zone are shown in blue.

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 *Loligo* biomass estimates in high-density or high-variability locations. The same fixed-station plan as previous surveys (e.g., Winter et al., 2012) was used, with trawls ranging in distance from 11.9 to 17.7 km (mean 15.4). The trawls were designed for an expected duration of 2 hours each, but this is variable with the fishing power of the vessel. 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 trawling speed were recorded on the ship's bridge in 15-minute intervals, and a visual assessment was made 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 *Loligo* 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 *Loligo* amounts <100 kg were iteratively aggregated by adjacent intervals (if the total *Loligo* catch in a trawl was <100 kg it was assigned to one interval; the middle one).

Catch estimation

Catch of every trawl was processed separately by the factory crew and retained catch weight of *Loligo*, by size category, was estimated from the number of standard-weight blocks of frozen *Loligo* recorded by the factory supervisor. Catch weights of commercially valued fish species, including rock cod, were recorded in the same way, although without size categorization. Discards of damaged, undersized, or commercially unvalued fish and squid were estimated by FIFD survey personnel either visually (for small quantities) or by noting the ratio of discards to commercially retained fish and squid in sub-portions of the catch (for larger quantities). Discards were added to the product weights (as applicable) to give total catch weights of all fish and squid.

Biomass calculations

Biomass density estimates of *Loligo* 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, from the Marport net sensor system) according to the equation:

trawl width = (door dist. × footrope length) / (footrope + bridle lengths)

(www.seafish.org/media/Publications/FS40_01_10_BridleAngleandWingEndSpread.pdf)

Measurements of *Golden Chicha*'s trawl were: footrope = 95 m and bridle = 145 m.

In a previous survey report (Winter et al., 2010) it was found that *Loligo* catches taken in daylight were significantly higher than those that extended into darkness, due to *Loligo*'s diel migratory behaviour (Rodhouse, 2005). The daylight effect was re-examined in this survey by assigning to every 15-minute trawl interval (and its corresponding apportioned *Loligo* catch density) an index of whether it was completed within or without the period from sunrise to sunset. Sunrise and sunset times at each location were calculated using the algorithms of the NOAA Earth System Research Laboratory (www.esrl.noaa.gov/gmd/grad/solcalc/calcdetails.html). Generalized additive models (GAM) were then calculated of *Loligo* density per interval as a function of latitude and longitude (converted to projected coordinates), or latitude and longitude plus the daylight index as a factorial variable. The GAM with daylight index had a lower Akaike information criterion (AIC) (Akaike, 1973) than the GAM with only latitude and longitude, and it was concluded that the daylight effect significantly influenced *Loligo* catches in this survey. Two sets of biomass density estimates were therefore calculated according to the methods described below; one using all trawl intervals, and the other using only trawl intervals completed during daylight. The estimate that obtained the best geostatistic model fits and lowest coefficient of variation was taken as the final result.

Biomass density estimates were extrapolated to the fishing grounds area using geostatistical methods described in Roa-Ureta and Niklitschek (2007). The methods are based on the approach of separately modelling positive (non-zero) catch densities, and the probability of occurrence (presence/absence) of the positive catch densities (Pennington, 1983), then multiplying the two together. Positive catch densities were modelled with spatial correlation using a fitted variogram (kriging; Cressie, 1993) and Box-Cox transformation to normalize the data (MacLennan and MacKenzie, 1988). Presence/absence was modelled with spatial correlation by simulation using a Monte Carlo Markov Chain (MCMC) (Christensen, 2004; Roa-Ureta and Niklitschek, 2007). The same fishing area as the previous 2nd season (Winter et al., 2012) was delineated (Figure 2), i.e., more restricted than the fishing area of the 1st season this year (Winter et al., 2013). The present delineated fishing area is 14,865.7 km^2, and partitioned for analysis as 592 area units of 5×5 km.

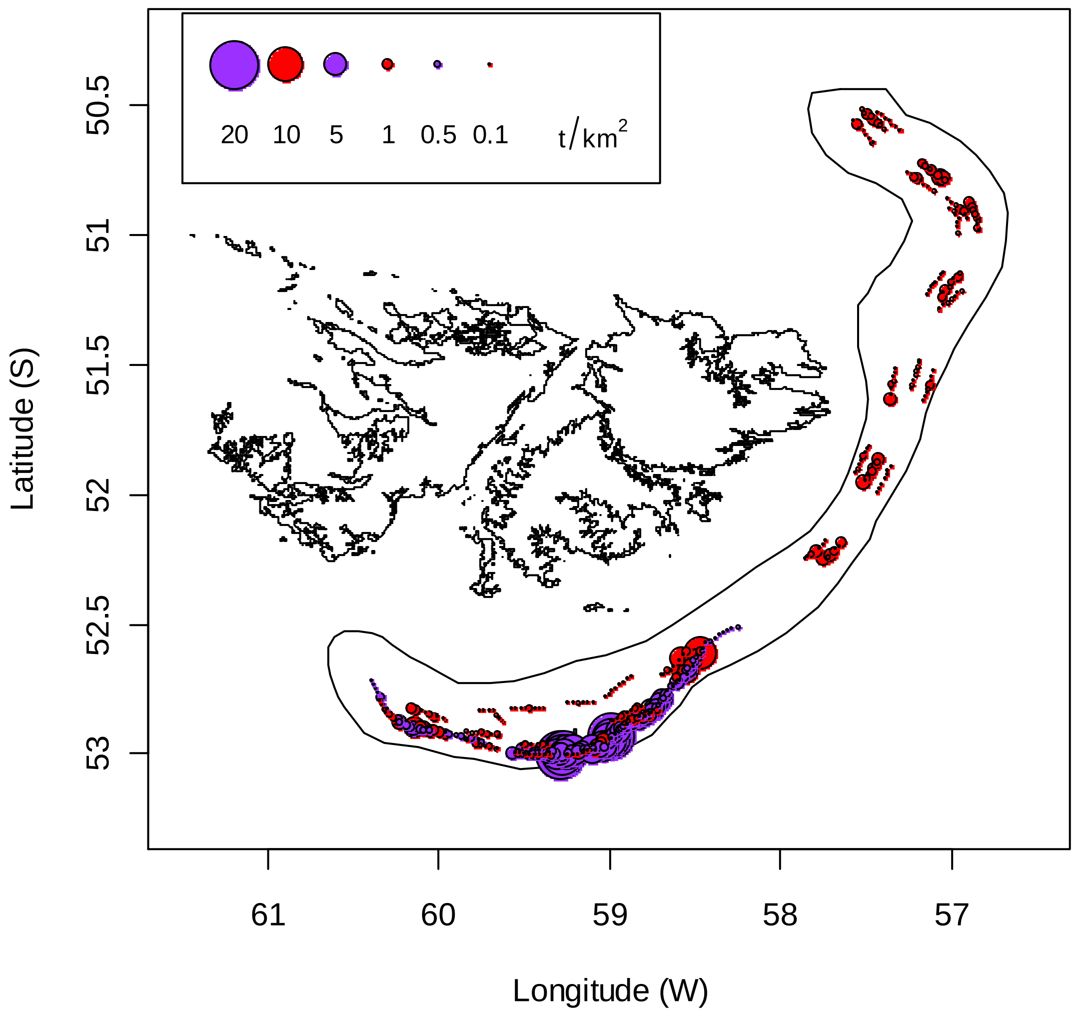


Figure 2 [previous page]. *Loligo* CPUE (t km^{-2}) of fixed-station trawls (red) and adaptive trawls (purple), per 15-minute trawl interval. The boundary of the fishing area is outlined.

Uncertainty of biomass on the fishing grounds was estimated by a hierarchical bootstrap re-sampling (Efron, 1981) of biomass densities in each of the 592 area units. Biomass densities per area unit were draws from the random normal distribution with mean equal to the empirical biomass density of each unit and standard deviation equal to the empirical biomass density multiplied by the average density coefficient of variation. The density coefficient of variation is the combination of positive catch density variation and presence/absence variation and was calculated jointly using the algorithm of Shono (2008). To this coefficient of variation was added a measure of error of acoustic apportionment. Assessing the acoustic marks (as described above; Sampling procedures) is a visual judgement and does not objectively differentiate *Loligo* from other echo targets entering the net. There is therefore no definitive way to quantify the potential error of this assessment. The error was instead approximated by re-running the geostatistic algorithms with density data that assumed all intervals within any one trawl had catches proportional only to the duration of the interval (i.e., equalizing the acoustic assessment), then calculating a total biomass estimate under this assumption, and computing the difference between the biomass estimate from the equalized assumption and the biomass estimate from the acoustically apportioned trawl intervals. The proportional value of this difference was taken as the measure of error of acoustic apportionment. The bootstrap for biomass uncertainty was iterated 10000×. This uncertainty is nevertheless still an understatement because it does not include evaluation of model error of the variogram itself.

Sea temperature and salinity measurements

Sea temperature and salinity measurements were recorded using a mini-CTD instrument (Valeport Ltd., UK) attached to the headrope of the trawl (Figure 2 in Winter et al., 2011). The instrument recorded conductivity (mS/cm), temperature (ºC) and pressure (dBar) continuously at a frequency setting of 1 Hz. Pressure was converted to depth as:

$$\text{Depth (m)} \quad = \quad \text{dBar} / 1.01325 \quad \text{(one atmosphere)}$$

Conductivity was converted to salinity units according to the practical salinity scale PSS-78 (UNESCO, 1983).

Surface temperature, surface salinity, bottom temperature and bottom salinity were extracted for archiving. Surface temperature and salinity were defined as the average of measurements between 1 m and 3 m tare depth[1] after deployment and before retrieval; thus two data each per trawl. Surface positions were linear extrapolated from the start and end trawl positions, as the vessel moves in a straight line when setting or retrieving a trawl. Bottom temperature and salinity were defined as all measurements sequentially recorded while the trawl was on the sea bottom, determined by cross-referencing the bridge log trawl start and end times with the CTD time stamp. To reduce the volume of data, measurements were sub-sampled from 1 per second (1 Hz) to 1 per 2 minutes. Bottom positions were assigned by interpolating the bridge log start and end trawl positions. Surface and bottom temperature and salinity, and depth, were then mapped across the fishing area by kriging.

[1] Shallower than 1 m is considered too turbulent for reliable measurement.

Biological analyses

Samples of 132 to 529 *Loligo* were collected from the factory at all trawl stations; 10850 in total. Biological analysis at sea included measurements of the dorsal mantle length (ML) rounded down to the nearest half-centimetre, sex, and maturity stage. The length-weight relationship $W = \alpha \cdot L^{\beta}$ (Froese, 2006) for *Loligo* was calculated by optimization from a subset of individuals that were weighed as well as measured. This subset included non-randomly selected individuals, to increase representation of the size ranges. Other subsets of *Loligo* were selected according to area stratification (north, central, south) and depth (shallow, medium, deep) of the trawl, and frozen for statolith extraction and age analysis (Arkhipkin, 2005). Length-weight measurements were also taken from one mullet (*Eleginops maclovinus*) and one fathead (*Neophrynichthys marmoratus*). Length-frequency measurements were taken from 4142 common rock cod (*Patagonotothen ramsayi*) and 38 marbled rock cod *Patagonotothen tessellata*.

Results

Catch rates and distribution

The survey started with fixed-station trawls in the north of the Loligo Box and proceeded southward through Transect 8 (Figure 1 and Appendix Table A1). From there the ship moved to the southwest of the survey area (Transect 0) and proceeded back northwards with the intent of finishing the survey around the centre (Transect 7) on the last day, in position to disembark the FIFD survey personnel a short distance away from Stanley. A schedule of 4 scientific trawls per day was maintained except for July 14th, when trawling had to be cancelled because of rough weather (Table A1). In total 56 scientific trawls were recorded during the survey: 36 fixed station trawls catching 51.34 t *Loligo* and 20 adaptive trawls catching 112.32 t *Loligo*. The first trawl on July 1st was discounted from spatial analysis because a rope was mistakenly left tied around the codend, restricting the normal opening (Table A1). The second trawl on July 13th was discounted because a whale carcass (presumed orca, judging by the teeth) was caught in the fore part of the codend, requiring the whole codend to be dumped back into the sea (Table A1). *Loligo* catch in that trawl was visually estimated at 3-4 tonnes by the vessel officers, but could not be accurately quantified or sampled. The second trawl on July 2nd was hauled early because the net was full (with medusae, as it turned out). This trawl was counted, because the effective catch was representative of the area trawled. Optional trawls (made after survey hrs) yielded an additional 32.83 t *Loligo*, bringing the overall total catch for the survey to 196.49 t. The scientific catch of 163.66 t was the lowest for a 2nd season since 2010, but higher than the four consecutive 2nd seasons from 2007 through 2010 (Table 1).

Average *Loligo* catch density among fixed-station trawls was 1.38 t km^{-2} north of 52º S and 2.58 t km^{-2} south of 52º S. Average *Loligo* catch density among adaptive-station trawls was 7.54 t km^{-2} (only taken south of 52º S). The ratio difference between adaptive-station densities and fixed-station densities in the south (7.54/2.58 = 2.92) was the highest for a 2nd season since at least 2009, and given the schedule of this survey (above), coincided with adaptive-station trawls being undertaken about a day earlier than in the previous 2nd season surveys since 2009. The outcome suggests that *Loligo*, at least in the south, are initially concentrated before migrating more diffusely throughout the fishing area. Average *Loligo* catch densities calculated only from trawl intervals in daylight were: 1.85 t km^{-2} north of 52º S, 2.98 t km^{-2} for fixed-station trawls south of 52º S and 8.55 t km^{-2} for adaptive-station trawls south of 52º S.

Table 1. *Loligo* 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

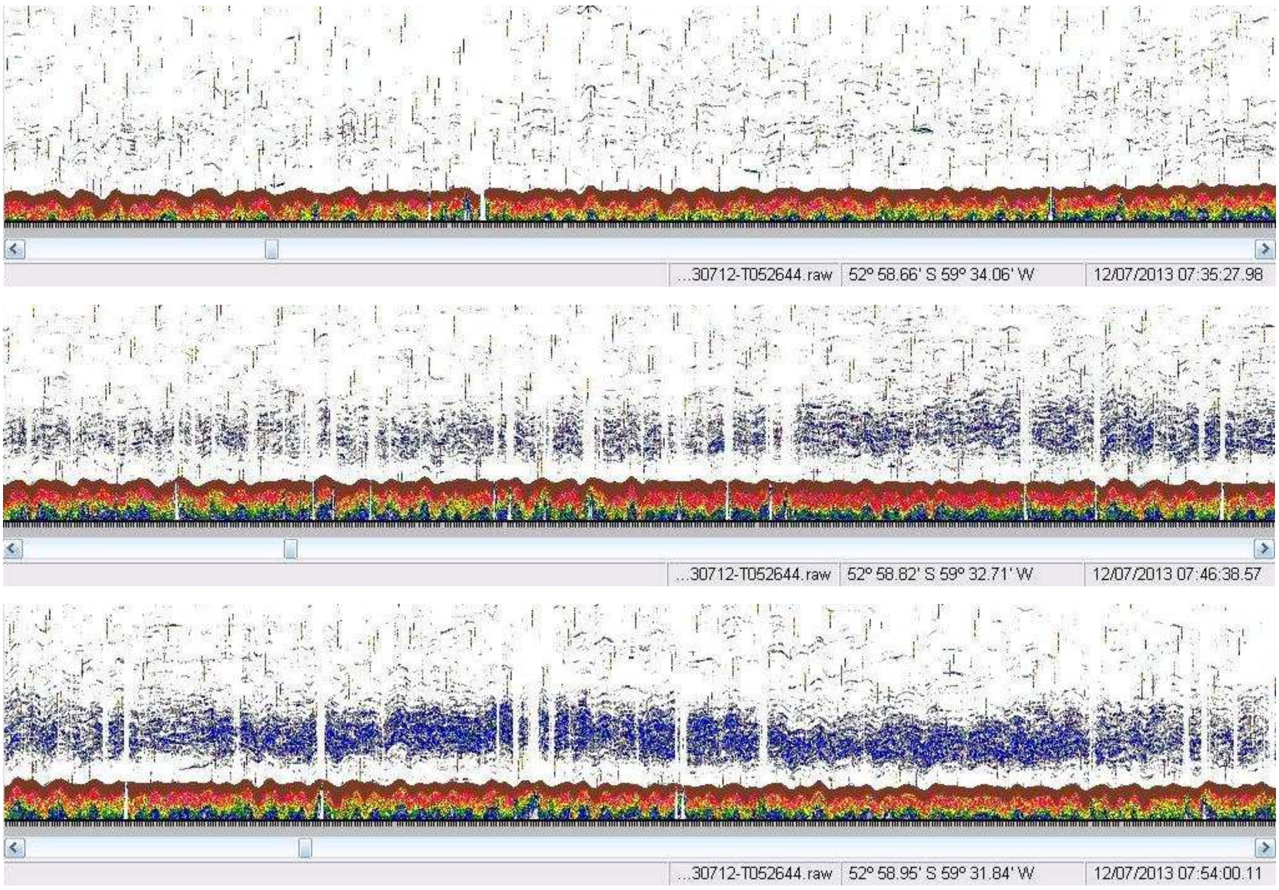


Figure 3. Target strength plots of the ship's Simrad ES 60 echosounder showing increasing acoustic backscatter concentration shortly before sunrise (7:35 to 7:54), on July 12th.

Biomass estimation

Trawl intervals taken only in actual daylight according to the NOAA ESRL algorithm represented 65% of the total (285/441). The total biomass calculation from all trawl intervals resulted in a coefficient of variation of 9.7%, and the total biomass calculation from only daylight trawl intervals resulted in a coefficient of variation of 6.9%. The geostatistical model for positive density gave similar fits in either case, but the geostatistical model for presence/absence gave a plausible range estimate only with daylight trawl intervals. Based on these outcomes, the *Loligo* biomass was estimated from the daylight trawl intervals only, and all further calculations refer to the daylight model. Expectedly, the biomass in daylight trawl intervals was higher: of the 12 trawls that passed through both daylight and non-daylight and caught ≥500 kg *Loligo*, 9 trawls showed higher average acoustic density in the daylight intervals than the non-daylight intervals. A typical observation was that acoustic backscatter sign would begin to concentrate around daybreak (Figure 3).

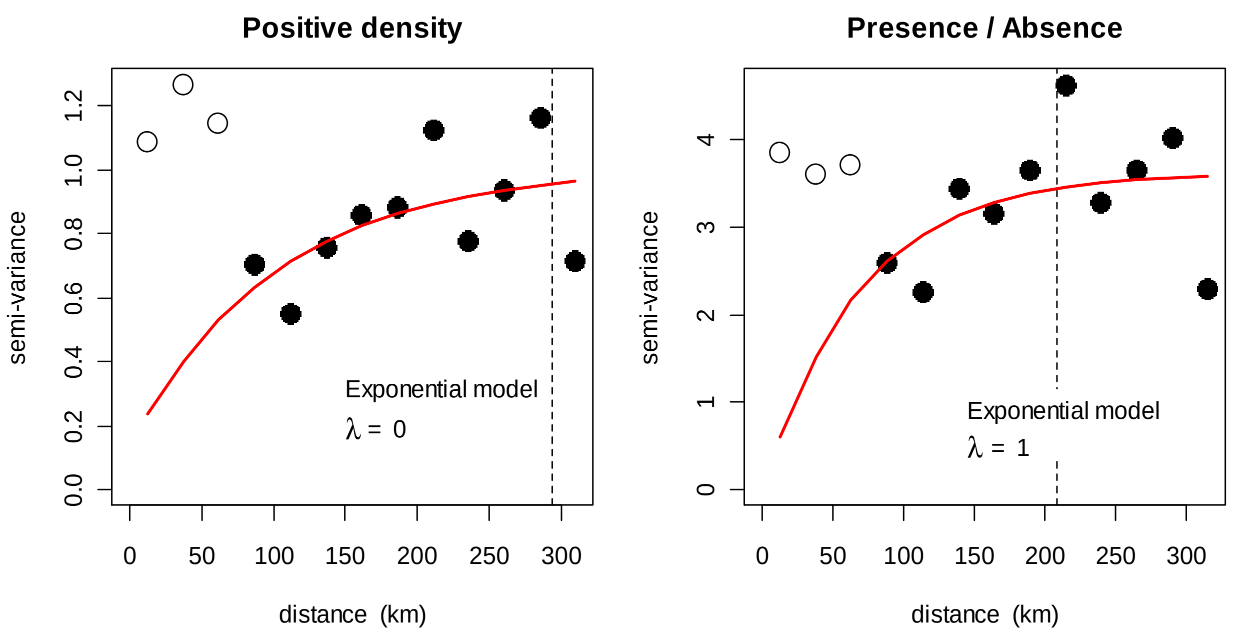


Figure 4. Empirical variogram (black circles) and model variogram (red line) of *Loligo* positive catch density distributions (left) and presence / absence (right). Empirical variogram values shown as open black circles were not included in the model fits. Practical correlation ranges are indicated by dotted lines on the plots; 295.0 km for positive density and 208.3 km for presence / absence.

Geostatistical modelling of the positive catch densities and presence/absence showed an unusual dual distribution. Over short distances up to approximately 65 km, catches were less strongly correlated than over subsequent distances >65 km. This is due to the high catches having been concentrated in one comparatively small area, but the same small area having also yielded some low catches, resulting in much variability at a small spatial scale (Figure 2). To remove this effect, the variogram was fit (red lines in the Figure 4 plots) only on spatial correlations at distances >65 km (solid black dots in the Figure 4 plots). While this represents a somewhat artificial approach, the alternative would be to model the spatial distribution by interpolation, which likewise infers that the shortest distances are the most closely correlated, but can give spurious results when calculated over an irregular surface (e.g., densities or probabilities <0 at outlying points). The positive density variogram was modelled with an exponential function and λ = 0 Box-Cox transformation (i.e., logarithmic transformation), obtaining a practical range (range at which the variogram value reaches 95% of the sill; Yadav et al., 2012) of 295.0 km (Figure 4, left). The MCMC for presence/absence was modelled on the binomial distribution with likewise an exponential function for spatial correlation, at λ = 1 (no transformation). The presence /absence variogram obtained a practical range of 208.3 km (Figure 4, right).

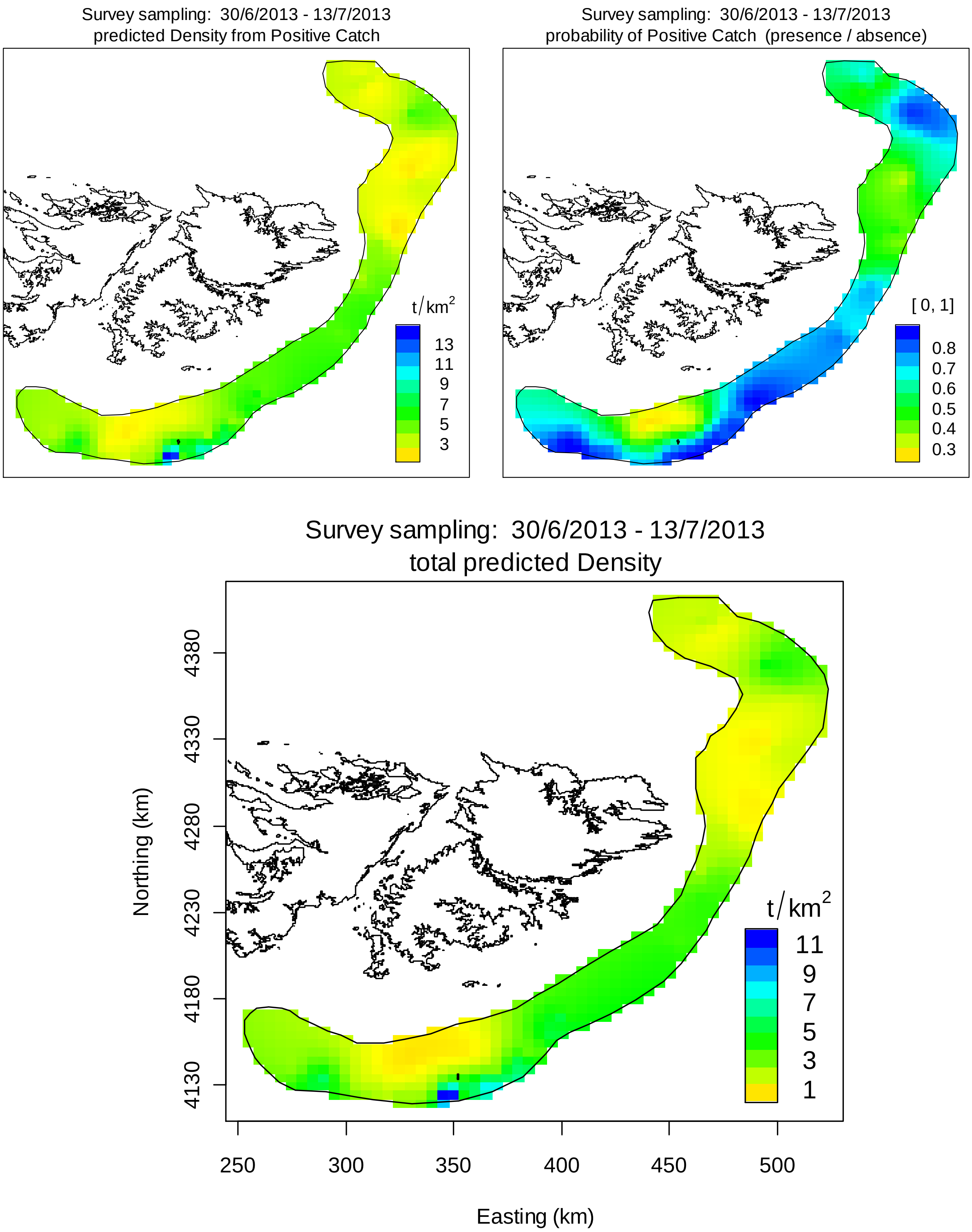


Figure 5 [previous page]. *Loligo* density estimates per 5 × 5 km area units. Top left (A): catch density distribution from variogram model of positive catches. Top right (B): probability of positive catch modelled from MCMC of presence/absence. Main plot (C): predicted density = A × B. For calculating geostatistical estimates, coordinates were converted to WGS 84 projection in UTM sector 21F using Quantum GIS software (www.qgis.org).

Total *Loligo* biomass in the fishing area was estimated by the geostatistical model at 36,283 t, with a 95% confidence interval of [31,359 to 41,162 t]. Highest concentrations of *Loligo* were in the small area south of Beauchêne Island (Figure 5). Of the estimated total biomass, 11,740 t [9,565 to 13,997 t] were north of 52 °S, and 24,544 t [20,380 to 28,916 t] were south of 52 °S. The estimated total biomass of 36,283 t was the third highest for a 2nd season since 2006 inclusively.

Sea temperature and salinity

The Valeport mini-CTD returned useable temperature and salinity data from 48 of the 56 scientific trawls, plus the cancelled trawl on the last morning. Spatial distributions are shown in Figures 6 and 7. Compared to the 2nd season survey of 2012 (Winter et al., 2012), bottom temperatures varied over a greater range and were warmer on average, while surface temperatures varied less and were warmer than the full range of survey temperatures in the 2nd season survey of 2012. Salinities differed little between the 2nd season surveys of 2012 and 2013.

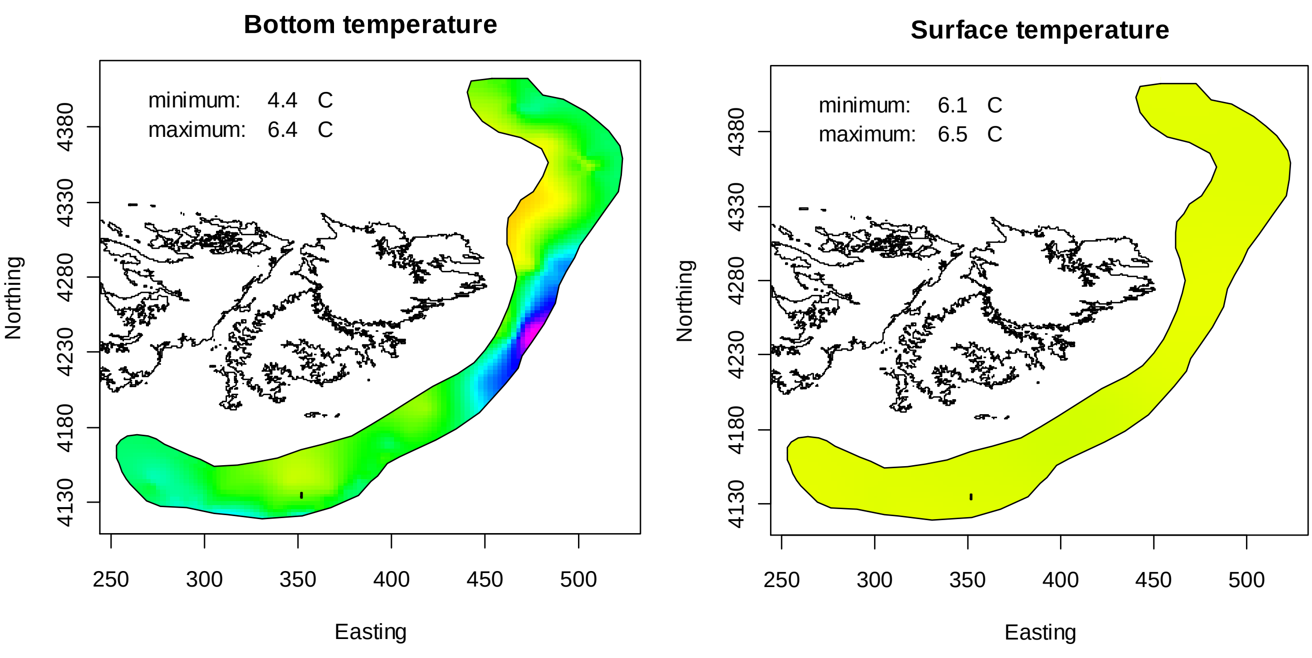
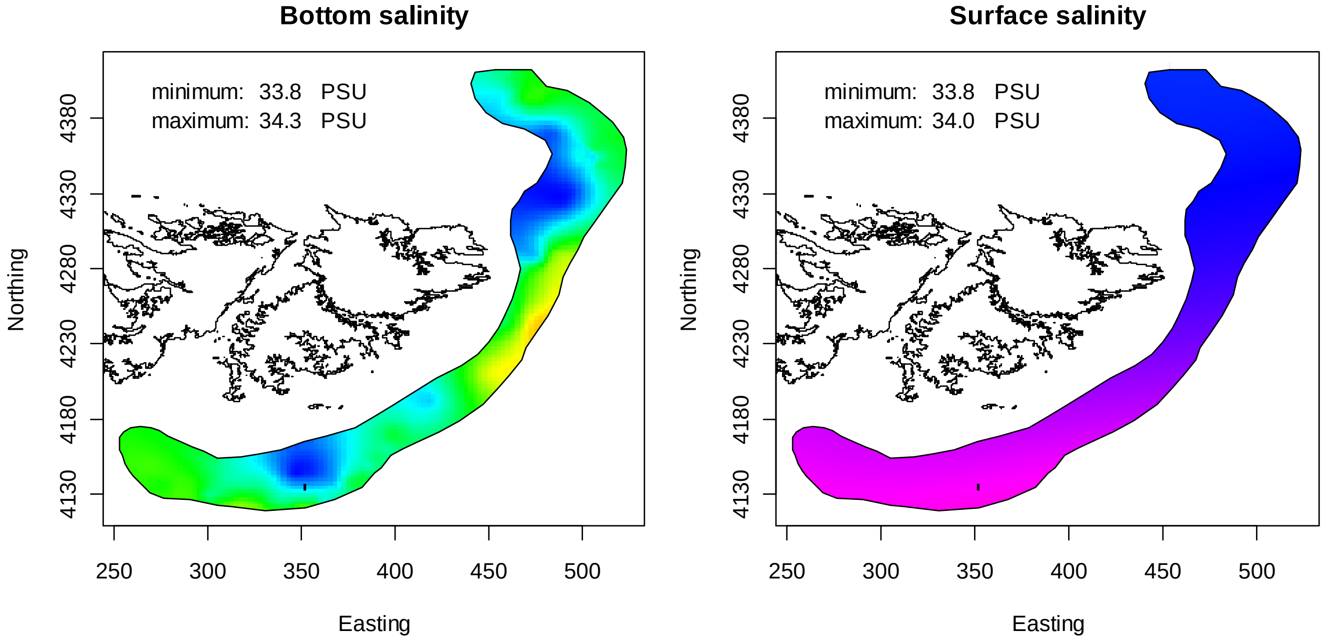


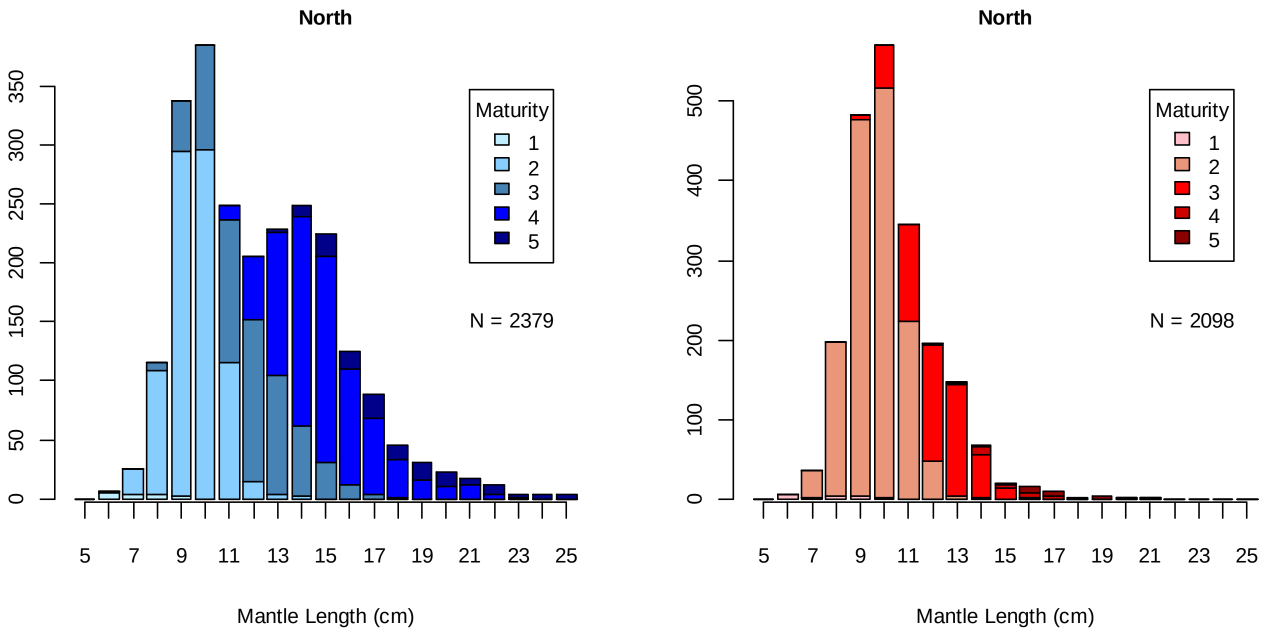
Figure 6. Bottom and sea surface temperatures mapped from measurements of the mini-CTD attached to the trawl. Both plots to same scale; temperature increasing purple → yellow.

Figure 7 [next page]. Bottom and surface salinities mapped from measurements of the mini-CTD attached to the trawl. Both plots to same scale; salinity increasing purple → yellow.



Biological data

Thirty-nine taxa were identified in the catches (Appendix Table A2), of which *Loligo* made up 71.7% by weight. Compared to 1st season of this year (Winter et al., 2013), the catch composition was characterized by much lower abundances of rock cod, hake, and hoki. Compared to 2nd season of last year (Winter et al., 2012), the catch composition was characterized by lower abundance of rock cod and higher abundance of medusae. 10,850 *Loligo* were measured for length and maturity, and 539 *Loligo* were sampled for the length-weight relationship.



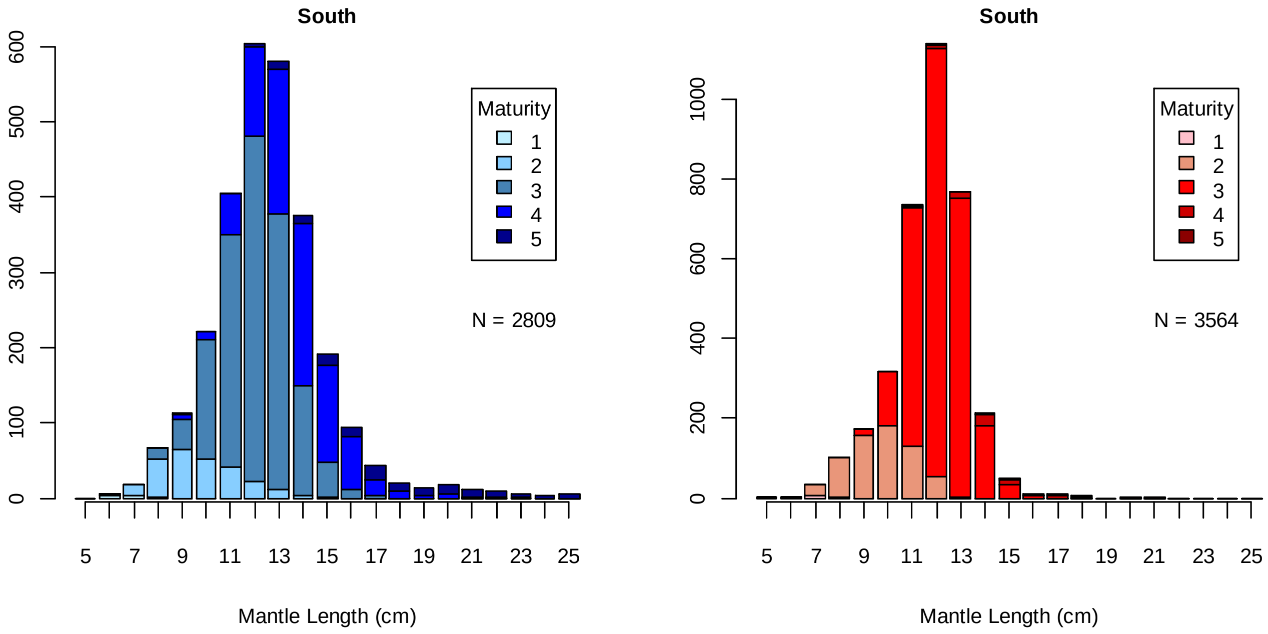


Figure 8. Length-frequency distributions by maturity stage of male (blue) and female (red) *Loligo* from trawls north (top) and south (bottom) of latitude 52 ºS.

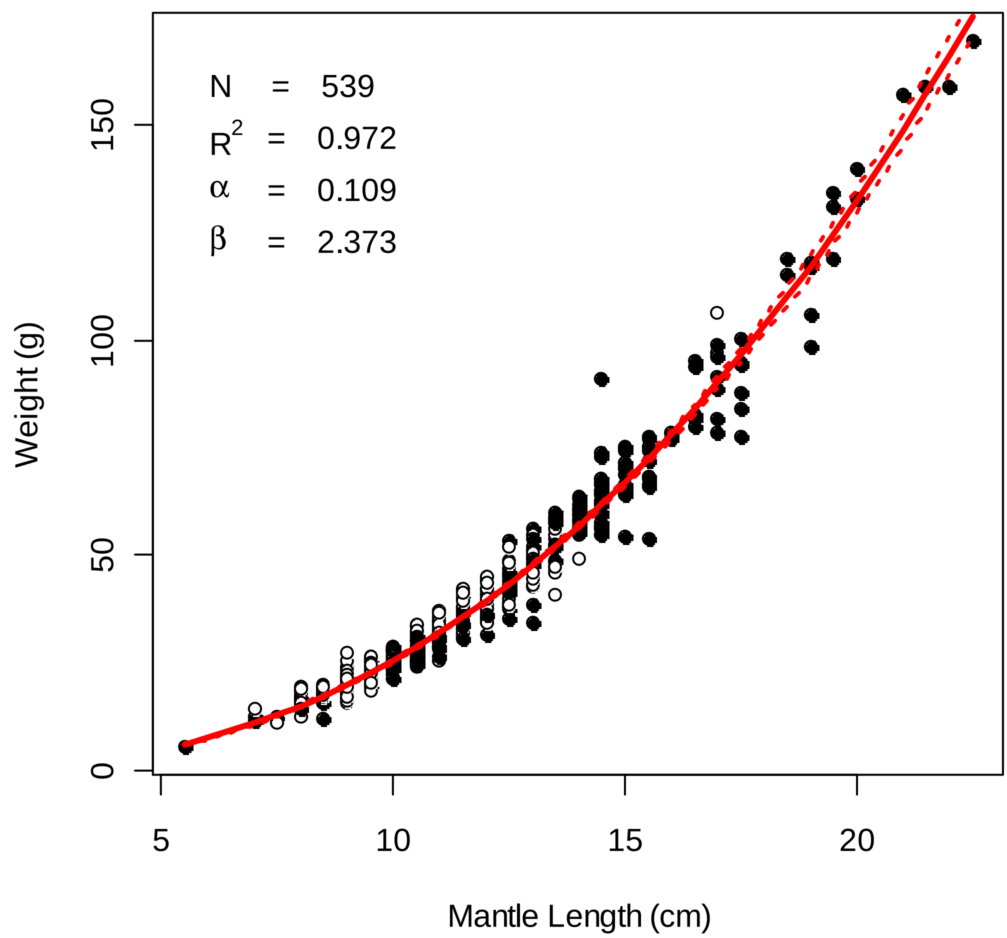


Figure 9. Length – weight relationship of *Loligo* sampled during the survey. Filled circles: males, open circles: females. Dotted lines: 95% confidence interval of the relationship.

Loligo mantle length and maturity distributions north and south of 52° S are plotted in Figure 8. Females in the south had higher modal length (12 cm) and maturity (81% at maturity stage ≥ 3) than in the north (modal length 10 cm and 28% at maturity stage ≥ 3). Males in the south were unimodal in length (12 cm) and predominantly (55%) stage 3, while in the north males had a bimodal length distribution (10 and 14 cm) predominated by maturity stages 2 (36%) and 4 (33%). Females had a considerably narrower length range with a maximum of 20.5 cm and only 1% > 15 cm, vs. a maximum of 31 cm and 11% > 15 cm for males.

The *Loligo* length-weight relationship was calculated from 539 individuals, resulting in parameters $\alpha = 0.10850 \pm 0.00594$ and $\beta = 2.37257 \pm 0.02163$ (± 1 sd) (Figure 9). Optimized separately, the 291 male and 248 female data gave significantly although narrowly different length-weight relationships (bootstrap test, $p < 0.001$), characterized by males having higher weight per mantle length below approx. 11.5 cm, and lower weight per mantle length above 11.5 cm.

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Appendix

Table A1. Survey stations with total *Loligo* catch. Time: local (Stanley, F.I.), latitude: °S, longitude: °W.

Transect	Station	Obs Code	Date	Start			End			Depth (m)	*Loligo* (kg)
				Time	Lat	Lon	Time	Lat	Lon		
14	39	616	30/06/2013	7:05	50.52	57.45	8:57	50.6	57.29	289	15
14	38	617	30/06/2013	9:58	50.60	57.37	12:00	50.52	57.52	252	1925
14	37	618	30/06/2013	13:03	50.55	57.58	14:55	50.65	57.46	140	625
13	34	619	30/06/2013	16:08	50.75	57.27	18:28	50.83	57.10	132	775
13	36	620	01/07/2013	7:04	50.75	57.03	9:18	50.68	57.21	297	(30)[a]
13	35	621	01/07/2013	10:12	50.71	57.19	12:06	50.79	57.03	253	3400
12	33	622	01/07/2013	13:07	50.87	56.91	15:19	50.99	56.84	250	1900
12	32	623	01/07/2013	16:02	50.96	56.90	17:47	50.86	57.02	121	900
12	31	624	02/07/2013	7:00	50.88	57.02	8:45	50.99	56.96	114	250
11	28	625	02/07/2013	10:00	51.13	57.02	11:58	51.23	57.14	129	50
11	29	626	02/07/2013	12:50	51.25	57.07	14:55	51.15	56.95	143	1425
11	30	627	02/07/2013	15:47	51.20	56.91	17:42	51.29	57.07	271	475
10	25	628	03/07/2013	6:55	51.50	57.31	8:57	51.63	57.35	152	950
10	26	629	03/07/2013	9:50	51.61	57.24	11:41	51.49	57.18	227	550
10	27	630	03/07/2013	12:35	51.51	57.08	14:36	51.64	57.16	289	375
9	24	631	03/07/2013	16:30	51.88	57.34	18:24	52.00	57.43	287	75
9	22	632	04/07/2013	6:56	51.94	57.58	8:51	51.82	57.48	164	350
9	23	633	04/07/2013	9:39	51.85	57.41	11:50	51.96	57.51	220	2850
8	20	634	04/07/2013	13:39	52.18	57.62	15:26	52.25	57.74	258	2200
8	19	635	04/07/2013	16:33	52.17	57.71	18:29	52.25	57.85	197	975
0	1	636	05/07/2013	6:55	52.78	60.36	8:51	52.88	60.22	254	1850
1	3	637	05/07/2013	9:35	52.89	60.17	11:24	52.93	59.96	234	6000
2	6	638	05/07/2013	12:15	52.94	59.88	14:10	52.98	59.65	240	975
3	9	639	05/07/2013	14:55	52.99	59.58	16:54	53.00	59.35	239	10
1	2	640	06/07/2013	6:54	52.82	60.18	9:06	52.87	59.96	195	1500
2	5	641	06/07/2013	9:49	52.91	59.87	11:46	52.93	59.64	169	1300
3	8	642	06/07/2013	12:25	52.96	59.58	14:10	52.97	59.36	179	675
4	11	643	06/07/2013	14:59	53.01	59.27	17:11	52.95	59.03	260	2800
2	4	644	07/07/2013	7:04	52.83	59.79	8:59	52.88	59.62	159	100
3	7	645	07/07/2013	9:44	52.83	59.60	11:40	52.83	59.38	147	200
4	10	646	07/07/2013	12:20	52.82	59.32	14:24	52.80	59.09	111	100
5	12	647	07/07/2013	15:05	52.79	59.05	17:09	52.70	58.86	125	49
5	13	648	08/07/2013	6:54	52.81	58.79	9:16	52.87	58.98	148	725
5	14	649	08/07/2013	9:55	52.89	58.95	11:57	52.84	58.72	212	1700
6	16	650	08/07/2013	13:06	52.72	58.64	15:17	52.60	58.47	233	10900
6	15	651	08/07/2013	16:09	52.59	58.54	18:37	52.70	58.69	166	2350
A	1	652	09/07/2013	6:52	52.70	60.40	8:55	52.83	60.31	257	500
A	2	653	09/07/2013	9:39	52.86	60.27	11:40	52.91	60.06	246	3250
A	3	654	09/07/2013	12:25	52.92	59.99	14:27	52.95	59.75	217	1750
A	4	655	09/07/2013	15:18	52.99	59.61	17:29	53.01	59.33	247	4300
A	5	656	10/07/2013	6:52	52.99	59.52	8:59	53.00	59.28	222	4425
A	6	657	10/07/2013	9:44	53.00	59.27	11:50	52.97	59.02	217	3700
A	7	658	10/07/2013	12:40	52.96	59.01	14:47	52.86	58.82	245	8225
A	8	659	10/07/2013	15:34	52.83	58.75	17:41	52.72	58.59	254	4750
A	9	660	11/07/2013	7:02	52.64	58.48	9:11	52.75	58.63	259	2150
A	10	661	11/07/2013	9:57	52.76	58.64	12:05	52.87	58.79	254	4650
A	11	662	11/07/2013	12:51	52.86	58.80	15:10	52.94	58.99	254	4950
A	12	663	11/07/2013	16:03	52.94	58.99	18:07	52.99	59.15	252	3775
A	13	664	12/07/2013	6:56	53.00	59.30	9:04	52.98	59.51	202	1825
A	14	665	12/07/2013	9:46	52.99	59.51	11:52	53.00	59.27	235	13625
A	15	666	12/07/2013	12:55	53.01	59.32	14:56	52.98	59.10	211	27025
A	16	667	12/07/2013	15:51	52.98	59.06	18:00	52.89	58.89	234	15250

A	17	668	13/07/2013	6:53	52.90	58.94	9:05	52.83	58.74	247	4900
A	18	669	13/07/2013	9:55	52.83	58.74	12:00	52.73	58.60	257	(0)[b]
A	19	670	13/07/2013	13:35	52.71	58.59	15:37	52.60	58.45	242	2795
A	20	671	13/07/2013	16:23	52.58	58.46	18:28	52.51	58.25	226	375
7	17	672	14/07/2013	7:50	52.38	58.14	8:25	52.39	58.17	183	(0)[c]

a: Catch discounted because a strap was mistakenly left tied around the front of the codend, restricting the opening.

b: Catch estimated at 3-4 tonnes *Loligo*, but had to be dumped entirely because a whale carcass was caught in the fore part of the codend.

c: Trawl abandoned because of rough weather.

Table A2. Survey total catches by species / taxon.

Species Code	Species / Taxon	Total catch (kg)	Total catch (%)	Sample (kg)	Discard (kg)
LOL	*Loligo gahi*	163664	71.7	395	4
PAR	*Patagonotothen ramsayi*	32143	14.1	300	28088
MED	Medusae sp.	17901	7.8	0	17901
BLU	*Micromesistius australis*	2577	1.1	0	2577
WHI	*Macruronus magellanicus*	2253	1	0	10
BAC	*Salilota australis*	2232	1	0	66
DGH	*Schroederichthys bivius*	1907	0.8	0	1892
HAK	*Merluccius hubbsi*	1561	0.7	0	55
RBR	*Bathyraja brachyurops*	744	0.3	0	92
KIN	*Genypterus blacodes*	707	0.3	0	43
ZYP	*Zygochlamys patagonica*	700	0.3	0	700
LAR	*Lampris immaculatus*	450	0.2	0	50
CGO	*Cottoperca gobio*	384	0.2	0	384
TOO	*Dissostichus eleginoides*	230	0.1	0	9
RFL	*Zearaja chilensis*	220	0.1	0	10
RAL	*Bathyraja albomaculata*	154	0.1	0	14
PTE	*Patagonotothen tessellata*	112	<0.1	7	110
RPX	*Psammobatis* spp.	74	<0.1	0	74
GRC	*Macrourus carinatus*	64	<0.1	0	56
RSC	*Bathyraja scaphiops*	53	<0.1	0	4
POR	*Lamna nasus*	50	<0.1	0	0
RBZ	*Bathyraja cousseauae*	28	<0.1	0	3
PAT	*Merluccius australis*	17	<0.1	0	0
NEM	*Neophyrnichthys marmoratus*	14	<0.1	3	14
MUL	*Eleginops maclovinus*	14	<0.1	4	12
RDO	*Amblyraja doellojuradoi*	11	<0.1	0	10
ILL	*Illex argentinus*	10	<0.1	0	0
GRF	*Coelorhynchus fasciatus*	10	<0.1	0	10
SEC	*Seriolella caerulea*	8	<0.1	0	7
EEL	*Iluocoetes fimbriatus*	8	<0.1	0	8
RMC	*Bathyraja macloviana*	5	<0.1	0	0
RED	*Sebastes oculatus*	5	<0.1	0	5
MYA	*Myxine australis*	2	<0.1	0	2
DGS	*Squalus acanthias*	2	<0.1	0	2
BUT	*Stromateus brasiliensis*	2	<0.1	0	2
OCM	*Octopus megalocyathus*	1	<0.1	0	0
MMA	*Mancopsetta maculata*	1	<0.1	0	1
CHE	*Champsocephalus esox*	1	<0.1	0	1
NOW	*Paranotothenia magellanica*	<0.1	<0.1	0	0
		228,321		710	52,217