FALKLAND
ISLANDS
FISHERIES
DEPARTMENT

Loligo gahi Stock Assessment Survey, 1st Season 2012

Vessel	Kalatxori (ZDLB2), Falkland Islands
Dates	09/02/2012 - 23/02/2012
Scientific Crew	A. Winter, D. Davidson, E. Hancox

SUMMARY

A stock assessment survey for *Loligo gahi* squid was conducted in the 'Loligo Box' from 9th to 23rd February 2012. Fifty-six scientific trawls were taken during the survey, catching 127.6 tonnes of *Loligo*. The highest *Loligo* catches were obtained in grid XPAP in the north, and more diffusely; in the south from grids XUAL and XVAL westward. However, these grid areas were also the latest in the survey to be fished, suggesting that *Loligo* were still in the process of out-migrating while the survey was underway.

A geostatistical estimate of 30,706 tonnes *Loligo* biomass was calculated for the fishing zone. This represents the second highest first-season biomass estimate since surveys began in the present format in 2006. *Loligo* density distributions were statistically correlated with temperature and salinity distributions, but the correlation was weakly predictive, mainly showing highest densities with bottom temperatures of ~7.9° C and surface temperatures of ~10.2° C. *Loligo* sizes and maturities by sex were correlated with latitude, longitude, and survey day, according to trends that indicated different patterns of migration in north and south sub-areas of the fishing zone.

INTRODUCTION

A stock assessment survey for *Loligo gahi* (Patagonian squid) was conducted by FIFD personnel onboard the fishing vessel *Kalatxori* from 9th to 23rd February 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 area (Arkhipkin et al., 2008) 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 1st fishing season 2012.
2) Estimate the biomass and spatial distribution of rock cod (*Patagonotothen ramsayi*).
3) Collect biological information on *Loligo*, rock cod, and opportunistically other commercially important fish and squid taken in the trawls.

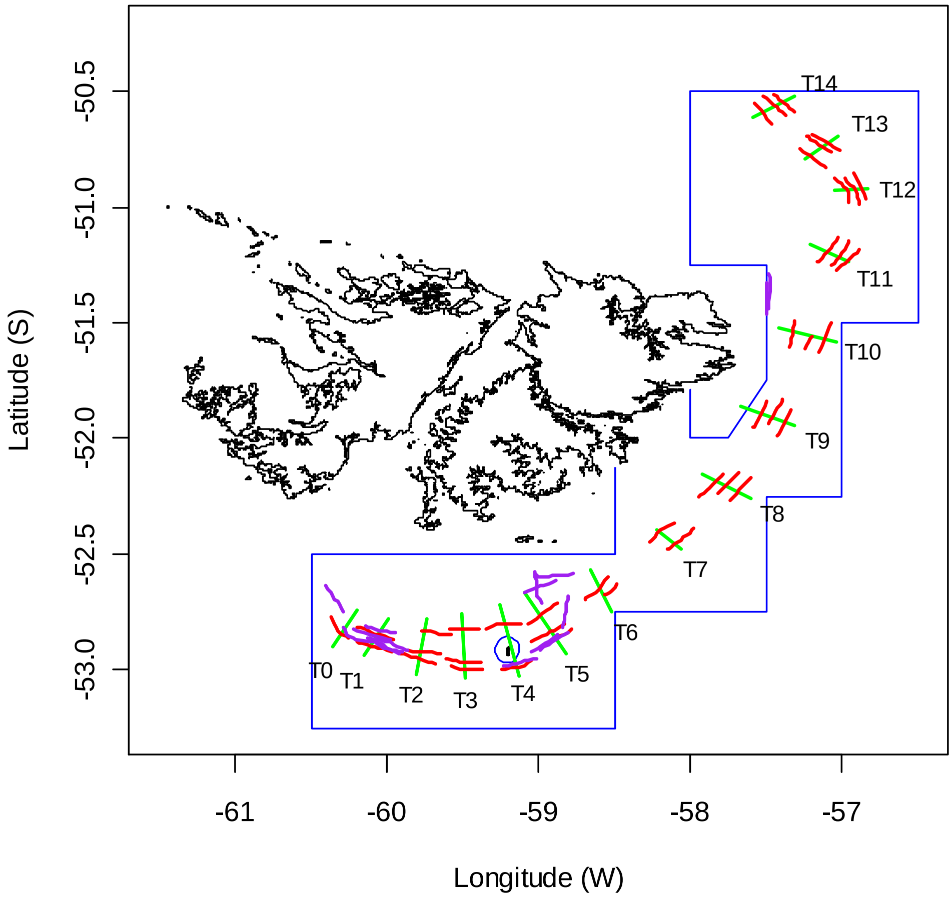


Figure 1. Transects (green lines), fixed-station trawls (red lines), and adaptive-station trawls (purple) sampled during the pre-season 1 2012 survey. Boundaries of the ‘Loligo Box’ fishing area and the Beauchêne Island exclusion zone are shown in blue.

The F/V *Kalatxori* is a Stanley, Falkland Islands - registered stern trawler of 49.44 m length, 950 mt gross registered tonnage, and 1995 main engine bhp. Additional crew and equipment specifications are listed in Anders (2011) and Parker (2011). Like all vessels employed for these pre-season surveys, *Kalatxori* operates regularly in the commercial *Loligo* fishery and used its commercial trawl gear for the survey catches.

The following personnel from FIFD participated in the survey:

Andreas Winter	Chief scientist
Deborah Davidson	Observer
Emily Hancox	Observer

METHODS

Sampling procedures

The survey plan was designed to include 39 fixed-station trawls located on a series of 15 transects perpendicular to the shelf break within 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. In conformity with previous surveys (Paya, 2008; Paya and Winter, 2009), the trawls were set to standard durations of 2 hours and conducted 4 times per day. All trawls were bottom trawls. During the progress of each trawl, latitude, longitude, bottom depth, bottom temperature, net vertical opening, 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 therefore iteratively aggregated by adjacent intervals (and 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 bosun. Catch weights of commercially valued finfish species, including rock cod, were recorded in the same way, although without size categorization. Discards of damaged, undersized, or commercially unvalued finfish 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; the product of trawling distance × trawl horizontal opening (width). Trawling 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 by acoustic sensors) according to the equation:

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

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

Measurements of *Kalatxori*'s trawl were: footrope = 77.57 m, sweep = 130 m, and bridle = 15 m.

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 (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 delineated fishing area of 14,099.5 km^2 as the previous season (Winter et al., 2011b) was assumed, and partitioned for analysis as 557 area units of 5×5 km.

Uncertainty of total biomass on the fishing grounds was estimated by randomly re-sampling trawls 4000× and fitting the geostatistical methods above to each re-sample. Re-samples differed from a standard bootstrap approach (Efron, 1981) insofar as trawls were selected by replacement, but duplicate selections removed, to preserve the realistic structure of the survey (trawls were not duplicated).

Because duplication varied randomly, the re-sampling algorithm thus generated variability in both the number and distribution of trawls.

Vessel comparison

In previous survey reports (Paya, 2008; Winter et al., 2010) the concern was addressed that a survey vessel smaller than the fleet average would result in a biased underestimate of *Loligo* biomass on the fishing grounds. This concern is re-examined in the present report because *Kalatxori* is one of the smallest trawlers in the fleet (Table 1). Vessels employed for 1st season surveys since 2008 were compared by generalized linear models (GLM) with reference to a CPUE index standardized per trawl net width. Calculations and details of the comparisons are described in Winter et al., 2010.

Table 1. Size and fishing power characteristics of vessels used for the *Loligo* first pre-season surveys since 2008.

Survey	Survey Vessel	LOA	GRT	Main HP	Net width*
2008 1	*Golden Chicha*	62.98 m	1345	2200	40.89 m
2009 1	*Castelo*	59.65 m	1321	2450	42.69 m
2010 1	*Beagle*	92.23 m	2849	2944	41.54 m
2011 1	*Venturer*	84.20 m	1881	2450	46.59 m
2012 1	*Kalatxori*	49.44 m	950	1995	45.80 m

* Average from pre-season survey

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. 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).

For this report, surface temperature and salinity, and bottom temperature and salinity were examined. Surface temperature and salinity were defined as the average of measurements within 2 m of the surface after deployment and before retrieval; thus two data each per trawl. Surface positions were assigned as the start and end trawl positions. While this is not technically accurate (start and end trawl positions are recorded when the net is in fishing position), it is a sufficient approximation for area coverage. Bottom temperature and salinity were defined as all measurements sequentially recorded while the trawl was on the sea bottom, determined by inspection of the depth profile. To reduce the volume of data, measurements were sub-sampled from 1 per second (1 Hz) to 1 per minute. Bottom positions were assigned by interpolating the start and end trawl positions. Surface and bottom temperature and salinity were then mapped across the fishing area by cubic-spine interpolation (Akima, 1996) from the assigned measurement positions. Relationships between *Loligo* densities from the geostatistical algorithm, and as predictor variables the sea surface and bottom temperatures and salinities, were analyzed using a generalized additive model (GAM). The predictor variables were added to the GAM by forward selection and retained if they decreased the Akaike information criterion (AIC).

Biological analyses

Random samples of approximately 150 *Loligo* were collected from the factory at all trawl stations (as far as available). Biological analysis at sea included measurements of the dorsal mantle length (ML) rounded down to the nearest half-centimetre, sex, and maturity stage. Relationships between average dorsal mantle length or maturity stage, per trawl, and predictor variables latitude, longitude, depth, and survey day, were analyzed using GAM; calculated separately for males and females. Predictor variables again were added to the GAMs by forward selection and retained if they decreased the Akaike information criterion (AIC). A separate GAM was calculated to analyze the relationship of male/female ratio with the predictor variables. The allometric 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. Samples of *Loligo* were additionally taken according to area stratification (north, central, south) and depth (shallow, medium, deep), and frozen for statolith extraction and age analysis (Arkhipkin, 2005). Random samples of up to 100 rock cod were collected from trawls in which rock cod were caught. Biological analysis of rock cod included measurements of total length (TL) rounded down to the nearest centimetre, sex, and maturity stage, and specimen collection for fat tissue analysis. Length frequency, sex, maturity, and otolith samples were taken from other commercial fish when these occurred in trawls.

RESULTS

Catch rates and distribution

As in prior seasons (Winter et al., 2010; Winter et al., 2011a, b), the survey was started with fixed-station trawls in the north of the Loligo Box (on transect 14; Figure 1) and proceeded southward. Fifty-six scientific trawls were recorded during the survey: 39 fixed station trawls catching 35.24 t *Loligo* and 17 adaptive trawls catching 92.38 t *Loligo*. Additionally, optional trawls (made after survey hrs) yielded 16.46 mt *Loligo*, bringing the total catch for the survey to 144.08 mt. Total *Loligo* catch was 2.5× higher than the 1st pre-season survey of 2011 (Winter et al., 2011a) but >2.5× lower than the 1st pre-season survey of 2010 (Arkhipkin et al., 2010) (Table 2), whereby the *Kalatxori* is a notably smaller vessel than the *Beagle F.I.* used for the 2010 1st pre-season survey (Table 1).

Table 2. *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			

Average *Loligo* catch density among fixed-station trawls was 0.05 t km^{-2} north of 52º S and 2.41 t km^{-2} south of 52º S. Average *Loligo* catch density among adaptive-station trawls was 26.38 t km^{-2} north of 52º S and 6.10 t km^{-2} south of 52º S. The large difference in catch density between fixed and adaptive trawls north of 52º S reflects a difference in location: the adaptive trawls were taken in an area further inshore than any fixed trawls north of 52º S (Figure 2). That same are had been noted for high

Loligo density in the previous year's first season survey (Winter et al., 2011a), suggesting that *Loligo* in the north have consistently not out-migrated further into deep water by the time of the survey. Fixed-station sampling on this survey had begun in the north, but the two adaptive trawls in the north had been taken on the last day of the survey, thus maximizing the time delay between the two subsets of data. In the south, fixed and adaptive trawls were closer in time, and more spatially interspersed (Figure 2), although adaptive trawls were still shallower on average (90.6 m vs. 102.1 m). Expectedly, the catch density difference between fixed and adaptive trawls in the south was lower.

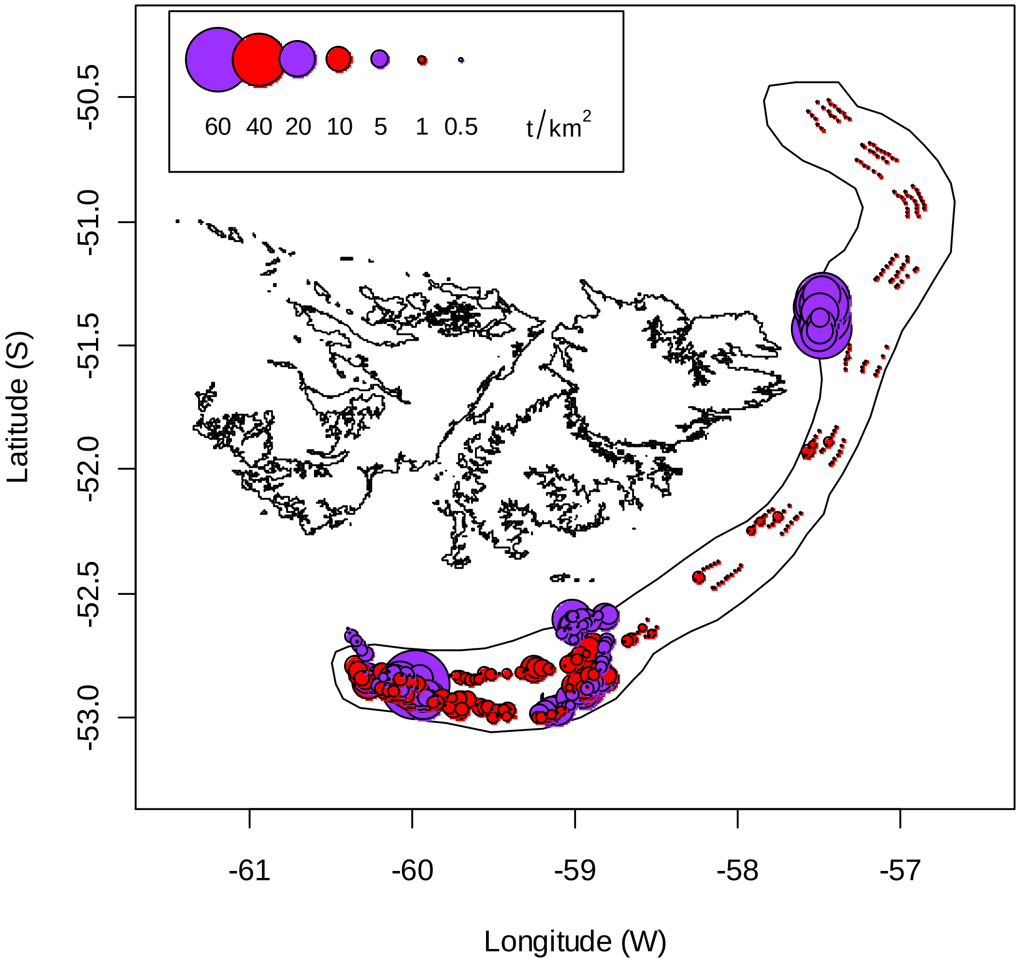
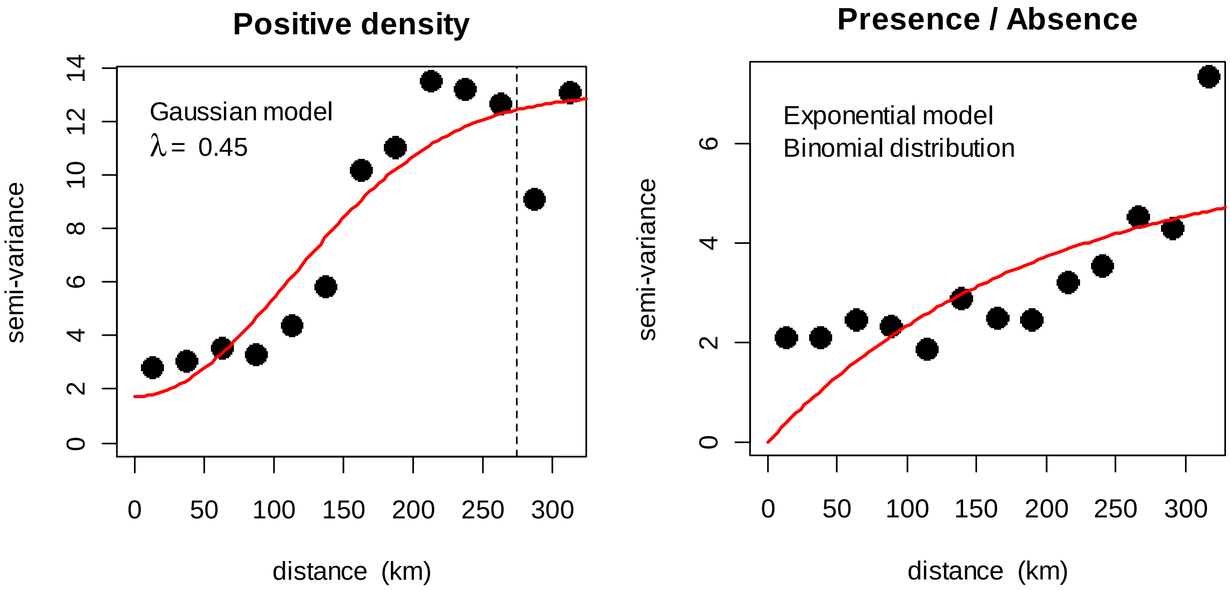


Figure 2. *Loligo* CPUE (mt km^{-2}) of fixed-station trawls (red) and adaptive trawls (purple), per 15-minute trawl interval. The boundary of the fishing area is outlined.

Figure 3 [next page]. Empirical variogram (black points) and model variogram (red line) of *Loligo* positive catch density distributions (left) and presence / absence (right). The correlation range for positive catch densities (left) is indicated by a dotted line (274.8 km); for presence / absence the correlation range exceeded 300 km.



Biomass estimation

Geostatistical modelling of the positive catch densities and presence / absence gave reasonable but not perfect fits. The best variogram fit for positive catch densities was obtained with a Gaussian correlation function and λ = 0.45 Box-Cox transformation of catch densities (Figure 3, left). This variogram function converged with a range of 274.8 km, indicating that *Loligo*, where present, spatially correlated over a maximum of 274.8 km separation distance. Semi-variances showed a decrease at 285 km (Figure 3, left), this being the approximate linear distance between the two 'poles' of high density concentration (Figure 4, top left). The MCMC for presence/absence was modelled on the binomial distribution with an exponential function for spatial correlation (Figure 3, right). This model predicted *Loligo* catch probability >50% in 204 of the 557 units (Figure 4, top right).

Total *Loligo* biomass in the fishing area was estimated by the geostatistical model at 30,706 t, with a 95% confidence interval of [20,543 to 44,626 t]. Of this estimated total, 10,484 t were north of 52 °S, and 20,222 t were south of 52 °S. The median density per area unit was 1.02 t km^{-2}, with a 95% confidence interval of [0.02 to 7.65 t km^{-2}]. The 30,706 t biomass estimate was 90% higher than the first season biomass estimate of 2011, and was the second highest first season biomass estimate since surveys began in the present format in 2006 (Table 2).

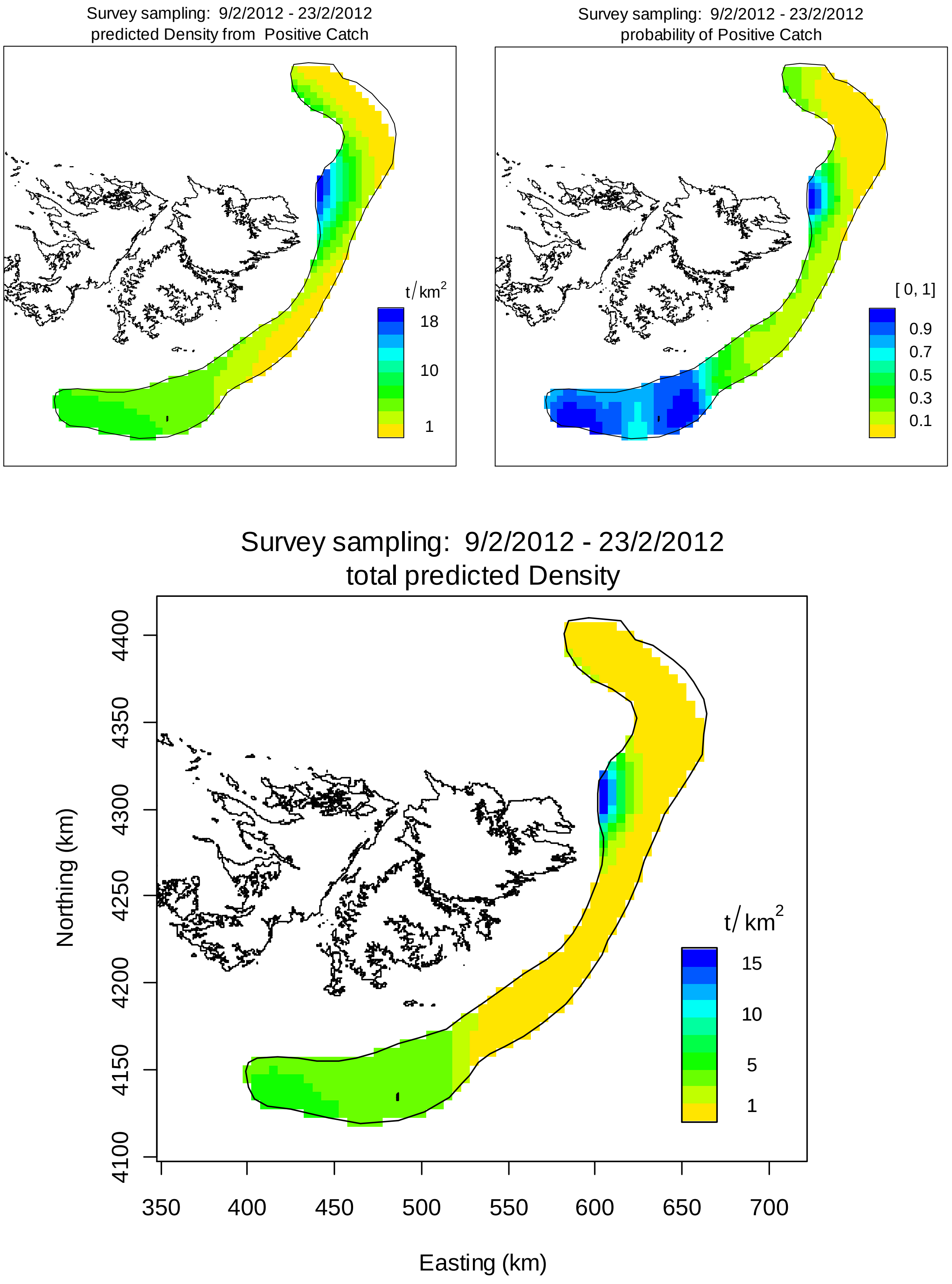


Figure 4. *Loligo* density estimates per 5 × 5 km area units. Top left (A): catch density distribution from variogram model of positive catches. Top right (B): probability of positive catch modelled from MCMC of presence/absence. Main plot (C): predicted density = A × B. For calculating geostatistical estimates, coordinates were converted to WGS 84 projection (GeoConv software, www.kolumbus.fi/eino.uikkanen/geoconvgb/index.htm).

Vessel comparison

Kalatxori had either the lowest or second-lowest average first-season CPUE index per year among vessels used for the surveys (Table 3). However, *Kalatxori*'s CPUE difference was consistently significant ($p < 0.05$) only vs. *Beagle F.I.*; the largest of the vessels (Table 3). It is therefore concluded that *Kalatxori* was not underpowered relative to the fleet average and catches from this survey did not result in biased underestimation.

Table 3. Average standardized CPUE indices (iCPUE; kg per hour per m trawl width) predicted from GLM. Asterisks indicate vessel factors that were significantly different ($p < 0.05$) from the *Kalatxori* in each season's GLM.

Survey Vessel	Commercial season				
	2008 1	2009 1	2010 1	2011 1	2012 1†
Golden Chicha	55.4	25.4	65.2	26.6	69.0
Castelo	58.1	30.6*	66.9	36.5	68.3
Beagle	70.0*	38.5*	93.6*	41.2*	114.8*
Venturer	60.1	22.9	63.9	29.3	80.9*
Kalatxori	**52.3**	**23.3**	**62.2**	**28.3**	**58.5**

† Through the first 21 days of the season.

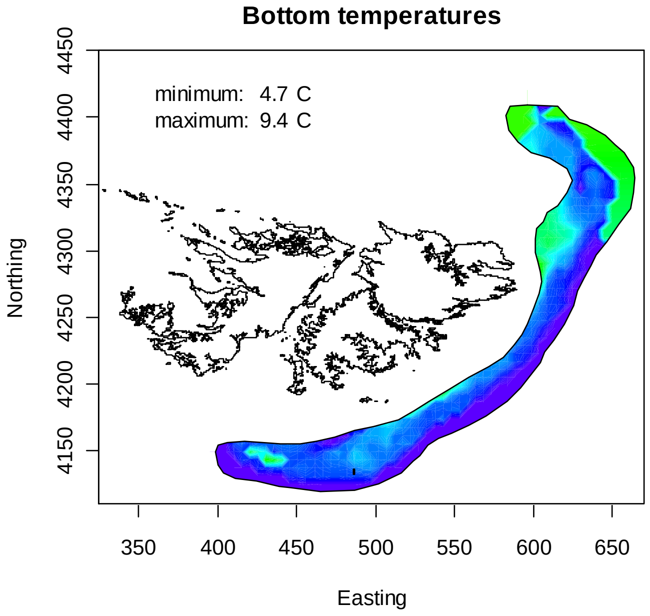
Sea temperature and salinity

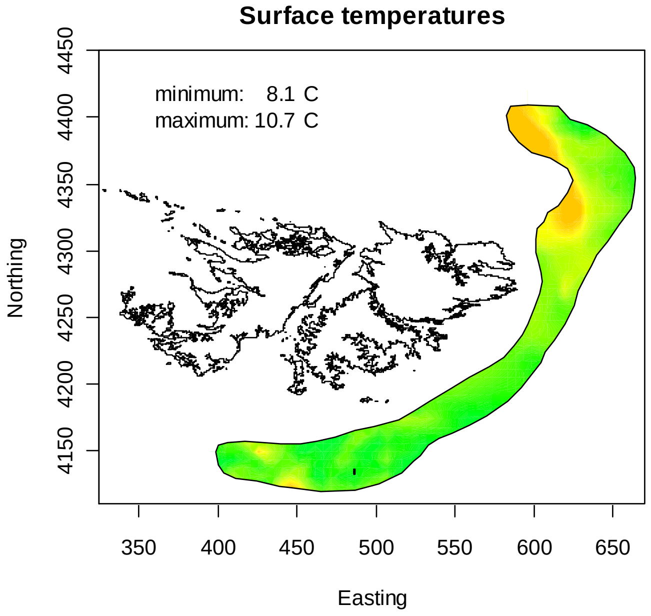
The Valeport mini-CTD returned useable temperature and salinity data from 52 of the 56 scientific trawls. Spatial distributions are shown in Figures 5 and 6. All four oceanographic variables (sea surface temperature, bottom temperature, surface salinity, bottom salinity) were statistically significant predictors of *Loligo* density, although the combined GAM explained only 36.2% of deviance (Wood, 2006). Sea surface temperature, bottom temperature, and surface salinity (but not bottom salinity) were correlated with each other at $|r| > 78\%$.

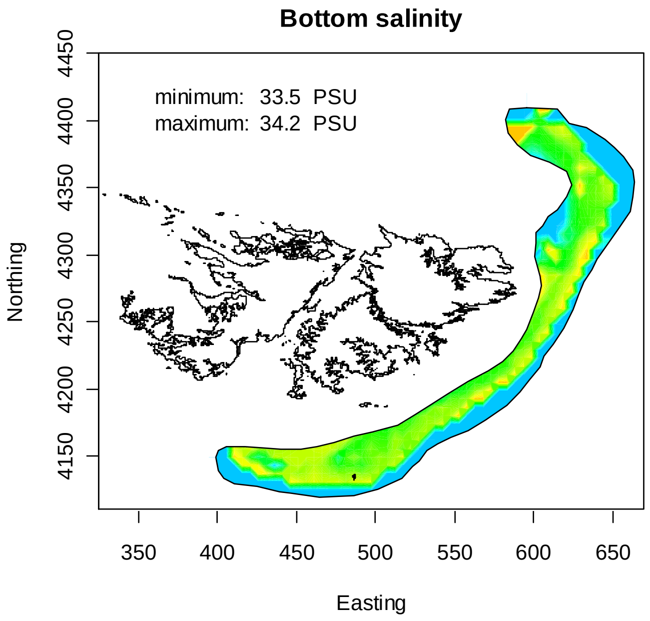
Figure 5 [next page]. Bottom and surface sea temperatures interpolated from measurements of the mini-CTD attached to the trawl. Both plots to same scale; temperature increasing purple → yellow.

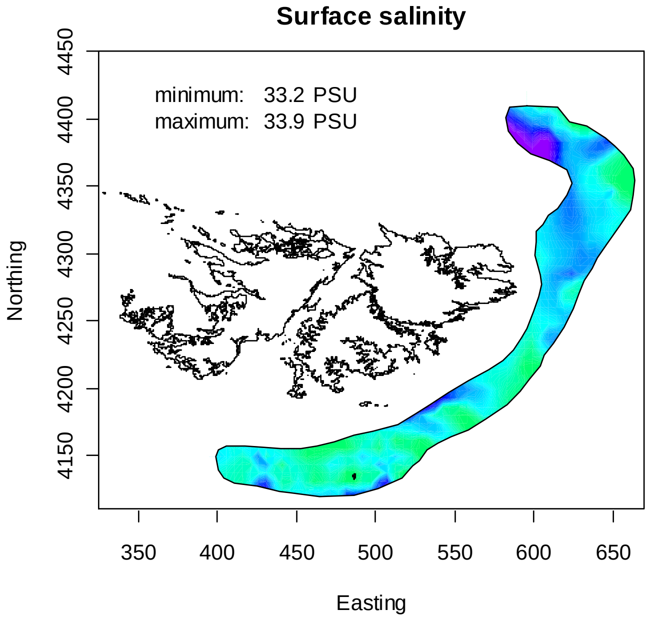
Figure 6 [next page]. Surface (upper) and bottom (lower plot) salinities interpolated from measurements of the mini-CTD attached to the trawl. Both plots to same scale; salinity increasing purple → yellow.

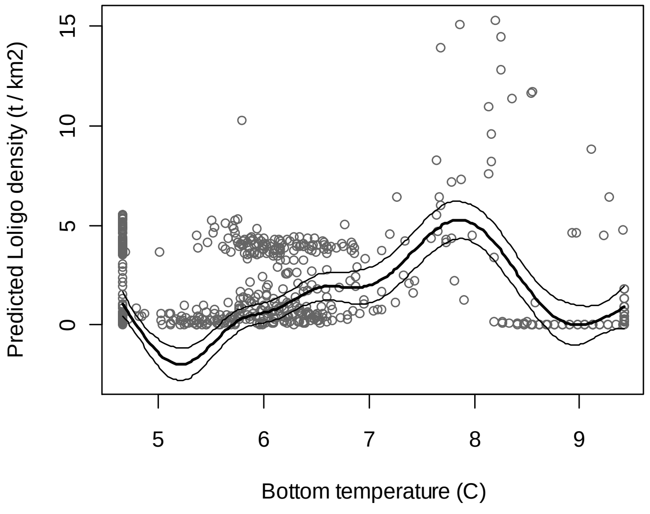
Figure 7 [next page]. GAM smooths of oceanographic co-variables related to *Loligo* density. The GAM was calculated jointly on the four co-variables, thus each plot shows the partial effect. Outer lines are the 95% confidence intervals.

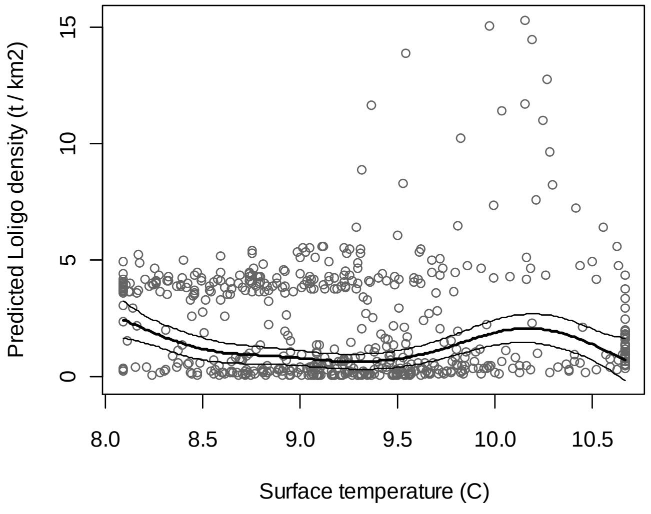

Bottom temperatures

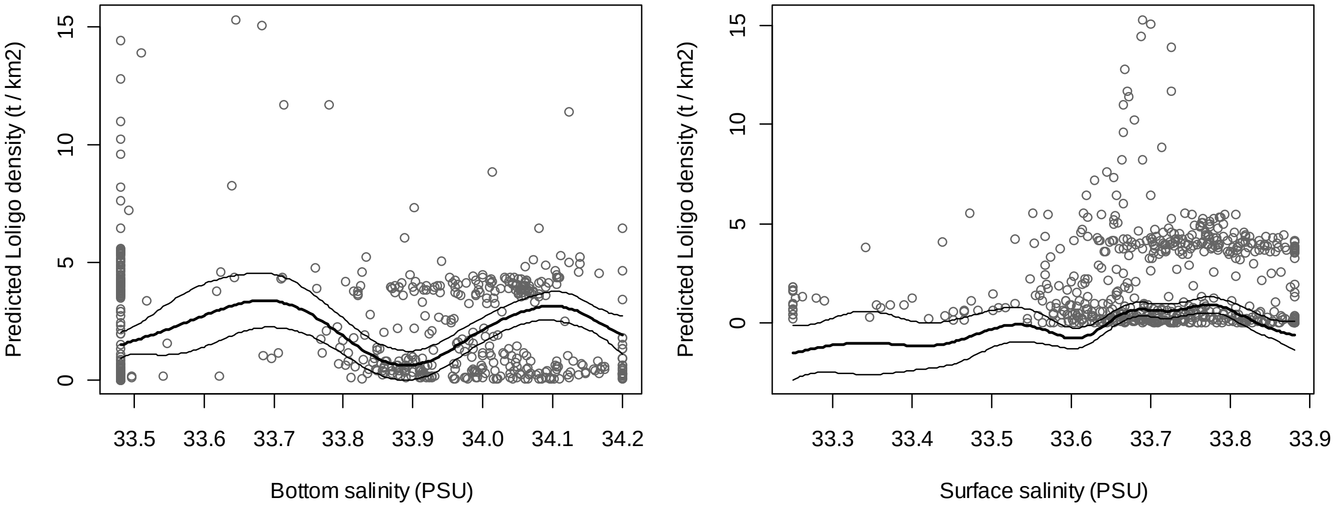

Surface temperatures


Bottom salinity


Surface salinity







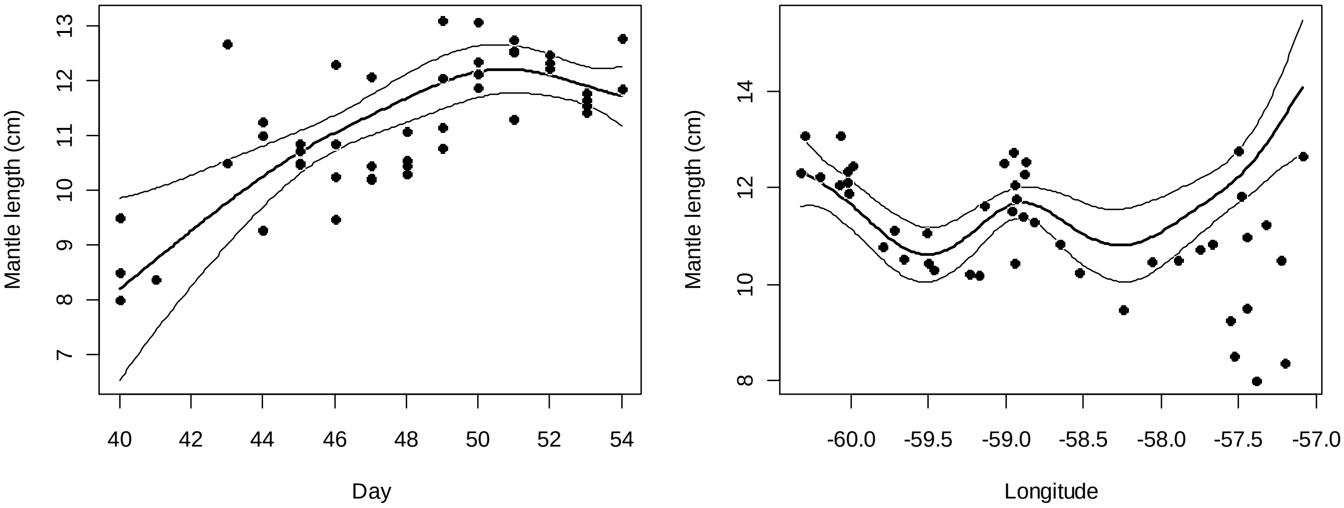
The *Loligo* density trend was highest with bottom temperature ~ 7.9° C, surface temperature ~10.2° C, bottom salinities 33.7 or 34.1 PSU, and surface salinity 33.7 PSU (Figure 7). The trend was generally driven by the relatively small number of high density values.

Biological data

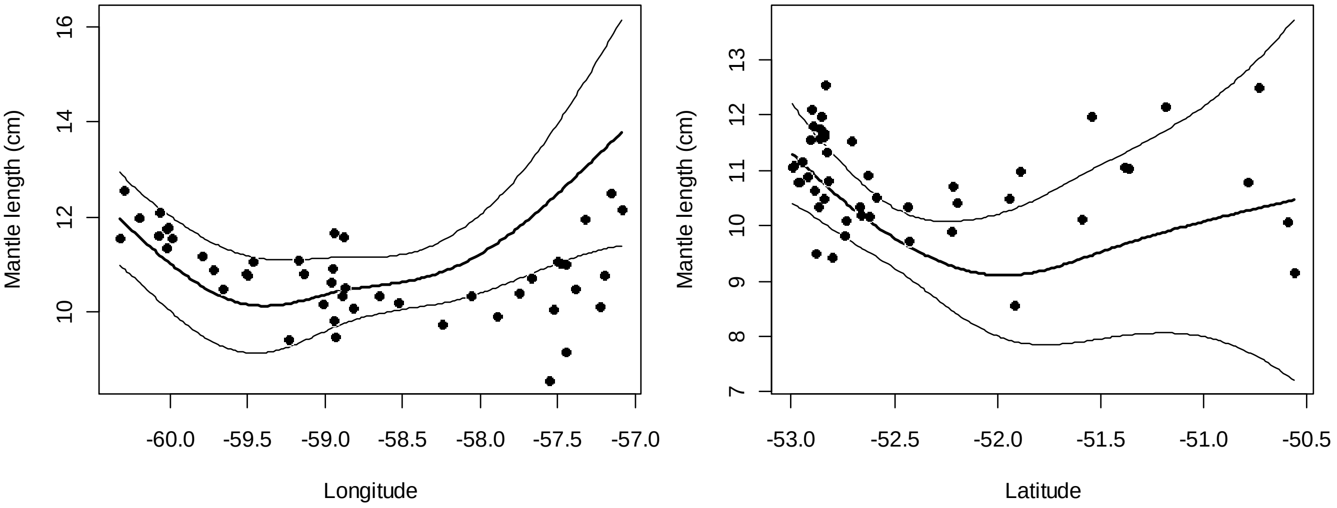
The totals of all catch by taxon are summarized in Appendix Table 1; sample numbers by species are summarized in Appendix Table 2. Fifty-three taxa were identified in the catches, of which fifteen were sampled.

Male *Loligo* size averages (mantle lengths) were significantly related to survey day and longitude. The GAM explained 73.4% of mantle length deviance, and effect plots are shown in Figure 8. Male mantle lengths had an increasing trend up to approx. day 51 (February 20), indicative that they continued to grow over the course of the survey. Male mantle lengths had increasing trends east, west, and a peak in the middle, which likely represent distinct target areas to which the squid migrate. East of 58° W the longitude trend mostly dissociated from the actual mantle length data, suggesting that this was not the primary effect (east of 58° W the survey distribution is mostly northeast - southwest).

Figure 8 [next page]. GAM smooths of variables predictive for male *Loligo* mantle lengths. Outer lines are the 95% confidence intervals.



Female *Loligo* size averages were significantly related to longitude, latitude and survey day. The GAM explained 74.9% of mantle length deviance, and effect plots are shown in Figure 9. Similar to males, female *Loligo* sizes had an increasing trend with longitude towards both the east and west ends of the survey range, but did not have a notable peak in the middle. Female *Loligo* sizes had a decreasing trend with latitude from approx. 53° S to 52.25° S. With respect to the survey, this indicates that female *Loligo* were generally larger further offshore in the Beauchêne sub-area, but not the North-Central sub-area. Survey day was not a significant main effect but intensified the longitude and latitude effects with a slight increasing trend up to approx. day 51, similar to males.



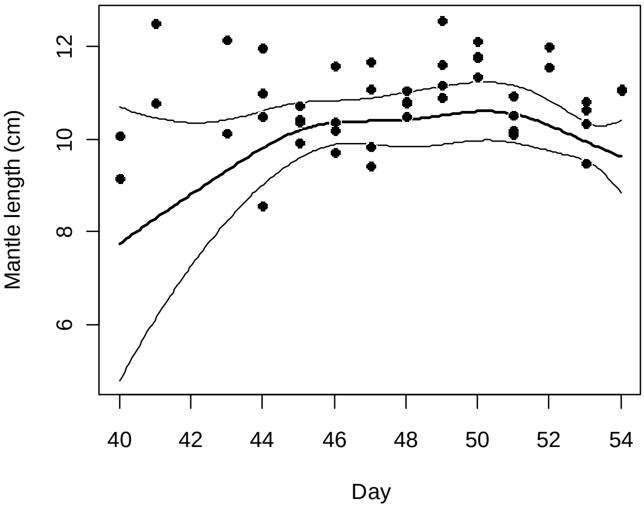
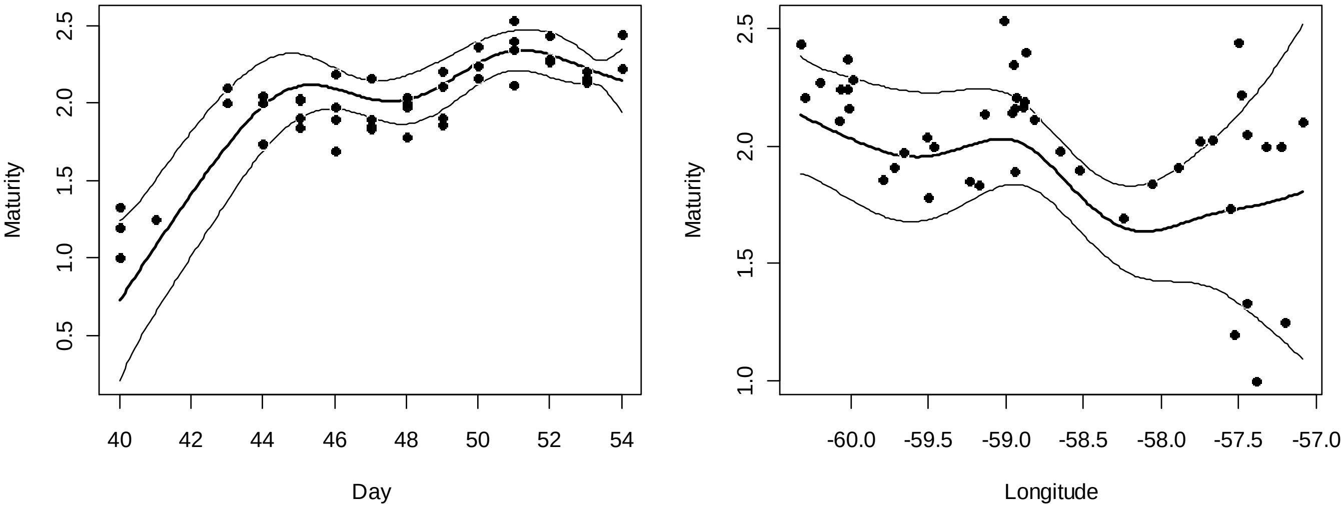


Figure 9. GAM smooths of variables predictive for female *Loligo* mantle lengths. Outer lines are the 95% confidence intervals.

Male *Loligo* average maturity indices were significantly related to survey day, longitude and latitude. The GAM explained 82.0% of maturity deviance, and effect plots are shown in Figure 10. Male maturity increased with survey day, following (as would be expected) the same general trend as male size. Maturity showed a decrease transition with longitude at approx. 58.5° W, suggesting separate sub-stocks east and west of this longitude. Maturity showed a slightly increasing trend towards north, but the trend did not include the four trawls furthest north which had the lowest maturities. These trawls caught only low amounts of *Loligo,* and therefore had little influence on the trend (GAMs were weighted by number of data per trawl).



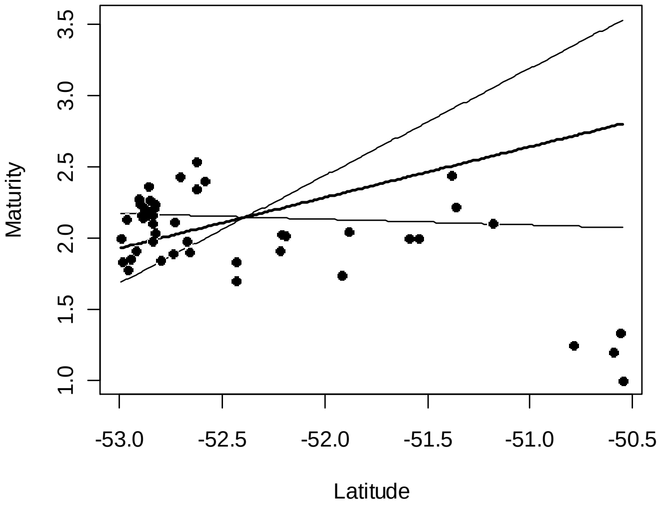


Figure 10. GAM smooths of variables predictive for male *Loligo* maturity indices. Outer lines are the 95% confidence intervals.

Female *Loligo* average maturity indices were significantly related to longitude and latitude. The GAM explained 49.2% of maturity deviance, and effect plots are shown in Figure 11. The maturity trend was lowest around the mid-longitude of 59° W, similar to the distribution of lengths with longitude, suggesting that female *Loligo* migrate first to the southwest and north, and only later to the central part of the fishing zone. Latitude was not a significant main effect but intensified the longitude effect with a slight increasing trend towards south.

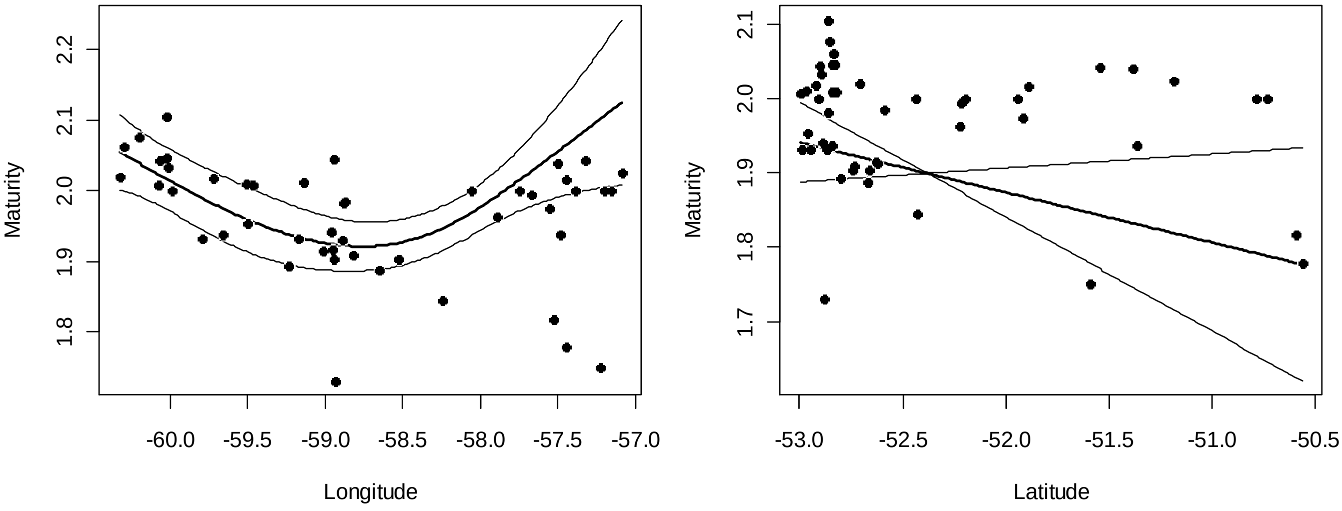


Figure 11. GAM smooths of variables predictive for male *Loligo* maturity indices. Outer lines are the 95% confidence intervals.

Loligo size and maturity distributions are plotted in Figure 12, with the usual zonal partition at 52° S (e.g., Winter, 2011). Modal mantle lengths were fairly uniform at 11 cm for males and 12 cm for females north of 52° S, and 12 cm for males and 11 cm for females south of 52° S. The maximum mantle length recorded for females was 17 cm, while 9% of males north and 3% of males south were larger than 17 cm.

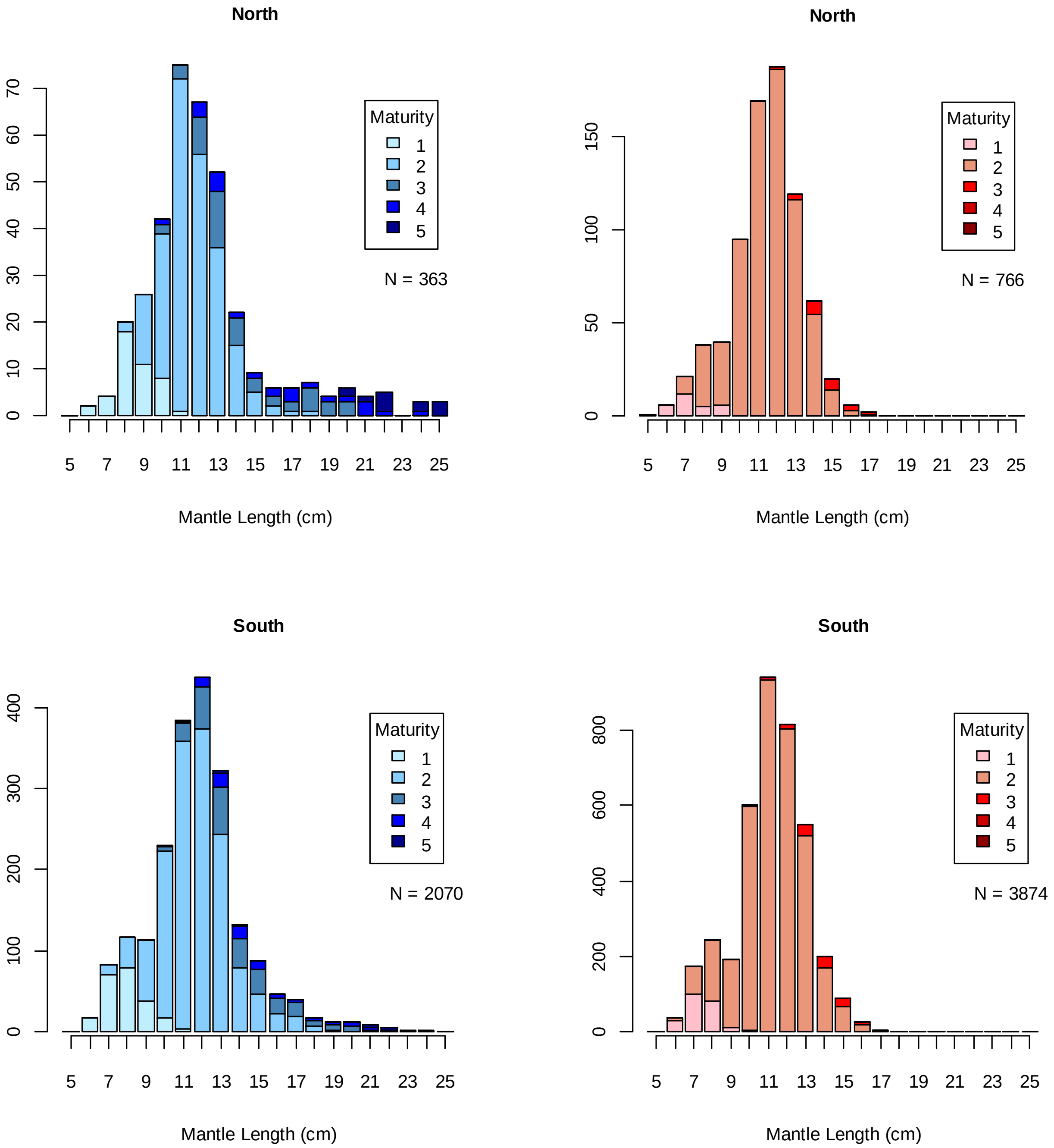


Figure 12. Length-frequency distributions by maturity stage of male (blue) and female (red) *Loligo* from trawls north (top) and south (bottom) of latitude 52 ºS.

Female *Loligo* proportion in the trawl samples was significantly related to all four predictor variables. The GAM explained 77.1% of maturity deviance, and effect plots are shown in Figure 13. Female proportion increased with depth and decreased with survey day, consistent with previous findings that females out-migrate earlier and move into deeper water (Arkhipkin and Middleton, 2002). Female proportion varied with latitude and longitude along trends that suggest higher female proportion in the Beauchêne sub-area than North-Central, also consistent with previous findings (Arkhipkin and Middleton, 2002). The latitude trend peak near 51.25° S reflects that the survey returned north on the last day.

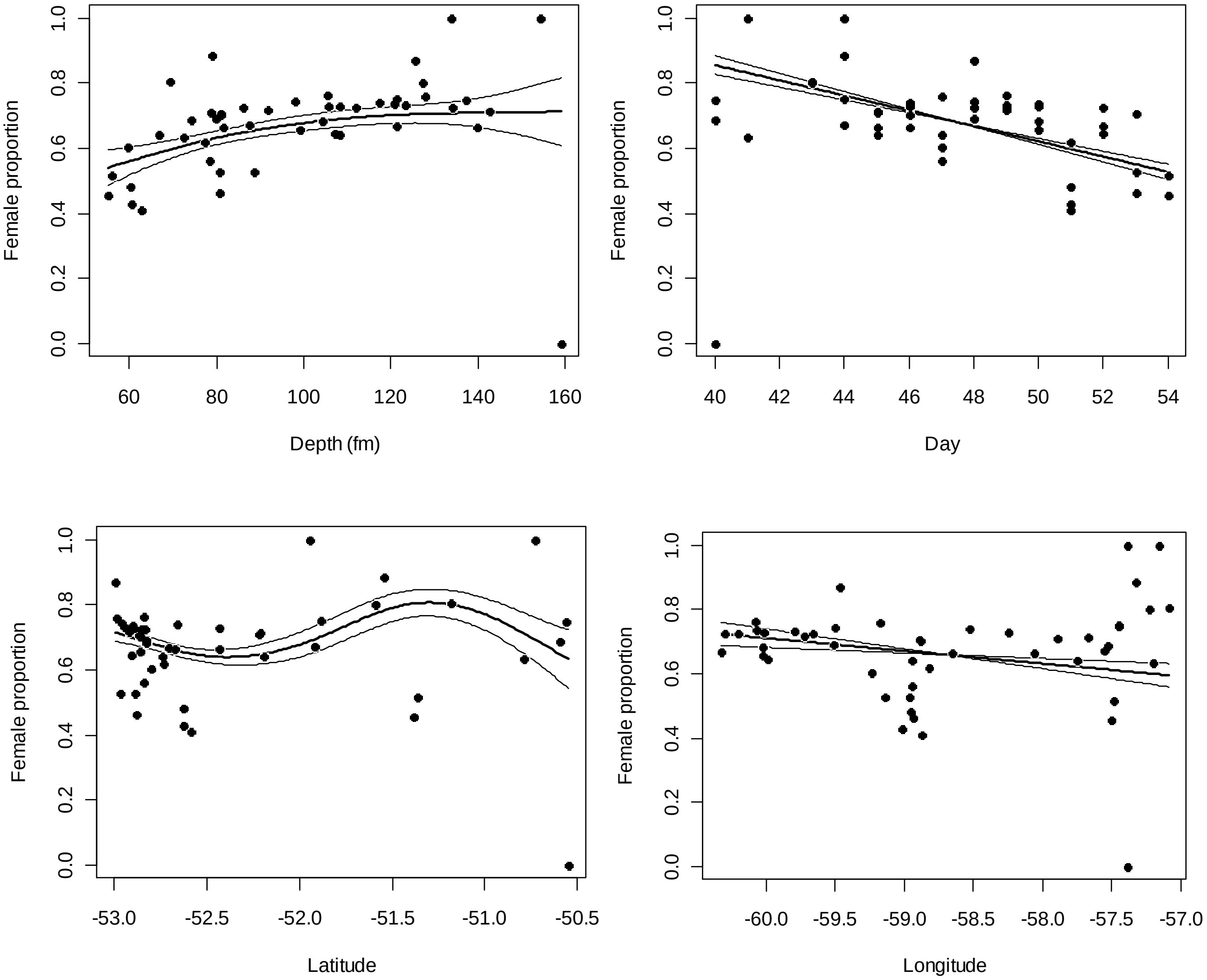


Figure 13. GAM smooths of variables predictive for *Loligo* female proportion in the trawls. Outer lines are the 95% confidence intervals. The one data point at 0 represents a sample of a single *Loligo* in a trawl, and this sample was correspondingly down-weighted in the GAM.

The *Loligo* length-weight relationship was calculated from 839 individuals (Figure 14), resulting in parameters α = 0.20308 ± 0.03184 and β = 2.16559 ± 0.06402 (± 1 sd). Optimized separately, the 302 male and 537 female data gave slightly but statistically different length-weight relationships (likelihood ratio test, df = 2, χ^2 = 48.58, $p < 0.001$), characterized by males having higher weight per mantle length below 10.3 cm, and lower weight per mantle length above 10.3 cm.

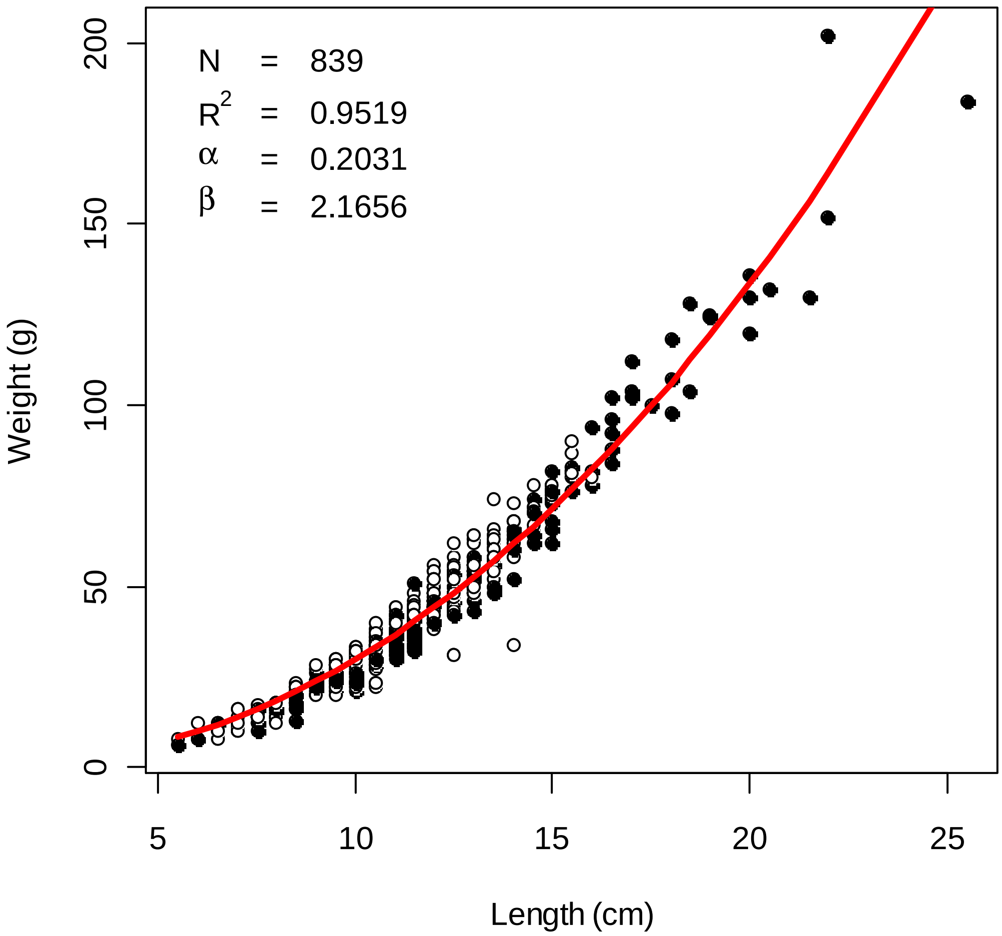


Figure 14. Length – weight relationship of *Loligo* sampled during the survey. Filled circles: males, open circles: females.

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APPENDIX

Table A1. Survey total catches by species / taxon.

Species Code	Species / Taxon	Total catch (kg)	Total catch (%)	Sample (kg)	Discard (kg)
LOL	*Loligo gahi*	127621.06	47.6	345.47	309.26
PAR	*Patagonotothen ramsayi*	80,650.56	30.1	629.53	29940.93
WHI	*Macruronus magellanicus*	30,850.81	11.5	343.17	71.82
BLU	*Micromesistius australis*	17,668.90	6.6	70.43	7266.86
RAY	Ray *spp.*	5,679.05	2.1	0	901.01
ING	*Moroteuthis ingens*	1,095.99	0.4	0	1095.99
TOO	*Dissostichus eleginoides*	751.82	0.3	4.34	19.42
CGO	*Cottoperca gobio*	683.67	0.3	0	683.66
GRC	*Macrourus carinatus*	297.62	0.1	0	297.62
BAC	*Salilota australis*	250.93	0.1	2.60	43.46
EEL	*Iluocoetes fimbriatus*	238.51	0.1	0	238.51
SPN	Porifera	219.14	0.1	0	219.14
HAK	*Merluccius hubbsi*	200.50	0.1	2.06	0
SQT	*Ascidiacea*	186.63	0.1	0	186.63
KIN	*Genypterus blacodes*	174.75	0.1	0	0
ALG	Algae	164.07	0.1	0	164.07
PTE	*Patagonotothen tessellata*	161.24	0.1	0.59	161.24
DGH	*Schroederichthys bivius*	138.75	0.1	0	138.75
MED	Medusae *sp.*	126.65	< 0.1	0	126.65
GRF	*Coelorhynchus fasciatus*	85.63	< 0.1	0	85.62
ANM	Anemone	82.53	< 0.1	0	82.53
SAR	*Sprattus fuegensis*	82.19	< 0.1	6.14	76.05
NEM	*Neophyrnichthys marmoratus*	74.70	< 0.1	0	74.70
PAT	*Merluccius australis*	61.32	< 0.1	2.05	0
GOC	*Gorgonocephalas chilensis*	56.69	< 0.1	0	56.69
STA	*Sterechinus agassizi*	53.08	< 0.1	0	53.08
ZYP	*Zygochlamys patagonica*	44.41	< 0.1	0	44.41
MLA	*Muusoctopus l. akambei*	39.22	< 0.1	0	39.22
CHE	*Champsocephalus esox*	35.81	< 0.1	3.13	33.11
DGS	*Squalus acanthias*	35.50	< 0.1	0	35.50
ODM	*Odontocymbiola magellanica*	32.15	< 0.1	0	32.15
CAZ	*Calyptraster sp.*	22.13	< 0.1	0	22.13
WRM	*Chaetopterus variopedeatus*	21.17	< 0.1	0	21.17
POA	*Porania antarctica*	19.86	< 0.1	0	19.32
OCM	*Octopus megalocyathus*	15.83	< 0.1	0.01	15.29
FUM	*Fusitriton m. magellanicus*	8.96	< 0.1	0	8.96
AST	Asteroidea	7.66	< 0.1	0	7.66
BUT	*Stromateus brasiliensis*	7.01	< 0.1	0	7.01
LOS	*Lophaster stellans*	6.34	< 0.1	0	6.34
SOR	*Solaster regularis*	6.14	< 0.1	0	6.14
ILL	*Illex argentinus*	5.93	< 0.1	2.21	3.73
COT	*Cottunculus granulosus*	4.75	< 0.1	0	4.75
BAO	*Bathybiaster loripes*	4.63	< 0.1	0	4.63
OCT	*Octopus spp.*	3.98	< 0.1	0	3.98
SUN	*Labidaster radiosus*	3.66	< 0.1	0	3.66
AUC	*Austrocidaris canaliculata*	3.49	< 0.1	0	3.49
OCC	Octocoralia	2.77	< 0.1	0.36	2.40
CEX	*Ceramaster sp.*	1.76	< 0.1	0	1.76
CRY	*Crossaster sp.*	1.74	< 0.1	0	1.74
MUO	*Muraenolepis orangiensis*	1.73	< 0.1	0	1.73
CYX	Cycethra *sp.*	1.26	< 0.1	0	1.26
COG	*Patagonotothen guntheri*	1.20	< 0.1	0.06	1.14
ASA	*Astrotoma agassizii*	1.14	< 0.1	0	1.14
		268006.83		1414.07	42636.01

Table A2. Survey sample numbers by species.

Sample	Species code	Species	Number
Length / maturity	LOL	*Loligo gahi*	7073
	PAR	*Patagonotothen ramsayi*	4993
	WHI	*Macruronus magellanicus*	499
	BLU	*Micromesistius australis*	289
	ILL	*Illex argentinus*	20
	TOO	*Dissostichus eleginoides*	16
	CHE	*Champsocephalus esox*	6
	BAC	*Salilota australis*	3
	HAK	*Merluccius hubbsi*	2
	PAT	*Merluccius australis*	2
Otolith	TOO	*Dissostichus eleginoides*	16
	CHE	*Champsocephalus esox*	6
	BAC	*Salilota australis*	3
	HAK	*Merluccius hubbsi*	2
	PAT	*Merluccius australis*	2
Statolith	LOL	*Loligo gahi*	244
	ILL	*Illex argentinus*	20