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Preliminary results of research cruises carried out by IEO on the High Seas of the SW Atlantic (2008-2009), regarding cephalopod target species (*Illex argentinus* and *Loligo gahi*).

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ABSTRACT

In March 2008 the Instituto Español de Oceanografía (IEO) through its Oceanographic Centre in Vigo (IEO-COV) initiated a historical series of research cruises aiming the assessment of the main commercial stocks on the High Seas (HS) of the SW Atlantic, including the study of two cephalopod species of important commercial interest, Argentine short-fin squid (*Illex argentinus*) and Patagonian squid (*Loligo gahi*).

This working document presents a brief description of the methodology used in the cruises and preliminary results concerning CPUE by depth strata and geographical distribution of both mentioned species.

INTRODUCTION

In October 2007, IEO undertook jointly with Secretaría General del Mar (SGM) owner of the R/V MIGUEL OLIVER, a series of multidisciplinary research cruises aiming the study of VMEs and the assessment of fishery resources on the High Seas (HS) of the SW Atlantic. These cruises were grouped into two main blocks carried out the first of them between the 28th October 2007 and the 18th April 2008, and the second one between the 16th October 2008 and the 30th March 2009. A total of 11 surveys were made during the mentioned periods.

The last cruise of the first block (ATLANTIS 2008, 12/03/08-15/04/08) initiated a historical series of research cruises aiming the assessment of the main commercial fish and cephalopod stocks (fishery cruises) and the study of interactions between fishing activities and VMEs, marine mammals, seabirds and marine turtles. The second cruise of the historical series (ATLANTIS 2009) took place between the 27th February and the 30th March 2009.

The study area comprised the HS waters extending to the east of the Argentinean EEZ and north of the Falkland Island (Malvinas) conservation zones (Falkland Interim

Conservation Zone, FICZ, and Falkland Outer Conservation Zone, FOCZ) until the 1500 m depth contour, between parallels 48º and 44º S (Figure 1). The study area includes the zone were commercial fishing activities by the Spanish fleet takes place, which mainly occur at depths lower than 300 m.

The specific objectives of these campaigns were:

1. To estimate the abundance and biomass of the target species, as well as to improve the demographic structure of their populations. Sampling of megafaunal epibenthic communities present in the catch.
2. Mapping of the seabed (EM-302D Multibeam echosounder) and seismic profiles (Topas 018 system) to complete bottom bathymetry and seek for appropriate places for bottom trawling.
3. CTD stations to study the oceanographic conditions in the work area.
4. Analysis of interactions between fishing activities and cetaceans, seabirds and marine turtles.

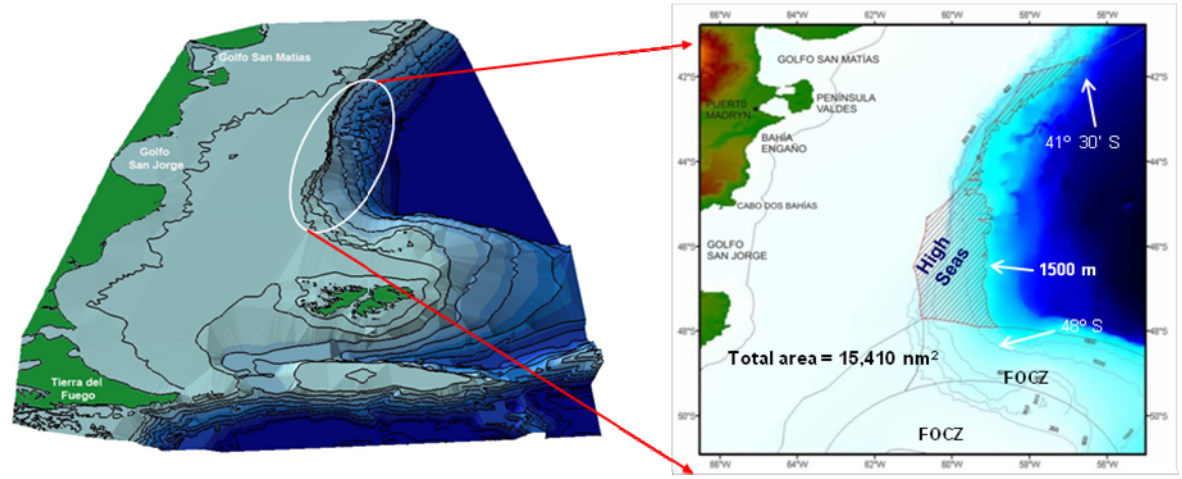

Figure 1.- Study area of the fishery research cruises (2008 and 2009)

Methodology

The fishing gear used during the stock assessment surveys initiated in 2008 and subsequent years was a LOFOTEN type gear of 35 mm codend mesh size fitted with a "Rockhopper" mix train equipped with bobbins and rubber separators especially suitable for deepwater fishing at irregular bottom depths. A stratified random scheme was designed for the allocation of fishing stations (hauls) of 30' time lag.

The study area (Figure 1) was divided into 13 depth strata characterized by the bathymetric ranges and surface indicated in Table 1. At last, hauls were randomly allocated according to the following criteria:

- The number of hauls in each stratum being proportional to its surface, with a minimum of two hauls by strata.
- For each stratum hauls were randomly allocated among all possible grids, provided they were not in contiguous squares.

- When fishing was not possible to in a selected grid due to bottom characteristics, this was done in the nearest one suitable for bottom trawling.

A total of 147 and 149 hauls were respectively scheduled for cruises ran in 2008 and 2009 (Tables 1 and 2). The total surface of the study area was slightly increased in 2009 after the cartographic activities carried out during the preceding cruises, which enabled the updating of the bathymetry previously designed by using the GEBCO software.

Table 1.- Characteristics of depth strata and fishing operations (ATLANTIS 2008)

Depth stratum	Depth range m	Surface nm^2	# of grids ~5 nm^2	Planned hauls	Hauls made		Total hauls
					Valid	Null	
1	<200	1148	219	12	12		12
2	201-300	272	51	3	4		4
3	301-400	381	71	4	3		3
4	401-500	518	119	7	7		7
5	501-700	1513	318	18	18		18
6	701-1000	1952	349	20	20	3	23
7	1001-1500	2007	435	24	2	5	7
8	<200	1394	254	14	15		15
9	201-300	111	24	2	2		2
10	301-400	121	21	2	2		2
11	401-500	78	26	2	2		2
12	501-1000	933	170	10	12		12
13	1001-1500	2507	515	29	26	5	31
TOTAL		**12933**	**2571**	**147**	**125**	**13**	**138**

Table 2.- Characteristics of depth strata and fishing operations (ATLANTIS 2009)

Depth stratum	Depth range m	Surface nm^2	# of grids ~5 nm^2	Planned hauls	Hauls made		Total hauls
					Valid	Null	
1	<200	1144	229	13	13		13
2	201-300	279	56	3	3		3
3	301-400	366	73	4	4	1	5
4	401-500	538	108	6	6		6
5	501-700	1483	297	17	17	2	19
6	701-1000	1964	393	22	21	1	22
7	1001-1500	2037	407	22	-	-	-
8	<200	1395	279	16	18	1	19
9	201-300	111	22	2	2		2
10	301-400	123	25	2	2		2
11	401-500	74	15	2	2		2
12	501-1000	977	195	11	11		11
13	1001-1500	2547	509	29	28		28
TOTAL		**13038**	**2608**	**149**	**127**	**5**	**132**

Figures 2 and 3 represent the position of hauls made by depth stratum during cruises ATLANTIS 2008 and 2009. It can be noted that in 2009, activities planned for stratum 7 couldn't be performed due to bad bottoms for trawling, combined with a shortage in the duration of the campaign. It is also important to stress the high proportion of null hauls in this stratum during the cruise in 2008.

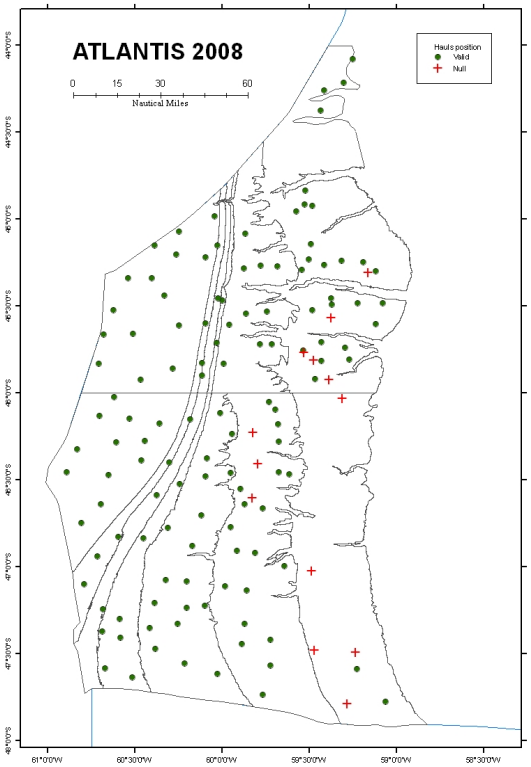

Figure 2.- Location of fishing operations by depth stratum (ATLANTIS 2008)

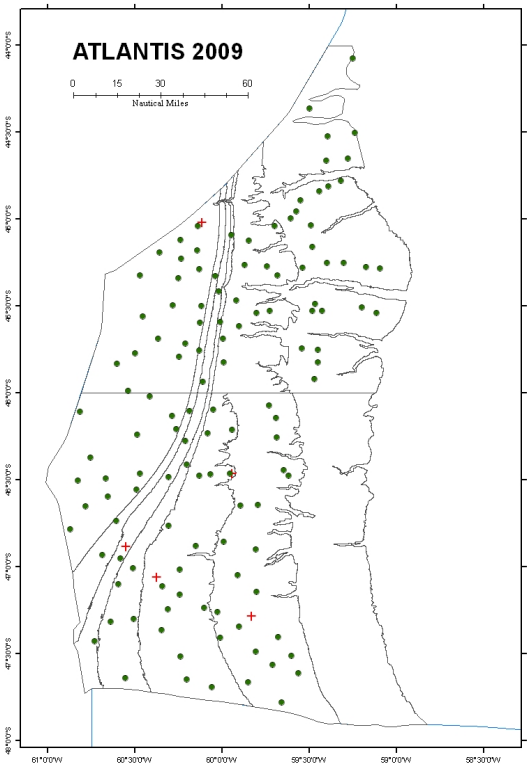

Figure 3.- Location of fishing operations by depth stratum (ATLANTIS 2009)

Geomorphological information from the previous cruises was used for identification of the most appropriate locations for fishing stations, all of them being made at daylight. Next, at the twilight, works for identification of hauls' location in the following day were initiated each day by using a Simrad EM-302 (30 kHz) multi-beam system and a seismic parametric system Topas 18. Before the day light, the chief of the cruise in coordination with the responsible of the cartography team decided if the location of fishing stations for that day should be moved from its original position, depending on the type and/or the orography of the seabed.

Furthermore to its primarily fishing objective, the LOFOTEN bottom gear was used as a sampler for benthic studies, complementary to the more specific samplers (mega box-corer and rock dredge) used in the four previous cruises carried out between October 2007 and February 2008.

Specific activities for sightings of marine mammals, seabirds and marine turtles were made by specialized personnel using specifically designed protocols, with the objective of define the species occurring in the study area, its distribution and abundance, and to analyze possible interactions with fishing activities.

Length and biological sampling by sex of a selected sample of the two cephalopod target species were made in each haul, recording dorsal mantle length (DML, nearest half cm below) and weight of each individual in the case of length sampling and additionally to this, maturity, live weight, and stomach content, in the case of biological sampling.

Density maps for all target species were made by using the *Density* tool of *ArcGis* software. For calculations, the Kernel quadratic function (Silverman, 1986) was employed, so that the density values are expressed in kg/h/surface unit^2, being in this case the surface unit 0.125*0.125 degrees. The radius within which the density is being sought from a given value was set at 1.5 degrees. The colours represented in the map of densities are an extrapolation of the CPUE values obtained, where a <1% indicates an expected zero CPUE and 100% corresponds to the maximum value along the campaign.

Results and Discussion

Until now only two research cruises for stock assessment of fish and cephalopods on the HS of the SW Atlantic have been made (ATLANTIS 2008 and ATLANTIS 2009). Final results of the first survey are included in this WD, but currently only preliminary results from the second one are available.

Results presented in this document refer to data on catches, abundance and biomass indices of the two cephalopod species target of the campaigns, as well as to the geographical distribution of catches and density maps of both species.

Data presented in Tables 3 to 6 match to catch in number of individuals and weight, abundance, biomass, mean abundance per haul (MAH), mean catch per haul (MCH), abundance per unit effort (APUE) and catch per unit effort (CPUE) for *Illex argentinus* and *Loligo gahi* in 2008 and 2009 cruises respectively.

Illex argentinus

Abundance

During the cruise ran in 2008, short-fin squid was found to be the second more abundant of all caught species, with a total estimated biomass in the study area of 45,073 t and a mean catch per haul of 53.9 kg (Table 3). Catches of this species were obtained throughout all the explored depth strata with the exception of stratum 13 (1001-1500 m), corresponding the highest yields to strata 4, 2, 10, and 3 respectively by order of importance, standing out a mean CPUE of 914.6 kg/h in stratum 4 (401-500 m depth).

Table 3.- Catch, abundance and biomass indices of short-fin squid by depth strata (ATLANTIS 2008)

Stratum	Surface nm^2	Catch n	Catch kg	Abundance ´000	Biomass t	MAH n	MCH kg	APUE n/h	CPUE kg/h	Valid hauls
1	1148	16559	1074,7	136637	8868	1379,9	89,6	2760	179,1	12
2	272	3233	1032,8	17371	5549	808,3	258,2	1617	516,4	4
3	381	4663	609,1	49352	6446	1554,4	203,0	3109	406,1	3
4	518	7138	3201	43059	19309	1019,8	457,3	2040	914,6	7
5	1513	122	61,9	825	419	6,8	3,4	14,0	6,9	18
6	1952	2	0,5	16	4	0,1	0	0,2	0,1	20
7	2007	-	-	-	-	-	-	-	-	2
8	1394	975	207,9	7393	1577	65	13,9	130	27,7	15
9	111	200	50,8	897	228	100	25,4	200	50,8	2
10	121	971	413,9	5054	2154	485,6	207	971	413,9	2
11	78	26	10,1	85	33	13	5	26	10,1	2
12	933	156	74,9	1013	487	13	6,2	26	12,5	12
13	2507	0	0	0	0	0	0	0	0	26
Total	**12935**	**34045**	**6737,6**	**261702**	**45073**	**272,4**	**53,9**	**545**	**107,8**	**125**

Table 4.- Catch, abundance and biomass indices of short-fin squid by depth strata (ATLANTIS 2009)

Stratum	Surface nm^2	Catch n	Catch kg	Abundance ´000	Biomass t	MAH n	MCH kg	APUE n/h	CPUE kg/h	Valid hauls
1	1144	5010	1401.4	37463	10478	385	107.8	771	215.6	13
2	279	1255	415.0	9729	3216	418	138.3	837	276.7	3
3	366	224	82.5	1777	655	56	20.6	112	41.3	4
4	538	114	49.4	879	381	19	8.2	38	16.5	6
5	1483	24	11.6	183	88	1	0.7	3	1.4	17
6	1964	0	0.4	0	3	0	0	0	0	21
7	2037	-	-	-	-		-	-	-	-
8	1395	4072	938.1	27145	6254	226	52.1	452	104.2	18
9	111	329	124.7	1524	577	165	62.4	329	124.7	2
10	123	78	26.4	413	139	39	13	78	26.4	2
11	74	6	3.0	21	11	3	1	6	3.0	2
12	977	104	45.1	798	347	9	4.1	19	8.2	11
13	2547	0	0	0	0	0	0	0	0	28
Total	**13038**	**11217**	**3097.5**	**79933**	**22149**	**88**	**24.4**	**177**	**48.8**	**127**

In 2009 a sharp decrease of the estimated biomass was observed (Table 4), reaching values less than half of those obtained in 2008 (22,149 t in 2009 versus 45,073 t in 2008). Mean catch per haul also presented a reduction to 24.4 kg (53.9 kg/haul in 2008). Catch by depth strata followed a different pattern than in previous year with the exception of depth stratum 13th, which, similarly to 2008 was the only one with no catches recorded for this species. Maximum yields by order of importance (kg/h) were found in strata 2, 1, 9 and 10, while stratum 4 with only 16.5 kg/h (914.6 kg/h in 2008) was among the strata with lower CPUE values, all these results showing a depth distribution pattern absolutely different to this in 2008.

Catch distribution and density maps

Figures 4a and 4b shown the distribution of catches and density maps of short-fin squid in cruises ATLANTIS 2008 and 2009 correspondingly. Higher density values obtained in 2008 distributed around latitude 47º 30' S, where hauls with maximum catches were located at about 400 m depth (Figure 4a). The map presenting results for 2009 seems to show higher values than those in 2008, but this is attributable to the remarkably different density scale used to enable visualization of lower values obtained in 2009. In 2009 maximum catches were obtained in the continental shelf (< 200m). Results from the fishing sector for the first fishing season in 2009 confirmed the strong reduction of the catches observed during the survey.

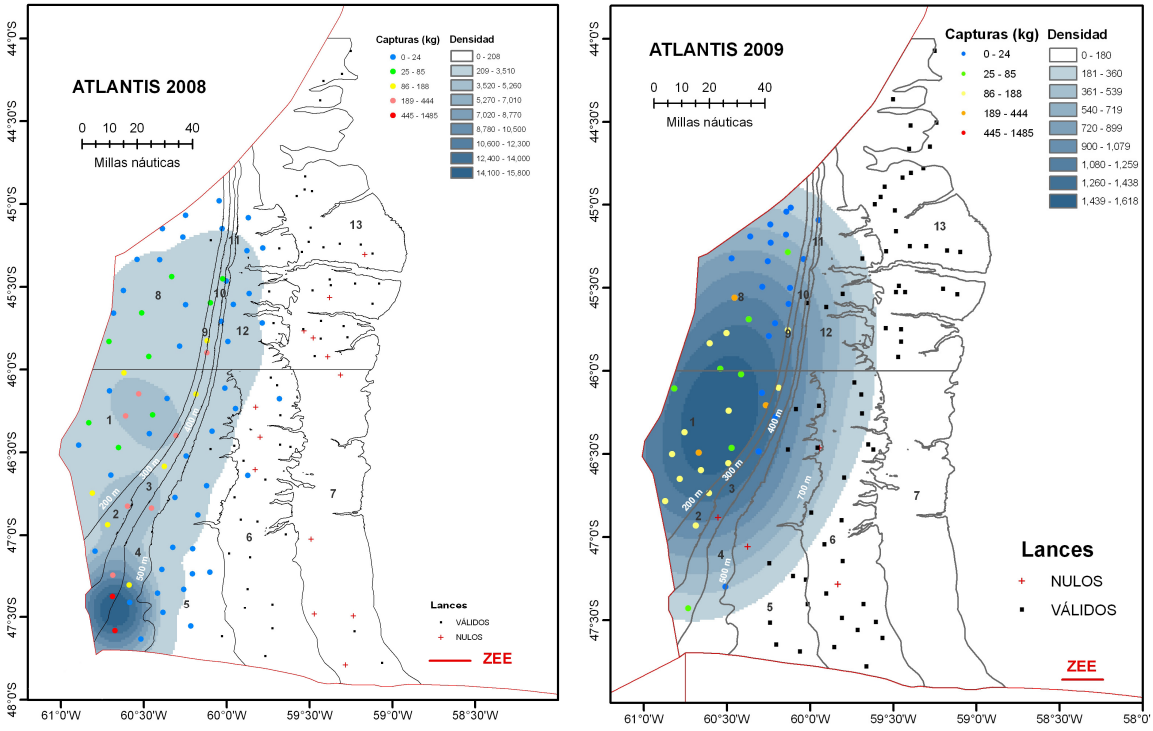

Figure 4a and 4b.- Distribution of catches and density maps of short-fin squid during cruises ATLANTIS 2008 (4a) and ATLANTIS 2009 (4b)

Size distributions

Size distributions of Illex squid recorded along ATLANTIS 2008 in percentage terms (0/00) are presented in Figure 5, ranging from 7 to 30 cm dorsal mantle length (DML). Individuals of lower size corresponded to catches at depths less than 200 m (strata 1 and

8), presenting a unimodal distribution with a strong modal class in 21.5 cm DML. Length size of this species increases with depth, reaching modal length classes of 23, 24 and 25 cm DML in strata 2, 3 and 4, respectively.

Analysis of length distributions by sex show that males are more abundant until 26 cm DML, being this more evident between 19 and 22 cm DML. From that size on (26 cm DML), the proportion of females is bigger than males, disappearing those ones from the catches at sizes higher than 30 cm DML. Sex ratio in the total catch was relatively similar (53,9% males and 46,1% females).

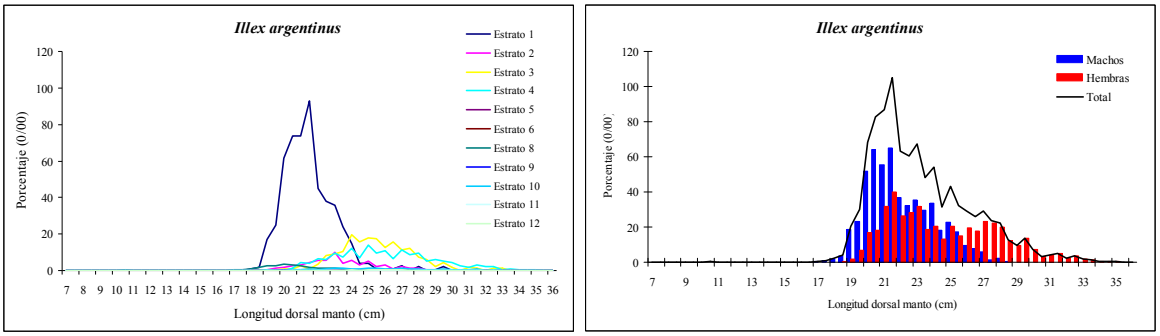

Figure 5.- Size distributions of short-fin squid (DML) by depth strata and sex (ATLANTIS 2008)

Results obtained during survey ATLANTIS 2009 shown a size range between 12 and 35 cm DML, representing a slight displacement to higher DML sizes in comparison to 2008. Smaller individuals being caught at depths lower than 200 m (stratum 1 and 8) as in the 2008 survey, but differently to this last cruise, the proportion of animals caught in stratum 8 was much higher than in previous year, with a proportion of 14.7% and 26.5% in the number of animals caught in 2008 and 2009 respectively (Figure 6).

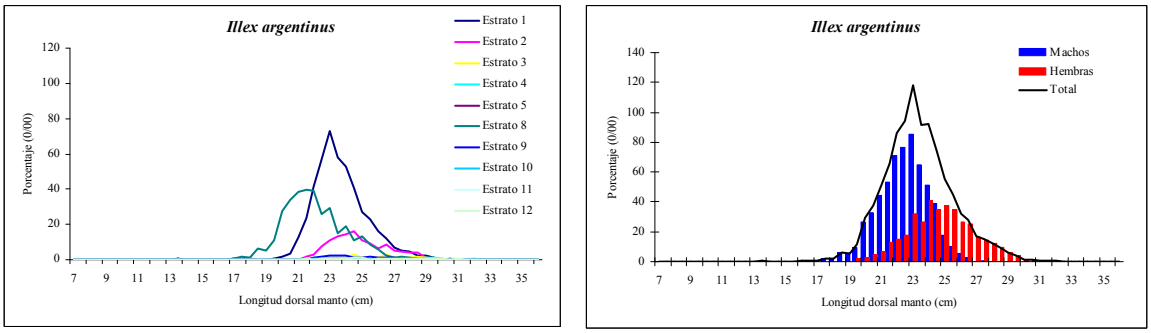

Figure 6.- Size distributions of short-fin squid (DML) by depth strata and sex (ATLANTIS 2009)

Length distributions by sex in 2009 show a similar pattern than in the previous year, being males (DML modal class at 23 cm) of slightly lower size than females (DML modal class 24 cm), but reaching females higher size than males (size for males ranging between 13.5 and 29 cm, but from 12 to 35 cm in females).

Loligo gahi

Abundance

As expected and due to its southernmost distribution, Patagonian squid appear to be less abundant than Illex squid in the prospected area during cruises in 2008 and 2009. In 2008 main catches were obtained mostly in stratum 1 and in a lesser extent in stratum 8, both within a depth range below the 200 m depth contour. Total estimated biomass for this species in the study area was 2,108 t (99% of it within strata 1 and 8) with a mean catch of 2.1 kg/haul (Table 5).

Table 5.- Catch, abundance and biomass indices of long-fin squid by depth strata (ATLANTIS 2008)

Stratum	Surface nm^2	Catch n	Catch kg	Abundance ´000	Biomass t	MAH n	MCH kg	APUE n/h	CPUE kg/h	Valid hauls
1	1148	11861	188,0	97871	1551	988,4	15,7	1977	31,3	12
2	272	68	1,9	366	10	17,0	0,5	34	0,9	4
3	381	1	0	11	0	0,3	0	1	0	3
4	518	0	0	0	0	0	0	0	0	7
5	1513	0	0	0	0	0	0	0	0	18
6	1952	0	0	0	0	0	0	0	0	20
7	2007	-	-	-	-	-	-	-	-	2
8	1394	5046	71,1	38284	540	336,4	4,7	673	9,5	15
9	111	27	0,7	122	3	13,6	0,4	27	0,7	2
10	121	40	0,8	208	4	20	0,4	40	0,8	2
11	78	0	0	0	0	0	0	0	0	2
12	933	1	0	6	0	0,1	0	0	0	12
13	2507	0	0	0	0	0	0	0	0	26
Total	**12935**	**17045**	**262,5**	**136869**	**2108**	**136,4**	**2,1**	**273**	**4,2**	**125**

Table 6.- Catch, abundance and biomass indices of long-fin squid by depth strata (ATLANTIS 2009)

Stratum	Surface nm^2	Catch n	Catch kg	Abundance ´000	Biomass t	MAH n	MCH kg	APUE n/h	CPUE kg/h	Valid hauls
1	1144	8393	163.9	62757	1226	646	12.6	1291	25.2	13
2	279	222	4.4	1719	34	74	1.5	148	2.9	3
3	366	19	0.4	151	3	5	0	10	0	4
4	538	1	0	8	0	0	0	0	0	6
5	1483	0	0	0	0	0	0	0	0	17
6	1964	0	0	0	0	0	0	0	0	21
7	2037	-	-	-	-		-	-	-	-
8	1395	5090	85.6	33935	571	283	4.8	566	9.5	18
9	111	396	7.2	1832	33	198	3.6	396	7.2	2
10	123	0	0	0	0	0	0	0	0	2
11	74	14	0.1	49	0	7	0	14	0	2
12	977	0	0	0	0	0	0	0	0	11
13	2547	0	0	0	0	0	0	0	0	28
Total	**13038**	**14135**	**261.7**	**100450**	**1867**	**111**	**2.1**	**223**	**4.1**	**127**

In 2009 a weak reduction of the total estimated biomass was observed compared with the previous year (2,108 t in 2008 against 1,867 t in 2009). Observed mean catch per haul remained exactly the same than in 2008 (2,1 kg). Catch by depth strata also followed the same pattern than in 2008, with maximum CPUEs in strata 1 and 8. Biomass at less than 200 m depth represented 96,3% of the estimated biomass for the whole area (Table 6).

Catch distribution and density maps

In 2008 main catches were obtained around parallel 46º 30' S with maximum density values in shallower waters below the 200 m depth contour (Figure 7a). Figure 7b presents the same problem than Figure 4b (distribution of catches and density maps of short-fin squid) of using a different scale for representation of densities for long-fin squid. In 2009 higher densities for this species were more than half of that in the previous year, but the distribution of catches and densities present a similar spatial pattern than in 2008 (i.e. around parallel 46º 30' S).

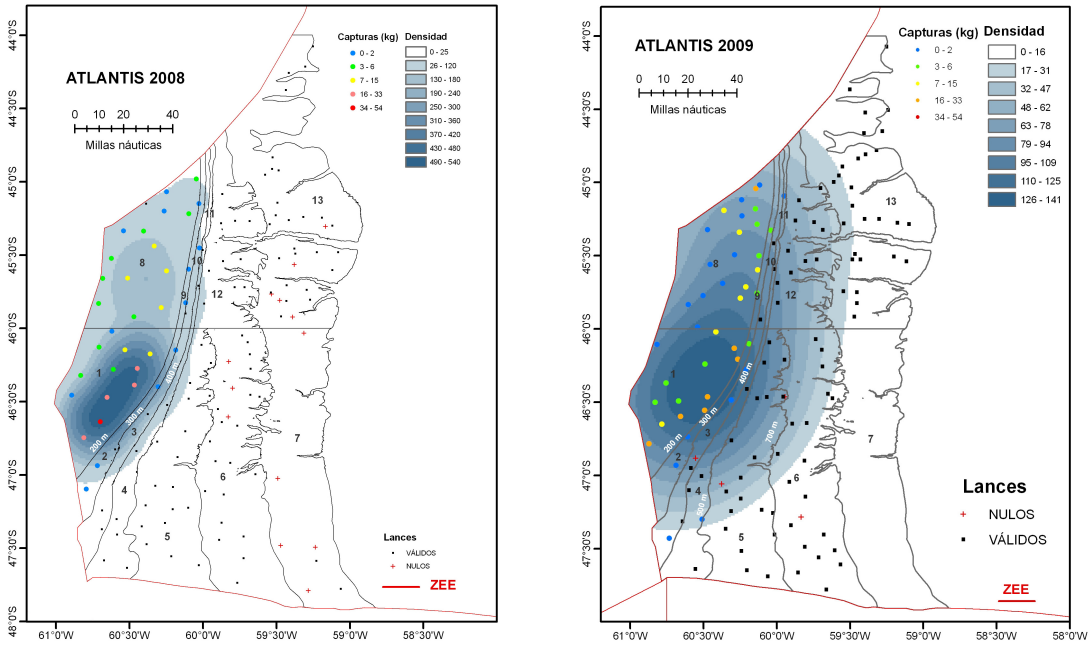

Figure 7a and 7b.- Distribution of catches and density map of long-fin squid (ATLANTIS 2008)

Size distributions

Size distributions (DML) in percentage terms by sex and depth strata for ATLANTIS 2008 are presented in Figure 8 showing a length range between 4 and 18.5 cm DML, although the most abundant size classes were found between 6 and 10 cm DML. Size composition presents a modal length class at 10 cm DML, corresponding almost exclusively to strata 1 and 8 by order of importance. Males predominated over females in all length classes with a sex-ratio of 68.8% of males over the total number of individuals.

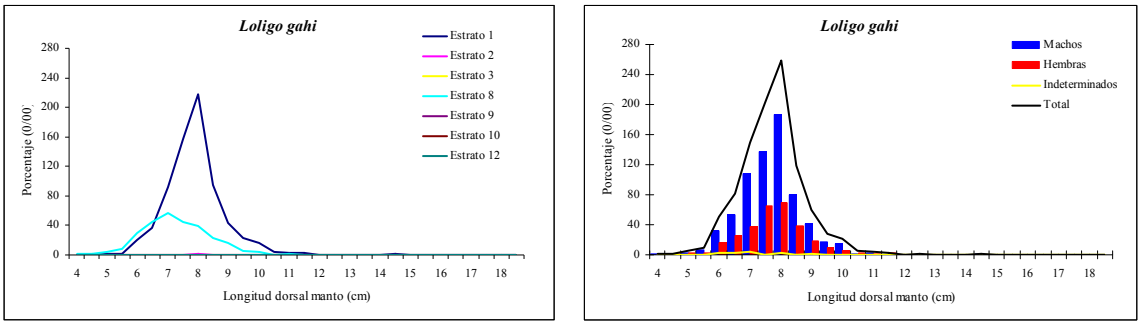

Figure 8.- Size distributions of long-fin squid by depth strata and sex (ATLANTIS 2008)

In 2009 length size distributions of long-fin squid (Figure 9) ranged between 4.5 and 17.5 cm DML, being quite similar to the size range observed in 2008 (4 to 18.5 cm DML). Size distributions by depth strata and sex followed also a similar pattern than in the previous year, but sex ratio changed to a more well-balanced proportion than in 2008, presenting a ratio 59/41 of males over females (70/30 in 2008).

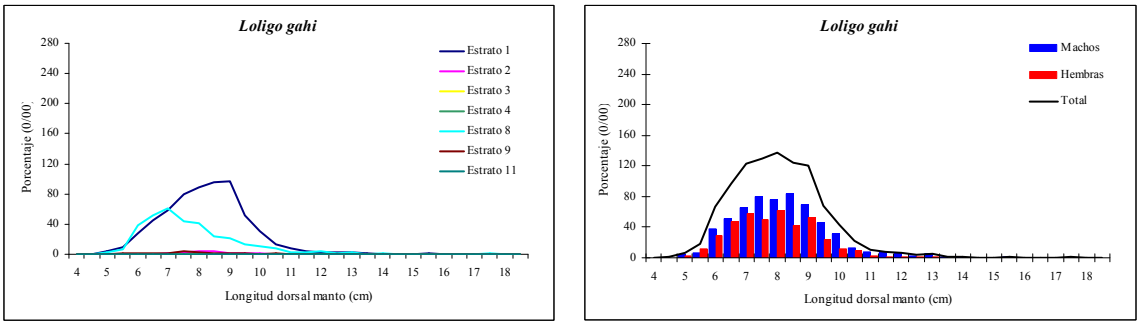

Figure 9.- Size distributions of short-fin squid by depth strata and sex (ATLANTIS 2009)

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