ICES STATUTORY MEETING 1993 Shellfish Committee K:36

PRELIMINARY STUDY ON BIOLOGICAL CHARACTERS OF *ALLOTEUTHIS SUBULATA* AND DISTRIBUTION OF THE GENUS *ALLOTEUTHIS* (CEPHALOPODA: LOLIGINIDAE) IN PORTUGUESE WATERS

by

A. Moreno
Instituto Nacional de Investigação das Pescas
Av. de Brasília, 1400 Lisboa, Portugal

ABSTRACT

Samples of *Alloteuthis subulata* from southeastern and south portuguese waters in tree periods between January 1990 to June 1991 were analysed. Mature males and females as well as recruits were present in all sampling periods. In both sexes there were squids maturing at a mantle length significantly shorter than others. By late spring the highest proportion of mature specimens was found. At least tree spawning periods for females were inferred. Size distribution with depth changed seasonally. Weight at length was greater for females than for males for squids larger than 40-50 mm of mantle length.

Seasonal catch rate patterns of *Alloteuthis* from the whole portuguese coast between July 1991 and march 1992 showed patchily distribution and evidences of inshore-offshore migrations.

INTRODUCTION

Alloteuthis subulata ranges from the North Sea and western Baltic southward to spanish Sahara (Voss, 1973). In portuguese waters it can be found in some abundance in particular between 20 and 200 m of bottom depth.

Data from bottom trawl surveys by the Research Vessel "Noruega" from Instituto Nacional de Investigação das Pescas between 1985 and 1991 for the same period (October/November) shows a relatively small fisheries yield but in some years the genus *Alloteuthis* (*A. subulata* and *A. media*) was quite important within portuguese cephalopod catches (Fig.1).

This resource is underexploited or not even exploited. The very low commercial value is due to the small size in relation to other common loliginids. Frequently mistaken for juveniles of *Loligo vulgaris* and *Loligo forbesi* they don't appear in fishery statistics making for a difficult evaluation of their real importance in our marine ecosystem.

Very little is known about *Alloteuthis subulata* in portuguese waters and this paper intends to be a first approach to biological aspects of the species and to the distribution of the genus *Alloteuthis*.

MATERIALS AND METHODS

Samples of *Alloteuthis subulata* were collected from southeastern and south portuguese waters by the research vessels "Noruega" and "Mestre Costeiro" from INIP during January (winter) and July (summer) 1990 and May/June (late spring) 1991. Table 1 gives information on the specific cruises from which data were taken. Animals were sampled in order to obtain length frequencies, maturation and length-weight relationships. Assuming the annual variation not to be very

significant, sampling periods were interpreted sequentially by seasons.

The length frequency structure in 2 depth ranges (20 to 100 m - onshore and 100 to 200 m - offshore) was analysed only in 1990 as in the May/June 1991 the deepest limit of the species distribution was found to be 100 m.

From each sample a number of individuals were selected randomly. From those, dorsal mantle length was measured to the nearest millimetre, sex was determined and total body weight was recorded. Each squid was assigned a maturity stage on a scale from 1 to 4 after Ngoile (1987), modified so that stages 4 and 5 were grouped together as 4.

Modal values in size distribution for each sex were determined by Battacharya method with the software package "ELEFAN".

The length-weight curves were calculated by multiplicative regression (model $Y=aX^b$) for both males and females. Analysis of covariance was used to examine differences among slopes.

Data from 3 cruises in vessel "Noruega" were analysed to obtain seasonal catch rate patterns for *Alloteuthis* (*A. subulata* and *A. media* together). The 3 cruises, the first in summer (6 July to 6 August, 1991), the next in Autumn (12 October 14 November, 1991) and the last in winter (12 February to 22 March, 1992) covered the portuguese waters between latitudes 42°N and 36°N, longitudes 10,5°W and 7°W and between 20 and 750 m of bottom depth. The methodology related to these cruises follows a stratified fixed station program.

RESULTS

Maturation

Progressive maturation can be seen from winter to late spring with some delay for females in relation to males (Fig.2). By late

spring and summer the majority of the population was made of mature squids.

The relationship between mantle length and maturity stage for winter and summer of 1990 and late spring of 1991 is shown in figure 3 and table 2. There was a clearly consistent increase in maturity stage with size for all sampling periods. Females were mature at a mantle length of 50-60 mm. Males had functional spermatophores at minimum mantle lengths between 40 and 50 mm. While in winter immature females of 75 mm and males of 120 mm (stages 1 and 2) could be found, in summer and late spring both sexes were found maturing (stage 3) or mature (stage 4) at lengths from 60 mm. In all sampling periods there were mature males and females of a very wide range of sizes.

Length Frequency Structure

Length frequency distributions for females and males in January (winter) and July (summer) of 1990 and May/June (late spring) of 1991 are illustrated in Fig.4. Length structure for 2 bottom depth ranges for the same periods in 1990 are present in Fig.5. Animals could be sexed from a mantle length of 20-30 mm.

-Females-

In January the population overall contained 1 size class with mode at 47.2 mm and ranged between 24 and 87 mm. The presence of recruits indicates that spawning occurred some months before, probably during Autumn and the absence of females larger than 87 mm indicates death after spawning as *A. subulata* females attain 120 mm dorsal mantle length in portuguese waters (unpublished data from INIP survey cruises). In May/June the distribution was bimodal with modes at 42 and 80.1 mm and sizes ranged between 34 and 104 mm. In July the distribution had a single mode at the 65.1 mm and sizes ranged between 47 and 89 mm. It seems a period of spawning took place in June resulting in a unimodal distribution in July after the death of

the spent females. In May/June the cohort with mode at 42 mm was probably originated from another spawning period between January and May.

- Males -

In January the male population ranged between 26 and 174 mm and contained 3 size classes with modes at 51.7, 97.6 and 149.1 mm . Recruitment and growth gave rise to a polimodal size distribution in May/June and July. Three modes could be identified in May/June (40.5, 81.5, and 108.9 mm) and also in July (48.6, 120.2 and 178.9 mm). By this time males attained the highest dorsal mantle length, 183 mm.

- Size distribution with depth -

Juveniles smaller than 40 mm were present in January mainly offshore. In May/June the whole population was concentrated inshore. In July most part of the population was located at 20 to 100 m depth range. Females above 40 mm showed a similar distribution in all depth ranges in January. In July larger specimens were present mainly inshore. Males above 40 mm were present mainly offshore in January. In July size increased with increasing depth.

Length-weight relationship

Length-weight relationships for males and females (Fig.6) differed significantly in slope (ANCOVA, $P < 0.001$). Slope for females (1.87) was greater than for males (1.2) indicating that increase in weight with length was greater for females than males.

Results similar to these have been found for other loliginids (Holme, 1974; Howard, 1979; Martins, 1982). Weight at length was greater for females than for males for specimens larger than 40-50 mm in dorsal mantle length.

Geographic distribution of the genus *Alloteuthis*

Catch rate patterns of the genus *Alloteuthis* for the 3 seasonal survey periods from July 1991 to March 1992 are shown in figures. 7, 8 and 9.

- Summer (Jul/Aug 91) -

The largest concentrations were found at the area between 40 and 41°N followed by another area between 36.75 and 37.75°N and 8°W (Fig.7). Catch rates in between those areas were low as well as north of 41°N and east of 8°W. In relation to depth the range of higher abundance was between 20 and 100 m in particular within the north area. Specimens were caught between 23 and 126 m depth.

- Autumn (Oct/Nov 91) -

By late season, squid concentration appeared more contiguous and more widely dispersed then earlier in the year. Catch rates were much reduced over the entire area of distribution (Fig.8). The highest abundance was found north of 38°N. Squid distribution with depth was between 20 to 200 m, again with preference to the range 20 to 100 m but catch rates for the range 100 to 200 m were greater then in summer north of 38°N. Specimens were found between 40 and 128 m depth.

- Late Winter (Feb/Mar 92) -

The overall catch rates increased (Fig.9) approaching the values of the previous summer. Squid were dispersed along the surveyed area but with tendency to brake into the 2 discrete areas defined in summer. North of 39°N the majority of the population was found at the range 20 to 100 m as in this area only 2 stations recorded *Alloteuthis* at depths greater then 100 m. South of 39°N distribution was contiguous between 20 and 200 m. In this period the limits of distribution were 41 and 301 m depth.

DISCUSSION

In spite of the temporal discontinuity of sampling, the biological characters seemed to agree with most of the life cycle features for the species found by Rodhouse *et al.* (1988) in the English Channel.

Alloteuthis subulata presented, in all sampling periods, mature females as well as males. According to Rodhouse *et al.* (1988) it's the presence during much part of the year of females in mating condition that probably resulted in the earlier maturation in males which was verified. Also recruitment was found in the 3 periods.

At least 3 spawning periods were identified: one in autumn, another between January and May a third in June. The duration of each spawning period was not possible to determine. Progressive maturation took place from winter to late spring. The change in the size structure of females from bimodal in late spring to unimodal distribution in summer together with the decrease in the proportion of mature individuals may indicate death after reproduction. The absence of spent females in all samples leads us to the same conclusion.

There was evidence of males and females (in winter) maturing at a mantle length much shorter then others. This seems to be common for *Loligo forbesi* and *Loligo vulgaris* (Guerra *et al.*, 1992). The differences can be a result of different growth rates rather then different rates in the process of maturation.

In common with other loliginids (Holme, 1974; Howard, 1979; Martins, 1982) growth in length in *Alloteuthis subulata* proceeds at faster rate than mass especially in males, in these due to the development of the long "tail" in large adults of this species, which increases length with little increase in weight. Rodhouse *et al.* (1988) also found this selection for growth in length at the expense of body mass for *A. subulata* in the English Channel.

The differences between sexes were more significant to specimens larger than 40-50 mm corresponding to lengths where most part of the squids were maturing (stage 3) or mature (stage 4). So the greater increase in weight with length for females than for males could also be a reflex of the gonad weight for females significantly greater at those maturity stages.

In the referred sampling periods specimens of the genus *Alloteuthis* were caught between 23 and 301 m of depth. Deeper limits of distribution were reported by Guerra (1982) in Galicia that caught *A. media* between 50 and 100 m while *A. subulata* extended to 510 m deep.

The presence of 2 discrete areas of abundance can be related to geographic and/or environmental reasons. The continental shelf shows important submarine canyons such as Nazaré, Lisboa, Setúbal, S.Vicente and Portimão, generally defining limits between areas with different hydrological environments (Fiuza, 1983). On the other hand, there are from north to south of Lisbon differences in species composition with a transition area in between (Serrão, 1989). One or both factors could determine the patchy distribution of the species. Also the large extension of the upper continental shelf in the north, in contrast with the narrow shelf in the south (Vanney and Mougenot, 1981), may be the reason for the scarce abundance of squids at bottoms deeper then 100 m in north area.

Alloteuthis seemed to exhibit an inshore-offshore migration similar to other loliginids (Holme, 1974; Mangold-Wirz, 1963; Roper and Young, 1975; Worms, 1983). Knowing that *Alloteuthis media* has, in portuguese waters, a very low abundance, catch rate patterns of the genus *Alloteuthis* must be a reflex, essentially, of the behaviour of *Alloteuthis subulata*. Together with the differences verified for this species in size distribution with depth, one may hypothesize the following reasons for seasonal variation of distribution: In summer males and females migrate to shallow coastal waters for mating and egg laying. In autumn adult squids remain inshore for another mating

and spawning period and juveniles starts the migration to deeper waters. So by this season the overall distribution was more contiguous and dispersed. Grimpe (1925) reported the migration of juveniles during autumn to overwinter in warmer deeper atlantic waters. In fact deeper limits of distribution were recorded in winter.

ACKNOWLEDGMENTS

I would like to thank João Pereira and Manuela Morais da Cunha for their helpfull criticism in revising this paper.

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Table 1 - Samples of *Alloteuthis subulata*. Vessel, time, location, catch.

VESSEL	DATE	LAT. N	LONG. W	DEPTH (m)	CATCH (g)	SAMPLE Wt (g)	SAMPLE nº
M.COSTEIRO	16-01-90	38° 34.3'	9° 25.3'	120	105	104.4	18
"	17-01-90	38° 19.0'	8° 57.5'	115	130	58.6	29
"	18-01-90	38° 14.4'	8° 59.6'	147	700	67.6	28
"	19-01-90	37° 39.3'	8° 52.1'	80	345	322.6	65
"	19-01-90	37° 43.6'	8° 58.2'	147	700	108.8	42
"	21-01-90	37° 30.0'	8° 54.3'	119	700	329.3	76
"	22-01-90	37° 24.2'	8° 51.2'	50	230	200.3	61
"	25-01-90	36° 50.2'	8° 10.1'	110	200	91.4	23
"	25-01-90	36° 49.7'	8° 21.3'	180	30	29.2	8
"	28-01-90	36° 53.9'	8° 05.6'	90	200	118.4	21
NORUEGA	09-07-90	36° 57.3'	8° 21.3'	73	1150	70.4	12
"	14-07-90	37° 13.1'	8° 55.7'	62	160	69.0	12
"	14-07-90	37° 15.9'	9° 04.3'	136	1130	73.0	17
"	16-07-90	37° 39.5'	8° 51.1'	79	290	71.6	15
"	16-07-90	37° 34.6'	8° 54.1'	118	880	70.0	12
"	18-07-90	38° 12.3'	8° 53.9'	115	240	57.0	12
"	19-07-90	38° 32.2'	9° 23.2'	119	460	76.6	24
"	19-07-90	38° 35.1'	9° 25.7'	100	2000	35.0	12
M.COSTEIRO	30-05-91	37° 40.3'	8° 51.0'	78	1350	226.8	38
"	01-06-91	37° 17.4'	8° 55.3'	71	4780	210.8	38
"	03-06-91	37° 04.6'	8° 28.9'	31	840	219.8	40
"	03-06-91	36° 58.0'	8° 26.6'	64	670	109.8	20
"	04-06-91	37° 01.5'	7° 29.2'	92	480	193.0	39

Table 2 - Percentage of each maturity stage and dorsal mantle length (DML) range of *Alloteuthis subulata* males (M) and females (F).

Maturity Stage		1		2		3		4	
		%	DML Range	%	DML Range	%	DML Range	%	DML Range
Winter	M	16.3	26-54	41.2	32-118	32.1	40-145	10.4	50-174
	F	35.6	24-52	20.8	37-70	30.9	41-87	12.7	54-75
Late Spring	M	9.7	25-45	4.3	37-44	8.6	35-74	77.4	39-158
	F	10.3	34-52	15.3	36-59	10.3	50-97	64.1	57-104
Summer	M	6.3	27-37	4.2	39-56	16.6	47-92	72.9	55-183
	F	2.9	47-50	2.9	53-56	35.3	52-87	58.9	58-89

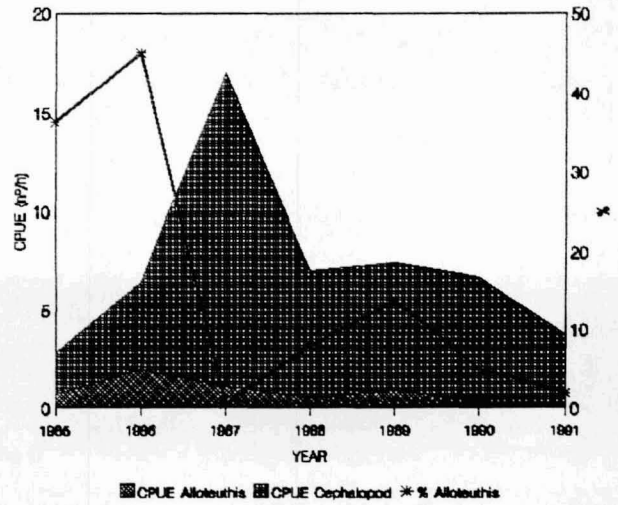

Figure 1 - Percentage of *Alloteuthis* within cephalopods and their capture per unit effort (n°/h) in October/November of 1985 to 1991. Results from bottom trawl surveys by the R/V "Noruega".

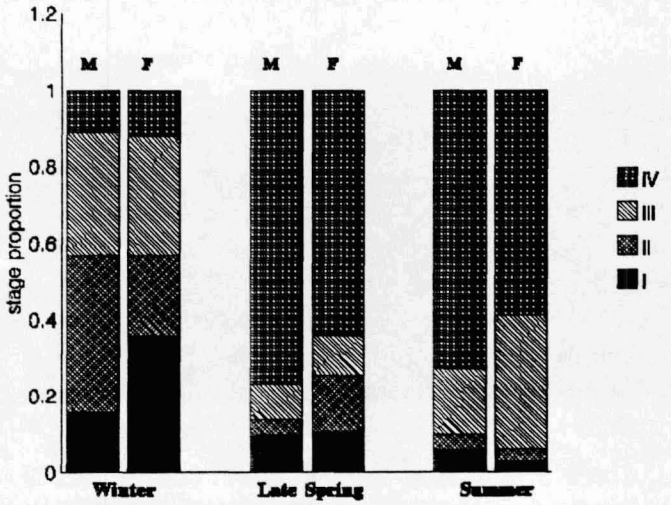

Figure 2 - Proportion of maturity stages of males (M) and females (F) of *Alloteuthis subulata*.

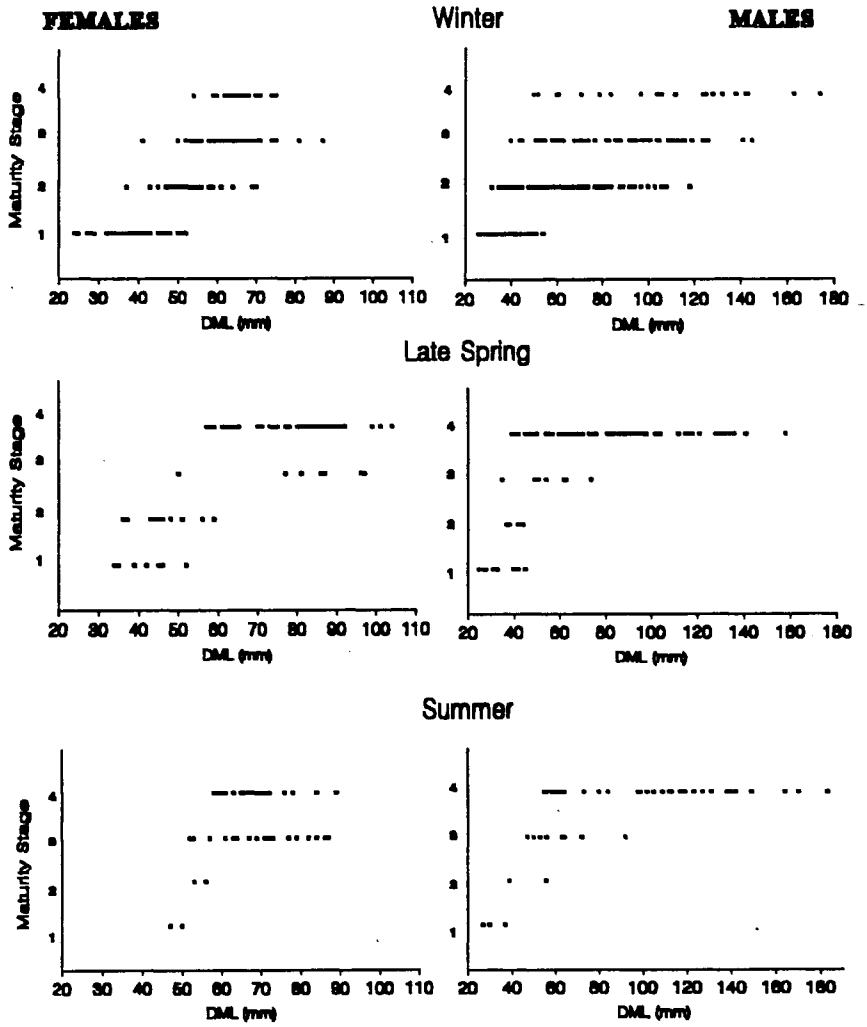

Figure 3 - Relation between maturity stage and dorsal mantle length (DML) of *Alloteuthis subulata* males and females.

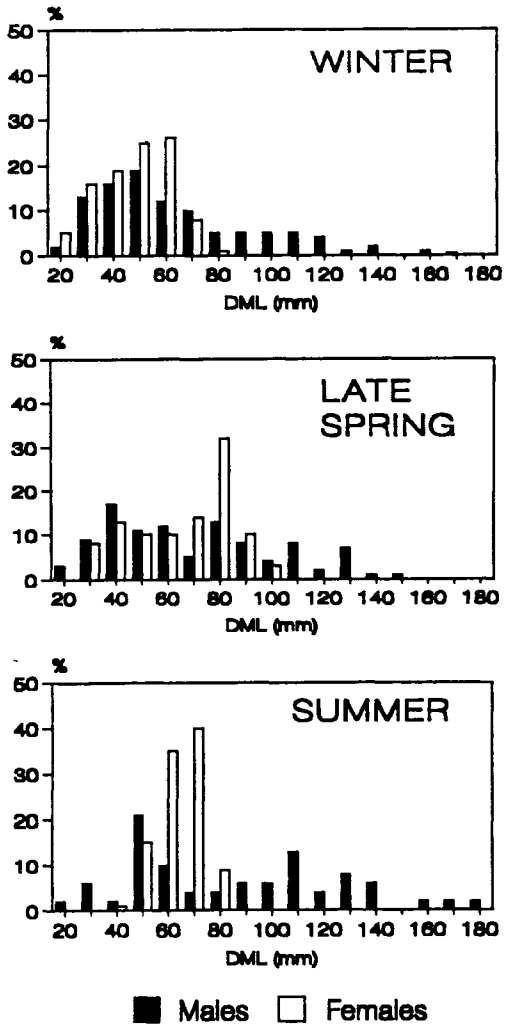

Figure 4 - Seasonal length frequency distributions of *Alloteuthis subulata* males and females.

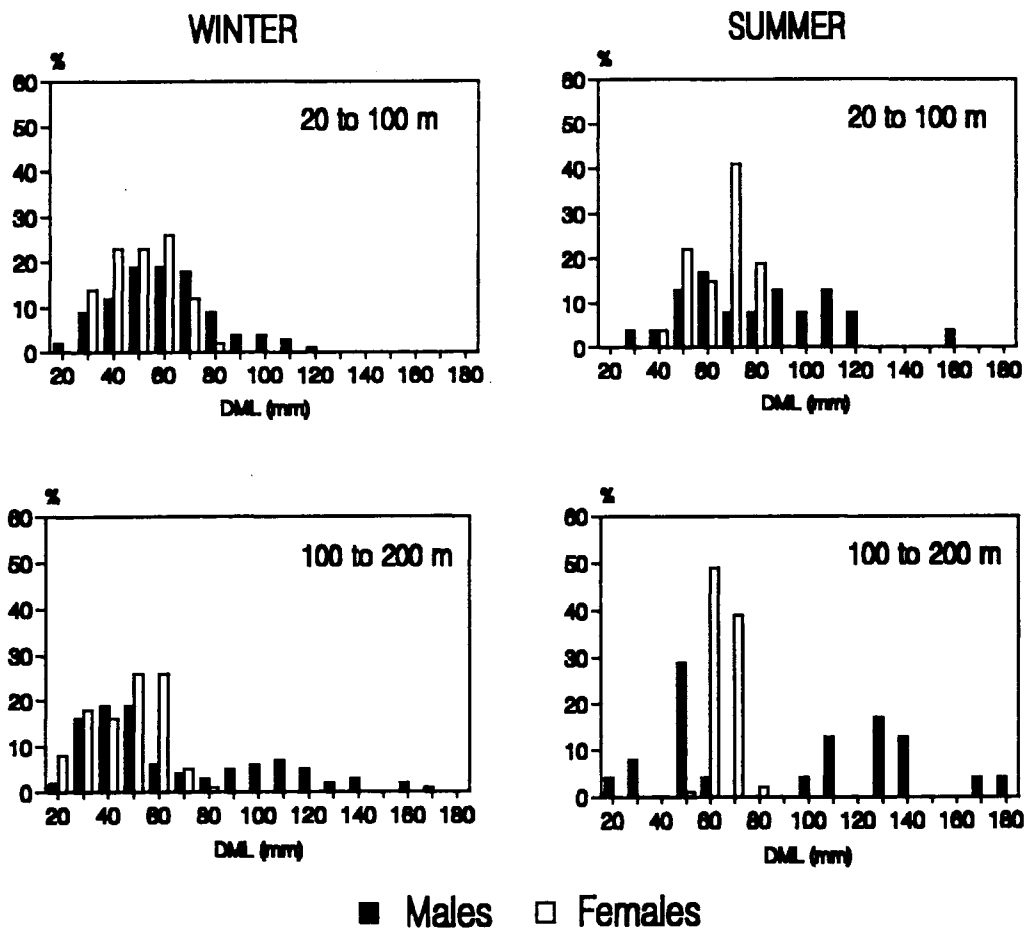

Figure 5 - Length frequency structure within two depth ranges (20 to 100 and 100 to 200 m) of *Alloteuthis subulata* males and females in winter and summer of 1990.

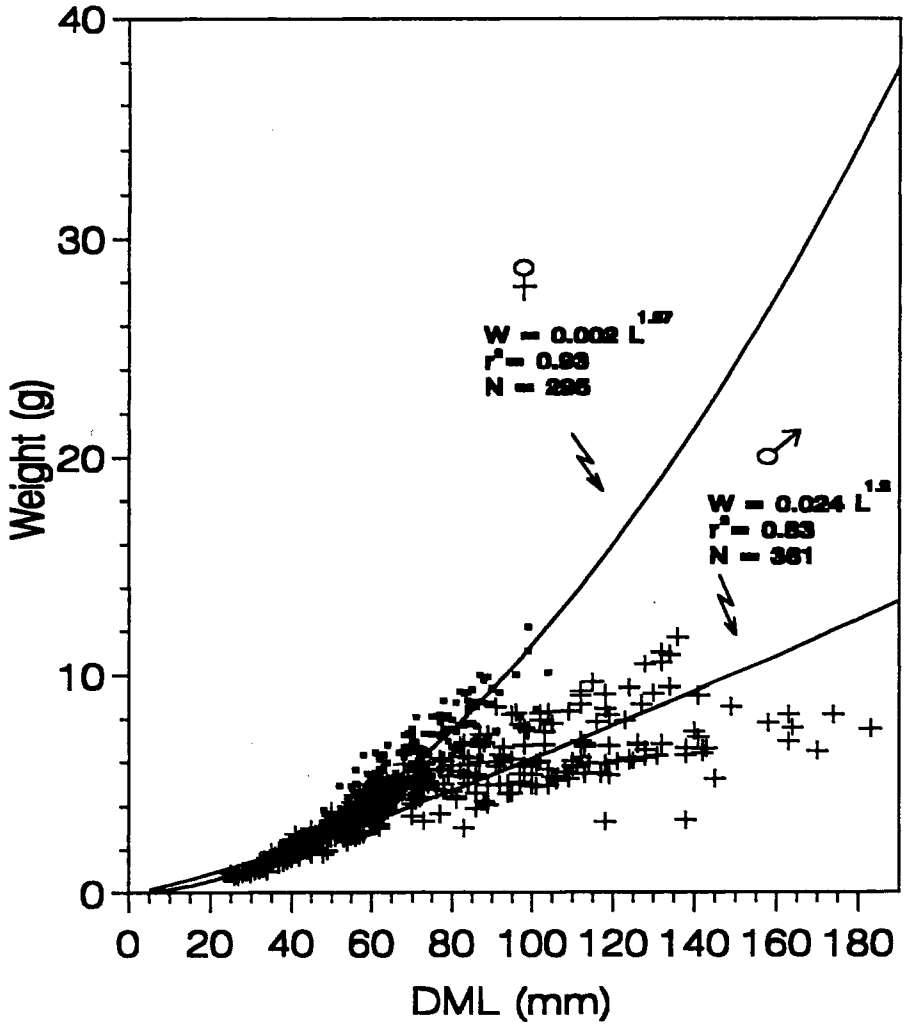

Figure 6 - Length-weight relationships of *Alloteuthis subulata* males (♂) and females (♀). Regression equations of the fitting curves (W = body weight; L = dorsal mantle length; r^2= correlation coefficient; N = sample number).

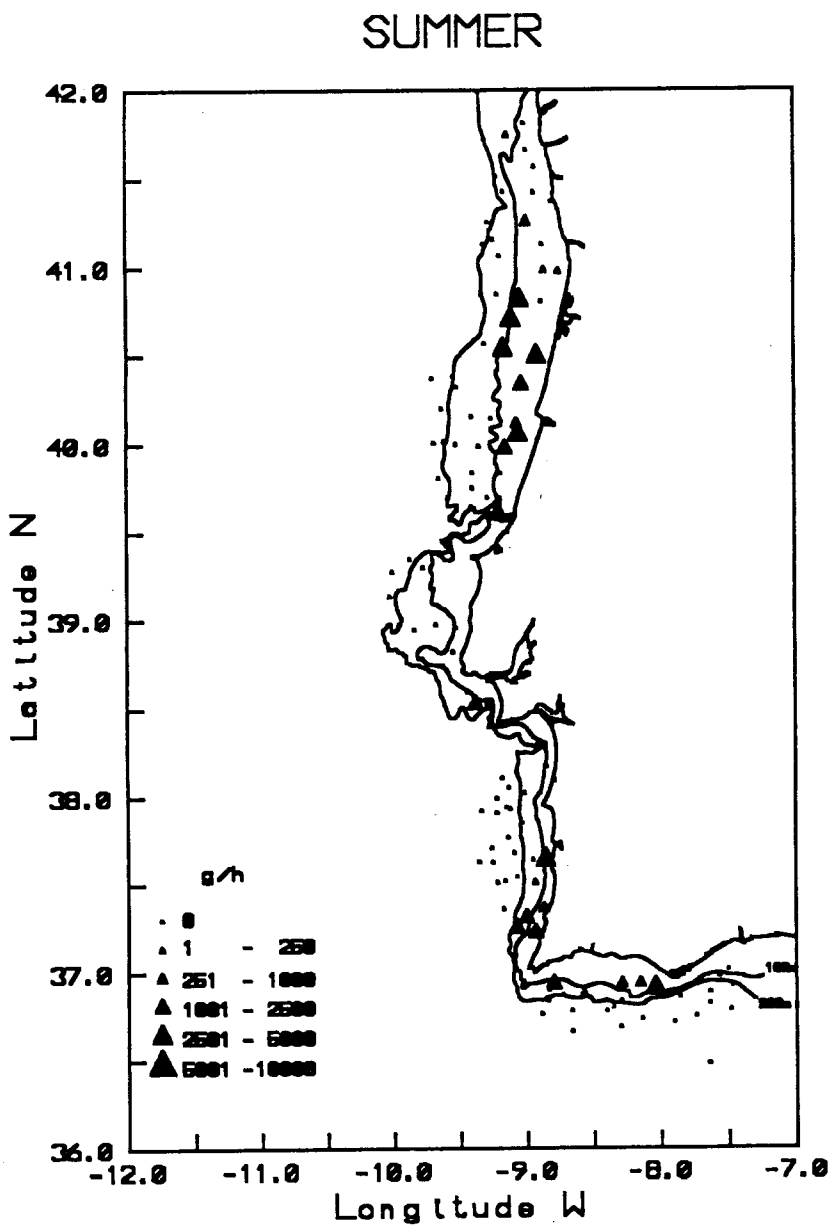

Figure 7 - Abundance and distribution of *Alloteuthis*. Sampling stations by R/V "Noruega" during July 1991.

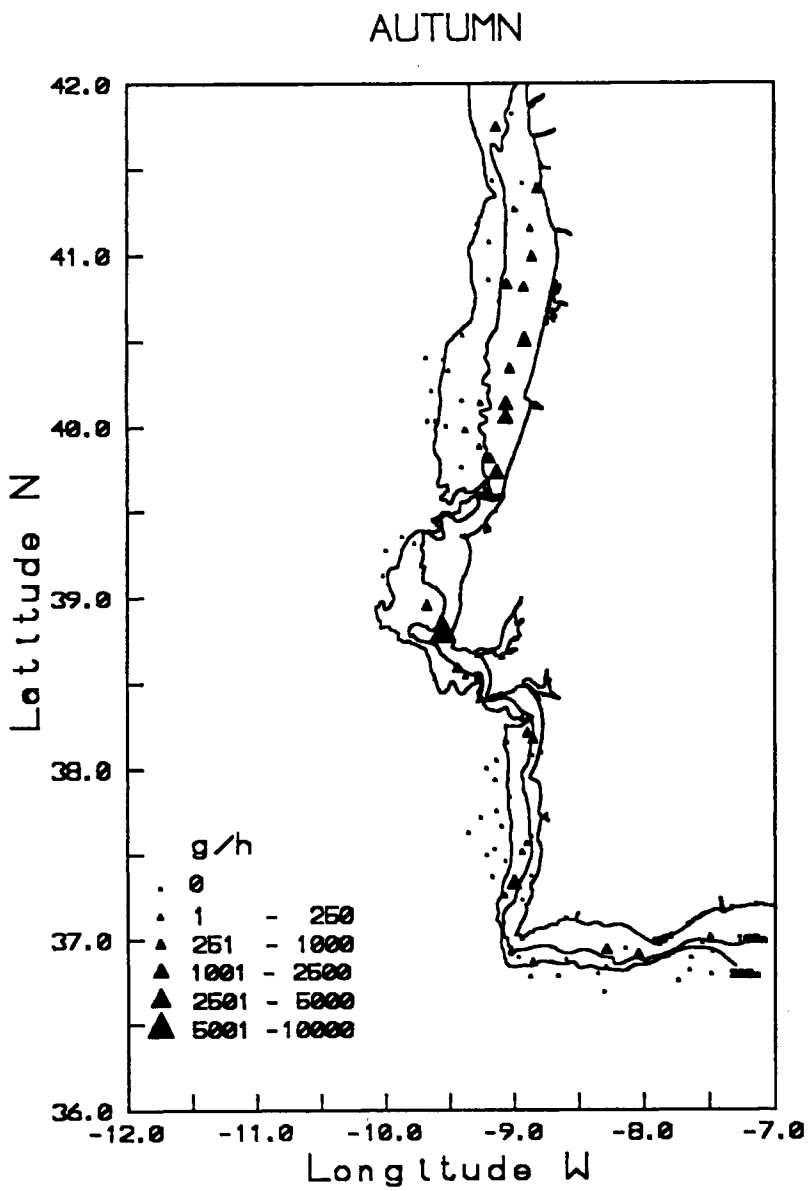

Figure 8 - Abundance and distribution of *Alloteuthis*. Sampling stations by R/V "Noruega" during October/November 1991.

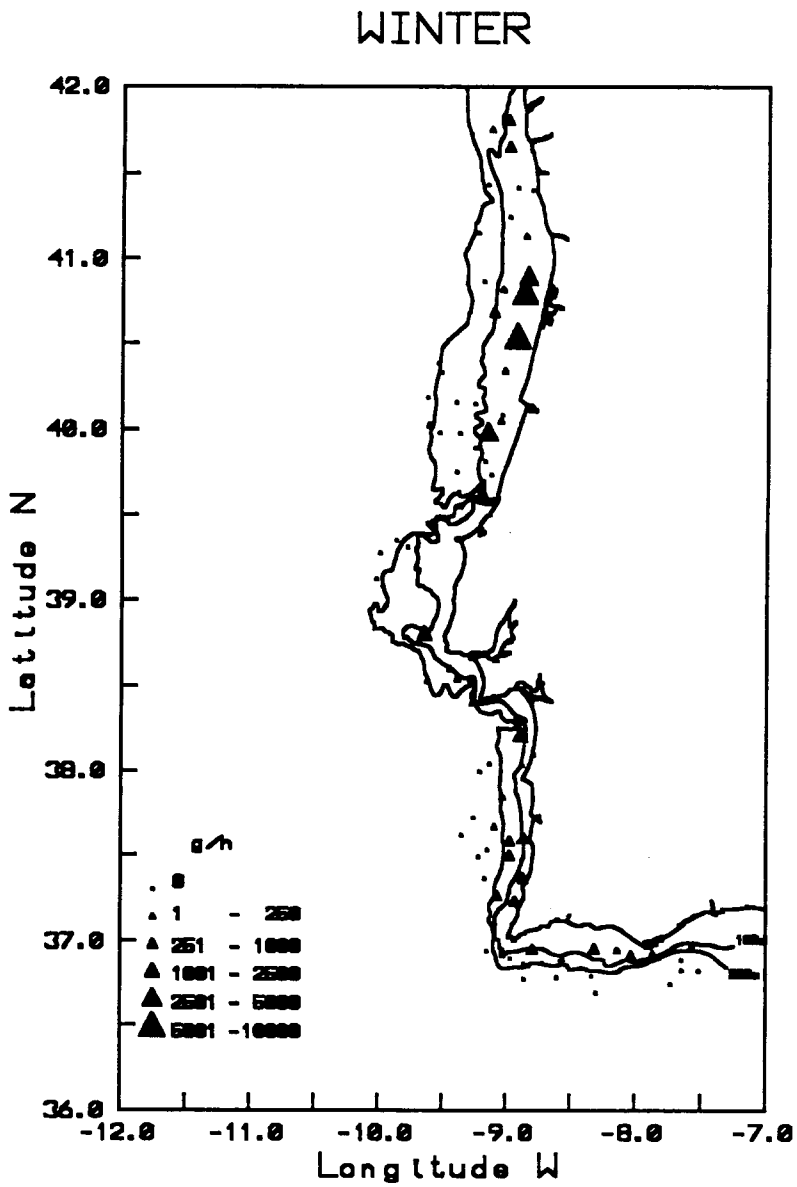

Figure 9 - Abundance and distribution of *Alloteuthis*. Sampling stations by R/V "Noruega" during February/March 1992.