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Observations of a ten-year period on the biology and fishery of albacore,
Thunnus alalunga (Bonn. 1788), carried out in the North Ionian and
South Adriatic seas

by

De Metrio G. and Megalofonou P.
Department of Animal Production
University of Bari- Italy

Marano G., De Zio V., Rositani L., Vlora A.
Laboratory of Marine Biology
Bari - Italy

1. Introduction

Until 1984, in Italian seas, the studies of albacore were limited to the few investigations carried out by Arena et al. (1980) and Arena & Li Greci (1970) who principally studied some problems of the biology of this species in the South Tyrrhenian Sea and Potoschi et al. (1982) who studied albacore fishing and biology in the Gulf of Taranto.

In Italy a systematic research on large pelagic stocks began in 1984 with the entry into force of Law n.41 (17/2/1982) which, among other things, provides for triennial research programmes on the evaluation of fishery resources, as scientific support in order to carry out a rational exploitation of the national marine resources.

Due to the above mentioned law, from 1984 several research groups from different Italian Scientific Institutions began their investigations on different Italian seas, firstly, thanks to financial support by Italian Ministry of Merchant Marine and after, from 1990, thanks also to the funds granted by EEC with the projects MA 1.101/XIV/FAR and XIV/MED/91-92.

In this ambit the Department of Animal Production of University of Bari and the Provincial Laboratory of Marine Biology of Bari, carried out investigations on large pelagic fish fished in the North Ionian and South Adriatic Seas respectively and, in this paper, the results obtained from the studies carried out on albacore (*Thunnus alalunga* Bonn.) during the period from 1984 to 1993 are reported.

2. Material and Methods

During the albacore fishing period from 1984 to 1993, fishery and biological data were collected from the main fishing ports for albacore fishery in the North Ionian and the South Adriatic seas: Monopoli and Mola di Bari situated on the Adriatic coast of Apulia and Porto Cesareo located on the Ionian coast of the same region. (Figure 1).

Fishery data were collected for a significant number of boats constituting the sampled fleets and they were used to estimate the catch per effort statistics.

Measurements of fork length in cm (FL) for 6802 and round weight for 3152 animals landed at the three aforementioned ports were taken.

Sex was identified for 223 albacore caught in the Ionian sea by a macroscopic observation of the gonads.

For the purpose of age estimation a total of 372 albacore, caught in the Ionian Sea, were sampled. The spines of the first dorsal fin were used for age estimation.

Three serial sections of about 0.7-1 mm thick were obtained from each spine at the point where the spine flares. Fin sections were read under a binocular microscope at 2.5x magnification.

The distances of the spine radius and of the annulus radius were measured with an optical micrometer and were used for back-calculations of length at estimated age (Garces and Farina, 1983). The relationship between spine radius and LF was determined using linear regression analysis.

Estimates of theoretical growth in length were obtained by fitting the back calculated length at age data to the von Bertalanffy growth equation using the Newton iteration method (Sparre, 1987). Back calculations of length at estimated age were obtained from a modified version of the direct proportion formula (Fraser, 1916; Lee, 1920).

* Data on albacore from Ionian Sea are provided in the framework of a Ph.D thesis by Persefoni Megalofonou.

3. Results and discussion

3.1. Catches and effort

In the North Ionian sea the most important albacore fishing area is the Gulf of Taranto. Fishery is generally carried out by long-lines in a period from the end of July to the middle of December, but especially in the last years, October and November have been much more involved in this kind of fishery. In this area fishery data were collected at the pilot port of Porto Cesareo where the main fleet of the whole Gulf of Taranto for the albacore fishing is located. (Fig. 1) The albacore production of this port represents the 80% of the total albacore production of the Gulf of Taranto. Catch statistic data for ten-year period 1984-1993 (excepted 1989) are given in Table I.

Tab. I - Summarized data of albacore fishery collected in the North Ionian Sea from 1984 to 1993

Year	E (x 1000 hooks)	Total catch (kg)	Total number	CPUE (kg)	CPUE (number)	Average weight
1984	1126.6	87040	17046	77.3	15.1	5.1
1985	819.8	58810	11041	71.1	13.5	5.3
1986	335.7	21190	4295	63.1	12.8	4.9
1987	218.5	16260	3040	74.4	13.9	5.3
1988	387.5	25387	4466	88.3	15.5	5.7
1990	513.3	63816	11394	124.3	22.2	5.6
1991	662.6	58233	10274	87.9	15.5	5.7
1992	386.6	25955	4359	67.1	11.3	5.9
1993	994.8	63716	11005	64.0	11.1	5.8

It is easy to observe that the trend of fishing effort (E) shows a decrease from 1984 to 1987 and an increase from 1988 to 1993 with the exception of a temporary decrease in 1992. Also CPUE show a decrease during the first three-year period which was followed by a three-year period of increase and then a further decrease during the last two-year period.

It seems that the CPUE values bias those of the effort, because the fishermen change their activity immediately turning their interest to other more profitable resources when their daily yield goes under acceptable levels.

The average weight remains almost uniform during the first four-year period while it shows a slight increase during the last years.

In the South Adriatic sea albacore fishing areas are 15-20 miles far from Italian coasts, quite close to the Albanian and Jugoslavian coasts, especially off Monopoli where the depths range about from 500 to 800 mt. (Fig. 1) The fishing period is generally included between the first days of September and the middle of December. The fishing is carried out only by long-lines.

Fishery data were collected in the pilot ports of Monopoli and Mola di Bari. Monopoli is the most important port in the South Adriatic as for great pelagic fishing, both for boats number and fishing amount. Mola di Bari has got a lower number of boats. Both ports fish the 80% of the total production of the Albacore in the South Adriatic.

Catch statistic data for ten-year period 1984-1993 (excepted 1988 and 1989) are given in table II.

Tab. II - Summarized data of albacore fishery collected in the South Adriatic Sea from 1984 to 1993

Year	E (x 1000 hooks)	Total catch (kg)	Total number	CPUE (kg)	CPUE (number)	Average weight
1984	1633.5	137904	27398	84.4	16.8	5.0
1985	2895.0	303573	56753	104.9	19.6	5.3
1986	2903.2	326472	64679	112.4	22.3	5.0
1987	1291.9	320374	65309	248.0	50.5	4.9
1990	578.6	127622	22691	172.2	29.6	5.6
1991	1087.8	196296	37675	180.4	34.6	5.2
1992	807.8	152102	29186	188.3	36.1	5.2
1993	643.6	80081	15641	124.4	24.3	5.1

The effort fishing trend during the studied years points out some fluctuations which seem to be illogical. Really the trend mainly depends on the market prices and since they are not considered remunerative, the most of the fleet turn the fishing effort to other resources as the hake or other nectobenthic species. The CPUE trend has showed in these years, excpeted 1993, a steady increase with the highest value in 1987. The average weight remains constant for the whole considered period.

From the investigations carried out during the ten-year period 1984-1993, differences in CPUE indices among the different pilot ports seem evident. From the results shown in Tables I and II, it seems evident that in the South Adriatic area are observed generally CPUE values higher than the ones in the Gulf of Taranto.

3.2. Size distribution

A total of 6802 individuals were sampled at the ports: 2919 in North Ionian for the period 1985-1993; 3883 in the South Adriatic, for the period 1990-1993. The measurements of fork length (FL) were analyzed and the summatized results are presented in Tables III and IV.

Tab. III - Summarized analysis of the lengths of albacore samples collected at the pilot ports of the North Ionian sea.

North Ionian					
Year	Sample size	Average FL (cm)	Standard deviation	Min.	Max
1985	127	69.51	3.51	60.0	82.0
1986	10	70.03	3.17	66.0	75.0
1987	822	67.96	4.08	57.0	84.0
1988	117	70.08	5.31	59.0	88.0
1989	603	66.16	3.86	53.0	84.0
1990	208	69.90	3.18	62.0	80.0
1991	241	69.50	4.95	60.0	84.0
1992	355	70.68	4.36	44.0	86.0
1993	436	68.56	5.08	56.0	122.0

Tab. IV - Summarized analysis of the lengths of albacore samples collected at the two pilot ports of the South Adriatic sea.

South Adriatic Sea					
Year	Sample size	Average FL (cm)	S.Deviation	Min	Max
1990	890	73.13	6.59	49.0	95.0
1991	975	66.8	7.80	41.0	88.0
1992	1458	65.88	9.10	39.0	100.0
1993	560	65.68	12.86	35.0	95.0

The lenght distributions of the samples are shown in Figures 2 and 3.

3.3. Length - Weight relationship

The relationship between fork length and round weight was calculated in 1991, 1992, 1993 separately for North Ionian and South Adriatic Sea. The forms and the correlation coefficient found are given in the following table:

Year	North Ionian Sea			South Adriatic Sea		
	Samples	Form	r	Samples	Form	r
1991	447	$\ln W = -9.05 + 2.55 \ln LF$	0.86	719	$\ln W = -9.31 + 2.59 \ln LF$	0.89
1992	351	$\ln W = -9.29 + 2.61 \ln LF$	0.91	903	$\ln W = -7.26 + 2.10 \ln LF$	0.81
1993	350	$\ln W = -8.90 + 2.53 \ln LF$	0.92	382	$\ln W = -7.89 + 2.26 \ln LF$	0.88

The analysis of covariance reveals significant differences in the length-weight relationship for the two geographical areas. The differences observed, although these cannot be completely explained, are probably due to the high number of measurements in the samples and to the differences in the range of fork lengths in the samples. However, since the relationship between weight and length provides an index of the condition of the fish (Wootton, 1990) which may reflect the effects of both environmental (exogenous) and endogenous factors, probable differences in the food availability in the two areas may also affect the length-weight relationship considering that the presence of albacore in these areas is due to seasonal trophic concentrations (Cefali et al., 1986; Magalofonou, 1990).

3.4. Sex ratio

The sex was determined in 100 albacore in 1988, 138 in 1991, 27 in 1992 and 58 in 1993 caught in the North Ionian sea. The sex ratio (male/female) was:

1988	1: 0.72	1992	1: 0.35
1991	1: 1.06	1993	1: 2.22

No individuals with ripe gonads were found whereas a lot of just spent gonads were observed.

3.5. Age and growth

Spines from 372 specimens caught in the Ionian Sea ranging in size from 58.5 to 92 cm were examined.

The maximum estimated age was 7 yr. while the minimum 2 yr. Age groups 2 and 3 were the most numerous in the sample. The frequency distribution of the fish into the age groups indicated that fish with estimated ages 2 and 3 dominated the Ionian population.

The fork length at the end of each year of life was back-calculated for each individual and these lengths were averaged to obtain mean lengths at age. Back-calculation was based on the modified direct proportion formula (Fraser, 1916; Lee, 1920) and on the intercepts values obtained from the relationship between fork length and spine radius which was found to be:

$$FL = 47.1 + 13.7S \quad r = 0.66$$

The back-calculated lengths of individuals assigned to each age group were used to fit the von Bertalanffy growth model and the vital parameters for the growth equation were found to be:

$$L_{\infty} = 104.1 \text{ cm}, \quad k = 0.139 \text{ and } t_0 = -4.88$$

Mean observed and back-calculated fork lengths at estimated age based on spine analysis from the two geographical areas are shown in table V:

Table V - Mean observed and back-calculated fork length (cm) at estimated age for 372 albacores from the Ionian sea.

Age	Observed	Back-calculated
1	-	61.2
2	66.3 (113)	65.8
3	69.8 (193)	69.3
4	74.0 (50)	73.5
5	78.7 (12)	77.0
6	77.0 (2)	77.7
7	83.0 (2)	82.3

An effort to validate the age estimation for albacore was made using the modal method was unsuccessful due to the short range of the lengths in the samples and the difficulties in the identification of modes.

Several age and growth studies using dorsal spine have been carried out for Atlantic albacore (Bard, 1981; Garcés and Farina, 1983; and Fernandez, 1991). However, the size at age computed from the resulting growth curves do not agree (ICCAT, 1990).

Recently, Ortiz de Zarate et al. (1994) have made an attempt to validate the age determination of immature atlantic albacore, injected with oxytetracycline, by using the first dorsal fin spine method.

The analysis of the translucent zones identified after the oxytetracycline mark showed that the examined albacore did not follow a single pattern in formatting the annuli. In most cases two annuli were formed in one year at liberty, but cases with one or three annuli were also present.

3.6 Tagging Campaigns

Some tagging campaigns for albacore were carried out in 1990, 1991, 1992 and 1993 in the Gulf of Taranto, and in 1991 also in South Adriatic using chemical tracers and "spaghetti" tags for the study of growth and stock structure.

The chemical tracer utilized was Oxitetracycline (Izomicina 100) at 70 mg/kg body weight. The "spaghetti" tags were those supplied by ICCAT.

The fish treated with the chemical tracer were tagged with red tags while the fish it was impossible to inject with tracer were tagged with yellow tags. A total of 397 albacore were tagged.

Summary results all tagging campaigns are presented in following table:

Year	With Oxytetracycline	Without Oxytetracycline	Total	Range FL (cm)	Area
1990	44	10	54	62-87	North Ionian Sea
1991	141	35	176	60-78	"
1992	4	-	4	71-76	"
1993	86	-	86	62-81	"
1991	53	24	77	52-80	South Adriatic Sea
Total	328	69	397	-	-

3.6.1 Recaptures

Till now only two tags from albacore tagged in 1990 have been recovered. Their recapture came about in the same place of release that is in the Gulf of Taranto approximately localized in the quadrilateral area which is delimited with lines joining the following four co-ordinates:

40° 08' N	40° 10' N	39° 56' N	39° 54' N
17° 10' E	17° 34' E	17° 37' E	17° 19' E

The recapture was made by sporting fishermen who just sent us the tags accompanied by brief explanations as to the place of recapture.

The data for capture and recapture are the following:

No Tag	Date and area of release	Date and area of recapture
5364	01.11.90 Gulf of Taranto	10.11.91 Gulf of Taranto
5336	20.11.90 Gulf of Taranto	29.10.91 Gulf of Taranto

Both animals were tagged with Oxitetracycline but it was not possible to obtain the hard parts for the study of fluorescent tracks from either animal.

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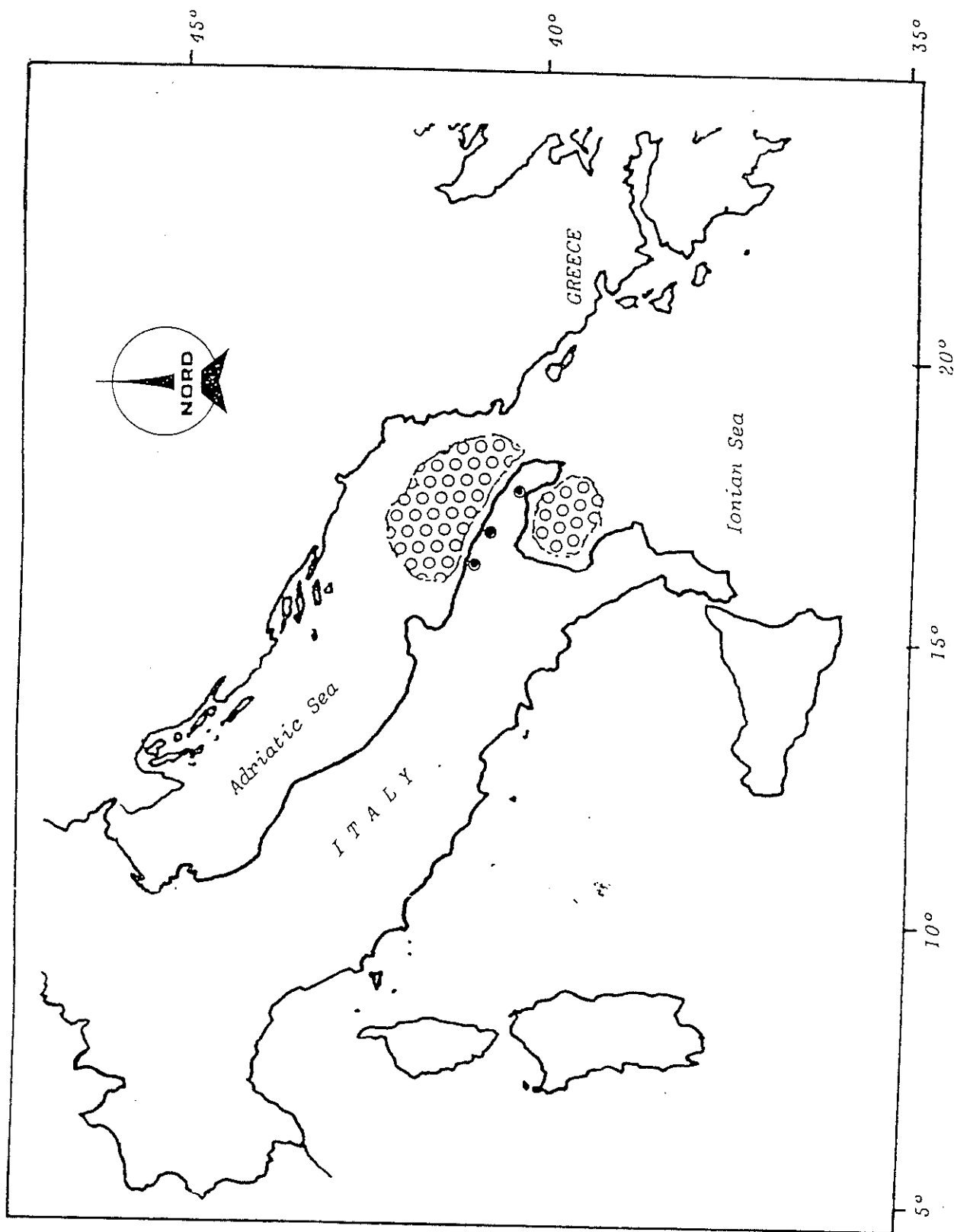


Fig. 1 - Fishing areas and pilot ports in the studied seas

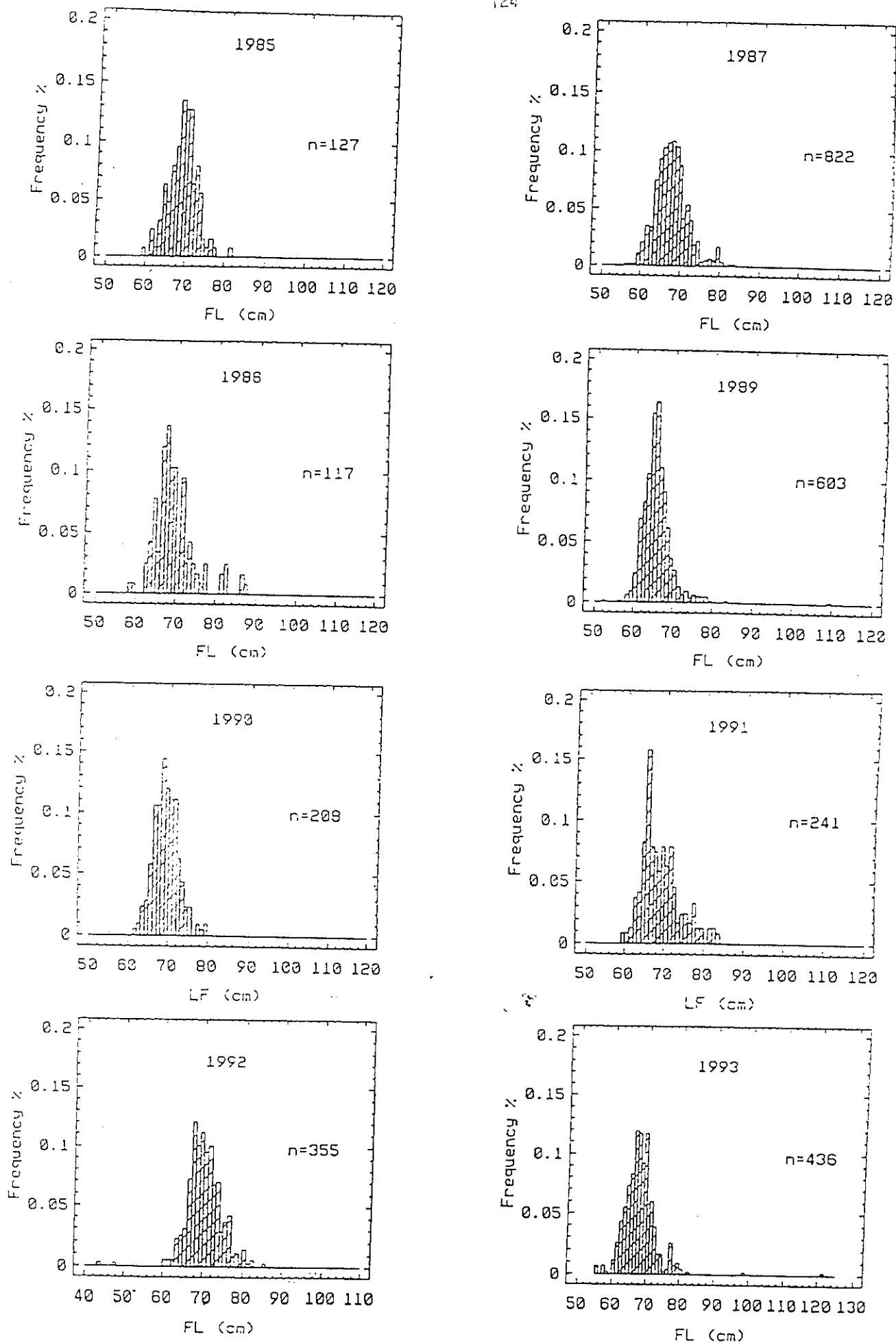


Fig. 2 - Percentage length frequency distribution of the total sampled of albacore fished by long-line in the North Ionian Sea from 1985 to 1993. (1986 not included).

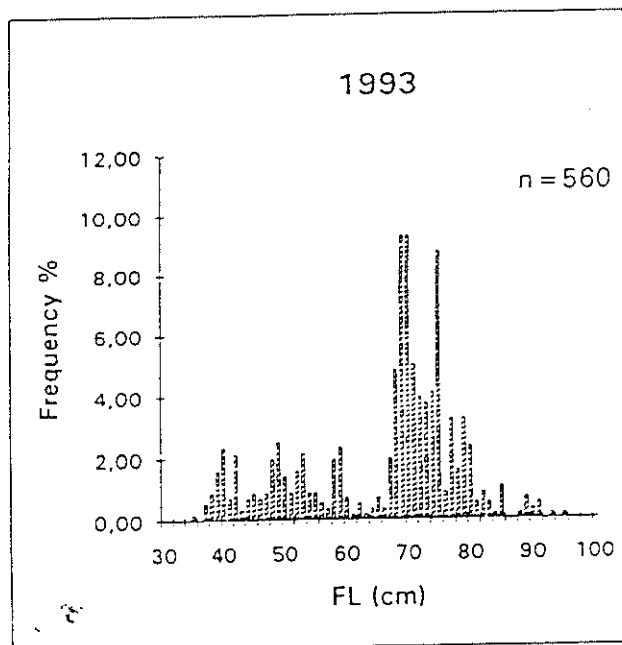
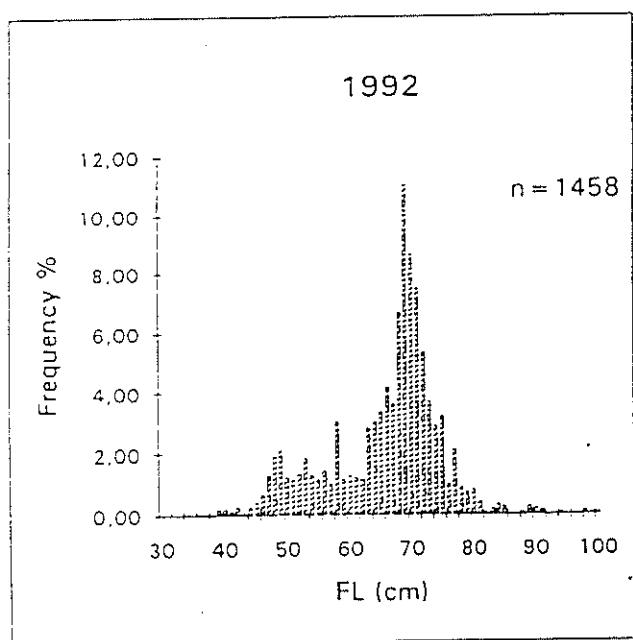
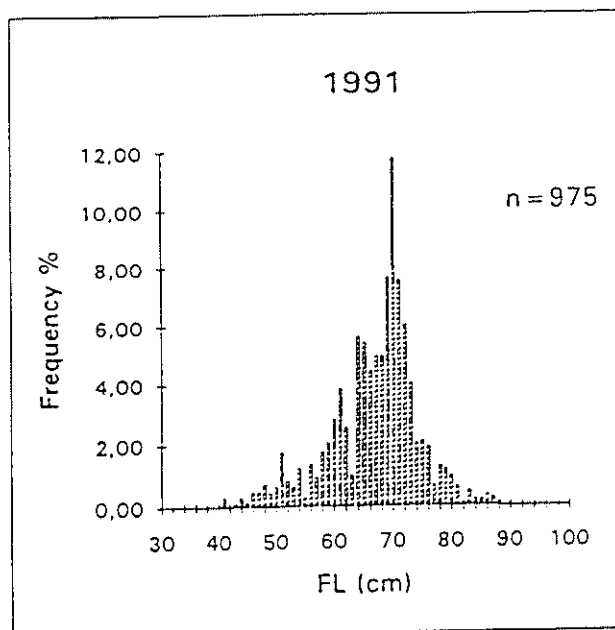
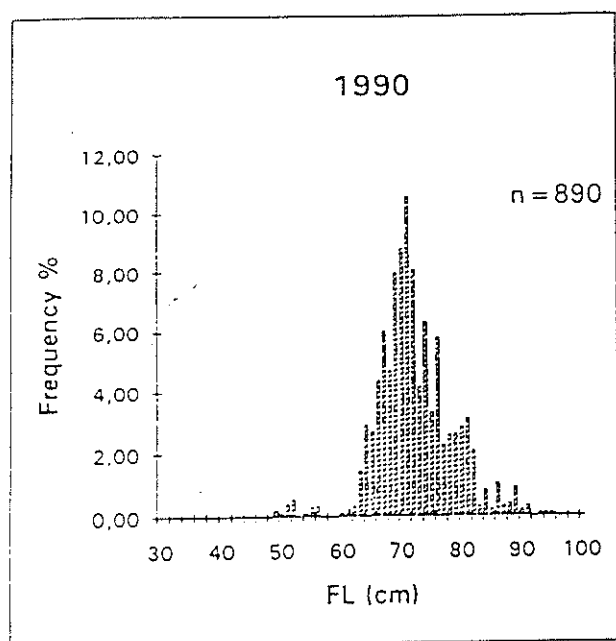


Fig. 3 - Percentage length frequency distribution of the total sampled of albacore fished by long-line in the South Adriatic Sea from 1990 to 1993.