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# The growth of the Red Mullet (*Mullus barbatus*, L. 1758) during the first years of life in the Ligurian Sea (Mediterranean)

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**SUMMARY** - Trawl studies were carried out seasonally in the Ligurian Sea for studying the growth of the Red Mullet (*Mullus barbatus*, L. 1758) during its first years of life. The mean length at age was obtained by using both indirect and direct methods. The analysis of the steady length structures for 12 month-old individuals gives a modal length of 11.9 cm t.l. in males and 13.4 cm t.l. in females; in 24 month-old individuals these lengths are respectively 16.3 cm and 17.6 cm t.l. The modal progression analysis, carried out without taking in account sex, shows that the average length for 12 month-old individuals is 13.0 cm t.l. while for 24 month-old ones is 17 cm t.l. The growth rate shows a clear seasonal pattern with a decrease during the first winter of life and during the second autumn/winter. Sagitta readings have shown the occurrence of a well-defined "hyaline ring" in a large group of recently recruited fish, which cannot have a yearly meaning. Generally from the third ring onward these are laid down mainly between the winter and spring season. Considering difficulties in interpreting sagitta readings, the age groups were allocated on the basis of two criteria. The first criterion selects all fish whose sagitta shows hyaline rings, regardless their position. The second criterion isolates only those which present fully formed annuli (subperipheral or inner position) in the otoliths. Regardless of sex and according to the first criterion, *M. barbatus* results to be 12.7 cm t.l. at one year, 13.9 cm at two years and 16.3 cm at three years. When considering the second grouping criterion, the mean length becomes 13 cm t.l. at one year, 16.1 cm at two years and 17.6 cm at three years. While there is a good agreement among methods for the evaluation of the mean length at one year, the simple counting of hyaline rings in otolith readings leads to the underestimation of length from year two onward. The influence of method in growth rate estimates is discussed while comparing growth rates from different areas obtained by different methods.

**Key words:** *Mullus barbatus*, Red Mullet, growth, length-frequency analysis, otolith readings, Ligurian Sea, Mediterranean.

***RESUME*** *- "La croissance du rouget de vase* (Mullus barbatus, *L. 1758) pendant les premières années de vie dans la Mer de Ligurie (Méditerranée)". On a utilisé, pour l'analyse de la croissance du rouget de vase* (Mullus barbatus, *L. 1758) pendant les premières années de vie, des échantillons saisonniers obtenus par essais de chalutage en Mer Ligure. Les longueurs moyennes par âge ont été tirées en utilisant des méthodes indirectes et directes. L'analyse de la structure de taille stationnaire fournit des longueurs modales de 11,9 cm (au total) pour les mâles et 13,4 pour les femelles à l'âge d'environ 12 mois ; à environ 24 mois ces longueurs sont de 16,3 cm et 17,6 cm respectivement. L'analyse de la progression modale, effectuée sans distinction de sexe, indique que la longueur moyenne à 12 mois est de 13 cm au total et à 24 mois de 17 cm. La croissance montre une claire tendance saisonnière avec une diminution du taux de croissance pendant le premier hiver de vie et une autre diminution pendant le second automne-hiver. On relève deux faits importants par la lecture des sagittae qui rendent difficile leur usage dans la détermination de l'âge. Avant tout la présence sur la plus grande partie des poissons recrutés récemment d'un anneau hyalin, qui n'a pas peut-être une valeur annuelle. Deuxièmement, l'absence d'un caractère saisonnier clair dans la déposition de l'anneau, au moins jusqu'à ce que paraissent deux anneaux hyalins bien définis dans l'intérieur de la sagitta. Compte tenu de ces difficultés de lecture des sagittae, on a préparé les groupes d'âge, soit en calculant tous les anneaux hyalins présents dans l'otolithe, soit en considérant seulement ceux complètement formés (en position sub-périphérique ou interne). En considérant les deux sexes ensemble,* M. barbatus *mesure 12,7 cm de longueur totale à un an, 13,9 cm à deux ans et 16,3 à trois ans (premier critère : tous les anneaux hyalins) ; et respectivement 13 cm à un an, 16,1 à deux et 17,6 à trois ans (deuxième critère : les anneaux bien formés). On a relevé une bonne concordance entre les estimations des longueurs à un an, tirées par différentes méthodes, alors que le simple compte de tous les anneaux à partir du deuxième an, semble conduire à une surestimation de l'âge. L'influence de la méthode sur les estimations de la croissance est discutée en comparant les résultats obtenus pour* M. barbatus *dans différentes aires de la Méditerranée.*

***Mots-clés :*** Mullus barbatus, *rouget de vase, croissance, analyse des tailles, lecture des otolithes, Mer Ligure, Méditerranée.*

## Introduction

*Mullus barbatus* is one of the most important demersal resources in the Mediterranean.

Many Authors have studied its growth by using different approaches such as rings on scales and otoliths, modal progression analysis and more recent techniques of length analysis (ELEFAN, MULTIFAN and so on).

The literature on growth gives very different results. Some Authors have considered these differences reflect the existence of different stocks in the Mediterranean (Levi *et al.*, 1992). Although this idea is realistic, it is also possible that the noted differences are due to the methods employed.

The principal aim of this work is the study of the first years growth in *M. barbatus* of the Ligurian Sea comparing indirect and direct methods.

## Material and methods

Approximately 49,000 specimens, from 5 to 25 cm total length, were collected in 14 seasonal surveys of standard trawling on fixed hauls in the range 20-135 m depth along the Ligurian coast, from summer 1990 to autumn 1993.

The sampling areas and the haul sites are shown in Fig. 1.

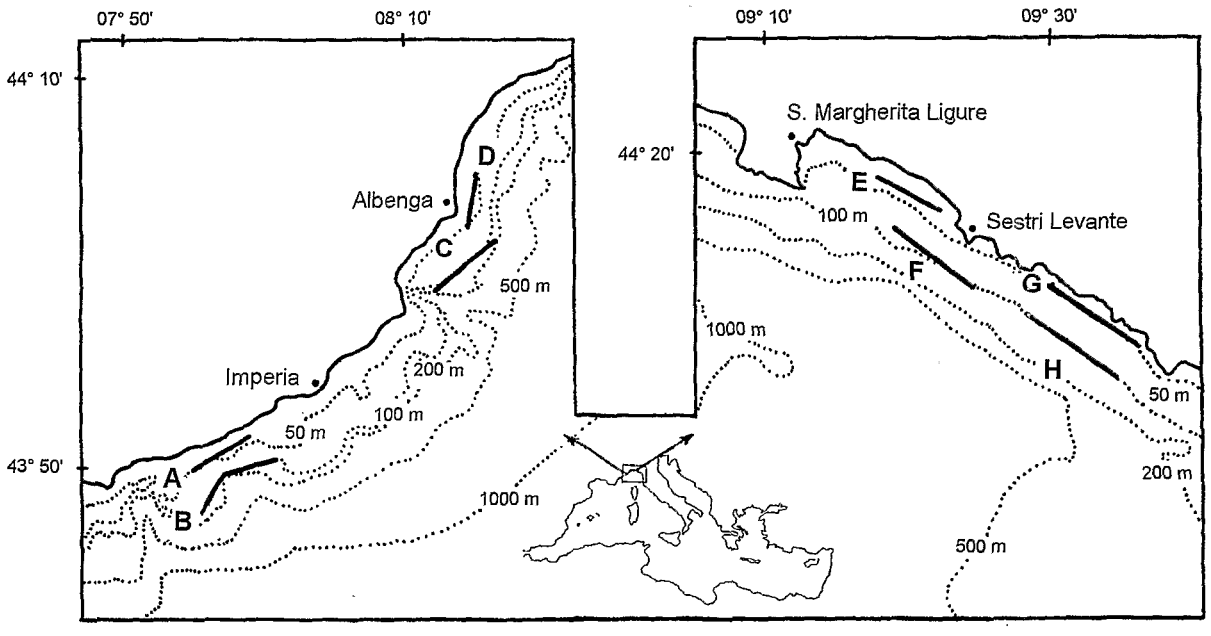


Fig. 1. Sampling areas and haul sites.

The whole red mullet catches or large subsamples were measured at below half cm and sex was allocated. Their sagittae were extracted and preserved in water.

The length structure of the seasonal catches was split into gaussian components using the Bhattacharya method (1967), as implemented in the package FISAT (Gayanilo *et al.*, 1996). Before processing the data, the size distributions were smoothed by using the 3 point moving average. The sagittae were read in "toto" by using a stereomicroscope and observing the otolith in water against a black background.

As concern the indirect methods for the study of growth we used two different approaches: the analysis of steady length structure collected near the spawning period and the more popular modal progression analysis.

Considering that spawning of *M. barbatus* in the Ligurian Sea occurs mainly between may and June (Orsi Relini and Arnaldi, 1986) the steady length structure of May catches, were prepared keeping sex separate and adding the samples collected during 1991, 1992 and 1993.

This steady structure is characterized by two useful features: (i) the absence of young recruits belonging to the 0 group, whose sex is difficult to allocate; and (ii) the yearly meaning of the components which is possible to identify in the length distribution.

## Results

The results of the analysis of steady length structures are shown in Fig. 2.

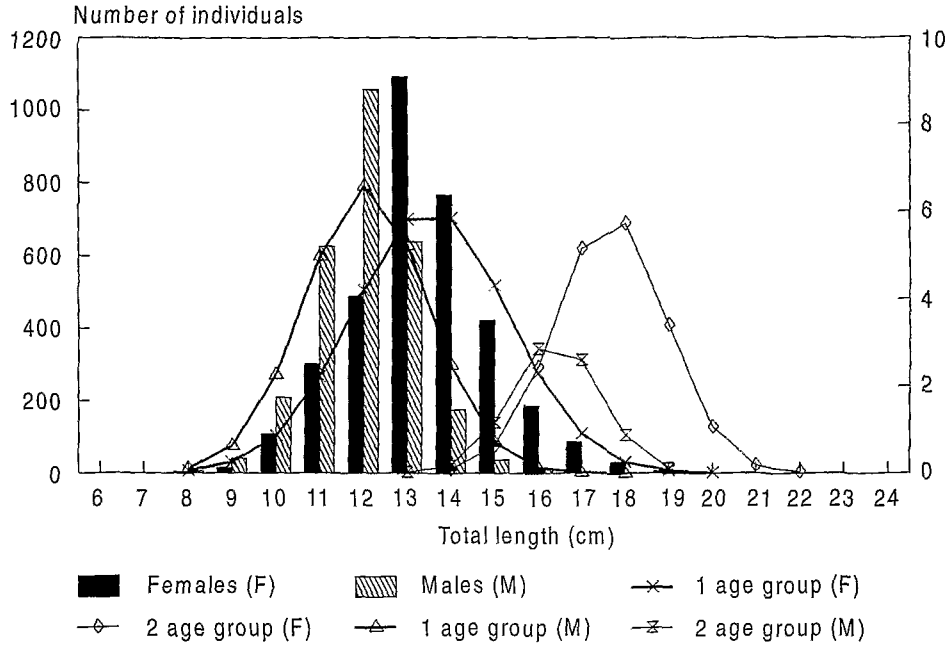


Fig. 2. Histograms representing the steady length structures of *Mullus barbatus* collected during springs 1991, 1992 and 1993, keeping sex separate (on the left scale). The first gaussian components (on the left scale) and the second ones (on the right scale) are also shown.

The Bhattacharya splitting method has allowed to identify two components. The first component represents the main group, which should be approximately 12 month old and whose mean length is 11.9 ± 1.4 cm t.l. in males and 13.4 ± 1.8 cm t.l. in females. The second component represents the group which should be approximately 24 month old; although only a few individuals of this group were sampled, the mean length in males is 16.3 ± 1.0 cm t.l. while in females 17.6 ± 1.2 cm t.l.

Differences in length at age between sexes are about 1.5 cm in the first year; the same probably applies to the second year too.

These small differences suggest to process the length distribution according to the modal progression analysis regardless of sex. Growth was evaluated by considering all samples collected between summer 1990 and autumn 1993.

Figure 3 and Table 1 show the results of the splittings of the sequential length distributions.

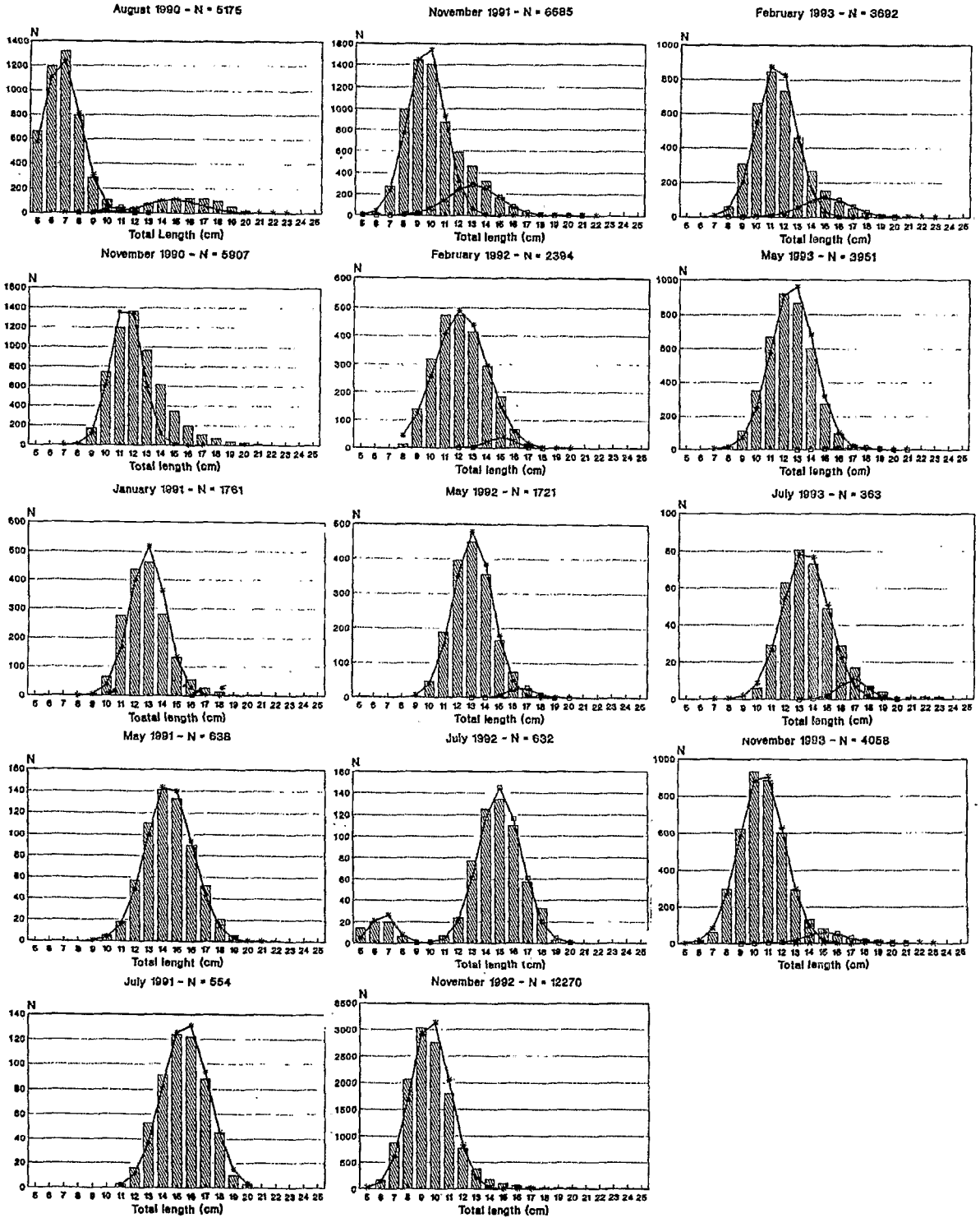


Fig. 3. Bhattacharya splitting of the *Mullus barbatus* sequential length distributions, collected between summer 1990 and autumn 1993 (regardless the sex).

Figure 4 illustrates the modal progression analysis. The growth rate shows a seasonal pattern with a decrease during the first winter of life in the 1990 and 1991 cohorts. However the 1992 cohort seems to have a more regular growth pattern throughout the year.

Table 1. Main statistical parameters obtained from the Bhattacharya splitting of sequential length distributions collected between summer 1990 and autumn 1993. Data were processed regardless the sex. The components having the separation index less than 2 or whose numerousness is less than 10 individuals are marked with the symbol "*". The groups which do not seem deriving from the main spawning are marked with symbol "?"

| Time | Components | Length interval | Mean t.l. (cm) | St. dev. | No. | Age (years) | Sep. Index | Age group | Year class |
|---|---|---|---|---|---|---|---|---|---|
| August 1990 | I | 5-12 | 6.6 | 1.4 | 4313 | 0.25 | - | 0 | 1990 |
| | II | 9-12 | 10.5 | 0.6 | 86 | ? | 3.912 | 0 | ? |
| | III | 9-21 | 14.7 | 1.9 | 543 | 1.25 | 3.373 | 1 | 1989 |
| | IV | 14-22 | 17.8 | 1.3 | 226 | 2.25 | 1.902* | 2 | 1988 |
| November 1990 | I | 9-16 | 11.4 | 1.1 | 4173 | 0.5 | - | 0 | 1990 |
| January 1991 | I | 10-18 | 12.8 | 1.3 | 1646 | 0.67 | - | 0 | 1990 |
| May 1991 | I | 10-20 | 14.3 | 1.6 | 605 | 1 | - | 1 | 1990 |
| | II | 17-21 | 17.5 | 1.0 | 31 | 2 | 2.406 | 2 | 1989 |
| | III | 23 | 21.8 | 0.9 | 2* | 3 | 4.455 | 3 | 1988 |
| July 1991 | I | 12-21 | 15.5 | 1.6 | 547 | 1.17 | - | 1 | 1990 |
| November 1991 | I | 6-15 | 9.5 | 1.3 | 5346 | ? | - | ? | ? |
| | II | 8-20 | 13.0 | 1.8 | 1323 | ? | 2.229 | ? | ? |
| | III | 19-23 | 19.6 | 1.0 | 15 | ? | 4.596 | ? | ? |
| February 1992 | I | 9-20 | 12.0 | 1.9 | 2301 | 0.75 | - | 0 | 1991 |
| | II | 14-18 | 14.9 | 0.8 | 93 | 1.75 | 2.140 | 1 | 1990 |
| May 1992 | I | 10-19 | 13.0 | 1.4 | 1647 | 1 | - | 1 | 1991 |
| | II | 16-20 | 16.5 | 0.9 | 70 | 2 | 3.133 | 2 | 1990 |
| July 1992 | I | 6-10 | 6.6 | 0.8 | 60 | 0.17 | - | 0 | 1992 |
| | II | 11-21 | 14.9 | 1.5 | 551 | 1.17 | 7.093 | 1 | 1991 |
| November 1992 | I | 6-16 | 9.5 | 1.4 | 11570 | 0.5 | - | 0 | 1992 |
| February 1993 | I | 8-17 | 11.3 | 1.4 | 3162 | 0.75 | - | 0 | 1992 |
| | II | 11-21 | 15.0 | 1.7 | 501 | 1.75 | 2.369 | 1 | 1991 |
| | III | 18-23 | 19.6 | 1.2 | 28 | 2.75 | 3.214 | 2 | 1990 |
| May 1993 | I | 8-19 | 12.5 | 1.6 | 3908 | 1 | - | 1 | 1992 |
| | II | 16-21 | 16.7 | 1.2 | 41 | 2 | 3.193 | 2 | 1991 |
| July 1993 | I | 10-19 | 13.3 | 1.6 | 329 | 1.17 | - | 1 | 1 |
| | II | 16-20 | 16.8 | 1.0 | 28 | ? | 2.622 | ? | ? |
| November 1993 | I | 6-17 | 10.5 | 1.6 | 3785 | 0.5 | - | 0 | 1993 |
| | II | 12-20 | 15.1 | 1.5 | 230 | ? | 3.003 | ? | ? |
| | III | 16-24 | 18.8 | 1.8 | 40 | ? | 2.252 | ? | ? |

The absolute age of the fish belonging to the isolated components was estimated by assuming that the main group should originate from the main spawning months of May-June.

We consider useful to combine the growth rates of the observed cohorts in order to obtain an average growth pattern, which is shown in Fig. 5.

The average length at 12 months was of 13.0 cm (t.l.), ranging between 12.5 and 14.3 cm, and at 24 months of 17 cm (t.l.), ranging between 16.5 and 17.5 cm. As reported in other Mediterranean areas, the growth shows a clear seasonal pattern with a decrease of the growth rate during the first winter of life and another one during the second autumn/winter.

Sagitta readings of large group of recently recruited fish have revealed the presence of a well-defined "hyaline ring", which can not have an yearly meaning.

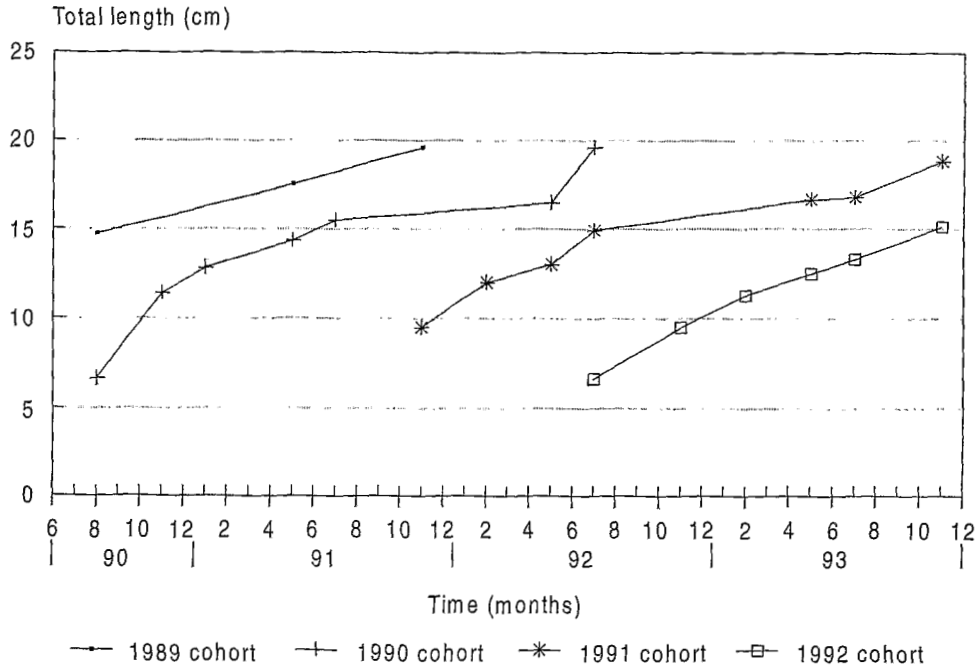


Fig. 4. Modal progression analysis describing growth of the *Mullus barbatus* cohorts between 1989 and 1992 (regardless the sex).

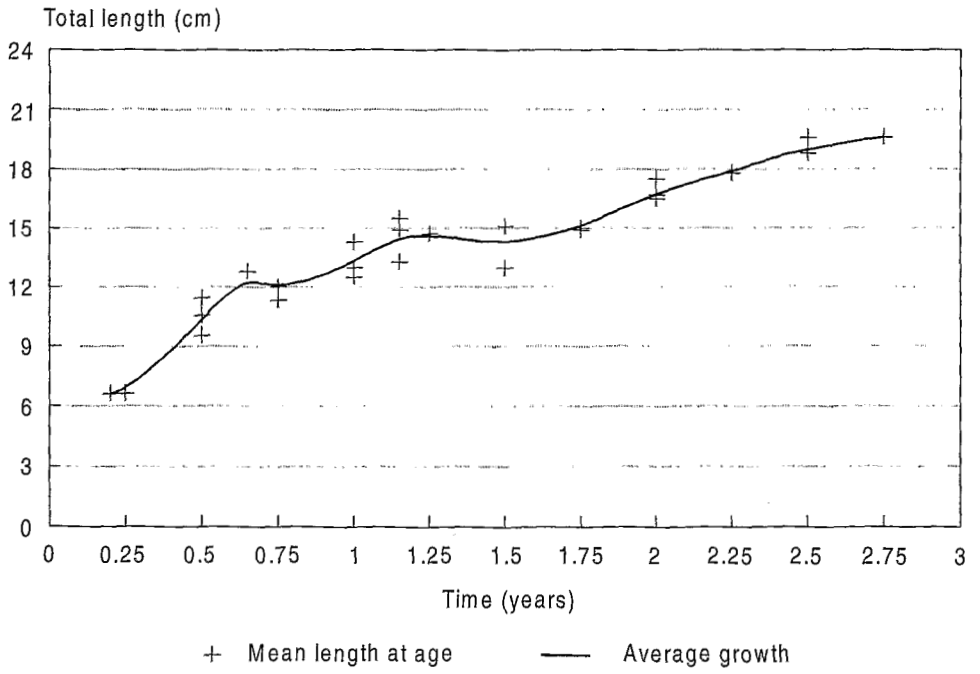


Fig. 5. Average growth pattern of the 989-1992 cohorts of *Mullus barbatus* in the Ligurian Sea (regardless the sex).

Figure 6 shows the presence and the position of the hyaline rings in individuals of *M. barbatus* of different size from the recruitment in July 1992 till May 1993 when they should be about 1 year old.

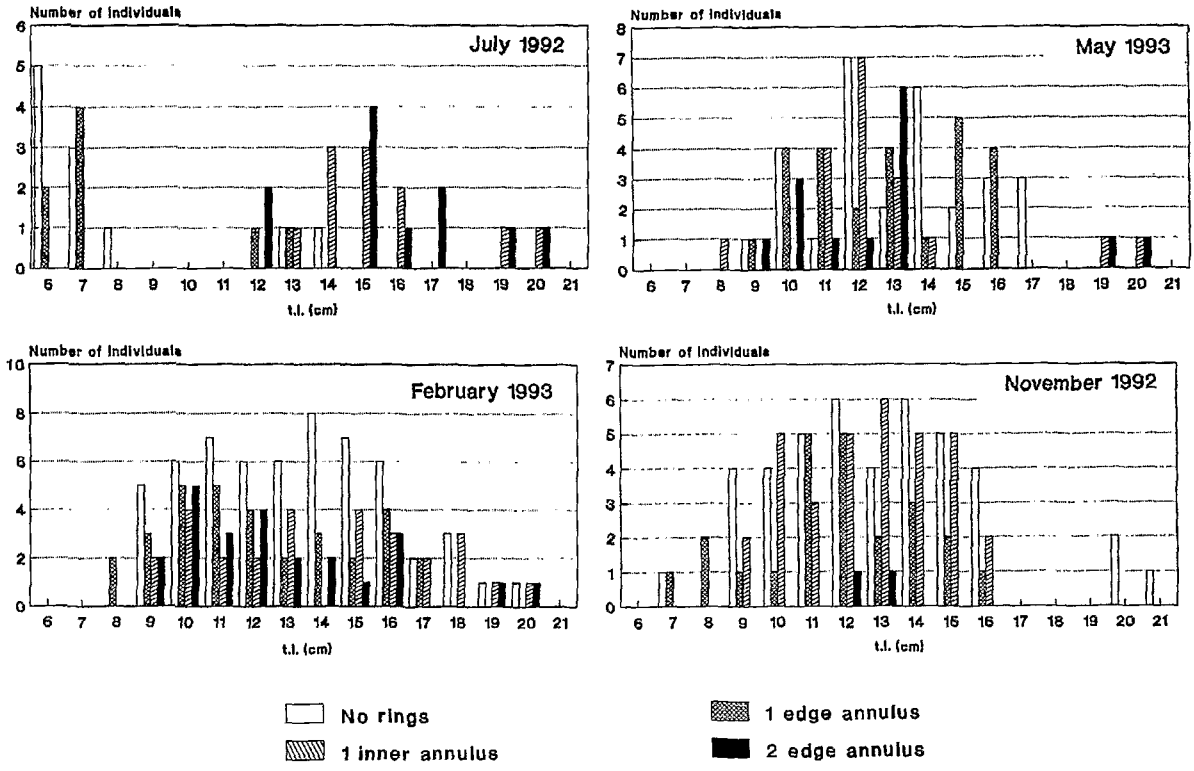


Fig. 6. Presence and position of the hyaline rings in the otoliths of *Mullus barbatus* from the recruitment to approximately one years old.

In July 1992 the youngest red mullets have a mean total length of 6.6 cm. About 60% of them show in the sagittae no hyaline rings while the remaining 40% has one hyaline ring on the edge ($n$=15; 5≤ lt ≤8 cm).

In November 1992 the fish reached a mean total length of 9.5 cm and presented a more complex pattern, which 39.2% without rings, 29.4% with 1 inner ring and 29.4% a peripheral one (n=51; 8≤ lt ≤12 cm).

In February 1993, the red mullet mean total length was of 11.3 cm. The examined fish (n=94; 8≤ lt ≤14 cm) could be split in several fractions: 40.4% without rings, 14.9% having a first inner annulus, 25.5% with a first annulus at the edge of the otolith and finally 19.1% showing a first inner ring and a second one at the edge.

In May 1993, when the mean total length was of 12.5 cm, the fraction changed to: 32.9% without ring, 20.2% with one inner ring, 31.6% with a first peripheral ring and finally 15% with a first inner ring and a second one at the edge.

Since rings lay out can vary with fish age (Williams and Bedford, 1973), fish with different number of annuli were kept separate while studying time of ring deposition.

Figure 7 shows variability in the ring deposition of young fish. On the contrary older individuals tend to lay down rings mainly during spring and winter. There is no clearly defined seasonally in the ring deposition at least until the appearance of the first two well-defined "hyaline rings" in the inner position of the sagitta.

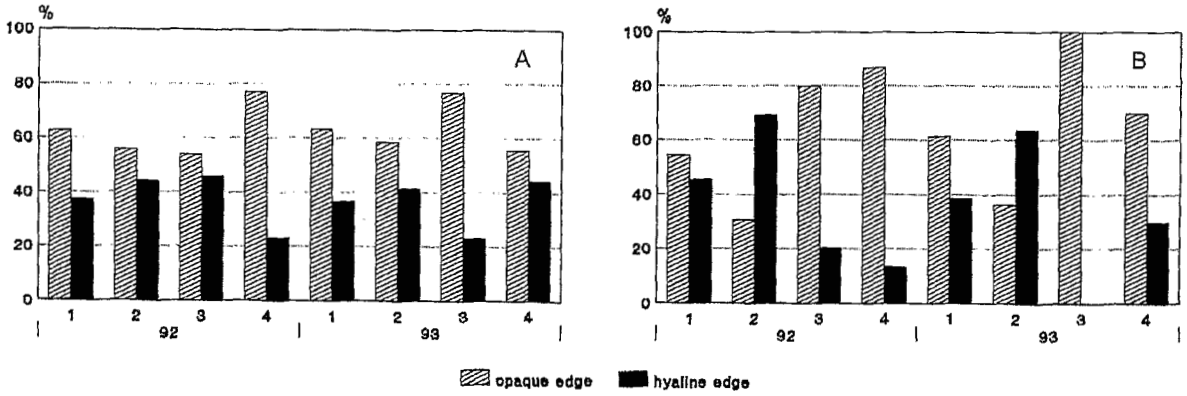


Fig. 7. Season of the lay down of rings in the *Mullus barbatus* otoliths of different age (1=winter; 2=spring; 3=summer and 4=autumn). (A) concerns with the fish having no ring or one inner ring in the sagitta; (B) shows those presenting two or more inner rings.

The examined fish was divided into groups according to two different criteria: firstly considering the number of all annuli counted on the otolith and secondly counting only the fully formed ones, in subperipheral or inner position, while bearing in mind that the first annulus may be laid down just after recruitment. The mean length of each group was considered the best estimate of the average length at that age.

Regardless of sex and according to the first criterion *M. barbatus* is 12.7 ± 5.2 cm t.l. (n=347) long at one year, 13.9 ± 3.0 cm (n=200) at two years and 16.3 ± 2.8 (n=67) at three years. According to the second grouping criterion the mean length is 13 ± 4.4 cm t.l. (n=334) at one year, 16.1 ± 2.9 cm (n=106) at two years and 17.6 ± 2.5 (n=41) at three years.

In general, differences in length between sexes were approximately 1.5 cm during the first year and 2.5 during the second and third one.

Figure 8 (keeping separate sex) and Figure 9 (regardless the sex) show the length distributions of age groups derived from otolith readings according to the fully formed rings criterion.

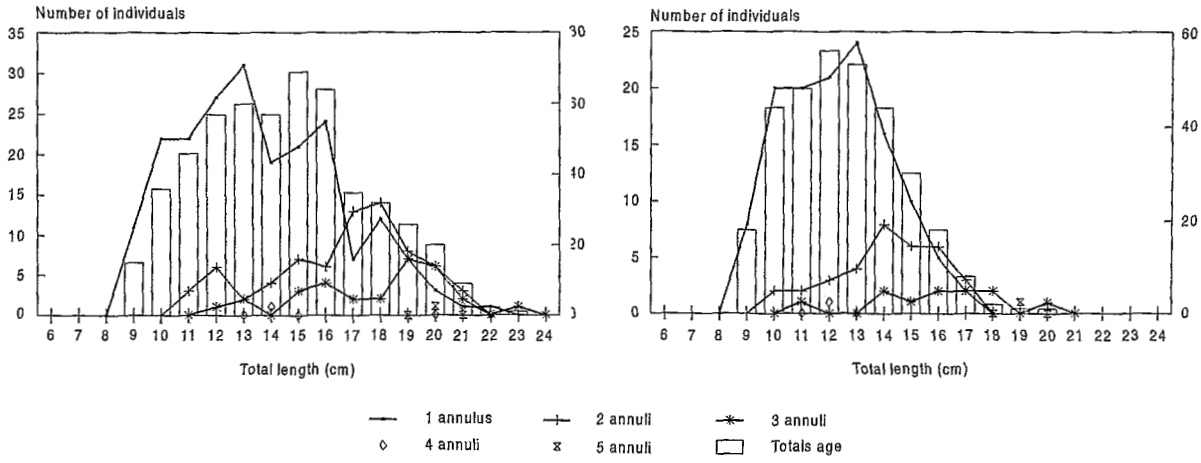


Fig. 8. Length distributions of *Mullus barbatus* age groups, keeping sex separate, derived from otolith readings, according to the full formed rings criterion (on the left scale). Data concern samples collected every season in 1992 and 1993. There are also shown the total aged individuals (on the right scale).

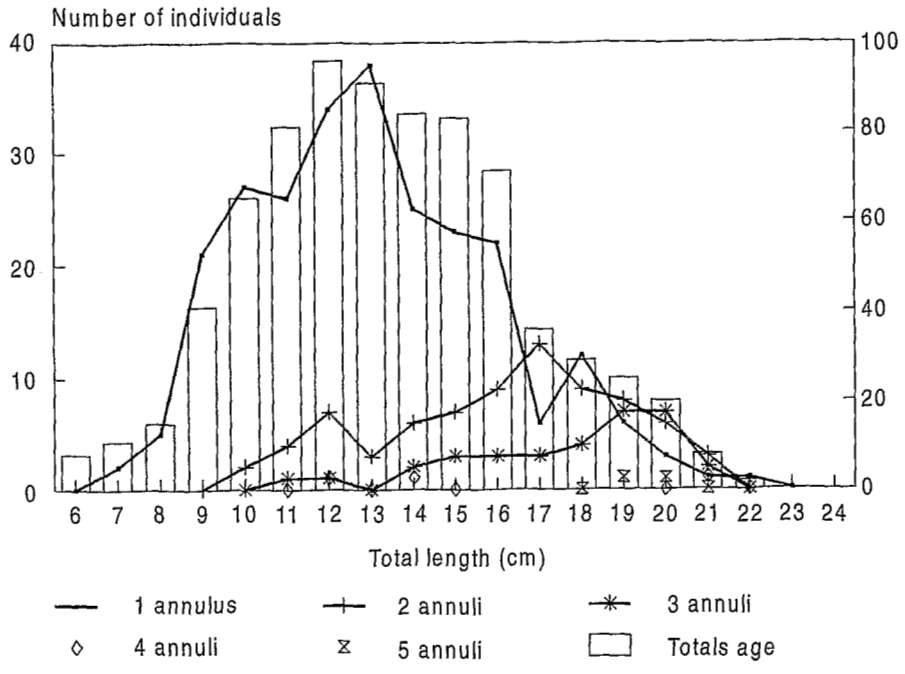


Fig. 9. Length distributions of *Mullus barbatus* age groups, regardless the sex, derived from otolith readings, according to the full formed rings criterion (on the left scale). Data concern samples collected every season in 1992 and 1993. There are also shown the total aged individuals (on the right scale).

## Discussion

Table 2 reports the different average lengths at age obtained by using different methods.

Table 2. Average total length (in cm) at age (in years) in *Mullus barbatus* of the Ligurian Sea, obtained by using different methods (F=females, M=males and I=unsexed)

| Methods | Sex | Age 1 | Age 2 | Age 3 |
|---|---|---|---|---|
| Analysis of steady length distribution | F | 13.4 ± 1.8 | 17.6 ± 1.2 | |
| | M | 11.9 ± 1.4 | 16.3 ± 1.0 | |
| Modal progression analysis | F + M + I | 13 (12.5 - 14.3) | 17 (16.5 - 17.5) | |
| Otolith readings (All rings considered) | F + M + I | 12.7 ± 5.2 | 13.9 ± 3.0 | 16.3 ± 2.8 |
| Otolith readings (Only inner rings considered) | F | 13.6 ± 2.9 | 16.6 ± 2.6 | 18.8 ± 2.6 |
| | M | 12.2 ± 1.9 | 14.1 ± 1.9 | 16.0 ± 2.4 |
| | F + M + I | 13.0 ± 4.4 | 16.1 ± 2.9 | 17.6 ± 2.5 |

When comparing the results obtained with the different approaches, it becomes clear that there is a good agreement among methods employed for the evaluation of the mean length in one year individuals. For two and three years old individuals otolith readings, according to the "all ring" criterion, give values smaller than the ones provided by the length analysis and by the "full formed" sagitta lectures.

This difference is probably due to the lay down of a recruitment ring in a large fraction of the population, which causes an overestimation of the red mullet age.

The presence of false annuli was reported by Gottlieb (1956). He distinguished two main kinds of preannual hyaline rings in the sagitta of *M. barbatus.* The first ring, called "larval ring", surrounds the opaque zone in the central part of sagitta and is due to the transition from the pelagic to demersal phase. The second one, which may be found in the middle of the first opaque zone or less commonly in the middle of the second and subsequent ones, is laid down during the summer and it is very similar to the true annulus, deposited in winter. The morphological criterion, given for distinguishing the true annulus from the summer ring, suggests that the former should be more marked and continuos around the otolith than the latter. The larval ring is found in approximately 41% of the individuals, while the summer ring in 54% of the 41 examined red mullets. According to the author, from the first annulus onward only true winter rings should be laid down.

Recently, Vrantzas *et al.* (1992), studying the growth of *M. barbatus* of the Saronikos Gulf (Greece), remarked the presence of false annuli, laid down in summer (at 4-5 cm of backcalculated total length) and in autumn (at 7.5-10 cm of backcalculated total length) in many young specimens. The first true annulus should be deposited between winter and late spring or early summer. Looking at the figures, which are published in their paper, it looks as if the authors have not systematically counted the first hyaline ring in order to obtain the length-age key, used to derive the mean length at age. Since the preannual rings are laid down only in a fraction of the young fish, we think that the methodic exclusion of the first ring should lead to an underestimation of the age of *M. barbatus.*

The presence of one or two preannual rings in the sagitta of *M. barbatus*, should lead to an overestimation of the age by using the "traditional" length-age key approach. From the other hand the use of the back-calculation in sagitta reading could lead to an overestimation of age due to the Lee's phenomenon (Richer, 1975; Campana, 1990).

To verify if the otolith readings give systematically length at age smaller than other methods we decided to compare data of literature on the first two years of growth of *M. barbatus* from different areas of the Mediterranean and obtained by using different methods.

If you plot on a graph the mean length at one and two years of age given in each study, you can see that some points are closer than others (see Fig. 10).

Considering that the closer these points are the more similar the growth is, it is interesting to notice that mainly methods seem to explain the scattering of the points. Unfortunately the most of the otolith readings derives from the Eastern Mediterranean while the most of the length analysis and scales lectures derives from the Western basin.

To improve this graphical approach, we have tried to classify the growth data by using an agglomerative hierarchical clustering with euclidean distance and average linkage (Digby and Kempton, 1987).

For the cluster analysis we used the PARVUS package (Forina *et al.*, 1995). The cluster analysis, shown in Fig. 11, identifies four main groups with similar pattern growth: two of them are charachterized by the methodology, being the first group (09, 16, 18, 10, 11, 13, 14, 19 reference in Table 3) formed by all otolith lectures and the second one (02, 07, 04, 06 reference in Table 3) for the 75% by scale readings. The third one (05, 08, 20, 21, 22 reference in Table 3) is formed by the values obtained in this study and by those found in Castellón and in the Gulf of Tunis. The fourth group (01, 17, 12, 15 reference in Table 3) is formed by the data of those papers which gave the highest growth rates in *M. barbatus* of the Mediterranean, regardless of method and geographic area.

As shown by the cluster analysis, since the method influences at least in part the growth estimate, we should be very careful in comparing growth rates from different areas of the Mediterranean.

Against what suggested in literature, we do not think it is possible to distinguish false rings from true annuli. However in our materials the mean lengths at age derived from the length-age key, prepared by using the "fully formed ring" criterion in samples collected throughout the year, are very close to that one obtained from the length analysis. This "operational" approach in sagitta readings should allow to obtain "almost unbiased" mean lengths at age for those individuals older than two, which could be hard to be estimated by using the length-analysis approaches.

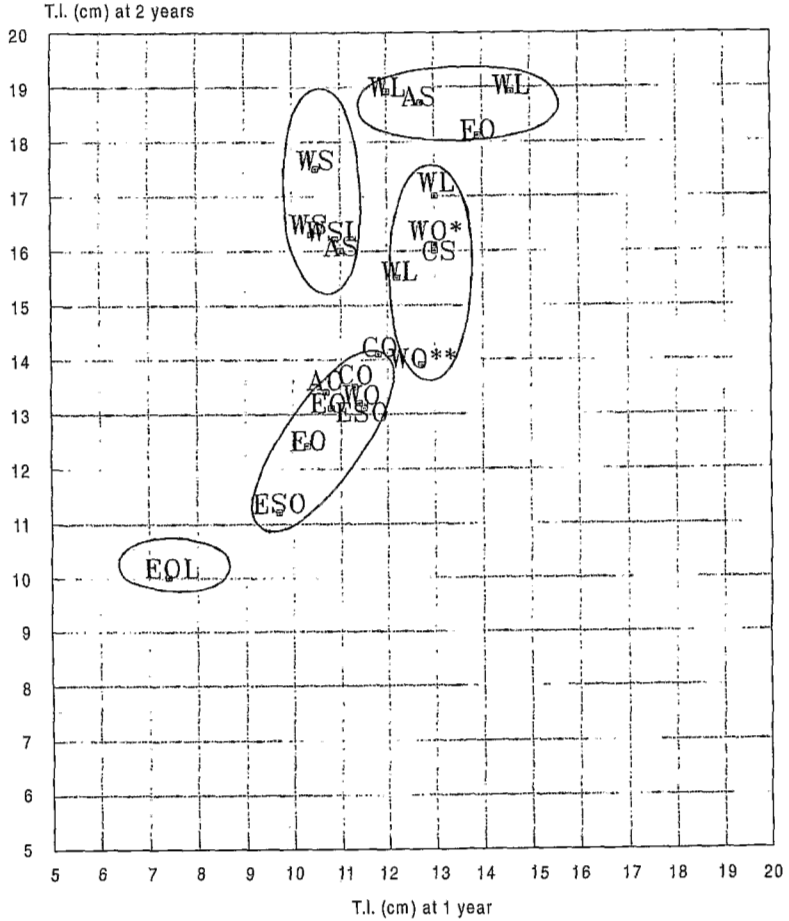


Fig. 10. Mean length at 1 and 2 years (cm) found in literature for *Mullus barbatus* of Mediterranean Sea. The methods (O=otolith readings; S=scale readings; L=length analysis) and the areas (W=Western Mediterranean; E=Eastern Mediterranean; C=Strait of Sicily and A=Adriatic Sea) are reported. The ellipses show the groups identified by the cluster analysis.

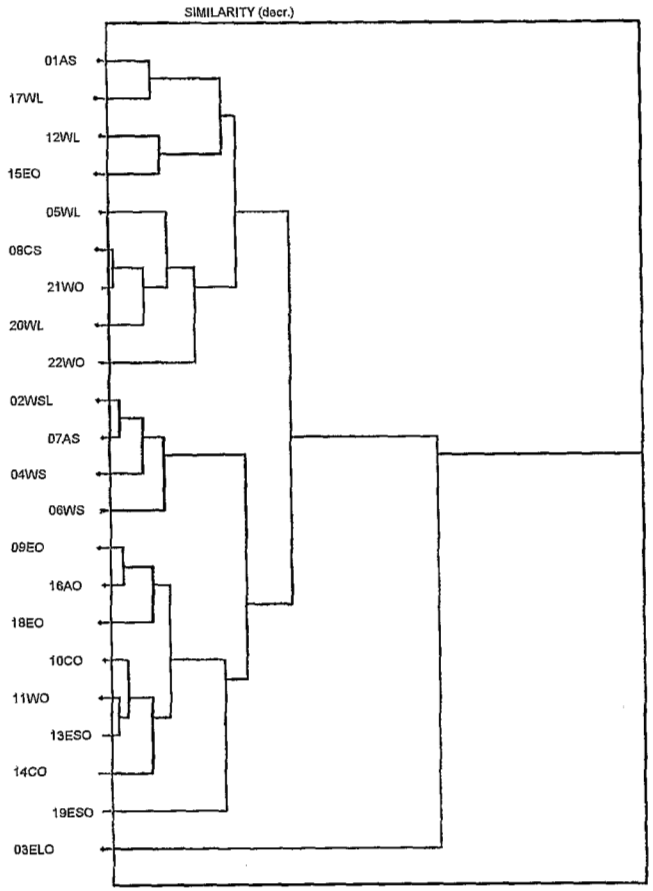


Fig. 11. The dendrogram showing similarity in the first two years growth pattern in *Mullus barbatus* of Mediterranean, derived by cluster analysis. Four main groups are identified (see text). The code reports both the method (O=otolith readings; S=scale readings; L=length analysis) and the area (W=Western Mediterranean; E=Eastern Mediterranean; C=Strait of Sicily and A=Adriatic Sea).

Finally, it is worth to remark that, regardless of sex, *M. barbatus* is charachterized by high growth during the first year of life. In fact, in the first year it can reach nearly 60% of the maximum length, which is approximately 23 cm t.l. (from our data, 21 cm t.l. in males and 25 cm t.l. in females).

This growth performance, together with the low age at first reproduction (1 year old for both sexes), could explain the capacity of the *Mullus barbatus* to rebuild heavily exploited stocks when a small decrease in the fishing effort is applied (Relini *et al.*, 1996).

Table 3. Mean length at 1 and 2 years (in cm) found in literature for *Mullus barbatus* of Mediterranean Sea. The methods (O=otolith readings; S=scale readings; L=length analysis) and the areas (W=Western Mediterranean; E=Eastern Mediterranean; C=Strait of Sicily and A=Adriatic Sea) are reported

| Code | Author | Year | Locality | Area | Method | Length at 1 year | Length at 2 years |
|---|---|---|---|---|---|---|---|
| 1 | Scaccini | 1947 | Mean Adriatic (I) | A | S | 12.7 | 18.7 |
| 2 | Bougis | 1948 | Gulf of Lion (F) | W | SL | 10.9 | 16.2 |
| 3 | Wirszbuski | 1953 | Israelian coast | E | LO | 7.4 | 10 |
| 4 | Nümann and Denizci | 1955 | Turkish coast | E | SO | 9.7 | 11.2 |
| 5 | Gottlieb | 1956 | Israelian coast | E | O | 10.3 | 12.4 |
| 6 | Planas and Vives | 1956 | Catalan Sea (SP) | W | S | 10.4 | 16.3 |
| 7 | Larrañeta and Rodríguez-Roda | 1956 | Castellón (SP) | W | L | 12.2 | 15.5 |
| 8 | Suau and Vives | 1957 | Catalan Sea (SP) | W | S | 10.5 | 17.5 |
| 9 | Bougis and Muznic | 1958 | Mean Adriatic (YU) | A | S | 11 | 16 |
| 10 | Gharbi and Ktari | 1981 | Gulf of Tunis | C | S | 13 | 16 |
| 11 | Papacostantinou *et al.* | 1981 | Gulfs of Saronikos and Thermaikos (GR) | E | O | 10.8 | 13.1 |
| 12 | Andaloro and Prestipino-Giarritta | 1985 | Strait of Sicily (I) | C | O | 11.3 | 13.5 |
| 13 | Morales Nin | 1986 | Catalan Sea (SP) | W | O | 11.4 | 13.2 |
| 14 | Wurtz and Matricardi | 1986 | Ligurian Sea (I) | W | L | 14.6 | 18.9 |
| 15 | Livadas | 1989 | Cypriot coast | E | SO | 11.5 | 13.1 |
| 16 | Levi *et al.* | 1992 | Strait of Sicily (I) | C | O | 11.8 | 14.1 |
| 17 | Vrantzas *et al.* | 1992 | Saronikos Gulf (GR) | E | O | 13.9 | 18.1 |
| 18 | Ungaro *et al.* | 1994 | Southern Adriatic (I) | A | O | 10.7 | 13.4 |
| 19 | Auteri *et al.* | 1994 | Ligurian Sea (I) | W | L | 12 | 18.9 |
| 20 | This study | 1996 | Ligurian Sea (I) | W | L | 13 | 17 |
| 21 | " | " | " | " | O* | 13 | 16.1 |
| 22 | " | " | " | " | O** | 12.7 | 13.9 |

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