

# Age and growth of the horse mackerel *Trachurus trachurus*(Linnaeus, 1758) catches in the bay of M'diq (Mediterranean coast of Morocco)

**Maha kerkich**

Laboratory of biodiversity and conservation of  
biologiques resources  
University Abdelmalek Essadi, Faculty of Sciences  
Tetouan, Morocco

**Moustapha Aksissou**

Laboratory of biodiversity and conservation of  
biologiques resources  
University Abdelmalek Essadi, Faculty of Sciences  
Tetouan, Morocco

**Jose A. Hernando Casal**

Department of biology  
University of Cadiz, Faculty of Sciences Sea and  
environment  
Puerto Real, Cadiz, Spain.

**Abstract**—the horse mackerel *Trachurus trachurus* (L) is pelagic and migratory fish. Common in the North eastern Atlantic and Mediterranean. The aim of this study was to estimate the age and the growth rate of horse mackerel. It was analyzed for horse mackerel collected in the port of M'diq (Mediterranean of Morocco). A total of 1143 individuals were collected. The total length of sampled individuals ranged 10 from to 30.4cm and weight from 8.4 to 260.59g. Age was determined by the sagitta otolith rings reading. The commonly used length-weight relationship  $W = aL^b$  was applied. Length and age data were used to estimate growth parameters ( $L_{\infty}$ ,  $K$ ,  $t_0$ ) of Von Bertalanffy growth equation  $L_t = L_{\infty} (1 - e^{-K(t-t_0)})$ . Age ranged from 0-6. The length-weight relationship, which differs between sexes was estimated for males  $b = 3.0686$ ,  $a = 0.0068$  ( $N = 551$ ); females  $b = 3.114$ ,  $a = 0.0055$  ( $N = 335$ ) and whole sample  $b = 3.065$ ,  $a = 0.0069$  ( $N = 1143$ ). Indicating isometric growth for males and positive allometric growth for female and whole sample. Growth parameters for males  $L_{\infty} = 40.9$  cm,  $K = 0.11$ ,  $t_0 = -0.07$ ; females  $L_{\infty} = 53.42$  cm,  $K = 0.08$ ,  $t_0 = -0.27$ ; whole sample  $L_{\infty} = 43.9$ cm,  $K = 0.1$ ,  $t_0 = -0.32$  were calculated.

**Keywords:** *Trachurus*, age, growth, length-weight, M'diq, Morocco.

## I. INTRODUCTION

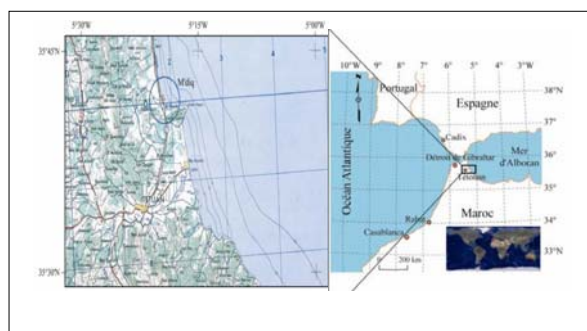
The horse mackerel (*Trachurus trachurus*, Linnaeus, 1758) is member of the large Carangidae family which includes many important commercial species worldwide. The name of the horse mackerel is misleading as the true mackerel like fish such as tunas o bonitos belong to the scombrid family horse Mackerel is schooling species, caught mainly with pelagic nets, but close to sea floor [30]

The total commercial catch of the genus *Trachurus* increased from about 1 mill t in 1960 to more than 6.5 mill t in 1995, and then decreased to 2.5 mill t in 1999 [2]. Because of the worldwide importance of the horse mackerel fishery. It

has been the focus of several studies in the different geographic locals. Recently, the mackerel was the subject of research on the reproduction [1,10,15,21,22,23,26,35,36], growth [13,6,14,27,41,38,44] diet [12,46,48,50,32] the evaluation of stock [24,25,28]. the geographical repartition [17,29] and Biometric [11,33].

Until now, no study to estimate the parameters of weight and the linear growth has been conducted on this species in Moroccan Mediterranean. The objective of this work is to estimate the parameters of weight and flax growth ( $a$ ,  $b$ ,  $L_{\infty}$ ,  $K$  and  $t_0$ ) and to compare our results with those others authors who have studied the growth of this species in other parts of Mediterranean.

## II. MATERIAL AND METHODS



**Fig 1 .** Sampling locations by bay of M'diq (Mediterranean of Morocco)

Sample of horse mackerel was collected from commercial trawler. These sample was taken monthly from May 2005 to November 2006 in the bay of M'diq (Mediterranean sea of Morocco) "Fig. 1". In the mean of 60 individual monthly .

In the laboratories for each fish was measured to cm total length (Lt), with precision of 0.1cm, sexed and weighted to the gram above. The otoliths of all individual samples were extracted and their age was established by interpreting the growth rings observed in the otoliths. Otoliths were prepared for reading following the broken burnt/method [20] the criteria adopted for ageing were those established in [31]. Monthly, portions of opaque and translucent bets along the edge of the otolith were examined. All the otolith readings were done by the same person.

Using the data length and age were developed age-length key (ALK) by sex for the period considered and sex combined for each key to mean lengths were calculated by age and the total length distribution by age class was fitted to the von Bertalanffy equation :

$$L_t = L_\infty [1 - \exp^{-k(t-t_0)}]$$

Where  $L_t$  is the mean fish length and age  $t$ ,  $L_\infty$ ,  $K$  and  $t_0$  are the parameters that determine the shape of the growth curve.  $L_\infty$  is defined as the asymptotic mean length,  $K$ : the rate at which the curve approaches the asymptote and  $t_0$  the age at which mean length is zero. The growth constants were calculated using the Ford-Walford method.

The length-weight ( $w$ ) relationship represented by the formula  $w = aL^b$  was log transformed to  $\ln w = \ln a + b \ln L$ . where  $a$  and  $b$  is are regressive constants,  $W$  is the total weight (g) and  $L$  is the total length (cm). The value of ( $b=3$ ) indicates the isometric growth and allometric growth ( $b \neq 3$ ) [16].

### III. RESULTS

#### A. Length composition

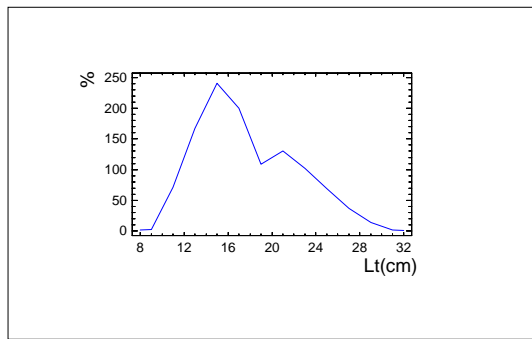


Fig 2. Frequency length distribution of all capture

Length frequency distribution among the 1143 fish was determined for the entire research period “Fig.2”. The shortest fish was 10cm. While the longest was 30.4cm.

Generally, according to the length frequency distribution the majority of the Mediterranean horse mackerel were caught less than 16.4cm long.

#### B. Sex composition

Overall the sex ratio was as follows: 22.5 % immature. 29.3 females and 48 % . Males were observed more frequently than females within all length groups and the difference was significant according to the test  $\chi^2$   $P < 0.05$ . The number (N) and percentage (%) of males, females and immature horse mackerel within each length group are shown in table I.

TABLE I. Number (N) And Percentage (%) Of Males, Females and Immature Specimens Of Horse Mackerel Within Each Group From Mediterranean Of Morocco.

| Age   | Length (cm) | Males |       | Females |       | Immature |       | Total |
|-------|-------------|-------|-------|---------|-------|----------|-------|-------|
|       |             | N     | %     | N       | %     | N        | %     |       |
| 0     | 10.3-20.9   | 60    | 38.7  | 18      | 11.61 | 77       | 49.68 | 155   |
| 1     | 10-22.8     | 261   | 48.33 | 133     | 24.63 | 146      | 27.03 | 540   |
| 2     | 10.6-26.4   | 141   | 52.61 | 93      | 34.7  | 34       | 12.9  | 268   |
| 3     | 16.8-27.9   | 57    | 50.89 | 55      | 49.1  |          |       | 112   |
| 4     | 21.6-28.8   | 21    | 47.72 | 23      | 52.27 |          |       | 44    |
| 5     | 25.1-30.4   | 8     | 42.11 | 11      | 57.89 |          |       | 19    |
| 6     | 25.8-29.9   | 3     | 60    | 2       | 40    |          |       | 5     |
| Total | 10.3-30.9   | 551   | 48    | 335     | 29.3  | 257      | 22.25 | 1143  |

#### C. Otoliths edge

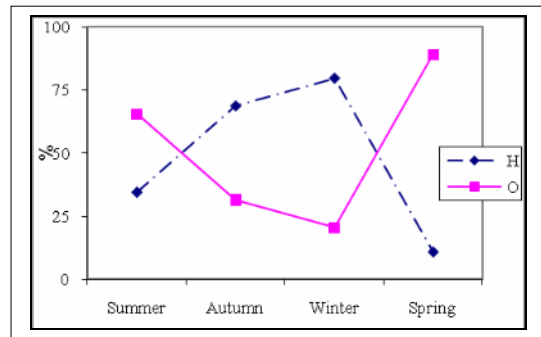


Fig 3. Mean seasonal percentage of otoliths(H= hyaline. O=Opaque) of *Trachurus trachurus* of coast Mediterranean of morocco with opaque and hyaline edge

The otoliths showed a seasonal variation in the formation of hyaline and opaque zones during the period of the study “Fig.3”. Analysis of the border of the otolith showed a general pattern where two rings, one opaque and one hyaline, were deposited during the period of one year. Opaque bands begin form at the beginning of spring (March and April), ending during late summer (September or October), while translucent bands predominate during the remaining months of the year. Formation of the rings was regular and the otoliths could, therefore, be used to determine growth

D. Length-Weight Relationships

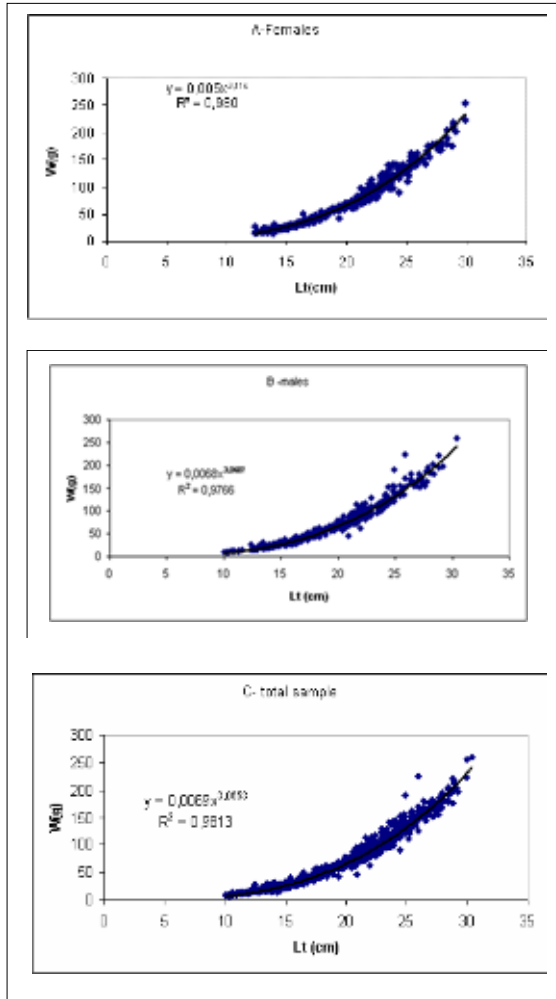


Fig 4. Length-Weight relationship of horse Mackerel: A-females (N=551). B-males (N=335). C -total sample (N= 1143)

Length –weight regressions were calculated separately for males, females and total capture. The length –weight equation calculated was:

Females:  $W = 0.0055L_t^{3.114}$   $r^2 = 0.9804$

Or:  $\log(W) = -5.12634 + 3.11395 \cdot \log(L_t)$

Males:  $W = 0.0068L_t^{3.0687}$   $r^2 = 0.9766$

Or:  $\log(W) = -4.99325 + 3.06867 \cdot \log(L_t)$

Total capture:  $W = 0.0069L_t^{3.0653}$   $r^2 = 0.9813$

Or:  $\log(W) = -4.98223 + 3.06534 \cdot \log(L_t)$

It should be noted that the various correlations are highly significant  $p < 0.001$  in both females and males of mackerel. The slope (constant b) for female’s length –weight relation

was significantly different from 3. Which indicates slightly positive allometric. The constant b for males and the total capture are not significantly different from 3, which indicate isometric growth. the length–weight curve for males. Females and total sample are shown in “Fig.4”.

E. Age and growth

TABLE II. Age–Length For The Horse Mackerel In The Mediterranean Of Morocco Based On Otoliths Reading

| Length range (cm) | 0     | 1     | 2     | 3    | 4    | 5    | 6    | Total |
|-------------------|-------|-------|-------|------|------|------|------|-------|
| 10-10.9           | 11    | 24    | 1     |      |      |      |      | 36    |
| 11-11.9           | 13    | 19    | 3     |      |      |      |      | 35    |
| 12-12.9           | 18    | 30    | 2     |      |      |      |      | 50    |
| 13-13.9           | 26    | 84    | 3     |      |      |      |      | 113   |
| 14-14.9           | 18    | 91    | 11    |      |      |      |      | 120   |
| 15-15.9           | 23    | 85    | 12    |      |      |      |      | 120   |
| 16-16.9           | 26    | 66    | 22    | 1    |      |      |      | 115   |
| 17-17.9           | 10    | 55    | 24    |      |      |      |      | 89    |
| 18-18.9           | 4     | 31    | 23    | 2    |      |      |      | 60    |
| 19-19.9           | 5     | 26    | 14    | 4    |      |      |      | 49    |
| 20-20.9           | 1     | 18    | 34    | 7    |      |      |      | 60    |
| 21-21.9           |       | 8     | 42    | 19   | 3    |      |      | 72    |
| 22-22.9           |       | 3     | 31    | 21   | 3    |      |      | 58    |
| 23-23.9           |       |       | 18    | 18   | 9    |      |      | 45    |
| 24-24.9           |       |       | 10    | 19   | 8    |      |      | 37    |
| 25-25.9           |       |       | 15    | 8    | 3    | 5    | 1    | 32    |
| 26-26.9           |       |       | 3     | 9    | 5    | 1    |      | 18    |
| 27-27.9           |       |       |       | 4    | 10   | 4    |      | 18    |
| 28-28.9           |       |       |       |      | 3    | 7    | 1    | 11    |
| 29-29.9           |       |       |       |      |      | 1    | 3    | 4     |
| 30-30.9           |       |       |       |      |      | 1    |      | 1     |
| Total             | 155   | 540   | 268   | 112  | 44   | 19   | 5    | 1143  |
| %                 | 13.56 | 47.24 | 23.45 | 9.79 | 3.85 | 1.66 | 0.47 | 100   |

The results of the sagitta otolith rings reading for all samples are given in the table II.

Seven age classes ranging from 0 to 6 years were defined . Modal age was 1° year (N=540. 47.24 %). The overlapping of total body length between different ages classes was noticed the von Bertalanffy growth equations for males, females and total capture were as follows:

Males:  $L_t = 40.9(1 - e^{-0.11(t+0.27)})$

Females :  $L_t = 53.42(1 - e^{-0.08(t+0.07)})$

Total capture:  $L_t = 43.9(1 - e^{-0.1(t+0.32)})$

The theoretical maximum length (males 40.9 cm. females 53.16cm) is unrealistic since the largest specimen sampled during the survey was 30.4cm. Females grow more slowly (k=0.08) than males (k=0.11).

IV. DISCUSSION

The observation and interpretation of otoliths for the horse mackerel is considered to be adequate and consistent for assigning age of this species and previous studies have used otoliths to age *Trachurus trachurus* [50,19,46,43,4,5,7,39,34,3]. Two rings , one opaque and one hyaline were laid down each year on the otoliths [3]. The opaque zone was mainly formed during the spring season and summer months while hyaline bets were formed during the autumn and winter months according with other studies. The use of scales is not recommended for use in estimates of growth parameters due the high possibility that the fish live for many years with little or no scale growth [9].

The observed variability in the relative abundance of the sizes is explained by the migratory character of the species. This is reflected in the catches of the fleet operating in fishing area M’diq the total lengths fluctuation between 10 and 30 cm with an average size around 17.84.

According to [3], the mackerel showed great variability in growth throughout its range. The differences in length at age distributions between areas are remarkable especially when comparing the extreme values.

In Table 3, the growth characteristics *Trachurus trachurus* of the Mediterranean coast Moroccan are compared to those of other populations the Mediterranean.

The total length weight relationship for horse mackerel in the Mediterranean sea are scare. The b values of *T. trachurus* was isometric. i.e. equal in the length and weight. The isometric growth of the horse mackerel was also recorded in the central Adriatic [4] and Mediterranean Sea [37 ] (Table 3).

In the present study, the b = 3.06 for the total capture indicate the isometric growth .These variations could be attributed to differences in age, maturity , sex ,geographic location and associated environmental conditions. Such as seasonality, stomach fullness, disease and parasite loads can also affect the value of b [8].

The bertallanfy parameters of total capture in the bay of M’diq (Table 3) is  $L_{\infty}=43.9\text{cm}$ ,  $k =0.1$  and  $t_0= -0.32$ . The lowest and highest values of k estimates might be explained by the difficulties in obtaining both very small and large fish. This affects the estimate of the  $t_0$  and  $L_{\infty}$  and consequently of k [42].

In general, growth parameters need to be checked for the quality and validity. A positive value  $t_0$  is often erroneous while a negative close to zero value of  $t_0$  is a good indicator for the reliability of the determined ages [39].

Since horse mackerel is recruited to the fishery during its first year of life and the growth rate is high in early life. Several values of length at time increments less than one year required to fit better the growth curve to the data [18]. For this reason to study the differences in growth rate between areas were compared by age class distributions instead of using the parameters derived from a growth model. Narrowness of the size and age ranges available for some areas has led to get some credible estimates of growth parameters in model like von Bertalanffy [3].

TABLE III. Horse Mackerel Growth Parameters From Bertallanfy Equation And Length Weight Relation Ship, Provided By Different Authors In The Different Region Of The Mediterranean.

| Authors                     | Study area               | Aging material | b     | L     | K         | t <sub>0</sub> |
|-----------------------------|--------------------------|----------------|-------|-------|-----------|----------------|
| Carillo (1978)              | NW Mediterranean         | Otolith        | 2.945 | 37.66 | 0.22      | -1.016         |
| Alegria-H (1984a.b)         | Adriatic Sea             | Otolith        | 2.92  | 37.55 | 0.21<br>8 | -1.28          |
| Karlou-Riga et Sinis (1997) | Greek coast              | Otolith        | 3.07  | 30.27 | 0.36      | -0.94          |
| Santic et al (2002)         | Adriatic Sea             | Otolith        | 3.01  | 37.68 | 0.23      | -0.3           |
| <b>Present study</b>        | Mediterranean of Morocco | Otolith        | 3.065 | 43.9  | 0.1       | -0.32          |

References

[1].Abaunza P., Farina A.C. and Carrera P.. 1995. Geographic variations in sexual maturity of the horse mackerel. *Trachurus trachurus*. in the Galician and Cantabrian shelf. Science Marine. 59. 211-222.

[2].Abaunza. P., Gordo L., Karlou-Riga C., Murta A., Eltink A.T.G.W., Garcia Santamaria M.T., Zimmermann C., Hammer C., Lucio P., Iversen S.A., Molloy J. and Gallo E.. 2003c. Growth and reproduction of horse mackerel. *Trachurus trachurus*(carangidae). Fish Biology and Fisheries 13(1). 27-61.

[3].Abaunza. P., Gordo. L.S., García Santamaría. M.T., Iversen. S.A., Murta. A.G., Gallo. E.. 2008. Life history parameters as an important basis for

- the initial recognition of stock management units in horse mackerel (*Trachurus trachurus*). Fisheries Research 89. 167-180.
- [4]. Alegria H. V.. 1984a.Observations on the age and growth of *Trachurus trachurus* ( L.) in the middle Adriatic. Institute of Oceanography and Fisheries. Biljeske-notes 58. 1-6.
- [5]. Alegria H. V.. 1984b.Some aspects of horse mackerel (*Trachurus trachurus* L.)biology in the Adriatic.In : GFCM Report of the third Technical Consultation on stock Assessment in the Adriatic.Fano. Italy.6-10 June 1983. 123-125 .FAO Fish Report 290-255.
- [6]. Alegria H. V.. 1994. Reproductive cycle and changes in condition of the horse mackerel (*Trachurus trachurus* L.) from the Adriatic Sea. Acta Adriatica.35 (1/2) 59-67.
- [7]. Arruda L. M.. 1984.Sexual maturation and growth of horse mackerel *Trachurus trachurus* (L.) along the Portuguese coast. Investigacion Pesquera. 48. 419-430.
- [8]. Bagenal T.B .. Tesch F .W ..1978. Aspects of fish fecundity .In S.D. Gerking (ed) Ecology of freshwater fish Production .Blackwell Scientific Publications. Oxford.75-105.
- [9]. Beamish. R.J and Mc Farlane. G.A.. 1987.Current trends in age determination methodology.In: Summerfelt. R.C and Hall. G.E (eds). Age and growth of fish .Ames.Iowa State University Press. 15-42.
- [10]. Ben Salem M. and Ktari M. H.. 1980. Présentation des espèces du genre *Trachurus* Rafinesque. 1810 et *Caranx* Lacepède. 1801 (Poissons. Téléostéens. Carangidae) des côtes tunisiennes : Morphologie et Biologie. Bulletin de l'office Nationale de Pêche. Tunisie. 4 (1) .155-168.
- [11]. Ben Salem M.. 1983. Ligne latérale des poissons du genre *Trachurus* de la Méditerranée et de l'Atlantique Est. Rapport . P.V. Réunion. C.I.E.S.M.. 28 (5). 83-86.
- [12]. Ben Salem M.. 1988.Régime alimentaire de *Trachurus trachurus* (Linnaeus. 1758) et de *T. mediterraneus* (Steindachner. 1868). (Poissons. Téléostéens. Carangidae) de la province Atlantico-Méditerranéenne. Cybium. 12(3) .247-253.
- [13]. Ben Salem M.. 1990.Révision du genre *Trachurus* Rafinesque. 1810. biologie et génétique des espèces tunisiennes. Thèse Doctorat d'Etat. Université de Tunis II. 351.
- [14]. Ben Salem M. and Daget J.. 1991. Nouvelle méthode d'estimation des paramètres de la croissance chez les poissons. Cybium. 15 (2) .103-109.
- [15]. Ben Salem M. and Ktari M.. 1994. Sexualité et reproduction des espèces du genre *Trachurus* Rafinesque. 1810 des côtes tunisiennes (Poissons Téléostéens Carangidae). Bulletin de l'Institut National des Sciences. technologies et océanographie. Pêche Salammbô. 21 .88 – 103.
- [16]. Bernard D.R (1981) Canadian Journal of Fisheries and Aquatic Sciences,38. 233-236.
- [17]. Borges M. F. and Gordo L. S.. 1991.Spatial distribution by season and some biological parameters of horse mackerel (*Trachurus trachurus* L.) in the Portuguese continental waters (Division IXa). ICES. CM 1991. H/54.
- [18]. Caddy. J.F.. 1998. Iszsues in Mediterranean fisheries management: geographical units and effort control .FAO Study. Review 70. 56.
- [19]. Carillo. J.. 1978. Biología y crecimiento del jurel (*Trachurus trachurus* (L) y *Trachurus mediterraneus* (Steindachner) del mar mediterráneo cataln .Tesina de Licenciatura. Departamento. De zoología ciencias marinas .Universidad de la laguna. Tenerife. Espana. 103.
- [20]. Eltink.A. . Kuitter . C.J..1989. Validation of ageing techniques on otoliths of horse mackerel (*Trachurus trachurus* L). ICES. CM1989. H/44.
- [21]. Eltink A.. 1990. Horse mackerel egg production and spawning stock size in the North Sea in 1989. ICES. CM 1990.H/ 20.
- [22]. Eltink A.. 1991. Horse mackerel egg production and spawning stock size in the North Sea in 1990. International Council for the exploitation of the sea. Council Meeting 1991.H/ 27.
- [23]. Eltink A.. 1992. Horse mackerel egg production and spawning stock size in the North Sea in 1991 ICES. CM 1992. H/21.
- [24]. Ezzeddine S.. Gharbi H.. Chemmem B.. Fezzani S.. Ben Meriem S.. Zarrad R.. Bedoui R.. Ghorbel M.. Sallem F.. Besbes Y.. Ben Abdallah L. and El Abed A.. 2001. Etat du stock des principales espèces marines exploitées sur la côte Nord de Tunisie. Actes des 8ème Journées Nationales sur les Résultats de la Recherche Agronomique. Nabeul .Tunisie. 13 et 14 Novembre 2001. 368 - 373.
- [25]. Fezzani S.. Ben Salem S.. Gaamour A. and El Abed A.. 2001. Exploitation state of *Trachurus trachurus* (fish. Carangidae) in the South of Tunisia. Proceedings of the 4thInternational Conference on the Mediterranean Coastal Environment. MEDCOAST 01. E. Özhan (Editor). 23 - 27 October 2001. Hammamet. Tunisia. Vol.2 . 815 - 822.
- [26]. Fezzani –Serbaji S.. Gaamour A.. Ben Abdallah L. and El Abed A.. 2002. Période de reproduction et taille de première maturité sexuelle chez les Chinchards (*Trachurus trachurus* et *Trachurus mediterraneus*) de la région Nord de la Tunisie. Bulletin de l'Institut National des Sciences et Technologies de la Mer. Salammbô. Numéro Spécial (7). Actes des 5ème Journées Tunisiennes des Sciences de la Mer (ATSMer). Ain Draham.Tunisie. du 21 au 24 Décembre 2002. 9 –12.
- [27]. Fezzani Serbaji S.. Ben Salem M. and El Abed A.. 2003. Estimation de la croissance du Chinchard commun (*Trachurus trachurus*) de la région Nord de la Tunisie par application de la méthode de Bhattacharya (1967). Bulletin de l'Institut National des Sciences et Technologies de la Mer. Salammbô. Numéro Spécial (8). Actes des 6ème Journées Tunisiennes des Sciences de la Mer (ATSMer). Tunis. Tunisie du 28 au 30 Novembre 2003, 80-83.
- [28]. Fezzani Serbaji S.. Chemmam-Abdelkader B.. and Ben Salem M.. 2004. Structure démographique et exploitation du chinchard à queue jaune (Carangidés) dans la région Est de la Tunisie. Bulletin de l'Institut National des Sciences et Technologies de la Mer. Salammbô. Numéro

- Spécial (9). Actes des 7ème Journées Tunisiennes des Sciences de la Mer .Zarzi . Tunisie du 18 au 22 décembre 2004. 69-72.
- [29]. Fezzani Serbaji S., Ben Salem M., Chemmam B. and Bel Hassen M.. 2006. Répartition bathymétrique des Saurels dans la région Nord de la Tunisie. Actes du 6ème Congrès Maghrébin des Sciences de la Mer .Monastir. Tunisie du 18 au 22 décembre 2005.Bulletin de l'Institut National des Sciences et Technologies de la Mer. Salammbô. Numéro Spécial (10) . 68-71.
- [30]. ICES.1999a. Report of the horse Mackerel otolith Workshop. Lowestoft 15-19 January 1999.ICES.C.M.1999.G/16.57.
- [31]. ICES. 1999c. Report of Horse Mackerel Otolith Workshop. ICES. CM 1999.G/16 (including addendum: effects of age reading errors on the assessment of horse mackerel).
- [32]. Iversen S.A., Skogen M. and Svendsen E.. 1998. Influx of Atlantic water and feeding migration of horse mackerel. ICES. C.M. 1998.R/18-9.
- [33]. Jardas I., Santic M. and Pallaoro A.. 2003. Biometric properties of Horse mackerel. *Trachurus trachurus* (Osteichthyes: Carangidae). from the middle Adriatic Sea. Acta Adriatica. 44 (1). 85-95.
- [34]. Junquera .S.C.,Porteiro C.and Moguedand . P..1988.Contribution to the interpretation of the ring distribution pattern of Horse mackerel (*Trachurus trachurus* L) otoliths ICES C.M 1988.H/25-13.
- [35]. Karlou-Riga C. and Economidis P. S.. 1996. Ovarian atretic rates and sexual maturity of European horse mackerel. *Trachurus trachurus* (L.). in the Saronikos Gulf (Greece). Fishery Bulletin. 94 (1). 66-76.
- [36]. Karlou-Riga C. and Economidis P. S.. 1997. Spawning frequency and batch fecundity of horse mackerel. *Trachurus trachurus* (L.) in the Saronikos Gulf (Greece). Journal of Applied Ichthyology. 13 (3). 97-104.
- [37]. Karlou-Riga. C. and Sinis. A.. 1997. Age and growth of horse mackerel *Trachurus trachurus* ( L) in the Gulf Sarnikos ( Greece). Journal of Applied Ichthyology. 13.97-104.
- [38]. Karlou-Riga C. and Sinis A.. 1997. Age and growth of horse mackerel. *Trachurus trachurus* (L.). in the Gulf of Sarnikos (Greece). Fisheries Research. 32. 157-171.
- [39]. Kerstan M.. 1985. Age. growth. maturity. and mortality estimates of horse mackerel (*Trachurus trachurus*) from the waters west of Great Britain and Ireland in 1984.Archeology Fishwiss.36. 115-154.
- [40]. Kerstan M.. 1995. - Sex ratios and maturation patterns of horse mackerel (*Trachurus trachurus*) from the NE- and SE-Atlantic and the Indian Ocean - a comparison. ICES C.M. 1995. H/6.
- [41]. Kerstan M. and Waldron M. E.. 1995.Age validation in horse mackerel (*Trachurus trachurus*) otoliths from the NE- and SE-Atlantic Ocean. ICES C.M. 1995. H/ 23.
- [42]. king.M ..1995. Fisheries biology .Assessment and Management. Fishing New Books. 341.
- [43]. Loudres Marceos. M.L.C.. 1986.Preliminary analysis of horse mackerel (*Trachurus trachurus*) otolith (L1) measurements.ICES C.M 1986. H/ 72.
- [44]. Lucio P.. 1996. Biological aspects (growth and reproduction) of Mediterranean horse mackerel (*Trachurus mediterraneus* Steindachner 1868) in the Bay of Biscay. ICES CM 1996. H/19. 1-12.
- [45]. Murta A. G., Borges M. F. and Cabral H.. 1993. Analysis of stomach contents of horse mackerel in the Portuguese waters (Division IXa) 1990-1992. ICES C.M. 1993. H/ 39.
- [46]. Nazarov. N.A.. 1978. Age and growth rate of the North East Atlantic horse mackerel. ICES C.M.1978.H/22.23.
- [47]. Olaso I., Cendrero O. and Abaunza P.. 1999. The diet of the horse mackerel. *Trachurus trachurus* (Linnaeus 1758). in the Cantabrian Sea (north of Spain). Journal of Applied Ichthyology. 15: 193-198.
- [48]. Santic. M., Jardas. I., Pallaoro. A.. 2002. Age. growth and mortality rate of horse mackerel *Trachurus trachurus* (L.) living in the eastern central Adriatic. Periodicum Biologorum 104. 165-173.
- [49]. Temming A. and Herrmann J. P.. 2001. Gastric evacuation in horse mackerel. I. The effects of meal size. temperature and predator weight. Journal of Fish Biology and Fisheries. 58. 1230-1245.
- [50]. Wengryn J.. 1975.Age and growth of *Trachurus trachurus* L.from North West african Waters. ICES C.M.1975.17-19.

