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Population size structure, age and growth of *Naucrates ductor* in the small scale FADs fishery of Mallorca Island (western Mediterranean)*

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SUMMARY: The pilotfish (*Naucrates ductor*) is mainly caught as a by-catch of the dolphinfish fishery using FADs deployed around Mallorca (western-Mediterranean) from the end of August to December. The age and growth parameters of this species were estimated by length frequency analysis and daily growth increments observed in the otoliths. To validate the daily formation of the ring observed in the sagittae otoliths, a marking otoliths experiment with $SrCl_2$ was carried out with juvenile specimens kept in laboratory conditions. The growth parameters obtained from otolith interpretation were based on age at length of 99 specimens ranging between 15 and 31.2 cm FL. Length frequency analyses were based on the monthly length distribution obtained in 1990, 1991, 1995 and 1996. The results obtained from the two methods were similar and showed rapid growth during the first 6 months of life. The von Bertalanffy growth equation from otoliths was $FL= 28.97 (1-e^{(-6.87(t - 0.055))})$. Positive allometric growth was observed in the length-weight relationship, with no differences existing between sexes: $W (g)= 0.0147*FL^{3.040}$ (cm).

Key words: *Naucrates ductor*, validation, modal progression, daily increments, growth parameters, FADs fishery, W Mediterranean.

INTRODUCTION

The pilotfish (*Naucrates ductor* Linnaeus, 1758) (Pisces: Carangidae) is an epipelagic oceanic species that is almost cosmopolitan in tropical and subtropical seas. In the Eastern Atlantic it is found from the British Isles, where it is rare (Smith-Vaniz, 1986), to Namibia (Lloris, 1986). *N. ductor* also inhabits the Mediterranean, and has occasionally been caught in the Black Sea (Bauchot, 1987).

This species is one of the most characteristic of the pelagic fish assemblage associated with fish aggregating devices (FADs) in the western and central Mediterranean (Massutí and Reñones, 1994; Relini *et al*., 1994) and in the central Atlantic (Hunter and Mitchell, 1967).

In the Mediterranean this fish assemblage is exploited by different seasonal small scale fisheries. One of the most important ones takes place in Malta (Galea, 1961), Sicily (A. Potoschi, comm. pers) and Mallorca (Massutí and Morales-Nin, 1995) from the end of summer to the beginning of winter. This fishery is directed towards the capture of *Coryphaena hippurus* (Linnaeus, 1758) and its two principal by-catch species are the carangidae *N. ductor* and *Seriola dumerili* (Risso, 1810). While the top predator

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fast swimming species *C. hippurus* and *S. dumerili* are associated with drifting objects only in the juvenile stages (Massutí, 1997; Badalamenti *et al.*, 1995), *N. ductor* shows a different life history. It is associated with FADs in both the juvenile and adult phases (Reñones *et al.*, 1998), and whilst beneath FADs it is plantivorous, feeding mainly on amphipods, gastropods and crustacean larvae.

The biology of this species is poorly known and very few studies have been carried out. Lo Bianco (1909), Roule and Angel (1930), Sanzo (1931) and Padoa (1956) studied its eggs and larval development and Chaine (1957) described the otolith morphology. Makssimov (1968) studied its trophic and reproductive biology in the Galapagos Islands and more recently Vaske (1995) described the diet of specimens captured under *Prionace glauca* and *Isurus oxyrinchus* in Brazil. In the Mediterranean Relini *et al*. (1994) reported some data on its length-frequency distribution and feeding behaviour from specimens associated with an offshore buoy in the Ligurian Sea, and Reñones *et al*. (1998) carried out a preliminary study of otolith structure, reproduction and feeding patterns.

This paper describes the age and growth of *N. ductor,* mainly based on specimens caught in the dolphinfish fishery in Mallorca waters. Samples taken outside the fishing season were also analysed. A preliminary marking experiment was carried out to partially validate the age determination.

MATERIAL AND METHODS

Sampling and laboratory procedures

Monthly catch data for *N. ductor* from 1981 to 1996 were obtained from the data bank of the control sales wharf of Mallorca, where catches offloaded at all the ports on the island are sold fresh.

Length-frequency data were obtained from August to December of 1990, 1991, 1995 and 1996 in 69 samplings on board dolphin-fish fishing vessels. Additional samples were obtained with handline in July 1991 and 1996 under live specimens of loggerhead turtle (*Caretta caretta* Linneaeus, 1758) and blue shark (*Prionace glauca* Linnaeus, 1758) respectively, and in April 1996 and January 1997 under permanent buoys. Furthermore, specimens smaller than 12 cm fork length were obtained with a dip net in different months under drifting objects or under the FADs used in the fishery. A total of 3708 specimens (639 in 1990, 1501 in 1991, 742 in 1995, 769 in 1996 and 54 in 1997) were measured to the nearest centimetre fork length.

The length frequency data were analysed by the Bhattacharya method as applied by the ELEFAN computer program (Gayanillo *et al*., 1988) to identify the modal groups in the samples pooled with fortnightly periodicity.

Subsamples covering the whole length range were taken for determination of length-weight relationships and sex ratio. From 559 specimens, the fork length (FL) accurate to the nearest mm, total weight (TW) and sex were recorded.

Otolith morphology

In 180 specimens, obtained in 1990 and 1991, sagittal otoliths were removed, cleaned and stored in destilled water. Otolith radius (OR: from the focus to the rostrum) and otolith length (OL: from the rostrum to the post rostrum) were measured using an ocular micrometre in a compound microscope (400x) in order to determine the relationship between otolith growth and fish growth. Correlation between fish length and otolith measurements were calculated by applying linear and exponential regression analysis, and the allometric indices obtained were tested by the Student t-test (Zar, 1984).

Validation of ageing techniques

Marking calcium structures by immersion in a solution of $SrCl_2$ of specimens kept in captivity was used to determine whether the increments observed in the otoliths were deposited daily. This technique has been widely used to validate ring deposition rates in larvae, juveniles and adults of species which cannot be reared in laboratory conditions (Campana and Neilson, 1985). Juveniles from 3 to 9.2 cm FL were collected in October 1996 and kept for 3 days in culture conditions to allow time for acclimation. Then the specimens were transferred to a 50 l tank with a solution of 1.25 g $SrCl_2$ per liter, and kept in a closed system with aeration for 24 hours. Afterwards the specimens were kept in 2 m^3 tanks in an open water system under natural photoperiod and temperature conditions. They were fed ad libitum with fish enriched with vitamins due to the high nutritional requirement of this species in this length range. After 11 and 21 days, 4 and 5 specimens were sacrificed.

The sagittal otoliths were dissected, dried and mounted as for age determination. Sagittal sections were obtained and the increments were highlighted with EDTA for 1 minute. The otoliths were dried and coated with carbon for scanning electron microscopy (SEM) observation. The Sr band was visualised using X-ray Kebex detector with the detector at an angle of 30º from the electron beam. The detections were carried out interactively with a mean of 7 interactions per analysis and an acquisition time of 100 seconds. A point analysis was performed at 7000 magnifications and an area analysis at 10000 magnifications. The analyses were carried out in the centre of the otolith and in the marginal otolith zone.

Age determination and growth

The otoliths were mounted on slides, slightly angled towards the antirostrum with the internal face uppermost, using petropoxy as a mounting medium. In the majority of cases, otoliths were polished before reading in a grinder-polisher with 3 mm micropolish alumina. The otoliths were examined under high magnification in a light microscope coupled to a high-resolution video camera and monitor system. Depending on the size and zone of the otolith, the magnification used ranged from 250x to 1000x at the screen. Each otolith was read at least twice and only interpretations with less than 5% variation in the ring number were accepted.

The von Bertalanffy growth parameters (L_∞, K and t_0) were estimated by two independent methods: by length-frequency analysis using the ELEFAN I procedure (Pauly and David, 1981) included in the ELEFAN software package (Gayanillo *et al.*, 1988) and from age-length relationship obtained by otolith reading, using the FISHPARM program (Prager *et al.*, 1987). The length frequency analysis was performed for each year analysed separately and for consecutive years together.

As L_∞ and K are inversely correlated, the growth performance index Φ (Munro and Pauly, 1983) was employed to compare growth rates obtained by the two methods and for the different sampling years.

RESULTS

Catches

N. ductor are caught all year around, but the bulk of the catches occur during the dolphinfish fishing season (from the end of August to December). Catches from January to July are occasional and never represent more than 1% of the total annual catch of the species.

N. ductor annual catches from 1981 to 1996 showed periodic fluctuations ranging from 0.9 to 30.5 metric tonnes (Fig. 1). Since the decrease of the catches in 1992, the annual captures have remained low and less than the mean value of the

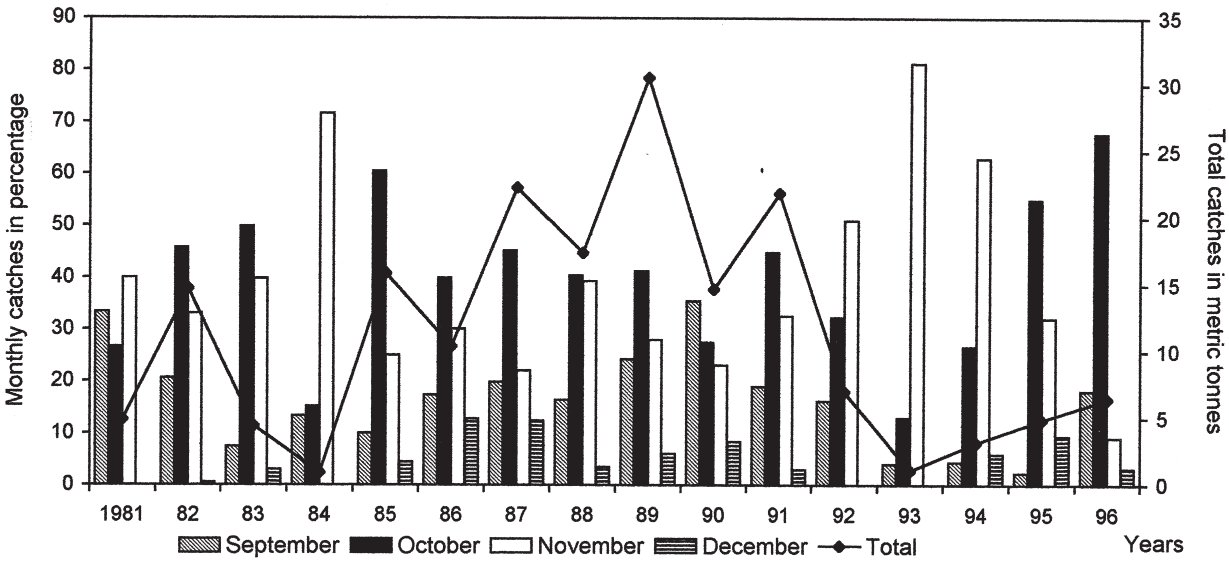

FIG. 1. – Historical monthly (bars) and annual (line) catches of *Naucrates ductor* obtained by the dolphin fish fishery carried out around Mallorca (Balearic Islands, Western Mediterranean).

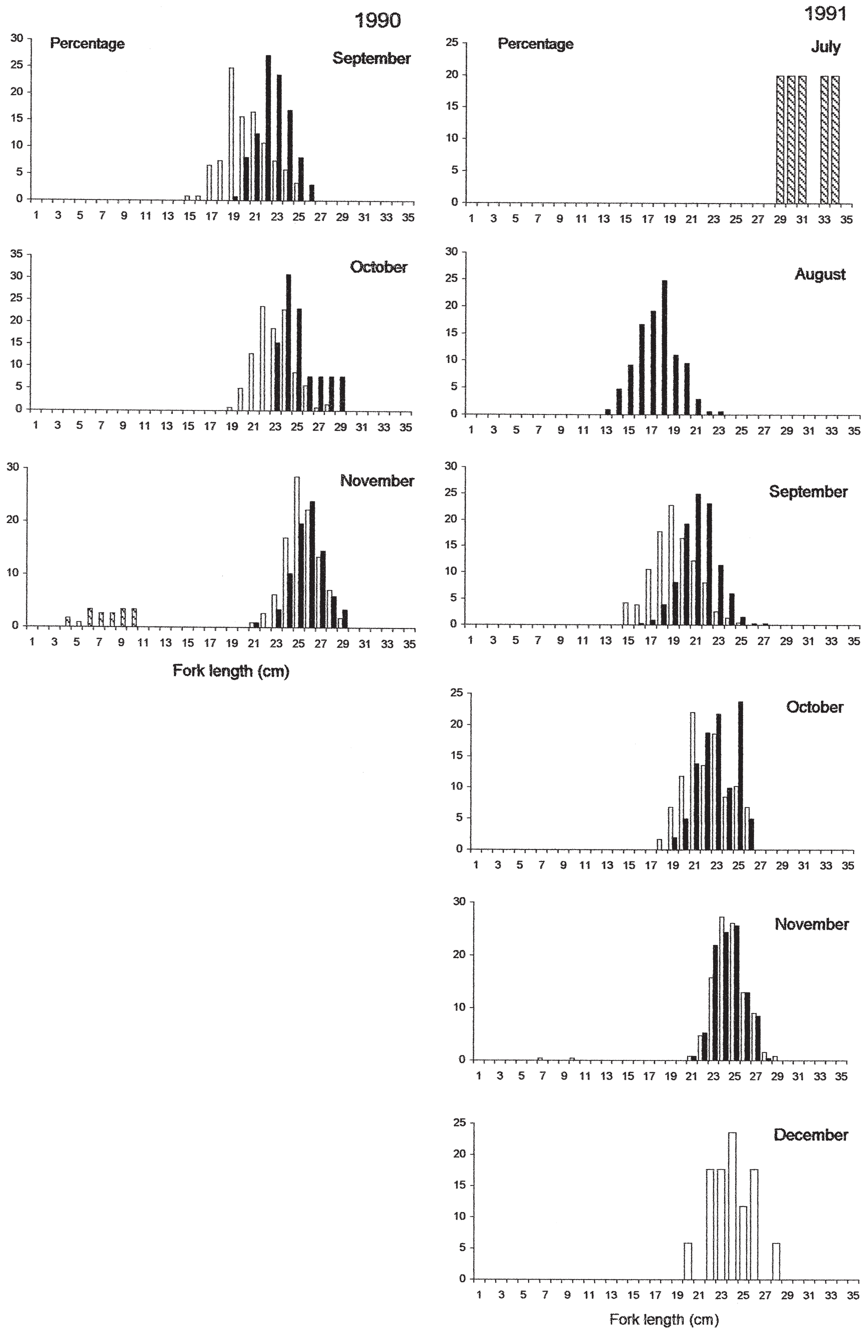

FIG. 2. – Fortnightly length frequency distribution of *Naucrates ductor* in 1990, 1991, 1995, 1996 and 1997. White bars correspond to the first fortnight of the month and black ones to the second one of specimens captured in the dolphinfish fishery. Shadowed bars correspond to specimens not captured in the fishery.

available historical series. The historical monthly data series indicates that in years of high annual catch the highest ones occur in October, while in the years with low catches November is the month with maximum captures of the species (Fig.1).

Length distribution

The length range caught in the dolphin-fish fishery from the end of August to December was 13 to 30 cm FL (Fig. 2, Table 1). The smallest specimens were caught at the beginning of the fishing season (13-15

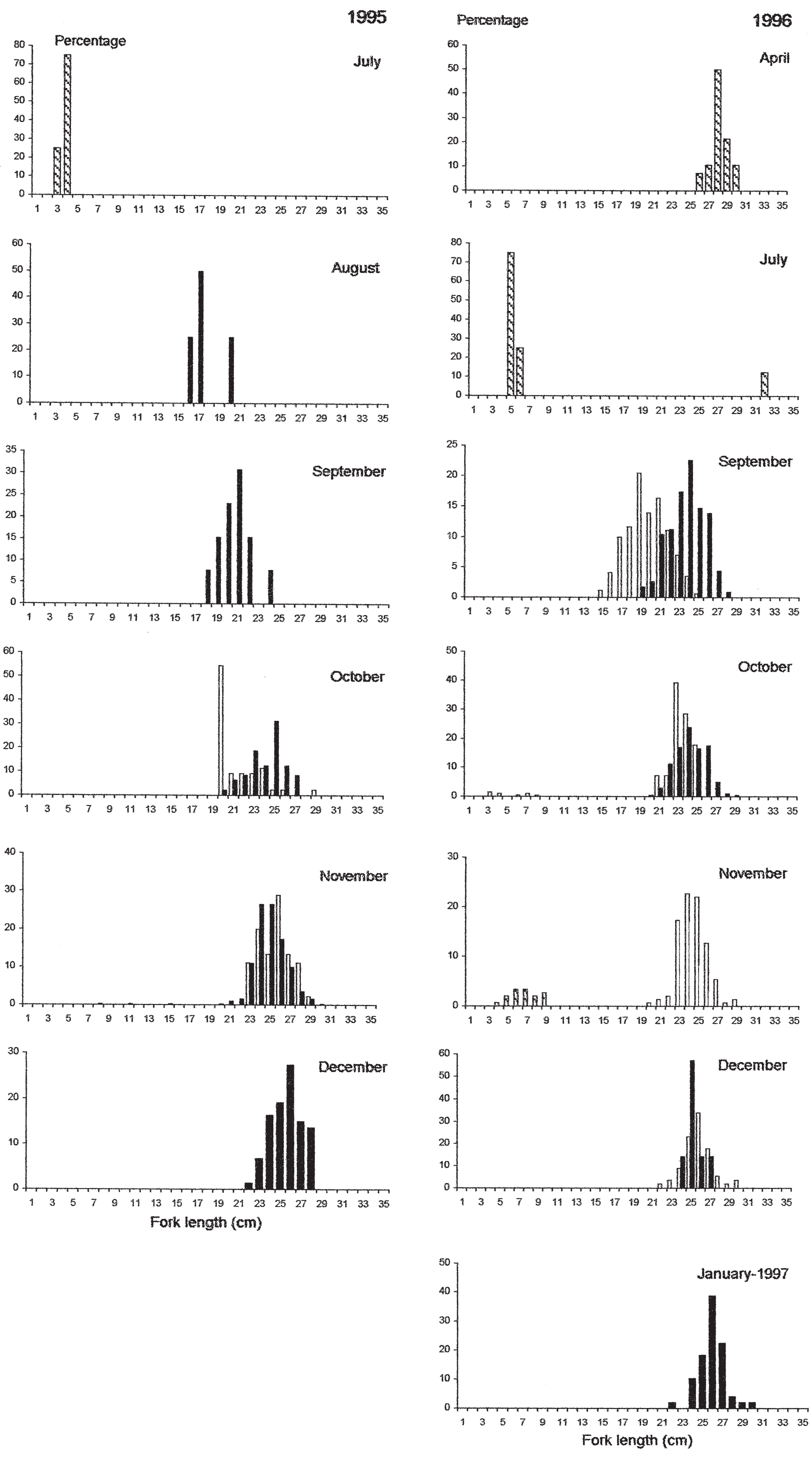

FIG. 2. – (Cont.) Fortnightly length frequency distribution of *Naucrates ductor* in 1990, 1991, 1995, 1996 and 1997. White bars correspond to the first fortnight of the month and black ones to the second one of specimens captured in the dolphinfish fishery. Shadowed bars correspond to specimens not captured in the fishery.

cm FL) and the largest ones (29-30 cm FL) from the end of October to the beginning of November.

Considering the catches obtained outside the dolphinfish fishing season, the length range of specimens caught under live animals was 29 to 34 cm FL, while the length range of specimens caught in April and January under buoys ranged from 23 to 30 cm FL. The smallest individuals,

TABLE 1. – Fortnightly and monthly mean geometric fork length (FL) in cm, standard deviation (sd), length range and number of specimens sampled (n) of *Naucrates ductor*. The dates marked with * correspond to specimens not obtained in the dolphinfish fishery.

			Fortnightly data				Monthly data			
Year	Month	Date	Mean FL	sd	FL range	n	Mean FL	sd	FL range	n
1990	September	First	20.2	2.10	15 - 25	121	21.4	2.14	15 - 26	257
		Second	22.6	1.50	19 - 26	136				
	October	First	22.9	1.70	19 - 28	140	23.1	1.79	19 - 29	153
		Second	25.0	1.71	23 - 29	13				
	November	First	25.3	1.54	21 - 29	112	25.5	1.52	21 - 29	208
		Second	25.7	1.48	21 - 29	96				
		Second*	7.2	1.90	4 - 10	22				
1991	July	Second*	31.4	2.07	29 - 34	5	31.4	2.07	29 - 34	5
	August	Second	17.3	1.82	13 - 23	318	17.3	1.82	13 - 23	318
	September	First	19.1	1.96	15 - 25	237	20.3	2.05	15 - 26	502
		Second	21.2	1.64	16 - 27	333				
	October	First	22.1	2.03	18 - 26	59	22.7	1.89	18 - 26	160
		Second	23.0	1.74	19 - 26	101				
	November	First	24.6	1.45	21 - 29	253	24.5	1.42	21 - 29	497
		Second	24.4	1.39	21 - 28	246				
		Second*	8.4	2.12	7 - 10	2				
	December	First	23.9	1.84	20 - 28	17	23.9	1.84	20 - 28	17
1995	July	First*	3.7	0.50	3 - 4	4	3.7	0.50	3 - 4	4
	August	Second	17.4	1.73	16 - 20	5	17.4	1.73	16 - 20	5
	September	Second	20.5	1.39	18 - 24	13	20.5	1.39	18 - 24	13
	October	First	21.4	2.07	20 - 29	44	22.8	2.34	20 - 29	92
		Second	24.1	1.73	20 - 27	48				
	November	First	25.5	1.60	23 - 30	45	25.0	1.49	20 - 30	552
		Second	24.9	1.47	20 - 30	507	10.2	2.08	8 - 12	3
		Second*	10.2	2.08	8 - 12	3				
	December	Second	25.6	1.51	22 - 28	73	25.6	1.51	22 - 28	73
1996	April	First*	28.2	1.02	26 - 30	28	28.2	1.02	26 - 30	28
	July	First*	5.2	0.46	5 - 6	8	5.2	0.46	5 - 6	8
	September	First	19.7	2.11	15 - 25	171	21.2	2.78	15 - 28	286
		Second	23.6	1.89	19 - 28	115				
	October	First	23.4	1.10	21 - 25	28	24.1	1.58	20 - 29	225
		Second	24.2	1.62	20 - 29	197	4.6	2.00	3 - 8	9
		Second*	4.6	2.00	3 - 8	9				
	November	First	24.5	1.49	20 - 29	129	24.5	1.49	20 - 29	129
		First*	6.7	1.49	4 - 9	21				
	December	First	25.9	1.53	22 - 30	56	25.8	1.49	22 - 30	63
		Second	25.3	0.95	24 - 27	7				
1997	January	Second	25.9	1.31	22 - 30	49	25.9	1.31	22 - 30	49

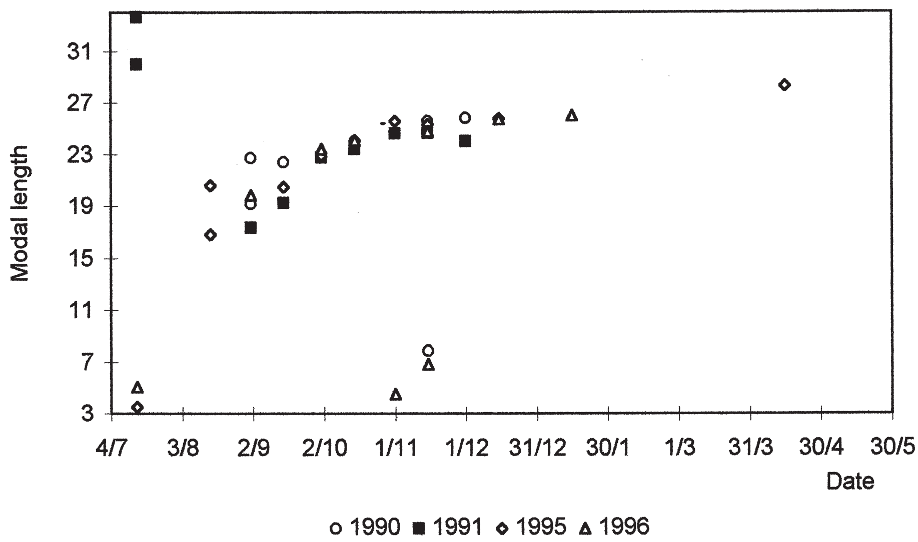

FIG. 3. – Modal progression analysis of *Naucrates ductor* length frequency distribution for 1990, 1991, 1995 and 1996. The mean values calculated using Bhattacharya methods as applied by the ELEFAN computer programme are shown.

ranging from 3 to 12 cm FL, were caught in July, October and November.

The length distribution from July to October showed a rapid increase in the mode, mean, minimum and maximum sizes of the catch (Fig. 2, Table 1). The monthly length increment, calculated for all years together, showed a maximum increment of 12.6 cm between July and August, which decreased sharply from September onwards. The monthly length increment from September to January was 3.45, 2.52, 1.54, 0.66 and 0.42 cm respectively.

The modal groups identified by the Bhattacharya methods were similar for the four years studied (Fig. 3). From July to October only one mode was found in the majority of the samples except in September 1990 and August 1995 when two modes could be identified. In the November samples of 1990 and 1996 two separate modes were identified, with the smallest individuals occurring in the same range as those identified in July.

From a total of 559 specimens studied, 269 were females, 260 males and 30 could not be sexed. The sex-ratio was not significantly different from 1:1 ($\chi^2 = 0.153$, $p>0.25$).

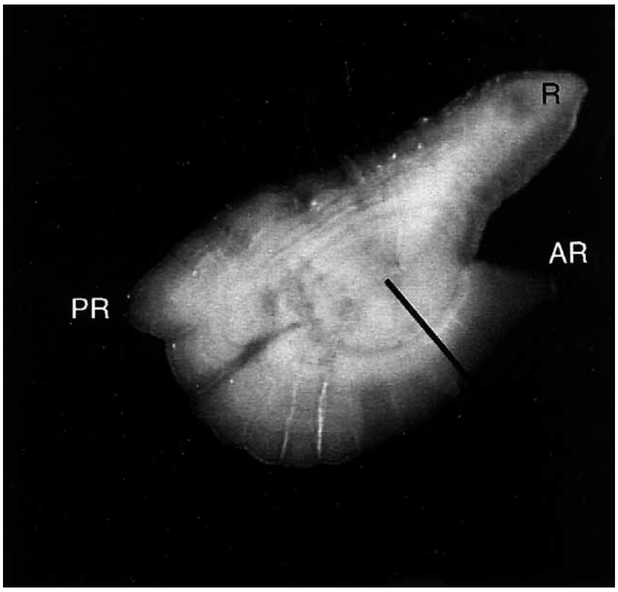

FIG. 4. – *Naucrates ductor* sagittae otolith showing the reading line (40x). AR, antirostrum; PR, postrostrum; R, rostrum.

Otolith morphology

The sagitta otolith was elongated, with the rostrum and the post-rostrum clearly differentiated (Fig. 4) and the internal face was slightly convex. The sulcus extended from the anterior to the posterior zone, with a broad ostium and cauda. Under the

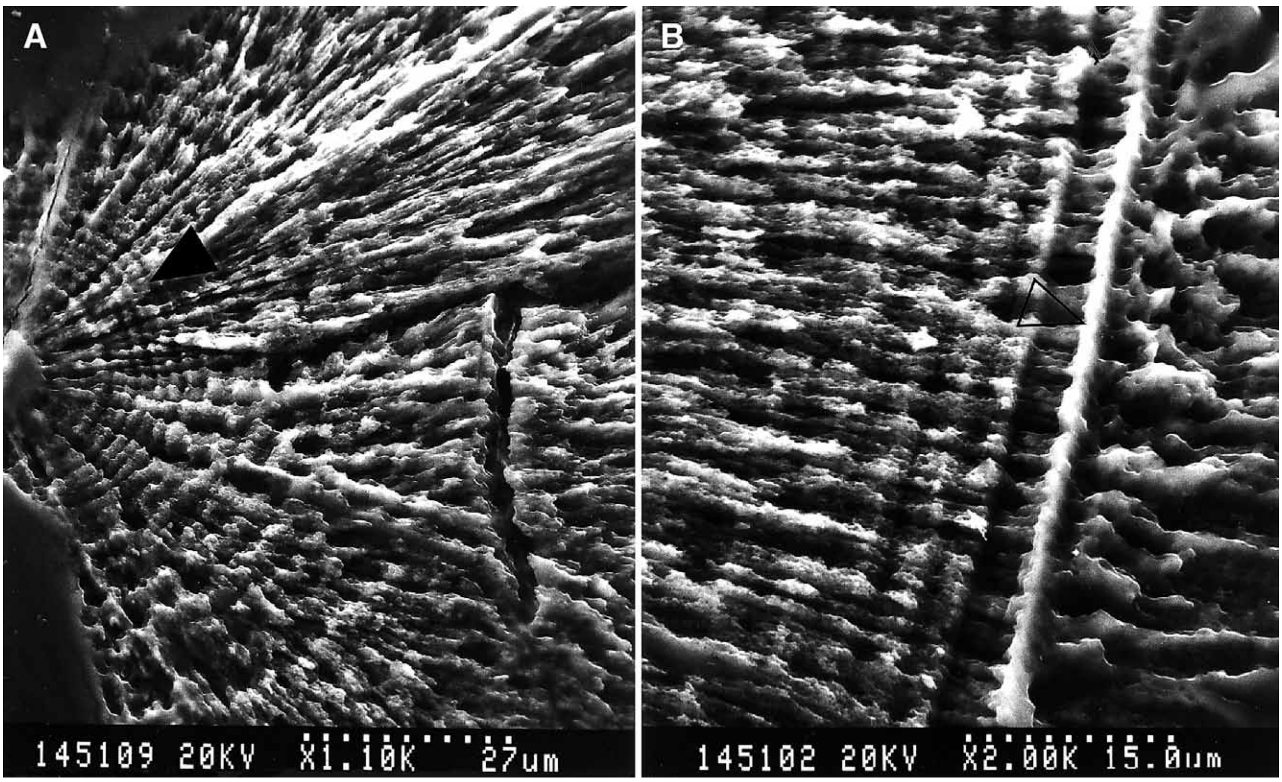

FIG. 5. – Scanning electron microscope micrographs of a sagittae otolith of *Naucrates ductor*. A, Central area showing the core and first increment (arrow). B, The marginal area showing the discontinuity (arrow) produced by the marking experiment.

TABLE 2. – Relationship between sagittal otoliths and morphometric measures of *Naucrates ductor* (OL: otoliths radius; OR: otoliths length; FL: Fork length; TW: total weight; r^2: correlation coefficient; n: number of specimens).

		n	r^2
	LO (mm) = 0.0339 * FL $^{0.7307}$(mm)	150	0.95
	OR (mm) = 0.0190 * FL $^{0.7312}$ (mm)	150	0.94
Females	W (g) = 0.0143 * FL $^{3.049}$ (cm)	269	0.99
Males	W (g) = 0.0141 * FL $^{3.050}$ (cm)	260	0.99
Total	W (g) = 0.0147 * FL $^{3.040}$ (cm)	559	0.99

LIM the otoliths showed alternating concentric dark-light ring patterns surrounding a core. The mean width of the increments increased with the age, without the appearance of an accessory nucleus. In the otolith marginal zone of fish larger than 15 cm, the increments decreased sharply in width.

In SEM preparations the clear and narrow first 8 increments (1.92 µm on average, SD = 0.33) appeared around the core, followed by thicker increments (3.5 µm on average, SD = 0.64) with wide discontinuous units (Fig. 5a). These increments are above the detection limit of LIM, so an underestimation of age was not expected (Campana, 1992).

The relationship between FL-OR and FL-OL obtained from 150 sagitta fitted better in an exponential regression (Table 2). In both cases, negative allometry was found between fish length and otolith size (FL-OR: $t_{0.05\ (2)\ 150} = 12.94$, $p< 0.001$ and FL-OL: $t_{0.05\ (2)\ 150} = 13.\ 88$, $p< 0.001$).

Validation of ageing techniques

From the seven otoliths analysed, one had no Sr in detectable quantities and two had no mark that could be related to the marking experiment. In the rest, the structural discontinuity, which was related with the marking experiment (Fig. 5b), had Sr incorporated into the otolith composition in considerable quantities (Table 3). The number of increments from the discontinuity to the otolith edge corresponded to the days elapsed between marking and sacrifice (Table 3).

Age determination and growth

Positive allometric growth was found in the length-weight relationship for males, females and for the whole population ($p<0.05$) (Table 2) but no significant differences were obtained between males and females for the allometric coefficient ($t_{0.05\ (2)\ 525} = 0.097$, $p> 0.5$).

Otolith rings were enumerated along the shortest radius from the nucleus to the dorsal side of the otoliths. In specimens with an FL greater than 22 cm, in which the marginal increments were very fine, the presence of an intermediate opaque zone with thick microincrements made the selection of a unique reading axis difficult. In these cases, the lack of an adequate axis made it necessary to follow a reading path, following prominent increments laterally to an area where clear increments were found.

Age could not be determined in 18.6% of the otoliths because the error in reading precision was greater than 5% or because they could not be clearly read. Therefore, counts of growth increments were obtained from 122 specimens, 21 in 1990 and 101 in 1991, ranging from 4.2 to 31.2 cm FL. All specimens studied were age 0. The minimum and maximum increments identified were 37 and 221 respectively.

As temperature and food availability are likely to be the major determinants affecting growth rates (Suthers *et al.*, 1989; Deacon and Hecht, 1996) and the results of the birthdate distribution reported by Reñones *et al.* (1997) showed two different annual cohorts in the area, the von Bertalanffy growth curve

TABLE 3. – Atomic percent of strontium (Sr) and calcium (Ca) obtained in the central area (Blank area) and in the structural discontinuity observed in the marginal area (Mark) on *Naucrates ductor* otoliths after marking with $SrCl_2$. The time elapsed between marking experiment and sacrifice and the number of increments observed are given.

	Blank area		Mark		Days after	
FL (mm)	Ca	Sr	Ca	Sr	marking	Nº increments
40	90.17	0.10	90.06	1.54	11	11
49	92.45	1.20	-	-	11	-
58	98.47	1.53	-	-	21	-
78	99.04	0.96	94.88	5.13	21	22
83	98.18	0.17	91.88	5.12	21	20
96	85.83	1.77	-	-	11	
100	97.25	2.66	96.68	8.35	21	21

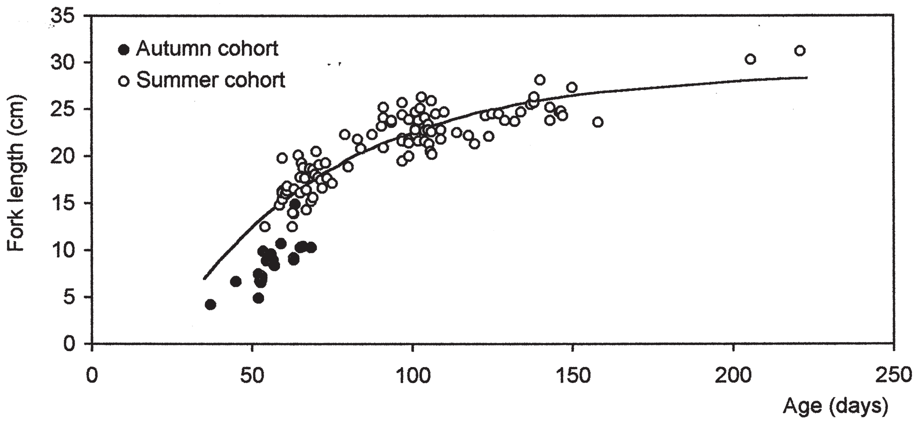

FIG. 6. – Relationship between fork length and estimated age for all specimens of *Naucrates ductor* studied in 1990 and 1991, and the von Bertalanffy growth curve fitted using data from the age determination of the 1991 summer cohort.

TABLE 4. – Estimated parameters of the von Bertalanffy equation (± standard error). Results based on the otolith readings of specimens caught in 1991 (summer cohort) and on the length frequency distribution for 1990, 1991, 1995 and 1996. Φ: growth performance index (Munro and Pauly, 1983).

	Otolith	Length frequency distribution					
	1991	1990	1991	1995	1996	1990-1991	1995-1996
K ($year^{-1}$)	6.872 ± 1.259	5.8	5.7	5.4	5.3	6.0	5.4
L_∞ (cm)	28.97 ± 1.283	28	27	27	28	27	28
t_0	0.055 ± 0.016						
Rn		0.517	0.564	0.545	0.490	0.583	0.462
Φ	3.761	3.66	3.62	3.60	3.62	3.64	3.63

$\Phi = 2 \log_{10} L_\infty + \log_{10} K$

was calculated only for the 1991 summer cohort. Thus, the growth parameters obtained from otolith interpretation were based on daily increments of 99 specimens ranging between a length of 15 and 31.2 cm FL. The relationship between FL and the number of growth increments and the estimated von Bertalanffy curve are shown in Figure 6.

The growth parameters estimated by count of the daily increment observed in the otoliths (FISHPARM) and by length frequency analysis (ELEFAN I) are given in Table 4. The values of the asymptotic length (L_∞) estimated for both methods ranged from 29 to 27 cm FL, being lower than the maximum length sampled (34 cm FL).

The growth coefficient (K) was high, ranging from 6.8 to 5.3 yr^{-1} depending on which data set or methods were used (Table 4). The slope of the regression of the natural logarithm of monthly growth increments of the length frequency against month provides another estimate of K = 6.6 yr^{-1}. This value is consistent with otolith and length results. The good fit of t_0 might be related to the inclusion of very young fish in the calculations. The values of Φ were similar using both methods (otoliths and length frequency analysis) and showed a rapid growth of the species during its first year of life.

DISCUSSION

Naucrates ductor is a by-catch species of the dolphinfish fishery with low commercial value. The seasonality of the catches is not directly determined by the abundance of the species in the fishing ground but rather by the seasonality of the dolphinfish fishery, which is related to the migratory behaviour of its target species (*C. hippurus*) (Massutí and Morales-Nin, 1995).

We obtained specimens from fishery-independent and fishery-dependent sources, with specimens smaller than 13 cm FL and larger than 30 cm FL coming from fishery-independent sources, whereas the intermediate sizes were caught in the dolphin fish fishery. Consequently, our sample could be biased towards certain size classes and the size frequency distribution may not reflect that of the population in the area.

The results obtained from the length frequency distribution and modal progression analysis are similar for the four years studied, since they show a unimodal pattern, with a clear progression in length during the first month of seasonal exploitation of the species (August to October). Small specimens (less than 12 cm FL) could be seen in July (before the beginning of the fishery) and from the end of October under floating objects or beneath the FADs deployed in the fishery, showing that there are at least two peaks of recruitment during the year in the western Mediterranean. The relative importance of the autumn cohort is not reflected in the length distribution due to the fact that the smallest juveniles escaped through the net used in the fishery. The minimum size captured with the traditional purse seine was 13 cm FL. These two cohorts agree with the evolution of the spawning period proposed for this species in Mallorca waters by Reñones *et al*. (1998) and in other areas of the Mediterranean (Lo Bianco, 1909; Sanzo, 1931; Relini *et al*., 1994).

N. ductor sagittae otoliths were thin and small, and their relative size with respect to the fish decreased throughout their development. The otoliths showed clear growth increments consisting of alternating light and dark bands with a thickness and appearence similar to that of other species.

This study provided the first data of the daily nature of growth increments observed in the sagittae otolith of *N. ductor,* at least in the range sizes studied, using a marking technique (Geffen, 1992). Although the experimental sample was small, the good correlation obtained between the number of growth increments from the mark outwards and days after marking, partially validates the use of the growth increments observed in the sagittae otolith for the ageing of this species. However, the age at initial increment deposition was not determined. Initial growth increments have been shown to be deposited prior to egg hatching, at hatching, just after hatching and at onset of exogenous feeding (Brothers *et al*., 1976). It was assumed that the first otolith increment was laid down at hatching, so the estimated age of pilotfish must be proportional to the real age of the fish but not necessarily equal to it. However, further research is required to validate the daily nature of rings observed in the otoliths throughout the whole size range of the species in a large sample and to determine the moment in the life history when the innermost growth increment its former.

The results of daily increment interpretation in the otoliths show that all specimens studied were in their first year of life. The von Bertalanffy growth parameters obtained by the two independent methods used were similar, showing a fast growth of the species during the first 6 months of life. The predicted asymptotic length is in relation to the maximum length captured during the fishing season, but is very much lower than that reported for the species in the Mediterranean Sea (Hureau and Tortonese, 1973) and in the Atlantic Ocean (Smith-Vaniz, 1981), which is about 63 cm FL. The only available data for the life span of *N. ductor* are based on a few individuals kept in captivity (Riera, pers. comm.), which have reached a maximum age of 3 years under culture conditions. However, the values of the growth parameters obtained might be biased due to the inclusion of only the age 0 specimens in the calculations, and they have therefore been considered only as representative of the exploited fraction of the population in the western Mediterranean.

The length frequency distributions obtained under drifting objects after four years study are in the same range as those reported by Relini *et al.* (1994) in the Ligurian sea throughout an annual cycle, and they show that the maximum length reached by the species under drifting objects is about 30 cm FL. Similarly, only juveniles ranging from 3 to 14 cm FL were observed under flotsam in the central Atlantic by Hunter and Mitchel (1967). In contrast, specimens larger than this length have been caught under live animals.

There was no overlapping between the length distributions under the floating objects and those obtained under live animals, which, together with the homogeneity of size distribution obtained during the dolphin fish fishery, suggests that the pilotfish may move from the drifting objects as they grow, therefore showing a size-dependent behaviour. We support the hypothesis that this species is part of the fish assemblage associated with floating objects until it reaches a size of about 30 cm FL, at which point it leaves them and becomes associated with living animals. It then either remains in the area, but is not accessible to the fishing operations, or it may migrate along with its host.

The evolution of the maximum length obtained in the length frequency distribution throughout the fishing season supports this hypothesis, since from the end of October to the beginning of November an increase in the maximum length was not observed. Moreover, the results of the modal progression analysis were also indicative of a migratory species (Sousa, 1988) with a size-dependant behaviour. The largest specimens from the summer cohort start to leave the FADs at the beginning of November when they reach their maximum length, while the largest specimens of the autumn cohort start to be caught at the end of the fishing season, which gives an apparent negative growth.

Furthermore, our field observations also suggest that simultaneously to a change in habitat, related to size, the species could change from a shoaling behaviour under floating objects to living in small groups under live animals. The shoaling behaviour occurs when individual fish have significantly more foraging and antipredator advantages from being together with conspecifics (Pitcher, 1995), these advantages decreasing with growth in length. During its association with drifting objects *N. ductor* is a plantivorous species (Relini *et al*., 1994; Reñones *et al*., 1998) and according to Dale (1957) this species also has a commensalism relationship with sharks. In addition, Vaske (1995) found a high percentage of teleostean rest in the stomach contents of specimens caught under living animals. Therefore, for this species the size-dependant behaviour could be related to a change in the nutritional requirements, but more studies directed towards understanding the diet, distribution and behaviour of this species are needed in order to obtain a complete representation of pilotfish life strategies.

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