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Age at maturity of Mediterranean marine fishes

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Abstract

In this review, we collected data on the age at maturity (t_m) and maximum reported age (t_max) for 235 stocks of Mediterranean marine fishes, belonging to 82 species, 37 families, 12 orders and 2 classes (Actinopterygii and Elasmobranchii). Among Actinopterygii (mean t_m ± SD = 2.20 ± 1.43 y, n = 215), t_m ranged from 0.3 y, for the common goby Pomatoschistus microps, to 12 y, for the dusky grouper Epinephelus marginatus, while among Elasmobranchii (mean t_m ± SD = 5.94 ± 2.47 y, n = 20), t_m ranged between 2.7 y, for brown ray Raja miraletus, and 12 y for the picked dogfish Squalus acanthias. Overall, t_max ranged between 1 y, for the transparent goby Aphia minuta, and 70 y, for the wreckfish Polyprion americanus. Mean t_max of Actinopterygii (t_max ± SD = 10.14 ± 9.42 y) was lower than that of Elasmobranchii (t_max ± SD = 14.05 ± 8.47 y); t_m exhibited a strong positive linear relation with t_max for both Actinopterygii (log t_m = 0.58 x log t_max – 0.25, r² = 0.51, P < 0.001) and Elasmobranchii (log t_m = 0.67 x log t_max – 0.006, r² = 0.51, P = 0.007). Mean t_m/t_max did not differ significantly with sex within Actinopterygii (ANOVA: F = 0.27, P = 0.60, n = 90; females: mean ± SD = 0.276 ± 0.143; males: mean ± SD = 0.265 ± 0.138) and Elasmobranchii (ANOVA: F = 1.44, P = 0.25, n = 10; females: mean ± SD = 0.499 ± 0.166; males: mean ± SD = 0.418 ± 0.133). Finally, the dimensionless ratio t_m/t_max was significantly lower (ANOVA: F = 31.04, P < 0.001) for Actinopterygii (mean ± SD = 0.270 ± 0.135, n = 180) than for Elasmobranchii, (mean ± SD = 0.458 ± 0.152, n = 20), when stocks with combined sexes were excluded from the analysis.

Keywords: Age at maturity, maximum age, empirical equations, life history.

Introduction

The reproductive life history characteristics of stocks, such as spawning period (Tsikliras et al., 2010), length at maturity (Tsikliras & Stergiou, 2014) and fecundity (Despoti & Stergiou, 2013) are important for assessing the effects of fishing on populations and ecosystems (Jennings et al., 1998). Age at maturity (t_m) is a key element of the life history strategies of fishes and has been widely used in modelling and grouping fish species based on their traits (Winemiller & Rose, 1992; Rochet, 2000; King & McFarlane, 2003), as well as a stress indicator for fisheries (Trippel, 1995). Olsen et al. (2004) have shown that simultaneous decreases in growth rate and t_m are evidence of fishery-induced evolution in Atlantic cod (Gadus morhua) following population decrease that has been attributed to overfishing. The t_m is also essential in demographic analyses (Chen & Yuan, 2006) being the lower limit of generation time (= the mean age of the spawning stock), which is highly correlated with the intrinsic rate of population growth (Ainsley et al., 2011).

The availability of t_m estimates is limited compared to length at maturity data (Tsikliras & Stergiou, 2014) because it requires either ageing of caught individuals or knowledge of the local growth parameters in order for t_m to be estimated from the corresponding length at maturity. Therefore, the literature on the variability of t_m among families and orders of fish is rather scarce. Jennings et al. (1998) analyzed the life history traits of 18 fish stocks and report that stocks with high t_m, such as rays and skates, tend to decline more than expected from their rates of fishing mortality. Recently, Drazen & Haedrich (2012) analyzed the life history characteristics of 41 deep-sea demersal fishes and report that t_m increases with depth.

This review article is the third in the series of reviews on the reproductive biology of Mediterranean marine fishes, the first being by Tsikliras et al. (2010) on their spawning period, and complements the review on the size at maturity of Mediterranean fishes (Tsikliras & Stergiou, 2014).

The aim of the present work was to collect the available data on the age at maturity (t_m, y) and maximum reported age (t_max, y) for Mediterranean marine fish stocks and study: (a) the phylogenetic (between classes), sexual (between sexes) and habitat (among habitats - only for Actinopterygii) variability of t_m, (b) the relationship between t_m and t_max per class and (c) the dimensionless ratio.
Results

Perciformes were the most represented order (128 stocks; 54.5% of the total) of the dataset, Sparidae the most represented family (38 stocks; 16% of the total) and Trachurus trachurus the most represented species (17 stocks) (Table 1).

Overall, we collected data on $t_m$ for 235 stocks, belonging to 82 species, 37 families, 12 orders and 2 classes (Table 1). Among Actinopterygii ($n = 215$), $t_m$ ranged from 0.3 y, for the common goby Pomatoschistus microps, to 12 y for the dusky grouper Epinephelus marginatus, while among Elasmobranchii ($n = 20$), it ranged between 2.7 y, for the brown ray Raja miraletus, and 12 y for the picked dogfish Squallus acanthias. The mean $t_m \pm SD$ was 2.20 $\pm$ 1.43 y for Actinopterygii and 5.94 $\pm$ 2.47 y for Elasmobranchii (Table 1). The $t_{\text{max}}$ ranged between 1 y, for the transparent goby Aphia minuta, and 70 y, for the wreckfish Polyprion americanus. Mean $t_{\text{max}}$ was lower for Actinopterygii ($t_{\text{max}} \pm SD = 10.14 \pm 9.42$ y) compared to Elasmobranchii ($t_{\text{max}} \pm SD = 14.05 \pm 8.47$ y). The frequency distribution of $t_m$ was unimodal for both classes, with a peak at 2 y for Actinopterygii and a peak at 5 y for Elasmobranchii (Fig. 1).

The $t_m$ exhibited a strong positive linear relation with $t_{\text{max}}$ for both Actinopterygii and Elasmobranchii (Fig. 2). The slopes of the relations did not differ between Actinopterygii and Elasmobranchii (ANCOVA: $F = 0.16$, $P = 0.69$) but the intercepts did (ANCOVA: $F = 72.45$, $P < 0.001$). The empirical equations on the logarithmic values were (the non-transformed equations are also given for comparability purposes):

$$\text{Actinopterygii} \quad \log t_m = 0.58 \times \log t_{\text{max}} - 0.25, \quad r^2 = 0.51, \quad P < 0.001, \quad n = 215$$

$$t_m = 0.11 \times t_{\text{max}} + 1.10$$

Fig. 1: Percentage frequency distribution of age at maturity ($t_m$, y) of Mediterranean marine stocks per class. Grey bars refer to Actinopterygii ($n = 215$) and black bars to Elasmobranchii ($n = 20$).
Table 1: Age (tm) at maturity of Mediterranean marine fish stock and location of study. Habitats: D: demersal, P: pelagic, R: reef-associated, BEP: benthopelagic, BAD: bathydemersal, BAP: bathypelagic. Years of sampling: Sex: F: females, M: males, C: combined sexes. N: number of specimens examined; Lmax: maximum length (cm); tm: age at maturity (y); tmax: maximum reported age (y); the tm/tmax ratio. Nomenclature based on FishBase. Italicized Lmax and tmax values were taken from FishBase (Froese & Pauly, 2014).

| No | CLASS/Order/Family | Species | Location | Habitat | Year | Sex | N  | Lmax | tm  | tmax | tm/tmax | Reference |
|----|---------------------|---------|----------|---------|------|-----|----|------|-----|------|---------|-----------|
| 1  | ACTINOPTERYGII      | Chlorophthalmidae | Chlorophthalmus agassizi | Ionian Sea | BAD | F   | 3342 | 19.2 | 3.0  | 8     | 0.38     | D'Onglia et al. (2006) |
| 2  | Synodontidae        | Saurida undosquamis | Levantine Sea | R     | 1999-2000 | F   | 234 | 30.0 | 1.0  | 8     | 0.13     |  |
| 3  |                | Saurida undosquamis | Levantine Sea | R     | 1999-2000 | M   | 368 | 29.0 | 1.0  | 7     | 0.14     |  |
| 4  | Beloniformes        | Belone belone | Aegean Sea | P     | 1997 | F   | 240 | 57.5 | 2.0  | 8     | 0.25     | Uckun et al. (2004) |
| 5  | Clupeiformes        | Sardina pilchardus | Aegean Sea | P     | 1993-1996 | C   | 1271 | 15.6 | 1.0  | 4     | 0.25     | Akyol et al. (1996) |
| 6  |                | Sardina pilchardus | Aegean Sea | P     | 19.5 | F   | 500 | 24.8 | 1.0  | 5     | 0.25     | Mouhoub (1986) |
| 7  |                | Sardina pilchardus | Aegean Sea | P     | 17.5 | M   | 500 | 24.3 | 1.3  | 5     | 0.27     | Mouhoub (1986) |
| 8  |                | Sardina pilchardus | Aegean Sea | P     | 2000-2002 | F   | 2849 | 17.3 | 1.0  | 4     | 0.25     | Tsikliras & Koutrakis (2013) |
| 9  |                | Sardina pilchardus | Aegean Sea | P     | 2000-2002 | M   | 1993 | 16.2 | 0.9  | 4     | 0.22     | Tsikliras & Koutrakis (2013) |
| 10 |                | Sardinella aurita | Aegean Sea | P     | 2000-2002 | F   | 500 | 24.8 | 1.0  | 5     | 0.25     | Tsikliras & Antonopoulou (2006) |
| 11 |                | Sardinella aurita | Aegean Sea | P     | 2000-2002 | M   | 500 | 24.3 | 1.3  | 5     | 0.27     | Tsikliras & Antonopoulou (2006) |
| 12 |                | Sardinella aurita | Aegean Sea | P     | 2000-2002 | C   | 1271 | 15.6 | 1.0  | 4     | 0.25     | Tsikliras & Antonopoulou (2006) |
| 13 |                | Dussumieriidae | Etrumeus sadina | Alexandria coast | P     | 2008 | F   | 656 | 25.0 | 1.0  | 3     | 0.67     | Osman et al. (2011) |
| 14 |                | Etrumeus sadina | Alexandria coast | P     | 2008 | M   | 656 | 25.0 | 1.0  | 3     | 0.67     | Osman et al. (2011) |
| 15 |                | Engraulidae | Engraulis encrasicolus | Bay of Cadiz | P     | 1989 | F   | 757 | 18.0 | 1.0  | 4     | 0.25     | Millán (1999) |
| 16 |                | Engraulis encrasicolus | Bay of Cadiz | P     | 1990 | F   | 1326 | 18.0 | 1.0  | 4     | 0.25     | Millán (1999) |
| 17 |                | Engraulis encrasicolus | Bay of Cadiz | P     | 1991 | F   | 469 | 18.0 | 1.0  | 4     | 0.25     | Millán (1999) |
| 18 |                | Engraulis encrasicolus | Bay of Cadiz | P     | 1992 | F   | 500 | 18.0 | 1.0  | 4     | 0.25     | Millán (1999) |
| 19 |                | Engraulis encrasicolus | Bay of Cadiz | P     | 1989 | M   | 751 | 18.0 | 1.0  | 4     | 0.25     | Millán (1999) |
| 20 |                | Engraulis encrasicolus | Bay of Cadiz | P     | 1990 | M   | 1181 | 18.0 | 1.0  | 4     | 0.25     | Millán (1999) |
| 21 |                | Engraulis encrasicolus | Bay of Cadiz | P     | 1991 | M   | 564 | 18.0 | 1.0  | 4     | 0.25     | Millán (1999) |
| 22 |                | Engraulis encrasicolus | Bay of Cadiz | P     | 1992 | M   | 612 | 18.0 | 1.0  | 4     | 0.25     | Millán (1999) |
| 23 |                | Engraulis encrasicolus | Bay of Cadiz | C     | 19.0 | F+M | 500 | 24.8 | 1.0  | 5     | 0.21     | Bouaziz & Benoufi (2004) |
| 24 | Gadidae           | Micromesistius poutassou | Adriatic Sea | BAP  | 1986-1988 | C   | 320 | 3.0  | 1.0  | 8     | 0.13     | Fogliano & Granito (1981) |
| 25 |                | Trisopterus capelanus | Aegean Sea | BAP  | 1995 | F+M | 1502 | 25.0 | 2.0  | 5     | 0.25     | Politou & Papaconstantinou (1995) |
| 26 |                | Trisopterus capelanus | Aegean Sea | BAP  | 1995 | F+M | 1011 | 25.0 | 2.0  | 5     | 0.25     | Politou & Papaconstantinou (1995) |
| 27 |                | Trisopterus capelanus | Aegean Sea | BAP  | 1996 | F+M | 887 | 25.0 | 2.0  | 5     | 0.20     | Fogliano & Granito (1995) |
| 28 |                | Micromesistius poutassou | Adriatic Sea | BAP  | 1995-1998 | C   | 423 | 66.0 | 2.0  | 4     | 0.50     | Zobal (2001) |

(continued)
| No | CLASS/Order/Family | Species                  | Location        | Habitat | Year         | Sex | N    | $t_{max}$ | $t_n$ | $t_{max}$ | $t_n$ | Reference                          |
|----|--------------------|--------------------------|-----------------|---------|--------------|-----|------|-----------|-------|-----------|-------|------------------------------------|
| 29 | Merluccius merluccius | Algerian coast           | D               | F       | 73           |     | 65.5 | 2.9       | 9     | 0.32      |       | Bouaziz et al. (2001)              |
| 30 | Merluccius merluccius | -                        | D               | F       | 955          |     | 68.0 | 2.7       | 9     | 0.30      |       | Garcia-Rodriguez & Esteban (1995) |
| 31 | Merluccius merluccius | -                        | D               | M       | 502          |     | 52.5 | 2.2       | 7     | 0.31      |       | Garcia-Rodriguez & Esteban (1995) |
| 32 | Merluccius merluccius | Gulf of Lions            | D               | F       | 308          |     | 50.0 | 3.5       | 8     | 0.44      |       | Recasens et al. (1998)            |
| 33 | Merluccius merluccius | Gulf of Lions            | D               | M       | 619          |     | 42.0 | 3.0       | 8     | 0.38      |       | Recasens et al. (1998)            |
| 34 | Merluccius merluccius | Libyan coast             | D               | F       | 81           |     | 44.0 | 4.0       | 9     | 0.44      |       | Mugahid & Hashem (1982)           |
| 35 | Merluccius merluccius | Libyan coast             | D               | M       | 198          |     | 41.0 | 4.0       | 9     | 0.44      |       | Mugahid & Hashem (1982)           |
| 36 | Merluccius merluccius | Balearic Sea             | D               | F       | 955          |     | 68.0 | 2.0       | 7     | 0.29      |       | Garcia-Rodriguez & Esteban (1995) |
| 37 | Merluccius merluccius | Balearic Sea             | D               | M       | 502          |     | 52.5 | 2.0       | 7     | 0.29      |       | Garcia-Rodriguez & Esteban (1995) |
| 38 | Merluccius merluccius | Algerian coast           | D               | F       |              |     | 60.0 | 3.0       | 8     | 0.38      |       | Bouaziz et al. (1998)            |
| 39 | Merluccius merluccius | Algerian coast           | D               | M       |              |     | 60.0 | 2.0       | 8     | 0.25      |       | Bouaziz et al. (1998)            |

**Mugiliformes**

| No | CLASS/Order/Family | Species                  | Location       | Habitat | Year         | Sex | N    | $t_{max}$ | $t_n$ | $t_{max}$ | $t_n$ | Reference                          |
|----|--------------------|--------------------------|----------------|---------|--------------|-----|------|-----------|-------|-----------|-------|------------------------------------|
| 40 | Mugilidae          | Liza aurata              | Ionian Sea     | P       | 1992-1994    | F   | 393  | 50.0     | 1.8   | 3         | 0.61  | Hotos (1999)                       |
| 41 | Mugilidae          | Liza aurata              | Ionian Sea     | P       | 1992-1994    | M   | 312  | 50.0     | 2.1   | 3         | 0.70  | Hotos (1999)                       |
| 42 | Mugilidae          | Liza haematocheila       | Aegean Sea     | P       | 2003-2009    | C   | 32   | 74.4     | 5.0   | 15        | 0.33  | Minos et al. (2010)                |
| 43 | Mugilidae          | Liza haematocheila       | Black Sea      | D       | 1995         | F   | 87   | 66.7     | 3.0   | 15        | 0.20  | Okumus & Bascan (1997)             |
| 44 | Mugilidae          | Liza haematocheila       | Black Sea      | D       | 1995         | M   | 79   | 66.7     | 2.0   | 15        | 0.13  | Okumus & Bascan (1997)             |
| 45 | Mugilidae          | Liza ramada              | Aegean Sea     | P       | 1989-1990    | F   | 39   | 38.6     | 3.0   | 10        | 0.30  | Koutrakis (1994)                   |
| 46 | Mugilidae          | Liza ramada              | Ionian Sea     | P       | 1990-1995    | F   | 80   | 54.8     | 3.0   | 10        | 0.30  | Minos (1996)                       |
| 47 | Mugilidae          | Liza ramada              | Ionian Sea     | P       | 1990-1995    | M   | 64   | 42.0     | 3.0   | 10        | 0.30  | Minos (1996)                       |
| 48 | Mugilidae          | Liza ramada              | Levantine Sea  | P       | 1992-1994    | F   | 114  | 36.9     | 3.0   | 10        | 0.30  | Ergene (2000)                      |
| 49 | Mugilidae          | Liza ramada              | Levantine Sea  | P       | 1992-1994    | M   | 87   | 36.9     | 3.0   | 10        | 0.30  | Ergene (2000)                      |
| 50 | Mugilidae          | Liza saliens             | Aegean Sea     | D       | 1989-1990    | F   | 123  | 30.5     | 3.0   | 4         | 0.75  | Koutrakis (1994)                   |
| 51 | Mugilidae          | Liza saliens             | Aegean Sea     | D       | 1989-1990    | M   | 55   | 30.5     | 3.0   | 4         | 0.75  | Koutrakis (1994)                   |
| 52 | Mugilidae          | Liza saliens             | Ionian Sea     | D       | 1991-1995    | F   | 217  | 30.0     | 2.9   | 4         | 0.73  | Katselis (1996)                    |
| 53 | Mugilidae          | Liza saliens             | Ionian Sea     | D       | 1991-1995    | M   | 272  | 24.0     | 2.1   | 4         | 0.52  | Katselis (1996)                    |

**Perciformes**

| No | CLASS/Order/Family | Species                  | Location        | Habitat | Year         | Sex | N    | $t_{max}$ | $t_n$ | $t_{max}$ | $t_n$ | Reference                          |
|----|--------------------|--------------------------|-----------------|---------|--------------|-----|------|-----------|-------|-----------|-------|------------------------------------|
| 54 | Apogonidae         | Apogon imberbis          | NW Mediterranean | R       | 1998-1999    | F   | 122  | 12.1     | 1.0   | 5         | 0.20  | Klein & Raventos (2007)            |
| 55 | Apogonidae         | Apogon imberbis          | NW Mediterranean | R       | 1998-1999    | M   | 127  | 12.1     | 1.0   | 5         | 0.20  | Klein & Raventos (2007)            |
| 56 | Blednidae          | Parablennius ruber       | D               |         |              |     | 14.1 | 1.0       | 3     | 0.40      |       | Azevedo & Homem (2002)            |
| 57 | Carangidae         | Caranx cryosus           | Gulf of Gabes   | R       | 2004-2006    | F   | 777  | 41.4     | 2.8   | 11        | 0.25  | Sley et al. (2012)                |
| 58 | Carangidae         | Caranx cryosus           | Gulf of Gabes   | R       | 2004-2006    | M   | 891  | 41.6     | 2.4   | 11        | 0.22  | Sley et al. (2012)                |
| 59 | Seriola dumerili   | Seriola dumerili         | S Mediterranean | R       | 1990-1992    | F   | 211  | 150.0    | 4.0   | 15        | 0.27  | Minno et al. (1995)               |
| 60 | Seriola dumerili   | Seriola dumerili         | S Mediterranean | R       | 1990-1992    | M   | 205  | 150.0    | 3.5   | 15        | 0.23  | Minno et al. (1995)               |
| 61 | Trachurus mediterraneus | Trachurus mediterraneus | Aegean Sea     | P       | 1989-1991    | F   | 369  | 39.3     | 1.4   | 10        | 0.14  | Karlou-Riga (1995)                |

(continued)
| No | CLASS/Order/Family | Species | Location | Habitat | Year       | Sex | N   | L<sub>max</sub> | t<sub>m</sub> | t<sub>max</sub> | L<sub>m</sub>/L<sub>max</sub> | Reference |
|----|-------------------|---------|----------|---------|------------|-----|-----|---------------|---------|-----------|-------------------------|-----------|
| 62 |                  | Trachurus trachurus | Aegian Sea | P | 1989-1991 | F | 595 | 33.9 | 2.6 | 10 | 0.26 | Karlou-Riga (1995) |
| 63 |                  | Trachurus trachurus | Adriatic Sea | P | 1986 | F | 154 | 32.0 | 2.1 | 10 | 0.21 | Alegria (1990) |
| 64 |                  | Trachurus trachurus | Adriatic Sea | P | 1986 | M | 150 | 32.0 | 2.6 | 10 | 0.26 | Alegria (1990) |
| 65 |                  | Trachurus trachurus | Adriatic Sea | P | 1987 | F | 134 | 32.0 | 2.7 | 10 | 0.27 | Alegria (1990) |
| 66 |                  | Trachurus trachurus | Adriatic Sea | P | 1987 | M | 155 | 32.0 | 2.8 | 10 | 0.28 | Alegria (1990) |
| 67 |                  | Trachurus trachurus | Adriatic Sea | P | 1988 | F | 201 | 32.0 | 2.5 | 10 | 0.25 | Alegria (1990) |
| 68 |                  | Trachurus trachurus | Adriatic Sea | P | 1988 | M | 180 | 32.0 | 2.7 | 10 | 0.27 | Alegria (1990) |
| 69 |                  | Trachurus trachurus |         | P |       | F | 27.5 | 1.0 | 10 | 0.10 | Koriichi (1988) |
| 70 |                  | Trachurus trachurus |         | P |       | M | 27.5 | 1.0 | 10 | 0.10 | Koriichi (1988) |
| 71 |                  | Trachurus trachurus | Balearic Sea | P | 2001 | F | 33 | 22.0 | 2.0 | 10 | 0.20 | Abaunza et al. (2003) |
| 72 |                  | Trachurus trachurus | Balearic Sea | P | 2001 | M | 67 | 22.0 | 2.0 | 10 | 0.20 | Abaunza et al. (2003) |
| 73 |                  | Trachurus trachurus | Ionian Sea | P | 2001 | F | 43 | 37.0 | 1.9 | 10 | 0.19 | Abaunza et al. (2003) |
| 74 |                  | Trachurus trachurus | Ionian Sea | P | 2001 | M | 41 | 43.0 | 2.7 | 10 | 0.27 | Abaunza et al. (2003) |
| 75 |                  | Trachurus trachurus | Aegian Sea | P | 2001 | F | 85 | 34.0 | 2.6 | 10 | 0.26 | Abaunza et al. (2003) |
| 76 |                  | Trachurus trachurus | Aegian Sea | P | 2001 | M | 67 | 37.0 | 0.9 | 10 | 0.09 | Abaunza et al. (2003) |
| 77 |                  | Trachurus trachurus | Alboran Sea | P | 2001 | F | 29 | 39.0 | 1.8 | 10 | 0.18 | Abaunza et al. (2003) |
| 78 |                  | Trachurus trachurus | Alboran Sea | P | 2001 | M | 60 | 37.0 | 1.8 | 10 | 0.18 | Abaunza et al. (2003) |
| 79 | Centracanthidae   | Spicara flexuosa | Ionian Sea | P | 1984-1985 | F | 1870 | 14.7 | 1.0 | 5 | 0.20 | Mytilineou (1988) |
| 80 | Spicara flexuosa  | Ionian Sea | P | 1984-1985 | M | 885 | 16.8 | 1.0 | 5 | 0.20 | Mytilineou (1988) |
| 81 | Spicara maena     | Aegian Sea | P | 2004-2007 | F | 1766 | 20.0 | 2.0 | 5 | 0.40 | Soykan et al. (2010) |
| 82 | Spicara maena     | Aegian Sea | P | 2004-2007 | M | 398 | 20.0 | 2.0 | 5 | 0.40 | Soykan et al. (2010) |
| 83 | Cepolidae         | Cepola macrpphalma | Aegian Sea | D | 1986-1988 | F | 1763 | 40.0 | 1.9 | 5 | 0.38 | Stergiou et al. (1996) |
| 84 | Cepola macrpphalma | Aegian Sea | D | 1986-1988 | M | 1588 | 60.0 | 2.6 | 6 | 0.43 | Stergiou et al. (1996) |
| 85 | Gobiidae          | Aphro minuta | Balearic Sea | P | 1985-1993 | F | 168 | 4.4 | 0.7 | 1 | 0.70 | Iglesias & Morales-Nin (2001) |
| 86 | Aphro minuta      | Balearic Sea | P | 1985-1993 | M | 182 | 4.0 | 0.6 | 1 | 0.60 | Iglesias & Morales-Nin (2001) |
| 87 | Crystalllogobius linearis | Adriatic Sea | D | 1996 | F | 114 | 3.3 | 0.4 | 1 | 0.42 | La Mesa (2001) |
| 88 | Crystalllogobius linearis | Adriatic Sea | D | 1996 | M | 100 | 4.1 | 0.4 | 1 | 0.42 | La Mesa (2001) |
| 89 | Deltentosteus quadrimaculatus | Aegian Sea | D | 2004-2007 | F | 527 | 9.2 | 2.0 | 5 | 0.40 | Metin et al. (2011b) |
| 90 | Deltentosteus quadrimaculatus | Aegian Sea | D | 2004-2007 | M | 470 | 9.2 | 2.0 | 5 | 0.40 | Metin et al. (2011b) |
| 91 | Gobius vitatus     | Adriatic Sea | D | 2001-2002 | F | 402 | 5.4 | 0.8 | 2 | 0.35 | Kovicic (2007) |
| 92 | Gobius vitatus     | Adriatic Sea | D | 2001-2002 | M | 302 | 5.3 | 0.8 | 2 | 0.35 | Kovicic (2007) |
| 93 | Pomatoschistus marmoratus | Suez Canal | D | 1986-1987 | F | 311 | 5.6 | 1.0 | 2 | 0.50 | Fouda et al. (1993) |
| 94 | Pomatoschistus marmoratus | Suez Canal | D | 1986-1987 | M | 115 | 5.6 | 1.0 | 2 | 0.50 | Fouda et al. (1993) |
| 95 | Pomatoschistus microps | Mauguiro Lagoon | D | 1985-1989 | C | 7363 | 4.7 | 0.3 | 2 | 0.15 | Bouchereau et al. (1993) |
| 96 | Silhouetsea aegyptia | Suez Canal | D | 1986-1987 | F | 300 | 5.2 | 1.0 | 2 | 0.50 | Fouda et al. (1993) |
| 97 | Silhouetsea aegyptia | Suez Canal | D | 1986-1987 | M | 178 | 5.2 | 1.0 | 2 | 0.50 | Fouda et al. (1993) |

(continued)
| No | CLASS/Order/Family | Species | Location | Habitat | Year | Sex | N  | \( t_{\text{max}} \) | \( t_{\text{min}} \) | \( t_{\text{max}} \) | \( t_{\text{min}} / t_{\text{max}} \) | Reference |
|----|-------------------|---------|----------|---------|------|-----|----|-----------------|--------------|-----------------|-------------------|-----------|
| 98 | Mullidae           | Mullus surmuletus | Mediterranean coast | D | 2001 | F | 171 | 20.0 | 0.9 | 5 | 0.18 | Franco et al. (2012) |
| 99 | Moronidae         | Dicentrarchus labrax | Gulf of Annaba | D | 1990-1991 | F | 300 | 60.0 | 3.0 | 15 | 0.20 | Kara (1997) |
| 100| Dicentrarchus labrax | Gulf of Annaba | D | 1990-1991 | M | 227 | 60.0 | 2.0 | 15 | 0.13 | Kara (1997) |
| 101| Dicentrarchus labrax | Tunisian coast | D | 1973-1975 | F | 56.0 | 4.5 | 15 | 0.30 | Quignard et al. (1978) |
| 102| Dicentrarchus labrax | Tunisian coast | D | 1973-1975 | M | 56.0 | 2.5 | 15 | 0.17 | Quignard et al. (1978) |
| 103| Dicentrarchus labrax | Alexandria coast | D | 1981-1982 | F | 467 | 67.0 | 4.0 | 15 | 0.27 | Wassef & El Emary (1989) |
| 104| Dicentrarchus labrax | Alexandria coast | D | 1981-1982 | M | 232 | 44.4 | 2.0 | 15 | 0.13 | Wassef & El Emary (1989) |
| 105| Mullidae           | Mullus barbatus barbatus | Mediterranean coast | D | 1995-1998 | C | 104 | 24.9 | 1.9 | 7 | 0.29 | Zoubi (2001) |
| 106| Mullus surmuletus | Mediterranean coast | D | 2009 | F | 179 | 30.0 | 2.0 | 6 | 0.33 | Lamrini (2010) |
| 107| Mullus surmuletus | Mediterranean coast | D | 2009 | M | 113 | 29.0 | 2.0 | 5 | 0.40 | Lamrini (2010) |
| 108| Mullus surmuletus | Mediterranean coast | D | 2007-2008 | C | 1385 | 28.0 | 1.4 | 6 | 0.25 | Mehanna (2009) |
| 109| Mullus surmuletus | Aegean Sea | D | 1991-1992 | F | 157 | 29.9 | 2.0 | 6 | 0.33 | Vassilopoulou & Papaconstantinou (1995) |
| 110| Mullus surmuletus | Aegean Sea | D | 1991-1992 | M | 245 | 26.4 | 1.0 | 5 | 0.20 | Vassilopoulou & Papaconstantinou (1995) |
| 111| Mullus surmuletus | Aegean Sea | D | 1990-1992 | F | 32.0 | 1.0 | 6 | 0.17 | Remones et al. (1995) |
| 112| Mullus surmuletus | Balaeric Sea | D | 1990-1992 | M | 32.0 | 1.0 | 5 | 0.20 | Remones et al. (1995) |
| 113| Upeneus moluccensis | Levantine Sea | R | 2002-2003 | F | 343 | 21.1 | 1.0 | 5 | 0.20 | Ozvarol et al. (2010) |
| 114| Upeneus moluccensis | Levantine Sea | R | 2002-2003 | M | 121 | 16.4 | 1.0 | 5 | 0.20 | Ozvarol et al. (2010) |
| 115| Upeneus pori | Levantine Sea | D | 1999-2000 | F | 324 | 17.0 | 1.0 | 5 | 0.20 | Ismen (2006) |
| 116| Upeneus pori | Levantine Sea | D | 1999-2000 | M | 292 | 15.1 | 1.0 | 5 | 0.20 | Ismen (2006) |
| 117| Polyprionidae      | Polyprion americanus | Ionian Sea | D | 1995-1996 | F | 127 | 59.2 | 2.6 | 21 | 0.12 | Chakroun-Marzouk & Kiari (2003) |
| 118| Pomatomidae       | Pomatomus saltatrix | Gulf of Gabès | P | 1998-2000 | F | 34.5 | 1.9 | 9 | 0.21 | Dhib et al. (2006) |
| 119| Pomatomidae       | Pomatomus saltatrix | Gulf of Gabès | P | 1998-2000 | M | 288 | 34.5 | 2.4 | 9 | 0.27 | Dhib et al. (2006) |
| 120| Scaridae           | Sperisomia cretensis | Aegian Sea | R | 1985-1986 | F | 157 | 32.5 | 1.0 | 8 | 0.13 | Papaconstantinou et al. (1988) |
| 121| Scombrids          | Scombrids | P | 2005-2006 | C | 694 | 71.0 | 1.0 | 4 | 0.25 | Ates et al. (2008) |
| 122| Serranidae         | Epinephelus marginatus | Algerian coast | R | 1994-1996 | F | 219 | 119.0 | 5.0 | 50 | 0.10 | Marino et al. (2001) |
| 123| Serranidae         | Epinephelus marginatus | Balaeric Sea | R | 1994-1996 | M | 59 | 129.0 | 12.0 | 50 | 0.24 | Marino et al. (2001) |

(continued)
| No | CLASS/Order/Family | Species | Location | Habitat | Year | Sex | N   | L_{\text{max}} | t_{m} | t_{\text{max}} | L_{m}/t_{\text{max}} | Reference |
|----|-------------------|---------|----------|---------|------|-----|-----|-------------|------|-------------|----------------|-----------|
| 134 | Sparidae          | Serranus hepatus | Adriatic Sea | D | 2002-2003 | C | 1218 | 9.0 | 2.0 | 7 | 0.29 | Dulcie et al. (2007) |
| 135 |                  | Boops boops    | Mediterranean coast | D | 1995-1998 | C | 110  | 25.6 | 1.4 | 5 | 0.29 | Zoubi (2001) |
| 136 |                  | Boops boops    | Adriatic Sea | D | 1957-1958 | F | 335  | 23.0 | 2.0 | 5 | 0.40 | Alegria-Hernández (1990) |
| 137 |                  | Boops boops    | Adriatic Sea | D | 1957-1958 | M | 440  | 20.0 | 1.5 | 5 | 0.30 | Alegria-Hernández (1990) |
| 138 |                  | Boops boops    | Algerian coast | D |       | F |      | 23.5 | 2.0 | 5 | 0.40 | Chali-Chabane (1988) |
| 139 |                  | Boops boops    | Cretan Sea | D | 1988-1990 | F | 778  | 18.0 | 1.0 | 5 | 0.20 | Kallianiotis (1992) |
| 140 |                  | Boops boops    | Cretan Sea | D | 1988-1990 | M | 597  | 18.0 | 1.0 | 5 | 0.20 | Kallianiotis (1992) |
| 141 |                  | Boops boops    | Cretan Sea | D | 1988-1990 | F | 695  | 18.0 | 1.0 | 5 | 0.20 | Kallianiotis (1992) |
| 142 |                  | Boops boops    | Cretan Sea | D | 1988-1990 | M | 456  | 18.0 | 1.0 | 5 | 0.20 | Kallianiotis (1992) |
| 143 |                  | Dentex dentex | Balaeic Sea | BEP | 1993-1995 | F | 210  | 80.0 | 2.2 | 28 | 0.08 | Morales-Nin & Moranta (1997) |
| 144 |                  | Dentex dentex | Balaeic Sea | BEP | 1993-1995 | M | 75.0 | 6.7 | 28 | 0.24 | Morales-Nin & Moranta (1997) |
| 145 |                  | Diplodus annularis | Adriatic Sea | BEP | 2000-2002 | F | 745  | 23.0 | 2.6 | 13 | 0.20 | Matić-Skoko et al. (2007) |
| 146 |                  | Diplodus annularis | Adriatic Sea | BEP | 2000-2002 | M | 780  | 20.0 | 2.1 | 13 | 0.16 | Matić-Skoko et al. (2007) |
| 147 |                  | Diplodus sargus sargus | Gulf of Tunis | D | 2002-2004 | F | 108  | 37.2 | 4.0 | 10 | 0.40 | Mouine et al. (2007) |
| 148 |                  | Diplodus sargus sargus | Gulf of Tunis | D | 2002-2004 | M | 37   | 30.0 | 4.0 | 10 | 0.40 | Mouine et al. (2007) |
| 149 |                  | Diplodus sargus sargus | Algerian coast | D |       | F | 98   | 34.6 | 4.0 | 10 | 0.40 | Benchalel & Kara (2010) |
| 150 |                  | Diplodus sargus sargus | Algerian coast | D |       | M | 143  | 34.6 | 4.0 | 10 | 0.40 | Benchalel & Kara (2010) |
| 151 |                  | Diplodus sargus sargus | Algerian coast | D | 2005-2006 | F | 98   | 34.6 | 4.0 | 10 | 0.40 | Benchalel & Kara (2013) |
| 152 |                  | Diplodus sargus sargus | Algerian coast | D | 2005-2006 | M | 143  | 24.0 | 4.0 | 10 | 0.40 | Benchalel & Kara (2013) |
| 153 |                  | Diplodus vulgaris | Sicilian Channel | BEP | 1997-1999 | F | 235  | 30.0 | 1.5 | 7 | 0.21 | Beltrano et al. (2003) |
| 154 |                  | Diplodus vulgaris | Sicilian Channel | BEP | 1997-1999 | M | 209  | 30.0 | 2.0 | 7 | 0.29 | Beltrano et al. (2003) |
| 155 |                  | Diplodus vulgaris | Syrian coast | BEP | 1999-2001 | F | 30.0 | 2.0 | 7 | 0.29 | Hammond & Saad (2007) |
| 156 |                  | Diplodus vulgaris | Syrian coast | BEP | 1999-2001 | M | 30.0 | 2.0 | 7 | 0.29 | Hammond & Saad (2007) |
| 157 |                  | Lithognathus mormyrus | Levantine Sea | D | 1998-1999 | F | 1612 | 27.7 | 2.0 | 12 | 0.16 | Türkmen & Akyurt (2003) |
| 158 |                  | Lithognathus mormyrus | Levantine Sea | D | 1998-1999 | M | 1626 | 22.8 | 1.7 | 12 | 0.14 | Türkmen & Akyurt (2003) |
| 159 |                  | Lithognathus mormyrus | Sicilian Channel | D | 1997-1998 | F | 221  | 34.0 | 1.7 | 12 | 0.14 | Vitale et al. (2003, 2011) |
| 160 |                  | Lithognathus mormyrus | Sicilian Channel | D | 1997-1998 | M | 230  | 34.0 | 1.7 | 12 | 0.14 | Vitale et al. (2003, 2011) |
| 161 |                  | Lithognathus mormyrus | Sicilian Channel | D | 1997-1998 | F | 142  | 35.0 | 1.6 | 12 | 0.13 | Vitale et al. (2003, 2011) |
| 162 |                  | Lithognathus mormyrus | Sicilian Channel | D | 1997-1998 | M | 188  | 35.0 | 1.6 | 12 | 0.13 | Vitale et al. (2003, 2011) |
| 163 |                  | Lithognathus mormyrus | Aegean Sea | D | 1997-1999 | F | 821  | 34.1 | 3.6 | 12 | 0.30 | Kallianiotis et al. (2005) |
| 164 |                  | Lithognathus mormyrus | Aegean Sea | D | 1997-1999 | M | 477  | 28.8 | 2.5 | 12 | 0.21 | Kallianiotis et al. (2005) |
| 165 |                  | Pagellus acarne | Mediterranean coast | BEP | 1995-1998 | C | 101  | 25.5 | 1.9 | 8 | 0.23 | Zoubi (2001) |
| 166 |                  | Pagellus erythrinus | Cretan Sea | BEP | 1988-1991 | F | 27.1 | 1.8 | 6 | 0.30 | Somarakis & Machias (2002) |
| 167 |                  | Pagellus erythrinus | Cretan Sea | BEP | 1988-1991 | M | 27.1 | 2.0 | 7 | 0.29 | Somarakis & Machias (2002) |
| 168 |                  | Pagellus erythrinus | Gulf of Alger | BEP |       | F | 36.5 | 1.0 | 6 | 0.17 | Cherabi (1987) |
| 169 |                  | Pagellus erythrinus | Aegean Sea | BEP | 2002-2007 | F | 1717 | 24.9 | 2.0 | 7 | 0.29 | Metin et al. (2011a) |
| No | CLASS/Order/Family | Species                          | Location            | Habitat     | Year   | Sex | N  | L<sub>max</sub> | H<sub>n</sub> | t<sub>max</sub> | L<sub>max</sub>/H<sub>n</sub> | Reference                  |
|----|-------------------|----------------------------------|---------------------|-------------|--------|-----|----|----------------|----------|------------|----------------|-----------------------------|
| 170| Xiphiidae         | Pagellus erythrinus              | Aegean Sea          | BEP         | 2002-2007 | M   | 136 | 27.8           | 3.0      | 7          | 0.43            | Metin et al. (2011a)        |
| 171| Sarpa salpa       | Adriatic Sea                     | BEP                 | 2004        | M       | 601 | 36.8 | 2.0            | 15       | 0.13       |                      | Pallaoro et al. (2008)      |
| 172| Spondylusoma cantharus | Gulf of Tunis                  | BEP                 | 2005-2006   | F       | 330 | 31.6 | 4.0            | 13       | 0.31       |                      | Mouine et al. (2011)        |
| 173| Sphyraenidae      | Sphyraena chrysotaenia           | Mediterranean coast  | P           | F       | 27.0| 1.0  | 8              | 0.13     |            |                      | Wadie et al. (1988)         |
| 174| Sphyraena chrysotaenia | Mediterranean coast              | P                  | M           | 27.0   |     |     |                |          | 0.13       |                      | Wadie et al. (1988)         |
| 175| Sphyraena chrysotaenia | Gulf of Gabes                  | P                  | 2003-2005   | F       | 432 | 28.3 | 2.0            | 8        | 0.25       |                      | Zouari-Ktari et al. (2009)  |
| 176| Sphyraena chrysotaenia | Gulf of Gabes                  | P                  | 2003-2005   | M       | 516 | 24.9 | 2.0            | 8        | 0.25       |                      | Zouari-Ktari et al. (2009)  |
| 177| Sphyraena phryrena | Mediterranean coast              | P                  | F           | 42.0   |     |     |                |          | 0.13       |                      | Wadie et al. (1988)         |
| 178| Sphyraena phryrena | Mediterranean coast              | P                  | M           | 42.0   |     |     |                |          | 0.13       |                      | Wadie et al. (1988)         |
| 179| Uranoscopus scaber | Tunisian coast                   | D                  | F           | 537    |     |     | 33.0           | 2.0      | 5          | 0.40            | Kartas & Bonda (1986)       |
| 180| Uranoscopus scaber | Tunisian coast                   | D                  | M           | 347    |     |     | 26.0           | 1.0      | 5          | 0.20            | Kartas & Bonda (1986)       |
| 181| Xiphias gladius   | Ligurian Sea                     | P                  | 1990-2001   | F       | 1847| 334.5| 4.0            | 10       | 0.40       |                      | Orsi Relini et al. (2003)   |

Pleuronectiformes

| 182| Scophthalmidae    | Lepidorhombus boscii             | Aegean Sea          | D           | 1990-1992 | F   | 1422| 29.5           | 2.0      | 13        | 0.15            | Vassilopoulos et al. (1997) |
| 183| Lepidorhombus boscii | Aegean Sea                  | D           | 1990-1992   | M       | 1009| 23.5| 1.0            | 11       | 0.09       |                      | Vassilopoulos et al. (1997) |
| 184| Soleidae           | Bathysolea profundiocola       | Sardinia           | BAP         | F       | 16.5| 2.9    | 12           |          | 0.24       |                      | Cau & Deiana (1983)         |
| 185| Bathysolea profundiocola | Sardinia              | BAP         | M           | 14.7   |     |     |                |          | 0.20       |                      | Cau & Deiana (1983)         |
| 186| Buglossidium luteum | Aegean Sea                     | D           | 2004-2007   | F       | 563 | 11.6 | 2.0            | 13       | 0.15       |                      | Ilkayaz et al. (2010)       |
| 187| Buglossidium luteum | Aegean Sea                     | D           | 2004-2007   | M       | 395 | 10.1 | 2.0            | 13       | 0.15       |                      | Ilkayaz et al. (2010)       |
| 188| Buglossidium luteum | Adriatic Sea                   | D           | C           | 3400   | 14.5| 1.0   | 13           | 0.08     |            |                      | Giovannardi & Piccinetti (1981) |
| 189| Microchirus azetzi | Algarve Coast                   | D           | 1998-1999   | F       | 623 | 37.6 | 2.9            | 8        | 0.36       |                      | Afonso-Dias et al. (2005)   |
| 190| Monochirus hispidus | Sardinia                  | D           | F           | 14.1   |     |     |                |          | 0.17       |                      | Cau & Deiana (1983)         |
| 191| Monochirus hispidus | Sardinia                  | D           | M           | 10.7   |     |     |                |          | 0.06       |                      | Cau & Deiana (1983)         |
| 192| Synapturichthys kleinii | Sardinia             | D           | F           | 39.5   |     |     | 3.6           | 9        | 0.40       |                      | Cau & Deiana (1983)         |
| 193| Synapturichthys kleinii | Sardinia             | D           | M           | 38.9   |     |     | 1.9           | 8        | 0.24       |                      | Cau & Deiana (1983)         |

Scorpaeniformes

| 194| Sebastidae        | Helicolenus dactylopterus       | Algerian coast     | BAD        | F       | 32.0| 4.0    | 40           | 0.10     |            |                      | Nouar (2003)                |
| 195| Helicolenus dactylopterus | Algerian coast     | BAD        | M           | 28.0   |     |     |                |          | 0.10       |                      | Nouar (2003)                |
| 196| Scorpaenidae      | Scorpaena elongata           | Sicilian channel   | D           | 1985-1998 | F   | 664 | 57.0           | 8.0      | 30         | 0.27            | Ragonese et al. (2003)      |
| 197| Scorpaena porcus  | Gulf of Gabes              | D           | F           | 540    |     |     | 22.9           | 3.0      | 10         | 0.30            | Bradi & Bouain (1991)       |
| 198| Scorpaena porcus  | Gulf of Gabes              | D           | M           | 684    |     |     | 20.8           | 3.0      | 10         | 0.30            | Bradi & Bouain (1991)       |
| 199| Scorpaena loppei  | Balearic Islands            | D           | 2005-2010   | F       | 85  | 12.8 | 1.0            | 5        | 0.20       |                      | Ordines et al. (2012)       |
| 200| Scorpaena loppei  | Balearic Islands            | D           | 2005-2010   | M       | 90  | 12.8 | 1.0            | 5        | 0.20       |                      | Ordines et al. (2012)       |
| 201| Triglidae         | Chelidonichthys cuculus     | Tyrrhenian Sea     | D           | 1994-1997 | F   | 27.0| 2.0            | 21       | 0.10       |                      | Colloca et al. (2003)       |
| 202| Chelidonichthys cuculus | Tyrrhenian Sea     | D           | 1994-1997   | M       | 27.0| 2.0  | 13           | 0.15     |            |                      | Colloca et al. (2003)       |
| 203| Chelidonichthys lucerna | Gulf of Gabes     | D           | 2003-2004   | F       | 195 | 36.0 | 3.0            | 15       | 0.20       |                      | Boudaya et al. (2008)       |

(continued)
| No. | CLASS/Order/Family | Species                  | Location         | Habitat | Year       | Sex | N  | L<sub>max</sub> | t<sub>m</sub> | t<sub>max</sub> | t<sub>m</sub> / t<sub>max</sub> | Reference               |
|-----|-------------------|--------------------------|------------------|---------|------------|-----|----|---------------|-------------|--------------|---------------------|-------------------------|
| 204 |                  | Chelidonichthys lucerna  | Gulf of Gabes    | D       | 2003-2004  | M   | 91 | 26.0         | 1.5         | 14           | 0.11                | Boudaya et al. (2008)   |
| 205 |                  | Chelidonichthys lucerna  | Iskenderun Bay   | D       | 1999-2000  | F   | 199| 30.3         | 2.0         | 15           | 0.13                | Ismen et al. (2004)     |
| 206 |                  | Chelidonichthys lucerna  | Iskenderun Bay   | D       | 1999-2000  | M   | 143| 21.2         | 2.0         | 14           | 0.14                | Ismen et al. (2004)     |
| 207 |                  | Chelidonichthys lucerna  | Marmara Sea      | D       | 1996-1997  | F   | 98 | 41.5         | 3.0         | 15           | 0.20                | Eryilmaz & Meric (2005) |
| 208 |                  | Chelidonichthys lucerna  | Marmara Sea      | D       | 1996-1997  | M   | 45 | 37.0         | 3.0         | 14           | 0.21                | Eryilmaz & Meric (2005) |
| 209 |                  | Lepidotrigla cavillone   | Aegean Sea       | D       | 1976-1978  | F   | 1429| 16.0        | 1.5         | 5            | 0.30                | Papaoconstantinou (1982) |
| 210 |                  | Lepidotrigla cavillone   | Tyrrhenian Sea   | D       | 1985-1995  | F   | 308| 14.0         | 2.0         | 5            | 0.40                | Colloca et al. (1997)   |
| 211 |                  | Lepidotrigla cavillone   | Tyrrhenian Sea   | D       | 1985-1995  | M   | 2196| 14.0         | 2.0         | 5            | 0.40                | Colloca et al. (1997)   |
| 212 |                  | Lepidotrigla cavillone   | Aegean Sea       | D       | 2004-2007  | F   | 824| 14.0         | 2.0         | 5            | 0.40                | Ilkyaz et al. (2010)    |
| 213 |                  | Lepidotrigla cavillone   | Aegean Sea       | D       | 2004-2007  | M   | 603| 15.0         | 2.0         | 5            | 0.40                | Ilkyaz et al. (2010)    |

Zeiformes

| No. | Species                  | Location         | Reference               |
|-----|--------------------------|------------------|-------------------------|
| 214 | Zeids                      | Aegean Sea       | Ismen et al. (2013)     |
| 215 | Zeus faber                 | Aegean Sea       | Ismen et al. (2013)     |

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Rajiformes

| No. | Species                  | Location         | Year       | Sex | N  | L<sub>max</sub> | t<sub>m</sub> | t<sub>max</sub> | t<sub>m</sub> / t<sub>max</sub> | Reference               |
|-----|--------------------------|------------------|------------|-----|----|---------------|-------------|--------------|---------------------|-------------------------|
| 216 | Dasyatis pastinaca        | Levantine Sea    | 1999-2000  | F   | 110| 88.0         | 4.5         | 10           | 0.45                | Ismen (2003b)           |
| 217 | Dasyatis pastinaca        | Levantine Sea    | 1999-2000  | M   | 146| 73.0         | 4.5         | 10           | 0.45                | Ismen (2003b)           |
| 218 | Dipoturus oxyrinchus       | Aegean Sea       | 2005-2007  | F   | 89 | 100.0        | 8.0         | 9            | 0.89                | Yigin & Ismen (2010)    |
| 219 | Dipoturus oxyrinchus       | Aegean Sea       | 2005-2007  | M   | 90 | 86.5         | 6.0         | 9            | 0.67                | Yigin & Ismen (2010)    |
| 220 | Rajia radula              | Gulf of Gabes    | 2007       | F   | 550| 80.0         | 5.9         | 12           | 0.49                | Kadri et al. (2013)     |
| 221 | Rajia radula              | Gulf of Gabes    | 2007       | M   | 400| 65.0         | 4.5         | 9            | 0.50                | Kadri et al. (2013)     |
| 222 | Rajia miraletus           | Gulf of Gabes    | 2007       | F   | 95 | 56.0         | 4.4         | 9            | 0.49                | Kadri et al. (2012)     |
| 223 | Rajia miraletus           | Gulf of Gabes    | 2007       | M   | 85 | 58.0         | 2.7         | 7            | 0.39                | Kadri et al. (2013)     |
| 224 | Rajia undulata            | Algarve Coast    | 1999-2000  | F   | 93 | 88.2         | 9.0         | 14           | 0.64                | Coelho & Erzini (2006)  |
| 225 | Rajia undulata            | Algarve Coast    | 1999-2000  | M   | 94 | 83.2         | 8.0         | 14           | 0.57                | Coelho & Erzini (2006)  |

Squaliformes

| No. | Species                  | Location         | Year       | Sex | N  | L<sub>max</sub> | t<sub>m</sub> | t<sub>max</sub> | t<sub>m</sub> / t<sub>max</sub> | Reference               |
|-----|--------------------------|------------------|------------|-----|----|---------------|-------------|--------------|---------------------|-------------------------|
| 228 | Squalus acanthias         | Black Sea        | BEP        | F   | 150.0| 12.0        | 38           | 0.32        | Demirhan & Seyhan (2007) |
| 229 | Squalus acanthias         | Black Sea        | BEP        | M   | 150.0| 10.5        | 38           | 0.28        | Demirhan & Seyhan (2007) |
| 230 | Squalus blainville        | Sicilian Channel | D          | 1985-1991 | F  | 812| 92.0         | 5.1         | 14           | 0.36                | Cannizzaro et al. (1995) |
| 231 | Squalus blainville        | Sicilian Channel | D          | 1985-1991 | M  | 1038| 73.5         | 3.3         | 13           | 0.25                | Cannizzaro et al. (1995) |
| 232 | Squalus blainville        | Gulf of Gabés    | D          | 2004-2005 | F  | 81 | 100.0        | 7.4         | 14           | 0.53                | Marouani et al. (2007, 2010) |
| 233 | Squalus blainville        | Gulf of Gabés    | D          | 2004-2005 | M  | 71 | 100.0        | 4.8         | 13           | 0.37                | Marouani et al. (2007, 2010) |

Carcharhiniformes

| No. | Species                  | Location         | Year       | Sex | N  | L<sub>max</sub> | t<sub>m</sub> | t<sub>max</sub> | t<sub>m</sub> / t<sub>max</sub> | Reference               |
|-----|--------------------------|------------------|------------|-----|----|---------------|-------------|--------------|---------------------|-------------------------|
| 234 | Prionace glauca          | E Mediterranean   | P          | 1998-2003 | F  | 178| 349         | 5.5         | 12           | 0.46                | Megalofonou et al. (2009) |
| 235 | Prionace glauca          | E Mediterranean   | P          | 1998-2003 | M  | 323| 330         | 4.9         | 12           | 0.41                | Megalofonou et al. (2009) |
Elasmobranchii log\(t_m\) = 0.67 x log\(t_{max}\) + 0.006, \(r^2 = 0.51\), \(P = 0.007\), \(n = 20\)

\((t_m = 0.23 x t_{max} + 2.72)\)

Mean \(t_m/t_{max}\) was not significantly different (ANOVA: \(F = 0.27\), \(P = 0.60\)) between female (mean ± SD = 0.276 ± 0.143, \(n = 90\)) and male (mean ± SD = 0.265 ± 0.138, \(n = 90\)) Actinopterygii (Fig. 3). Similarly, mean \(t_m/t_{max}\) was not significantly different (ANOVA: \(F = 1.44\), \(P = 0.25\)) between female (mean ± SD = 0.499 ± 0.166, \(n = 10\)) and male (mean ± SD = 0.418 ± 0.133, \(n = 10\)) Elasmobranchii (Fig. 3). Consequently, sexes were combined per class and mean \(t_m/t_{max}\) was then compared between classes. Mean \(t_m/t_{max}\) was significantly higher (ANOVA: \(F = 31.04\), \(P < 0.001\)) in Elasmobranchii (mean ± SD = 0.458 ± 0.152, \(n = 20\)) compared to Actinopterygii (mean ± SD = 0.270 ± 0.135, \(n = 180\)) (Fig. 4).

With respect to habitat, the mean \(t_m/t_{max}\) of Actinopterygii ranged between 0.06 and 0.43 for benthopelagic (BEP: mean ± SD = 0.22 ± 0.086, \(n = 23\)), between 0.06 and 0.75 for demersal (D: mean ± SD = 0.29 ± 0.142, \(n = 107\)), between 0.09 and 0.70 for pelagic (P: mean ± SD = 0.28 ± 0.143, \(n = 63\)), and between 0.10 and 0.27 for reef-associated stocks (R: mean ± SD = 0.19 ± 0.053, \(n = 16\)) (Fig. 5). Elasmobranchii (\(n = 20\)) as well as bathydemersal (BAD: \(n = 3\)) and bathypelagic (BAP: \(n = 3\)) actinopterygian stocks were excluded from this comparison because of their small sample size. Overall, mean \(t_m/t_{max}\) values were significantly different among the four habitat categories of Actinopterygii (ANOVA: \(F = 3.67\), \(P = 0.013\)). Based on Fisher’s LSD test, there were no differences in the means between benthopelagic and reef-associated (BEP and R), between benthopelagic and pelagic (BEP and P) and between demersal and pelagic (D and P) stocks, whereas reef-associated stocks, which had the lowest mean \(t_m/t_{max}\) differed significantly from demersal and pelagic ones (Fig. 5).

**Discussion**

The ranges of \(t_m\) values reported in the present work for Mediterranean marine fishes fall within the previously reported range of \(t_m\) values for actinopterygian and elasmobranch fishes. Actinopterygii generally mature earlier in life compared to Elasmobranchii (Goldman et al., 2015).
For the latter, \( t_m \) is variable, and has been reported to range from 2 to 26 y in 18 populations of 15 species (Chen & Yuan, 2006). The same range has been reported by Cailliet & Goldman (2004), with a bimodal distribution with one peak at 5–6 y and a second one at 15–25 y. Higher \( t_m \) values have been reported for long-lived elasmobranchs, such as the whale shark \( Rhincodon typus \) (> 22 y) and the picked dogfish \( Squalus acanthias \) (25–26 y) (Chen & Yuan, 2006; Dulvy et al., 2008). Similarly, for long-lived actinopterygians, such as the bluemouth rockfish \( Helicolenus dactylopterus \), ages at maturity higher than 15 y are known (Kelly et al., 1999). In their work, that reviewed the life history traits of 41 actinopterygian species, Drazen & Haedrich (2012) report that \( t_m \) ranges between 2 and 36 y, with six species having \( t_m \) that exceeds 20 y and five species having \( t_m \) that exceeds 100 y. A similar range of ages at maturity (0.5 to 35.5 y) has been reported by He & Stewart (2001) in their review of 235 fish stocks, including marine and freshwater finfishes, as well as a few elasmobranchs. It seems that, at least regarding elasmobranchs, and considering their small sample size in the present work, long-living, late-maturing sharks are rare in the Mediterranean Sea. Given that the larger elasmobranchs are more susceptible to overfishing (Dulvy et al., 2014), this under-representation may be due to their overexploitation that is known to occur in the Mediterranean (Stergiou & Tsikliras, 2011; Tsikliras et al., 2013b).

The positive relation between \( t_m \) and \( t_{max} \) (Fig. 2) confirms the general pattern that longer-lived species mature later and grow slower compared to their shorter-lived counterparts (Frisk, 2010). Indeed, elasmobranchs are located at the upper end of that spectrum (Fig. 2). A significant positive relation between longevity (\( t_{max} \)) and \( t_m \) has been reported previously for female and male batoids (females: \( t_m = 0.57 \cdot t_{max} + 1.02 \); males: \( t_m = 0.57 \cdot t_{max} + 0.47 \)) (Frisk, 2010). The empirical relation between \( t_m \) and \( t_{max} \) can be used for estimating \( t_m \) for species for which only \( t_{max} \) is known.

The dimensionless \( t_m/t_{max} \) ratio shows that actinopterygians mature very early, at around 1/3 of \( t_{max} \) within their lifespans. In contrast, elasmobranchs mature later, close to 1/2 of their \( t_{max} \). Similar results have been reported for several shark and skate stocks with this ratio being generally higher for skates than for other elasmobranch groups and teleosts generally (Frisk, 2010). In general, the onset of maturity may depend mainly on age for short-lived species that mature early, and mainly on size for their longer-lived, late-maturing counterparts, with developmental or genetic constraints more evident in longer lived species (Archibald et al., 1983; Roff, 1983). There are benefits and costs associated with reproducing early or late in life. Benefits associated with early maturity include increased probability of surviving to reproduce and reduced generation time, while the costs of early maturity include reduced survival and fecundity later in life (Roff, 1992). High adult mortality, as a result of fishing, may favour earlier maturation (Rochet, 1998). Such a cost of reproduction, i.e. a trade-off between present reproductive effort and future age-specific reproductive success, is evident across animals (Williams, 1966; Bell, 1980).

Although \( t_m \) might differ between sexes, the fact that, in the present work, we found no difference in the \( t_m/t_{max} \) ratio between males and females within both classes, may simply be attributed to the fact that \( t_m \) and \( t_{max} \) vary simultaneously and, within species, are determined by the corresponding growth and mortality patterns (e.g. Tsikliras et al., 2007; Gislason et al., 2010). For instance, a male that matures earlier will experience higher future mortalities and will have a shorter lifespan compared to a female that will mature later (e.g. Tsikliras & Koutrakis, 2013), i.e. age at maturity may co-vary with maximum age and, in the same way, size at maturity co-varies with asymptotic length (Beverton, 1992). Thus, the \( t_m/t_{max} \) ratio will remain the same and bi-maturism will be absent, as has been reported to occur for the length at maturity to maximum reported length (\( L_{m}/L_{max} \)) ratio (Tsikliras & Stergiou, 2014).

With the exception of reef-associated species, which exhibited the lowest \( t_m/t_{max} \) values, the \( t_m/t_{max} \) ratio of actinopterygians remained rather constant among the remaining habitat categories (Fig. 5) and had similar values with the overall \( t_m/t_{max} \) ratio for actinopterygians. A similar constancy among habitat categories has been reported for the \( L_{m}/L_{max} \) ratio of Mediterranean marine fishes (Tsikliras & Stergiou, 2014). Although there are several large-sized, long-lived, and late-maturing reef-associated species (e.g. groupers) in the Mediterranean Sea, in the
present dataset these species were rare in favour of small- and medium-sized reef inhabitants (Table 1). This might explain the lower $t_m$/$t_{max}$ ratio for reef-associated species. Drazen & Haedrich (2012) report that $t_m$ increases with depth but in our dataset there are no real deep-water species given that most of the species are commercial living on the continental shelf. Thus, we could not test this hypothesis. Besides deep-water species, special or complex cases of reproductive strategies, such as hermaphroditism and strategies involving spawning migrations were also rare in the dataset. Such strategies could also result in deviations from the general pattern that is presented here.

Finally, it should be noted that length at maturity and $t_m$ should be independently estimated in reproductive biology, instead of $t_m$ being indirectly estimated from the von Bertalanffy growth equation. This is because the growth trajectory may differ as a result of quicker or slower rates of approaching asymptotic lengths among individuals (He & Stewart, 2001). Hence, maturity can be reached at same length and different age and vice versa (Kozlowski, 1996).

References
Abuzaa, P., Gordo, L., Karlou-Riga, C., Murta, A., Eltink, A.T.G.W. et al., 2003. Growth and reproduction of horse mackerel, Trachurus trachurus (Carangidae). Reviews in Fish Biology and Fisheries, 13, 27-61.
Afonso-Dias, I., Reis, C., Andrade, J.P., 2005. Reproductive aspects of Microchirus azevia (Risso 1810) (Pisces: Soleidae) from the south coast of Portugal. Scientia Marina, 69, 275-283.
Ainsley, S.M., Ebert, D.A., Cailliet, G.M., 2011. Age, growth, and maturity of the whitebrow skate, Bathyura minispinosa, from the eastern Bering Sea. ICES Journal of Marine Science, 68, 1426-1434.
Akyol, O., Tokaç, A., Ünsal, S., 1996. An investigation on the growth and reproduction characteristics of the sardine (Sardina pilchardus) in the bay of Izmir (Aegean Sea). Turkish Journal of Fisheries and Aquatic Sciences, 13, 383-394
Alegria-Hernández, V., 1990. Some aspects of the reproductive biology of bogue (Boops boops L., Pisces, Sparidae) from the mid-Adriatic channels. Acta Adriatica, 31, 301-313.
Alegria, V., 1990. Size and age at first maturity in Horse mackerel (Trachurus trachurus L.) from the Adriatic Sea. Rapport du Congrès de la Commission Internationale pour l’Exploration Scientifique de la Mer Méditerranée, 32, 261.
Archibald, C.P., Fournier, D., Leaman, B.M., 1983. Reconstruction of stock history and development of rehabilitation strategies for Pacific ocean perch in Queen Charlotte Sound, Canada. North American Journal of Fisheries Management, 3, 283-294.
Ates, C., Cengiz-Deval, M., Bok, T., 2008. Age and growth of Atlantic bonito (Sardina sarda) in the Sea of Marmara and Black Sea, Turkey. Journal of Applied Ichthyology, 24, 546-550.
Azevedo, J.M.N., Homem, N., 2002. Age and growth, reproduction and diet of the red bream Parableniuss ruber (Bleniidae). Cybium, 26, 129-133.
Bell, G., 1980. The costs of reproduction and their consequences. American Naturalist, 116, 45-76.
Beltrano, A.M., Cannizzaro, L., Vitale, S., Milazzo, A., 2003. Aspetti della biologia di Diplodus vulgaris (Pisces: Sparidae) nello stretto di Sicilia. Biologia Marina Mediterranea, 10, 287-290.
Benchalel, W., Kara, M.H., 2010. Age, croissance et reproduction du sar commun Diplodus sargus sargus (Sparidae) des cotes de l’est algérien. Rapport du Congrès de la Commission Internationale pour l’Exploration Scientifique de la Mer Méditerranée, 39, 451.
Benchalel, W., Kara, M.H., 2013. Age and growth and reproduction of the white seabream Diplodus sargus sargus (Linnaeus, 1758) off the eastern coast of Algeria. Journal of Applied Ichthyology, 29, 64-70.
Beverton, R.J.H., 1992. Patterns of reproductive strategy parameters in some marine teleost fishes. Journal of Fish Biology, 41 (Suppl. B), 137-160.
Binohlan, C., 1998. The MATURITY table. p. 176-179. In: FishBase 98: Concepts, Design and Data Sources. Froese R., Pauly, D. (Eds). ICLARM, Manila, Philippines.
Bouaziz, A., Bennoui, A., 2004. Etat d’exploitation du banc d’Engraulis encrasicolus (Linné, 1758) dans la baie d’Alger. Rapport du Congrès de la Commission Internationale pour l’Exploration Scientifique de la Mer Méditerranée, 37, 318.
Bouaziz, A., Bennoui, A., Brahim, B., 2001. Sur l’estimation de l’état d’exploitation du merlou Merluccius merluccius (Linnaeus 1847) de la région centre de la cote algérienne. Rapport du Congrès de la Commission Internationale pour l’Exploration Scientifique de la Mer Méditerranée, 36, 243.
Bouaziz, A., Bennoui, A., Djebali, F., Maurin, C., 1998. Reproduction du merlou Merluccius merluccius de la région de bouismail. Cahiers Options Méditerranée, 35, 109-117.
Bouchereau, J.-L., Quiignard, J.-P., Joyeux, J.-C., Tomasini, J.-A., 1993. Structure du stock des géniteurs de la population de Pomatoschistus microps (Kroyer, 1838) (Gobiidae), dans la lagune de Mauguito, France. Cybium, 17, 3-15.
Boudaya, L., Neifar, L., Rizzo, P., Badalucco, C., Bouain, A., et al., 2008. Growth and reproduction of Chelidonichthys lucerna (Linnaeus) (Pisces: Triglidae) in the Gulf of Gabès, Tunisia. Journal of Applied Ichthyology, 24, 581-588.
Bradai, M.N., Bouain, A., 1991. Reproduction de Scorpæna porcus (Linné, 1758) et de S. scrofa (Linné 1758) (Pisces, Scorpaenidae) du Golfe de Gabès. Oebalia, XVII, 167-180.
Cailliet, G.M., Goldman, K.J., 2004. Age determination and validation in Chondrichthyan fishes. p. 399-448. In: Biology of Sharks and Their Relatives. Carrier, J., Musick, J.A., Hetthaus, M.R. (Eds). CRC Press LLC, Boca Raton, FL.
Cannizzaro, L., Rizzo, P., Levi, D., Gancitano, S., 1995. Age determination and growth of Squalus blainvilli (Risso, 1826). Fisheries Research, 23, 113-125.
Carbonara, P., Constantino, G., Giovine, G., Lembo, G., Spedicato, M.T. et al., 2003. Some aspects of the life history of Polypterus africanus (Schneider, 1801) along the coasts of the north western Ionian Sea. Biologia Marina Mediterranea, 10, 102-112.
Cau, A., Deiana, A.M., 1983. Reproduction and accroissement dans quelques Soleidae de la Mediterranee de centre occidental. Rapport du Congres de la Commission Internationale pour l’Exploration Scientifique de la Mer Mediterranee, 28, 227.
Chakroun-Marzouk, N., Khari, M.-H., 2003. Le corb des cotes tunisiennes, Sciaena umbra (Sciaenidae): cycle sexuel, age et croissance. Cybium, 27, 211-225.
Chali-Chabane, F., 1988. Contribution a l’étude biologique et dynamique de la population de Boops boops de la baie de Bouismail (Alger). MSc Thesis, ISMAL, 133 pp.
Chen, P., Yuan, W., 2006. Demographic analysis based on the growth parameter of sharks. Fisheries Research, 78, 374-379.
Cherob, O., 1987. Contribution a l’étude de la biologie du pageot commun Pagellus erythrinus et a l’écologie de la famille des Sparidés de la baie d’Alger. MSc Thesis, USTHB, 203 pp.
Coelho, R., Erzini, K., 2006. Reproductive aspects of the undulate ray, *Raja undulata*, from the south coast of Portugal. *Fisheries Research*, 81, 80-85.

Colloca, F., Cardinale, M., Ardizzone, G.D., 1997. Biology, spatial distribution and population dynamics of *Lepidotrigla cavi- lome* (Pisces: Triglidae) in the central Tyrrhenian Sea. *Fisheries Research*, 32, 21-32.

Colloca, F., Cardinale, M., Marcello, A., Ardizzone, G.D., 2003. Tracing the life history of red gurnard (*Aspistriga cuxus*) using validated otolith annual rings. *Journal of Applied Ichthyology*, 19, 1-9.

Corriero, A., Karakulak, S., Santamaria, N., Deflorio, M., Spedcato, D. et al., 2005. Size and age at sexual maturity of female bluefin tuna (*Thunnus thynnus*). *Journal of the Mediterranean Sea*. *Journal of Applied Ichthyology*, 21, 483-486.

Demirhan, S.A., Seyhan, K., 2007. Maturity and fecundity of spiny dogfish (*Squalus acanthias* L., 1758) in the eastern Black Sea. *Turkish Journal of Zoology*, 31, 301-308.

Despoti, S., Stergiou, K.L., 2013. Fecundity of fishes: a review. p. 62-66. In: More Fish and More. Stergiou, K.L., Bobori, D., Tsikiras, A.C. (Eds), Aristotle University of Thessaloniki, Thessaloniki, Greece.

Dhieb, K., Ghorbel, M., Jarboui, O., Bouaïn, A., 2006. Interactions between reproduction and fisheries in Bluefish, *Pomatomus saltatrix* (Pomatodidae), from Gulf of Gabes (Tunisia). *Cybium*, 30, 355-364.

D’Onghia, G., Sion, L., Maiorano, P., Mytilineou, Ch., Dalessandro, S. et al., 2006. Population biology and life strategies of *Chlo- rophalumus agassizii* Bonaparte, 1840 (*Pisces*: Ostichthyidae) in the Mediterranean Sea. *Marine Biology*, 149, 435-446.

Drazen, J.C., Hacidrich, R.L., 2012. A continuum of life histories in deep-sea demersal fishes. *Deep-Sea Research I*, 61, 34-42.

Dulcić, J., Matic-Skoko, S., Paradin, A., Kraljević, M., 2007. Age, growth and mortality of brown comber, *Serranus hepatus* (Linnaeus, 1758) (*Pisces*: Serranidae), in the eastern Adriatic (Croatian coast). *Journal of Applied Ichthyology*, 23, 195-197.

Dulvy, N.K., Baum, J.K., Clarke, S., Compagno, L.J.V., Cortés, E. et al., 2008. You can swim but you can’t hide: the global status and conservation of oceanic pelagic sharks and rays. *Aquatine Conservation: Marine and Freshwater Ecosystems*, 18, 459-482.

Dulvy, N.K., Fowler, S.L., Musick, J.A., Cavanagh, R.D., Kyne, P.M. et al., 2014. Extinction risk and conservation of the world’s sharks and rays. *eLife*, 3, e00590.

Enajjar, S., Bradai, M.N., Bouain, A. 2012. Age, growth and sexual maturity of the blackchin guitarfish *Rhinobatos cuniculus* in the Gulf of Gabès (southern Tunisia, central Mediterranean).

Cahiers de Biologie Marine, 53, 17-23.

Ergene, S., 2000. Reproduction characteristics of thinline grey mullet *Liza ramada* (Risso, 1825) inhabiting Akgıl-Parandiz Lac- goons (Göksü Delta). *Turkish Journal of Zoology*, 24, 159-164.

Eryilmaz, L., Meric, N., 2005. Some biological characteristics of *Cynoscion luridus* (Pisces: Mugilidae) of the Mesolongi-Etoliko (Greece) lagoon. *Scientia Marina*, 77, 105-118.

Giovanardi, O., Piccinetti, C., 1981. Biology and fishery of the yellow sole, *Solea lutea* (Risso, 1810), in the western Adriatic Sea. *FAO Fisheries Reports*, 253, 101-103.

Gislasson, H., Daan, N., Rice, J.C., Pope, J.G., 2010. Size, growth, temperature and the natural mortality of fish. *Fish and Fisheries*, 11, 149-158.

Goldman, K.J., Cailliet, G.M., Andrews, A.H., Natanhon, L.J., 2012. Assessing the age and growth of Chondrichthyan fishes. p. 423-448. In: *Biology of Sharks and Their Relatives*. Carrier, J., Musick, J.A., Heithaus, M.R. (Eds). 2nd edition, CRC Press, Francis, Boca Raton, FL.

Hammond, V., Saad, A., 2007. Reproductive biology of *Diplodus vulgaris* (Family Sparidae) in the syrian coast. *Rapport du Congrès de la Commission Internationale pour l’Exploration Scientifique de la Mer Méditerranée*, 38, 495.

He, X.J., Stewart, D.J., 2001. Age and size at first reproduction of fishes: predictive models based only on growth trajectories. *Ecology*, 82, 784-791.

Hotos, G.N., 1999. *Biology and population dynamics of Liza aurata* (Risso, 1810) (*Pisces*: Mugilidae) of the Mesolongi-Etoliko lagoon. PhD thesis, University of Patra, Greece, 415 pp.

Iglesias, M., Morales-Nin, B., 2001. Life cycle of the pelagic goby *Aphria minuta* (*Pisces*: Gobiidae). *Scientia Marina*, 65, 183-192.

Ilkay, A.T., Metin, G., Soykan, O., Kinacigil, H.T., 2010. Growth and reproduction of large-scaled gurnard (*Lepidotrigla cavi- lome*) (*Pisces*: Triglidae) in the eastern Aegean Sea, eastern Mediterranean. *Turkish Journal of Zoology*, 34, 471-478.

İşmen, A., 2003a. Maturity and fecundity of lizardfish (*Saurida undosquamis* Richardson, 1848) in İskenderun Bay (eastern Mediterranean). *Turkish Journal of Zoology*, 27, 231-238.

İşmen, A., 2003b. Age, growth, reproduction and food of common stingray (*Dasyatis pastinaca* L. 1758) in İskenderun Bay, the eastern Mediterranean. *Fisheries Research*, 60, 169-176.

İşmen, A., 2006. Growth and reproduction of Por’s goatfish (*Upeneus pori* Ben-Tuvia & Golani, 1989) in İskenderun Bay, the Eastern Mediterranean. *Turkish Journal of Zoology*, 30, 91-98.

İşmen, A., İşmen, P., Baustna, N., 2004. Age, growth and repro-
duction of Tub Gurnard (Chelidonichthys lucerna L. 1758) in the Bay of Iskenderun in the eastern Mediterranean. Turkish Journal of Veterinary and Animal Sciences, 28, 289-295.

İşmen, A., Arslan, M., Yigin, C.C., Bozbay, N.A., 2013. Age, growth, reproduction and feeding of John Dory, Zeus faber (Pisces: Zeidae), in the Saros Bay (North Aegean Sea). Journal of Applied Ichthyology, 29, 125-131.

Jennings, S., Reynolds, J.D., Mills, S.C., 1998. Life history correlates of responses to fisheries exploitation. Proceedings of the Royal Society of London B: Biological Sciences, 265, 333-339.

Jukić, S., Piccinetti, C., 1981. Quantitative and qualitative characteristics of demersal resources in the Adriatic Sea with some population dynamics estimates. FAO Fisheries Reports, 253, 73-79.

Kadri, H., Marouani, S., Bradai, M.N., Bouain, A., 2013. Age, growth and reproductive biology of the rough skate, Raja radiula (Chondrichthyes: Rajidae), off the Gulf of Gabès (southern Tunisia, central Mediterranean). Marine and Freshwater Research, 64, 540-548.

Kallianiotis, A.D., Marouani, S., Saidi, B., Bradai, M.N., Ghorbel, M. et al., 2012. Age, growth and reproduction of Raja mirarelaeus (Linnaeus, 1758) (Chondrichthyes: Rajidae) of the Gulf of Gabès (Tunisia, Central Mediterranean Sea). Marine Biology Research, 8, 388-396.

Kallianiotis, A.A., 1992. Biology and population structure of bogue [Boops boops (L.)] populations in the marine area of Crete. PhD thesis, University of Crete, Greece, 234 pp.

Kallianiotis, A., Torre, M., Argyri, A., 2005. Age, growth, mortality, reproduction and feeding habits of the striped seabream, Lithognathus mormyris (Pisces: Sparidae), in the coastal waters of the Thracian Sea, Greece. Scientia Marina, 69, 391-404.

Kara, M.H., 1997. Cycle sexuel et fécondité du loup Dicentrarchus labrax (Poisson Moronidé) du golfe d’Annaba. Cahiers de Biologie Marine, 38, 161-168.

Kara, M.H., Derbal, F., 1999. Données biologiques sur le mérou Epinephelus marginatus (Lowe, 1834) des cotes algériennes. Marine Life, 9, 21-27.

Karlov-Riga, C., 1995. Biology and dynamics of the Trachurus species (Pisces, Carangidae) in the Saronikon Gulf. PhD Thesis, Aristotle University of Thessaloniki, Greece, 296 pp.

Kartas, F., Bondka, B., 1986. Cycle sexual et reproduction de l’uranoscope Uroncus scaber des cotes Tunisiennes. Rapport du Congrès de la Commission Internationale pour l’Exploration Scientifique de la Mer Méditerranée, 30, 228.

Katselis, G.N., 1996. Biology and population dynamics of Liza saliens (Pisces: Mugilidae) in the Mesolongi-Etioliko lagoon. PhD Thesis, University of Patra, Greece, 193 pp.

Kelly, C.J., Connolly, P.L., Bracken, J.J., 1999. Age estimation, growth, maturity and distribution of the bluemouth rockfish Sebastes mystinus, in the Southern California Bight. ICES Journal of Marine Science, 56, 61-74.

King, J.R., McFarlane, G.A., 2003. Marine fish life history strategies: applications to fishery management. Fisheries Management and Ecology, 10, 249-264.

Klein, N.R., Raventos, N., 2007. Age, growth and reproductive parameters of the Mediterranean cardinal fish, Apogon imberbis. Journal of Applied Ichthyology, 23, 675-678.

Korich, H.S., 1988. Contribution à l’étude biologiques des deux espèces de saurets: Trachurus trachurus et T. mediterraneus et de la dynamique de T. trachurus en baie de Bou-Ismail. MSc Thesis, ISMAL, 203 pp.

Koutrakis, E.T., 1994. Biology and population dynamics of grey mullets (Pisces, Mugilidae) in the Lake Vistonis and the Lagoon of Porto-Lagos. PhD Thesis. Aristotle University of Thessaloniki, Greece, 233 pp.

Kovačić, M., 2007. Reproductive biology of the striped goby, Gobius vittatus (Gobiidae) in the northern Adriatic Sea. Scientia Marina, 71, 145-151.

Kozlowski, J., 1996. Optimal allocation of resources explains interspecific life-history patterns in animals with indeterminate growth. Proceedings of the Royal Society of London B: Biological Sciences, 263, 559-566.

La Mesa, M., 2001. Age and growth of Crystallogobius linears (von Duben, 1845) (Teleostei: Gobiidae) from the Adriatic Sea. Scientia Marina, 65, 375-381.

Lamrini, A., 2010. Croissance et reproduction du rouget barbe de roche (Mullus surmuletus l. 1758) dans la baie de M’Diq (Maroc). Rapport du Congrès de la Commission Internationale pour l’Exploration Scientifique de la Mer Méditerranée, 39, 565.

Marino, G., Azzurro, E., Massari, A., Finoia, M.G., Mandich, A., 2001. Reproduction in the dusky grouper from the southern Mediterranean. Journal of Fish Biology, 58, 909-927.

Marino, G., Mandich, A., Massari, A., Andaloro, F., Porrello, S. et al., 1995. Aspects of reproductive biology of the Mediterranean amberjack (Seriola dumerili Risso) during the spawning period. Journal of Applied Ichthyology, 11, 9-24.

Marouani, S., Bradai, M.N., Bouain, A., 2007. Taille à la maturité sexuelle de Squalus blainvillei (Risso, 1826) du golfe de Gabès (Tunisie). Rapport du Congrès de la Commission Internationale pour l’Exploration Scientifique de la Mer Méditerranée, 38, 536.

Marouani, S., Kadri, H., Saidi, B., Bouain, A., Bradai, M.N., 2010. Age, growth and age at sexual maturity of the longnose spurdog, Squalus blainvillei, in the Gulf of Gabès (Tunisia). Rapport du Congrès de la Commission Internationale pour l’Exploration Scientifique de la Mer Méditerranée, 39, 581.

Matić-Skoko, S., Kraljević, M., Dulcić, J., Jardas, I., 2007. Age, growth, maturity, mortality, and yield-per-recruit for annular sea bream ( Diplodus annularis L.) from the eastern middle Adriatic Sea. Journal of Applied Ichthyology, 23, 152-157.

Megalofonou, P., Damalas, D., De Metrio, G., 2009. Biological characteristics of blue shark, Prionace glauca, in the Mediterranean Sea. Journal of the Marine Biological Association of the United Kingdom, 89, 1233-1242.

Mehanna, S.F., 2009. Growth, mortality and spawning stock biomass of the striped red mullet Mullus surmuletus, in the Egyptian Mediterranean waters. Mediterranean Marine Science, 10, 5-17.

Metin, G., Ilyaz, A.T., Soykan, O., Kimaciil, H.T., 2011a. Biological characteristics of the common pandora, Pagellus erythrinus (Linnaeus, 1758), in the central Aegean Sea. Turkish Journal of Zoology, 35, 307-315.

Metin, G., Ilyaz, A.T., Soykan, O., Kimaciil, H.T., 2011b. Age, growth and reproduction of four-spotted goby, Deloventosteus quadrimaculatus (Valenciennes, 1837), in İzmir Bay (central Aegean Sea) (in English). Turkish Journal of Zoology, 35:711-716.

Millán, M., 1999. Reproductive characteristics and condition status of anchovy Engraulis encrasicolus L. from the Bay of Cadiz (SW Spain). Fisheries Research, 41, 73-86.

Minos, G.C., 1996. Biology and dynamics of Liza ramada (Pisces: Mugilidae) of the Mesolongi-Etioliko lagoon. PhD thesis, University of Patra, Greece, 272 pp.

Minos, G., Kokokiris, L., Economidis, P.S., 2010. Sexual maturity of the alien redlip mullet, Liza haematocheilus (Temminck & Schlegel, 1845) in north Aegean Sea (Greece). Journal of Applied Ichthyology, 26 (Suppl. 2), 96-101.
Morales-Nin, B., Moranta, J., 1997. Life history and fishery of the common dentex (Dentex dentex) in Mallorca (Balearic Islands, western Mediterranean). Fisheries Research, 30, 67-76.

Mouhoub, R., 1986. Contribution a l’étude de la biologie et de la dynamique de la population exploitee de la sardine Sardina pilchardus des cotes algéroises. MSc Thesis, USTHB, 163 pp.

Mouine, N., Francour, P., Ktari, M.-H., Chakroun-Marzouk, N., 2007. The reproductive biology of Diplodus sargus sargus in the Gulf of Tunis (central Mediterranean). Scientia Marina, 71, 461-469.

Mouine, N., Ktari, M.-H., Chakroun-Marzouk, N., 2011. Reproductive characteristics of Spondyliosoma canthus (Linnaeus, 1758) in the Gulf of Tunis. Journal of Applied Ichthyology, 27, 827-831.

Mugahid, A.R., Hashem, M.T., 1982. Some aspects of the fishery and fisheries research. Bulletin of the National Institute of Oceanography and Fisheries, ARE, 40, 145-162.

Mytilineou, C., 1988. L’hermaphrodisme et le cycle sexuel de la Gerie Spicara flexuosa (Centracanthidae) dans le golfe de Patraikois, Grece. Rapport du Congrès de la Commission Internationale pour l’Exploration Scientifique de la Mer Méditerranée, 31, 272.

Nouar, A., 2003. Ecologie, biologie et exploitation d’une espèce de la famille de Scorpaenidae Helicolenus dactylopterus des cotes algériennes. PhD Thesis, USTHB, 154 pp.

Okumuş, İ., Başçinar, M., 1997. Population structure, growth and reproduction of introduced Pacific mullet, Mugil so-iuy, in the Black Sea. Fisheries Research, 33, 131-137.

Olsen, E.M., Heino, M., Lilly, G.R., Morgan, M.J., Bratty, J. et al., 2004. Maturation trends indicative of rapid evolution preceded the collapse of northern cod. Nature, 428, 932-935.

Ordines, F., Valls, M., Gourgue, A., 2012. Biology, feeding, and habitat preferences of Cadenat’s rockfish, Scorpaena loppei (Actinopterygi: Scorpaenidae), in the Bal- earic Islands (western Mediterranean). Acta Ichthyologica et Piscatoria, 42, 21-30.

Orsi Relini, L., Palandri, G., Garibaldi, F., 2003. Reproductive parameters of the Mediterranean swordfish. Biology Maria Mediterranea, 10, 210-222.

Osman, A.G.M., Akel, E.S.H., Farrag, M.M.S., Moustafa, M.A., 2004. Reproductive biology of round herring, Mugil so-iuy, in the Black Sea. Fisheries Research, 33, 131-137.

Ozvarol, Z.A.B., Balci, B.A., Gokoglu, M., Tasi, A., Kaya, Y. et al., 2010. Age growth and reproduction of goldband goatfish (Up- eneus molluccensis, Bleeker 1855) from the Gulf of Antalya (Tur- key). Journal of Animal and Veterinary Advances, 9, 939-945.

Pallaoro, A., Dulcič, J., Matić-Skoko, S., Kraljević, M., Jardas, I., 2008. Biology of the salema, Sarpa salpa (L. (1758)) (Pisces, Sparidae) in the middleeastern Adriatic. Journal of Applied Ichthyology, 24, 276-281.

Papacosmatatou, C., 1982. On the biology of Lepidotrigla cavill- triga (Triglidae) in Greek seas. Thalassographica, 5, 33-59.

Papacosmatatou, C., Caragitsou, E., Vasilopoulou, V., Petrikis, G., Stergiou, K., 1988. The coastal fisheries in the Kastellori- zo area (Dodecanese). NCMR Special Publication, 15, 1-106.

Paul, D. 1995. Adult longevity and the remaining population of fish. Trends in Ecology and Evolution, 10, 430.

Politou, C.-Y., Papacosmatatou, C., 1991. Population biology of Trisopterus minutus capelanus (Gadidae) from the eastern coast of Greece. Cybium, 15, 69-81.

Quignard, J.-P., Bouain, A., Ktari, M.H., 1978. Reproduction des loupes (Poissons, Teleosteen, Serranidae) Dicentrarchus la- brax (Linne, 1758) et D. punctatus (Bloch, 1792) des cotes tunisiennes. Bulletin de la Société des Sciences Naturelles Tunisie, 13, 19-24.

Ragonese, S., Gancitano, S., Norrito, G., Rizzo, P., Bono, G., 2003. Life history traits of the slender rockfish, Scorpaena elongata Can- denat, 1943 (Pisces, Scorpaenidae) of the Strait of Sicily (Mediterranean Sea). Biologia Marina Mediterranea, 10, 223-232.

Recasens, L., Lombarte, A., Morales-Nin, B., Torres, G.J., 1998. Spatiotemporal variation in the population structure of the European hake in the NW Mediterranean. Journal of Fish Bi- ology, 53, 387-401.

Reñones, O., Grau, A., Mas, X., Riera, F., Saborido-Rey, F., 2010. Reproductive pattern of an exploited dusky grouper Epinephe- lus marginatus (Lowe 1834) (Pisces: Serranidae) population in the western Mediterranean. Scientia Marina, 74, 523-537.

Reñones, O., Massuti, E., Morales-Nin, B., 1995. Life history of the red mullet Mullus surmuletus from the bottom trawl fishery off the Island of Majorca (north-west Mediterranean). Marine Biology, 123, 411-419.

Rochet, M.J., 1998. Short-term effects of fishing on life history traits of fishes. ICES Journal of Marine Science, 55, 371-391.

Rochet, M.J., 2000. A comparative approach to life-history strategies and tactics among four orders of teleost fish. ICES Jour- nal of Marine Science, 57, 228-239.

Roff, D., 1992. The evolution of life histories: theory and analysis. Chapman and Hall, New York, 548 pp.

Roff, D.A., 1983. An allocation model of growth and reproduction in fish. Canadian Journal of Fisheries and Aquatic Sciences, 40, 1395-1404.

Sley, A., Janbo, O., Ghorbel, M., Bouain, A., 2012. Annual re- productive cycle, spawning periodicity and sexual maturity of blue runner Caranx crysos (Pisces, Carangidae) from the Gulf of Gabes (Tunisia, Eastern Mediterranean). Journal of Applied Ichthyology, 28, 785-790.

Somarakis, S., Machias, A., 2002. Age, growth and bathymetric distribution of red Pandora (Pagellus erythrinus) on the Cre- tan shelf. Journal of the Marine Biological Association of the UK, 82, 149-160.

Soykan, O., Ilkyaz, A.T., Metin, G., Kinacigil, H.T., 2010. Growth and reproduction of spotted picarel (Spicara maena Linmae- us, 1758) in the central Aegean Sea, Turkey. Turkish Journal of Zoology, 34, 453-459.

Stergiou, K.I., Tsiklaris, A.C., 2011. Fishing-down, fishing- through and fishing-up: fundamental process versus technical details. Marine Ecology Progress Series, 441, 295-301.

Stergiou, K.I., Economidis, P., Sinis, A.I., 1996. Sex ratio, spawning season and size at maturity of red bandfish in the western Mediterranean. Journal of Fish Biology, 49, 561-572.

Trippel, E.E., 1995. Age at maturity as a stress indicator in fish- eries. BioScience, 45, 759-771.

Tsiklaris, A.C., Antonopouloou, E., 2006. Reproductive biology of the round sardinell (Sardinellina aurita) in the northeastern Mediterranean Sea. Scientia Marina, 32, 231-240.

Tsiklaris, A.C., Koutrakis, E.T., 2013. Growth and reproduction of European sardine, Sardina pilchardus (Pisces: Clupeidae), in northeastern Mediterranean. Cahiers de Biologie Marine, 54, 365-374.

Tsiklaris, A.C., Stergiou, K.I., 2014. Size at maturity of Medi- terranean marine fishes. Reviews in Fish Biology and Fisheries, 24, 219-268.
Tsikliras, A.C., Antonopoulou, E., Stergiou, K.I., 2007. A phenotypic trade-off between previous growth and present fecundity in round sardinella Sardinella aurita. Population Ecology, 49, 221-227.

Tsikliras, A.C., Antonopoulou, E., Stergiou, K.I., 2010. Spawning period of Mediterranean marine fishes. Reviews in Fish Biology and Fisheries, 20, 499-538.

Tsikliras, A.C., Stergiou, K.I., Froese, R. 2013a. Editorial on reproductive biology of fishes. Acta Ichthyologica et Piscatoria, 43, 1-5.

Tsikliras, A.C., Dinouli, A., Tsalkou, E., 2013b. Exploitation trends of the Mediterranean and Black Sea fisheries. Acta Adriatica, 54, 273-282.

Türkmen, M., Akyurt, İ., 2003. Growth characteristics, sex inversion and mortality rates of striped sea beram, Lithognathus mormyrus L., in İskenderun Bay. Turkish Journal of Zoology, 27, 323-329.

Uçkun, D., Akalin, S., Taşkavak, E., Toğulga, M., 2004. Some biological characteristics of the garfish (Belone belone L., 1761) in Izmir Bay, Aegean Sea. Journal of Applied Ichthyology, 20, 413-416.

Vassilopoulou, V., Papaconstantinou, C., 1995. Sexual maturity of the striped mullet (Mullus surmuletus) in the Aegean Sea. Rapport du Congrès de la Commission Internationale pour l’Exploration Scientifique de la Mer Méditerranée, 34, 261.

Vassilopoulou, V., Ondrias, I., Papaconstantinou, C., 1997. Data on the sexual maturity of the flatfish Lepidorhombus boscii (Risso) in the northeastern Mediterranean Sea (Greece). Proceedings of the American Fisheries Society Annual Meeting, 127, 42-43.

Vitale, S., Arkhipkin, A., Cannizzaro, L., Scalisi, M., 2011. Life history traits of the striped seabream Lithognathus mormyrus (Pisces, Sparidae) from two coastal fishing grounds in the Strait of Sicily. Journal of Applied Ichthyology, 27, 1086-1094.

Vitale, S., Cannizzaro, L., Bono, G., Beltrano, A.M., Milazzo, A. et al., 2003. Sexual maturation, age and growth of striped seabream Lithognathus mormyrus (L., 1758) (Pisces: Sparidae) south west coast of Sicily. Biologia Marina Mediterranea, 10, 233-241.

Wadie, W., Riskalla, S., Dowidar, N., 1988. Maturity of family Sphyraenidae in the southeastern Mediterranean Sea. Rapport du Congrès de la Commission Internationale pour l’Exploration Scientifique de la Mer Méditerranée, 31, 269.

Wassef, E., El Emary, H., 1989. Contribution to the biology of bass, Dicentrarchus labrax L. in the Egyptian Mediterranean waters off Alexandria. Cybium, 13, 327-345.

Williams, G.C., 1966. Natural selection, the cost of reproduction and a refinement of Lack’s principle. American Naturalist, 100, 687-690.

Winemiller, K.O., Rose, K.A., 1992. Patterns of life-history diversification in North American fishes: implications for population regulation. Canadian Journal of Fisheries and Aquatic Sciences, 49, 2196–2218.

Yigin, C., Ismen, A., 2010. Age, growth, reproduction and feed of longnosed skate, Dipturus oxyrinchus (Linnaeus, 1758) in Saros Bay, the north Aegean Sea. Journal of Applied Ichthyology, 26, 913-919.

Zouari-Ktari, R., Bradaï, M.-N., Bouaïn, A., 2009. Reproduction and Growth of the yellowstripe barracuda Sphyraena chrysaena Klunzinger, 1884, in Central Mediterranean. Reviews in Fisheries Science, 17, 485-493.

Zoubi, A., 2001. Biologie de reproduction des principales espèces demersales de la Méditerranée marocaine. Rapport du Congrès de la Commission Internationale pour l’Exploration Scientifique de la Mer Méditerranée, 36, 340.