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UPDATED GAP ANALYSIS ON THE BIOLOGY OF MEDITERRANEAN MARINE FISHES

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Abstract

We updated the investigation of the knowledge gap in the biological characteristics of Mediterranean marine fishes, five years after the initial gap analysis was published. We extracted literature containing information on eight characteristics, namely, length-weight relationships, growth, maximum age, mortality, spawning, maturity, fecundity and diet, for the 722 fish species of the Mediterranean Sea listed in FishBase. The results showcased a considerable knowledge gap as 37% of the species have no information at all, while 13% have information on only one characteristic. Out of all the biological characteristics, the smallest gap was found in the length-weight relationships (studied for 51% of the species), while the least studied characteristic was mortality (studied for 10% of the species). The most studied species were European hake (*Merluccius merluccius*), red mullet (*Mullus barbatus*) European anchovy (*Engraulis encrasicolus*), European pilchard (*Sardina pilchardus*), common pandora (*Pagellus erythrinus*) and annular seabream (*Diplodus annularis*), which are all highly commercial. The gap seems to have shrunk compared to the previous gap analysis five years ago and it appears that research has slightly shifted towards species that have been traditionally neglected, e.g., the elasmobranchs. The effort needs to continue in this direction as many of these species are particularly vulnerable in the everchanging Mediterranean region.

Keywords: growth, mortality, diet, knowledge gap, Mediterranean Sea.

1. Introduction

The Mediterranean Sea has been identified as an area with a large information gap on biological characteristics of many fish species (Dimarchopoulou et al., 2017). The lack of biological information impedes the efforts of scientists working in the fields of Fish Ecology and Fisheries Management, as this information is needed for a variety of models. Fish stock assessment models alone require an array of biological information such as length- weight relationships, maximum age, size at maturity and growth parameters (Chrysafi & Kuparinen, 2016). Moreover, life history traits such as maximum age, growth rate and age at maturation, affect species resilience against overexploitation (Russ & Alcala, 1998) and climate change (Wang et al., 2020), therefore playing an important role in modelling the resilience of a particular species. Additionally, ecosystem based fisheries management (EBFM) needs all ecosystem components, in addition to the characteristics of individual stocks, to be taken into consideration for the decision-making process (Garcia et al., 2003). The more holistic approach of EBFM requires life history knowledge of both commercial and non-commercial fish species of the ecosystem in question (Claudet et al., 2010). Granting the importance of acknowledging and highlighting the existing gaps, Dimarchopoulou et al. (2017) published a gap analysis on the biological traits of Mediterranean marine fishes. Considering that five years have passed since this publication and given the everchanging profile of the Mediterranean region (Turley, 1999), we revisited the topic to monitor the existing gap and identify any progress made.

2. Materials and Methods

An updated gap analysis was carried out on the Mediterranean marine fish species, which followed the existing methodology (Dimarchopoulou *et al.*, 2017) regarding the missing biological information in the Mediterranean as a whole, and on a subregional basis (W: western; C: central; E: eastern, Mediterranean). The gap stems from the difference between the current status and the ideal scenario in which all biological characteristics -or as many characteristics as possible- are known for every species -or at least for as many species as possible- (Dimarchopoulou *et al.*, 2016).

We updated the gap analysis now covering the years 2016-2021 to report the number of fish species and their related biological characteristics that has been fully or partially studied and to compare the results with the ones previously published (Dimarchopoulou et al., 2017). To do that, we collected data on all fish species which have been recorded in the Mediterranean Sea large marine ecosystem as they are listed in FishBase (Froese & Pauly, 2021). Altogether, 758 Mediterranean marine fishes are currently listed in FishBase, of which 36 fish species were excluded as misidentified and questionable records. For each of the 722 remaining species, the available information on length-weight relationships, growth parameters, maximum age, mortality rate, spawning period, size at maturity, fecundity and diet composition was extracted from FishBase and published papers found in SCOPUS. For length-weight relationships (LWR) records we registered species with both the slope (b) and intercept (a) of the equation, for somatic growth (G) records with the asymptotic length (L_{∞}) and the rate at which L_{∞} is approached (K) and for lifespan, records with the maximum age (t_{max}) . Concerning the reproduction parameters, we considered the onset and duration of spawning (Spawn) and length at maturity (L_m) to identify spawning and maturity related information, respectively. Additionally, we regarded absolute and relative number of oocytes for fecundity (Fec). Lastly, we used prey items, stomach content and feeding preferences as records for diet, while the natural mortality rate was used as natural mortality (M), no matter the estimation method.

Moreover, we recorded the protection status (IUCN Red List of Threatened Species) of each species based on the IUCN categories (LC: least concern; EN: endangered; DD: data deficient; NE: not evaluated; NT: near threatened; VU: vulnerable; CR: critically endangered), alongside their commercial value (Val), which was shown as "price category" in FishBase (VH: very high; H: high; M: medium; L: low). Lastly, we extracted the Mediterranean landings averaged for the years 2015-2019 from the FAO-GFCM database (FAO, 2021).

3. Results

Within the data we collected for the 722 Mediterranean fish species, there is no information on any biological characteristic for 270 species (37%), while for 95 (13%) of them there is information for only one characteristic. Regarding the biological characteristics separately, the gap is smaller for the most common characteristic, i.e., length-weight relationships, as they have been studied for 366 (51%) species, followed by spawning (312 species; 43%), diet (284 species; 39%), growth (211 species; 29%), maturity (192 species; 27%), maximum age (184 species; 25%) and fecundity (142 species; 20%). The largest gap occurs in natural mortality (70 species; 10%) for which information is sparse. Concerning the studied species that are listed under the categories near threatened (NT), vulnerable (VU), endangered (EN) and critically endangered (CR) of the IUCN Red List (n = 91), the percentages for all biological characteristics except mortality and growth were higher compared to the total of the species. In terms of commercial value, the species listed under the categories high (H) and very high (VH) (n = 167), had higher percentages in every biological characteristic, compared to all species listed.

With respect to the studied characteristics, the record distribution pattern is consistent among the western, central and eastern Mediterranean, with the exception of some spatial variations within each biological characteristic. Spawning, maturity, fecundity and diet were most extensively studied in the western subregion, length-weight relationships and maximum age were studied mostly in the eastern subregion. Growth and mortality records were rather evenly distributed among the three subregions (Fig. 1).

In terms of number of records, the most studied species were European hake Merluccius merluccius

(227 records in total with 46 new records in the last five years), red mullet *Mullus barbatus* (163 records in total with 34 new), European anchovy *Engraulis encrasicolus* (142 records in total with 55 new), European pilchard *Sardina pilchardus* (125 records in total with 43 new), common pandora *Pagellus erythrinus* (124 records in total with 26 new), annular seabream *Diplodus annularis* (115 records in total with 17 new), surmullet *Mullus surmuletus* (115 records in total with 15 new) and bogue *Boops boops* (100 records in total with 24 new). Furthermore, we identified a newfound interest for elasmobranchs as records for a lot of elasmobranch fish species were published in the last five years. The least studied species were those belonging to the Gobiidae, Blennidae, Myctophidae, Carangidae, Labridae, Gobiesocidae and Syngnathidae families.

Concerning the Mediterranean fish species with at least one studied biological characteristic and with available landings data, the number of records had a weak positive correlation to total landings (n = 125, Spearman ρ = 0.31, P < 0.001) and maximum reported length (n = 451, Spearman ρ = 0.20, P < 0.001). In opposition to total landings, the trophic level (n = 451, Spearman ρ = 0.086, P = 0.068) did not appear to correlate with the number of records.

Regarding the distribution of the records amongst the three Mediterranean subregions, spawning, maturity, fecundity and diet were most extensively studied in the western subregion, while the majority of the length-weight relationships and maximum age records came from the eastern subregion. The central part of the Mediterranean Sea holds the least number of records compared to the other two regions. Growth and mortality records were rather evenly distributed among the three subregions (Fig. 1).



Fig. 1: Percentage of fish species with (green, from Dimarchopoulou et al., 2017 & blue, from the present study) and without (pink) information on length-weight relationships (LWR), growth parameters (G), maximum age (tmax), mortality rate (M), spawning period (Spawn), size at maturity (Lm), fecundity (Fec) and feeding preferences (Diet), across the western, central and eastern Mediterranean Sea.

4. Discussion/Conclusions

The results showed that during the last five years (2016-2021) the knowledge gap on the biology of Mediterranean marine fishes was slightly reduced, as the percentage of fish species without any biological characteristics has dropped from 43% (Dimarchopoulou *et al.*, 2017), to 37% in 2021. The scientific interest is still focused on length-weight relationships, spawning and diet with 124 new diet records, 122 new length-weight relationship records and 64 new spawning records. Mortality records are still very few and exist for only 10% of the Mediterranean fish species. For the species of high commercial value and of poor protection status, the percentages were, overall, higher for all biological characteristics in comparison with all the species. Focusing on the biological characteristics, the least studied remain mortality and fecundity, the same as previously reported (Dimarchopoulou *et al.*, 2017).

With respect to the number of records per species the most studied ones were the same as in the 2017 gap analysis: European hake, red mullet, European anchovy, European pilchard, annular seabream and common pandora, which are all highly commercial species and information on them exists for all the biological characteristics. The minimization of the gap is also evident from the new records of elasmobranchs (Tsikliras & Dimarchopoulou, 2021) that were published since 2017. This is particularly hopeful as elasmobranchs are, generally, vulnerable species due to the fact that they have slow growth, late maturity, produce only a few oocytes and a lot of them are of poor protection status (Bradai *et al.*, 2012), so they are priority species to be studied. Apart from the apparent rise in the records regarding fish biological characteristics, knowledge about species belonging to the Gobiidae, Blennidae, Myctophidae, Carangidae, Labridae, Gobiesocidae and Syngnathidae families is still missing.

In conclusion, the knowledge gap seems to be getting smaller as the papers published the last five years fill in a considerable part of the gap that was previously identified (Dimarchopoulou *et al.*, 2017). Regarding the scientific effort, although the number of records of non-commercial species has increased, the focus remains on the more commercial species and needs to be expanded to the less commercial, as well as to the more vulnerable species of the list. With the constant influx of new species entered from the Red Sea, the effort to fill in the existing knowledge gaps needs to be intensified.

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