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REVIEWS

Diel activity of littoral and epipelagic teleost fishes in the Mediterranean Sea

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Abstract Diel activity patterns are an important aspect of behavioural ecology, yet summarising works on diel activity patterns of fishes are lacking for several regions of the world, including the Mediterranean Sea. Based on a comprehensive review of literature, internet searches, citizen science and personal observations, we compile existing knowledge of diel activity of Mediterranean pelagic and demersal teleosts commonly occurring at depths shallower than 200 m as adults (393 native and 165 newcomer species, representing 124 families), using the categories strictly or mainly diurnal and nocturnal, crepuscular, cathemeral and diel vertical migration. Most of the available data refer to foraging activity patterns of adult fishes, while knowledge of time of reproduction, migratory movements, or territorial defence remains unknown for more than half of the species. Confamilial species often have the same activity pattern, although a high plasticity or diversity in diel activity patterns is seen in some families (Belonidae, Carangidae, Clupeidae, Gadidae, Gobiidae, Scombridae, Scorpaenidae, Sparidae, and Triglidae). We found correlations between adult feeding activity patterns and trophic level, habitat use and depth range: diurnal species have a lower trophic level, prefer shallower depths, and tend to occur over hard bottoms or have multi-habitat use, nocturnal species are mostly carnivorous and prefer soft bottoms in deeper waters, while cathemeral species are commonly carnivorous and pelagic. Our results do not support the hypothesis that nocturnal Indo-Pacific immigrants are more successful colonizers. The present work highlights the perils of over-generalizing activity patterns and shows that several gaps in knowledge of diel activity patterns of fishes remain despite that such knowledge can support conservation efforts.

Keywords Circadian activity · Ecological traits · Feeding · Spawning · Trophic level · Indo-Pacific immigrants

Erik Arndt has passed away.

Introduction

Diel activity is one of the most important species traits. It is connected with species interactions such as competition (Hixon 2006), predator avoidance

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strategies (Helfman 1978, 1993) and the exploitation of resources with foraging as a key function (Hobson 1973). More generally, diel activity is closely connected with the species' niche (Collette and Talbot 1972; Hobson 1972; Helfman et al. 2014). Diel activity also plays a major role with regard to migration (Hobson 1973; Neilson and Perry 1990; Gibson et al. 1996; Luckhurst 2007), reproductive strategies (Lobel 1978a, b; Thresher 1984; DeMartini and Sikkel 2006; Lowerre-Barbieri et al. 2011) and many other aspects of fishes' life (Allen et al. 2006; Helfman et al. 2014). Diel patterns lead to changes in the abundance of active fish between day and night, and at a higher level to changes in the community composition of the ecosystem (Collette and Talbot 1972; Hobson 1972; Helfman 1993; Pessanha et al. 2003). Even deep-sea fishes living in permanent darkness show activity patterns. These patterns are usually triggered by lunar or tidal cycles, possibly through pressure transductions into the deep water (Priede 2017; Wagner et al. 2007), rather than by the solar cycle. However, activity patterns linked to solar cycles may also occur in the deep sea, with species undertaking bathymetrically extensive diel vertical migrations conveying the day-night signal to deeper waters (Aguzzi et al. 2015a).

Considering the ecological significance of diel activity patterns, it is surprising how little is known about these patterns of many marine fishes. Some authors give only a general introduction on the topic (i.e. Helfman 1993; Helfman et al. 2014; Lowe-McConnell 1987, the latter with main focus on tropical freshwater fish). Others focused on specific aspects, such as the plasticity of diel rhythms (Reebs 2002), the molecular and physiological bases for circadian rhythms (Zhdanova and Reebs 2006), or the crepuscular or so-called day-night changeover (Collette and Talbot 1972; Hobson 1972; Potts 1990). Information at the species level is scattered over a multitude of recent publications, reflecting the significant increase in ecological knowledge of species during the last two decades, aided by development of new monitoring technologies. This includes the accumulation of activity data by means of acoustic recording, tagging, mark-recapturing, in situ monitoring including through cabled observatories and using remote sensing techniques such as sonar, LIDAR or telemetry (Gunn et al. 2003; Cartamil and Lowe 2004; Hoolihan 2005; Simmonds and MacLennan, 2006; Johnsen and Godø 2007; Luckhurst 2007; Engelhard et al. 2008; Fox and Bellwood 2011; Staby et al. 2011; de Pontual et al. 2012; Aguzzi et al. 2013, 2015b; Doya et al. 2014; Abascal et al. 2015; Braun et al. 2015; Amilhat et al. 2016; Alós et al. 2017; Priede 2017: pp. 65 ff.; Lindseth and Lobel 2018). However, summarizing works on diel activity of fishes in specific regions of the world are scarce and most were published some decades ago. The publications by Hobson (1965, 1972, 1974) represent basic works that summarize the knowledge of diel activity of fishes in the Gulf of California and Hawaii, at the family level and with regard to different periods of the 24-h cycle respectively. Ebeling and Bray (1976), Hobson and Chess (1976), Hobson et al. (1981), Allen (1982) and Lowe and Bray (2006) continued with Hobson's approach in the temperate eastern Pacific. In European Seas, there are several local studies (e.g. Bertram 1965 for Malta; Nickell and Sayer 1998 for western Scotland; Azzurro et al. 2013 for the Italian island of Linosa), but the only summarizing work is the analysis of activity patterns of 19 fish species in the Baltic Sea by Westin and Aneer (1987). Comparable reviews are lacking for other regions of the world, including traditionally well-studied areas such as the North Atlantic and the Mediterranean Sea.

Knowledge of diel activity patterns of fishes can provide useful ecological insights. For instance, diel activity has been used in studies of diversity of marine fishes (Horn 1980; DeMartini and Allen 1984; Kwik et al. 2010; Olivar et al. 2012) and in ecological trait analyses. Trait analyses which considered diel patterns helped to explain colonization or establishment success of non-indigenous fish species (Golani 2010; Belmaker et al. 2013) as well as competition or niche separation (Colmenero et al. 2010; Carpentieri et al. 2016; Arndt et al. 2018a). However, in many of these studies, diel activity was handled as a nominal parameter comprising two categories (diurnal and nocturnal; e.g. Schmitz and Wainwright 2011; Luiz et al. 2013; Brandl and Bellwood 2014) or three categories (diurnal, nocturnal and 'both'; e.g. Belmaker et al. 2013; Samaha et al. 2016; Arndt et al. 2018a). The restriction to two or three simple trait values hardly reflects the complexity of activity patterns in a fish community, due to the following reasons:

1. *'Diel' means more than diurnal and nocturnal.* 'Diurnal' and 'nocturnal' activities cover only two phases. The activity of several species peaks in crepuscular periods, while other species do not show distinct activity periods, but so-called cathemeral patterns (Helfman 1993; Coles 2014). Thus, diel activity patterns cannot be represented by a simple 'diurnal vs. nocturnal' scheme. Species exhibiting diel vertical migrations also do not fit in a 'diurnal vs. nocturnal' scheme, not to mention non-migrating species that show different behaviour in different depth ranges.
2. *Diel activity is the result of different needs.* Activity patterns are closely linked to or even regulated by the day-night cycle, but they result from different individual needs such as ontogenetic phase, foraging, reproduction-related behaviour, or migration. Thus, they may be distributed over different periods of day and night (Helfman 1993). Generally, the patterns of larvae, juveniles and adult fishes of a certain species may differ considerably from each other, including through ontogenetic shifts in diel feeding activity (Nunn et al. 2012). For instance, in several scorpionid species juveniles may be diurnal while adults are nocturnal (Lowe and Bray 2006). In many fishes, the window of courtship and spawning contrasts with the period of feeding and migration (a so-called "breakdown in normal activity pattern"; Helfman 1993). Many species of cardinalfishes are strictly nocturnal, but spawn during day (Kuwamura 1983; Thresher 1984), while some herrings are day feeders but spawn at night (Ferraro 1980; Ganias et al. 2014). Last but not least, the day-night cycle of activity may be regulated or maintained by further exogenous cues such as lunar phase, tide and salinity (Lowe and Bray 2006).
3. *The diel pattern of a species is not cast in stone.* In contrast to the circadian rhythms common in higher vertebrates, circadian behaviour in fishes is not always rigidly confined to the light or dark phase. Some fish species exhibit a highly flexible circadian system that is capable of change – a feature that is not reported in higher vertebrates (Eriksson 1978). At least in the adult stage, species of many fish families show a great plasticity in activity patterns that can differ between individuals, populations and seasons (see Reebs 2002 for a review and the information given in the Electronic Supplementary Material [ESM]). Diel plasticity in feeding of adult fishes has been linked with differences in habitat (Fox and Bellwood 2011), storm-caused turbidity (Collette and Talbot 1972), rainfall (Payne et al. 2012), temperature (Fraser et al. 1993), response to hunger or satiation (Metcalfe and Steele 2001), and predator abundance (McCauley 2012). Seasonal changes in diel foraging periods often result from seasonal differences in supply of food species; examples are *Conger conger* (Bozzano and Sardà 2002), *Gobius niger* (Hesthagen 1976; Westin and Aneer 1987), *Trachinotus ovatus* (Nash et al. 1994), *Pleuronectes platessa* (de Groot 1971), *Dicentrarchus labrax* (Sánchez-Vásquez et al. 1998) or *Eutrigla gurnardus* (Bahamon et al. 2009). Intraspecific variation in activity patterns (i.e. where some individuals are, for example, diurnal, while others are crepuscular or nocturnal) is known from co-occurring individuals as well as from those living in different depth ranges (Westin and Aneer 1987; Aguzzi et al. 2015b). Additionally, the phase of activity in a species may depend on abiotic parameters, e.g. tide cycles, solar altitude or water temperature (Gibson 1970, 2005; Antholz et al. 1991; Ribeiro et al. 2006; Campos et al. 2008 and further information given in the ESM). Thus, individuals of the same species may have different behaviour, resulting in varied diel patterns at the species level (Magurran, 1993).

The present study provides a comprehensive review of the diel activity patterns of fishes at the regional scale of the Mediterranean Sea. It not only summarizes the existing knowledge of diel activity, but separates the complex patterns into different aspects of activity, i.e. feeding, courtship and spawning, as well as migrating. In addition, the diel activity information is then used to address a series of ecological questions. Since the diel activity pattern is an important species trait, influencing food availability, predation avoidance and competition, and is therefore closely connected to the species' niche, we assessed the link between activity pattern and species affinities and niche parameters. We also looked for relationships between activity pattern and colonization success, given that it has been suggested that nocturnal feeding favours establishment of Indo-Pacific non-indigenous species in the Mediterranean due to reduced competition by native species (Mooney and Cleland 2001; Otero et al. 2013). Therefore, the goals of our paper comprise a first synthesis and review of so far dispersed facts about activity patterns of Mediterranean fishes on the one hand, and an analysis of scientific questions based on hypotheses on the other hand. In detail these aims are: (1) to develop a comprehensive scheme for classifying activity type that goes beyond the simple dichotomous 'diurnal vs. nocturnal' categorisation; (2) to give the first overview of diel activity patterns of teleost fishes inhabiting above 200 m depth in the Mediterranean Sea and to highlight gaps of knowledge; (3) to test the hypothesis that closely related species share similar diel patterns; (4) to test the hypothesis that there is an association between activity pattern and other ecological traits, namely trophic level, habitat, and depth preference; and finally (5) to test the hypothesis that a certain activity pattern may facilitate colonisation by newcomer fishes because this type of activity pattern is underrepresented in native Mediterranean fishes.

Methods

Diel activity classification and review of diel activity patterns

Examined taxa

All teleost fish species that are regularly found in Mediterranean waters at depths shallower than 200 m as adults were considered in this study, including littoral and epipelagic fishes, and also mesopelagic species showing diel vertical migrations (DVM) from deeper water to near surface layers. Besides native Mediterranean species, newcomers (i.e. non-indigenous or range-expanding species) originating from the Atlantic and Indo-Pacific were also considered. The list of selected fish species was based on Psomadakis et al. (2012) and was extended according to information given by Louisy (2015), Froese Pauly (2019) and recent publications about Atlantic and Indo-Pacific immigrants (see Evans et al. 2020 and ESM, Part 4). The classification of families follows Nelson et al. (2016).

Species of the native families Berycidae (Alfonsinos), Centrolophidae (Medusafishes), Lophotidae (Crestfishes), Macrouridae (Grenadiers), Moridae (Deepsea cods), Peristediidae (Armored searobins), and Trachichthyidae (Slimeheads) were excluded because they are mainly deep-water fishes and were only recorded above 200 m as juveniles or exceptionally as adults. Only newcomer fishes first recorded before the year 2014 were included in the study, which allowed to examine spread and establishment success of Indo-Pacific species (aim v of this paper, see Introduction) and to compare these results with those by Arndt and Schembri (2015). Since colonisation success depends on the time elapsed since first introduction, non-indigenous fish species first recorded in 2014 or later were excluded, as they were considered too recent for assessment of their spread and establishment success.

Based on the above, a total of 558 species (393 native and 165 newcomer species) representing 124 families were considered in more detail, of which 14 families are represented only by Indo-Pacific immigrants and five families are represented only by Atlantic newcomers.

Collection of data on diel activity

The basis for the present work is a comprehensive review of the literature of fish ecology and behaviour. Standard references like Hobson (1965, 1972, 1974), Thresher (1984), Helfman (1993), Pitcher (1993), Reebs (2002), Allen et al. (2006), Sloman Wilson Balshine (2006) and Helfman et al. (2014) constituted the first important source in the early phase of the investigation. The second and most important source was a search for scientific papers in online libraries of large publishers such as Elsevier, Springer, Wiley a.s.o., and the scientific online data banks Biological Abstracts/BIOSIS Previews (part of the Web of Science suite), CAB Abstracts Archive and Zoological Record. The following search terms were used: taxon + diel; taxon + diurnal [or nocturnal respectively]; taxon + activity + day [or night respectively]; whereby 'taxon' was a certain genus or a certain fish species. Thirdly, scientific papers, research reports and student degree theses were also searched in the internet via the Google and Microsoft Bing search engines, using the same search terms listed above. The internet searches complemented those made in scientific online libraries and data banks, since the latter are limited to scientific papers only. These searches were repeated for all examined fish species. The search was completed in December 2018. About 1600 publications, reports and theses with data on diel activity of fish species or families were included in the present analysis.

Moreover, the following data have been contributed to the present study:

1. Citizen science; almost 400 diving centres from Portugal, Spain, France, Italy, Malta, Greece, Croatia, Montenegro, Turkey, Cyprus, Israel, and the users of the German internet forum 'Taucher.-net' were contacted. The divers were asked specifically for night-time observations of remoras (Echeneidae), gurnards (Triglidae), porgies (Sparidae), gobies (Gobiidae) and clingfishes (Gobiesocidae). Several divers replied and provided new information, especially on remoras. This information was verified based on photos or short movies.
2. TV-documentaries.
3. Observations by one of us (EA) in the Mediterranean Sea and north-east Atlantic during the last 20 years, mainly relating to intertidal fishes.

Based on this extensive data collection exercise, a species-level summary of the diel activity patterns of the 558 Mediterranean fishes included in the present work, taking into consideration different aspects such as feeding, courtship, spawning, or migrations, was prepared (ESM Part 1).

Definition of terms

Diel activity pattern refers to the temporal changes in behavioural activity during the 24-h cycle (Helfman et al. 2014). It includes active and inactive phases. Active phases may be feeding, courtship, spawning, active broodcare (e.g. by defending nests or fanning water), and migration. Resting and predator avoidance behaviour by hiding in rock crevices or substrate represent inactive phases. Schooling may be a form of activity if schooling fish move actively, or a part of inactivity, e.g. if nocturnally active fish form schools hovering nearly motionless over the substrate during the day (Hobson 1965, Hobson 1972: p. 730; Ehrlich and Ehrlich 1973; Helfman 1978; Rooker and Dennis 1991: p. 694; Pereira and Ferreira 2013). Diel activity patterns may or may not be generated by an endogenous circadian clock, whereas the term 'circadian' refers to an endogenous mechanism (Reebs 2002). Laboratory-based observations are needed to establish if a given diel activity pattern is due to an endogenous circadian clock.

Descriptions of species' activity patterns were made in accordance with the following types of pattern:

Strictly diurnal Active during daylight; resting at night.

Mainly diurnal Mainly active during daytime, to a lesser extent also during crepuscular periods and at night; spawning may take place at night.

Crepuscular Mainly active during dusk and/or dawn.

Mainly nocturnal Mainly active during the night, to a lesser extent also during crepuscular periods and by day; spawning may take place during the day.

Strictly nocturnal Active during the night; resting during the day.

Cathemeral Neither predominantly nocturnal nor diurnal nor crepuscular, but irregularly active at any time of night or day, according to prevailing circumstances (Allaby 2014). In its strict definition, cathemeral does not mean reversals of activity patterns from one season to the next (also called 'inversion pattern', i.e. seasonal change from diurnal to nocturnal or vice versa) or changes of activity periods between different populations of the same species. However, in practice, the distinction between a lack of distinct patterns (i.e. cathemeral activity) and an inversion pattern, or a change in activity periods from population to population, may be impossible to make if not enough data are available. Therefore, for practical reasons, we treat these various cases collectively under the cathemeral label in the following examination. The increasing volume of data arisen during the last two decades suggests however that true cathemeral patterns in marine fishes are more abundant than assumed earlier (see e.g. Coles 2014).

Diel vertical migration (hereafter abbreviated DVM): Cyclic changes in the position within the water column that occur with 24-h periodicity (Neilson and Perry 1990). It may occur from larval to adult stages of fishes and may traverse distances of several hundred meters in adults. There are two general patterns of DVM: staying in deeper water during day and migrating to near surface water at night, or vice versa. The second type, i.e. migration to deep water during night, is far less common in adults of marine fishes (Neilson and Perry 1990).

Assigning species to diel activity categories

Based on the above definitions, a comprehensive scheme for classifying activity type was formulated, including seven diel activity types: (1) strictly diurnal; (2) mainly diurnal; (3) crepuscular; (4) mainly nocturnal; (5) strictly nocturnal; (6) cathemeral; (7) diel vertical migration. The terms "diurnal" and "nocturnal" are hereafter used in a collective sense, including both strictly and mainly diurnal, or nocturnal, species. While different aspects of the fishes' life such as feeding, courtship, spawning, or migrations were taken into consideration when describing their activity patterns (see ESM Part 1), we focused on feeding as the primary driver of activity when assigning species to these activity categories. This approach was necessary since for most fishes, only data on foraging activity were available. In addition, species for which not enough data were available were placed in a separate category ('unknown or not sufficiently known').

For the purposes of this review, the definition of DVM was interpreted in a very narrow sense to include only species that regularly migrate from deeper water to surface water in order to feed there at night, and descend again to the deep water during dawn. This type of diel vertical migration is characteristic of mesopelagic fishes (e.g. hatchetfishes, lightfishes, laternfishes) and a few other taxa (see ESM Part 1). Species classified as having a DVM activity category are therefore essentially nocturnal feeders, but they are here treated separately from littoral and epipelagic nocturnal species (which do not undertake DVM as defined here).

Vertical movements are also widespread in small schooling pelagic taxa (e.g. anchovies), large pelagic-oceanic fishes (e.g. tunas, marlins, dolphinfish, ocean sunfish), and various eels, but all of these differ from the above-described narrow definition of DVM by performing multiple short dives or a cathemeral feeding pattern, or by showing vertical migration that is linked to occurrence of prey in a very short period of the year only or to populations in a restricted part of the distribution area. Therefore, these species were not placed in the category DVM.

Analysis of scientific hypotheses

Link between diel activity and species affinities

To assess the link between activity pattern and species affinities, the information for species belonging to the same family was compared qualitatively. This allowed us to determine the most common activity pattern(s) for each family, and identify those families with high variability in their activity patterns (ESM Part 2).

Link between diel activity and other ecological traits

To investigate whether there is any relationship between activity pattern and other ecological traits in Mediterranean native fishes, information on the trophic level, preferred depth, and habitat of each species was included in our database (ESM Part 3).

Trophic level (TL) data were extracted from the FishBase databank (Froese and Pauly 2019), except in the case of two species for which FishBase does not give a TL value (*Salaria basilisca*, *Speleogobius llorisi*). The data were checked by comparing the TL of each species to its diet as reported in the same databank, and by comparing the TL values of closely related species to identify outliers. Five species were excluded from the analysis: the blennies *Lipophrys dalmatinus* and *Lipophrys trigloides* and the pipefishes *Nerophis lumbriciformis*, *Nerophis ophidion*, *Syngnathus typhle* (all having TL $\geq$ 4.0; inconsistent with their diet and also considering that all other members of Blenniidae and Sygnathidae with similar diets have TL $\leq$ 3.7).

The preferred depth zone (minimum and maximum depths at which species commonly occurs) was obtained from Louisy (2015) as primary source, or FishBase as secondary source. When neither of these sources contained information on the preferred depth zone, the IUCN Red List of Threatened Species Factsheets for the Mediterranean region (IUCN 2020) were consulted. When none of these sources included the preferred depth zone, the minimum and maximum depths of occurrence were taken instead. These values were used to calculate the midpoint (Dpref_mid, in metres) between the shallower and deeper ends of the preferred depth zone.

Species were assigned to five nominal habitat type categories (pelagic, hard bottom, soft bottom, vegetated bottom, multi-habitat use) based on the information on habitat use included in FishBase and Louisy (2015), and in the IUCN Factsheets for the Mediterranean when necessary.

Comparisons between activity categories were made separately for pelagic and demersal native species, given the potentially different ecologies between the pelagic and demersal realms. However, in the case of pelagic species, the low species counts ($n \leq 5$) for four of the seven activity categories precluded detailed analyses. For the two numerical variables (TL, Dpref_mid), Levene's test for homogeneity of variances indicated heteroscedasticity, and the Welch F-test was hence used to test for differences in mean values between the different activity categories. Where relevant, Bonferroni-corrected Mann–Whitney pairwise tests were subsequently used to determine significant differences between pairs of activity categories. In the case of the nominal variable habitat type, a χ^2-test was used to check for a significant association between the habitat type and activity pattern categories. Species with an unknown activity pattern were excluded from all analyses, while species showing DVM were excluded from the depth and habitat type analysis since they are obviously primarily pelagic and have the widest depth ranges. All analyses were based on a level of significance of $\alpha = 0.05$ and made using Past v.4 (Hammer et al. 2001).

Link between diel activity and colonization success of newcomer species

To test if a specific activity pattern facilitates colonization by newcomer species due to being underrepresented amongst native Mediterranean fishes, the proportions of species having different activity patterns for native species were compared with those of Atlantic and Indo-Pacific newcomers using a χ^2-test, excluding counts for species with an 'Unknown' pattern. Particular focus was given to potential differences in the proportion of nocturnal species, given assertions in the literature that nocturnal immigrants might be more successful colonisers.

Further assessment of links between colonization success and activity pattern was undertaken separately for Atlantic and Indo-Pacific species. Atlantic newcomer species comprise a heterogeneous group that includes non-indigenous, vagrant and range-expanding species, as well as several species which cannot be conclusively assigned to one of these categories and which are therefore regarded as cryptogenic, and they were therefore classified into these four categories following Evans et al. (2020). By definition, range-expanding species are ones that have successfully dispersed and established populations, so for this group a quantitative comparison of the proportion of species having different activity patterns was undertaken. On the other hand, the number of alien and vagrant species was too low ($n \leq 7$) to undertake further detailed analysis for these groups.

Indo-Pacific newcomer fishes are all considered to be non-indigenous in the Mediterranean; apart from a handful of species, most have entered the Mediterranean via the Suez Canal (so called Lessepsian species). These species differ greatly in their colonization success. To test if a specific activity pattern facilitates the invasion by Indo-Pacific immigrants, two invasion parameters were linked to their activity patterns:

1. *Dispersal success* This parameter describes the distance travelled by the Lessepsian species within the Mediterranean. We used three ordinal categories: (1) Low dispersal success: records only in one locality or region near the entrance of the Suez Canal. (2) Medium dispersal success: records from the coast from Lebanon to South Turkey and Rhodes or Egypt west of Alexandria but not west of Rhodes or the Egypt-Libya boundary respectively. (3) High dispersal success: dispersal to the Central and / or Western Mediterranean Sea beyond the boundaries of the Levantine Sea.
2. *Establishment success* The 'establishment success' is a surrogate of abundance or population size. A successful establishment is not necessarily related to the dispersal ability. On the one hand, large abundances, even dominating fishery catches, can be achieved in a restricted area, e.g. the Israeli and/or the Lebanon coasts. On the other hand, a species may travel as far as the Central Mediterranean Sea but is recorded only

sporadically. Analogous to the dispersal success we used three ordinal categories for the establishment success: (1) Low: single or only a few sporadic records, either of solitary individuals or of small groups of schooling fish. (2) Medium: repeated records, up to 50 individuals in schooling fish. (3) High: large numbers, at least locally dominant in fishery trawls [> 1% of total catch] **or** frequent sightings of non-schooling fish in many different localities.

The activity patterns were condensed to three nominal categories: diurnal; nocturnal; without constant pattern. Because the data of dispersal and establishment were not normally distributed, Mann–Whitney U-tests were used to test if categories of activity patterns differed from each other. Species and data used in these analyses are listed in Part 4 of the ESM. All analyses were based on a level of significance of $\alpha = 0.05$ and made using Past v.4 (Hammer et al. 2001).

Results

State of knowledge of diel activity patterns of Mediterranean species

A total of 558 littoral and epipelagic fish species from the Mediterranean Sea, representing 124 different teleost families, were included in the analysis. Activity data are completely lacking for 110 species (19.7%), comprising 73 indigenous and 37 newcomer fishes (cf. ESM Part 1).

The level of knowledge of diel activity patterns differs not only from species to species but also from family to family. Generally, the patterns of fishes that play an important role in fisheries and mariculture are well known. Thus, we have a high level of knowledge in Anguillidae, clupeiform families, Myctophidae, Merlucciidae, carangiform and scombriform families. Furthermore, activity patterns of families used for aquarium keeping are also well known, e.g. Syngnathidae, Chaetodontidae, Acanthuridae and Pomacentridae. In the Mediterranean Sea, the latter three families represent mainly species of Indo-Pacific or tropical Atlantic origin. On the other hand, the knowledge about activity patterns is much lower in circalittoral fishes and in small, often cryptobenthic, fishes colonizing mostly shallow water or sometimes even very shallow water, such as gobies, clingfishes and blennies. Only fragmentary information exists about the activity of mud eels (Heterenchyidae), pike congers (Muraenesocidae), duckbill eels (Nettastomatidae), flagfins (Aulopidae), greeneyes (Chlorophthalmidae), lancetfishes (Alepisauridae), oarfishes (Regalecidae), remoras (Echeneidae), tonguefishes (Cynoglossidae), threadfins (Polynemidae), bandfishes (Cepolidae) and louvar (Luvaridae).

The information at family level, based on all available information about activity patterns of individual species, is summarized in the ESM (Part 2).

Adult feeding activity patterns

The large majority of available data concentrates on foraging activity patterns of adult fishes, therefore the following data as well as those in Table 1 and Fig. 1 refer to adult feeding patterns. More than a third (37%) of native Mediterranean fishes are diurnal, while 19% are nocturnal species. The share of species with crepuscular activity is insignificantly low (2.3%). The percentage in these activity categories is comparable in newcomer species (Table 1). An important portion of native species (23%) shows indistinct rhythms or alternative patterns, such as DVM or patterns that change between day and night from population to population or from season to season. These patterns, split in Table 1 into the categories cathemeral and DVM, are more frequent in native species than in non-indigenous fishes.

Apparent differences in the distributions of activity categories occur in native species if pelagic and benthic fishes are regarded separately (Fig. 1). Whereas cathemeral patterns and DVM dominate in the group of pelagic species, the portion of cathemeral species is much smaller in demersal species, and DVM is a rare exception in the latter group. On the other hand, the portion of diurnal and nocturnal fishes is much higher in demersal species. The patterns of newcomer species are similar to those of native demersal fishes (Table 1).

Diel patterns going beyond adult feeding patterns

While we have data about adult feeding patterns from more than 80% of native and more than 75% of newcomer species in the Mediterranean, knowledge

Table 1 Species number and percentage of different categories of (foraging) activity in native and newcomer Mediterranean fish species

	All species		Native species		IP species		A species		All NF	
	Count	%	Count	%	Count	%	Count	%	Count	%
Strictly diurnal	89	15.9	60	15.3	16	14.4	13	24.1	29	17.6
Mainly diurnal	129	23.1	87	22.1	26	23.4	16	29.6	42	25.5
Crepuscular	11	2.0	9	2.3	2	1.8	0	0.0	2	1.2
Mainly nocturnal	64	11.5	45	11.5	14	12.6	5	9.3	19	11.5
Strictly nocturnal	45	8.1	29	7.4	11	9.9	5	9.3	16	9.7
Cathemeral	78	14.2	63	16.0	12	10.8	4	7.4	16	9.7
DVM	32	5.6	27	6.9	1	0.9	3	5.6	4	2.4
Unknown	110	19.7	73	18.6	29	26.1	8	14.8	37	22.4
Total N	558		393		111		54		165	

IP—Species of Indo-Pacific origin; A—Species of Atlantic origin; All NF (Newcomer fishes)—Sum of Atlantic and Indo-Pacific immigrants; DVM—Diel vertical migration

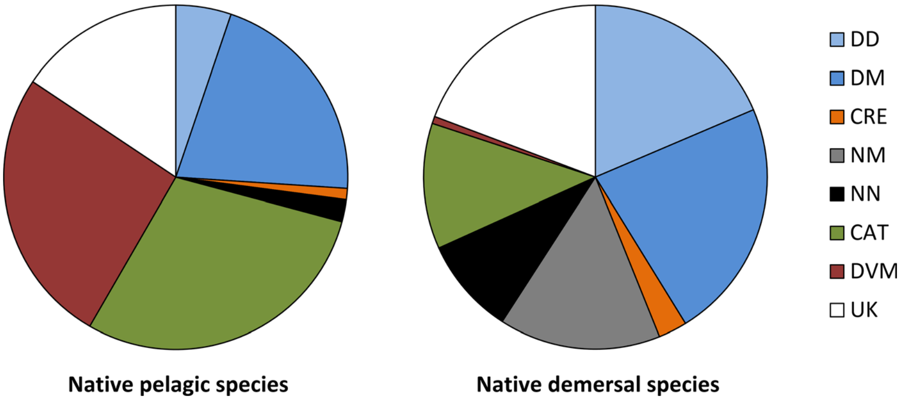

Fig. 1 Distribution of (foraging) activity in Mediterranean fishes. Left: native pelagic species (n = 96); right: native demersal species (n = 297); Abbreviations: DD–strictly diurnal; DM–mainly diurnal; CRE–crepuscular; NM–mainly nocturnal; NN–strictly nocturnal; CAT–cathemeral; DVM–diel vertical migration; UK–unknown or insufficiently known

about time of the day of reproduction, migratory movements, defence of territories and other non-foraging activities is much lower. Information about the exact diel period of courtship and spawning exists for approximately 40% of examined species, with about the same level of knowledge in native and newcomer species (see ESM Part 1). Information about diel activity patterns of larvae and juveniles is much more scattered than that of adults and generally limited to taxa that are important for fisheries. Examples of taxa well known in the developmental stages are Carangidae, Engraulidae, Clupeidae, Gadidae, Mugilidae, Mullidae as well as *Dicentrarchus labrax*, *Pagrus pagrus* and *Thunnus* spp. (see details in ESM Part 1).

Activity patterns of phylogenetically related species

The large majority of closely related species have similar activity patterns, since notable interspecific differences are only present in around 30% of the Mediterranean fish families. In the Mediterranean Sea, there are 26 families with five or more species, 17 of which show a clear choice in their diel activity, i.e. most or all species have the same pattern (Table 2 and ESM Part 2). A further two families have cathemeral patterns showing a high plasticity at the species level. Only seven families, including about a fourth of species-rich families, do not reveal a clear pattern. This trend continues in families comprising 2–4 Mediterranean species, where more than 30 families with clear choice in their diel activity patterns contrast with just six that do not (the remaining families have

Table 2 Predominant categories of diel activity of teleost families with five or more species in the Mediterranean Sea

Diurnal		Nocturnal	DVM	No distinct pattern	
				Cathemeral	Various categories
Acanthuridae	Mugilidae	Apogonidae	Myctophidae	Belonidae	Carangidae
Blennidae	Mullidae	Ophichthidae		Scombridae	Clupeidae
Bothidae	Pomacentridae	Sciaenidae			Gadidae
Callionymidae	Serranidae (Anthiinae and Serraninae)*	Soleidae			Gobiidae
Gobiesocidae	Syngnathidae				Scorpaenidae
Labridae	Tetraodontidae				Sparidae
					Triglidae

*Note that many species of Epinephelinae are cathemeral, but patterns of most species are still insufficiently described

The categories diurnal and nocturnal include 'strictly' and 'mainly' diurnal or nocturnal species respectively. The crepuscular pattern did not predominate species-rich families. Families that do not show a uniform trend in activity are listed under 'various categories'

too large gaps in knowledge of species' patterns). Examples of families with a large variability in their activity patterns are:

- Carangidae (jacks and pompanos) include diurnal, nocturnal and cathemeral species; three native and two newcomer species are insufficiently known.
- Gobiidae (gobies): Most species are mainly diurnal or do not show a clear pattern, however, mainly nocturnal and crepuscular species do occur as well; 40 percent of the species are still insufficiently known.
- Sparidae (porgies): Most species are mainly diurnal, but crepuscular, nocturnal and cathemeral species also occur, and 12 species are insufficiently known.
- Diodontidae (porcupinefishes) and moray eels (Muraenidae) belong to families containing less than five species with diverse patterns.

Most of the species-rich families with uniform patterns show diurnal activity, merely four are nocturnal. Myctophidae are the only representatives of the species-rich families with regular DVM. However, at least some species of bristlemouths (Gonostomatidae), cutlassfishes (Trichiuridae), hatchetfishes (Sternoptychidae), lightfishes (Phosichthyidae) and gapers (Champsodontidae) undertake DVM too. Cathemeral patterns are widely distributed in large pelagic fish. Beside needlefish (Belonidae), mackerels and tunas (Scombridae), cathemeral activity is also known from dolphinfishes (Coryphaenidae), billfishes (Istiophoridae), pomfrets (Bramidae) and sunfishes (Molidae). Among demersal fishes, cathemeral patterns are typical only in lizardfishes (Synodontidae) and grunters (Terapontidae), two families represented mainly by non-indigenous species in the Mediterranean Sea.

Link between activity patterns and other ecological traits

Mean trophic level (TL) values per activity type in demersal native species ranged between 3.31 and 3.80 (Fig. 2); the extent of any differences in TL is therefore small. Nonetheless, there was a statistically significant difference in mean TL (Welch $F_{5,225} = 6.07$, $p < 0.001$). This was primarily due to strictly and mainly diurnal species having significantly lower mean TL values than strictly nocturnal ones ($p < 0.001$ in both cases). Although the mean TL of crepuscular species was the second highest, there was also a large variability in TL among species belonging to this category. As a result, the pairwise tests did not indicate a significant difference in TL between crepuscular species and any other activity category. In the case of mainly nocturnal and cathemeral species, the mean TL was intermediate between those of diurnal species at the lower end, and those of crepuscular and strictly nocturnal species at the higher end.

In the case of pelagic native species, the mean TL for cathemeral species (mean TL = 3.95) was higher

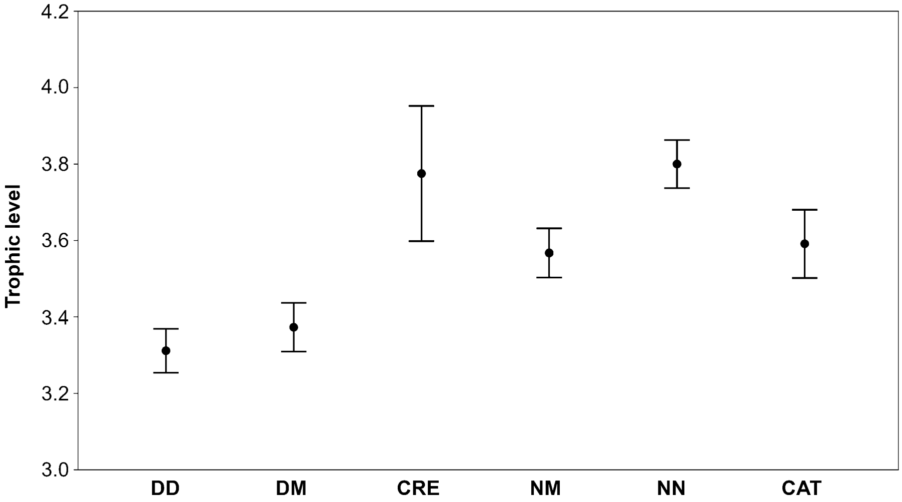

Fig. 2 Mean ± SE values of trophic level for each activity category in demersal native species. Abbreviations: DD–strictly diurnal; DM–mainly diurnal; CRE–crepuscular; NM–mainly nocturnal; NN–strictly nocturnal; CAT–cathemeral

than that of mainly diurnal species (mean TL = 3.42), while the number of pelagic species in the other activity patterns was too low ($n \leq 5$) to reach any meaningful conclusion. Species undertaking DVM had a low mean TL (3.32) comparable to that of diurnal species.

Significant differences in mean values of the preferred depth zone midpoint (Dpref_mid) of demersal native species were recorded when comparing the different activity categories (Fig. 3, Welch $F_{5,231} = 7.66$, $p < 0.001$). Post-hoc multiple comparisons showed that strictly diurnal species had a significantly lower mean Dpref_mid value compared to the mainly diurnal, mainly nocturnal and strictly nocturnal categories ($p < 0.01$), whereas strictly nocturnal species had a significantly higher value compared to diurnal and cathemeral ones ($p < 0.05$). The other pairwise comparisons returned a non-significant p-value.

In the case of pelagic native species, the mean Dpref_mid value for cathemeral species (mean Dpref_mid = 77.6 m) was higher than that of mainly diurnal species (mean Dpref_mid = 27.6 m), while the number of pelagic species in the other activity

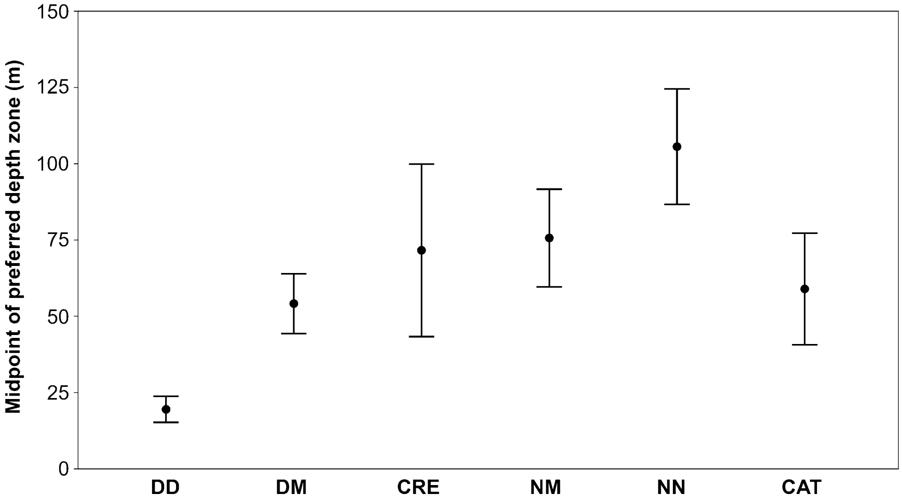

Fig. 3 Mean ± SE values of the midpoint of preferred depth zone for each activity category in demersal native species. Abbreviations: DD–strictly diurnal; DM–mainly diurnal; CRE–crepuscular; NM–mainly nocturnal; NN–strictly nocturnal; CAT–cathemeral

patterns was too low ($n \leq 5$) to reach any meaningful conclusion.

There was also a significant association between the habitat type of a species and its activity pattern ($\chi^2_{20} = 100.09$; $p < 0.001$). Sole use of vegetated bottoms is very rare across all activity categories. More than half of the crepuscular species are multi-habitat users, while this habitat type is also the most common in strictly diurnal species (43%); it is also seen in around one fourth of the species in all other activity categories. Most of the other strictly diurnal species (35%) primarily occur on hard bottoms; this is also the second most common habitat type of crepuscular species. On the other hand, cathemeral species occur in higher proportions in the water column (44%), whereas species having mainly diurnal activity pattern are more evenly distributed among different habitat types. Nocturnal species differ from the rest by being predominantly found on soft bottoms (58% and 66%) (Table 3).

Novelty of traits: Are immigrants with a particular activity pattern more successful?

As shown in Table 1, a nocturnal activity pattern is less prevalent among native Mediterranean fishes (18.9% of species) than a diurnal activity pattern (37.4% of species). However, the same is true for Indo-Pacific newcomers (22.5% nocturnal vs 37.8% diurnal) and immigrants of Atlantic origin (18.6% nocturnal vs 53.7% diurnal). We found no significant association between the activity pattern and origin (native, Atlantic, or Indo-Pacific) of fishes ($\chi^2_{12} = 7.58$; $p = 0.817$).

In the case of Atlantic range-expanding species, which are considered to be successful colonizers, the portion of nocturnally feeding species (20%) was not appreciably different to that of native species, and the majority of Atlantic range-expanding species are diurnally active (50% of species). While the low number of vagrant and non-indigenous species of Atlantic origin ($n \leq 7$) precludes detailed assessment, both groups were also represented by more diurnal fishes than nocturnal ones.

In the case of non-indigenous species of Indo-Pacific origin, neither dispersal success nor establishment success differed significantly between nocturnal species and diurnal species or species without uniform pattern (mean dispersal success = 2.2 in nocturnal species, compared to 2.25 in diurnal Indo-pacific immigrants; mean establishment success = 2.1 in nocturnal species, compared to 2.0 in diurnal species). Thus, there was no significant difference in the colonisation success of non-indigenous species having different types of diel activity pattern.

Discussion

State of knowledge of diel activity patterns of Mediterranean species

The present review highlights that knowledge of diel activity patterns for most Mediterranean fishes is largely limited to adult feeding activity. While feeding

Table 3 Number of native species having a particular habitat type (HT) for each activity category, together with the percentage within each activity category

	DD		DM		CRE		NM		NN		CAT	
	Count	%	Count	%	Count	%	Count	%	Count	%	Count	%
HTpel	5	8.3	20	23.0	1	11.1	0	0.0	2	6.9	28	**44.4**
HThb	21	**35.0**	14	16.1	2	22.2	5	11.1	1	3.4	8	12.7
HTsb	5	8.3	26	29.9	1	11.1	26	**57.8**	19	**65.5**	12	19.0
HTvb	3	5.0	1	1.1	0	0.0	2	4.4	0	0.0	1	1.6
HTmulti	26	**43.3**	26	29.9	5	**55.6**	12	26.7	7	24.1	14	22.2

Instances where a habitat type includes more than one third of all species for a given activity category are indicated in bold. Abbreviations: *DD* strictly diurnal, *DM* mainly diurnal, *CRE* crepuscular, *NM* mainly nocturnal, *NN* strictly nocturnal, *CAT* cathemeral, *pel* pelagic, *hb* hard bottom, *sb* soft bottom, *vb* vegetated bottom; multi–multi-habitat use is undoubtedly an important driver of activity patterns, many other aspects of fishes' life can exhibit diel patterns, including the time of reproduction, migratory movements and defence of territories. Ecological data on these traits, including their diel periodicity, are essential for better understanding interactions in species communities, trends in population dynamics, and even the effects of anthropogenic activities. Lowerre-Barbieri et al. (2011) accentuated the importance of diel spawning patterns, whereby spawning time directly affects survival and dispersion of offspring. In particular, the timing and site of egg release determine the environment first encountered by an egg, and thus the suitability of physical conditions (e.g., salinity, temperature and current), the probability of fertilization, and the presence of potential predators (Lowerre-Barbieri et al. 2011). The diel periodicity in relation to spawning varies with species and may encompass any period of the 24-h cycle. Moreover, some marine species do not show a distinct diel spawning pattern at all, e.g. European hake *Merluccius merluccius* (Murua and Motos 2006) and Atlantic mackerel *Scomber scombrus* (Priede and Watson 1993).

Several fishes show territorial behaviour that is linked to diurnal activity patterns due to visual cues playing an important role in territorial defence. Examples are several species of Bothidae (e.g. *Bothus podas*, Carvalho et al. 2003), Gobiidae (e.g. *Zosterisessor ophiocephalus*, Mazzoldi et al. 2000), and Blenniidae (e.g. *Ophioblennius atlanticus*, Côté and Hunte 1989), as well as the non-indigenous butterflyfish *Chaetodon larvatus* (Zekeria 2003) and the damselfish *Stegastes variabilis* (Medeiros et al. 2010). At least some species of dragonets are territorial and diurnally active during their period of courtship and reproduction, including *Callionymus lyra* (Holt 1898; Wilson 1978) and several non-Mediterranean species (Wittenrich and Ho 2013). A similar behaviour can also be assumed in other Mediterranean dragonets due to their peculiarly enlarged dorsal fin. Several demersal spawners define nest territories that are defended during the day, e.g. Balistidae (Thresher 1984; Simmons and Szedlmayer 2012) and Batrachoididae (Amorim 2006).

The migration of fishes over large distances, e.g. to spawning places, may be a further factor influencing diel activity patterns during certain periods of the year. The European plaice *Pleuronectes platessa*, European flounder *Platichthys flesus* and common sole *Solea solea* are examples of flatfish exhibiting diel migratory patterns (Riede 2004). The oceanodromous plaice and sole show nocturnal migration activity (Verheijen and de Groot 1967; Solmundsson et al. 2003; Hunter et al. 2004; Gibson 2005). The migratory behaviour of the catadromous European flounder is very variable and even differs between sections of the same estuarine population (Summers 1979; Wolff et al. 1981). Many large vagrant fishes, e.g. swordfish, billfishes, tunas and mackerels, are active during all periods of the day or swim continuously during the 24-h cycle (e.g. Magnuson and Prescott 1966; Hoolihan 2005; Chancollon et al. 2006; Mourato et al. 2010; Chiang et al. 2013; Abascal et al. 2015). Moreover, swordfish, several billfishes and scombrids show oscillatory vertical movements (Horodysky et al. 2007; Schaefer and Fuller 2007; Mourato et al. 2010; Cosgrove et al. 2014).

Several species combine oceanodromous migration with DVM. A well-known example is the European eel *Anguilla anguilla* that not only crosses the Atlantic Ocean, but also undertakes DVM during its migration to the spawning area in the Sargasso Sea, occupying shallow warm water during night and diving into the cool zone at dawn (Aarestrup et al. 2009). The ocean sunfish *Mola mola* has a quite complex migratory pattern with elements of vertical movements as well (Cartamil and Lowe 2004; Hays et al. 2009; Dewar et al. 2010; Pope et al. 2010; Potter and Howell 2010). Other examples include the mesopelagic pomfret *Brama brama* (Mead 1972; Bauchot 1987), greater forkbeard *Phycis blennoides* (Bahamon et al. 2009), saury *Scomberesox saurus* (Korkosh 1992) and lanternfishes (Myctophidae; Roe and Badcock 1984; Hulley 1990, 1991). Several small pelagic clupeids and engraulids that perform DVM are oceanodromous as well (Riede 2004). Examples are the round sardinella *Sardinella aurita* (Johnson and Vaught 1986; Gonzales et al. 1998), sprat *Sprattus sprattus* (Nilsson et al. 2003) and blue anchovy *Engraulis encrasicolus* (Sabatés et al. 2008).

The interplay between feeding and other ecological traits influencing activity patterns is particularly evident when considering DVM. This concept was reviewed in detail by Neilson and Perry (1990), who distinguished two types: Type-I ('normal' DVM, i.e. migrating to shallower waters at night), and Type-II ('inverted' DVM). DVM may be undertaken in response to food availability including movement of prey, but can also be related to predation avoidance, gaining a bioenergetic advantage (in thermally stratified waters), or movement of commensal species (Neilson and Perry 1990). Our review suggests that Type-II DVM is practically absent in the Mediterranean adult fishes. In fact, the examples cited by Neilson and Perry (1990) include mostly larval and juvenile stages. Although these authors indicate that adults of the Atlantic cod show Type-II DVM, this species can also exhibit Type-I DVM (Cohen et al. 1990). Within its very wide range, the cod shows non-uniform activity patterns and thus should be regarded as a cathemeral species.

These considerations highlight three important points. First, even when it comes to foraging activity, the diel pattern is unknown for around one fifth of the species considered in this study. In particular, knowledge about activity patterns is much lower in circalittoral and small, cryptobenthic fishes, which may be due to methodological difficulties associated with studying behavioural patterns of such species. Secondly, besides the general lack of information on adult activities other than feeding for most species, there is also very scarce knowledge of diel patterns of larval and juvenile stages, which may differ considerably from adults through ontogenetic shifts in diel feeding activity (Helfman 1978; Lockett and Suthers 1998; Annese and Kingsford 2005; Nunn et al. 2012). Finally, even in adults, the activity patterns can be complex and dependent on various factors. Thus, as amply discussed above (see Introduction), binary categorisations of activity used in several trait analyses oversimplify the variety of patterns seen in marine fish communities. In the present work, we considered diel activity patterns to be more differentiated and adopted a far more nuanced classification of activity patterns then a simple dichotomous ‘diurnal versus nocturnal’ scheme. The differentiation of seven categories as used in the present study (or six in the future version of the FishBase databank; see Froese Pauly 2019 in prep.) allows a more detailed correlation of activity patterns with other species’ traits. However, it also poses risks. Very few data are available for a number of species such that classification to a certain activity category may be incorrect due to incomplete knowledge, for instance due to monitoring capacity limitations to track fish activity over larger spatial scales (e.g. across habitat gradients). This is especially true for species which are really cathemeral, and which may be identified, based only on single studies with narrow geographical coverage, as being diurnal or nocturnal. Indeed, the present work highlights that cathemeral activity patterns are quite common in Mediterranean marine fishes, particularly in pelagic species, and it is likely that the portion of species with cathemeral patterns will even increase with more available data in the future.

Are same activity patterns common among species of the same family?

Related species may be characterized by similar activity patterns due to their common evolutionary history, for example in relation to their foraging strategy, morphology, development of eyes, chemoreceptors or other sensory organs. If we define closely related species as members of the same family, a survey of activity patterns at the family level yields insights on the link between activity patterns and affinities of species. Extensive summaries of diel activity of fishes at the family level are the works by Helfman (1978, 1993), Lowe-McConnell (1987) and Helfman et al. (2014), who defined their categorization as “major feeding period”. Thus, the categories in the present study based on adult feeding activity are directly comparable with those of these earlier studies. The conclusion of our study that a large majority of closely related species have similar activity patterns, is also true on a global scale. Helfman et al. (2014: p. 500), representing the most comprehensive survey, list 32 marine fish families in the categories ‘diurnal’ or ‘nocturnal’ and nine families as ‘both, diurnal and nocturnal’ or ‘without distinct periods’. Of the 26 families with five or more species included in the present study (see Table 2), only 13 were already listed by Helfman et al. (2014), and the herrings (Clupeidae) represent the only non-conformity between both tables. These were listed by Helfman (1993) and Helfman et al. (2014) under “all or most species nocturnal”. The 11 herring species occurring in Mediterranean Sea, which include some of the best-studied fishes, represent five different activity categories. Only two of these species are mainly nocturnal, while eight species are cathemeral, diurnal or crepuscular (cf. ESM Part 1). Therefore, the Clupeidae is one of the families that includes species having ‘various categories' (Table 2), i.e. where activity patterns differ between the closely related confamilial species.

Most confamilial species tend to share similar diel activity patterns as a consequence of their affinities, which leads to shared functional morphologies, ecological characteristics, and behavioural patterns. However, from an ecological point of view, a diversification of activity patterns makes sense. Closely related species with similar adaptations to foraging behaviour and diet components could avoid competition by shifting their feeding times. Such a shift was described for two co-occurring anglerfishes, *Lophius budegassa* and *L. piscatorius*. Both share (1) common biological traits, especially in their feeding strategy and food items, (2) the preference of soft bottoms, and (3) an overlapping depth range between about 100–500 m. However, they show a temporal separation of main activity between late morning to early night in *L. piscatorius* and early night to early morning in *L. budegassa* (Colmenero et al. 2010). There are different cases among the species-rich families with varied patterns in the Mediterranean Sea. The Gadidae, with cods, rocklings, cuskfishes and physic hakes currently all combined in one family (Nelson et al. 2016), represent one example. These gadoid taxa show quite different functional morphology and preferences for habitats and diet components, which may be linked with different activity patterns. On the other hand, gobies and porgies, two of the families with the highest numbers of species in the Mediterranean Sea, are each represented by several species that co-occur in the same habitat. In these cases, as with the anglerfishes, the different activity patterns reduce the likelihood of competition between the syntopic species. A further reason for apparently varied patterns in certain families could be an insufficient knowledge of their activity, which may be the case in Triglidae (gurnards).

Link between activity patterns and other ecological traits

Correlation of activity patterns with other species' traits based on the more elaborate classification of activity patterns used in the present work showed a small but significant difference in the trophic level of species having different diel activity patterns. More specifically, mean TL values of demersal native species were lowest in diurnal ones, and were significantly higher in strictly nocturnal species, whereas fishes with mainly nocturnal or cathemeral activity had an intermediate mean TL value. The mean TL values of pelagic diurnal and DVM species were similar to those of demersal diurnal species, while pelagic cathemeral species had a much higher mean TL value comparable to that of strictly nocturnal demersal species. The same patterns are also evident when comparing families. Those characterised by nocturnal feeding activity represent carnivorous species only, whereas families comprising mainly diurnally active fishes include many herbivorous and omnivorous species, but also some planktonic feeders and small-mouthed carnivores such as some wrasses, lefteye flounders and pipefishes (see Table 2). The two families characterised by cathemeral activity (Belonidae and Scombridae) represent pelagic species with carnivorous diets. These results on Mediterranean fishes corroborate the observations by Hobson (1965, 1972, 1973), who showed that nocturnal species in the Gulf of California and Hawaii were predators, while the herbivorous and omnivorous fishes showed predominantly diurnal feeding habits. Indeed, Hobson (1965) suggested that the timing of peak activity in fishes can be generalised in relation to their feeding habits and schooling behaviour. Referring specifically to coral reef ecosystems, Helfman et al. (2014) also noted that herbivorous fishes are almost exclusively diurnal, while nocturnally active fishes are primarily carnivorous. While previous studies have noted a link between nocturnal or crepuscular activity and carnivorous diets, in agreement with the present findings of higher mean TL values associated with these activity patterns, our results indicate that species having cathemeral activity patterns, particularly pelagic ones, also generally occupy higher trophic levels.

The potential link between activity patterns and ecological traits besides diet does not appear to have been addressed in detail in the literature. In the case of Mediterranean littoral and epipelagic native fishes, some interesting patterns emerge from the present analysis. Overall, there seems to be a gradual shift in trait values from strictly diurnal, to mainly diurnal, to mainly nocturnal, to strictly nocturnal species. Besides the mean trophic level, the midpoint of the preferred depth zone also increased in this order, together with a decrease in prevalence of hard bottom occupiers and increase in the proportion of soft-bottom species.

Cathemeral species share similar depth preferences with mainly nocturnal species, but are more commonly pelagic species. We suggest that these links between activity patterns, preferred depths and habitats are also related to feeding habits, and that based on our results the following broad generalisations can be made with regards to littoral demersal species found at depths of down to 200 m:

- Species with lower TL values (i.e. herbivorous and omnivorous ones) are generally strictly or mainly diurnal, live in shallower waters, and are more commonly multi-habitat users or found on hard bottoms. This is primarily related to their food sources, since algae are found on hard bottoms in the infralittoral zone. While herbivorous species are mostly diurnal, the opposite is not true, since several diurnally active species have a high TL.
- Species which are mainly diurnal differ from strictly diurnal ones by having slightly deeper depth preferences and higher occurrence on soft bottoms or in the water column.
- Strictly nocturnal species predominantly have high TL values (i.e. are chiefly carnivorous), tend to occur in deeper waters (i.e. extending beyond the infralittoral to the circalittoral zone), and are often associated with soft bottoms. Their occurrence on soft bottoms could be due to their preference for deeper waters, where such habitats are more prevalent. However, it may also be linked to their habits, allowing them to easily hide by burrowing as well as find their prey in the same habitat.
- Mainly nocturnal and cathemeral species share intermediate traits between those of strictly diurnal and strictly nocturnal ones, but differ in their habitat preferences: mainly nocturnal species occur predominantly on soft bottoms while demersal cathemeral species make use of various habitat types.
- Finally, crepuscular species have a mainly carnivorous diet (i.e. have relatively high TL values) and are mostly multi-habitat users. However, these results must be interpreted with caution since only eight demersal species belonging to this group were included in our analyses, so the outcomes may also be an artefact of the small sample size for this activity type.

Most epipelagic species have either a mainly diurnal or a cathemeral activity pattern. These two groups differ in their ecology, with mainly diurnal species having lower TL values and residing in the shallower end of the epipelagic zone, while cathemeral pelagics tend to have higher TL values (being chiefly carnivorous) and have a wider depth range. Our results also show that Mediterranean mesopelagic fishes that undertake DVM (in the narrow sense used in the present work) ascending to shallow waters (< 200 m depth) belong to lower trophic levels, essentially because these are mainly planktivorous species feeding at the surface at night. They therefore have a similar trophic ecology to most diurnal epipelagic species, but feed at a different time of the day.

Given that the present review focuses on fishes that are regularly found in Mediterranean waters at depths shallower than 200 m, the above generalisations cannot be extended to deep-water fishes (i.e. those with shallowest preferred depth > 200 m).

Novelty of traits: are immigrants with a particular activity pattern more successful?

Traits novel to an invaded community are regarded advantageous for the establishment of non-indigenous fishes in a newly invaded area. Novel traits are often represented by genera or even families not already present in the recipient ecosystem. Conversely, new genera and families may serve as predictors for trait novelties in the recipient ecosystem, and for success of invaders (Strayer et al. 1999; Ricciardi and Atkinson 2004; Dick et al. 2013; Arndt et al. 2018b). The Champsodontidae, Fistularidae, Holocentridae, Leiognathidae, Nemipteridae, Oplegnathidae, Pempheridae, Platycephalidae, Plotosidae, Siganidae, Sillaginidae, Teraponidae as well as the Pteroini all represent higher taxa only recently introduced into the Mediterranean Sea. All of these taxa are represented by at least one successfully established non-indigenous species.

Novel traits may be linked to specific physiological tolerances, high dispersal ability, tolerance to high human disturbance or a specific hunting behaviour against which potential prey have not evolved defence mechanisms (Arndt et al. 2018b). Specific activity patterns are not a ‘trait novelty’ in the strict sense of the term, but may be linked to settlement success, fast distribution in the invaded area, and to the impact of the new invader. Mooney and Cleland (2001: p. 5447) and Otero et al. (2013) considered the nocturnal species of Indo-Pacific origin *Sargocentron rubrum* and *Pempheris vanicolensis* as especially successful colonizers in the Mediterranean Sea, because their nocturnal foraging was a "novel behaviour". Nocturnal feeding was suggested as a trait favouring low competition by native species and thus allowing access to unsaturated niches in the Mediterranean Sea (Mooney and Cleland 2001; Otero et al. 2013). Such a mechanism could, presumably, also facilitate the establishment Atlantic newcomers that may include range-expanding fishes besides non-indigenous ones.

Arndt and Schembri (2015) identified traits of Indo-Pacific fish immigrants that were associated with their establishment and dispersal success in the Mediterranean Sea, but these authors excluded diel activity from their model calculations due to large gaps of knowledge in diel patterns of the Indo-Pacific immigrants. In the present study, we were able to close this gap (at least with regards to adult feeding activity) and to test the hypothesis that Atlantic and Indo-Pacific immigrants have successfully established populations in the Mediterranean Sea due to their nocturnal activity, because night-time foraging is an uncommon strategy among native Mediterranean fish. However, we did not find any support for this hypothesis. The percentage of well-established nocturnal Atlantic or Indo-Pacific immigrants is not significantly higher than that of autochthonous nocturnally feeding littoral fishes, and the number of well-established or invasive diurnal immigrants is distinctly higher than that of nocturnal immigrants in both cases. Examples of diurnal non-indigenous Indo-Pacific species with large populations in the Mediterranean are *Atherinomorus forskalii*, *Fistularia commersonii*, *Lagocephalus* spp., *Scarus ghobban*, *Siganus* spp. and *Upeneus* spp. Successfully established and widely distributed diurnal Atlantic range-expanding species include *Acanthurus monroviae*, *Parablennius pilicornis*, *Seriola fasciata* and *Sphoeroides pachygaster*.

Our results also show that the proportion of crepuscular and cathemeral species, and especially of species that perform DVM, is much lower in newcomer species than in autochthonous ones (Table 1). One reason for these differences may be a lower state of knowledge of the ecology of the immigrating, mainly tropical species. Species with regular DVM are hardly able to overcome the Suez Canal due to its low depth (Arndt & Schembri 2015). Moreover, crepuscular and cathemeral patterns may be characteristic in northern seas with distinct seasons and longer twilight periods, whereas most newcomer species originate in southern, i.e. tropical, areas with more stable temperature regimes and much shorter crepuscular periods. Differences dependent on ecoregions (temperate vs. tropical habitats), namely a reduction in crepuscular predation in warm temperate faunas and a shift in activity patterns due to longer twilight periods, were already suggested by Helfman (1993: p. 504 ff.).

Concluding remarks

Our study has revealed that several gaps in knowledge of diel activity patterns of fishes remain even for an area as well studied as the Mediterranean Sea. Most knowledge concerns adult feeding activity, but even in this regard, over one fifth of the species considered had to be categorised as having an 'unknown' activity pattern. In addition, we still have limited data for a number of species, such that the classification to a certain activity category may be incorrect in several cases due to incomplete knowledge. Future field studies should close these gaps, and focus not only on foraging activity but also on reproductive activities. Knowledge of the latter and of diel patterns in other activities such as migratory movements and territorial defence remains lacking for more than half of the species. Furthermore, the link between the tidal cycle and diel activity deserves more attention. While we did not consider this in the present work, since tidal cycles are not an important parameter in the Mediterranean Sea, we identified 16 species that also occur in the North Atlantic where the diel pattern is likely controlled by tides. A detailed study of the link between tidal cycle and diel activity will improve our understanding of the fishes' diel activity patterns. Such a study could also assess whether species that occur in both macrotidal and microtidal areas exhibit regional differences in their diel patterns, further informing knowledge of plasticity in, and drivers of, activity patterns.

The present work also highlights how knowledge of species' diel activity patterns can provide insights on their ecology. While we are conscious of the perils of over-generalizing with respect to the diverse ichthyofauna, the present results do show that common descent plays an important role in the activity patterns of fishes, with closely related confamilial species sharing similar patterns in around two thirds of the families. We also demonstrate a link between diel activity and other ecological traits, notably feeding habits (trophic level), depth preferences and habitat occupancy. Since activity patterns are an important aspect of behavioural ecology, they can even serve as a basis for applied ecological assessments. Here, we compared the activity patterns of native Mediterranean fishes with those of Atlantic and Indo-Pacific immigrants, finding that, contrary to previous assertions, nocturnal activity is not a predictor for colonization success. Such findings have important implications as they demonstrate that diurnally active newcomers are as relevant as nocturnal ones for management of biological invasions.

The present paper is hopefully an impulse for more intensive studies on this topic. In contrast with some other marine examinations, studies of the diel activity of fishes, especially those occurring in shallower waters, do not necessarily require sophisticated sampling gear. Diel activity of fish can easily be studied using a laboratory equipped with aquariums and natural day/night simulation. Given that the current knowledge is still patchy even in the case of species living in the shallowest water, SCUBA diving or snorkelling in habitats such as seagrass meadows, mangroves and tidepools during the day, crepuscular periods and especially at night will also produce valuable results. On the other hand, accurate assessment of activity patterns of fish species occurring in wide depth ranges, and where individuals may move considerable distances across habitat gradients, requires observations over wide spatial and bathymetric scales. New infrastructural imaging and acoustic tagging technologies set up in networks of monitoring stations would allow collection of activity data at different spatial scales, although high development costs currently limit their deployment (Rountree et al. 2020).

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Declarations

Conflict of interest The authors declare that they have no conflict of interest.

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Reviews in Fish Biology and Fisheries

ESM - Electronic Supplementary Material

Diel activity of littoral and epipelagial teleost fishes in the Mediterranean Sea

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ESM, Part 1. Diel activity of Mediterranean fish species

ESM, Part 2. Description of diel activity at the family level

ESM, Part 3. Ecological data for trophic level, depth and habitat preferences (native species only).

ESM, Part 4. Data of dispersal and establishment success non-indigenous fishes of Indo-pacific origin.

ESM, Part 5. References

ESM, Part 1. Diel activity of Mediterranean fish species

Note: The table below includes available data on diel activity of all Mediterranean fish species (excluding deepwater species). The categorisation of activity is based on the main activity (i.e. feeding) of adult fish.

Abbreviations for diel feeding pattern used in column 3 (Cat.=Category): **CAT** - cathemeral; **CRE** - crepuscular; **DD** - strictly; **DM** - mainly diurnal (may be active during crepuscular periods and at night to a lesser extent); **DVM** - diel vertical migration; **NM** - mainly nocturnal (may be active during crepuscular periods and day to a lesser extent); **NN** - strictly nocturnal; **UK** - unknown or insufficiently known pattern.

Abbreviations used in column 4 (Remarks): **DVM** - diel vertical migration; **VNP** - virtually nothing has been published about diel activity patterns of this species and conclusions cannot be drawn from a homogenous family pattern.

Family	Species	Cat.	Remarks
Acanthuridae	*Acanthurus chirurgus* (Bloch, 1787)	**DD**	Diurnal species (Reeson 1983). Spawning is presumed around the evening time (Singh 2015; but the stated reference is incorrect and does not refer to *A. chirurgus*).
Acanthuridae	*Acanthurus coeruleus* Bloch and Schneider, 1801	**DD**	Diurnal species (Reeson 1983). It forms resident spawning aggregations in late afternoon after high tide (Randall 1961a; Domeier & Colin 1997; Rocha et al. 2015).
Acanthuridae	*Acanthurus monroviae* Steindachner, 1876	**DD**	Diurnal species (Brandl & Bellwood 2014). Spawning takes place at midday (Luiz et al. 2010).
Alepisauridae	*Alepisaurus ferox* Lowe, 1833	**UK**	Mainly nocturnal acc. to Post (1984), but daytime feeder acc. to Haedrich (1964), Potier et al. (2007) and Varghese et al. (2010). Rancurel (1970), Moteki et al. (1993) and Tsuchiya et al. (1998) suggest a DVM. Spawning patterns are not known so far.
Ammodytidae	*Gymnammodytes cicerelus* (Rafinesque, 1810)	**DM**	Though published data on this species are rare, observations and fishery data imply activity patterns as described for the family as a whole (Lleonart et al. 2014). The fish feeds during the daylight and spends the night burrowed into the seabed. Vertical migrations are typically undertaken during crepuscular periods; the fish ascend to pelagic waters during the morning and descend in order to bury themselves in the evening each day. Data on spawning time are lacking.
Ammodytidae	*Gymnammodytes semisquamatus* (Jourdain, 1879)	**DM**	Though published data on this species are rare, observations and fishery data imply activity patterns as described for the family as a whole (Lleonart et al. 2014). The fish feeds during the daylight and spends the night burrowed into the seabed. Vertical migrations are typically undertaken during crepuscular periods; the fish ascend to pelagic waters during the morning and descend in order to bury themselves in the evening each day. Data on spawning time are lacking.
Anarhichadidae	*Anarhichas lupus* (Linnaeus, 1758)	**CAT**	Wolffish are frequently found in open water during both daylight and nighttime, especially in spring and summer (Simpson et al. 2015). The species does not show differences in activity between day and night (concluded from laboratory experiments, Liao 1999). However, activity in fall and winter peaks in crepuscular periods, suggesting a feeding linked to the vertical movement of particular prey and forage species through the water column at sunrise and sunset (Simpson et al. 2015).
Anguillidae	*Anguilla anguilla* (Linnaeus, 1758)	**NM**	Feeding takes place primarily at night with feeding peaks at dawn and at dusk (Clarke et al. 1993; Tesch 2003; Trancart et al. 2012), and activity is ceased before sunrise (Baras et al. 1998). But during stormy weather, feeding may also occur during daylight (Arndt, unpubl. observ.) and in stormy or dark nights nocturnal feeding is increased (Müller 1987). In Southern Europe (NW Spain), a cathemeral feeding acitivity was recorded (Costa-Dias & Lobón-Cerviá 2008). The fish do not leave their (daytime) residence before sunset, except on cloudy days or when turbidity is increased (Baras et al. 1998 observing tagged indiviuals; Westerberg et al. 2007). During migration to the spawning area in the Sargasso Sea, the eel undertakes vertical migrations, occupying shallow warm water (average depth 282 m) during night, diving into the cool zone (average depth 564 m) at dawn and ascending again the following night (Aarestrup et al. 2009). Spawning takes place in

			dark nights in new moon periods (Deelder 1984). Larvae show DVM and prefer a depth of 350–550 m in daytime and 30–120 m at night in the North Atlantic (Tesch 2003: 84). Juveniles migrate upstream mainly at night (Rosengarten 1954; Mann 1961; Trancart et al. 2012). However, the difference between day and night migration is not so substantial and upstream migration during daytime can even predominate if the number of migrating eels is high (Tesch 2003). When temperature plunges at night, upstream migratory activity likewise can be lower than on the previous day (Tesch 2003).
Apogonidae	*Apogon imberbis* (Linnaeus, 1758)	**CRE**	Feeding during dark hours, but with a strong crepuscular peak at dawn (Aguzzi et al. 2013). Hiding in small groups under shaded rock overhangs or in caves during the day (Dooley et al 1985). Courtship behaviour is seen throughout the day, its highest frequency as well as spawning occurs at sunset (Garnaud 1950; Mazzoldi et al. 2008).
Apogonidae	*Apogonichthyoides pharaonis* (Bellotti, 1874)	**NN**	In shaded rock overhangs or caves during the day and moving out of the shelter to forage at night (Golani et al. 2013). Data on spawning patterns have not been published so far.
Apogonidae	*Cheilodipterus novemstriatus* (Rüppell, 1838)	**NM**	Primarily nocturnal, hiding in small groups under shaded rock overhangs or in caves during the day (Golani et al. 2013). Data on spawning patterns have not been published so far.
Apogonidae	*Jaydia queketti* (Gilchrist, 1903)	**NM**	Primarily nocturnal, hiding in small groups under shaded rock overhangs or in caves during the day (Golani et al. 2013). Data on spawning patterns have not been published so far.
Apogonidae	*Jaydia smithi* (Kotthaus, 1970)	**NM**	Primarily nocturnal, hiding in small groups under shaded rock overhangs or in caves during the day (Golani et al. 2013). Data on spawning patterns have not been published so far.
Apogonidae	*Ostorhinchus fasciatus* (White, 1790)	**NN**	Nocturnal species (Brandl & Bellwood 2014).
Argentinidae	*Argentina sphyraena* Linnaeus, 1758	**DM**	Information about diel activity of this species is scarce . Pulcini et al. (2008) list it as "diurnal". Bottom trawling data (Aguzzi et al. 2015) suggest activity during dawn and day. In northern Europe, it may ascend to shallower water (20–50 m) at night (Louisy 2015: 46).
Ariidae	*Carlarius parkii* (Günther, 1864)	**UK**	Nothing special is known about this species, other species of the family are apparently nocturnal (Oliveira-Neto et al. 2006).
Atherinidae	*Atherina boyeri* (Risso, 1810)	**DM**	Active during the day, forming pelagic schools, but resting near the bottom at night (Arndt, unpubl. obs.). The species has eyes with a duplex retina typical of diurnal teleost fishes (Reckel 2001). Based on beach seine fishing, Dulčić et al. (2004) did not find activity peaks in any period of the day.
Atherinidae	*Atherina hepsetus* Linnaeus, 1758	**DM**	Active during the day, forming pelagic schools, but resting near the bottom at night (Fischer et al. 2007; Louisy 2015).
Atherinidae	*Atherina presbyter* (Cuvier, 1829)	**DM**	Active during the day, forming pelagic schools, but resting near the bottom at night (cf. Louisy 2015).
Atherinidae	*Atherinomorus forskalii* (Rüppell, 1838)	**DM**	Active during the day, forming pelagic schools, but resting on the bottom at night (Neumann & Paulus 2005).
Aulopidae	*Aulopus filamentosus* (Bloch, 1792)	**NN**	The species occurs in depths from 35 to about 1000 m and can be observed in littoral waters exceptionally during nighttime (Louisy 2015). The knowledge of its activity patterns is scarce.

Balistidae	*Balistes capriscus* Gmelin 1789 syn. *carolinensis* Gmelin 1789	**DD**	The gray triggerfish shows diurnal activity (Vose & Nelson 1994), though a cathemeral activity with feeding migrations away from their diurnal habitat during night was supposed by Coles (2014). Spawning was rarely observed during day (Simmons, unpubl. obs.), and it cannot be excluded that the fish may spawn during dusk or night.
Batrachoididae	*Halobatrachus didactylus* Bloch & Schneider, 1801	**CAT**	Individuals show activity during all periods of the day, but activity during dawn and night distinctly dominates. The feeding activity peaks at the beginning of night (Costa 2004). The frequency of movements is influenced by the circadian cycle, tidal stage and type of tide: short movements are undertaken during ebb and flood, but migrations over longer distance are much more frequent during ebb, neap tide and at night (Campos et al. 2008). Courtship, i.e. calling to attract females and spawning, is mainly controlled by tides and therefore may takes place during day or night (Amorim et al. 2011).
Belonidae	*Belone belone* (Linnaeus, 1761)	**CAT**	Active during day and night. In the Mediterranean Sea, feeding takes place mainly during dusk and dawn (Reckel 2001).
Belonidae	*Belone svetovidovi* Collette & Parin, 1970	**CAT**	VNP, but compare family information (ESM, part 2).
Belonidae	*Tylosurus acus* (Lacepède, 1803)	**CAT**	It was listed as a diurnal species (Brandl & Bellwood 2014), but a partly nocturnal activity seems likely (see family information).
Belonidae	*Tylosurus choram* (Rüppell, 1837)	**UK**	VNP. A partly nocturnal activity seems likely (see family information).
Belonidae	*Tylosurus crocodilus* (Péron & Lesueur, 1821)	**CAT**	The species was listed as diurnal (Brandl & Bellwood 2014), but nocturnal activity was observed several times, e.g. fish jump out of the water, when attracted to lights at night (Froese & Pauly 2019).
Blenniidae	*Aidablennius sphynx* (Valenciennes, 1836)	**DD**	Diurnal species (Almada & Santos 1995; Arndt, unpubl. obs.). As in many other blennid species, diurnal activity comprises feeding, courtship, spawning and guarding eggs.
Blenniidae	*Blennius ocellaris* Linnaeus, 1758	**CAT**	Mostly a diurnal species (Santos et al. 2002). However, bottom trawl data suggest activity also in the latest part of the night (Aguzzi et al 2015). Neumann & Paulus (2005) regard the species as nocturnal.
Blenniidae	*Coryphoblennius galerita* (Linnaeus, 1758)	**DD**	Feeding, courtship and other acitivities are shown during day (Almada et al. 1983 and Guitel 1983 in Almada & Santos 1995; Faria & Almada 2006). The circadian activity may be triggered by tidal cycle in regions with distinct tides (Gibson 1970). The species can be found in the surf zone both below and above the water surface, on rocky bottoms and in rock pools. They are commonly observed outside the water at night (Fischer et al. 2007). The fish sojourns parts of the night on moist rocks above the water line in order to sleep outside the water (Heymer 1982; Louisy 1987).
Blenniidae	*Hypleurochilus bananensis* (Poll, 1959)	**UK**	VNP
Blenniidae	*Lipophrys pholis* (Linnaeus, 1758)	**DD**	Diurnal species (Almada & Santos 1995; Neumann & Paulus 2005; Faria & Almada 2006), most active in the morning and during the rising tide or in the high-tide period (Burrows et al. 1999). Spawning takes place during daytime as well (Faria et al. 2002).

Blenniidae	*Lipophrys trigloides* (Valenciennes, 1836)	**CAT**	This species is active and may feed during day and night; diurnal activity predominates from spring to autumn, but the portion of nocturnal activity increases in winter (Nieder & Zander 1994). It can be found in the surf zone both below and above the water surface on rocky bottoms and in rock pools. Outside the water the fish are commonly seen at night while resting (Heymer 1982; Louisy 1987; Fischer et al. 2007). Spawning takes place during daytime (Faria et al. 2005).
Blenniidae	*Microlipophrys adriaticus* (Steindachner & Kolombatovic, 1883)	**DD**	Diurnal species (Neumann & Paulus 2005).
Blenniidae	*Microlipophrys canevae* (Vinciguerra, 1880)	**DD**	Diurnal species (Almada & Santos 1995; Neumann & Paulus 2005; Faria & Almada 2006).
Blenniidae	*Microlipophrys dalmatinus* (Steindachner & Kolombatovic, 1883)	**DD**	Diurnal species (Neumann & Paulus 2005).
Blenniidae	*Microlipophrys nigriceps* (Vinciguerra, 1883)	**DD**	Diurnal species (Neumann & Paulus 2005).
Blenniidae	*Ophioblennius atlanticus* (Valenciennes, 1836)	**DD**	Diurnal species (Nursall 1977; Wirtz 2011; Arndt, unpubl. obs.). About 60% of their time is spent resting, 15% swimming and 8.5% feeding. Feeding is concentrated in the afternoon and is time-minimized (Nursall 1981). Courtship and pairing take place in the first three hours of daylight (Côté & Hunte 1989).
Blenniidae	*Omobranchus punctatus* Valenciennes, 1836	**UK**	VNP
Blenniidae	*Parablennius gattorugine* (Linnaeus, 1758)	**CAT**	This species is mostly active during dawn and dusk (Neumann & Paulus 2005), but can be found active during daylight (Faria & Almada 2006; Arndt, unpubl. obs.) and night (Nieder & Zander 1994) as well.
Blenniidae	*Parablennius incognitus* (Bath, 1968)	**DD**	Diurnal species (Almada & Santos 1995).
Blenniidae	*Parablennius pilicornis* (Cuvier, 1829)	**DD**	Active during the day (Almada et al. 1987 in Almada & Santos 1995; Faria & Almada 2006).
Blenniidae	*Parablennius rouxi* (Cocco, 1833)	**DD**	Strictly diurnal (Santos et al. 2002). As in many other blennid species, diurnal activity comprises feeding, courtship, spawning and guarding eggs.
Blenniidae	*Parablennius sanguinolentus* (Pallas, 1814)	**DD**	Diurnal species (Almada & Santos 1995; Neumann & Paulus 2005; Faria & Almada 2006). Feeding peak is in afternoon (Taborsky & Limberger 1980).
Blenniidae	*Parablennius tentacularis* (Brünnich, 1768)	**DD**	Nothing has been published specifically about the activity pattern of this species, but the depictions by Orlando-Bonaca & Lipej (2008) indirectly imply a diurnal activity.
Blenniidae	*Parablennius thysanius* (Jordan & Seale, 1907)	**UK**	VNP
Blenniidae	*Parablennius zvonimiri* (Kolombatovic, 1892)	**DM**	This species prefers shadow and crepuscular periods (Pallaoro 1989 in Orlando-Bonaca & Lipej 2007; Neumann & Paulus 2005), but may also be active in full sunlight (Arndt, unpubl. obs.). Courtship takes place during the day (Almada & Santos 1995).

Blenniidae	*Petroscirtes ancylodon* Rüppell, 1835	**UK**	VNP
Blenniidae	*Salaria basilisca* (Valenciennes, 1836)	**DD**	Diurnal species (Neumann & Paulus 2005).
Blenniidae	*Salaria pavo* (Risso, 1810)	**DD**	Diurnal species, also courtship and spawning takes place during the day (Patzner et al. 1986 and Almada 1989 in Almada & Santos 1995; Neumann & Paulus 2005).
Blenniidae	*Scartella cristata* (Linnaeus, 1758)	**DM**	Mainly diurnal species that feed and court during daylight (Neat et al. 2003; Mackiewicz et al. 2005). Individuals active at night were observed by Nieder & Zander (1994), however the authors report a lower portion of amphipods in the food of *S. cristata* compared to nocturnal blenniid species.
Bothidae	*Arnoglossus grohmanni* Bonaparte, 1837	**UK**	VNP
Bothidae	*Arnoglossus imperialis* (Rafinesque, 1810)	**DD**	Diurnal feeder (De Groot 1971). Nothing has been published about spawning and migration activities.
Bothidae	*Arnoglossus kessleri* Schmidt, 1915	**UK**	VNP
Bothidae	*Arnoglossus laterna* (Walbaum, 1792)	**DM**	Mainly foraging during the day (De Groot 1971; Gibson & Ezzi 1980; Darnaude et al. 2001), however to a minor part also active at night (Letourneur et al. 2001). Aguzzi et al. (2015) term this species "arhythmic" and their bottom trawl data suggest a partially crepuscular activity.
Bothidae	*Arnoglossus rueppelii* (Cocco, 1844)	**UK**	VNP
Bothidae	*Arnoglossus thori* (Kyle, 1913)	**DM**	Predominantly diurnally active species (De Groot 1971, Ribeiro et al. 2006). Nothing has been published about spawning activities.
Bothidae	*Bothus podas* (Delaroche, 1809)	**DM**	Feeding during the day (Esposito et al. 2009a). Courtship and spawning were observed in early morning (Carvalho et al. 2003: 253). Juveniles showed diurnal and nocturnal activity in hauls in summer but predominantly diurnal acitivity in September (Nash et al. 1994)
Bramidae	*Brama brama* (Bonaterre, 1788)	**CAT**	Species shows DVM, feeding in deep water during the day, and at the water surface at night (Mead 1972; Bauchot 1987). Spawning patterns are not known.
Bregmacerotidae	*Bregmaceros nectabanus* Whitley, 1941	**UK**	Knowledge about diel activity is scarce in this species. It probably undergoes DVM, migrating into and out of anoxic water on a diurnal basis (Froese & Pauly 2019).
Bythitidae	*Bellottia apoda* Giglioli, 1883	**NM**	Active during day and night, but mainly nocturnal (Letourneur et al. 2001, Louisy 2002).
Bythitidae	*Grammonus ater* (Risso, 1810)	**NN**	Strictly nocturnal cave dwelling species (Göthel 1992; Neumann & Paulus 2005).

Callanthiidae	*Callanthias ruber* (Rafinesque, 1810)	**DD**	Very few data on the ecology of this species are available. Photos by Bo et al. (2012, Supplementary material) show individuals active during the day. Neumann & Paulus (2005) report on mixed schools together with the diurnal species *Anthias anthias*.
Callionymidae	*Callionymus fasciatus* Valenciennes, 1837	**NM**	Burrowed in the sediment during the day, but active at dusk and at night (Neumann & Paulus 2005; see also photo in Louisy 2015).
Callionymidae	*Callionymus filamentosus* Valenciennes, 1837	**DM**	Diurnally active species (Brandl & Bellwood 2014).
Callionymidae	*Callionymus lyra* Linnaeus, 1758	**DM**	Feeding from morning to sunset or to early night (van der Veer et al. 1990; Fernández et al. 1995). Courtship and spawning take place during the day as described in other *Callionymus* species (Holt 1898). Thus, the statement "burrowed in the sediment during day but active at dusk and at night" by Neumann & Paulus (2005) cannot be confirmed.
Callionymidae	*Callionymus maculatus* Rafinesque, 1810	**DM**	Predominantly diurnally active species (Ribeiro et al. 2006).
Callionymidae	*Callionymus pusillus* Delaroche, 1809	**UK**	Burrowed in the sediment during day but active at dusk and at night acc. to Neumann & Paulus (2005), but individuals may be active in the afternoon (Arndt, unpubl. obs.). The peculiarly enlarged dorsal fin and territorial behaviour of males also indicate an at least partly diurnal activity.
Callionymidae	*Callionymus reticulatus* Valenciennes, 1837	**NM**	Burrowed in the sediment during day but active at dusk and at night (Neumann & Paulus 2005; see also photo in Louisy 2015). However, the peculiarly enlarged dorsal fin and territorial behaviour of males indicate an at least partly activity during daylight hours.
Callionymidae	*Callionymus risso* Le Sueur, 1814	**DM**	Diurnal species. Burrowed in the sediment at night (Letourneur et al. 2001)
Callionymidae	*Synchiropus sechellensis* Regan, 1908	**NM**	Possibly nocturnal (Irmak et al. 2016).
Callionymidae	*Synchiropus phaeton* (Günther, 1861)	**UK**	VNP
Caproidae	*Capros aper* (Linnaeus, 1758)	**DM**	The boarfish prefers depths between 100–400 m but is sporadically found much deeper or in shallower water respectively. It shows cathemeral or mainly diurnal diel patterns (Fock et al. 2002; Aguzzi et al. 2015; Carpentieri et al. 2016). Feeding takes place mainly from sunrise to late afternoon and decreases significantly during the night in a Central Mediterranean population (Carpentieri et al. 2016; long term study in Italy), wheras a significant portion of nocturnal feeding was found in NE Atlantic population (Fock et al. 2002). Spawning takes place during different periods of the day, but spawning activity is more intense during daylight (Fässler et al. 2013). Diurnal spawning was confirmed by aquarium observations ("within an hour of the tank lights being turned on in the morning"; Gardner & Hemdal 2011) and field observations (Davies in litt.)
Carangidae	*Alectis alexandrina* (Geoffroy Saint-Hillaire, 1817)	**UK**	VNP

Carangidae	*Alepes djedaba* (Forsskål, 1775)	**NM**	This species feeds during the night (Kagwade 1967, study of an Indian population).
Carangidae	*Campogramma glaycos* (Lecepède, 1801)	**UK**	VNP
Carangidae	*Caranx crysos* (Mitchell, 1815)	**CAT**	Feeding takes place in any period of the day (Keenan 2002).
Carangidae	*Caranx hippos* (Linnaeus, 1766)	**DD**	Active during daylight only (Emmanuel et al. 2008, based on gill net catches).
Carangidae	*Caranx rhonchus* Geoffroy Saint-Hillaire, 1817	**DD**	Active during the day; feeds only diurnally with a feeding peek around midday (Kompowski 1976).
Carangidae	*Chloroscombrus chrysurus* (Linnaeus, 1766)	**DM**	Specific information about diel activity of this species is scarce. Trawl catches suggest a mainly diurnal activity. Larvae feed mainly during the day (Sánchez-Ramírez 2003).
Carangidae	*Decapterus russelli* (Rüppell, 1830)	**DM**	Diurnal species (Brandl & Bellwood 2014). Spawning was observed at night (Delsman 1926; Tiews et al. 1971; Murty 1991).
Carangidae	*Elagatis bipinnulata* (Quoy & Gaimard, 1825)	**DD**	Active and feeding during the day (Gillibrand et al. 2007; Brandl & Bellwood 2014).
Carangidae	*Lichia amia* (Linnaeus, 1758)	**UK**	VNP
Carangidae	*Naucrates ductor* (Linnaeus, 1758)	**DD**	Diurnal species, resting in shoals at night (Brandl & Bellwood 2014; Loyer 2015).
Carangidae	*Pseudocaranx dentex* (Bloch & Schneider, 1801)	**DM**	Diurnal species acc. to Brandl & Bellwood (2014). However, Afonso et al. (2009) show that is has distinct diel rhythms with back-and-forth migrations alongshore during different but repeating (diurnal, crepuscular and nocturnal) periods of the day. In some areas, cyclic tidal patterns dominated the diel pattern (Afonso et al. 2009). Data on diel spawning patterns are lacking so far.
Carangidae	*Selene dorsalis* (Gill, 1862)	**NM**	Fishery catches from the Canary Islands suggest that this species is at least partly active at night (Castro-Hernández 2001), but detailed data are lacking.
Carangidae	*Seriola carpenteri* Mather, 1971	**UK**	VNP
Carangidae	*Seriola dumerili* (Risso, 1810)	**DM**	Diurnal species (Brandl & Bellwood 2014), feeding during the day (Andaloro & Pipitone 1997), probably with feeding peak at dusk (Coles 2014).
Carangidae	*Seriola fasciata* (Bloch, 1993)	**DM**	Specific information about diel activity is lacking, but see Coles (2014).
Carangidae	*Seriola rivoliana* Valenciennes, 1833	**DM**	Active during the day (Brandl & Bellwood 2014), probably with feeding peak at dusk (Coles 2014).

Carangidae	*Trachinotus ovatus* (Linnaeus, 1758)	**DM**	Feeding starts in the morning, peaks in the afternoon and does not occur at night. Also swimming activity is significantly decreased at night (Tutman et al. 2004). Seasonal changes of diel activity between diurnal and nocturnal activity are implied by beach seine catches (Nash et al. 1994, Azores; elevated catches occurred in August and September at night, but switched towards daytime catches in October). Juveniles feed strictly during daylight (Batistić et al. 2005).
Carangidae	*Trachurus indicus* Nekrasov, 1966	**UK**	Specific information about diel feeding activity is lacking. Spawning takes place in early night (Thangaraja & Al-Aisry 2011)
Carangidae	*Trachurus mediterraneus* (Steindachner, 1868)	**CAT**	Bottom trawl data by Aguzzi et al. (2015) strongly suggest diurnal activity. However, feeding takes place at different periods of the day acc. to Sirotenko & Istomin (1978), similar to patterns seen in *T. trachurus* are likely. No details about diel spawning patterns have been published so far.
Carangidae	*Trachurus picturatus* (Bowdich, 1825)	**CAT**	Feeds during different periods of the day with highest feeding activity in the evening (Kompowski 1976, north-east Atlantic).
Carangidae	*Trachurus trachurus* (Linnaeus, 1758)	**CAT**	Feeding takes place during different periods of the day. In the north-eastern Atlantic, feeding takes place mainly during daytime with feeding peaks around noon in large specimens, but in the evening in lower size classes (25 cm; Kompowski 1976). The highest feeding intensity was recorded at night and during early morning hours, but the fish fed at lower intensity also during day and evening in the Adriatic Sea (Jardas et al. 2004). However, this pattern may vary even in the Mediterraenan depending on area and season (Garrido et al. 2008; feeding peek in afternoon off Portugal). The composition of diet (cf. Jardas et al. 2004) may suggest diel vertical migrations as detected in the closely related Cape horse mackerel *T. trachurus capensis* (Pillar & Barange 1995; Axelsen et al 2004). *T. trachurus* is a night spawner (van Damme et al. 2014).
Carapidae	*Carapus acus* (Brünnich, 1768)	**NN**	The pearl fish lives in holothurians leaving its host only at night (Fischer et al. 2007; Froese & Pauly 2019).
Carapidae	*Echiodon dentatus* (Cuvier, 1829)	**NN**	Poorly known species, mainly occurring in deep water. There are scattered reports of nocturnal activity (Markle & Olney 1990).
Cepolidae	*Cepola macrophthalma* (Linnaeus, 1758)	**NM**	This species shows feeding and spawning in crepuscular and nocturnal periods (Neumann & Paulus 2005), however spring data of trawling also suggest a partly diurnal activity (Aguzzi et al. 2015).
Chaetodontidae	*Chaetodon austriacus* Rüppel, 1836	**DM**	Diurnally active (Lieske & Myers 2004). Specific data on spawning have not been published so far.
Chaetodontidae	*Chaetodon hoefleri* (Steindachner, 1881)	**DM**	Diurnal species like other *Chaetodon*, but no specific data have been published so far.
Chaetodontidae	*Chaetodon larvatus* Cuvier, 1831	**DM**	Feeding and defending of territories take place during day (Zekeria 2003). Spawning aggregations occur in the Red Sea in the evening hours (of April and May) and last for a few minutes only (Zekeria 2003).
Chaetodontidae	*Heniochus intermedius* Steindachner, 1893	**CRE**	Spends most of the daytime hiding below coral and is seen feeding occasionally. Feeding is very low throughout the day but increases sharply in the evening just before dusk, and is continued after sunset (Zekeria 2003).

Champsodontidae	*Champsodon capensis* Regan, 1908	**DVM**	The species performs DVMs, staying in great depths during the day but migrating to surface waters at night to feed (Nemeth 1994; Smith & Heemstra 1995). Data on spawning patterns are lacking.
Champsodontidae	*Champsodon nudivittis* (Ogylbi, 1895)	**UK**	VNP
Champsodontidae	*Champsodon vorax* Günther, 1867	**UK**	VNP
Chanidae	*Chanos chanos* (Forskål, 1775)	**DM**	Diel activities of adult milkfishes comprise diurnal, crepuscular and nocturnal components in varying proportions. Milkfishes may ingest at day and night nearly at the same rate (Lückstädt & Reiti 2002), but most studies conclude that diurnal feeding clearly predominates (Chiu & Benitez 1982, Chiu et al. 1986, Kühlmann et al. 2009). During daytime schools move with the rising tide to feed in shallower areas of the habitat (Buri 1980). Feeding by larvae takes place diurnally (Hara et al. 1983; Bagarinao 1991), juveniles feed predominantly diurnally (Kumagai et al. 1985). Juveniles are active and schooling during daytime but resting at night (Kawamura & Shimoda 1980; Buri 1980). There is scattered information about other types of activity. Larvae use springtides to move inshore (Johannes 1978). Virtually nothing has been published about migrating activity. Spawning is usually observed around midnight but daytime spawning occurs sometimes (Bagarinao 1991, 1994).
Chirocentridae	*Chirocentrus dorab* (Forsskål, 1775)	**DM**	Knowledge about diel activity of dorab wolf-herring is scarce. There is some evidence for diurnal feeding (Luther 1985a, b; Munroe et al. 1999a; Sazima et al. 2004), but feeding during night fishing with lights was also reported (Whitehead 1985). Information about diel spawning patterns are not available.
Chlopsidae	*Chlopsis bicolor* Rafinesque, 1810	**NN**	Active at night, a nocturnal predator that remains in burrows during daylight hours (Carpentieri et al. 2007).
Chlorophthalmidae	*Chlorophthalmus agassizi* Bonaparte, 1840	**NM**	Diel activity of this species is poorly known. The species live in deeper water, but may ascend during night to feed into depths of about 50 m (Louisy 2015).
Citharidae	*Citharus linguatula* (Linnaeus, 1758)	**UK**	Diel activity of this species is poorly known. Diurnal feeder acc. to Redon et al. (1994) and De Groot (1971). However, data from bottom trawls (Bahamon et al. 2009; Aguzzi et al. 2015) and prey analysis of *Squatina squatina*, a nocturnal species feeding on *Citharus linguatula* (Ebert & Stehmann 2013), strongly suggest activity at dusk and night.
Clinidae	*Clinitrachus argentatus* (Risso, 1810)	**DD**	Knowledge of activity patterns of this species is scarce, but through ecological and behavioural data it can be concluded that the species is diurnal (Wirtz 1978; Velasco et al. 2010).
Clupeidae	*Alosa alosa* (Linnaeus, 1758)	**CAT**	Feeding activity in adults has not been described in detail so far, but available information suggests food intake during day and night (similar *to A. pseudoharengus*, see Stone & Jessop 1994). Main feeding activity of juveniles occurred between 10:00 and 22:00 (Cassou-Leins & Cassou-Leins 1981). Fish migrates upstream from midday until early night with highest activity in evening (Travade et al. 1998). Spawning takes place at night (Cassou-Leins et al. 2000).

Clupeidae	*Alosa fallax* (Lacépède, 1803)	**CAT**	Feeding activity in adults has not been described in detail so far, but available information suggests food intake during day and night (similar to *A. pseudoharengus*, see Stone & Jessop 1994). Larvae and juvenils take in food to all times of the day (Oesmann & Thiel 2001; Aprahamian et al. 2003). Migration takes places mainly during dawn and day (Aprahamian et al. 2003). The fish moves to riverine spawning grounds at night. It spawns in large, very noisy schools near the surface and leaves these areas before daybreak (Quignard & Douchement 1991; Cassou-Leins et al. 2000).
Clupeidae	*Dussumieria elopsoides* Bleeker, 1849	**DD**	This species feeds only during the day (Radhakrishnan Nair 1982; Munroe et al. 1999b). Crepuscular and/or nocturnal spawning is a general pattern of the pelagic spawning clupeoids (Ganias et al. 2014)
Clupeidae	*Etrumeus golanii* Dibattista, Randall & Bowen, 2012	**NM**	The study by Osman et al. (2013) suggests a diel vertical migration as is known from *Etrumeus whiteheadi* (Lindsey 2006) and a mainly, if not exclusively, nocturnal feeding activity. Crepuscular and/or nocturnal spawning is a general pattern of the pelagic spawning clupeoids (Ganias et al. 2014)
Clupeidae	*Herklotsichthys punctatus* (Rüppell, 1837)	**NM**	Feeding most probably takes place at night (Wilson 1977; Milton et al. 1994a, b), similar to closely related species. Crepuscular and/or nocturnal spawning is a general pattern of the pelagic spawning clupeoids (Ganias et al. 2014; Milton et al. 1994a).
Clupeidae	*Sardina pilchardus* (Walbaum, 1792)	**CAT**	In summer, feeding activity of adults is lowest at early morning, increases during the day and reaches a peak between midday and dusk. It can be continued in early night. In winter, the highest feeding rates were observed in afternoon or first 6 hours after sunset (Nikolioudakis et al 2011). Juveniles have a similar activity pattern (Nikolioudakis et al 2011; Costalago & Palomera 2014). Larvae and juveniles feed during the day (Blaxter & Hunter 1982, Fernández & González-Quirós 2006; Morote et al. 2010). Adults and larvae may show a DVM. Adults stay in deeper water during the day and move to surface at night (Cushing 1957; Giannoulaki et al. 1999). Dias et al. (1989) and Zwolinski et al. (2006, 2007) detected diel vertical migration in the opposite directions, i.e. sardine aggregations deeper at night than by day. Sardines spawn in evening and early night with a spawning peak at 19:00 in the Mediterranean (Ganias et al. 2014) and 21:00-23:00 off Portugal (Ferraro 1980; Ré et al. 1988).
Clupeidae	*Sardinella aurita* Valenciennes, 1847	**CAT**	Feeding during day and night, patterns depend mainly on the season as well as the availability of food supply (Komarovsky 1959; Lomiri et al. 2008; Bayhan & Sever 2015). Adults may perform a DVM, staying near bottom during day and migrating to midwater at dusk (Johnson & Vaught 1986; Gonzales et al. 1998) indicating a mainly nocturnal feeding. Larvae feed diurnally (Last 1980; Ostergaard et al. 2005; Morote et al. 2008a). Spawning occurs during the night (Ditty et al. 1994; Ohs et al. 2013).
Clupeidae	*Sardinella gibbosa* (Bleeker, 1849)	**DM**	Mainly feeding during the day, but also by moonlight at night (Okera 1973). Crepuscular and/or nocturnal spawning is a general pattern of the pelagic spawning clupeoids (Ganias et al. 2014)
Clupeidae	*Sardinella maderensis* (Lowe, 1838)	**UK**	Diel inshore and offshore migrations linked to feeding (Minta 2003; Correira 2018), but details are unclear. Crepuscular and/or nocturnal spawning is a general pattern of the pelagic spawning clupeoids (Ganias et al. 2014)

Clupeidae	*Spratelloides delicatulus* (Bennett, 1832)	**CRE**	Adults feed at night (Milton et al. 1994a), but feeding peaks occur during early morning and evening acc. to Sivadas & Nasser (2000). Spawning takes place from the early part of the night to midnight (Milton et al. 1994b).
Clupeidae	*Sprattus sprattus* (Linnaeus, 1758)	**DM**	The species undertakes a DVM (Nilsson et al. 2003). Feeding below the surface (in a depth of about 50 m in the Baltic Sea) during the day, at night the fish migrate to the surface water and do not feed (Tičina et al. 2000; Cardinale et al. 2003; Stepputtis 2006). Spawning takes place at night (Alheit et al. 1987).
Congridae	*Ariosoma balearicum* (Delaroche, 1809)	**NN**	Hiding in sand during daytime (Fischer et al. 2007).
Congridae	*Conger conger* (Linnaeus, 1758)	**NN**	Nocturnal species (Göthel 1992). Active during or after sunset (Letourneur et al. 2001; Aguzzi et al. 2015) and at night (Reina-Hervás & Serrano 1987). In great depths, feeding may take place during day and night (100–300 m; Bozzano & Sardà 2002). Actively swimming individuals were observed in the North Atlantic occasionally during day by Nickel & Sayer (1998).
Congridae	*Gnathophis mystax* (Delaroche, 1809)	**NN**	Active at night, a nocturnal predator that remains in burrows during daylight hours (Dooley et al. 1985; Carpentieri et al. 2007).
Coryphaenidae	*Coryphaena equiselis* Linnaeus, 1758	**CAT**	Ecological information is extremely scarce for this species. Often it is treated together with *C. hippurus* (see next column) and it remains unclear if statements apply to both species.
Coryphaenidae	*Coryphaena hippurus* Linnaeus, 1758	**CAT**	Feeds during the day as well as at night (Rothschild 1964; Massutí et al. 1998; Oxenford & Hunte 1999; Olson & Galván-Magaña 2002). Common dolphinfish show vertical movements (see family description; Furukawa et al. 2011; Merten et al. 2012, 2014). Larvae may be active during day and night (Parin 1967). Spawning was observed in the afternoon, dusk and night (Hagood et al. 1981; Solchi 1978).
Cottidae	*Taurulus bubalis* (Euphrasen, 1786)	**DM**	Active during the day (Westin & Aneer 1987). Data on spawning are not available.
Cyclopteridae	*Cyclopterus lumpus* Linnaeus, 1758	**DM**	Active during day (Westin & Aneer 1987). Individuals of the same population may show a complex and different diel behaviour, i.e. (i) staying near bottom but ascending to shallow layers several times for a short period, or (ii) staying at the surface but descending several times for a more or less prolonged period during daylight, or (iii) staying in the epipelagic zone around 100-150m but ascending or descending several times during day and night (early spring, North Atlantic, Kennedy et al. 2016). Observations in aquaculture indicate feeding during daylight (Imsland et al. 2014), but feeding at night is not excluded. Courtship and spawning was observed at night (Fulton 1907; Davenport 1985; both are aquarium observations). Spawning may depend on high tides, a spawning during daylight cannot be excluded (Mochek 1973).
Cynoglossidae	*Cynoglossus sinusarabici* (Chabanaud, 1931)	**UK**	VNP
Cynoglossidae	*Symphurus ligulatus* (Cocco, 1844)	**UK**	VNP

Cynoglossidae	*Symphurus nigrescens* Rafinesque, 1810	**CAT**	Diet composition (Karachle & Stergiou 2009) implies a nocturnal feeding activity. Bottom trawl data indicate a predominantly nocturnal activity in shallow water, but mainly diurnal activity at a depth of 400 m (Aguzzi et al. 2015). The latter suggests a preference forf low light conditions.
Cyprinodontidae	*Aphanius dispar* (Rüppell, 1829)	**DM**	This species is mainly diurnal (Plaut 2000).
Cyprinodontidae	*Aphanius fasciatus* (Valenciennes, 1821)	**DD**	This species is strongly diurnal (Cavraro et al. 2013).
Cyprinodontidae	*Aphanius iberus* (Valenciennes, 1846)	**DM**	Gascón et al. (2013) did not find significant differences of feeding actitivities between day and night. However this species shows more activity during daylight and diurnal spawning is likely (Paterna, pers. comm.) that is indirectly confirmed by Clavero et al. (2005).
Dactylopteridae	*Dactylopterus volitans* (Linnaeus, 1758)	**NM**	Active during the night (Luiz et al. 2013).
Diodontidae	*Chilomycterus reticulatus* (Linnaeus, 1758)	**DM**	Diurnal species, brace themselves against the substrate to sleep at night (Fitch & Lavenberg 1975; Brandl & Bellwood 2014; Froese & Pauly 2019).
Diodontidae	*Chilomycterus spinosus mauretanicus* (Le Danois, 1954)	**DM**	Most likely a diurnal species (Dantas et al. 2016).
Diodontidae	*Cyclichthys spilostylus* (Leis & Randall, 1982)	**NM**	Active during the night (Kuiter & Tonozuka, 2001; Leis 2001; Brandl & Bellwood 2014).
Diodontidae	*Diodon hystrix* Linnaeus, 1758	**NM**	Active during the night (Hobson 1974; Leis 2001; Brandl & Bellwood 2014). Feeds at night and spawns during dusk (Lower Breede River Conservancy Trust 2016).
Echeneidae	*Echeneis naucrates* Linnaeus, 1758	**DM**	Diurnally active species (Brandl & Bellwood 2014; Arndt unpubl. observ.). Attached to large objects with smooth surface (e.g. sharks, metal hull of tanks or ships) and inactive at night (Divemecressi, unpubl. obs.). Spawning takes place in early night (Nakajima et al. 1987).
Echeneidae	*Remora brachyptera* (Lowe, 1839)	**DM**	VNP, but species of this family are generally active during the day.
Echeneidae	*Remora osteochir* (Cuvier, 1829)	**DM**	VNP, but species of this family are generally active during the day.
Echeneidae	*Remora remora* (Linnaeus, 1758)	**DM**	Diurnally active species (Strasburg 1962).
Engraulidae	*Engraulis albidus* Borsa et al., 2004	**UK**	VNP
Engraulidae	*Engraulis encrasicolus* (Linnaeus, 1758)	**DM**	Feeding activity pattern varies in this species depending on region (Garrido & van der Lingen 2014). In the Mediterranean it is mainly diurnal, with lowest stomach fullness around sunrise and maximum stomach fullness in early evening, but includes feeding at dusk and night to a certain level (Tudela & Palomera 1995, 1997; Plounevez & Champalbert 1999; Borme et al. 2009). The species feeds partly at night in the Black Sea

			and other productive surface waters such as Benguela current, relating to their diel vertical migrations (James 1987; Garrido & van der Lingen 2014). Larvae are generally visual (diurnal) feeders (Garrido & van der Lingen 2014), intaking food from sunrise to sunset (Conway et al. 1998). At least in parts of the year, larvae and adults show a diel vertical migration, with larger quantities of larvae and postlarvae found near the surface during the night (Regner 1972; Sabatés et al. 2008). Adults stay close to the surface during night and form schools just before dawn at shallow layers (at least in summer; Tsagarakis et al. 2012). These schools move to deeper depths, close to the seabed during daytime and return to the surface to disperse after dusk (Tsagarakis et al. 2012). Spawning takes place during dusk and night and was observed in the Mediterranean between 18:00-04:00 (García & Palomera 1996; Somarakis et al. 2002; Ganias et al. 2014; Basilone et al. 2015). The spawning peak occurs between 20:00 and 22:00 in any examined population or area (Basilone et al. 2015).
Engraulidae	*Stolephorus insularis* Hardenberg, 1933	**UK**	VNP
Ephippidae	*Platax teira* (Forsskål, 1775)	**DD**	Diurnal species (Brandl & Bellwood 2014; Field &Field 2016). Details of courtship and spawning have not been published so far.
Exocoetidae	*Cheilopogon furcatus* (Mitchill, 1815)	**UK**	VNP
Exocoetidae	*Cheilopogon heterurus* (Rafinesque, 1810)	**DM**	Diurnal species (Louisy 2015).
Exocoetidae	*Exocoetus obtusirostris* Günther, 1866	**DM**	Observed during day while 'flying' above the water surface (photo in Louisy 2015). Spawning pattern seems to be heterogeneous depending on location and oceanographic features (Lewallen in litt.).
Exocoetidae	*Exocoetus volitans* (Linnaeus, 1758)	**CAT**	Observed during day while 'flying' above the water surface. Larvae are active at the surface during the day (04:00-20:00 with highest abundance between 06:00-18:00), but disappear at night (Parin 1967). Spawning pattern seems to be heterogeneous depending on location and oceanographic features (Lewallen in litt.).
Exocoetidae	*Hirundichthys rondeletii* (Valenciennes, 1847)	**DM**	Observed during day while 'flying' above the water surface (photo in Louisy 2015). Spawning may occur during the day (Lewallen in litt.).
Exocoetidae	*Parexocoetus mento* (Valenciennes, 1847)	**UK**	VNP
Fistulariidae	*Fistularia commersonii* Rüppell, 1838	**DD**	Diurnal species (Karpestam et al. 2007; Brandl & Bellwood 2014). Data about spawning time are apparently not published so far.
Fistulariidae	*Fistularia petimba* Lacépède, 1803	**CAT**	Active during day and night (Hobson 1974; Gray et al. 1998). Data about spawning time are apparently not published so far.
Gadidae, Gadinae	*Gadiculus argenteus* Guichenot, 1850	**NN**	Nocturnal species (Pulcini et al. 2008). However, trawling data indicate a cathemeral pattern in deep water ("arhythmic species" acc. to Aguzzi et al. 2015 at a trawl depth of 400 m).

Gadidae, Gadinae	*Gadus morhua* Linnaeus, 1758	**CAT**	During the day, this species forms schools above the bottom and disperses at night (Cohen et al. 1990). It undertakes diel vertical migrations, moving from the bottom to the surface at night (Cohen et al. 1990) and migrates onshore at dusk and offshore at dawn (Gibson et al. 1996). Atlantic cod has a flexible diel activity cycle linked to spatio-temporal variations in food availability and other environmental parameters (Reubens et al. 2013). Feeding by adults occurs mainly at dawn and dusk (Cohen et al. 1990, Adlerstein & Welleman 2000), but may vary dependent on region and food availability. Cod may search more actively for food during the day than during the night (Løkkeborg 1998), swim more actively and wider distances during that day than at night (Løkkeborg & Fernö 1999). They use sight to detect food in midwater and on the bottom and are able to detect odours from many prey species and capture prey also in the dark (Brawn 2001). Food ingestion peaks in small juveniles between 12:00 and 20:00, whereas juveniles of 3-5 cm length switch to mainly nocturnal feeding, ingestion by larger juveniles seems to peak again in the middle of the day (Bromley et al. 1997, northern North Sea). Spawning takes place during evening and night (Brawn 1961; Breder & Rosen 1966 in Ferraro 1980).
Gadidae, Gadinae	*Merlangius merlangus* (Linnaeus, 1758)	**CAT**	This species performs vertical migrations, staying near the bottom during the day but tending to disperse in the upper water layers at night (Blaxter & Parrish 1958; Patterson 1985; Mergardt & Temming 1997). The population may consists of two subpopulations, a vertically migrating subpopulation feeding on pelagic prey and a non-migrating demersal subpopulation feeding on demersal prey (Pedersen 2000; Rindorf 2003). Migration was observed onshore at dusk and offshore at dawn (Gibson et al. 1996). Feeding peaks were observed in the morning (Hall et al. 1995, Pedersen 2000) and at night (Patterson 1985, Mergardt & Temming 1997). The diel pattern of feeding and even the diel vertical migration may vary depending on region and on the availability of the prey (Rindorf 2003). In contrast to other authors, Rindorf (2003) observed bottom dwelling prey in *M. merlangus* mainly during the night but free swimming prey mainly during the daylight hours. In small juveniles food ingestion peaks at 18:00-20:00, whereas juveniles of >3 cm length switch to cathemeral feeding (Bromley et al. 1997, northern North Sea). Courtship and spawning take place at night (Povoa et al. 2011) or in the morning (Storrow 1913 in Burchard et al. 2014).
Gadidae, Gadinae	*Micromesistius poutassou* (Risso, 1827)	**CAT**	This species undertakes vertical migrations, moving from deep water to the surface at night (Cohen 1990; Neumann & Paulus 2005). The day-night differences in vertical distribution drop markedly when the bottom depth exceeds 550 m, the depth at which blue whiting seem to lose their bottom association (Johnsen & Godø 2007). It feeds most probably during all periods of the day depending on region and food availability. Larvae as well intake food during day and night (Hillgruber & Kloppmann 1999). Blue whiting spawn at depths of 300–600 m, hatching larvae ascend to the upper 100 m of the water column to initiate feeding (Coombs et al. 1981; Hillgruber & Kloppmann 1999). Spawning may be independent of time of day.
Gadidae, Gadinae	*Trisopterus luscus* (Linnaeus, 1758)	**NM**	Information about diel avitivty is very scarce for this species. An analysis of stomach fullness implies that feeding takes place during most periods of the day with highest activity in evening and night (Fernández et al. 1995).

Gadidae, Gadinae	*Trisopterus capelanus* (Lacepède, 1800) syn. *T. minutus capelanus* (Lacepède, 1800)	**CAT**	Feeding takes place at quite different periods of the day (Albert 1995: Fig. 5d p. 881). Using bottom trawling, the species was fished twice as common during dawn and day compared to dusk and night (Bahamon et al. 2009) suggesting a stay in the midwater at dusk and night but near the seabed in daytime. Videotaped feeding individuals in depths of 100 m during day (Bozzano & Sardà 2002) confirm the latter scenario. Diurnal activity prevails in the study by Nickell & Sayer (1998; videotape recording). Bottom trawl data indicate a predominant activity from afternoon during dusk to the night in shallow water and activity during any period of the time in a depth of 400 m (Aguzzi et al. 2015). Migration onshore at dusk and offshore at down (Gibson et al. 1996). [Some of the cited sources refer to *T. minutus* that was earlier regarded as conspecific with *T. capelanus*.]
Gadidae, Phycinae	*Phycis blennoides* (Brünnich, 1768)	**CAT**	Data by Bahamon et al. (2009) suggest a DVM. The species stays in midwater (ca 400 m) during day and in the upper layers (ca 100 m) from dusk to dawn. This pattern is more pronounced in summer than in October, i.e. the portion of individuals remaining in the upper layer during day was around 2.5% in June compared to 15% in October (Bahamon et al. 2009). "Arhythmic" in deep water (Aguzzi et al. 2015).
Gadidae, Phycinae	*Phycis phycis* (Linnaeus, 1758)	**NM**	Nocturnal, hiding between rocks during the day (Cohen et al. 1990).
Gadidae, Gaidropsarinae	*Gaidropsarus biscayensis* (Collett, 1890)	**NM**	Information about diel activity is scarce. Nieder & Zander (1994) note this species as a member of the nocturnally active littoral rock dwelling fauna.
Gadidae, Gaidropsarinae	*Gaidropsarus granti* (Regan, 1903)	**UK**	VNP
Gadidae, Gaidropsarinae	*Gaidropsarus mediterraneus* (Linnaeus, 1758)	**NM**	Mainly nocturnal; agonistic behaviour and sound production as part of courtship behaviour was also observed mainly at night (Almada et al. 1996; Neumann & Paulus 2005).
Gadidae, Gaidropsarinae	*Gaidropsarus vulgaris* (Cloquet, 1824)	**UK**	VNP
Gadidae, Lotinae	*Molva molva* (Linnaeus, 1758)	**CRE**	Crepuscular activity with two peaks of moving and feeding, highest swimming activity at dawn and a less pronounced activity peak at dusk (Løkkeborg et al. 2000).
Gobiesocidae	*Apletodon dentatus* (Facciola, 1887)	**UK**	VNP
Gobiesocidae	*Apletodon incognitus* Hofrichter & Patzner, 1997	**DM**	Nothing in particular has been published about diel patterns in this species. However, Patzner (1999) reports about habitat use and obviously refers to a study during daylight.
Gobiesocidae	*Diplecogaster bimaculata* (Bonnaterre, 1788)	**DM**	Predominantly diurnally active species (Ribeiro et al. 2006).
Gobiesocidae	*Gouania wildenowi* (Risso, 1810)	**DM**	Nothing in particular has been published about diel patterns in this species. However, Patzner (1999) reports about habitat use and obviously refers to a study during daylight.
Gobiesocidae	*Lepadogaster candolii* Risso, 1810	**DD**	Strictly diurnal (Nickell & Sayer 1998). This is indirectly confirmed by observations on behaviour and habitat use made during daylight (Gonçalves et al. 1998; Patzner 1999).

Gobiesocidae	*Lepadogaster lepadogaster* (Bonnaterre, 1788)	**DM**	Nothing in particular has been published about diel patterns in this species. However, Patzner (1999) reports about habitat use and obviously refers to a study during daylight.
Gobiesocidae	*Lepadogaster purpurea* (Bonnaterre, 1788)	**DM**	Predominantly diurnally active species (Gonçalves et al. 1996). Spawning takes places during daylight (Emanuel Gonçalves in litt.)
Gobiesocidae	*Opeatogenys gracilis* (Canestrini, 1864)	**UK**	VNP
Gobiidae	*Aphia minuta* (Risso, 1810)	**CAT**	This species feeds during all periods of the day (La Mesa et al. 2008), but nocturnal feeding dominates acc. to Tirelli et al. (2014).
Gobiidae	*Buenia affinis* Iljin, 1930	**DM**	Nothing specifically about diel activity of this species has been published. Observations imply a predominantly diurnal activity (Kovačić & La Mesa 2010).
Gobiidae	*Buenia jeffreysii* (Günther, 1867)	**UK**	VNP
Gobiidae	*Buenia massutii* Kovačić, Ordines & Schliewen 2016	**UK**	VNP
Gobiidae	*Chromogobius quadrivittatus* (Kolombatovic, 1894)	**UK**	VNP. Cryptobenthic species, a nocturnal activity is not excluded.
Gobiidae	*Chromogobius zebratus* (Steindachner, 1863)	**UK**	VNP. Cryptobenthic species, a nocturnal activity is not excluded.
Gobiidae	*Corcyrogobius liechtensteini* (Kolombatovic, 1891)	**UK**	VNP
Gobiidae	*Coryogalops ocheticus* (Norman, 1927)	**UK**	VNP. Species of the genus *Coryogalops* occur in tidepools "often hidden in holes and under stones" (Kovačić et al. 2014).
Gobiidae	*Crystallogobius linearis* (von Düben, 1845)	**NM**	The diel activity of this species is incompletely known. Depth range (up to 400 m) and exclusively nocturnal fishery catches (La Mesa 2001) imply a nocturnal activity. Larvae of this species show at least in May and June a DVM indicating they stay closer to the bottom during daytime (Olivar & Sabatés 1997). It is possible that adults also show a DVM at times. Description of mating and spawning (Louisy 2015; Froese & Pauly 2019) suggests diurnal courting and spawning.
Gobiidae	*Deltentosteus collonianus* (Risso, 1826)	**DD**	Diurnally active species, resting in sand burrows under stones at night (WHATSTHATFISH 2011).
Gobiidae	*Deltentosteus quadrimaculatus* (Valenciennes, 1837)	**DM**	Feeding takes place from dawn to dusk (Villiers 1982). Bottom trawl data show an activity from midday to early nigth (Metin et al. 2011; Aguzzi et al. 2015).
Gobiidae	*Didogobius bentuvii* Miller, 1966	**UK**	VNP. Cryptobenthic species, a nocturnal activity is not excluded.
Gobiidae	*Didogobius schlieweni* Miller, 1993	**NM**	Predominantly nocturnal species (Francour 2008; Louisy 2015).

Gobiidae	*Didogobius splechtnai* Ahnelt & Patzner, 1995	**UK**	VNP. Cryptobenthic species, a nocturnal activity is not excluded.
Gobiidae	*Favonigobius melanobranchus* (Fowler, 1934)	**UK**	VNP. Feeding was observed diurnally in a related Pacific species (Yamamoto & Tominaga 2007).
Gobiidae	*Gammogobius steinitzi* Bath, 1971	**UK**	VNP. Cave inhabiting species.
Gobiidae	*Gobius ater* (Bellotti, 1888)	**CAT**	VNP. Data by Verdiell Cubedo (2009) imply indirectly a similar behaviour as in co-occurring *C. cobtitis*.
Gobiidae	*Gobius auratus* Risso, 1810	**DD**	Diurnal species (Patzner 2016: "Diese Grundeln sind tagsüber aktiv und verbergen sich nachts in ihren Verstecken"; Louisy 2015: "often seen hovering in open water above the substrate"; Macpherson 1994).
Gobiidae	*Gobius bucchichi* Steindachner, 1870	**DM**	Diurnal species (Macpherson 1994; La Mesa et al. 2006; Tesi 2008; De Raedemaecker et al. 2010), but it is not known if the species is partly active at night, because it stays in the same position and habitat in the night (Arndt, unpubl. obs.).
Gobiidae	*Gobius cobitis* Pallas, 1814	**CAT**	This species is active during night (Nieder & Zander 1994; Dulčić et al. 2004) and day (Macpherson 1994; Faria & Almada 2006; De Raedemaecker et al. 2010). Subadults often active during day, but large adults are crepuscular and nocturnal (Arndt unpubl. obs.). Courtship and spawning takes place during daylight (Faria et al. 1998, Malavasi et al. 2008; description of methods indirectly imply that all observations were made during daylight).
Gobiidae	*Gobius couchi* Miller & El-Tawil, 1974	**CAT**	The species is active during day and night (Ribeiro et al. 2006). However, more detailed data are not available.
Gobiidae	*Gobius cruentatus* Gmelin, 1789	**NM**	Diurnal species (Wilkins & Myers 1995; Picciulin et al. 2010), but it is not known if the species is partly active at night.
Gobiidae	*Gobius fallax* Sarato, 1889	**UK**	VNP. Cryptobenthic species (De Raedemaecker et al. 2010), a mainly nocturnal activity is possible.
Gobiidae	*Gobius gasteveni* Miller, 1974	**CAT**	This species is active during both day and night. This conclusion can be drawn based on the observations published by Alberto et al. (1999). The authors trawled and observed the species during the day. The diet however indicates at least a partial activity during night. Additionally, the authors found a very similar compostion of diet in the co-occurring *Lesueurigobius friesii* that is also active during day and night (see below). Details on courtship and spawning are not known.
Gobiidae	*Gobius geniporus* Valenciennes, 1837	**CAT**	In the Adriatic Sea, the acitivity of this species peaks at night (Dulčić et al. 2004), but it is at least partly active during daylight (De Raedemaecker et al. 2010).
Gobiidae	*Gobius niger* (Linnaeus, 1758)	**CAT**	There is contrasting information about diel activity. Predominantly nocturnally active species acc. to Ribeiro et al. (2006; Portugal) and Dulčić et al. (2004; Adriatic Sea), but diurnal acc. to Westin & Aneer (1987; Baltic sea). An inversion pattern (i.e. seasonal change from diurnal to nocturnal) is possible (Hesthagen 1976; Westin & Aneer 1987). Bottom trawl data indicate activity at any period of the day with a possible shift from afternoon/early night in October to a late night/diurnal pattern in June (Aguzzi et al. 2015). Diurnal and

			nocturnal activity was observed in the Aegean Sea in summer (Arndt, unpubl. obs.) that confirm stomach fullness data and a cathemeral activity (Fernández et al. 1995). Activity is influenced by tidal cycle, i.e. it significantly decreases during high tide (Ribeiro et al. 2006). Feeding peaks occur at dawn and dusk (Hesthagen 1976). Courtship and spawning take place during daytime (Mazzoldi & Rasotto 2002; Malavasi et al. 2008).
Gobiidae	*Gobius paganellus* (Linnaeus, 1758)	**CAT**	Active during day and night (Ribeiro et al. 2006; De Raedemaecker et al. 2010). Courtship and spawning take place during daylight (Malavasi et al. 2008; Parmentier et al. 2013; Parmentier in litt.)
Gobiidae	*Gobius roulei* de Buen, 1928	**DD**	Diurnal species, courtship takes also place during daytime (Pillon & Louisy 2016).
Gobiidae	*Gobius vittatus* Vinciguerra, 1883	**DM**	Active during the day (Kovačić 2007; De Raedemaecker et al. 2010), composition of diet (e.g. large portions of polychaetes) however suggests a partial nocturnal activity too.
Gobiidae	*Gobius xanthocephalus* Heymer & Zander, 1992	**DM**	Probably a diurnally active species (Monteiro et al. 2008), but no details have been published so far.
Gobiidae	*Hetereleotris vulgaris* (Klunzinger, 1871)	**UK**	VNP
Gobiidae	*Knipowitschia caucasica* (Berg, 1916)	**DM**	At least mainly diurnally active species, courtship and spawning also take place during day (Economou et al. 1994; Lugli & Torricelli 1999; see also diet and collecting methods described by Kevrekidis et al. 1990).
Gobiidae	*Knipowitschia panizzae* (Verga, 1841)	**DD**	Feeding and courtship take place during the day (Lugli & Torricelli 1999; Malavasi et al. 2008; Pizzolon et al. 2008).
Gobiidae	*Lebetus guilleti* (Le Danois, 1913)	**DM**	Nothing specifically about diel activity of this species has been published. But the data in Herler & Kovačić (2002) and Engin et al. (2015) imply a diurnal activity similar that in *Knipowitschia* species.
Gobiidae	*Lesueurigobius friesii* (Mahn, 1874)	**CAT**	No marked diurnal variation in the feeding pattern was noticed, although the amount of food in the stomachs was lowest in the early hours of the morning (Gibson & Ezzi 1978; Fernández et al. 1995). Bottom trawl data confirm an activity during day and night ("arhythmic species" acc. to Aguzzi et al. 2015). Nash (1982) found a clearly diurnal pattern in Scotland.
Gobiidae	*Lesueurigobius sanzi* (De Buen, 1918)	**UK**	VNP
Gobiidae	*Lesueurigobius suerii* (Risso, 1810)	**NM**	This species seems to be predominantly nocturnal (Louisy 2015), but detailed studies do not exist.
Gobiidae	*Millerigobius macrocephalus* (Kolombatovic, 1891)	**UK**	VNP. Cryptobenthic species, a mainly nocturnal activity is possible.
Gobiidae	*Odondebuenia balearica* (Pellegrin & Fage, 1907)	**UK**	VNP. Cryptobenthic species, a mainly nocturnal activity is possible.
Gobiidae	*Oxyurichthys petersii* (Klunzinger, 1871)	**DM**	VNP. Several observations were made during the day (photos available in the internet).

Gobiidae	*Pomatoschistus bathi* Miller, 1982	**DD**	Nothing specifically about diel activity of this species has been published. Data in Zander & Hagemann (1989), Zander (1995), Fischer et al. (2007) and Boltachev et al. (2016) indirectly indicate a diurnal activity. Courtship takes place during day (Bata 2013).
Gobiidae	*Pomatoschistus canestrinii* (Ninni, 1883)	**DM**	Data of this species including courtship suggest an at least mainly diurnal acitivity (Malavasi et al. 2008).
Gobiidae	*Pomatoschistus knerii* (Steindachner, 1861)	**UK**	VNP
Gobiidae	*Pomatoschistus marmoratus* (Risso, 1810)	**CAT**	This species shows diurnal territorial behaviour, courtship and spawning (Mazzoldi & Rasotto 2001; Malavasi et al. 2008). The investigation by Dulčić et al. (2004) suggests however no specific diel pattern and partly nocturnal activity.
Gobiidae	*Pomatoschistus microps* (Krøyer, 1838)	**CAT**	Predominantly nocturnal species in southern Portuguese Atlantic (Nash 1986; Ribeiro et al. 2006). However, general and feeding activity occurs mainly during day in the Baltic Sea, where it depends on light intensity and temperature. Only young individuals were observed to feed at night in the Baltic Sea (Meyer-Antholz 1987; Antholz et al. 1991). The data imply activity patterns changing from region to region and possibly from season to season.
Gobiidae	*Pomatoschistus minutus* (Pallas, 1770)	**CAT**	Active during night and day. The species exhibits an inversion pattern, i.e. seasonal change from nocturnal to diurnal during light intensity not exceeding 20 lx in winter (Westin & Aneer 1987; McCloskey 2013). Mainly active during night, usually buried in the sand during the day (Nash 1986; Ehrenberg & Ejdung 2007). Feeding may take place during day and night (Hesthagen 1971, observation in Baltic Sea; Edlund & Magnhagen 1981) and is highest during crepuscular periods (Norte-Campos & Temming 1994 in Thetmeyer 1997). Activity is influenced by tidal cycle and decreases significantly during high tide (Ribeiro et al. 2006). At least in areas with small or unpredictable tides, it has a considerable variability between individual fish (Gibson & Hesthagen 1981). Courtship and spawning take places during the day (Forsgren 1992; Lindström et al. 2006; Pedroso et al. 2013).
Gobiidae	*Pomatoschistus norvegicus* (Collett, 1902)	**CRE**	A mainly crepuscular species acc. to Nash (1982). Feeding may take place from night to early morning (Gibson & Ezzi 1981). This pattern must be verified in Mediterranean populations.
Gobiidae	*Pomatoschistus pictus* Miller, 1973	**DM**	Generally active during the day, closely associated with the substratum at night and during crepuscular periods, possibly as a result of decreasing activity (Wilkins & Myers 1992). Feeding peaks during dawn and dusk (Casabianca & Kiener 1969; Hesthagen 1980). Courtship and spawning take place during daylight (Amorim & Neves 2007, Pedroso et al. 2013, description of methods indirectly imply that all observations were made during daylight).
Gobiidae	*Pomatoschistus quagga* (Heckel, 1837)	**UK**	VNP, however reports of the species swimming actively up to 1 m above the bottom during the day imply an at least partly diurnal activity.
Gobiidae	*Pomatoschistus tortonesei* Miller, 1969	**UK**	VNP

Gobiidae	*Pseudaphya ferreri* (de Buen & Fage, 1908)	**DM**	Activity patterns are not examined in detail, but it can be seen swimming actively up to 1 m above the bottom during the day (Louisy 2015).
Gobiidae	*Silhouettea aegyptia* (Chabanaud, 1933)	**UK**	VNP
Gobiidae	*Speleogobius llorisi* Kovačić, Ordines & Schliewen 2016	**UK**	VNP
Gobiidae	*Speleogobius trigloides* Zander & Jelinek, 1976	**UK**	VNP
Gobiidae	*Thorogobius ephippiatus* (Lowe, 1839)	**NM**	Predominantly nocturnally active species acc. to Louisy (2015; Mediterranean). Mainly diurnal, but also active during dusk and dawn acc. to Nickell & Sayer (1998; Atlantic off Scottland; videotape recording). Details in Wilkins & Myers (1995) indicate indirectly diurnal activity.
Gobiidae	*Thorogobius macrolepis* (Kolombatovic, 1891)	**UK**	Activity patterns of this epibenthic species are not known so far. It was observed being active during day (Ahnelt & Kovačić 1997). Spawning time is unknown.
Gobiidae	*Tridentiger trigonocephalus* (Gill, 1859)	**UK**	VNP
Gobiidae	*Trypauchen vagina* (Bloch & Schneider, 1801)	**NM**	VPN. Reduced eyes and life in burrows suggest a predominantly nocturnal activity.
Gobiidae	*Vanderhorstia mertensi* Klausewitz, 1974	**DD**	Strictly diurnal (Karplus & Thompson 2011).
Gobiidae	*Vanneaugobius dollfusi* Brownell, 1978	**UK**	VNP
Gobiidae	*Vanneaugobius pruvoti* (Fage, 1907)	**UK**	VNP
Gobiidae	*Zebrus zebrus* (Risso, 1826)	**NM**	Specific information about diel activity is scarce. Cryptobenthic species, during day usually found in cracks or under stones (Louisy 2015).
Gobiidae	*Zosterisessor ophiocephalus* (Pallas, 1811)	**DM**	This species shows diurnal territorial behaviour, courtship and spawning (Mazzoldi et al. 2000). Also juveniles are active during day (Privileggi et al. 1997).
Gonostomatidae	*Gonostoma denudatum* Rafinesque, 1810	**DVM**	This mesopelagic species exhibits DVMs, juveniles and adults staying in 400–700 m by day and 100–200 m by night (Badcock 1984) suggesting a similar activiy pattern as in *Sigmops elongatus*. Detailed information is still not available.
Gonostomatidae	*Sigmops elongatus* (Günther, 1878)	**DVM**	This mesopelagic species undertakes DVMs, staying at midwater or sometimes near-bottom in depths from 500–1200 m during daytime, but migrating to the epipelagic or upper mesopelagic layers (50–400 m) during night (Badcock 1984; Potoschi et al. 2009). Feeding may takes place at any time, but feeding activity is much higher at night (Lancraft et al 1988).

Haemulidae	*Parapristipoma octolineatum* (Valenciennes, 1833)	**NN**	VPN, but see information at family level.
Haemulidae	*Plectorhinchus mediterraneus* (Guichenot, 1850)	**NN**	VPN, but see information at family level.
Haemulidae	*Pomadasys incisus* (Bowdich, 1825)	**NN**	Diurnal schooling while resting, nocturnal dispersing and foraging (Neumann & Paulus 2005, see also Santos et al. 2002).
Haemulidae	*Pomadasys stridens* (Forsskål, 1775)	**NN**	Diurnal schooling while resting, nocturnal dispersing and foraging (Neumann & Paulus 2005).
Hemiramphidae	*Hemiramphus far* (Forsskål, 1775)	**CAT**	VNP, but see information at family level.
Hemiramphidae	*Hyporhamphus affinis* (Günther, 1866)	**CAT**	VNP, but see information at family level.
Hemiramphidae	*Hyporhamphus picarti* (Valenciennes, 1847)	**CAT**	VNP, but see information at family level.
Heterenchelyidae	*Panturichthys fowleri* (Ben Tuvia, 1953)	**NN**	Morphological characters and fishery data suggest that it spends much of its time buried in the bottom sediment, emerging at night to search for food (Eagderi & Adriaens 2010; Smith et al. 2012).
Holocentridae	*Sargocentron rubrum* (Forsskål, 1775)	**NN**	Strictly nocturnal (Brandl & Bellwood 2014; Randall 1995).
Holocentridae	*Holocentrus adscensionis* Osbeck, 1765	**NN**	Strictly nocturnal (Hobson 1965).
Istiophoridae	*Istiompax indica* (Cuvier, 1832)	**DD**	Black marlin stay mainly at the surface at night, but dive repeatedly into deeper water for a short time during daylight (Chiang et al. 2014). Feeding takes place during daylight (Varghese et al. 2014).
Istiophoridae	*Istiophorus albicans* (Latreille, 1804)	**CAT**	Atlantic sailfish stay most of the time in surface waters, but display frequent short duration vertical dives from surface waters to depths of nearly 400 m during day and night (Mourato et al. 2010, 2014). The length of period spent in deeper water may differ from individual to individual or from season to season. Feeding takes place during daylight (filmed by Domenici et al. 2014). However the fish feeds during dives in deeper water too (Mourato et al. 2010), therefore it is likely that feeding takes place during day and night. Spawning is suggested off Florida during afternoon and early night (Richardson et al. 2009).
Istiophoridae	*Kajikia albida* (Poey, 1860)	**CAT**	White marlin do not show significant differences between diurnal and nocturnal behaviour (Horodysky et al. 2007; Dutton 2010). The species displays frequent short duration vertical excursions from surface waters to depths, number and depths of dives vary from individual to individual and from day to day. Dives are untertaken during day and night and may serve foraging (Horodysky et al. 2007). White marlin spent more time in the upper 10 m of the water column during night. Daytime depth distributions were bimodal, with a peak at the surface (0–10m) and a broader peak at depth in a study by Vaudo et al. (2017).

Istiophoridae	*Tetrapturus belone* Rafinesque, 1810	**UK**	The fish shows frequent short duration vertical dives from surface waters to depths of 30 m during day, but near surface movements at night (Arostegui et al. 2018; summer, Mediterranean). It is mostly caught at night by fisheries at night (Nakamura 1985). However, feeding or mating pattern are not known so far.
Istiophoridae	*Tetrapturus georgii* Lowe, 1841	**UK**	VNP
Kyphosidae	*Kyphosus sectatrix* (Linnaeus, 1758)	**DM**	Diurnal species (Randall 1967; Humann & DeLoach 2002). Spawning was observed from afternoon to dusk (Nemeth & Kadison 2013).
Kyphosidae	*Kyphosus vaigiensis* (Quoy & Gaimard, 1825)	**DM**	Diurnal species (Helfman 1993; Brandl & Bellwood 2014).
Labridae	*Acantholabrus palloni* (Risso, 1810)	**DD**	Diurnal species (Neumann & Paulus 2005).
Labridae	*Centrolabrus exoletus* (Linnaeus, 1758)	**DD**	Diurnal species (Costello et al. 1995). Its activity probably peaks between dawn and midday but declines afterwards (Thangstad 1999).
Labridae	*Centrolabrus melanocercus* (Risso, 1810)	**DD**	Diurnal species (Neumann & Paulus 2005). Courtship and spawning take place during the day as well (Fiedler 1964; Lejeune 1985).
Labridae	*Coris julis* (Linnaeus, 1758)	**DM**	Diurnal and crepuscular species (Santos et al. 2002; Koblmüller et al. 2003; Azzurro et al. 2013). At least in autumn, the species is in the Mediterranean Sea strictly diurnal (Aguzzi et al. 2013).
Labridae	*Ctenolabrus rupestris* (Linnaeus, 1758)	**DD**	Diurnal species (Neumann & Paulus 2005). Its activity peaks between dawn and midday, afterwards declining towards dusk (Costello et al. 1995; Nickell & Sayer 1998).
Labridae	*Iniistius pavo* (Valenciennes, 1840)	**DD**	Diurnal species (Neumann & Paulus 2005; Brandl & Bellwood 2014).
Labridae	*Labrus merula* Linnaeus, 1758	**DD**	Diurnal species (Koblmüller et al. 2003; Neumann & Paulus 2005).
Labridae	*Labrus mixtus* Linnaeus, 1758	**DD**	Diurnal species (Costello et al. 1995).
Labridae	*Labrus viridis* Linnaeus, 1758	**DD**	Diurnal species (Neumann & Paulus 2005). Courtship and spawning also take place during diurnal periods; courtship lasts several days, spawning was observed around midday (Kožul et al. 2011).
Labridae	*Lappanella fasciata* (Cocco, 1833)	**DD**	Diurnal species (Neumann & Paulus 2005). Diurnal spawning is very likely (see remark and source in Froese & Pauly 2019).
Labridae	*Pteragogus trispilus* Randall, 2013	**DD**	Diurnal species (Neumann & Paulus 2005).
Labridae	*Symphodus bailloni* (Valenciennes, 1839)	**DM**	Predominantly diurnal species (Ribeiro et al. 2006). Courtship and spawning take place during the day as well (Fiedler 1964; Lejeune 1985).
Labridae	*Symphodus cinereus* (Bonnaterre, 1788)	**DM**	Feeding takes place predominantly during the day (Fernández et al. 1995; Ribeiro et al. 2006). Courtship and spawning take place during day as well (Fiedler 1964; Lejeune 1985).

Labridae	*Symphodus doderleini* Jordan, 1890	**DD**	Diurnal species (Neumann & Paulus 2005). Courtship and spawning take place during the day as well (Fiedler 1964; Lejeune 1985).
Labridae	*Symphodus mediterraneus* (Linnaeus, 1758)	**DD**	Diurnal species (Neumann & Paulus 2005; Raposeiro et al. 2009). Courtship and spawning take place during the day as well (Fiedler 1964; Lejeune 1985).
Labridae	*Symphodus melops* (Linnaeus, 1758)	**DD**	Diurnal species (Neumann & Paulus 2005). Its activity probably peaks between dawn and midday but declining afterwards (Thangstad 1999). Courtship and spawning take place during the day as well (Fiedler 1964; Lejeune 1985).
Labridae	*Symphodus ocellatus* (Linnaeus, 1758)	**DD**	Diurnally active species, also courtship and spawning take place during full daylight (Taborsky et al. 1987; Neumann & Paulus 2005).
Labridae	*Symphodus roissali* (Risso, 1810)	**DD**	Diurnal species (Koblmüller et al. 2003; Neumann & Paulus 2005; Louisy 2015). Courtship and spawning take place during the day as well (Fiedler 1964; Lejeune 1985).
Labridae	*Symphodus rostratus* Bloch, 1791)	**DD**	Diurnal species, it often rests at night in vertical position between *Posidonia* (Neumann & Paulus 2005).
Labridae	*Symphodus tinca* (Linnaeus, 1758)	**DD**	Diurnal species (Koblmüller et al. 2003; Neumann & Paulus 2005). Courtship and spawning take place during the day as well (Fiedler 1964; Lejeune 1985).
Labridae	*Thalassoma pavo* (Linnaeus, 1758)	**DM**	Mainly diurnal; however the activity starts at a low level in early morning and dawn, and lasts through dusk until the early night (Azzurro et al. 2013). Spawning peaks around midday (Sara et al. 2005).
Labridae	*Xyrichthys novacula* (Linnaeus, 1758)	**DD**	Diurnal species (Neumann & Paulus 2005, Alós et al. 2012). Details about diel spawning pattern are lacking, however diurnal spawning is likely. Courtship and spawning were recorded in related species during afternoon (Victor 1987; Randall & Earle 2002).
Lampridae	*Lampris guttatus* (Brünnich, 1788)	**CAT**	See details in the information at family level (Polovina et al. 2008).
Leiognathidae	*Equulites elongatus* (Günther, 1874)	**NN**	Nocturnal species that has large eyes and a light organ (Sasaki et al. 2003; Chakrabarty et al. 2011). They are found in night trawls (Golani et al. 2011).
Leiognathidae	*Equulites klunzingeri* (Steindachner, 1898)	**NN**	Nocturnal species that has large eyes and a light organ (Sasaki et al. 2003; Chakrabarty et al. 2011).
Lethrinidae	*Monotaxis grandoculis* (Forsskål, 1775)	**NN**	Nocturnal species, feeding at night (Lieske & Myers 2004; Gillibrand et al. 2007; Brandl & Bellwood 2014). Diel spawning patterns are not available so far; species of the related genus *Lethrinus* spawn at night and spawning depends on lunar and tidal cycles (Hamilton 2005; Taylor & Mills 2013).
Lobotidae	*Lobotes surinamensis* (Bloch, 1790)	**CAT**	Tripletails may be active during all periods of the day (Streich 2010, Fig. 2-4, p. 52), with peaks during crepuscular periods and a slightly lower activity around midday. A predominantly nocturnal activity was suggested bei Streich et al. (2013). The species is diurnal acc. to Sazima et al. (2006), this information however could refer to juveniles due to their leaf mimicking behaviour.
Lophiidae	*Lophius budegassa* Spinola, 1807	**NM**	Bottom trawl data strongly suggest a diel migration from deep water (ca. 400 m), where the fish stay during day and dusk, to shallow water at night (ca. 100 m) (Aguzzi et al. (2015). The species is active during night

			and dawn (Colmenero et al. 2010). Its niche is temporally separate from the co-occuring *L. piscatorius*, supported by heavier otolith sagittae, i.e. a mostly acoustically driven behaviour (Colmenero et al. 2010).
Lophiidae	*Lophius piscatorius* Linnaeus, 1758	**DM**	Bottom trawl data suggest a crepuscular activity, but periods with activity occur in the afternoon or at night as well (Aguzzi et al. 2015). The species is mainly active during day and dusk (Colmenero et al. 2010, study in June in western Mediterranean Sea); it migrates mainly during the night (Ofstad 2013). Its niche is temporally separate from the co-occuring *L. budegassa*, supported by larger eyes but smaller otolith sagittae, i.e. a mostly visually driven behaviour (Colmenero et al. 2010).
Lutjanidae	*Lutjanus argentimaculatus* (Forsskål, 1775)	**NN**	The species is nocturnal (Cowden 1995; Gillibrand et al. 2007; Froese & Pauly 2019). It feeds at night with acitivity strongly decreasing in the morning and being very low during the day (Purnama Fitri et al. 2010). The listing as diurnal acc. to Brandl & Bellwood (2014) is erroneous. Spawning takes place at night, mainly between 23:00 and midnight (Leu et al. 2003).
Lutjanidae	*Lutjanus fulviflamma* (Forsskål, 1775)	**NM**	Nocturnal species (Gillibrand et al. 2007; Brandl & Bellwood 2014). The species feeds mainly during crepuscular and nocturnal periods with feeding peaks at dusk and dawn (Kamukuru & Mgaya 2004).
Lutjanidae	*Lutjanus sebae* (Cuvier, 1816)	**UK**	Diurnal species (acc. to Brandl & Bellwood 2014), but this has to be verified.
Lutjanidae	*Lutjanus jocu* (Bloch & Schneider, 1801)	**NM**	Nocturnal species (Murray 2015; Ramdhanie 2016). Spawning takes place at afternoon (Heyman & Kjerfve 2008; photo in Ramdhanie 2016).
Luvaridae	*Luvarus imperialis* Rafinesque, 1810	**UK**	VNP
Macroramphosidae	*Macroramphosus scolopax* (Linnaeus, 1758)	**DM**	The species is active during daytime and crepuscular periods, forming large schools mainly from earliest morning to mid-day and in late afternoon. It feeds from early morning to late afternoon (Carpentieri et al. 2016). During night snipefish schools are less clearly defined (Marques et al. 2005, Aguzzi et al. 2015). Larvae show a DVM (John 1973). The fish spawns in early evening ("last two hours of light", De Oliveira et al. 1993)
Merlucciidae	*Merluccius merluccius* (Linnaeus, 1758)	**NN**	Adults feed at night (Froglia 1973; Maynou et al. 2003). The hake stays near the seabed in daytime, but migrates up to the surface, probably related to foraging at night (de Pontual et al. 2012). Juveniles show a diel vertical migration as well (Bozzano et al. 2005). Larvae feed during most periods of the day, juveniles feed at night and may follow vertical migrations of their food (Froglia 1973; Morote et al. 2011; Papaconstantinou & Caragitsou 1987; Orsi-Relini et al. 1989; Carpentieri et al. 2008). Spawning takes place at night, because eggs and larvae occur in surface water and do not drift markedly (Olivar et al. 2003; Alvarez et al. 2004; Groison 2010).
Molidae	*Mola mola* (Linnaeus, 1758)	**CAT**	The ocean sunfish reveals a complex activity pattern that includes repeated dives into deeper layers (often below 200 m) and ascents during day and night (Cartamil & Lowe 2004; Hays et al. 2009; Dewar et al. 2010; Pope et al. 2010; Potter & Howell 2010). In some cases *M. mola* shows a more typical DVM while individuals stay in deep water during day but ascend at night (Sims et al. 2009). The depth and the number of dives differ between day and night, between seasons and between individuals (Sims et al. 2009; Dewar et al.

			2010; Potter & Howell 2010). The dives are less numerous and less deep in colder periods but more numerous and deeper in the summer (e.g. 12 daytime dives during a day in April vs. >40 dives in August; Dewar et al. 2010). This behaviour is linked to feeding and most probably a response to vertical migration of (gelatinous) zooplankton, attempting to locate maximum prey abundances (Sims et al. 2009). It is likely but not proven that sunfish also feed at night. Data for diel spawning pattern are not available.
Molidae	*Ranzania laevis* (Pennant, 1776)	**UK**	Information about this species is very scarce. Juvenile stages of this species feed (at least partly) at night (Robison 1975, concluding on the basis of food component analyses).
Monacanthidae	*Aluterus monoceros* (Linnaeus, 1758)	**DD**	Nothing specifically about diel pattern in this species has been published, but filefishes are generally diurnal (Brandl & Bellwood 2014; Hobson 1974).
Monacanthidae	*Stephanolepis diaspros* Fraser-Brunner, 1940	**DD**	Nothing specifically about diel pattern in this species has been published, but filefishes are generally diurnal (Brandl & Bellwood 2014; Hobson 1974).
Moronidae	*Dicentrarchus labrax* (Linnaeus, 1758)	**CAT**	This species is nocturnal in winter and mainly diurnal (65.5±7.5% of the activity displayed during the day) during the remainder of the year (Sánchez-Vásquez et al. 1998; Villamizar et al 2012). Trials under controlled conditions in tanks with juvenile sea bass suggest that particular specimens (a) may have individual diel patterns and (b) may dominate, i.e. trigger, the behaviour of the whole shoal (Millot & Bégout 2009). Larvae feed mainly during daylight hours (Ré et al. 1985). In the NE Atlantic/North Sea population, adults undertake short time dives from water surface to 30–80 m depth. These dives are performed at approx. 5-7 (max. 29) succeeding days, alternating with periods of non-diving, mainly (but not only) during crepsucular and nocturnal periods (Quayle et al. 2009). This study confirmed distinct differences in the behaviour between various individuals. Juveniles switch to mainly nocturnal activity, if they are solitary but show a mainly diurnal activity in shoals (Bégout Anras et al. 1997). Spawning takes place during the dark phase with two peaks, 6 and 11 h after nightfall (Villamizar et al 2012).
Moronidae	*Dicentrarchus punctatus* (Bloch, 1792)	**UK**	VNP
Mugilidae	*Chelon auratus* (Risso, 1810)	**DM**	Few studies deal with diel patterns of this species. The species is strictly diurnal acc. to the observations by Santos et al. (2002). The study by Arechavala-Lopez et al. (2010) indirectly suggests that adults are active during day and night. However, the 'feeding period' was not examined. Fry feed predominantly during day (Torricelli et al. 1988).
Mugilidae	*Chelon labrosus* (Risso, 1827)	**UK**	Few studies deal with diel patterns of this species. Results by Arechavala-Lopez et al. (2010) indirectly suggest that adults are active during day and night. However, the 'feeding period' was not examined. Fry feed predominantly during day (Torricelli et al. 1988). Spawning in tanks under natural light conditions took place all day round (Crosetti & Cordisco 2004).
Mugilidae	*Chelon ramada* (Risso, 1827)	**DM**	Feeding increases from dawn to dusk and distinctly decreases during night (Almeida 1993, 2003). Feeding rhythm does not depend on tidal cycle, at least in some parts of the distribution area (Almeida 2003). A diurnal pattern of migration in the tidal system of estuaries was shown by Trancart et al. (2012). Fry feed predominantly during day (Torricelli et al. 1988).

Mugilidae	*Chelon saliens* (Risso, 1810)	**DM**	Mainly diurnal feeding can be concluded, because adults are herbivorous (Froese & Pauly 2019), reports from aquaculture indirectly imply feeding during the day (Guinea & Fernández 1991) and due to a similar pattern in *C. ramada*. Juveniles feed from early morning (before dawn) to late evening (after dusk) but varying between seasons. In spring the fish feeds from morning to dusk, in summer during whole day from dawn to dusk and in autumn feeding peaks during dawn and dusk up to early night (Cardona 1999). Fry feed predominantly during day, a second feeding peak occurs around sunset (Torricelli et al. 1988).
Mugilidae	*Liza carinata* (Valenciennes, 1836)	**UK**	Few studies deal with diel patterns of this species. Fry feed predominantly during day (Torricelli et al. 1988).
Mugilidae	*Mugil cephalus* Linnaeus, 1758	**DM**	Mainly active during day (Froese & Pauly 2019). Diel feeding patterns show a certain plasticity dependent from area and/or environmental influences. Feeding takes place mainly during day, peaking around midday (De Silva & Wijeyaratne 1977 [Sri Lanka], Collins 1981 [Florida]) with a secondary peak at dawn (De Silva & Wijeyaratne 1977). The tidal phase may influence the foraging activity as there is some evidence for increased ingestion rates during incoming tides (Thomson 1966 [Australia], Odum 1970 [Atlantic US coast]), however De Silva & Wijeyaratne (1977) did not find a dependence between feeding peaks and tidal rhythm (see more details compiled by Whitfield et al. 2012). Feeding also takes place, at a much lower degree, during dusk and early night (Dankwa et al. 2005 [West Africa], Arndt unpubl. obs. [Mediterranean, summer]). Fry feed predominantly during day (Torricelli et al. 1988 revising their own results in Torricelli et al. 1982). Spawning takes place at night (Arnold & Thompson 1958; Thomson 1966; Martin & Drewry 1978; Ferraro 1980).
Mugilidae	*Oedalechilus labeo* (Cuvier, 1829)	**NM**	Nothing specifically about diel acitivity of this species has been published. However, its diet composition (cf. Londoño et al. 2011) indicates strictly nocturnal behaviour. This is confirmed by Reina-Hervás & Serrano (1987).
Mugilidae	*Planiliza haematocheila* (Temminck & Schlegel, 1845)	**UK**	Few studies deal with diel patterns of this species. Spawning takes place during evening and night (Chesalina 2000).
Mullidae	*Mullus barbatus* Linnaeus, 1758	**DM**	Diurnal species (Neumann & Paulus 2005; Ünlüoğlu et al. 2002). Feeding begins in the first hours of daylight, increases during the morning and decreases after the evening (Caragitsou & Tsimenides 1982; Onay & Dalgic 2019).
Mullidae	*Mullus surmuletus* Linnaeus, 1758	**DM**	Diurnal (Neumann & Paulus 2005), may be partly active during night in spring and summer (Dulčić et al. 2004; Arndt unpubl. obs.). Juveniles show a feeding peak between 12:00-20:00 (Mazzola et al. 1999). Feeding in the first half of the night was observed by Arndt (unpubl. obs., summer, Aegean Sea). Larvae show a diurnal feeding activity with peaks in early morning and late afternoon (Sabatés et al. 2015).
Mullidae	*Parupeneus forsskali* (Fourmanoir & Guézé, 1976)	**DM**	Most probably diurnal, data specifically on this species have not been published so far.
Mullidae	*Pseudupeneus prayensis* (Cuvier, 1829)	**DM**	Most probably diurnal, data specifically on this species have not been published so far.
Mullidae	*Upeneus moluccensis* (Bleeker, 1855)	**DM**	Most probably diurnal, data specifically on this species have not been published so far.

Mullidae	*Upeneus pori* Ben-Tuvia & Golani, 1989	**DM**	Diurnal (Neumann & Paulus 2005). Juvenile fish show a peak of feeding activity between 12:00-20:00 (Mazzola et al. 1999).
Muraenesocidae	*Cynoponticus ferox* (Costa 18,46)	**UK**	VNP.
Muraenesocidae	*Muraenesox cinereus* (Forsskål, 1775)	**NN**	Nocturnal species (Smith 1997), feeding at night (Nielsen 1974, data based on longline fisheries).
Muraenidae	*Enchelycore anatina* (Lowe, 1838)	**NN**	Nocturnal species (Debelius 2007; PIYW 2017).
Muraenidae	*Gymnothorax reticularis*, Bloch, 1795	**NM**	The retina shows characteristics of nocturnal species (Wang et al. 2011).
Muraenidae	*Gymnothorax unicolor* (Delaroche, 1809)	**UK**	Nothing specifically about diel activity of this species has been published.
Muraenidae	*Muraena helena* Linnaeus, 1758	**CAT**	Originally regarded a nocturnal species (Bauchot 1986; Ré & Meneses 2008; Matić-Skoko et al. 2014). However, it is generally active during various times, i.e. hunting in rocky areas and boulder fields even during daytime or while hidden in rock crevices holding out its head and looking for prey diurnally (Göthel 1992; Hess et al. 1998; Fischer et al. 2007; Arndt unpubl. obs.). The species was active 59.5±6% of the day and 85.8±3.1% of the night during a cage experiment (Meisel et al. 2013).
Myctophidae	*Benthosema glaciale* (Reinhardt, 1837)	**DVM**	This species performs DVMs, staying deeper than 375 m during daytime and in the epipelagic or upper mesopelagic layer during night (Badcock & Merrett 1977; Roe & Badcock 1984; Hulley 1990). However, depending on season or environment, this diel migration may be short or lacking, or not performed by all individuals (Albikovskaya 1988; Sutton et al. 2013). The oldest and largest individuals apparently do not ascend at night (Olivar et al. 2012). Feeding and spawning takes place at night (Gjøsaeter 1973; Gjøsæter & Tilseth 1988; Kinzer 1977).
Myctophidae	*Ceratoscopelus maderensis* (Lowe, 1839)	**DVM**	This species performs DVMs, staying deeper than 650 m during daytime and in the epipelagic or upper mesopelagic layer during night (Roe & Badcock 1984; Hulley 1990). Feeding during night (Bernal et al. 2015).
Myctophidae	*Diaphus dumerilii* (Bleeker, 1856)	**DVM**	This species performs DVMs, staying between 225 and 750 m during daytime and bimodally near the surface at night (Reiner 1996; Cavallaro et al. 2016).
Myctophidae	*Diaphus holti* Tåning, 1918	**DVM**	The species performs DVMs, staying deeper than 225m during daytime and bimodally in the epipelagic or upper mesopelagic layer at night (Roe & Badcock 1984; Hulley 1990).
Myctophidae	*Diaphus metopoclampus* (Cocco, 1829)	**DVM**	This species performs DVMs, staying deeper than 375 m during daytime and in the epipelagic or mesopelagic layer at night (Hulley 1986). As in many other myctophid species not all individuals seem to perform a DVM.
Myctophidae	*Diaphus rafinesquii* (Cocco, 1838)	**DVM**	This species performs DVMs, staying deeper than 375 m during daytime and bimodally in depths of 40–200 and 300–600 m at night (Hulley 1990).

Myctophidae	*Diogenichthys atlanticus* Tåning, 1928	**DVM**	This species performs DVMs, staying deeper than 400 m during daytime and in the epipelagic or mesopelagic layer at night (Hulley 1990). As in many other myctophid species, not all adult individuals seem to perform a DVM. Larvae and juveniles do not migrate (Hulley 1990).
Myctophidae	*Electrona risso* (Cocco, 1829)	**DVM**	This species performs DVMs, staying at depths of 225–750 m during the day and between 90–375 m (juveniles) and 450–550 m (adults) at night (Moser & Ahlstrom 1996).
Myctophidae	*Gonichthys cocco* (Cocco, 1829)	**DVM**	Similar to *Benthosema glaciale*, staying deeper than 425 m during daytime and in the epipelagic or upper mesopelagic layer at night (Hulley 1990).
Myctophidae	*Hygophum benoiti* (Cocco, 1838)	**DVM**	This species performs DVMs, staying deeper than 600 m during daytime and in the epipelagic or upper mesopelagic layer at night (Hulley 1990). Post-larvae and juveniles do not migrate (Hulley 1990). However, data suggest feeding during day and night (Bernal et al. 2015).
Myctophidae	*Hygophum hygomii* (Lütgen, 1892)	**DVM**	This species performs DVMs, staying deeper than 600 m during daytime and in the epipelagic or upper mesopelagic layer at night (Hulley 1990). However, data suggest feeding during day and night (Bernal et al. 2015).
Myctophidae	*Lampanyctus crocodilus* (Risso, 1810)	**DVM**	This species performs DVMs, staying deeper than 400 m during daytime and in the epipelagic or upper mesopelagic layer (100–600 m) at night (Roe & Badcock 1984; Hulley 1990). The data suggest that not all adult individuals seem to perform a DVM; the oldest and largest individuals do not ascend at night (Olivar et al. 2012). Feeding usually takes place during the night (Stefanescu & Cartes 1992); however in winter specimens may ingest at the bottom during the day as well (Bernal et al. 2015).
Myctophidae	*Lampanyctus intricarius* Tåning, 1928	**DVM**	This species performs DVMs, staying at depths between 550–750 m during the day, and between 40–550 m at night (Coad & Reist 2004; Sutton et al. 2013). Juveniles are most abundant at a depth of 75 m (Roe & Badcock 1984; Froese & Pauly 2019).
Myctophidae	*Lampanyctus pusillus* (Johnson, 1890)	**DVM**	Stays at depths below 425 m during the day and in the epipelagic or upper mesopelagic layer at night (Roe & Badcock 1984; Hulley 1990). Adults feed at night, both in near-surface depths and in the 400 m deep scattering layer (Bernal et al. 2015). Larvae feed actively near surface during the day (Bernal et al. 2013).
Myctophidae	*Lobianchia dofleini* (Zugmayr, 1911)	**DVM**	Stays at depths between 300–750 m during the day and in the epipelagic or upper mesopelagic layer at night. Feeds nocturnally or during vertical migration (Hulley 1986).
Myctophidae	*Lobianchia gemellarii* (Cocco, 1838)	**DVM**	Adults found at depths between 300–800 m during the day and 200–300 m at night. Feeds nocturnally or during vertical migration. Juveniles were found between 25–100 m (Hulley 1990). Nocturnal feeding as in previous species is likely.
Myctophidae	*Myctophum punctatum* Rafinesque, 1810	**DVM**	Adults found in the mesopelagic during the day and from the surface down to 125 m at night. Feeds nocturnally or during vertical migration (Hulley 1990).
Myctophidae	*Notoscopelus bolini* Nafpaktidis, 1975	**DVM**	Adults found in the mesopelagic during the day and in the epipelagic at night (Hulley 1984; Froese & Pauly 2019).
Myctophidae	*Notoscopelus elongatus* (Costa, 1844)	**DVM**	Adults found in the mesopelagic during the day and in the epipelagic at night (Froese & Pauly 2019), however the oldest and largest individuals do not ascend at night (Olivar et al. 2012). Feeding takes place during the night (Bernal et al. 2015).

Myctophidae	*Symbolophorus veranyi* (Moreau, 1888)	**DVM**	Adults found in the mesopelagic during day and from the surface down to 800 m (with maximum abundance at the surface) at night (Hulley 1990). Small sub-adults stay deeper at night than large sub-adults and adults (Hulley 1984). This size stratification implies feeding at night. The data suggest that not all adult individuals perform a DVM.
Nemichthyidae	*Nemichthys scolopaceus* Richardson, 1848	**CAT**	Feeding takes place at any time of day (Karmovskaya 1982; Feagans-Bartow & Sutton 2014). Juveniles, which generally occur at depths down to 100 m, do not perform a vertical migration, but larger specimens (>80 mm) may exhibit a DVM (Castonguay & McCleave 1987).
Nemipteridae	*Nemipterus randalli* Russell, 1986	**UK**	Diurnal activity is a common trait of the genus (John 1989, Russel 1990) and confirmed in specimens of the Red Sea. However, basing on trawl catches, Stern et al. (2014) vaguely assumed a shift toward nocturnal activity both in terms of food availability and by minimizing predation risk and competition.
Nettastomatidae	*Facciolella oxyrhyncha* (Bellotti, 1883)	**NN**	VNP, but see details in the information at family level.
Nettastomatidae	*Nettastoma melanurum* Rafinesque, 1810	**NN**	VNP, but see details in the information at family level.
Nomeidae	*Cubiceps gracilis* (Lowe, 1843)	**DVM**	Feeds at the surface at night, but descends to deeper layers during day as do other species of this genus (Gorelova et al. 1994).
Nomeidae	*Psenes pellucidus* Lütken, 1880	**UK**	VNP
Ophichthidae	*Apterichthus anguiformis* (Peters, 1877)	**NN**	VNP, but see details in the information at family level.
Ophichthidae	*Apterichthus caecus* (Linnaeus, 1758)	**NN**	This species is active during night (Gökoğlu et al. 2009).
Ophichthidae	*Dalophis imberbis* (Delaroche, 1809)	**NN**	VNP, but see details in the information at family level.
Ophichthidae	*Echelus myrus* (Linnaeus, 1758)	**NN**	VNP, but see details in the information at family level.
Ophichthidae	*Ophichthus rufus* (Rafinesque, 1810)	**NM**	*O. rufus* buries itsself during daytime and is active at night (Tortonese 1970; Matallanas 1979). However, some individuals are also seen swimming and feeding during daylight (Bozzano 2003; Bozzano & Sardà 2002). For instance, there up to 9 individuals during the day and up to 30 individuals at night were recorded by Bozzano & Sardà (2002) using a camera and providing baits. Spawning takes place probably at night (Casadevall et al. 2001).
Ophichthidae	*Ophisurus serpens* (Linnaeus, 1758)	**NN**	*O. serpens* hides in the subtratum during daylight. Feeding takes place at night (Heß 2005).
Ophichthidae	*Pisodonophis semicinctus* (Richardson, 1848)	**NN**	Feeding was observed at night (Bilecenoğlu et al. 2009).

Ophidiidae	*Ophidion barbatum* Linnaeus, 1758	**NN**	Strictly nocturnal (Matallanas & Riba 1980; Matallanas 1981; Neumann & Paulus 2005). Aguzzi et al. (2015) fished it also during dusk.
Ophidiidae	*Ophidion rochei* Müller, 1845	**NN**	Adults and juveniles are active during or after sunset (Matallanas & Riba 1980; Matallanas 1981; Letourneur et al. 2001; Dulčić et al. 2004; Codina et al. 2012). The fish emits sounds at night (Bolgan et a. 2020). During the day they hide buried in the sand (Fischer et al. 1987; Kéver et al. 2012).
Ophidiidae	*Parophidion vassali* (Risso, 1810)	**NN**	Nocturnal species (Louisy 2002; Ourgaud et al. 2015).
Oplegnathidae	*Oplegnathus fasciatus* (Temminck and Schlegel, 1844)	**DD**	This species eats during the day and rests in rock crevices at night (Myoung 2013). Spawning takes place from afternoon (3pm) to early night and peaks around sunset (Japanese Society of Scientific Fisheries 1974).
Ostraciidae	*Ostracion cubicus* (Linnaeus, 1758)	**DM**	Active during the day (Brandl & Bellwood 2014). Spawning most probably takes place in the evening (Moyer 1979a, Sancho 1998a).
Ostraciidae	*Tetrosomus gibbosus* (Linnaeus, 1758)	**DM**	Active during the day (Brandl & Bellwood 2014).
Pempheridae	*Pempheris rhomboidea* Kossmann & Räuber, 1877	**NN**	Nocturnally feeding species (Gillibrand et al. 2007). Spawning take place at night (Koeda et al. 2012).
Phosichthyidae	*Vinciguerria attenuata* (Cocco, 1838)	**CAT**	Few and contradictory data are published for this species. Both juveniles and adults exhibit vertical migrations, occurring at 250–600 m during the day but ascending to 100–500 m at dusk acc. to Badcock (1984) and Mundy (2005). Olivar et al. (2012) could not detect any diel migration.
Phosichthyidae	*Vinciguerria poweriae* (Cocco, 1838)	**DVM**	Both juveniles and adults exhibit DVMs; they are found at 300–600 m during the day and at 50–350 m at night (Badcock 1984; Mundy 2005).
Pinguipedidae	*Pinguipes brasilianus* Cuvier, 1829	**DD**	Diurnal species. Locally, its activity may be significantly dependent on tidal cycle but not on period of the day, i.e. morning vs. afternoon (Irigoyen et al. 2013). Details about spawning pattern have not been published so far.
Platycephalidae	*Elates ransonnettii* (Steindachner, 1876)	**UK**	VNP
Platycephalidae	*Papilloculiceps longiceps* (Cuvier, 1829)	**DM**	Data about diel activity are scarce for this species. Feeding during the day (Gillibrand et al. 2007).
Platycephalidae	*Platycephalus indicus* (Linnaeus, 1758)	**CAT**	Feeding was observed during both day and night (Hashemi & Taghavimotlagh 2013).
Platycephalidae	*Sorsogona prionota* (Sauvage, 1873)	**UK**	VNP
Pleuronectidae	*Platichthys flesus* (Linnaeus, 1758)	**NM**	Diel activity comprises diurnal and nocturnal movements, but nocturnal acitivity prevails (Bregnballe 1962; Muus 1967; Verheijen & de Groot 1967; Wolff et al. 1981; Holmes & Gibson 1983; Raffelli et al. 1990; Pereira 2004). Movements occur both in combination with tidal cycles as well as alone where the tidal amplitude is negligible. Tidal activity has been attributed to an increased feeding potential in the intertidal

			zone and predator avoidance. Feeding was observed during day and night, whereupon specimens of size most preferred by diurnal avian predators (i.e. 10–25 cm) move and feed predominantly at night (Verheijen & de Groot 1967, Wolff et al. 1981, Raffelli et al. 1990). Other studies revealed the flounder as a day-feeder (De Groot 1971; Mattila & Bonsdorff 1998), with feeding peak activities during dawn and dusk (De Groot 1971; Muus 1967). Juvenile flounders feed mainly at night (Pereira 2004; Rasmussen 2005: 53) or in turbid estuarine waters mainly at dawn, dusk and night (Pihl 1982 in Vinagre et al. 2008). Migratory behaviour is also variable and even differs between sections of the same estuarine population (Wolff et al. 1981; Summers 1979).
Pleuronectidae	*Pleuronectes platessa* (Guichenot, 1850)	**CAT**	Diel movements occur both in combination with tidal cycles as well as alone where the tidal amplitude is negligible, and comprise diurnal, crepuscular and nocturnal activities (Gibson 2005, p. 172). Tidal flats (e.g. in the Wadden Sea) are used to the same extent during day and night (Berghahn 1986). On open coasts with a tidal regime, plaice primarily settles in the subtidal zone, moving with each tidal cycle, but their distribution in these areas is modified by a superimposed diel migration pattern with onshore tidal movement being more prononced during the night (Burrows et al. 1994; Arnold & Metcalfe 1995). On coasts with low tidal amplitude (<0.3m) the diel pattern also shows onshore movements during night and a return to deeper water at dawn. This activity has been attributed to an increased feeding potential in the intertidal zone and predator avoidance (Gibson 1973, 2005; Ansell & Gibson 1993; Raffaeli et al. 1999). Feeding by adults mainly takes place in afternoon and dusk (Verheijen & de Groot 1967) and may change with season or locality (de Groot 1971). Young plaice feed during both day and night on large prey, but meiofauna (harpacticoids and ostracods) prevail diurnally (Gibson et al. 1998). Food consumption in juvenile plaice is significantly higher at night (Gibson et al. 1998). Nocturnal swimming activity (migration) is reported by Verheijen & de Groot (1967), Solmundsson et al. (2003) and Hunter et al. (2004). The nocturnal swimming activity of plaice observed by Solmundsson (2003) is unlikely to be related to feeding behaviour, as the feeding by the mature plaice sampled was negligible according to a visual inspection of their stomach contents. The plaice spawns mostly at night and only sporadically during daylight (Forster 1953; Beverton 1964; Simpson 1971; Nichols 1989).
Plotosidae	*Plotosus lineatus* (Thunberg, 1787)	**NM**	Adults are nocturnal and known to hide under ledges during the day (Wright 1989; Kasai et al. 2009, Clark et al. 2011). Juveniles were active during day and resting during night (Clark et al. 2011).
Polynemidae	*Galeoides decadactylus* (Bloch, 1795)	**UK**	VNP. "Diurnal" acc. to Pulcini et al. (2008, Table A1). However, none of the sources cited therein (i.e. Hobson 1965, Helfman 1978, Potts 1990) deals with this species or even the family Polynemidae, thus this classification is very doubtful.
Polyprionidae	*Polyprion americanus* (Bloch & Schneider, 1801)	**CAT**	Information about activity in this species is very scarce. It is generally demersal but undertakes some vertical movements at night and feed on pelagic prey, suggesting that the species feeds at different periods of the day (Peres & Haimovici 2003). Spawning takes place in depths of 300–500 m (Peres & Klippel 2003) and therefore probably at night.

Pomacanthidae	*Holacanthus ciliaris* (Linnaeus, 1758)	**DM**	Diurnal species. Spawning takes place in the evening, especially at sunset (Moyer et al. 1983; Shah 2015).
Pomacanthidae	*Pomacanthus imperator* (Bloch, 1787)	**DM**	Diurnal species. Spawning takes place during dusk (Thresher 1982; Randall 1995; Lieske & Myers 2004).
Pomacanthidae	*Pomacanthus maculosus* (Forsskål, 1775)	**DM**	Diurnal species (Randall 1995; Lieske & Myers 2004).
Pomacentridae	*Abudefduf hoefleri* (Steindachner 1881)	**DM**	The species is diurnal (Helfman 1993, Morais, et al. 2017). Males guard theirs eggs including at dusk and night (Breder & Rosen 1966).
Pomacentridae	*Abudefduf saxatilis* Linnaeus, 1758	**DM**	Diurnal species (Maurakis et al. 2010), approaching the bottom to seek nighttime shelter at dusk (Thresher 1984). During spawning season males also approach the bottom to build spawning territories. Courtship starts in mid-morning or at early dusk with spawning following soon after acc. to Thresher (1984). Spawning peaks at or prior to first light in the morning and is continued to a small extent until early afternoon acc. to Foster (1987). Brood care continues during night (Foster 1987; Reebs 2002 and references herein). Larvae hatch soon after sunset (Roberston et al. 1990; McAlary & McFarland 1991).
Pomacentridae	*Abudefduf vaigiensis* (Quoy & Gaimard, 1825)	**DM**	Diurnal species (Frédérich et al. 2008). Spawning takes place in the morning and is continued to about midday (Lieske & Myers 2004; Brough et al. 2018).
Pomacentridae	*Chromis chromis* (Linnaeus, 1758)	**DD**	The fish are active during the day, swim closer to the surface at dusk, but disperse over the substratum to select holes and rock crevices afterwards in order to rest during night. At first light they re-appear and form schools within half an hour (Cambrige University Underwater Exploration Group 1965; Harmelin 1987; Pinnegar & Polunin 2006; Aguzzi et al. 2013). The description by Neumann & Paulus (2005) implies that the species is active, courts and spawns during the day.
Pomacentridae	*Chrysiptera cyanea* (Quoy & Gaimard 1825)	**DM**	Diurnal species (Hobson 1972, 1974). Males guard theirs eggs (Breder & Rosen 1966).
Pomacentridae	*Stegastes variabilis* (Castelnau, 1855)	**DD**	Diurnal species (Humann & DeLoach 2008; Medeiros et al. 2010). Specific data on diel spawning pattern are lacking, but a similar pattern as in its congener *S. nigricans* is likely (Karino & Kuwamura 1997).
Pomatomidae	*Pomatomus saltatrix* (Linnaeus, 1758)	**DM**	This species is the only representative of its family, see details in the family description. Additional information: Though numerous fishery data suggest a nocturnal part of adult activity as well (see e.g. Gaelzer & Zalmon 2008), otter trawl catches suggest that bluefish descend to near-bottom to feed upon schools of anchovies during the day, and then ascend at night to where they are less accessible to otter trawls (Wiedenmann & Essington 2006).
Priacanthidae	*Priacanthus arenatus* Cuvier, 1829	**NN**	Nocturnal feeder (Böhlke & Chaplin 1993).
Priacanthidae	*Priacanthus sagittarius* Starnes, 1988	**NN**	Nocturnal feeder (Randall 1995; Lieske & Myers 2004).
Rachycentridae	*Rachycentron canadum* (Linnaeus, 1766)	**DM**	The species is the only representative of its family, see details in the family description.

Regalecidae	*Regalecus glesne* Ascanius, 1772	**UK**	Observation of active individuals were always made during daylight (see e.g. Benfield et al. 2013, Loyer 2015), but it is not known if this species is also active during night or when it spawns.
Scaridae	*Scarus ghobban* Forsskål, 1775	**DM**	Diurnal species (Brandl & Bellwood 2014), specific data on feeding and spawning patterns have not been published so far.
Scaridae	*Sparisoma cretense* (Linnaeus, 1758)	**DM**	Diurnal and crepuscular active species (Neumann & Paulus 2005; Azzurro et al. 2013). Spawning takes place during dawn (Afonso et al. 2008) or dusk (de Girolamo et al. 1999).
Scatophagidae	*Scatophagus argus* (Linnaeus, 1766)	**DM**	This species is diurnally active (Brandl & Bellwood 2014). Feeding takes place mainly, but not exclusively, during daylight hours (Allen 1984; Mathew 1988). During the night food may be uptaken 'passively', not actively (Mathew 1988). Several authors report observations that indirectly imply diurnal food intake (Barry 1991; Sivan & Radhakrishnan 2011). Courtship behaviour and antagonistic behaviour between males during courtship are shown during the day, but it is not evident if spawning also take place diurnally or rather in the evening or during night (see Barry 1991).
Sciaenidae	*Argyrosomus regius* (Asso, 1801)	**NN**	Nocturnal species (Corbera et al. 1996; Gil Oviedo 2013).
Sciaenidae	*Sciaena umbra* Linnaeus, 1758	**NM**	Active during different periods of the day (night, morning and midday, but not in afternoon; Lök et al. 2008), but more active at night than at day (Froese & Pauly 2019).
Sciaenidae	*Sciaenops ocellatus* (Linnaeus, 1766)	**NN**	Nocturnal species (Corbera et al. 1996; Cruz & Lombarte 2004), "nocturnal descent" (Hickford 2000; Lyczkowski-Schultz & Steen 1991). Spawning occurs from afternoon to dusk or night (Lowerre-Barbieri et al. 2008; Saillant et al. 2007).
Sciaenidae	*Umbrina canariensis* Valenciennes, 1843	**NN**	Nocturnal species (Corbera et al. 1996).
Sciaenidae	*Umbrina cirrosa* (Linnaeus, 1758)	**NN**	Nocturnal species (Corbera et al. 1996).
Sciaenidae	*Umbrina ronchus* Valenciennes, 1843	**NN**	Nocturnal species (Corbera et al. 1996).
Scomberesocidae	*Scomberesox saurus* (Walbaum, 1792)	**DVM**	Adults undertake DVM, moving into deeper water during the day and rising to the surface at night to feed (Korkosh 1992; Department of Fisheries and Aquaculture 2015). However, Reckel (2001) reported in this species eyes with duplex retina typical of diurnal teleost fishes. The eggs and larvae of this species are found at any time of the day in the surface layer, mostly at 0–1 m (Parin 1967; Dudnik et al. 1981).
Scombridae	*Acanthocybium solandri* (Cuvier, 1832)	**CAT**	This species is active during both day and night and spends >98% of the time within the warm waters of the upper mixed layer. The number of dives does not vary significantly between day and night (Sepulveda et al. 2011, observations off Baja California, Mexico). Wahoo feed during crepuscular and diurnal periods with feeding peaks in early morning and in the evening (Vaske et al. 2003; Franks et al. 2007).
Scombridae	*Auxis rochei* (Risso, 1810)	**UK**	Feeding patterns of adults are not known in detail, but studies indirectly imply nocturnal activity (Whitney 1969; see also Uchida 1981). The larvae feed continuously during daylight (Morote et al. 2008b).

Scombridae	*Euthynnus alletteratus* (Rafinesque, 1810)	**CAT**	Adults of this species are active during different periods of the day, including diurnal (Wichlund 1968; Chur 1977; García & Posada 2013) and nocturnal (Bullis & Juhl 1967; Bahou et al. 2007) feeding. Larvae feed during daylight (Llopiz et al. 2010).
Scombridae	*Katsuwonus pelamis* (Linnaeus, 1758)	**CAT**	This species shows a variable behaviour and diel patterns with activity phases during day and night and, most probably, varying from season to season and from area to area depending on water temperatures and vertical distribution of prey ressources. E.g. adults spend the night in surface waters, but show a more differentiated diurnal activity pattern. During day the fish are often associated with floating objects. When not associated with floating objects, skipjack tuna display repetitive bounce-diving behaviour below the thermocline, spending there in total more than 33% of daytime (Schaefer & Fuller 2007, observations in equatorial East Pacific). Adults feed during different periods of the day. The feeding activity peaks in the early morning and late afternoon (Dragovic 1970; Collette & Nauen 1983), but feeding is possible at night too (Neumann & Paulus 2005). The frequent diurnal dives are also interpreted as prey exploitation (Schaefer & Fuller 2007). Larvae feed during daylight (Llopiz et al. 2010). Spawning takes place at night (Hunter et al. 1986), however other sources report diurnal spawning (Iverson et al. 1970; Matsumoto et al. 1984).
Scombridae	*Orcynopsis unicolor* (Geoffroy Saint-Hillaire, 1817)	**UK**	VNP
Scombridae	*Rastrelliger kanagurta* (Cuvier, 1816)	**CAT**	Feeding takes place during different periods of the day (e.g. at night, Kamanyi 1975; during dayligth, cf. photo in Louisy 2015) and may depend on different regions or seasons. Spawning occurs at night (Devanesan & John 1940; Vijayaraghavan 1962; Yohannan & Abdurahiman 1998).
Scombridae	*Sarda sarda* (Bloch, 1793)	**CRE**	Atlantic bonito feed diurnally with peaks in the early morning and towards the evening (Demir 1963).
Scombridae	*Scomber colias* Gmelin 1789	**DVM**	Spanish mackerel show vertical migrations, staying near the bottom during day and moving the open water at night (Maigret & Ly 1986). Spawning takes place in the night (Kamiya 1925 in Ferraro 1980).
Scombridae	*Scomber scombrus* Linnaeus, 1758	**DM**	Mainly diurnal while occurring in schools (Froese & Pauly 2019). The species feeds diurnally with feeding peak from afternoon until sunset (Dahl & Kirkegaard 1986). Diurnal activity is also supported based on trawling data (Aguzzi et al. 2015). Larvae perform DVMs, ascending toward the surface at night and descending toward the thermocline at day (Sette 1943). The Atlantic mackerel may spawn during all times of the day and night (Bigelow & Welsh 1925; Sette 1943; Ferraro 1980; Walsh & Johnstone 1992).
Scombridae	*Scomberomorus commerson* (Lacépède, 1800)	**CAT**	Feeding apparently takes place during day and night (McPherson 1981). The fish spawn between afternoon and the early hours of darkness (Munro 1942; Mackie et al. 2003).
Scombridae	*Scomberomorus tritor* (Cuvier, 1832)	**UK**	Detailed patterns of activity are not described so far, but a behaviour similar to *S. commerson* is likely. Louisy (2015) provides a photo showing this species taking a bait during day.
Scombridae	*Thunnus alalunga* (Cetti, 1777)	**CAT**	Four different types of movement and diving behaviours were recorded so far in albacores (Cosgrove et al. 2014). Type (a): similar diel depth distributions (≤50 m) during day and night. Type (b): shallow diurnal depth distributions (≤50 m) but distinctly shallower nocturnal distributions between 20 and 30 m deep. Type (c): substantially deeper diurnal depth distributions associated with regular V shaped dives (partly deeper as 200

			m) and shallower nocturnal distributions (≤80 m). Type (d): regular repetitive diurnal bounce dives predominantly between 150 and 250 m returning to depths of ~50 m after each bounce; type (d) behaviour was observed in one tagged individual only (Cosgrove et al. 2014). Albacore feed during both day and night (Iversen 1962), but the stomach content of fish caught at night is reduced, probably due to less successful foraging since albacore is most likely a visual feeder (Murphy 1969). Juvenile albacore feed mainly during night (Goñi etal. 2009, Bay of Biskay, summer). Larvae feed during daylight (Llopiz et al. 2010). The fish spawn between midnight and early morning (Farley et al. 2013).
Scombridae	*Thunnus thynnus* (Linnaeus, 1758)	**CAT**	Bluefin tunas show a rather irregular pattern of repeated short duratoin dives from the surface to deeper layers (>50 – >150 m; Teo et al. 2007) or more defined patterns of activity foraging at the surface at night but in slightly deeper water during crepuscular periods. During day they use short duration 'V-shaped' dives or longer 'U-shaped' dives to the mid-water to forage (Wilson & Block 2009). Daytime swimming depths are usually deeper than those at dusk, night, and dawn (Wilson et al. 2005), but exceptions are documented (Stokesbury et al. 2004). Larvae feed during daylight (Llopiz et al. 2010). Distinct changes in the diving behaviour occurring in the Gulf of Mexico during the breeding phase are considered as potential signals of spawning period (Teo et al. 2007). The latter behaviour coincides with distinctive oscillatory diving (brief oscillatory movements below the mixed layer) showed by schools in the Balearic area during spawning season between midnight and sunrise. These oscillatory dives started shortly after the onset of courtship behaviour (from 12:00) (Aranda et al. 2013). Spawning takes place from midnight to sunrise with a peak between 02:00-03:00 (or 5:00) hours (Gordoa 2010; Gordoa et al. 2009, 2015, Gordoa & Carreras 2014).
Scophthalmidae	*Lepidorhombus boscii* (Risso, 1810)	**UK**	Only few data have been published. Bottom trawl data from deep water indicate comparable numbers during different parts of the day (Bahamon et al. 2009; Aguzzi et al. 2015).
Scophthalmidae	*Lepidorhombus whiffiagonis* (Walbaum, 1792)	**UK**	VNP
Scophthalmidae	*Scophthalmus maximus* (Linnaeus, 1758)	**DM**	Diel activity comprises diurnal as well as nocturnal onshore/offshore movements that may coincide with tidal cycles (Gibson et al. 1996). Boulenger (1929 in de Groot 1971) reported more swimming acitivity during the night than during the day based on aquarium observations. In contrast, diurnal swimming and bottom activity clearly predominates in adult fish acc. to Imsland et al. (1995). Juveniles show primarily nocturnal activity (Westin & Aneer 1987; Nash et al. 1994; Champalbert et al. 1998). However Imsland et al. (1995) detected diurnal activity in laboratory experiments with juveniles. Waller (1992) found two activity peaks in juveniles (morning and evening), whereas Dietz (2012) recognized only a morning peak in juveniles. De Groot (1971) describes a diurnal feeding pattern. Spawning most probably takes place during the evening and nighttime (cf. Ferraro 1980, Jones 1972), but in tanks it was also observed during the morning (Bromley et al. 1986).
Scophthalmidae	*Scophthalmus rhombus* (Linnaeus, 1758)	**DM**	Diurnal swimming and bottom activity predominates in adult fish (de Groot 1971). Juveniles show nocturnal activity in hauls (Nash et al. 1994). Spawning most probably takes place in the evening and at night (cf. Ferraro 1980).

Scophthalmidae	*Zeugopterus regius* (Bonnaterre, 1788)	**DM**	This species is mainly (spring, autumn) or strictly (summer) diurnal, but a shift to a mainly nocturnal activity may occur in winter (Nickell & Sayer 1998: videtape recorning). A mainly diurnal pattern is confirmed by Neumann & Paulus (2005).
Scorpaenidae (Pteroini)	*Pterois miles* (Bennett, 1828)	**NM**	In its native distribution area, this species primarily forages during crepuscular and nocturnal hours, starting activity typically around nightfall and continuing through the night. It hovers near ledges, caves and in wrecks by day (Lieske & Myers 2004). The majority of foraging activities occurrs around or after sunset (McTee & Grubich 2014). However, the diel foraging pattern may be highly variable in newly occupied areas, including atypical mid-morning, mid-day, and early afternoon feeding (Morris & Akins 2009, Côté & Maljkovic 2010), as well as diurnal inactivity and crepuscular feeding (Green et al. 2011, Cure et al. 2012, Jud & Layman 2012). In the Mediterranean Sea, *P. miles* seems to feed mainly during the crepuscular periods (D'Agostino et al. 2020). Courtship, which includes circling, side winding, following, and leading, begins shortly before dark and extends well into nighttime hours (Fishelson 1975; Morris et al. 2009).
Scorpaenidae (Scorpaeini)	*Pontinus kuhlii* (Bowdich, 1825)	**UK**	VNP
Scorpaenidae (Scorpaeini)	*Scorpaena elongata* Cadenat, 1943	**DM**	Predominantly feeding during day (Ordines et al. 2012). Note that this species occurs in rather deep water (75–800 m; Louisy 2016).
Scorpaenidae (Scorpaeini)	*Scorpaena loppei* Cadenat, 1943	**NM**	The prey found in the stomach contents of *S. loppei* presented a high level of digestion during daylight hours, indirectly indicating feeding at night (Ordines et al. 2012).
Scorpaenidae (Scorpaeini)	*Scorpaena maderensis* Valenciennes, 1833	**NM**	Predominantly nocturnal (Micael et al. 2005; Arndt unpl. obs. in Croatia), however Azzurro et al. (2007) reported similar diurnal and nocturnal activity. Night dive videos showed feeding specimens (Alejandra Pérez, Aquatours Almería Aventuras Subacuáticas, unpubl. obs.).
Scorpaenidae (Scorpaeini)	*Scorpaena notata* Rafinesque, 1810	**DM**	Predominantly diurnal species (Lök et al. 2008).
Scorpaenidae (Scorpaeini)	*Scorpaena porcus* Linnaeus, 1758	**CAT**	Predominantly active during the day acc. to Lök et al. (2008). Predominantly feeding at night, but not inactive during day (Harmelin-Vivien et al. 1989; Pallaoro & Jardas 1991; Arculeo et al. 1993).
Scorpaenidae (Scorpaeini)	*Scorpaena scrofa* Linnaeus, 1758	**DM**	Predominantly diurnal species (Lök et al. 2012). Spawning takes place in early morning (Maricchiolo et al. 2014).
Scorpaenidae (Scorpaeini)	*Scorpaena stephanica* Cadenat, 1943	**DM**	Predominantly diurnal feeding activity (Ordines et al. 2012). This species may occur in rather deep water (46–600 m; Louisy 2016).
Scorpaenidae (Scorpaeini)	*Scorpaenodes arenai* Torchio, 1962	**NM**	Nocturnal feeding species (Micael et al. 2005).
Scorpaenidae (Scorpaeini)	*Sebastapistes strongia* (Cuvier, 1829)	**NM**	Nocturnal feeding species (Allen & Erdmann 2012).
Scorpaenidae (Sebastini)	*Helicolenus dactylopterus* (Delaroche, 1809)	**CAT**	Predominantly feeding during night acc. to Torres Leal (2013). In bottom trawls it was fished much more commonly during the day than during the night in summer, but in similar proportions during day and night in

			autumn (Bahamon et al. 2009; Aguzzi et al. 2015: "arhythmic species"). The species was caught during the day in 400 m depth bottom trawls, suggesting a preference for low light conditions (Aguzzi et al. 2015).
Scorpaenidae (Synanceini)	*Synanceia verrucosa* Bloch & Schneider, 1801	**DM**	Active and feeding during the day (Gillibrand et al. 2007; Brandl & Bellwood 2014).
Serranidae (Anthiinae)	*Anthias anthias* (Linnaeus, 1758)	**DM**	Diurnal species (Helfman 1993; Neumann & Paulus 2005), hiding under rock cliffs or in caves during the night (Micarelli & Barlettani 2005). Nocturnal species acc. to Malak et al. (2011). Data on spawning period are not published, but related species spawn after sunset and during the night.
Serranidae (Anthiinae)	*Paranthias furcifer* (Valenciennes, 1828)	**DM**	Diurnal species, hiding and resting during night (Rooker et al. 1997). Data on spawning period are not published for this species, but related species spawn after sunset and during the night.
Serranidae (Epinephelinae)	*Cephalopholis hemistiktos* (Rüppell, 1830)	**DM**	Diurnal feeder (Froese & Pauly 2019).
Serranidae (Epinephelinae)	*Cephalopholis taeniops* (Valenciennes, 1828)	**DM**	Mainly diurnal with an activity peak in late afternoon, but some individuals may also be active in late night to early morning (Lino et al. 2011).
Serranidae (Epinephelinae)	*Epinephelus aeneus* (Geoffroy Saint-Hilaire, 1817)	**UK**	VNP
Serranidae (Epinephelinae)	*Epinephelus caninus* (Valenciennes, 1843)	**UK**	VNP
Serranidae (Epinephelinae)	*Epinephelus coïoïdes* (Hamilton, 1822)	**UK**	Classified as "diurnal" by (Brandl & Bellwood 2014). Spawning takes place during dusk (Sudaryanto & Mous 2004)
Serranidae (Epinephelinae)	*Epinephelus costae* (Steindachner, 1878)	**CAT**	Mainly a diurnal feeder (Gracia López & Castelló i Orvay 2005; Hackradt 2012). However some individuals do not show a clear diurnal pattern and one observed individual was nocturnal (Hackradt 2012).
Serranidae (Epinephelinae)	*Epinephelus fasciatus* (Forsskål, 1775)	**CAT**	Classified as "diurnal" by Brandl & Bellwood (2014) but "nocturnal" by Gillibrand et al. (2007). Feeding occurs during both day and night (Harmelin-Vivien & Bouchon 1976).
Serranidae (Epinephelinae)	*Epinephelus malabaricus* (Bloch & Schneider, 1801)	**UK**	Classified as "diurnal" by (Brandl & Bellwood 2014).
Serranidae (Epinephelinae)	*Epinephelus marginatus* (Lowe, 1834)	**CAT**	Predominantly diurnal and crepuscular species with activity peaks at midday and during dusk (Abel 1962; Neill 1967; Ghafir & Guerrab 1992; Gibran 2006; Azzurro et al. 2013; Koeck et al. 2014; Afonso et al. 2016). There is a great individual plasticity in the diurnal pattern. Hackradt (2012) observed a distinct diurnal pattern (with peaks at midday or in the afternoon) in the majority of individuals, a cathemeral pattern in about 40% of individuals and one nocturnal specimen. Spawning takes place at dusk and night (Zabala et al. 1997; Bertucci et al. 2015).
Serranidae (Epinephelinae)	*Epinephelus merra* Bloch, 1793	**UK**	Classified as "diurnal" by (Brandl & Bellwood 2014). Spawning takes place during night (Jagadis et al. 2007; Sanchez-Cardenas & Arreguin-Sanchez 2012).
Serranidae (Epinephelinae)	*Hyporthodus haifensis* Ben-Tuvia, 1953	**UK**	VNP

Serranidae (Epinephelinae)	*Mycteroperca fusca* (Lowe, 1838)	**UK**	No specific details were published about diel patterns of this species. Note that Coles (2014) found predominantly diurnal patterns in West Atlantic *Mycteroperca* species.
Serranidae (Epinephelinae)	*Mycteroperca rubra* (Bloch, 1793)	**UK**	No specific details were published about diel patterns of this species. Note that Coles (2014) found predominantly diurnal patterns in West Atlantic *Mycteroperca* species.
Serranidae (Serraninae)	*Serranus atricauda* Günther, 1874	**DM**	Feeding takes place during day with a peak in afternoon (Morato et al. 2000).
Serranidae (Serraninae)	*Serranus cabrilla* (Linnaeus, 1758)	**DM**	Predominantly diurnal species with feeding peaks often in dawn, afternoon or dusk, but the latter may change from specimen to specimen and even from day to day in the same specimen (Alós et al. 2011; Azzurro et al. 2013).
Serranidae (Serraninae)	*Serranus hepatus* (Linnaeus, 1758)	**DM**	Active during the day with a peak at dawn (Bahamon et al. 2009; Aguzzi et al. 2015).
Serranidae (Serraninae)	*Serranus scriba* (Linnaeus, 1758)	**DM**	The species is mainly diurnal (Arculeo 1993; Reñones et al. 1995; Azzurro et al. 2007, 2013), often found resting motioneless near the bottom at night (Arndt, unpubl. obs.). However, a distinct diel pattern seems to be absent and different individuals show varying patterns acc. to March et al. (2010). Courtship and spawning take place at night (Lejeune et al. 1980; Louisy 2002).
Siganidae	*Siganus luridus* (Rüppell, 1829)	**DD**	Diurnal species (Karpestam et al. 2007; Lieske & Myers 2004; Wambiji et al. 2008). Sleeps in the night while lying motionless on the bottom (Neumann & Paulus 2005). In the Red Sea, the species courts and probably spawns early in the morning (Popper & Gundermann 1975).
Siganidae	*Siganus rivulatus* Forsskål & Niebuhr, 1775	**DD**	Diurnal species, feeding during daylight and moving from dawn to dusk (Karpestam et al. 2007; Lieske & Myers 2004; Wambiji et al. 2008; Pickholtz et al. 2018). Sleeps in the night while lying motionless on the bottom (Neumann & Paulus 2005). In the Red Sea, the species courts and probably spawns early in the morning (Popper et al. 1979).
Sillaginidae	*Sillago suezensis* Golani, Fricke and Tikochinsky, 2013	**NM**	The species (or its close relative *S. sihama* respectively) is mainly nocturnal and mainly feeds at night (Kwik et al. 2010). However, more detailed studies suggest that *S. sihama* feeds during day and night using vision to pursue to prey in the water column during the day and employing its protrusive jaws and large mouth to suck up prey from the substrate surface at night (Gunn & Milward 1985; Kwak et al. 2004). Diel migrations may also depend on tidal cycle (Kwik et al. 2010). Spawning takes place during the night (Lee et al. 1981; Lee & Hirano 1985).
Soleidae	*Buglossidium luteum* (Risso, 1810)	**NM**	Active during day and night, but mainly nocturnal (De Groot 1971; Letourneur et al. 2001, Louisy 2002)
Soleidae	*Dicologlossa cuneata* (Moreau, 1881)	**NM**	Feeding takes place nocturnally or diurnally and nocturnally depending on season (Lagardère 1975; Torres Leal 2013).
Soleidae	*Dicologlossa hexophthalma* (Bennett, 1831)	**UK**	VNP
Soleidae	*Microchirus azevia* (Capello, 1867)	**NM**	The biology of this species is poorly known. Predominantly nocturnal feeding activity (Torres Leal 2013).

Soleidae	*Microchirus boscanion* (Chabanaud, 1926)	**UK**	VNP
Soleidae	*Microchirus ocellatus* (Linnaeus, 1758)	**UK**	VNP
Soleidae	*Microchirus variegatus* (Donovan, 1808)	**NM**	Species feeds at night (Louisy 2002).
Soleidae	*Monochirus hispidus* Rafinesque, 1814	**NM**	Nocturnal species (Louisy 2002; Amaral & Cabral 2004).
Soleidae	*Pegusa lascaris* (Risso, 1810)	**NM**	Nothing specifically was published about this species. A broad overlap of diet with *Buglossidium luteum* and *Dicologlossa cuneata* suggests a similar way of life (Cabral et al. 2002).
Soleidae	*Pegusa impar* (Bennett, 1831)	**UK**	VNP
Soleidae	*Solea aegyptiaca* Chabanaud, 1927	**NM**	Activity pattern most probably similar to that of *S. solea* (Tortonese 1975; Fischer et al. 1987).
Soleidae	*Solea senegalensis* Kaup, 1858	**NM**	Adults show an activity peak linked to feeding in the first part of the dark period and that gradually decreases towards morning (Bayarri et al. 2004; Rubio et al. 2009; Blanco-Vives et al 2012); they also show larger home range areas and greater movement during nighttime (Gandra et al. 2018). Juveniles have an activity peak during crepuscular periods, but are also active during day and night, partly dependent on tide level and moon phase (Vinagre et al. 2006). Larvae display a temporal change in food intake during development. Early larvae feed during day, whereas post-metamorphic individuals show strongest feeding at night, but continue feeding during the day (Navarro-Guillén et al. 2015; Blanco-Vives et al 2012).
Soleidae	*Solea solea* (Linnaeus, 1758)	**NM**	Mainly nocturnal activity with feeding maxima in dusk and dawn (De Groot 1971; Lagardère 1987; Beyst et al. 1999; Cabral 1998). Larvae are known to be diurnal plankton predators (Blaxter 1972, Appelbaum et al. 1983) but undertake diel (nocturnal) vertical movements to the water surface (Champalbert et al. 1994, Lagardère et al. 1999). Spawning takes place at night (Baynes et al. 1994) or in the evening (Child et al. 1991, North Sea).
Soleidae	*Synaptura lusitanica* de Brito Capello, 1868	**NM**	Nothing specifically about diel acitivity of this species has been published. However, its diet composition (cf. Londoño et al. 2011) lets assume strictly nocturnal feeding.
Soleidae	*Synapturichthys kleinii* (Risso, 1827)	**NM**	Few ecological details are known, indicating nocturnal activity (Dallavalle & Chanet 2009).
Sparidae	*Acanthopagrus bifasciatus* (Forsskål, 1775)	**DM**	Diurnal feeding (Gillibrand et al. 2007).
Sparidae	*Boops boops* (Linnaeus, 1758)	**DD**	Active and feeding during dayligth (Girardin 1981; Aguzzi et al. 2015). Shoals of adults may migrate onshore to artificial structures such as ports and marinas seeking shelter at dusk and night (Mavraki et al. 2016, reported for various locations in Greece; Arndt, upubl. obs. in Croatia). Migrations from the bottom to the

			surface at night to feed on plankton are also reported (Bauchot & Hureau 1986, Jardas 1996; Froese & Pauly 2019).
Sparidae	*Centracanthus cirrus* Rafinesque, 1810	**UK**	VNP
Sparidae	*Crenidens crenidens* (Forsskål, 1775)	**UK**	VNP
Sparidae	*Dentex dentex* (Linnaeus, 1758)	**CRE**	This fish is mainly active in crepuscular periods, to a much lower degree also during daylight (Sbragagli et al. 2013; Aguzzi et al. 2013). Common dentex usually spawns at nightfall or early morning (Abellan 2000). However, fishermen observed courtship and spawning during the day and during the night at full moon (Marengo et al. 2014).
Sparidae	*Dentex gibbosus* (Rafinesque, 1810)	**UK**	VNP
Sparidae	*Dentex macrophthalmus* (Bloch, 1791)	**NM**	This species feeds at night (Domanevskaya & Patokina 1984).
Sparidae	*Dentex maroccanus* (Valenciennes, 1830)	**UK**	VNP
Sparidae	*Diplodus annularis* (Linnaeus, 1758)	**CAT**	Contrasting data are available: diurnal activity and feeding (in autumn; Bell & Harmelin-Vivien 1983; Santos et al. 2002; Aguzzi et al. 2013) or predominantly nocturnal (during spring and summer; Dulčić et al. 2004).
Sparidae	*Diplodus bellottii* (Steindachner, 1882)	**DM**	Mainly diurnal species (Santos et al. 2002).
Sparidae	*Diplodus cervinus* (Lowe, 1838)	**DM**	Diurnal species (Santos et al. 2002), at least in autumn with distinct peaks in early morning and afternoon (Aguzzi et al. 2013).
Sparidae	*Diplodus puntazzo* (Walbaum, 1792)	**DM**	Diurnal species (Santos et al. 2002).
Sparidae	*Diplodus sargus* (Linnaeus, 1758)	**DM**	Diurnal species, active in the Mediterranean Sea from one hour before sunrise to one hour before sunset in spring (Lino et al. 2009) and from sunrise to one hour after sunset in autumn (Aguzzi et al. 2013). Feeding takes places from sunrise, during daylight, dusk to early night, with a peak between midday and afternoon (Sala & Ballesteros 1997; Figueiredo et al. 2005; D'Anna et al. 2011; Di Lorenzo et al. 2016). Large individuals rest near bottom motionless at night (Arndt, unpubl. obs.).
Sparidae	*Diplodus vulgaris* Geoffroy Saint-Hillaire, 1817	**CRE**	Activity of this species peaks in both crepuscular periods (Santos et al. 2002; Aguzzi et al. 2013), but nocturnal activity periods (Ribeiro et al. 2006) and diurnal periods (Aguzzi et al. 2013) do exist as well. Dulčić et al. (2004) did not find activity peaks in any period of the day.
Sparidae	*Lithognathus mormyrus* (Linnaeus, 1758)	**DM**	Diurnally active (Neumann & Paulus 2005). The otolith size is as small as in *Diplodus* species, also suggesting a mainly diurnal activity (Cruz & Lombarte 2004).

Sparidae	*Oblada melanura* (Linnaeus, 1758)	**CRE**	Mainly active in crepuscular periods, to a much lower degree also during daylight (Agguzzi et al. 2013).
Sparidae	*Pagellus acarne* (Risso, 1827)	**DM**	Diurnal and crepuscular feeding activity (Patokina 1984; Santos et al. 2002). The otolith is medium-sized (Cruz & Lombarte 2004).
Sparidae	*Pagellus bellottii* Steindachner, 1882	**UK**	VNP
Sparidae	*Pagellus bogaraveo* (Brünnich, 1768)	**DM**	Active and feeding during daylight hours (Azevedo 2000; Aguzzi et al. 2015).
Sparidae	*Pagellus erythrinus* (Linnaeus, 1758)	**CRE**	Predominantly active during the day, with main feeding period 16:00-22:00 and feeding peak at dusk (Benli et al. 2001; feeding peak in summer at 18:00). Comparably large otoliths suggest a nocturnal portion of activity (Cruz & Lombarte 2004).
Sparidae	*Pagrus auriga* (Valenciennes, 1843)	**UK**	VNP
Sparidae	*Pagrus coeruleostictus* (Valenciennes, 1830)	**UK**	VNP
Sparidae	*Pagrus major* (Temminck and Schlegel, 1843)	**UK**	Few specific data were published about diel acitivity of this species, spawning was observed from afternoon to early night with peak around sunset (Japanese Society of Scientific Fisheries 1974).
Sparidae	*Pagrus pagrus* (Linnaeus, 1758)	**DM**	Diurnally active at the western Atlantic coast (Coles 2014). The fish feeds during daylight, moves to shallower water after sunset and shows strongly reduced activity during the night (Azores, Afonso et al. 2009). Laboratory experiments confirm diurnal feeding activity (Pavlidis et al. 1999). The comparably large otolith suggests a nocturnal portion of activity (Cruz & Lombarte 2004). Juveniles are diurnal feeders as well (Maragoudaki et al. 2001).
Sparidae	*Rhabdosargus haffara* (Forsskål, 1775)	**UK**	VNP
Sparidae	*Sarpa salpa* (Linnaeus, 1758)	**DM**	Mainly diurnal with an activity and feeding peak in the late afternoon or during crepuscular periods (Verlaque 1990; Jadot et al. 2002, 2006; Azzurro et al. 2013). The activity starts at a low level in dawn and early morning and lasts through the daytime to dusk until the early night (Abecasis et al. 2012; Azzurro et al. 2013; Aspillaga et al. 2016). Large individuals rest under rock overhangs near shore motionless at night (Arndt, unpubl. obs.). A few individuals may differ in their diel pattern and show nocturnal activity (Jadot et al. 2002). Spawning is suggested in crepuscular periods (morning and evening; Connell 2012).
Sparidae	*Sparus aurata* Linnaeus, 1758	**CAT**	Two different types of diel behaviour were recorded, with some individuals more active at night and others during day time (Abecasis & Erzini 2008). Spawning takes place during the night (Somarakis et al. 2013)
Sparidae	*Spicara flexuosa* (Rafinesque, 1810)	**UK**	VNP

Sparidae	*Spicara maena* (Linnaeus, 1758)	**CRE**	This fish is mainly active in crepuscular periods, to a much lower degree also during daylight (Agguzzi et al. 2013).
Sparidae	*Spicara smaris* (Linnaeus, 1758)	**UK**	VNP
Sparidae	*Spondyliosoma cantharus* (Linnaeus, 1758)	**NM**	Active at night (Reina-Hervás & Serrano 1987). The otolith is medium-sized (Cruz & Lombarte 2004). Spawning takes place in the early night (10 pm), very early morning and possibly also during remaining of the night (Wilson 1958).
Sphyraenidae	*Sphyraena obtusata* Cuvier, 1829	**DM**	Feeding and active during daylight (Gillibrand et al. 2007; Froese & Pauly 2019).
Sphyraenidae	*Sphyraena pinguis* Günther, 1874	**UK**	VNP
Sphyraenidae	*Sphyraena sphyraena* (Linnaeus, 1758)	**DM**	Diurnally active species, lying on sand or within seagrass at night (Louisy 2015).
Sphyraenidae	*Sphyraena viridensis* Cuvier, 1829	**CAT**	This species feeds during day and night (Barreiros et al. 2002). Inshore feeding activity of is high, especially in the hour before sunrise or after sunset (Merciai et al. 2020).
Sternoptychidae	*Argyropelecus hemigymnus* Cocco, 1829	**DVM**	Mesopelagic species that may perform DVMs, staying at depths below 200 m during the day and migrating to depths of 100–200 m during night. Feeding may take place at any time but feeding activity is much higher at night (Gibbs & Krueger 1987; Bernal et al. 2015).
Sternoptychidae	*Maurolicus muelleri* (Gmelin, 1789)	**DM**	Predominantly mesopelagic species. Diel (crepuscular) vertical migrations of different ontogenetic stages (larvae to adults) towards shallow layers at night and towards deeper water during day were reported by several authors (Okiyama 1971; Baliño & Aksnes 1993; Staby & Aksnes 2011; Staby et al. 2011), but other studies did not reveal a diel vertical migration of adults, at least in parts of the year (Olivar et al. 2012; Staby et al. 2013). Feeding takes place mostly during the day (Rasmussen & Giske 1994; Staby et al. 2013). Spawning occurs in subsurface waters (Landaeta & Castro 2002) and therefore most probably at night.
Stromateidae	*Pampus argenteus* (Euphrasen, 1788)	**CAT**	This species undertakes diel vertical migrations. It feeds in surface water during the night and deeper in the water column during daytime (Pati 1980). Feeding at dawn and in the morning near the surface was reported by Dadzie et al. (2000).
Stromateidae	*Stromateus fiatola* Linnaeus, 1758	**UK**	VNP
Syngnathidae	*Entelurus aequoraeus* (Linnaeus, 1758)	**DD**	Diurnal species (Kuiter 2009, Poortenaar et al. 2004).
Syngnathidae	*Hippocampus fuscus* Rüppell, 1838	**DD**	Diurnal species (Kuiter 2009, Poortenaar et al. 2004).
Syngnathidae	*Hippocampus guttulatus* (Cuvier, 1829)	**DD**	Diurnal species (Kuiter 2009, Poortenaar et al. 2004).

Syngnathidae	*Hippocampus hippocampus* (Linnaeus, 1758)	**DD**	Diurnal species (Kuiter 2009, Poortenaar et al. 2004).
Syngnathidae	*Minyichthys sentus* Dawson, 1982	**DD**	Diurnal species (Kuiter 2009, Poortenaar et al. 2004).
Syngnathidae	*Nerophis lumbriciformis* (Jenyns, 1835)	**NM**	Hidden under algae or stones during the day, but active at night (Louisy 2015). Courtship and spawning take place during the day with peak activity at afternoon (Monteiro et al. 2002).
Syngnathidae	*Nerophis maculatus* Rafinesque, 1810	**NM**	Mostly active at night (Louisy 2015; Dulčić et al. 2004).
Syngnathidae	*Nerophis ophidion* (Linnaeus, 1758)	**NM**	More active during the night than during the day (Dulčić et al. 2004). Courtship and spawning seem to take place during the day (Rosenqvist 1990).
Syngnathidae	*Syngnathus abaster* Risso, 1827	**DD**	Diurnal species (Kuiter 2009, Poortenaar et al. 2004). Courtship and spawning are exhibited during day (Santos da Silva 2008). Pregnant males release their brood in the night or early in the morning (Varvara 2015).
Syngnathidae	*Syngnathus acus* Linnaeus, 1758	**DD**	Diurnal species (Kuiter 2009, Poortenaar et al. 2004), feeding takes place during daylight hours only (Bennett & Branch 1990).
Syngnathidae	*Syngnathus phlegon* Risso, 1827	**DD**	Diurnal species (Kuiter 2009, Poortenaar et al. 2004).
Syngnathidae	*Syngnathus rostellatus* Nilsson, 1855	**DD**	Diurnal species (Kuiter 2009, Poortenaar et al. 2004).
Syngnathidae	*Syngnathus taenionotus* Canestrini, 1871	**DD**	Diurnal species (Kuiter 2009, Poortenaar et al. 2004).
Syngnathidae	*Syngnathus tenuirostris* Rathke, 1837	**DD**	Diurnal species (Kuiter 2009, Poortenaar et al. 2004).
Syngnathidae	*Syngnathus typhle* Linnaeus, 1758	**DD**	Diurnal species (Kuiter 2009, Poortenaar et al. 2004). Pregnant males release their brood in the night or early in the morning (Varvara 2015).
Synodontidae	*Saurida lessepsianus* Russell et al. 2015 syn. *undosquamis* (Richardson, 1848)	**CAT**	The species feeds during most hours of day and night (Hayashi et al. 1960; Golani 1993). At least locally, the most intensive feeding takes place during the early morning hours (Toriyama 1958; Rao 1964). (Note that Hayashi et al. 1960, Rao 1964 and Toriyama 1958 refer to the Indo-Pacific species *S. undosquamis*, formerly regarded to be conspecific with *S. lesspesianus*.)
Synodontidae	*Synodus saurus* (Linnaeus, 1758)	**CAT**	The species feeds during different times of day and night (Esposito et al. 2009b).
Terapontidae	*Pelates quadrilineatus* (Bloch, 1790)	**CAT**	Specific information about diel activity is scarce. A mainly diurnal activity is implied by the study by Travers & Potter (2002) whereas similar activities between day and night were found in other studies (Kiswara et al. 1991; Kwik et al. 2010) .

Terapontidae	*Terapon jarbua* (Forsskål, 1775)	**CAT**	Active and feeds most probably during both day and night (Macia et al. 2003; Kwik et al. 2010).
Terapontidae	*Terapon puta* Cuvier, 1829	**UK**	VNP
Terapontidae	*Terapon theraps* Cuvier, 1829	**CAT**	Active and feeding most probably during both day and night (Kwik et al. 2010). The chorus appears around dusk with peaks just before dawn and just after dusk. The sound production very likely coincides with courting and spawning (Mahanty et al. 2015).
Tetragonuridae	*Tetragonurus cuvieri* Risso, 1810	**UK**	This species exhibits vertical migrations (Grey 1955; Tanonaka 1957), but knowledge about diel activity is fragmentary.
Tetraodontidae	*Ephippion guttifer* (Benett, 1831)	**DD**	VNP, but species of this family are generally active during day (Brandl & Bellwood 2014).
Tetraodontidae	*Lagocephalus lagocephalus* (Linné, 1758)	**DD**	VNP, but species of this family are generally active during day (Brandl & Bellwood 2014).
Tetraodontidae	*Lagocephalus guentheri* Miranda-Ribeiro, 1915 (syn. *spadiceus* (Richardson, 1845)	**DD**	VNP, but species of this family are generally active during day (Brandl & Bellwood 2014).
Tetraodontidae	*Lagocephalus sceleratus* (Gmelin, 1789)	**DD**	This fish is active during the day and found resting on the bottom during the night (Louisy 2015).
Tetraodontidae	*Lagocephalus suezensis* Clark & Gohar, 1953	**DD**	VNP, but species of this family are generally active during day (Brandl & Bellwood 2014).
Tetraodontidae	*Sphoeroides marmoratus* (Lowe, 1838)	**DD**	VNP, but species of this family are generally active during day (Brandl & Bellwood 2014).
Tetraodontidae	*Sphoeroides pachygaster* (Müller & Troschel, 1848)	**DD**	VNP, but species of this family are generally active during day (Brandl & Bellwood 2014).
Tetraodontidae	*Torquigener flavimaculosus* Hardy & Randall, 1983	**DD**	VNP, but species of this family are generally active during day (Brandl & Bellwood 2014).
Tetraodontidae	*Tylerius spinosissimus* (Regan, 1908)	**DD**	VNP, but species of this family are generally active during day (Brandl & Bellwood 2014).
Trachinidae	*Echiichthys vipera* (Cuvier, 1829)	**NM**	Predominantly nocturnal and mostly buried in sand with eyes and tip of first dorsal fin exposed during daylight (Nash et al. 1994; Dulčić et al. 2004; Neuman & Paulus 2005). Using beam trawl data, Ribeiro et al. 2006 obtained a higher 'abundance' during daylight than during night indicating that this trawl technique recorded most probably resting fish as well.
Trachinidae	*Trachinus araneus* Cuvier, 1829	**NM**	Predominantly active at night, mostly buried in sand with eyes and tip of first dorsal fin exposed during daylight (Reina-Hervás & Serrano 1987; Neuman & Paulus 2005).

Trachinidae	*Trachinus draco* Linnaeus, 1758	**NM**	Species rests on the bottom, often buried in sand with eyes and tip of first dorsal fin exposed during the day, but swims around and feeds at night (Morte et al. 1999; Muus & Nielsen 1999; Bagge 2004; Neuman & Paulus 2005; Froese & Pauly 2019). Feeding experiments in the field confirm ambush hunting and proportionate feeding activity at the day and in evening (Olaso et al. 2002; Kruschel & Schultz 2012).
Trachinidae	*Trachinus radiatus* Cuvier, 1829	**NM**	Predominantly active at night, mostly buried in sand with eyes and tip of first dorsal fin exposed during daylight (Neuman & Paulus 2005).
Trachipteridae	*Zu cristatus* (Bonelli, 1819)	**NN**	Activity patterns of *Z. cristatus* were not described in detail. However, a melanized layer within the intestinal wall was described in this species. This cover within the gut was suggested to shield the light of bioluminescent food items in night-active predators (Fishelson et al. 1997, 2012).
Trichiuridae	*Lepidopus caudatus* (Euphrasen, 1788)	**DVM**	The fish shows DVM, staying at depths of 250–750 m during daytime and moving to shallower waters (up to 50 m) at night (Franquet & Brito 1995; Brito et al. 2003). Occasionally it ascends to the water surface during the night, approaching the shore and sometimes "lying on the sand to sleep" during the night (Louisy 2015). Spawning takes place in the afternoon in outer shelf waters 50–200 m deep (Robertson 1980).
Trichiuridae	*Trichiurus lepturus* (Linnaeus, 1758)	**DVM**	Adults undertake DVM, forming large schools in the bottom layer during the day, ascending during dusk and scattering to midwater or surface at night to follow their prey, and descending back to the bottom just before sunrise (Munekiyo 1990). In adults, feeding peaks at early night (Martins et al. 2005, Brazil; Bryan & Gill 2007, off Florida) in surface waters. Acc. to Nakamura & Parin 1993 "Adults and juveniles have opposing complementary vertical diurnal feeding migration. Large adults usually feed near the surface during the daytime and migrate to the bottom at night. Juveniles and small adults form schools 100 m above the bottom during the daytime and form loose feeding aggregations at night near the surface." It remains unclear if *T. lepturus*, a species with worldwide temperate to tropical distribution, has extremely flexible patterns, varies in its patterns strongly from region to region, or if the information in Nakamura & Parin (1993) is incorrect. Juveniles also perform DVM. They feed primarily around midday (Schultz 2011).
Triglidae	*Chelidonichthys cuculus* (Linnaeus, 1758)	**DM**	Feeding takes place during day and night, but diurnal diet predominates distinctly (Terrats et al. 2000).
Triglidae	*Chelidonichthys lucerna* (Linnaeus, 1758)	**DM**	Diurnally active species (Arndt unpubl. obs.). Indirect evidence of diurnal feeding activity given by Morte et al. (1997) indicates that this species feeds mainly on mysids that stay at the surface of sediment only during the day.
Triglidae	*Chelidonichthys obscurus* (Walbaum, 1792)	**DM**	Probably a diurnally active species (Louisy 2002).
Triglidae	*Eutrigla gurnardus* (Linnaeus, 1758)	**CAT**	Active during all parts of the diel cycle ("arhythmic" acc. to Aguzzi et al. 2015). Feeding intensity peaks around midday (Moreno-Amich 1994, NW Mediterranean Sea, from July to May). A peak in bottom trawl catches was found at dusk in June (Bahamon et al. 2009, NW Mediterranean Sea). Migration onshore at dusk and offshore at dawn (Gibson et al. 1996).
Triglidae	*Lepidotrigla cavillone* (Lacépède, 1801)	**DM**	Feeding takes place during day and night, but diurnal diet predominates at least seasonally, i.e. in spring (Terrats et al. 2000). The feeding peaks from morning to noon (Caragitsou & Papaconstantinou 1990).

Triglidae	*Lepidotrigla dieuzeidei* Blanc & Hureau 1973	**UK**	VNP
Triglidae	*Trigla lyra* Linnaeus, 1758	**UK**	VNP. If bottom trawl data can be linked to diel activity, the pattern in this species is quite similar as in *Lepridotrigla cavillone* (Arndt, unpubl. analysis of trawl data by Edelist et al., off the Israeli coast).
Triglidae	*Trigloporus lastoviza* (Bonnaterre, 1788)	**UK**	VNP
Tripterygiidae	*Tripterygion delaisi* Cadenat & Blache, 1970	**DD**	This species is strictly diurnal (Abel 1955, Wirtz 1978). At night the fish sit unprotected on the substrate and 'sleep' (Abel 1959).
Tripterygiidae	*Tripterygion melanurus* Guichenot, 1850	**DD**	This species is strictly diurnal (Abel 1955, Wirtz 1978). At night the fish sit unprotected on the substrate and 'sleep' (Abel 1959).
Tripterygiidae	*Tripterygion tripteronotum* (Risso, 1810)	**DD**	This species is strictly diurnal (Abel 1955, Wirtz 1978). At night the fish sit unprotected on the substrate and 'sleep' (Abel 1959).
Uranoscopidae	*Uranoscopus scaber* (Linnaeus, 1758)	**NM**	Mainly nocturnal, during the day they are usually buried in sand or mud with only the eyes and mouth exposed (Kishimoto 2001; Louisy 2002). Partial feeding during day or crepuscular periods is likely, because the fish use the appendage of the respiratory valve in the mouth as a 'bait' (Neuman & Paulus 2005).
Xiphiidae	*Xiphias gladius* Linnaeus, 1758	**CAT**	Feeding takes place during both day and night (Carey & Robison 1981; Matsumoto et al. 2003; Chancollon et al. 2006; Varghese et al. 2014; Abascal et al. 2015). See details in the family description.
Zeidae	*Zenopsis conchifer* (Lowe, 1852)	**DVM**	Information about diel activity of this species is still scarce. It may perform diel vertical migrations given a variety of observed data (see Zidowitz et al. 2002 for a summary). Fischer et al. (2007) observed the fish during night in shallow water. Mesopelagic prey is utilised during the night but bentho-pelagic fish dominate the prey during the day (Fock et al. 2002) that strongly supports regular diel vertical migrations.
Zeidae	*Zeus faber* Linnaeus, 1758	**CAT**	Information about diel activity is extremely scarce. Active during night acc. to Fischer et al. (2007). A cathemeral activity pattern of this species is likely based on food animals (Akyol 2001) and fishery trawl data.

ESM, Part 2. Description of diel activity at the family level

Note: The summary of diel activity includes families of native and non-indigenous species (excluding deepwater species). In order to give information as complete as possible, the summary may also contain data from non-Mediterranean species. The classification of orders and families follows Nelson et al. (2016), but note that we listed Pomacentridae (Damselfishes) under Perciformes, whereas Nelson et al. (2016) did not place this family into any order. For the reference list see Part 5 of this document.

Abbreviations: DVM - Diel vertical migrations; MS – Mediterranean Sea.

A summarizing table with counts of the number of species for each activity category per family per family is given at the end ESM part 2.

Order Anguilliformes

Heterenchelyidae (Mud eels)

The ecology of mud eels is nearly unkown. The morphology of these fishes (Eagderi & Adriaens 2010) and fishery data of *Panturichthys fowleri* suggest that mud eels spend much of their time buried in the bottom sediment, emerging at night to search for food (Smith et al. 2012).

Only *P. fowleri* occurs in the MS.

Muraenidae (Moray eels)

Moray eels were regarded as primarily active at night by several authors (Bardach et al. 1959; Böhlke & Chaplin 1993; Young & Win 2003). However, many species, especially in the genus *Gymnothorax*, are active during both day and night, showing cathemeral activity patterns (Hobson 1974; Chave & Randall 1971; Randall 1995; Hess et al. 1998; Michael 1998; Gilbert et al. 2005; Gillibrand et al. 2007; Naumann & Wild 2013). These species may have retina characters typical of diurnal or crepuscular species (Hess et al. 1998; Wang et al. 2011).

Courtship and spawning in moray eels were observed from midday to dusk, most events took place around sunset (Moyer & Zaiser 1982; Thresher 1984; Ferraris 1985; Loh & Chen 2018). Generally, these data need updates in two respects: pattern of a particular species and possible patterns in the family as a whole.

Two autochthonous and two non-indigenous species, one each of Atlantic and Indo-Pacific origin, are known from the MS.

Chlopsidae (False morays)

Few data are known about the activity patterns of false morays. They coincide with patterns in snake eels. These species bury themselves during daytime and are generally active at night (Carpentieri et al. 2007). As far as is known, false morays spawn in aggregations at night, but data are restricted to a few tropical species (Thresher 1984).

Chlopsis bicolor is the only Mediterranean species.

Ophichthidae (Snake eels)
Snake eels bury themselves during daytime and are generally active at night (Tortonese 1970; Matallanas 1979). However, some species are occasionally seen swimming and feeding during daylight (Randall 1995; Bozzano & Sardà 2002; Bozzano 2003). Spawning takes place at night (Naplin & Obenchain 1980 in Ferraro 1980; Ross & Rohde 2003).
Seven species of snake eels are known from the MS, one of which is a range-expanding species from the Atlantic Ocean.

Muraenesocidae (Pike congers)
Ecological data are scarce in this family. Pike congers seem to be nocturnal (Nielsen 1974; Smith 1997) and may have similar activity patterns as conger or snake eels. Data about diel spawning pattern are not available.
Cynoponticus ferox is the only native species in the MS; one Indo-Pacific species has been known since 1979.

Nettastomatidae (Duckbill eels)
Virtually nothing has been published about activity patterns of these species. However, known details of their way of life, i.e. feeding on benthic crustaceans, burying themself in the muddy sediment, rarely seen by divers (Louisy 2002), suggest a similar ecology and behaviour to conger or snake eels.
Two species of duckbill eels occur in the MS.

Congridae (Conger eels)
Conger eels are generally nocturnal, becoming active during or after sunset (Letourneur et al. 2001; Aguzzi et al. 2015b). They remain in crevices or bury themself during daylight hours (Dooley et al. 1985; Carpentieri et al. 2007). However, in some species (e.g. *Conger conger*) feeding was observed during day as well (Bozzano & Sardà 2002).
Few data are available about spawning patterns. Spawning behaviour in a Pacific *Ariosoma* species was seen at night (Watanabe et al. 2016).
Three autochthonous species occur in the Mediterranean, at least partially in the littoral zone; they were recorded from shallow water down to 1,200 m.

Nemichthyidae (Snipe eels)
Snipe eels mainly represent meso- to bathypelagic species. *Nemichthys scolopaceus* undertakes DVM in the adult stage, lingering in the epipelagic zone at night, but in much greater depths during day. Feeding takes place all day round (Karmovskaya 1982; Feagans-Bartow & Sutton 2014).
Very likely snipe eels spawn at night in surface water, which is implied by records of leptocephali (Castonguay & McCleave 1987).
Nemichthys scolopaceus is the only species in the Mediterranean.

Anguillidae (Freshwater eels)
Species of this family are catadromous fishes. Feeding is mainly concentrated to the night, individuals are passively resting during daylight (McCleave & Fried 1975; Helfman 1986; Sorensen et al. 1986; Baras et al. 1998; Westerberg et al. 2007). However, diurnal feeding may occur depending on stormy weather, turbid waters (Arndt, unpubl. obs.) or in populations in specific areas (Costa-Dias & Lobón-Cerviá 2008). The European eel *Anguilla anguilla* and several other species undertake vertical migrations during migration to the spawning area, swimming in shallow warm water at night, making steep dives into deeper

and colder water levels at dawn and ascending again in the following night (Jellyman & Tsukamoto 2005; Aarestrup et al. 2009; Manabe et al. 2011; Chow et al. 2015). Juveniles feed mainly at night (Tesch 2003) and migrate upstream during night but also during daytime (Rosengarten 1954; Mann 1961; Tesch 2003; Trancart et al. 2012).

Spawning occurs in dark nights (new moon periods; Deelder 1984; Tsukamoto et al. 2011).

The European eel is the only Mediterranean species.

Order Clupeiformes

Engraulidae (Anchovies)

Diel feeding activity varies in adults from species to species and even between populations of a certain species from region to region (Garrido & van der Lingen 2014). Anchovies feed during the day, dusk and night, depending on the density of planktonic food and on vertical migrations that also vary between populations and regions. In the Mediterranean, *Engraulis encrasicolus* is mainly diurnal, with lowest stomach fullness around sunrise and maximum stomach fullness in early evening (Tudela & Palomera 1997; Borme et al. 2009). In productive surface waters of other seas, anchovies feed at night at the surface while staying in deeper water during day (James 1987; Garrido & van der Lingen 2014). Larvae are generally visual and diurnal feeders (Garrido & van der Lingen 2014) that intake food from sunrise to sunset (Conway et al. 1998).

Species may undertake vertical migrations, where adults stay close to the surface at night, but form schools just before dawn and move to deeper layers during daytime (Tsagarakis et al. 2012). Surface light intensity and bottom depth determine much of the variability in the vertical position of schools (Tsagarakis et al. 2012). At least locally, larvae also perform vertical migrations (Sabatés et al. 2008).

Spawning takes place during evening and night in several species of different genera (Ferraro 1980; Blaxter & Hunter 1982; Clarke 1987; Wright 1992; Hwang et al. 2007; Ganias et al. 2014; Basilone et al. 2015). *E. encrasicolus* spawns in the Mediterranean between 18:00-04:00 with a spawning peak between 20:00 and 22:00 (García & Palomera 1996; Basilone et al. 2015).

Two native anchovies and two Indo-Pacific immigrants occur in the MS.

Chirocentridae (Wolf herrings)

The knowledge about ecological and behaviour, including diel activity, is scarce for species of this family. There is some evidence for diurnal feeding (Luther 1985a, b; Munroe et al. 1999a; Sazima et al. 2004), but feeding during night fishing with lights was also reported (Whitehead 1985). Information about diel spawning patterns is not available.

The family comprises only two extant species; *Chirocentrus dorab*, an Indo-Pacific immigrant, is the only species in the MS.

Clupeidae (Herrings)

The diel activity of herrings varies from species to species. Feeding was observed in adults during the day, dusk and first half of the night depending on region, season, food densitiy and corresponding vertical migration patterns (Nikolioudakis et al 2011; Garrido & van der Lingen 2014). A feeding peak during the day and dusk may exist (Cassou-Leins & Cassou-Leins 1981; Blaxter & Hunter 1982; Fernández & González-Quirós 2006; Morote et al. 2010). Sprat (*Sprattus prattus*) forms schools during daylight, feeding in deeper water layers at around 50 m depth, but disperses in surface layers showing no feeding activity during the night (Tičina et al. 2000; Cardinale et al. 2003). Species of *Alosa* and *Clupeus* may feed continuously over 24 hours with varying food composition reflecting a change in feeding strategy from particulate feeding during the day to filter feeding during the night (Batty et al. 1986; Stone & Jessop 1994; Oesmann & Thiel 2001). At least in some species, larvae and juveniles intake food at all times of the day (Oesmann & Thiel 2001; Aprahamian et al. 2003). Several species undertake vertical migrations (e.g. *Alosa alosa*, de Groot 2002; *Sardina pilchardus*, Cushing 1957, Dias et al. 1989; Giannoulaki et al. 1999, Zwolinski et al. 2007; *Sardinella aurita*, Gonzales et al. 1998; *Sprattus sprattus*, Nilsson et al. 2003 and the South-east Atlantic *Etrumeus whiteheadi*, Lindsey 2006). The vertical migrations in the adult stage may be synchronized with tides (de Groot 2002). Already larvae and juveniles of some species show diel vertical movement patterns (Regner 1972).

Spawning generally takes place during evening and night (Ferraro 1980; Alheit et al. 1987; Milton et al. 1994b; Cassou-Leins et al. 2000; Ganias et al. 2014). Species of *Sardina* show a spawning peak in the first hours of night (Ré et al. 1988).

Six native and five immigrant Indo-Pacific species are known from the MS.

Chanidae (Milkfishes)

Diel activities of adult milkfishes comprise diurnal, crepuscular and nocturnal components in varying proportions. Milkfishes may ingest at day and night nearly at the same rate (Lückstädt & Reiti 2002), but most studies conclude that diurnal feeding clearly predominates (Chiu & Benitez 1982, Chiu et al. 1986, Kühlmann et al. 2009). During daytime, schools move with the rising tide to feed in shallower areas (Buri 1980). Feeding of larvae takes place diurnally (Hara et al. 1983; Bagarinao 1991), juveniles also feed predominantly diurnally (Kumagai et al. 1985). Juveniles are active and schooling during daytime but resting at night (Kawamura & Shinoda 1980; Buri 1980). There is scattered information about other types of activity. Larvae use springtides to move inshore (Johannes 1978). Virtually nothing has been published about migrating activity.

Spawning was observed usually around midnight but sometimes daytime spawning occurs (Bagarinao 1991, 1994).

The family comprises only one extant species, *Chanos chanos*, which is a Red Sea immigrant.

Order Siluriformes

Plotosidae (Eeltail catfishes)

Adult eeltail catfishes are mainly nocturnal. They feed predominantly at night (e.g. *Cnidoglanis macrocephalus*, Nel et al. 1985; *Plotosus lineatus*, Wright 1989; Kasai et al. 2009, Clark et al. 2011). Juveniles are active during the day and rest during the night (*P. lineatus*, Adriaens & Verraes 1997; Kasai et al. 2009 a, b; Clark et al. 2011) or active during both day and night (*C. macrocephalus*, Robertson & Lenanton 1984; Crawley et al. 2006).

Data about diel spawning pattern are apparently lacking. Some species (e.g. *C. macrocephalus*, Laurenson et al. 1993) spawn in burrows and subsequently males guard their eggs, but the exact spawning time was not described.

One Indo-Pacific immigrant, *P. lineatus*, occurs in the MS.

Ariidae (Sea catfishes)

The knowledge of diel activity patterns is scarce in this family. Nocturnal activity and feeding is likely in several Brazilian species (Oliveira-Neto et al. 2008; Denadai et al. 2013).

The tropical West-Atlantic species *Carlarius parkii* was recorded in the MS.

Order Argentiniformes

Argentinidae (Argentines)

Knowledge about diel activity is extremely scarse in species of this family. They are nocturnal predators foraging at the bottom and in midwater acc. to Cefas (2007). Pulcini et al. (2008), however, listed one "nocturnal" and one "diurnal" species of argentinas. The latter is *Argentina sphyraena*. Its activity during dawn and day is also suggested by bottom trawling data (Aguzzi et al. 2015).

Data on diel spawning patterns are not available in this family so far.

Argentina sphyraena is the only argentine in the MS, it occurs predominantly in deeper water.

Order Stomiiformes

Gonostomatidae (Bristlemouths)

Information about diel activity is scarce in this family. The two mesopelagic Mediterranean species exhibit DVMs (Badcock 1984; Lancraft et al 1988). Feeding activity was observed in one species only and may takes place at any time, but a higher activity was recorded at night (Lancraft et al 1988). Data on diel spawning pattern has not been published.

Four bristlemouth species are known from the MS. Two mesopelagic and two bathypelagic species (the latter are not considered in this review). *Cyclothone braueri*, one of the bathypelagic species, shows cathemeral feeding activity without evident DVM (Roe & Badcock 1984; Bernal et al. 2015).

Sternoptychidae (Hatchetfishes)

Hatchetfishes represent a family of mesopelagic fishes, many species of which frequently migrate to the epipelagic layer. The family includes species exhibiting regular DVM, species that do no migrate at all, and species having only a part of the population that migrates vertically (Gibbs & Krueger 1987). A similar broad variance occurs in feeding activity which generally may occur during all diel periods, but is higher during night in *Argyropelecus*, while mainly concentrating on daytime in the other two genera containing Mediterranean species (Badcock 1970, 1984; Clarke 1974; Gibbs & Krueger 1987; Rasmussen & Giske 1994; Staby et al. 2013; Bernal et al. 2015).

Little is known about spawning time, but a nocturnal spawning is suggested because as far as is known it occurs in subsurface waters (Landaeta & Castro 2002). Spawning at night is verified for *Maurolicus muelleri* off South Africa (Armstrong & Prosch 1991).

Three hatchetfishes are known from the MS and two of them occur temporarily in the surface water.

Phosichthyidae (Lightfishes)

Lightfishes of the family Phosichthyidae belong to the epi-, meso- and bathypelagic marine fauna. Several widespread species of the genera *Vinciguerria* and *Pollichthys* exhibit DVMs in the adult stage: *V. attenuata* and *V. poweriae* (Badcock 1984; Schaefer et al. 1986; Mundy 2005), *V. lucetia* (Rosas-Luis et al. 2011), *V. nimbaria* (Marchal & Lebourges 1996; Lebourges-Dhaussy et al. 2000; Stequert et al. 2003), *P. mauli* (Froese & Pauly 2019). The DVM is not necessarily performed year-round, but may be restricted to certain areas or parts of the year. Thus, Olivar et al. (2012) did not find any DVM in a Mediterranean population of *V. attenuata*. Adults of *V. nimbaria* were found to interrupt the DVM (November, tropical Eastern Atlantic, Marchal & Lebourges 1996); the species stayed in or even ascended to the epipelagic layer during day to feed near the thermocline (with a feeding peak in afternoon). Alterations of diel behaviour in this way occur in several mesopelagic fish (families) and may be related to reproduction (Marchal & Lebourges 1996). Adults of the circumglobal *Ichthyococcus ovatus* and *Polymetme corythaeola* also do not migrate vertically (Badcock 1984). However, in the latter species it is not clear if DVM is generally absent or if the observations refer to an intermittent interruption in DVM as known from *V. nimbaria*. *V. nimbaria* shows a bimodal feeding with feeding peaks in evening and morning off Southern Japan (Ozawa et al. 1977). Phosichthyid larvae and juveniles perfom a DVM as well (Badcock 1984; Gôngora Goçalo et al. 2011).

Diel spawning pattern are not known so far, but a nocturnal spawning is likely because larvae occur in epipelagic layers above 100 m (see e.g. Gôngora Goçalo et al. 2011).

Three species of lightfishes live in the MS, one of which is bathypelagial.

Order Aulopiformes

Synodontidae (Lizardfishes)

Species of this family are generally diurnal (Hobson 1974), but feeding may take place in some genera during all times of the day (Hayashi et al. 1960; Golani 1993). Most extensive feeding was observed during early morning in *Saurida undosquamis* (Toriyama 1958) and other species of this genus (Rao 1964, 1981).

Spawning was not described for the Mediterranean species so far. Courtship starts just before sunset and females spawn in the crepuscular period or at night in several Indo-Pacific *Synodus* species (Zaiser & Moyer 1981; Donaldson 1990). After development of the planktonic larval stage is completed, settlement to the bottom takes place at night (Leis & Rennis 1983; Thresher 1984).

The native species *Synodus saurus* (Linnaeus) and one Indo-Pacific immigrant occur in the MS.

Aulopidae (Flagfins)

Knowledge of activity patterns is scarce in this family. *Aulopus filamentosus*, the only Mediterranean species, is nocturnal (Louisy 2015). Diel spawning patterns are not known so far.

Chlorophthalmidae (Greeneyes)

Activity patterns greeneyes are hardly known. The only Mediterranean species, *Chlorophthalmus agassizi*, stays in deeper water during day and may ascend to shallow water to feed at night (Louisy 2015). Data on diel spawning patterns are not available.

Alepisauridae (Lancetfishes)

The knowledge of behaviour and activity patterns of lancetfishes is scarce and restricted to a single species, *Alepisaurus ferox*. It is a nocturnally (Post 1984) or diurnally (Haedrich 1964; Potier et al. 2007; Varghese et al. 2010) active and feeding species. The available data of *A. ferox* strongly suggest vertical movements (Rancurel 1970; Moteki et al. 1993; Tsuchiya et al. 1998). The patterns of spawning or further activities are not known so far.

A. ferox is the only representative of lancetfishes in the MS.

Order Myctophiformes

Myctophidae (Laternfishes)

Nocturnal feeding is a common pattern in adult myctophids. Feeding takes place at epipelagic or mesopelagic depths with peak activity in the early part of the night or periods after midnight (Yatsu et al. 2005; Takagi et al. 2009; Dypvik & Kaartvedt 2013; Bernal et al. 2015; Stefanescu & Cartes 1992; Contreras et al. 2015). Some laternfishes seem to take in food during both day and night (e.g. the vertical migrating species *Hygophum benoiti* and *H. hygomii*, Bernal et al. 2015). Diurnal feeding may be restricted to the winter (e.g. *Lampanyctus crocodilus*, Bernal et al. 2015). Most myctophid larvae are visual predators that feed primarily during daylight hours (Sabatés & Saiz 2000; Rodríguez-Graña et al. 2005; Sassa & Kawaguchi 2005; Bernal et al. 2013). Larvae of *Ceratoscopelus maderensis*, *Hygophum benoiti* and *Benthosema glaciale* showed exclusively daytime feeding, independent of their vertical distribution (Contreras et al. 2015). Transformation phases between larvae and juvenile fish of different species of myctophids feed during day and night without defined diel pattern, as inferred from stomach contents of both day and night samples (Contreras et al. 2015).

Many species, probably including all Mediterranean representatives, perform a DVM during the crepuscular periods, with adults staying in the mesopelagic during daytime and in the epipelagic or upper mesopelagic layer during night (Badcock & Merrett 1977; Roe & Badcock 1984; Hulley 1984, 1986, 1990; Moser & Ahlstrom 1996). Beside the active DVM of the whole population, alternative distribution and migrations patterns exist in several species, i.e. some individuals of a certain species do not migrate depending on season or environment while others do (Albikovskaya 1988; Watanabe et al. 1999; Sutton et al. 2013). E.g., *Benthosema glaciale* and further *Benthosema* species show a distinct bimodal nocturnal distribution: a large part of the population remains in the mesopelagic zone during night whereas the other part ascends during dusk and stays at the surface at night (Gjøsæter & Tilseth 1988; Sutton et al. 2013). Non-migrating species also exist (Watanabe et al. 1999). Juveniles show similar migration patterns (Parin 1967) or do not migrate vertically (Hulley 1990). Larvae migrate vertically in the opposite direction, i.e. they are found at the surface during daylight (05:00-19:00) with peaks in the morning (06:00-08:00) and evening (16:00-18:00), whereas their surface activity is reduced during the middle of the day (Parin 1967). Surface activity of larval myctophids is not confined to species with adult DVM. Larvae without vertical migration may also exist (Hulley 1990).

Spawning takes place only during the night in epipelagic layers (Gartner 1993; Gjøsæter & Tilseth 1988; Flynn & Paxton 2012).

A total of 20 laternfishes were recorded in the MS, including the above mentioned species.

Order Lampriformes

Lampridae (Opahs)

Opahs undertake distinct diel vertical movements, ascending to the level between 50–150 m during night but occcuring mainly in 150–400 m depth at day. *Lampris guttatus* is seen feeding and migrating during all periods of the day (Polovina et al. 2008). Information about spawning time does not exist so far.

The family includes two species, of which *Lampris guttatus* occurs in the study area.

Trachipteridae (Ribbonfishes)

Ribbonfishes represent a little known family and virtually nothing has been published about diel activity patterns of these species. However, there is indirect evidence of nocturnal feeding activity (see Fishelson et al. 2012).

The family includes two species, of which *Zu cristatus* occurs in the MS.

Regalecidae (Oarfishes)

Knowledge about the diel activity of oarfishes is at most rudimentary. Several observation of active individuals (e.g. feeding or fast vertical migrations) were made during daylight (e.g. Benfield et al. 2013, Loyer 2015), but their nocturnal behaviour and diel spawning pattern is

unknown.
The family includes two extant species, one of which (*Regalecus glesne*) occurs in the MS.

Order Zeiformes

Zeidae (Dories)

Information about diel activity is scarce in this family. Representative of the genus *Zenopsis* perfom vertical migrations (Parin et al. 1997; Zidowitz et al. 2002). The fish feed diurnally and nocturnally during their vertical migrations. Mesopelagic prey is utilised during the night by *Zenopsis conchifer* but bentho-pelagic fish dominate their prey during the day (Fock et al. 2002) strongly supporting regular vertical migrations. A cathemeral activity pattern is concluded in *Zeus faber* based on prey analyis (Akyol 2001) and fishery trawl data. Date on spawning patterns are lacking so far.
Two species occur in the MS.

Order Gadiformes

Merlucciidae (Merluccid hakes)

Activity patterns, especially those of feeding, can be manifold in merluccid hakes (Roel & Macpherson 1988; Gordoa & Macpherson 1991; Pillar & Barange 1995). Vertical migrations are verified in many species of *Merluccius* (see Carpentieri et al. 2008 for a summary). The European hake (*Merluccius merluccius*) is a mainly nocturnal species. It stays near the seabed during day and undertakes vertical migrations due to feeding in surface waters at night in the adult stage. Juveniles of the European hake are also nocturnal feeders (Carpentieri et al. 2008) and show a diel vertical migration as well (Bozzano et al. 2005). Larvae may feed during all periods of the day (Froglia 1973; Morote et al. 2011; de Pontual et al. 2012).
Merluccid hakes spawn at night in surface waters (Landaeta & Castro 2006; Groison 2010), the North-west Atlantic *Merluccius bilinearis* spawns in the afternoon acc. to Kendall & Naplin (1981).
Only *M. merluccius* occurs in the MS.

Bregmacerotidae (Codlets)

Information about diel activity is scarce in this family. Several species carry out DVMs (Clancey 1956; Milliken & Houde 1984; Cohen 1986; Froese & Pauly 2019). Spawning most probably occurs at night.
Only one Indo-Pacific species, *Bregmaceros nectabanus*, was rarely recorded in the MS.

Gadidae (Cods; incl. Gaidropsarinae, Lotinae and Phycinae)

The diel patterns of gadoid fishes are not homogeneous, though there is a general trend towards cathemeral activity (Potts 1990 and references below). Several species undertake vertical migrations, moving from the bottom to the surface at night (Cohen et al. 1990). Migrations onshore at dusk and offshore at dawn were also reported (Gibson et al. 1965). Courtship and spawning predominate at dusk and night, but there are exceptions and spawning can even occur throughout the diel cycle.

Gadinae (Cods): Different subpopulations with varying acitivity patterns occur in *Merlangius merlangus*, i.e. a vertically migrating subpopulation feeding on pelagic prey during the day and a non-migrating demersal subpopulation feeding on demersal prey mainly at night (Pedersen 2000; Rindorf 2003). The feeding pattern and even vertical migrations of species may also depend on region and on availability of prey (Adlerstein & Welleman 2000; Rindorf

2003). Larvae of north Atlantic *Melanogrammus aeglefinus* have a crepuscular feeding peak (MacKenzie et al. 1999).

In *M. merlangus*, courtship and spawning take place after sunset with a peak between 20:00-03:00 (Povoa et al. 2011). Species that spawn in midwater (e.g. *Micromesistius poutassou*, spawning at depths of 300 to 600 m) may differ from this pattern. *M. aeglefinus* spawns throughout the diel cycle with a peak spawning during the evening (17:00–21:00 hours; Burchard et al. 2014). This coincides with the higher intensity and frequency of sound production related to courtship and spawning behaviour in haddock during dusk and night (Lanĝard et al. 2008).

Gaidropsarinae (Rocklings): Information about diel activity is scarce in this subfamily. Nocturnal activity including courtship behaviour predominates (Nieder & Zander 1994; Almada et al. 1996; Neumann & Paulus 2005).

The time of appearance of eggs in open water suggested the spawning of *Enchelyopus cimbrius* in the morning (Battle 1930, north Atlantic).

Lotinae (Cuskfishes): Information about diel patterns is scarce in this subfamily. As far as is known, species show mainly nocturnal or crepuscular activity (Almada et al. 1996; Løkkeborg et al. 2000; Neumann & Paulus 2005).

Phycinae (Phycid hakes): *Phycis phycis* has a completely nocturnal way of life, hiding below rocks or in caves during the day (Cohen et al. 1990; Neumann & Paulus 2005). At least some phycid species carry out vertical migrations (as data by Bahamon et al. 2009 suggest).

In Gadidae, a total of 14 species is known from the MS, one of which does not occur in shallow water.

Order Holocentriformes

Holocentridae (Squirrelfishes)

All squirrelfishes are strictly nocturnal (Randall 1995; Gillibrand et al. 2007; Ménard et al. 2008; Brandl & Bellwood 2014). As do other species, *Sargocentron rubrum* is found hiding in caves or under rock overhangs during day but active and feeding during the night (Thresher 1984; Louisy 2015).

There is little information about diel spawning patterns, but Thresher (1984) describes several observations about pre-spawning behaviour of different squirrelfishes that make spawning during dusk or at night very likely.

One squirrelfish of Atlantic origin and *S. rubrum* of Indo-Pacific origin occur in the MS.

Order Ophidiiformes

Carapidae (Pearlfishes)

Members of this family have strictly nocturnal activity patterns, regardless of free-living or parasitic way of life (Markle & Olney 1990; Froese & Pauly 2019). However, information is scarce in this familiy.

Two species occur in the MS.

Ophidiidae (Cusk-eels)

Littoral cusk-eels are nocturnal. During the day they hide buried in the substrate (Kéver et al. 2012), but they emerge to feed at night. Some species are already active during dusk (Matallanas & Riba 1980; Matallanas 1981; Letourneur et al. 2001; Neumann & Paulus 2005; Codina et al. 2012). Species that occur in a wide depth range are nocturnal in shallow water but actively foraging during the day in deeper water (Lowe & Bray 2006).

Not much is known about spawning patterns. The West Atlantic species *Ophidion marginatum* spawns at evening and early night. Courtship and spawning are associated with

sound production (Courtenay 1971; Mann et al. 1997).
One Mediterranean species is a deepwater inhabitant, three species occur in the littoral zone.

Bythitidae (Viviparous brotulas)

Viviparous brotulas are strictly or mainly nocturnal species and hide in caves during the day (Göthel 1992; Neumann & Paulus 2005). The Mediterranean species *Bellottia apoda* is to a certain extent active during day (Letourneur et al. 2001). Diel spawning patterns are not described in detail so far.
Four species are known from the MS, two of which are restricted to depths below 460 m.

Order Batrachoidiformes

Batrachoididae (Toadfishes)

Toadfishes show a higher activity during the night than during daytime (Mensinger & Case 1991; Campos et al. 2008). Feeding may take place during the day (Palmer et al. 2005), but feeding activity peaks at night (Gosline 1996; Costa 2004) or is restricted to the night (Sisneros et al. 2009). Frequency of movements may be influenced not only by the circadian cycle but also by tidal stage and type of tide and differs from species to species.
Males of several species, including *Halobatrachus didactylus*, produce sounds in order to attract females and to defend their nest territory (Sisneros et al. 2009). Males of many species call at night (McIver et al. 2014) or both at day and night (Maruska & Mensinger 2009). Courtship, i.e. calling to attract females, and spawning are mainly controlled by tides in *H. didactylus* and hence take place during day or night (Amorim et al. 2011; McIver et al. 2014).
H. didactylus is the only species in the MS.

Order Kurtiformes

Apogonidae (Cardinalfishes)

The family comprises diurnal and nocturnal species (Brandl & Bellwood 2014), however Hobson (1974) regarded cardinalfishes generally nocturnal. All species in the Mediterranean Sea feed during the night and linger under shaded rock overhangs or in caves during the day. However, the Mediterranean cardinalfish *Apogon imberbis* is more crepuscular rather than strictly nocturnal (Aguzzi et al. 2013).
In many species, courtship, spawning and intake of eggs take place during midday (Kuwamura 1983; Thresher 1984), but courtship may start before sunset followed by nocturnal spawning in some species (Fishelson 1970; Thresher 1984). *A. imberbis* shows courtship behaviour throughout the day, its highest frequency as well as spawning occurs at sunset (Mazzoldi et al. 2008). Cardinalfishes' larvae hatch soon after sunset to early night (Okuda & Ohnishi 2001).
Six species of cardinalfishes were recorded in the MS including the native *A. imberbis* and five non-indigenous Indo-Pacific species.

Order Gobiiformes

Gobiidae (Gobies)

Gobies represent the most species rich family of marine fishes both worldwide and in the Mediterranean Sea. Although many species of this family are easily to approach and to observe, surprisingly few data have been published about activity patterns of these fishes. The family includes benthic and pelagic taxa and is divided in several subfamilies (Froese & Pauly 2019). If we exclude all species with insufficiently known pattern, about 50% of the

Mediterranean representatives are diurnal and 50% of the species show a nocturnal, crepuscular or cathemeral activity. Crepuscular periods represent those with highest feeding activity in several species of *Pomatoschistus* and *Gobius* (Casabianca & Kiener 1969; Hesthagen 1980; Nash 1982; Norte-Campos & Temming 1994 in Thetmeyer 1997).

Species with cathemeral or very complex diel activity patterns may change their pattern from region to region, between seasons or they may be influenced by tidal rhythms. An inversion pattern (i.e. seasonal change from nocturnal activity during 'summer' to diurnal activity in 'winter') is supposed for *Gobius niger* and *Pomatoschistus minutus* (Hesthagen 1976; Westin & Aneer 1987; McCloskey 2013; Aguzzi et al. 2015b).

Partner gobies, associated to shrimps of the genus *Alphaeus*, are strictly diurnal. Both goby and shrimp remain in their burrow during night (Yanagisawa 1984; Karplus 1987; Karplus & Thompson 2011). The Red Sea immigrants *Vanderhorstia mertensi* and *Cryptocentrus caeruleopunctatus* are the only partner gobies in the Mediterranean Sea so far.

Shoaling open water species (e.g. *Aphia minuta*, *Crytallogobius linearis*) probably feed during all periods of the 24-hour cycle, but predominantly at night (La Mesa et al. 2008; Tirelli et al. 2014). At least *Crytallogobius* seasonally undertakes vertical migrations, staying closer to the bottom during daytime but ascending during night (Olivar & Sabatés 1997).

Generally, courtship and spawning are similar for all species and may take place during all diurnal periods, but most frequently in the early morning (Thresher 1984). Diurnal spawning and/or courtship in Mediterranean gobies was described by Tavolga (1958 in Parmentier et al. 2013), Forsgren (1992), Mazzoldi et al. (2000), Mazzoldi & Rasotto (2002), Lindström et al. (2006), Amorim & Neves (2007), Malavasi et al. (2009) and Pedroso et al. (2013).

Currently there are known 54 native and 10 Indo-Pacific gobies in the MS.

Order Mugiliformes

Mugilidae (Mullets)

Species of this family are regarded mainly diurnal by several authors (Helfman 1993; Santos et al. 2002; Trancart et al. 2012; Brandl & Bellwood 2014). Some species show a diurnal pattern of migration in the tidal system of estuaries (Trancart et al. 2012). Mullets, however, are actually active during both day and night (Drake et al. 1984; Almeida 2003; Arndt upubl. data).

Diel feeding patterns show a certain plasticity depending on area and/or environmental influences. Feeding mainly takes place during daytime and increases from dawn to dusk, but distinctly decreases during night (e.g. in *Liza ramada*, Almeida 2003; *Mugil cephalus*, Collins 1981; Dankwa et al. 2005). Beside light, the tidal cycle may play an important role in feeding pattern. Several species show highest feeding activity during high tide (Thomson 1966; Odum 1970; Marais 1980; Torriceli et al. 1988). Feeding in adults of some *Mugil* species including *M. cephalus* may peak during low tide at day, but a second feeding peak occurs during low tide at dusk and beginning night (Dankwa et al. 2005, study in West Africa). Co-occurring mugilid species have been reported to feed at different times (Marais 1980; Drake et al. 1984; Dankwa et al. 2005) and their differences in the peak feeding time are taken as avoiding competition (Blaber 1976). Nocturnal feeding can be assumed in *Oedalechilus labeo* (Reina-Hervás & Serrano 1987; Londoño et al. 2011).

Fry feed predominantly during day (Torricelli et al. 1988). Feeding of juveniles takes place from early morning (before dawn) to late evening (after dusk) or early night, but varies depending on season (Cardona 1999).

Spawning was observed in few species; mostly it takes place during evening or at night (Thomson 1966; Martin & Drewry 1978; Ferraro 1980; Chesalina 2000). *Chelon labrosus* spawned all day round in a tank under natural light conditions (Crosetti & Cordisco 2004). Eight species occur in the MS, including one Indo-Pacific immigrant.

Order Blenniformes

Tripterygiidae (Triplefin blennies)

Triplefin blennies are diurnal fishes. At night the fish sit unprotected on the substrate (not under stones or in boreholes) and 'sleep'. Sleep can be deduced from immobility of the individuals, immobility of their eyes, and reduced frequency of opercular movements (Abel 1959). The diurnal activity of territorial males includes 'swimming' (> 50% of total activity between 05:00-21:00 hr), 'feeding' (5-15% of total activity during the spawning season), courtship (loop swimming), 'spawning', 'plucking at the eggs' (an egg care behaviour) and 'fighting' (Wirtz 1978). The fish feed steadily during the day (Wirtz 1978).

The spawning activity is highest in the morning, can continue for several hours and decreases in the late afternoon (Abel 1955, Wirtz 1978; Thresher 1984). Thereafter male blennies guard their eggs (Wirtz 1978, Thresher 1984).

There are three triplefin blennies in the MS.

Blenniidae (Combtooth blennies)

Most blennies feed and display courtship behaviour during the daylight period (Wirtz 1978), but the family as a whole includes diurnal and nocturnal species (Hobson 1974). In the MS, the large majority of species is diurnal. At night, these blennies usually hide under stones, in crevices and in boreholes (Abel 1955). Some species (*Coryphoblennius galerita* and, to a lower degree, *Lipophrys trigloides*) sojourns parts of the night on moist rocks above the water line in order to sleep outside the water (Heymer 1982; Louisy 1987). A few Mediterranean representatives actively swim and feed during both day and night (e.g. *L. trigloides*, Nieder & Zander 1994) or show activity peaks in the crepuscular periods (e.g. *Parablennius zvonimiri* and *P. gattorugine*, Pallaoro 1989 in Orlando-Bonaca & Lipej 2007; Neumann & Paulus 2005).

Spawning takes place during daylight and may be restricted to a short period (e.g. early morning or midday) or continue throughout the day (Thresher 1984). As far as is known, Mediterranean species spawn during daylight as well (Faria et al. 2002, 2005). Thereafter male blennies guard their eggs (Almada & Santos 1995). However, the knowledge of diel activity, in particular of spawning patterns, is far from complete in this familiy.

With 19 native species, two newcomers of Atlantic origin and three non-indigenous species of Indo-Pacific origin, blennies represent one of the most diverse families in the MS.

Clinidae (Kelp blennies)

Ecological data of kelp blennies are scarce. Studies on the behaviour of *Clinitrachus argentatus s*uggest diurnal activity (Wirtz 1978 and references cited therein; Velasco et al. 2010). A Pacific species of the same subfamily also feeds during the day (Stepien 1986).

Few data exist about courtship and spawning patterns of clinids; both are exhibited during daylight and may be restricted to a short period (e.g. early morning, midday or late afternoon; Coyer 1982; Thresher 1984).

C. argentatus is the only species in the MS.

Order Gobiesociformes

Gobiesocidae (Clingfishes)

Knowledge of diel activity in clinghfishes is still limited. Generally, clingfishes may feed during the day, crepuscular periods and at night (Hirayama et al. 2005; Pires et al. 2011), but specific studies are rare and currently confined to non-Mediterranean species. All Mediterranean species of this family seem to be predominantly diurnal (Neumann & Paulus 2005; Gonçalves et al. 1996; Ribeiro et al. 2006). A north Atlantic *Apletodon* species is diurnal as well (Gordon 1983).

As far as is known, courtship and spawning occur during daylight, even if the species feeds mainly at night (Pires et al. 2011).

Eigth species are known from the MS.

Order Atheriniformes

Atherinidae (Silversides)

Mediterranean species are diurnally active, forming pelagic schools. They rest at night near the bottom or hover motionless nearshore in the water column with no remarkable escape distance when approached with light (Neumann & Paulus 2005; Arndt, unpubl. obs.). All examined species have eyes with a duplex retina typical for diurnal teleost fishes (Reckel 2001). Aguzzi et al. (2013) identified an "*Atherina* sp." as strictly nocturnal using video observatories. Several tropical Indo-Pacific *Atherinomorus* species are known as nocturnal planktivores, feeding dispersed in the water column, while building schools of relatively inactive individuals during day (Hobson 1974). *Atherinomorus lacunosus* (Forster) can be attracted by light at night (Conand 1993).

Spawning patterns of Mediterranean species were not described so far. Generally silversides may spawn during day or night (Hubbs 1921, referring to a freshwater species, Middaugh et al. 1986, Coleman 1999). High tides per night are key stimuli for spawning in certain species (Middaugh et al. 1981).

Three to five native species depending on different taxonomical concepts (see Louisy 2015) and the nonindigenous *Atherinomorus forskalii* occur in the MS.

Order Beloniformes

Exocoetidae (Flyingfishes)

The diel patterns of flyingfishes are hardly known so far. Exocoetid species are often observed during day while 'flying' above the water surface. Maurakis et al. (2010) listed a *Cheilopogon* species in their group of "diurnal planktivores" and Reckel (2001) stated that all examined representatives have a duplex retina typical for diurnal teleost fishes.

On the other hand, examination of stomach contents showed that feeding of some species takes place at night (Lewis et al. 1962). This coincides with observations that flying fishes are attracted by light at night (Parin 2002). The brightness of the moon may affect flyingfishes' activity and depth, although this phenomenon needs further examination (Gillet & Ianelli 1993). Smaller larvae occur at the surface only during the day (04:00-20:00 with highest abundance between 06:00-18:00), but disappear at night (Parin 1967).

Timing of spawn varies greatly by taxon. Spawning was observed during day in several neritic taxa, while oceanic epipelagial species (e.g. *Exocoetus volitans*) seem to have a heterogeneous pattern depending on geographic location and local oceanographic features (Lewallen in litt.).

Four native and two non-indigenous species were recorded in the MS.

Hemiramphidae (Halfbeaks)

The knowledge of diel patterns of halfbeaks is scarce. Obervations indicate that they are active during both day and night. An Australian *Hyporhamphus* species was proven to be herbivorous during daylight but carnivorous at night (Robertson & Klumpp 1983; Earl et al. 2011). As all beloniform families, halfbeaks have eyes with a duplex retina typical of diurnal teleost fishes (Reckel 2001). Spawning also takes place during both day and night (Senta 1966, 1967), but was not described for the Mediterranean representatives so far. Smaller larvae of the Indo-Pacific *Oxyporhamphus micropterus* occur at the surface only during the day (04:00-20:00 with highest abundance between 06:00-18:00), but disappear at night (Parin 1967).

One native and two non-indigenous species of Indo-Pacific origin are known from the MS.

Belonidae (Needlefishes)

Detailed studies about diel patterns in needlefishes are scarce. Many or all species are active during both day and night (Sogard et al. 1989; Reckel 2001; Randall 2005; Brandl & Bellwood 2014; Froese & Pauly 2019; Arndt, unpubl. obs. of different species). Cathemeral activity comprises migration and feeding. The garfish *Belone belone* has eyes with a duplex retina typical of diurnal teleost fishes, but shows a hexagonal pattern of dorsal retina, possibly an adaptation to feeding under low light conditions (Reckel 2001).

Information about diel spawning patterns is hardly available. Courtship and spawning were observed during daylight (see e.g. Childs et al. 2017). Courtship and spawning of needlefishes were also described by aquarists and divers in internet forums. Concordantly, these fish enthusiasts described that courtship takes place pairwise, the male courts dance-like and the female spawns a few large eggs that are attached to plants or floating material, implying daylight observations.

Three native and two non-indigenous species of Indo-Pacific origin are distributed in the MS.

Scomberesocidae (Sauries)

Ecological information about activity patterns is scarce in this family. The Pacific saury (*Cololabis saira*) shows a feeding peak at dusk (Sugisaki & Kurita 2004). Nocturnal feeding is suggested in Atlantic saury (*Scomberesox saurus*) (Korkosh 1992). The Atlantic saury is known to undertaking diel vertical migrations in the adult stage, moving into deeper water during the day and rising to the surface at night to feed (Korkosh 1992; Department of Fisheries and Aquaculture 2015).

Eggs and larvae of this species are found all day round in the surface layer (mostly at 0–1 m), coinciding with depth range used by adults at night and may imply nocturnal spawning (Parin 1967; Dudnik et al. 1981).

S. saurus is the only species in the MS.

Order Cyprinodontiformes

Cyprinodontidae (Pupfishes)

The species of this family are mainly or strictly diurnal (Helfman 1993). Feeding predominates during daylight (Plaut 2000), agonistic behaviour, courtship and spawning is also exhibited during daylight but may shift between morning and afternoon depending on season (Echelle 1973; Kodric-Brown & Mazzolini 1992; Cavraro et al. 2013; Liu & Echelle 2013).

Most pupfishes are freshwater fishes, at least three species occur in Mediterranean brackish waters, lagoons or even hypersaline lakes.

Order Carangiformes

Coryphaenidae (Dolphinfishes)

Dolphinfishes feed during both day and night (Rothschild 1964; Massutí et al. 1998; Oxenford & Hunte 1999; Olson & Galván-Magaña 2002). They show vertical migration patterns, spending most of the daylight time at the surface but may dive into deeper layers

predominantly at night (Furukawa et al. 2011; Merten et al. 2012). Larvae may be active during day and night too (Parin 1967).
Spawning takes place from afternoon to early night (Hagood et al. 1981; Solchi 1978).
Both *Coryphaena* species are recorded from the MS. Most published data refer to *C. hippurus*, and it is not sure yet if they are completely applicable to *C. equiselis*.

Rachycentridae (Cobias)
The cobia is a diurnal species (Kuiter & Debelius 2009; Brandl & Bellwood 2014). Feeding by adults mainly takes place during the day, but peaks in the crepuscular periods (06:00-08:00 and 18:00-20:00). Feeding decreases significantly in the first part of the night and no feeding happens during the period of 00:00-04:00 (Sun et al. 2006). Juveniles also feed during the day including both crepuscular periods (Franks et al. 1996).
Spawning takes place in the afternoon, early evening or at dusk (Benetti et al. 2008; van der Velde et al. 2010; Lefebvre & Denson 2012).
The family is monotypical, *Rachycentron canadum* is widespread from the Atlantic to the Indo-Pacific.

Echeneidae (Remoras)
The knowlegde about diel patterns is very scarce in species of Echeneidae. All remoras are regarded as diurnally active (Strasburg 1962; Brandl & Bellwood 2014; Arndt unpubl. observ.). Remoras are found resting at night (e.g. attached to metallic constructions at the sea floor) or were observed attached to large animals (veryfied unpubl. information by divers).
Spawning takes place in early night (Nakajima et al. 1987).
Four of the widespead remora species are recorded from the MS.

Carangidae (Jacks and Trevallies)
Carangids represent one of the most species-rich families in the Mediterranean. Though all are strong-swimming pelagic or at least bentho-pelagic species, their diversity is reflected by quite different behaviour and activity patterns. Regarding feeding activity, all possible types can be found in representatives of this family. Many species are strictly or mainly diurnal (Hobson 1975; Blaber & Cyrus 1983; Cermak 2002; Gillibrand et al. 2007; Meyer et al. 2007), some *Caranx* species also feed, albeit to a much lesser extent, during dusk (Major 1978; Sancho 2000). Species of other genera have a crepuscular feeding peak (e.g. *Seriola* spp, incl. taxa that occur in the MS; Jardas et al. 2004; Coles 2014; see also de Carvalho & Soares 2006 for a summary of references) or intake food at night (e.g. *Alepes djedaba*, *Elagatis bipinnulatus*, *Selar crumenophthalmus*, *Uraspis helvola*, with the first two occurrring in the MS; Kagwade 1967; Munro 1983; Honebrink 1990; Randall 1995; Siwat et al. 2016). Many of the nocturnal carangids are characterized by comparably large eyes. *Caranx crysos* and several Mediterranean *Trachurus* species feed continuously or at any time of the day (Sirotenko & Istomin 1978; Blaber & Cyrus 1983; Keenan 2002). The Indo-Pacific *Caranx sexfasciatus* forms large schools which either stay stationary or slowly move around the reef complexes they inhabit during the day, but schools dissolve and the fish become actively feeding at night (Randall 1995). Similar to *Caranx*, species of the genus *Decapterus* feed at different periods of the day, i.e. the genus *Decapterus* includes both mainly nocturnal or mainly diurnal feeding species (McNaughton 2008, unpubl. master thesis).
Vertical migrations, i.e. staying near the seabed during day and ascending to midwater at night, are supposed for the Indo-Pacific *Caranx bucculentus* (Brewer et al. 1994, based on indirect evidence from trawl catches) and at least some of the Mediterranean *Trachurus*

species (Pillar & Barange 1998; Axelsen et al. 2004). These species intake food during the whole 24h period with feeding peaks at night and early morning (Jardas et al. 2004). Spawning of carangids takes place predominantly at night (Delsman 1926; Subrahmanyam 1964; Watson & Leis 1974; Murty 1991; Macewicz & Hunter 1993; Moriwake et al 2001; van Damme et al. 2014) and, as far as is known, all Mediterranean species perfom a nocturnal egg release. The East Pacific *Gnathanodon speciosus* starts to spawn in the early evening hours and continues for some hours into the night (Honebrink 2000). Spawning in crepuscular periods is also known from a Caribbean *Decapterus* species (McBride et al. 2002). A diurnal courtship and/or spawning was reported so far in one or two species each of *Alectis*, *Caranx*, *Decapterus*, *Selis* and *Seriola* (von Westernhagen 1974; Clarke & Privitera 1995; Stuart & Drawbridge 2012; see also McBride et al. 2002 for a summary).
A total of 22 species is known from the MS including 14 native and eight non-indigenous species.

Order Istiophoriformes

Sphyraenidae (Barracudas)

Barracudas include primarily diurnal as well as predominantly nocturnal species. The latter form schools of inactive individuals during the day (Russell 2002). Mediterranean representatives seem to feed predominantly during the day (Gillibrand et al. 2007; Louisy 2015). *Sphyraena sphyraena*, one of the diurnal species, can be found lying on sand or within seagrass at night (Louisy 2015). *Sphyraena viridensis*, however, feeds during both day and night while exhibiting a shift in hunting behaviour. In summer, this species hunts in schools during the day, but individually during dark periods (Barreiros et al. 2002).
Data on diel spawning patterns of barracudas are scarce. As far as is known, barracudas spawn during night at full moon. Thus their spawning patterns may be controlled by the lunar cycle (Neumann & Paulus 2005).
Four barracuda species are known from the MS, two of which are Indo-Pacific immigrants.

Xiphiidae (Swordfishes)

The swordfish performs vertical migrations, staying near the surface by night (0–90 m) and descending regularly as deep as 800 m by day (Luckhurst 2007; Abascal et al. 2015); only a few individuals may differ from this pattern by remaining in deep water during daytime. The feeding is cathemeral (Varghese et al. 2014), the swordfish forages in deep water during the day (Carey & Robison 1981; Abascal et al. 2015) and in the shallow layer at night (Carey & Robison 1981; Matsumoto et al. 2003; Chancollon et al. 2006). Larvae are active at the sea surface and intake food predominantly in the morning and evening, but at much lower levels during midday or night (Parin 1967; Gorbunova 1969).
Spawning takes place at night as can be concluded indirectly from Nakamura (1985).
The family is monotypical, *Xiphias gladius* has a cosmopolitan distribution.

Istiophoridae (Billfishes)

Billfishes are highly migratory and vagrant species; these abilities result in a complex behaviour. The fish stay most of the time near the water surface but display frequent short duration vertical excursions from surface waters to deeper waters. The short duration dives depend on several factors such as thermal parameters of the body, water, region, season, and they may differ between individuals (Braun et al. 2015; Sippel et al. 2011). These dives are deeper during daylight hours than during the night, e.g. in black marlin (*Istiompax indica*, Chiang et al. 2015) and blue marlin (*Makaira nigricans*, Holland et al. 1990; Block et al. 1992; Pepperell & Davis 1999; Kerstetter et al. 2003; Goodyear et al. 2008). Sailfishes (*Istiophorus* spp.) do not show distinct differences of diving behaviour between day and night (Hoolihan 2005; Mourato et al. 2010). *I. platypterus* spends >85% of its time in the upper layer above ~50 m in water of about 25°C (~72% during the day and ~98% during the night, Chiang et al. 2013), but untertakes more extensive vertical movements during the daytime than nighttime. Sailfish show basking behaviour during daylight (Chiang et al. 2011, 2013). Contradictory data exist for the striped marlin *Kajikia audax*. Three different patterns were observed in striped marlin: (i) no differences in diving behaviour between day and night (Holts & Bedford 1990), (ii) deeper dives at night (Gunn et al. 2003), or (iii) significantly longer dives below 100 m during the day than at night (Sippel et al. 2007).

Probably, billfishes forage mainly in deeper water during the day (Graves et al. 2003; Horodysky et al. 2007). It is unclear if white marlin and other istiophorids dive to feed directly on deeper-dwelling prey or to obtain olfactory or visual cues, such as silhouetting concentrations of epipelagic prey above them against downwelling light. The silhouetting hypothesis is supported by the prevalence of U-shaped dives during daylight hours and on nights with brighter moon phases (Horodysky et al. 2007). Feeding in deeper water is also supported by high CPUE values for white marlin, blue marlin and sailfish at calculated hook depths of 105–170 m in the tropical Atlantic (Maksimov 1970 and Gonzalez & Gaertner 1990 in Horodysky et al. 2007). The Indo-Pacific blue marlin *Makaira mazara* feeds at night (Nakamura 1985). The blue marlin is believed not to feed on the surface at night; surface-trolled baits are taken by this species especially in the morning between 10:00 and 11:00 hours (Nakamura 1985). Larvae of billfishes are active at the surface mostly during daylight with peaks in the morning (06:00-08:00) and early evening (16:00-19:00) (Parin 1967).

Knowledge of billfishes' spawning patterns is still scarce. A description of spawning events has not been published for any species so far. However, late afternoon to early night was estimated as the spawning period for the Atlantic sailfish (*Istiophorus albicans*) off Florida (Richardson et al. 2009).

Five species of billfishes were recorded in the MS.

Order Pleuronectiformes

Citharidae (Largescale flounders)

Knowledge about ecology and behaviour is scarce in species of this family. Inconsistent data are available about diel activity in *Citharus linguatula* (de Groot 1971; Redon et al. 1994; Aguzzi et al. 2015; see details in ESM), leading to the conclusion that this species may be active during all periods of the day.

C. linguatula is the only known species in the MS.

Scophthalmidae (Turbots)

Turbots exhibit diurnal as well as nocturnal activity, but diurnal activity clearly predominates in adults (Gibson et al. 1996). The species are diurnal feeders using visual cues for food detection (de Groot 1971; Braber & de Groot 1973). Juveniles of *Scophthalmus maximus* are predominantly nocturnal (Westin & Aneer 1987) or show peak activity in the morning and evening (Waller 1992; Dietz 2012). Data on activity are lacking in species of the genus *Lepidorhombus*.

Spawning in turbot takes place during the evening and nighttime (Ferraro 1980; Jones 1972), but in tanks it was also observed during the morning (Bromley et al. 1986). Diel spawning data are lacking in other species so far.

Five species of Scophthalmidae are known from the MS, two of which (*Lepidorhombus* spp) are predominantly deepwater species.

Pleuronectidae (Righteye flounders)

Diel activities of righteye flounders comprise diurnal, crepuscular and nocturnal components. Feeding may take place during all diel periods, varying from species to species, between seasons or localities. E.g. in European flounder *Platichthys flesus*, specimens of size most preferred by diurnal avian predators (i.e. 10–25 cm length) move and feed predominantly at night (Verheijen & de Groot 1967; Wolff et al. 1981; Raffelli et al. 1990). Other studies revealed the European flounder as a day-feeder (De Groot 1971; Mattila & Bonsdorff 1998), with feeding peaks during dawn and dusk (De Groot 1971; Muus 1967). In the North-west Atlantic, *Pseudopleuronectes americanus* and *Pleuronectes putnami* also showed a preferred diurnal activity (McCleave & Fried 1975). Feeding activity of pleuronectids may be superimposed by tidal cycles, i.e. onshore movements during high tide at night. Even on coasts with low tidal amplitude (<0.3m), the plaice *Pleuronectes platessa* shows onshore movements during the night and a return to deeper water at dawn (Ansell & Gibson 1993; Gibson 1973, 2005; Verheijen & de Groot 1967). Some species including the European flounder are highly migratory, exhibiting a highly variable behaviour that may even differ between sections of the same estuarine population (Wolff et al. 1981; Summers 1979). Juvenile pleuronectids mainly feed at night (Gibson et al. 1998; Pereira 2004; Rasmussen 2005: 53) or in turbid estuarine waters mainly during dusk, night and dawn (Bregnballe 1962; Muus 1967, Pihl 1982 in Vinagre et al. 2008).

Data from courtship and spawning are far from complete. *P. americanus* is seen courting and spawning at dusk or night (Breder 1922; Stoner et al. 1999). The plaice also spawns mainly at night (Forster 1953, Beverton 1964, Simpson 1971, Nichols 1989). The Pacific halibut (*Hippoglossus stenolepis*) shows a very complex spawning behaviour that includes migrations to deeper water, ascending and descending movements with spawning during daytime (Loher & Seitz 2008).

Two species, *P. flesus* and *P. platessa*, occur in the MS.

Bothidae (Lefteye flounders)

Bothidae are diurnal feeders using visual cues for food detection (de Groot 1971, Braber & de Groot 1973; Beyst et al. 1999). A few species of *Arnoglossus* are partially active during crepuscular periods or to a minor part at night (Aguzzi et al. 2015; Letourneur et al. 2001).

In lefteye flounders, courtship and spawning activity takes place in the early morning (*Bothus podas*, Carvalho et al. 2003: 251) or from mid-afternoon to evening (several *Bothus* and *Crossorhombus* species; Konstantinou & Shen 1995; Manabe et al. 2000; Gibson 2005: 218; Habrun & Sancho 2012). At least in western Atlantic *Bothus ocellaris*, individuals show different behaviour after spawning events: males move to shallower water whereas females swim to deeper water in the evening but re-occupy the spawning territories in the following morning (Gibson 2005: 218). Knowledge about ecology and behaviour is scarce in many species of the genus *Arnoglossus*.

Bothus podas and six species of *Arnoglossus* occur in the MS.

Soleidae (Soles)

Adult soles are mainly nocturnal (Baynes et al. 1994; de Groot 1971; Gibson 2005), during the day these fish usually stay buried in the sediment. Feeding mainly takes place at night (Letourneur et al. 2001, Louisy 2002; Bayarri et al. 2004; Torres Leal 2013). Nocturnal activity may be combined with crepuscular feeding peaks, e.g. in the common sole (*Solea solea*, De Groot 1971; Lagardère 1987; Beyst et al. 1999; Cabral 1998). *Dicologlossa cuneata* may change feeding activity depending on season (Lagardère 1975; Torres Leal 2013). Larvae (of *Solea* spp.) are diurnal feeders (Blaxter 1972; Appelbaum et al. 1983;

Navarro-Guillén et al. 2015) and may undertake diel vertical movements (Champalbert et al. 1994; Lagardère et al. 1999). Post-metamorphic and juvenile stages shift from a continuous take in of food during both day and night, to a predominant feeding at night (Navarro-Guillén et al. 2015; Blanco-Vives et al 2012). Knowledge of activity in several species of the genera *Dicologlossa*, *Microchirus*, *Pegusa* and *Synapturichthys* is scarce or lacking.

The spawning activity is hardly known. Spawning in common sole takes place at night (Baynes et al. 1994); likely the other sole species follow this pattern.

The family comprises 15 sprecies in the MS, four of which are of Atlantic origin.

Cynoglossidae (Tonguefishes)

Knowledge about diel patterns is scarce in tonguefishes. The littoral species are mainly nocturnal (DeMartini & Allen 1984; Switzer 2003; Louisy 2016). However, there is some evidence that tonguefishes with wider depth range are active under low light conditions resulting in a more complex activity pattern: *Symphurus nigrescens* is mainly active during the night in the littoral zone, but is diurnal or active from late night to midday in deeper water depending on different seasons (Aguzzi et al. 2015). Young larvae feed diurnally, but in the post-metamorphosis stage feeding pattern shifts to evening and night (Ma et al. 2006).

No information is available about spawning patterns.

Two native species, distributed in a depth range from about 20 m down to the continental slope, and one non-indigenous shallow water species of Indo-Pacific origin are known from the MS.

Order Syngnathiformes

Syngnathidae (Pipefishes and Seahorses)

Most syngnathids are diurnal feeders (Bennett & Branch 1990, Kendrick 2002, Poortenaar et al. 2004, Kuiter 2009). At night, seahorses usually attach themselves to holdfasts where they remain mostly inactive (see e.g. Felicio et al. 2006). However, diurnal and nocturnal activity is known in some species of *Hippocampus* (Perante et al. 2002, Foster & Vincent 2004, Manning et al. 2019) and one species of *Syngnathus* (Garcia et al. 2005). Pipefishes of the genus *Nerophis* may be predominantly nocturnal, hiding under algae or stones during the day (Dulčić et al. 2004; Louisy 2015).

Courtship and spawning take place during the day in all species including those of *Nerophis*. Spawning activity is most intensive during the early morning hours (Masonjones & Lewis 1996, 2000; Sogabe & Yanagisawa 2007) or peaks in the afternoon (Monteiro et al. 2002). Pregnant males of syngnathids release their brood in the night (Vincent 1990; Foster & Vincent 2004) or early in the morning (Varvara 2015).

There are 15 species known from the MS, including one pipefish of Atlantic and one seahorse of Indo-Pacific origin.

Fistulariidae (Cornetfishes)

Fistularia petimba is a diurnally and nocturnally active species (Hobson 1974; Gray et al. 1998), feeding during day and night with possible crepuscular feeding peaks at least in some specimens (Hobson 1974). *Fistularia commersonii* is a diurnal species (Brandl & Bellwood 2014; Karpestam et al. 2007).

Diel spawning patterns of cornetfishes are hardly known. They likely spawn at dusk or at night (Delsman 1921).

Two non-indigenous species, *F. commersonii* and *F. petimba* occur in the MS.

Macroramphosidae (Snipefishes)

Knowledge about activity of snipefishes is scarce, most data are based on the *Macroramphosus scolopax* species complex. Snipefishes are active and feed during diurnal and crepuscular periods (Marques et al. 2005, Gillibrand et al. 2007; Aguzzi et al. 2015; Carpentieri et al. 2016). At least larvae undertake DVM (John 1973). Courtship and spawning take place in the evening (De Oliveira et al. 1993).

M. scolopax is the only representative of the family in the MS.

Dactylopteridae (Flying gurnards)

Knowledge of ecology and behaviour is scarce in this family. *Dactylopterus volitans* and a *Dactylopterus* species from the Indian ocean are active and feed at night (Gillibrand et al. 2007; Luiz et al. 2013). Data on spawning activity are lacking.

D. volitans is the only Mediterranean species.

Order Callionymiformes

Callionymidae (Dragonets)

Dragonets mainly feed during the day (van der Veer et al. 1990; Fernández et al. 1995; Letourneur et al. 2001). However, data are scarce in several species and more detailed information is much-needed even in near-shore dwelling species.

Courtship and spawning may start in the morning (Holt 1898), but usually take place during afternoon to early evening. The behavioural and chronological patterns of courtship and spawning were described for several species of dragonets including species of *Callionymus* from the Mediterranean Sea as well as other marine regions of the world (Holt 1898; Takita & Okamoto 1979; Zhu et al. 1981; Gonzales et al. 1997; Harrington 1997; Awata et al. 2009; Wittenrich & Ho 2013). Seven native and one non-indigenous species of Indo-Pacific origin are reported for the MS.

Order Scombriformes

Trichiuridae (Cutlassfishes)

The Mediterranean species of this family colonize depths between the water surface and about 700 m and undertake DVMs, staying deeper than 250 m during daytime and moving to shallower water layers at night, often ascending up to the water surface (Munekiyo 1990; Franquet & Brito 1995; Brito et al. 2003; Neumann & Paulus 2005; Schultz 2011). *Lepidopus caudatus* occasionally approaches the shore during the night and was found "lying on the sand to sleep" (Louisy 2015). DVM is a widespread character of cutlassfishes and amongst others known for the littoral Indo-West Pacific *Eupleurogrammus glossodon*, *E. muticus*, *Lepturacanthus savala*, *Trichiurus gangeticus* and the Atlantic deep water species *Aphanopus carbo* (Nakamura & Parin 1993). *A. carbo* performs DVM between about 1700 and 200 m with upward migration during the night in order to feed in the upper water column (Nakamura & Parin 1993; Delgado et al. 2013).

Feeding takes place during both day (in deeper layers) and night; a distinct feeding peak was found in *Trichiurus lepturus* in the first period of night (Martins et al. 2005, study off southern Brazil). Larvae and juveniles of the Mediterranean species were found in moderate water depths (30–50 m) (Bordes et al. 1999; Olivar et al. 2014).

Spawning in *L. caudatus* takes place in the afternoon in depths between 50–200 m (Robertson 1980). *A. carbo* spawns in midwater at night (Nakamura & Parin 1993).

The two species *L. caudatus* and *T. lepturus* occur in the MS.

Scombridae (Mackerels and Tunas)

Species of Scombridae show very diverse patterns of activity rather than well-defined uniform diel patterns. Mackerels and tunas may be active during all diel periods or swim continuously during the 24 h cycle (Magnuson & Prescott 1966). Several species show oscillatory vertical movements (also called "repetitive bounce diving", Schaefer & Fuller 2007; Cosgrove et al. 2014) until or below the thermocline that may consist of irregular patterns in terms of depth and dive length and may be associated with foraging, courtship, spawning or migrating. Examples of species with vertical movements are wahoo (*Acanthocybium solandri*), skipjack tuna (*Katsuwonus pelamis*), albacore (*Thunnus alalunga*), Atlantic bluefin tuna (*T. thynnus*) and the Atlantic chub mackerel (*Scomber colias*). Environmental cues may be responsible for longer periods of frequent diving below the thermocline in the skipjack tuna, Atlantic bluefin tuna, Southern bluefin tuna (*Thunnus maccoyii*), yellowfin tuna (*T. albacares*) and bigeye tuna (*T. obesus*) (Dagorn et al. 2000; Block & Stevens 2001; Musyl et al. 2003; Schaefer & Fuller 2007; Teo et al. 2007; Wilson & Block 2009; Cosgrove et al. 2014). Wahoo spend more than 98% of the time within the warm waters of the upper mixed layer, and the number of dives does not vary significantly between day and night (Sepulveda et al. 2011, off Baja California). Skipjack tuna and albacore show variable patterns with diurnal and nocturnal activity varying from season to season and from area to area dependent on water temperatures and vertical distribution of prey resources. Skipjack tuna adults spend the night in surface waters, but show a more differentiated diurnal activity pattern: when not associated with floating objects, *K. pelamis* displays oscillatory vertical movements to depths between 50 and 300 m (max. 596 m) during the day (Schaefer & Fuller 2007, East Pacific). The above described diving patterns are not necessarily shown by the whole population, but may be performed by only some individuals of a certain species (see e.g. Cosgrove et al. 2014). Vertical movements vary in albacore between localities, seasons and individuals as well. They move between the depths of approximately 100 and 400 m during the day but between 10 and 270 m at night in tropical South Pacific (New Caledonia, Tonga) during July, but exhibit a similar day-night pattern (dives approximately between 10 and 220 m) off temperate New Zealand during May (Williams et al. 2015).

Feeding of several species predominates during crepuscular and diurnal periods with peaks in early morning and late afternoon to dusk (wahoo: Vaske et al. 2003; skipjack tuna: Waldron & King 1963 and Nakamura 1965 in Bayliff 1980, Dragovic 1970, Collette & Nauen 1983; yellowfin tuna: Vaske et al. 2003, Franks et al. 2007; Atlantic bonito *Sarda sarda*: Demir 1963; Atlantic mackerel *Scomber scombrus*: Dahl & Kirkegaard 1986). Some species continue to feed at night (little tunny *Euthynnus alletteratus*: Bullis et al. 1967; Wichlund 1968; Chur 1977; Bahou et al. 2007, García & Posada 2013; Indian mackerel *Rastrelliger kanagurta*: Kamanyi 1975; and albacore: Iversen 1962; Williams et al. 2015). Bigeye tuna, Atlantic bluefin tuna, Southern bluefin tuna and skipjack tuna may show more defined patterns while foraging at the surface at night, in slightly deeper water during crepuscular periods following the ascending or descending prey organisms of the deep-scattering layer respectively, but using short time dives to the middle water to forage during the day (Schaefer & Fuller 2007 and references herein; Patterson et al. 2008; Wilson & Block 2009). Juvenile albacore feed in the Bay of Biskay in summer mainly during night (Goñi etal. 2009). Larvae of *Auxis* spp, *E. alletteratus*, *K. pelamis* and *Thunnus* spp are dayfeeders and feed continuously from sunrise onwards (Parin 1967; Sánchez-Velasco et al. 1999; Morote et al. 2008b; Llopiz et al. 2010).

Spawning time of mackerels may be evening and night or is very variable (Ferraro 1980). E.g. Atlantic mackerel spawn during all diel periods (Bigelow & Welsh 1925; Sette 1943; Ferraro 1980; Walsh & Johnstone 1992). Tunas tend to spawn near the water surface at night (*T. albacares*: McPherson 1991; Schaefer 1996, 1998; *T. obesus*: Nikaido et al. 1991; Matsumoto & Miyabe 2002; *T. thynnus*: Schaefer 2001; Gordoa et al. 2009) or in the early morning hours (*T. alalunga*: Farley et al. 2013).

Atlantic bluefin tuna change their diving behaviour in the Gulf of Mexico during the breeding phase, which was considered as potential signals of spawning period (Teo et al. 2007). A distinctive oscillatory diving behaviour below the mixed layer between midnight and sunrise is also performed by bluefin tuna schools in the Western Mediterranean during the spawning season. The oscillatory dives start shortly after the onset of courtship behaviour (Aranda et al. 2013). Spawning of Atlantic bluefin tuna takes place in this area from midnight to sunrise with a peak between 02:00-03:00 hours (Gordoa et al. 2009; Gordoa 2010; Gordoa & Carreras 2014). Spawning of skipjack tuna takes place during the night (Hunter et al. 1986), however earlier sources report diurnal spawning (Iverson et al. 1970; Matsumoto et al. 1984).

There are 13 species of this family known from the MS, two of which are Lessepsian immigrants.

Nomeidae (Driftfishes)

Diel pattern of driftfishes are hardly known, and data are available from non-Mediterranean species only. Adults of the circumtropical *Cubiceps pauciradiatus* perform DVM between the mesopelagic and epipelagic zones. At night, they occur in the upper layers, but they move to depths of 200–300 m during daytime (Salekhov 1990; Agafonova 1994; Potier et al. 2008). The circumglobal *C. capensis* shows a similar DVM (Fahay 2007). The Indo-Pacific *Ariomma indicum* appears to be pelagic at night but demersal by day (Froese & Pauly 2019). These data imply indirectly that the fish feeds at least partly at night because they follow their ascending prey. Juvenile *C. pauciradiatus* do not migrate daily but stay in a layer below the surface in the stratum of 30–90 m (Salekhov 1990).

Spawning pattern are not known so far.

Two species, one of which has recently immigrated from the Atlantic, occur in the MS.

Tetragonuridae (Squaretails)

Squaretails, including only one genus and three species, are a further group with hardly known diel pattern. At least *Tetragonurus cuvieri* undertakes vertical movements, feeding at night in surface water but deeper in the water column during the day (Grey 1955; Tanonaka 1957). Data on diel spawning patterns do not exist so far.

T. cuvieri is the only squaretail species in the MS.

Stromateidae (Butterfishes)

Butterfishes are active during different periods of the diel cycle. At least some species, including *Pampus argenteus*, undertake vertical movements, feeding in surface water at night but deeper in the water column during the day (Pati 1980; Haedrich 2002). Larvae may undertake DVMs as well (Kendall & Naplin 1981 in Cross et al. 1999).

Peprilus triacanthus, a North-west Atlantic species, spawns primarily in the evening or at night (Ferraro 1980; Cross et al. 1999). Diel spawning patterns of other species are so far unknown.

Two species are known from the MS, one of which (*P. argenteus*) is a rare vagrant.

Order Trachiniformes

Champsodontidae (Gapers)

The acitivity patterns of gapers are still poorly known. As far as is known, some species perform DVM, staying in bathypelagic depths (Smith & Heemstra 1986: *Champsodon* *capensis*) or at the bottom (Morohoshi & Sasaki 2003: *Champsodon snyderi*) during the day and ascending to surface waters to feed at night. It is still unknown when spawning occurs. Three non-indigenous species were recorded in the MS.

Pinguipedidae (Sandperches)

Knowledge of diel activity of sandperches is limited. Probably, the species are active during diurnal and crepuscular periods; Brandl & Bellwood (2014) classify all 12 listed species as "diurnal". *Parapercis hexophtalma* (Indian Ocean) shows a crepuscular and diurnal activity in feeding and social interactions with an activity peak at dusk (Sano 1993; Heemstra & Heemstra 2004). *P. australis* feeds during daylight (Chase et al. 2018). At night, *P. hexophtalma* hides in shallow depressions or burrows near rocks or parts of the reefs (Heemstra & Heemstra 2004).

Courtship and spawning take place in several *Parapercis* species around dusk (Sano 1993; Ohnishi et al. 1997).

Pinguipes brasilianus, a diurnal species of tropical West-Atlantic origin has been recorded in the MS.

Ammodytidae (Sandeels or sandlances)

Sand eels generally feed during the daylight and spending the night burrowed into the seabed (Langham 1971; Helfman 1993), though additional nocturnal activity was reported in a few cases (*Ammodytes* spp; Senta 1965, Macer 1966). Sand eels typically perform vertical migrations during crepuscular periods: the fish ascend to pelagic waters in the morning and descend in order to bury themselves in the evening of each day (Hobson 1986). Laboratory experiments confirm the vertical migrations (Inoue et al. 1967; van Deurs et al. 2011) as well as diurnal feeding (Winslade 1974a, b). Feeding was maximal at light intensities between 100 and 1000 lux, much reduced at 10 lux, and almost nonexistent at 1 lux (Winslade 1974b). Beside vertical movements, sand eels perform diurnal horizontal movements from suitable nighttime shelter and to daytime feeding opportunities and vice versa (Reay 1970). Though knowledge about activity was obtained from species of *Ammodytes*, fishery data suggest that Mediterranean species of *Gymnammodytes* show very similar patterns (Lleonart et al. 2014). *Ammodytes* larvae undergo vertical migrations too, occurring in shallow water during daylight but moving to deeper depths (30–50 m) at night (Covill 1959; Richards & Kendall 1973). The range of these migrations increases with larval size. Movements are undertaken during crepuscular periods and have been attributed to predator avoidance (Yamashita et al. 1985).

Sand eel populations may spawn during day (morning, afternoon, dusk) and night and during any period of tidal cycle except low tide; the exact point in time may differ from day to day (Robards et al. 1999; Gotthardt et al. 2005). However, data on spawning pattern in Mediterranean species are still lacking.

Two species of *Gymnammodytes* occur in the MS.

Trachinidae (Weeverfishes)

The diel activity patterns of trachinid species seem to coincide widely, at least in the Mediterranean species. Weeverfishes rest on the bottom during day, often buried in sand with eyes and tip of first dorsal fin exposed. They are active, feed and may swim around mainly at night (Morte et al. 1999; Muus & Nielsen 1999; Bagge 2004; Neuman & Paulus 2005), but feeding during the day seems to occur at a certain level as well (Olaco et al. 2002; Kruschel & Schultz 2012).

Data about diel spawning pattern are lacking, but spawning at night is likely, because the

species are pelagic spawners (Tortonese 1986).
Four trachinid species occur in the MS.

Uranoscopidae (Stargazers)

Knowledge about diel patterns is limited in this family. Generally, stargazers are nocturnal. During the day they are usually buried in sand or mud with only eyes and mouth exposed (Kishimoto 2001; Louisy 2002). However, a certain diurnal and crepuscular feeding activity may exist, because *Uranoscopus scaber* use their appendage of the respiratory valve in the mouth as a 'bait' by moving it like a worm (Neuman & Paulus 2005).
Virtually nothing has been published about the diel spawning patterns in these species. Spawning during nighttime is likely, because eggs are pelagic (Hureau 1986).
U. scaber is the only Mediterranean species.

Order Labriformes

Labridae (Wrasses)

The large majority of wrasses, including all Mediterranean representatives, is diurnally active and feeding (Costello 1991; Helfman 1993; Hobson 1974; Gillibrand et al. 2007). The fishes rest or sleep at night, partly covered by a mucus envelope and/or buried in sand ground. *Symphodus rostratus* rests at night in vertical position between *Posidonia* leaves (Neumann & Paulus 2005).
Courtship and spawning of wrasses can take place during the day, evening or at night depending on the species (Ferraro 1980; Kuwamura 1981). However, courtship and spawning of the large majority of species are restricted to a short period of the day between early morning and dusk (Thresher 1984; Lejeune 1985). Surprisingly few data are published on diel spawning patterns of Mediterranean species. Most likely, all Mediterranean species are diurnal spawners (Lejeune 1985; Taborsky et al. 1987; Costello 1991; Neumann & Paulus 2005). *Labrus viridis* and *Thalassoma pavo* spawn around midday (Sara et al. 2005; Kožul et al. 2011). *Symphodus* species, including those from MS, spawn 'during daylight' (Fiedler 1964; Lejeune 1985; Taborsky et al. 1987). Several wrasses including non-Mediterranean representatives of *Coris* and *Thalassoma* spawn during different periods of the day (Colin & Bell 1991; Donaldson 1995a; Craig 1998; Habrun & Sancho 2012). Spawning may be influenced locally by tidal rhythms (Tribble 1982; Thresher 1984; Colin & Bell 1991) in regions of the Atlantic and Pacific Oceans with high tidal range.
Twenty native wrasse species are known from the MS, and a couple of non-indigenous species were also recorded. The Indo-Pacific *Pteragogus trispilus* is currently the only non-indigenous species with wider distribution in the MS.

Scaridae (Parrotfishes)

The large majority of parrotfishes is diurnal (Hobson 1974; Helfman 1993). Some species secrete a mucus envelope around themselves during their 'sleep' at night, making the fish less detectable by nocturnal predators (Munro 1983, p. 173; Helfman et al. 2014). Feeding takes place during the day, although some species also feed during the crepuscular periods (e.g. *Sparisoma cretense*, Neumann & Paulus 2005).
Spawing of most species takes place during the day with a spawning peak in afternoon (Randall & Randall 1963; Colin 1978; Robertson & Warner 1978), but may extend to evening and night (Ferraro 1980, North-west Atlantic). In species that spawn throughout the day, the exact spawning time may be triggered by the tide level (Barlow 1975; Robertson & Warner 1978; Gladstone 1986; Colin & Bell 1991). Some species spawn during dawn or dusk (e.g. *S. cretense*, Afonso et al. 2008; de Girolamo et al. 1999).

Two species, the autochthonous *S. cretense* and the Indo-Pacific immigrant *Scarus ghobban*, occur in the MS.

Order Perciformes

Pomacentridae (Damselfishes)

Damselfishes are generally diurnal (Hobson 1974; Helfman 1993; Coles 2014). Feeding takes place during daylight (Emery 1973; Lobel 1980; Thresher 1984; Zemke-White et al. 2002; Barneche et al. 2009), however some damselfishes feed until late dusk (Sancho 1998b). At night, damselfishes seek shelter, e.g. between corals or in crevices, or lie on the sandy bottom to rest (Ebeling & Bray 1976; Randall & Allen 1977; Thresher 1984; Fishelson 1998; Harmelin 1987; Holbrook & Schmitt 2002; Pinnegar & Polunin 2006). During breeding time, parental care is is exhibited in several species continuously over the diel period (Breder & Rosen 1966; Emery 1973).

Courtship and spawning usually take place from dawn to morning (Doherty 1983; Thresher 1984; Gladstone 2007; Karino & Kuwamura 1997), but rarely continue past middday, e.g. in *Abudefduf* sp., *Chromis* sp. and *Stegastes* sp. (Foster 1987; Kohda 1988; Gladstone 2007). A few species spawn late in the day (e.g. *Abudefduf saxatilis*, Cummings 1968; *Glyphidodontops biocellatus*, Keenleyside 1972; *Pomacentrus nagasakiensis* and *Eupomacentrus flavilatus*, Thresher 1984). *Microspathodon chrysurus* starts courtship before dawn and spawns near dawn, which is triggered by the lunar cycle (Pressley 1980). Hatching of pomacentrid larvae takes place after early evening and before early morning respectively (Alcalay & Sikkel 1994) or soon after sunset (Kohda 1988; Robertson et al. 1990; McAlary & McFarland 1991).

Chromis chromis is the only autochthonous representative of damselfishes in the MS, and so far six non-indigeneous species have been recorded, three each of Atlantic and Indo-Pacific origin.

Polyprionidae (Wreckfishes)

Wreckfishes comprise only a few species and ecological data are incomplete or lacking. Adults of *Polyprion* sp. live in greater depths, are generally demersal but undertake vertical movements at night. Prey analyses suggest that feeding takes place at different periods of the day and night (Peres & Haimovici 2003). Juveniles live under floating debris near the water surface, cathemeral feeding is likely.

Spawning in *Polyprion americanus* takes place in depths of 300–500 m, probably at night (Peres & Klippel 2003).

P. americanus is the only species of this family in the MS.

Mullidae (Goatfishes)

The large majority of species is considered as diurnally active and feeding (Hobson 1974; McCormick 1992; Helfman 1993; Gillibrand et al. 2007), and the native Mediterranean mullet species *Mullus barbatus* and *M. surmuletus* are diurnal feeders acc. to several authors (Mazzola et al. 1999; Neumann & Paulus 2005; Ünlüoğlu et al. 2002). At night these species are by far less active, less aggregated and change their colour pattern (Cambrige University Underwater Exploration Group 1965). However, locally or temporarily both species disperse for bottom feeding at night while they can form large, inactive (non-feeding) 'schools' during the day-time (Mahmoud et al. 2017, Mediterranean Egypt). Feeding during day and in the first part of night was observed by Arndt (unpubl. obs. in summer, Aegean Sea). Some Indo-Pacific species are nocturnal or active during both day and night (Lieske & Myers 2004). The Hawaiian *Parupeneus porphyreus* makes diel movements between a foraging area at night and a daytime protected hiding place (Meyer et al. 2000). Larvae and adults of Caribbean *Mulloidichthys martinicus* feed at night (Munro 1983).

Knowledge about diel spawning patterns is scarce in this family and virtually lacking in native Mediterranean species. Spawning of several mullets was observed during dusk (Colin & Clavijo 1978; Lobel 1978, 1989; Sancho et al. 2000; Habrun & Sancho 2012). The Indo-Pacific *Parupeneus cyclostomus* spawns around midday (Thresher 1984). Spawning may be influenced additionally by moonphase (spawning before full moon, Lobel 1978).

Six species are recorded in the MS so far, two native mullets, one species of Atlantic and three of Indo-Pacific origin.

Pempheridae (Sweepers)

Sweepers are generally nocturnal (Helfman 1993; Gillibrand et al. 2007; Brandl & Bellwood 2014). During the day the fish shelter in shallow caves or under shaded ledges (Louisy 2016). *Pempheris* species undertake extended nocturnal migrations (Fishelson et al. 1971; Gladfelter 1979; Golani & Diamant 1991).

Spawning takes place after sunset or at night (Koeda et al. 2012, 2014).

Pempheris rhomboidea immigrated via the Suez Canal into the MS and is forming large populations locally.

Oplegnathidae (Knifejaws)

There is little information about diel patterns in knifejaws and apparently all data refer to *Oplegnathus fasciatus*. The fish feeds during the day and rests in rock crevices at night (Myoung 2013). Experiments in aquaculture confirm diurnal feeding (Oh & Maran 2014).

Spawning takes place from afternoon (15:00) to early night and peaks around sunset (Japanese Society of Scientific Fisheries 1974).

O. fasciatus was introduced into the Mediterranean Sea.

Polynemidae (Threadfins)

Knowledge of ecology and diel activity is scarce in this family. Threadfins feed primarily at night (Austin & Austin 1971). Two species (*Eleutheronema tetradactylum* and *Galeoides decadactylus*) were classified as "diurnal" acc. to Pulcini et al. (2008, Table A1), however, the sources cited by Pucini et al. (i.e. Hobson 1965, Helfman 1978, Potts 1990), do not mention this species or even this family. Therefore, this classification is very doubtful.

Data on spawning or migration pattern are lacking.

Only *Galeoides decadactylus*, a species of Atlantic origin, was recorded in the MS so far.

Kyphosidae (Sea chubs)

Sea chubs are generally diurnal species (Hobson 1974; Helfman 1993; Brandl & Bellwood 2014; Loyer 2015). However, nocturnal movement and feeding activity is known from certain places in the Indo-Pacific area (Atu 2005).

Spawning was observed from afternoon to dusk in *Kyphosus sectatrix* (Nemeth & Kadison 2013), but data on other species are not available so far.

Two *Kyphosus* species were seldom recorded in the MS.

Terapontidae (Grunters)

Knowledge of diel activity is limited in species of this family. As far as is known, grunters are generally active and feed during both day and night (Crawley et al. 2006; Kwik et al. 2010). A predominantly diurnal feeding is suggested for *Terapon jarbua* (Macia et al. 2003).

The species produce sounds in choruses which is interpreted as courting and spawning

behaviour. These choruses occur around dusk, at night (after midnight) or around dawn (McCauley 2012; Mahanty et al. 2015).
Several non-indigenous Indo-Pacific grunters were recorded in the MS.

Serranidae (Sea basses)

There are not well-defined, uniform patterns in members of this family (Helfman 1993). McCauley et al. (2012) and Coles (2014) classified most of the serranid species they examined as 'cathemeral'. The family comprises three subfamilies, all including Mediterranean representatives, that differ markedly in terms of morphology, diet and behaviour.
Serraninae: Species of the genus *Serranus* feed during all periods of the day or are diurnal with an activity peak in the afternoon (Arculeo 1993; Reñones et al. 1995; Bahamon et al. 2009; March et al. 2010; Morato et al. 2000; Alós et al. 2011). The Mediterranean representatives are predominantly diurnal feeders.
Courtship and spawning of *Serranus* species take place at night (Lejeune et al. 1980; Louisy 2002), from late afternoon to dusk (Thresher 1984; Erisman & Allen 2006; Petersen 2006; Militelli & Rodrigues 2011), or, in few species only, from morning to midday (Cheek 1998).
Anthiinae: *Anthias* and related genera are diurnal (Helfman 1993; Neumann & Paulus 2005; Morato et al. 2000; Erisman 2008;).
They court and spawn at sunset or during the night (Popper & Fishelson 1973; Thresher 1984; Siliotti 2002; Schultz III 2006).
Epinephelinae: Groupers feed both by night and day, but are most active at dawn and dusk (Randall 1967; Potts 1990). This is confirmed for Mediterranean species of Epinephilinae by several authors (Abel 1962; Neill 1967; Ghafir & Guerrab 1992; Gibran 2006; Hackradt 2012; Azzurro et al. 2013; Afonso et al. 2016). However, Neumann & Paulus (2005) suggest a predominantly nocturnal feeding in Mediterranean groupers. Two Mediterranean species of *Cephalopholis* are predominantly diurnal with peaks in midday and/or in the afternoon (Lino et al. 2011; Froese & Pauly 2019), whereas a closely related West Atlantic *Cephalopholis* is nocturnal (Popple & Hunte 2005). West Atlantic species of *Mycteroperca* are predominantly diurnal (Coles 2014). Several species, e.g. the West Pacific *Epinephelus akaara*, show a feeding peak just before sunset (Ottolenghi et al. 2004).
Groupers are known to mate and spawn during late afternoon or dusk (Thresher 1984 and references therein; Fischer 1986; Donaldson 1989, 1995b; Zabala et al. 1997; Sudaryanto & Mous 2004; Erismen et al. 2010; Sanchez-Cardenas & Arreguin-Sanchez 2012). The tropical Western Atlantic *Epinephelus striatus* and some Indo-Pacific species of the genera *Cromileptes* and *Epinephelus* spawn in the night up to beyond midnight, often depending on moon phase (Guitart Manday & Fernandez 1966; Sugama et al. 2002; Sudaryanto & Mous 2004; Jagadis et al. 2007). Occasionally, courtship was observed during the day (Goeden 1978; Thresher 1984).
Twelve native species occur in the MS, and an additional 11 non-indigenous seaperches and groupers have been recorded. Most of the latter were found in one or two localities only.

Pomatomidae (Bluefishes)

Adults and juveniles of the bluefish *Pomatomus saltatrix* are mainly active and feed during day and crepuscular periods (Wilk 1977; Buckel & Conover 1997; Gibran 2010). The species is mainly caught during dusk and dawn by recreational fishers, suggesting a mainly crepuscular feeding activity (Smallwood et al. 2013). The fish schools at daytime, but is more dispersed and displays longer periods of low activity in the darkness while the interfish distance increases (Olla & Studholme 1971, 1972).

Juveniles become active usually after dawn with a peak at midday and a decrease in activity in the afternoon (Olla & Studholme 1972; Stehlik 2009). Stomach fullness of juveniles is greatest in the afternoon (Marks & Conover 1993; Juanes & Conover 1994). Depending on season or water temperature, the period of juvenile activity may be longer (e.g. the gut of juveniles was fullest during twilight and daytime, suggesting food intake at least from dawn to dusk in a study by Buckel & Conover 1997). They move nearshore during daylight and retreat to midchannel or open bays at night and twilight. Larvae feed during the day and perform a short DVM occurring at the water surface at night but staying in a depth of about 4 m during daylight (Kendall & Naplin 1981).
Spawning takes place in the evening (Nocross et al. 1974 in Ferraro 1980).
The family Pomatomidae is monotypical.

Bramidae (Pomfrets)
Knowledge of diel patterns is scarce in this family. Several species undertake vertical migrations feeding in deep water during the day and at the water surface at night (Mead 1972; Bauchot 1987; Gray 2016). The species may have to swim continuously to ventilate their gills (Pearcy et al. 1993). Details about diel spawning patterns have not been published so far.
Only *Brama brama*, an oceanodromous species exhibiting vertical migrations is distributed in the MS.

Priacanthidae (Bigeyes)
Species of this family generally nocturnally active and feeding (Dooley et al. 1985; Helfman 1993; Randall 1995; Gillibrand et al. 2007). However, ingestion may also take place in shelters or rock crevices where they spend the day. Data about spawning patterns are still lacking, but nocturnal spawning is probable.
Two non-indigenous species were recorded in the MS so far.

Leiognathidae (Ponyfishes)
Ponyfishes represent a strictly nocturnal family with several morphological adaptations to nocturnal behaviour (Sasaki et al. 2003; Chakrabarty et al. 2011; Karplus 2014), though details on diel patterns are scarce. As far as is known, they are active, feed and reproduce at night. Deeper dwelling species may move from the bottom to midwater at night (Woodland et al. 1999). Details about spawning patterns are not published so far.
Two non-indigenous ponyfishes of Indo-Pacific origin occur in the study area.

Chaetodontidae (Butterflyfishes)
Most butterflyfishes are diurnal species (Hobson 1974; Helfman 1993). At night they rest under corals or in crevices (Zekeria 2003; Lieske & Myers 2004; Boland & Parrish 2005). E.g., the feeding rate of *Chaetodon larvatus* is low in the morning, increases around noon and decreases again during the afternoon (Zekeria 2003). However, differing feeding patterns do exist in a few species. *Heniochus intermedius* has a feeding peak at dusk and continues to feed in the dark (Zekeria 2003; Red Sea). Some *Chaetodon* species may be partially or mainly nocturnal (*C. fasciatus* and *C. semilarvatus*, Bemert & Ormond 1981; Red Sea). This was confirmed by Coles (2014, subtropical US Atlantic coast) who classified *Chaetodon* spp as 'cathemeral'.
Courtship and spawning takes place during dusk (Lobel 1978b, 1989; Thresher 1982, 1984; Colin 1989; Sancho et al. 2000; Habrun & Sancho 2012; Koeda et al. 2012). Spawning may be influenced additionally by moonphase (i.e. spawning before full moon, see Lobel 1978). At

least some species form spawning aggregations that last a few minutes only, during which the fishes exhibit short-time courting-like behaviour. This behaviour is repeated many times per evening (Zekeria 2003).
One East Atlantic species that reached the western Mediterranean and three non-indigenous species of Indo-Pacific origin are known from the MS.

Pomacanthidae (Angelfishes)
Angelfishes are generally diurnal (Hobson 1974; Helfman 1993; Lieske & Myers 2004). At night they hide in reef or rock crevices (Reynolds 1979; Jennings et al. 1998; Carroll 2015; Rover 2010). Light intensity is the fundamental Zeitgeber as the behaviour during a solar eclipse shows (Jenning et al. 1998). However, a cathemeral activity is suggested for the West Atlantic blue anglefish *Holacanthus bermudensis* (Coles (2014).
Spawning takes place around around dusk, just before sunset (Lobel 1978a, 1989; Thresher 1982, 1984; Colin & Bell 1991; Moyer et al. 1983).
Four non-indigenous angelfishes, two each of Atlantic and Indo-Pacific origin were recorded in the MS so far.

Haemulidae (Grunts)
The vast majority of grunts including all Mediterranean species are nocturnal (Helfman et al. 1982; Helfman 1993; Nagelkerken et al. 2000; Neumann & Paulus 2005). Several species, e.g. *Pomadasys stridens*, *Haemulon* spp. and *Anisotremus* spp. are typically found inactively schooling by day and disperse to feed at night (Cummings et al. 1966; Randall 1968; Neumann & Paulus 2005), while certain non-Mediterranean *Haemulon* spp. may continue feeding during daytime (Verweij et al. 2006; Pereira & Ferreira 2013) or show a dusk peak or are cathemeral (Coles 2014). Some grunts undertake daily feeding migrations that are often precisely timed and occur along fixed routes, for distances up to 1000 m (Ogden & Buckman 1973; Ogden & Ehrlich 1977; Morrison et al. 2002). The Indo-Pacific *Pomadasys commersonnii* feeds mainly during dusk and dawn (Blaber 1984). *Pomadasys* larvae of tropical species undertake a DVM. Recuritment of larvae was observed during nighttime (McFarland et al. 1985).
Spawning usually takes place at night (Lindemann 2002; Palazón-Fernández 2007), but was reported in the evening for the West Atlantic species *Orthopristis chrysoptera* by Hildebrand & Cable (1930 in Ferraro 1980). Diel spawning patterns have not been described for any of the Mediterranean species.
Four native grunts and one Indo-Pacific immigrant are known from the MS.

Lutjanidae (Snappers)
The majority of snappers of the genus *Lutjanus* predominantly feed at night, and some are cathemeral (Hobson 1968; Starck & Davis 1966; Randall 1967; McFarland et al. 1979; Rooker & Dennis 1991; Helfman 1993; Gillibrand et al. 2007; McCauley et al. 2012; Coles 2014). *Lutjanus fulviflamma*, one of the species occurring in the MS, feeds from dusk to dawn with peaks in the crepuscular periods (Kamukuru & Mgaya 2004). *L. campechanus* is an example for cathemeral feeding (Ouzts & Szedlmayer 2003; Coles 2014). In contrast, Brandl & Bellwood (2014) list 86% (n=29) of *Lutjanus* species as 'diurnal'; however this needs confirmation because it contradicts too many other authors. Representatives of the genera *Aphareus*, *Aprion*, *Paracaesio*, *Pinjalo*, *Symphorichthys* and *Symphorus* are mainly diurnal (McCauley et al. 2012; Brandl & Bellwood 2014), but none of these occur in the MS. *Rhomboplites aurorubens* shows a crepuscular activity peak (Coles 2014). Some species of the family undertake daily feeding migrations that are often precisely timed and occur along

fixed routes for distances up to 1000 m (Ogden & Buckman 1973; Ogden & Ehrlich 1977; Nagelkerken et al. 2000; Morrison et al. 2002). Nocturnally feeding snapper are known to form inactive schools during the day in order to reduce predation risk (Hobson 1972; Rooker & Dennis 1991).

Most species spawn in the evening or night (Suzuki & Hioki 1979; Thresher 1984; Grimes 1987; Hamamoto et al. 1992; Carter & Perrine 1994; Anderson 2002; Leu et al. 2003) or at least from late afternoon to evening (e.g. *Lutjanus jocu*, Heyman & Kjerfve 2008; Ramdhanie 2016). Spawning often coincids with spring tides. A few species (e.g. *Lutjanus analis*, *L. vitta*) spawn during different periods of the day depending on tides (Sadovy 1996; Heyman & Kjerfve 2008).

Four *Lutjanus* species of Atlantic or Indo-Pacific origin occur in the MS, but so far the establishment of any of them is questionable.

Cepolidae (Bandfishes)

Knowledge about activity patterns in bandfishes is extremely scarce. The fish feed during crepuscular and nocturnal periods (Neumann & Paulus 2005). Spawning was not observed so far, but a nocturnal spawning pattern is likely.

Cepola macrophthalma is the only species of this family in the MS.

Scatophagidae (Scats)

Knowledge of activity patterns is limited in species of this family. Scats are diurnal (Brandl & Bellwood 2014). Feeding takes place mainly, but not exclusively, during daylight hours (Allen 1984; Mathew 1988).

Courtship behaviour and antagonistic behaviour between males during courtship are shown during the day in *Scatophagus argus* (Barry 1992), but details about spawning patterns are not known so far.

So far, only *S. argus* has been recorded in the MS.

Siganidae (Rabbitfishes)

Most rabbitfishes including both representatives in the Mediterranean Sea are strictly diurnal (Woodland 1990; Lieske & Myers 2004; Neumann & Paulus 2005; Karpestam et al. 2007). Feeding in these species peaks at mid-afternoon (Fox 2012) or during periods of low light in morning and evening (Popper & Gundermann 1975). They become inactive at night. During the night *Siganus rivulatus* and *S. luridus* form schools near the bottom or lie at the bottom on their side or press the body against vertical rocks or into holes. This behaviour does not differ between individuals in the Red Sea and the MS (Popper & Gundermann 1975). A certain plasticity in diel activity, with portions of nocturnal activity periods, was observed in the Indo-West Pacific *Siganus lineatus* (Fox & Bellwood 2011; Fox 2012) and interpreted as a response to predation and/or competition (Fox & Bellwood 2011). *S. vermiculatus* is also known to feed partly at night (Gundermann et al. 1983). Larvae ingest during daylight with feeding maxima in crepuscular periods (Hara 1987, p. 155).

Spawning takes place during different periods at day or at night (Hara et al. 1986). Several rabbitfishes, including those in the MS, court and spawn in early morning (Popper & Gundermann 1975; Burgan & Zseleczky 1979; Luchavez & Carumbana 1982; Gundermann et al. 1983) or later during the day (Johannes 1981; Samoilys et al. 2013). A few species spawn at night, e.g. *Siganus guttatus* between 23.00-03.00 (Rachmansyah & Ahmad 2007). *Siganus* sp. (presumably *S. canaliculatus*, cf. Thresher 1984) begins to spawn after midnight and spawning may last until dawn (Lam 1974). The spawning time may be triggered by the tidal cycle, because the fish often spawn on outgoing tide (Thresher 1984).

Siganus rivulatus and *S. luridus* immigrated from Red Sea into the MS and form very large populations locally.

Order Scorpaeniformes

Scorpaenidae (Scorpionfishes; incl. Sebastidae and Synanceiidae)

Scorpionid fishes are a rather heterogenous group and the increasing knowledge of their diel patterns suggests manifold patterns of diel activity. Species of *Scorpaenodes* (Micael et al. 2005), *Sebastapistes* (Hobson 1974; Allen & Erdmann 2012) and some *Sebastes* (Hobson et al. 1981) are nocturnal feeders. *Synanceia* spp. and most *Scorpaena* spp. are diurnal feeders (Gillibrand et al. 2007; Lök et al. 2008; Ordines et al. 2012). Some species of *Scorpaena* (e.g. *S. loppei*, *S. plumieri*, *S. guttata*) seem to feed mainly at night (Hobson et al. 1981; Lieske & Myers 1994; Ordines et al. 2012; Ramsubhag 2015). *Helicolenus dactylopterus* is regarded an 'arhythmic species' (Aguzzi et al. 2015b).

The majority of foraging activities in *Pterois* spp from the Red Sea occurs in crepuscular periods and at night (Fishelson 1975; McTee & Grubich 2014) with peak foraging activities for both *P. miles* and *P. radiata* around or after sunset (McTee & Grubich 2014). The Indo-Pacific *Pterois volitans* mainly feeds during the night (Sano et al. 1984; Ruiz-Carus et al. 2006; Froese & Pauly 2019). However, acc. to Priyadharsini et al. (2013, 2014) *P. volitans* and *P. russelli* feeds in early morning, late afternoon and at night. The lionfishes hover nearly motionless near ledges or caves etc. by day (Ruiz-Carus et al. 2006). Nevertheless, lionfishes may show atypical feeding patterns, including mid-morning, mid-day and early afternoon feeding events in newly invaded areas (Morris & Akins 2009, Côté & Maljković 2010).

Regarding the feeding period of species that occur in the Mediterranean, as far as is known five species are mainly diurnal, four are mainly nocturnal and three do not have a well-defined pattern (Arculeo et al. 1993; Lieske & Myers 2004; Micael et al. 2005; Azzurro et al. 2007; Lök et al. 2008; Ordines et al. 2012; Torres Leal 2013; McTee & Grubich 2014; some data stem from studies in the North-Atlantic or Red Sea and data are completely lacking in one species). However, this classification is preliminary because it is often based on one study only. Taking the latter into consideration, the Mediterranean data support Helfman (1993), who classified scorpionfishes in his group "Several species without well-defined [feeding] activity periods".

Courtship in lionfishes begins shortly before dark and extends into nighttime hours, spawning takes place in dusk and at night (Fishelson 1975; Moyer & Zaiser 1981; Thresher 1984; Morris et al. 2009). The huge majority of rockfishes (genera *Sebastes*, *Sebasticus*, etc.) spawns at night (Eldridge et al. 1991; Fujita & Kohda 1998; Sogard et al. 2008). A Japanese species of *Sebasticus* displayed courtship from 15:00 afterwards, continuing during afternoon and spawning within one hour after sunset (Fujita & Kohda 1996). Scorpionfishes of the genus *Scorpaena* may spawn during early morning (Maricchiolo et al. 2014).

Rockfishes of the genus *Sebastes* produces sounds. While these sounds were recorded at all times of the diel cycle in the field, courtship behaviour could not be linked to the sound production, rather it seems to be an agonistic short-range communication between individuals or species. The sound is not species-specific (Nichols 2005; Širovic et al. 2009).

Eleven native scorpaenids, including representatives of Scorpaeini and Sebastini as well as two widespread Lessepsian species occur in the MS. The latter are *Pterois miles* (Pteroini) and *Synanceia verrucosa* (Synanceini). One further deepwater species of Atlantic origin (*Trachyscorpia cristulata*) does not fall within the scope of the present study.

Triglidae (Gurnards)

The diel acivity of gurnards is not well known. Feeding can take place during both day and night (Terrats et al. 2000), but generally species of the family show a mainly diurnal feeding activity (Ross 1977). Diurnal feeding predominates in most examined species, e.g. *Chelidonichthys lucerna* (Morte et al. 1997), *Aspitrigla cuculus* (Terrats et al. 2000), *Eutrigla gurnardus* (Moreno-Amich 1994) and *Lepidotrigla cavillone* (Caragitsou & Papaconstantinou 1990). A diel migration onshore at dusk and offshore at dawn is also known from *E. gurnardus* (Gibson et al. 1996).

Spawning was observed in NE Atlantic species during evening and night (Ferraro 1980).

Eight species occur in MS.

Platycephalidae (Flatheads)

Knowledge about diel patterns in flatheads is scarce. The fish are predominantly ambush predators and lie motionless on the bottom or covered by sediments for long periods of the day (Taquet & Diringer 2012). Feeding takes place during the day (*Papilloculiceps longiceps*, Gillibrand et al. 2007; several genera and species, Taquet & Diringer 2012) or during day and night (*Platycephalus indicus*, Hashemi & Taghavimotlagh 2013; Yeragi & Yeragi 2015). More detailed studies are required to check if nocturnal feeding is a more widespread trait in this family.

So far spawning has only been observed in the temperate Australian *Platycephalus bassensis* and took place from dawn to early afternoon (Bani et al. 2009).

One non-indigenous species of Atlantic and three of Indo-Pacific origin are known from the MS; only *Platycephalus indicus* is widespread so far.

Anarhichadidae (Wolffishes)

Diel activity patterns of wolffishes are not well-known. In spring and summer, wolffishes are frequently found in open water during both daylight and nighttime. But in fall and winter, they seem to be active in both crepuscular periods. These activities are supposed feeding periods (Simpson et al. 2015). A generally and consistently low activity during day and night was confirmed by Liao (1999) in laboratory experiments.

Diel spawning patterns are not known so far.

One species of Atlantic origin (*Anarhichas lupus*) is kown from the MS.

Cottidae (Sculpins)

Sculpins feed during both day and night, or have feeding patterns that changes between winter (diurnal) and summer (mainly nocturnal; McPhail & Lindsey 1970; Westin 1971; Westin & Aneer 1987; Welton et al. 1991; Janssen & Jude 2001; Kotusz et al. 2004; COSEWIC 2010). Most ecological data originate from fresh water sculpins. *Taurulus bubalis* is active during the day (Westin & Aneer 1987).

Data on spawning patterns are scarce, spawning in dusk or at night is likely; however, data from marine species are virtually lacking.

T. bubalis is the only species in the MS.

Cyclopteridae (Lumpfishes)

The knowledge about diel patterns in lumpfishes is low and apparently confined to *Cyclopterus lumpus*. This species is regarded as active and feeding during day by several authors (Westin & Aneer 1987; Imsland et al. 2014). But at least during spring, individuals may show a much more complex diel behaviour, comprising a stay near bottom or near surface and regular or irregular vertical movements during day and/or night (Kennedy et al.

2016). Courtship and spawning were observed at night (Fulton 1907; Davenport 1985), however, spawning may depend on high tides and a spawning during daylight cannot be excluded (Mochek 1973).
C. lumpus, a species of Atlantic origin, is the only representative in the MS.

Order Moroniformes

Moronidae (Temperate basses)

Though temperate basses play an important role as food fish, diel activity patterns are well known in a few species only, and these patterns show a high plasticity. Movement activity does not differ between day and night in *Morone saxatilis* (Koo & Wilson 1972), but feeding by this species takes place mainly during night (Burnley 2006; Wittenberg 2011).
Dicentrarchus labrax, one of the Mediterranean species, feeds and swims mainly during daylight from spring to autumn, but at night in winter (Sánchez-Vásquez et al. 1998; Villamizar et al. 2012). However, the diel pattern may vary in particular individuals (Millot & Bégout 2009). Fry and juveniles feed during the day and at night (McHugh & Heidinger 1977; Buckel & McKown 2002).
Some species undertake vertical migrations that may depend on the water temperature, i.e. fish do not migrate in winter below a certain temperature (Keyser et al. 2016). Larvae of some species of *Morone* may undertake vertical migrations as well, or tidally-timed or reverse vertical migrations in order to track dense food concentrations (Bennett et al. 2002; North & Houde 2006).
Diel spawning patterns are very variable within this family, and even within some species. In *Dicentrarchus labrax*, spawning takes place during the dark phase with two peaks, 6 and 11 h after nightfall (Villamizar et al. 2012). In *Morone saxatilis* spawning peaks occur most often at dawn or dusk, but spawning has been recorded at all hours during the day as well as at night (Morgan & Gerlach 1950; Hardy 1978; Setzler et al. 1980; McCoy 1959).
Two species occur in the MS.

Ephippidae (Spadefishes)

Spadefishes are generally known as diurnal species (Brandl & Bellwood 2014; Field & Field 2016). However, little is known about specific activity patterns and the few detailed studies reveal a much more complex picture. Juvenile *Platax orbicularis* feed predominantly during daylight, but continue to feed in the adult stage at night (Barros et al. 2008). Significant day-night differences in spectral responses of the visual system are evident in the West Atlantic *Chaetodipterus faber*, in contrast to the visual systems of true diurnal species of other families that do not show diel shifts (Horodysky et al. 2013).
C. faber spawns during dusk (short-time information by the Tennessee Aquarium under www.tnaqua.org in 2017).
One Indo-Pacific species, *Platax teira*, was recorded in the MS.

Order Acanthuriformes

Sciaenidae (Drums or croakers)

Species of this family are generally active and feeding at night (Hobson & Chess 1976; Smale & Bruton 1985; Helfman 1993; Herbinson et al. 2001). The Mediterranean sciaenids also show nocturnal activity (Corbera et al. 1996; Cruz & Lombarte 2004). *Sciaena umbra* is mainly nocturnal, but may also be active in the morning or midday (Lök et al. 2008; Louisy 2016). Juvenile sciaenids may feed during different periods of the diel cycle, but nocturnal feeding is strongest (Soares & Vazzoler 2001). During inactive phases such as in the afternoon, species occur in sedentary groups near caves or hover nearly motionless above a seagrass meadow (e.g. *Seriphus politus*, Herbinson et al. 2001; *S. umbra*, Louisy 2016; Arndt unpubl. observ.).

Spawning takes place during evening and at night (Ferraro 1980 and references therein; Holt et al. 1985; Connaughton & Taylor 1995; Griffiths 1996; Yamaguchi et al. 2006; Saillant et al. 2007). Sciaenids produce sounds during courtship and spawning. This sound production is performed by West Atlantic species of genus *Cynoscion* from late afternoon (17:30) to after midnight (i.e. 02:30, Locascio & Mann 2008).

Five native species occur in the MS, and one West Atlantic species was recorded once from Israel.

Luvaridae (Louvar)

The louvar (*Luvarus imperialis*) is probably predominantly active in the twilight of midwater (Bauchot 1995; Pepperell 2010). The ecology of this species and especially its activity patterns are hardly known. Based on fishery data, colouration and known habits of this species, its activity pattern may resemble that of opah or oarfish.

Data on diel spawning time are not available.

The family is monotypical.

Acanthuridae (Surgeonfishes)

In general, surgeonfishes are diurnally active and feeding (Walsh 1984; Montgomery et al 1989; Fouda & El-Sayed 1994; Randall 2002; Brandl & Bellwood 2014) and relatively inactive at night (Hobson 1974).

Spawning takes place in well defined periods of the day, with the exact period depending on the species: dawn, midday, afternoon or dusk, with apparently more species spawning from late afternoon to dusk than in the earlier periods of the day (Randall 1961a, b; Robertson 1983; Lobel 1989; Colin & Bell 1991; Craig 1998; Sancho et al. 2000; Luiz et al. 2010; Claydon et al. 2014; Habrun & Sancho 2012). The diurnal spawning may be influenced by tidal pattern (spawning at low tide or high tide respectively; Roberton 1983; Colin & Bell 1991; Domeier & Colin 1997).

Seven non-indigenous species were recorded in the MS, to date only *Acanthurus monroviae*, a species of Atlantic origin, seems to be established.

Order Spariformes

Callanthiidae (Seaperches)

Ecological data on seaperches are scarce in this family. A few species, including that of the MS, occur from the upper slope to the shallow water layer. These species are active during the day and stay in crevices or caves at night (Anderson 1999, Neumann & Paulus 2005; Francis 2012). Courtship and spawning were also observed during the day (Doak 1972, Francis 2012).

Callanthias ruber is the only representative of this family in the MS.

Sillaginidae (Sillagos or Whitings)

Whitings are mainly nocturnal carnivores (Brewer & Warburton 1992; Tongnunui et al. 2005), but feeding may be continued during day and night (Gunn & Milward 1985; Kwak et al. 2004). Diel migrations, i.e. movements to the beach, may also depend on the tidal cycle (Kwik et al. 2010).

Spawning takes place during the night (Lee et al. 1981; Lee & Hirano 1985).

The Indo-Pacific immigrant *Sillago suezensis* (formerly *S. sihama*) is the only whiting in the MS.

Lobotidae (Tripletails)

Information about activity patterns is scarce in this family. Adult tripletails may be active during all periods of the day, with peak activity during crepuscular periods or at night, and a slightly lower activity around midday (Streich 2010, Fig. 2-4, p. 52; Streich et al. 2013). Juveniles are active during daylight (Sazima et al. 2006) and occasionally mimic dead leafs of mangrove trees while lying on the side, floating near ground and near shore (Randall 2005, Arndt, unpubl. obs.).

Data on spawning pattern are lacking.

Lobotes surinamensis is a rare vagrant and the only representative of this family in the MS.

Nemipteridae (Threadfin breams)

Most threadfin breams, i.e. species of the genus *Nemipterus*, feed during the day (Eggleston 1970; Said et al. 1983; Sainsburg & Whitelaw 1985; John 1989; Russell 1990; Gillibrand et al. 2007). Adult *Scolopsis bilineatus* feed at night, whilst their recruits and juveniles are diurnal feeders (Boaden & Kingsford 2012). Stern et al. (2014) vaguely assumed a shift from diurnal toward nocturnal activity both in terms of food availability and by minimizing predation risk and competition in Mediterranean populations of *Nemipterus randalli*. This assumption was based on trawl catches and has to be confirmed.

As far as is known, spawning takes place during evening and night (Puentes Granada et al. 2004).

N. randalli, an Indo-Pacific immigrant, is currently the only threadfin bream in the MS.

Lethrinidae (Emporers)

Emporers include diurnal and nocturnal species. Feeding takes place mainly during the night acc. to Carpenter & Allen (1989), but diurnal activity predominates acc. to Brandl & Bellwood (2014) and Lieske & Myers (2004). Diurnal patterns may include crepuscular movements between daytime and nighttime locations. Significant differences in activity patterns occur between various species and between individuals within a species (Taylor & Mills 2013). *Monotaxis grandoculis* is a nocturnal feeder (Lieske & Myers 2004; Gillibrand et al. 2007).

Data on diel spawning patterns are scarce in this family. Spawning at night was observed in Indo-West Pacific *Lethrinus* species and coincided with lunar and tidal cycles (Hamilton 2005; Taylor & Mills 2013).

Emporers represent a Indo-Pacific family, *Monotaxis grandoculis* is the only species with a record in the MS.

Sparidae (Porgies)

Though porgies represent a morphologically rather uniform group compared to other large families, the sparid genera and species differ widely in terms of habitat use (e.g. demersal, open water, seagrass beds, soft substrates or rock habitats) and feeding type (herbivorous, carnivorous, omnivorous) (cf. Antonucci et al. 2009, Lousiy 2015). Due to this ecological background, diel activity patterns vary significantly between species. The activity patterns range from diurnal to a "dusk peak" to cathemeral in the study by Coles (2014) on several Northwest Atlantic taxa. The activity patterns of Mediterranean species include diurnal (e.g. *Acanthopagrus bifasciatus*, *Boops boops*, *Pagellus bogaraveo*, *Pagrus pagrus* and many *Diplodus* species; Girardin 1981; Azevedo 2000; Santos et al. 2002; Jadot et al. 2006; Gillibrand et al. 2007; Coles 2014), mainly crepuscular (e.g. *Dentex dentex*, *Pagellus erythrinus*, *Spicara maena*; Agguzzi et al. 2013; Sbragagli et al. 2013), mainly nocturnal (e.g. *Spondyliosoma cantharus*, *Diplodus vulgaris*; Reina-Hervás & Serrano 1987; Ribeiro et al.

2006) and cathemeral species (e.g. *Sparus aurata*; Abecasis & Erzini 2008). Given the high number of Mediterranean species, the ecological knowledge of porgies is still fragmentary and the above mentioned classification of species into a few categories is still preliminary. Different otholith sizes confirm a variety of activity patterns, even in closely related species (Cruz & Lombarte 2004, also confirmed by Hartill et al. 2003).

The diel spawning patterns of porgies, especially those of Mediterranean taxa, are hardly known. Spawning was observed during dusk and night (Ferraro 1980; Garratt 1993; Cowden 1995; Sheaves et al. 1999) and may be triggered by tidal cycle (Garratt 1993). In *D. dentex*, fishermen noticed courtship and spawning during the day as well as during the night at full moon (Marengo et al. 2014). Indo-Pacific *Rhabdosargus sarba*, *Acanthopagrus schlegelii* and *Pagrus major* spawn from afternoon to early night (10 pm) with peak around sunset (Japanese Society of Scientific Fisheries 1974).

A total of 33 species are currently reported from the Mediterranena Sea, including four species of Indo-Pacific and three range-expanding species of Atlantic origin. Activity data of these non-indigenous species are hardly available.

Order Caproiformes

Caproidae (Boarfishes)

Activity data of boarfishes are available for two species only, *Capros aper* and *Antigonia capros*. These species may be active during different periods of the day (Fock et al. 2002; Aguzzi et al. 2015). Feeding takes place during the day (between 05:00 and 18:00) or during both day and night with changing diet preferences depending on prey availability in different diel periods (Fock et al. 2002; Carpentieri et al. 2016).

C. aper also spawns during different periods of the day, but spawning activity is more intense during daylight when the fish occur in high-density aggregations within the first 50 m below the surface (Fässler et al. 2013). Diurnal spawning was confirmed by aquarium observations ("within an hour of the tank lights being turned on in the morning"; Gardner & Hemdal 2011). *C. aper* is the only species in the MS.

Order Lophiiformes

Lophiidae (Anglerfishes)

The diel activity of species in this family is still insufficiently known. The two Mediterranean anglerfishes co-occur in depths from 20 to 800 m and show a remarkable temporal niche separation in activity that could be linked to feeding: *L.* The two *Lophius* species co-occuring in the MS show a remarkable temporal niche separation in activity that could be linked to feeding: *L. budegassa* is mainly active at night and dawn, but *L. piscatorius* is mainly active during the day (Colmenero et al. 2010; study in June, western MS). Both species untertake seasonal migrations over long distances, and a daily opposite in- and offshore movement is supposed (Landa et al. 2008; Colmenero et al. 2010; Ofstad 2013). Nothing is known about temporal pattern of spawning so far, however spawning takes place in deep water (Hislop et al. 2001).

Two anglerfishes live in the study area.

Order Tetraodontiformes

Balistidae (Triggerfishes)

In general, triggerfishes are diurnally active (Helfman 1993; Gillibrand et al. 2007; Brandl & Bellwood 2014). A declining abundance of the gray triggerfish (*Balistes capriscus*) was observed during dusk by Coles (2014) and explained by feeding migrations away from the reef. Such nocturnal feeding however, has not been verified so far for *B. caprsicus* (cf. Vose

& Nelson 1994).

Triggerfishes display courtship behaviour and preparation of nesting sites during the whole day or in the afternoon (Kawabe, 1984; Clark et al 2015). The species may spawn during the day or at dusk (Kawabe 1984; Kawase 1998 in Kawase 2003; Clark et al. 2015), after sunset or before sunrise (Fricke 1980; Gladstone 1994; Donaldson & Dimalanta 2012). After spawning, eggs are guarded by several individuals until hatching of larvae. Hatching of larvae takes place during night of the same day or the next day (Lobel & Johannes 1980; Ishihara & Kuwamura 1996; Clark et al. 2015).

B. capriscus is the only native triggerfish in the MS. An Indo-Pacific species (*Balistoides conspicillum*) was recorded only one time so far.

Monacanthidae (Filefishes)

Filefishes are generally active and feed during the day (Brandl & Bellwood 2014, Hobson 1974). Species of some genera (*Stephanolepis*, *Aluterus*) may have a feeding peak during dusk (Coles 2014).

Spawning takes place during the day (morning, Kawase 2002; late afternoon, Nakazono & Kawase 1993), but is not generally fixed in the family (Kawase 2002).

Two non-indigenous monacanthid species (*Aluterus monoceros* and *Stephanolepis diaspros*) occur in the MS.

Ostraciidae (Boxfishes)

Boxfishes are active during the day (Brandl & Bellwood 2014) or during both day and night (Hobson 1974), but most species including the representatives recorded in the MS feed predominantly or exclusively during daytime.

Courtship and spawning take place during various periods of the day, but more frequent from late afternoon (*Lactoria diaphana*, *Ostracion cubicus*, Moyer 1979; *Lactophrys triqueter*, Heyman & Kjerfve 2008) to dusk (*Ostracion* spp., *Lactoria fornasini*, Moyer 1979, 1984; Thresher 1984; Lobel 1989; Sancho 1998a; Habrun & Sancho 2012).

Two Indo-Pacific boxfishes (*Ostracion cubicus* and *Tetrosomus gibbosus*) were recorded in the MS.

Tetraodontidae (Puffers)

In general, puffers are diurnally active species (Helfman 1993; Brandl & Bellwood 2014; Coles 2014), but Indo-Pacific species of the genus *Arothron* may feed also or even exclusively at night (Hobson 1974; Gillibrand et al. 2007; Kuiter & Tonozuka 2001).

Courtship and spawning behaviour is not uniform in this family, but differs considerably between species and genera (Thresher 1984). Diurnal spawning is evident in many species and most of them spawn in the morning (e.g. *Canthigaster valentini* in mid-morning, Thresher 1984, Gladstone 1987; *C. rivulata*, Arai & Fujita 1988; *C. rostrata*, D'Arbasie 2016). An example of puffers spawning from afternoon to dusk is *Takifugu niphobles* (spawning triggered by tide, Munro et al. 1990, Yamahira 1994, 1996, 1997, 2004). However, knowledge about courtship and spawning patterns is still rudimentary.

Two native (*Ephippion guttifer* and *Lagocephalus lagocephalus*) and seven non- indigenous species are known from the MS.

Diodontidae (Porcupinefishes)

The activity patterns are non-uniform in porcupinefishes. Most species are active during the night (Hobson 1974; Leis 2001; Brandl & Bellwood 2014), but some (or all) species of the genus *Chilomycterus* (e.g. *C. reticulatus*) feed during the day (Fitch & Lavenberg 1975;

Brandl & Bellwood 2014; Froese & Pauly 2019).

Spawning takes place during dusk or night (Wolfscheimer 1957 and; several internet pages from aquarists).

One species of Indo-Pacific origin (*Cyclichthys spilostylus*) and three porcupinefishes of Atlantic origin were recorded in the MS, the Atlantic species (one record each) are cryptogenic, however.

Molidae (Molas)

Activity patterns of molas are not well known. The ocean sunfish *Mola mola* is the only species investigated in detail. It undertakes repeated dives from the surface waters into deeper layers (40–400 m, occasionally below 800 m) and subsequent ascents. These short duration dives are undertaken during both day and night (Cartamil & Lowe 2004; Hays et al. 2009; Dewar et al. 2010; Pope et al. 2010; Potter & Howell 2010). The dives are related to feeding. In some cases *M. mola* shows more typical vertical migrations, individuals stay in deep water during the day but ascend at night (Sims et al. 2009). The vertical movements enable the ocean sunfish to feed in depths with optimal prey abundance (Sims et al. 2009; Hays et al. 2009). *Masturus lanceolatus* shows a similar pattern consisting of vertical movements, but this species dives much deeper and usually ascends to a layer between 50–200 m (Seitz et al. 2002). *Mola ramsayi* was recorded in a depth of about 500 m during daytime (Phillips et al. 2015) suggesting a possibly similar diving pattern in the southern sunfish as in the other *Mola* species.

During the day, ocean sunfish may lie and drift on their sides at the sea surface ('basking'). This behaviour may serve to warm the fish after diving into cold deep water (Cartamil & Lowe 2004) and to remove parasites (Abe et al. 2012). No data for diel pattern of spawning are available.

Two mola species, *M. mola* and *Ranzania laevis*, occur in the MS.

Table ESM, part 2. Number of shallow-water Mediterranean species for each activity category per family.

Family	**Strictly diurnal**	**Mainly diurnal**	**Crepuscular**	**Mainly nocturnal**	**Strictly nocturnal**	**Cathemeral**	**Diel vertical migration**	**Unknown**	**Conclusion on the family pattern**
Heterenchelyidae					1				nocturnal
Muraenidae				1	1	1		1	mainly nocturnal or cathemeral
Chlopsidae					1				nocturnal
Ophichthidae				1	6				nocturnal
Muraenesocidae					1			1	nocturnal
Nettastomatidae					2				nocturnal
Congridae					3				nocturnal
Nemichthyidae						1			not sufficiently known
Anguillidae				1					mainly nocturnal
Engraulidae		1						2	very variable, no clear pattern
Chirocentridae		1							not sufficiently known

Family	**Strictly diurnal**	**Mainly diurnal**	**Crepuscular**	**Mainly nocturnal**	**Strictly nocturnal**	**Cathemeral**	**Diel vertical migration**	**Unknown**	**Conclusion on the family pattern**
Clupeidae	1	2	1	2		4		1	very variable, no clear pattern
Chanidae		1							(only one species)
Plotosidae				1					mainly nocturnal
Ariidae								1	not sufficiently known, probably nocturnal
Argentinidae		1							not sufficiently known
Gonostomatidae							2		no conclusion possible*
Sternoptychidae		1					1		variable, no clear pattern
Phosichthyidae						1	1		not sufficiently known
Synodontidae						2			not sufficiently known
Aulopidae					1				not sufficiently known
Chlorophthalmidae				1					not sufficiently known
Alepisauridae								1	not sufficiently known
Myctophidae							20		Diel vertical migration
Lampridae						1			not sufficiently known
Trachipteridae					1				not sufficiently known
Regalecidae								1	not sufficiently known
Zeidae						1	1		not sufficiently known
Merlucciidae					1				not sufficiently known
Bregmacerotidae								1	not sufficiently known
Gadidae			1	4	1	5		2	very variable, no clear pattern
Holocentridae					2				nocturnal
Carapidae					2				nocturnal
Ophidiidae					3				nocturnal
Bythitidae				1	1				(mainly) nocturnal
Batrachoididae						1			mainly nocturnal or cathemeral
Apogonidae			1	3	2				(mainly) nocturnal
Gobiidae	6	12	1	7		12		25	very variable, no clear pattern
Mugilidae		4		1				3	mainly diurnal or cathemeral
Tripterygiidae	3								diurnal
Blenniidae	15	2				3		4	mainly diurnal
Clinidae	1								diurnal
Gobiesocidae	1	5						2	mainly diurnal
Atherinidae		4							mainly diurnal
Exocoetidae		3				1		2	mainly diurnal
Hemiramphidae						3			not sufficiently known, probably cathemeral
Belonidae						4		1	not sufficiently known, probably cathemeral
Scomberesocidae							1		not sufficiently known
Cyprinodontidae	1	2							mainly diurnal
Coryphaenidae						2			cathemeral

Family	**Strictly diurnal**	**Mainly diurnal**	**Crepuscular**	**Mainly nocturnal**	**Strictly nocturnal**	**Cathemeral**	**Diel vertical migration**	**Unknown**	**Conclusion on the family pattern**
Rachycentridae		1							(only one species)
Echeneidae		4							not sufficiently known, probably diurnal
Carangidae	4	7		2		4		5	very variable, no clear pattern
Sphyraenidae		2				1		1	variable, no clear pattern
Xiphiidae						1			(only one species)
Istiophoridae	1					2		2	probably cathemeral
Citharidae								1	not sufficiently known
Scophthalmidae		3						2	mainly diurnal
Pleuronectidae				1		1			cathemeral
Bothidae	1	3						3	mainly diurnal
Soleidae				11				4	mainly nocturnal
Cynoglossidae						1		2	not sufficiently known
Syngnathidae	12			3					diurnal (one genus mainly nocturnal)
Fistulariidae	1					1			variable
Macroramphosidae		1							mainly diurnal
Dactylopteridae				1					not sufficiently known, probably nocturnal
Callionymidae		4		3				2	variable, no clear pattern
Trichiuridae							2		no conclusion possible*
Scombridae		1	1			7	1	3	variable, no clear pattern
Nomeidae							1	1	not sufficiently known
Tetragonuridae								1	not sufficiently known
Stromateidae						1		1	not sufficiently known
Champsodontidae							1	2	not sufficiently known
Pinguipedidae	1								(mainly) diurnal
Ammodytidae		2							(mainly) diurnal
Trachinidae				4					(mainly) nocturnal
Uranoscopidae				1					(mainly) nocturnal
Labridae	18	4							diurnal
Scaridae		2							diurnal
Pomacentridae	2	4							diurnal
Polyprionidae						1			not sufficiently known
Mullidae		6							mainly nocturnal
Pempheridae					1				nocturnal
Oplegnathidae	1								not sufficiently known
Polynemidae								1	not sufficiently known
Kyphosidae		2							mainly diurnal
Terapontidae						3		1	not sufficiently known
Serranidae		8				3		8	variable, no clear pattern
Pomatomidae		1							(only one species)
Bramidae						1			not sufficiently known
Priacanthidae					2				nocturnal

Family	**Strictly diurnal**	**Mainly diurnal**	**Crepuscular**	**Mainly nocturnal**	**Strictly nocturnal**	**Cathemeral**	**Diel vertical migration**	**Unknown**	**Conclusion on the family pattern**
Leiognathidae					2				nocturnal
Chaetodontidae		3	1						mainly diurnal
Pomacanthidae		3							mainly diurnal
Haemulidae					4				nocturnal
Lutjanidae				2	1			1	mainly nocturnal
Cepolidae				1					not sufficiently known
Scatophagidae		1							mainly diurnal
Siganidae	2								diurnal
Scorpaenidae		5		5		2		1	variable, no clear pattern
Triglidae		4				1		3	variable, most species are mainly diurnal
Platycephalidae		1				1		2	not sufficiently known
Anarhichadidae						1			not sufficiently known, probably cathemeral
Cottidae		1							variable, no clear pattern
Moronidae						1		1	not sufficiently known, probably cathemeral
Ephippidae	1								diurnal
Sciaenidae				1	5				nocturnal
Luvaridae								1	not sufficiently known (only one species)
Acanthuridae	3								diurnal
Callanthiidae	1								not sufficiently known
Sillaginidae				1					mainly nocturnal
Lobotidae						1			not sufficiently known, probably cathemeral
Nemipteridae								1	not sufficiently known
Lethrinidae					1				variable, no clear pattern
Sparidae	1	10	5	2		2		11	very variable, no clear pattern
Caproidae		1							not sufficiently known
Lophiidae		1		1					no conclusion possible*
Balistidae	1								diurnal
Monacanthidae	2								diurnal
Ostraciidae		2							mainly diurnal
Tetraodontidae	9								diurnal
Diodontidae		2		2					variable, no clear pattern
Molidae						1		1	not sufficiently known, probably cathemeral

* No conclusion possible at the family level due to not regarded deepwater species

ESM, Part 3. Ecological data for trophic level, depth and habitat preferences (native species only).

Note: The table below includes available data on trophic level, depth preferences, and habitat use of all native Mediterranean shallow-water fish species included in the present review; N/A = not available

Column headings:

Dpref_min	Shallowest limit of preferred depth range (metres)
Dpref_max	Deepest limit of preferred depth range (metres)
Dpref_mid	Midpoint between shallowest and deepest limits of preferred depth range (metres)

Abbreviations for diel activity feeding pattern used in column 2 (Category):

- CAT – cathemeral
- CRE – crepuscular
- DD – strictly diurnal
- DM – mainly diurnal (may be active during crepuscular periods and at night to a lesser extent)
- DVM – diel vertical migration
- NM – mainly nocturnal (may be active during crepuscular periods and day to a lesser extent)
- NN – strictly nocturnal
- UK – unknown or insufficiently known pattern.

Data sources:

- Trophic level: Froese & Pauly (2019)
- Depth data: Louisy (2015) as primary source; Froese & Pauly (2019) as secondary source; IUCN (2020) as tertiary source. When neither of these sources included the preferred depth zone, the minimum and maximum depths of occurrence were taken instead
- Habitat data: Froese & Pauly (2019); Louisy (2015); IUCN (2020)

Family	Species	Category	Trophic Level	Dpref_min (m)	Dpref_max (m)	Dpref_mid (m)	Habitat
Alepisauridae	*Alepisaurus ferox* Lowe, 1833	**UK**	4.0	1	1000	501	Pelagic
Ammodytidae	*Gymnammodytes cicerelus* (Rafinesque, 1810)	**DM**	3.4	1	30	16	Soft bottom
Anguillidae	*Anguilla anguilla* (Linnaeus, 1758)	**NM**	3.6	0	15	8	Multi-habitat use
Apogonidae	*Apogon imberbis* (Linnaeus, 1758)	**CRE**	3.4	5	50	28	Multi-habitat use
Argentinidae	*Argentina sphyraena* Linnaeus, 1758	**DM**	3.5	50	200	125	Soft bottom
Atherinidae	*Atherina boyeri* (Risso, 1810)	**DM**	3.2	0	3	2	Pelagic
Atherinidae	*Atherina hepsetus* Linnaeus, 1758	**DM**	3.2	0	3	2	Pelagic
Atherinidae	*Atherina presbyter* (Cuvier, 1829)	**DM**	3.7	0	3	2	Pelagic
Aulopidae	*Aulopus filamentosus* (Bloch, 1792)	**NN**	4.2	100	300	200	Soft bottom
Balistidae	*Balistes capriscus* Gmelin 1789 syn. *carolinensis* Gmelin 1789	**DD**	4.1	10	50	30	Multi-habitat use
Batrachoididae	*Halobatrachus didactylus* Bloch & Schneider, 1801	**CAT**	4.0	5	30	18	Multi-habitat use
Belonidae	*Belone belone* (Linnaeus, 1761)	**CAT**	4.2	0	1	1	Pelagic
Belonidae	*Belone svetovidovi* Collette & Parin, 1970	**CAT**	4.0	0	1	1	Pelagic
Belonidae	*Tylosurus acus* (Lacepède, 1803)	**CAT**	4.5	0	5	3	Pelagic
Blenniidae	*Aidablennius sphynx* (Valenciennes, 1836)	**DD**	2.8	0	1	1	Hard bottom
Blenniidae	*Blennius ocellaris* Linnaeus, 1758	**CAT**	3.5	30	100	65	Hard bottom
Blenniidae	*Coryphoblennius galerita* (Linnaeus, 1758)	**DD**	2.3	0	1	1	Hard bottom
Blenniidae	*Hypleurochilus bananensis* (Poll, 1959)	**UK**	3.2	0	5	3	Hard bottom
Blenniidae	*Lipophrys pholis* (Linnaeus, 1758)	**DD**	3.1	0	3	2	Hard bottom
Blenniidae	*Lipophrys trigloides* (Valenciennes, 1836)	**CAT**	4.5	0	1	1	Hard bottom
Blenniidae	*Microlipophrys adriaticus* (Steindachner & Kolombatovic, 1883)	**DD**	3.4	0	1	1	Hard bottom
Blenniidae	*Microlipophrys canevae* (Vinciguerra, 1880)	**DD**	2.1	0	2	1	Hard bottom
Blenniidae	*Microlipophrys dalmatinus* (Steindachner & Kolombatovic, 1883)	**DD**	4.0	0	2	1	Hard bottom
Blenniidae	*Microlipophrys nigriceps* (Vinciguerra, 1883)	**DD**	3.2	1	5	3	Hard bottom
Blenniidae	*Parablennius gattorugine* (Linnaeus, 1758)	**CAT**	3.6	3	20	12	Hard bottom
Blenniidae	*Parablennius incognitus* (Bath, 1968)	**DD**	2.7	0	2	1	Hard bottom
Blenniidae	*Parablennius rouxi* (Cocco, 1833)	**DD**	3.0	3	30	17	Hard bottom
Blenniidae	*Parablennius sanguinolentus* (Pallas, 1814)	**DD**	2.1	0	2	1	Hard bottom
Blenniidae	*Parablennius tentacularis* (Brünnich, 1768)	**DD**	3.3	5	15	10	Multi-habitat use
Blenniidae	*Parablennius zvonimiri* (Kolombatovic, 1892)	**DM**	2.6	1	5	3	Hard bottom
Blenniidae	*Salaria basilisca* (Valenciennes, 1836)	**DD**	N/A	2	10	6	Multi-habitat use
Blenniidae	*Salaria pavo* (Risso, 1810)	**DD**	3.6	0	2	1	Multi-habitat use
Blenniidae	*Scartella cristata* (Linnaeus, 1758)	**DM**	2.5	0	2	1	Hard bottom
Bothidae	*Arnoglossus grohmanni* Bonaparte, 1837	**UK**	3.6	0	10	5	Multi-habitat use
Bothidae	*Arnoglossus imperialis* (Rafinesque, 1810)	**DD**	3.8	80	150	115	Soft bottom

Bothidae	*Arnoglossus kessleri* Schmidt, 1915	**UK**	4.1	10	200	105	Soft bottom
Bothidae	*Arnoglossus laterna* (Walbaum, 1792)	**DM**	3.6	10	100	55	Soft bottom
Bothidae	*Arnoglossus rueppelii* (Cocco, 1844)	**UK**	4.0	85	150	118	Soft bottom
Bothidae	*Arnoglossus thori* (Kyle, 1913)	**DM**	3.3	15	50	33	Soft bottom
Bothidae	*Bothus podas* (Delaroche, 1809)	**DM**	3.4	10	50	30	Soft bottom
Bramidae	*Brama brama* (Bonaterre, 1788)	**CAT**	4.1	0	200	100	Pelagic
Bythitidae	*Bellottia apoda* Giglioli, 1883	**NM**	3.4	30	569	300	Soft bottom
Bythitidae	*Grammonus ater* (Risso, 1810)	**NN**	3.5	5	50	28	Hard bottom
Callanthiidae	*Callanthias ruber* (Rafinesque, 1810)	**DD**	3.8	60	300	180	Multi-habitat use
Callionymidae	*Callionymus fasciatus* Valenciennes, 1837	**NM**	3.3	20	60	40	Soft bottom
Callionymidae	*Callionymus lyra* Linnaeus, 1758	**DM**	3.3	5	100	53	Soft bottom
Callionymidae	*Callionymus maculatus* Rafinesque, 1810	**DM**	3.3	45	500	273	Soft bottom
Callionymidae	*Callionymus pusillus* Delaroche, 1809	**UK**	3.3	1	5	3	Soft bottom
Callionymidae	*Callionymus reticulatus* Valenciennes, 1837	**NM**	3.3	1	40	21	Soft bottom
Callionymidae	*Callionymus risso* Le Sueur, 1814	**DM**	3.0	10	80	45	Soft bottom
Callionymidae	*Synchiropus phaeton* (Günther, 1861)	**UK**	3.2	80	848	464	Soft bottom
Caproidae	*Capros aper* (Linnaeus, 1758)	**DM**	3.1	100	400	250	Multi-habitat use
Carangidae	*Alectis alexandrina* (Geoffroy Saint-Hillaire, 1817)	**UK**	3.6	0	50	25	Soft bottom
Carangidae	*Campogramma glaycos* (Lecepède, 1801)	**UK**	4.5	15	30	23	Multi-habitat use
Carangidae	*Caranx crysos* (Mitchell, 1815)	**CAT**	4.1	0	40	20	Multi-habitat use
Carangidae	*Caranx hippos* (Linnaeus, 1766)	**DD**	3.6	1	40	21	Multi-habitat use
Carangidae	*Caranx rhonchus* Geoffroy Saint-Hillaire, 1817	**DD**	3.6	30	50	40	Soft bottom
Carangidae	*Elagatis bipinnulata* (Quoy & Gaimard, 1825)	**DD**	4.3	10	30	20	Pelagic
Carangidae	*Lichia amia* (Linnaeus, 1758)	**UK**	4.5	1	30	16	Pelagic
Carangidae	*Naucrates ductor* (Linnaeus, 1758)	**DD**	3.4	0	30	15	Pelagic
Carangidae	*Pseudocaranx dentex* (Bloch & Schneider, 1801)	**DM**	3.9	10	50	30	Hard bottom
Carangidae	*Seriola dumerili* (Risso, 1810)	**DM**	4.5	20	70	45	Pelagic
Carangidae	*Trachinotus ovatus* (Linnaeus, 1758)	**DM**	3.7	1	10	6	Pelagic
Carangidae	*Trachurus mediterraneus* (Steindachner, 1868)	**CAT**	3.8	10	50	30	Pelagic
Carangidae	*Trachurus picturatus* (Bowdich, 1825)	**CAT**	3.3	0	370	185	Pelagic
Carangidae	*Trachurus trachurus* (Linnaeus, 1758)	**CAT**	3.7	10	100	55	Pelagic
Carapidae	*Carapus acus* (Brünnich, 1768)	**NN**	4.0	20	50	35	Soft bottom
Carapidae	*Echiodon dentatus* (Cuvier, 1829)	**NN**	3.6	100	300	200	Soft bottom
Cepolidae	*Cepola macrophthalma* (Linnaeus, 1758)	**NM**	3.1	40	100	70	Soft bottom
Chaetodontidae	*Chaetodon hoefleri* (Steindachner, 1881)	**DM**	3.5	20	75	48	Multi-habitat use
Chlopsidae	*Chlopsis bicolor* Rafinesque, 1810	**NN**	3.7	20	350	185	Soft bottom
Chlorophthalmidae	*Chlorophthalmus agassizi* Bonaparte, 1840	**NM**	3.7	50	1000	525	Soft bottom
Citharidae	*Citharus linguatula* (Linnaeus, 1758)	**UK**	4.0	20	40	30	Soft bottom
Clinidae	*Clinitrachus argentatus* (Risso, 1810)	**DD**	3.5	0	1	1	Hard bottom
Clupeidae	*Alosa alosa* (Linnaeus, 1758)	**CAT**	3.0	5	30	18	Pelagic
Clupeidae	*Alosa fallax* (Lacépède, 1803)	**CAT**	4.0	5	30	18	Pelagic

Clupeidae	*Sardina pilchardus* (Walbaum, 1792)	**CAT**	3.1	5	60	33	Pelagic
Clupeidae	*Sardinella aurita* Valenciennes, 1847	**CAT**	3.4	10	80	45	Pelagic
Clupeidae	*Sardinella maderensis* (Lowe, 1838)	**UK**	3.2	5	50	28	Pelagic
Clupeidae	*Sprattus sprattus* (Linnaeus, 1758)	**DM**	3.0	5	50	28	Pelagic
Congridae	*Ariosoma balearicum* (Delaroche, 1809)	**NN**	3.9	20	100	60	Soft bottom
Congridae	*Conger conger* (Linnaeus, 1758)	**NN**	4.3	5	100	53	Multi-habitat use
Congridae	*Gnathophis mystax* (Delaroche, 1809)	**NN**	3.5	50	800	425	Soft bottom
Coryphaenidae	*Coryphaena equiselis* Linnaeus, 1758	**CAT**	4.5	0	50	25	Pelagic
Coryphaenidae	*Coryphaena hippurus* Linnaeus, 1758	**CAT**	4.4	2	30	16	Pelagic
Cottidae	*Taurulus bubalis* (Euphrasen, 1786)	**DM**	3.6	1	30	16	Hard bottom
Cynoglossidae	*Symphurus ligulatus* (Cocco, 1844)	**UK**	3.5	20	800	410	Soft bottom
Cynoglossidae	*Symphurus nigrescens* Rafinesque, 1810	**CAT**	3.5	20	1140	580	Soft bottom
Cyprinodontidae	*Aphanius dispar* (Rüppell, 1829)	**DM**	2.0	0	5	3	Multi-habitat use
Cyprinodontidae	*Aphanius fasciatus* (Valenciennes, 1821)	**DD**	2.7	0	5	3	Multi-habitat use
Cyprinodontidae	*Aphanius iberus* (Valenciennes, 1846)	**DM**	3.4	0	5	3	Multi-habitat use
Dactylopteridae	*Dactylopterus volitans* (Linnaeus, 1758)	**NM**	3.7	15	50	33	Multi-habitat use
Echeneidae	*Echeneis naucrates* Linnaeus, 1758	**DM**	3.7	0	15	8	Pelagic
Echeneidae	*Remora brachyptera* (Lowe, 1839)	**DM**	3.5	0	50	25	Pelagic
Echeneidae	*Remora osteochir* (Cuvier, 1829)	**DM**	3.5	0	50	25	Pelagic
Echeneidae	*Remora remora* (Linnaeus, 1758)	**DM**	3.5	0	100	50	Pelagic
Engraulidae	*Engraulis albidus* Borsa et al., 2004	**UK**	3.0	2	20	11	Pelagic
Engraulidae	*Engraulis encrasicolus* (Linnaeus, 1758)	**DM**	3.1	2	50	26	Pelagic
Exocoetidae	*Cheilopogon heterurus* (Rafinesque, 1810)	**DM**	3.4	0	5	3	Pelagic
Exocoetidae	*Exocoetus obtusirostris* Günther, 1866	**DM**	3.1	0	5	3	Pelagic
Exocoetidae	*Exocoetus volitans* (Linnaeus, 1758)	**CAT**	3.0	0	5	3	Pelagic
Exocoetidae	*Hirundichthys rondeletii* (Valenciennes, 1847)	**DM**	3.0	0	5	3	Pelagic
Gadidae (Gadinae)	*Gadiculus argenteus* Guichenot, 1850	**NN**	3.6	100	1000	550	Pelagic
Gadidae (Gadinae)	*Merlangius merlangus* (Linnaeus, 1758)	**CAT**	4.4	30	100	65	Soft bottom
Gadidae (Gadinae)	*Micromesistius poutassou* (Risso, 1827)	**CAT**	4.1	50	400	225	Pelagic
Gadidae (Gadinae)	*Trisopterus luscus* (Linnaeus, 1758)	**NM**	3.7	10	100	55	Multi-habitat use
Gadidae (Gadinae)	*Trisopterus capelanus* (Lacepede, 1800)	**CAT**	3.7	25	200	113	Multi-habitat use
Gadidae (Phycinae)	*Phycis blennoides* (Brünnich, 1768)	**CAT**	3.7	100	450	275	Soft bottom
Gadidae (Phycinae)	*Phycis phycis* (Linnaeus, 1758)	**NM**	4.3	20	100	60	Multi-habitat use
Gadidae (Gaidropsarinae)	*Gaidropsarus biscayensis* (Collett, 1890)	**NM**	3.6	80	600	340	Soft bottom
Gadidae (Gaidropsarinae)	*Gaidropsarus granti* (Regan, 1903)	**UK**	3.6	20	250	135	Hard bottom
Gadidae (Gaidropsarinae)	*Gaidropsarus mediterraneus* (Linnaeus, 1758)	**NM**	3.5	1	25	13	Hard bottom
Gadidae (Gaidropsarinae)	*Gaidropsarus vulgaris* (Cloquet, 1824)	**UK**	3.5	20	80	50	Multi-habitat use

Gadidae (Lotinae)	*Molva molva* (Linnaeus, 1758)	**CRE**	4.4	50	400	225	Hard bottom
Gobiesocidae	*Apletodon dentatus* (Facciola, 1887)	**UK**	3.1	0	20	10	Hard bottom
Gobiesocidae	*Apletodon incognitus* Hofrichter & Patzner, 1997	**DM**	3.1	1	20	11	Multi-habitat use
Gobiesocidae	*Diplecogaster bimaculata* (Bonnaterre, 1788)	**DM**	3.4	10	50	30	Soft bottom
Gobiesocidae	*Gouania wildenowi* (Risso, 1810)	**DM**	3.2	0	1	1	Soft bottom
Gobiesocidae	*Lepadogaster candolii* Risso, 1810	**DD**	2.8	1	20	11	Hard bottom
Gobiesocidae	*Lepadogaster lepadogaster* (Bonnaterre, 1788)	**DM**	3.3	0	5	3	Soft bottom
Gobiesocidae	*Lepadogaster purpurea* (Bonnaterre, 1788)	**DM**	3.3	0	5	3	Hard bottom
Gobiesocidae	*Opeatogenys gracilis* (Canestrini, 1864)	**UK**	3.1	3	20	12	Vegetated bottom
Gobiidae	*Aphia minuta* (Risso, 1810)	**CAT**	3.1	2	5	4	Multi-habitat use
Gobiidae	*Buenia affinis* Iljin, 1930	**DM**	3.2	5	20	13	Soft bottom
Gobiidae	*Buenia jeffreysii* (Günther, 1867)	**UK**	3.6	5	330	168	Soft bottom
Gobiidae	*Buenia massutii* Kovačić, Ordines & Schliewen 2016	**UK**	3.1	57	67	62	Soft bottom
Gobiidae	*Chromogobius quadrivittatus* (Kolombatovic, 1894)	**UK**	3.4	0	2	1	Hard bottom
Gobiidae	*Chromogobius zebratus* (Steindachner, 1863)	**UK**	3.3	1	5	3	Hard bottom
Gobiidae	*Corcyrogobius liechtensteini* (Kolombatovic, 1891)	**UK**	3.1	5	20	13	Hard bottom
Gobiidae	*Crystallogobius linearis* (von Düben, 1845)	**NM**	3.4	1	400	201	Soft bottom
Gobiidae	*Deltentosteus collonianus* (Risso, 1826)	**DD**	3.6	5	120	63	Multi-habitat use
Gobiidae	*Deltentosteus quadrimaculatus* (Valenciennes, 1837)	**DM**	3.1	15	50	33	Soft bottom
Gobiidae	*Didogobius bentuvii* Miller, 1966	**UK**	3.2	37	37	37	Soft bottom
Gobiidae	*Didogobius schlieweni* Miller, 1993	**NM**	3.2	1	15	8	Multi-habitat use
Gobiidae	*Didogobius splechtnai* Ahnelt & Patzner, 1995	**UK**	3.1	5	18	12	Hard bottom
Gobiidae	*Gammogobius steinitzi* Bath, 1971	**UK**	3.2	5	20	13	Hard bottom
Gobiidae	*Gobius ater* (Bellotti, 1888)	**CAT**	3.2	1	10	6	Vegetated bottom
Gobiidae	*Gobius auratus* Risso, 1810	**DD**	3.0	10	30	20	Hard bottom
Gobiidae	*Gobius bucchichi* Steindachner, 1870	**DM**	3.1	0	3	2	Multi-habitat use
Gobiidae	*Gobius cobitis* Pallas, 1814	**CAT**	3.0	0	3	2	Hard bottom
Gobiidae	*Gobius couchi* Miller & El-Tawil, 1974	**CAT**	2.9	0	15	8	Soft bottom
Gobiidae	*Gobius cruentatus* Gmelin, 1789	**NM**	3.4	10	30	20	Multi-habitat use
Gobiidae	*Gobius fallax* Sarato, 1889	**UK**	3.3	1	20	11	Multi-habitat use
Gobiidae	*Gobius gasteveni* Miller, 1974	**CAT**	3.3	5	50	28	Soft bottom
Gobiidae	*Gobius geniporus* Valenciennes, 1837	**CAT**	3.3	5	20	13	Soft bottom
Gobiidae	*Gobius niger* (Linnaeus, 1758)	**CAT**	3.3	0	10	5	Multi-habitat use
Gobiidae	*Gobius paganellus* (Linnaeus, 1758)	**CAT**	3.3	0	3	2	Hard bottom
Gobiidae	*Gobius roulei* de Buen, 1928	**DD**	3.2	3	20	12	Multi-habitat use
Gobiidae	*Gobius vittatus* Vinciguerra, 1883	**DM**	2.9	20	40	30	Hard bottom
Gobiidae	*Gobius xanthocephalus* Heymer & Zander, 1992	**DM**	3.2	5	20	13	Multi-habitat use
Gobiidae	*Knipowitschia caucasica* (Berg, 1916)	**DM**	3.3	0	5	3	Multi-habitat use
Gobiidae	*Knipowitschia panizzae* (Verga, 1841)	**DD**	3.5	0	5	3	Multi-habitat use

Gobiidae	*Lebetus guilleti* (Le Danois, 1913)	**DM**	3.1	6	17	12	Soft bottom
Gobiidae	*Lesueurigobius friesii* (Mahn, 1874)	**CAT**	3.4	10	130	70	Soft bottom
Gobiidae	*Lesueurigobius sanzi* (De Buen, 1918)	**UK**	3.4	70	100	85	Soft bottom
Gobiidae	*Lesueurigobius suerii* (Risso, 1810)	**NM**	3.6	12	50	31	Soft bottom
Gobiidae	*Millerigobius macrocephalus* (Kolombatovic, 1891)	**UK**	3.2	1	5	3	Multi-habitat use
Gobiidae	*Odondebuenia balearica* (Pellegrin & Fage, 1907)	**UK**	3.1	25	50	38	Hard bottom
Gobiidae	*Pomatoschistus bathi* Miller, 1982	**DD**	3.2	2	10	6	Soft bottom
Gobiidae	*Pomatoschistus canestrinii* (Ninni, 1883)	**DM**	3.2	1	20	11	Soft bottom
Gobiidae	*Pomatoschistus knerii* (Steindachner, 1861)	**UK**	3.3	0	30	15	Soft bottom
Gobiidae	*Pomatoschistus marmoratus* (Risso, 1810)	**CAT**	3.4	1	20	11	Soft bottom
Gobiidae	*Pomatoschistus microps* (Krøyer, 1838)	**CAT**	3.3	0	5	3	Soft bottom
Gobiidae	*Pomatoschistus minutus* (Pallas, 1770)	**CAT**	3.2	1	20	11	Soft bottom
Gobiidae	*Pomatoschistus norvegicus* (Collett, 1902)	**CRE**	3.3	10	325	168	Soft bottom
Gobiidae	*Pomatoschistus pictus* Miller, 1973	**DM**	3.1	0	20	10	Soft bottom
Gobiidae	*Pomatoschistus quagga* (Heckel, 1837)	**UK**	3.3	5	15	10	Soft bottom
Gobiidae	*Pomatoschistus tortonesei* Miller, 1969	**UK**	3.4	1	5	3	Soft bottom
Gobiidae	*Pseudaphya ferreri* (de Buen & Fage, 1908)	**DM**	3.1	2	5	4	Soft bottom
Gobiidae	*Speleogobius llorisi* Kovačić, Ordines & Schliewen 2016	**UK**	N/A	40	70	55	Soft bottom
Gobiidae	*Speleogobius trigloides* Zander & Jelinek, 1976	**UK**	3.0	8	30	19	Hard bottom
Gobiidae	*Thorogobius ephippiatus* (Lowe, 1839)	**NM**	3.0	10	30	20	Multi-habitat use
Gobiidae	*Thorogobius macrolepis* (Kolombatovic, 1891)	**UK**	3.3	20	40	30	Multi-habitat use
Gobiidae	*Vanneaugobius dollfusi* Brownell, 1978	**UK**	3.2	30	160	95	Multi-habitat use
Gobiidae	*Vanneaugobius pruvoti* (Fage, 1907)	**UK**	3.1	50	270	160	Hard bottom
Gobiidae	*Zebrus zebrus* (Risso, 1826)	**NM**	3.2	1	5	3	Hard bottom
Gobiidae	*Zosterisessor ophiocephalus* (Pallas, 1811)	**DM**	3.2	1	5	3	Vegetated bottom
Gonostomatidae	*Gonostoma denudatum* Rafinesque, 1810	**DVM**	3.3	100	700	400	Pelagic
Gonostomatidae	*Sigmops elongatus* (Günther, 1878)	**DVM**	3.3	100	1500	800	Pelagic
Haemulidae	*Parapristipoma octolineatum* (Valenciennes, 1833)	**NN**	3.6	10	30	20	Multi-habitat use
Haemulidae	*Plectorhinchus mediterraneus* (Guichenot, 1850)	**NN**	3.5	5	50	28	Soft bottom
Haemulidae	*Pomadasys incisus* (Bowdich, 1825)	**NN**	3.8	10	100	55	Multi-habitat use
Hemiramphidae	*Hyporhamphus picarti* (Valenciennes, 1847)	**CAT**	2.0	0	5	3	Multi-habitat use
Heterenchelyidae	*Panturichthys fowleri* (Ben Tuvia, 1953)	**NN**	3.9	30	100	65	Soft bottom
Istiophoridae	*Istiophorus albicans* (Latreille, 1804)	**CAT**	4.5	0	50	25	Pelagic
Istiophoridae	*Kajikia albida* (Poey, 1860)	**CAT**	4.5	0	150	75	Pelagic
Istiophoridae	*Tetrapturus belone* Rafinesque, 1810	**UK**	4.4	0	200	100	Pelagic
Istiophoridae	*Tetrapturus georgii* Lowe, 1841	**UK**	4.3	0	200	100	Pelagic
Kyphosidae	*Kyphosus sectatrix* (Linnaeus, 1758)	**DM**	2.0	2	15	9	Multi-habitat use
Labridae	*Acantholabrus palloni* (Risso, 1810)	**DD**	3.5	30	100	65	Hard bottom
Labridae	*Centrolabrus melanocercus* (Risso, 1810)	**DD**	3.2	3	15	9	Multi-habitat use

Labridae	*Coris julis* (Linnaeus, 1758)	**DM**	3.4	1	60	31	Multi-habitat use
Labridae	*Ctenolabrus rupestris* (Linnaeus, 1758)	**DD**	3.6	5	20	13	Hard bottom
Labridae	*Labrus merula* Linnaeus, 1758	**DD**	3.6	2	25	14	Multi-habitat use
Labridae	*Labrus mixtus* Linnaeus, 1758	**DD**	3.9	15	50	33	Hard bottom
Labridae	*Labrus viridis* Linnaeus, 1758	**DD**	3.9	10	30	20	Multi-habitat use
Labridae	*Lappanella fasciata* (Cocco, 1833)	**DD**	3.3	50	150	100	Hard bottom
Labridae	*Symphodus bailloni* (Valenciennes, 1839)	**DM**	3.5	1	50	26	Multi-habitat use
Labridae	*Symphodus cinereus* (Bonnaterre, 1788)	**DM**	3.5	5	20	13	Multi-habitat use
Labridae	*Symphodus doderleini* Jordan, 1890	**DD**	3.4	5	30	18	Multi-habitat use
Labridae	*Symphodus mediterraneus* (Linnaeus, 1758)	**DD**	3.2	3	20	12	Multi-habitat use
Labridae	*Symphodus melops* (Linnaeus, 1758)	**DD**	3.4	2	15	9	Multi-habitat use
Labridae	*Symphodus ocellatus* (Linnaeus, 1758)	**DD**	3.5	1	15	8	Multi-habitat use
Labridae	*Symphodus roissali* (Risso, 1810)	**DD**	3.5	1	10	6	Multi-habitat use
Labridae	*Symphodus rostratus* Bloch, 1791)	**DD**	3.5	3	20	12	Multi-habitat use
Labridae	*Symphodus tinca* (Linnaeus, 1758)	**DD**	3.3	1	20	11	Multi-habitat use
Labridae	*Thalassoma pavo* (Linnaeus, 1758)	**DM**	3.5	0	20	10	Multi-habitat use
Labridae	*Xyrichthys novacula* (Linnaeus, 1758)	**DD**	3.5	5	20	13	Soft bottom
Lampridae	*Lampris guttatus* (Brünnich, 1788)	**CAT**	4.2	5	366	186	Pelagic
Lobotidae	*Lobotes surinamensis* (Bloch, 1790)	**CAT**	4.0	0	10	5	Pelagic
Lophiidae	*Lophius budegassa* Spinola, 1807	**NM**	4.4	50	500	275	Soft bottom
Lophiidae	*Lophius piscatorius* Linnaeus, 1758	**DM**	4.5	20	500	260	Multi-habitat use
Luvaridae	*Luvarus imperialis* Rafinesque, 1810	**UK**	3.8	5	200	103	Pelagic
Macroramphosidae	*Macroramphosus scolopax* (Linnaeus, 1758)	**DM**	3.5	50	120	85	Soft bottom
Merlucciidae	*Merluccius merluccius* (Linnaeus, 1758)	**NN**	4.4	70	300	185	Soft bottom
Molidae	*Mola mola* (Linnaeus, 1758)	**CAT**	3.3	0	30	15	Pelagic
Molidae	*Ranzania laevis* (Pennant, 1776)	**UK**	3.7	1	140	71	Pelagic
Moronidae	*Dicentrarchus labrax* (Linnaeus, 1758)	**CAT**	3.5	1	30	16	Multi-habitat use
Moronidae	*Dicentrarchus punctatus* (Bloch, 1792)	**UK**	3.9	1	10	6	Multi-habitat use
Mugilidae	*Chelon auratus* (Risso, 1810)	**DM**	2.8	0	5	3	Pelagic
Mugilidae	*Chelon labrosus* (Risso, 1827)	**UK**	2.6	0	5	3	Multi-habitat use
Mugilidae	*Chelon ramada* (Risso, 1827)	**DM**	2.3	0	5	3	Pelagic
Mugilidae	*Chelon saliens* (Risso, 1810)	**DM**	2.9	0	10	5	Multi-habitat use
Mugilidae	*Mugil cephalus* Linnaeus, 1758	**DM**	2.5	0	5	3	Multi-habitat use
Mugilidae	*Oedalechilus labeo* (Cuvier, 1829)	**NM**	2.5	0	10	5	Multi-habitat use
Mugilidae	*Planiliza haematocheila* (Temminck & Schlegel, 1845)	**UK**	2.5	0	20	10	Pelagic
Mullidae	*Mullus barbatus* Linnaeus, 1758	**DM**	3.1	10	300	155	Soft bottom
Mullidae	*Mullus surmuletus* Linnaeus, 1758	**DM**	3.5	3	80	42	Soft bottom
Muraenesocidae	*Cynoponticus ferox* (Costa 18,46)	**UK**	3.6	10	100	55	Soft bottom
Muraenidae	*Gymnothorax unicolor* (Delaroche, 1809)	**UK**	3.4	0	20	10	Hard bottom
Muraenidae	*Muraena helena* Linnaeus, 1758	**CAT**	4.2	5	50	28	Hard bottom
Myctophidae	*Benthosema glaciale* (Reinhardt, 1837)	**DVM**	3.0	0	1407	704	Pelagic

Myctophidae	*Ceratoscopelus maderensis* (Lowe, 1839)	**DVM**	3.1	51	1480	766	Pelagic
Myctophidae	*Diaphus holti* Tåning, 1918	**DVM**	3.1	40	777	409	Pelagic
Myctophidae	*Diaphus metopoclampus* (Cocco, 1829)	**DVM**	3.3	90	1085	588	Pelagic
Myctophidae	*Diaphus rafinesquii* (Cocco, 1838)	**DVM**	3.4	40	2173	1107	Pelagic
Myctophidae	*Diogenichthys atlanticus* Tåning, 1928	**DVM**	3.1	0	1050	525	Pelagic
Myctophidae	*Electrona risso* (Cocco, 1829)	**DVM**	3.4	90	1485	788	Pelagic
Myctophidae	*Gonichthys cocco* (Cocco, 1829)	**DVM**	3.2	0	1000	500	Pelagic
Myctophidae	*Hygophum benoiti* (Cocco, 1838)	**DVM**	3.0	51	700	376	Pelagic
Myctophidae	*Hygophum hygomii* (Lütgen, 1892)	**DVM**	3.0	0	1485	743	Pelagic
Myctophidae	*Lampanyctus crocodilus* (Risso, 1810)	**DVM**	3.2	0	1000	500	Pelagic
Myctophidae	*Lampanyctus pusillus* (Johnson, 1890)	**DVM**	3.4	40	850	445	Pelagic
Myctophidae	*Lobianchia dofleini* (Zugmayr, 1911)	**DVM**	3.0	0	4000	2000	Pelagic
Myctophidae	*Lobianchia gemellarii* (Cocco, 1838)	**DVM**	3.0	25	800	413	Pelagic
Myctophidae	*Myctophum punctatum* Rafinesque, 1810	**DVM**	3.4	0	1000	500	Pelagic
Myctophidae	*Notoscopelus bolini* Nafpaktidis, 1975	**DVM**	3.1	0	1300	650	Pelagic
Myctophidae	*Notoscopelus elongatus* (Costa, 1844)	**DVM**	3.4	45	1000	523	Pelagic
Myctophidae	*Symbolophorus veranyi* (Moreau, 1888)	**DVM**	3.3	0	800	400	Pelagic
Nemichthyidae	*Nemichthys scolopaceus* Richardson, 1848	**CAT**	3.5	100	1000	550	Pelagic
Nettastomatidae	*Facciolella oxyrhyncha* (Bellotti, 1883)	**NN**	3.5	30	500	265	Soft bottom
Nettastomatidae	*Nettastoma melanurum* Rafinesque, 1810	**NN**	3.5	80	400	240	Soft bottom
Nomeidae	*Cubiceps gracilis* (Lowe, 1843)	**DVM**	3.4	3	250	127	Pelagic
Ophichthidae	*Apterichthus anguiformis* (Peters, 1877)	**NN**	4.0	10	50	30	Soft bottom
Ophichthidae	*Apterichthus caecus* (Linnaeus, 1758)	**NN**	4.1	5	20	13	Soft bottom
Ophichthidae	*Dalophis imberbis* (Delaroche, 1809)	**NN**	4.0	20	50	35	Soft bottom
Ophichthidae	*Echelus myrus* (Linnaeus, 1758)	**NN**	4.3	20	60	40	Soft bottom
Ophichthidae	*Ophichthus rufus* (Rafinesque, 1810)	**NM**	4.3	50	300	175	Soft bottom
Ophichthidae	*Ophisurus serpens* (Linnaeus, 1758)	**NN**	4.1	15	300	158	Soft bottom
Ophidiidae	*Ophidion barbatum* Linnaeus, 1758	**NN**	3.6	3	120	62	Soft bottom
Ophidiidae	*Ophidion rochei* Müller, 1845	**NN**	3.6	15	60	38	Soft bottom
Ophidiidae	*Parophidion vassali* (Risso, 1810)	**NN**	3.5	20	200	110	Multi-habitat use
Phosichthyidae	*Vinciguerria attenuata* (Cocco, 1838)	**CAT**	3.1	100	600	350	Pelagic
Phosichthyidae	*Vinciguerria poweriae* (Cocco, 1838)	**DVM**	3.1	50	600	325	Pelagic
Pleuronectidae	*Platichthys flesus* (Linnaeus, 1758)	**NM**	3.3	1	25	13	Soft bottom
Pleuronectidae	*Pleuronectes platessa* (Guichenot, 1850)	**CAT**	3.2	5	100	53	Soft bottom
Polynemidae	*Galeoides decadactylus* (Bloch, 1795)	**UK**	3.6	5	20	13	Soft bottom
Polyprionidae	*Polyprion americanus* (Bloch & Schneider, 1801)	**CAT**	4.1	40	200	120	Multi-habitat use
Pomacentridae	*Chromis chromis* (Linnaeus, 1758)	**DD**	3.8	5	20	13	Hard bottom
Pomatomidae	*Pomatomus saltatrix* (Linnaeus, 1758)	**DM**	4.5	10	40	25	Pelagic
Regalecidae	*Regalecus glesne* Ascanius, 1772	**UK**	3.2	20	200	110	Pelagic
Scaridae	*Sparisoma cretense* (Linnaeus, 1758)	**DM**	2.9	1	20	11	Multi-habitat use
Sciaenidae	*Argyrosomus regius* (Asso, 1801)	**NN**	4.3	15	100	58	Multi-habitat use

Sciaenidae	*Sciaena umbra* Linnaeus, 1758	**NM**	3.8	10	30	20	Multi-habitat use
Sciaenidae	*Umbrina canariensis* Valenciennes, 1843	**NN**	3.4	50	200	125	Soft bottom
Sciaenidae	*Umbrina cirrosa* (Linnaeus, 1758)	**NN**	3.4	5	50	28	Multi-habitat use
Sciaenidae	*Umbrina ronchus* Valenciennes, 1843	**NN**	3.4	20	200	110	Multi-habitat use
Scomberesocidae	*Scomberesox saurus* (Walbaum, 1792)	**DVM**	3.9	0	30	15	Pelagic
Scombridae	*Auxis rochei* (Risso, 1810)	**UK**	4.4	0	30	15	Pelagic
Scombridae	*Euthynnus alletteratus* (Rafinesque, 1810)	**CAT**	4.5	0	40	20	Pelagic
Scombridae	*Katsuwonus pelamis* (Linnaeus, 1758)	**CAT**	4.4	0	30	15	Pelagic
Scombridae	*Orcynopsis unicolor* (Geoffroy Saint-Hillaire, 1817)	**UK**	4.5	0	40	20	Pelagic
Scombridae	*Sarda sarda* (Bloch, 1793)	**CRE**	4.5	0	50	25	Pelagic
Scombridae	*Scomber colias* Gmelin 1789	**DVM**	3.9	10	100	55	Pelagic
Scombridae	*Scomber scombrus* Linnaeus, 1758	**DM**	3.6	0	100	50	Pelagic
Scombridae	*Scomberomorus tritor* (Cuvier, 1832)	**UK**	4.3	20	25	23	Pelagic
Scombridae	*Thunnus alalunga* (Cetti, 1777)	**CAT**	4.3	0	100	50	Pelagic
Scombridae	*Thunnus thynnus* (Linnaeus, 1758)	**CAT**	4.5	0	70	35	Pelagic
Scophthalmidae	*Lepidorhombus boscii* (Risso, 1810)	**UK**	3.7	50	400	225	Soft bottom
Scophthalmidae	*Lepidorhombus whiffiagonis* (Walbaum, 1792)	**UK**	4.3	50	400	225	Soft bottom
Scophthalmidae	*Scophthalmus maximus* (Linnaeus, 1758)	**DM**	4.4	10	80	45	Soft bottom
Scophthalmidae	*Scophthalmus rhombus* (Linnaeus, 1758)	**DM**	4.4	2	70	36	Soft bottom
Scophthalmidae	*Zeugopterus regius* (Bonnaterre, 1788)	**DM**	3.8	20	50	35	Hard bottom
Scorpaenidae (Scorpaeini)	*Pontinus kuhlii* (Bowdich, 1825)	**UK**	4.1	100	460	280	Hard bottom
Scorpaenidae (Scorpaeini)	*Scorpaena elongata* Cadenat, 1943	**DM**	3.9	75	800	438	Hard bottom
Scorpaenidae (Scorpaeini)	*Scorpaena loppei* Cadenat, 1943	**NM**	3.5	80	300	190	Soft bottom
Scorpaenidae (Scorpaeini)	*Scorpaena maderensis* Valenciennes, 1833	**NM**	4.1	3	20	12	Hard bottom
Scorpaenidae (Scorpaeini)	*Scorpaena notata* Rafinesque, 1810	**DM**	3.7	10	50	30	Hard bottom
Scorpaenidae (Scorpaeini)	*Scorpaena porcus* Linnaeus, 1758	**CAT**	3.9	5	20	13	Hard bottom
Scorpaenidae (Scorpaeini)	*Scorpaena scrofa* Linnaeus, 1758	**DM**	4.3	20	100	60	Hard bottom
Scorpaenidae (Scorpaeini)	*Scorpaenodes arenai* Torchio, 1962	**NM**	3.6	14	50	32	Hard bottom
Scorpaenidae (Scorpaeini)	*Sebastapistes strongia* (Cuvier, 1829)	**NM**	3.8	0	3	2	Multi-habitat use
Scorpaenidae (Sebastini)	*Helicolenus dactylopterus* (Delaroche, 1809)	**CAT**	3.5	100	300	200	Multi-habitat use
Serranidae (Anthiinae)	*Anthias anthias* (Linnaeus, 1758)	**DM**	3.8	30	80	55	Hard bottom

Serranidae (Epinephelinae)	*Epinephelus aeneus* (Geoffroy Saint-Hilaire, 1817)	**UK**	4.0	20	100	60	Multi-habitat use
Serranidae (Epinephelinae)	*Epinephelus caninus* (Valenciennes, 1843)	**UK**	3.8	30	100	65	Soft bottom
Serranidae (Epinephelinae)	*Epinephelus costae* (Steindachner, 1878)	**CAT**	3.9	10	80	45	Multi-habitat use
Serranidae (Epinephelinae)	*Epinephelus marginatus* (Lowe, 1834)	**CAT**	4.4	10	50	30	Hard bottom
Serranidae (Epinephelinae)	*Hyporthodus haifensis* Ben-Tuvia, 1953	**UK**	4.0	80	150	115	Hard bottom
Serranidae (Epinephelinae)	*Mycteroperca rubra* (Bloch, 1793)	**UK**	4.1	15	50	33	Hard bottom
Serranidae (Serraninae)	*Serranus atricauda* Günther, 1874	**DM**	4.3	10	50	30	Hard bottom
Serranidae (Serraninae)	*Serranus cabrilla* (Linnaeus, 1758)	**DM**	3.4	5	90	48	Multi-habitat use
Serranidae (Serraninae)	*Serranus hepatus* (Linnaeus, 1758)	**DM**	3.5	25	200	113	Multi-habitat use
Serranidae (Serraninae)	*Serranus scriba* (Linnaeus, 1758)	**DM**	3.8	5	30	18	Multi-habitat use
Soleidae	*Buglossidium luteum* (Risso, 1810)	**NM**	3.3	10	40	25	Soft bottom
Soleidae	*Dicologlossa cuneata* (Moreau, 1881)	**NM**	3.3	10	150	80	Soft bottom
Soleidae	*Microchirus azevia* (Capello, 1867)	**NM**	3.2	20	250	135	Soft bottom
Soleidae	*Microchirus ocellatus* (Linnaeus, 1758)	**UK**	3.2	20	300	160	Soft bottom
Soleidae	*Microchirus variegatus* (Donovan, 1808)	**NM**	3.3	50	300	175	Soft bottom
Soleidae	*Monochirus hispidus* Rafinesque, 1814	**NM**	3.5	10	100	55	Soft bottom
Soleidae	*Pegusa lascaris* (Risso, 1810)	**NM**	3.3	20	50	35	Soft bottom
Soleidae	*Pegusa impar* (Bennett, 1831)	**UK**	3.3	5	60	33	Soft bottom
Soleidae	*Solea aegyptiaca* Chabanaud, 1927	**NM**	3.2	1	50	26	Soft bottom
Soleidae	*Solea solea* (Linnaeus, 1758)	**NM**	3.2	0	60	30	Soft bottom
Soleidae	*Synapturichthys kleinii* (Risso, 1827)	**NM**	3.6	20	120	70	Soft bottom
Sparidae	*Boops boops* (Linnaeus, 1758)	**DD**	2.8	5	30	18	Multi-habitat use
Sparidae	*Centracanthus cirrus* Rafinesque, 1810	**UK**	3.4	30	80	55	Hard bottom
Sparidae	*Dentex dentex* (Linnaeus, 1758)	**CRE**	4.5	15	50	33	Hard bottom
Sparidae	*Dentex gibbosus* (Rafinesque, 1810)	**UK**	4.1	40	130	85	Hard bottom
Sparidae	*Dentex macrophthalmus* (Bloch, 1791)	**NM**	3.5	50	150	100	Multi-habitat use
Sparidae	*Dentex maroccanus* (Valenciennes, 1830)	**UK**	3.9	50	100	75	Multi-habitat use
Sparidae	*Diplodus annularis* (Linnaeus, 1758)	**CAT**	3.6	1	20	11	Multi-habitat use
Sparidae	*Diplodus cervinus* (Lowe, 1838)	**DM**	3.0	10	50	30	Hard bottom
Sparidae	*Diplodus puntazzo* (Walbaum, 1792)	**DM**	3.2	10	50	30	Hard bottom
Sparidae	*Diplodus sargus* (Linnaeus, 1758)	**DM**	3.4	1	40	21	Multi-habitat use
Sparidae	*Diplodus vulgaris* Geoffroy Saint-Hillaire, 1817	**CRE**	3.5	2	50	26	Multi-habitat use

Sparidae	*Lithognathus mormyrus* (Linnaeus, 1758)	**DM**	3.4	5	50	28	Soft bottom
Sparidae	*Oblada melanura* (Linnaeus, 1758)	**CRE**	3.4	0	10	5	Multi-habitat use
Sparidae	*Pagellus acarne* (Risso, 1827)	**DM**	3.8	20	100	60	Multi-habitat use
Sparidae	*Pagellus bogaraveo* (Brünnich, 1768)	**DM**	4.2	30	300	165	Multi-habitat use
Sparidae	*Pagellus erythrinus* (Linnaeus, 1758)	**CRE**	3.5	20	100	60	Multi-habitat use
Sparidae	*Pagrus auriga* (Valenciennes, 1843)	**UK**	3.8	10	80	45	Hard bottom
Sparidae	*Pagrus coeruleostictus* (Valenciennes, 1830)	**UK**	3.7	20	80	50	Hard bottom
Sparidae	*Pagrus pagrus* (Linnaeus, 1758)	**DM**	3.9	15	100	58	Multi-habitat use
Sparidae	*Sarpa salpa* (Linnaeus, 1758)	**DM**	2.0	0	15	8	Multi-habitat use
Sparidae	*Sparus aurata* Linnaeus, 1758	**CAT**	3.7	10	30	20	Multi-habitat use
Sparidae	*Spicara flexuosa* (Rafinesque, 1810)	**UK**	4.2	5	50	28	Multi-habitat use
Sparidae	*Spicara maena* (Linnaeus, 1758)	**CRE**	4.2	5	50	28	Multi-habitat use
Sparidae	*Spicara smaris* (Linnaeus, 1758)	**UK**	3.0	15	70	43	Multi-habitat use
Sparidae	*Spondyliosoma cantharus* (Linnaeus, 1758)	**NM**	3.3	10	60	35	Multi-habitat use
Sphyraenidae	*Sphyraena sphyraena* (Linnaeus, 1758)	**DM**	4.0	5	40	23	Pelagic
Sphyraenidae	*Sphyraena viridensis* Cuvier, 1829	**CAT**	4.3	5	30	18	Pelagic
Sternoptychidae	*Argyropelecus hemigymnus* Cocco, 1829	**DVM**	3.1	100	700	400	Pelagic
Sternoptychidae	*Maurolicus muelleri* (Gmelin, 1789)	**DM**	3.0	50	400	225	Pelagic
Stromateidae	*Stromateus fiatola* Linnaeus, 1758	**UK**	4.0	10	70	40	Pelagic
Syngnathidae	*Entelurus aequoraeus* (Linnaeus, 1758)	**DD**	3.5	1	20	11	Vegetated bottom
Syngnathidae	*Hippocampus guttulatus* (Cuvier, 1829)	**DD**	3.2	1	20	11	Multi-habitat use
Syngnathidae	*Hippocampus hippocampus* (Linnaeus, 1758)	**DD**	3.5	1	10	6	Multi-habitat use
Syngnathidae	*Minyichthys sentus* Dawson, 1982	**DD**	3.2	50	100	75	Pelagic
Syngnathidae	*Nerophis lumbriciformis* (Jenyns, 1835)	**NM**	4.0	0	5	3	Hard bottom
Syngnathidae	*Nerophis maculatus* Rafinesque, 1810	**NM**	3.4	1	20	11	Vegetated bottom
Syngnathidae	*Nerophis ophidion* (Linnaeus, 1758)	**NM**	4.0	1	10	6	Vegetated bottom
Syngnathidae	*Syngnathus abaster* Risso, 1827	**DD**	3.2	0	5	3	Vegetated bottom
Syngnathidae	*Syngnathus acus* Linnaeus, 1758	**DD**	3.3	1	20	11	Multi-habitat use
Syngnathidae	*Syngnathus phlegon* Risso, 1827	**DD**	3.5	0	50	25	Pelagic
Syngnathidae	*Syngnathus taenionotus* Canestrini, 1871	**DD**	3.4	0	10	5	Soft bottom
Syngnathidae	*Syngnathus tenuirostris* Rathke, 1837	**DD**	3.3	1	25	13	Multi-habitat use
Syngnathidae	*Syngnathus typhle* Linnaeus, 1758	**DD**	4.3	1	20	11	Vegetated bottom
Synodontidae	*Synodus saurus* (Linnaeus, 1758)	**CAT**	4.5	5	50	28	Soft bottom
Tetragonuridae	*Tetragonurus cuvieri* Risso, 1810	**UK**	3.8	1	800	401	Pelagic
Tetraodontidae	*Ephippion guttifer* (Benett, 1831)	**DD**	3.6	5	100	53	Multi-habitat use
Tetraodontidae	*Lagocephalus lagocephalus* (Linné, 1758)	**DD**	3.6	0	30	15	Pelagic

Trachinidae	*Echiichthys vipera* (Cuvier, 1829)	**NM**	4.4	0	10	5	Soft bottom
Trachinidae	*Trachinus araneus* Cuvier, 1829	**NM**	4.0	5	50	28	Soft bottom
Trachinidae	*Trachinus draco* Linnaeus, 1758	**NM**	4.2	5	20	13	Soft bottom
Trachinidae	*Trachinus radiatus* Cuvier, 1829	**NM**	4.0	30	60	45	Soft bottom
Trachipteridae	*Zu cristatus* (Bonelli, 1819)	**NN**	4.5	1	1000	501	Pelagic
Trichiuridae	*Lepidopus caudatus* (Euphrasen, 1788)	**DVM**	3.8	40	300	170	Soft bottom/Pelagic
Trichiuridae	*Trichiurus lepturus* (Linnaeus, 1758)	**DVM**	4.4	11	350	181	Soft bottom/Pelagic
Triglidae	*Chelidonichthys cuculus* (Linnaeus, 1758)	**DM**	3.8	30	200	115	Multi-habitat use
Triglidae	*Chelidonichthys lucerna* (Linnaeus, 1758)	**DM**	4.0	20	150	85	Soft bottom
Triglidae	*Chelidonichthys obscurus* (Walbaum, 1792)	**DM**	3.7	20	70	45	Soft bottom
Triglidae	*Eutrigla gurnardus* (Linnaeus, 1758)	**CAT**	3.9	20	150	85	Multi-habitat use
Triglidae	*Lepidotrigla cavillone* (Lacépède, 1801)	**DM**	3.3	15	500	258	Soft bottom
Triglidae	*Lepidotrigla dieuzeidei* Blanc & Hureau 1973	**UK**	3.7	30	200	115	Soft bottom
Triglidae	*Trigla lyra* Linnaeus, 1758	**UK**	3.7	50	400	225	Soft bottom
Triglidae	*Trigloporus lastoviza* (Bonnaterre, 1788)	**UK**	3.5	20	100	60	Multi-habitat use
Tripterygiidae	*Tripterygion delaisi* Cadenat & Blache, 1970	**DD**	3.4	5	20	13	Hard bottom
Tripterygiidae	*Tripterygion melanurus* Guichenot, 1850	**DD**	3.5	0	15	8	Hard bottom
Tripterygiidae	*Tripterygion tripteronotum* (Risso, 1810)	**DD**	3.4	0	3	2	Hard bottom
Uranoscopidae	*Uranoscopus scaber* (Linnaeus, 1758)	**NM**	4.4	18	91	55	Soft bottom
Xiphiidae	*Xiphias gladius* Linnaeus, 1758	**CAT**	4.5	10	125	68	Pelagic
Zeidae	*Zeus faber* Linnaeus, 1758	**CAT**	4.5	50	150	100	Multi-habitat use

ESM, Part 4. Data of dispersal and establishment success of non-indigenous fishes of Indo-pacific origin.

Note: Examined species are listed in alphabetic order, with level of dispersal and establishment success, activity pattern and year of first record in the Mediterranean Sea. "Other pattern" means a cathemeral or crepuscular activity or a diel vertical migration pattern. Diurnal and nocturnal categorties include also "mainly diurnal" and "mainly nocturnal" activity, respectively. A question mark in the column "Dispersal" indicates species that were most probably introduced via aquarium release, and spread more or less subsequently.
Data of dispersal and establishment were adopted from Arndt & Schembri (2015), and updated based on a few more recently published sources (Akyol & Vahdet 2013; Boltachev & Karpova 2013; Sami et al. 2014; Crocetta et al. 2015; Iglesias and Frotté 2015; Chartosia & Michailidis 2016; Farrag et a. 2016; Harold & Golani 2016; Azzuro et al. 2017; Dailianis et al. 2017; Tiralongo et al. 2019; Zenetos et al. 2016).
Note that deepwater species and Elasmobranchii were included in Arndt & Schembri (2015) but excluded here. The activity category of three species (*Liza carinata*, *Lutjanus sebae*, *Sphyraena pinguis*) was determined on the basis of their family characters, because detailed data of the species' activity are lacking.

Family	**Species**	**Dispersal**	**Establishment**	**1-Diurnal**	**2-Nocturnal**	**3-Other pattern**	**4- Insufficiently known**	**First record**
Pomacentridae	*Abudefduf vaigiensis* (Quoy & Gaimard, 1825)	**3**	**3**	1	0	0	0	1997
Sparidae	*Acanthopagrus bifasciatus* (Forsskål, 1775)	**2**	**1**	1	0	0	0	2010
Carangidae	*Alepes djedaba* (Forsskål, 1775)	**3**	**3**	0	1	0	0	1924
Apogonidae	*Apogonichthyoides pharaonis* (Bellotti, 1874)	**2**	**3**	0	1	0	0	1924
Atherinidae	*Atherinomorus forskalii* (Rüppell, 1838)	**3**	**3**	1	0	0	0	1902
Bregmacerotidae	*Bregmaceros nectabanus* Whitley, 1941	**3**	**2**	0	0	0	1	1965
Callionymidae	*Callionymus filamentosus* Valenciennes, 1837	**3**	**3**	1	0	0	0	1953
Serranidae	*Cephalopholis hemistiktos* (Rüppell, 1830)	**1?**	**1**	1	0	0	0	2009
Chaetodontidae	*Chaetodon austriacus* Rüppel, 1836	**1**	**1**	1	0	0	0	2011
Chaetodontidae	*Chaetodon larvatus* Cuvier, 1831	**2**	**1**	1	0	0	0	2011
Champsodontidae	*Champsodon capensis* Regan, 1908	**2**	**1**	0	0	1	0	2010
Champsodontidae	*Champsodon nudivittis* (Ogylbi, 1895)	**3**	**3**	0	0	0	1	2008
Champsodontidae	*Champsodon vorax* Günther, 1867	**2**	**1**	0	0	0	1	2010
Chanidae	*Chanos chanos* (Forskål, 1775)	**2**	**1**	1	0	0	0	2011
Apogonidae	*Cheilodipterus novemstriatus* (Rüppell, 1838)	**2**	**2**	0	1	0	0	2010
Chirocentridae	*Chirocentrus dorab* (Forsskål, 1775)	**2**	**1**	1	0	0	0	1999
Pomacentridae	*Chrysiptera cyanea* (Quoy & Gaimard 1825)	**1?**	**1**	1	0	0	0	2014
Gobiidae	*Coryogalops ocheticus* (Norman, 1927)	**2**	**1**	0	0	0	1	1924
Sparidae	*Crenidens crenidens* (Forsskål, 1775)	**3**	**1**	0	0	0	1	1970

Diodontidae	*Cyclichthys spilostylus* (Leis & Randall, 1982)	**2**	**2**	0	1	0	0	1992
Cynoglossidae	*Cynoglossus sinusarabici* (Chabanaud, 1931)	**2**	**3**	0	0	0	1	1953
Carangidae	*Decapterus russelli* (Rüppell, 1830)	**2**	**3**	1	0	0	0	2005
Clupeidae	*Dussumieria elopsoides* Bleeker, 1849	**2**	**2**	1	0	0	0	1949
Platycephalidae	*Elates ransonnetti* (Steindachner, 1876)	**3**	**1**	0	0	0	1	2005
Serranidae	*Epinephelus coioides* (Hamilton, 1822)	**3**	**1**	0	0	0	1	1966
Serranidae	*Epinephelus fasciatus* (Forsskål, 1775)	**1**	**1**	0	0	1	0	2011
Serranidae	*Epinephelus malabaricus* (Bloch & Schneider, 1801)	**3**	**1**	0	0	0	1	1966
Serranidae	*Epinephelus merra* Bloch, 1793	**1?**	**1**	0	0	0	1	2004
Leiognathidae	*Equulites elongatus* (Günther, 1874)	**1**	**1**	0	1	0	0	2011
Leiognathidae	*Equulites klunzingeri* (Steindachner, 1898)	**3**	**3**	0	1	0	0	1924
Clupeidae	*Etrumeus golanii* Dibattista, Randall & Bowen, 2012	**3**	**3**	0	1	0	0	1961
Gobiidae	*Favonigobius melanobranchus* (Fowler, 1934)	**1**	**2**	0	0	0	1	1978
Fistulariidae	*Fistularia commersonii* Rüppell, 1838	**3**	**3**	1	0	0	0	2000
Muraenidae	*Gymnothorax reticularis*, Bloch, 1795	**1**	**1**	0	1	0	0	2013
Hemiramphidae	*Hemiramphus far* (Forsskål, 1775)	**3**	**3**	0	0	1	0	1924
Chaetodontidae	*Heniochus intermedius* Steindachner, 1893	**2**	**2**	0	0	1	0	2002
Clupeidae	*Herklotsichthys punctatus* (Rüppell, 1837)	**3**	**2**	0	1	0	0	1943
Gobiidae	*Hetereleotris vulgaris* (Klunzinger, 1871)	**1**	**1**	0	0	0	1	<1986
Syngnathidae	*Hippocampus fuscus* Rüppell, 1838	**2**	**3**	1	0	0	0	1994
Hemiramphidae	*Hyporhamphus affinis* (Günther, 1866)	**2**	**2**	0	0	1	0	1924
Labridae	*Iniistius pavo* (Valenciennes, 1840)	**2**	**1**	1	0	0	0	2004
Apogonidae	*Jaydia queketti* (Gilchrist, 1903)	**2**	**2**	0	1	0	0	2004
Apogonidae	*Jaydia smithi* (Kotthaus, 1970)	**2**	**3**	0	1	0	0	2007
Tetraodontidae	*Lagocephalus guentheri* Miranda-Ribeiro, 1915 (= *spadiceus* (Richardson, 1845)	**3**	**3**	1	0	0	0	1930
Tetraodontidae	*Lagocephalus sceleratus* (Gmelin, 1789)	**3**	**3**	1	0	0	0	2003
Tetraodontidae	*Lagocephalus suezensis* Clark & Gohar, 1953	**3**	**3**	1	0	0	0	1977
Mugilidae	*Liza carinata* (Valenciennes, 1836)	**3**	**2**	1	0	0	0	1924
Lutjanidae	*Lutjanus argentimaculatus* (Forsskål, 1775)	**3**	**1**	0	1	0	0	1977
Lutjanidae	*Lutjanus fulviflamma* (Forsskål, 1775)	**1**	**1**	0	1	0	0	2014
Lutjanidae	*Lutjanus sebae* (Cuvier, 1816)	**1?**	**1**	0	1	0	0	2010
Lethrinidae	*Monotaxis grandoculis* (Forsskål, 1775)	**2**	**1**	0	1	0	0	2007
Muraenesocidae	*Muraenesox cinereus* (Forsskål, 1775)	**1**	**1**	0	1	0	0	1979
Nemipteridae	*Nemipterus randalli* Russell, 1986	**3**	**3**	0	0	0	1	1974
Blenniidae	*Omobranchus punctatus* Valenciennes, 1836	**1**	**1**	0	0	0	1	2003
Oplegnathidae	*Oplegnathus fasciatus* (Temminck and Schlegel, 1844)	**3**	**2**	1	0	0	0	2009
Apogonidae	*Ostorhinchus quadrifasciatus* (White 1790)	**3**	**3**	0	1	0	0	2008
Ostraciidae	*Ostracion cubicus* (Linnaeus, 1758)	**2**	**1**	1	0	0	0	2010
Gobiidae	*Oxyurichthys petersi* (Klunzinger, 1871)	**2**	**2**	1	0	0	0	1982
Sparidae	*Pagrus major* (Temminck and Schlegel, 1843)	**3**	**1**	0	0	0	1	2004
Stromateidae	*Pampus argenteus* (Euphrasen, 1788)	**3**	**1**	0	0	1	0	1896
Platycephalidae	*Papilloculiceps longiceps* (Cuvier, 1829)	**1**	**1**	1	0	0	0	1986
Blenniidae	*Parablennius thysanius* (Jordan & Seale, 1907)	**2**	**1**	0	0	0	1	2013
Exocoetidae	*Parexocoetus mento* (Valenciennes, 1847)	**3**	**2**	0	0	0	1	1935
Mullidae	*Parupeneus forsskali* (Fourmanoir & Guézé, 1976)	**3**	**2**	1	0	0	0	2000
Teraponidae	*Pelates quadrilineatus* (Bloch, 1790)	**2**	**2**	0	0	1	0	1969

Pempheridae	*Pempheris rhomboidea* Kossmann & Räuber, 1877 =*vanicolensis* Cuvier, 1831	**3**	**3**	0	1	0	0	1978
Blenniidae	*Petroscirtes ancylodon* Rüppell, 1835	**3**	**2**	0	0	0	1	1988
Ephippidae	*Platax teira* (Forsskål, 1775)	**3**	**2**	1	0	0	0	2006
Platycephalidae	*Platycephalus indicus* (Linnaeus, 1758)	**2**	**2**	0	0	1	0	1924
Plotosidae	*Plotosus lineatus* (Thunberg, 1787)	**2**	**3**	0	1	0	0	2001
Pomacanthidae	*Pomacanthus imperator* (Bloch, 1787)	**2**	**1**	1	0	0	0	2009
Pomacanthidae	*Pomacanthus maculosus* (Forsskål, 1775)	**2**	**1**	1	0	0	0	2010
Haemulidae	*Pomadasys stridens* (Forsskål, 1775)	**2**	**2**	0	1	0	0	1971
Priacanthidae	*Priacanthus sagittarius* Starnes, 1988	**2**	**1**	0	1	0	0	2009
Labridae	*Pteragogus pelycus* Randall, 1981	**3**	**3**	1	0	0	0	1991
Scorpaenidae	*Pterois miles* (Bennett, 1828)	**3**	**3**	0	1	0	0	1991
Rachycentridae	*Rachycentron canadum* (Linnaeus, 1766)	**2**	**1**	1	0	0	0	1978
Scombridae	*Rastrelliger kanagurta* (Cuvier, 1816)	**1**	**1**	0	0	1	0	1967
Sparidae	*Rhabdosargus haffara* (Forsskål, 1775)	**1**	**2**	0	0	0	1	1991
Clupeidae	*Sardinella gibbosa* (Bleeker, 1849)	**1**	**1**	1	0	0	0	2008
Holocentridae	*Sargocentron rubrum* (Forsskål, 1775)	**3**	**3**	0	1	0	0	1945
Synodontidae	*Saurida lessepsianus* Russell et al. 2015 syn. *S. undosquamis* (Richardson, 1848)	**3**	**3**	0	0	1	0	1952
Scaridae	*Scarus ghobban* Forsskål, 1775	**2**	**3**	1	0	0	0	2001
Scatophagidae	*Scatophagus argus* (L., 1766)	**1?**	**1**	1	0	0	0	2007
Scombridae	*Scomberomorus commerson* (Lacepède, 1800)	**3**	**3**	0	0	1	0	1935
Siganidae	*Siganus luridus* (Rüppell, 1829)	**3**	**3**	1	0	0	0	1955
Siganidae	*Siganus rivulatus* Forsskål & Niebuhr, 1775	**3**	**3**	1	0	0	0	1924
Gobiidae	*Silhouettea aegyptia* (Chabanaud, 1933)	**2**	**2**	0	0	0	1	1979
Sillaginidae	*Sillago suezensis* Golani, syn. S. *sihama* (Forsskål, 1775)	**3**	**3**	0	1	0	0	1977
Platycephalidae	*Sorsogona prionota* (Sauvage, 1873)	**1**	**1**	0	0	0	1	1946
Sphyraenidae	*Sphyraena obtusa* Cuvier, 1829 syn. *S. flavicauda* Rüppell, 1838)	**3**	**2**	1	0	0	0	1991
Sphyraenidae	*Sphyraena pinguis* Günther, 1874 syn. *S. chrysotaenia* Klunzinger, 1884)	**3**	**3**	1	0	0	0	1931
Clupeidae	*Spratelloides delicatulus* (Bennett, 1832)	**2**	**2**	0	0	1	0	1973
Monacanthidae	*Stephanolepis diaspros* Fraser-Brunner, 1940	**3**	**3**	1	0	0	0	1924
Engraulidae	*Stolephorus insularis* Hardenberg, 1933	**2**	**2**	0	0	0	1	2009
Scorpaenidae	*Synanceia verrucosa* Bloch et Schneider, 1801	**2**	**2**	1	0	0	0	2010
Callionymidae	*Synchiropus sechellensis* Regan, 1908	**3**	**2**	0	1	0	0	2014
Teraponidae	*Terapon jarbua* (Forsskål, 1775)	**1**	**1**	0	0	1	0	2009
Teraponidae	*Terapon puta* Cuvier, 1829	**2**	**1**	0	0	1	0	1973
Teraponidae	*Terapon theraps* Cuvier, 1829	**3**	**1**	0	0	1	0	2007
Ostraciidae	*Tetrosomus gibbosus (Linnaeus, 1758)*	**1**	**1**	1	0	0	0	1987
Tetraodontidae	*Torquigener flavimaculosus* Hardy & Randall, 1983	**3**	**2**	1	0	0	0	1987
Carangidae	*Trachurus indicus* Nekrasov, 1966	**2**	**1**	0	0	0	1	2004
Gobiidae	*Tridentiger trigonocephalus* (Gill, 1859)	**3?**	**2**	0	0	0	1	2006
Gobiidae	*Trypauchen vagina* (Bloch & Schneider, 1801)	**2**	**2**	0	1	0	0	2009
Tetraodontidae	*Tylerius spinosissimus* (Regan, 1908)	**3**	**2**	1	0	0	0	2004
Belonidae	*Tylosurus choram* (Rüppell, 1837)	**2**	**2**	0	0	0	1	1962
Belonidae	*Tylosurus crocodilus* (Péron & Lesueur, 1821)	**3**	**1**	0	0	1	0	2005
Mullidae	*Upeneus moluccensis* (Bleeker, 1855)	**3**	**3**	1	0	0	0	1946
Mullidae	*Upeneus pori* Ben-Tuvia & Golani, 1989	**3**	**3**	1	0	0	0	1942
Gobiidae	*Vanderhorstia mertensi* Klausewitz, 1974	**2**	**1**	1	0	0	0	2008

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