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Juveniles of non-resident fish found in sheltered rocky subtidal areas

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Juvenile fishes of 22 species collected on a rocky shore area at Arrábida (Portugal) fell into three groups: (i) incidentals (four species); (ii) those in transit to a nearby estuary (three species); and (iii) nursery residents (15 species). For groups ii and iii this habitat seems to play an important role in their early life stages.

Key words: rocky shore habitats; nursery grounds; juvenile fishes; Portugal.

There is a large body of literature that emphasizes the role of estuaries (Claridge *et al.*, 1986; Lenanton & Potter, 1987), salt marshes (Shenker & Dean, 1979), mangroves (Laegdsgaard & Johnson, 1995) and coastal lagoons (Antunes *et al.*, 1988) as nurseries for the juveniles of a variety of marine fishes. This role has also been recognized for a growing number of marine coastal habitats, namely sheltered sandy beaches (Nash *et al.*, 1994) and even the surf-zone (Lasiak, 1986), particularly when there is accumulation of macrophyte detritus (Lenanton *et al.*, 1982). For a recent comparison of estuarine and marine sheltered sites see Potter *et al.* (1997). The data available for rocky shores are much less abundant and the importance of these areas as nurseries has been underestimated (Lenanton, 1982; Smale & Buxton, 1989) probably, at least in part, due to the difficulties in applying conventional fishing techniques in the close vicinity of hard substrata at the shore line. Nevertheless, a growing number of marine biological studies emphasize the importance of rocky shore habitats in the processes of recruitment, growth, and protection from predators of juvenile fishes (Gibson, 1969, 1982). Wheeler (1980) discusses the importance of algae for young fishes and Lenanton *et al.* (1982) the role of detached macrophytes, while Marliave (1986) studied some of the mechanisms that ensure that the larvae of resident species remain near the shore and recruit to the inshore habitats. This study presents some evidence on the importance of a sheltered rocky shore area to the juveniles of several non-resident marine fishes.

This study was undertaken along 10 km of a sheltered rocky coast at Arrábida, Portugal (38°27′ N, 9° W), in the vicinity of the Sado Estuary. This shore faces south, thus being protected from the prevailing north winds. In most places, steep cliffs extend down to the lower intertidal zone. Boulders are sometimes present, often forming piles and other complex structures at depths <10 m. Juvenile fishes were observed monthly from 1992 to 1997. Observations were made by the first author scuba diving in close proximity to these hard substrata at depths of 0–10 m. Variations in weather conditions and other logistic limitations prevented the use of a network of fixed sampling points. Care was taken, however, to ensure that all the micro-habitats mentioned in Table I were inspected monthly. The relative abundance of the juvenile fishes was estimated on a three-point scale. When the identity of the fishes was in doubt, they were collected and identified in the laboratory. Individuals of some species were grown in aquaria and identified when they had grown.

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TABLE I. Occurrences of juveniles of non-resident fish species

Family	Species	M	S	Ab	Mh
Clupeidae	*Sardina pilchardus* (Walbaum, 1792)	1–8	1.5–10	II	SW
Gadidae	*Pollachius pollachius* (Linnaeus, 1758)	5–7	10	I	RC
	Trisopterus luscus (Linnaeus, 1758)	3–6	6–9	II	RC
Carangidae	*Trachurus* spp. Rafinesque, 1810*	4–6	5–10	I	SW
Mullidae	*Mullus surmuletus* Linnaeus, 1758	7–8	4	I	BRS, RC
Sparidae	*Boops boops* (Linnaeus, 1758)	7–10	4–10	II	RC, SW
	Diplodus cervinus (Lowe, 1841)	y	1.5–a	II	SW
	Diplodus puntazzo (Cetti, 1777)	3	2	I	SW
	Diplodus sargus (Linnaeus, 1758)	y	1–a	III	BRS, RC, SW
	Diplodus vulgaris (E. G. Saint-Hilaire, 1817)	y	1–a	III	BRS, RC, SW
	Oblada melanura (Linnaeus, 1758)	9, 10	1–2	II	RC
	Pagellus acarne (Risso, 1826)	6–9	2–10	II	BRS, RC
	Pagrus auriga (Valenciennes, 1843)	7–8	6–9	II	BRS, SW
	Pagrus pagrus (Linnaeus, 1758)	7–9	5–9	II	BRS, SW
	Sarpa salpa (Linnaeus, 1758)	y	1.5–a	III	RC, SW
	Spondyliosoma cantharus (Linnaeus, 1758)	y	4–8	II	BRS
Ammodytidae	Ammodytidae (unidentified)	2–5	5–10	I	BRS, SW
	Hyperoplus lanceolatus (Sauvage, 1824)	7	7	I	BRS, SW
Mugilidae	*Chelon labrosus* (Risso, 1826)	7	2	II	SW
	Liza ramada (Risso, 1836)†	2	1.5–3	III	SW
	Mugil cephalus Linnaeus, 1758‡	9–10	1.5	II	SW
Atherinidae	*Atherina presbyter* Cuvier, 1829§	4–9	1–a	III	SW

M, Range of months when the juveniles were seen (y indicates that juveniles were present year round); S, estimated size range in cm (a indicates that the species occurred in the study site up to adult size); Ab, relative abundance: [I, rare; II, common; III, very common (this scale refers to the number of independent occasions when the species was observed and not to the number of individuals. Thus, a very large shoal of a species seen only once would lead to a rating of that species as rare)]; Mh, micro-habitat [BRS, boundary between rock and sand and sandy patches among rocks; RC, rocky substratum, specially near cliffs, crevices and small caves; and SW, shallow water (less than 2 m deep) on the shoreline mainly in small bays and other sheltered places].

*Not all the specimens were identified to species, although some of them were *T. mediterraneus* (Steindachner, 1868). The most abundant member of this genus in the area is *T. trachurus* (Linnaeus, 1758).

†At this small size *L. ramada* and *L. aurata* (Risso, 1810), both common in the area, are difficult to distinguish in the field. Those individuals that were collected for laboratory identification and aquarium raising, all proved to be *L. ramada*.

‡Probably *L. saliens* (Risso, 1810) and *Mugil cephalus* according to the time of recruitment (October) (Salgado, unpubl.), but all juveniles reared in aquaria were *Mugil cephalus*.

§The systematic position of the European members of the genus *Atherina* is still controversial (Bamber & Henderson, 1985 and Creech, 1991). Our material meets the criteria that Whitehead *et al.* (1986) propose as diagnostics for *A. presbyter*.

Juveniles of at least 22 non-resident fish species were observed (Table I). At least 38 resident species from the families Muraenidae, Congridae, Syngnathidae, Serranidae, Pomacentridae, Labridae, Gobiidae, Callionymidae, Blenniidae, Tripterygiidae, Scophthalmidae and Gobiesocidae must be added to this list. Here the term resident is used for fishes, which after metamorphosis live permanently in the area and also breed there. The gadoids *Gaidropsarus mediterraneus* (Linnaeus, 1758) and *Ciliata mustela* (Linnaeus, 1758) were excluded from the count of non-resident fishes because, although not spawning inshore, they often stay there from small juveniles until they are adult (Wheeler, 1969; pers. obs.). Thus, in addition to the non-resident species considered in this paper, the sheltered rocky shore in the area is an important habitat for these 40 species also.

Several distinct patterns of occurrence can be recognized (Table I): (i) a group of rare species (*Trachurus* spp., *Mullus surmuletus* Linnaeus, 1758, Ammodytidae (unidentified) and *Hyperoplus lanceolatus* (Le Sauvage, 1824)) that occur usually in open water or sandy

shores (Wheeler, 1969; Whitehead *et al.*, 1986) and whose presence in the rocky area studied is probably incidental; (ii) juveniles that are present in the study site only for very short periods and at very small sizes (Mugilidae species) (these fishes spawn mainly offshore (Whitehead *et al.*, 1986) and their juveniles are found in large numbers and up to larger sizes in the nearby Sado Estuary (Salgado, unpubl.): the study site seems to be a stepping stone in their movement to the estuarine nursery grounds); and (iii) species that seem to spend most or all of their juvenile phase in the rocky coast. Some of them (*Trisopterus luscus* (Linnaeus, 1758), *Diplodus sargus* (Linnaeus, 1758), *D. vulgaris* (E. G. Saint-Hilaire, 1817), *Spondyliosoma cantharus* (Linnaeus, 1758) and *Atherina presbyter* Cuvier, 1829) also use estuaries as nurseries to varying degrees (Claridge *et al.*, 1986; Antunes *et al.*, 1988), while others (*Sardina pilchardus* (Walbaum, 1792), *Boops boops* (Linnaeus, 1758), *Diplodus cervinus* (Lowe 1841), *D. puntazzo* (Catti, 1777), *Oblada melanura* (Linnaeus, 1758), *Pagellus acarne* (Risso, 1826), *Pagrus auriga* (Valenciennes, 1843), *P. pagrus* (Linnaeus, 1758) and *Sarpa salpa* (Linnaeus, 1758)) are typically marine and usually are not found in other coastal or estuarine habitats. For these typically marine species, the rocky coast seems to function as an important nursery ground. The pollack *Pollachius pollachius* (Linnaeus, 1758) is at its southern limit and is too rare to show a clear pattern. It is interesting to note, however, that it was found on the rocky coast but not in the nearby estuary (Cunha & Peneda, 1985), whereas in British waters it occurs both in estuaries (Claridge *et al.*, 1986) and on rocky shores (Wheeler, 1969).

Our results show that a number of commercially important species use this sheltered rocky coast as juveniles, suggesting that it can play an important nursery role, as do estuaries. No data on zooplankton abundance in these inshore waters are available but values for phytoplankton are high (Cabeçadas *et al.*, unpubl.). The rocky shore is very rich in sessile organisms that emit large quantities of planktonic eggs and larvae, whose importance for juvenile fishes should be evaluated. Most juveniles were found near cliffs, on the boundary between sand and rock, and in the vicinity of crevices and caves, suggesting that they may be difficult to catch both by avian and aquatic predators. Moreover, very shallow waters exclude most large fishes, both heterospecifics and conspecifics, thus limiting the occurrence of potential predators.

It is suggested that inshore sheltered waters with diverse rocky substrata could be important for juvenile fishes in three respects: first, for resident inshore fishes; second as a first recruitment area for larvae and small juveniles of species that spawn offshore and are on their way to estuaries (group ii); and third as a nursery ground for non-resident fishes (group iii). For some of the latter, the rocky shore is probably the most important nursery area, while for others it may function as an alternative to estuaries (estuarine opportunists *sensu* Lenanton & Potter, 1987).

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