

---

## **Estuarine colonization, population structure and nursery functioning for 0-group sea bass (*Dicentrarchus labrax*), flounder (*Platichthys flesus*) and sole (*Solea solea*) in a mesotidal temperate estuary**

Filipe Martinho<sup>1,\*</sup>, Ricardo Leitão<sup>1</sup>, João Magalhães Neto<sup>1</sup>, Henrique Cabral<sup>2</sup>, Françoise Lagardère<sup>3</sup>, Miguel Ângelo Pardal<sup>1</sup>

<sup>1</sup> Institute of Marine Research (IMAR), c/o Department of Zoology, University of Coimbra, 3004-517 Coimbra, Portugal.

<sup>2</sup> Instituto de Oceanografia, Faculdade de Ciências da Universidade de Lisboa, Campo Grande, 1749-016 Lisboa, Portugal.

<sup>3</sup> Centre de Recherche sur les Ecosystèmes Littoraux Anthropisés (CRELA) (UMR 6217 CNRS – IFREMER - Université de La Rochelle) Place du Séminaire B.P. 5, 17137 L'Houmeau, France

\*: Corresponding author : Filipe Martinho, Tel: +351239837797; Fax: +351239823603; email address: [fmdm@ci.uc.pt](mailto:fmdm@ci.uc.pt)

---

### **Abstract:**

The function of the Mondego estuary as a fish nursery habitat was investigated from June 2003 to June 2004 by comparing the timing of estuarine colonization with juveniles of sea bass *Dicentrarchus labrax*, flounder *Platichthys flesus*, and sole *Solea solea*, while also analysing their population structure, growth and diet composition. Differences in the onset of estuarine colonization were observed, since sole juveniles were the first to enter the estuary (in January), followed by flounder in April and sea bass in June. The estuarine population of these species consisted of several age-groups, although the majority of individuals belonged to age-groups 0 and 1. The growth rates determined for 0-group fish were within the range of those reported for other European estuarine systems. Some differences were also recognized regarding the timing of estuarine colonization and the length of the growing season. Diet of 0-group sea bass consisted mainly of Crustacea, Polychaeta and Mollusca. Flounder juveniles fed chiefly on Amphipoda (especially *Corophium* spp.), with Polychaeta, Isopoda and Decapoda also being common prey. The diet of 0-group sole was dominated by Polychaeta, with Amphipoda, Mollusca and Decapoda ranking highest, with other important benthic organisms also being present. Dietary overlap among these species was relatively low.

**Keywords:** Estuarine colonization, Nursery areas, Feeding ecology, Trophic niche overlap, Mondego estuary

### **Introduction**

44 Estuaries are recognised to play an important role for a large number of marine fish  
45 species as nursery habitats and migration routes. According to Beck et al. (2001), the  
46 nursery role of estuarine areas implies high densities of fish during the first years, juveniles  
47 finding refuge from predators, high food availability and favourable conditions for rapid  
48 growth and good survival, thereby contributing significantly to the population recruitment.  
49 Recently, Dahlgren et al. (2006) proposed the concept of Effective Juvenile Habitat in  
50 order to describe fish habitats that are most important, regardless of area coverage, for their  
51 overall contribution to population size. Nevertheless, estuarine areas have long been  
52 subjected to anthropogenic pressures. Waste disposal from human activities and its  
53 consistent effects, particularly eutrophication, can have serious impacts on biological  
54 communities (Pardal et al., 2000; Dolbeth et al., 2003) changing the quantity and/or the  
55 quality of suitable habitats.

56 In estuaries, juveniles undertake upstream/downstream movements (Coggan and  
57 Dando, 1988; Dorel et al., 1991), which under particular circumstances may enhance their  
58 survival potential during winter months (Henderson and Seaby, 2005). Still, recruitment's  
59 strength and pattern variations are acknowledged to be mainly determined by various  
60 processes operating during the early life (mainly larval and post-settlement stages): tidal  
61 transport, wind regime, fluvial discharge, and predation (Marchand, 1991; Leggett and  
62 DeBlois, 1994; Van der Veer et al., 2000). Accordingly, shifts in the estuarine environment  
63 and in predation pressure can lead to important fluctuations in recruitment and population  
64 dynamics (Phil, 1990; Nash and Geffen, 2000). During the estuarine phase, the use of  
65 resources by organisms has a major influence on population and community interactions,  
66 on the dynamics of resource availability, and on the fate of resources in the ecosystem

67 (Elliott et al., 2002). As a result, resource partitioning within estuarine fish species is an  
68 important and interesting issue for understanding the structure and dynamics of these  
69 communities (Cabral, 2000).

70 Sea bass, *Dicentrarchus labrax* (Linnaeus, 1758), flounder, *Platichthys flesus*  
71 (Linnaeus, 1758), and sole, *Solea solea* (Linnaeus, 1758) are the most abundant marine fish  
72 whose juveniles use the Mondego estuary as a nursery area (Leitão et al., 2007; Martinho et  
73 al., 2007), similarly to other European estuarine systems (Aprahamian and Barr, 1985;  
74 Lagardère, 1987; Fonds et al., 1992; Cabral, 2000; Cabral and Costa, 2001). The specific  
75 objectives of this paper were to analyse the way the Mondego estuary functions as a  
76 nursery ground for 0-group sea bass, flounder and sole through the fish responses in terms  
77 of estuarine colonization, population structure, growth, feeding ecology and trophic niche  
78 overlap. Knowledge on the ecology of these species in southern European estuaries is  
79 scarce, specifically in the case of stressed areas like the Mondego estuary, which has been  
80 subjected to intense organic enrichment (Pardal et al., 2000). This environmental pressure  
81 may have a major impact on habitat quality for these juvenile fish, decreasing the  
82 abundance and biomass of benthic fauna as a consequence of hypoxic or anoxic conditions  
83 (Pardal et al., 2000).

84

## 85 **MATERIALS AND METHODS**

### 86 *Study area*

87 The Mondego River estuary (40°08'N, 8°50'W) is a small intertidal estuary located  
88 in the western coast of Portugal (Figure 1). In the upstream areas, about 7 km of the coast,  
89 it divides itself in two arms, north and south, that join again near the mouth. The two arms  
90 have very different hydrological features: the north arm is deeper (5 to 10 m during high

91 tide, tidal range 2 to 3 m), while the south arm (2 to 4 m deep, during high tide) is almost  
92 silted up in the upstream areas, causing the freshwater of the river to flow mainly by the  
93 north arm. A small freshwater input is carried out in the southern arm through the Pranto  
94 River, a small tributary system, which is regulated by a sluice according to the water needs  
95 in the surrounding rice fields. In the south arm, about 75% of the total area consists of  
96 intertidal mudflats, while in the northern arm this value is less than 10%.

97         The main environmental pressures in the Mondego estuary are: a) dredging and  
98 shipping in the north arm and b) raw sewage disposal and high nutrient inputs from  
99 agricultural and fish farms in the upstream areas of the south arm. Combined with a high  
100 water residence time, this led to an eutrophication process, resulting in macroalgae blooms  
101 of *Enteromorpha* spp. over the past two decades (Pardal et al., 2000; Dolbeth et al., 2003).  
102 However, the most downstream areas still remain relatively unchanged, exhibiting *Zostera*  
103 *noltii* meadows.

104

#### 105 *Sampling procedures*

106         Sampling in the Mondego estuary (Figure 1) was carried out monthly, at five  
107 stations (M, N1, N2, S1, S2), between June 2003 and June 2004. Fishing took place during  
108 the night at high water of spring tides, using a 2 m beam trawl with one tickler chain and 5  
109 mm mesh-size in the cod end. Three trawls were towed for an average of 5 minutes each on  
110 all sampling stations, covering at least an area of 500 m<sup>2</sup>. Additionally, in June 2003,  
111 October 2003, January 2004 and June 2004, three hauls of about 15 minutes each, were  
112 performed at stations M, N1 and N2 using a 10 m bottom otter trawl (10 mm mesh size)  
113 (this gear could not be operated in stations S1 and S2, due to constrains imposed by the

114 shallow depth in these areas). Both fishing techniques were performed approximately at the  
115 speed of 1 knot, along the current. All fish caught were identified, counted, measured (total  
116 length to the nearest 1mm) and weighed (wet weight with 0.01 g precision). Data from the  
117 replicates of each station were added to form one sample. Density values were estimated  
118 based only on beam trawl data. Hydrological records (bottom water temperature, salinity  
119 and dissolved oxygen) were obtained during the fishing campaigns.

120

### 121 *Population structure and growth*

122 Population structure and growth rates were estimated by tracking recognizable  
123 cohorts from successive sampling dates through size frequency distribution analysis,  
124 performed by ANAMOD software package (Nogueira, 1992).

125 Absolute growth rates (AGR) were determined only for 0-group fish as:

126 
$$AGR = \frac{Lt_2 - Lt_1}{t_2 - t_1}$$
, where  $Lt_2$  and  $Lt_1$  are the total length at time  $t_2$  and  $t_1$ , respectively.

127

### 128 *Feeding ecology*

129 The diet of 0-group *D. labrax* (n=324), *P. flesus* (n=204) and *S. solea* (n=304) was  
130 studied based only on the stomach contents, which were removed and preserved in 4%  
131 buffered formalin for later identification to the lowest possible taxonomical level. Each  
132 prey item was counted and weighted (wet weight with 0.001 g precision). The relative  
133 importance of preys was assessed using the numerical (NI), occurrence (OI) and  
134 gravimetric (GI) indices (Hyslop, 1980), and feeding activity was evaluated using the  
135 vacuity index (VI), given by the percentage of empty stomachs.

136 Diet overlap was evaluated by Schoener's Index:  $I_S = 1 - 0.5 \left( \sum_{i=1}^n |p_{i_A} - p_{i_B}| \right)$ , where  
137  $p_{i_A}$  and  $p_{i_B}$  are the numerical frequencies of item  $i$  on the diet of species  $A$  and  $B$ ,  
138 respectively (Linton et al., 1981). Although there are no critical levels for this index,  
139 Wallace and Ramsey (1983) suggested that values higher than 0.6 should be considered as  
140 biologically significant.

141

## 142 **RESULTS**

### 143 *Environmental conditions in the Mondego estuary*

144 Temperature and salinity showed a typical pattern for a southern temperate region,  
145 with summer values in the range 18-26°C and mild winter temperature. Both the highest  
146 temperature, 26°C in July 2003, and the lowest, 10° C in January 2004, were recorded in  
147 the shallow-water area of Station S2 (Figure 2). During the 2003 sampling series, salinity  
148 was highly variable in all stations, except in the upstream Station N2. A salinity gradient  
149 characterized the estuary from Station N2, under freshwater influence, to the mouth of the  
150 estuary – Station M, where the highest salinities were recorded. However, in 2004 there  
151 was a clear increase in salinity on all sampling stations. Dissolved oxygen showed a  
152 seasonal pattern, with lowest values in the summer and highest in the winter. In general,  
153 stations S2 and N2 presented the lowest oxygen concentrations. For further details on the  
154 environmental characteristics of the sampling stations, see Martinho et al. (2007).

155

### 156 *Estuarine colonization and population structure*

157 *D. labrax* was the most abundant species throughout the study, with 0-group  
158 maximum densities reaching 320 ind.1000 m<sup>-2</sup> (Figure 3). *P. flesus* and *S. solea* 0-group  
159 fish presented lower densities, with maximum values of 30 and 23 ind.1000 m<sup>-2</sup>,  
160 respectively (Figure 3). High variability in densities between years was registered for all  
161 species. The estuarine colonization started in June for *D. labrax*, in April for *P. flesus*,  
162 whereas *S. solea* started to colonize the estuary in late January. Four cohorts of *D. labrax*  
163 were recognised in June 2003, with C1, C2 and C3 for the 2-, 1- and 0-groups, respectively  
164 (Figures 4, 5). Observed at the end of the survey, the C4 was relative to newly 2004 0-  
165 group. For *P. flesus* and *S. solea*, only three cohorts were found between June 2003 and  
166 June 2004, with C1 and C2 representing 1- and 0-groups, respectively, and C3 the newly  
167 2004 group.

168

#### 169 *Growth*

170 The growth rates of 0-group fish were calculated based on the modal progression  
171 analysis (Figure 5). Sea bass growth rates presented an average growth rate of 0.24 mm d<sup>-1</sup>  
172 and maximum value of 0.65 mm d<sup>-1</sup>. From June 2003 to May 2004, 0-group fish size  
173 increased from 41.9 mm to 111.3 mm. For 0-group flounder, the maximum growth rate was  
174 0.91 mm d<sup>-1</sup>, with an average value of 0.20 mm d<sup>-1</sup>. From June 2003 to April 2004, mean  
175 total length ranged from 78.6 mm to 132.8 mm. The average growth rate of juvenile soles  
176 was 0.44 mm d<sup>-1</sup>, with a maximum value of 0.90 mm d<sup>-1</sup>. From June 2003 to December  
177 2003, mean total length increased from 77.7 mm to 168.1 mm.

178

#### 179 *Feeding ecology*

180 Diet of 0-group sea bass consisted mainly of crustaceans, polychaetes and molluscs  
181 (Table 1). Copepoda, Amphipoda (mainly *Corophium* spp.) and Decapoda (mainly  
182 *Crangon crangon*) were the most important preys in number (NI=53%), occurrence  
183 (OI=42%) and weight (GI=34%), respectively. Polychaeta was the second most important  
184 prey according to the three indices (NI=31%; OI=35%; GI=22%), Mollusca (mainly  
185 represented by siphons of *Scrobicularia plana*) were also important in number and  
186 occurrence, and Teleostei in weight.

187 The main prey of 0-group flounder was *Corophium* spp. (indices values higher than  
188 72%), followed by Polychaeta (NI = 9%, OI = 23% and GI = 17%), Isopoda (mainly  
189 *Cyathura carinata*) and Decapoda (especially *C. crangon*) (Table 1).

190 Sole juveniles fed mostly on Polychaeta (NI=81%, OI=69% and GI=65%).  
191 Amphipoda (mainly *Corophium* spp.), Teleostei, Mollusca (especially siphons of *S. plana*)  
192 and Decapoda (mainly *C. crangon*) were also important prey items in soles' diet, although  
193 with lower indices values when compared to Polychaeta (Table 1). Feeding activity, given  
194 by the percentage of empty stomachs (Vacuity Index, VI), was higher in *D. labrax* and  
195 lower in *S. solea*. Dietary overlap between the three species was low (all  $I_S$  values were  
196 lower or equal to 0.45) (Table 2).

197

## 198 **DISCUSSION**

### 199 *Sampling methodological approach*

200 In the present work, two sampling methodologies were used: a beam trawl and a  
201 bottom otter trawl, with different fishing efforts (beam trawl – monthly; otter trawl – every  
202 three months). While the beam trawl is easier to operate and to estimate densities (since the



203 area for catchment is constant), providing a good base for monthly/regular sampling of  
204 estuarine fish species, the otter trawl, gifted with a wider area for catchment, can be used  
205 for sampling larger specimens, that can easily escape the beam trawl (Fig. 6). Also, and  
206 according to Hemingway and Elliott (2002), beam trawl is an effective and appropriate  
207 method for collection of live specimens (and subsequent stomach analysis). Thus, it is  
208 suggested that otter trawl can be used as a complement for beam trawl surveys.

209

### 210 *Growing season*

211 The timing for settlement relies on the species' spawning period, the spawning  
212 ground location and the duration of the pelagic life. In the Mondego estuary, located in the  
213 southern areas of the geographic distribution for *D. labrax*, *P. flesus* and *S. solea*, the range  
214 of temperatures over the studied period covered 10-26° C. Temperature may act on fish  
215 growth and habitat use by promoting higher growth rates and/or higher length of the  
216 growing season, providing a production of prey liable to sustain fish requirements. The  
217 growth rates determined for the three species in the Mondego estuary were within the range  
218 of the values reported for other European estuaries (Table 3), although non maximal, at  
219 least for sole, as demonstrated by rearing experiments (see Van der Veer et al., 2001).

220 Throughout south-western Europe, mean total lengths of *D. labrax* juveniles at the  
221 end of their first year were similar, with values of 173 mm and 181 mm reported in the  
222 Tagus estuary (Portugal) (Cabral and Costa, 2001) and South Spain (Arias, 1980),  
223 respectively. These values were higher than those obtained for the Mondego estuary, with  
224 an estimated size of 100 mm at the same age (Table 3). This can be a consequence of the  
225 particular conditions of the Mondego estuary, mainly its small area (3.4 km<sup>2</sup>) and high

226 freshwater influence, inducing an earlier migration to the adjacent coastal areas by the  
227 largest fish since the end of summer, as observed by a decrease in mean length. For older  
228 fish, the results suggest that migration pulses can also occur throughout the year.

229         Regarding *P. flesus* juveniles, growth studies are scarce. However, differences in  
230 mean total length with those reported for the Wadden Sea (Lake Grevelingen) (Doornbos  
231 and Twisk, 1984) were found, since the individuals from the Mondego exhibited longer  
232 total lengths at the end of the fast growing season (Table 3). A migration pattern by the  
233 largest 0-group individuals was also observed, occurring only in the end of winter.

234         *S. solea* 0-group juveniles showed a marked latitudinal pattern in fish size. By the  
235 end of the fast growing season (end of autumn), in the northern areas, the mean total length  
236 varied from 90 mm to 115 mm, for the United Kingdom and Wadden Sea, respectively.. In  
237 the southernmost areas, the mean length of sole juveniles ranged from 166 mm to 173 mm,  
238 for Portugal and South Spain, respectively. Cabral (2003) suggested that these differences,  
239 leading to a larger fish size in the southernmost areas, may rely on higher growth rates  
240 during a longer fast growing season. The mean total length for this species in the Mondego  
241 (168.1 mm) was within the range for its geographical area (Table 3).

242         Winter temperature was not yet limiting for sole. Fonds and Rijnsdorp (1988) data's  
243 predicted a maximum AGR of 0.25 mm per day at 10° C and under the summer max (26°  
244 C), growth is predicted to be maximal (AGR = 1.6 mm per day) but it reaches the  
245 asymptote (see Van der Veer et al., 2001). According to Lefrançois and Claireaux (2003),  
246 the optimum temperature for metabolic scope for 1-year sole is 18.8° C, which combined  
247 with different food composition and availability (Van der Veer et al., 2001) and additional  
248 energy expenditures, probably results in non maximal growth, at least for sole. Bigger total

249 lengths than those measured in northern countries are also a result of a longer growing  
250 season.

251

### 252 *Population structure and estuarine colonization*

253         Distinct periods of estuarine colonization were observed. *S. solea* juveniles were the  
254 first to enter the estuary, in late January. This early colonization likely reflects a winter  
255 spawning period and a shorter pelagic life due to warmer waters in this area than  
256 northwards. In the Bay of Biscay, sole spawn from winter to spring at sea-water  
257 temperature around 8-9° C (Koutsikopoulos and Lacroix, 1992) and settlement is  
258 completed in late spring (Amara et al., 1994). Differences in the onset of colonization by  
259 sole in neighbour estuaries (Mondego and the Tagus) may be attributed to the wintering  
260 conditions and fluvial regime of each estuarine system (Le Pape et al., 2003) or to between-  
261 year climate induced variations (Cabral and Costa, 2001; Van der Veer et al., 2001).

262         *D. labrax* and *P. flesus* entered the estuary in late and early spring, respectively, as  
263 they are spring spawners (Van der Veer, 1985; Jennings and Pawson, 1992). By the end of  
264 the second year, all species carried out a seawards migration. In the following year(s) they  
265 returned to the estuary sporadically, as supported by the few older individuals caught  
266 occasionally at the mouth of the estuary, mainly in the otter trawl surveys. For the three  
267 species, only one annual cohort was found. This clearly contrasts with results obtained for  
268 other southern estuaries, namely the Tagus estuary (Cabral, 2003) and Ria Formosa  
269 (Andrade, 1992), where two distinct cohorts of 0-group juveniles of *S. solea* were  
270 described. This pattern can be attributed to an oceanographic boundary south to the

271 Mondego, the Peniche Peninsula, which is the northern limit for Mediterranean influence  
272 and the southern limit for North-Atlantic influence (Fiúza, 1982).

273 In the Bay of Biscay, the three species spawn roughly at the same season (winter-  
274 spring, depending on wintering conditions). Estuarine conditions resulted in non maximal  
275 growth rates for sole (and may be for the flounder), but a protracted growing season and  
276 food availability allowed 0-groups to reach big sizes before winter, contrary to the typical  
277 pattern of offshore emigration that occurs at higher latitudes.

278 All species showed a high variability in densities, which could be the result of inter-  
279 annual variations in recruitment strength (caused by either density-dependent or density-  
280 independent factors), that affect or promote recruitment and settlement of fishes in estuaries  
281 (Cabral et al., 2007).

282

### 283 *Nursery functioning*

284 Diet analysis showed that 0-group sea bass fed mostly on Crustacea, Polychaeta and  
285 Mollusca, as outlined in other studies (Arias, 1980; Aprahamian and Barr, 1985; Cabral  
286 and Costa, 2001). The most significant difference that can be observed when comparing  
287 results from other geographical areas is the low importance of Mysidacea in the diet of  
288 juveniles in the Mondego estuary. This clearly contrasts with the results reported by Arias  
289 (1980) for the Mediterranean, and by Cabral and Costa (2001) for the Tagus estuary, and  
290 may be due to a lower abundance of mysids in the Mondego estuary.

291 Flounder 0-group juveniles ate chiefly *Corophium* spp., which is the most abundant  
292 invertebrate species in the upstream areas colonized by this species (Martinho et al., 2007).  
293 Polychaetes, isopods and decapods were lesser important preys. Similar results were

294 obtained by Aarnio et al. (1996), in which amphipods and mysids composed most of the  
295 diet of 0-group flounders caught in the northern Baltic Sea. The preference for mobile and  
296 active prey, such as amphipods, was outlined by De Groot (1971), as this species is  
297 essentially a visual feeder.

298         The diet of juvenile soles consisted mainly of Polychaeta, being also important  
299 items Amphipoda, Mollusca and Decapoda. These feeding habits were similar to the ones  
300 described in the Tagus estuary, being the most important items Polychaeta and Amphipoda,  
301 particularly *Corophium* spp. (Cabral, 2000). This similarity can be attributed to the similar  
302 nursery and feeding grounds (mainly intertidal mudflats) occupied by this species in both  
303 estuaries.

304         The present results of the diet composition are consistent with the ones for other  
305 European estuaries (e.g. Arias, 1980; Aprahamian and Barr, 1985; Lagardère, 1987; Fonds  
306 et al., 1992; Aarnio et al., 1996; Cabral, 2000; Cabral and Costa, 2001; Hampel et al.,  
307 2005), reflecting mainly the available benthic fauna and emphasizing the generalist and  
308 opportunistic behaviour of these species. Analysis of trophic niche overlap showed that  
309 these species most likely did not compete directly for food. Partitioning of the available  
310 resources by the likely competitors is most probably prevented by an abundant food supply  
311 (Costa et al., 2002) and in agreement, the Mondego estuary appears to be a very productive  
312 system when compared to other tidal flats (Dolbeth et al., 2003). In addition, the observed  
313 spatial and temporal segregation between the three species seems to prevent direct  
314 competition, favouring a better partitioning of the available resources (Cabral et al., 2007),  
315 as observed in more northern systems (e.g. Hampel et al., 2005).

316 In conclusion, the nursery functioning greatly depends on the geographic area: in  
317 northern ecosystems an earlier cooling of coastal waters and estuarine habitats due to  
318 freshwater runoffs, set fish to disperse offshore from late summer onwards (Henderson and  
319 Seaby, 2005). The present results showed that milder conditions of southernmost estuaries  
320 allow fish to stay over winter inshore, probably protracting the growing season. In the  
321 Mondego estuary, this may also rely on the improvements of the global ecological quality  
322 due to a recovery of seagrass beds and the associated benthic fauna due to the  
323 implementation of eutrophication mitigation measures (Pardal et al., 2000; Dolbeth et al.,  
324 2003), thus increasing the carrying capacity of the whole system.

325

#### 326 **ACKNOWLEDGEMENTS**

327 The authors are indebted to the IMAR for funding and support and to all colleagues  
328 who assisted in field work and particularly to Marina Dolbeth and Heliana Teixeira for the  
329 help with the identification of stomach contents. This work was partially supported by III -  
330 Instituto de Investigação Interdisciplinar - Universidade de Coimbra, Research Project  
331 III/AMB/4/2005. The authors also wish to acknowledge the comments and suggestions of  
332 both the referees and the editor, who improved greatly the final manuscript.

333

#### 334 **REFERENCES**

335 Aarnio, K., Bonsdorff, E., Rosenback, R., 1996. Food and feeding habits of juvenile  
336 flounder, *Platichthys flesus* (L.), and turbot, *Scophthalmus maximus* L., in the Åland  
337 archipelago, northern Baltic Sea. *J. Sea Res.* 36, 311–320.

338 Amara, R.; Desaunay, Y.; Lagardère, F., 1994. Seasonal variation in growth of larval sole,  
339 *Solea solea* (L.) and consequences on the success of larval immigration. *Neth. J.*  
340 *Sea Res.* 32, 287–298.

341 Andrade, J. P., 1992. Age, growth and population structure of *Solea senegalensis* Kaup,  
342 1858 (Pisces, Soleidae) in the Ria Formosa (Algarve, Portugal). *Sci. Mar.* 56, 35–  
343 41.

344 Aprahamian, M. W.; Barr, C. D., 1985. The growth, abundance and diet of 0-group sea  
345 bass, *Dicentrarchus labrax*, from the Severn Estuary. *J. Mar. Biol. Assoc. U.K.* 65,  
346 19–180.

347 Arias, A., 1980. Crecimiento, régimen alimentario y reproducción de la dorada (*Sparus*  
348 *aurata* L.) y del robalo (*Dicentrarchus labrax* L.) en los esteros de Cádiz. *Invest.*  
349 *Pesq.* 44, 59–83.

350 Beck, M. W.; Heck Jr., K. L.; Able, K. W.; Childers, D. L.; Eggleston, D. B.; Gillanders, B.  
351 M.; Halpern, B.; Hays, C. G.; Hoshino, K.; Minello, T. J.; Orth, R. J.; Sheridan,  
352 P.F.; Weinsetin, M.P., 2001. The identification, conservation, and management of  
353 estuarine and marine nurseries for fish and invertebrates. *BioScience* 51(8), 633–  
354 641.

355 Cabral, H. N., 2000. Comparative feeding ecology of sympatric *Solea solea* and *S.*  
356 *senegalensis*, within the nursery areas of the Tagus estuary, Portugal. *J. Fish Biol.*  
357 57, 1550–1562.

358 Cabral, H. N., 2003. Differences in growth rates of juvenile *Solea solea* and *Solea*  
359 *senegalensis* in the Tagus estuary, Portugal. *J. Mar. Biol. Assoc. U.K.*, 83, 861–868.

360 Cabral, H. N.; Costa, M. J., 1999. Differential use of the nursery areas within the Tagus  
361 estuary by sympatric soles, *Solea solea* (Linnaeus, 1758) and *Solea senegalensis*  
362 (Kaup, 1858). *Env. Biol. Fish.* 56, 389–397.

363 Cabral, H. N.; Costa, M. J., 2001 Abundance, feeding ecology and growth of 0-group sea  
364 bass, *Dicentrarchus labrax*, within the nursery areas of the Tagus estuary. *J. Mar.*  
365 *Biol. Assoc. U.K.* 81, 679–682.

366 Cabral, H. N.; Vasconcelos, R.; Vinagre, C.; França, S.; Fonseca, V.; Maia, A.; Reis-  
367 Santos, P.; Lopes, M.; Ruano, M.; Campos, J.; Freitas, V.; Santos, P. T.; Costa, M.  
368 J., 2007. Relative importance of estuarine flatfish nurseries along the Portuguese  
369 coast. *J. Sea Res.* 57, 209-217.

370 Coggan, R. A.; Dando, P.R., 1988. Movements of juvenile Dover sole, *Solea solea* L., in  
371 the Tamar estuary, South-western England. *J. Fish Biol.* 33(A), 177-184.

372 Costa, M. J.; Cabral, H. N.; Drake, P.; Economou, A. N.; Fernandez-Delgado, C.; Gordo,  
373 L.; Marchand, J.; Thiel, R., 2002. Recruitment and Production of Commercial  
374 Species in Estuaries. In: *Fishes in Estuaries*. Eds: M. Elliot; K. Hemingway,  
375 Blackwell Science, United Kingdom. pp 54-123.

376 Dahlgren, C. P.; Kellison, G. T.; Adams, A.; Gillanders, B. M.; Kendall, M. S.; Layman, C.  
377 A.; Ley, J. A.; Nagelkerken, I.; Serafy, J.E., 2006. Marine nurseries and effective  
378 juvenile habitats: concepts and applications. *Mar. Ecol. Prog. Ser.* 312, 291-295.

379 De Groot, S. J., 1971. On the relationships between morphology of the alimentary tract,  
380 food and feeding behaviour in flatfishes (Pisces: Pleuronectiformes). *Neth. J. Sea*  
381 *Res.* 5, 121–196.



- 382 Desaunay, Y.; Perodou, J. B. ; Beillois, P., 1981. Étude des nurseries des poissons du littoral  
383 de la Loire-Atlantique. *Sci. Pech.* 319, 1–23.
- 384 Dolbeth, M.; Pardal, M. A.; Lillebø, A. I.; Azeiteiro, U.; Marques, J. C., 2003. Short- and  
385 long-term effects of eutrophication on the secondary production of an intertidal  
386 macrobenthic community. *Mar. Biol.* 143, 1229-1238.
- 387 Doornbos, G.; Twisk, F., 1984. Density, growth and annual food consumption of plaice  
388 (*Pleuronectes platessa* L.) and flounder (*Platichthys flesus* L.) in Lake Grevelingen,  
389 the Netherlands. *Neth. J. Sea Res.* 18(3/4), 434–456.
- 390 Dorel, D.; Koutsikopolous, C.; Desunay, Y.; Marchand, J., 1991. Seasonal distribution of  
391 young sole (*Solea solea* (L.)) in the nursery ground of the Bay of Vilaine (Northern  
392 Bay of Biscay). *Neth. J. Sea Res.* 27(3/4), 297–306.
- 393 Elliott, M.; Hemingway, K. L.; Costello, M. J.; Duhamel, S.; Hostens, K.; Labropoulou,  
394 M.; Marshall, S.; Winkler, H., 2002. Links between fish and other trophic levels. In:  
395 Fishes in Estuaries. Eds: M. Elliot; K. Hemingway, Blackwell Science, United  
396 Kingdom. pp 124-216.
- 397 Fiúza, A. F. G., 1982. The Portuguese upwelling system. Actual problems of oceanography  
398 in Portugal. Junta Nacional de Investigação Científica e Tecnológica, Lisboa,  
399 Portugal. pp 45-71.
- 400 Fonds, M.; Rijnsdorp, A. D., 1988. Eten en groeien. In: Als een Vis in het Water. Eds  
401 J.W.M. Osse; J.J. Zilstra; H.M. Van Emdem, Pudoc, Wageninen. pp 120-138.
- 402 Fonds, M.; Cronie, R.; Vethaak, A. D.; Van Der Puyl, P., 1992. Metabolism, food  
403 consumption and growth of plaice (*Pleuronectes platessa*) and flounder (*Platichthys*  
404 *flesus*) in relation to fish size and temperature. *Neth. J. Sea Res.* 29, 127–143.

405 Gravier, R., 1961. Les bars (loups) du Maroc Atlantique *Morone labrax* (Linné) et *Morone*  
406 *punctata* (Bloch). *Rev. Trav. Inst. Pech. Marit.* 25, 281–292.

407 Gordo, L. S., 1989. Age, growth and sexuality of sea bass, *Dicentrarchus labrax* (Linnaeus,  
408 1758) (Perciformes, Moronidae) from Aveiro lagoon, Portugal. *Sci. Mar.* 53, 121–  
409 126.

410 Hampel, H.; Cattrijsse, A.; Elliot, M., 2005. Feeding habits of young predatory fish in  
411 marsh creeks situated along the salinity gradient of the Schelde estuary, Belgium  
412 and The Netherlands. *Helgol. Mar. Res.* 59, 151-162.

413 Hemingway, K L.; Elliott, M., 2002. Field Methods. In: Fishes in Estuaries. Eds: M. Elliot;  
414 K. Hemingway, Blackwell Science, United Kingdom. pp 410-509.

415 Henderson, P. A.; Seaby, R. M., 2005. The role of climate in determining the temporal  
416 variation in abundance, recruitment and growth of sole *Solea solea* in the Bristol  
417 Channel. *J. Mar. Biol. Ass. U.K.* 85, 197-204.

418 Hyslop, E. J., 1980. Stomach contents analysis: a review of methods and their application.  
419 *J. Fish Biol.* 17, 415–429.

420 Jager, Z.; Kleef, H.; Tydeman, P., 1995. Mortality and growth of 0-group flatfish in the  
421 brackish Dollard (Ems estuary, Wadden Sea). *J. Fish Biol.* 34, 119–129.

422 Jennings, S.; Lancaster, J. E.; Ryland, J. S.; Shackley, S. E., 1991. The age structure and  
423 growth dynamics of young-of-the-year bass, *Dicentrarchus labrax*, populations. *J.*  
424 *Mar. Biol. Assoc. U.K.* 71, 799–810.

425 Jennings, S.; Pawson, M. G., 1992. The origin and recruitment of bass, *Dicentrarchus*  
426 *labrax*, larvae to nursery areas. *J. Mar. Biol. Assoc. U.K.* 72, 199–212.

427 Koutsikopoulos, C.; Lacroix, N., 1992. Distribution and abundance of sole (*Solea solea*  
428 (L.)) eggs and larvae in the Bay of Biscay between 1986 and 1989. *Neth. J. Sea Res.*  
429 29, 81-91.

430 Lagardère, J. P., 1987. Feeding ecology and daily food consumption of common sole *Solea*  
431 *vulgaris* Quensel, juveniles on the French Atlantic Coast. *J. Fish Biol.* 30, 91–104.

432 Lefrançois, C.; Claireaux, G., 2003. Influence of ambient oxygenation and temperature on  
433 metabolic scope and scope for heart rate in the common sole *Solea solea*. *Mar.*  
434 *Ecol. Prog. Ser.* 259, 273-284.

435 Leggett, W. C.; DeBlois, E., 1994. Recruitment in marine fishes: is it regulated by  
436 starvation and predation in the eggs and larval stages. *Neth. J. Sea Res.* 32, 119–  
437 134.

438 Leitão, R.; Martinho, F.; Cabral, H.; Jorge, I.; Marques, J. C.; Pardal, M. A. The fish  
439 assemblage of the Mondego estuary: composition, structure and trends over the past  
440 two decades. *Hydrobiologia* 587, 269-279.

441 Le Pape, O.; Chauvet, F.; Désaunay, Y.; Guérault, D., 2003. Relationship between  
442 interannual variations of the river plume and the extent of nursery grounds for the  
443 common sole (*Solea solea*, L.) in Vilaine Bay. Effects on recruitment variability. *J.*  
444 *Sea Res.* 50, 177-185.

445 Linton, R. L.; Davies, R. W.; Wrona, F.J., 1981. Resource utilization indices; an  
446 assessment. *J. Anim. Ecol.*, 50, 283-293.

447 Marchand, J., 1991. The influence of environmental conditions on settlement, distribution  
448 and growth of 0-group sole (*Solea solea* (L.)) in a macrotidal estuary (Vilaine,  
449 France). *Neth. J. Sea Res.* 27, 307-316.

450 Martinho, F.; Leitão, R.; Neto, J. M.; Cabral, H.; Marques, J. C.; Pardal, M. A. The use of  
451 nursery areas by juvenile fish in a temperate estuary, Portugal. *Hydrobiologia* 587,  
452 281-290.

453 Nash, R. D. M.; Geffen, A. J., 2000. The influence of nursery ground processes in the  
454 determination of year-class strength in juvenile plaice *Pleuronectes platessa* L. in  
455 Port Erin Bay, Irish Sea. *Neth. J. Sea Res.* 44, 101–110.

456 Nogueira, A. J., 1992. ANAMOD — Extracção dos componentes modais de distribuições  
457 de frequências de variáveis biométricas. Thesis, University of Coimbra, Coimbra,  
458 Portugal.

459 Pardal, M. A.; Marques, J. C.; Metelo, I.; Lillebø, A. I.; Flindt, M. R., 2000. Impact of  
460 eutrophication on the life cycle, population dynamics and production of *Ampithoe*  
461 *valida* (Amphipoda) along an estuarine spatial gradient (Mondego estuary,  
462 Portugal). *Mar. Ecol. Prog. Ser.* 196, 207-219.

463 Pihl, L., 1990. Year-class strength regulation in plaice (*Pleuronectes platessa* L.) on the  
464 Swedish west coast. *Hydrobiologia* 195, 79–88.

465 Ramos, J., 1982. Estudio de la edad y crecimiento del lenguado *Solea solea* (Linneo,  
466 1758) (Pisces, Soleidae). *Invest. Pesq.* 46, 15–28.

467 Rogers, S. I., 1994. Population density and growth rate of juvenile *Solea solea*. *Neth. J. Sea*  
468 *Res.* 32, 353–360.

469 Van der Veer, H. W., 1985. Impact of coelenterate predation on larval plaice *Pleuronectes*  
470 *platessa* and flounder *Platichthys flesus* stock in the western Wadden Sea. *Mar.*  
471 *Ecol. Prog. Ser.* 25, 229–238.

- 472 Van der Veer, H. W.; Berghahn, R.; Miller, J.; Rijnsdorp, A. D., 2000. Recruitment in  
473 flatfish, with special emphasis on North Atlantic species: progress made by the  
474 Flatfish Symposia. *ICES J. Mar. Sci.* 57, 202–215.
- 475 Van der Veer, H. W.; Dapper, R.; Witte, J. I. J., 2001. The nursery function of intertidal  
476 areas in the western Wadden Sea for 0-group sole *Solea solea* (L.). *J. Sea Res.* 45,  
477 271-279.
- 478 Wallace, H.; Ramsey, J. S., 1983. Reliability in measuring diet overlap. *Can. J. Fish.*  
479 *Aquat. Sci.* 40, 347–351.

480 **Table 1.** Relative importance of prey items on the diet of *D. labrax* (n=324), *P. flesus*  
 481 (n=204) and *S. solea* (n=304), according to the numeric (NI), occurrence (OI) and  
 482 gravimetric (GI) indices (ni – not identified items; VI - Vacuity index).  
 483

Prey item	<i>D. labrax</i>			<i>P. flesus</i>			<i>S. solea</i>		
	NI	OI	GI	NI	OI	GI	NI	OI	GI
<b>Mollusca</b>	<b>3.70</b>	<b>24.01</b>	<b>3.98</b>	<b>0.67</b>	<b>3.95</b>	<b>2.15</b>	<b>4.39</b>	<b>13.37</b>	<b>4.16</b>
<i>Abra alba</i>	-	-	-	-	-	-	0.08	0.50	1.12
<i>Cerastoderma edule</i>	0.02	0.72	0.01	-	-	-	0.08	0.50	0.00
<i>Cerastoderma</i> sp.	-	-	-	0.15	0.66	0.75	0.08	0.50	0.01
<i>Corbicula</i> sp.	-	-	-	0.41	1.32	0.16	0.57	0.50	0.17
<i>Hidrobia ulvae</i>	0.03	0.36	0.02	0.04	0.66	0.01	0.08	0.50	0.00
<i>Scrobicularia plana</i>	3.64	22.22	3.86	0.04	0.66	0.13	3.01	9.41	1.88
Solecurtidae ni	-	-	-	-	-	-	0.08	0.50	0.12
Bivalvia ni	0.02	0.72	0.09	0.04	0.66	1.10	0.41	0.99	0.85
<b>Polychaeta</b>	<b>30.69</b>	<b>35.13</b>	<b>22.25</b>	<b>9.40</b>	<b>23.03</b>	<b>17.25</b>	<b>80.75</b>	<b>68.81</b>	<b>65.33</b>
<i>Alkmaria rominji</i>	0.02	0.36	0.01	-	-	-	0.24	0.50	1.14
<i>Chone</i> sp	-	-	-	-	-	-	0.16	0.50	5.41
<i>Glycera tridactyla</i>	-	-	-	-	-	-	0.24	0.50	0.58
<i>Lagis koreni</i>	-	-	-	-	-	-	0.65	3.47	1.64
<i>Nephtys</i> sp	-	-	-	0.07	1.32	2.89	6.74	9.90	35.19
<i>Nereis diversicolor</i>	0.46	14.70	7.44	0.04	0.66	2.77	0.24	1.49	6.12
Capitellidae ni	28.92	16.13	14.64	5.44	7.89	2.87	39.16	16.34	2.55
Spionidae ni	-	-	-	3.26	8.55	6.85	13.40	11.88	4.37
Terebellidae ni	-	-	-	-	-	-	0.24	1.49	1.77
Polychaeta ni	1.29	3.94	0.16	0.59	4.61	1.87	19.66	22.77	6.58
<b>Acarina ni</b>	<b>0.05</b>	<b>1.08</b>	<b>0.00</b>	-	-	-	-	-	-
<b>Arachnida ni</b>	<b>0.01</b>	<b>0.36</b>	<b>0.00</b>	-	-	-	-	-	-
<b>Cladocera ni</b>	<b>0.18</b>	<b>0.36</b>	<b>0.05</b>	-	-	-	-	-	-
<b>Copepoda ni</b>	<b>53.43</b>	<b>17.92</b>	<b>3.89</b>	<b>0.07</b>	<b>1.32</b>	<b>0.01</b>	<b>1.22</b>	<b>5.45</b>	<b>0.06</b>
<b>Insecta</b>	<b>0.05</b>	<b>2.51</b>	<b>0.05</b>	-	-	-	-	-	-
Heteroptera ni	0.02	0.72	0.03	-	-	-	-	-	-
Insecta ni	0.04	1.79	0.02	-	-	-	-	-	-
<b>Cumacea ni</b>	-	-	-	-	-	-	<b>0.08</b>	<b>0.50</b>	<b>0.01</b>
<b>Mysidacea</b>	<b>1.61</b>	<b>20.43</b>	<b>4.26</b>	<b>0.04</b>	<b>0.66</b>	<b>0.25</b>	<b>0.81</b>	<b>2.48</b>	<b>0.36</b>
<i>Mesopodopsis slaberi</i>	0.02	0.36	0.01	-	-	-	-	-	-
<i>Neomysis integer</i>	0.05	1.43	0.09	-	-	-	-	-	-
<i>Paramysis nouveli</i>	0.02	0.72	0.02	-	-	-	0.08	0.50	0.22
<i>Praunus flexuosus</i>	0.12	1.43	0.40	-	-	-	-	-	-
Misidacea ni	1.41	16.49	3.74	0.04	0.66	0.25	0.73	1.98	0.14
<b>Isopoda</b>	<b>0.56</b>	<b>12.90</b>	<b>1.15</b>	<b>1.11</b>	<b>9.21</b>	<b>0.63</b>	<b>1.06</b>	<b>4.95</b>	<b>0.83</b>
<i>Cyathura carinata</i>	0.14	3.58	0.43	1.00	7.89	0.57	1.06	4.95	0.83
<i>Sphaeroma serratum</i>	0.36	6.81	0.68	0.11	1.32	0.06	-	-	-
Idoteidae ni	0.04	1.79	0.00	-	-	-	-	-	-

Isopoda ni	0.02	0.72	0.03	-	-	-	-	-	-
<b>Amphipoda</b>	<b>6.74</b>	<b>42.29</b>	<b>14.16</b>	<b>87.79</b>	<b>94.74</b>	<b>72.14</b>	<b>6.99</b>	<b>17.82</b>	<b>3.34</b>
<i>Corophium</i> spp.	5.92	21.15	11.98	84.57	66.45	69.97	5.77	11.39	2.75
<i>Echinogammarus</i> sp.	0.04	0.72	0.01	0.33	4.61	0.32	-	-	-
<i>Gammarus</i> sp.	0.06	2.15	0.45	0.70	8.55	0.49	0.08	0.50	0.03
<i>Leptocheirus pilosus</i>	0.02	0.72	0.00	0.70	2.63	0.14	-	-	-
<i>Melita palmata</i>	0.07	2.15	0.10	0.04	0.66	0.01	-	-	-
<i>Orchestia</i> sp.	0.23	5.02	0.98	0.33	2.63	0.37	0.08	0.50	0.01
Amphipoda ni	0.41	10.39	0.63	1.11	9.21	0.84	1.06	5.45	0.56
<b>Decapoda</b>	<b>2.23</b>	<b>27.24</b>	<b>33.65</b>	<b>0.30</b>	<b>3.29</b>	<b>2.87</b>	<b>0.89</b>	<b>5.45</b>	<b>20.51</b>
<i>Carcinus maenas</i>	0.15	6.09	8.43	-	-	-	0.16	0.99	17.64
<i>Crangon crangon</i>	2.07	20.43	24.90	0.30	3.29	2.87	0.73	4.46	2.87
<i>Palaemon</i> sp.	0.02	0.72	0.32	-	-	-	-	-	-
<b>Crustacea ni</b>	<b>0.48</b>	<b>13.26</b>	<b>6.02</b>	<b>0.04</b>	<b>0.66</b>	<b>0.30</b>	<b>0.73</b>	<b>2.97</b>	<b>0.57</b>
<b>Echinodermata</b>	-	-	-	-	-	-	<b>0.16</b>	<b>0.99</b>	<b>0.40</b>
Echinoidea ni	-	-	-	-	-	-	0.16	0.99	0.40
<b>Teleostei</b>	<b>0.17</b>	<b>7.89</b>	<b>9.39</b>	<b>0.15</b>	<b>2.63</b>	<b>0.13</b>	<b>1.30</b>	<b>7.92</b>	<b>1.16</b>
<i>Pomatoschistus</i> sp.	0.05	2.51	2.80	-	-	-	0.08	0.50	0.04
Teleostei ni	0.11	5.38	6.58	0.15	2.63	0.13	1.22	7.43	1.12
<b>Algae ni</b>	-	-	-	-	-	-	<b>0.32</b>	<b>1.98</b>	<b>0.20</b>
<b>ni</b>	<b>0.10</b>	<b>4.66</b>	<b>1.18</b>	<b>0.44</b>	<b>7.89</b>	<b>5.27</b>	<b>1.30</b>	<b>7.92</b>	<b>3.06</b>
<b>VI</b>		13.9			25.5			33.6	

484

485

486

487 **Table 2.** Schoener Index values between 0-group *D. labrax*, *P. flesus* and *S. solea* in the  
488 Mondego Estuary nursery areas, indicating diet overlap between species (values above 0.6  
489 are considered as biologically significant).

490

491

492

493

494

	<i>D. labrax</i>	<i>P. flesus</i>
<i>P. flesus</i>	0.18	-
<i>S. solea</i>	0.45	0.19



495 **Table 3.** Mean total length (mm) and absolute growth rate (AGR) (mm d<sup>-1</sup>) maximum  
 496 values of 0-group *D. labrax*, *P. flesus* and *S. solea* at the end of the fast growing season,  
 497 according to the geographical area.

Species	Geographical area	Total length (month)	AGR	Author(s)
<i>D. labrax</i>	United Kingdom, South Wales Coast	-	0.60	Jennings et al., (1991)
<i>D. labrax</i>	Portugal, Aveiro Lagoon	170 (December)	-	Gordo (1989)
<i>D. labrax</i>	Portugal, Mondego Estuary	111 (December)	0.65	Present study
<i>D. labrax</i>	Portugal, Tagus Estuary	173 (November)	1.53	Cabral and Costa (2001)
<i>D. labrax</i>	Spain, San Pedro Estuary (Cádiz)	181	-	Arias (1980)
<i>D. labrax</i>	Morocco, Atlantic Coast	-	0.83	Gravier (1961)
<i>P. flesus</i>	Netherlands, Lake Grevelingen	110	-	Doornbos and Twisk (1984)
<i>P. flesus</i>	Portugal, Mondego Estuary	125 (November)	0.91	Present study
<i>S. solea</i>	Wadden Sea, Ems Estuary	115 (October)	1.95	Jager et al. (1995)
<i>S. solea</i>	United Kingdom, North Wales Coast	90 (October)	0.57	Rogers (1994)
<i>S. solea</i>	France, Loire Estuary	110 (December)	-	Desaunay (1981)
<i>S. solea</i>	Portugal, Mondego Estuary	168 (December)	0.90	Present study
<i>S. solea</i>	Portugal, Tagus Estuary	166 (October)	1.51	Cabral (2003)
<i>S. solea</i>	Spain, Castellón Coast	173 (December)	-	Ramos (1982)

498

499

500

501

502

503 **FIGURE LEGENDS**

504

505 Figure 1 – The Mondego estuary and the location of the 5 sampling stations (A–E) (2003-  
506 2004).

507

508 Figure 2 –, Monthly variation of (A) temperature (°C), (B) salinity and (C) dissolved  
509 oxygen ( $\text{mg L}^{-1}$ ) in the Mondego estuary during the period of June 2003 to June 2004.

510

511 Figure 3 - Monthly variation of 0-group *D. labrax* (A), *P. flesus* (B), *S. solea* (C) per 1000  
512  $\text{m}^2$  (based on beam trawl surveys).

513

514 Figure 4 – Size frequency distribution of (A) *D. labrax*, (B) *P. flesus* and (C) *S. solea*  
515 populations. Arrowheads indicate the identified cohorts (C); N indicates the total number of  
516 measured individuals.

517

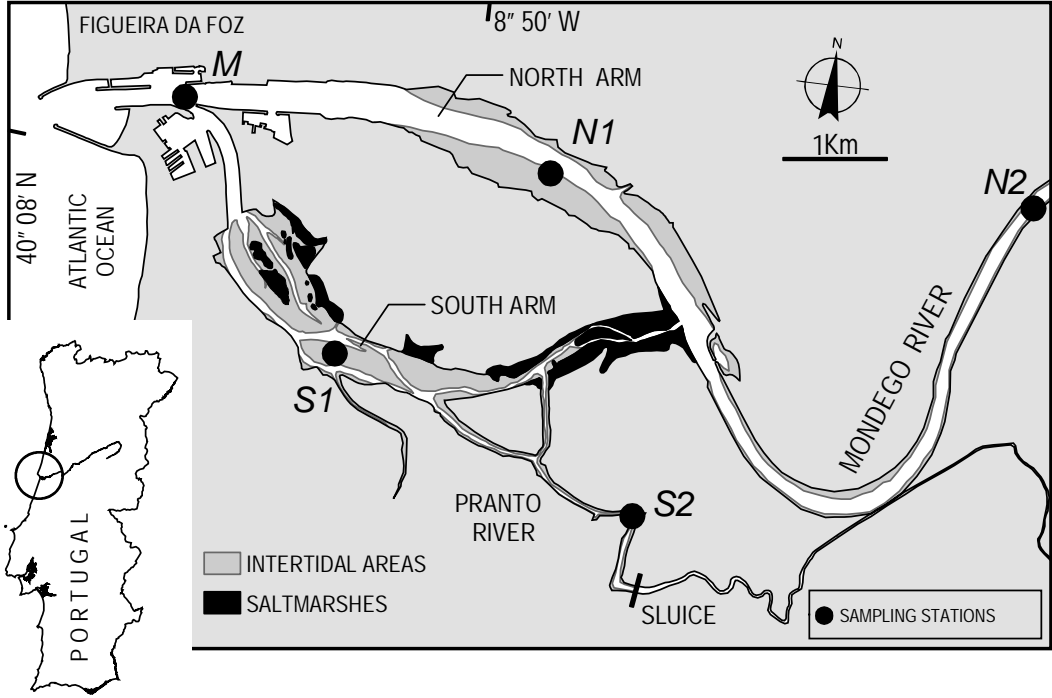
518 Figure 5 – Variation of mean fish length ( $\pm$  standard deviation) during the study period, for  
519 each cohort identified for juvenile (A) *D. labrax*, (B) *P. flesus* and (C) *S. solea*.

520

521 Figure 6 – Comparison between the average total length of *D. labrax*, *P. flesus* and *S.*  
522 *solea*, captured with different fishing methodologies: beam and otter trawl.

523 **Figure 1**

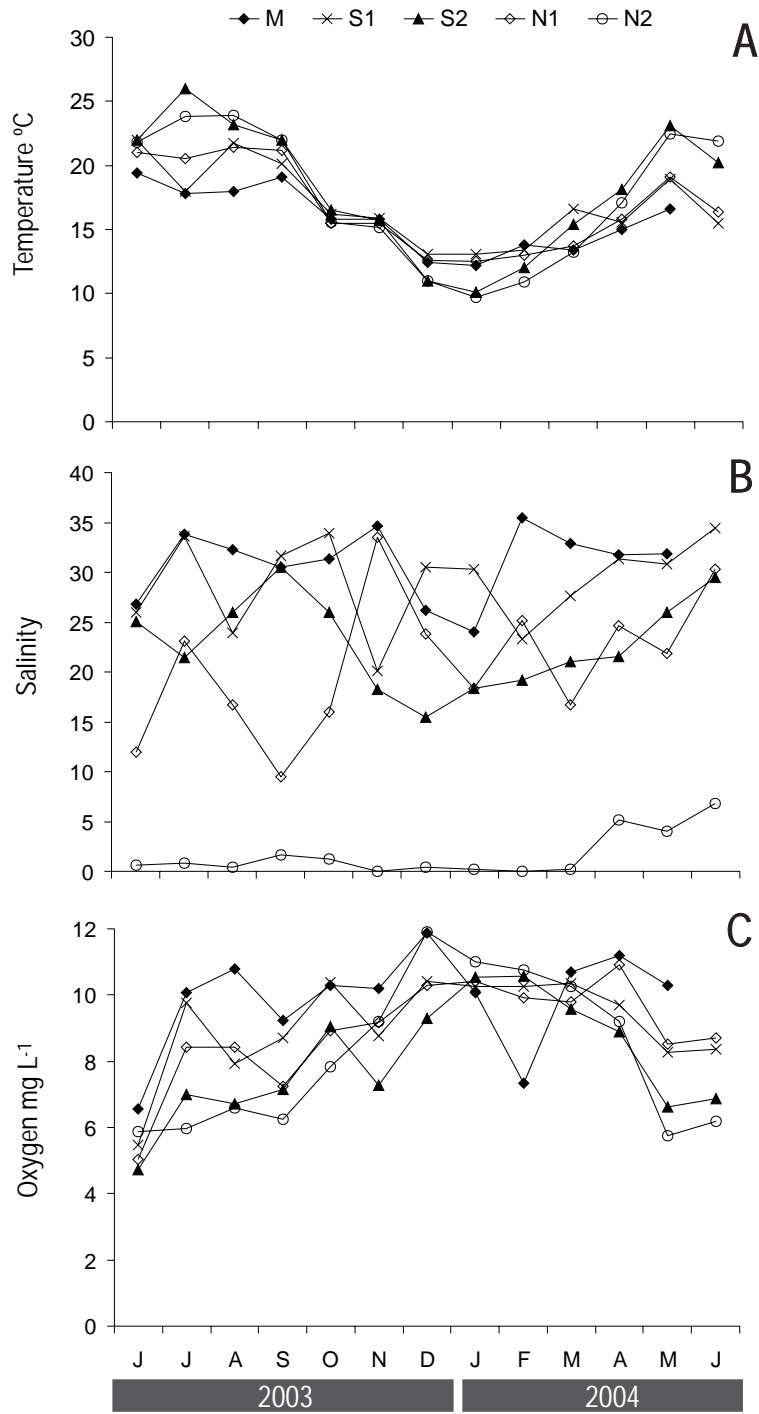
524



525

526

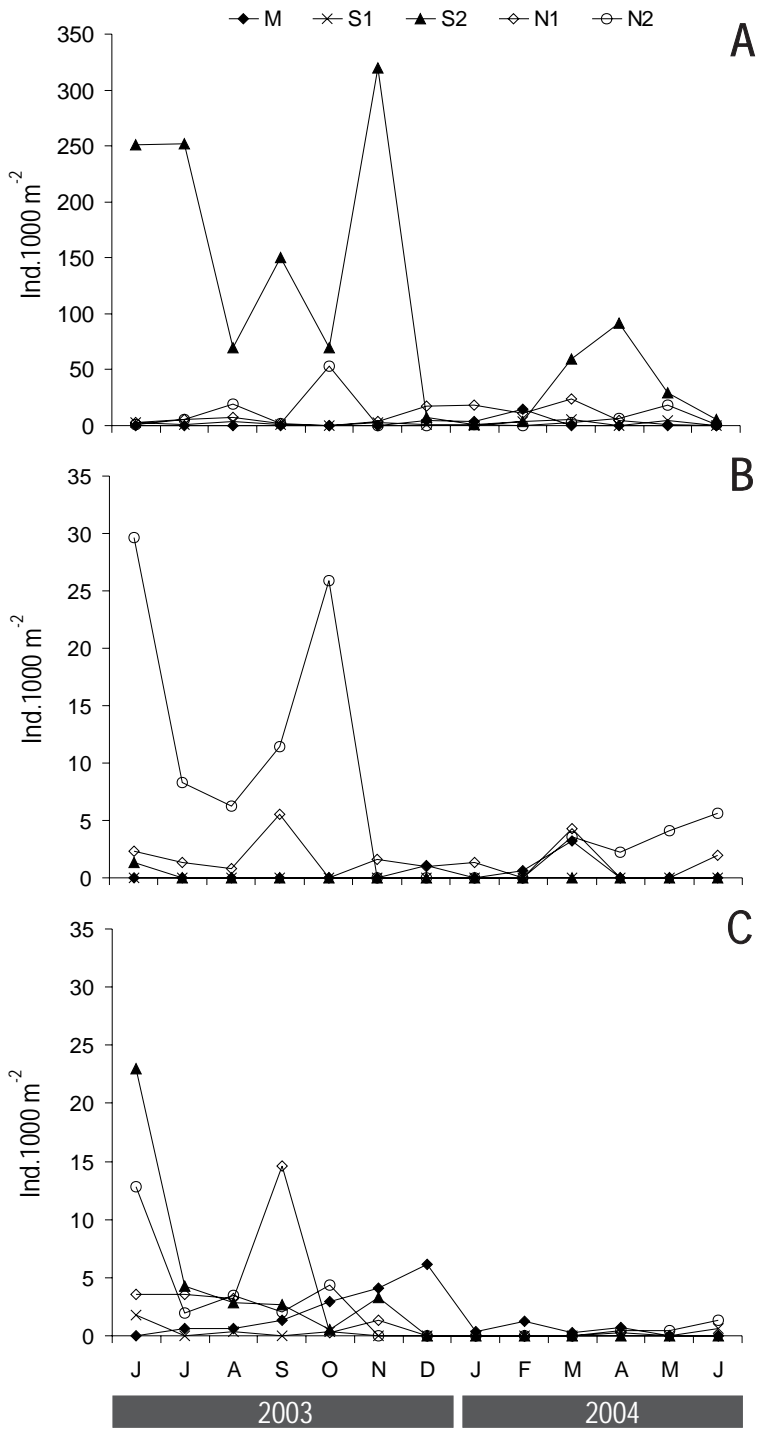
527 **Figure 2**



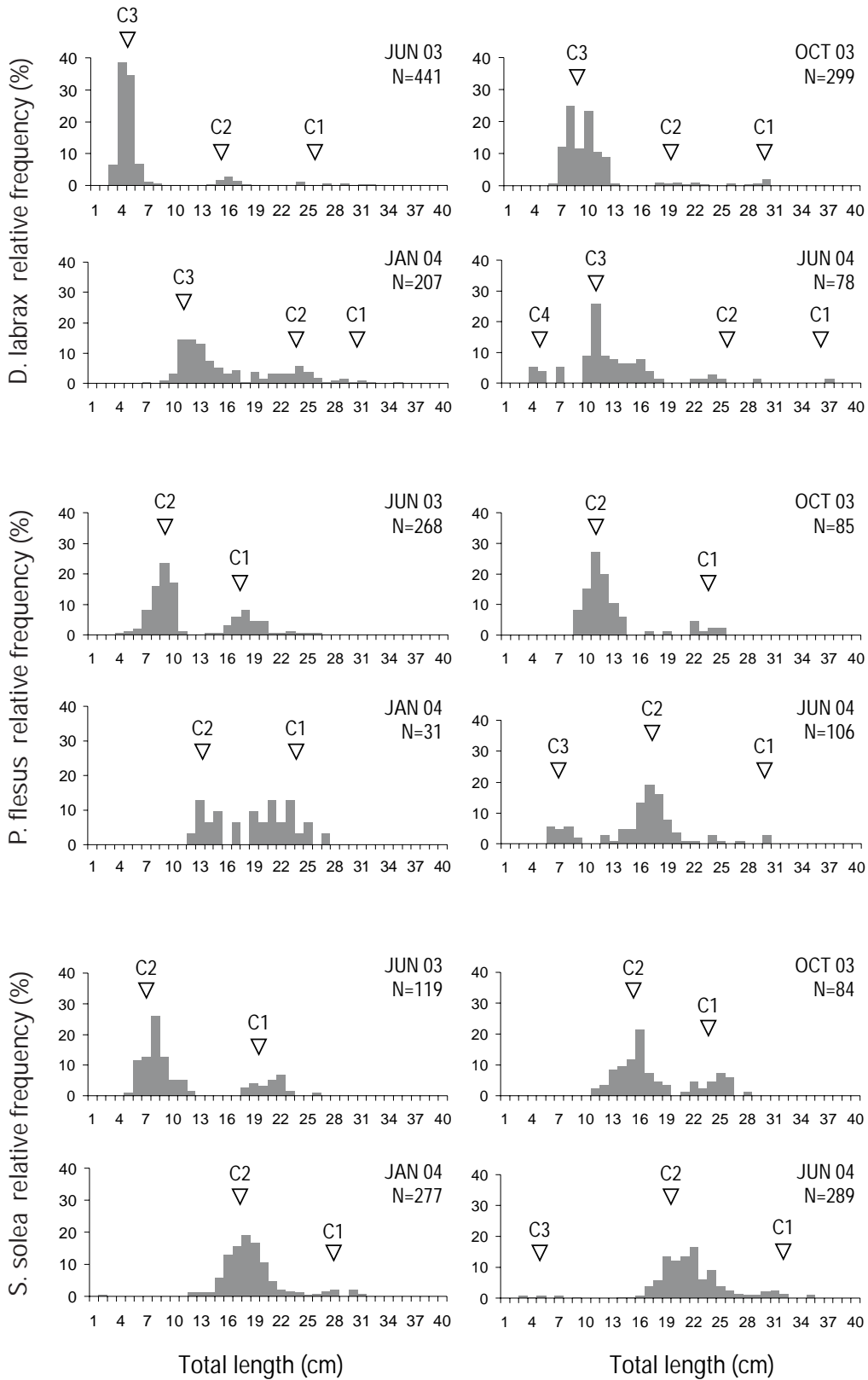
528

529

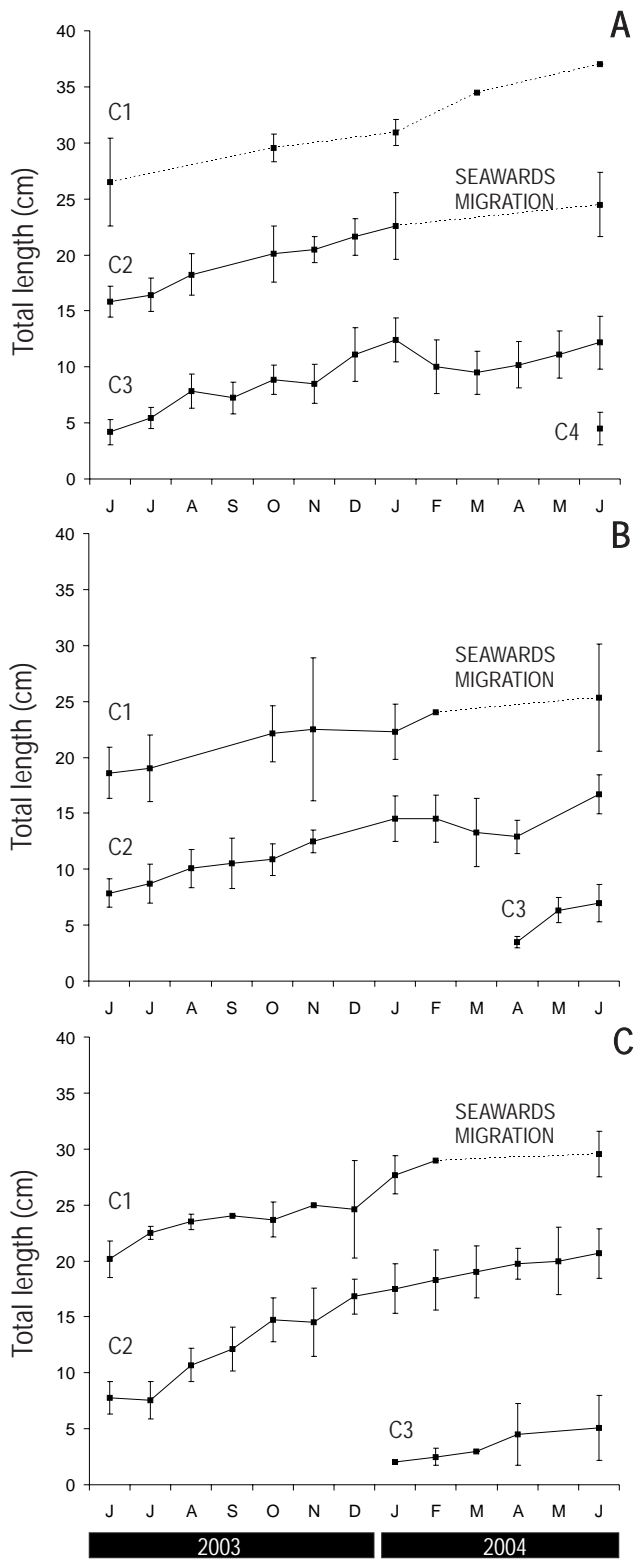
530 **Figure 3**



531

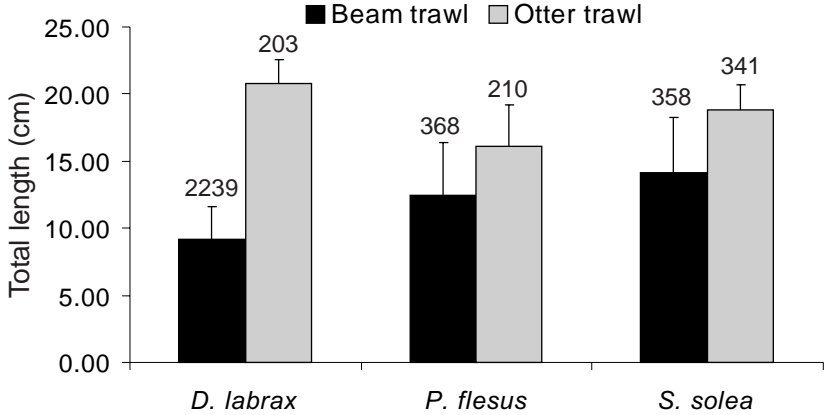


534 **Figure 5**



535

536 **Figure 6**



537

538