

# $\delta N$ and $\delta C$ in the Mondego estuary food web: seasonal variation in producers and consumers

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## Accepted Manuscript

 $\delta$   $^{15}N$  and  $\delta$   $^{13}C$  in the Mondego estuary food web: seasonal variation in producers and consumers

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| 1        | $\delta^{15}N$ and $\delta^{13}C$ in the Mondego estuary food web: seasonal variation in producers and  |
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| 18       |   |
| 19       |   |
| 20       | Abstract  |
| 21       | Assessments of temporal variation in stable carbon and nitrogen ratios were used to   |
| 22       | examine seasonal trends of the water column and benthic food webs in the Mondego estuary  |
| 23       | (Portugal). There was a marked seasonality in weather and water column conditions,  |
| 24<br>25 | any iron mental changes, we found little evidence of seasonal variation in $\delta^{13}$ C and $\delta^{15}$ N of   |
| 25<br>26 | producers and consumers in the Mondego estuary with a few notable exceptions. Nitrogen  |
| 27       | isotope ratios in macrophytes (Zostera noltii Illya sp. Enteromorpha sp. Gracilaria sp.)  |
| 28       | and in two grazers (Idotea chelines Lekanesnhaera levii) increased during late summer with  |
| 29       | the highest $\delta^{15}$ N values being measured in July, during a period of elevated temperatures and   |
| 30       | drought, which may have favored high rates of denitrification and heavier $\delta^{15}N$ values. The  |
| 31       | results suggest that stable isotope values from macrophytes and selected grazers are useful as  |
| 32       | tracers of seasonal changes in nitrogen inputs into estuaries, and that those of consumers  |
| 33       | reflect other factors beyond seasonal variations in N and C sources.  |
| 34       |   |

*Keywords*: Mondego estuary;  $\delta^{13}$ C;  $\delta^{15}$ N; Coastal eutrophication; Seasonality; Estuarine 36 species

## **1. Introduction**

| 39 | Increased anthropogenic delivery of nutrients to water bodies, both freshwater and                           |
|----|--|
| 40 | estuarine, has caused detrimental changes in habitat, food web structure, and nutrient cycling               |
| 41 | (Valiela et al., 1997; Cole et al., 2004). The resulting eutrophication has many adverse effects             |
| 42 | within the estuaries (D'Avanzo et al., 1996; Hauxwell et al., 2003). Increased N loading can                 |
| 43 | lead to the loss of important estuarine habitats like seagrass meadows (Hauxwell et al.,                     |
| 44 | 2003). Eutrophic estuaries can also suffer from hypoxia and anoxia (Zimmerman and Canuel,                    |
| 45 | 2000), and phytoplankton and macroalgal blooms (Hauxwell et al., 2003).                                      |
| 46 | To better understand management of water quality it is important to know the sources,                        |
| 47 | as well as the amount of inputs of the nutrient limiting production. In the Mondego estuary,                 |
| 48 | as in most estuarine ecosystems, there is evidence that at least for macroalgal growth,                      |
| 49 | nitrogen is the limiting factor (Teichberg et al., submitted). $\delta^{15}N$ has proven useful as a tracer  |
| 50 | of the major source of nitrogen entering coastal waters. Joint use of $\delta^{15}N$ and $\delta^{13}C$ have |
| 51 | further shown promise as a tool that helps to explain how the external N sources, as well as                 |
| 52 | the C sources, move up into estuarine food webs. Application of these isotopic ratios has                    |
| 53 | largely remained an item of research rather than a management tool (Peterson and Fry, 1987;                  |
| 54 | Cole et al., 2004). The practical utility of stable isotopic ratios to some degree depends on the            |
| 55 | relative sensitivity of $\delta^{15}N$ and $\delta^{13}C$ to seasonal variation.                             |
| 56 | Stable isotopic N ratios might, in addition, change with increased temperatures such                         |
| 57 | as we might find seasonally, but also as might be forced by global atmospheric warming.                      |
| 58 | Microbial processes such as denitrification are strongly affected by temperatures (Valiela                   |

59 1995), and higher denitrification could result in notable fractionation of  $\delta^{15}$ N. This indirect 60 linkage could furnish heavier N that is taken up by producers.

Some studies reported that  $\delta^{15}$ N and  $\delta^{13}$ C of producers showed seasonal variation 61 62 (Riera and Richard, 1996; 1997; Fourgurean et al., 1997; Kang et al., 1999; Adin and Riera, 63 2003; Machás et al., 2003; Riera and Hubas, 2003; Pruell et al., 2006), while others did not 64 (McClelland and Valiela, 1998; Cole et al., 2004). Similarly, some studies showed variation 65 in consumers (Goering et al., 1990; Riera and Richard, 1996; 1997; Buskey et al., 1999; 66 Kang et al., 1999; Carman and Fry, 2002; Kibirige et al., 2002; Moens et al., 2002; Adin and 67 Riera, 2003; Machás et al., 2003; Riera and Hubas, 2003; Vizzini and Mazzola, 2003, 2005), 68 and others did not (Goering et al., 1990). Knowledge of seasonal variation in stable isotopic 69 ratios is important as a reflection of biogeochemical and ecological processes, as well as in 70 regard to sampling schedules and expected variability for applied monitoring schedules. 71 In this paper we examine the seasonal variation in N and C stable isotopic ratios of 72 producers and consumers within the food web of the Mondego estuary, and compare the 73 changes in ratios in organisms to the seasonal changes in temperature, precipitation, 74 dissolved nutrients, and phytoplankton chlorophyll we measured in the Mondego ecosystem. 75 This comparison aims to discern the degree to which seasonally varying driving factors 76 might be manifest in the isotopic ratios of the food web, as well as identify the components 77 of the food web that might be reasonably reliable indicators of changes in nutrient 78 enrichment and warming. 79

80 **2. Methods** 

81 2.1. Study site

82 The Mondego estuary is a relatively small (1600 ha), warm-temperate, polyhaline,
83 intertidal system located on the Atlantic coast of Portugal, and consists of two arms, north and

| 84  | south (Fig. 1). The southern arm is characterised by large areas of intertidal mudflats (almost   |
|-----|---|
| 85  | 75% of the area) exposed during low tide. The system receives agricultural runoff from            |
| 86  | 15000 ha of upstream cultivated land (mainly rice fields) and supports a substantial              |
| 87  | population, industrial activities, salt-works, and aquaculture farms, and is also the location of |
| 88  | the Figueira da Foz city harbour, which constitutes a tourism centre. All these activities have   |
| 89  | imposed a strong anthropogenic impact. A mixture of inputs from sewage effluent,                  |
| 90  | agricultural runoff, as well as releases from maricultural activity contributes to the nutrient   |
| 91  | loads entering the Mondego estuary.   |
| 92  | In the early 1990s the southern arm was almost silted up in the upstream areas,                   |
| 93  | causing the river discharge to flow essentially through the northern arm. Consequently, the       |
| 94  | water circulation in the southern arm became mostly dependent on the tides and on the small       |
| 95  | freshwater input from a tributary, the Pranto River, artificially controlled by a sluice          |
| 96  | (Marques et al., 2003). In 1990-1992, the communication between the two arms of the estuary       |
| 97  | became totally interrupted in the upstream area due to the completion of stonewalls in the        |
| 98  | northern arm banks. Following this interruption, the ecological conditions in the southern arm    |
| 99  | suffered a rapid deterioration. The combined effect of an increased water residence time and      |
| 100 | of nutrient concentrations became major driving forces behind the occurrence of seasonal          |
| 101 | blooms of Ulva sp. and a concomitant severe reduction of the area occupied by Zostera noltii      |
| 102 | beds, previously the richest habitat in terms of productivity and biodiversity (Marques et al.,   |
| 103 | 1997; 2003). The shift in benthic primary producers affected the structure and functioning of     |
| 104 | the biological communities, and through time such modifications started inducing the              |
| 105 | emergence of a new selected trophic structure, which has been analysed in abundant literature     |
| 106 | (e.g. Dolbeth et al., 2003; Cardoso et al., 2004 a; b; Patrício et al., 2004).                    |
| 107 | From 1998 to 2006 several interventions were carried out to ameliorate the condition of           |
| 108 | the system, namely by improving water circulation, which was followed by a partial recovery       |

- of the area occupied by *Z. noltii* and the cessation of green *Ulva* sp. blooms (Lillebo et al.,
  2005; 2007).
- 111
- 112 2.2. Sample collection and preparation

113 To assess water quality of the Mondego waters, we collected water samples on a 114 monthly basis at two sites (Zostera site and bare sediment site; Fig. 1), from November 2005 115 to July 2006. In a companion paper (Baeta et al. submitted) we established that there were no 116 differences in nutrients or chlorophyll concentrations in samples taken from the two sites, 117 and so here we treat the samples as replicates. In each sample we measured concentrations of nitrate (NO<sub>3</sub><sup>-</sup>), ammonium (NH<sub>4</sub><sup>+</sup>), and phosphate (PO<sub>4</sub><sup>3-</sup>), and the concentration of 118 119 chlorophyll a. Samples were immediately filtered (Whatman GF/F glass-fibre filter) and 120 stored frozen at -18 °C until the analysis following standard methods described in 121 Limnologisk Metodik (1992) for  $NH_4^+$  and  $PO_4^{3-}$ , and in Strickland and Parsons (1972) for 122  $NO_3^{-}$ , and nitrite  $NO_2^{-}$ . The phytoplankton chlorophyll *a* determinations were performed by 123 filtering 0.5-1.0 l of water through Whatman GF/F glass-fibre filters (Parsons et al., 1985). In 124 the field and during transportation to the laboratory, samples were stored on ice and protected 125 from light. Data on monthly precipitation and air temperature derive from the nearby city of 126 Coimbra (Instituto de Meteorologia, Coimbra forecast station). 127 We measured stable isotopic values in components of the Mondego food web, 128 including particulate organic matter (POM), sedimentary organic matter (SOM), meiofauna, 129 seagrass, macroalgae, macrobenthos, zooplankton, and the fish in each of the two sites. To 130 evaluate the seasonal variation in the isotopic values, we repeated the sampling in November 131 (2005), and February, May, and July (2006) at the two sites in the south arm of the estuary. 132 Water samples for POM were collected monthly.

133 POM was obtained by filtering 0.5-11 of seawater, from a depth of 0.5 m below the surface, 134 onto precombusted (450°C, 4h) Whatman GF/F filters (0.45 µm pore size) with a low 135 pressure vacuum pump. Sediment samples from the upper 1 cm were collected with an 136 acrylic corer (31 mm of diameter), and analysed for the isotopic composition. For the 137 meiofauna, sediment samples were collected, and the top 3 cm of each sediment core was 138 then passed through 500  $\mu$ m and 38  $\mu$ m sieves. Meiofauna were examined from the 38  $\mu$ m 139 fraction, and samples for isotopic analysis were composites of 50 to 300 individuals. 140 Seagrass leaves and roots, and macroalgae were collected by hand and gently cleaned of 141 epiphytic material. Macroinvertebates were also taken manually from each site, and held in 142 filtered sea water for 24 h to allow their guts to clear. 143 Zooplankton was collected by towing a Bongo net (0.5 m diameter, 200  $\mu$ m mesh 144 size) against the current for 20 min. The zooplankton samples for isotope analysis were 145 composites of 20 to 200 individuals. Resident (Atherina boyeri, Pomatoschistus microps, 146 Pomatoschistus minutus, Syngnathus abaster, Syngnathus acus) and transient (Dicentrarchus 147 *labrax*, *Solea solea*) fish species were collected using a 2 m beam trawl, with 5 mm stretched 148 mesh size on the cod end. The trawls were carried out during the night, at low water during 149 spring tides, but only at the bare sediment site. These mobile taxa (fish) could easily manage 150 the short distance between the two sites (Fig. 1), so it was not considered worthwhile to 151 collect samples at the two sites. 152 All samples were rinsed with Milli-Q water (filters with POM were rinsed with 153 ammonium formate to removed the salts), and then freeze-dried. When dry, samples were 154 ground (filters with POM were kept whole) into a homogenous powder using mortar and 155 pestle, and combined to make single composite samples of each species/group per site per 156 sampling date. Samples were then weighed, and loaded into tin capsules. Whole organisms 157 were used in all cases except for bivalves and decapods, the shells of which were removed,

- and for fish, only muscle of the dorsal region was analysed. No acidification was applied to
- 159 the samples to avoid alterations in the isotopic signal (Mateo et al. 2008).
- 160 Samples were analysed using an EA-IRMS (Isoprime, Micromass, UK). Isotopic
- 161 values were expressed in the  $\delta$  unit notation as deviations from standards (Vienna Pee Dee
- 162 Belemnite for  $\delta^{13}$ C and N<sub>2</sub> in air for  $\delta^{15}$ N) following the formula:  $\delta^{13}$ C or  $\delta^{15}$ N= [( $R_{\text{sample}}$ /
- 163  $R_{\text{standard}}$ -1] x 10<sup>3</sup>, where R is <sup>13</sup>C/<sup>12</sup>C or  $\delta^{15}$ N/<sup>14</sup>N. The analytical precision for the
- 164 measurement was 0.2% for both carbon and nitrogen.
- 165 The data were analyzed using ANOVA to test the null hypothesis that there were no
- 166 significant differences in either the  $\delta^{15}$ N or  $\delta^{13}$ C composition of each group/species among
- 167 seasons (autumn, winter, spring, summer).
- 168

#### 169 **3. Results and discussion**

170 3.1. Seasonal ambient conditions

Weather varied substantially during the sampling period (Fig. 2). Temperatures varied 171 172 according to the season, with, on average, winter maxima around 15°C rising to 25°C in 173 summer. In addition, during the period over which we sampled the estuary there were marked 174 departures from average conditions. In particular, during our last sampling interval in July, 175 very warm temperatures (near 40 °C) (Fig. 2, top) were brought about by a northern incursion 176 of an African air mass. The sampling period was also one during which Portugal suffered a 177 lengthy drought, relative to average long-term precipitation (Fig. 2, bottom). 178 There was a marked seasonality to conditions in the water column (Fig. 3). Nitrate 179 concentrations were high during winter, and diminished about four-fold during the warmer months. Concentrations of  $NH_4^+$  and  $PO_4^{3-}$  were usually much lower than those of  $NO_3^-$  (Fig. 180 181 3, top). N/P was generally above the 16:1 Redfield ratio during colder months and below it in 182 warmer months. This suggests that throughout the winter months, P supply might have been

the limiting nutrient, while during the summer, N might limit producer growth (Fig. 3,

| 184 | middle). Chlorophyll a concentrations peaked in spring, perhaps drawing down nitrate                          |
|-----|---|
| 185 | concentration during warmer months (Fig. 3, bottom).  |
| 186 |   |
| 187 | 3.2. Seasonal changes in isotopic values  |
| 188 | We collected 45 different taxa and analysed their stable carbon and nitrogen isotopic                         |
| 189 | composition. These taxa included 5 primary producers, POM, sediment, 21                                       |
| 190 | macroinvertebrates species, 2 meiofauna groups, 8 fish species, and 7 zooplankton taxa                        |
| 191 | (Table 1).  |
| 192 | There was a consistent lack of seasonal pattern in the isotopic values in most                                |
| 193 | compartments of the Mondego ecosystem (Figs. 4, 5). Thirty of the 37 compartments                             |
| 194 | measured showed no evidence of seasonal changes (Table 2).  |
| 195 | For $\delta^{13}$ C only the copepod <i>Acartia tonsa</i> showed a seasonal variation, becoming less          |
| 196 | negative in spring and summer. Buskey et al. (1999) showed that A. tonsa living over                          |
| 197 | seagrass beds obtain a larger proportion of their carbon from seagrass than do nearby                         |
| 198 | populations living over muddy bottoms without seagrass. In our study, during the most                         |
| 199 | intense periods of the phytoplankton bloom, $\delta^{13}$ C values in A. tonsa became less negative,          |
| 200 | suggesting that more seagrass carbon might have been entering their diets. On the other hand,                 |
| 201 | the much depleted carbon signatures for the most of the year could be due to a great                          |
| 202 | contribution of terrestrial organic matter, since several studies have shown that terrestrial                 |
| 203 | plants have the most depleted $\delta^{13}$ C signatures, around -26% (e.g. Vizzini and Mazzola,              |
| 204 | 2003).  |
| 205 | The $\delta^{15}N$ of producers and consumers consistently lacked significant seasonal                        |
| 206 | variation across most of the growing season (Table 2), and only on one date in July did it                    |
| 207 | become significantly higher ( $p < 0.05$ ) in the $\delta^{15}$ N of producers. The stable isotopic values of |

208 C and N in these producers and consumers therefore showed no seasonal variation. In 209 contrast, the  $\delta^{15}$ N of producers rapidly increased seemingly as a seasonal response to certain 210 conditions.

High nitrogen isotopic signatures found in producers in July may have resulted from seasonal changes in biogeochemical processes, such as denitrification. Denitrification is temperature-dependent and takes place under anaerobic conditions. This process may lead to a loss of isotopically light <sup>14</sup>N, which enriches the remaining DIN pool with <sup>15</sup>N. During the unusually warm event in July there was a strong sulfitic smell, which suggested widespread anoxia that could have favoured high denitrification rates.

217 The enrichment of  $\delta^{15}$ N in the producers increased significantly with warmer 218 temperatures (Fig. 6), as might be expected if a temperature-dependent process such as 219 denitrification was indeed involved. It is not surprising to find that macrophyte isotopic 220 values show seasonal changes in N supply: isotopic values of macrophyte fronds change in a 221 matter of hours to a few days (Teichberg et al. 2007) since their internal nitrogen pools turn 222 over rather quickly. The importance of the results of Figure 6 are that if indeed global 223 atmospheric warming increases water temperatures in estuaries such as the Mondego, we can expect a gradually increase in  $\delta^{15}$ N in the producers.  $\delta^{15}$ N values then could therefore be 224 225 thought of as indirect indicators of warming.

Nitrogen isotope ratios in two isopods also showed seasonal variation, increasing in July. Both *I. chelipes* and *L. levii* are grazers, feeding on macrophytes (Bamber, 2004), so the increased nitrogen isotopic ratio in summer could be due to the enrichment found in the producers during this period, since complete turnover of these populations could occur in a matter of days if all individuals were equally mobile (Shafir & Field, 1980). Accordingly, the lack of seasonal variation of  $\delta^{15}$ N enrichment in most consumers of the Mondego food web might be related to a slower turnover of internal N pools in consumers (weeks/months)

| 233 | compared to pools in macrophytes (days), position of species in the food web and omnivores            |
|-----|---|
| 234 | feeding behaviour, and also probably due to the fact that, excepting isopods, the other groups        |
| 235 | do not feed directly on fresh macrophytes. This suggests that consumer isotopic values                |
| 236 | constitute a more time-integrated reflection of nitrogen isotopic values, as reported by              |
| 237 | Vander Zanden et al. (1998).  |
| 238 | The results of this study show that there were strong seasonal driving variables in the               |
| 239 | Mondego estuary. Increased temperature increased $\delta^{15}N$ of important producers; this might    |
| 240 | be an indirect result of microbial N transformations and suggests that producer $\delta^{15}$ N might |
| 241 | become an indicator of larger climatic trends. The influence of this seasonal forcing, as             |
| 242 | manifest in stable isotopic ratios of consumers within the Mondego food web, was                      |
| 243 | surprisingly modest, with most species showing no significant seasonal trends. These results          |
| 244 | suggest that the seasonal variation in the various factors we measured (temperature,                  |
| 245 | precipitation, nutrients, chlorophyll) within the Mondego was not enough to change isotopic           |
| 246 | signatures in consumers. This is convenient for monitoring purposes, as it frees sampling             |
| 247 | protocols from seasonal schedules.  |
| 248 |   |

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- 259

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- 381 Table 1.  $\delta^{13}$ C and  $\delta^{15}$ N of primary producers and consumers collected from Mondego
- 382 estuary. Data are sample size (*N*), and mean  $\delta$  values (± SE), from November 2005 to July
- 383 2006.

| $ \begin{array}{c c c c c c c c c c c c c c c c c c c $   |          |                                   |             |                       |                |        |
|---|----------|-----------------------------------|-------------|-----------------------|----------------|--------|
| Group/species         Abreviation         MeantSE         MeantSE         N           Macroplytes         Enternomorpha sp.         E $-12.940.4$ $12.781.2$ 8           Facus sp.         G $-17.440.7$ $9.724.4$ 8           Gracilloria sp.         U $-11.440.7$ $9.724.4$ 8           Zostera noliii (leaves)         Z $-12.240.2$ $11.343.3$ 8           Particulate organic matter         POM $-22.840.2$ $5.940.2$ 18           Sediment         SOM $-21.3140.4$ $4.820.4$ 8           Amphipoda         Amphipoda         14.740.5 $10.940.2$ 8           Bivalvia         Me $-10.240.4$ $7.243.3$ 8           Cerastoderma edule         Ce $-10.140.2$ $7.840.3$ 8           Bivalvia         Gu $-12.240.4$ $7.243.3$ 8           Cerastoderma edule         Ce $-10.140.5$ $9.040.2$ 8           Bivalvia         Cerastoderma edule         Ce $-10.140.5$ $9.040.2$ 8           Cerastoderma edule         Ce  |          | ~                                 |             | $\delta^{13}C$        | $\delta^{15}N$ |        |
| Macrophytes         Enteromorpha sp.         E $12.9\pm0.4$ $12.7\pm1.2$ 8           Fuerous sp.         G $17.4\pm0.7$ $9.7\pm1.0$ 8           Cracilaria sp.         U $-11.4\pm0.7$ $9.7\pm1.0$ 8           Utva sp.         U $-11.4\pm0.7$ $9.7\pm1.5$ 8           Zostera nolii (leaves)         Z $-12.5\pm0.1$ $9.5\pm1.5$ 8           Zostera nolii (leaves)         Z $-12.2\pm0.2$ $11.3\pm3.3$ 8           Particulate organic matter         POM $-22.8\pm0.2$ $5.9\pm0.2$ 18           Sceiment         SOM $-21.3\pm0.4$ $4.8\pm0.4$ 8           Amphithoe valida         Av $-14.8\pm0.3$ $10.9\pm0.2$ $8$ Echinogeannarus marinus         Em $-14.7\pm0.5$ $10.6\pm0.3$ 8           Mytitus eduits         Me $-9.240.4$ $7.2\pm0.3$ 8           Gravistoderma eduite         Ce $-9.240.4$ $7.2\pm0.3$ 8           Gravistoderma eduite         Ce $-19.240.4$ $7.2\pm0.2$ 8           Decapola         Cerratista maetas         <   |          | Group/species                     | Abreviation | Mean+SE               | Mean+SE        | - N    |
| Macrophytes         Enteromorphyses,         E $-12.940.4$ $12.7\pm1.2$ 8           Fueros sp.         G $-17.440.7$ $9.7\pm1.0$ 8           Gracilaria sp.         G $-17.440.7$ $9.7\pm1.0$ 8           Ulva sp.         U $-11.440.3$ $12.340.9$ 8           Zostera nolii (leaves)         Z $-12.240.2$ $13.343.3$ 8           Particulate organic matter         POM $-22.840.2$ $5.9\pm0.2$ 18           Sediment         SOM $-21.31\pm0.4$ $4.8\pm0.4$ 8           Amphipoda         -         - $-41.740.5$ $10.920.2$ 8           Edimeosumariss marinus         Em $-14.740.5$ $10.920.2$ 8           Bivalvia         Cerastoderma edule         Ce $-19.140.2$ $7.840.3$ 8           Carcinus maenus         Cm $-16.440.3$ $12.140.2$ 8         5           Decapoda         Cr $-15.30.3$ $11.640.1$ 8         11.530.3 $9.660.1$ 8           Grastropoda         Carainus maenus         Cm $-16.440.3$  |          |                                   |             |                       |                |        |
| Entersonorpha sp.       E $-1.2940.4$ $12.741.2$ 8         Facas sp.       F $-16.380.5$ $9.724.0.4$ 8         Gracillaria sp.       G $-17.480.7$ $9.724.10.8$ 8         Uiva sp.       U $-11.480.3$ $22.340.8$ $22.54era$ noltii (covis) $Zr$ $-12.240.2$ $11.343.3$ 8         Zostera noltii (covis) $Zr$ $-12.240.2$ $11.343.3$ 8         Sediment       SOM $-21.3140.4$ $4.840.4$ 8         Amphipoda       Av $-14.840.3$ $10.940.2$ 8         Melita palmata       Em $-14.740.5$ $10.640.3$ 8         Multia calula       Av $-14.840.3$ $10.940.2$ 8         Bivalvia       Echinogammarus marinus       Em $-14.740.5$ $9.040.2$ 8         Mytlus calulais       Me $-19.240.4$ $7.240.3$ 8         Caratoms maenas       Cm $-16.480.3$ $12.140.2$ 8         Caratoms maenas       Cm $-16.480.3$ $12.140.2$ 8         Caratoms maenas       Cm $-16.480.3$ $12.140.2$   |          | Macrophytes                       |             |                       |                |        |
| Functors sp.       F       -16.340.5       9.720.4       8         Gracilaria sp.       G       -17.440.7       9.721.0       8         Uva sp.       U       -11.440.3       12.340.9       8         Zostera noltii (roots)       Zr       -12.540.1       9.541.5       8         Zostera noltii (roots)       Zr       -12.540.1       9.541.5       8         Zostera noltii (roots)       Zr       -12.540.2       11.343.3       8         Particulate organic matter       POM       -22.840.2       5.940.2       18         Sediment       SOM       -21.3140.4       4.840.4       8         Amphithoe valida       Av       -14.740.5       10.640.3       8         Milia palmata       Mp       -15.540.7       9.940.2       8         Scrobicularia fana       Sp       -17.440.5       9.040.2       8         Decapoda       Ce       -19.140.2       7.840.3       8         Carcinus meanas       Cm       -16.440.3       12.140.2       8         Carangon crangon       Ccr       -15.340.3       11.640.1       8         Gastropoda       Gu       -12.041.5       10.711.3       3         Hydrobi  |          | Enteromorpha sp.                  | E           | -12.9±0.4             | 12.7±1.2       | 8      |
| Graditaria sp.       G       -11.440.7       12.340.9       8         Zostera nolii (leaves)       Z       -12.540.1       9.541.5       8         Zostera nolii (leaves)       Z       -12.240.2       5.940.2       18         Sediment       SOM       -22.820.2       5.940.2       18         Sediment       SOM       -21.3140.4       4.820.4       8         Amphipoda  |          | Fucus sp.                         | F           | -16.3±0.5             | 9.7±0.4        | 8      |
| $\begin{array}{c c c c c c c c c c c c c c c c c c c $  |          | Gracilaria sp.                    | G           | -17.4±0.7             | 9.7±1.0        | 8      |
| Zostera nolii (leaves)       Z       -12.340.1       9.351.5       8         Zostera nolii (toots)       Z       T       -12.240.2       11.353.3       8         Particulate organic matter       POM       -22.840.2       5.940.2       18         Sediment       SOM       -21.3140.4       4.840.4       8         Amphipoda $$  |          | Ulva sp.                          | U           | -11.4±0.3             | 12.3±0.9       | 8      |
| Zostera noliti (roots)       Zr $-12.240.2$ $11.3\pm3.3$ 8         Particulate organic matter       POM $-22.8\pm0.2$ $5.9\pm0.2$ 18         Sediment       SOM $-21.31\pm0.4$ $4.8\pm0.4$ 8         Amphihoda       Mp $-14.3\pm0.3$ $10.9\pm0.2$ 8         Echinogammarus marinus       Em $-14.2\pm0.5$ $10.6\pm0.3$ 8         Melita palmata       Mp $-15.5\pm0.7$ $9.9\pm0.2$ 8         Bivalvia       Ce $-9.11\pm0.2$ $7.8\pm0.3$ 8         Scrobicularia plana       Sp $-17.4\pm0.5$ $9.0\pm0.2$ 8         Decapoda       Cer $-15.2\pm0.3$ $11.6\pm0.2$ 8         Crangon crangon       Cer $-15.2\pm0.3$ $11.6\pm0.1$ 8         Gastropoda       Gu $-12.0\pm1.5$ $10.7\pm1.3$ 3         Hydrobia unbilicalitis       Gu $-11.2\pm0.4$ $12.2\pm0.1$ 4         Hopoda       Ce $-14.3\pm0.4$ $11.7\pm0.2$ 8         Gastropoda       Ce $-14.3\pm0.4$ $11.5\pm0.3$ $9.6\pm0.5$ 8         Litorina litorea       Li $-11.2\pm0.4$   |          | Zostera noltii (leaves)           | Zl          | $-12.5\pm0.1$         | 9.5±1.5        | 8      |
| Particulate organic matter         POM $-22.840.2$ $5.940.2$ $18$ Sediment         SOM $-21.3140.4$ $4.840.4$ $8$ Amphipoda         m $-14.420.5$ $10.0400.3$ $8$ Echinogommarus marinus         Em $-14.420.5$ $10.0640.3$ $8$ Melita palmata         Mp $-15.540.7$ $9.940.2$ $8$ Bivabia         Cc $-19.140.2$ $7.840.3$ $8$ Cerastoderme edule         Cc $-17.440.5$ $9.040.2$ $8$ Decapoda         Car $-16.440.3$ $12.140.2$ $8$ Carcinus maenas         Cm $-11.540.3$ $9.640.1$ $8$ Castropoda         Gu $-12.041.5$ $10.7\pm 1.3$ $3$ Hydrobia ulvae         Hu $-11.540.3$ $9.640.1$ $8$ Castropoda         Ca $-14.340.4$ $11.740.2$ $8$ Idorea helipes         Le $-11.240.4$ $12.240.1$ $4$ Lidorea helipes         Le $-12.040.4$ $8.740.4$ <  |          | Zostera noltii (roots)            | Zr          | -12.2±0.2             | 11.3±3.3       | 8      |
| Sediment         SOM $-21.3140.4$ $4.840.4$ 8           Amphipoda         Amphibole valida         Av $-14.340.5$ $10.940.2$ 8           Echinogommarus marinus         Em $-14.720.5$ $10.060.3$ 8           Melita palmata         Mp $-15.540.7$ $9.940.2$ 8           Bivalia         Me $-19.220.4$ $7.240.3$ 8           Carasis definia edule         Cc $-17.440.5$ $9.040.2$ 8           Decapoda         Car $-16.440.3$ $12.140.2$ 8           Carains maenas         Cm $-16.440.3$ $12.140.2$ 8           Castropoda         Gu $-12.041.5$ $10.7\pm1.3$ 3           Hydrobia ulvae         Hu $-11.540.3$ $9.640.1$ 8           Castropoda         Cc $-14.340.4$ $11.740.2$ 8           Idorea chelipes         L         L $-11.220.4$ $11.220.4$ $12.240.1$ Litorina linorea         L $-11.240.4$ $12.240.1$ $4$ Lidorea chelipes         Le $-12.040.4$  |          | Particulate organic matter        | POM         | -22.8±0.2             | 5.9±0.2        | 18     |
| Amphiphola         Avv $-14.840.3$ $10.940.2$ 8           Echinoganmarus marinus         Em $-14.720.5$ $10.640.3$ 8           Melita palmata         Mp $-15.520.7$ $9.920.2$ 8           Biralvia         Carastoderma edule         Ce $-19.120.2$ $7.840.3$ 8           Mytilus edulis         Me $-19.220.4$ $7.240.3$ 8           Scrobicularia plana         Sp $-17.440.5$ $9.040.2$ 8           Decapoda         Car $-16.440.3$ $12.140.2$ 8           Carcins meanas         Cm $-16.440.3$ $12.140.2$ 8           Gastropoda         Car $-15.340.3$ $11.640.1$ 8           Gastropoda         Gu $-11.540.3$ $9.640.1$ 8           Litorina litorea         L $-11.240.4$ $12.240.1$ 4           Isopoda         Ca $-14.320.4$ $11.740.2$ 8           Litorina litorea         Le $-11.540.3$ $9.640.1$ 8           Cyathura carinata         Le $-14.320.4$ $11.740.2$   |          | Sediment                          | SOM         | -21.31±0.4            | 4.8±0.4        | 8      |
| Amplithoe validaAv $-14.840.3$ $10.9\pm0.2$ 8.Echinogammarus marinusEn $-14.740.5$ $10.6\pm0.3$ 8.Meitra palmataMp $-15.540.7$ $9.940.2$ 8Ecrastoderma eduleCe $-19.120.2$ $7.840.3$ 8.Mytilus edulaisMe $-19.220.4$ $7.240.3$ 8.Mytilus edulaisMe $-19.220.4$ $7.240.3$ 8.DecapodaCarcinus maenasCm $-16.420.3$ $12.140.2$ 8.Crangon crangonCcr $-15.320.3$ $11.640.1$ 8.GastropodaGuCu $-12.0\pm1.5$ $10.7\pm1.3$ 3.Hydrobia ulvaeHu $-11.540.3$ $9.640.1$ 8.Littorina litoreaLi $-11.240.4$ $12.220.1$ 4.LogodaCc $-14.340.4$ $11.740.2$ 8.Cyathura carinataCc $-14.340.4$ $11.740.2$ 8.Idotea chelipesIc $-14.540.5$ $9.940.5$ 8.Lekanesphaera levitiLev $-12.040.4$ $8.740.4$ 8.MeiofaunaNe $-16.340.5$ $11.340.3$ 8.CopepodaCo $-16.340.4$ $10.940.3$ 8.CopepodaCo $-16.340.4$ $10.940.3$ 8.CopepodaCo $-16.340.4$ $10.940.3$ 7.GibychaetaNe $-16.540.7$ $10.740.2$ 6.Copitella capitataCca $-16.440.3$ $10.840.3$ 7.Gierea tridacrylaGt $-14.340.2$  |          | Amphipoda                         |             |                       |                |        |
| $\begin{array}{c ccccccccccccccccccccccccccccccccccc$   |          | Amphithoe valida                  | Av          | -14.8±0.3             | 10.9±0.2       | 8      |
| Melia palmata         Mp $-15.520.7$ $9.940.2$ 8           Bivalvia         Cerastoderma edule         Ce $-19.140.2$ $7.840.3$ 8           Mytilus edulis         Me $-19.240.4$ $7.240.3$ 8           Mytilus edulis         Me $-19.240.4$ $7.240.3$ 8           Scrobicularia plana         Sp $-17.440.5$ $9.040.2$ 8           Decapoda         Cm $-16.440.3$ $12.149.2$ 8           Crangon crangon         Ccr $-15.340.3$ $11.040.1$ 8           Gastropoda         Gu $-12.041.5$ $10.7\pm1.3$ 3           Hydrobia ulvaa         Hu $-11.260.4$ $12.240.1$ 4           Isopoda         Cu $-14.340.4$ $11.7\pm0.2$ 8           Idote a chelipes         Ic $-14.340.4$ $11.7\pm0.2$ 8           Idote a chelipes         Ic $-14.340.4$ $10.940.3$ 8           Copeoda         Co $-16.340.4$ $10.940.3$ 8           Copeoda         Co $-16.340.5$ $10.940.3$ <t< td=""><td></td><td>Echinogammarus marinus</td><td>Em</td><td>-14.7±0.5</td><td>10.6±0.3</td><td>8</td></t<>  |          | Echinogammarus marinus            | Em          | -14.7±0.5             | 10.6±0.3       | 8      |
| Bivatia       Cerastoderma edule       Ce $-19, 1\pm 0.2$ 7, 8\pm 0.3       8         Mynilus edulis       Me $-19, 2\pm 0.4$ 7, 2\pm 0.3       8         Scrobicularia plana       Sp $-17, 4\pm 0.5$ 9, 90, 02       8         Decapola       Carcinus maenas       Cm $-16, 4\pm 0.3$ $12, 1\pm 0.2$ 8         Carsingon crangon       Ccr $-15, 3\pm 0.3$ $11, 6\pm 0.1$ 8         Gastropoda       Gu $-12, 0\pm 1.5$ $10, 7\pm 1.3$ 3         Hydrobia ubvae       Hu $-11, 5\pm 0.3$ $9, 6\pm 0.1$ 8         Littorina litorea       Li $-11, 2\pm 0.4$ $12, 2\pm 0.1$ 4         Isopoda       Cc $-14, 3\pm 0.4$ $11, 7\pm 0.2$ 8         Latanesphaera levii       Le $-11, 2\pm 0.4$ $12, 2\pm 0.1$ 4         Isopoda       Cc $-14, 3\pm 0.4$ $11, 7\pm 0.2$ 8         Idotea chelipes       Ic $-14, 3\pm 0.4$ $11, 7\pm 0.2$ 8         Idotea chelipes       Ic $-16, 3\pm 0.5$ $11, 3\pm 0.3$ 8         Copepoda       Co $-16, 3\pm 0.5$ $11, 3\pm 0.3$ 8         Hei  |          | Melita palmata                    | Мр          | -15.5±0.7             | 9.9±0.2        | 8      |
| Bivalvia       Cerastoderma edule       Ce $-19.1\pm0.2$ $7.8\pm0.3$ 8         Mytilus edulis       Me $-19.2\pm0.4$ $7.2\pm0.3$ 8         Scrobicularia plana       Sp $-17.4\pm0.5$ $9.0\pm0.2$ 8         Decapoda       Carcinus maenas       Cm $-16.4\pm0.3$ $12.1\pm0.2$ 8         Carcinus maenas       Cm $-16.4\pm0.3$ $12.1\pm0.2$ 8         Gastropoda       Gu $-12.0\pm1.5$ $10.7\pm1.3$ 3         Hydrobia ulvae       Hu $-11.2\pm0.4$ $12.2\pm0.1$ 4         Isopoda       Cc $-14.3\pm0.4$ $11.7\pm0.2$ 8         Littorina litorea       Li $-11.2\pm0.4$ $12.2\pm0.1$ 4         Meiodauna       Cc $-14.3\pm0.4$ $11.7\pm0.2$ 8         Idotea chelipes       Ic $-14.5\pm0.5$ $9.9\pm0.5$ 8         Lekanesphaera levit       Llev $-10.3\pm0.5$ $11.3\pm0.3$ 8         Copepoda       Co $-16.3\pm0.4$ $10.9\pm0.3$ 8         Meiofauna       Ne $-16.3\pm0.4$ $10.9\pm0.3$ 8         Meiofauna       Cc $-16.3\pm0.4$ <td></td> <td><i>F</i></td> <td></td> <td></td> <td></td> <td></td>   |          | <i>F</i>                          |             |                       |                |        |
| Cerastoderma edule       Ce $-19.19.0.2$ 7.520.3       8         Mytilus edulis       Me $-19.240.4$ 7.240.3       8         Scrobicularia plana       Sp $-17.440.5$ $9.040.2$ 8         Decapoda       Carcinus maenas       Cm $-16.440.3$ $12.140.2$ 8         Caragon crangon       Ccr $-15.340.3$ $11.640.1$ 8         Gastropoda       Gibbula umbilicalis       Gu $-12.0\pm1.5$ $10.7\pm1.3$ 3         Hydrobia ulvae       Hu $-11.540.3$ $9.640.1$ 8         Littorina litorea       L $-11.240.4$ $12.240.1$ 4         Isopoda       Cc $-14.3\pm0.3$ $9.640.1$ 8         Lekanesphaera levii       Llev $-12.0\pm0.4$ $8.720.4$ 8         Idorea chelipes       k $-14.3\pm0.5$ $9.940.5$ 8         Lekanesphaera levii       Llev $-12.040.4$ $8.720.4$ 8         Meiofauna       Ne $-16.3\pm0.5$ $11.3\pm0.3$ 8       Copepoda       Co $-16.3\pm0.5$ $11.3\pm0.3$ 8         Copepoda       Co $-16.3\pm0.5$   |          | Bivalvia                          | -           | 10.1:0.2              | 70:00          | ~      |
| Myillus edulisMe $-19.240.4$ $7.240.3$ 8Scrobicularia planaSp $-17.440.5$ $9.040.2$ 8DecapodaCarcinus maenasCm $-16.440.3$ $12.140.2$ 8Carcinus maenasCm $-15.340.3$ $11.640.1$ 8GastropodaGuibula umbilicalisGu $-12.041.5$ $10.741.3$ 3Hydrobia ulvaeHu $-11.540.3$ $9.640.1$ 8Littorina litoreaLi $-11.240.4$ $12.240.1$ 4IsopodaCc $-14.340.4$ $11.740.2$ 8Cyathura carinataCc $-14.340.4$ $11.740.2$ 8Idotea chelipeslc $-16.340.5$ $11.340.3$ 8CopepodaCo $-16.340.5$ $11.340.3$ 8CopepodaCo $-16.340.5$ $11.340.3$ 8CopepodaCo $-16.340.5$ $11.340.3$ 8CopepodaCo $-16.340.5$ $11.340.3$ 7Heiste diversicolorHd $-14.240.2$ $11.840.3$ 7Hediste diversicolorHd $-14.240.2$ $11.840.3$ 7Hediste diversicolorHd $-16.240.3$ $10.840.3$ 7Heteromastus filiformisHf $-16.240.2$ $11.540.2$ 7Nephys cirrosaNc $-15.640.7$ $10.740.2$ 6Streblospio shrubsoliiSsh $-16.940.3$ $14.420.2$ $11.840.3$ 7Heteromastus filiformisHf $-16.240.2$ $11.840.3$ 7Hetrina boyer  |          | Cerastoderma edule                | Ce          | -19.1±0.2             | 7.8±0.3        | 8      |
| Scrobicularia plana       Sp $-17.440.5$ $9.0\pm0.2$ 8         Decapoda       Carcinus maenas       Cm $-16.440.3$ $12.1\pm0.2$ 8         Castropola       Gu $-12.0\pm1.5$ $11.6\pm0.1$ 8         Gastropola       Gu $-12.0\pm1.5$ $10.7\pm1.3$ $3$ Hydrobia ulvae       Hu $-11.5\pm0.3$ $9.6\pm0.1$ $8$ Littorina litorea       Lu $-11.2\pm0.4$ $12.2\pm0.1$ $4$ Isopota       C $-14.3\pm0.4$ $11.7\pm0.2$ $8$ Idotea chelipes       Ic $-14.3\pm0.4$ $11.7\pm0.2$ $8$ Idotea chelipes       Ic $-14.3\pm0.4$ $10.9\pm0.5$ $8$ Lekanesphaera levii       Llev $-12.0\pm0.4$ $8.7\pm0.4$ $8$ Meiofauna       Ne $-16.3\pm0.5$ $11.3\pm0.3$ $8$ Copepoda       Ce $-16.3\pm0.5$ $11.3\pm0.3$ $8$ Polychaeta       Meinaria romijni       Ar $-16.2\pm0.7$ $10.7\pm0.2$ $6$ Capitella capitata       Ceca $-16.4\pm0.2$ $11.8\pm0.3$ $7$ Heteromastus filiformis   |          | Mytilus edulis                    | Me          | -19.2±0.4             | 7.2±0.3        | 8      |
| Decapoda<br>Carcinus maenasCm $-16.4\pm0.3$<br>$-15.3\pm0.3$ $12.1\pm0.2$<br>$-16.4\pm0.1$ 8<br>R<br>Crangon crangonCastropoda<br>Gibbula umbilicalisGu $-12.0\pm1.5$<br>$-10.7\pm1.3$ $10.7\pm1.3$<br>$-10.7\pm1.3$ 3<br>Hydrobia ulvaeHu $-11.5\pm0.3$<br>$-11.2\pm0.4$ $9.6\pm0.1$<br>$-12.2\pm0.1$ 8<br>$-12.2\pm0.1$ Isopoda<br>Cyathura carinata<br>Idotea chelipesCu $-14.3\pm0.4$<br>$-12.2\pm0.1$ $11.7\pm0.2$<br>$-12.2\pm0.1$ 8<br>$-16.3\pm0.5$ $11.3\pm0.3$<br>$-12.2\pm0.1$ 8<br>$-16.3\pm0.5$ Meiofauna<br>NematodaNe<br>Nematoda $-16.3\pm0.5$<br>$-16.3\pm0.4$ $11.3\pm0.3$<br>$-10.3\pm0.3$ 8<br>$-16.3\pm0.5$ 11.3\pm0.3<br>$-10.3\pm0.3$ 8<br>$-16.3\pm0.5$ Meiofauna<br>NematodaNe<br>$-16.3\pm0.5$ $11.3\pm0.3$<br>$-10.9\pm0.3$ 8<br>$-16.3\pm0.5$ 11.3\pm0.3<br>$-10.9\pm0.3$ 8<br>$-16.3\pm0.5$ Polychaeta<br>Alkmaria romijni<br>Gipcera tridactyla<br>Gt $-16.7\pm0.7$<br>$-10.7\pm0.2$<br>$-10.8\pm0.3$ 7<br>$-10.8\pm0.3$<br>$-10.8\pm0.3$ 7<br>$-10.8\pm0.3$<br>$-10.8\pm0.3$ 7<br>$-10.8\pm0.3$ 7<br>$-10.8\pm0.2$<br>$-11.5\pm0.2$<br>$-11.5\pm0.2$<br>$-11.5\pm0.2$<br>$-11.5\pm0.2$<br>$-11.5\pm0.2$<br>$-11.5\pm0.2$<br>$-11.5\pm0.2$<br>$-11.5\pm0.2$<br>$-11.5\pm0.2$<br>$-11.5\pm0.2$<br>$-11.5\pm0.2$<br>$-11.5\pm0.2$<br>$-11.5\pm0.2$<br>$-11.5\pm0.2$<br>$-11.5\pm0.2$<br>$-11.5\pm0.2$<br>$-11.5\pm0.2$<br>$-11.5\pm0.2$<br>$-11.5\pm0.2$<br>$-11.5\pm0.2$<br>$-11.5\pm0.2$<br>$-11.5\pm0.2$<br>$-11.5\pm0.2$<br>$-11.5\pm0.2$<br>$-11.5\pm0.2$<br>$-11.5\pm0.2$<br>$-11.5\pm0.2$<br>$-11.5\pm0.2$<br>$-11.5\pm0.2$<br>$-11.5\pm0.2$<br>$-11.5\pm0.2$<br>$-11.5\pm0.2$<br>$-11.5\pm0.2$<br>$-11.5\pm0.2$<br>$-11.5\pm0.2$<br>$-11.5\pm0.2$<br>$-11.5\pm0.2$<br>$-11.5\pm0.2$<br>$-11.5\pm0.2$<br>$-11.5\pm0.3$<br>$-11.5\pm0.3$<br>$-11.5\pm0.3$<br>$-11.5\pm0.3$<br>$-11.5\pm0.3$   |          | Scrobicularia plana               | Sp          | -17.4±0.5             | 9.0±0.2        | 8      |
| Carcinus maenasCm $-16.440.3$ $12.140.2$ 8Carangon crangonCcr $-15.340.3$ $11.640.1$ 8GastropodaGu $-11.540.3$ $9.640.1$ 8Gibbula umbilicalisGu $-11.540.3$ $9.640.1$ 8Littorina litoreaLi $-11.540.3$ $9.640.1$ 8Littorina litoreaLi $-11.540.3$ $9.640.1$ 8Littorina litoreaLi $-11.240.4$ $12.240.1$ 4IsopotaCc $-14.340.4$ $11.740.2$ 8Idotea chelipeslc $-14.540.5$ $9.940.5$ 8Lekanesphara leviiLiev $-12.040.4$ $8.740.4$ 8MeiofaunaNe $-16.340.5$ $11.340.3$ 8CopepodaCo $-16.340.4$ $10.920.3$ 8CopepodaCca $-16.440.3$ $10.840.3$ 7GlychaetaA $-16.340.4$ $10.920.3$ 8Alkmaria romijniAr $-16.740.7$ $10.740.2$ 6Gapitella capitataCca $-16.440.3$ $10.840.3$ 7Glycera tridactylaGt $-14.340.2$ $11.340.3$ 7Hediste diversicolorHd $-14.240.2$ $11.840.3$ 7Hediste diversicolorHd $-16.940.7$ $10.740.2$ 6Steblospio shrubsoliiSsh $-16.940.7$ $10.740.2$ 7Dipentrarchus labrax (juv)Di $-18.240.6$ $11.740.7$ 2Dicentrarchus labrax (juv)Di $-18.240.6$ $1$  |          | Decapoda                          |             |                       |                |        |
| Caragon crangonCar-15.3±0.311.6±0.18GastropodaGibbula umbilicalisGu-12.0±1.510.7±1.33Hydrobia ulvaeHu-11.5±0.39.6±0.18Littorina litoreaU-11.2±0.412.2±0.14IsopodaCc-14.3±0.411.7±0.28Cyathura carinataCc-14.5±0.59.9±0.58Lekanesphaera leviiLlev-12.0±0.48.7±0.48MeiofaunaNe-16.3±0.511.3±0.38CopepodaCo-16.3±0.511.3±0.38CopepodaCo-16.3±0.410.9±0.38PolychaetaNe-16.7±0.710.7±0.26Glyčera tridactylaGt-14.3±0.213.5±0.35Hediste diversicolorHd-14.2±0.211.8±0.37Glyčera tridactylaGt-14.3±0.211.5±0.27Nephys cirrosaNc-15.6±0.712.6±0.36Streblospio shrubsoliiSsh-16.9±0.710.8±0.45Fishes210.8±0.45Atherina boyeriAb-18.0±0.611.7±0.72Dicentrarchus labrax (juv)Di-18.2±0.614.2±0.62Diplodus vulgaris (juv)Dv-17.9±0.515.0±0.34Pomatoschistus microps (juv)Pm-22.4±0.314.0±0.72P. minutusSac-16.2±0.011.4±0.92Solea solea (juv)Ss </td <td></td> <td>Carcinus maenas</td> <td>Cm 🦾</td> <td>-16.4±0.3</td> <td>12.1±0.2</td> <td>8</td>   |          | Carcinus maenas                   | Cm 🦾        | -16.4±0.3             | 12.1±0.2       | 8      |
| Gastropola       Gu $-12.0\pm1.5$ $10.7\pm1.3$ $3$ Gibbula umbilicalis       Hu $-11.5\pm0.3$ $9.6\pm0.1$ $8$ Littorina litorea       Li $-11.2\pm0.4$ $12.2\pm0.1$ $4$ Isopola       C $-11.2\pm0.4$ $12.2\pm0.1$ $4$ Isopola       C $-11.2\pm0.4$ $11.7\pm0.2$ $8$ Idote a chelipes       Ic $-14.5\pm0.5$ $9.9\pm0.5$ $8$ Lekanesphaera levii       Llev $-12.0\pm0.4$ $8.7\pm0.4$ $8$ Meiofauna       Ne $-16.3\pm0.5$ $11.3\pm0.3$ $8$ Copepoda       Co $-16.3\pm0.5$ $11.3\pm0.3$ $8$ Polychaeta       Alkmaria romijni       Ar $-16.7\pm0.7$ $10.7\pm0.2$ $6$ $Capitella capitata$ Cca $-16.4\pm0.3$ $10.8\pm0.3$ $7$ Giycera tridactyla       Gt $-14.3\pm0.2$ $11.3\pm0.3$ $8$ $Copepoda$ $7$ $10.7\pm0.2$ $6$ Grigera tridactyla       Gt $-14.4\pm0.2$ $11.3\pm0.3$ $7$ $Giycera tridactyla       Gt -14.3\pm0.2 13.5\pm0.3 5         Id$   |          | Crangon crangon                   | Cer         | -15.3±0.3             | 11.6±0.1       | 8      |
| GastropodaGibbula umbilicalisGu $-12.0\pm1.5$ $10.7\pm1.3$ 3Hydrobia ulvaeHu $-11.5\pm0.3$ $9.6\pm0.1$ 8Littorina litoreaLi $-11.2\pm0.4$ $12.2\pm0.1$ 4IsopodaC $-14.3\pm0.4$ $11.7\pm0.2$ 8Cyathura carinataCc $-14.3\pm0.5$ $9.9\pm0.5$ 8Idotea chelipesIc $-14.5\pm0.5$ $9.9\pm0.5$ 8MeiofaunaLev $-12.0\pm0.4$ $8.7\pm0.4$ 8NematodaNe $-16.3\pm0.5$ $11.3\pm0.3$ 8CopepodaCo $-16.3\pm0.4$ $10.9\pm0.3$ 8PolychaetaH $-16.7\pm0.7$ $10.7\pm0.2$ 6Alkmaria romijniAr $-16.7\pm0.7$ $10.7\pm0.2$ 6Giycera tridactylaGt $-14.3\pm0.2$ $13.5\pm0.3$ 5Hediste diversicolorHd $-14.2\pm0.2$ $11.5\pm0.2$ 7Heteromastus filifornisHf $-16.2\pm0.2$ $11.5\pm0.2$ 7Nephys cirrosaNc $-15.6\pm0.7$ $12.6\pm0.3$ 6Streblospio shrubsoliiSsh $-16.9\pm0.7$ $10.8\pm0.4$ 5Fishes $11.7\pm0.7$ $2$ $2$ Atherina boyeriAb $-18.0\pm0.6$ $11.7\pm0.7$ $2$ <i>P. minutus</i> Pmi $-17.4\pm0.4$ $13.1\pm0.3$ $4$ <i>Pomatoschistus microps</i> (juv)Pm $-22.4\pm0.3$ $14.0\pm0.7$ $2$ <i>P. minutus</i> Pmi $-17.4\pm0.4$ $13.1\pm0.3$ $4$ Syngnathus abasterSa <td></td> <td>0.000</td> <td></td> <td></td> <td></td> <td></td>  |          | 0.000                             |             |                       |                |        |
| Gibbula umbilicalisGu $-12.0\pm1.5$ $10.7\pm1.3$ $3$ Hydrobia ulvaeHu $-11.5\pm0.3$ $9.6\pm0.1$ $8$ Litorina litoreaL $-11.2\pm0.4$ $12.2\pm0.1$ $4$ IsopodaC $-14.3\pm0.4$ $11.7\pm0.2$ $8$ Cyathura carinataCc $-14.3\pm0.4$ $11.7\pm0.2$ $8$ Idotea chelipesIc $-14.3\pm0.4$ $11.7\pm0.2$ $8$ Lekanesphaera leviiLlev $-12.0\pm0.4$ $8.7\pm0.4$ $8$ MeiofaunaNe $-16.3\pm0.5$ $11.3\pm0.3$ $8$ CopepodaCo $-16.3\pm0.5$ $11.3\pm0.3$ $8$ CopepodaCo $-16.3\pm0.4$ $10.9\pm0.3$ $8$ PolychaetaAr $-16.7\pm0.7$ $10.7\pm0.2$ $6$ Alkmaria romijniAr $-16.7\pm0.7$ $10.7\pm0.2$ $6$ Capitella capitataCca $-16.4\pm0.3$ $10.8\pm0.3$ $7$ Glycera tridactylaGt $-14.3\pm0.2$ $11.8\pm0.3$ $7$ Heteromastus filiformisHf $-16.2\pm0.2$ $11.5\pm0.2$ $7$ Nephys cirrosaNc $-15.6\pm0.7$ $12.2\pm0.6$ $42.2\pm0.6$ Dicentrarchus labrax (juv)Dv $-17.9\pm0.5$ $5.0\pm0.3$ $4$ Pomatoschistus microps (juv)Pm $-22.4\pm0.3$ $14.0\pm0.7$ $2$ P. minutusPrini $-17.4\pm0.4$ $13.1\pm0.3$ $4$ Syngnathus abasterSa $5$ $-50.2\pm0.5$ $44.2\pm0.6$ $2$ Diplodus vulgaris (juv)Dv $-17.9\pm0.5$ $5.0\pm0.3$ $4$ <t< td=""><td></td><td>Gastropoda</td><td></td><td></td><td></td><td></td></t<>  |          | Gastropoda                        |             |                       |                |        |
| Hydrobia ulvaeHu $-11.5\pm0.3$ $9.6\pm0.1$ 8<br>Littorina litoreaLiLittorina litoreaLi $-11.2\pm0.4$ $12.2\pm0.1$ 4IsopodaCyahura carinataCc $-14.3\pm0.4$ $11.7\pm0.2$ 8Cyahura carinataLc $-14.5\pm0.5$ $9.9\pm0.5$ 8Lekanesphaera leviiLlev $-12.0\pm0.4$ $8.7\pm0.4$ 8MeiofaunaNe $-16.3\pm0.5$ $11.3\pm0.3$ 8CopepodaCo $-16.3\pm0.4$ $10.9\pm0.3$ 8PolychaetaAr $-16.7\pm0.7$ $10.7\pm0.2$ 6Capitella capitataCca $-16.4\pm0.3$ $10.8\pm0.3$ 7Glycera tridactylaGt $-14.3\pm0.2$ $11.8\pm0.3$ 7Hediste diversicolorHd $-14.2\pm0.2$ $11.8\pm0.3$ 7Heteromastus filiformisHf $-16.2\pm0.7$ $10.8\pm0.4$ 5FishesNc $-15.6\pm0.7$ $12.6\pm0.3$ 6Atherina boyeriAb $-18.0\pm0.6$ $11.7\pm0.7$ 2Dicentrarchus labrax (juv)DI $-18.2\pm0.6$ $14.2\pm0.6$ 2Diplodus vulgaris (juv)Dv $-17.9\pm0.5$ $15.0\pm0.3$ 4Pomatoschistus microps (juv)Pm $-22.4\pm0.3$ $14.3\pm0.7$ 4Syngnathus abasterSa $-15.0\pm0.9$ $12.3\pm0.6$ $2.5$ $2.5acus$ $3acus$ $3acus$ $3acus$ Solea solea (juv)Ss $-23.2\pm0.9$ $9.7\pm0.4$ $8$ $Acartia sp.Asp.18.5\pm0.58.4\pm0.28CladoceraCl<$  |          | Gibbula umbilicalis               | Gu          | -12.0±1.5             | $10.7 \pm 1.3$ | 3      |
| Littorina litoreaII $-11.2\pm0.4$ $12.2\pm0.1$ 4IsopodaCyathura carinataCc $-14.3\pm0.4$ $11.7\pm0.2$ 8Idota chelipesIc $-14.5\pm0.5$ $9.9\pm0.5$ 8Lekanesphaera leviiLiev $-12.0\pm0.4$ $8.7\pm0.4$ 8MeiofaunaNe $-16.3\pm0.5$ $11.3\pm0.3$ 8CopepodaCo $-16.3\pm0.5$ $11.3\pm0.3$ 8CopepodaCo $-16.3\pm0.4$ $10.9\pm0.3$ 8PolychaetaAr $-16.7\pm0.7$ $10.7\pm0.2$ 6Alkmaria romijniAr $-16.7\pm0.7$ $10.7\pm0.2$ 6Gapiella capitataCca $-16.4\pm0.3$ $10.8\pm0.3$ 7Glycera tridactylaGt $-14.3\pm0.2$ $11.5\pm0.2$ 7Hediste diversicolorHd $-14.2\pm0.2$ $11.5\pm0.2$ 7Heteromastus filiformisHf $-16.2\pm0.7$ $10.8\pm0.4$ 5FishesNc $-15.6\pm0.7$ $12.6\pm0.3$ 6Atherina boyeriAb $-18.0\pm0.6$ $11.7\pm0.7$ 2Dicentrarchus labrax (juv)D1 $-18.2\pm0.6$ $11.2\pm0.6$ 2Diplodus vulgaris (juv)Dv $-17.9\pm0.5$ $15.0\pm0.3$ 4Pomatoschistus microps (juv)Pm $-22.4\pm0.3$ $14.0\pm0.7$ 2Solea soleaSa $-50.4\pm0.7$ $12.3\pm0.6$ 2Solea solea (juv)Ss $-23.2\pm0.9$ $9.7\pm0.4$ 8Acartia tonsaAt $-23.2\pm0.9$ $9.7\pm0.4$ 8Acartia tonsaAt <th< td=""><td></td><td>Hydrobia ulvae</td><td>Hu</td><td>-11.5±0.3</td><td>9.6±0.1</td><td>8</td></th<>  |          | Hydrobia ulvae                    | Hu          | -11.5±0.3             | 9.6±0.1        | 8      |
| $ \begin{array}{c ccccccccccccccccccccccccccccccccccc$  |          | Littorina litorea                 | , TI        | -11.2±0.4             | $12.2\pm0.1$   | 4      |
| Lorpotal<br>Cyathura carinata<br>(Lotea chelipes)<br>Lekanesphaera leviiCc $-14.3\pm0.4$ $11.7\pm0.2$ 8<br>ILotIdotea chelipes<br>Lekanesphaera leviiLlev $-12.0\pm0.4$ $8.7\pm0.4$ 8Meiofauna<br>NematodaNe $-16.3\pm0.5$ $11.3\pm0.3$ 8CopepodaCo $-16.3\pm0.4$ $10.9\pm0.3$ 8Polychaeta<br>Alkmaria romijniAr $-16.7\pm0.7$ $10.7\pm0.2$ 6Capitella capitata<br>Gerera tridactylaCca $-16.4\pm0.3$ $10.8\pm0.3$ 7Glycera tridactylaGt $-14.3\pm0.2$ $13.5\pm0.3$ 5Hediste diversicolorHd $-14.2\pm0.2$ $11.5\pm0.2$ 7Heeromastus filiformisHf $-16.2\pm0.2$ $11.5\pm0.2$ 7Heetromastus filiformisHf $-16.2\pm0.2$ $11.5\pm0.2$ 7Heetromastus filiformisSsh $-16.9\pm0.7$ $10.8\pm0.4$ 5Fishes $24.20.6$ $11.7\pm0.7$ 2Dicentrarchus labrax (juv)Dv $-17.9\pm0.5$ $15.0\pm0.3$ 4Pomatoschistus microps (juv)Pm $-22.4\pm0.3$ $14.9\pm0.7$ 2Solea solea (juv)Ss $-23.2\pm0.9$ $9.7\pm0.4$ 8Acartia tonsaAt $-23.2\pm0.9$ $9.7\pm0.4$ 8 <tr< td=""><td></td><td>Isonoda</td><td></td><td></td><td></td><td></td></tr<>  |          | Isonoda                           |             |                       |                |        |
| Liber of the second  |          | Cyathura carinata                 | Cc          | $-14.3\pm0.4$         | $11.7\pm0.2$   | 8      |
| Indication for the product of the  |          | Idotea chelines                   | k k         | -14 5+0 5             | 9 9+0 5        | 8      |
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| Heteromastus jujormisHi $-10.2\pm0.2$ $11.3\pm0.2$ $7$ Nephtys cirrosaNc $-15.6\pm0.7$ $12.6\pm0.3$ $6$ Streblospio shrubsoliiSsh $-16.9\pm0.7$ $10.8\pm0.4$ $5$ FishesAtherina boyeriAb $-18.0\pm0.6$ $11.7\pm0.7$ $2$ Dicentrarchus labrax (juv)Dl $-18.2\pm0.6$ $14.2\pm0.6$ $2$ Diplodus vulgaris (juv)Dv $-17.9\pm0.5$ $15.0\pm0.3$ $4$ Pomatoschistus microps (juv)Pm $-22.4\pm0.3$ $14.0\pm0.7$ $2$ P. minutusPmi $-17.4\pm0.4$ $13.1\pm0.3$ $4$ Syngnathus abasterSa $-15.0\pm0.9$ $12.3\pm0.6$ $2$ S. acusSac $-16.2\pm0.0$ $11.4\pm0.9$ $2$ Solea solea (juv)Ss $-23.2\pm0.9$ $9.7\pm0.4$ $8$ Acartia tonsaAt $-23.2\pm0.9$ $9.7\pm0.4$ $8$ Acartia sp.Asp $-18.5\pm0.5$ $8.4\pm0.2$ $8$ CladoceraCl $-21.9\pm1.0$ $9.4\pm0.8$ $3$ Mysidacea (juv)My $-18.9\pm0.7$ $8.1\pm0.4$ $4$ Pomatochistos sp. (larvae)Pl $-20.0\pm0.5$ $9.8\pm0.3$ $3$ Sagitta fridericiSf $-18.2\pm0.6$ $11.1\pm0.3$ $6$ Zoeae (brachyura)Zo $-18.7\pm0.4$ $9.0\pm0.2$ $6$  | A        | Hetenomastica Cliff               | TU<br>TE    | -14.2±0.2             | 11.0±0.3       | 7      |
| Nepntys ctrrosaNc $-15.0\pm0.7$ $12.b\pm0.3$ 6Streblospio shrubsoliiSsh $-16.9\pm0.7$ $10.8\pm0.4$ 5FishesAtherina boyeriAb $-18.0\pm0.6$ $11.7\pm0.7$ 2Dicentrarchus labrax (juv)Dl $-18.2\pm0.6$ $14.2\pm0.6$ $22\pm0.6$ Diplodus vulgaris (juv)Dv $-17.9\pm0.5$ $15.0\pm0.3$ 4Pomatoschistus microps (juv)Pm $-22.4\pm0.3$ $14.0\pm0.7$ 2P. minutusPmi $-17.4\pm0.4$ $13.1\pm0.3$ 4Syngnathus abasterSa $-15.0\pm0.9$ $12.3\pm0.6$ 2S. acusSac $-16.2\pm0.0$ $11.4\pm0.9$ 2Solea solea (juv)Ss $-23.2\pm0.9$ $9.7\pm0.4$ 8Acartia tonsaAt $-23.2\pm0.5$ $8.4\pm0.2$ 8CladoceraCl $21.9\pm1.0$ $9.4\pm0.8$ 3Mysidacea (juv)My $-18.5\pm0.5$ $8.4\pm0.2$ 8Mysidacea (juv)My $-18.9\pm0.7$ $8.1\pm0.4$ 4Pomatochistos sp. (larvae)PI $-20.0\pm0.5$ $9.8\pm0.3$ 3Sagitta fridericiSf $-18.2\pm0.6$ $11.1\pm0.3$ 6Zoeae (brachyura)Zo $-18.7\pm0.4$ $9.0\pm0.2$ 6   |          | Heteromastus filiformis           | HI          | $-10.2\pm0.2$         | $11.3\pm0.2$   |        |
| Strebiospio shrubsoluSsh $-10.9\pm0.7$ $10.8\pm0.4$ SFishesAtherina boyeriAb $-18.0\pm0.6$ $11.7\pm0.7$ 2Dicentrarchus labrax (juv)Dl $-18.2\pm0.6$ $14.2\pm0.6$ 2Diplodus vulgaris (juv)Dv $-17.9\pm0.5$ $15.0\pm0.3$ 4Pomatoschistus microps (juv)Pm $-22.4\pm0.3$ $14.0\pm0.7$ 2P. minutusPmi $-17.4\pm0.4$ $13.1\pm0.3$ 4Syngnathus abasterSa $-15.0\pm0.9$ $12.3\pm0.6$ 2S. acusSac $-16.2\pm0.0$ $11.4\pm0.9$ 2Solea solea (juv)Ss $-23.5\pm0.4$ $14.8\pm0.6$ 4 <b>Zooplankton</b> Acartia tonsaAt $-23.2\pm0.9$ $9.7\pm0.4$ Acartia sp.Asp $-18.5\pm0.5$ $8.4\pm0.2$ 8CladoceraCl $-21.9\pm1.0$ $9.4\pm0.8$ 3Mysidacea (juv)My $-18.2\pm0.6$ $11.1\pm0.3$ 6Zoeae (brachyura)Zo $-18.7\pm0.4$ $9.0\pm0.2$ 6   |          | Nephtys cirrosa                   | NC C        | -13.0±0.7             | 12.0±0.3       | 6      |
| FishesAtherina boyeriAb $-18.0\pm0.6$ $11.7\pm0.7$ 2Dicentrarchus labrax (juv)Dl $-18.2\pm0.6$ $14.2\pm0.6$ 2Diplodus vulgaris (juv)Dv $-17.9\pm0.5$ $15.0\pm0.3$ 4Pomatoschistus microps (juv)Pm $-22.4\pm0.3$ $14.0\pm0.7$ 2P. minutusPmi $-17.4\pm0.4$ $13.1\pm0.3$ 4Syngnathus abasterSa $-15.0\pm0.9$ $12.3\pm0.6$ 2S. acusSac $-16.2\pm0.0$ $11.4\pm0.9$ 2Solea solea (juv)Ss $-23.2\pm0.9$ $9.7\pm0.4$ 8Acartia tonsaAt $-23.2\pm0.5$ $8.4\pm0.2$ 8CladoceraCl $-21.9\pm1.0$ $9.4\pm0.8$ 3Mysidacea (juv)My $-18.9\pm0.7$ $8.1\pm0.4$ 4Pomatochistos sp. (larvae)Pl $-20.0\pm0.5$ $9.8\pm0.3$ 3Sagitta fridericiSf $-18.2\pm0.6$ $11.1\pm0.3$ 6Zoeae (brachyura)Zo $-18.7\pm0.4$ $9.0\pm0.2$ 6   |          | strebiospio shrubsolu             | Ssh         | -10.9±0./             | 10.8±0.4       | 3      |
| $\begin{array}{c ccccccccccccccccccccccccccccccccccc$   |          | Fishes                            |             |                       |                |        |
| $\begin{array}{c c} Dicentrarchus labrax (juv) & Dl & -18.2\pm 0.6 & 14.2\pm 0.6 & 2 \\ Diplodus vulgaris (juv) & Dv & -17.9\pm 0.5 & 15.0\pm 0.3 & 4 \\ Pomatoschistus microps (juv) & Pm & -22.4\pm 0.3 & 14.0\pm 0.7 & 2 \\ P. minutus & Pmi & -17.4\pm 0.4 & 13.1\pm 0.3 & 4 \\ Syngnathus abaster & Sa & -15.0\pm 0.9 & 12.3\pm 0.6 & 2 \\ S. acus & Sac & -16.2\pm 0.0 & 11.4\pm 0.9 & 2 \\ Solea solea (juv) & Ss & -23.5\pm 0.4 & 14.8\pm 0.6 & 4 \\ \hline \begin{tabular}{lllllllllllllllllllllllllllllllllll$  |          | Atherina boyeri                   | Ab          | -18.0±0.6             | 11.7±0.7       | 2      |
| $\begin{array}{c ccccccccccccccccccccccccccccccccccc$   |          | Dicentrarchus labrax (iuv)        | DI          | -18.2±0.6             | 14.2±0.6       | 2      |
| Pomatoschistus microps (juv)Pri $-12.4\pm0.3$ $14.0\pm0.7$ 2P. minutusPmi $-17.4\pm0.4$ $13.1\pm0.3$ 4Syngnathus abasterSa $-15.0\pm0.9$ $12.3\pm0.6$ 2S. acusSac $-16.2\pm0.0$ $11.4\pm0.9$ 2Solea solea (juv)Ss $-23.2\pm0.6$ 4ZooplanktonAcartia tonsaAt $-23.2\pm0.9$ $9.7\pm0.4$ 8Acartia sp.Asp $-18.5\pm0.5$ $8.4\pm0.2$ 8CladoceraCl $-21.9\pm1.0$ $9.4\pm0.8$ 3Mysidacea (juv)My $-18.9\pm0.7$ $8.1\pm0.4$ 4Pomatoschistos sp. (larvae)Pl $-20.0\pm0.5$ $9.8\pm0.3$ 3Sagitta fridericiSf $-18.2\pm0.6$ $11.1\pm0.3$ 6Zoeae (brachyura)Zo $-18.7\pm0.4$ $9.0\pm0.2$ 6   | ~        | Diplodus vulgaris (inv)           | Dv          | -17.9±0.5             | 15.0±0.3       | 4      |
| P. minutusPmi $-17.4\pm0.5$ $14.0\pm0.7$ 2P. minutusSyngathus abasterSa $-15.0\pm0.9$ $12.3\pm0.6$ 2S. acusSac $-16.2\pm0.0$ $11.4\pm0.9$ 2Solea solea (juv)Ss $-23.5\pm0.4$ $14.8\pm0.6$ 4ZooplanktonAcartia tonsaAt $-23.2\pm0.9$ $9.7\pm0.4$ 8Acartia sp.Asp $-18.5\pm0.5$ $8.4\pm0.2$ 8CladoceraCl $-21.9\pm1.0$ $9.4\pm0.8$ 3Mysidacea (juv)My $-18.9\pm0.7$ $8.1\pm0.4$ 4Pomatochistos sp. (larvae)Pl $-20.0\pm0.5$ $9.8\pm0.3$ 3Sagitta fridericiSf $-18.2\pm0.6$ $11.1\pm0.3$ 6Zoeae (brachyura)Zo $-18.7\pm0.4$ $9.0\pm0.2$ 6  |          | Pomatoschistus microns (inv)      | Pm          | -22.4+0.3             | 14.0+0.7       | 2      |
| $r.$ mutuas $rm$ $-17.4\pm0.4$ $15.1\pm0.5$ $4$ Syngnathus abasterSa $-16.2\pm0.4$ $12.3\pm0.6$ $2$ S. acusSac $-16.2\pm0.0$ $11.4\pm0.9$ $2$ Solea solea (juv)Ss $-23.2\pm0.4$ $14.8\pm0.6$ $4$ ZooplanktonAcartia tonsaAt $-23.2\pm0.9$ $9.7\pm0.4$ $8$ Acartia sp.Asp $-18.5\pm0.5$ $8.4\pm0.2$ $8$ CladoceraCl $-21.9\pm1.0$ $9.4\pm0.8$ $3$ Mysidacea (juv)My $-18.9\pm0.7$ $8.1\pm0.4$ $4$ Pomatochistos sp. (larvae)Pl $-20.0\pm0.5$ $9.8\pm0.3$ $3$ Sagitta fridericiSf $-18.2\pm0.6$ $11.1\pm0.3$ $6$ Zoeae (brachyura)Zo $-18.7\pm0.4$ $9.0\pm0.2$ $6$  |          | D minutus                         | T III<br>Di | -17 4+0 4             | 13 1±0 3       | ∠<br>∧ |
| Syngmanus abasterSa-13.0 $\pm$ 0.912.3 $\pm$ 0.02S. acusSac-16.2 $\pm$ 0.011.4 $\pm$ 0.92Solea solea (juv)Ss-23.5 $\pm$ 0.414.8 $\pm$ 0.64ZooplanktonAcartia tonsaAt-23.2 $\pm$ 0.99.7 $\pm$ 0.48Acartia sp.Asp-18.5 $\pm$ 0.58.4 $\pm$ 0.28CladoceraCl-21.9 $\pm$ 1.09.4 $\pm$ 0.83Mysidacea (juv)My-18.9 $\pm$ 0.78.1 $\pm$ 0.44Pomatochistos sp. (larvae)Pl-20.0 $\pm$ 0.59.8 $\pm$ 0.33Sagitta fridericiSf-18.2 $\pm$ 0.611.1 $\pm$ 0.36Zoeae (brachyura)Zo-18.7 $\pm$ 0.49.0 $\pm$ 0.26  |          | F. MINUUS                         | rmi<br>C-   | -17.4±0.4             | 12.1±0.5       | 4      |
| S. acusSac-16.2 $\pm$ 0.011.4 $\pm$ 0.92Solea solea (juv)Ss-23.5 $\pm$ 0.414.8 $\pm$ 0.64ZooplanktonAcartia tonsaAt-23.2 $\pm$ 0.99.7 $\pm$ 0.48Acartia tonsaAt-23.2 $\pm$ 0.58.4 $\pm$ 0.28CladoceraCl-21.9 $\pm$ 1.09.4 $\pm$ 0.83Mysidacea (juv)My-18.9 $\pm$ 0.78.1 $\pm$ 0.44Pomatochistos sp. (larvae)Pl-20.0 $\pm$ 0.59.8 $\pm$ 0.33Sagitta fridericiSf-18.2 $\pm$ 0.611.1 $\pm$ 0.36Zoeae (brachyura)Zo-18.7 $\pm$ 0.49.0 $\pm$ 0.26  |          | Syngnathus abaster                | Sa          | -13.0±0.9             | 12.3±0.0       | 2      |
| Solea solea (juv)Ss $-23.5\pm0.4$ $14.8\pm0.6$ 4ZooplanktonAcartia tonsaAt $-23.2\pm0.9$ $9.7\pm0.4$ 8Acartia sp.Asp $-18.5\pm0.5$ $8.4\pm0.2$ 8CladoceraCl $-21.9\pm1.0$ $9.4\pm0.8$ 3Mysidacea (juv)My $-18.9\pm0.7$ $8.1\pm0.4$ 4Pomatochistos sp. (larvae)Pl $-20.0\pm0.5$ $9.8\pm0.3$ 3Sagitta fridericiSf $-18.2\pm0.6$ $11.1\pm0.3$ 6Zoeae (brachyura)Zo $-18.7\pm0.4$ $9.0\pm0.2$ 6   |          | S. acus                           | Sac         | -10.2±0.0             | 11.4±0.9       | 2      |
| ZooplanktonAcartia tonsaAt $-23.2\pm0.9$ $9.7\pm0.4$ 8Acartia sp.Asp $-18.5\pm0.5$ $8.4\pm0.2$ 8CladoceraCl $-21.9\pm1.0$ $9.4\pm0.8$ 3Mysidacea (juv)My $-18.9\pm0.7$ $8.1\pm0.4$ 4Pomatochistos sp. (larvae)Pl $-20.0\pm0.5$ $9.8\pm0.3$ 3Sagitta fridericiSf $-18.2\pm0.6$ $11.1\pm0.3$ 6Zoeae (brachyura)Zo $-18.7\pm0.4$ $9.0\pm0.2$ 6   |          | Solea solea (juv)                 | Ss          | -23.3±0.4             | 14.8±0.6       | 4      |
| Acartia tonsaAt $-23.2\pm0.9$ $9.7\pm0.4$ 8Acartia sp.Asp $-18.5\pm0.5$ $8.4\pm0.2$ 8CladoceraCl $-21.9\pm1.0$ $9.4\pm0.8$ 3Mysidacea (juv)My $-18.9\pm0.7$ $8.1\pm0.4$ 4Pomatochistos sp. (larvae)Pl $-20.0\pm0.5$ $9.8\pm0.3$ 3Sagitta fridericiSf $-18.2\pm0.6$ $11.1\pm0.3$ 6Zoeae (brachyura)Zo $-18.7\pm0.4$ $9.0\pm0.2$ 6  |          | Zooplankton                       |             |                       |                |        |
| Acartia sp.Asp $-18.5\pm0.5$ $8.4\pm0.2$ 8CladoceraCl $-21.9\pm1.0$ $9.4\pm0.8$ 3Mysidacea (juv)My $-18.9\pm0.7$ $8.1\pm0.4$ 4Pomatochistos sp. (larvae)Pl $-20.0\pm0.5$ $9.8\pm0.3$ 3Sagitta fridericiSf $-18.2\pm0.6$ $11.1\pm0.3$ 6Zoeae (brachyura)Zo $-18.7\pm0.4$ $9.0\pm0.2$ 6   |          | Acartia tonsa                     | At          | -23.2±0.9             | 9.7±0.4        | 8      |
| CladoceraCl $-21.9\pm1.0$ $9.4\pm0.8$ $3$ Mysidacea (juv)My $-18.9\pm0.7$ $8.1\pm0.4$ $4$ Pomatochistos sp. (larvae)Pl $-20.0\pm0.5$ $9.8\pm0.3$ $3$ Sagitta fridericiSf $-18.2\pm0.6$ $11.1\pm0.3$ $6$ Zoeae (brachyura)Zo $-18.7\pm0.4$ $9.0\pm0.2$ $6$   |          | Acartia sp.                       | Asn         | -18.5±0.5             | 8.4±0.2        | 8      |
| Charles Charl |          | Cladocera                         | Cl          | -21.9+1.0             | 9.4+0.8        | 3      |
| Mystate (uv)My $-13.24.7$ $8.1\pm0.4$ $4$ Pomatochistos sp. (larvae)Pl $-20.0\pm0.5$ $9.8\pm0.3$ $3$ Sagitta fridericiSf $-18.2\pm0.6$ $11.1\pm0.3$ $6$ Zoeae (brachyura)Zo $-18.2\pm0.4$ $9.0\pm0.2$ $6$   |          | Musidacea (inv)                   | Ma          | -18 9+0 7             | 8 1+0 4        | 1      |
| Formatochistos sp. (tarvae)F1 $-20.0\pm0.5$ $9.0\pm0.5$ $3$ Sagitta fridericiSf $-18.2\pm0.6$ $11.1\pm0.3$ $6$ Zoeae (brachyura)Zo $-18.7\pm0.4$ $9.0\pm0.2$ $6$  |          | Pomatochistor an (longer)         | IVI Y       | -10.9±0.7             | 0.1±0.4        | 4      |
| Sagina priaerici         Si $-10.2\pm0.0$ $11.1\pm0.3$ 6           Zoeae (brachyura)         Zo $-18.7\pm0.4$ $9.0\pm0.2$ 6   |          | <i>Fomatochistos</i> sp. (larvae) | PI          | -20.0±0.3             | 9.0±0.3        | 5      |
| $200 = 10.7 \pm 0.4$ $9.0 \pm 0.2$ 6  |          | Sugitta friderici                 | SI          | -10.2±0.0<br>18 7±0.4 | $0.0\pm0.2$    | 0      |
|   |          | Zoeae (brachyura)                 | Zo          | -10./±0.4             | 9.0±0.2        | 0      |

- 385 Table 2. ANOVA results testing seasonal differences for C and N isotope ratios of
- 386 groups/species collected in the Mondego estuary.\* = p < 0.05, \*\* = p < 0.01; the absence of \*
- 387 means no significant differences.

| Crown/Species                           | $\delta^{13}$ | С  | δ <sup>15</sup> N | 1  |
|---|---------------|----|-------------------|----|
| Group/Species                           | F             | df | F                 | df |
| Macrophytes                             |               |    |                   |    |
| Enteromorpha sp.                        | 0.983         | 3  | 30.678**          | 3  |
| Fucus sp.                               | 0.822         | 3  | 3,990             | 3  |
| Gracilaria sp.                          | 1 051         | 3  | 2.801             | 3  |
| Ulva sp                                 | 3 615         | 3  | /0 330**          | 3  |
| Zastang naltii (laayaa)                 | 2.004         | 2  | 49.339            | 2  |
| Zostera notiti (teaves)                 | 2.004         | 2  | 32.239***         | 2  |
| Zostera notti (roots)                   | 1.229         | 3  | 32.24/**          | 3  |
| Particulate organic matter              | 1.926         | 3  | 2.046             | 3  |
| Sediment                                | 5.412         | 3  | 3.294             | 3  |
| Amphipoda                               |               |    |                   |    |
| Amphithoe valida                        | 0.218         | 3  | 0.77              | 3  |
| Echinogammarus marinus                  | 0.648         | 3  | 1,178             | 3  |
| Melita palmata                          | 1.074         | 3  | 4.091             | 3  |
| n                                       | 1.077         | 5  |                   |    |
| Bivalvia<br>Carastodarma adula          | 0.150         | 3  | 0.204             | 2  |
|   | 0.139         | 2  | 0.204             | 2  |
| Mytilus edulis                          | 0.797         | 3  | 0.899             | 3  |
| Scrobicularia plana                     | 1.167         | 3  | 1.856             | 3  |
| Decapoda                                |               |    |                   |    |
| Carcinus maenas                         | 0.397         | 3  | 0.526             | 3  |
| Crangon crangon                         | 0.315         | 3  | 0.561             | 3  |
| Gastropoda                              |               | N. |                   |    |
| Hydrobia ulvae                          | 0.347         | 3  | 1.348             | 3  |
| Isopoda                                 |               |    |                   |    |
| Cyatura carinata                        | 2.063         | 3  | 1.797             | 3  |
| Idotea chelipes                         | 0.532         | 3  | 11.204*           | 3  |
| Lekanesphaera levii                     | 0.116         | 3  | 10.327*           | 3  |
| Meiofauna                               |               |    |                   |    |
| Nematoda                                | 0.903         | 3  | 0 435             | 3  |
| Copepoda                                | 0.853         | 3  | 4 471             | 3  |
| Copepoda                                | 0.055         | 5  | 4.471             | 5  |
| Polychaeta                              | 1 202         | 2  | 1 774             | 2  |
| Aikmaria romijili<br>Capitalla agnitat- | 1.203         | 2  | 1.//4             | 2  |
| Capitella capitata                      | 0.039         | 3  | 0.009             | 3  |
| Glycera tridactyla                      | 0.77          | 3  | 0.359             | 3  |
| Hediste diversicolor                    | 4.305         | 3  | 0.645             | 3  |
| Heteromastus filiformis                 | 0.131         | 3  | 4.557             | 3  |
| Nephtys cirrosa                         | 1.943         | 3  | 0.552             | 3  |
| Streblospio shrubsolii                  | 2.966         | 2  | 1.746             | 2  |
| Fishes                                  |               |    |                   |    |
| Diplodus vulgaris (inv)                 | 7.428         | 3  | 4.261             | 3  |
| P minutus                               | 4.668         | 3  | 3.875             | 3  |
| Solea solea (juv)                       | 3.939         | 3  | 7.186             | 3  |
| Zoonlankton                             |               |    |                   |    |
| Acartia tonsa                           | 15.897*       | 3  | 3,628             | 3  |
| Acartia sp (marine species)             | 5 837         | 3  | 4 245             | 3  |
| Sagitta friderici                       | 8 585         | 2  | 3 613             | 2  |
| Musidagaa                               | 4.016         | 2  | 1 220             | 2  |
| Topo (C. machara)                       | 4.010         | 5  | 1.520             | 2  |
| zbea (C. maenus)                        | 0.787         | 2  | 14.035            | Z  |

| 389 | Figure captions   |
|-----|---|
| 390 | Fig. 1. Mondego estuary map showing sampling sites: Zostera and bare sediment sites (grey               |
| 391 | circles).   |
| 392 | Fig. 2. Top: daily maximum and minimum air temperature, from November 2005 to July                      |
| 393 | 2006 (black lines), and daily maximum and minimum air temperature means for 1961-1990                   |
| 394 | (grey lines). Black rectangles show when were the sampling periods. Bottom: precipitation               |
| 395 | values, from November 2005 to July 2006 (black bars), and precipitation means for 1961-                 |
| 396 | 1990 (grey bars).   |
| 397 | Fig. 3. Mean of nitrate, ammonium, and phosphate (top), DIN/PO <sub>4</sub> <sup>3-</sup> (middle), and |
| 398 | phytoplankton chlorophyll a (bottom) concentrations, from the two sampling sites, Zostera               |
| 399 | and bare sediment sites, in the Mondego estuary, from November 2005 to July 2006.                       |
| 400 | Fig. 4. C stable-isotopic values (mean $\pm$ SE) for all the groups/species collected in the            |
| 401 | Mondego estuary, from November 2005 to July 2006. Abbreviations of species/groups are                   |
| 402 | shown in table 1.   |
| 403 | Fig. 5. N stable-isotopic values (mean $\pm$ SE) for all the groups/species collected in the            |
| 404 | Mondego estuary, from November 2005 to July 2006. Abbreviations of species/groups are                   |
| 405 | shown in table 1.   |
| 406 | Fig. 6. N stable-isotopic ratio for primary producers (seagrass and macroalgae) collected in            |
| 407 | the Mondego estuary. N stable-isotopic data are plotted against the air temperature.                    |
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