Supplement 2

S2.1. Effect traits

Traits expressing sediment mixing types, ventilation/pumping and biodeposition could not be quantified solely based on simple affinity scores as species exhibited variable sizes and mobility that directly affect the magnitude of processes. Processes such as bioturbation can be specifically measured in situ (i.e. amount of sediments displaced per unit of time), but their quantification at the species level and for a large number of species remains unrealistic. However, and although complex, these processes are generated by movements of organisms that can be expressed by a few relatively simple traits (François et al. 1997, Gérino et al. 2003, Solan et al. 2004b). The modalities of such traits are scored so that their qualitative or quantitative nature expresses their bioturbation potential, enabling to rank species according to this potential (Solan et al. 2004a). In this respect, Swift (1993) provided a pioneer work in scoring benthic taxa for bioturbatory activity. Later, Solan et al. (2004a) built an improved version by adding biomass and sediment mixing types. So far, this practice has gained popularity in European benthic ecology (Queirós et al. 2013).

Our methodology to assess functional potential is based on the traits usually considered in the literature; these traits are provided in Supplement 1. According to previous works (Solan et al. 2004a, Queirós et al. 2013, Queirós et al. 2015), we conceived sediment mixing in a mechanistic way involving organism body size (biomass ash free dry mass, BM), and affinities for mobility (MB) and mixing type (AF) that modulate the mixing potential (MP). We proceeded in a different way as some species are able to generate several types of sediment mixing, so that an affinity trait "Sediment mixing type" was built with mixing types as modalities and fuzzy coded. Thus, each mixing type was a separate trait, its modalities being intervals of values defined on the distribution of calculated scores from the overall species pool:

$$MP = BM \times MB \times AF$$

Each variable was preliminarily rescaled between 0 and 1 to ensure calculations were not affected by different measurement scales, and subsequently for all the other calculations of trait performances; Fig. S2.1 illustrates this calculation.

	Sediment mixing type					Body mass						Mobility			
	None	Biodiffusion	Upward conveying	Downward conveying	Regeneration	<0.001	0.001-0.010	0.010-0.100	0.100-1.000	1.000-10.000	>10.000	Sessile	Limited	Active	Very active
	0.00	1.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00
Score of importance						1	2	3	4	5	6	0	1	2	3
Scaled score						0.17	0.33	0.5	0.67	0.83	1.00	0.00	0.33	0.67	1.00

Fig. S2.1. Illustration of data manipulation to quantify sediment mixing potential. The first line of values show the affinity scores of the bivalve *Abra alba* for sediment mixing types, body mass and mobility. *A. alba* is dominantly biodiffusor, its ash free dry body mass is a few milligrams and its mobility is limited. Body mass and mobility modalities are attributed scores of importance that are scaled between 0 and 1 after division by their maximum, respectively 6 and 3 for body mass and mobility. The sediment mixing potential score (MP) is then obtained by multiplying the three scores: $MP = 1.00 \times 0.33 \times 0.33 = 0.1089$. In case of more than one non-null scores per trait (e.g. 0.00/0.50/0.50/0.00/0.00/0.00 for body mass in *Philocheras trispinosus*, see Supplement 1), the mean of the non-null scaled scores was considered.

Then, categories from “Null” to “High” were attributed per intervals of MP distribution (Fig. S2.2).

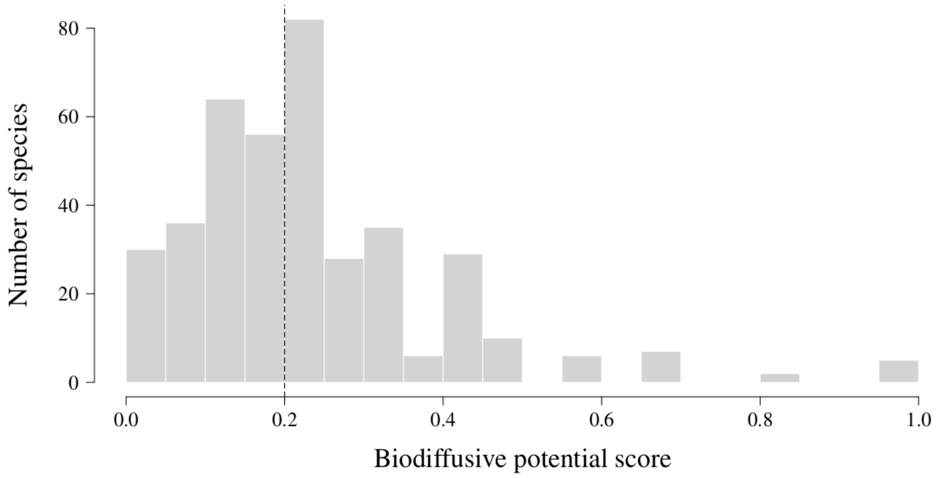

Fig. S2.2. Distribution of non-null biodiffusive potential (376 species) following the procedure described in Fig. S2.1. The vertical dashed line separates the low values (left) from the high values (right) and is positioned so that sufficient amounts of species are represented per interval. Thus, the modalities “Low” and “High” of the trait “Biodiffusion” correspond respectively to the intervals]0.0, 0.2] and]0.2, 1.0], the modality “Null” corresponding to the value 0. The case of *A. alba* illustrated in Fig. S2.1 (0.1089) falls in the modality “Low” and its final trait profile is 0.00/1.00/0.00 (see data in Supplement 1).

The procedure was applied for each sediment mixing type, but with different scores of importance for mobility when calculating biodiffusion and regeneration potentials. We considered that sessile species were deprived of biodiffusive and regenerative abilities whereas others such as some tubicolous worms, considered sessile, could vertically convey sediment or organic matter. Therefore, mobility was scored from 0 to 3 for biodiffusion and regeneration, and from 1 to 4 for upward and downward conveying. Also, body mass was not square root transformed like in the traditional version of bioturbation potential in order to linearise variations between species (Solan et al. 2004a, Queirós et al. 2013). Our scale of body mass intervals (i.e. modalities, Fig. S2.1) had a similar effect, like a logarithm transformation. Ventilation/pumping and biodeposition abilities were calculated simply by multiplying affinity scores for ventilation/pumping and suspension feeding with body mass. The modalities of these two traits, “Null”, “Low” and “High”, were attributed the scores 0, 1 and 2, respectively.

Bioirrigation is an important component of bioturbation (Lindroth 1941, Kristensen et al. 2012). However, an accurate assessment of water fluxes induced by ventilatory or pumping action of organisms through sediments was unrealistic as irrigation activity, which can be periodic or continuous (Kristensen & Kostka 2005), is undocumented for most irrigating species. Rather, bioirrigation was considered implicit through the concomitant expressions of the traits “Ventilation/Pumping”, “Endo-bioconstruction type”, “Burrow width” and “Substratum depth distribution”, of which the covariations of extreme modalities could suggest null or substantial bioirrigation (Table 2). These traits are known to be characteristic of bioirrigative mechanisms (Kristensen & Kostka 2005); the trait “Endo-bioconstruction type” is determinant as burrows with several accesses (i.e. U- or Y-shaped, or anastomosed) enhance water circulation and fluxes (“open-ended”, Kristensen et al. 2012). The trait “Ventilation/Pumping” was initially coded as a simple affinity, “Null” when absent (e.g. epibenthic) “Low” for some species resistant to hypoxia and “High” when systematically reported (in most of cases, the value 3 was attributed to only one of the 3 modalities); this affinity score was then multiplied by body mass and categories were determined as for MP. Like sediment mixing types, we considered the obtained values to represent bioturbative potential rather than effective processes (Solan et al. 2004a, Queirós et al. 2013).

Biodeposition is the transfer of matter from the water column to the sea floor (Graf & Rosenberg 1997); it was calculated by multiplying body mass by the degree of suspension feeding (modalities “None”, “Deposit-Suspension” and “Exclusive” coded from 0 to 3, respectively). Bioerosion, specific to hard substrata but relatively friable (carbonate matter, sandstone, limestone), is the erosion of the substratum through grazing (e.g. limpets, urchins), shelled species boring for protection (e.g. date mussel) or sessile species for anchoring (e.g. barnacles, some spionids) (Trudgill 1988). Biostabilisation, opposed to biodiffusive and regenerative sediment mixing, is the ability of an organism to stabilise the sediment thus preventing hydrological disturbance; it was coded across 3 modalities (“Null”, “Low” and “High”) expressing simply the likelihood of occurrence of the process when documented. It is the main cause for protective biogenic aggregations (e.g. mats, reefs), tube lawns (Fager 1964, Friedrichs et al. 2000), large shell debris (Cheng et al. 2021) or lawns/mats of mounds (Rhoads et al. 1978, Mouritsen et al. 1998, Wild et al. 2005).

Other traits were considered as part of habitat creation through “bioconstruction” (Ingrosso et al. 2018), which are not restricted to the substratum surface. Indeed, large burrows are known to host a variety of commensal, symbiotic, opportunistic and foraging organisms, including fish (Woodin 1978, Lackschewitz & Reise 1998, Reise 2002, Anker et al. 2005, Callaway 2006, Kinoshita et al. 2010, Henmi & Itani 2014, Tseng et al. 2019, Marin & Antokhina 2020). In this respect, “Endo-bioconstruction type” was considered for potential refuge or habitat (i.e. permanent or semi-permanent burrows), with additionally, “Burrow width” and “Endo-bioconstruction depth” informs on the extent of the available volume. Above the substratum, three traits were considered. “Epi-bioconstruction type” expresses the shape of the created emergent structure by a single individual organism. Mounds are colonised by a diversity of small organisms and concentrates high densities of microorganisms with possible important biogeochemical implications (Murray et al. 2002). Then, “Epi-bioconstruction extension” informs on possible horizontal and vertical development of the epi-bioconstruction by aggregation of individual organisms, from simple mat or lawn (e.g. some sponges or tubicolous worms) to complex reefs (e.g. oyster, coral). Finally, “Epi-bioconstruction size” expresses the maximum extent of the emergent structure; for instance, if a blue mussel is generally present in a habitat, it will form a reef (complex to highly complex) of large horizontal extent (>50 cm).

S2.2. Response traits

Response traits were used to calculate sensitivity, recoverability and vulnerability according to Beauchard et al. (2021). Since the larger species pool exhibited wider functional ranges, modalities were added to body length (>50 cm), life span (10-20 and >20 years) and offspring size (1.5-5.0 and >5.0 mm). Table S2.1 displays traits, modalities and scores.

Table S2.1. Response traits, modalities and respective scores used in the calculation of sensitivity, recoverability and vulnerability.

Trait	Modality	Raw score	Standardized score	Trait	Modality	Raw score	Standardized score
Body length (cm)	<1	1	0.00	Life span (years)	<1	1	0.00
	1-3	2	0.20		1-3	2	0.25
	3-10	3	0.40		3-10	3	0.50
	10-20	4	0.60		10-20	4	0.75
	20-50	5	0.80		>20	5	1.00
	>50	6	1.00	Mobility	Very active	1	0.00
Body resistance	0.00	1	0.00		Active	2	0.33
	0.25	2	0.25		Limited	3	0.67
	0.50	3	0.50		Sessile	4	1.00
	0.75	4	0.75	Offspring type	Juvenile	1	0.00
	1.00	5	1.00		Larva	2	0.50
Burrowing depth (cm)	>30	1	0.00		Egg	3	1.00
	15-30	2	0.25	Offspring size (mm)	>5.0	1	0.00
	5-15	3	0.50		1.5-5.0	2	0.25
	0-5	4	0.75		0.5-1.5	3	0.50
	0	5	1.00		0.1-0.5	4	0.75
					<0.1	5	1.00

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