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Considering the Functional Value of Common Marine Species as a Conservation Stake: The Case of Sandmason Worm *Lanice conchilega* (Pallas 1766) (Annelida, Polychaeta) Beds

Conservation of the marine environment mainly focuses on threatened elements and more precisely on vulnerable and endangered species like birds and mammals. When dealing with the conservation of marine habitats, the scientific community is mainly interested in hot spots of diversity, like seagrass beds in Europe, or hot spots of endemism, like coral reefs in tropical areas. Nevertheless, using the example of a common and widespread marine invertebrate, the sandmason worm (*Lanice conchilega*, Polychaeta, Terebellidae), we show that vulnerability and rarity are not the only criteria to take into account in order to select the best natural element for conservation. This species can form dense beds that increase biodiversity, are attractive feeding grounds for birds and fishes, and have a high socioeconomic value. In consequence, they have a high functional value that should be considered as an important conservation stake. Through the example of the Chausey archipelago and the Bay of the Mont Saint-Michel (France), we propose a synthetic interdisciplinary approach to evaluate the conservation needs of these beds. The issue is even more pressing when one considers that these natural elements and many similar ones still do not benefit from any legal protection in Europe despite their high heritage value.

INTRODUCTION

The scientific literature about the conservation of biodiversity mainly focuses on threatened or rare species (1). In marine biology, special interest is given to either the conservation of birds and mammals, or rich and diversified habitats known as "hot spots" (2–4), as illustrated by coral reefs in tropical areas (5). In consequence, common invertebrate species are generally excluded from any legal protection, despite their potential functional value. A lot of marine invertebrate species (e.g., the lugworm *Arenicola marina*) (6) can modify, create, or maintain natural habitats and can therefore be considered as "ecosystem engineers" (7). Several studies on these species have reported effects of their biogenic structures on the benthic boundary-layer flows. For example, current velocity significantly decreases within high-density patches of tube-building marine worms (8–10). There are also effects on sediment features and dynamics: engineer species are able to either stabilize or rework large quantities of sediments (8, 11, 12) and to modify their texture (13–15). Above a threshold density, marine invertebrates can even produce original sedimentological structures (16, 17). Finally, these studies have also reported positive effects on the macrozoobenthic assemblage features (increase of the abundance and the total diversity) associated with dense patches of engineer species (18–21). Furthermore, some ecosystem engineers are locally endangered by human activities (22–24).

Unfortunately, the studies relative to the functional values of populations of common engineer marine invertebrates are mainly restricted to ecological disciplines. Furthermore, with the exclusion of traditionally commercial-interest species, to our knowledge, no studies have integrated the potential socioeconomical benefits of common temperate marine invertebrate populations for human activities.

The aim of the present work is to assess the potential conservation stakes of populations of common soft-bottom marine invertebrates through their functional values, both from biological and socioeconomic points of view. The model species, the sandmason worm *Lanice conchilega* (Polychaeta, Terebellidae), has been chosen according to the following criteria.

Firstly, this species has a wide distribution (from Europe to California to Australia). Its largest populations are located in northern Europe (25, 26). Although Marcano and Bhaud (27) suggested that this widespread distribution may correspond to a mixing of species, we can expect their functional value to be similar and mostly dependent on the structure and on the dynamics of their populations. Above a critical threshold of density and diameters of individual tubes (8), surfaces colonized by this species are called *Lanice conchilega* beds. The largest beds are mainly found in the Wadden Sea (28–30) and in France, especially in the Veys (31–33) and in Mont Saint-Michel bays.

Secondly, several scientific articles focusing on *L. conchilega* beds have demonstrated their structuring impacts on the benthic environment: *L. conchilega* is known to produce its own sedimentary structures constituted of mounds and depression (16), to improve the abundance and the specific richness of the associated macrofauna (34–36), and to provide attractive feeding grounds for birds (37–39) and flat fishes (40–42). According to Zühlke (35) and Rabout et al. (43), *L. conchilega* can be considered to be an "engineer species."

Thirdly, because the *L. conchilega* beds occupy tidal flats from neap low tide to subtidal areas, they are submitted to strong anthropogenic pressures (including, for example, shellfish farming and recreational fishing).

Finally, we assume that this common tube-building polychaete may be considered to be a convenient model for the assessment of the environmental stakes of common marine invertebrates.

Nevertheless, despite these studies, the total functional value of the *L. conchilega* beds is difficult to assess for two main reasons. No interdisciplinary research, connecting both biological and human sciences, has focused on *L. conchilega*, and no authors have assessed the potential benefits of this species for human activities: the rare studies dealing with the relationships between *L. conchilega* beds and human activities concern trophic relationships between oyster cultivation and *L. conchilega* beds (32, 33, 44). In this paper, we compare two sites in the Normand-Breton Gulf (France) that host large *L. conchilega* beds and that are controlled by contrasting natural and anthropogenic pressures. Our aim is to assess the functional

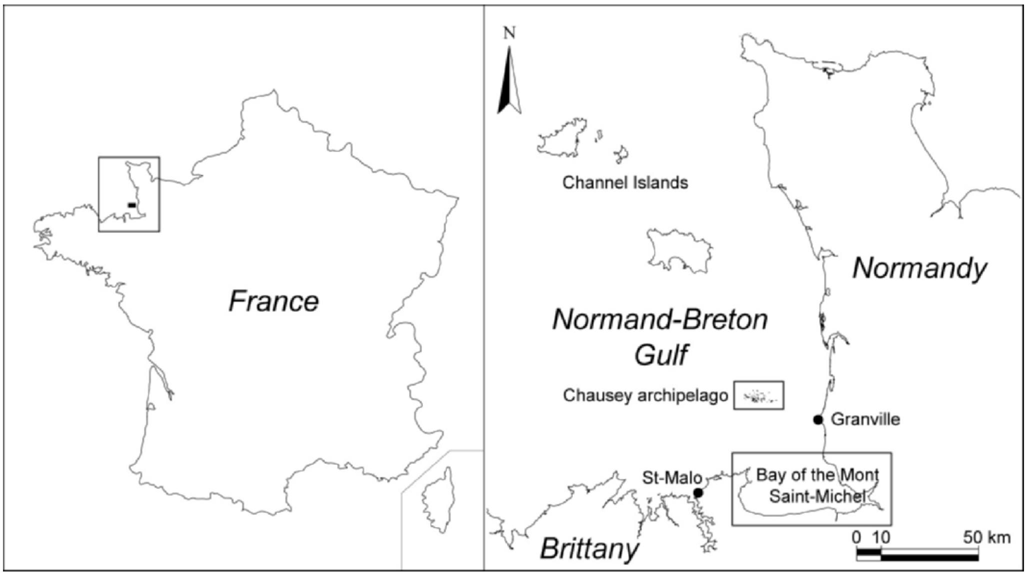


Figure 1. Location of the two study sites.

value of the beds as a whole through an interdisciplinary approach that takes into account both biological and socioeconomic parts. We propose to answer four main questions: *i)* What are the conservation stakes of the study sites? *ii)* What is the functional value of the *L. conchilega* beds according to the conservation stakes of the sites? *iii)* Is it possible to conserve them? *iv)* Does every *L. conchilega* bed have the same conservation stake?

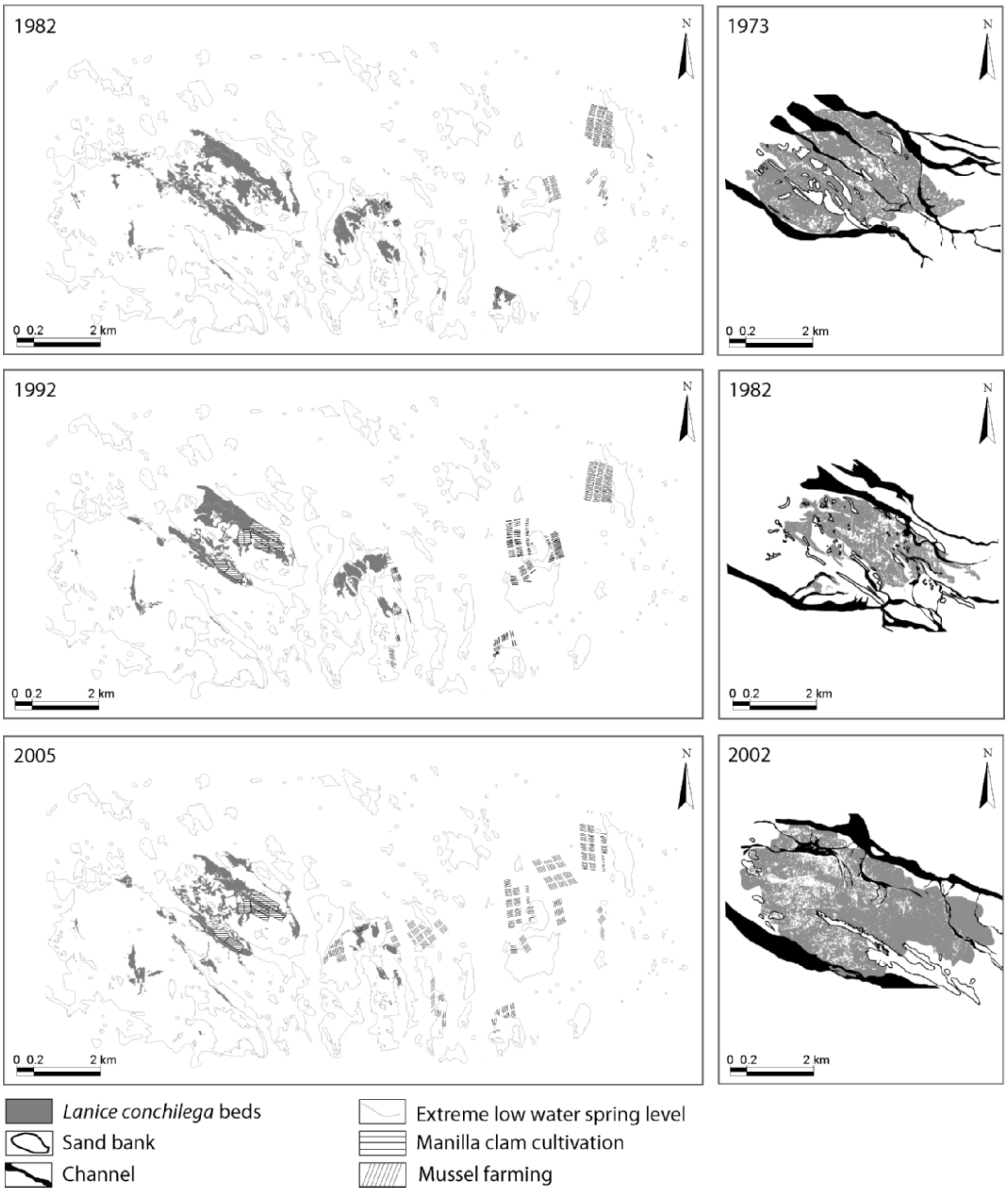
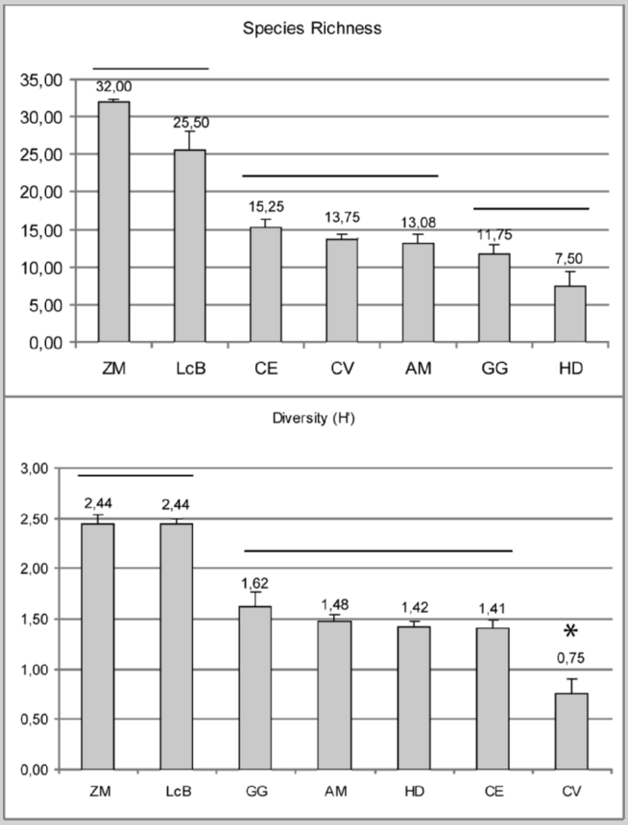


Figure 2. *Lanice conchilega* beds in the Chausey archipelago (left column) and in the BMSM (right column) during the last decades.

Box 1.
Mean species richness and mean species diversity (Shannon-Weaver H′) of the benthic macrofauna among the seven main habitats of the tidal flats of the Chausey archipelago.

Analyses of four stations of each of the five main habitats (*Hediste diversicolor* muds [HD], *Arenicola marina* muds [AM], *Glycymeris glycymeris* coarse sands [GG], *Zostera marina* beds [ZM], and *L. conchilega* beds [LcB]) and two stations of two more localized habitats (*Cerastoderma edule* sands [CE] and *Capsella variegata* sands [CV]) were performed. On each station, four 0.1-m^2 cores were used. Samples were washed through a 2-mm circular mesh sieve. After sieving, all samples were immediately preserved in 4.5% formalin solution. In the laboratory, samples were then sorted twice, the second time after Rose Bengal staining. All the components of the macrozoobenthos were identified to the lowest taxonomic order with the use of standard taxonomic keys, and individuals were counted. Vagile epifauna species were not included in our results.

Zostera marina and *L. conchilega* beds are significantly the richest and the most diversified among the seven main habitats of the archipelago (Kruskall-Wallis $p < 0.05$).

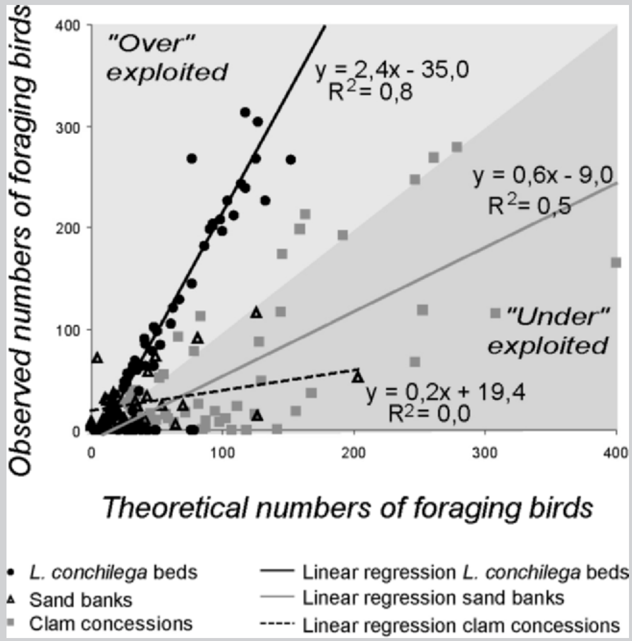


Box 2.
Attractiveness of the *Lanice conchilega* beds for birds in the Chausey archipelago.

We expected that birds would be able to select between different available habitats (*Lanice conchilega* beds of high densities, i.e., >100 m^{-2}, and low densities, i.e., <100 m^{-2}; sandbanks, and Manilla clam cultivation concessions) and that they would select *L. conchilega* beds of high densities for feeding.

Foraging waders and gulls were counted during seven spring tides in 2006: three times during spring migration, two times during breeding, and two times during wintering period on the intertidal area of Chausey that hosted the largest *L. conchilega* beds at the site. During each day-count, birds were counted every 20 min from the mid-tide to the low tide (77 counts in 2006) because bird abundance may vary during a tidal cycle. Because birds follow the tide line and feed preferentially on just-emerged areas, counts were performed in bathymetric sectors marked out on the bottom by plastic sticks. Next, theoretical bird numbers were calculated per habitat for each count, assuming that the bird distribution was homogeneous by bathymetric sectors: the theoretical bird number per habitat is equal to the total bird number of one sector at one time divided by the surface of specific habitat surface. Last, we compared, for each count, theoretical numbers of birds per habitat with the observed numbers of birds per habitat *via* linear regressions.

Birds tended to overexploit the *L. conchilega* beds (there were more birds than expected on the *L. conchilega* beds; $R^2 = 0.8$) and underexploit the sandbanks and clam concessions.



WHAT ARE THE CONSERVATION STAKES OF THE STUDY SITES?

The Chausey archipelago and the Bay of the Mont Saint-Michel (BMSM) are both located in the Normand-Breton Gulf, France (Fig. 1), which is subject to an extreme megatidal regime (tidal range up to 15.5 m during spring tides). Combined with very low beach slopes, the tides provide large sand flats that dominate both sites; total surfaces that reach more than 25 000 ha in the BMSM and 1410 ha in the Chausey archipelago.

The main natural original feature of Chausey lies in the mosaic of its intertidal habitats, which constitute a highly fragmented landscape. Chausey is also one of the first national breeding sites for several marine bird species (European shag *Phalacrocorax aristotelis*, oystercatcher *Haematopus ostralegus*, or red-breasted merganser *Mergus serrator*). The beauty of the site and the pleasure of visiting an archipelago make this site a very touristic place (45). Most people come in the summer and during spring tides for recreational fishing of bivalves and crustaceans. Professional activities include shellfish farming, especially mussel (*Mytilus edulis*) farming (2000 tons per year) and Manilla clam (*Ruditapes philippinarum*) farming (120 tons per year on 24 ha concessions) (46). This last activity started in France in the 1980s but collapsed due to many reasons, with the

Table 1. Mean densities of the four main fished bivalves (cockle *Cerastoderma edule*, wart venus *Venus verrucosa*, Manilla clam *Ruditapes philippinarum*, and dog cockle *Glycymeris glycymeris*) collected in four 1-m^2 rakings per habitat in Chausey. *Hediste diversicolor* muds were not taken into account because no fished bivalves were available on them. Differences have been tested by Kruskall-Wallis tests. Horizontal lines indicate no significant differences ($p > 0.05$); asterisks indicate significant differences ($p < 0.05$) performed by multiple comparison tests. LcB = *Lanice conchilega* beds; CE = *Cerastoderma edule* sands; AM = *Arenicola marina* muds; GG = *Glycymeris glycymeris* coarse sands; ZM = *Zostera marina* beds; CV = *Capsella variegata* sands.

	LcB	CE	AM	GG	ZM	CV	Kruskall-Wallis
Glycymeris glycymeris	—	—	—	1.58 (0.96)	0.17 (0.11)	0.25 (0.25)	$\overset{*}{\text{GG}}\ \overline{\text{CV ZM LcB CE AM}}$
Cerastoderma edule	9.84 (1.87)	7.25 (1.65)	2.3 (0.45)	—	—	—	$\overline{\text{LcB CE}}\ \overset{*}{\text{AM}}\ \overline{\text{GG ZM CV}}$
Ruditapes philippinarum	0.17 (0.11)	1.25 (0.48)	0.17 (0.11)	—	—	—	$\overset{*}{\text{CE}}\ \overline{\text{LcB AM}}\ \overline{\text{GG ZM CV}}$
Venus verrucosa	0.33 (0.14)	—	—	—	1.50 (0.54)	—	$\overset{*}{\text{ZM}}\ \overset{*}{\text{LcB}}\ \overline{\text{CE AM GG CV}}$
Total	10.33 (0.10)	8.5 (0.87)	2.50 (0.10)	1.58 (0.07)	1.67 (0.06)	0.25 (0.03)	$\overline{\text{LcB CE}}\ \overset{*}{\text{AM}}\ \overline{\text{ZM GG}}\ \overset{*}{\text{CV}}$

exception of the Chausey islands. Nowadays, the archipelago is the first national production site.

The BMSM differs drastically and is composed of a huge nonfragmented tidal flat. From a biological point of view, it is a wintering and migrating site of major international importance for wading birds (47, 48). The BMSM is also known to be an important nursery for flat fishes, especially for the high-economic value sole (*Solea solea*) (49, 50). Known to be very dangerous because of the intensity of the tidal currents and its quicksands, only the parts surrounding the Mont Saint-Michel are much frequented by tourists (one of the major European tourism sites). Major human activities are represented by professional shellfish farming. The BMSM is the foremost national site for mussel farming (10 000 tons per year) and one of great importance for oyster (*Crassostrea gigas* and *Ostrea edulis*) farming (51).

WHAT IS THE IMPORTANCE OF THE FUNCTIONAL VALUE OF THE *LANICE CONCHILEGA* BEDS ACCORDING TO THE CONSERVATION STAKES OF THE SITES?

Importance of the *Lanice conchilega* Beds in Terms of Area

The 2005 intertidal habitat mapping of Chausey (Fig. 2) reveals that *L. conchilega* beds, which cover 101 ha and thus partly dominate the site (10% of the tidal flats), are distributed in several quite small beds (from less than 1 ha to 20 ha each). In 2006, densities of *L. conchilega* varied among the beds between 200 and 400 individuals (ind.) m^{-2}, and values of 900 ind. m^{-2} were exceptionally reached. Such small beds with medium densities are fairly common in France (52, 53) and northern Europe (28), so that the *L. conchilega* beds of Chausey are not important on a regional scale but may be important on the site scale.

The *L. conchilega* beds of the BMSM (Fig. 2) differ drastically because they cover approximately similar superficies as the Chausey ones (190 ha in 2005) but only constitute a very small part of the tidal flats (less than 1% of the total area). These beds are distributed within one single large bed, conferring to this site an exceptional interest on an international scale. Similar beds may be found only in France in the Baie des Veys (eastern Normandy, 32) or in the German Wadden Sea (28–30). First results about the densities of the BMSM beds estimated by tube counts (as advocated by Ropert [32], Zühlke [35], and Van Hoey et al. [54]) revealed a mean density of 1950 ind. m^{-2} (Toupoint et al. unpubl. data), which is comparable to the values recently estimated in the Wadden Sea by Petersen and Exo (39) (between 1020 and 1630 ind. m^{-2}).

Biological Importance

In Chausey, recent benthic macrofauna surveys on the main intertidal habitats (i.e., covering more than 80% of the sand flats area of the site) reveal that *L. conchilega* beds and *Zostera marina* beds are the richest and the most diversified sites of the archipelago (Box 1).

Counting surveys conducted during winter and spring 2005 bird migrations showed that the *L. conchilega* beds at Chausey seem to be very attractive for waders and gulls, with ~80% of the birds feeding on them during spring winter tides. More than 70% of the western curlew (*Numenius arquata*) and 90% of the gray plovers (*Pluvialis squatarola*) at the site fed on one single *L. conchilega* bed in winter 2005 (Godet et al. unpubl. data). In Chausey, birds significantly selected *L. conchilega* beds over other available habitats for feeding (Box 2).

Nevertheless, the attractiveness of the *L. conchilega* beds depends on their accessibility during low-tide because they are located at a rather low bathymetric level (below neap low tide level). If we compare the surfaces of the main habitats of the archipelago that are available for birds (i.e., as a function of emersion time), the *L. conchilega* beds, although they cover a large area (101 ha), are accessible only during a short period.

Preliminary counts of birds in the BMSM revealed that more than 80% of several bird species (little egret *Egretta garzetta*, oystercatcher *Haematopus ostralegus,* bar-tailed godwit *Limosa lapponica*, and gray plover *Pluvialis squatarola*) fed exclusively

Table 2. Main effects of the Manilla clam cultivation on the *L. conchilega* beds densities and on the associated macrofauna. All differences are significant.

	Natural *L. conchilega* beds	Clam concession (just harvested)	
Mean densities of *L. conchilega* (m^{-2}) (Std. dev.)	458.35 (299.48)	32.05 (15.02)	Mann-Whitney U test $p < 0.05$
Mean species richness of the benthic macrofauna (Std. dev.)	23.25 (5.50)	10.25 (1.26)	t test $p < 0.05$
Mean species diversity [H′ Shannon-Weaver] of the benthic macrofauna (Std. dev.)	2.36 (0.24)	1.88 (0.25)	t test $p < 0.05$
Mean abundances of the benthic macrofauna (Std. dev.)	1267.50 (114.41)	317.50 (35.00)	t test $p < 0.05$

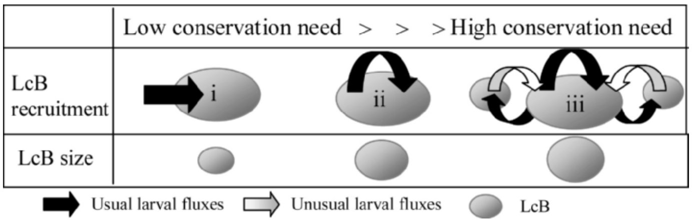


Figure 3. Different types of *Lanice conchilega* beds (LcB) in relation to the recruitment dynamics and the size of the population: *i)* recruitment from other beds (sink population); *ii)* autorecruitment; and *iii)* autorecruitment and recruitment in the other beds (source population).

on the *L. conchilega* beds during spring and autumn migration, as did almost the totality of the breeding birds at the site for other species (55, Godet et al. unpubl. data). In consequence, the *L. conchilega* beds of the BMSM could play a major role in the conservation of the avifauna.

Importance for the Human Activities

In the Chausey archipelago, Manilla clam cultivation is directly established on the *L. conchilega* beds. According to the clam farmers themselves, the presence of *L. conchilega* tubes reveals: *i)* a suitable bathymetric level for the growth of clams and for regular access on the shellfish concessions, *ii)* stable areas (from a sedimentological point of view) due to the stabilization effect of *L. conchilega* tubes, and *iii)* an indicator of food availability from the water column for the clams. This empirical knowledge has been corroborated by various scientific papers (16, 28, 56). In consequence, the clam farmers consider the *L. conchilega* to be the preliminary natural condition before any development of their activity. Consequently, we can consider the *L. conchilega* beds to be the starting point of an original economy.

Finally, young cohorts of flat fishes (dab, plaice, and sole) are known to feed on *L. conchilega* (40–42). The *L. conchilega* beds of Chausey and of the BMSM could constitute important natural biological nurseries of high-economic-value fishes on a regional scale for professional fishing, especially in the BMSM site, which is already known to be an important nursery for flat fishes (49).

In Chausey, sociological surveys indicate that the four main fished bivalves are the cockle *Cerastoderma edule*, the wart venus *Venus verrucosa*, the Manilla clam *Ruditapes philippinarum*, and the dog cockle *Glycymeris glycymeris* (45). Our results show that the cumulative densities of these four bivalves are significantly higher in *L. conchilega* beds and in the *Cerastoderme edule* sands than in the other intertidal habitats, especially due to the significantly higher abundances of *Cerastoderma edule* in these two habitats (Table 1). Contrary to other habitats (e.g., *Hediste diversicolor* or *Arenicola marina* muds), which are clearly avoided by tourists, bivalve fishermen directly exploit the areas that host the largest *L. conchilega* beds (45), and people do not hesitate to walk on them and so give to *L. conchilega* beds a "use value."

No human activities directly affect the *L. conchilega* beds of the BMSM, in part because of the low accessibility of these beds by foot or bivalve fishermen, who do not take the risk of being trapped by the flood tide.

IS IT POSSIBLE TO CONSERVE THE *LANICE CONCHILEGA* BEDS?

Evaluating the Stability and the Dynamics of the Beds and Their Origin

Evaluations of the stability of the *L. conchilega* beds at the two sites are fundamental. Currently, habitat conservation is almost always performed through protected areas. However, there is little interest in creating protected areas if the habitats in need of protection are very ephemeral. In other sites, *L. conchilega* beds are known to endure over several decades, but they also can quickly disappear after severe winters, as in the Wadden Sea (28, 35, 57).

Interpretations of aerial photographs highlight the global regression of the *L. conchilega* beds of Chausey during the last two decades (160 ha in 1982, 107 ha in 1992, 83 ha in 2005), but the largest beds have always been located in the same central area (Fig. 2). There was a global trend to stability for the total

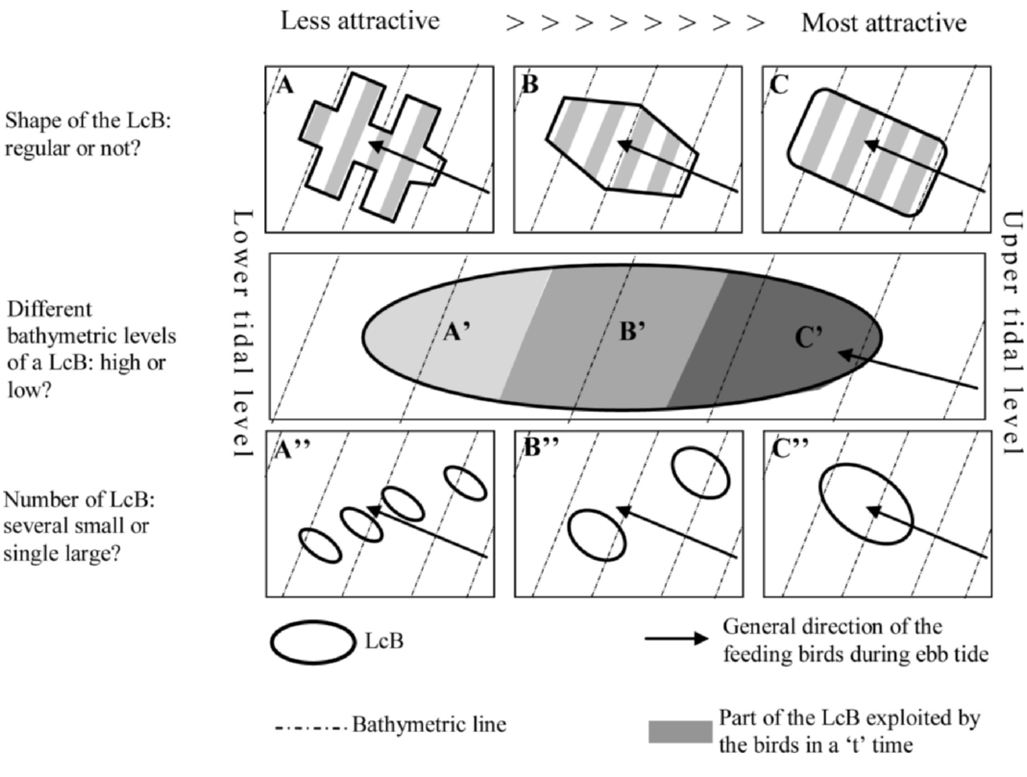


Figure 4. Influence of orientation, position, and total surface of the *Lanice conchilega* beds (LcB) for feeding birds. Cases A, B, and C: birds follow the tide line and exploit the just-emerged area. When the shape of a bed is regular, the area potentially exploited is similar during the whole tidal cycle (C), and a constant number of birds can feed on the same bed. On a bed of irregular shape (A), the exploitable area varies a lot during the tide, so that the birds have to switch to other beds to feed. Sectors A′, B′, and C′: the upper parts of a bed are more exploitable for the birds. Sector C′ is exploited at every low tide, whereas sector A′ emerges only during low spring tides. In cases A″, B″, and C″, a single large bed (C″) will be more suitable for feeding birds than several smaller ones (A″).

surface of the BMSM *L. conchilega* beds (134 ha in 1973, 68 ha in 1982, 239 ha in 2002, 209 ha in 2005) despite the decline in 1982 (Fig. 2). Thanks to this relative stability, conservation measures can be planned.

The sources of the spatial variations in the *L. conchilega* beds seem to be very different between the two sites. In the Chausey islands, the spatial variations of the *L. conchilega* beds are mainly dependent on anthropogenic activities, especially those relative to shellfish farming. A study of the impact of Manilla clam cultivation (which settles directly on the *L. conchilega* beds) revealed that superficial sediment scraping during the harvesting phase strongly decreased the *L. conchilega* densities, and also the abundances, the richness, and the diversity of the associated macrofauna (58) (Table 2). Secondly, an analysis of the aerial photographs of the last decades (Fig. 2) shows that all small beds previously located in the eastern part of the archipelago disappeared where mussel farming developed.

By contrast, because no activities take place directly on the *L. conchilega* beds of the BMSM, spatial variations are thought to be strongly dependent on environmental factors. During the last decades, interpretations of aerial photographs reveal that the spatial dynamics of the *L. conchilega* beds are limited northward by large channels and southward both by channels and sandbanks (Fig. 2).

The Need for Legal and Social Recognition

The ability to protect the *L. conchilega* beds is not only related to ecological processes, but it also involves legal and social aspects. A first legal stage has been reached because *L. conchilega* beds are now legally recognized by the European University Information Systems (EUNIS) classification scheme (Codes A2.245 and A5.127). Nevertheless, it does not imply a legal conservation, and neither the habitat nor the species is included in a legal conservation directive such as the Habitats Directive (92/43 EEC). *L. conchilega* can be found almost all along the European coasts, and, locally, it can forms dense beds. Therefore, on the contrary to habitat with clear boundaries, *L. conchilega* beds are more difficult to define and to map. This can explain why *L. conchilega* is only mentioned as an "indicating species" of different habitats in the Habitats Directive (habitats 1110–4 and 1160–2, for example) but not as an original habitat. Threshold densities and topographic and biological characteristics should be defined for *L. conchilega* beds. Up to now, the legal recognition of the habitat *via* EUNIS does not seem to be relevant because it artificially separates subtidal *L. conchilega* beds from intertidal ones.

Semidirective interviews performed during spring 2006 on various social groups at Chausey (59) revealed that most people directly fished on or near the *L. conchilega* beds, so people are able to recognize and locate them and have integrated the *L. conchilega* beds into interest for bivalve fishing.

DOES EVERY *LANICE CONCHILEGA* BED HAVE THE SAME CONSERVATION STAKE?

The conservation stakes for *L. conchilega* beds should be replaced on a metapopulation scheme in order to identify sink and source populations. Because *L. conchilega* is a benthoplanktonic species with a long larval stage (up to 2 mo) (60, 61), propagule fluxes probably exceed the spatial scale of one of our study sites. In consequence, different populations of *L. conchilega* beds in the Normand-Breton Gulf, and thus those of Chausey and the BMSM, may be connected. In this context, we assume that population renewal at the two sites may follow three patterns (Fig. 3). Furthermore, the size of the beds may

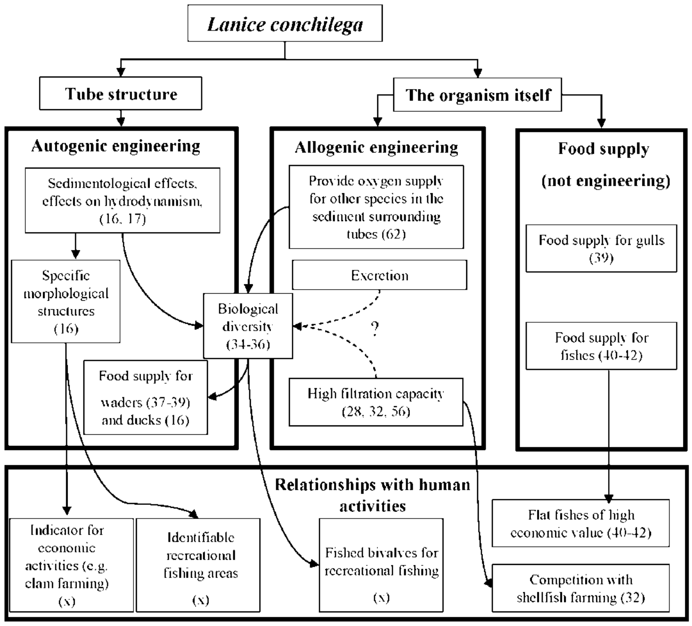


Figure 5. The functional value of *Lanice conchilega.* (References are included in this diagram, and 'x' corresponds to the present study.)

vary. The conservation needs are therefore highest for large-size source populations.

On a site scale, *L. conchilega* beds may have very different structures according to their individual densities, their topography, their shape, or their size. A threshold may be defined in order to select the best *L. conchilega* beds to be conserved. In Chausey and the BMSM, *L. conchilega* can be found in three typologies according to their densities and their topographic characteristics: *i)* areas with scattered tubes; *ii)* areas with tubes in low density; and *iii)* "true *L. conchilega* beds" with tubes at medium and high density (±500 ind. m^{-2}). At very high densities, the *L. conchilega* beds produce their own original sedimentary structures (16). We also assume that their shape and size may affect their functional value. In the Chausey archipelago, a wide variety of shapes and sizes of *L. conchilega* beds may be found. Figure 4 shows, for example, different kinds of orientations, positions, and numbers of beds, from the least to the most potentially attractive for birds.

DISCUSSION

As Many Sites, As Many Different Kinds of *Lanice conchilega* Beds

This study of two sites in the Normand-Breton Gulf highlights two different typologies of *L. conchilega* beds.

The *L. conchilega* beds of Chausey are rather anthropoecological systems. Several activities take place on them and have sometimes strong negative effects. Their biological functional value seems to be more local, and they are mainly beneficial to human activities and to the secondary consumers such as birds. To conserve them, managers have to develop human activities with respect to the particularities of the *L. conchilega* beds. The *L. conchilega* bed of the BMSM is a rather steady natural system, which has a potential and effective functional value on an international scale. Conserving this habitat means preserving it from possible destructives activities. This *L. conchilega* bed is something exceptional on a European scale and could even be protected for itself as a "natural monument." Depending on the hydrodynamic features of the sites and on the larval dispersion mechanisms, conservation needs must integrate exchanges

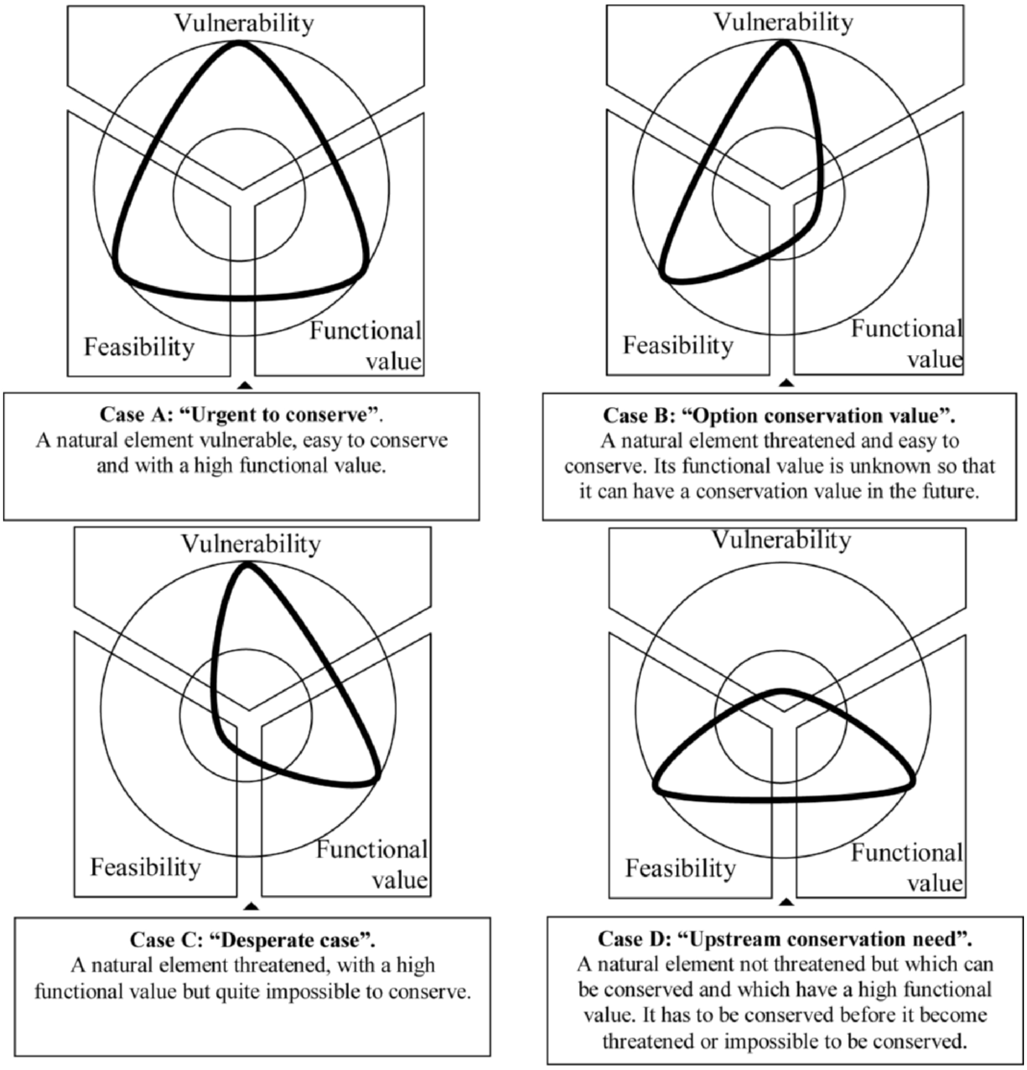


Figure 6. Four different conservation needs of natural elements according to the importance of: *i)* their vulnerability; *ii)* their functional value (i.e., what can you gain with this natural element, and what can you lose if it disappears); and *iii)* the feasibility (i.e., is it possible to conserve them?).

between *L. conchilega* beds. If one site hosts the main source populations of *L. conchilega* that supply the others, it must be conserved in priority. In fact, the conservation needs of the sandmason worm beds at the sites are multiple (biological, social, economical) and can only be analyzed site by site by an interdisciplinary approach that takes into account their spatial and temporal variations.

A Synthetic Overview of the Functional Value of the *Lanice conchilega* Beds

The functional value of the *L. conchilega* beds, highlighted through the study of two sites in this paper, has only been partially studied by several other authors. We propose a synthetic overview of this functional value (Fig. 5) based on the concept of "engineer species" provided by Jones et al. (7). Engineer species are "organisms that directly or indirectly modulate the availability of resources to others species by causing physical state changes in biotic or abiotic materials" (7). The authors further distinguish "autogenic engineers," which "change the environment *via* their own physical structures (i.e., their living and dead structures)" from "allogenic engineers," which "change the environment by transforming living or non-living materials from one physical state to another, *via* mechanical or other means." Figure 5 details the functional value of *L. conchilega* and its engineering characteristics. The organism itself (i.e., the animal) can be a food supply (which is not an engineering function) (39–42), but it can also be an allogenic engineer by providing oxygen supply (62) and high filtration capacities (32). On the other hand, the tube structure can be considered as an autogenic engineer through sedimentological (16) and biological effects (34–36, 63). Therefore, these modulations on biotic and abiotic materials play a crucial role for human activities, both leisure and professional (Fig. 5).

The Functional Value Has to Be Assessed to Conserve Natural Elements

Classically, conservation objectives are mostly based on the concepts of the rarity and vulnerability of natural components. In a conservation perspective, it is not only necessary to integrate the rarity/vulnerability criterion but also to couple it with *i)* the functional value, which can be viewed as a conservation stake itself (i.e., what can you gain with this natural element, and what can you lose if it disappears?), and *ii)* the feasibility of applying conservation measures (i.e., it is not relevant to spend time or money for something impossible to conserve).

By combining these three criteria, we may distinguish four main types of conservation needs (Fig. 6). Few species are both vulnerable and easy to conserve (Figs. 6A,B). Nevertheless, we can take the example of restricted-range species for which a few number of protected areas can easily include a large part of their population (64). Among this species, some of them have a high functional value (Fig. 6A) and some others have a low or unknown functional value (Fig. 6B). We consider that natural elements described in case A are "urgent to conserve." For example, the little auk (*Alle alle*) is one of the most numerous of the Atlantic Alcidae (65), but individuals are restricted to a very small number of breeding colonies, which locally have a high functional value (66). The natural elements of case B have an "option conservation value": they have to be conserved because they may have an unknown functional value or may have a high functional value in the future. For example, there is a great interest in conserving vulnerable plants because many of them are potentially medicinal or are already used in the pharmaceutical industry (67). In case C, there is no hope to conserve natural elements even with a high functional value because their populations are not viable (the ivory-billed woodpecker, *Campephilus principalis*, for example) (Fig. 6C).

These cases fit the majority of legally protected natural elements, but the present results relative to *L. conchilega* beds highlight new conservation needs for another category of natural elements (Fig. 6D): "an upstream conservation need." *L. conchilega* beds have to be conserved before they cross a vulnerability threshold because if they disappear, the ecosystem's functioning will be deeply altered (i.e., they constitute a high conservation stake). At first sight, many other marine invertebrates may be included in this category. For example, the *a priori* nonvulnerable lugworm *Arenicola marina* is considered to be an allogenic engineer species (6) and has strong effects on its environment (11, 68). However, the worm-feeding activity, although beneficial for a few species, is somewhat inhibitive for many others (benthic species and birds) (6), and associated potential benefits for human activities are little known. Moreover, even if the species may have a social recreational value (the species is traditionally used as bait in Europe) (69), conservation of such a species would be quite impossible because of its huge and diffuse spatial distribution.

To conclude, common marine species can have high positive functional value for biodiversity and/or human activities. *L. conchilega* should not be an isolated case, and other authors have shown positive biological functional value of other marine worms, such as *Sabellaria alveolata* (21) or *Serpula vermicularis* (70), for example. Unfortunately, most common marine species still do not benefit from any legal protection because the functional value is almost never considered as a suitable criterion for conservation of natural elements.

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