Journal of
Marine Science and Engineering

MDPI

Article

A Multidisciplinary Approach for a Better Knowledge of the Benthic Habitat and Community Distribution in the Central and Western English Channel

Jean-Claude Dauvin [1,*], Jean-Philippe Pezy [1], Emmanuel Poizot [2,3], Sophie Lozach [4] and Alain Trentesaux [5]

[1] Laboratoire Morphodynamique Continentale et Côtière, UMR CNRS 6143 M2C, Normandie University, UNICAEN, 2-4 rue des Tilleuls, 14000 Caen, France
[2] Laboratoire Universitaire des Sciences Appliquées de Cherbourg, EA, Normandie University, UNICAEN 4253, 14000 Cherbourg, France
[3] Conservatoire National des Arts et Métiers, Institut National des Sciences et Techniques de la Mer (CNAM/INTECHMER), B.P. 324, 50103 Cherbourg, France
[4] The Centre for Environment, Fisheries & Aquaculture Science (Cefas), Lowestoft Laboratory, Pakefield Road, Lowestoft, Suffolk NR33 OHT, UK
[5] Laboratoire d'Océanologie et de Géosciences, University of Lille, CNRS, Université Littoral Côte d'Opale, UMR 8187, LOG, 59000 Lille, France
* Correspondence: jean-claude.dauvin@unicaen.fr

Abstract: About 80% of the seabed of the English Channel (EC) is covered by coarse sediment, from coarse sand to pebbles. Quantitative data on the benthic macrofauna in these types of sediment remains are rare due to the difficulty of using grab corers in such hard substrates. The deepest central part of the EC (45–101 m depth) was prospected during two VIDEOCHARM surveys in June 2010 and June 2011 to increase knowledge of such sublittoral coarse sediment benthic habitats. Sampling focussed on a longitudinal transect in the deepest part of the EC (13 boxes), extending from the western approach to the Greenwich meridian. Both indirect (side scan sonar, Remote Operated Vehicule) and direct (grab sampling with benthos determination, and grain-size analyses) approaches were used and combined, permitting description of the benthic habitats and communities using seven methods. Five benthic EUNIS habitats (European Nature Information System) were reported: MC3215, MD3211, MC4, MC3212 and MC4215, of which two extended main habitats (MC3211 and M23212) corresponded to an eastern/western gradient from sandy gravel to sandy gravel and pebbles sediment. Three other spatially discrete habitats were associated with poor coarse sand and gravel habitats as well as sandy gravel and pebbles with the presence of the brittle star *Ophiothrix fragilis*. Taxonomic richness of both extended habitats was on the same order of magnitude as the coarse sand habitat reported elsewhere in the EC, whilst the abundances were among the lowest in deeper areas with low nutrient input and low primary production. The epifauna appeared relatively homogenous in this type of sediment at the scale of the sampling area and was not determined to assign a EUNIS habitat/class. ROV footage illustrated the presence of large epifauna and provided valuable information to ground truth in other sampling methods such as side scan sonar mosaic. Grab photos showing surface sediment was relevant to determine the sediment type, whilst granulometric analyses gave additional information on fine particles content (typically very low).

Keywords: English Channel; sublittoral; benthic habitats; EUNIS classification; community distribution; multidisciplinary approach

check for updates

Citation: Dauvin, J.-C.; Pezy, J.-P.; Poizot, E.; Lozach, S.; Trentesaux, A. A Multidisciplinary Approach for a Better Knowledge of the Benthic Habitat and Community Distribution in the Central and Western English Channel. *J. Mar. Sci. Eng.* **2022**, *10*, 1112. https://doi.org/10.3390/jmse10081112

Academic Editor: Fabio Crocetta

Received: 1 June 2022
Accepted: 30 July 2022
Published: 12 August 2022

1. Introduction

In the framework of the CHARM (Channel Habitat Atlas for Marine Resource management) project, the role of the macrobenthos as a fundamental prey resource for demersal fish had been determined across the three phases of this European project [1–4]. Additionally, the description of benthic communities in marine coastal protected areas, including distribution and functioning of sensitive benthic habitats, remains an important challenge [5,6]. Historical works at the scale of the English Channel (EC) as a model of a megatidal sea have been undertaken in the 1960s and 1970s, respectively, by two teams, Holme's coming from the Plymouth laboratory (United Kingdom) [7,8], and Cabioch's from the Roscoff Biological Station (France) [9–11]. Back then, benthic sampling was mainly qualitative, i.e., using a sampling technique such as the 'Rallier du Baty' dredge by the French team, and was devoted to the description of spatial distribution of the main benthic communities and to identify benthic species. During these studies, the distance between sampling stations only permitted explaining two large distribution patterns: first, the role of hydrodynamics in the sediment spatial distribution, with fine sediment located in areas with low tidal currents and, conversely, the absence of fine sediment in areas with high currents reaching up to 5 knots in some parts of the Normand Breton Gulf, the Cotentin and the Dover Straits, where rocky outcrops occur locally; second, the presence of a climatic gradient from the western approach of the Channel, influenced by the Atlantic waters, to the eastern approach, influenced by the input of freshwater coming mainly from the Seine estuary, where the winter temperatures are lower than in the western basin. The result is the impoverishment of benthic species from the western approach, the richest, to the eastern approach, the poorest. Cabioch et al. [10] hence described the importance of the edaphic–climatic gradients for the benthic species distribution. Moreover, the authors in [7,8] described the presence of Sarnian species occurring in the hydrological isolated Normand–Breton Gulf. Holme [8] was the first to collect quantitative data for the macrobenthic communities in some soft-bottom communities at the scale of the whole EC. He described the difficulties of sampling coarse sand, gravel and pebbles using quantitative sampling gears such as grabs. Most quantitative data were then collected near the shore in sandy and muddy sediments, which were much easier to collect with the type of grabs available at the time.

Obtaining quantitative data represented a challenge in a major part of the EC [12–14]. Quantitative data were therefore missing in offshore benthic habitats of the EC dominated by coarse sediment (>80% of its surface). Supplementary data were hence needed to describe the structure and distribution of main benthic communities of EC and to study benthic ecosystem function. Following European benthic classification, i.e., EUNIS classification, the authors of [15] used sonar and video footage to study the diversity of marine benthic habitats. The authors of [16] used photos of the seabed to determine the benthic assemblages of the central EC (south of the Isle of Wight) and offshore of North Brittany. Following these projects, CEFAS promoted the development of such integrated approaches along the English side of the Channel, especially to study the mixed soft-hard bottom organisation of benthic communities and to produce habitat maps of the seabed in coastal UK waters [17–22].

To increase our knowledge of the benthic habitats in the central deeper areas of the EC, two VIDEOCHARM surveys were carried out in 2010 and 2011. The study area covered a profile across the EC and was designed in the continuity of the CHARM II sampling grid to expand existing databases and to complement the UK work carried out in English waters [11,23–26]. During the surveys, benthic habitats were studied using acoustic remote sensing techniques, coupled with in situ grab sampling and collections of video footage using a small remotely operated vehicle (ROV), for a total of seven methods.

The aims of this paper were: (1) to characterise the benthic habitats along the VIDEOCHARM profile using the seven available methods; (2) to provide quantitative macrobenthic data in this offshore area of the EC; and (3) to propose EUNIS classification of the benthic habitats and communities in the central and eastern parts of the EC.

2. General Characteristics of the English Channel

The EC is a shallow epicontinental sea (77,000 km^2) bordered by the United Kingdom and France located at the transition between the Atlantic Ocean and the North Sea [27–29]. The depth is about 100 m at the entrance of the Channel to the west, reaching 174 m in its central trench then diminishes to 40 m in the Dover Strait [30]. The distribution of superficial sediment [31] and benthic communities [7–9,11,28,32] are the result of a tidal circulation, the offshore-inshore hydrodynamics leading to a bio-sedimentary gradient with extended pebble and sessile benthic communities dominating areas of strong tidal currents offshore, and fine sand and muddy fine sand communities inhabiting weak tidal currents areas (e.g., bays and estuaries) and the climatic conditions with thermic amplitude between minimal and maximal sea bottom temperature higher in the eastern basin than in the western basin. In the central part of the EC, the environmental conditions show a high hydrodynamic area offshore the Cotentin peninsula mainly covered by pebbles and rocky substrates, transitioning eastwards and westwards as residual currents decrease, to sediment dominated by gravel and coarse sand [30,31]. Following the benthic studies of Holme [7–11] completed a habitat mapping survey over an extensive area in the central part Channel using acoustic, underwater photography and traditional grab sampling techniques to create full-coverage modelled maps of the biotopes according to the EUNIS habitat classification system. The previous interpretations made by Holme and Cabioch for the central EC were very consistent with their own interpretations.

3. Material and Methods Used during the Videocharm 2011 and 2011 Campaigns

A series of 13 rectangular boxes was sampled during both the VIDEOCHARM 2010 (4–14 June) (boxes 1 to 7) and 2011 (14–29 June) (boxes 8 to 13) surveys combining side scan sonar (Table 1), Hamon grab sampling and video footage with a small ROV SeaBotix. All the boxes were south of the France–UK bordering to stay in French waters and were distributed from the Greenwich meridian to the EC entry, offshore Brest (Figure 1). Boxes 7–11 are located near the French coast due to the bad weather conditions in 2011; nevertheless, they were all on the circalittoral coarse sediment of the western part of the EC.

Table 1. Total length of side scan sonar profiles over each box of the two VIDEOCHARM surveys with the percentage of the identified morphological structures and the presence of dredge or trawl trace and wreck.

Morphological Structures	Box												
N°	1	2	3	4	5	6	7	8	9	10	11	12	13
Length (km)	83.2	77.5	84.5	82.1	83.5	75.3	39.4	53.4	50.3	53.0	51.5	50.1	45.0
Ribbons (km^2)	0	-	0	0	-	-	-	-	-	-	-	-	0
Furrows (km^2)	0	-	0.6	2.56	-	-	-	-	-	-	-	-	0
Small and medium dunes (km^2)	0	-	0	0	-	-	-	-	-	-	-	-	0
Very large dunes (km^2)	0	-	1.6	1.3	-	-	-	-	-	-	-	-	16.4
Sand veneer on rocks	0	-	0	0	-	-	-	-	-	-	-	-	0
Homogeneous zone (km^2)	0	-	0	0	-	-	-	-	-	-	-	-	0
Table rocks, outcropping or sub-flush rocks (km^2)	0	-	2.6	3.26	-	-	-	-	-	-	-	-	0
Rocky area (km^2)	0	-	0.5	4.55	-	-	-	-	-	-	-	-	0
Dredge or trawl trace (km)	88.5	-	3.0	1.0	-	-	-	-	-	-	-	-	3.14
Wreck or anthropic marks	25	-	64	33	-	-	-	-	-	-	-	-	0

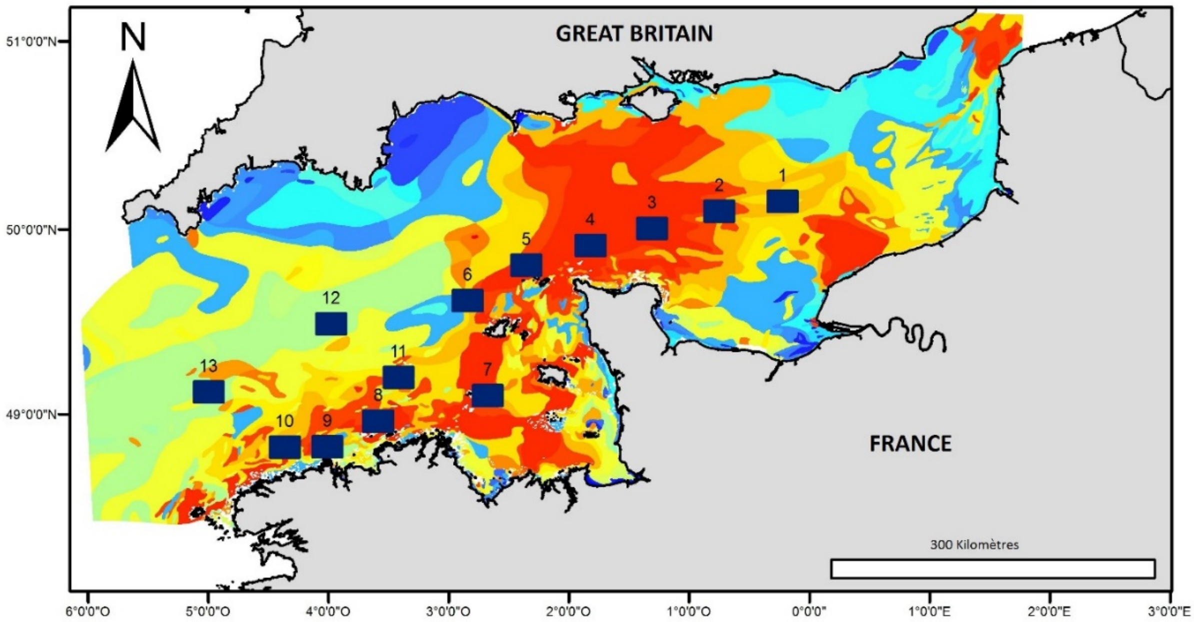


Figure 1. Location of the 13 boxes (1 to 13, blue rectangle) sampled during the VIDEOCHARM surveys in June 2010 and June 2011 with the map of the three main superficial sediment types in the English Channel: orange, pebbles and large gravel; yellow: gravel and blue: sands and muds (from 31 in 29).

Seven methods were used to identify and describe the characteristics of the benthic habitats: (1) side scan sonar to identify acoustic facies, (2) Hamon grab snapshot of sediments collected in all the grab samples; (3) endofauna identified and counted after sieving the sediment on a 2 mm sieve mesh; (4) endofauna identified and counted after sieving the sediment on a 1 mm sieve mesh; (5) non-denumerable epifauna identified in grab samples; (6) sediment granulometric composition using particle size distribution; (7) species richness obtained via ROV video footage.

Appendix A summarises the sampling efforts during both campaigns.

3.1. Side Scan Sonar Observations

A complete acoustic coverage of each sampling box was carried out during the VIDEOCHARM surveys in 2010 and 2011 using side scan sonar (Figure 2) (for the methodology of the acoustic survey, see [33]). A visual analysis of the side scan sonar mosaic was conducted on board, and observations of the sediment types from grab samples and ROV footage were used to describe acoustic facies. Side scan sonar technology has been used successfully for many years to produce high-resolution acoustic maps of the seabed [17–19,33–35]. Typically, side scan sonar data are produced using a pair of transducers mounted on either side of a tow fish which is connected to a survey vessel by means of a cable. The sound emitted from the transducers ensonifies a continuous surface of seabed either side of the transducers [36]. Reflected sound received by the transducers from the surface of the seabed provides information on the nature (e.g., hardness, roughness, texture) of the sediments and the presence and disposition of seabed features (e.g., sand waves, rock outcrops, algae cover, and anthropogenic features) across the swathe [37]. For the VIDEOCHARM surveys, side scan sonar data were collected using the DF 1000 Edgetech (100–400 kHz) side scan sonar system in conjunction with data acquisition software. Data were processed, georeferenced and mosaiced using the 'Caraïbes' software package from IFREMER to produce continuous acoustic maps of the area surveyed. The vessel position was provided by a Thales 3011/Fugro SeaStar DGPS system, and the position of the side scan tow fish was calculated by using vessel heading, vessel offsets, tow cable layback and tow fish depth.

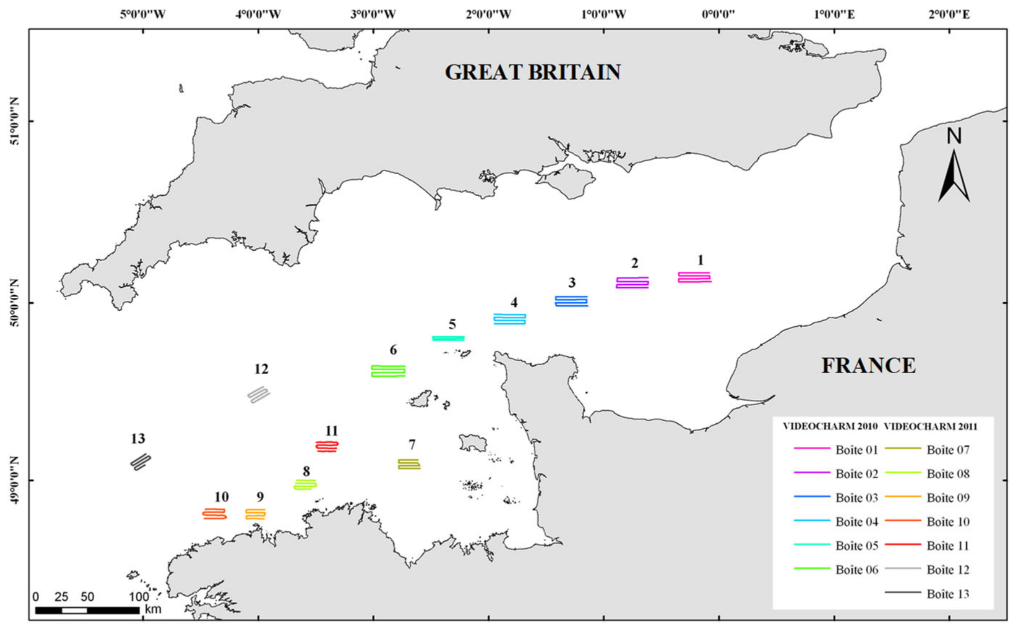


Figure 2. Side scan sonar profiles collected during VIDEOCHARM surveys in June 2010 and June 2011 for the 13 boxes 1 to 13.

Several morphological structures were identified from the scan sonar profiles.

- Zone with ribbons;
- Zone with furrows;
- Zone with dunes: small and medium/large and very large dunes;
- Sand veneer on rocks;
- Homogeneous zone;
- Table rocks, outcropping or sub-flush rocks;
- Rocky area;
- Presence of anthropic evidence: net traces (dredge or trawl) and wreck.

3.2. Grab Sample Collection

Sediment and macrofauna samples were collected with a 0.25 m^2 Hamon grab to ground-truth the acoustic surveys through the provision of information on sediment particle size distributions and macrofaunal communities. The grab sampling was also in the spatial continuity of the benthic sampling program CHARM II, to complement existing databases in the easternmost part of the Channel [25,38]. One replicate was used for sediment characterisation, and two replicates were used for macrofauna analyses. Snapshots of each replicate were made directly after the grabs were recovered. The two macrofauna grabs were then washed onboard the RV 'Côtes de la Manche' over two circular superposed mesh sieves (1 mm and 2 mm) to remove fine sediments. The biological and sediment content was fixed in containers with 10% buffered formaldehyde solution. Data species richness and abundances from both replicates (0.5 m^2) were pooled for ecological analyses, and colonial epifaunal taxa were reported only as present.

A subsample from the sediment grab was analysed for particle size distribution. First, sediment was wet sieved over a 50 µm mesh. The sieved sediment fraction (50 µm) was kept still and left to deposit for 48 h and then dried after the supernatant was removed. The rest of the sediment (>50 µm) was dried at 70 °C and then sieved using 32 sieve-column (50; 63; 80; 100; 125; 160; 200; 250; 315; 400; 500; 630; 800; 1000; 1250; 1600; 2000; 2500; 3150; 4000; 5000; 6300; 8000; 10,000; 12,500; 16,000; 20,000; 25,000; 31,500; 40,000; 50,000; 63,000 µm), and the total weight of each fraction was recorded. The sieve choice followed the modified Wentworth's classification to determine the sediment type of each station using a Folk diagram [25,26,38,39]. For each station, the sediments were characterised by five main sedimentary fractions: pebbles >20 mm; large gravel (20–5 mm); gravel (2–5 mm), sand (2 mm–63 μm), and silt–clay (<63 μm).

3.3. Remotely Operated Vehicle

A small ROV Seabotix LBV 200L2 was deployed in each box, except for in Box 10. Between one and four video observations were made in each box depending on the weather conditions, allowing the ROV to operate safely. The video system included a colour camera pointing at the ground at 45° from the horizontal, with the lens about 50 cm above the seabed. A couple of laser pointers (10 cm apart) were used to estimate the size of the surface sediment and the megafauna taxa on the seabed. The duration of the video footage varied from 4 to 10 min. Some snapshots were extracted from the video and were used to identify benthic taxa. The ROV Seabotix LBV 200L2 was a small piece of equipment, which was difficult to use in a megatidal sea such as the Channel (e.g., the need to use it when the vessel was anchored in slack water), which considerably reduces the number of observations per day [12].

A total of 30 videos were recorded (the ROVbis were not analysed) (Appendix A), and it characterised the surface sediments into five classes: coarse sands, gravel, pebbles, boulders and hard bottom; and into three classes of occurrence: existing, common (present throughout the footage but sparse) and dominant (prevailing sediment class throughout the footage), according to the expertise of J.C.D.

Megafauna taxa were identified for encrusting and erect sessile fauna and the motile fauna following the expertise of J.C.D.: sponges, bryozoans, *Flustrea fasciata*, *Alcyonidium* spp., cnidarians, dead man fingers *Alcyonium digitatum*, ross coral *Pentapora fasciata*, hydroids (tuff), *Nemertesia antennina*, polychaetes, *Spirobranchus* spp., *Sabella* spp., sea urchin, *Ophiothrix fragilis*, *Asterias rubens*, decapods, gastropods, the common whelk *Buccinum undatum*, and fish. Three classes of abundance of the taxa were established: (1) rare, one to some individuals, (2) common taxa (present throughout the footage but sparse) and (3) abundant taxa (present throughout the footage in abundance).

3.4. Database and Statistical Analyses

Appendix A reports all the operations realised during the VIDEOCHARM surveys in 2010 and 2011. The different operations permit to obtain seven data tables, corresponding to seven habitat sampling methods: (1 and 2) endofauna collected at the 40 grab stations after sieving on 2 mm and then on 1 mm (in most cases two replicates per station, apart from four stations B21, B32, B109, B129 where only one grab was available; in these cases, the data were doubled to obtain a total surface of 0.5 m^2); (3) nondenumerable epifauna identified on pebbles and blocks in the 40 stations; (4) Hamon grab snapshot of sediment collected for all replicates (see Appendix A); (5) sediment particle size distribution, (6) video footage of the ROV SeaBotix at 30 stations; (7) interpretation of the side scan sonar profiles to identify acoustic facies.

Faunal data were used to calculate the taxonomic richness (TR, number of taxa per 0.5 m^2), abundance (number of individuals per 0.25 m^2), and diversity indices for each station. The Shannon–Weaver diversity index (H′) in $\log_2$ and Pielou's evenness (J′) were calculated. Ecological status was estimated from diversity indices H′ and J values according to the thresholds defined previously and resumed in [39]: 0–1, bad; 1–2: poor; 2–3: moderate; 3–4: good and >4: high. For J, the thresholds are <0.2: bad; 0.2–0.4: poor; 0.4–0.6: moderate; 0.6–0.8: good and >0.8: high, which were independent from the organic matter concentration in the sediment. Data analysis was performed using the PRIMER version 6 software package (Plymouth Routines in Multivariate Ecological Research) [40].

Hierarchical cluster analysis (HCA) was carried out on the matrices based on Sorensen's coefficient for the presence/absence (all the taxa) and on Log10(x + 1) or square root transformed abundances per 0.5 m^2 used to down-weight the importance of very abundant denumerable taxa with the Bray–Curtis similarity using group average linking of the species found in the different stations, with the construction of dendrograms using the group average algorithm generated from the PRIMER-6 software package (Plymouth Routines in Multivariate Ecological Research). To identify those species within different groups which primarily account for the observed assemblage differences, SIMPER (SIMilarity PERcentage) routines were performed [40].

4. Results

4.1. Side Scan Sonar Observations

Figure 2 shows the localisation of side scan sonar profiles realised during the VIDEOCHARM surveys in June 2010 and June 2011. The lengths of the profiles extend between 39.4 km in Box 7 and 84.5 km in Box 13 (Table 1). The lengths of the profiles were higher in 2010 (boxes 1 to 6) than in 2011 (boxes 7–13) due to the bad weather during the second survey.

Figure 3 gives examples of the different structures observed along the side sonar profiles in three selected boxes along the east (Box 1), central (Box 3) to west (Box 13) gradient. The central part of EC North Cotentin peninsula is known to be an area of high hydrodynamic. Sediment coverage and bottom-recognized structures in this part of the EC highlight high gradients of variability.

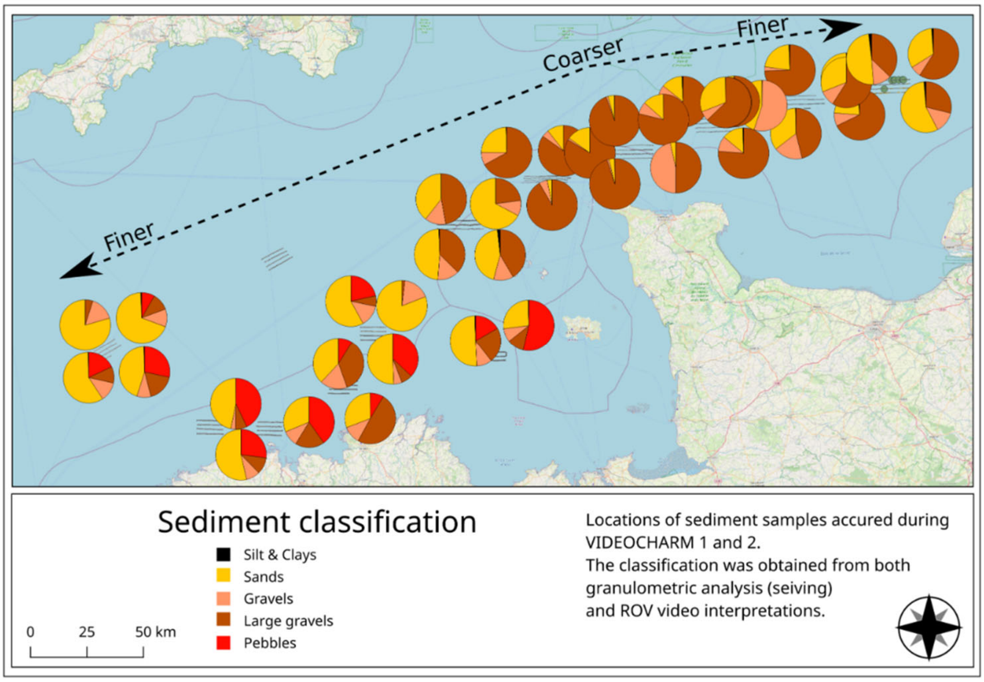


Figure 3. Five main sediment classes described during the VIDEOCHARM surveys in June 2010 and June 2011.

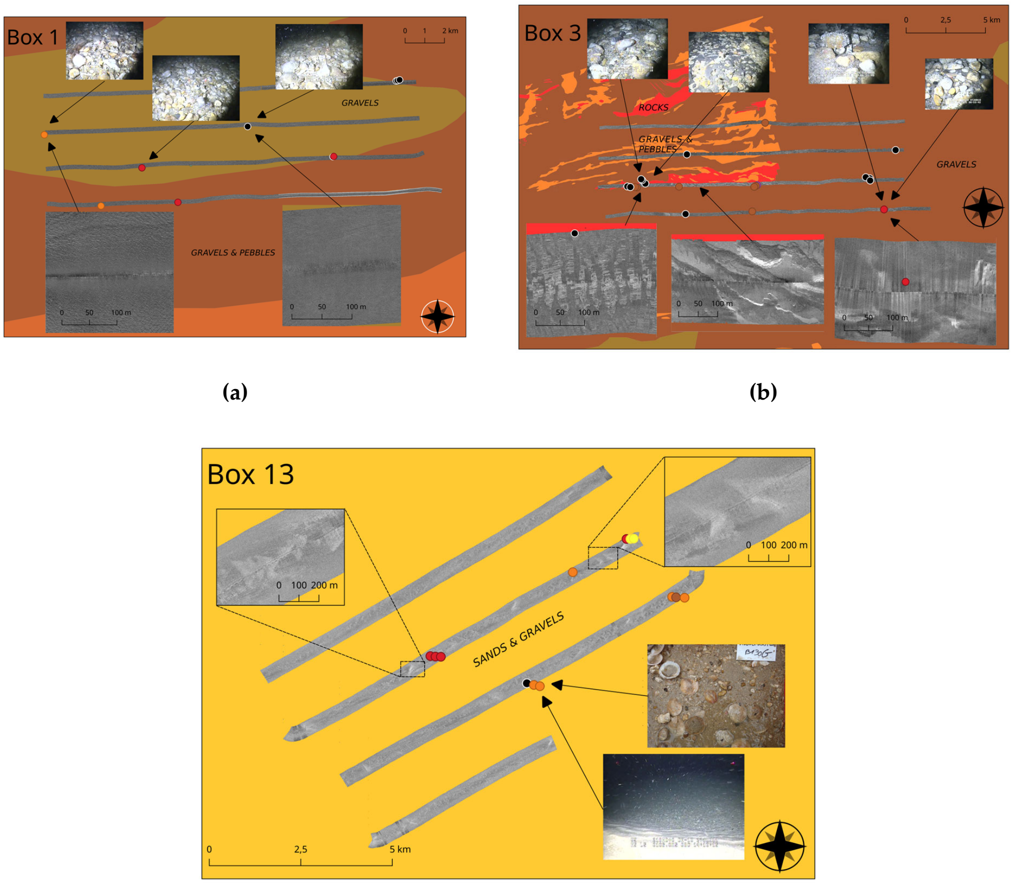
Within Box 1, side scan sonar profiles showed a relative homogeneity of the acoustic reflectivity. However, two different acoustic responses could be identified (Figure 3): rugged acoustic facies to the west and a smoother acoustic aspect to the east. Snapshot pictures extracted from ROV footage highlighted a relative homogeneity of the sediment cover with gravel mainly present. Coarse sands and pebbles were also present, acting as an armoured structure over a trapped coarse sand content. This coarsening gradient from west to east is likely to explain the different acoustic returns, i.e., the coarser the cover, the more homogeneous the acoustic response.

Sonograms are more contrasted in Box 3, located to the northeast of the Cotentin peninsula (Figure 3). Surface sediments were mostly coarse gravel and pebbles. Some longitudinal sedimentary features can be seen to the southeast of the box area. Their orientation, parallel to the tide, indicates a high current velocity allowing for movements of coarse sediments (mixed coarse sands and gravel). Additionally, some rocky outcrops can be identified to the south and east of Box 3, as well as in the centre. The movements of biogenic coarse sands, again under the effects of high current velocities, could recover and mask rocky outcrops explaining the intermittent appearance of these outcrops as the sedimentary cover is very thin in the area (i.e., a few centimetres).

Box 13 (around 100 m depth) is located offshore the Brittany coast, at the Channel entry, in deeper waters (~100 m). Some sedimentary features showed dunes and mega-dunes formed with coarse sands and gravel (Figure 3). At these locations, the ROV survey showed a succession of dunes of about 1.5–2 m high and 50–60 m wavelength. Some sedimentary figures were organised in crescent shape, showing both a high level of hydro-sedimentary dynamic and the direction of transport (towards the inner parts of the EC).

4.2. Sediment

Particle size analyses showed that all the sampling stations were classed as coarse sediment, ranging from sandy gravel to pebbles (Appendix B; Figure 4). The percentage of fine particles (<63 µm) was very low and varied from 0% to 1.89% of the dry sediment, with the highest percentage recorded in samples classed as sandy gravel. The percentage of sand varied strongly (3.5% to 80.9%), similarly to the percentage of gravel (2.6% to 54.7%) and large gravel (0.3% to 94.5%) (Appendix B). The pebbles were present only in the westernmost boxes offshore the Brittany coast (8.4% to 53.6%).



(a) (b)

(c)

Figure 4. Example of scan sonar profiles collected during the VIDEOCHARM surveys in June 2010 ((**a**,**b**) boxes 1 and 3) and June 2011 ((**c**) box 13) with inset views for some areas of interest and snapshots of the surface sediments extracted from the ROV video footage.

Sediments were classified into four main types (Table 2): gravel (11 stations located in boxes 3, 4 and 5), gravelly sand (two stations located in boxes 11 and 13); sandy gravel (15 stations located in boxes 1, 2, 3, 5 and 6) and sandy gravel and pebbles (12 stations located in boxes 7, 8, 9, 10, 11 and 13). Two sedimentary gradients were observed from each end of the transect to the central part of the EC, with sandy gravel and pebbles in the western part of the EC, gravel in the middle of the EC, and sandy gravel in the eastern part of the EC.

4.3. General Patterns of the Fauna

The total number of taxa including countable barnacles was 272. Among them, 233 taxa were recorded only on the 2 mm mesh size, 138 on 1 mm and 95 were recorded both on 2 and 1mm mesh sieve mesh. A total of 138 taxa were recorded only on 2 mm mesh size, and only 43 were recorded on 1 mm. The total richness included 110 Polychaeta (40% of the total taxa), 90 Crustacea (33%), 49 Mollusca (18%), 11 Echinoderms (4%) and 12 others (5%). The total number of individuals was 11,626 individuals, with 7425 on 2 mm (63%) and 5201 on 1 mm (37%). The dominant species was the barnacle *Balanus crenatus* (1644 individuals, 14% of the individuals), and the 10 more abundant taxa represented 40% of the fauna and the 20 more abundant taxa 60%. Among these 20-dominant taxa, 12 were Polychaeta, three Crustacea, three Bivalves and two Echinoderms. An additional 125 colonial taxa were identified in the epifauna found in the grab Hamon grab samples, with a dominance of Bryozoans and Hydrozoans.

A total of 34 invertebrate taxa were identified on the snapshots taken from the ROV footage, and amongst them, 12 taxa were not recorded in grab samples such as the Bryozoans *Alcyonidium* spp., the Cnidaria *Alcyonium digitatum*, and the large echinoderms *Asterias rubens*, *Echinocardium pennatifidum*, *Echinus esculentus*, *Henricia sanguinea*, *Ophiocomina nigra* and *Sollaster paposus*.

Overall, a total of 409 taxa was recorded during this study on the coarse sediment from the deeper part of the English Channel.

Univariate indices (TR per 0.5 m^2, abundance per 0.25 m^2, H′ and J) for the accounted taxa recorded on 2 mm and 1 + 2 mm sieve meshes are shown in Table 2. On 2 mm, the TR varied from two taxa at station 31 (Box 5) to 73 taxa at station 5 (Box 1), whilst on 1 mm the TR varied from two taxa at station 31, which was the poorest to 88 at station 28 (Box 6), which was the most diversified (Table 2). The number of taxa recorded per station increased from 0 to 34 when the sieving mesh was reduced to 1 mm, and the mean number of taxa per 0.5 m^2 was 36.35 on 2 mm to 51.08 on 1 mm, i.e., a 40% increase. On 1 mm, the mean TR per box varied from 24.5 for 0.5 m^2 in Box 5 to 76 for 0.5 m^2 in boxes 1 and 9; the poorest TR per box for 0.5 m^2 varied from 24.5 to 34 in boxes 5, 7 and 8, while the richest TR per box for 0.5 m^2 varied from 62 to 76 in boxes 1, 6 and 9. No west–east gradient was observed.

On 2 mm, the mean abundance per 0.25 m^2 varied from 11 at station 23 (Box 6) to 392.5 at station 5 (Box 5) both on sandy gravel, while on 1 mm, it varied from 20 at station 108 (Box 8) to 445 at station 5 (Table 2). The mean abundance per 0.25 m^2 on 2 mm was 93.31 and 145.33 on 1 mm, i.e., an increase of 52%. On 1 mm, the mean abundances per 0.25 m^2 varied from 36 in Box 8 to 261 in Box 1. The two eastern boxes 1 and 2 exhibited a mean abundance higher than 200 ind. 0.25 m^2. Five boxes (3, 4, 5, 6 and 9) showed a mean abundance included between 100, while the five last boxes showed a mean abundance lower than 100 ind. 0.25 m^2: boxes 7, 8, 10, 11 and 13.

On 2 mm, the Pielou's evenness J′ varied from 0.36 to 0.95 corresponding to an ecological status ranging from poor to high. Of the 40 stations, 18 were classified as high, 14 as good, six as moderate and two as poor (Table 2). On 1 mm, J′ varied from 0.40 to 0.96; 25 stations were classified as high, 13 as good and two as moderate. On 2 mm, the Shannon–Weaver diversity index (H′) varied from 0.26 to 2.73 corresponding to an ecological status ranging from bad to moderate. Of the 40 stations, 18 were classified as moderate, 19 as poor and 3 as bad. On 1 mm, H′ varied from 0.4 to 5.12; 21 stations were classified as high, 13 as good, four as moderate, one as poor and one as bad (Table 2).

Table 2. Univariate indices value and ecological quality status for the 40 stations classified per main sediment type and boxes according to the taxa accounted for on 2 mm and 1 + 2 mm mesh sieves. TR (taxonomic richness), total number of species recorded on 0.5 m^2; A: total abundance per 0.25 m^2; J′: Pielou's evenness and H′: Shannon–Weaver diversity. The colour coding corresponds to the Ecological Status of the Water Framework Directive: blue, high status; green, good status; yellow, moderate status; orange, poor status, and red bad status.

Main Sediment Type	Box	Station	2 mm				2 + 1 mm			
			TR	A	J′	H′	TR	A	J′	H′
Gravel	3	11	53	104.0 ± 25.5	0.74 ± 0.14	2.17 ± 0.82	75	234.0 ± 25.5	0.85 ± 0.03	4.97 ± 0.44
		12	60	135.0 ± 36.8	0.80 ± 0.02	2.49 ± 0.03	74	265.0 ± 36.8	0.84 ± 0.02	4.93 ± 0.11
		14	54	184.5 ± 51.6	0.65 ± 0.01	2.10 ± 0.10	76	286.5 ± 88.4	0.77 ± 0.01	4.42 ± 0.15
		15	21	19.0 ± 21.2	0.95 ± 0.01	1.41 ± 1.12	37	44.0 ± 36.8	0.94 ± 0.01	4.08 ± 0.82
	4	18	64	132.5 ± 40.3	0.83 ± 0.01	2.70 ± 0.17	87	195.5 ± 27.6	0.86 ± 0.01	5.02 ± 0.11
		19	47	282.0 ± 0.0	0.66 ± 0.00	2.31 ± 0.00	81	423.0 ± 164.0	0.74 ± 0.07	4.46 ± 0.69
		20	14	11.5 ± 3.5	0.97 ± 0.01	1.51 ± 0.23	27	39.5 ± 3.5	0.93 ± 0.01	4.24 ± 0.17
		21	27	52.0 ± 12.7	0.74 ± 0.03	1.70 ± 0.06	38	93.0 ± 12.7	0.82 ± 0.03	3.98 ± 0.18
	5	31	2	150.0 ± 0.0	0.40 ± 0.00	0.26 ± 0.00	2	150.0 ± 0.0	0.40 ± 0.00	0.40 ± 0.00
		36	29	37.0 ± 1.4	0.87 ± 0.04	2.01 ± 0.05	55	83.0 ± 29.7	0.89 ± 0.01	4.58 ± 0.29
		38	22	65.5 ± 20.5	0.45 ± 0.63	1.14 ± 1.62	34	112.5 ± 36.1	0.72 ± 0.22	3.27 ± 1.27
Gravelly Sand	11	126	8	15.5 ± 2.1	0.66 ± 0.09	0.77 ± 0.38	12	24.0 ± 0.0	0.83 ± 0.01	2.49 ± 0.48
	13	131	14	28.5 ± 30.4	0.81 ± 0.27	1.21 ± 0.01	26	53.5 ± 53.0	0.81 ± 0.24	3.18 ± 0.63
Sandy Gravel	1	2	43	175.0 ± 147.1	0.60 ± 0.46	1.74 ± 1.41	69	230.0 ± 144.2	0.66 ± 0.34	3.69 ± 2.08
		3	52	103.0 ± 17.0	0.89 ± 0.01	2.73 ± 0.02	68	170.0 ± 22.6	0.85 ± 0.01	4.80 ± 0.19
		4	63	123.5 ± 81.3	0.83 ± 0.17	2.63 ± 0.33	83	198.5 ± 94.0	0.86 ± 0.10	5.17 ± 0.52
		5	73	392.5 ± 200.1	0.66 ± 0.17	2.39 ± 0.51	81	445.0 ± 250.3	0.69 ± 0.13	4.06 ± 0.58
	2	6	39	161.0 ± 161.2	0.56 ± 0.14	1.47 ± 0.06	46	173.0 ± 161.2	0.61 ± 0.18	2.99 ± 0.70
		7	44	147.5 ± 74.2	0.73 ± 0.03	2.21 ± 0.16	58	239.5 ± 74.2	0.79 ± 0.03	4.41 ± 0.03
		8	27	119.0 ± 45.3	0.36 ± 0.10	0.84 ± 0.51	45	148.5 ± 54.4	0.53 ± 0.06	2.56 ± 0.61
		9	47	80.5 ± 3.6	0.85 ± 0.01	2.43 ± 0.02	79	262.5 ± 17.7	0.81 ± 0.05	4.66 ± 0.31
	3	10	7	39.0 ± 5.7	0.76 ± 0.01	1.05 ± 0.15	10	56.0 ± 7.1	0.79 ± 0.01	2.33 ± 0.45
		16	46	68.5 ± 14.8	0.90 ± 0.01	2.58 ± 0.10	63	140.0 ± 46.7	0.88 ± 0.06	4.83 ± 0.13
	6	22	66	145.0 ± 76.4	0.68 ±0.01	2.18 ± 0.33	76	156.5 ± 74.2	0.71 ± 0.01	3.95 ± 0.23
		23	14	11.0 ± 1.4	0.95 ±0.01	1.39 ± 0.09	26	22.5 ± 0.7	0.96 ± 0.01	3.94 ± 0.17
		24	43	44.0 ± 35.3	0.93 ± 0.02	2.26 ± 0.66	58	89.0 ± 50.9	0.89 ± 0.04	4.56 ± 0.39
		28	56	94.5 ± 47.4	0.90 ± 0.05	2.76 ± 0.15	88	278.5 ± 88.4	0.82 ± 0.02	4.84 ± 0.01
	5	32	7	67.0 ± 0.0	0.64 ± 0.00	1.12 ± 0.00	7	67.0 ± 0.0	0.64 ± 0.00	1.80 ± 0.00
Sandy Gravel and Pebbles	7	102	26	61.5 ± 3.5	0.68 ± 0.04	1.62 ± 0.10	35	79.0 ± 14.1	0.76 ± 0.01	3.49 ± 0.04
		105	19	70.5 ± 9.2	0.52 ± 0.07	1.10 ± 0.22	33	105.5 ± 19.1	0.68 ± 0.15	3.20 ± 1.04
	8	108	9	16.0 ± 0.0	0.90 ± 0.00	1.46 ± 0.00	13	20.0 ± 0.0	0.92 ± 0.00	3.40 ± 0.00
		109	25	33.5 ± 34.6	0.89 ± 0.07	1.68 ± 0.64	35	52.0 ± 52.3	0.91 ± 0.07	3.76 ± 0.62
	9	114	59	72.5 ± 21.9	0.92 ± 0.05	2.68 ± 0.17	76	154.5 ± 21.9	0.88 ± 0.03	5.12 ± 0.10
	10	119	35	45.5 ± 17.7	0.86 ± 0.06	2.08 ± 0.09	47	74.0 ± 53.7	0.90 ± 0.01	4.27 ± 0.65
		120	41	58.5 ± 82.7	0.44 ± 0.62	1.42 ± 2.01	68	99.5 ± 88.4	0.91 ± 0.04	4.65 ± 0.73
	11	125	35	73.0 ± 14.1	0.71 ± 0.14	1.79 ± 0.41	42	92.0 ± 8.5	0.75 ± 0.13	3.48 ± 0.83
		129	32	41.0 ± 18.4	0.78 ± 0.22	1.77 ± 0.47	37	72.0 ± 18.4	0.84 ± 0.09	3.99 ± 0.39
		130	57	156.0 ± 219.2	0.39 ± 0.55	1.44 ± 2.03	68	192.0 ± 236.2	0.84 ± 0.11	4.06 ± 0.78
	13	133	29	43.5 ± 44.6	0.84 ± 0.10	1.74 ± 1.19	40	69.5 ± 44.5	0.82 ± 0.12	3.64 ± 1.53
		134	45	73.0 ± 2.8	0.89 ± 0.03	2.58 ± 0.06	68	123.0 ± 29.7	0.90 ± 0.01	5.01 ± 0.25

4.4. Pattern of the 2 mm Macrofauna

The Hierarchical Cluster Analysis CA (not shown in this paper) within the Sorensen coefficient (presence/absence of the 239 taxa in the 20 stations) identified the presence of

16 groups of stations at 40% similarity without clear sedimentological and geographical patterns. The HCA within the Log(X + 1) transformation of the abundances identified seven groups of stations (24% of the Bray–Curtis similarity) (Figure 5). Two of the groups included a large number of stations characterised by high diversity, whilst the five other groups were characterised by a fewer number of species locally present in high abundance. The faunal group a included two stations from Box 5, characterised by two taxa, the bivalve *Pododesmus squama* and the barnacle *Balanus crenatus* (Table 3). Group b included only station 10, Box 3. Group c included two stations of the western boxes 11 and 13 characterised by two echinoderms *Echinocyamus pusillus* and *Spatangus purpureus* (Table 3). Group d corresponded to the isolated station 23 (Box 6) characterised by the bivalve *Glycymeris glycymeris*. Group e regrouped four stations from boxes 4 and 7 with abundant populations of the brittle star *Ophiothrix fragilis*. Group f included 10 stations from western boxes 8–13, characterised by the sea urchin *Echinocyamus pusillus*, the polychaetes *Glycera lapidum* and *Jasmineira elegans* and the amphipod *Ampelisca spinipes*. Finally, group g included 20 stations (50% of the stations) mainly from boxes 1 and 2 in the eastern part and stations from boxes 4, 5 and 6 in the central part of the English Channel. They were stations with high taxonomic richness; the SIMPER analysis showed that polychaetes *Glycera lapidum*, *Notomastus latericeus* and *Lumbrineris gracilis* and the barnacle *Balanus crenatus* were the main species contributing to this group.

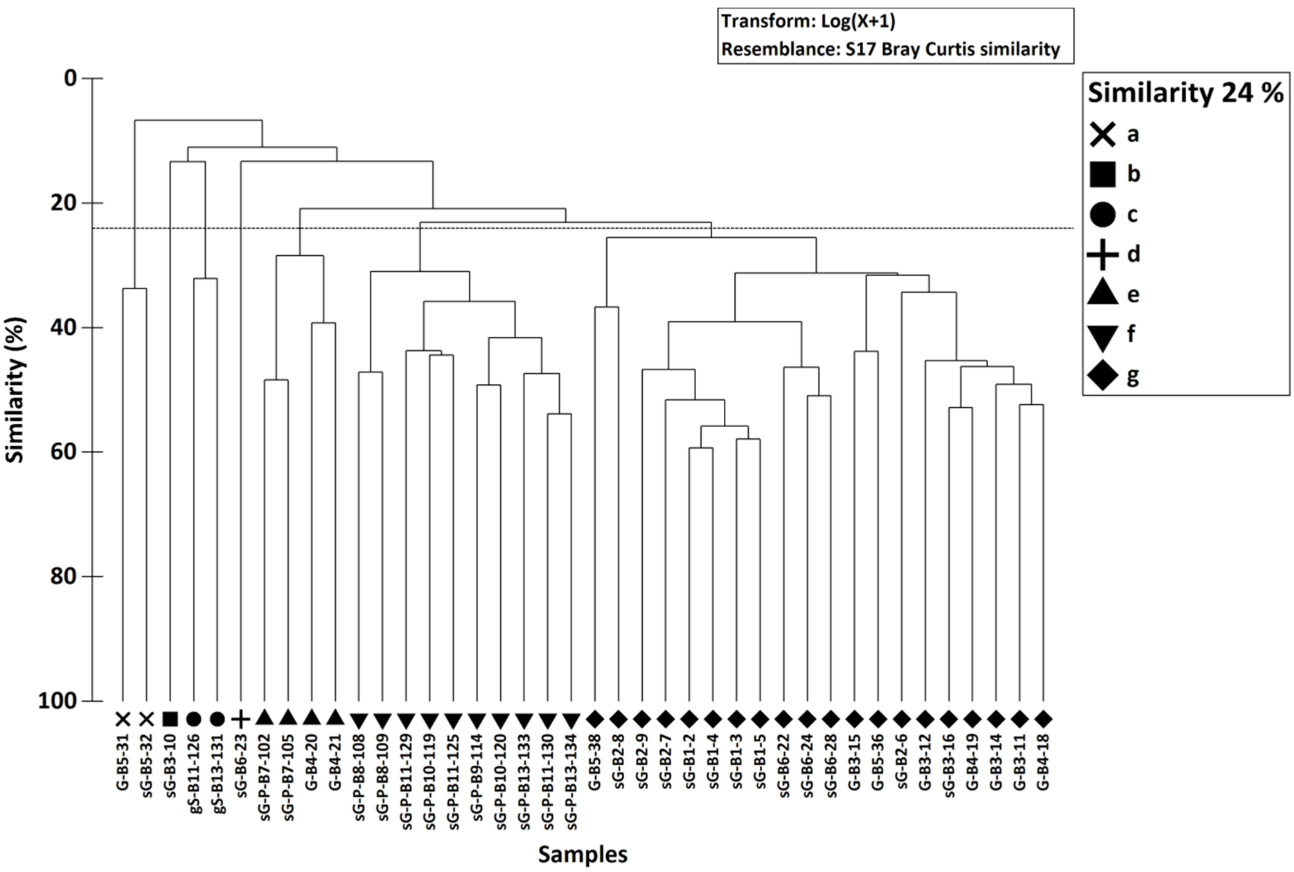


Figure 5. Cluster dendrogram showing the pattern of the 40 grab sampling stations (abundance per 0.5 m^2 of the accounted macrofauna retained on a 2 mm mesh sieve and 24% of similarity) according to the Bray–Curtis similarity after Log(X + 1) transformation of the abundances.

Table 3. SIMPER analysis on taxa accounted for on 2 mm mesh sieve with cumulative contribution (Cc in%) of the ten top species in the different groups identified by the cluster dendrogram analysis (Figure 5). (1): Group 1, . . . of Table 7. Group b (station 10, group 2). Group d (station 23, group 6).

Group a (1)	Cc (%)	Group c (2)	Cc (%)	Group e (5)	Cc (%)	Group f (4)	Cc (%)	Group g (3)	Cc (%)
Pododesmus squama	61.44	*Echinocyamus pusillus*	64.91	*Ophiothrix fragilis*	26.90	*Echinocyamus pusillus*	17.68	*Notomastus latericeus*	8.84
Balanus crenatus	100	*Schistomeringos neglecta*	82.46	*Aonides paucibranchiata*	40.31	*Glycera lapidum*	26.16	*Balanus crenatus*	16.59
		Spatangus purpureus	100	*Laonice bahusiensis*	52.70	*Jasmineira elegans*	31.76	*Lumbrineris gracilis*	21.71
				Notomastus latericeus	60.64	*Ampelisca spinipes*	36.34	Nemertea	25.84
				Lumbrineris gracilis	67.94	*Eunice vittata*	40.76	*Glycera lapidum*	29.85
				Aonides oxycephala	73.19	*Laonice bahusiensis*	45.02	Syllis spp.	33.27
				Eualus occultus	78.16	*Polycirrus medusa*	49.07	*Laonice bahusiensis*	36.37
				Pisidia longicornis	80.72	*Cheirocratus intermedius*	53.07	*Aonides paucibranchiata*	39.20
				Glycymeris glycymeris	83.22	*Timoclea ovata*	56.99	*Glycymeris glycymeris*	41.95
				Timoclea ovata	85.73	*Pagurus cuanensis*	60.56	*Pisidia longicornis*	44.63

4.5. Pattern of the 1 + 2 mm Macrofauna

The HCA using the Sorensen coefficient (not shown in the paper) on the matrix of 40 stations with 273 taxa identified 10 groups of stations at a 40% similarity without clear sedimentological and geographical patterns. The HAC within the Log(X + 1) transformation of the abundances identified five groups of stations at a level of 29% of the Bray–Curtis similarity (Figure 6). Group a from our study was similar to group a of the previous analysis gathering two stations from Box 5 characterised by two taxa the bivalve *Pododesmus squama* and the barnacle *Balanus crenatus* (Table 4). Group b gathered 24 stations from the eastern and central boxes 1 to 7 characterised by the polychaetes *Notomastus latericeus*, *Glycera lapidum*, *Aonides paucibranchiata* and *Eulalia mustela* (Table 4), comparable to group g in the previous analysis. Group c included 11 stations from western boxes 8 to 13 and was characterised by the sea urchin *Echinocyamus pusillus*, the polychaetes *Glycera lapidum* and *Eulalia mustela* and the amphipod *Ampelisca spinipes*, comparable to group f in the previous analysis. Group d was comparable to the isolated station 23 from Box 6 (which was also isolated in the previous analysis). The last group e included both stations 10 and 126 which were also separated from all stations in the previous analysis. This last group was characterised by the small annelids *Polygordius* and *Pisione remota*.

4.6. Pattern of the 1 + 2 mm Macrofauna + Colonial Epifauna Taxa

A total of 393 taxa were considered for the construction of the HCA using the Sorensen coefficient (presence/absence of the taxa) revealing the presence of five groups of stations at 35% similarity (Figure 7). Group a included stations 31 and 32 (Box 5) which were separated into different groups in the previous analyses. Both stations were characterised by two taxa: the bivalve *Pododesmus squama* and the barnacle *Balanus crenatus* (Table 5). Group b included three stations, 10 and 126 which were separated from other stations in both previous analyses, plus station 108 (Box 8). This group was characterised by the small annelids *Glycera lapidum*, *Polygordius* spp., *Pisione remota* and *Syllis* spp., the bivalve *Timoclea ovata* and the sea urchin *Echinocyamus pusillus*. Group c included 18 stations from boxes 1 to 4 corresponding to groups g and b from the previous analyses. This group was characterised only by polychaetes such as *G. lapidum*, *Notomastus latericeus* and *Laonice bahusiensis* and Nemertea (Table 5). Group d included 10 of the westernmost stations, mainly from boxes 9 to 13 characterised by *E. pusillus*, small polychaetes taxa such as *Eulalia mustela*, *G. lapidum*, *Cauleriella alata* and the amphipods *Cheirocratus* ssp. and *Ampelisca* *spinipes*. Lastly, group e included seven stations from boxes 3 to 8, again characterised by small polychaetes such as *E. mustela*, *G. lapidum* and *N. latericeus*, Nemertea, and the bivalve *Glycymeris glycymeris* as well as the brittle star *Ophiothrix fragilis* (Table 5).

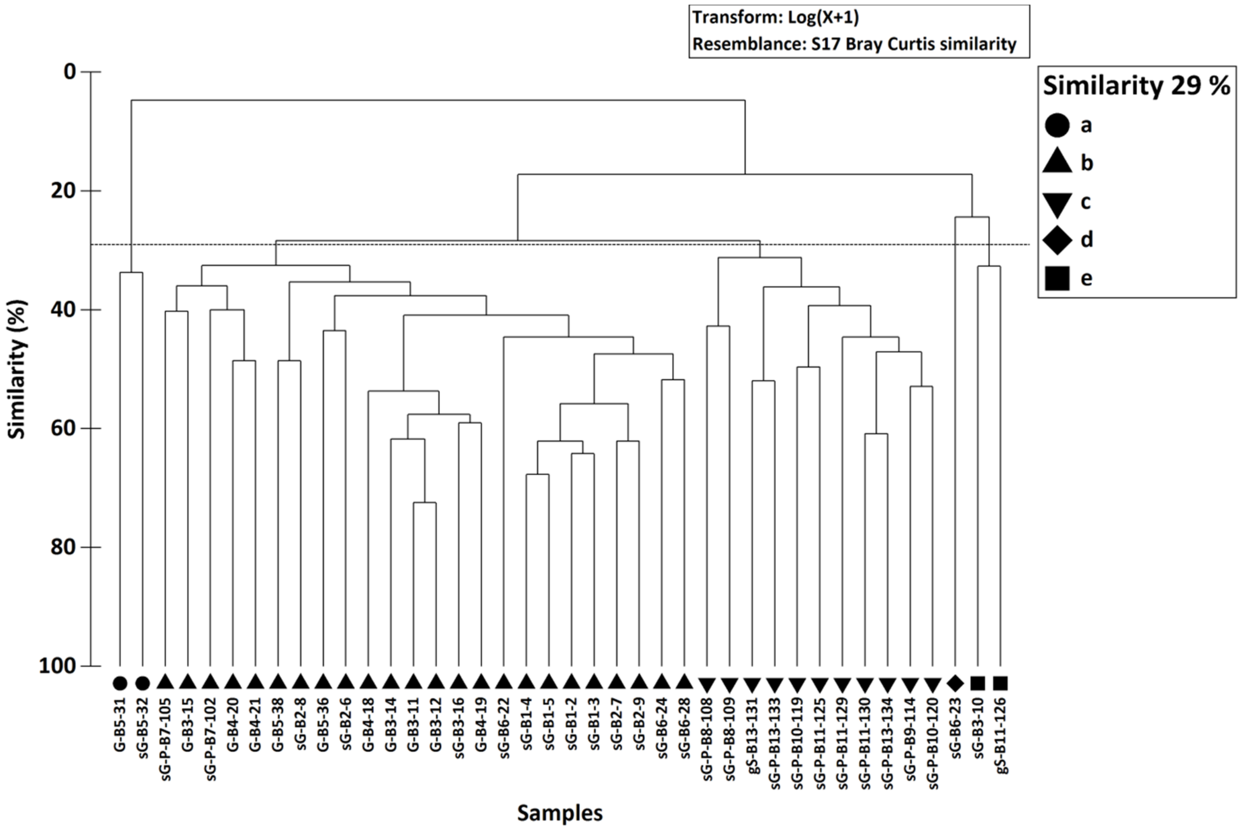


Figure 6. Cluster dendrogram showing the pattern of the 40 grab sampling stations (abundance per 0.5 m^2 of the accounted macrofauna retained on a 1 mm mesh sieve and 29% of similarity) according to the Bray–Curtis similarity after Log(X + 1) transformation of the abundances.

Table 4. SIMPER analysis on taxa accounted for on 2 + 1 mm mesh sieve with cumulative contribution (Cc in%) of the ten top species in the different groups identified by the cluster dendrogram analysis (Figure 6). (1): Group 1, . . . of Table 7. Group b (station 10, group 2). Group d (station 23, group 6).

Group a (1)	Cc (%)	Group b (3)	Cc (%)	Group c (4)	Cc (%)	Group e (2)	Cc (%)
Pododesmus squama	61.44	*Notomastus latericeus*	6.62	*Echinocyamus pusillus*	12.48	*Polygordius*	35.19
Balanus crenatus	100.00	*Glycera lapidum*	11.78	*Glycera lapidum*	21.28	*Pisione remota*	55.06
		Aonides paucibranchiata	16.56	*Ampelisca spinipes*	26.00	*Syllis* spp.	74.93
		Eulalia mustela	21.22	*Eulalia mustela*	30.38	*Glycera lapidum*	87.46
		Syllis spp.	25.75	*Cheirocratus*	34.43	*Timoclea ovata*	100
		Lumbrineris gracilis	29.69	*Jasmineira elegans*	38.27	-	-
		Laonice bahusiensis	33.54	*Syllis* spp.	41.95	-	-
		Timoclea ovata	36.87	*Laonice bahusiensis*	44.93	-	-
		Nemertea	40.08	*Timoclea ovata*	47.59	-	-
		Balanus crenatus	43.09	*Eurydice pulchra*	50.24	-	-

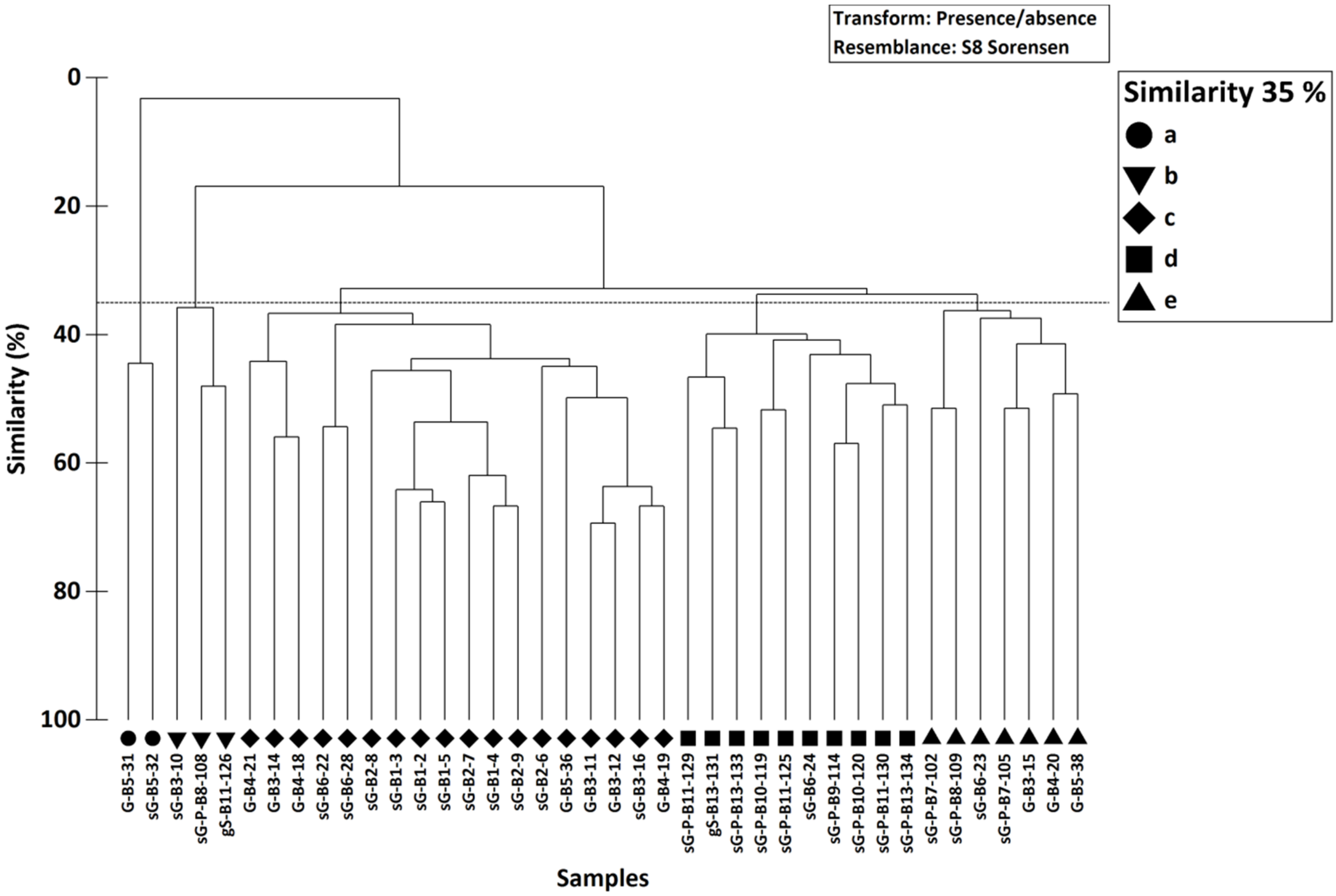


Figure 7. Cluster dendrogram showing the pattern of the 40 grab sampling stations (presence/absence of all taxa recorded per 0.5 m^2 of the motile and sessile macrofauna and 35% of similarity) according to the Sorensen similarity.

Table 5. SIMPER analysis on all sessile and motile taxa accounted on 2 + 1 mm mesh sieve with cumulative contribution (Cc in%) of the ten top species in the different groups identified by the cluster dendrogram analysis (Figure 7). (1): Group 1, . . . of Table 7.

Group a (1)	Cc (%)	Group b (2)	Cc (%)	Group c (3)	Cc (%)	Group d (4)	Cc (%)	Group e (5)	Cc (%)
Balanus crenatus	50.0	*Glycera lapidum*	21.6	*Glycera lapidum*	2.8	*Echinocyamus pusillus*	4.5	*Eulalia mustela*	7.8
Pododesmus squama	100.0	*Polygordius* sp.	43.1	*Notomastus latericeus*	5.7	*Eulalia mustela*	9.0	*Glycera lapidum*	15.7
-	-	*Timoclea ovata*	64.7	*Laonice bahusiensis*	8.3	*Glycera lapidum*	13.5	Nemertea	23.6
-	-	*Pisione remota*	72.3	Nemertea	10.8	*Cheirocratus*	17.1	*Notomastus latericeus*	31.4
-	-	*Syllis* spp.	79.9	*Syllis* spp.	13.3	*Caulleriella alata*	20.6	*Aonides paucibranchiata*	37.1
-	-	*Echinocyamus pusillus*	86.6	*Eulalia mustela*	15.7	*Ampelisca spinipes*	24.1	*Syllis* spp.	42.8
-	-	*Malmgreniella arenicolae*	93.3	*Lumbrineris gracilis*	18.2	*Eunice vittata*	27.5	Opisthodonta	48.4
-	-	-		*Polycirrus medusa*	20.6	*Laonice bahusiensis*	30.8	*Polygordius* sp.	52.3
-	-	-		*Aonides paucibranchiata*	22.9	Nemertea	34.1	*Glycymeris glycymeris*	56.0
-	-	-		*Websterinereis glauca*	25.1	*Syllis* spp.	37.5	*Ophiothrix fragilis*	59.7

4.7. ROV Observation

A total of 35 invertebrate taxa were identified from the 30 ROV videos. The Bray–Curtis similarity was calculated using the three classes of abundance ((1) rare; (2) common; (3) abundant). The HCA within the square root transformation permitted to identify six groups of stations at a 39% level of similarity (Figure 8). Station ROV111 (Group a) with only two identified taxa (*Spirobranchus* spp. and *Pisa* spp.) was isolated from the other stations. Two stations ROV13 and ROV112 (group b) were characterised by the Bryozoan *Alcyonidium* sp. (Table 6). Group c also included two stations ROV9 and ROV103, with dense populations of the brittle star *Ophiothrix fragilis* accompanied by *Alcyonium digitatum*, Hydroids and *Urticana felina* (Table 6). Group d gathered eight stations mainly located in the eastern boxes and characterised by the queen scallop *Aequipecten opercularis*. Group e included five stations all located in the western part of the English Channel and characterised by the Hydrozoa *Abietinaria abietina.* Finally, group f included 12 stations both in the central boxes and the western boxes and characterised by a diversified epifauna and the dominance of the Bryozoan *Flustra* and sponge taxa. The arrangement of the stations appeared to be governed primarily by the faunal composition and the geographical location rather than the sediment characteristics (Figure 7).

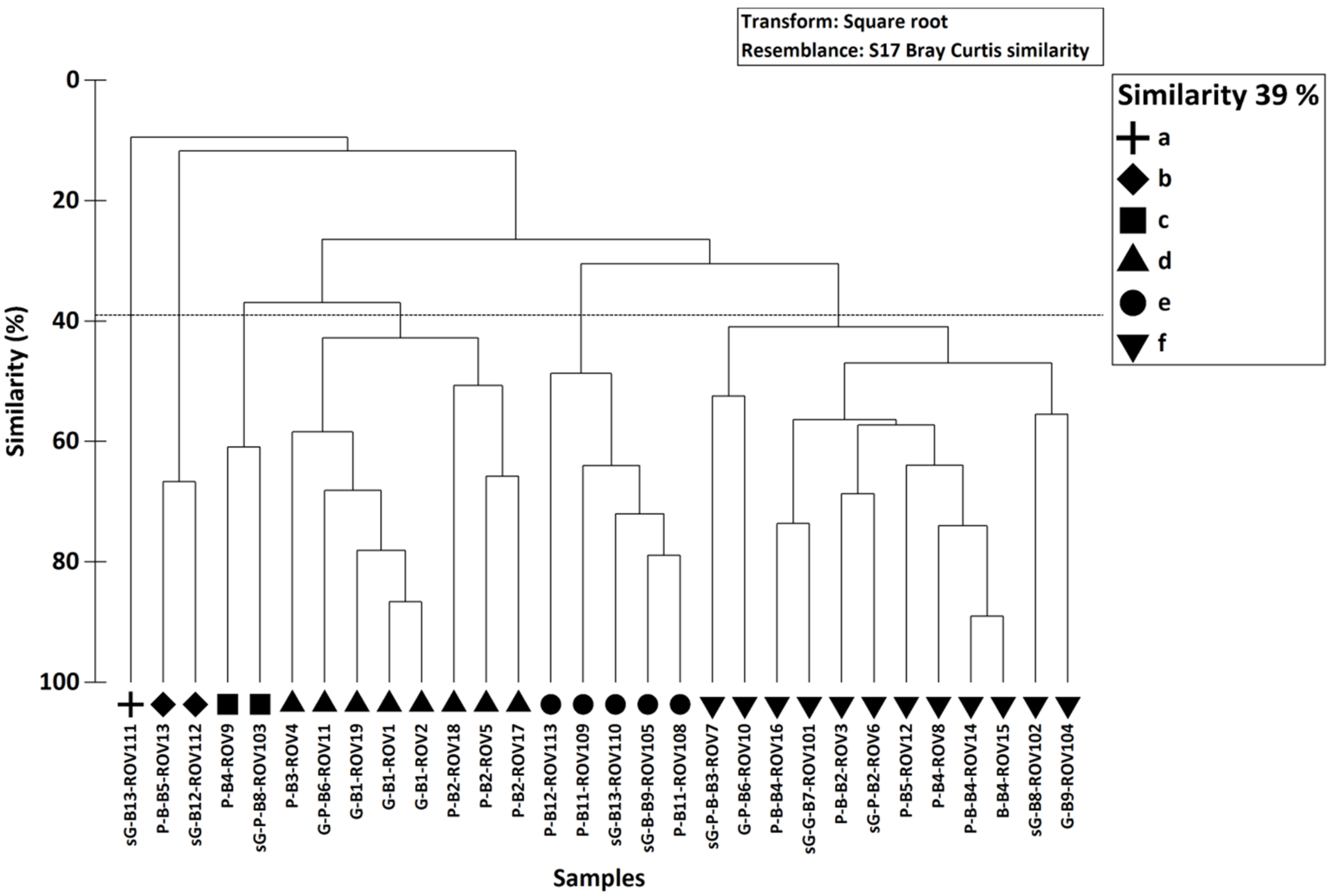


Figure 8. Cluster dendrogram showing the pattern of the 30 ROV sampling stations (motile and sessile taxa identified from the video and 35% of similarity) according to the Bray–Curtis similarity calculated using three classes of abundance ((1) rare; (2) common; (3) abundant and square root transformation).

Table 6. SIMPER analysis on sessile and motile taxa identified with the video from the mini ROV Seabotix with cumulative contribution (Cc in%) of the top species in the different groups identified by the cluster dendrogram analysis (Figure 8). (1): Group 1, . . . of Table 7. Group a (station ROV 111).

Group b (1)	Cc (%)	Group c (2)	Cc (%)	Group d (3)	Cc (%)	Group e (4)	Cc (%)	Group f (5)	Cc (%)
Alcyonium digitatum	100	*Ophiothrix fragilis*	33.66	*Aequipecten opercularis*	35.17	*Abietinaria abietina*	43.74	*Flustrea*	34.12
-	-	*Alcyonium digitatum*	61.14	Hydrozoa	55.69	Sponges	79.33	Sponges	50.47
-	-	Hydrozoa	80.57	*Pagurus* spp.	74.43	*Alcyonium digitatum*	89.79	Hydrozoa	63.66
-	-	*Urticina felina*	100	*Asterias rubens*	84.48	*Nemertesia*	97.67	*Nemertesia*	74.97
-	-	-	-	*Urticina felina*	90.15	-	-	*Balanus crenatus*	82.85
-	-	-	-	-	-	-	-	*Spirobranchus* spp.	89.61
-	-	-	-	-	-	-	-	*Alcyonium digitatum*	94.90

5. Discussion

The seabed of the EC is fashioned by high tidal hydrodynamics and is characterised by coarse sediments, especially in the subtidal areas. The management of this type of substrate is becoming more and more challenging for the marine blue economy in the EC due to the development of industries at sea such as marine aggregate extractions in the eastern channel paleo-valleys or the development of offshore wind farms, especially within French coastal waters where future wind farms sites have been allocated in the north of the Bay of Seine. The VIDEOCHARM study was a synoptic work in the central and the western part of the EC providing new quantitative data for the benthic communities at the end of spring, as both surveys were organised in June 2010 and 2011. Bad weather conditions affected the survey design, as most of the boxes sampled during the 2011 year (7 to 11) were relocated close to the Brittany coastline but remained in coarse circalittoral sediment, which is dominant in the EC [31].

5.1. EUNIS Classification

One of the aims of this study was to assess the diversity of coarse sediment offshore benthic habitats according to the EUNIS habitat classification [11,23,24,41]; https://www.eea.europa.eu/data-and-maps/data/eunis-habitat-classification-1 (accessed on 1 June 2022). Following the EUNIS 2012 classification, the sampling areas concerned two main habitats at Level 2—A5: sublittoral sediments and A4: circalittoral rocks and other substrata. Thus, the authors of [11] had modelled EUNIS map of the EC at this level of classification, and our study area corresponded in the eastern part (boxes 1 and 2) to the A5.14 habitat (circalittoral coarse sediment, i.e., MC32 Atlantic circalittoral coarse sediment of the EUNIS 2022 classification), while all the other boxes were classified as A5.15 habitat (deep circalittoral coarse sediment, i.e., MD2 offshore circalittoral coarse sediment of the EUNIS 2022 classification) (https://www.eea.europa.eu/data-and-maps/data/eunis-habitat-classification-1).

The EUNIS habitat classification was first published in the early 2000s and was developed according to the data available at the time. The classification was then better suited to describe shallow bays and estuarine environments (mobile muddy fine sediments) such as the Bay of Seine in the English Channel (42) rather than in coarser sediment habitats occurring in deeper areas such as those found in the central and western part of EC. The EUNIS habitat classification is now widely used to describe the diversity of marine benthic habitats of the European marine seabed [28,41].

The combination of approaches used in the VIDEOCHARM surveys (side scan sonar, video, photography, and sediment particle size and taxa identification) identified the offshore circalittoral coarse habitat to levels 5 and 6 of the EUNIS 2022 classification. The successive HCA proposed in this paper showed that most of the stations were always classified into the same cluster groups, whatever data source used, and only a few stations changed cluster groups according to the recorded taxa (Table 7). The cross analysis of these faunal groups with sediment data led to the allocation of the grab sampling stations to five EUNIS habitats.

Table 7. Summary information on the sediment types according to the photos (expert assessment) and sediment analyses for the 40 stations according to their location in the sampled boxes in June 2010 and June 2011. Positions of the stations according to the groups identified in the cluster dendrograms (see Figures 5–8 and Tables 3–6). The colours indicate the classification of each station into the five EUNIS 2022 habitat classifications. The numbers in red indicate that a station is classified in different groups according to the successive analyses; except MC4215 habitat in blue.

Box	Station	Photos	Sediment Type	G 2 mm	G 2 + 1 mm	G 2 + 1 mm + Epifauna	ROV	EUNIS
1	2	Sandy Gravel	Sandy Gravel	3	3	3	3	MD3211 (A5.151)
	3	Sandy Gravel	Sandy Gravel	3	3	3	3	MD3211 (A5.151)
	4	Sandy Gravel	Sandy Gravel	3	3	3	3	MD3211 (A5.151)
	5	Sandy Gravel	Sandy Gravel	3	3	3	3	MD3211 (A5.151)
2	6	Sandy Gravel	Sandy Gravel	3	3	3	5	MD3211 (A5.151)
	7	Sandy Gravel	Sandy Gravel	3	3	3	3	MD3211 (A5.151)
	8	Sandy Gravel	Sandy Gravel	3	3	3	3	MD3211 (A5.151)
	9	Sandy Gravel	Sandy Gravel	3	3	3	3	MD3211 (A5.151)
3	10	Coarse sand	Sandy Gravel	2	2	2	5	MC3215 (A5.145)
	11	Sandy Gravel and Pebbles	Gravel	3	3	3	5	MD3211 (A5.151)
	12	Sandy Gravel	Gravel	3	3	3	-	MD3211 (A5.151)
	14	Sandy Gravel	Gravel	3	3	3	5	MD3211 (A5.151)
	15	Sandy Gravel	Gravel	3	3	5	-	MD3211 (A5.151)
	16	Sandy Gravel	Sandy Gravel	3	3	3	5	MD3211 (A5.151)

Table 7. *Cont.*

Box	Station	Photos	Sediment Type	G 2 mm	G 2 + 1 mm	G 2 + 1 mm + Epifauna	ROV	EUNIS
4	18	Sandy Gravel and Pebbles	Gravel	3	3	3	5	MD3211 (A5.151)
	19	Sandy Gravel and Pebbles	Gravel	3	3	3	5	MD3211 (A5.151)
	20	Gravel	Gravel	5	3	5	5	MC4215 (A5. 445)
	21	Sandy Gravel and Pebbles	Gravel	5	3	3	2	MC4215 (A5. 445)
5	31	Gravel	Gravel	1	1	1	-	MC4 (A5. 44)
	32	Sandy Gravel	Sandy Gravel	1	1	1	1	MC4 (A5. 44)
	36	Sandy Gravel and Pebbles	Gravel	3	3	3	-	MD3211 (A5.151)
	38	Sandy Gravel and Pebbles	Gravel	3	3	5	-	MD3211 (A5.151)
6	22	Gravelly Sand	Sandy Gravel	3	3	3	-	MD3211 (A5.151)
	23	Gravelly Sand	Sandy Gravel	6	6	5	5	MD3211 (A5.151)
	24	Gravelly Sand	Sandy Gravel	3	3	4	5	MD3211 (A5.151)
	28	Gravelly Sand	Sandy Gravel	4	3	3	3	MD3211 (A5.151)
7	102	Sandy Gravel and Pebbles	Sandy Gravel and Pebbles	5	3	5	-	MC4215 (A5. 445)
	105	Sandy Gravel and Pebbles	Sandy Gravel and Pebbles	5	3	5	2	MC4215 (A5. 445)
8	108	Sandy Gravel and Pebbles	Sandy Gravel and Pebbles	4	4	2	-	MC3212 (A5.142)
	109	Gravelly Sand and Pebbles	Sandy Gravel and Pebbles	4	4	5	-	MC3212 (A5.142)
9	114	Gravelly Sand and Pebbles	Sandy Gravel and Pebbles	4	4	4	5	MC3212 (A5.142)

Table 7. *Cont.*

Box	Station	Photos	Sediment Type	G 2 mm	G 2 + 1 mm	G 2 + 1 mm + Epifauna	ROV	EUNIS
10	119	Sandy Gravel and Pebbles	Sandy Gravel and Pebbles	4	4	4	4	MC3212 (A5.142)
	120	Gravelly Sand and Pebbles	Sandy Gravel and Pebbles	4	4	4	-	MC3212 (A5.142)
11	125	Gravelly Sand and Pebbles	Sandy Gravel and Pebbles	4	4	4	-	MC3212 (A5.142)
	126	Coarse Sand	Gravelly Sand	2	2	2	4	MC3215 (A5.145)
	129	Coarse Sand and Pebbles	Sandy Gravel and Pebbles	4	4	4	4	MC3212 (A5.142)
	130	Gravelly Sand	Sandy Gravel and Pebbles	4	4	4	4	MC3212 (A5.142)
13	131	Coarse Sand	Gravelly Sand	2	4	4	6	MC3215 (A5.145)
	133	Gravelly Sand	Sandy Gravel and Pebbles	4	4	4	1	MC3212 (A5.142)
	134	Gravelly Sand	Sandy Gravel and Pebbles	4	4	4	4	MC3212 (A5.142)

MC3215 (A5.145). *Branchiostoma lanceolatum* in Atlantic circalittoral coarse sand with shell gravel. Only three stations (10 in Box 3, 126 in Box 126 and 131 in Box 13) on coarse sand corresponded to this habitat.

MD3211 (A5.151). *Glycera lapidum*, *Thyasira* spp. and *Amythasides macroglossus* in offshore circalittoral gravelly sand. A total of 21 stations corresponded to this habitat. They were located the eastern boxes 1 to 4, as well as in boxes 5 and 6 located in the north of the Channel Islands.

MC4 (A5.44) Circalittoral mixed sediment. Two stations, 31 and 32, from Box 5 corresponded to this habitat with a very low number of taxa permitting to identify the habitat only at level 2 of the classification.

MC3212 (A5.142) *Mediomastus fragilis*, *Lumbrineris* spp. and venerid bivalves in Atlantic circalittoral coarse sand or gravel. This habitat corresponded to 10 stations all located in boxes 8 and 13 in the western part of the EC.

MC4215 (A5.445) *Ophiothrix fragilis* and/or *Ophiocomina nigra* brittle star beds on circalittoral-mixed sediment. Four stations, two in Box 4 (20 and 20) and two in Box 7 (102 and 105), were assigned to this habitat characterised by the presence of the brittle star *Ophiothrix fragilis*.

Both MC3212 (A5.142) and MC4215 (A5.445) were dominant in the central part of the Bay of Seine [42]. Moreover, gravel and pebble sediment were largely distributed in the eastern part of the EC [25,26]. Nevertheless, these last authors did not distinguish the EUNIS habitat in their study.

On the Dieppe-Le Tréport (DLT) Offshore Wind Farm (French coastal part of the eastern EC), a sampling strategy was developed in 2014–2016 to establish a 'Before' state for the sediment and macrofauna. The coarse sediment assemblage sampled on sandy gravel and gravelly sand corresponds to two EUNIS habitats MC3212 characterised by molluscs with large biomass such as *Glycymeris* and *Polititapes rhomboids* [39]. Some stations are dominated by the cephalocordate *Branchiostoma lanceolatum*, yielding an assemblage corresponding rather to the EUNIS habitat MC3215, which was largely represented in coastal coarse sediment along the Brittany coast such as in the Bay of Morlaix [9,43].

Our study is the first to describe in such detail the patterns of distribution of the offshore coarse sediment habitats. Two habitats dominated the surveyed area, the Sandy Gravel MD3211 in the eastern part of the EC and the Gravelly Sand and Pebbles MC3212 in the western EC. The MC4215 (dense bed of *O. fragilis*) was rare in the offshore coarse sediment and was more largely distributed in the Bay of Seine [42]. Our study completed the review provided by [44].

5.2. New Quantitative Data on the Coarse Sediment of the Central Part of the English Channel

The taxonomic richness and the mean abundance per m^2 of the five EUNIS habitats reported in the central part of the EC were compared with values found on the sandy gravel and gravelly sand found elsewhere in the English Channel (Table 8) [39,43,45–54]. The taxonomic richness appeared to be correlated to the sampling area with the highest values corresponding to the largest sampling areas. Nevertheless, the low TR reported for the MC3215 (coarse sand) and MC4 (gravel) were among the smallest values recorded in similar coarse sediment habitats in the EC. The TR for the sandy gravel MD3211 and the sandy gravel MC3212 habitats, respectively 233 and 164, were however within the range of values found in the samples collected along the French coast of the eastern part of the EC and for similar sampling surfaces (from 147 in June from the future Offshore Wind Farm of Courseulles-sur-Mer to 277 in September/October from the future Offshore Wind Farm of Dieppe-Le-Tréport). The TR of the MC4215 habitat corresponding to coarse sand sediment with the presence of *Ophiothrix fragilis* was low; similarly, the abundance value (316 individuals per m^2) remained moderate in comparison with a similar habitat of the Bay of Seine where large populations of *O. fragilis* have been observed (>5000 individuals per m^2) [13,55].

As reported in Table 8, abundances on coarse sediments in the EC varied from a minimum of 192 individuals per m^2 to a maximum of 4590 individuals per m^2. Values were lowest in the western EC (coarse sand of the Bay of Morlaix; 192 individuals per m^2) compared to other sites in the eastern EC. Our study reported abundances between 223 and 800 individuals per m^2 in the central part of the EC, which were among the lowest reported in the EC for similar sediment types. The depths of the five habitats sampled during both our surveys were higher than those of other coastal studies (Table 8); moreover, the primary production and organic matter fluxes between the water column and the sea bottom were lower than those observed near the coast where nutrient fluxes coming from rivers increased the primary production [29,55].

In summary, in the offshore coarse sediment of the central part of the EC, the taxonomic richness of both extensive coarse habitats was on the same order of magnitude as the similar coarse sand habitat of the English Channel, whilst the abundances were lower than those found near the shallow coastal coarse sediment, especially in the Bay of Seine and in the eastern EC. These low abundance values, and probably low biomasses, of the macrofauna in the deep central zone of the EC can be related to a low nutrient input and primary production and low pelagic fluxes from the water column to the benthic habitat.

Table 8. Univariate indices and grab sampling details for the accountable macrofauna from the coarse sediment (sieving on 1 mm): coarse sand (Cs) sandy gravel (sG), gravelly sand (gS), gravel (G), pebbles (P) and O (*Ophiothrix fragilis*) for the English Channel. (wEC: west English Channel; eEC: east English Channel); UK: United Kingdom; Ss: sampling surface in m^2; D: depth in m; S: sediment type; TR: taxonomic richness: A: abundance, individual number per m^2 (in part from 39).

		Site	Month	Year	Ss	D	S	TR	A (m^2)	Reference
wEC	UK	West EC	-	-	-	-	sG and gS	-	390	MESL, 1999 [46]
	France	Morlaix	Each month	1977–1980	32.5	17	Cs	181	192	Dauvin, 1988 [43]
eEC	France	Dieppe	-	1996–1997	0.9	15	sG	50	1.940	Desprez, 2000 [47]
			-	1996–2001	0.8	15	sG	50	2.394	Desprez et al., 2010 [48]
		Dieppe-Le Tréport	September/October	2014–2016	14	12–25	sG	277	2.989	Pezy and Dauvin, 2021 [39]
			February/March		24		gS	224	1.605	
		Bay of Seine	June–August	2007	19	38–50	sG	198	1.309	Lozach and Dauvin, 2012 [13]
		PER Granulats du Havre	February	2012	2.5	16–22	sG	117	777	Pezy et al., 2021 [49]
			February	2021	6		sG and gS	157	1.219	Pezy et al., 2021 [49]
		Courseulles-sur-Mer	June	2009	8.1	22–28	sG	147	377	In Vivo, 2013 [50]
			March	2020	4.5	22–30	sG	182	3.303	Raoux et al., 2021 [51]
			March	2021	5.4	22–30	sG	159	2.008	
	UK	St Catherine	-	-	-	-	sG and gS	-	4.590	MESL, 1996 [45]
		West Bassurelle	-	-	-	-	sG and gS	-	932	MESL, 1999 [46]
		Folkestone	-	-	-	-	Cs	-	3.051	Newell et al., 2001 [52]
		Isle of Wight	March and September	1999	26.2	>10	Cs	316	998	Newell et al., 2004 [53]
		Hastings	-	-	-	-	sG	-	2.000	Cooper et al., 2007 [54]
Offshore central and western part of the EC			June	2010–2011	1.5	64–95	Cs	33	223	This study
					1	88–96	G	7	434	
					10.5	45–80	sG	233	800	
					5	73–101	sG and P	164	380	
					2	54–67	sG and P + O	80	316	

5.3. Information Gained from the Seven Benthic Habitats Sampling Methods

The originality of our study was the multidisciplinary approach used to assess the best method to identify the different circalittoral coarse sediment habitats. Both imagery (side scan sonar, photography and ROV) and direct approaches (grab sampling with benthic identifications for (epifauna and endofauna) on two sieving mesh, and particle size analyses) were developed and combined.

Even if sonar profiles did not fully cover all box areas, they gave more spatial information than grab samples and ROV video footage. Sedimentary and morphological structures are clearly highlighted (when present) to estimate rapidly possible habitats. Cross-analysis of the side scan sonar profiles with information obtained through the analysis of the grab samples should allow for semi-automatic spatial classification. However, this approach suffers in the present study from the lack of cross-information over the acoustic responses highlighted on survey boxes. The profiles showed a high variability of acoustic responses (in particular in boxes 3 and 4; Figures 4 and 9) that would require a high sampling effort to perform an exhaustive classification. At the scale of the EC, acoustic profiles also showed high frequency variations. These latter could not have been preliminarily taken into account, i.e., before the surveys, due to lack of associated sedimentary information.

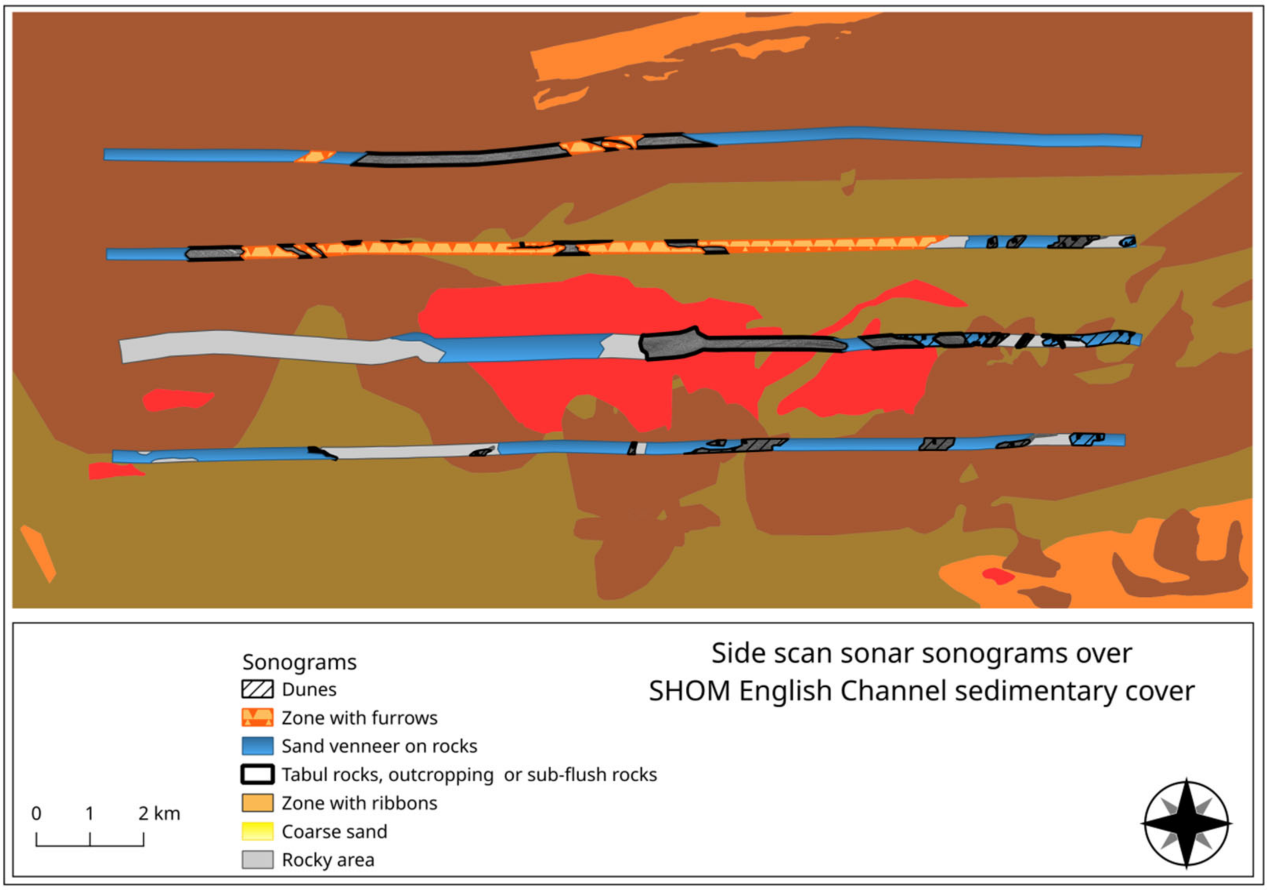


Figure 9. Side scan sonar profiles collected during the VIDEOCHARM surveys in June 2010 (box 4) over the SHOM sedimentary cover in the English Channel.

For example, the comparison of sonar responses with efficient EC sedimentary cover available at SHOM (data.shom.fr) showed a higher variability of sonograms (Figure 9). However, this approach can be applied to smaller areas in the frame of particular objectives, such as preliminary state establishment of environmental context before installation of marine renewable energy structures (wind farms or water turbine farms). Figure 10 shows the EUNIS habitat map from EUSeaMap product (https://www.emodnet-seabedhabitats.eu, accessed on 1 April 2022) with the VIDEOCHARM side scan sonar survey lines overimposed. VIDEOCHARM data sets confirm our EUNIS classification for boxes 1 and 2. Box 11 partially covers both high- and a moderate-energy circalittoral areas according to EUSeaMap. The difference between these two areas is highlighted on the side scan sonar profile with the presence of megadunes on the highest energy part (the two northwest profiles of Box 11). This is also the case for Box 11, entirely located on a high-energy circalittoral rock area, which shows megadunes both with sonar profile data and ROV. Moreover, it will be interesting in the future to integrate our VIDEOCHARM data in the EUSeaMap.

First, coding was developed for side-scan sonar images to describe seabed morphology (Table 1). The authors of [28,56] had suggested to add at level 2 of the EUNIS classification, for the circalittoral rocks and the sub-littoral sediment, additional information on the forms of the rocks and the presence of ribbon and dune bed forms (including dune wavelength), and to note evidence of anthropogenic activity. Such longitudinal furrows and sand ribbons and rocky reef had been previously observed in the central part of the EC [57,58]. This supplementary data can help to better understand the heterogeneity of such a deep habitat, as observed by [11,23], for coarse sediment offshore from the English side of the EC.

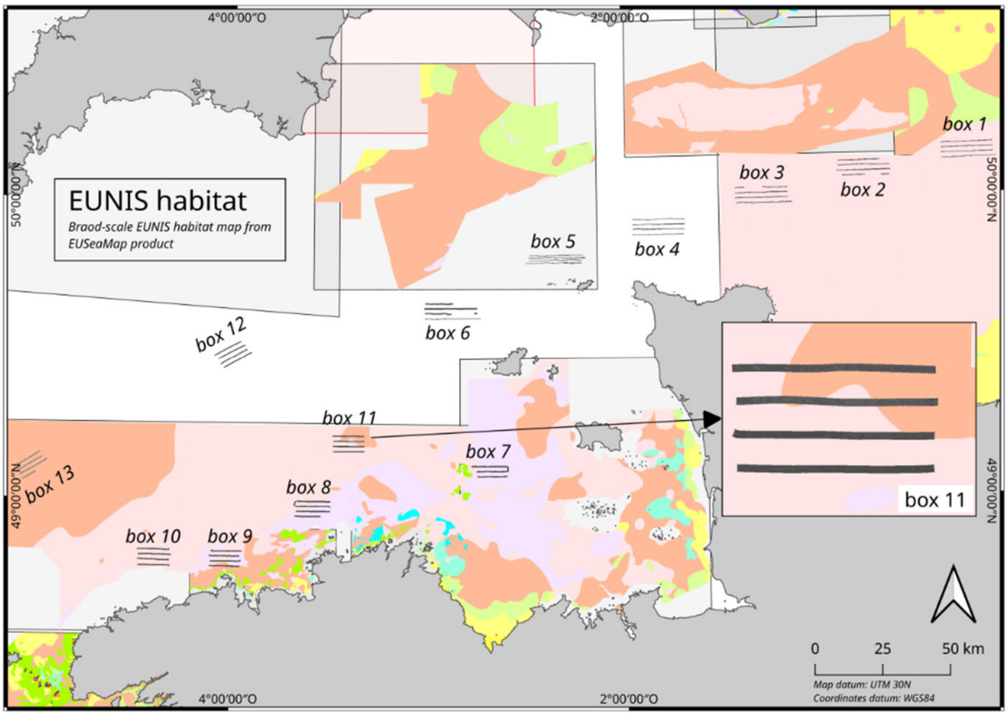


Figure 10. EUNIS habitat map from the library of marine habitats maps in European waters (EMODnet seabed habitats). VIDEOCHARM side scan sonar survey lines are shown with corresponding box number.

The sessile epifauna appeared relatively homogenous in this type of sandy gravel and gravel sediment at the scale of the sampling area and was not a driver in the classification of the offshore coarse sediment habitats of the central part of the EC. Nevertheless, the sampling surface remained small (0.5 m^2) and was probably insufficient for good insight into the diversity of the sessile fauna and could not detect the western–eastern impoverishment of these fauna identified at the scale of the whole EC by [10]. These authors have shown a gradual disappearance of sessile species from the western part to the eastern part of the EC in relation to the annual amplitude of the sea water temperature, which was higher in the east part than in the western part. Moreover, about 3000 sampling stations with a Rally du Baty dredge were used to describe this general distribution pattern of the sessile fauna in the whole EC.

As highlighted later by Foveau [25,26] for the benthic habitats of the eastern part of the EC, uncountable taxa, belonging to the sessile epifauna, were logically mainly associated with pebbled areas, located offshore the 'Pays de Caux' near the Antifer Cape and the Dover Strait. The location of diversity hotspots (total or sessile epifauna only) coincided with the distribution of large gravel and pebble sediment particles.

Sessile fauna taxa recorded in the 40 Hamon grab sampling stations in gravel and pebble sediments during both VIDEOCHARM surveys included 125 taxa which represented 31% of the total diversity. Sessile epifauna are often neglected in research projects on the soft-bottom benthic community despite representing an important source of diversity. Nevertheless, as numerous taxa are colonials, only their presence can be accounted for and used in statistical analyses.

ROV video footage was useful in accounting for the large vagile and sessile epifauna, which were spatially dispersed and not sampled by the Hamon grab, which only collects a relatively small surface of 0.25 m^2. This method gave valuable supplementary observations, providing information for the interpretation of the acoustic profiles on the nature of surficial sediment and presence of dispersed or dense epifauna such as the *Ophiothrix fragilis*. Some taxa were identified only on video footage such as the bryozoans *Alcyonidium* spp., the Cnidaria *Alcyonium digitatum*, and six large echinoderms. The epifauna assemblage pattern observed from the video footage was comparable to those of the endofauna. The videos were also useful as a communication tool to illustrate the results to non-scientists such as fishermen, stakeholders and marine environment managers.

Expert description on board of the sediment collected by the grab gave good information on the sediment type (the photo permitted to store a visual memory of the grab to verify the expert judgement if necessary). Granulometric analyses gave supplementary information on fine particles (very low content in such coarse sediment) and the respective percentage of particles between pebbles, gravel and sands as sediment components.

In the early benthic habitat studies in the EC, scientists used dredge [28], and then later in the first quantitative studies, they used grabs such as the Hamon grab which allowed the collection of sufficient volume of coarse sediment [13,25,26,55]. These authors then used a 2 mm sieve mesh to retain the macrofauna. Our results hence gave, for the first time at the scale of 80 Hamon grabs sampled in the coarse sediment on the French side of the EC, the taxonomic richness and abundances of the macrofauna retained on a 2 mm and on a 1 mm mesh size because there are many samples in the UK waters on 1 mm in the EC. Considering the taxonomic diversity, most of the species (84%) of the taxa) had been retained by a 2 mm mesh sieve, and only the remaining 16% (mainly small polychaetes and amphipods) passed through the 2 mm mesh sieve and had been retained by a 1 mm mesh size. Thus, the increase in taxonomic richness was weak with the double sieving on 2 and 1 mm. Then, considering the abundances, more than one third of the total number of individuals passed through on a 2 mm mesh size and was retained by a 1 mm mesh size. These small individuals had an important consequence on the ecological status of the benthic habitat (see Table 2), which showed better ecological status expressed by J' and H' when they were assessed with the macrofauna sampled on a 1 mm mesh sieve. Nevertheless, as underlined by [13], in most of the investigations of the French side of the EC, a 2 mm mesh sieve had been frequently used because more than 95% of macrobenthic biomass was generally retained. In summary, improvements of using a 1 mm mesh sieve mesh are highly important for abundances but are of low or moderate importance for the biomasses and taxonomic richness.

Nevertheless, based on these considerations, it is recommended to sieve the macrofauna on a 1 mm mesh for the entire area of the EC where grab (Hamon or others) can be used.

5.4. Perspectives on the Future of the EC Marine Management

The French government has announced in early March 2022 a 'target 40 gigawatts of marine renewable energy in service in 2050', which is the equivalent of about fifty offshore wind farms (OWF) to be installed in the French Metropolitan coastal waters. Four OWFs were under construction along the French side of the EC at a distance between 15 and 20 km from the coastline [59,60]. In the future, there is a plan to build OWF at a greater distance from the coast (around 50 km), similar to the area prospected during the VIDEOCHARM surveys offshore the Bay of Seine where two new OWF sites have been investigated [59]. Similarly, aggregate extraction areas are planned at a greater distance from the coast, such as the area located to the north of the Bay of Seine [13]. The VIDEOCHARM data could therefore be used as a reference point for the macrofauna compartment as well as an important source of information to carry out the environmental impact assessment needed prior to any industrial development at sea. Data on the biomass of the benthic macrofauna should be completed by data on other biological components such as phytoplankton, zooplankton, suprabenthos and fishes to understand fluxes between these components (e.g., by studying fish stomach contents) to provide an ecosystem approach of such an offshore system in the central part of the EC. The development of the marine renewable energy structure in the EC will be for the researchers an opportunity to increase the knowledge of the functioning of such offshore coarse sediment, which has remained, once again, poorly investigated [59–61].

Author Contributions: Conceptualization J.-C.D., S.L., E.P. and A.T.; methodology, J.-C.D., S.L., E.P. and A.T.; software, E.P. and J.-P.P.; validation, all the co-authors.; formal analysis, J.-P.P. and E.P.; investigation, J.-C.D., S.L., E.P. and A.T.; resources, J.-C.D. and E.P.; data curation, J.-C.D. and J.-P.P.; writing—original draft preparation, J.-C.D.; writing—review and editing, all the co-authors; visualization, J.-C.D.; supervision, J.-C.D.; project administration, J.-C.D.; funding acquisition, J.-C.D. All authors have read and agreed to the published version of the manuscript.

Funding: This research received financial support from the INTERREG IV A France (Channel)–England cross-border European cooperation programme, co-financed by the European Regional Development Fund as part of the CHannel integrated Approach for marine Resource Management (CHARM) Phase 3 project.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The raw data should be available.

Acknowledgments: This work was carried out under the INTERREG IV A France (Channel)–England cross-border European cooperation programme, co-financed by the European Regional Development Fund as part of the CHannel integrated Approach for marine Resource Management (CHARM) Phase 3 project. The authors thank the crews of RV 'Côtes de la Manche, as well as all the scientists and students who helped during the cruises, especially R. Abraham, D. Malengros, A. Baffreau, and A. Foveau who help the identifications of species and taxa. The authors also thank the two reviewers for their attentive lecture and their useful suggestions to amend the first version of this paper.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Appendix A. Details of the sampling effort during the VIDEOCHARM surveys in June 2010 (boxes 1 and 6) and June 2011 (boxes 7 to 13) in the central part of the English Channel. ST: station; RE: replicate; ROV: remote observatory vehicle; B: benthic samples; H1: Hamon grab replicate 1, H2: Hamon grab replicate 2, G: Hamon grab for granulometry. Sediment photos: sediment assessment from expert judgement during the survey.

DATE	Box	Code	ST	RE	LATITUDE	LONGITUDE	Depth	SEDIMENT PHOTOS
05/06/2010	1	ROV1	2	1	50.14906667	−0.20678333	49.64	
05/06/2010	1	B2H1	2	H1	50.14915	−0.20561667	46.6	gravel, coarse sand: sandy gravel
05/06/2010	1	B2H2	2	H2	50.14915	−0.20561667	46.6	coarse sand, gravel: sandy gravel
05/06/2010	1	B2G	2	G	50.14915	−0.20561667	46.6	coarse sand, gravel and pebbles: sandy gravel
05/06/2010	1	ROV1bis	2	2	50.14933333	−0.20676667	48.93	
05/06/2010	1	B3H1	3	H1	50.13373333	−0.14618333	50.12	coarse sand, gravel and shells: sandy gravel
05/06/2010	1	B3H2	3	H2	50.13388333	−0.14575	50.07	coarse sand, gravel, pebbles and shells: sandy gravel
05/06/2010	1	B3G	3	G	50.134	−0.14526667	50.03	gravel, coarse sand: sandy gravel
05/06/2010	1	B4G	4	G	50.16738333	−0.09878333	46.61	coarse sand, gravel and pebbles: sandy gravel
05/06/2010	1	B4H1	4	H1	50.16755	−0.09776667	47.61	coarse sand, gravel and pebbles: sandy gravel
05/06/2010	1	B4H2	4	H2	50.16781667	−0.0963	47.54	coarse sand, gravel and pebbles: sandy gravel
05/06/2010	1	ROV2	5	1	50.13233333	−0.28108333	46.55	
05/06/2010	1	B5G	5	G	50.13206667	−0.28183333	43.88	gravel, coarse sand, shells: sandy gravel
05/06/2010	1	B5H1	5	H1	50.13206667	−0.28183333	44.88	coarse sand, gravel and pebbles: sandy gravel
05/06/2010	1	B5H2	5	H2	50.13206667	−0.28183333	43.88	coarse sand, gravel: sandy gravel
06/06/2010	2	ROV3	6	1	50.11665	−0.70995	54.14	
06/06/2010	2	B6H1	6	H1	50.11688333	−0.71191667	53.14	pebbles, gravel and coarse sand: sandy gravel
06/06/2010	2	B6G	6	G	50.11651667	−0.71616667	53.14	pebbles, gravel and coarse sand: sandy gravel
06/06/2010	2	B6H2	6	H2	50.11663333	−0.71723333	52.14	gravel, coarse sand, shells: sandy gravel
06/06/2010	2	B7H1	7	H1	50.08251667	−0.6385	48.14	coarse sand, gravel, pebbles and shells: sandy gravel
06/06/2010	2	B7G	7	G	50.08265	−0.64048333	48.14	gravel, coarse sand: sandy gravel
06/06/2010	2	B7H2	7	H2	50.08313333	−0.64466667	48.14	coarse sand, gravel: sandy gravel
06/06/2010	2	B8G	8	G	50.06643333	−0.64038333	50.14	gravel, coarse sand: sandy gravel
06/06/2010	2	B8H1	8	H1	50.06623333	−0.64315	50.14	coarse sand and gravel: sandy gravel
06/06/2010	2	B8H2	8	H2	50.0664	−0.64425	50.14	gravel, coarse sand: sandy gravel
06/06/2010	2	B9G	9	G	50.06808333	−0.7975	57.14	gravel, coarse sand: sandy gravel
06/06/2010	2	B9H1	9	H1	50.06765	−0.79716667	58.14	pebbles and gravel: gravelly pebble
06/06/2010	2	B9H2	9	H2	50.06765	−0.79725	58.14	pebbles and gravel: gravelly pebble
06/06/2010	2	ROV4	9	1	50.0684	−0.79653333	58.14	
06/06/2010	2	ROV5	9	2	50.0684	−0.79653333	58.14	
07/06/2010	3	ROV6	10	1	49.98395	−1.16641667	62.46	
07/06/2010	3	B10H1	10	H1	49.98326667	−1.16828333	63.93	coarse sand (mineral)
07/06/2010	3	B10H2	10	H2	49.98326667	−1.16828333	63.99	coarse sand (mineral)
07/06/2010	3	B10G	10	G	49.98326667	−1.16828333	64.01	coarse sand (mineral)
07/06/2010	3	B11H1	11	H1	50.00111667	−1.18013333	55.43	pebbles, sand and gravel: sandy gravel and pebble
07/06/2010	3	B11H2	11	H2	50.00178333	−1.18365	57.5	pebbles, sand and gravel: sandy gravel and pebble
07/06/2010	3	B11G	11	G	49.99986667	−1.17986667	55.59	pebbles, sand and gravel: sandy gravel and pebble
07/06/2010	3	B12H1	12	H1	49.99875	−1.27925	66.9	pebbles with incrusting fauna
07/06/2010	3	B12G	12	G	49.99833333	−1.28043333	67.93	gravel and coarse sand: sandy gravel
07/06/2010	3	B12H2	12	H2	49.99783333	−1.28195	68.88	gravel and coarse sand: sandy gravel
07/06/2010	3	B13G	13	G	49.99888333	−1.34813333	95.26	gravel, coarse sand and mud: sandy gravel
07/06/2010	3	B14G	14	G	50.00106667	−1.37768333	74.23	pebbles, sand and gravel: sandy gravel
07/06/2010	3	B14H1	14	H1	50.00303333	−1.3803333	67.16	pebbles, sand and gravel: sandy gravel
07/06/2010	3	B14H2	14	H2	50.0036	−1.38125	68.13	pebbles, sand and gravel: sandy gravel
07/06/2010	3	ROV7	14	1	50.00116	−1.37737	74.25	
07/06/2010	3	B15H1	15	H1	49.999	−1.38511667	75.76	gravel and coarse sand: sandy gravel
07/06/2010	3	B15G	15	G	49.99941667	−1.3893	70.66	pebbles, sand and gravel: sandy pebble
07/06/2010	3	B15H2	15	H2	49.9992	−1.38666667	74.62	coarse sand and gravel: sandy gravel
07/06/2010	3	B16H1	16	H1	49.99925	−1.39091667	70.28	pebbles, sand and gravel: sandy gravel
07/06/2010	3	B16H2	16	H2	49.99963333	−1.39353333	67.14	pebbles, sand and gravel: sandy gravel
07/06/2010	3	B16G	16	G	49.99925	−1.39091667	70.28	pebbles, sand and gravel: sandy gravel

DATE	Box	Code	ST	RE	LATITUDE	LONGITUDE	Depth	SEDIMENT PHOTOS
08/06/2010	4	ROV8	17	1	49.91855	−1.814	72.28	
08/06/2010	4	B17G	17	G	49.8834	−1.86686667	68.49	pebbles
08/06/2010	4	B18G	18	G	49.8835	−1.92143333	68.75	pebbles, gravel and coarse sand: sandy gravel and pebbles
08/06/2010	4	B18H1	18	H1	49.8835	−1.92143333	68.75	pebbles, gravel and coarse sand: sandy gravel and pebbles
08/06/2010	4	B18H2	18	H2	49.8835	−1.92143333	68.75	pebbles, gravel and coarse sand: sandy gravel and pebbles
08/06/2010	4	B19H1	19	H1	49.93256667	−1.92101667	77.45	pebbles, gravel: sandy gravel and pebbles
08/06/2010	4	B20H1	20	H1	49.93568333	−1.7767	73.2	gravel, sand: sandy gravel + *Ophiothrix fragilis*
08/06/2010	4	B20H1	20	H2	49.93568333	−1.7767	73.2	clean gravel: gravel
08/06/2010	4	B20G	20	G	49.93568333	−1.7767	73.2	clean gravel: gravel
08/06/2010	4	B21H1	21	H1	49.91535	−1.69925	67.66	clean pebbles, gravel and sand: sandy gravel and pebbles
08/06/2010	4	B21G	21	G	49.91535	−1.70026667	67.68	clean pebbles, gravel and sand: sandy gravel and pebbles
08/06/2010	4	B21H2	21	H2	49.926	−1.7023	69.78	clean pebbles, gravel and sand: sandy gravel and pebbles
08/06/2010	4	ROV9	21	1	49.926	−1.7023	69.78	
11/06/2010	6	B22G	22	G	49.6074	−2.74438333	66.62	sand and gravel: gravelly sand
11/06/2010	6	B22H1	22	H1	49.60488333	−2.74753333	66.56	sand and gravel: gravelly sand
11/06/2010	6	B22H2	22	H2	49.60386667	−2.74903333	66.48	sand and gravel: gravelly sand
11/06/2010	6	B23H1	23	H1	49.60408333	−2.81343333	68.94	sand and gravel: gravelly sand
11/06/2010	6	B23H2	23	H2	49.60203333	−2.81508333	67.88	sand and gravel: gravelly sand
11/06/2010	6	B23G	23	G	49.60851667	−2.81373333	68.68	sand and gravel: gravelly sand
11/06/2010	6	ROV10	23	1	49.61246667	−2.81246667	69.08	
11/06/2010	6	ROV10bis	23	2	49.60955	−2.8122	68.54	
11/06/2010	6	B24G	24	G	49.60771667	−2.88858333	70.28	sand and gravel: gravelly sand
11/06/2010	6	B24H1	24	H1	49.60655	−2.87145	70.21	sand and gravel: gravelly sand
11/06/2010	6	B24H2	24	H2	49.6097	−2.89128333	70.2	sand and gravel: gravelly sand
11/06/2010	6	B25G	25	G	49.6065	−2.89561667	71.19	sand and gravel: gravelly sand
11/06/2010	6	B26G	26	G	49.60831667	−3.00031667	73.29	sand and gravel: gravelly sand
11/06/2010	6	B27G	27	G	49.62575	−2.96721667	74.4	sand and gravel: gravelly sand
11/06/2010	6	B28H1	28	H1	49.62561667	−2.87531667	71.64	sand and gravel: gravelly sand
11/06/2010	6	B28H2	28	H2	49.62648333	−2.874	71.69	sand and gravel: gravelly sand
11/06/2010	6	B28G	28	G	49.62725	−2.87323333	71.69	sand and gravel: gravelly sand
11/06/2010	6	ROV11	28	1	49.62463333	−2.874	72.32	
12/06/2010	5	ROV12	29	1	49.79016667	−2.3665	75.14	
12/06/2010	5	ROV12bis	29	2	49.79016667	−2.3665	79.14	
12/06/2010	5	B29G	29	G	49.79433333	−2.38095	78.14	pebbles + incrusting fauna
12/06/2010	5	B30G	30	G	49.79945	−2.43516667	89.14	pebbles + incrusting fauna
12/06/2010	5	B31G	31	G	49.80186667	−2.4638	89.14	gravel and piece of biogenic (shells) sediment: gravel
12/06/2010	5	B31H1	31	H1	49.80378333	−2.4664	88.14	gravel and piece of biogenic (shells) sediment: gravel
12/06/2010	5	B31H2	31	H2	49.80378333	−2.4664	88.14	gravel and piece of biogenic (shells) sediment: gravel
12/06/2010	5	B32G	32	G	49.8089	−2.47075	93.14	sand and gravel: sandy gravel
12/06/2010	5	B32H1	32	H1	49.81075	−2.47056667	96.14	sand and gravel: sandy gravel
12/06/2010	5	ROV13	34	1	49.79965	−2.22531667	61.14	
12/06/2010	5	B36G	36	G	49.80905	−2.22628333	60.14	clean gravel and pebbles: sandy gravel and pebbles
12/06/2010	5	B36H1	36	H1	49.80718333	−2.23335	67.64	clean gravel and pebbles: sandy gravel and pebbles
12/06/2010	5	B36H2	36	H2	49.80498333	−2.23906667	66.14	clean gravel and pebbles: sandy gravel and pebbles
12/06/2010	5	B37G	37	G	49.81445	−2.23598333	74.14	coarse sand
12/06/2010	5	B38G	38	G	49.816	−2.23496667	82.14	pebbles and sand: sandy gravel and pebbles
12/06/2010	5	B38H1	38	H1	49.81566667	−2.23761667	80.14	pebbles and sand: sandy gravel and pebbles
12/06/2010	5	B38H2	38	H2	49.81473333	−2.24168333	80.14	pebbles and sand: sandy gravel and pebbles
12/06/2010	4	B39G	39	G	49.9168	−1.92555	71.02	pebbles + incrusting fauna
12/06/2010	4	ROV14	39	1	49.91705	−1.92003333	71.3	
12/06/2010	4	B41G	41	G	49.88421667	−1.77513333	74.74	clean gravel: gravel
12/06/2010	4	B42G	42	G	49.90035	−1.708	68.13	clean gravel and pebbles

DATE	Box	Code	ST	RE	LATITUDE	LONGITUDE	Depth	SEDIMENT PHOTOS
13/06/2010	4	ROV15	42	1	49.89766667	−1.70868333	68.52	
13/06/2010	4	ROV16	42	1	49.90033333	−1.71645	68.96	
13/06/2010	3	B43G	43	G	49.98391667	−1.2842	51.00	gravel and coarse sand: sandy gravel
13/06/2010	3	B44G	44	G	50.03398333	−1.27103333	62.86	gravel and coarse sand: sandy gravel
13/06/2010	3	B45G	45	G	50.01706667	−1.34053333	67.11	pebbles, sand and gravel: sandy pebble + *Ophiothrix fragilis*
13/06/2010	3	B46G	46	G	49.98328333	−1.34286667	63.36	pebbles, sand and gravel: sandy pebble
13/06/2010	3	B47G	47	G	50.01678333	−1.15681667	62.58	pebbles, sand and gravel: sandy pebble
13/06/2010	2	B48G	48	G	50.11686667	−0.89631667	45.7	pebbles and coarse sand: sandy pebbles + *Ophiothrix fragilis*
13/06/2010	2	B49G	49	G	50.1181	−0.84986667	44.9	pebbles and coarse sand: sandy pebbles + *Ophiothrix fragilis*
13/06/2010	2	B50G	50	G	50.1029	−0.75853333	50.3	coarse sand, gravel and shells: gravelly sand
13/06/2010	2	B51G	51	G	50.10091667	−0.68713333	46.2	pebbles, gravel and coarse sand: sandy pebbles + *Ophiothrix fragilis*
13/06/2010	2	B52G	52	G	50.08298333	−0.8852	55.2	gravel with low coarse sand: gravel
13/06/2010	2	ROV17	52	1	50.08451667	−0.88268333	58.8	
13/06/2010	2	ROV18	51	1	50.09803333	−0.6792	53.8	
14/10/2010	1	ROV19	53	1	50.14986667	−0.35148333	46.8	
14/10/2010	1	B53G	53	G	50.14876667	−0.35038333	43.4	coarse sand, gravel: gravelly sand
14/10/2010	1	B54G	54	G	50.16706667	−0.25016667	42.64	gravel, coarse sand, shells: sandy gravel
14/10/2010	1	B55G	55	G	50.11571667	−0.25716667	45.03	gravel, coarse sand: sandy gravel
14/10/2010	1	B56G	56	G	50.11535	−0.3119	41.91	coarse sand, gravel and shells: gravelly sand
19/06/2011	7	ROV101	101	1	49.09993333	−2.73045	59.14	
20/06/2011	7	B101G	101	G	49.08051667	−2.66063333	54.14	pebbles, sand and gravel: sandy gravel and pebbles + *Ophiothrix fragilis*
20/06/2011	7	B102G	102	G	49.08053333	−2.69463333	55.14	pebbles, sand and gravel: sandy gravel and pebbles + *Ophiothrix fragilis*
20/06/2011	7	B102H1	102	H1	49.08188333	−2.6992	54.14	pebbles, sand and gravel: sandy gravel and pebbles + *Ophiothrix fragilis*
20/06/2011	7	B102H2	102	H2	49.08021667	−2.69173333	57.14	pebbles, sand and gravel: sandy gravel and pebbles + *Ophiothrix fragilis*
20/06/2011	7	B103G	103	G	49.09696667	−2.68266667	56.14	pebbles, sand and gravel: sandy gravel and pebbles + *Ophiothrix fragilis*
20/06/2011	7	B104G	104	G	49.09885	−2.65931667	56.14	pebbles, sand and gravel: sandy gravel and pebbles
20/06/2011	7	B105H1	105	H1	49.09933333	−2.61485	56.14	pebbles, sand and gravel: sandy gravel and pebbles + *Ophiothrix fragilis*
20/06/2011	7	B105H2	105	H2	49.09958333	−2.6116	56.14	gravel and coarse sand: sandy gravel and pebbles + *Ophiothrix fragilis*
20/06/2011	7	B105G	105	G	49.16633333	−2.61546667	56.14	pebbles and sand: sandy gravel and pebbles + *Ophiothrix fragilis*
20/06/2011	7	B106G	106	G	49.1700	−2.61546667	57.14	pebbles and sand: sandy gravel and pebbles + *Ophiothrix fragilis*
20/06/2011	8	ROV102	102	1	48.99886667	−3.5102	76.74	
20/06/2011	8	ROV103	103	2	48.97805	−3.60098333	76.14	
21/06/2011	8	B107G	107	G	48.96905	−3.5337	73.14	gravel and pebbles: sandy gravel and pebbles
21/06/2011	8	B108G	108	G	48.95188333	−3.57421667	73.14	coarse sand, gravel: sandy gravel and pebbles
21/06/2011	8	B108H1	108	H1	48.9519	−3.57325	72.64	coarse sand, gravel: gravelly sand
21/06/2011	8	B109H1	109	H1	48.9685	−3.61376667	76.14	coarse sand, gravel with pebbles: gravelly sand with pebbles
21/06/2011	8	B109G	109	G	48.96731667	−3.61525	76.14	coarse sand, gravel with pebbles: gravelly sand with pebbles
21/06/2011	8	B109H2	109	H2	48.96863333	−3.6084	76.14	coarse sand, gravel with pebbles: gravelly sand with pebbles
21/06/2011	8	B110G	110	G	48.98176667	−3.58828333	76.14	coarse sand, gravel with pebbles: gravelly sand with pebbles
24/06/2011	9	B112G	112	G	48.78071667	−3.98513333	67.14	pebbles with incrusting fauna
24/06/2011	9	B113G	113	G	48.81758333	−3.95718333	74.14	pebbles with incrusting fauna + *Ophiothrix fragilis*
24/06/2011	9	B114H1	114	H1	48.83406667	−3.94606667	77.14	coarse sand, gravel with pebbles: gravelly sand with pebbles
24/06/2011	9	B114G	114	G	48.83398333	−3.94153333	77.14	coarse sand, gravel with pebbles: gravelly sand with pebbles
24/06/2011	9	B114H2	114	H2	48.834	−3.93883333	77.14	coarse sand and gravel: gravelly sand
24/06/2011	9	ROV104	116	1	48.80266667	−4.00463333	83.14	
24/06/2011	9	ROV105	111	1	48.78348333	−3.9953	69.14	
24/06/2011	9	B117G	117	G	48.83215	−4.07756667	83.14	coarse sand with pebbles: gravelly sand and pebbles

DATE	Box	Code	ST	RE	LATITUDE	LONGITUDE	Depth	SEDIMENT PHOTOS
25/06/2011	10	B118G	118	G	48.83671667	−4.37348333	93.14	coarse sand, gravel with pebbles: gravelly sand with pebbles
25/06/2011	10	B119H1	119	H1	48.80138333	−4.3521	89.14	coarse sand with rare pebbles: sandy gravel and pebbles
25/06/2011	10	B119G	119	G	48.80155	−4.35165	89.14	coarse sand with rare gravel: sandy gravel and pebbles
25/06/2011	10	B119H2	119	H2	48.80155	−4.351	89.14	coarse sand, gravel with pebbles: gravelly sand with pebbles
25/06/2011	10	B120G	120	G	48.80156667	−4.38251667	89.14	coarse sand, gravel with pebbles: gravelly sand with pebbles
25/06/2011	10	B120H1	120	H1	48.80116667	−4.38211667	90.14	coarse sand, gravel with pebbles: gravelly sand with pebbles
25/06/2011	10	B120H2	120	H2	48.80103333	−4.38196667	90.14	coarse sand, gravel with pebbles: gravelly sand with pebbles
25/06/2011	10	B121G	121	G	48.8035	−4.44663333	91.14	coarse sand, gravel with pebbles: gravelly sand with pebbles
25/06/2011	11	B123G	123	G	49.2176	−3.47475	74.14	coarse sand with pebbles: gravelly sand and pebbles
26/06/2011	11	B124G	124	G	49.21748333	−3.40815	71.14	coarse sand with rare pebbles: gravelly sand and pebbles
26/06/2011	11	B125G	125	G	49.21843333	−3.38245	72.14	coarse sand with rare pebbles: gravelly sand and pebbles
26/06/2011	11	B125H1	125	H1	49.21878333	−3.38706667	71.14	pebbles and coarse sand: gravelly sand and pebbles
26/06/2011	11	B125H2	125	H2	49.21883333	−3.38893333	72.14	pebbles and coarse sand: gravelly sand and pebbles
26/06/2011	11	B126H1	126	H1	49.2001	−3.38335	71.14	coarse sand (biogenic)
26/06/2011	11	B126H2	126	H2	49.2002	−3.38675	71.14	coarse sand (biogenic)
26/06/2011	11	B126G	126	G	49.20013333	−3.38831667	72.14	coarse sand (biogenic)
26/06/2011	11	ROV108	126	1	49.20013333	−3.37973333	72.14	
26/06/2011	11	ROV109	128	1	49.18188333	−3.41553333	73.14	
26/06/2011	11	B128G	128	G	49.18428333	−3.4119	74.14	coarse sand (biogenic) with pebbles
26/06/2011	11	B129H1	129	H1	49.16468333	−3.43968333	76.14	coarse sand with pebbles
26/06/2011	11	B129G	129	G	49.16508333	−3.43923333	76.14	coarse sand, gravel with pebbles: gravelly sand with pebbles
27/06/2011	13	ROV110	130	1	49.09433333	−5.05886667	102.14	
27/06/2011	13	ROV111	131	1	49.10693333	−5.03501667	100.43	
27/06/2011	13	B130H1	130	H1	49.09991667	−5.00065	100.18	coarse sand, gravel with pebbles and shells: gravelly sand
27/06/2011	13	B130H1	130	H2	49.09955	−4.99801667	100.15	coarse sand with gravel and shells: gravelly sand
27/06/2011	13	B130G	130	G	49.09928333	−4.99576667	100.11	coarse sand with gravel and shells: gravelly sand
27/06/2011	13	B131H1	131	H1	49.10596667	−5.03701667	95.53	coarse sand (biogenic)
27/06/2011	13	B131H2	131	H2	49.10588333	−5.0351	95.03	coarse sand (biogenic)
27/06/2011	13	B131G	131	G	49.10586667	−5.03308333	96.03	coarse sand (biogenic)
27/06/2011	13	B132G	132	G	49.12751667	−4.98456667	99.02	coarse sand, gravel: gravelly sand
27/06/2011	13	B133H1	133	H1	49.13601667	−4.9648	96.04	coarse sand (biogenic)
27/06/2011	13	B133H2	133	H2	49.13605	−4.96331667	100.04	medium sand with pebbles
27/06/2011	13	B133G	133	G	49.13615	−4.9621	99.06	medium sand with shells
27/06/2011	13	B134H1	134	H1	49.1221	−4.94716667	99.12	coarse sand, gravel: gravelly sand
27/06/2011	13	B134H2	134	H2	49.122	−4.94568333	99.14	gravel with coarse sand: sandy gravel
27/06/2011	13	B134G	134	G	49.12195	−4.9425	101.43	coarse sand, gravel: gravelly sand
27/06/2011	12	ROV112	135	1	49.50126	−3.95402	92.41	
27/06/2011	12	ROV113	136	1	49.51450	−3.942804	95.22	

Appendix B

Granulometric composition in percentage of dry sediment of the 40 benthic stations (pebbles: >20 mm; large gravel: >5 mm; gravel: 2–5 mm; sand: 2 mm–63 μm; silt–clay: <63 μm) with Folk classification.

Box	Station	Pebbles	Large Gravel	Gravel	Sand	Silt–Clay	Sediment Type
1	2	0	37.21	11.66	49.24	1.89	Sandy Gravel
	3	0	28.83	13.54	56.37	1.27	Sandy Gravel
	4	0	59.07	7.04	32.73	1.16	Sandy Gravel
	5	0	67.84	8.30	22.81	1.06	Sandy Gravel
2	6	0	74.47	2.64	22.25	0.64	Sandy Gravel
	7	0	63.91	9.16	26.77	0.16	Sandy Gravel
	8	0	59.08	9.92	30.96	0.04	Sandy Gravel
	9	0	46.07	18.49	35.13	0.31	Sandy Gravel
3	10	0	0.32	54.77	44.91	0	Sandy Gravel
	11	0	81.12	6.58	12.13	0.17	Gravel
	12	0	76.21	9.75	13.55	0.49	Gravel
	14	0	77.13	8.58	13.50	0.79	Gravel
	15	0	81.99	5.88	12.05	0.08	Gravel
	16	0	62.88	6.14	30.87	0.11	Sandy Gravel
4	18	0	95.12	1.23	3.53	0.13	Gravel
	19	0	94.55	1.19	4.02	0.24	Gravel
	20	0	78.77	7.74	13.45	0.04	Gravel
	21	0	50.00	46.52	3.47	0.01	Gravel
5	31	0	91.66	5.27	2.95	0.12	Gravel
	32	0	67.04	8.03	24.50	0.43	Sandy Gravel
	36	0	83.65	1.19	15.13	0.02	Gravel
	38	0	84.78	4.64	10.58	0.01	Gravel
6	22	0	41.52	12.70	44.02	1.76	Sandy Gravel
	23	0	22.97	9.80	67.07	0.16	Sandy Gravel
	24	0	37.40	13.80	48.21	0.58	Sandy Gravel
	28	0	47.17	13.44	39.14	0.26	Sandy Gravel
7	102	16.64	22.77	9.80	50.35	0.44	Sandy Gravel and Pebbles
	105	53.60	10.67	8.67	26.58	0.48	Sandy Gravel and Pebbles
8	108	8.59	49.44	11.20	30.71	0.06	Sandy Gravel and Pebbles
	109	8.91	35.63	17.42	37.93	0.11	Sandy Gravel and Pebbles
9	114	40.15	18.62	9.99	31.21	0.02	Sandy Gravel and Pebbles
10	119	26.97	10.64	8.85	53.52	0.03	Sandy Gravel and Pebbles
	120	42.94	7.36	2.94	46.74	0.02	Sandy Gravel and Pebbles
11	125	21.54	6.73	13.74	57.98	0.02	Sandy Gravel and Pebbles
	126	0	1.92	17.16	80.89	0.03	Gravelly Sand
	129	37.05	7.15	5.24	50.52	0.03	Sandy Gravel and Pebbles
	130	17.97	10.48	12.30	58.84	0.41	Sandy Gravel and Pebbles

Box	Station	Pebbles	Large Gravel	Gravel	Sand	Silt–Clay	Sediment Type
13	131	0	4.92	15.65	79.35	0.07	Gravelly Sand
	133	8.39	10.96	11.31	68.77	0.57	Sandy Gravel and Pebbles
	134	28.40	17.55	8.96	44.65	0.45	Sandy Gravel and Pebbles

References

1. Carpentier, A.; Vaz, S.; Martin, C.S.; Coppin, F.; Dauvin, J.C.; Desroy, N.; Dewarumez, J.M.; Eastwood, P.D.; Ernande, B.; Harrop, S.; et al. *Eastern Channel Habitat Atlas for Marine Resource Management (CHARM). Report INTERREG IIIA*; IFREMER: Brest, France, 2005; 225p.
2. Carpentier, A.; Martin, C.S.; Vaz, S. (Eds.) *Channel Habitat Atlas for Marine Resource Management, Final Report (CHARM Phase II)*; INTERREG 3 A Programme; IFREMER: Boulogne-sur-mer, France, 2009; 626p.
3. Martin, C.S.; Carpentier, A.; Vaz, S.; Coppin, F.; Curet, L.; Dauvin, J.C.; Delavenne, J.; Dewarumez, J.M.; Dupuis, L.; Engelhard, G.; et al. The Channel habitat atlas for marine resource management (CHARM): An aid for planning and decision-making in an area under strong anthropogenic pressure. *Aquat. Liv. Res.* **2009**, *22*, 499–508. [CrossRef]
4. Martin, C.; Meaden, G.; Vaz, S.; Dupuis, L.; Lauria, V.; Ernande, B.; Dauvin, J.C.; Spilmont, N.; Dewarumez, J.M.; Foveau, A.; et al. Channel Habitat Atlas for Marine Resources Management (CHARM)–An Aid to Management of a Resource Stressed Marine Area. In *Ocean Globe*; Breman, J., Ed.; ESRI Press Academic: Redlands, CA, USA, 2010; pp. 57–73.
5. Delavenne, J.; Metcalfe, K.; Smith, R.J.; Vaz, S.; Martin, C.S.; Dupuis, L.; Coppin, F.; Carpentier, A. Systematic conservation planning in the eastern English Channel: Comparing the Marxan and Zonation decision-support tools. *ICES J. Mar. Sci.* **2012**, *69*, 75–83. [CrossRef]
6. Foveau, A.; Vaz, S.; Desroy, N.; Kostylev, V.E. Process-driven and biological characterisation and mapping of seabed habitats sensitive to trawling. *PLoS ONE* **2018**, *12*, e0184486. [CrossRef] [PubMed]
7. Holme, N.A. The bottom fauna of the English Channel. *J. Mar. Biol. Assoc. UK* **1961**, *41*, 397–461. [CrossRef]
8. Holme, N.A. The bottom fauna of the English Channel. Part II. *J. Mar. Biol. Assoc. UK* **1966**, *46*, 406–493. [CrossRef]
9. Cabioch, L. Contribution à la connaissance des peuplements benthiques de la Manche occidentale. *Cah. Biol. Mar.* **1968**, *9*, 493–720.
10. Cabioch, L.; Gentil, F.; Glaçon, R.; Retière, C. Le macrobenthos des fonds meubles de la Manche, distribution générale et écologie. In *Biology of Benthic Organisms*; Keegan, B., O'Ceidigh, P., Boaden, P., Eds.; Pergamon Press: Oxford, UK, 1977; pp. 115–128.
11. Coggan, R.; Diesing, M. The seabed habitats of the central English Channel: A generation on from Holme and Cabioch, how do their interpretations match-up to modern mapping techniques. *Cont. Shelf Res.* **2011**, *31*, S132–S150. [CrossRef]
12. Lozach, S.; Dauvin, J.C.; Méar, Y.; Murat, A.; Dominique Davoult, D.; Migné, A. Sampling epifauna, a necessity for a better assessment of benthic ecosystem functioning: An example of the epibenthic aggregated species *Ophiothrix fragilis* from the Bay of Seine. *Mar. Poll. Bull.* **2011**, *62*, 2753–2760. [CrossRef]
13. Lozach, S.; Dauvin, J.C. Temporal stability of a coarse sediment community from the central eastern English Channel palleovalleys. *J. Sea Res.* **2012**, *71*, 14–24. [CrossRef]
14. Coggan, R.; Populus, J.; White, J.; Sheehan, K.; Fitzpatrick, F.; Piel, S. (Eds.) Review of Standards and Protocols for Seabed Habitat Mapping. MESH. 2007. Available online: http://www.searchmesh.net/ (accessed on 1 February 2022).
15. Holme, N.A.; Barrett, R.L. A sledge with television and photographic cameras for quantitative investigation of the epifauna on the continental shelf. *J. Mar. Biol. Assoc. UK* **1977**, *57*, 391–403. [CrossRef]
16. Cabioch, L. Résultats obtenus par l'emploi de la photographie sous-marine sur les fonds du large de Roscoff. *Helgol. Meeresun.* **1967**, *15*, 361–370. [CrossRef]
17. Brown, C.J.; Cooper, K.M.; Meadows, W.J.; Limpenny, D.S.; Rees, H.L. Small-scale mapping of sea-bed assemblages in the Eastern English Channel using sidescan sonar and remote sampling techniques. *Estuar. Coast. Shelf Sci.* **2002**, *54*, 263–278. [CrossRef]
18. Brown, C.J.; Hewer, A.J.; Limpenny, D.S.; Cooper, K.M.; Rees, H.L.; Meadows, W.J. Mapping seabed biotopes using sidescan sonar in responses of heterogeneous substrata: Case study east offs the Isle of Wight, English Channel. *Underw. Technol. Int. J. Soc. Under.* **2004**, *26*, 27–36. [CrossRef]
19. Brown, C.J.; Hewer, A.J.; Meadows, W.J.; Limpenny, D.S.; Cooper, K.M.; Rees, H.L. Mapping seabed biotopes at Hastings Shingle Bank, eastern English Channel. Part 1. Assessment using side scan sonar. *J. Mar. Biol. Assoc. UK* **2004**, *84*, 481–488. [CrossRef]
20. Brown, C.J.; Smith, S.J.; Lawton, P.; Anderson, J.T. Benthic habitat mapping: A review of progress towards improved understanding of the spatial ecology of the seafloor using acoustic techniques. *Estuar. Coast. Shelf Sci.* **2011**, *92*, 502–520. [CrossRef]
21. Ehrhold, A.; Hamon, D.; Guillaumont, B. The REBENT monitoring network, a spatially integrated, acoustic approach to surveying nearshore macrobenthic habitats: Application to the Bay of Concarneau (South Brittany, France). *ICES J. Mar. Sci.* **2006**, *63*, 1604–1615. [CrossRef]
22. Schumchenia, E.J.; King, J.W. Comparison of methods for integrating biological and physical data for marine habitat mapping and classification. *Cont. Shelf Sci.* **2010**, *30*, 1717–1729. [CrossRef]
23. Coggan, R.; Diesing, M. Rock ridges in the Central English Channel. In *Seafloor Geomorphology as Benthic Habitats*; Harris, P.T., Baker, E.K., Eds.; Elsevier: Amsterdam, The Netherlands, 2012; pp. 471–480.

24. Coggan, R.; Barrio Frojan, R.S.; Diesing, M.; Aldridge, J. Spatial patterns in gravels habitats and communities in the central and eastern English Channel. *Estuar. Coast. Shelf Sci.* **2012**, *111*, 118–128. [CrossRef]
25. Foveau, A. Habitats et Communautés Benthiques du Bassin Oriental de la Manche: État Des Lieux au Début du XXIème Siècle. Ph.D. Thesis, University of Lille 1, Lille, France, 2009.
26. Foveau, A.; Desroy, N.; Dauvin, J.C.; Dewarumez, J.M. Distribution patterns in the benthic diversity of the eastern English Channel. *Mar. Ecol. Progr. Ser.* **2013**, *479*, 115–126. [CrossRef]
27. Dauvin, J.C. Are the Eastern and Western Basins of the English Channel Two Separate Ecosystems? *Mar. Poll. Bull.* **2012**, *64*, 463–471. [CrossRef]
28. Dauvin, J.C. History of benthic research in the English Channel: From general patterns of communities to habitat mosaic description. *J. Sea Res.* **2015**, *100*, 32–45. [CrossRef]
29. Dauvin, J.C. The English Channel: La Manche. In *World Seas: An Environmental Evaluation: Volume I: Europe, The Americas and West Africa*; Chapter 6; Academic Press: Cambridge, MA, USA, 2018; pp. 153–188.
30. Paphitis, D.; Bastos, A.C.; Evans, G.; Collins, M. The English Channel (La Manche): Evolution, oceanography and sediment dynamics–a synthesis. In *Micropaleontology, Sedimentology, Environments and Stratigraphy. A tribute to Dennis Curry (1912–2001)*; Whittaker, J.E., Hart, M.B., Eds.; Micropalaeontological Society: London, UK, 2010; pp. 99–132.
31. Larsonneur, C.; Bouysse, P.; Auffret, J.P. The superficial sediments of the English Channel and its western approaches. *Sedimentology* **1982**, *29*, 851–864. [CrossRef]
32. Dauvin, J.C. (Ed.) Les biocénoses marines et littorales françaises des côtes Atlantique, Manche et Mer du Nord, synthèse, menaces et perspectives. Laboratoire de Biologie des Invertébrés Marins et Malacologie-Service du Patrimoine Naturel: IEGB/MNHN, Paris. *Collect. Patrim. Nat.* **1997**, *28*, 1–376.
33. Boyd, S.E.; Coggan, R.A.; Birchenough, S.N.R.; Limpenny, D.S.; Eastwood, P.E.; Foster-Smith, R.L.; Philpott, S.; Meadows, W.J.; James, J.W.C.; Vanstaen, K.; et al. The role of seabed mapping techniques in environmental monitoring and management. *Sci. Ser. Tech. Rep. CEFAS Lowestoft* **2006**, *127*, 170.
34. Van Overmeeren, R.; Craeymeersch, J.; van Dalfsen, J.; Frouke Fey, F.; van Heteren, S.; Meesters, S. Acoustic habitat and shellfish mapping and monitoring in shallow coastal water–Sidescan sonar experiences in The Netherlands. *Estuar. Coast. Shelf Sci.* **2009**, *85*, 437–448. [CrossRef]
35. Freitas, R.; Ricardo, F.; Pereira, F.; Leandro Sampaio, L.; Carvalho, S.; Gaspar, M.; Quitino, V.; Rodrigues, A.M. Benthic habitat mapping: Concerns using a combined approach (acoustic, sediment and biological data). *Estuar. Coast. Shelf Sci.* **2011**, *92*, 598–606. [CrossRef]
36. Blondel, P.; Murton, B.J. *Handbook of Seafloor Sonar Imagery*; Wiley: Chichester, UK, 1997.
37. Fish, J.P.; Carr, H.A. *Sound Underwater Images: A Guide to the Generation and Interpretation of Side Scan Sonar Data*; Lower Cape Publishing: Orleans, France, 1990.
38. Garcia, C. Approche Fonctionnelle des Communautés Benthiques du Bassin Oriental du Bassin Oriental de la Manche et Du sud de la Mer du Nord. Ph.D. Thesis, University of Lille 1, Lille, France, 2010.
39. Pezy, J.P.; Dauvin, J.C. Large extent but few quantitative data: The English Channel coarse sediments. *Ecol. Ind.* **2021**, *121*, 107010. [CrossRef]
40. Clarke, K.R.; Gorley, R.N. *PRIMER V6: User Manual/Tutorial*; PRIMER-E: Plymouth, UK, 2006.
41. Galparsoro, I.; Connor, D.W.; Borja, Á.; Aish, A.; Amorim, P.; Bajjouk, T.; Chambers, C.; Coggan, R.; Dirberg, G.; Ellwood, H.; et al. Using EUNIS habitat classification for benthic mapping in European seas: Present concerns and future needs. *Mar. Poll. Bull.* **2012**, *64*, 2630–2638. [CrossRef]
42. Baffreau, A.; Chouquet, B.; Dancié, C.; Duhamel, S.; Foveau, F.; Hacquebart, P.; Navon, M.; Pezy, J.P.; Poisson, A.; Marmin, S.; et al. Mapping benthic communities: An indispensable tool for the preservation and the management of the Bay of Seine eco-socio-system. *Reg. Stud. Mar. Sci.* **2017**, *9*, 162–173. [CrossRef]
43. Dauvin, J.C. Structure et organisation trophique du peuplement des sables grossiers a *Amphioxus lanceolatus-Venus fasciata* de la Baie de Morlaix (Manche Occidentale). *Cah. Biol. Mar.* **1988**, *29*, 163–185.
44. Rolet, C.; Desroy, N. *Les Biocénoses Benthiques Circalittorales de la Manche, du Sud de la Mer du Nord et de la Mer d'Iroise: Synthèse des Connaissances*; Rapport Ifremer RST.LER/FBN-12-008.DN; Laboratoire Environnement Ressources Finistère-Bretagne Nord, Station de Dinard et Centre de Recherche et d'Etudes des Systèmes COtiers (CRESCO): Dinard, France, 2012.
45. Newell, R.C.; Seiderer, L.J. *Benthic Ecology off Lowestoft Dredging Application Area 454*; Report prepared for Oakwood Environmental No SCS/454/1; MESL (Marine Ecological Survey Ltd.): Wormley, UK, 1996; 48p.
46. MESL. *Benthic Ecology South West of the Isle of Wight. Area 465/1 & 465/2 (West Channel)*; Report prepared for Coastline Surveys Limited; MESL (Marine Ecological Survey Ltd.): Gloucestershire, UK, 1999; p. 39.
47. Desprez, M. Physical and biological impact of marine aggregate extraction along the French coast of the eastern English Channel: Short and long-term post-dredging restoration. *ICES J. Mar. Sci.* **2000**, *57*, 1428–1438. [CrossRef]
48. Desprez, M.; Pearce, B.; Le Bot, S. The biological impact of overflowing sands around a marine aggregate extraction site: Dieppe (eastern English Channel). *ICES J. Mar. Sci.* **2010**, *67*, 270–277. [CrossRef]
49. Pezy, J.P.; Raoux, A.; Legrain, M.; Boisserie, R.; Dauvin, J.C. *Etat initial avant exploitation, Suivi des Sédiments, des Habitats et Communautés Benthiques du Site Granulat Marin Havrais*; Publication Univ Rouen Havre: Caen, France, 2021; 66p.

50. Etienne, C.; In Vivo. Projet de parc éolien en mer au large de Courseulles-sur-Mer (Calvados). In *Synthèse de l'expertise "Analyse des Biocénoses Benthiques 2009*; Eoliennes Offshore du Calvados, La Forêt Fouesnant; Biotope Edition: Mèze, France, 2013; p. 23.
51. Raoux, A.; Pezy, J.P.; Legrain, M.; Boisserie, R.; Dauvin, J.C. *Etat de Référence Avant Construction MSu3, Suivi de la Qualité de l'eau, des Sédiments, des Habitats et Communautés Benthiques*; Rapport de L'état de Reference; Archimer: Caen, France, 2021; 98p.
52. Newell, R.C.; Seiderer, L.J.; Robinson, J.E. Animal: Sediment relationships in coastal deposits of the eastern English Channel. *J. Mar. Biol. Assoc. UK* **2001**, *81*, 1–9. [CrossRef]
53. Newell, R.C.; Seiderer, L.J.; Simpson, N.M.; Robinson, J.E. Impacts of Marine Aggregate Dredging on Benthic Macrofauna off the South Coast of the United Kingdom. *J. Coast. Res.* **2004**, *20*, 115–125. [CrossRef]
54. Cooper, K.; Boyd, S.; Eggleton, J.; Limpenny, D.; Rees, H.; Vanstaen, K. Recovery of the seabed following marine aggregate dredging on the Hastings Shingle Bank off the southeast coast of England. *Estuar. Coast. Shelf Sci.* **2007**, *75*, 547–558. [CrossRef]
55. Dauvin, J.C.; Ruellet, T. Macrozoobenthic biomass in the Bay of Seine (eastern English Channel). *J. Sea Res.* **2008**, *59*, 320–326. [CrossRef]
56. Lozach, S.; Trentesaux, A.; Baffreau, A.; Poizot, E.; Dauvin, J.C. Typologie des Habitats Benthiques Marins en Environnement Macrotidal: Approche Pluridisciplinaire dans la Partie Centrale de la Manche. Actes du Colloque Cartographie des Habitats Marins Benthiques: De l'Acquisition à la Restitution, Brest 26–28 mars 2013, pages 8–11. Available online: http://www.carhambar.org (accessed on 1 February 2022).
57. Holme, N.A.; Wilson, J.B. Faunas associated with longitudinal furrows and sand ribbons in a tide-swept area in the English Channel. *J. Mar. Biol. Assoc. UK* **1985**, *65*, 1051–1072. [CrossRef]
58. Diesing, M.; Coggan, R.; Vanstaen, K. Widespread rocky reef occurrence in the central English Channel and the implications for predictive habitat mapping. *Estuar. Coast. Shelf Sci.* **2009**, *83*, 647–658. [CrossRef]
59. Raoux, A.; Pezy, J.P.; Robin, I.; Bennis, A.C.; Dauvin, J.C. Multidisciplinary and multi-scale assessment of marine renewable energy structure in tidal system. *J. Energ. Power Tech.* **2021**, *3*, 012. [CrossRef]
60. Pezy, J.P. Approche Écosystémique d'un Futur Parc Éolien en Manche Orientale: Exemple du Site de Dieppe–Le Tréport. Ph.D. Thesis, Caen Normandy University, Caen, France, 2017.
61. Sheedan, E.V.; Stevens, T.F.; Attrill, M.J. A quantitative, non-destructive methodology for habitat characterization and benthic monitoring at offshore renewable energy developments. *PLoS ONE* **2010**, *5*, e14461.