



History of benthic research in the English Channel: From general patterns of communities to habitat mosaic description



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ABSTRACT

Benthic studies in the English Channel (EC), a shallow megatidal and epicontinental sea, began in the 1960s and 1970s with the work of teams led by Norman Holme (UK) and Louis Cabioch (F). During this period, benthic sampling was mainly qualitative, i.e. using a device such as the 'Rallier du Baty' dredge in the case of the French team and a modified anchor dredge in the case of the British team. Studies were focused on acquiring knowledge of the main distributions of benthic communities and species. Surveys on the scale of the whole EC led to the recognition of general features and two main patterns were identified: 1) the role of hydrodynamics on the spatial distribution of sediment, benthic species and communities; 2) the presence of a west–east climatic gradient of faunal impoverishment. Benthic studies in the 1980s–1990s were focused on the beginning of the implementation of long-term survey at a limited number of sites to identify seasonal and multi-annual changes. In the first decade of the 2000s, the implementation of the European Water Framework Directive and the Marine Strategy Framework Directive to define the Ecological Quality Status of marine environments increased the need to acquire better information of the structure and functioning of benthic communities, since benthic species and habitats were recognised as good indicators of human pressure on marine ecosystems. Faced with the increase of human maritime activities, the appearance of invasive species and the need to preserve sensitive marine habitats, benthic studies have been focused on developing a 'toolkit' to help in the decision-making and planning for both sound governance and sustainable management of marine resources and human activities in the English Channel. Multidisciplinary approaches were used to differentiate habitats in a more precise detail. Both indirect (side-scan sonar, ROV) and direct (grab sampling with benthos identification and grain-size analyses) approaches were used and combined to allow the description of benthic habitats using numerous descriptors. These approaches were mainly applied on a local scale, leading to the identification of habitat mosaics mainly in coarse sands, gravels and pebbly areas which cover 80% of the EC seabed. They also allowed the enrichment of the EUNIS habitat classification for infralittoral and circalittoral zones taking into account the scale of observations of benthic habitats. Moreover, several recommendations for future benthic studies are proposed within a HABITAT approach.

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1. Introduction

The English Channel (EC), called 'La Manche' in French, is a sea area shared between the United Kingdom to the north and France to the south. After a long historical process, the marine parts of each of these two bordering countries are now clearly delimited, especially for the Normano-Breton Gulf where the territories of the Channel Islands are not included in the European Union.

At the end of the 19th century, there was an increase in marine biology research mainly focused on the description of marine biodiversity and

developmental biology to investigate the evolutionary mechanisms and phylogeny of marine organisms. During this period, marine biological laboratories (Marine Stations) were established to conduct this type of research. Four main marine stations were created along the EC coast: in 1872 at Roscoff in North Brittany (Paris University), in 1874 at Wimereux in the Dover Strait (Lille University), in 1888 at Plymouth in the United Kingdom (Marine Biological Association) and in 1891 at Tatihou on the North Cotentin coast (National Museum of Natural History, Paris). Since 1935, this latter station has been located at Dinard in the Normano-Breton Gulf. Eighty years later, research on benthic communities at the scale of the EC was initiated at Plymouth under the authority of Norman Holme and at Roscoff under the authority of Louis Cabioch, following their regional observations (Cabioch, 1961; Holme, 1961). These two authors were the pioneers of benthic research

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in the entire EC, which probably represents one of the most intensively studied seas on the scale of the north-eastern Atlantic continental shelf, along with the North Sea and the Baltic. More recently, with the intensification of human activities, there has been a dramatic increase of benthic studies in the EC, aimed at identifying the contribution of anthropogenic factors to climatic change and assessing benthic quality status under the European Directives.

This paper presents a history of benthic habitat mapping in the English Channel over the last five decades (1960–2012) as a compilation of published and unpublished works and result. An overview of the researches performed on benthic communities and benthic habitat mapping is presented to show 1) the evolution of the research objectives; 2) the development of sampling and surveying methods to map benthic habitats, 3) the increase of studies dedicated to assessing the impact of various human activities on benthic communities, since the benthos is a good indicator of the ecological quality status of the marine environment and 4) the new challenges on benthic patterns occurring in the Channel. The overview takes into account the whole of the EC during the first two decades (1960–1970), but mainly concerns the eastern basin of the English Channel (EBEC) for three more recent decades (1980–2012). The choice to focus this paper on the eastern area is justified for several reasons: 1) the existence of a general map of benthic communities based on the EUNIS classification (Cabiocch et al., 1978); 2) human pressures on benthic habitats are significant, especially in relation to aggregate extraction; and 3) the benthic research of the European INTERREG CHARM project was mainly concentrated on this eastern basin.

2. The EC context

The EC is a shallow epicontinental sea (maximum depth of 174 m in the central trench) extending over an area of about 77,000 km² and comprising two main basins (Cabiocch, 1968): the western basin of the English Channel (WBEC) and the eastern basin of the English Channel (EBEC) (Fig. 1). The WBEC is deeper than the EBEC (Paphitis et al., 2010) and shows distinct characteristics in terms of oceanographic and human pressures (Dauvin, 2012). In the WBEC, hydrologic and oceanographic characteristics are influenced by the Atlantic water and the presence of a summer thermocline offshore Plymouth in the north-west, while the characteristics of the EBEC are mainly affected by the Seine Estuary. The most important forcing for the benthic habitats in the EC is the presence of very strong currents due to the tidal flow propagating from west to east. Nevertheless, due to the Coriolis force, the current velocities are higher along the French coast than the English coast. The strongest currents recorded during spring tide are >3 knots in north Brittany, off the Cotentin Peninsula and in the Dover Strait, rising to >8 knots off the Cap de La Hague (Salomon and Breton, 1991,

1993). Significant gyres are present around the Channel Islands and to the east of the headlands of Frehel, Barfleur, Antifer and Gris Nez (Salomon and Breton, 1991, 1993). Hence, the distribution of superficial sediments is the result of tidal circulation, with the development of an offshore–inshore hydrodynamic regime leading to a sedimentary gradient: extensive pebbly sediments dominate in areas of strong tidal currents located offshore and to the east of the headlands, whereas fine sands and muddy fine sands appear in areas of weak tidal currents in bays and estuaries (Larsonneur et al., 1982; Vaslet et al., 1979). As a result of hydrodynamic forces, areas of fine-grained sediment are more extensive on the English side than on the French side; the coarse-grained surface sediments are dominated by coarse sands and pebbles, which cover >80% of the EC seabed area (Larsonneur et al., 1982). Another particular feature of EC sediments is their high content in biogenic calcareous material, ranging up to 70% in the bioclastic sediments which dominate the central part of the WBEC; the proportion of terrigenous material is higher in the EBEC than in the WBEC (Larsonneur et al., 1982).

The Channel is a biogeographical transition zone since it is situated between the Lusitanian province to the south and the Boreal province to the north (Forbes, 1858); in this way, the EC is affected by a balance between the recovery of warm temperate species during warming periods and the recovery of boreal species during cooling periods (Southward et al., 2004).

Finally, the EC is strongly impacted by human activities (Dauvin, 2008, 2012). Halpern et al. (2008) pointed out that the North Sea, the EC and Japanese waters represent coastal marine zones where cumulative human impacts have the greatest influence on the worldwide Ocean. Moreover, Dauvin and Lozachmeur (2006) and Dauvin (2012) have stressed that the EBEC is more impacted by human activities than the WBEC, due to the accumulation of traditional activities (fisheries, navigation, sediment deposition, etc.) and the emergence of new activities (aggregate extraction, offshore wind farm installations, etc.).

3. Mapping studies in the English Channel during the early 1960s and 1970s

The main objective of the studies carried out by Holme and Cabiocch was to describe the species and distribution of macrobenthic communities at the scale of the EC (see also Coggan and Diesing, 2011 for a review). They mainly used the Decca navigational positioning system, as well as anchor-type or Rallier du Baty dredges, to collect qualitative or semi-quantitative data, respectively, by sieving a constant volume of 30 L in the case of the French team. They also utilised automatic sub-marine photography to obtain supplementary information on the nature of the sediment and the composition of the epifauna, mainly made up of sessile species on hard substrates (Cabiocch, 1967; Holme

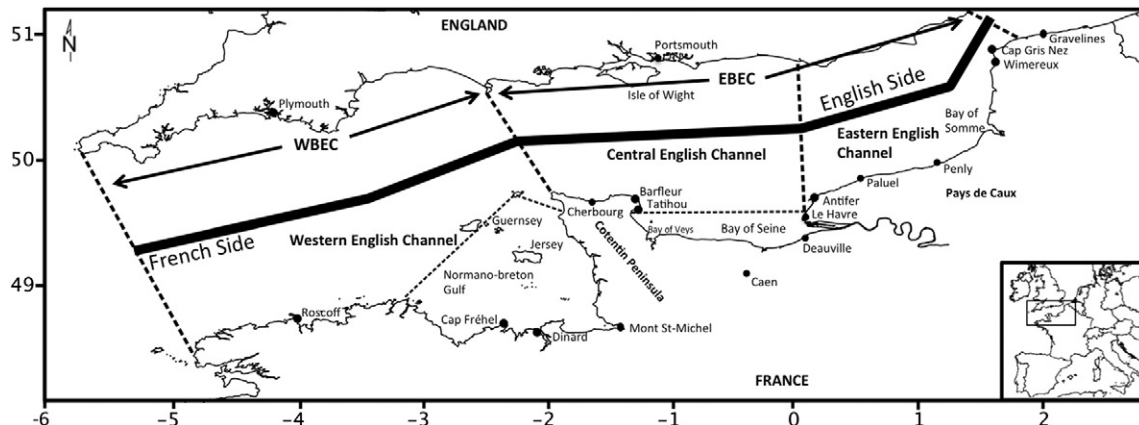


Fig. 1. Map of the English Channel. WBEC: Western Basin of the English Channel. EBEC: Eastern Basin of the English Channel, with indication of the cited locations.

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