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The English Channel: Contamination status of its transitional and coastal waters

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ABSTRACT

The chemical contamination (organic compounds, metals, radionuclides, microplastics, nutrients) of English Channel waters has been reviewed, focussing on the sources, concentrations and impacts. River loads were only reliable for Pb, whereas atmospheric loads appeared robust for Cd, Pb, Hg, PCB-153 and γ-HCH. Temporal trends in atmospheric inputs were decreasing. Contaminant concentrations in biota were relatively constant or decreasing, but not for Cd, Hg and HBCDD, and deleterious impacts on fish and copepods were reported. However, data on ecotoxicological effects were generally sparse for legacy and emerging contaminants. Intercomparison of activity concentrations of artificial radionuclides in sediments and biota on both Channel coasts was hindered by differences in methodological approaches. Riverine phosphate loads decreased with time, while nitrate loads remained uniform. Increased biomass of algae, attributable to terrestrial inputs of nutrients, has affected benthic production and shellfisheries. A strategic approach to the identification of contaminant impacts on marine biota is recommended.

1. Overview of the English Channel environment

1.1. Rationale

The first holistic assessment of the English Channel was given in the North Sea Task Force Sub-Region 9 Assessment (Reid et al., 1993) followed by an update by Tappin and Reid (2000), where particular emphasis was given to contaminants and their effects. In 2000 and 2010, Quality Status Reports (QSR) for the Oslo and Paris Commission (OSPAR) maritime area (essentially part of the NE Atlantic) were published (OSPAR, 2000, 2010a). In those reports, the English Channel was subsumed into the Greater North Sea, and its presence was overshadowed by the larger, and arguably, physico-chemically different North Sea partner. Nevertheless, the overview provided in the current paper has been guided by the previous QSRs, notably in respect of contaminants and their impacts i.e. the OSPAR Convention Thematic Strategies on hazardous and radioactive substances, and eutrophication, in relation to human uses and impacts. This approach also addresses issues of concern within the EU Marine Strategy Framework Directive (i.e. quality descriptors concerning concentrations of contaminants, contaminants in fish and other seafood, and human-induced eutrophication; Law et al., 2010) and within the EU Water Framework Directive (WFD). There are 8 groups of priority contaminants listed in the hazardous substances theme, of which 6 are discussed in this paper; these can loosely be described as 'legacy' contaminants. Tributyl tin is not included here as this is the subject of a separate paper in this Special Issue. There are also additional sections which serve to highlight emerging contaminants, including metals and micro-plastics, and their potential impacts on biota within the Channel.

1.2. Physical characteristics

The western limit of the English Channel is a line from 48°38′23″N 4°34′13″W to 50°04′N 5°43′W (essentially Ushant to the Scilly Isles) and the eastern limit (the Dover Strait) a line joining the Walde lighthouse (France) at 51°00′N 1°55′E and Leathercoat Point (England) at 51°10′N 1°55′E (IHO, 1953). It is widest in the west (200 km) and narrows to 30 km at the Dover Strait to give an overall area of 77,000 km^2 (Fig. 1). The Channel is also deepest in the west, the Hurd Deep is 174 m, and it shallows eastward (Fig. 1). Although the Channel region has many distinguishing geological features between the British and French catchments and coasts, from the viewpoint of its Quaternary history it can be considered as an integrated system (Gibbard and Lautridou, 2003).

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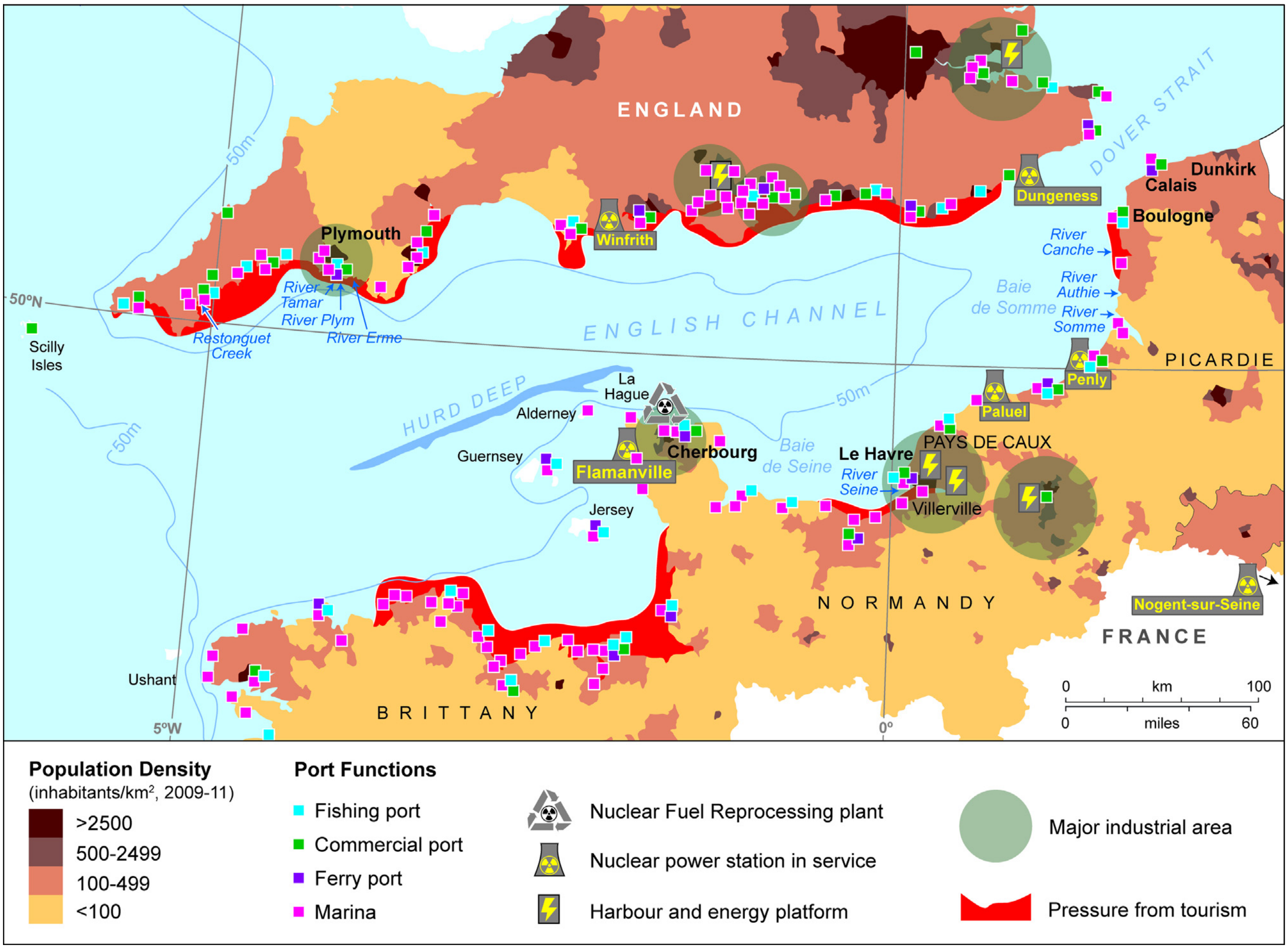

Fig. 1. Geography and bathymetry of the English Channel. The population density and coastal industries are also shown, as are place names given in the text (adapted from Uncles and Stephens (2007) and University of Caen (2014)).

There is considerable annual variability in salinity and temperature of the seawater, giving rise to the advance and retreat of the seasonal thermocline, as illustrated in Fig. 2a–e (Uncles and Stephens, 2007). Winds are predominantly from the south west and can produce long-period swell waves whose energy is dissipated before reaching the Straits of Dover, in the form of flooding which augments the spread of contaminants (Sibley and Cox, 2014). Over the long-term, coastal flooding will also be accentuated by predicted rises in sea level, which have been forecast from the records of sea level obtained from 16 stations around the English Channel coast (Haigh et al., 2011).

As a consequence of the persistent south west winds, residual currents generally flow from west to east (Fig. 2f), although locally, current directions are complex, especially around headlands (Salomon and Breton, 1993; Bailly du Bois and Dumas, 2005). Tidal and density-driven currents are also responsible for seabed stresses that influence the transport and grain size distribution of mobile sediments, although within the near shore, wind-induced currents become more important in this respect (Uncles and Stephens, 2007). As a result, sand and gravel predominate throughout the area, with rock outcrops nearer shore. In the central eastern English Channel gravel dominates due to high current scour (Fig. 2g). Locally, fine sands and muds accrete in estuarine bays and tidal flats, notably in the Baie de Seine, parts of the Brittany and Picardie-Artois coasts, and along the east Devon, Sussex and Kent coasts of England (Larsonneur et al., 1982). Sources of suspended particulate matter (SPM) to the Channel include rivers, coastal erosion, the Celtic Sea to the west, bed sediment resuspension and autochthonous biogenic production. River inputs of sediment are dominated by the River Seine and are of a similar order to the erosion of cliff sediments along the French coastline. Concentrations of SPM are highest in winter and are dominated by coarse silt (clay aggregates, clastic minerals), while spatially the coastal waters exhibit the highest concentrations of SPM. Mass balance considerations suggest most SPM is advected through the Dover Strait into the North Sea (Paphitis et al., 2010).

1.3. Catchments and anthropogenic pressures

The average population is ca 500 and ca 230 inhabitants km^{-2} along the English and French coasts respectively, and there is a general increasing density of population from west to east (Fig. 1). There is a wide range of economic activity, from heavy industry to agriculture, as exemplified in Fig. 1. Because of anthropogenic pressures, many transitional (=estuarine) and coastal waters are subject to contamination from point and diffuse sources, in particular the Brittany and Artois-Picardie coasts (Fig. 3(a)). In addition, and as shown in Fig. 3(b), >90% of French transitional and coastal waters east of Sud Contentin fail to achieve WFD defined good chemical status (ETC/ICM, 2012). Counter-intuitively, while >90% of the south-eastern Channel coast of England has its transitional and coastal waters classified as good chemical status, >90% of the waters are classified as less than WFD good ecological status, suggesting factors other than chemical contamination are affecting water quality (ETC/ICM, 2012). River inputs to the Channel occur from five River Basin Districts (RBD), the South

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