- **TITLE**

Mapping the marine "receiving basins" of the main tributaries to the French waters of the English Channel and the Bay of Biscay. Assessing their respective roles in the pelagic eutrophication process of the WFD water masses and the MSFD sub-regions.

- **ABSTRACT**

- This study (granted up to 50% by the French Office for Water and Aquatic Environments ONEMA) aimed at determining by modelling (hydrodynamical/biogeochemical ECOMARS3D model) the marine "receiving basins" of the main tributaries to the French waters of the English Channel and the Bay of Biscay. Knowing the respective part of each of these marine "receiving basins" in winter nutrient distribution, some optimal scenarios of nutrient loading reduction can be computed for nitrate or phosphate in order to bring back any marine water to the Good Ecological Status regarding eutrophication, at the best efficiency/cost ratio.
- The study encompasses 45 watersheds (or clusters of neighboring watersheds) which have been retained because of their sizes and flow rates. For each of these 45 watersheds in the wider sense, the study has computed the 10 year statistical map of the corresponding so-called "receiving basin". The calculus has been done using a general 4km x 4km grid and 3 refined 1km x 1km grids covering the French coastal zone of this area.
- At any point of the marine domain, the "receiving basins" allow the computation of the dilution of a conservative tracer. Winter concentrations of nitrate or phosphate can then be instantaneously computed on the Channel-Biscay continental shelf for various scenarios of nutrient loadings from the 45 rivers. If one can impose: 1/ the marine winter concentration not to be exceeded to keep a Good Ecological Status, 2/ a proxy for the cost of the unitary abatement of the nutrient concentration in each river, this linear dilution model can be coupled to a global optimisation method, in order to compute the set of concentrations in the 45 rivers which allows to obtain at the lowest price the best Ecological Status everywhere in the maritime domain under consideration. Two global optimisation techniques (linear Simplexe method and quadratic Beale's method) have been compared on various marine target areas : the marine WFD water masses considered separately or together, the 3 MSFD French sub-regions of the Channel-Biscay area, or the coastal strip laying between the seashore and the 50m isobath. Computations have been made using two successive nitrate and phosphate thresholds at sea, which are associated respectively to the WFD eutrophication Very Good Status and Good Status. This exercise has shown that focusing on a single small marine target area can sometimes prescribe a strong abatement of concentrations in the sole small neighboring rivers, but that dealing with a large marine target area points always to the biggest tributaries as being the main nutrient sources to be diminished, whereas small tributaries can be neglected. As it contains the whole big river plumes, the MSFD target requires stronger abatement of nitrate in some watersheds than the WFD target, which is limited to a thin, 1 nautical mile wide strip along the coasts. Whereas very few rivers (except the Seine river) require any abatement of their phosphate loadings, almost all the medium and large rivers require very strong abatements of their nitrate concentrations. The 7 main rivers (mean flow rate > 50 m^3/s) should move from their actual 15 mg/L NO_3 to 5 mg/L NO_3, whereas the 38 minor rivers should go back from their actual 24 mg/L NO_3 to 13 mg/L NO_3.
- As the most reliable descriptors of eutrophication impact are not the winter nutrient levels, but the spring-summer levels of chlorophyll and bottom dissolved oxygen, the ECOMARS3D model of the pelagic ecosystem has been used to simulate the real situation during the 2000-2010 decade and validated against a coastal data base. In order to assess the effects of loading reduction on some criteria of marine eutrophication, this reference simulation has then been compared to simulations using reduced river loadings: pristine loadings, globally optimal scenarios coming from the previous linear approach, academic modifications (-50%). The results are:
    - in eutrophicated areas, the chlorophyll 90^{th} percentile begins to decrease significantly only in case of 50% reduction of loadings, or even more in the Bay of Biscay, in front of Loire and Vilaine estuaries. This mirrors the behavior of the main component of the phytoplankton, the diatoms.
    - the dinoflagellate annual maximum however seems to respond quickly to nitrogen loading decrease, and this is enhanced in case of coupled phosphate loading decrease. In case of 50% reduction, the dinoflagellates vanish in the bay of Seine, whereas on the continental shelf of Biscay, their decrease may reach 90% in case of severe reductions.
    - the oxygen 10^{th} percentile is nearly insensitive to loading reductions: it may increase by 10% in case of the severe loading reductions.

- **KEY WORDS (THEMATIC AND GEOGRAPHICAL AREA)**

English Channel, Bay of Biscay, 3D modelling, watersheds, receiving basins, nitrate, phosphate, nutrient loading reduction, pristine situation, primary production, dissolved oxygen, WFD classification, Good Ecological Status, linear optimisation, Simplexe method, quadratic optimisation, Beale's method.