Title: GEOMATICS FOR THE MANAGEMENT OF OYSTER CULTURE LEASES

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Original publication reference: Just published by Kluwers, expecting reference.

Application tool: GIS.

Main Issues Addressed: Inventory and monitoring of aquaculture and the environment.

The general problem, or aim of the study, and the contribution of GIS, remote sensing and/or mapping to the solving the problem: GIS, by providing a capture and edition tool, a data base, script programming and mapping functions allowed to fully take advantage of the digital form of data layers and compute indicators essential to proper management of an economically important coastal resource.

Main Environments: Brackishwater.

Culture Systems: On bottom.

Organism Divisions: Molluscs.

Genera and Species: *Crassostrea gigas*.

Target Country: France.

Target Audience: Syndicates of producers, public health authorities, coastal planners, harbour authorities.

Duration of the Study and Year Begun: Two years, including digitization of complete cadastre, acquiring and processing depth data.

Personnel Involved: Mostly researchers, plus one technician (disciplines: geomaticians and biologists).

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Introduction

Spatial management of oyster culture seems to be a key factor for the future sustainable development of oyster industry. In relation with the administration in charge of this management (Affaires Maritimes), Ifremer has developed a GIS to integrate different spatial features (such as bathymetry, leases parcels, tidal levels) and allow their cross-analysis for improved decision making.

Materials and Methods

The coastal zone of Charente-Maritime in France has a leading position in oyster culture production. Yet it is being jeopardized by a number of problems such as overstocking, unadequate distribution of culture types, wild stock in excess, strong siltation processes. Some of these problems resort to a lack of communication within the professional community, others to obsolete management tools. The use of a GIS is believed to help provide some answers, besides alleviating the classical task of lease management. It also acts as a communication tool between the actors, i.e. the professionals, the local authorities and the research sector.

Results

The lease cadastral maps

One hundred and seventy cadastral paper maps covered the tidal area of Marennes-Oléron (Figure 1), containing 22 000 leases for a total surface area of 2 900 hectares were digitized.

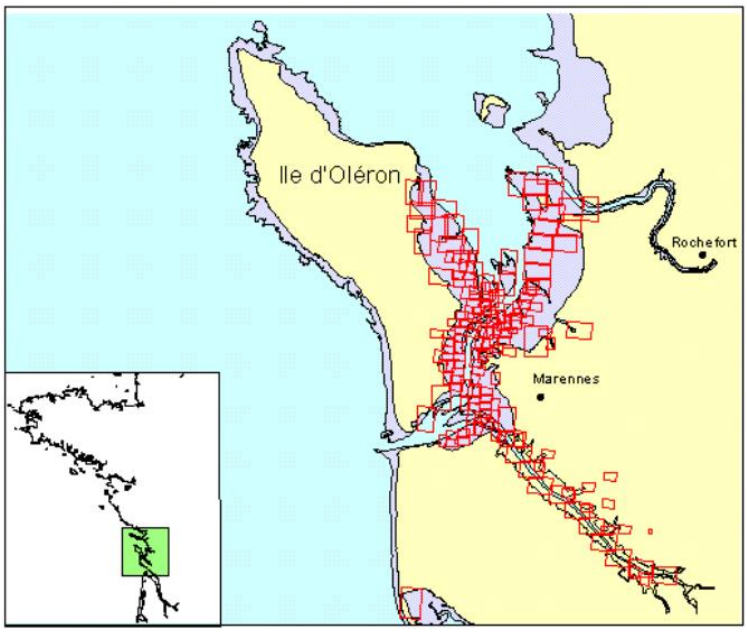

Figure 1 Bassin de Marennes-Oléron, Charente-Maritime, France. Leases maps appear in red.

Their attribution and management is run by Affaires Maritimes, a body within the Ministry of Transports. With the advent of digitization and numerical handling, the question of an accurate geo-referencing of the whole cadastre had to be dealt with. During this process, the consistency of the system was privileged rather than leases absolute positions. Finally, the estimated accuracy on lease locations was 5 metres.

Parcels in the field are grouped in entities referred to as « banks », which are both physical units and management units, i.e. under supervision of a bank committee. It is therefore quite a relevant geographical entity to be stored in the data base. Banks are built by aggregating parcels and filling up alleys between them.

The typical lease surface area is 1 000 m². The lease data base contains 32 attributes, most of them being for administrative use, some may being of interest for management and biological purposes. This data base is updated by Affaires Maritimes.

The depth chart

The whole area covered by oyster and mussel culture inside the Bassin is regularly surveyed by the Harbour Maritime Service, in charge of coastal civil engineering. The main concern is a siltation trend that has been occurring for many years and is suspected to be a consequence of shellfish farming. Depth surveys were conducted in 1970, 1985 and recently over the period 1994–1996. Soundings were performed every ten metres on transects 100 metres apart and corrected for tidal effects, to provide mapping on scale 1/10 000. Tidal constraints limited transects ashore to an altitude of approximately 4 metres above chart datum.

The interpolation was performed on a 20 metres mesh size grid encompassing the whole basin. A section of the depth digital terrain model (DTM) is shown in Figure 2, with depth varying between -11 and +4 metres.

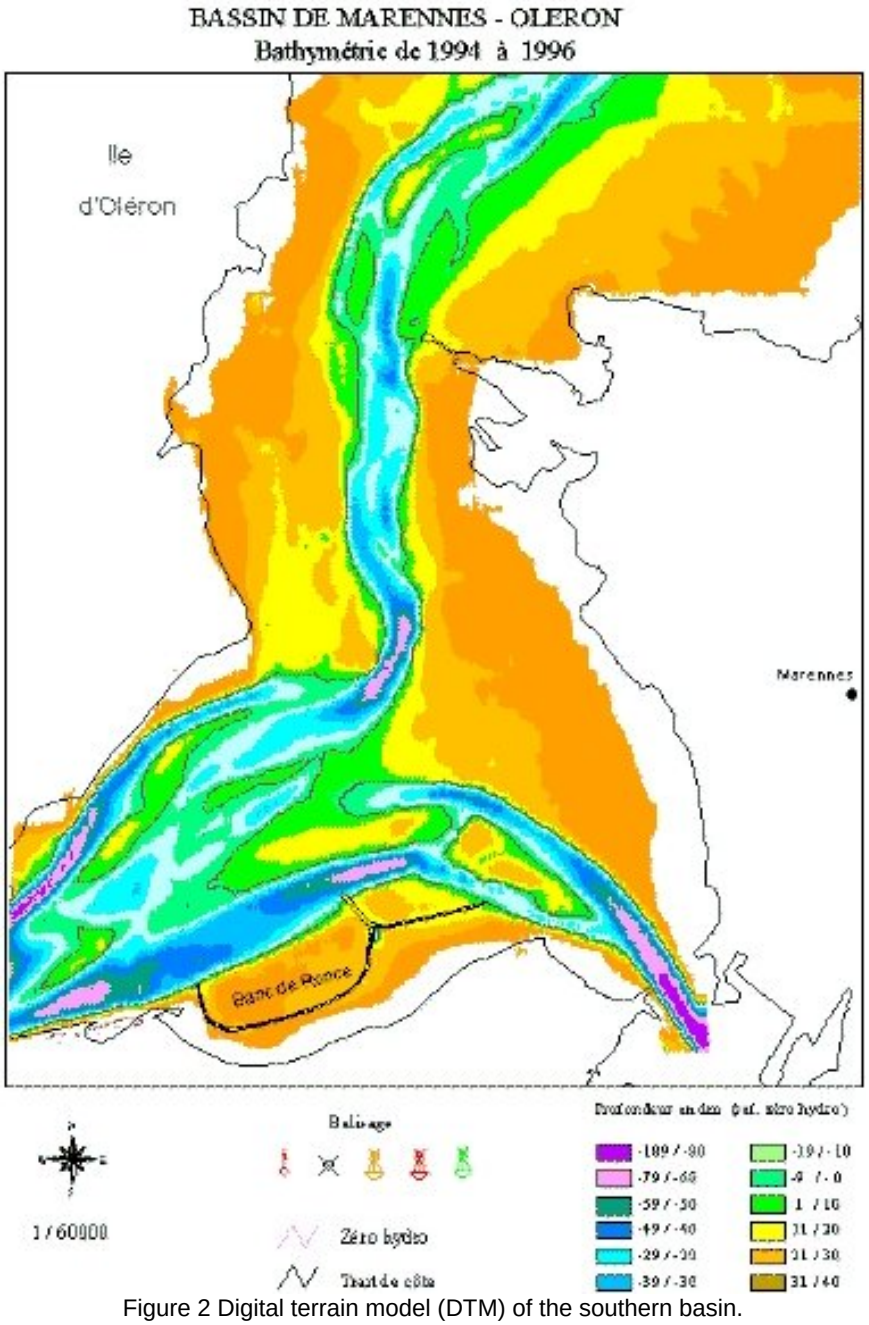

Figure 2 Digital terrain model (DTM) of the southern basin.

Merging depth to leases

The aim of this operation was to compute the average depth of each lease. It is a classical problem of raster to vector conversion, where the choice of the method depends on the respective sizes of the objects concerned. As these are comparable here, it is reasonable to use a function readily available in Arcview Spatial AnalystTM. This results in the attribute depth (or rather “elevation”, as we are above chart datum!) being appended to the lease file as a new attribute. Figure 3 illustrates the case of Banc de Ronce, with parcels colour-coded according to their elevation in decimetres.

Application to dredging in the Banc de Ronce

Severe siltation had been reported for years in the southern part of the Bassin, which led to the obstruction of Banc de Ronce main access channels. Local authorities therefore started funding dredging operations to both re-establish navigation and improve the flushing effect of the ebb tide through channels, namely the Etier de Perquis and the Coursière des Lézards (Figure 3).

The dredging site width is 50 metres, which means all parcels intersecting it (shown in red) must be removed and their owners granted equivalent leases elsewhere. The dredging corridor itself is only 20 metres wide. The objective is to compute the sediment volume between the present elevation and the projected one (Z final = 1 metre above chart datum). The volume computation makes use of the depth grid file combined with the corridor polygon, the lower threshold being at 1 metre. In Etier de Perquis and Coursière des Lézards, respectively 15 500 m^2 on an average sediment height of 0.7 metres, and 81 000 m^3 on a height of 1.6 metres are concerned. This provides a rough estimate of quantities at stakes.

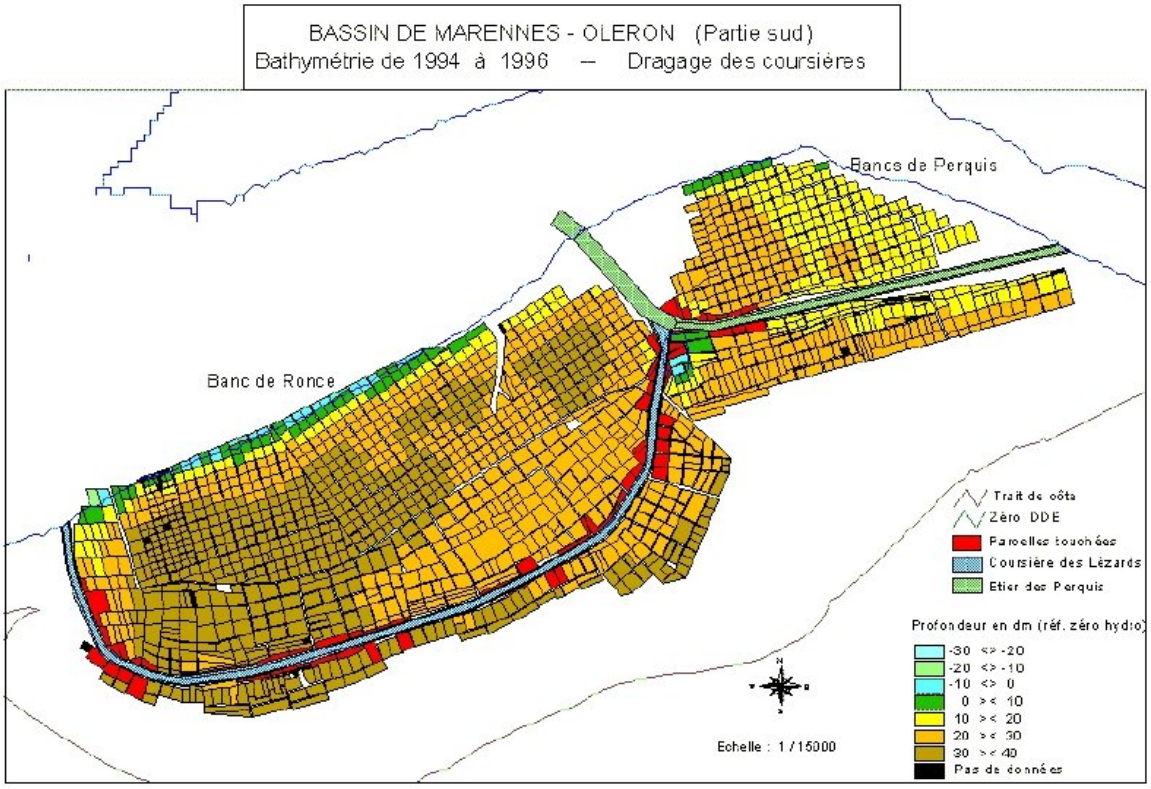

Figure 3 Dredging operation of bancs de Perquis et Ronce.

The tidal model and immersion time

Shellfish lease grounds are located on vast tidal mudflats and therefore are submitted to a variable duration of immersion when going up landward. Due to the oyster filtering activity, growth depends directly on this parameter. The tidal model provided by the Hydrographic Office is used to calculate this duration as a function of depth. Water level calculations are recorded in an ASCII file with a six minute time lag. By iteratively reading this file between two given dates (t_1 and t_2), time windows when the tide height is above a given elevation can be summarized. When rationed to the (t_1–t_2) period, a percentage of immersion is obtained.

Figure 4 illustrates the effect of a theoretical siltation height of 0.5 metres on the spatial distribution of immersion duration. It can be seen that such a ground upheaval entails a loss of

immersion time of up to 22% in higher elevation spots (shown darker in the figure), hence severely affecting oyster growth. This fact can be used by farmers to urge dredging operations.

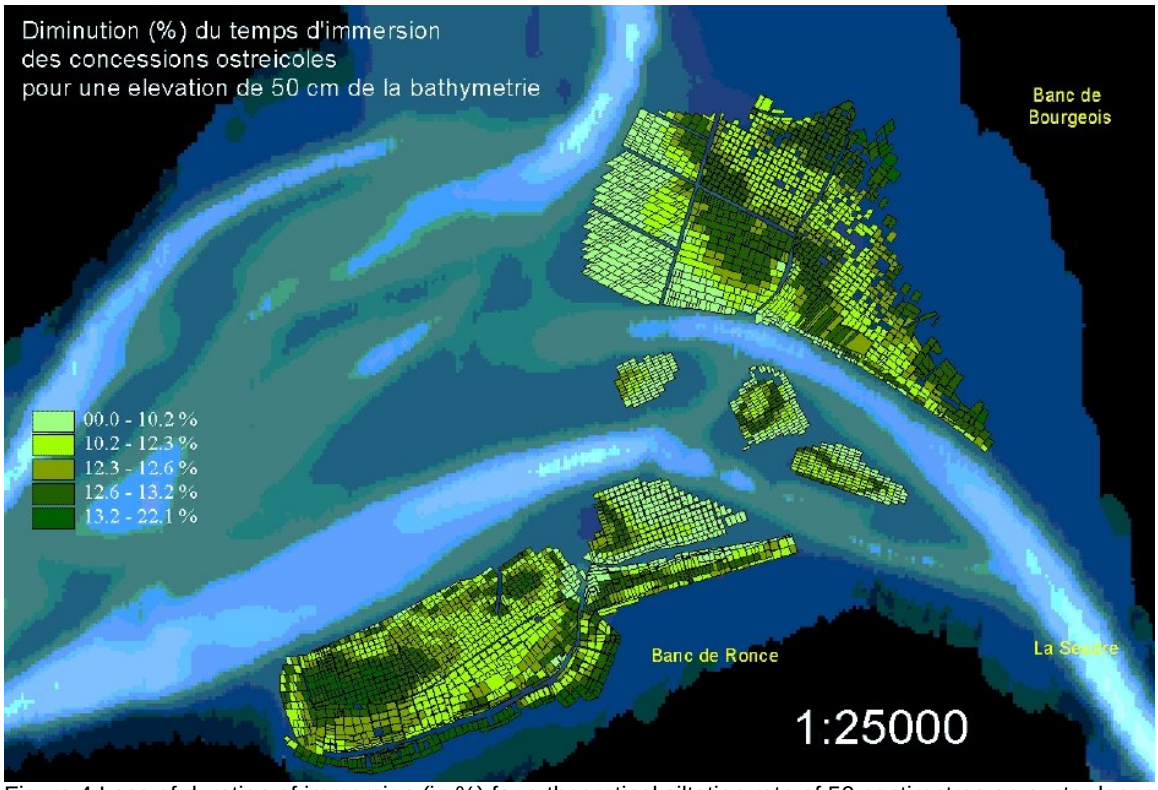

Figure 4 Loss of duration of immersion (in %) for a theoretical siltation rate of 50 centimetres on oyster lease grounds in Bancs de Ronce and Bourgeois.

Discussion

When compared to the former use of 170 paper maps to administrate the shellfish production area of Marennes-Oléron, GIS was indeed a revolution. The paramount gain is in updating or re-drawing lease spatial extents, which is planned to happen on a continuous basis until the whole area is restructured.

One of the major problems encountered was geo-referencing, as in the former system, each map was standalone. More accurate referencing will be possible in the future thanks to a recent air ortho-photo coverage of the entire French coast by low tide conditions. This will provide a referential with 2 metres absolute accuracy for tying up any other spatial layer. These difficulties fortunately will only happen once.

No uncertainty assessment was performed, e.g. on volumes computed for dredging operations. However, the method used for depth interpolation yields a standard deviation that is an estimate of the accuracy of the interpolation, hence a first approximation of the uncertainty. There remains to estimate the uncertainty when the depth of the pixel centre is extended to the whole pixel area (400 m²), a common challenge in raster-vector combination.

A number of further uses of the cadastre data base are foreseen:
- stock assessment, a major issue in this basin, is conducting with airphotography along with oyster biomass sampling. It helps having an updated view of parcels actual activities.

- productivity, mortality, epizooties are also of highest concern. Ways are sought to couple results of trophic and sedimentological models with field observations in test parcels, together with the incidence of rainfall sewage outfall.
- in socio-economy, there are prospects of a better understanding of the lease exchange system by computing a “theoretical” lease value based on major bio-physical parameters (essentially emerging time, position in terms of productivity, etc.).

GIS and digital mapping have eased the work of institutions dealing with the management of shellfish farming, in the first place Affaires Maritimes, responsible to keep the cadastre up to date, but also a number of bodies dealing with coastal management, e.g. biological research (public health), pollution and sedimentation mitigation etc.

Recent developments can be found on the Ifremer web site in Marennes-Oléron: www.ifremer.fr/lcpc and also at the Ifremer department of geomatics: www.ifremer.fr/delao.

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