A Geographical Information System for Ria Formosa (South Coast of Portugal)

Ana Rodrigues[1], António Carvalho[1], João Reia[1], Bruno Azevedo[2], Cláudia Martins[2], Pedro Duarte[2] Dalila Serpa[3] & Manuela Falcão[3]

[1]*Ria Formosa Natural Park.*
[2]*University Fernando Pessoa - Centre for Modelling and Analysis of Environmental Systems.*
[3]*National Research Institute for Fisheries and Sea.*

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Introduction

The DITTY Project (*Development of an Information Technology Tool for the Management of European Southern Lagoons under the influence of river-basin runoff*) is divided in eight work packages (WP). WP3 corresponds to the geographical information systems (GIS) and analysis tools. The main goals of such tools are database georeferencing and spatial statistical analysis. The GIS tools will be interfaced with the database for each particular test site and will be made accessible to all the participants through the web, in www.dittyproject.org.

The objective of this part of the work was to implement a GIS in order to be able to integrate environmental information about Ria Formosa lagoon and the area that covers the river network draining into the Ria. This GIS is supposed to be a two-way interface between environmental information and mathematical models of the watersheds and Ria Formosa.

Ria Formosa is a shallow mesotidal lagoon located at the south of Portugal (Algarve coast) (see Figure 1) with a wet area of 10 500 ha. The protected area of the Ria Formosa Natural Park covers 60 kilometres of Algarve coastline. The lagoon has several channels and an extensive intertidal area, around 50 % of the total area, mostly constituted by sand, muddy sand-flats and salt marshes. In Table 1 are shown the projected areas for high and low tides and the corresponding tidal prism for each case. The tidal prism is the volume of water that flows into and out of the estuary during a tide.

Table 1 – Areas and tidal prisms according to the type of tide.

Spring Tides (between 3.2 and 0.8 m)	Area at 0.8 m → 18.93 x 10^6 m^2
	Area at 3.2 m → 80.32 x 10^6 m^2
	Tidal Prism → 112.25 x 10^6 m^3
Neap Tides (between 1.6 and 2.3 m)	Area at 1.6 m → 33.32 x 10^6 m^2
	Area at 2.3 m → 54.82 x 10^6 m^2
	Tidal Prism → 30.45 x 10^6 m^3

The objectives of this report are to explain how the GIS was implemented, to identify the main sources of information, to show some examples of the GIS information available and to explain how the spatial information was interfaced with the lagoon model.

Figure 1 – Ria Formosa lagoon location in Portugal (Source: Kujala (2005)).

Methodology for GIS implementation

GIS Software

This work was done with ArcGIS 8.3, using the following applications:

- ✓ **<u>ArcCatalog</u>**

With ArcCatalog it is possible to manage, create, organize and search geographic and alphanumeric data. It contains publishers to introduce metadata, a structure for the storage of these and sheets of properties to visualize the data. It also allows data conversions among different formats (ESRI, 2003).

- ✓ **<u>ArcMap</u>**

The ArcMap application is used for all tasks of creation and edition of maps as well as data analysis. ArcMap allows to:

- Visualize geographic data;
- Identify new standards and distributions of the geographic data;
- Create maps;
- Perform spatial analysis (ESRI, 2003).

Data gathering

Data was obtained from four main sources:

- **<u>Ria Formosa Natural Park</u> – data related with the management plan.**
- **<u>Ria Formosa Natural Park</u> – technical report on sediment types.**
- **<u>Portuguese Hydrografic Institute</u> – bathymetrical data.**
- **<u>Environment Online Atlas</u> – several maps obtained online.**

Description of GIS data available

- **Ria Formosa Natural Park - data related with the management plan.**

The GIS of the Ria Formosa Natural Park was started in 2002, after the review of the Management Plan of this protected area. Since then, a large amount of cartographic and alfa-numeric data, concerning the territory of the park and its watershed, scattered over several institutions, was gathered. The information resulting from the review of the Management Plan, through scientific research and monitoring was also included.

Today, the GIS is the most important tool for the management of this protected area, and has the purpose of providing the public and the institutions, the best support possible, and represents the main reference as geographical information regarding this territory. The main data groups of the GIS are presented on Table 2.

Table 2 - Main groups of information in the Ria Formosa GIS.

Altimetry
Bird census
Ecologic National Reserve
Fauna
Flora
Geology
Ground slope
Hydrogeology
Hydrography
Landscape
Natura 2000 Network
Public Coastal Domain
Types of soil
Use of the soil

Water
Accessibility
Administrative borders Buildings/accommodations
Cultural values
Demography
Farming occupation
Hydrogeological use of Eastern Algarve
Information Base of the National Statistic Institute
Natural Park borders
Management of the territory
Municipal Directive Plans - PDM
Plan of Management of the Seashore - POOC
Public utilities and restriction services
Vulnerable zones
Agriculture
Cycle ways
Clam farms
Dune recover
Fish farms
Forest fires
Harbour and nautical activities
Recreation
Risks
Salt extraction
Waste water treatment plants

Based on this work, the RFNP Authority produced several maps, mainly regarding the limits of the park (Figure 2), land cover (Figure3), vegetation (Figure 4) and the geographical distribution of the shellfish farming areas (Figure 5). The cartography of soil, at the scale of 1:25000, was obtained from the interpretation of aerial colour-treated photographs.

Information from the Military Charts of Portugal was also used, although the cartography was made over the ortophotomaps, under GIS environment. Other coloured vertical-aerial photographs from 1997, available in RFNP, on an average scale of 1:8000 were used.

Figure 2 – Main layer of the GIS - Natural Park limits.

The main file, “limitepnrf.shp” (see Figure 2), represents the area covered by the Natural Park. The projected coordinate system was configured to “Lisboa Hayford Gauss IgeoE” (military coordinates). All the layers that were used or created were configured with this coordinate system.

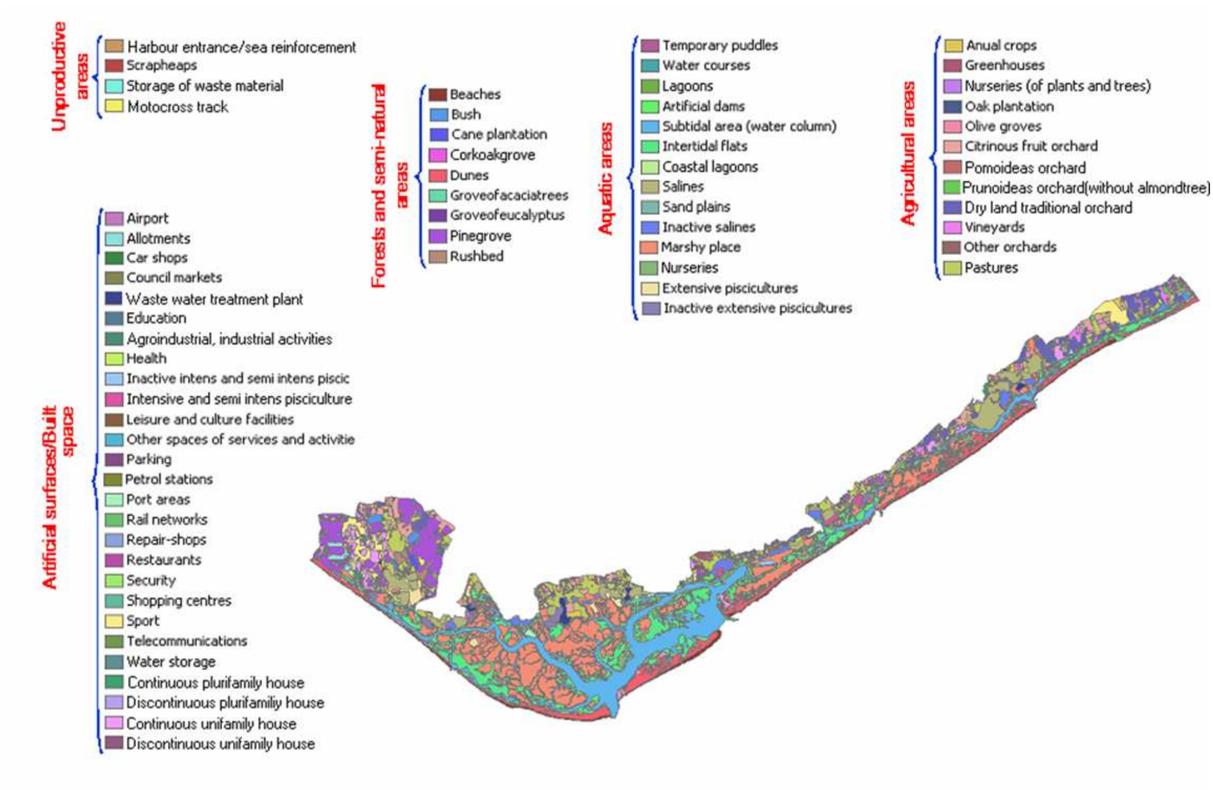


Figure 3 – Ria Formosa land cover map.

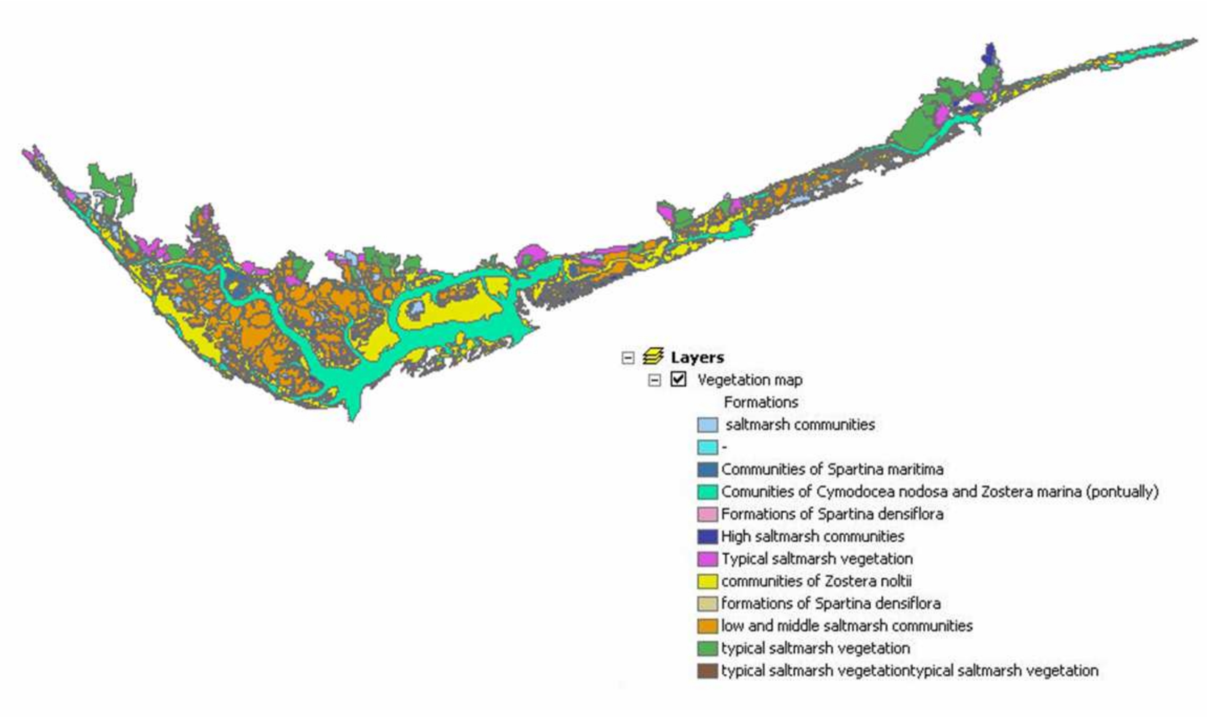


Figure 4 – Ria Formosa vegetation distribution map. The vegetation map represents the distribution of the vegetation characteristic of sub-tidal and inter-tidal areas (tidal flats, high salt marsh and low salt marsh).

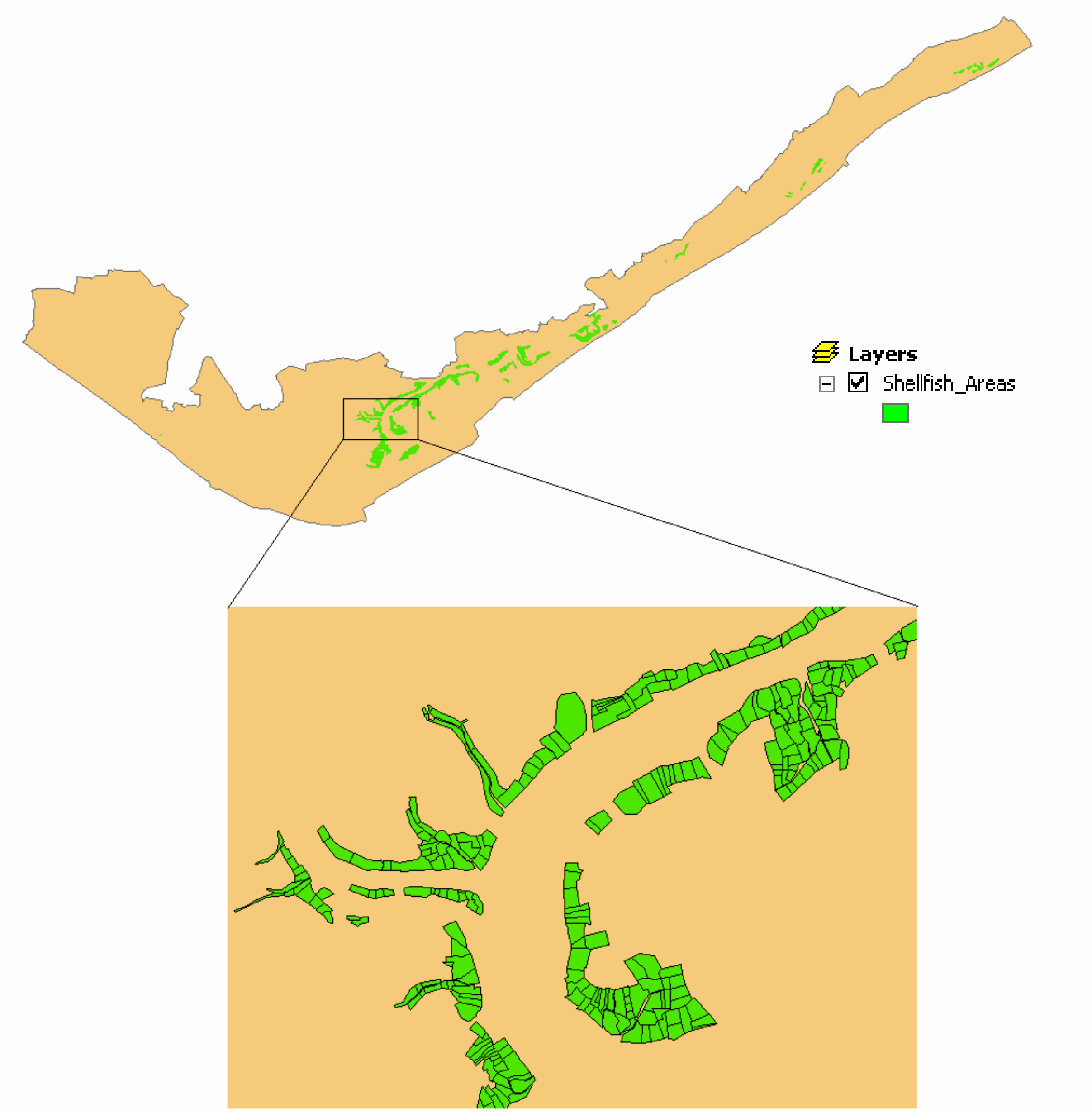


Figure 5 – Ria Formosa shellfish farming areas.

- **<u>Ria Formosa Natural Park</u>, technical report on sediment types.**

Based on a technical report (Abreu & Machado, 2000) about the lagoon sediment types, containing several maps, a new layer was created on the GIS, called "Sedimentos.lyr" (see Figure 6), with sediments type and location.

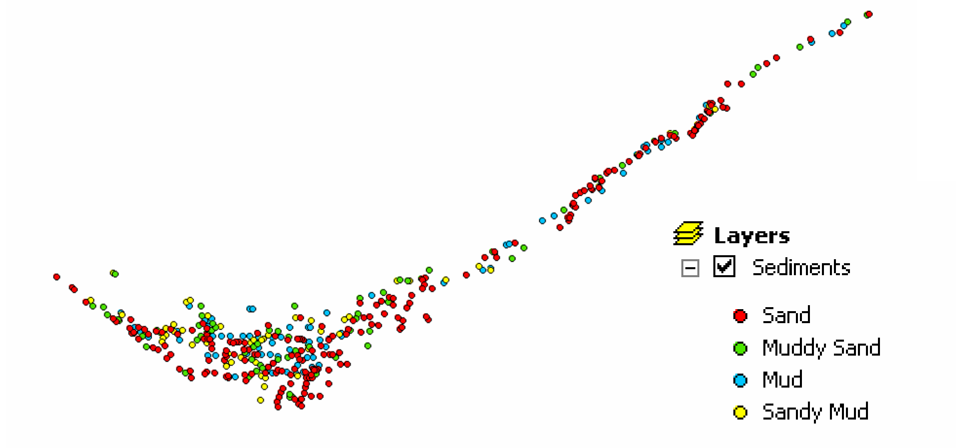


Figure 6 – Layer of sediments based on the technical report (Abreu & Machado, 2000).

This layer may be overlapped with the limits of the Natural Park (Figure 2), in order to evaluate the sediments location inside the lagoon area. The resulting view is shown in Figure 7.

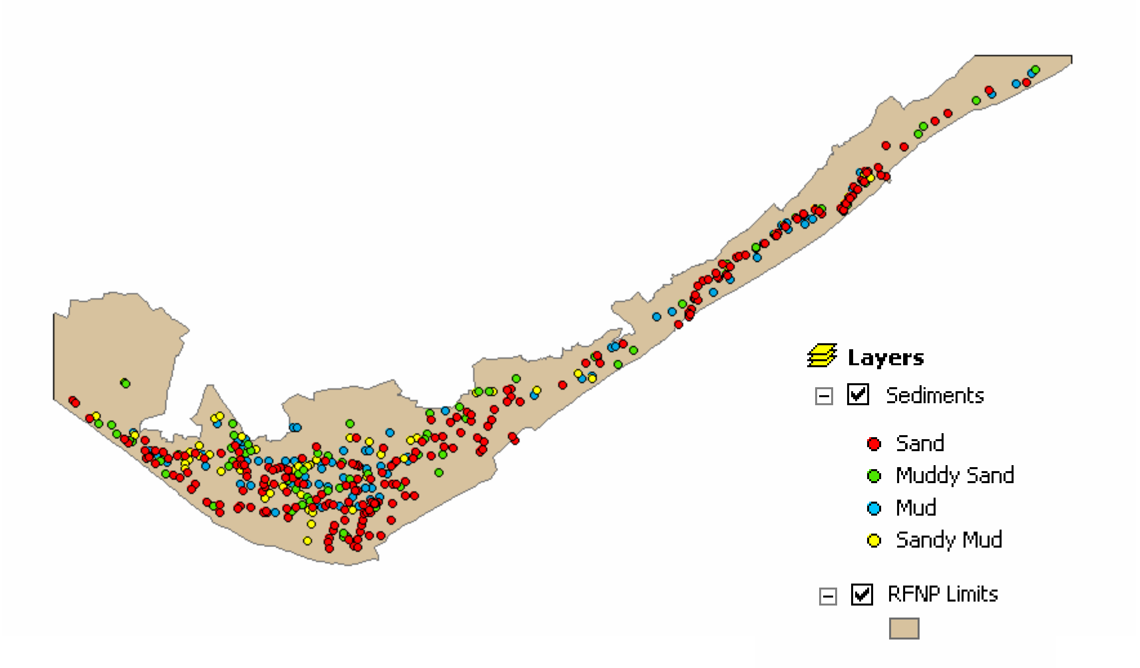


Figure 7 – View of the sediments layer with the Natural Park limits.

One of the extensions of ArcGis is Spatial Analyst (see Figure 8). Its main functions are: the study of the locations and shapes of geographic features and the relationships between them, the process of modelling, examining, and interpreting model results (ESRI, 2003).

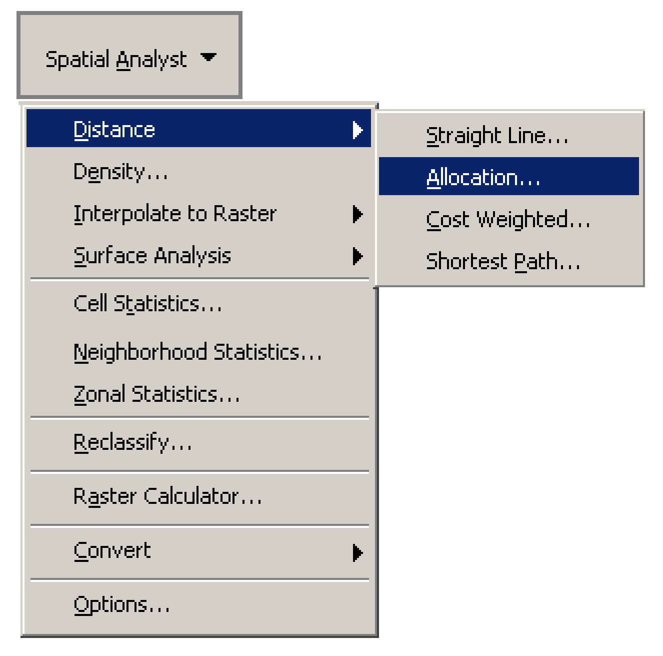


Figure 8 – Spatial Analyst menu and its tools.

Spatial analysis is useful for evaluating suitability and capability, for estimating and predicting, and for interpreting and understanding. There are four traditional types of spatial analysis: topological overlay and contiguity analysis; surface analysis; linear analysis; and raster analysis.

In the *distance component*, Spatial Analyst allows to execute the *Allocation* function (see Figure 9), that allows to identify which cells belong to which source, based on closest proximity (in a straight line). An output raster is produced that records the identity of the closest source cell for each cell. Each cell, in an allocation raster, receives the value of the source cell to which it will be allocated.

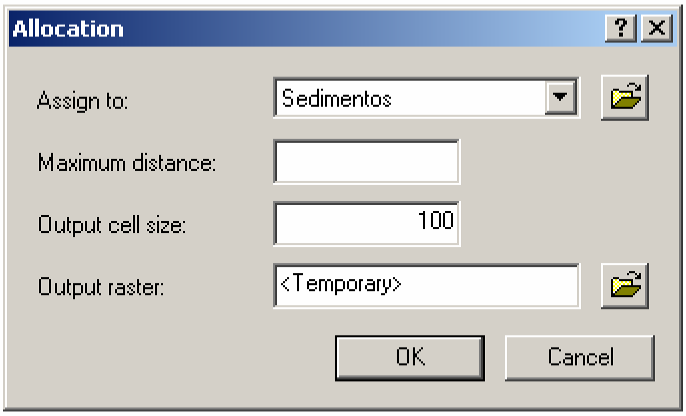


Figure 9 – Allocation command window.

Knowing this, the sediments layer ("Sedimentos.lyr") was allocated based on the lagoon shape layer ("limitepnrf.shp"), originating a new layer "allocation_to_sedimentos.lyr" (Figure 10).

Figure 10 – Sediments distribution layer originated with the allocation process (see text).

- **<u>Portuguese Hydrografic Institute, bathymetrical data.</u>**

Based on a bathymetric survey carried out by the Portuguese Hydrografic Institute, where nearly two millions of depth measurements were made in 2001, a bathymetric layer was created for Ria Formosa lagoon (Figure 11).

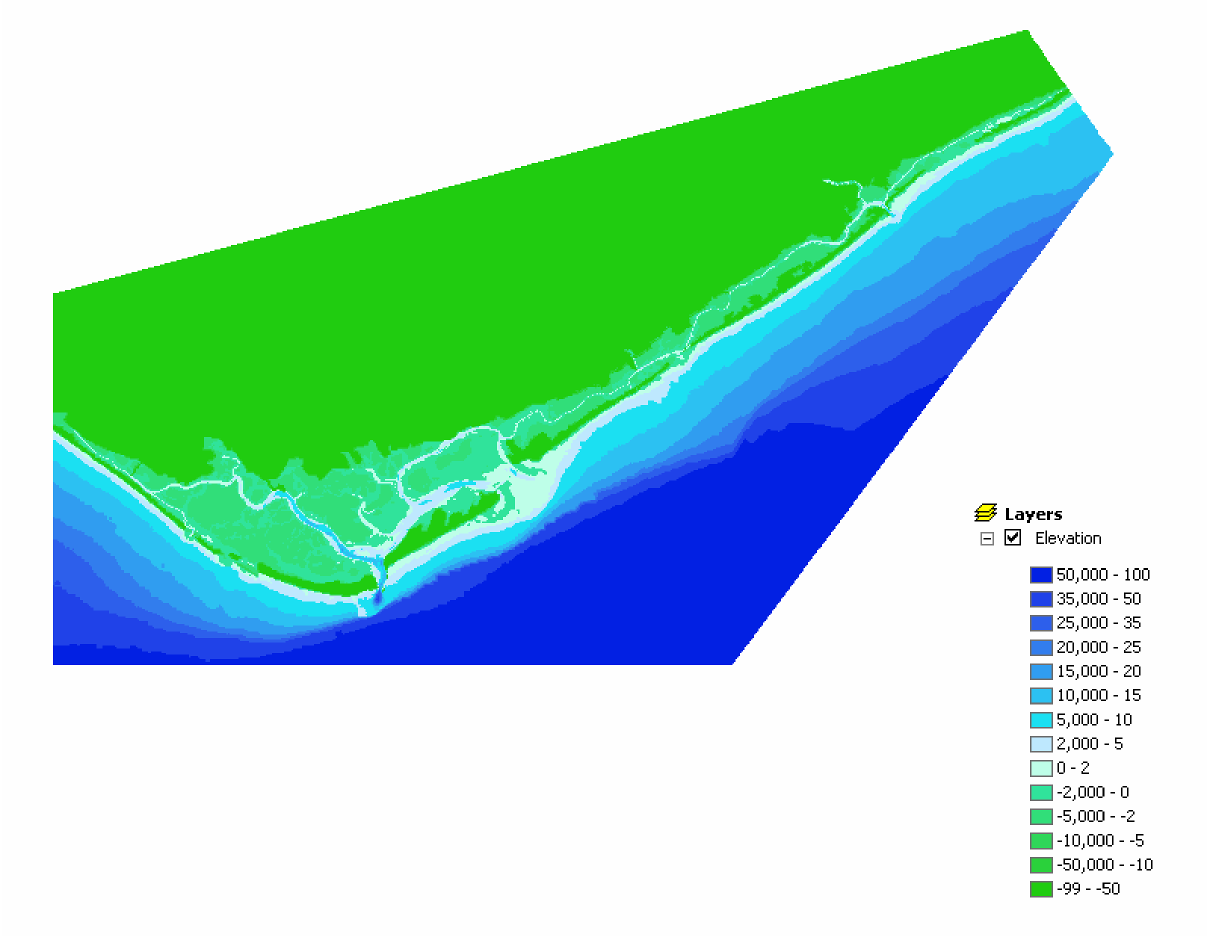


Figure 11 – Bathymetric layer for Ria Formosa lagoon (elevation in m above or below the hydrographic zero).

- **<u>Environment Online Atlas</u>, several maps obtained online.**

Currently, the online version of the Environment Atlas is part of a project that intents to make information more available and accessible to the general public. It is made of several layers of environmental information, which may be seen and downloaded from the internet, for example, precipitation (Figure 12) and drainage data (Figure 13), etc.

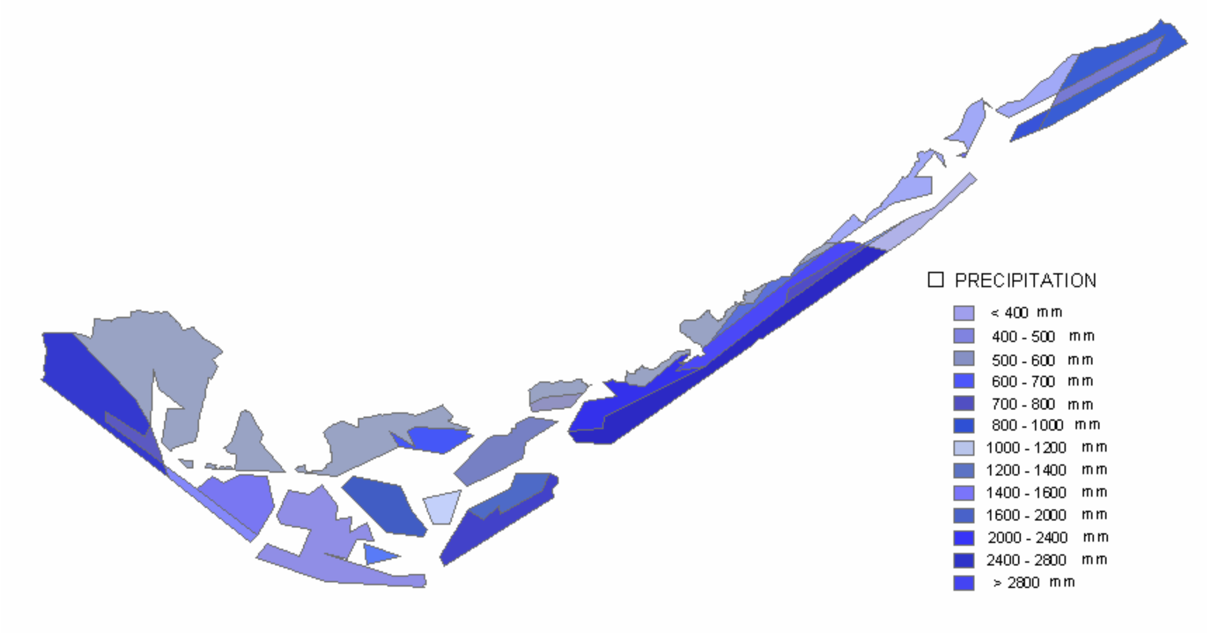


Figure 12 – Precipitation levels in the Ria Formosa Natural Park. The precipitation map represents the annual average values of total precipitation (mm).

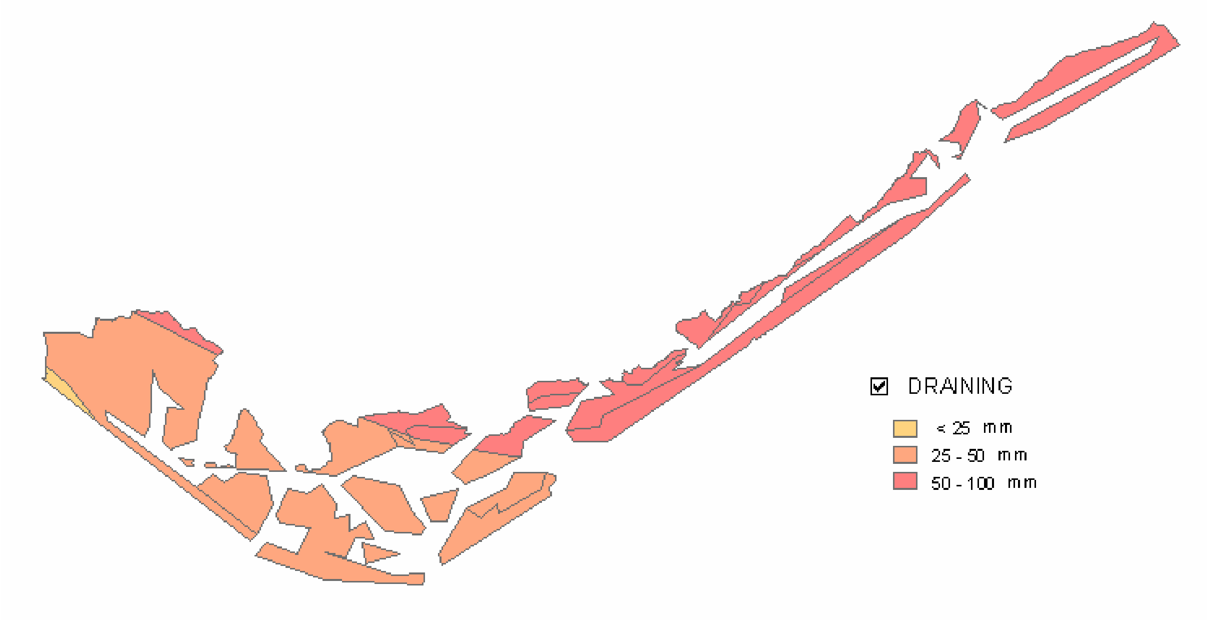


Figure 13 – Draining levels in the Ria Formosa Natural Park.

Interfacing the GIS with the lagoon model

In order to interface the GIS layers with the hydrodynamic model grid (Duarte & Pereira, 2005), a layer of points was created containing 470 columns x 282 lines, called "Grid_Lin-Col.lyr" (Figure 14).

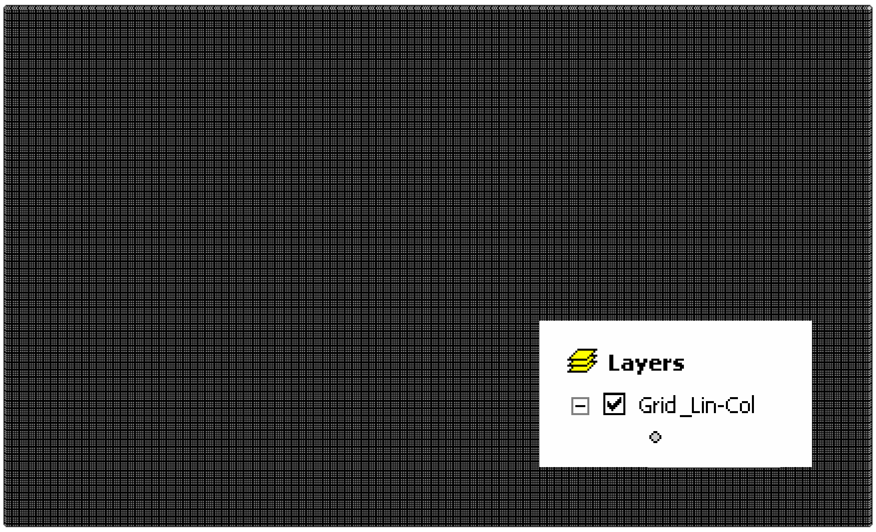


Figure 14 – Model grid layer.

The shellfish farming area layer was clipped with the model grid, in order to obtain its position on the model grid coordinate system. The resulting layer is shown in Figure 15, while in Figure 16, a part of the resultant *Attributes Table* is shown, containing information to be exported to the model.

A similar procedure was followed for the sediment types (Figure 17). Both the shellfish farming areas and sediment types are necessary for the biogeochemical model, where it is necessary to parameterise biogeochemical sediment processes as a function of sediment type and the presence or absence of bivalve farming (Duarte et al., in prep).

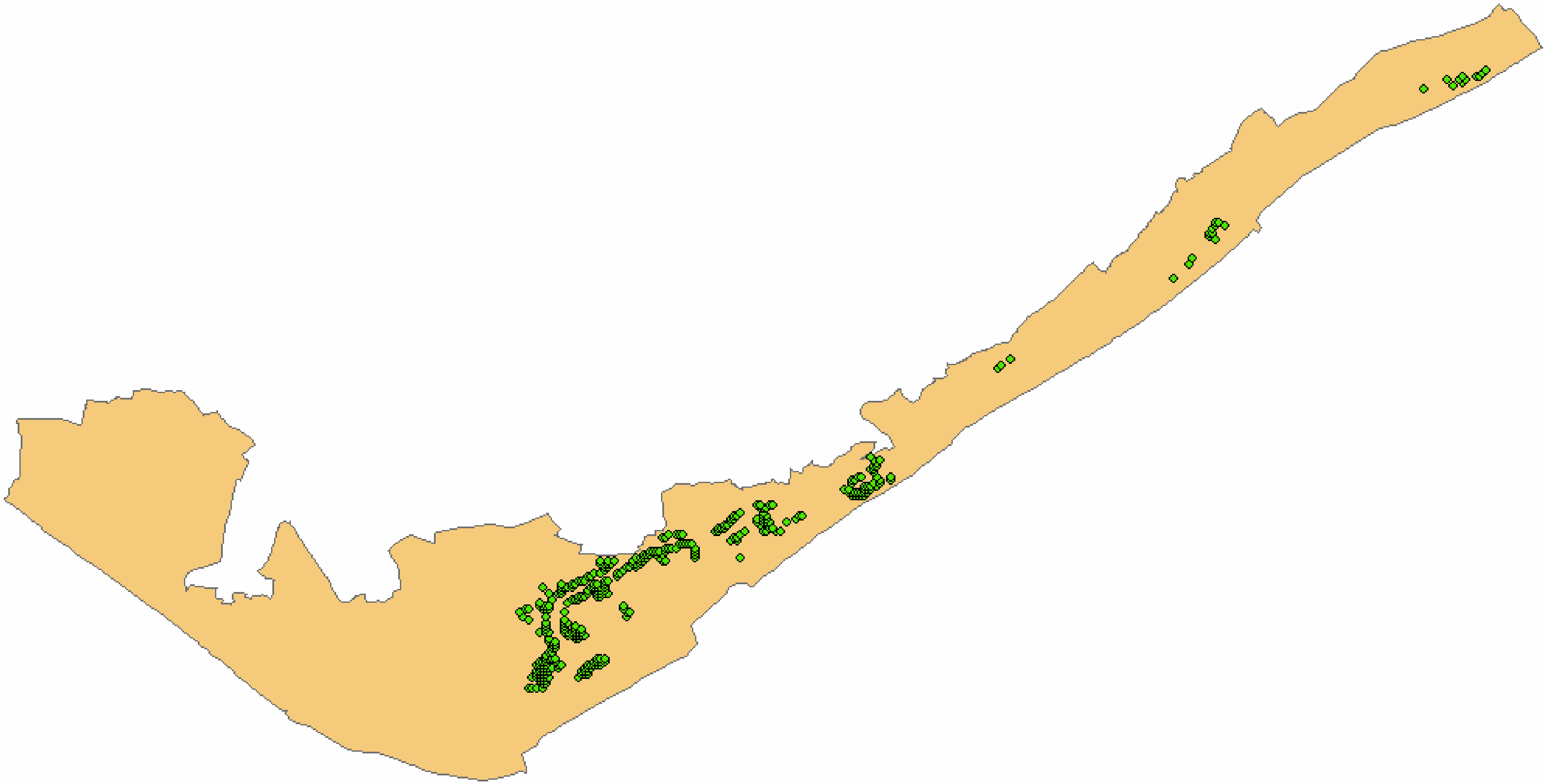
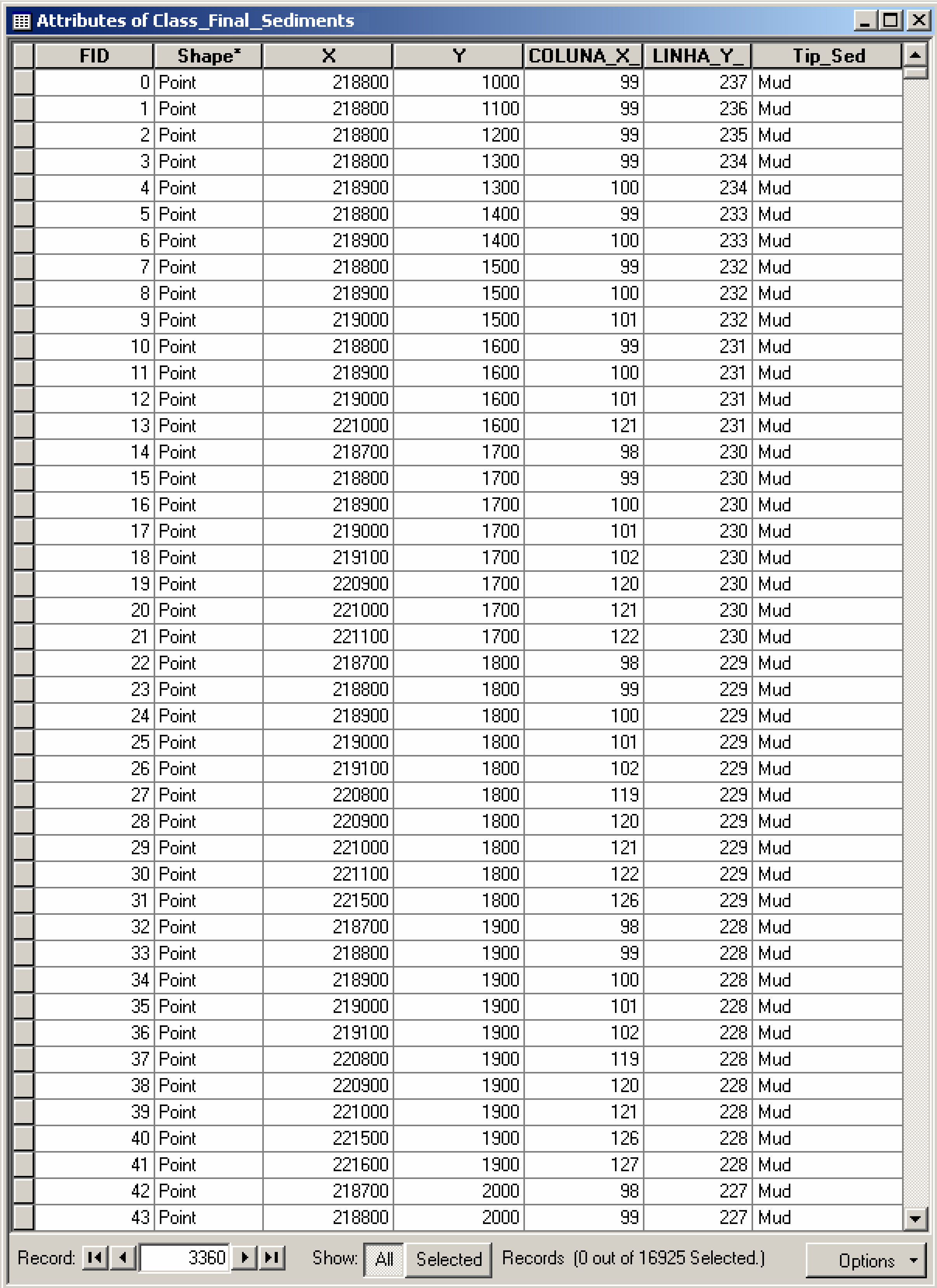


Figure 15 – Ria Formosa shellfish growth areas clipped with the model grid.



Attributes of Class_Final_Sediments

FID	Shape*	X	Y	COLUNA_X_	LINHA_Y_	Tip_Sed
0	Point	218800	1000	99	237	Mud
1	Point	218800	1100	99	236	Mud
2	Point	218800	1200	99	235	Mud
3	Point	218800	1300	99	234	Mud
4	Point	218900	1300	100	234	Mud
5	Point	218800	1400	99	233	Mud
6	Point	218900	1400	100	233	Mud
7	Point	218800	1500	99	232	Mud
8	Point	218900	1500	100	232	Mud
9	Point	219000	1500	101	232	Mud
10	Point	218800	1600	99	231	Mud
11	Point	218900	1600	100	231	Mud
12	Point	219000	1600	101	231	Mud
13	Point	221000	1600	121	231	Mud
14	Point	218700	1700	98	230	Mud
15	Point	218800	1700	99	230	Mud
16	Point	218900	1700	100	230	Mud
17	Point	219000	1700	101	230	Mud
18	Point	219100	1700	102	230	Mud
19	Point	220900	1700	120	230	Mud
20	Point	221000	1700	121	230	Mud
21	Point	221100	1700	122	230	Mud
22	Point	218700	1800	98	229	Mud
23	Point	218800	1800	99	229	Mud
24	Point	218900	1800	100	229	Mud
25	Point	219000	1800	101	229	Mud
26	Point	219100	1800	102	229	Mud
27	Point	220800	1800	119	229	Mud
28	Point	220900	1800	120	229	Mud
29	Point	221000	1800	121	229	Mud
30	Point	221100	1800	122	229	Mud
31	Point	221500	1800	126	229	Mud
32	Point	218700	1900	98	228	Mud
33	Point	218800	1900	99	228	Mud
34	Point	218900	1900	100	228	Mud
35	Point	219000	1900	101	228	Mud
36	Point	219100	1900	102	228	Mud
37	Point	220800	1900	119	228	Mud
38	Point	220900	1900	120	228	Mud
39	Point	221000	1900	121	228	Mud
40	Point	221500	1900	126	228	Mud
41	Point	221600	1900	127	228	Mud
42	Point	218700	2000	98	227	Mud
43	Point	218800	2000	99	227	Mud

Record: 3360 Show: All Selected Records (0 out of 16925 Selected.) Options

Figure 16 – Part of the final attribute table, showing the location (columns and lines) of different sediment types in the model grid (see text).

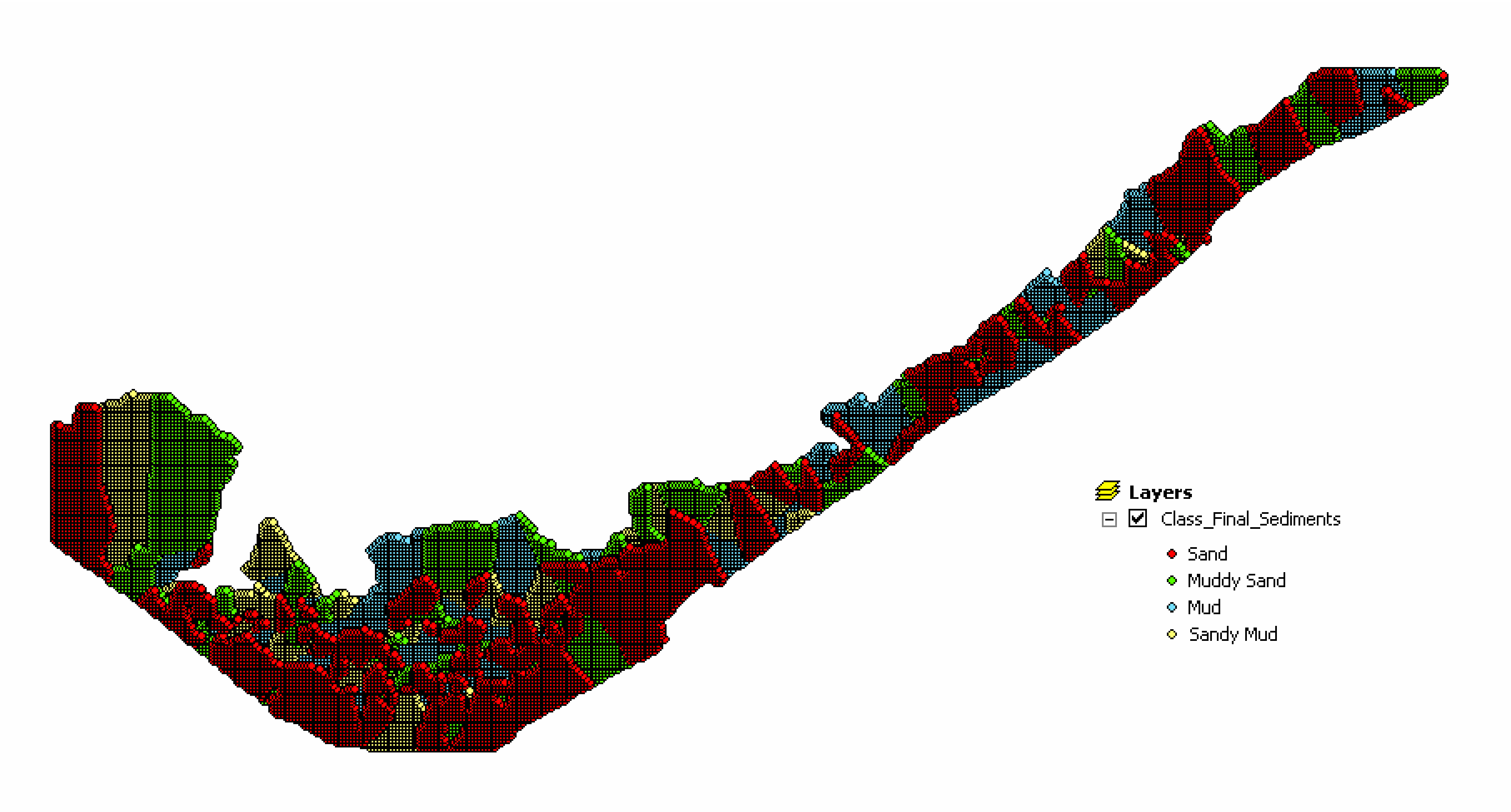


Figure 17 – Final sediments distribution layer clipped with the model grid.

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