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The nautical charts of the Spanish Mediterranean coasts in the 18th and 19th centuries: digital methods to compare the cartographical techniques of the main European Navies

Keywords: history of cartography; nautical charts; Spanish Mediterranean coasts; GIS, cartographic databases; cartographic heritage; 18th century.

Summary

Inside the frame established by the Council of the European Union about Digital Libraries, we are creating a complete and multilingual database on Spanish Ancient Cartography. The database includes digitised atlases, as well as maps at different scales, views and nautical charts, and is being associated to a GIS. The database allows to identify and to compare easily the cartographic documents of an historical period, as well as the different surveying and drawing techniques that have been applied in each case. An accurate knowledge of the coasts and the ports of the foreign nations has been an essential target for the different historical sea powers, whose naval war strategies mainly depended upon it. The Spanish Mediterranean coast has been particularly important since early times of the ancient historical cultures, that settled there their colonies and built fortresses until the 19th century. We have focused our search on the spherical nautical charts of these coasts that were drawn at the 18th and 19th centuries, in order to compare those that were produced by the Spanish cartographers with those produced by other European naval powers as England, France and Italy. And as a case study we have chosen the series of the spherical nautical charts of the Javea Bay (Alicante, Spain). We have applied some modern GIS tools to the digital images of the charts such as the georeferencing, in order to superpose the different seashores and their depictions. This search has evidenced the particular targets of each Nation, their cartographical techniques and their accuracy. Through those comparisons we can expose some concluding remarks, as the strong accurate methods applied by Vicente Tofiño de San Miguel in 1789 in his *Atlas Marítimo de España* (Atlas of the Spanish Coasts), where he applied the experiences of precedent French cartographers as La Hire and Picard.

Introduction

The Project of the Digital Map Library that we are developing collects all kinds of maps, plans, drawings and charts made by Spanish and foreign cartographers at the service of the Crown of Spain, which are kept at major Spanish archives and libraries.

The Project offers the possibility of comparing different cartographic documents made on the same territories in different historical periods. These comparisons can be established in many areas of study of cartography, ranging from the contents of the maps (the territory represented) to the mapping techniques, including the analysis of different methods of surveying. The comparison also evidences the evolution of map symbols and the precision of successive maps, showing the skill of the cartographers and the accepted accuracy depending on the various uses of the map.

A particular case study is the charts as they evidence the need for an increasing knowledge of the coasts for strategic and defensive purposes. The important work developed by the Spanish Navy

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on the successive hydrographic campaigns, undertaken along the 18th century, yet remains unknown to the public and the scientific community.
The result of those campaigns was a complete collection of charts of the Spanish and American coasts (along the Atlantic Ocean from the east coast of Florida to the Strait of Magellan, and in the Pacific along the coast of Chile to Nootka), as well as of the Philippines, the Marianas, and other islands in the South Pacific. This interesting collection of nautical charts was drawn applying scientific methods, whose accuracy has only been enhanced with the recent introduction of the georeference by GPS.
The case of the Spanish coast of the Mediterranean is particularly important because it has been a military target sought after by different nations from the Middle Ages until the 19th century (Fig. 1).

Figure 1: Anonymous, *Portulano the western coasts of the Mediterranean* (ca. 1550), manuscript. Madrid, Museo Naval.

Those circumstances led the different European naval powers to build their own charts.
The transition from the 'literary' maps to scientific cartography can be clearly appreciated, as they show clear differences in both the type of representation and in accuracy. Their comparison can be of great interest for the understanding of the evolution of European scientific cartography.
This paper will also assess this transition from literary to scientific cartography along the 18th century.

First steps of the scientific cartography

The main rival powers of Spain in cartographic production during the 18th century were France and England.
In France the desire to develop scientific cartography began with Colbert with initiatives like the foundation of the *Academie des Sciences* (1666) and the Paris Observatory (1667). Of great importance for the drafting of nautical charts was the creation of private schools such as Dieppe, and the creation of the *Hydrographes du Roi* (1699), so that already in 1689 France had completed the surveys of the French coasts. Chazelles and Père Laval had worked on it, and there were also other important cartographers as Cassini and Borda (who participated in the measurement of the

arc of meridian between Dunkerque and Barcelona), whose works culminated in the formation of the *Dépôt Général des Cartes et Plans, Journaux et Mémoires concernant la Navigation* (1720).
The *Dépôt* was successively directed by Jacques Nicolas Bellin, Rigobert Bonne, Buache of Neuville and Beautemps-Beaupré, that promoted many hydrographic campaigns as those on the coasts and harbours of the Atlantic and the Mediterranean seas (conducted by Pène, Michelot and Bremond, Ayronard, Bougard, etc.), and on the Pacific ocean (Baudin 1800-1803, Freycenet 1817-1820, Duperrey 1822-1825, Dumont d'Urville, etc.).
The travels of Chappe d'Auteroche to Siberia (1761) and to the Lower California (1769) must be also mentioned, as he was accompanied by the Spanish cartographers Doz and Medina with the target of observing the transit of Venus. And also the expeditions of Bougaiville that made several measures of the position of the Canary Islands and explored the Strait of Magellan (1766), and the one of Count de La Pérouse (1741-1788) along the shores of the Pacific between America and Asia, later completed by Bruny d'Entrecasteaux (1800-1803).
As a result of these campaigns numerous books, nautical almanacs and manuals were published in France during the 18th century, like those of Bellin *(L'Hydrographique Français* and the *Petit Atlas Maritime,* 1764), Bonne *(Atlas Maritime* and *Neptune Northern Amerique, 1762),* Buache *(Neptune of Baltique,* 1785 and *Coasts of France,* 1824), and Charles Pène *(Le Neptune français ou Atlas Nouveau des Cartes Marines,* 1693) among others. Concerning the Mediterranean coasts, the following atlases and charts were edited:

- *Recueil de plusieurs plans des ports et rades de la Mediterranee,* 1730, by Michelot and Bremond.
- *Recueil de plusieurs plans des ports et rades et quelques chartes particulières de la Mer Mediterranée,* 1732-1746, by pilot Jacques Ayronard, engraved by Louis Corne, and with a remarkable shaded relief.
- *Le Petit Flambeau de la Mer,* by lieutnant R. Bougard, a seamans manual that contains 67 cards and was widely used in the sailing schools from 1684 until 1817.

The British initiatives to get reliable navigation and a scientific approach to cartography increased with the creation of the Greenwich Observatory in 1675 and the charge of the Royal Astronomer (Flamsteed, Halley, Newton, etc..), and culminated with the creation of the British Hydrographic Service of the Admiralty (1795). It became the largest center of cartographic production of Europe, and promoted numerous exploration expeditions.
The activities of its first director Alexander Dalrymple must be highlighted, as he impulsed the surveying campaigns of William Henry Smith in the Mediterranean coasts. The second director Thomas Hurd, was an active publisher of navigation books *(Sailing Directions, Light List, Tide Tables,* etc.).
The British Hydrographic Service organized many expeditions as those of Flinders to Australia (1801-1803), of Smith both to the Indian and the Pacific Ocean, of Horsburg to the Far East and of Broughton on the coasts of China and Japan. But we must also highlight the findings of Lord Anson's circumnavigation (1740-1744), the surveys of the Strait of Magellan by Commodore Byron (1764-1766) and by Walls and Carteret (1766-1769), as well as the travels of James Cook (1768-1779), later completed by Blight (1787), Mackenzie (researcher of magnetism) and Vancouver (1791-1795); and even the later travel of the Beagle (1826-1836) with the participation of Darwin.
Among their remarkable results some publications can be mentioned, as those by:

- Barre, author of the excellent *Atlantic Neptune* (1734), that used the Greenwich meridian as the origin of longitudes for the first time.

- Dalrymple, author of the treatise of navigation *Essay on Nautical Surveying* and editor of many documents of some previous explorations.
- Murdoch Mackenzie, author of the *Treatise on Maritim Surveying* (1774).

The secret Spanish Hidrographic Campaigns

Unlike the French and British hydrographic campaigns, the Spanish governments chose to keep the policy of secrecy that had been practiced since the beginning of the mapping of America in the late 15th century, were the *Padron Real* began to be drafted.
This silence was also due to nonsensical reprisals from politicians and court intrigues, and led to abort major initiatives and to remove (or even punish) their leaders, erasing from the collective memory all their cartographic achievements.
Finally, some international conflicts such as the *Nootka Sound Controversy* helped to spread false topics about the Spanish behaviour overseas, that affected directly the Spanish scientific image and production. All those circumstances shaped a negative opinion about the Spanish scientific contributions (remember the infamous remark of Nicolas Masson Monvilliers: "What do we owe to Spain? For two, four, six centuries, what has Spain done for Europe? ") that, unfortunately, still remains present in many areas.
But the campaigns and initiatives in cartography led by Spanish scientists were numerous and remarkable.
With the reorganization undertaken by the first Bourbon king Philip V, and conducted by the Auditor General de la Marina Vicente Patiño since 1717, ended the activities of the *Casa de la Contratación*. Modern Navigation Schools for training the Spanish Navy pilots, officials and experts in nautical astronomy were created. In 1748 they were renamed *Cuerpo de Pilotos de Altura*, and were responsible for drafting the maps of the various scientific expeditions in the second half of the 18th century. The officers of the Spanish Army reached a scientific level equivalent to those of the other contemporary naval powers.
Among the most important cartographic and astronomical initiatives that must be cited are the several proposals about the formation of the *Geometric Map of Spain* by Jorge Juan (1751), by Alcalá Galiano (1796) and by Espinosa y Tello (1792, 1800), and the foundation of the Observatory of Madrid (1757).
But we must also mention the numerous Spanish campaigns overseas in the 18th century, as:

- The travel for measuring the meridian arc of La Condamine to Peru (1735), accompanied by the marine officers Jorge Juan and Antonio de Ulloa.
- The expeditions led by the Marquis de Valdelirios (1753-1756) to explore the borders of Paraguay and Portugal, and the one of José de Iturriaga in the Orinoco (1754-1760), and of Millau and Maravall by the borders of Rio de la Plata (1768), completed by Madariaga a year later. The jesuit Jose Garcia (1765-1767) explored the Rio de la Plata to the Patagonia, and Jose Dominguez the south of Chile (1763); Peri also visited the Patagonian coasts (1767-1768), and Ugarte and Mansilla to the 53° S (1767-1768). Also worth mentioning are the campaigns of Pando (1768-1769) and Goycoechea (1770) along the coasts of Tierra del Fuego, and of Machado to the western islands of Chile (1768-1769); the later of the Garcia del Nodal brothers to the Straits of Magellan and Le Maire (1776); those to the mouth of Black River (1778) by Viedma and De la Piedra, and to the rivers Colorado, Negro and Limay by Villarino and Francisco de Viedma.
- The expedition of Langara along the Brazilian coast (1774).

- Those of Cavantús and Alvarez in Honduras and the Mosquitos Coast (1758-1771), and some years later those of Sierra Estévez (1776) and Obregon (1783), of Muñoz (1767) and Alderete y Valderrama, and of J. Gonzalo Ruiz in the Yucatan (1788).
- 1777-1779 campaigns to the Gulf of Mexico and Nicaragua, commanded respectively by Ulloa and F. Javier Vargas; the one of Jose de Evia (1785) along the west coast of Florida and the Gulf of Mexico, and of Jose A. del Río on the East coast of Florida (1787), completed by Ceballos and Herrera.
- The travels of Arevalo and Monti to the Darien (1761), and the later of Juan de Carranza (1785).
- Those of Aragon (1773) and Girón (1782) in Cuba, continued by San Martin (1783) and later by Ventura Barcáiztegui (1790); the hydrographic works of F. Ramón Mendez in Puerto Rico (1782), in Jamaica by Obregón (1786), and of Juan Enrique de la Rigada in the channel of the Bahamas (1792).
- The successive campaigns of the *Santa Expedition* to the Alta California of Vicente Villa and Juan Pérez (1768, 1769-1770, 1774). His work was continued by the explorations in the northern Pacific due to Hezeta, Bodega y Quadra and Ayala to the 58 º N (1775); also those due to Bodega, Arteaga and Quiros to the Prince William Sound (1778), and the same year the campaign of Jose Esteban Martinez. Their steps were followed by Martinez and Lopez de Haro to the northern Pacific to the 58 º 32' N (1786); to Nootka by Esteban José Martínez (1788); but also by Eliza, Fidalgo and Quimper in search of the Northwest Passage (1790). Among the most relevant travels is the one of Alejandro Malaspina and José Bustamante (1791) following the route of Fidalgo, later continued by Alcala Galiano and Valdés (1792). The travel of Caamaño to Nootka (1792), those of Juan Bautista Matute and of Eliza to the port of Bodega (both in 1792). Bodega y Quadra made also an expedition together with Vancouver to delimitate the territories of the sovereignties of Spain and Britain in the current Canada (1792).
- The campaigns promoted by the Virrey Amat as those of Gonzalez Aedo and Domonte to the South Pacific (1770-1772), those of Boenechea and Joseph Andia to Tahiti (1772-1773, 1774-1775), and those developed in the following years by Langara.
- Antonio de Cordoba went into the Strait of Magellan (1785-1786), Moraleda in Chiloé (1787-1790) and Patagonia (1792), Murillo in the Chilean coast (1788), and Antonio de Cordoba and Fernando de Miera went into the W sector of the Strait of Magellan to the Pacific (1788-1789).
- The Malaspina and Bustamante expedition (1789-1793) from the Canary Islands to the Falkland Islands and Montevideo, the Strait of Magellan, Chile and Peru coasts to San Blas, North Pacific, the Philippines and Australia.
- The travels of Espinosa y Tello with Bauzá across South America. And those expeditions into *Tierra Firme* of Fidalgo, and those of Churruca in the Antilles, both targeteed to draft the *American Atlas* (1795).

The work developed by the Depósito Hidrográfico was also very important since its creation in 1797. The former director was Jose Espinosa y Tello, followed by Felipe Bauza, that continued producing maps and charts during his exile in London until his death in 1834.

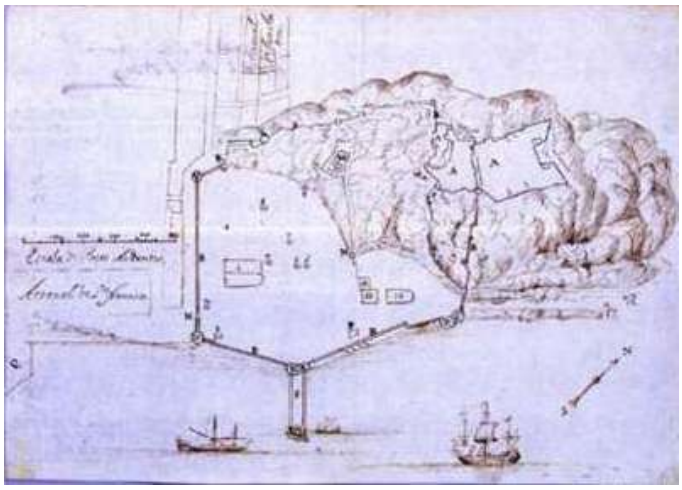

Figure 2: J.B. Palavivino, *Declaración del recinto de la ciudad de Alicante en la forma que ahora se alla* (1693), manuscript. Barcelona, Archivo de la Corona de Aragón.

About the hydrographic campaigns on the Spanish peninsular coast of the Atlantic and the Mediterranean, must be mentioned the important one led by Vicente Tofino with the aim of drawing the *Maritime Atlas of Spain* (1783-1787).

Until then existed the 'literary cartography' that gave an idea of the topological relationships between different landmarks and towns on the coast, but that could not be used to make measurements or to navigate because of its lack of accuracy (Fig. 2).

The principal exponent of such maps was the work of Tomás López and his atelier, who was trained in Paris with Bourguignon d'Anville and developed since 1760 a huge collection of cartographic production by compiling the geographic information (Fig. 3). There are lots of similar examples printed abroad (Speed 1626, Wit 1675, Coronelli, 1691, Sanson 1692, Keulen 1695, Nolin 1698, De Fer 1705 Vaugondy 1775, etc.).

But there were also some important precedents of the hydrographic work of Tofiño, as the numerous surveys carried out by the military engineers and other marine officers during the 18th century. Although they were not spherical charts, and their maps were very often associated to projects for the construction of ports, fortifications, etc., they achieved a remarkable degree of accuracy in mapping small areas (Fig. 4).

Figure 3: T. López, *Mapa del Reyno de Valencia* (Madrid, Imp. A. Sanz, 1762).
Valencia, Fundación Giménez Lorente.

Fig. 4, A. Berlinguero, *Proyecto de puerto en Denia, Alicante* (1780), detail, manuscript.
Madrid, Museo Naval.

The *Maritime Atlas of Spain* (1785-1789)

The works began in May 1783 by order of Charles III, according to the project of Antonio Valdés y Bazán, Secretary of State and of the Despacho Universal de la Marina.
The project was assigned to the brigadier of the Spanish Royal Army Vicente Tofiño San Miguel y Van der Walle (1732-1795), director of the Academy of Guardias Marinas in Cadiz, and responsible of the foundation of the Royal Astronomical Observatory (which was praised by French scientists like Florien, Borda and Verdu de la Crème). He was also the author of several works on mathematics and astronomical observations to be used by the seafarers.
Between 1785 and 1788 he dealt with the formation and publication of the *Maritime Atlas of Spain* (Madrid, Dirección de Hidrografía, 1789), a work of great quality and beauty that includes 47 maps engraved by Carmona, with a cover of Raphael Mengs (son of the famous painter) (Fig. 5).

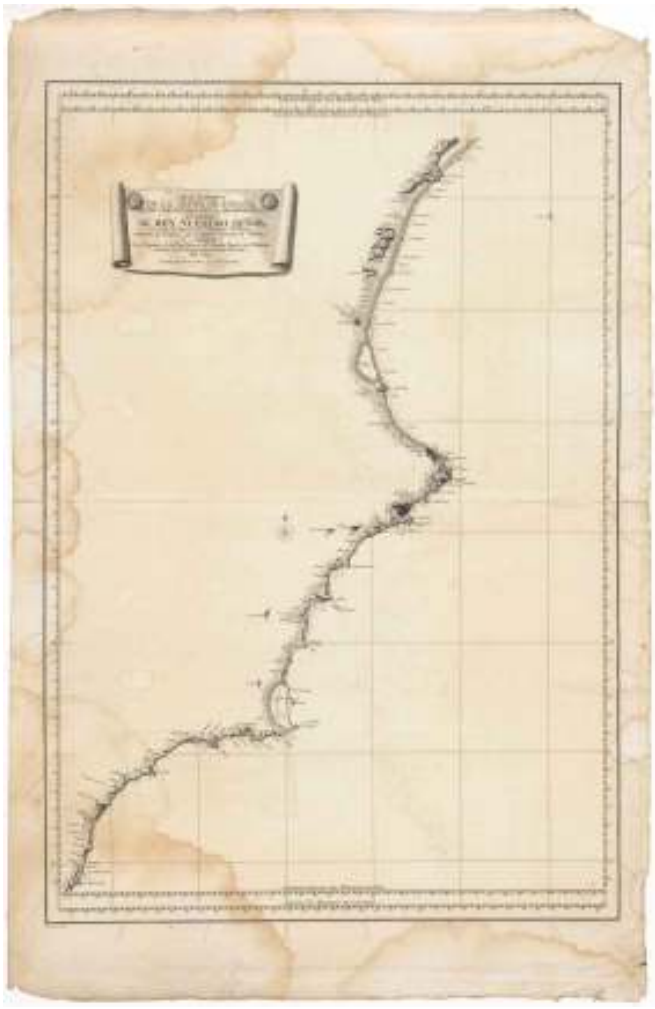

Figure 5: V. Tofiño, *Carta esférica de la costa de España desde Cabo de Gata hasta Cabo de Oropesa* (Madrid, Dirección de Hidrografía, 1789). Madrid, Museo Naval.

In 1787 he published as a supplement the *Derrotero de las costas de España en el Mediterráneo y su correspondiente de África para la inteligencia y uso de las cartas esféricas* (Madrid, 1787) and two years later appeared the *Derrotero de las costas de España en el Océano Atlántico y de las Islas Azores o Terceras para la inteligencia y uso de las cartas esféricas* (Madrid,

1789).
The *Atlas* was the result of an extensive campaign of surveys and triangulations of the coasts carried out by a group of officers of the Army under the command of Tofiño, formed at the Astronomical Observatory of Cadiz. They were Alejandro Malaspina, Dionisio Alcalá Galiano, Jose Ortiz Canelas, Juan Vernacci, Jose Espinosa y Tello, Felipe Bauzá and Cayetano Valdés.
To draw the charts they applied a combined method of geodetic triangulation, astronomical observations and estimates, and the result was an accurate product of scientific cartography that served as basis to the charts of other foreign naval powers, and even to the *Spain's National Topographic Map* 1:50,000.

Case study: the charts of Las Marinas coast in Alicante (Spain)

The area where we have proposed to compare the different charts is Las Marinas, on the coast of Alicante (Spain).
Inhabited since the Phoenicians in the 4th century bC, their geographical references and landmarks are visible from the sea and have facilitated seafaring since the Antiquity.
Among them are several mountains as the Montgo in the North, and Granadella and Puig Campana mounts descending towards the South; the main capes from north to south are those of San Antonio, San Martín, Nao, Moraira and the Peñón de Ifach; and among the ports can be cited those of Denia, Javea, Calpe and Altea.
Our comparison is proposed on the port of Javea (Xavier) area, that was fairly depicted by Tofiño (1787, p. 185) in this *Derrotero* of the Mediterranean coast, as in pictures like the one of Mariano Sánchez (Fig. 6).

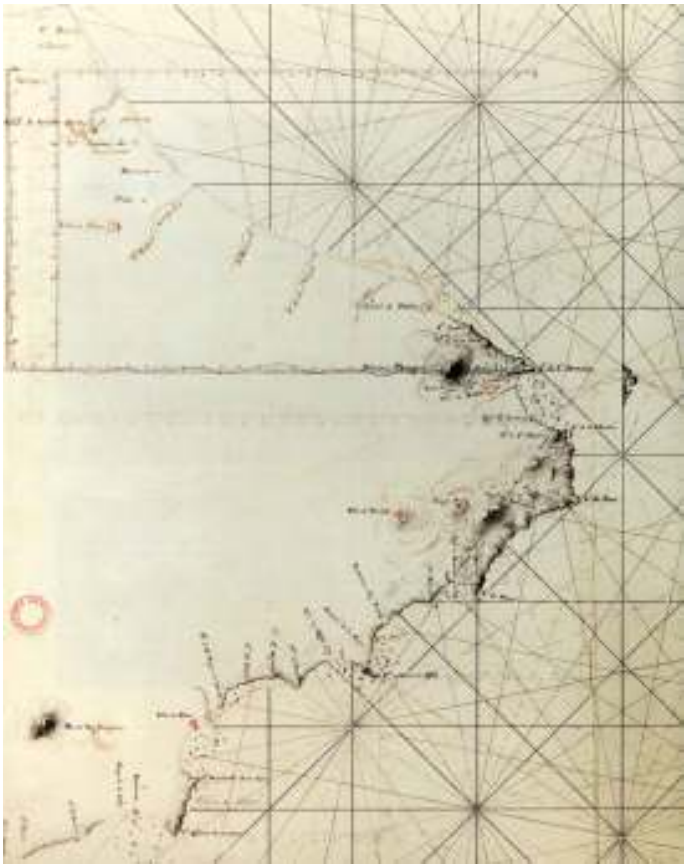

Figure 6: *Carta de la costa del Mediterráneo en Alicante* (19th century), detail of Las Marinas, manuscript. Madrid, Museo Naval.

Figure 6 : M. Sánchez, *Cabo de San Antonio y fuerte de San Jorge* (1780), oil on canvas. Madrid, Patrimonio Nacional.

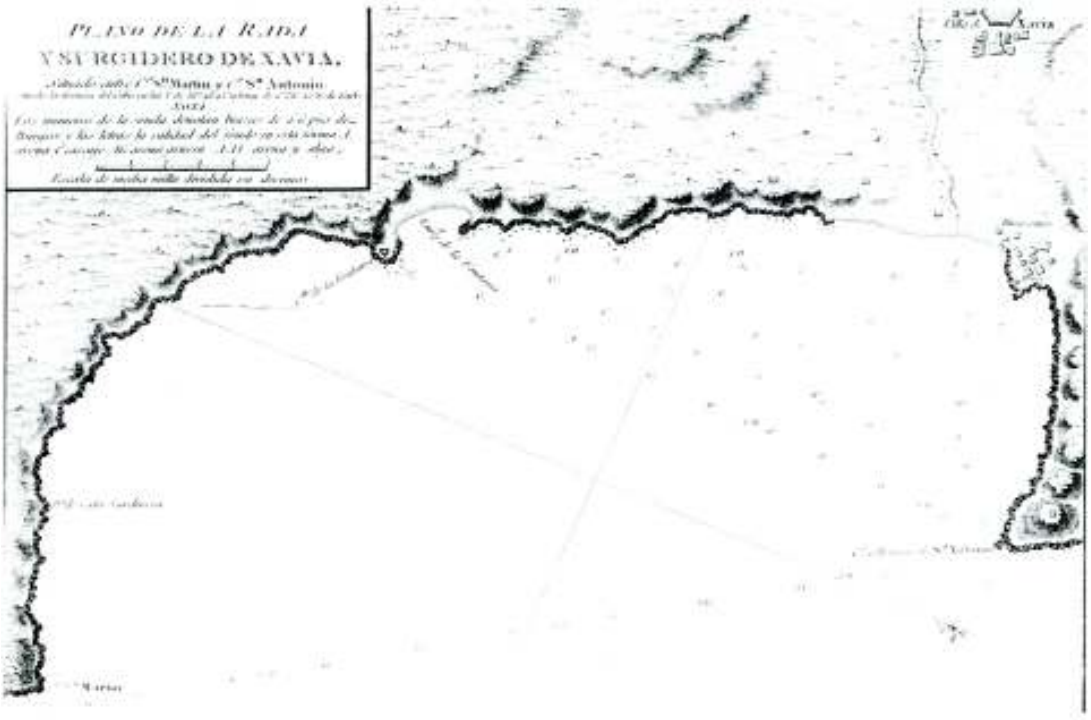

Figure 7: Spanish Army, *Atlas portulano de las Costas de España y Portugal: Plano de la Rada y surgidero de Xavia, situado entre el Cº San Martín y el Cº San Antonio* (1812). Madrid, Museo Naval.

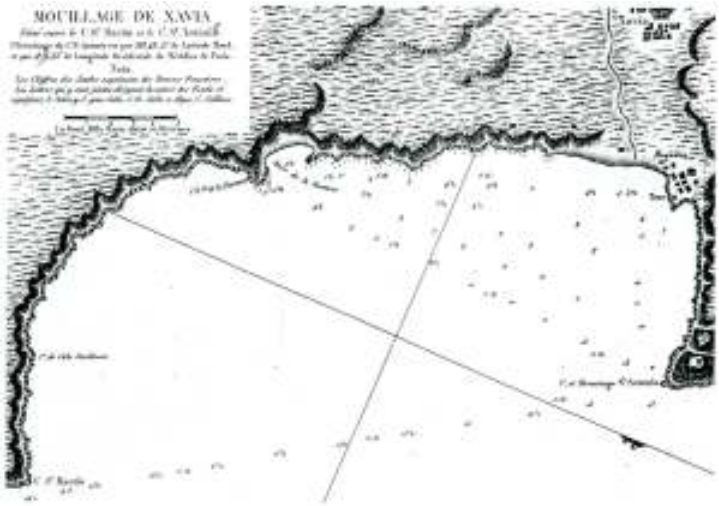

Figure 8: French Army, *Mouillage de Xavia* (19th century). Madrid, Museo Naval.

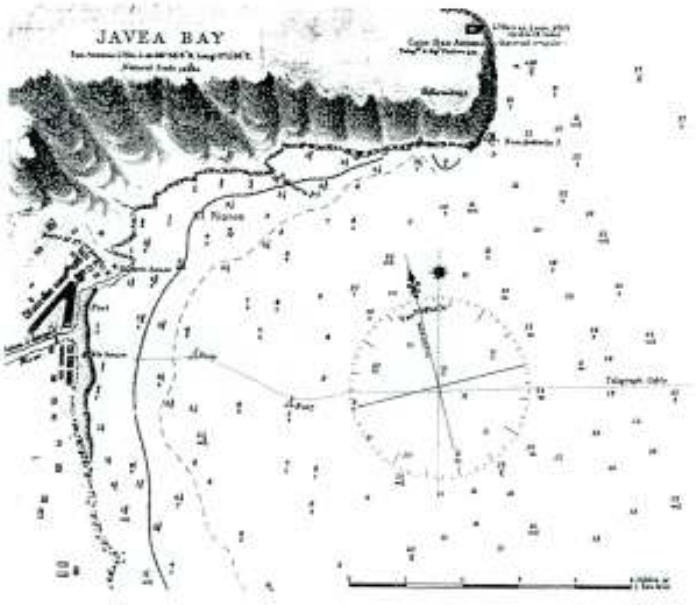

Figure 9: British Army, *Javea Bay* (19th century). Madrid, Museo Naval.

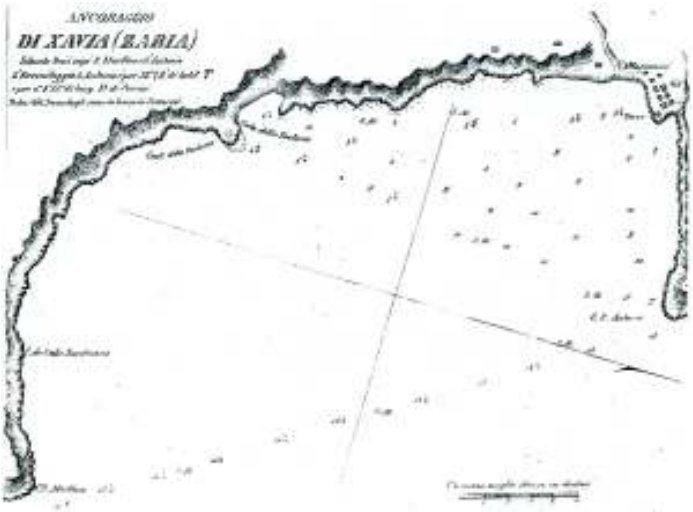

Figure 10: Italian Army, *Ancoraggio di Xavia (Zabia)* (19th century). Madrid, Museo Naval.

The charts that we are comparing are respectively drafted by the Spanish, French, English and Italian Armies in the early 19th century.

Digital technologies and particularly Geographic Information Systems (GIS) allow new ways of integrating early maps with other information, combining historical maps and associated textual and numerical information to achieve a spatial analysis.

The possibilities that GIS tools and georeferencing bring to the study of the geometric content and accuracy of the early maps and charts are of special interest.

We have used as a basis the *National Topographic Map* 1:50,000 (MTN, 1945 edition), where we have identified the geodetic vertices (the lighthouse at Cape San Antonio, the tower of the church of Javea, the East point of Cape San Martin, the vertex of mount Montgo), in order to have a common coordinate system.

Afterwards, those control points have been transferred to the four charts to get a proper georeferencing.

We have planned to follow two main strategies:

- The use of geometric transformations (scaling, rotating, but not stretching).
- And the application of transparencies to the charts.

The application of the scale factor and the rotation angle should determine an affine transformation. But the control points have revealed that the triangles of the local maps and the MTN were not affine, and that other control points did not superpose.

Those strategies allowed us to observe differences in the delineation of the coastline and the variation of the morphology of the geographic elements in the coast (Figs. 11, 12 and 13).

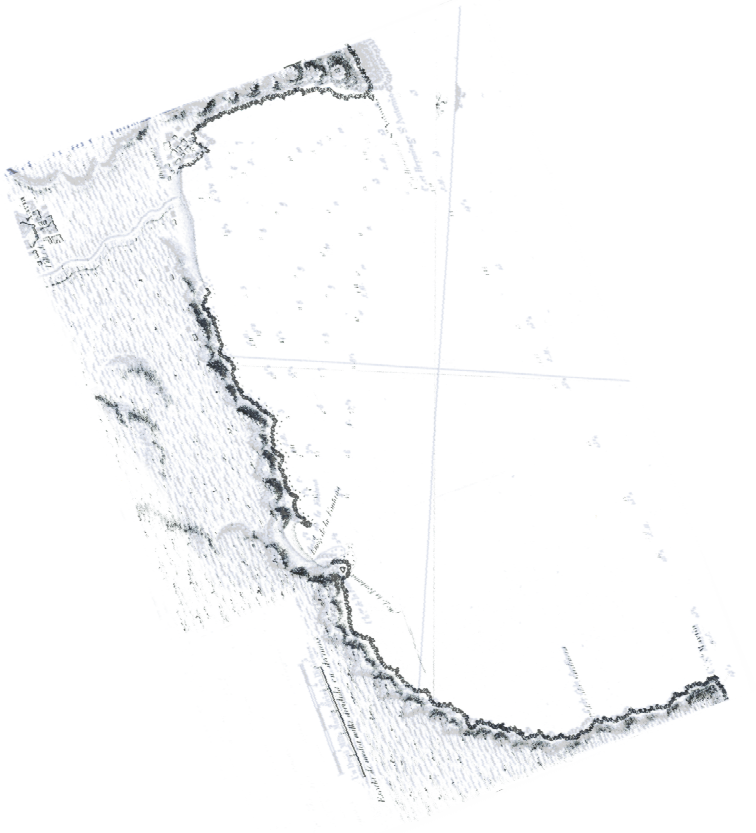

Figure 11: Overlay of the Spanish chart (black) and the French chart (gray-blue).

Figure 12: Overlay of the Spanish chart (black) and the British chart (green).

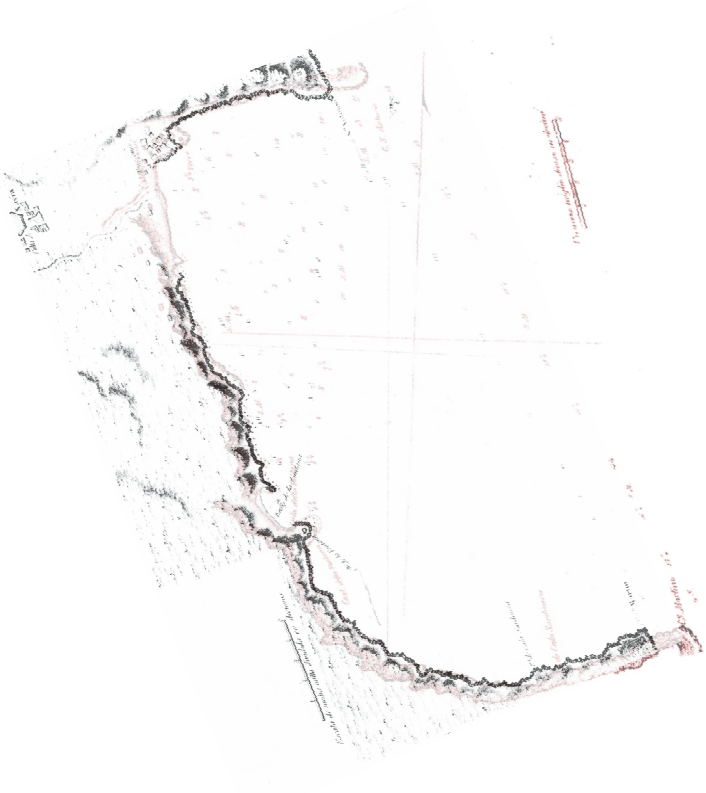

Figure 13: Overlay of the Spanish chart (black) and the Italian chart (red).

It is possible to appreciate that the largest distortions are concentrated in three main areas:

- In the southern shoreline of the bay.
- In the length of Cape San Antonio at the NE.
- In the length of Cape St. Martin at the SE.

There was also a greater overlap in the coastline between the Spanish and English charts, against the most schematic French and Italian ones.
Those facts demonstrate a lack of accuracy on the later ones and of the surveying techniques employed by the French and the Italian Armies at the beginning of the 19th century, or even the tradition of copying other foreign charts.
It also allows comparing the symbols employed to represent the topography, the villages and constructions, the ports and the depth of the cove, etc.

Conclusion

The Spanish contribution to the history of modern cartography and science remains almost unknown, both in the national and the international scopes.
This situation is mainly due to internal political matters that took place along the 18th century. They imposed an unfair silence about the importance of the Spanish cartographic campaigns, that were mostly led by the Spanish Army: the several proposals about the creation of a national map (Jorge Juan, Espinosa, Alcalá Galiano), the hydrographic expeditions to America, the Philipines and the Marianas (Malaspina and Bustamante, Alcalá Galiano and Valdés, Espinosa, Gutiérrez de la Concha, etc.), and the *Maritime Atlas of Spain* (Tofiño).
Our search proposes to study and spread such an important and unpublished heritage, focusing on the search on the cartographic and bibliographic materials, as well as on the instruments and techniques that were applied on the hydrographic and cartographic works.
The results will be also compared with those reached by the contemporary campaigns organised by other European countries. Our main targets are: 1/ to find, study and spread the cartography, the instruments and the techniques of the different expeditions, approaching from the point of view of the history of science and of the history of the Spanish cartography; and 2/ to compare the methods of both the Spanish campaigns and the foreign contemporary ones on the same territories.
The comparison has been made by georeferencing each chart, with the aim of superposing them and checking their accuracy.
The search took place at the different Spanish and foreign archives and museums, with the aim of finding the maps, instruments, letters and books that were used at the different campaigns.
Those unpublished materials will supply a new and complete approach to the methods and techniques applied on the land surveying and the map making. Their comparison will provide a new approach to their evolution.

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