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Coastal landscape as part of a global ocean: two shifts

Hervé Regnauld¹ and Patricia Limido²

Oceans and seas have long been considered as distinct areas, different from one another. At the end of the eighteenth century the idea began to appear (among romantic painters and poets) that they all formed a single space that would be a 'global ocean'. Humboldt was the first scientist to take this idea seriously and to study oceans as a 'whole'. He drew the first map (with isotherms) which could explain why oceans had to be understood as a global climatic machine. Since then the global behaviour of the ocean has become an undisputed scientific fact and many artists have produced paintings which 'represent' this state of knowledge. During the same period the coast lines were not considered as a global scientific object but as a discrete series of sites, all different from one another. Tourism was partly responsible for this division of coasts as each tourist place had to show it was unique and worth being visited. Many painters helped to highlight certain sites (Hudson River, Normandy, south coast of England). Then, at the end of the twentieth century some new equations dealing with sea level allowed the idea there was something like a global coastline, responding to a global climatic forcing. Few artists today tend to work with this global idea of local coasts but some of them, taking part in scientific cruises or fieldwork, do produce a new type of image for a global coastline.

Key words oceans; images; mapping; global environmental images; coastal; art; coast; sea level

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The concept of a global ocean is a relatively ancient idea that turned into a scientific paradigm only at the beginning of the nineteenth century. In Kant's geography for instance it is hardly present, but the concept was developed considerably during Humboldt's travels to South America, and further elaborated later by Darwin and other geographers, hydrologists and geologists such as Wallace, Penck and Wegener to name only a few. The interesting point here is that the shift between Kant's idea (that there are different seas) and Humboldt's one (that there is such a thing as a global ocean) is based on a very clear opposition between on the one hand pure Kantian rationality, and on the other an almost romantic feeling of how a scientist should work, draw maps and paint landscapes for scientific purposes, such as Goethe and Carus did. The concept of a global ocean emerged in other words out of a whole set of global scientific and romantic images.

A second shift, from a global ocean to a global coastline, which we will also analyse in more depth in this

article, is much more difficult to assess. It took place during two distinct episodes, the first consisting of turning coastlines into discrete, non-global, site-specific features; the second helping to re-unify these features according to three new scientific concepts. During the first episode which took place during the nineteenth and most of the twentieth centuries, coastlines were solely taken into consideration as local sites, as 'interesting' environments (places, sites, cities, etc.) especially during the rise of tourism. Coastlines, for instance, were socially created as 'interesting' places also because Princess Eugenie frequently travelled to Biarritz, and English tourists enjoyed visiting Nice, Naples or Corfu (Corbin 1988; Goeldner-Gianella 2001). Hence each part of the coastline had to express or to represent its own, very particular singularity. Political issues were also essential as coastlines often expressed the actual limits of a country (visualised mostly with the help of a line on a map) and they were the starting points of numerous colonial sailing

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Page 1 | 2016 | Volume 3 | Issue 2 | e00029

adventures. Within the visual realm, German painters (such as Friedrich, Goethe and Rottmann) had a crucial influence on this development and Pre-Raphaelites (such as Millais or Waterhouse) played an important role too, together with Impressionists painting Etretat or Belle Ile, as well as Gauguin painting the Marques Islands. The result was a general trend to consider coasts as *local*, picturesque sites, all different from one another. This also had ramifications within the sciences. In the Earth sciences, this development spurred a whole set of classifications of coasts involving many different typologies. In particular, within this context, images played a fundamental role because they helped convey the idea not of a global landscape but of a fragmented one.

During the second episode (during the last three decades of the twentieth century), a global view of coastlines slowly began to emerge, yet only after three relatively new scientific concepts became important: the mobility of the sea surface, the sedimentary budget of the coasts, and accommodation space.¹ However, as these concepts are closely linked to processes, movements, transformations and changes, they cannot be easily represented by static images. As a consequence, present representations of the global coastlines are more often films, videos, performances and installations than paintings. This critical role that images play in science does not mean that no other causes have played some important part in the building of a global ocean and of a global coastline. As Brunet *et al.* (1999), Durand *et al.* (1992) and Steinberg (2001) have shown, the idea of a global ocean also derives from social factors and abstract (non-visual) ideas. It developed at least in part out of the quest to find a marine equivalent to the terrestrial idea of 'territoire', which in French is called 'meritoire'. This however is not the object of our paper which deals with the role of images. The proper epistemic question this paper wants to tackle concerns the fundamental role images play in science. As we would like to argue here, images are not only illustrations but they can also interact with theoretical issues and contribute to the modification of theories. Images may in other words lead to 'theory writing by other means' (Van Fraassen 2011, 112).

The importance of images in the slow building of a global ocean

Maps and images have played an important role in Western European geographical knowledge since the Middle Ages. Zumthor (1993) as well as Lewis (1999) studied in great detail the slow construction of the science of the Earth's surface. They explain that for medieval travellers there was no absolute separation of reality and imagination. For instance Zumthor writes about the 'inadequacy of opposing reality to imagination' (p. 306, our translation). Indeed, European

geographers working with travel reports were not always able to sort out what was real and what was not. Brook (2012) explains that a Chinese geographer, Zhang Xie in 1625, was probably the first non-European geographer to collect travel narratives and to write a book dealing with all the parts of the world where merchant ships (Chinese or European) had sailed. During the Modern period (Bayly 2006) geographical knowledge was built from stories and maps were drawn in order to illustrate these stories. It was only during the eighteenth century that naval officers began to organise the collections of spatial knowledge in a systematic, rational way – mostly in order to avoid errors. Joseph Banks the President of the Royal Society organised a network of observers: all the doctors of the British navy were advised to collect observational data and bring it back from their travels to London (Bayly 2006, 359) where it could be assembled into a coherent vision of the world and drawn onto a map.

During the same period Kant (1999) was the only modern philosopher who taught geography and collected his lessons in a book. In his geography course he explains that there are two sorts of sciences. Some sciences use different concepts (which he calls 'logical concepts') whereas other sciences describe different types of objects. Among these descriptive sciences, history describes the world according to time, geography according to space, yet both are descriptions and not logical theories. He writes: 'we have, by now no "systema naturae"' (p. 69). Anyhow 'Geography and History fill the whole of our knowledge, Geography for space, History for time'. Obviously, this statement is aimed at linking the two *a priori* forms (time and space) with two sciences. Kant's geography was published in 1802, whereas the Critique of Pure Reason was published in 1781, although Kant was already teaching geography long before he wrote the Critique. There are probably links between space as an *a priori* and geography as a description of space, but these links are complex (Ruby 1998) and will not be considered here. Our concern is rather with 'global environmental images' and Kant's point of view is of great interest here. Space as an *a priori* is a top-down conception, involving control of subjectivity and reason, but space is not a scientific, 'logical concept'. Nonetheless, space may be represented by textual descriptions: 'In Guinea it's the seventh wave which is the biggest' (p. 121); 'On desert islands dogs do not bark at all' (p. 74). In some parts of his text Kant takes for granted what he picked up in travel and exploration accounts and writings of other geographers. Although most of the time he tries to describe parts of the world in a way which makes their location understandable, there is also some sort of logical spatial order which is not linked to theory but to the actual location of climates and mountains. Indeed, the location of the

main continental features (forests, cities, roads) may, then, be described and explained: it is, for example logical that there is no forest in a desert. But this spatial order does not allow one to explain anything in relation to the seas. The problem is that it is very difficult to describe a mass of water because 'water has no form' by itself and only gives (or is given) a form to the surrounding lands (p. 95). Within this epistemic context, oceanic space simply does not exist at the same level of importance as terrestrial space. In Kant's geography there is consequently no description of the ocean as a global object but there is rather a long list of the various seas, gulfs, straits, internal seas, marginal seas and bays which all are part of the 'global ocean' (pp. 95–9).

This way of considering the ocean as a sum of different local seas may be understood as a wide epistemic issue in Europe at this moment. While Kant was writing, other philosophers had already thought about the two opposite ideas of resemblance and difference. They wanted to make science without confounding reality and imagination. Locke makes a distinction between imagination and judgement, and Burke (quoting Locke) writes that 'wit' is 'chiefly conversant in tracing resemblances' and that 'the business of judgment is rather in finding differences'. Therefore 'the most ignorant and barbarous nations have frequently excelled in similitudes' whereas scientific nations have disregarded similitudes and have searched for differences, with a rational act of judgment (Martinet 1980, 148). In this epistemic context, looking at all the seas as a global ocean is an act of mythology, whereas dividing the entire ocean into different parts is an act of science. In spite of this limitation, Kant actually writes that the world ocean is a reservoir for the totality of the earth's waters (p. 95). It is precisely here that the idea of a global ocean (Datson 2015; Besse 2015b) started to appear.

Around the same time (1800–03), Humboldt was sailing from Europe to South America and began to think about his 'geography of plants' (Gayet 2006; Buttner 2012). He also enjoyed sailing and being at sea (whereas Kant had neither sailed nor travelled outside of Europe). Later, while Humboldt was writing *Cosmos*, he explained that 'the contact with the sea implies directly a positive influence on the intellectual improvements of many various people' (2000 [1845], 298). He also added that great pleasure is to be found in the contemplation of nature (Péaud 2015a). This pleasure (the feeling of waves and wind) makes the scientist think differently about received ideas of stability, horizontality or sea level. This pleasure also moves our soul and comes to us 'as a mysterious inspiration' (p. 39): nature must be understood as a system that has an order and is organised according to laws. Here, the epistemic context is partly different from the Kantian one. The first main difference lies in the fact that science has some relations with the physical

pleasure of travelling, and a science dealing with space cannot be done inside of a cabinet. Fieldwork and the physical, bodily experience of the studied sites are absolutely indispensable. Yet on the other hand, for Kant and for Humboldt as well, nature does obey some understandable order. The second main difference between Kant and Humboldt is that for Kant this order is mechanical and not theoretical (location of climates for instance) whereas for Humboldt this order may be explained by theory, as for example a physical model of the air temperature and a rotating planet. Within this specific context, geography became a physical science. Henceforth, geography must not only describe the planet – it also has to explain it. In this precise case, geography has to explain why certain objects (for Humboldt: plants) are to be found at very specific places and not elsewhere. Hence the status of an image (such as a drawing showing plants along the slope of a mountain) had to change in a profound way (Péaud 2015b). Images could no longer serve as mere illustrations but they also had to incorporate an explanatory function, in other words they became models.

Figure 1 presents the first map describing temperature in order to explain plant locations. It uses isotherms, a term Humboldt coined for lines of equal average yearly temperature. These lines concern of course both oceans and continents because they are mainly caused by an interaction between three elements, the first two being the 'laws of nature', the third being a quantity of matter reacting to these laws. The two laws of nature describe the two main global controls, the inclination of the rotation axis on the ecliptic plane (23°27') and the driving Coriolis force. These universal processes act on a global object, a mass of water with surface currents forced by seasonal winds. The combination of latitude, Coriolis force and oceanic currents determines air temperature. And in the end, air temperature controls the location of plants, each plant being able to live within a definite temperature range and not elsewhere. It is important to note that nobody will ever 'see' an isotherm but that anyone may observe that there are no baobabs to be found in Iceland and no larch in the Galapagos. This map is one of the first and essential scientific images that helped coin the idea of a global planet because it represents something that exists and is invisible: average temperature. The planet has to be thought of as a whole, global object with universal laws. Yet these laws cannot be seen – just as no person can ever see the entire circumference of a sphere – but they can be made visible and rendered evident with the help of images.

This idea of a global, harmonious planet also relates to 'romantic' ideas, such as those expressed by Carl Gustav Carus. Carus was a scientist (1779–869) and painter and he believed that some metaphysical instance was overlooking the whole world, organising it in a logical and admirable way.

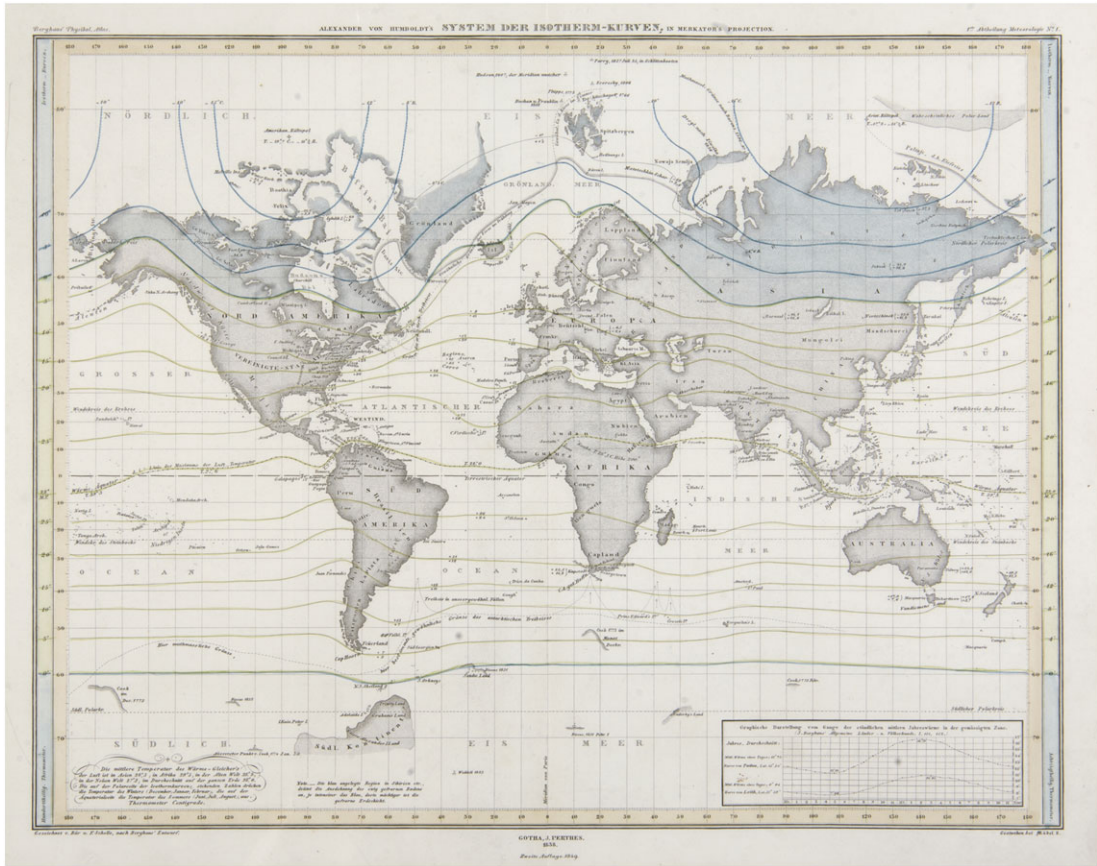


Figure 1 Isotherms as background for global mapping

Source: H. Berghaus, 1849, *Physikalischer Atlas*, vol. I, plate No.1. Available at: <http://cybergeog.revues.org/docannexe/image/25478/img-9.jpg>

While travelling to the Baltic Sea, Carus (1999) made a stop at the Rügen cliffs. He made several paintings (as Friedrich did some years before) but none of them may be exactly located because he did not paint a precise landscape, but rather the effect of landscape on his holistic understanding of nature (Figure 2). He painted the ocean so that it could be seen and understood as a global and ‘perfect’ effect of the laws of nature.

In one of his letters on landscape painting, Carus wrote: ‘[J]ust as any true investigation of natural history conducts us to the threshold of higher mysteries ... we may expect an open-minded consideration of art to do the same’ (Carus 2002, 82). According to Carus, art and science aim at the same higher mysterious level, which is the contemplation of the harmony of the natural world. They aim at making us ‘enter into the circle of nature and transcend ourselves’ (p. 65, for the translation above: p. 87). Carus and Friedrich’s (2003) writings and paintings have been very influential in this matter and they probably played an important role in helping Humboldt (who was himself a good painter) to conceive the global world with the help of

global images. According to Kwa (2005), Humboldt’s idea was to present the natural world as a ‘painted landscape’. He may also have been influenced by the writings of Anson, who sailed around the world between 1740 and 1744 and wrote that a marine officer who is used to drawing maps and landscapes acquires new abilities. He is able to see ‘parts he would otherwise have missed’. He is also able to reconstruct parts of the landscape he has not actually seen but that he can imagine without errors (Anson 1992, 24). This new way of using drawings and maps leads to a new epistemology for the so-called ‘natural sciences’. Sachs (2007) writes it is the beginning of an area of ‘humboldtian science’, which is obviously true if one thinks of the later works of Wallace, or Ritter.

Conversely Humboldt’s drawings also had an influence on art and especially on panoramas. Besse (2015a) has shown how ‘panoramas’ were specially drawn after Humboldt’s works. One of the most famous panoramas was by Hocquart entitled: ‘Le monde, ou panorama géographique rédigé d’après M. de Humboldt’ (79 cm on 52 cm). These works of art attracted



Figure 2 Moonlit night near the island of Rügen c.1819 by Carl Gustav Carus (1789-1869)

Source: © Staatliche Kunstsammlungen Dresden; German, out of copyright. Available at: https://commons.wikimedia.org/wiki/File:Carl_Gustav_Carus_-_Mondnacht_bei_R%C3%BCgen.jpg

a large audience and Humboldt was convinced that by producing and circulating many of these panoramas and powerful images, scientists could help men to get 'familiar with the unity of the world and make them feel the harmony of nature' (quoted by Besse 2015a, 65).

During the first half of the nineteenth century there is in other words a two-way interaction between images and science, which leads to the establishment of a global concept and of a global image of the ocean. Images and concepts do fit together and this tight bond lasted throughout the second half of the century, even when

Romantic ideas began to become out of date. Darwin, who visited many sites where Humboldt had been about 30 years earlier, also drew a map which shares this epistemological importance. His map deals with coral reefs.

Darwin explains (1982) that fringing reefs have formed in locations where there is no movement or only uplift. Barrier reefs have formed in locations where the land is subsiding. As volcanoes and fringing reefs coincide very often and are mainly along the borders of the oceans, there must be some link between positive tectonics, proximity of a continent and volcanic activities.

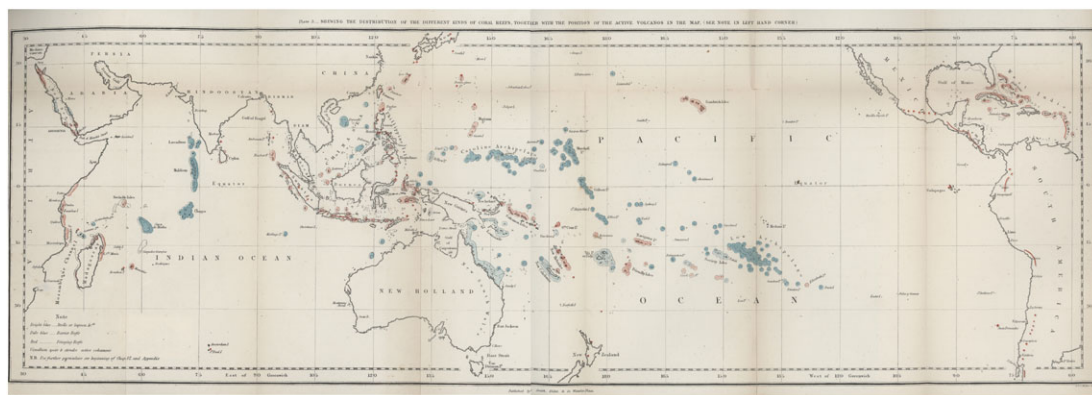


Figure 3 The structure and distribution of coral reefs by Charles Darwin, developed during his voyage of the Beagle 1832-1836

Source: This map was first published in "The Structure and Distribution of Coral Reefs" (London, 1842). Available at: http://landsat.gsfc.nasa.gov/wp-content/uploads/2015/06/20150617_nu1-lg.png. Atolls are in deep blue, barrier reefs in light blue, fringing reefs in red, and light red points are volcanoes

Conversely, blue barrier reefs are mainly in the middle of oceans, far from volcanoes and continents. Darwin concludes that there must be some sort of theoretical behaviour of the Earth's crust, suggesting 'that uplifts and subsidence obey to the same laws' (p. 272) and that these movements are very slow.

The two maps we discussed up to here (Humboldt's isotherms and Darwin's corals) differ greatly from usual maps (Figure 3). They do not aim at localising countries, routes, cities or travels. They rather show natural processes controlled by physical laws, implying that these processes and laws must be understood at a global scale. In this sense, these maps may be counted amongst the first models of a global forcing on natural behaviour and natural evolution. Moreover, most of these maps were presented and perceived within a larger visual context, mostly accompanied by illustrations of ancient ruins, landmarks and scenes of everyday life (Palsky 2010). Classic aesthetic codes were therefore important to both scholars: Humboldt drew many representations of vegetation zones according to these codes, and the same can be said of several of Darwin's figures (for the subsidence of volcanoes inside atolls for instance).

Figure 4, Humboldt's drawing of vegetation zones, is a typical example of one of these new kinds of drawings. It may be seen as a classical representation of plants with a very descriptive depiction of each tree. In this respect there is nothing new and it looks like an illustration that may be found in many travel reports (such as Cook's or Bougainville's reports). But there is more to it. The three mountains are located at different latitudes, far from one another and no scientist may ever see the three together. The apparent realism (mimetic resemblance) does not refer to an actual landscape but rather to a natural law, which is the variation in average temperature with altitude and latitude. So what is drawn here does not exist for the natural perception, but for a scientist it is true anyway.

The role of drawings, which 'represent' things that exist and have a scientific meaning but that cannot be seen, has also been very important for sea floor studies. The first maps of the submarine relief were not only drawn with the help of curves but also in perspective (Palsky 2009) from a bird's eye view that could 'see' through water.

Marie Tharp was working in the Lamont Observatory in Columbia University but as a female she was not allowed, from 1948 to 1965, to participate in the

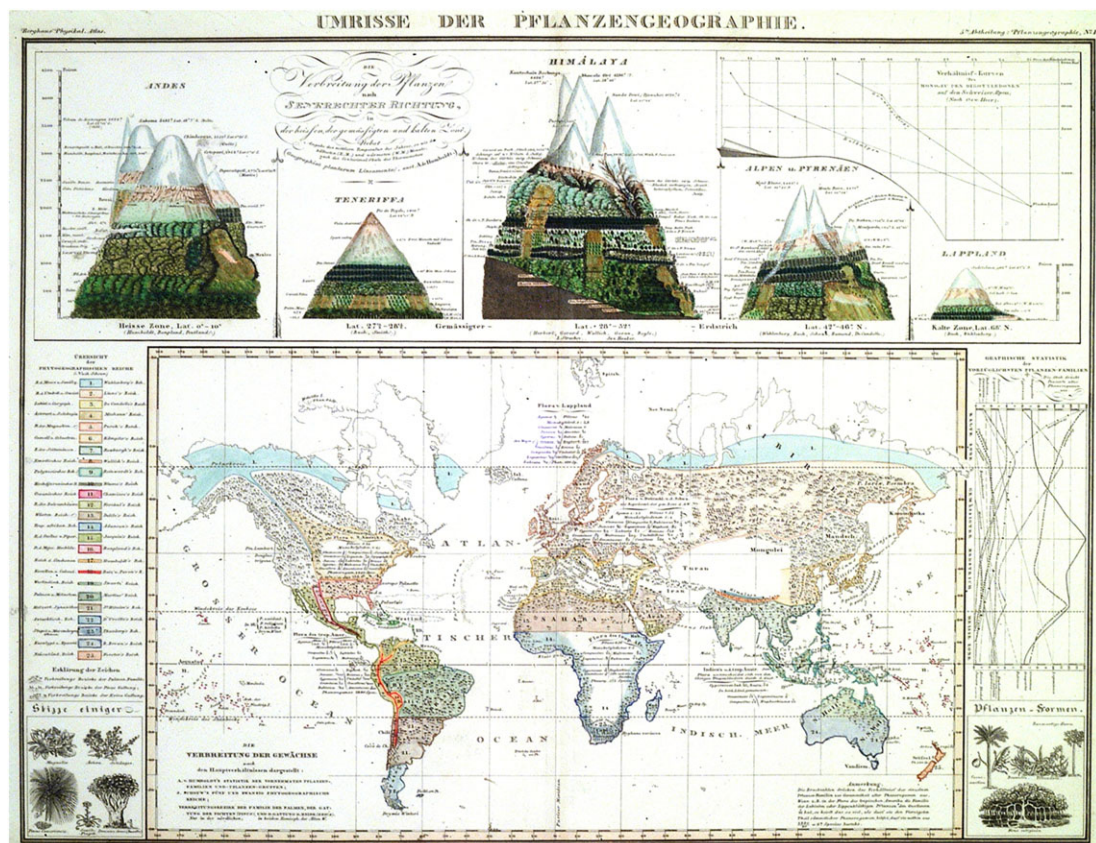


Figure 4 Umriss der Pflanzengeographie (Sketch Outline of the Geography of Plants) by Humboldt

Source: H. Berghaus, 1851, Physikalischer Atlas, vol.V, plate No.1. Available at: <http://cybergeo.revues.org/docannexe/image/25478/img-12.jpg>

oceanographic cruises mapping the sea floor (Felt 2012). When the ship was back in harbour, she collected the data and drew them together (Figure 5). The first plate tectonics model (1968 by Le Pichon and Mc

Kenzie) was inspired by some of her drawings and later, after the 'Famous' (French American Middle Ocean Underwater Surveys) cruises that explored the mid-Atlantic ridge (1973–7), she finished the 'definitive'

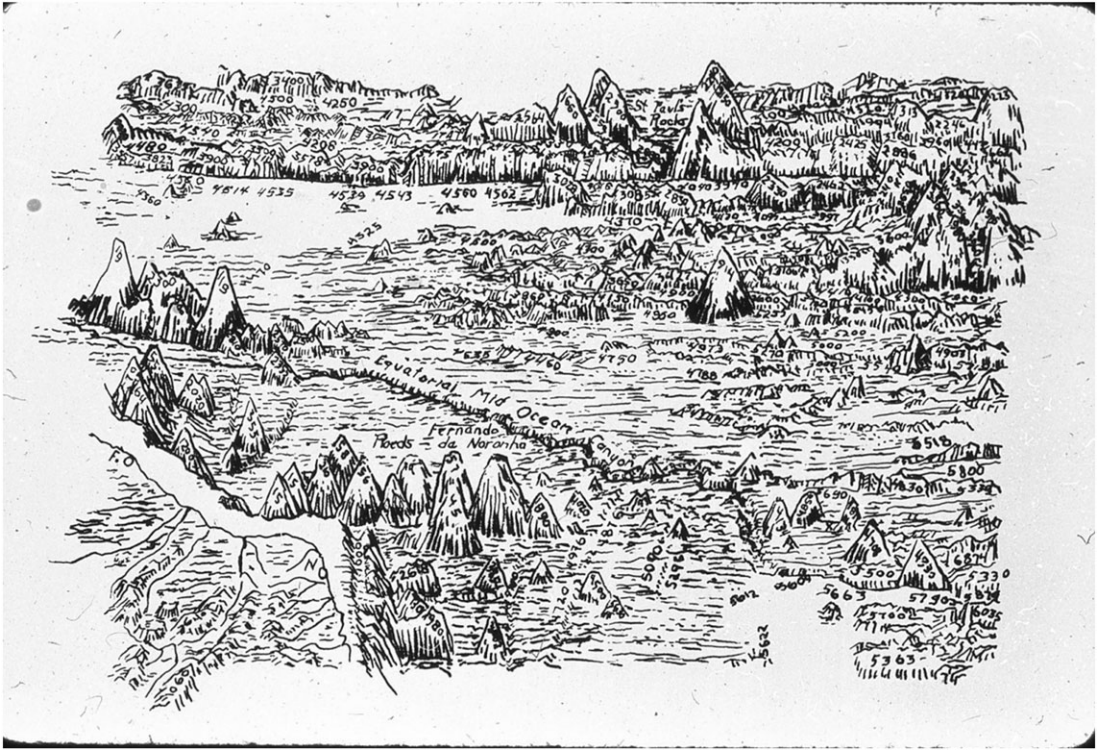


Figure 5 A close-up of Marie Tharp's 1961 South Atlantic physiographic diagram, showing the Equatorial Mid-Ocean canyon off the coast of Brazil

Source: Available at: http://i.huffpost.com/gadgets/slideshows/246579/slide_246579_1423183_free.jpg

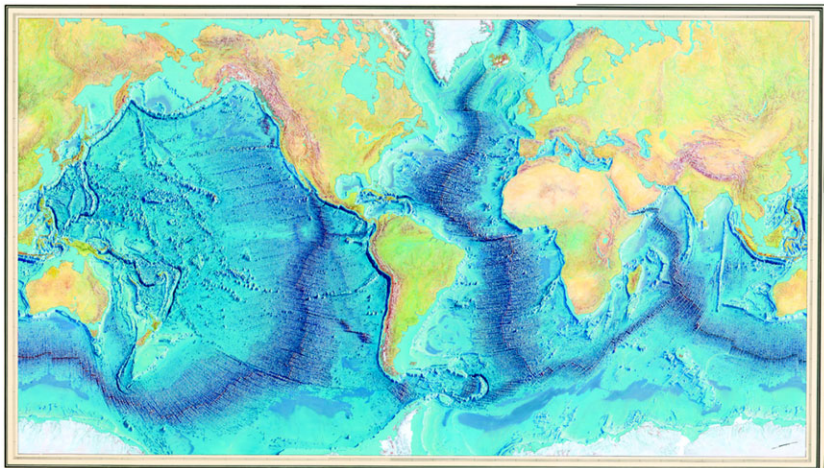


Figure 6 "World ocean floor" c.1977, drawn by Marie Tharp and Bruce C. Heezen, and painted by Heinrich Berann

Source: Library of Congress, Geography and Map Division. Available at: <https://www.loc.gov/resource/g9096c.ct003148/>

global sea floor map (Figure 6) with the help of a professional landscape painter.

It is therefore fair to say that the global ocean is a two-fold process. It first relies on a visual construction. Just as in the case of continents (for Antarctica, see Grevsmühl 2010), the image of the global ocean is not a description from a realistic (mimetic) point of view but it is a logical construction derived from the observations of so-called laws of nature. A recent and widely recognised important book is Vanney's *Géographie de l'Océan Global* (2002). There, the global ocean is 'represented' by some figures, one of them being the 'chain of environmental changes between ocean and continent' (p. 222).

Figure 7 shows the series of modifications that the global ocean has been through since the middle of the Tertiary period. It shows the history of the environmental changes forced by different physical and biological processes. It represents each process as a symbol located somewhere between the deepest sea floor and the highest mountain summit. It is exactly the same type of drawing as Humboldt's plants and mountains.

The present construction of a global ocean also has a second basis, which is linked to political and social issues. During the 1980s and 1990s, French geographers (Durand *et al.* 1992; Brunet *et al.* 1999) calculated the density of population of the Baltic sea as well as the density of the English channel and found that it was higher than the density of some remote parts of the French territory (such as the department Lozère). Indeed, when ferry boats, merchant boats, fishing boats and military boats are considered, the amount of human beings actually present on the sea surface may greatly exceed numbers that may be found in some mountainous regions in 'solid earth' France. Drawing on these insights, they decided to consider the sea surface as a 'territory' (in French, the employed neologism is 'meritoire') where no border would restrict

movements. In that respect also, the ocean became part of a global conception.²

Images promote local coastlines

Coastlines could have been included in this globalisation process but, as we have seen above, they were rather perceived as local, specific picturesque features. Political, economic and scientific reasons explain why coasts were considered as non-global. In all the cases, images were produced and used in order to enhance the local character of coasts.

A coastline may be first seen as a borderline. In all the leading scientific countries at the time of Humboldt and Darwin, naval warfare was much more politically important than science. Coasts had to be fortified, and therefore they had to be described and mapped. Of the highest importance was the fact that a map could provide visual information that the officers on board could rely on when sailing to a harbour. So, on all maps, one finds very precise drawings showing the main beacons, rocks, towers, lighthouses, etc. (Figure 8).

This is the first reason that helped promote the idea of coastlines as discrete, non-global features. For a sailor, each harbour is different from any other. The second reason is all about maps. A coastline is, on a map, a line showing where the coast is. It is the location of the average sea level. Sea level is usually measured in a Tide Gauge (in Marseille and in Brest in the case of France) and the average of all the measurements is calculated. The operation is exactly the same as when Humboldt calculated an average with all the temperature data he had. Just as Humboldt did with his famous figure on isotherms, the average sea level is represented as a line on a map. These maps correlate a seen landscape (beacons, hills, bays ...) and a calculated boundary, the sea level. Though the sea level

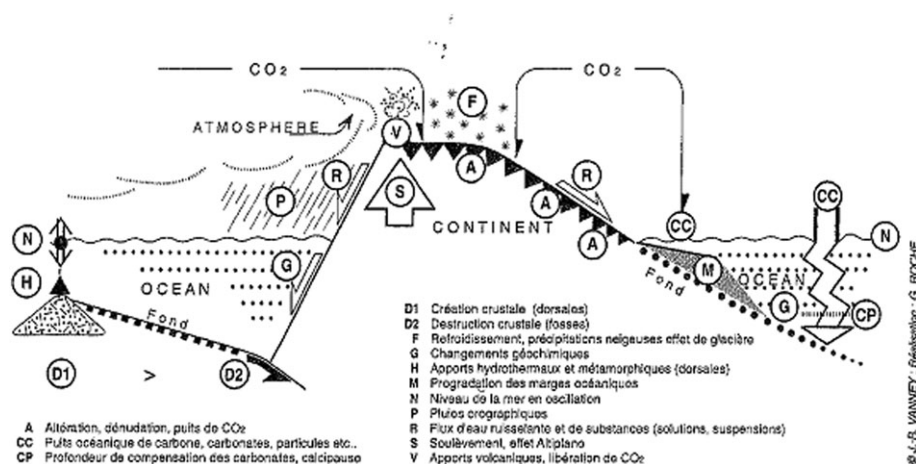


Figure 7 Sketch of the global ocean behaviour, by J R Vanney 2002

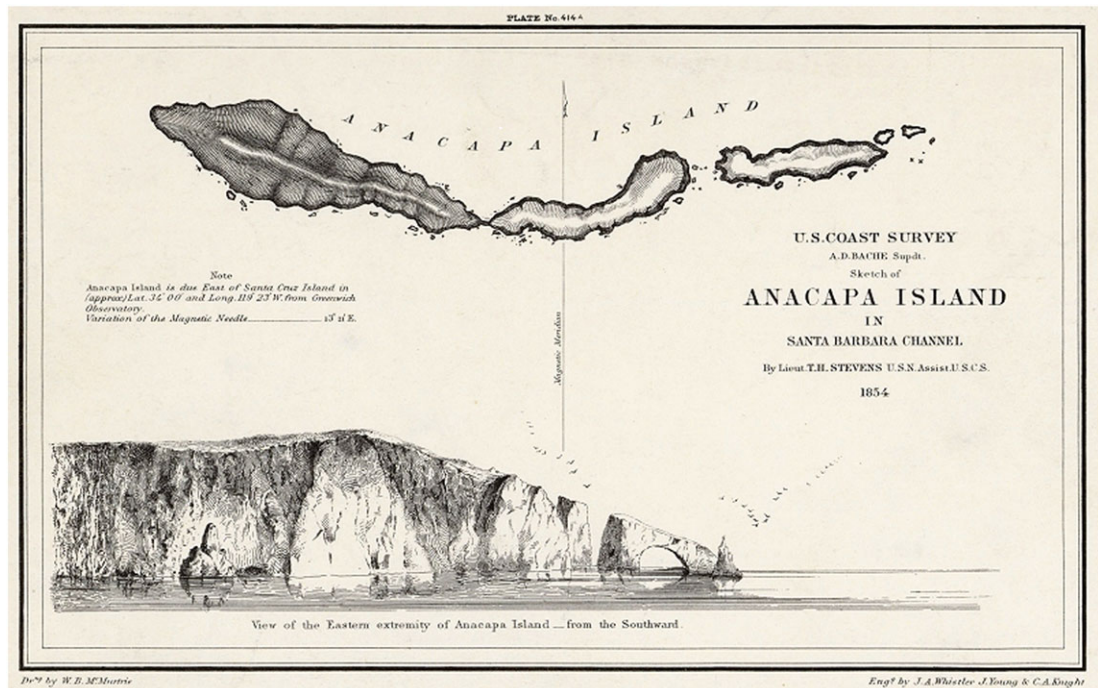


Figure 8 Sketch of Anacapa Island, 1854, by J McNeill Whistler

Source: Record Group 23 Records of the Coast And Geodetic Survey National Archives and Records Administration, A, A. Available at: <https://www.archives.gov/exhibits/featured-documents/whistler-etching>

is supposed to be universal (everywhere the same), landscape clearly is not. Therefore coastlines are not considered as global but as site-specific features. The calculated line (average sea-level height) leads to the idea of a fragmented space, locally controlled by *in situ* factors. The difference with the isotherm calculated line is obvious. An isotherm drawn on a map shows that the climate is global, the zero line (sea level base on a map) shows that the coast line is local. This difference is due to the fact that an isotherm cannot make a reference to any visible thing and can only be theoretically thought of, whereas the sea-level line makes an obvious reference to a seen landscape, the originality of which cannot be theoretically abstracted in a global model.

The initiation of tourism also played an immense role in the making of coastal images. Many studies have already been devoted to this aspect. Collectif (1990, 2000), Delouche (2005) and Motte (2014) have shown that paintings (such as the ones by the painters of the school of Pont Aven) were widely used by railway companies to attract people to coastal destinations. Local seaside cities had to compete one against the other in order to attract more tourists. In that context, images were a significant part of the city-marketing strategy.

Many scientists who studied coastlines at the beginning of the twentieth century were (unconsciously?) strongly influenced by these images. Vidal de La Blache

(1903) wrote the *Tableau de la Géographie de la France* that has been considered one of the most important books in French geography. There is of course no chapter on coastlines because each region has its own coasts. The coasts of Brittany for instance are welcoming to humans 'better than the rigid cliffs of Normandy' (p. 336). A coast is a contact between the continent and the sea and this contact is mainly controlled by the continental geological structure. There are granitic coasts, limestone or karstic coasts, sandstone coasts and so on. The role of the sea comes second because the main processes, which shape the coast, are linked for instance to folding, faults and volcanic activity. The structure of a basin (either a sedimentary basin or a graben) may provide some variety: the sea may penetrate inland and new coastal features develop such as marshes or sand dunes. In these cases the actual role of the sea is taken into account but not in a way that would lead to consider it as more important than geology (see for instance Melton 1940).

Deriving from Vidal's important book (and from the political position of Vidal and of his followers in the French system) coastal science in France has mainly been an epistemic grandson of the 'cabinet of curiosities'. Almost all the books dealing with coastlines are organised so as to end with a classification of the various types of coasts. Students had to learn about the 'dalmatian coast

type' or 'azovian spits'. Many local examples (such as Azov sea, or the Eastern Adriatic coast) were taken as archetypes, as if each coastal feature had somewhere in the world its best expression, and elsewhere some not so good ones. Coastal features were seen through the prism of exceptionality. Of course, each 'perfect' type of feature was photographed and displayed as a sort of geomorphological model in the textbooks (and not only in France; see for instance Valentin 1952).

Yet these visions of the coastlines as a collection of different, specific types are of course at odds with the vision of the ocean as a whole, global system. Though probably inherited from an old-fashioned scientific attitude towards natural objects, this is not at all an out-of-date scientific issue. Coasts are effectively composed of very local features, which for at least two main reasons must be considered carefully with very precise attention to local peculiarities.

Cities, harbours and tourist infrastructures most often occupy coasts. So coastlines must be managed according to these economical and cultural requirements. A beach dune system located in a micro tidal 'warm' sea (such as the Mediterranean) is obviously devoted to tourism in a way which cannot compare with a similar beach dune system located in a macro tidal 'cold' sea (such as the St George channel). Many excellent papers have been produced showing how knowledge of local conditions is the key to successful coastal management (for instance Guilcher and Hallegouet 1991; Jennings and Shulmeister 2002; Hesp 2002). Coasts are strongly influenced by the way they are used by local people and tourists. A mangrove coast cannot compare with a fringing reef coast. Moreover, some structural (geological) components of the coastal classifications are very efficient in describing the various behaviours of many sites: a karstic limestone coast with submarine caves and calanques is definitely different from a granite coast with tors and taffonis. So it seems that local landforms have an importance, which is not only local. Local landforms actually beg the question of how important it is, or not, to think globally.

This provides a second and interesting link with tourism, as the most 'beautiful' landscapes may coincide with the most 'perfect' landforms. This way of looking at coasts is today the basis of the 'geoparks' movement (Figure 9). A geopark is a natural preserve classified as such by Unesco after a long process of consultation with international experts. It protects a part of the coast (or any other place) because of its scientific and esthetical values. The scientific value is not dependent on biodiversity but on geology and geomorphology. The point is that what is protected is elected because it is a specific feature, or set of features, which has no equivalent elsewhere. As any preserve/conservation policy, the geoparks movement is a site-specific affair. Local space matters. And images, once again, play a prominent role in displaying this local aesthetic excellence. What is



Figure 9 The geopark of Yehliu, Northern Taiwan coast

global is the preservation issue, as a theoretical point of view. What is local is the object of the policy, that is, the protected part of the coast. In this sense coastlines are involved in what Steinberg (2001) calls the 'territorial trap' – a landward bias imposed by the state to which the coast belongs.

Three key new ideas for a global coastline: the relative sea level, the sedimentary cell, and the accommodation space

Coasts are local objects and need to be managed as such. At the same time, coasts are the limit of the ocean, which in turn is global. It is therefore also useful to think of coasts from the point of view of the global ocean as from an 'oceanic trap', from a 'meritoire' position. From a sailor's point of view, the sea is not a flat and immobile surface but a constantly moving challenge. The sea level varies and the sea is full of surface currents. There is nothing like a sea level, nothing like an absolute basis for making maps such as the IGN benchmark in Marseille which has – nevertheless – been used to draw maps since the nineteenth century. Sea level is always relative to tides, storm surges and currents. Kant has mentioned in his geography that between two oceans the level was not horizontal and that in straits there were compensation currents. This means that seascape is very different from landscape. Seascape is mobile within short periods and is never stable.

Many explorers have observed that in many places there were features that were looking like coasts (dunes, notches, cliffs and even dead corals) and that they were located away from the coasts, inland or in elevated positions. Darwin finds bizarre, ancient sea-level traces in Magellan's strait, Humboldt in Chile, Baudin (2001) in Australia. In Brittany, as early as 1912 (Daire *et al.* 2011), archaeologists described the variations of sea level because they saw ancient standing stones, cromlechs or covered tombs half drowned by seawaters.

Sea level is a forcing element and it is a changing control. At different moments different types of scale have to be considered (storms, tides, tectonics and climatic changes have radically different temporalities). So the concept of relative sea level (RSL) was, little by little, introduced and accepted within the very exclusive realm of scientific concepts (Pirazzoli 1976; 1996). Its main function was to complement the basic idea of a universal zero level. Whereas there is a universal original meridian (at Greenwich), no equivalent for the sea level existed. With the introduction of RSL, scientists hoped to close this gap, at least partially, and it has become an important explanatory tool. For instance, RSL changes force the coast according to some great principles, which are summarised, in the famous Bruun (1962) rule: inland migration of the coast is dependent on the rate of RSL rise and on the slope of the beach (Cowell *et al.* 1992). In Brittany, for the last 5000 years a RSL rise of 1 mm produced a migration of the dune/barrier systems of 7–15 mm inland (Regnaud and Jennings, 1996; Regnaud *et al.* 2004).

A second influential concept is the sedimentary cell (Bray *et al.* 1995). Coasts are submitted to waves and to moving water energy. Some places are retreating, others are prograding. The sediment that accumulates in one place (a sink site) comes from the eroding sites (source sites), by-passing other sites (transit sites). The extent of this cell or set of connected features which exchange material is the proper scale at which the behaviour of the coast may be understood. Even if a chalk cliff in Etretat is not a gravel spit in Cayeux, their behaviour is connected because the retreat of the cliffs feeds the spit, if there is no obstacle in between. Therefore, by furnishing an explanatory model for apparently disconnected and distant processes, the sedimentary cell was also a key element of the emergence of a global image of the coastline.

Finally, the third important concept for connecting the global ocean to the coastline is accommodation space. A transit site is a place where sediment arrives and departs. During some periods a lot may arrive because the retreating site is submitted to intense erosion. During other periods, when long shore drift is very active, a lot of sediment may depart. Hence the transit site has a changing morphology. It must be able

to cope with a large amount of incoming material as well as with a relative scarcity of matter. This means the site does not always contain the same volume and it occupies space at various degrees. The changing space, which is needed for the natural behaviour of a coastal site, is named the accommodation space and it varies a lot over time.

Moreover, these three concepts may be interwoven together: the coast is a set of sites which behave according to a certain quantity of energy, a certain quantity of sediment and a certain quantity of space. Therefore we have to shift from a (fixed) image-based idea of landscapes to a (mobile) process-controlled model of seascapes. Only if we think of the coast as a moving machinery forced by three quantities can we think of coasts as a whole, a global holistic system.

Yet this epistemic issue is not simple at all. During the nineteenth century, Humboldt used a not so large set of temperature data; he calculated averages and drew a map with isotherms. This map has been redrawn several times with more data and still is in principle scientifically valid and solid. At the same time cartographers calculated averages using a large set of sea-level measurements; they drew them as a line on a map, and today, the line is not considered able to represent sea level. In other words, two images made out of the same type of data and with the same mathematical operation have radically different scientific destinies. The underlying problem here is that Humboldt's isoline represents a value whereas the zero level represents both a value (average sea level) and a place (the coast line). As any scientist would argue today, the actual location of the coastline is not (only) linked to the actual position of the average sea level but to the position of the highest storm surges and floods. So the two values (the position of the coast line and the position of the zero level) do not always fit. Therefore the drawing of a line works well for isotherms but it does not work well for coasts. Hence the two maps are not comparable.

Images of a global coastline, three main fields of research

If a simple line cannot represent the image of a global coastline, how can scientists and artists invent an 'image' or a 'representation' of the global coastline? There are three main possibilities. Artists may decide to avoid the problem. Instead of representing the coastline itself they may represent the processes that shape the coasts. A second possibility is to deal directly with the problem and to create images, which present the possible line and ask all sorts of questions about it. The third possibility is to search for new types of images that would present, or make visible the scientific works dealing with the global coastline concept (Regnaud 2012; Valette 2001).

Images representing waves or wind have been drawn and painted for a long time. A famous series of paintings by Courbet represents waves, breaking on a coastline that is not visible in the painting. In one of them (located today in the Tokyo Museum) the main visible object is a breaking wave, the crest of which is higher than the horizon. The sky is visible and one part of the shore may be guessed, under the foam. The painting presents in other words a landscape in which the land is invisible, though its effects are obvious: if the wave breaks, it is because it meets a submarine bank of sands, or the sub-tidal part of the beach face. Land is present as it changes the behaviour of the waves (refraction) and these refracted waves do impact back on the beach profile, the morphology of which will then be modified. Though there is a clear divide between water and sky, this divide is not a horizontal line and therefore the usual Albertian perspective is lost. There is no line that would allow one to tell if and where a horizontal plane exists, or where parallel lines would converge in a vanishing point. Coasts, when painted like that, beg the question of our common situated visual knowledge. They are not simple three-dimensional objects that classical perspective would make visible on a two-dimensional surface, as in any classical landscape image. Coasts are places where we have to think anew about our mode of understanding visual space and where we have to ask ourselves about processes before we think about morphology. More recently, the French artist Marcel Dinahet has been playing with the idea of the absence of lines and of horizon in coastal areas (www.marceldinahet.co.uk). He places video equipment in a waterproof case and sets a very precise amount of weight in it so that one half of the lens of the camera is above water and one half under water. What is filmed is exactly that boundary layer which is the porous contact between hydrosphere and atmosphere. And as the waves move the camera, sometimes the entire lens is under water, sometimes it is completely outside. In the end the question of where the line is becomes undecidable; the only known fact is that the camera is never immobile. Coasts are precisely like that: they cannot be visualised as a simple line or landscape, they are ever-changing features and should be seen as processes, not as landforms.

Another way to tackle the coastal image issue is to expose the problem, to question the reality of the line that is supposed to map the coast. Some artists have indeed been using lines but have decided to show the coast as a changing object. For example, Ariane Michel has chosen a small skerry just outside Baie d'Audierne (Western Brittany) and drew a horizontal white line around it (<http://arianemichel.com/>). At low tide, the line is not the coast: it is too 'high'. At high tide, the line is a submarine object. At the very precise moment when the tide reaches the same theoretical height as the line, they should coincide but the sea is

never flat and because of local waves some parts of the line remain under water, some appear above sea level. The problem is that at a local scale, the sea is never a horizontal line or a plane, and Ariane Michel's line could be drawn around any skerry, anywhere in the world at a global scale. There is a clear question about the possible scalar link between the pertinence of the horizontality concept at a local level and at a global level. Coasts are scale dependent and nevertheless global, all together. Mobilising the same type of artistic attitude, the Dutch artist Jan Dibbets has exhibited series of videos where the incoming tide erases lines that were previously ploughed on a flat beach by a mechanical plough (www.mam.paris.fr/fr/expositions/exposition-jan-dibbets). Some years ago Gette (1989) was working in the vicinity of Saint-Malo and placed a large panel with '0 m' printed on it at the highest point the wave run up was reached. Within minutes, a new wave could either reach higher on the beach face, or it did not reach the panel et al. A photo of the device could be taken at each of these various moments, yet there will never be an exact fit between the actual sea surface (the relative sea level) and the position of the device which is supposed to decide of the '0 m' beacon and base for maps.

Finally, a last way of treating the problem of global images for a global coastline is to reinvent an old practice: making artists and scientists work together, just as when painters were systematically enrolled as members of the exploration cruises in order to draw the newly discovered landscapes. Today, some artists do take part in scientific expeditions, to Antarctica for instance, to Greenland or even on oceanographic cruises. Catherine Rannou presented some of her works which were realised when she was part of a cruise around Tristan da Cunha Island (<http://ddab.org/fr/oeuvres/Rannou>). She decided to make a website with a real time story of the scientific and artistic questions the crew had to solve. In this case what is 'shown' is not the natural processes that shape the global coasts, or the theoretical (calculated) device that sets the basis for science, but the scientific work itself. Scientists are, in this particular pictorial context, the makers of the global coastline concept. In other words, in order to show the concept you have to show how it is invented. Through this interdisciplinary process, the coastal landscape becomes a technical landscape, mainly caused by a series of scientific fieldwork and laboratory analyses.

Conclusion

The slow building of a global image of oceans and of coastlines has taken place through different periods, during which the relationship between art and science has always been important but in fundamentally different ways (Gargani 2013; Cometti 2012). Sometimes,

artists would act under scientific leadership; at other times, artists would propose images that scientists could take for the basis (one of the bases) of new theories. However, the main and most important point is that as scientific knowledge and artistic practices evolve, new objects emerge and are created (scientific theories as well as artistic devices) which have the power to question the new modes of collaboration between scientists and artists. From a more theoretical perspective, this points to the need for a reflection on the respective epistemological status of scientific images and artistic objects. Is it possible to write theory with images?

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Notes

- 1 The area which is needed for a coastal system to be displaced by storms without being destroyed.
- 2 Although the idea of a global ocean is mainly a visual construction, other factors also have to be considered, for instance discursive theoretical explanations as put forward by Steinberg (2001).

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