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Hydrographische Nachrichten

Verfügbar unter/Available at: <https://hdl.handle.net/20.500.11970/107851>

Vorgeschlagene Zitierweise/Suggested citation:

Hartmann, Knut; Tait, Alexander M. (2018): Coastline delineation and coastline dynamics - How satellite data support disputed boundary cases. In: Hydrographische Nachrichten 111. Rostock: Deutsche Hydrographische Gesellschaft e.V.. S. 22-23.
<https://doi.org/10.23784/HN111-04>.

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Coastline delineation and coastline dynamics

How satellite data support disputed boundary cases

An article by *KNUT HARTMANN* and *ALEXANDER M. TAIT*

When it comes to maritime boundary disputes between two States the core questions in a case are often about the identification of the coastline used to generate the median line. A detailed understanding of the morphology of the coastline is key. Historically, nautical charts have been the reference for identifying the low-tide coast, but today satellite data can be used for this mapping purpose. What sounds like a simple task is very complex.

What if the coastline has changed over time? What are the tidal influences on the measurement of a low-tide coast? And how can one account for a dynamic coastline?

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UNCLOS | median line | coastline | low-tide coast | boundary dispute | satellite data

Fewer than half of the world's maritime boundaries have been officially agreed. Maritime boundary disputes frequently occur due to commercial, economic and security interests and are a common but underrated investment risk in the energy sector. Those disputes result from bilateral or multilateral negotiations between States. In cases where unresolvable disagreements over the delimitation of a boundary occur, the dispute may be taken to an international court or tribunal for resolution. These court cases typically include a series of written pleadings followed by oral hearings of all involved parties during which arguments are exchanged. Each State's case will include reference to established international law – including the UN Convention on the Law of the Sea (UNCLOS), historic maps and charts, current practice of the States, and other relevant information. Because of a critical provision of UNCLOS that a »median line«, a line equidistant from the adjacent or opposing coasts of the States involved, is used as a starting point to resolve disputes, the core questions in a case are often about the identification of the shoreline used to generate the median line. The construction of the line is based on a set of control points along the low-tide coast of each State.

A detailed understanding of the morphology of the coastline is key. Historically, nautical charts have been the reference for identifying the low-tide coast, but today satellite data can be used for this mapping purpose. What sounds like a simple task is very complex in practice. What if the coastline has changed over time due to coastal construction? What are the tidal influences on the measurement of a low-tide coast? And last but not least how can one account for a dynamic coastline? An evaluation of the technical mapping approaches used for two international court cases, in which the authors participated, addresses these questions. Before looking at these cases in particular, the next section focuses on the use of satellite

imagery to map shorelines and to map shallow-water bathymetry.

Satellite data – high-frequency observation of the earth

Never before have there been so many satellites in orbit that record earth's surface and collect information on surface properties. Each day satellite sensors record every portion of the globe in high spatial resolution and contribute to a constantly growing archive of images.

By using optical satellite data – in other words, sensors which record the wavelengths of light in the visible and near and mid infrared – it is possible to distinguish land and water areas by their spectral characteristics. Long wavelengths of the infrared portion of the spectrum are reflected by land surfaces but only very little from water bodies. If the water level is known or modelled it can be linked to the satellite-derived land-water boundary and through time series of data a delineation of various land-water lines, each representing a certain water level can be created. With even more advanced analysis it is also possible to use these data and physics based Satellite-Derived Bathymetry (SDB) solutions to create densely gridded bathymetric data for shallow waters. This method has already been addressed at this journal (HN 108) and will not be described in detail here. The outcome of this SDB data is a shallow-water grid that represents water depth down to the sunlight extinction depth.

ITLOS: Ghana vs. Côte d'Ivoire

The International Tribunal for the Law of the Sea (ITLOS) in Hamburg handled a case, from 2014 to 2017, to resolve a dispute between Ghana and Côte d'Ivoire. Discussions to resolve the dispute reached a critical point with the discovery of large oil fields offshore of the land boundary terminal between the two countries in 2007. In 2014, following failed bilateral negotiations to establish a maritime boundary, Ghana filed a case at ITLOS in

2014 to rule on the delimitation of the maritime areas of the two countries. The coastline immediately adjacent to the land boundary terminus is an almost straight line. The largest-scale nautical charts of coastal morphology were mapped on British Admiralty nautical charts which had been surveyed in the pre-GPS era from lead-line surveys. Despite the age of the original survey work, British Admiralty charts have regularly been considered as primary reference in maritime boundary delimitation cases such as this one. During the arbitration the parties used different satellite images to derive updated delineation of the coastline. Ghana's approach relied on time series analysis of satellite data over a time period of almost two years, in order to eliminate short term effects of wave action and derived a stable and persistent coastline. Whereas Côte d'Ivoire used a single set of satellite images from which they published an updated nautical chart during the arbitration phase. Although slightly different in methodology all derived coastlines showed the same coastline azimuth and resulted in nearly identical median lines – which also closely matched a median line derived from the British Admiralty chart. A median line from the adjacent coasts is the starting point under UNCLOS, given no additional factors, for determining a maritime boundary. In this case, Côte d'Ivoire argued for a substantial shift to the east for the azimuth of the maritime boundary from the land boundary terminus, away from the median line. ITLOS rejected Côte d'Ivoire claims and decided in favour of a strict median line, similar to the one determined from satellite-derived coastlines (and published nautical charts). This resulted in only minor adjustments to Ghana's original boundary claims.

UNCLOS Special Tribunal: Republic of the Philippines vs. People's Republic of China

In July 2016, an arbitration tribunal established under the United Nations Convention on the Law of

the Sea (UNCLOS) ruled that China had violated the Philippines' sovereign rights. While not ruling on the sovereignty of the islands in the South China Sea, the tribunal ruled that some of China's maritime claims and maritime activities were within the Economic Exclusive Zone (EEZ) of the Philippines, to which China did not have rights under the UN Convention. The Philippines initiated the case in 2014, after conflicts in the area of dispute. Without going into the details of the complex court case, it is important to understand the main elements of the legal arguments. Nine reefs and shoals within the South China Sea – an area whose centre is approximately 200 km west of the Philippines mainland and 1,000 km south of the Chinese mainland and rich in natural resources – were the focus of the arbitration. The establishment of whether or not these atoll and shoal features rest above high tide or low tide has direct legal impact on the sovereignty of the adjacent water areas. There are follow-on impacts for rights to fishing and to the natural resources of the sea floor. To make it more complex, some of these sites were significantly enhanced in their size and height by China's program of erecting structures and island building on reefs and shoals (Fig. 1). Sufficient information from pre-construction charts and maps was not available. Analysis of archived satellite data from this time, however, allowed EOMAP to create of a shallow-water bathymetric grid (SDB) of these reefs and shoals, and then provide coastline delineation at different tidal heights. The legal team for the Philippines presented this information to the court and it was considered by the tribunal as they deliberated before issuing a final judgement which ruled in favour of the Philippines in nine of their thirteen submissions. This court case shows the power of using archived satellite data together with modern Satellite-Derived Bathymetry techniques to provide technical support in understanding coastal features for complex cases regarding UNCLOS. //

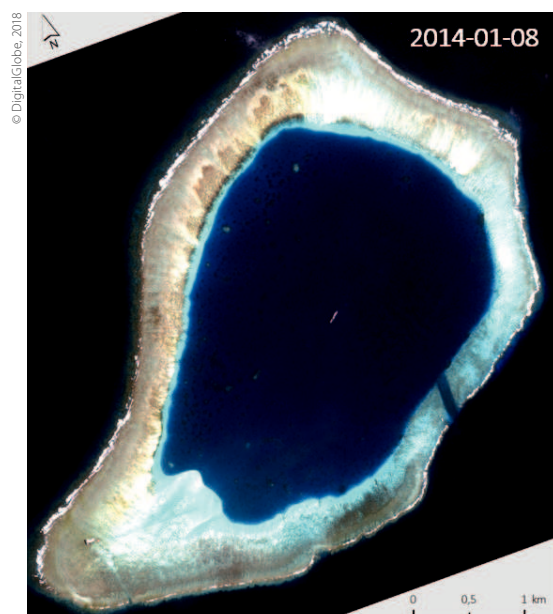


Fig. 1: Subi Reef, South China Sea. The imagery show the reef before (left) and following engineering activities of China (right)