Under Keel Clearance For Ships Carrying Dangerous Goods

A Study on Groundings and Pilotage in Danish Waters

Master thesis, Geoinformatics at Aalborg University, Copenhagen By Kristoffer Guldbæk Stentebjerg & Maria Skov Engqvist

Abstract

Transportation of goods at sea is common, and several national, as well as international, regulations are provided in that field. To prevent ships from colliding or grounding, different actors plays a part by monitoring the ships and make analysis on the traffic patterns. This takes places in real-time as well as on historic data. This project concerns ships navigating with dangerous goods in the Danish waters. The danger and cost of ships grounding with the seabed can have a huge impact, and therefore the use of pilots is important when requested. The different regulation and factors that plays a role when navigating in Danish waters are investigated, for an analysis to be performed. The analysis concerns whether ships have been in a critical situation, i.e. where the under keel clearance have been less than recommended. It is furthermore investigated if ships are using pilots when regulated and if there are any locations outside the regulated areas, where pilotage should be compulsory. The methods used in the project as well as the results, are discussed and evaluated in the last phase of the project.

Problem

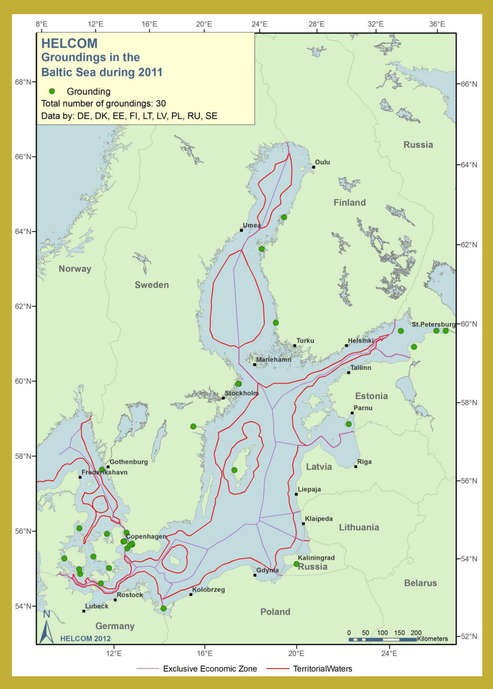
A pilot is a person with expert knowledge of a certain geographic area, who are able to assist the master of ship when navigating. By Danish law, the use of pilots is mandatory in Danish inner and outer territorial waters, unless the master of ship has a pilot exemption certificate.

Many ships navigate through the Danish waters without using a pilot, despite IMO recommending the use of these for large ships and ships carrying dangerous goods.

Often, companies choose not to use pilots because it is an extra expense and because they believe that their master of ship is fully capable of navigating the waters safely.

Recently, Danish media have been focusing on this issue, claiming that some ships, when navigating Danish waters, have an under keel clearance (UKC) of a few centimeters.

An average of 45 groundings have occured annually in the Baltic Sea since 2004. Because of this, and because of the growing amount of ship traffic in the region, the Baltic Sea was the first to be fully covered with land-based AIS-stations back in 2005. The Danish waters are very narrow and shallow at several locations. This is the reason why most of the groundings occuring in the Baltic Sea is in Danish waters.

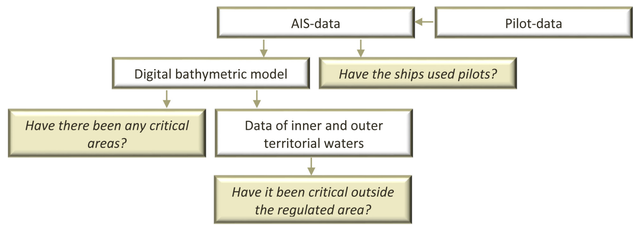


Problem Statement
How can it be analysed whether ships carrying dangerous goods are using pilots, as required by law, and if the ships have been in danger of grounding with the seabed?

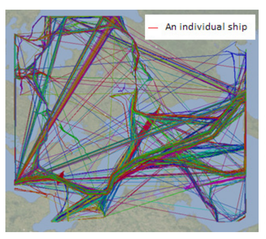
What is the importance of using pilots when sailing in Danish waters?
Can the use of pilots be incorporated in the analysis, to be able to identify if a ship is using pilots when requested?
How can the sea depth be compared to the draught?
Are there critical paths outside the pilotage requested areas where pilots should be compulsory?

Data Preparation

Four sets of data were used to answer the problem statement. The white boxes illustrates data, while the brown ones are parts of the problem statement. Statistics of AIS and pilot-data are investigated, and the bathymetric model is compared to the draught of the ships while the boundaries of the inner and outer territorial waters are used in comparison to the bathymetric model.

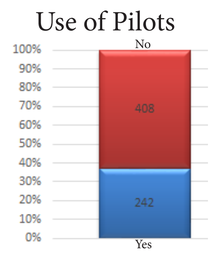


Before the data can be used, it needs preparation. The figure shows the phases and states that the AIS-data have gone through, all the way from binary format in the AIS transmitter to the raster format used in the last analysis. Some of the steps, coloured green, were carried out as part of a routine before this project started. The step coloured blue were done by Svend Jacob Senstius, by request from the groupmembers, while the last three steps were done in the project using Python-scripts.



When the AIS-data were converted to feature classes a lot of errors occured, as seen in the picture. Because of the geographic extent of the project, ships would appear a long way from where they left the area, leading to the errors. By utilizing the timestamps, the errors could have been prevented.

Data from the Great Belt VTS centre were collected, and the use of pilots in the Great Belt were examined. The statistics showed, that most of the ships navigating the Great Belt were not using pilots, even though IMO recommends this.



Discussion and Conclusion

Problems arose due to the interval between the logged points and the resolution of the bathymetric model. With ships having an average speed of 22,7 km/h and the bathymetric model's resolution being 50m*50m, the optimal maximum interval between logged points were calculated to 8 seconds:

$$\frac{\Delta V}{3.6} = V_i \quad \Leftrightarrow \quad \frac{22.7\,\text{km/h}}{3{,}6} = 6.3\,\text{m/s}$$

$$\frac{\text{Resolution}_{\text{raster}}}{V_i} = \text{Interval}_{\max} \quad \frac{50\,\text{m}}{6.3\,\text{m/s}} = 7.93\text{s} \sim 8\,\text{s}$$

The current interval of the logged points are 3-6 min, which indicates a route that differs from the actual route.

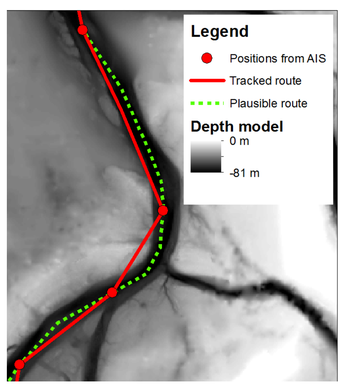
The bathymetric model contains lots of measured depths, however close to shore the survey ships are unable to fare. Therefore, interpolation is used to make the model cover the entirety of the water.

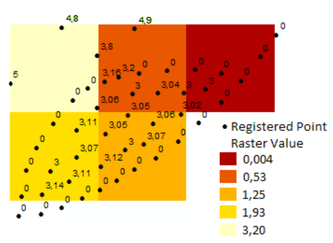
The bathymetric model used is interpolated using natural neighbour, which assumes a gradual change in depth. For every 20 meters along the shoreline, points with the value 0 were created. These points are part of the problems in and around ports, since they create an overrepresentation of low values, thus overruling the actual measurements. This means, that the indicated depths in and around ports and shorelines will be considerably shallower than in reality.

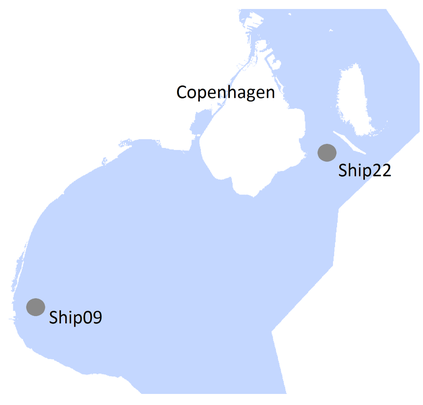
With all the errors eliminated, only two ships had an UKC less than recommended, both located in or around the Sound.

The methods used throughout this project is based on historic data, which makes it easy to analyse. However, the method is not very suitable for preventing groundings – the most reasonable way to do this, is by real-time tracking and reacting before potentially critical situations arise.

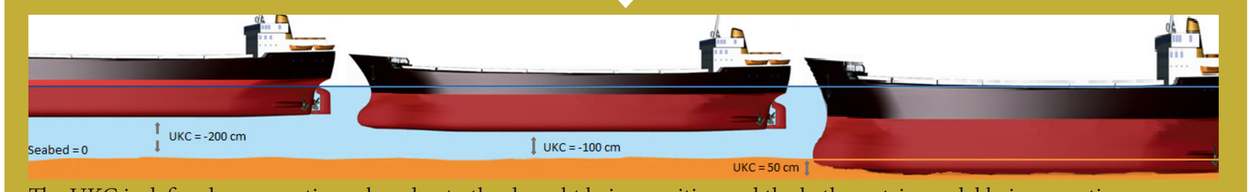
The method used in this project is more suitable for identifying ships that do not comply with IMO's recommendations regarding the use of pilots – had the AIS-signals held information regarding the use of pilots, our method could have been greatly improved.



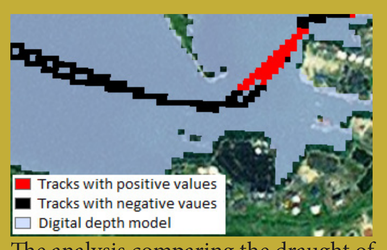




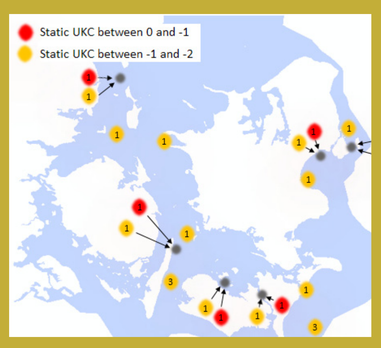
Analysis



The UKC is defined as a negative value, due to the draught being positive and the bathymetric model being negative. Therefore, a positive UKC will indicate a ship being grounded. Based on the number of groundings in the Baltic Sea compared to the number of positive values, we realised that the result was inconsistent with the actual number of groundings.



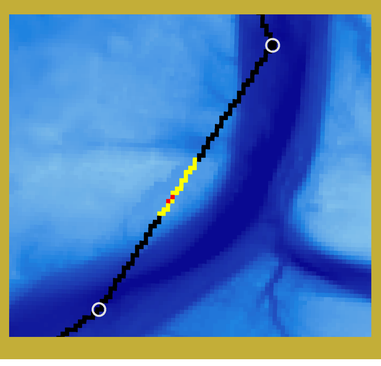
The analysis comparing the draught of the ships with the depth of the water, based on the bathymetric model, gave a number of positive results. Two examples of positive values found in the project are shown in the pictures. As can be seen, the location is near a port, which was a general tendency amongst the positive values.



Based on IMO's recommendations, a critical UKC was defined as 2 meters in the Great Belt and 60 cm in the Sound.

Critical UKCs were divided into two groups, not including situations in or near ports, and was plotted on a map.

This presented locations widely spread within the Danish waters.



Problems arose especially when ships were navigating in dredged channels.

Because of the interval between the logged points, the change in direction appears much sharper than in reality, in this case leading the track to cut a corner.

Acknowledgements

The project has been supported by Associate Professor Thomas Balstrøm, Professor Esben Munk Sørensen, Data Analyst Svend Jacob Senstius, Geographer Charlotte Bjerregaard, Nautical Caseworker Søren Nielsen and Hansi(surname and title unknown) from Great Belt VTS, whom have all helped by supervising, supplying data as well as replying to questions - A big "Thanks" goes out to all of them, without whom this project could have never been realised.

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