Spatial Analysis of Hurricane Sandy's Effect on Ship Traffic

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Abstract

Ship locations are tracked using Automatic Identification Systems (AIS), which is an automatic tracking system used for maritime collision avoidance. AIS tranceivers transmit GPS position and movement information over very high frequencies between ships and to shore stations and satellite receivers. By using this data within a GIS system to visualize and analyze ship traffic routes before and during Hurricane Sandy, it was apparent that the hurricane had a detrimental effect on ship traffic.

Introduction

The National Weather Service Ocean Prediction Center in conjunction with the National Ocean Service Office of Coast Survey, have an interest in ship traffic patterns in response to inclement weather and forecasts released by the National Weather Service. As weather events unfold, ships have to change their course and by studying these courses in a specific weather event, patterns can be discovered between the typical ship traffic and the change in the ship traffic due to weather.

The main objective of this project is to analyze AIS point ship location data to identify patterns and calculate the changes in typical ship traffic during inclement weather, namely Hurricane Sandy, in the Atlantic Ocean using density and hot spot analysis.

Study Area and Data

The study area for this project is the western Atlantic Ocean to show the region impacted by Hurricane Sandy. Hurricane Sandy formed in the tropics and made its way through the Caribbean making landfall on the New Jersey coast. Data used for the project were:

- AIS point ship location data from the Office of Coast Survey for the month of September 2012, and October 21-31 and November 1-4, 2012
- National Hurricane Center- Hurricane Sandy data up to 3Z October 31, 2012 including the past track, past point, error swath, and wind range

Methods

The main purposes of the analysis of the AIS data within ArcMap were to perform Getis Ord Gi* Hot Spot Analyses, build ship track lines, and perform Kernel Density Analyses. The following was done to the data:

- Pre-processed to separate the data into 6 hour and 24 hour increments and project data
- Model created to join the point data with a fishnet grid to get the total count of ships per grid
- Hot Spot Analysis along with a Kernel Density Analysis performed
- Ship tracks built using Marine Cadastre Track Builder tool

Once all analyses were complete, maps were shared from ArcMap to the University of Maryland Map Server. Within ArcGIS Online, new maps were created and used in an ESRI Story Map Journal to give background on the severity of Hurricane Sandy and represent a majority of the results of the different analyses located at the following address: http://arcg.is/1RKT45F

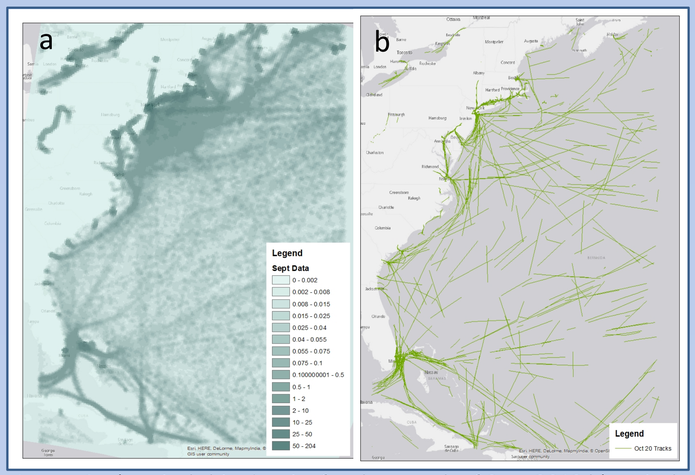

Image 1. a) typical ship density for the month of Sept 2012 b) typical ship traffic for a 24 hour period with no adverse weather Oct 20, 2012

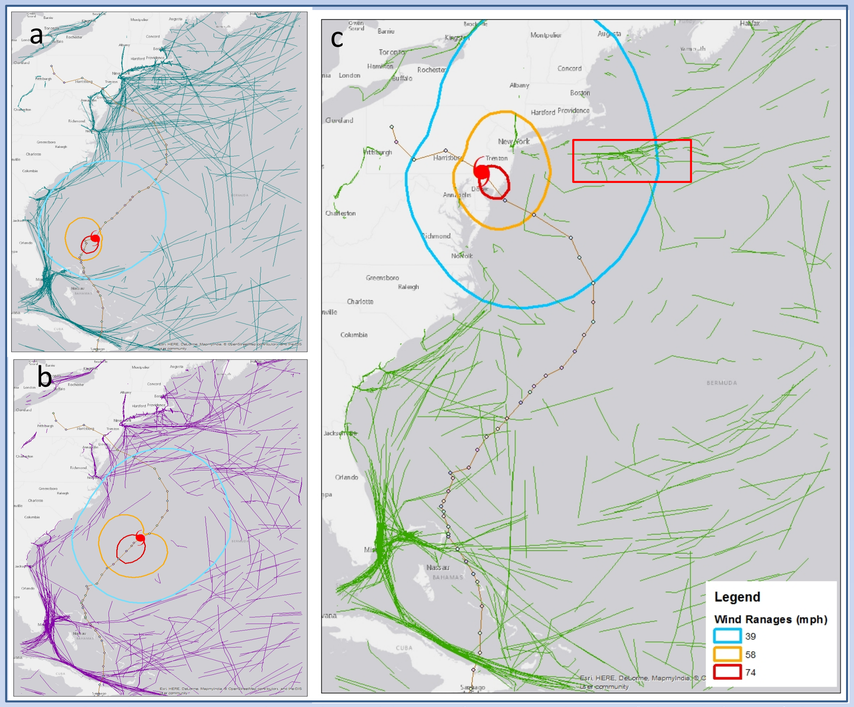

Image 3. Ship tracks showing ship avoidance of at least 50 knots/58 mph from a) Oct 27 b) Oct 28 and c) Oct 29 during landfall with wind ranges, red box shows where ships waited out the storm

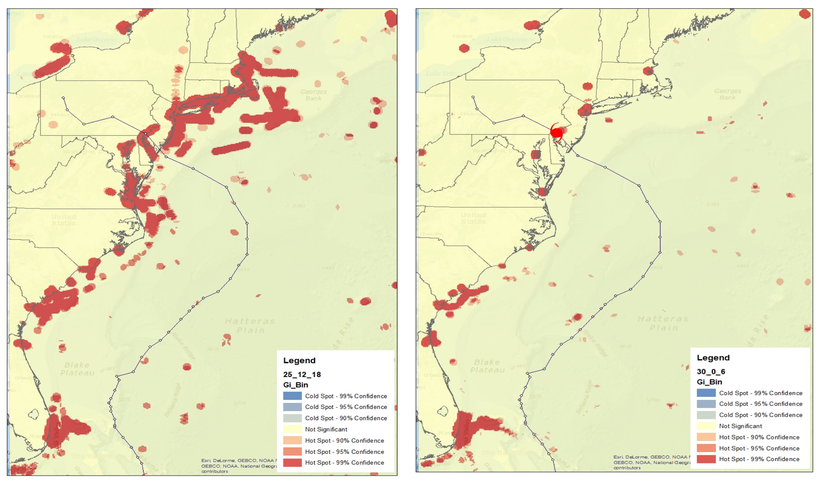

Image 4. Hot spot analysis from October 25, 12-18Z on the left and October 30, 0-6Z on the right as Hurricane Sandy made landfall

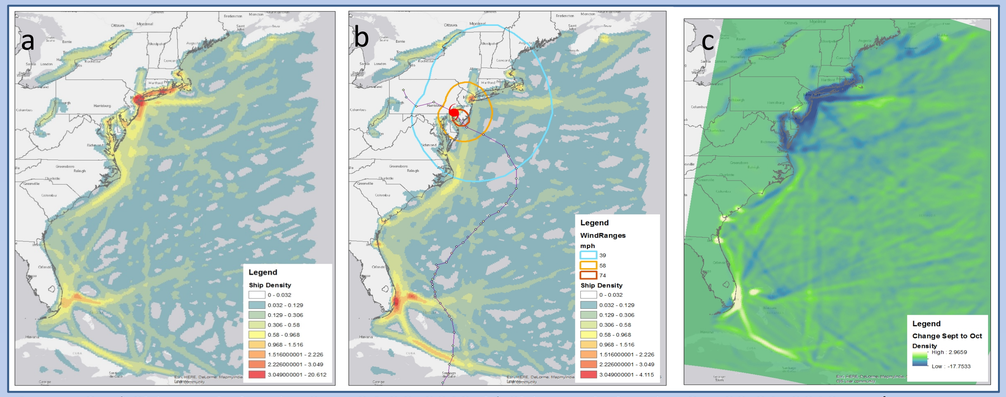

Image 2. a) Ship track density Sept 24-26, 2012, b) Ship track density Oct 29-31, 2012 pre/post Hurricane Sandy with the wind ranges at landfall , c) difference between density analysis from image a and b showing a large drop in the Northeast and a small increase in the Southeast.

Results

Upon completion of the analyses for each time period, it was clear that traffic drastically dropped off the map the closer Hurricane Sandy approached. A comparison of before and during Hurricane Sandy can be seen in image 2, 3, and 4. In the 24 hour track lines building up to Hurricane Sandy's landfall, the drop in ship track count can be seen in Table 1 and Image 3c on October 29 and 30 as landfall occurred and traffic off the Northeast U.S. coast was halted. The standard deviation (Table 1) shows the most information since it was much higher on October 29, showing a larger range of track distances, when Hurricane Sandy was just off the coast and about to make landfall.

	10/25	10/26	10/27	10/28	10/29	10/30
Count (# of ship tracks)	1328	1309	1294	1139	950	1101
Maximum	2385042	881493	1000924	934172	4133120	828233
Average	151167	146415	153395	157206	164113	140802
Standard Deviation	185995	176284	184682	187290	228988	186785

Table 1. Track count, maximum track length, average track length, and standard deviation (meters) for 24 hour days, standard deviation is much larger 10/29/2012.

Discussion and Conclusions

Analysis of the evolution of ship traffic density in response to the forecasts of Hurricane Sandy illustrated:

- Commercial vessel traffic in the New York Bight area ceased within 24 hours of Sandy's approach and landfall
- Many ships avoided high winds and seas by heaving to southeast of Cape Cod.
- Avoidance threshold of forecast conditions appears to be the 50 knot radius of winds
- Increased traffic density was evident offshore south of Hurricane Sandy off Florida and the Bahamas.
- Increased traffic density was evident at alternative ports to New York such as Halifax, Boston and all major ports south of North Carolina.
- Results indicate potential utility to help prioritize NOAA charting surveys.
- Results indicate analysis techniques are applicable for future work where there is a potential weather impact to marine traffic.

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