MarineCadastre.gov

# Tutorial: How to Build Vessel Density Maps with AIS

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## Introduction

This document provides a brief overview of the data, tools, and steps needed to make a vessel density map using MarineCadastre.gov data. All the data used in this overview are historical Automatic Identification System (AIS) data collected in 2011 by the U.S. Coast Guard. These data have been filtered and reformatted for ease of use by the ocean planning and GIS community. There are three main steps that this how-to covers: 1) getting set up with the data and software, 2) generating track lines, and 3) generating density grids.

## Step 1 – Getting Set Up

### Configuration

- Retrieve Broadcast point data for your desired time period and geography
- Retrieve the AIS Track Builder software at the AIS page
- Have ArcGIS 10.1 or above with the advanced or standard license, the 64 bit Desktop Geoprocessing Patch and the Spatial Analyst installed
- Windows computer with 8+GB RAM

### Getting Started with the Data

Access the AIS page and search for and download the time period and geography of the data you want. The Broadcast point files are formatted in zipped file geodatabases and organized by year, UTM zone, and month. Even one month of data can contain many millions of records. Consider dividing up your processing approach according to your geographic scope and available hardware. For example, our Atlantic product is built from monthly UTM zone 17, 18, and 19 points. After unzipping the Broadcast points, view and optionally filter out outlier points using native ArcMap edit commands. Outliers can show up over land masses and lead to poor track line and density results.

TIP: The ArcGIS CLIP command is an effective function to extract a smaller area of interest.

## Getting Started with the Software

From the AIS page, download Track Builder software and unzip it to your working directory. Do not separate the files in this directory. Note there are ReadMe and Instruction files available. The Esri Model Builder tools are used extensively in this how-to. For an overview of the Model Builder, visit *http://resources.arcgis.com/en/help/main/10.1/index.html#/A_quick_tour_of_ModelBuilder/002w00 000028000000/.* All these steps can also be completed using native ArcGIS Desktop commands, batch commands, and ArcPy. See the "Other Resources" section for more links to ArcPy and Track Builder options.

# Step 2 – Generating Track Lines

The track line process is made up of three interim steps: A) building monthly track lines, B) aggregating the monthly tracks, and C) extracting the annual vessel tracks by major vessel type.

## Monthly Track Line Creation

The ArcGIS Model interface is used in this step to process multiple months and zones of the data. Sometimes three or even four models will be used. Start by creating a custom tool box. Once complete, complete the following:

1. Within the custom toolbox, right-click and select New Model
2. Within the Model interface drag in the Track Builder script tool
3. Input your arguments as shown in the example below
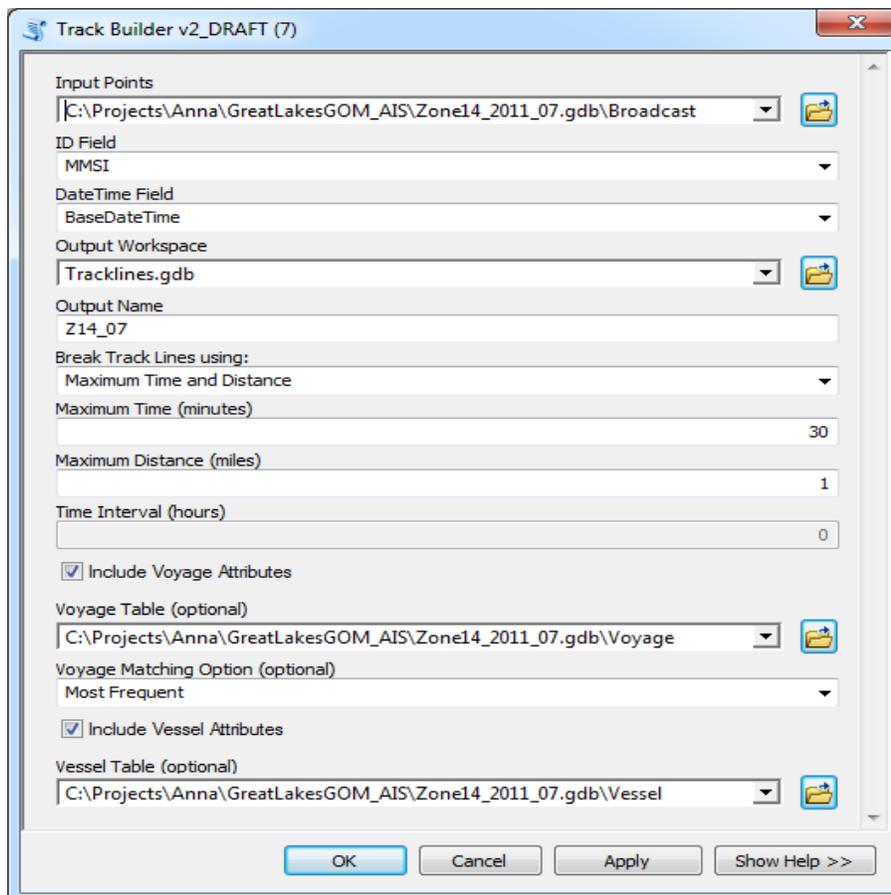
Track Builder interface

Table 1. Description of Track Builder Parameters.

| Parameter Name | Value |
| --- | --- |
| Input Points | Feature class representing the vessel points - often referred to as "Broadcast Points" |
| ID Field | "MMSI" |
| DateTime Field | "BaseDateTime" |
| Output Workspace | Location you want to store the monthly track line layer |
| Output Name | Desired name of the monthly track line layer. Make sure to specify the UTM Zone and Month when working with multiple zones and months |
| Break Track… | Maximum Time and Distance |
| Maximum Time (minutes) | 30 |
| Maximum Distance (nm) | 1 |
| Include Voyage Attributes | Check |
| Voyage Table | Location of the associated Voyage table for the same month and zone Input Points |
| Include Vessel Attributes | Check |
| Vessel Table | Location of the associated Vessel table for the same month and zone as the Input Points |

4.  Press OK within the Track Builder Script. Your model should resemble the figure below.
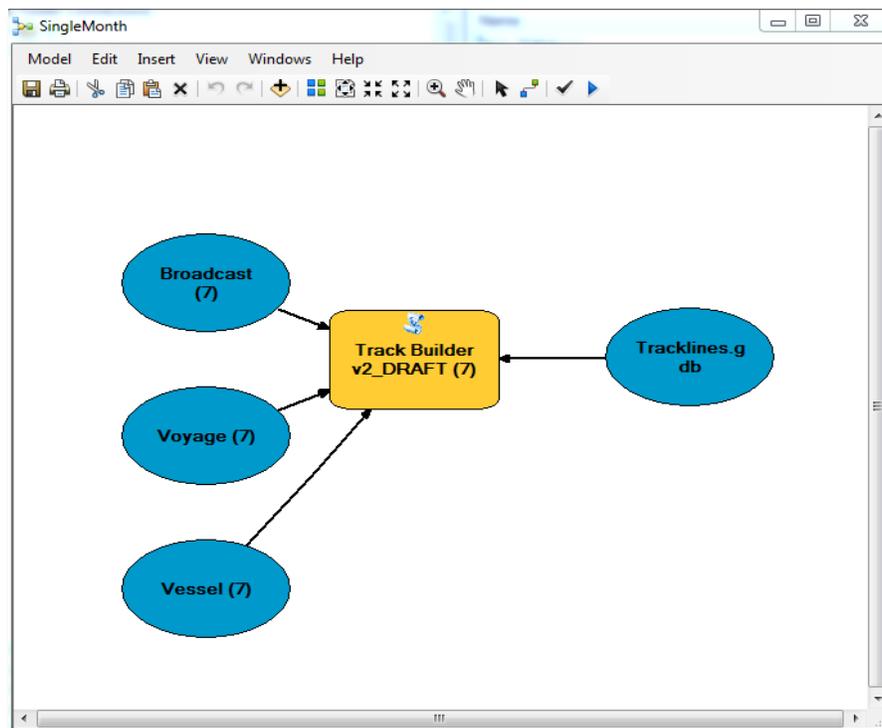
5. Select all of these parameters, right-click, and select copy.
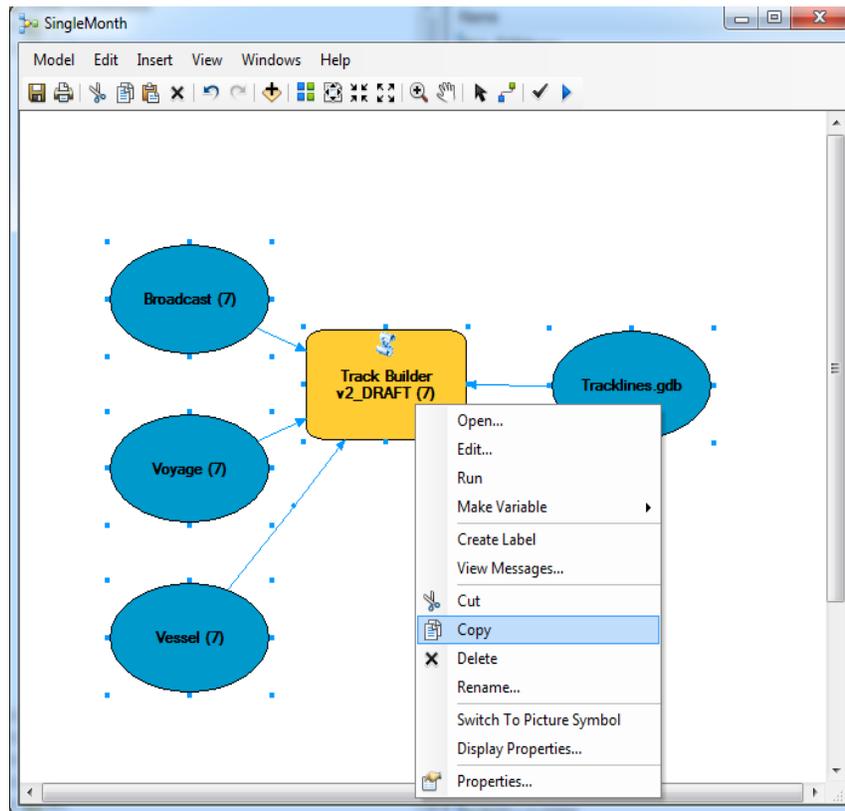


6. Paste this process until you have the desired amount to process all 12 months for a particular zone.
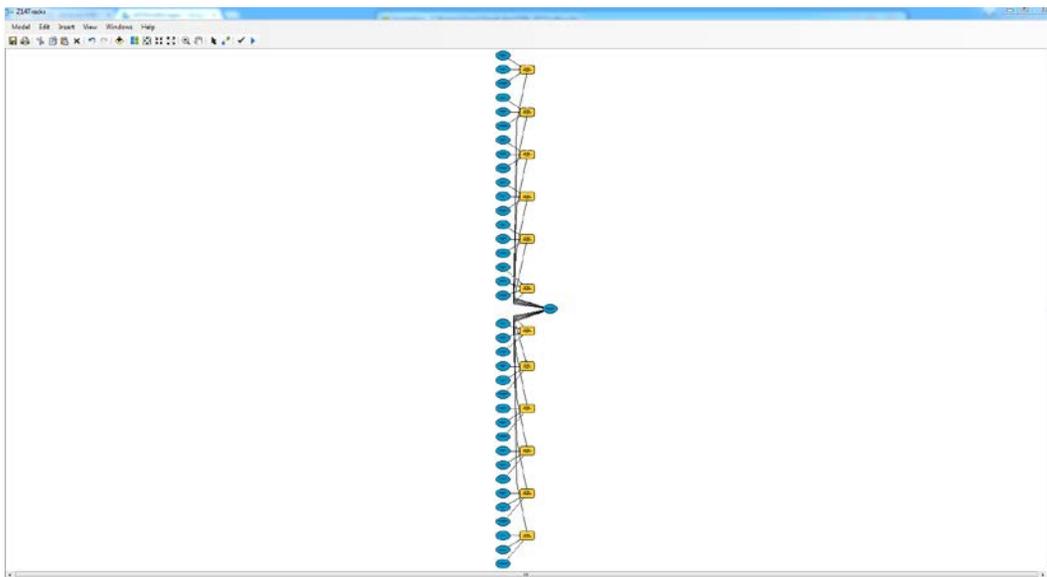


7. Within each of the new processes, edit the parameters so that each of the processes is customized to process a different month of data. Ensure that the Input Point, Voyage, and

Vessel tables are originating from the same zone and month file geodatabase and that the Time and Distance inputs remain the same.

8.  Save the model.

9.  Once all 12 months are set up, run the model by clicking the right arrow: 

TIP: If you are processing a large volume of data such as an entire UTM zone and you are running into errors or the process is failing, try clipping this into smaller pieces, running the Track Builder tool on these smaller areas, and then merging these track line files together to create the regional product. The MarineCadastre.gov team needed to do this for some or all of the months in these zones: 10, 11, 15, 16, and 18.
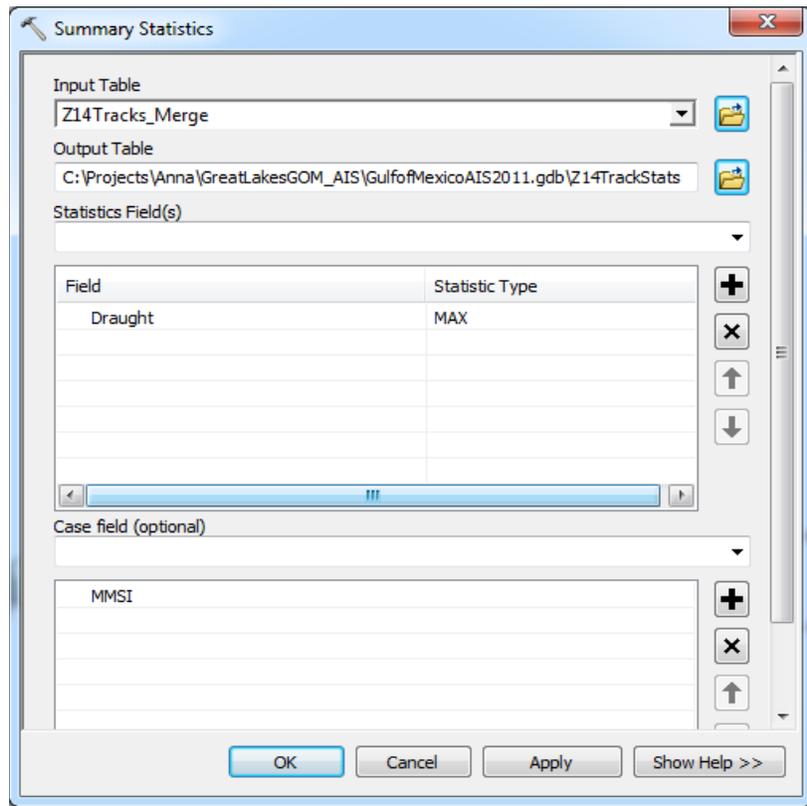
## Annual Track Line Creation

Once the 12 months of track lines have completed processing, set up a model to merge these monthly layers into one layer representing a whole year of track lines. In creating the annual track line file, you can also create and calculate a maximum draught field, project this into Web Mercator, and run the repair geometry function. The figure below is a representation of this model with all these processes set up.
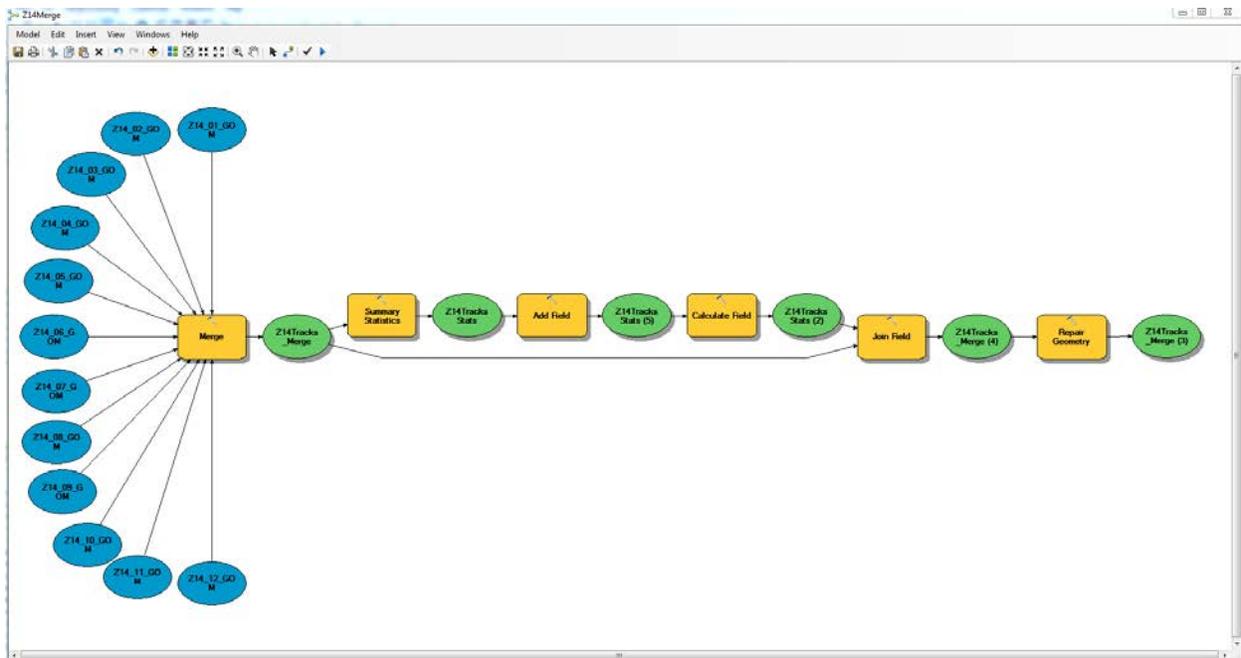


Using the same custom toolbox you used previously, follow these steps:

1.  Right-click, select New, and then select Model.
2.  Drag each of the monthly data layers into the model interface.
3.  Open ArcGIS Toolbox within the Data Management toolbox, select the General toolbox, and then select the Merge tool. Drag this into the model.

4.  Connect all the data layers to this tool by using the connector icon,
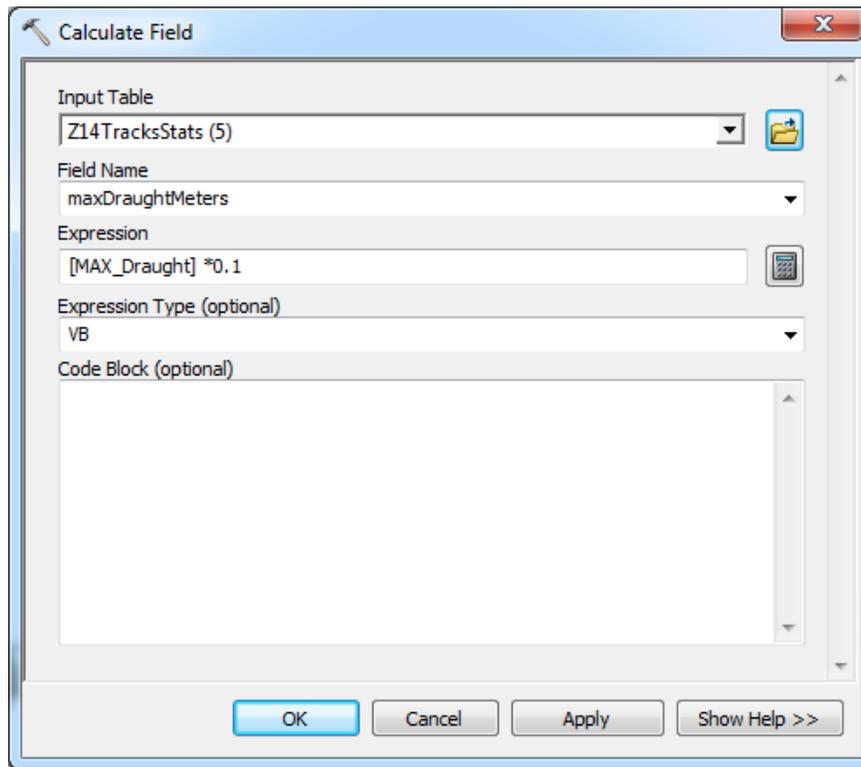5.  Within the Merge tool dialog, name and save the output.

6. Use the Summary Statistics tool to find the maximum value in the Draught field. This creates an intermediate table.
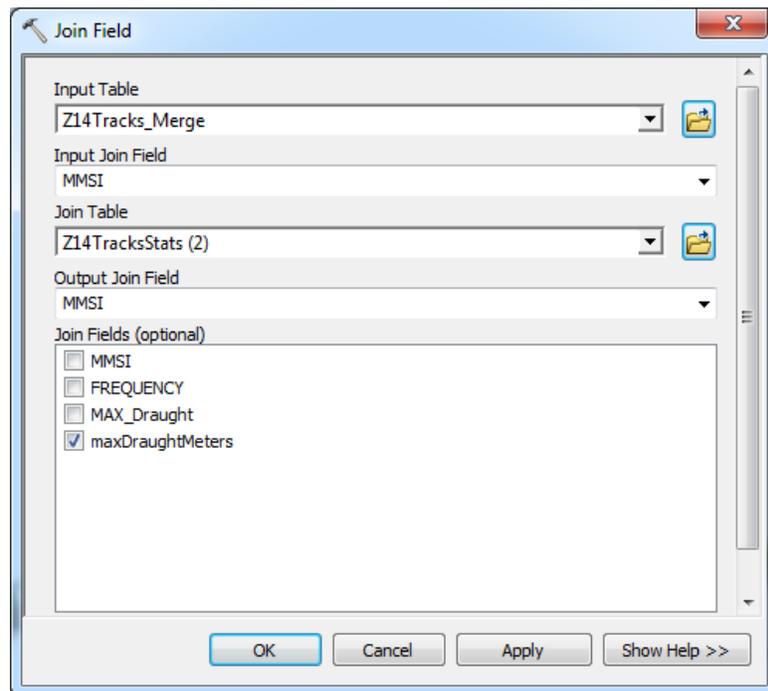


7. Add a field to the intermediate statistics table.
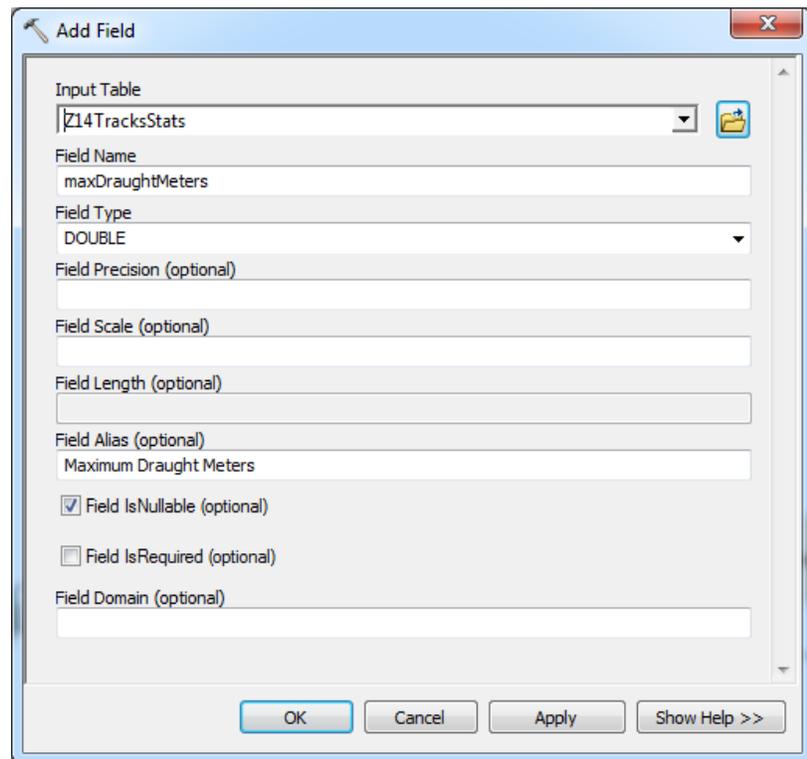
8. Calculate the field to look at the summary statistics and convert this to meters.



9. Join this field back to the annual track lines you created with the merge tool.

10. Repair Geometry on the annual track lines layer, enabling the option to delete features with null geometry in the tool dialog.
11. Save the model.
12. Run the model by clicking on the right arrow icon:

## Vessel Type Extraction

Now that you have an annual track line layer, you can group vessel types into six common categories: Cargo, Fishing, Passenger, Pleasure Craft and Sailing, Tanker, and Tug and Towing. To run this all at once, you can set up the model so that these queries are performed against the annual track line layer and exported into their own feature classes using the select tool.

TIP: Another option is to create layer files containing Definition Queries.

Using the same custom toolbox you used previously, follow these steps:

1. Right-click, select New, and then select Model.
2. Add in the Annual Vessel Track line layer.
3. Within ArcGIS Toolbox, go to the Extract toolbox within the Analysis Tools toolbox and drag the Select tool into the model
4. Connect the Annual Vessel Track line layer to the select tool using the connector icon:

5. Within the Select tool, enter the output feature class name and the SQL expression for the desired vessel type.
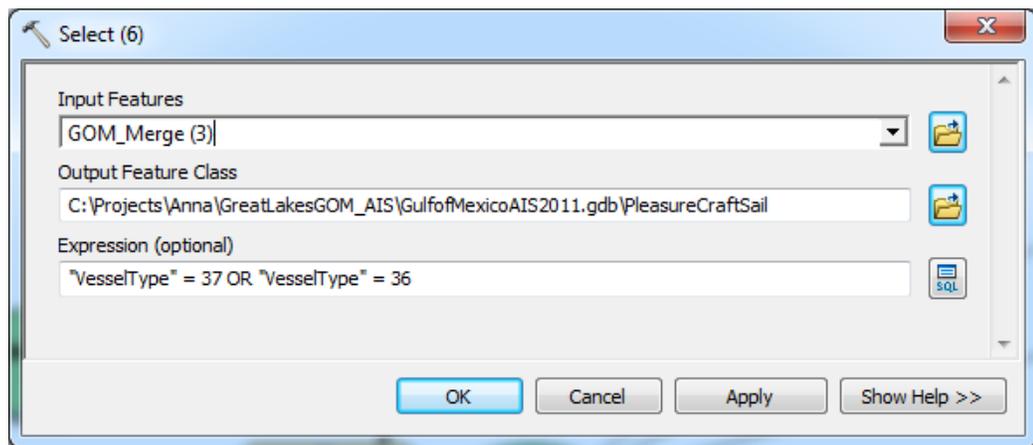


6. Copy and paste this Select tool until you have six you can customize for each vessel type.

Table 2. Vessel categories, their associated identification numbers, and the SQL query language to use within the Expression field to select and extract each of the vessel categories.

| Vessel Type | ID Numbers | SQL Expression |
|---|---|---|
| Cargo | 70-79 | "VesselType" = 70 OR "VesselType" = 71 OR "VesselType" = 72 OR "VesselType" = 73 OR "VesselType" = 74 OR "VesselType" = 75 OR "VesselType" = 76 OR "VesselType" = 77 OR "VesselType" = 78 OR "VesselType" = 79 |
| Fishing | 30 | "VesselType" = 30 |
| Passenger | 60-69 | "VesselType" = 60 OR "VesselType" = 61 OR "VesselType" = 62 OR "VesselType" = 63 OR "VesselType" = 64 OR "VesselType" = 65 OR "VesselType" = 66 OR "VesselType" = 67 OR "VesselType" = 68 OR "VesselType" = 69 |
| Pleasure Craft and Sailing | 36, 37 | "VesselType" = 36 OR "VesselType" = 37 |
| Tanker | 80-89 | "VesselType" = 80 OR "VesselType" = 81 OR "VesselType" = 82 OR "VesselType" = 83 OR "VesselType" = 84 OR "VesselType" = 85 OR "VesselType" = 86 OR "VesselType" = 87 OR "VesselType" = 88 OR "VesselType" = 89 |
| Tug and Towing* | 31, 32, 52 | "VesselType" = 31 OR "VesselType" = 32 OR "VesselType" = 52 |

*Note: Vessel type numbers 21 and 22 can also be used in the Tug and Towing category.

The figure below is the model setup with all the vessel types to extract.
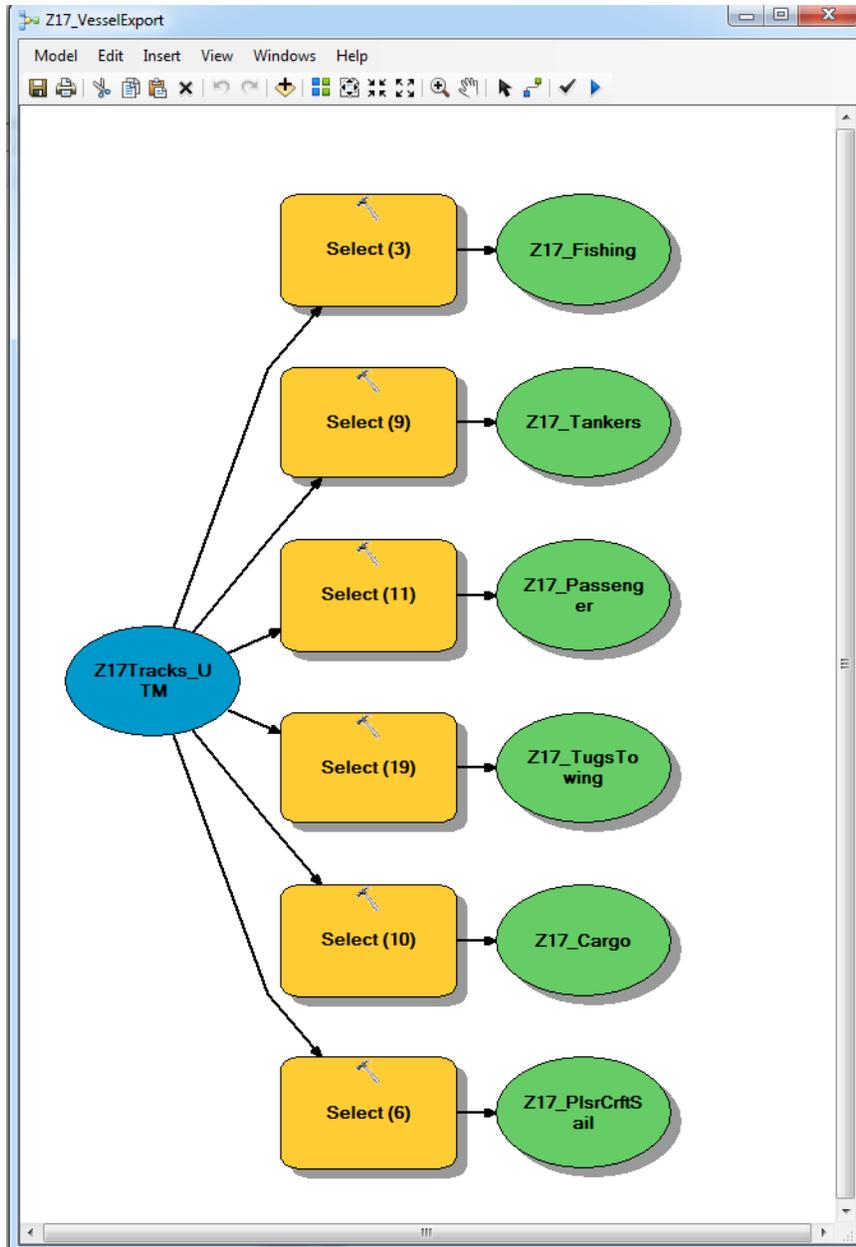


7.  Save the model.

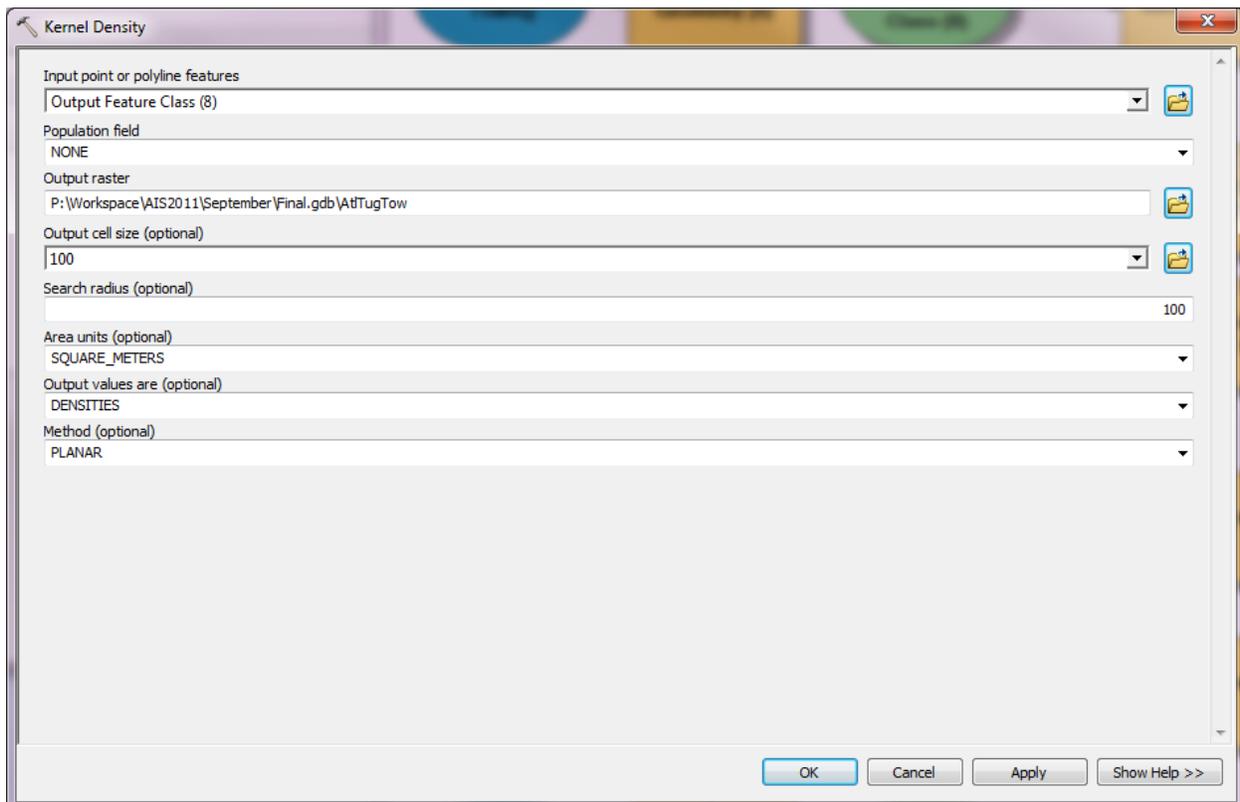8.  Run the model by clicking on the right arrow icon: ▶

# Step 3 – Generating Density Grids

Now that you have the annual total vessel traffic and the vessel traffic by groups, it is time to create the density grids. Activate your Spatial Analyst Extension license to run processes detailed in the section.

Using the same custom toolbox that you used previously, follow these steps:

1. Right-click, select New, and then select Model.
2. Drag in each of the track line layers you want to process, which should be each of the vessel type layers plus the total vessel traffic layer.
3. In ArcGIS Toolbox, navigate to the Data Management toolbox within the Projections and Transformations toolbox and drag the Project tool into the model.
4. In ArcGIS Toolbox, navigate to the Spatial Analyst toolbox, and then from the Density toolbox drag the Kernel Density tool into the model.
5. Copy the Project and Kernel Density tools into the model six times, once for each of the track line layers.
6. Connect each of the track line layers to a Project tool using the connector icon:
7. Within the project dialog, project the NAD83 data to WGS84 Web Mercator Auxiliary Sphere and rename the outputs with unique names.
8. Connect each of the outputs from the Project tool to a Kernel Density tool.
9. Double-click on each Kernel Density tool and enter the following parameters into the dialog box, making sure to name each of the output rasters with the vessel type; click OK.

10. Save the model.
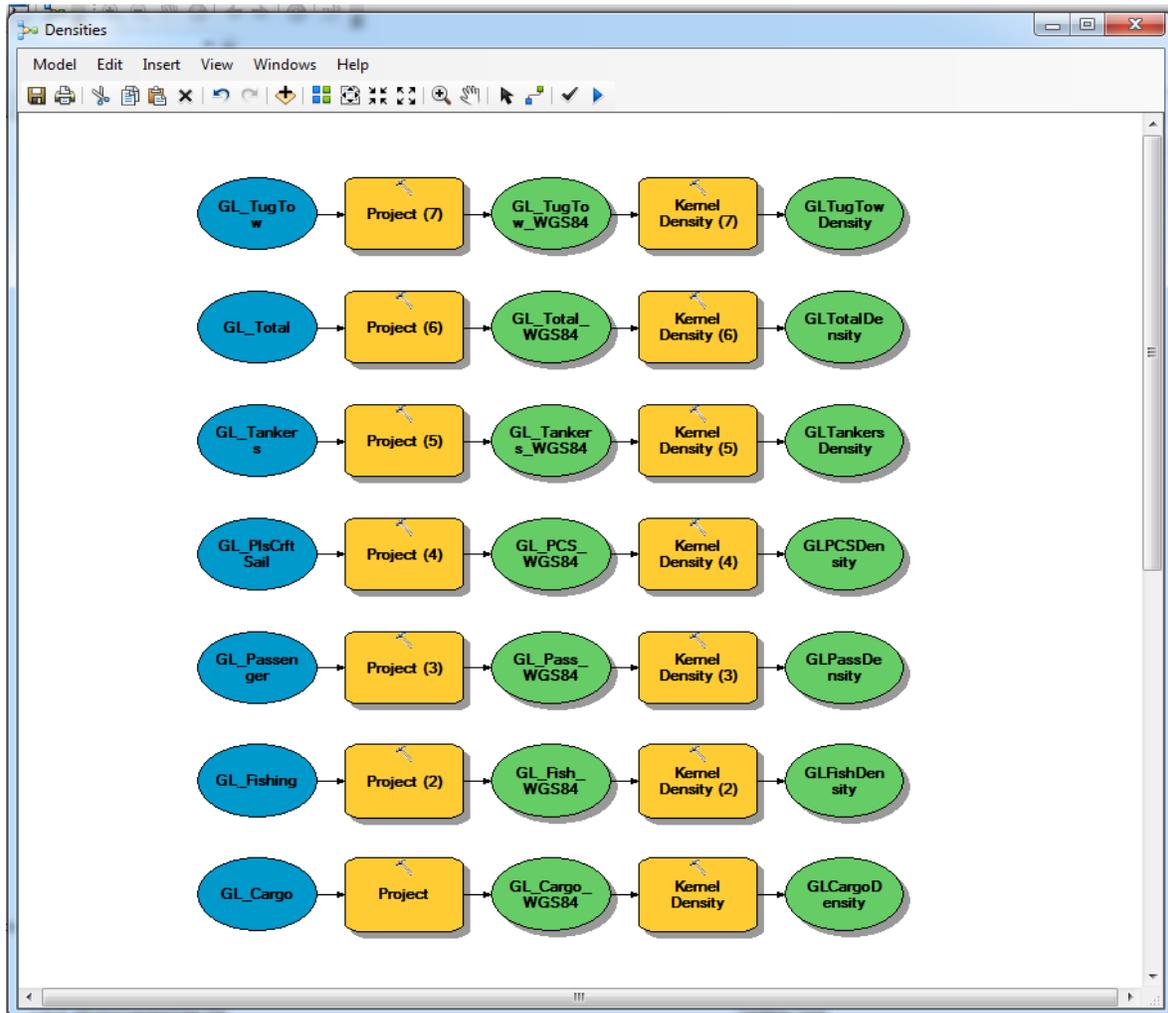


11. Run the model by clicking on the right-arrow icon: 

To merge multiple regional density grids into a seamless grid, use the Mosaic to New Raster tool. We did this to combine the East Coast, West Coast, Great Lakes, and Gulf of Mexico data into a seamless grid for the contiguous United States.

## Final Results

The final end products created using these processes and published on MarineCadastre.gov are the trackline layer and the density layers by vessel type. The trackline layer contains four regional download files for these regions: East Coast, Great Lakes, Gulf of Mexico, and West Coast. For each of these regional files you will find seven layers for each of the vessel types. The density layers contain seamless grids for each of the vessel types for the contiguous United States and are also provided as map services. All of these layers have metadata records associated with them. The layer names are listed below:

2011 Vessel Tracklines
2011 Vessel Density
2011 Vessel Density: Cargo
2011 Vessel Density: Fishing
2011 Vessel Density: Passenger
2011 Vessel Density: Pleasure Craft and Sailing
2011 Vessel Density: Tanker
2011 Vessel Density: Tug and Towing

This list will grow as we publish additional years. In general, we plan to use the same format for layer names, using the respective year within the title. If you have any questions or require more information please email our team at *ocm.aisdata@noaa.gov*.

## Other Resources

Track Builder Script Download:
*www.marinecadastre.gov/AIS/AIS%20Documents/TrackBuilderVersion2.zip*

Track Builder Tutorial: *www.marinecadastre.gov/ais/AIS%20Documents/TrackBuilderTutorial.pdf*

A quick tour of Model Builder:
*http://resources.arcgis.com/en/help/main/10.1/index.html#/A_quick_tour_of_ModelBuilder/002w00 000028000000/*

A quick tour of Batch Processing:
*http://resources.arcgis.com/en/help/main/10.1/index.html#//00210000000w000000*