BIOM4051 R Practical 3. Vessel Traffic

Figure 1: Fishing and other forms of marine traffic are among the leading threats to marine biodiversity

Introduction

Fisheries, shipping and other forms of marine traffic represent some of the most significant threats to global marine biodiversity. In addition to well-documented impacts of fishing on habitats and species, collisions between vessels and marine fauna ("vessel strike"), submarine noise pollution, chemical spills and transport of invasive species all represent substantial threats Erbe et al. 2020. Until recently, the scale and impacts of offshore marine traffic were relatively hidden. However, the increasing availability of satellite-based vessel tracking data is enabling us to map the global distribution of shipping and fishing in unprecedented detail Kroodsma et al. 2018.

Two main forms of vessel tracking data are available: Vessel Monitoring Systems (VMS), which are generally owned and used by national maritime authorities to monitor the movement of specific fleets (e.g. fishing); and Automatic Identification Systems (AIS), which are primarily intended as a maritime safety tool but which can be used to track global vessel movements. The International Convention for the Safety of Life at Sea (SOLAS) requires all vessels $>$ 300 tonnes to transmit on AIS, so it is mostly used for tracking the movements of larger, ocean going vessels.

In this practical, you are going to use satellited-derived AIS data to map the distribution of marine traffic around the Isles of Scilly. The exercise will allow you to practice implementing some of the vector-raster operations introduced in Tutorials 5 and 6, while also getting hands on experience working with an important source of spatial data in marine conservation.

Datasets

In the Practical 3 data folder you will find the following datasets:

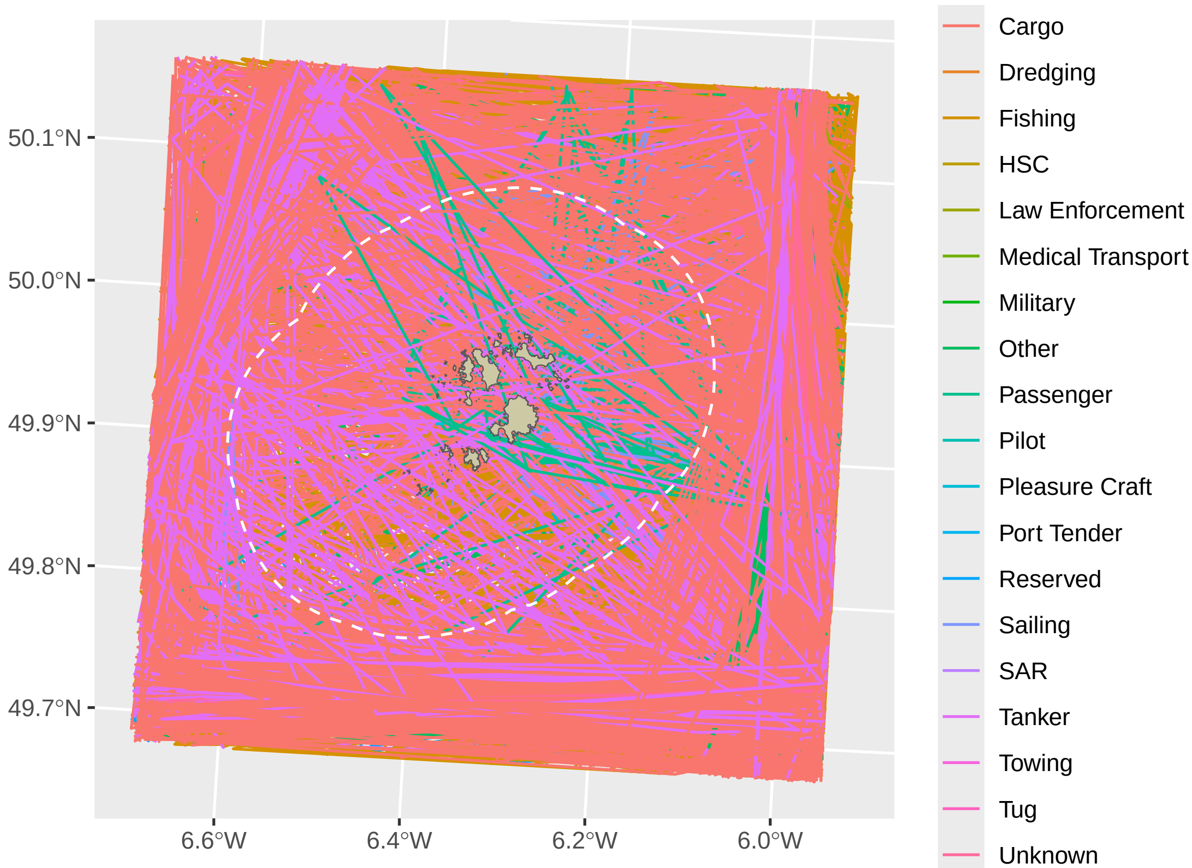
1. *scilly.gpkg* A polygon vector layer of the Isles of Scilly.
2. *fish_limit_6nm.gpkg* The six nautical mile inshore fishing limit of the Isles of Scilly.
3. *scilly_AIS_2018.gpkg* Satellite AIS data collected around the Isles of Scilly between January and April 2018 (commercial data purchased from https://spire.com/maritime). The data has been converted into line features containing the tracks for individual vessels identified by their Maritime Mobile Service Identity (MMSI) and callsign. The vessel type is also included in the attribute table.

1. Mapping marine traffic around the Isles of Scilly

First, let's inspect our data by plotting our vessel AIS tracks, shaded by vessel type.

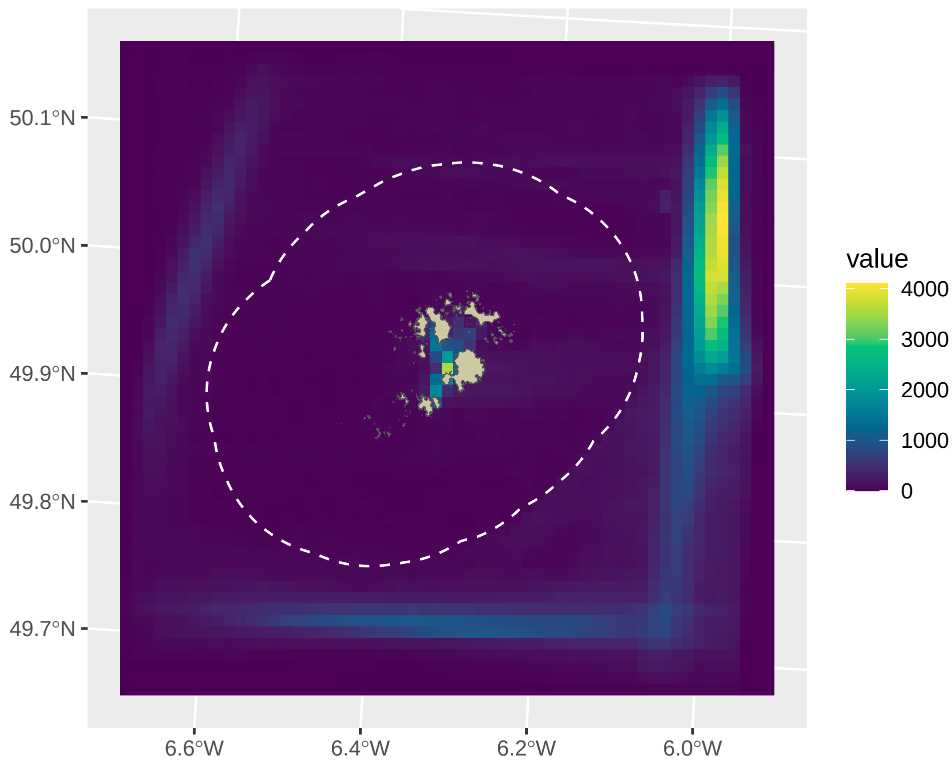
```
library(terra)
library(sf)
library(tidyterra)
library(tidyverse)
library(lubridate)
library(colorspace)
```

```
scilly = st_read('data/scilly.gpkg')

limit  = st_read('data/fish_limit_6nm.gpkg') %>%
         st_transform(27700)

AIS    = st_read('data/scilly_AIS_2018.gpkg')

ggplot() +
  geom_sf(data = AIS, mapping = aes(colour = vessel_type)) +
  geom_sf(data = limit, colour = 'white',linetype='dashed') +
  geom_sf(data = scilly, fill = 'lemonchiffon3')
```



Quite a lot of traffic for 4 months! To help us to visualize this better, let's produce a marine traffic raster layer showing the total number of vessel crossings for each 1 x 1 km cell in our study area. You should end up with a map something like this (**HINT**: Look at the `background` option in `?rasterize`):

```
AIS = vect(AIS)
aisgrid = rast(AIS, resolution = c(1000,1000))
aisgrid = rasterize(AIS, aisgrid, fun = 'count', background = 0)

ggplot() +
  geom_spatraster(data = aisgrid) +
  geom_sf(data = limit, colour = 'white',linetype='dashed') +
  geom_sf(data = scilly, fill = 'lemonchiffon3') +
  scale_fill_continuous_sequential('Viridis', rev=FALSE)
```



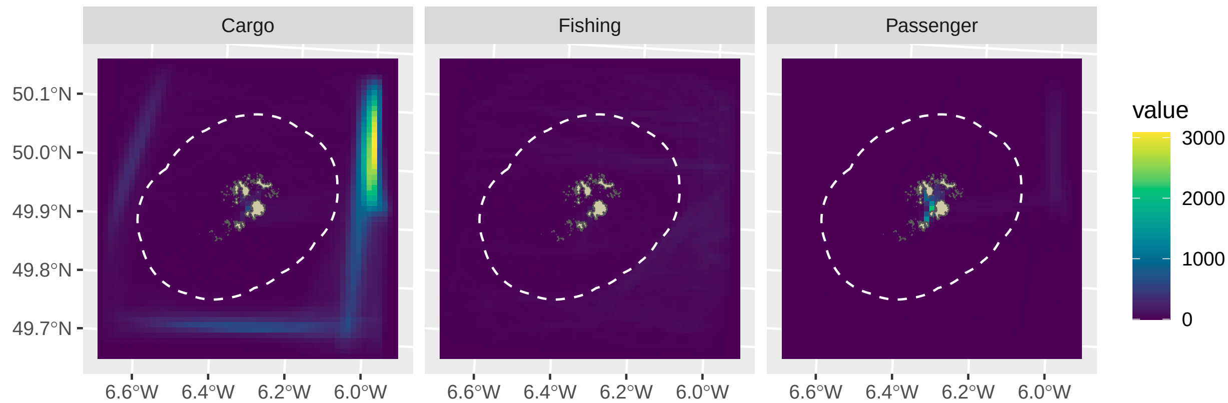
Some of our cells were criss-crossed more than 4000 times over a 4 month period [*note that individual vessels may cross a cell more than once so the total crossings are larger than the number of unique vessel tracks*]

2. Mapping marine traffic by vessel class within the Scilly 6NM fishing limit

This map currently represents the distribution of all marine traffic, regardless of vessel type. However, given that different vessel classes represent different threats to marine ecosystems, we might want to divide this up by vessel class. For the purposes of this analysis, we will focus on three principle vessel types: Fishing, Cargo and Passenger. Let's produce a plot showing the distribution of each of our three vessel classes (**HINT**: There are different ways to do this but try exploring the 'by' option in the rasterize function by looking at the help with `?rasterize`):

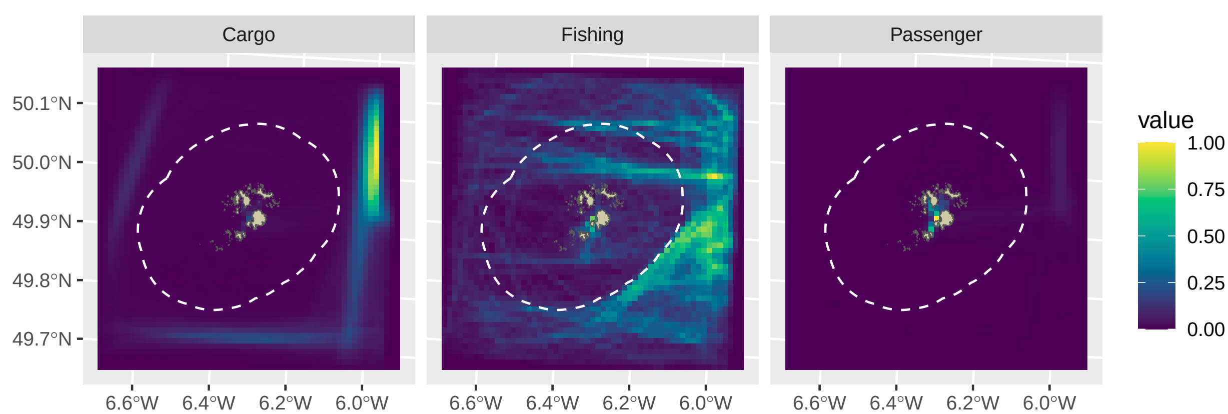
```
# First subset the vessels we want
by.vessel =
  st_as_sf(AIS) %>%
  subset(vessel_type %in% c('Fishing','Cargo','Passenger'))

# The %in% part is the same as lots of OR statements:
# subset(vessel_type =='Fishing' |vessel_type =='Cargo' | vessel_type =='Passenger'))

by.vessel =
  vect(by.vessel) %>%
  rasterize(aisgrid, fun = 'count', by = 'vessel_type', background = 0)

names(by.vessel) <- c('Cargo','Fishing','Passenger')
```

```r
ggplot() +
  geom_spatraster(data = by.vessel) +
  geom_sf(data = limit, colour = 'white',linetype='dashed') +
  geom_sf(data = scilly, fill = 'lemonchiffon3') +
  scale_fill_continuous_sequential('Viridis', rev=FALSE) +
  facet_wrap(~lyr)
```



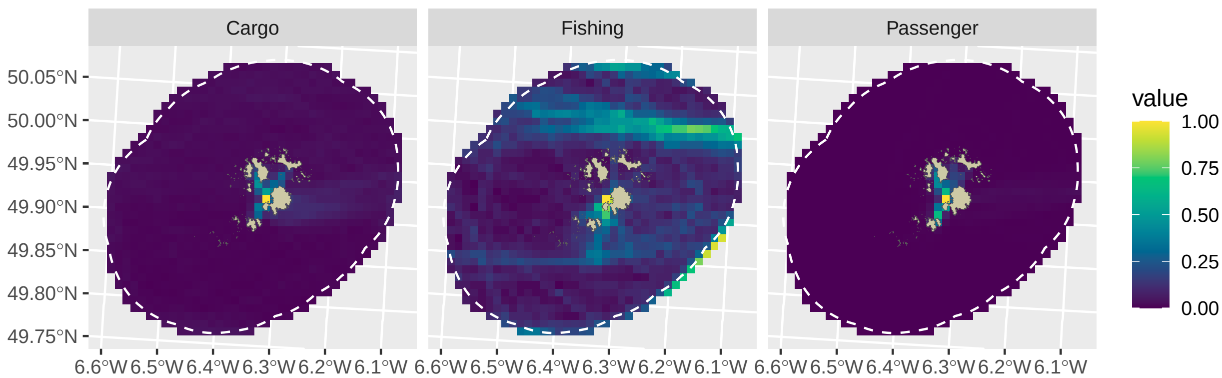
The shared fill scale is quite stretched here by some very high values for cargo traffic. As an alternative we could plot the relative activity by dividing each layer by its maximum cell value:

```r
max = global(by.vessel,fun='max',na.rm=TRUE)[,1]
by.vessel = by.vessel/max

ggplot() +
  geom_spatraster(data = by.vessel) +
  geom_sf(data = limit, colour = 'white',linetype='dashed') +
  geom_sf(data = scilly, fill = 'lemonchiffon3') +
  scale_fill_continuous_sequential('Viridis', rev=FALSE) +
  facet_wrap(~lyr)
```



We can see the major shipping lanes, ferry traffic within the islands, and also the fishing fleet hugging the boundary of the inshore fishery limit. Finally, let's look at just the distribution of marine traffic within the Isle of Scilly 6 nautical mile limit.

```r
mask = st_cast(limit,'POLYGON') %>% vect()

by.vessel = crop(by.vessel,mask) %>%
            mask(mask)

# Rescale here to get relative effort again just inside the 6NM limit
by.vessel = by.vessel/global(by.vessel,fun='max',na.rm=TRUE)[,1]

ggplot() +
geom_spatraster(data = by.vessel) +
geom_sf(data = limit, colour = 'white',linetype='dashed') +
geom_sf(data = scilly, fill = 'lemonchiffon3',linewidth=0.05) +
scale_fill_continuous_sequential('Viridis', rev=FALSE,na.value='transparent') +
facet_wrap(~lyr)
```



This shows the relative distribution of each vessel class, with 1 representing higher activity. We can see cargo and passenger traffic concentrated around the main anchorages between the islands and fishing more widely distributed with some high use areas in the north.