FFI Forsvarets forskningsinstitutt

Density mapping of ship traffic

FOSS4G – Boston 2017

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Introduction

Norwegian Defence Research Establishment (FFI) stores data from sensors like AIS[1], LRIT[2] and VMS[3] in databases. These historical data on ship positions and metadata, accumulated, enables the creation of density maps of the ship traffic.

Density maps give the opportunity to visually analyze and understand the ship traffic patterns and behavior.

[1]AIS – Automatic Identification System (Position information and static/voyage related data)

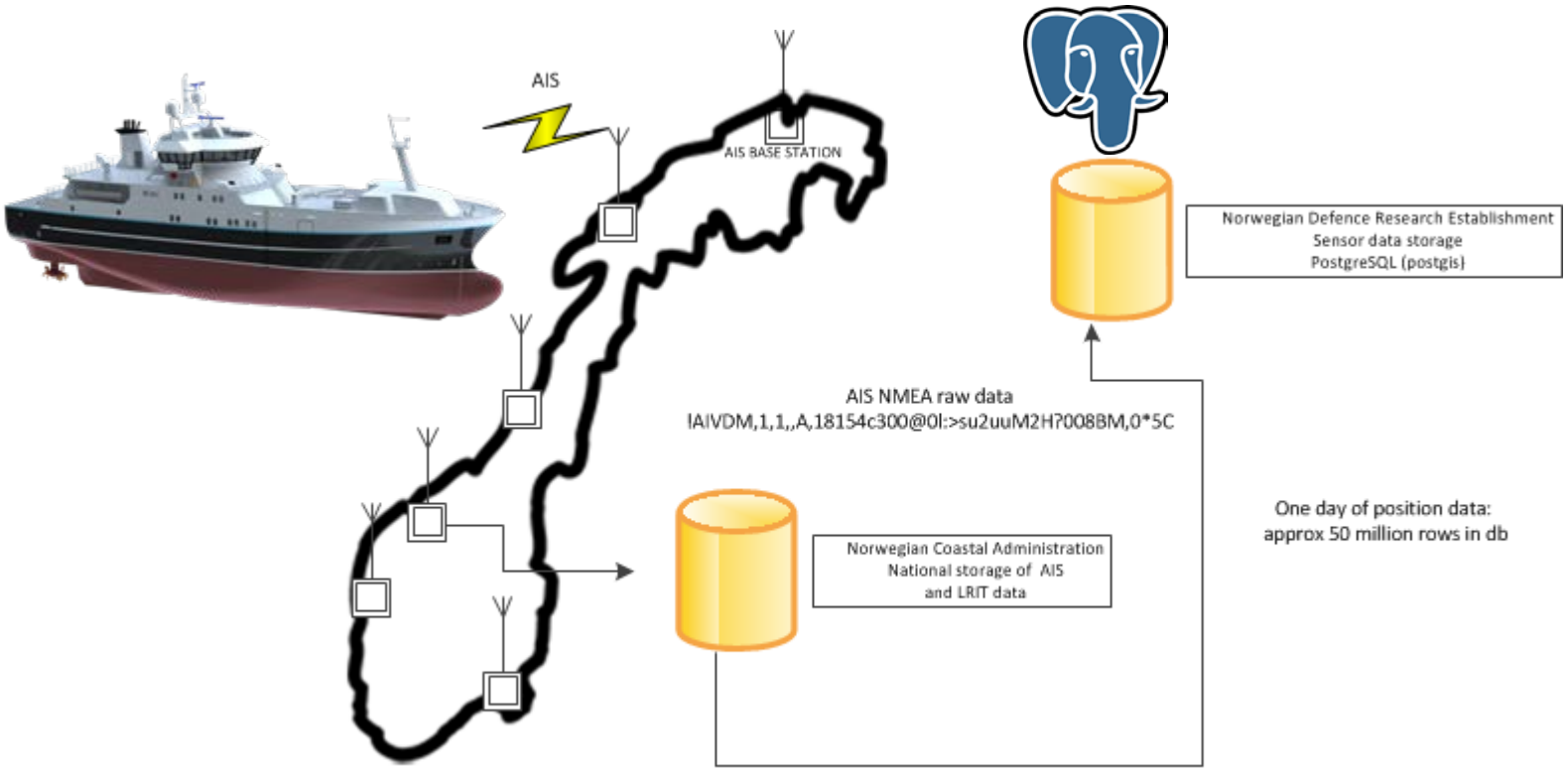
[2]LRIT – Long Range Identification and Tracking

[3]VMS – Vessel Monitoring System (fishery related)

Ship traffic data used in the density maps

- AIS *(Messages 1,2,3,18 and 19 – position messages)*
  - Norwegian land based AIS-network (incl. Svalbard, Bear Island, Offshore installations etc.)
  - Norwegian AIS-satellites
  - ISS (NORAIS)
  - EXACT EARTH
  - LUXSPACE
  - SPIRE SAT
  - Other North European AIS sources
- Vessel Monitoring System (VMS)
  - Position messages only
- Long Rang Identification and Tracking (LRIT)
  - Conveyed from Norwegian Costal Administration (NCA) as AIS-data to FFI

Organizing the data

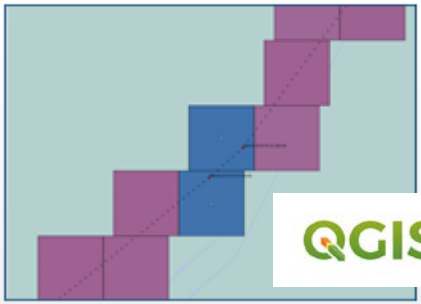


Organizing the data

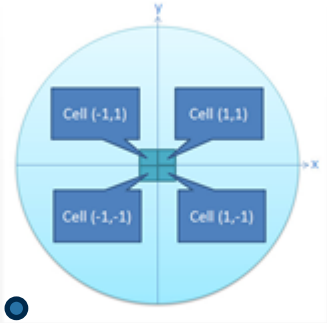
Organizing step 1
remove positions on land

187.776.081 positions on land Des. 2016

Organizing step 2
implementing intermediate positions



Organizing step 3
Aggregate by unique mmsi in cell for every hour



Summarize time in cell

dt date	hr integer	mmsi integer	sec_cnt integer	nav_status integer	sensor_type integer	sog numeric	grid_point_type boolean	xcol integer	yrow integer
2015-01-01	23	276421000	2401	0	1	0.1	TRUE	8468	35652
2015-01-01	16	258358000	42	15	1000	8.5	FALSE	-376	34500
2015-01-01	12	258358000	240	15	1000	2.8	TRUE	-23	34501

Organizing step 4
aggregate selected values monthly

Npgsql

mmsi integer	sec_cnt integer	sensor_type integer	sog numeric	grid_point_type boolean	xcol integer	yrow integer
1073741695	8924	10	0.7	TRUE	24338	9946
1073741695	3042	10	0.9	TRUE	24313	10223
1073741695	900	100	0.4	TRUE	24121	9855
1073741695	3174	100	0.5	TRUE	24025	10032
1073741695	354	110	1.9	TRUE	24025	10031

Max registered speed,total seconds and sensors holding MMSI in cell

PostGIS

GDAL

Npgsql

QGIS

Organizing the data

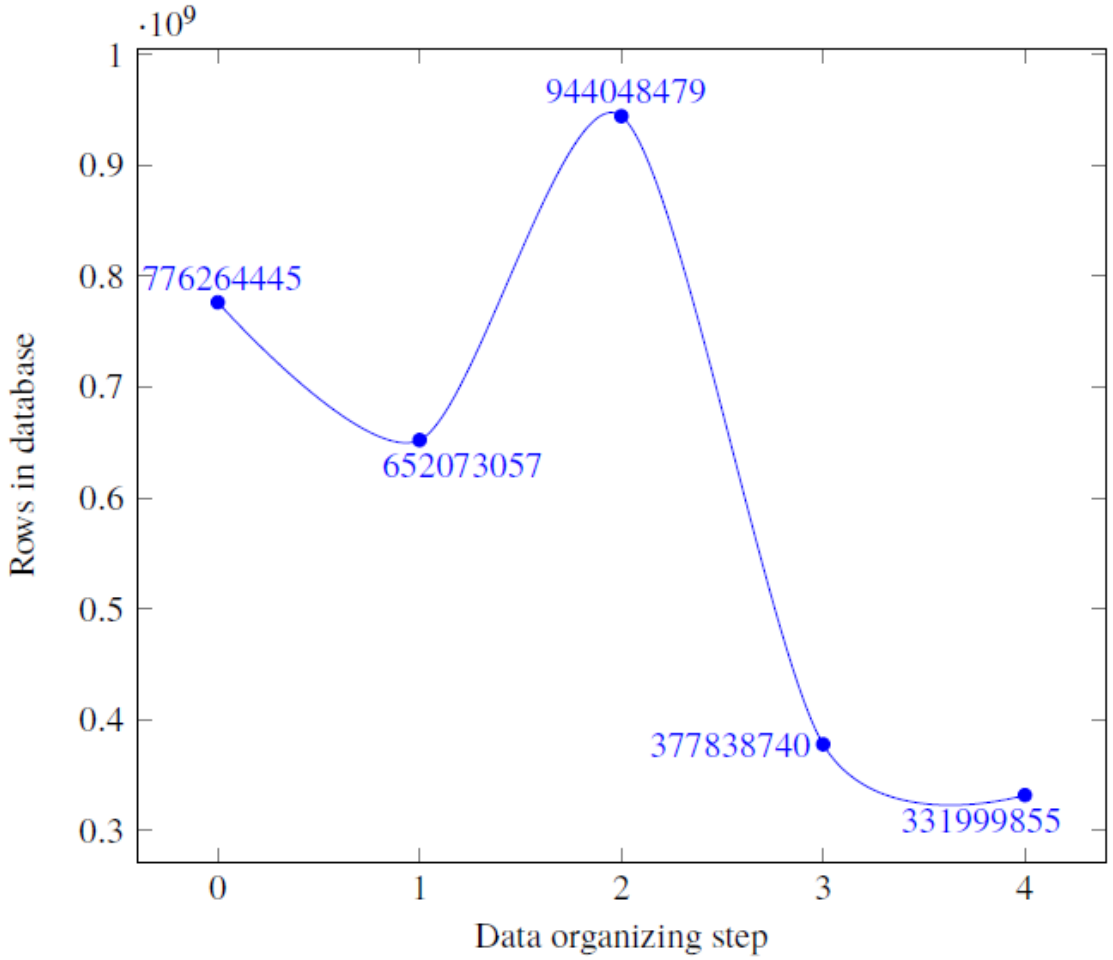


Figure 3.1 *Data reduction while organizing in time and space, June 2015*

PostGIS

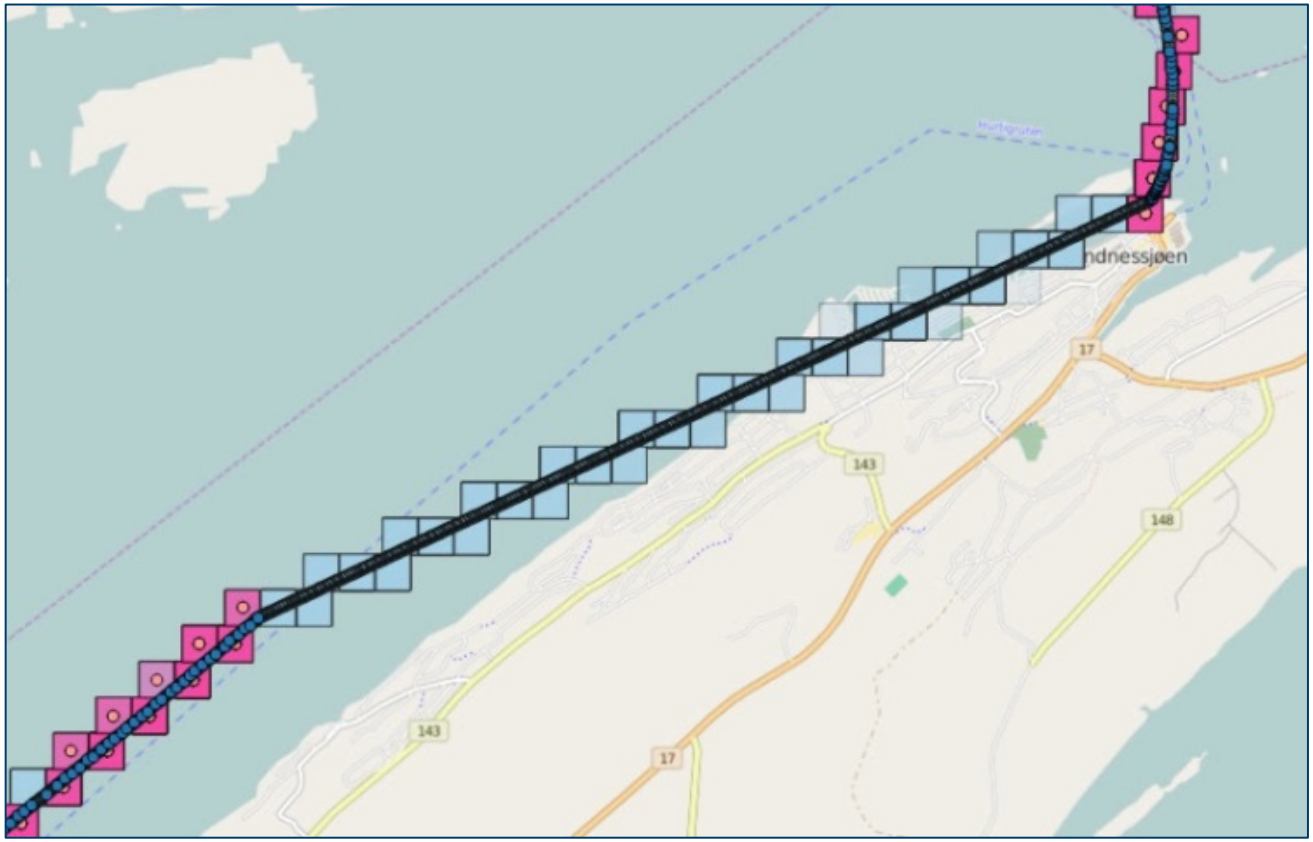
GDAL

Npgsql

QGIS

Organizing the data – step 2, intermediate pos.

Organizing the data – step 2, intermediate pos. & remove position segments on land



PostGIS

GDAL

Npgsql

QGIS

Calculating density

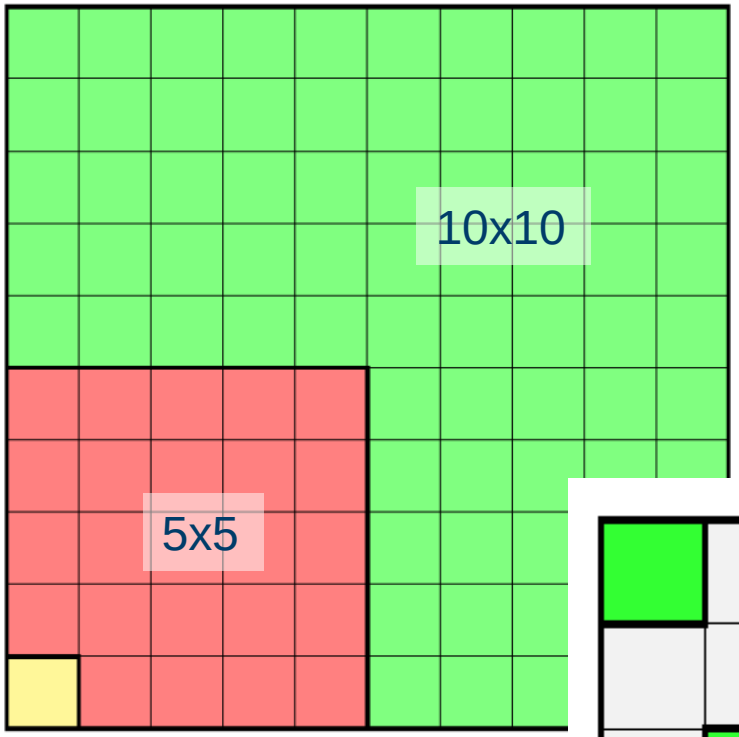
The following equation shows an *example* for a given area over the time period of January where the scale factor is 5. Ω represents the 5 x 5 basic cell area and the density is represented as constant over the time period Ja 1st (T_1)- January 31st (T_2). M is total amount of hours in January (744)

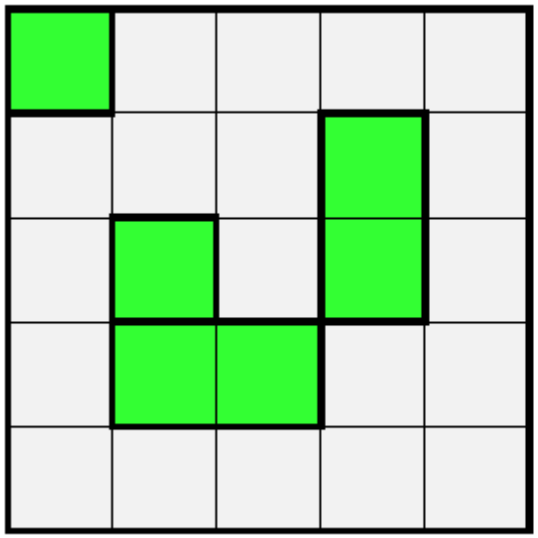
MATH...

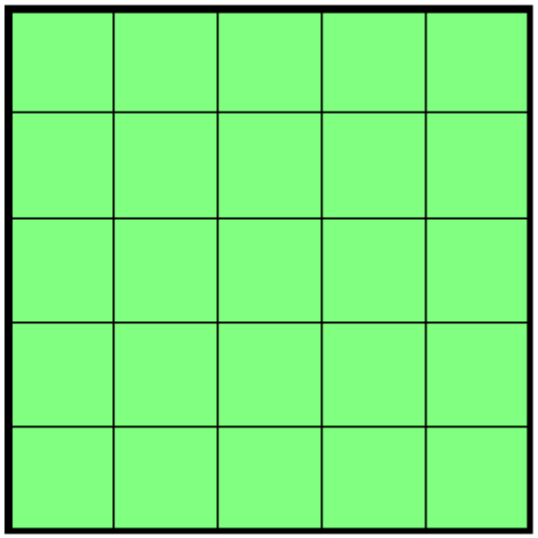
$$\rho_{\Omega}(T_1, T_2) = \frac{1}{(T_2 - T_1)\text{area}(\Omega)} \sum_{k=1}^{M} \sum_{i=1}^{5} \sum_{j=1}^{5} \left(\sum_{s=1}^{N(k,i,j)} \tau_{k,i,j}^{s} \right)$$

Here $\tau_{k,i,j}^{s}$ is visit time of ship track s in basic cell (i, j) in area Ω at time step k. N(k, i, j) is the number of ship tracks intersecting the space-time cell (k, i, j).

Creating the density map – scale factor







PostGIS

GDAL

Npgsql

QGIS

Density mapping

GeoPackage – vector

Create/merge etc. with:

- Spatialite
- GDAL/**OGR**

Proj.NET

Ship types classified by StatCode 5 IHS Fairplay (Lloyds) 4 different levels

Feature	
Europe_2016_01_lvl3	
fid	
(Derived)	
(Actions)	
fid	
X	330
Y	7057
MAXSOG	15.5
DENSITY	0.000104345878136201
BULK DRY	4.31600955794504e-06
BULK DRY/LIQUID	
CHEMICAL	6.75029868578256e-06
CONTAINER	
DREDGING	
FISH CATCHING	4.36081242532855e-06
GENERAL CARGO	3.05406212664277e-05
INLAND WATERWAYS DRY CARGO/PASSENGER	
INLAND WATERWAYS OTHER NON SEAGOING	
INLAND WATERWAYS TANKER	
LIQUEFIED GAS	6.8847072879331e-06
NON MERCHANT SHIPS	
NON PROPELLED	
NON SHIP STRUCTURES	
OFFSHORE SUPPLY	3.9426523297491e-06
OIL	4.92831541218638e-06
OTHER ACTIVITIES	
OTHER BULK DRY	
OTHER DRY CARGO	
OTHER FISHING	
OTHER LIQUIDS	
OTHER OFFSHORE	5.10752688172043e-06
PASSENGER	
PASSENGER/GENERAL CARGO	
PASSENGER/RO-RO CARGO	2.89725209080048e-06
REFRIGERATED CARGO	3.01672640382318e-06
RESEARCH	
RO-RO CARGO	6.45161290322581e-06
SELF DISCHARGING BULK DRY	5.97371565113501e-06
TOWING/PUSHING	1.56063321385902e-05
UNKNOWN	3.56929510155317e-06

PostGIS

GDAL

Npgsql

QGIS

Proj.NET

Web Processing Services (WPS)

- and executables

- creating GeoPackages
- merging GeoPackages
- extracting GeoPackage layers (i.e., creating a new GeoPackage based on desired attributes, e.g. a specific ship type, area)

PostGIS

GDAL

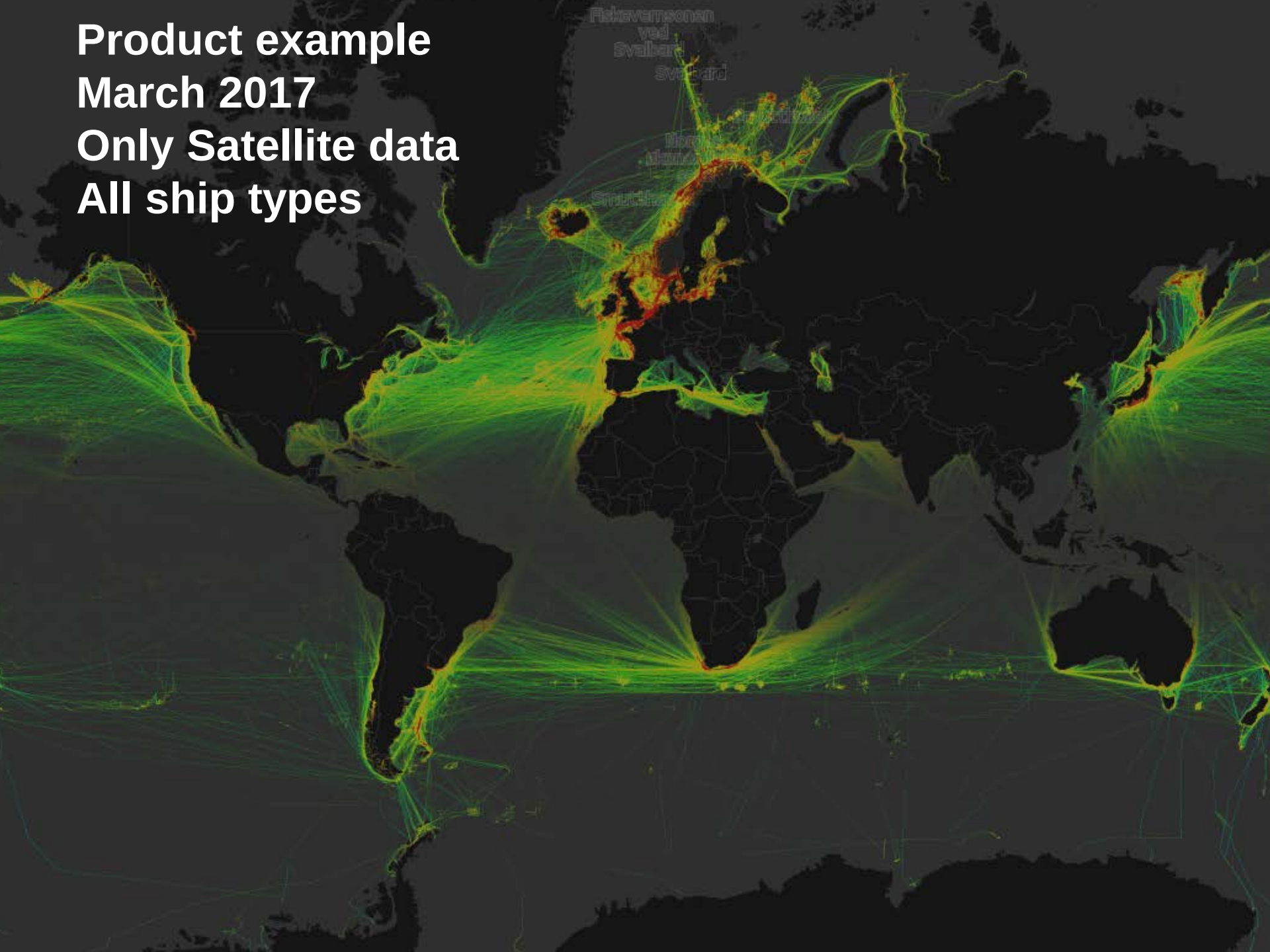
Npgsql

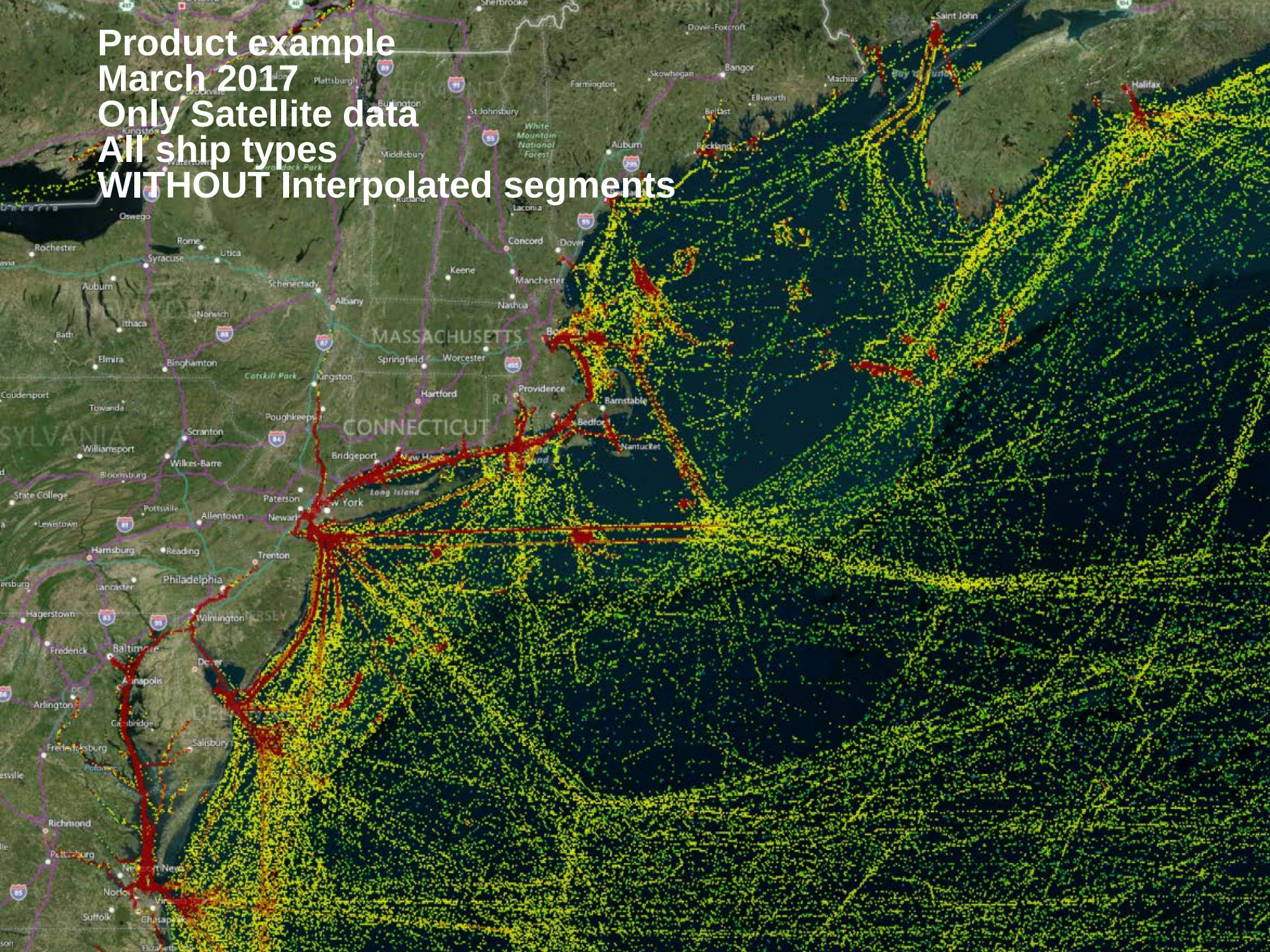
QGIS

GeoPackage

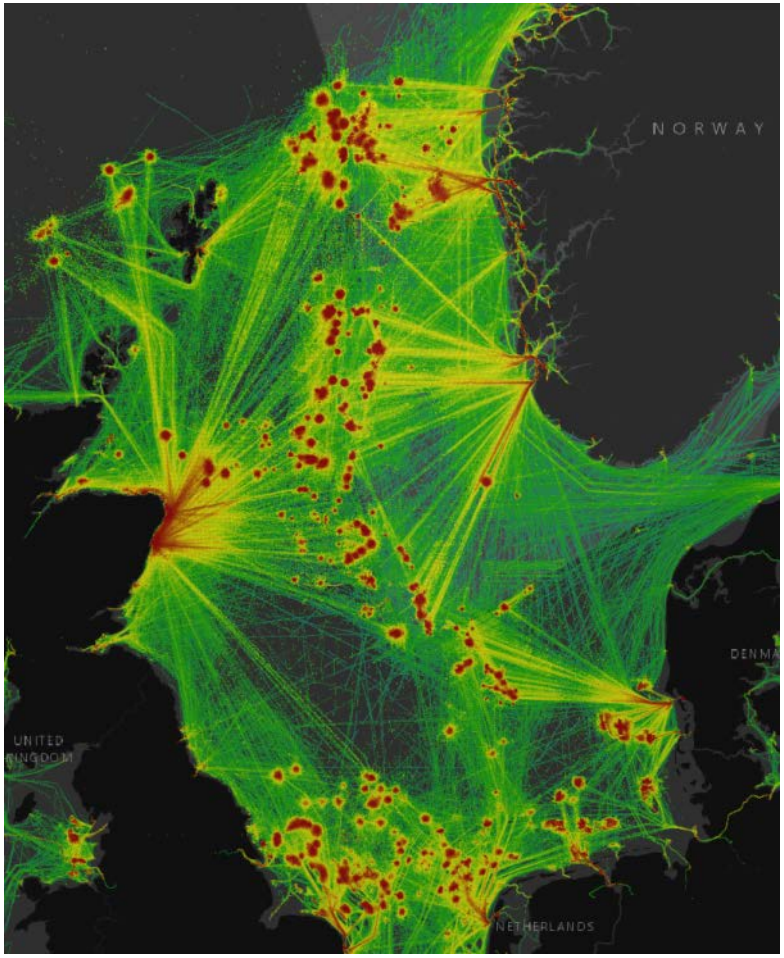
Proj.NET

ZOO


Product example
March 2017
Only Satellite data
All ship types

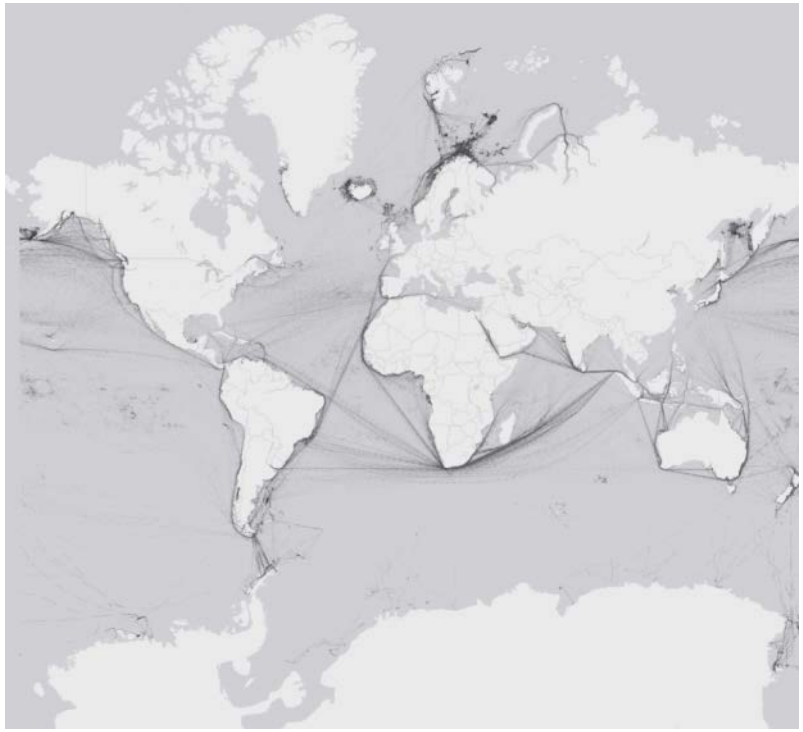

Product example
March 2017
Only Satellite data
All ship types
WITHOUT Interpolated segments

Product examples – Offshore related traffic



Product examples – SAT coverage (no color styling)

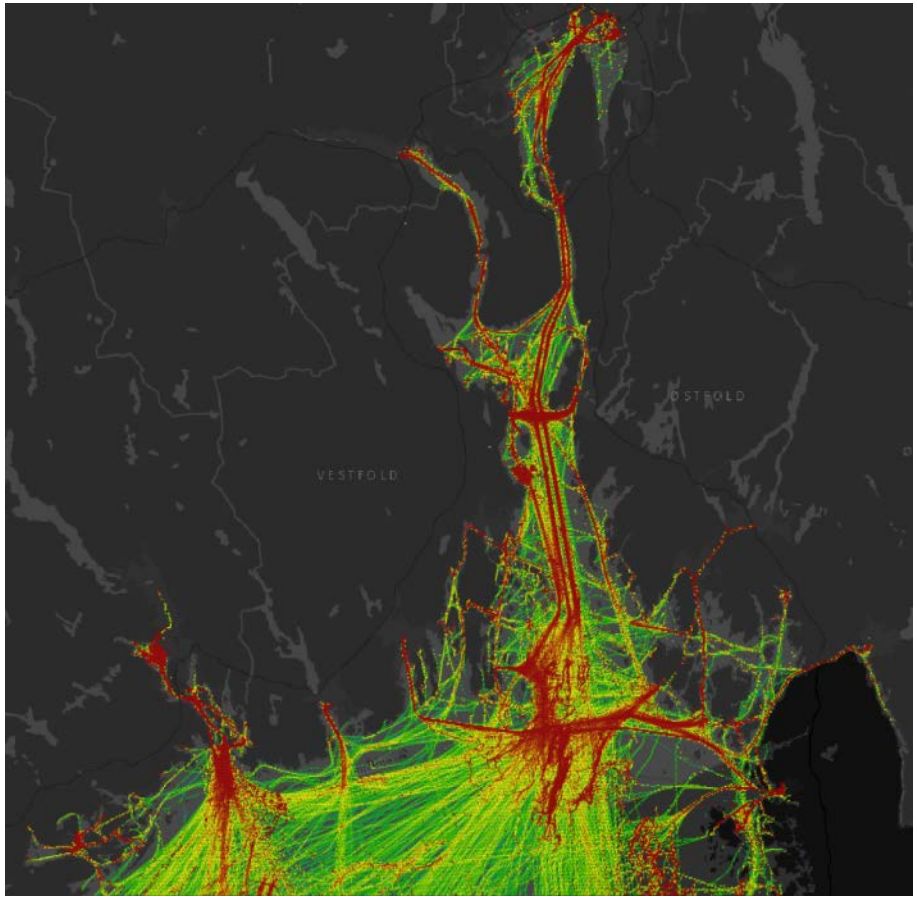
AISSAT 1/2

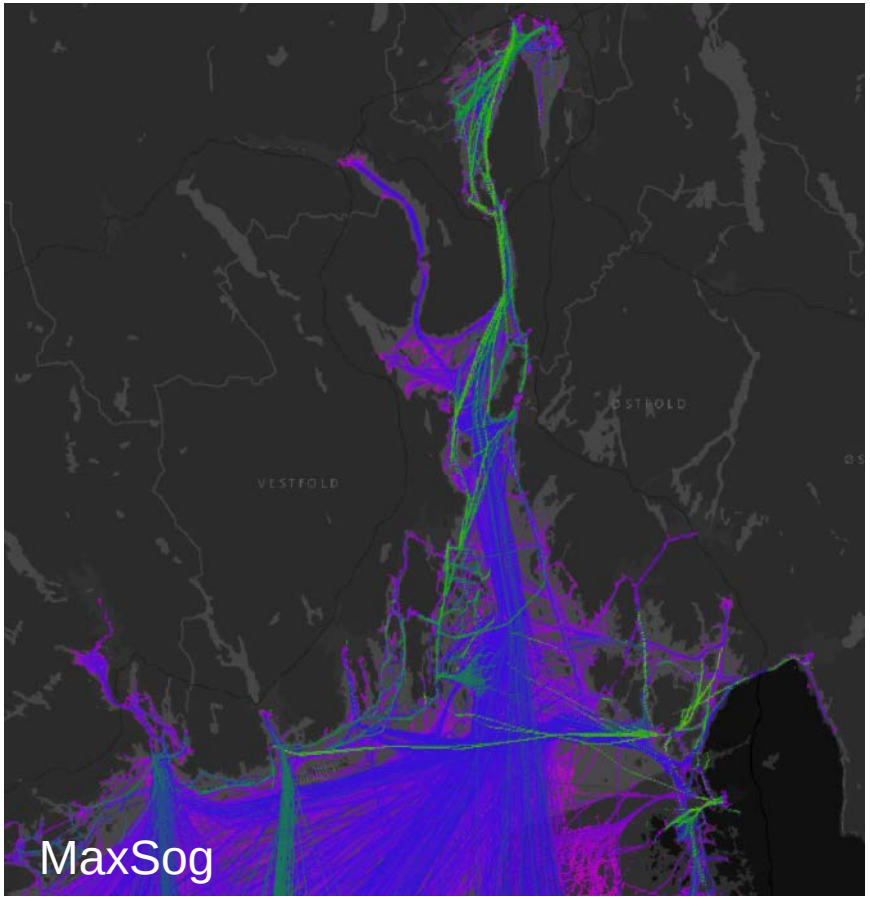


NORAIS - ISS

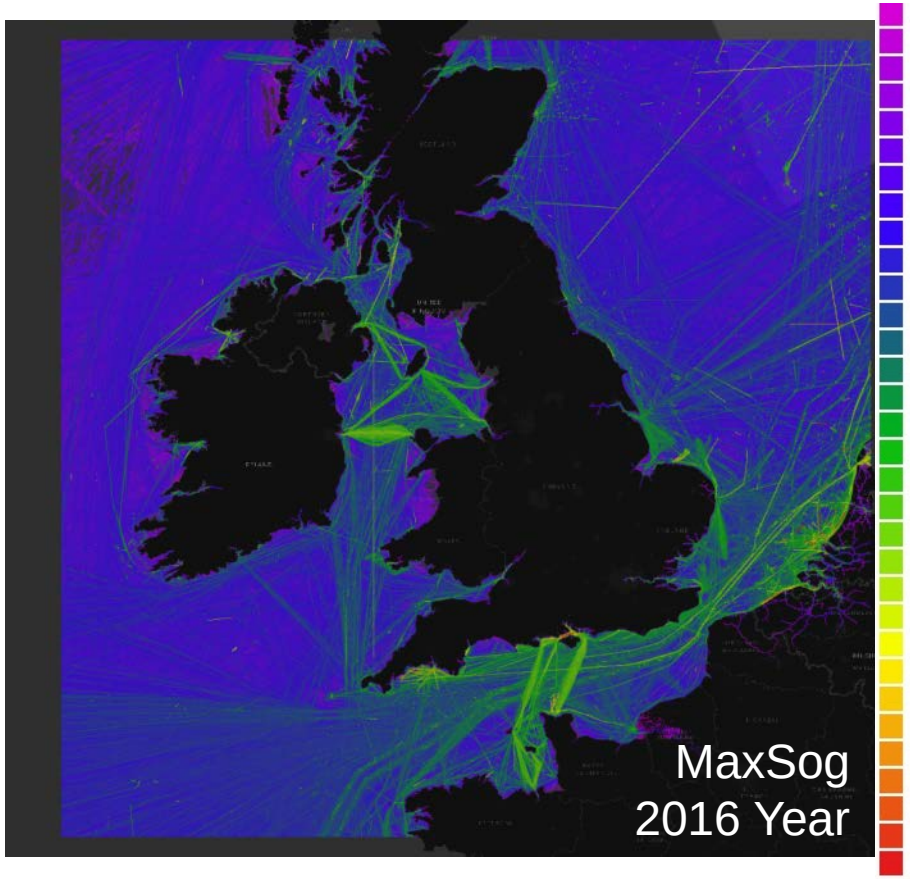
Product examples – smaller area

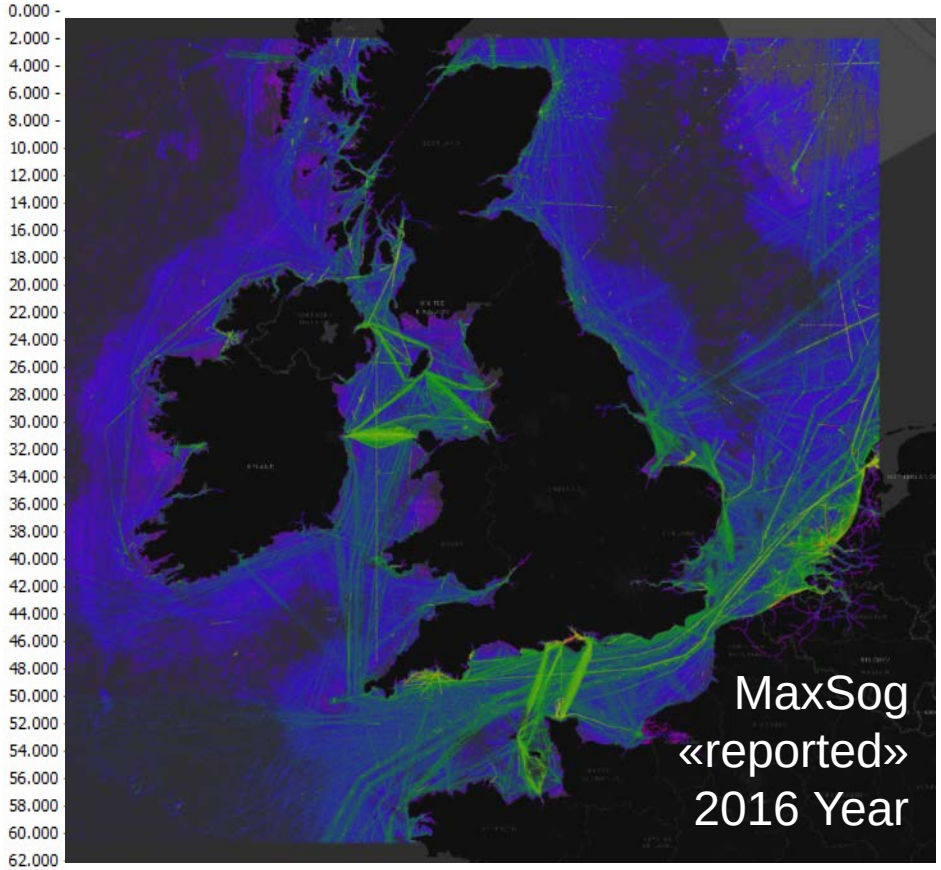
Oslo Fjord January 2015



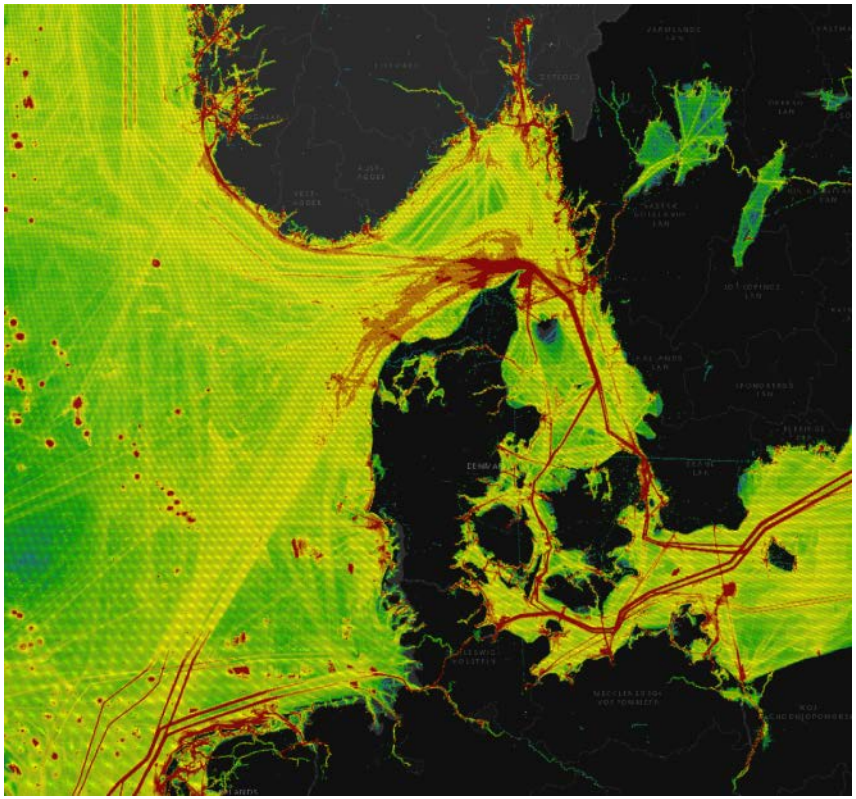


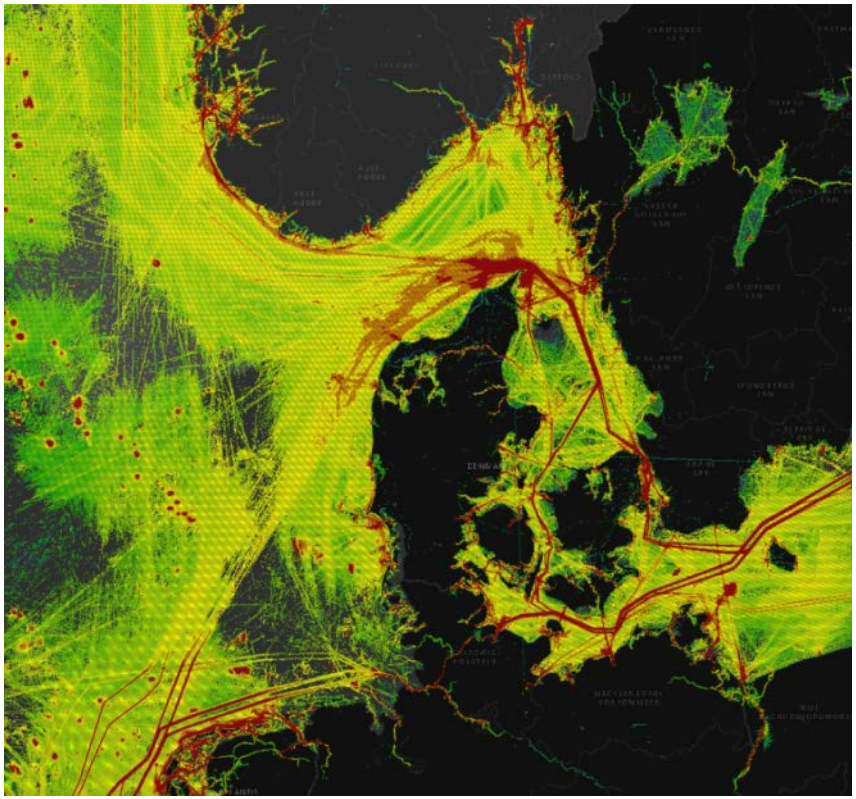
Product examples - Maximum registered speed



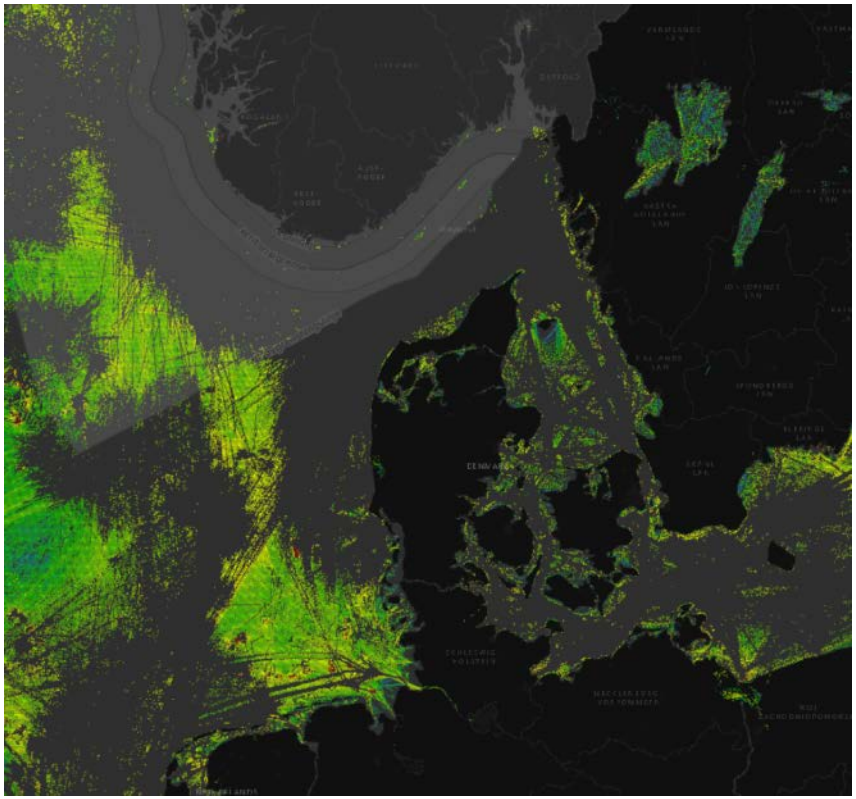


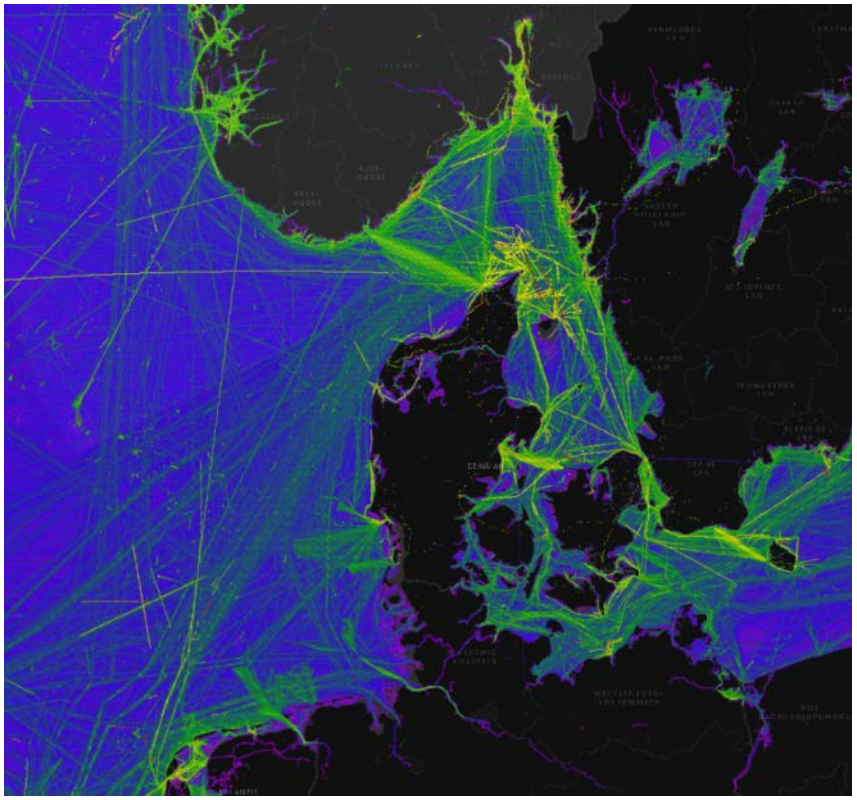
Product examples – reported/interpolated



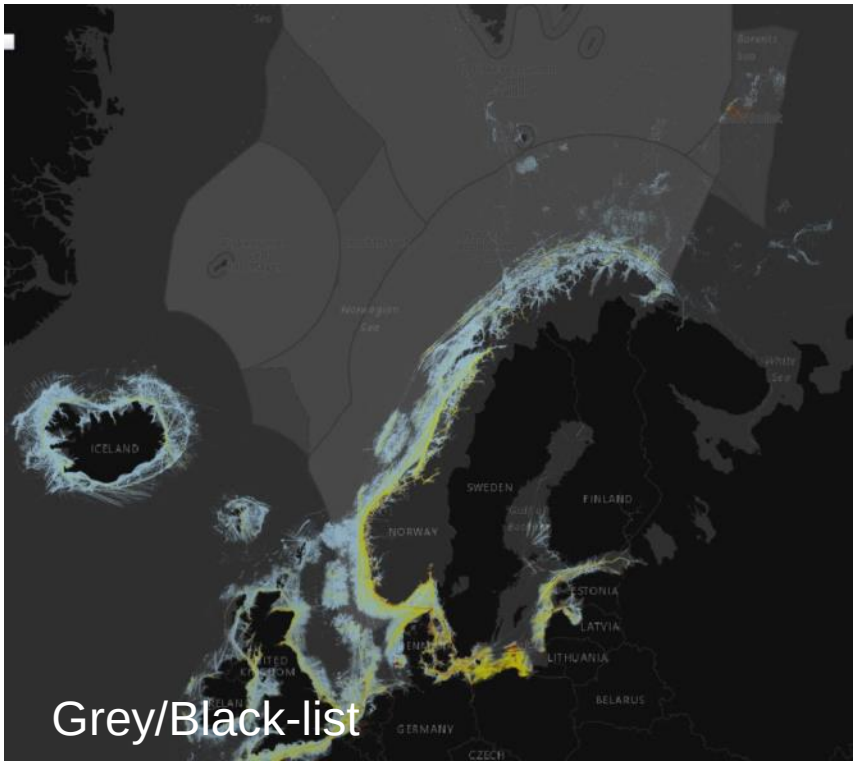


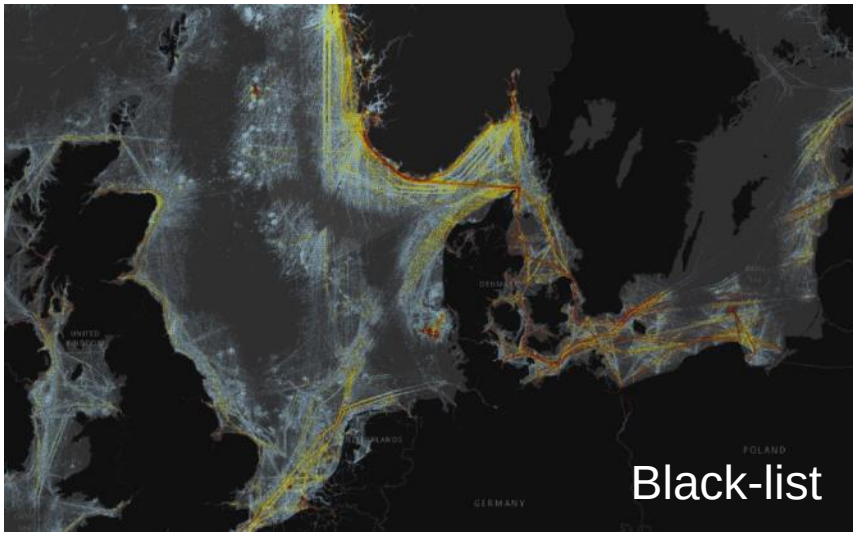
Product examples –interpolated & maxsog





Product examples –
Paris Memorandum of Understanding (MoU)

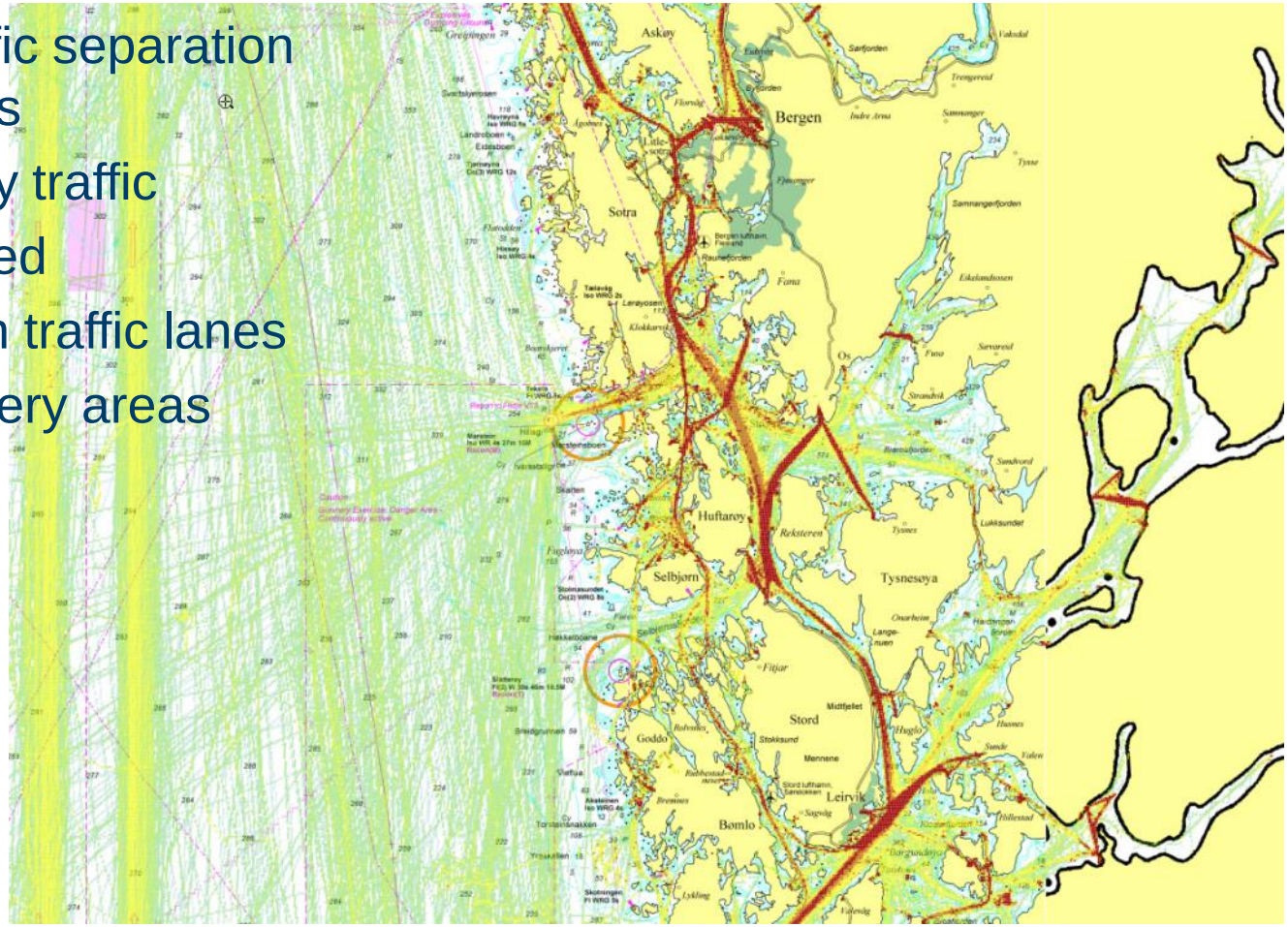




The “White, Grey and Black (WGB) list” presents the full spectrum, from quality flags to flags with a poor performance that are considered high or very high risk. It is based on the total number of inspections and detentions over a 3-year rolling period for flags with at least 30 inspections in the period.

Product examples – Voyage planning/Nav.plan.

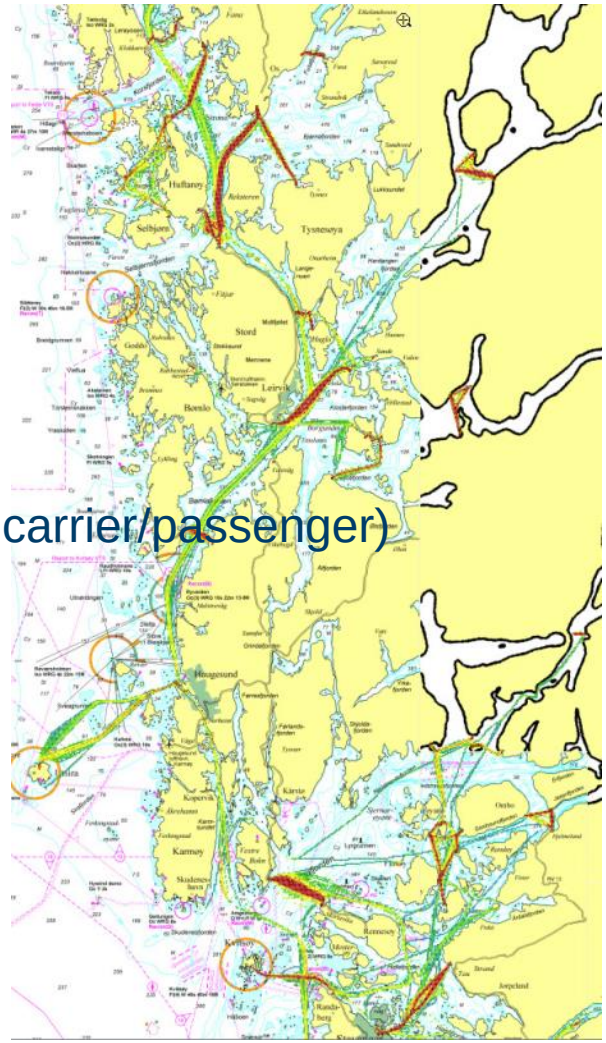
- Traffic separation lanes
- Ferry traffic
- Speed
- Main traffic lanes
- Fishery areas
- ++



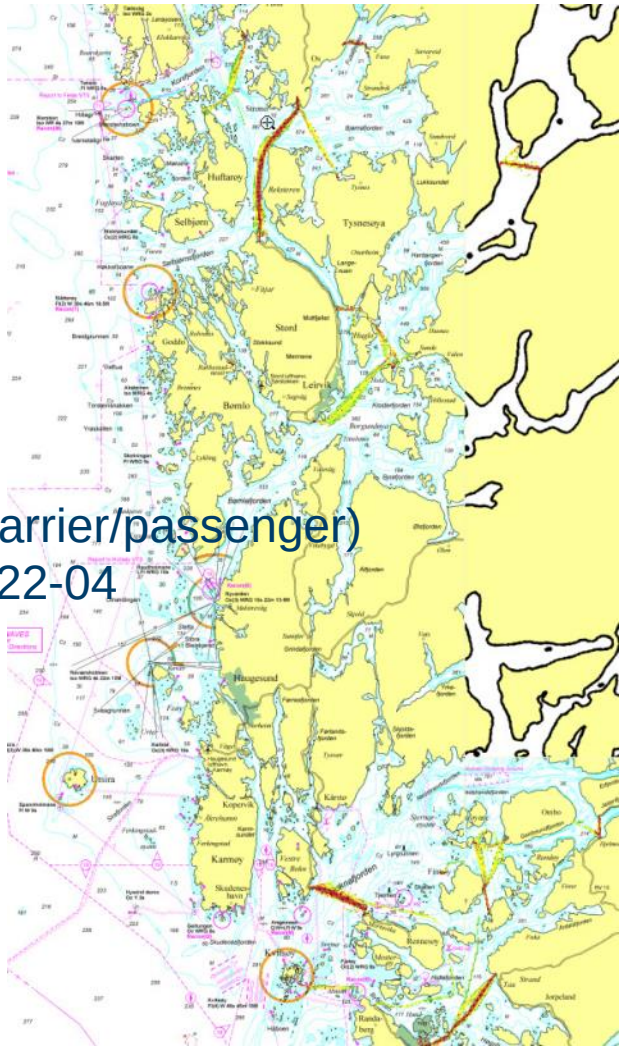
Desember 2015

Product examples – Voyage planning/Nav.plan.

Ferry
(Ro-Ro carrier/passenger)



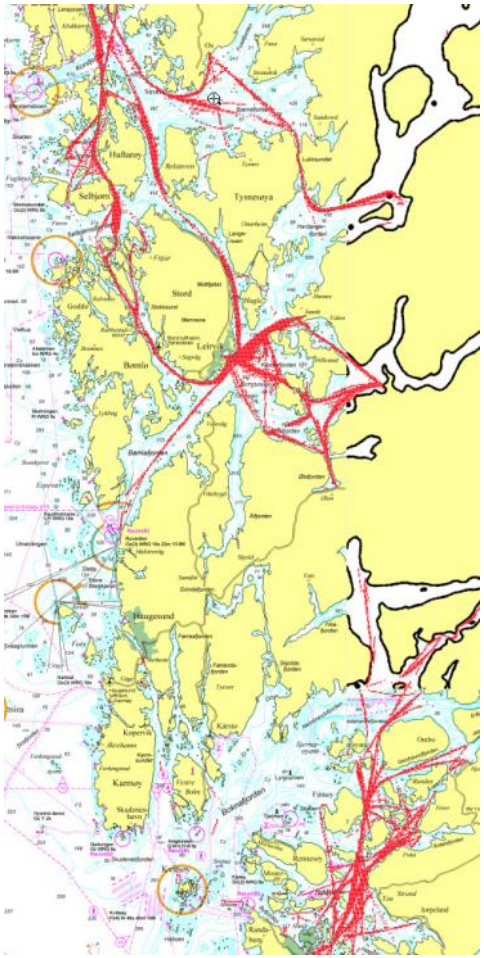
Ferry
(Ro-Ro carrier/passenger)
At night: 22-04



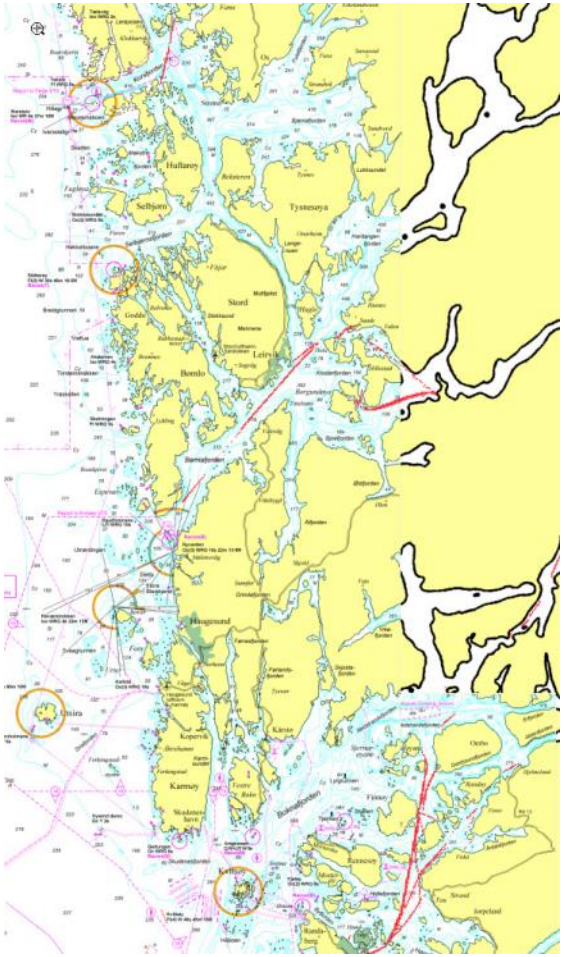
Desember 2015

Product examples – Voyage planning/Nav.plan.

Max Sog > 30 kts



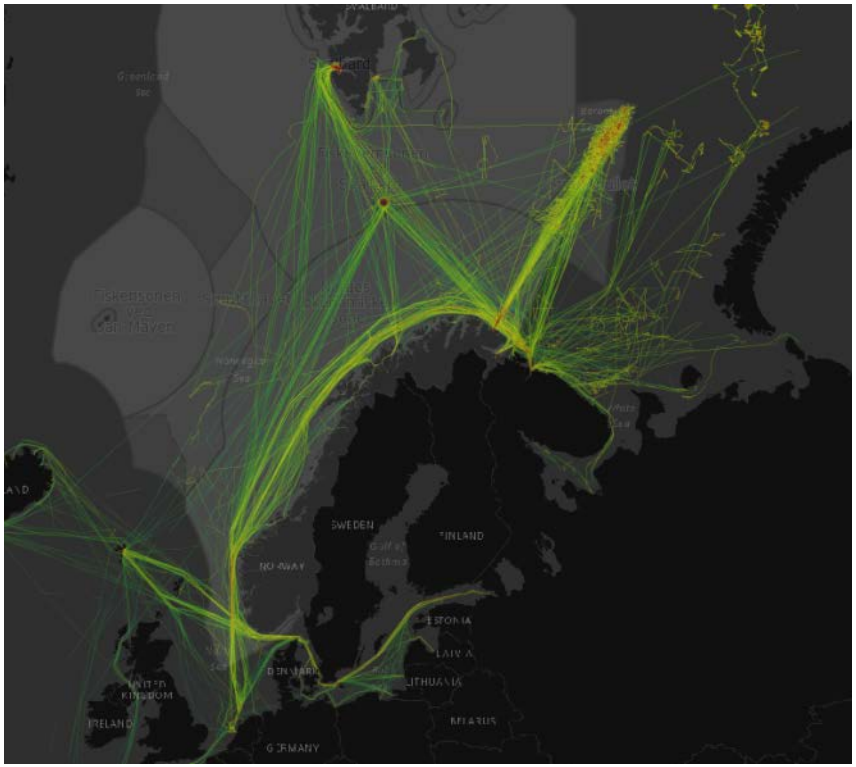
Night 22-04 Max Sog > 30 kts

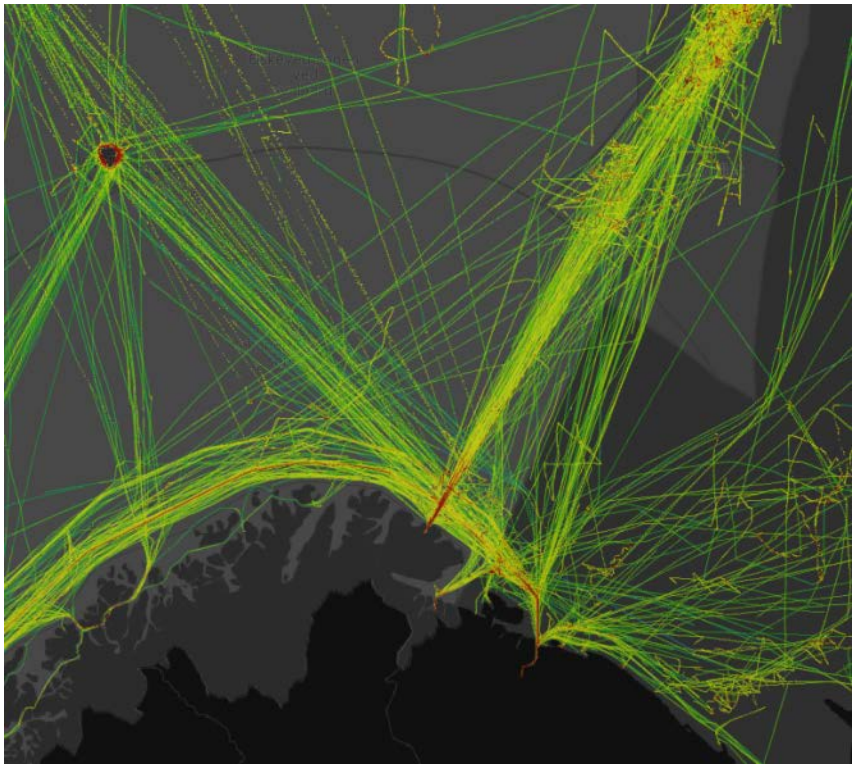


Desember 2015

Analysis of transport ships

2016
Specific pre-selected MMSIs





FOSS(4G) experience

- In general C# support is good
- OGR write GPKG is very slow! (driver issue?)
- In Visual Studio NuGet gives most FOSS
- Used **GISInternals** (Tamas Szekeres) for GDAL/OGR C# drivers/wrappers (http://www.gisinternals.com)

FOSS(4G) used in project

Npgsql

Proj.NET