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Assessing data from Energy Management Systems on ferries to gain insights for enhanced sustainability

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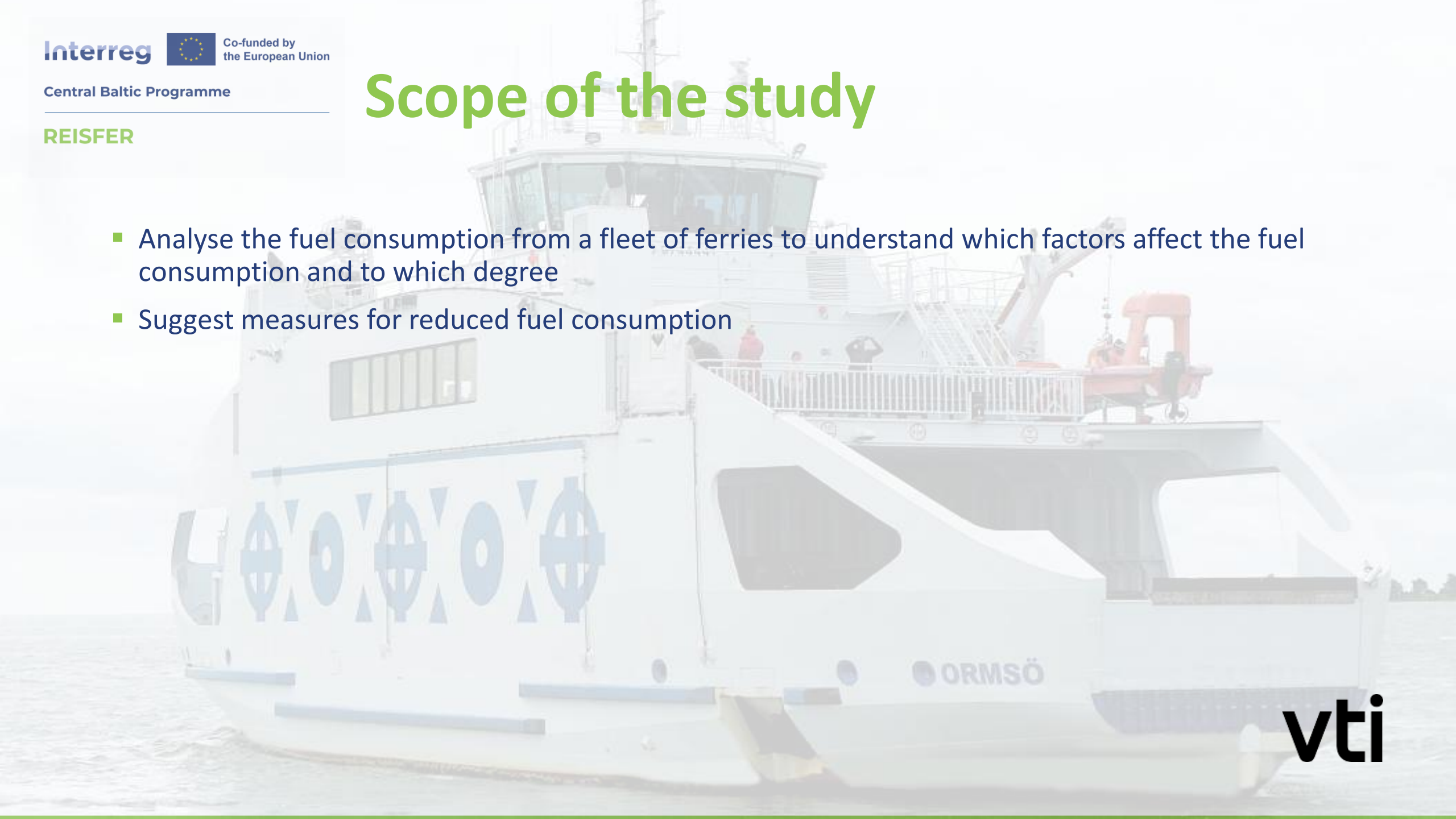
Scope of the study

- Analyse the fuel consumption from a fleet of ferries to understand which factors affect the fuel consumption and to which degree
- Suggest measures for reduced fuel consumption



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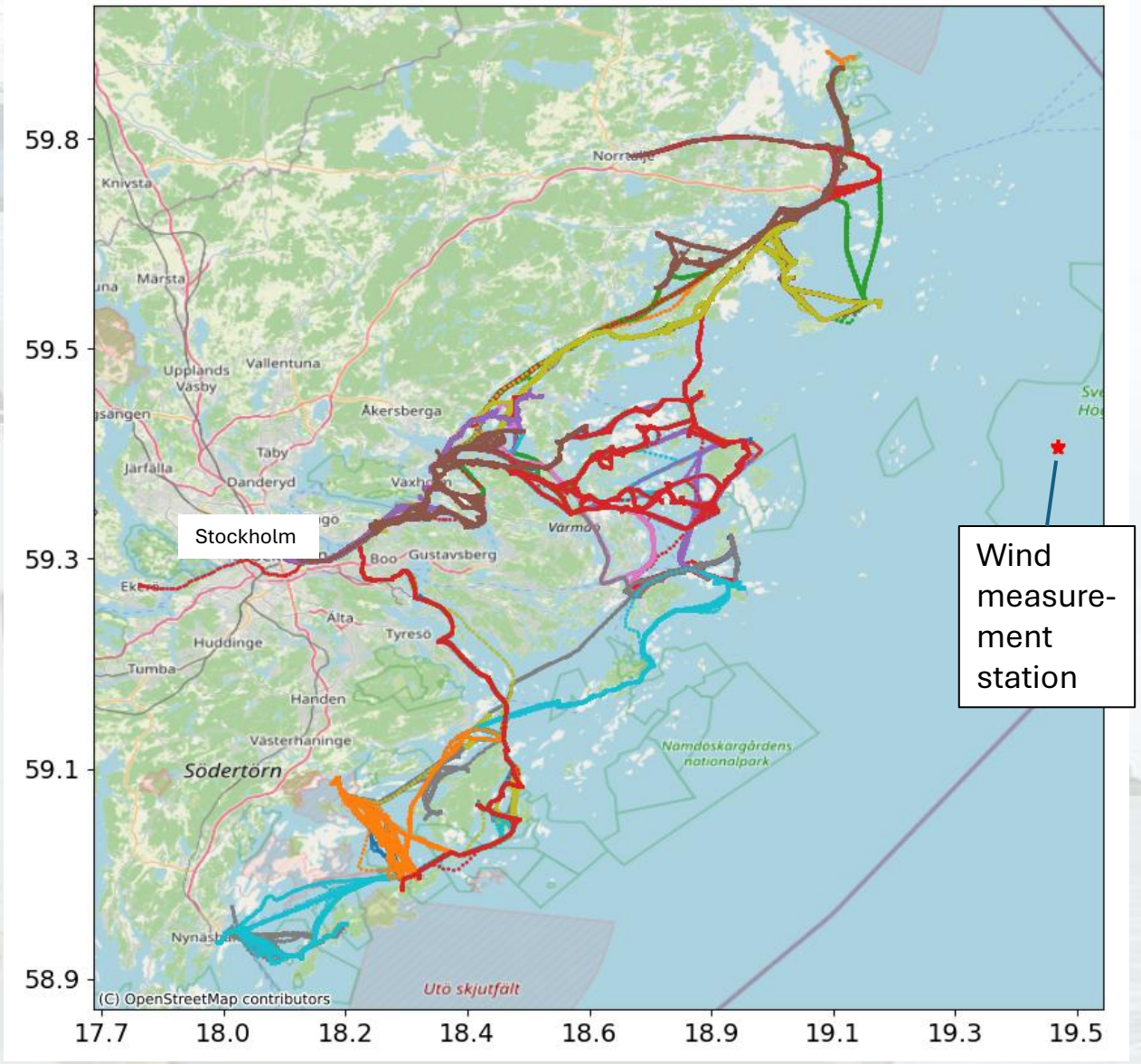
The data

- Blueflow energy management system
  - 1-second resolution
  - Variables:
    - Speed
    - Location
    - Fuel consumption (FC)
- 25 ferries. Each ferry is unique in terms of engine, speed, number of seats, weight etc.

Photo: Nina Svensson



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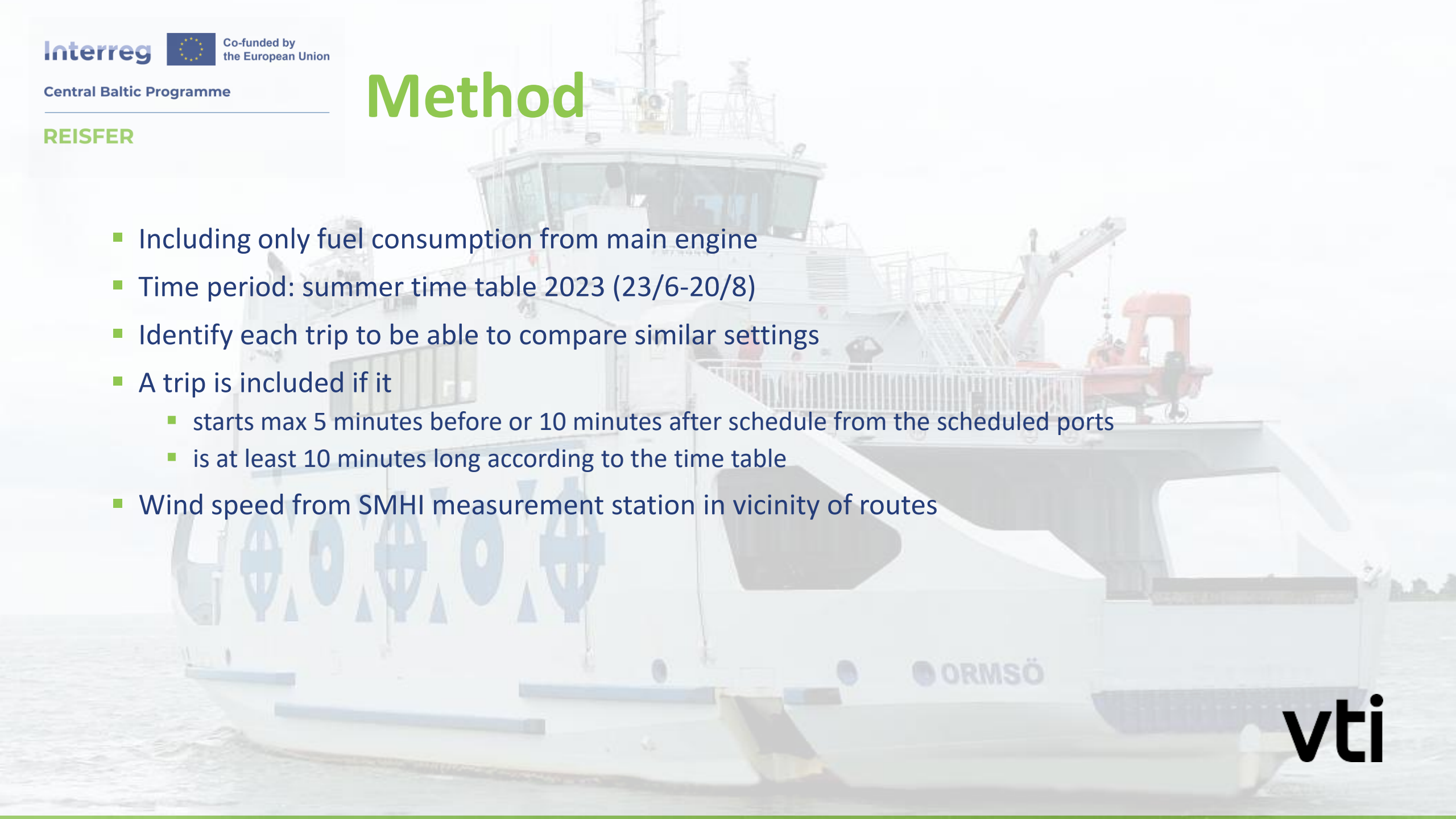
Method

- Including only fuel consumption from main engine
- Time period: summer time table 2023 (23/6-20/8)
- Identify each trip to be able to compare similar settings
- A trip is included if it
  - starts max 5 minutes before or 10 minutes after schedule from the scheduled ports
  - is at least 10 minutes long according to the time table
- Wind speed from SMHI measurement station in vicinity of routes



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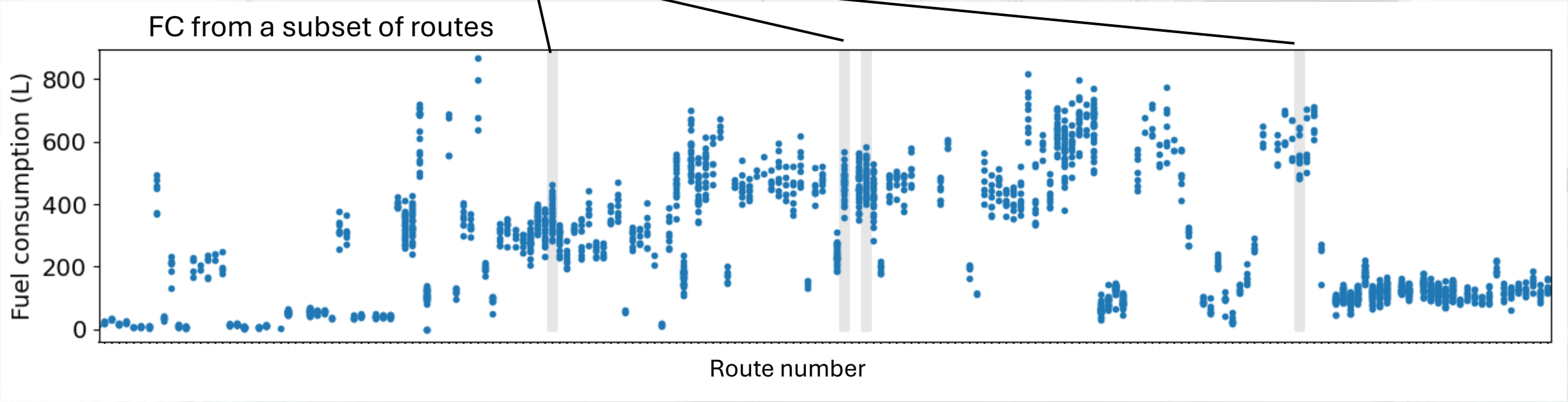
The routes

- 5649 (79 %) identified trips
- 467 different routes

More than one ferry operates on the same route



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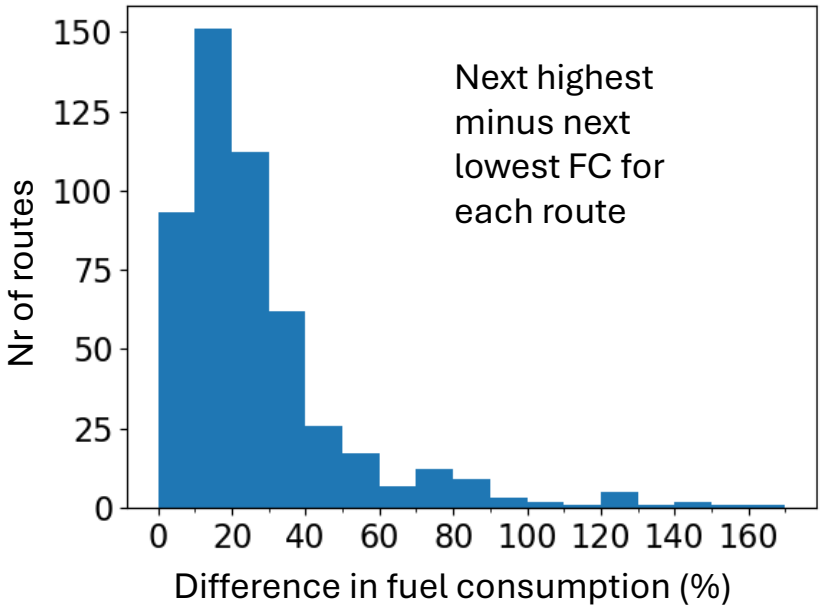
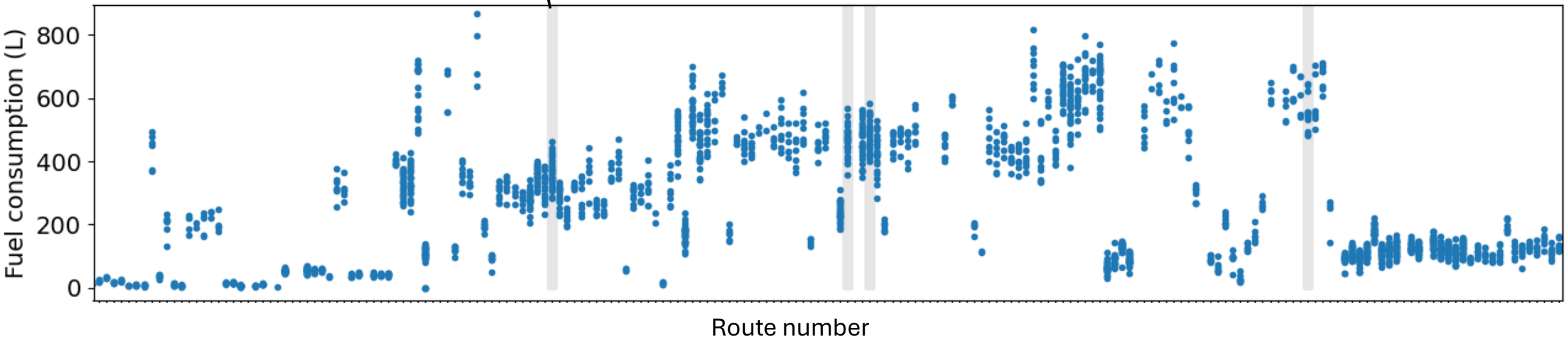


More than one ferry operates on the same route

FC from a subset of routes



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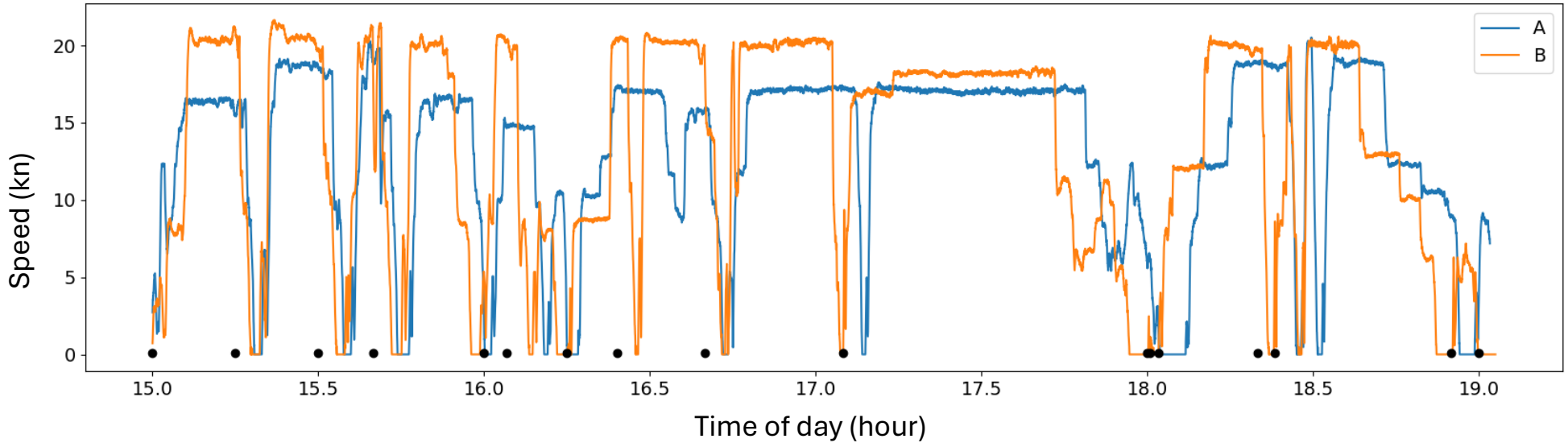
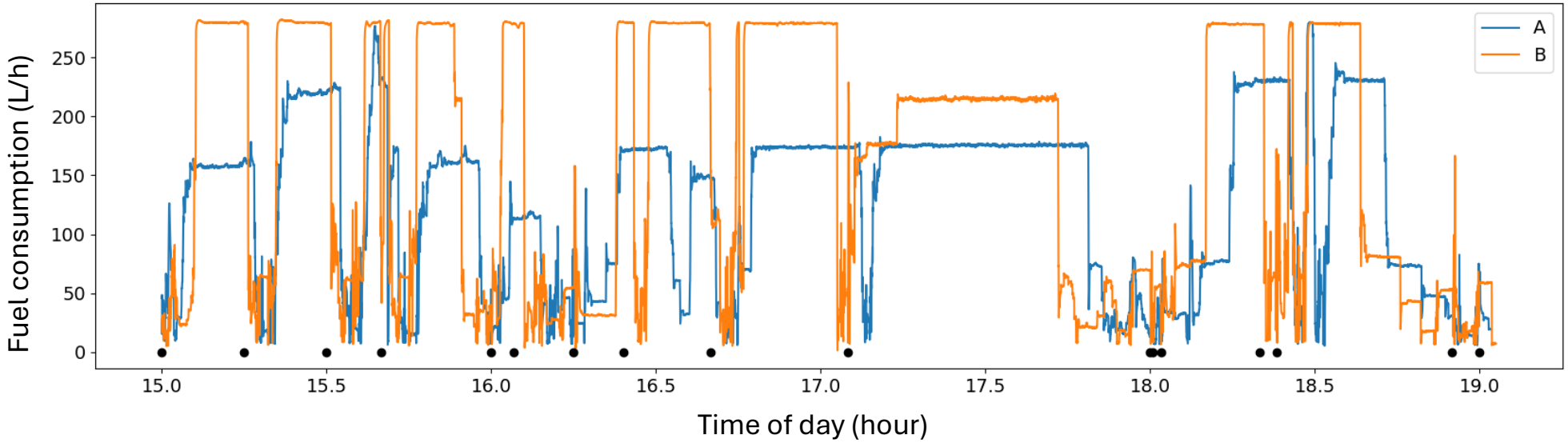
Captain





Two captains (A and B) on the same route and ferry

	A	B
Avg. speed (kn)	13.0	13.4
FC (L)	504	633
Distance (nm)	52.4	53.5
Delay at end (min)	2	-1

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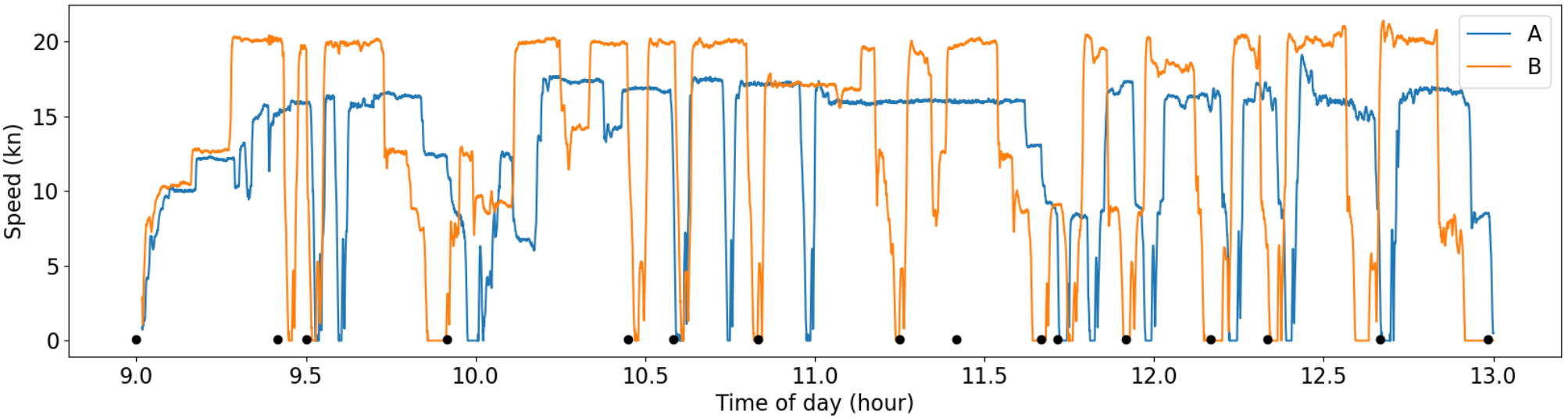
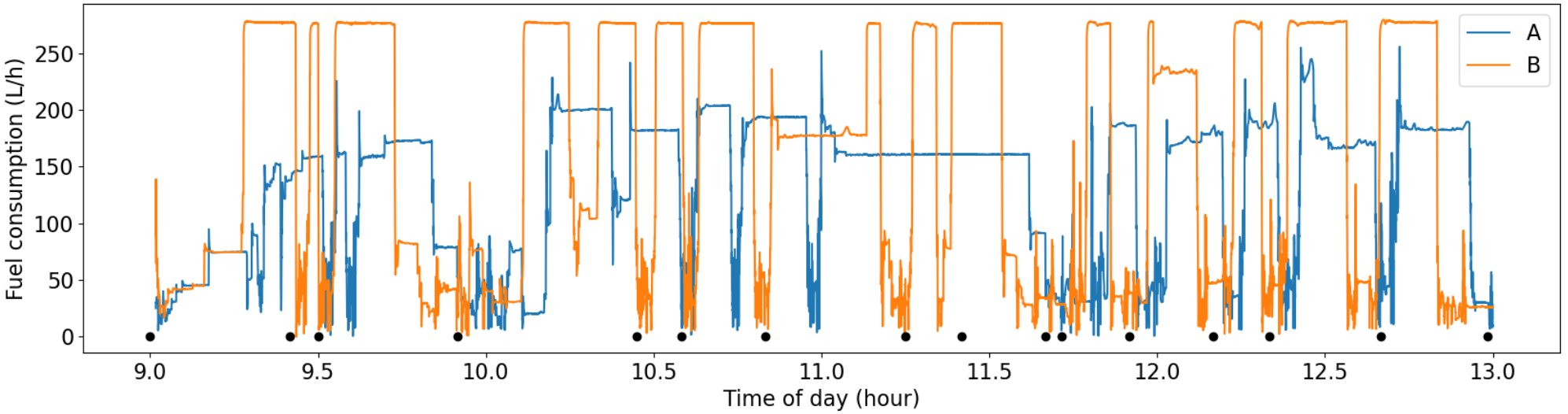
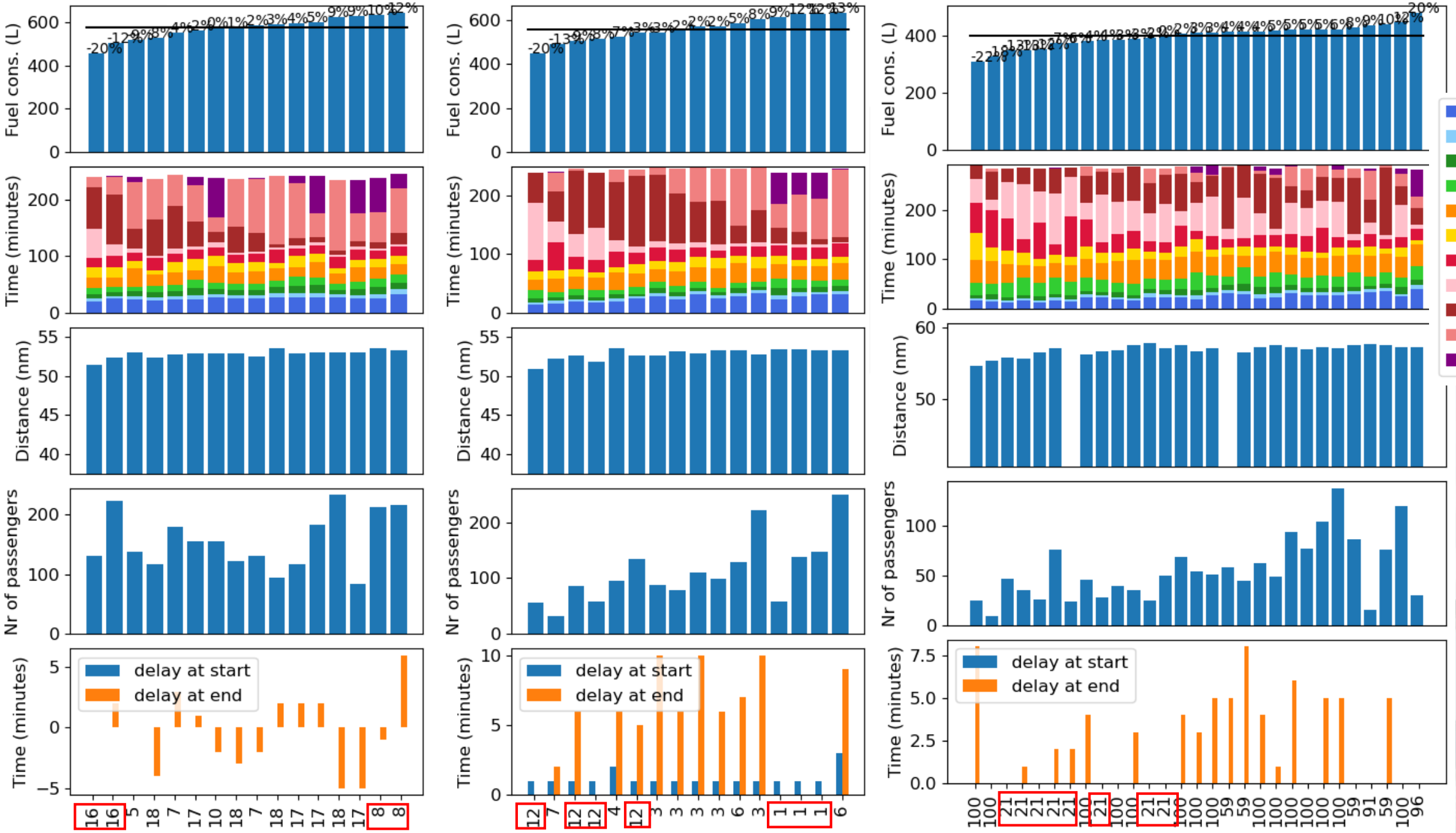
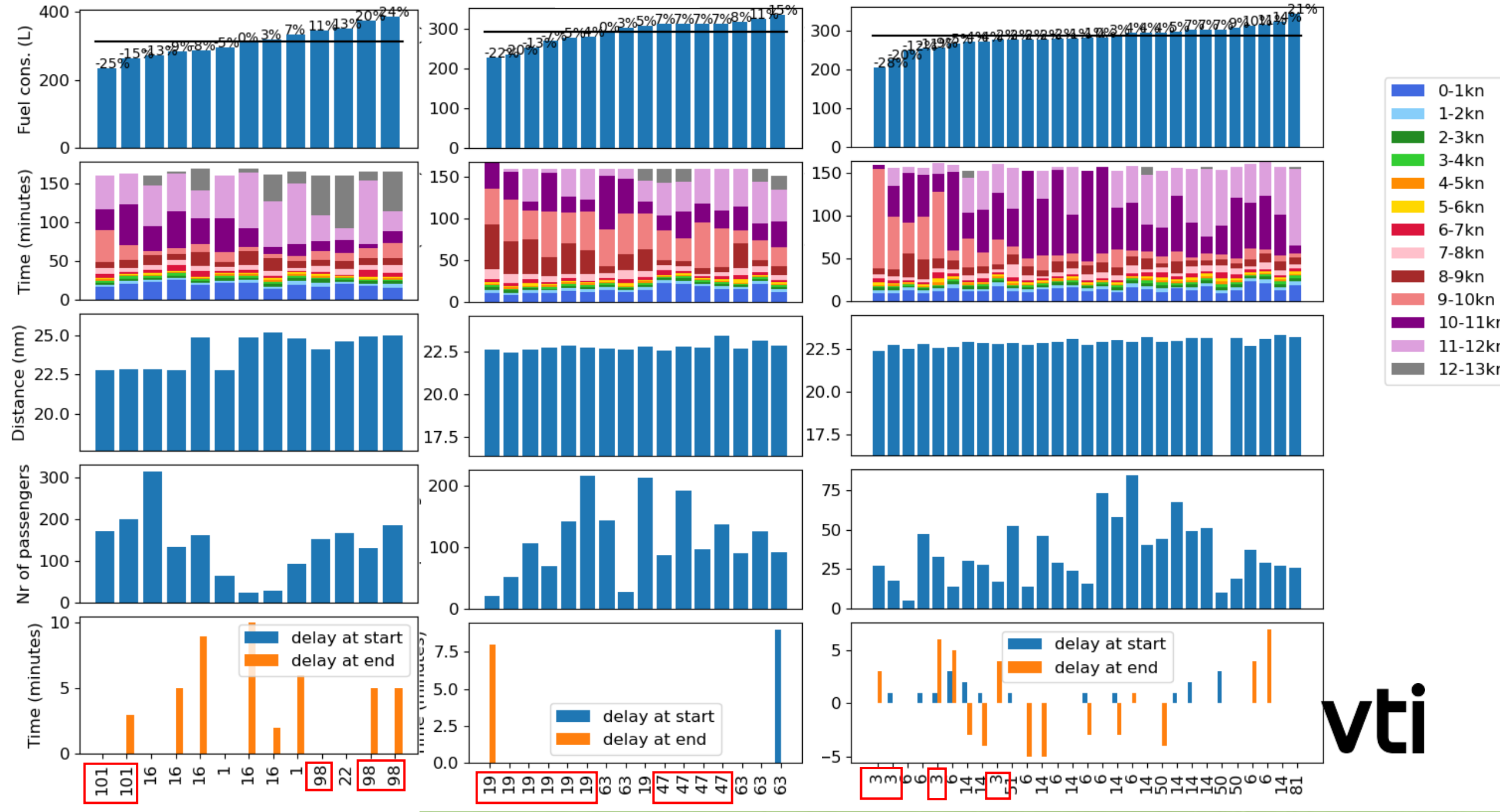




	A	B
Avg. speed (kn)	13.0	13.4
FC (L)	515	628
Distance (nm)	51.8	53.4
Delay at end (min)	0	0


Fuel cons. (L)
Time (minutes)
Distance (nm)
Nr of passengers
Time (minutes)
delay at start
delay at end
0-2kn
2-4kn
4-6kn
6-8kn
8-10kn
10-12kn
12-14kn
14-16kn
16-18kn
18-20kn
20-22kn


Fuel cons. (L)
Time (minutes)
Distance (nm)
Nr of passengers
Time (minutes)
delay at start
delay at end
0-1kn
1-2kn
2-3kn
3-4kn
4-5kn
5-6kn
6-7kn
7-8kn
8-9kn
9-10kn
10-11kn
11-12kn
12-13kn
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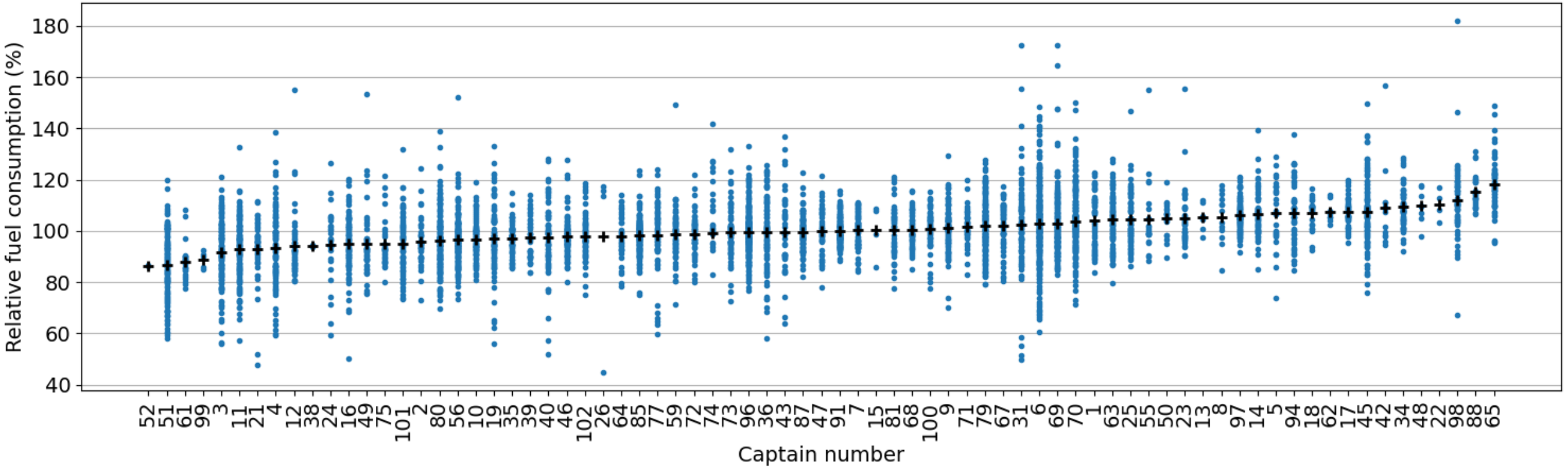
Relative fuel consumption (%)
180
160
140
120
100
80
60
40
52 51 61 99 3 11 21 4 12 38 24 16 49 75 101 2 80 56 10 19 35 39 40 46 102 26 64 85 77 59 72 74 73 96 36 43 87 47 91 7 15 81 68 100 9 71 79 67 31 6 69 70 1 63 25 55 50 23 13 8 97 14 5 94 18 62 17 45 42 34 48 22 98 88 65
Captain number

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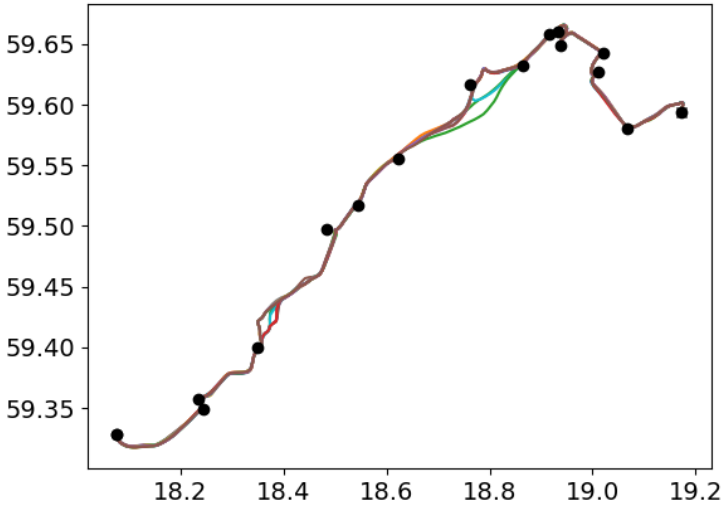
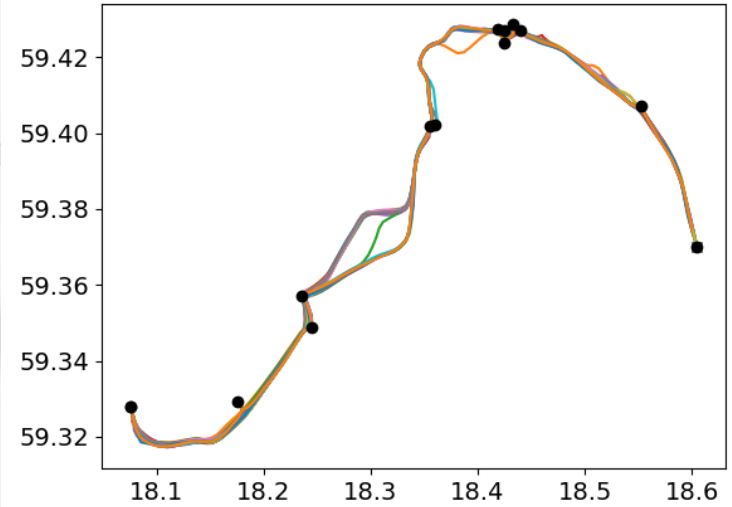
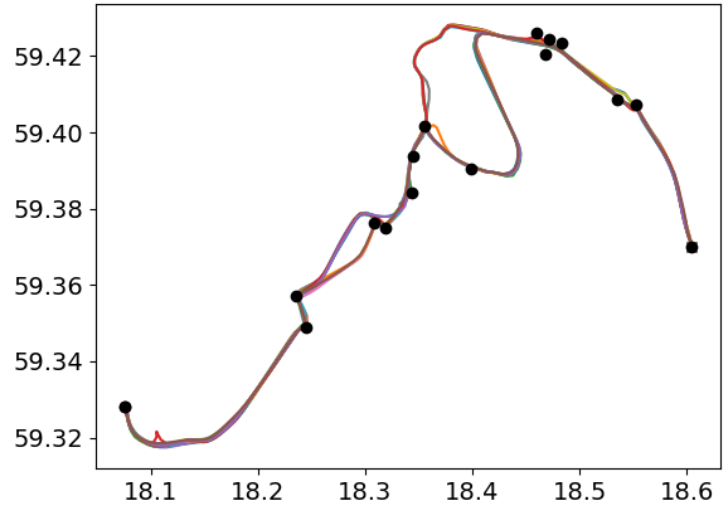
Distance







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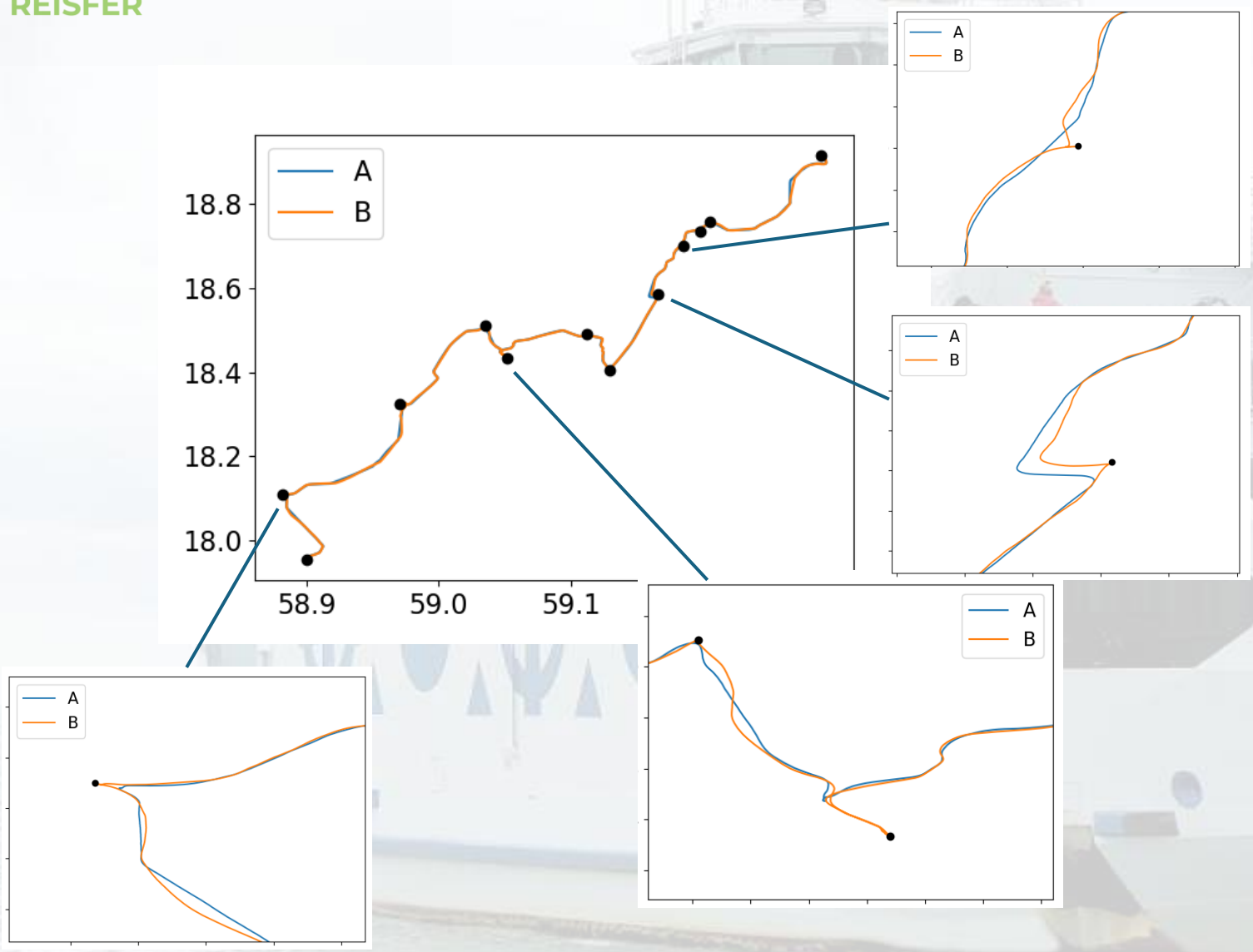
Passengers



Same captain, same ferry, different nr of passengers

	A	B
Nr of passengers	9	120
Avg. speed (kn)	11.7	12.0
FC (L)	326	448
Distance (nm)	55.4	57.2
Delay at end (min)	0	0

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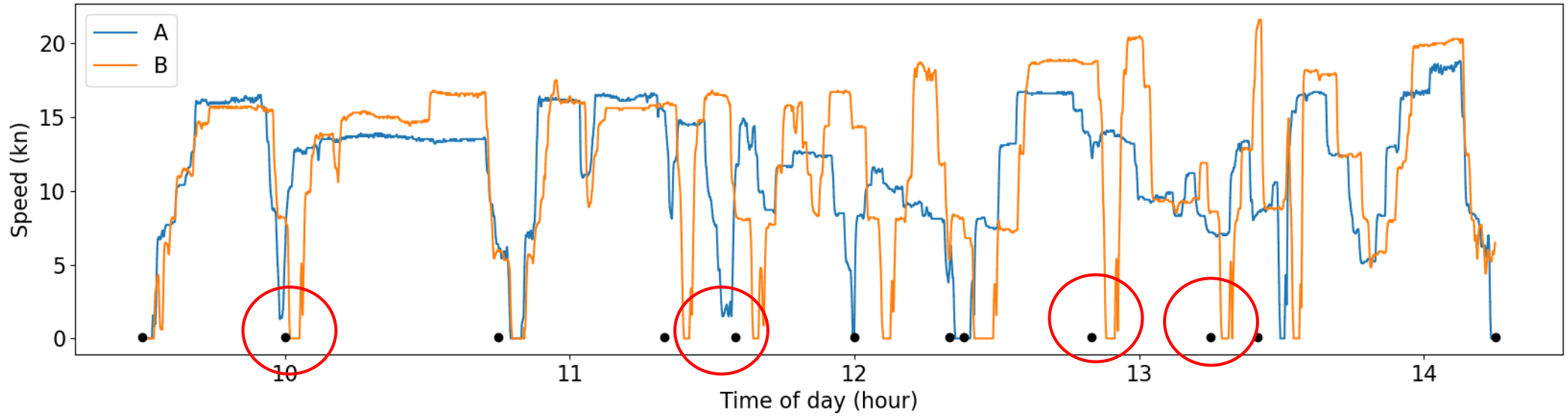
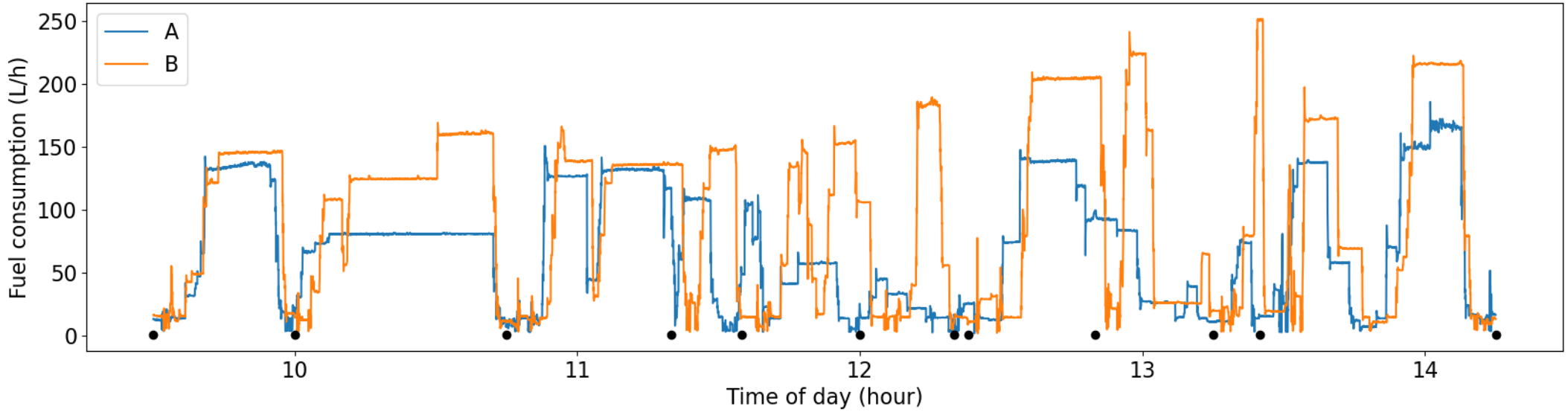
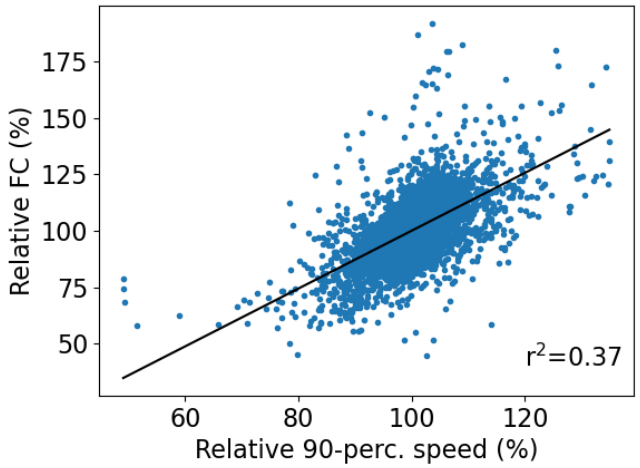
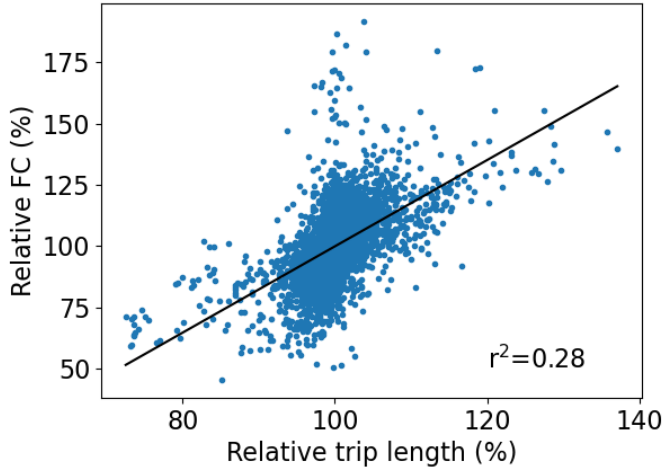
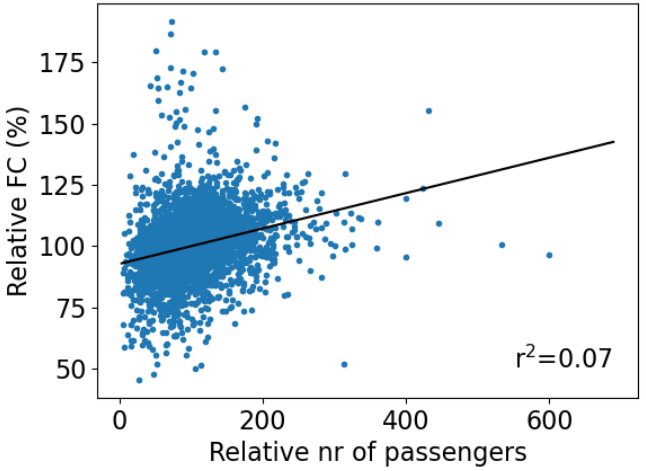

A
B
Speed (kn)
0
5
10
15
20
10
11
12
13
14
Time of day (hour)

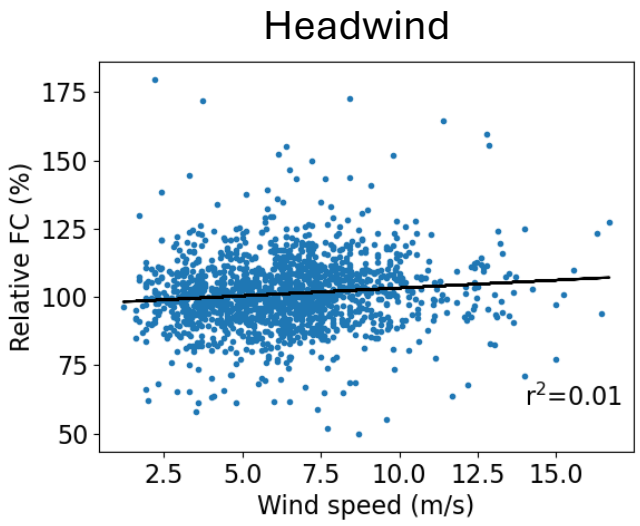

A
B
Fuel consumption (L/h)
0
50
100
150
200
250
10
11
12
13
14
Time of day (hour)

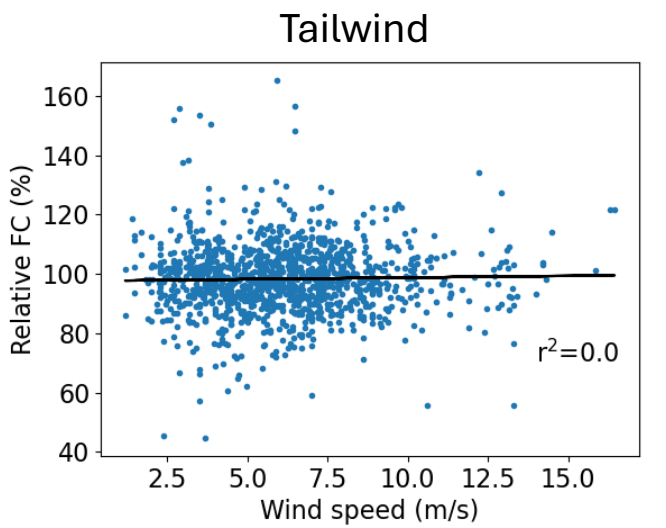
Linear relationships

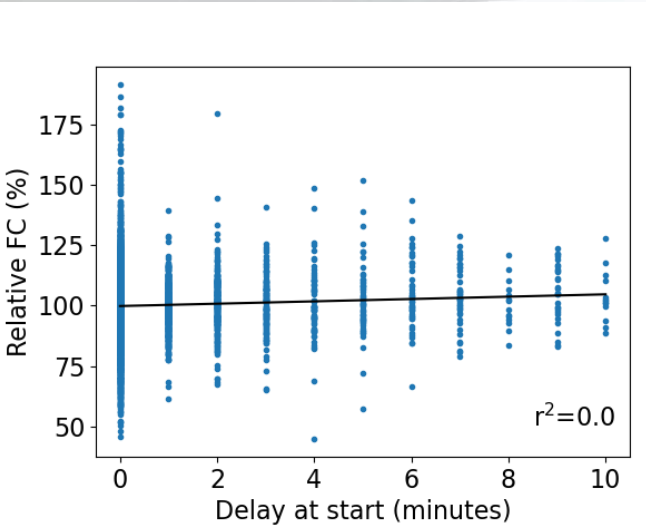






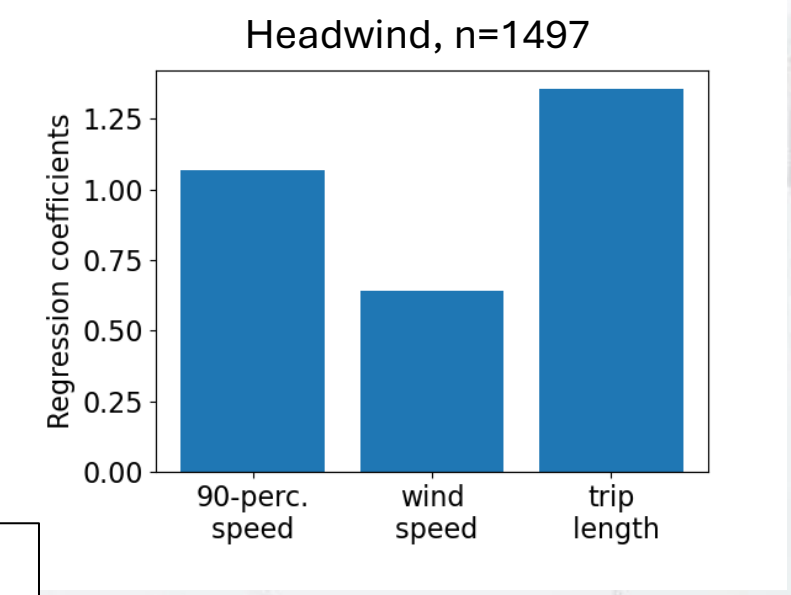


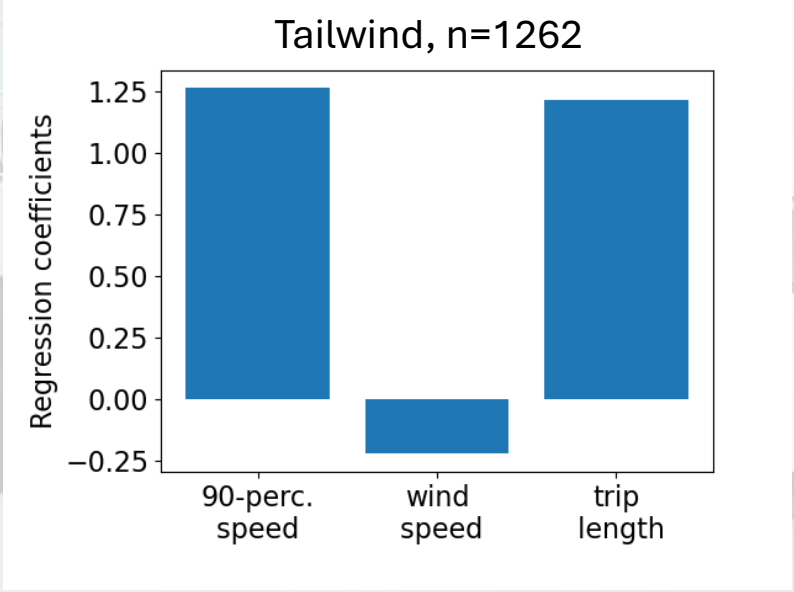




Multiple regression

- Mixed linear model with captain as random effect





proportion of variance explained by fixed variables

Marginal R^2: 53 %

proportion of variance explained by fixed variables + random effect

Conditional R^2 : 60 %

Marginal R^2: 54 %

Conditional R^2 :66 %

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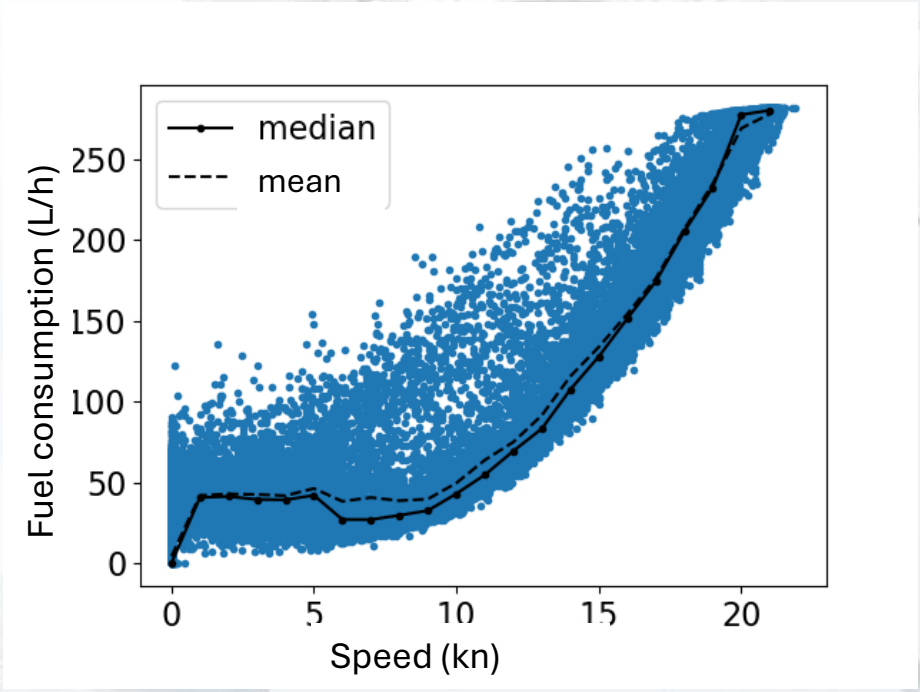
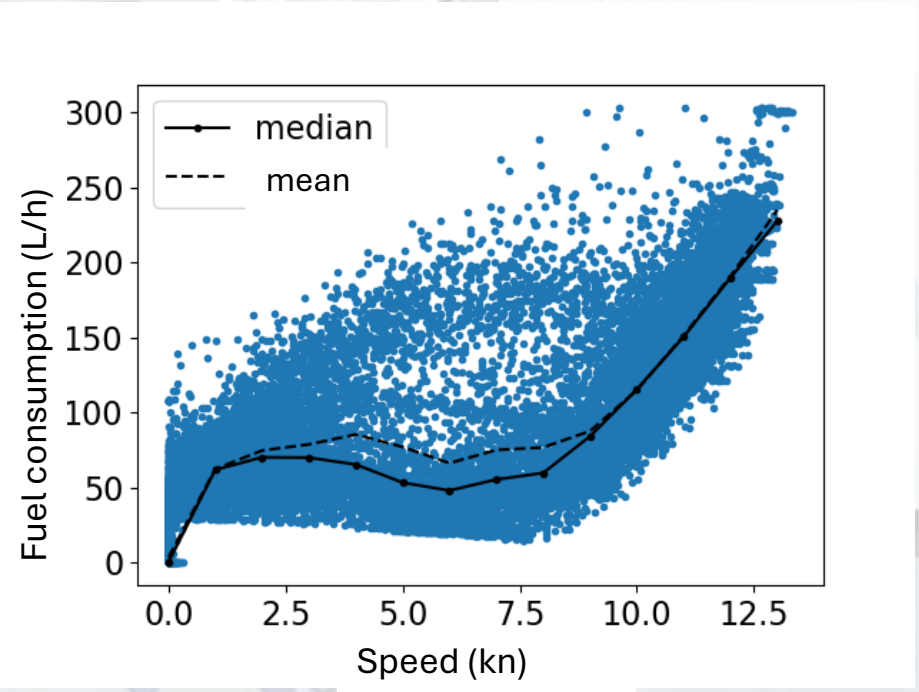
Speed dependence





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Possibilities for reduction in fuel consumption

Measure	Reduction CO2 (%)	Reduction CO2 (tonnes)	Cost savings (kr)	Number of average ferries that could be run on HVO with cost savings
Speed reduction +5 % time increase on each trip	-9	-268	-704 000	1.8
Speed reduction +10 % time increase on each trip	-19	-548	-1 486 000	3.7
Every trip is like the average or better	-4	-118	-320 000	0.8
Every trip is like the second lowest or better	-12	-345	-932 000	2.3

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Conclusions

- Distance and wind speed are main factors affecting fuel consumption. Wind speed and captain behaviour are also important
- It is possible to reduce fuel consumption noticeably by cost efficient measures, such as
  - Scheduled speed reduction
  - Aiming for speed reduction while keeping the normal time table through eg.
    - Ecodriving
    - Shorter stops
    - Less tight time tables to reduce speeding
  - Choosing the shortest route when possible – electrical semaphors could reduce uneccesary distance
- More options
  - Route network optimization
  - Vessel choice optimization

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Thank you!