

Geovisualization of fishing vessel movement patterns using hybrid fractal/velocity signatures

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Problem

- Spatio-temporal movement data sets are often quite large
- Many existing techniques help in reducing this amount of data
- None take into account both the physical and fractal properties of movement patterns



Objectives

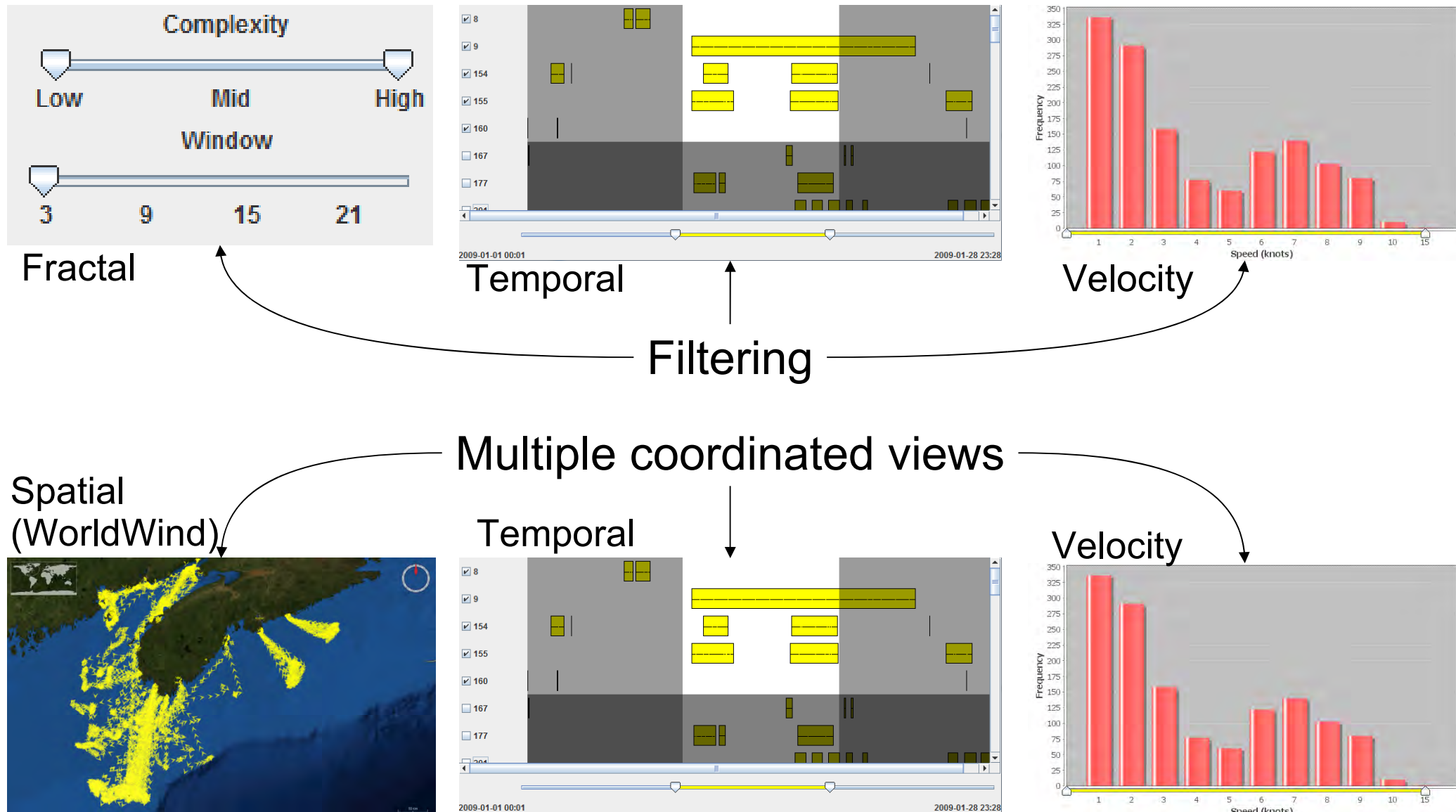
1. To elaborate a method of extracting movement patterns based on velocity and fractal dimension estimates.
1. To design an appropriate geovisualization system for the interactive elaboration of fractal/velocity signatures.
1. To test the usefulness of this approach, in a fisheries context, by getting experts to use a prototype system for their regular activities.

Proposed solution

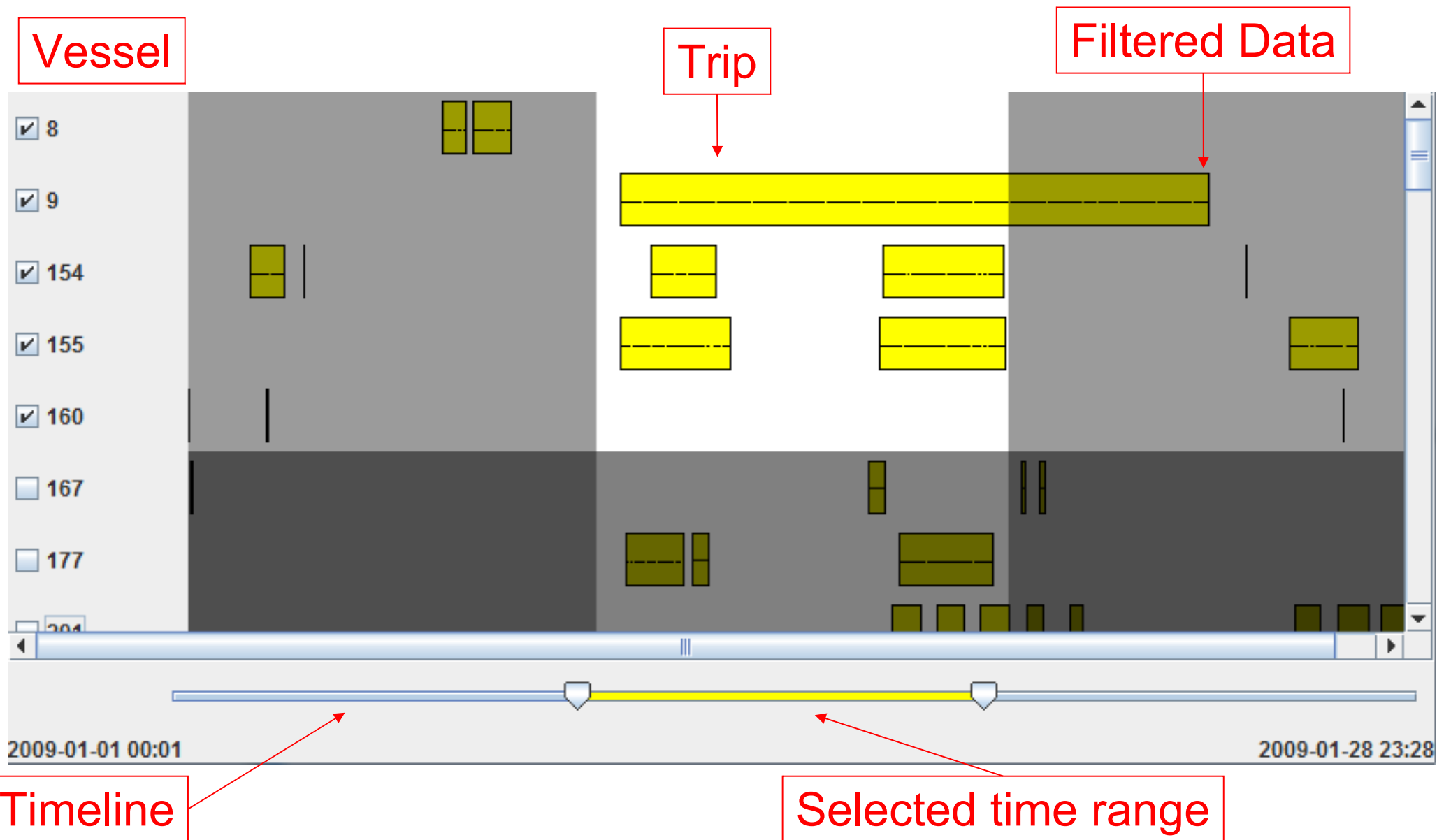
- Extraction of movement patterns existing within the data
- Each user develops a particular signature for each pattern of interest
- Data which match this signature get highlighted



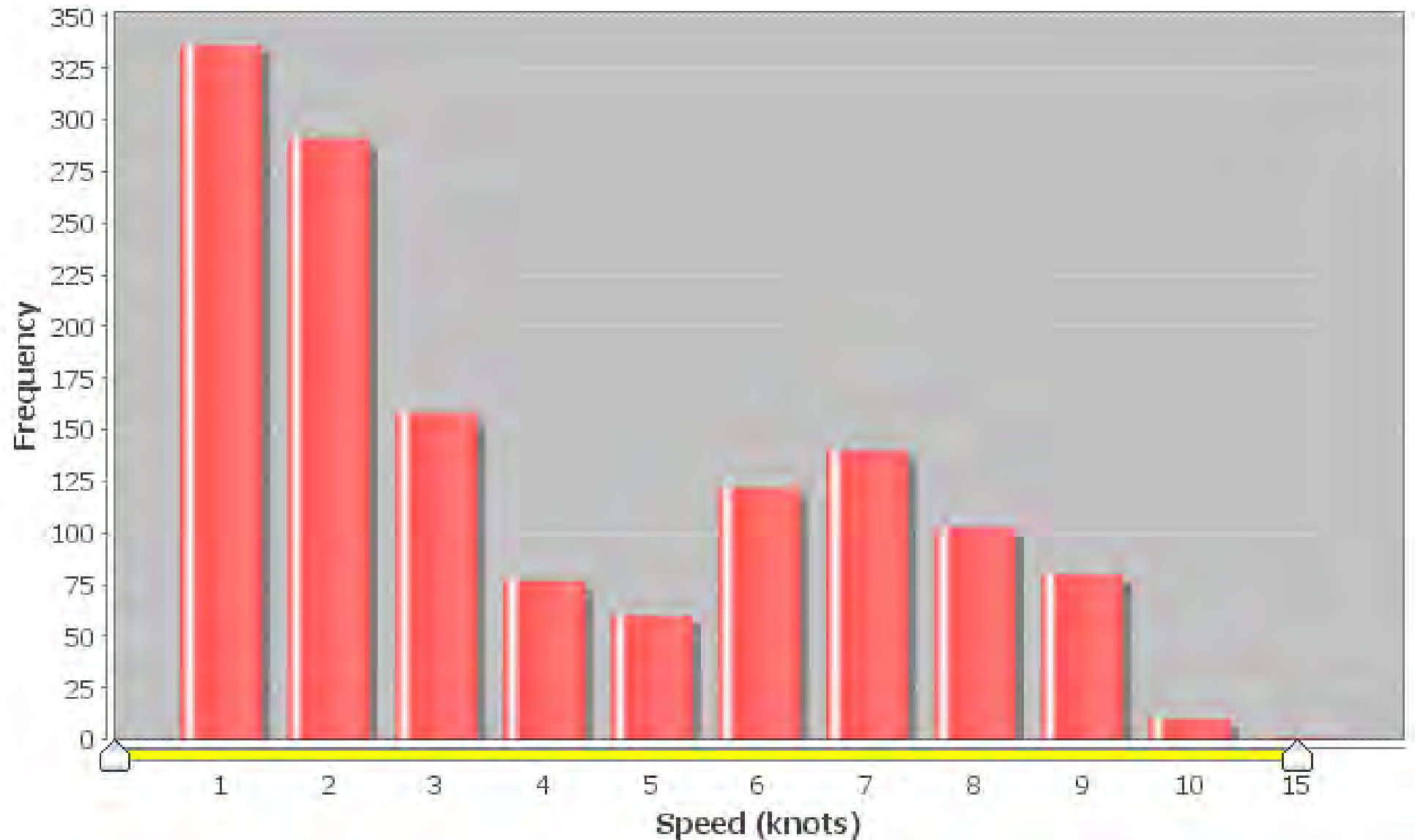
Methods



Filtering - Temporal



Filtering - Velocity



Filtering - Fractal

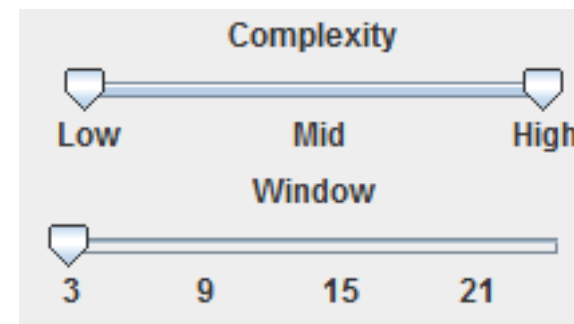
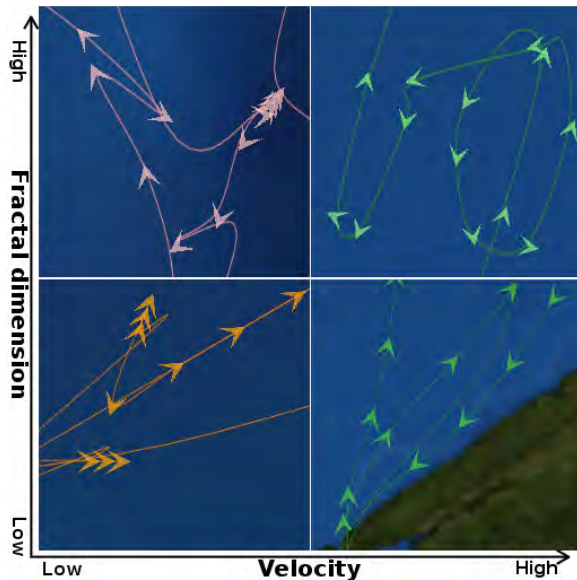
- Tortuosity: a measure of the amount of winding or twisting
- Fractal dimension (D) can be used as an estimate of tortuosity

$$D_{Sevcik} = 1 + \frac{\log(L)}{\log(2N)}$$

L = length of the path standardized to a unit-length

N = number of points in the current sample (window size)

- D is estimated over all data using a moving-window



Effect of window size

Window size:

3



9



25



All data filtered using medium to high fractal dimension and low velocity

Signature use

Three different patterns: steaming, trawling, and longlining

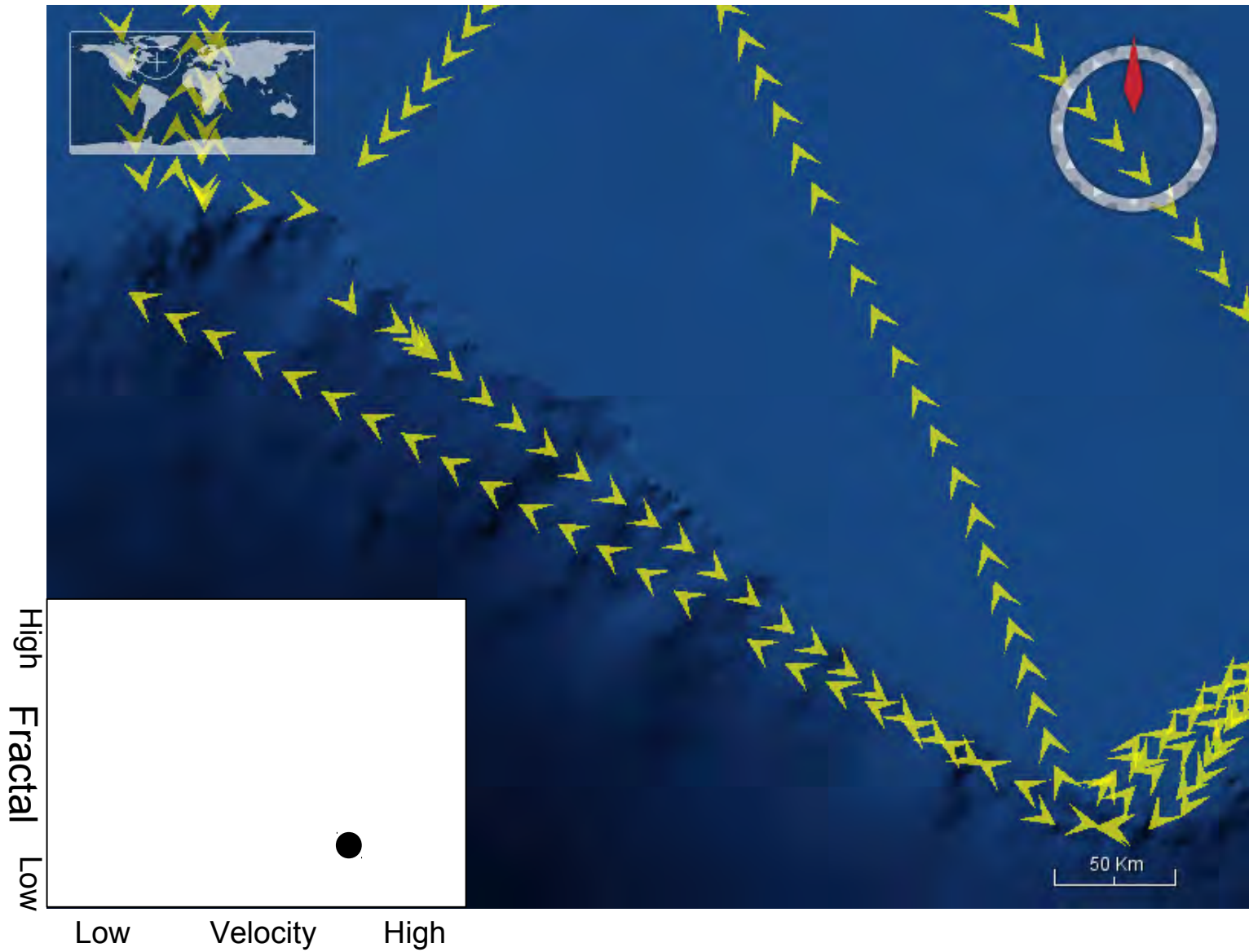


Signature use

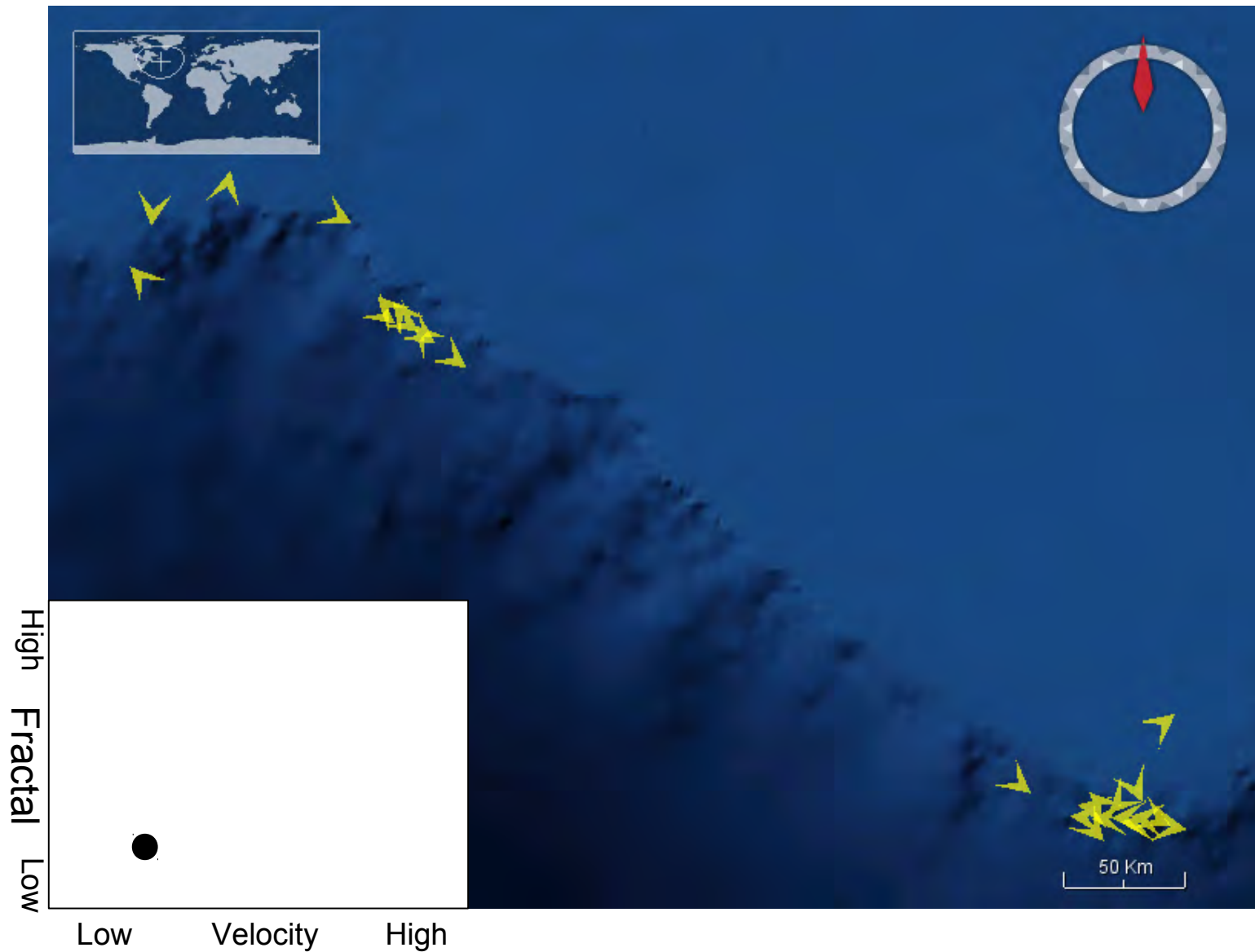
Vessel tracks only help identify different



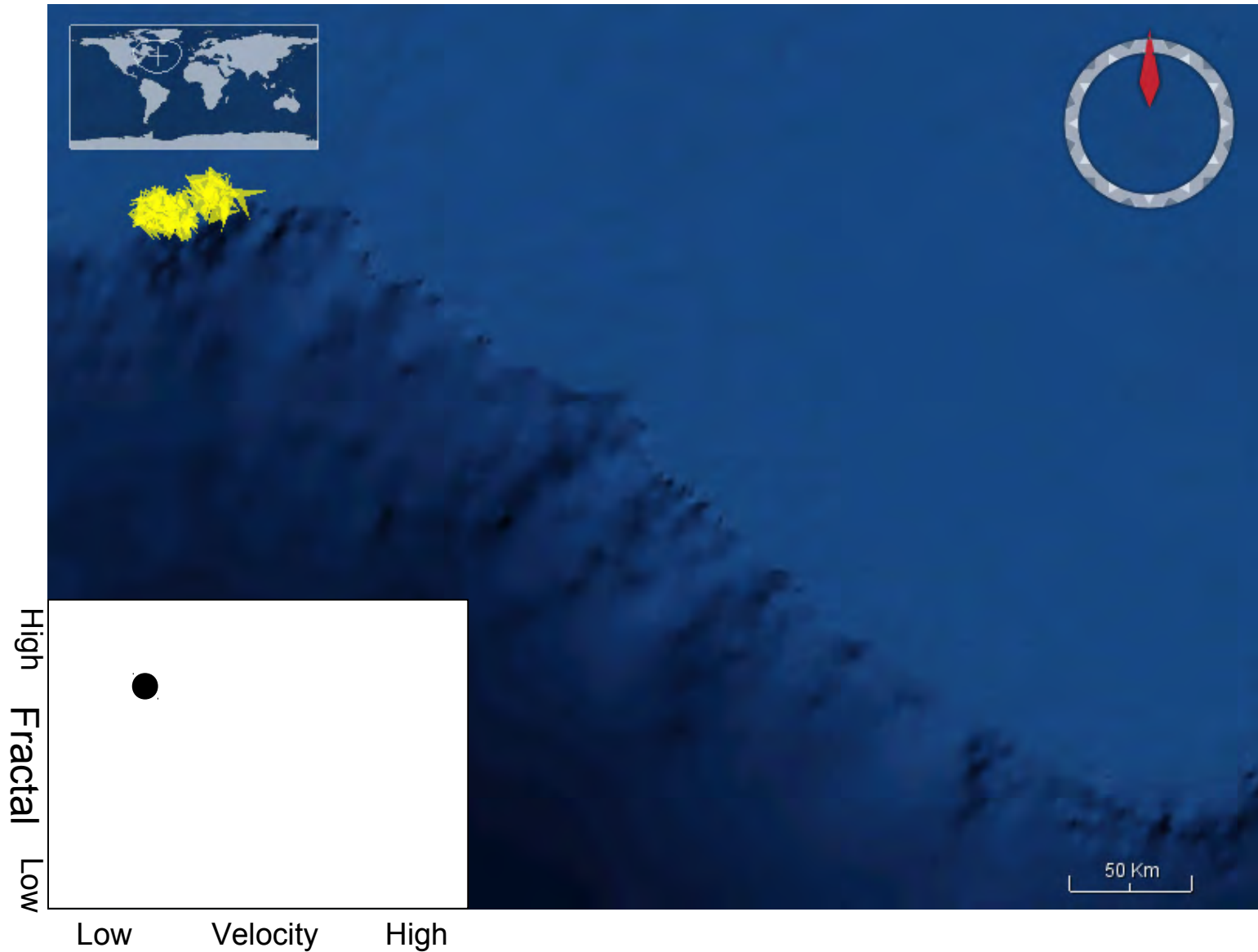
Linear pattern (steaming)



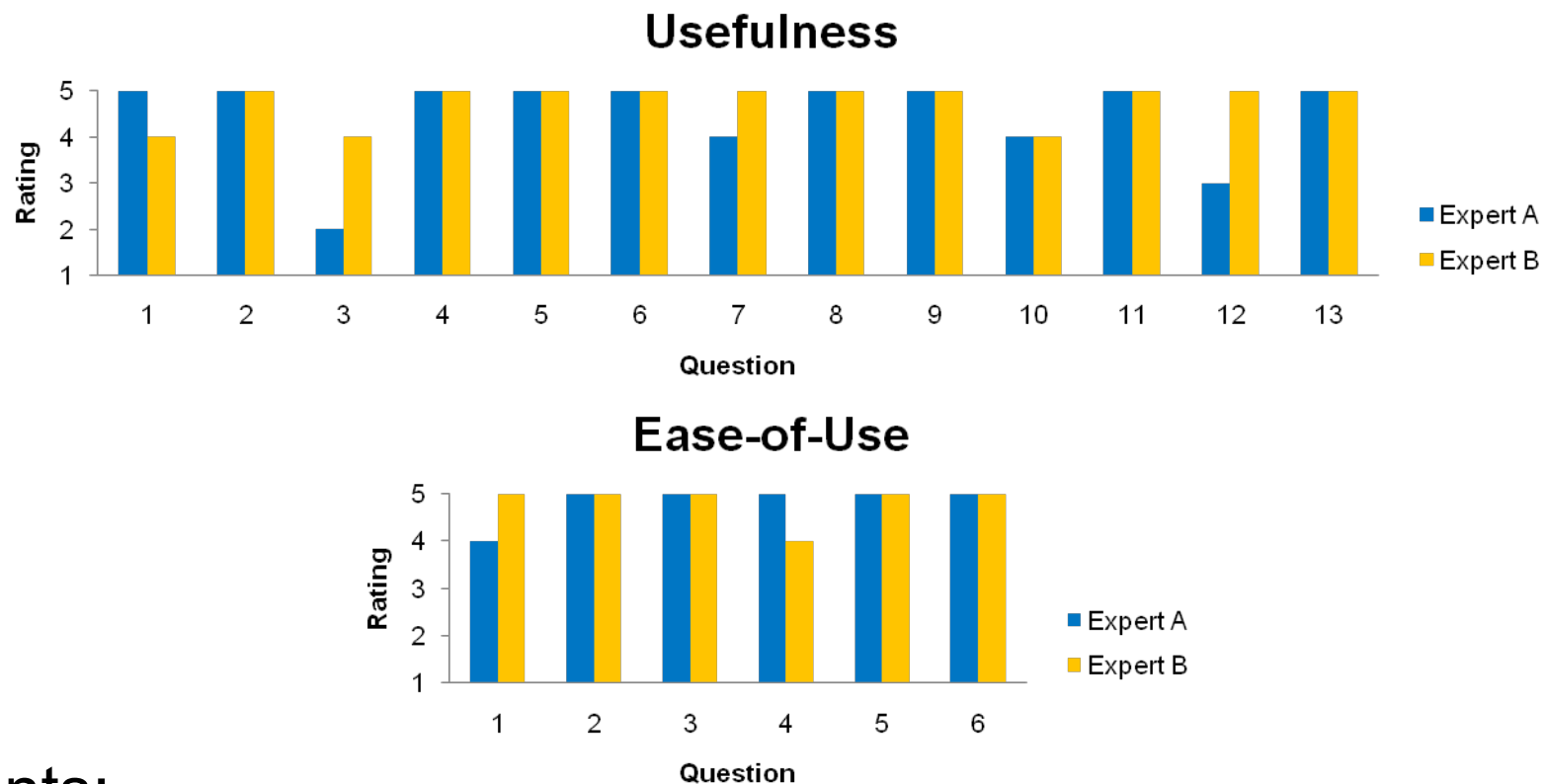
Linear pattern (trawling)



Fractal pattern (longlining)



Field study



Comments:

- Velocity filtering is very useful
- Fractal dimension filtering can be useful (crab, long-line fishing)
- Signatures allow more time to be spent on investigation

Field study - Questions

•Usefulness:

- Q1 - Using the prototype system enabled me to accomplish my usual tasks more quickly.
- Q2 - Using the prototype system improved my performance in exploring data.
- Q3 - Using the prototype system increased my productivity.
- Q4 - Using the prototype system enhanced my effectiveness at exploring data-sets.
- Q5 - Using the prototype system made it easier to explore data-sets.
- Q6 - I found the prototype system useful.
- Q7 - I found the ability to access data point information by hovering over their arrows to be useful.
- Q8 - I found the histogram representation of vessel speeds to be useful.
- Q9 - I found the automatic rescaling of the histogram to be useful.
- Q10 - I found that the ability to filter by fractal dimension was useful.
- Q11 - I found that the ability to filter by vessel velocity was useful.
- Q12 - I found that the ability to combining both fractal dimension and velocity filters was more useful than each one used separately.
- Q13 - I found that the ability to filter by temporal range was useful.

Ease-of-use :

- Q1 - Learning to operate the prototype system was easy for me.
- Q2 - I found it easy to get the prototype system to do what I wanted it to do.
- Q3 - My interaction with the prototype system was clear and understandable.
- Q4 - I found the prototype system to be flexible to interact with.
- Q5 - It was easy for me to become skillful at using the prototype system.
- Q6 - I found the prototype system easy to use.

Conclusion

- Both velocity and fractal dimension filtering reduce visual complexity
- Combining both techniques can allow for the targetting of specific patterns
- Experts found this technique easy to use and potentially useful
- Specific behaviours with distinctive patterns (longline fishing) are better suited for this technique

Questions?



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Fisheries and Oceans Canada
Pêches et Océans Canada



NSERC
CRSNG



Signature development

Original data – Unfiltered:



Signature development

Data filtered using $1.27 < D < 1.5$, window = 9



Signature development

Data filtered using $1.27 < D < 1.5$, window = 9, $0 \text{ kt} < V < 2 \text{ kt}$

