Identifying fishing trip behaviour and fishing effort from VMS data, using Bayesian Hidden Markov Models

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CAFE Project

VMS: a new source of data

TO:

-Improve estimation of fishing effort

-Monitor responses to management measures (models computing fishing mortality from fishing effort)

-Improve evaluation of costs associated with fishing effort

- Costs may differ between steaming and fishing
- Fuel context: métiers with long pathways will be less attractives

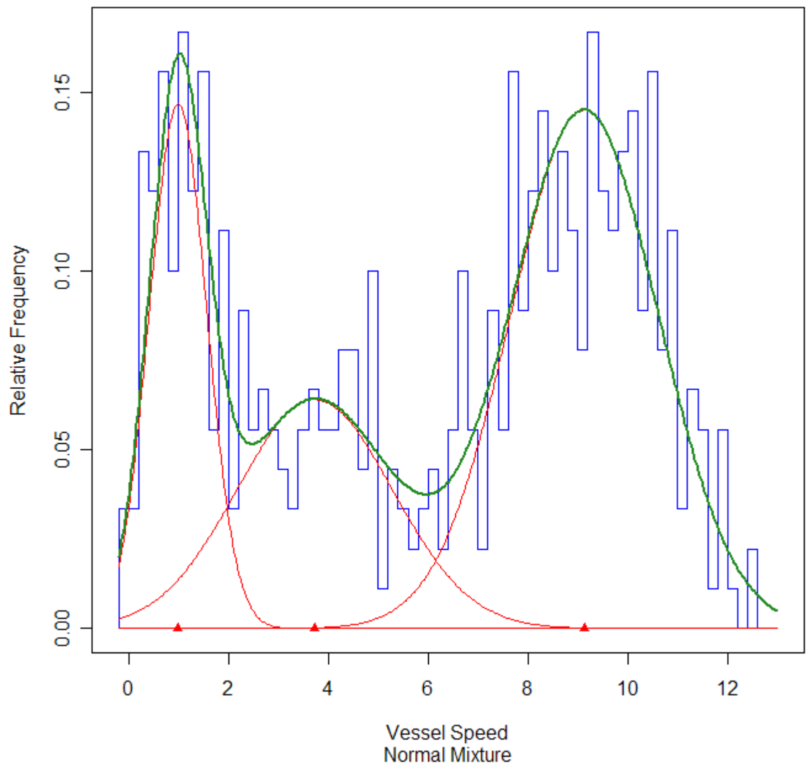
BUT: How to discriminate time spent at port / fishing / travelling?

Empirical identification of fishing boat behavior from :

-Speed

-directionality rules

-But:



Empirical identification of fishing boat behavior from :

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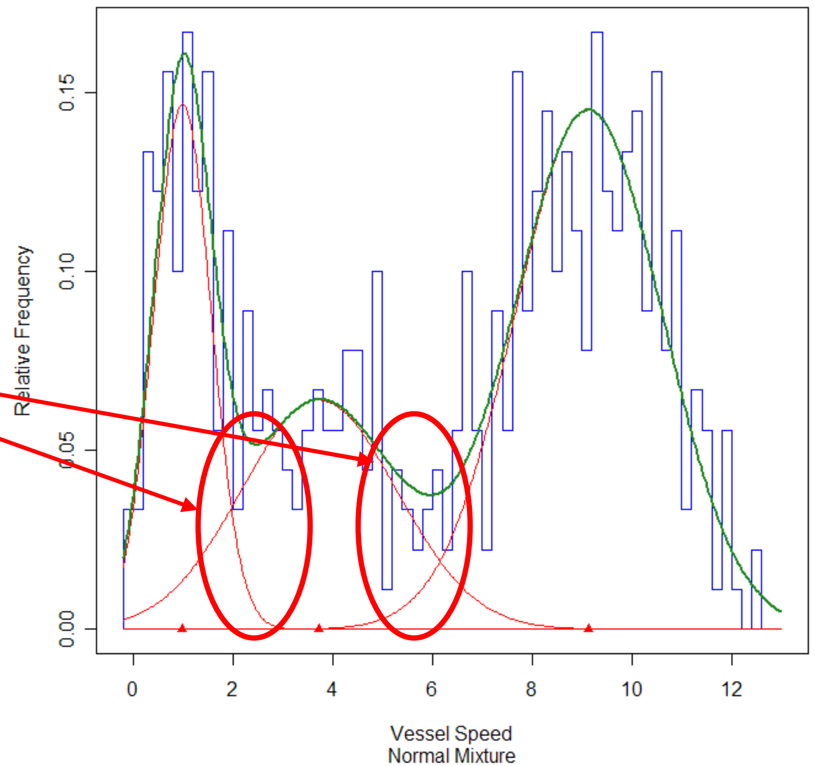
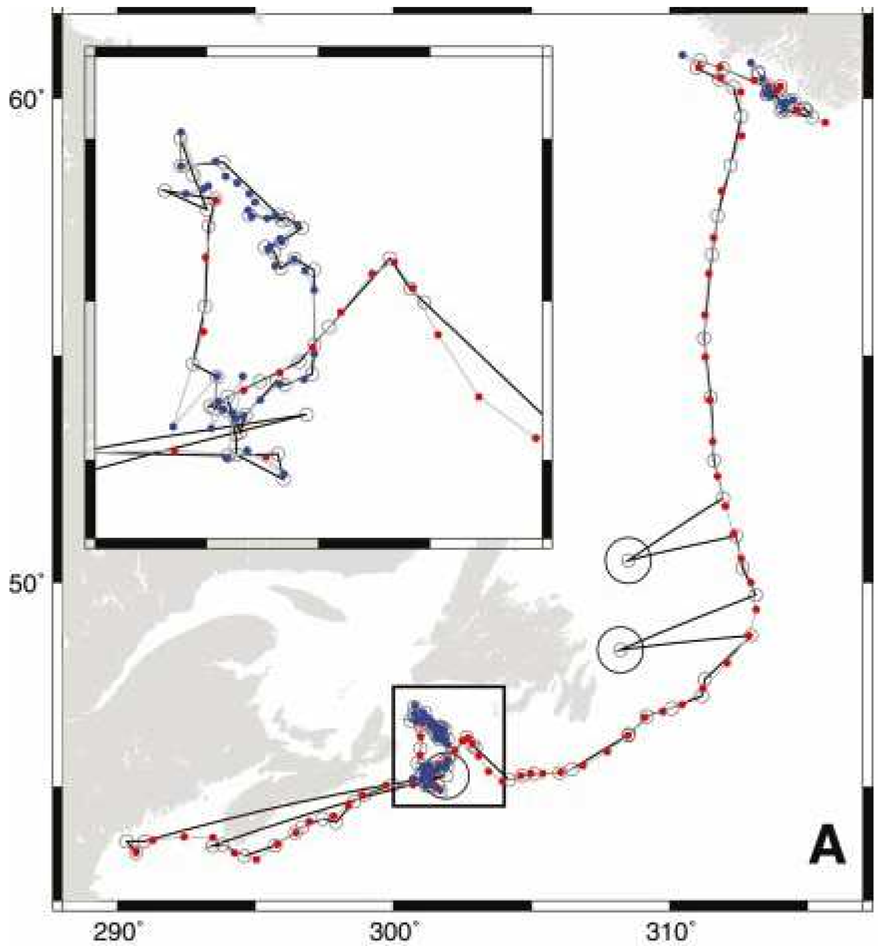
Problem



Background : State-space models for identifying individual animal movements



Seals pathway and states estimate (travelling or foraging)

From Jonsen et al. 2005

Bayesian Hidden Markov Models to analyse VMS data

Introduction

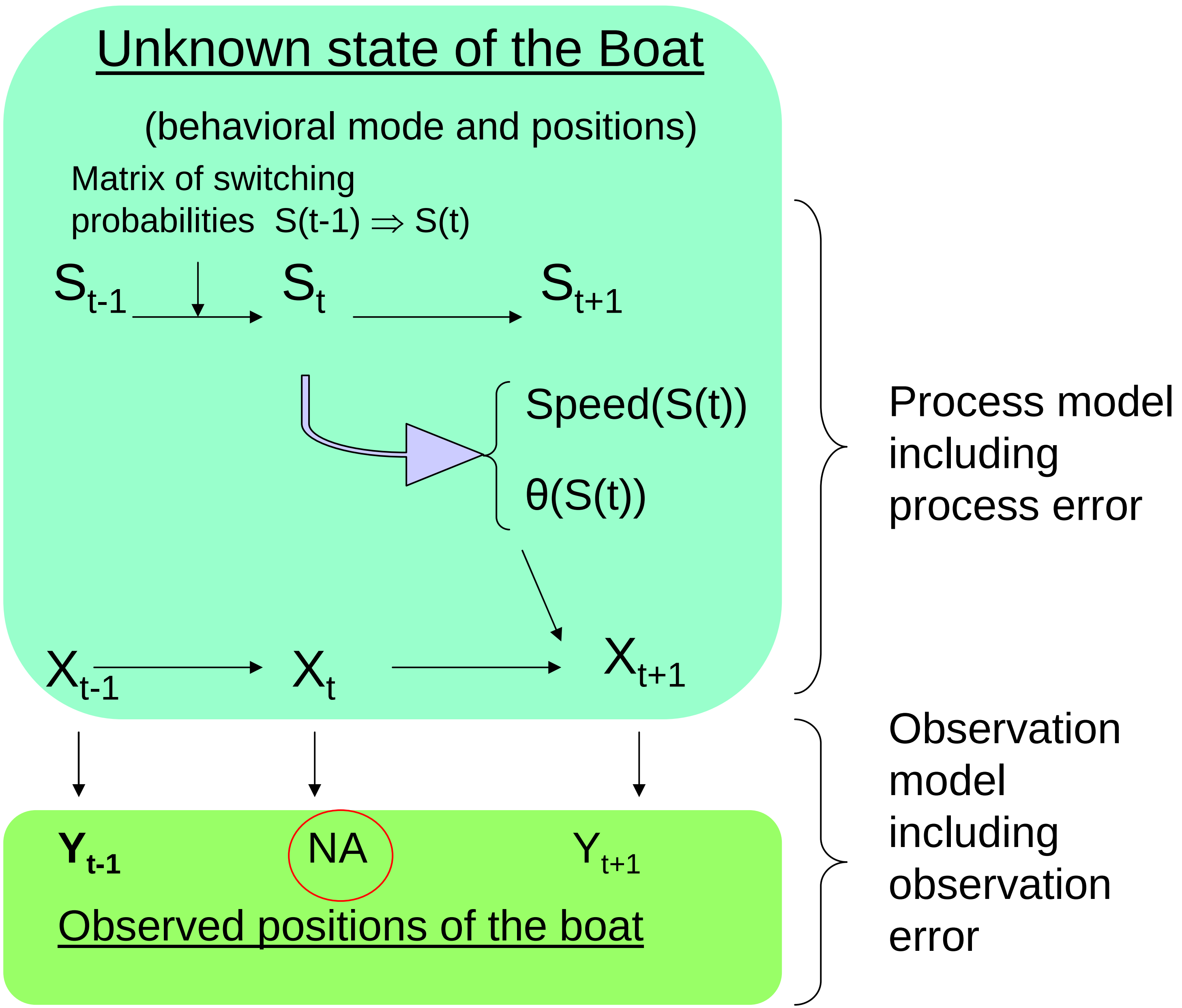
The model

Test on simulated data

Real data

Conclusion

Perspectives

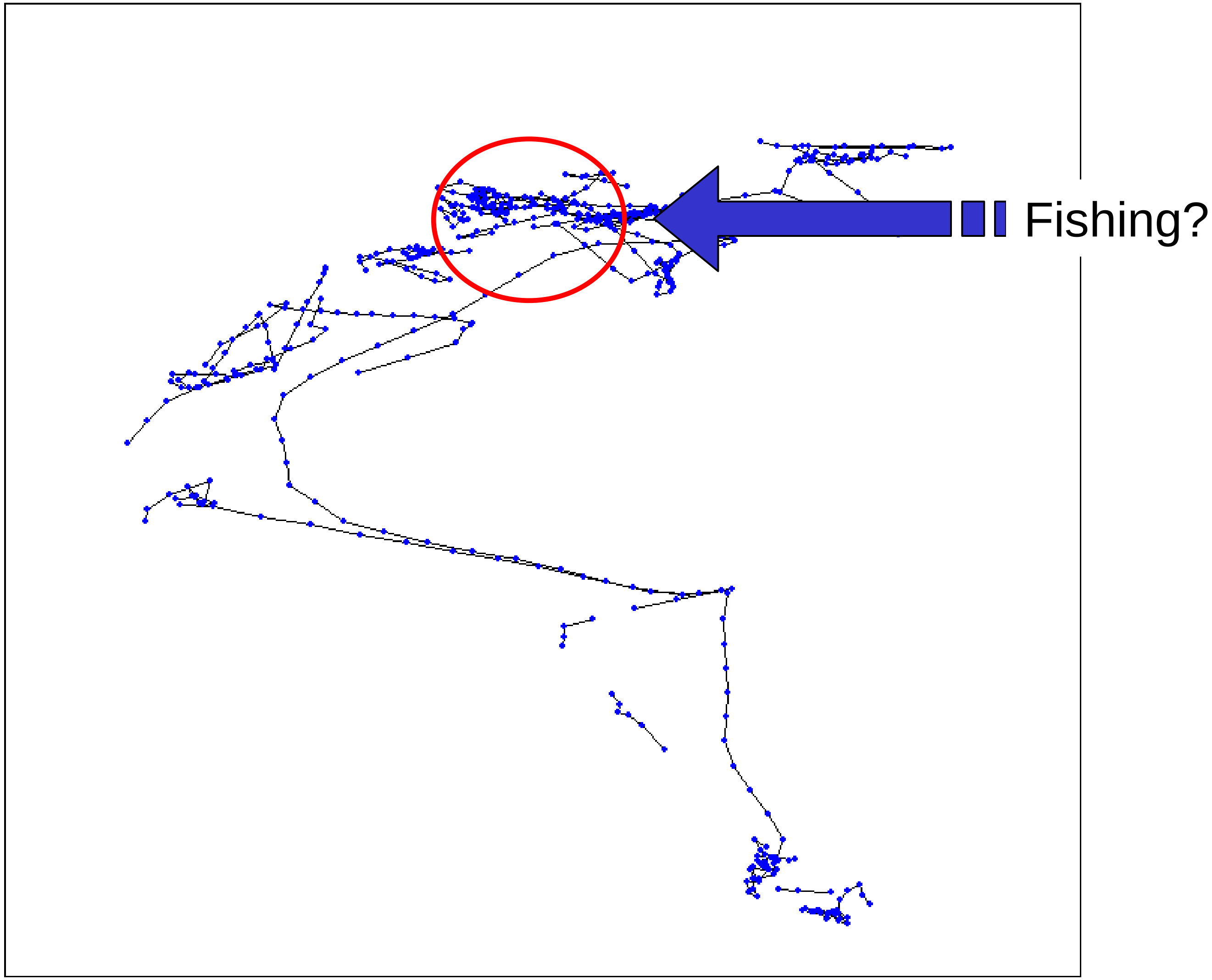


Assumption:Time step=1h

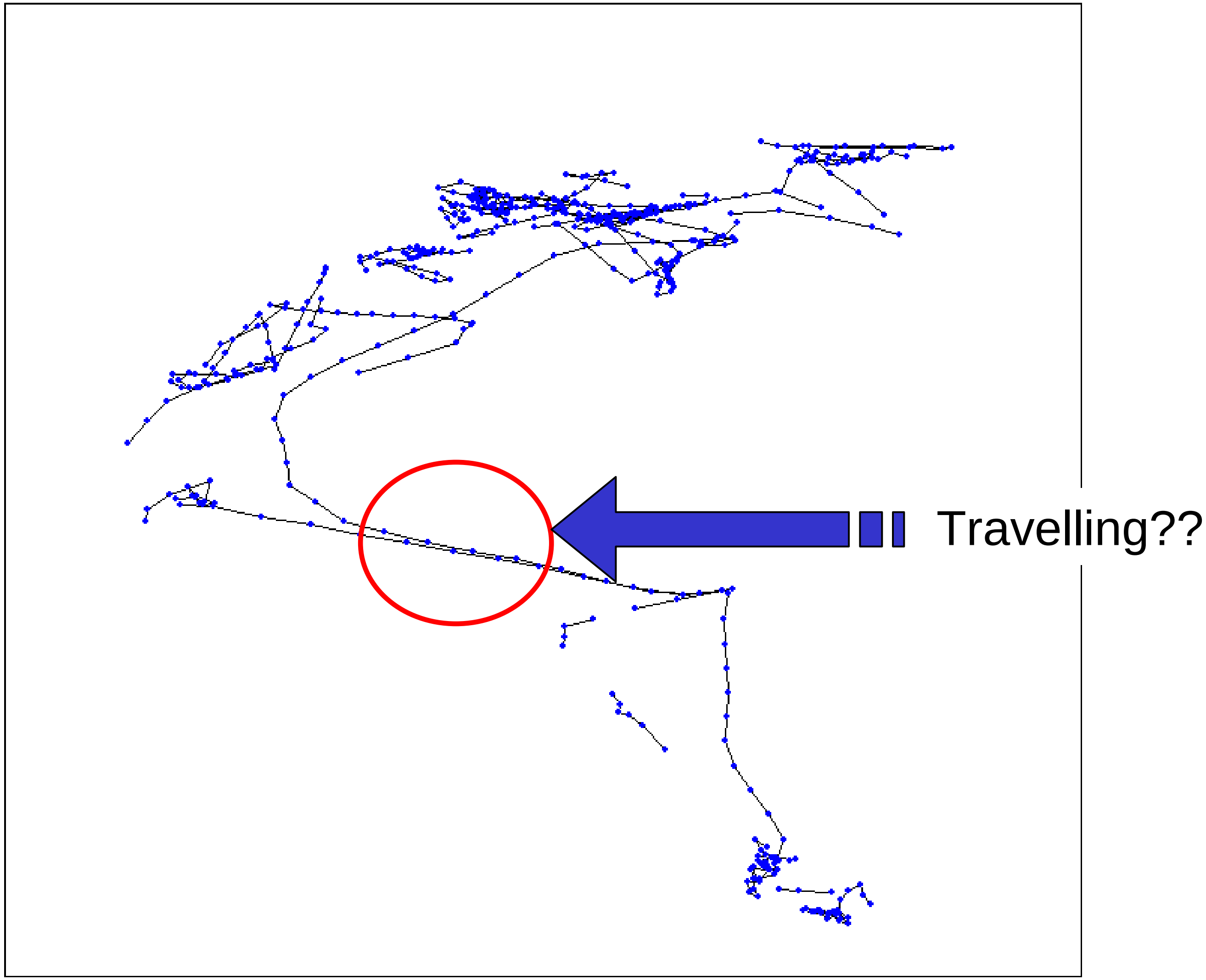
Application

A real pathway

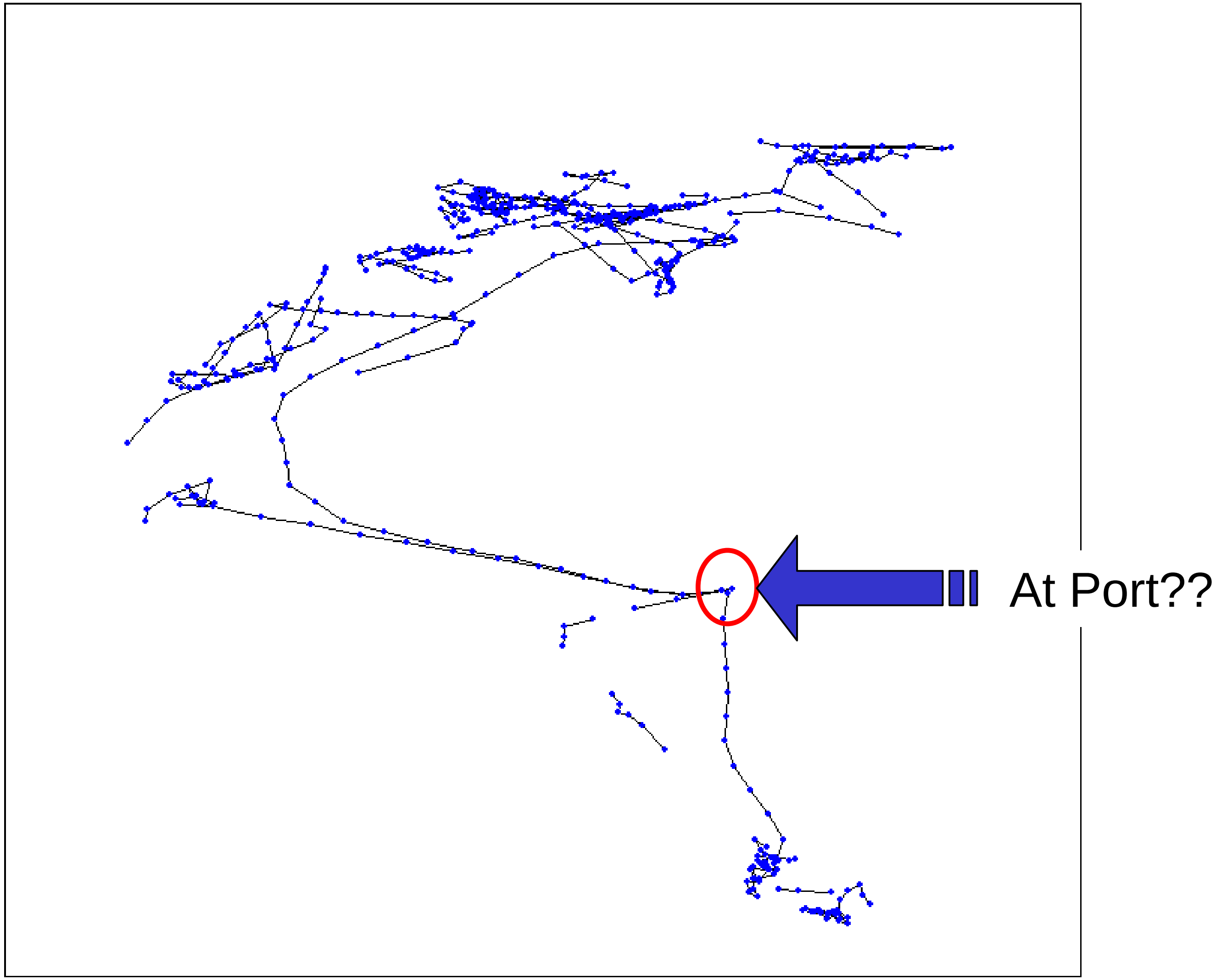
A real pathway



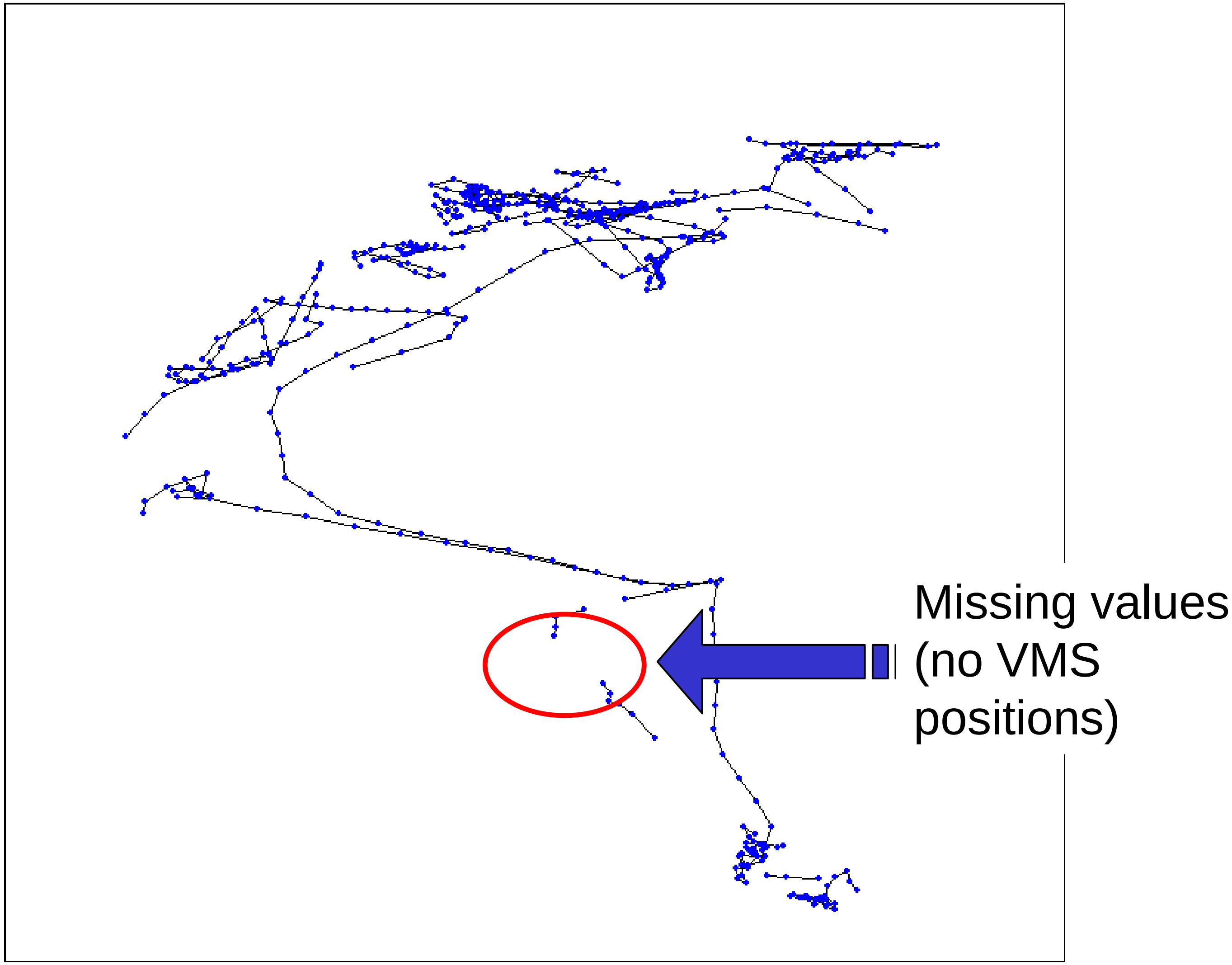
A real pathway



A real pathway



A real pathway



Prior knowledge on boat behavioral modes

3 behavioral modes (states)

Travelling (T), Fishing (F) or at Port (P)

		Next state (t+1)		
		T	F	P
Previous state (t)	T	P(T/T)	P(F/T)	P(P/T)
	F	P(T/F)	P(F/F)	P(P/F)
	P	P(T/P)	P(F/P)	P(P/P)

Prior knowledge on Speed and Directional rules

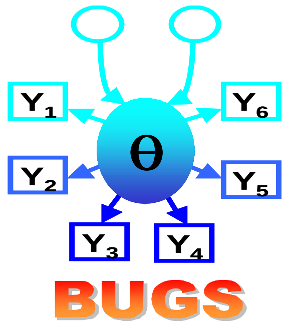
- Speed(Fishing) < Speed(Steaming)
- Speed(At port) = 0
- θ(Fishing) > θ(Steaming)

Bayesian estimation

Vague prior were used on all parameters

Bayesian computation

- MCMC sampling
- WinBUGS (Gibbs sampling)



Test of the model on simulated data

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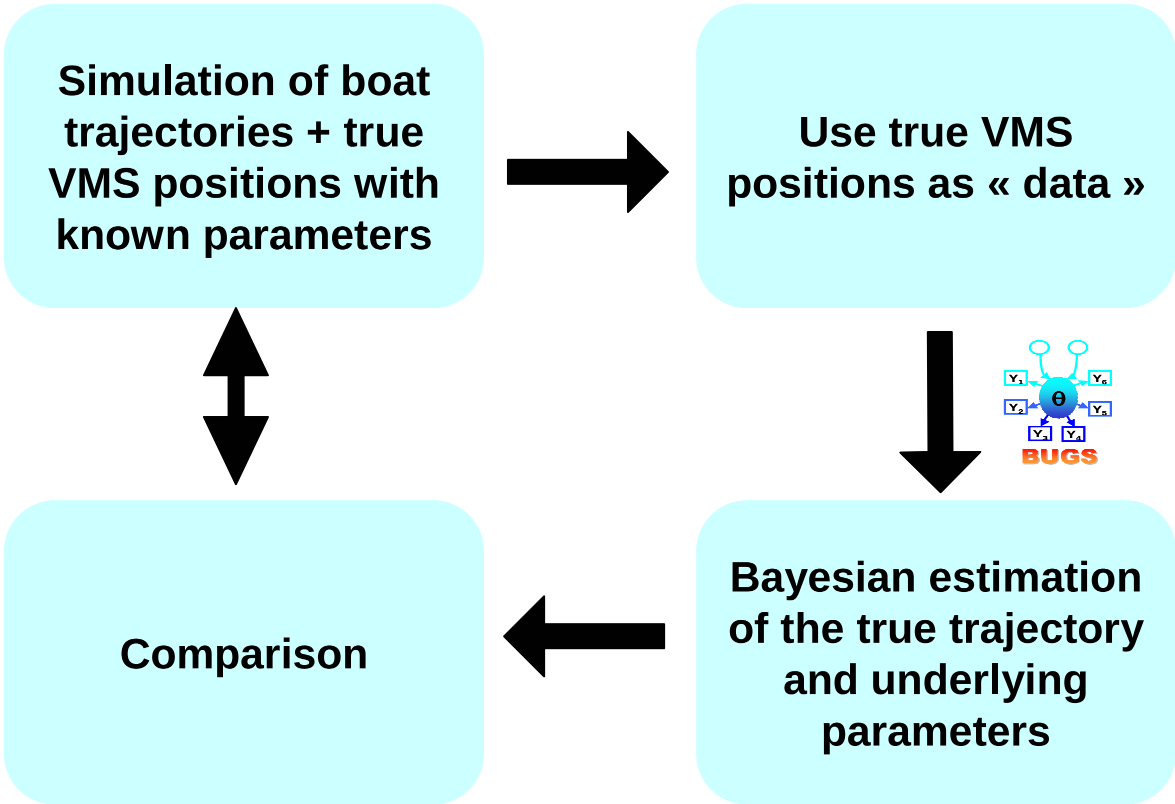

⇒ Is the model able to estimate the « true » pathway ?

⇒ Is the model able to estimate (catch) the fishing boats behavioral modes at each time step ?

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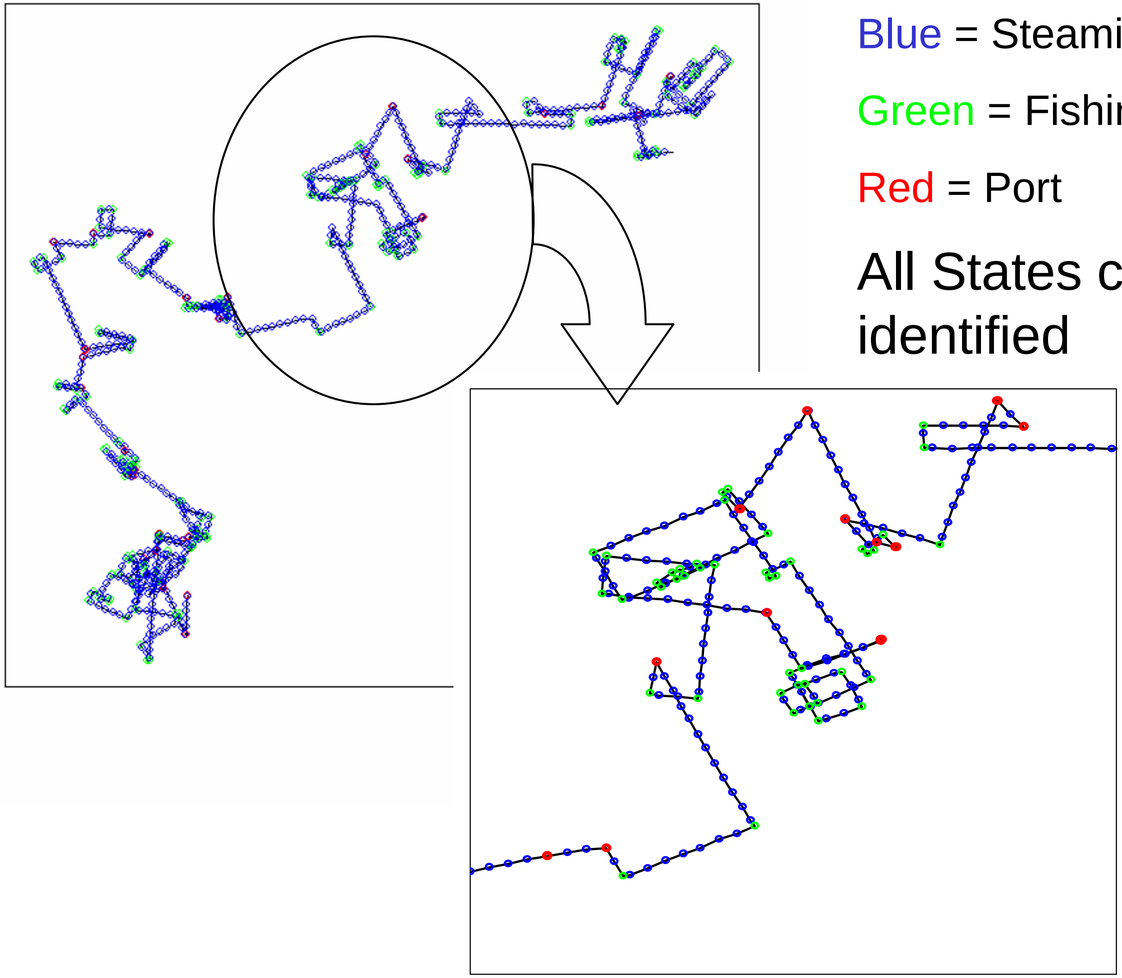


Blue = Steaming

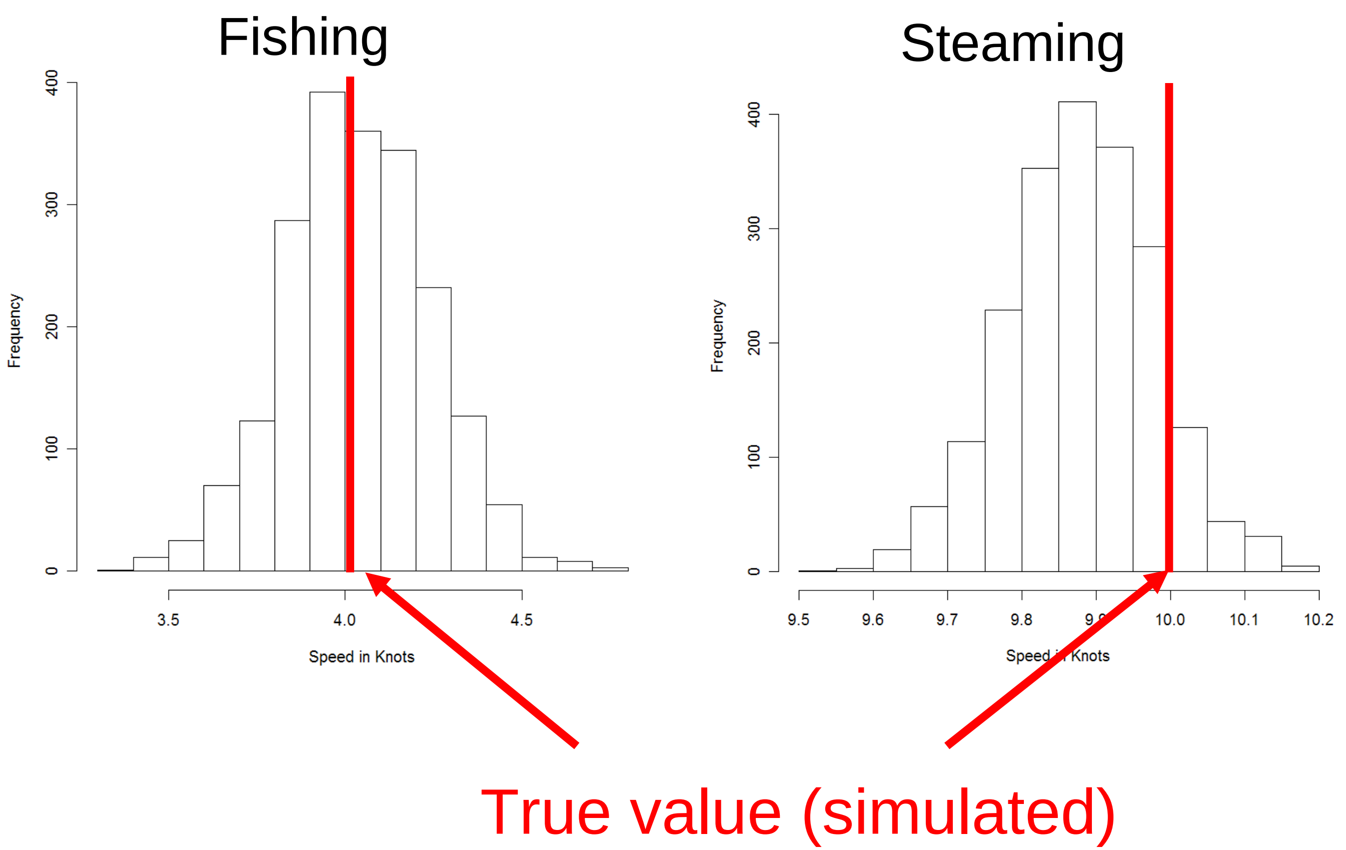
Green = Fishing

Red = Port

All States correctly identified

The model reproduces the simulated pathway and states

Posterior for the Speeds during:



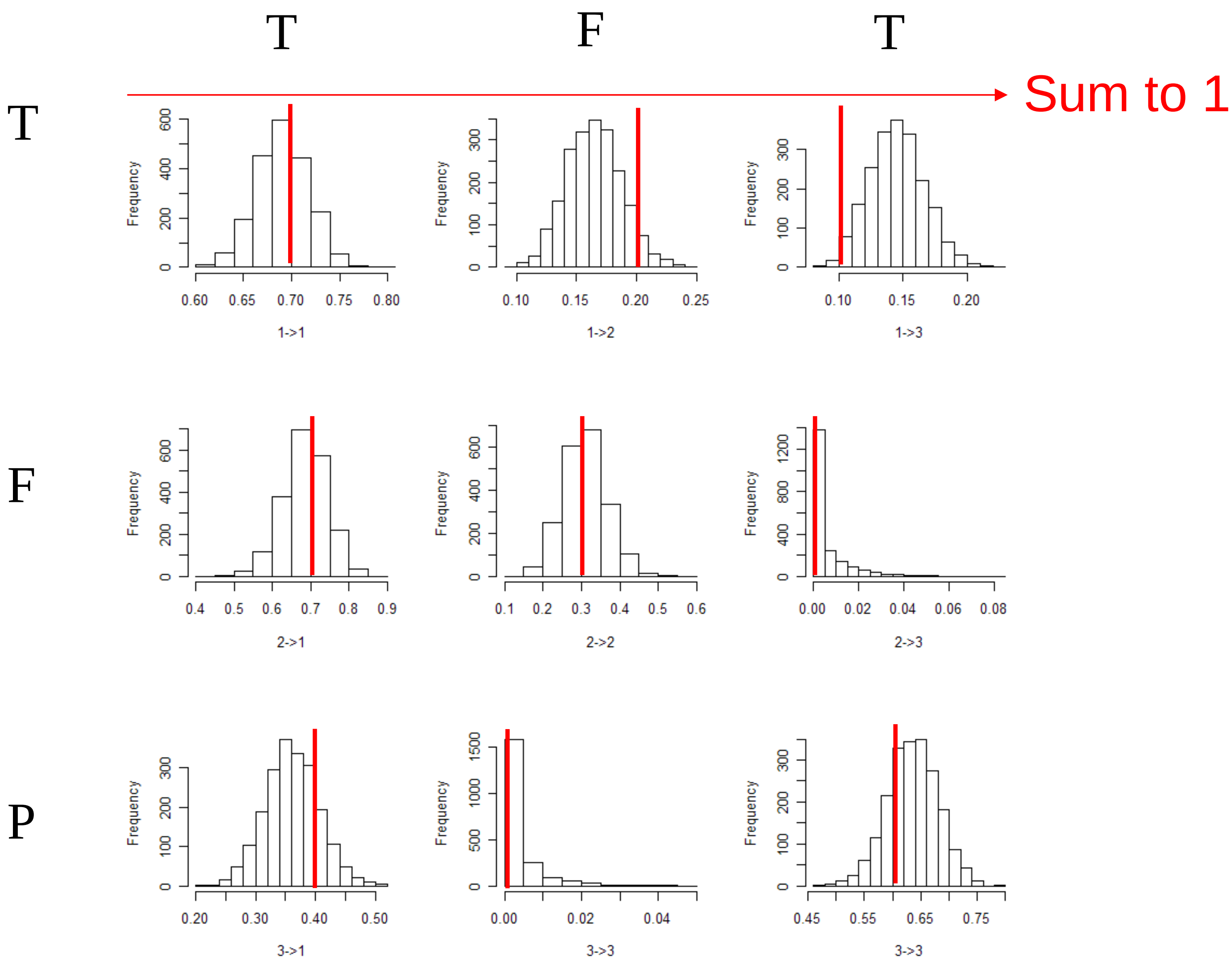
Estimated fishing speed=4

True fishing speed=4

Estimated steaming speed=9.9

True fishing speed=10

Posterior for transition probabilities



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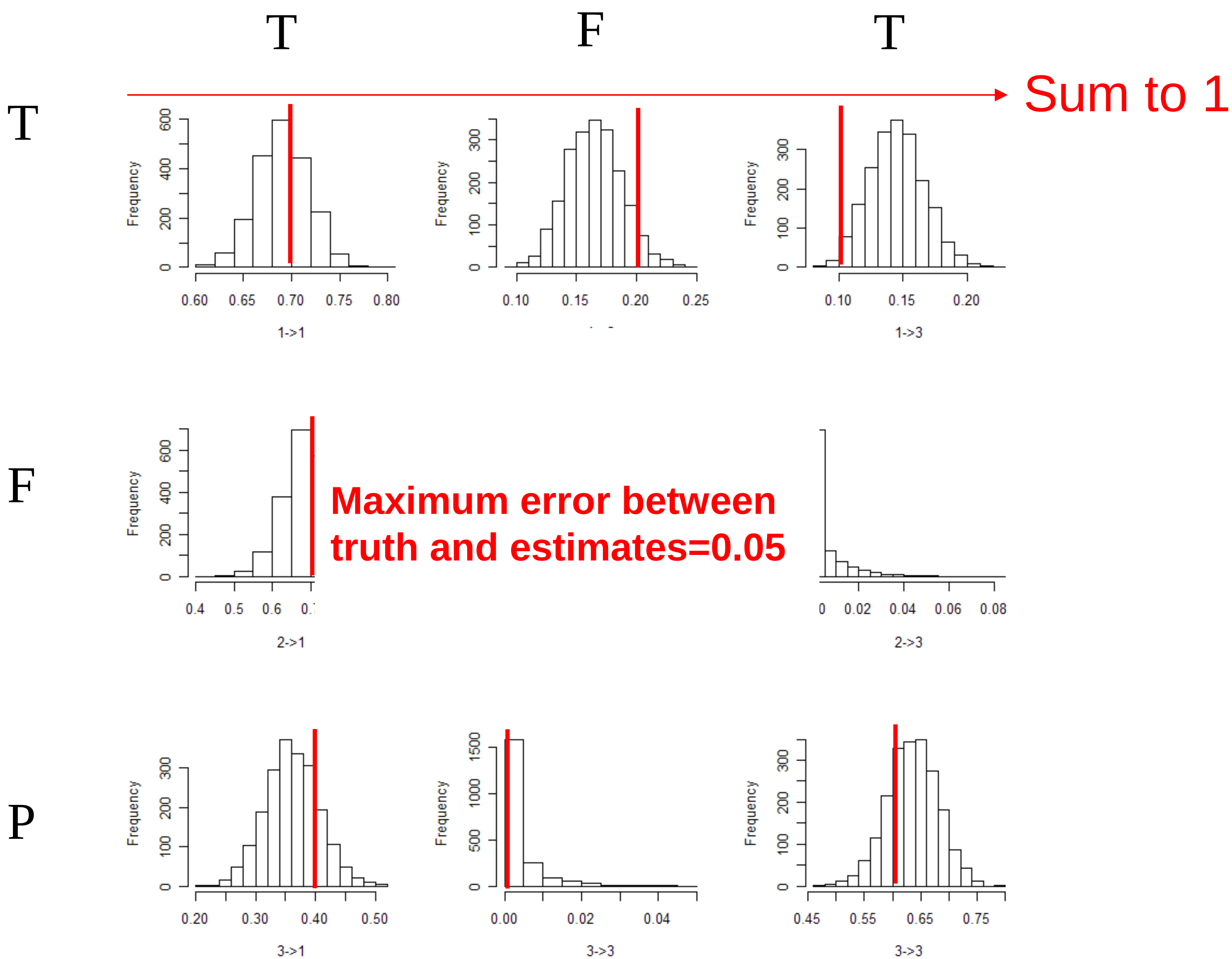
Posterior for transition probabilities



First application on a real data set

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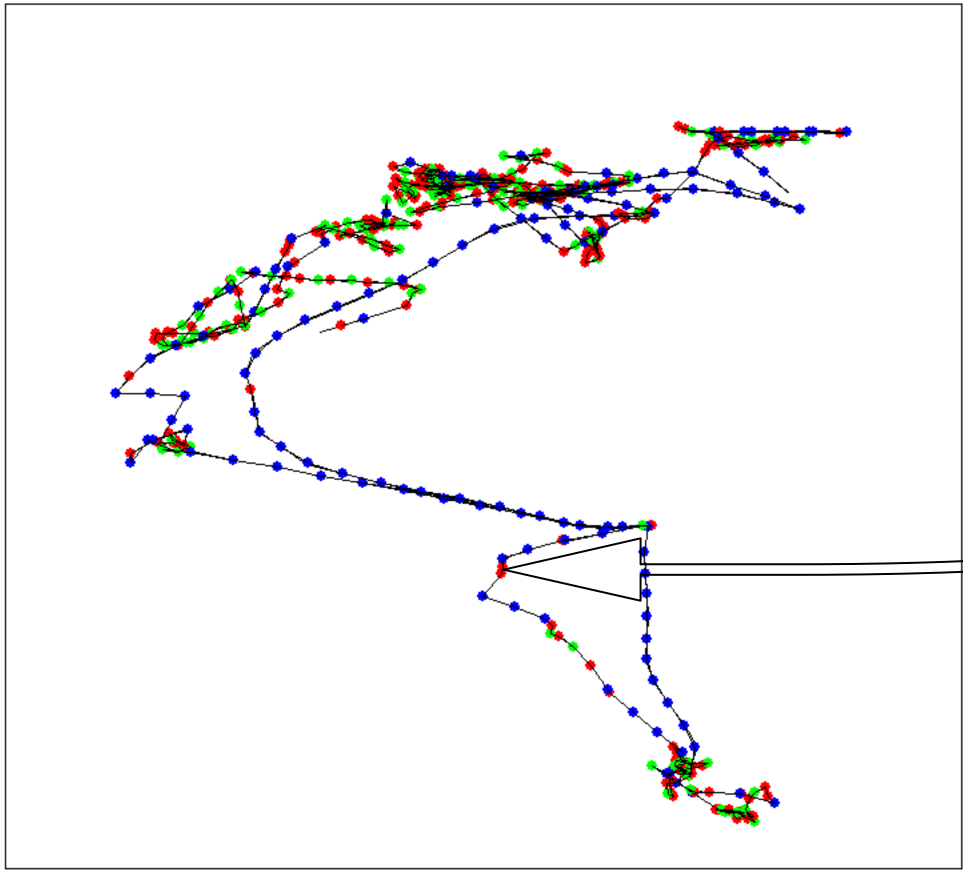
Predicted pathway and states of the boat



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Problem in the time step emission

Problems in the identification of « at port » state

Useful outputs of the model

	mean	Sd
Speed of Travelling (in knots)	11.6	0.005
Speed of Fishing (in knots)	5.9	0.013
theta of Travelling (in radians)	0.01	0.0002
theta of Fishing (in radians)	2.99	0.0015
Total distance Travelling	1731.0	0.4
Total distance Fishing	1012.0	0.8
Number of time step Travelling	22%	0.0
Number of time step Fishing	26%	0.3
Number of time step at port	52%	0.3

Proportion of time spent on each state

Effort/costs measure

Direct outputs of the model with the associated uncertainty

Advantages

1. VMS data are integrated in a unified modelling framework including :
   - A markovian model for boats behavior and trajectories
   - Errors both on process and observations
2. Unknown quantity of interest for each state (speed, angles, time spent in each behavioral mode, distance spent travelling/fishing …) are readily estimated in a Bayesian framework (with uncertainty)
3. Prior knowledge could be introduced from other studies/data

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Some perspectives

- Improving the observation model
- Improving the modelling of the transition matrix
    - time dependent shifting probabilities
    - coupling with covariates (harbour positions…)
- Use outputs to compute proxies of the costs associated to each state

Thank you for your attention