A Waterborne Commerce Inventory

Integrating Economic, Transportation, and Emissions Data

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Non-road Inventories

- Challenges
  - geographic characterization
  - treatment of uncertainty
- Two important weaknesses
  - model assumptions may not be “real world”
    - models are not informed by in-service sampling
  - calculations typically use national averages
    - ignore regional variability in activity

Nonetheless, non-road inventories significant contributor to regional air quality problems

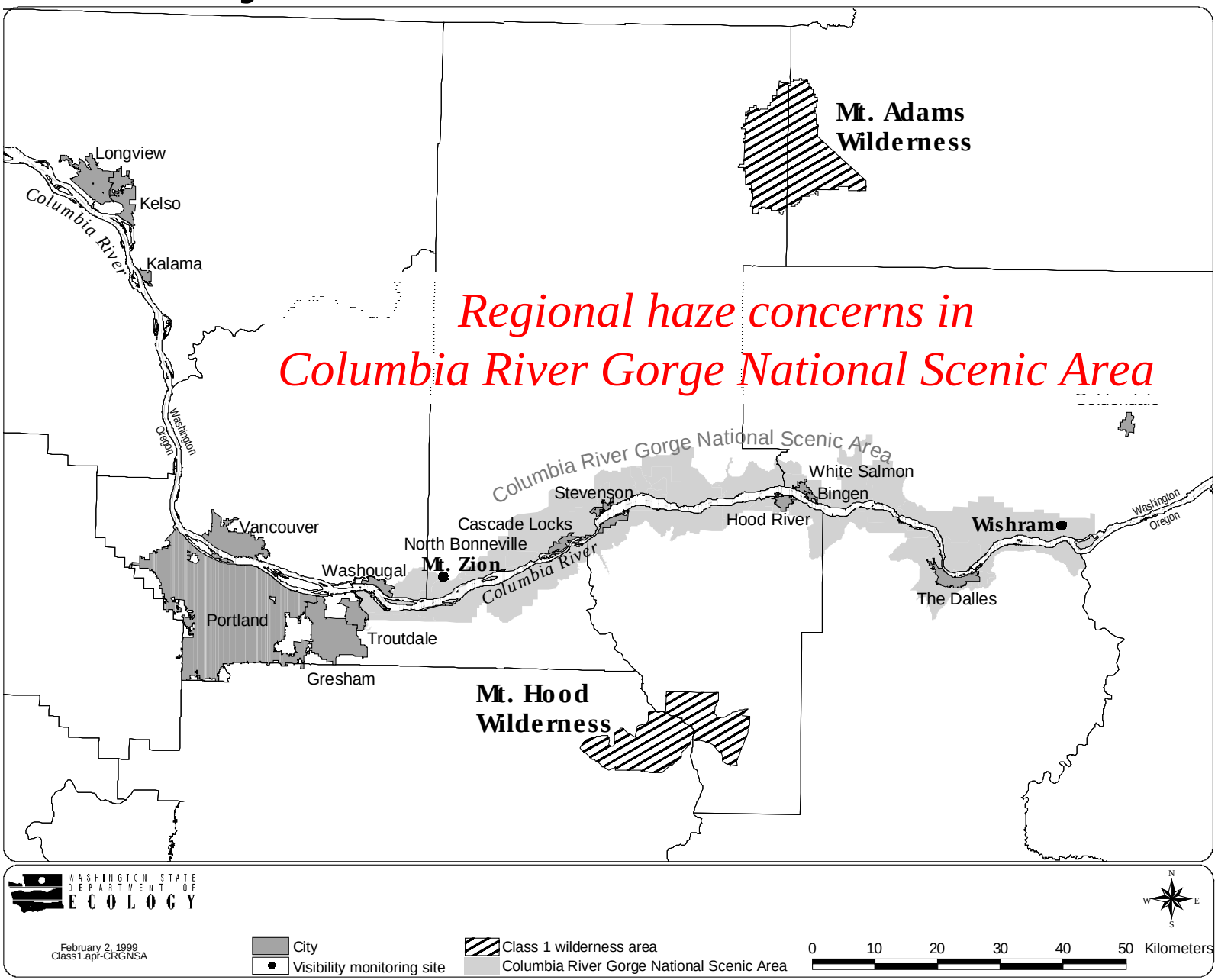
Commercial Marine Vessel Emissions: *Previous inventory results*

- Global inventories: international shipping important to global pollution, climate change
- Domestic inventories for waterborne commerce
  - Emissions in shipping channels and rivers matter
  - Ship emissions in coastal US waters are not a problem of US ships, but of international trade
  - In inland rivers, US ships dominate emissions

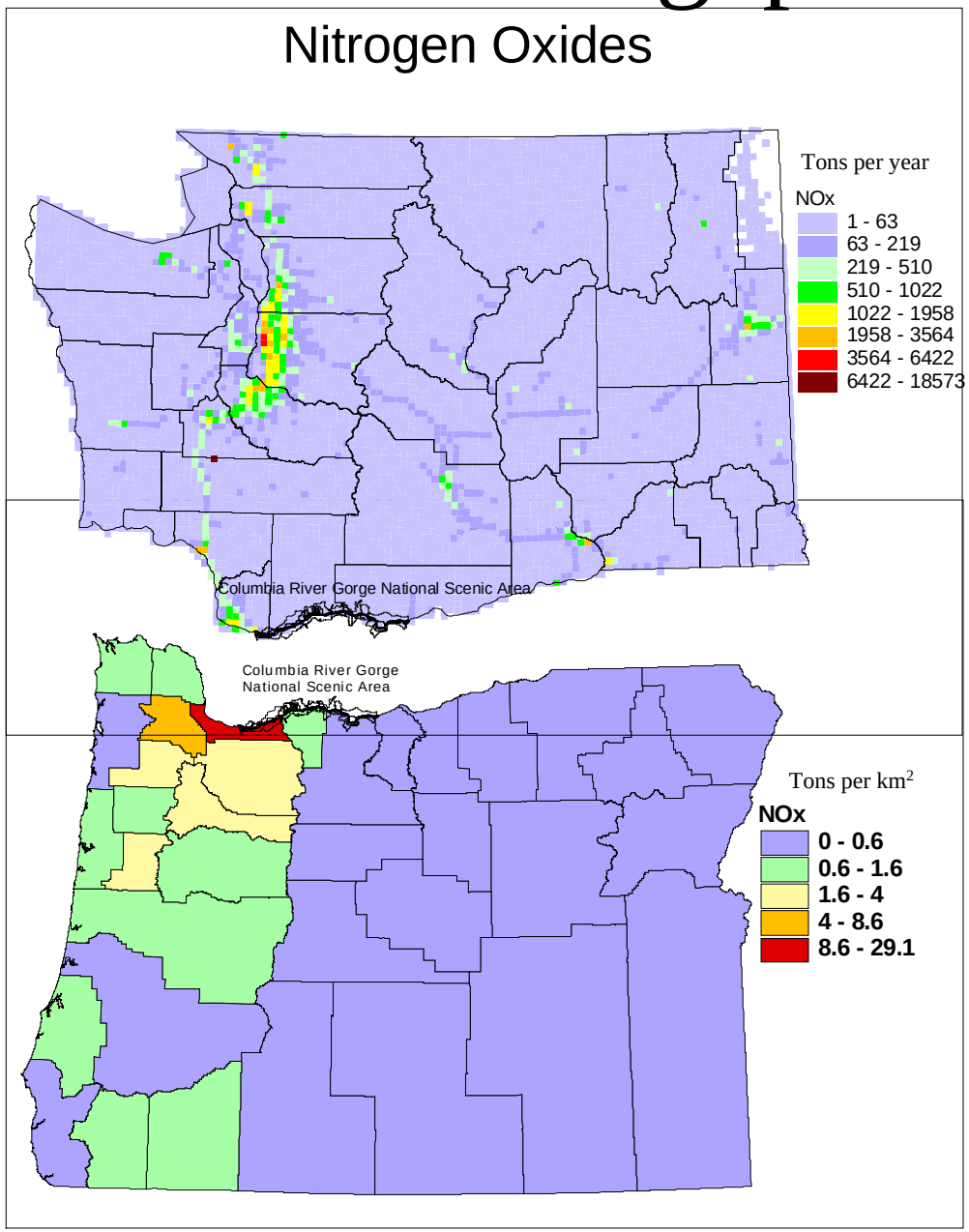
WA and OR in top-twenty states for CMV NOx:
prompted focused study of Columbia-Snake River

Sources: J. Corbett and P. Fischbeck, Science, 1997;
J. Corbett and P. Fischbeck, ES&T, 2000

Inventory focus: Columbia-Snake Rivers



Goal: Fill the gap in state inventories



Comparisons difficult, depend on units

- Units reported differently for each state (WA and OR)

This study:

Produces inventory on annual basis

Reports GIS output in NOx/mile of waterway

- Provides line-source emissions intensity

Columbia-Snake River Methodology

- Use “bottom-up” fuel consumption data
  - TVA barge costing model evaluates fuel usage by river segment for fuel tax purposes - accurate to 0.8%
- Assumptions:

Base Case rated power: full throttle = 80%; maneuvering = 20%

Upper bound power: full throttle = 95%; maneuvering = 20%

Lower bound power: full throttle = 75%; maneuvering = 15%

Fuel Density and Emissions Factors	Best Estimate	Lower Bound	Upper Bound
	kg/l	kg/l	kg/l
Fuel Density for Towboats	0.8401	0.8401	0.9400
Fuel Density for All Other Vessels	0.8401	0.8401	0.9870
	kg NOx/tonne fuel	kg NOx/tonne fuel	kg NOx/tonne fuel
NOx Emissions Factor for Towboats	57	56	63
NOx Emissions Factor for All Other Vessels	59	56	96

Results

- Base Case: 6,909 tonnes NOx/yr

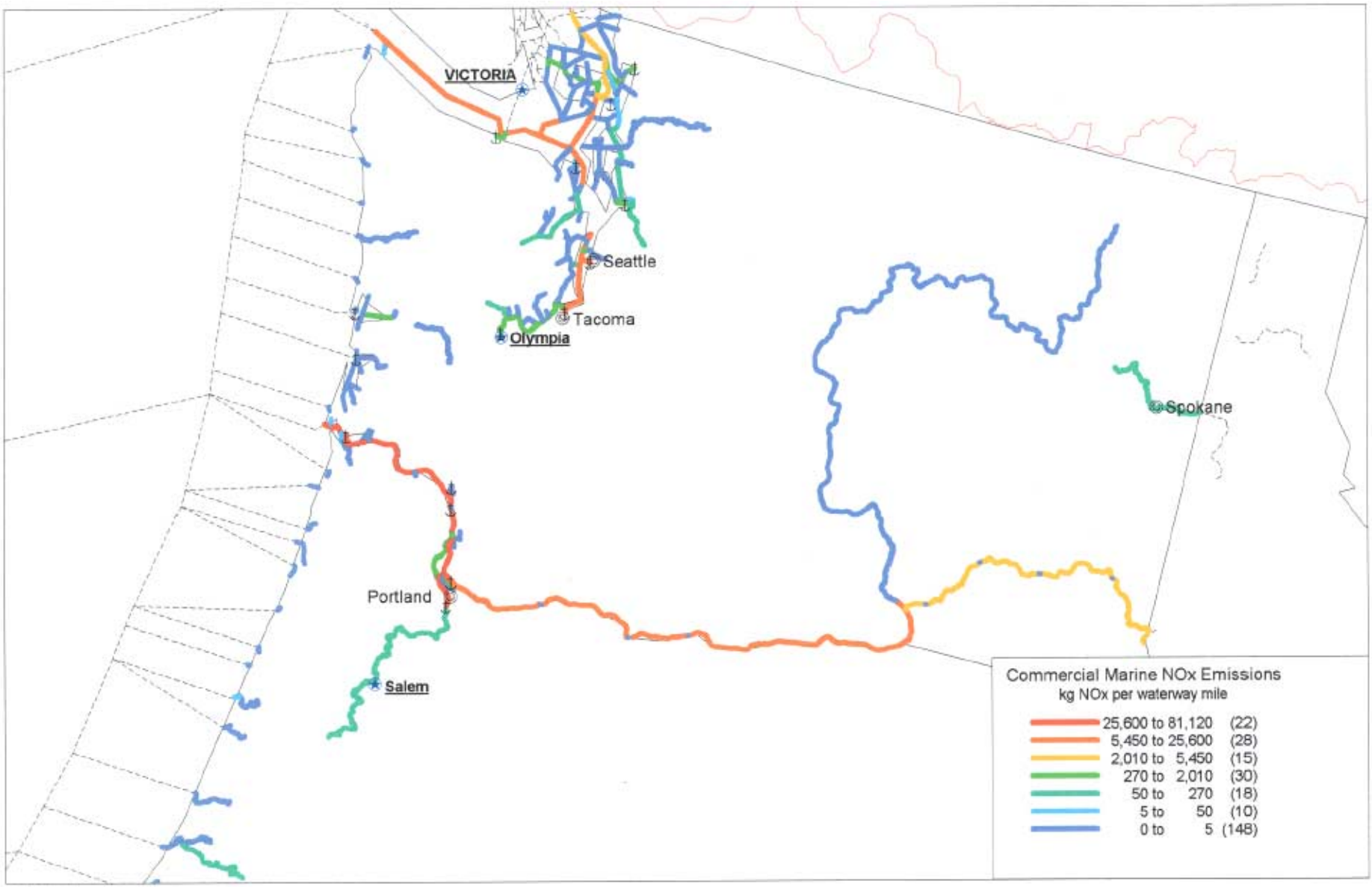
  Lower-bound 6,520 tpy; Upper-bound 8,305 tpy

  – Ten river segments specified within estimates
    - 63% of NOx emissions on Columbia and Lower Willamette below Vancouver; only 17% from towboats
    - 85% of all CMV emissions occur below McNary Dam
    - 10% of total (30% of towboat) NOx emitted in gorge

This estimate 2.6 times greater than previous work

While only 3% of WA-OR onroad inventory, ranks 8th among NOx source categories

Base case results: geographic distribution

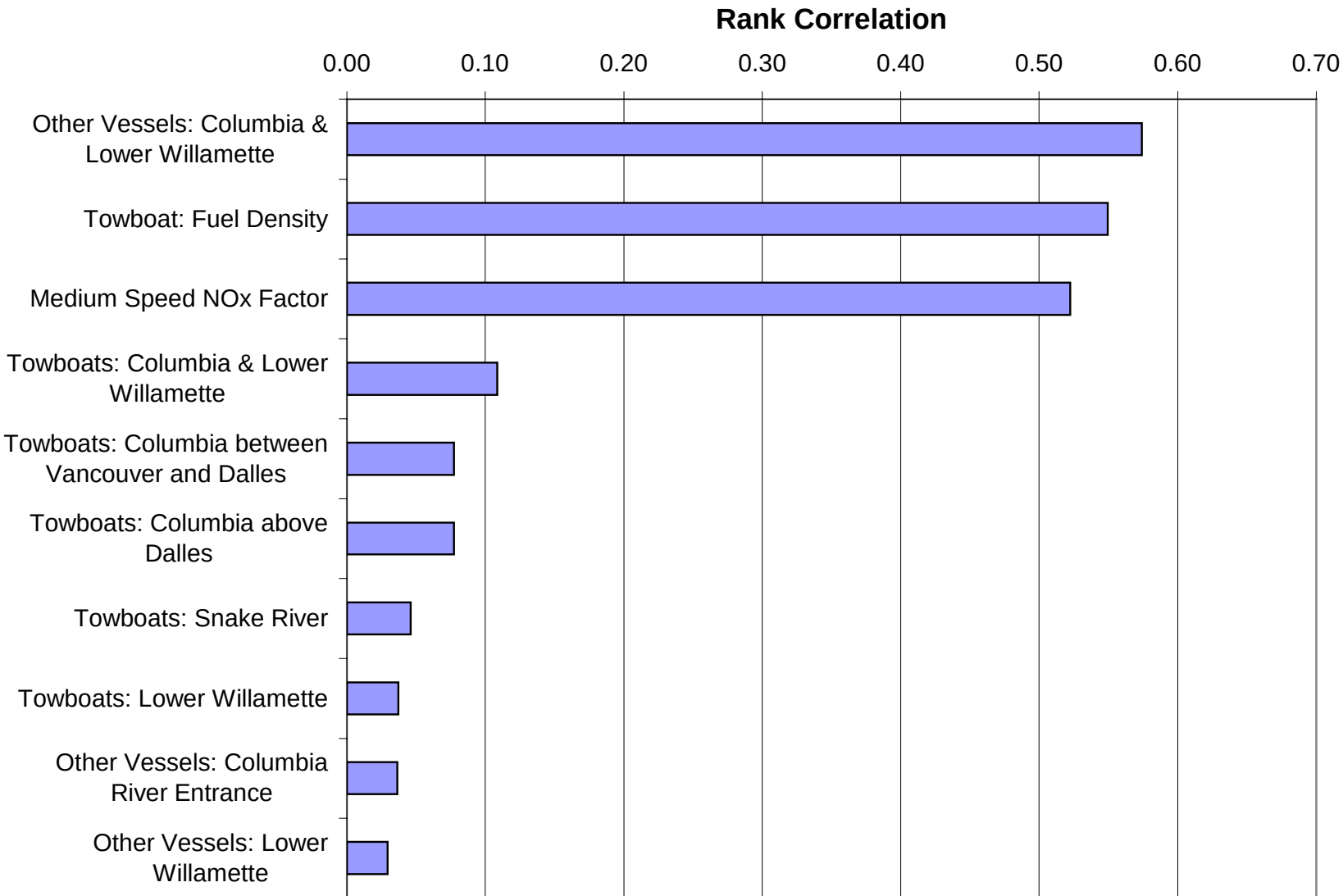


Uncertainty Analysis

- Monte Carlo simulation to evaluate which input variables contribute most uncertainty
- Included all uncertain inputs, defining triangular distributions (lower, base case, upper)
- Performed sensitivity analysis of simulation

Results of sensitivity analysis:

Three input parameters contribute most uncertainty



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Conclusions

- CMV emissions appear important to region
  - more than 2.5 times greater that previous work
  - comparable to local sources along most of river
- Emissions intensity (per mile of waterway)
  - For NOx, comparable to emissions intensity per mile for interstate freeways (I-5, I-205)
- Uncertainty analysis shows opportunity for improvement in inventories
  - Better vessel traffic characterization, fuel properties, emissions testing

Future Work

- Evaluate the impact on regional haze
- Develop better inventories for other regions
- Continue to evaluate and reduce uncertainty

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http://www.riverbarges.com/riverfun/riverpics/picsintro.htm