

Maritime safety and security: Tools and trends

Ronald Pelot, Ph.D., P.Eng.

Department of Industrial Engineering

Dalhousie University

Ronald.Pelot@Dal.ca

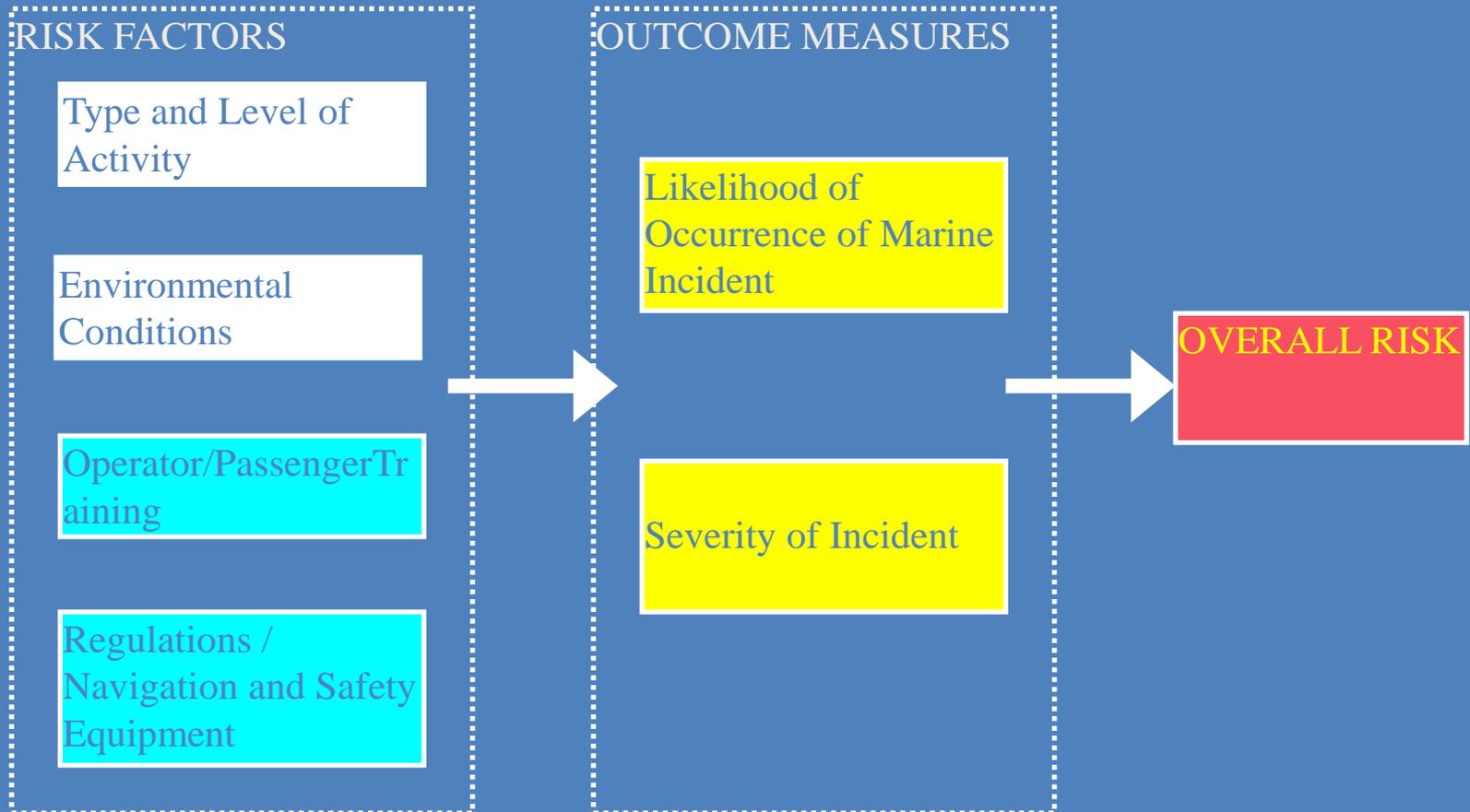
www.marin-research.dal.ca

Maritime Activity and Risk Investigation Network

Spheres of Interest

- Maritime Security: defending the coasts
- Maritime Safety: responding to accidents
- Environmental Protection: responding to spills
- Coastal Zone Risk Management

Maritime Risk Model



Activity Types

Commercial shipping

Commercial fishing

Commercial recreational

Aquaculture

Ferries

Cruise ships

Private recreational



Traffic Modelling Processes

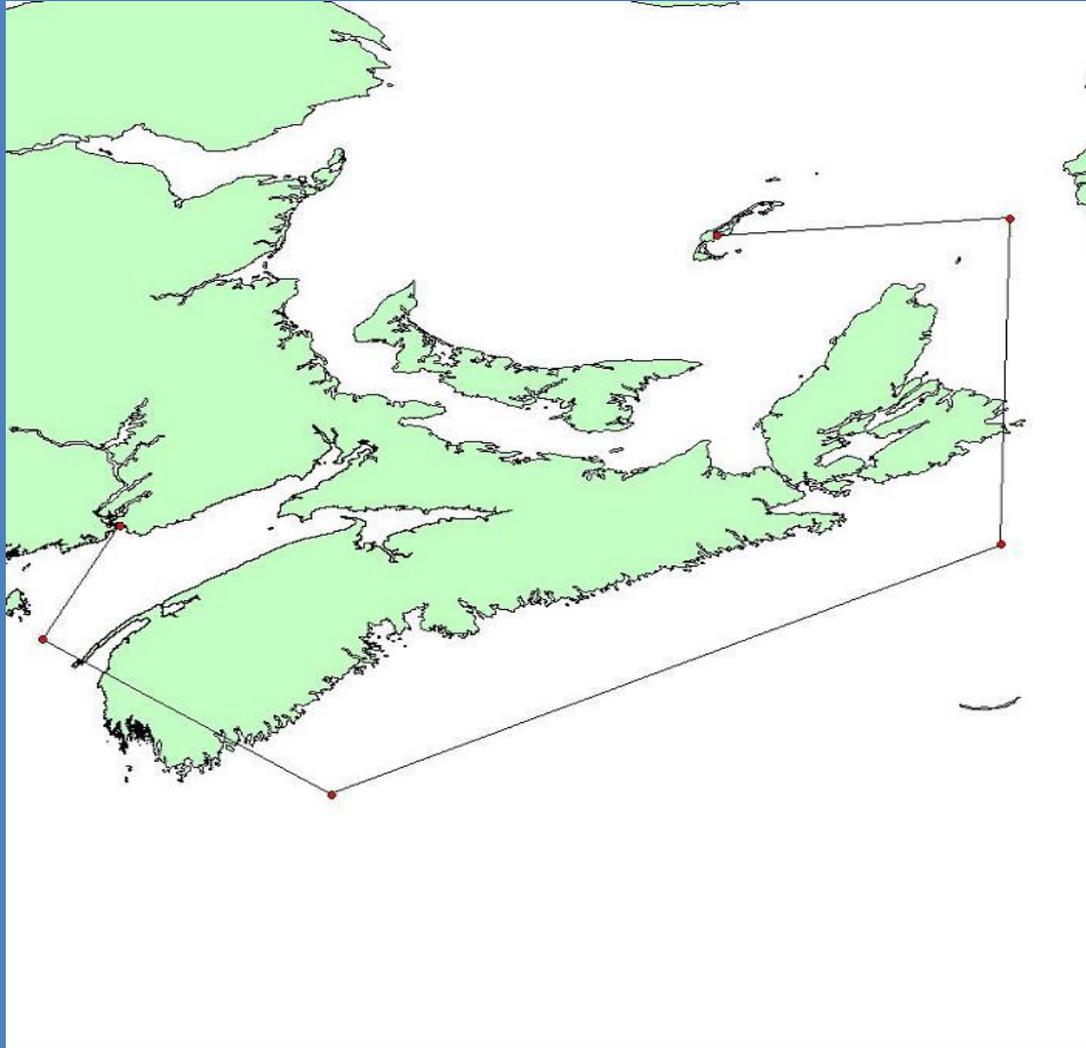
- Maximize use of information:
 - source: location, date, time
 - intermediate points: way points, fishing efforts
 - final destination: location, date, time
 - frequency
- Extrapolate using more general information
 - feasible range: distance, time
 - feasible location; eg. fishing grounds; tourist sites
 - typical locations: cluster analysis



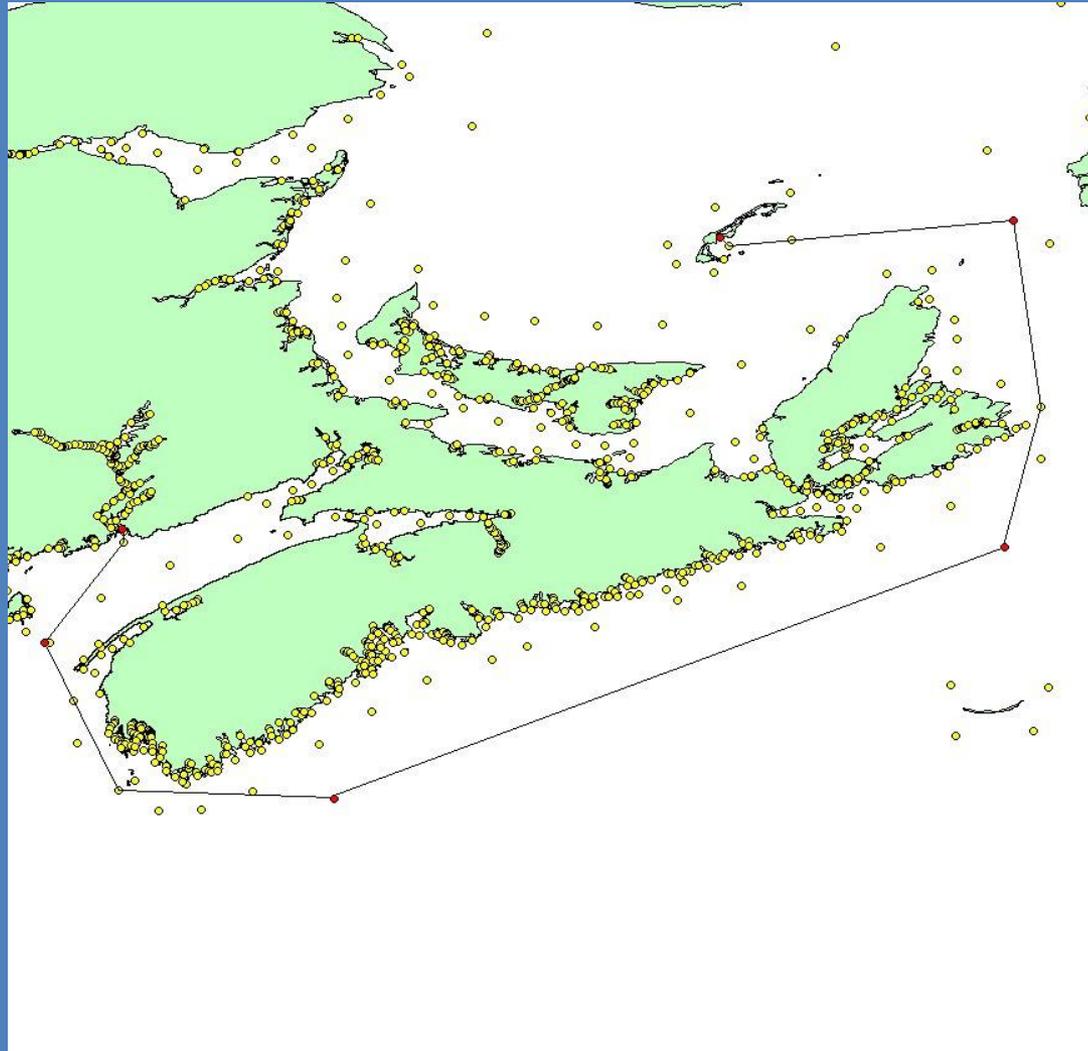
Data quality

Class	Available Information	Example
A	Continuous time-stamped position data; vessel info	Canadian West Coast shipping transits; Automatic Identification System (AIS)
B	Specific origin & destination, and intermediate waypoints; travel dates; vessel info	Canadian East Coast shipping transits
C	Specific origin & destination; travel dates; vessel info	Ferries; Cruise ships
D	Specific origin; general destination; travel dates; vessel info	Commercial fishing by NAFO zones
E	Specific origin; general destination; frequency of trips; vessel info	Lobster fishing; ecotours
F	General origin; general destination; frequency of trips; classes of vessels	Recreational boating

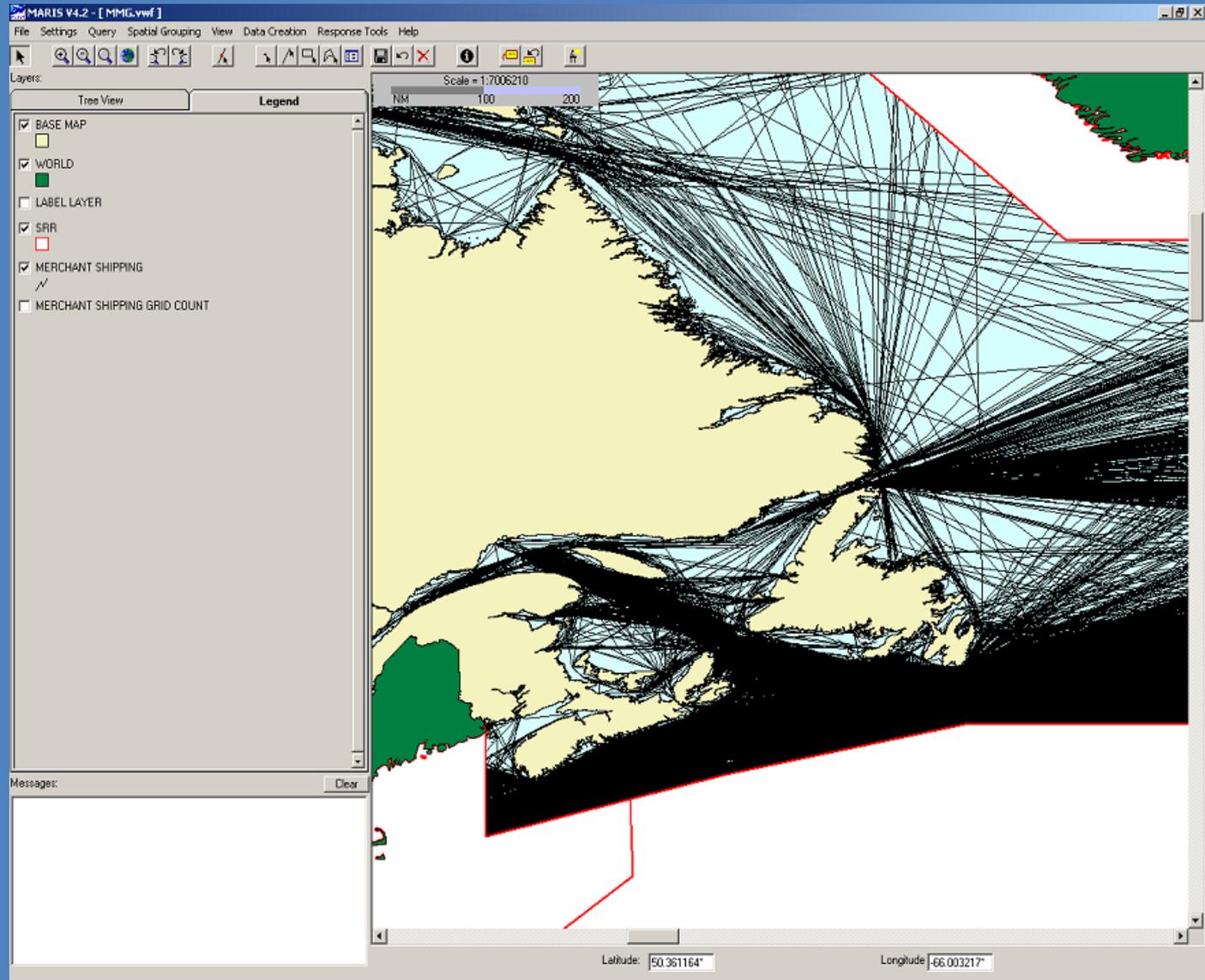
Direct Connection Results



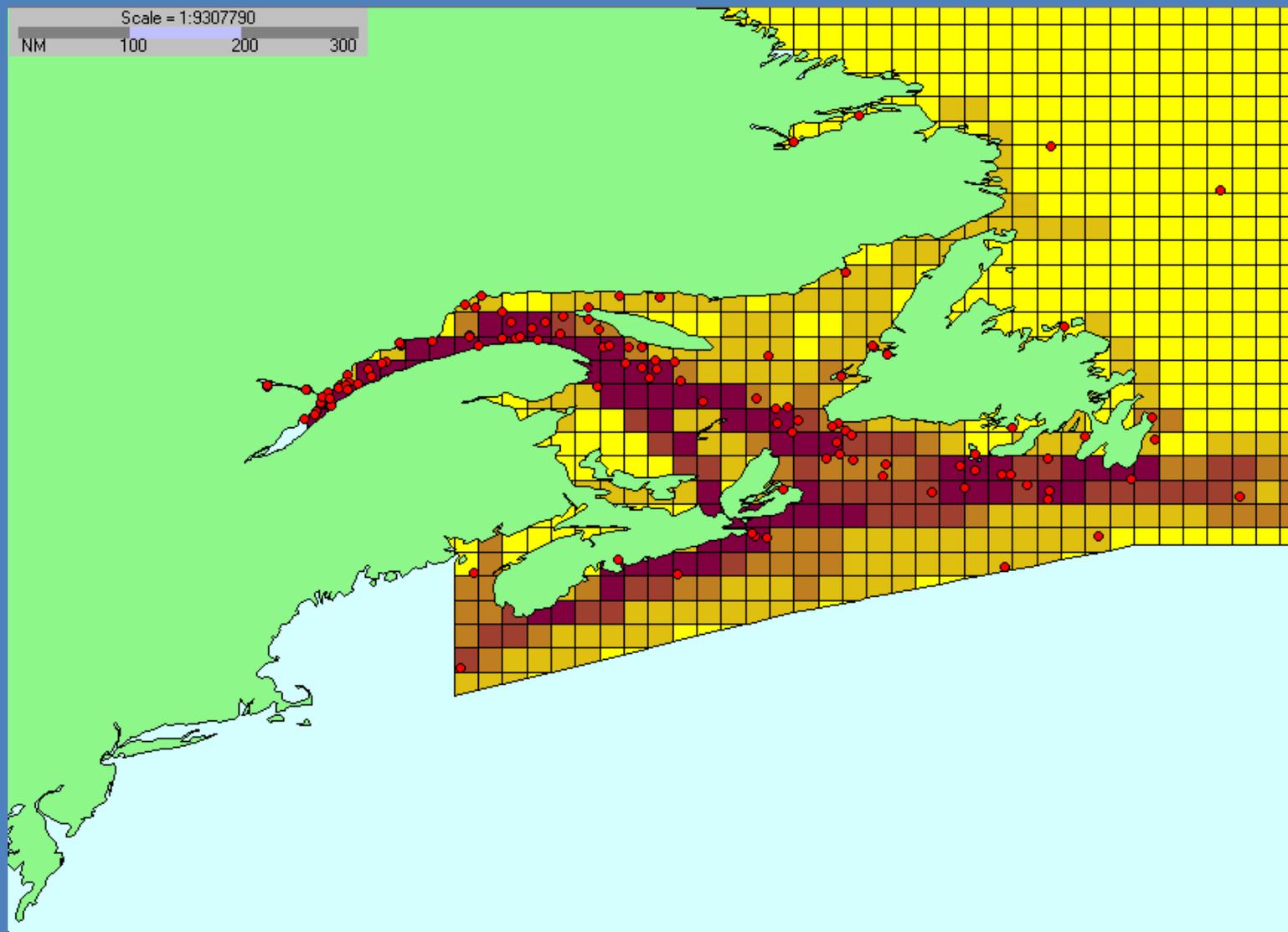
Land avoidance path



East Coast Merchant Shipping



Merchant Shipping Incidents vs traffic



Data proliferation

- Sources
 - Transmission from ship
 - Airborne surveillance
 - Satellite surveillance
 - Coastal sensors
- Challenges
 - Amount of data
 - Reconciling different sources
 - Detecting unusual events
 - Storing info for multiple purposes

Research issues

- Limitations of each type of sensor
- Data fusion challenges
- Establishing baseline “typical” traffic patterns (Recognized Maritime Picture – RMP)
- Detecting and categorizing anomalous behaviour
- Process new information sources to maximize use Coastal Safety: AIS, LRIT, HITS

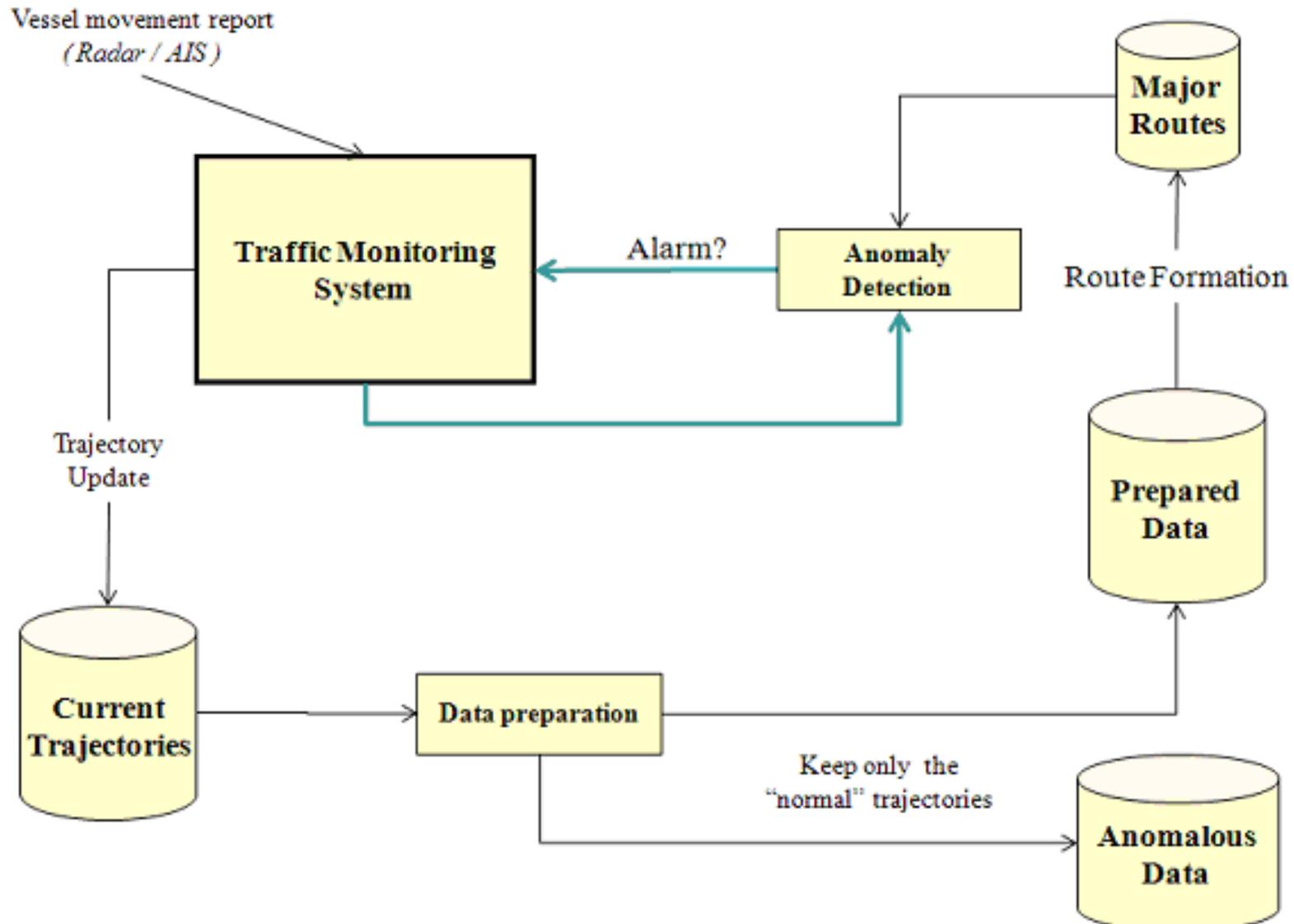
Research issues (cont'd)

- Small Boat Detection
- Resource Location models (SAR)
- Risk Modelling
 - Prioritize threats/hazards
 - Identify hot spots
 - Allocate resources optimally to achieve the best overall risk reduction
 - Can be used for prevention and/or response

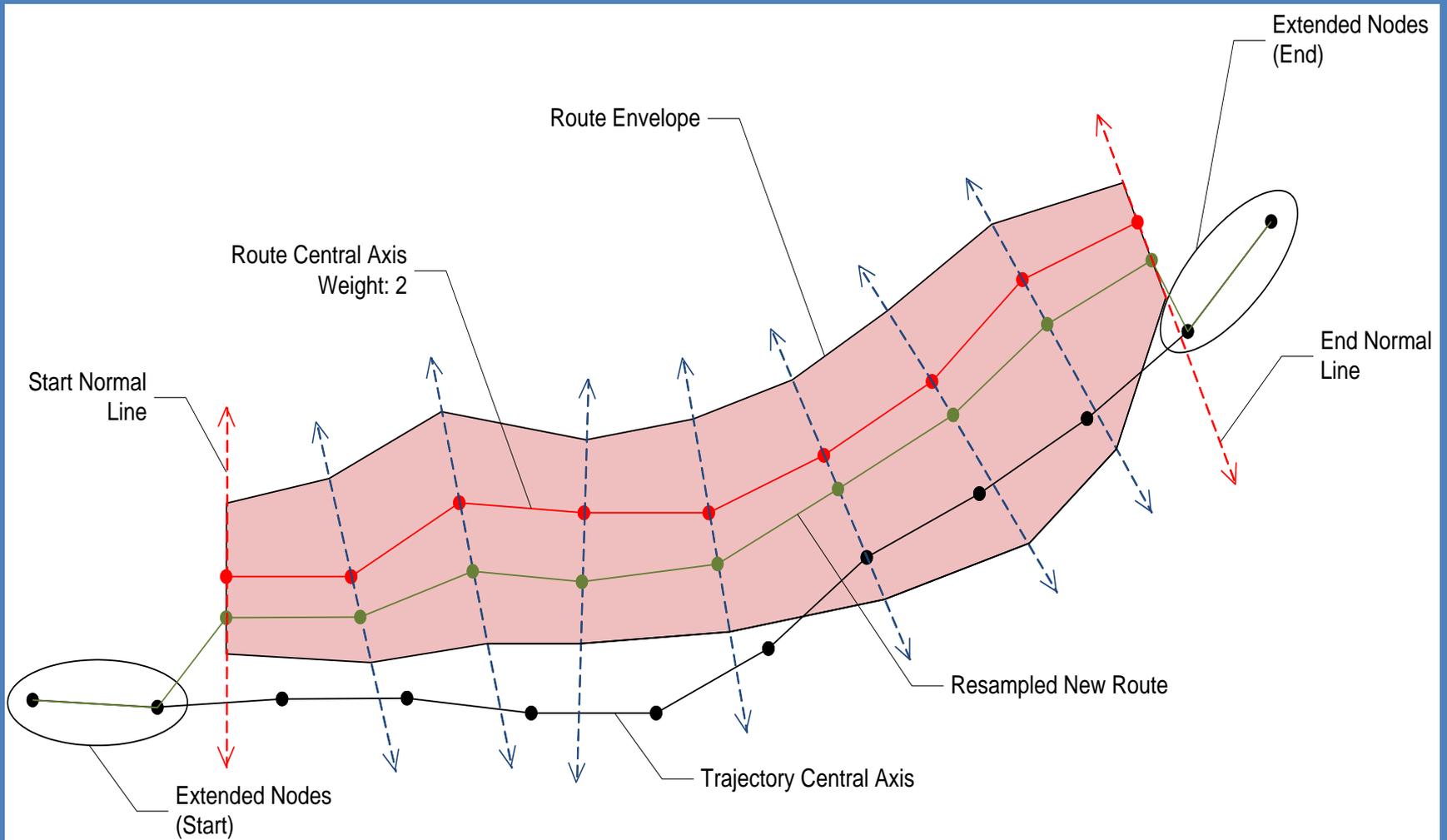
Example 1

Abnormal ship trajectories

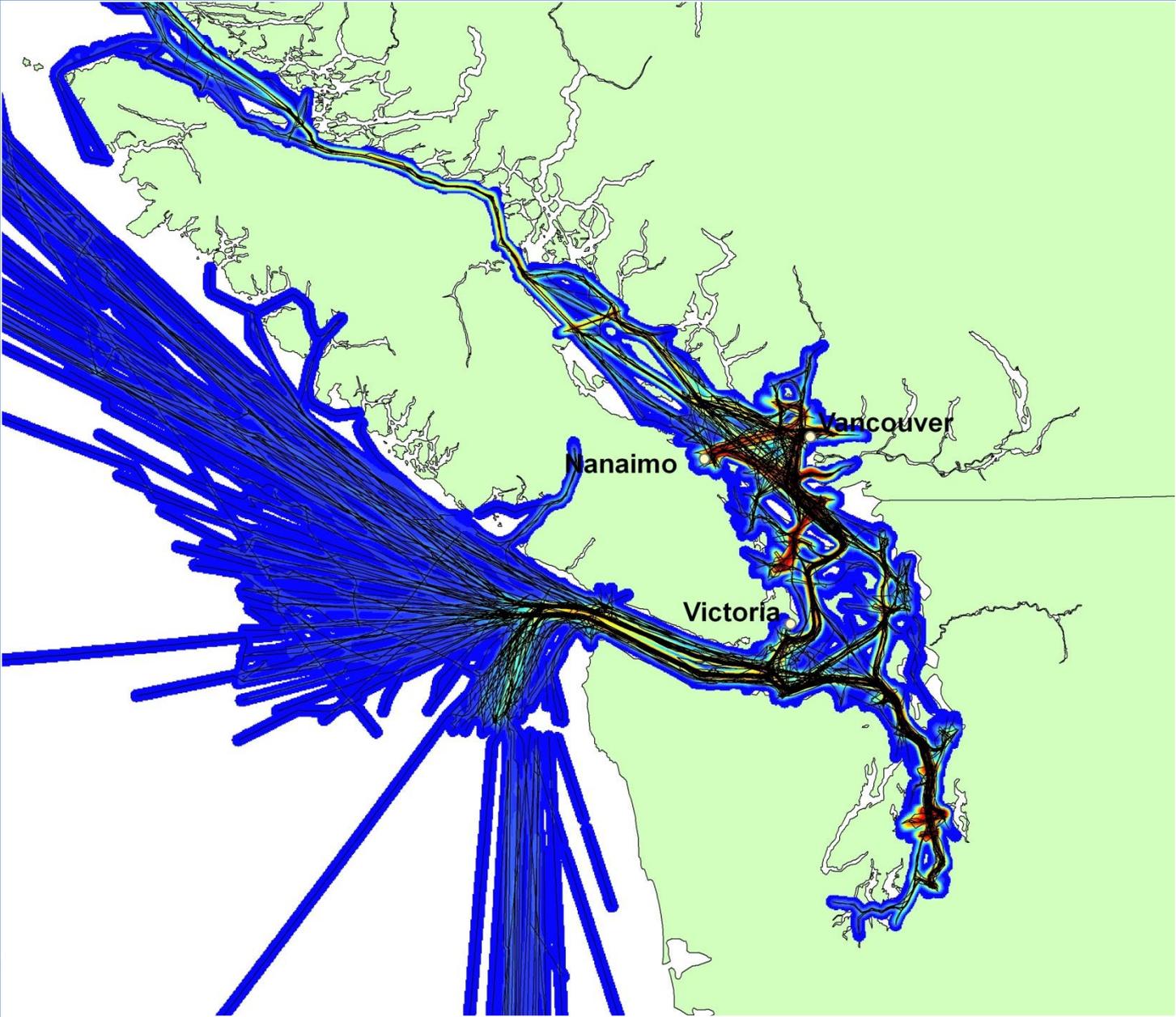
Traffic Monitoring System



Route-Trajectory Updating



West Coast shipping: typical route identification



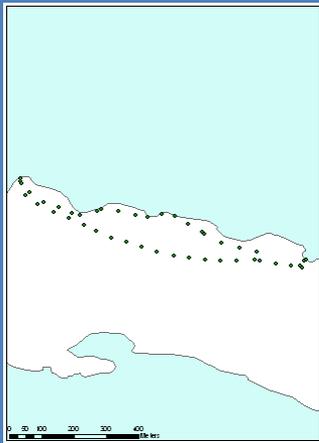
Two individual atypical trajectories



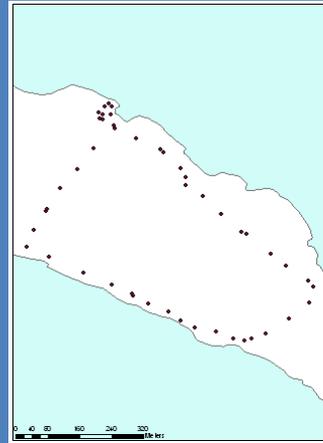
Example 2

Discriminating recreational boat types

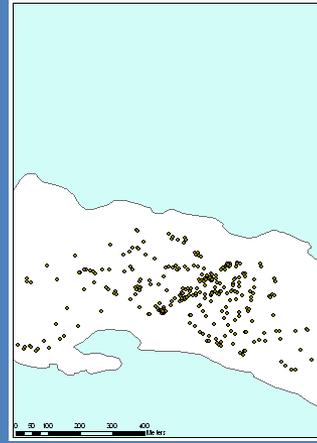
Characterizing Recreational Boating Patterns based on GPS Trajectory Point



(a) Trajectory 1



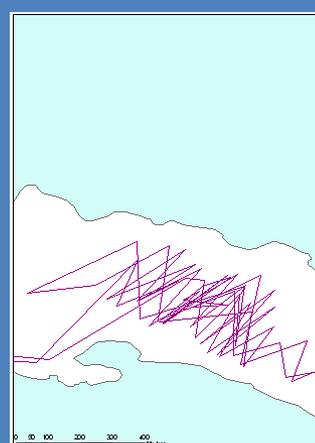
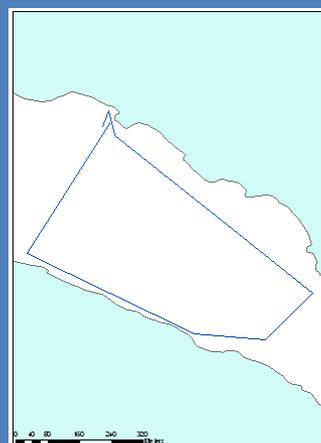
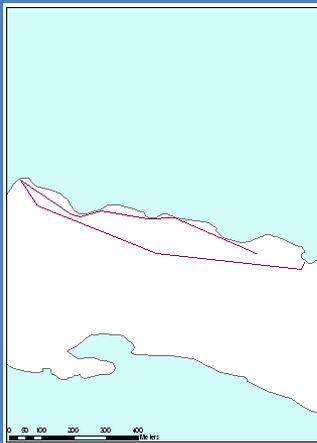
(b) Trajectory 2



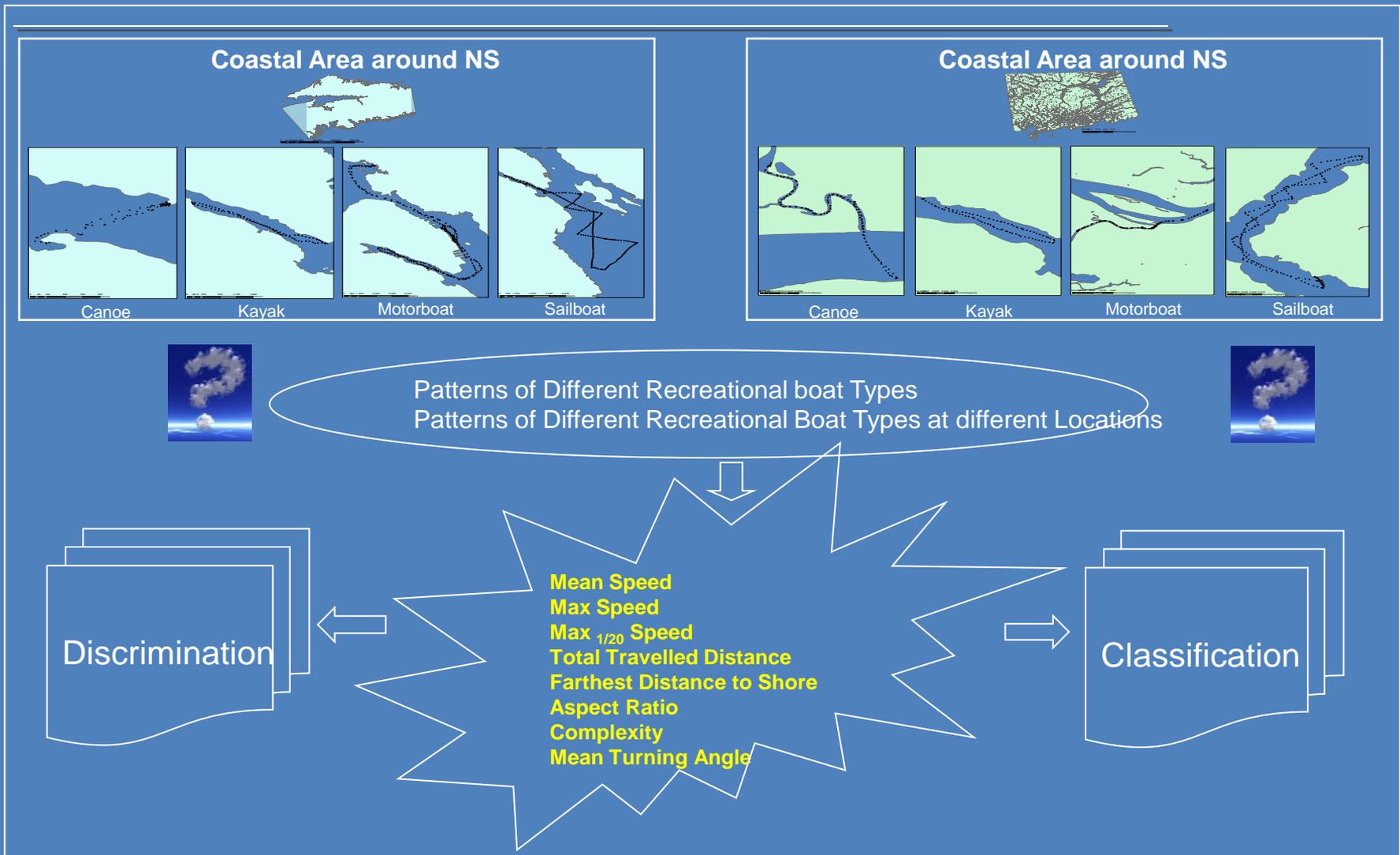
(c) Trajectory 3



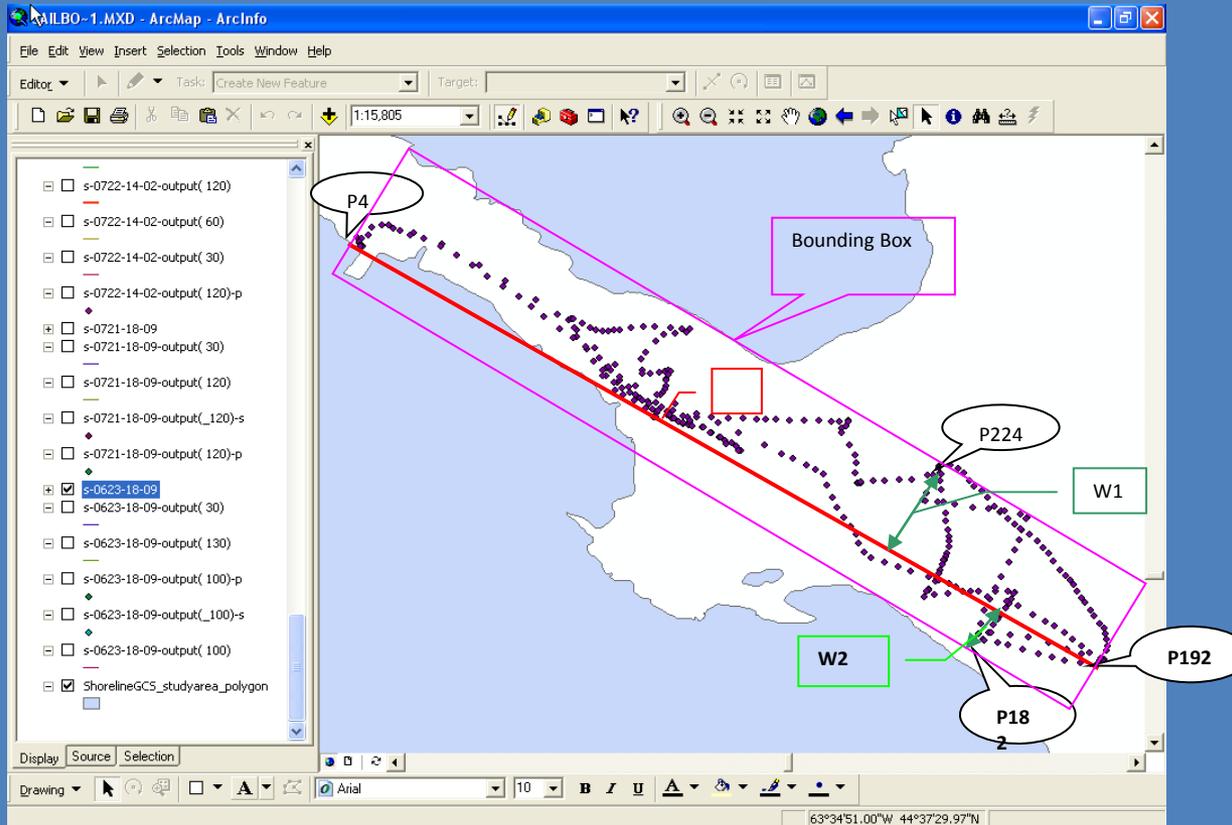
(d) Trajectory 4



Boat classification by movement

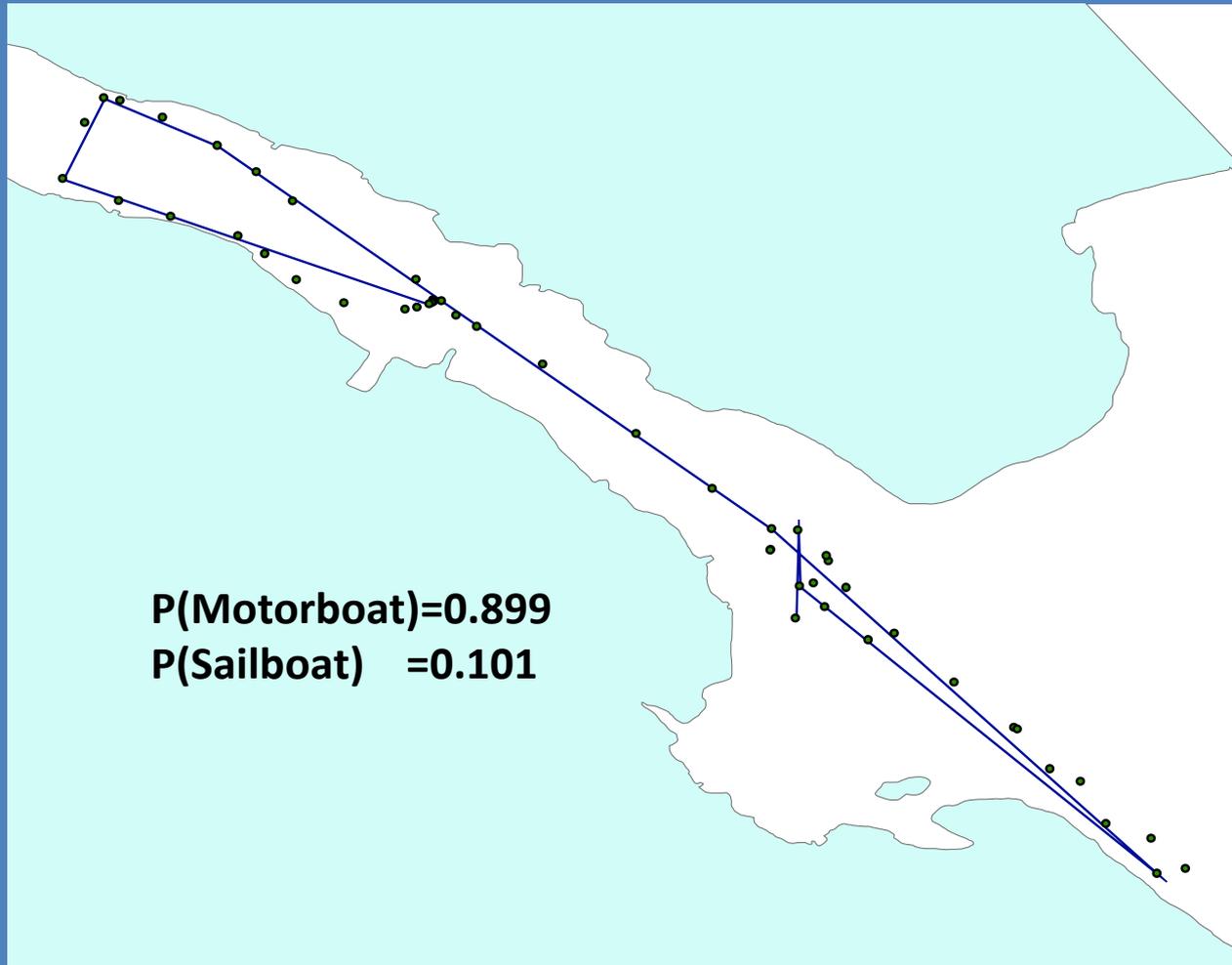


Pattern analysis



- Aspect Ratio: Width of Bounding Box/Length of Bounding box
- Coverage Index: Perimeter of Bounding box/Total Distance

Vessel classification



Classification Results from Coastal Data

•Stepwise Computational Classification

$$\text{Canoe} = -6.878 + 3.066MS + 0.125MTA + 0.0002739DFS$$

$$\text{Kayak} = -5.624 + 3.183MS + 0.104MTA + 0.0002293DFS$$

$$\text{Motorboat} = -27.071 + 9.611MS + 0.192MTA + 0.0002997DFS$$

$$\text{Sailboat} = -13.720 + 5.293MS + 0.178MTA + 0.001683DFS$$

	Predicted Group Membership				Total
TYPE	canoe	kayak	motorboat	sailboat	
canoe	94.1	5.9	0.0	0.0	100.0
kayak	33.3	61.9	0.0	4.8	100.0
motorboat	20.0	0.0	80.0	0.0	100.0
sailboat	4.3	2.1	2.1	91.5	100.0

* 84.2% of original grouped cases correctly classified



Example 3

SAR Coverage

Station Location Decision

Site Characteristics

Response Characteristics

Calculations

Views

C1 C2 C3

C4 C5 C6

Average Response

Response Distribution

Load Balance

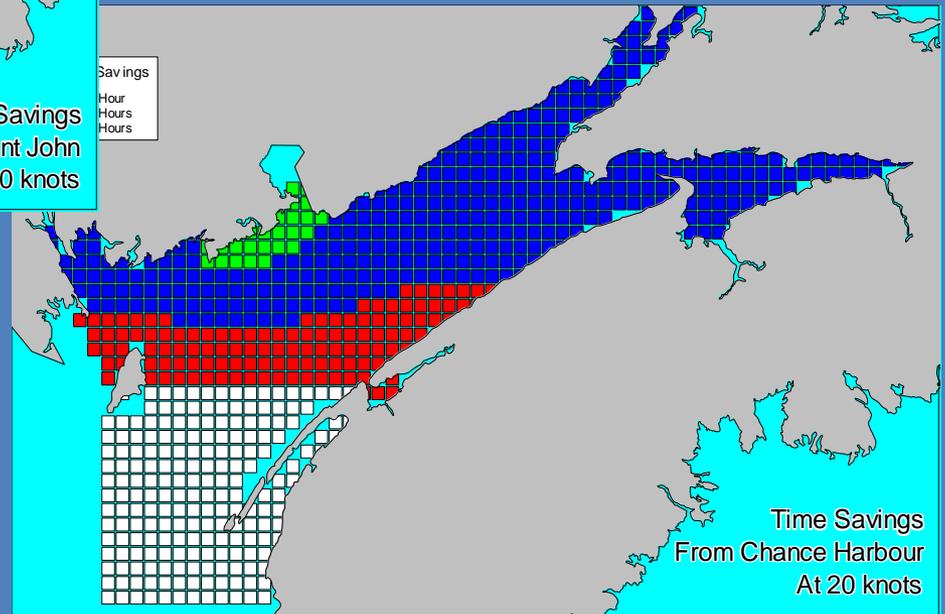
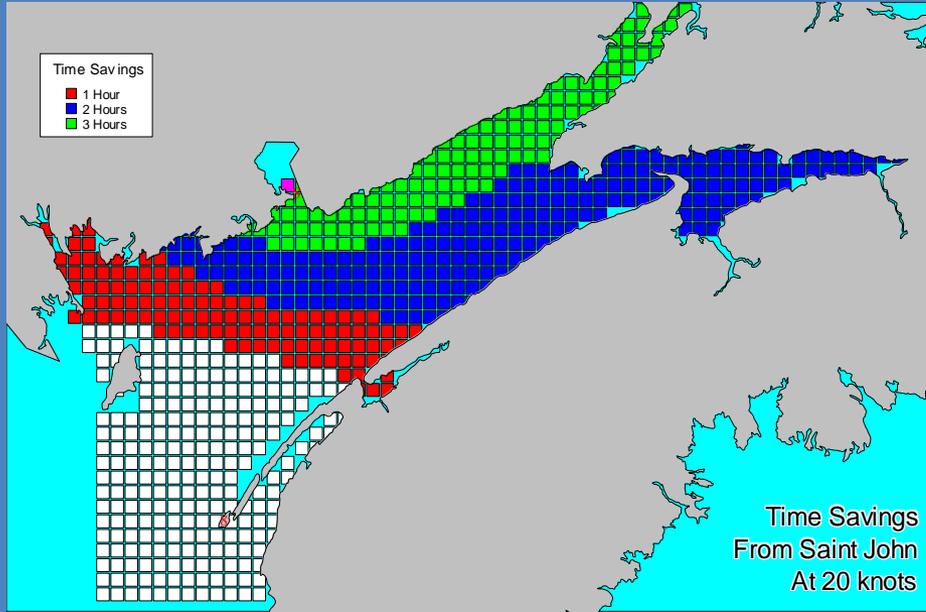
Coverage Balance

Go/No Go

Multiple Attributes



Response Time Improvements

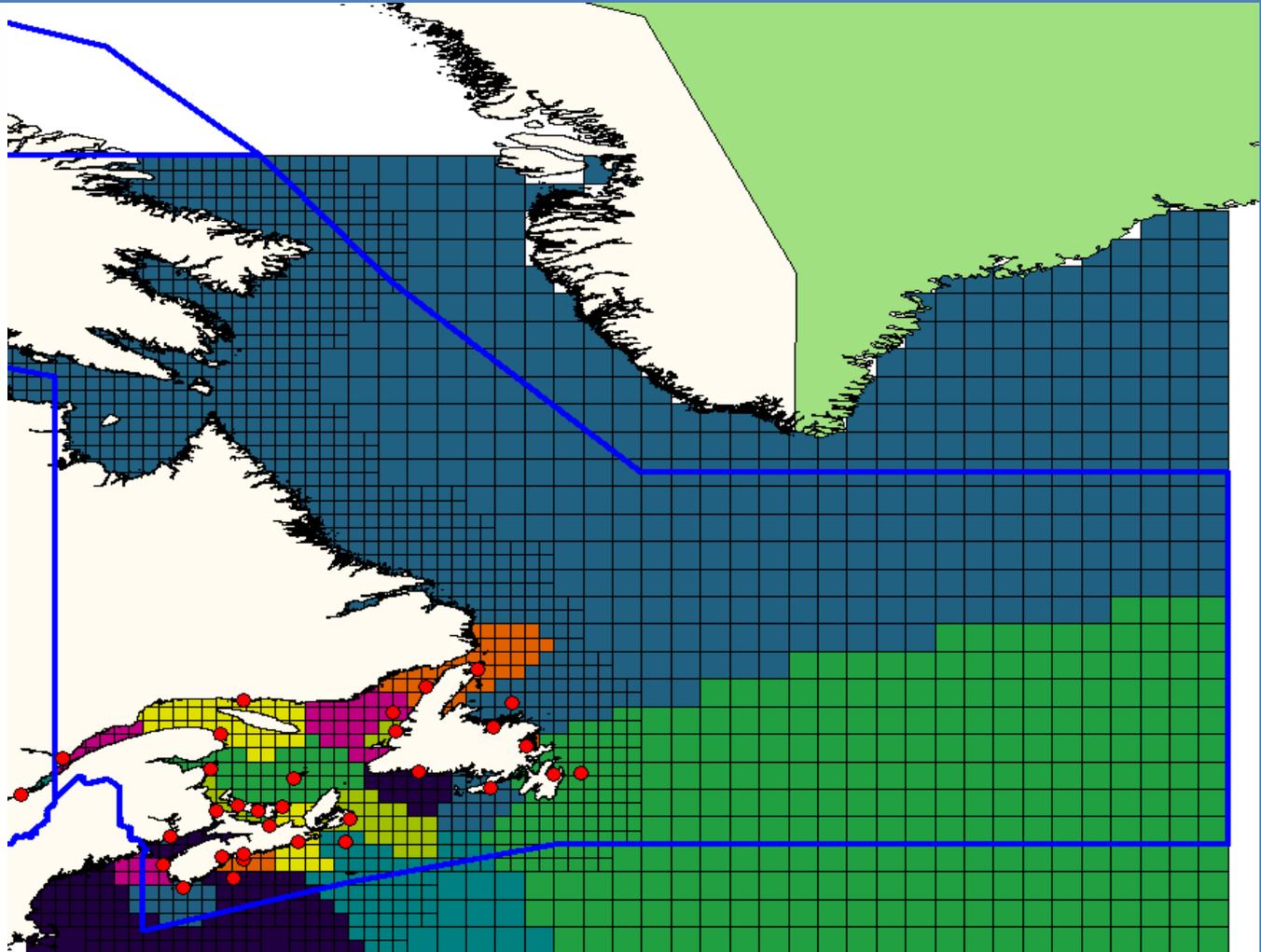


Saint John vs.
Chance Harbour

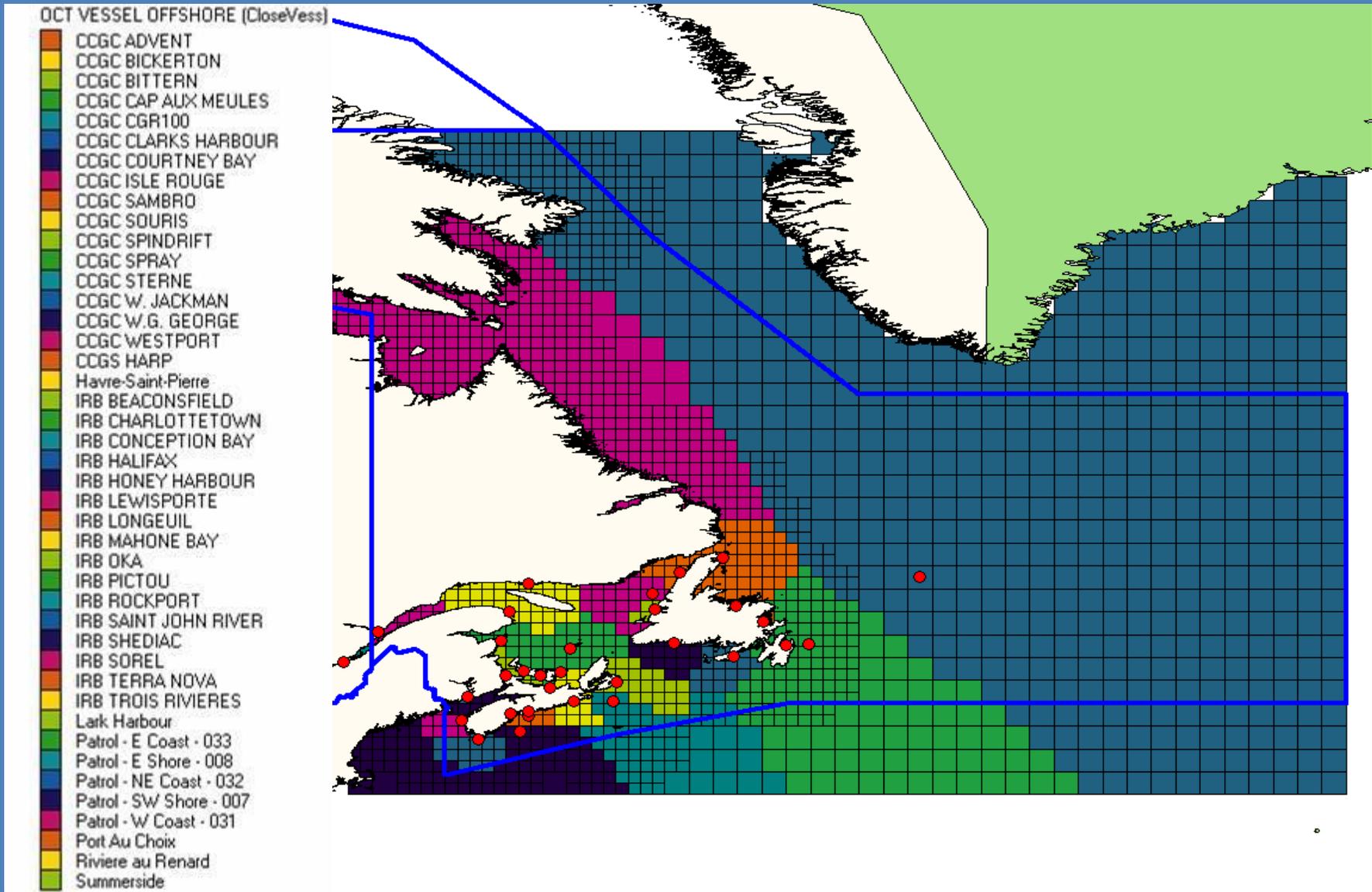
Coast Guard vessel coverage

SRR HOME PORTS (CloseVess)

- CCGC ADVENT
- CCGC BICKERTON
- CCGC BITTERN
- CCGC CAP AUX MEULES
- CCGC CGR100
- CCGC CLARKS HARBOUR
- CCGC COURTNEY BAY
- CCGC ISLE ROUGE
- CCGC SAMBRO
- CCGC SOURIS
- CCGC SPINDRIFT
- CCGC SPRAY
- CCGC STERNE
- CCGC W. JACKMAN
- CCGC W.G. GEORGE
- CCGC WESTPORT
- CCGS HARP
- Havre-Saint-Pierre
- IRB BEACONSFIELD
- IRB CHARLOTTETOWN
- IRB CONCEPTION BAY
- IRB HALIFAX
- IRB HONEY HARBOUR
- IRB LEWISPORTE
- IRB LONGEUIL
- IRB MAHONE BAY
- IRB OKA
- IRB PICTOU
- IRB ROCKPORT
- IRB SAINT JOHN RIVER
- IRB SHEDIAC
- IRB SOREL
- IRB TERRA NOVA
- IRB TROIS RIVIERES
- Lark Harbour
- Patrol - E Coast - 033
- Patrol - E Shore - 008
- Patrol - NE Coast - 032
- Patrol - SW Shore - 007
- Patrol - W Coast - 031
- Port Au Choix
- Riviere au Renard
- Summerside



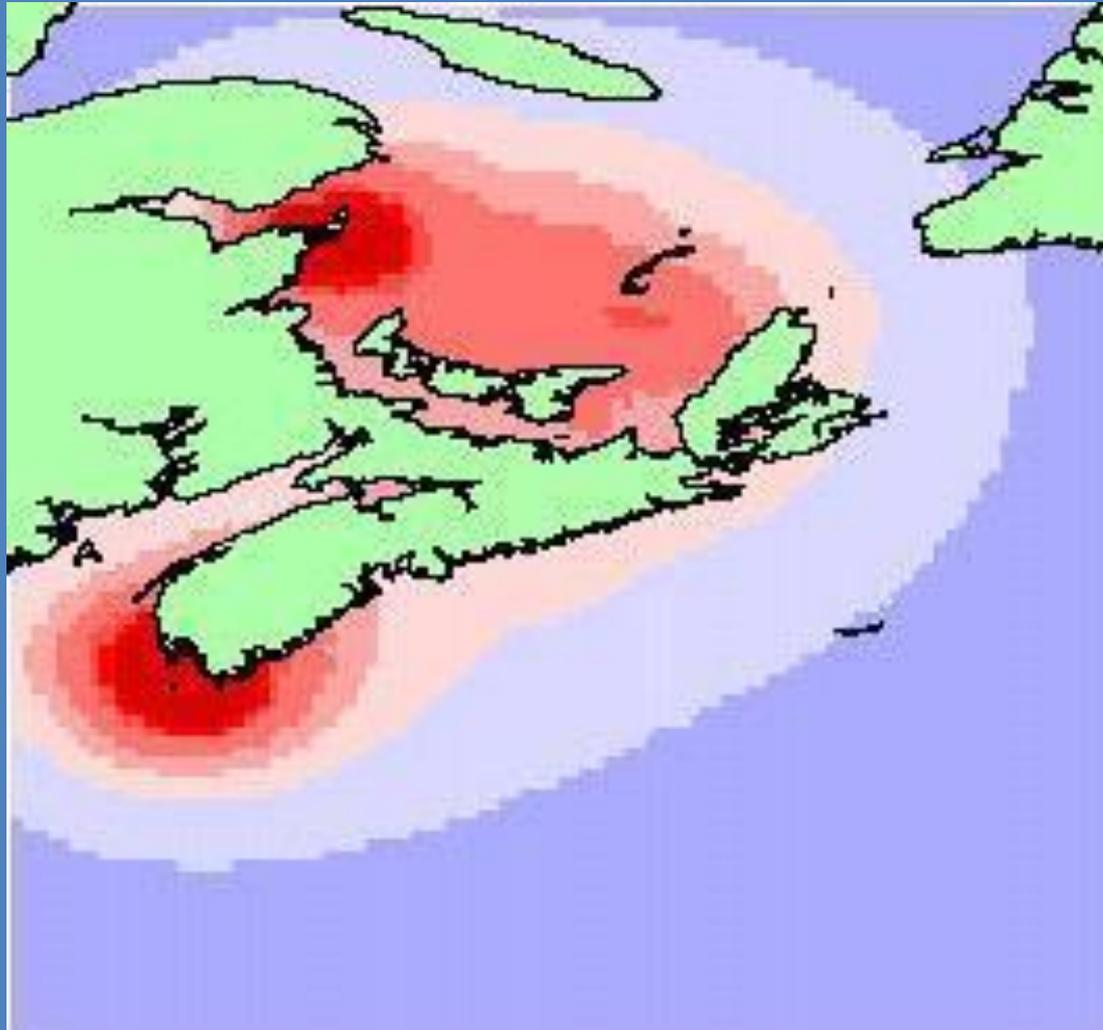
Effect of moving lifeboats



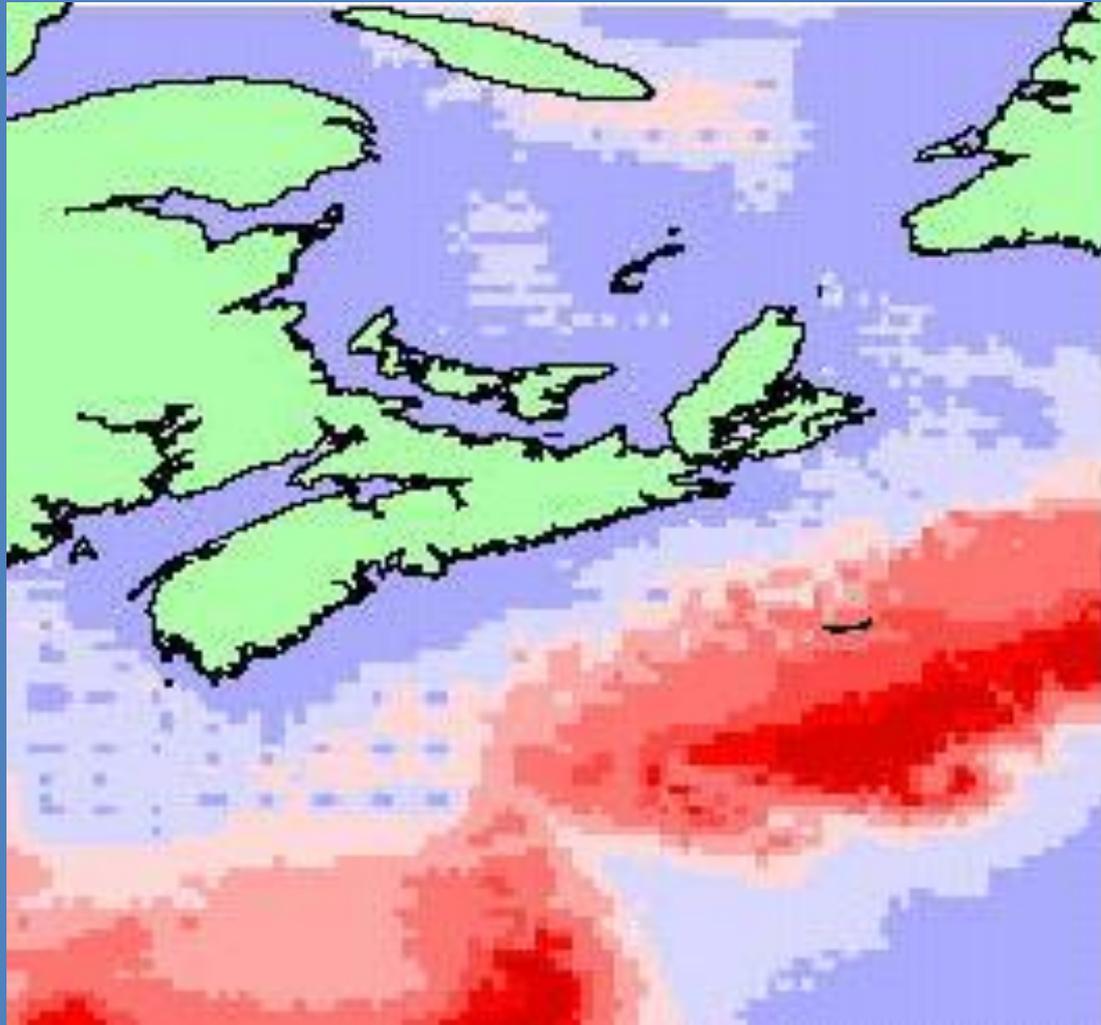
Example 4

Fishing incident characterization

Fishing Incidents Density



Fishing Incident Rate Distribution



Example 5

How are the incident rates related to weather conditions?



Results

2 of these 6 factors are related to **incident severity**

Wave Height (m)

Ice Concentration (%)

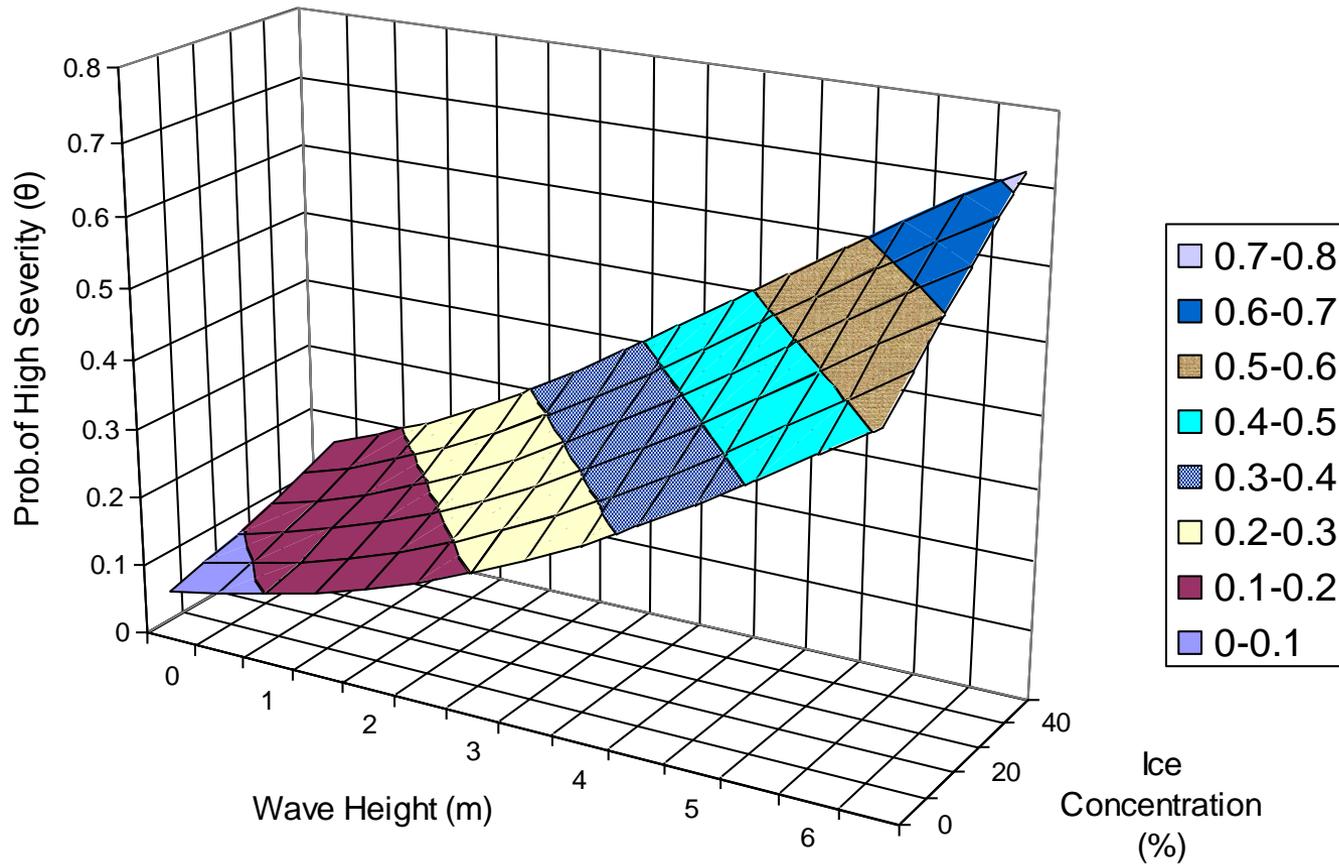
Air Temperature (°C)

Amount of Precipitation (mm/day)

Sea Surface Temperature (°C)

Fog Existence Indicator

Sensitivity Analysis of Logistic Regression Model



MARIN – Current activities

- Maritime Traffic Pattern Analysis for Coastal Protection
- Boating Safety for Anglers & Hunters: a Survey of Perceptions and Practices
- Oil in Canadian Waters: Assessing Oil Pollution, Commercial Shipping and Ecological Impacts on Canada's Three Coasts
- Sensor Interaction for Small Ship Tracking and Awareness in Harbour – A study of the value of using sensors together



MARIN – Current activities (cont'd)

- PIRACY (Policy Development and Interdisciplinary Research for Actions on Coastal Communities, Youth and Seafarers)
- Multi-Criteria Decision Making Framework and Risk model for Carbon Capture & Storage (CCS)
- A Multi-Disciplinary Approach to Risk Governance: Best Practices, Workshops and Online Training
- Factors affecting seaplane crash survival
- Traffic modelling for risk-based hydrographic survey prioritization



