Predicting the probability of encounter between fish species and tidal stream energy devices using acoustic telemetry

Charles W. Bangley, Daniel J. Hasselman, Joanna Mills Flemming, Frederick Whoriskey, Michael Stokesbury, Joseph Beland, Rod Bradford, and Brian G. Sanderson

force | Fundy Ocean Research Centre for Energy
ACADIA UNIVERSITY
OCEAN TRACKING NETWORK
Fisheries and Oceans Canada

Minas Passage

Risk Assessment Program (RAP)

RAP Objectives

- Build and test species distribution and encounter rate models
- Enhance understanding of fish distribution and behaviour within Minas Passage
- Build tools to support science-based decision making for tidal projects

RISK ASSESSMENT PROGRAM
FOR TIDAL STREAM ENERGY

Research Objectives

- Identify spatial and seasonal patterns of presence and residency
- Identify relationships between presence and environmental conditions
- Use environmental associations to develop predictive species distribution models within Minas Passage

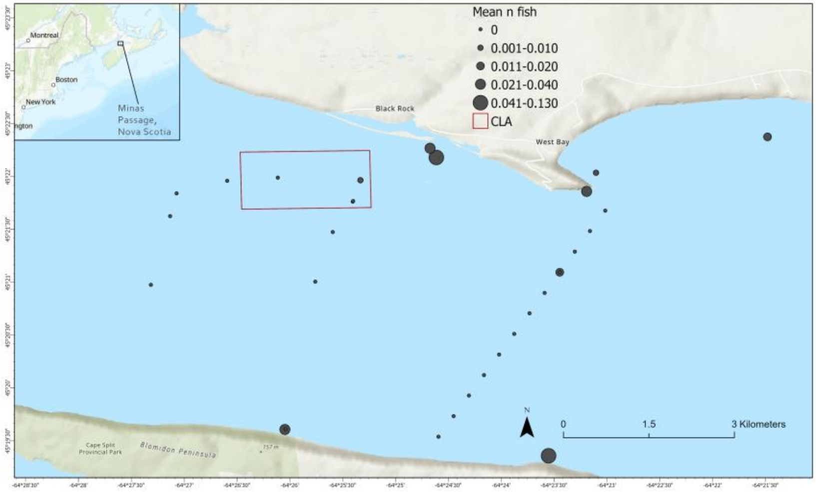
Species of Interest

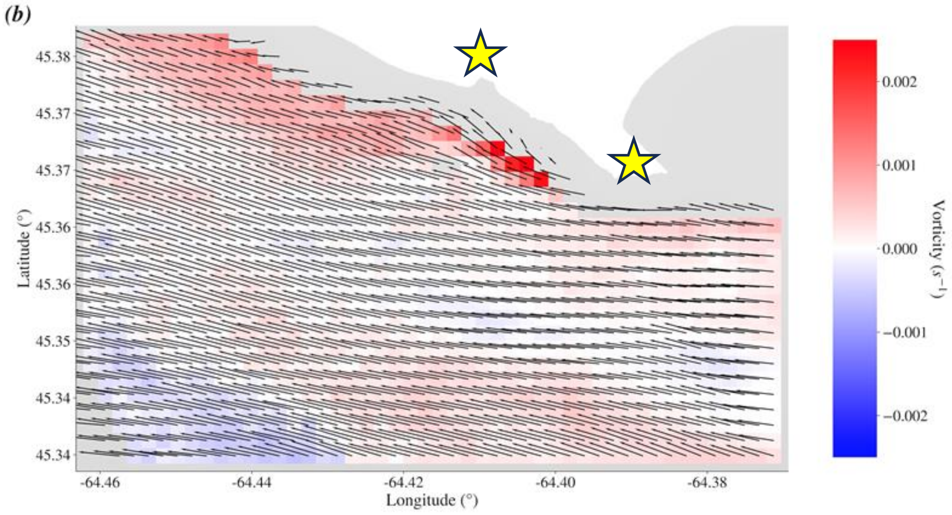
Alewife
American eel
American shad
Atlantic salmon
Atlantic sturgeon
Atlantic tomcod
Spiny dogfish
Striped bass
White shark

Methods

Environmental associations using boosted regression tree modeling – 2017-2020 data

- Sea surface height anomaly, current velocity, vorticity, divergence, bathymetry standard deviation – derived from FORCE X-band radar installations
- Temperature - receiver sensors
- Environmental data and presence/absence from tag detections summarized by hour
- Environmental and modeled results grids at 150-m x 150-m resolution



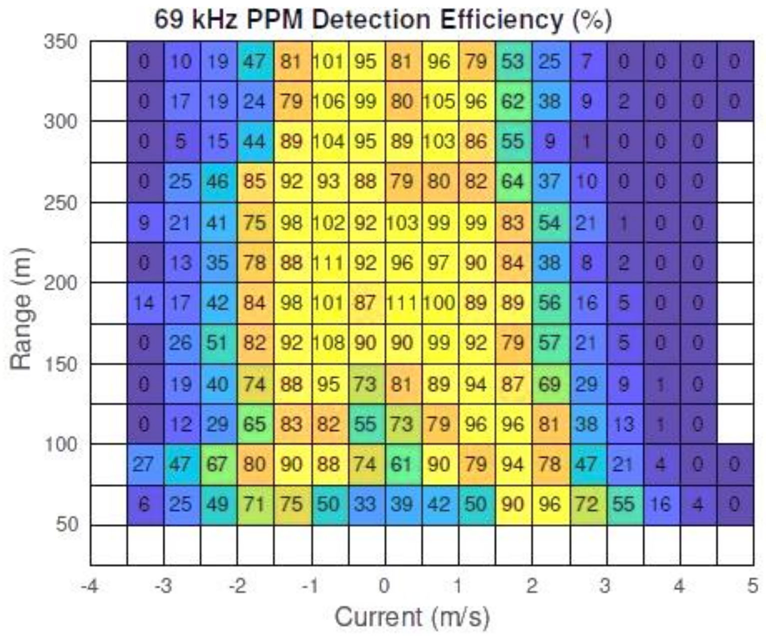


Radar installation

Methods

Accounting for detection efficiency

- 69-kHz ppm tags can have limited detection efficiency at high current speeds
- Range testing in Apr-May 2021 using line of receivers and sentinel tags over full tide cycle
- Scaled mapped model presence probability to reflect probability of presence given probability of detection – based on MacKenzie et al. 2002
- Weights observations made during poor conditions



Probability of presence given probability of missing detection

Probability of absence given probability of missing detection

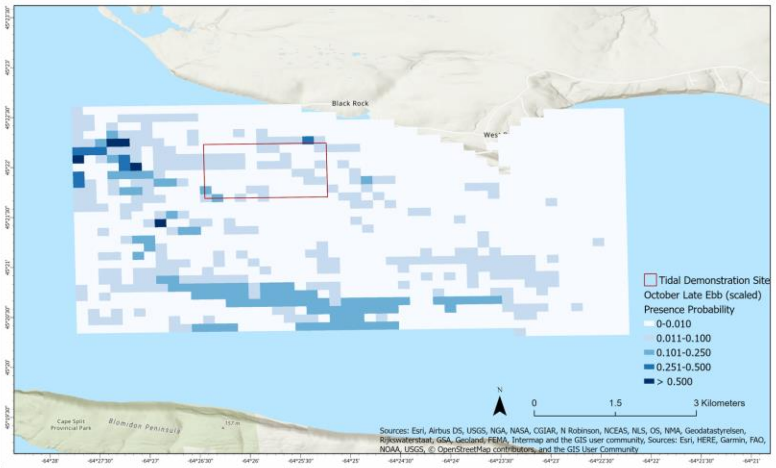
$$(p \times (1 - d)) \times (d(1 - p) + (1 - d))$$

Methods

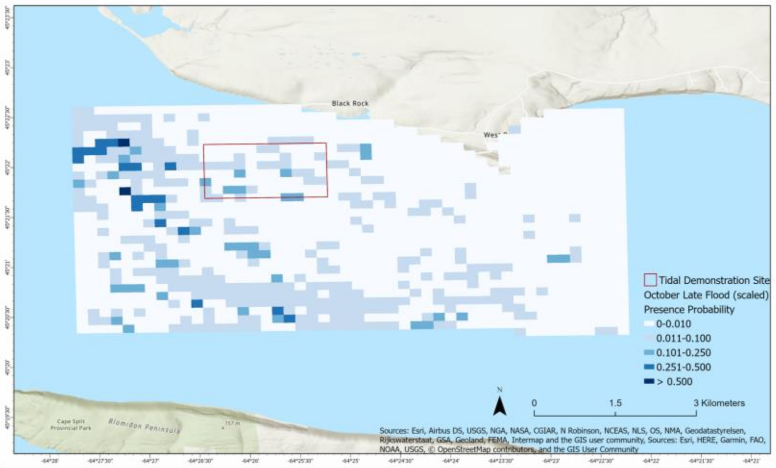
Model validation

- Model metrics compared between runs using 2017-2020 data and including 2021-2022 data
    - Cross-validation, area under curve (AUC), % deviance explained
- Predictions run against mapped 2021 data
- Scaled and unscaled mapped results compared – percentile of predicted presence probability

A



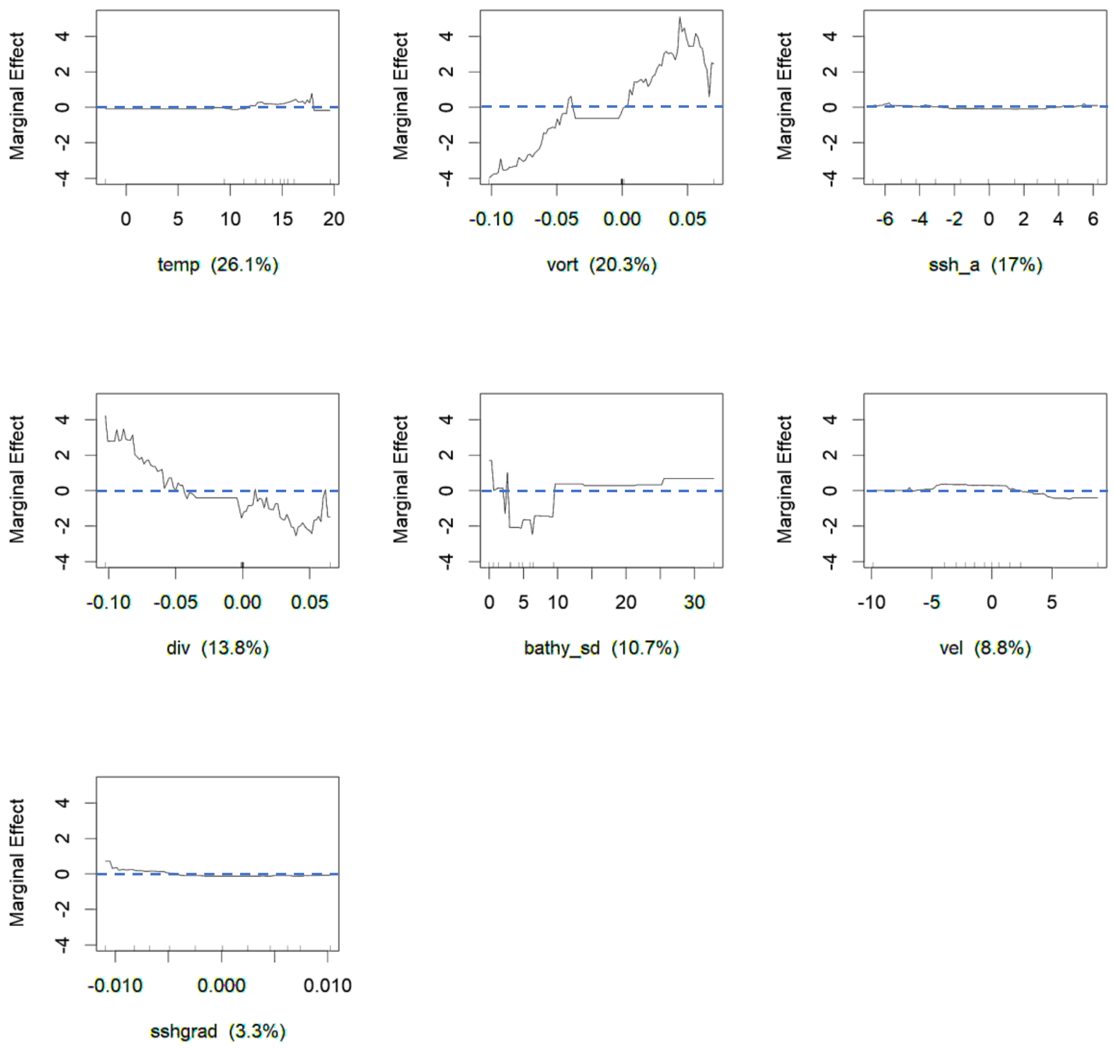
B



Results

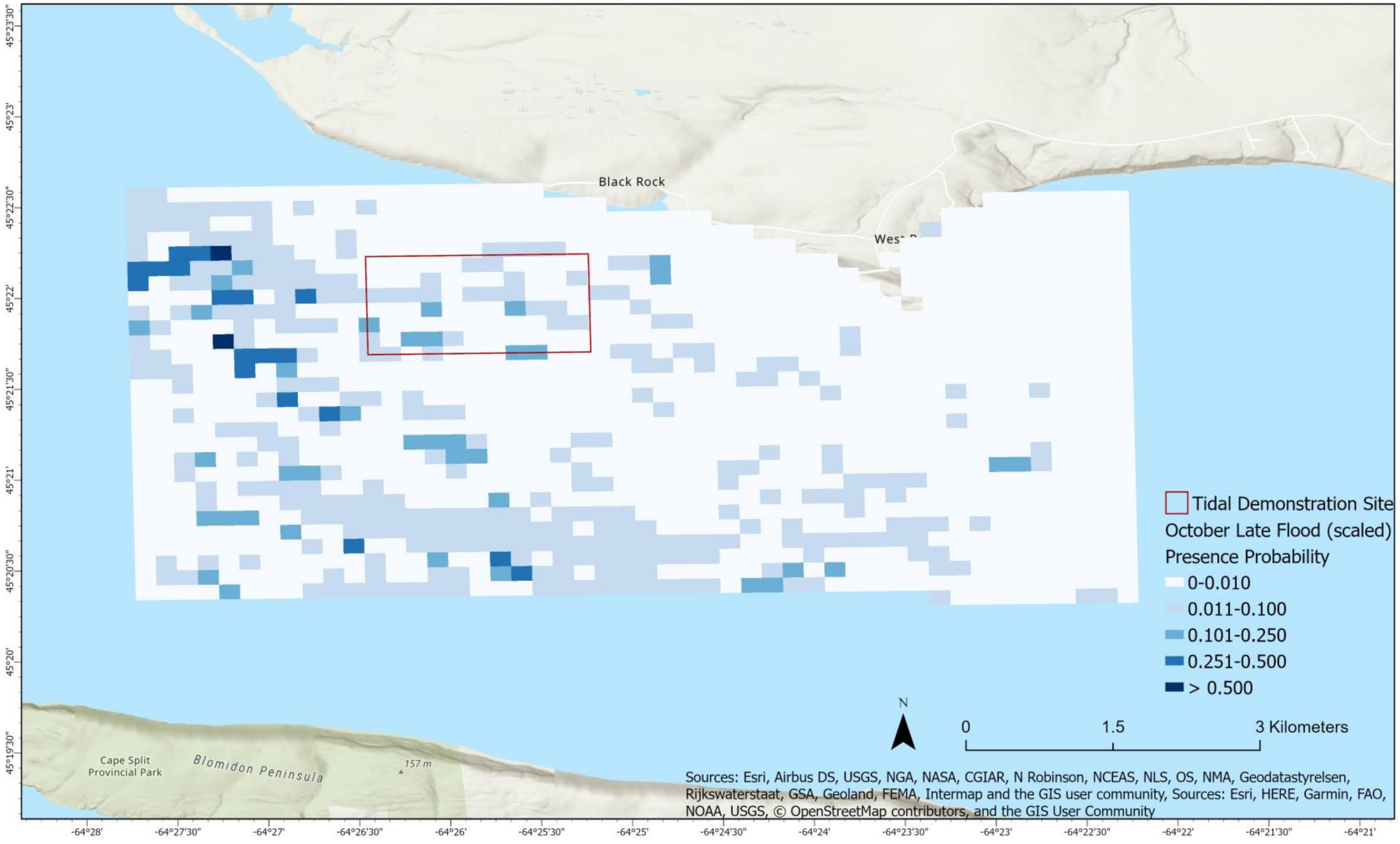
Marginal effect plots

- Temperature 12-17 °C
- Relatively active water
- Sea surface high associated with higher/lower tide stages



Results

Mapped results



Results

Model parameter and metric comparison

Model	2017-2020	2017-2022
Learning rate (lr)	0.05	0.05
Bag fraction (bf)	0.6	0.5
Tree complexity (tc)	7	7
N trees	1950	4850
Training correlation	0.69	0.78
Training AUC	0.99	0.99
Cross-validation AUC	0.97	0.97
Overfitting (training-CV AUC)	0.02	0.02
% False positive	6.6	4.1
% False negative	5.4	3.7
% Deviance explained	62.4	70.44

Results

Modeled and scaled probability comparison

* = significant at 0.05

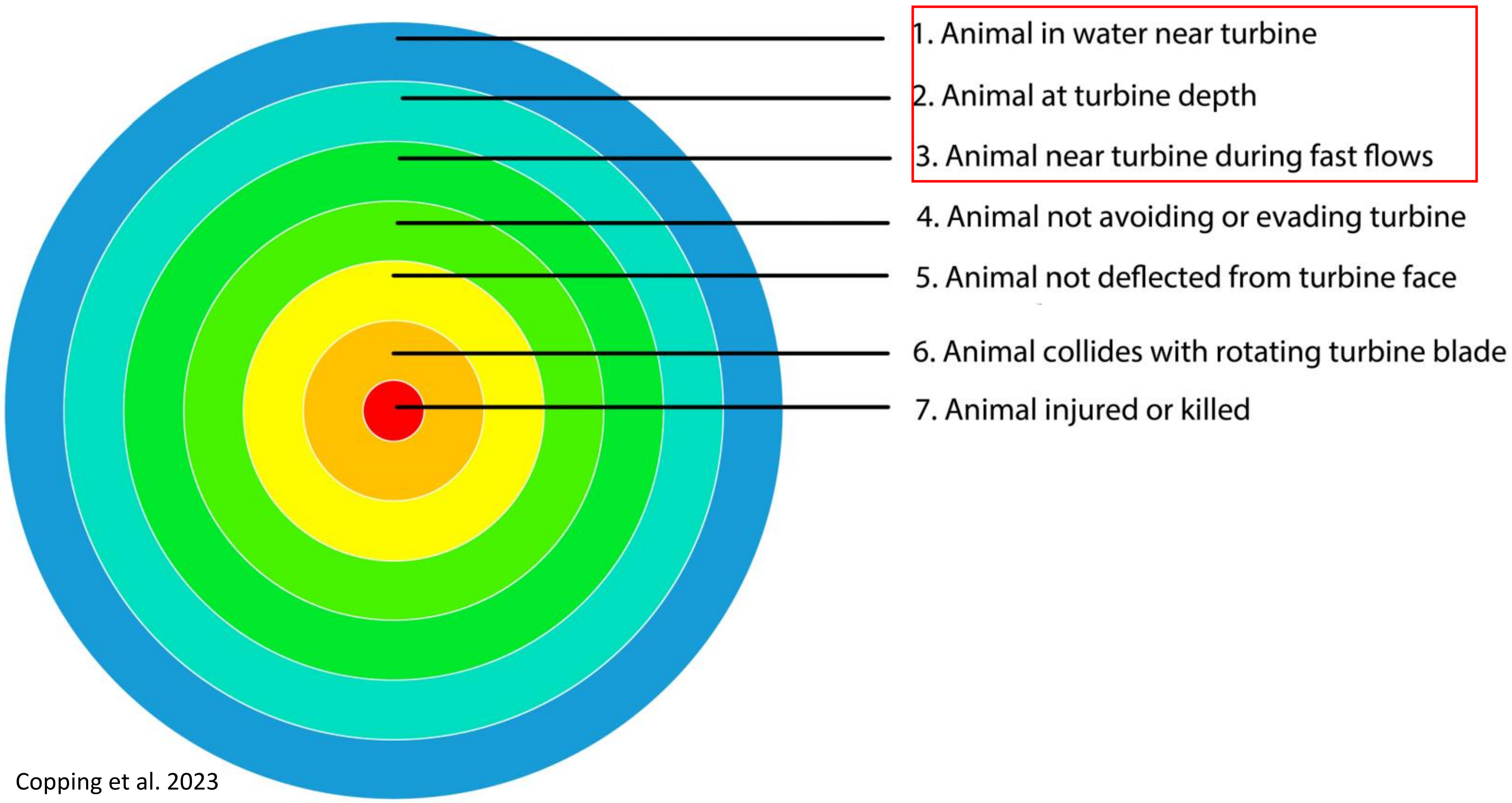
Conclusions

Model performance and validation

- Base model (2017-2020 data) performs well
- Performance improves by including 2021-2022 data
- Scaling function seems to improve predictive performance during flood tide

Conclusions

FORCE RAP SDM can provide accurate estimates for at least first three layers of collision risk



Copping et al. 2023

Acknowledgements

Project team

force

MI'KMAW CONSERVATION GROUP
THE CONFEDERACY OF MAINLAND MI'KMAQ

PROJECTABLE CONSULTING

OCEAN TRACKING NETWORK

marine renewables canada

ACADIA UNIVERSITY

Project support

22 data contributors for nine species

Fisheries and Oceans Canada

Local fishers

DALHOUSIE UNIVERSITY

Natural Resources Canada / Ressources naturelles Canada

Canada

Questions?