Using an Agent-Based Model to Estimate Effects of EMF Exposure from Offshore Wind Infrastructure on Benthic Marine Organisms

Daniel Dawson, Damian Preziosi, Conner Schultz, Robert Pastorok, *Integral Consulting Inc.*

5.13.P-Mo-209

A methodology to relate EMF exposure to potential ecologically meaningful effects

Offshore wind infrastructure generates electric and magnetic fields (EMF) that may affect benthic organisms nearby.

Potential EMF risks to species are usually assessed using threshold methods comparing project EMF outputs with exposure experiments.

Threshold assessments might be overly conservative, as most observed EMF effects are short-term behavioral changes and potentially not impactful at a population level.

Agent-Based Models (ABMs) to evaluate effects of EMF exposure

Population-level effects can emerge from mechanistic interactions of agents with their environment, and ABMs explicitly model individual agents (e.g., animals, particles) in a population.

For the EMF-sensitive species little skate, previous research[1] suggests EMF exposure increases frequency of large turns and distance traveled, bringing about implications for energetics.

We are developing an ABM to evaluate effects using a sensitive species as a test case: **Little skate (*Leucoraja erinacea*)**.

By modeling bioenergetics, the ABM can link EMF exposure to **biologically meaningful effects.**

Our Agent-Based Model

PLATFORM: NetLogo 3D, v.6.3[2]
WORLD: 200 (w) x 200 (l) x 9 (depth) cells (Fig. 1)
SCALE: ~2.5 m per side of cell, 0.5 km x 0.5 km (0.25 km²)
TIMESTEP: 1 minute

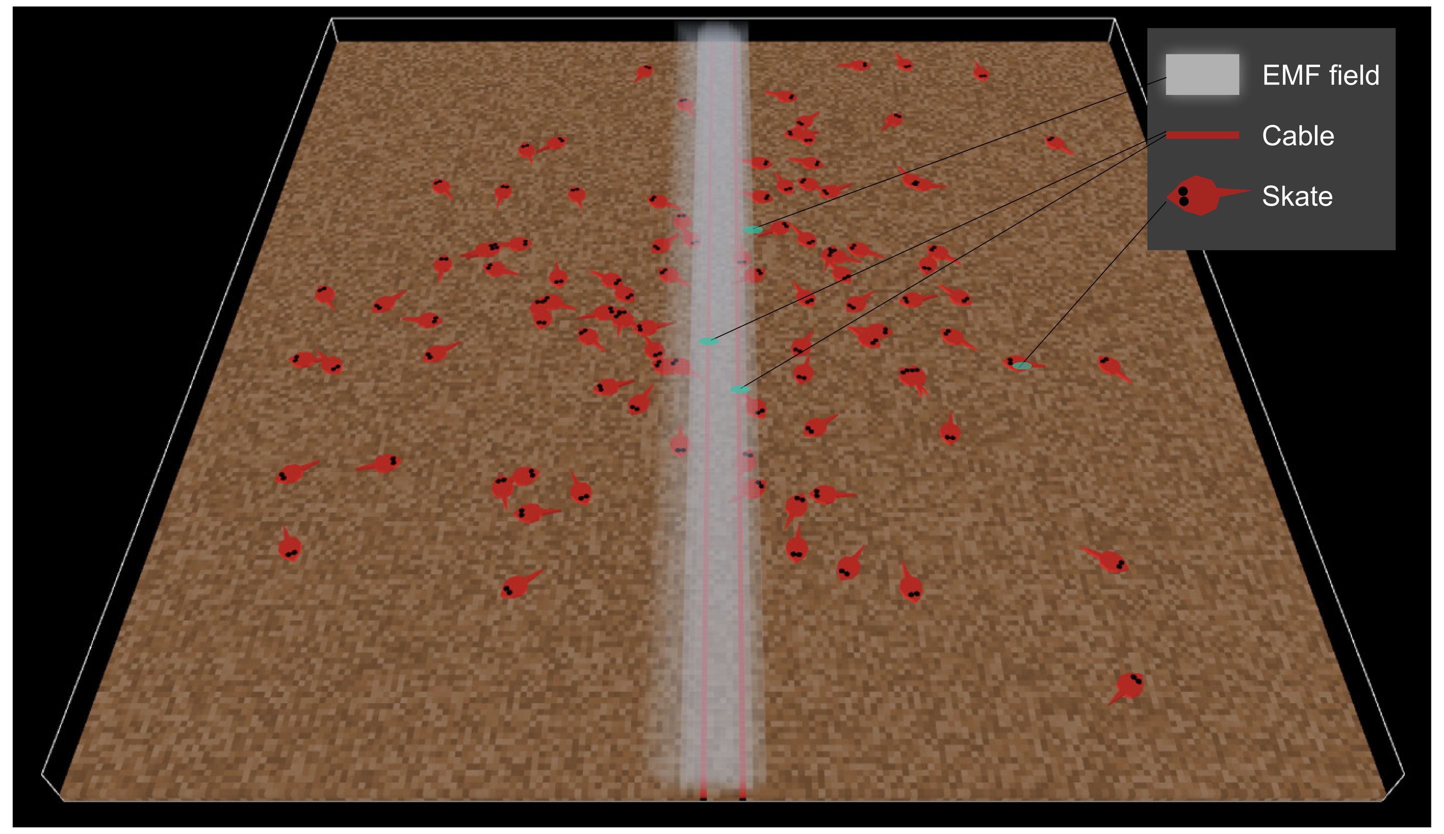
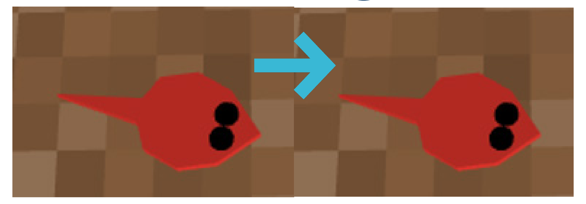


Figure 1. The NetLogo model world. Features include two buried cables (represented by red bars) running along the seafloor, the EMF field (shown as a translucent zone) from the cables, and skates (shown as red fish).

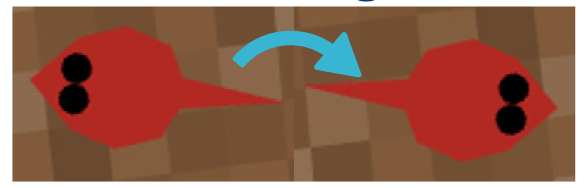
Sub-models

SKATE ACTIVITY: Exploring and resting
SKATE MOVEMENTS[1]
SKATE ENERGETICS: Energy per km/hr traveled[3,4]
EMF: Emitted by two cables buried below seafloor; DC magnetic field flux (mG) using Biot-Savart Law equation[5]
EMF EXPOSURE: Passive uptake of EMF by skates

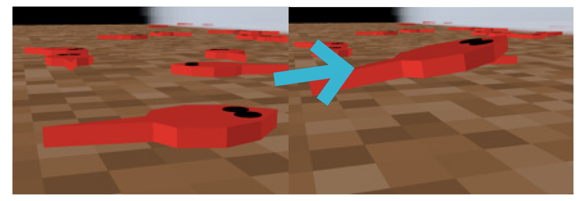
Moving



Turning



Rising/Sinking



Proof-of-concept application

MODEL: Movement frequency and turn frequency are influenced by EMF exposure[1]

HYPOTHESIS: EMF exposure may lead to higher energy usage

METHOD: (I) Simulate skate population movements over 24 hours across multiple cable amperages

(II) Compare energy use, distance traveled, and turn frequency to cumulative exposure

FINDINGS:

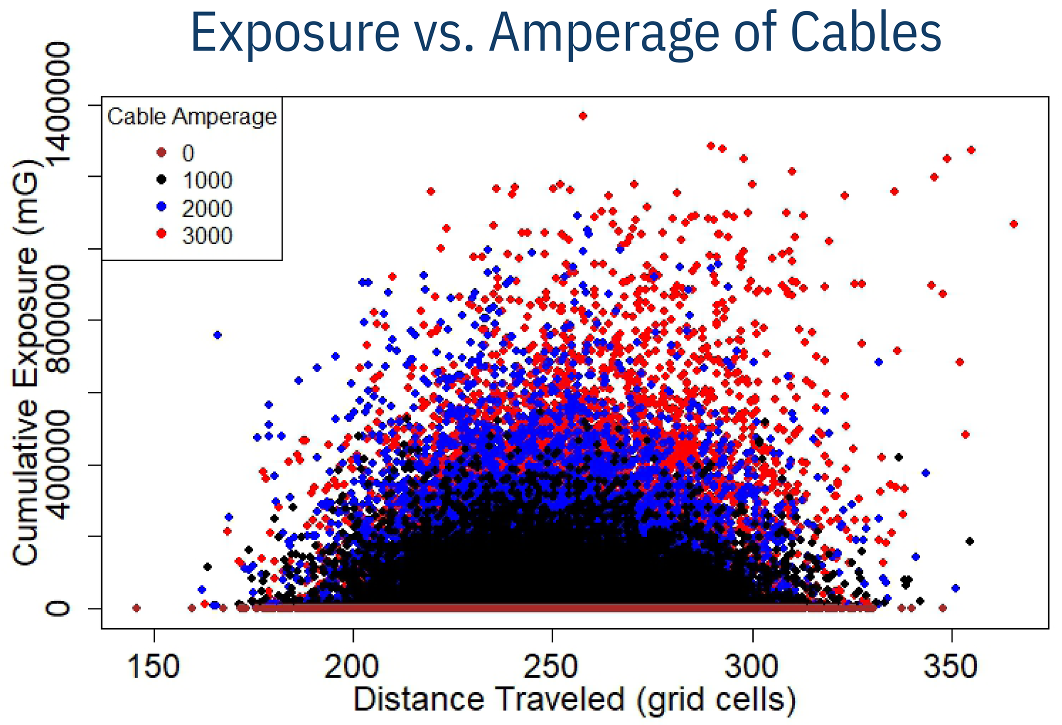


Figure 2. A clear increase in daily cumulative exposure with increase in cable amperage, and slight skew of higher exposure with higher distance. Data from simulations with different amperages are represented by different colors.

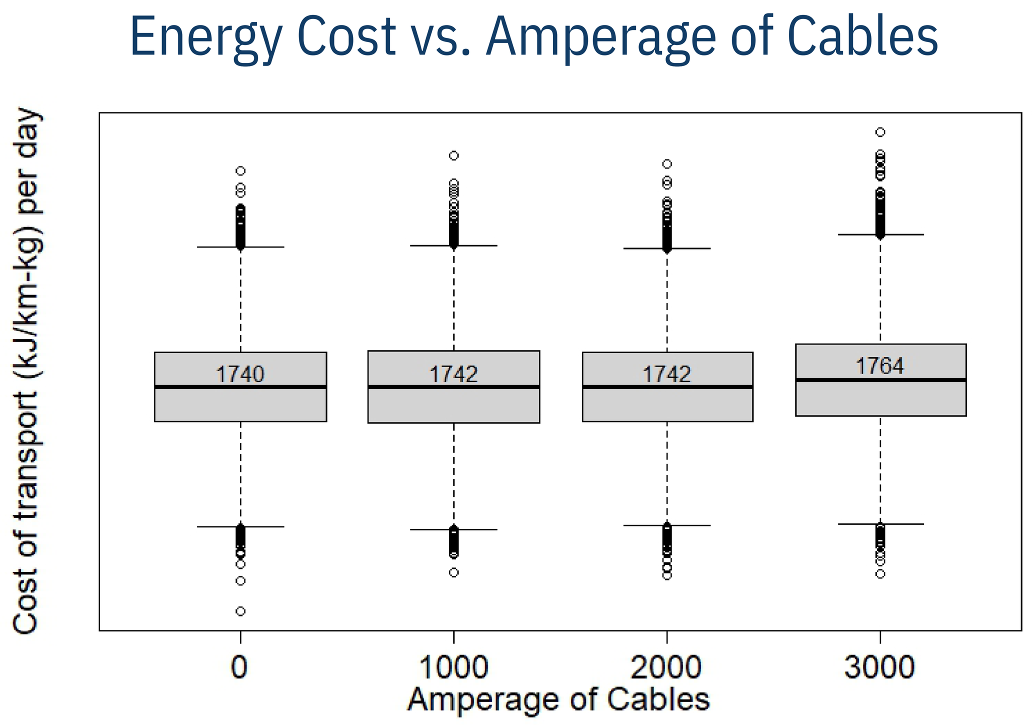


Figure 3. Slight increase in average energy costs (listed) with increasing amperage. This was due to slightly higher mean travel distances with higher exposure due to higher amperages.

What can we conclude?

1. As cable amperage rises, exposure to EMF increases; however, its effect on populations may be limited due to its very minor impact (Figs. 2 and 3).

2. The region with high EMF exposure is limited, covering only about 10% of 0.25 km² (Fig. 1).

3. EMF effects on energetics needs further consideration.

4. **This study, while not extensive, offers valuable insights. Even if the effects aren't dramatic, it provides more detailed information than previous simple threshold assessments.**

Next steps

1. Model potential changes in energetics to EMF exposure

QUESTIONS TO CONSIDER

- How do changes in swimming affect energy budgets when swimming efficiency is factored?
- Do changes in swimming result in changes in foraging efficiency?
- Do changes in energetics translate to population-level changes?

2. Repeat the model process for American lobster

Daniel Dawson
Integral Consulting Inc.
919-971-2096
ddawson@integral-corp.com

integral consulting inc.

1. Hutchinson et al. 2020. Anthropogenic electromagnetic fields (EMF) influence the behavior of bottom-dwelling marine species. *Scientific Reports*. 10:4219.
2. Wilensky, U. 1999. NetLogo. http://ccl.northwestern.edu/netlogo/. Center for Connected Learning and Computer-Based Modeling, Northwestern University, Evanston, IL.
3. Di Santo and Kenaley, 2016. Skating by: low energetic costs of swimming in batoid fish. *Journal of Experimental Biology*. 219:1804–1807.
4. Di Santo et al. 2022. EcoPhysioMechanics: integrating energetics and biomechanics to understand fish locomotion under climate change. *Integrative and Comparative Biology*. 62(3):711–720.
5. Ostojić and Ćalasan. 2017. Magnetic field of the bipolar HVDC cable Italy-Montenegro in the sea and in the land section. *Cigré Science and Engineering*. 8:123–130.