Eubalaena glacialis foraging habitat suitability under future climate scenarios in the Northwest Atlantic

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Background

- North Atlantic Right Whales (NARW, *Eubalaena glacialis*) are critically endangered
- Since 2010, climate shifts in and around the Gulf Stream have introduced uncertainty in NARW distributions
- NARW primarily feed on *Calanus finmarchicus,* but are increasingly moving to new habitat and may start relying on other prey species such as *Calanus hyperboreus*
- **Prey-based, USA-Canada modeling of suitable NARW foraging habitat may reveal insight into future distribution shifts**

Calanus finmarchicus. *Photo: David Fields*

North Atlantic right whale. *Photo: Peter Crosson, licensed under CC BY-NC-SA 2.0.*

Methods

- *C. finmarchicus* and *C. hyperboreus* abundance data (µg *Calanus* · m^{-2}) derived from Ecosystem Monitoring Program (EcoMon), Atlantic Zone Monitoring Program (AZMP), and Sorochan et al. (2019) biomass conversions
- High-resolution (1/12° x 1/12°) environmental variables sourced from Bedford North Atlantic Model (BNAM)
  - 1990-2015 "historical" data and RCP 8.5 2066-2085 "year-2075" data (extreme warming scenario)

AZMP → EcoMon (corrected) → BNAM present-day

Calanus spp. abundance data | *Input covariate data*

Threshold Conversion $x \geq 5.85 \cdot 10^6 \ \mu g \cdot m^{-2}$ → Boosted Regression Tree Algorithms *classification model*

C. hyperboreus aggregation model | *C. finmarchicus* aggregation model

Machine learning models

Bioenergetic Correction

BNAM present-day, future → NARW foraging habitat projections *Present, Future*

Projection covariate data

NARW habitat shift maps *Present vs. Future*

A diagram of the methodology used for this study.

EcoMon and AZMP data for C. finmarchicus high-density aggregations (19,222 points). A similar dataset exists for C. hyperboreus (21,344 points).

Model Performance

- Both *C. finmarchicus* and *C. hyperboreus* models displayed strong performance year-round
- Bathymetry and bottom water covariates most important for both models

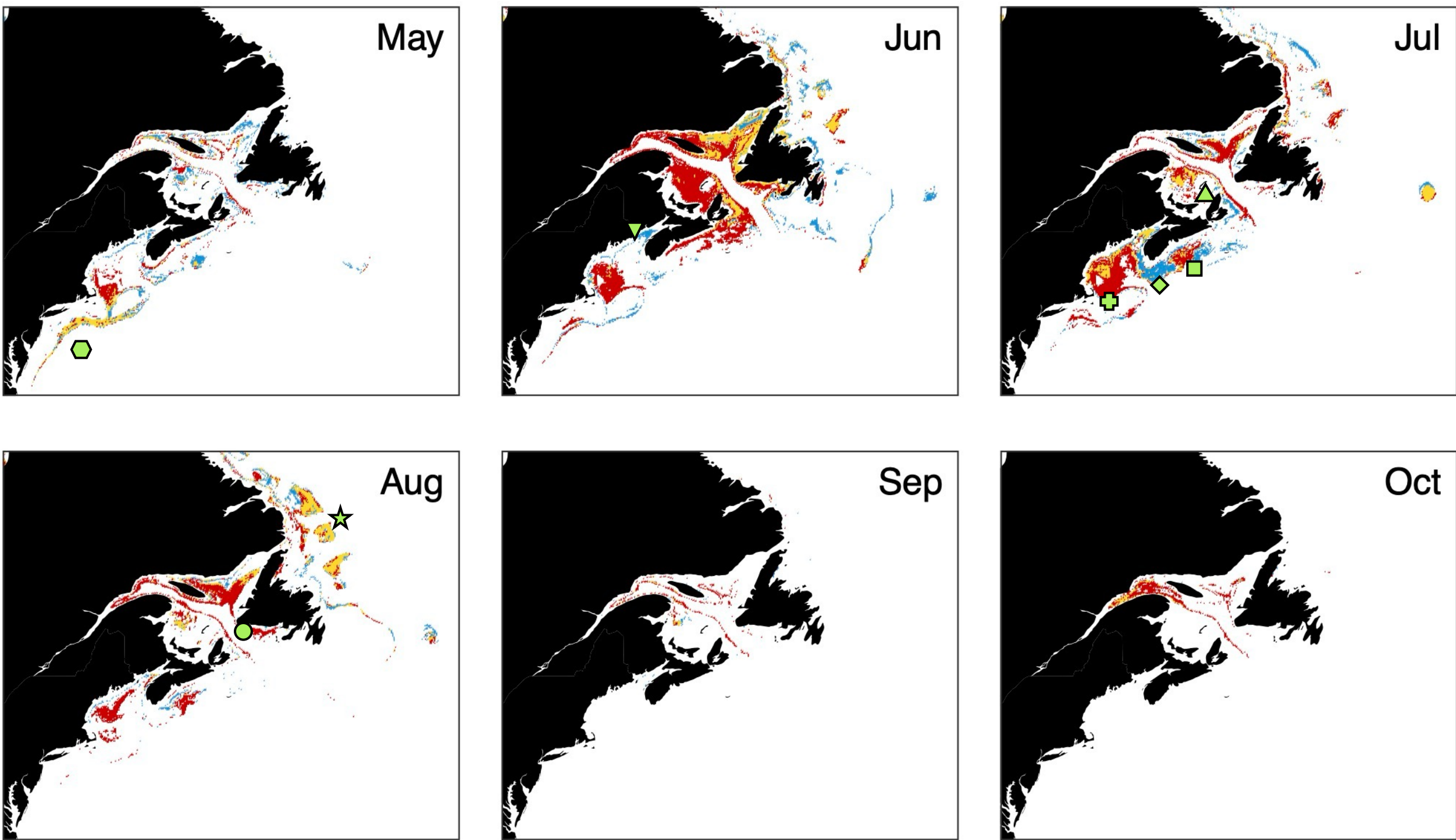|	C. finmarchicus	C. hyperboreus
AUC score *(0 to 1, 1 being perfect)*	.881	.985
Accuracy *% correct predictions*	90%	97%

Historical Projections

- Similar to input *Calanus* spp. data and historical NARW foraging
- **Projected foraging habitat:** Gulf of Maine (⊕), Southwestern Gulf of St. Lawrence (△), Western Scotian Shelf (■), Newfoundland and Labrador Shelves (★)

a) Feb   b) May   c) Aug   d) Nov

Patch Probability   0.0 0.1 0.2 0.3 0.4 0.5
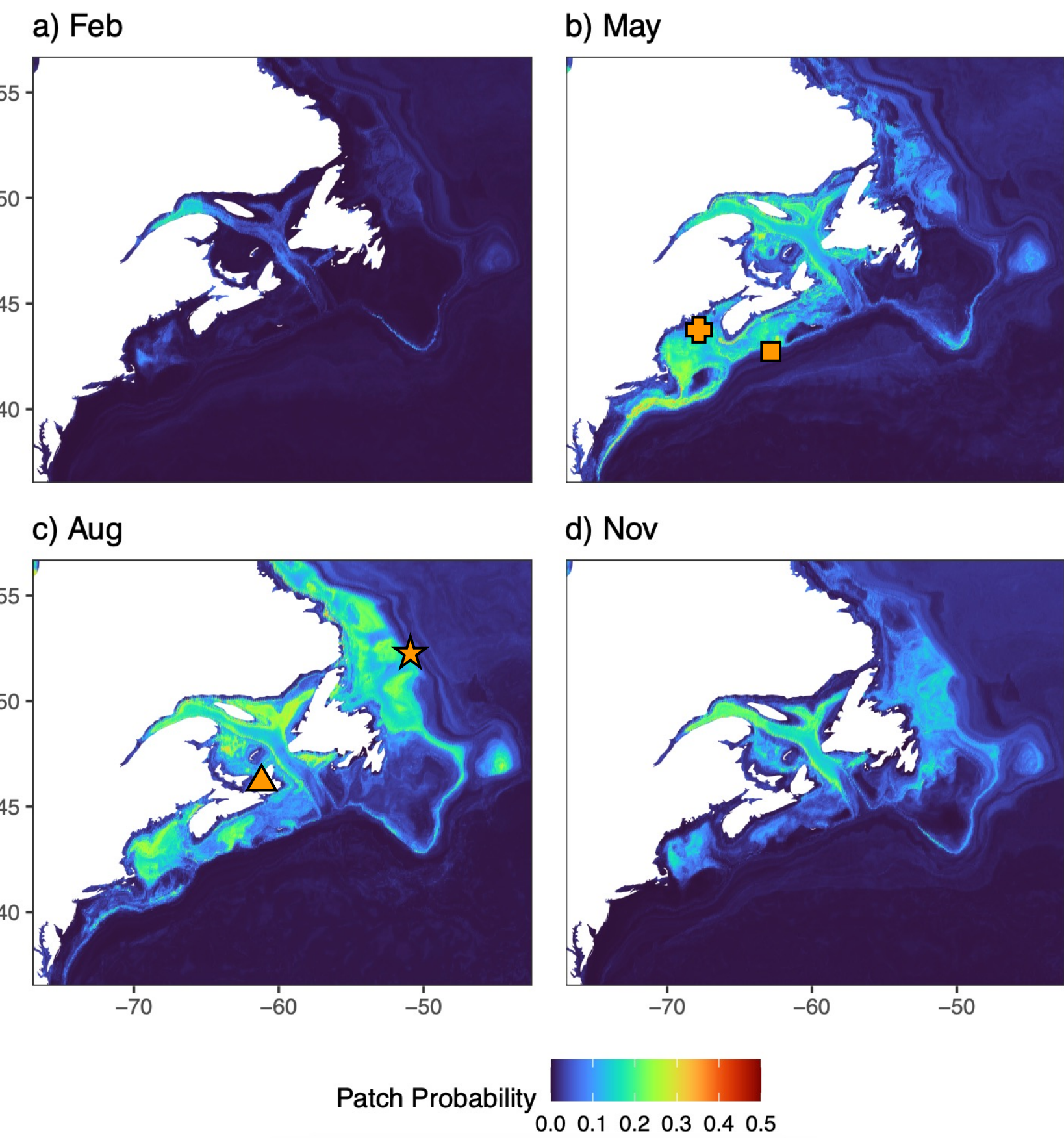
Projected right whale foraging habitat probability for 1990-2015 historical environmental conditions during representative months of February, May, August, and November.

Future Projections & Conclusions

- "Habitat shift maps" display differences between historical and year-2075 RCP 8.5 projections relative to a "habitat threshold" of 20% — showing areas of new, lost, and retained foraging suitability
- Little habitat suitability observed during winter months. Most change during spring/summer, aligning with NARW foraging season
- Foraging habitat suitability generally moved away from historical areas, with larger regions of lost suitability than gained
  - **Projected lost foraging:** Gulf of Maine (⊕), Western Scotian Shelf (■), Laurentian Channel (○)
  - **Projected new and retained foraging:** Southwestern Gulf of St. Lawrence (△), Roseway Basin (◇), Bay of Fundy (▽), Southern shelf break (●), Newfoundland and Labrador Shelves (★)

May   Jun   Jul   Aug   Sep   Oct

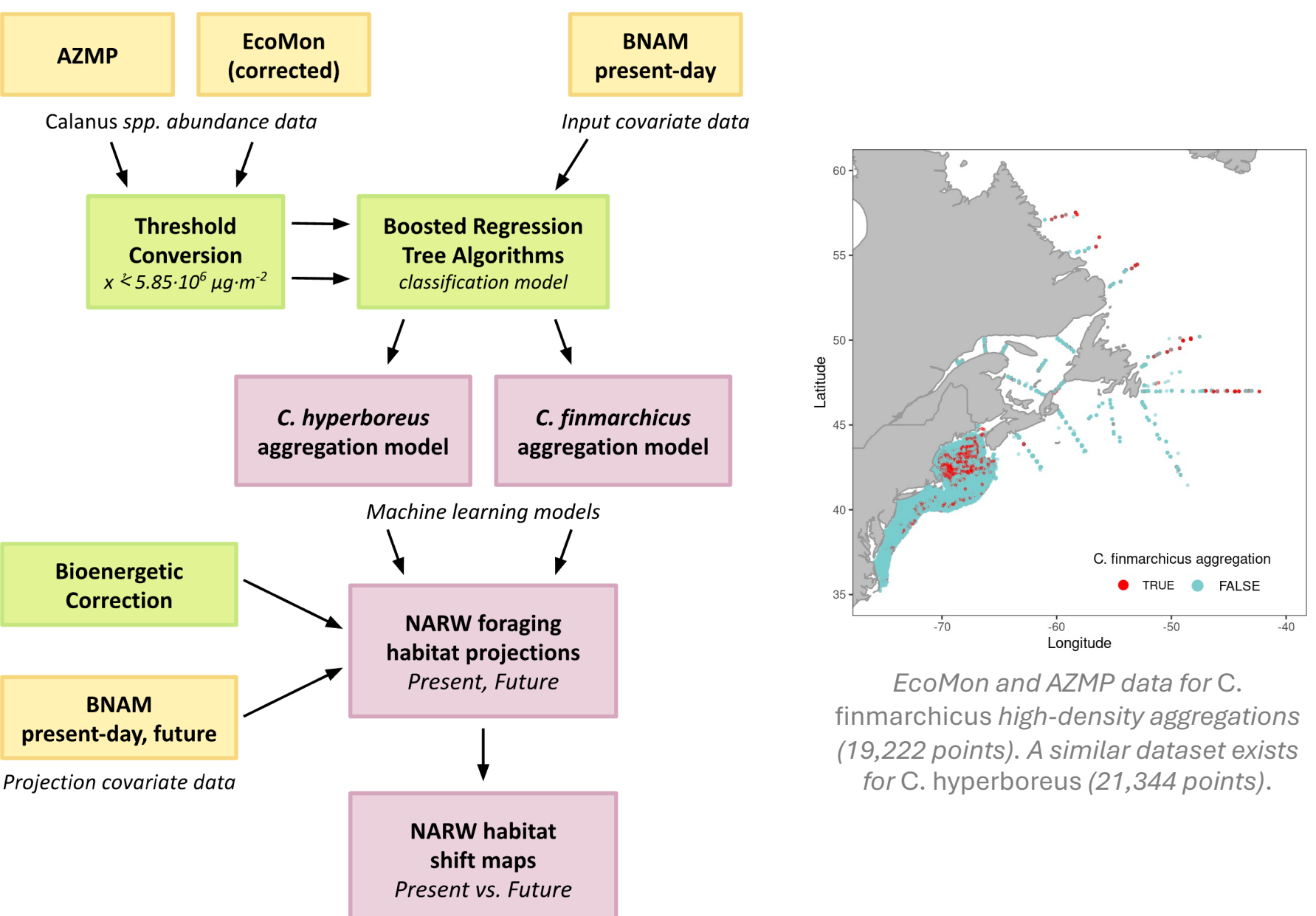□ No Habitat   ■ New Habitat   ■ Lost Habitat   ■ Retained Habitat

Habitat shift maps for NARW foraging habitat probability, May - October. Colors represent how NARW foraging habitat probability shifted between historical and year-2075 RCP 8.5 relative to a "habitat threshold" of 20%.

- The general projected migration of projected foraging habitat suitability is consistent with prior studies and current observed distribution shifts (e.g. Chust et al. 2014, Grieve et al. 2017, Ross et al. 2021, Meyer-Gutbrod et al. 2023)
- **Results can help direct survey effort and further modeling to understand North Atlantic right whale migration under climate change and inform management techniques**

Acknowledgements