

# Sex- and maturity-specific species distribution modeling for eastern Bering Sea snow crab

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# Motivation for developing new SDMs

- ▶ Shifts northward seen for males, immature females in recent years.
- ▶ Could there be movement outside of the EBS survey area?
- ▶ Need for improvement of previous SDMs – past EFH maps not sex and size specific.
- ▶ Past maps also not developed using hindcasts to allow for short-term projections.





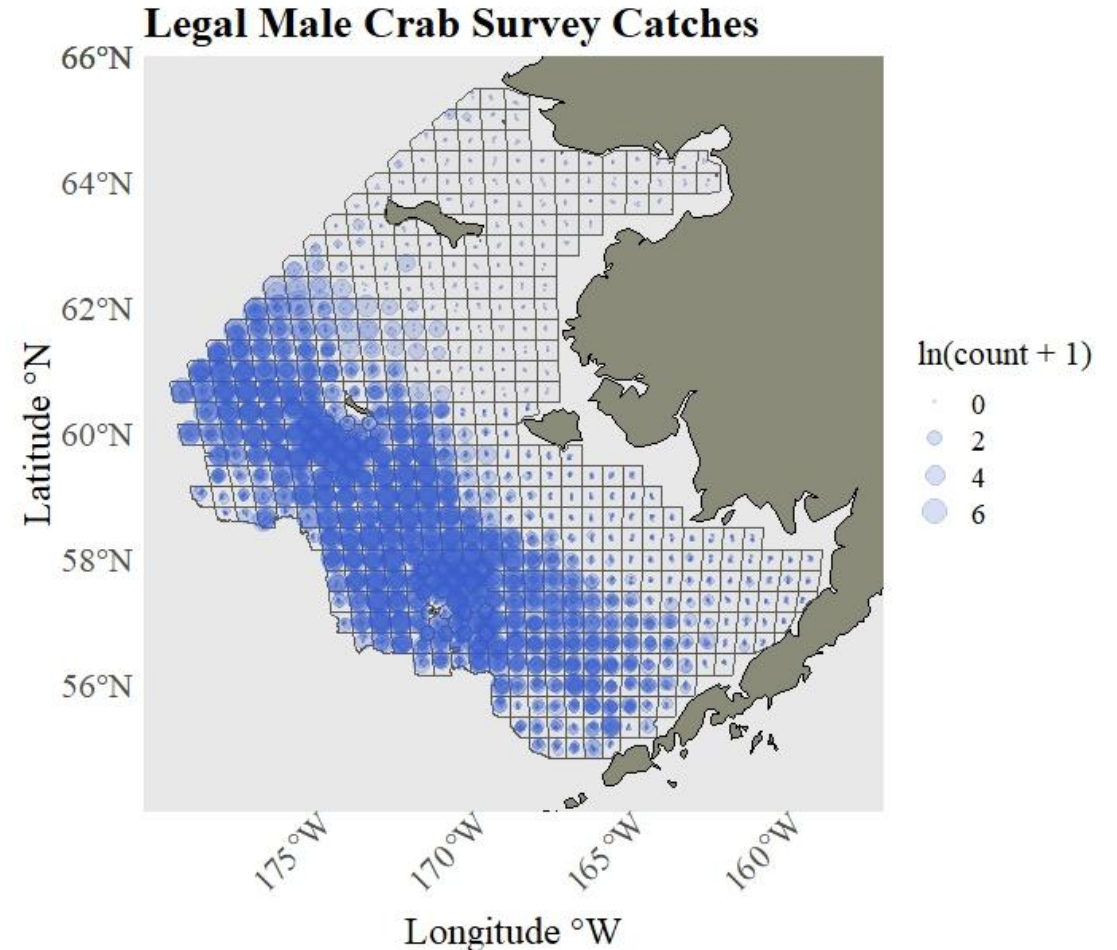
A scenic view of a snowy mountain landscape. In the foreground, a calm river flows through a valley. The banks are covered in snow, and a few small wooden structures are visible in the water. In the middle ground, a cluster of houses with snow-covered roofs is nestled in the valley. The background features large, snow-capped mountains under a cloudy sky.

# Research Questions

1. How do environmental conditions, fishing pressure, disease, and predation affect snow crab sex- and maturity-specific distributions?
2. Does inclusion of anomalous years (e.g., 2018-2019) improve both overall predictions and spatial error?
3. How do models trained on survey temperature data perform compared to ROMS?

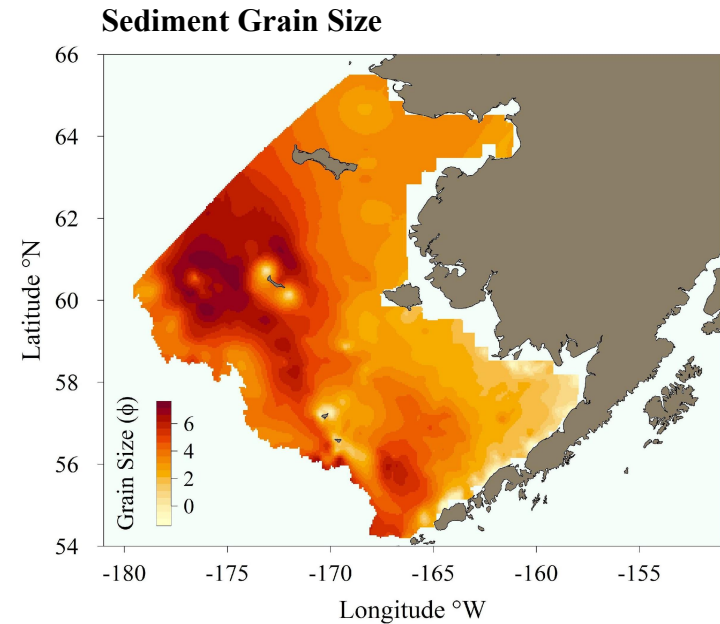
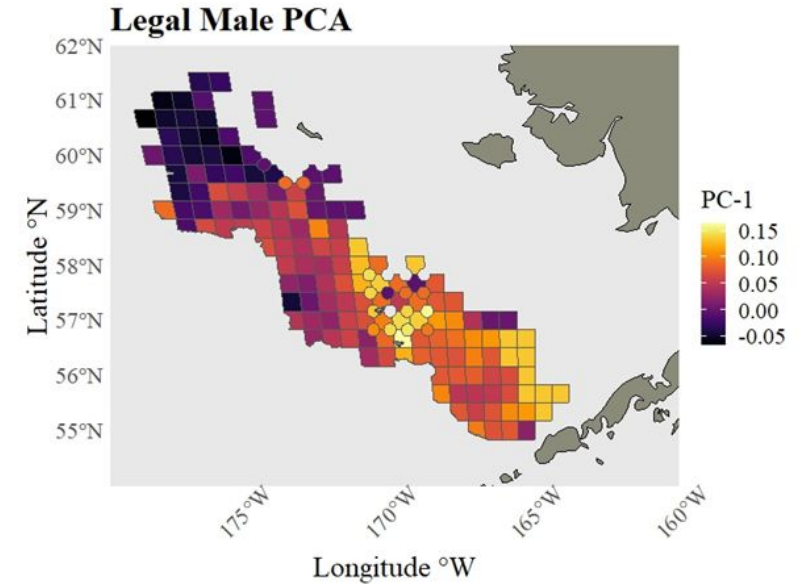
# Data

- ▶ NOAA AFSC Bottom Trawl Survey
  - Crab catches by sex and maturity stage
    - Train: 1995-2014
    - Test: 2015-2021
  - Pacific cod abundance
  - Bitter crab syndrome (BCS) prevalence
  - Bottom temperature
  - Depth



# Data

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- ▶ Observer data from the directed fishery
- ▶ Sediment grain size (EBSSSED-2)
- ▶ Sea ice concentration (ERA5)







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# Methods

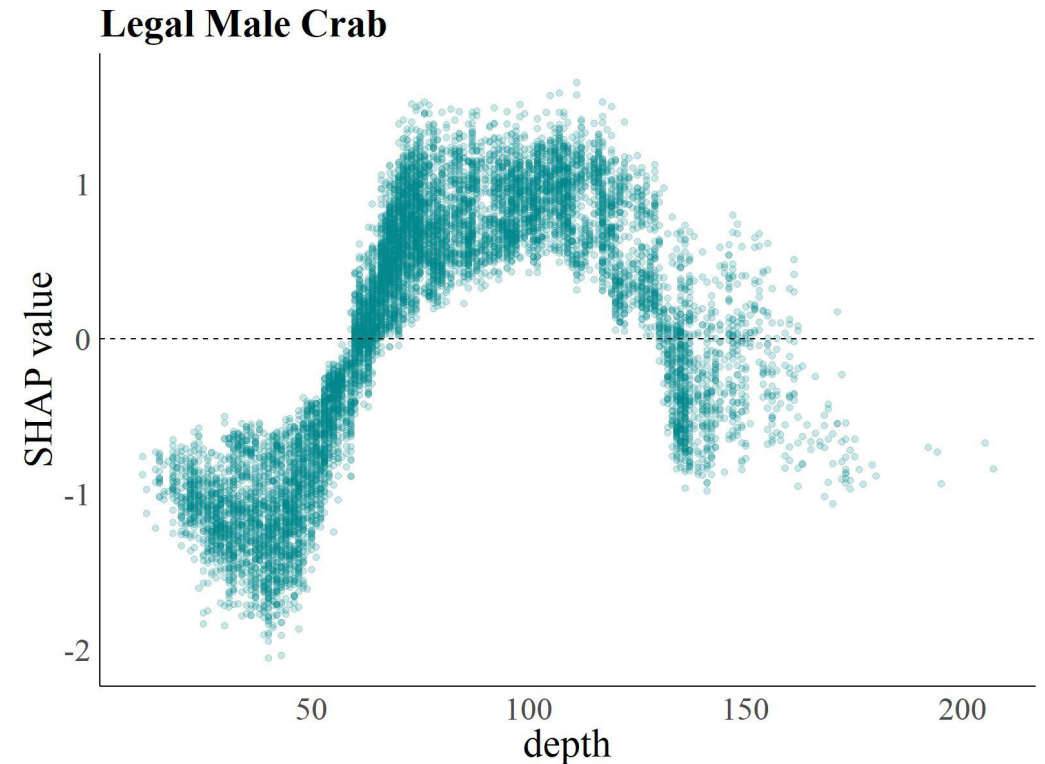
## Boosted regression trees (BRT)

- ▶ Selected after comparison with generalized additive models (GAMs).
- ▶ Two-part delta method due to zero-inflated data.
  - Presence-absence model
  - Abundance model
- ▶ Hyperparameters tuned using a grid search for each component of model.

# Methods

## SHAP Values

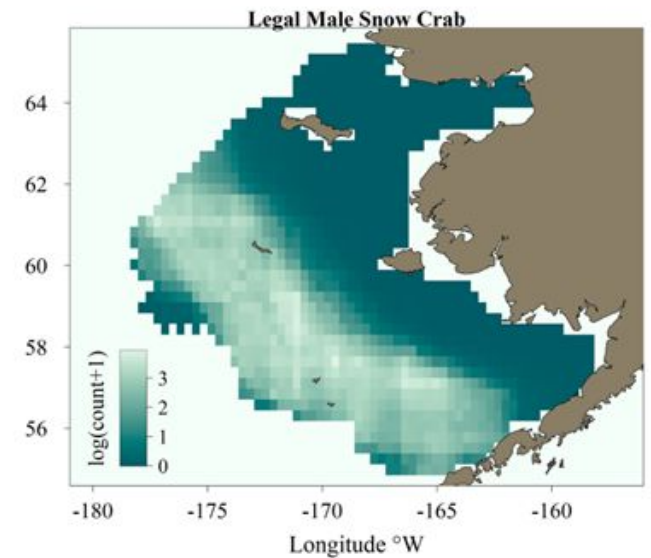
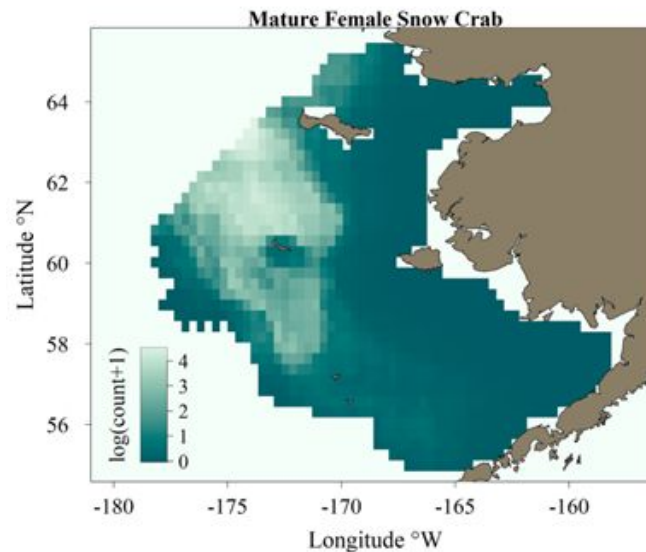
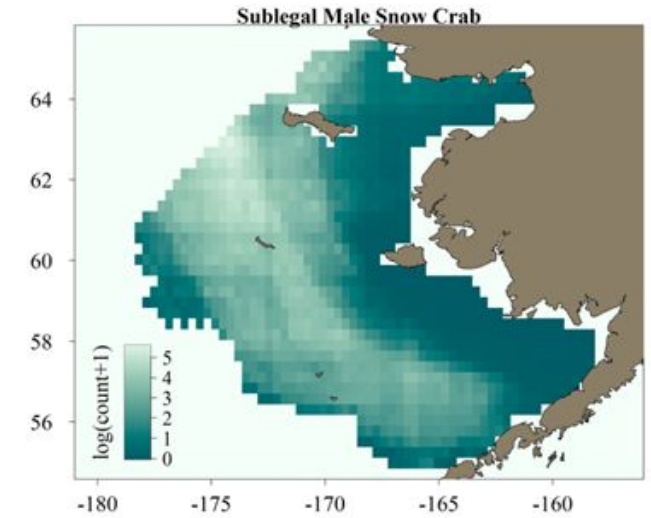
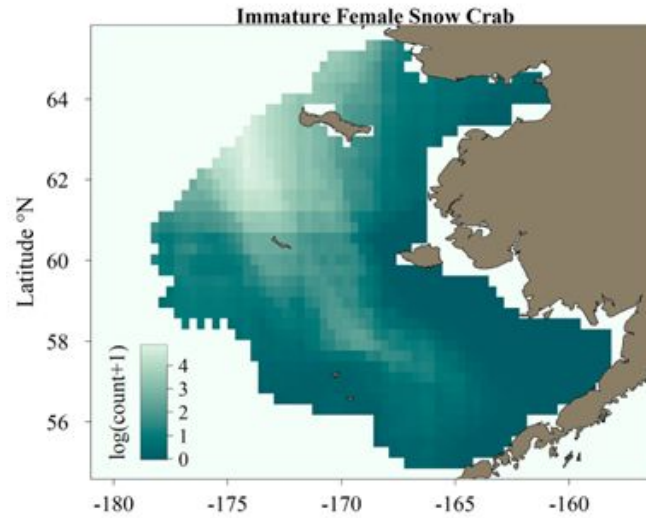
- Explain the contribution of each covariate to a given prediction.
- Negative/positive SHAP values indicate a negative/positive effect on the prediction.
- Greater SHAP magnitude indicates a greater effect.
- Provides both mean effect and variation.
- Additive





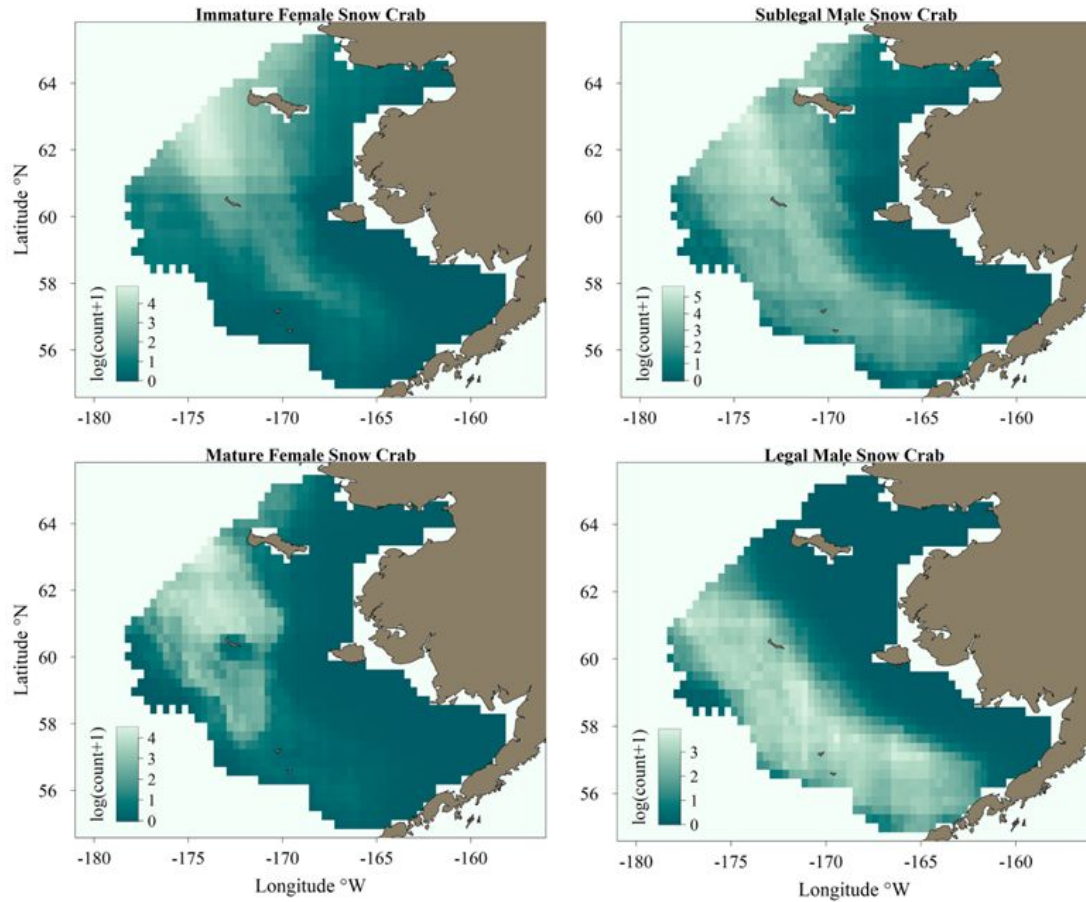
# Results

How do environmental conditions, fishing pressure, disease, and predation affect snow crab sex- and maturity-specific distributions?

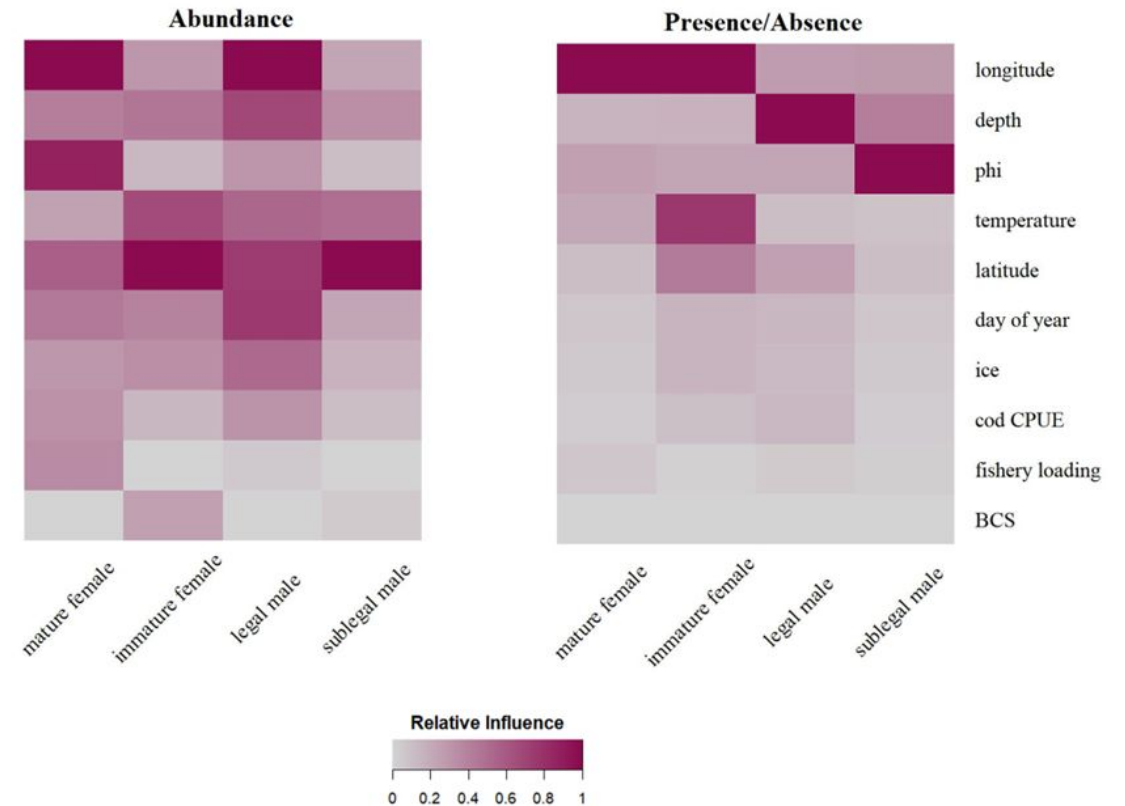




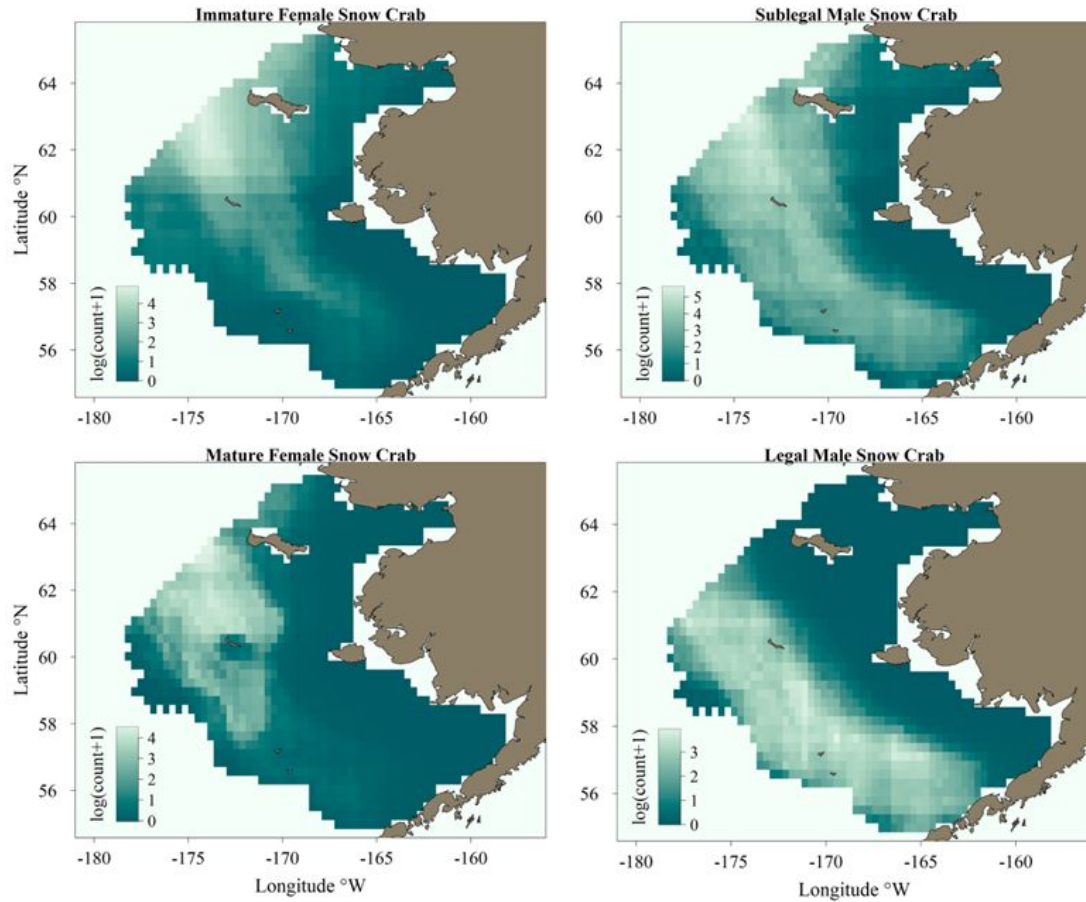
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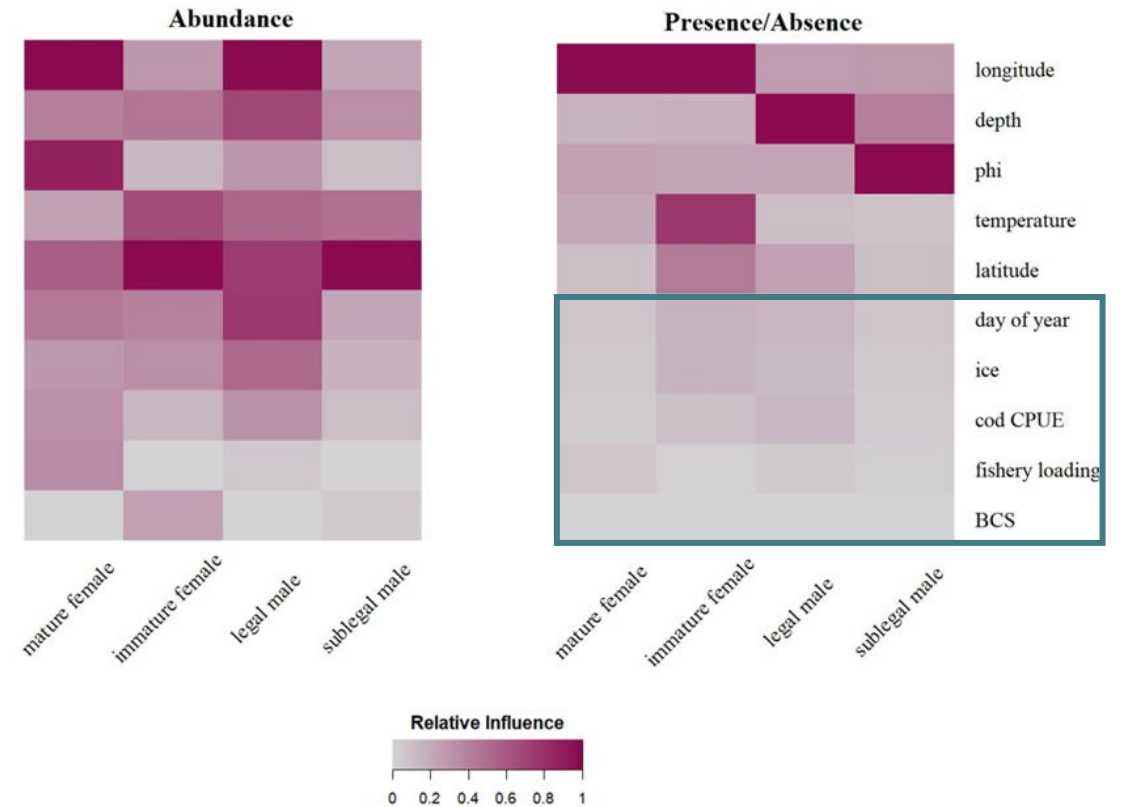
Spatial distributions differ by sex and maturity, which are likely explained by sex- and maturity-specific variable importance.



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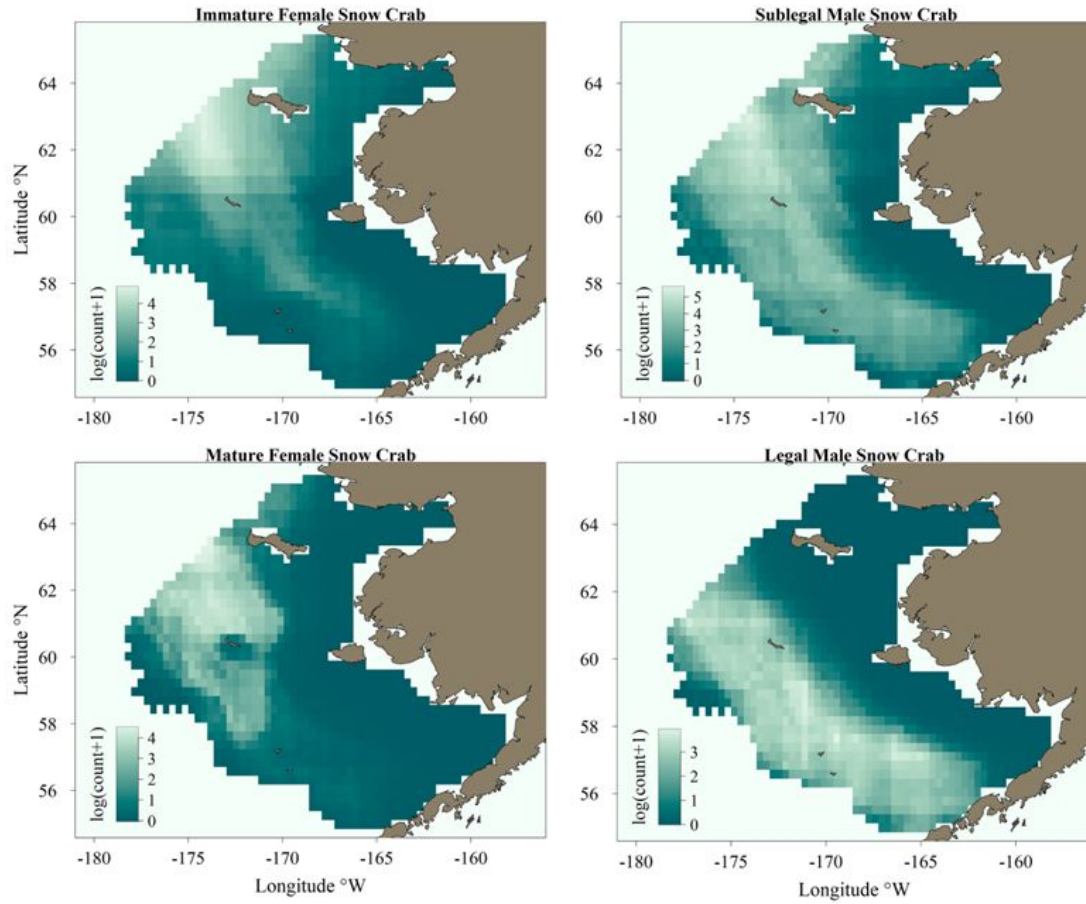


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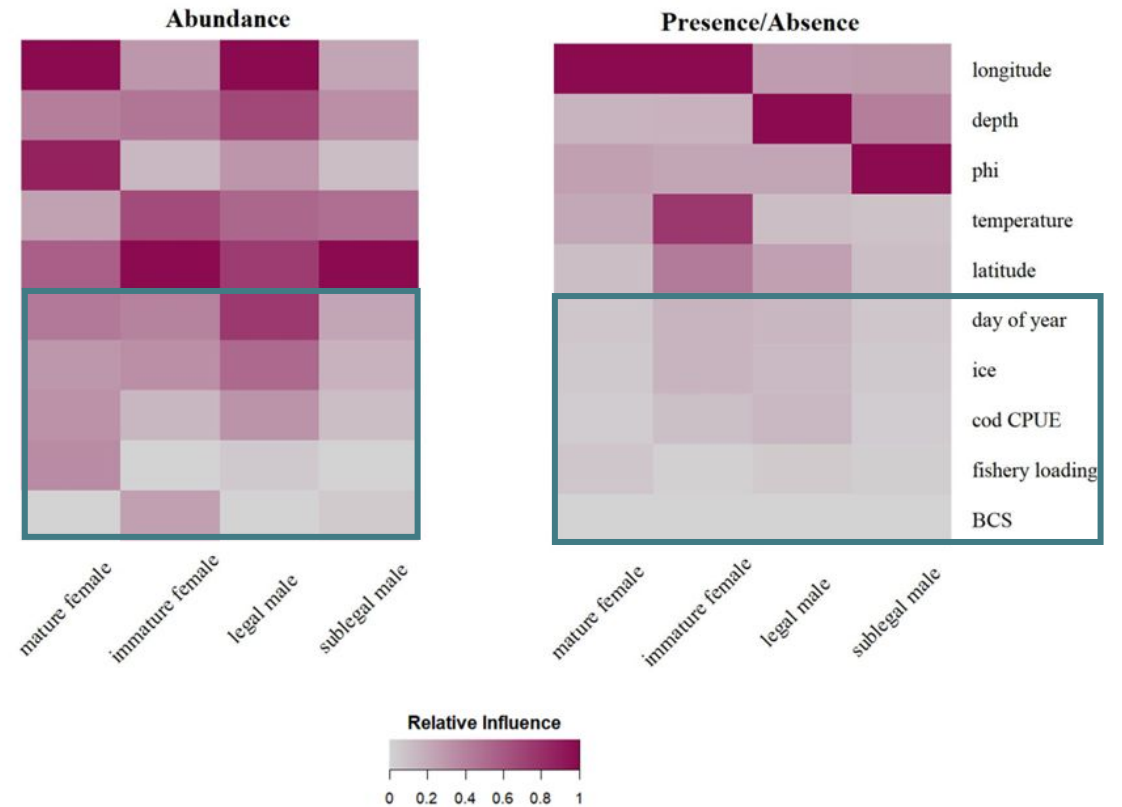




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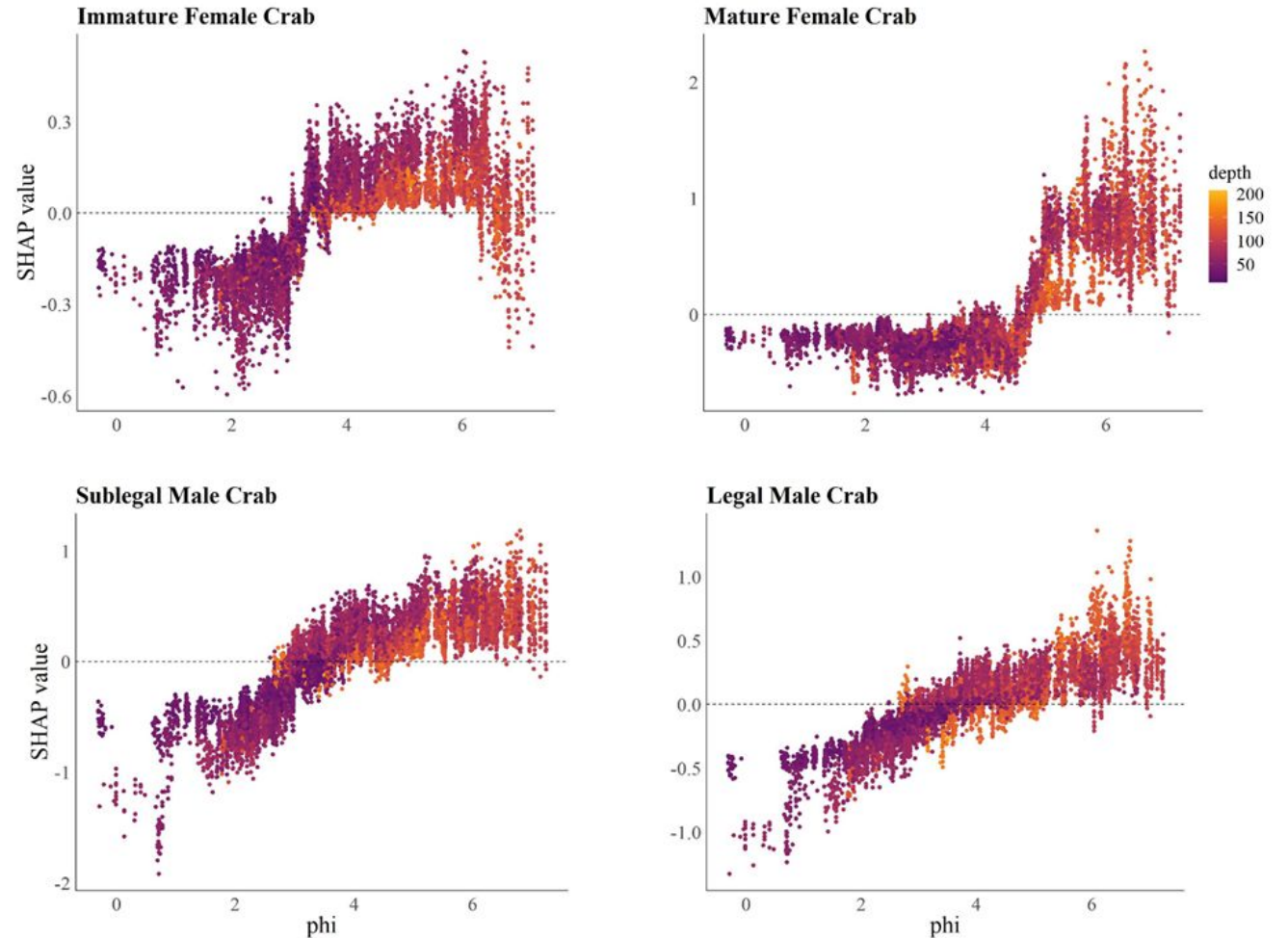
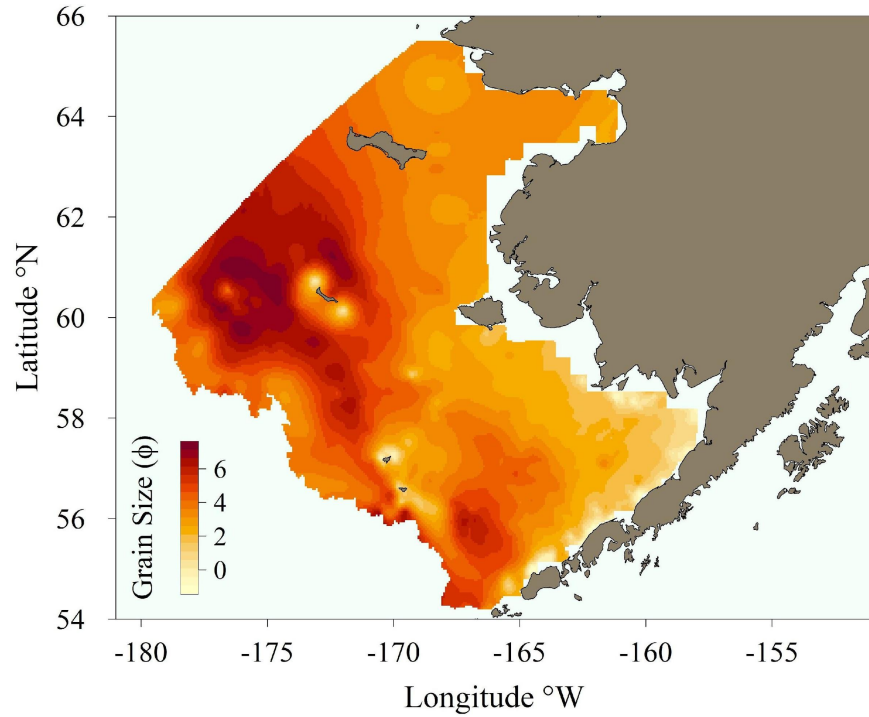


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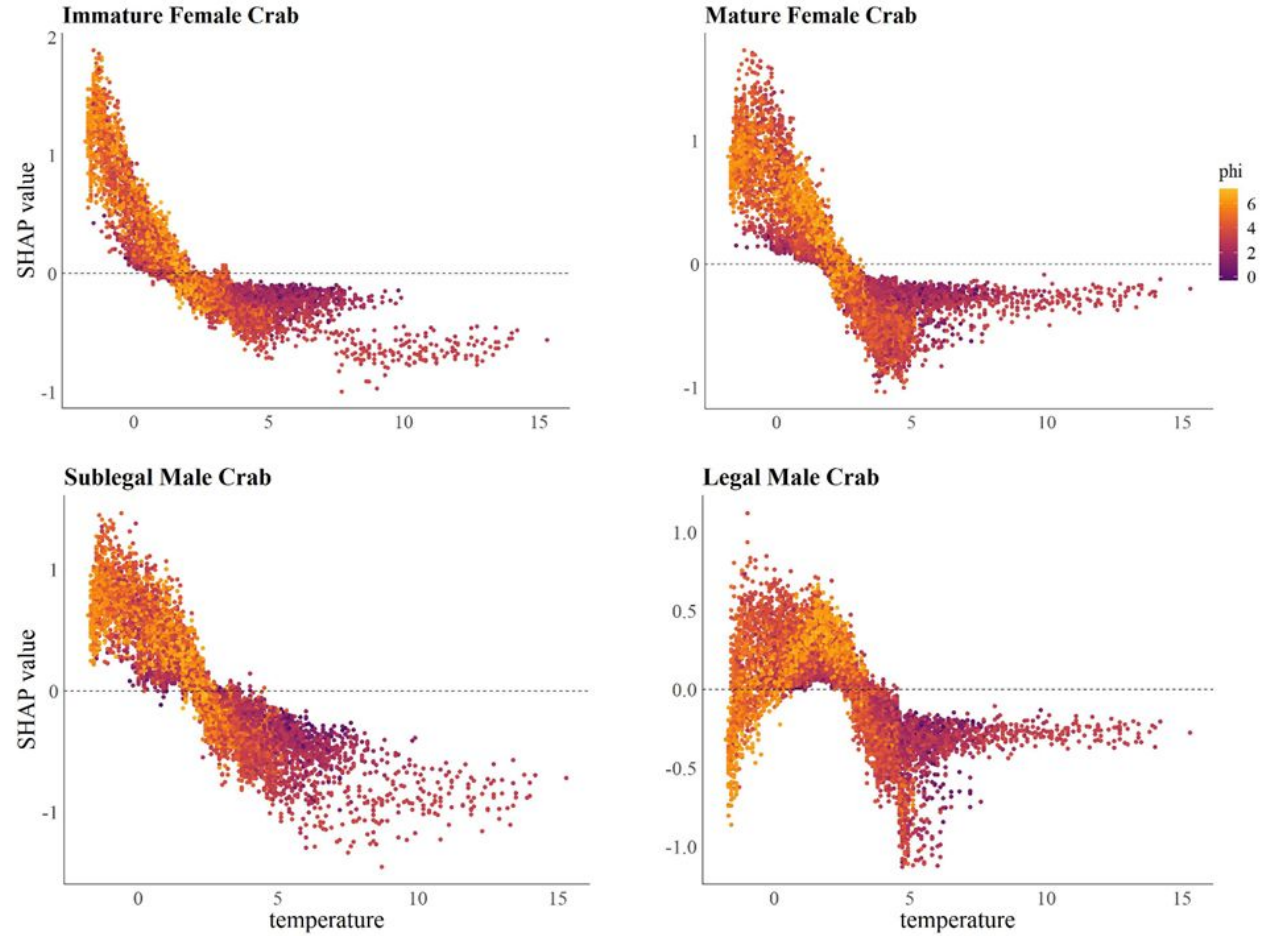
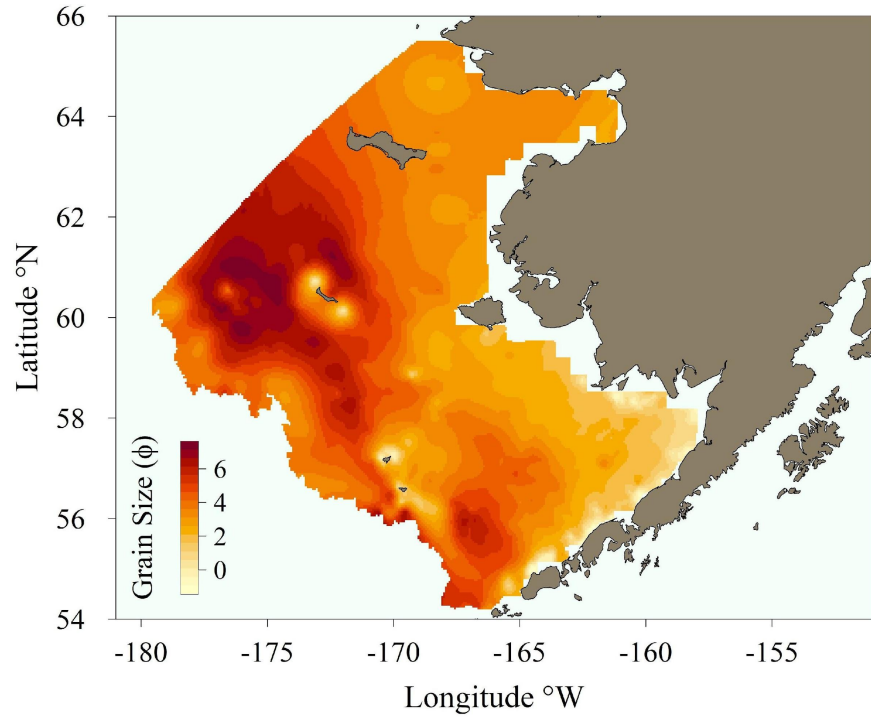
There is a threshold effect of grain size for female crab, but in general all sexes and maturities prefer cool water and small sediment sizes.





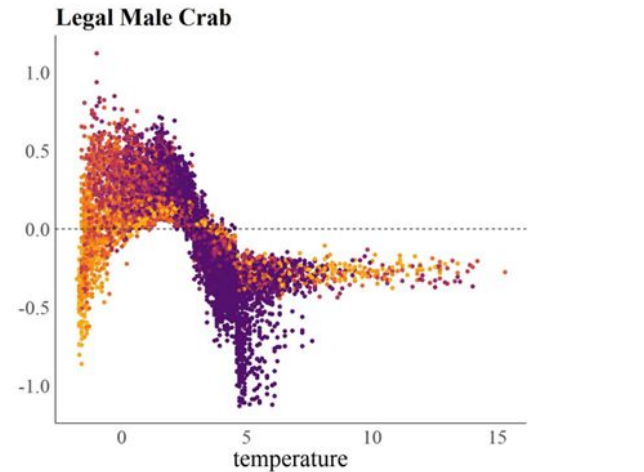
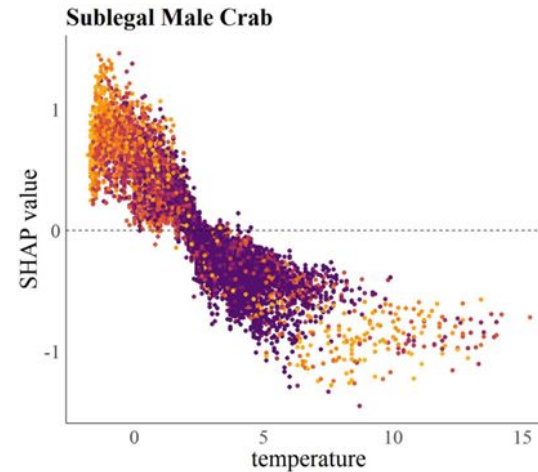
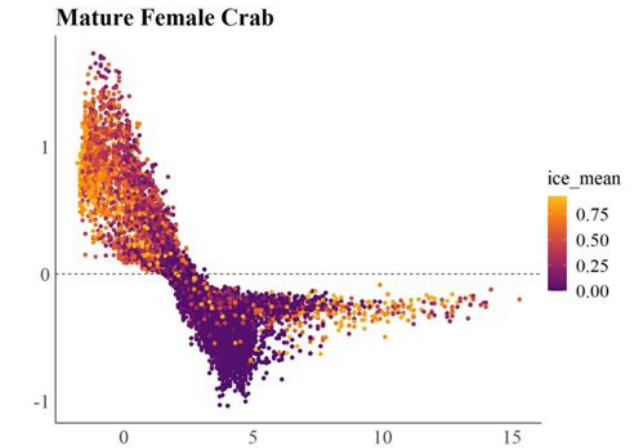
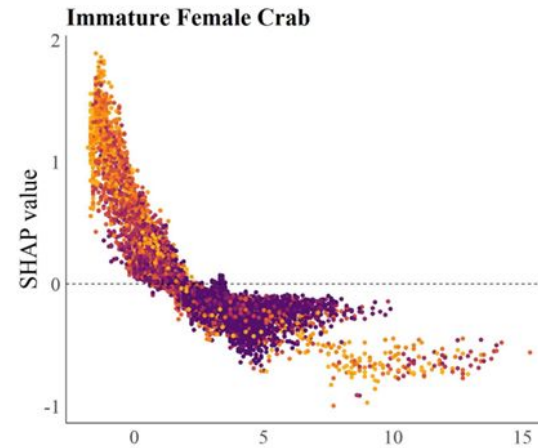
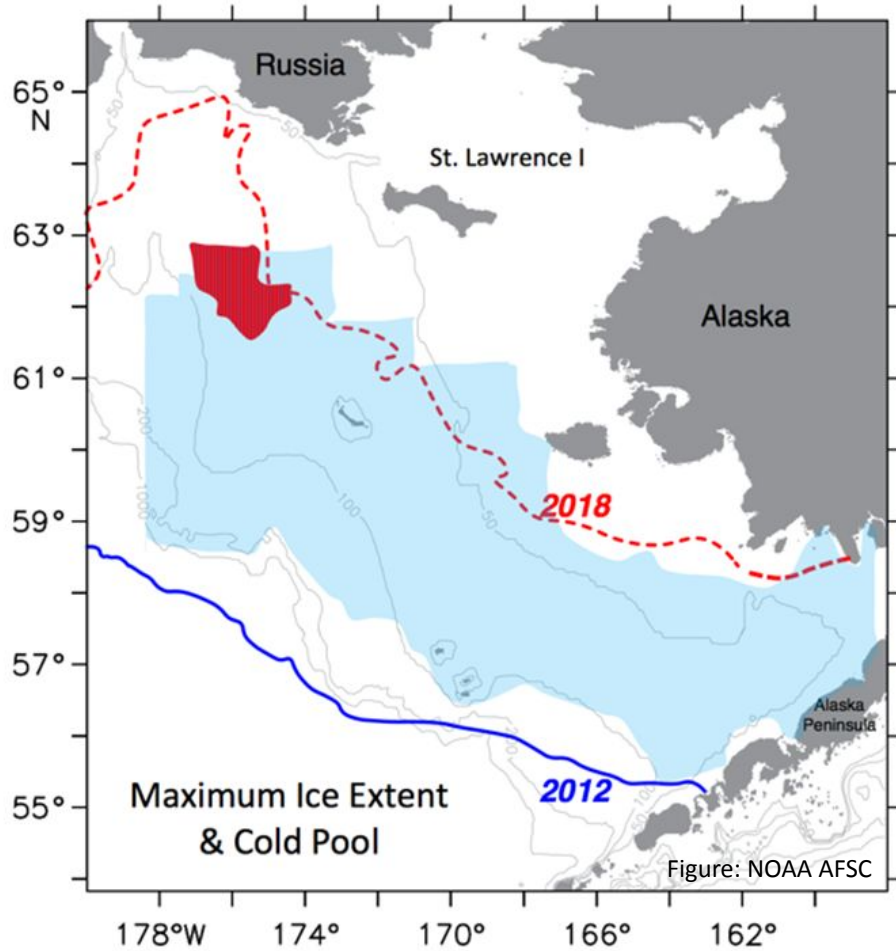
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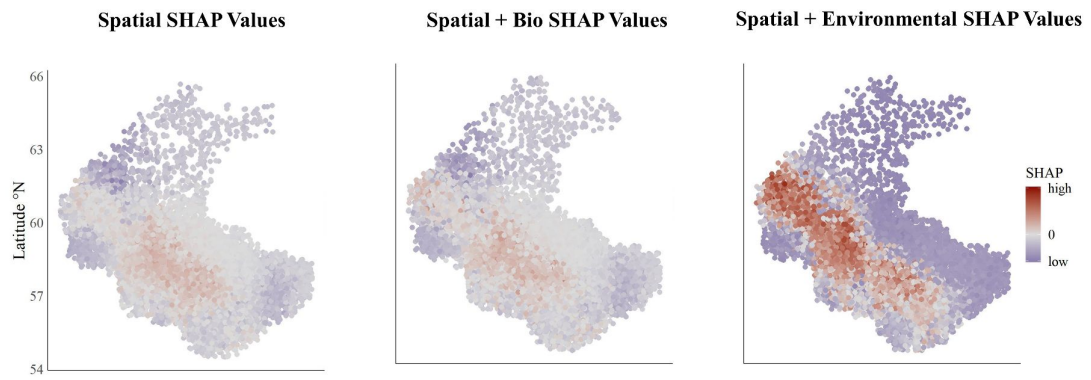
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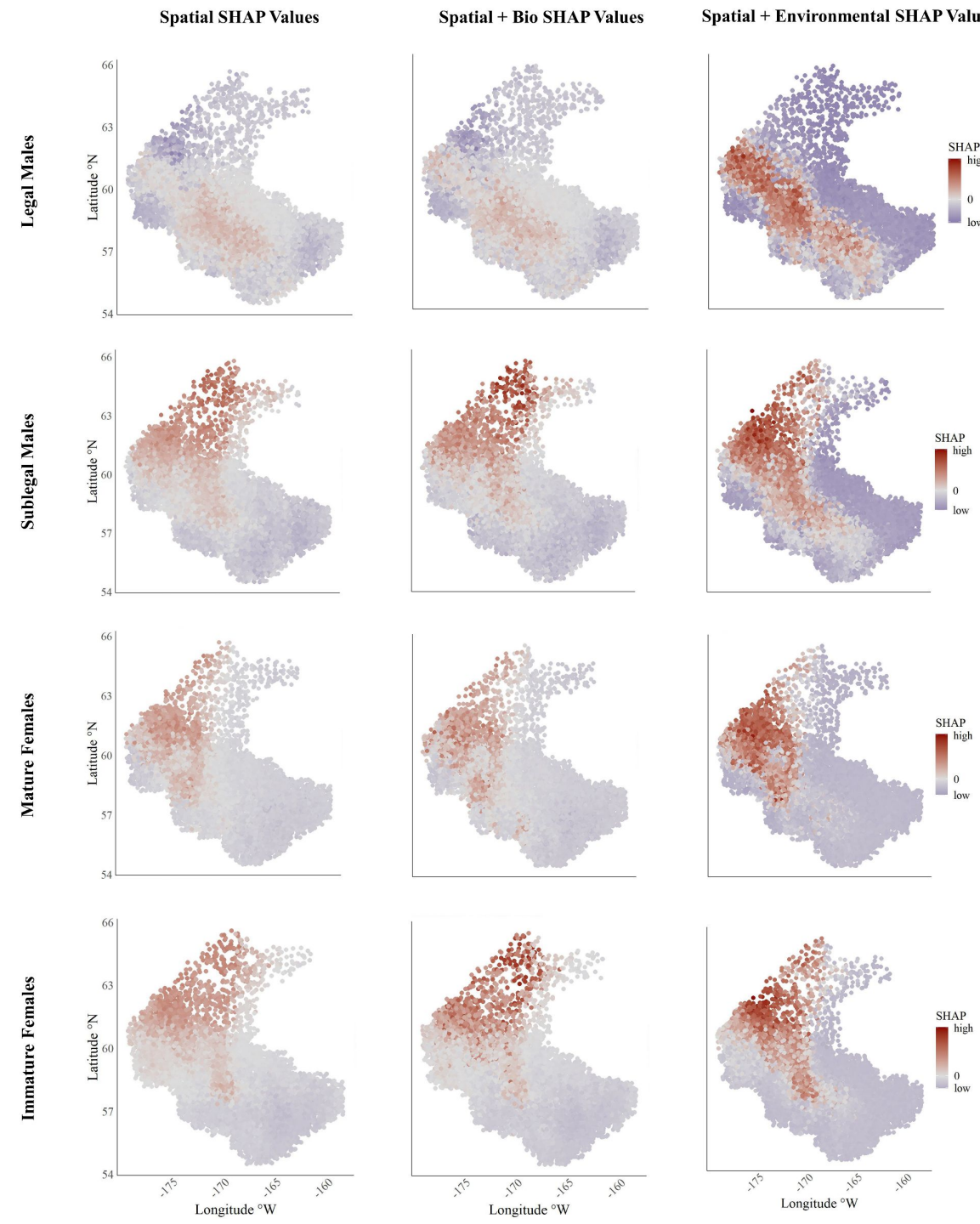
Low temperature has a negative effect on legal male crab abundance when combined with high ice concentrations – this is not seen for the other sex and maturity combinations.





Legal Males





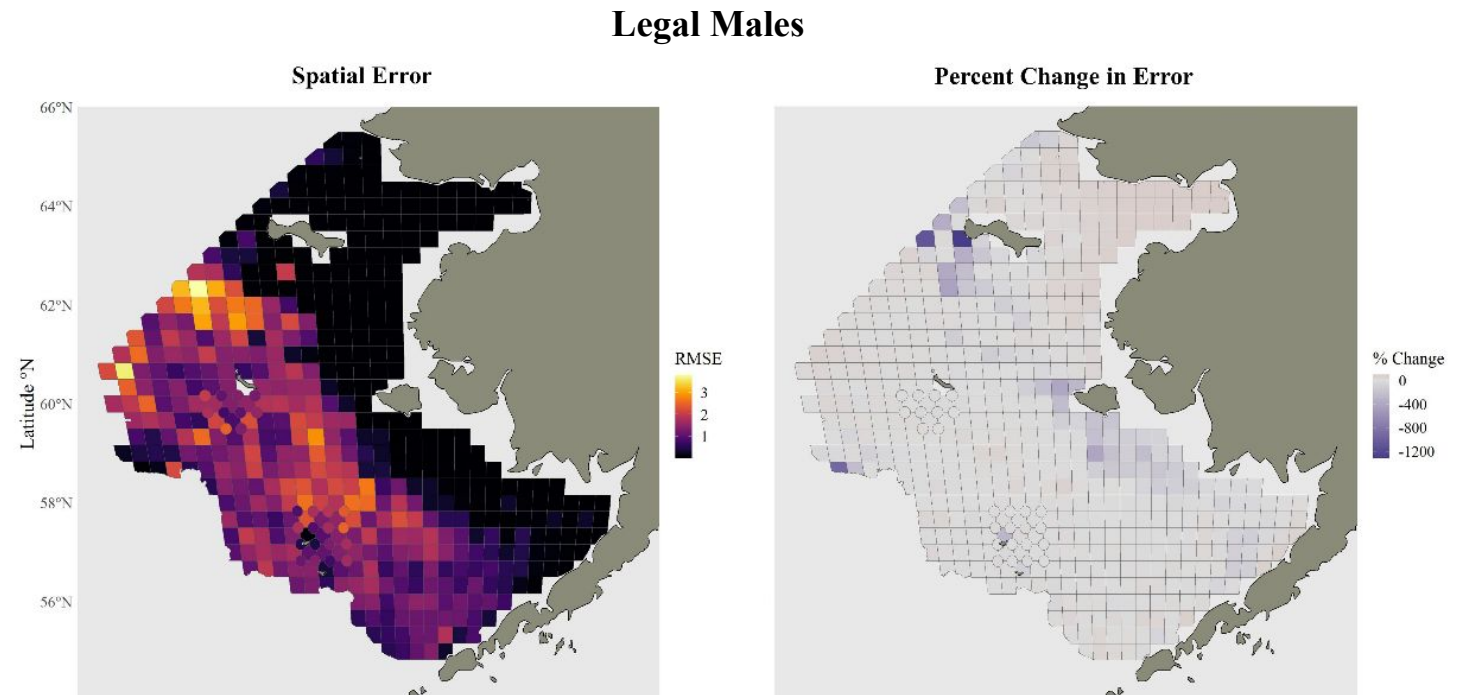


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- ▶ Added 2018 to training data, removed from test.
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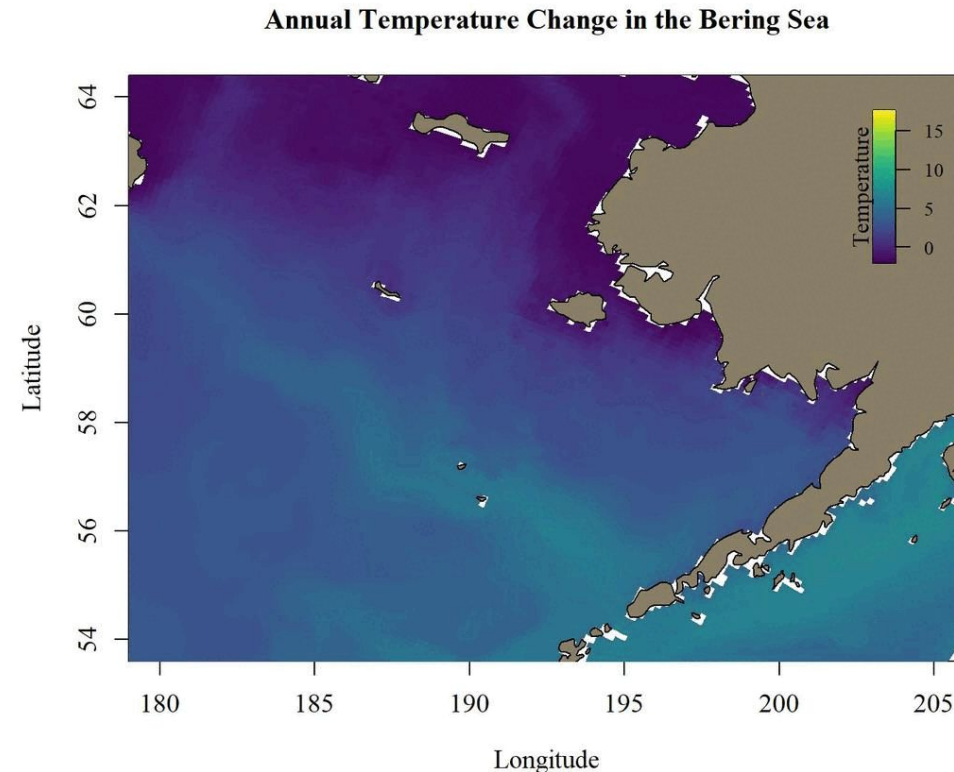




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## Ongoing work

- ▶ Remove cod, BCS prevalence, observer data from models.
- ▶ Use temperature output from the Bering10K ROMS hindcast and forecasts.

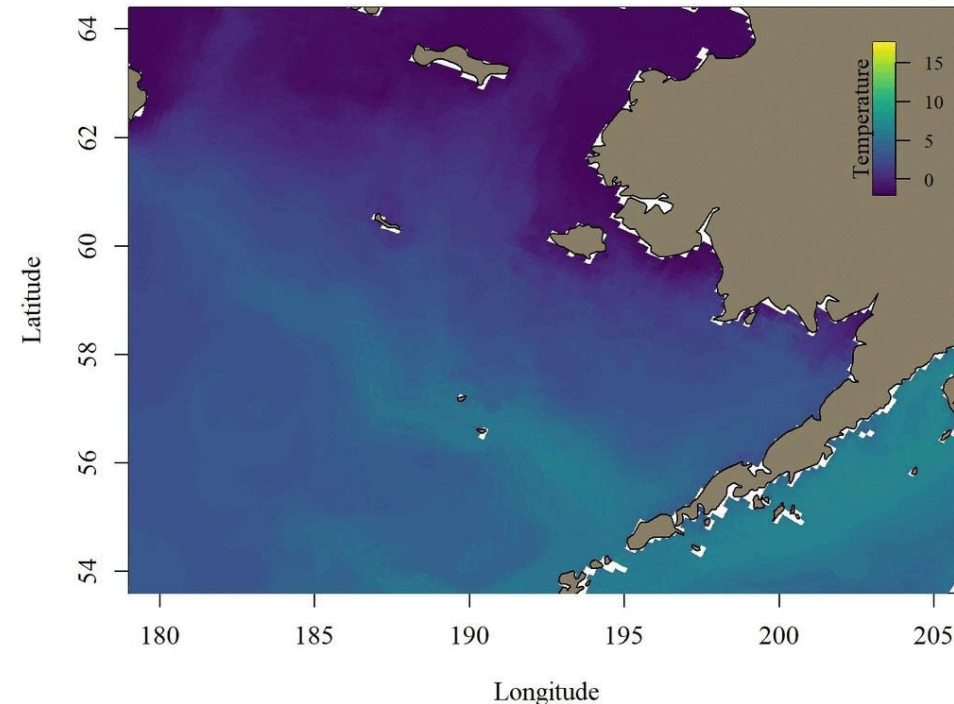


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## Ongoing work

- ▶ Remove cod, BCS prevalence, observer data from models.
- ▶ Use temperature output from the Bering10K ROMS hindcast and forecasts.
- ▶ Compare models with ROMS temperatures to models with the previous season's temperatures.

Annual Temperature Change in the Bering Sea







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## Main Findings

- ▶ Maturity/sex differences in distribution appear to be driven by different relationships with environment.
- ▶ Interactions between static and dynamic variables may prevent northward movement of snow crab.
- ▶ Inclusion of anomalous years may have minimal impact on predictions.
- ▶ Ongoing work will determine if the Bering10K can be used to predict snow crab abundance for the next survey season.