A MAXIMUM ENTROPY MODEL TO PREDICT KRILL DISTRIBUTIONS

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RESEARCH QUESTION & PREDICTIONS

Research Questions:

1. Where are krill found in the Southeastern Bering Sea?
2. How has krill's spatial distribution changed over time?
3. What environmental conditions predict krill presence?

Predictions:

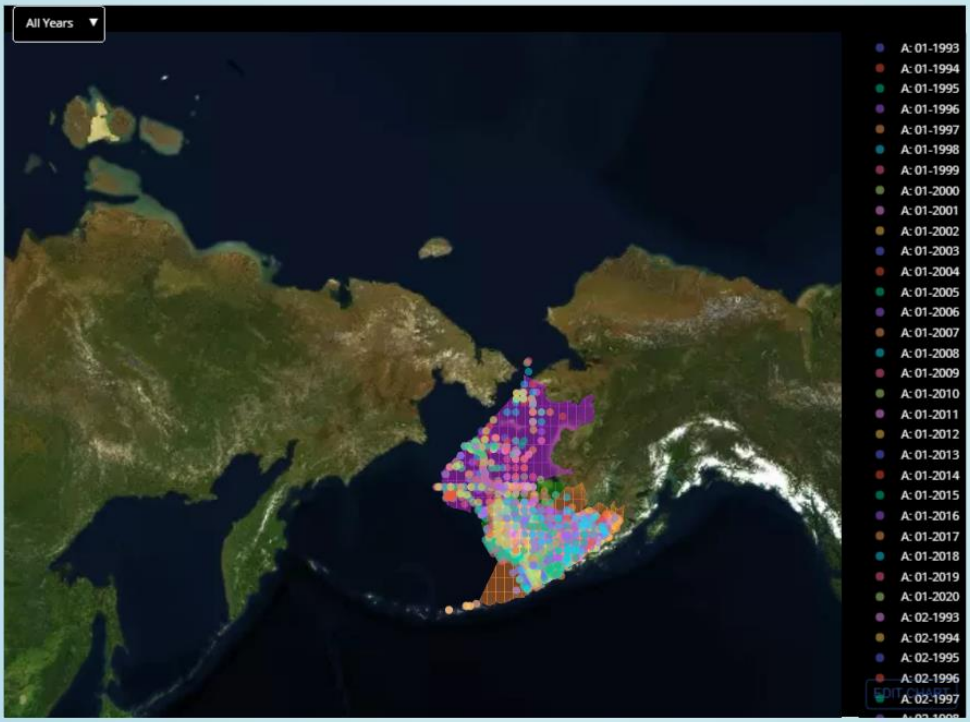
1. Krill presence (response) will be spatially (predictor) concentrated along the middle and inner domains of the SEBS due to wind-induced upwelling of nutrients and krill.
2. Krill presence (response) will exhibit a northward shift over time (predictors) due to the shrinking cold pool.
3. Proximity to the Bering Canyon paired with wind-induced upwelling, chlorophyll A concentration, and bottom water temperature (predictors) influence krill presence due to vertical transport, food availability, and low metabolic rates.

PROCURED DATA

For the maximum entropy (maxent) model:

Category	Sample Size	Spatial Distribution	Time
Krill	21,581	SEBS	1993-2020
Bottom Temperature	0.1 degrees	SEBS	1981-2018
Chlorophyll A	0.1 degrees	Global	2002-2020
Sea Surface Temperature	0.1 degrees	SEBS	1981-2018
Bathymetry	1.0 degree	Global	static
Salinity	25 km	Global	2010-2020
Canyon	Categorical	SEBS	static
Currents	0.1 degrees	SEBS	1981-2018
Wind	1.0 degree	Global	1980-2022
Precipitation	1.0 degree	SEBS	1979-2022

ANALYTICAL APPROACH: SAMPLING BIAS

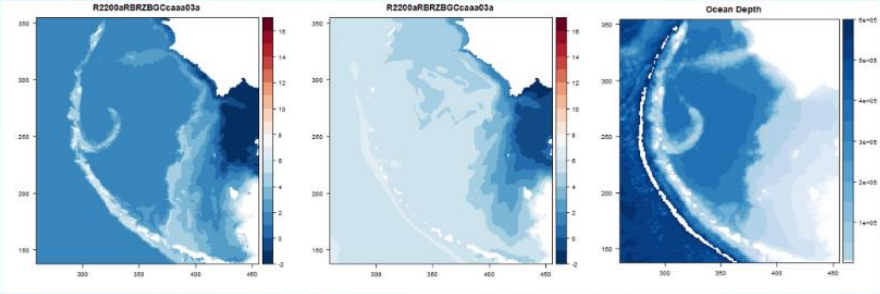


ANALYTICAL APPROACH: MAXENT

Annual maxent models will be fitted for region 1 from 1999-2020 to assess suitability of environmental and spatial covairates to predict krill presence. These years and areas represent the most regularly sampled region. Subsequent analyses will require background interpolation.

```
maxent()

#measure variable importance using jackknife and produce response curves
mx <- maxent(stack(beringSeaStack),
             presTrain,
             path=filePath,
             args=c("jackknife", "responsecurves"))
plot(mx)

# evaluate the model using the test data
e <- evaluate(presTest, bgTest, mx, beringSeaStack)

# predict back to geography
mxPred <- predict(mx, beringSeaStack)
plot(mxPred, col=rgb.tables(1000), main="Maxent Prediction")
# Predict in 'raw' format and save raster of prediction
mxPred <- predict(mx, beringSeaStack, args=c("outputformat=raw"),
                  filename=paste0(filePath, '/maxent_predictionJacknife.tif'))

#check model quality using the Boyce Index
predRast <- raster(paste0(filePath, '/maxent_predictionRAW.tif'))
ecospat.boyce(predRast, presTest)
```

ANALYTICAL APPROACH: ENVIRONMENT



Environmental covariates like temperature and bathymetry tend to be spatially consistent over short timescales and are thus easier to view in two (or 3) spatial dimensions. Wind and currents require time to discern vectors' velocity.

PROGRESS & WORKFLOW

Completed:

- visualization of sampling bias
- subregion construction
- computed presence/absence

In Progress:

- visualizing environmental conditions
- separation of the cold pool

To Do:

- raster stack data
- identify testing and training sets
- run maxent
- identify spatial, temporal, environmental drivers