Prediction of Fish Migration Caused by Ocean Temperature Change

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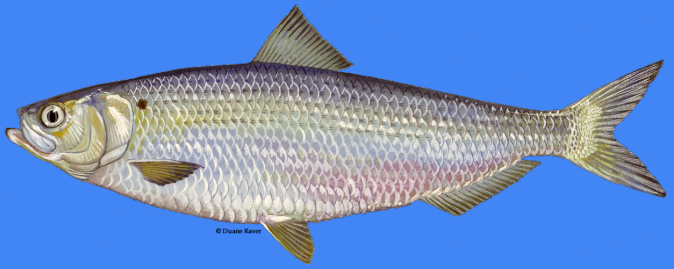
Mackerel



Herring

Introduction

- Two Scotland fish
- Mackerel: 8.86~9.6°C
- Mainly distributed around (5°E, 58.5°N)
- Herring: 8.8~9.8°C
- Mainly distributed around (1.3°W, 60°N)

Introduction

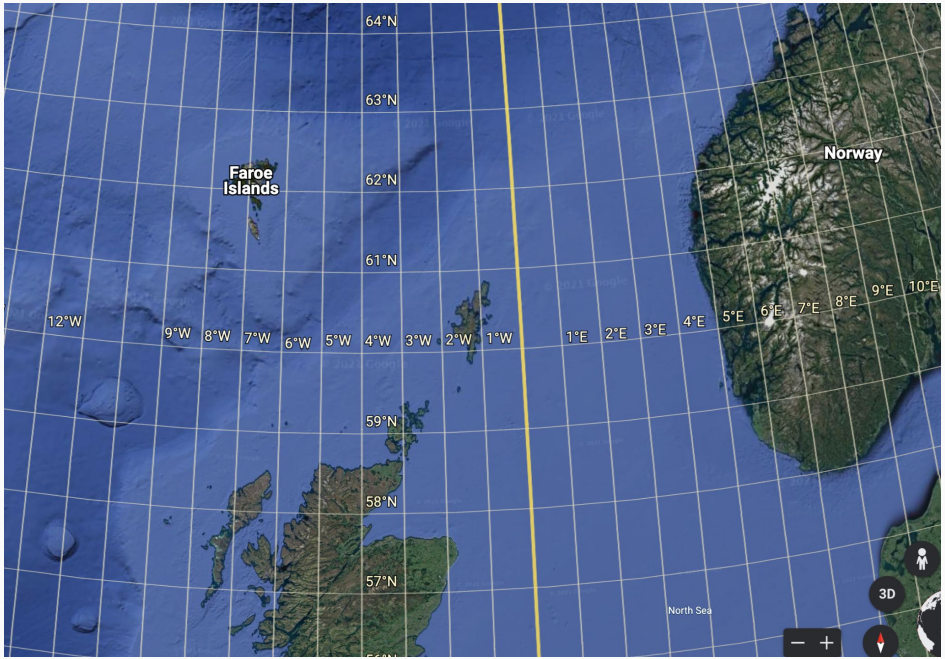
- Rising ocean temperatures
- Moving north
- Small fishing companies: no refrigeration, back in one day
- Prediction of migration location to prevent loss

General Assumptions

- Focus on the sea surface temperature in range “12°W ~ 10°E, 50°N ~ 80°N”
- The suitable temperature of the fishes will not change and will migrate to the sea area where the temperature is suitable
- The population of fishes has the same age, size, swimming capacity and uniform distribution in each region
- Fishes won’t go extinct in the next 100 years
- Humans have conscience
- Some natural factors are neglected

Research Idea:
Temperature by Regions to Locate the Fish

- Subdivided ocean 12°W ~ 10°E, 50°N ~ 80°N into small regions
- Region size: 1°longitude✖1° latitude, 660 regions in total
- Predict future temperature for each region (prediction interval and expected value)



Research Idea:
Temperature by Regions to Locate the Fish

- Limitation of suitable living temperature for fish
- Pinpoint which region to survive
- Target migration position
- Compare the position with the fishing range of companies

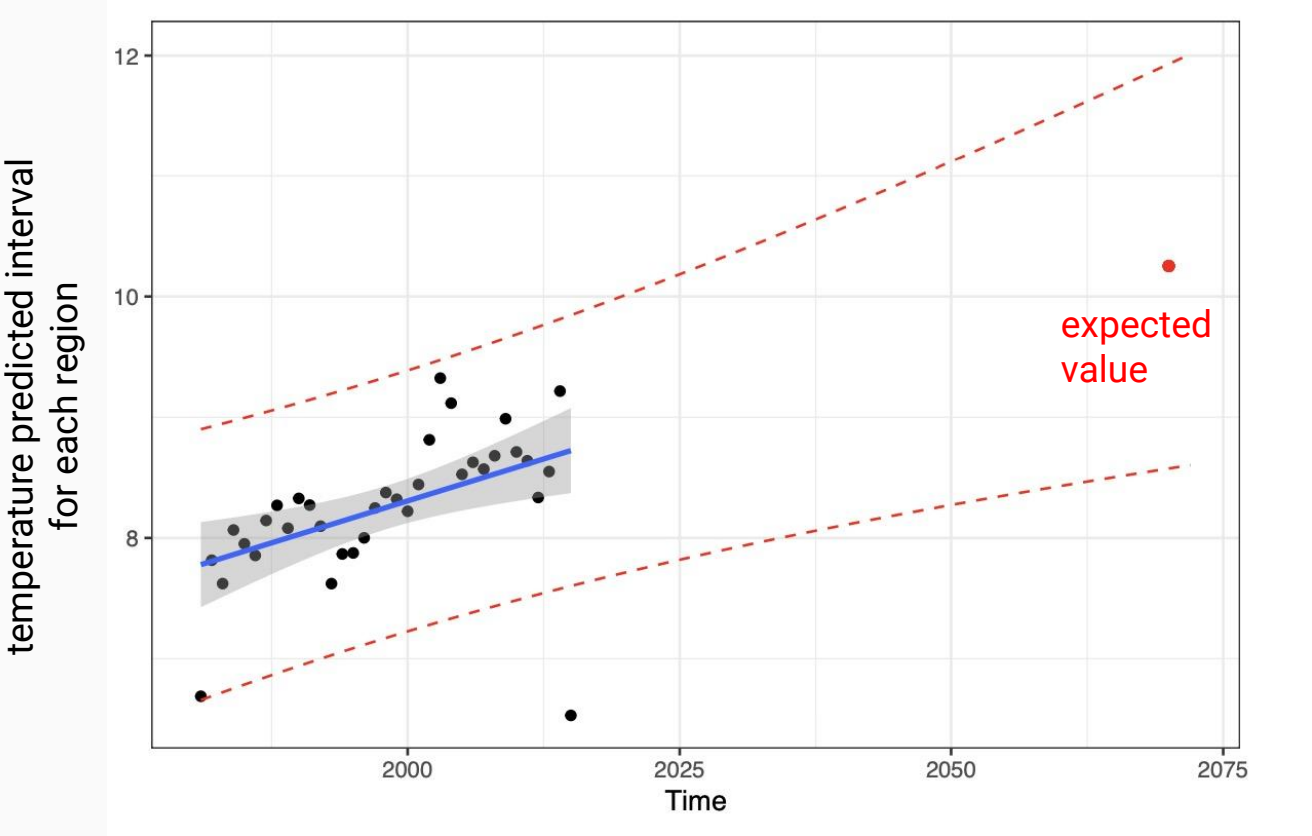
Prediction Interval

The formula of prediction interval:

$$\hat{y_h} \pm t_{\frac{\alpha}{2},n-2} \cdot \sqrt{MSE(1 + \frac{1}{n} + \frac{(x_h - \overline{x})^2}{\sum(s_i - \overline{x})^2})}$$

Modeling Process

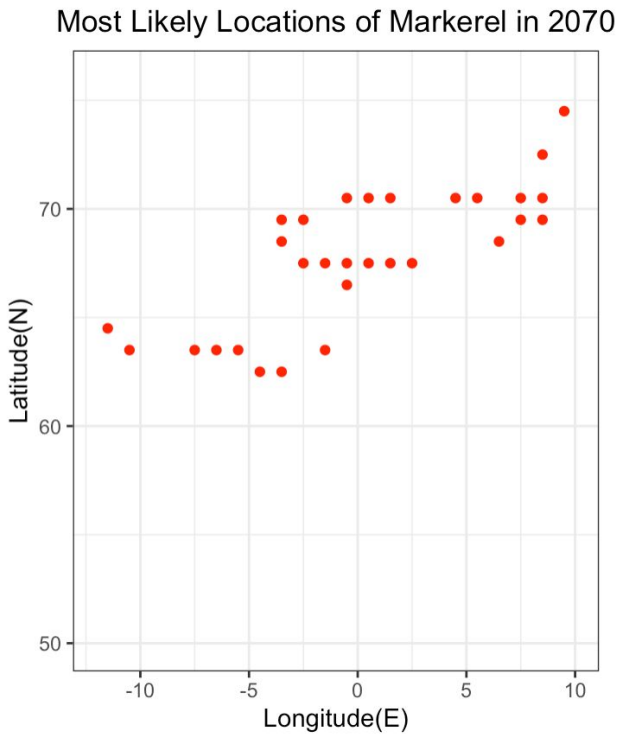
- To predict future temperature for each region, we model on the lower bound and upper bound to include randomness
- For the most likely temperature for each region, the expected value is shown



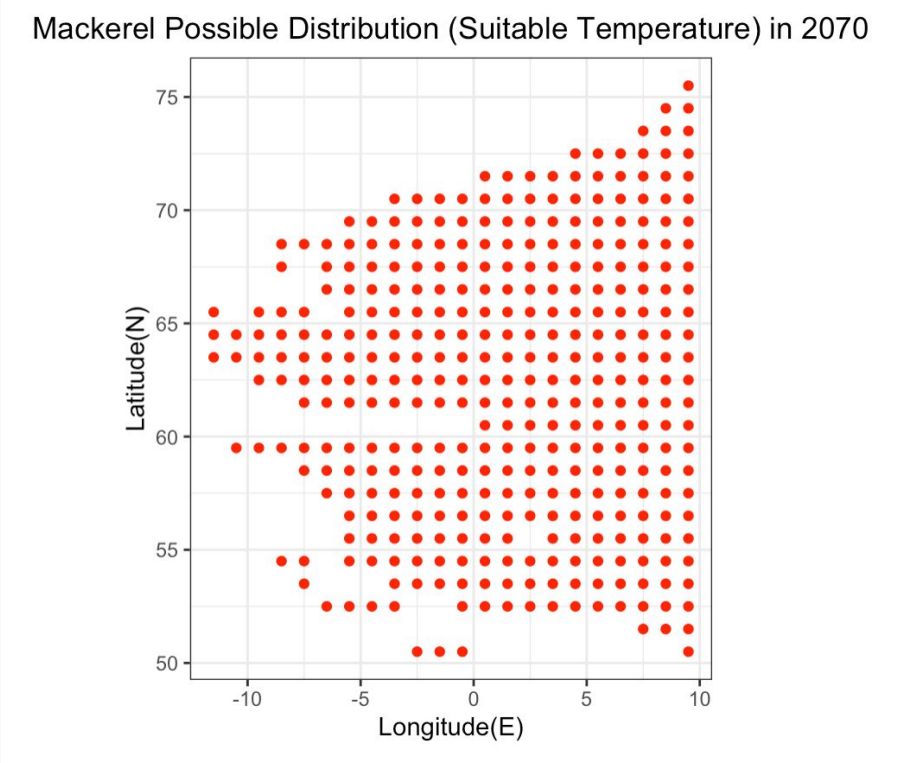
2070 Predicted Temperature Interval and Expected Value for Each Region

Model on Mackerel Distribution in 2070

Expected Value

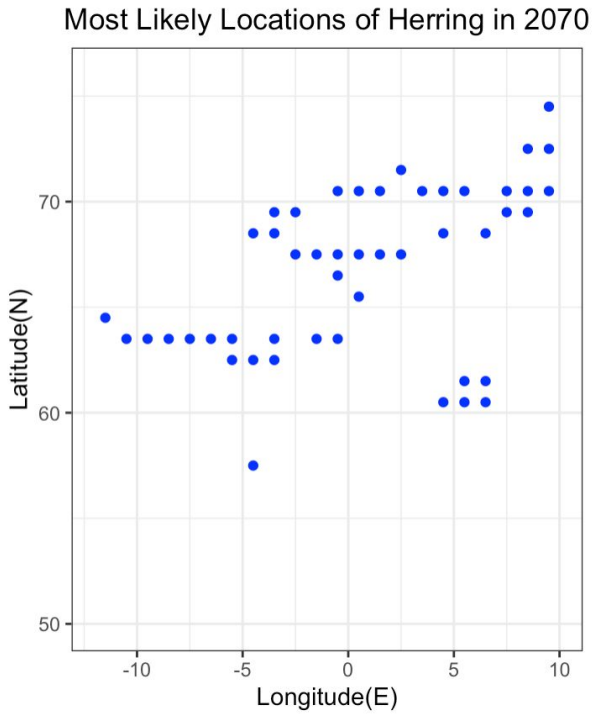


Lower bound and Upper bound (Prediction Interval)

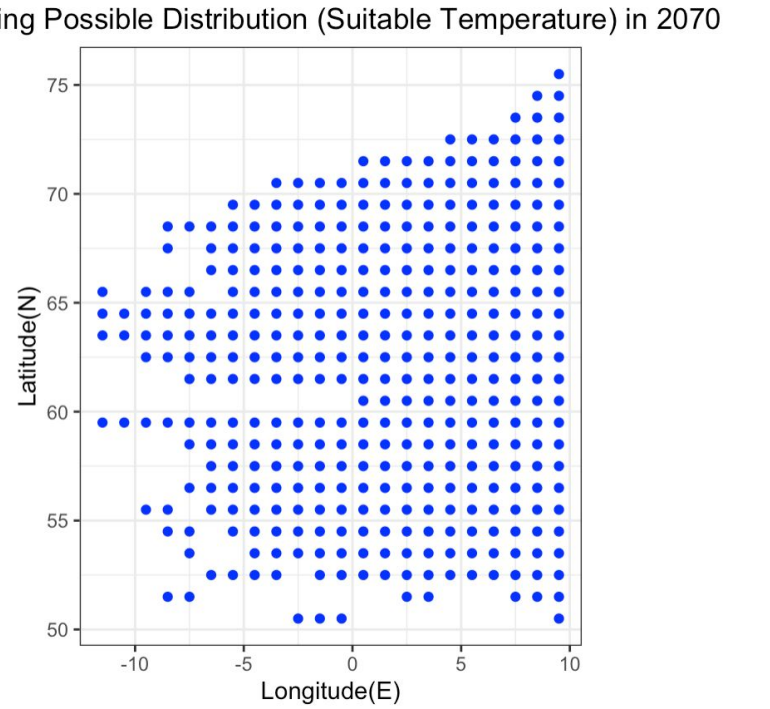


Model on Herring Distribution in 2070

Expected Value



Lower bound and Upper bound (Prediction Interval)



When will the fishing companies be unable to harvest?

- Fishing companies location: Inverness Harbour, 57.4908° N, 4.2331° W
- Fishing range estimated by fuel range
- 1 gallon for 3 miles
- Fishing range: radius 500 miles, center at the harbour

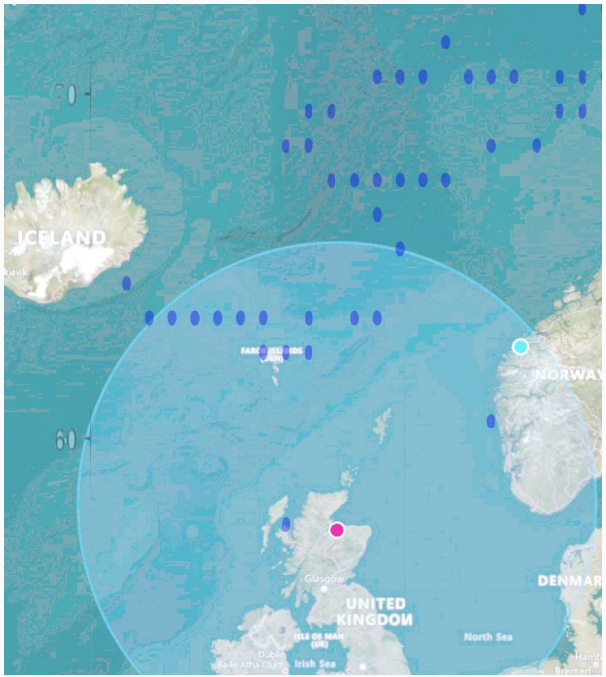
Best, Worst, and Expected Elapsed Time

- Videos below: northward migration of both species
- Best case: southern bound; Worst case: northern bound

Youtube link for the mackerel video: https://youtu.be/mnCoqY1DGYM
Youtube link for the herring video: https://youtu.be/iXpgTCZq1fA

Fishing Range and Fish Locations - 2070

Mackerel



Scottish Herring

Best, Worst, and Expected Elapsed Time

Category	Expected Case	Best Case	Worst Case
Mackerel	2060	2070+	1997
Scottish Herring	2045	2070+	2000

Proposals for Fishing Companies

- Connect with local companies for larger vessels
- Enter the territorial waters of Iceland and Norway, collaborate with their fishing companies
- Offshore ports

Retrieved from: https://www-gs.llnl.gov/energy-homeland-security/cargo-inspection

Limitations and Future Research

- Unpredictable human activities and environment
- Lack of actual locations of mackerel and herring in recent years
- Movement of other species due to temperature change
- Expand to a larger context

The End