

# **What are models**

**REM 412/661 - Environmental Simulation Modelling**

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# Question

- What are some environmental, or resource problems that you hope/plan/expect to work on in the future?





# Question

What do these problems have in common?



# Question

**What do these problems have in common?**

**THEY ARE COMPLEX!**

To determine the location and size of a forest cut block, you might consider:

- tree species  
trunk diameter  
tree growth rate  
climate change predictions  
distance from road  
distance from stream  
sensitive species  
invasive species  
local environmental values  
sight lines  
local expertise
- **Can you hold all these things in your head and consider them all?**

# Question

**What do these problems have in common?**

**Impacts are in the future**

Should you set limits on carbon use?

- Questions:
  - What are long-term impacts on economy?
  - How will the workforce transition?
  - Will jobs go elsewhere?
  - What are impacts on the environment?
  - What are impacts on the insurance industry? Banking? Infrastructure?
- **Can you measure these things proactively?**



# Question

**What do these problems have in common?**

**Several possible options**

How can you set economic policy

- Questions:  
Cap-and-trade?  
Neutral tax?  
Carbon tax to fund transition?  
Anything at all?

# Question

**What do these problems have in common?**

## **Data are uncertain**

All data are uncertain (you sample from the broader population) or limited/absent

Uncertainty in data contributes to uncertainty in impact assessment or forecast

For example, which \$10,000 investment would you choose?

- Option 1: chance of gaining \$10,000
- Option 2: guaranteed gain of \$500

# Question

**What do these problems have in common?**

## **Data are uncertain**

All data are uncertain (you sample from the broader population) or limited/absent

Uncertainty in data contributes to uncertainty in impact assessment or forecast

For example, which \$10,000 investment would you choose?

- Option 1: 20% chance of gaining \$10,000; 80% chance of losing \$2,000
- Option 2: guaranteed gain of \$500



# Why do we need models?

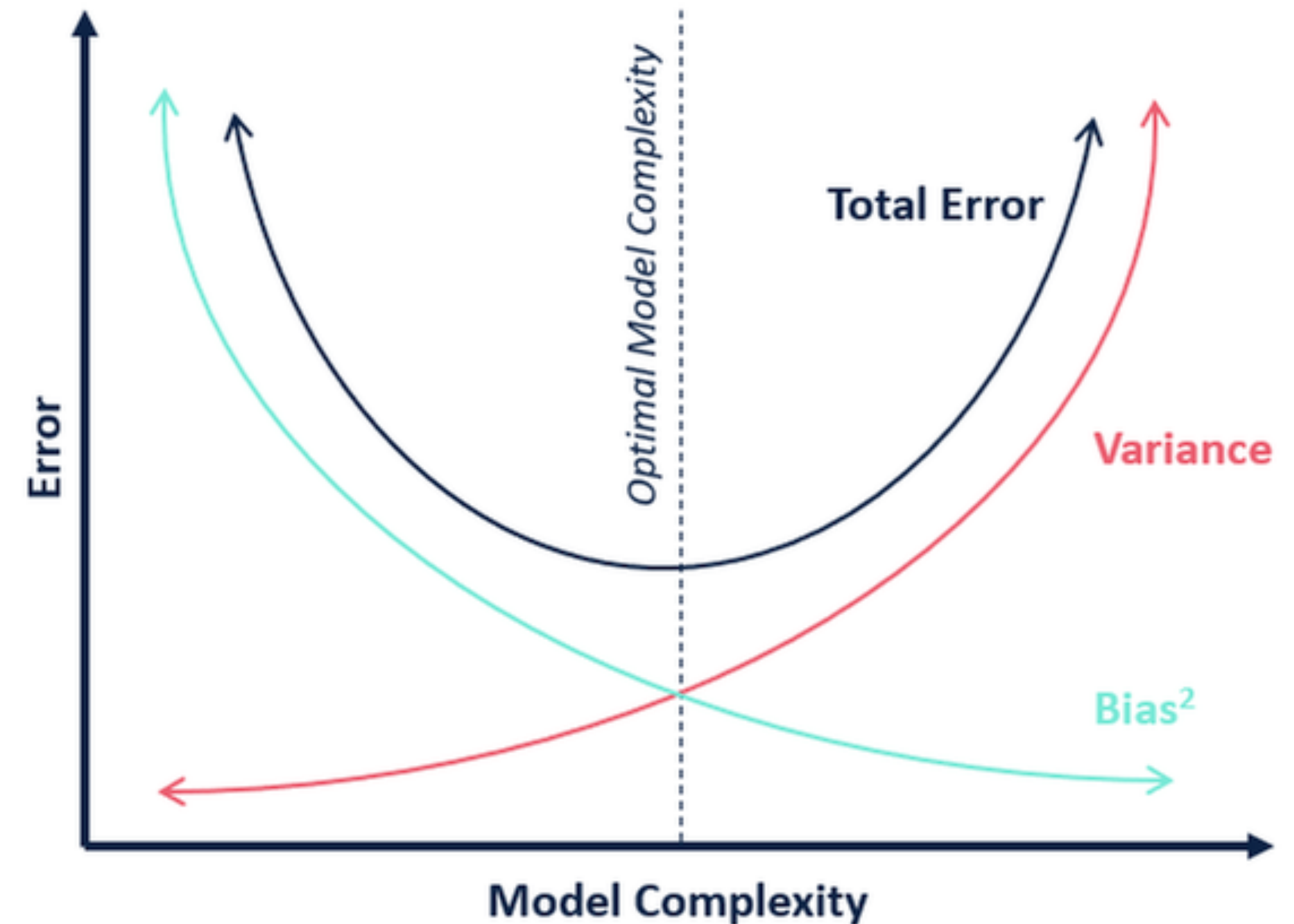
- Real-world problems are complex
- We are often interested in future impacts
- Want to evaluate options
- Data can be limited, uncertain, or absent

# What are models?

- **A Model** is a simplified description or representation of a real process, phenomenon, or object

# Occam's razor

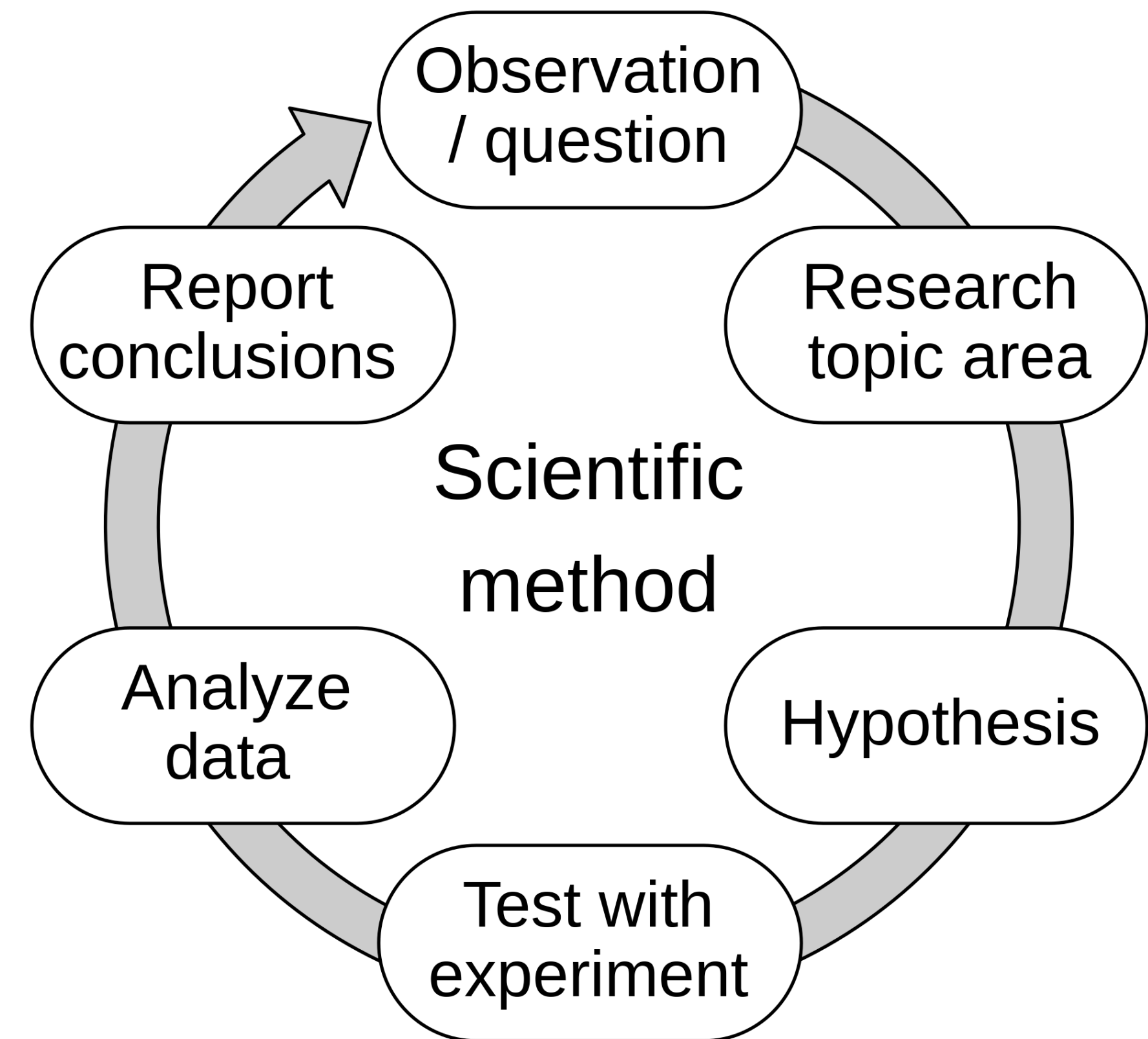
- “All things being equal, the simplest solution tends to be the best one”
  - William of Ockham
- Simpler theories are preferable because they are more testable
- “[A model] should be as simple as possible and yet no simpler”
  - Albert Einstein





# How are models used in the scientific process?

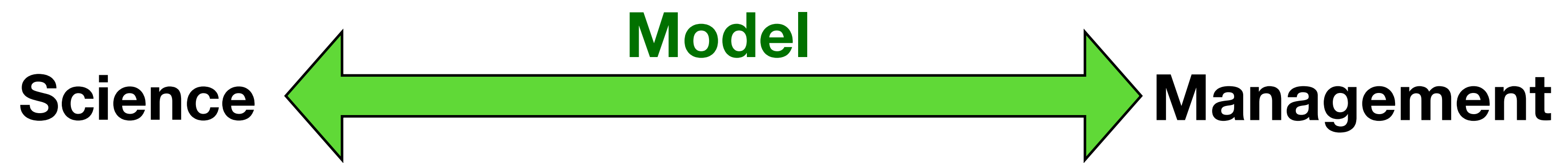
1. Document the state of knowledge on a certain topic
2. [Mathematical] models formalize the state of knowledge in an explicit fashion
3. Models are the starting point for the formulation of an hypothesis
4. Testing an hypothesis can lead to a new model



Wikipedia

# What is the role of models in environmental management?

- Learn and enhance knowledge
- Forecasting: assist decisions by predicting consequences of proposed control actions (what-if scenarios)
- Informed decision-making: compare various management decisions without affecting the real system
- Identify knowledge gaps and areas of uncertainty
- Make quantitative estimates





# Types of models

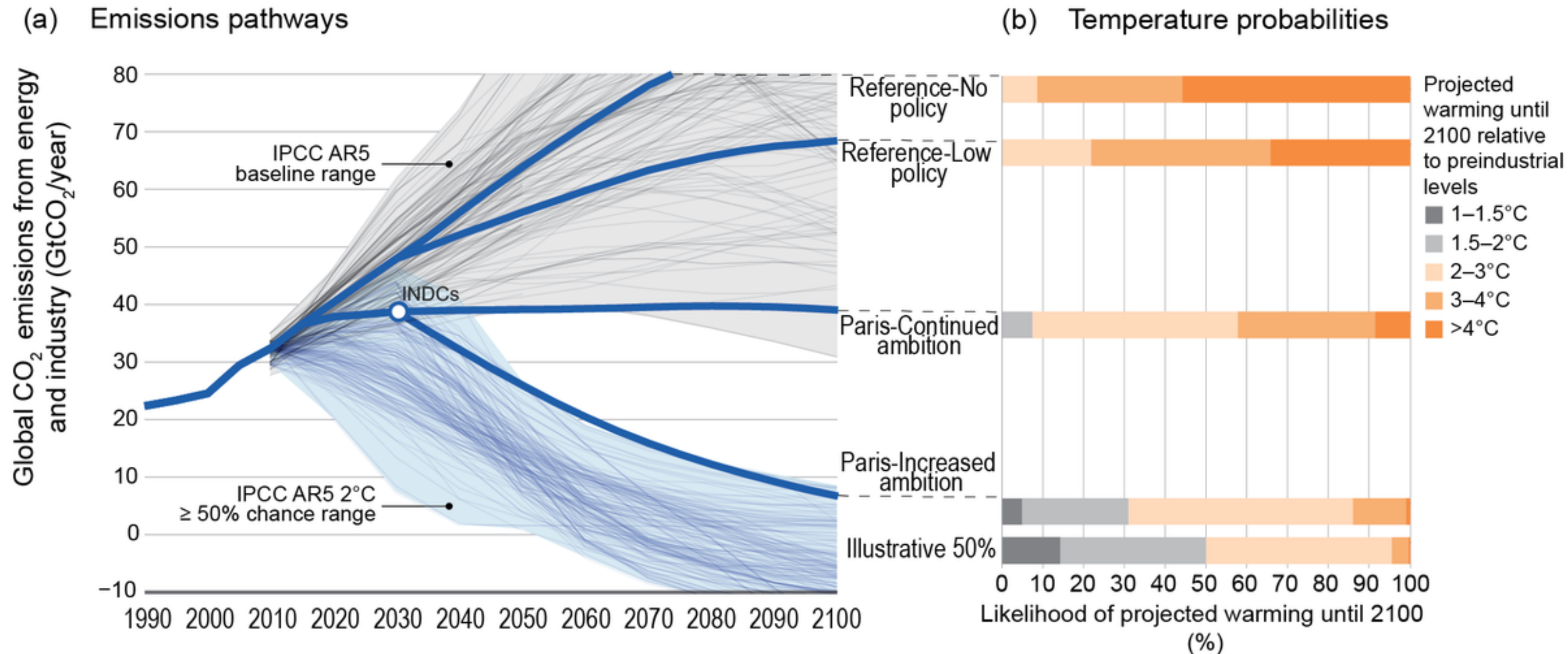
## Deterministic models

- Determined at the beginning
- No uncertainty
- Can be used in extrapolation
- Model outcomes are computed exactly
- Repeated model outcomes are the same

# Types of models

## Stochastic models

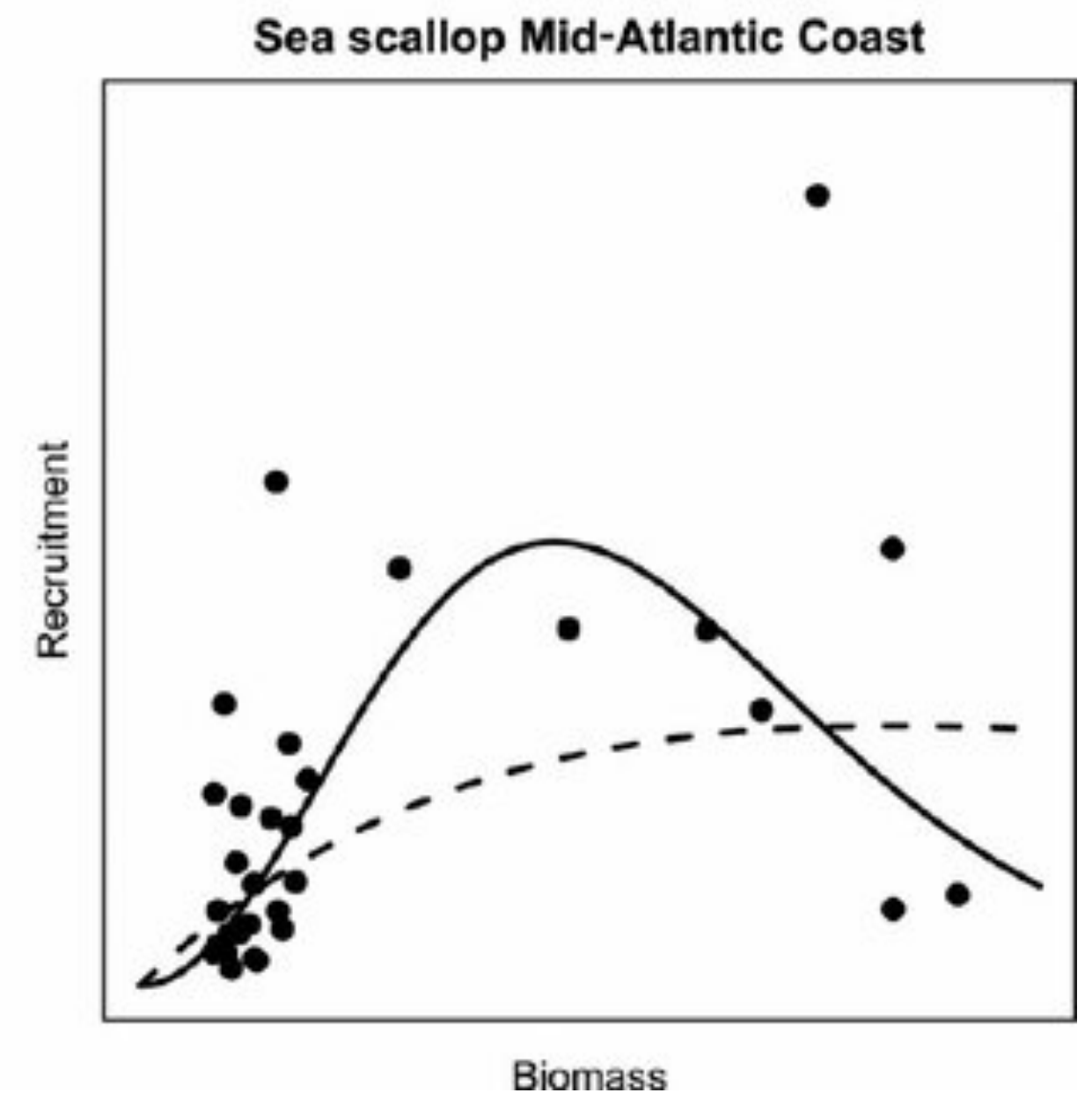
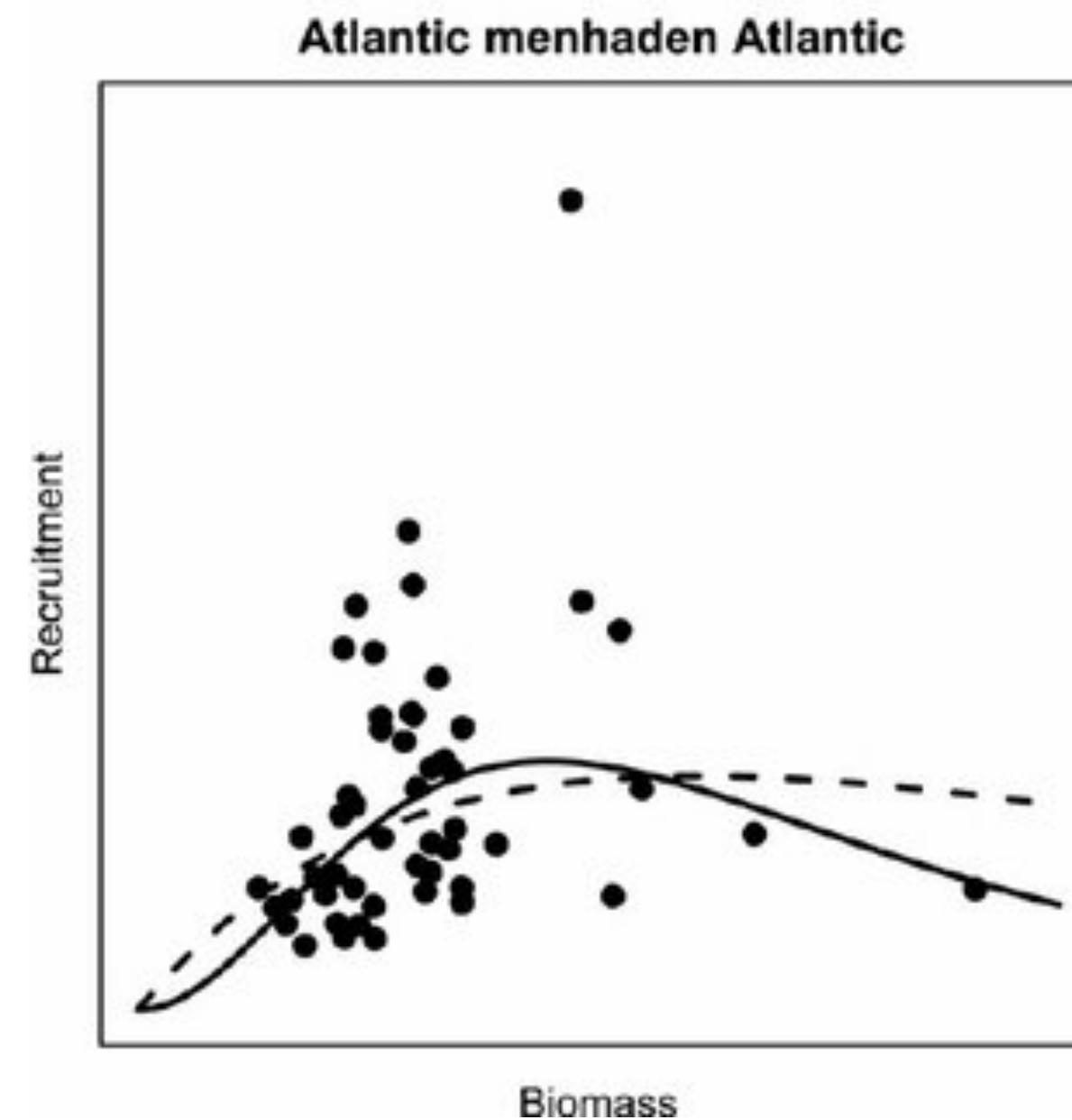
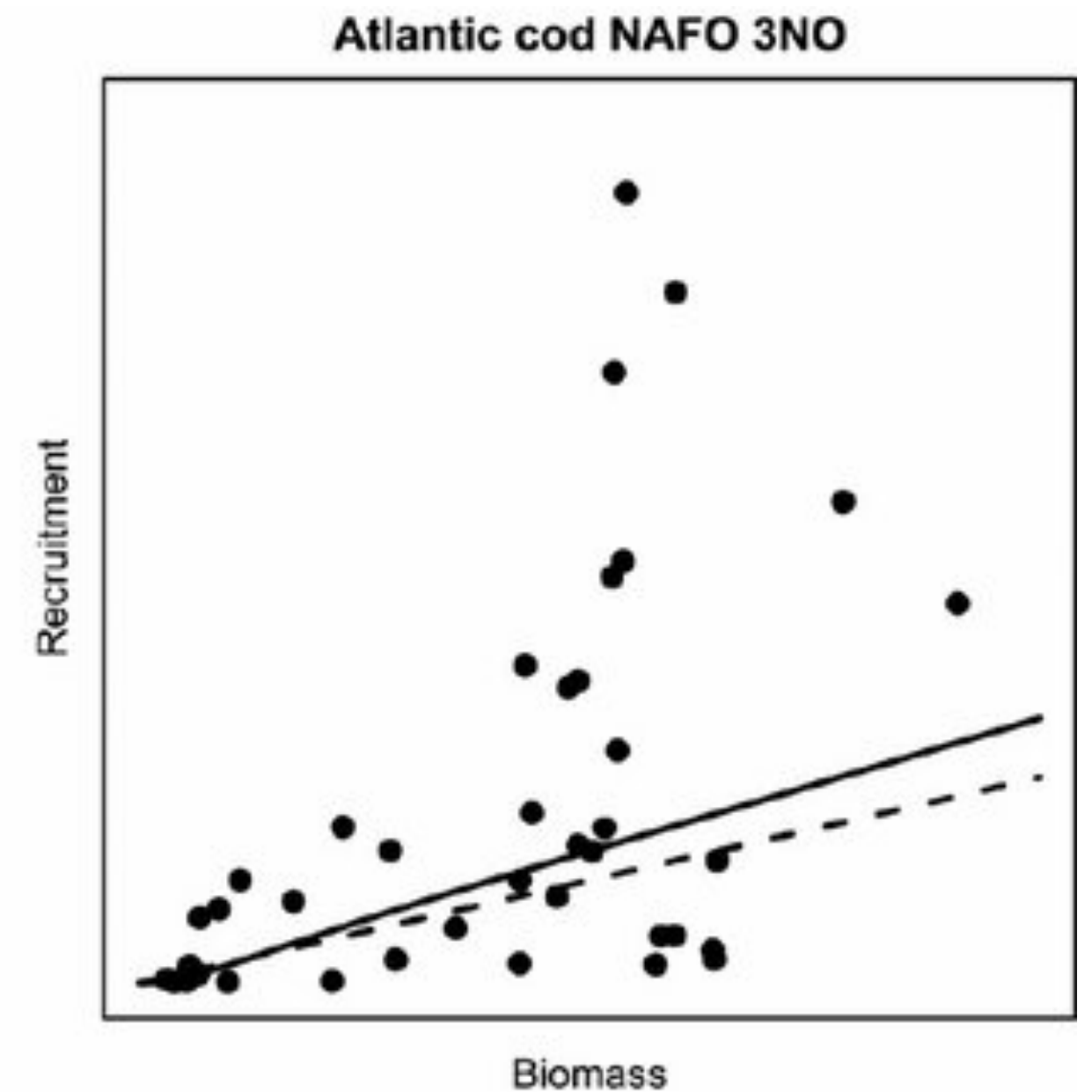
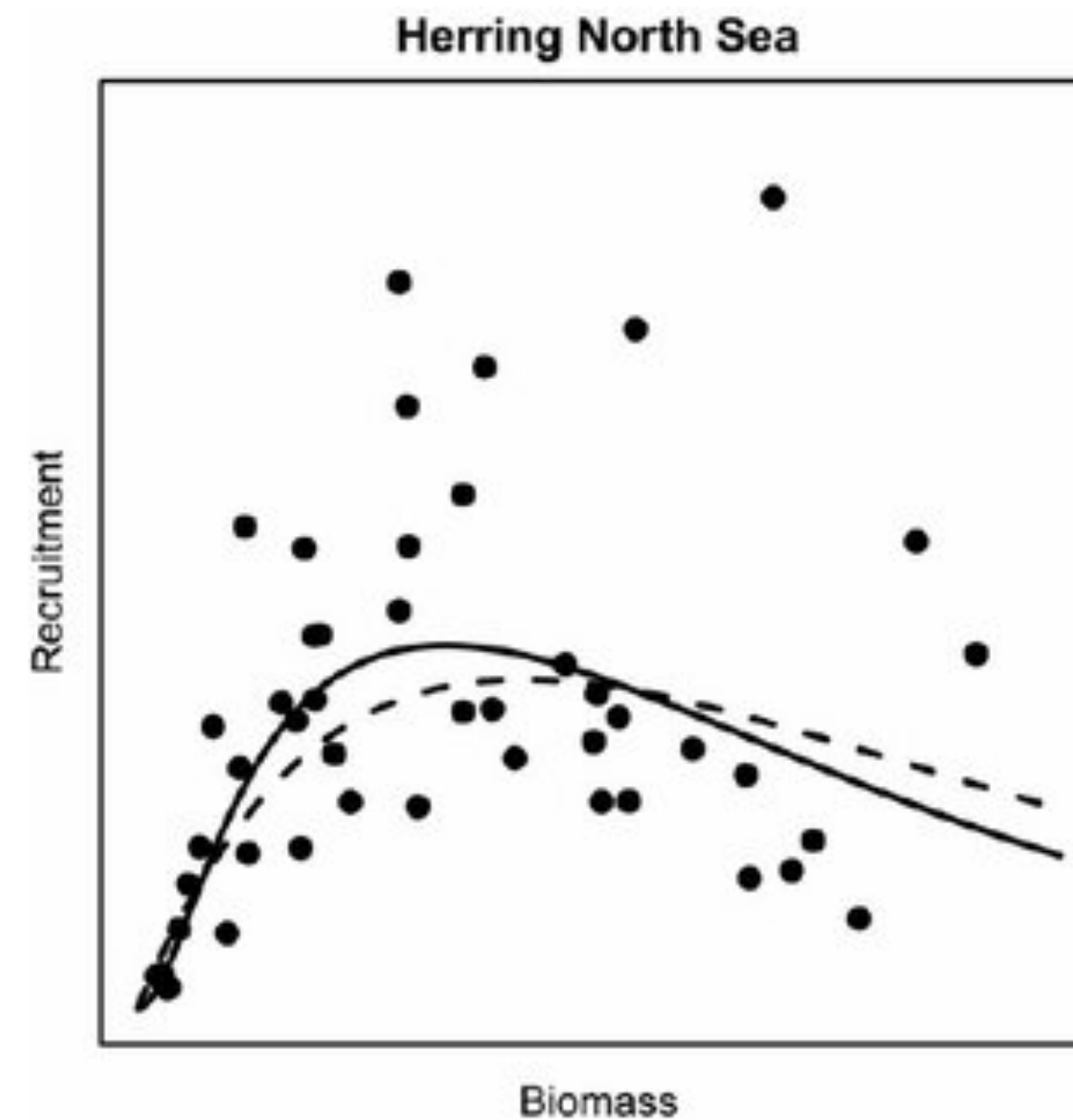
- Outcomes depend on a probability distribution
- Repeated model outcomes are not the same
- Used to determine likelihood, probability, and uncertainty



# Types of models

## Empirical models

- Based on site and/or temporally-specific observations regarding the relationship between an external variable and state variables
- Not causal
- used for interpolation





# Summary

Models are useful to us because environmental problems are

- complex
- uncertain
- involve many options
- may come with poor data

Models are an integral part of the scientific process

Models are integral to understanding the environment

There are multiple types of models