



Introduction to Modeling

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About me



2010 – Slept through Lotka-Volterra



2011 – Missed 3 weeks of first R course



2012 – Skipped GLMs for machine learning



2013 – Finally learned most things are LMs



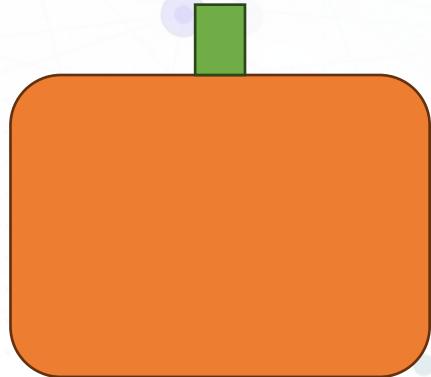
2015 – Learned some TMB



2017+ – “Learned” STAN

what are models?

A model is an abstraction of something



Realistic

Abstract

what are models?

Draw a shark!



what are models?

Draw a shark again!



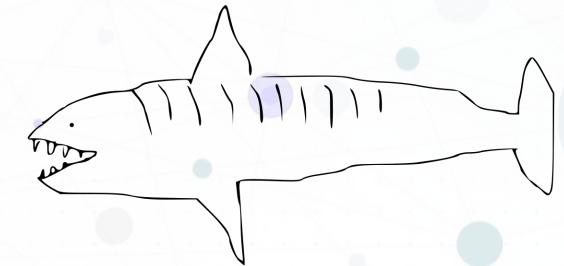
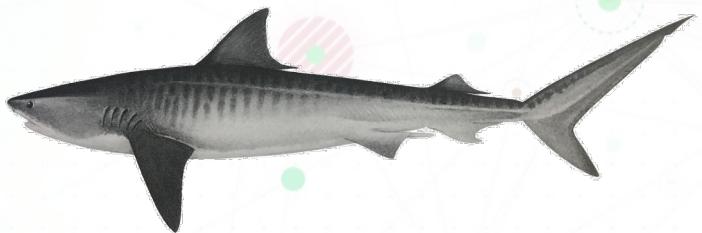
what are models?

Add to your first shark!



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Realistic

Abstract

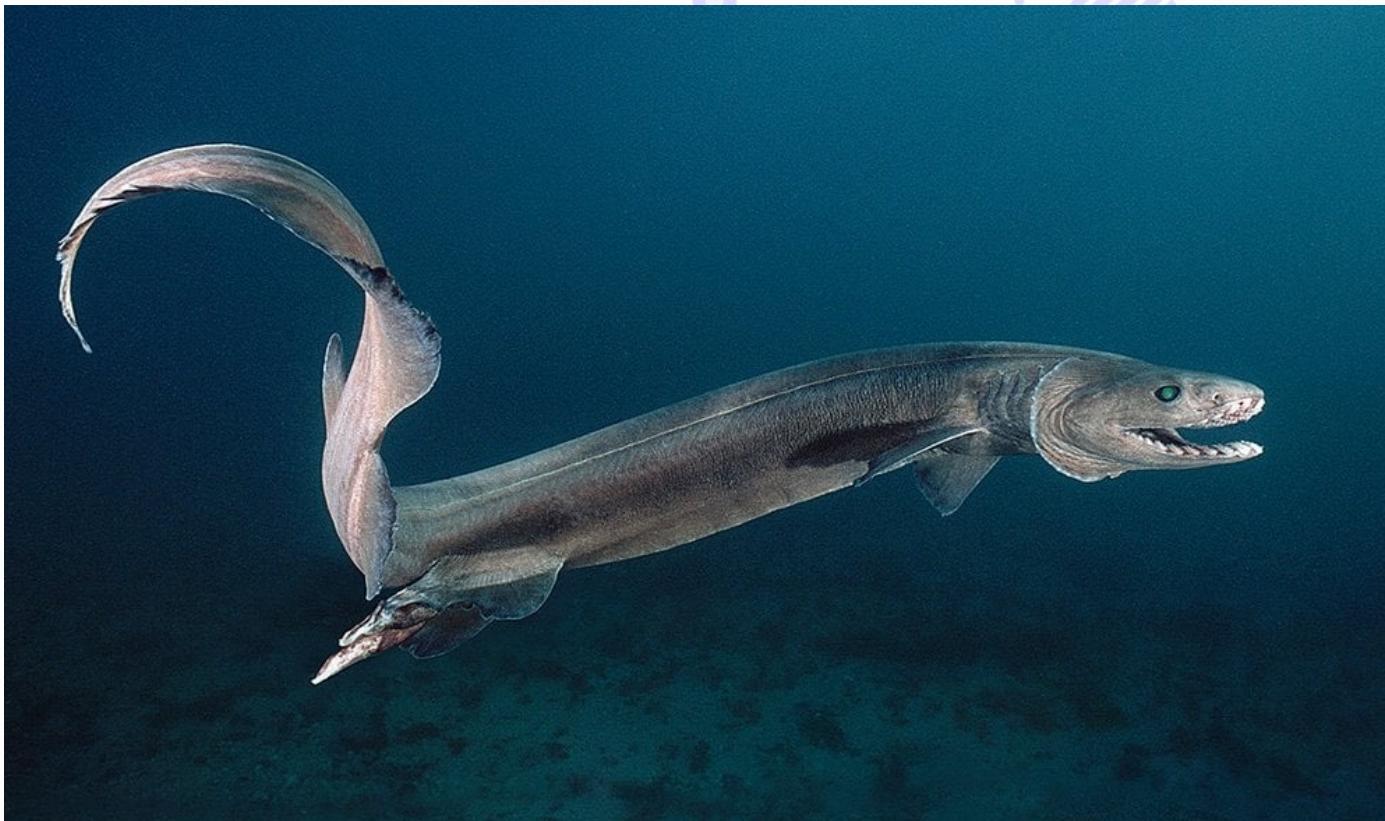
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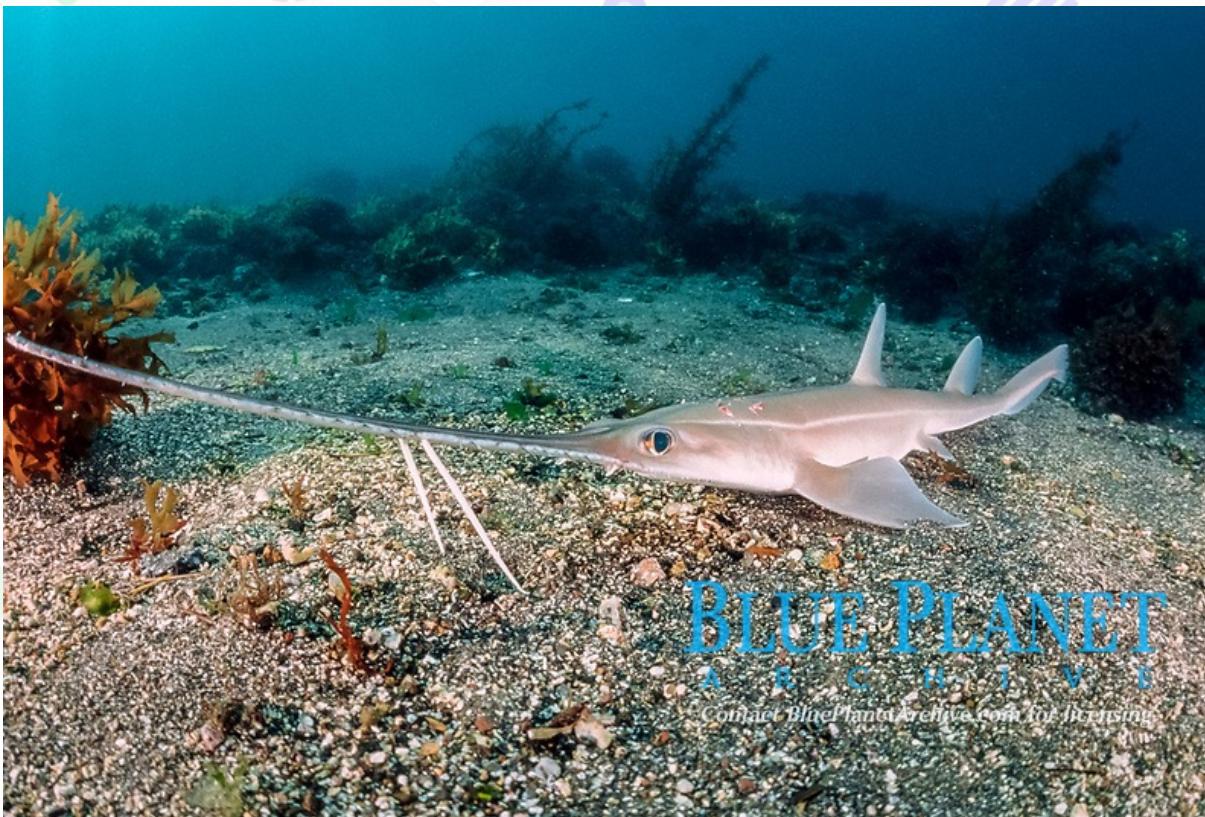
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what are models?

In ecology/natural resources:

A model is an abstract description of a natural system that (attempts) to capture features essential for addressing the modeling objectives

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The **model** depends upon the **objectives** ←

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Abstraction is the process of modeling...

What do you include? How do you represent it?

what are models?

In ecology/natural resources:

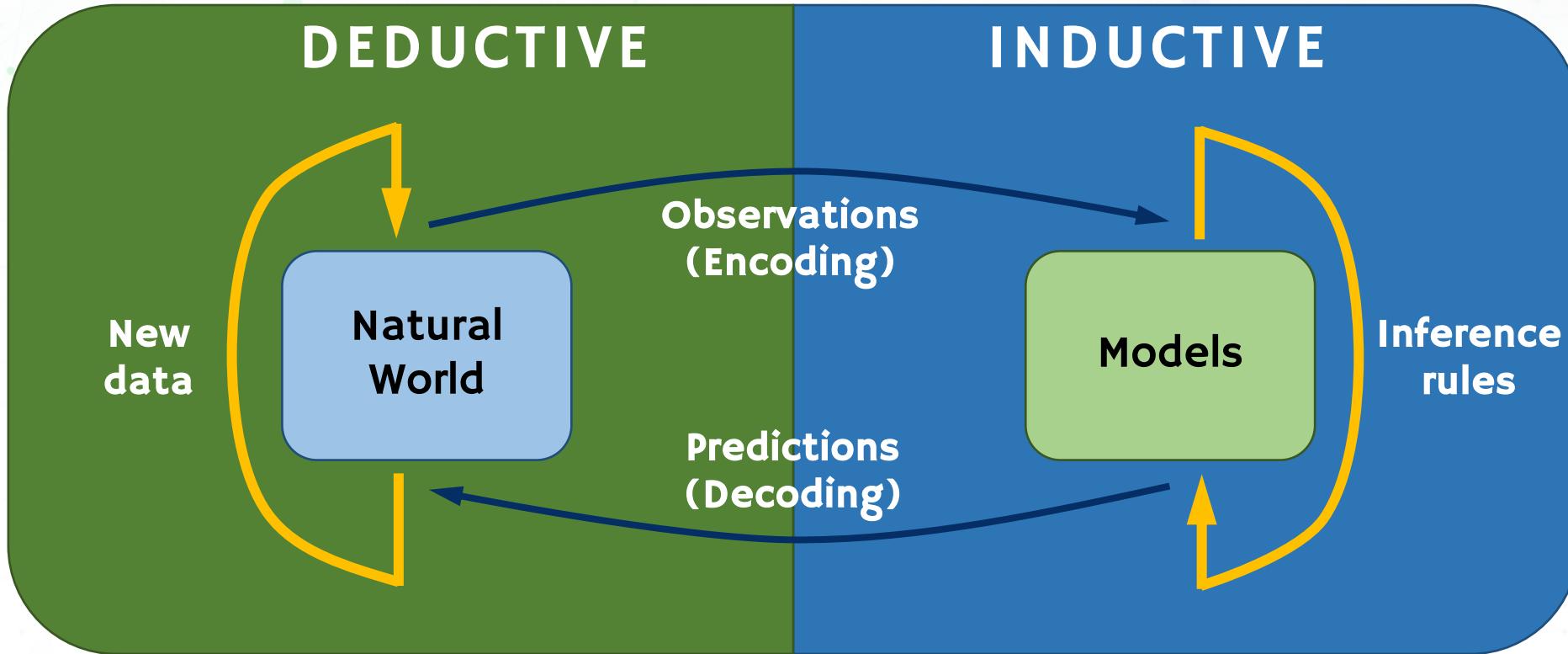
A model is an abstract description of a **natural system** that (attempts) to capture features essential for addressing the modeling objectives

The **model** depends upon the **definition** of a natural system

Abstraction is the process of modeling...

What do you include? How do define boundaries?

Philosophy



Casti (1992)

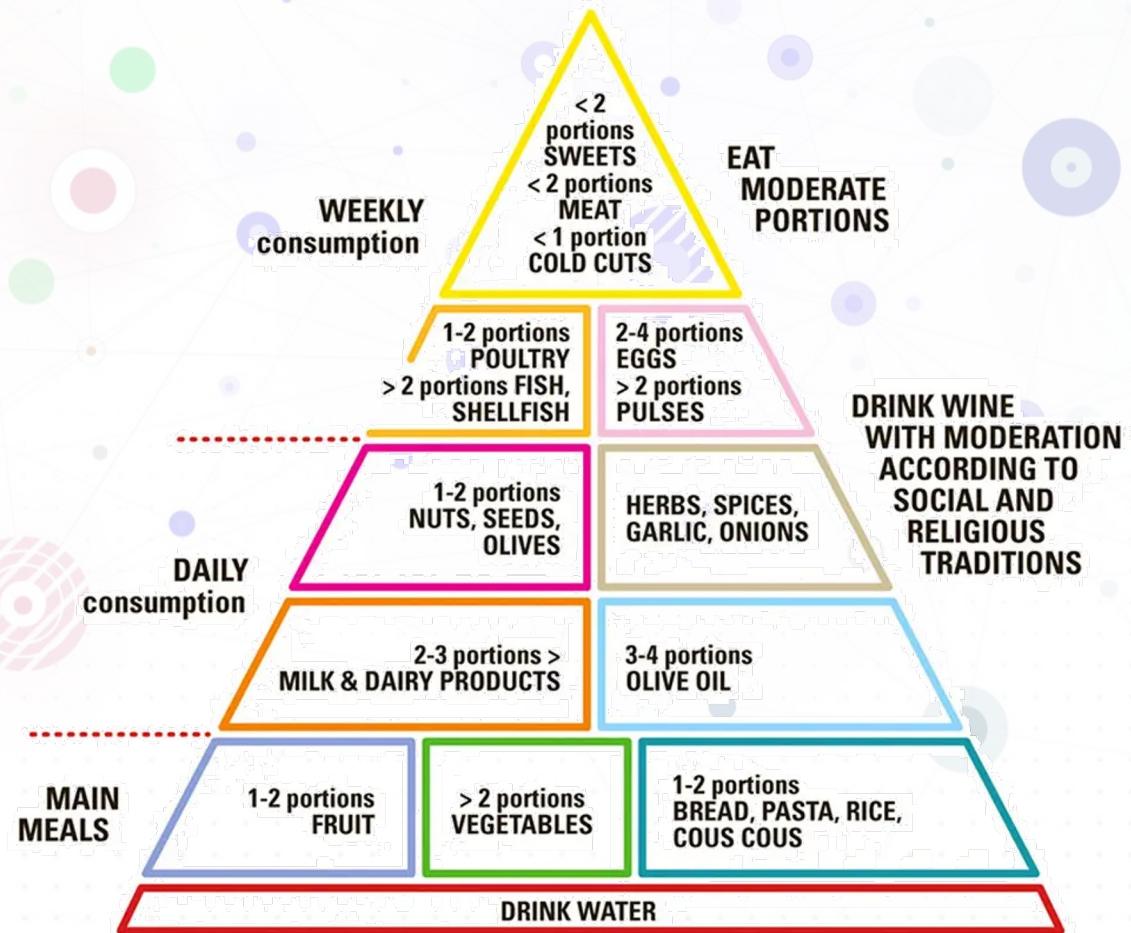
Encoding – Decoding relationship

Mentis (1988)

Deductive – Inductive cycle

Types of models

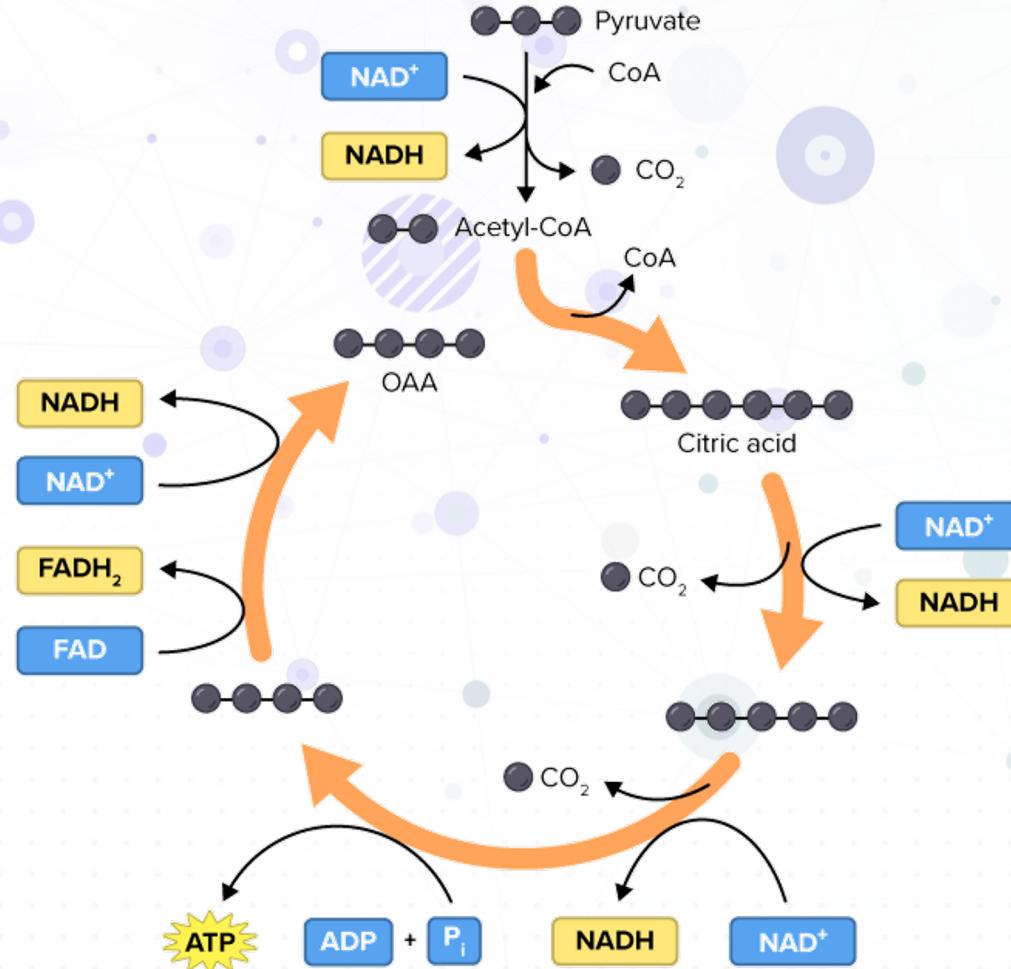
Conceptual



Types of models

Diagrammatic

- Process diagrams
- Flow diagrams
- Concept Maps
- Time lines
- Forrester Diagrams



Types of models

Physical Models



Types of models

Formal Models

- Typically, mathematics

$$L_t = L_\infty \left(1 - e^{-k(t-t_0)} \right)$$

Formal models

Axes of mathematical models

- Qualitative vs. quantitative
- Empirical vs. mechanistic
 - Are we explicitly writing out the mechanism?
- Static vs. dynamic
 - How do we handle future states?
- Temporally discrete vs. continuous
 - Difference eq., differential eq., algorithms
- Spatially homogeneous vs. heterogeneous
 - Is space represented explicitly?
- Deterministic vs. stochastic
 - Random variables? Environmental & Process error

Philosophy

Cooper (1998)
Ecological Study
Generalizations &
their relation

Causal
(Experimental)

Theoretical
(Formal
Models)

Phenomenological
(Empirical)

Covariates of Interest

Mechanisms

Hypotheses Tests
Hypotheses

Experimental pattern
Causation refinement
Experimental description

Phenomenological
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Philosophy

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Models

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Experimental pattern
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Causation refinement

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Mechanisms

Utility of models



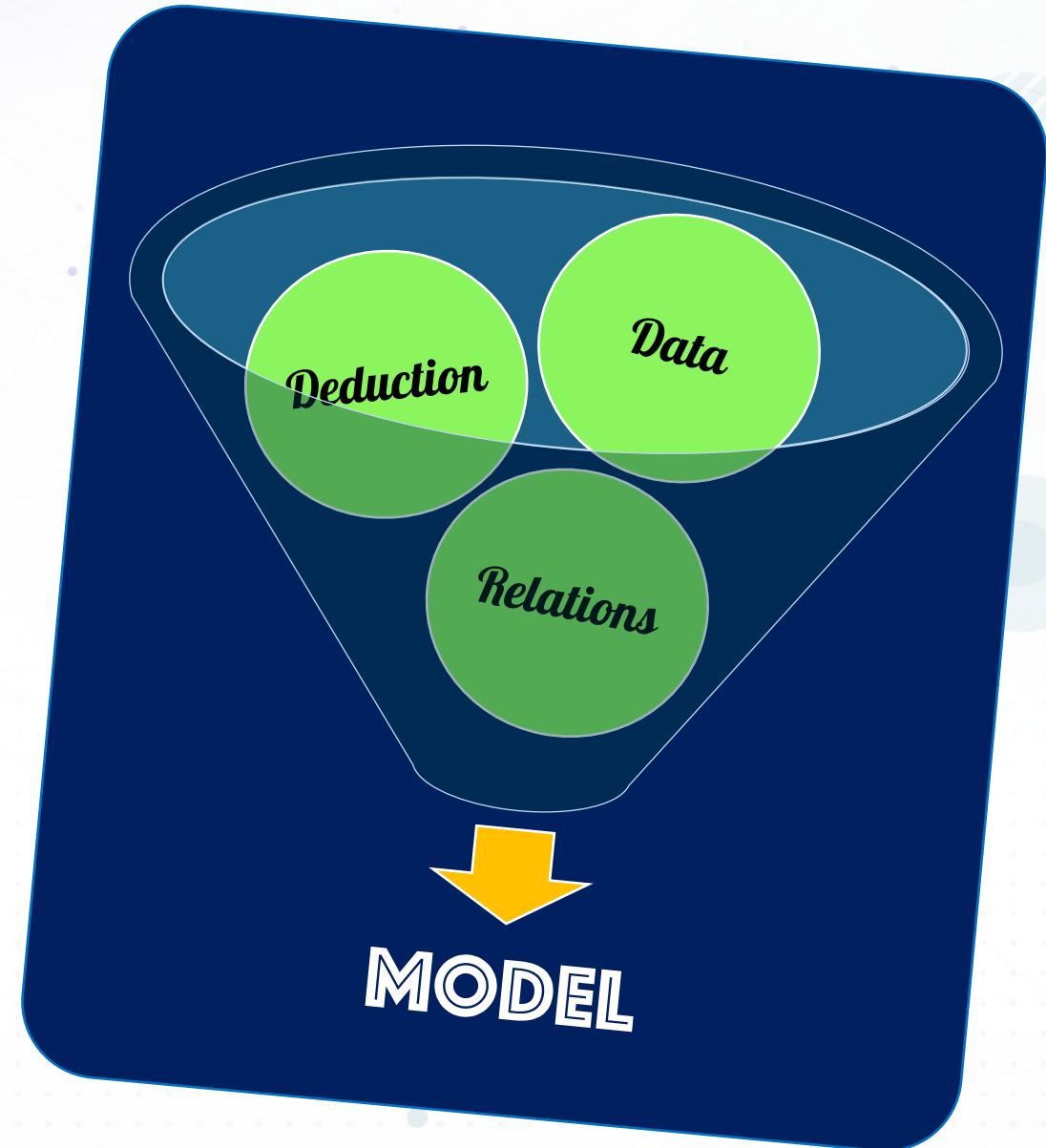
Synthesis & Integration



Prediction & Forecasting



Observation & Experimentation



Utility of models



Synthesis & Integration



Prediction & Forecasting



Observation & Experimentation

WHY I MODEL

Utility of models



Synthesis & Integration



Prediction & Forecasting



Observation & Experimentation

WHAT ARE YOU
HOPING TO USE
MODELS FOR?

Modeling resources

fishmethods

- Ecological Methodology 2nd Edition (Krebs, 1999)
- Analysis and Management of Animal Populations (Williams, Nichols, & Conroy, 2002)
- ■ ■ Introduction to WinBUGS for Ecologists (Kéry, 2010)
- ■ ■ Bayesian Population Analysis using WinBUGS (Kéry and Royle, 2012)



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brms

■ ■ ■ Bayesian Data Analysis 3rd Edition (Gelman et al. 2015)

■ ■ ■ Analytical Methods for Social Research: Data Analysis Using Regression and Multilevel/Hierarchical Models (Gelman and Hill, 2007)

■ ■ ■ Analytical Methods for Social Research: Regression and Other Stories (Gelman, Hill, Vehtari, 2021)

rethinking

■ ■ Statistical Rethinking (McElreath, 2020)



Packages I like

Quality of life

- abind
- dplyr
- lubridate
- reshape2
- parallel/foreach/doParallel

Model output interrogation

- emmeans
- loo
- bayestestR
- DHARMa
- coda

Modeling

- truncnorm/mvtnorm
- glmmTMB
- sdmTMB
- jagsUI
- cmdstanr

Modeling Workflow

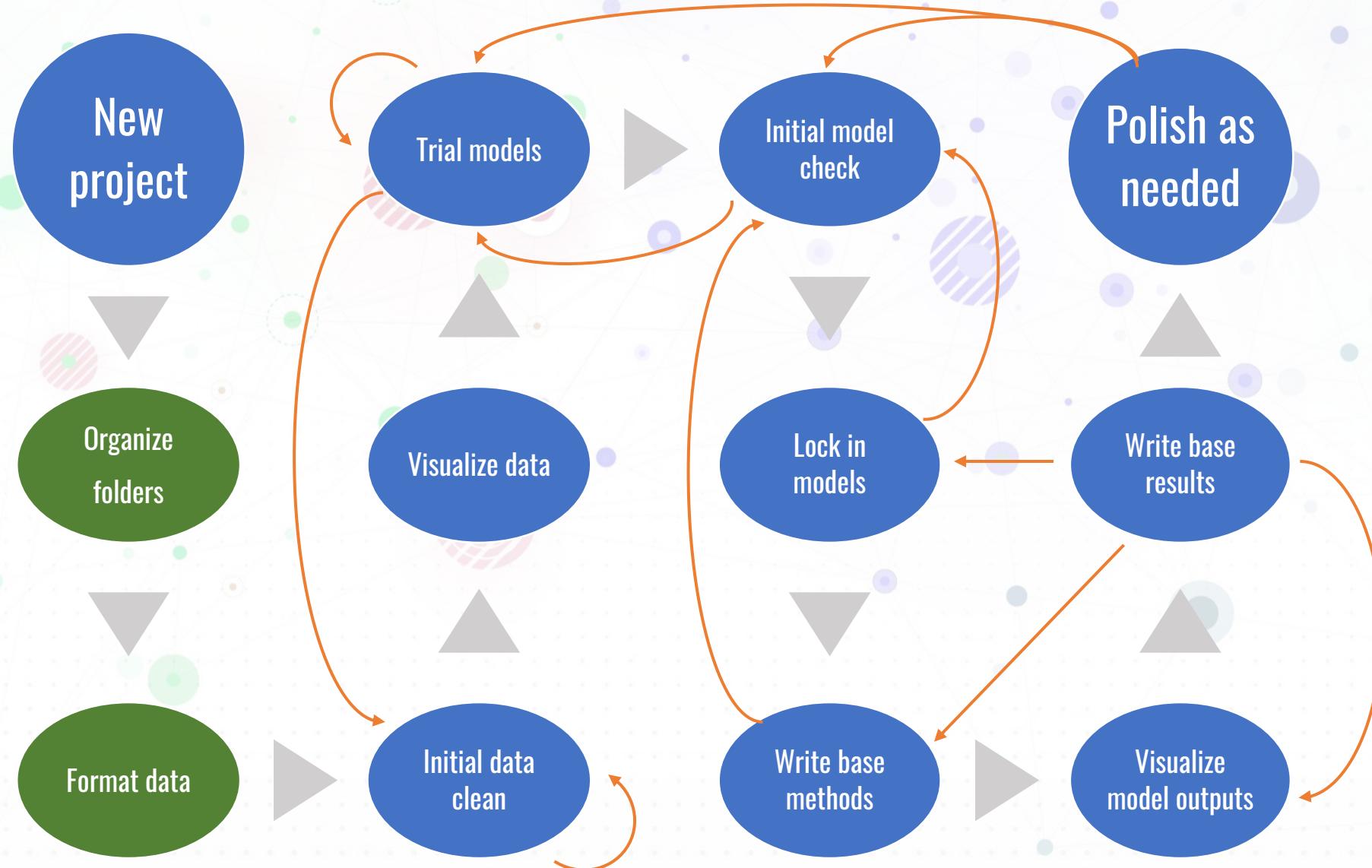
First some tips:

- Organization is key
- Commenting is crucial
- Use some version control
 - From Save As... to GitHub
- Code with the future in mind
- Copy + paste is not your friend
- Keybind find & replace
- Ditch RStudio

Idealized Modeling Workflow



Actual Modeling Workflow



Modeling Workflow

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Everything you'll in developing/presenting models is iterative

Build model → check → fix
Write draft → comments → revise

PLAN AHEAD

Most of my models are run 5+ times before I'm through

- No hard coding -
- functionize -
- write out from R -
- mostly format in R -
- label/comment well -

Repeatability/reproducibility is gold