# Modeling of social & environmental issues

Dr. Eric Edlund

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# Our list of high-level topics to consider

- Immigration
- Food supply
- Forest management
- Poverty
- Air/water pollution
- College debt
- Endangered species
- Political partisanship
- World population
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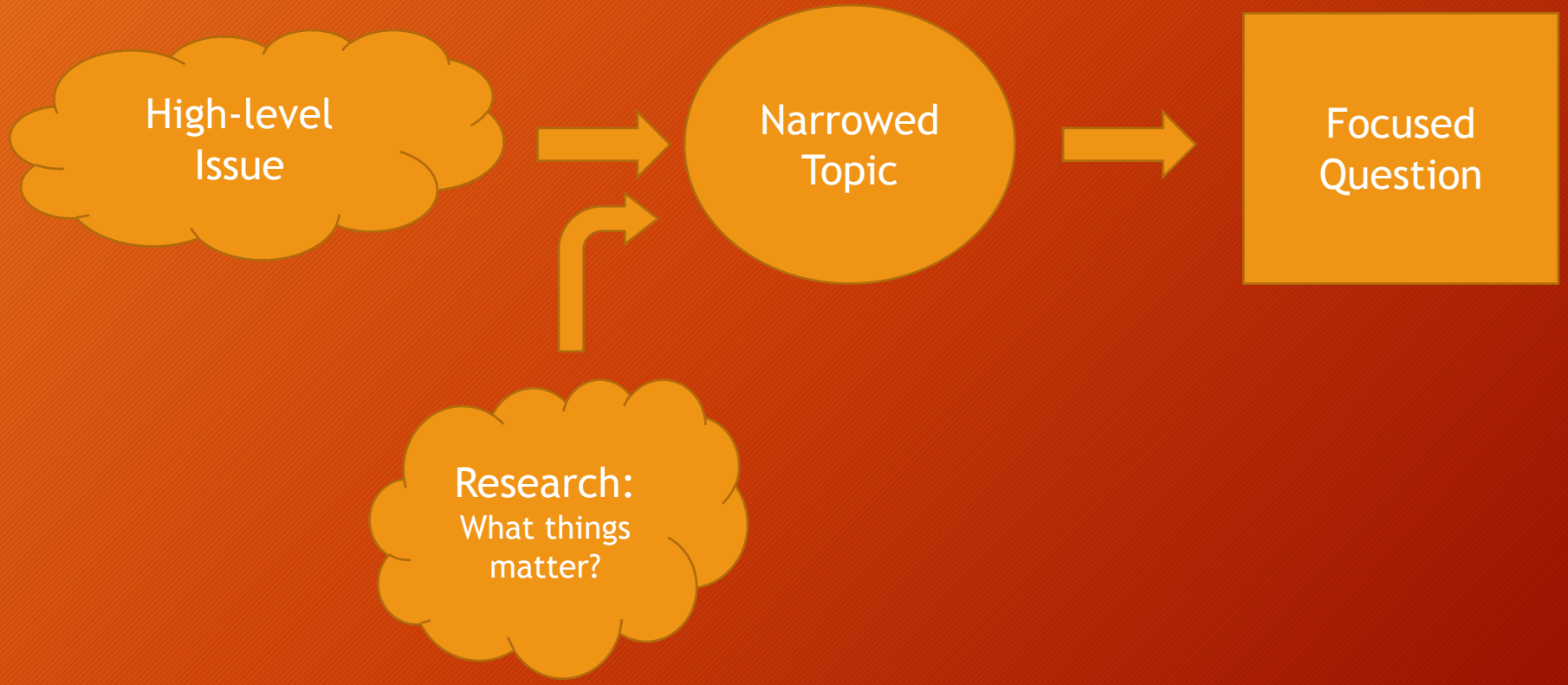

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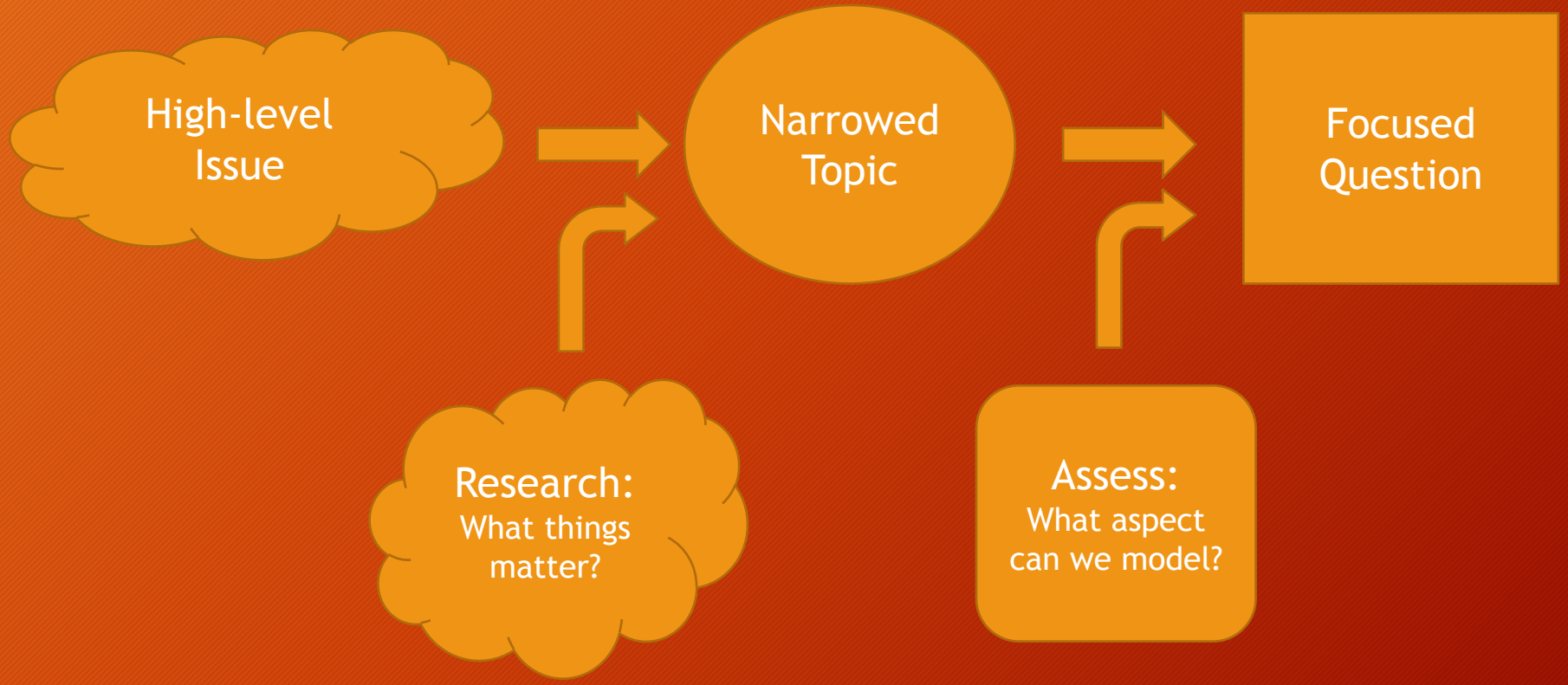

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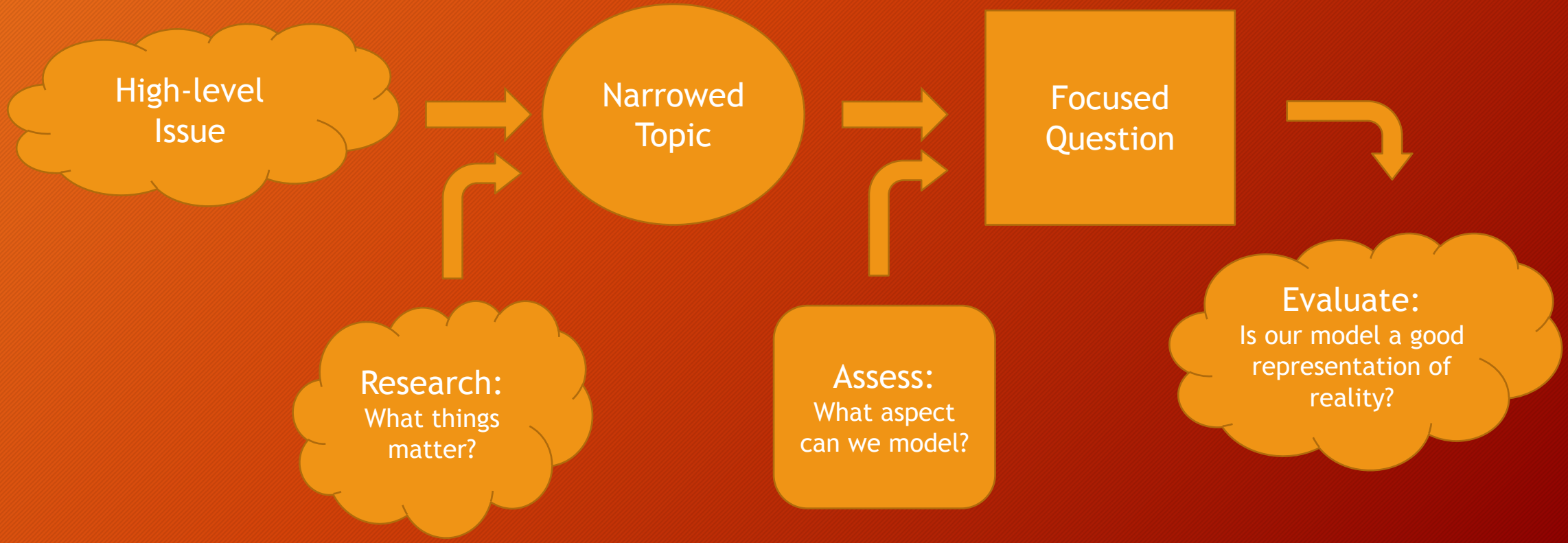

# Example: brainstorming for sustainability

Phase 1a: Define some relevant issues related to the broad topic.

- Sustainable energy
- Sustainable economic growth
- Sustainable resource usage
- Sustainable mind control of a consumer population
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- How might we translate each of these topics into a specific question that can be addressed with further study?
  - Study news trends, review scientific literature, talk to experts, …

# In recent news

https://www.nytimes.com/2019/02/28/climate/fish-climate-change.html


"Fish make up 17 percent of the global population's intake of protein, and as much as 70 percent for people living in some coastal and island countries, according to the Food and Agriculture Organization of the United Nations."

"Warm areas fared even worse when they were overfished. The researchers suggested that overfishing made fish even more vulnerable to temperature changes by hurting their ability to reproduce and damaging the ecosystem."

# Example: brainstorming for sustainability

Phase 2a: Generate a specific question for each well-defined issue.

- How do variations in wind affect the price of electricity?
- How does a carbon tax that depends on the average annual global temperature affect economic growth?
- How does the use of a limited food resource affect population growth?
- How does the implementation of police suppression of riots affect the long-term tendency of a population to revolt?
- How does the number of vacation houses affect one's happiness?

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# The tale of the fish and the fisher-people

Physics 203, Spring 2019

Dr. Eric Edlund

# Creating a model for population interactions

- Basic concepts:
  1. Fish population ($P_F$):
     1. There is some maximum fish population that the oceans can support.
     2. The more fish people eat, the fewer fish there are.
     3. The fish population regenerates on some characteristic time scale (a fish generation).

  2. Human fisher-people population ($P_H$):
     1. People need to eat fish to survive and reproduce.
     2. The growth of the human population depends on how many people there are, and also how many fish they can harvest.
     3. The population grows on some characteristic time scale (a human generation).

# The fish and fisher-people model

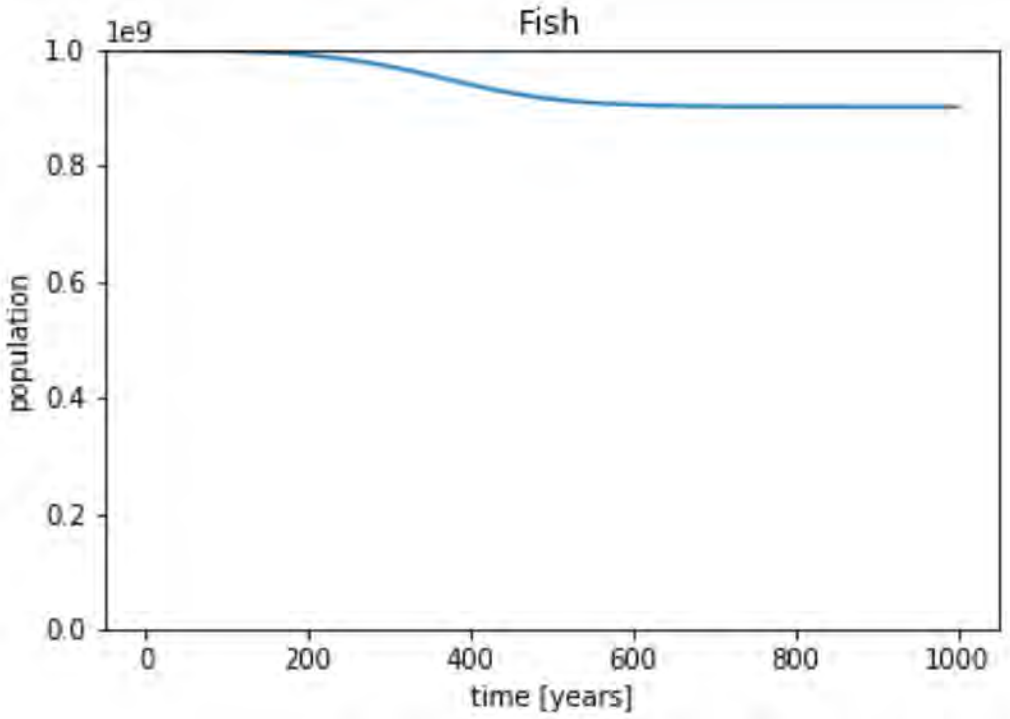
- We make a separate equation for each population:

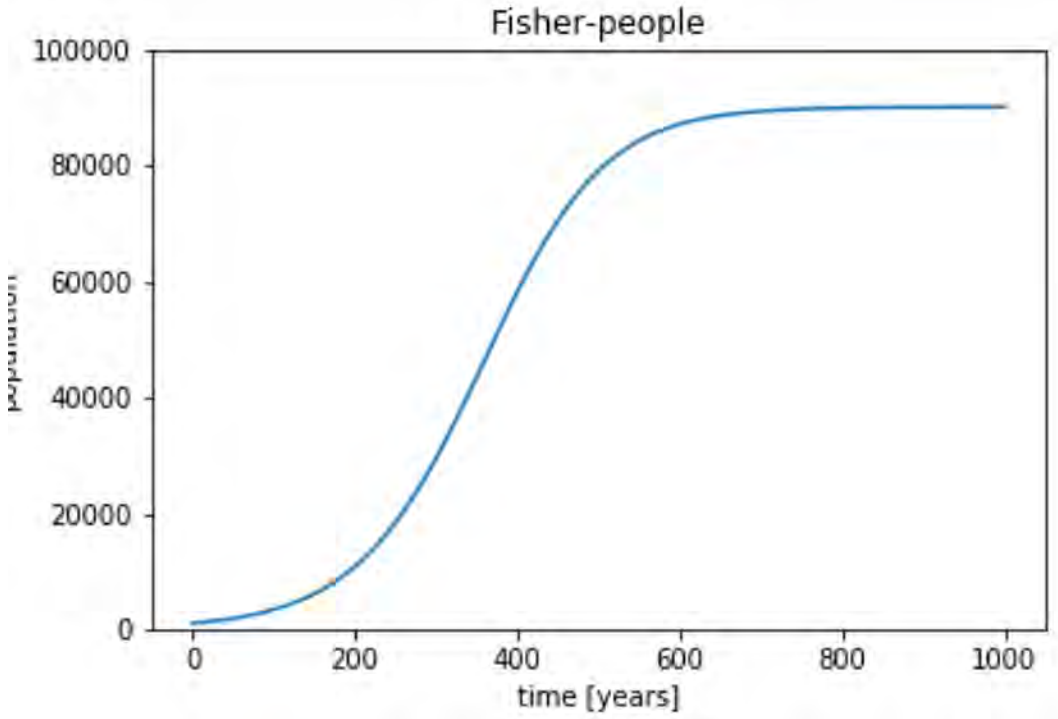
$$\frac{d}{dt}P_{fish} = \frac{1}{\tau_{fish}}\left(1 - \frac{P_{fish}}{P_{fish}^{max}}\right)P_{fish} - RP_{humans}$$

$$\frac{d}{dt}P_{humans} = \frac{1}{\tau_{humans}}\left(1 - \frac{P_{humans}}{P_{humans}^{max}}\right)P_{humans}$$

- We note two things:
  - Each population has its own generational time-scale.
  - The human population equation does not have a second term on the RHS.

# The successful population




$P_{0,fish} = 1\times10^9$

$\tau_{fish} = 1$ year

$P_{fish}^{max} = 1\times10^9$

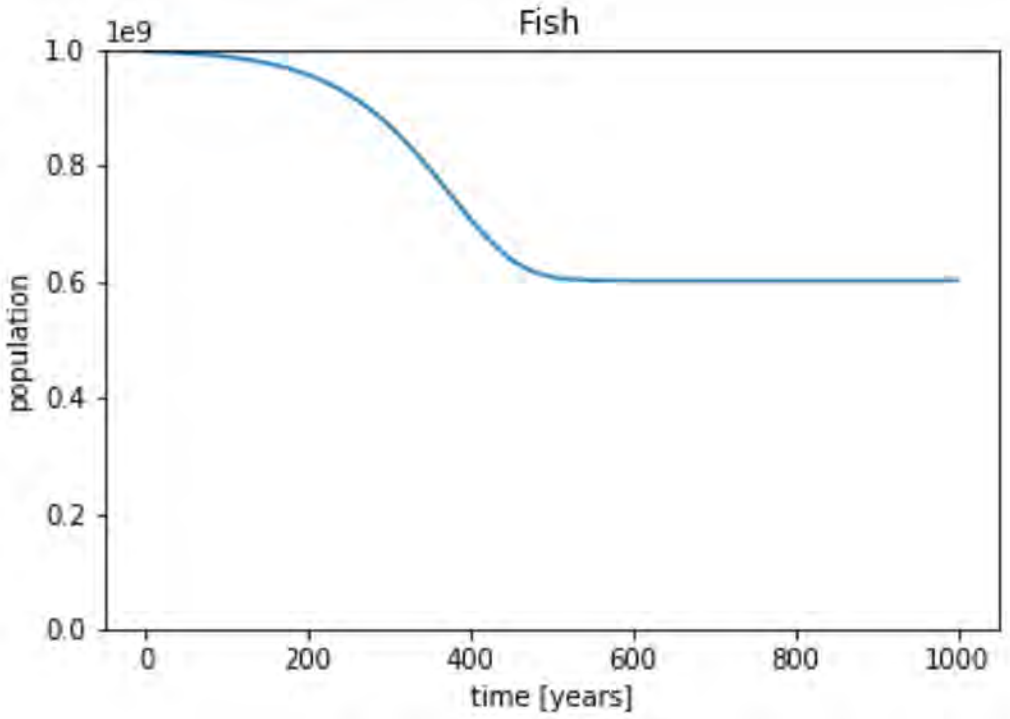
$R = 1000$

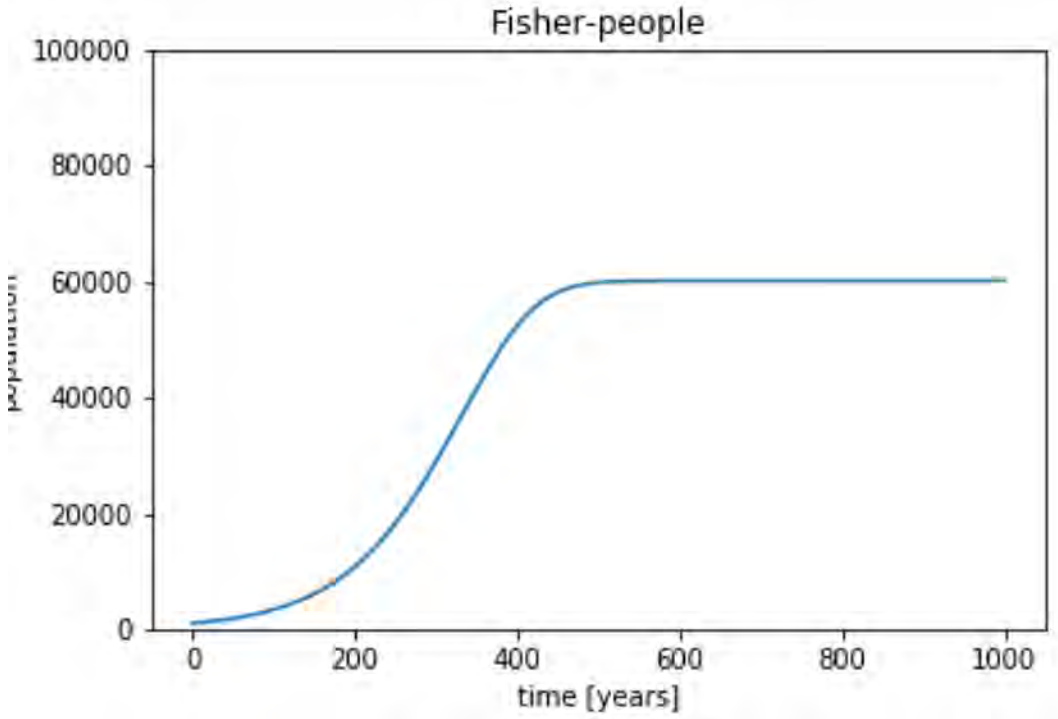
$P_{0,humans} = 1000$

$\tau_{humans} = 80$ years

$c = 0.0001$

# The hungry population




$P_{0,fish} = 1\times10^9$

$\tau_{fish} = 1$ year

$P_{fish}^{max} = 1\times10^9$

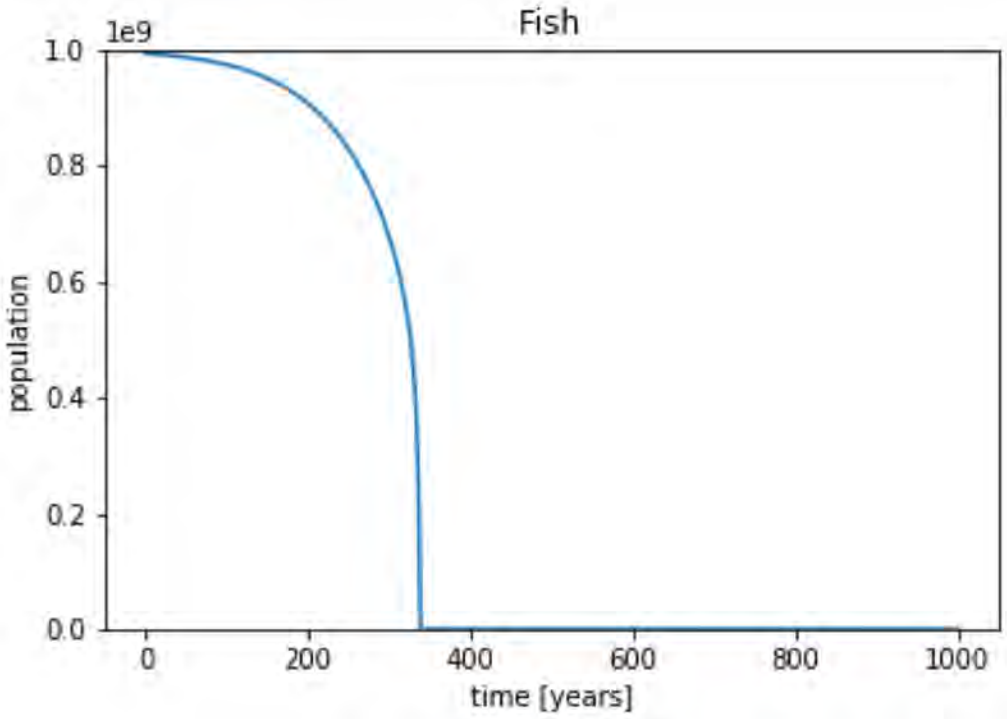
$R = 4000$

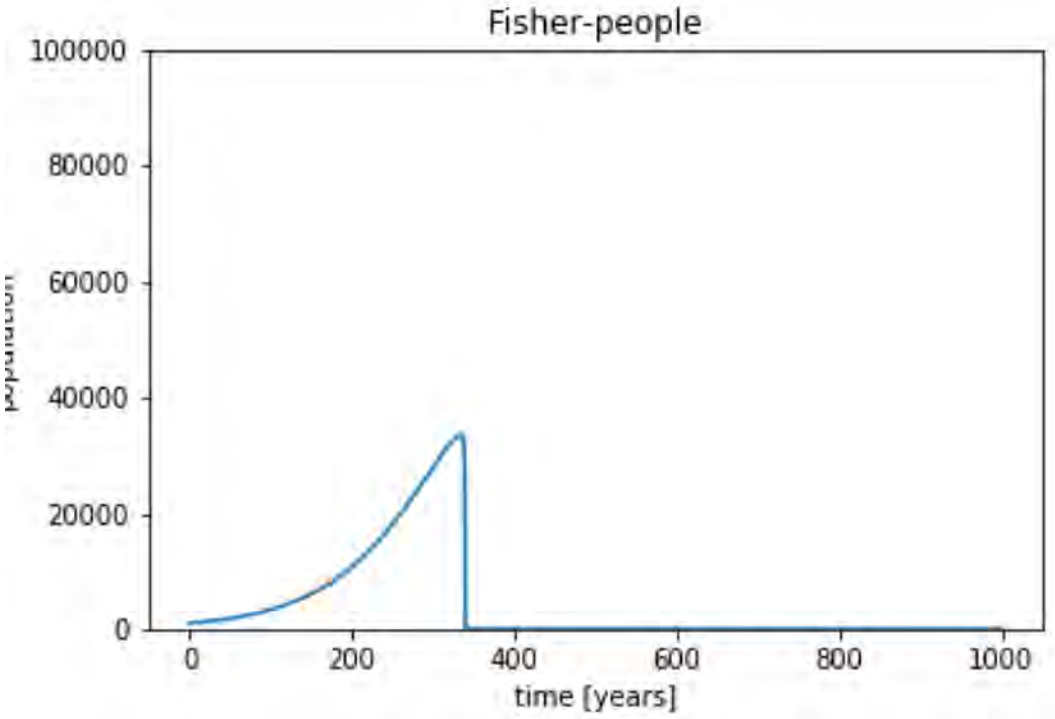
$P_{0,humans} = 1000$

$\tau_{humans} = 80$ years

$c = 0.0001$

# The gluttons




$P_{0,fish} = 1\times10^9$

$\tau_{fish} = 1$ year

$P_{fish}^{max} = 1\times10^9$

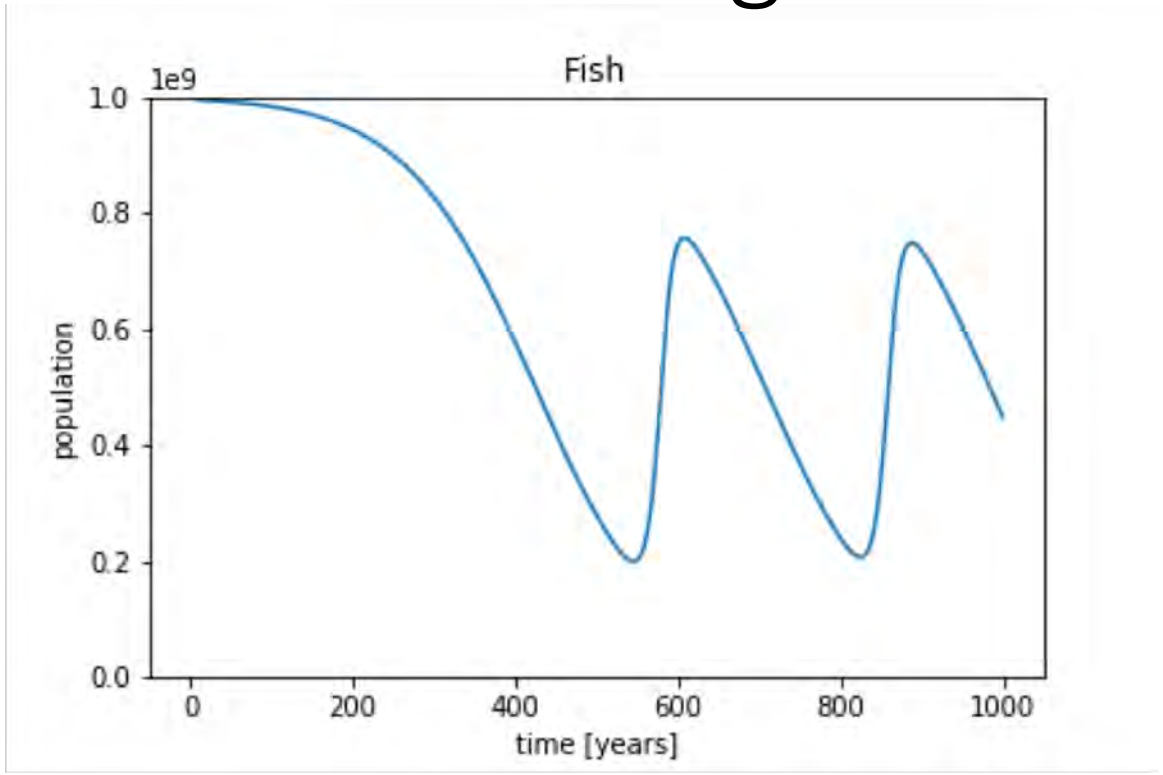
$R = 8000$

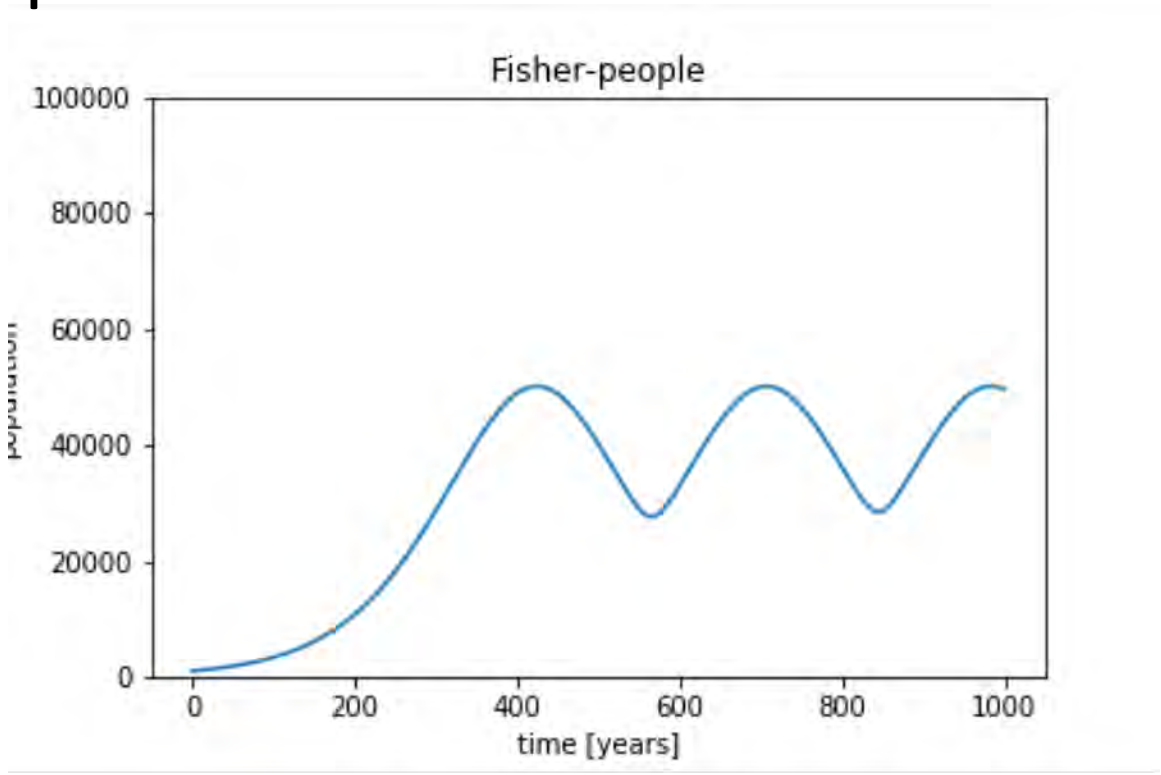
$P_{0,humans} = 1000$

$\tau_{humans} = 80$ years

$c = 0.0001$

# An oscillating relationship with nature




$P_{0,fish} = 1\times10^9$

$\tau_{fish} = 5$ years

$P_{fish}^{max} = 1\times10^9$

$R = 1063$

$P_{0,humans} = 1000$

$\tau_{humans} = 80$ years

$c = 0.0001$

# What kind of story can you tell about the fish and the fisher-people?

- Long-term outcomes for the fisher-people population depends on their relationship with the fish.
  - Weak to moderate fishing results in equilibrium.
    - Steady population levels that depend on the consumption rate.
  - Strong fishing results in resource depletion and extinction of both groups
    - e.g. Atlantic cod, Easter Island, …
  - Intermediate cases result in wild population swings.
    - Such variations are indicative of a society on the edge of collapse.
    - Where else in our world do we see wild swings?
      - Climate, politics, stock markets, behavior (road rage), …