1. What is a theory?

2. What is the relationship of ideas, or principles, to empirical data in science?

3. What is an ecological principle? Give an example.

4. What is a hypothesis?

5. What is a model? Why are models important?

6. Is a model the same thing as a theory?

7. Why is mathematics used to state ideas in science?

8. What is the role of statistics in science?
1. What is a theory?
2. What is the relationship of ideas, or principles, to empirical data in science?
3. What is an ecological principle? Give an example.
4. What is a hypothesis?
5. What is a model? Why are models important?
6. Is a model the same thing as a theory?
7. Why is mathematics used to state ideas in science?
8. What is the role of statistics in science?
What Do Theorists Do?

Introduction to Theoretical Ecology, Peter Yodzis, 1989
“Simplify the vast complexity of nature by abstracting out certain essential features (modeling) that the theorist regards as essential.”
“Deduce the consequences of these assumptions.”
“Compare these consequences with observed data to look for patterns in the data.”
Purpose of a Model

Introduction to Theoretical Ecology, Peter Yodzis, 1989
“A model is not a literal description of some system.”
“A model provides a *conceptualization* (representation) of the system and its workings, so that one can think about the system and understand something of its behavior.”
Reasons for Mathematical Models in Ecology

Introduction to Theoretical Ecology, Peter Yodzis, 1989
“Systems being studied in ecology tend to be very complex.”
“Mathematics is ideally suited to the expression of complex relationships in a form that makes it relatively easy to examine their consequences.”
“In principle, one could attempt to do all the same reasoning verbally, or in some extraordinarily complicated diagram.”
“Mathematics forces one to (try to) say exactly what one’s ideas are, and it enables one to find out exactly what their consequences are.”
On the Relation Between Theory and Observation

Introduction to Theoretical Ecology, Peter Yodzis, 1989
“Theory *sharpens hypotheses*, pinpointing just exactly which measurements need to be made to test the hypotheses.”
“Theory often generates new hypotheses that flow from its inner logic.”
Hypothesis

“Population is growing”
Hypothesis

“Population is growing linearly in time”
Hypothesis

“Population is growing exponentially”
Let us assume that the growth of the human population is proportional to its size,

\[ \frac{dP}{dt} = rP, \]

where \( P \) is size,
\( r \) is the growth rate and
\( t \) is time.
The solution is

\[ P(t) = pe^{rt}, \]

where \( p \) is the initial population size.
$P(t) = pe^{rt}$

$P(t) = 44513808e^{0.0022t}$
\[ P(t) = p e^{rt} \]
\[ P(t) = 170000000 e^{rt} \]
Hypothesis Rejected

“Population is growing faster than exponentially”
$\log[P(t)] = \log[pe^{rt}]$
Dungeness Crab Observations
Scaled population density

- Tillamook, ...
- Newport, ...
- Astoria, ...
- Grays Harbor, ...

Year


Northern Ports
The graph shows the scaled population density of various Southern Ports from 1950 to 1990.

- **Fort Bragg**
- **Eureka, Crescent City**
- **Brookings, Gold Beach, Port Orford**
- **Coos Bay, Winchester Bay**

The data indicates fluctuations in population density over the years, with peaks and troughs in different periods.
Hypotheses

- Population is constant.
- Population is growing linearly.
- Population is growing exponentially.
- Population is growing some times and declining other times.
- Population fluctuations are caused by internal population forces – life history.
- Population fluctuations are caused by environmental forces.
- Population fluctuations may be caused by the interaction between these forces.
Dungeness Crab Life History

- **Eggs**
  - $F_0, M_0$

- **Females**
  - Age 1: $F_1$
  - Age 2: $F_2$
  - Age 3: $F_3$
  - Age 4: $F_4$

- **Males**
  - Age 1: $M_1$
  - Age 2: $M_2$
  - Age 3: $M_3$

Infertile or Dead

Harvest

\[ s_a e^{-c_1 F_2(t-1)} \]

\[ s_a e^{-c_2 F_3(t)} \]

\[ \frac{1}{2} (F_3(t) + F_4(t)) e^{-c_3 F_4(t)} \]
Compare Dungeness Crab Model to Data

Dungeness Crab catch (1000 kg)

ndp
rms = 0.215
Compare Dungeness Crab Model to Data

Using estimated parameters from Newport and Depoe Bay
Supported Hypotheses

- Population is constant *(yes and no)*.
- Population is growing linearly *(no)*.
- Population is growing exponentially *(no)*.
- Population is growing some times and declining other times *(obviously yes)*.
- Population fluctuations *may be caused by* internal population forces – life history.
- Cannibalism *(supported)*.
- Population fluctuations *may be caused by* environmental forces.
- Population fluctuations *may be caused by* the interaction between these forces.