Marine Ecology

BIOL 529, 529L, 529I

Dr. Mark Steele
Magnolia 4100
Office Hours: Tue & Thur 11-12, or by appt.

Mike Schram
Magnolia 4103
Office Hours: Wed 10-11, or by appt.

Course Objectives

1. Gain a general understanding of marine ecology
2. Learn how to do marine ecology
   A. Identify & quantify patterns in nature
   B. Develop testable hypotheses
   C. Test hypotheses & interpret results

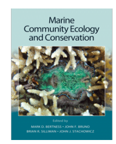
Format of Course

1. Lecture
   - key concepts and theories
   - review basic ecology, move to specific marine systems and questions
2. Lab & Field (participation mandatory)
   - exposure to marine systems
   - learn common methods for studying these systems
   - learn how to pose and test hypotheses
   - learn how to carry out and present scientific studies

Text and other Reading

Textbook:
– No textbook

Required Reference Books:
– *Seashore Life of Southern California* (Sam Hinton 1988)
– *A student handbook for writing in biology* (Knisely 2009)
– *The elements of style* (W. Strunk and E.B. White)



Research Papers:
Downloadable from the class website

A good reference text:
Marine Community Ecology and Conservation (Bertness et al. 2014)

Please read all assigned reading before lecture
(See online schedule)

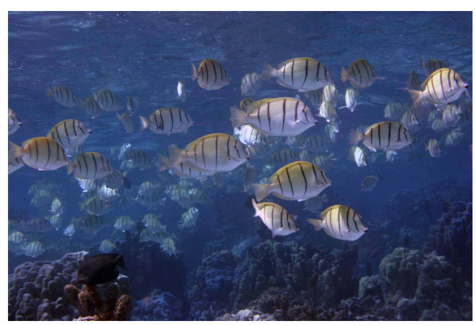
Grading

Midterm Exam 1	15%
Midterm Exam 2	15%
Final Exam	20%
Lecture Quizzes	5%
Research Paper 1	10%
Research Paper 2	15%
Research Proposal	2%
Research Presentation	8%
Field/Lab Study Q sets	10%
Total	100%

- Exams will be short answer
- Final will be cumulative

Lab & Field Study:
20% of your grade in 529L & 592I will be based on participation; the rest on the components listed to the left

What is Ecology?



History and meaning of the word "Ecology"

A. Etymology - origin of the the word
Oikos, ology - "the study of the house" - the place we live

B. Definitions

1. Earliest… Haeckel (1869) - "Comprehensive science of relationship of organism and environment"
2. Elton (1927) - "Scientific natural history"
3. Andrewartha (1961) - "Scientific study of the distribution and abundance of organisms"
4. Krebs (1985) - **"The scientific study of the interactions that determine the distribution and abundance of organisms"**

Ecology is young as a formal branch of science (since late 1860's)

- virtually all ecological theory has been developed in the last century
- but humans have been concerned with ecology throughout our evolutionary history (e.g., where and when do you go to harvest food?)

Ecology: The scientific study of the interactions that determine the distribution and abundance of organisms

Distribution = where an organism is found

Abundance = how common an organism is

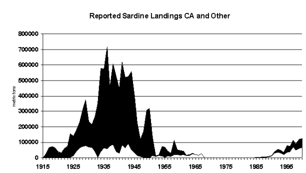
Questions for Ecologists:

- Why are organisms found where they are?
- Why do some places have more organisms than others?
- Why do the numbers of individuals change over time?

Ecology consists of a system of theories and ideas concerning interactions among species and their environment that attempt to explain their distribution and abundance

Goal of Ecology:

To predict how patterns of distribution and abundance will change over time



Levels of Biological Organization:

Ecology {
- biosphere
- ecosystems
- communities
- populations
- organisms

}
- organ systems
- organs
- tissues
- cells
- organelles
- molecules

↑ Complexity

- Ecology is less predictable than sub-organismic biology
- yet much of ecology should seem like common sense to you -- due to our evolution

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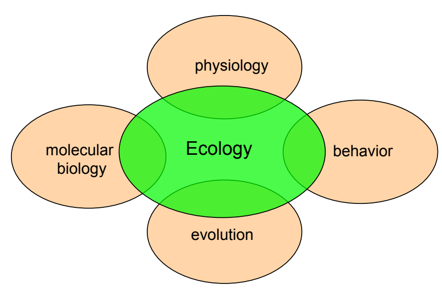
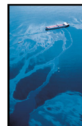
Ecology overlaps with many different fields of science:



And many non-biological sciences:
meteorology, oceanography, geography, etc.

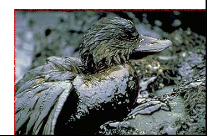
Role of Ecology in Society

- Provide impartial information gathered from scientific study that can be used to guide public policy
- NOT to make moral judgments on issues and policies



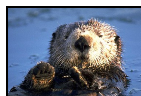
An Example: Otters, oil, and killer whales

- 1989: Exxon Valdez ran aground in Prince William Sound, Alaska
  - — Largest oil spill ever in North America
  - — Plants and animals devastated
    - -- one role of ecologists was to document the short term impact on the organisms

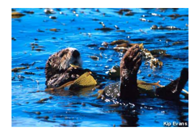


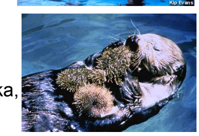
What about the sea otters?

- over two decades since the spill and they still haven't recovered
- should Exxon pay more -- are they at fault?



Sea otter (*Enhydra lutris*)





- small (≈ 75 lb) marine mammal
- relies on fur, not fat, for insulation
- oil mats fur and reduces insulation
- historically hunted for fur
- nearly driven to extinction in 1800's
- had recovered in central CA and Alaska, but still protected by law
- voracious predator of invertebrates

Ecologists job:
Is Exxon responsible for the failure of otters to recover in Prince William Sound?

- Jim Estes (UC Santa Cruz) & colleagues have been studying sea otters in Alaska for over 25 years
- key observations:
  - — sea otter populations throughout Alaska began crashing in 1990's
  - — most of these populations were not impacted by the oil spill
  - — other parts of the biota of PW Sound have recovered

Indicates that the current problem with otters is not due to the oil spill…

But what then?

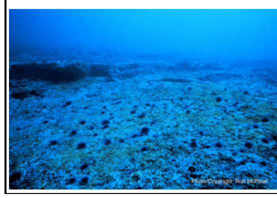
- Ecosystem level effect caused by overfishing?
  - — Observation: killer whales seen eating otters
  - — Estimation: a single killer whale could eat 2000 otters/year
  - — Why now?

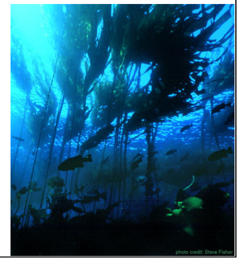
What's going on?

- Alaskan killer whales used to eat Stellar sea lions & harbor seal
- these prey items have become rare
- Why?
  - — overfishing of the prey of the sea lions & seals (pollock & salmon)
- Result: Killer whales started eating sea otters

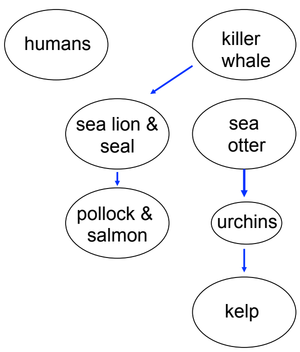
Other consequences:

- **Sea urchin abundance up**
- **Kelp beds down**

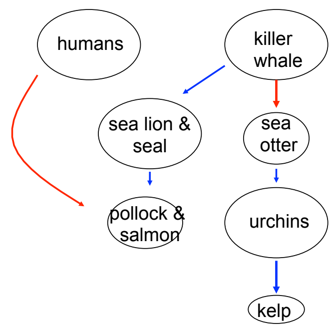




Food web: pre-overfishing



Food web: post-overfishing



The role of the ecologist:

- Determine how much the oil spill contributed to current problems with the sea otter population in PW Sound (estimate the effect)
  - – not decide whether or how much Exxon should pay
- Measure the effects of overfishing on the ecosystem

Philosophy of science: the scientific method

1. What is Science?

2. How is science done?

Ecology evolved from Natural History

- Natural History is not science
  - — natural history uses observations to describe the habits of living organisms
  - — natural history is purely descriptive
  - — the best field ecologists are also excellent natural historians
- What makes Ecology a science & Natural History not?

Philosophy of science: the scientific method

Philosophy → How we understand the world

↓

Science → A "method" for achieving this goal

- Development of theory
- Formulation of hypotheses - predictions
- *Tests of predictions*

↓

Design & Analysis → How we test predictions of hypotheses

Statistics → Tool for quantitative tests

Definitions

Theory: a set of ideas formulated to explain something

Hypothesis:

***general* –** supposition or conjecture put forth in the form of a prediction according to a theory, observation, belief, or problem

***specific* –** formulation of a general hypothesis for application to a specific test

(*Observational* or *Experimental*)

Null hypothesis: expected outcome if supposed mechanism is not manifested (i.e. "no effect")

Predictions: expected outcomes if *both* assumptions and conjecture are correct

Definitions

Induction (*inductive reasoning*):
-- reasoning that general laws exist because particular cases that seem to be examples of it exist

Deduction (*deductive reasoning*):
-- reasoning that something must be true because it is a particular case of a general (universal) law known to be true

induction →

Specific — 5 swans seen; all 5 are white

General — all swans are white

← *deduction*

Examples

Induction:
Every swan I have seen is white, therefore all swans are white
(if) (particular/observation), (then) (universal/ inference)

Deduction:
All swans are white, therefore next swan I see will be white
(if) (universal/ theory), (then) (particular/observation)

"DIGS": deductive is general to specific

Comparison:

1. Which is more testable? What if next swan is not white?
2. Which is normally used in everyday experience?
3. Which is more repeatable by different people?

Hypothetico-deductive reasoning

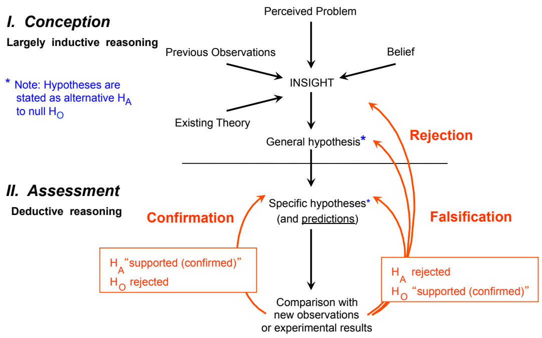
Deduction (*deductive reasoning*):
- formalized and popularized as basis of scientific method by Karl Popper

Two phases:

1. **Conception:** how one comes up with a new idea or insight ("rules" of formulation are not obvious)
   - — theory, observation, belief, problem
   - — creative, difficult to teach, but often inductive!
2. **Assessment:** deductive phase, should be repeatable

Together form "hypothetico-deductive reasoning"

Hypothetico-deductive reasoning



Hypothetico-deductive reasoning

1) Is there provision for "accepting" general hypothesis? i.e., Can you prove a general hypothesis to be true?

   NO!

   Despite many confirmatory observations, there is always the possibility that a negative observation may yet be made.

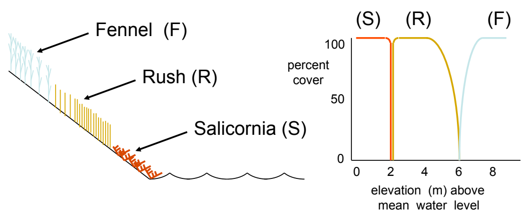
   Only one negative observation refutes a hypothesis absolutely

2) propositions that are not subject to rejection (not falsifiable) are not "scientific"

3) progress is made by repeated testing (rejection or confirmation) of alternative hypotheses until all reasonable ones have been tested ("last man standing")

Example – "Strong Inference" (Platt 1964)

1) **Observation:** vegetation along an elevation gradient adjacent to an estuary has a characteristic distribution (zonation)



Example – "Strong Inference"

1) **Observation:** vegetation along an elevation gradient adjacent to an estuary has a characteristic distribution (zonation)

   Is there any existing theory to explain this pattern?

   - *Limits of species distributions are often set by their tolerance to physical factors:*

     — water immersion
     — salinity
     — desiccation
     — soil characteristics

Insight!

— distribution limits are set by tolerance to water immersion

Example – "Strong Inference"

1) **Observation:** vegetation along an elevation gradient adjacent to an estuary has a characteristic distribution (zonation)

2) **General hypothesis:**

H_A: Lower limit of rush distribution set by tolerance to immersion

alternatively, "null hypothesis"

H_o: No effect of immersion on lower limit of rush distribution

Example – "Strong Inference"

2) **General hypothesis:**

   Lower limit of rush distribution set by tolerance to immersion

3) **Specific hypotheses:**

Observational –

H_A: average water level coincides with lower limit of rush

H_o: no relationship between water level and lower limit

Experimental –

H_A: rush plants transplanted to clearing below lower limit will die

H_o: no difference in survival between transplants and controls

Example – "Strong Inference"

4) Test of predictions:

Observational –

- Method: repeatedly <u>observe</u> water levels relative to rush lower limit
- Result A: find that rush lower limit coincides with mean water level
  ⇒ support hypothesis that lower limit set by immersion
- Result B: find that lower limit of rush does NOT coincide with mean water level
  ⇒ reject hypothesis that lower limit set by immersion

Experimental – parallel results and conclusions from <u>experimental</u> tests of predictions**, strengthen support & reveal causes**

To test **generality of hypothesis, consider other tests** (e.g., other species)

5) Consider other alternative hypotheses until you can't reject one

Example – "Strong Inference"

1) **Observation** (or theory)

2) **General hypothesis**

3) **Specific hypothesis** (that state testable predictions that are directly related to the general hypothesis)

4) **Test(s) of prediction(s)**

confirm hypothesis → consider other tests of general hypothesis to possibly reject or further support

• *note that we <u>don't</u> use the word "**prove**"*

reject hypothesis → consider other alternative hypotheses until you can't reject one

Problems

1) This process leads to **"paradigms"** – ways of thinking that have many followers, with great inertia. Contrary evidence is considered an exception rather than evidence for falsification.

2) Some argue that this is **not actually how we do science**. Instead, we build a convincing case of many different lines of evidence.

3) Others (e.g., Quinn & Dunham 1983) argue that ecology, in particular, is **too complex to devise unequivocal tests** (many variables that interact with one another).

   Examples:
   - multiple mechanisms of succession
   - changing interactions depending on species density

4) In ecology, we're often interested in **relative effects** and **strengths of effects** (rather than simply presence-absence of effects).