WF4133-Fisheries Science

Class 15: Effort, Catchability, and Overfishing

Housekeeping

Now is the time to be applying for summer jobs!
- State agency sites
- Fisheries.org
- Texas A&M Job board

Housekeeping

Homework 15 point

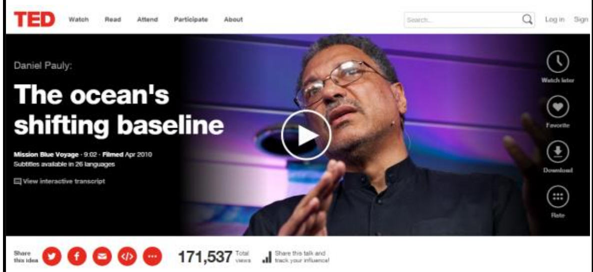
- Fit a length weight regression to the data provided in the Class 15 Link on the course website.
- DUE Friday March 10th by 5 pm
  - Report estimates of a', a and b using the linked form.
  - http://goo.gl/forms/sqsjK2QJBO
  - https://youtu.be/7QbRpHDPBFE

Fisheries icon

Dr. Daniel Pauley
- Heads the Sea Around Us Project
- Based at the Fisheries Centre at the University of British Columbia

Claims to fame

- Ecopath ecological/ecosystem modeling software suite
- FishBase



Catch per effort (CPE)

$$Catch = catchability \cdot effort \cdot Abundance$$

$$\frac{Catch}{effort} = catchability \cdot Abundance$$

- Rearrange to get catch and effort on the left side
- CPE is a 'linear' function of *catchability* & *Abundance*

Catch per effort (CPE)

$$Catch = catchability \cdot effort \cdot Abundance$$

$$\frac{Catch}{effort} = catchability \cdot Abundance$$

- Lets assume:
- Catchability = 0.001
- Biomass = 100, 300, 800, 1000

CPE- Example

$$\frac{Catch}{effort} = catchability \cdot Abundance$$
$$\frac{Catch}{effort} = 0.01 \cdot 100$$
$$\frac{Catch}{effort} = 1$$

$$\frac{Catch}{effort} = catchability \cdot Abundance$$
$$\frac{Catch}{effort} = 0.01 \cdot 300$$
$$\frac{Catch}{effort} = 3$$

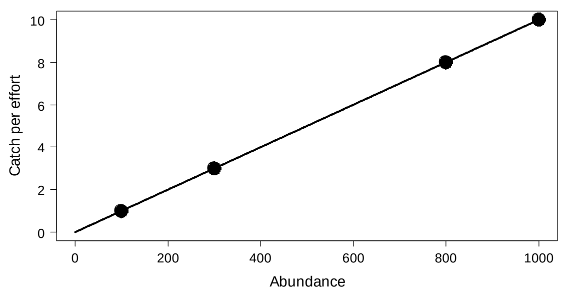
$$\frac{Catch}{effort} = catchability \cdot Abundance$$
$$\frac{Catch}{effort} = 0.01 \cdot 800$$
$$\frac{Catch}{effort} = 8$$

$$\frac{Catch}{effort} = catchability \cdot Abundance$$
$$\frac{Catch}{effort} = 0.01 \cdot 1000$$
$$\frac{Catch}{effort} = 10$$

Effort, catchability, and catch

- Catchability assumes that catch per effort (CPE) is linearly related to biomass (or abundance)
- What does this look like?

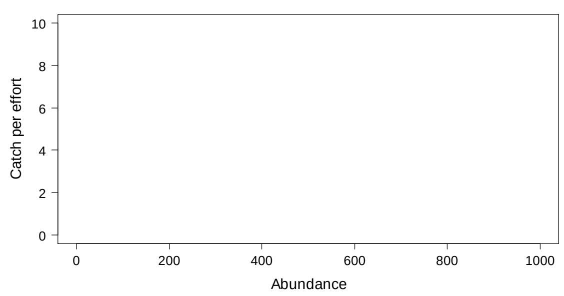
CPE, catchability, & biomass



Reasonable assumptions?

- Gear saturation
  - Gear captures so many fish that it can't capture any more
  - Underestimates number of fish
- Gear avoidance
  - Fish see gear and run away
  - Underestimates number of fish
- Let's see…

CPE, Catchability, & Abundance



The illusion of plenty

Hyperstability

- Overestimation of abundance & biomass
- Underestimation of fishing mortality

Hyperstability

$$\frac{Catch}{effort} = catchability \cdot Abundance^{\beta}$$

- Lets assume:
- Catchability = 0.01
- β = 0.85, 0.5
- Biomass = 100, 300, 800, 1000

Example: β = 0.85

$$\frac{Catch}{effort} = catchability \cdot Abundance^{\beta}$$
$$\frac{Catch}{effort} = 0.001 \cdot 100^{0.85}$$
$$\frac{Catch}{effort} = 0.14$$

$$\frac{Catch}{effort} = catchability \cdot Abundance^{\beta}$$
$$\frac{Catch}{effort} = 0.001 \cdot 300^{0.85}$$
$$\frac{Catch}{effort} = 0.35$$

$$\frac{Catch}{effort} = catchability \cdot Abundance^{\beta}$$
$$\frac{Catch}{effort} = 0.001 \cdot 800^{0.85}$$
$$\frac{Catch}{effort} = 0.82$$

$$\frac{Catch}{effort} = catchability \cdot Abundance^{\beta}$$
$$\frac{Catch}{effort} = 0.001 \cdot 1000^{0.85}$$
$$\frac{Catch}{effort} = 1$$

Example: β = 0.5

$$\frac{Catch}{effort} = catchability \cdot Abundance^{\beta} \qquad \frac{Catch}{effort} = catchability \cdot Abundance^{\beta}$$

$$\frac{Catch}{effort} = 0.001 \cdot 100^{0.5} \qquad \frac{Catch}{effort} = 0.001 \cdot 300^{0.5}$$

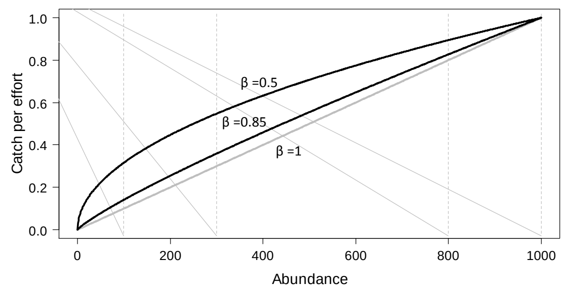
$$\frac{Catch}{effort} = 0.32 \qquad \frac{Catch}{effort} = 0.55$$

$$\frac{Catch}{effort} = catchability \cdot Abundance^{\beta} \qquad \frac{Catch}{effort} = catchability \cdot Abundance^{\beta}$$

$$\frac{Catch}{effort} = 0.001 \cdot 800^{0.5} \qquad \frac{Catch}{effort} = 0.001 \cdot 1000^{0.5}$$

$$\frac{Catch}{effort} = 0.89 \qquad \frac{Catch}{effort} = 1$$

Hyperstability



Example: β = 1.5

$$\frac{Catch}{effort} = catchability \cdot Abundance^{\beta} \qquad \frac{Catch}{effort} = catchability \cdot Abundance^{\beta}$$

$$\frac{Catch}{effort} = 0.001 \cdot 100^{1.5} \qquad \frac{Catch}{effort} = 0.001 \cdot 300^{1.5}$$

$$\frac{Catch}{effort} = 0.03 \qquad \frac{Catch}{effort} = 0.16$$

$$\frac{Catch}{effort} = catchability \cdot Abundance^{\beta} \qquad \frac{Catch}{effort} = catchability \cdot Abundance^{\beta}$$

$$\frac{Catch}{effort} = 0.001 \cdot 800^{1.5} \qquad \frac{Catch}{effort} = 0.001 \cdot 1000^{1.5}$$

$$\frac{Catch}{effort} = 0.71 \qquad \frac{Catch}{effort} = 1$$

Example: β = 1.85

$$\frac{Catch}{effort} = catchability \cdot Abundance^{\beta} \qquad \frac{Catch}{effort} = catchability \cdot Abundance^{\beta}$$

$$\frac{Catch}{effort} = 0.001 \cdot 100^{1.85} \qquad \frac{Catch}{effort} = 0.001 \cdot 300^{1.85}$$

$$\frac{Catch}{effort} = 0.01 \qquad \frac{Catch}{effort} = 0.10$$

$$\frac{Catch}{effort} = catchability \cdot Abundance^{\beta} \qquad \frac{Catch}{effort} = catchability \cdot Abundance^{\beta}$$

$$\frac{Catch}{effort} = 0.001 \cdot 800^{1.85} \qquad \frac{Catch}{effort} = 0.001 \cdot 1000^{1.85}$$

$$\frac{Catch}{effort} = 0.66 \qquad \frac{Catch}{effort} = 1$$

Appears worse than it is

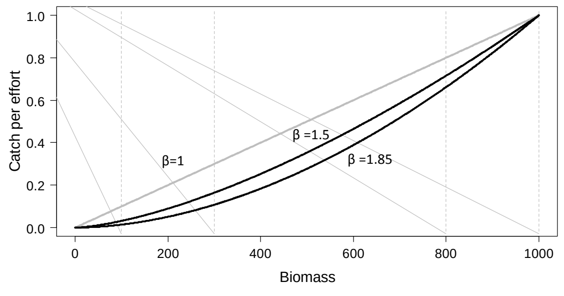
Hyperdepletion
- Biomass is underestimated
- Fishing mortality is overestimated

Hyperdepletion

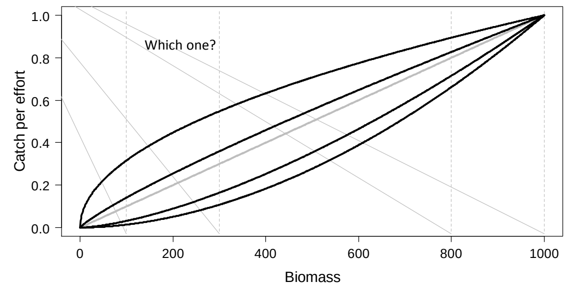
$$\frac{Catch}{effort} = catchability \cdot Abundance^{\beta}$$

- Lets assume:
- Catchability = 0.01
- β = 1.85, 1.5
- Biomass = 100, 300, 800, 1000

Hyperdepletion



The whole picture



Is catch-per-unit-effort proportional to abundance?

Shelton J. Harley, Ransom A. Myers, and Alistair Dunn

Abstract: We compiled 297 series of catch-per-unit-effort (CPUE) and independent abundance data (as estimated by research trawl surveys) and used observation error and random effects models to test the hypothesis that CPUE is proportional to true abundance. We used a power curve, for which we were interested in the shape parameter (β). There was little difference among species, ages, or gear types in the distributions of the raw estimates of β for each CPUE series. We examined three groups: cod, flatfish, and gadiformes, finding strong evidence that CPUE was most likely to remain high while abundance declines (i.e., hyperstability, where β < 1). The range in the mean of the random effects distribution for β was quite small, 0.64–0.75. Cod showed the least hyperstability, but still, 76% of the mass of the random effects distribution was below 1. Based on simulations, our estimates of β are positively biased by approximately 10%; this should be considered in the application of our findings here. We also considered the precision of CPUE indices through a meta-analysis of observation error variances. The most precise indices were those from flatfish (median coefficient of variation of ~0.42).

Most fish evaluated exhibited hyperstablity

Harley, S.J., Myers, R.A., Dunn, A., 2001. Is catch-per-unit-effort proportional to abundance? Canadian Journal of Fisheries and Aquatic Sciences 58, 1760-1772.

Does catch reflect abundance?

Researchers are divided over the wisdom of using estimates of the amount of fish hauled in each year to assess the health of fisheries.

POINT

Yes, it is a crucial signal

The only data available for most fisheries are the weight of fish caught each year, insists Daniel Pauly.

In developed countries such as the United States, Australia and members of the European Union, many fisheries are monitored by fisheries scientists using expensive stock assessments. To infer the size of the fish populations being exploited, scientists use the age and size distributions of the fish caught; the results of scientific surveys carried out from research vessels; and information about growth and migration from tag and recapture studies. Yet the only data ▸

COUNTERPOINT

No, it is misleading

Many factors as well as abundance determine the hauls of fishermen, warn Ray Hilborn and Trevor A. Branch.

The major database on all the fisheries of the world is the *FAO Yearbook. Fishery and Aquaculture Statistics*. This collates the amount (in weight) of haddock, bream, cod and more than 1,000 other species hauled in each year by fishermen, whether from commercial trawlers or canoes, using estimates sent in by officials from individual countries.

For the past few years, researchers have been conducting analyses ▸