

## Lecture 12 – food webs and secondary productivity

### READINGS:

- Text: Ch 24, 491-503, p. 670-676
- Beddington, J. 1995 “The Primary Requirements” Nature 374: 213-214 (W)
- Pauly, D. and V. Christensen. 1995. Primary Production Required to Sustain Global Fisheries. Nature: 374: 255-257 (W)
- Pauley, D. et al 2000. “ Fishing Down Aquatic Food Webs”. Am. Sci. 88: 46-51

### Optional and or Background for Lecture

- For background on stable isotopes: <http://wwwrcamnl.wr.usgs.gov/isoig/res/funda.html>
- Stapp et al. 1999. Stable isotopes reveal strong marine and El Nino effects on island food webs. Nature: 401: 467 – 469.
- Peterson, B. et al. 1986. Sulfur and Carbon Isotopes as tracers of salt-marsh organic matter flow. Ecology. 67:865

*It's a very odd thing  
As odd as can be—  
That whatever Miss T eats  
Turns into Miss T.*

—Walter De La Mare, 1913

### Outline:

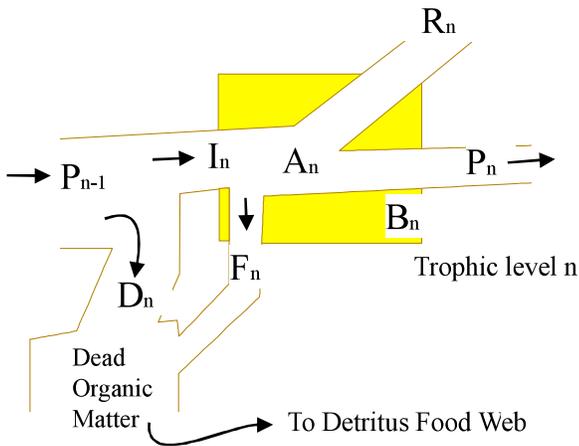
- Secondary Production
  - Production Efficiencies
  - Assimilation Efficiencies
  - Food Chain Efficiencies
- Grazing Food Webs vs. Decomposer Food Webs
- Analysis of efficiencies in a marine ecosystem

### STUDY GUIDE

This lecture is designed to get you to think about the structure of food webs and how energy flows through an ecosystem...i.e. how one would construct an energy budget for an ecosystem if we could measure everything (which we can't, of course, except in model systems.).

- Construct an energy flow diagram for both an organism and a food web. What are the similarities? Differences?
- Could you measure energy flow through a food web? How might you try to do this?
- How does the flow of energy through a carnivore differ from that of a herbivore? An endotherm vs. an ectotherm?
- What does fish production in the sea have to do with the structure of food webs?
- There are two hypotheses for why the average length of a food chain is 5. One is energy limitation. What is the other? Can you find any evidence for the second one in the literature?
- Why is the world green? (see your textbook)
- How might the biosphere be changed if all humans were vegetarians? If all animals were herbivores?
- Some have argued that “game ranching” may give higher yields (secondary production) than that of livestock in the same area. What is the evidence for or against this (see your textbook)

**ENERGY FLOW, FOOD WEBS, AND EFFICIENCIES:**



- $P_n$  = Productivity at trophic level n (net)
- $P_{n-1}$  = Productivity (net) of trophic level n-1
- $R_n$  = Respiration at trophic level n
- $F_n$  = Faecal material produced at trophic level n (for microorganisms, this would be excreted organic carbon)
- $I_n$  = Amount ingested by trophic level n
- $A_n$  = Amount assimilated and available for metabolism
- $D_n$  = Fraction of  $P_{n-1}$  not consumed by trophic level n
- $B_n$  = Biomass in trophic level n

**We can now define the following efficiencies (%)**

$$\text{Exploitation Efficiency} = EE = \frac{I_n}{P_{n-1}} \times 100$$

(sometimes called consumption efficiency)

n-1	n	$I_n/P_{n-1}$
Trees	Insects	1-10%
Grass	Animals	20%
Phytoplankton	Zooplankton	20-40%

$$\text{Assimilation Efficiency} = AE = \frac{A_n}{I_n} \times 100$$

Herbivores 20-50%  
Carnivores 80%

$$\text{Production Efficiency} = PE = \frac{P_n}{A_n} = \frac{P_n}{P_n + R_n} \times 100$$

$$\text{Ecological Efficiency} = \frac{I_n}{P_{n-1}} \times \frac{A_n}{I_n} \times \frac{P_n}{A_n} = \frac{P_n}{P_{n-1}} \times 100$$

- Tells you how much energy is lost in one trophic transfer in the grazing food chain
- Some of this goes to the detritus food web, some goes to respiration

King: Now, Hamlet, where's Polonius?  
 Hamlet: At supper.  
 King: At supper! Where  
 Hamlet: Not where he eats, but where he is eaten: a certain convocation of politic worms are e'en at him. Your worm is your only emperor for diet: we fat all creatures else to fat us, and we fat ourselves for maggots: your fat king and lean beggar is but variable service; two dishes, but to one table: that's the end.  
 King: Alas, alas!  
 Hamlet: A man may fish with the worm that hath eat of a king, and eat of the fish that hath fed of that worm.  
 King: What dost though mean by this?  
 Hamlet: Nothing, but to show a king may go a progress through the guts of a beggar.  
 King: Where is Polonius?

***Hamlet, IV, II, 17-35***

MIT OpenCourseWare  
<http://ocw.mit.edu>

1.018J / 7.30J Ecology I: The Earth  
Fall 2009

For information about citing these materials or our Terms of Use, visit: <http://ocw.mit.edu/terms>.