Bioenergetics Model

- **Modeling Strategy**
  - Consumption = Metabolism (Respiration) + Wastes (Excreted) + Growth (Production)
  - $C = M + W + G$

- **Consumption = Metabolism + Wastes + Growth**

- **For Carnivores** 100 = 44 + 27 + 29
- **For Herbivores** 100 = 37 + 43 + 20

- What can we see?
  - 1) Herbivores have lower growth rates and higher waste-loss rates – makes sense
  - 2) Both fishes have higher rates of growth efficiency than birds and mammals

Bioenergetics Model

- **Answer questions about factors that constrain growth:**
  - diet quality or environmental stressors
  - use measured growth to estimate how much of an effect a predator has had on a population

- **Further Breakdown – Core Processes in Bioenergetics: Energy Mass Balance Equation**

- Consumption = Metabolism (Respiration) + Wastes + Growth
  - $C = R + W + G$
- $C = (\text{respiration} + \text{active metabolism} + \text{SDA specific dynamic action}) + (W = \text{egestion} + \text{excretion}) + (G = \text{somatic growth} + \text{gonad production} + \text{repairs})$
  - $C = (R + A + S) + (F + U) + (B + G)$
Bioenergetics Model

• Repeat
• Metabolism = respiration + active metabolism + SDA specific dynamic action
• Waste = egestion + excretion
• Growth = somatic growth + gonad production + repairs
• \( C = (R + A + S) + (F + U) + (B + G) \)

Bioenergetics Model

• Nuts and Bolts
• Respiration = amount of energy used for routine metabolism; Dependent on fish size, water temperature and activity

Bioenergetics Model

• Nuts and Bolts
• Consumption = proportion of the maximum daily ration for a fish at a particular mass and temperature (g prey per g body mass per day)
• Allometric function of mass from ad libitum feeding experiments at optimum temperatures

Bioenergetics Model

• Nuts and Bolts
• Waste Losses (Egestion= fecal waste and Excretion= nitrogenous waste) = constant proportion of consumption or as functions dependent on water temperature and consumption
Bioenergetics Model

• Nuts and Bolts
• Growth – Reproduction – gonads produced during normal growth; loss occurs at spawning.

Bioenergetics Model

• Nuts and Bolts
• Predator Energy Density = (joules per gram wet mass)
• Scaling from Individuals to Populations

Bioenergetics Model

• Nuts and Bolts
• Cohort as a Population
• Cohort = group of similar sized (age) fish of same species experiencing identical environment conditions (temperature, diet, growth, and reproductive losses)

Bioenergetics Model

• Nuts and Bolts
• Population Mortality – multiple causes and additive – fishing, natural etc.
• Can also do Extended Topics: Flow rates of other materials that are transferred through interactions of fishes and their prey.
Bioenergetics Model

Analyses of Nutrient Regeneration – Items such as N and P are maintained at relatively constant conditions in fish tissue through homeostatic mechanisms – interested in transfer rates and rate of elimination (i.e. role fish play in lake nutrient cycles by regenerating these primary production limiting nutrients through excretion.

Bioenergetics Model

• Contaminant Accumulation – Bioaccumulation – largely a function of its lipophilicity = efficiency with which it is eliminated from tissue; Heavy metals like mercury or polycholinated biphenyls (PCBs). More concerned with predicting concentrations of material in fish tissue and how different environmental conditions (temperature, diet, growth, etc) alter concentrations.

Bioenergetics Model

• Kitchell et al. 1997 – Ecological Applications
• Results (Current levels = large mesh, small mesh and beach seines):
  • Absence of fishing, total predation on haplochromines increase 4X
  • Large Gill Nets only, total predation on haplochromines increase 2X
  • Beach Seines and small mesh gill nets = slightly greater
  • Harvest of Nile Perch increase (about 3X) when only large gill nets allowed
• Conclusions:
  • For cichlid conservation – let the fishery stay the same
  • For Nile Perch and Fisheries economics – Ban small gill nets and beach seines – increase Lates yields 2-3X
• Trade-Off:
  • Goal A – Restore cichlids and old web web – do nothing, the fishery is doing it for us.
  • Goal B - Maximize social/economic benefits of fishery yield – Large mesh gill nets only