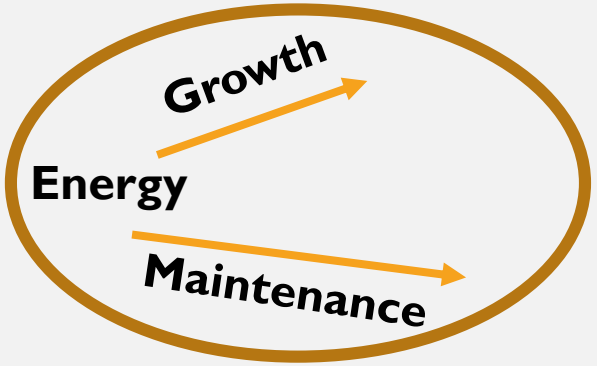
USE OF CONDITION INDEX FOR MUSSEL HEALTH ASSESSMENT

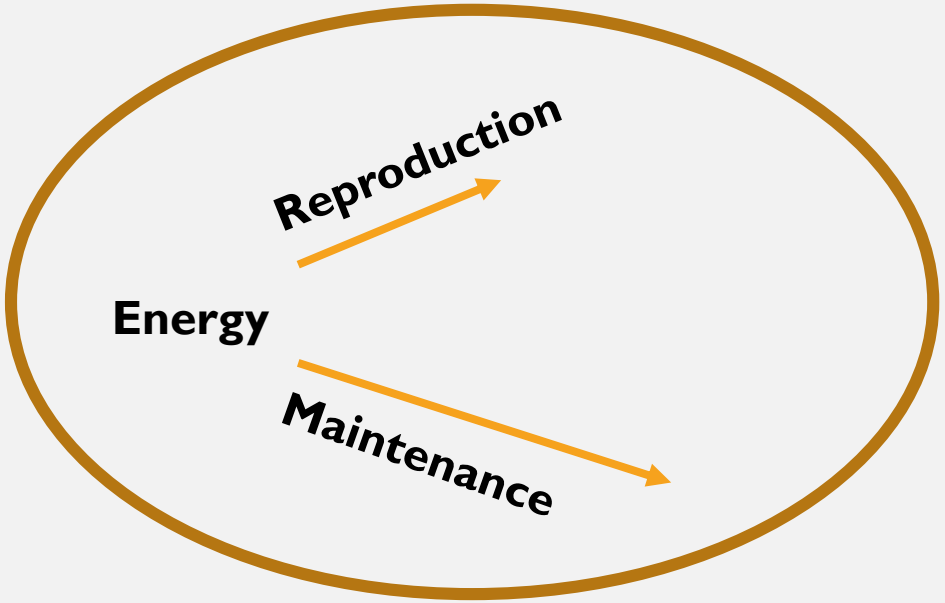
Serena Ciparis, Ty Stephenson, Garrett Rhyne, and Susan Lingenfelser

CONDITION INDEX: CONCEPT

- **Allocation of energy stored in soft tissue**



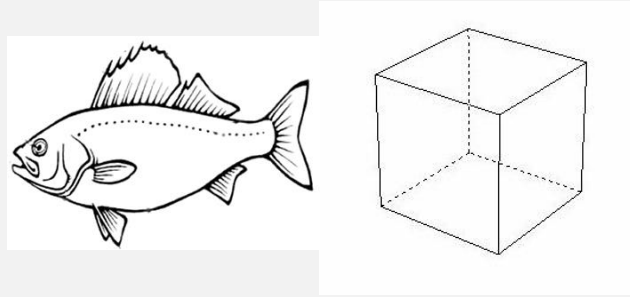
Juvenile



Adult

CONDITION INDEX: MEASUREMENT

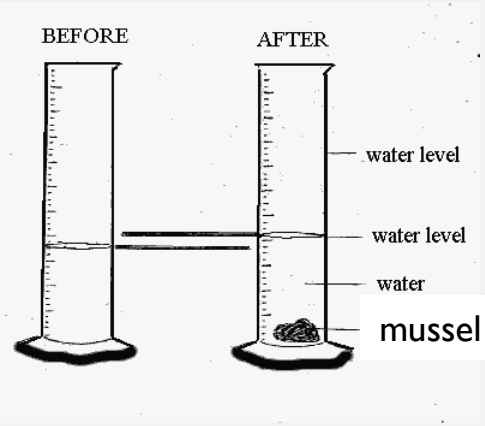
- **Weight of tissue normalized to 'size'**



- **Fish (Heincke, 1908):**
  - **Fulton's condition factor (K) = (weight (g) / length (cm) ^ 3) * 100**

Volume displacement: whole animal - shell

- **Bivalves (Higgins, 1938):**
  - **Condition index = tissue dry weight (g) / shell cavity volume (ml)**



- **Freshwater bivalves (modern)**
  - **Condition index = tissue weight (g) / "something related to the shell"**

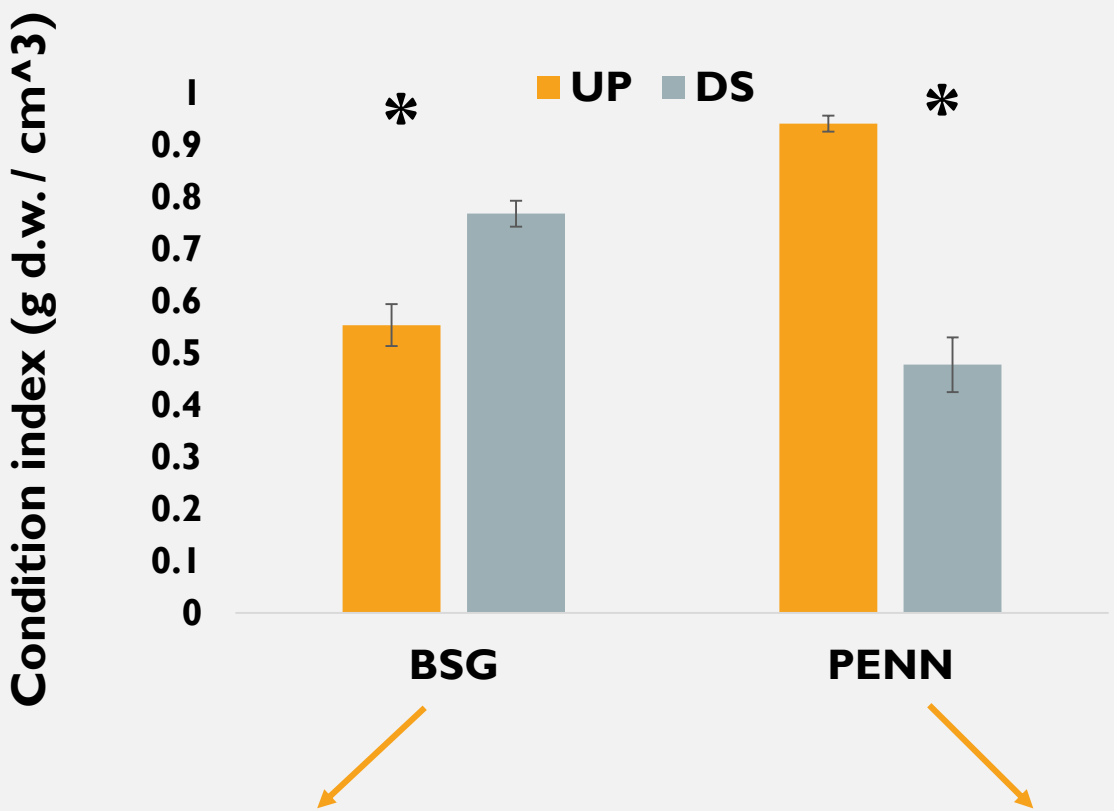
C.I. IN FRESHWATER BIVALVE LITERATURE

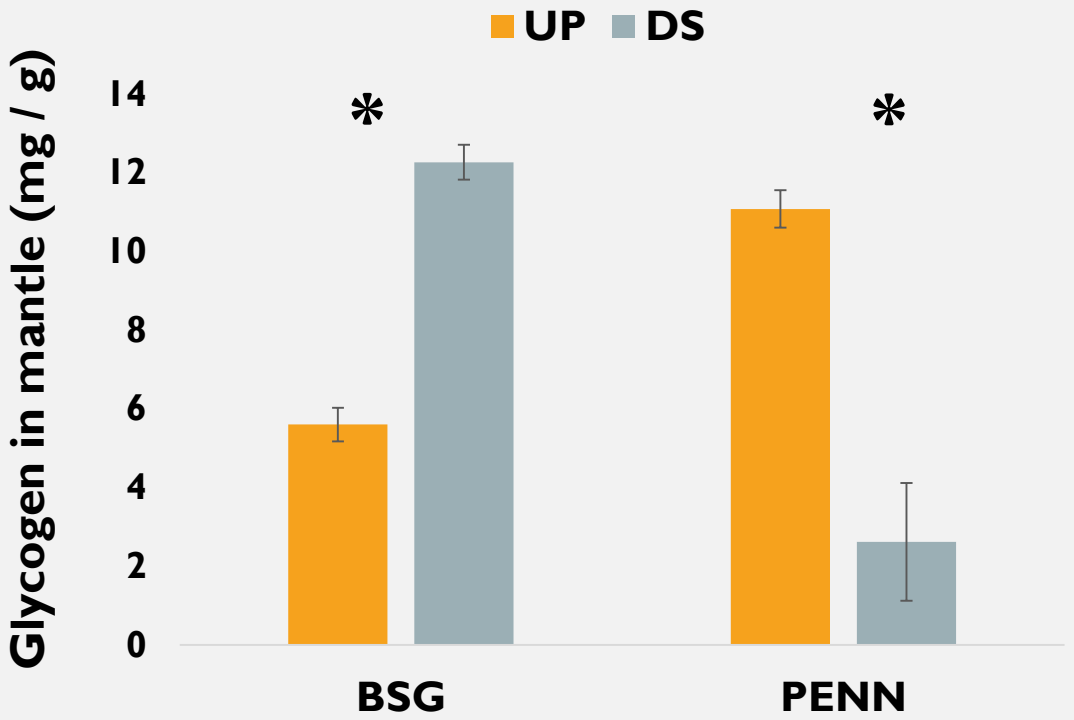
Search terms: "Condition index" AND ("freshwater mussel" or "freshwater bivalve"

Calculation	Year published
Tissue wet weight / length	2017
Tissue dry weight / length ^3	2011
(Tissue wet weight / shell dry weight) * 100	2017
(Tissue dry weight / shell dry weight) * 100	2017
Tissue wet weight / shell cavity volume	2015
(Tissue dry weight / shell cavity volume) * 1000	2015

STUDY OF WWTP EFFLUENT

- **Measured biochemical endpoints upstream and downstream of WWTPs**
- ***Lampsilis fasciola* (2 yrs old), 8 wk. exposure**





Conductivity > 900 µS/cm upstream

Chlorinated effluent

LABORATORY EXPOSURE

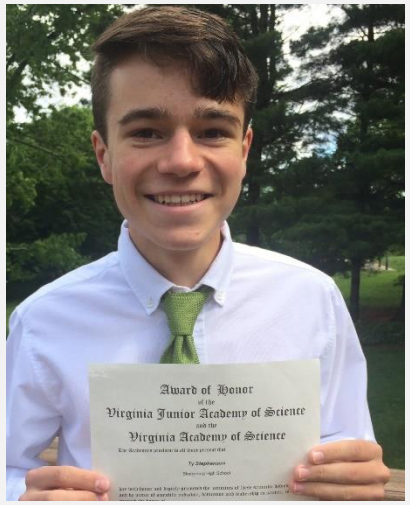
- **Do elevated concentrations of major ions affect energy storage in mussels?**

- **Simulated Powell River water (conductivity ~1,000 µS/cm)**
  - **No effect on growth of juvenile *Villosa iris* (Ciparis et al. 2015)**

- **Added a sediment treatment**
  - **Powell River, coal = 1.5 % dry weight**

- **Adult *L. fasciola* (5 years old), 6 wk. exposure**

Garrett – VT undergrad

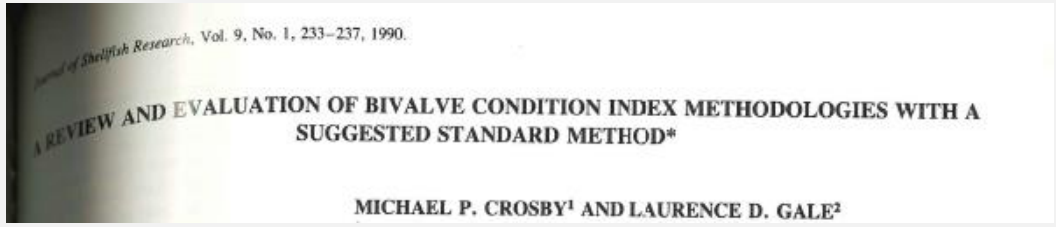


Ty – Blacksburg H.S.

MEASUREMENTS

- **Biochemical markers (Garrett)**
  - **Glycogen in mantle tissue, glutathione-dependent enzymes in digestive gland**

- **Multiple methods of measuring condition index (Ty)**
  - **Weight (g) / length (cm)^3 of live mussels**
  - **Weight (g) / volume (ml; displacement) of live mussels**
  - **Tissue weight (wet and dry; g) / shell cavity volume (ml; capacity of 1 valve * 2)**
  - **Tissue weight (wet and dry; g) / shell cavity weight (g)**
    - **Shell cavity weight = whole wet weight – dry shell weight (Crosby and Gale, 1990)**
  - **Tissue dry weight (g) / length (cm) ^3**


Journal of Shellfish Research, Vol. 9, No. 1, 233–237, 1990.

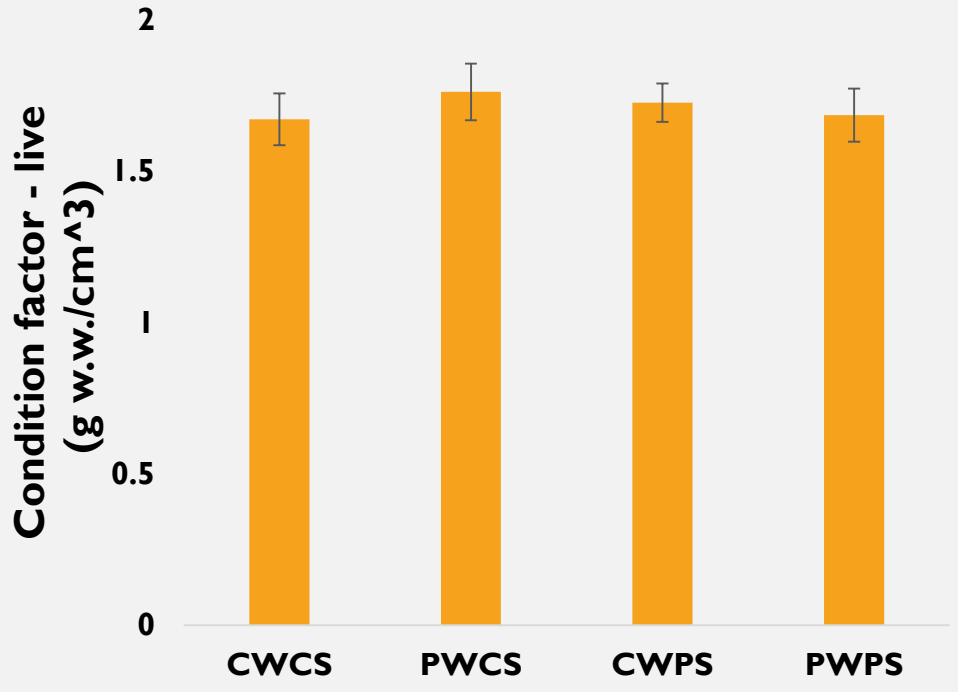
A REVIEW AND EVALUATION OF BIVALVE CONDITION INDEX METHODOLOGIES WITH A SUGGESTED STANDARD METHOD*

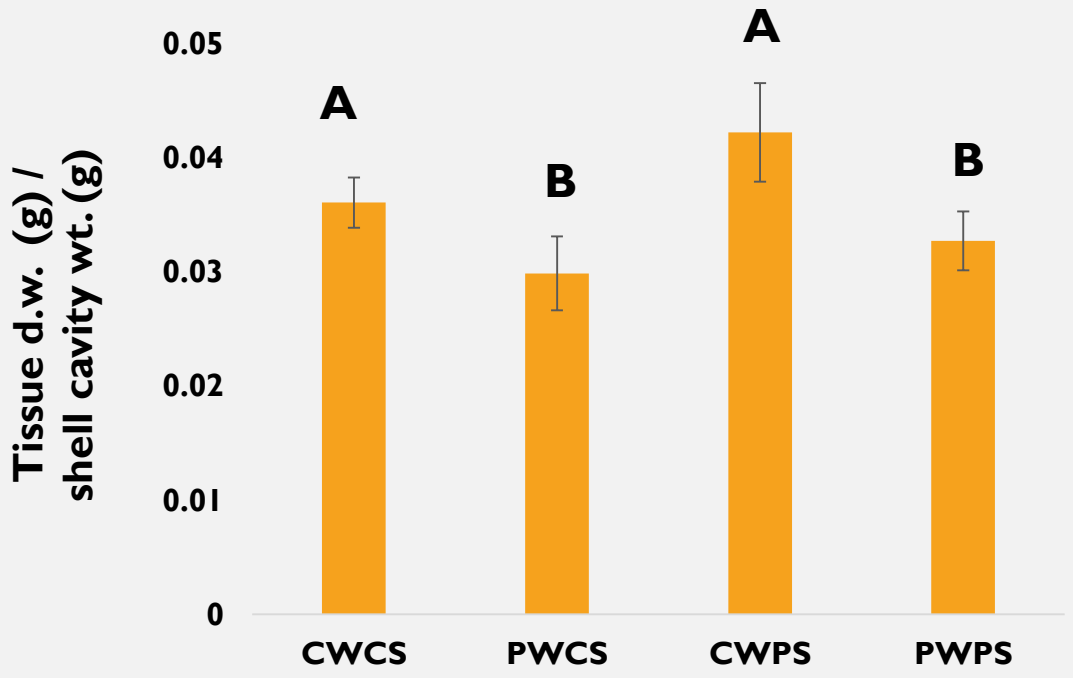
MICHAEL P. CROSBY[1] AND LAURENCE D. GALE[2]

C.I. RESULTS: SUMMARY

Method	Water	Sediment	Sex
Weight (g) / length (cm) ^3 - live	-	-	p=0.0004
Weight (g) / volume (ml) - live	-	-	-
Tissue w.w. (g) / shell cavity volume (ml)	p=0.06	-	-
Tissue d.w. (g) / shell cavity volume (ml)	p=0.011	-	-
Tissue w.w. (g) / shell cavity weight (g)	p=0.015	-	-
Tissue d.w. (g) / shell cavity weight (g)	p=0.003	-	-
Tissue d.w. (g) / length (cm) ^3	p=0.015	-	-

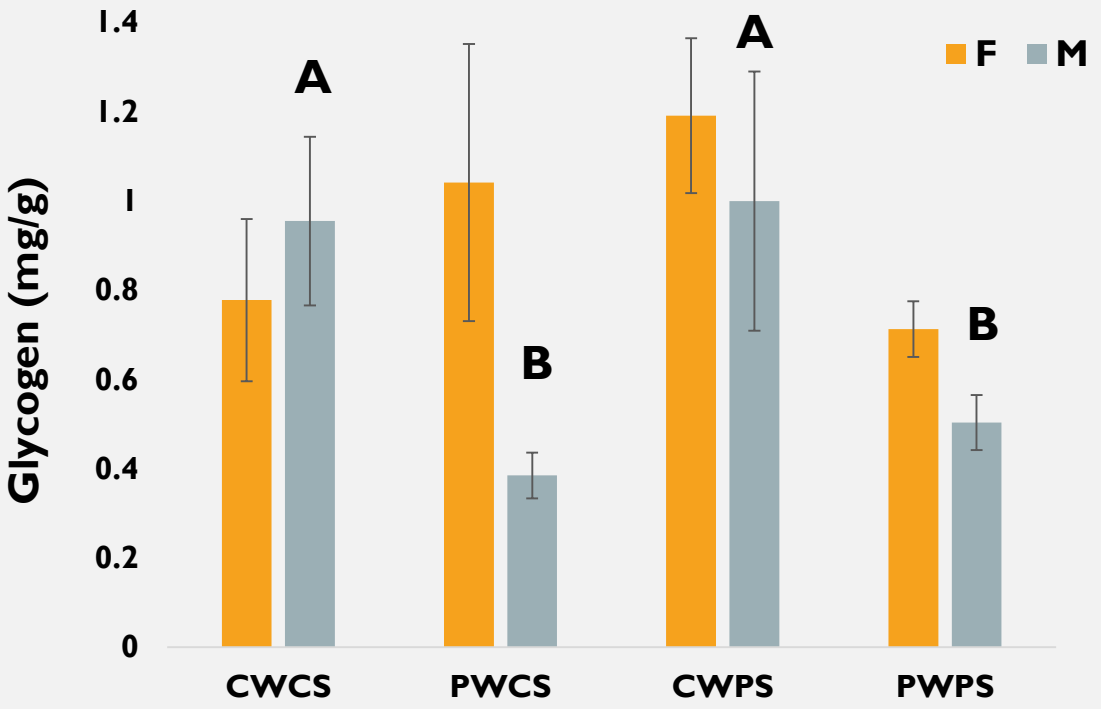
C.I. RESULTS





- **Significant difference between water treatments (CW vs. PW) for dissected mussels only**
- **Best measure = tissue dry weight / shell cavity weight**

BIOCHEMICAL RESULTS



- **Significant difference (p=0.014) in mantle glycogen content between water treatments (CW vs. PW) for males only**

- **Activity of glutathione reductase (GR) was significantly higher in females (p=0.0087); no effect of treatment**

$$GSSG + NADPH + H^+ \xrightarrow{GR} 2\,GSH + NADP$$

CONCLUSIONS

- All mussels 'got thinner' when exposed to simulated Powell River water
  - No effect of coal-contaminated sediment
  - No effect of sex
- Lower glycogen content in mantle tissue in males only
- Females were likely using energy (lipids) from resorbing gametes
  - More available energy for glutathione reductase
- Elevated concentrations of major ions affect energy storage in adult freshwater mussels
  - Did we miss something by only measuring growth in juveniles in our first exposure (Ciparis et al. 2015)?
- Condition index is a worthwhile measurement

MEASURING CONDITION INDEX

- **Dissect your mussels whenever possible, take measurements**
- **Can be used for juveniles**
  - **Whole wet weight, whole dry weight, shell 'ashed' weight**
- **Follow the recommendations of Crosby and Gale (1990)**
  - **C.I. = tissue dry weight (g) *1000 / shell cavity weight (g)**

currently in use. We have statistically compared the three primary formulae from which all others are derived. We conclude that the following gravimetric formula has less measuring errors, lower coefficient of variation, is the easiest and fastest to use, and is most meaningful as an index of current bivalve nutritive status and recent stress: Condition Index = [dry soft tissue wt (g) × 1000]/internal shell cavity capacity (g). We recommend that it be accepted as the future standard method for determining bivalve condition index.