

Non-lethal estimation of proximate body composition of Channel Catfish using bioelectrical impedance analysis

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Condition

- Well being of an individual
 - Equated to energy reserves
- Lipids
 - Stored energy
 - Important to survival and reproduction
- Whole body lipid analysis
 - Best measure of body condition
 - Costly, time consuming, and lethal



Channel Catfish – *Ictalurus punctatus*

- Native
- Recreation
 - Important sportfish nationwide
 - Condition reflective of population health
 - 2011: 7 million anglers, 96 million days
 - Average \$30/day expenditures
- Aquaculture
 - Condition reflective of value of product
 - 2014: 139,479 tonnes
 - \$660,170,000 industry



Bioelectrical Impedance Analysis (BIA)

- Measures impedance of small current
 - Resistance = interstitial space
 - Reactance = measurement of cell volume
- Impedance values can be used to predict fat, protein, water
- Additional factors
 - Temperature
 - Location of electrodes
- Accurate, fast, low cost, non-lethal



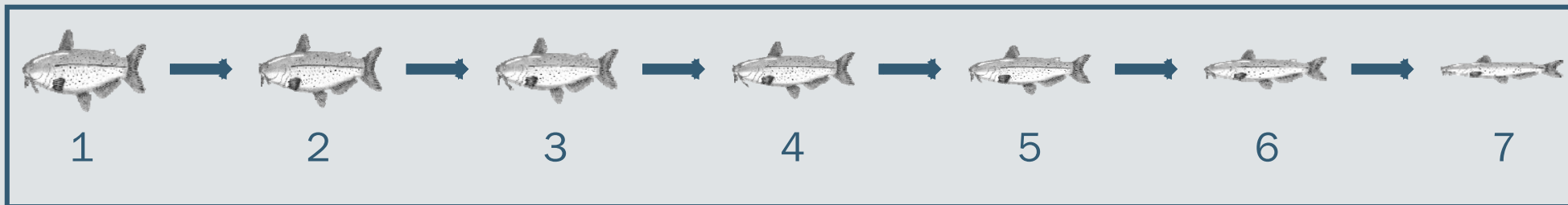
Objectives

Use BIA to determine total water content of Channel Catfish

1. Determine optimal electrode location on fish
2. Correlate impedance measurements to water (g)
3. Assess repeatability of measurements
4. Develop temperature corrections for impedance measurements
 - 10 (12), 20 (22.5), 30 (28) °C

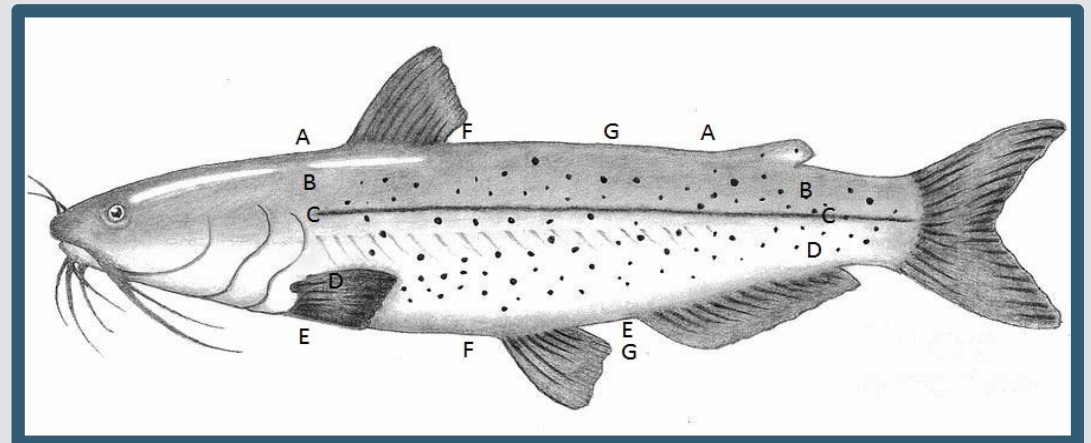
Methods: Design

- N = 134
- Total length range = 179 mm – 358 mm
- Fed ad libidum → high starting body condition
- Feed restriction 3 or 4 months → wide range of body condition
- Sample fish 7 times, each time selecting 1/7 of fish



Methods: Optimal Electrode Location

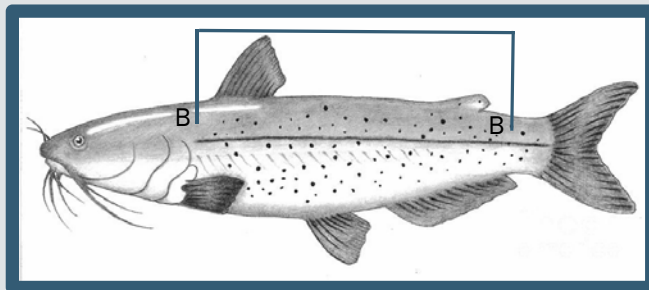
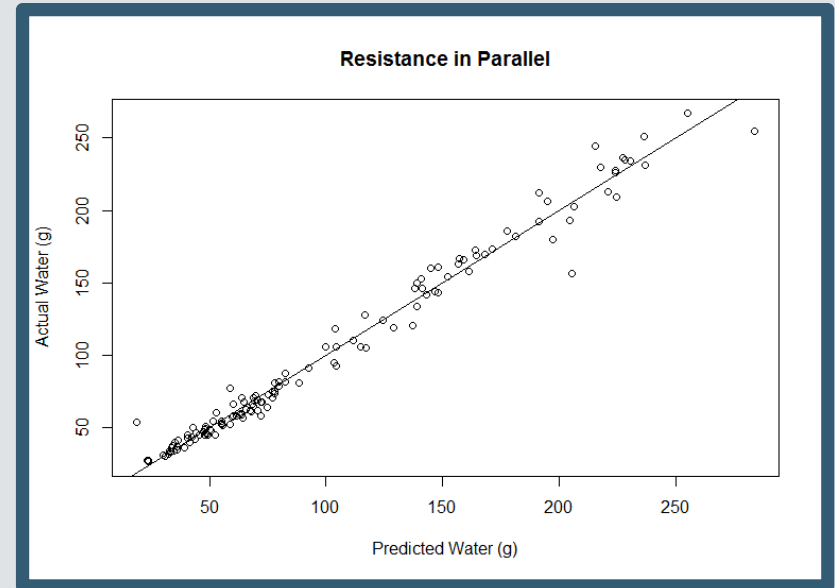
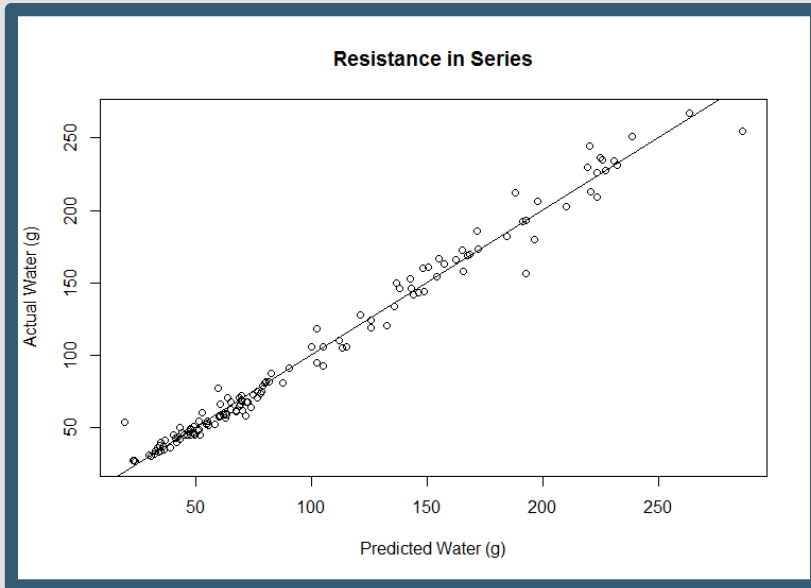
- Measure impedance values for each fish at 7 locations
 - Locations are ordered randomly for each fish
- 5 repeated measures for each location
- Correlate impedance measures to water (g)
 - Linear model



Methods: Parameter Calculations

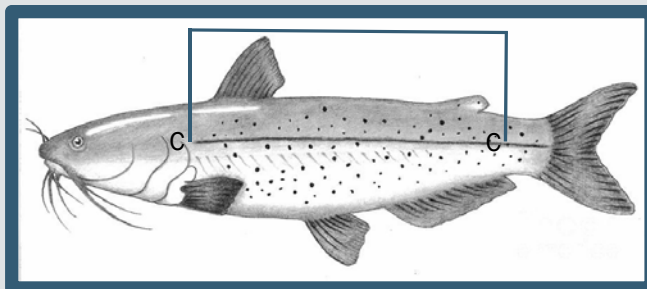
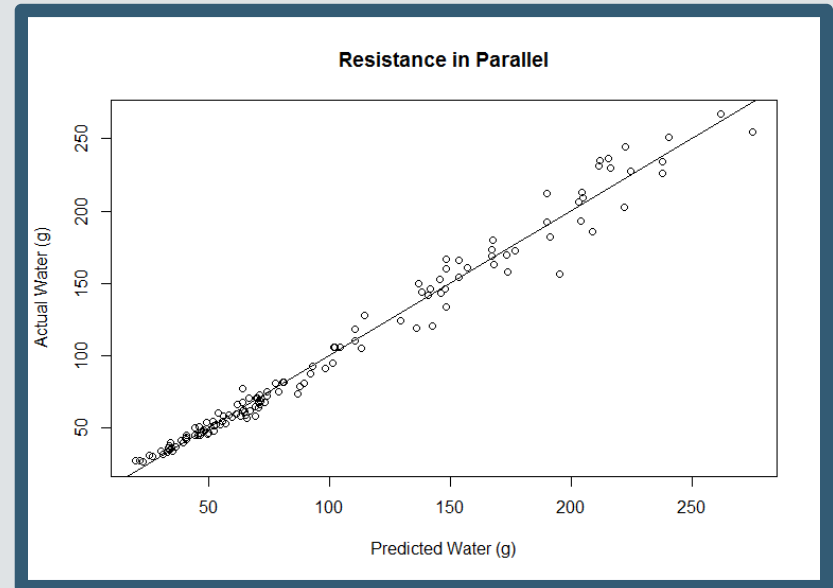
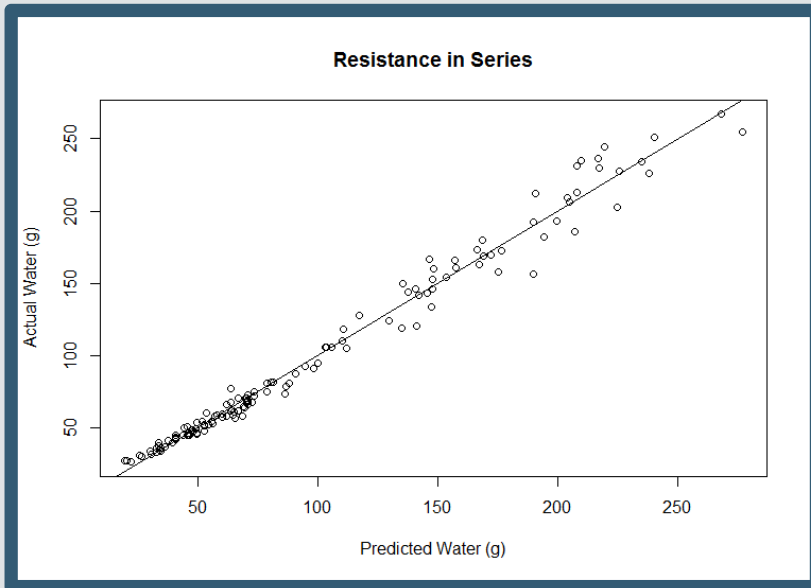
Parameter	Symbol	Units	Calculation
Resistance	r	Ohms	Measured by Quantum IV
Reactance	x	Ohms	Measured by Quantum IV
Resistance in series	R_s	Ohms	D_L^2/r
Reactance in series	X_c	Ohms	D_L^2/x
Resistance in parallel	R_p	Ohms	$D_L^2 / (r + (x^2/r))$
Reactance in parallel	X_p	Ohms	$D_L^2 / (x + (r^2/x))$
Capacitance	C_{pf}	PicoFarads	$D_L^2 / ((1/(2 \cdot \pi \cdot 50000 \cdot r)) \cdot (1 \cdot 10^{12}))$
Impedance in series	Z_s	Ohms	$D_L^2 / (r^2 + x^2)^{0.5}$
Impedance in parallel	Z_p	Ohms	$D_L^2 / (r \cdot x / (r^2 + x^2)^{0.5})$
Phase angle	A_p	Degrees	$\text{atan}(x/r) \cdot 180/\pi$
Standardized phase angle	$D_L A_p$	Degrees	$D_L \cdot (\text{atan}(x/r) \cdot 180/\pi)$

Results: Dorsal Total Length (B)



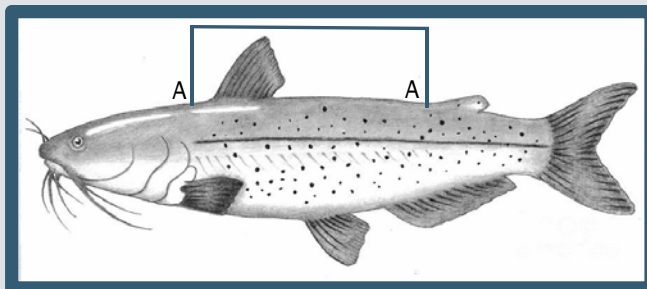
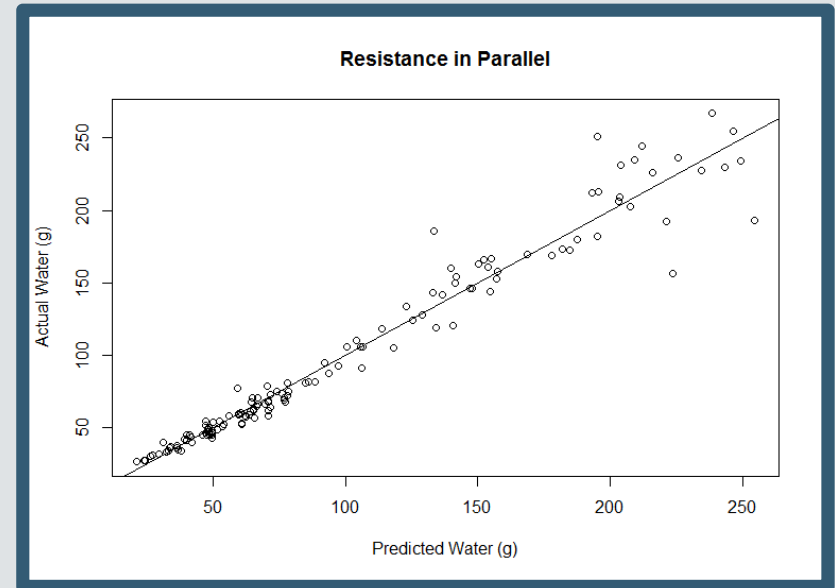
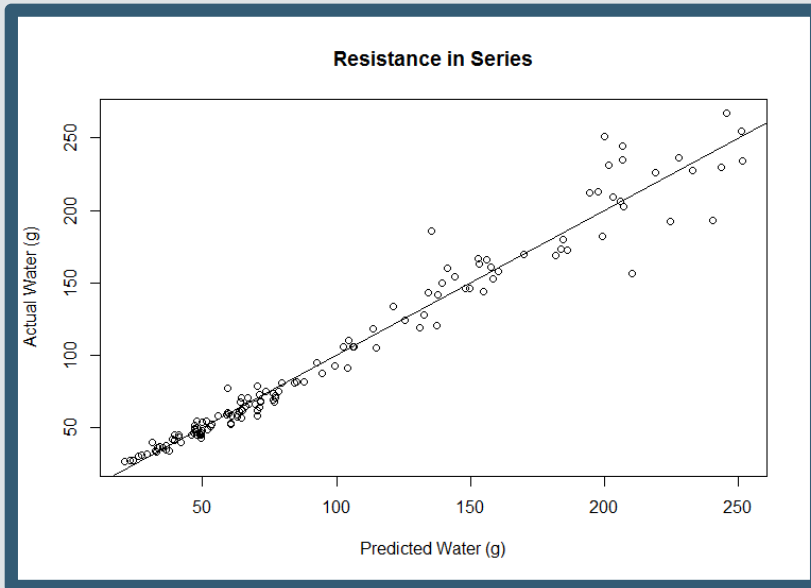
Position	Predictor	Equation	R ²
B	r_s	$-4.16474 + 4.35419*r_s$	0.9834
C	r_s	$-7.89271 + 4.61001*r_s$	0.9826
C	r_p	$-8.15903 + 4.75552*r_p$	0.9819
B	r_p	$-5.24920 + 4.68213*r_p$	0.98
A	r_s	$-9.02695 + 5.71331*r_s$	0.9632
A	r_p	$-9.95 + 6.116*r_p$	0.9562

Results: Lateral Line (C)



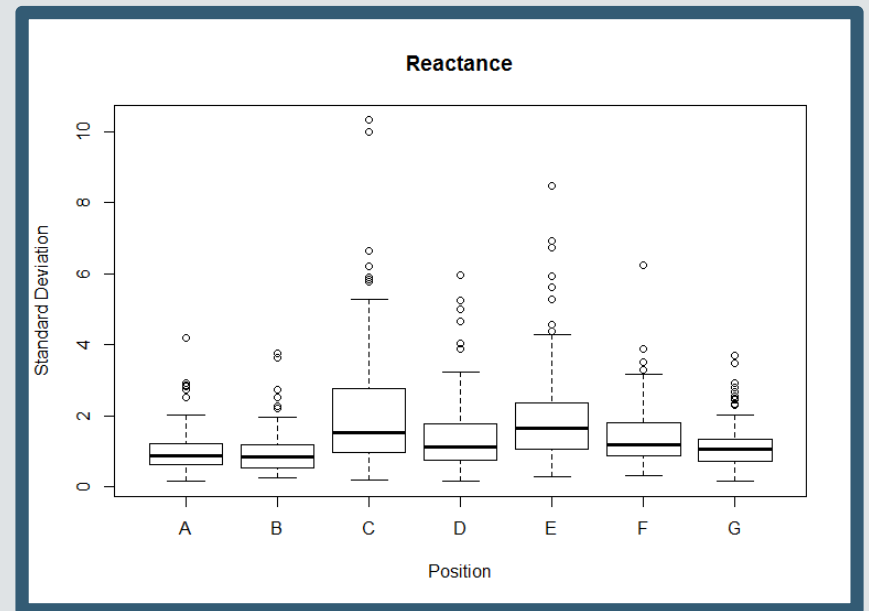
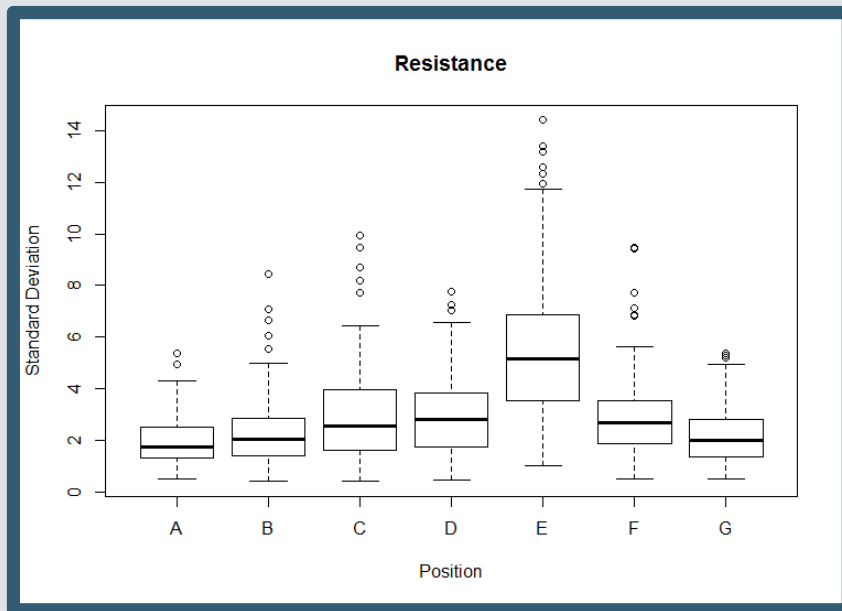
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Results: Dorsal Midline (A)



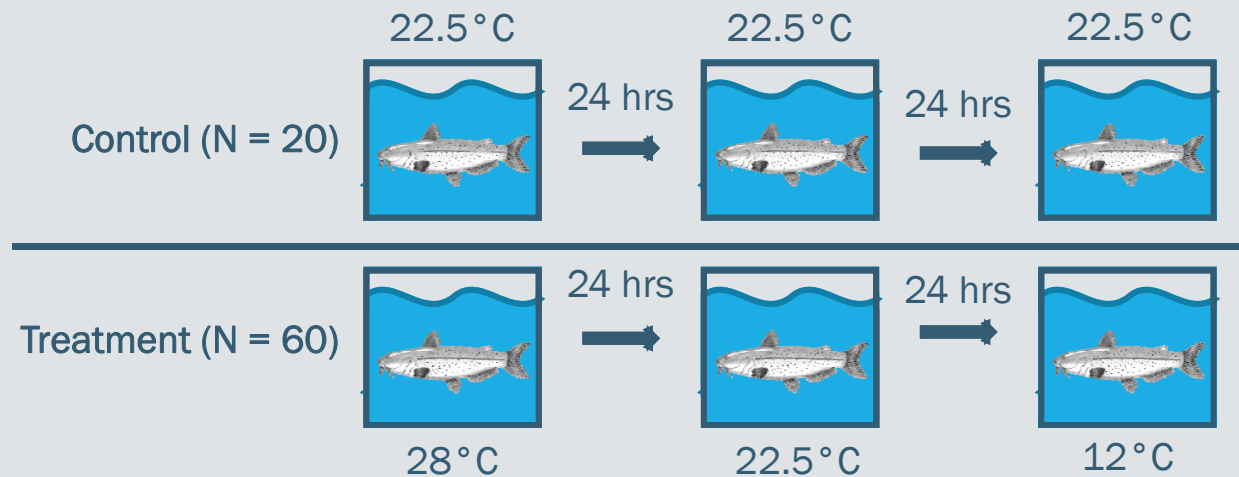
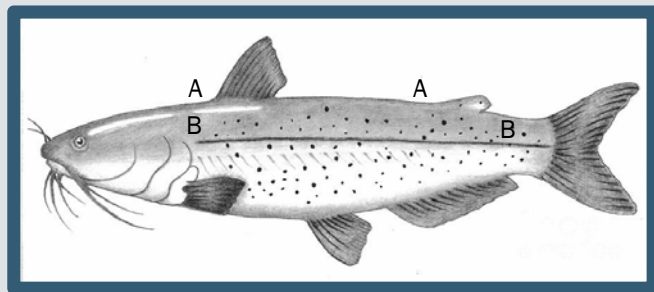
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Repeatability

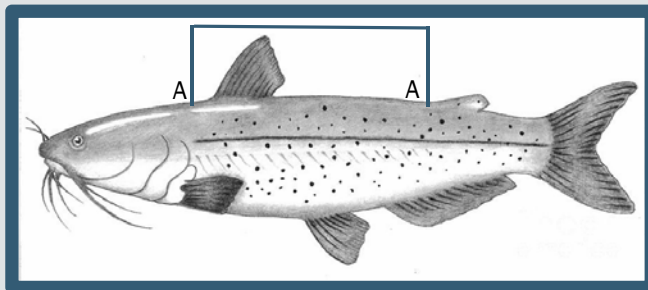
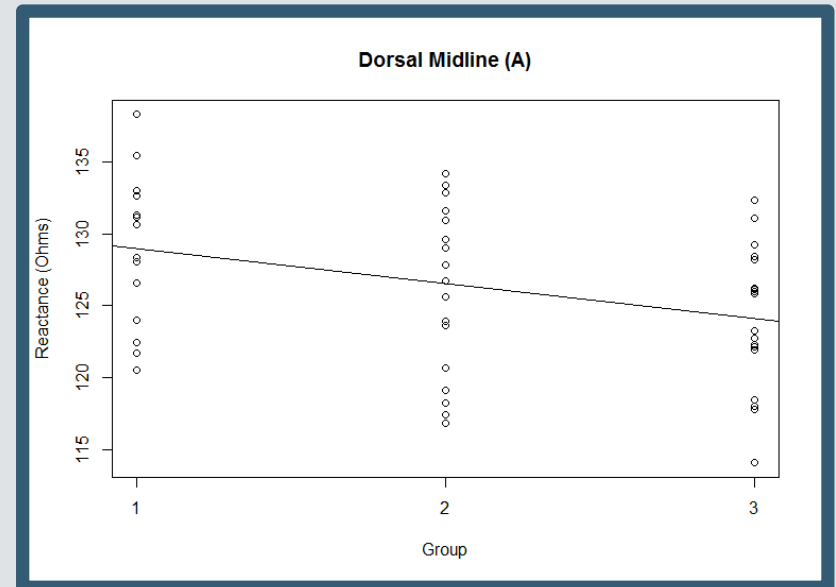
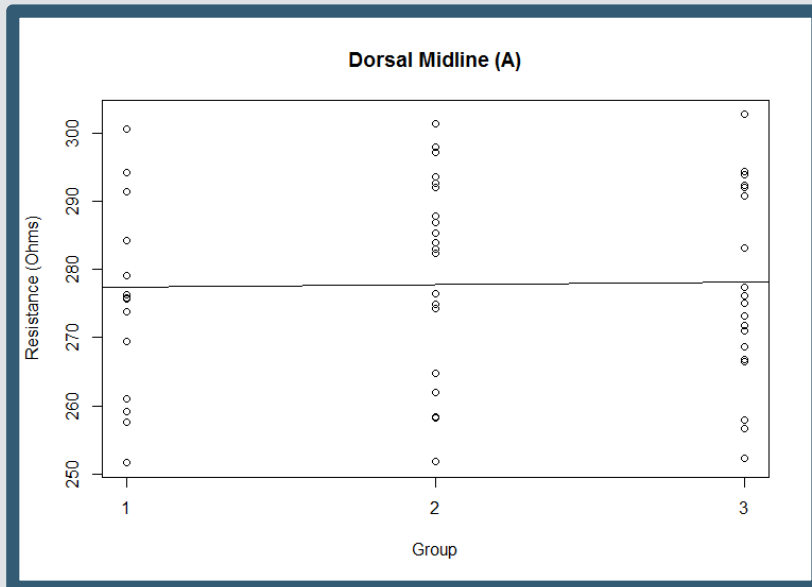


Methods: Temperature Corrections

- Impedance values measured at optimal location for all fish
- Fish acclimated at each temperature ≥ 24 hours
- Correct for change in impedance at each temperature
 - Generalized linear mixed effect model

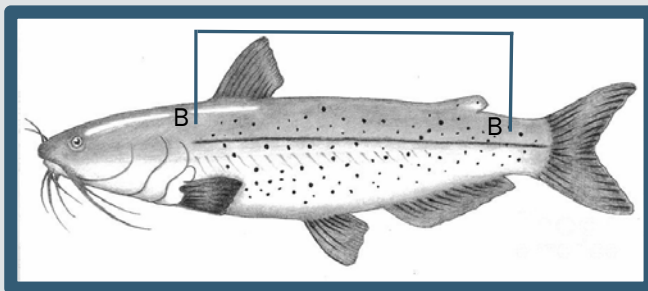
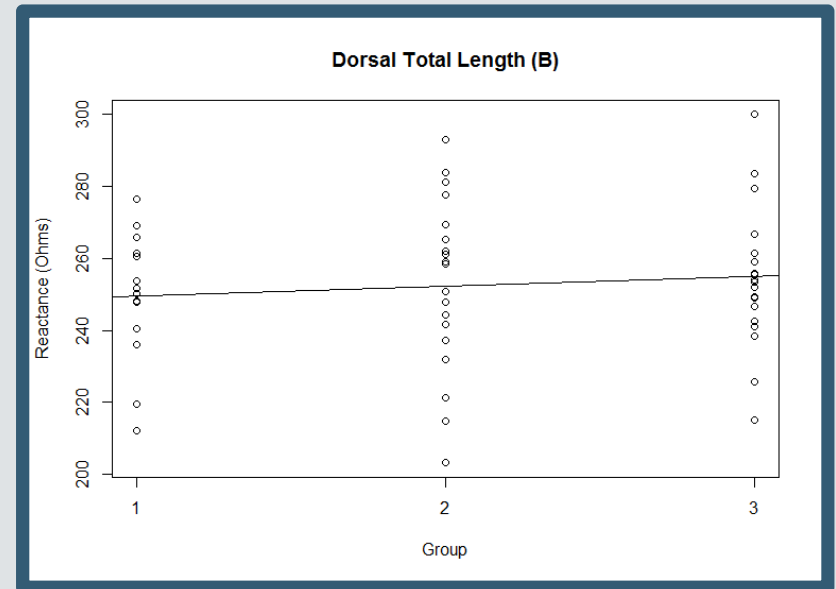
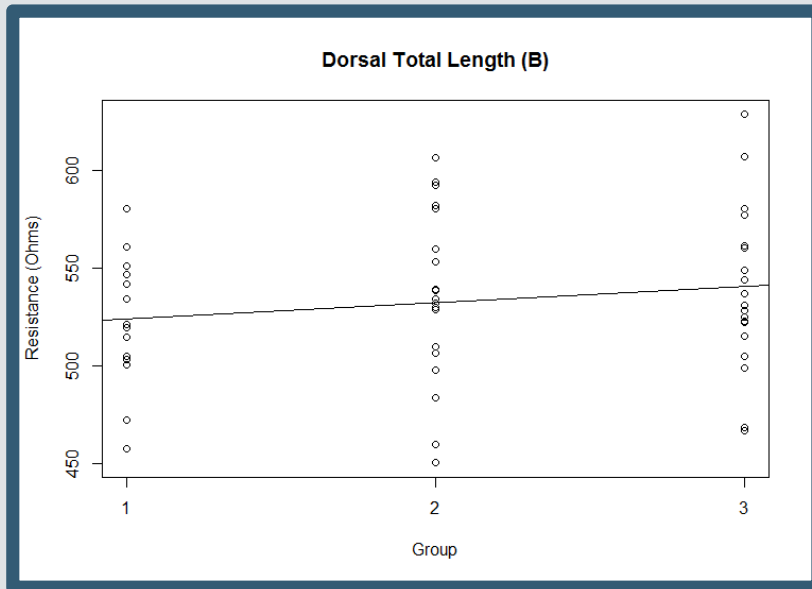


Temperature Control



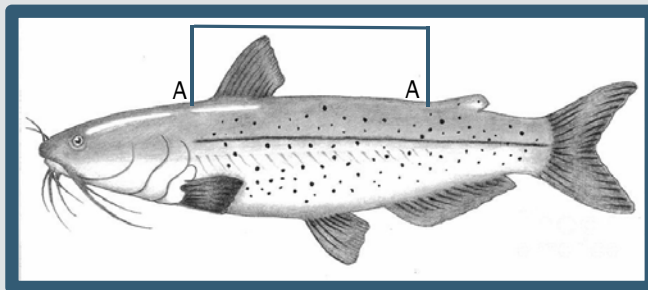
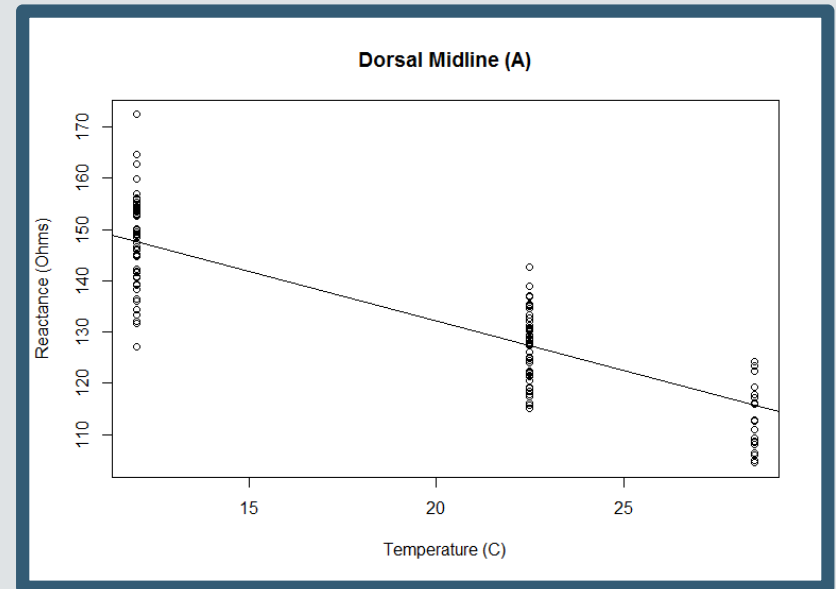
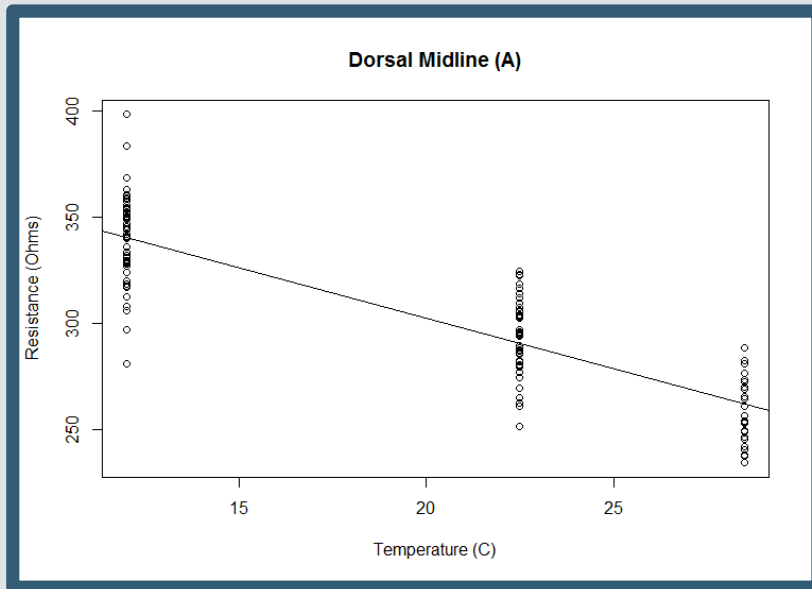
Position	Measurement	Slope	P-value
A	r	0.40737	0.6718
A	X	-2.42764	<0.001
B	r	8.2077	0.0041
B	X	2.8162	0.147

Temperature Control



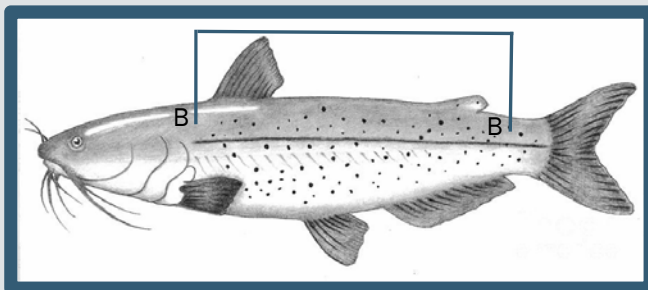
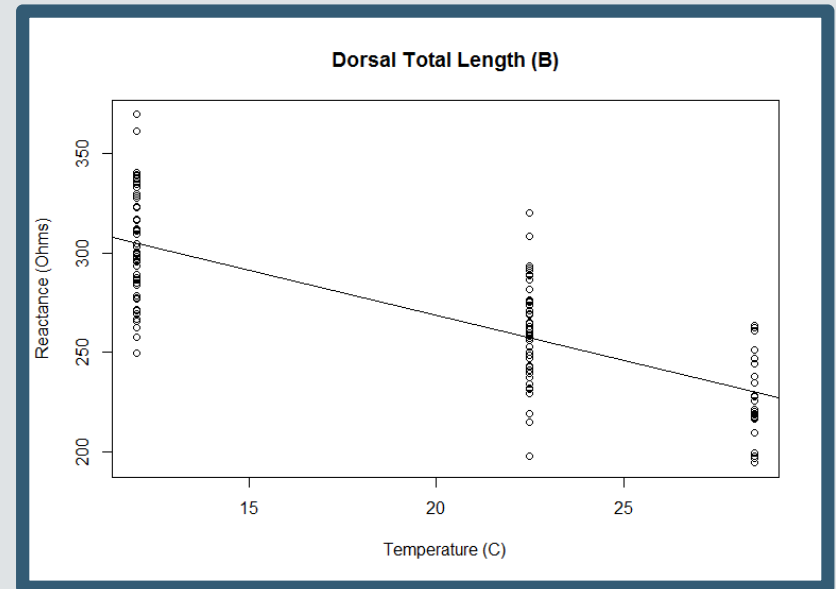
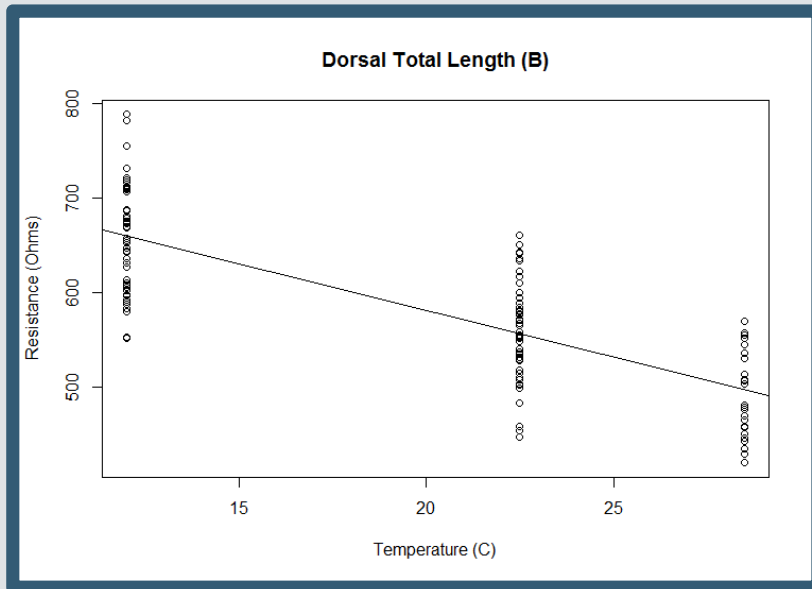
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Temperature Correction



Position	Measurement	Equation
A	r	$-4.7628 (T_c - T_m) + r_m$
A	X	$-1.92524 (T_c - T_m) + X_m$
B	r	$-9.8262 (T_c - T_m) + r_m$
B	X	$-4.5224 (T_c - T_m) + X_m$

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Discussion

- Correlation between water and r_s/r_p
- Best positions: B, C, A
 - Recommend B or A
 - C → 34% bleeding
- Resistance and reactance ↓ as temperature ↑
 - Position specific
 - Corrections → eliminates source of error

Future Research

- Determine body composition values (lipid & protein) and relationship to water(g) and/or dry weight
- Validation
 - Field/Species with similar morphologies
- Compression electrode models
- Assessing condition of wild populations of (Channel) Catfish
- Spatial and temporal comparisons
- Increasing accuracy and efficiency
 - Fish condition
 - Body composition
 - Bioenergetics

Acknowledgements

■ Committee:

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- Dr. Keith Cox



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