Jun 26th, 1:30 PM - 1:50 PM

# Concurrent Sessions B: Integrating Fish Physiology or Behavior With Passage - A Predictive Model of Swimming Performance for Small-Bodied Fishes

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# Can We Predict Swimming Performance of Small-Bodied Fishes?

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# Overview

- Quick introduction to western Great Plains streams
- Stream alterations in these systems
  - Fragmentation
- Improving fish passage for small, nonsalmonid fishes
  - Predictive swimming model
  - Review of swimming abilities
  - Field study of existing rock ramps
  - Lab study using experimental rock ramps

Photo: Matt Kondratieff

# Western Great Plains Streams

- Many semi-arid systems
  - Some have mountain headwaters
  - Large inter- and intra-annual flow variability
  - Large range of physicochemical conditions
- Many of these streams are highly fragmented

# Western Great Plains Fishes

- Many small-bodied fishes
  - Adult TL ~ 100 – 150 mm
- Movement essential part of life history for most species


Photo: Matt Kondratieff


Photo: Jon Wardell

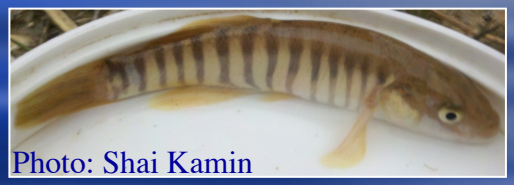


Photo: Shai Kamin


http://outdoornebraska.ne.gov

# Facilitating Fish Passage

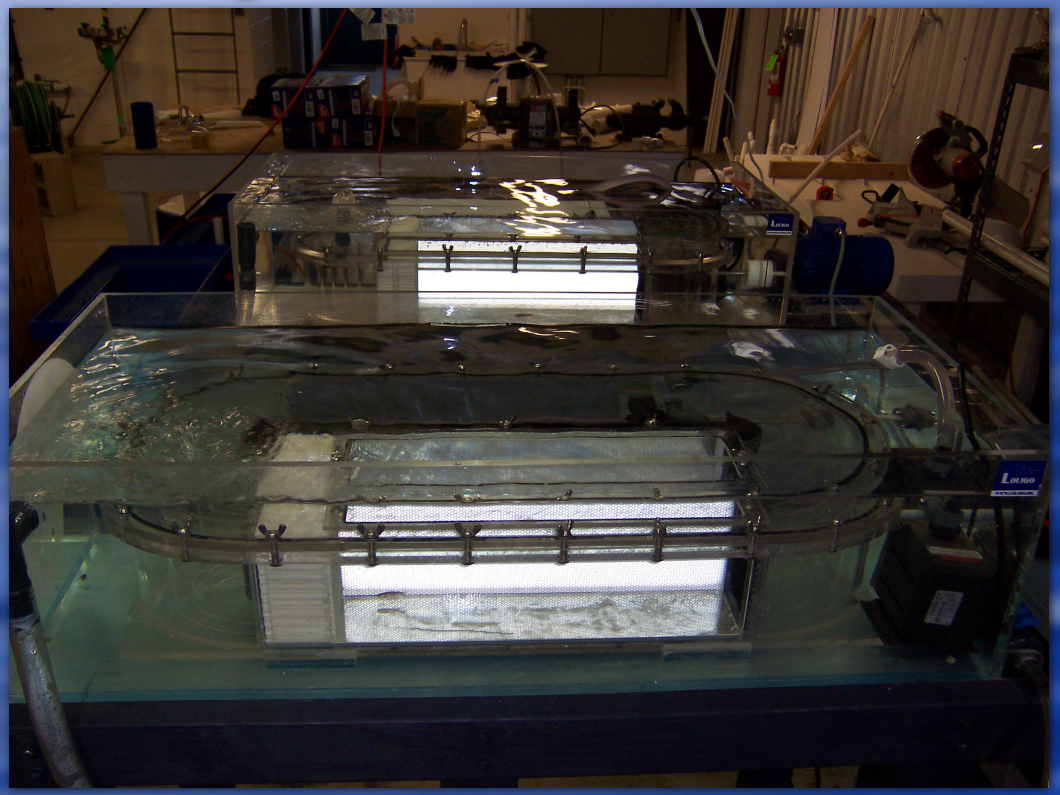
- Typically accomplished with fishways
- Multiple fishway types
- Incorporating swimming data into design is ideal
- Many questions remain
  - Swimming ability quantified for few species
  - Collection of swimming ability data requires expensive, long-term studies

# Facilitating Fish Passage: Goal

- Develop a predictive model of swimming performance for small-bodied North American fishes.
  - Predictor variables = simple to collect
  - Combination of shape and physiological measurements

# Methods: A Predictive Swimming Model

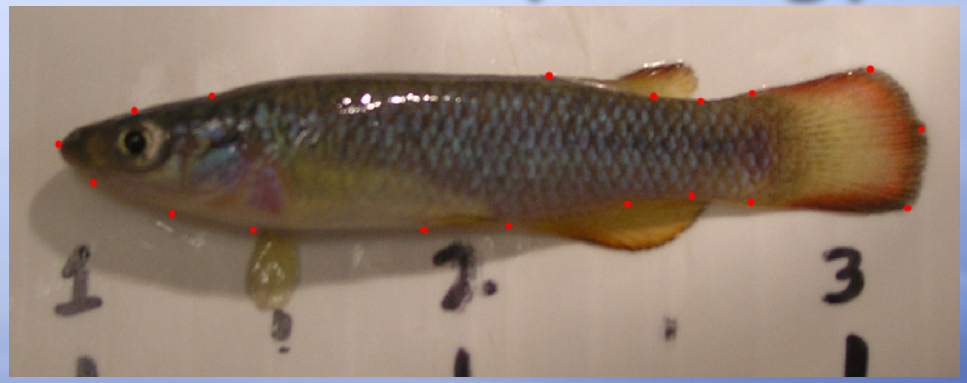
- Aerobic and sprint swimming as a function of…
- Morphology
  - Landmark Analyses
- Physiology
  - Hematocrit, $Hb^{+}$
  - Percent red muscle
  - Percent white muscle



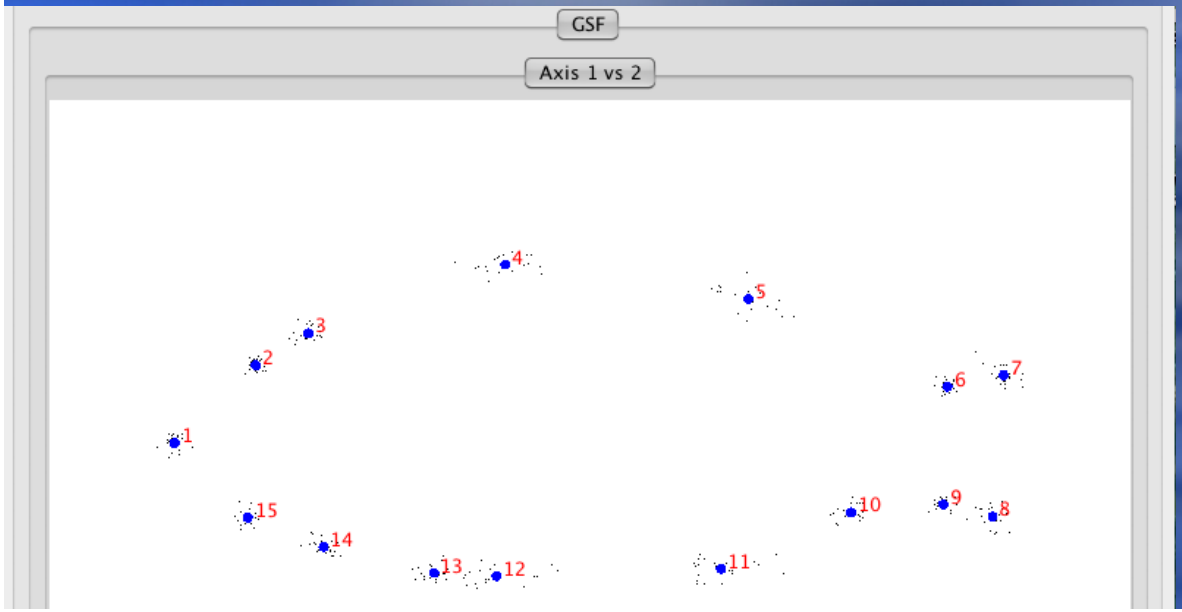
# Dependent Variables: Swimming Abilities

- Loligo Model 32 & Model 90 swim tunnels
  - Constant acceleration tests (CATs)
  - Start velocity = 11 cm/s
  - Increments = 5 cm/s every 5 s
- Measurements
  - Aerobic ability = gait transition speed
  - Sprint ability = speed at “exhaustion”

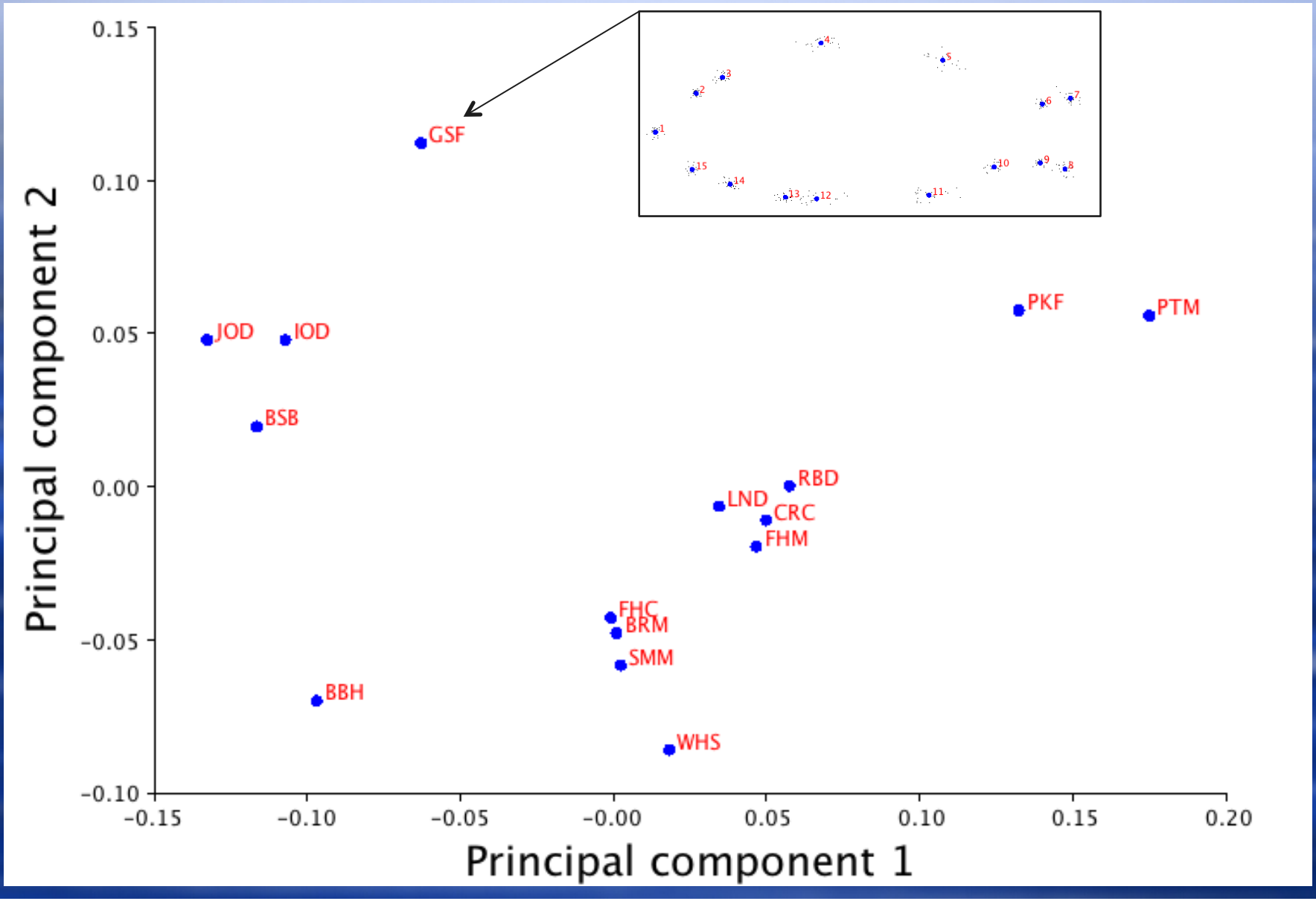
# Independent Variables: Morphology




- Total length
- Landmark analysis
  - 15 landmarks per fish
  - Procrustes analysis provides “typical shape” for species
  - PCA converts (x , y) coordinates to scores
  - Scores can be used in statistical analyses

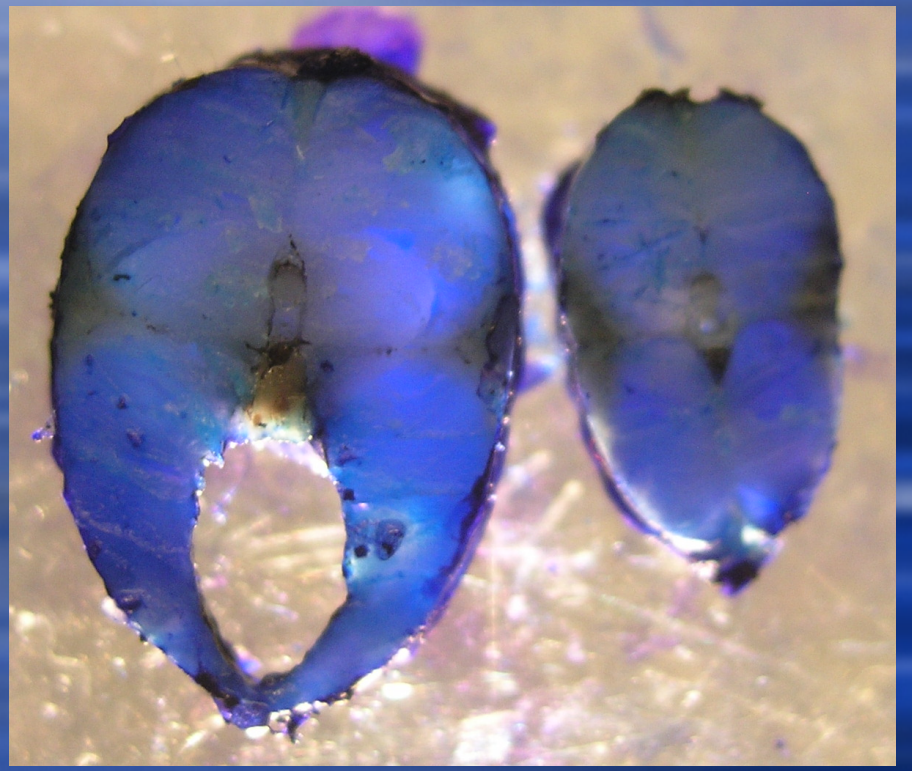


# Independent Variables: Morphology



# Independent Variables: Physiology

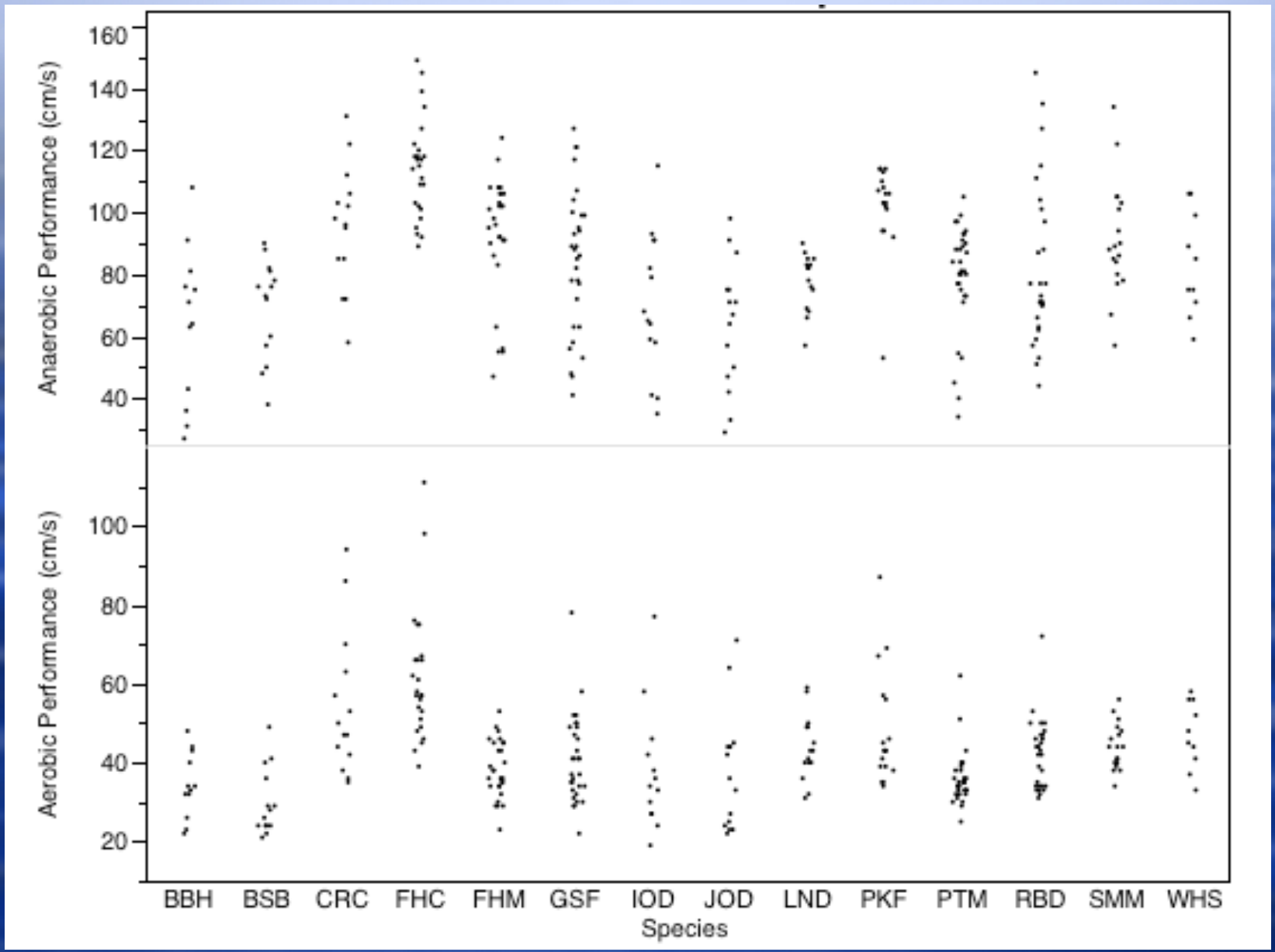
- Hematocrit
  - Hematocrit tubes centrifuged
  - Packed cell volume read
- Hemoglobin concentration
  - Quantichrom Hemoglobin Assay
- Red and white muscle
  - Percent @ 50% of TL
  - Preserved & stained cross sections analyzed with ArcGIS

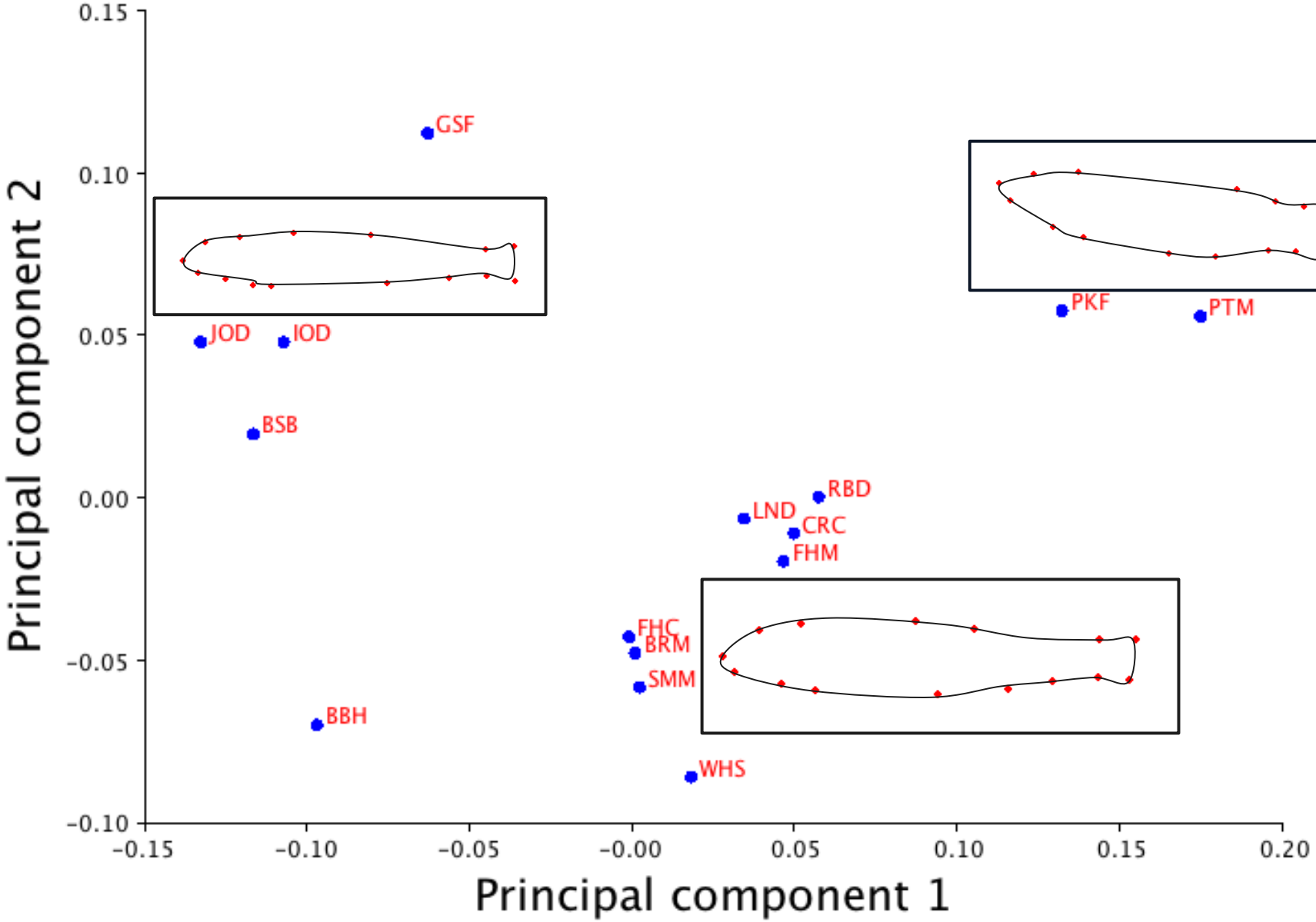
# Integrated Analysis

- Boosted regression trees
  - Strong predictive power
- Two analyses
  - Aerobic swimming ability
  - Sprint swimming ability
- Independent variables for both analyses:
  - Total length
  - Average body shape scores (PCA scores) for each species
  - Hematocrit
  - Hemoglobin concentration
  - Red and white muscle percentages

# Results: Swimming Performance

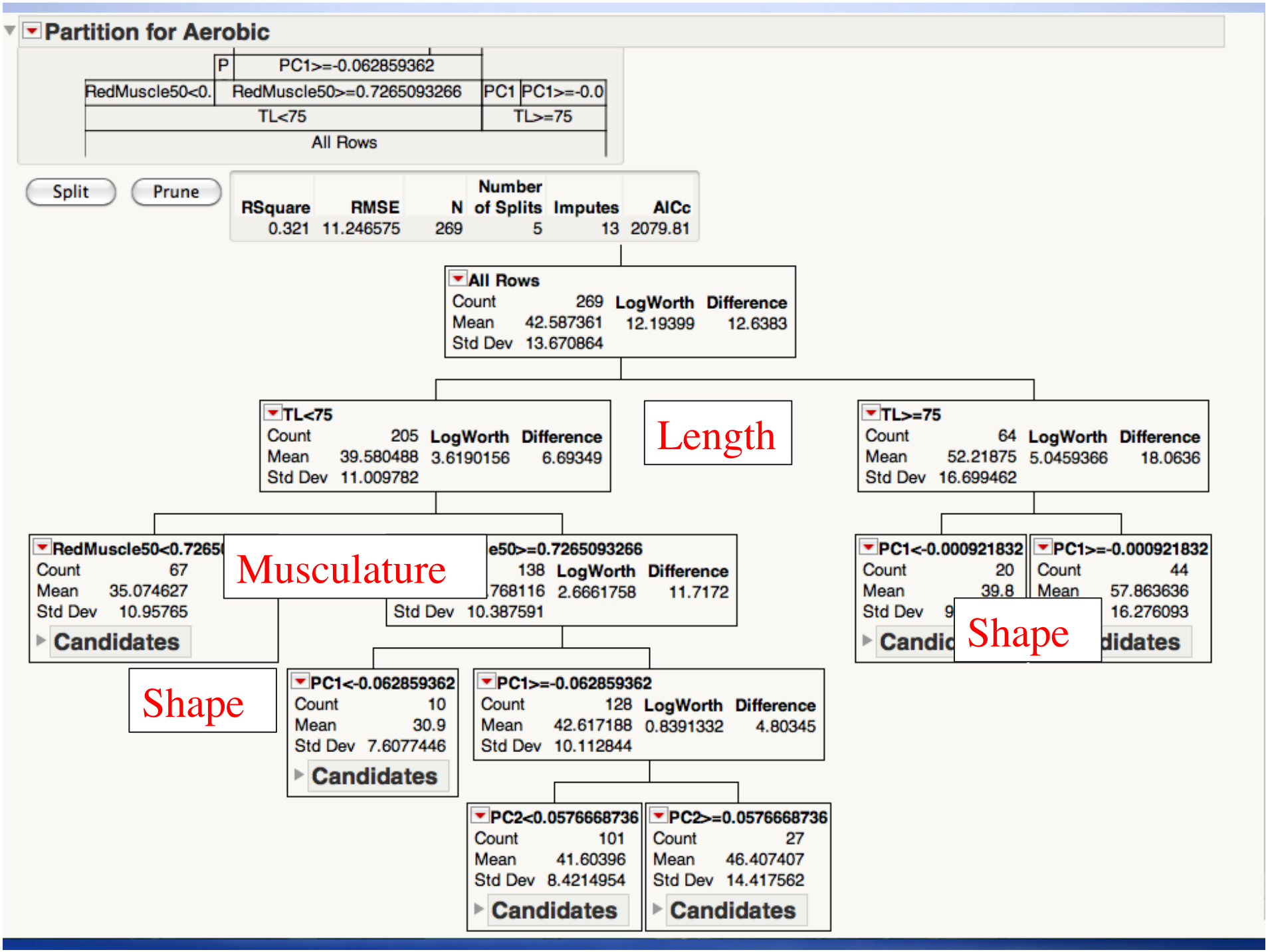


# Results: Morphology



# Effects on Swimming Performance

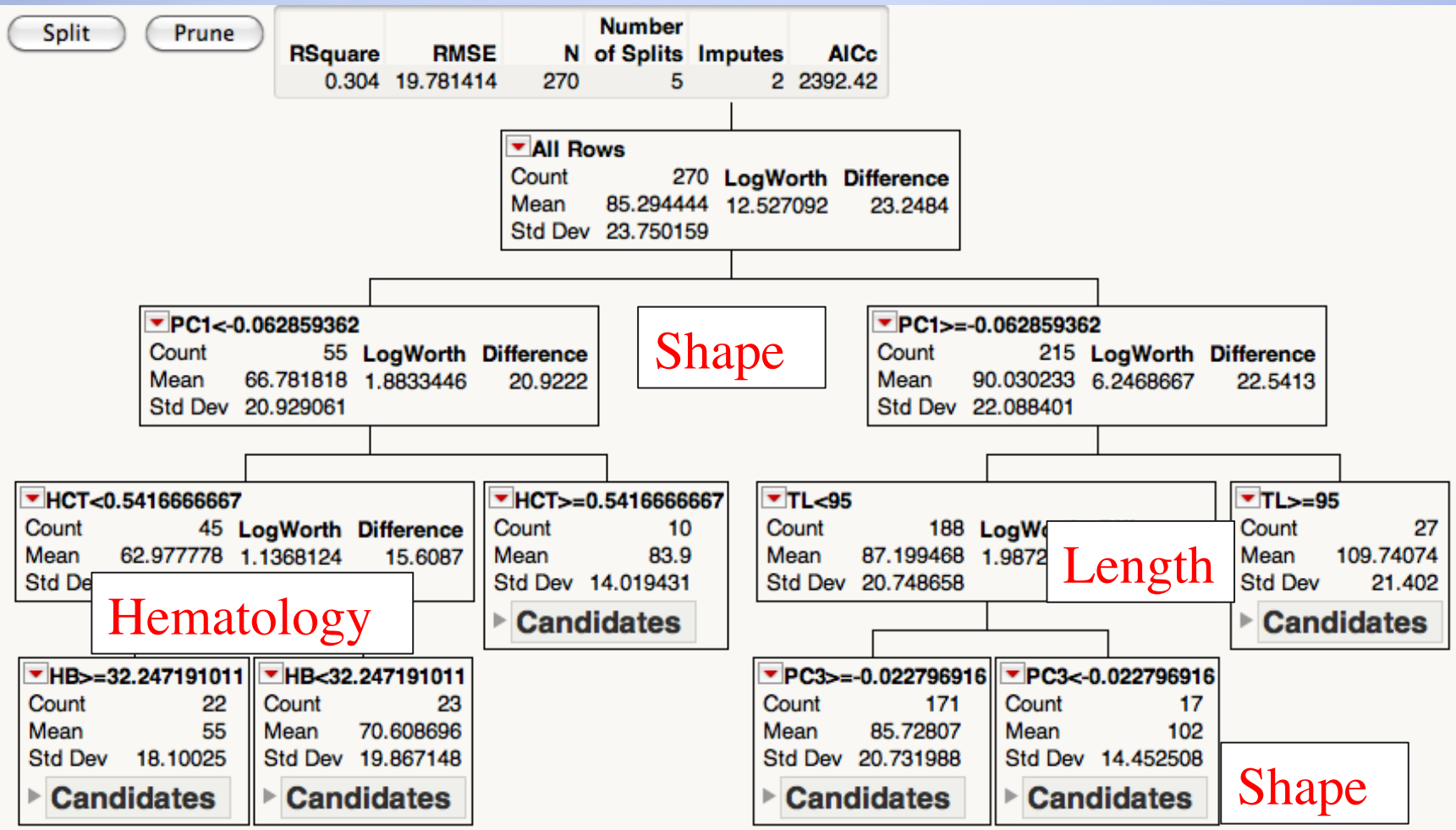
- Aerobic
  - Total length
  - Red Muscle
  - PC1 and PC2
- Sprint
  - PC1
  - Total length
  - HCT and $Hb^{+}$
  - PC3


Partition for Aerobic
P
PC1>=-0.062859362
RedMuscle50<0.
RedMuscle50>=0.7265093266
PC1
PC1>=-0.0
TL<75
TL>=75
All Rows
Split
Prune
RSquare 0.321
RMSE 11.246575
N 269
Number of Splits 5
Imputes 13
AICc 2079.81
All Rows
Count 269
LogWorth 12.19399
Difference 12.6383
Mean 42.587361
Std Dev 13.670864
TL<75
Count 205
LogWorth 3.6190156
Difference 6.69349
Mean 39.580488
Std Dev 11.009782
Length
TL>=75
Count 64
LogWorth 5.0459366
Difference 18.0636
Mean 52.21875
Std Dev 16.699462
RedMuscle50<0.7265
Count 67
Mean 35.074627
Std Dev 10.95765
Candidates
Musculature
e50>=0.7265093266
138
LogWorth 2.6661758
Difference 11.7172
768116
Std Dev 10.387591
PC1<-0.000921832
Count 20
Mean 39.8
Std Dev 9
Candic
PC1>=-0.000921832
Count 44
Mean 57.863636
16.276093
didates
Shape
Shape
PC1<-0.062859362
Count 10
Mean 30.9
Std Dev 7.6077446
Candidates
PC1>=-0.062859362
Count 128
LogWorth 0.8391332
Difference 4.80345
Mean 42.617188
Std Dev 10.112844
PC2<0.0576668736
Count 101
Mean 41.60396
Std Dev 8.4214954
Candidates
PC2>=0.0576668736
Count 27
Mean 46.407407
Std Dev 14.417562
Candidates

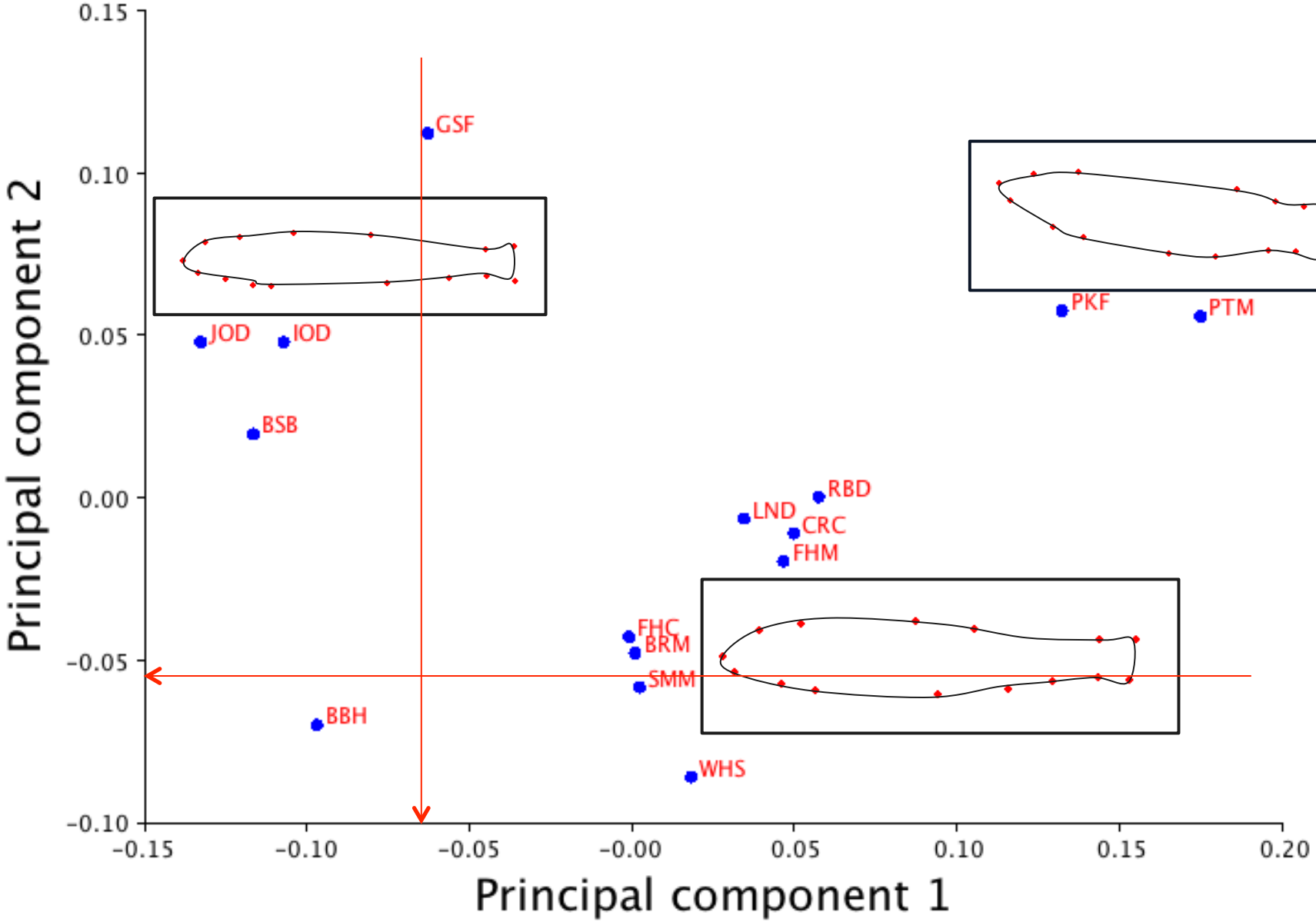
# Effects on Swimming Performance

- Aerobic
  - Total length
  - Red Muscle
  - PC1 and PC2
- Sprint
  - PC1
  - Total length
  - HCT and $Hb^{+}$
  - PC3

# Effects on Sprint Performance



# Results: Morphology



# Conclusions

- Different factors may affect aerobic and anaerobic ability
  - We remain confident that we can produce a predictive model
- Integrating physiology and morphology important
- Important but unmeasured…
  - Behaviors (station-holding, searching)
  - Fin area and morphology (to be continued…)
- Estimating ability of untested fish will improve fishway efficacy

# Acknowledgements


- Funding: M. Kondratieff (Colorado Parks and Wildlife); Dr. K. Wilson (Fish, Wildlife, and Conservation Biology); S. Krantz, U.S. Fish and Wildlife (Great Plains Prairie Fish Habitat Partnership); Colorado Trout Unlimited; and J. and M. Peters
- Graduate Committee: Dr. C. Myrick, Dr. K. Bestgen, Dr. K. Fausch, and Dr. C. Thornton
- Indispensible help with lab work, statistics, and logistics: J. Anderson, J. Callison, C. Craft, B. Fox, E. Gardunio, Dr. C. Ghalambor, C. Handelsman, A. Herdrich, A. Hansen, Dr. M. Hooten, S. Hoyer, Dr. S. Kanatous, K. Oles, D. Pruitt, A. Schwindt, T. Swarr, Z. Underwood, J. Wardell, N. Wilson, and R. Winkelman
- GEI Consultants, Inc.