Climate Match Fails to Explain Variation in Establishment Success of Non-native Freshwater Fishes in a Warm Climate Region

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Invasion Ecology

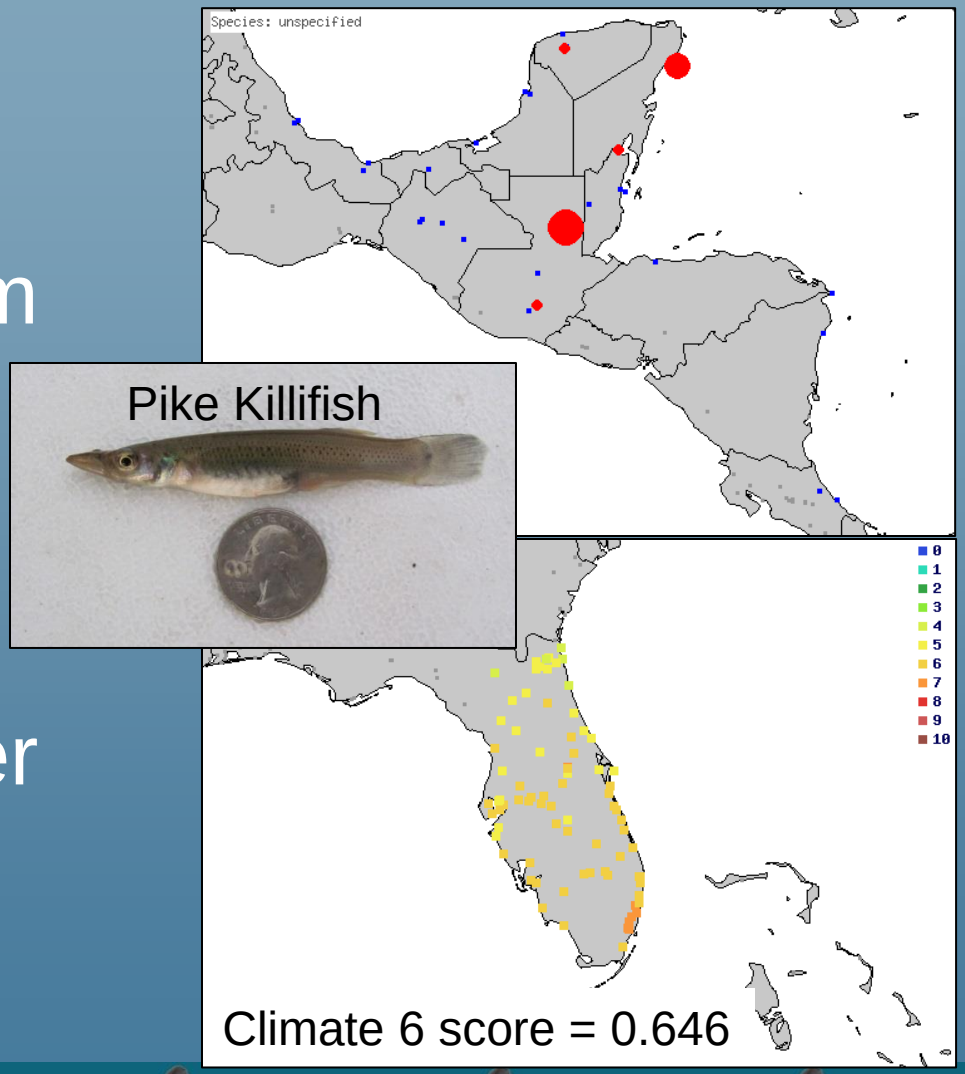
- Predicting successful invaders a central question
- Consistent predictors? (Hayes and Barry 2008)
  - Climate match
  - Prior invasion success
  - Propagule pressure

Climate Match

- Strong filter on invasion (Chapman et al. 2014)
- Fundamental mismatch can prevent establishment and spread

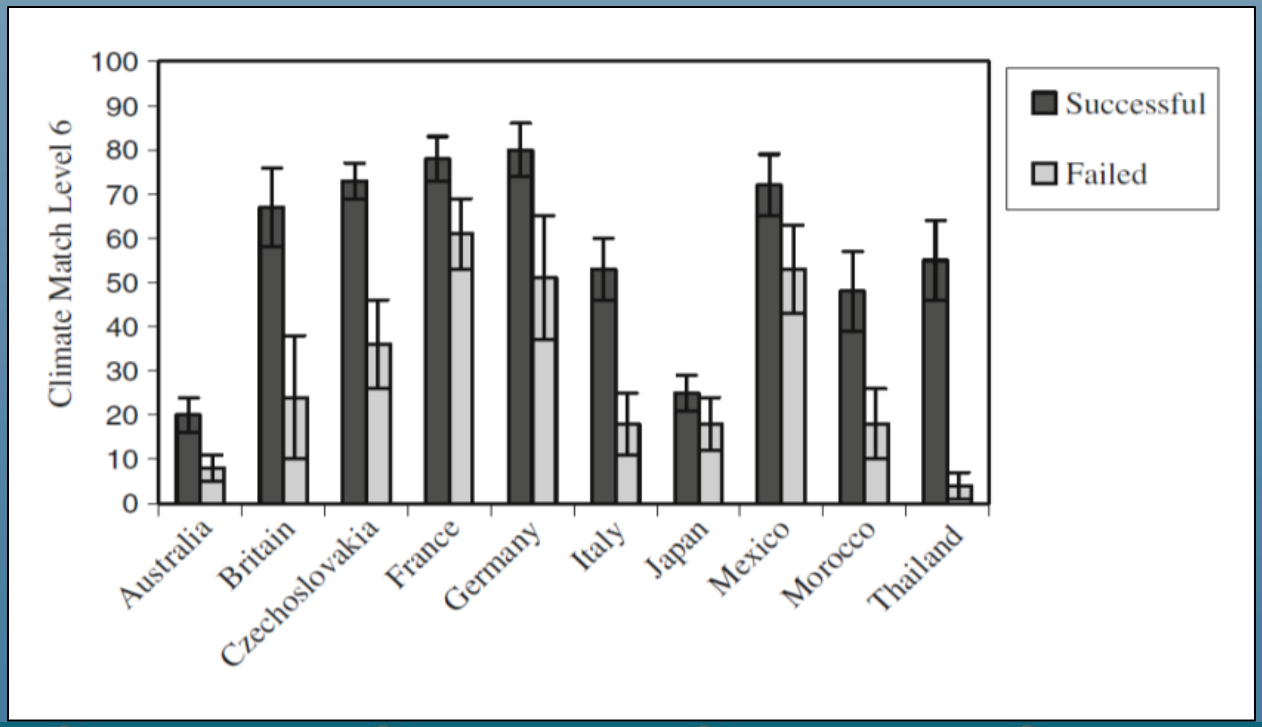
CLIMATCH

- Simple, free
- Similarity algorithm
- 16 variables
  - Temperature
  - Precipitation
- Compares weather stations in source with target region



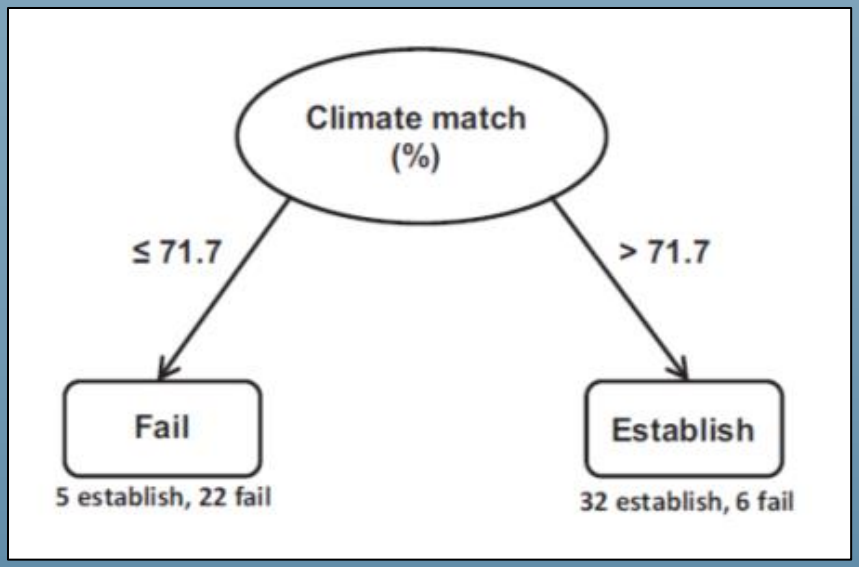
Bomford et al. 2010

- Mean successful > mean failed
- Variety of climate types



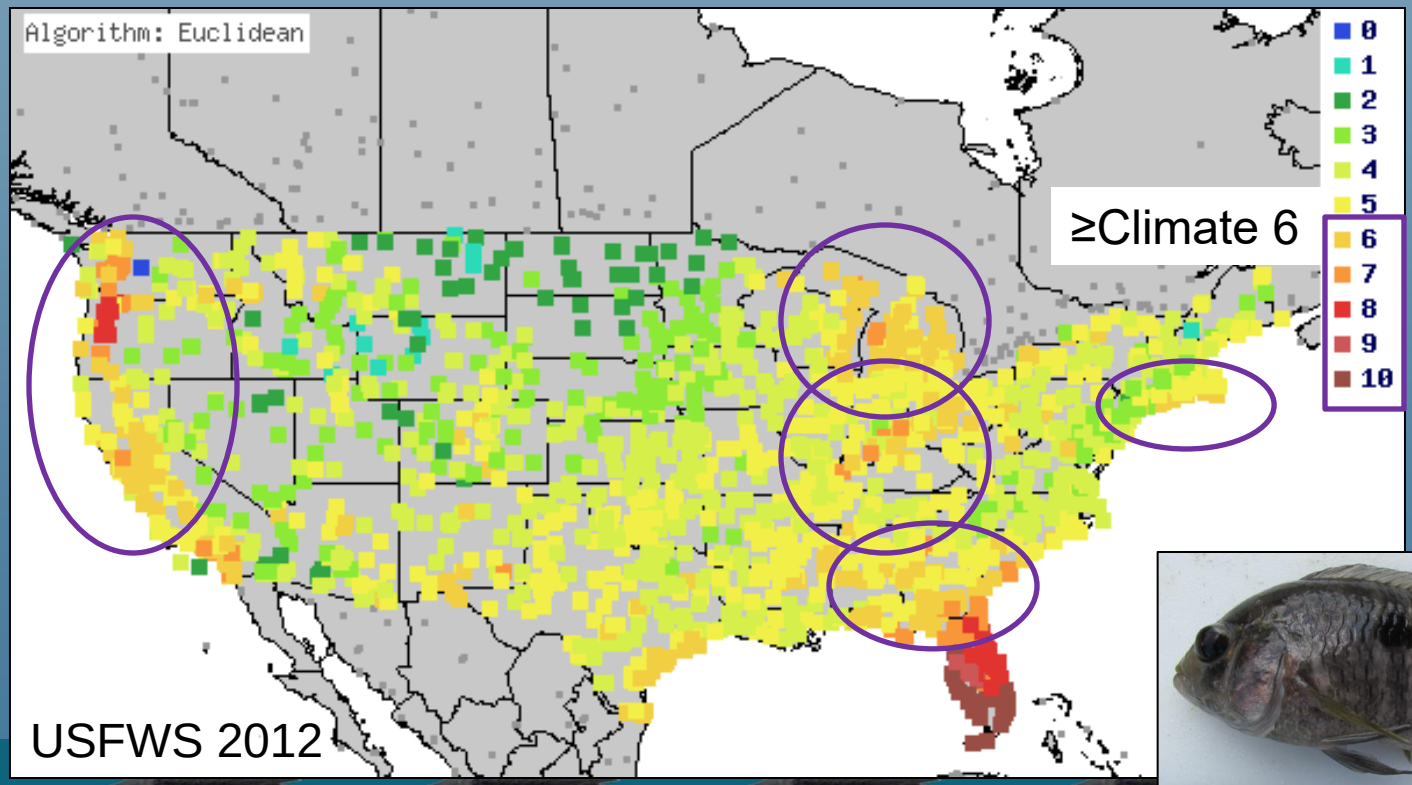
Howeth et al. 2016

- Climate match – 75-81% accuracy
- Extreme (cold) climate region
- USFWS – ERSS risk screening tool (Hoff 2014)



Range of Tropical Fishes?

- Black Acara – tropical; established in FL
- Chronic lower lethal temp = ~9°C



Differing Protocols

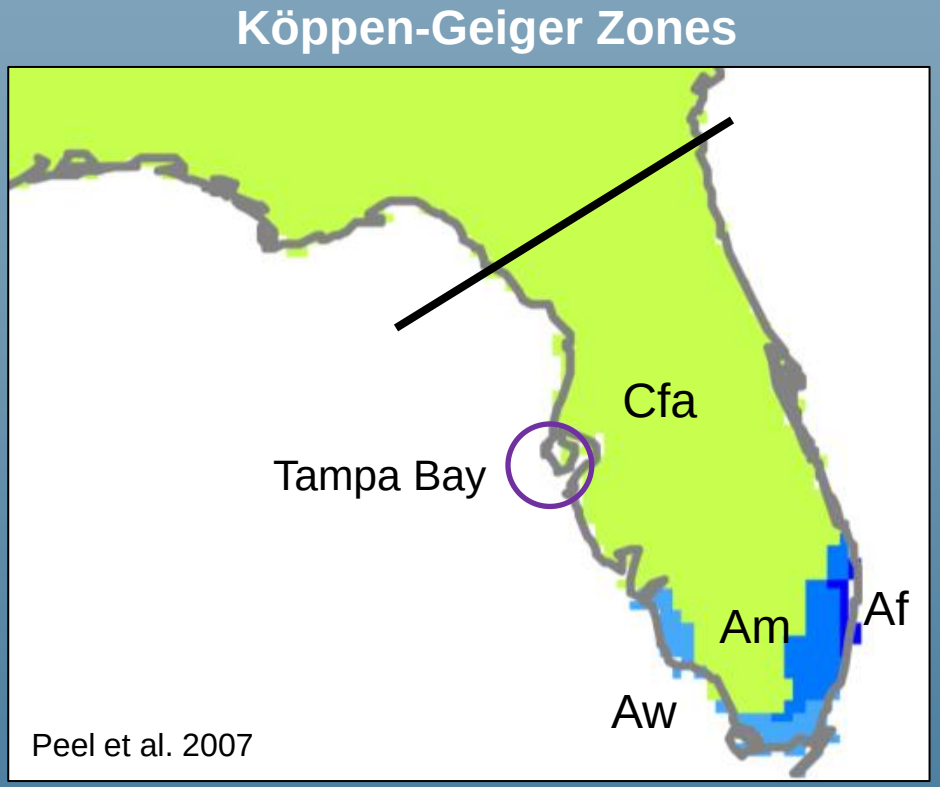
- Bomford et al. 2010 and Hoff 2014
  - Use native and established range as source
- Bomford et al. 2010
  - Do not use source locations within RA area
  - *A priori* analysis
- Hoff 2014
  - Use all source locations (includes RA area)
  - *Post hoc* analysis

Objectives

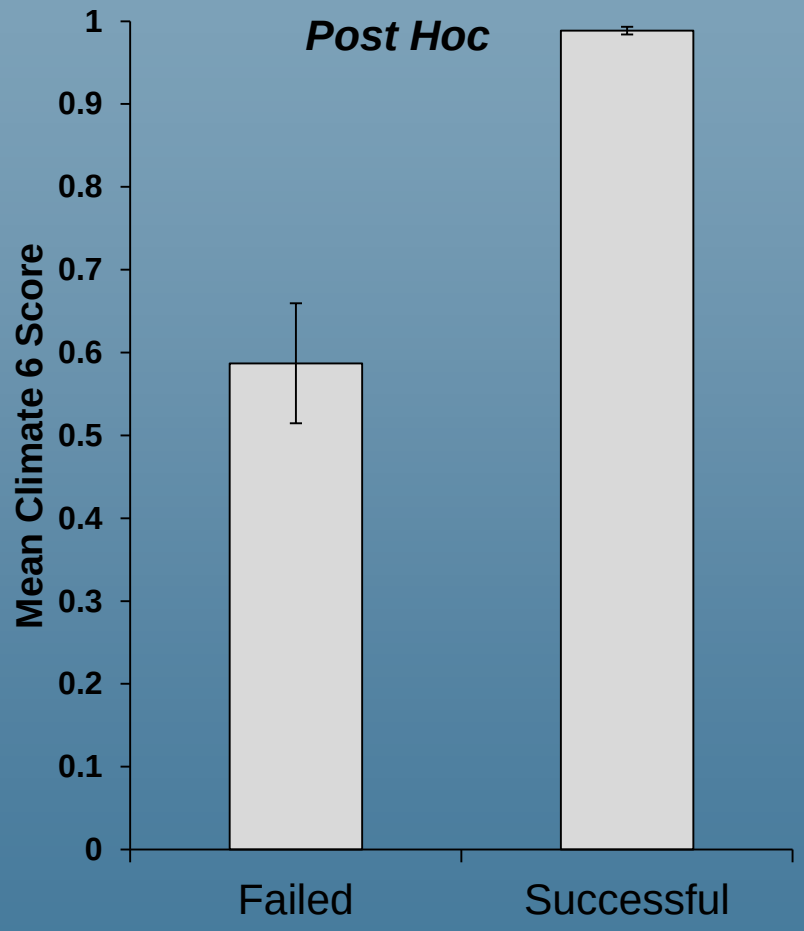
- Can CLIMATCH distinguish between successful and failed invasions in FL?
- Objectives
  - Test for mean differences in climate match between successful and failed freshwater fishes using 2 common protocols
    - *Post hoc*
    - *A priori*
  - (Incorporate into a decision tree analysis?)

Peninsular Florida

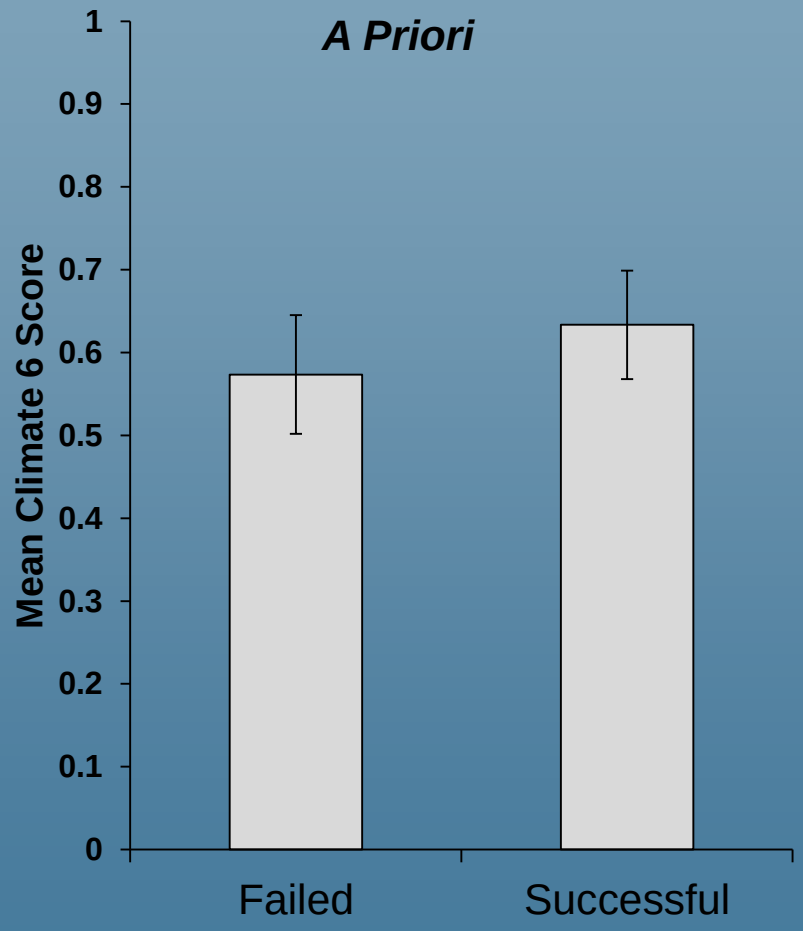
- About 100 species paired down to:
  - 34 successful
  - 36 failed species
- Cold temperatures important!



Post Hoc vs. A Priori



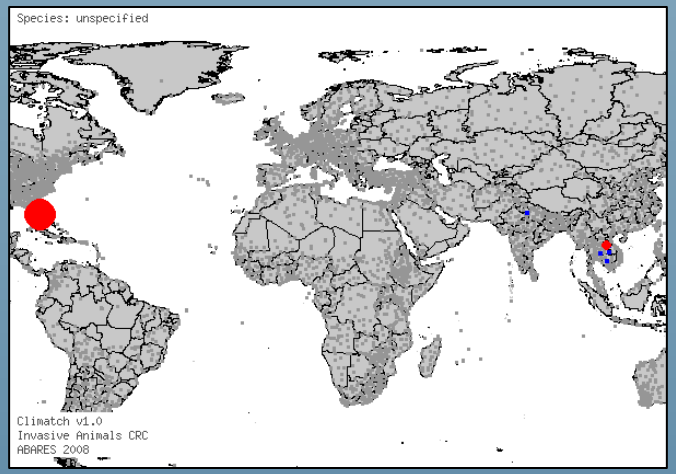
$X^2 = 15.43$, df = 1, $P < 0.0001$

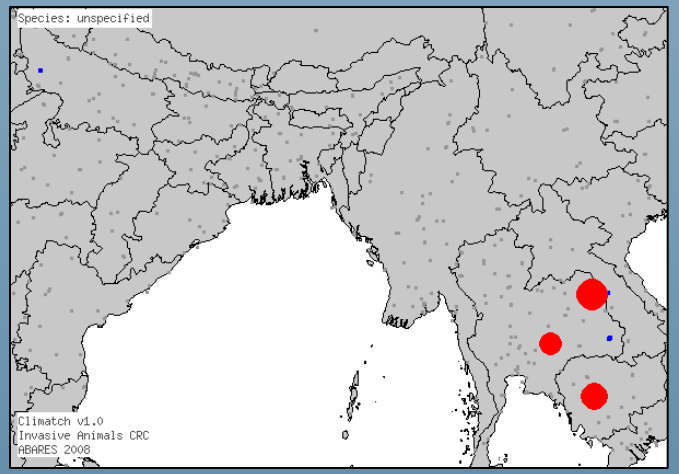


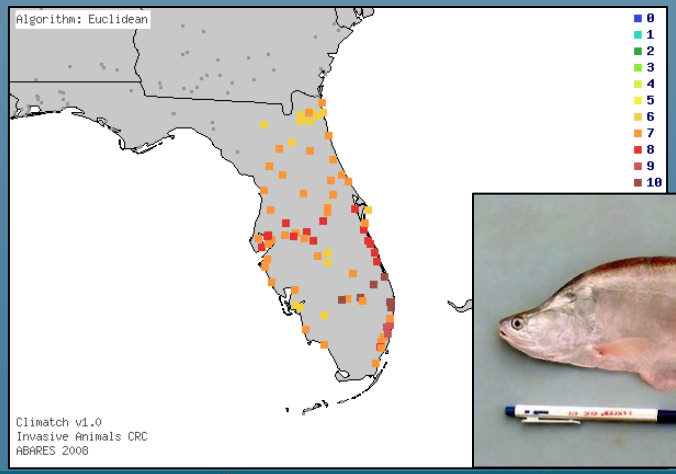
$X^2 = 0.0145$, df = 1, $P < 0.904$

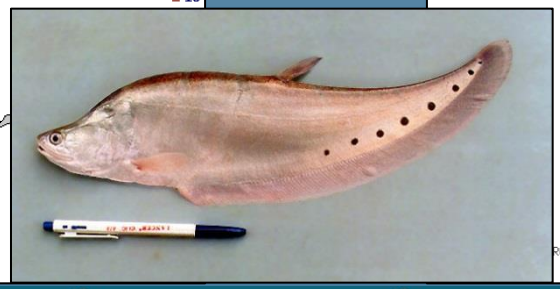
Post Hoc vs. A Priori

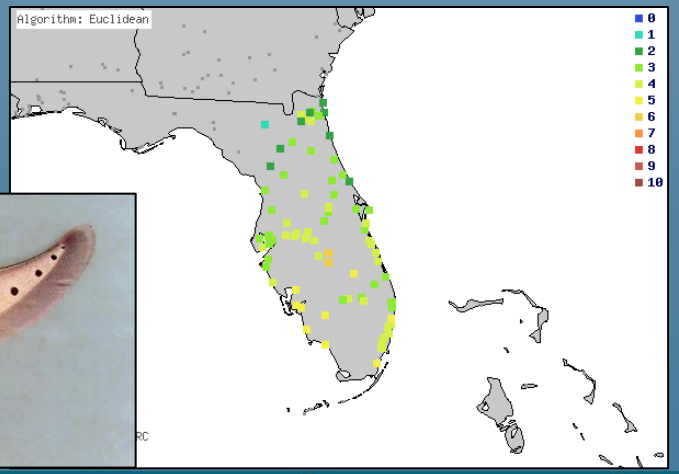
Clown Knifefish: Chronic Lower Lethal Temp = 12°C







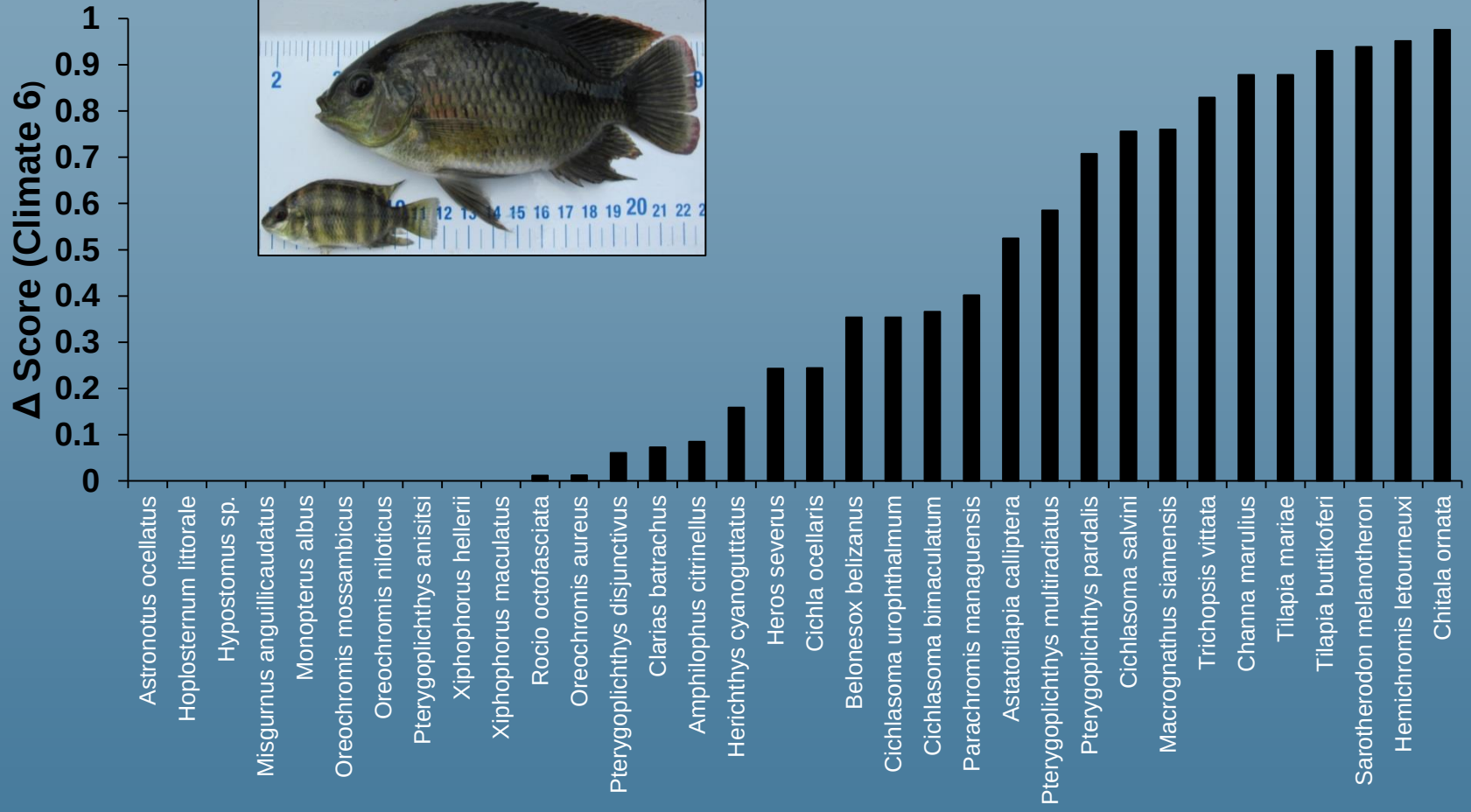




Climate 6 Score = 1.0

Climate 6 Score = 0.0244

Post Hoc – A Priori Scores



A Priori Match Categories

- Climate 6 Score categories – ERSS (Hoff 2014)
- Categories not useful in Florida



Climate 6 Score	Climate Match Category	Failed Species	Successful Species
0.000 ≤ X ≤ 0.005	Low	3	1
0.005 ≤ X ≤ 0.103	Medium	4	4
≥ 0.103	High	29	29

Post Hoc vs. *A Priori*

- Climate is suitable if species already established – tautology!
- More useful to study spread?
- Care needed if used as the basis of a predictive tool

- Needed for proactive risk assessment
- CLIMATCH best for pre-entry analysis (Froese 2012)
- Was not predictive in Florida

Why Does it Not Work?

- *Post hoc* vs *a priori*
- 16 Variables
- Hospitable climate
- Source region
- Life history traits
- Biotic interactions
- (invasion history & propagule pressure)

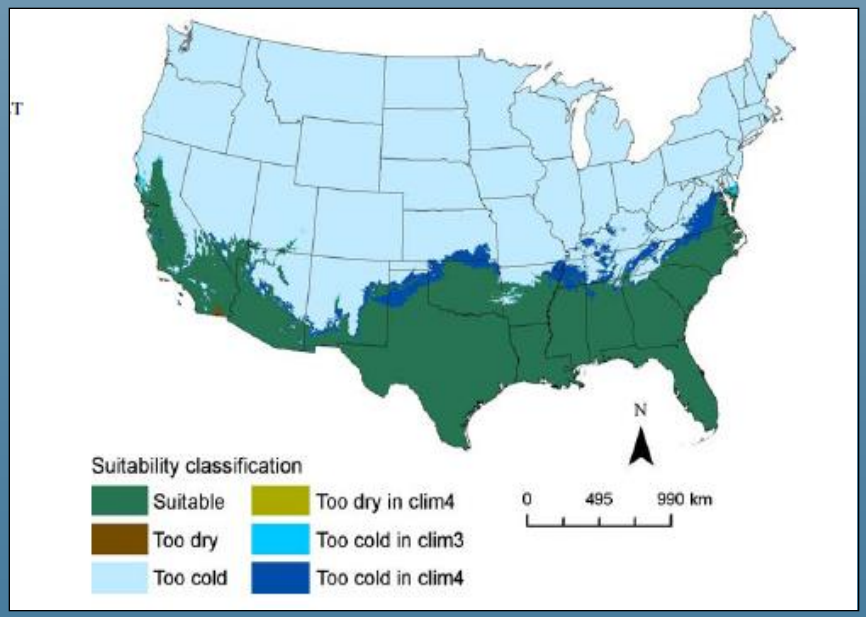
Way Forward

- Important variables?
- Other SDMs?
- Habitat variables
- Physiological tolerances

Prediction

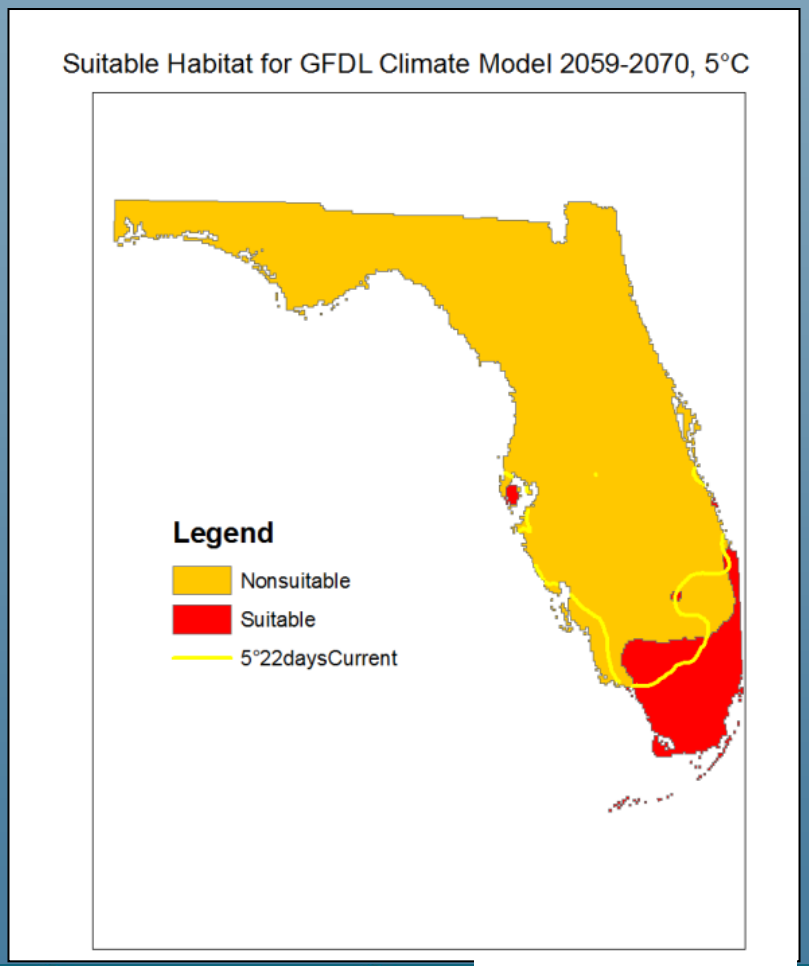
- Predictions may not agree
- Burmese Pythons

Rodda et al. 2009



Pyron et al. 2008

Expanding/Contracting?



Walters 2015

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