Pretty Fish in Cold Places

The Ornamental Fish Trade as a Pathway for Invasive Species in the Great Lakes

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RISK??? Questions?

Historical Perspective

- 1848 First U.S. pet store
- 1910 Importers/growers
- 1980s Marine hobby
- Currently
  - 800+ varieties farmed in Florida
  - 2000+ species in trade (freshwater/marine)
- 14.3 million U.S. households with fish
- 145 million pet fish
  - APPMA 2014

Top 25 Freshwater Varieties

(** = temperate)

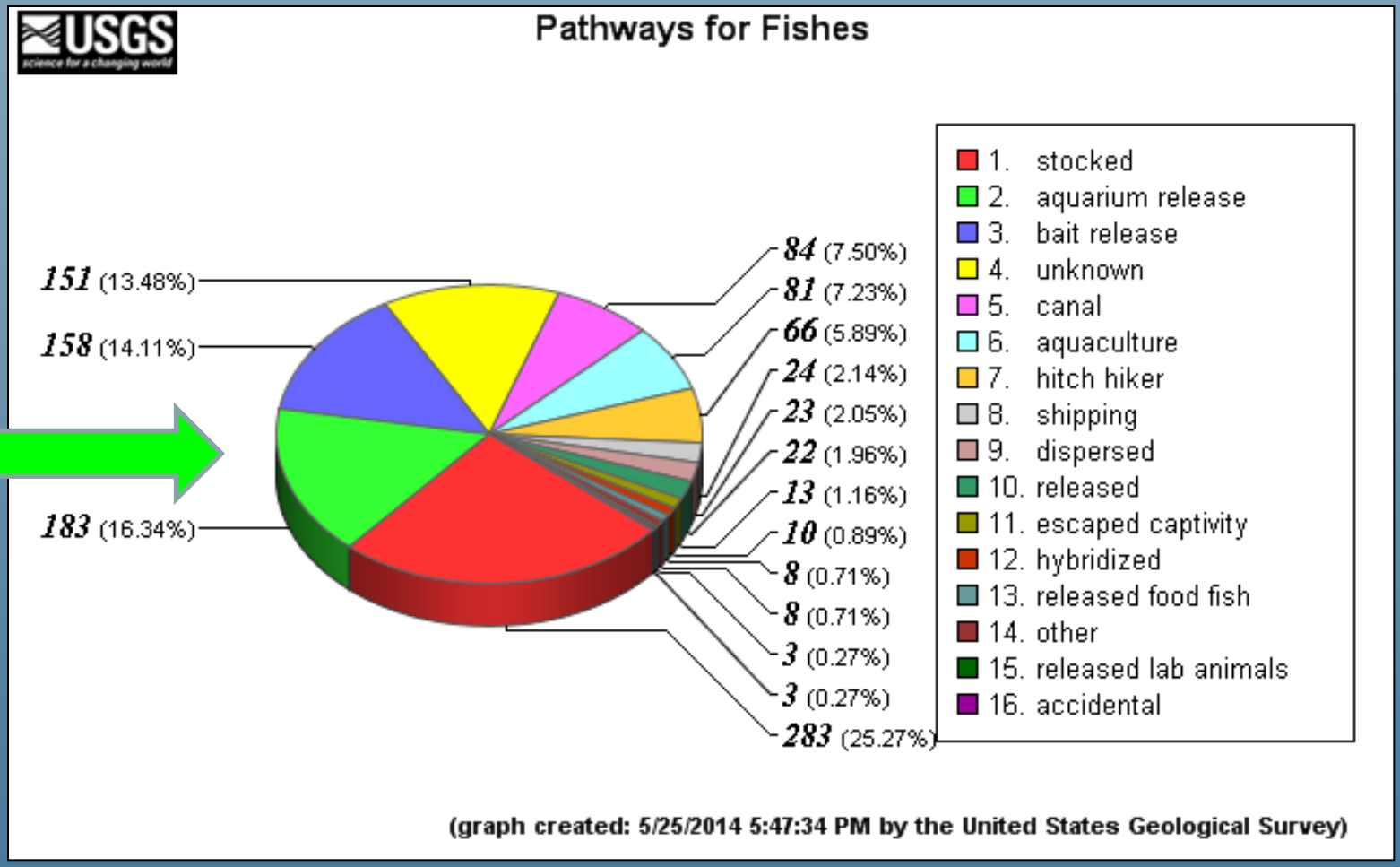
- Neon Tetra *Paracheirodon innesi*
- Zebra Danio *Danio rerio*
- Plecostomus *Pterygoplichthys* spp.
- Feeder Guppy *Poecilia reticulata*
- Male Betta *Betta splendens*
- **Comet Goldfish *Carassius auratus*****
- Ghost Shrimp *Nantia* sp.
- Painted Glassfish *Chanda ranga*
- Red Wag Platy *Xiphophorus maculatus*
- Black Molly *Poecilia latipinna*
- Tiger Barb *Puntius tetrazona*
- **Mixed Fantail Goldfish *Carassius auratus*****
- Velvet Swordtail *Xiphophorus hellerii*
- Black Neon Tetra *Hyphessobrycon herbertaxelrodi*
- Fancy Guppy Pair *Poecilia reticulata*
- Algae Eater *Gyrinocheilus aymonieri*
- Cherry Barb *Puntius titteya*
- Black Skirt Tetra *Gymnocorymbus ternetzi*
- Bala Shark *Balantiocheilus melantopterus*
- Serpae Tetra *Hyphessobrycon callistus callistus*
- Velvet Wag Swordtail *Xiphophorus hellerii*
- Otocinclus *Otocinclus affinis*
- Albino Aeneus Cory *Corydoras aeneus "albino"*
- Bloodfin Tetra *Aphyocharax anisitsi*

Ornamental Fish Introductions

- **Aquarium release**
- **Water gardens**
- **Others – bait, live food fish, ceremonial release, aquaculture escape**
- **Relatively little hitchhiking (SRAC Pub 3902)**

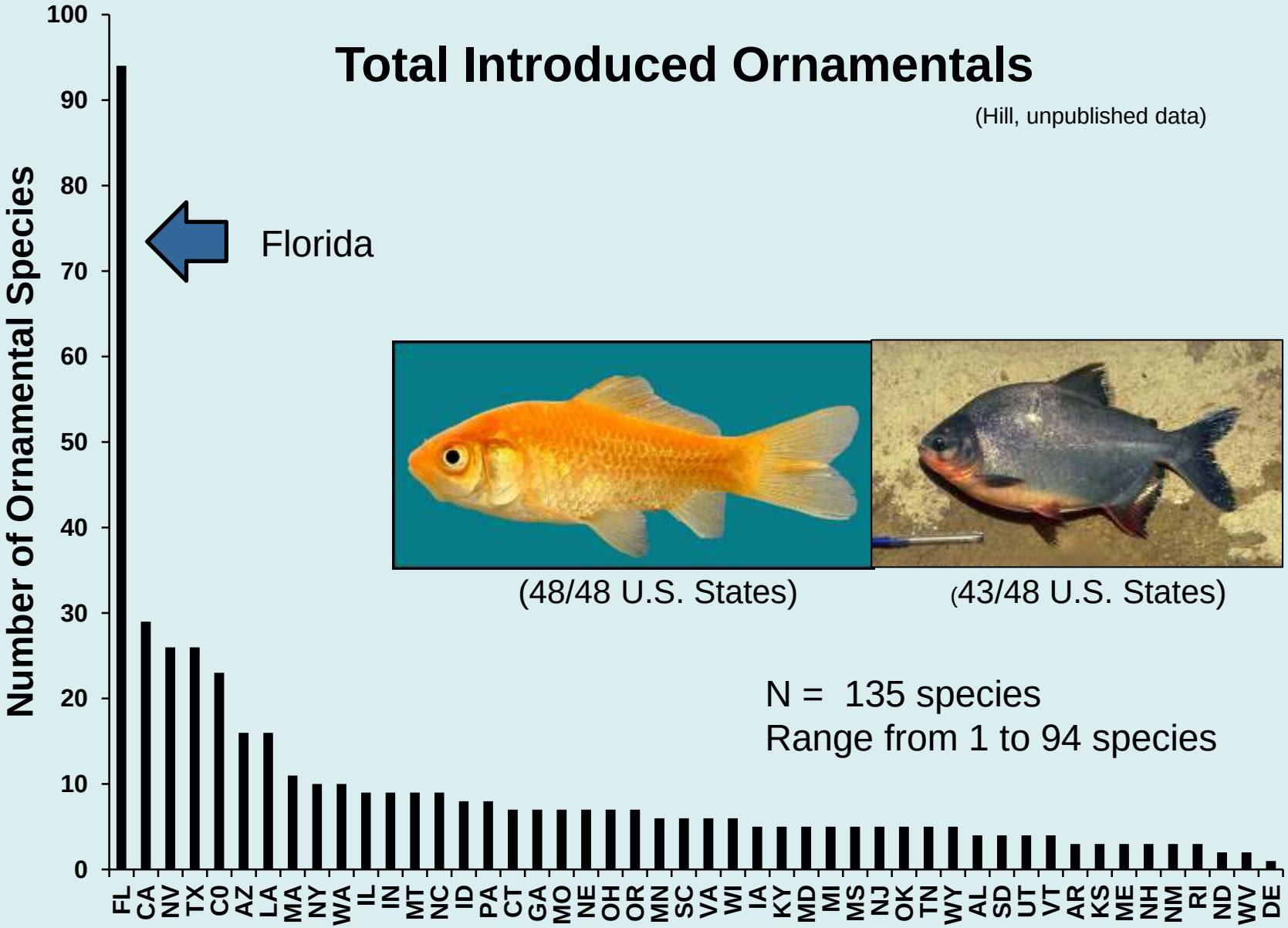
- **How many released?**
- **10,104 fish/yr released in Montreal** (95% CI = 3,800-27,900; Gertzen et al. 2008)

US Pathways -- USGS



Total Introduced Ornamentals

(Hill, unpublished data)



Florida

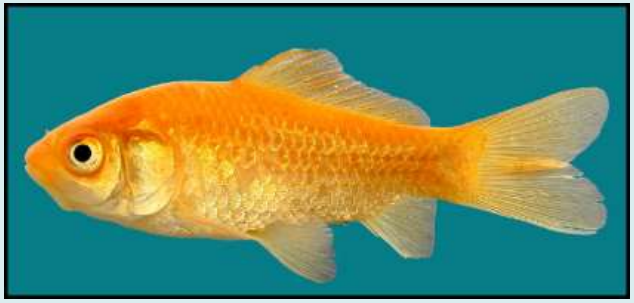
(48/48 U.S. States)

(43/48 U.S. States)

N = 135 species
Range from 1 to 94 species

Established and Locally Established Ornamentals

(Hill, unpublished data)



Florida

N = 44 species
Range from 0 to 32

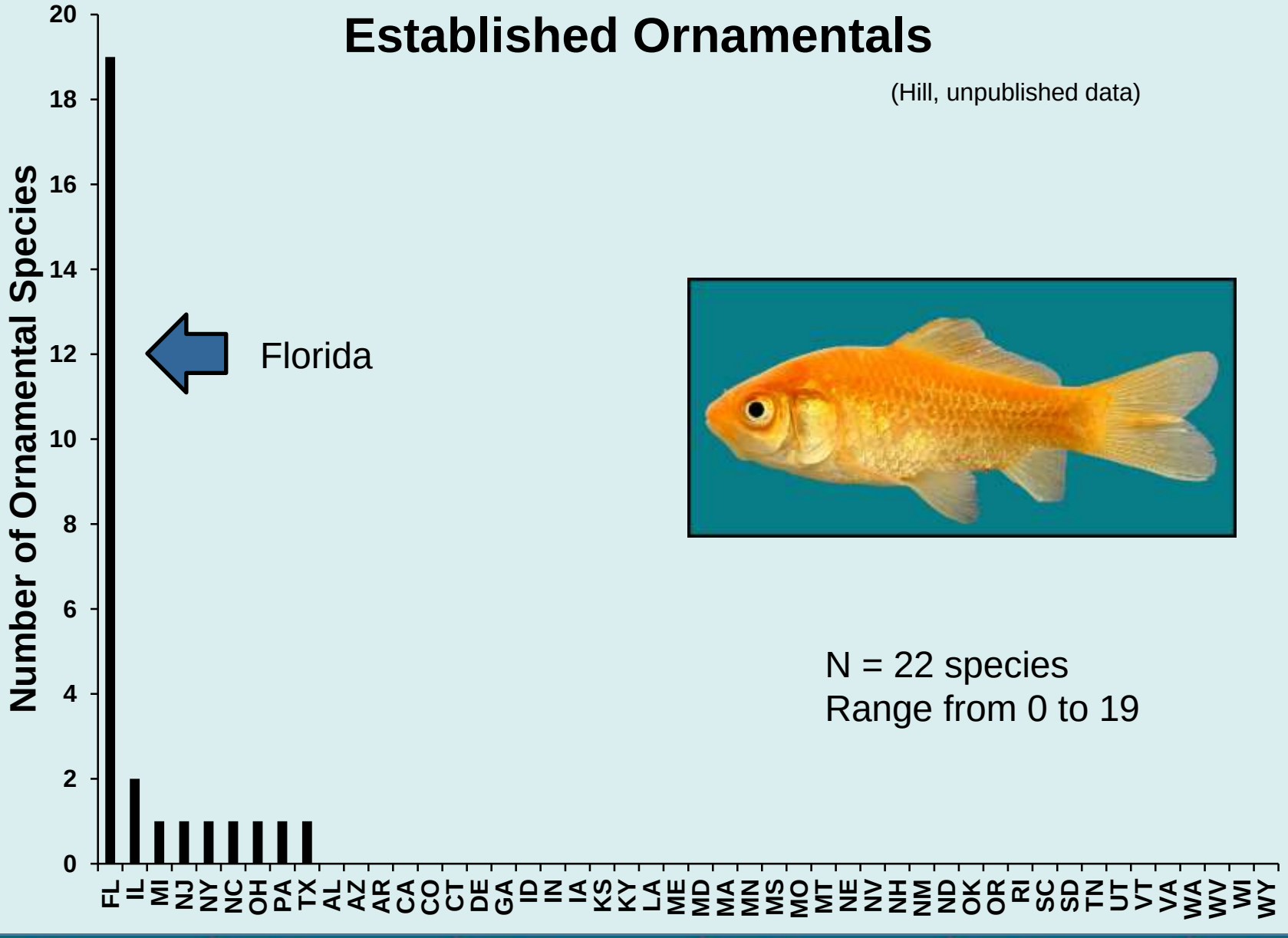
Number of Ornamental Species

0 5 10 15 20 25 30 35

FL NV TX CA ID MT CO LA NC WY NY AZ GA IL MI NJ NM OR SD WA AL AR CT DE IN IA KS KY MD MA MN MS MO NE NH ND OH OK PA RI SC TN VA WI ME UT VT WV

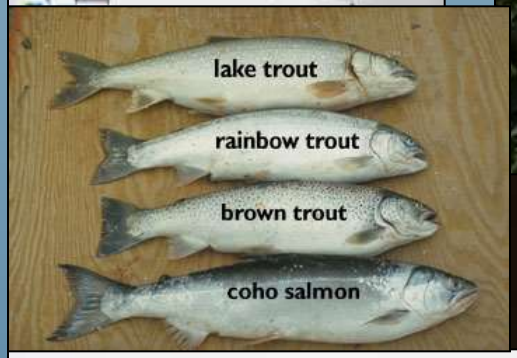
Established Ornamentals

(Hill, unpublished data)

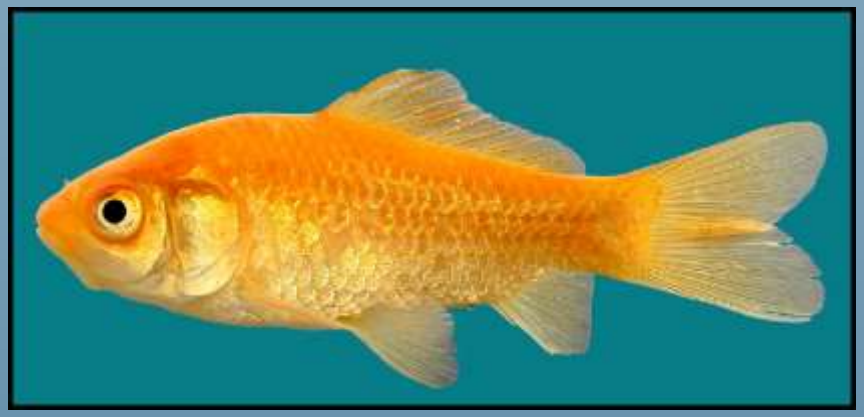


N = 22 species
Range from 0 to 19

Non-natives in the Great Lakes



Ornamentals in the GL



Goldfish *Carassius auratus*

Oriental Weatherfish
Misgurnus anguillicaudatus

Rudd *Scardinius erythrophthalmus*

Blue-spotted Sunfish
Enneacanthus gloriosus

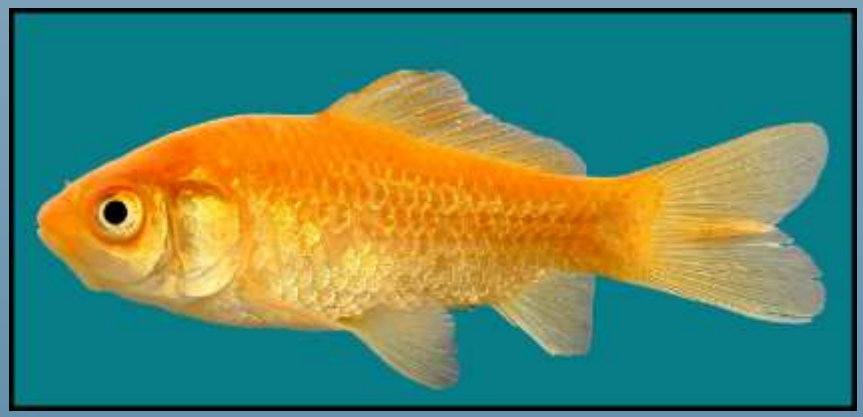
Koi? or… Common Carp?

- Common carp widely established
- Little published on koi establishment

Impacts?

- Goldfish can (at high density):
  - ↓ aquatic plant density
  - ↑ turbidity
- Oriental Weatherfish
  - reduce invertebrate abundance
  - (vs. fish-less controls)

…so???



Risks of Ornamental Fishes

- Risk
  - Probability of establishment
  - Consequences of establishment
- Few established outside of warm spots
  - FL, HI, CA, PR, TX, etc.
  - Geothermal springs
- Few impacts overall

Why Not the Rest of USA?

- Nearly all ornamental species are tropical
  - Low climate match
- Require strong and reliable thermal refuge
  - Hot springs
  - Power plants
- Winter kills in Florida
- Loss of tropical species in TX cooling reservoirs

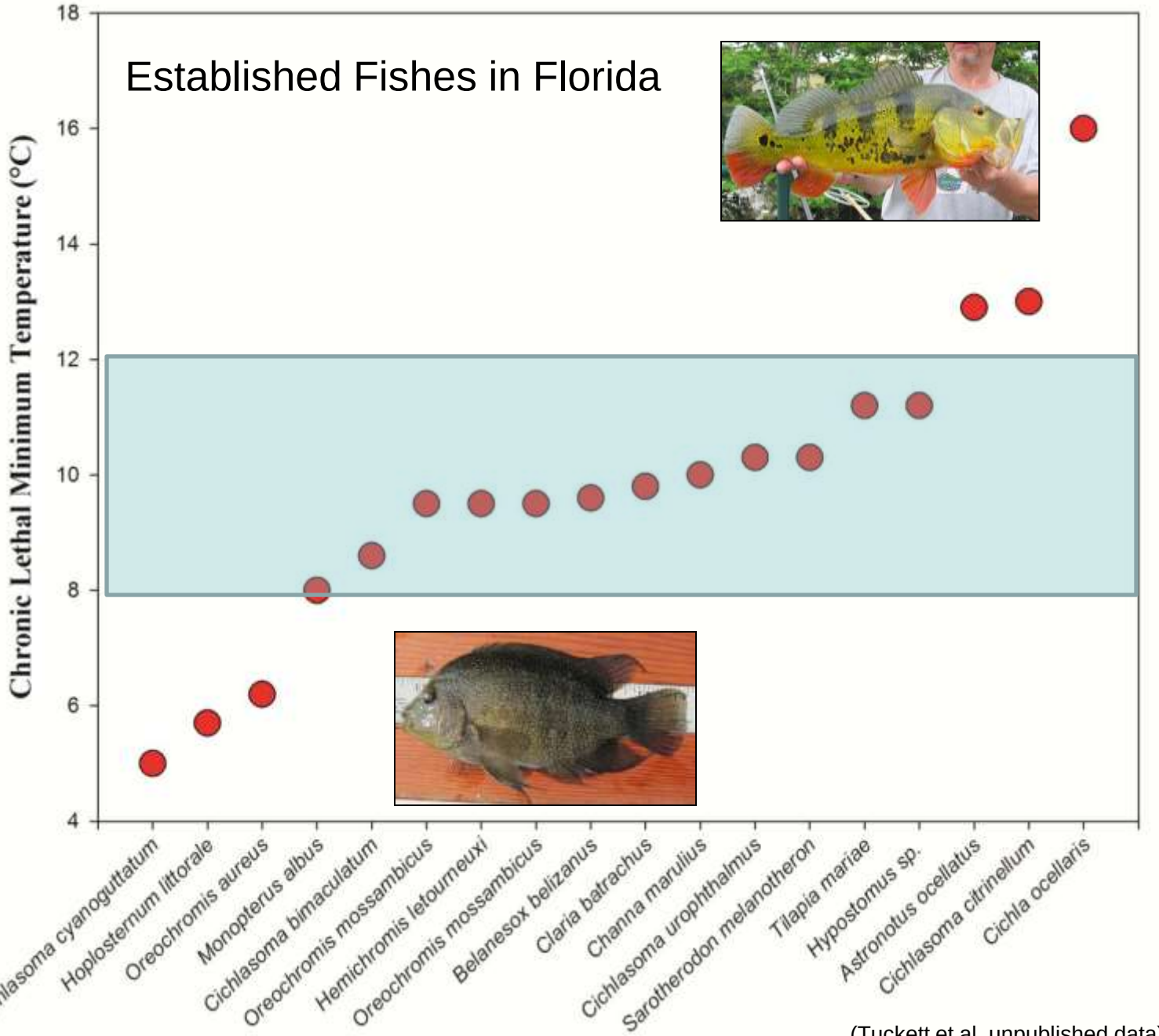
Limits on Success: Florida

- Cold winter temperatures
  - Most in south Florida

- Biotic resistance
  - Predators
  - Aggressive competitors

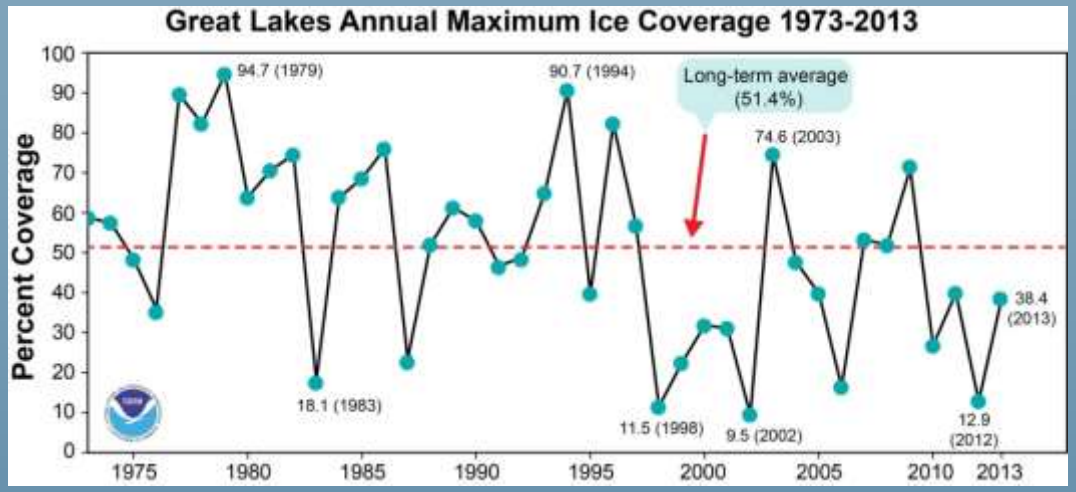
- Chance?

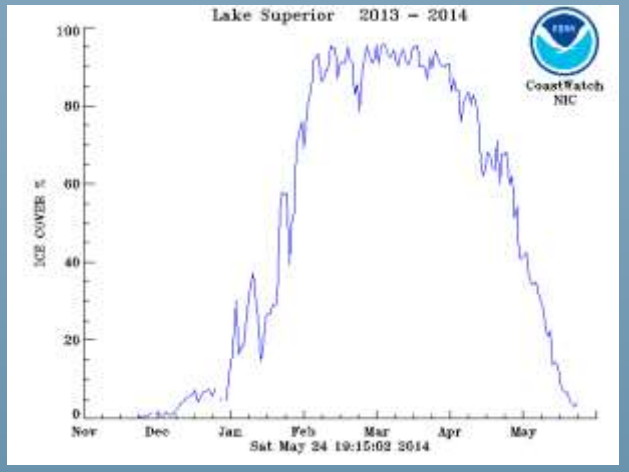
Established Fishes in Florida

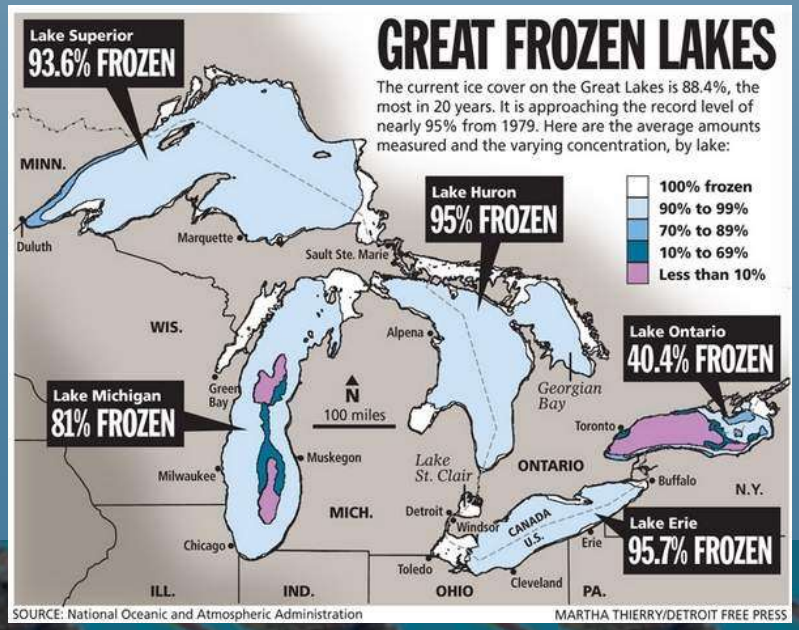


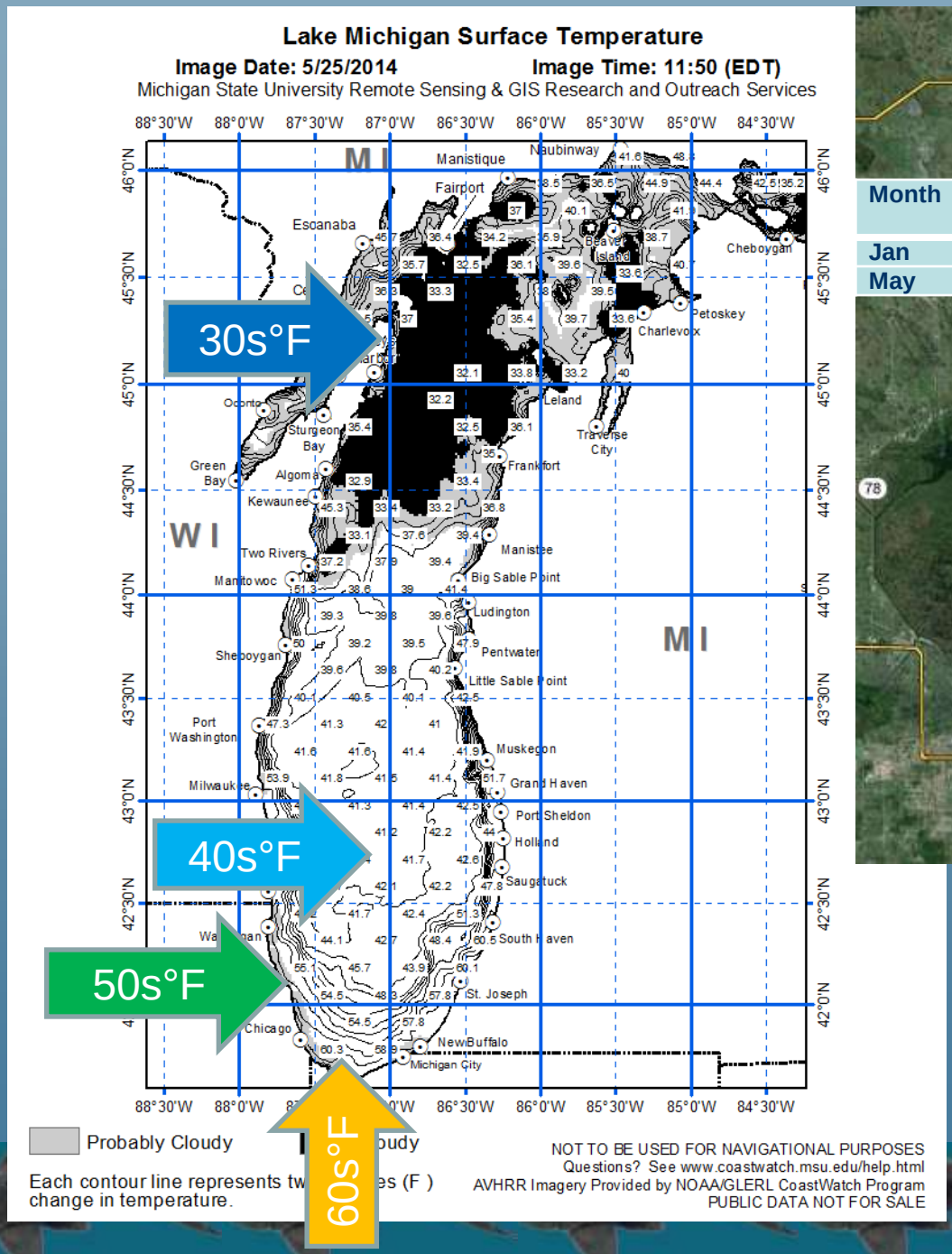
(Tuckett et al. unpublished data)

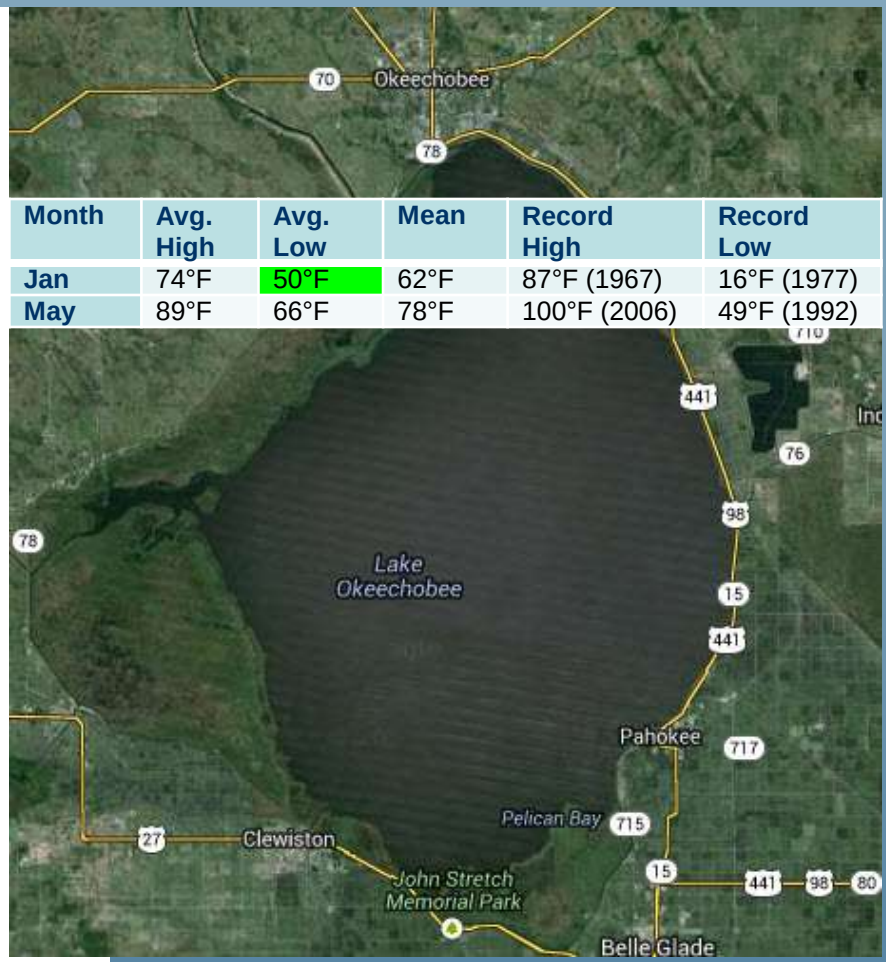
GL Percent Ice Cover







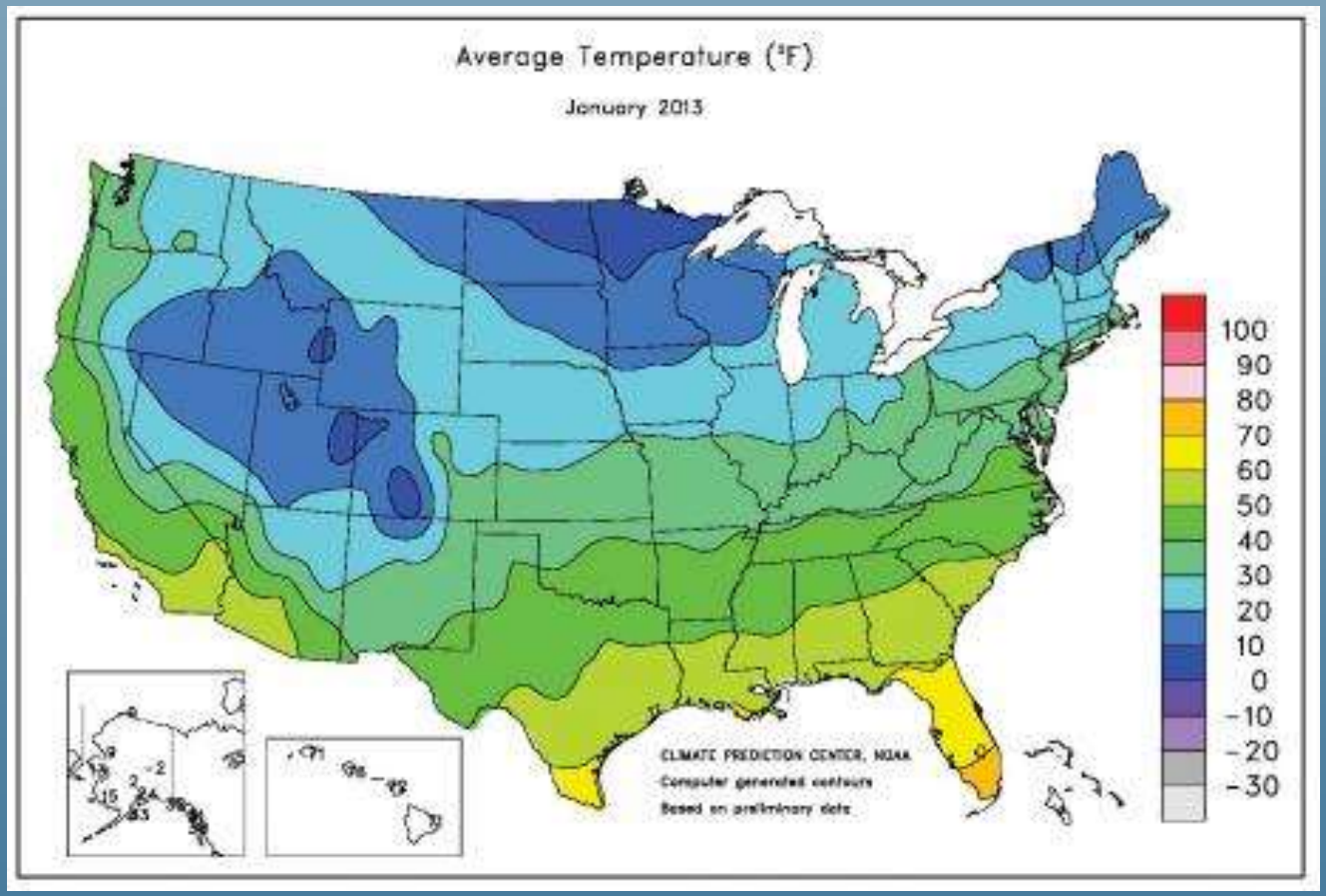




Month	Avg. High	Avg. Low	Mean	Record High	Record Low
Jan	74°F	50°F	62°F	87°F (1967)	16°F (1977)
May	89°F	66°F	78°F	100°F (2006)	49°F (1992)

Avg. low air temp in January in Okeechobee is warmer than most GL surface temps in late May

A warm winter…



GL Studies

- "…only seven recorded species could potentially survive winter temperatures in the Great Lakes." Rixon et al. 2005
- Excluded "…tropical fish, which have high diversity but pose a negligible invasion risk to the Great Lakes." Keller and Lodge 2007
- "…the establishment of most aquarium species is limited in this region owing to environmental tolerances…" Gertzen et al. 2008
- "There are currently very few common aquarium fish species considered to be significant AIS threats to Canadian waters, primarily because most of the species originate from tropical climates and cannot tolerate the cold northern winter temperatures." Marson et al. 2009

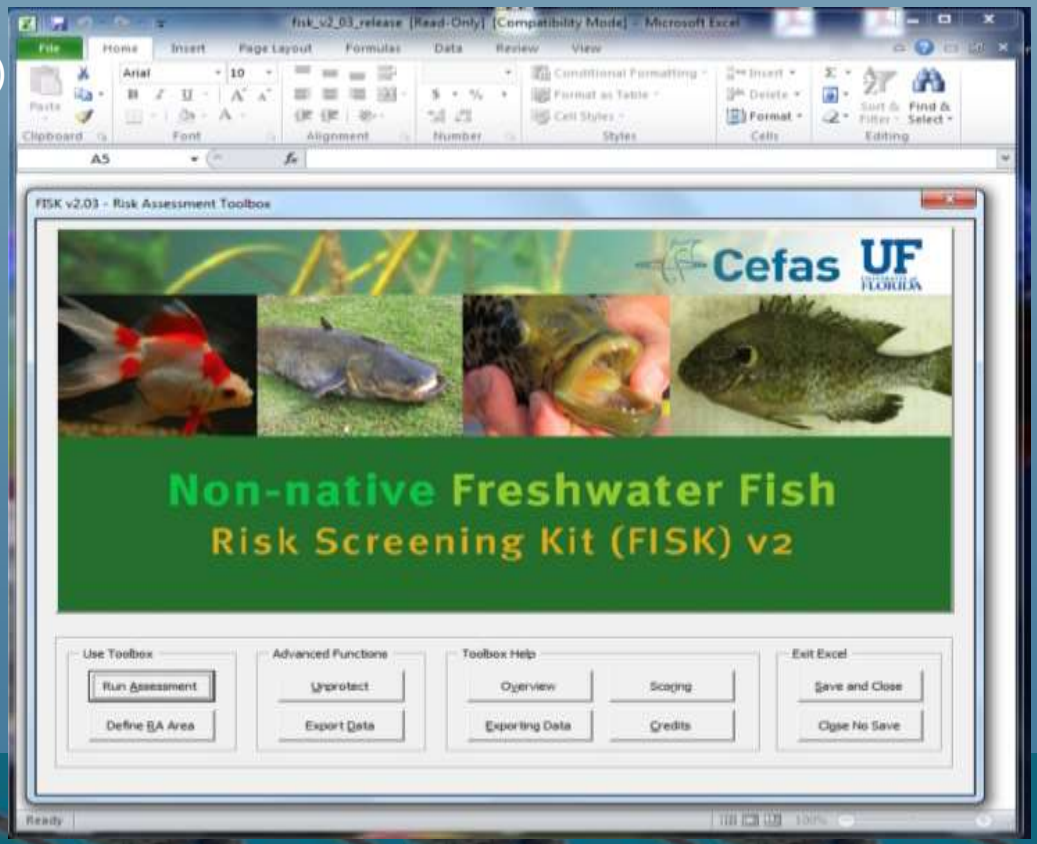
Fish Invasiveness Screening Kit (FISK)

- Adapted from Australian Weed Risk Assessment (WRA)- Pheloung *et al*. (1999) by Copp *et al*. (2005)
- FISK v2 (Lawson et al. 2013)
- Semi-quantitative
  - Scores -11 to 57: Low risk < 1, High risk >19
  - Adapted to multiple environments and taxa
- Biogeography, introduction/invasion history (including impacts), and biology/ecology
- Widely used outside the United States

FISK v2

- **FISK:** 49 questions (each with guidance notes)
  - **Biogeography/History**
    - Domestication/cultivation (3)
    - Climate and distribution (5)
    - Invasive elsewhere (5)
  - **Biology and ecology**
    - Undesirable traits (12)
    - Feeding guild (4)
    - Reproduction (7)
    - Dispersal (8)
    - Persistence (5)

http://www.cefas.defra.gov.uk/our-science/ecosystems-and-biodiversity/non-native-species/decision-support-tools.aspx



Mean FISK Score Florida Fishes

HIGH RISK

LOW RISK

40
35
30
25
20
15
10
5
0
-5
-10

Lawson 2014

FISK Assessment of GloFish

- USA
- Low risk
  - Climate match only in warm regions
  - Little invasive history
  - Few traits of concern
- Hill et al. 2014 *TAFS* 143:817-829

Common Name	Scientific Name	FISK v2 Score
Black Tetra	*Gymnocorymbus ternetzi*	-3.5
Tiger Barb	*Systomus tetrazona*	-2.5
Zebra Danio	*Danio rerio*	-0.5

Bottom Line

- Most species in the ornamental fish trade are tropical and have a low climate match for most regions

- The Great Lakes region has a lot of problems with invasives, but the aquarium fish trade is a minor risk

Recommendations

- **Evaluate the overall ornamental trade (i.e., plants, invertebrates, fish, & other vertebrates):**
  - **Species capable of surviving the cold climate and establishing permanent populations**
  - **Species likely to cause noticeable impacts if they establish**
- **Use risk-based approaches to inform management**

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- Marshall Meyers (PIJAC)
- Courtenay and Meffe 1989