# Freshwater mussel die-offs: insights from a compilation of known cases

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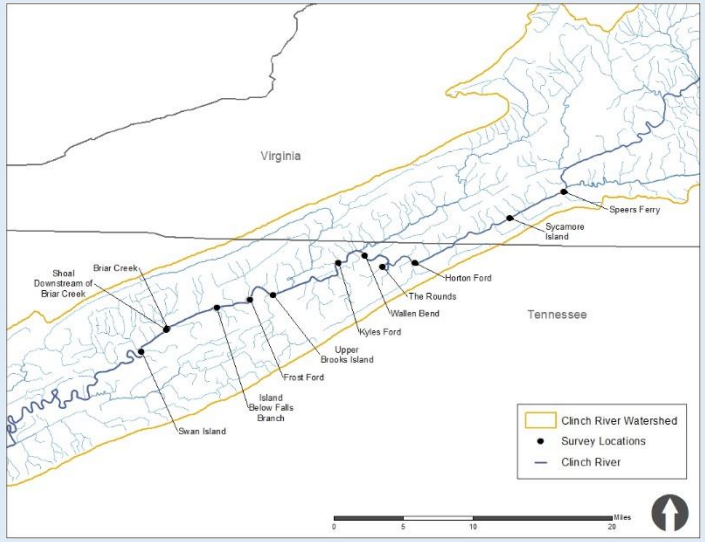
# What is a die-off?

- Mass mortality events
- Die-off or mussel kill?

# 2016 Clinch River mussel die-off

- Began summer 2016
- Ongoing as of January 2018
- > 50% declines in *Actinonaias pectorosa* across multiple shoals
- Many other species likely affected
- No causes identified

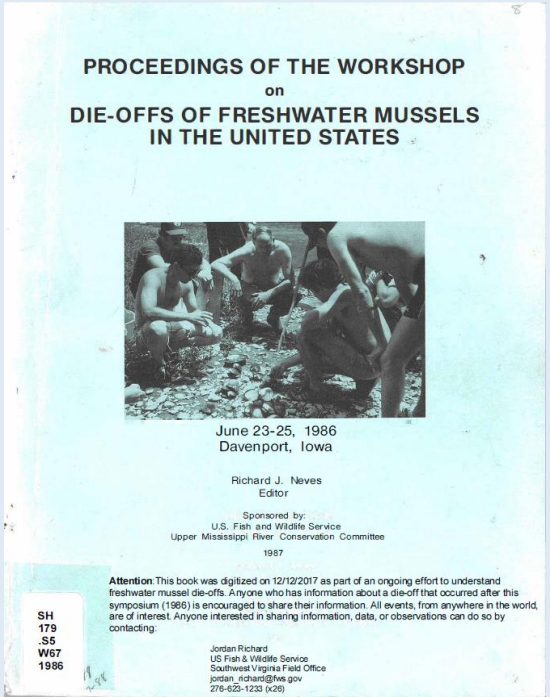


# What's going on?

- Began literature search to understand context Clinch River event
  - Little data available
- Initiated effort to compile and review data on known cases of freshwater mussel die-offs
- Goals:
  - Describe typical aspects of die-offs
  - List common causes
  - Understand what observations can be attributed to a particular cause

# History – 1986 Workshop on Die-offs of Freshwater Mussels in the United States

- Workshop held to address growing threat of mussel die-offs
- Described 17 cases in eastern North America
  - 13 Rivers
  - 4 Lakes
- Subsequent die-off literature sparse
  - Only a handful of published articles
  - Product of failing to identify causes?



PROCEEDINGS OF THE WORKSHOP
on
DIE-OFFS OF FRESHWATER MUSSELS
IN THE UNITED STATES

June 23-25, 1986
Davenport, Iowa

Richard J. Neves
Editor

Sponsored by:
U.S. Fish and Wildlife Service
Upper Mississippi River Conservation Committee

1987

# Current call for die-off information

- Messages sent out through Unio listserv and to FMCS mailing list
- Seeking information about die-offs after 1986

# Results - Summary

- 31 new entries
  - 7 Countries
  - 19 US States
  - 25 Rivers, 6 Lakes
- Brings total # cases to **48**, including 1986 results
- A note on summary stats:
  - Some cases are separate incidents on same waterbody
  - Some single entries represent locality observations in multiple years
- Varying magnitude/severity
  - Range: small corbicula kills to population losses

# Causes – some confirmed or very likely

- Spills
  - Pesticides
  - Other toxics (e.g., rubber accelerant, sulfuric acid)
  - Fly ash
  - Blackwater (mining)
- HABs
- Predation
- Others

# Potential Causes - Invasions

- Corbicula
- Dreissena
- Often reported concurrent with declines/die-offs
- Potential vectors or hosts?
- Ecological alterations?

# Potential Causes - Pesticides

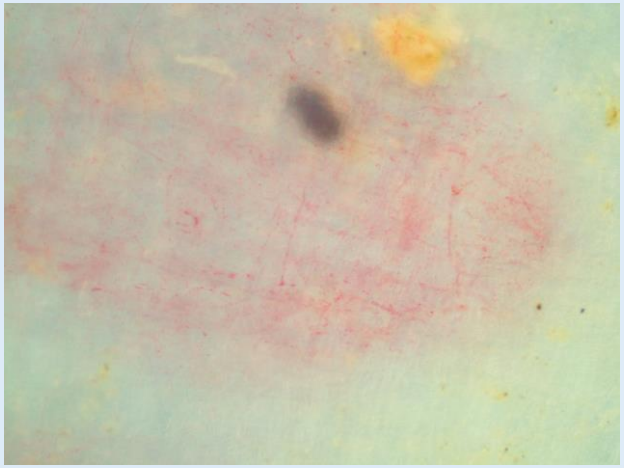
- ROW maintenance
- Agriculture
- Private

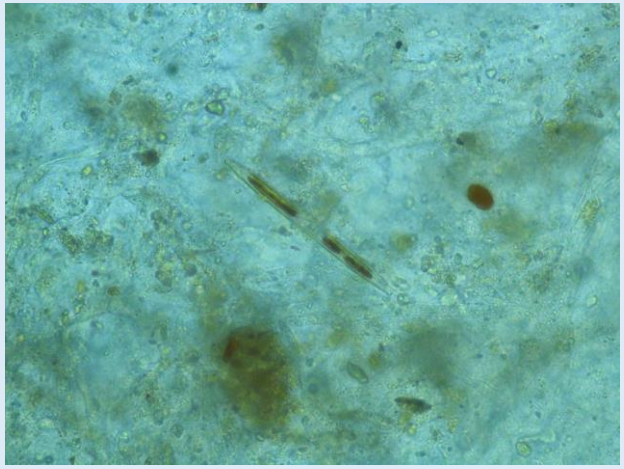
# Potential Causes – Habitat Alteration

- Impoundment construction/removal
- “Moving Rivers”

# Potential Causes - Disease

- Viral
- Bacterial
- Fungal
- Parasitic
  - Mites
  - Trematodes





# Mussel Health – Lessons From the Marine World

- The search for the “Smoking Gun”
- Marine diseases
  - MSX
  - Dermo
  - ROD
  - QPX
  - *Vibrio*
- Are freshwater mussels different?

# Understanding the Case Types – Toxic Spills

- Toxic spills
  - Clinch River, VA
    - 1967 – Fly ash spill
    - 1970 – Sulfuric acid spill
    - 1998 – Cedar Bluff rubber accelerant
    - For all of these, the event created a wide swath of destruction, apparently killing all mussels, snails, fish, macroinvertebrates, etc. for some distance downstream (1967 spill killed fish/mussels >80 miles downstream)
  - Peshtigo River, WI (~2000)
    - Accidental over-application of lampricide – not adjusted for the very low flow occurring at the time
    - Killed significant #s of fish and mussels
  - River Sauer – Belgium/Luxembourg
    - Pesticide spill in an upstream tributary to River Sauer
    - >30,000 individuals lost
  - Deep Fork River, OK
    - USFWS NRDAR Cases – tied to a facility upstream of a refuge

# Attributes Common to Toxic Spills (Rivers)

- Widespread mortality
  - Fish
  - Mussels
  - Macroinvertebrates
  - Snails
- Point source – can trace to a point upstream, above which no effects are observed
- Mortality within a group (e.g., mussels) tends to be much more even across species
  - Dead/dying animal abundances correspond to their relative abundance
- Mortality attenuates downstream
- Temporal effects
  - Acute “Slug” of toxin
  - Delayed mortality?

# Unexplained Sources

- **Clinch River**, TN – 2016-Present
- **Middle Fork Holston River**, VA – 1999
- **Powell River**, VA/TN – 1983
- **Tennessee River**, AL/TN – 1985, 2001, 2002, 2004, 2006, 2007, 2008, 2009
- **Big Darby Creek**, OH – 2016
- **Little TN River**, NC/TN – 2005-Present – Appalachian Elktoe (and Slippershell?)
- **Middle Fork John Day River**, OR – 2002

# Common attributes of many unexplained die-offs

- “Semi-chronic” – often last or seasonally recur over multiple years
- Species specificity
- Lots of dead bodies
- Small #’s observed can translate to large population losses
- No evidence of recovery in subsequent years
- Occurs across multiple sites

- Variability in observed attributes to be expected, given the numerous potential causes

# Questions

# Middle Fork Holston River, VA – 1999

- Observed June 7-8, 1999
- At least 25 river miles
- 711 dead mussels of 11 species collected from
  - 95% *Pleuronaia dolabelloides* (Slabside pearlymuss
- No federally listed species found dead
- Slabside pearlymussel later listed endang

- No signs of significant recov

# Tennessee River, AL/TN – 1985, 2001 – 2009

- Repeated observations of mussel die-offs
- *Fusconaia ebena* frequently affected
- *F. ebena* density across 5 sites (TRM 203, 201, 199, 197, 195):
  - 2000 to 2010, declined 54.8 to 20.1 per $m^2$
  - Densities have not recovered
- Problem seems to have subsided with alteration of Pickwick Landing Dam flow regime

# Little Tennessee River – Appalachian Elktoe

- Die-off first detected February 2005 in Little Tennesse River
- 70-80% of *Alasmidonta raveneliana* lost in first year of die-off
  - Larger animals more affected/died first
- Appeared starved
  - Abnormal foot/shell color (pale)
  - Shells thin & brittle
  - Shell shape different → more compressed/elongated than normal
- Follow up showed only small individuals remained
  - Growth of survivors slow
  - Limited recruitment
  - Poor condition/appearance
- Prior to die-off, individuals found up to 40/$m^2$

# Big Darby Creek, OH – 2016

- October – November 2016
- Distressed and fresh dead mussels observed over 58 miles
- All species appeared affected, including *Corbicula*
- Distressed & fresh dead mussels observed as of February 2017
- No known observations of fish mortality
- No macroinvertebrate analysis
  - Cursory observations – no effects to macroinvertebrate fauna
- Relatively low flow

# 2016 Clinch River mussel die-off

- Will discuss details in small group sessions