The Uncertain State of Molluscan Health

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and

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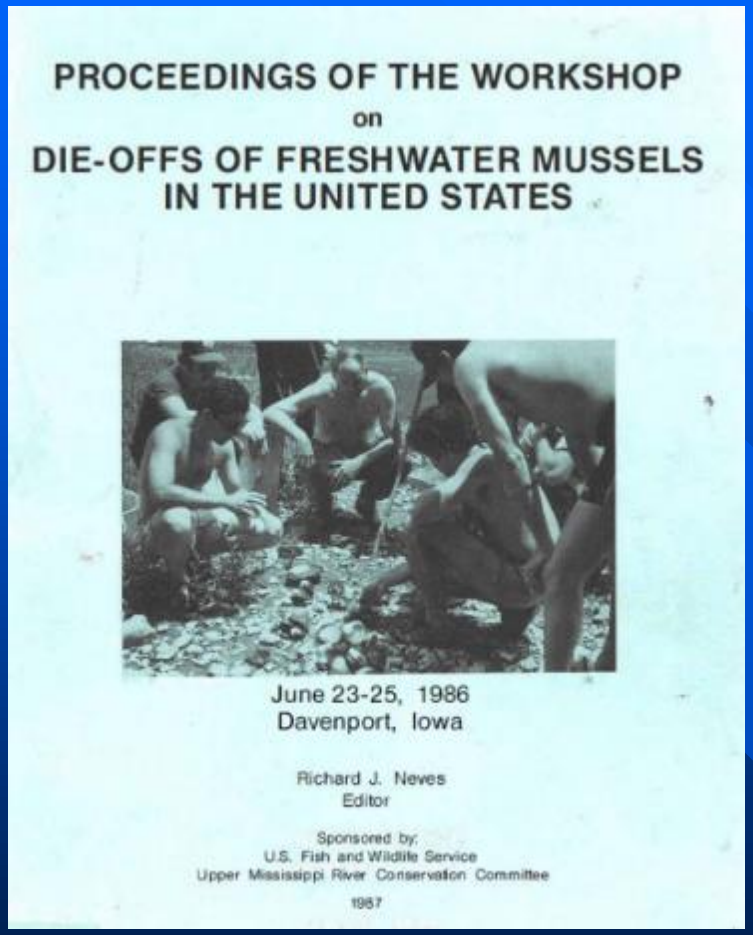
U.S Department of Interior
U.S. Geological Survey

Presented at the Freshwater Mollusk Conservation Society, Workshop on Mussel Health and Disease, March 13-15, 2018 La Crosse, WI

Historical Perspective

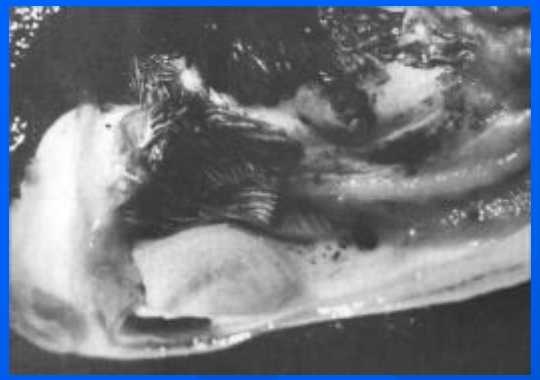


- Reports spanned years from 1977-1986
- Geographic range from Virginia to Washington, Ontario to Mississippi
- Causes:
  - Weather related – 1
  - Unionicolid mites -1
  - Unknown – all of the rest

USGS

Common threads in the 1986 Workshop

- "..mussel die-offs have been poorly documented because of the lag time between cause and obvious effect."
- "Differentiating live from dead mussels is rather difficult… The animal dies differentially…"
- "…..the etiology of mussel diseases has been given little attention in North America."
- "Cause unknown"



USGS

1986 Workshop - Identified information gaps and needs

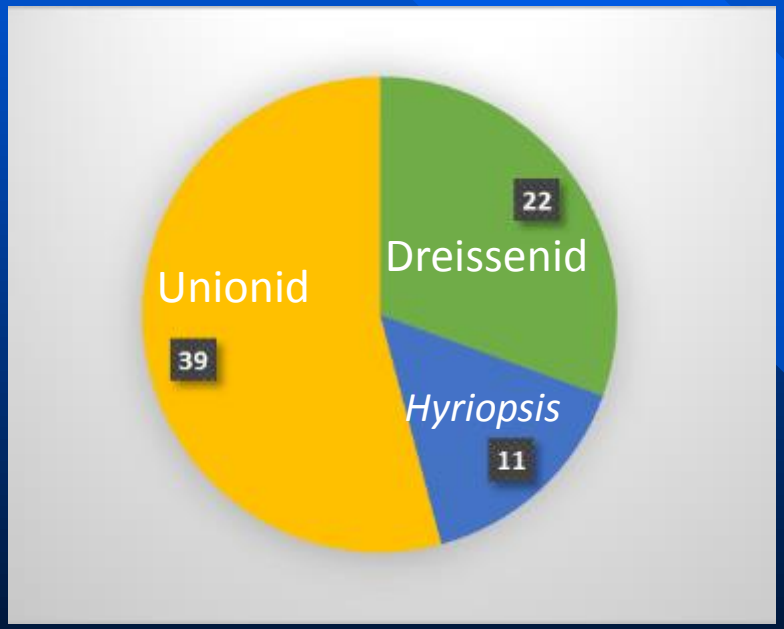
- Standardized sampling techniques
- Adequate documentation: Die-off report form
- Communication among agencies and states
- Histological/pathological study to distinguish healthy and diseased-states
- Standard diagnoses for identifying causative disease agents

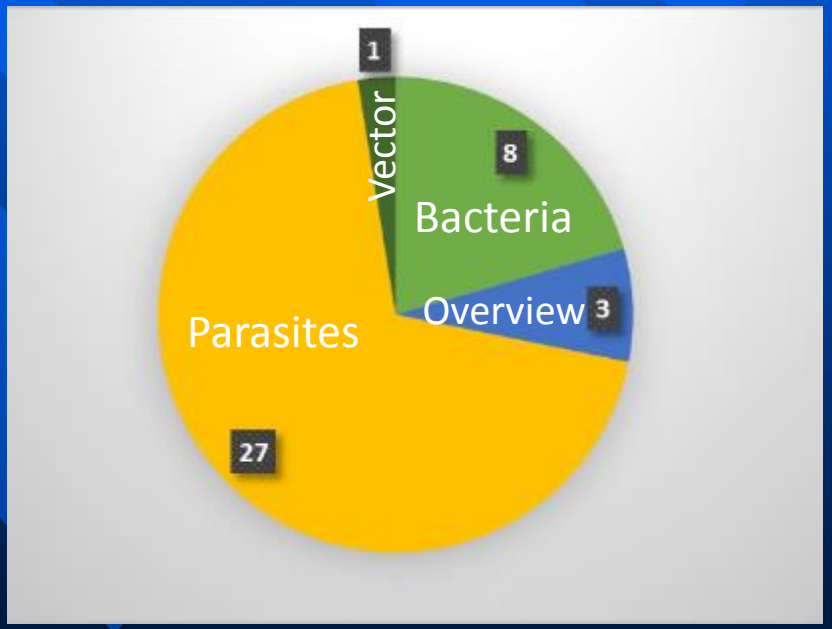
USGS

Freshwater mussel disease studies

- Since 1986
  - 72 publications related to freshwater mussel disease

C. Starliper recommended "..regularly scheduled pathogen and disease examinations…."





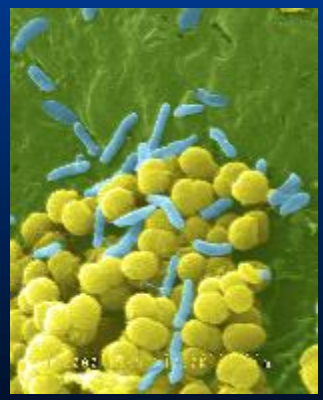
USGS

Progress at a snails pace….

- Limited resources force prioritization
  - Immediate threats
    - »Invasive species
    - »Habitat degradation
    - »Contaminants
  - Conservation/propagation

Photo by Andrea Fritts, USGS

- Limited training of field biologists in aquatic animal health
- Limited geographic reach and connections



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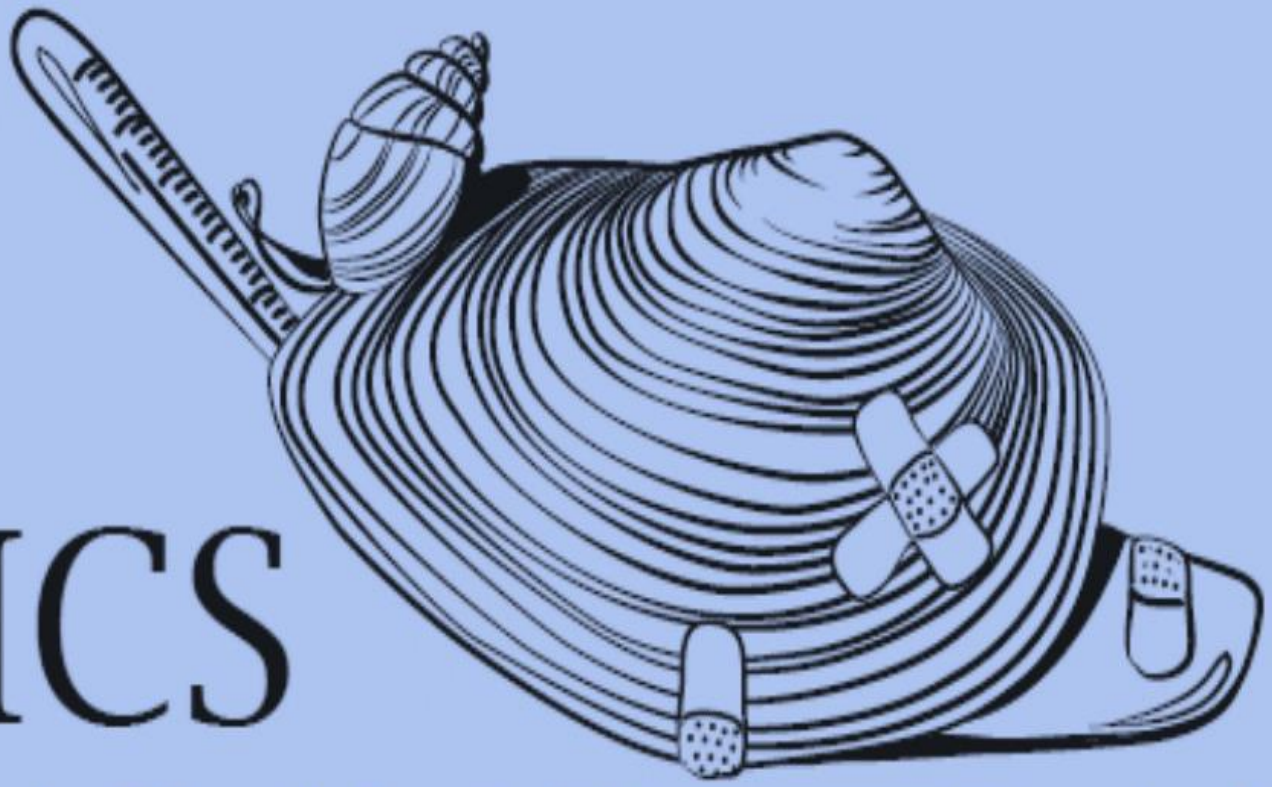


FMCS

Mollusk Health & Disease Workshop

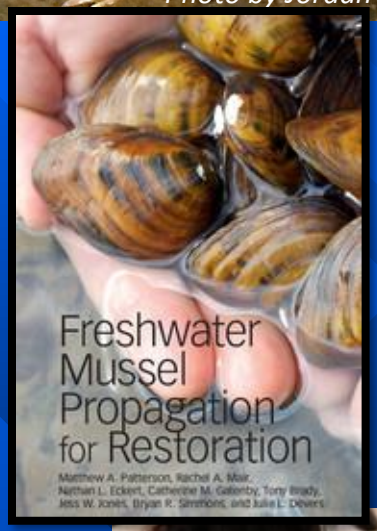
March 13-15, 2018

USGS

Why now?

- Mollusk die-offs remain unsolved mysteries
- Freshwater mollusk propagation is booming
- Emerging stressors (e.g., disease) are forecast
- Technology and tools provide new opportunities


Photo by Jordan Richard, USFWS

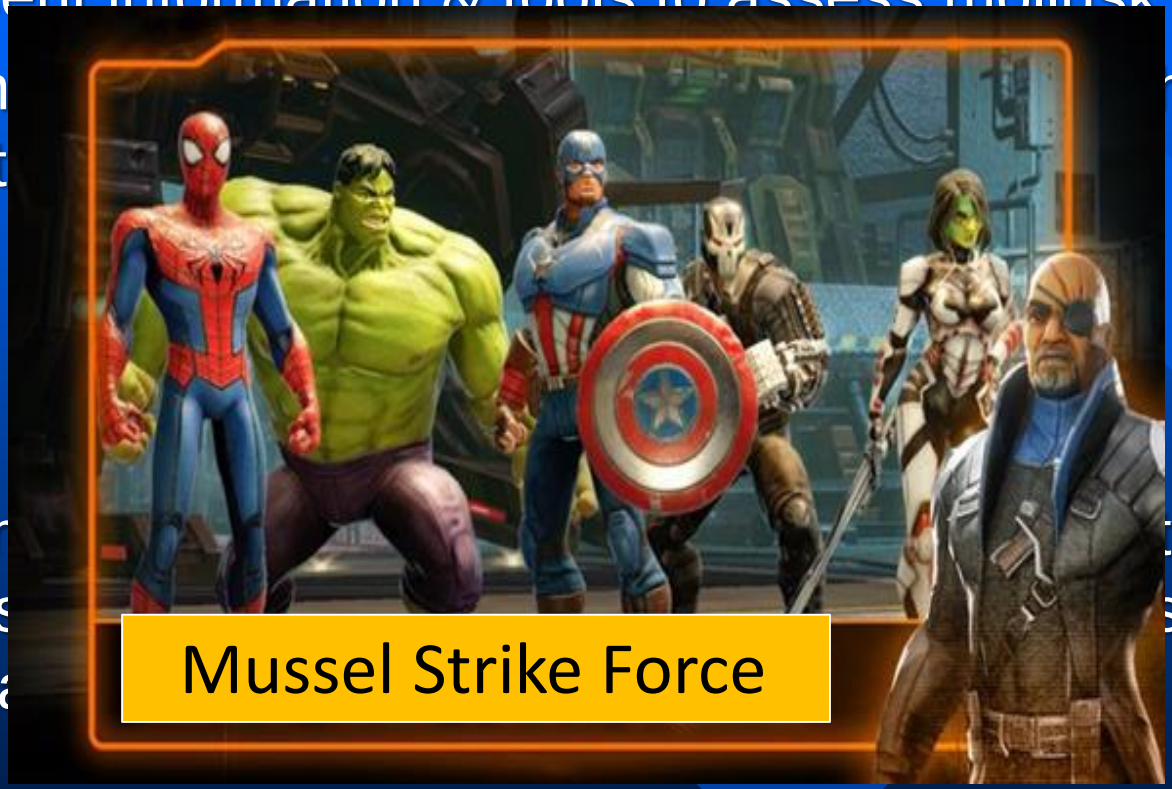


USGS

Workshop on Mollusk Health & Disease 2018

Goal: Focus attention on freshwater mollusk health and the role of disease in mollusk communities.

- Present information & tools to assess mollusk health
- Align … hose for healt…
- Prom… tworking acros… ssel morta…



USGS

Outline

- Highlights of Scientific Progress
  - Health focus vs. Biomarker tools
  - What constitutes a “healthy” mussel?
- New Way of Thinking—One Health Approach
  - Learn and Integrate from Disciplinary Experts
  - Translate/Adapt from Fish Health, Marine Bivalves
- Unresolved Questions and Emerging Issues
  - Funding for Mollusk Health Initiative
  - Plan and Prepare for Die-off Investigations
  - How to Deal with Unregulated/Unknown agents

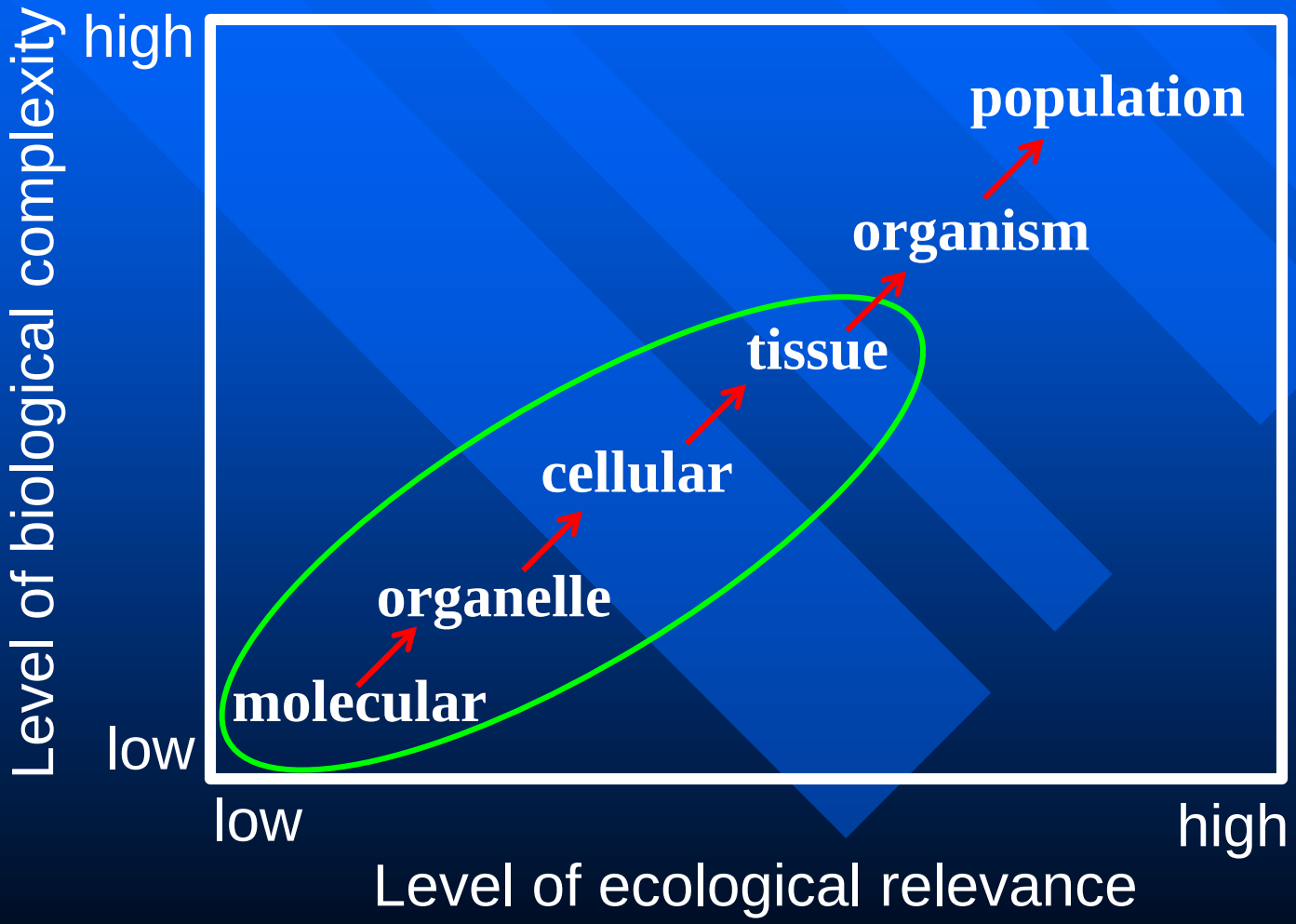
Holistic Health Focus

- What constitutes a “healthy” mussel?
  -We are still uncertain….
- Applied research and management focus vs. basic science understanding—driven by funding and immediate needs
- Advocate for a human health clinical approach
- Need well-defined baseline data (natural variation vs. contaminant induced)

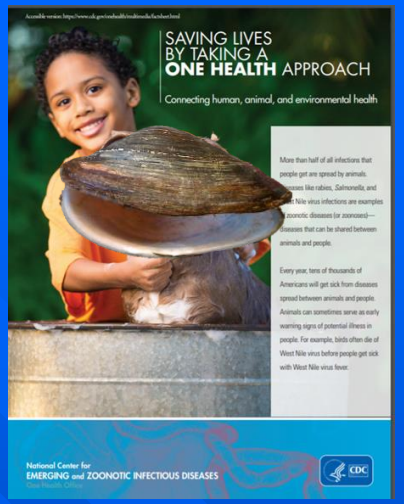
Biomarker Health Focus
Toxicology Driven

- *Change in a biological response that can be related to exposure to, toxic effects, or susceptibility to contaminants or other stressors*
- Biomarkers measured in organisms can provide sensitive indices, or early warning signs, of health decline, ecosystem degradation
- Compared with chemical residue analysis, biomarkers have the advantage of measuring the stress on the organism, thus likely being more biologically relevant

Biomarker Levels of Biological Organization



A New Way of Thinking One Health Approach



- World Health Organization, US CDC
- *Goal of One Health is to encourage the collaborative efforts of multiple disciplines- working locally, nationally, and globally-to achieve the best health for people, animals, and our environment*
- Recognizes that the health of people is connected to the health of animals and the environment
- Animals share our susceptibility to some diseases and environmental hazards

Learn and Integrate from Disciplinary Experts

- Virologists, Bacteriologists, Parasitologists, Histopathologists (Goldberg, Leis, McElwain, Starliper)

- *Published research:*

Bacterial pathogen contagion studies among freshwater bivalves and salmonid fishes.

FindText@NCSU

Author(s) : Starliper, C. E.; Morrison, P.
Author Affiliation : USGS-BRD Leetown Science Center, National Fish Health Research Laboratory, Kearneysville, WV 25430, USA.
Journal article : Journal of Shellfish Research 1999 Vol.19 No.1 pp.251-258 ref.39

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Infectious Diseases of Freshwater Mussels and Other Freshwater Bivalve Mollusks

JOHN M. GRIZZLE[1] and CINDY J. BRUNNER[2]
[1]Department of Fisheries and Allied Aquacultures, Auburn University, Auburn, Alabama, USA
[2]Department of Pathobiology, Auburn University, Auburn, Alabama, USA

MALACOLOGIA, 2014, 57(1): 99–239

HISTOLOGICAL ATLAS OF FRESHWATER MUSSELS (BIVALVIA, UNIONIDAE): *VILLOSA NEBULOSA* (AMBLEMINAE: LAMPSILINI), *FUSCONAIA CERINA* (AMBLEMINAE: PLEUROBEMINI) AND *STROPHITUS CONNASAUGAENSIS* (UNIONINAE: ANODONTINI)

Andrew McElwain* & Stephen A. Bullard

frontiers in Physiology
MINI REVIEW
published: 01 November 2016
doi: 10.3389/fphys.2016.00489

Disease and Disorders of Freshwater Unionid Mussels: A Brief Overview of Recent Studies

*Francesca Carella *, Grazia Villari, Nicola Maio and Gionata De Vico*
Department of Biology, University of Naples Federico II, Naples, Italy

Learn and Integrate from Disciplinary Experts

- Marine Bivalve Experts (Carnegie, Powell, Carella, Zannella)

- *Published research:*

PHILOSOPHICAL TRANSACTIONS B

rstb.royalsocietypublishing.org

Review

Managing marine mollusc diseases in the context of regional and international commerce: policy issues and emerging concerns

Ryan B. Carnegie[1], Isabelle Arzul[2] and David Bushek[3]

Journal of Invertebrate Pathology 131 (2015) 212–225

Contents lists available at ScienceDirect

Journal of Invertebrate Pathology

journal homepage: www.elsevier.com/locate/jip

Models of marine molluscan diseases: Trends and challenges

Eric N. Powell[a], Eileen E. Hofmann[b,*]

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[b] Center for Coastal Physical Oceanography, Department of Ocean, Earth and Atmospheric Sciences, 4111 Monarch Way, Old Dominion University, Norfolk, VA 23529, United States

Journal of Invertebrate Pathology 131 (2015) 107–120

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Journal of Invertebrate Pathology

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Comparative pathology in bivalves: Aetiological agents and disease processes

F. Carella[a,*], S.W. Feist[b], J.P. Bignell[b], G. De Vico[a]

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marine drugs

MDPI

Review

Microbial Diseases of Bivalve Mollusks: Infections, Immunology and Antimicrobial Defense

Carla Zannella [1], Francesco Mosca [2], Francesca Mariani [2], Gianluigi Franci [1], Veronica Folliero [1], Marilena Galdiero [1], Pietro Giorgio Tiscar [2] and Massimiliano Galdiero [1,*]

Translate/Adapt from Fish Health

- Federal and State Hatcheries—Millions of dollars spent annually worldwide on mollusk propagation for restoration and conservation

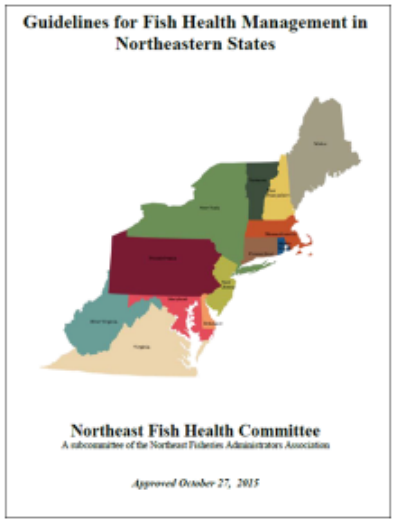
- *Models:*

U.S. Fish & Wildlife Service

National Fish Health Centers

Aquatic Animal Health Handbook | USFWS Inspection Manual | What's New & Interesting

National Wild Fish Survey | National Wild Fish Health Survey Database



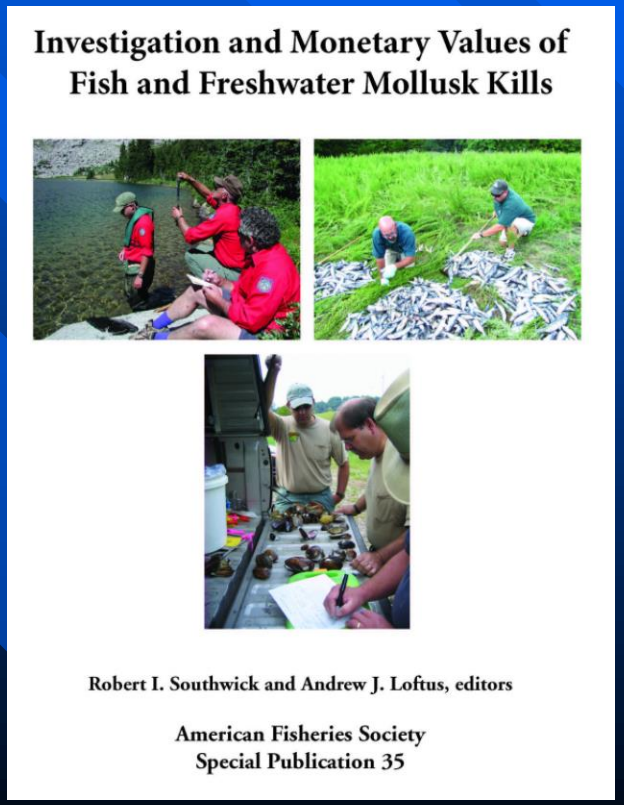
- **Regional Aquatic Health Plan**
  - **Importation and transfer of fish**
  - **Communication**
  - **Management strategies**
- **Needed for Mollusks???**

Sport Fish Restoration Program

NORTH CAROLINA Wildlife RESOURCES COMMISSION

Unresolved Needs and Emerging Issues

- Advocate Funding for Freshwater Mollusk Health Initiative
  – FMCS, US FWS, USGS, EU, State Agencies, others
- Plan and Prepare for Disease and Die-off Investigations
  – New 2017 Manual Available



Unresolved Questions and Emerging Issues

- How do we deal with unregulated and unknown agents? – We find only what we look for!
  - Toxicants (chemicals), Toxins (cyanobacterial, others)
  - Diseases (bivalve contagious cancers, others)

Environmental Toxicology and Chemistry—Volume 37, Number 2—pp. 336–344, 2018

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Environmental Chemistry

Novel Contaminants Identified in Fish Kills in the Red River Watershed, 2011–2013

Tammy L. Jones-Lepp,[a,*] Vince Taguchi,[b] Wayne Sovocool,[a,1] Don Betowski,[a] Patrick DeArmond,[a] Brian Schumacher,[a] Witold Winnik,[c] Rick McMillin,[d] and Chris Armstrong[e]

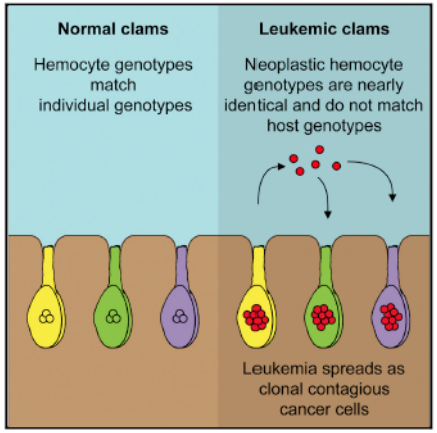
- 4 unexplained fish kills; Red R., OK
- ID'd a geoporphyrin from cyano(bacterium)
- Also human therapeutic cancer drug
- Co-transport of metals
- Elevated levels of Mn?

Article

Cell

Horizontal Transmission of Clonal Cancer Cells Causes Leukemia in Soft-Shell Clams

Graphical Abstract



Authors
Michael J. Metzger, Carol Reinisch, James Sherry, Stephen P. Goff

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In Brief

A fatal form of cancer is spreading between animals in the marine environment as a clonal horizontally transmissible cell, likely derived from a single original clam.

Highlights

- Clam leukemia genotypes are distinct from their hosts and nearly identical to each other
- The transmissible cancer clone likely arose in a single individual
- Clam leukemia is transmitted horizontally between animals as contagious cancer cells
- Contagious cancer cell transmission may be widespread in the marine environment