Perspective on Bivalve Mollusc Disease from the Marine Environment

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Major Disease Emergence In Bivalve Molluscs

Malpeque disease
*Crassostrea virginica*
Prince Edward Island

Winter mortality
*Saccostrea glomerata*
SE Australia

MSX disease
*Crassostrea virginica*
USA Mid-Atlantic

QX disease
*Saccostrea glomerata*
SE Australia

Dermo disease
*Crassostrea virginica*
USA Mid-Atlantic

QPX disease
*Mercenaria mercenaria*
E. Canada, USA

Bonamia exitiosa
*Ostrea chilensis*
New Zealand

Gill iridovirus
*Crassostrea angulata*
France

Bonamia ostreae
*Ostrea edulis*
France

Marteilia refringens
*Ostrea edulis*
France

Herpesviral infection
*Crassostrea gigas*
France

Denman Island disease
*Crassostrea gigas*
British Columbia

Martelilia refringens
*Ostrea edulis*
France

Oyster, Virginia

Aubrey Bodine photo, 1960
Strengths of Marine Shellfish Pathology

- Familiar list of established pathogens and disease agents
- Effective diagnostic tools for their detection
- National and international networks of laboratories sharing information on their status, and new disease emergence
- Deepening pool of biological/ecological knowledge informs management
We Have a Good Handle on Who the Pathogens Are

- *Perkinsus, Haplosporidium, Bonamia, Marteilia, Mikrocytos*
- OsHV-1 herpesviruses (presently microvariants thereof)
- QPX
- *Vibrio, Roseovarius* bacteria
- Or do we?
Coming to Terms with Pathogen Diversity

- New pathogens of concern emerge or are discovered all the time
  - *Perkinsus beihaiensis*
  - *Mikrocytos* spp.
  - Haplosporidians
  - RLOs?

- What level of genetic diversity is important?
  - For OsHV-1, is it just the microvariants? Or the “reference” strains too?
The Notifiable List

- Powerful tool for aquatic animal health management
- OIE, national lists; pathogens of concern at state level
- Focuses diagnostic effort on “pathogens that count”
Problems with Lists

- Incomplete understanding of susceptible hosts
- Challenges defining pathogens, strains
- Politicization of listing (or not)
- Focus on specific host-pathogen systems can create blind spots with regard to other pathogens

*Paradox of the List*: We think it strengthens biosecurity, but may actually *reduce* biosecurity by creating blind spots
We Have Effective and Advanced Diagnostics

- Histopathology a workhorse platform
- PCRs for major pathogens; qPCR assays coming online
Some pathogens can only be (practically) detected by PCR (e.g., OsHV-1)
  ➢ Not inherently a problem

Molecular methods promise exquisite sensitivity and high specificity

Can be rapid and economical

Quantitation with qPCRs
The Downside with Molecular Diagnostics

- Detection ≠ infection ≠ disease; we can only detect what is targeted.

- Overreliance on “advanced diagnostics” to the exclusion of broader methods may reduce biosecurity by creating blind spots with regard to other pathogens: a Paradox of Advanced Diagnostics.

- Loss of expertise in microscopic recognition of pathogens increasingly limits our broader perspective.

- Maintaining fundamental capacity for “traditional” pathology (and virology, and microbiology, etc.) is essential.

Lauren Huey

Corinne Audemard
Which Molecular Assays Should We Use?

- Careful design, proper validation of assays is essential

- What is “careful design”? 

- Ensuring proper sensitivity and specificity

- Likely the case that assays in use, particularly older assays, may not target all the diversity inherent in pathogens of concern
Inadequacy in Validation

- Few molecular assays in the mollusc realm have been properly validated
- While all may “work”...
- There is no empirical basis for recommending one over another
- Multiple assays for individual pathogens across various laboratories, with little appreciation for their relative performance

*Bonamia exitiosa*
We Have Effective Networks of Laboratories

- World Organisation for Animal Health (OIE) Reference Centres
- EU Reference Labs
- US state, university and private laboratories (VIMS, Rutgers, Roger Williams, Florida Atlantic, Stony Brook, Cooperative Oxford Lab, Kennebec River Biosciences)
- Strains the definition of “network” at times, as communication can be non-existent
Managing Marine Mollusc Diseases in the Context of Regional and International Commerce: Policy Issues and Emerging Concerns

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Knowledge of Pathogen Biology Informs Management
But Uncertainty Abounds

- Basic information lacking or not readily available (unpub/gray lit)
  - Geographic distributions
  - Host distributions/specificity
  - Life cycles & basic ecology

- Can lead to regulatory paralysis
  - Just say no = zero tolerance
  - Even where risk is low

- Can harm typically reasonable aquaculture commerce

- At least maximizes biosecurity if not economic benefits to industry
Inconvenience can drive industry to surreptitious channels, reducing biosecurity—a Paradox of Uncertainty
The Way Forward

- Develop more broad-based surveillance programs
- Promote and apply wider training in general methods like histopathology
- Demand focus on assessment and validation as fundamental to assay development

Sea Grant  USDA APHIS
Invest in research to close key knowledge gaps and reduce uncertainty

Apply risk analysis to avoid regulatory paralysis
Complex Problems Will Require Broader Collaboration

- “Not just about counting *Perkinsus* cells anymore”

- The nature of health and disease challenges may not be obvious, or straightforward . . .

- Broader expertise may be required to understand, and solve, contemporary questions
A Final Vignette
Change: Emergence of Hypervirulent *Perkinsus marinus*
Evolutionary Perspective on Health Management

- Preserving capacity for evolutionary response to disease and environmental changes is important

- Can we fundamentally influence wild populations by hatchery supplementation?

- If we can . . . Should we?

- Chesapeake Bay example highlights the relevance of genetics to health management and conservation/restoration