

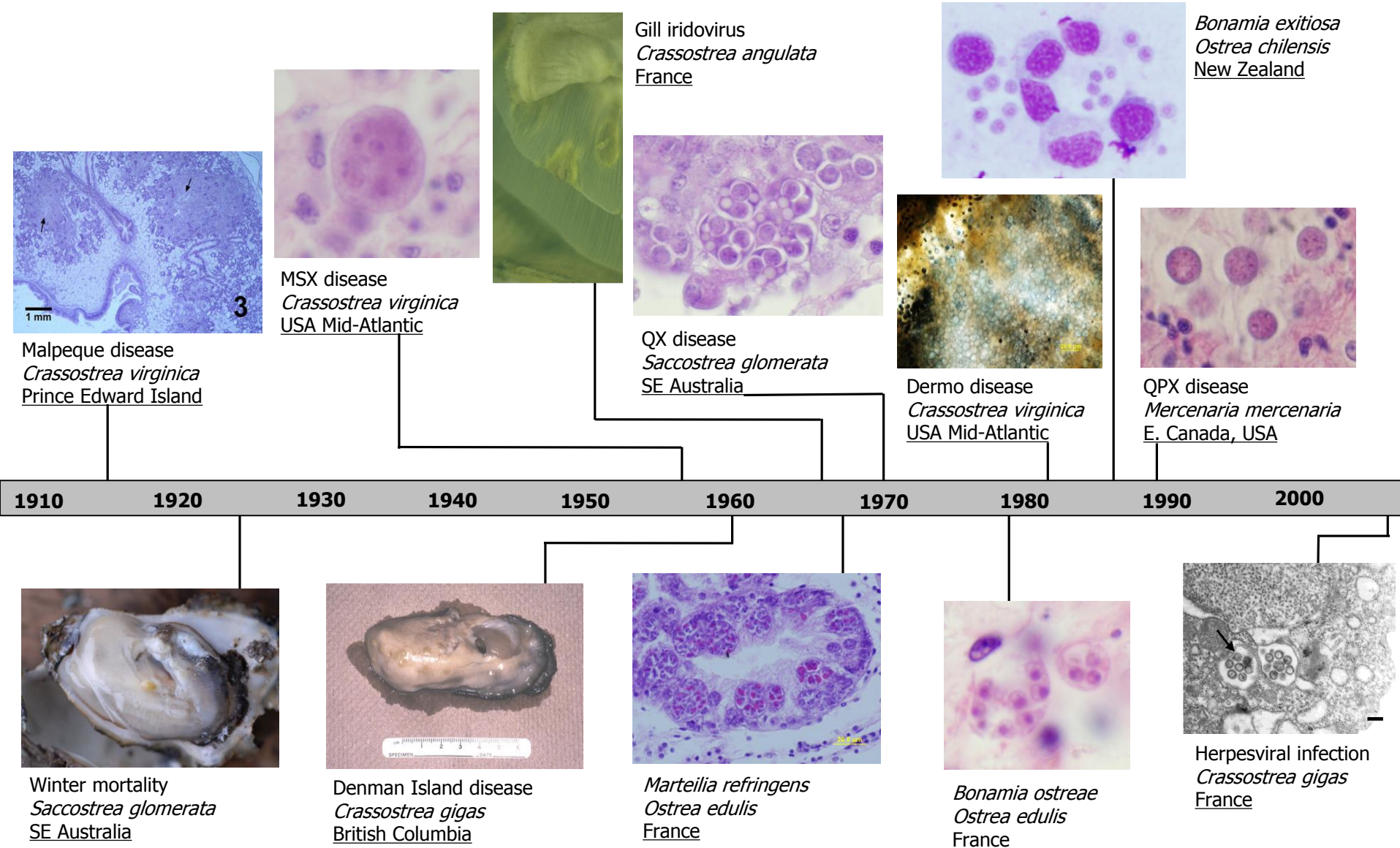
# Perspective on Bivalve Mollusc Disease from the Marine Environment

Ryan B. Carnegie, PhD  
*Virginia Institute of Marine Science*





# Major Disease Emergence In Bivalve Molluscs



# Oyster, Virginia

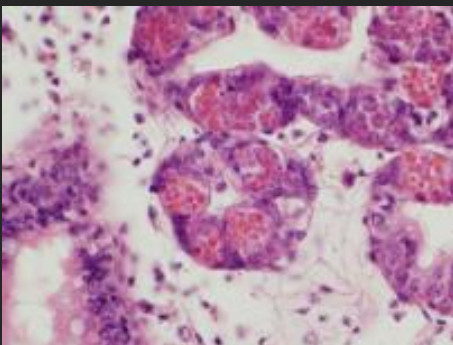


Aubrey Bodine photo, 1960

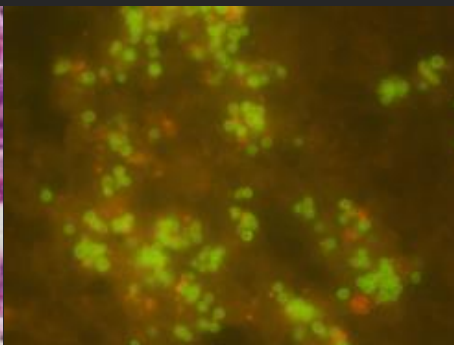


# Strengths of Marine Shellfish Pathology

- ❖ 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



*Marteilia*



FISH for *Bonamia*



Survey site

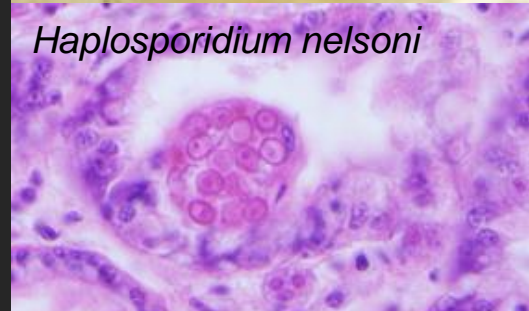
# *We Have a Good Handle on Who the Pathogens Are*

- ❖ *Perkinsus, Haplosporidium, Bonamia, Marteilia, Mikrocytos*
- ❖ OsHV-1 herpesviruses (presently microvariants thereof)
- ❖ QPX
- ❖ *Vibrio, Roseovarius* bacteria
- ❖ Or do we?

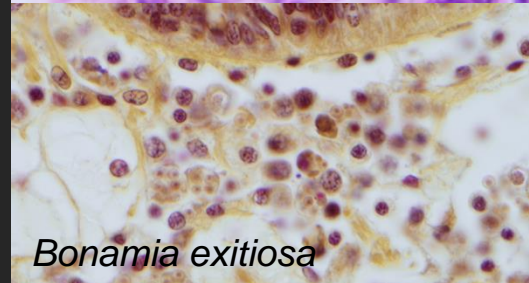
*Perkinsus marinus*



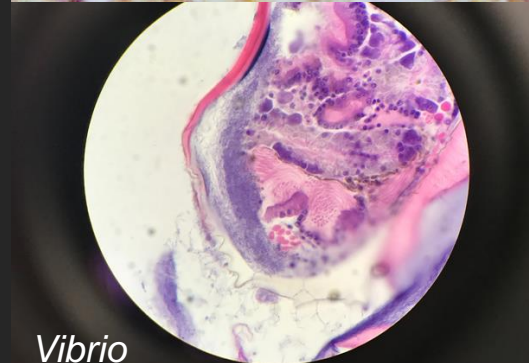
*Haplosporidium nelsoni*



*Bonamia exitiosa*

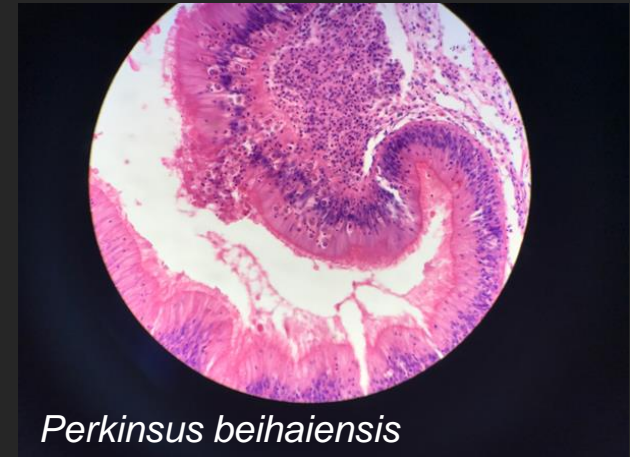


*Vibrio*

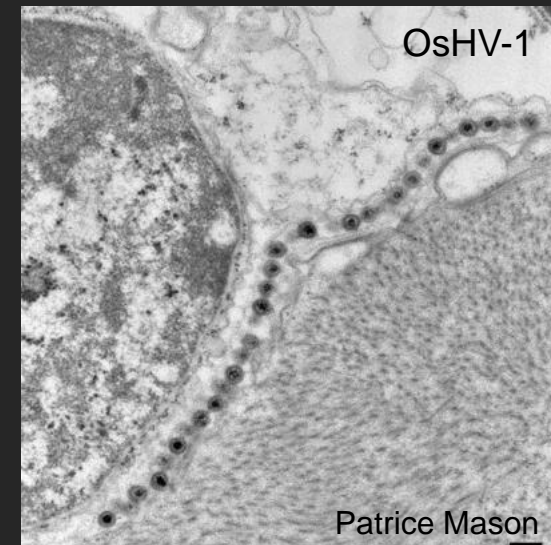


# Coming to Terms with Pathogen Diversity

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

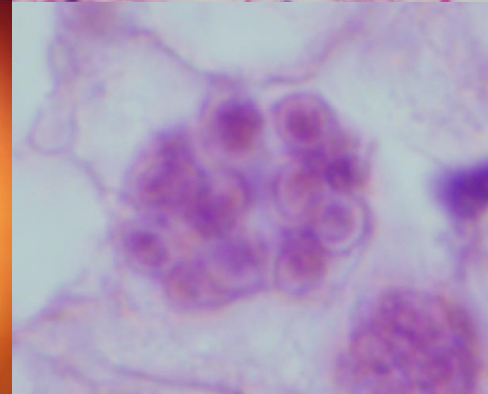
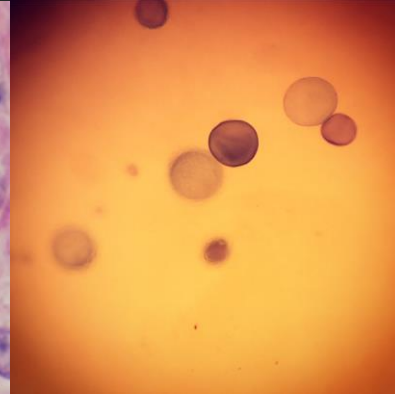
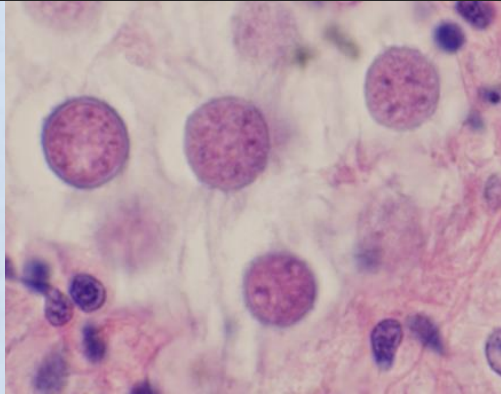
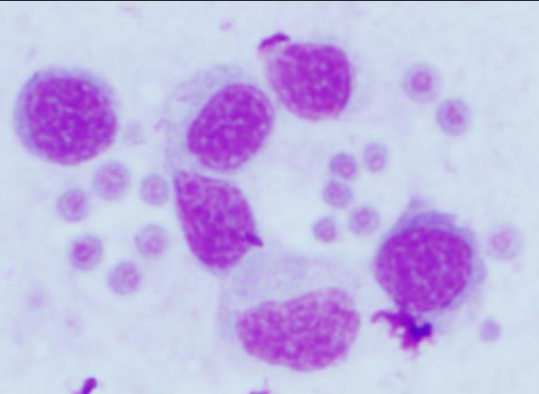
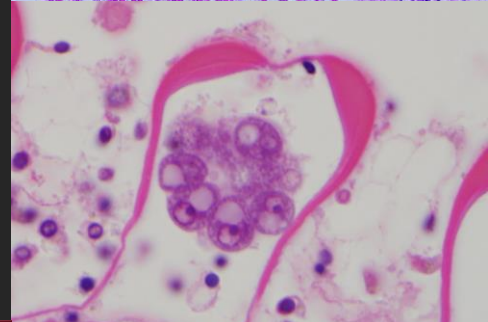
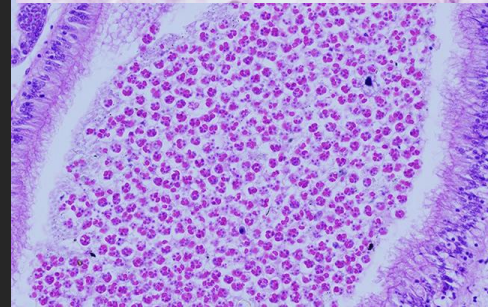
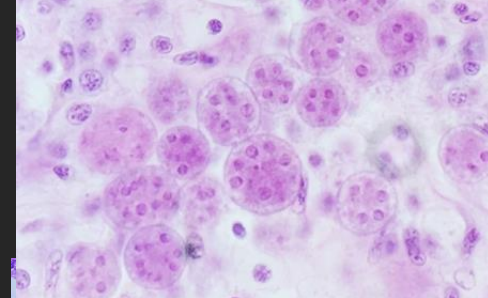


- ❖ What level of genetic diversity is important?
  - For OsHV-1, is it just the microvariants? Or the “reference” strains too?



# The Notifiable List

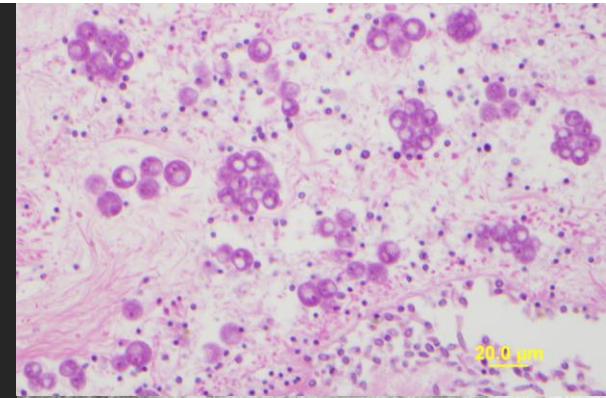
- ❖ Powerful tool for aquatic animal health management
- ❖ OIE, national lists; pathogens of concern at state level
- ❖ Focuses diagnostic effort on “pathogens that count”





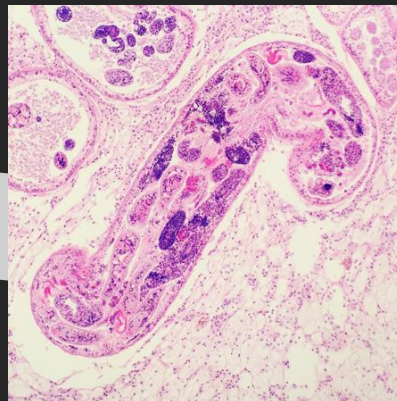
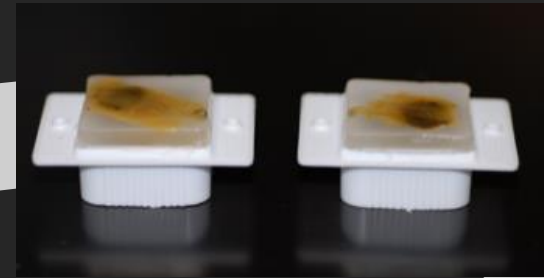
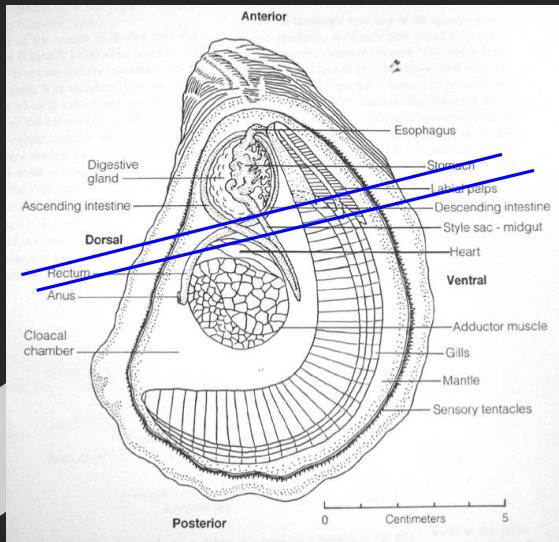
# Problems with Lists

- ❖ 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



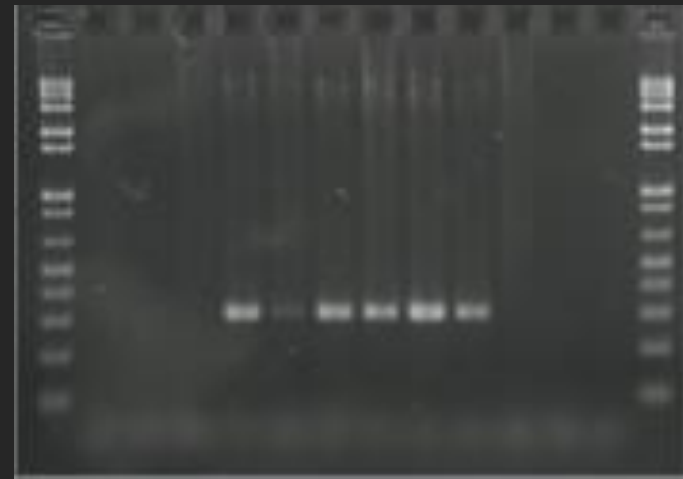
# *We Have Effective and Advanced Diagnostics*

- ❖ Histopathology a workhorse platform
- ❖ PCRs for major pathogens; qPCR assays coming online



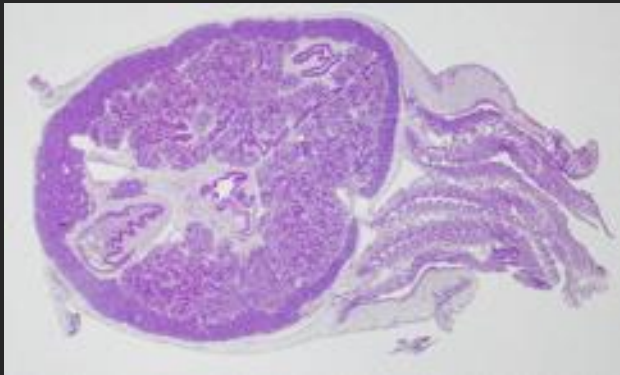
# Increasing Use of Molecular Diagnostics

- ❖ 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

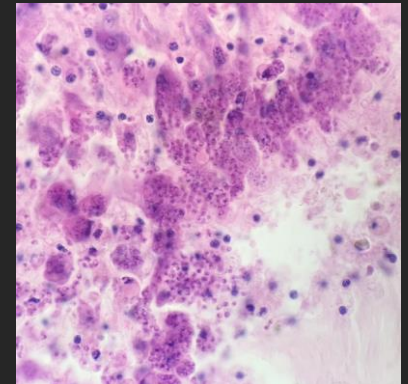
- ❖ Detection  $\neq$  infection  $\neq$  disease; we can only detect what is targeted
- ❖ Overreliance on “advanced diagnostics” to the exclusion of broader methods may to reduce biosecurity by creating blind spots with regard to other pathogens: a *Paradox of Advanced Diagnostics*
- ❖ Loss of expertise 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



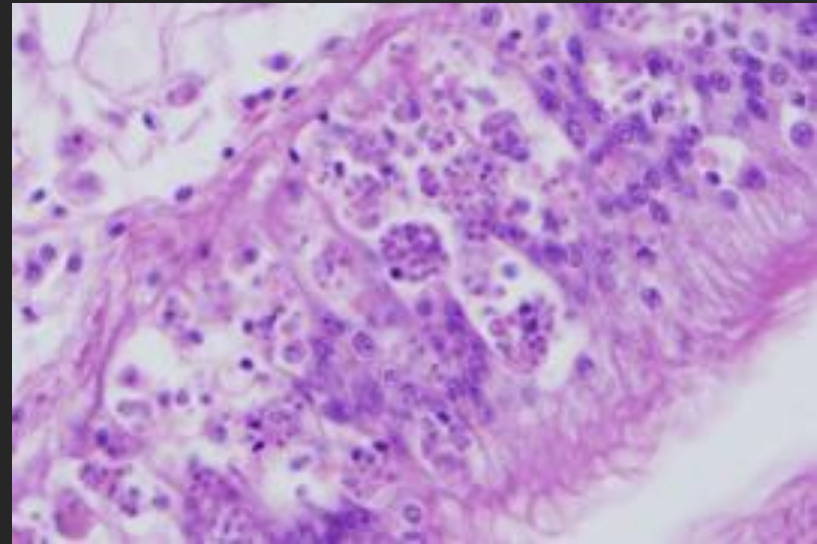
Corinne Audemard



# 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

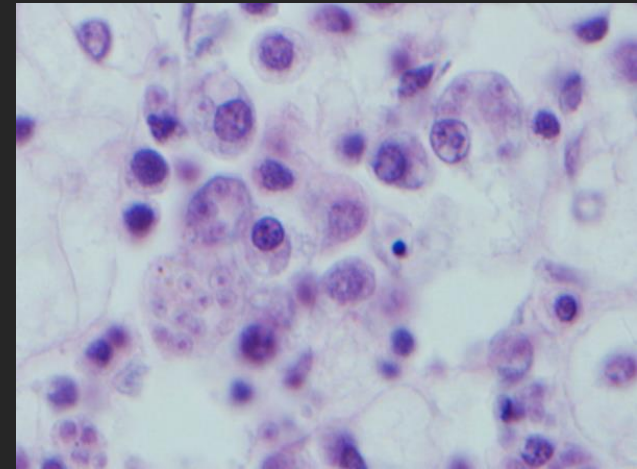
*Perkinsus marinus*



# 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

Ryan Carnegie

*Virginia Institute of Marine Science, College of William & Mary*

Dave Bushek

*Rutgers University Haskin Shellfish Research Laboratory*

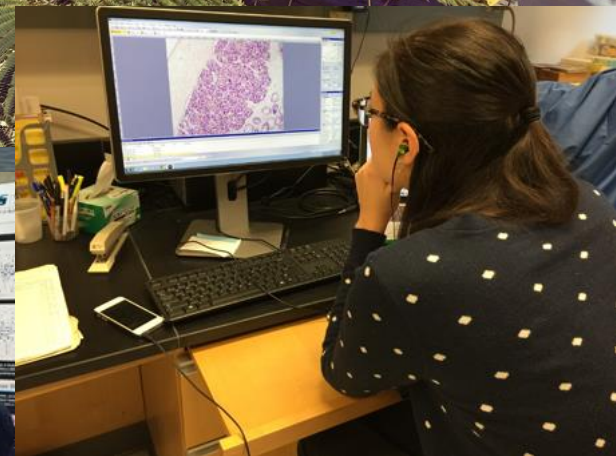
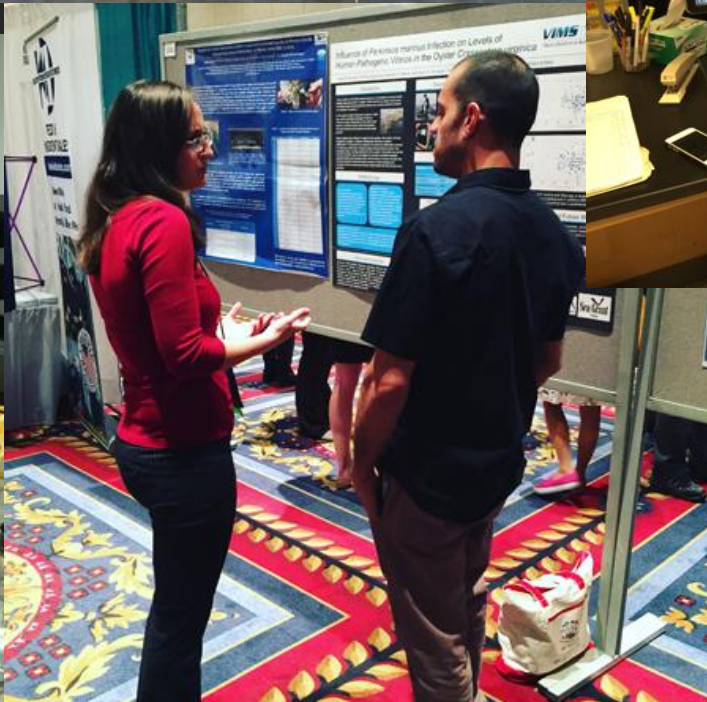
Isabelle Arzul

*Ifremer, Laboratoire de Génétique et Pathologie des Mollusques Marins*



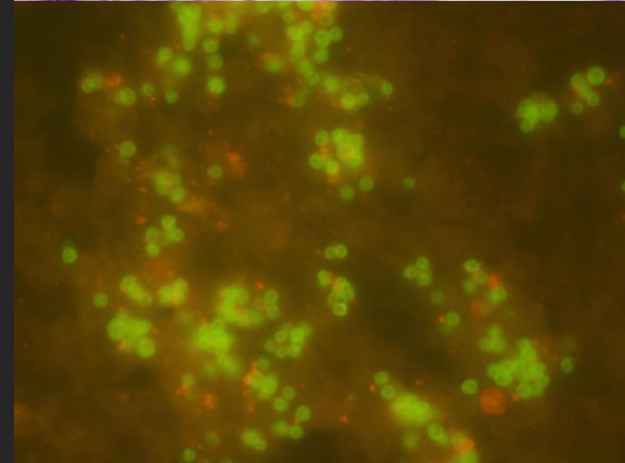
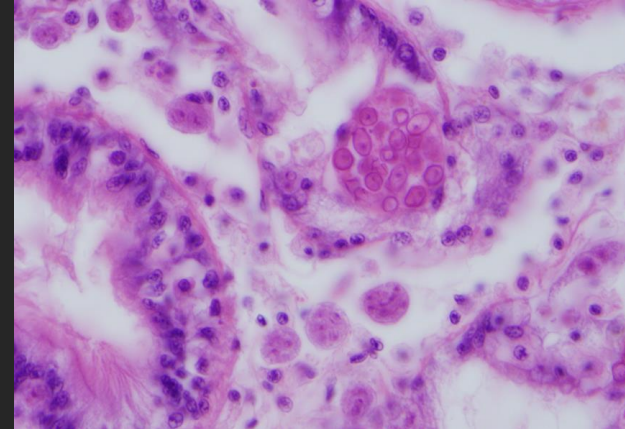
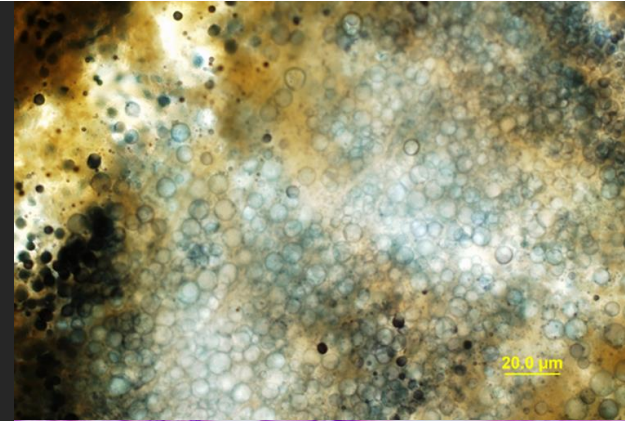


# *Knowledge of Pathogen Biology Informs Management*



# 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



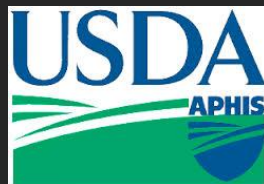
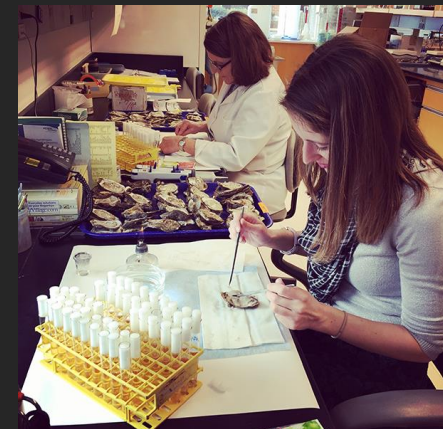
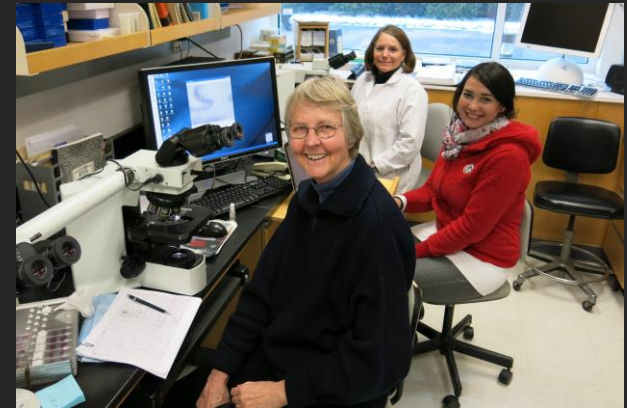
# Or Does It?



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



# The Way Forward

- ❖ 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



Hatchery Health

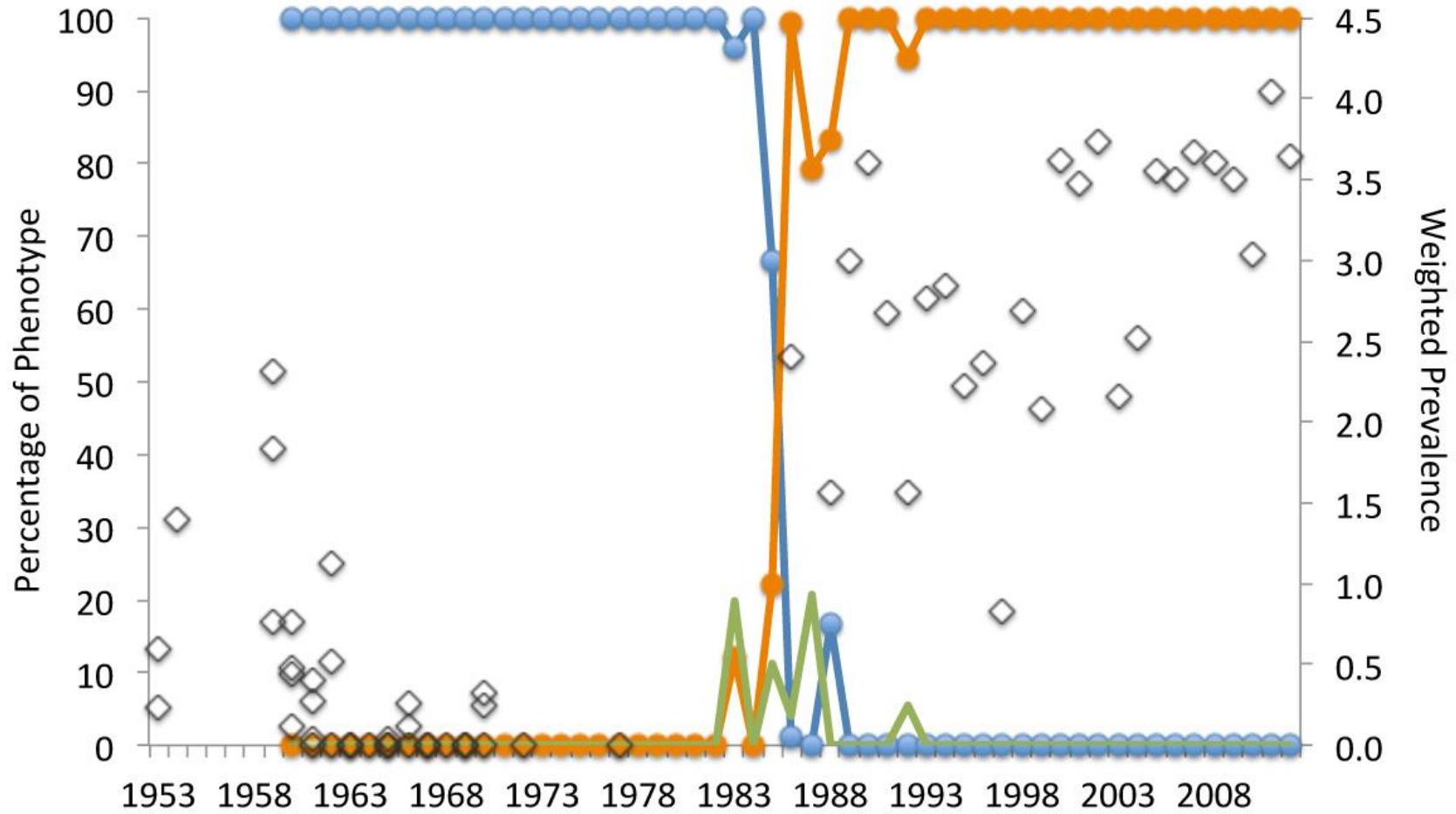


Triploid Mortality

# A Final Vignette

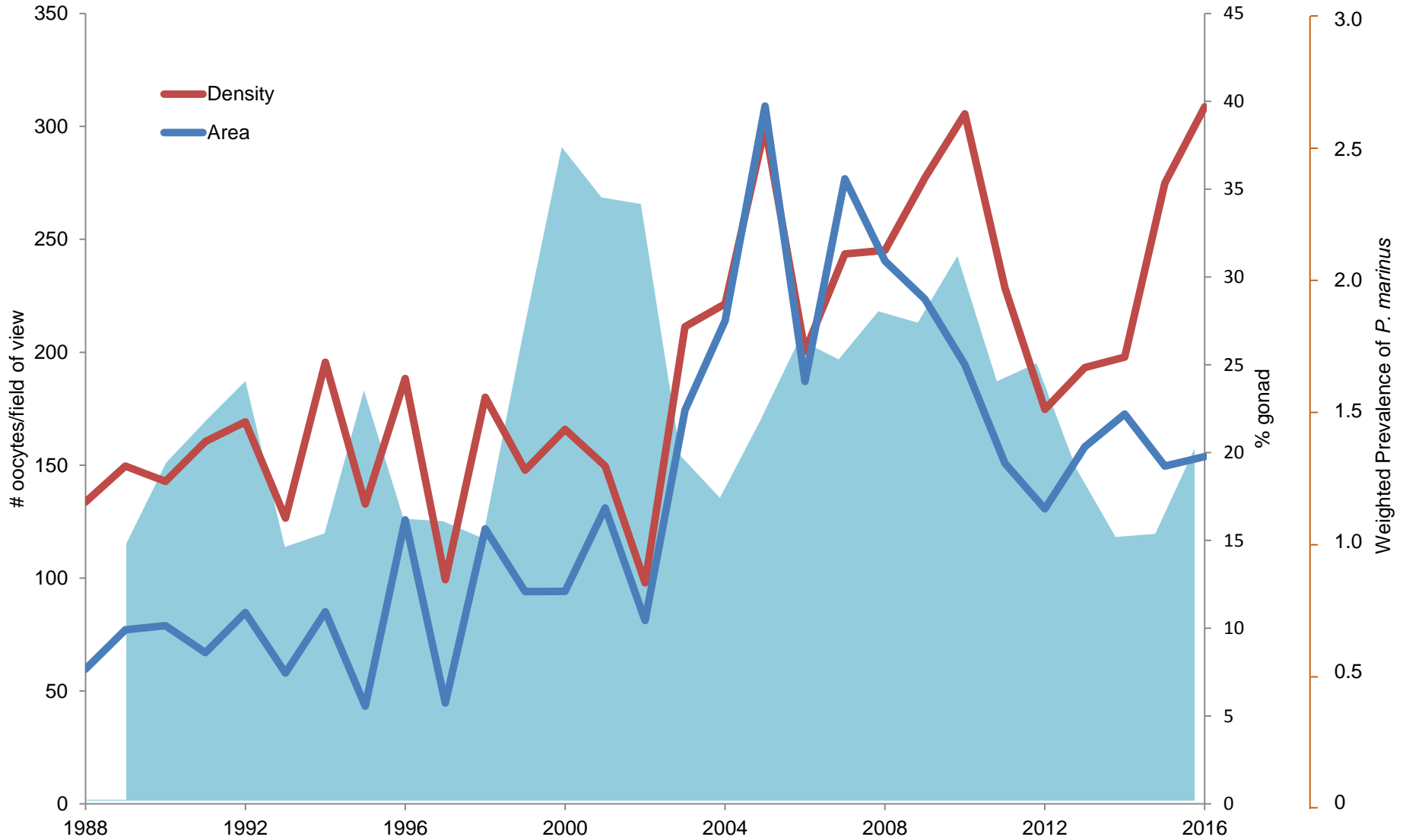


# Change: Emergence of Hypervirulent *Perkinsus marinus*





# Increased Disease Tolerance



# 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

## ENVIRONMENT

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### Billion and billions of new oysters to be added to Chesapeake Bay

By Dave Mayfield  
The Virginian-Pilot  
Feb 26, 2018



Allison Hess | The Virginian-Pilot

Baskets of oysters make their way to restored reefs in the Lafayette River following a ceremony to celebrate the progress in re-establishing the river's oyster population at the Norfolk Yacht and Country Club in Norfolk on Friday, July 7, 2017. Federal grants announced Monday Sept. 25, 2017, will help restore an additional 5.5 acres of reefs, and put the river in contention to be declared as having met its oyster restoration goal under the Chesapeake Bay cleanup.

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#### LET'S TALK



#### ICYMI: TOP STORIES

- 1 Three inches of snowfall expected, causing power outages and slick roadways
- 2 Surfer, Cyclist, Fighter pilot. Meet Oceana's new commanding officer.
- 3 Hampton Roads sea level rise is accelerating, report says
- 4 Coming to Norfolk: new hotel, TCC center - and a Ferris wheel. Leaving: Greenies.

