Emerging Infectious Disease in Marine Mammals: Sentinels of Environmental Change

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October 18, 2012
MMHSRP

The MMPA recognizes the need for health data from marine mammals. The MMHSRP was formally established in 1992 under Title IV of the MMPA with three purposes:

1. Facilitate the collection and dissemination of Health and Health Trends in marine mammal populations in the wild
2. Correlate the Health of marine mammals with biological, physical, chemical environmental parameters
3. Coordinate efficient responses to unusual mortality events
Marine Mammal Stranding Network

NMFS Offices and Authorized Stranding Network Organizations:

- NMFS Headquarters
- NMFS Regional Office
- NMFS Science Center
- NMFS Field Station/lab/Research Division
- Authorized Stranding Network Organization
- U.S. Exclusive Economic Zone (EEZ)
Marine Mammal Health Assessments

Kucklick et al 2011 Environmental Science & Technology
All TOPP Species (Block et al., 2011, Nature)
Viruses
- Avian Influenza
- West Nile

Fungal
- Cryptococcus
- Coccidioides
- Lacazia

Bacteria
- Brucella
- Leptospira
- Coxiella

Protozoa
- Toxoplasma
- Sarcocystis
- Neospora
- Giardia
Fungal Diseases

*Cryptococcus gatti* - Yeast
- Historically Sub-tropical/tropical disease

Found in Environment
- air, soil, water, associated with trees

Transmission – Inhalation

*Coccidioides immitis* - Mold
- Terrestrial fungus that causes “Valley Fever” in SW United States

Found in Environment
- air, soil, water, transported by dust storms

Transmission - Inhalation
Cryptococcus gatti in the Pacific Northwest

Since 2000-

- 25 Cetaceans – Dall’s and Harbor porpoise, Pacific white sided dolphin
- Necropsy findings
  - Lung infections
  - Isolated *Cryptococcus gatti*, type B from lung and mediastinal lymph node

Environmental reservoirs
  — Douglas fir, alder and cedar trees

Stephen et al 2002 Canadian Veterinary Journal
Norman et al 2011 Emerging Infectious Diseases
Coccidioides immitis
Infection Pacific Coast

Infections in sea lions, dolphins/porpoises, sea otters

• Lung and disseminated infections

Increase in marine mammal cases
  — temporally & spatially linked to increased human cases

Linked to dust deposition

Photos: M. Miller
**Coxiella burnetti**
“Q Fever”
Gram negative bacteria
Transmission – direct contact (milk, urine, feces, placenta), inhalation, vectors, environmental contamination
- Commonly infects small ruminants
- Abortions

**Brucella spp.**
“Brucellosis”
Gram negative intra-cellular bacteria
Transmission - direct contact (milk, placenta), inhalation, breeding
- Commonly infects ruminants, dogs, swine
- Abortions
**Coxiella burnetti** Infection
Seals and Sea Lions

Alaska and Pacific Northwest

- Clinical Disease in harbor seals, steller sea lion
  — Placental infections, abortion
- Organism found in placentas of Northern fur seals at rookery sites

Food Safety and Security
Public Health

Duncan et al 2011 Vector-borne and Zoonotic Diseases
Kersh et al 2012 Journal of Wildlife Diseases

Photos: S Raverty
Marine Mammal Brucella

Sero-surveys 1990s (14 pinnipeds; 26 cetaceans)

*B. ceti* and/or *pinnipedialis*

• Since 2011 Culture/PCR positive cetaceans:
  • HI, CA, TX, AL, MS, FL, SC, NC, MA, ME, GA
    • 25 Bottlenose dolphins
    • 8 Common dolphins
    • 2 Striped dolphins
    • 1 Harbor porpoise

Pathology in cetaceans:
  • Late-term abortions
  • Brain infections
  • Lung abscesses
  • Bone infections
  • Skin infection (blubber abscesses)

• Pathology in seals: No definitive lesions but *Brucella* spp. has been isolated

• CDC Occupational Study

Sears et al 2012 MMWR; Nymo et al 2011 Vet Research
Lambourn et al Journal of Wildlife Diseases, in review
Protozoal Diseases

Protozoa spp.
- *Toxoplasma, Sarcocystis, Neospora*

Transmission
- Ingestion of oocysts from water, soil, feces
- Ingestion of prey with tissue cysts

Disease
- Brain infections
- Abortions

Photo: http://www.forschung3r.ch/de/publications/bu24.html
Sea otters and Toxoplasma

Brain Infections, Seizures

• Otters near river outflows at highest risk
• Marine invertebrates can concentrate oocysts - remain infectious for weeks
• High-risk foods: bivalves, snails

Land-sea transfer with concentration in invertebrate prey is most likely route for infection

• Public Health


Photos: M. Miller
Influenza viruses are RNA viruses that are found in the family: Orthomyxoviridae

- There are three types of influenza viruses: A, B and C
- Human influenza A and B viruses cause seasonal epidemics

Influenza A viruses can infect humans, mammals and birds

- Transmission –
  - Direct contact, inhalation

Influenza A viruses subtypes based on two proteins on the viral surface:
  - Hemagglutinin (H) (assists with binding to cell)
  - Neuraminidase (N) (assists with viral replication).

- 16 different Hemagglutinin
- 9 different Neuraminidase

Photo: Molecular Expressions
Avian Influenza

- Previous outbreaks of AI in HS:
  - H7N7 (80), H4N5 (82), H4N6 (91) and H3N3 (92)
- UME - September 2011 to Present
  - ME, NH, MA
  - 168 seals
- Majority of animals stranded dead
  - Pneumonia & Skin ulcerations
- Isolated Avian Influenza A H3N8
- The AI H3N8 virus has adapted to mammalian replication
- Harbor seals have receptors for both avian and mammalian influenza viruses

Anthony et al 2012 mBio

Photo: B. Friel
Reservoir Inf A

- Anseriformes
- Charadiiformes

Influenza A

Other mammals

Opportunities for Influenza Transmission With Changing Climate
Alaska UME

• 2011 to present
• Food safety and security
• Over 100 ice seals and walrus
  • Hair loss
  • Skin lesions
  • Septicemia
• No definitive infectious cause isolated
  • Trans-boundary
  • Multi-factorial
    • Environmental, hormonal, etc.
    • Biotoxins?

Photos: T. Fishbach & K. Burek
The freshwater-marine interface is a pollutant deposition zone:

- Rapid changes: salinity, pH, charge, turbidity, turbulence, temperature
- Poorly understood & massively under-studied
- Most predictive models stop upstream & offshore
- Is area where most humans live worldwide

Pathogens, cyanotoxins, chemicals, nutrients, oil, garbage
One Ocean-One Climate-One Health:
Linking Environmental Health, Public Health, Wildlife Health, And Domestic Animal Health
Acknowledgments


• National Marine Mammal Stranding Network

• UME Investigative Teams
  • Alaska UME
  • Northeast UME
  • Gulf of Mexico UME

• North American Marine Brucella Working Group

• Alaska Native Tribal Communities

• NMFS and NOS Science Centers

• CDC Partners
  • NCEZID, NIOSH, NCIRD

Photo: NMFS NERO