

Science, Service, Stewardship



Emerging Infectious Disease in Marine Mammals: Sentinels of Environmental Change

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Response Program

Office of Protected Resources

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**NOAA
FISHERIES
SERVICE**



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:

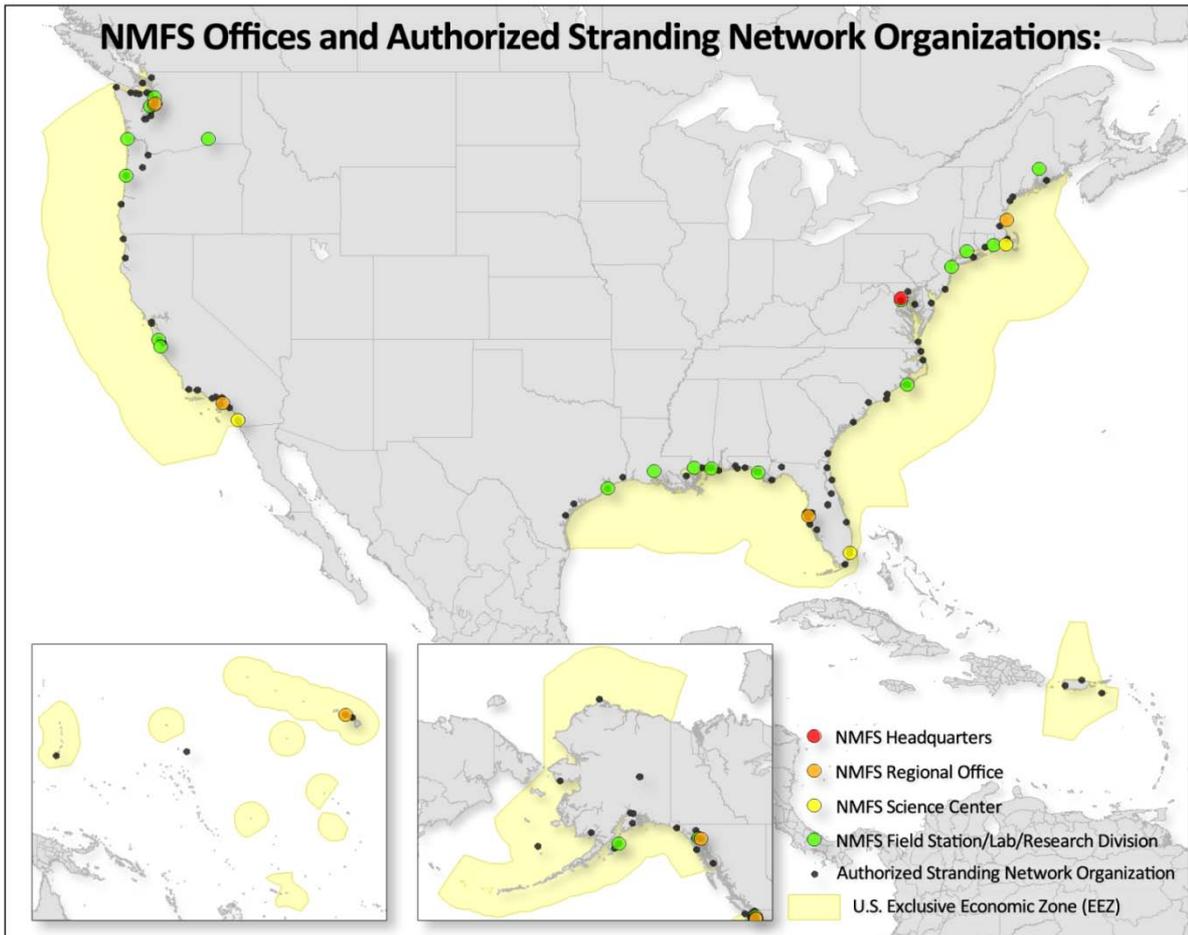
- 1. Facilitate the collection and dissemination of Health and Health Trends in marine mammal populations in the wild**
- 2. Correlate the Health of marine mammals with biological, physical, chemical environmental parameters**
- 3. Coordinate efficient responses to unusual mortality events**



Marine Mammal Stranding Network



NMFS Offices and Authorized Stranding Network Organizations:





Marine Mammal Health Assessments



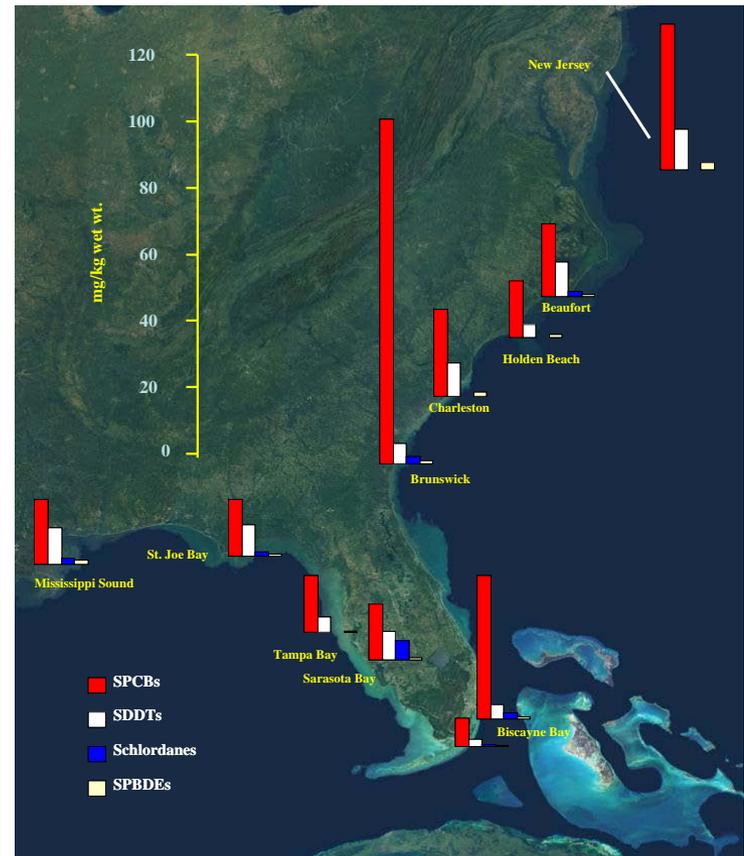
NOAA Permit 932-1905-MA009526



NOAA Permit 0358-1564



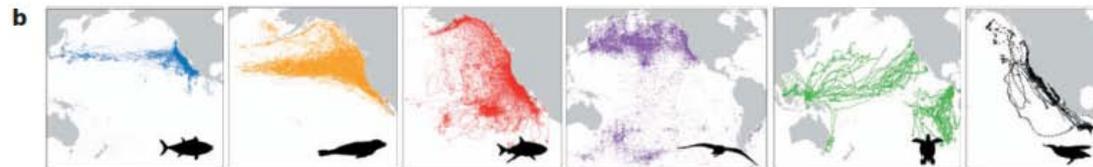
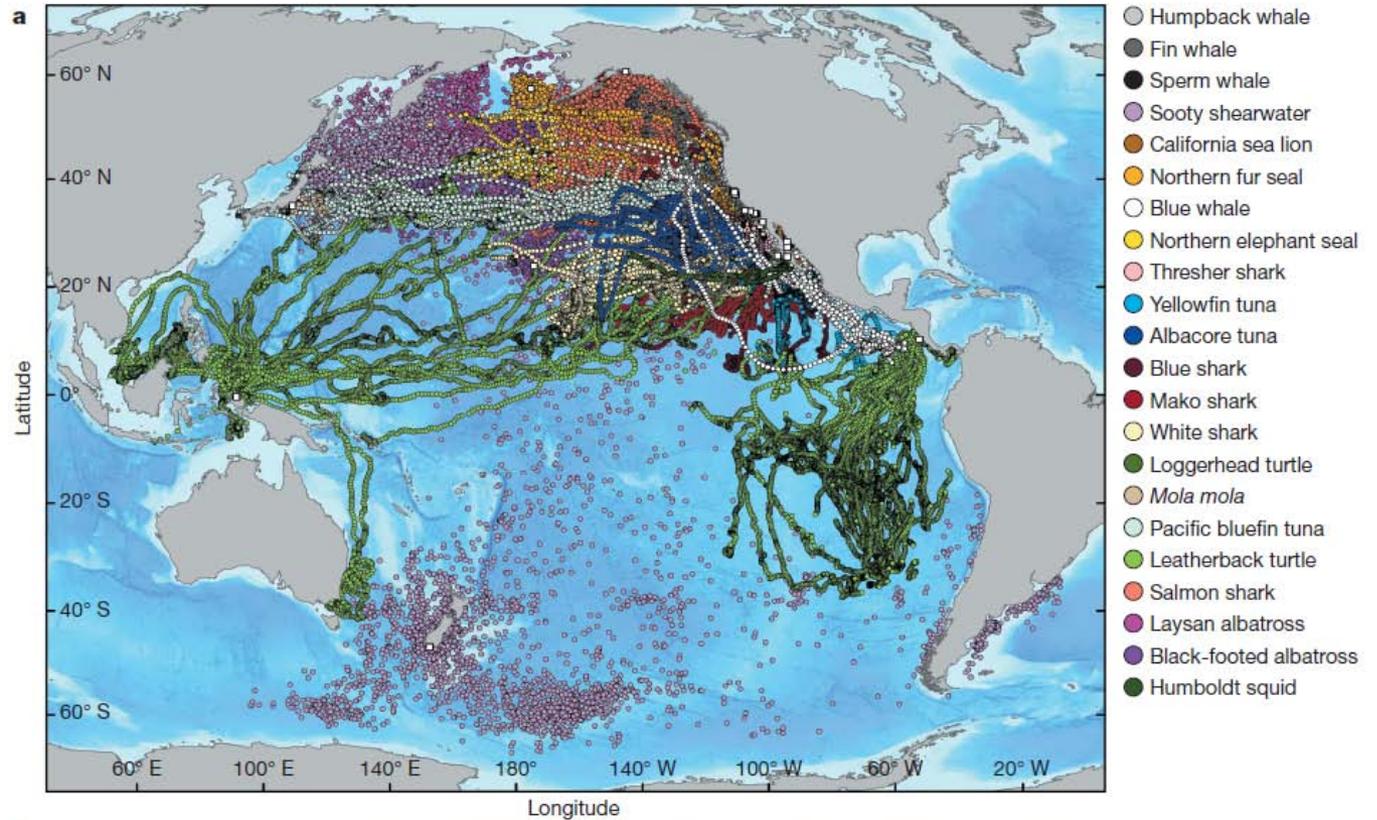
NOAA Permit 15126-02



Kucklick et al 2011 Environmental Science & Technology



All TOPP Species (Block et al., 2011, Nature)

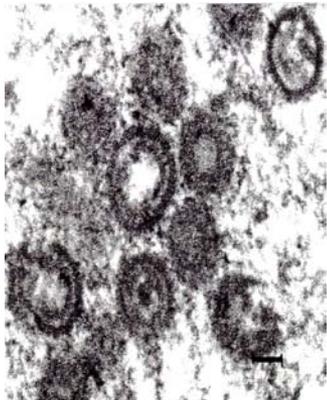




Emerging Infectious Agents

Viruses

- Avian Influenza
- West Nile



Fungal

- Cryptococcus
- Coccidioides
- Lacazia



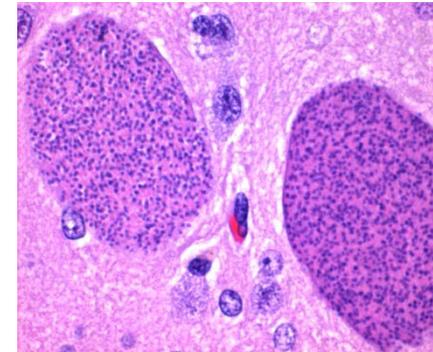
Bacteria

- 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



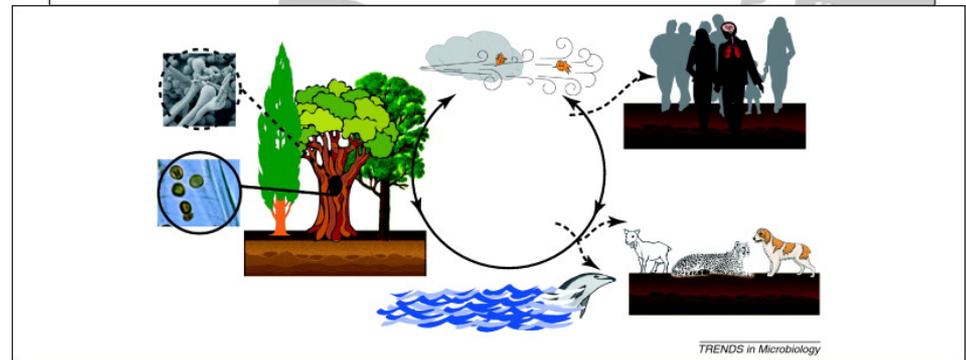
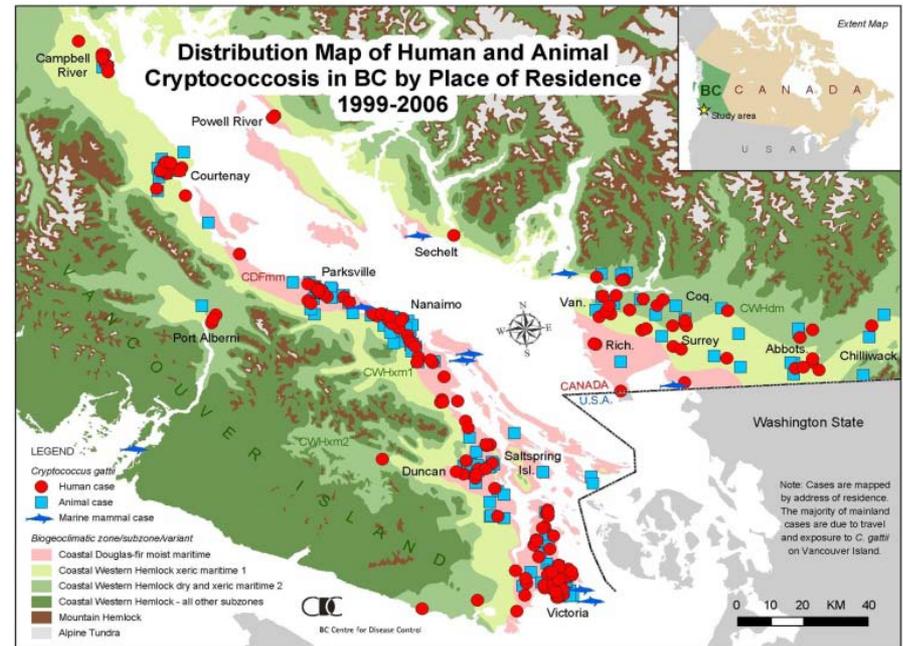
Cryptococcus gatti in the Pacific Northwest

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





Coccidioides immitis Infection Pacific Coast

Infections in sea lions,
dolphins/porpoises, sea
otters

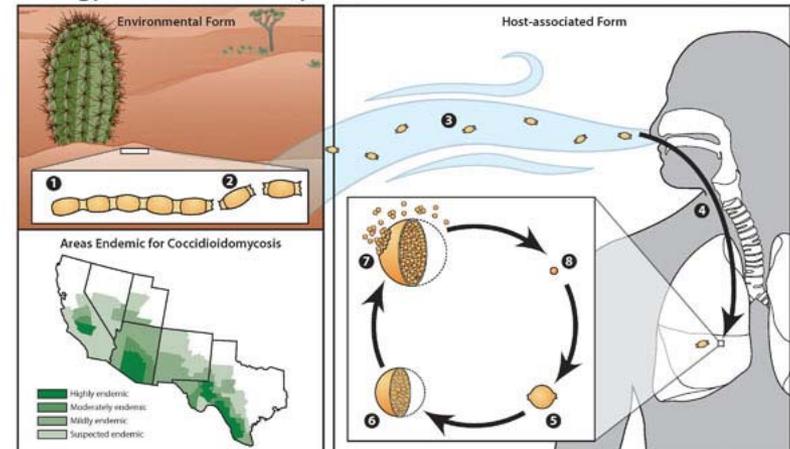
- Lung and disseminated
infections

Increase in marine
mammal cases

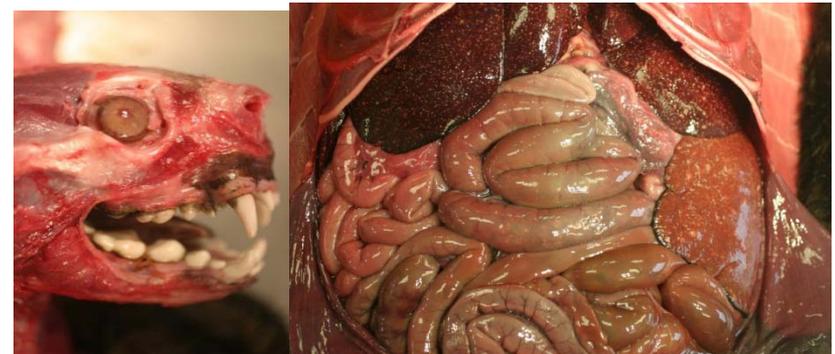
—temporally & spatially
linked to increased
human cases

Linked to dust deposition

Biology of Coccidioidomycosis



In the environment, *Coccidioides* ssp. exists as a mold (1) with septate hyphae. The hyphae fragment into arthroconidia (2), which measure only 2-4 µm in diameter and are easily aerosolized when disturbed (3). Arthroconidia are inhaled by a susceptible host (4) and settle into the lungs. The new environment signals a morphologic change, and the arthroconidia become spherules (5). Spherules divide internally until they are filled with endospores (6). When a spherule ruptures (7) the endospores are released and disseminate within surrounding tissue. Endospores are then able to develop into new spherules (6) and repeat the cycle.





Bacterial Diseases



Photo: S. Raverty

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

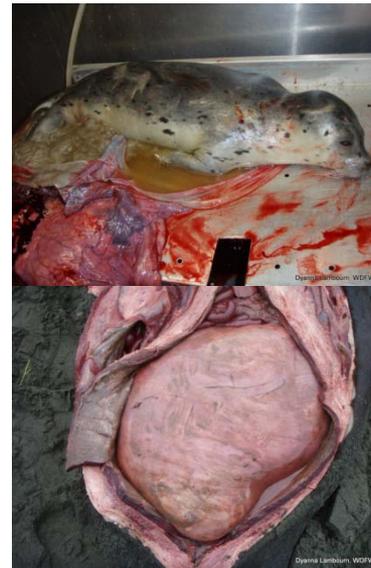
Alaska and Pacific
Northwest

-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



Photos: S Raverty

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



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



Protozoal Diseases

Protozoa spp.

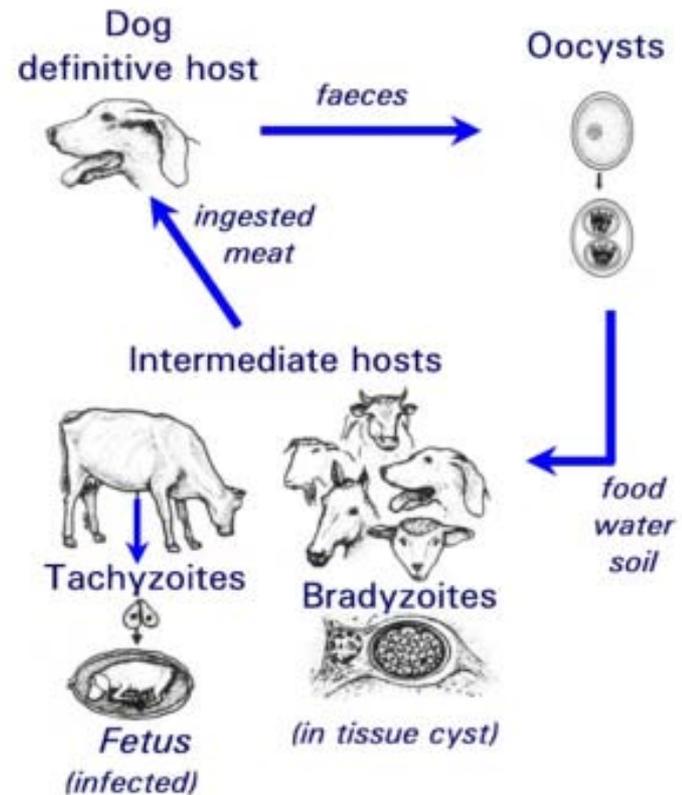
- *Toxoplasma*, *Sarcocystis*, *Neospora*

Transmission

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

Disease

- Brain infections
- Abortions





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





Influenza Virus

Influenza viruses are RNA viruses that are found in the family: Orthomyxoviridae

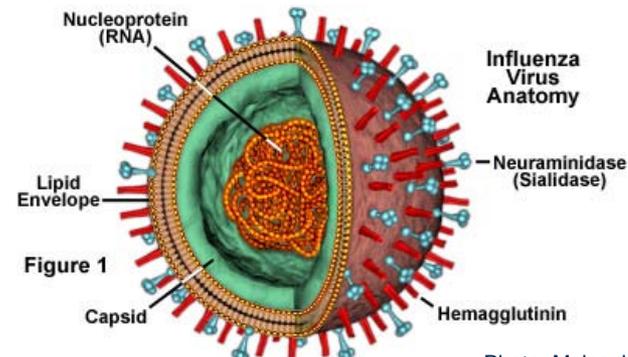
- There are three types of influenza viruses: A, B and C
- Human influenza A and B viruses cause seasonal epidemics

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





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

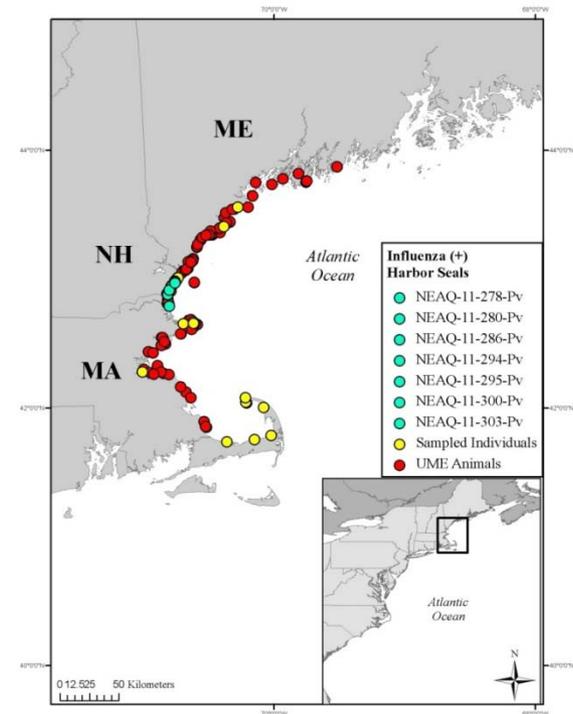


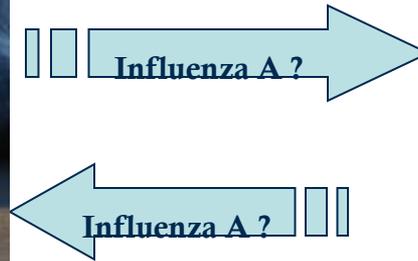
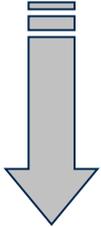
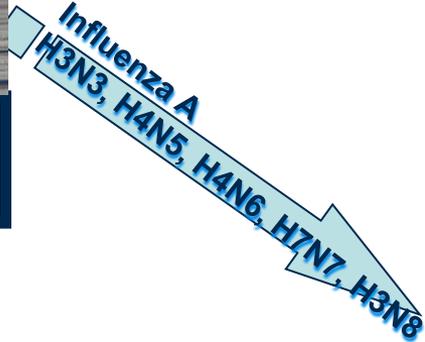
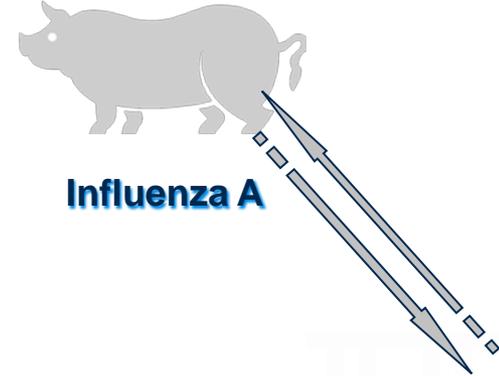
Photo: B. Friel



- Anseriformes
- Charadiiformes

Reservoir Inf 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?



The freshwater-marine interface
is a pollutant deposition zone:

**Pathogens, cyanotoxins, chemicals,
nutrients, oil, garbage**

- 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

One Ocean-One Climate-One Health:

Linking Environmental Health, Public Health, Wildlife Health, And Domestic Animal Health





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- 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