Southern Sea Otter Recovery
An exemplar with climate-related contingencies

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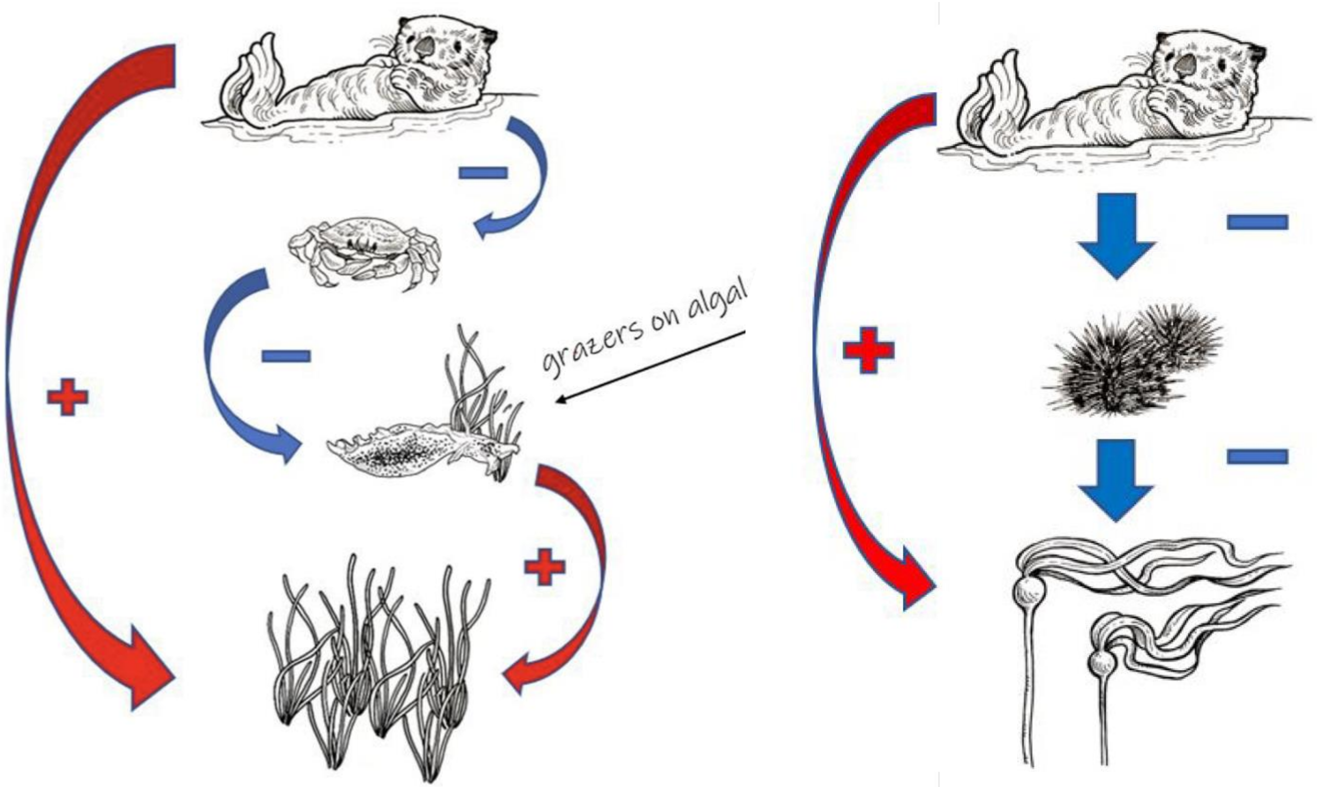
Southern Sea Otters
(Enhydra lutris nereis)

- Keystone species along the central California coast
- Restore and maintain health of kelp forests and seagrass beds
  - Sequester CO_2
  - Combat nutrient pollution
  - Critical habitat for fish, invertebrates, mammals, birds



Crowley Zwartjes

Sea Otters

Indicators of Ecosystem Change

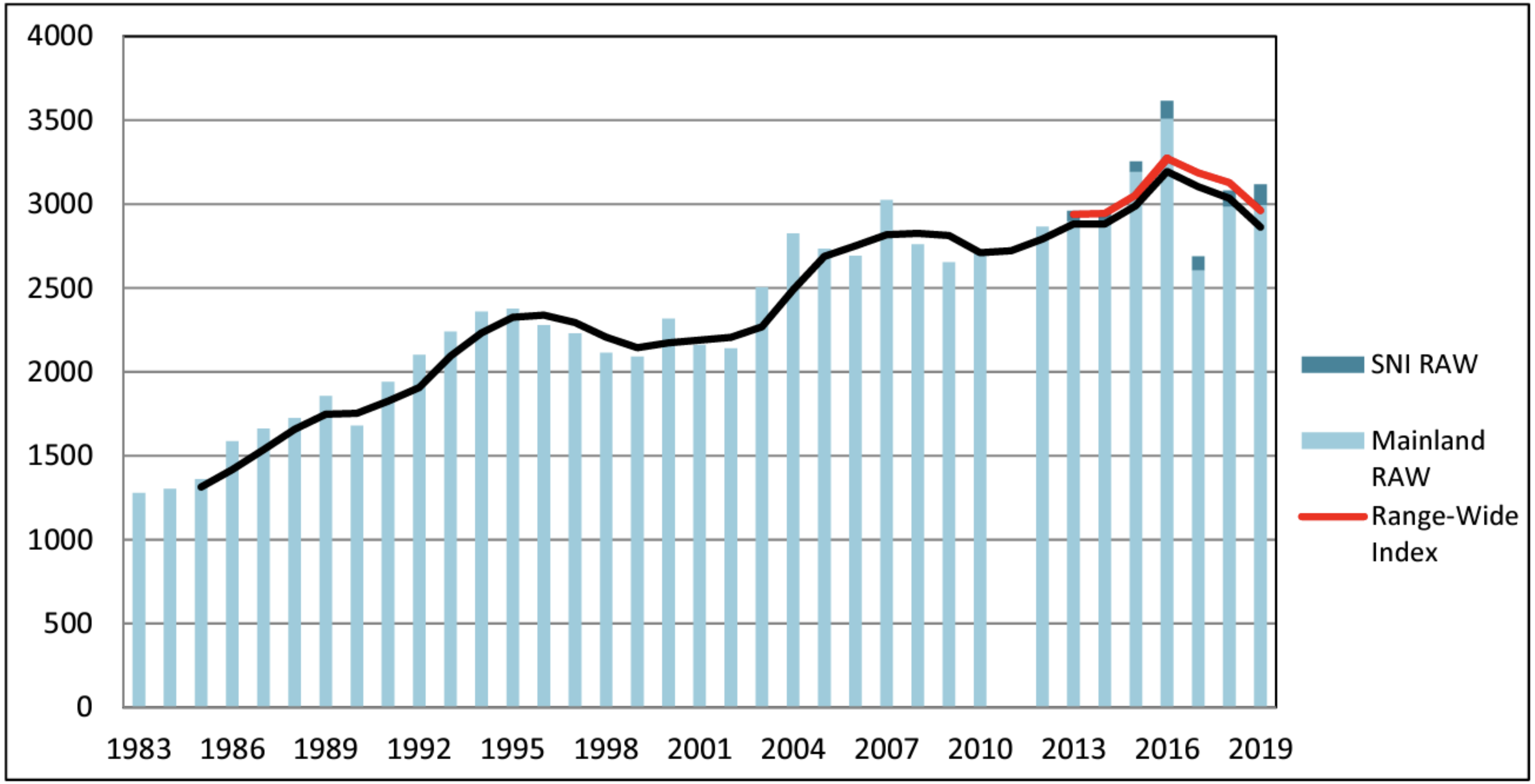
- Highly visible marine mammal
  - Near-shore distribution
  - Bring prey to surface
  - Site fidelity (esp females)
- Amenable to intensive longitudinal studies
  - Daily locations using telemetry (triangulation from shore or boat)
  - 24 hour time budget (foraging behavior, diet, daily movements, range use, reproduction, and survival)
  - Beachcast carcass necropsy program > 20 yrs
- Population health reflects spatially and temporally explicit changes in the near-shore system

Hunted to near extinction

- Maritime Fur Trade
  - 1740-1860s ~ 800,000 sea otters harvested
- Scattered small remnant populations remained in 1900
  - Russia and Aleutian Islands
  - Central California (~50 individuals, Big Sur)
- Expanded after international and federal protections
  - 1911 International Fur Seal Treaty
  - 1972 Marine Mammal Protection Act
  - 1977 Endangered Species Act
- Re-introduced sea otter populations in Washington, British Columbia, and Alaska account for ~35% of population globally

Source: USFWS Sea Otter Reintroduction Feasibility Assessment (2022)

Southern Sea Otter Recovery



Southern sea otter counts 1983–2019. Bars show raw counts for each year for the central California mainland and San Nicolas Island (SNI), whereas lines represent 3-year running averages. The annual census was not completed in 2011 (due to weather) or after 2019 (due to COVID-19 restrictions and plane availability).

USFWS. 2023. Species Status Assessment for the Southern Sea Otter (Enhydra lutris

Where are we now?

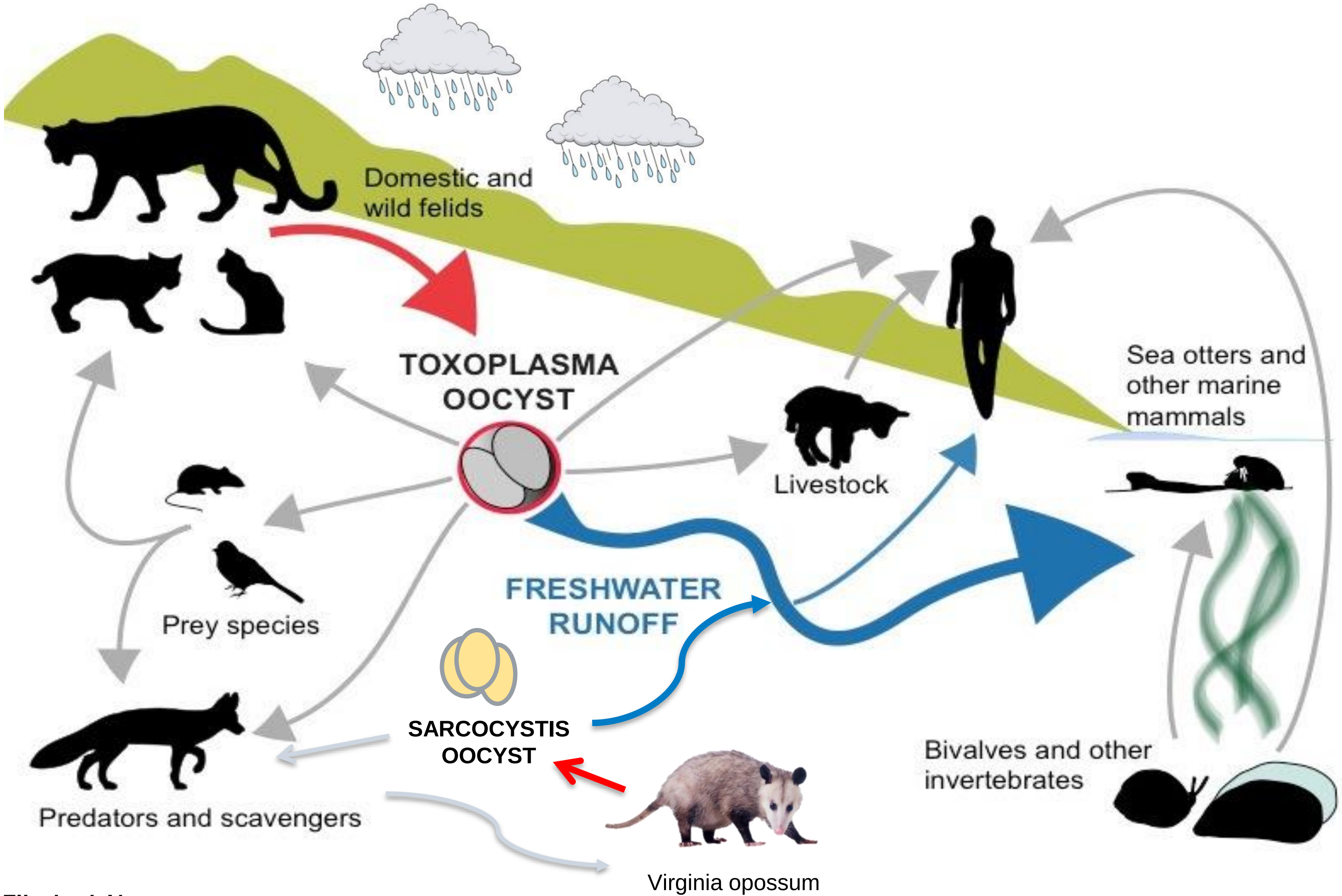
- Southern Sea otters ~3,000 individuals
- At or near carrying capacity in central CA (food limited)
- Limited expansion to north and south over past ~20 years
- 2023 5 year review by FWS retained protected status under ESA because . . .
    - restricted to a small fraction of historic range;
    - large oil spill could affect a large proportion of the population;
    - high levels of shark-bite mortality preventing range expansion;
    - disease/biotoxins, mortality in fishing gear, and recreation-related harassment emerged since listing;
    - limited genetic diversity indicate limited capacity to adapt to novel pathogens or new risks associated with climate change;

USFWS. 2023. Species Status Assessment for the Southern Sea Otter (*Enhydra lutris nereis*)

USFWS

Climate-related Threats on the Horizon

Land-to-Sea Pathogen Pollution



Elizabeth Vanwormer

Sarcocystis neurona
Toxoplasma gondii

Protozoal parasites linked to . . .

.

- Non-native species (cats, opossums)
- Loss of wetlands facilitating unfiltered runoff
- Heavy rainfall/storms
- Fatal disease in susceptible marine mammals

Climate-related Threats on the Horizon
Harmful Algal Blooms

- Domoic acid persists in preferred prey
  - Acute, large doses -> fatal neurological disease
  - Chronic, repeated exposure -> heart disease
- High temperature and nutrient inputs drive certain algae to produce toxins, e.g., domoic acid (DA)
- HABs expected to increase in magnitude, persistence, and frequency with climate change

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Contents lists available at ScienceDirect
Harmful Algae
journal homepage: www.elsevier.com/locate/hal

Original Article

Exposure to domoic acid is an ecological driver of cardiac disease in southern sea otters[☆]

Megan E. Moriarty[a,*], M. Tim Tinker[b,c,†], Melissa A. Miller[a,d,†], Joseph A. Tomoleoni[b], Michelle M. Staedler[e], Jessica A. Fujii[e], Francesca I. Batac[d], Erin M. Dodd[d], Raphael M. Kudela[f], Vanessa Zubkousky-White[g], Christine K. Johnson[a,*]

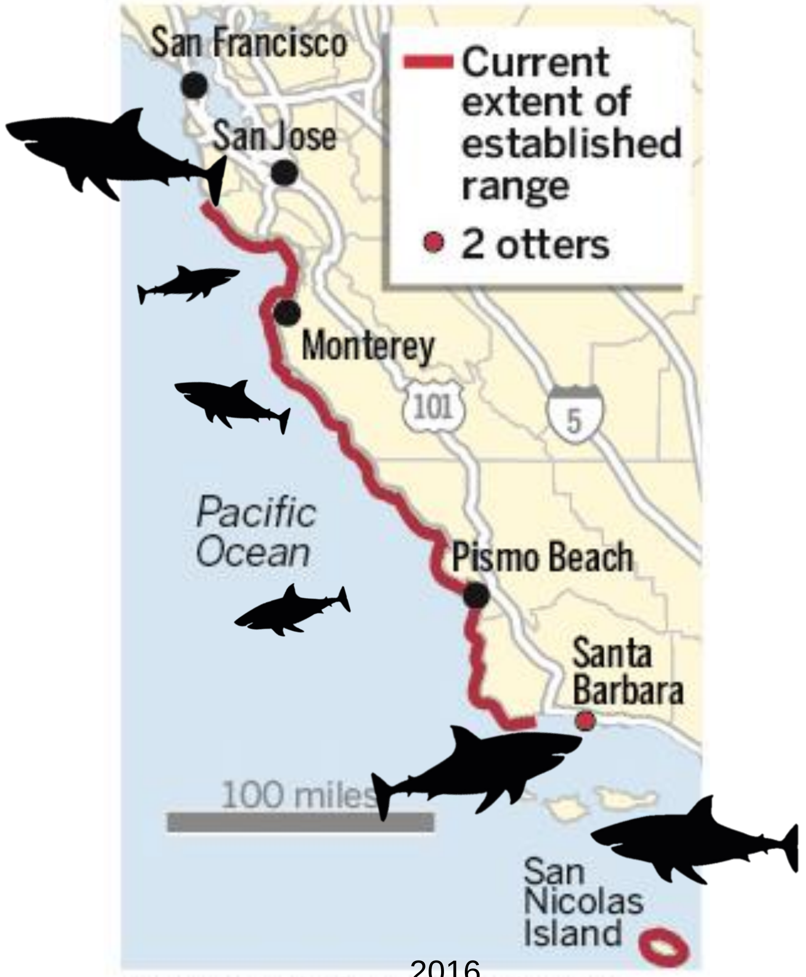
Climate-related Threats on the Horizon
White Shark Attacks

Marine Mammal Science
https://doi.org/10.1111/mms.12261

Dramatic increase in sea otter mortality from white sharks in California

M. Tim Tinker, Brian B. Hatfield, Michael D. Harris, Jack A. Ames

- Shark bite = #1 cause of death in sea otters between 1998-2012
- Limits otter range expansion to north and south
- Bite frequency increasing
  - Utilizing nearshore waters
  - Following prey (pinniped) availability
  - Changing abundance/distribution
- Juvenile white sharks and climate change
  - From 1982-2013, upper range limit was Santa Barbara
  - Frequently seen off Monterey since 2014-2016 marine heat wave
- Future climate conditions likely to increase susceptibility to white shark bites through losses in kelp canopy cover and increases in thermal conditions favorable to subadult white sharks in coastal proximity



2016
Source: U.S. Geological Survey

Sources: Miller et al 2020; USFWS. 2023. Species Status Assessment for the Southern Sea Otter (*Enhydra lutris nereis*)

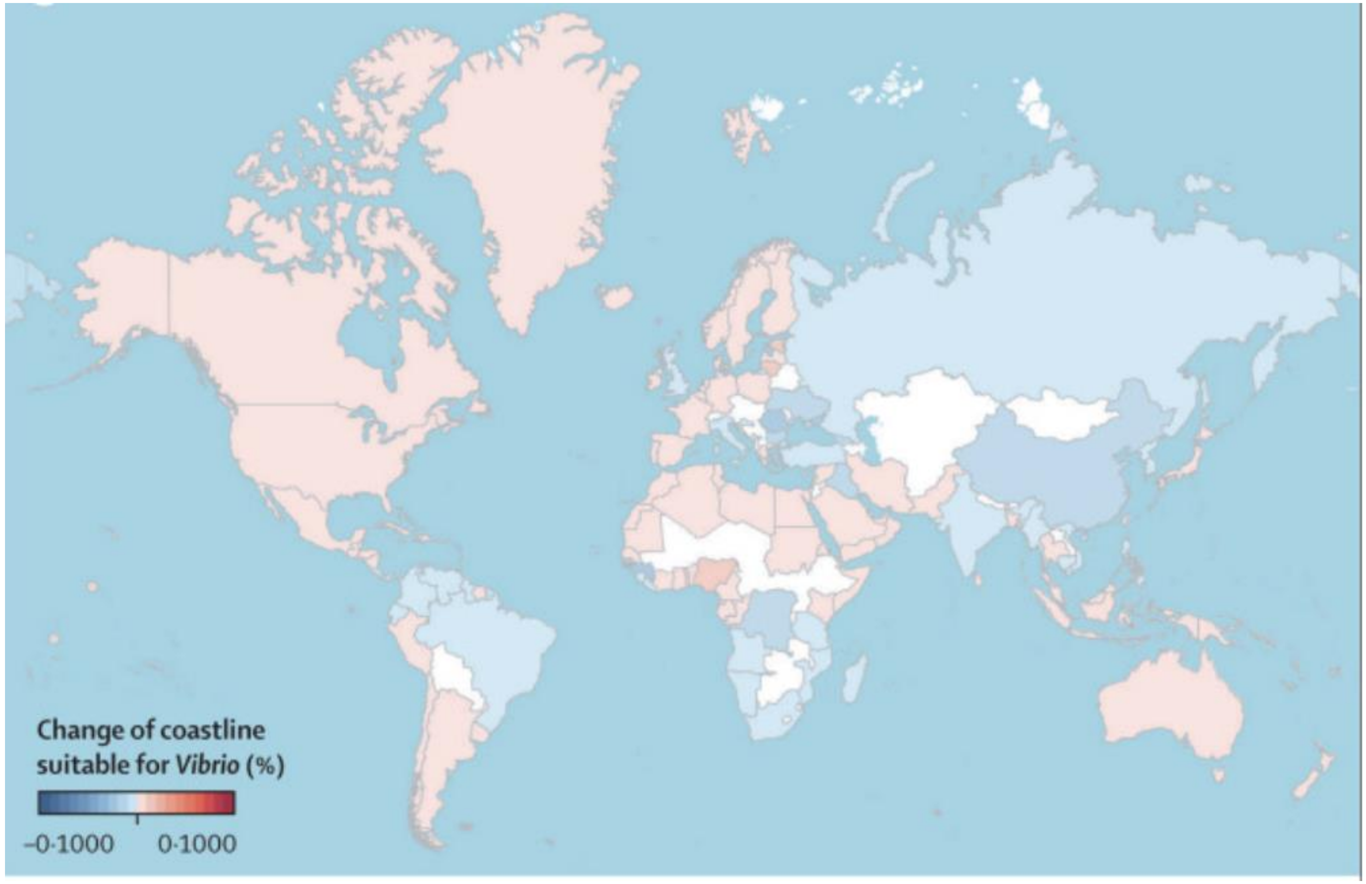
Climate-related Threats on the Horizon
Vibrio bacteria

- Warming trends in sea surface temperature strongly associated with spread of Vibrios
- *Vibrio cholera, V. vulnificus, V. parahemolyticus, V. diabolicus*
- Important cause of disease in humans, opportunistic infections marine species

Future scenarios of risk of *Vibrio* infections in a warming planet: a global mapping study

Joaquin Trinanes, Jaime Martinez-Urtaza

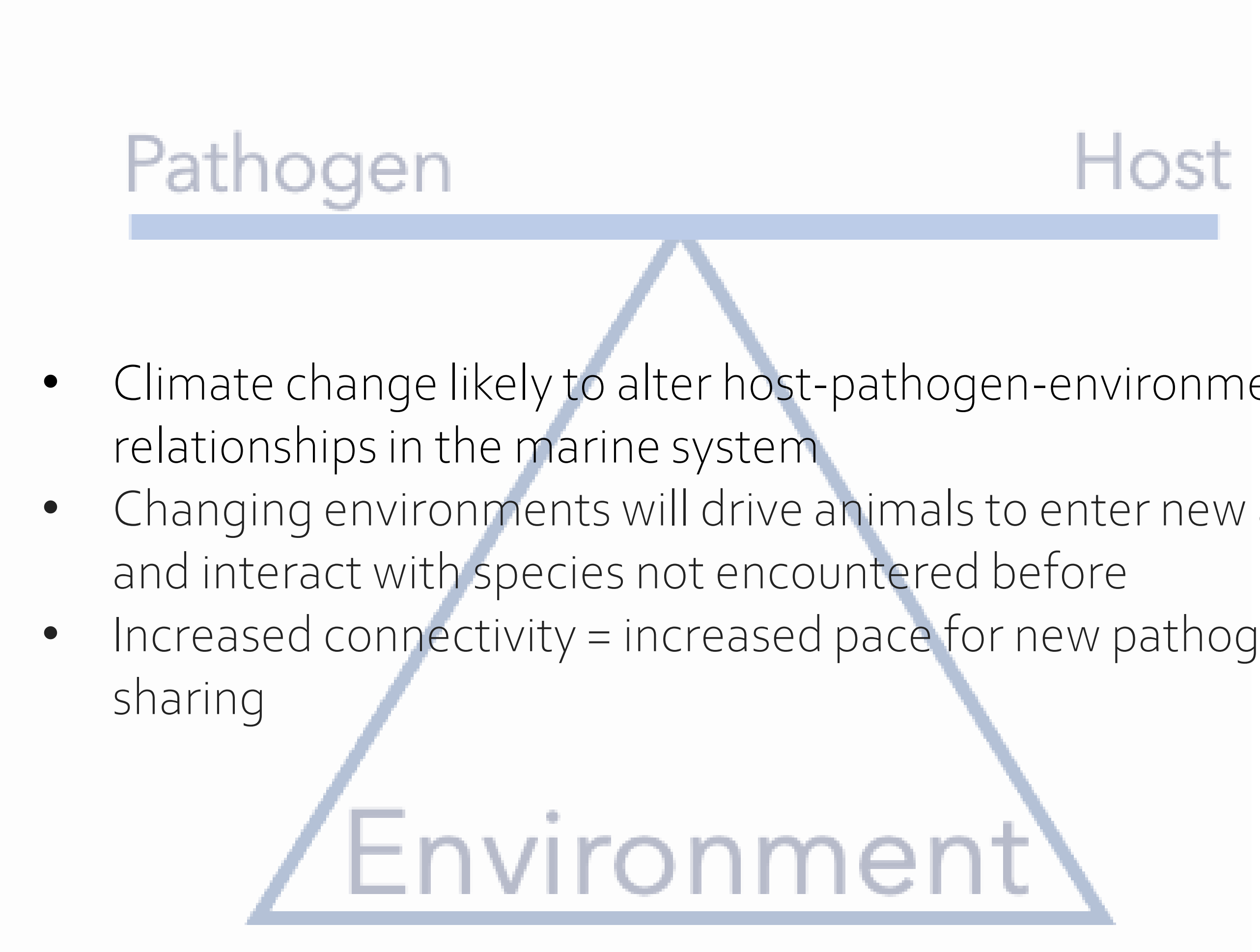
www.thelancet.com/planetary-health **Vol 5 July 2021**



Maps showing the percentage increment by year and country of coastline affected by conditions suitable for Vibrio 1850–2014

Climate Change

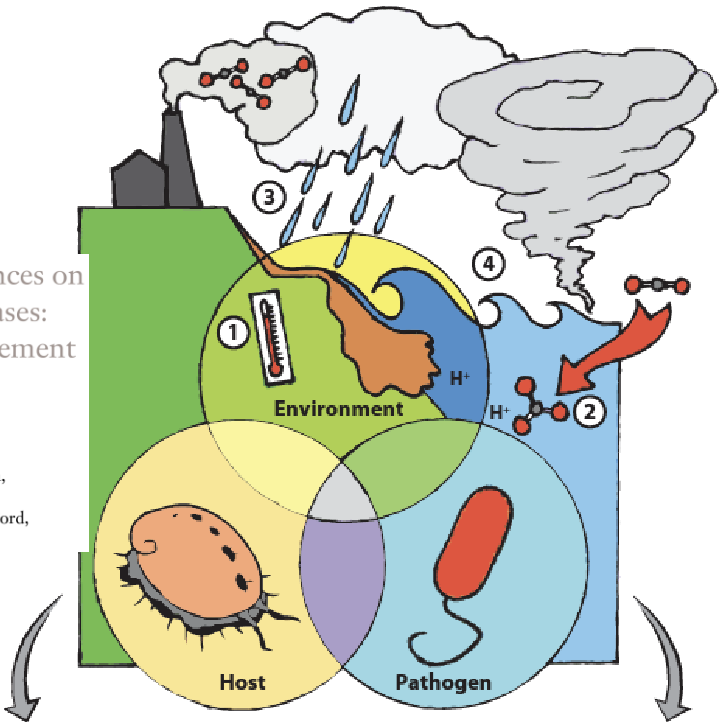
Shifting the Host-Pathogen-Environment Equilibrium



- Climate change likely to alter host-pathogen-environment relationships in the marine system
- Changing environments will drive animals to enter new areas and interact with species not encountered before
- Increased connectivity = increased pace for new pathogen sharing

Climate Change Influences on Marine Infectious Diseases: Implications for Management and Society

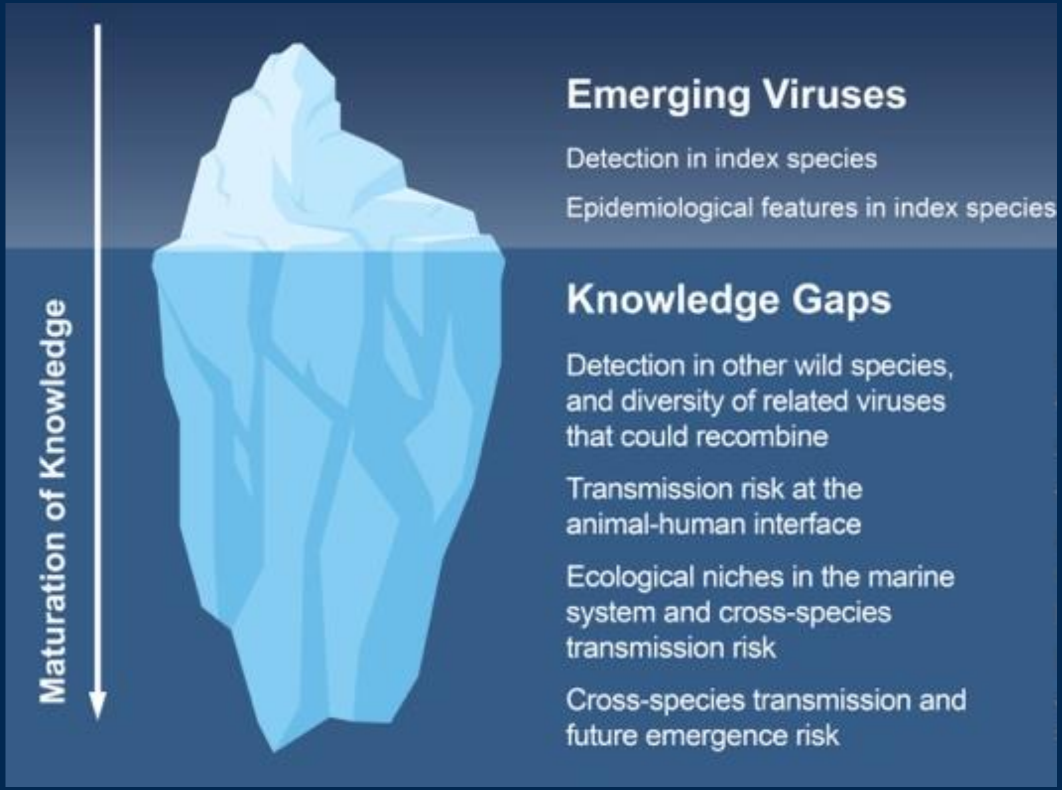
Colleen A. Burge,[1] C. Mark Eakin, Carolyn S. Friedman, Brett Froelich, Paul K. Hershberger, Eileen E. Hofmann, Laura E. Petes, Katherine C. Prager, Ernesto Weil, Bette L. Willis, Susan E. Ford, and C. Drew Harvell[1]

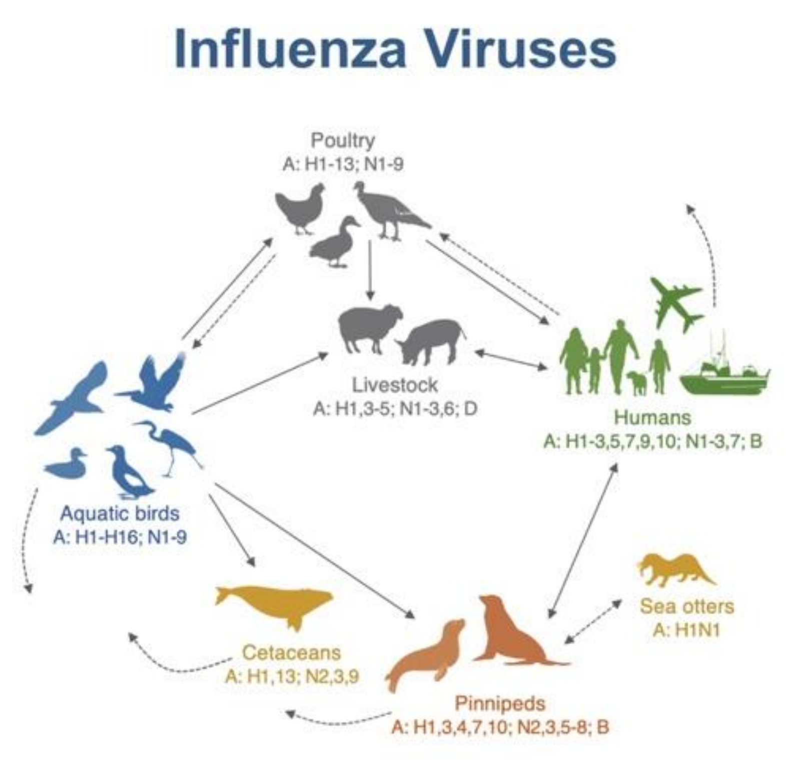


Changes in host	Climate factor	Changes in pathogen
• Increased susceptibility • Change in behavior • Invasions • Range shifts	1	• Increased activity • Change in virulence • New emergence • Invasions • Range shifts
• Increased susceptibility (?) • Change in larval survival/recruitment • Change in behavior • Reductions in diversity (?)	2 (2– H+ H+)	• Change in virulence • Change in abundance
• Increased susceptibility • Nutrient stress • Salinity stress • Contaminant stress	3	• New emergence • Change in virulence • Invasions • Range shifts • Increased nutrients
• Increased susceptibility • Physical injury	4	• New emergence • Invasions • Range shifts • Mixing/resuspension of particles

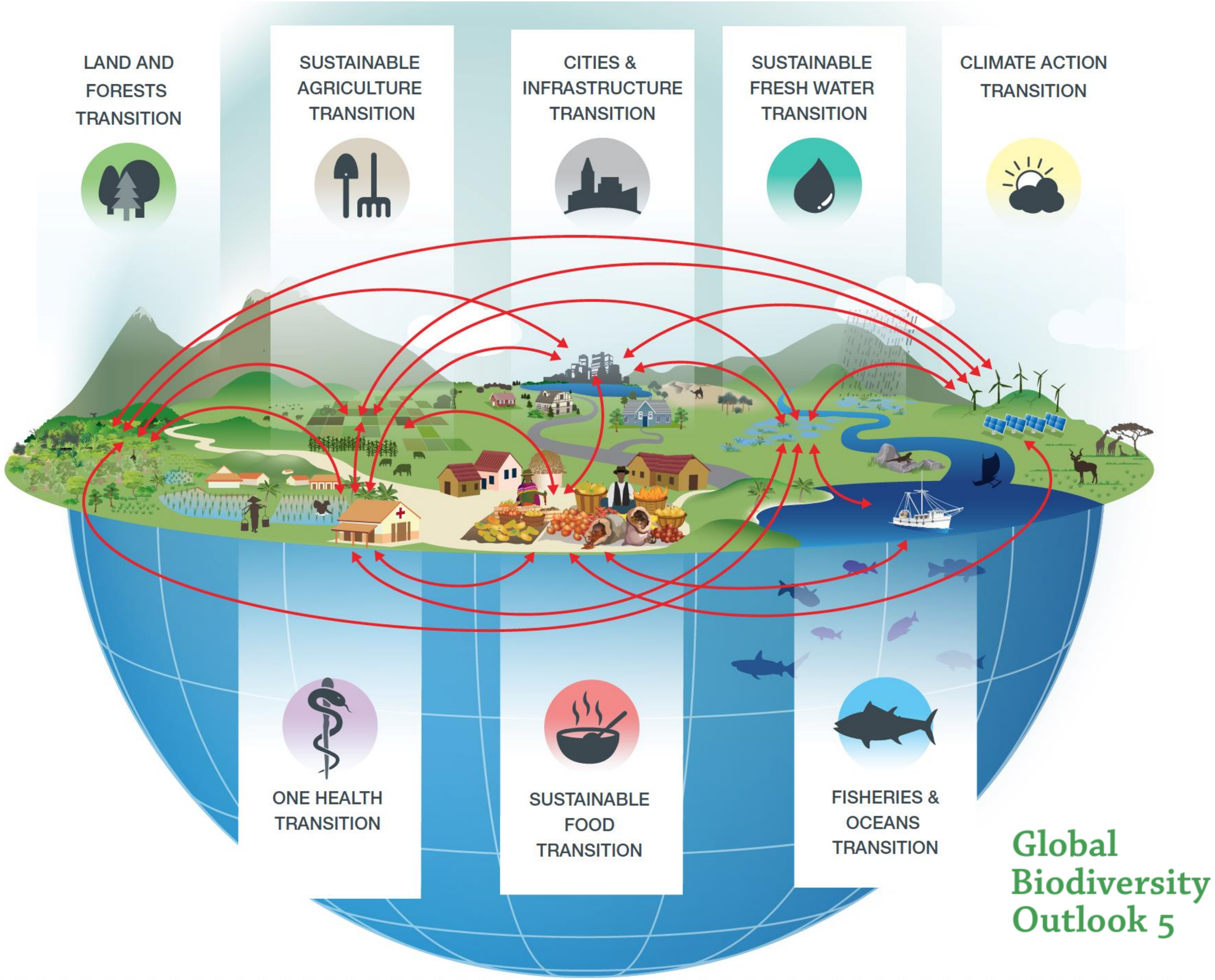
Annu. Rev. Mar. Sci. 2014. 6:249–77

Emerging Pathogens
Major Concerns for Species of Conservation Risk





Paradigm Shifts, Global Transitions



Thank you

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