Keynote Presentation

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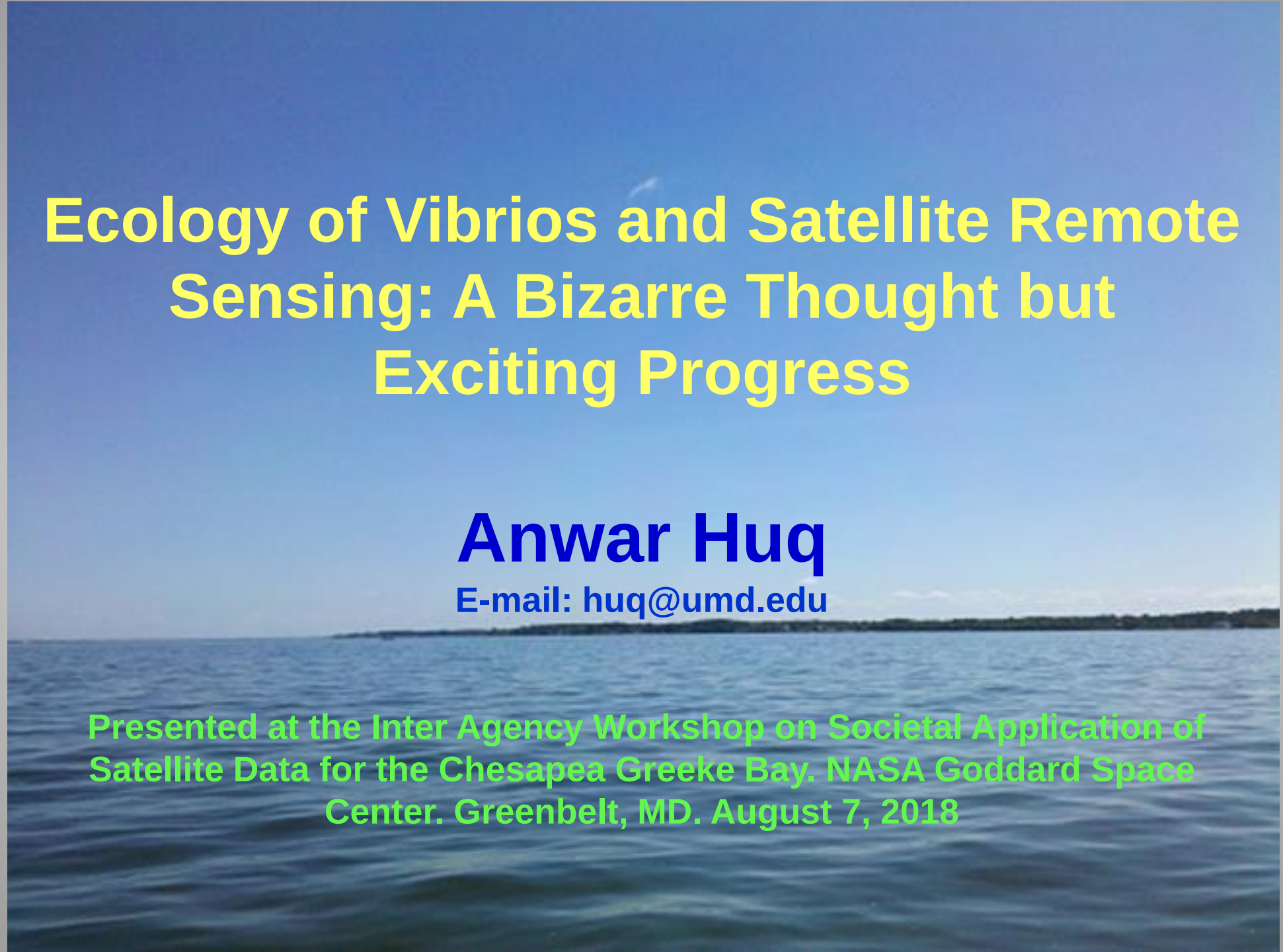

Ecology of Vibrios and Satellite Remote Sensing: A Bizarre Thought but Exciting Progress

Anwar Huq

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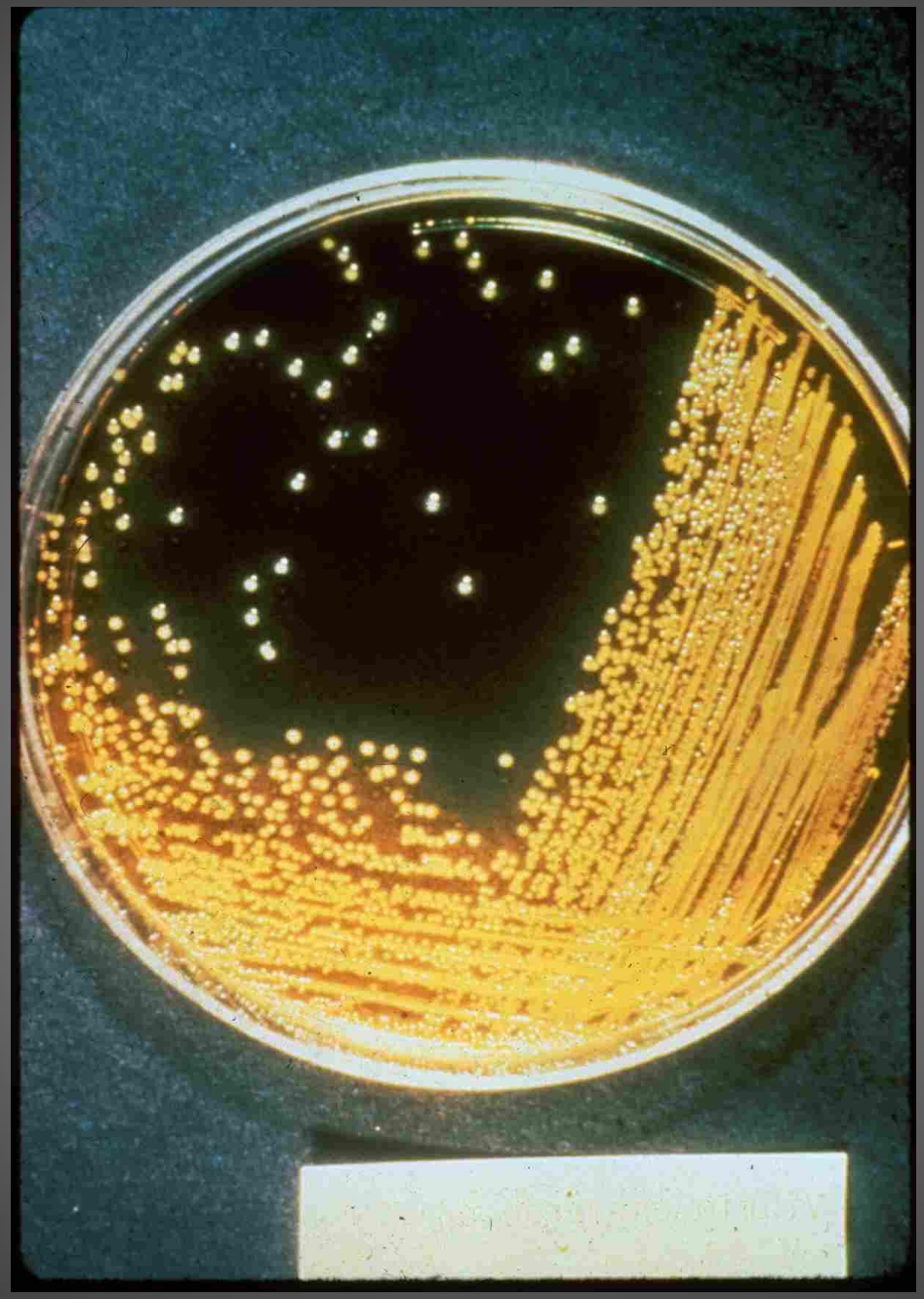
Presented at the Inter Agency Workshop on Societal Application of Satellite Data for the Chesapea Greeke Bay. NASA Goddard Space Center. Greenbelt, MD. August 7, 2018



***Scanning Electron Micrograph of V. cholerae* O1**

The Chesapeake Bay, Vibrios and Vibrio cholerae: An interesting story

Source:NASA/Goddard Space Flight Center
Scientific Visualization Studio

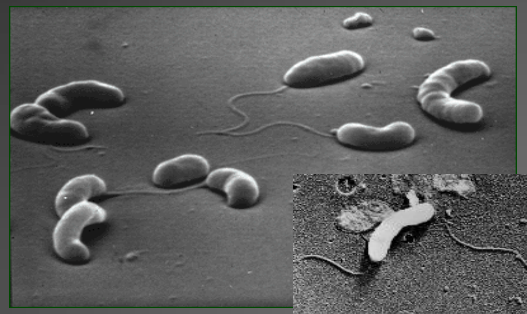
Environment and vibrios

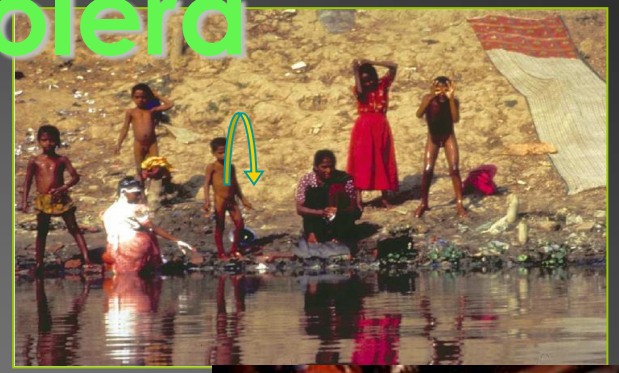
- Early 60's work on numerical taxonomy of *Vibrio* by Colwell and her group *(Colwell and Morita (1964) J. Bact. 88:831-837)*
- 1969 - Colwell et al isolated *V. parahaemolyticus* from blue crab in the Chesapeake Bay
- 1977 - First report of *V. cholerae* in the Chesapeake Bay. (Colwell et al,1977. Science. 198:394 396)
- 1981- Report on the presence *V. cholerae* O1 in the Bay
- Subsequently, studies continued at UMD on survival and multiplication of *V. cholerae* with plankton

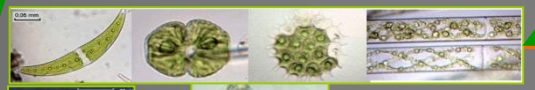
Environment and vibrios…….

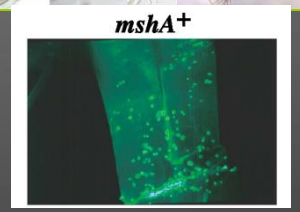
- **In 1983 we reported a unique and specific association *V. cholerae* O1 and copepods**
- **~25^{o}C water temperature, ideal for survival and multiplication *V. cholerae* with copepods**
- **Copepods feed on phytoplankton. So, an increase of phytoplankton results an increase in copepods.**

Ecology of Vibrios & Cholera



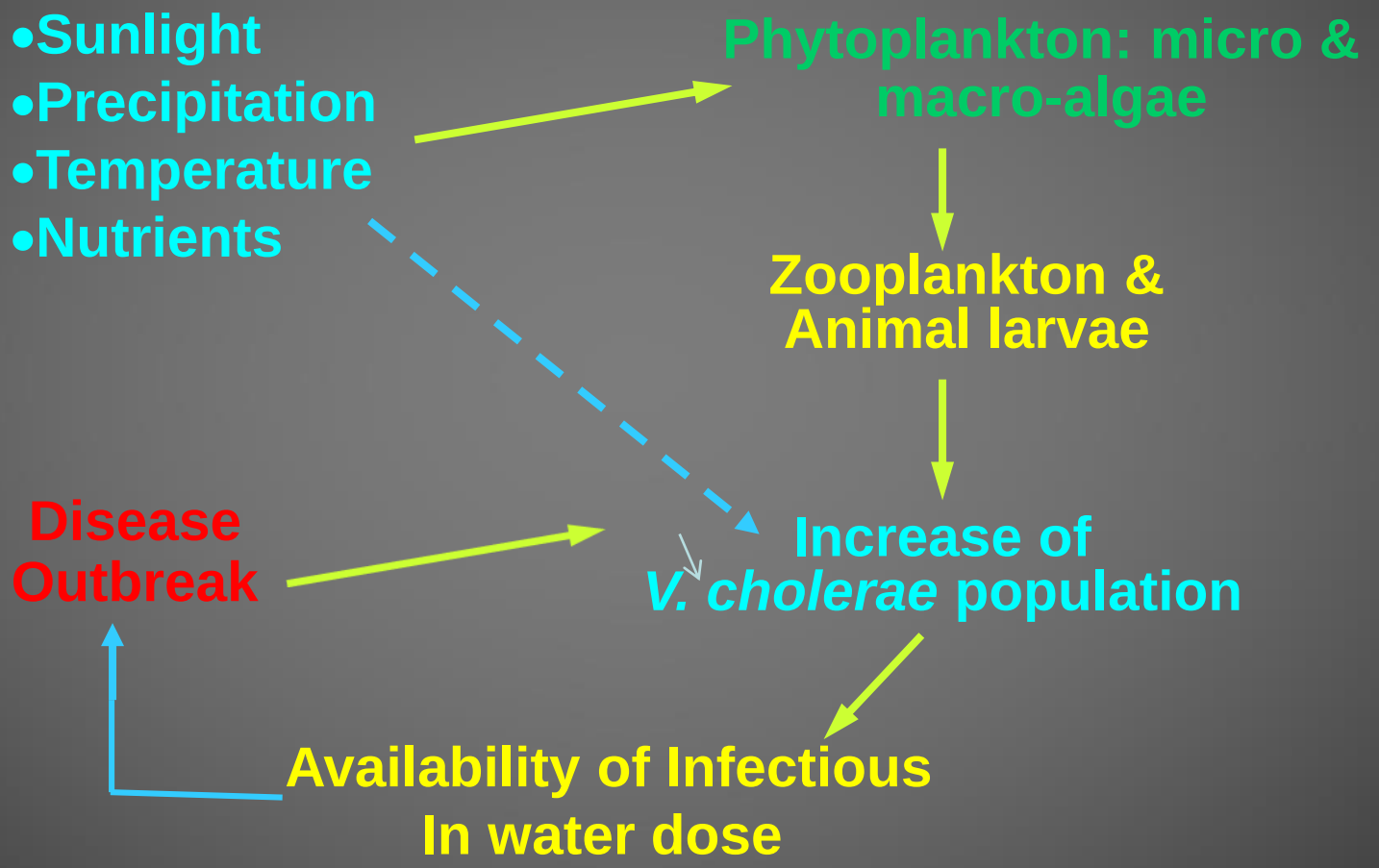






G. Constantin de Magny

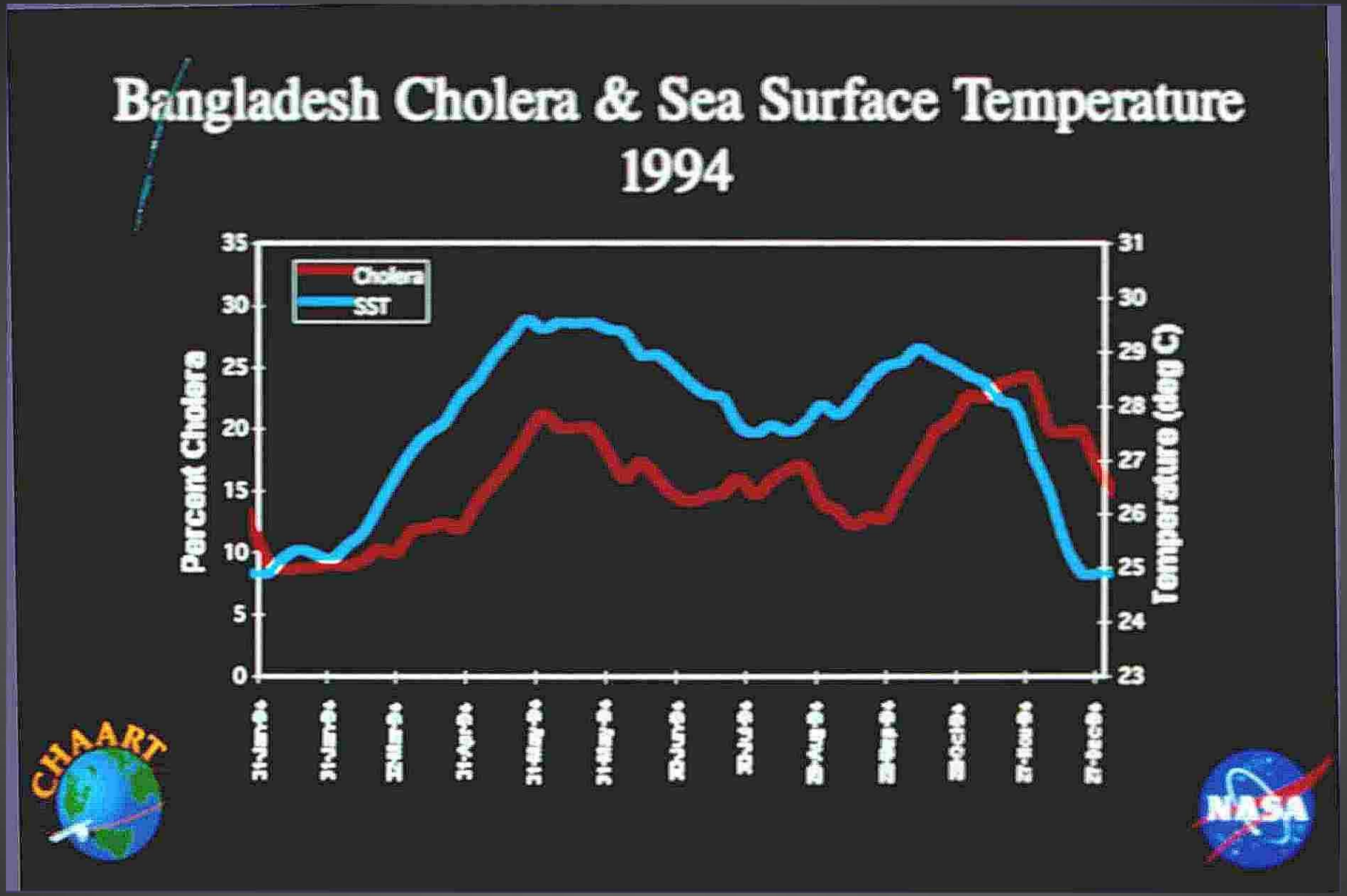
A Model for Cholera Epidemic



Huq et al, 1988. In Biological Monitoring of Environment Pollution. Yasuno and Whitton (Ed). Tokai University Press, Tokyo, Japan.

Remote sensing and *Vibrio* work begins

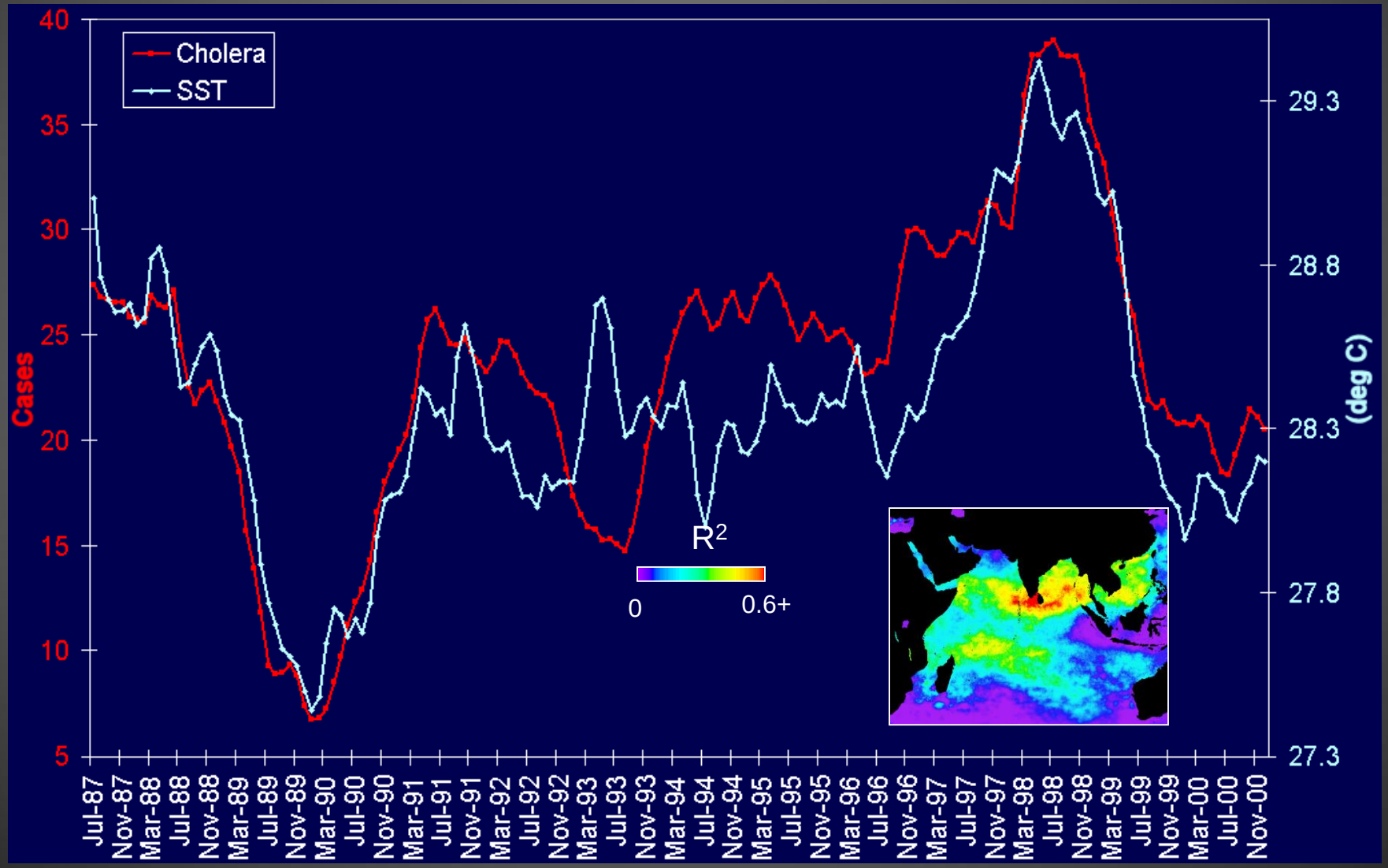
- ~1992: Personal communication with Byron Wood and his team at NASA Ames Res Center
- Remote sensing temperature data of Bay of Bengal was analyzed with the number of cases of cholera in Matlab, Bangladesh



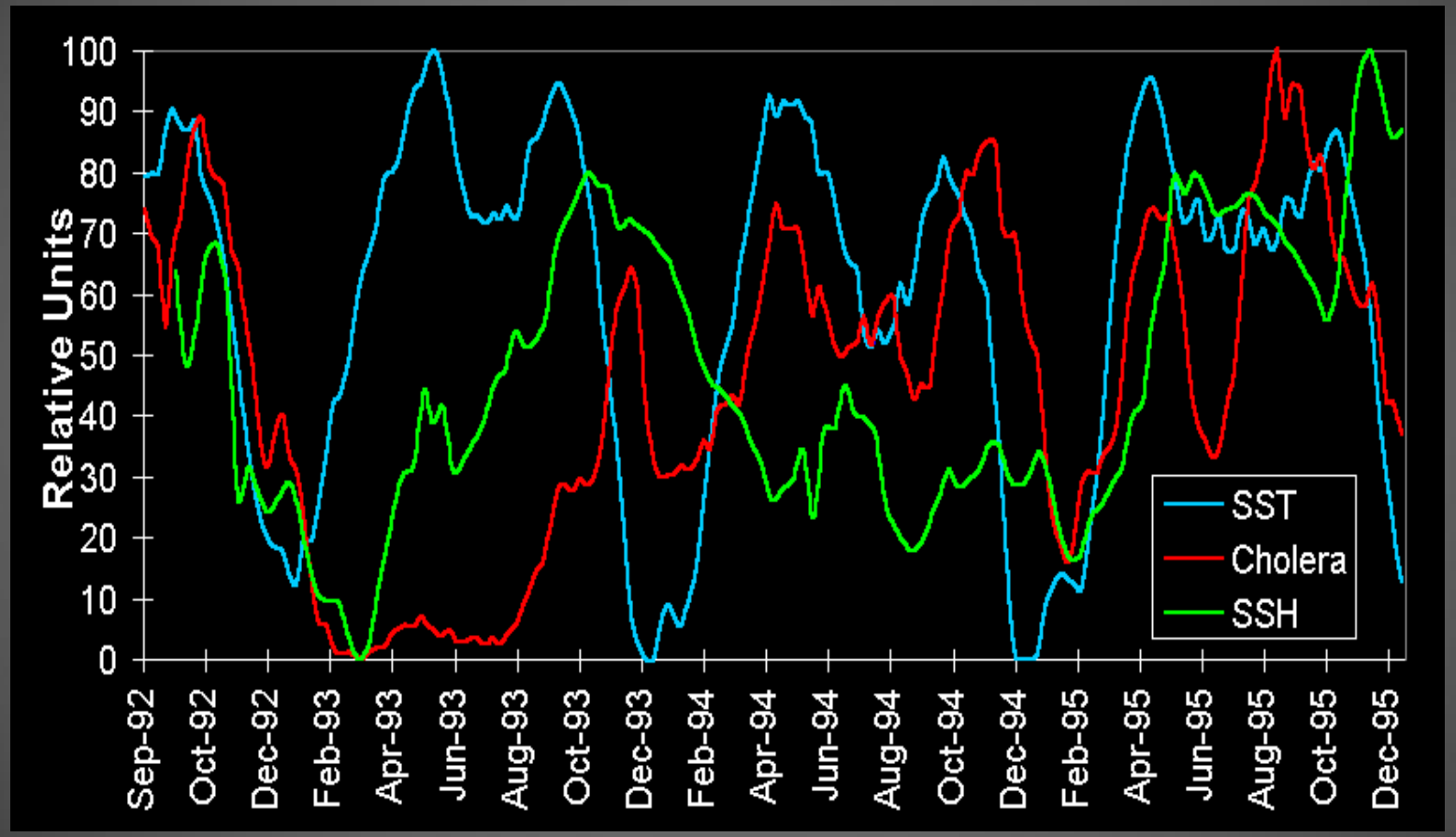
Colwell, (1996) Science, 274:5295.2025

Cholera and SST in the Indian Ocean (1987-2000)

Six-month SST lead: $R^2 = 0.72$



Bangladesh Sea Surface Temperature (SST), Sea Surface Height (SSH), and Cholera: 1992-1995



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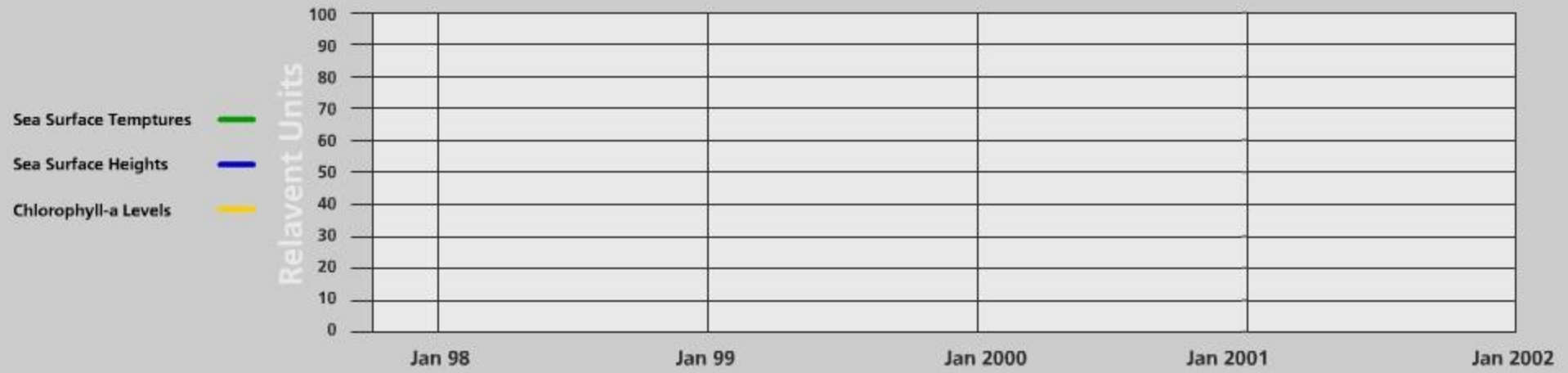
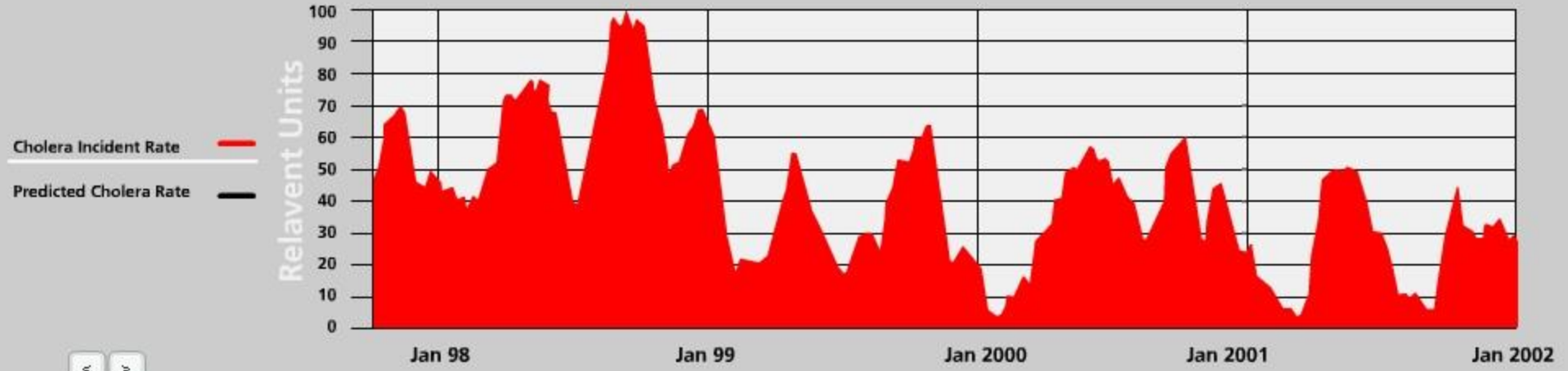
Predicting Cholera Rate

Cholera Incident Rate...





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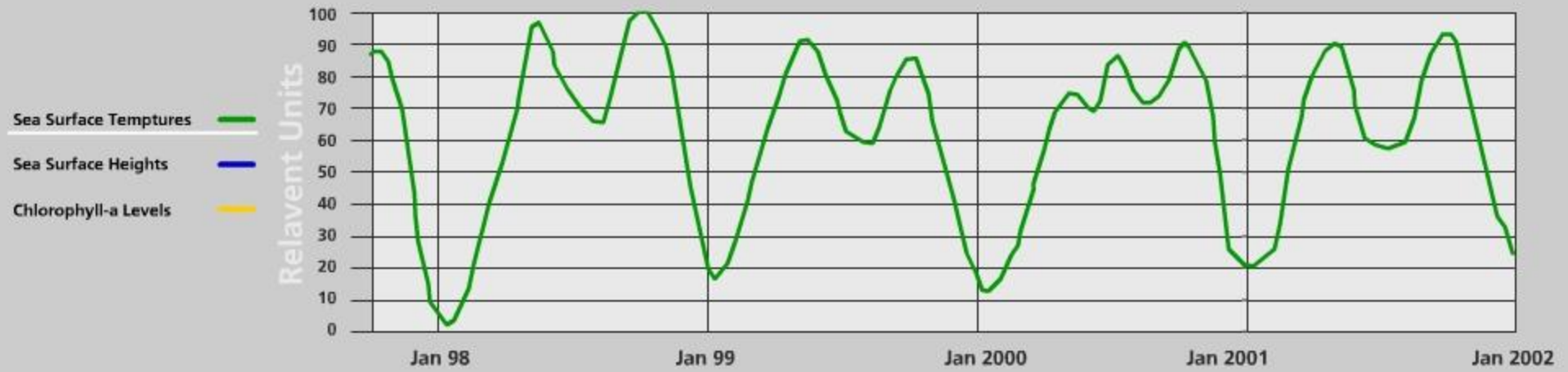
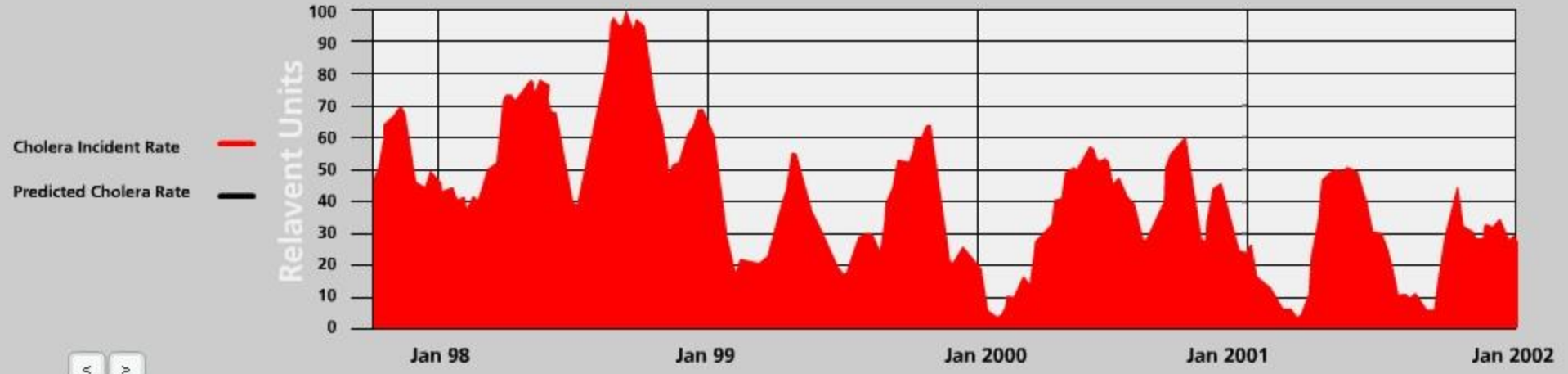
Predicting Cholera Rate

Sea Surface Temperatures...





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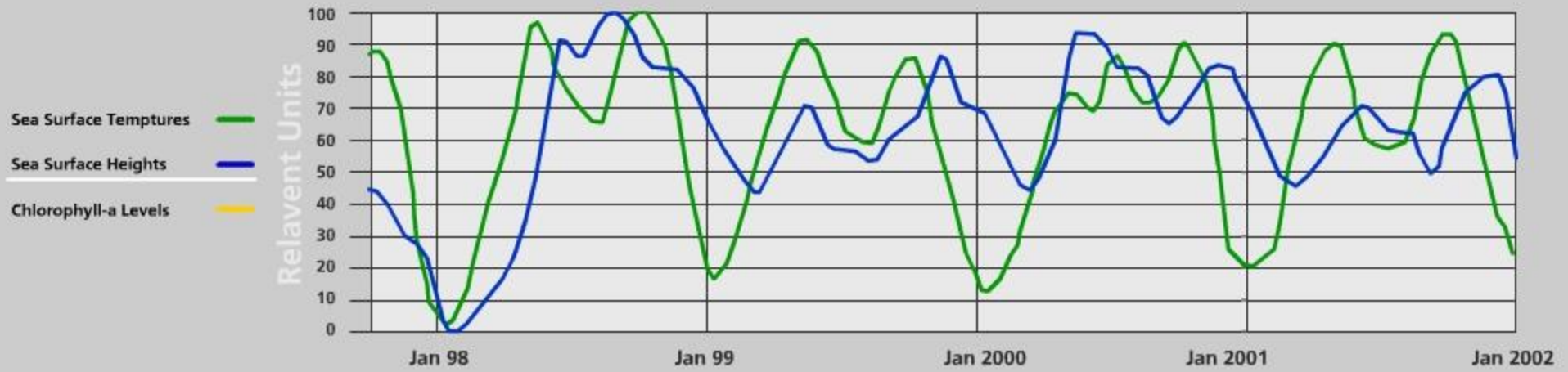
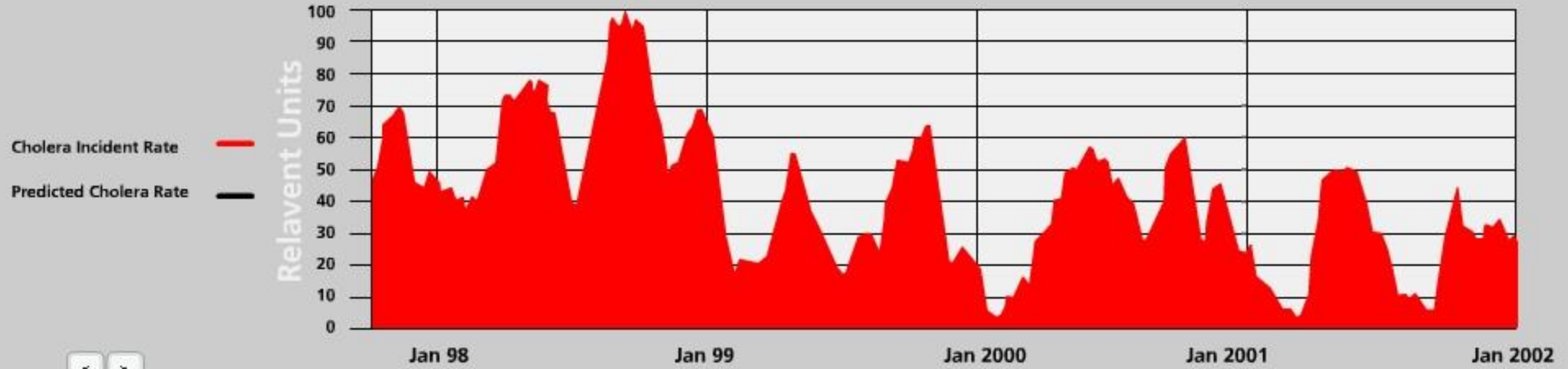
Predicting Cholera Rate

Sea Surface Heights...





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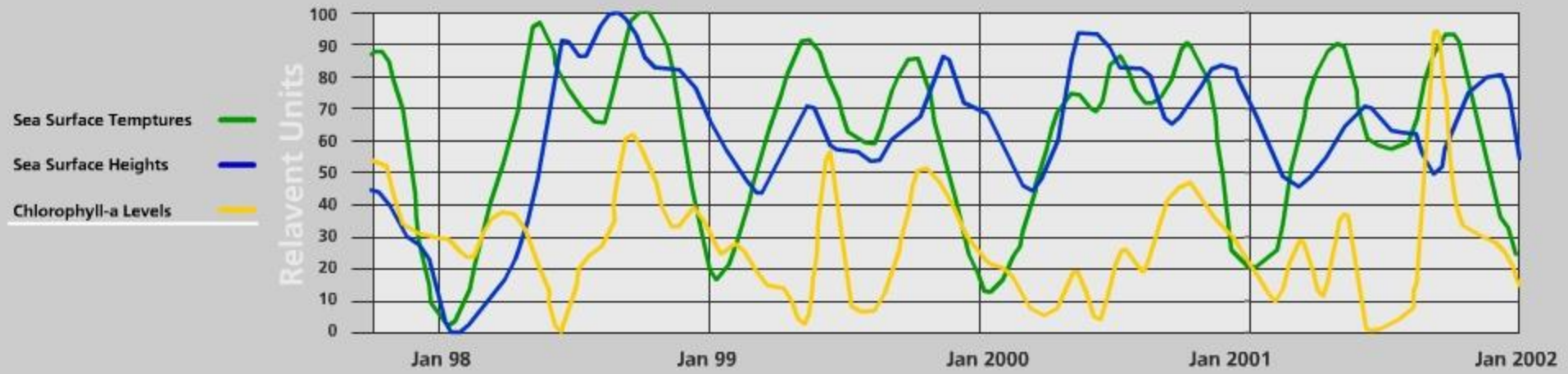
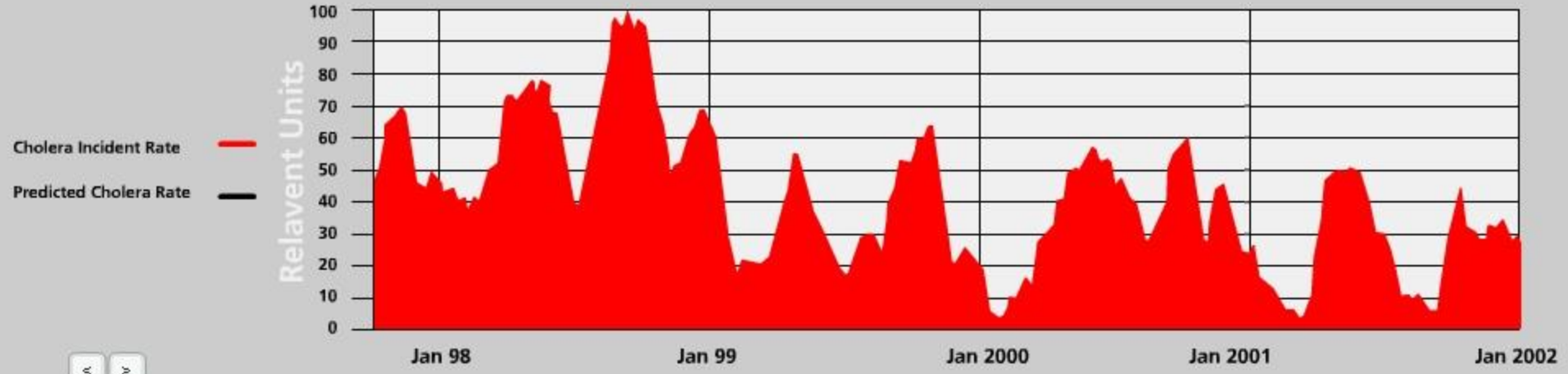
Predicting Cholera Rate

Cholorophyll-a Levels...





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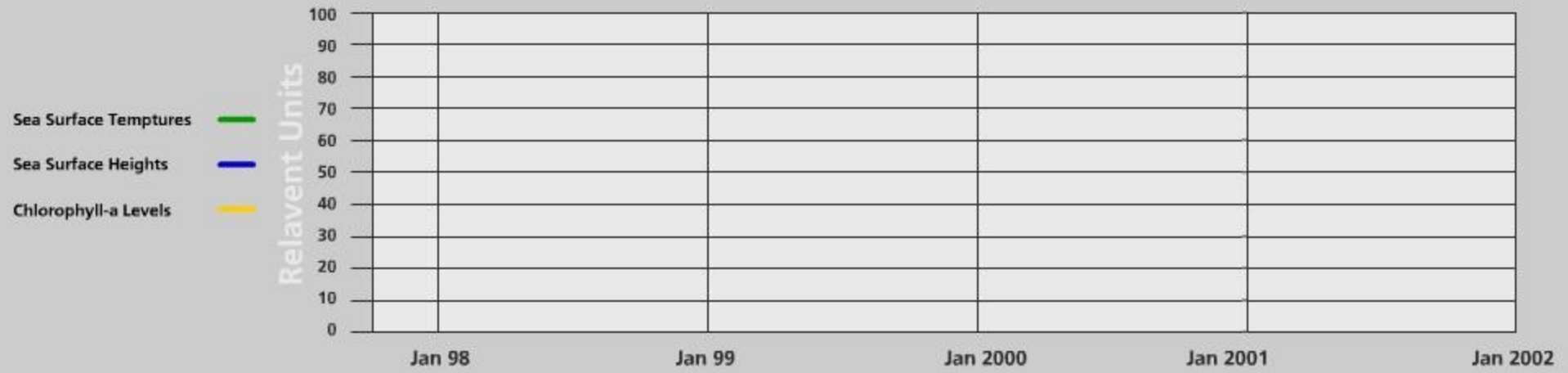
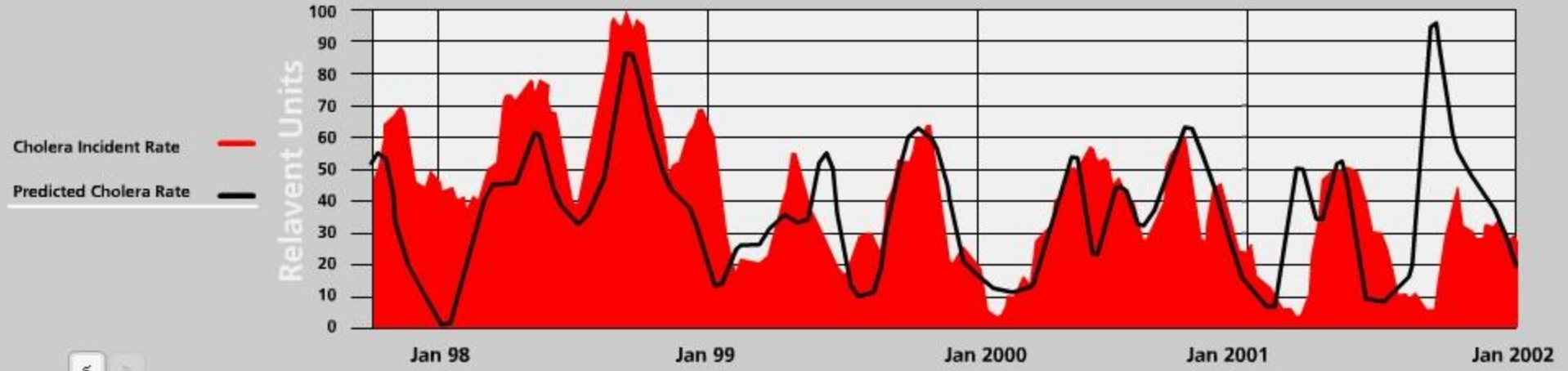
Predicting Cholera Rate

Predicted Cholera Rate.





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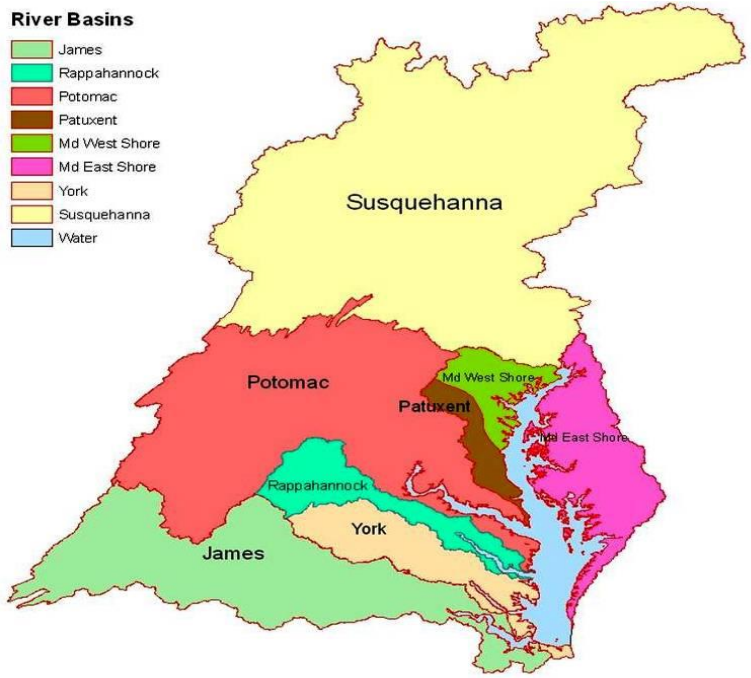
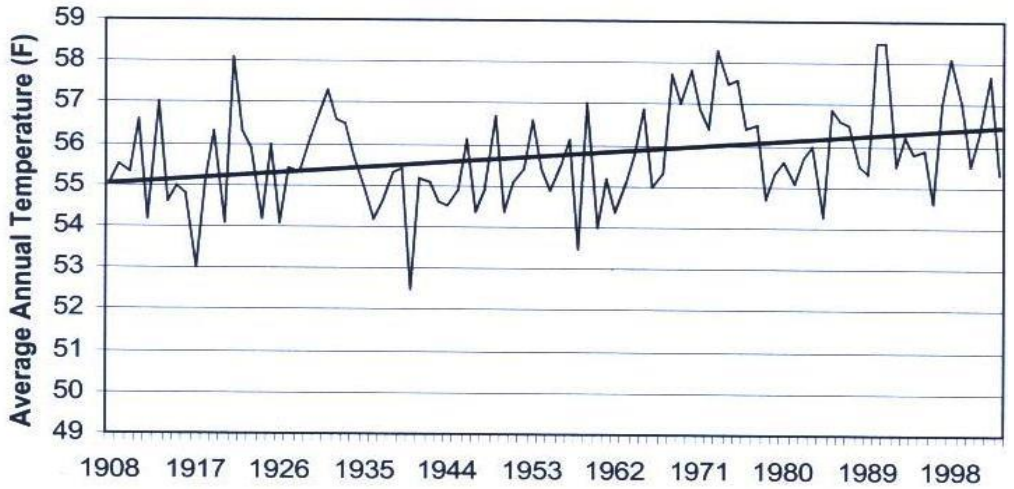


Figure of Chesapeake Bay watershed including delineated river basins that will be modeled using ArcSWAT.

Figure 2. Annual Mean Temperatures in Maryland[20]



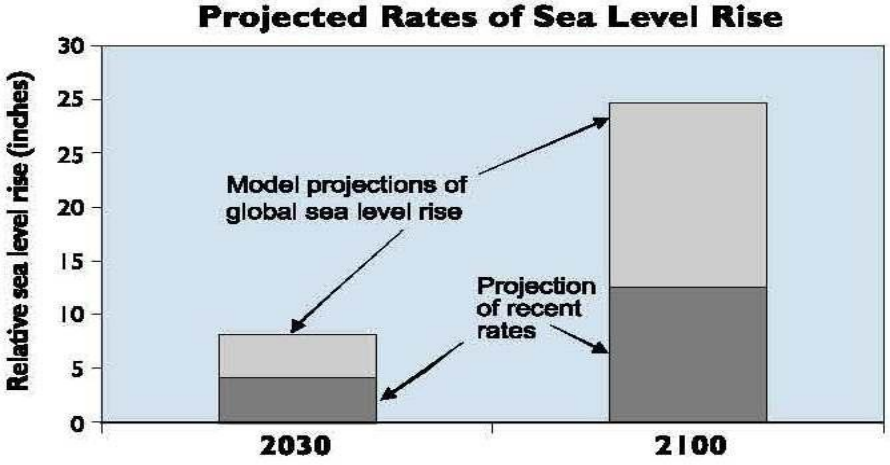


Figure 4-6. Projected sea level rise, given rates observed in the recent past (dark bars) and expected increases due to global warming (light bars). Together, these stacked bars show the projected mean for future sea level rise in the Chesapeake region.

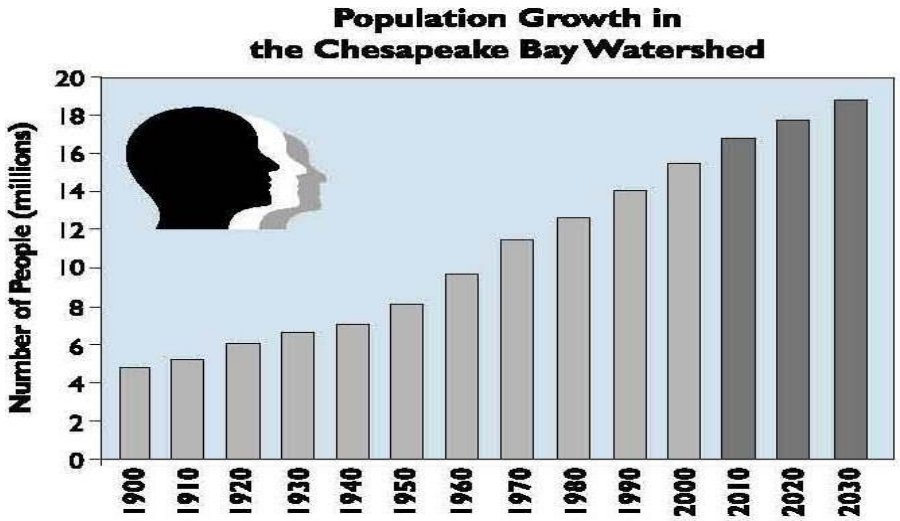


Figure 2-1. Since the beginning of the last century, population levels have shown a steady increase in the Bay watershed. Experts predict that numbers will continue to rise through the next three decades.

Courtesy R. Murtugudde ESSIC

Sea level increase due to temperature increase

"Sea levels may rise three times faster than the official predictions of the IPCC and the global average sea level may increase by as much as 1.9 meters (6ft 3in) by 2100". *(Vermeera and Rahmstorf, PNAS, 2009, 106(51): 21527-21532)*

Vibrios and Chesapeake Bay

- ***Vibrio cholerae***
- ***Vibrio vulnificus and***
- ***Vibrio parahaemolyticus***

Vibrio parahaemolyticus

- ***V. parahaemolyticus*** **gastroenteritis worldwide and constantly in rise since 2000 (*Martinez-Urtaza et al, 2004, Caburlotto et al., 2010, Ceccarelli et al, 2013*)**

- **It is the leading cause of seafood-induced enteritis from consumption of raw or undercooked seafood (*DePaola et al., 2003*)**

- **According to the Centers for Disease Control, in the US, there are estimated 4,500 cases per year (*Johnson et al., 2010*)**

Vibrio vulnificus

- **Mortality rate of *V. vulnificus* septicemia can exceed 50% and death may occur within 48 hours and mortality from wound infection can be 25% (*Jones et al, 2010*).**

- **Readily isolated from water, sediment and shellfish when environmental conditions are favorable (*Johnson et al, 2012*)**

- **2013- Florida Department of Health reported 36 cases and 10 deaths due to *V. vulnificus* infection (*Skrzypek, 2013*).**
  2015- 13 cases along the east cost with 7 deaths

- **>200 cases of *V. vulnificus* infection per year in the US (https://www.cdc.gov/disasters/vibriovulnificus.html)**

Vibrio cholerae

- **Estimated ~3 million cases & 95,00 deaths/year with more than a billion people are at risk of cholera in endemic countries (*Ali et al, PloS, Negl Trop Dis, 2015*)**

- **More than 87,00 cases in non-endemic countries with 2,500 deaths.**

- **Most of the endemic countries are in Asia, Africa and south America**

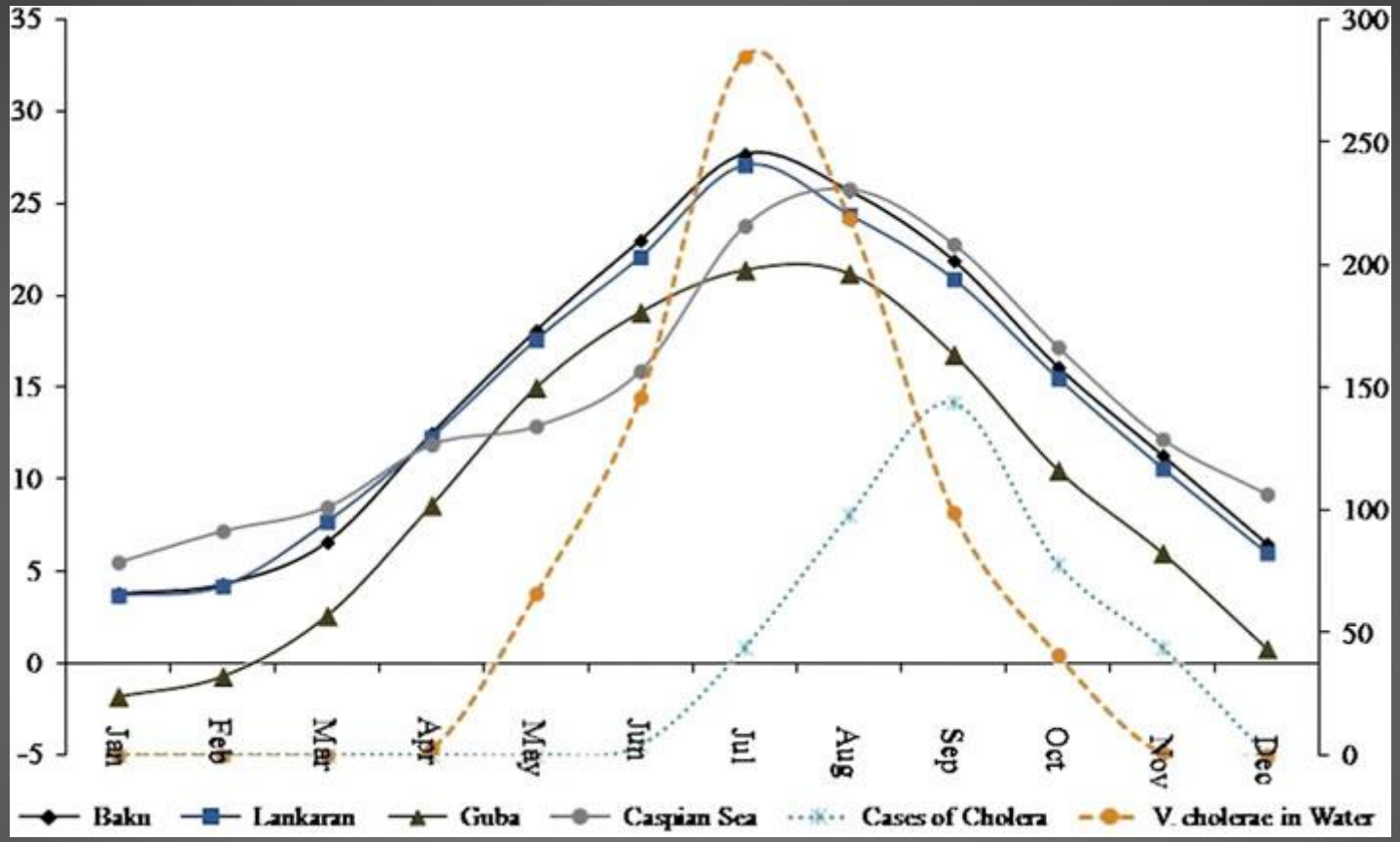
- **Most the reported cases in the developed counties are imported, but some are indigenous including the USA**

Influence of environmental factors

- Sea surface temperature (SST), sea surface height (SSH), and chlorophyll have been shown to be predictors of zooplankton and thus factors linked to *Vibrio* populations.

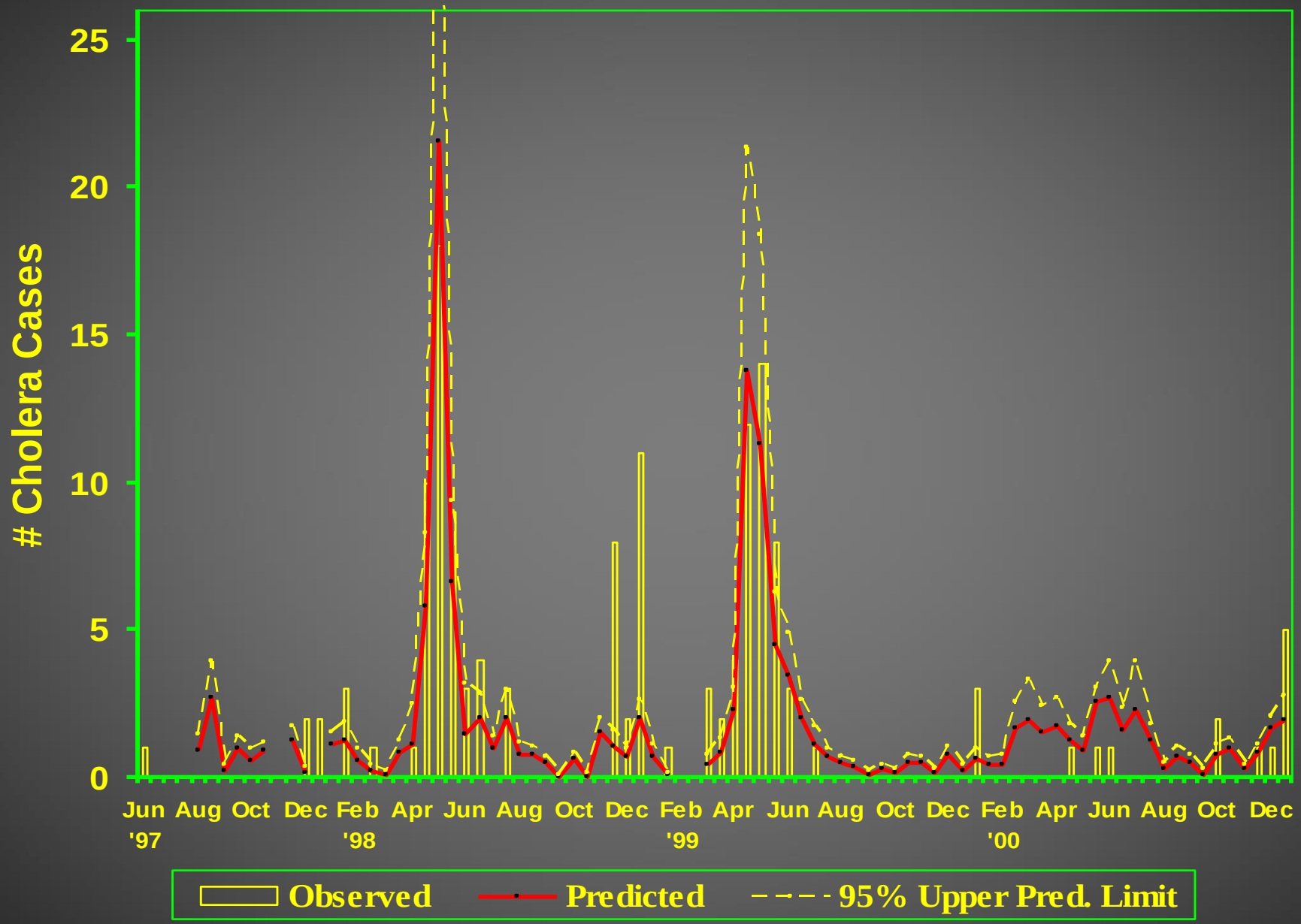
- Salinity, conductivity, turbidity, and dissolved organic carbon influence the incidence and distribution of *Vibrio* spp.

- SST and suspended particulate matter were found to be strong
- predictors of total and potentially pathogenic *V. parahaemolyticus* and *V. vulnificus*.



Monthly air surface temperature at the Caspian sampling sites and water temperatures at Baku Lankaran, and Guba (X-axix), and number of cases of cholera/number of *V. cholerae* positive water samples (Y-axis), 1970–1998).

Shair et al, J EcoHealth, 2012


Cholera Cases
25
20
15
10
5
0
Jun '97
Aug
Oct
Dec
Feb '98
Apr
Jun
Aug
Oct
Dec
Feb '99
Apr
Jun
Aug
Oct
Dec
Feb '00
Apr
Jun
Aug
Oct
Dec
Observed
Predicted
95% Upper Pred. Limit

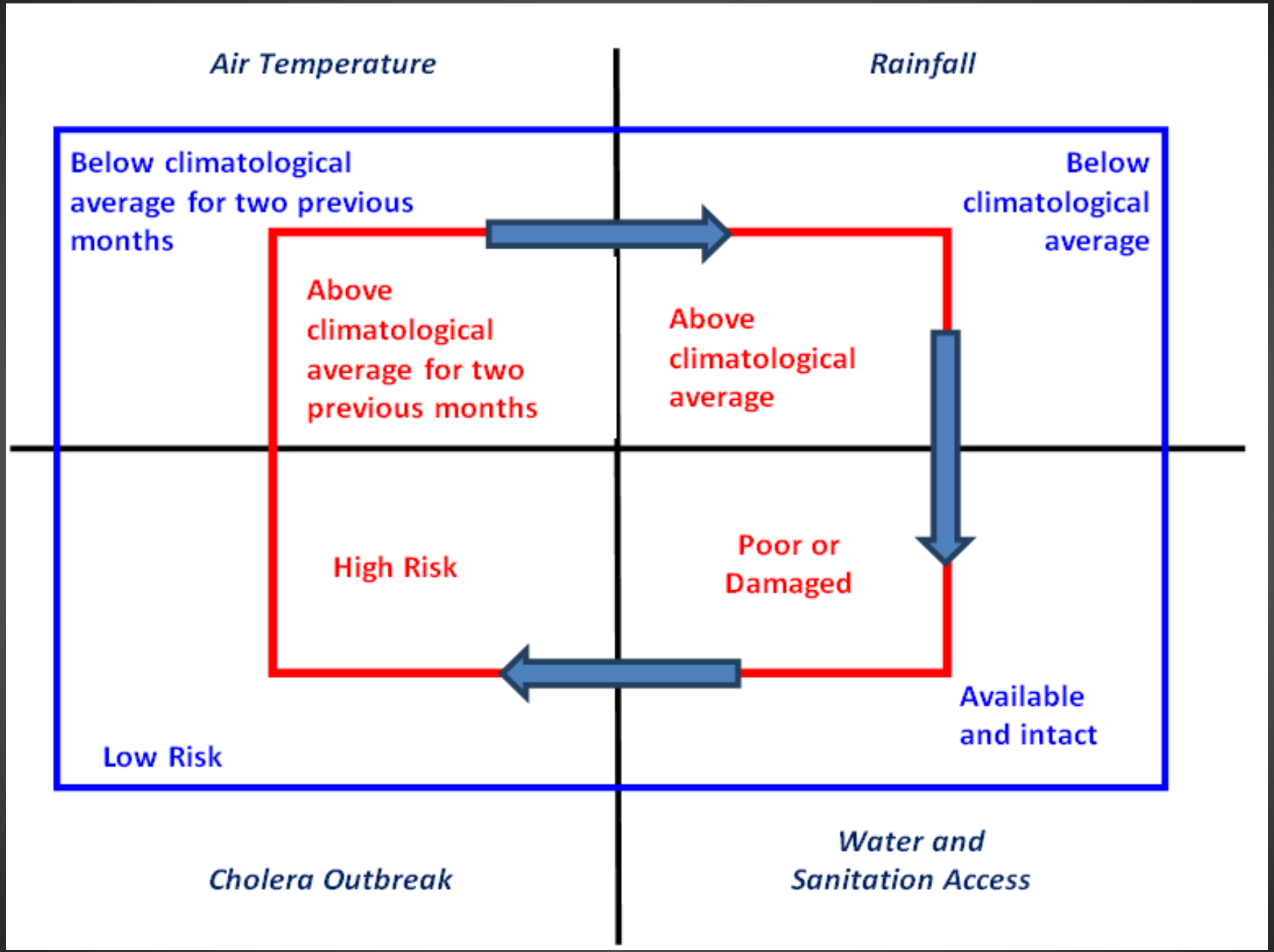
Temperature is the most influencing environmental factor known so far……..

5 ^{o}C increase in the water temperature showed a 3.3 fold increased risk (with 95% confidence) of cholera with a lag of six weeks.

Huq et al , 2005, Appl Environ Microbiol. 71(8): 4645–4654

- Ground truth data from the ecological studies provided the foundation for the first model
- Need a model for global prediction
- Goal is to predict just like weather forecast

That's where we need satellite remote sensing, and ……we need NASA


Air Temperature
Rainfall
Below climatological average for two previous months
Below climatological average
Above climatological average for two previous months
Above climatological average
High Risk
Poor or Damaged
Available and intact
Low Risk
Cholera Outbreak
Water and Sanitation Access

Global prediction will help…..

- **Early detection of occurrence of vibrios in the environment.**
- **Generate awareness for precaution**
- **Prevent *Vibrio* infection associated with seafood and recreational activities and also minimize economic loss**
- **Well prepared to combat in case of an outbreak**


Sari Filtration

Infectious Dose of Toxigenic *Vibrio cholerae* O1

(Cash et al, 1974)

Inoculum	Symptom
10^3 with antacids	Mild diarrhea
10^6 with food	Severe diarrhea
$>10^6$ with water	Severe diarrhea

Oithona spp female with eggs

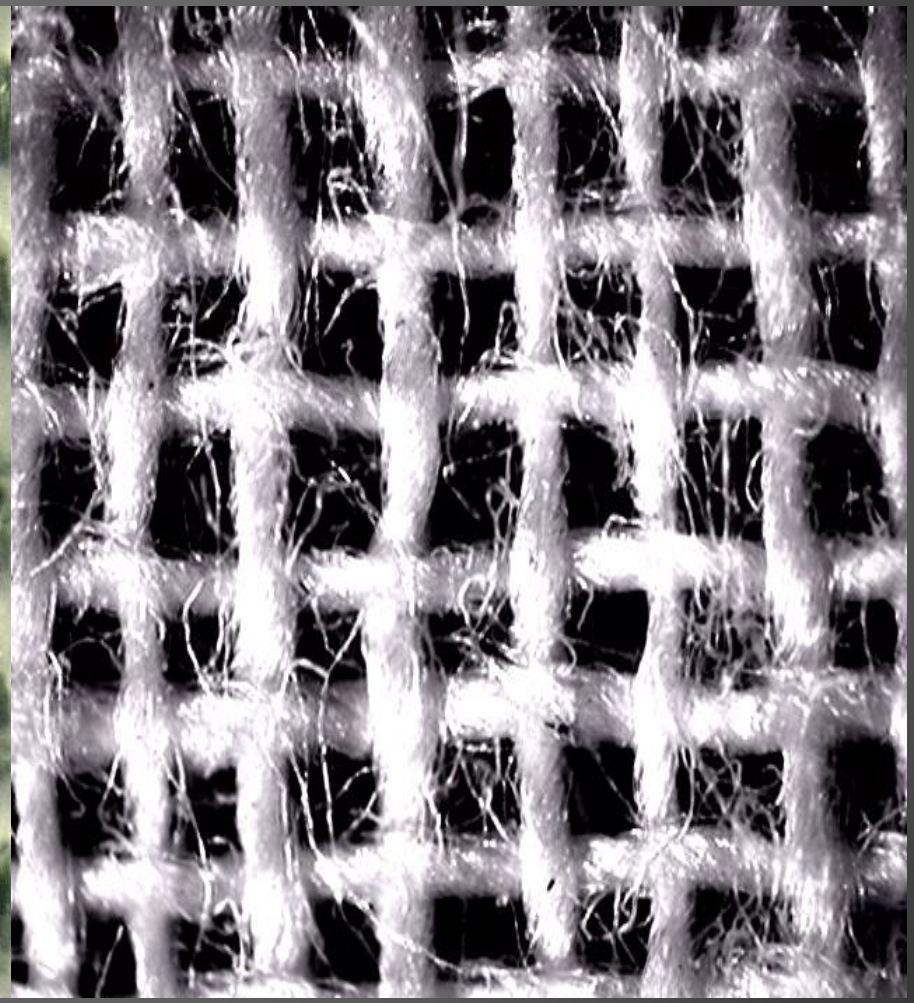
Eurytemora affinis, female with eggs

Acartia tonsa

Source: T. Rawlings

OLD SARI

NEW SARI



A Simple Filtration Method To Remove Plankton-Associated *Vibrio cholerae* in Raw Water Supplies in Developing Countries

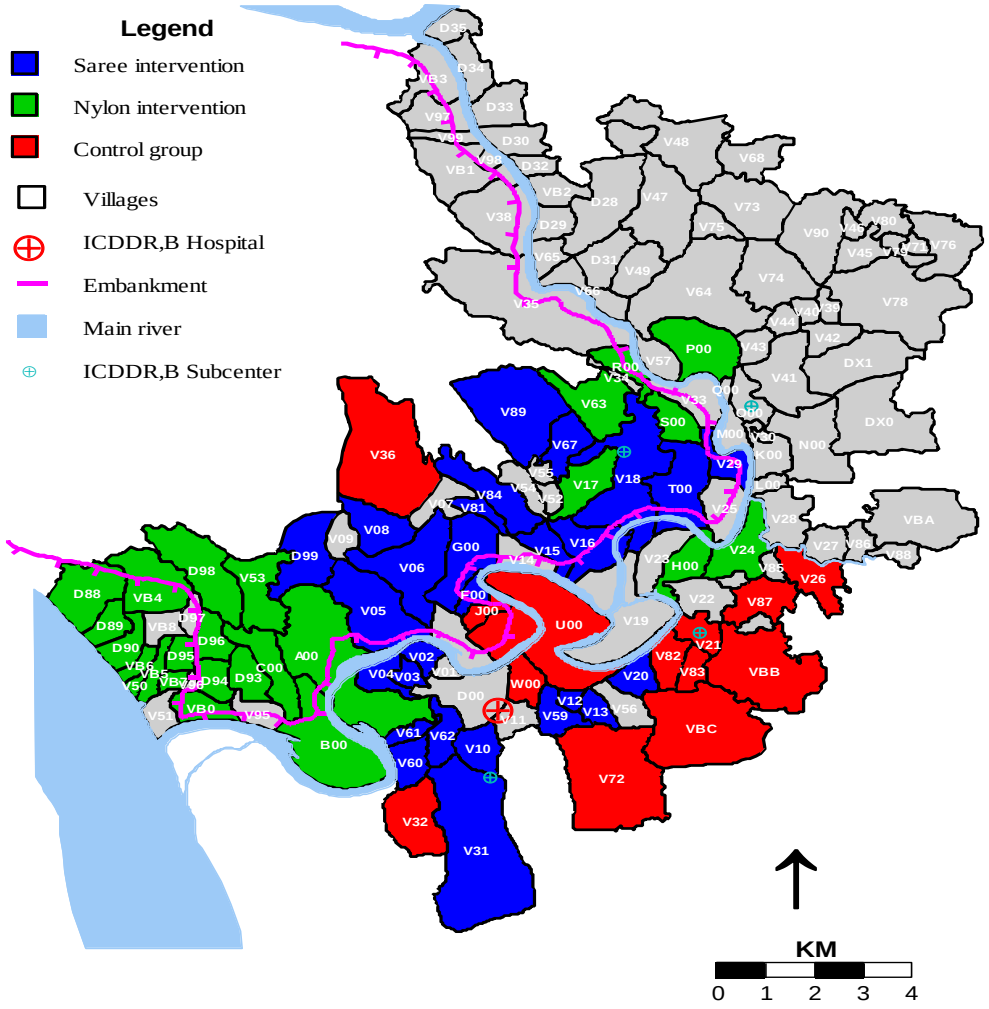
A. Huq[1], B. Xu[1], M. A. R. Chowdhury[1], M.S. Islam[2],
R. Montilla[1] and R. R. Colwell[1, 3]

Department of Microbiology, University of Maryland at College park[1], and University of Maryland Biotechnology Institute, College park[1],
Maryland, and International Center for Diarrhoeal Disease Research, Bangladesh, Dhaka, Bangladesh[2]

Appl. Environ. Microbiol. 62 (7):2508-2512, July, 1996

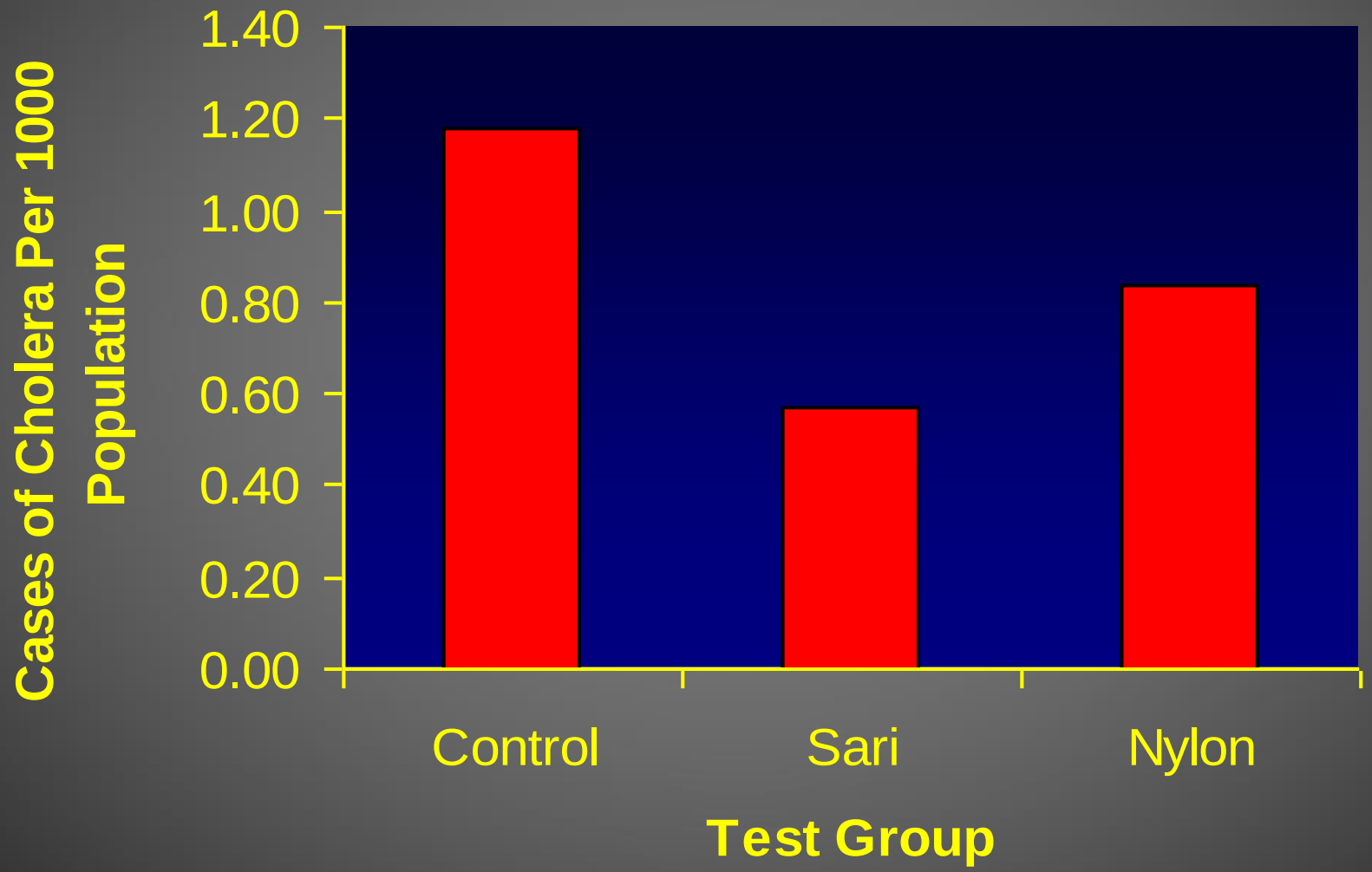
Villagers in Bangladesh collect filtered water in the same pond used for bathing

Matlab map showing study villages of filtration project for the second phase



Source: GIS unit, ICDDR,B

2-year Study


Cases of Cholera Per 1000 Population
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
Control
Sari
Nylon
Test Group

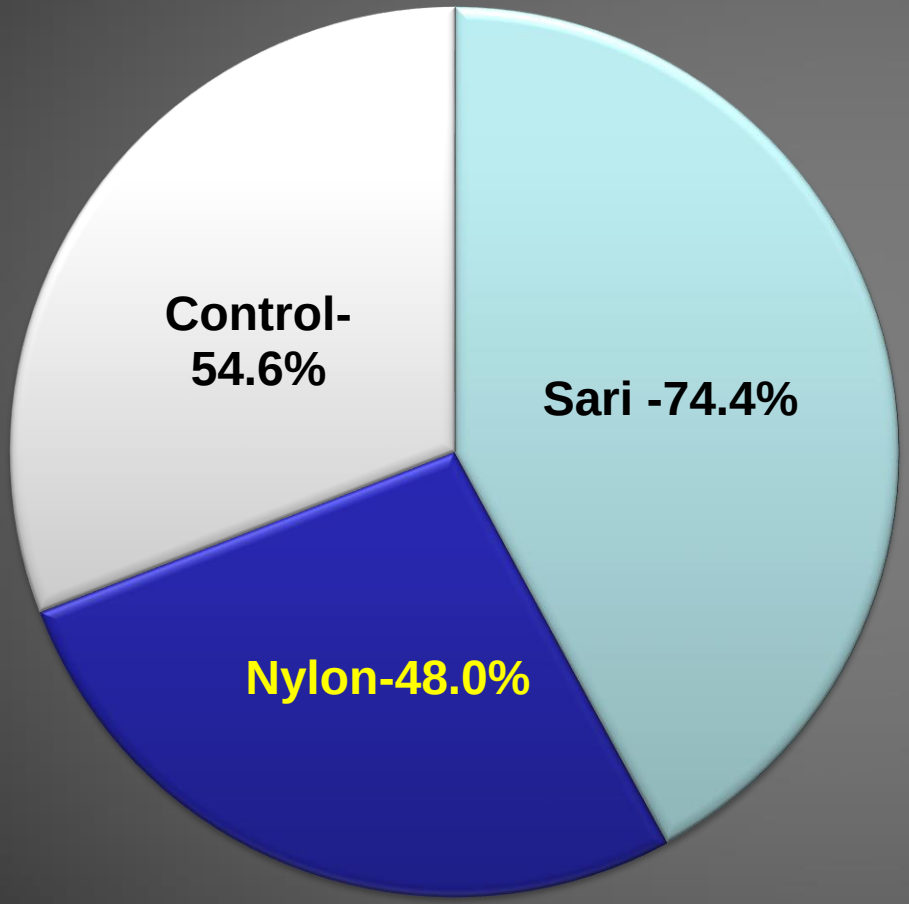
Reduction of Cholera in Bangladesh Villages by Simple Filtration

Rita R. Colwell[1]*, Anwar Huq[1], Siraj Islam[2], K.M. A. Aziz[2], M. Yunus[2], Nurul Huda Khan[2], A. Mahmood[2], R. Bradley Sack[4], J. Chakrabarti[2], G. B. Nair[2], David Sack[2], and E. Russek-Cohen[3]

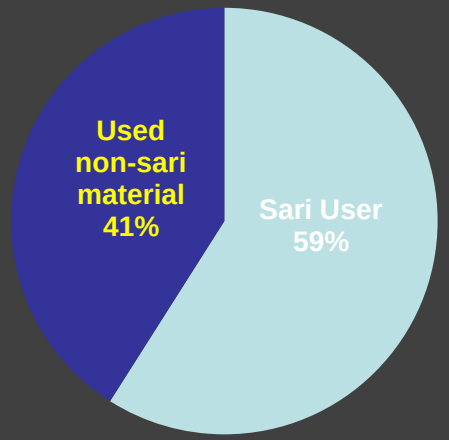
[1]Center of Marine Biotechnology, University of Maryland Biotechnology Institute, 701 East Pratt Street, Baltimore, Maryland 21202 and Dept. of Cell Biology and Molecular Genetics, University of Maryland, College Park, Maryland 20742[2], International Centre for Diarrhoeal Disease, Bangladesh, Dhaka, Bangladesh[3]Department of Animal Science, University of Maryland at College Park, Maryland 207424, [4]School of Public Health and Hygiene, Johns Hopkins University, Baltimore, Maryland 21205

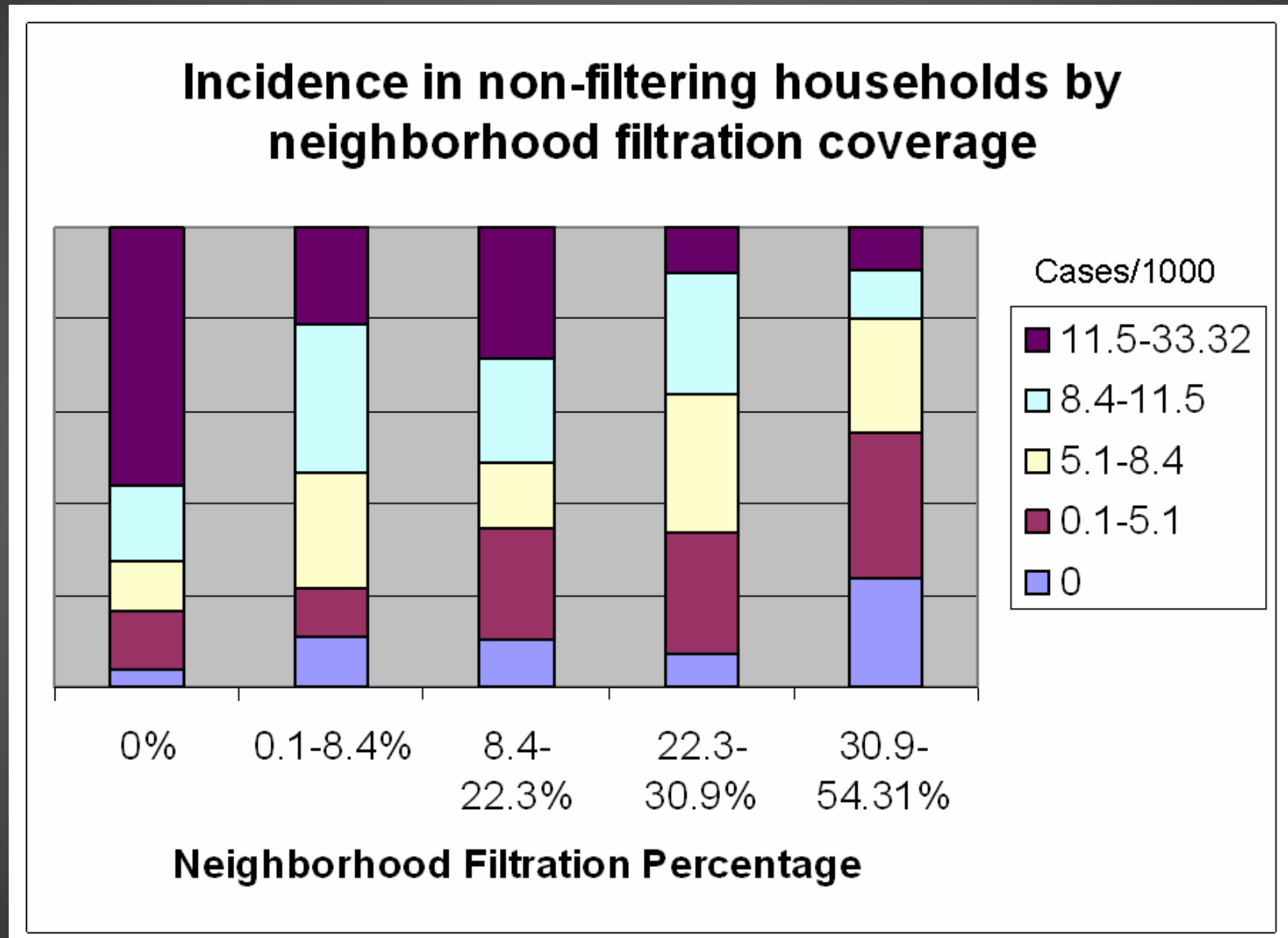
PNAS February 4, 2003. Vol. 100 (3) 1051-1055

Filtering population in 3 original study groups using sari



Use of sari among the total filtering population




Incidence in non-filtering households by neighborhood filtration coverage
Cases/1000
11.5-33.32
8.4-11.5
5.1-8.4
0.1-5.1
0
0%
0.1-8.4%
8.4-22.3%
22.3-30.9%
30.9-54.31%
Neighborhood Filtration Percentage

Cholera prediction in Bangladesh will help health officials to caution public of the risk via radio and television.

Public can use sari filtration if they have no other choice but to depend on natural water for domestic purpose including for drinking

Using satellite remote sensing data, models for global prediction of the occurrence of vibrios any where in the world including the Chesapeake Bay will help prevent and reduce the number of infection and suffering and even save life in extreme cases.

Acknowledgement to recent collaborators:

Ana Gil, Institute for Nutrition, Lima Peru
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Balakrish Nair, ICDDR,B, Dhaka, Bangladesh
Brad Lobitz, NASA, Ames, California, USA
Brad Sack, School of Public Health, JHU, Baltimore, Maryland, USA
Carla Pruzzo, University of Ancona, Italy
Chris Whitehouse, USAMRIID, Frederick, MD, USA
Estelle Russek-Cohen, Univ. of Maryland, College Park, USA
Glenn Morris, University of Maryland, Baltimore, Baltimore, USA
Guillaume deMagny, University of Maryland, Maryland, USA
Irma Rivera, University of Sao Paulo, Brazil
Leonardo Lizzarrhaga-Partida, CISECE, Ensenada, Mexico
Marina Tediashvili, Eliava Institute, Tbilisi, Georgia
Mohammad Yunus, ICDDR,B, Dhaka, Bangladesh
Munir Alam, ICDDR,B, Dhaka, Bangladesh
Norma Binsztein, Institute of National Infect Dis, Argentina
Rita Colwell, University of Maryland, Maryland, USA
Ron Taylor, Dartmouth College, New Hampshire, USA