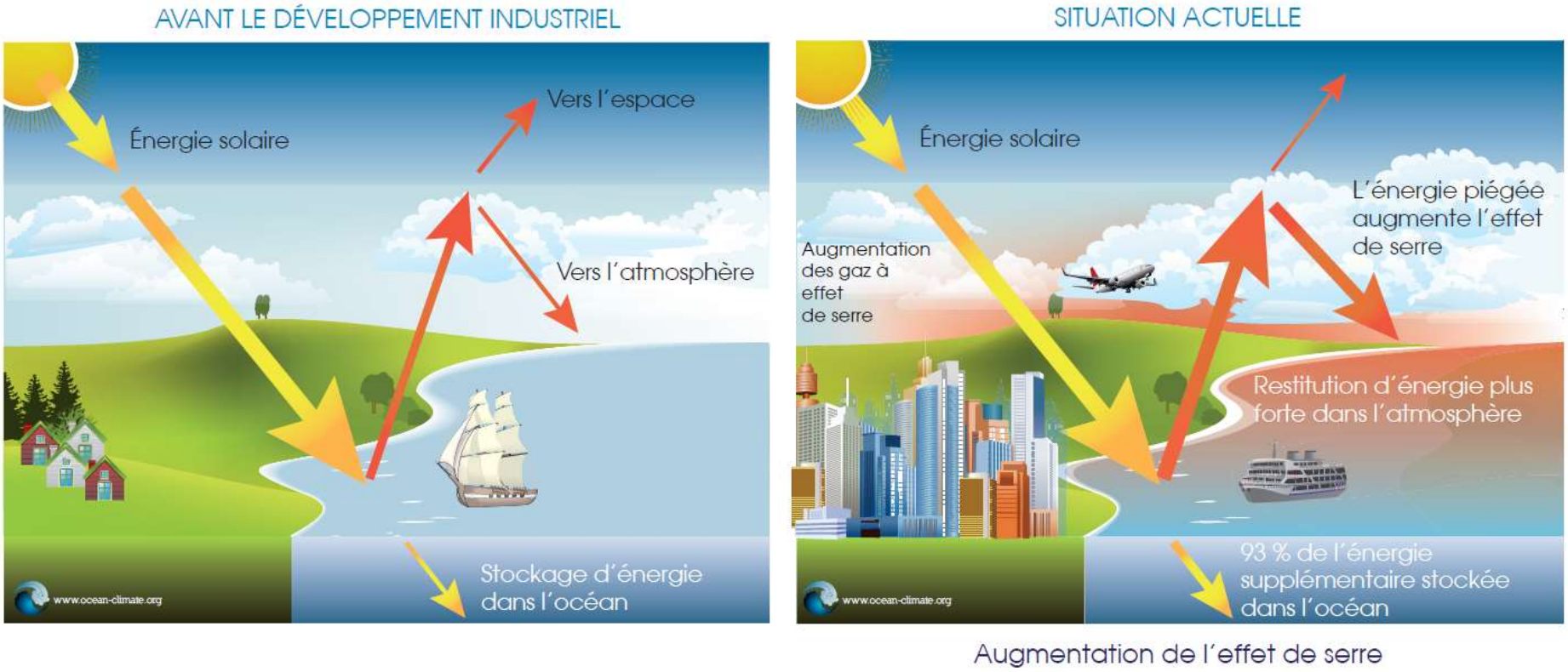
Les microbes marins : acteurs de la santé de la planète et marquers de la santé des océans

Chris Bowler
CNRS
Institut de Biologie
de l'Ecole Normale Supérieure

Summary of talk

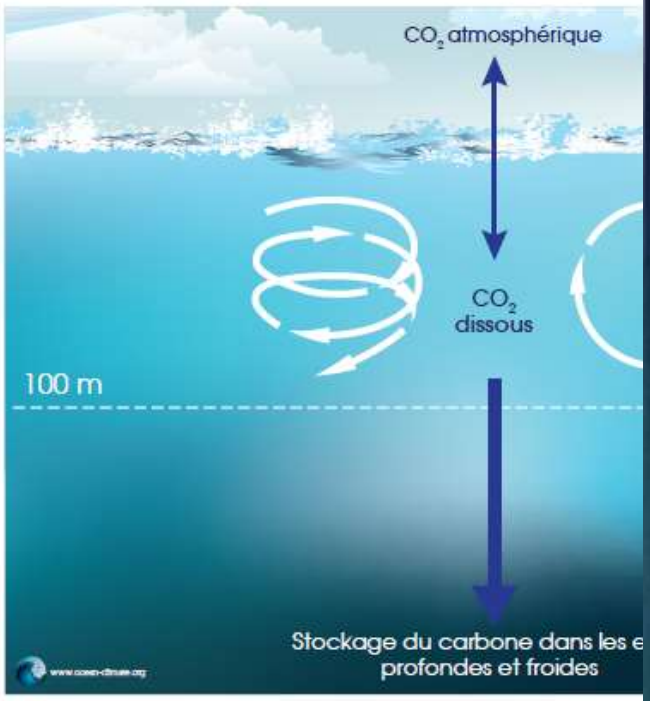
- ☑ The ocean that protects us
- ☑ The ocean under threat
- ☑ The ocean and human health
- ☑ Exploration of marine microbes

The ocean, the planet's thermostat

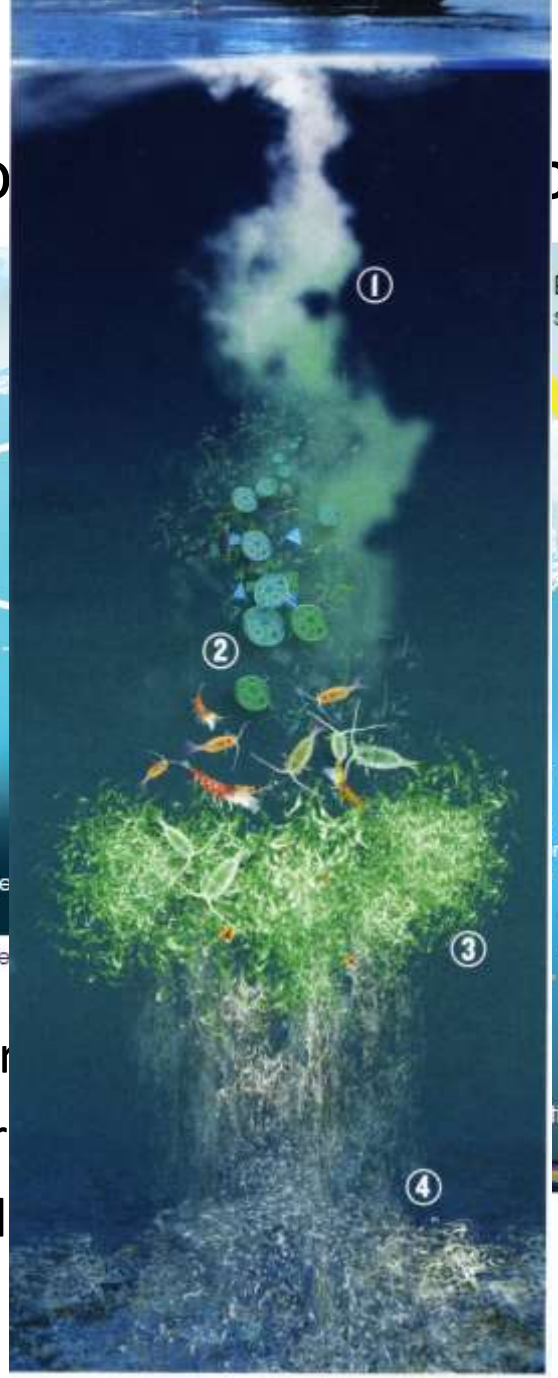


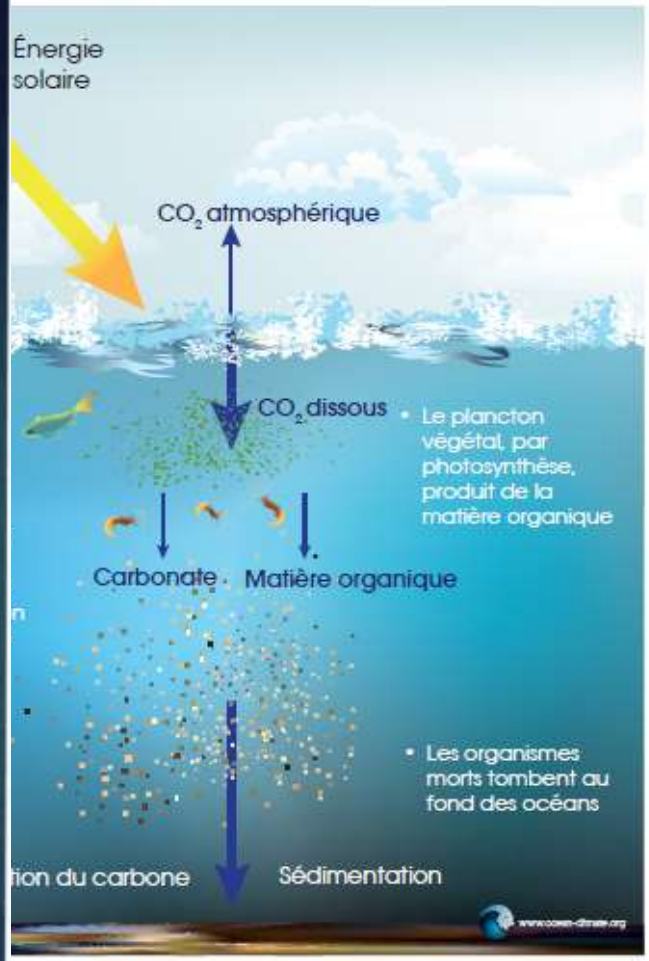
Augmentation de l'effet de serre

The o ump



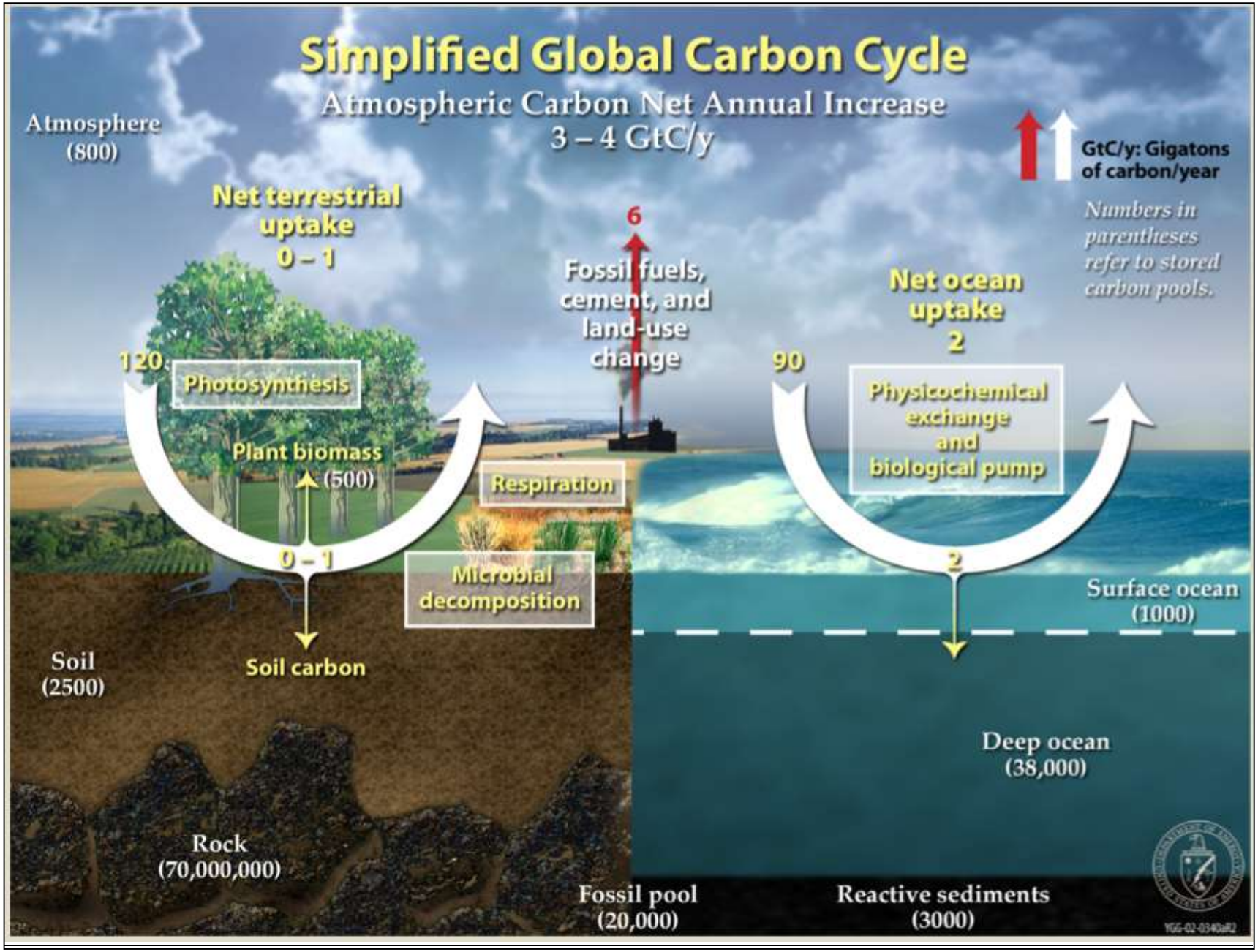
Pompe à carbone physique

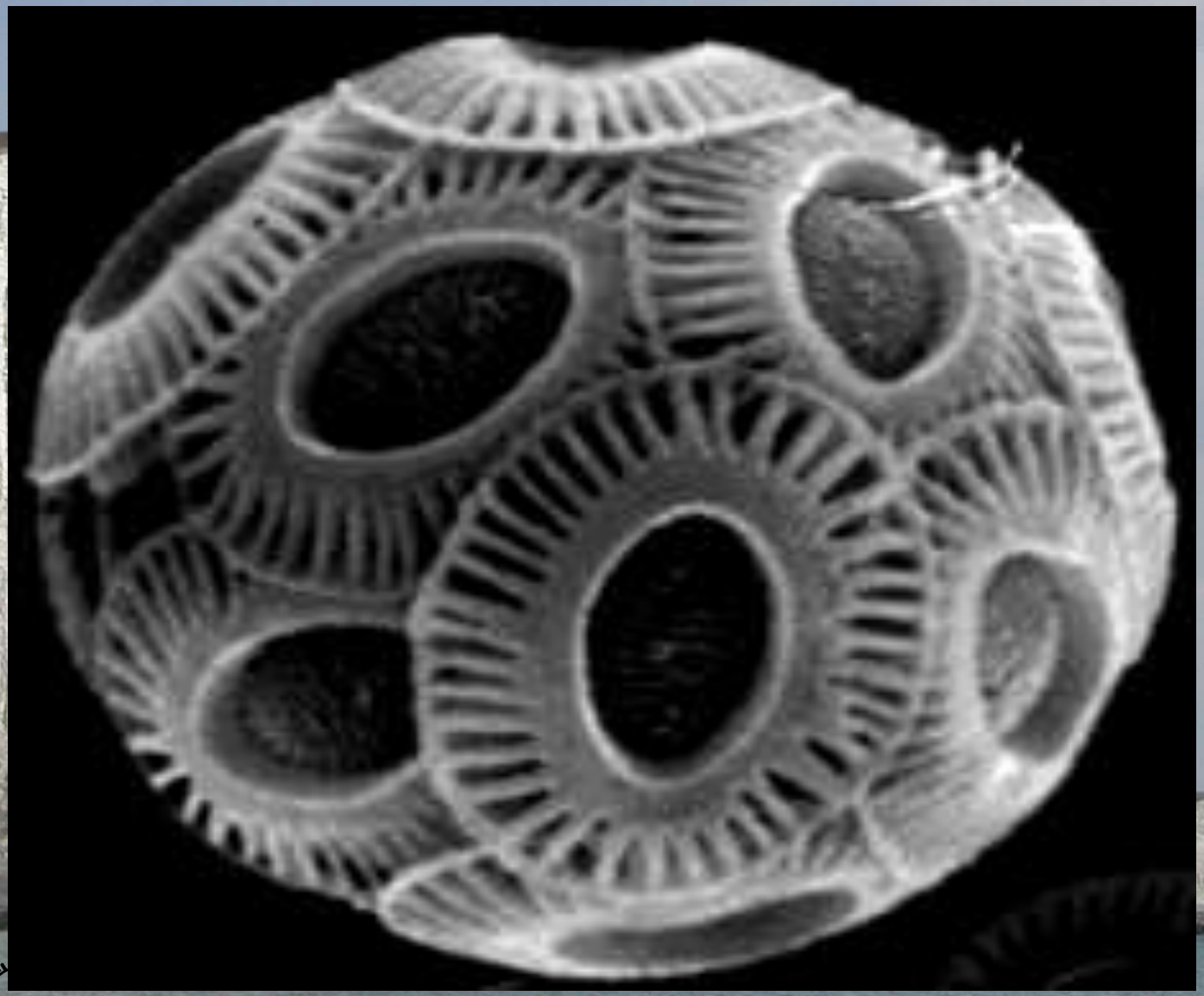




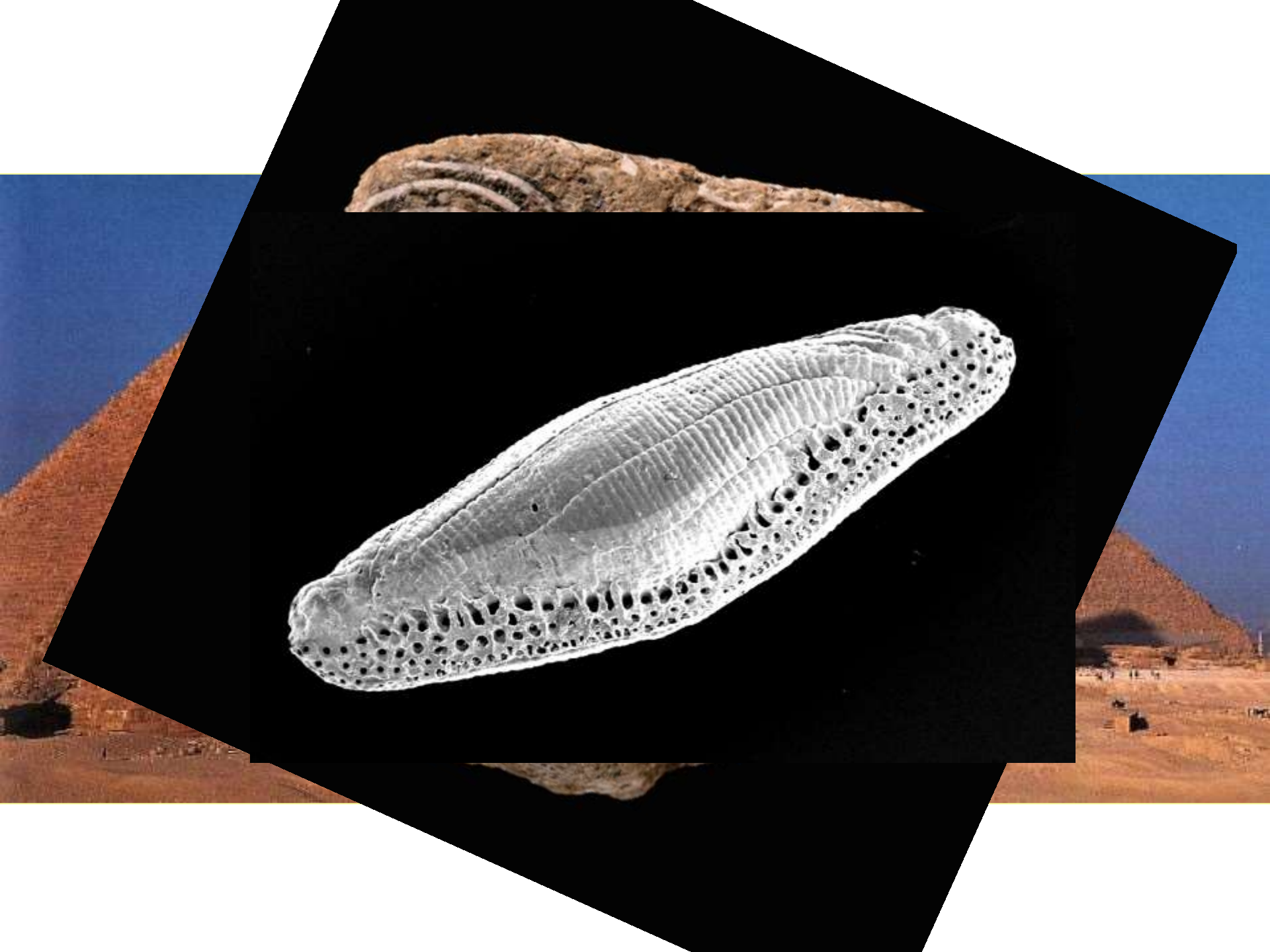
Pompe à carbone biologique

Around 25% of the CO2 gener
activities has been absor
cean since the start of the ind

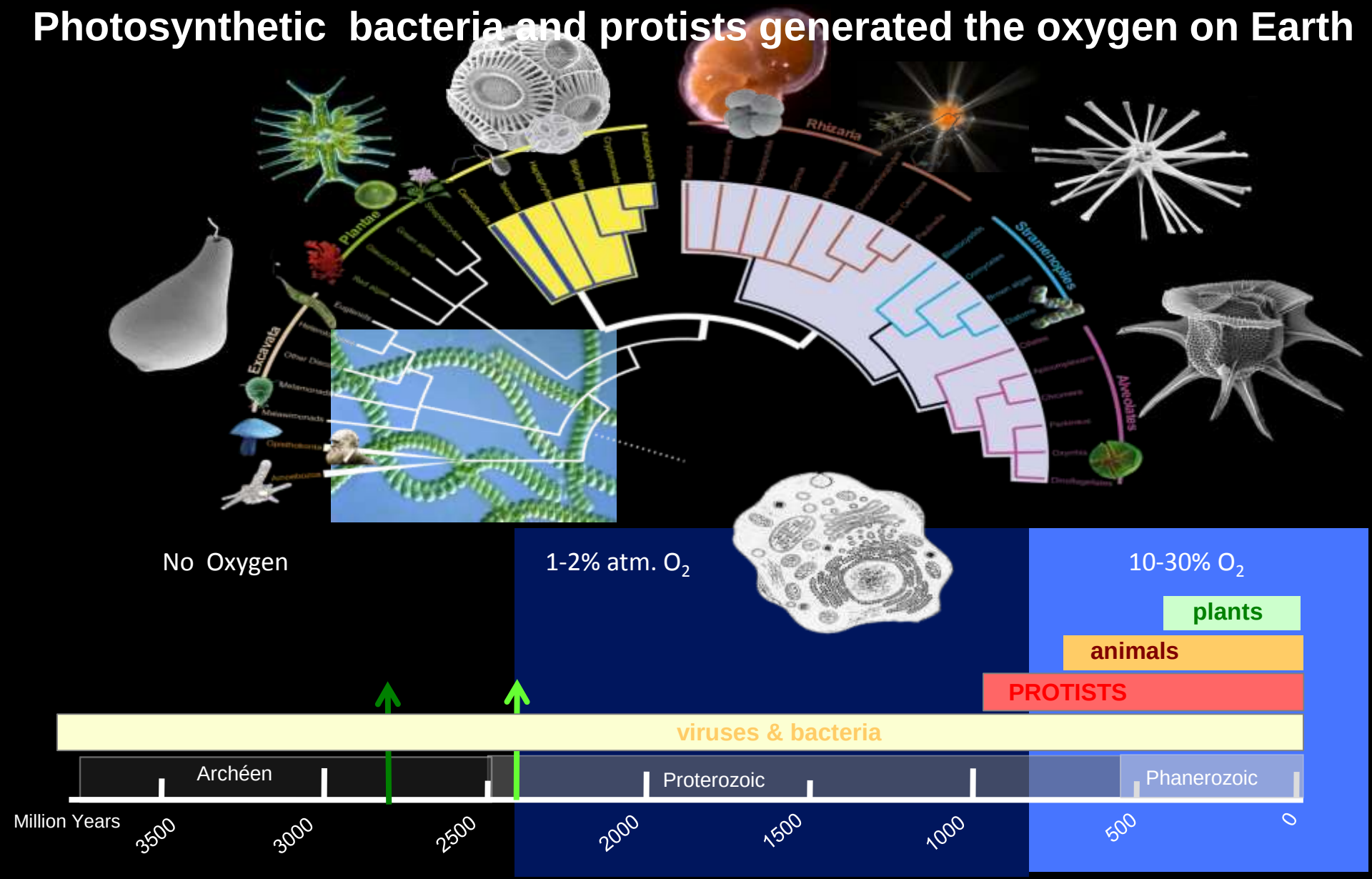

Simplified Global Carbon Cycle
Atmospheric Carbon Net Annual Increase
3 – 4 GtC/y
Atmosphere
(800)
GtC/y: Gigatons of carbon/year
Numbers in parentheses refer to stored carbon pools.
Net terrestrial uptake
0 – 1
6
Fossil fuels, cement, and land-use change
Net ocean uptake
2
120
Photosynthesis
90
Physicochemical exchange and biological pump
Plant biomass
(500)
Respiration
0 – 1
Microbial decomposition
2
Surface ocean
(1000)
Soil
(2500)
Soil carbon
Deep ocean
(38,000)
Rock
(70,000,000)
Fossil pool
(20,000)
Reactive sediments
(3000)



« Dover »

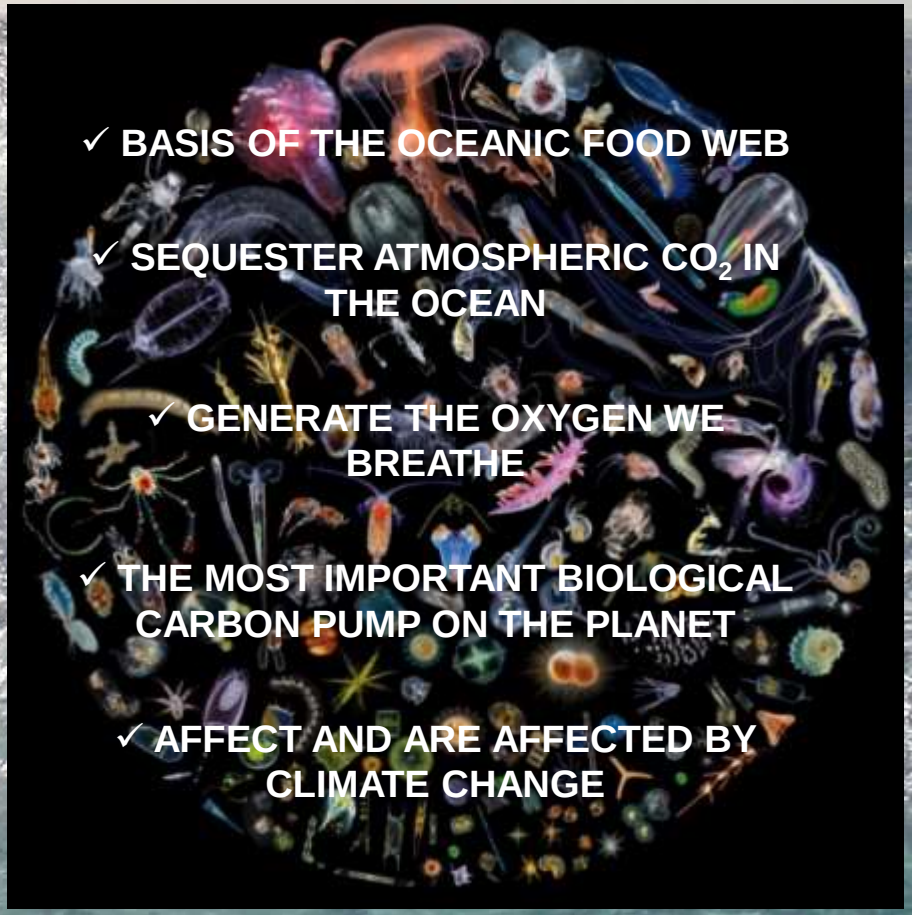


Photosynthetic bacteria and protists generated the oxygen on Earth



The Plankton

THE INVISIBLE MULTITUDE



>90% of the biomass in the ocean

TARA OCEANS

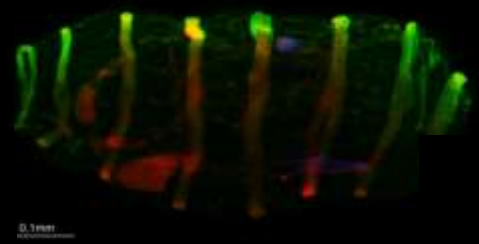
Protists:

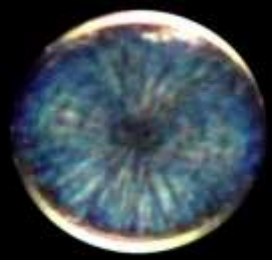
0.1-10 million/litre

TARA OCEANS

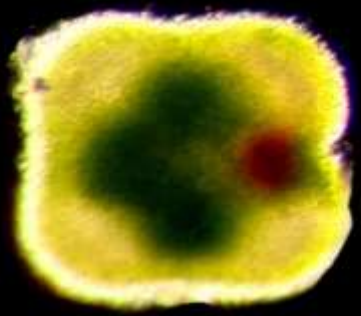
Zooplankton:

0.1-100/litre

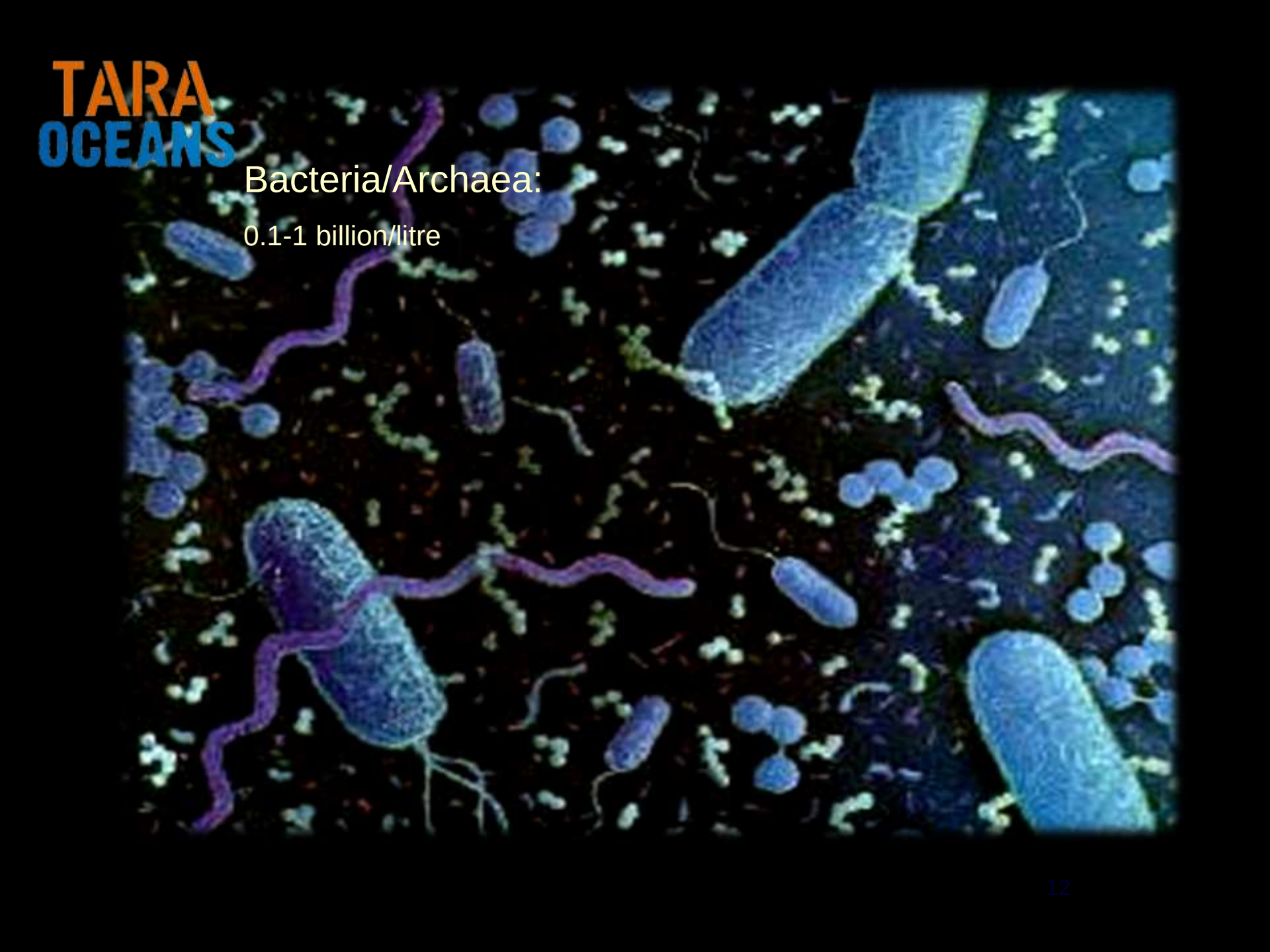




E.Reynaud, UCD, Dublin

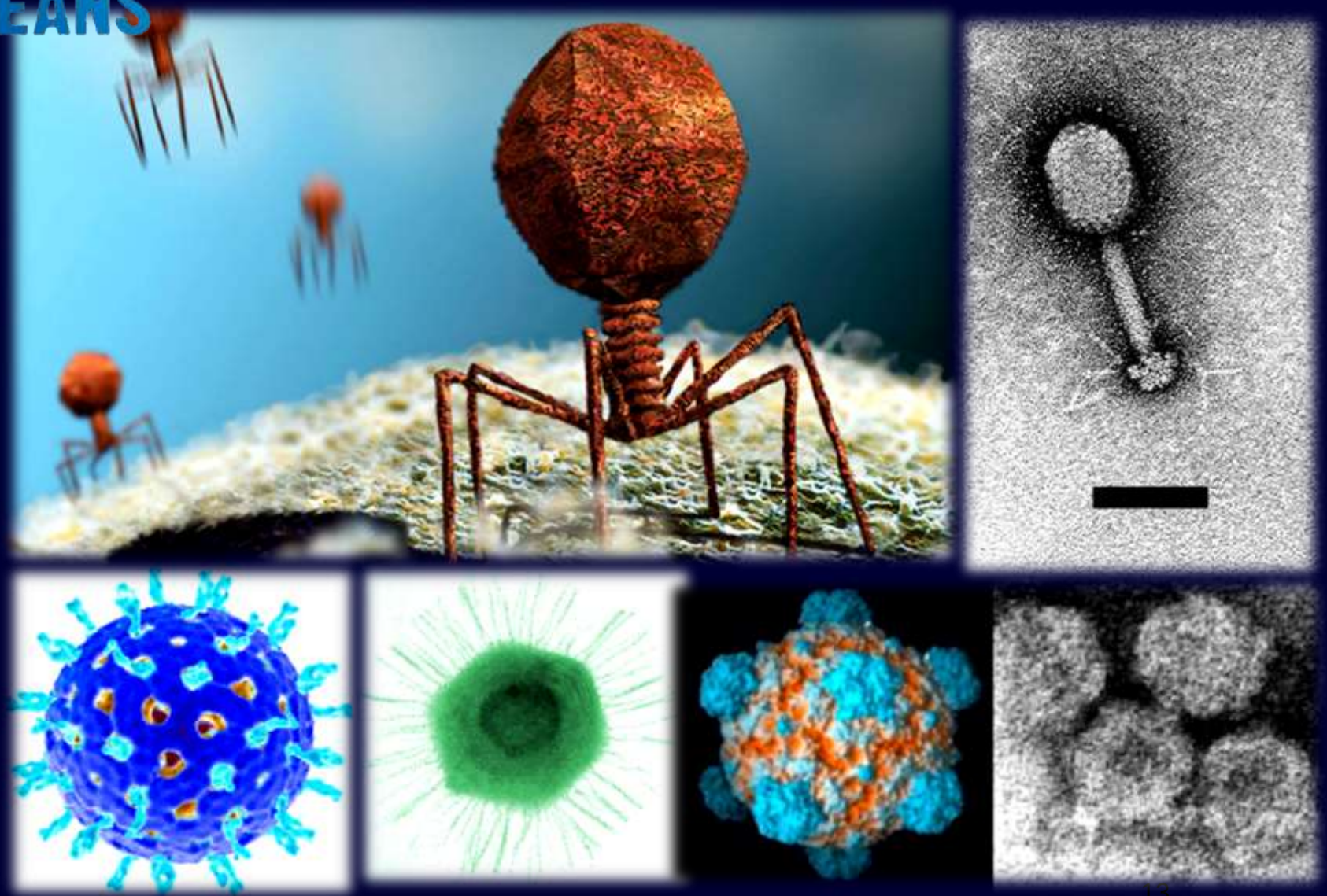


E.Reynaud, UCD, I


TARA
OCEANS
Bacteria/Archaea:
0.1-1 billion/litre

TARA OCEANS

Viruses and giruses: 1-10 billion/litre



Ocean Life Affects and is Affected by Climate

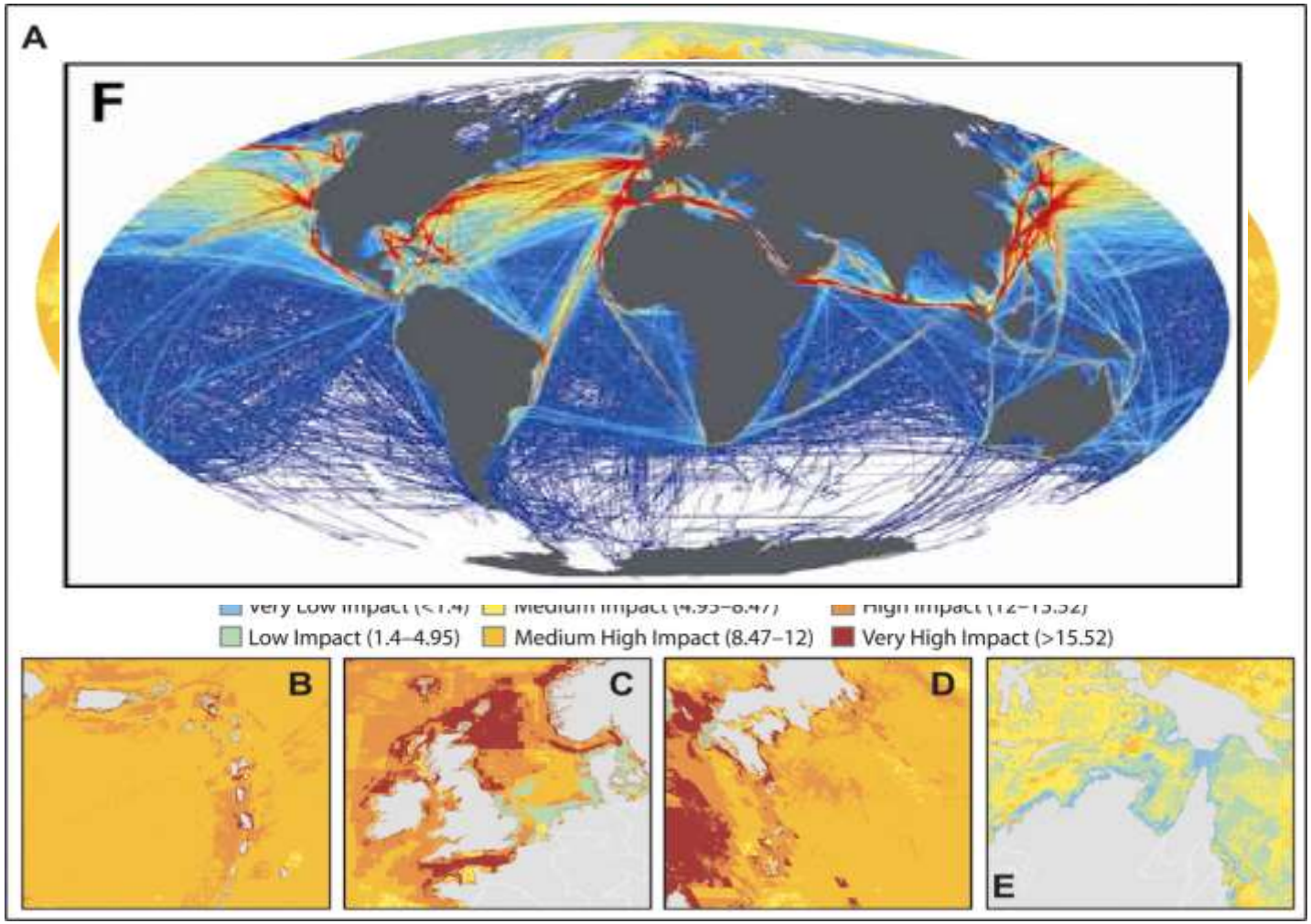
- ✓ SEQUESTRATION OF CO2
- ✓ SNOWBALL EARTH EVENTS
- ✓ GENERATION OF CLOUD-GENERATING DMSP AND OTHER AEROSOLS

- ✓ CHANGES IN ABUNDANCE AND SPECIES DIVERSITY
- ✓ SPECIES MIGRATIONS
- ✓ DESTABILIZATION OF FOOD CHAINS
- ✓ EVOLUTION AND EXTINCTION

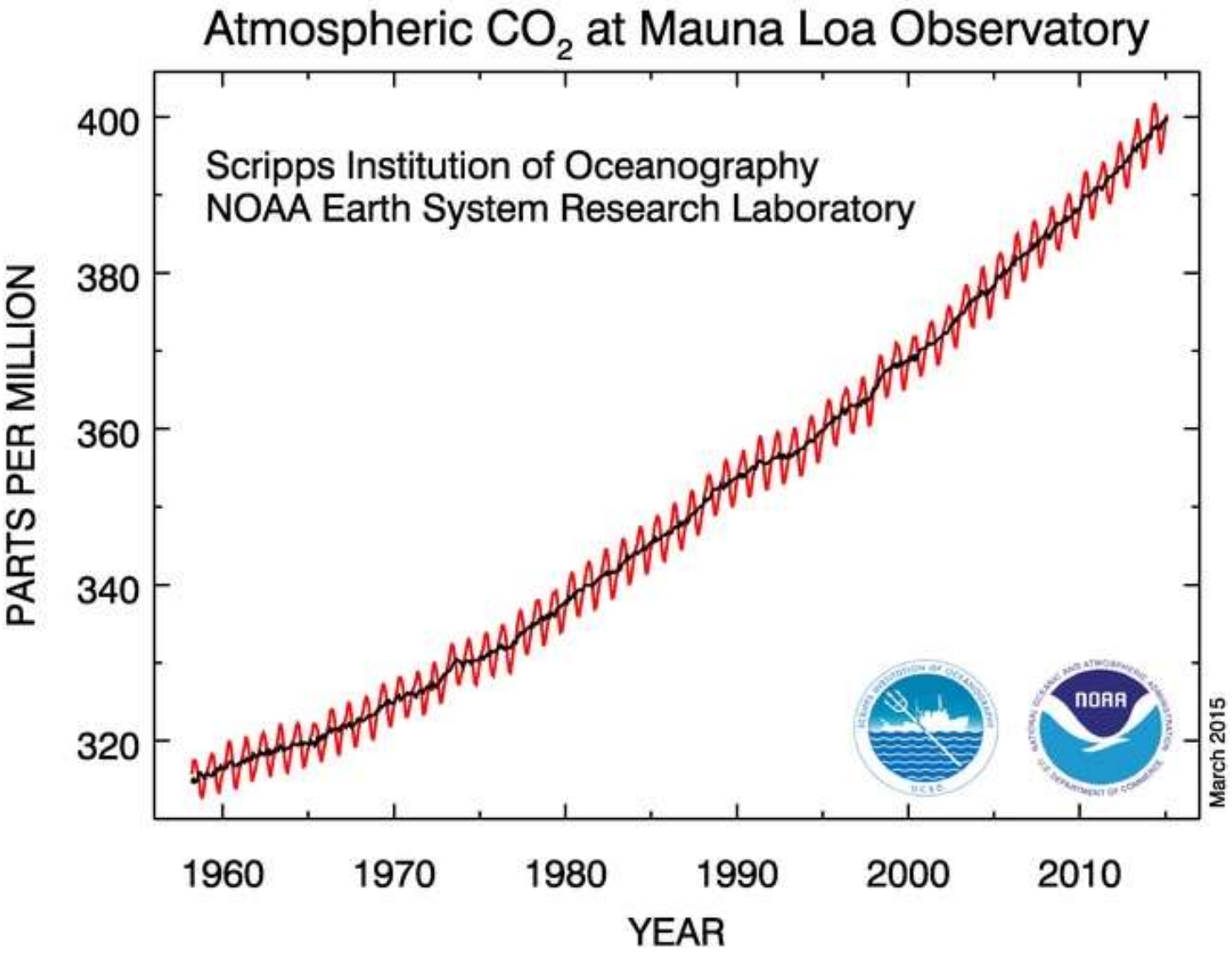
Summary of talk

- The ocean that protects us
- **The ocean under threat**
- The ocean and human health
- Exploration of marine microbes

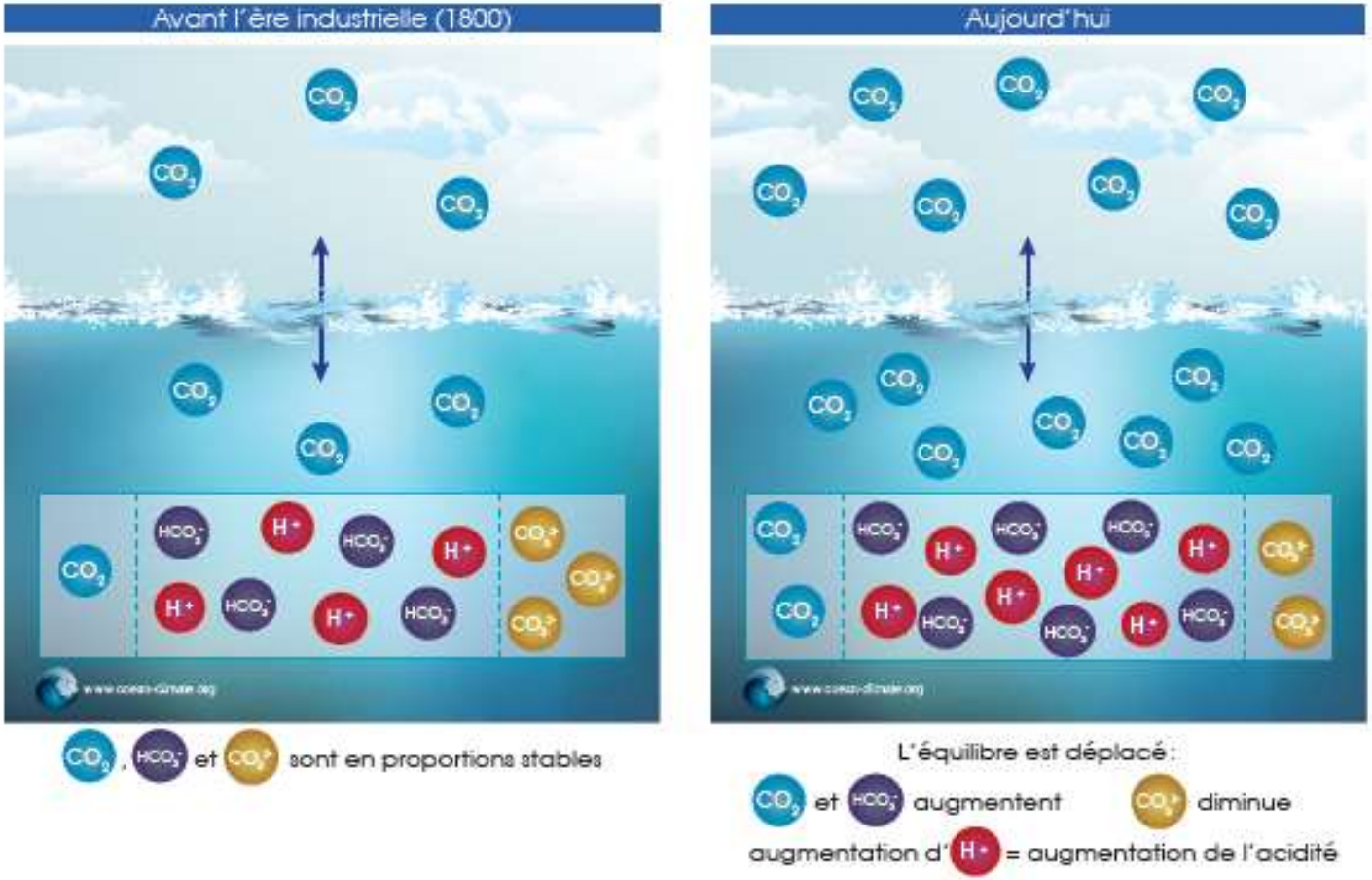
Human impact on the oceans



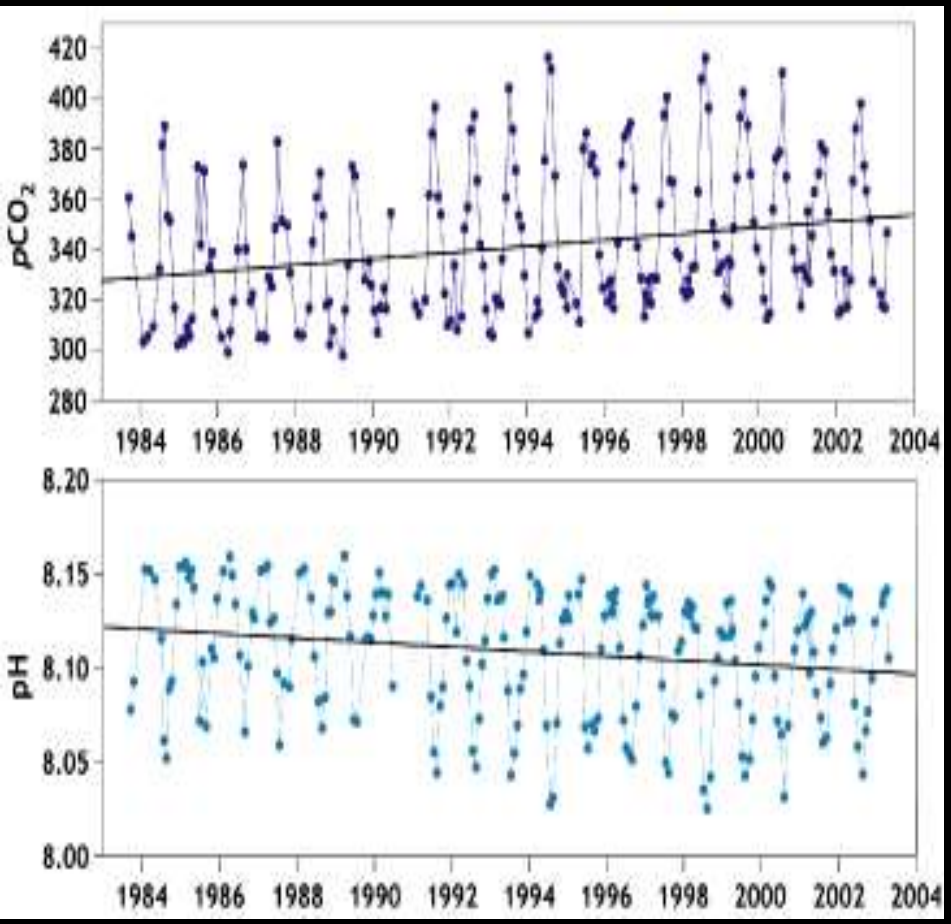
Halpern et al. Science 2011


Atmospheric CO_2 at Mauna Loa Observatory
Scripps Institution of Oceanography
NOAA Earth System Research Laboratory
PARTS PER MILLION
400
380
360
340
320
1960
1970
1980
1990
2000
2010
YEAR
NOAA
March 2015

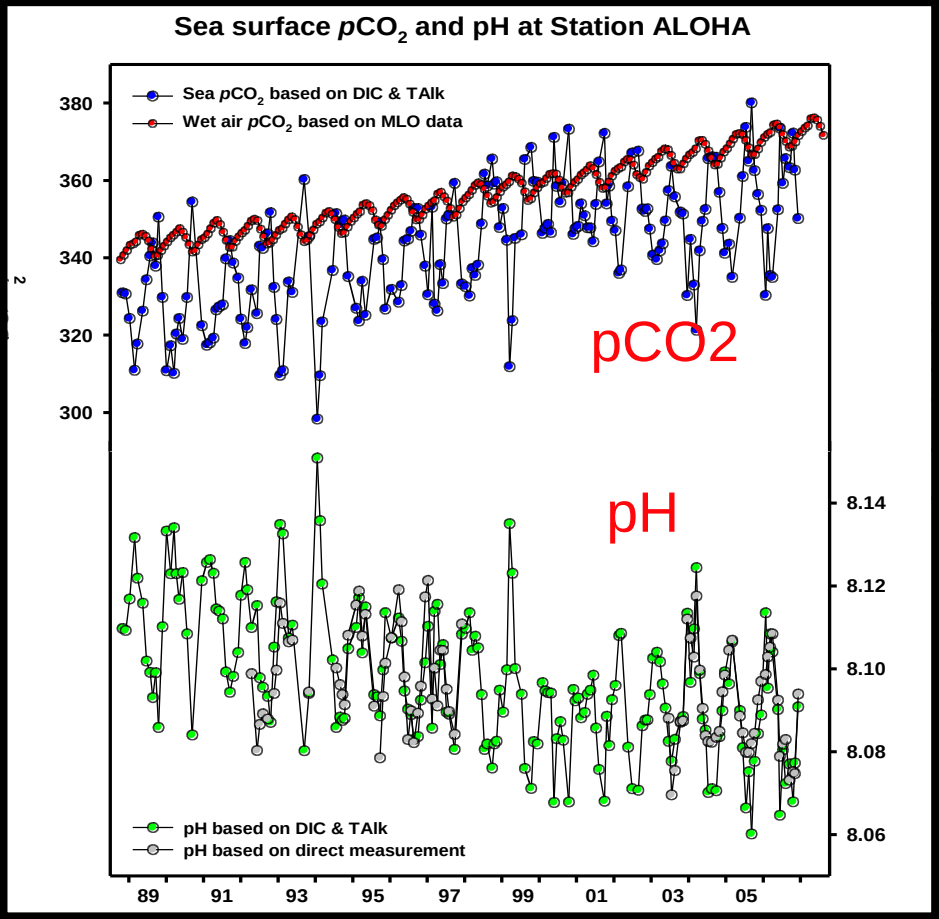
Ocean acidification



Ocean pCO2 + pH measurements

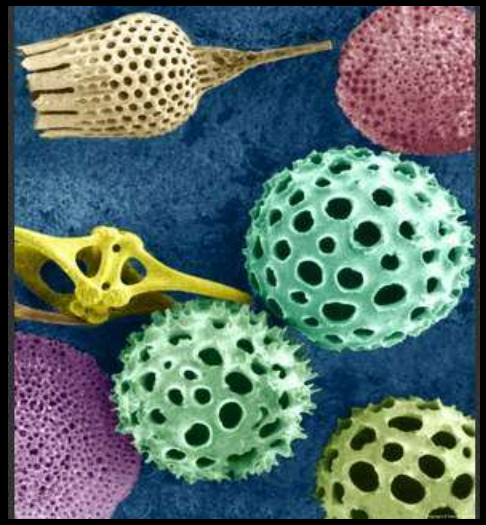


Bermuda Atlantic Time Series,
http://www.seafriends.org



Hawaii Ocean Time series,
Dave Karl, UHawaii

Lowered pH could alter Calcification of Marine Organisms

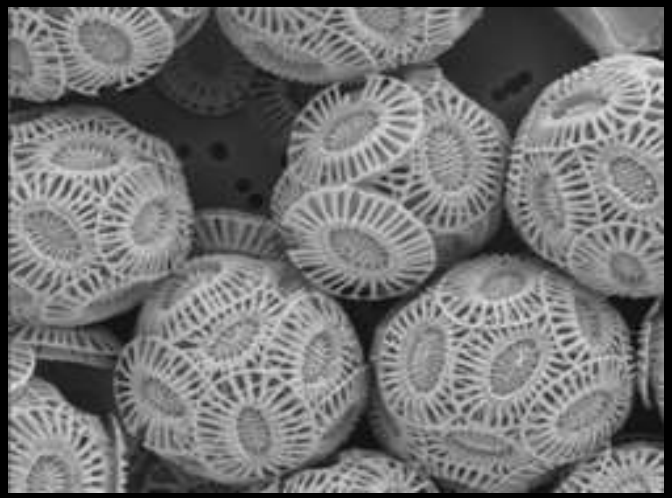


Radiolarians
(http://www.astrographics.com)

Coralline algae
(http://tidechase.blogspot.com)

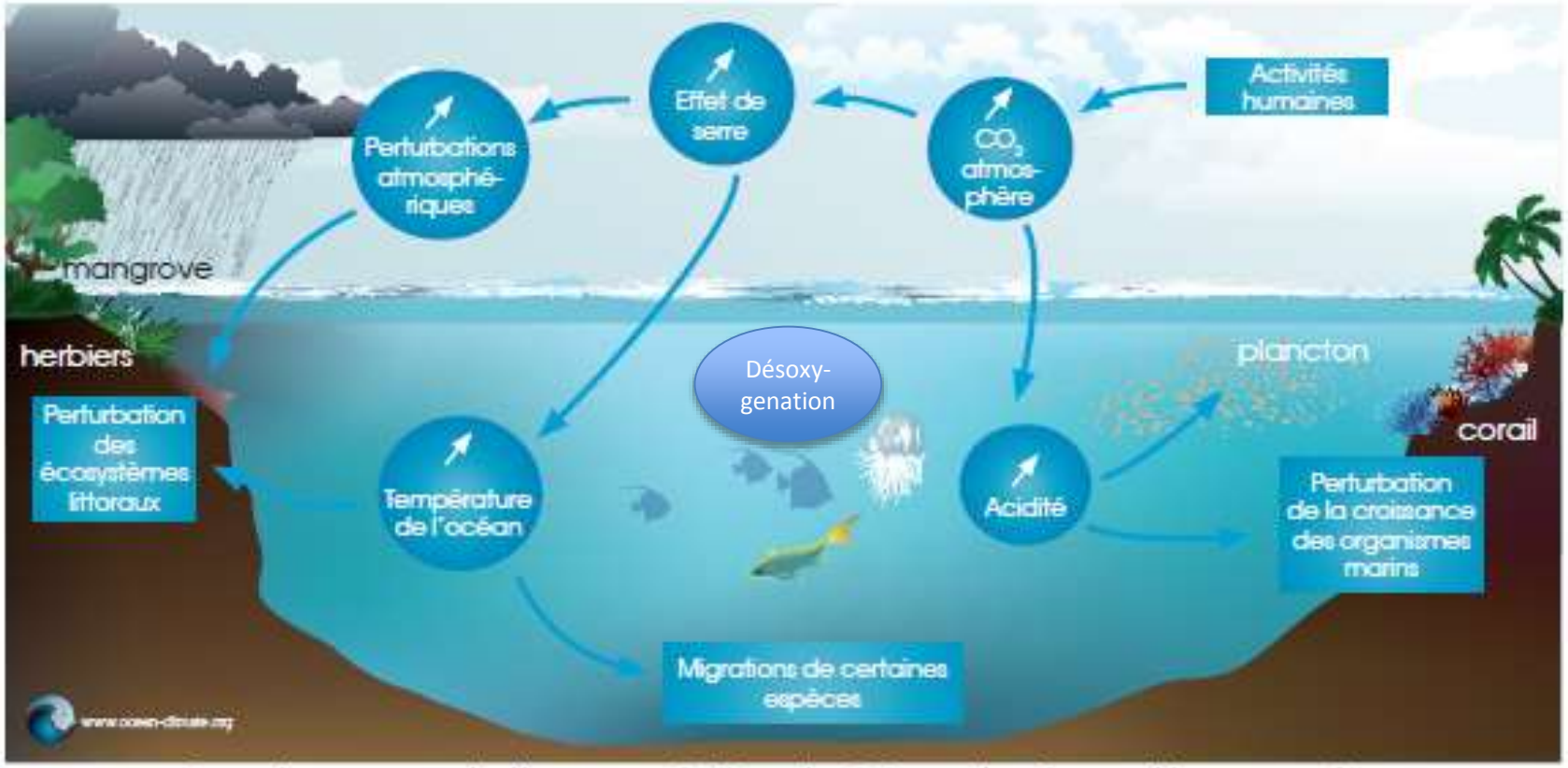
Coral
(http://www.aboututila.com)

Pteropod
(http://noaa.gov)



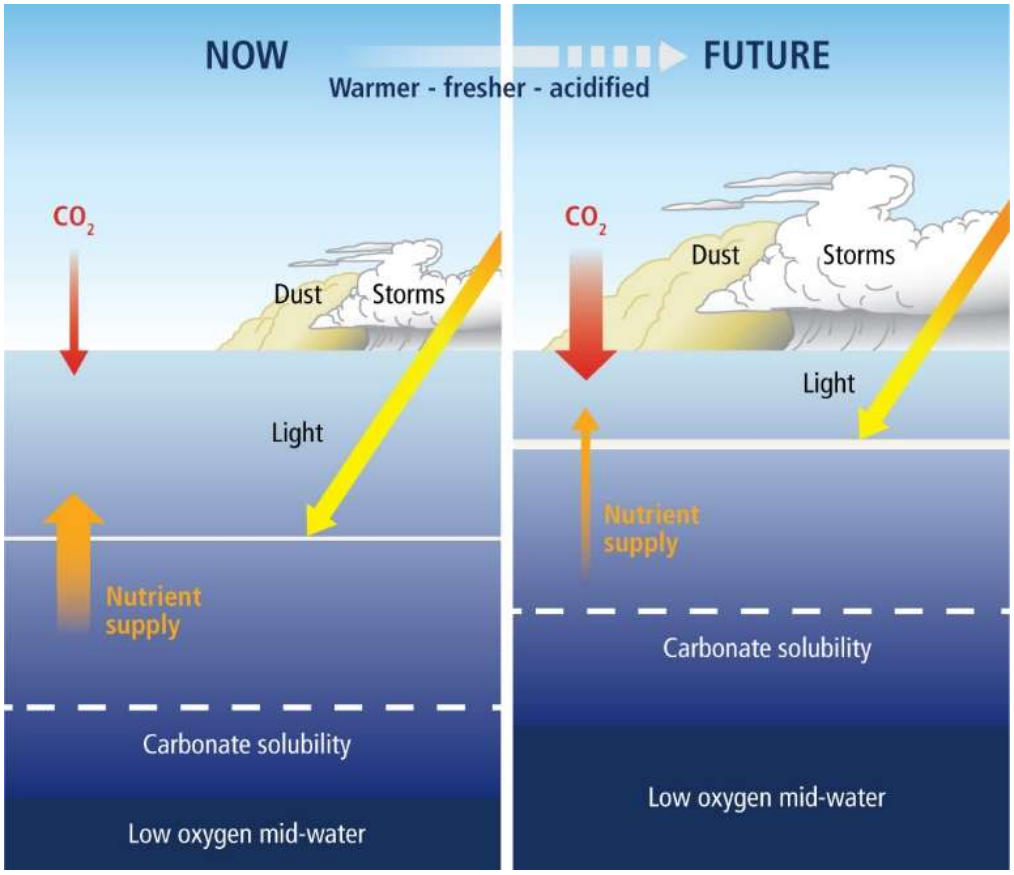
Coccolithophores
(http://users.uoa.gr)

An ocean under pressure



Conséquences de l'augmentation du CO_2 sur les écosystèmes marins

The ocean is changing

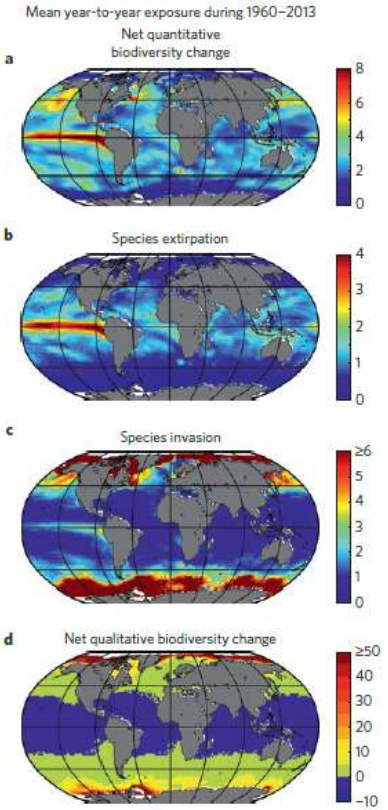


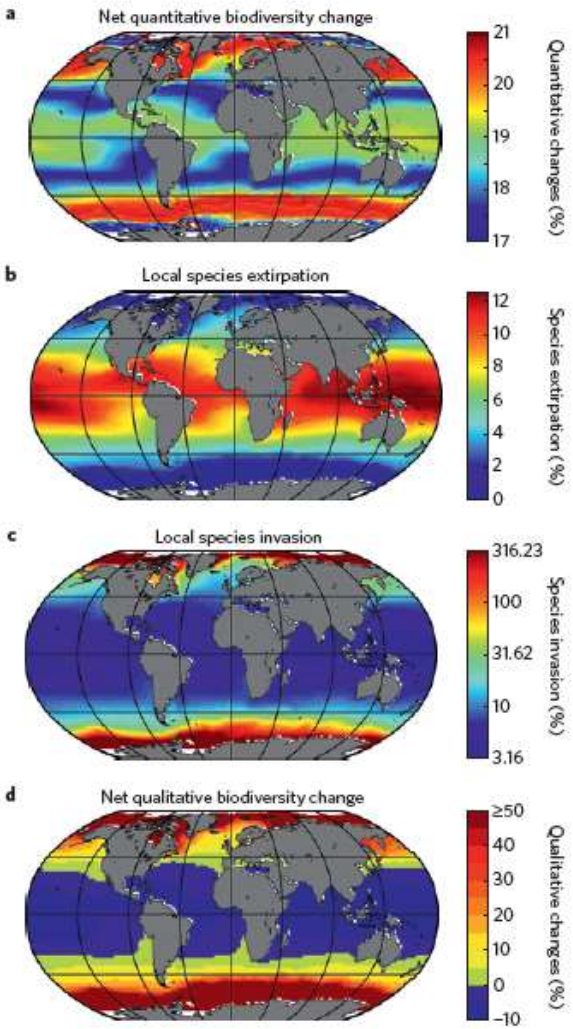
nature climate change
ARTICLES
PUBLISHED ONLINE: 1 JUNE 2015 | DOI: 10.1038/NCLIMATE2600

Future vulnerability of marine biodiversity compared with contemporary and past changes

Grégory Beaugrand[1,2*], Martin Edwards[2,3], Virginie Raybaud[4,5], Eric Goberville[1,2] and Richard R. Kirby[3,6*]

Estimated changes in marine biodiversity with respect to ocean temperature (1960-2013)





Expected sensitivity of marine biodiversity to a 2° C temperature increase

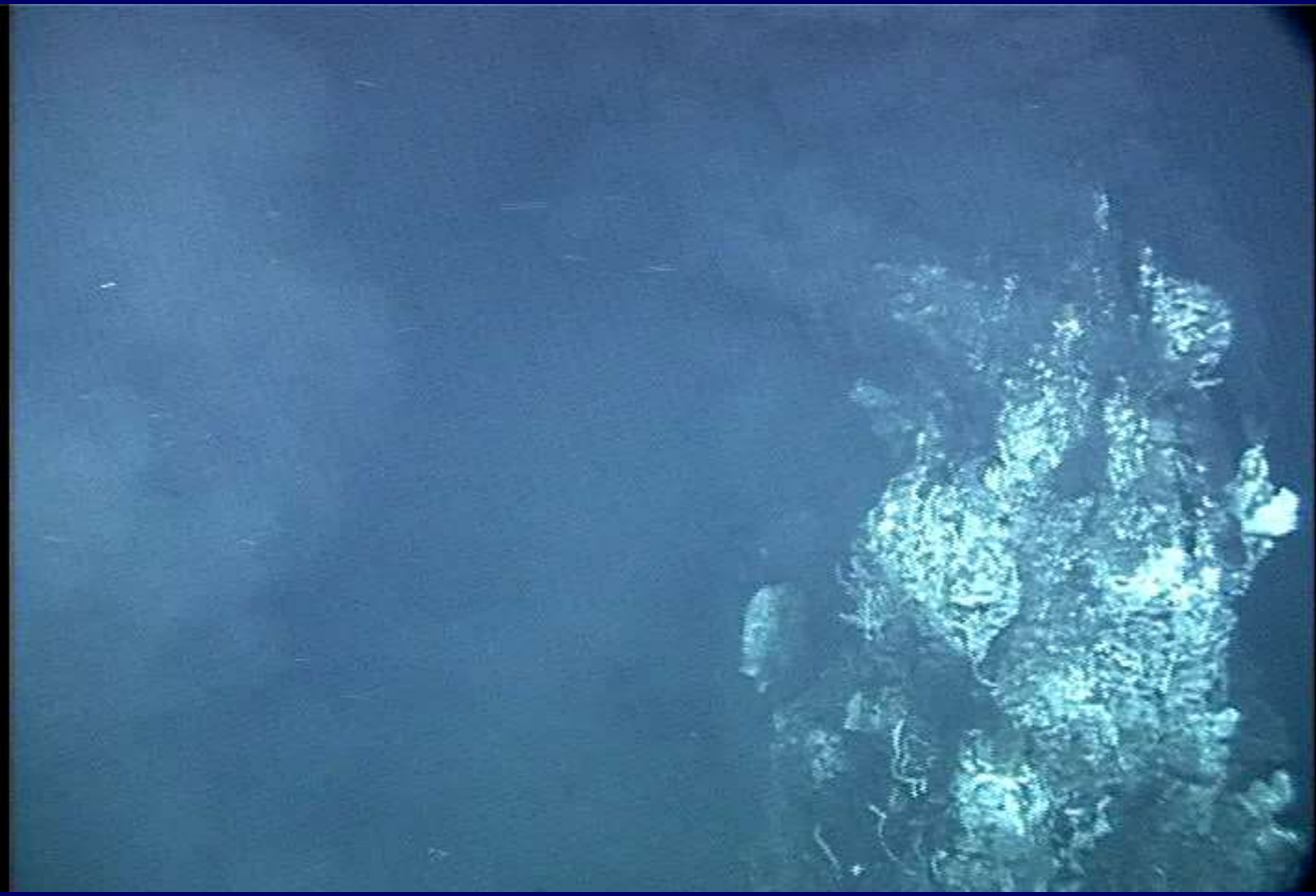
Summary of talk

- ☑ The ocean that protects us
- ☑ The ocean under threat
- ☑ **The ocean and human health**
- ☑ Exploration of marine microbes

The ocean and human health

- I[illegible]s:
  - [illegible]2, removal of CO2, temperature

- D[illegible]
  - [illegible]v[illegible]m of the coast
  - Consumption of c[illegible]
  - Swimming in pollu[illegible]
  - Exposure to toxin[illegible]
  - Source of new dru[illegible]
  - Disease transmission



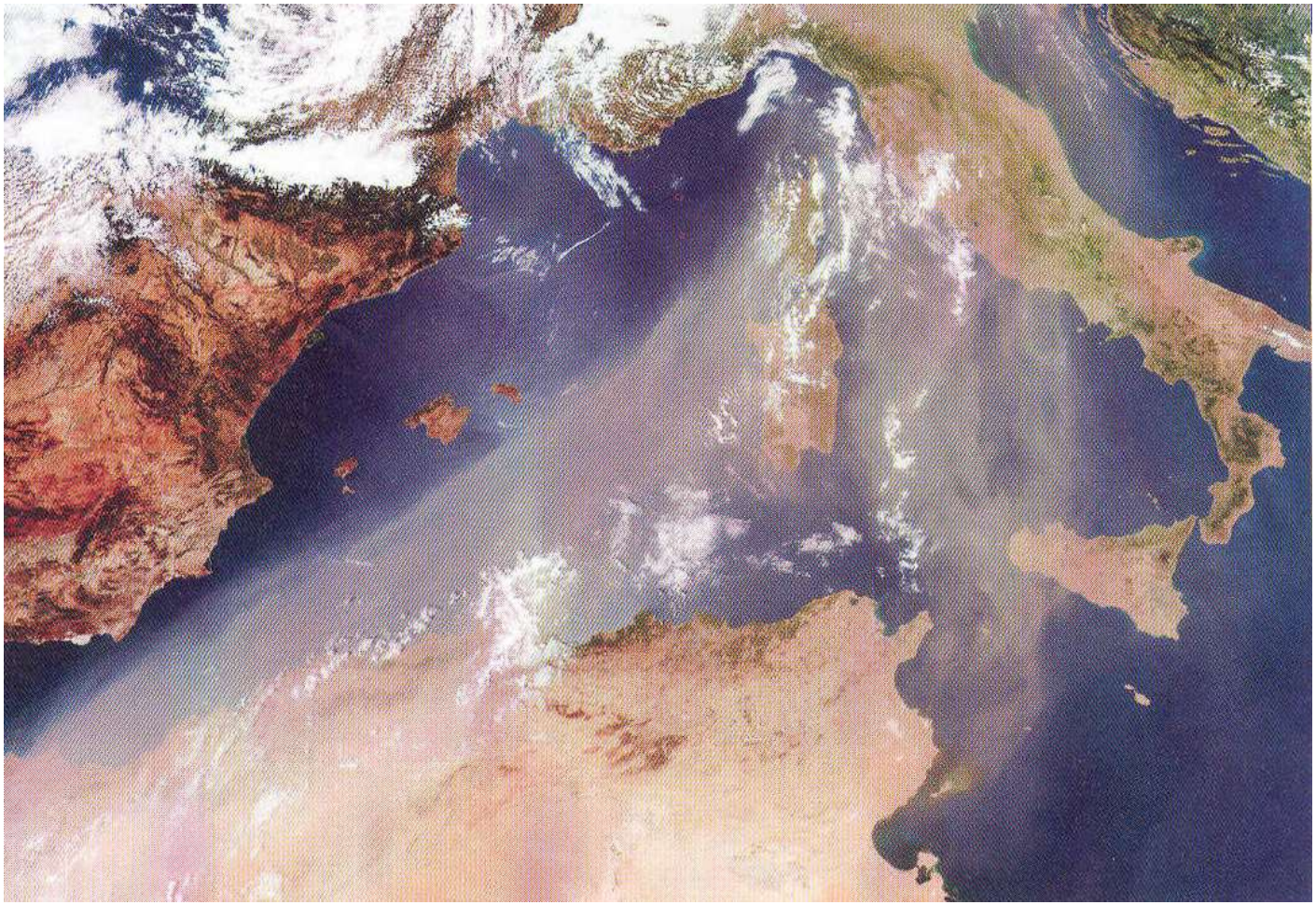
The ocean and human health

Indirect effects:

- Generation of O2, removal of CO2, temperature regulation

Direct effects:

- One half of the world's population lives within 100km of the coast
- Consumption of contaminated seafood
- Swimming in polluted water
- Exposure to toxins from harmul algal blooms
- Source of new drugs for medicine
- Disease transmission



Terra satellite image of a dust plume crossing the Mediterranean sea. Sand and dust from North Africa and the Sahara has blown north towards Italy in a large plume. This image was taken on 16 July 2003 by NASA's Moderate Resolution Imaging Spectroradiometer (MODIS).

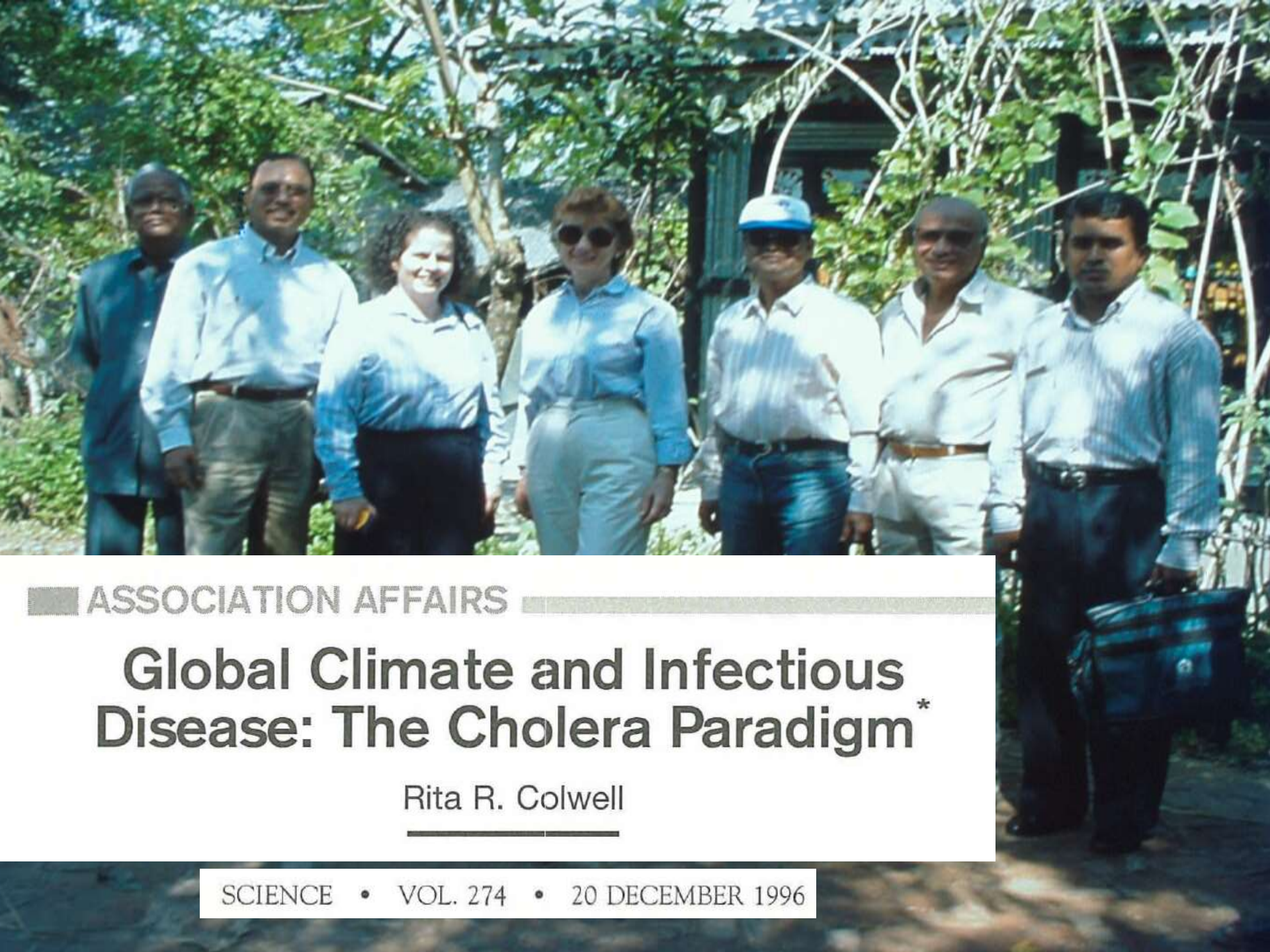
NASA/Science Photo Library

Atmospheric sample taken during a dust event in Mali, Africa, showing heavy growth of bacteria and fungi. The volume of air filtered was ~75 litres.

Photo Dale Griffin Microbiology Today (Nov 2005) p 182.

The Case of Cholera

Source: NSF/E. Myers



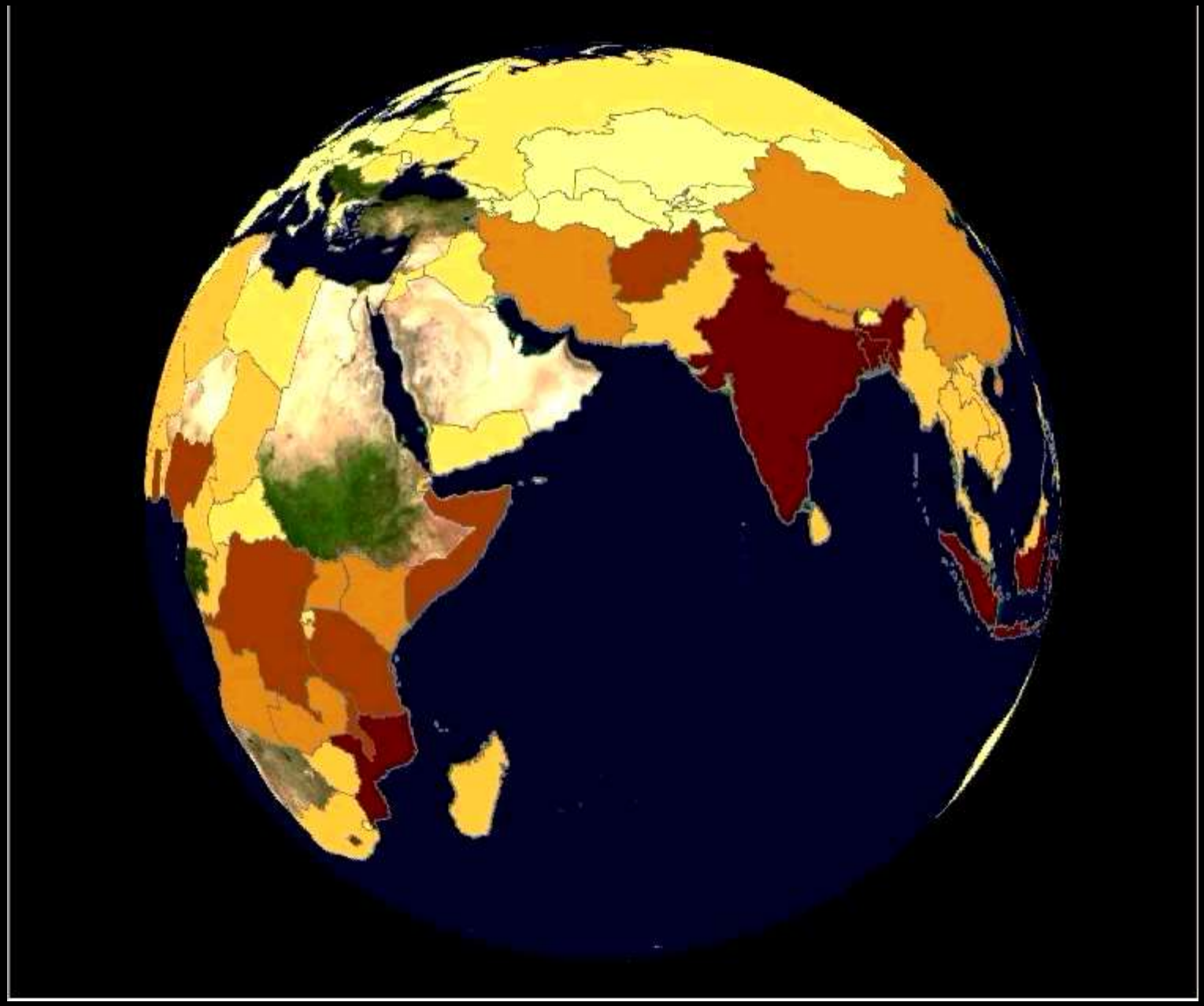
ASSOCIATION AFFAIRS

Global Climate and Infectious Disease: The Cholera Paradigm*

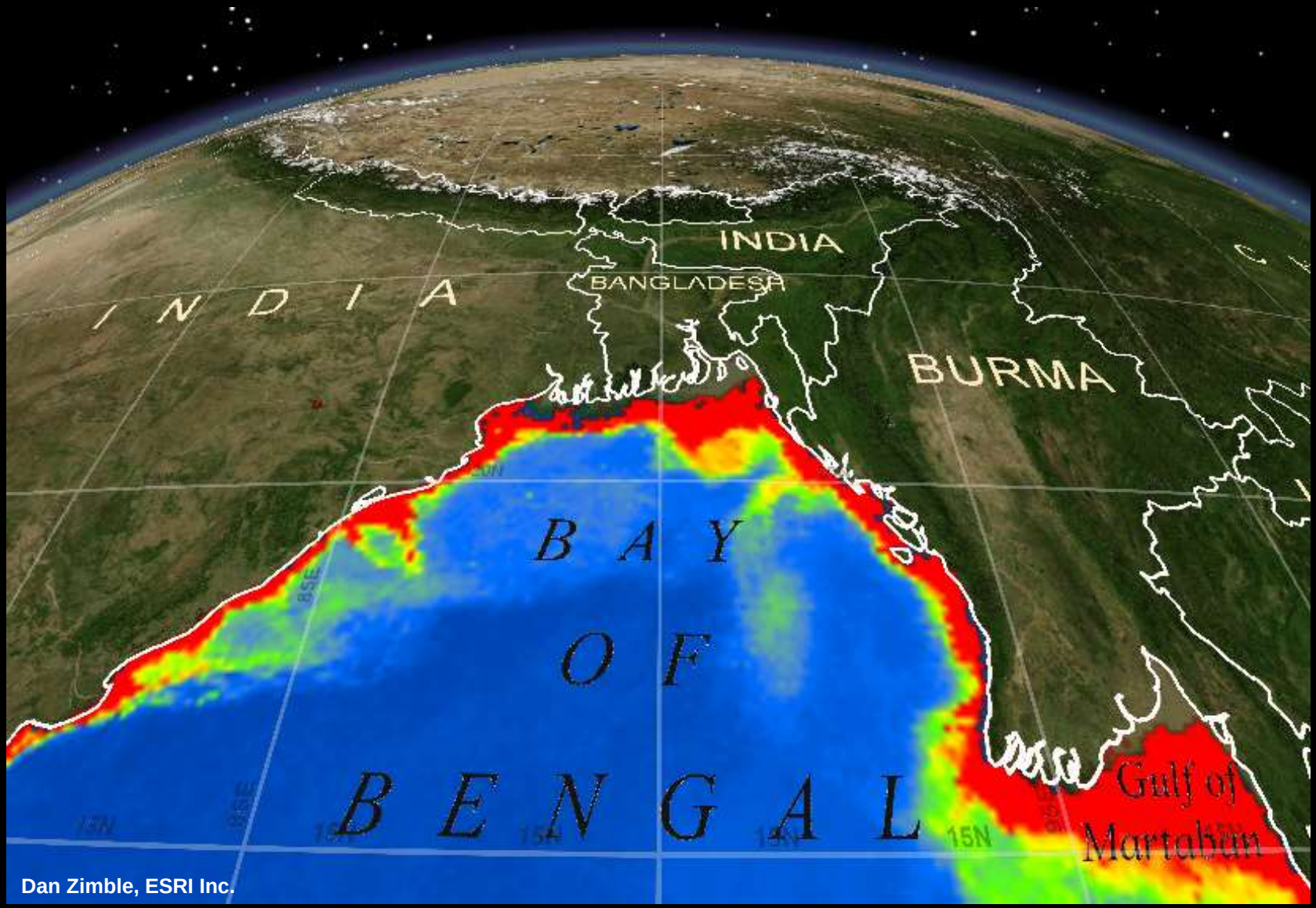
Rita R. Colwell

SCIENCE • VOL. 274 • 20 DECEMBER 1996

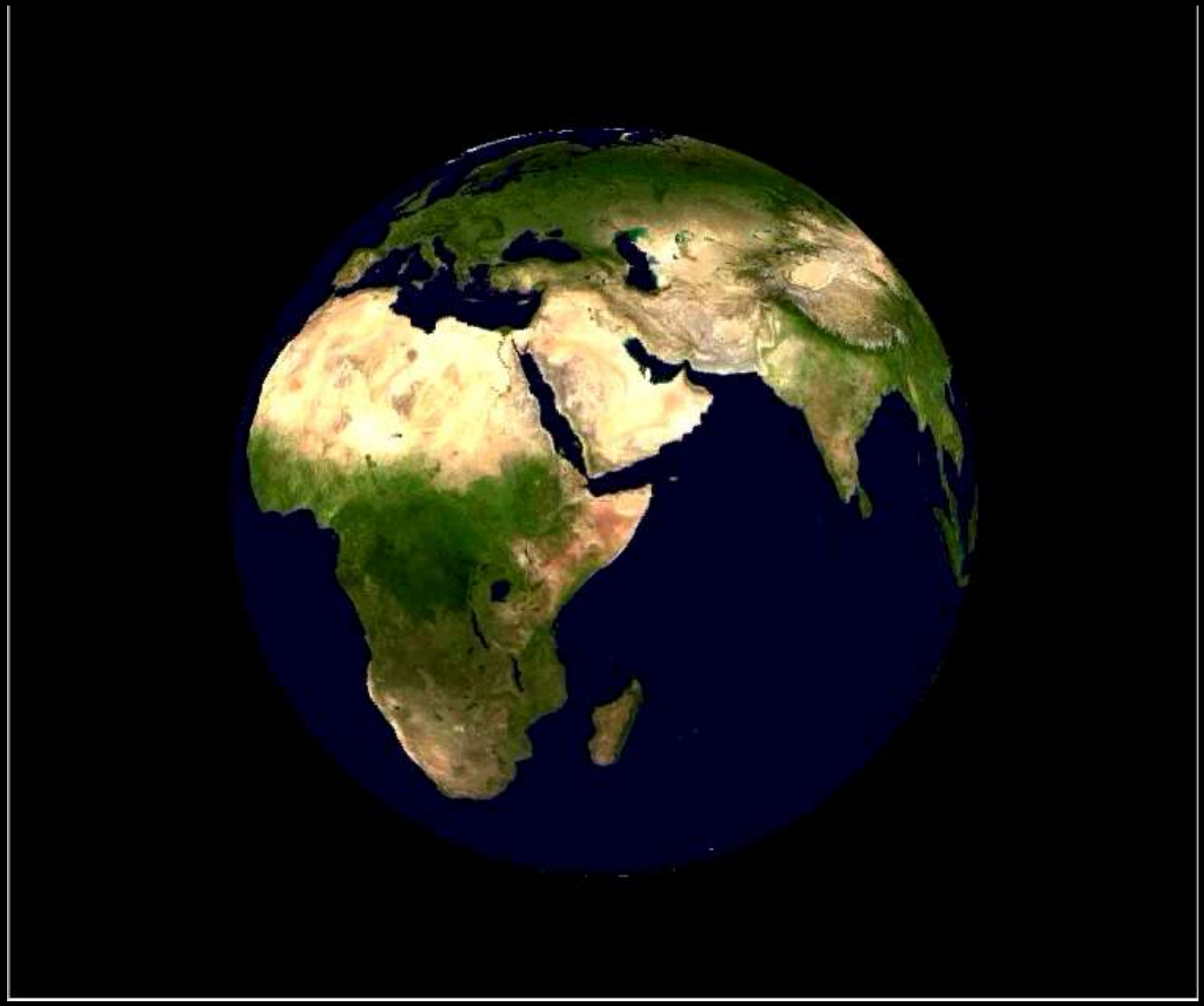
Vibrio cholerae



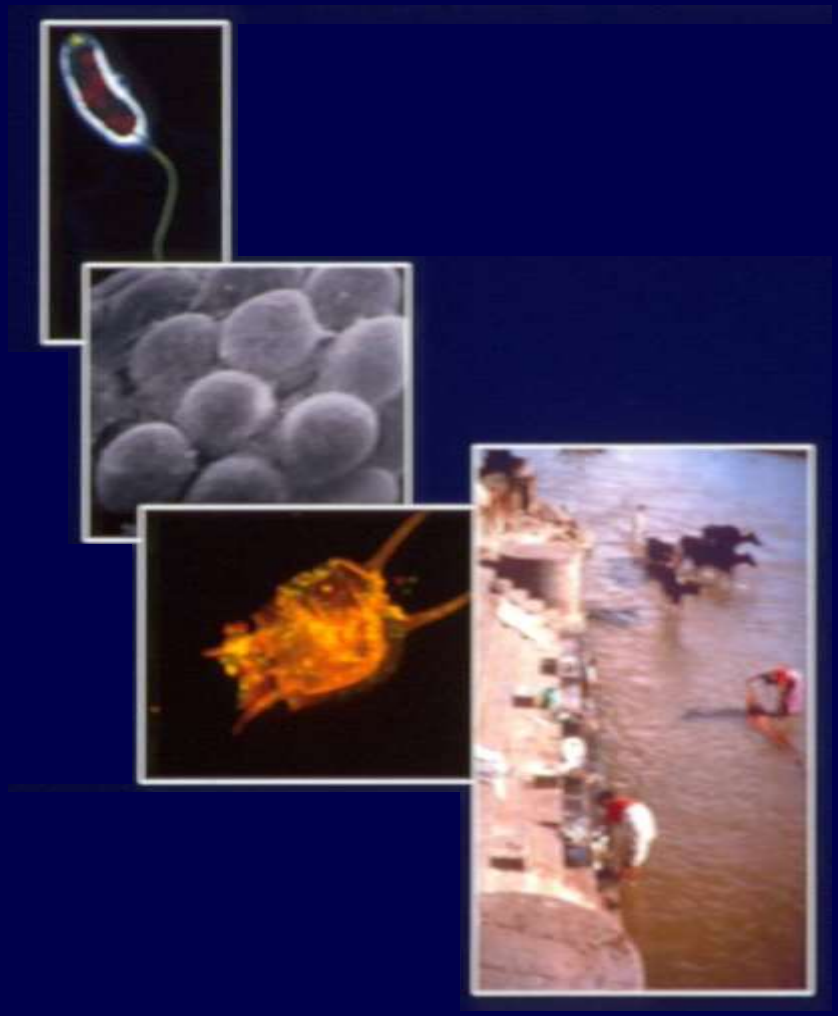
Environmental Signatures Related To Cholera Epidemics

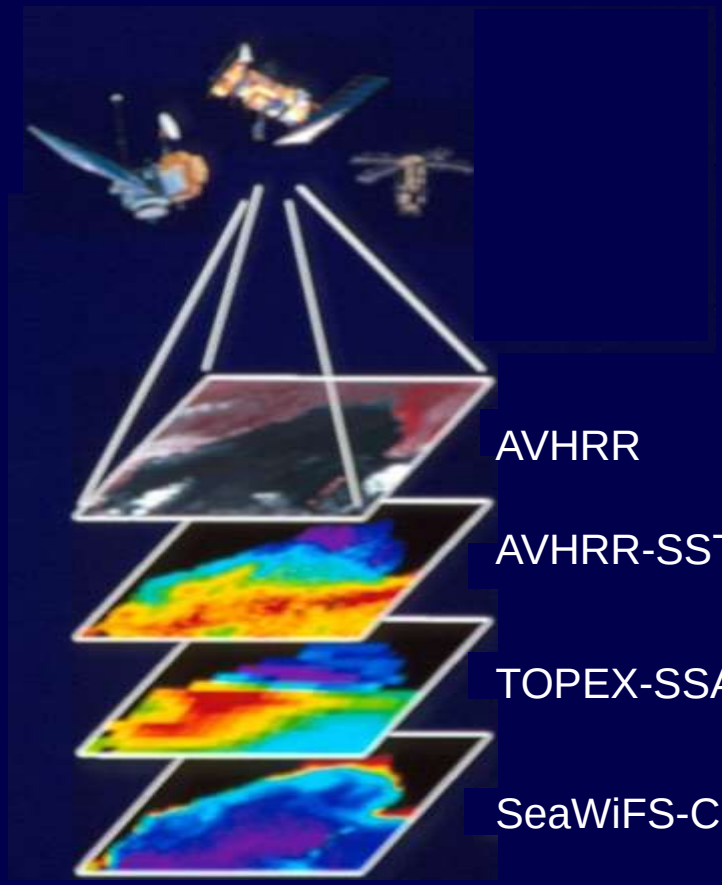


Dan Zimble, ESRI Inc.

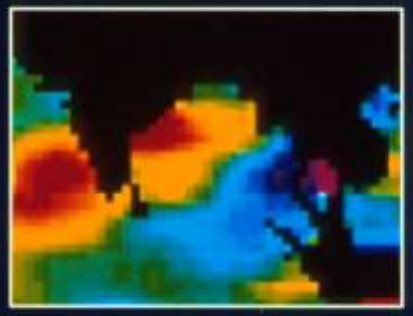


Monitoring the Temporal Patterns of Cholera Transmission Risk

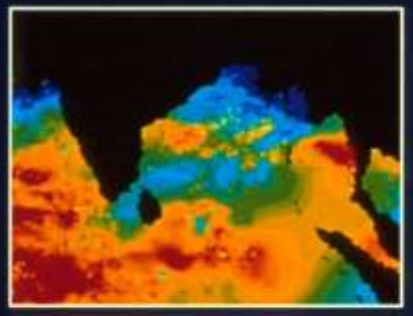




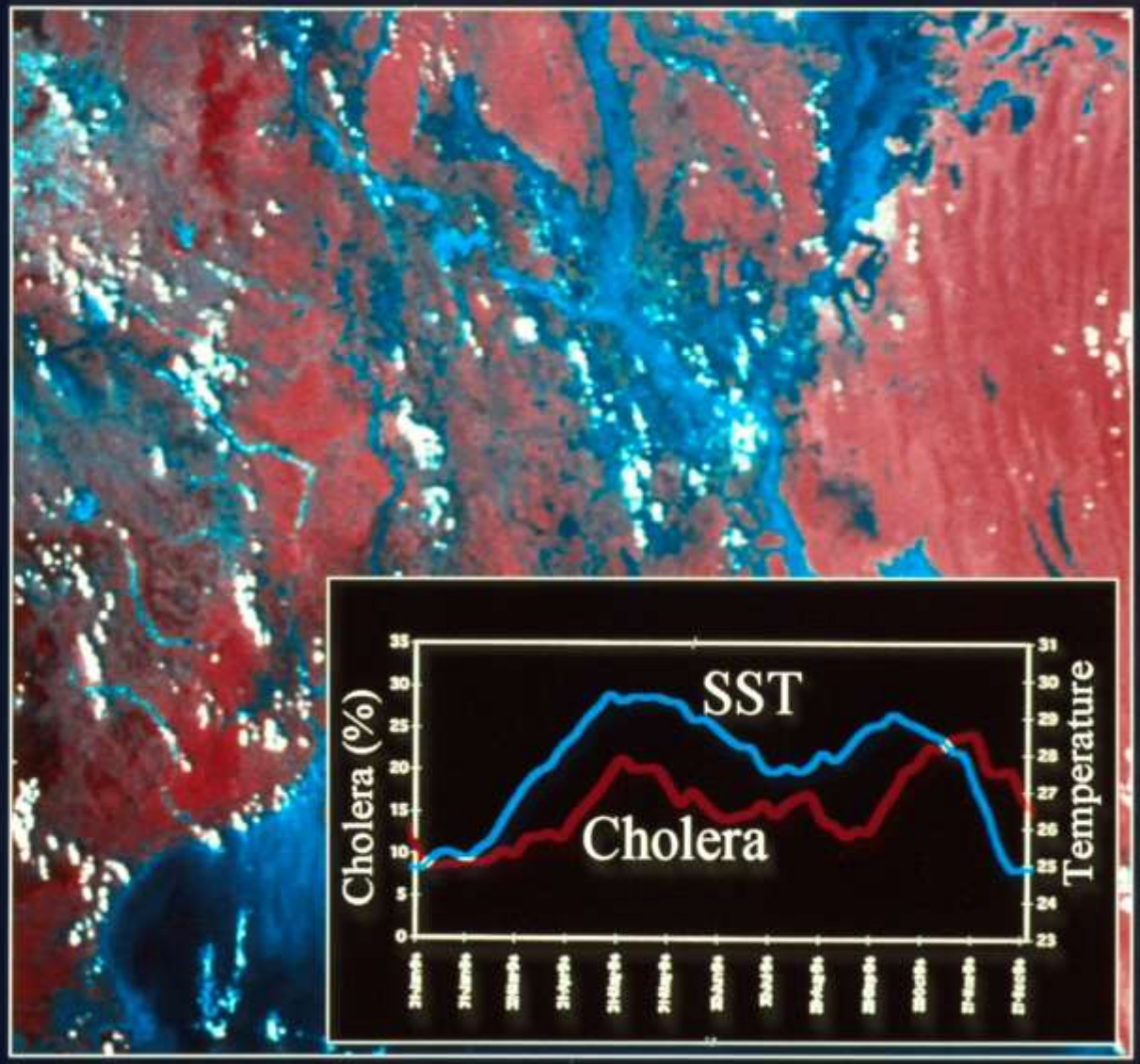
Cholera in the Bay of Bengal - Bangladesh



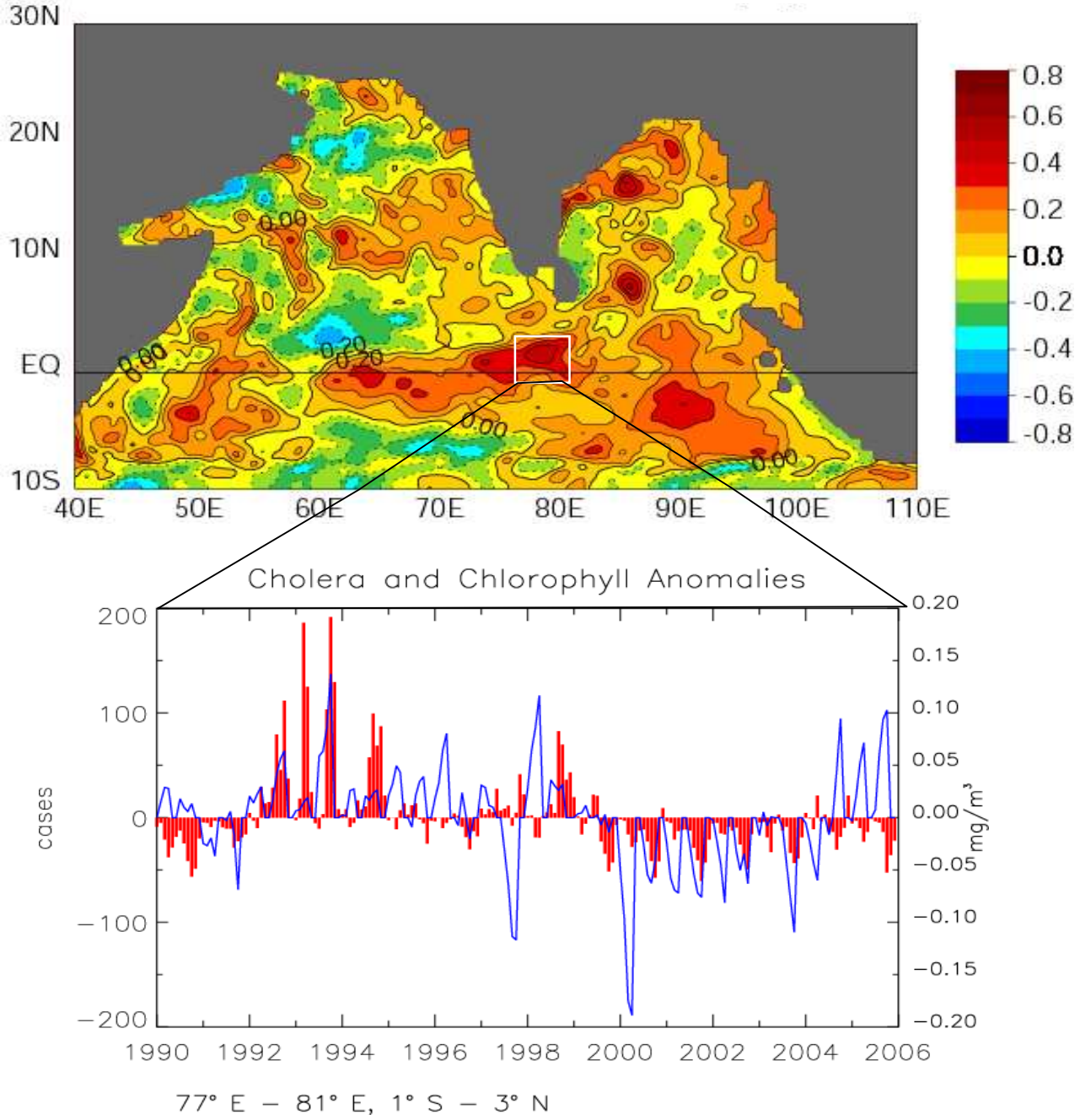
Sea Surface Temperature
March 1994



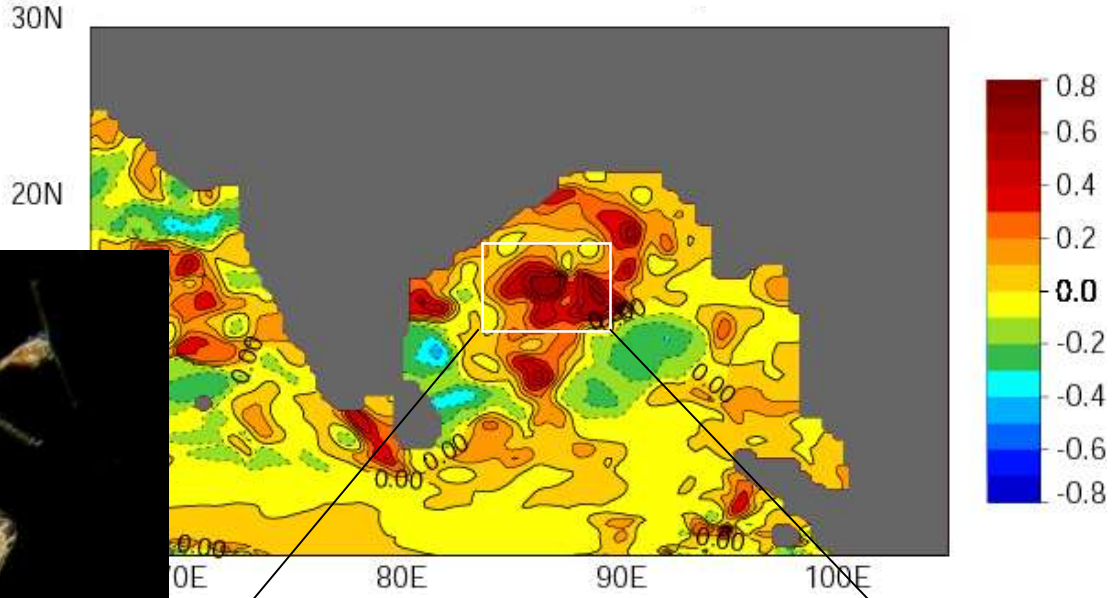
Sea Surface Height
Anomaly
March 1994

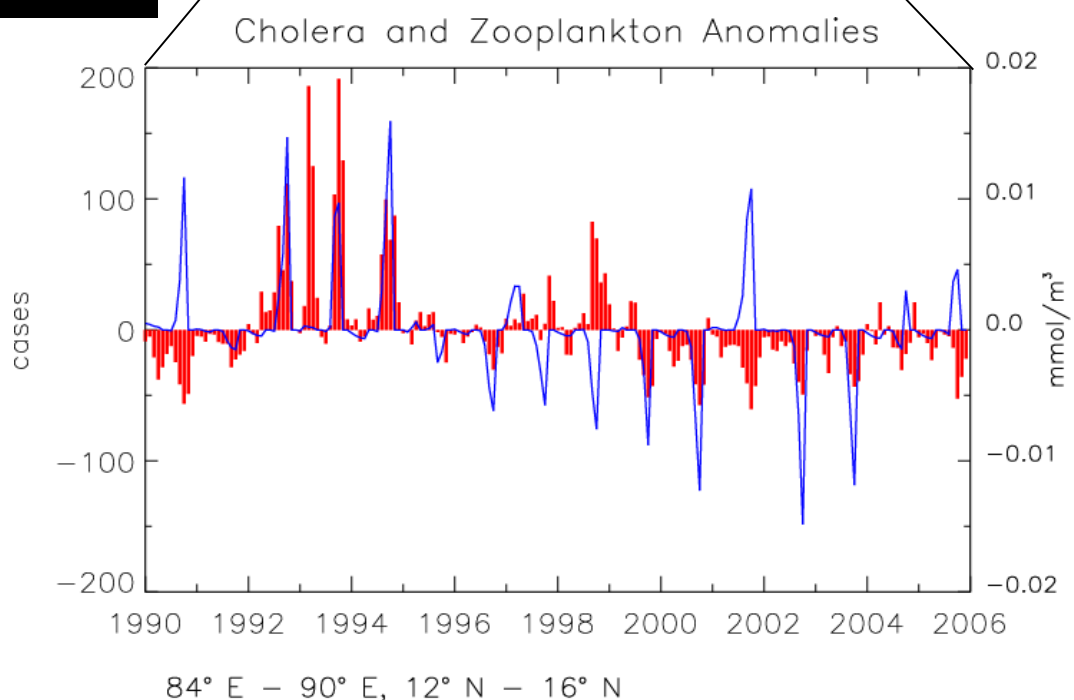


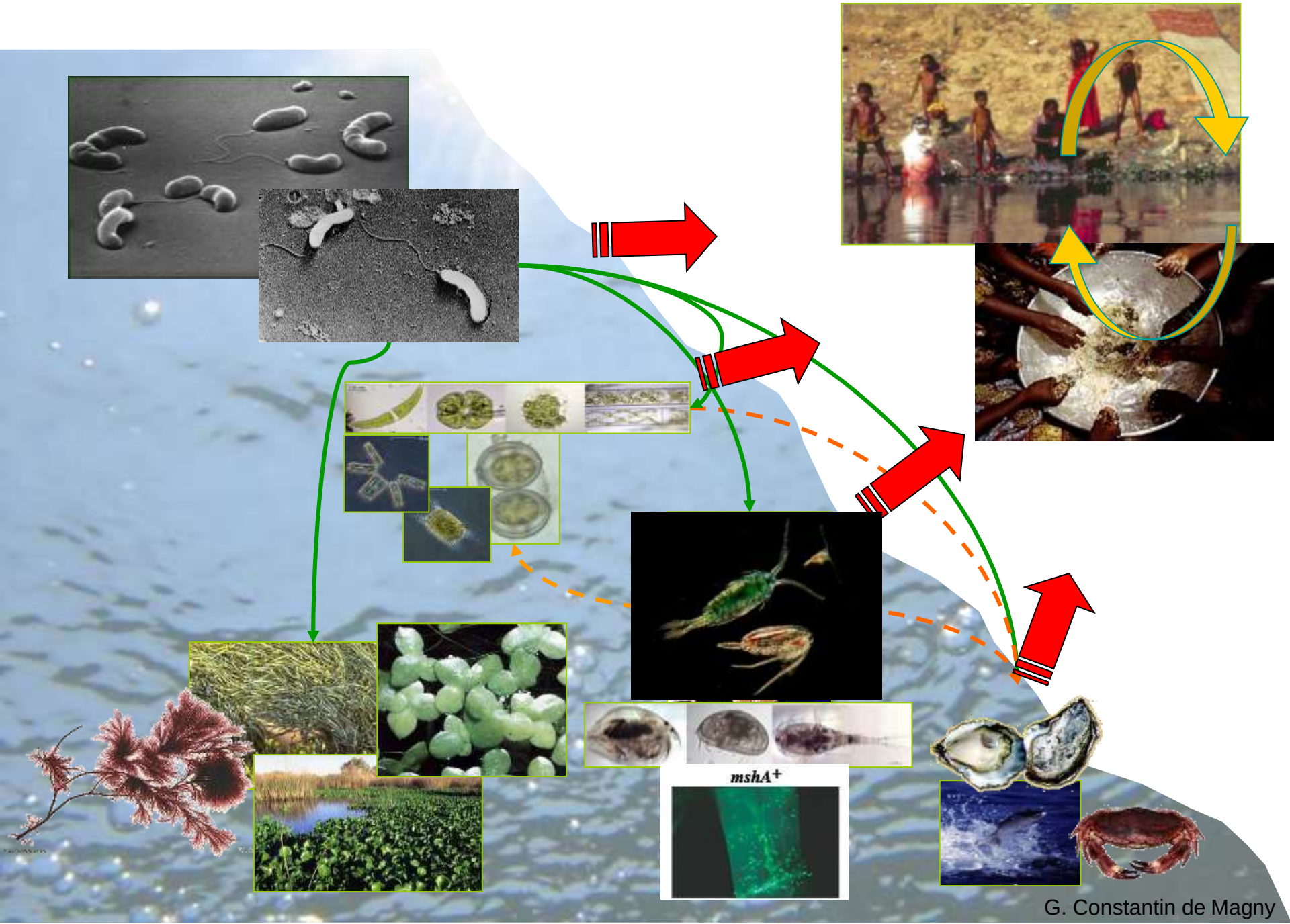
Correlation of Cholera and Chlorophyll Anomalies



Correlation of Cholera and Zooplankton Anomalies



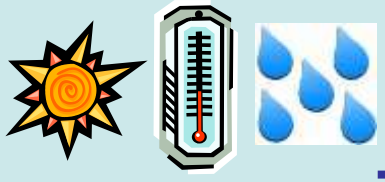




G. Constantin de Magny

Model for the Transmission of *Vibrio Cholerae* from the Environment to Humans

Physical & Chemical Characteristics of Water
- temperature
- sunlight
- rainfall
- pH
- dissolved oxygen
- salinity & nutrients



Biological Characteristics
- algae bloom
- phytoplankton bloom

Zooplankton bloom
(enters into non-culturable state)

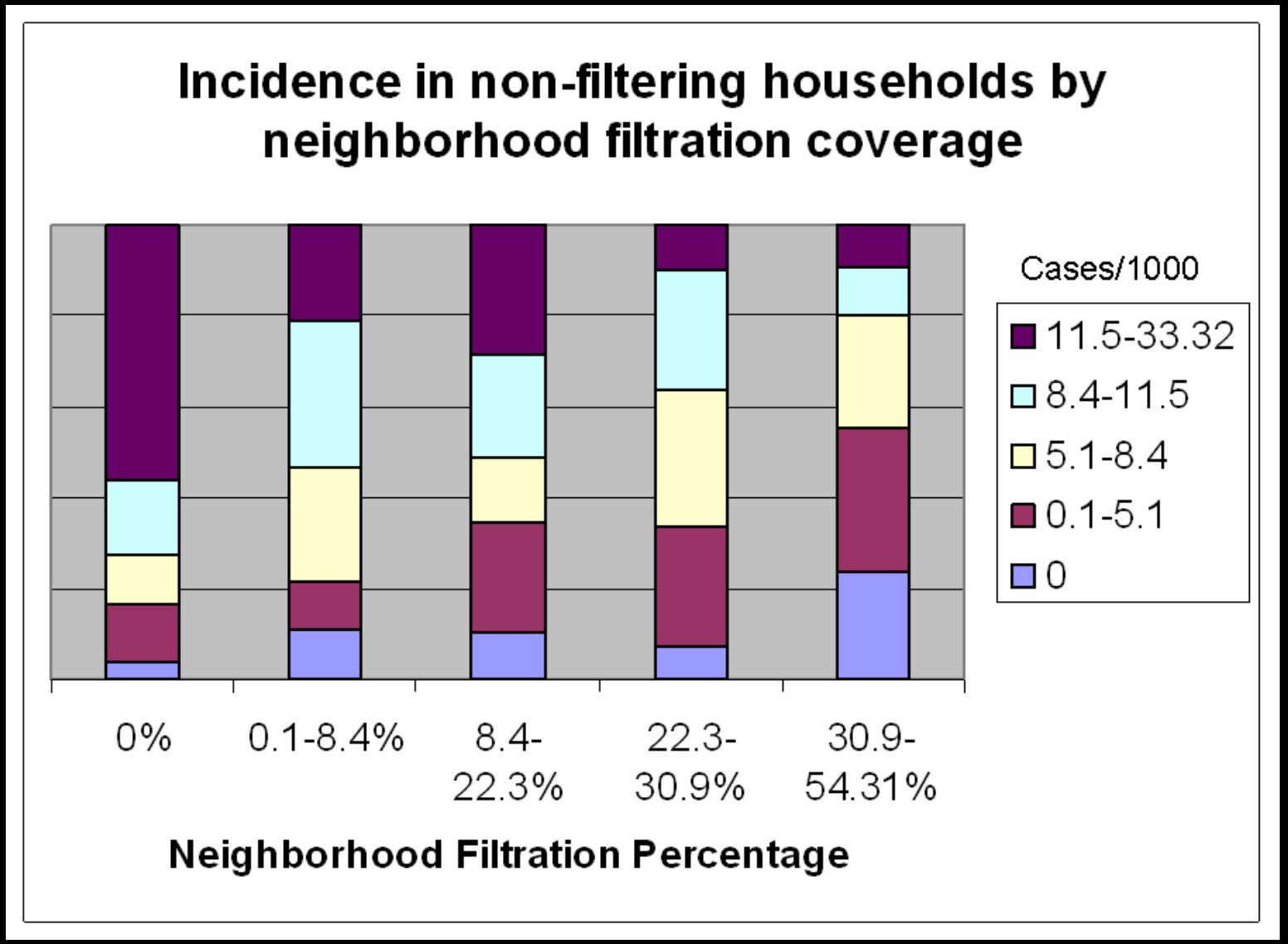
V. Cholerae
viable but non-culturable state in the water column & attached to particulates. Commensal or symbiotic relationships

Fecal shedding
returns *V. cholerae* to the water

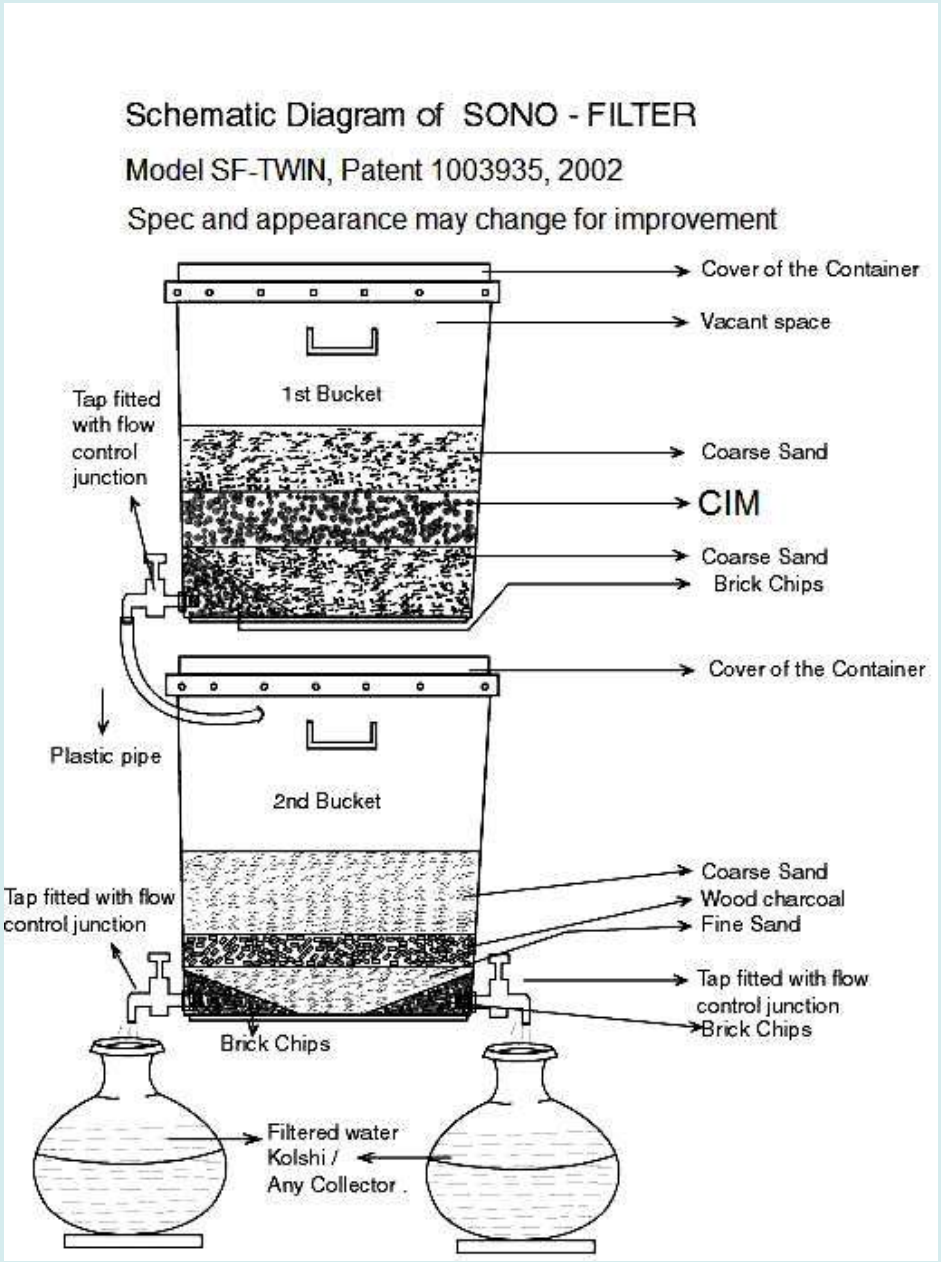
Transmission of *V. cholerae*
to humans via ingested water containing colonized copepods or other vectors.

Source: Dr. Rita Colwell

Incidence Proportion by Coverage Rate



Source: Dr. Abul Hussam



Arsenic Filter Based on Composite Iron Matrix

Flow: 20-60 liters per hour

As(Total) < 10 ppb (CL 95%)

As(III) < 2 ppb (CL 99.9%)

Life: 5 years minimum

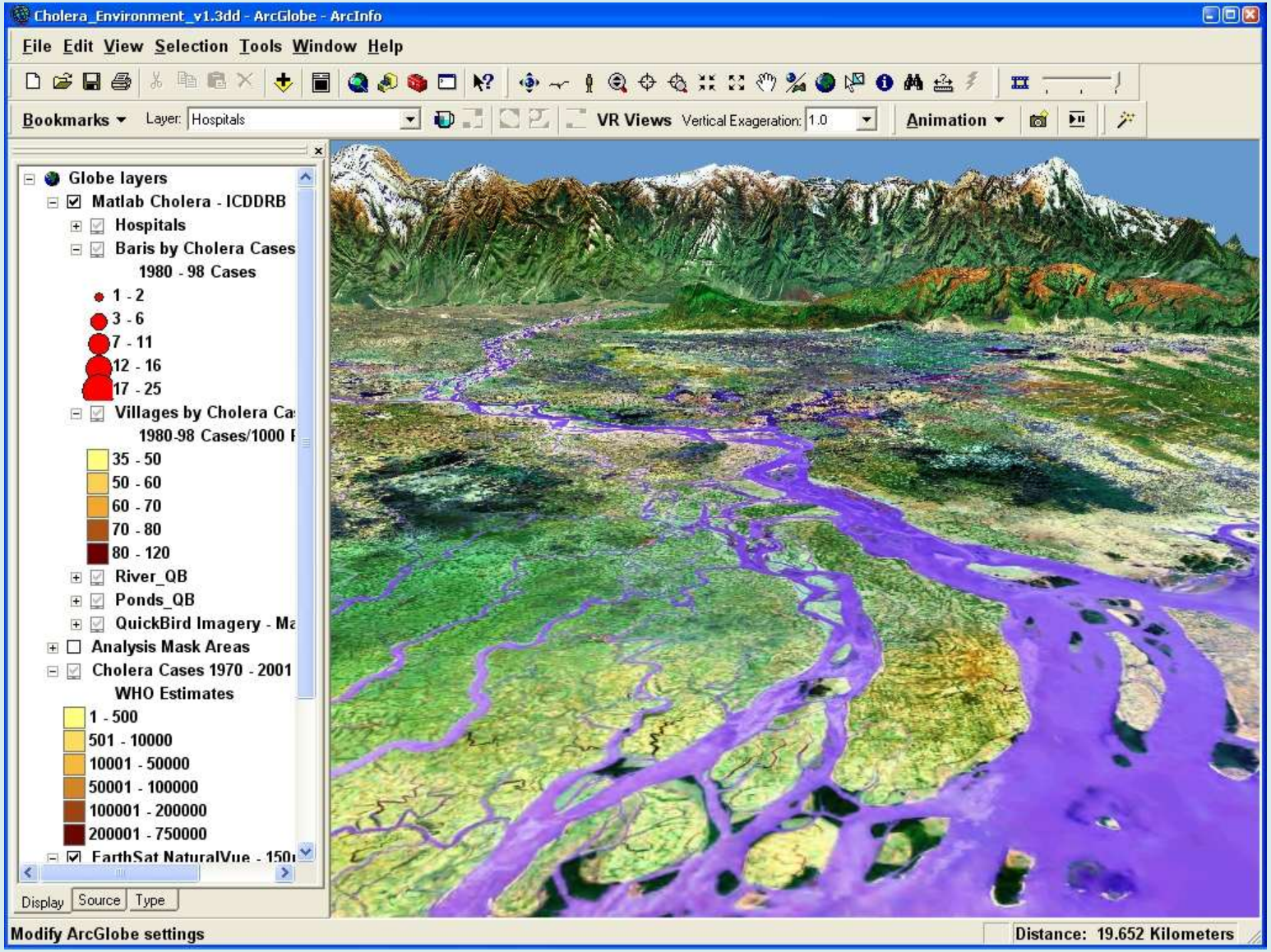
Maintenance: very low

Cost: US $35.00 -$40.00

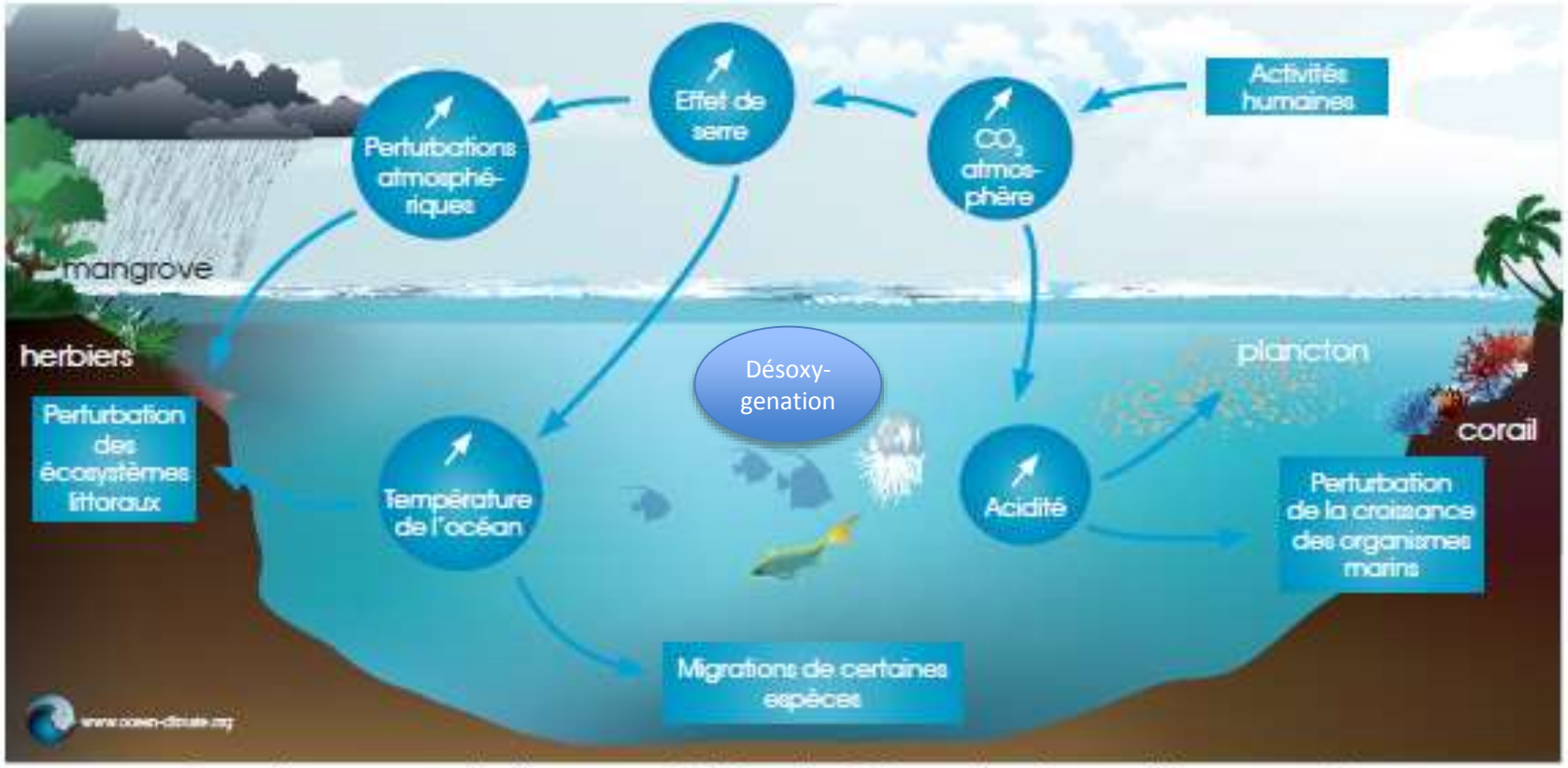
Waster: Completely nontoxic

Government approved and ETVAM program verified

Bangladesh

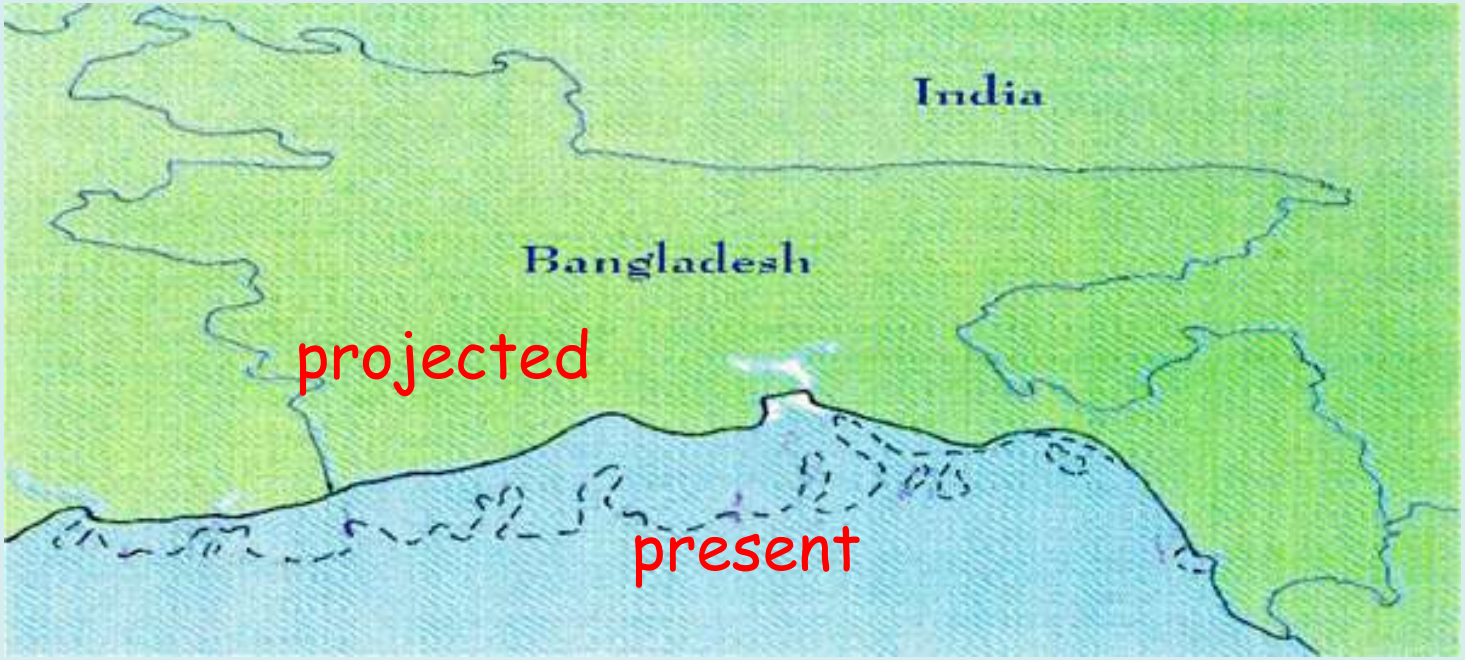

Cholera_Environment_v1.3dd - ArcGlobe - ArcInfo
File Edit View Selection Tools Window Help
Bookmarks
Layer: Hospitals
VR Views
Vertical Exageration: 1.0
Animation
Globe layers
Matlab Cholera - ICDDRB
Hospitals
Baris by Cholera Cases
1980 - 98 Cases
1 - 2
3 - 6
7 - 11
12 - 16
17 - 25
Villages by Cholera Ca
1980-98 Cases/1000
35 - 50
50 - 60
60 - 70
70 - 80
80 - 120
River_QB
Ponds_QB
QuickBird Imagery - Ma
Analysis Mask Areas
Cholera Cases 1970 - 2001
WHO Estimates
1 - 500
501 - 10000
10001 - 50000
50001 - 100000
100001 - 200000
200001 - 750000
Display
Source
Type
Modify ArcGlobe settings
Distance: 19.652 Kilometers

An ocean under pressure



Conséquences de l'augmentation du CO_2 sur les écosystèmes marins

Increased risk of floods, potentially displacing tens of millions of people, due to sea level rise and heavy rainfall events, especially in small island states and low-lying deltaic areas.



Bangladesh is projected to lose about 17% of its land area with a sea level rise of one meter - very difficult to adapt due to lack of adaptive capacity

Summary of talk

- ☑ The ocean that protects us
- ☑ The ocean under threat
- ☑ The ocean and human health
- ☑ **Exploration of marine microbes**

TARA OCEANS

Co-directed by
Etienne Bourgois
and Eric Karsenti

tara EXPEDITIONS www.taraexpeditions.org agnès b.

EMBL

cnrs

cea

TARA FOUNDATION FOR MARINE RESEARCH

agnès b.

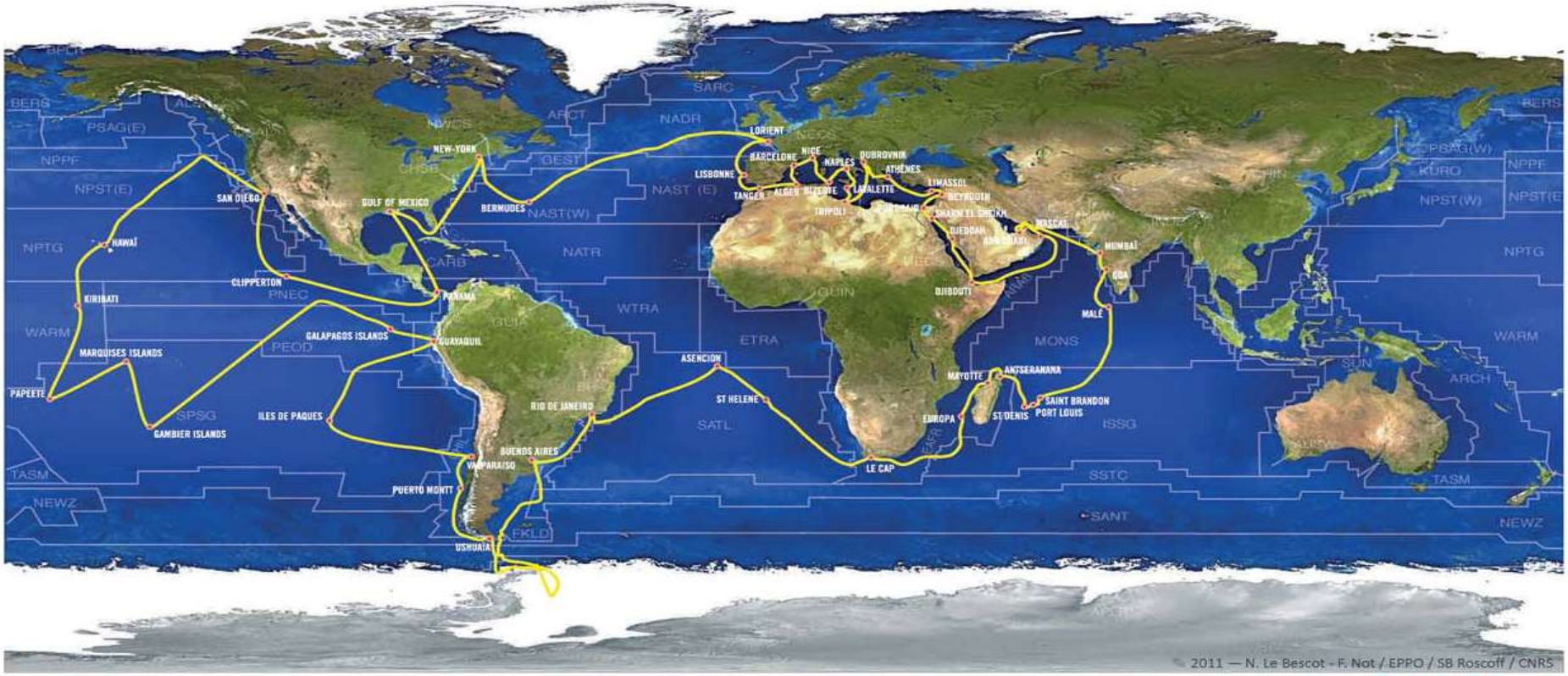
Foundation VEOLIA ENVIRONNEMENT

Région BRETAGNE

WORLD COURIER

FONDATION EDF DiversiTerre

TARA OCEANS
2009 - 2012



TARA OCEANS

TARA OCEANS POLAR CIRCLE
www.taraexpeditions.org

THE TARA OCEANS POLAR CIRCLE EXPEDITION
MAY – DECEMBER 2013

Science May 22 2015


SPECIAL SECTION

Tara Oceans studies plankton at

PLANETARY SCALE


SPECIAL SECTION TARA OCEANS

Eukaryotic plankton diversity in the sunlit ocean

Patterns and ecological drivers of ocean viral communities

Structure and function of the global ocean microbiome

Determinants of community structure in the global plankton interactome

Plankton diversity

Environmental characteristics of Agulhas rings affect interocean plankton transport

TARA OCEANS

All *Tara* Oceans data are public

40 million genes

Largest-ever DNA sequencing effort for ocean science.

Genetic sequences collected could represent tens of thousands of new species and ecosystem interactions.

Considering the size of the world's ocean, there is much, much more to discover.

11,535 gigabytes

Size of the *Tara* datasets in the European Nucleotide Archive as of May 2015. This represents 12,581 gigabases - roughly equivalent to 135 fully sequenced human genomes.

Unlimited

Potential to discover new knowledge about life in the world's ocean.

Tara data: www.ebi.ac.uk/services/tara-oceans-data

EMBL-EBI

Ocean Microbial Reference Gene Catalog

Global representation

68 stations

3 depths

sequence

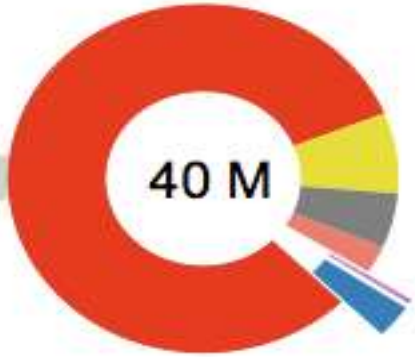
40 million genes : Gene catalog is close to saturation

1,000 times more sequence than GOS

23,000 times more sequence than human genome

Ocean microbiome
68 sites
243 samples
111.5 M predicted genes
+ 26 M external genes

Clustering

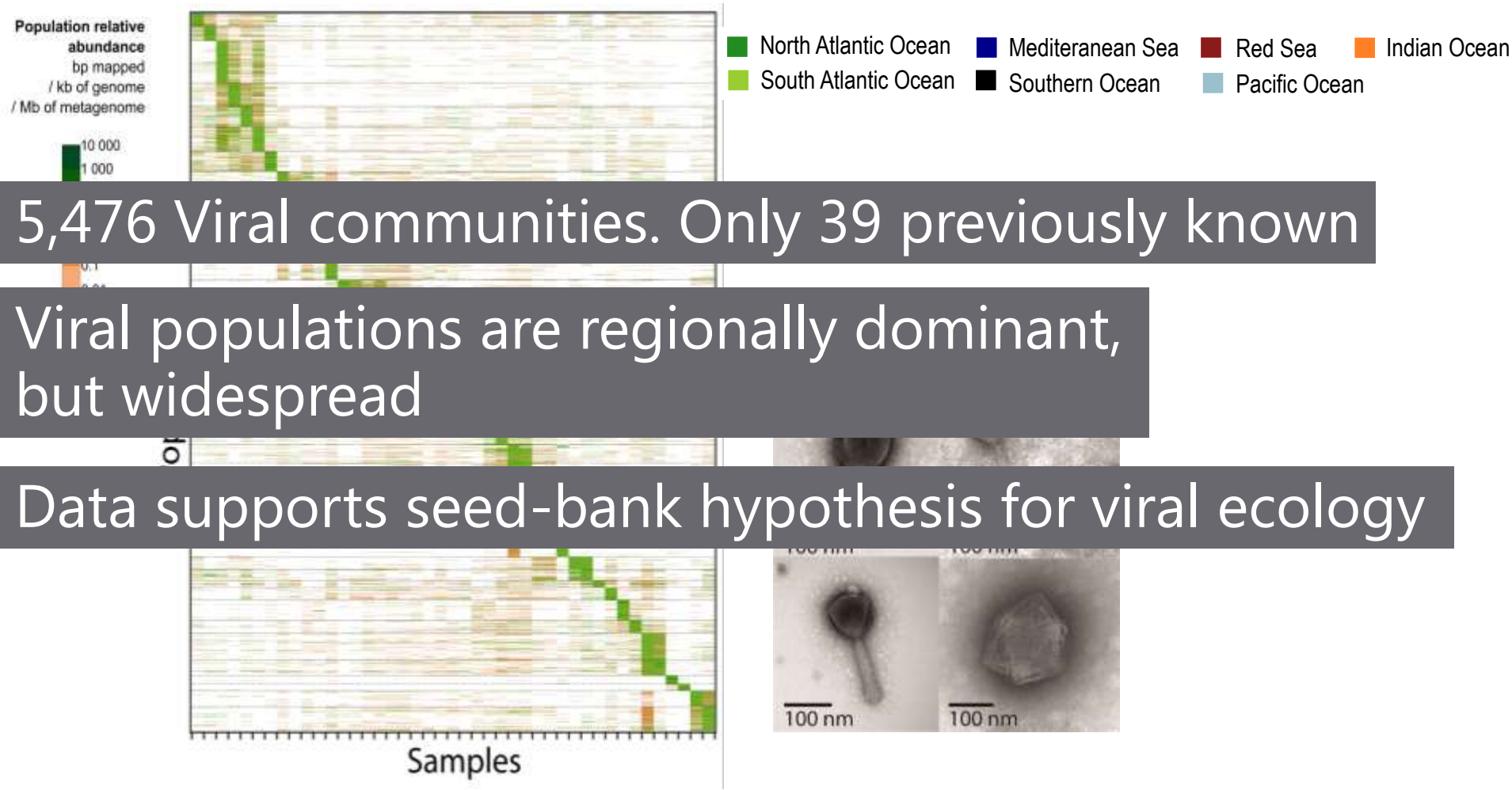


81.38% TARA
7.49% GOS
5.11% TARA/GOS
2.48% MetaG (other)
0.44% RefG with MetaG
3.11% RefG

Of 40M genes, 28% no annotation, rest (60%) mainly bacteria

Sunagawa et al. Science (2015)

Assessment of global viral communities



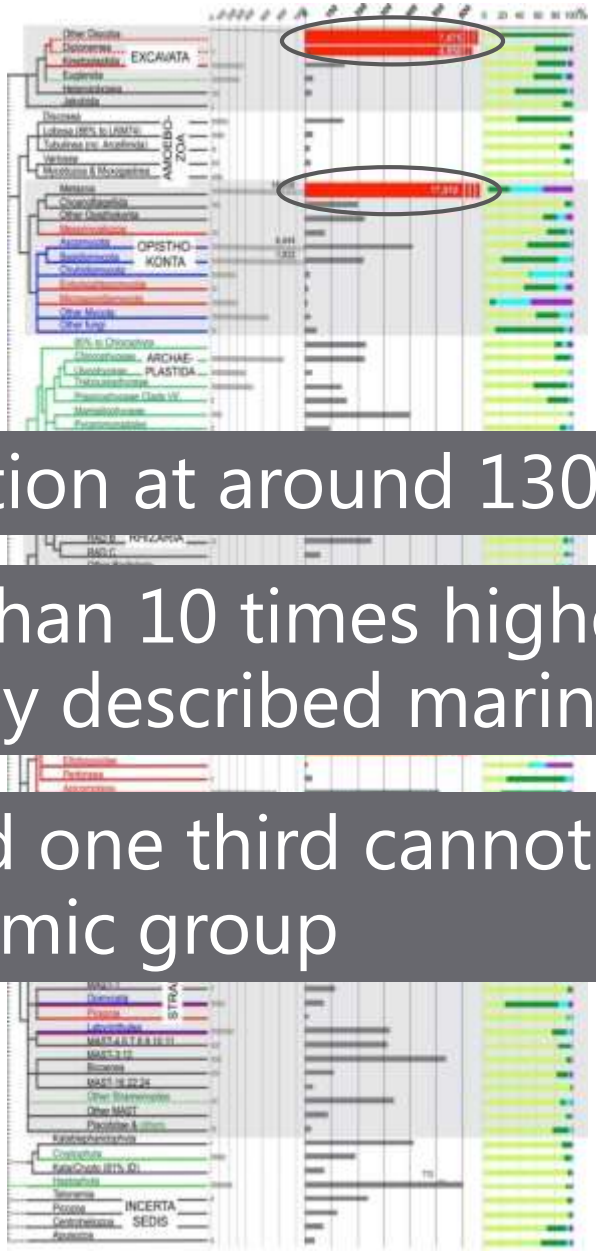
5,476 Viral communities. Only 39 previously known

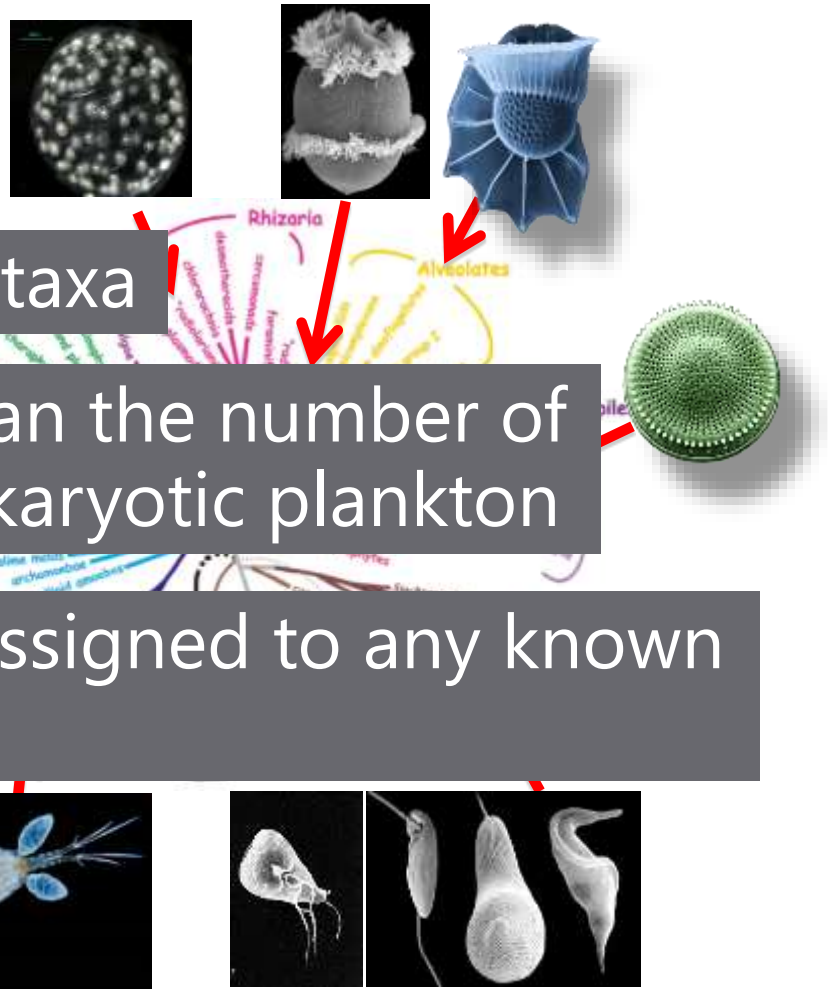
Viral populations are regionally dominant, but widespread

Data supports seed-bank hypothesis for viral ecology

Brum, Ignacio-Espinoza, Roux, *et al.* Science (2015)

A new world of marine protists



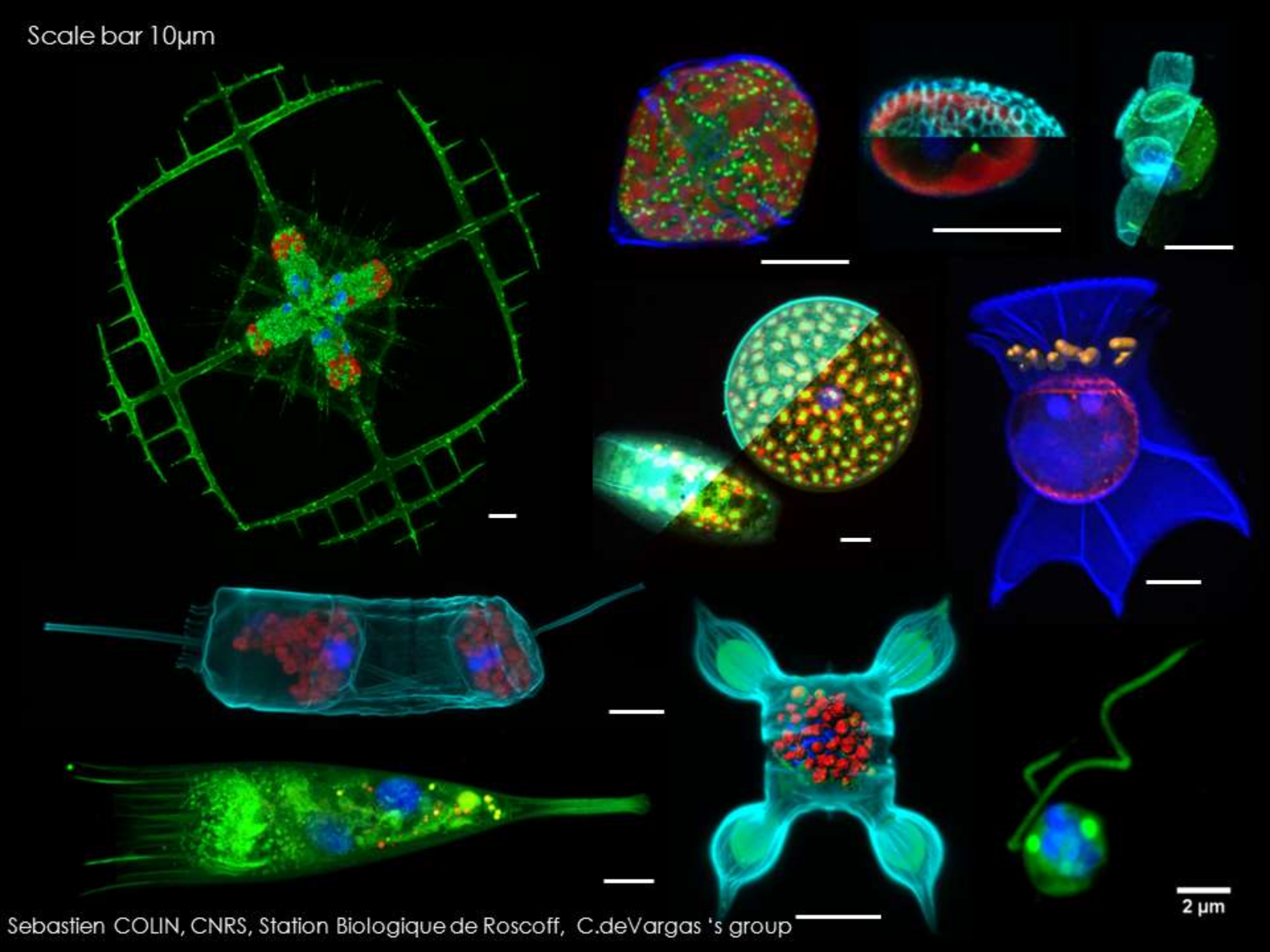


Saturation at around 130,000 taxa

More than 10 times higher than the number of formally described marine eukaryotic plankton

Around one third cannot be assigned to any known taxonomic group

de Vargas et al. Science 2015


Scale bar 10µm
2 µm
Sebastien COLIN, CNRS, Station Biologique de Roscoff, C.deVargas 's group

Merci !