Les Microbes Marqueurs de la Santé des Océans

Chris Bowler
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Scientific Director of *Tara* Oceans

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Inserm

TARA OCEANS

1794
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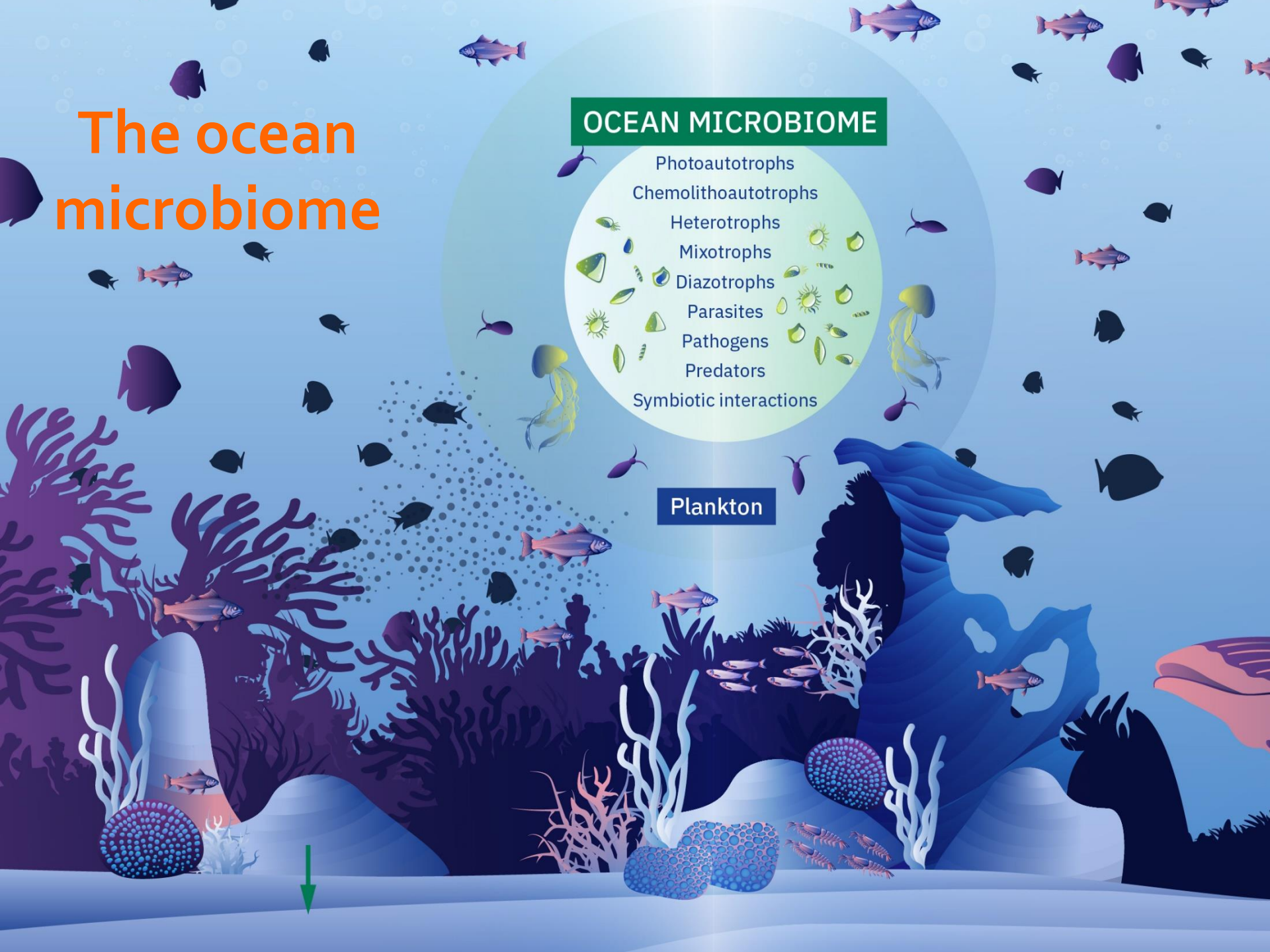
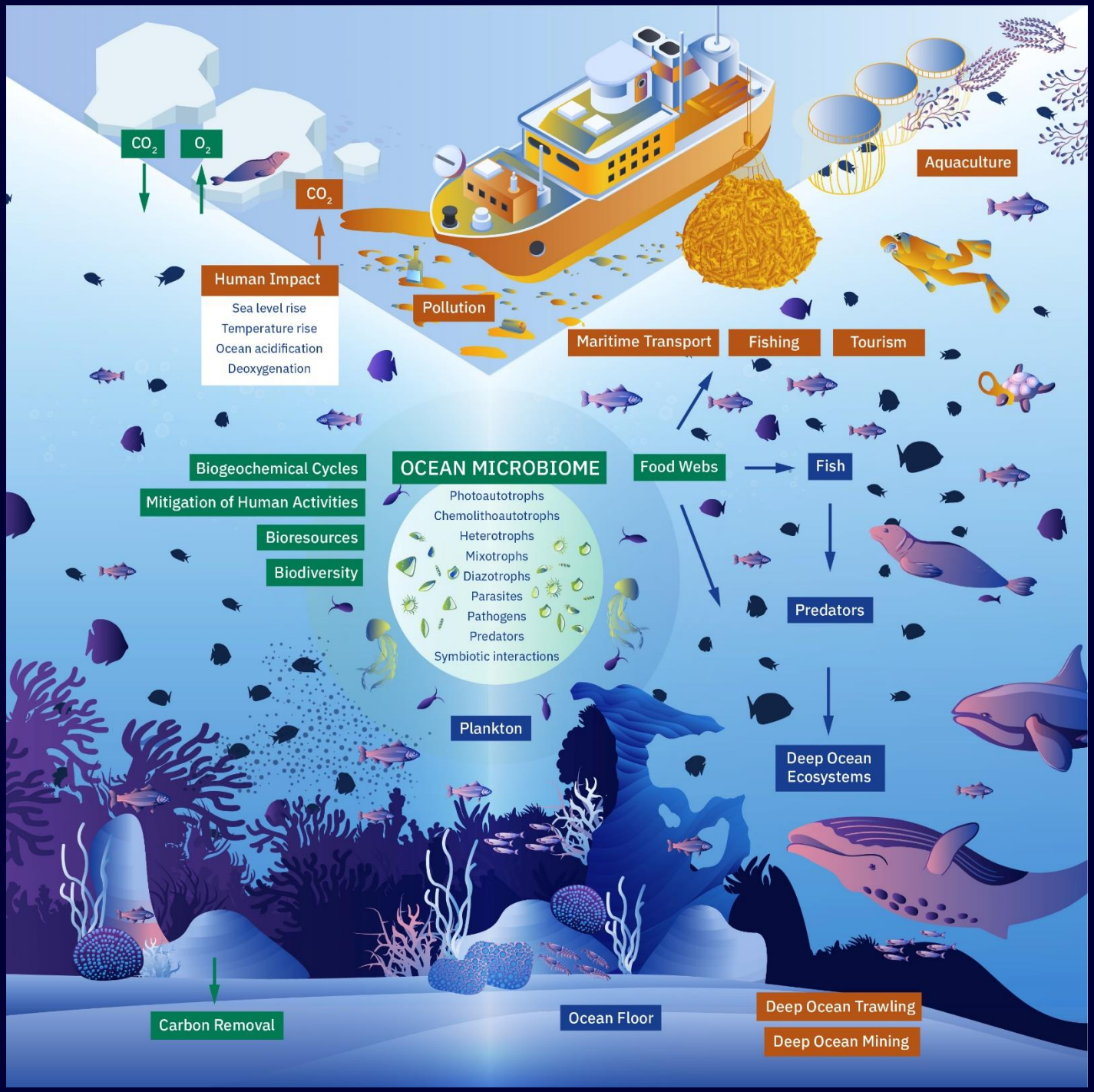
PSL
RESEARCH UNIVERSITY

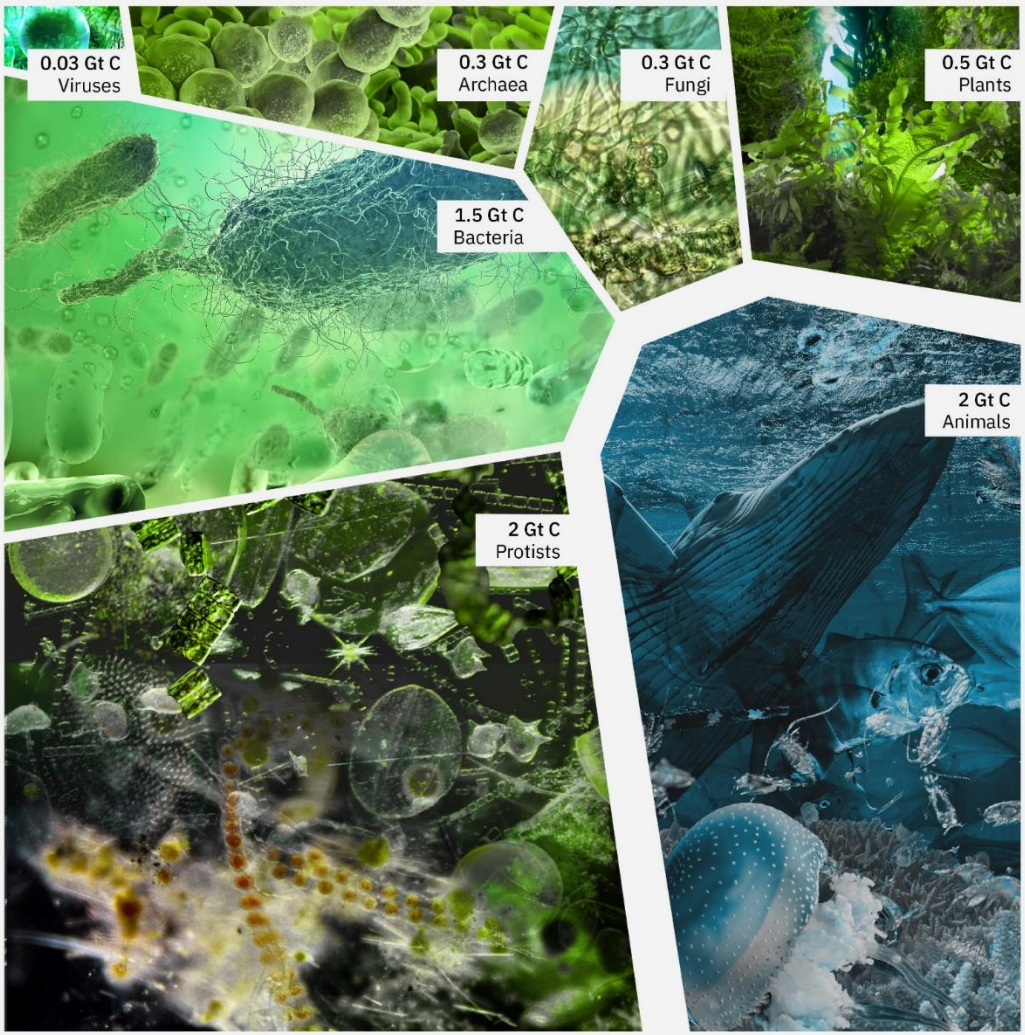
The ocean microbiome



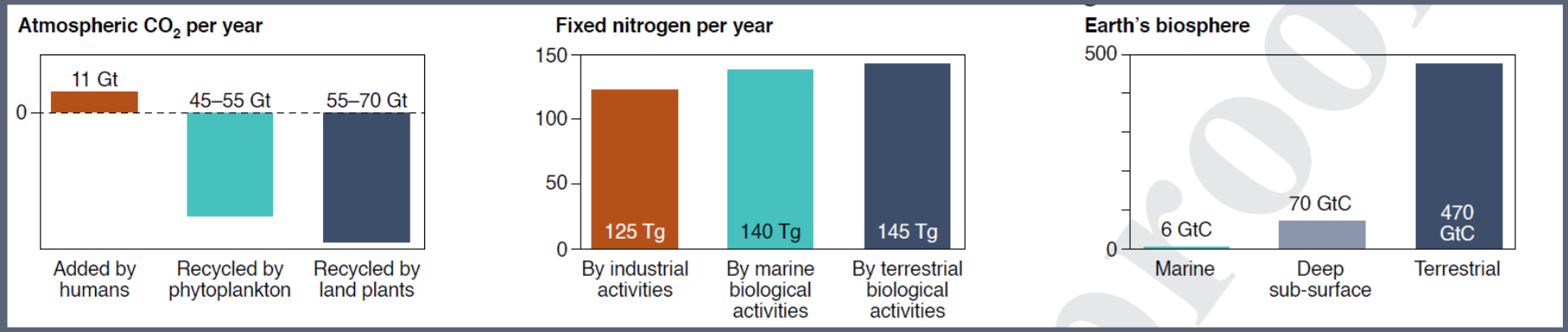
The ocean microbiome assures the well-being of our ocean



Microscopic organisms respresent >60% of the biomass in the ocean



Marine biomass is very small, but its role in carbon and nitrogen fixation is equivalent to that on land



What does the ocean have to do with human health ?

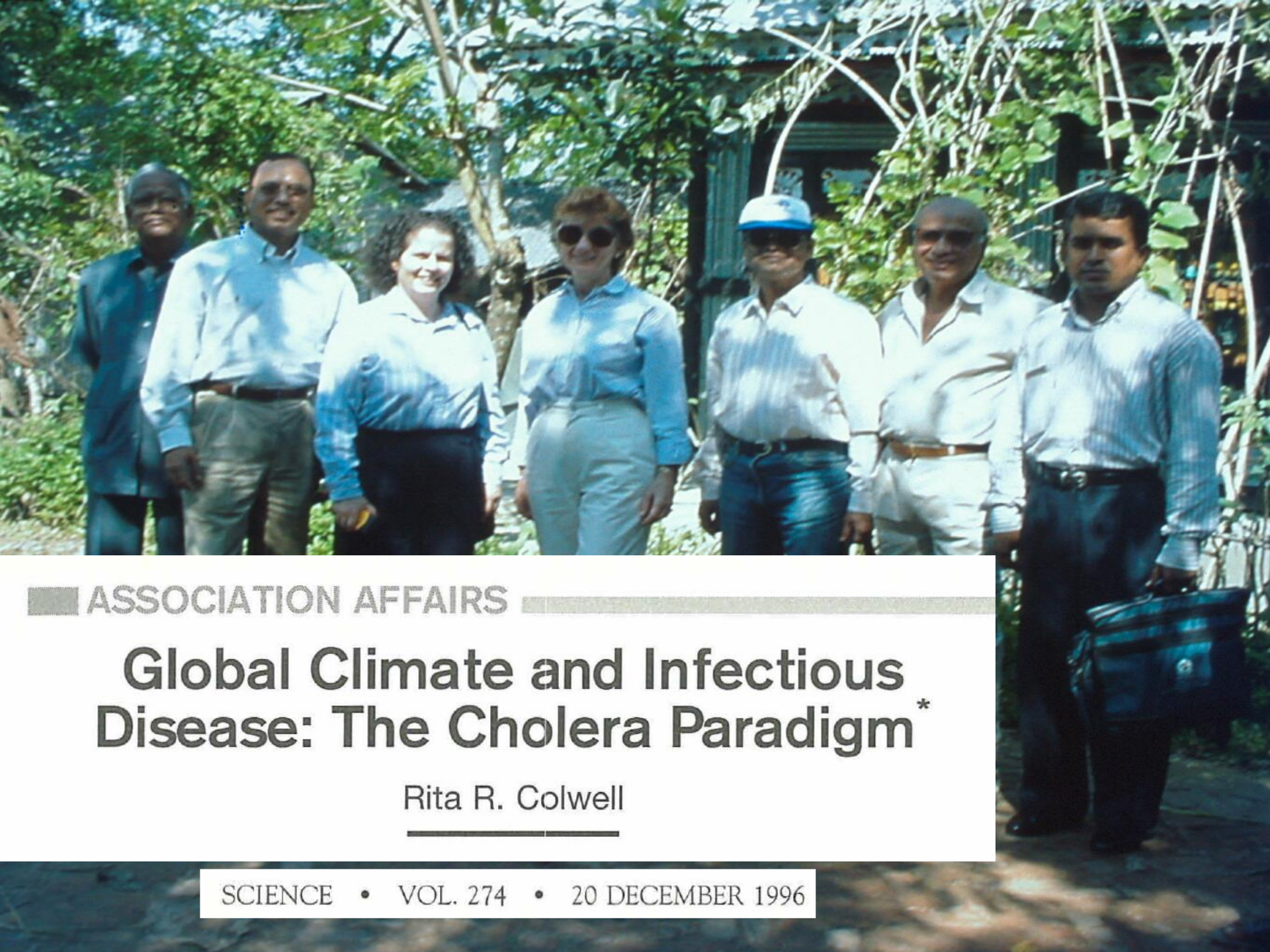
The ocean and human health

Indirect effects:

- Generation of O_2, removal of CO_2, climate 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 harmful algal blooms
- Source of new drugs for medicine
- Disease transmission



ASSOCIATION AFFAIRS

Global Climate and Infectious Disease: The Cholera Paradigm*

Rita R. Colwell

SCIENCE • VOL. 274 • 20 DECEMBER 1996

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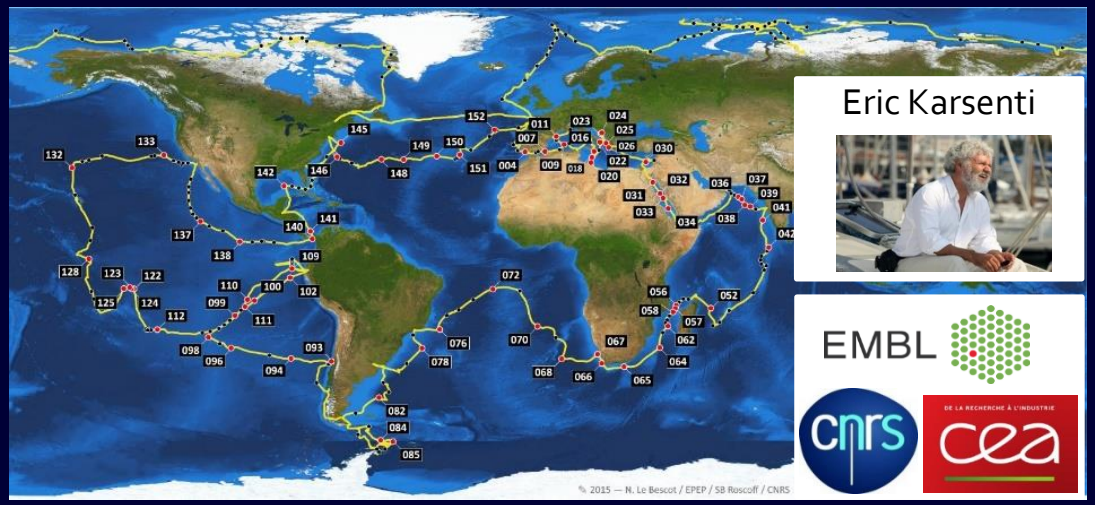
A four year expedition

- To explore marine planktonic ecosystems and their sensitivity to climate change-induced modifications to the ocean
- To popularize science
- To educate
- To influence policy



Eric Karsenti

EMBL

cnrs

cea

Fondation tara océan explore and share

agnès b.

Foundation VEOLIA ENVIRONNEMENT

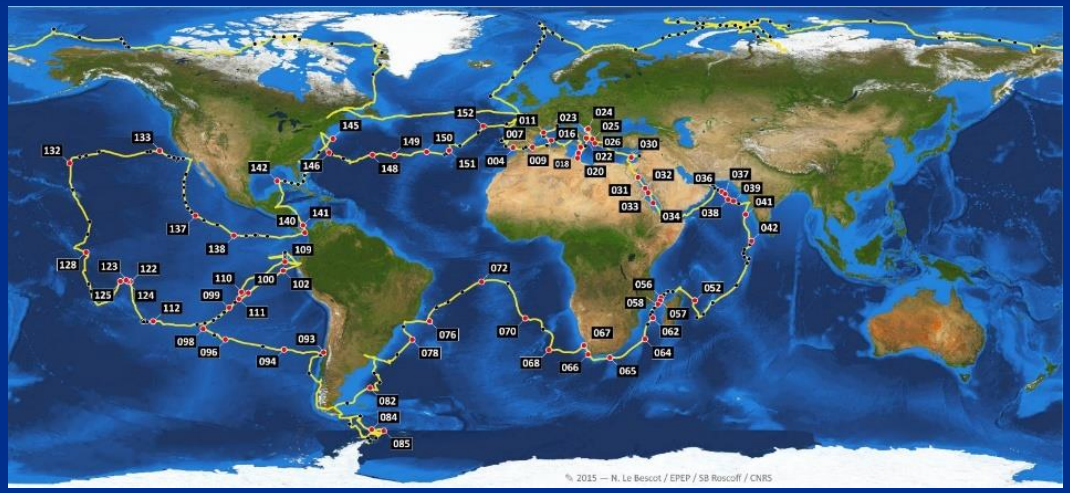
Région BRETAGNE

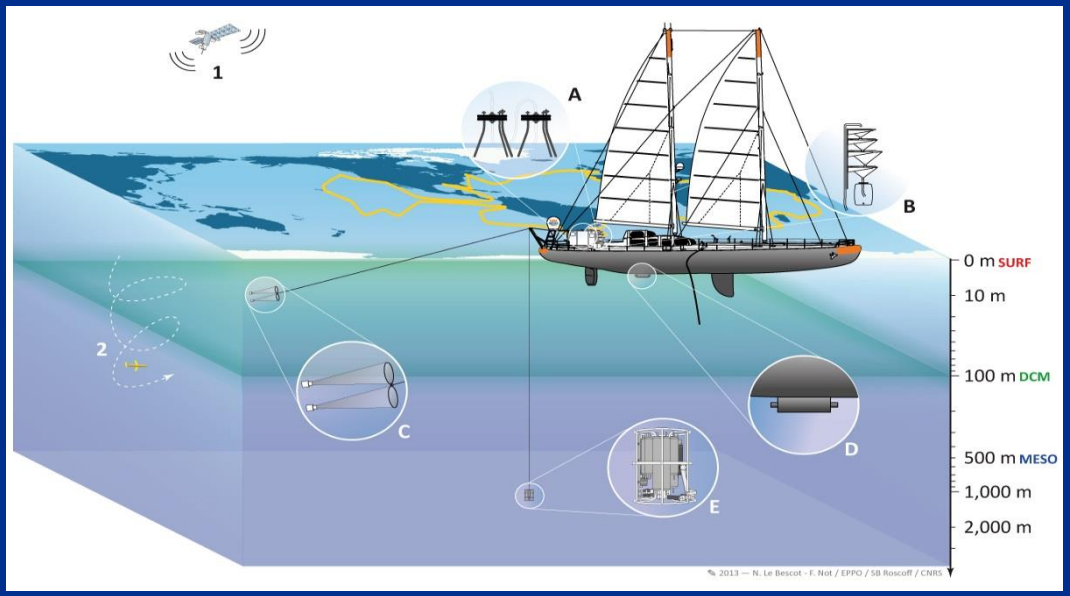
FONDATION PRINCE ALBERT II DE MONACO

WORLD COURIER A SERVICE NO ONE ELSE CAN DELIVER

FONDATION EDF DiversiTerre

Tara Oceans Global Sampling
September 2009 – October 2013





- ☑ 210 stations
- ☑ 40,000 samples for biology
  - Surface, DCM, meso
  - DNA, RNA sequencing
  - Microscopy
  - Flow cytometry
- ☑ > 1,500 CTD profiles
- ☑ Underway measurements
  - TSG, Ac-S, FRRF, Alfa
- ☑ > 2,000 nutrient samples
- ☑ > 1,800 HPLC samples
- ☑ > 900 carbonate samples

47 million genes from around 35,000 prokaryotic taxa – majority are new and with unknown functions

200,000 types of (dsDNA) viruses - only 39 were known previously. Hosts largely unknown, multiple evidence for important roles in gene transfer

130,000 genetic types of protists. More than 10 times higher than number of formally described species of marine eukaryotic plankton. Around one third cannot be assigned to any known taxonomic group. 116 million genes described from marine eukaryotes – the largest catalogue of genes from a single biome

>900 single cell genomes (SCGs) from diverse abundant uncultured protists

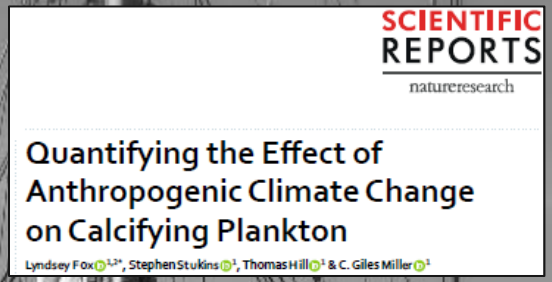
Several thousand metagenome assembled genomes (MAGs) from both prokaryotes and eukaryotes

TARA OCEANS

>150 publications

Tara Oceans and climate change

- Evidence for effects of ocean acidification

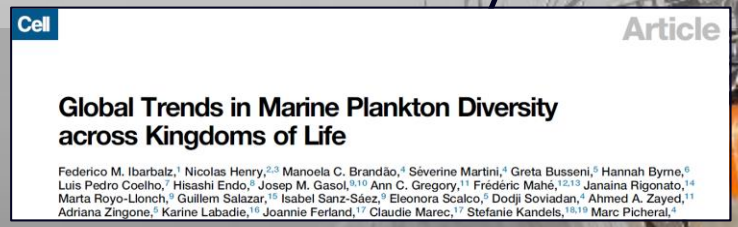


SCIENTIFIC REPORTS
nature research

Quantifying the Effect of Anthropogenic Climate Change on Calcifying Plankton

Lyndsey Fox[1,2*], Stephen Stukins[1], Thomas Hill[1] & C. Giles Miller[1]

- Projected changes in plankton biodiversity by end 21st century

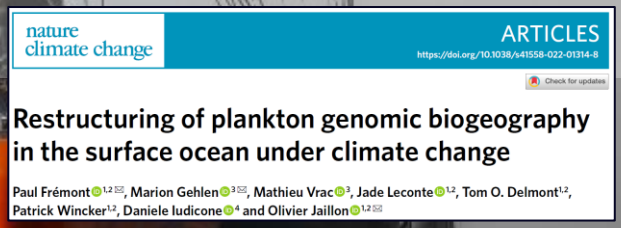


Cell

Article

Global Trends in Marine Plankton Diversity across Kingdoms of Life

Federico M. Ibarbalz,[1] Nicolas Henry,[2,3] Manoela C. Brandão,[4] Séverine Martini,[4] Greta Busseni,[5] Hannah Byrne,[6] Luis Pedro Coelho,[7] Hisashi Endo,[8] Josep M. Gasol,[9,10] Ann C. Gregory,[11] Frédéric Mahé,[12,13] Janaina Rigonato,[14] Marta Royo-Llonch,[9] Guillem Salazar,[15] Isabel Sanz-Sáez,[9] Eleonora Scalco,[5] Dodji Soviadan,[4] Ahmed A. Zayed,[11] Adriana Zingone,[5] Karine Labadie,[16] Joannie Ferland,[17] Claudie Marec,[17] Stefanie Kandels,[18,19] Marc Picheral,[4]



nature climate change

ARTICLES

https://doi.org/10.1038/s41558-022-01314-8

Check for updates

Restructuring of plankton genomic biogeography in the surface ocean under climate change

Paul Frémont[1,2], Marion Gehlen[3], Mathieu Vrac[3], Jade Leconte[1,2], Tom O. Delmont[1,2], Patrick Wincker[1,2], Daniele Iudicone[4] and Olivier Jaillon[1,2]

- The uniqueness of Arctic plankton communities

SCIENCE ADVANCES | RESEARCH ARTICLE

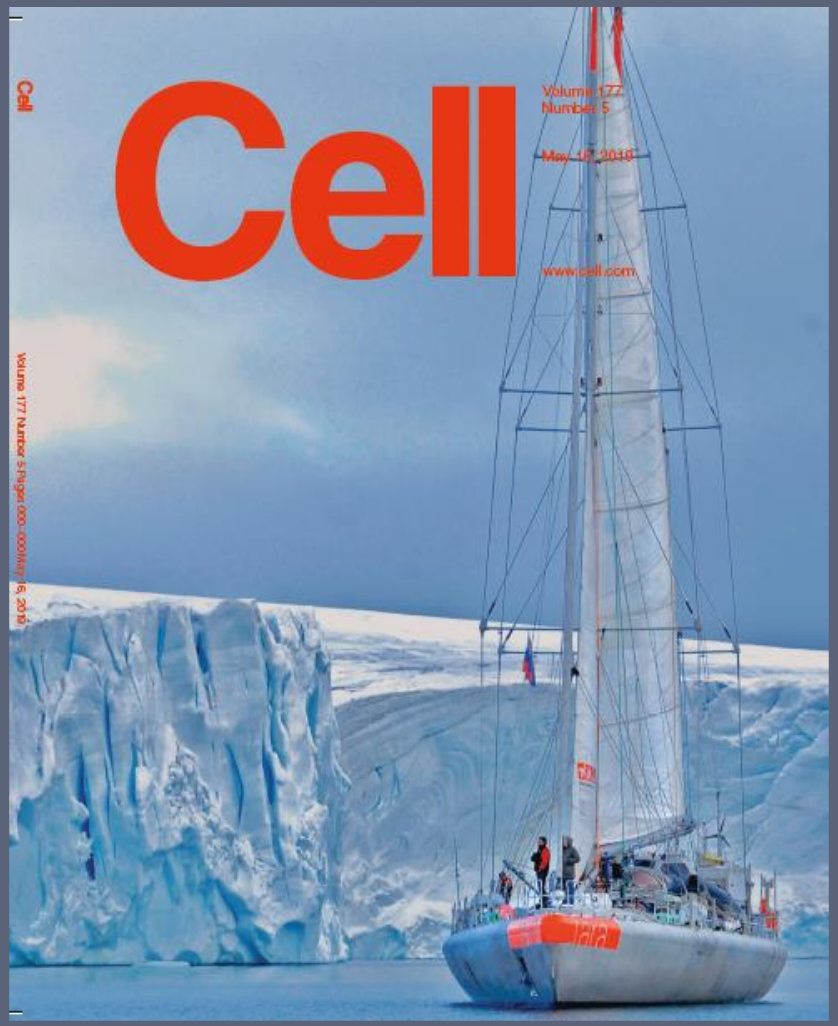
ECOLOGY

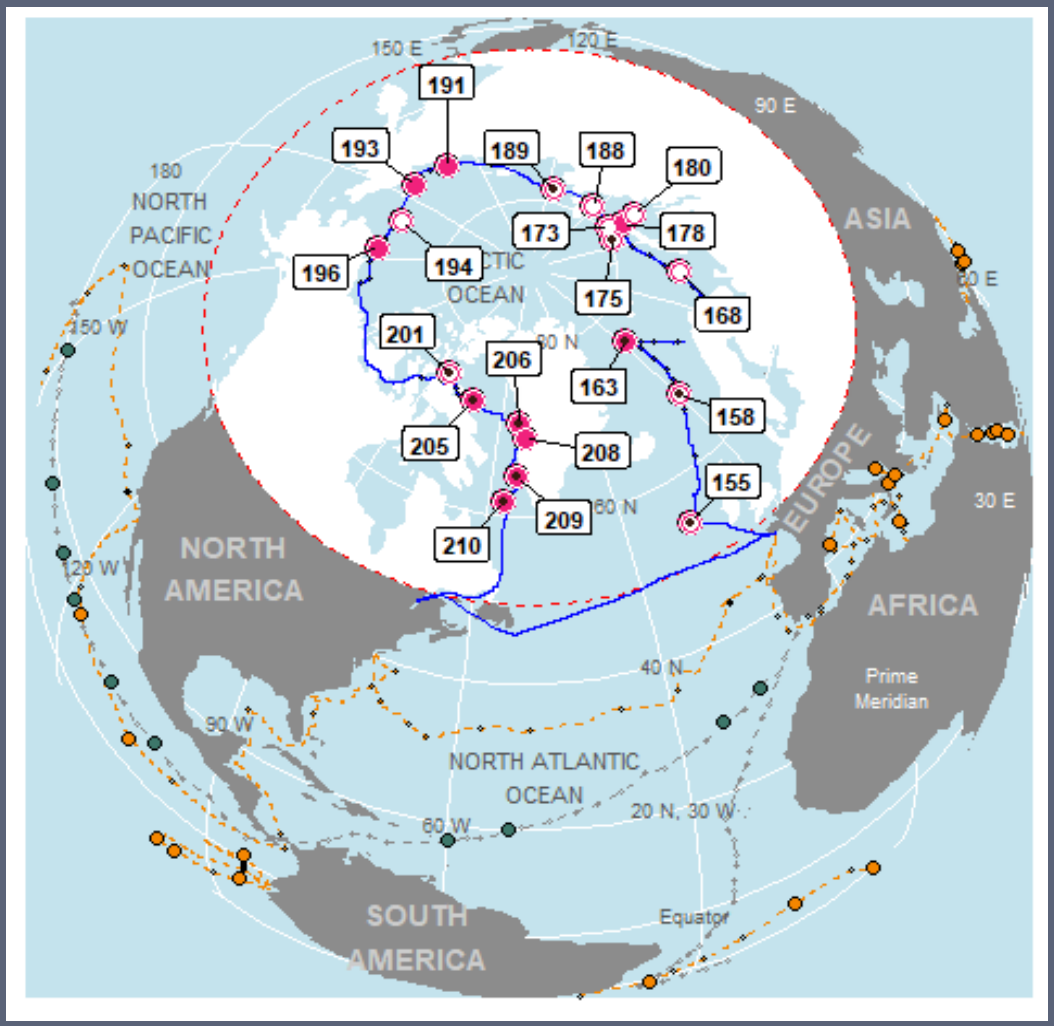
Environmental vulnerability of the global ocean epipelagic plankton community interactome

Samuel Chaffron[1,2*†], Erwan Delage[1,2†], Marko Budinich[2,3], Damien Vintache[1], Nicolas Henry[2,3], Charlotte Nef[2,4], Mathieu Ardyna[5,6], Ahmed A. Zayed[7], Pedro C. Junger[8], Pierre E. Galand[2,9], Connie Lovejoy[10], Alison E. Murray[11], Hugo Sarmento[8], Tara Oceans coordinators, Silvia G. Acinas[12], Marcel Babin[6,13], Daniele Iudicone[14], Olivier Jaillon[2,15], Eric Karsenti[2,4], Patrick Wincker[2,15], Lee Karp-Boss[16], Matthew B. Sullivan[7,17], Chris Bowler[2,4], Colomban de Vargas[2,3], Damien Eveillard[1,2]

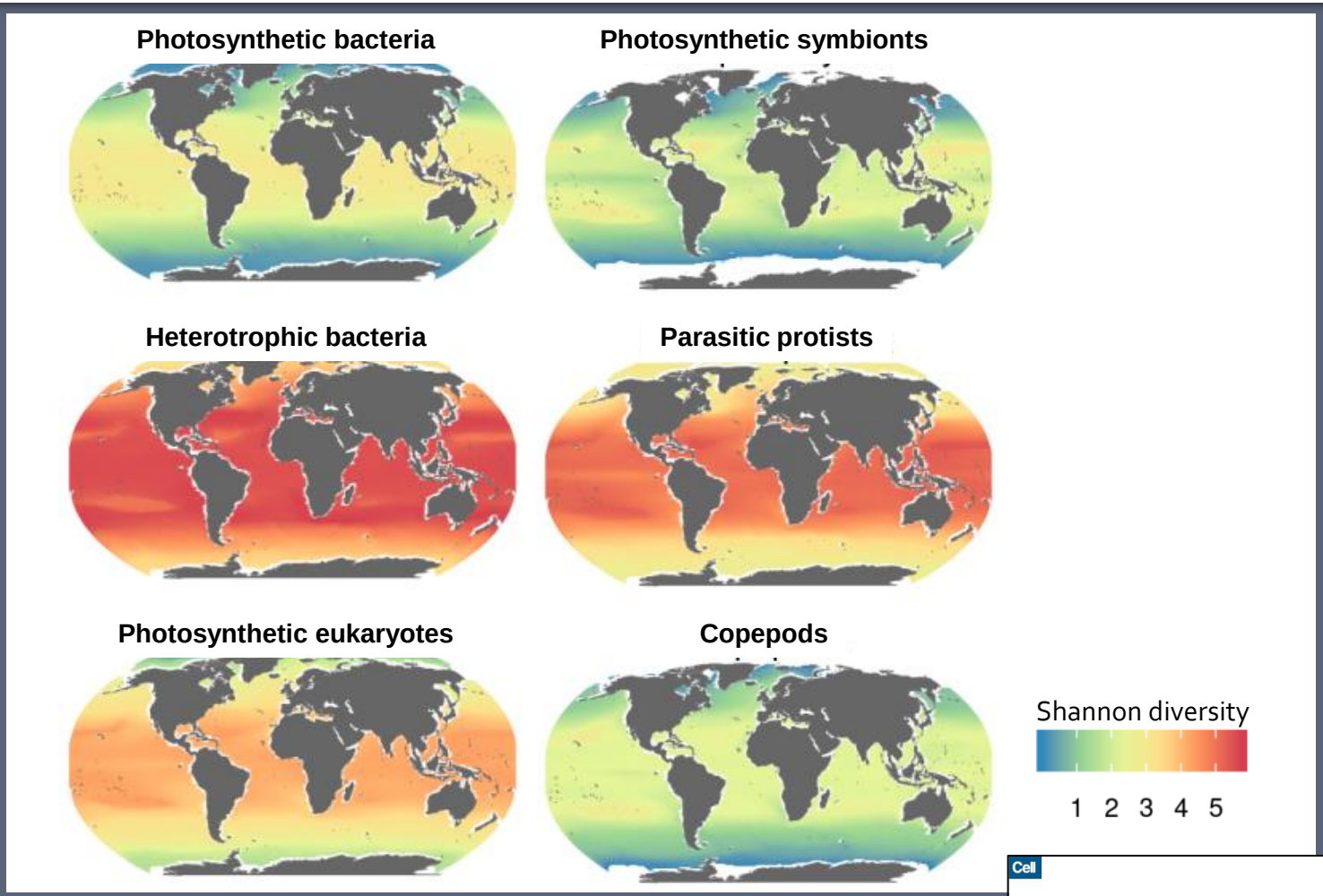
TARA OCEANS POLAR CIRCLE

Moving our lens towards the Arctic biome





Current patterns of diversity of major plankton functional groups



Six plankton functional groups have highly explanatory GAMs

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Cell Article

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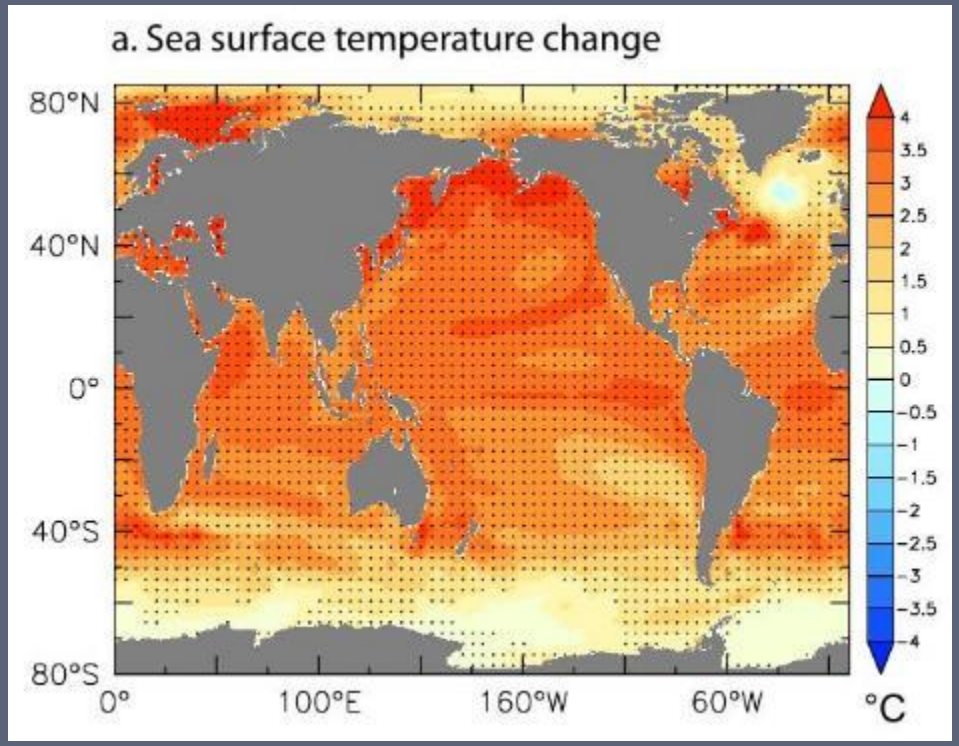
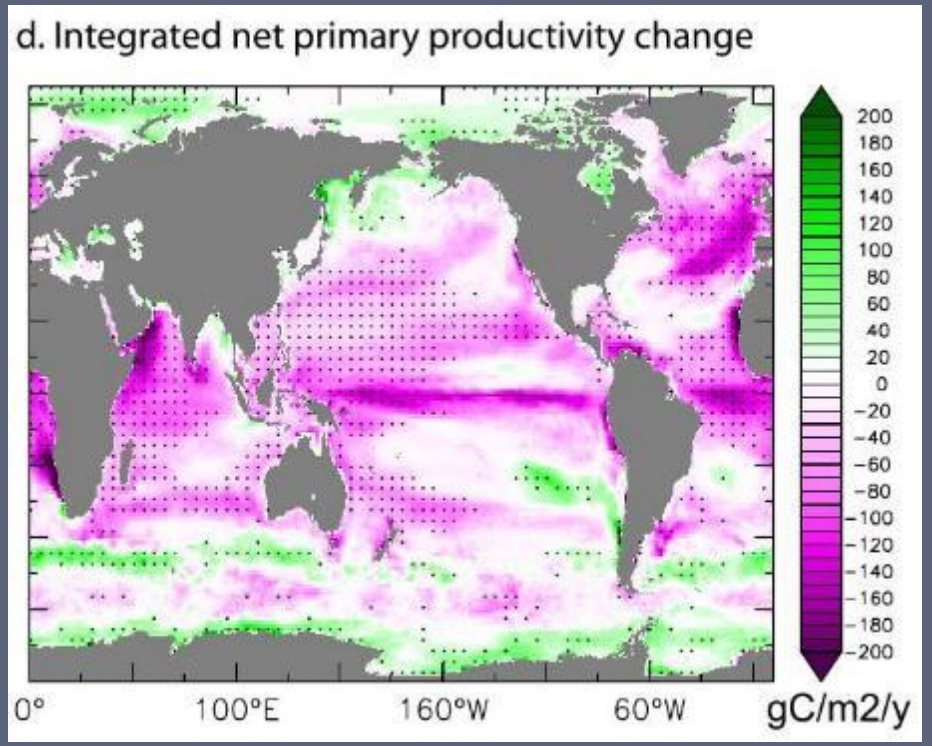
Projected changes in ocean temperatures and primary productivity by 2100





IPCC CMIP5 model outputs
Bopp et al. 2013
Dots show areas of highest certainty

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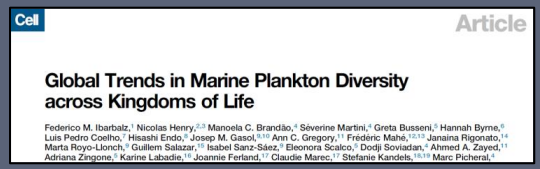
Cell Article

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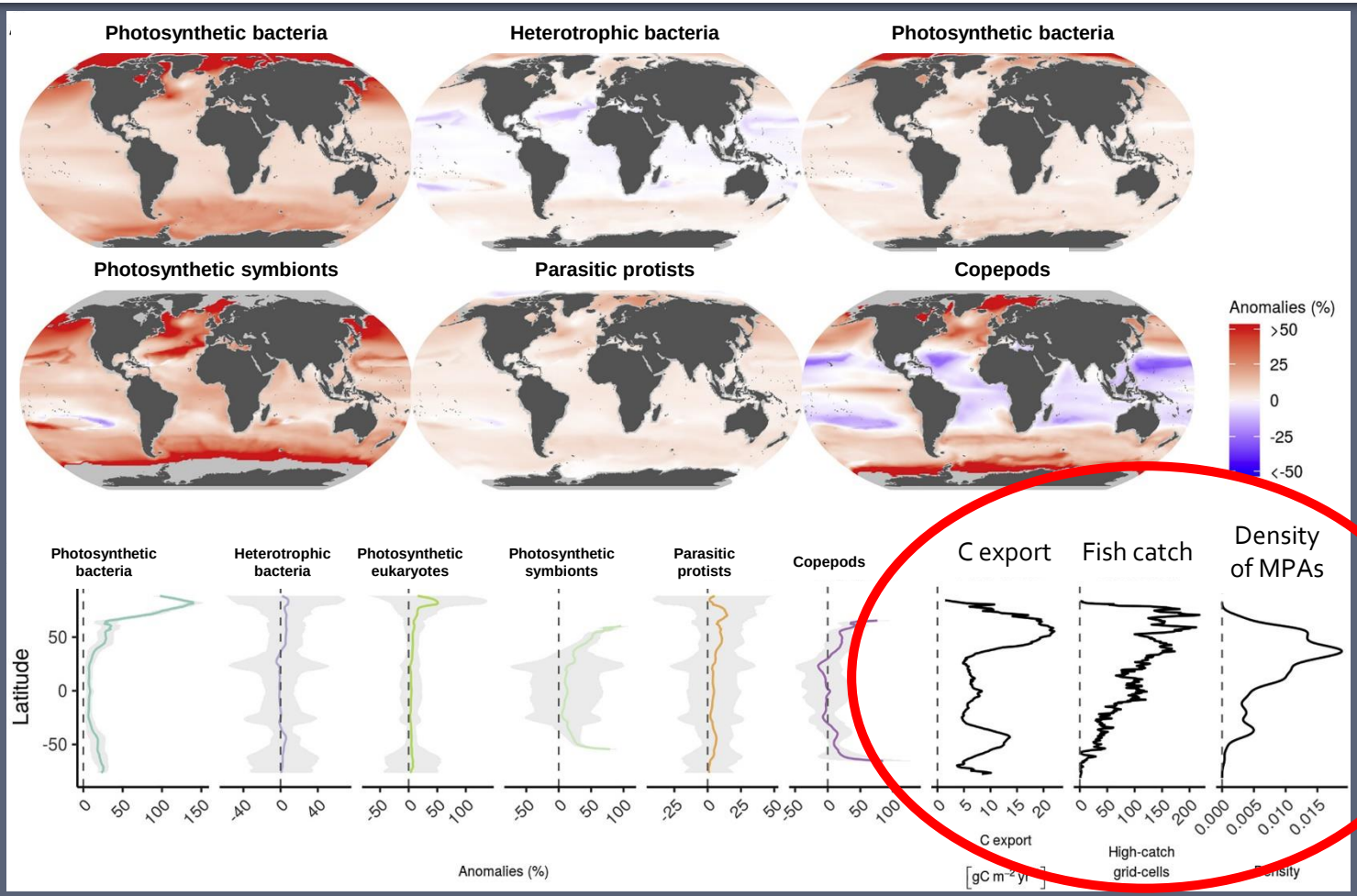
Projected diversity anomalies by end of 21st century



Based on CMIP5 outputs

Cell Article
Global Trends in Marine Plankton Diversity across Kingdoms of Life

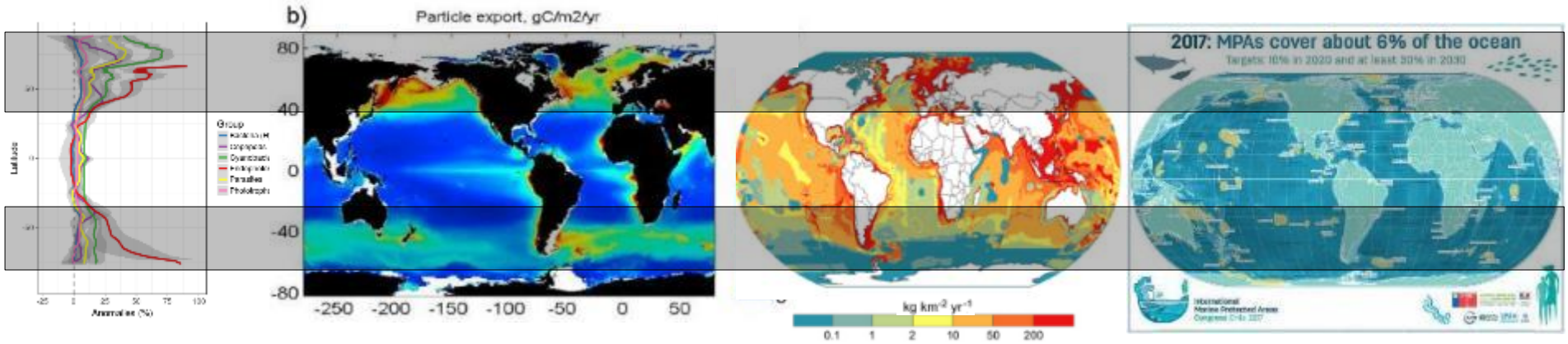
Projected effects of diversity changes on marine ecosystems, fisheries, and biogeochemical cycles

Diversity anomalies

C export

Fish catch

Density of MPAs



Based on CMIP5 outputs
C export data from Henson et al. 2014
Fish landings from Watson 2017
MPA data based on Bruno et al. 2018

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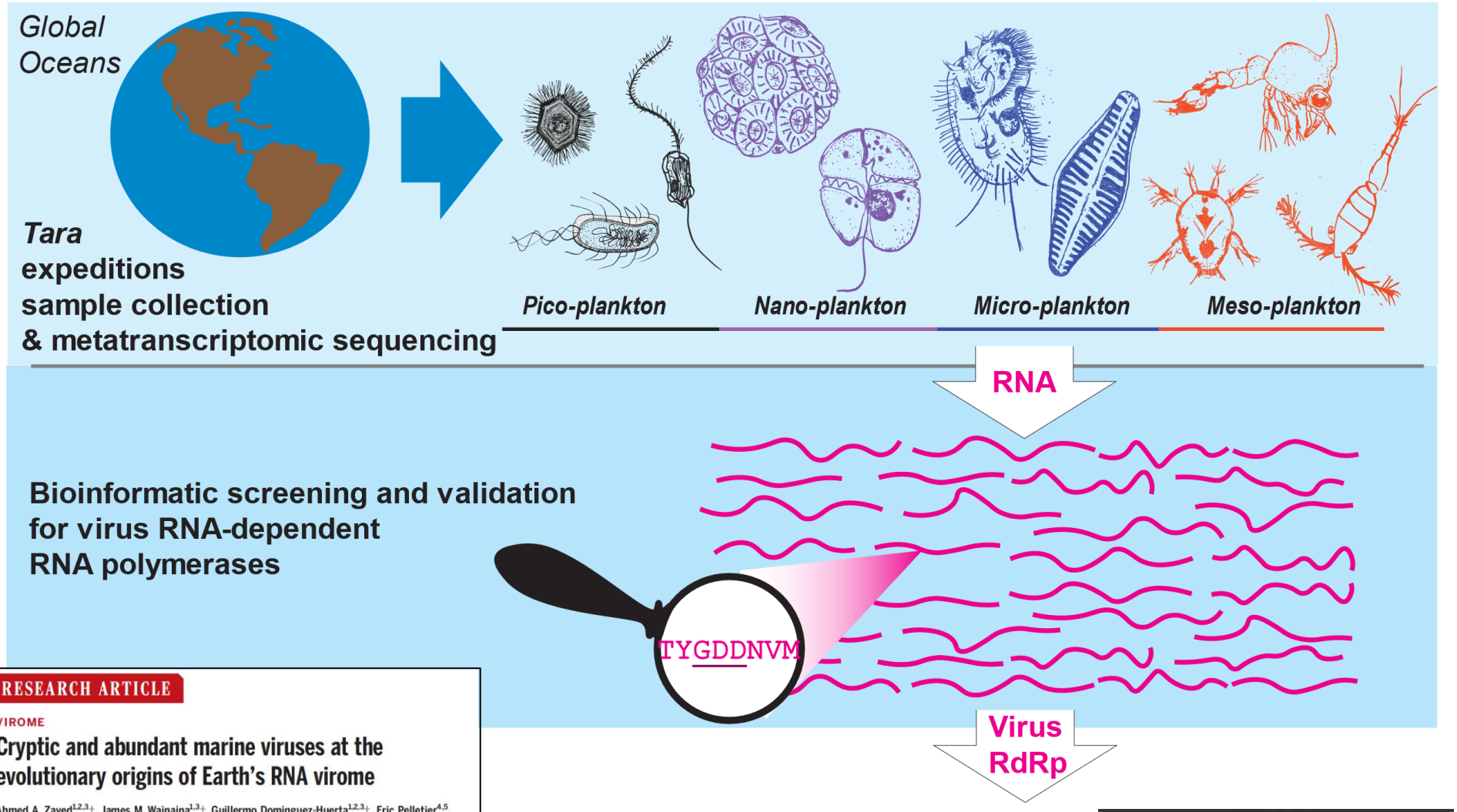
Cell Article

Global Trends in Marine Plankton Diversity across Kingdoms of Life

From dsDNA viruses to RNA viruses (at last !)



RESEARCH ARTICLE

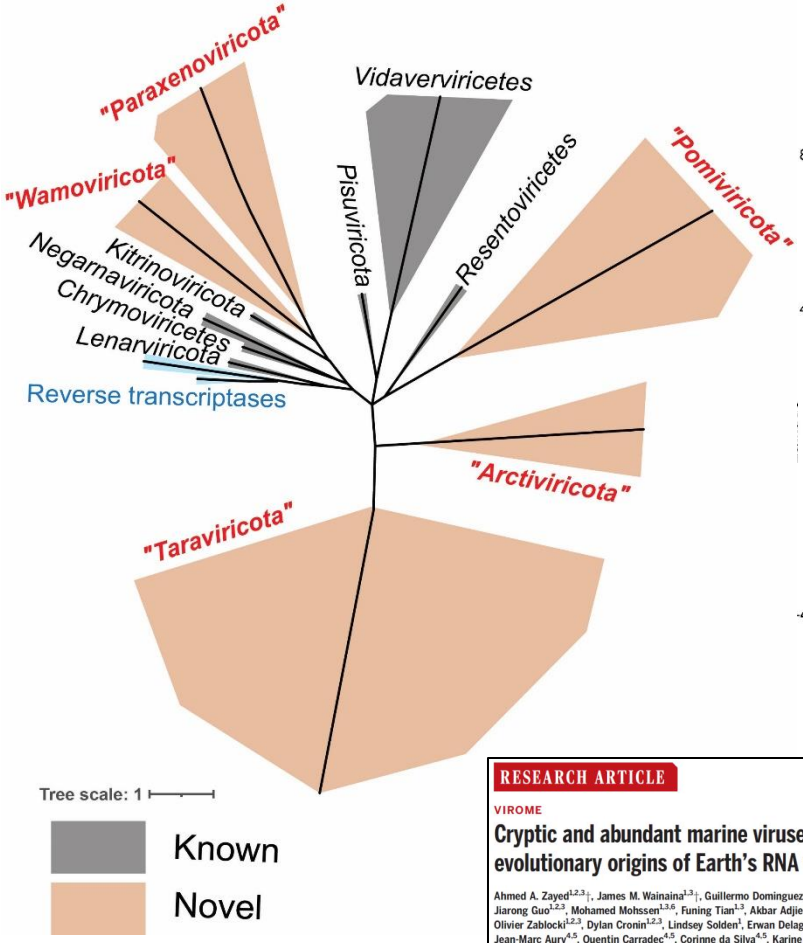
VIROME

Cryptic and abundant marine viruses at the evolutionary origins of Earth's RNA virome

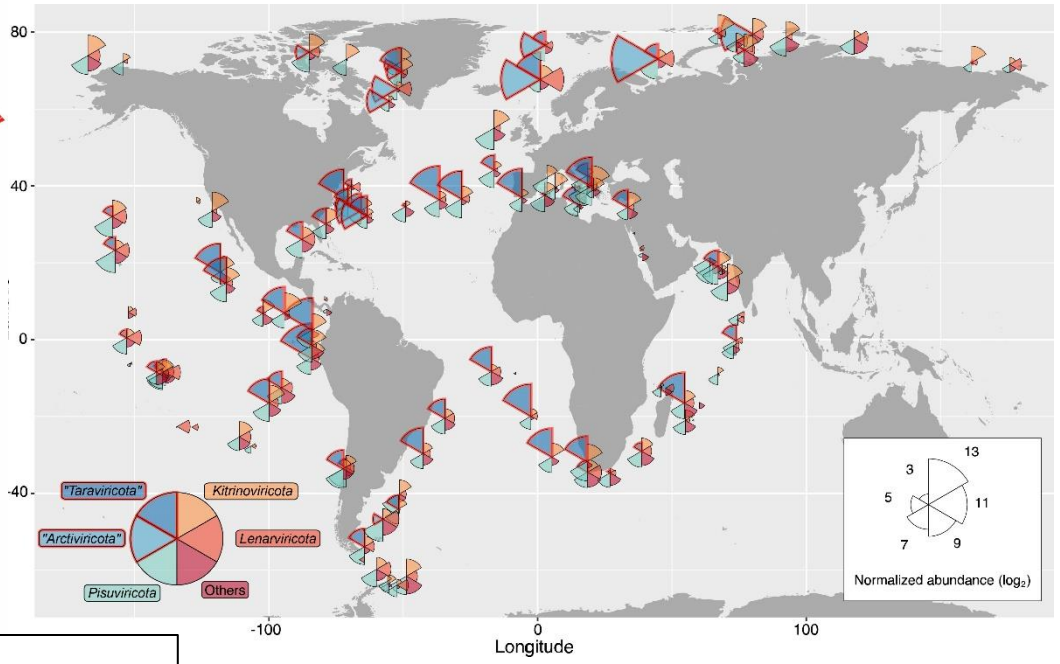
Ahmed A. Zayed[1,2,3]†, James M. Wainaina[1,3]†, Guillermo Dominguez-Huerta[1,2,3]†, Eric Pelletier[4,5], Jiarong Guo[1,2,3], Mohamed Mohssen[1,3,6], Funing Tian[1,3], Akbar Adjie Pratama[1,2], Benjamin Bolduc[1,2,3], Olivier Zablocki[1,2,3], Dylan Cronin[1,2,3], Lindsey Solden[1], Erwan Delage[5,7], Adriana Alberti[4,5]§, Jean-Marc Aury[4,5], Quentin Carradec[4,5], Corinne da Silva[4,5], Karine Labadie[4,5], Julie Poulain[4,5], Hans-Joachim Ruscheweyh[8], Guillem Salazar[8], Elan Shatoff[9], Tara Oceans Coordinators‡, Ralf Bundschuh[6,9,10,11], Kurt Fredrick[1], Laura S. Kubatko[12,13], Samuel Chaffron[5,7], Alexander I. Culley[14], Shinichi Sunagawa[8], Jens H. Kuhn[15], Patrick Wincker[4,5], Matthew B. Sullivan[1,2,3,6,12,16]*

Around 50,000 RdRP sequences detected in *Tara* Oceans, the majority represent novel classes, and likely represent the vast majority of RNA viruses in the ocean

Five novel orthornaviran phyla emerged from the RdRp phylogeny



Two novel phyla are distributed and abundant across the Global Oceans



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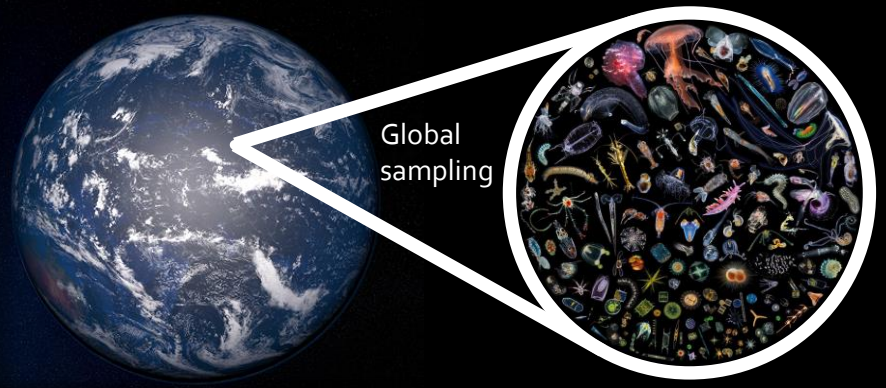
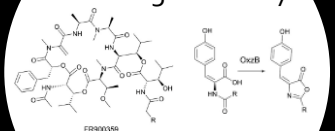
Uncharted biosynthetic potential of the ocean microbiome



Construction of a genomic database

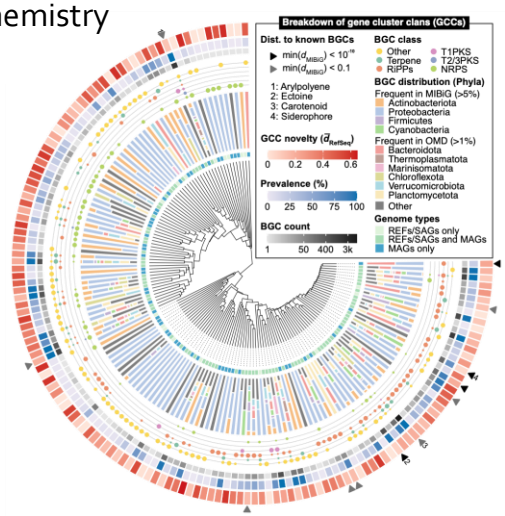
incl. >26,000 new MAGs
~8,300 species

Towards enzyme and drug discovery

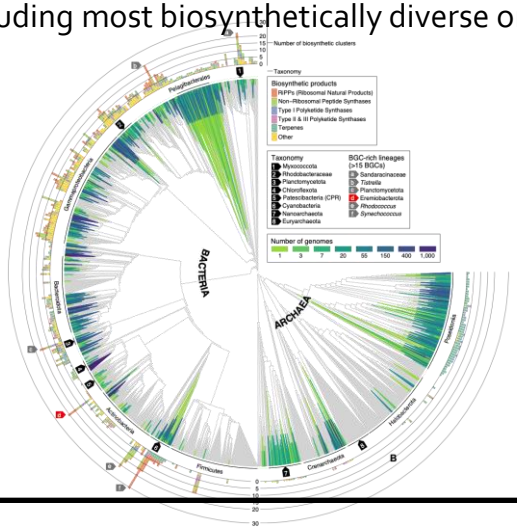


40k biosynth. gene clusters from 7,000 families
56% of them new

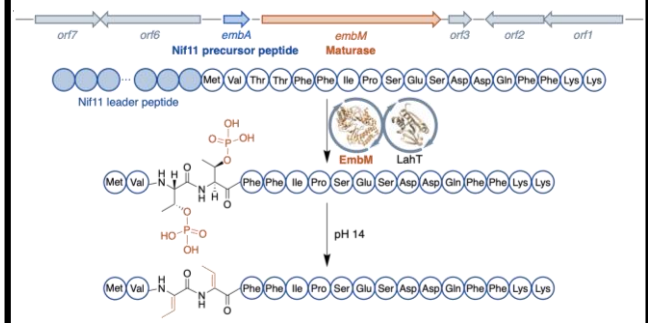
High discovery potential for novel chemistry



Rich potential in many unknown clades, including most biosynthetically diverse one



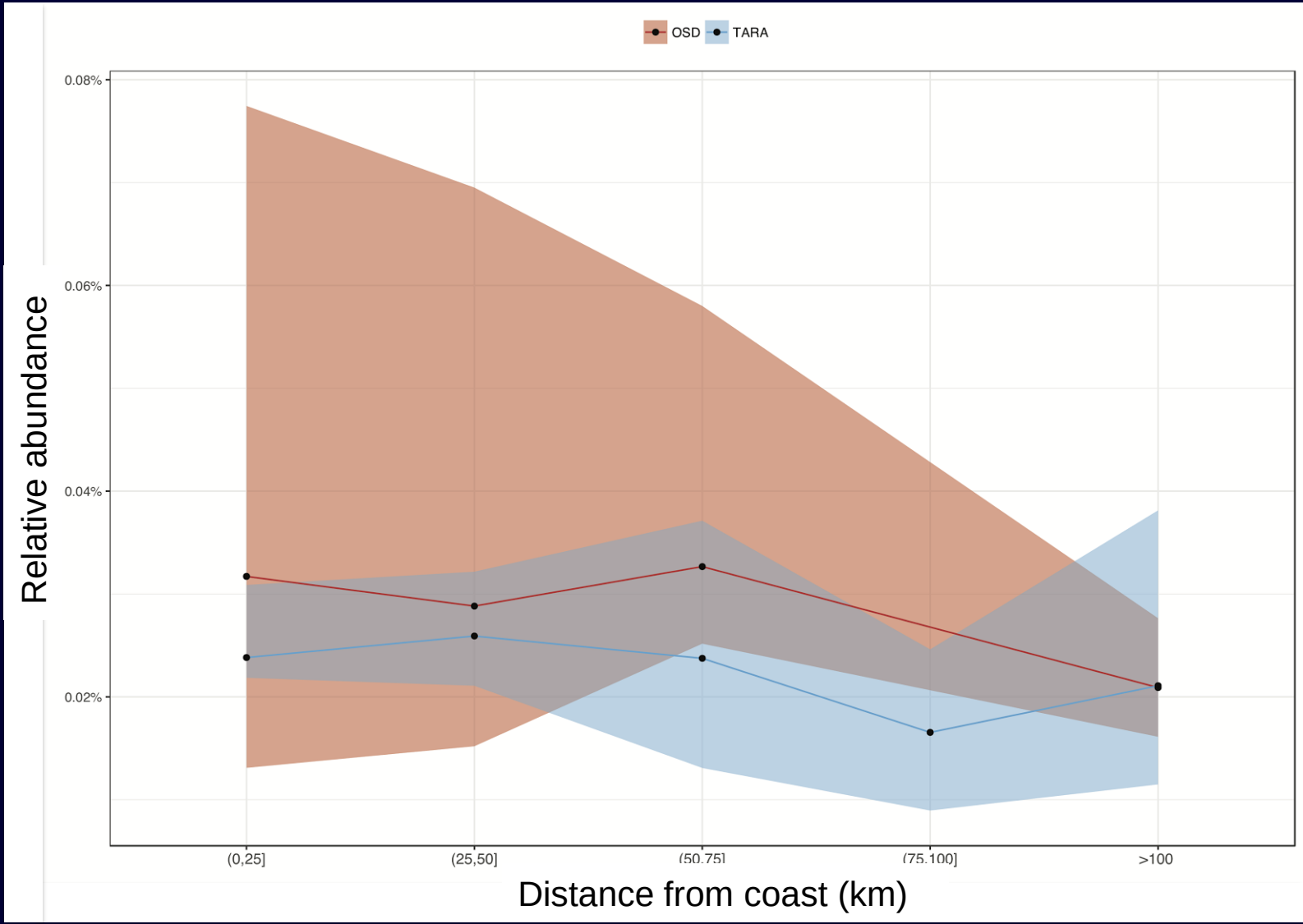
Characterization of the first natural product from this unexplored and 'talented' bacterial group



Paoli et al., and Sunagawa. *Nature. In press*.

ETH zürich

Antibiotic resistance genes in the ocean



Traversing European Coastlines (TREC)

Cross-sectional
- Water
- Sediments
- Soil
- Selected species

Contextual data
- Environmental parameters
- Chemical screening
- ...

HIGHLY COLLABORATIVE FRAMEWORK

EMBL

A major focus will be the ‘exposome’

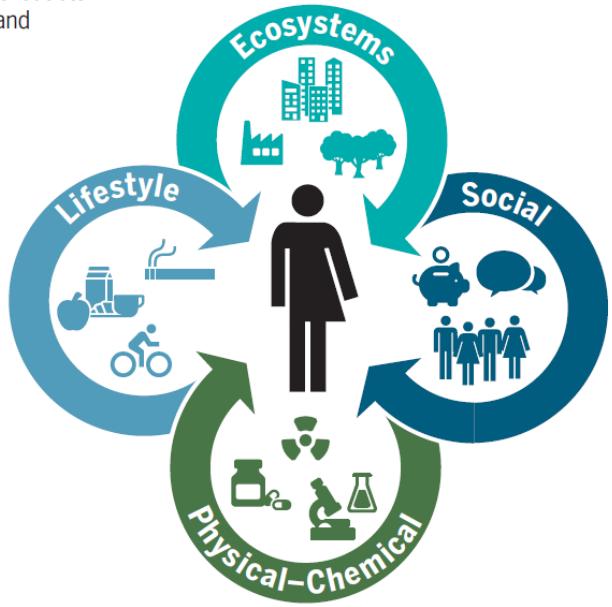
A measure of all the exposures of an individual in a lifetime and how those exposures relate to health

Chris Wild, 2005

Ecosystems
Food outlets, alcohol outlets
Built environment and urban land uses
Population density
Walkability
Green/blue space

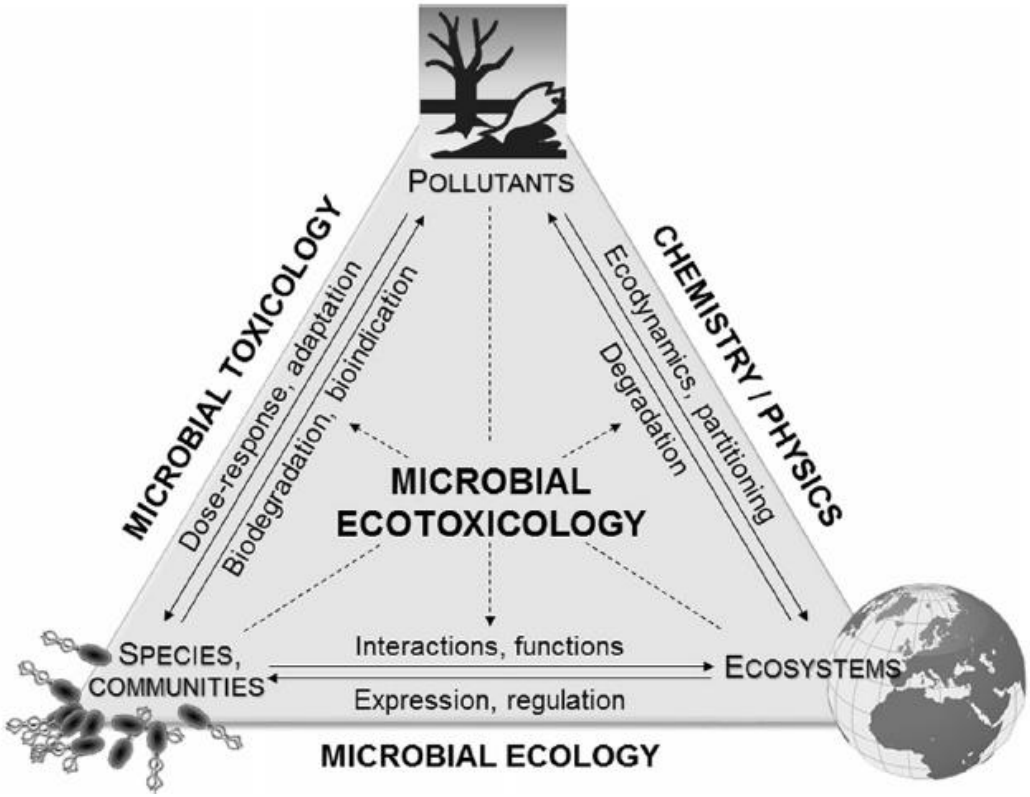
Lifestyle
Physical activity
Sleep behavior
Diet
Drug use
Smoking
Alcohol use

Social
Household income
Inequality
Social capital
Social networks
Cultural norms
Cultural capital
Psychological and mental stress

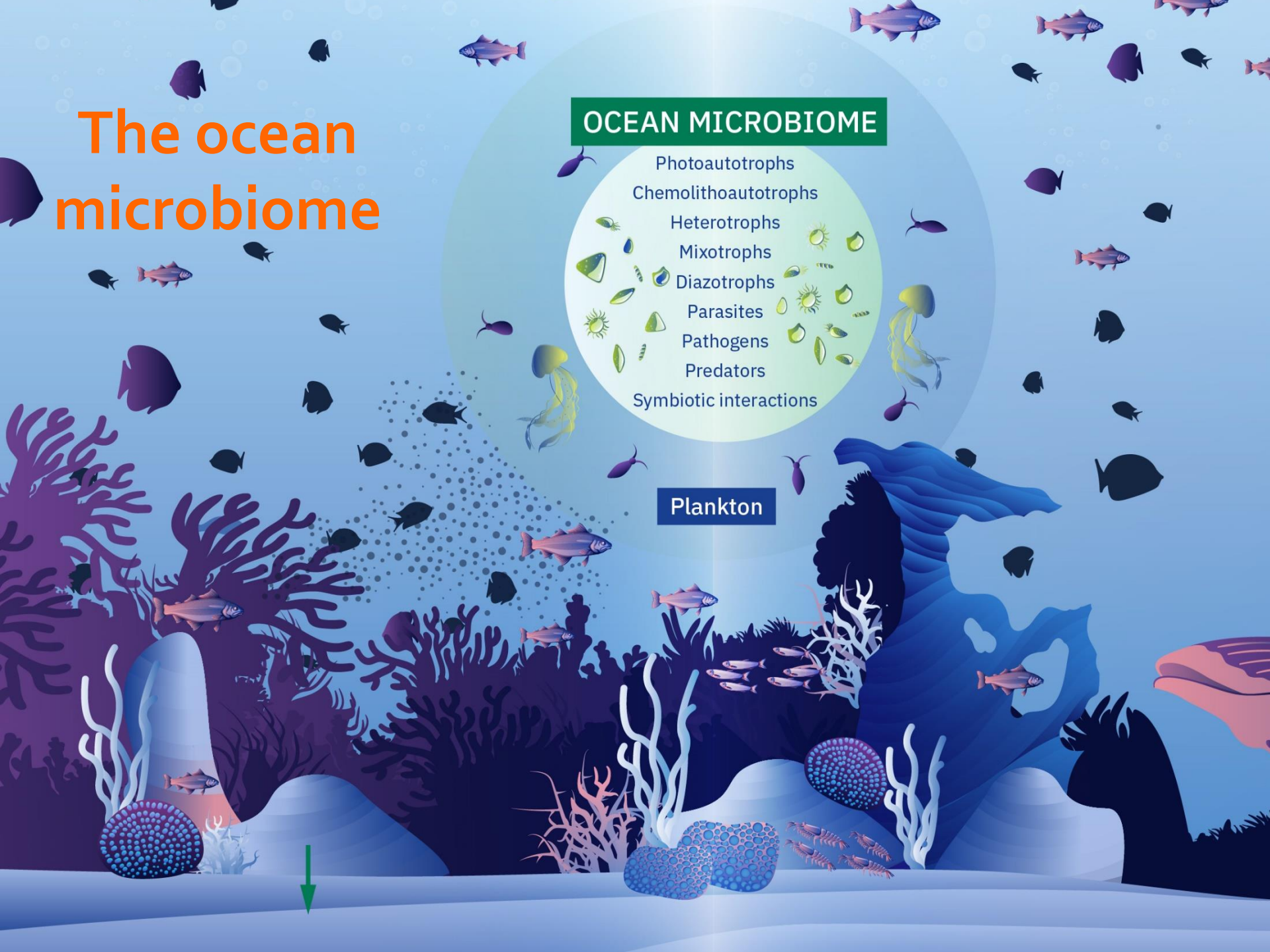


Physical–Chemical
Temperature/humidity
Electromagnetic fields
Ambient light
Odor and noise
Point, line sources, e.g, factories, ports
Outdoor and indoor air pollution
Agricultural activities, livestock
Pollen/mold/fungus
Pesticides
Fragrance products
Flame retardants (PBDEs)
Persistent organic pollutants
Plastic and plasticizers
Food contaminants
Soil contaminants
Drinking water contamination
Groundwater contamination
Surface water contamination
Occupational exposures

Adapting the exposome concept to ocean health



The ocean microbiome



TARA OCEANS

INSTITUTIONS

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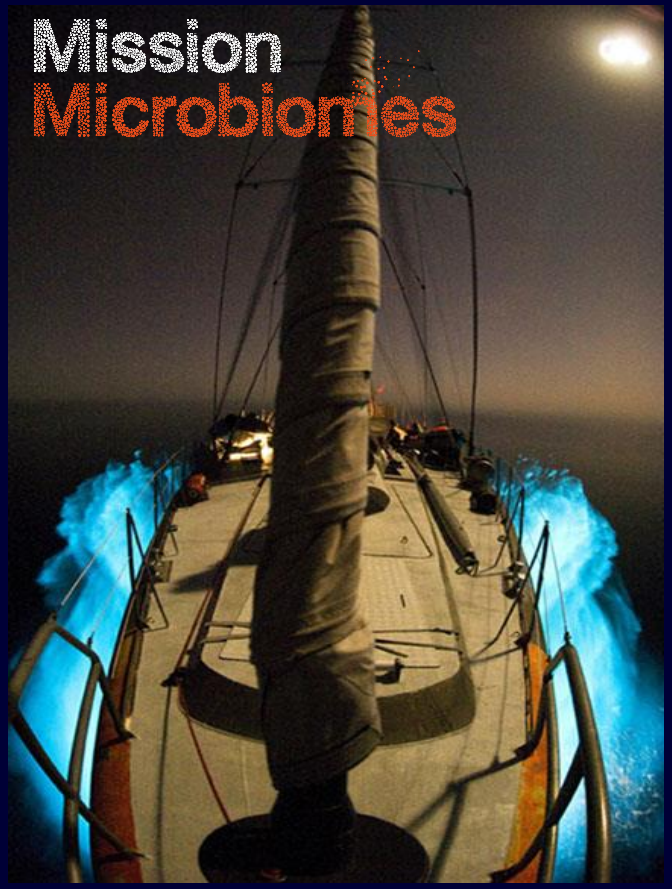
MAIN PARTNERS & SPONSORS



Plankton assure the well-being of our ocean