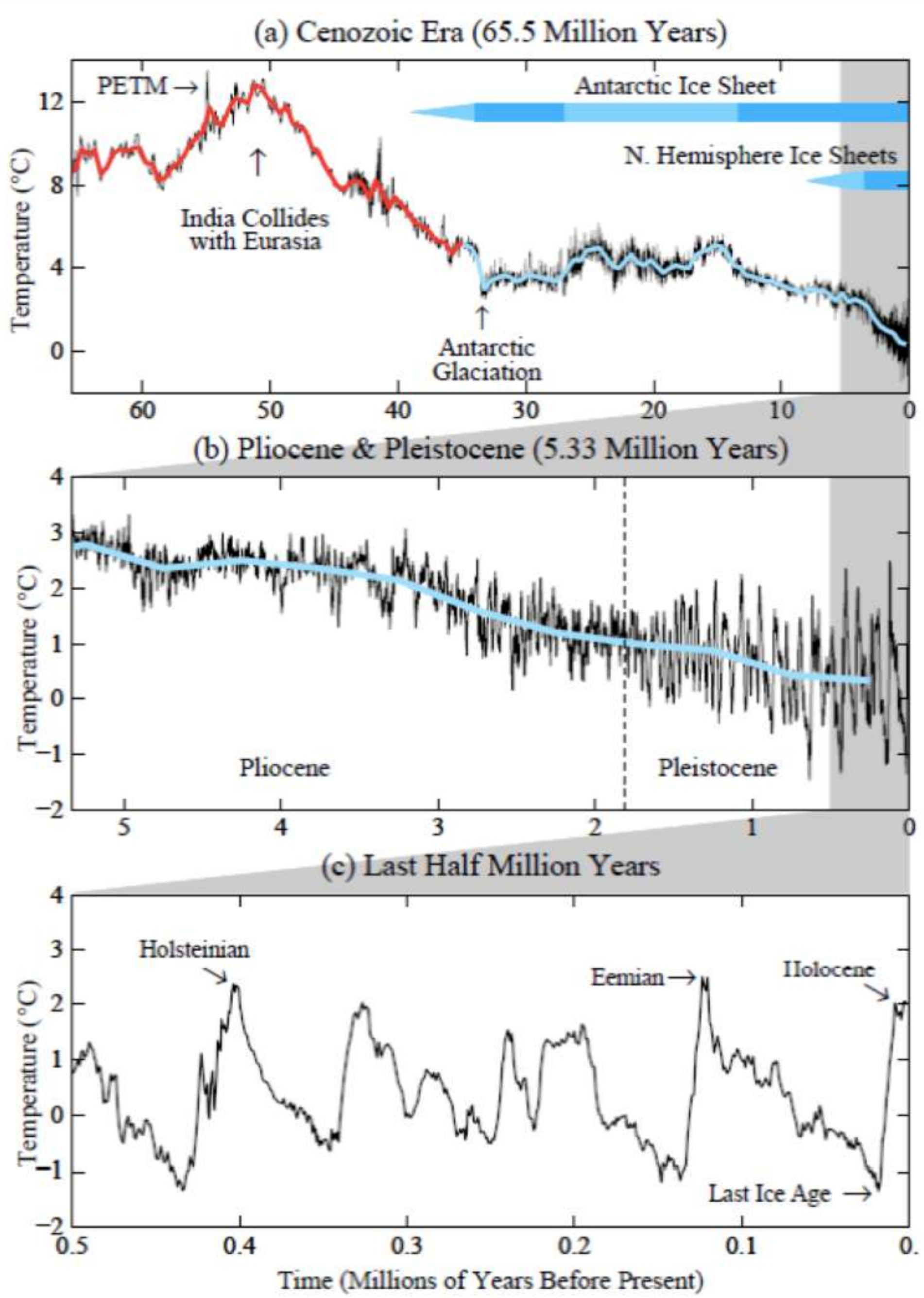
Climate change and global change

Climate change refers to changes of climatic factors at a global scale (e.g., increasing SST, but also sea level rise, ice melting, and atmospheric phenomena)

Global warming is the increasing warming temperature at global scale in the last century, mostly due to fossil fuel use, referring to the baseline of 1950-1980 (Goddard Institute for Space Studies –NASA)

Global change refers to all changes that are occurring as a consequence human activities, including climate modifications, biodiversity loss, alterations of the natural environments and so on…

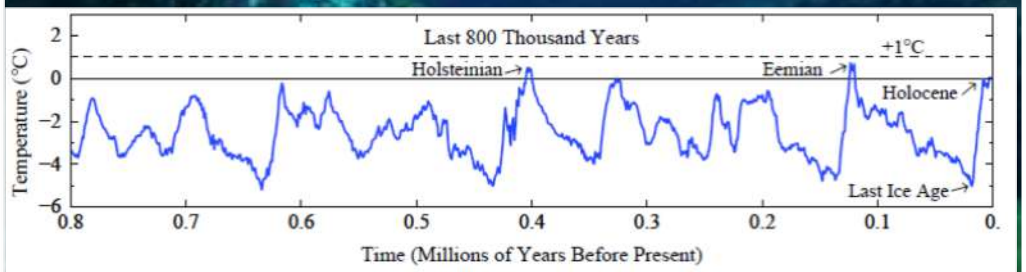
Paleoclimate



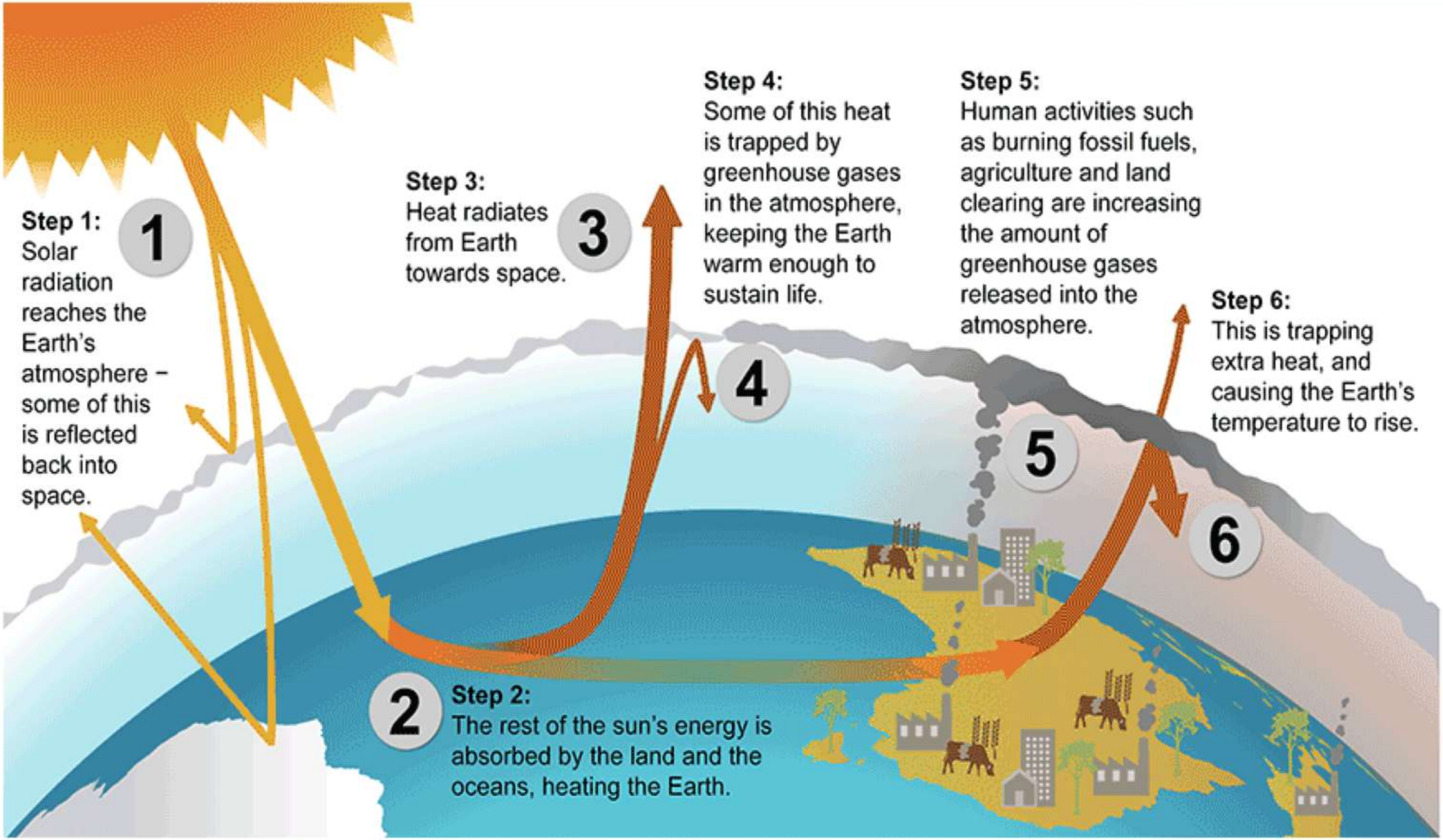
We are in a Glacial Era started 40 millions years ago. Within a glacial era, glacial and interglacial periods alternate. The last glacial period started more than 100k years ago and finished about 10k years ago.

Now we are in a interglacial period. However, we are less than 1 degree cooler than warmer peak in past interglacial periods.

(Hansen and Sato, 2011)



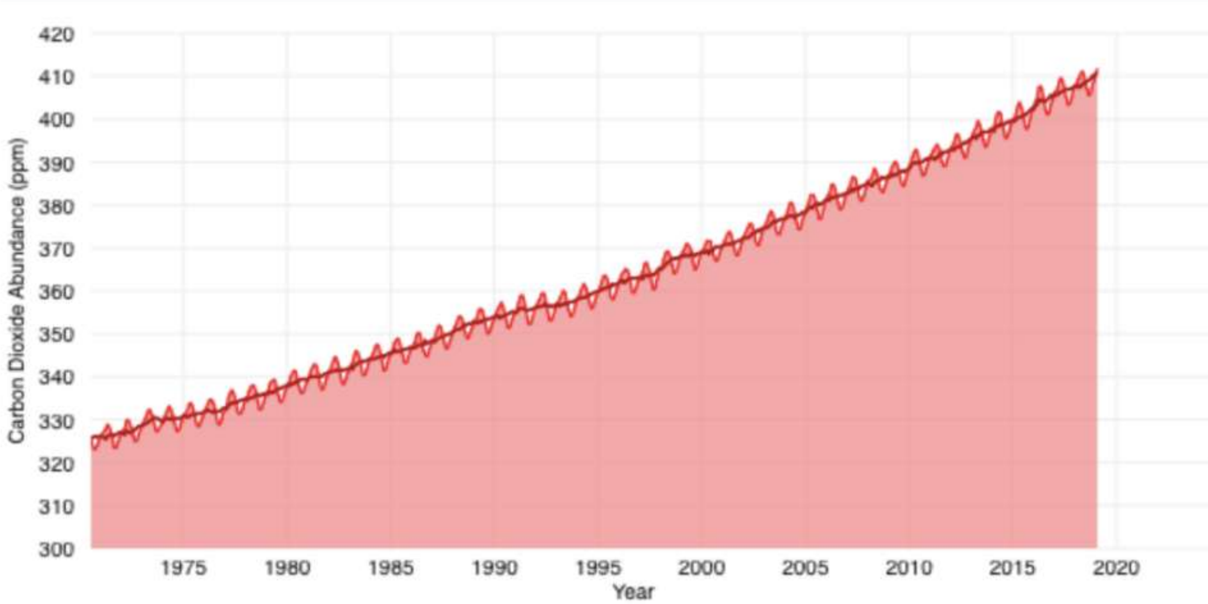
Greenhouse effect

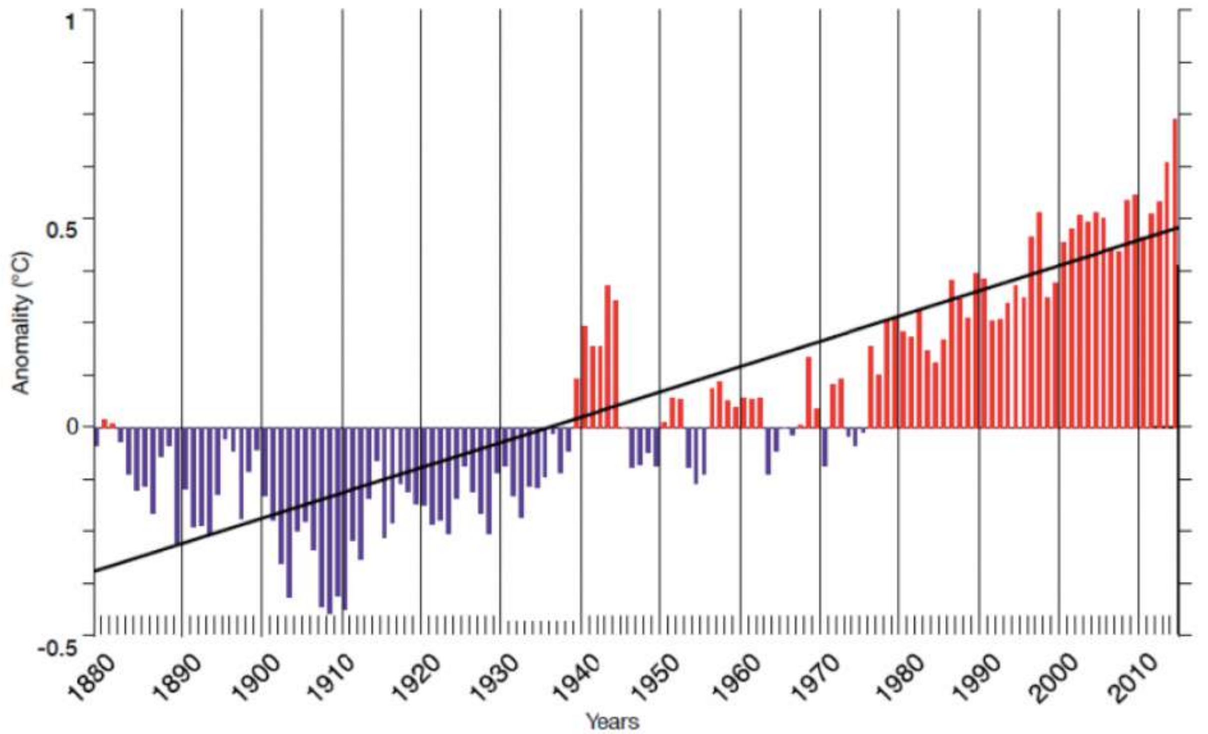


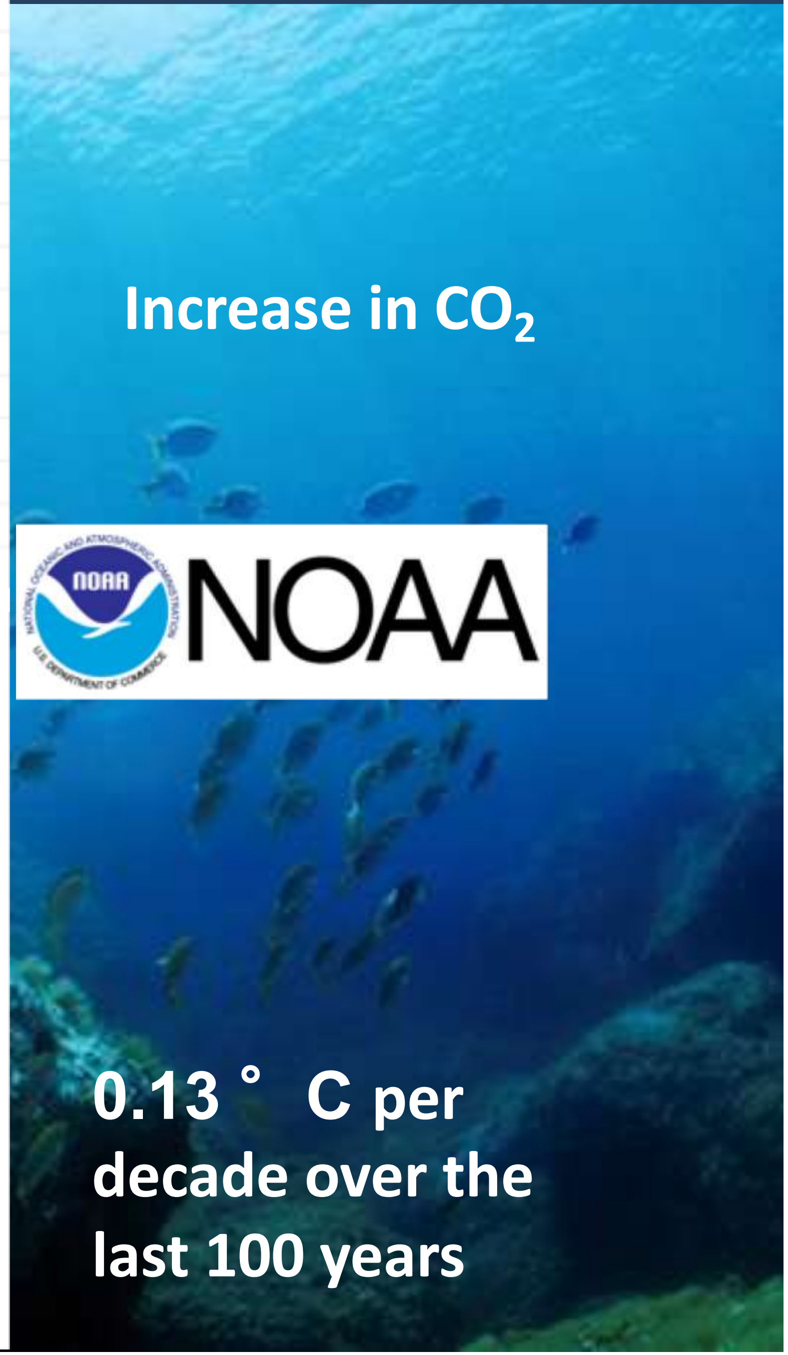
Greenhouse effect

CO_2 N_2O CH_4 H_2O CFC

Carbon dioxide emissions







Increase in CO_2

0.13 ° C per decade over the last 100 years

Methane in the subpolar regions

nature COMMUNICATIONS

Article | OPEN | Published: 15 August 2018

21st-century modeled permafrost carbon emissions accelerated by abrupt thaw beneath lakes

Katey Walter Anthony, Thomas Schneider von Deimling, Ingmar Nitze, Steve Frolking, Abraham Emond, Ronald Daanen, Peter Anthony, Prajna Lindgren, Benjamin Jones & Guido Grosse

Specific heat

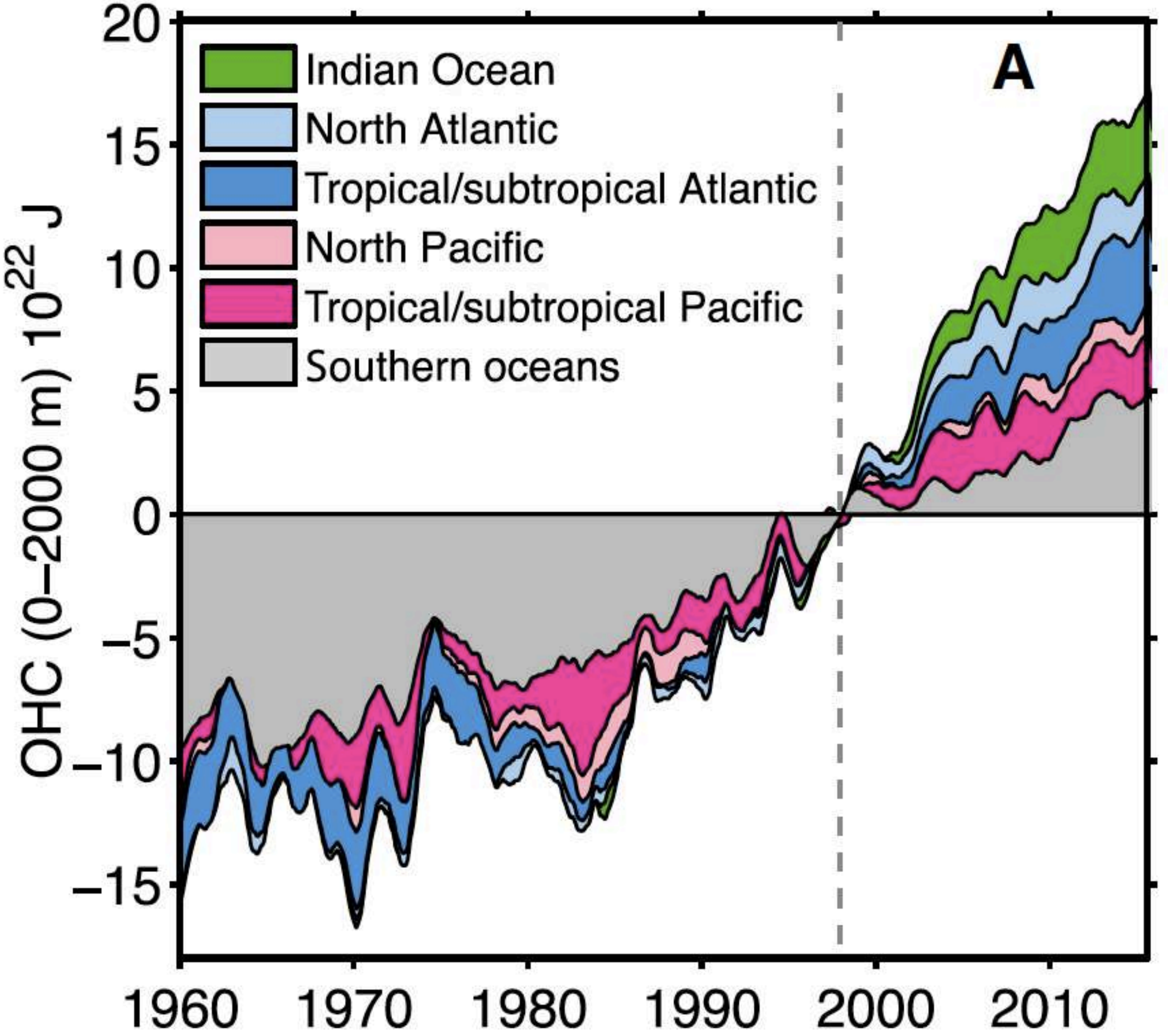
Specific heat: the amount of heat necessary to raise the temperature per unit mass by 1 degree kelvin

Air 0.25 Kcal/kg ° C

Rock (average) 0.20 Kcal/kg ° C

Seawater 0.95 Kcal/kg ° C

Earth Energy Imbalance



Improved estimates of ocean heat content from 1960 to 2015

Lijing Cheng,[1]* Kevin E. Trenberth,[2] John Fasullo,[2] Tim Boyer,[3] John Abraham,[4] Jiang Zhu[1]

More than 90% of energy imbalance of the planet is stored in the ocean, increasing ocean heat content (OHC), while the residual heat is manifest in melting of both land and sea ice, and in warming of the atmosphere and land surface. OHC is increasing due to greenhouse gases.

Storming

Geophysical Research Letters

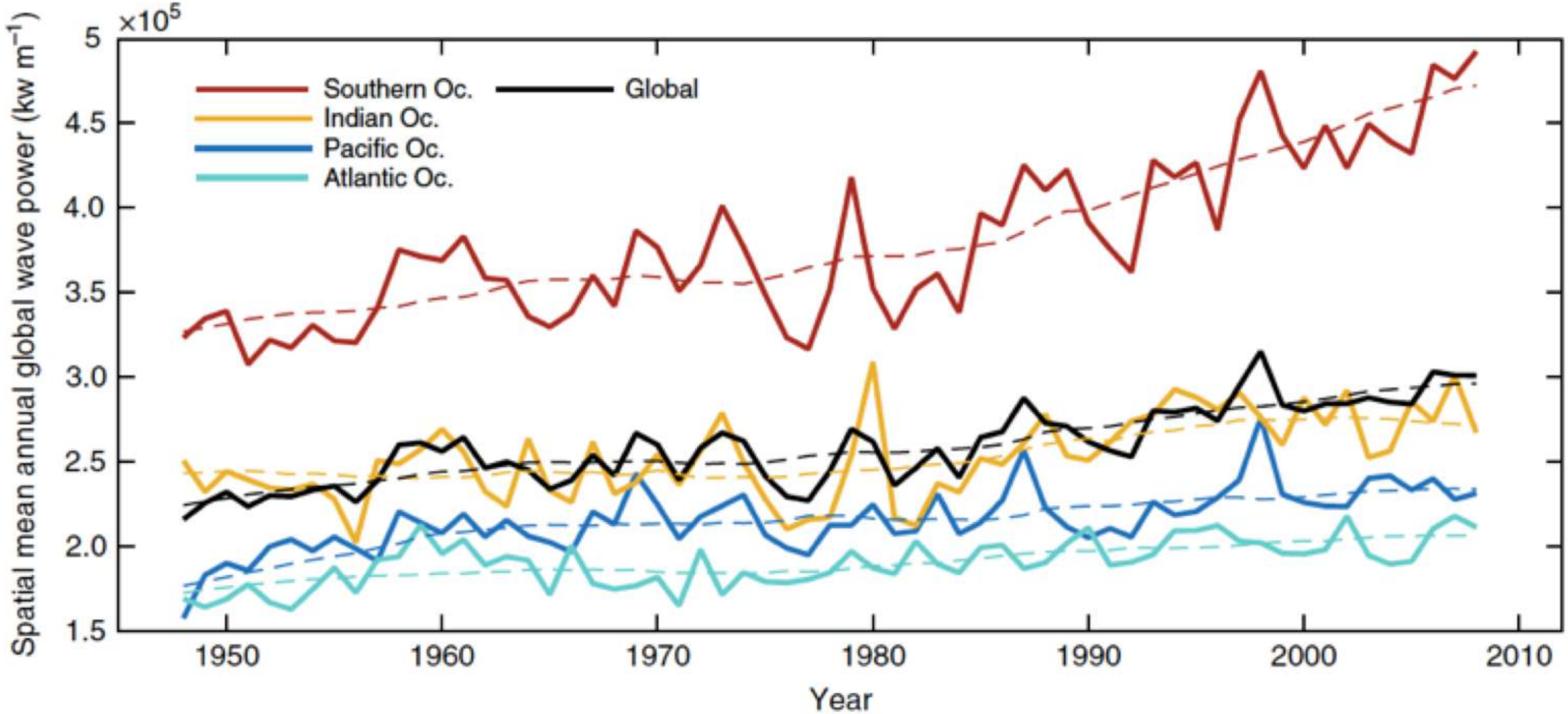
Research Letter

Attributable Human-Induced Changes in the Likelihood and Magnitude of the Observed Extreme Precipitation during Hurricane Harvey

Mark D. Risser, Michael F. Wehner

Increase in strength and frequency of hurricanes, coastal flooding

Increasing energy in weather phenomena



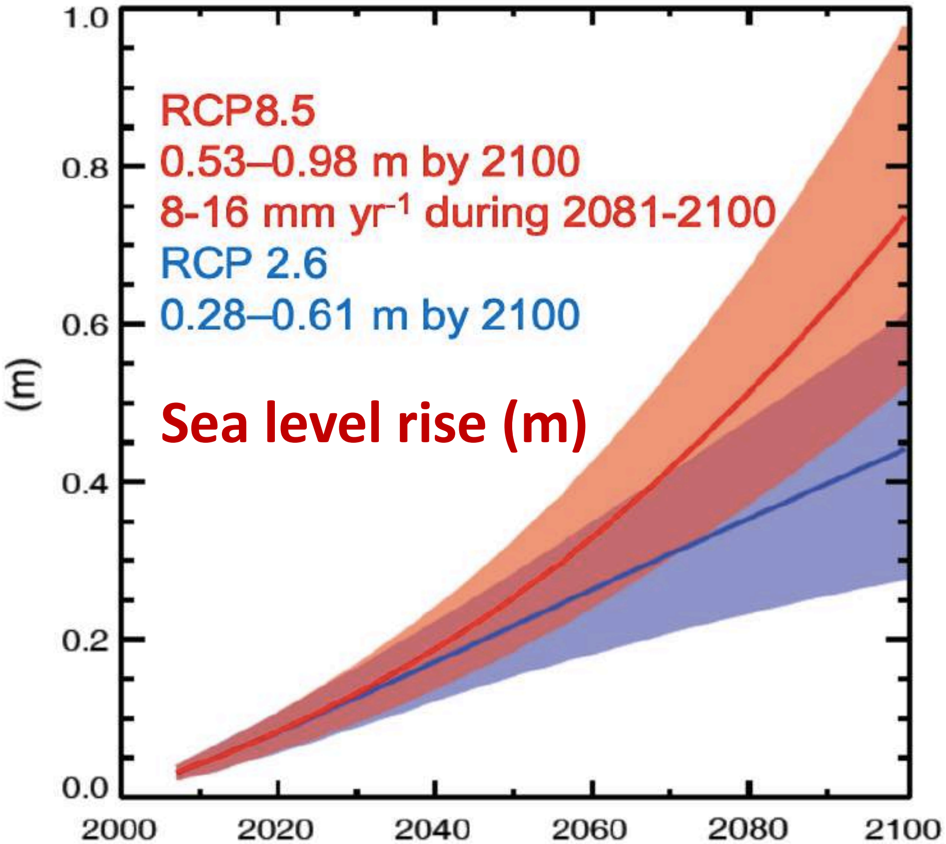
nature COMMUNICATIONS

A recent increase in global wave power as a consequence of oceanic warming

Borja G. Reguero[1,2], Iñigo J. Losada[1] & Fernando J. Méndez[1]

Increasing storm intensity and frequency

Sea level rise



IPCC — INTERGOVERNMENTAL PANEL ON climate change — WMO UNEP

Representative Concentration Pathway (RCP) has been defined by IPCC, as carbon dioxide atmospheric concentration, to depict climate scerario by IPCC.

Numbers (2.6, 4.5, 6.0, 8.5 are radiative forcing levels, delta between radiation adsorbed and dispersed back to space, in W/m^2).

RCP2.6 carbon dioxide emission peak is now and then decline

RCP4.5 peak in 2040

RC6.0 peak in 2080

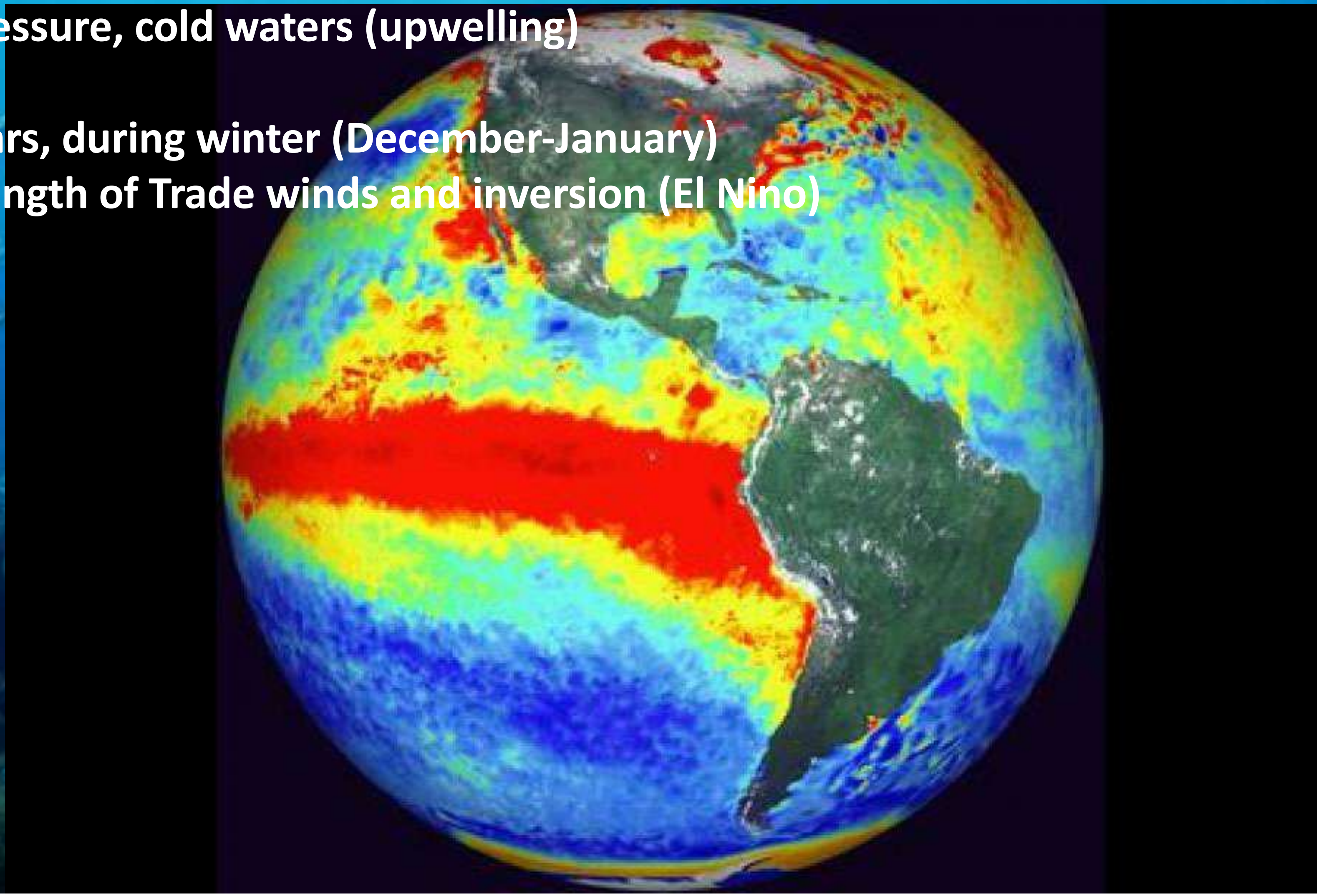
RCP8.5 continue to increase until the end of century

El Nino

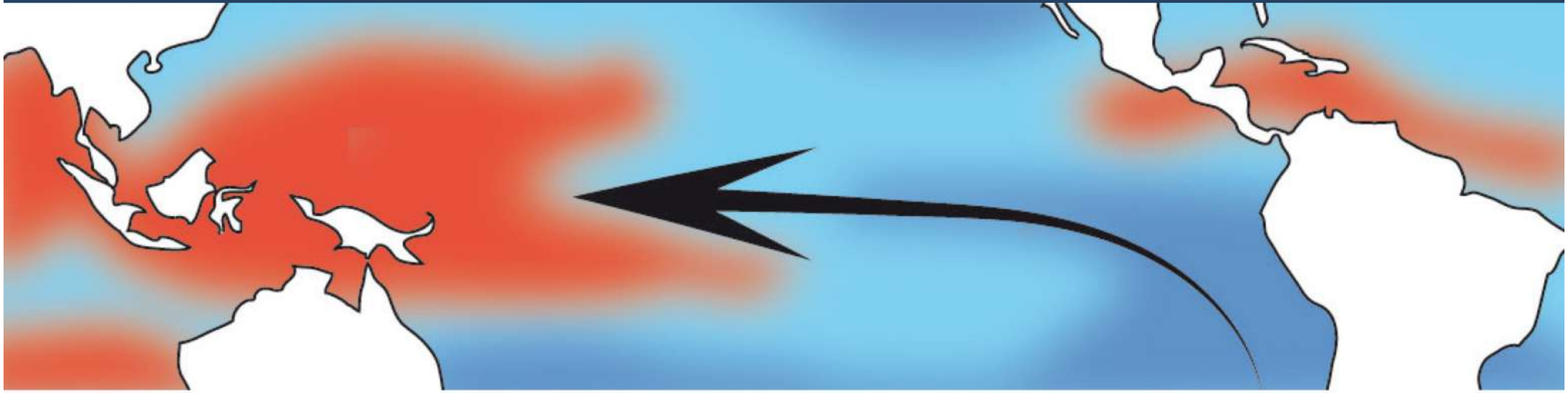
Atmospheric-oceanic coupled process El Nino - Southern Oscillation (ENSO)

Strong Trade winds
WC Pacific high pressure, precipitations, warm waters
EC Pacific low pressure, cold waters (upwelling)

Cycles of few years, during winter (December-January)
Reduction in strength of Trade winds and inversion (El Nino)

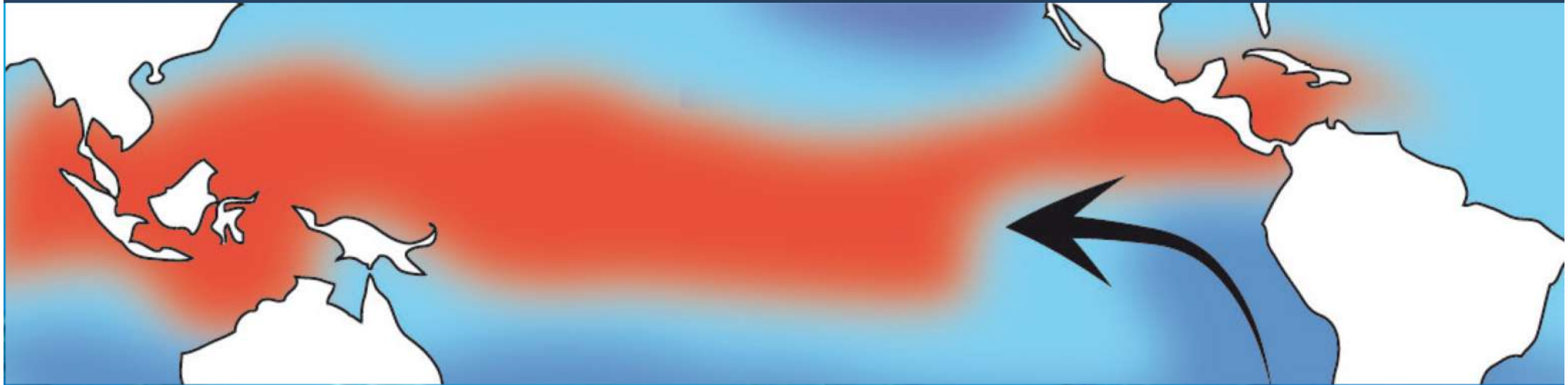


ENSO (El Nino Southern Oscillation)



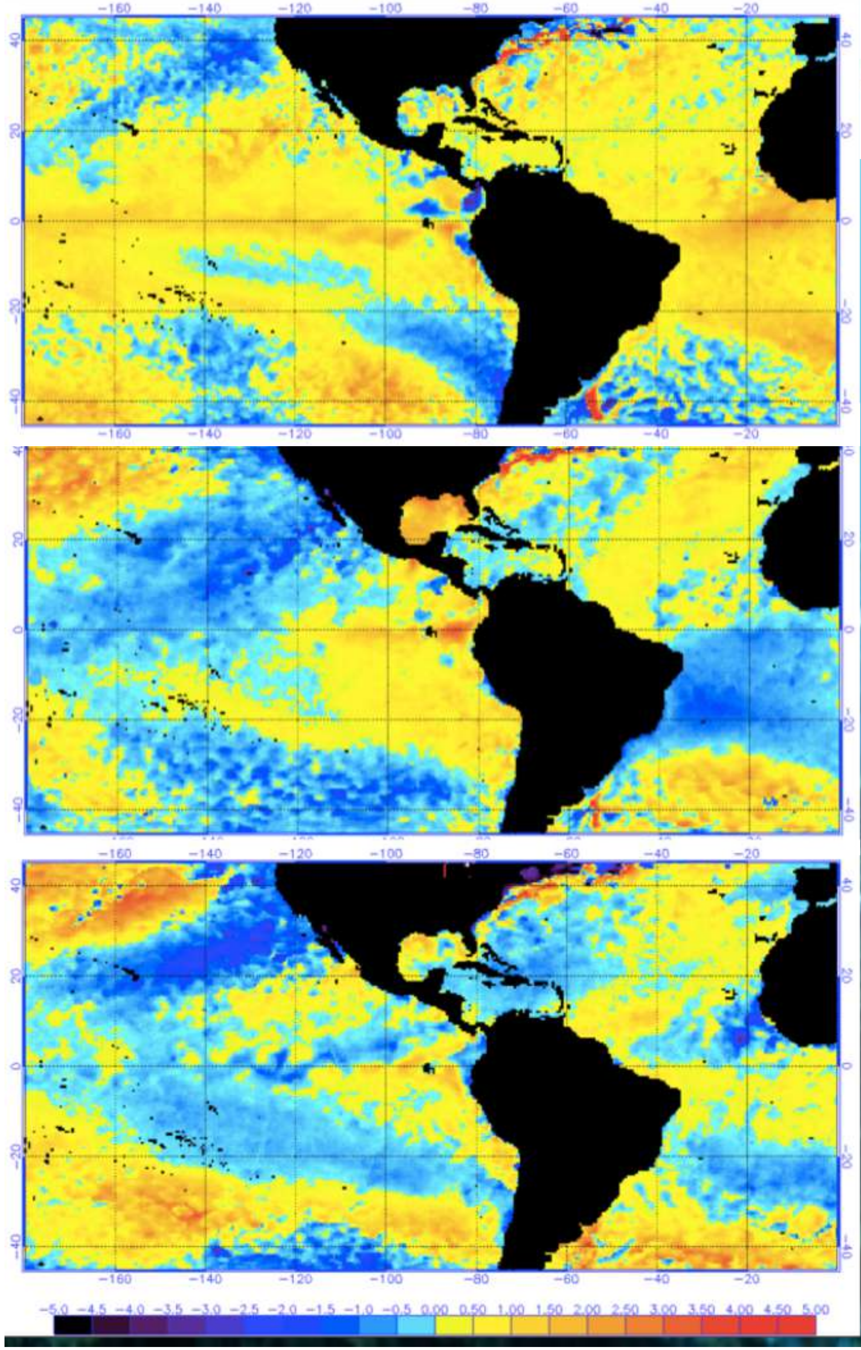
Normal conditions: wind trades blow strong, the Humboldt current is strong, upwelling occurs on the S America coasts (Chile and Ecuador), high pressure is on S-central Pacific and low pressure (wet, warm) on the Australian and Indonesian coasts. Superficial waters in the east Pacific are cold. When T is 0.5 ° C or more below the seasonal average, we have **la Nina**.

ENSO (El Nino Southern Oscillation)



El Nino: cyclic but irregular, every 2-7 years (5 on average) with max during winter (december). It is an increase in superficial water temperature in the central-SE Pacific of at least 0.5 °C above the average T for at least 5 months. Wind trades are weak, the Humboldt current is weak, upwelling on the S America coasts (Chile and Ecuador) is strongly reduced or absent, high pressure is on the Australian and Indonesian coasts and low pressure (wet, warm) on the S-central Pacific coasts. Superficial waters in the east Pacific are warm.

Thermal anomalies and melting ice

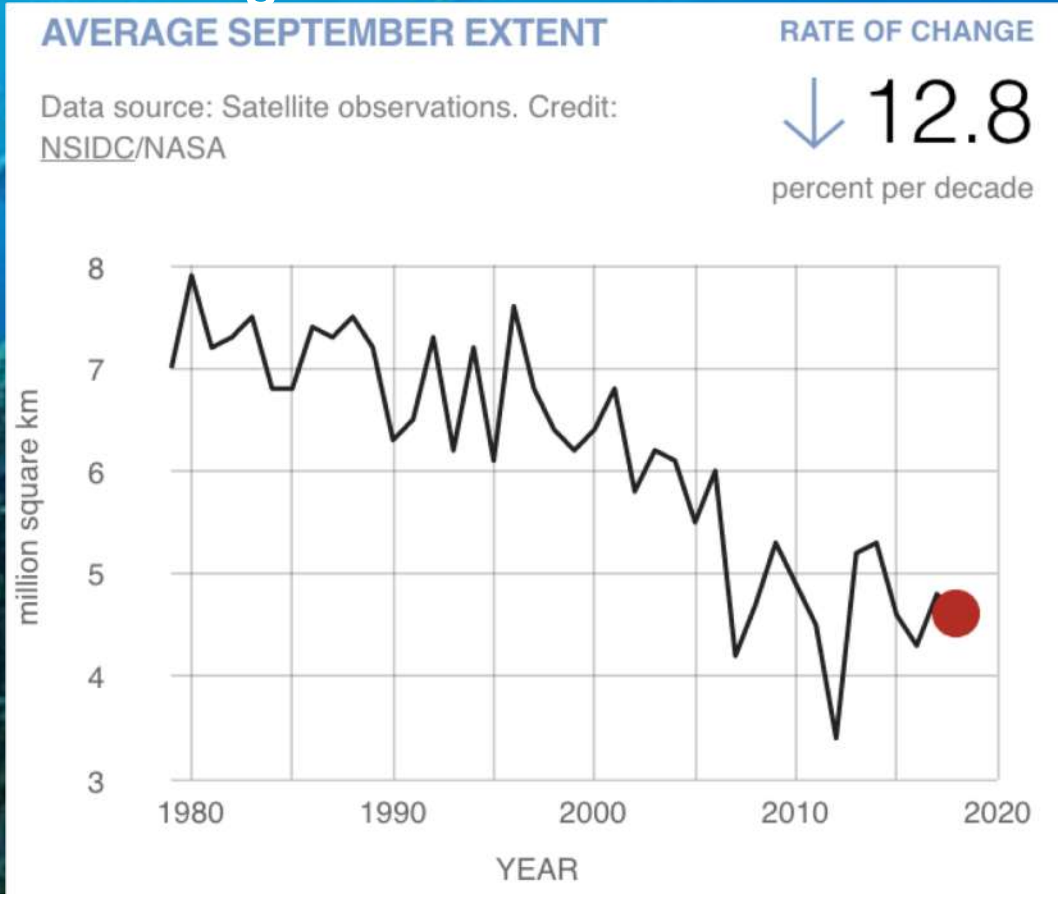


2019

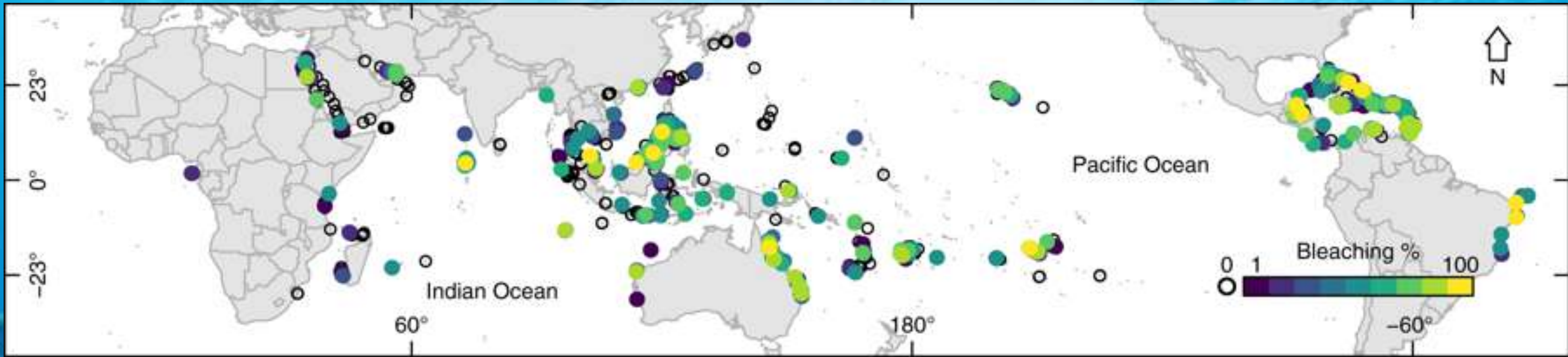
2012

2009

Increasing SST, causing thermal anomalies, melting polar ice, and altering oceanic currents



Mass mortalities



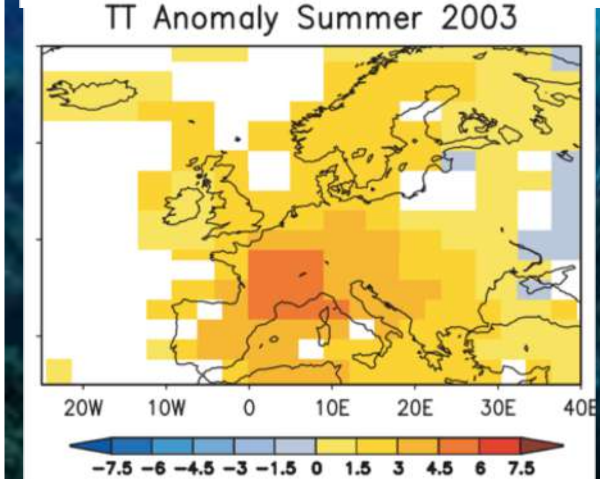
nature COMMUNICATIONS

A global analysis of coral bleaching over the past two decades

S. Sully, D. E. Burkepile, M. K. Donovan, G. Hodgson & R. van Woesik

Mass mortality of marine species of key ecological role

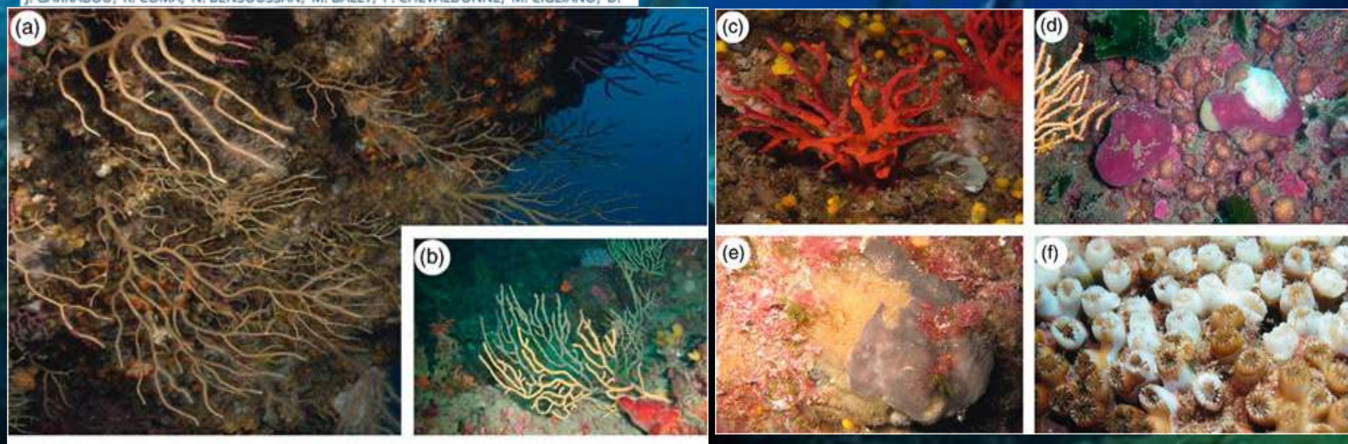
European Seasonal and Annual Temperature Variability, Trends, and Extremes Since 1500
Jürg Luterbacher, *et al.*
Science **303**, 1499 (2004);
DOI: 10.1126/science.1093877



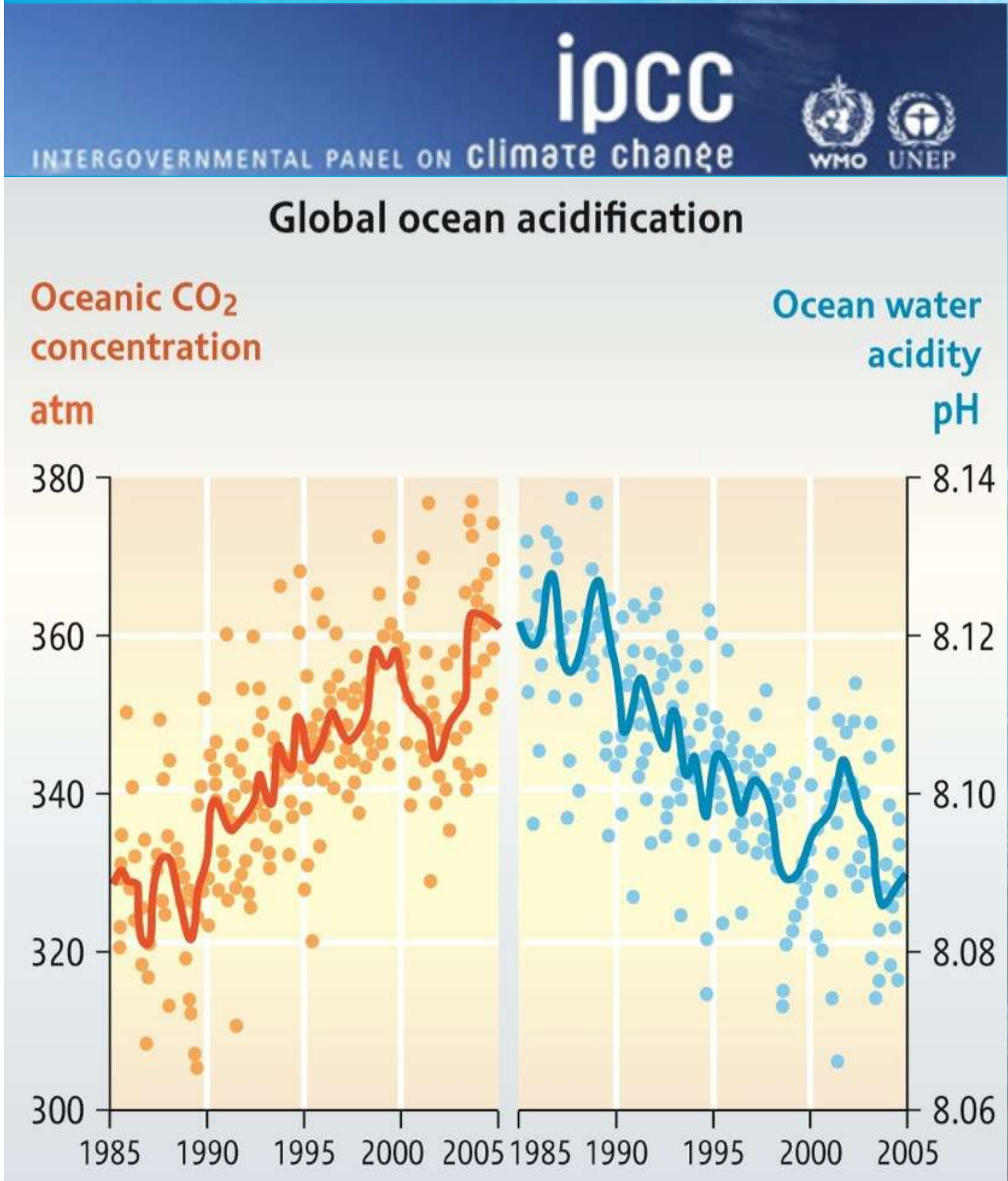
Global Change Biology

Mass mortality in Northwestern Mediterranean rocky benthic communities: effects of the 2003 heat wave

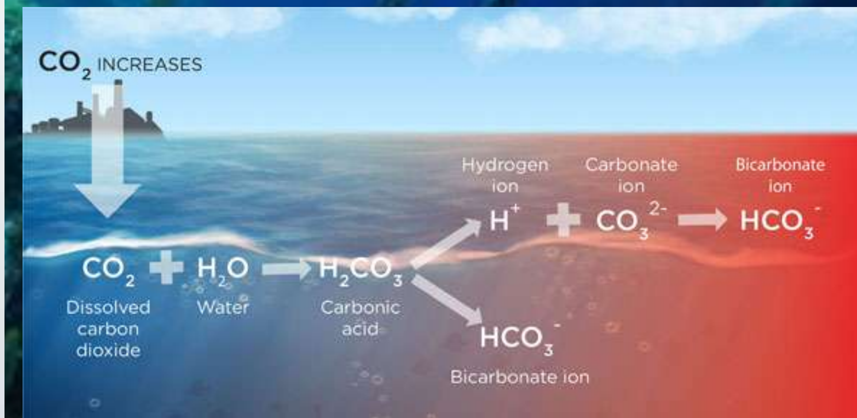
J. GARRABOU, R. COMA, N. BENSOUSSAN, M. BALLY, P. CHEVALDONNÉ, M. CIGLIANO, D.



Acidification

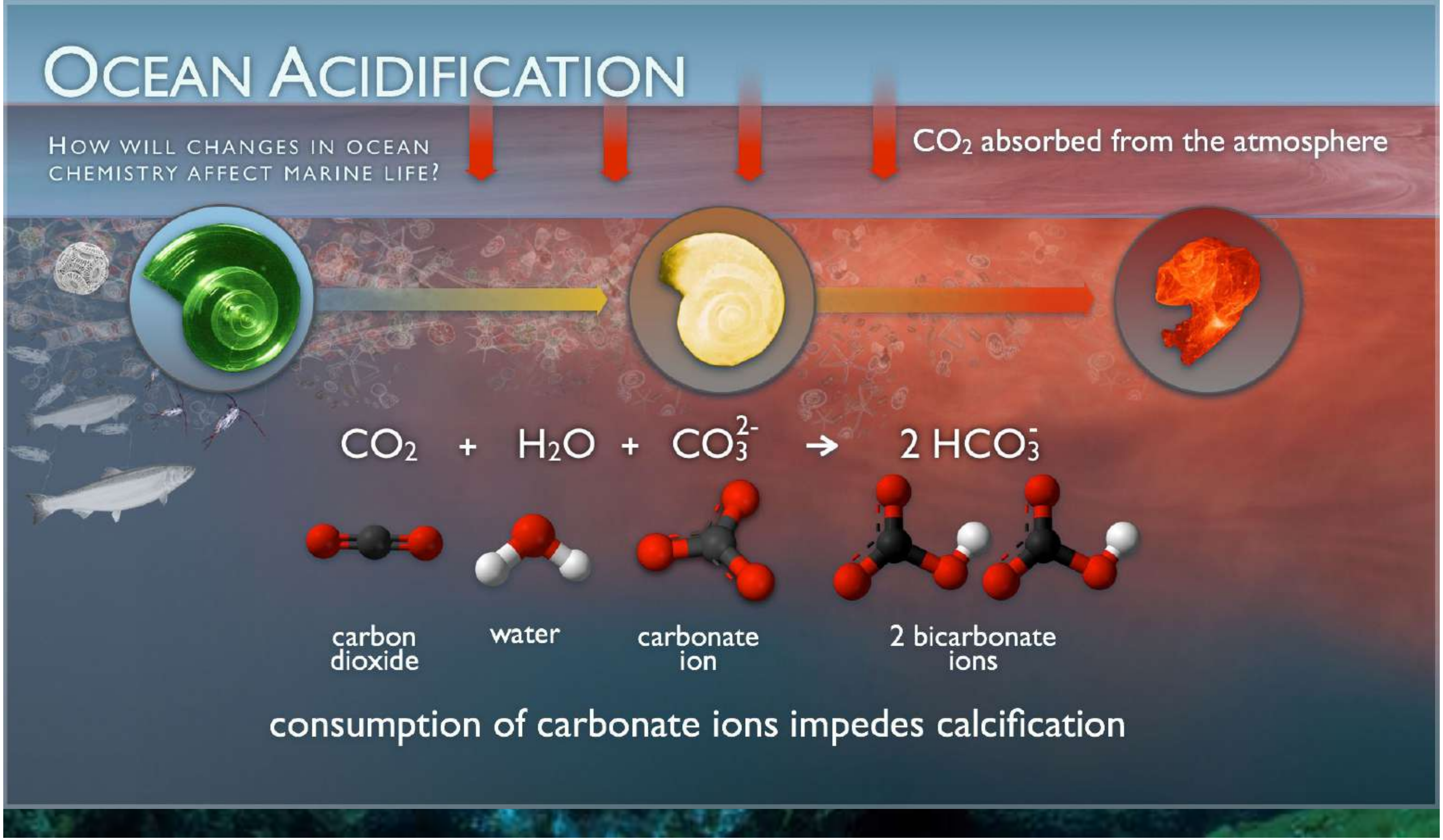


Oceans absorb about one third of atmospheric CO^2. So, increasing level of carbon dioxide in the air results in increasing levels in sea water. **This lead to increase in carbonic acid, and H^+ ions that decrease ocean pH, which is generally slightly basi**c.



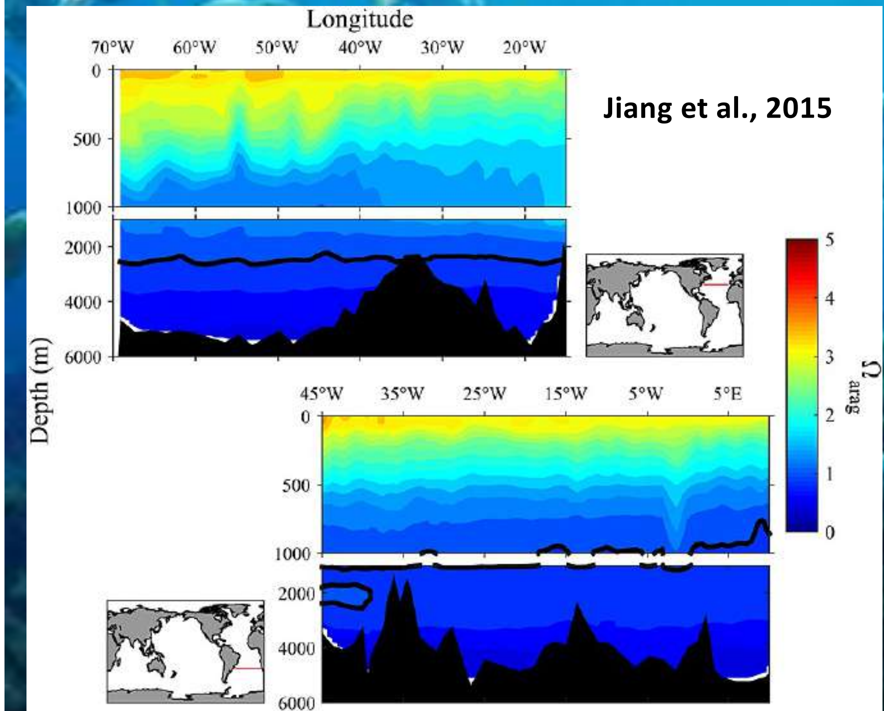
Acidification

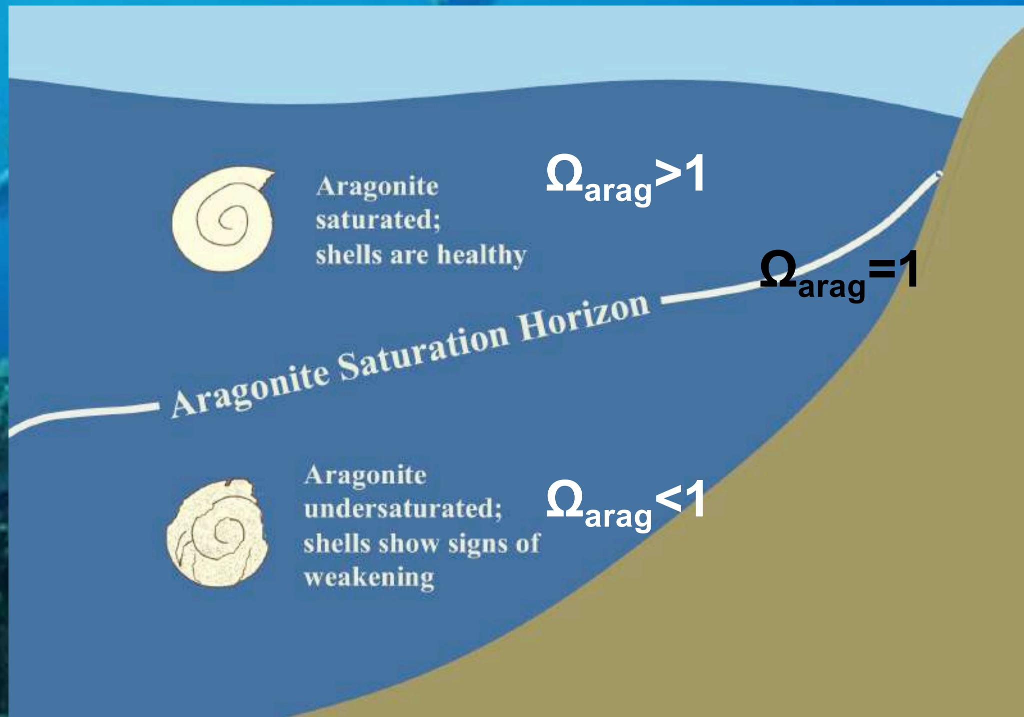
Oceans absorb about one third of anthropogenic atmospheric CO_2. So, increasing level of carbon dioxide in the air results in increasing levels in sea water. **This lead to increase in carbonic acid, and H^+ ions that decrease ocean pH, which is generally slightly basi**c.



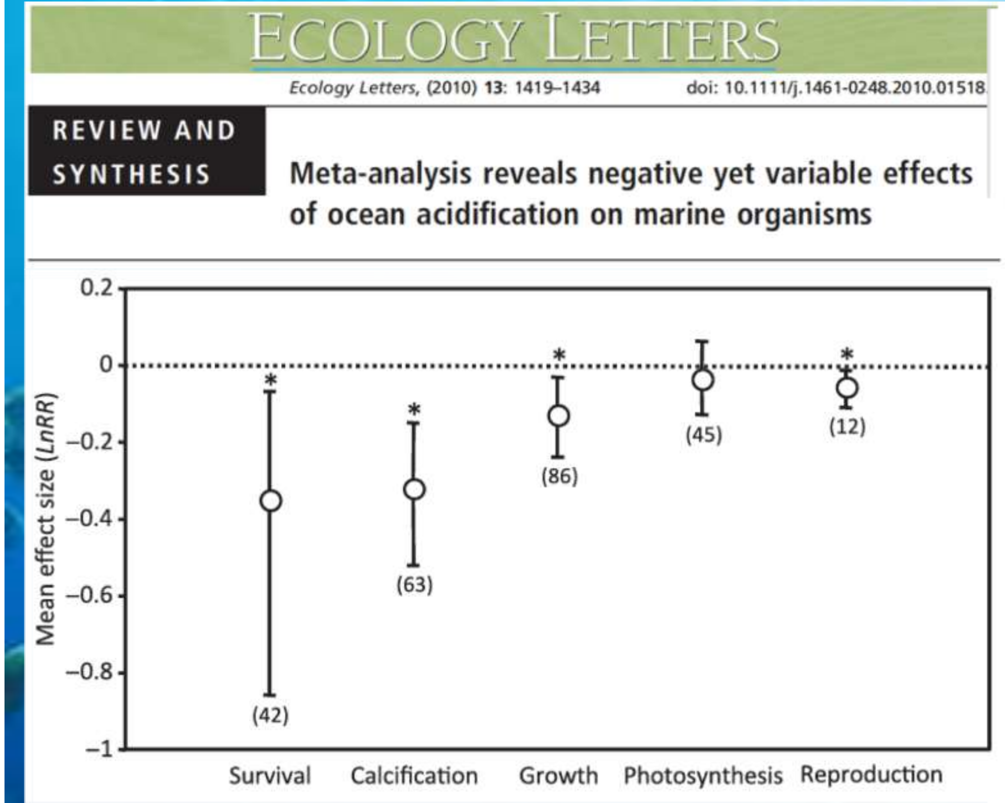
Effects on carbonate deposition

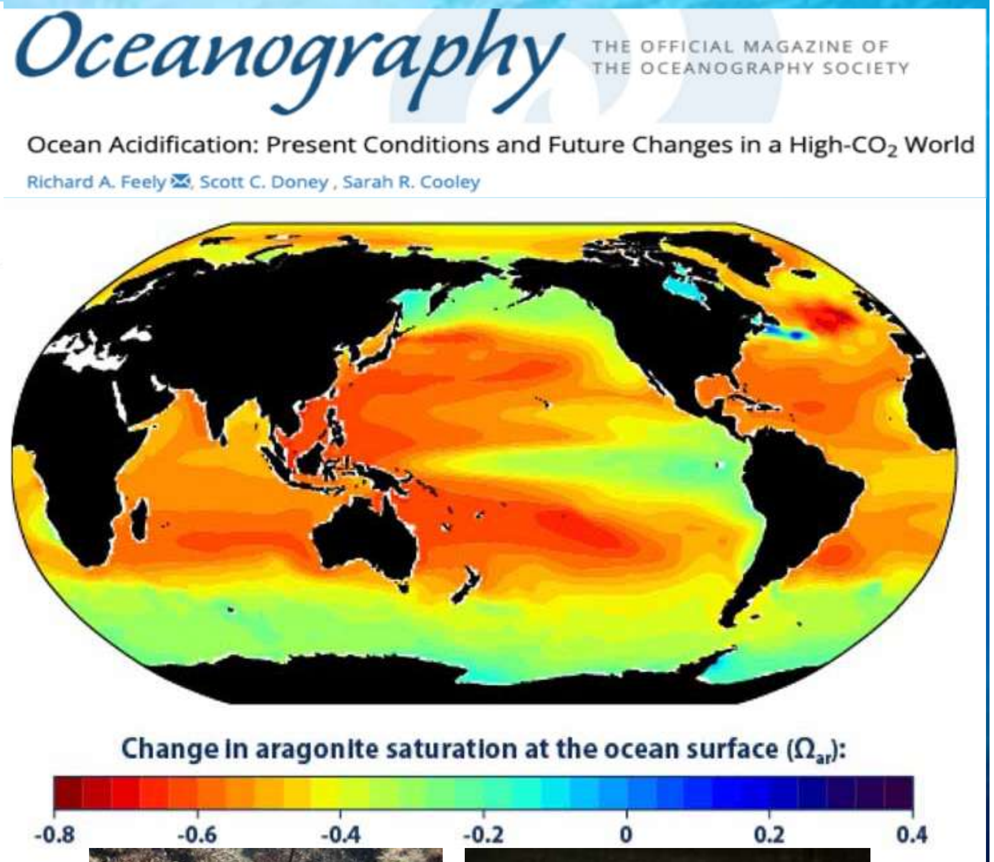
Aragonite and calcite are the two cristalline forms of calcium carbonate, used by most of marine organisms with calcified structures (corals, molluscs, crustaceans, coralline algae, etc.). Ω_{arag} was higher in the surface mixed layer. Higher hydrostatic pressure, lower water temperature, and more CO_2 buildup from biological activity in the absence of air-sea gas exchange helped maintain lower Ω_{arag} in the deep ocean.





Effects



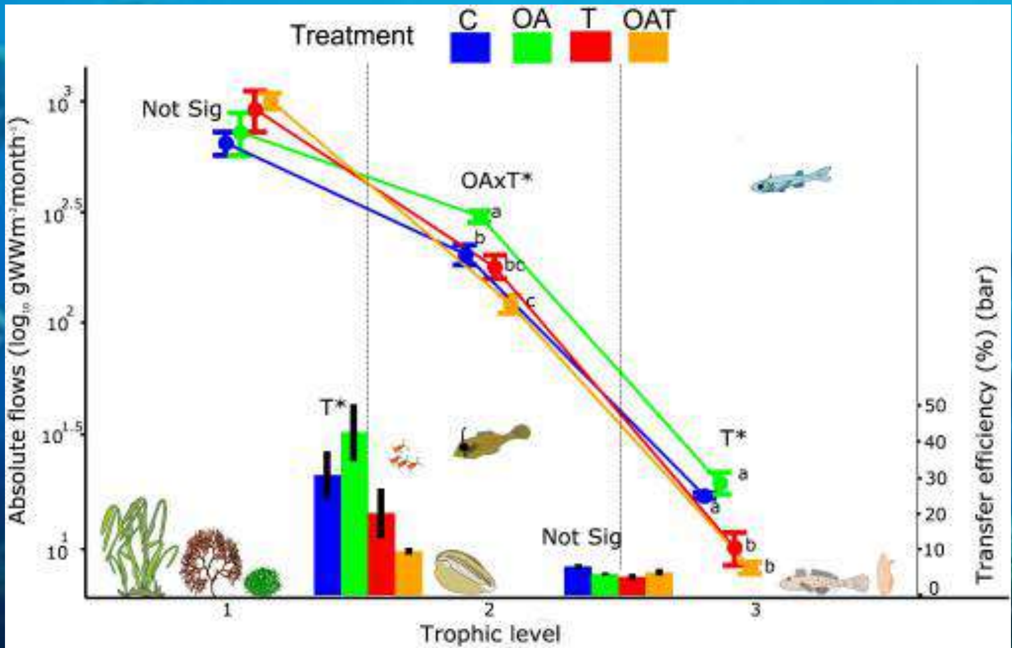


Many marine organisms, from phytoplankton to fish, are sensitive to changes in carbonate chemistry, and their **responses to the predicted changes could lead to profound ecological shifts in marine ecosystems.**

Food webs

PLOS | BIOLOGY A Peer-Reviewed, Open Access Journal

Climate change could drive marine food web collapse through altered trophic flows and cyanobacterial proliferation



Habitat destruction for seals and bears with consequent loss of feeding grounds and refuge. Plankton can be affected with bottom-up cascading effects. Shift in composition of plankton producers could reduce energy transfer through trophic webs, leading to the decline of apical species populations.

Shifting Patterns of Life in the Pacific Arctic and Sub-Arctic Seas

Annual Review of Marine Science

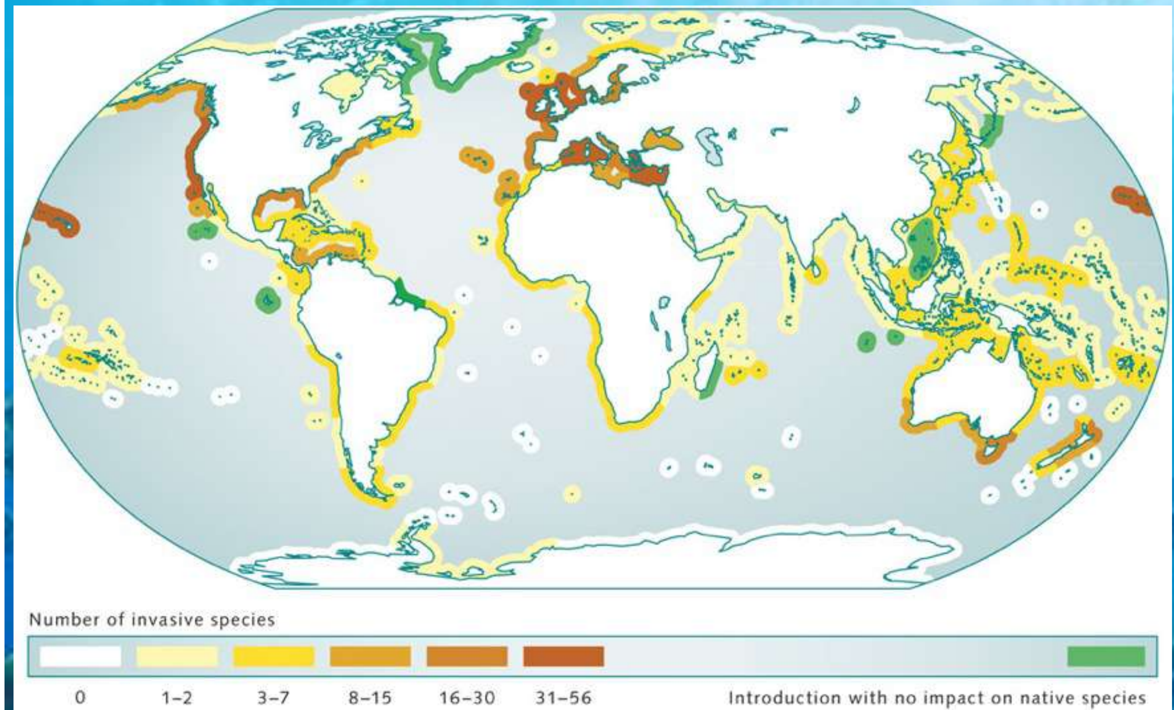
Vol. 4:63-78 (Volume publication date January 2012)

First published online as a Review in Advance on September 19, 2011

https://doi.org/10.1146/annurev-marine-120710-100926

Jacqueline M. Grebmeier

Invasions



REVIEWS REVIEWS REVIEWS

Assessing the global threat of invasive species to marine biodiversity

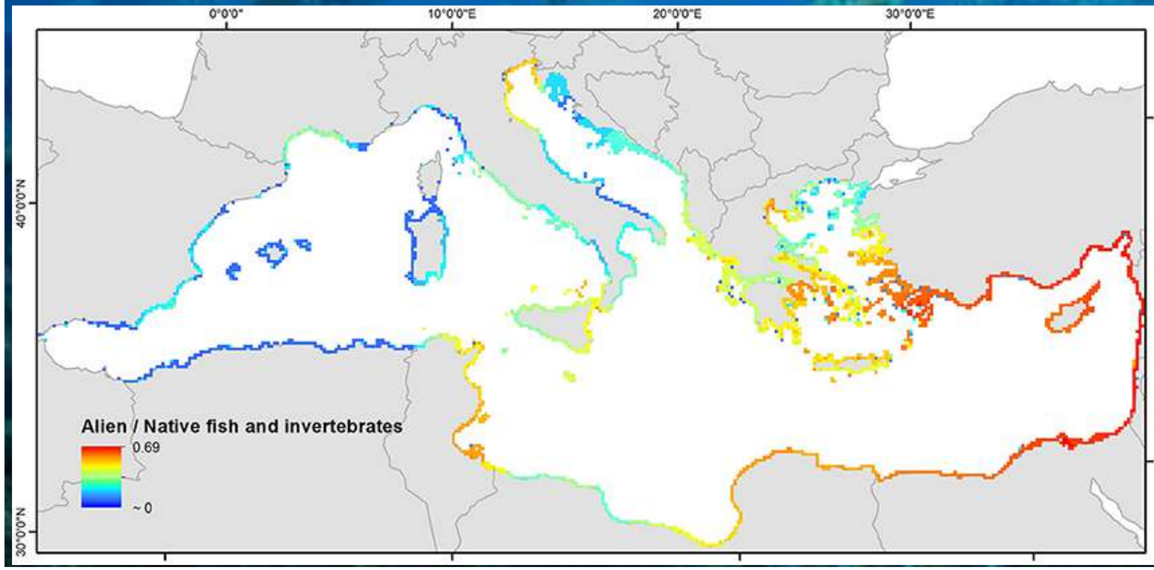
Jennifer L Molnar[1*], Rebecca L Gamboa[1], Carmen Revenga[2], and Mark D Spalding[3]

Ecological Society of America esa Frontiers in Ecology and the Environment

PNAS Proceedings of the National Academy of Sciences of the United States of America

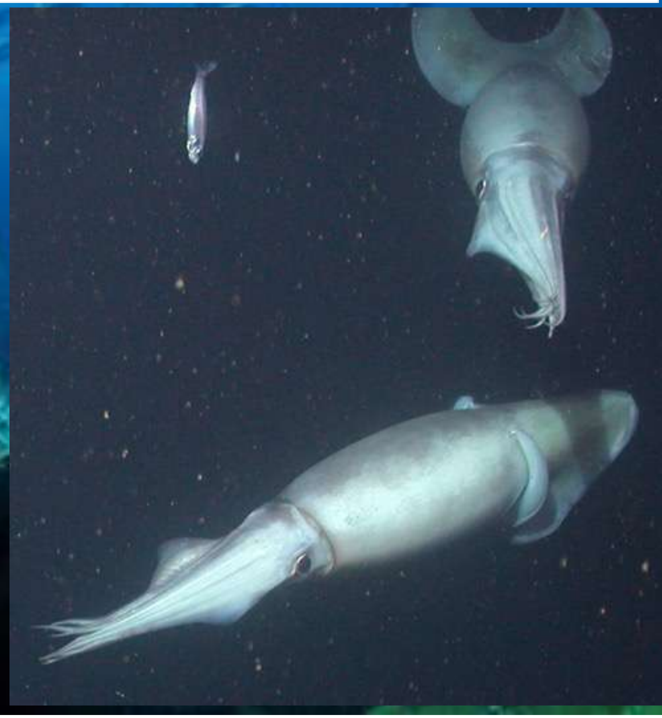
Invasive range expansion by the Humboldt squid, *Dosidicus gigas*, in the eastern North Pacific

Species invasions and poleward shift in distribution

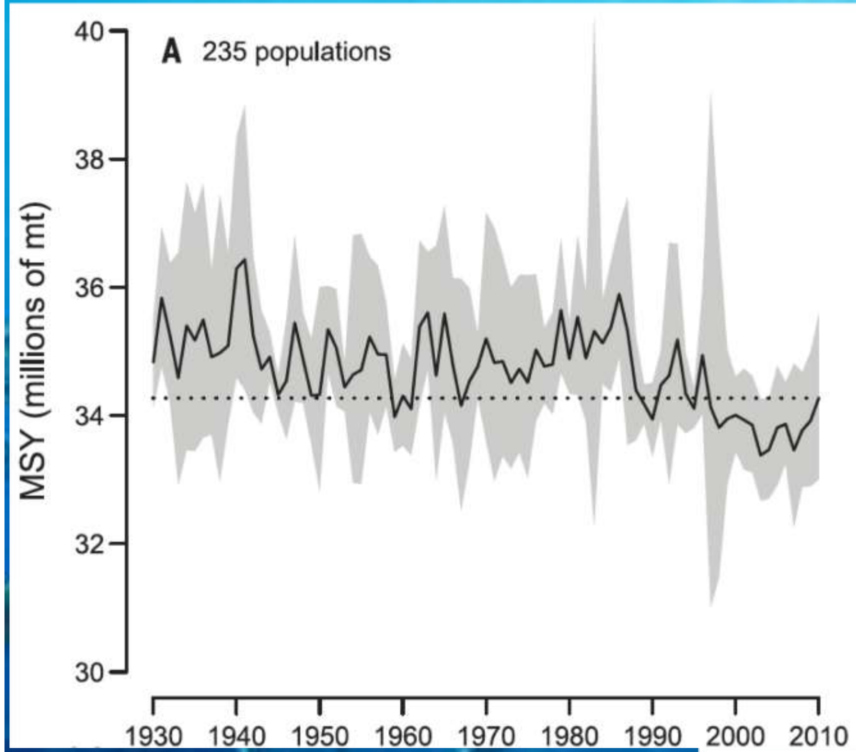


frontiers in Marine Science | Marine Ecosystem Ecology

Invading the Mediterranean Sea: biodiversity patterns shaped by human activities



Impact on fisheries

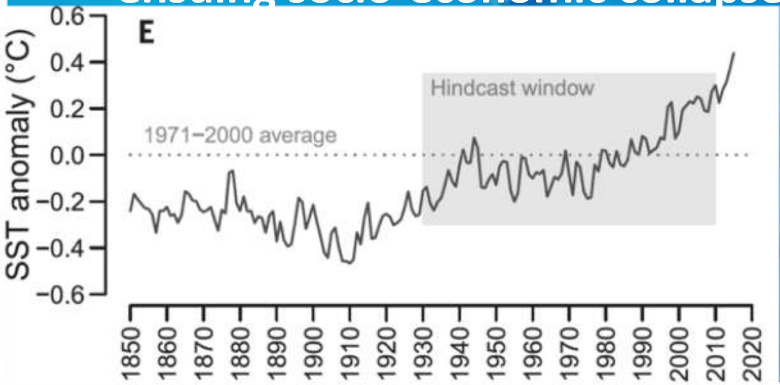


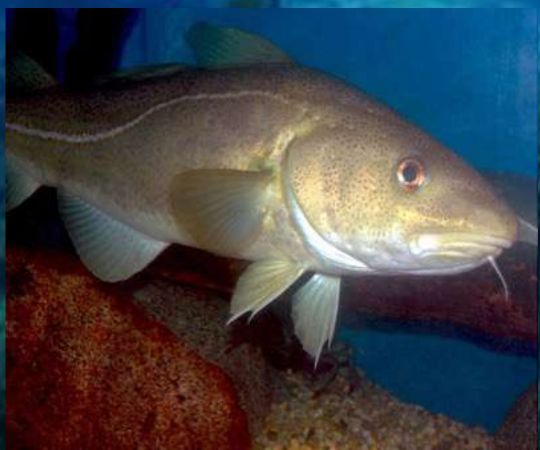
Science

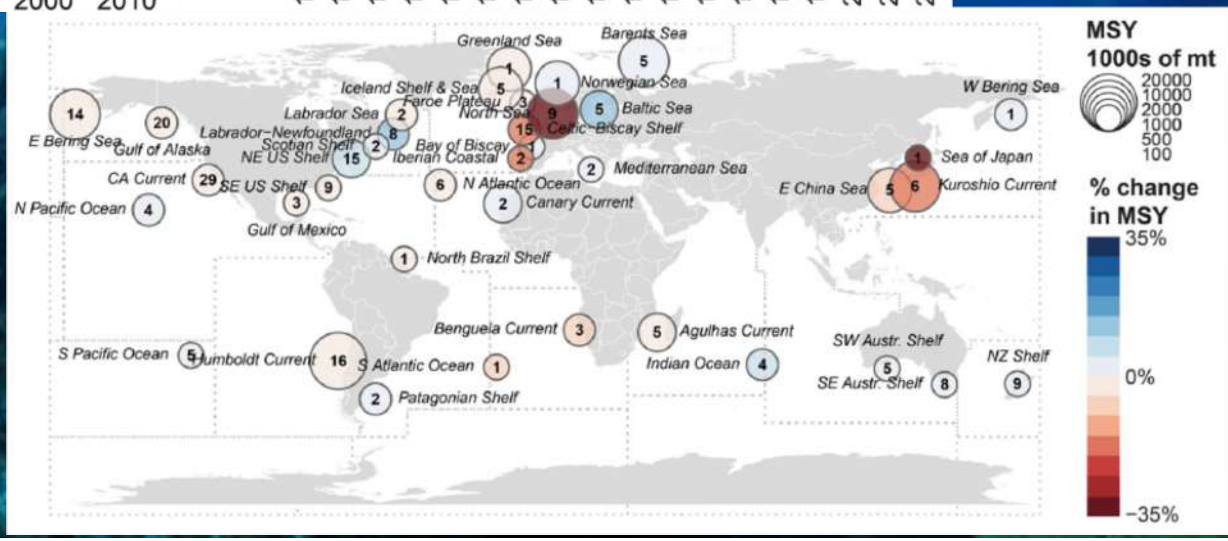
Impacts of historical warming on marine fisheries production

Christopher M. Free[1,2]*, James T. Thorson[3,4], Malin L. Pinsky[5], Kiva L. Oken[1,6], John Wiedenmann[5], Olaf P. Jensen[1]

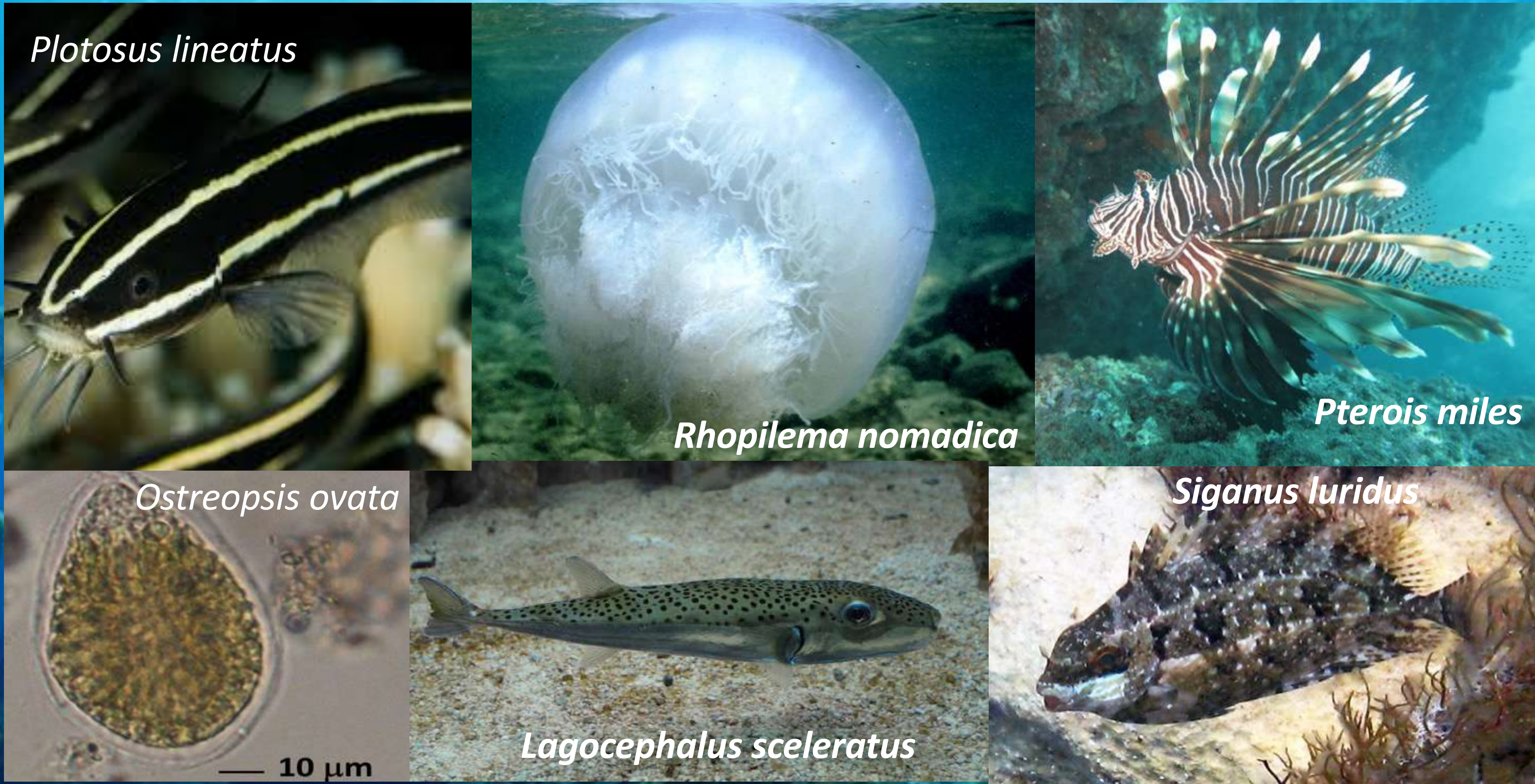
Decline of of fish and invertebrate living resources, reduction of seafood provision and ensuing socio-economic collapses







Harmful species



The Mediterranean Sea
Its history and present challenges

Metamorphoses: Bioinvasions in the Mediterranean Sea 2014

B.S. Galil and Menachem Goren

Increasing risk for human health due to the introduction of toxic or harmful species