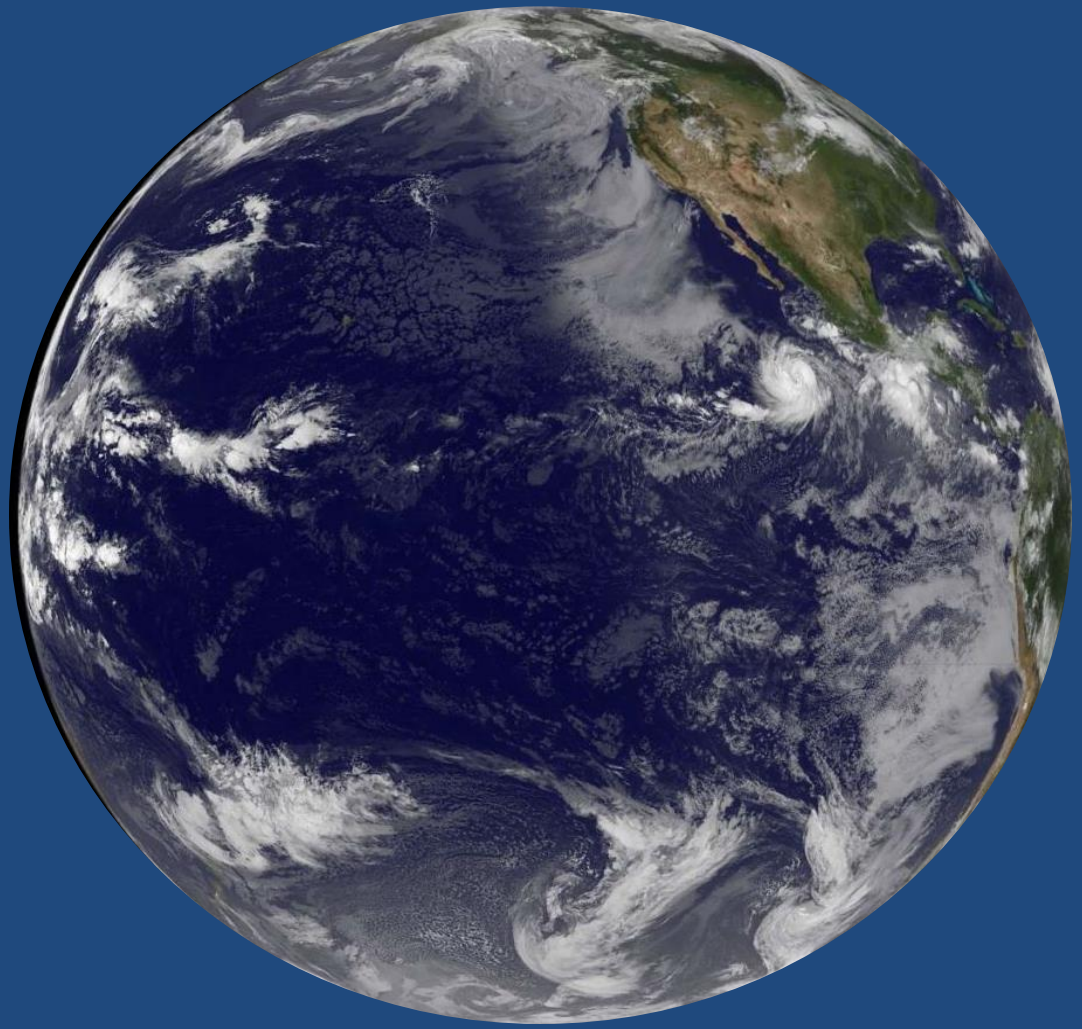
Predicting and adapting to ocean thresholds



MIT Global Change Forum
March 29, 2019

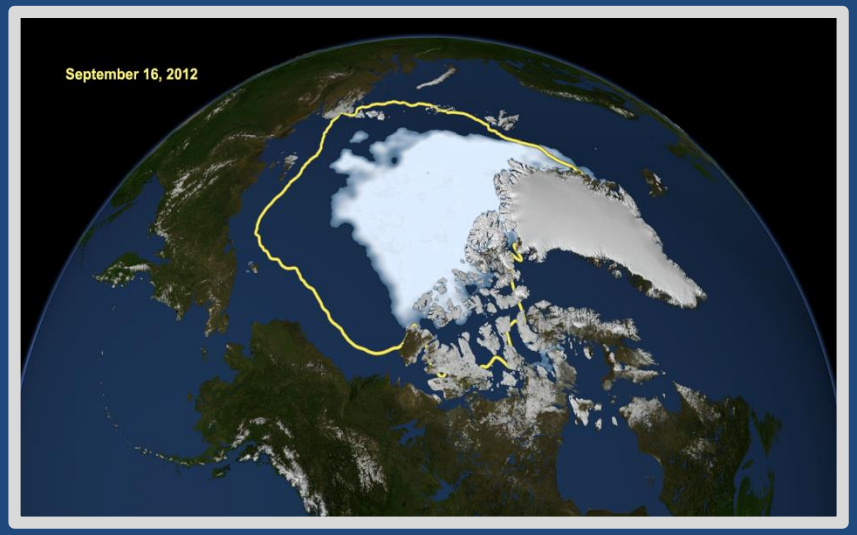
Charles Stock
Research Oceanographer
NOAA/GFDL

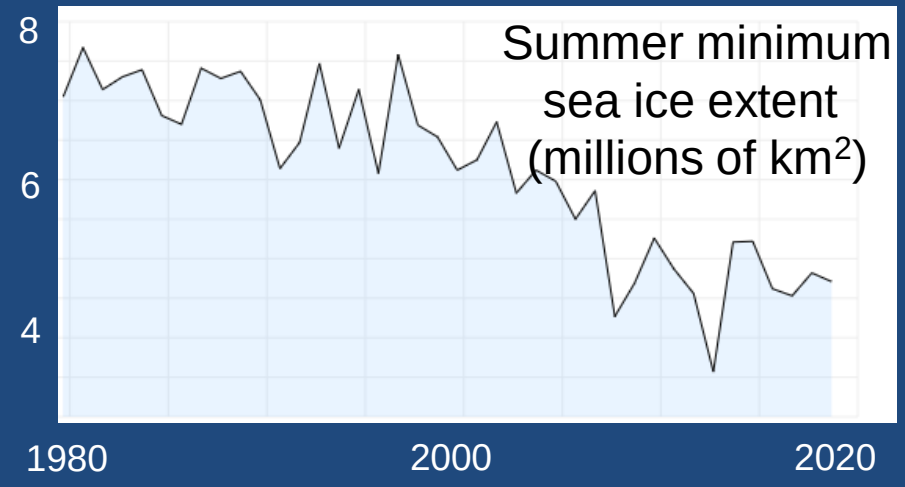
Our reliance on living marine resources

- More people eating more fish
- 180 million tons of fish, with nearly half now from aquaculture
- Provides 2.9 billion people with >20% of their animal protein intake
- Value at first sale is $362 Billion
- 59.6 million people employed in fisheries and aquaculture
- World trade in fish and fish products 143 billion

Source: FAO 2018 State of World Fisheries and Aquaculture

Threshold: a point above which something is true, and below which it is not





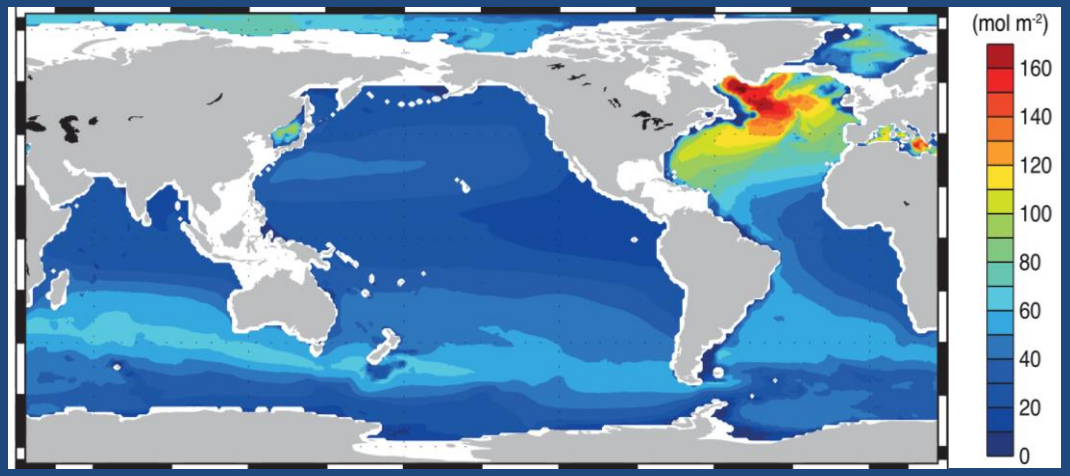
- When will there be an Arctic summer without sea ice?
- What if the North Atlantic overturning circulation collapsed?
- What if the Greenland ice sheet were to melt?

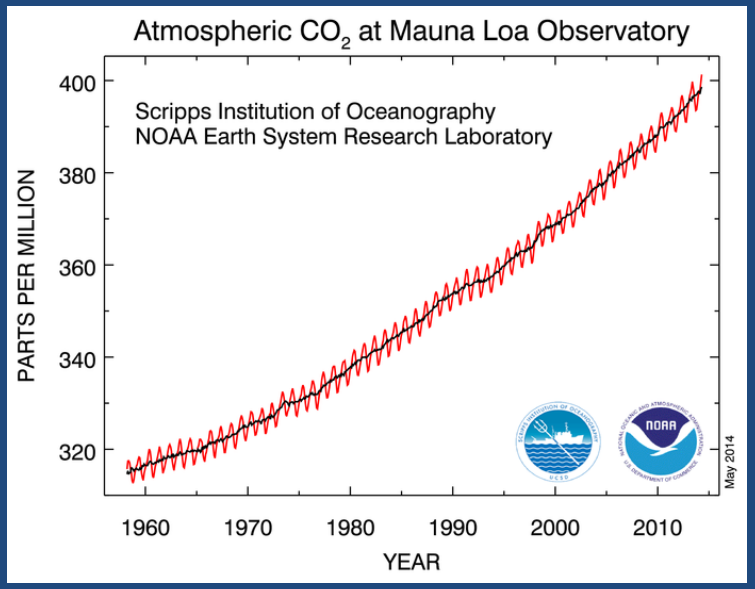
Powerful binary events, but we are regularly crossing meaningful thresholds now

Data: Data from NOAA National Snow and Ice Data Center Figures, Top: NASA Scientific Visualization Studio; Bottom: NOAA/Climate.gov

Thank your local ocean, it has provided humankind a great service

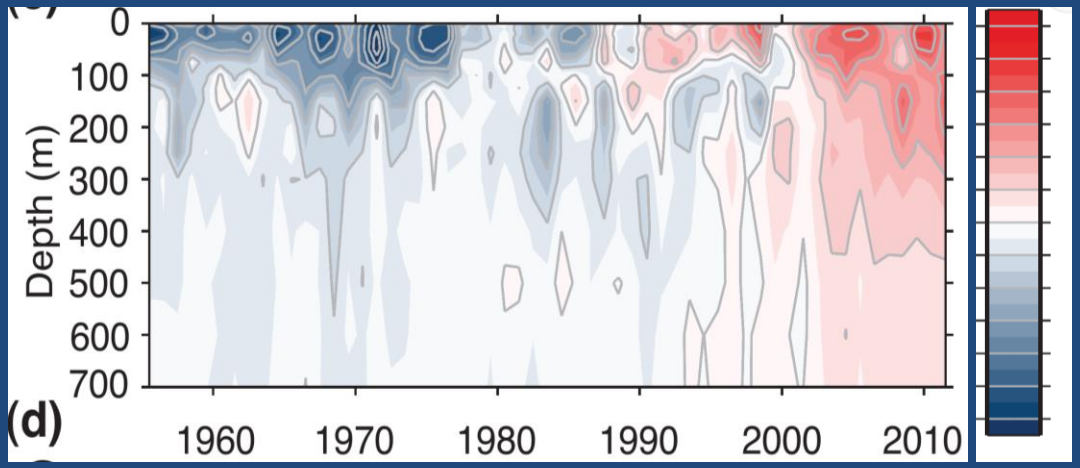
The ocean has absorbed 1/2 of our carbon emissions since the industrial revolution





+0.3ºC

The ocean has absorbed 90% of the heat energy added from GHGs Between 1971-present

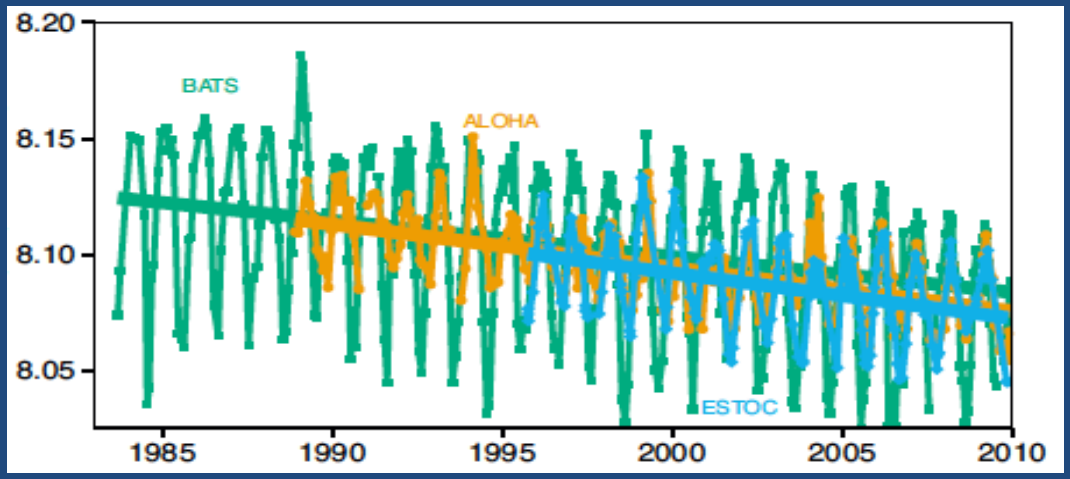


-0.3ºC

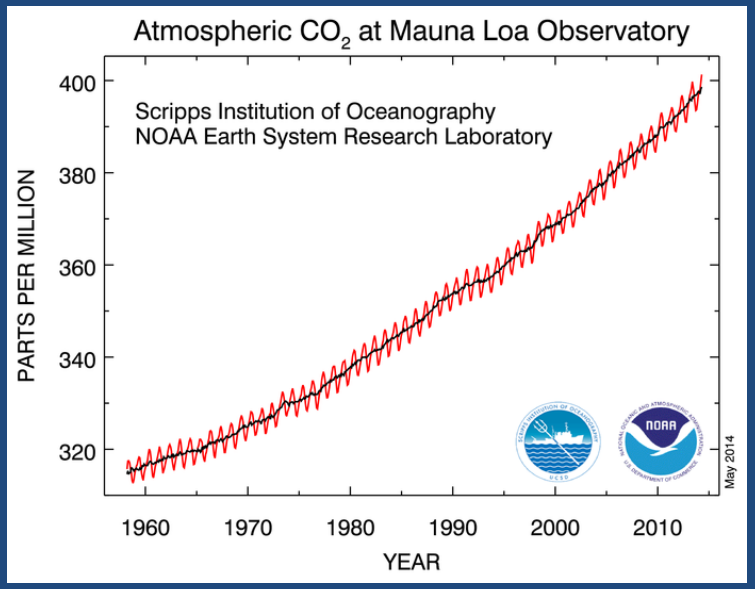
Source: IPCC AR5 report working group 1 report, Sabine et al., 2004

But this service has come with a cost

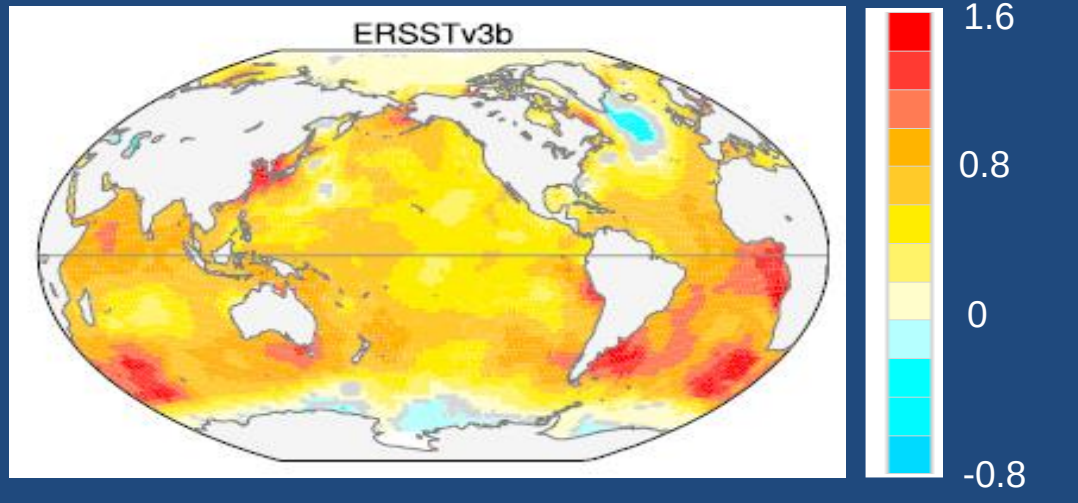
Ocean pH dropping →



IPCC AR5 working group 2 report



Surface ocean temperatures
(ºC per century) increasing →

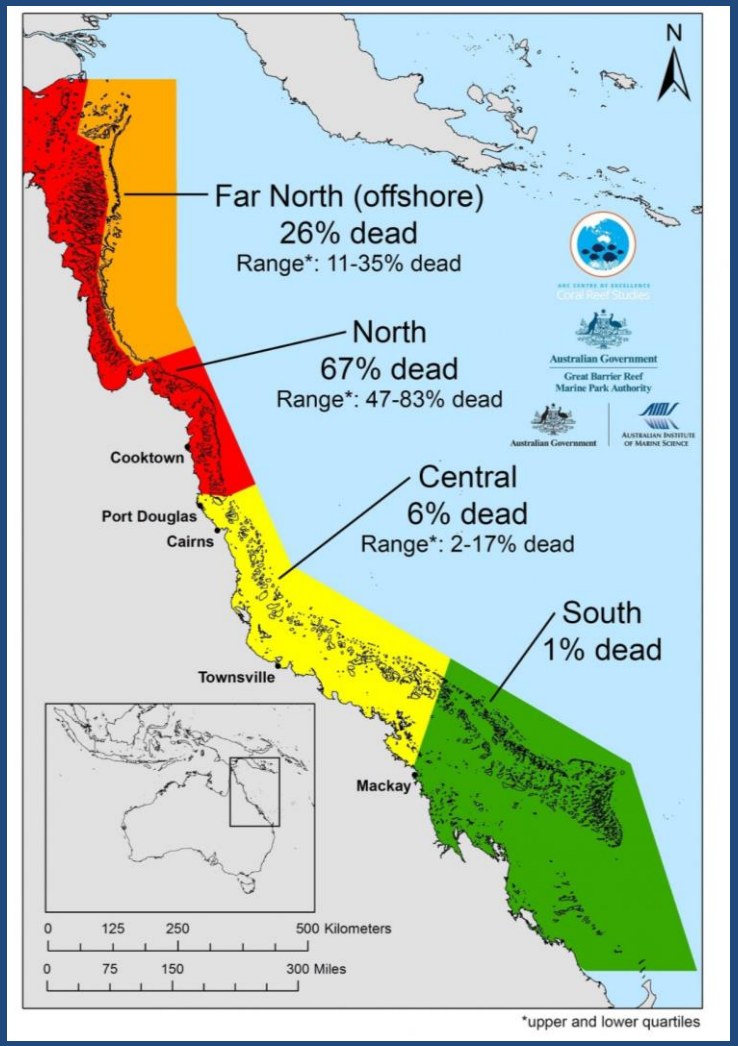


Deser et al., 20th century tropical SST trends revisited, GRL, 2010

Unprecedented ocean heat waves compounded by acidification

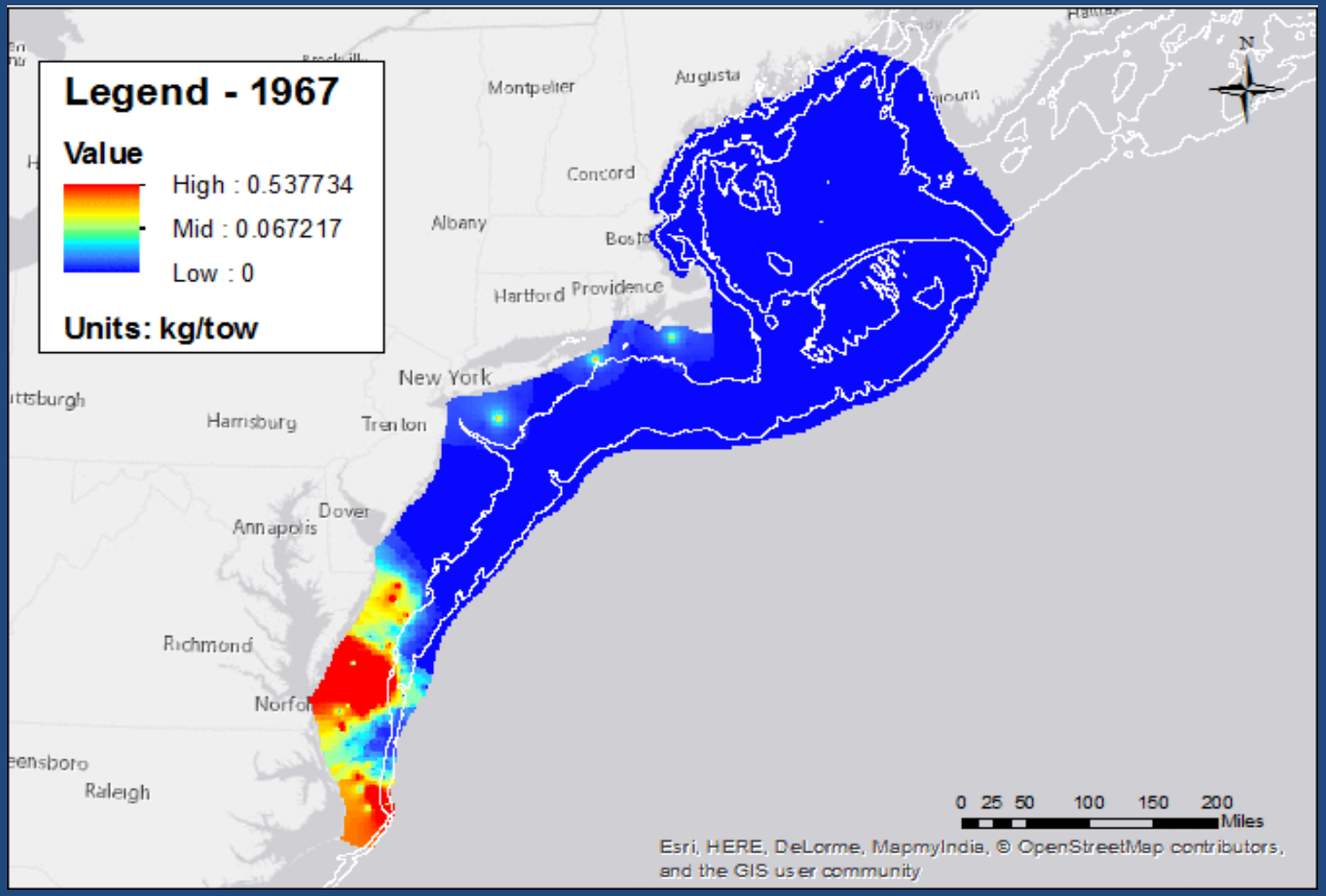
Bleached staghorn coral on the Great Barrier Reef between Townsville and Cairns, March 2017, Credit, Bette Willis.

Large-scale bleaching and coral death on Great Barrier Reef due to 2016 “ocean heat wave”



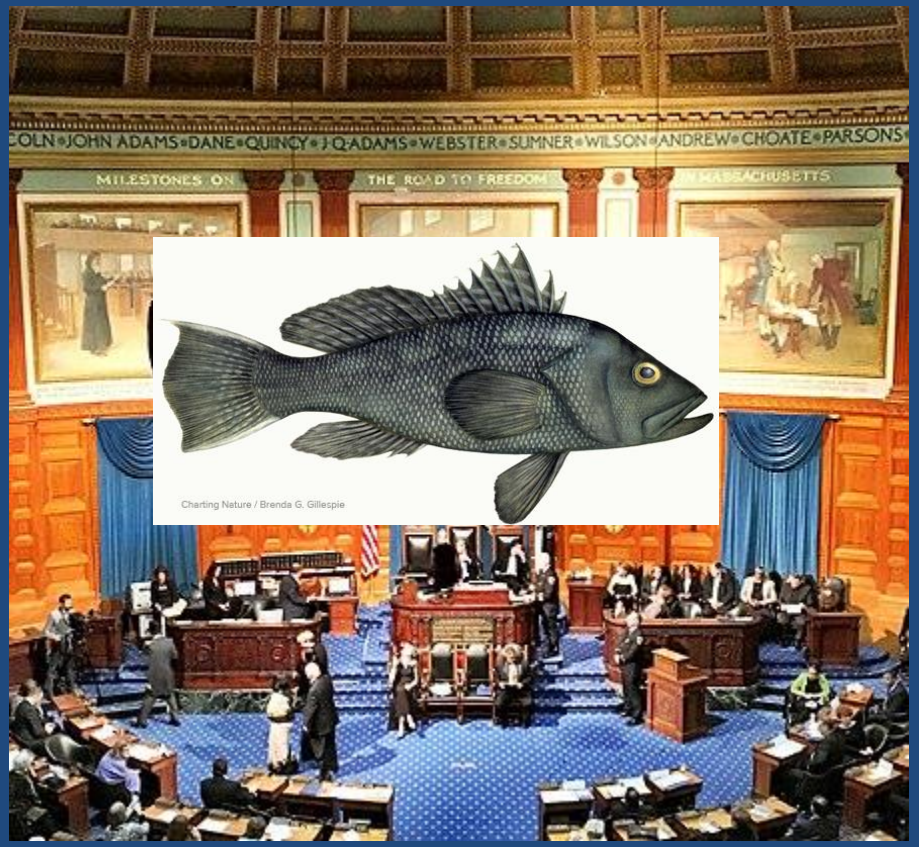
Hughes et al., Nature, 2017; Figures from James Cook Univ. via Washington Post

Thresholds also crossed through persistent change



Movie: oceanadapt.rutgers.edu (Pinsky, Selden);

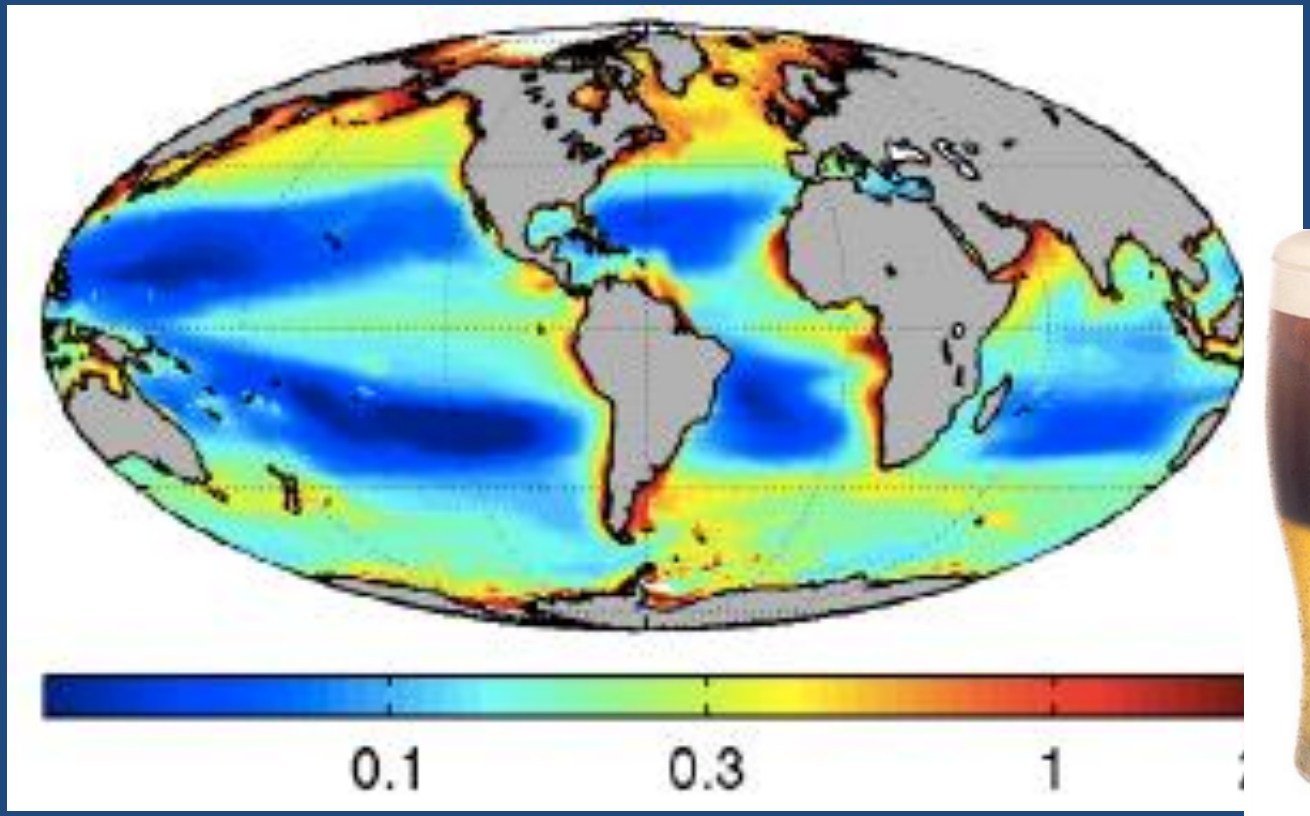
A sacred black sea bass in 2100?



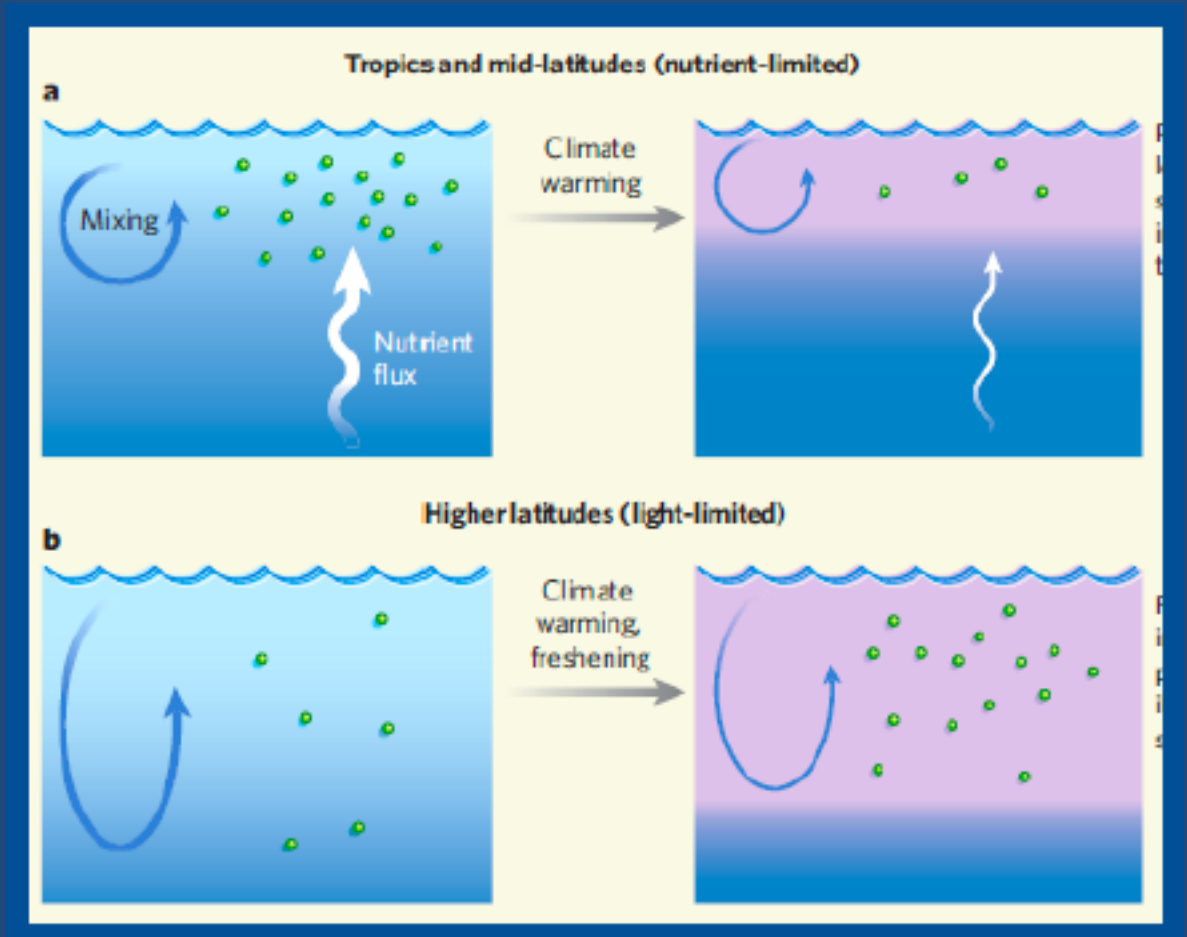
Source: Wikipedia

Ocean productivity is driven by the confluence of nutrients and light

Surface Chlorophyll from SeaWiFS

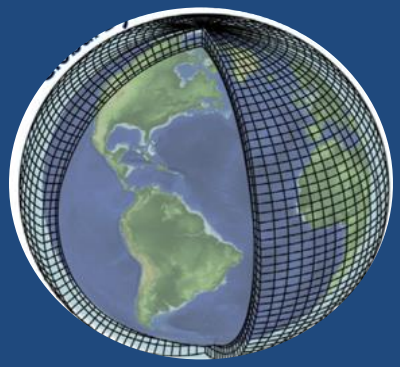


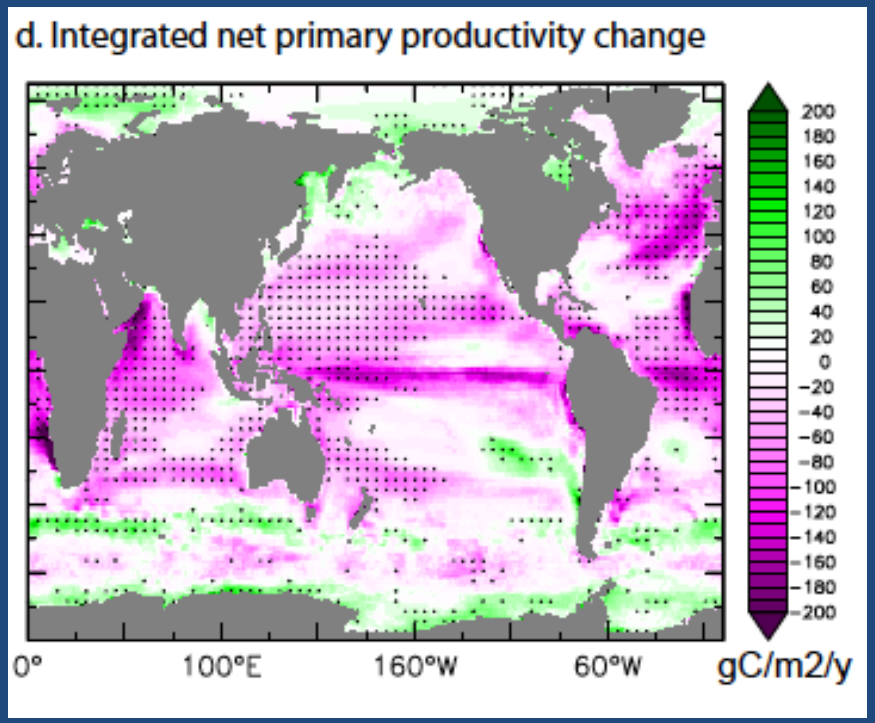
Increased stratification of warming waters hinders delivery of nutrients to surface

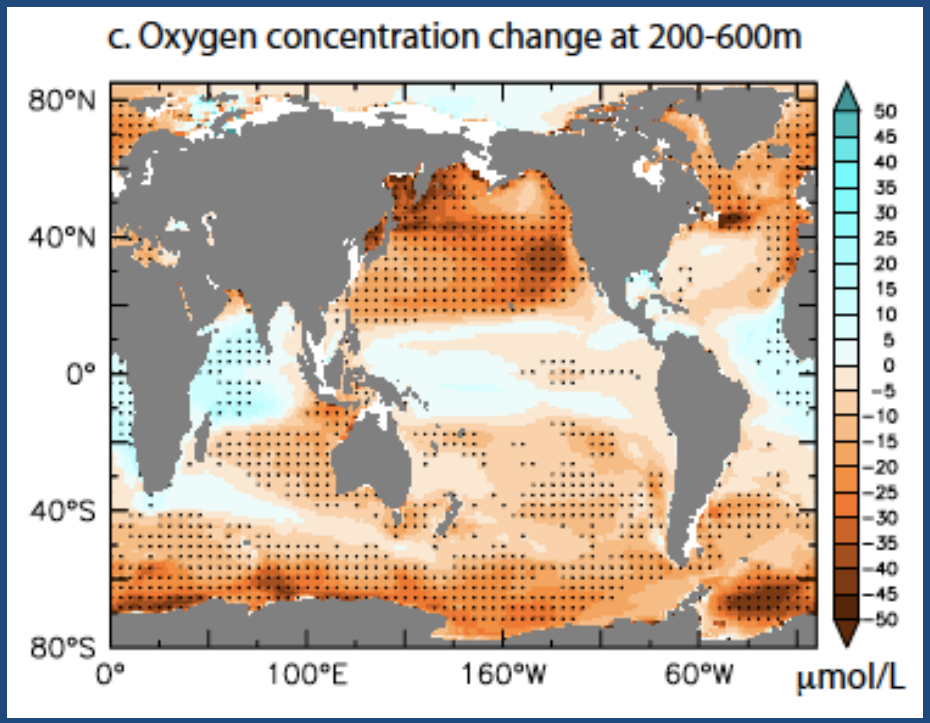


Doney, Nature, 2006; see also Bopp et al., GBC 2001; Sarmiento et al., GBC 2004; Steinacher et al., 2010

Projected declines in ocean productivity and oxygen in most low and mid-latitude regions







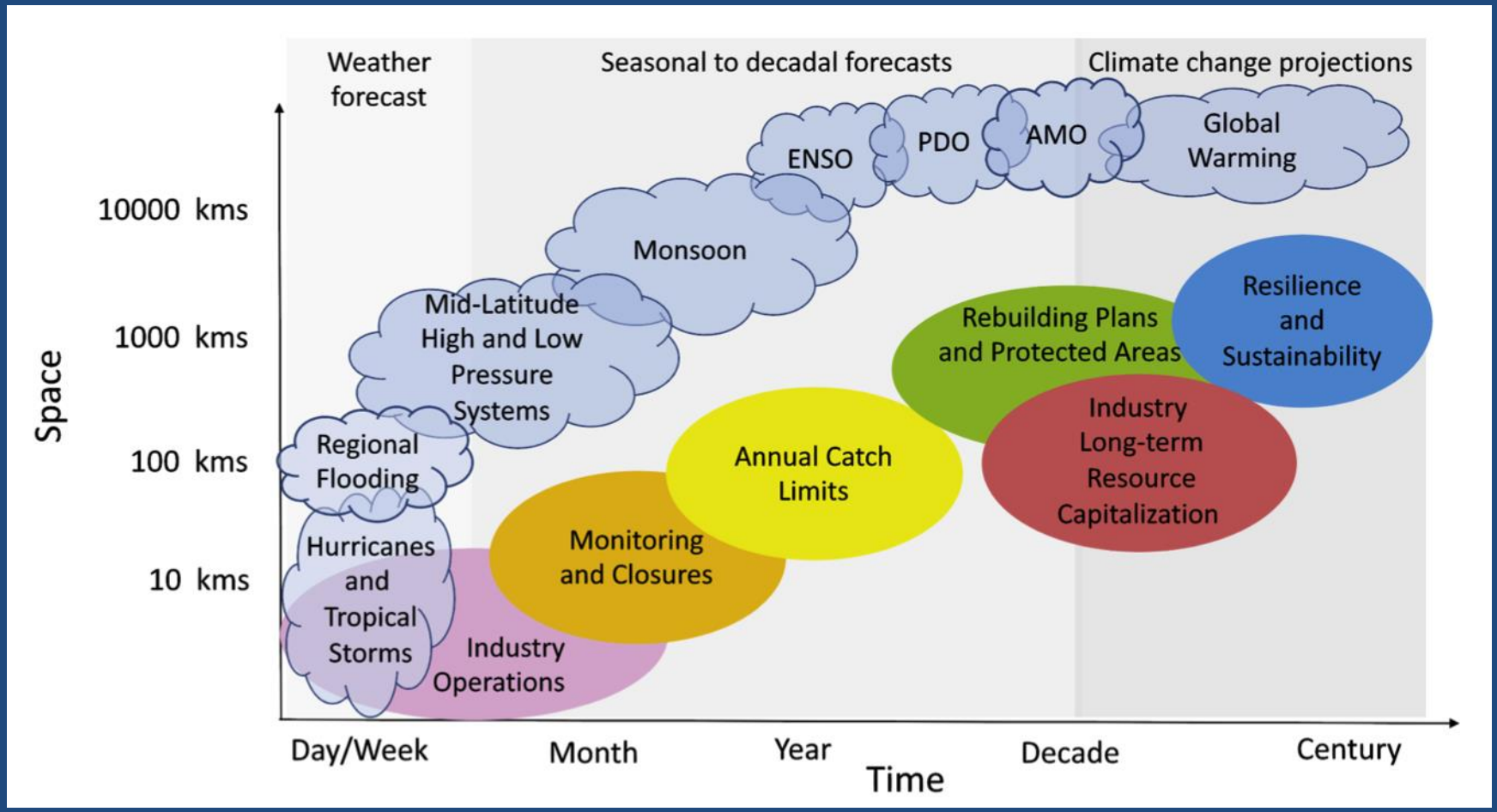
Bopp et al., 2013, Biogeosciences, 10, 6225-62

A brief summary thus far….

- There is tremendous inertia in the “vast and unyielding” ocean, but we are already crossing ocean thresholds with tangible impacts on marine resources
- Seemingly small ocean changes can have large marine resource impacts.
- Marine resources may increase in some regions, but strong evidence for net negative impacts globally.

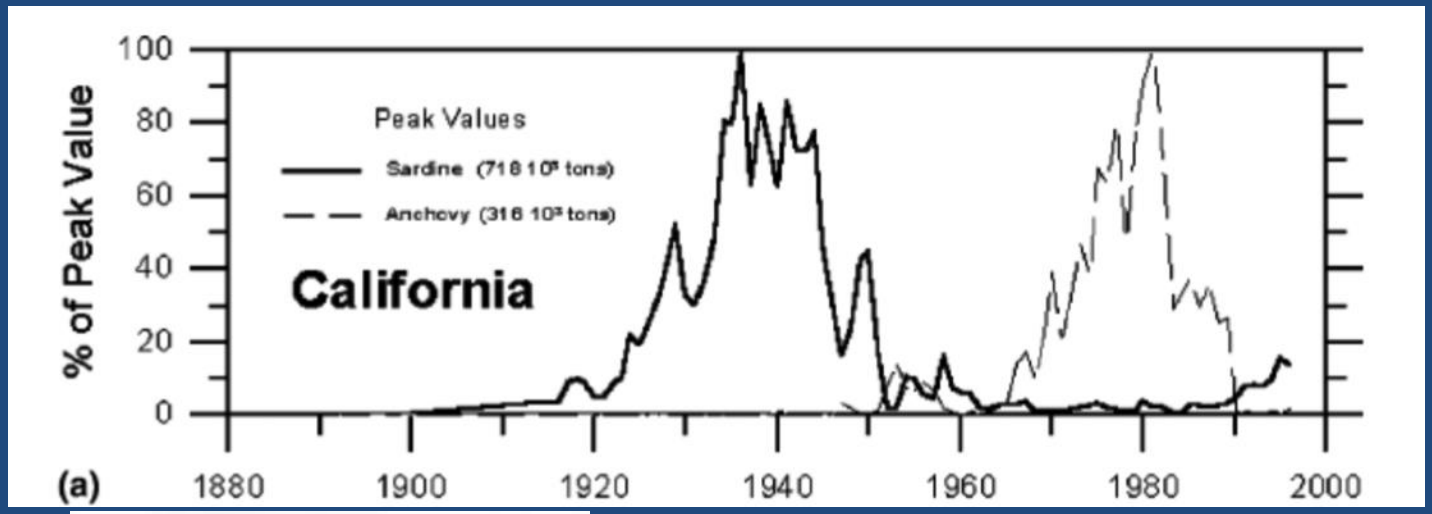
Great, apart from reducing CO_2 emissions, or capturing carbon, what can we do?

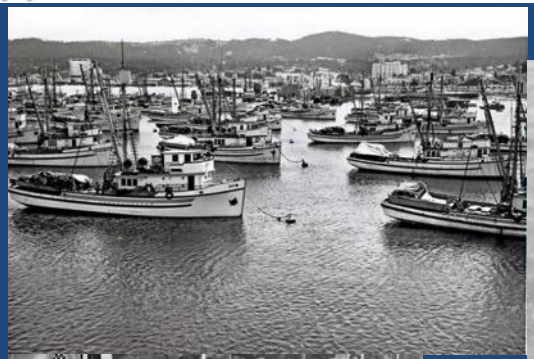
Anticipate and account for changing environmental baselines in both tactical and strategic decisions



Tommasi et al., Managing Living Marine Resources in a Changing Climate, the role of seasonal to decadal climate forecasts, Progress in Oceanography, 2017

A visit to cannery row….





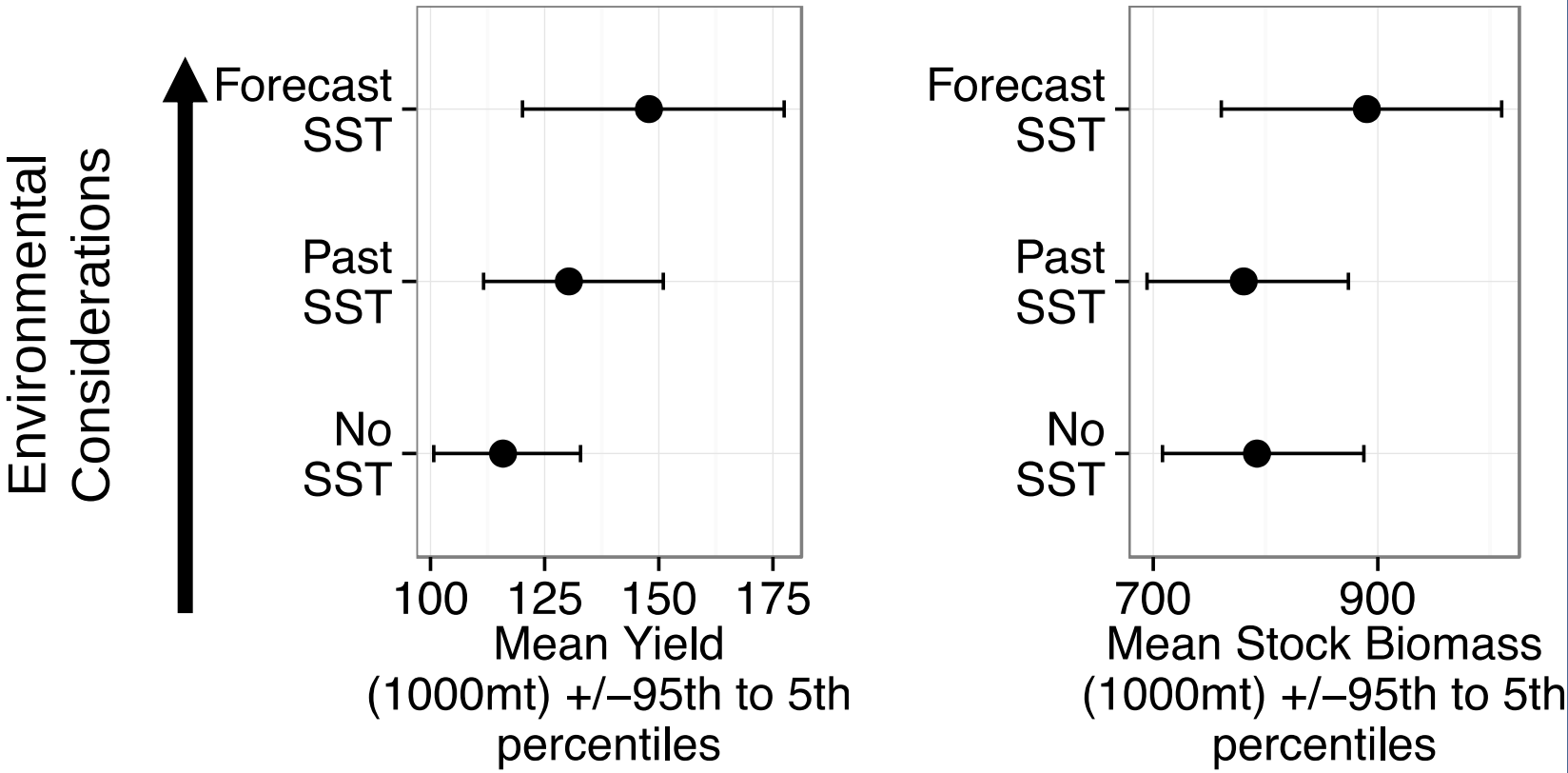
Women cannery workers on the line - 1949

Unloading sardines - 1920s

End of an Era - Cannery Row.1950

Photos courtesy of the city of Monterey, time series de Young et al., PinO, 2004

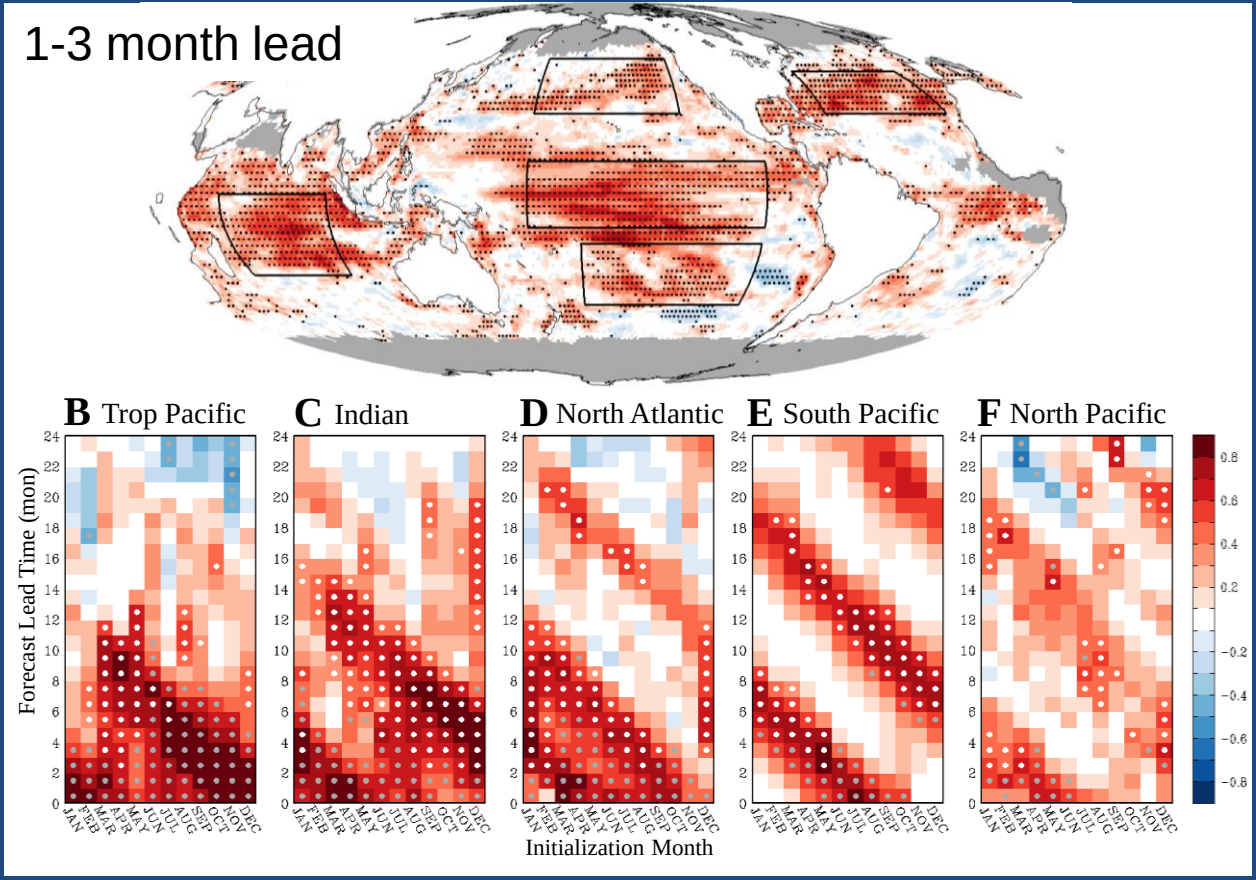
Increased expected yield and stock biomass through anticipatory management



Tommasi et al., Improved management of small pelagic fisheries through seasonal predictions, Ecological Applications, 2017

Seamless earth system observation and prediction to sustain marine resources

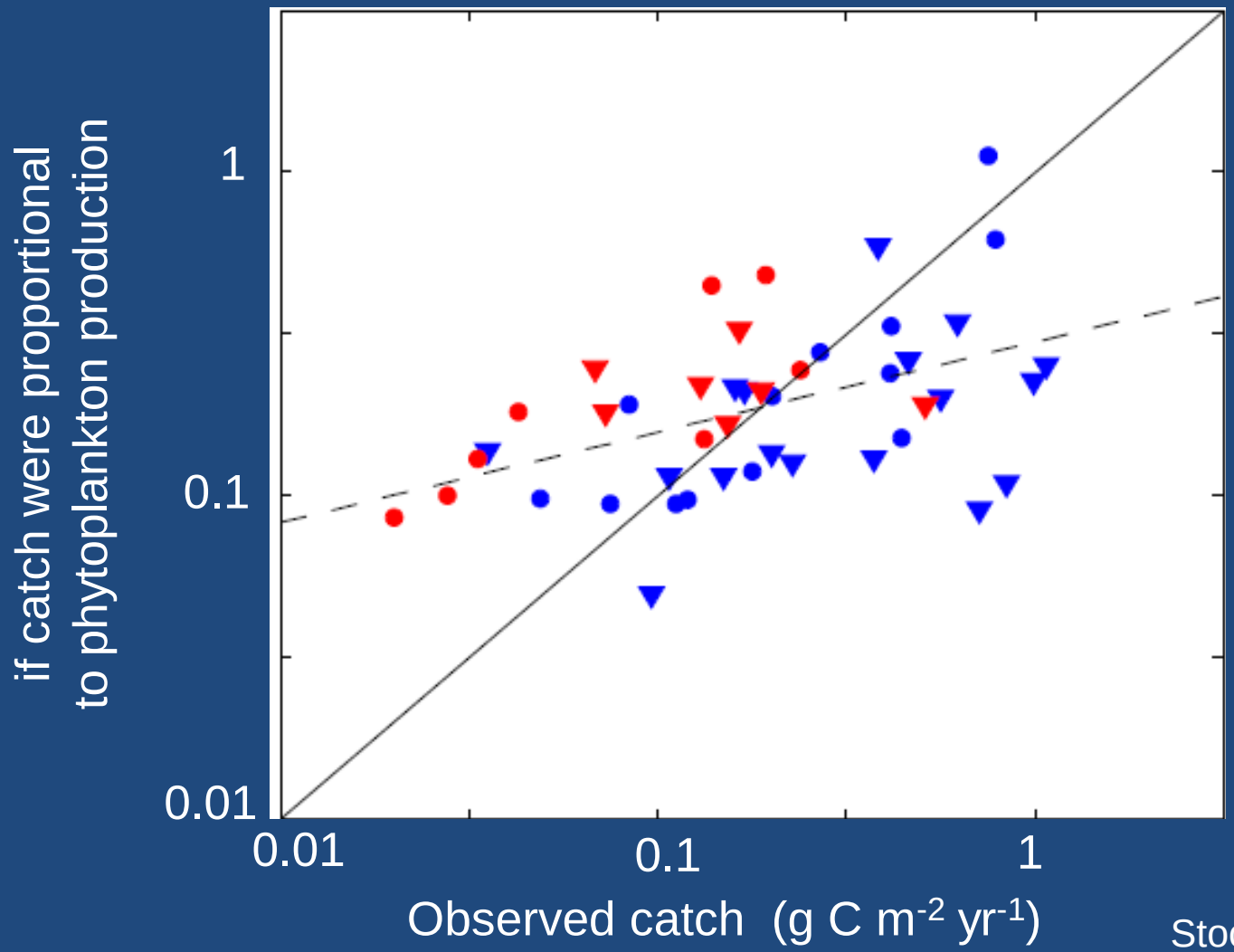
Predicting changes in ocean productivity



Park et al., Seasonal to multi-annual marine ecosystem prediction with a global earth system model, under review.

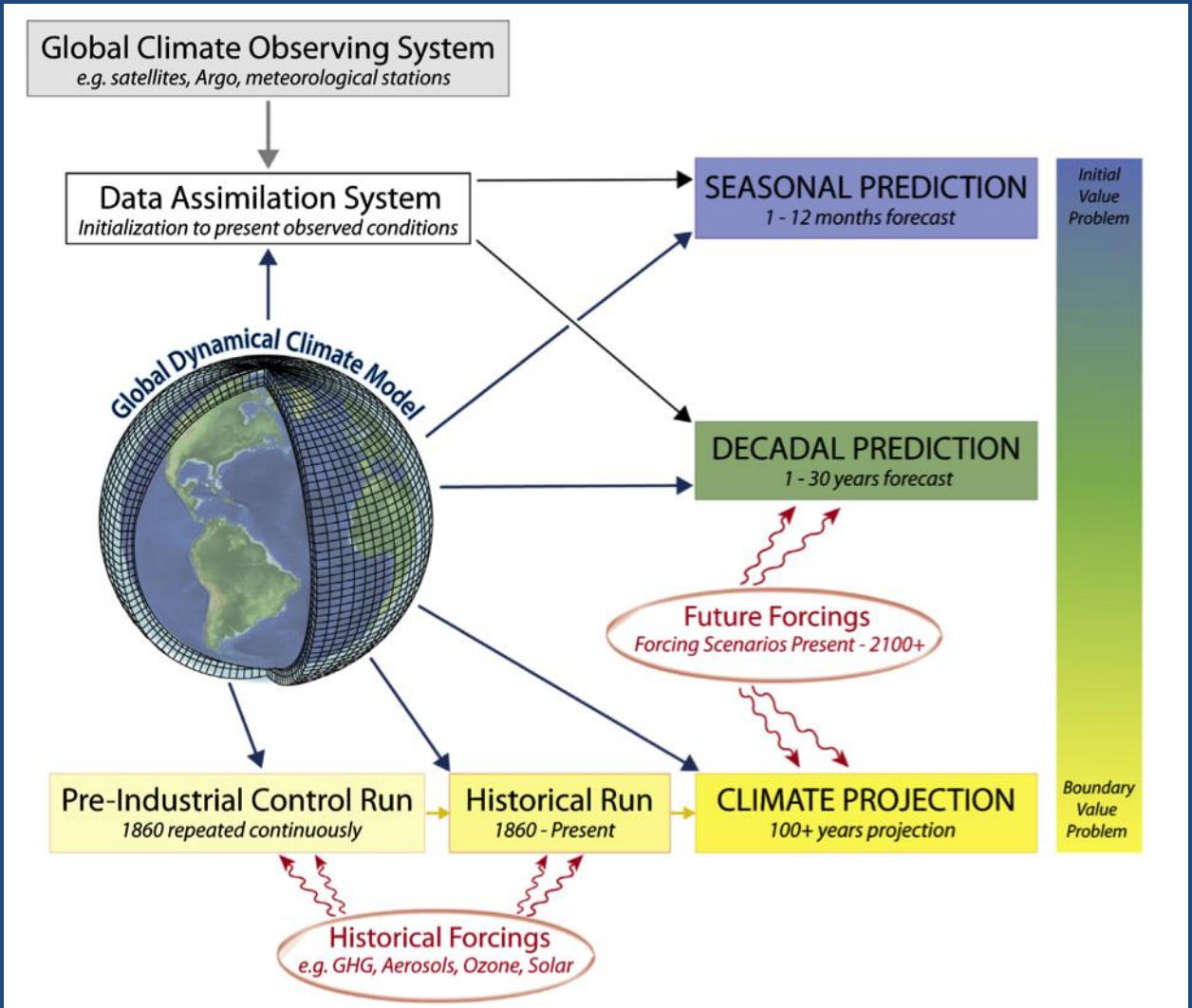
Extra slides

Modest changes in ocean conditions may lead to larger changes in fish catch



Stock et al., PNAS, 2017

Seamless climate predictions across time scales



Tommasi et al., Managing Living Marine Resources in a Changing Climate, the role of seasonal to decadal climate forecasts, Progress in Oceanography, 2017