Ocean Biogeochemistry & Air-Sea Carbon Exchange in an Evolving Climate

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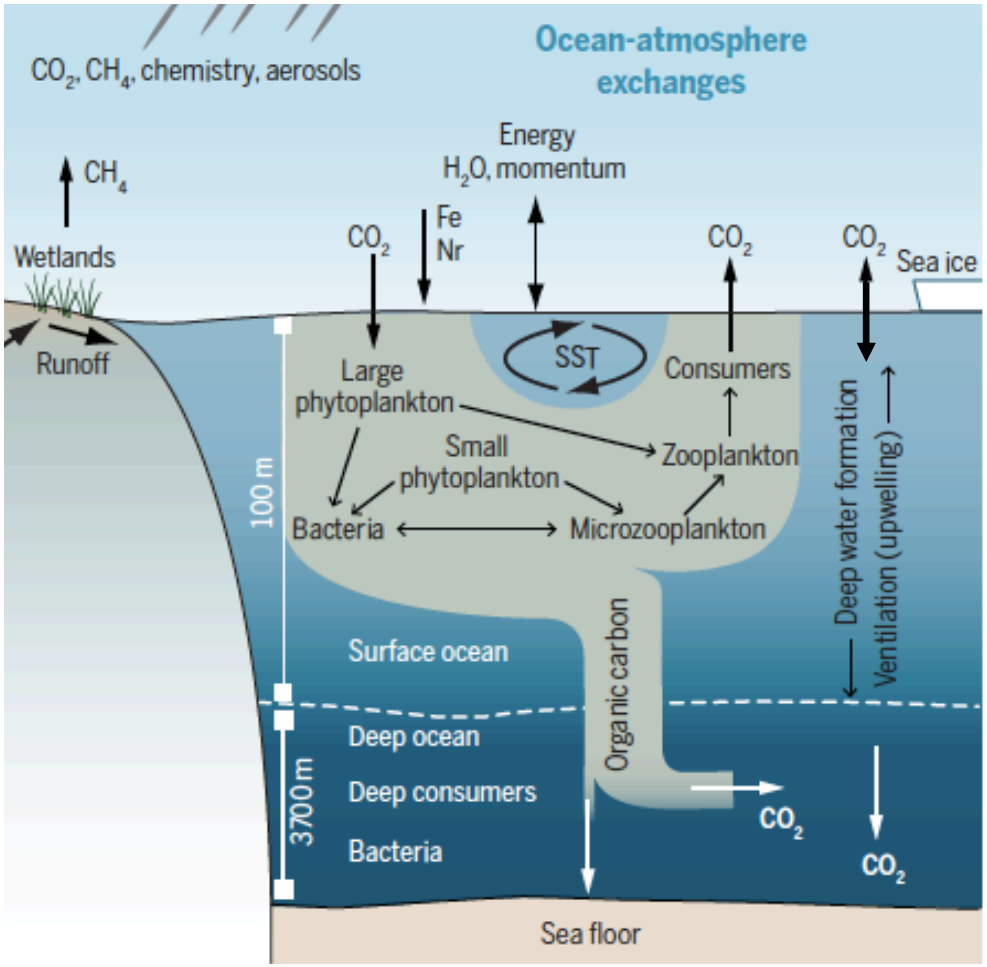
AMS 2019 Annual Meeting
Inez Fung Symposium
Session 2 Future Biosphere and Climate

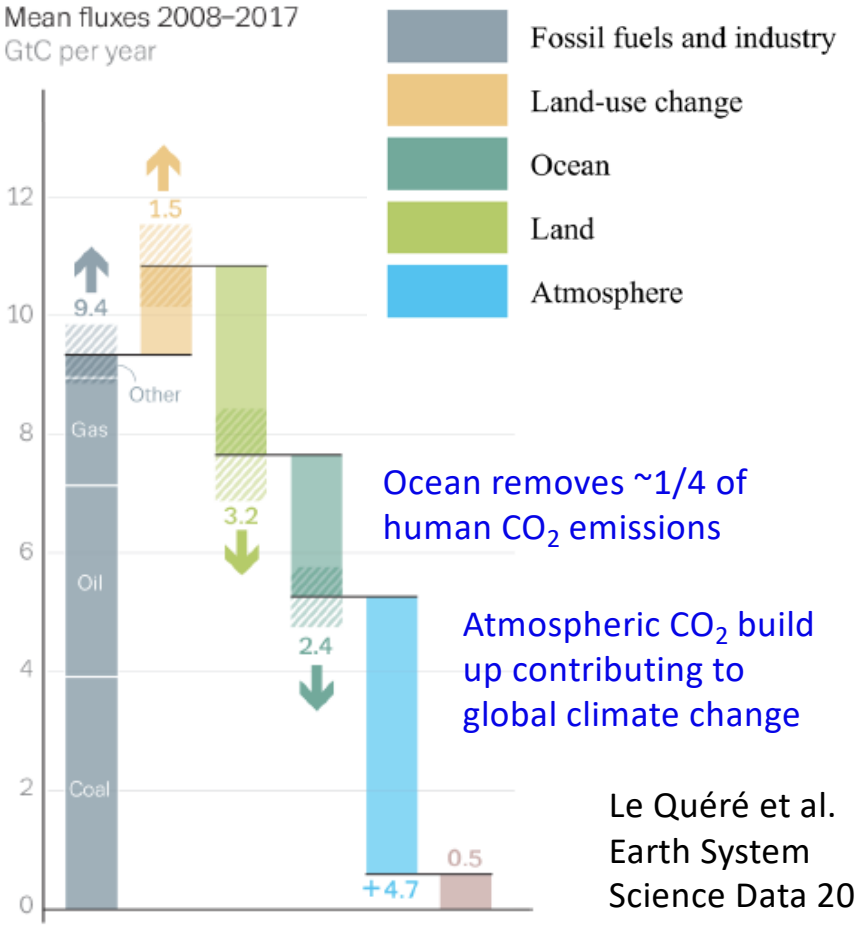


UNIVERSITY of VIRGINIA
DEPARTMENT of ENVIRONMENTAL SCIENCES

Ocean CO_2 Uptake, Climate Warming & Ocean Acidification

How effective will ocean CO_2 sink be in future warmer world?

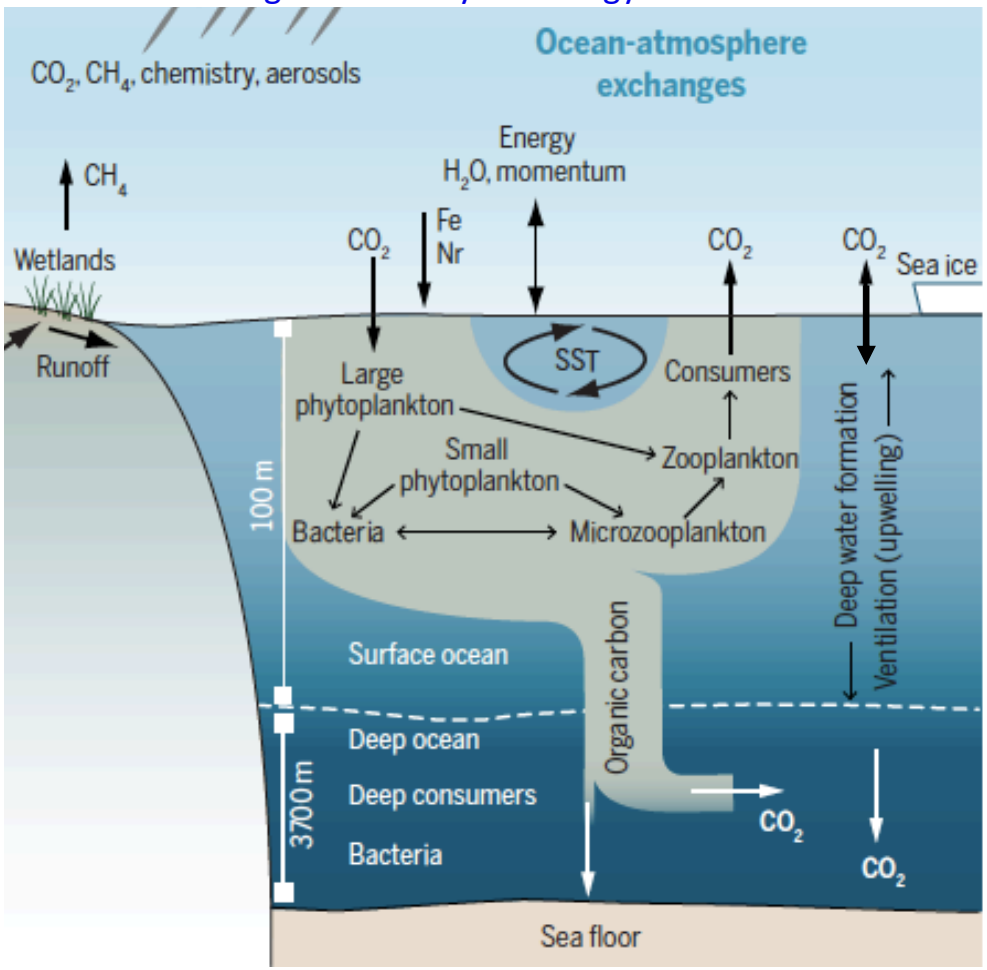
How will warming & ocean acidification affect marine biogeochemistry & ecology?



Ocean removes ~1/4 of human CO_2 emissions

Atmospheric CO_2 build up contributing to global climate change

Le Quéré et al. Earth System Science Data 2018



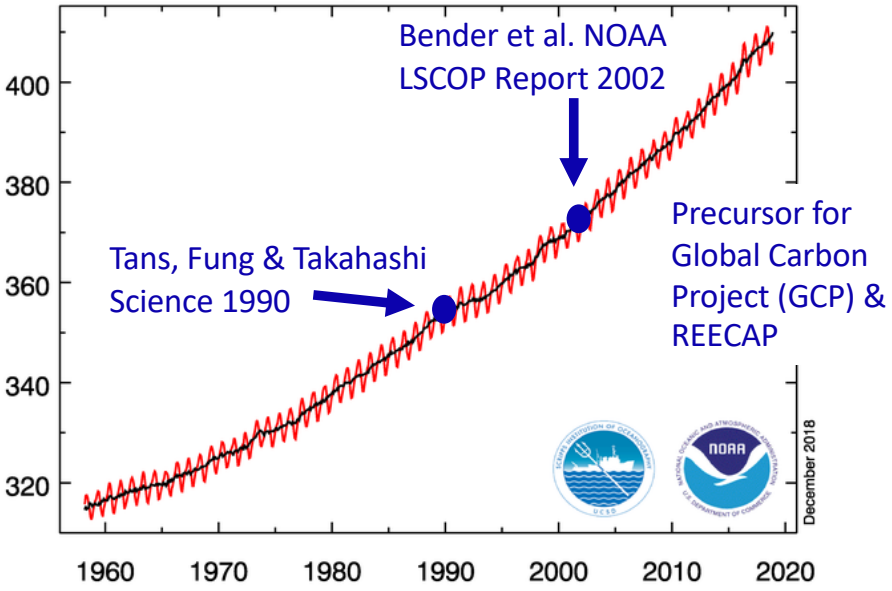
Ocean CO_2 Flux & Net Uptake

Observational Constraints on the Global Atmospheric CO_2 Budget

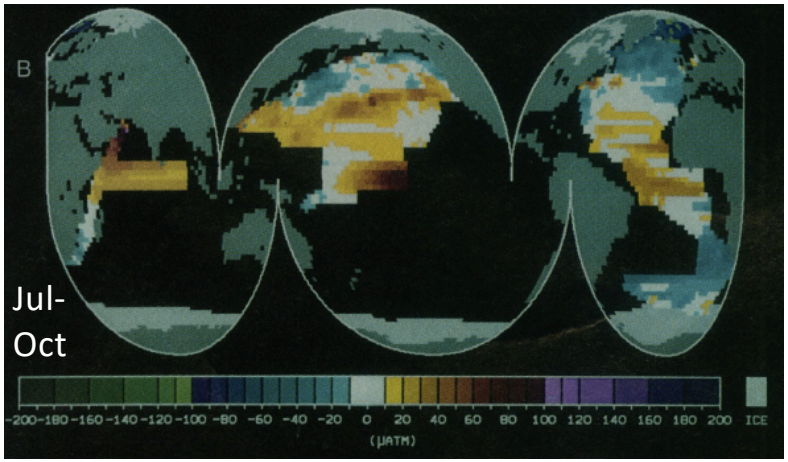
PIETER P. TANS, INEZ Y. FUNG, TARO TAKAHASHI

A Large-Scale CO_2 Observing Plan: In Situ Oceans and Atmosphere (LSCOP)

In Situ Large-Scale CO_2 Observations Working Group:
Bender, M., S. Doney, R.A. Feely, I. Fung, N. Gruber, D.E. Harrison, R. Keeling, J.K. Moore, J. Sarmiento, E. Sarachik, B. Stephens, T. Takahashi, P. Tans, and R. Wanninkhof

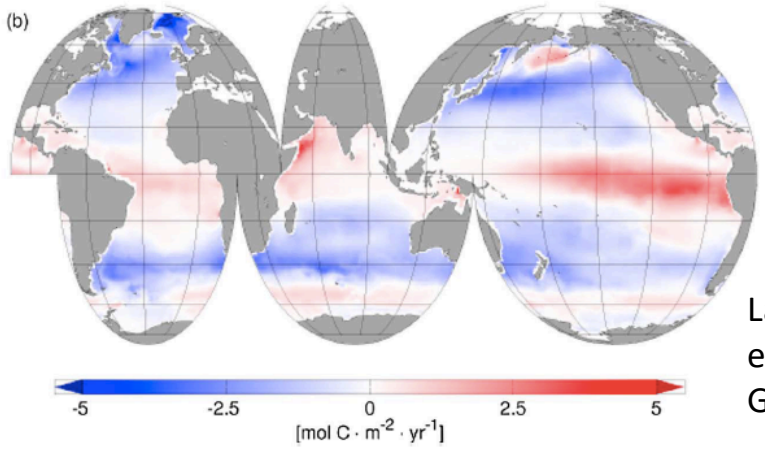


1990: Air-sea ΔpCO_2 data inconsistent with large Northern Hemisphere ocean sink



Tans et al. Science 1990

Present: Greatly improved pCO_2 data & air-sea CO_2 flux estimates from Surface Ocean Carbon Atlas (SOCAT)



Landschützer et al. GBC 2014

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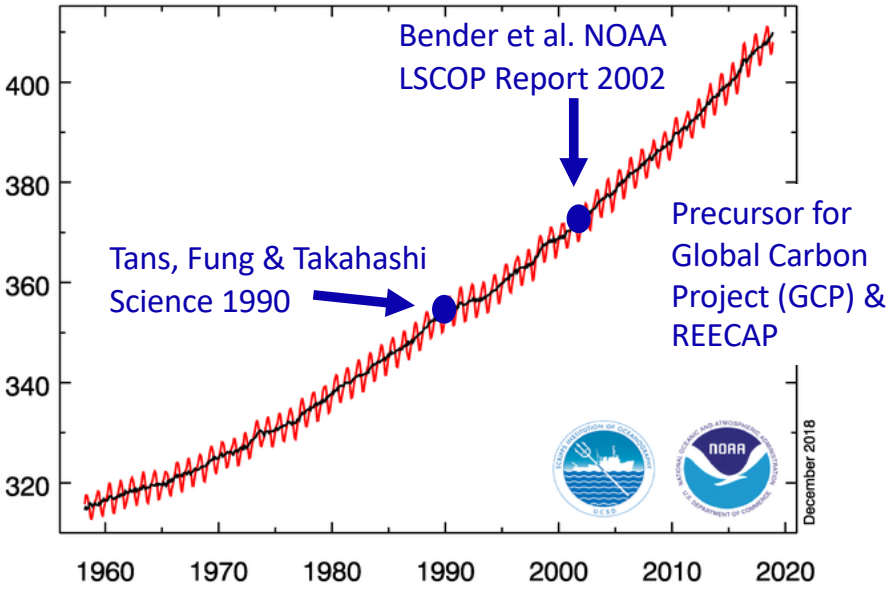
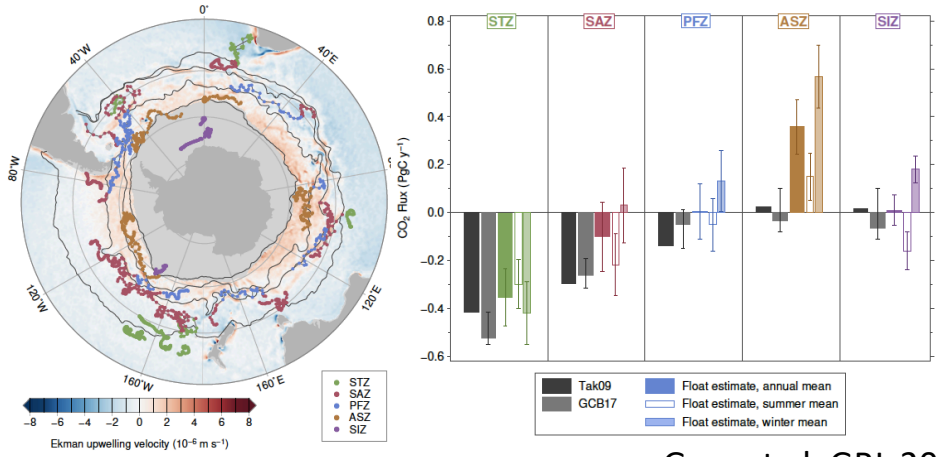
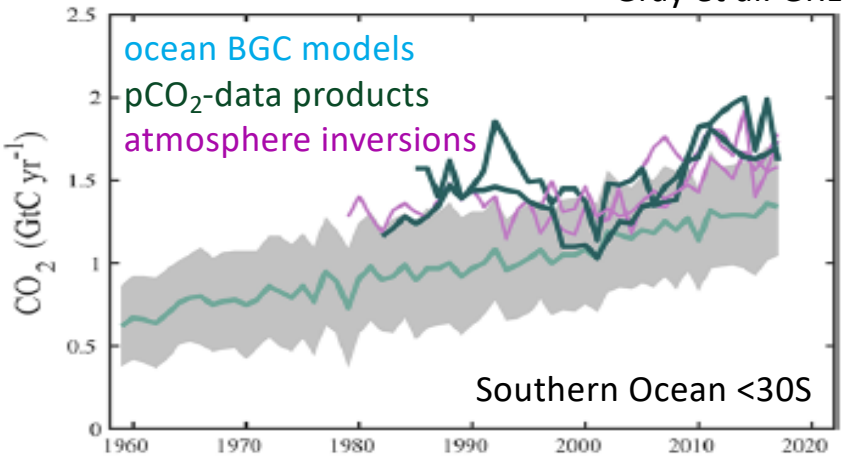


Future: Integrate data from new autonomous ocean platforms (e.g., profiling floats) & reconcile air-sea CO_2 flux inconsistencies from ocean & atmosphere data and models



Gray et al. GRL 2018



Le Quéré et al. Earth System Science Data 2018

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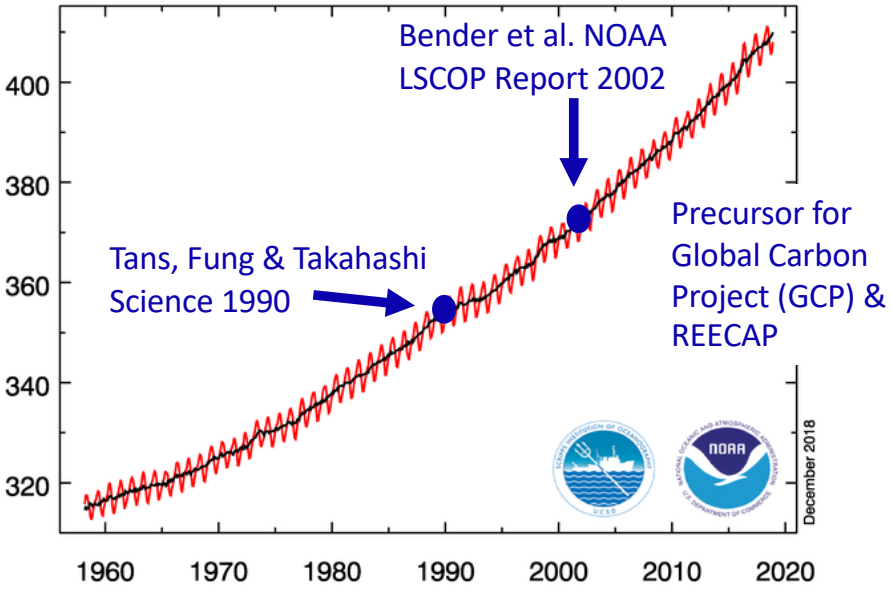
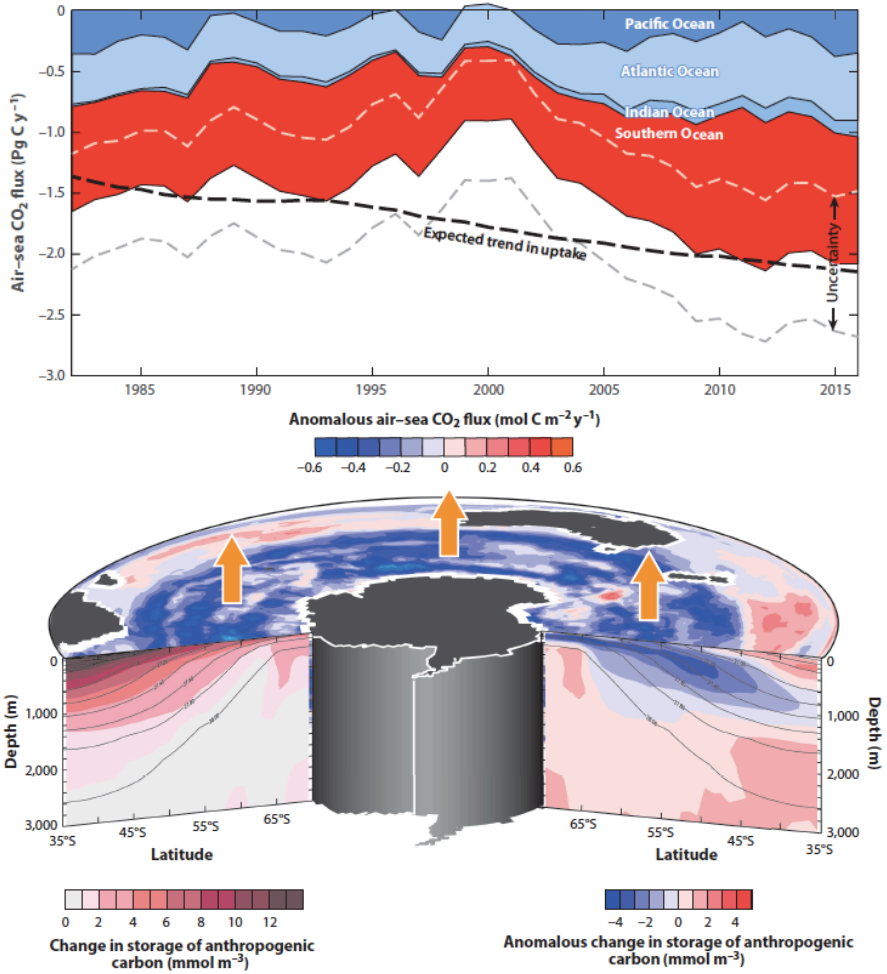


Future: Combine air-sea flux & ocean CO2 storage data/ models to detect climate change signal from natural variability



Gruber et al. Ann. Rev. Marine Science 2019

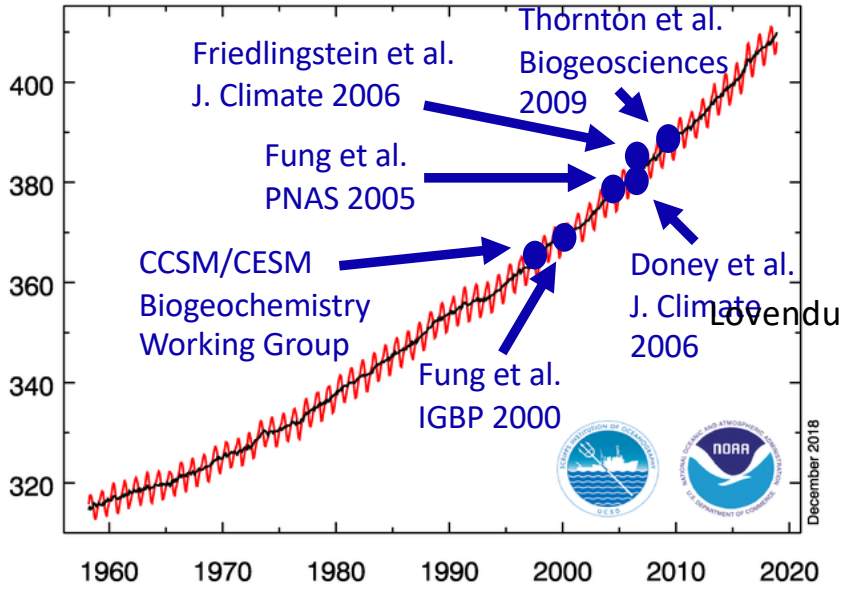
Climate-Carbon Feedbacks

Full-Form Earth System Models:
Coupled Carbon-Climate Interaction Experiment
(the "Flying Leap")

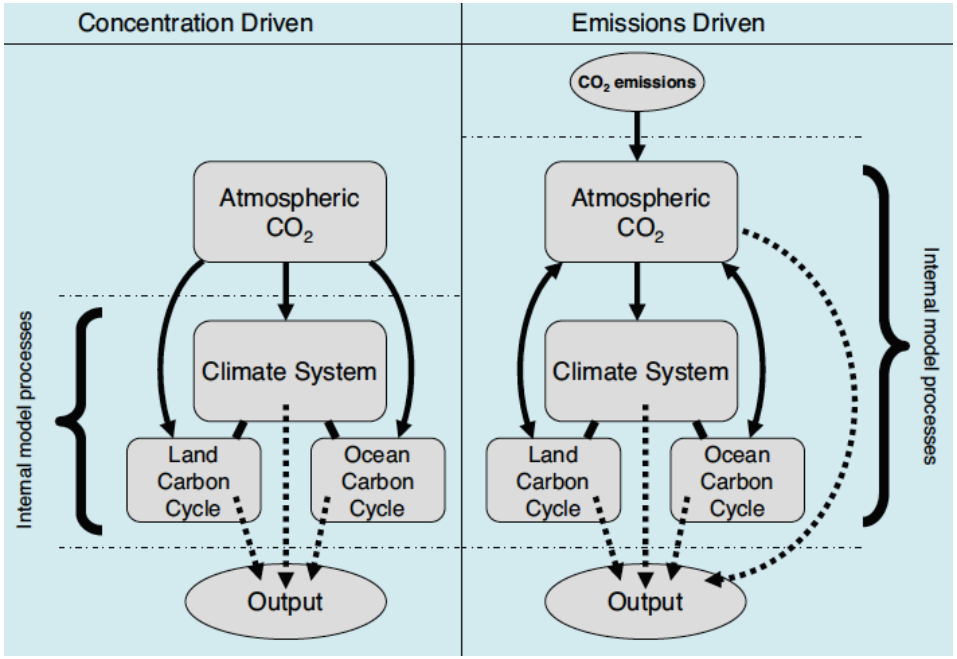
by Inez Fung, Peter Rayner, and Pierre Friedlingstein; Edited by Dork Sahagian

Evolution of carbon sinks in a changing climate

Inez Y. Fung*†, Scott C. Doney‡, Keith Lindsay§, and Jasmin John*



2005: Pilot studies with Earth System Models that integrate active land & ocean carbon dynamics with climate



Lovenduski et al. GBC 2016

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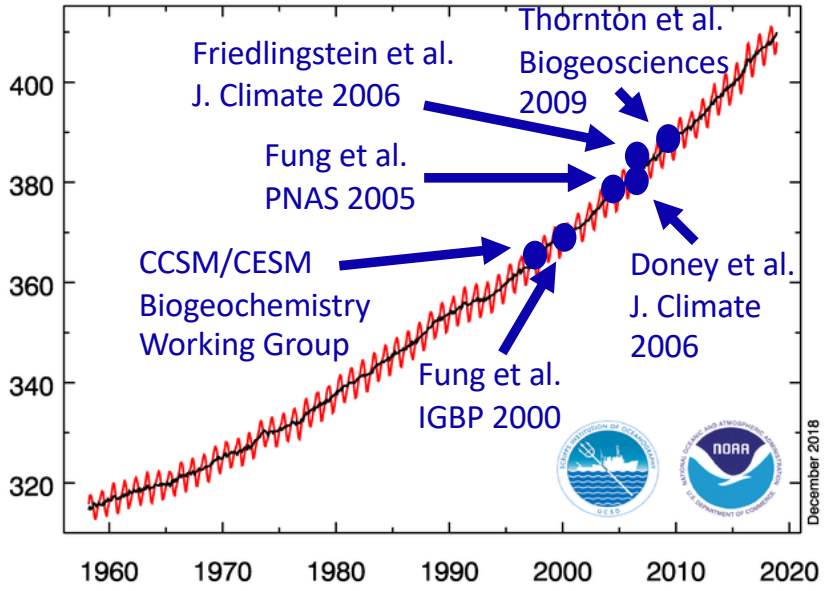
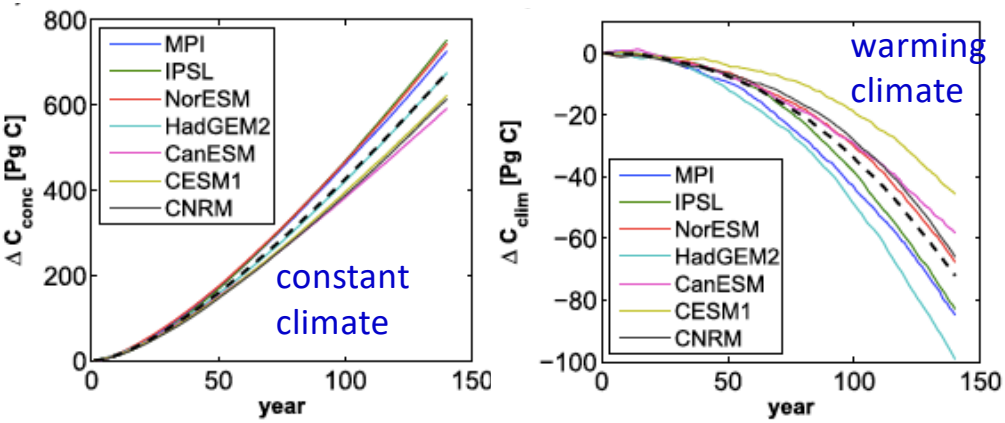


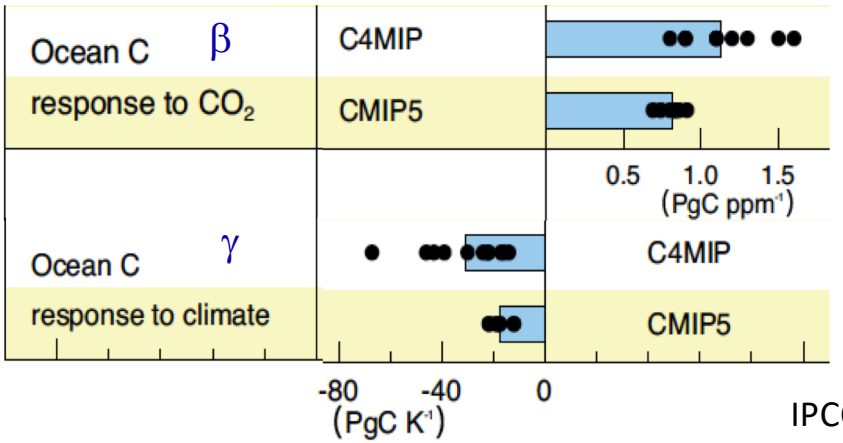
Present: Standard CMIP ESM analyses indicating climate reduces ocean uptake but ocean physics is larger uncertainty



Schwinger et al. J. Climate 2014

Linear decomposition of cumulative ocean carbon inventory

$\Delta C = \beta\, \Delta CO_2^{atm} + \gamma\, \Delta T$ β (PgC/ppm); γ (Pg C/K)



IPCC 2013

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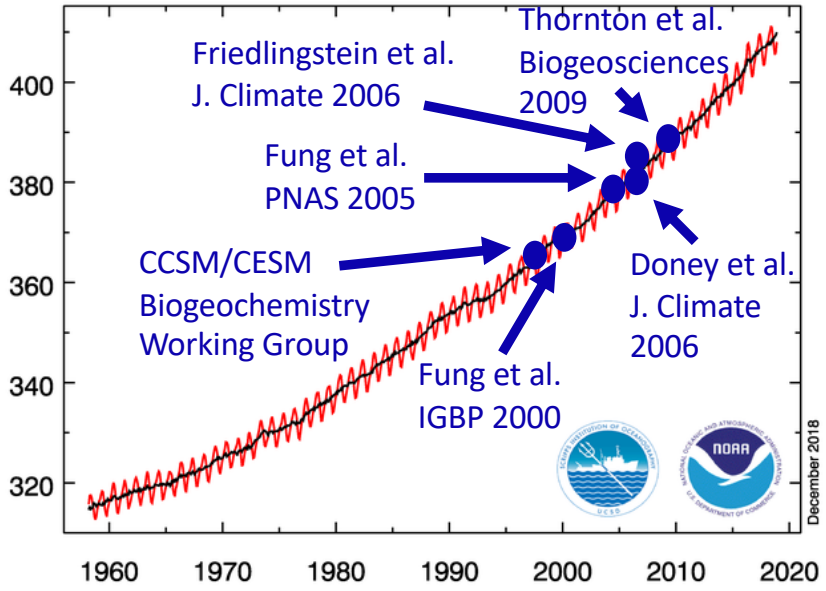
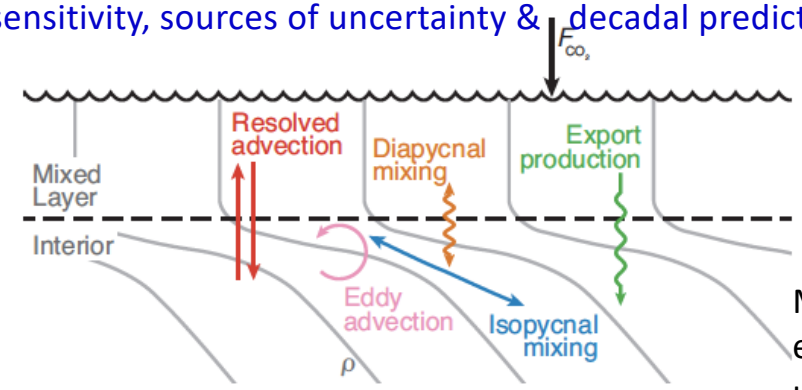
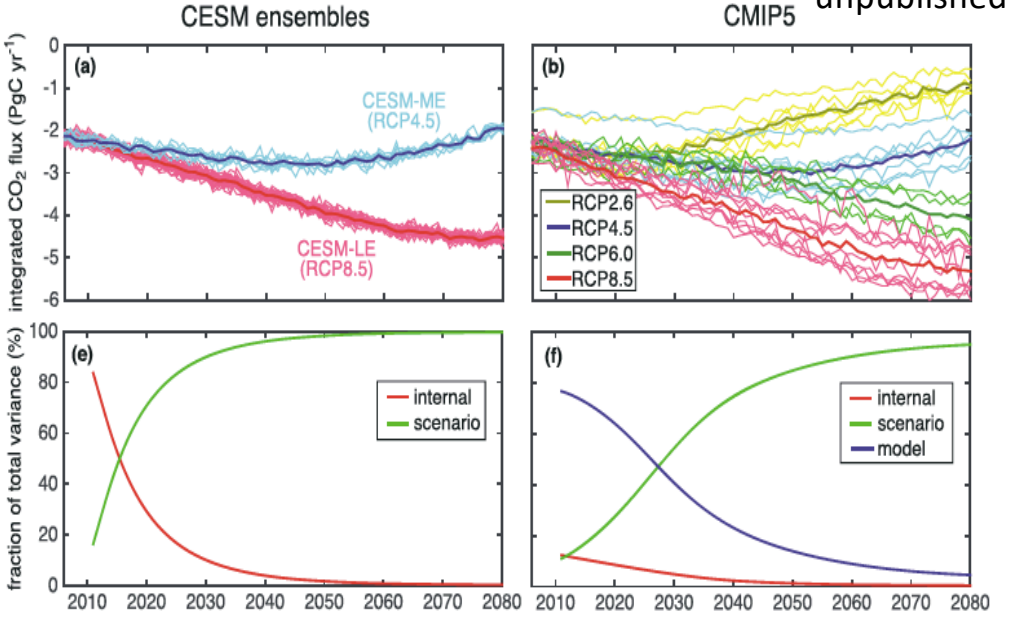


Future: Quantify better ocean CO_2 uptake mechanisms, climate sensitivity, sources of uncertainty & decadal predictability



Matt Long et al. unpublished



Lovenduski et al. Global Biogeochemical Cycles 2016

Climate-Carbon Feedbacks

Future: Expand scope of ESM to capture carbon cycle for Land-Ocean Aquatic Continuum & coastal blue carbon storage

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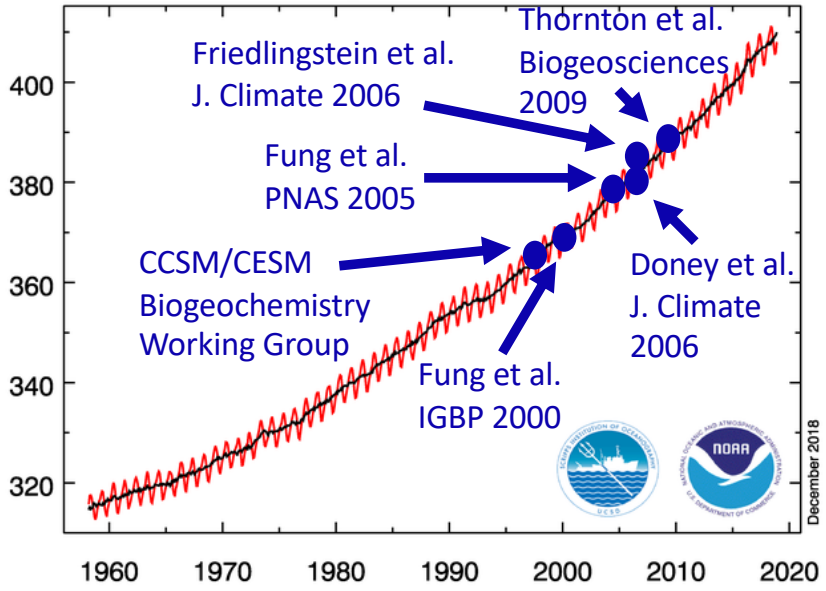
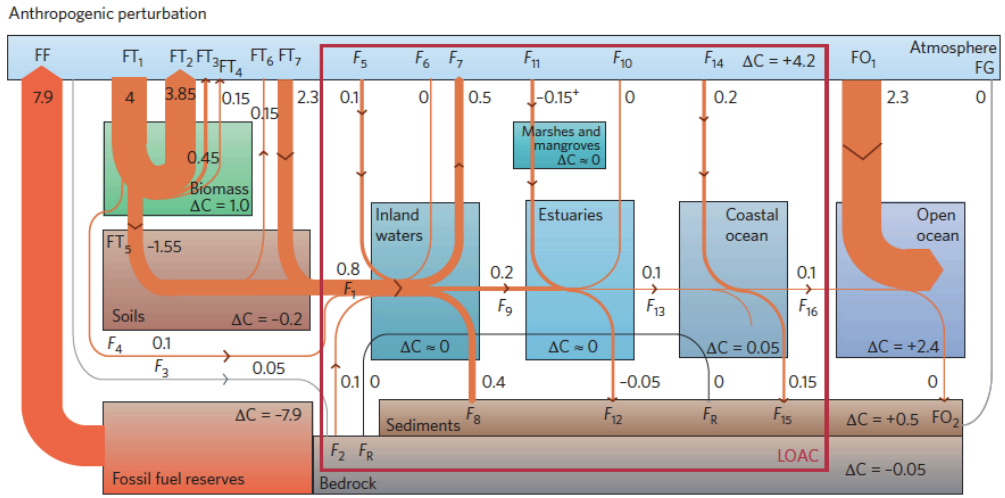
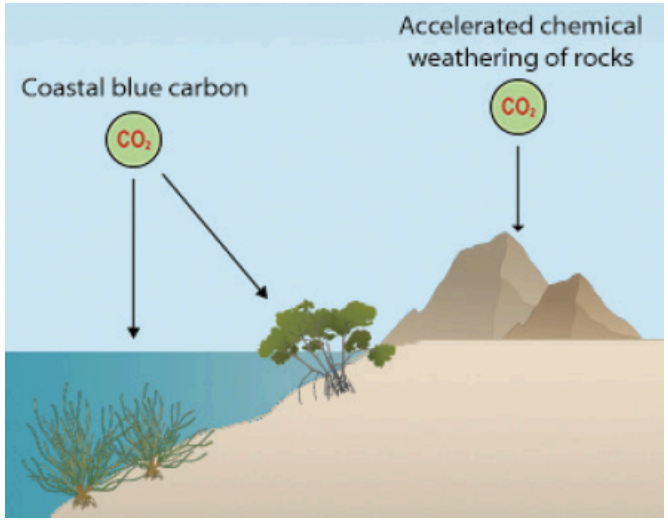






Regnier et al. Nature Geoscience 2013

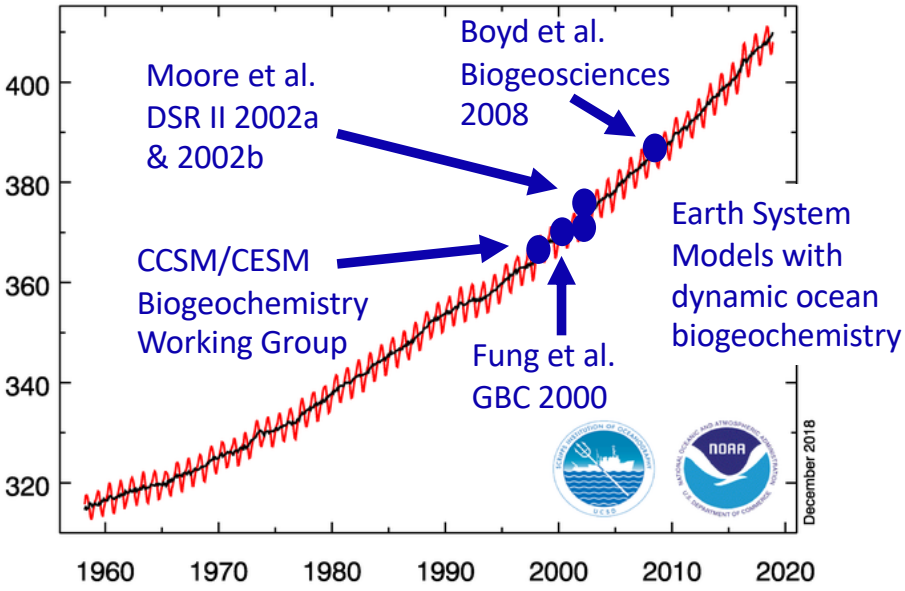
Ocean Iron & Biogeochemistry

Iron supply and demand in the upper ocean

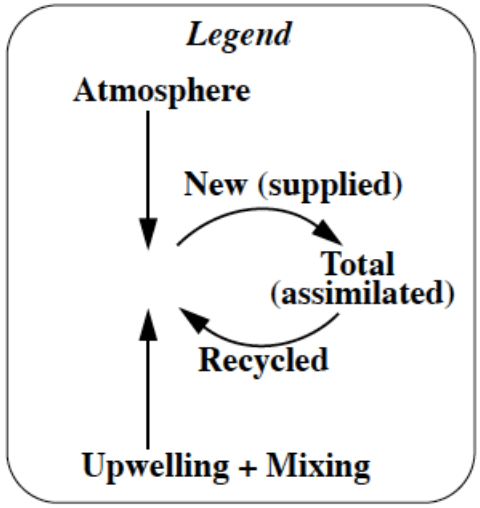
Inez Y. Fung,[1] Stephanie K. Meyn,[2] Ina Tegen,[3]
Scott C. Doney,[4] Jasmin G. John,[1] and James K. B. Bishop[5]

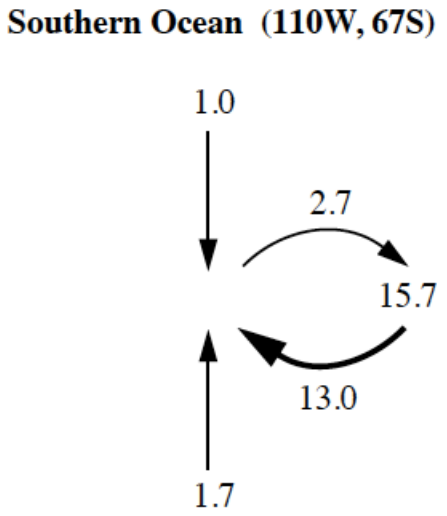
Iron cycling and nutrient-limitation patterns in surface waters of the World Ocean

J. Keith Moore[a,*], Scott C. Doney, David M. Glover[b], Inez Y. Fung[c]



2000: Using limited available field data quantify upper-ocean cycle of iron, key limiting micronutrient for phytoplankton





Fung et al. Global Biogeochemical Cycles 2000

Ocean Iron & Biogeochemistry

Future: Leverage new ecosystem models & rapidly expanding biogeochemical & plankton data syntheses: GEOTRACES trace elements; MAREDAT plankton functional types; genomics

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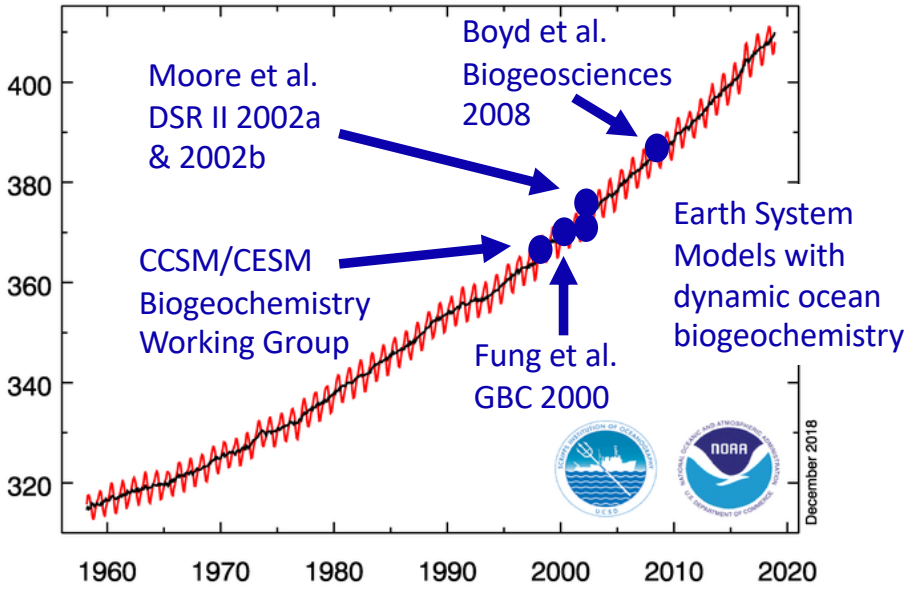
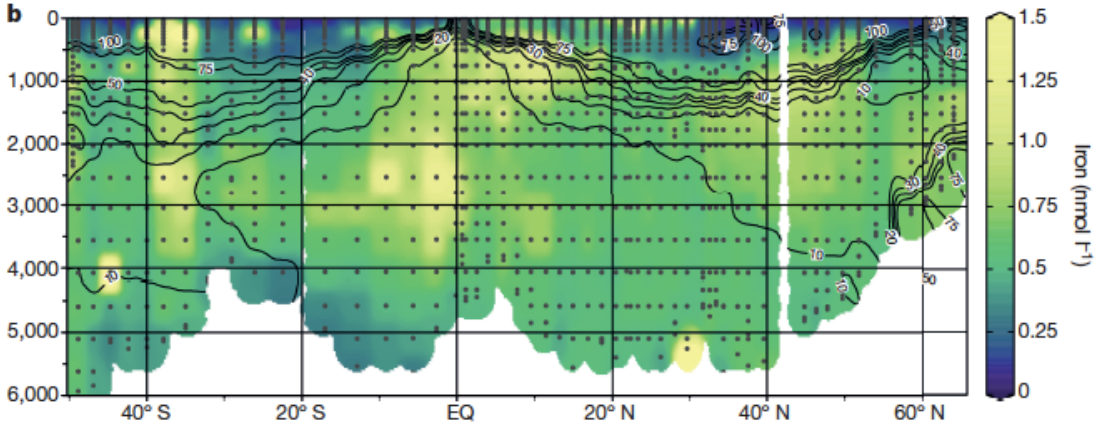
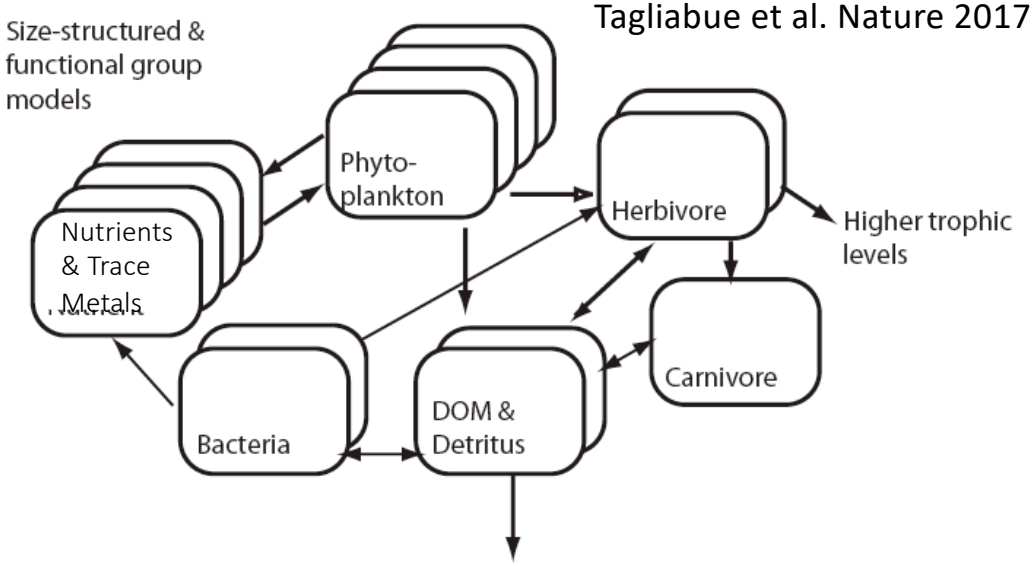




Tagliabue et al. Nature 2017



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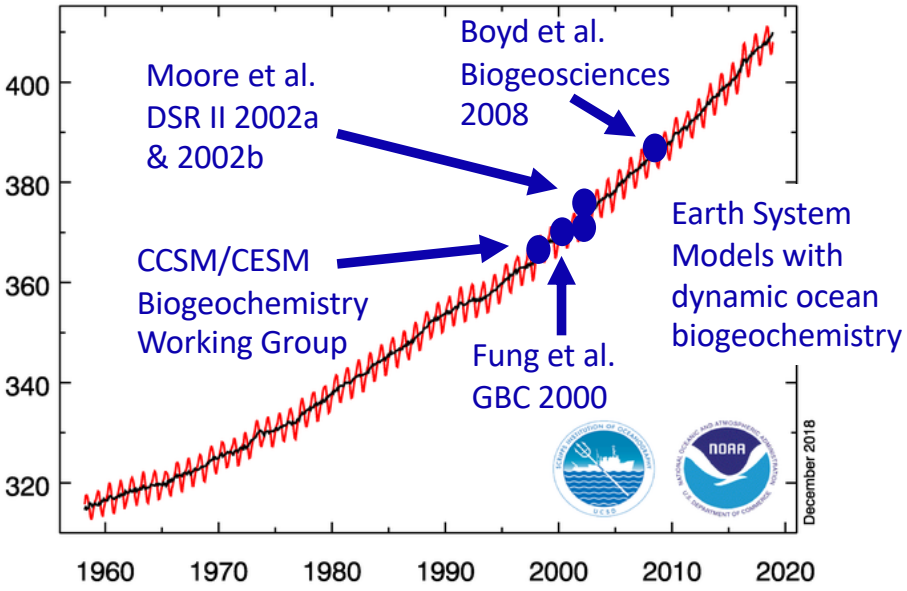
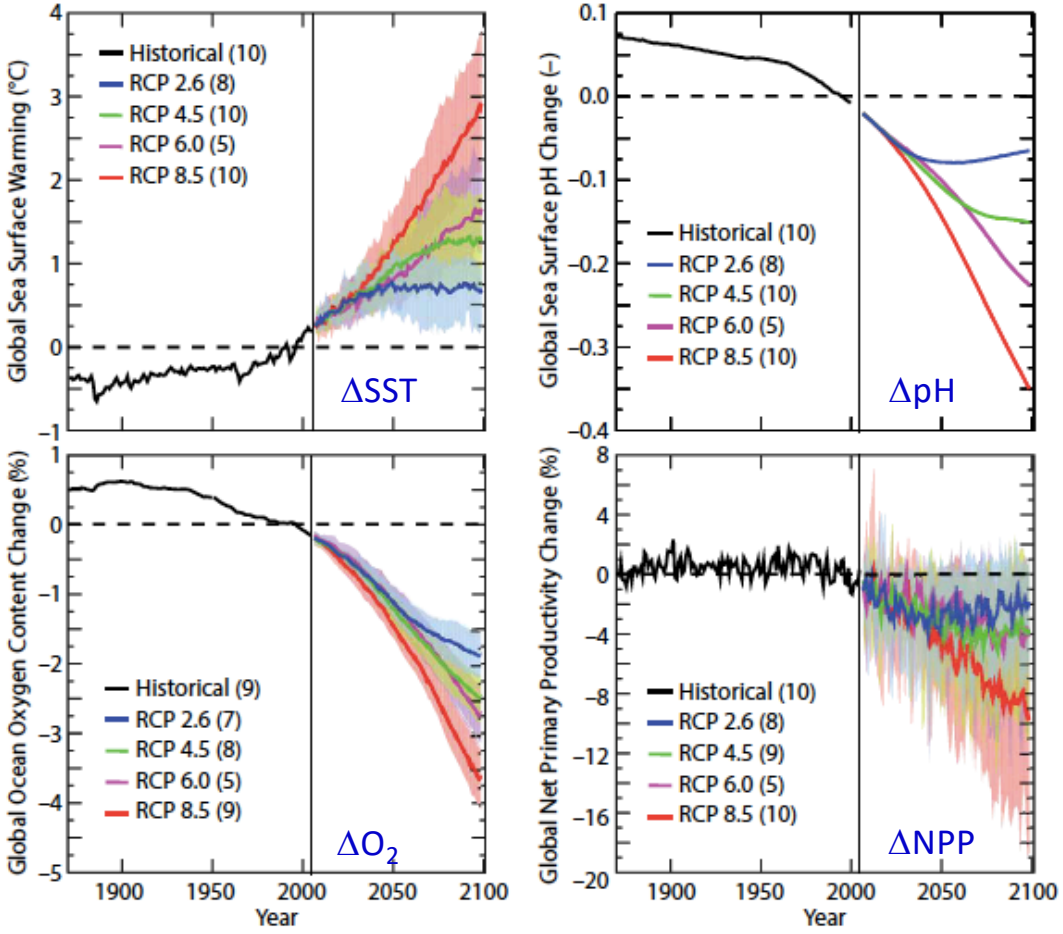


Future: Employ Earth System Models incorporating coupled plankton-biogeochemistry-carbon cycle-fisheries dynamics to address climate, deoxygenation & acidification impacts



Bopp et al. Biogeosciences 2013

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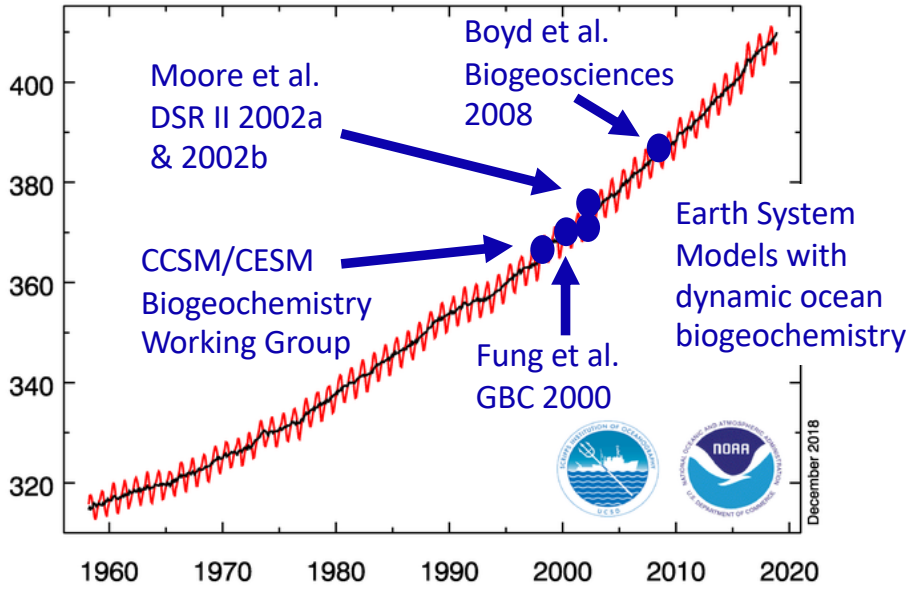

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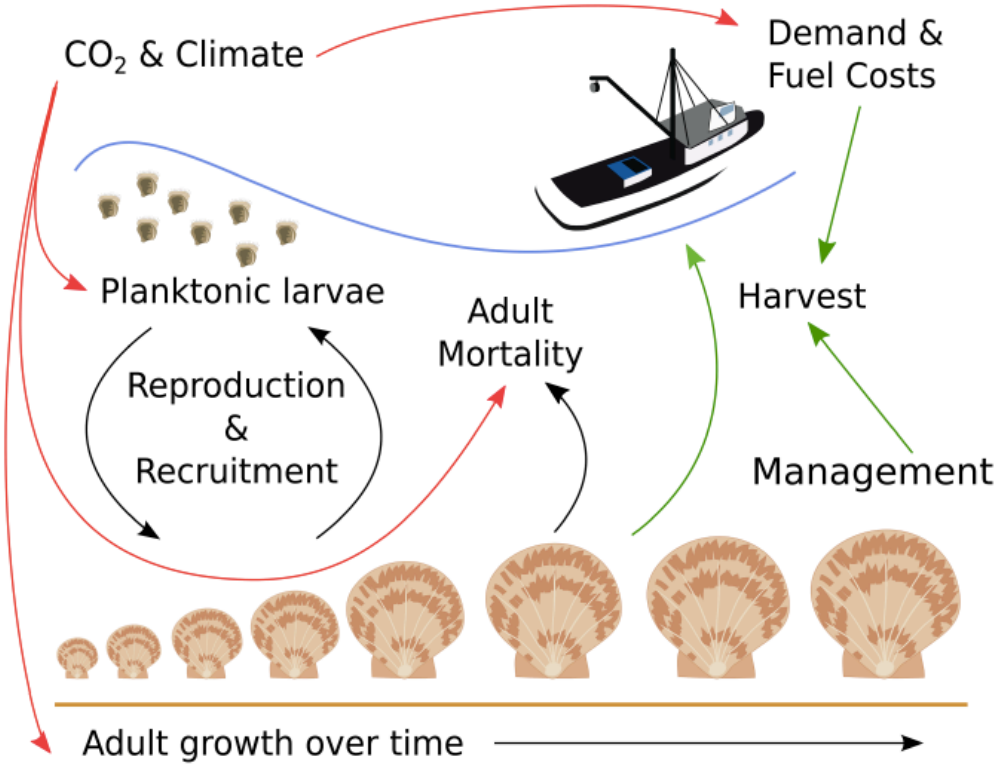
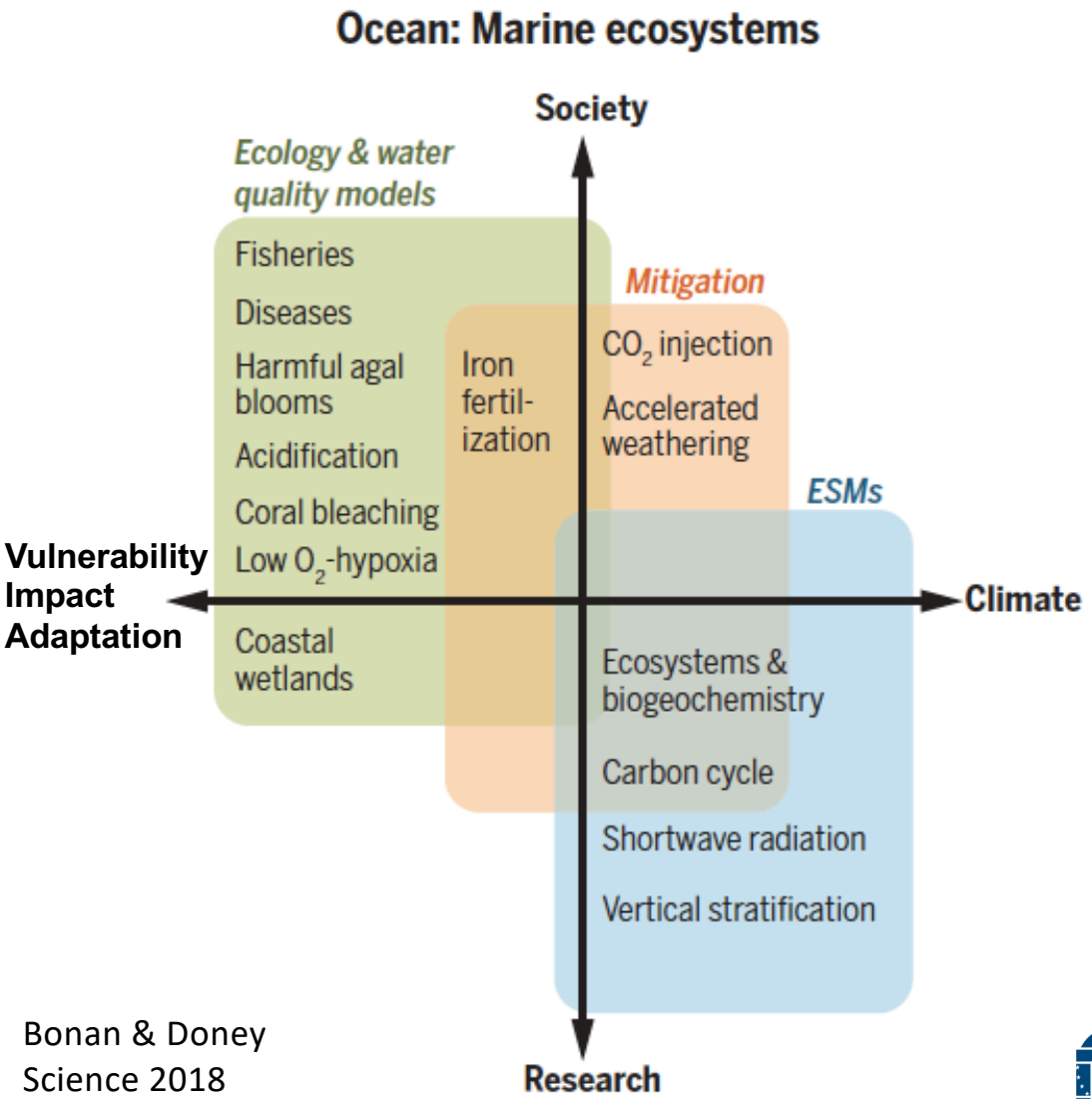
Integrated assessment model of U.S. Northeast scallop fishery coupling biology, chemistry & socio-economics



Cooley et al. PLoS One 2015; Rheuban et al. PLoS One 2018



Bonan & Doney
Science 2018

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Department of Environmental Sciences