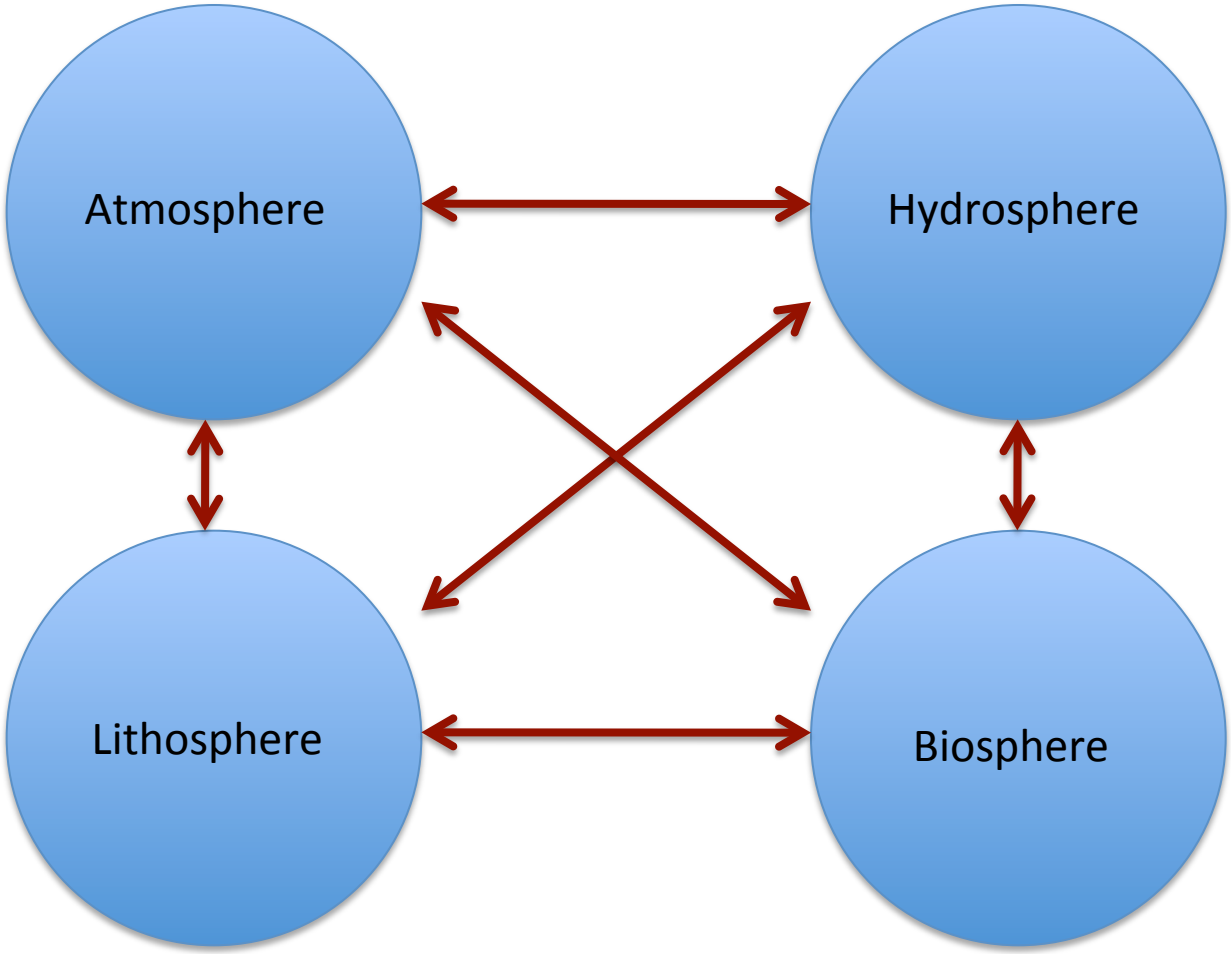
Paleoecology

Four Earth Systems



Talk to your neighbor: for each arrow identify a process that is represented by that arrow

Organisms interacting with their physical environment

- Limiting factors: determine diversity and abundance in environment

Time out for vocab

- Diversity:
- Number of different kinds of organisms (e.g., # of species, # of families)
- Abundance
- Number of organisms

Organisms interacting with their physical environment

- Limiting factors: determine diversity and abundance in environment.
- Determine what organisms can live in a given environment

Common limiting factors in marine environments

- Temperature
- Oxygen
- Salinity
- Depth
- Substrate

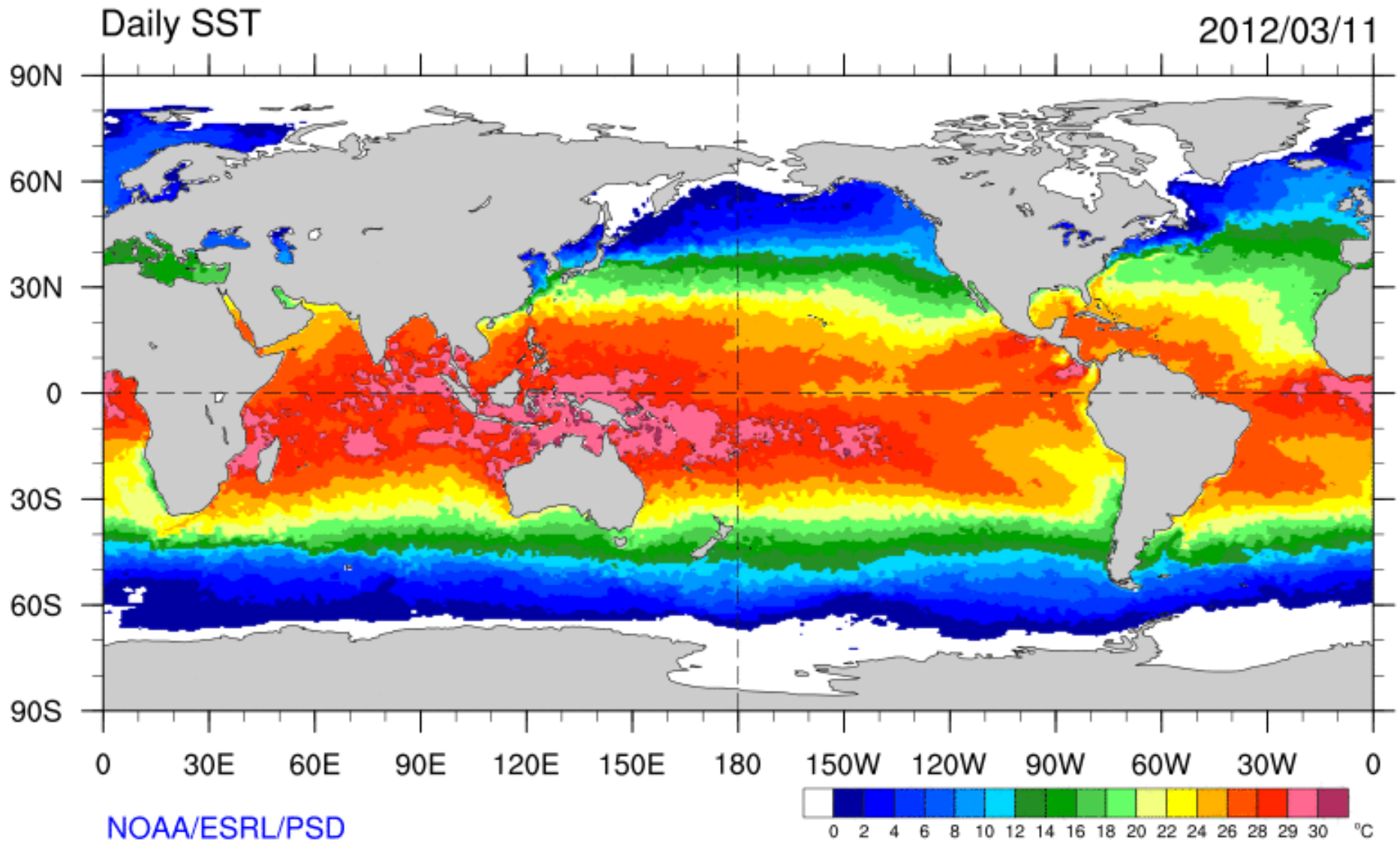
Temperature

- Affects
  - Physiological rates
  - CO_2 & O_2 solubility (⬆ Temp, ⬇ solubility)
  - Salt solubility (⬆ Temp, ⬆ solubility)
- Determined by latitude, ocean circulation, depth
- Usually stable – most organisms have narrow tolerances

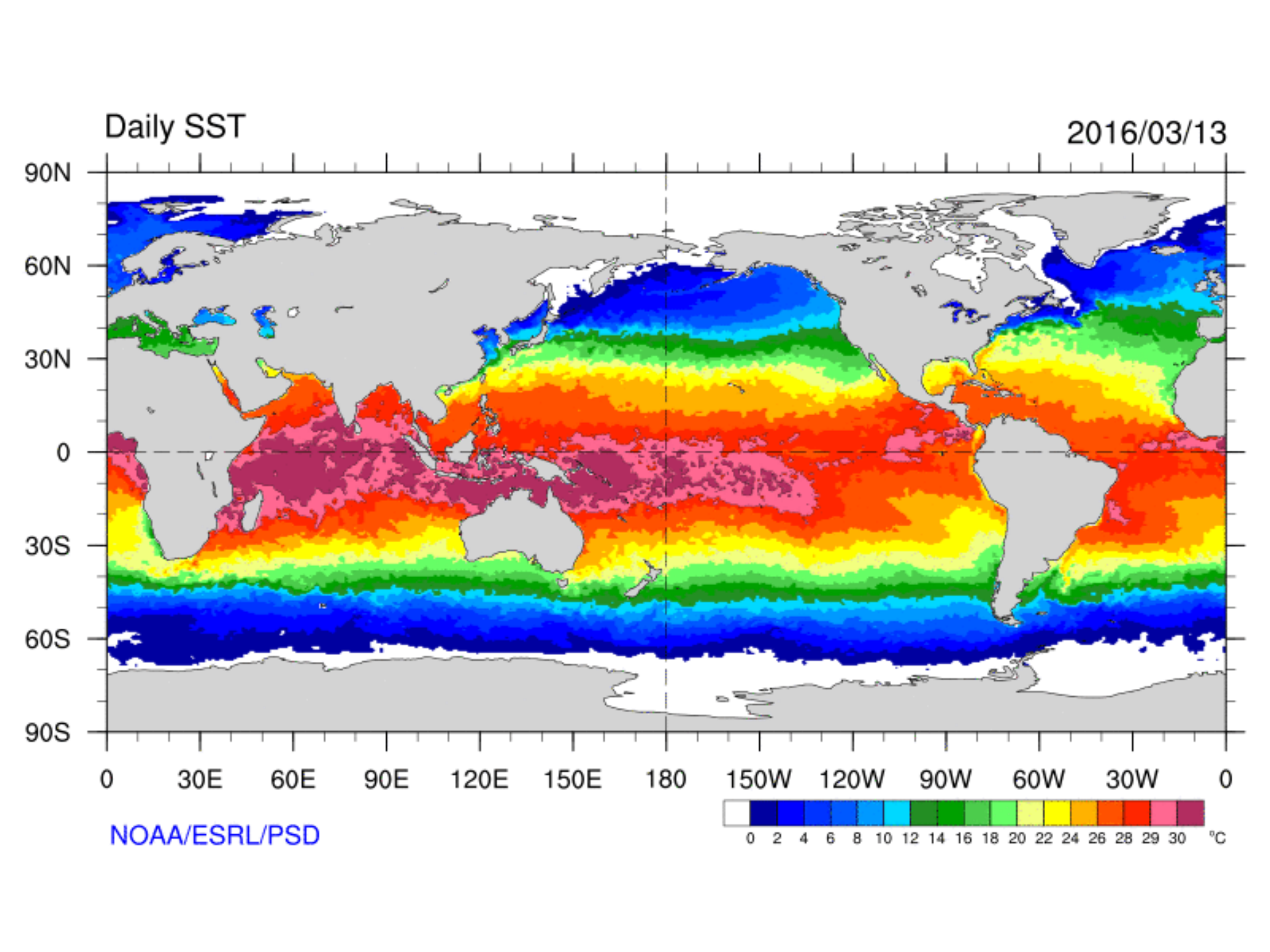
How does temperature vary

- Increase in latitude:
  - Temperature ⬇
- Increase in depth:
  - Temperature ⬇
- Relation to Ocean circulation
  - Currents coming from equator ⬆
  - Currents coming from poles ⬇
  - Isolated gyres

Depends on latitude – high latitude will be cold, low will be warm

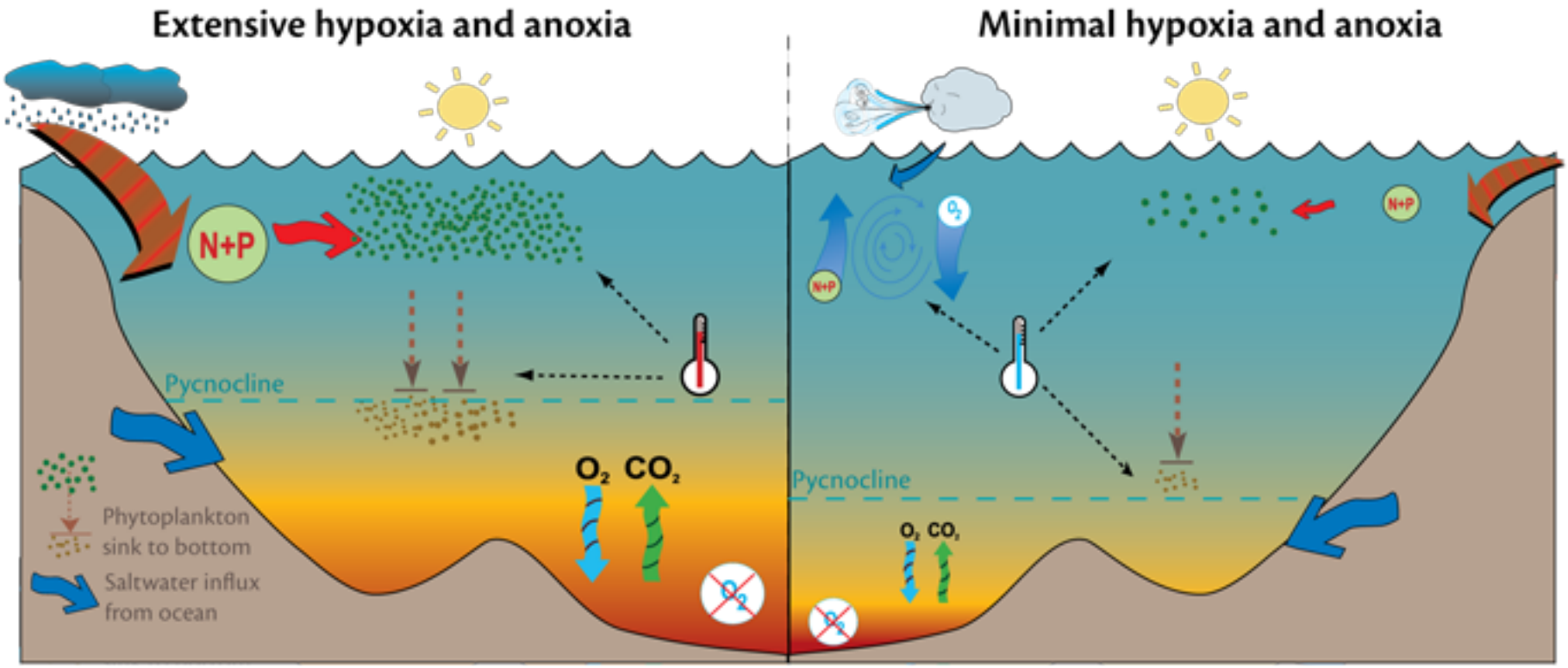


http://www.esrl.noaa.gov/psd/map/clim/sst.shtml


Daily SST
2016/03/13
90N
60N
30N
0
30S
60S
90S
0
30E
60E
90E
120E
150E
180
150W
120W
90W
60W
30W
0
NOAA/ESRL/PSD
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 29 30 °C

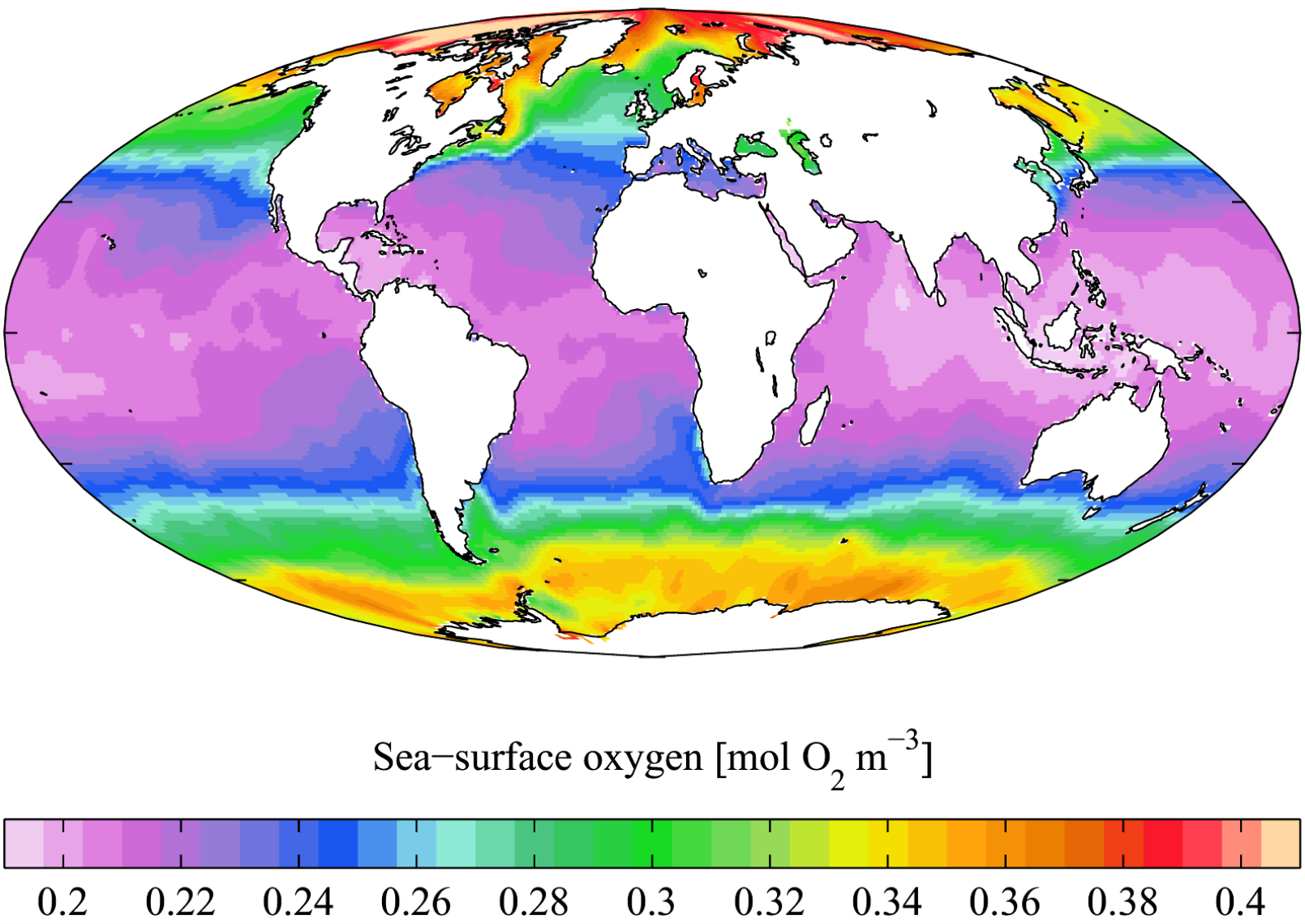
Oxygen

- Affects
  - Metabolic rates through respiration
- Determined by
  - Turbulence ↑
  - Plant production ↑
  - Biodensity ↓
  - Decomposition ↓
- Oceans have been typically stratified with respect to oxygen

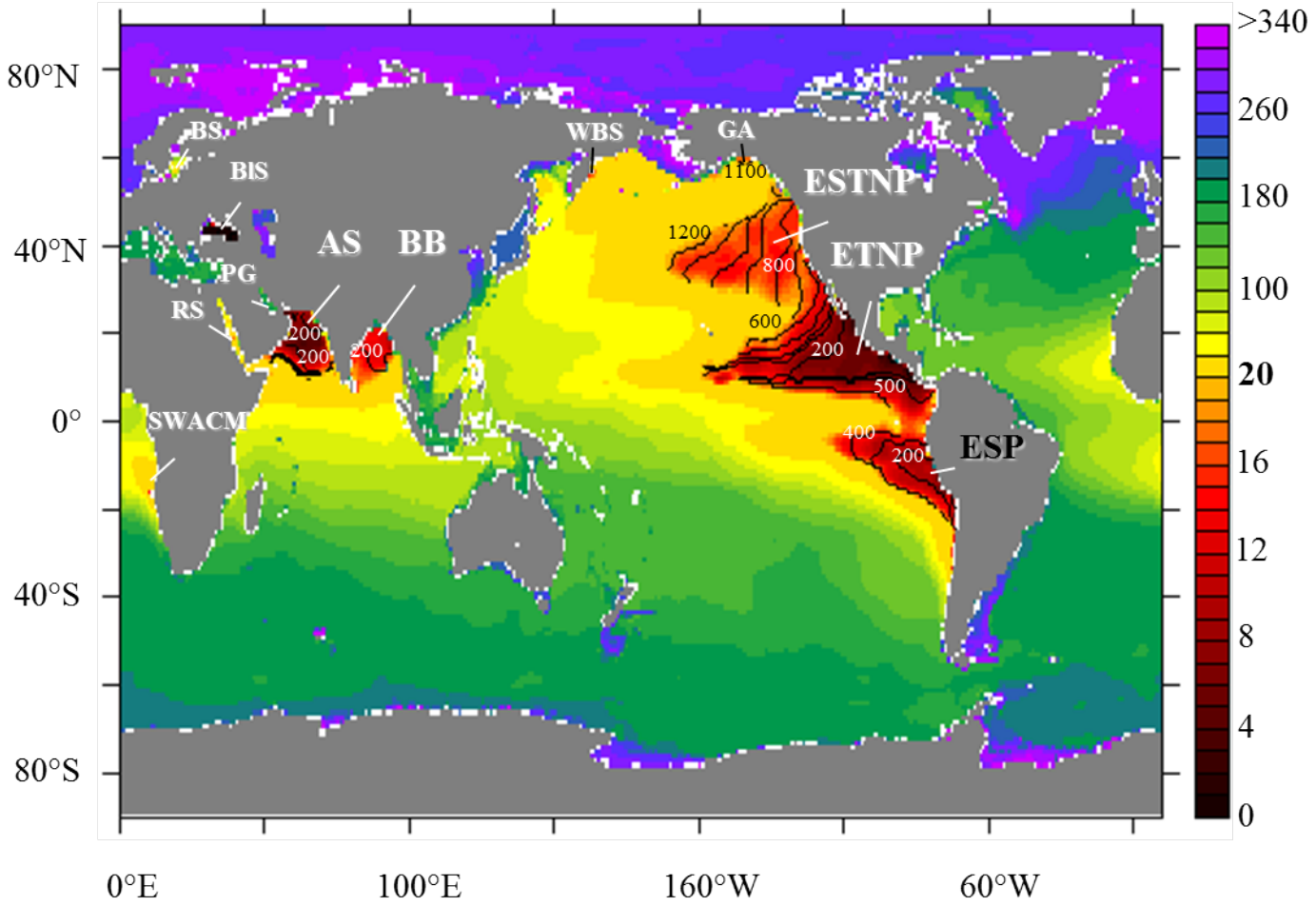


	Loads	Phytoplankton	Decomposition	Temperature	Wind event
Large amount of low dissolved oxygen	Large nitrogen and phosphorus loads	Elevated nutrients cause large phytoplankton blooms	High oxygen consumption by decaying phytoplankton	Warm water a) Stimulates decomposition b) Stratifies water column c) Stimulates phytoplankton	No wind event: water column remains stratified
Little amount of low dissolved oxygen	Small nitrogen and phosphorus loads	Less nutrients lead to small phytoplankton blooms	Low oxygen consumption by decaying phytoplankton	Cool water: a) Slow decomposition b) Mixed water column c) Slow phytoplankton growth	Wind events destratifies water column: a) Bottom water aerated b) Nutrients move to surface

http://ian.umces.edu/ecocheck/images/do_conceptual_diagram.png



https://upload.wikimedia.org/wikipedia/commons/3/3b/WOA05_sea-surf_O2_AYool.png

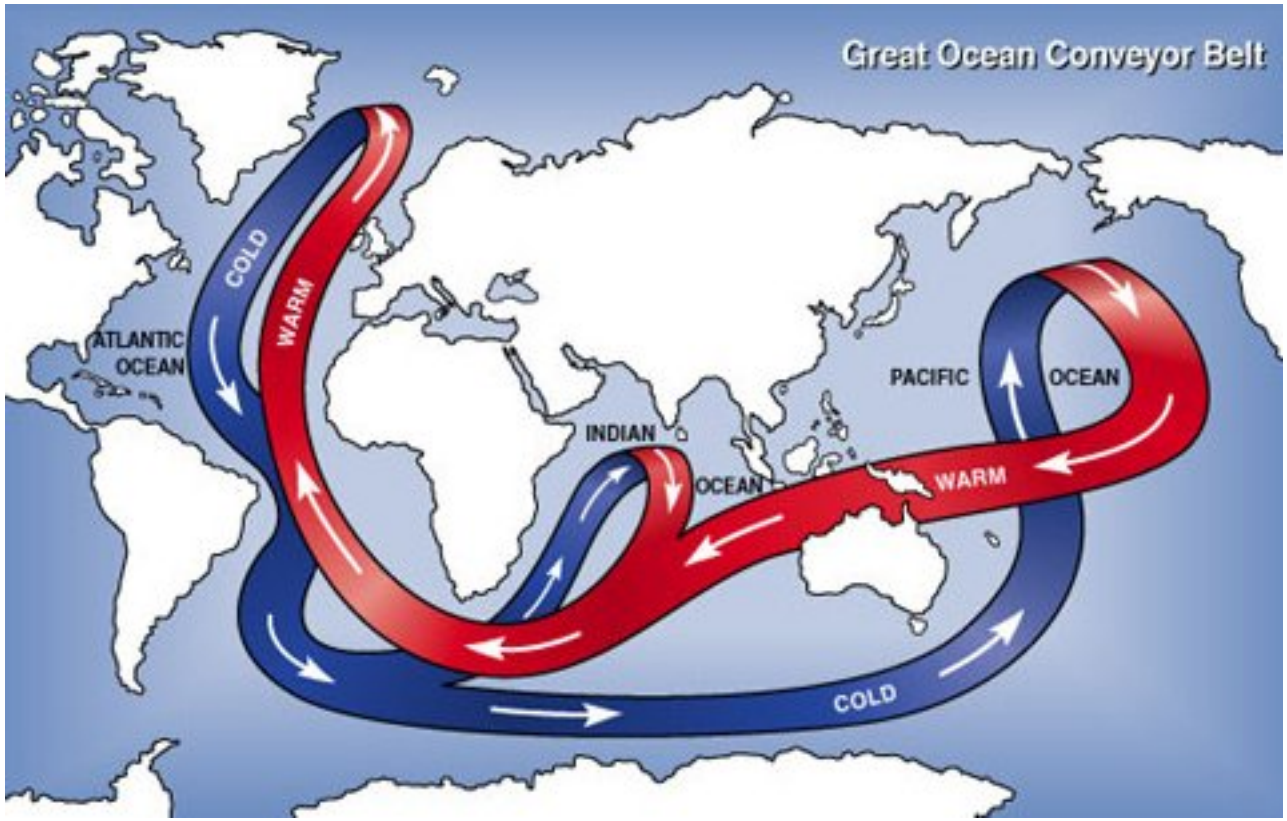


O_2 distribution (µM) at depth where O_2 concentration is minimal, indicating the extent of the OMZs (in red) according to the WOA2005 climatology. The color bar scale corresponds to a 1±2 µM interval between 0 and 20 µM, and a 20±2 µM interval between 20 and 340 µM. The isolines indicate the limit of the upper OMZ CORE depth in meters with a 100-m contour interval. For more details, cf *Paulmier and Ruiz-Pino, PiO (2009)*.

http://www.legos.obs-mip.fr/recherches/projets-en-cours/amop

Oceans now and then

- Now:
  - Global conveyor belt carries oxygenated water around the world's oceans
- Then:
  - Deep water typically anoxic



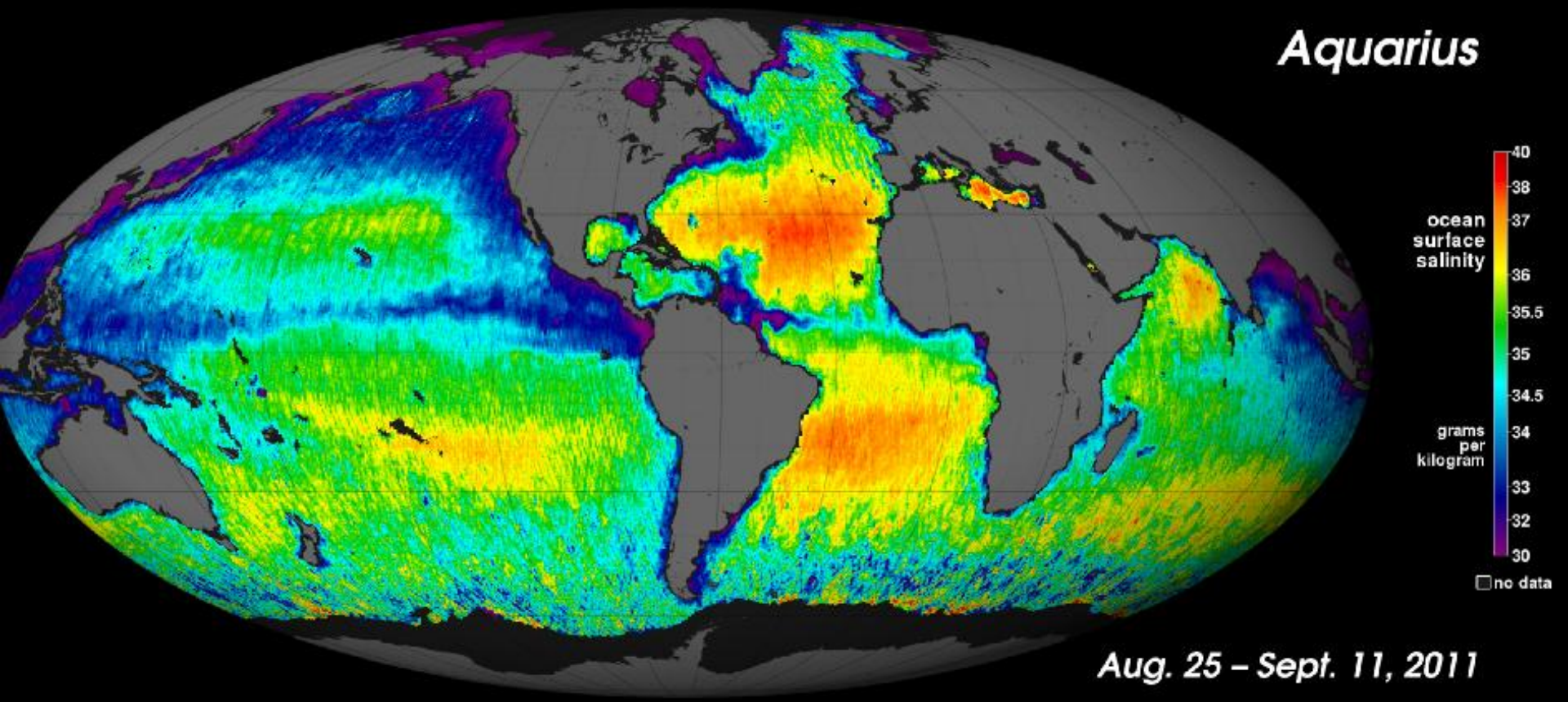
Cold water falls off the edge of the shallow (oxygenated) Arctic sea, then makes its way around the bottom of the world's oceans

http://www.enviroliteracy.org/images/page-spec//conveyor%20belt4.jpg

Salinity

- Variation
  - Normal 35 ‰ (parts per thousand)
  - Greatest variability in near shore environments
  - Affected by evaporation ⬆ , precipitation ⬇

Why is the map purple near coastlines?
Why is the Atlantic so much more saline than the Pacific?



http://www.nasa.gov/mission_pages/aquarius/multimedia/gallery/pia14786.html

Daily salinity animation

- https://svs.gsfc.nasa.gov/vis/a030000/a030400/a030493/aquarius_salinity_33-37.mp4

Salinity

- Tolerances
  - Most organisms have narrow tolerances
    - Osmotic pressure
  - Exceptions: oysters, mussels, snails, some crustaceans

Depth: Three intertwined variables

- Light
  - Photic zone (well-lit water) to 200 meters in open ocean, much less closer to land where there is sediment in the water
  - Surface ecosystems based on primary producers
  - Bottom ecosystems based on material drifting down
- Pressure
- Carbonate Compensation Depth (CCD): below 3000-4000 ft., water is undersaturated with CO_2 – calcite & aragonite skeletons dissolve

Substrate

- Organisms specialize for specific substrates
  - Rocky: attached filter feeders, borers, grazers, mobile & immobile predators
  - Mud: deposit feeders, other infauna
  - Sand: mobile filter feeders and predators, few grazers or deposit feeders

Understanding common environments

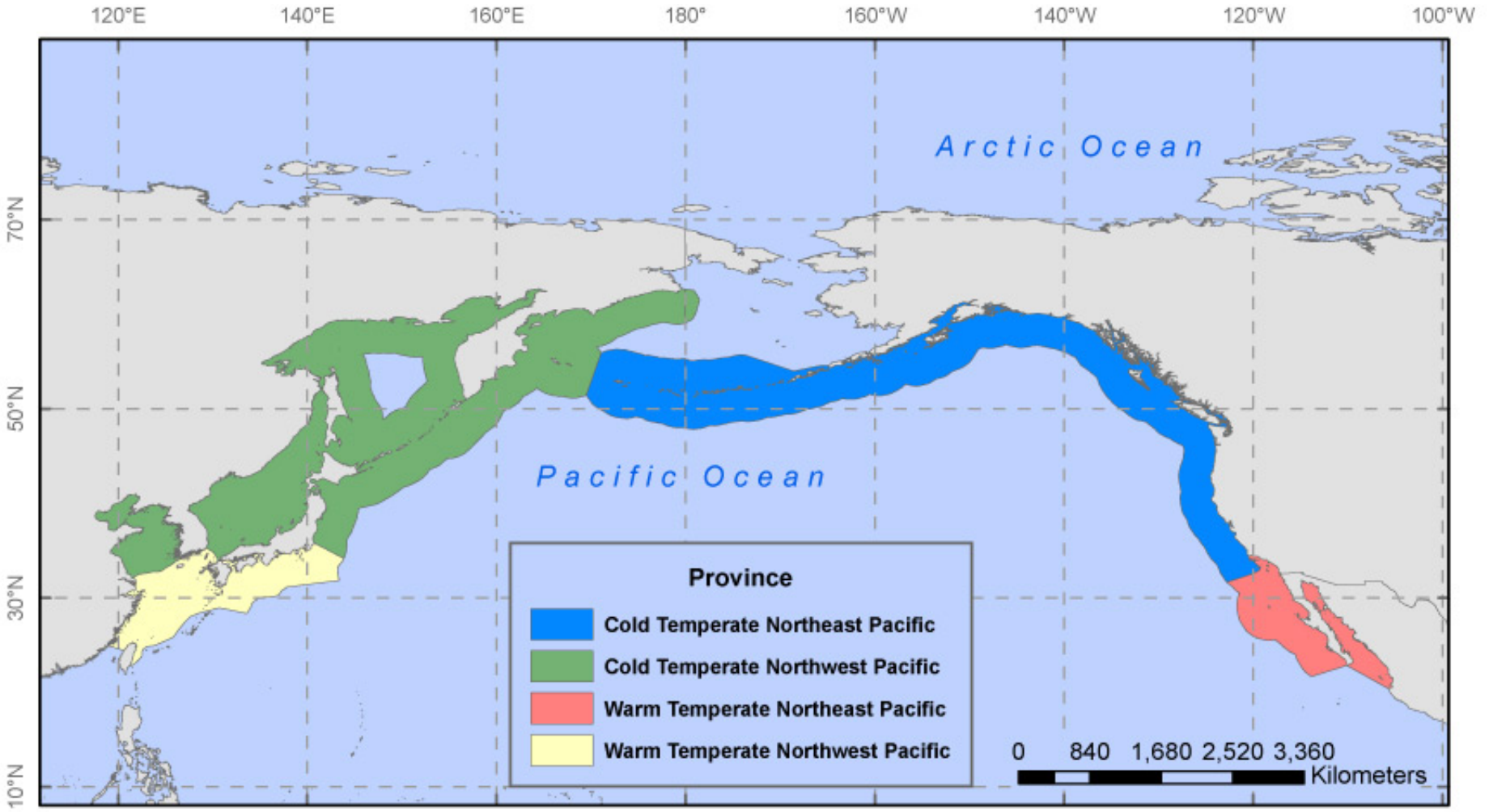
- Rocky intertidal – between high and low tides
- Muddy intertidal – tide flats
- Sandy subtidal – below wave base, shallow water

Work on your environment

Environment	Rocky intertidal	Muddy intertidal	Sandy subtidal
Temperature			
Oxygen			
Salinity			
Depth			
Substrate			
Adaptations			

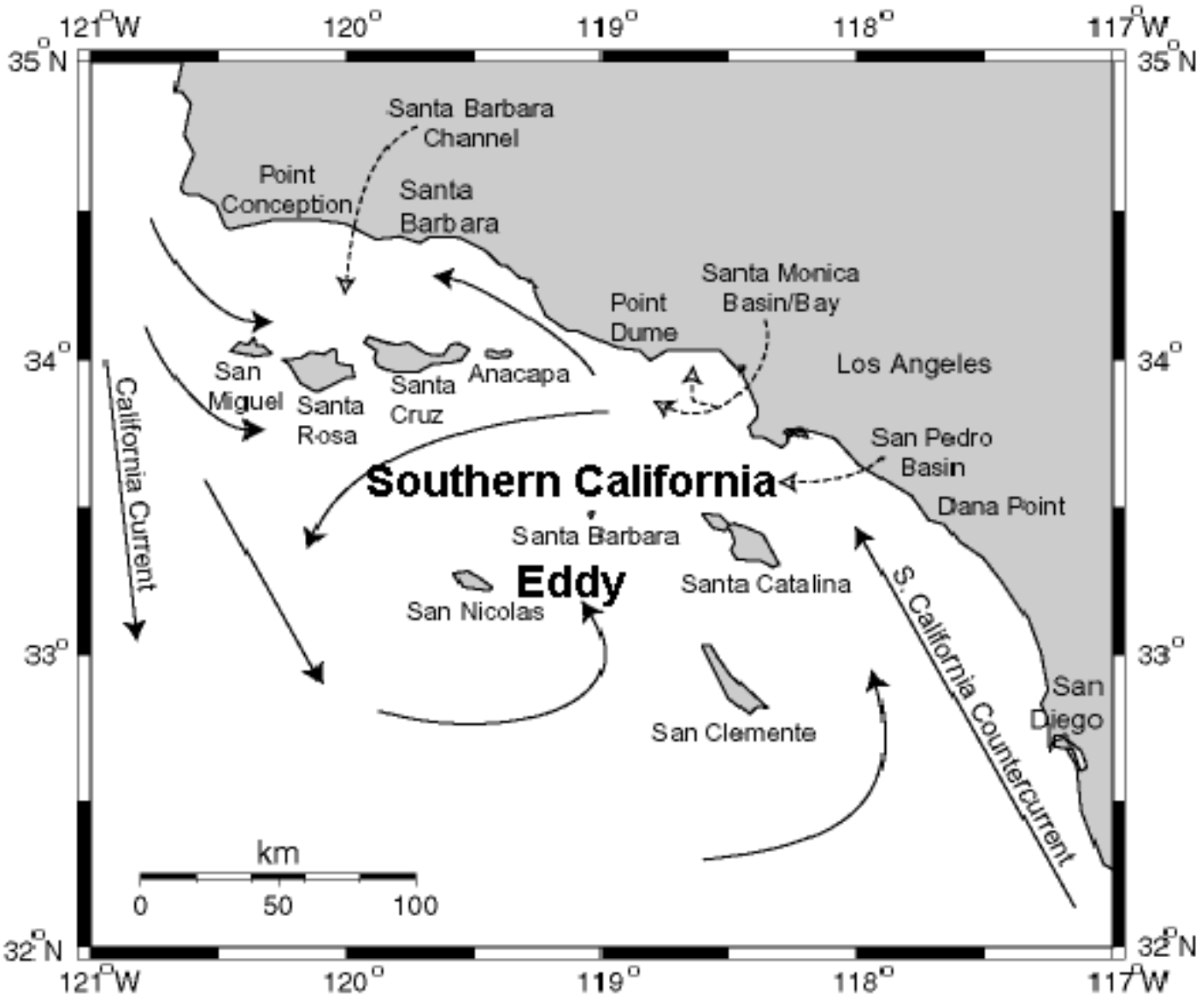
Water Masses

- Oceans are divided into surprisingly stable masses of water with relatively uniform temperature & salinity conditions
- Properties of a water mass are determined by latitude and circulation patterns
- Results in Biotic Provinces



http://pubs.usgs.gov/of/2010/1251/figure3.html

Circulation Patterns in the Southern California Bight



(After Hickey, B. M., 1992, Progress in Oceanography, V30: 37-115)

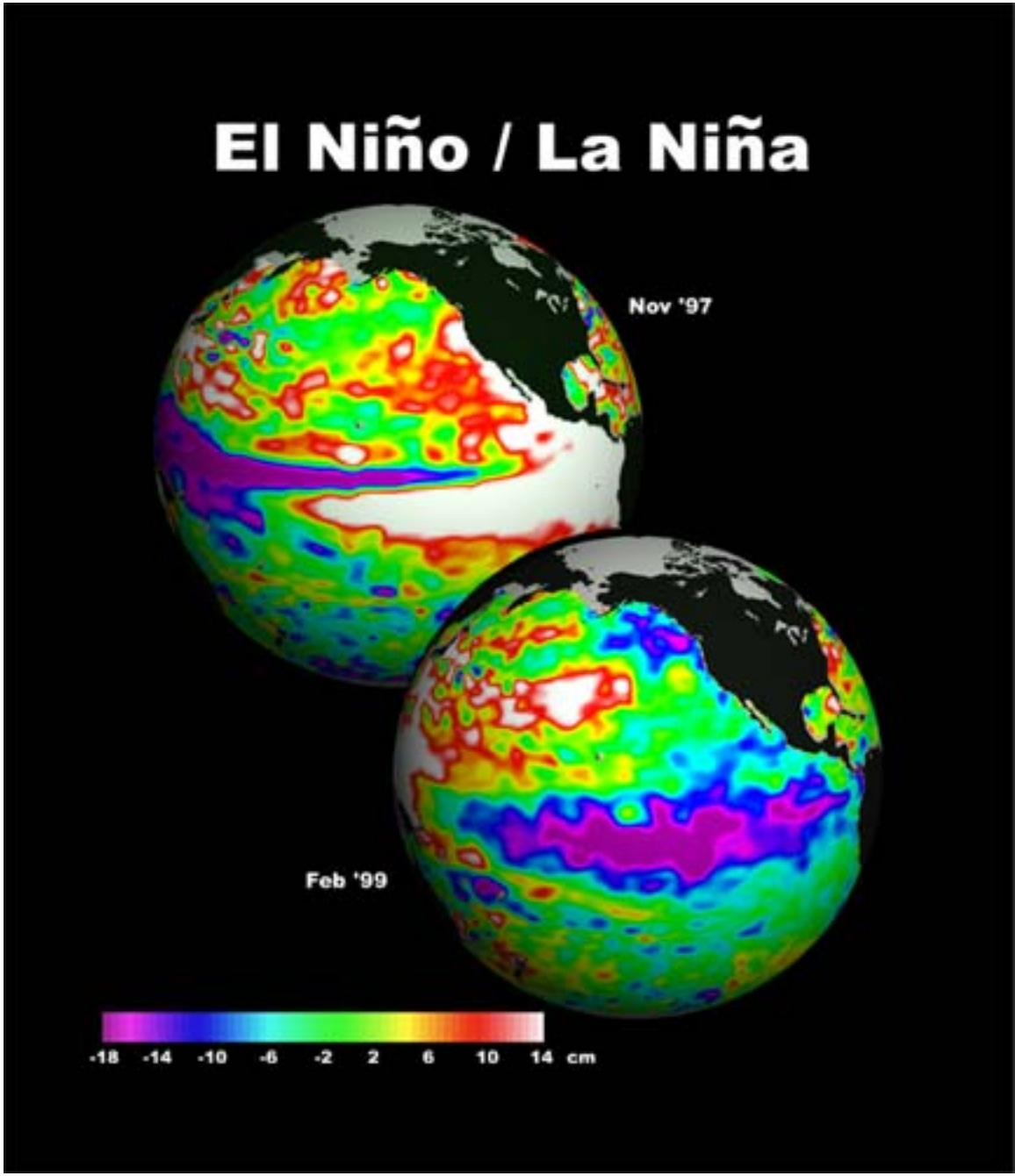
http://geology.cnsm.ad.csulb.edu/people/bperry/geology303/geol303text.html

Disrupted by cyclic perturbations

El Nino: warm water flows W to E across Pacific

La Nina: persistent cold water in tropical latitudes

http://sealevel.jpl.nasa.gov/science/elninopdo/learnmoreninonina/



Biological environment

- Competition: organisms compete for same resource
  - Food
  - Space
  - Light
- Think of examples from our field trip

Biological environment

- Interference competition:
  - Organisms aren't directly competing, but their use of the environment interferes with each other
  - E.g. Humans & habitat disruption (freeways)
  - Biologic bulldozers

Biological Environment

- Predation & parasitism
  - Eliminates some species from some environments
  - Evidence in fossil record
    - Shell breakage
    - Teeth holes

http://www.ucmp.berkeley.edu/about/flat_stanley07.php

Symbiosis

- Organisms live together
- Mutualism – for mutual benefit
  - Zooxanthellae

How does mutualism evolve?

- One example:
  - Some nudibranchs retain zooxanthellae from the coral that they eat.
  - Gut has transparent pockets that hold the chloroplasts from the algae
  - If the nudibranch retains the entire algae and the algae is able to reproduce: mutualism
  - Natural selection could drive the nudibranch to provide algae a safe place to live

This nudibranch has lived 10 months without food in the lab, using the chloroplasts it took from the algae to photosynthesize and make sugars.

This nudibranch keeps living algae in its tissues.

http://www.seaslugforum.net/solarpow.htm