

Announcements

Lab Finals this Week
in 3820 Geology

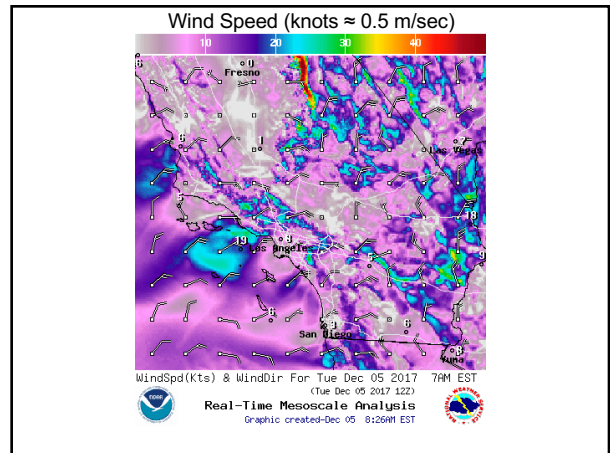
Lecture Final
Thur., December 14, 3:00p-6:00p Dodd 147

Extra Credit Video
Today! 3:00-3:50p, Young CS76

Lecture Final Review Session
Thursday, 3:00-3:50pm, Young CS24

Course Evaluations until Friday!
Extra Credits due Friday!

Lights on squid fishing boats. Hakodate, Hokkaido, Japan.
Photo by Geomr-commonswiki, Creative Commons Attribution-Share Alike 3.0 Unported.
https://commons.wikimedia.org/wiki/File:Hakodate_squid_fishing_2005-08.JPG



Types of Marine Resources

- **Physical Resources**
 - Mineral deposits, petroleum & natural gas (methane), etc
- **Biological Resources**
 - Animal and plant life collected for our use
- **Nonextractive Resources**
 - Transportation, recreation, waste disposal

Oil platforms, Huntington Beach CA. Photo by Aaron Logan, CC A 2.0, http://commons.wikimedia.org/wiki/File:Lightmatter_oilrigs.jpg

Jack mackerel net. Photo by C. Ortiz Rojas, NOAA, Public Domain, <http://www.photolib.noaa.gov/htmls/fish2172.htm>

Cargo ship MV Lehmann Timber. US Navy photo, http://www.navy.mil/view_single.asp?id=61335

Nori seaweed nets, Japan. Made based on [http://w3land.mlit.go.jp/WebGIS/National_Land_Image_Information_\(Color_Aerial_Photosatellite\).](http://w3land.mlit.go.jp/WebGIS/National_Land_Image_Information_(Color_Aerial_Photosatellite).) Japan Ministry of Land, Infrastructure, Transport and Tourism

Sustainability of Marine Resources

Renewable Resources

Replaceable on a relatively short timescale, if harvested responsibly
i.e., wind, seaweed

Nonrenewable Resources

Present in the ocean in essentially fixed amounts on a human timescale
i.e., oil deposits

Oceanic Biological Resources

- **BIG PICTURE:**
7.44 x 10⁹ Humans as of December 2, 2017
(US Census Bureau projection model)
- + 78 million more every year
– i.e., a 1.0% Growth Rate

One new Rose Bowl-full every 10 hours!



Many depend on food and other products of life in the ocean...

Rose Bowl image from UCLA Bands, www.uclaband.com/script_only.jpg

Oceanic & Aquatic Biological Resources

- ~20% or more of animal protein for 3.0 billion people
- at least 15% of animal protein for 4.3 billion people
- 65%* of from oceans, 35% from fresh water

Global Commercial Harvest

- 158 Million metric tons in 2012
 - increasing ~3% per year (but wild harvest stagnant!)
- Direct Human Consumption: 86%
- Other uses (e.g., feed for livestock): 14%
 - “Trash” fish: anchovies, herrings, sardines, etc.

*Most statistics are from the 2014 World Fisheries Report of the Food and Agriculture Organization of the United Nations

Global Wild Catch

WORLD CAPTURE FISHERIES AND AQUACULTURE PRODUCTION

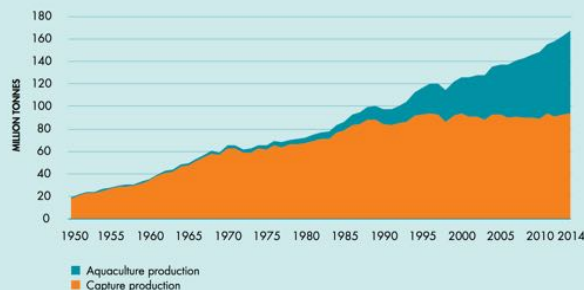


Figure from UN Food and Agriculture Organization World Review of Fisheries and Agriculture 2016, <http://www.fao.org/fishery/sofia/en>

WORLD FISHERIES AND AQUACULTURE PRODUCTION AND UTILIZATION

	2009	2010	2011	2012	2013	2014
(Million tonnes)						
PRODUCTION						
Capture						
Inland	10.5	11.3	11.1	11.6	11.7	11.9
Marine	79.7	77.9	82.6	79.7	81.0	81.5
Total capture	90.2	89.1	93.7	91.3	92.7	93.4
Aquaculture						
Inland	34.3	36.9	38.6	42.0	44.8	47.1
Marine	21.4	22.1	23.2	24.4	25.5	26.7
Total aquaculture	55.7	59.0	61.8	66.5	70.3	73.8
TOTAL	145.9	148.1	155.5	157.8	162.9	167.2
UTILIZATION¹						
Human consumption	123.8	128.1	130.8	136.9	141.5	146.3
Non-food uses	22.0	20.0	24.7	20.9	21.4	20.9
Population (billions)	6.8	6.9	7.0	7.1	7.2	7.3
Per capita food fish supply (kg)	18.1	18.5	18.6	19.3	19.7	20.1

Note: Excluding aquatic plants. Totals may not match due to rounding.
¹ Data in this section for 2014 are provisional estimates.

Figure from UN Food and Agriculture Organization World Review of Fisheries and Agriculture 2016, <http://www.fao.org/fishery/sofia/en>

Fisheries Management

- Maximum Sustainable Capture
 - Maximum wild harvest of an organism that will not irreparably harm future generations
 - Estimated Value ~100 Million metric tons (fresh & salt water combined)
- It is likely that we have reached or over-reached the sustainable limit

Fisheries Management

- Overfishing
 - When a fish stock has been harvested to the point that there is not enough breeding stock left to replenish the species
 - FAO estimates ~1/4 of global fisheries are presently unsustainable
 - Common Fix: Reduce harvest until species recovers, rough on regional fishing economies.
- Commercial Extinction
 - Depletion of a species to the point that it is no longer profitable to harvest

Overexploitation & collapse of fisheries

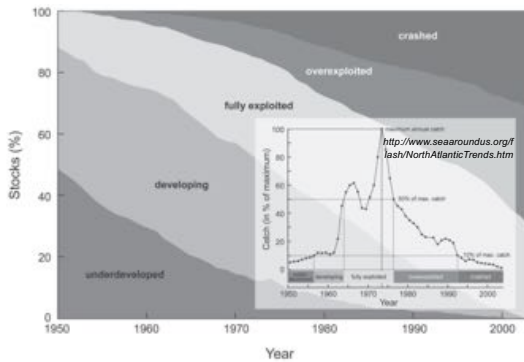
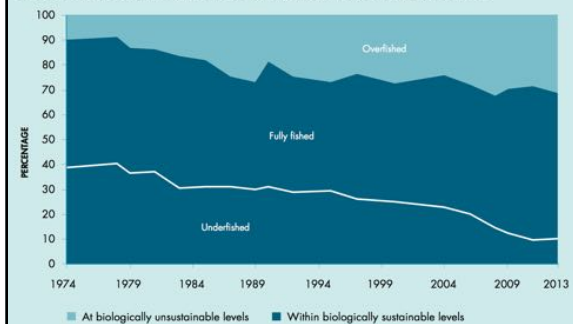


Figure by Rainer Froese, Kiel U./Sea Around Us, <http://www.seaaroundus.org/newsletter/issue37.pdf>

GLOBAL TRENDS IN THE STATE OF WORLD MARINE FISH STOCKS SINCE 1974



Notes: Dark shading = within biologically sustainable levels; light shading = at biologically unsustainable levels. The light line divides the stocks within biologically sustainable levels into two subcategories: fully fished (above the line) and underfished (below the line).

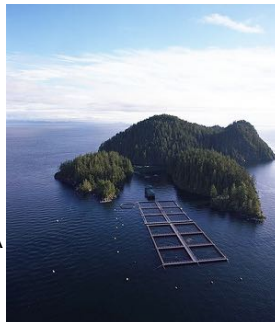
Figure from UN Food and Agriculture Organization World Review of Fisheries and Agriculture 2016, <http://www.fao.org/fishery/sofia/en>

Solutions

Improved Fisheries Management

Sensible harvesting, characterization of resources

Aquaculture/mariculture (Especially catfish, tilapia, crayfish)



Salmon pens, British Columbia CA

Photo by BC Salmon Farmers Association, reproduction allowed with attribution. http://en.wikipedia.org/wiki/File:Salmon_farming.jpg

Aquaculture...

WORLD CAPTURE FISHERIES AND AQUACULTURE PRODUCTION

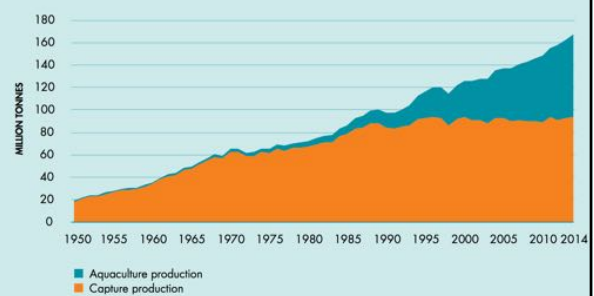


Figure from UN Food and Agriculture Organization World Review of Fisheries and Agriculture 2016, <http://www.fao.org/fishery/sofia/en>

Aquaculture/mariculture

Accounts for ~40% of total world harvest for all uses, and as of 2014 **more than 50% of fish harvested for direct human consumption.** our oceans, rivers and lakes are being domesticated!

FIGURE 29

RELATIVE CONTRIBUTION OF AQUACULTURE AND CAPTURE FISHERIES TO FISH FOR HUMAN CONSUMPTION

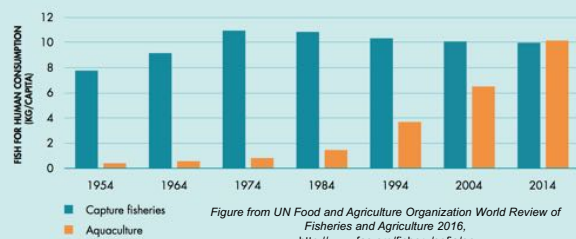


Figure from UN Food and Agriculture Organization World Review of Fisheries and Agriculture 2016, <http://www.fao.org/fishery/sofia/en>

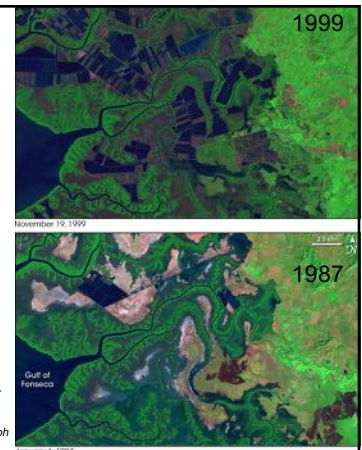
Mariculture

The growth segment of modern fisheries.

Very important where wild fisheries have already collapsed (e.g., Bangladesh)

Shrimp farming in particular may occur at expense of mangrove swamps & other sensitive areas

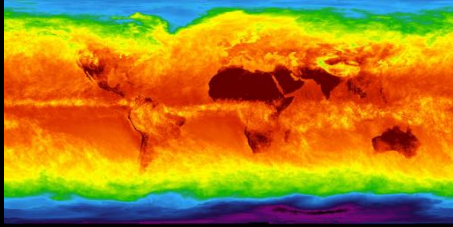
Growth of shrimp farming, Honduras, 1987-1999. Image by Jesse Allen, NASA Earth Observatory, Public Domain. <http://earthobservatory.nasa.gov/IOTD/view.php?id=6339>



Definition of "Climate"

Climate: The accumulation of daily and seasonal weather events over a long period of time

Global Climate: Climate extending over the entire Earth.



NASA image, Public Domain, http://airsteam.jpl.nasa.gov/multimedia/image_releases_2003/apr03/air_avgbrtmstp_2003/

AIRS Average Brightness Temperature for month of April 2003
Data from AIRS Surface Channel 2516 cm⁻¹

Questions about changing climate

- Why is the climate changing?
 - Is this temporary and/or cyclical?
 - Is it caused by human activity?
 - What's going to happen in the future?
- As scientists we want to build a predictive model of future climate.
- What's the first thing to do?

Understanding Past Climates

- Past century or so: thermometer records
 - care needed to track calibration, drift, global sampling
- For climate before ~1900 this is difficult
 - Methods that work in one area (ice caps) may not work elsewhere (tropical ocean).
 - High resolution records (tree rings) don't often extend back very far.
- Requires multidisciplinary approaches
- Timescales of interest and locations both important
- All methods depend on "proxies" for temperature
 - Impossible to **directly** measure past temperatures except for very recent past in areas with people (w/ thermometers!).

Paleo-climate Evidence

Geologic features

- Ancient clues in old continental rocks
- Landforms show effects of past glacial activity



Yosemite Valley, by snty-act, Creative Commons A-SA 3.0, http://commons.wikimedia.org/wiki/File:Yosemite_Valley.JPG

Ocean Sediment Cores

- ~200 Million Year Record

Deep Ice Cores

- Contain info going back ~800,000 years



National Ice Core Lab storage freezer, by Eric Craven, Public Domain, http://commons.wikimedia.org/wiki/File:NICL_Freezer.jpg

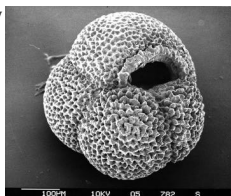
- **Others:** Coral cores, lake sediment cores (pollens), tree rings, etc...

Paleoclimate: Oceanic Proxies

Foraminifera CaCO₃ shells are used to study past sea surface temperature

Most O atoms have 8 p + 8 n = ¹⁶O

- 1/500 oxygen atoms has 2 extra neutrons: ¹⁸O isotope
- H₂¹⁸O evaporates slightly less easily than H₂¹⁶O
- Ice caps form from snow - precipitated from water vapor - and are ¹⁸O-poor.
- Remaining ocean water becomes ¹⁸O-rich



Foraminifera: Neogloboquadrina pachyderma
Micrograph by Hannes Grobe, Alfred Wegener Institut, Creative Commons A 3.0 Unported, http://commons.wikimedia.org/wiki/File:Neogloboquadrina-pachyderma_hg.jpg

**** ¹⁸O concentration of ancient seawater is preserved in CaCO₃ shells**

H₂¹⁸O evaporates slightly less easily than H₂¹⁶O.

Ice caps have little H₂¹⁸O, the leftover water in the ocean has extra H₂¹⁸O

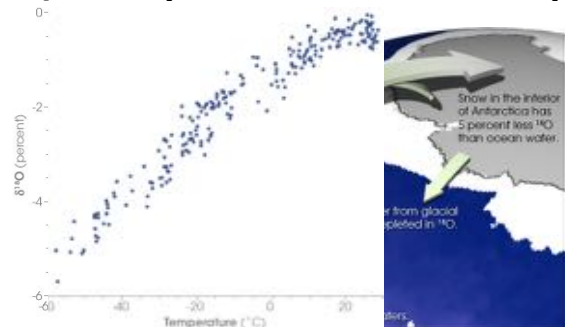
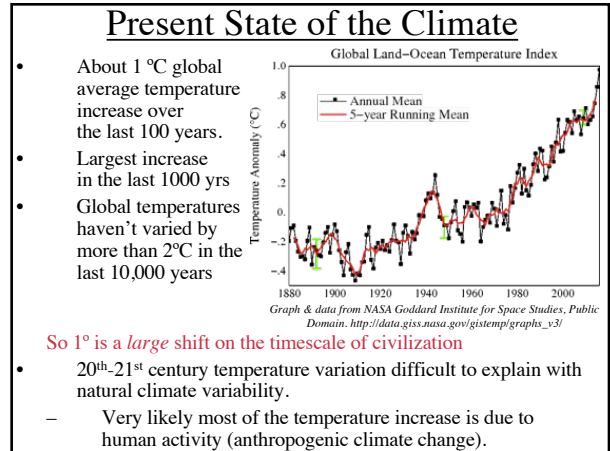
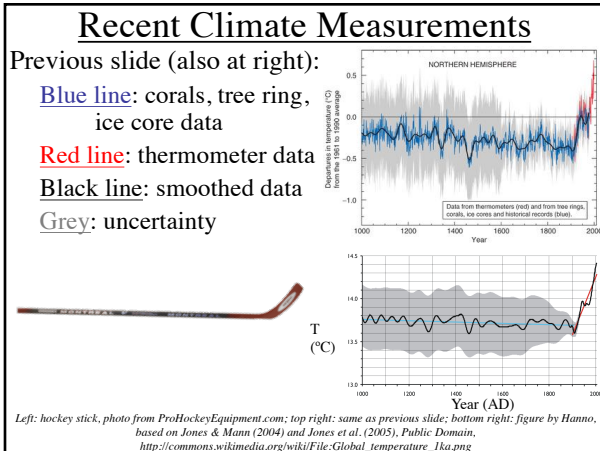
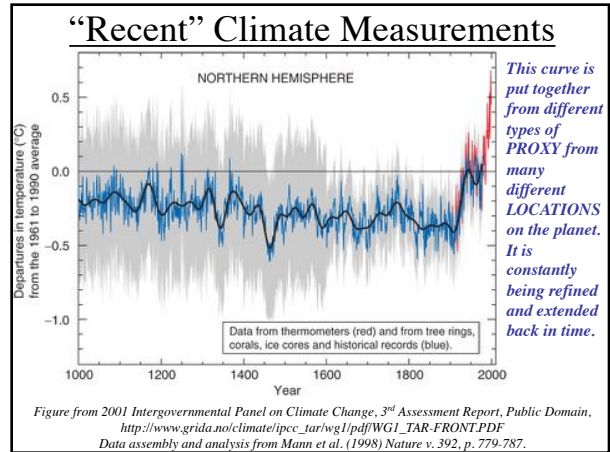
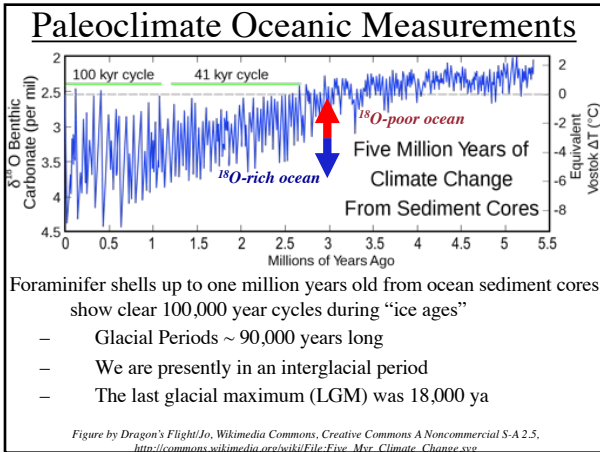


Illustration: Robert Simmon, NASA GSFC, Public Domain.

http://earthobservatory.nasa.gov/Features/Paleoclimatology/OxygenBalance/oxygen_balance.php
Graph: Jouzel, J., R. D. Koster, R. J. Suozzo, G. L. Russell, 1994. Stable water isotope behavior during the last glacial maximum: A general circulation model analysis. *Journal of Geophysical Research*, 99: 25791-25802.



Why is the Climate Warming?

- Most likely cause: enhanced atmospheric greenhouse effects.
- GREENHOUSE EFFECT?

A greenhouse stays warm because it is transparent to incoming sunlight.

But glass traps infrared (heat) radiation, preventing the energy absorbed from the sun from escaping.

Photo by National Rural Knowledge Exchange, Flickr, Creative Commons A 2.0. <http://www.flickr.com/photos/8228133@N04/1091783222>

Greenhouse Earth

Our atmosphere acts like a greenhouse!

Instead of glass or plastic, heat radiation is absorbed and scattered by gasses like CO₂ and H₂O-vapor

CO₂ H₂O

Frédéric Bellaiche/NASA, GNU PL/Public Domain. <http://commons.wikimedia.org/wiki/File:Jar.svg> & http://commons.wikimedia.org/wiki/File:Earth_Western_Hemisphere_white_background.jpg

Animations by E. Schauble, UCLA. http://www2.ess.ucla.edu/~schauble/molecular_vibrations.htm