LECTURE 2_5:
JAN. 21, 2014

OCEANS & FISHERIES

OCEANIC ECOSYSTEMS

Text Reference: Dearden and Mitchell (2012), Ch. 8, pp. 238-245; 258-259.

T. Randall, Lakehead University, WA 2014

Outline

From: Dearden and Mitchell (2012)

Chapter 8

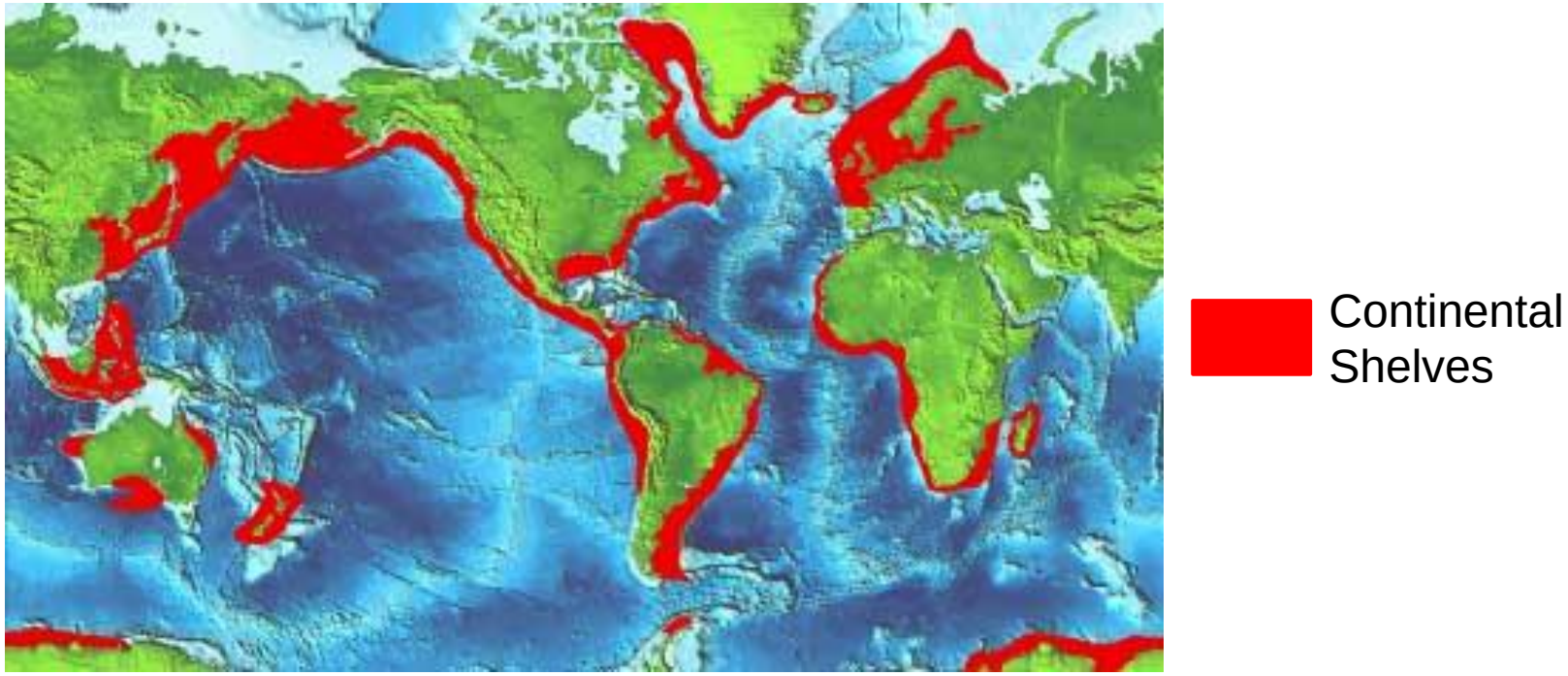
- Ocean Productivity {upwelling; continental shelves; CO_2 uptake}
- Ocean Circulation {thermocline; thermohaline circulation; surface currents and deep ocean circulation}
- Coral Reefs {benefits and environmental challenges}

Oceans: basics and importance

- Oceans are key components in global cycles and energy flows, and thus to sustaining life on the planet;
- They provide significant “marine ecological goods and services” ($21 trillion annually, Costanza *et al*., 1997)
- However, oceanic systems are not well understood;
- While there is considerable research complete/being done, much still evades us …
- Oceanic productivity governed by nutrient distribution, which generally increases with depth …

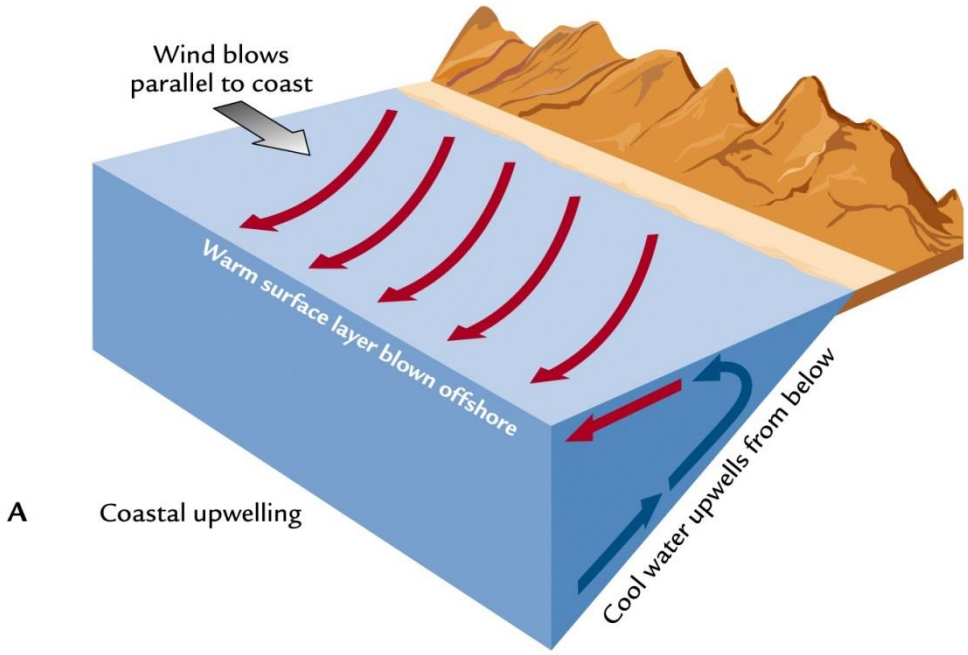
Productive zones of oceans

- Coastal zones;
- Upwelling zones (bringing nutrients from deep ocean)
- Most productivity in oceans is on the **<u>continental shelves</u>** (at depths <200 m) → *most fisheries in these areas*



Coastal Upwelling

- Winds blowing southward along the west coast of the United States cause the surface layer of the ocean to move away from the coast



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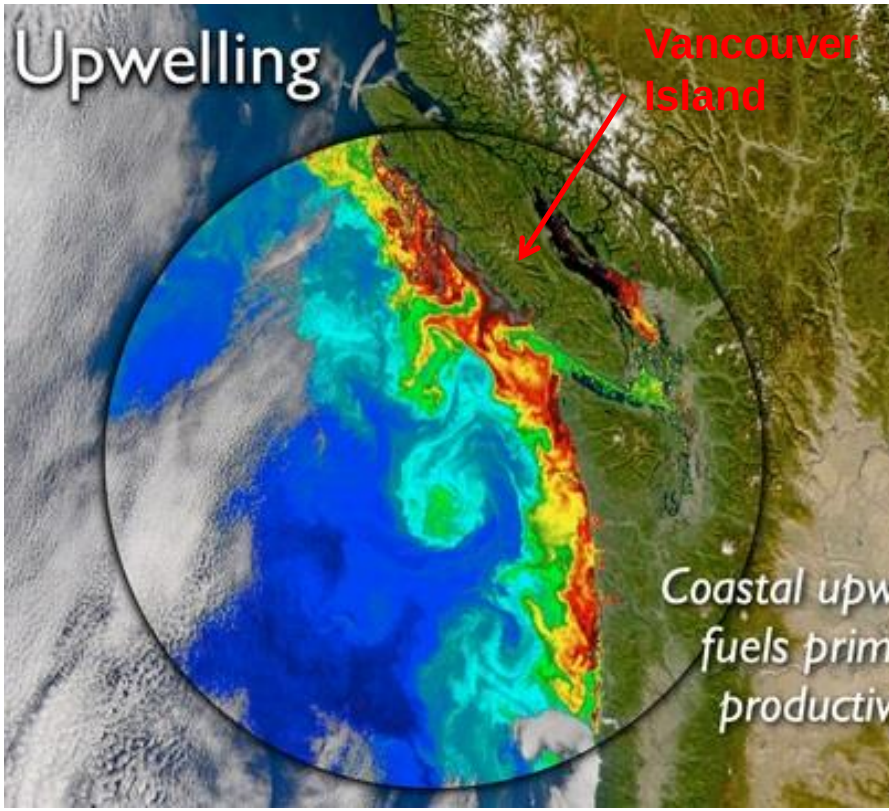
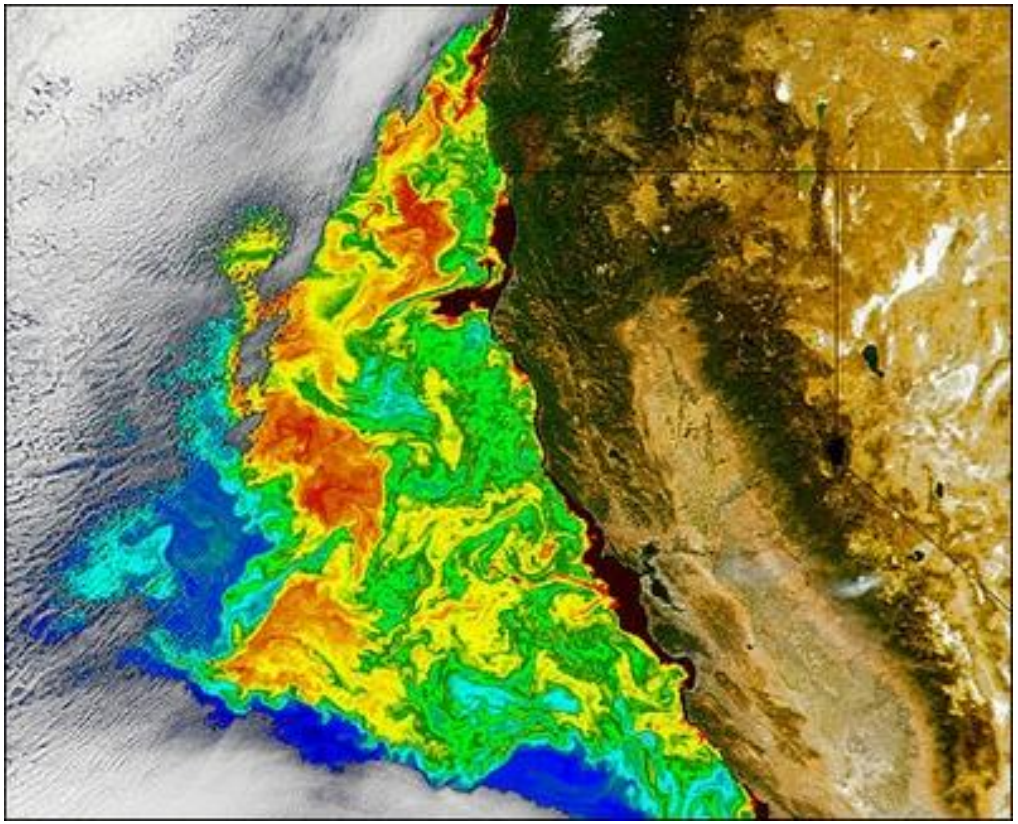


http://www.ooi.washington.edu/file/Coastal_Upwelling

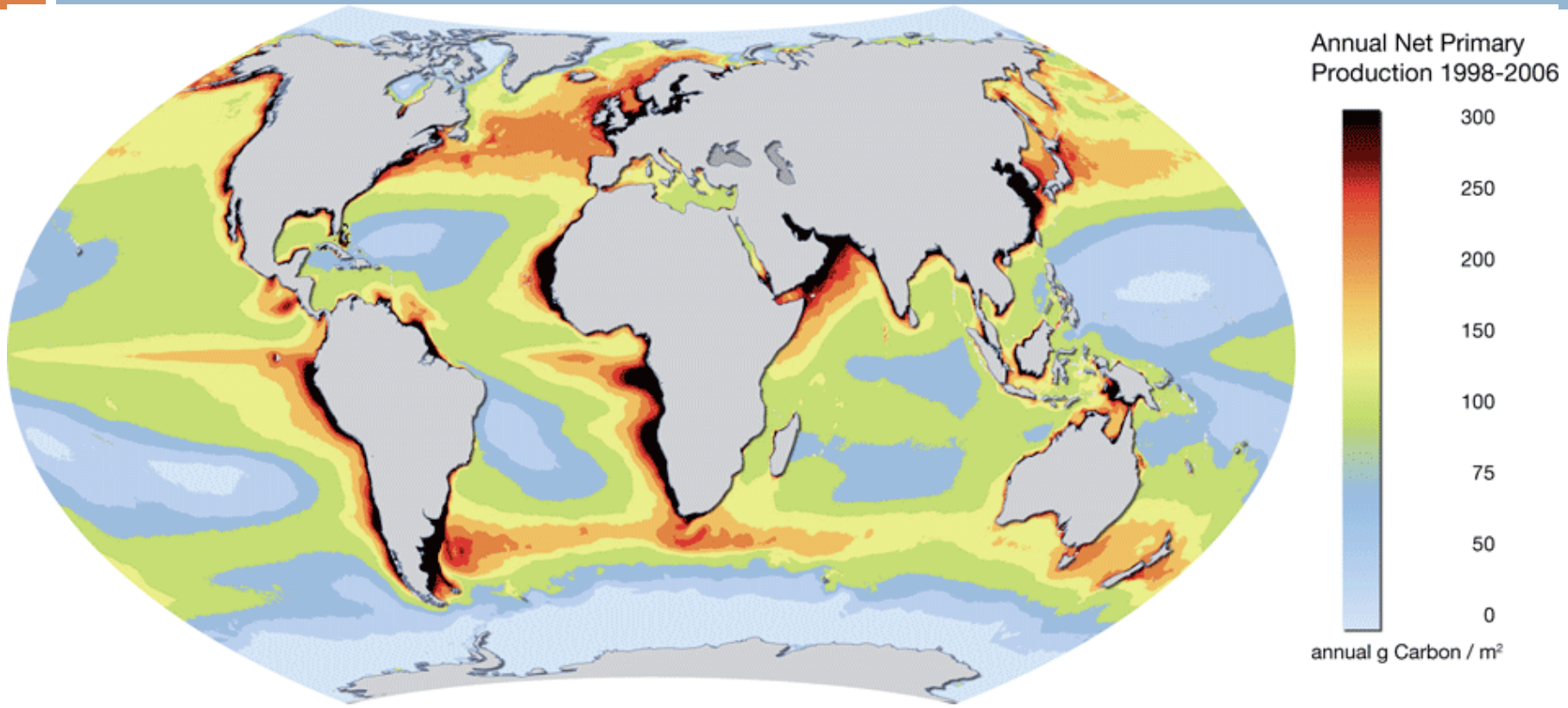
Coastal Upwelling



http://science.nasa.gov/earth-science/oceanography/living-ocean/remote-sensing/

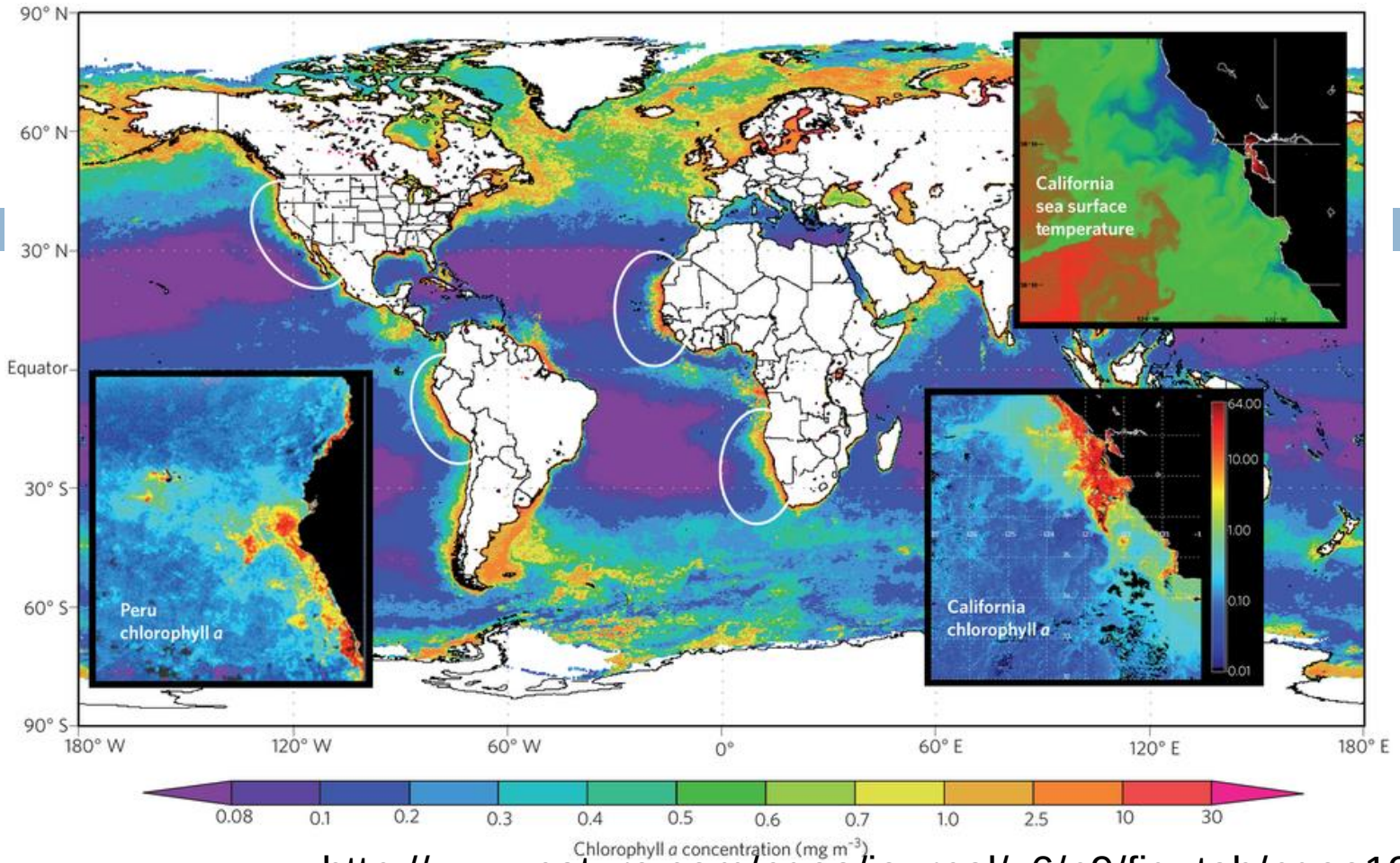
- The ocean areas (image collected on 6 Oct 2002) are color coded to show chlorophyll concentrations in the ocean off the coast of California. Bright reds indicate high concentrations and blues indicate low concentrations.
- Measuring chlorophyll can identify areas rich in nutrients and monitor such processes such as upwelling.
- Winds blowing southward along the west coast of the United States cause the surface layer of the ocean to move away from the coast
- Since phytoplankton moves with the ocean currents, the pattern of chlorophyll concentrations reveal intricate patterns of ocean currents.

Ocean Productivity (Net Primary Productivity)



The most productive sea areas, presented in this map, are those with the highest biodiversity and biomass. These are also, in most cases, the areas with the highest harvesting pressure.

Source map: Oregon State University (2007); located January 2014 on http://nordpil.com/go/portfolio/mapsgraphics/ocean-productivity/



http://www.nature.com/ngeo/journal/v6/n9/fig_tab/ngeo1916_F1.htr

A global false-colour compilation of satellite data on ocean chlorophyll *a* for the year 2011 shows the California, Peru, Canary and Benguela ecosystems (white ovals). Also shown are close-up views of chlorophyll *a* levels in upwelling-supported phytoplankton blooms in Peru (lower left inset) and California (lower right inset), as well as a satellite-derived view of sea surface temperature in cold, nutrient-rich upwelling plumes off California (upper right inset). Imagery courtesy of NASA.

Ocean Circulation

Ocean-Atmospheric Carbon Interaction

Thermocline

Poleward heat transfer

Thermohaline circulation

Ocean Currents

Ocean-Atmospheric Carbon Cycle (Figure 8.1)

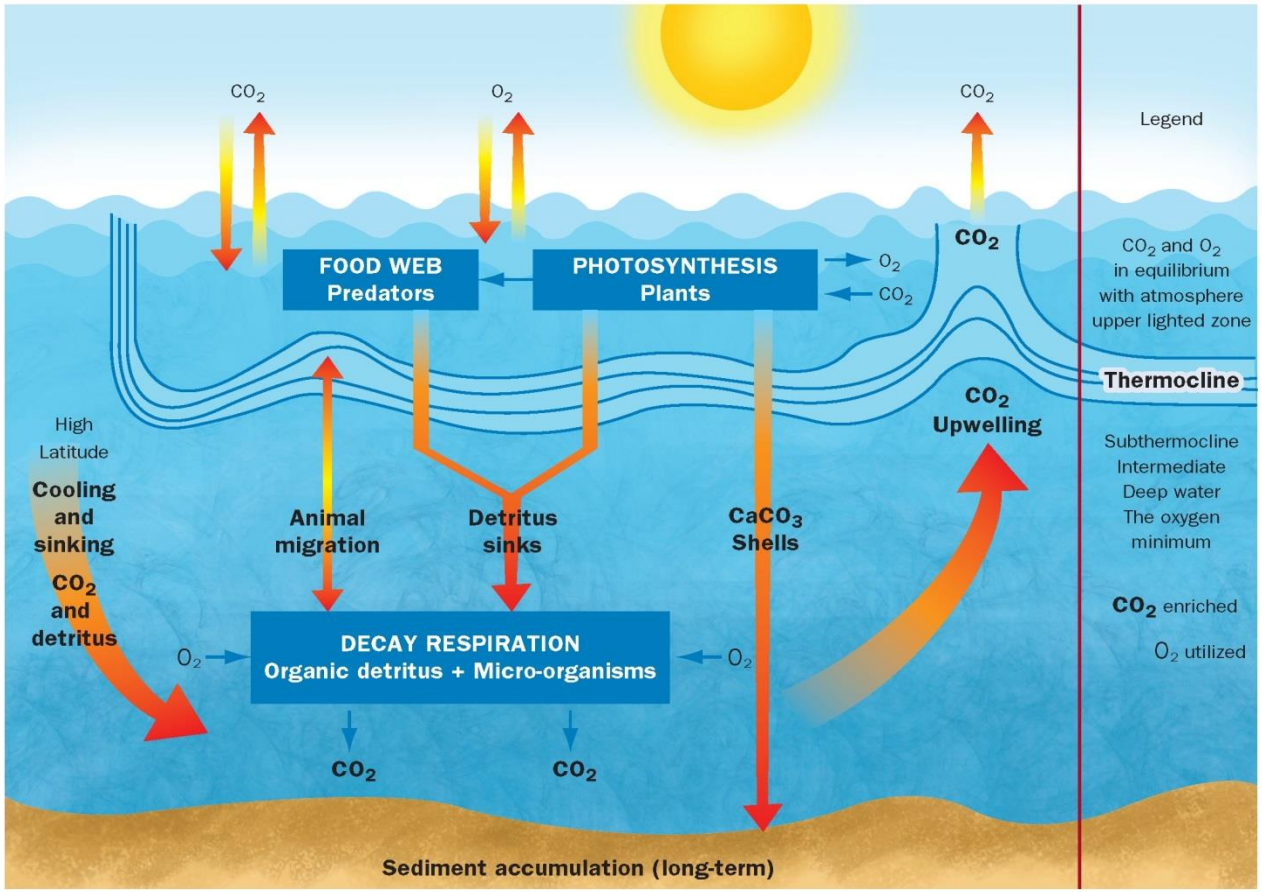


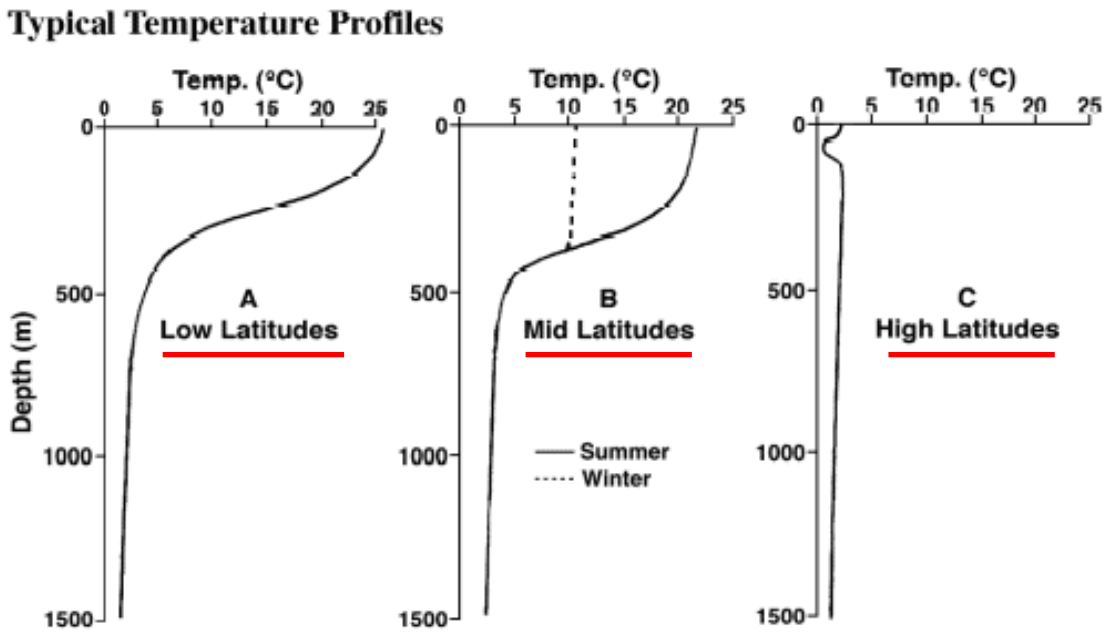
Figure 8.1 | The ocean–atmosphere carbon cycle. Source: Field et al. (2002: 13). *Copyright © 2002 Island Press. Reproduced by permission.*

From: Dearden and Mitchell (2012)

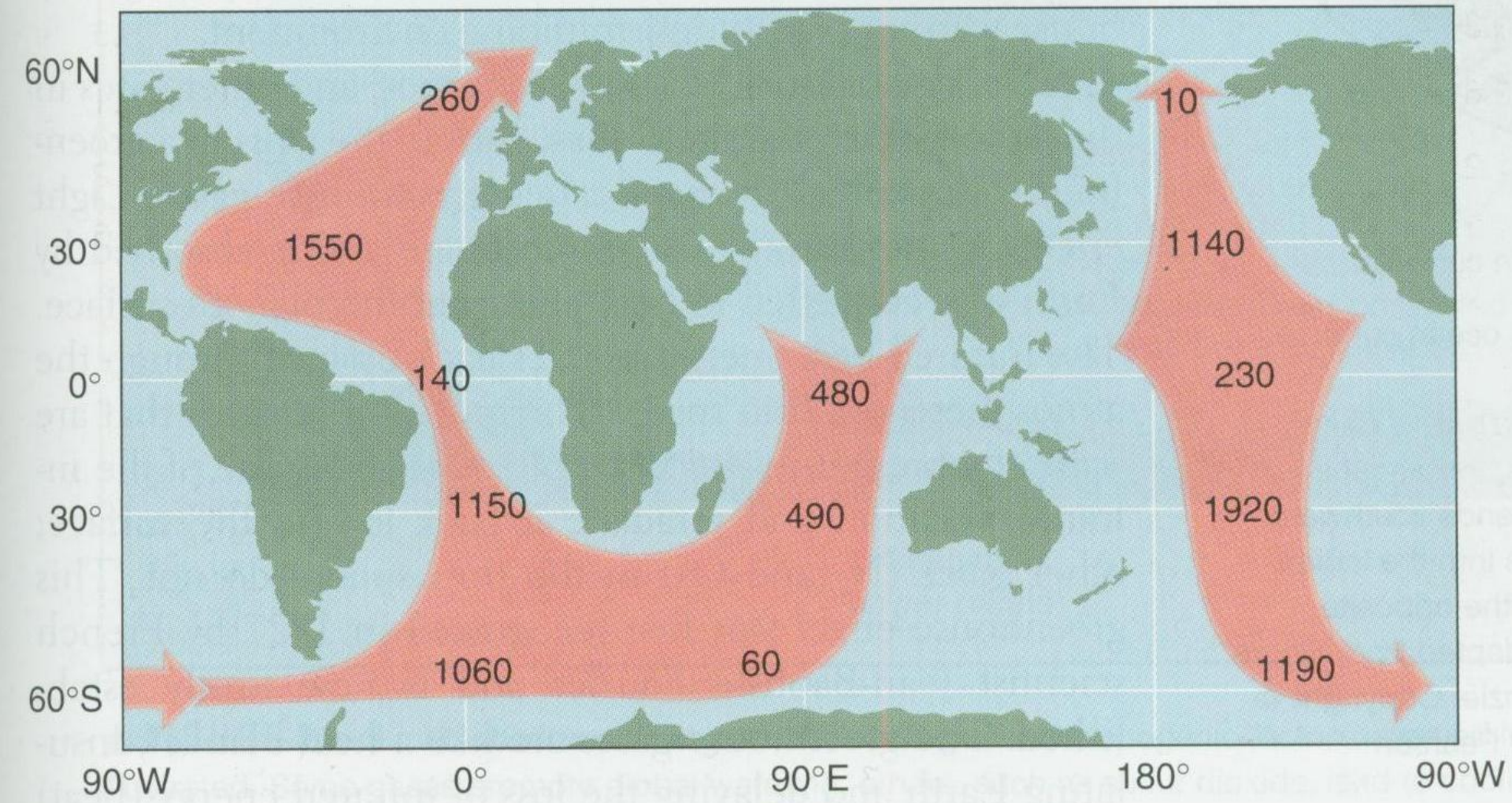
- Oceans annual uptake of CO_2 is ~ 1/3 of anthropogenic emissions;
- Carbon stores in deeper water, dead organisms. Ocean sediments and coral reefs;
- Considerable lag in this uptake, however – too slow to compensate for current rate of CO_2 emission increase;
- Ocean acidity forecast to increase 150% by 2100

Thermocline

- Sharp transition in ocean temperature, between warmer surface waters and cooler waters at depth;
- Typically at 120-240 m depth, but varies dependent on ocean currents and latitude.



http://earthguide.ucsd.edu/virtualmuseum/Glossary_Climate/gencircocean.html



Heat transport by the oceans. These estimates are in units of terrawatts (10^{12}W). Much **more significant energy delivery** to the N. Atlantic vs N. Pacific.

From: Wright and Nebel (2002)

Thermohaline Circulation

"The Great Conveyor Belt"

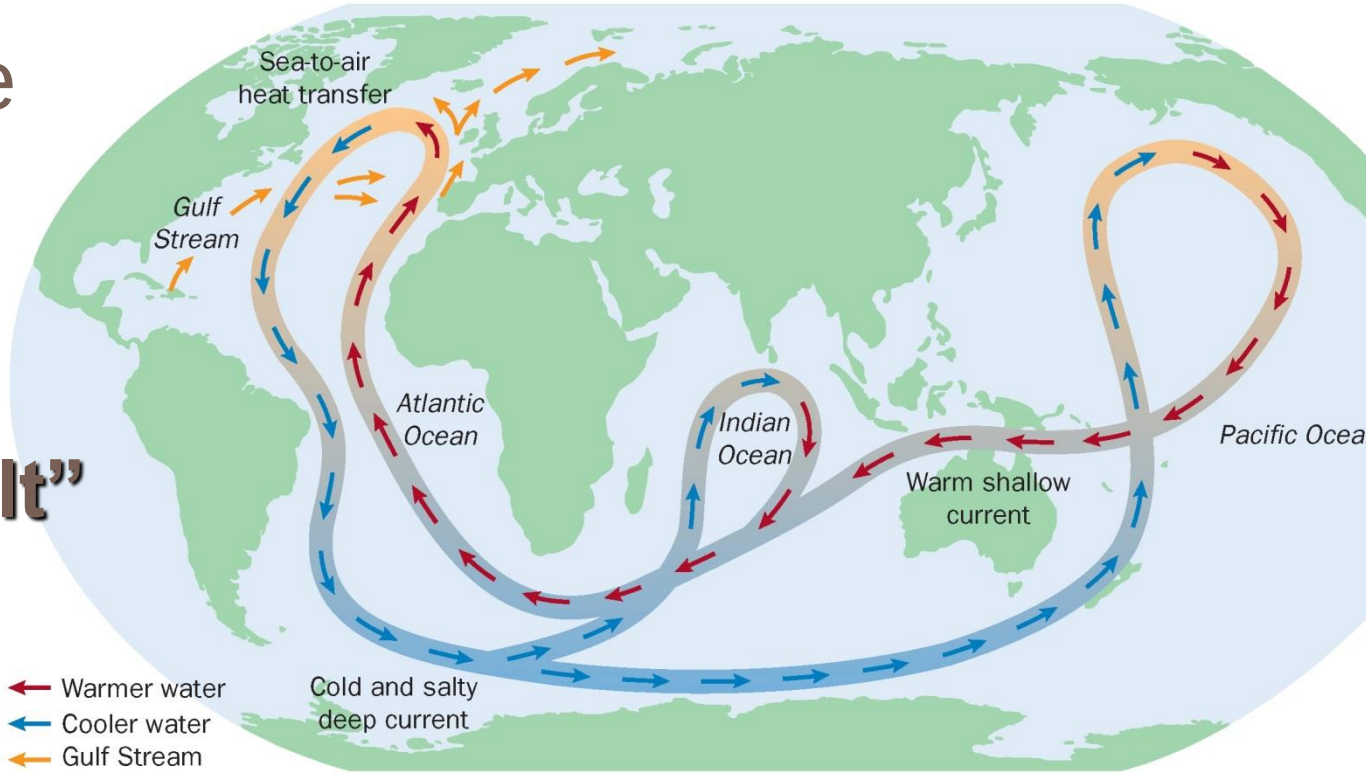
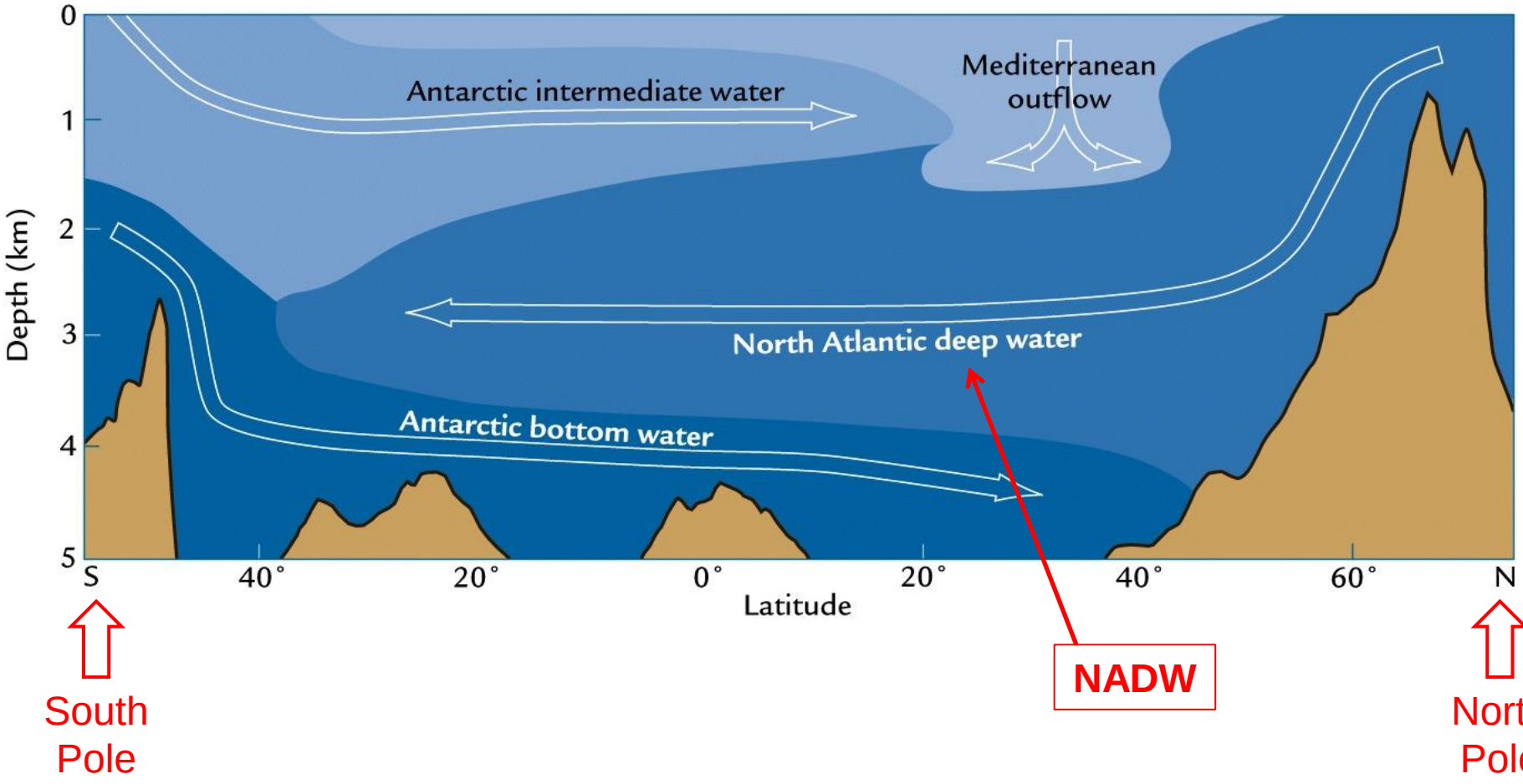


Figure (Figure 8.2) *From: Dearden and Mitchell (2012)*

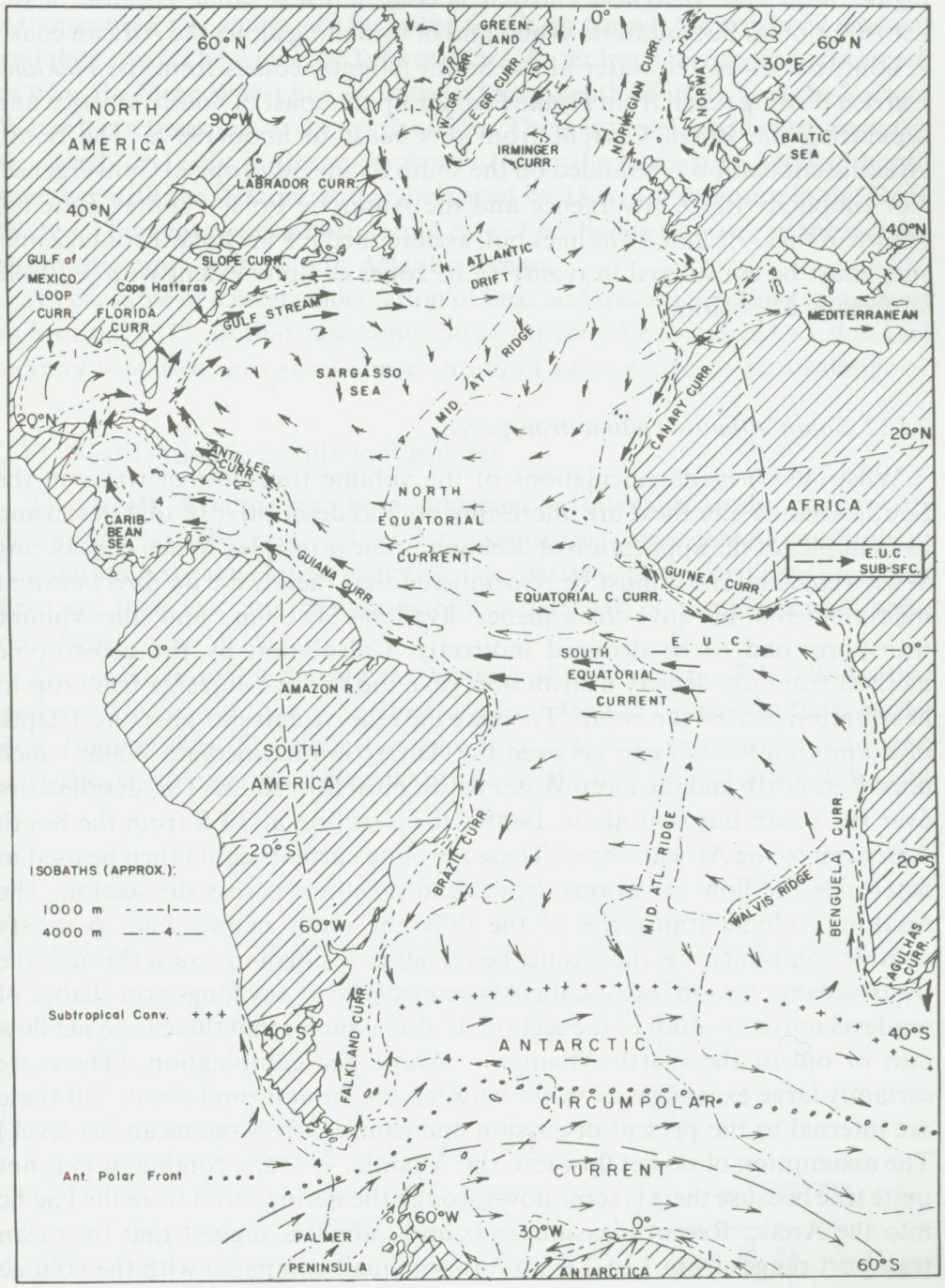
- A global ocean circulation system, to transfer heat poleward; driven by differences in the density of seawater
- Seawater density a function of temperature (*thermo*) and salinity (*haline*)
- Cold sea water sinks at: N. Atlantic, Arctic Ocean, Weddell Sea (in the Antarctic); forming 'deep waters' (water may remain here for 1000's of years)
- Flow of the NADW is equivalent to that of 100 Amazon Rivers (Broecker 1995). (NADW = North Atlantic Deep Water)

Deep Atlantic Circulation



http://www.sonoma.edu/users/f/freidel/global/372lec2images.htm

Energy Transfer – N. Atlantic



- Gulf Stream – N. Atlantic Drift – Norwegian Current
- Moderates climate of Western Europe
- Contrast to N. Pacific Ocean

Figure 7.4: Atlantic Ocean – bathymetry and surface circulation

From: Pickard and Emery (1982)

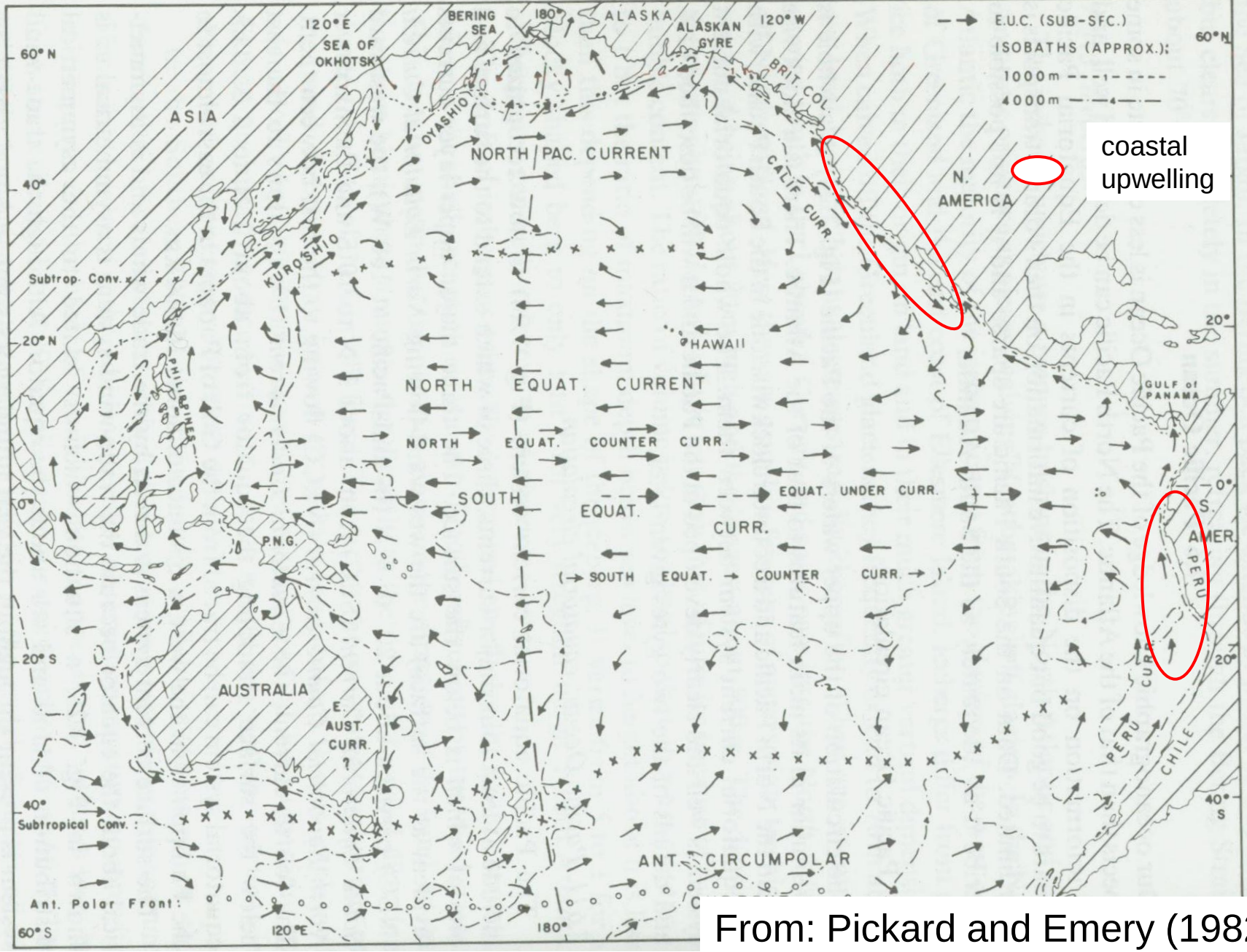
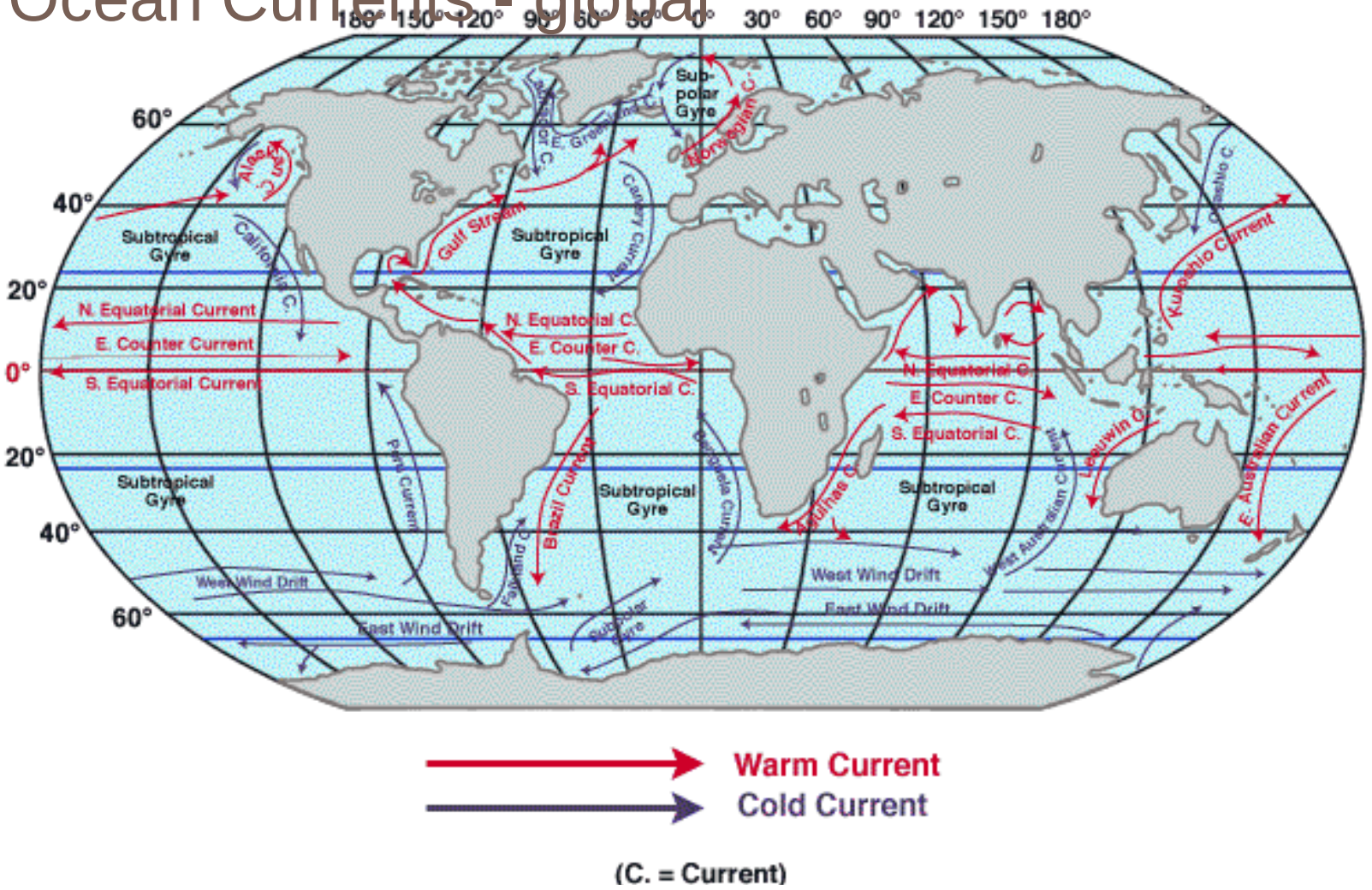


FIG. 7.24. *Pacific Ocean—surface circulation.*

From: Pickard and Emery (1982)

Figure 7.24: **Pacific Ocean** – surface circulation

Ocean Currents - global



- Currents of note to Canadian context: Alaskan current; Gulf Stream; Kuroshio – North Pacific Drift; Labrador current

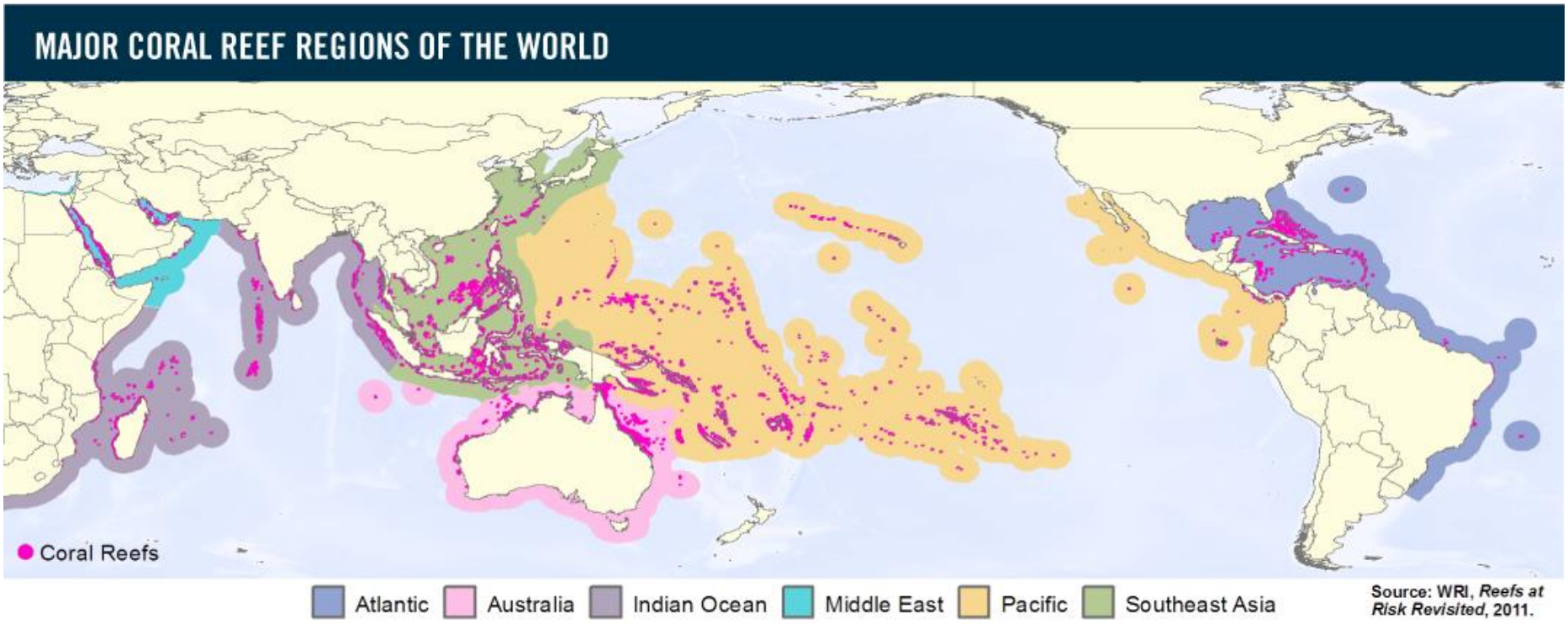
http://www.bigelow.org/shipmates/nc_currents_lg.gif

Coral Reefs

Coral Reefs

- found throughout tropics & sub-tropics
- a diverse and ancient ecosystem (having first appeared ~ 225 million years ago)
- can take centuries to accumulate – through the deposition of calcium carbonate skeletons
- types of:

1. fringing reefs (found along continental margins and offshore islands)
2. barrier reefs (those separated from the land by lagoons)
3. atolls (distinct coral islands, developed around now submerged lagoon areas) (e.g., Maldives)



http://sites.duke.edu/biology217_01_s2011_pv24/files/2011/04/regional-map.png

Threats to Coral Reefs

1. **coral bleaching** – caused when water temperatures are too warm; 3 deg C warming by 2100 in shallow waters may result in annual or biannual bleaching, causing severe damage and widespread death of coral polyps; (i.e., climate change effects)
2. **ocean acidification** – increased acidity (carbonic acid) caused by increasing atmospheric CO_2 concentrations;
3. destructive fishing practices
4. coastal erosion
5. marine pollution
6. irresponsible tourism activities

- rates of destruction of coral reefs now exceed 2% per year – nearly 5 times the rate of rain forest elimination (Bruno and Selig, 2007)

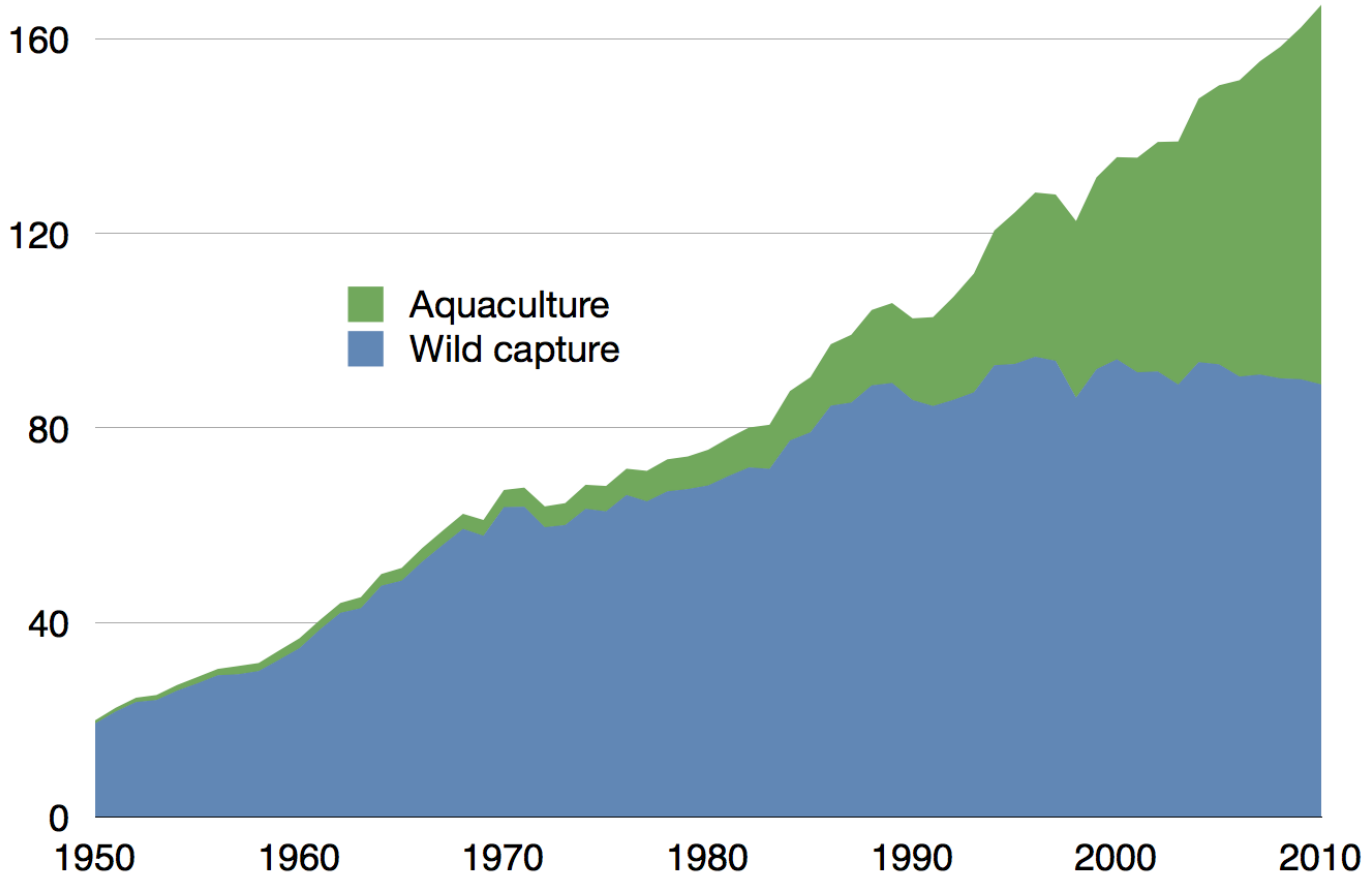
Segway to Thursday lecture

Major fishing areas of the world

Leading fishing producers & consumers

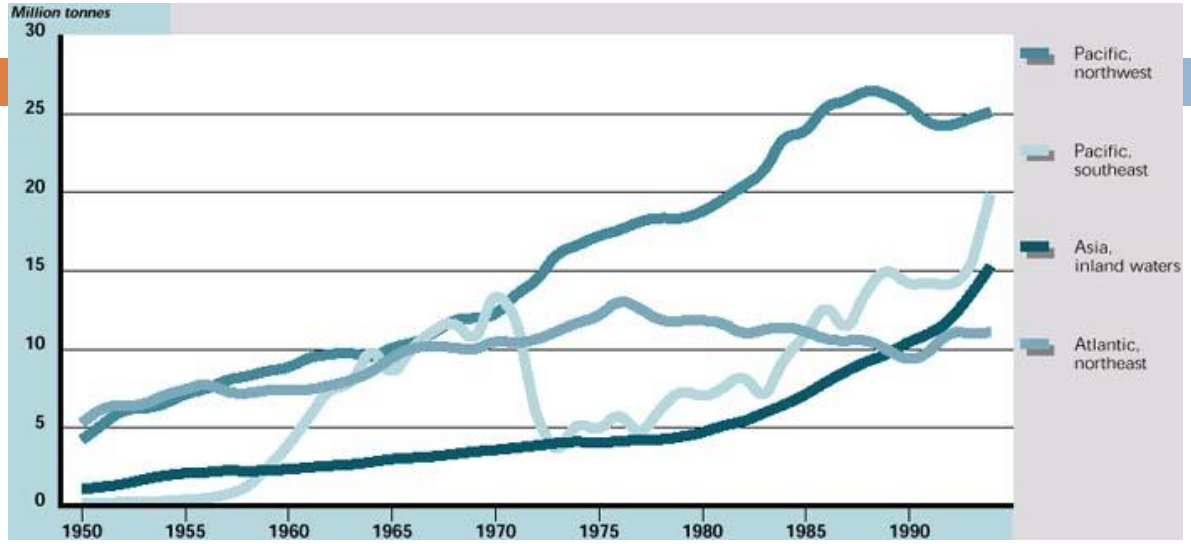
Fisheries collapse (Case Study: NFLD)

Increasing amounts of farmed fish / aquaculture …



World fisheries harvest, wild capture versus aquaculture production, in million tonnes 1950–2010 Source: FAO (2012)

Production for principal major fishing areas

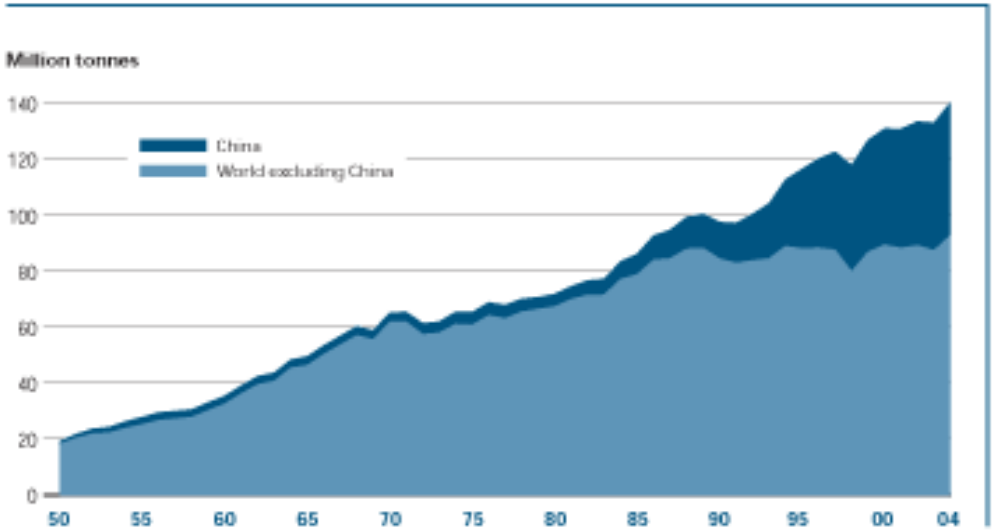


FAO : Food and Agricultural Organization of the United Nations.

http://www.fao.org/docrep/003/w3265e/w3265e02.htm

Figure 1

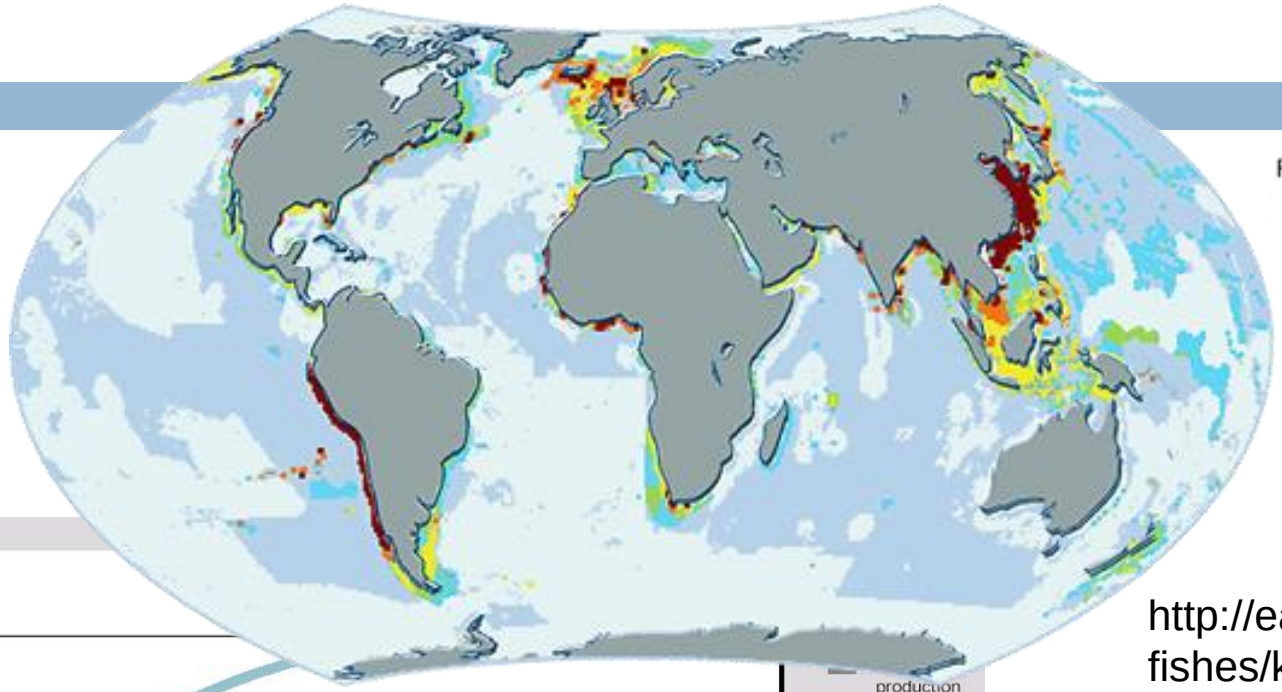
World capture and aquaculture production

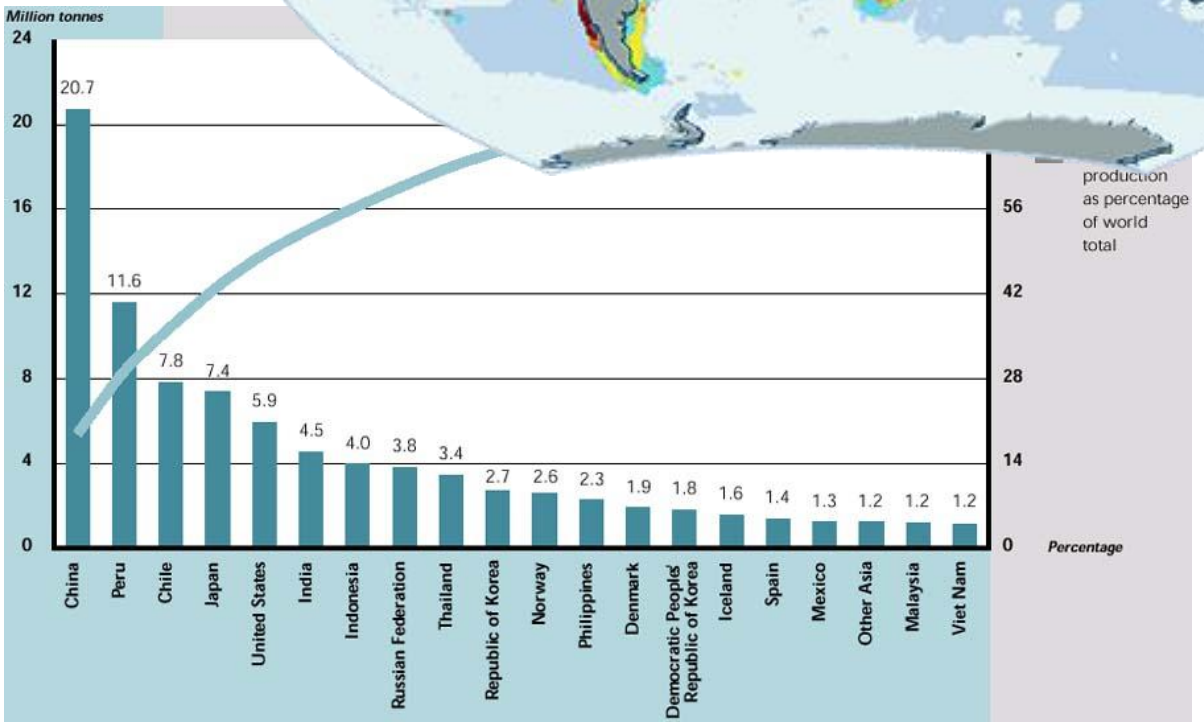


Because of the importance of China and the uncertainty about its production statistics, as in previous issues of this report, China is generally discussed separately from the rest of the world.

http://www.fao.org/docrep/009/a0699e/A0699E04.htm

Production for principal major fishing areas





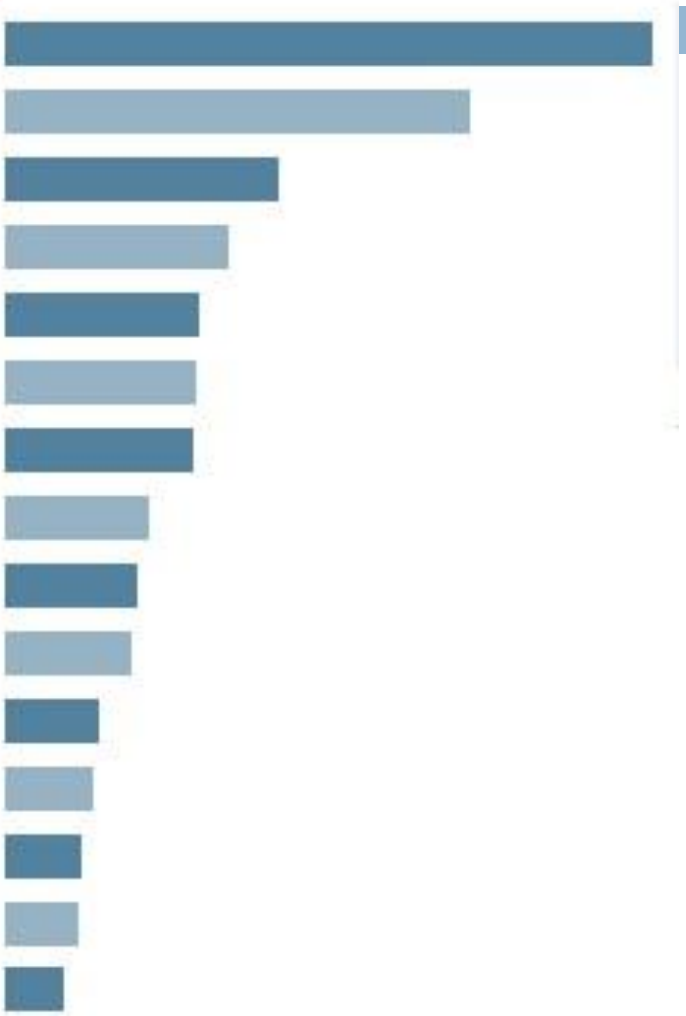
http://earthguide.ucsd.edu/fishes/kinds/images/fisheries_world_2.png

FAO : Food and Agricultural Organization of the United Nations.

http://www.fao.org/docrep/003/w3265e/w3265e02.htm

Marine Fish Catch (by country, top 10)

Rank	Countries	Amount
# 1	China:	11,500,600 tons
# 2	Peru:	8,257,120 tons
# 3	Chile:	4,886,810 tons
# 4	Japan:	3,961,330 tons
# 5	Russia:	3,467,190 tons
# 6	Indonesia:	3,414,900 tons
# 7	United States:	3,329,230 tons
# 8	Norway:	2,551,180 tons
# 9	Thailand:	2,340,430 tons
# 10	India:	2,242,890 tons
# 11	Iceland:	1,678,890 tons
# 12	Philippines:	1,592,090 tons
# 13	Korea, South:	1,372,770 tons
# 14	Denmark:	1,293,370 tons
# 15	Malaysia:	1,057,190 tons



http://www.nationmaster.com/graph/env_mar_fis_cat-environment-marine-fish-catch

Canada's Oceans

(Figure 8.10) *From: Dearden and Mitchell (2012)*

Figure 8.10 | Canada's coastline and continental shelf.

- Canada has the longest coastline of any country and the second largest continental shelf
- The federal government largely holds jurisdiction for the marine environment below the high-water mark
- The lead agency is the Department of Fisheries and Oceans (DFO)

References

- Costanza *et al.* 1997. The value of the world's ecosystem services and natural capital, *Nature*, 387: 253-260.
- Dearden, P and Mitchell, B. 2012. *Environmental Change and Challenge*, Fourth Edition, Don Mills, Ontario: Oxford University Press {chapter 8}
- Wright, R.T. and Nebel, B.J., 2002. *Environmental Science: Toward A Sustainable Future* (8th Edition)