
Why don't lobsters share?

And also, some technical inquiries into and info about oceanography.

— **NC Science Olympiad Coaches Clinic** —

Dynamic Planet/Oceanography (B & C)

Saturday, October 5, 2019

Breaking the Ice

Q: Why don't lobsters share?

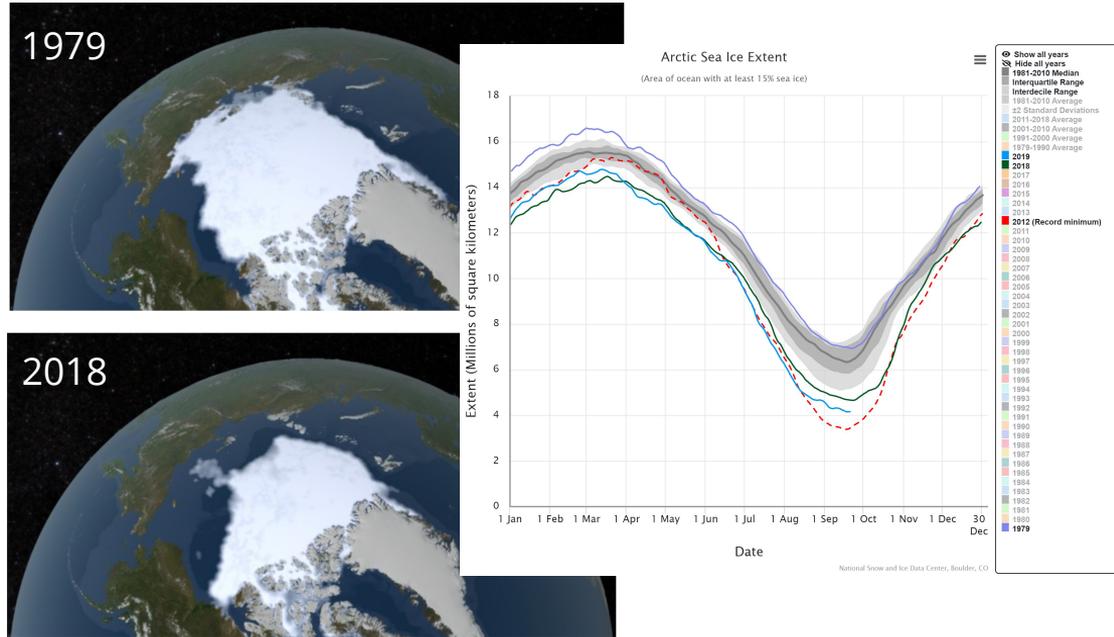
A: Because they are shellfish.

These puns are krakken me up!



<https://oceanservice.noaa.gov/gallery/image.php?siteName=nosimages&cat=Spiny%20Lobster>

Q: How does melting sea ice affect seawater density and ocean circulation?



Agenda - 1 hr session

Introductions **(2 min)**

2020 Dynamic Planet Event Structure and Rules Overview **(5 min)**

2020 Dynamic Planet/Oceanography Topics: Some Basic Concepts **(15 min)**

Practice!

- Density demo **(10 min)**
- Mapping the seafloor **(15 min)**

Study resources and how to find more info **(2 min)**

Close **(1 min)**

Note: Most of this presentation benefits both Div B and C coaches and students. A small portion of this presentation focuses on topics for Div C only.

B,C

Look for Div letters in upper right of each slide.

Introductions

Who am I?

Once an earth science and outdoors nerd...
always an earth science and outdoors nerd



Who are you?

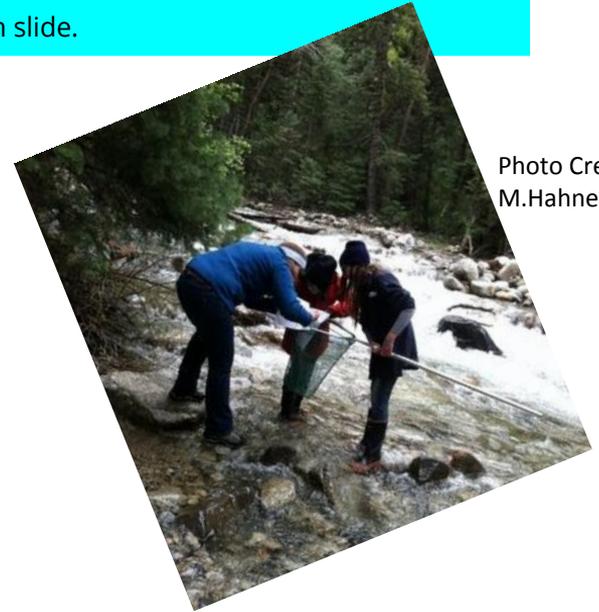
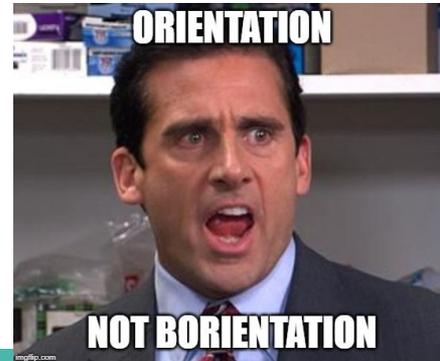


Photo Credit:
M.Hahnenberger

Please please please:

- ask questions
- throw ideas out there
- let's make this session not-a-boring-lecture!



2020 Event Structure and Rules Overview

Preparation BEFORE Competition Day

- Dynamic Planet = a study event
 - most costly thing for this event is time - start early, study often
- Study and **KNOW** the rules!
 - number of students on a team = 1 or 2
 - 3-ring binder



- size restriction - interior diameter of rings must be **less than or equal to 2 inches**
 - any info, from any source, as long as size requirement is met
 - sheet protectors, lamination, tabs, labels are permitted
 - * if rotating stations, no material may be removed from the binder during the event *
- calculators - a team may have **two** - *calculators on computers/mobile devices NOT allowed*
- stand-alone, any kind - see calc. guide in rules manual



2020 Event Structure and Rules Overview

Competition Day!

- possible event format(s) - NC has used both in the past:
 - **sit-down-and-take-a-test**
 - Pro: flexibility - students work through the test mostly however they want
 - Con: flexibility - students work through the test mostly however they want (*and can get stuck*)
 - **rotating stations**
 - Pro: students are usually made to visit more topics, less chance they get stuck in one area of test
 - Con: shuffling can be disorienting and disruptive
- what to bring:
 - writing utensils!!!!
 - calculator(s) - OPTIONAL
 - binder - OPTIONAL
- Remember the rules!
 - Make sure:
 - binder complies
 - calculators comply
- Turn phones off or to silent when event starts

2020 Dynamic Planet Event Topics: Basic Concepts

Condensed overview of selected (not all) topics from 2020 rules follows.

- Many graphics and materials are borrowed from the National Oceanic and Atmospheric Administration (NOAA) and its offices:
 - **National Ocean Service (NOS)** - <https://oceanservice.noaa.gov/education/>
 - **NOAA Office of Education**, which built a resource collection for 2020 Dynamic Planet - <https://www.noaa.gov/education/resource-collections/special-topics-education-resources/2020-science-olympiad-physical-and>
 - Everything from NOAA (and other agencies too!) is awesome!
 - Some topics might be overwhelming at first, but



KEEP CALM
BECAUSE
EVERYTHING
IS AWESOME

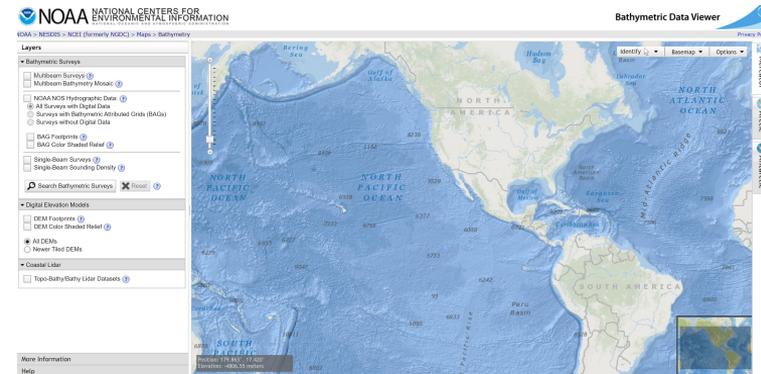
(AND WE HAVE RESOURCES TO
HELP YOU AND YOUR STUDENTS).

Not explicitly in the rules, but always important!

Practice basic geography, especially in coastal and oceanic areas!



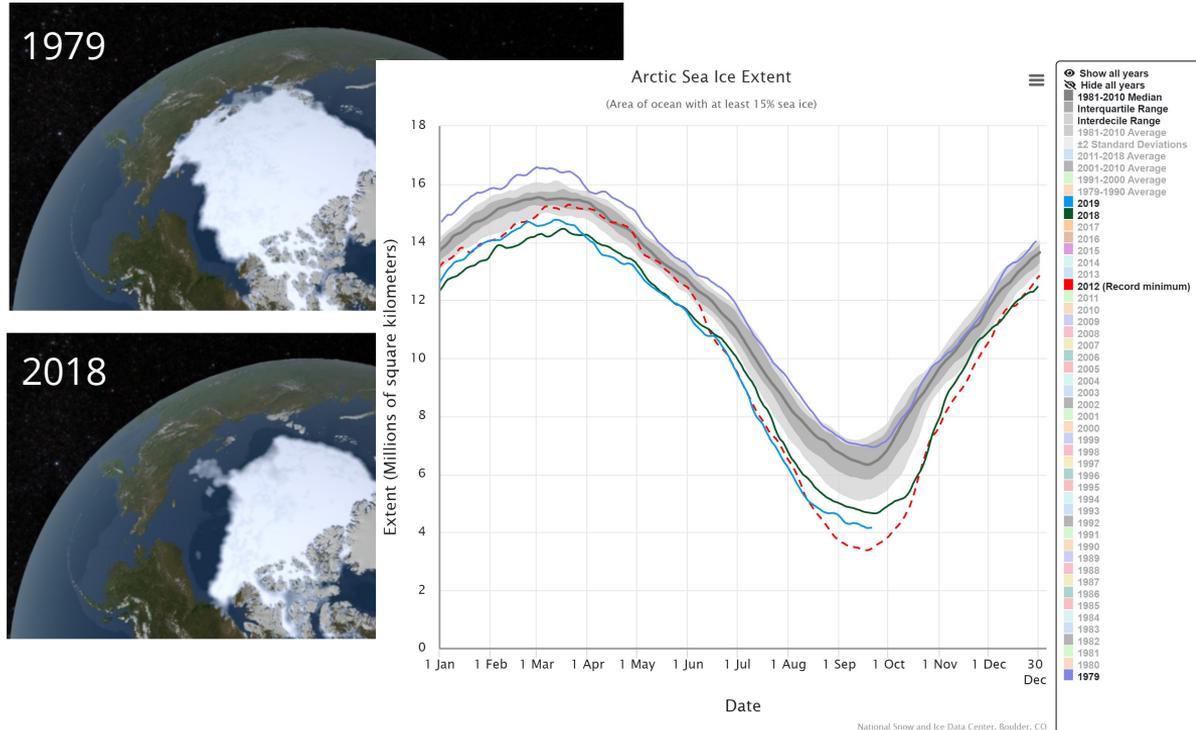
- U.S. states and territories
- local geography - names of counties (or boroughs or parishes) in your state
- What the underwater terrain like in coastal and oceanic areas?
 - Simple and free ways to explore bathymetry and underwater features:
 - NOAA Bathymetric Data Viewer - <https://maps.ngdc.noaa.gov/viewers/bathymetry/>, uncheck all boxes in legend at left for simplest viewing of map
 - maps.google.com, turn on "Satellite" or "Terrain" background - or <https://earth.google.com/web/>



Not explicitly in the rules, but always important!

Practice reading and interpreting graphs, maps, charts, and images.

- Do the images show the North (Arctic) or South (Antarctic) polar region?
- How is sea ice extent different between 1979 and 2018, according to the images/maps?
- What are the units on the x-axis of the graph? Y-axis?
- How does the graph of sea ice extent change with respect to units on the axes?
- Is there a maximum or minimum on the graph? If so, what might they mean?



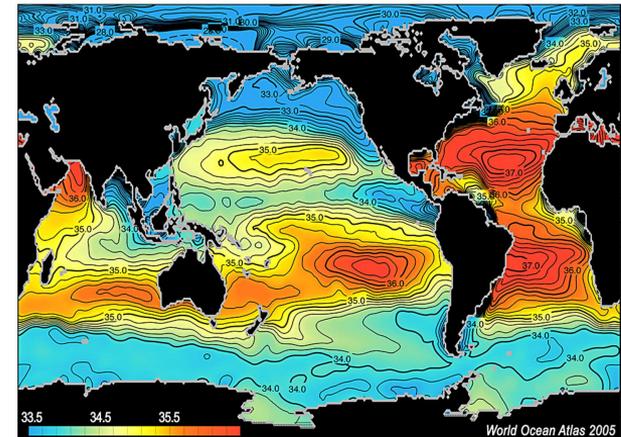
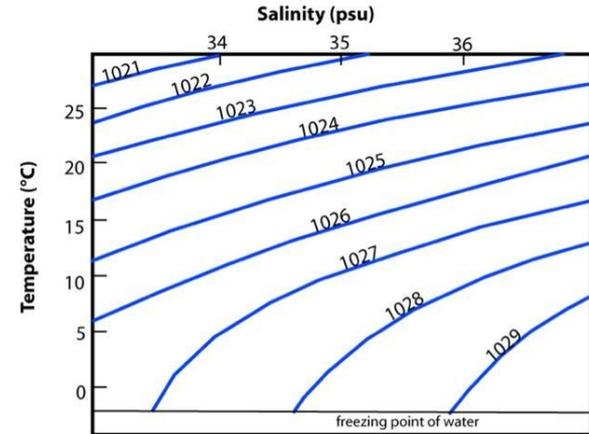
3.b.i. Seawater

Composition - what elements and molecules are present?

Density - what determines the density of water? Is seawater more or less dense than freshwater?

Variations in salinity - where is the ocean saltiest? Why? Are salinity patterns constant through the year?

Where do ocean salts come from?



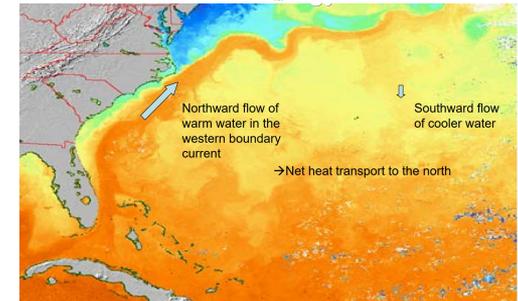
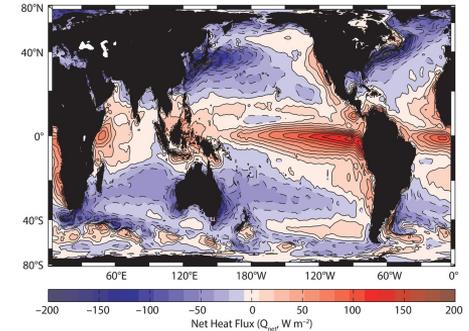
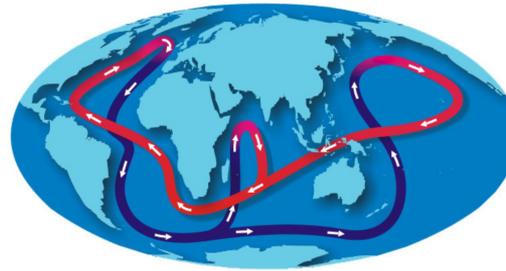
3.b.ii. Energy Balance, Heat Transport

SW, LW Radiation - what comes in from the Sun? What goes out from Earth?

Heat fluxes - latent, sensible

Geothermal heat - very small contribution

Heat transport - net heat transport is toward poles, depends on currents



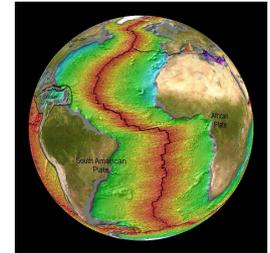
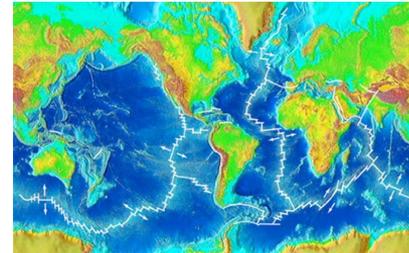
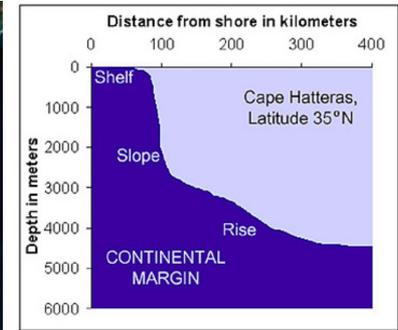
3.b.iv. Topographic features

Estuary - where water masses of different characteristics meet and mix

Continental margin - shelf, slope, rise

Mid-ocean ridge - underwater mountains, located at certain type of plate boundaries, geologically-young rocks

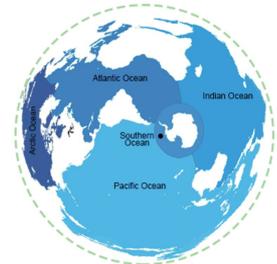
Ocean basins - continental margin + ridges + trenches + abyssal plains + other features



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OCEAN BASINS

Arctic, Atlantic, Indian, Pacific, Southern
(modern-day ocean names and boundaries)



3.b.viii. Waves

Characteristics - wavelength, height, period, frequency, travel speed

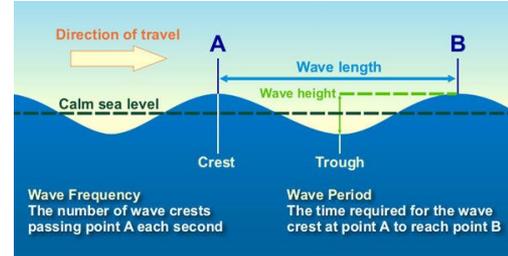
- longer waves travel faster
- dependent on wind speed and duration, as well as fetch

Fetch - uninterrupted distance over which the wind blows without significant change in direction

Swell - waves produced by a storm that also outrun the storm. As they outrun the storm, they:

- lengthen and their height decreases
- organize into groups
- travel thousands of miles unchanged in height and period
- as they near the coast, they interact with the sea bottom
- height increases, the wave becomes unstable, and it breaks against the shore as

Surf



3.b.viii. Waves

Tsunami

- giant waves caused by earthquakes or volcanic eruptions under the sea or other large displacement of seawater
- Travel speed of tsunami waves depends on ocean depth (d) and gravity (g)
 - Tsunami waves may travel as fast as jet planes over deep waters, only slowing down when reaching shallow waters.
 - wave speed equation aids forecasters and emergency managers in predicting when tsunami waves might reach coasts
- In deep water, tsunami waves do not dramatically increase in height.
- As the waves travel towards coastal areas, they build up to higher and higher heights as the depth of the ocean decreases.
- Note: tsunami waves actually have little to do with tides; the name “tidal wave” is misleading and incorrect. “Tsunami” is the proper term.

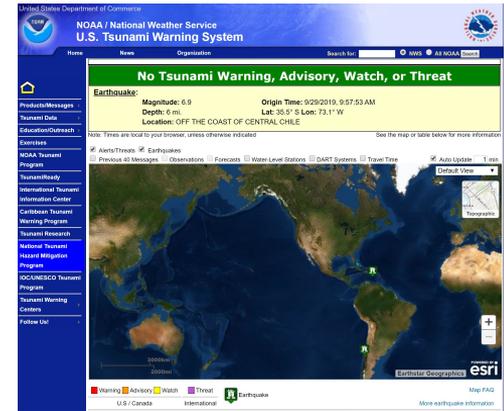
Wave Speed Formula

$$\text{speed} = \sqrt{g \times d}$$



More tsunami info:

Alerts at NOAA's tsunami.gov



National Oceanic and Atmospheric Administration
U.S. Department of Commerce

<https://www.noaa.gov/education/resources/connections/ocean-coasts-education-resources/tsunamis>

NOAA Tsunami Program

<https://tsunami.noaa.gov/pmel-theme/about-tsunami-program>

3.b.ix. Surface Currents

Surface currents - driven by wind

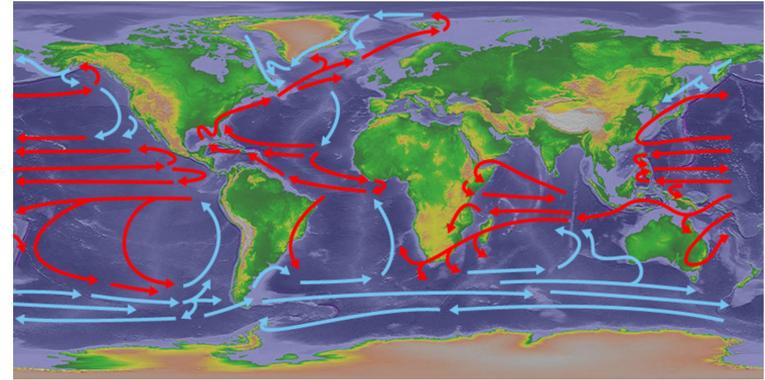
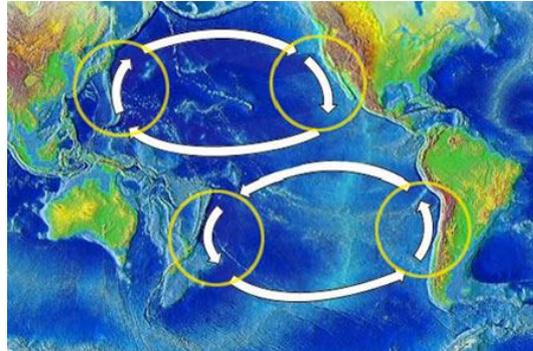
Warm - transport warm water towards poles

Cold - transport cold water towards equator

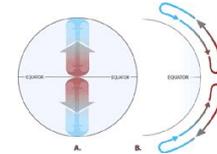
Coriolis effect - deflection of flow due to Earth's rotation - to the right in NH, left in SH

Gyres

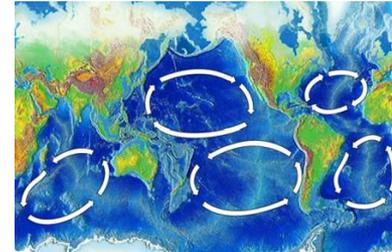
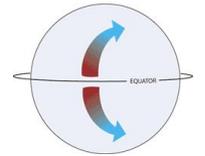
- related to Coriolis effect
- strong and narrow "western boundary current", weak and broad "eastern boundary current"
- 5 major ocean-wide gyres



No rotation of Earth



WITH rotation



3.b.x. Ekman and geostrophic balances (Div C only)

Oceanography 101, Richard Strickland

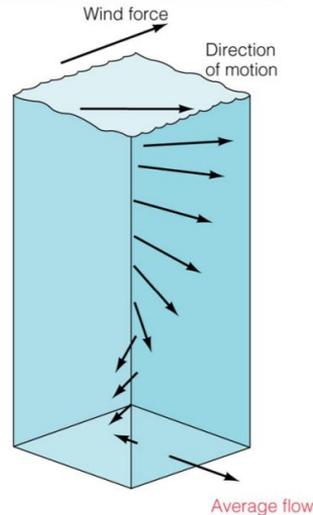
Lecture 14

© 2006 University of Washington

Ekman \neq Geostrophic



- Ekman transport is a short-term phenomenon
 - Coriolis & friction
 - Upper water layer responds to change in wind speed and/or direction
 - Takes a few hours to a few days
 - Transient, not equilibrium



The average direction of all this turning water is ~ 90 degrees (right angle) from the wind direction. This average is Ekman transport.

Oceanography 101, Richard Strickland

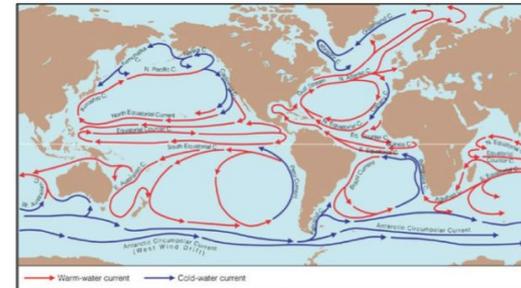
Lecture 14

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Ekman \neq Geostrophic



- Geostrophic current is a long-term pattern
 - Integrates conditions over months to years
 - Equilibrium between Coriolis & pressure
 - Slow to change with wind fluctuations
 - Local variations occur with storms, etc.



2

3.b.x. Ekman and geostrophic balances (Div C only)

Oceanography 101, Richard Strickland

Lecture 14

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Ekman → Geostrophic



- Consider an ocean with no motion
 - Turn on the wind
 - Within hours-days, the Ekman Spiral develops
- Ekman is the agent of its own demise
 - Ekman transport pushes water 90° to the wind
 - Builds a hill of sea water to one side
 - Right north, left south
 - The hill slope creates pressure (gradient) force
 - Counteracts Coriolis & Ekman
 - Current turns to parallel the wind
 - Geostrophic flow

3

Oceanography 101, Richard Strickland

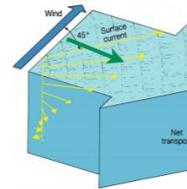
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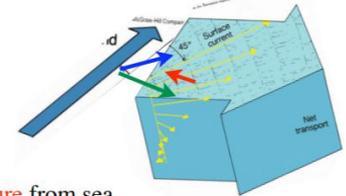
Ekman → Geostrophic



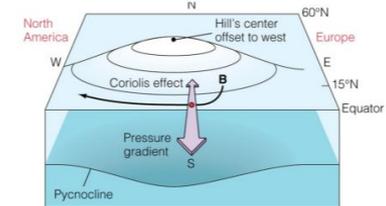
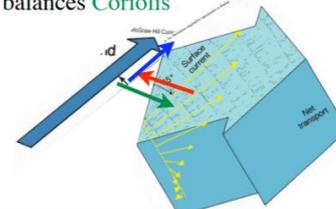
Step 1: Wind on a calm ocean produces Coriolis effect & Ekman transport



Step 2: Current turns as Ekman transport builds a sea water hill & pressure



Step 3: Geostrophic current parallels wind as pressure from sea water hill balances Coriolis

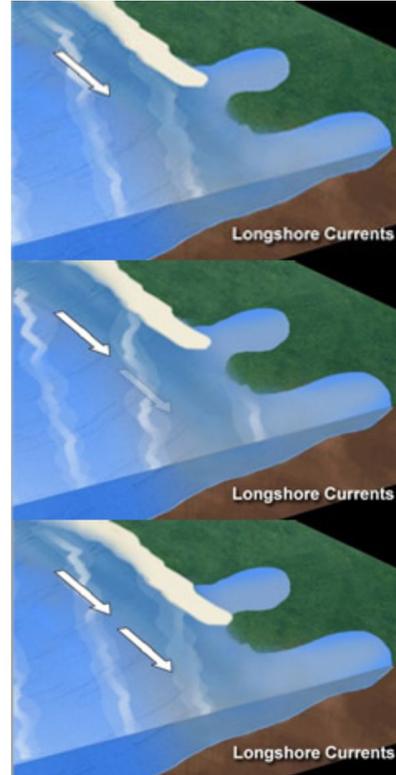


4

3.b.xi. Coastal Currents

Longshore

- Waves approach shore and tend to bend and conform to the general shape of the coastline.
- Waves do not typically reach the beach perfectly parallel to the shoreline. Instead, they arrive at a slight angle, called the “angle of wave approach.”
- When a wave reaches a beach or coastline, it releases a burst of energy that generates a current, which runs parallel to the shoreline. (longshore current)
- Longshore currents can cause significant beach erosion.

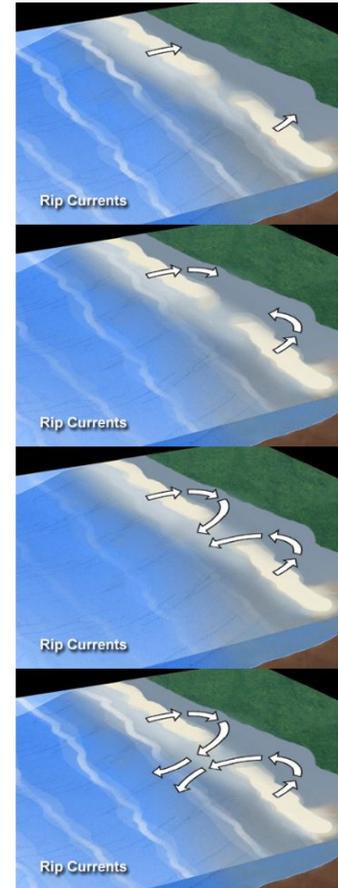


In 1927, the lighthouse on Tucker's Island, NJ was destroyed when powerful longshore currents washed over 300 yards of the surrounding land out to sea.

3.b.xi. Coastal Currents

Rip

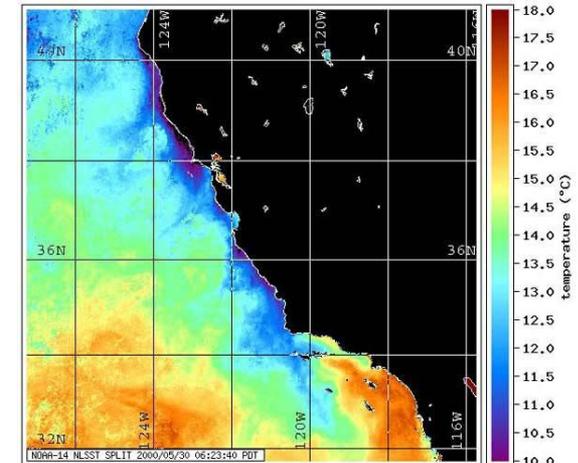
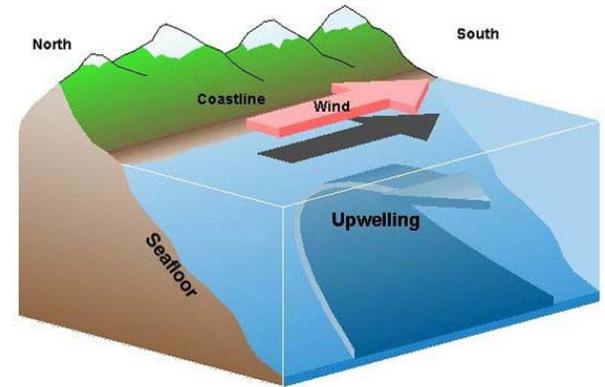
- As longshore currents move on and off the beach, “rip currents” may form
 - around low spots or breaks in sandbars
 - near structures such as jetties and piers
- sometimes incorrectly called a rip tide
- localized current that flows away from the shoreline toward the ocean, perpendicular or at an acute angle to the shoreline
- usually breaks up not far from shore and is generally not more than 25 meters (80 feet) wide
- Because rip currents move perpendicular to shore and can be very strong, beach swimmers need to be careful. A person caught in a rip can be swept away from shore very quickly.



3.b.xi. Coastal Currents

Upwelling

- Along a coastline oriented North-South, like much of the west coast of the U.S.:
 - winds that blow from the north tend to drive ocean surface currents to the right of the wind direction, thus pushing surface waters offshore.
 - As surface waters are pushed offshore, water is drawn from below to replace them.
 - The upward movement of this deep, colder water is called **upwelling**.
- Upwelling brings cold nutrient-rich waters from the ocean bottom to the surface, supporting many of the most important fisheries and ecosystems in the world.



3.b.xii. Deep ocean circulation

Circulation and ocean overturning

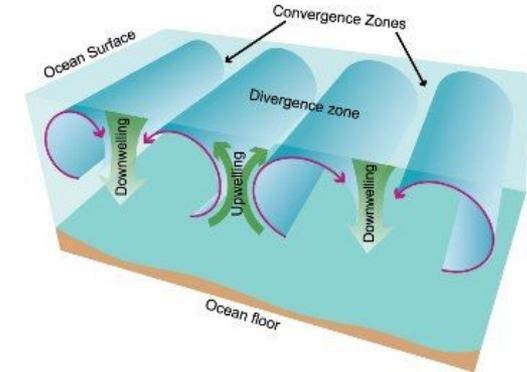
- Depends on differences in water density, which depends on water temperature (thermo) and salinity (haline) ⇒ thermohaline circulation
- In cold regions, such as the North Atlantic Ocean:
 - ocean water loses heat to the atmosphere, becomes cold & dense
 - ocean water freezes, forming sea ice, leaving behind salt, becomes saltier and denser
 - Dense-cold-salty water sinks to the ocean bottom.
- Surface water flows in to replace the sinking water, which in turn becomes cold and salty enough to sink.
- This "starts" the global conveyor belt, a connected system of deep and surface currents (~1000 years to circulate)
- Deep water flows horizontally between continents, eventually flowing back towards equatorial regions, where it rises to the surface, closing the current loop.
- In general, sinking of dense water and replacement by surface water is called ocean overturning.



3.b.xii. Deep ocean circulation

Water masses

- Deep ocean is generally considered to be the portion below the thermocline.
- Deep water masses are produced at the surface of the ocean and are transported deeper by downwelling.
- Downwelling occurs in high-latitude regions of the northern and southern hemisphere
- 3 major deep ocean masses
 - North Atlantic Deep Water - mainly produced where the surface ocean is cooled in the Norwegian Sea in the northern part of the North Atlantic on the north side of a ridge that runs between Greenland, Iceland, and Scotland
 - Antarctic Bottom Water - produced by evaporative cooling off the coast of Antarctica and under the Ross ice shelf
 - Antarctic Intermediate Water - produced near the Antarctic Convergence or Polar Front where downwelling occurs as a result of the convergence of surface currents



3.b.xiv. Coastal processes

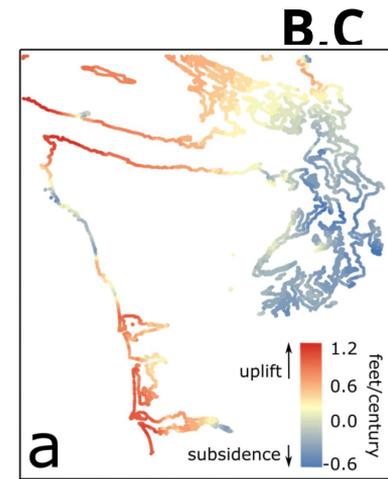
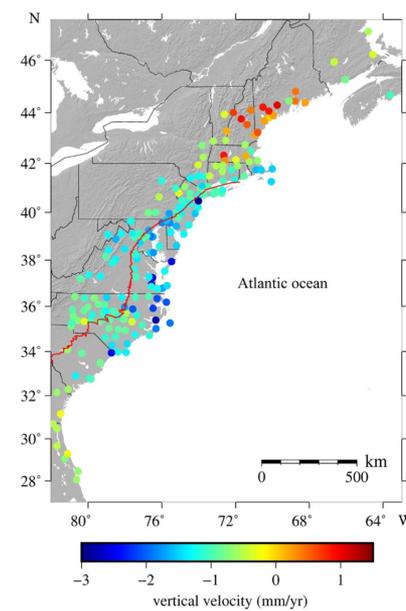
Subsidence - sinking of the ground because of underground material movement

Uplift

- glacial isostatic adjustment
- convergent plate boundaries

Land mass changes + sea level changes
= impacts on coastal areas

- saltwater intrusion
- flooding
- loss or gain of land
- building codes



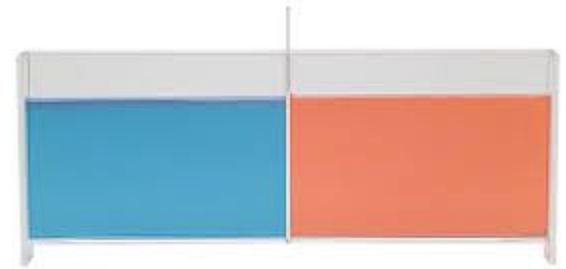
A screenshot of the Digital Coast Coastal Flood Exposure Mapper interface. The interface includes a search bar at the top right, a 'My Map' section, and several layers to toggle. The 'HAZARD LAYERS' section includes Coastal Flood Hazard Composite, High Tide Flooding, FEMA Flood Zones, Tsunami, Storm Surge, and Sea Level Rise. The 'SOCIAL EXPOSURE' section includes Population Density, Poverty, and Density. A 'SAVE MAP' button is at the bottom. The map itself shows a coastal area with various flood hazard overlays.

<https://oceanservice.noaa.gov/subsidence.html>, <https://oceanservice.noaa.gov/facts/glacial-adjustment.html>, <https://www.unavco.org/science/snapshots/ocean/2016/karegar.html>, <https://www.washington.edu/news/2018/07/30/sea-level-rise-report-contains-best-projections-yet-for-washingtons-coasts/>, <https://tidesandcurrents.noaa.gov/est/faq.shtml>, <https://www.nps.gov/articles/coastal-processes-changes-in-sea-level.htm>, <https://www.noaa.gov/explainers/tracking-sea-level-rise-and-fall>, <https://coast.noaa.gov/digitalcoast/>, <https://coast.noaa.gov/digitalcoast/tools/flood-exposure.html>

Practice!

Density Demo

- What are the properties of the water masses (prior to mixing)?
- Which water mass (prior to any mixing) has higher density than the other?
- What happens when divider is removed?
- What happens after a few minutes elapse?



More Practice!

Mapping the seafloor

- Shoeboxes contain underwater topographic (bathymetric) features
- Find out what the features are by using the skewers as hydrographic instruments!



Hands – On Science with NOAA

TITLE: Hydrographic Surveying: Mapping the Sea Floor



Add'l Resources and Finding More Info



scioly.org: discussion forums focused specifically on Dynamic Planet, test archive for practice

<https://www.sciencenc.com/resources/middle-school/dynamic-planet/>

<https://www.sciencenc.com/resources/high-school/dynamic-planet/>



NOAA Office of Education:

<https://www.noaa.gov/education/resource-collections/special-topics-education-resources/2020-science-olympiad-physical-and-geological-oceanography>



Office for Coastal Management
DIGITALCOAST

<https://coast.noaa.gov/digitalcoast/training/home.html>



National Oceanic and Atmospheric Administration
U.S. Department of Commerce

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2020 Science Olympiad: Physical and geological oceanography

Resources for the 2020 Science Olympiad challenge in Dynamic Planet: Physical and geological oceanography

Education

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National Oceanic and Atmospheric Administration
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NOS Education

Building **ocean, coastal, and climate** literacy for students and educators.

<https://oceanservice.noaa.gov/education/>



Close

Thank you!

Grab a NOAA sticker because science is cool!

One last question!

Q: What is the pirate's favorite letter of the alphabet?

A: Not R! The pirate is actually quite fond of the C!

