* MOTION OF THE OCEAN: LOCAL (and back to global)

Lecture 3 – Sept 21, 2015

Intro to Marine Science

Instructor: Lauren Bell

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* Changes to syllabus

I’ve changed up the order of topic areas for the semester
The syllabus on Blackboard has been revised – please take note

September 28th	**BIOLOGY OF MARINE SPECIES**	
	Organisms: plants & plankton	
		microbes
		macroalgae
		phytoplankton and zoops - biology, differences at latitude, ideal environments
October 5th	Organisms: macrofauna part 1	
		major taxonomic divisions
		basic biology - body plans and ecological niches
October 12th	Organisms: macrofauna part 2	
		major taxonomic divisions
		basic biology - body plans and ecological niches
October 19th	MIDTERM (any time this week, Oct 19-23rd)	
	MARINE ECOLOGY	
	Ecosystems	
		tidal: mangroves, salt marshes, mudflats, rocky intertidal, estuaries
		coastal: shelves, seagrasses, coral reefs
		lesser-seen: pelagic, deep-sea, polar
October 26th	Physiological adaptations	
		all organisims: hydrodynamics, energetics, osmoregulation
		deep sea
		intertidal
		marine mammals

*Changes to syllabus

Themes of global change to be scattered in throughout course, to prepare you for <u>Critical Issue Debate</u>

November 2nd	**MARINE ECOLOGY CONTINUED**
	<u>Critical issue topic and justification due on blackboard</u>
	Community processes
	biodiversity, productivity, biotic interactions
	food webs, energy flow
	population dynamics - disturbance, reproductive strategies
November 9th	**FISHERIES**
	Fisheries management
	overview of population modeling - what do we need to know?
	overview of management process (scientists, users, BoF, etc.)
	ecosystem-based management, cross-borders
	case studies - methods of management
November 16th	Human dimensions
	historical use, fishing as culture
	competing interests, environmental justice
	tragedy of the commons vs. tragedy of open access
November 23rd	**CRITICAL ISSUE CLASS DEBATE**
November 30th	**CHANGING OCEAN**
	Current topics (esp. those not covered in debate)
	Recent research
	The "good news" - next directions for marine science
December 7th	<u>FINAL</u>

May still change.. (November 9th: Fisheries)

* Current events

THE BLOB

AOOS Alaska Ocean Observing System

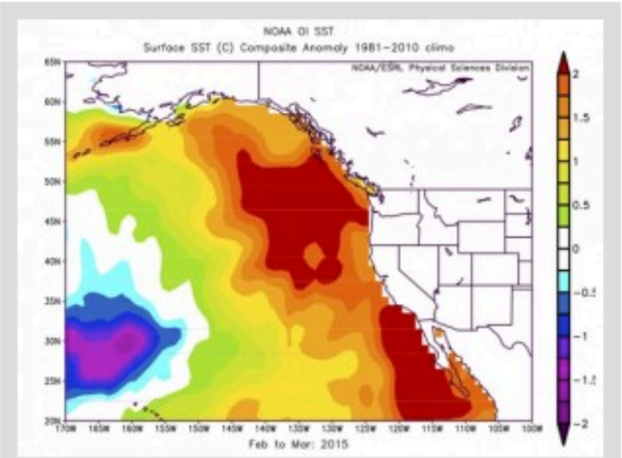
THE EYE ON ALASKA'S COASTS AND OCEANS

The Alaska "Blob" Tracker Launched

Posted on August 7, 2015 by Holly Kent

alaskapacificblob.wordpress.com

The media has recently been filled with a lot of news items about this thing called the "Pacific Blob", a large pool of unusually warm water off the West Coast in the United States and Canada, reaching as far north as the Gulf of Alaska. To help Alaska media and the public keep up with the latest information, the Alaska Ocean Observing System (AOOS) has launched a "Blob" Tracker that features some basic background information and Alaska relevant resource links and current observations. AOOS will maintain the site with contributions from a team of experts and questions addressed on a FAQ page. The purpose of this blog is to provide the public and media with information about this oceanic occurrence and the Blob's realized and potential effects on Alaska's marine resources. To



"It's not the same as **El Niño** which has its origins in the equatorial ocean, and it's not clear if The Blob is related to the **Pacific Decadal Oscillation,** a longer-term cycle of ocean climate variability. The Blob's formation may have been generated by a lingering high pressure system over the Northeast Pacific that diverted winds and passing storm systems. As a result, the ocean surface did not have the chance to cool off as usual." – KTOO Public Media report, 5/20/15

*Learning objectives

After this lesson, you will be able to:

- Describe the basic features of a wave, and understand the different drivers of wave formation
- Describe the impact and importance of tides to marine animals and primary productivity
- Discuss how oceanic features such as the Benthic Boundary Layer, polynyas, and Langmuir streaks impact local biological activity
- Diagram the processes associated with coastal upwelling and downwelling, and link these features to biological productivity
- Recognize the importance of physical oceanography in understanding our changing ocean

*Assignment

- What is your feature?
- How is it formed?
- Where might you find it?

Roy Neese

- What are impacts of your feature on marine plants (i.e., primary productivity) and animals?

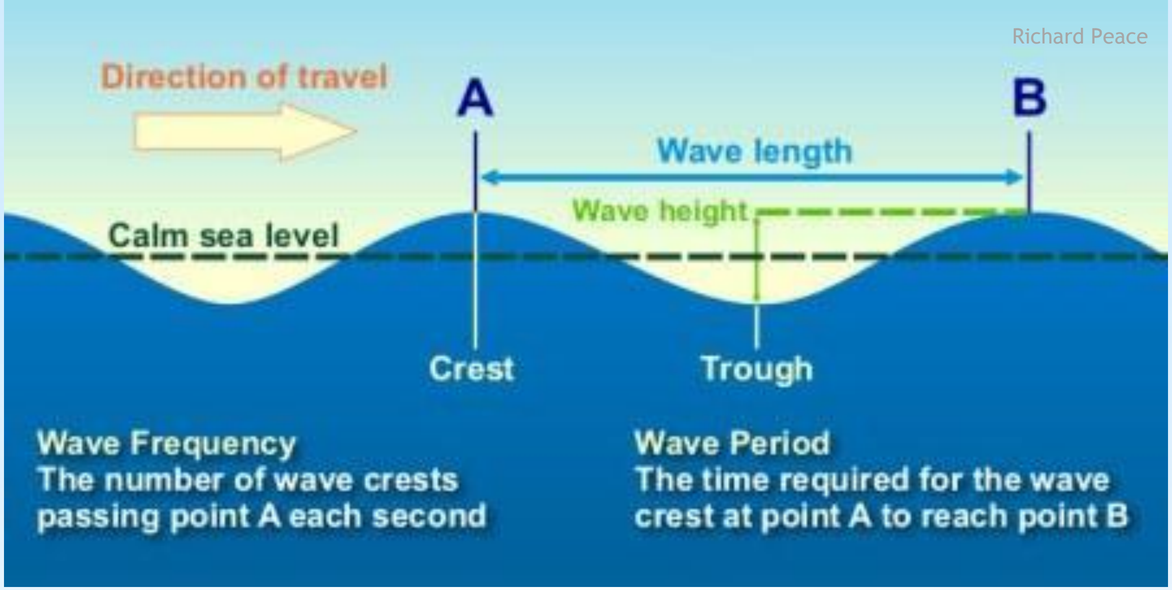
*Waves

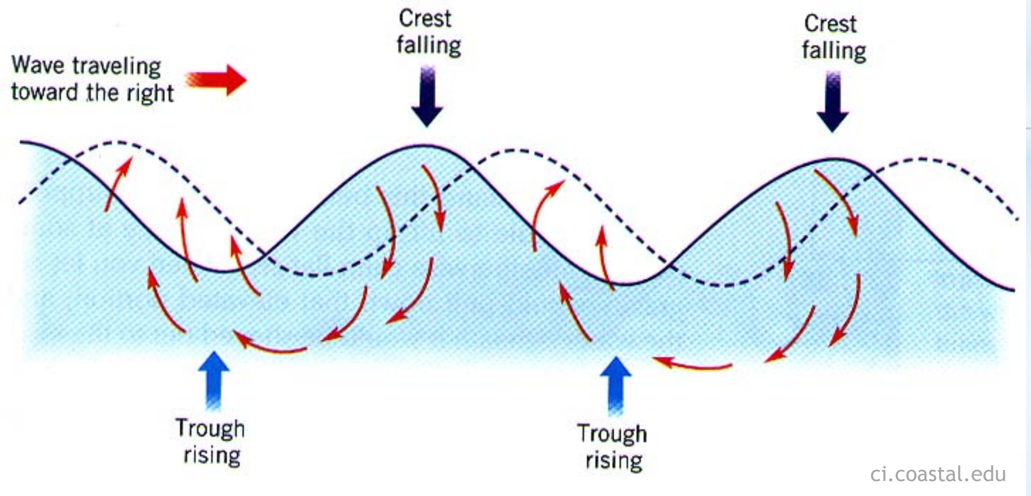
Consider wave motion:

- Disturbance is transferred
  ripples across a pond…
- Material not transferred (far)
  think of a bobbing cork…

If material itself is not being transferred by wave propagation, what is being transported?

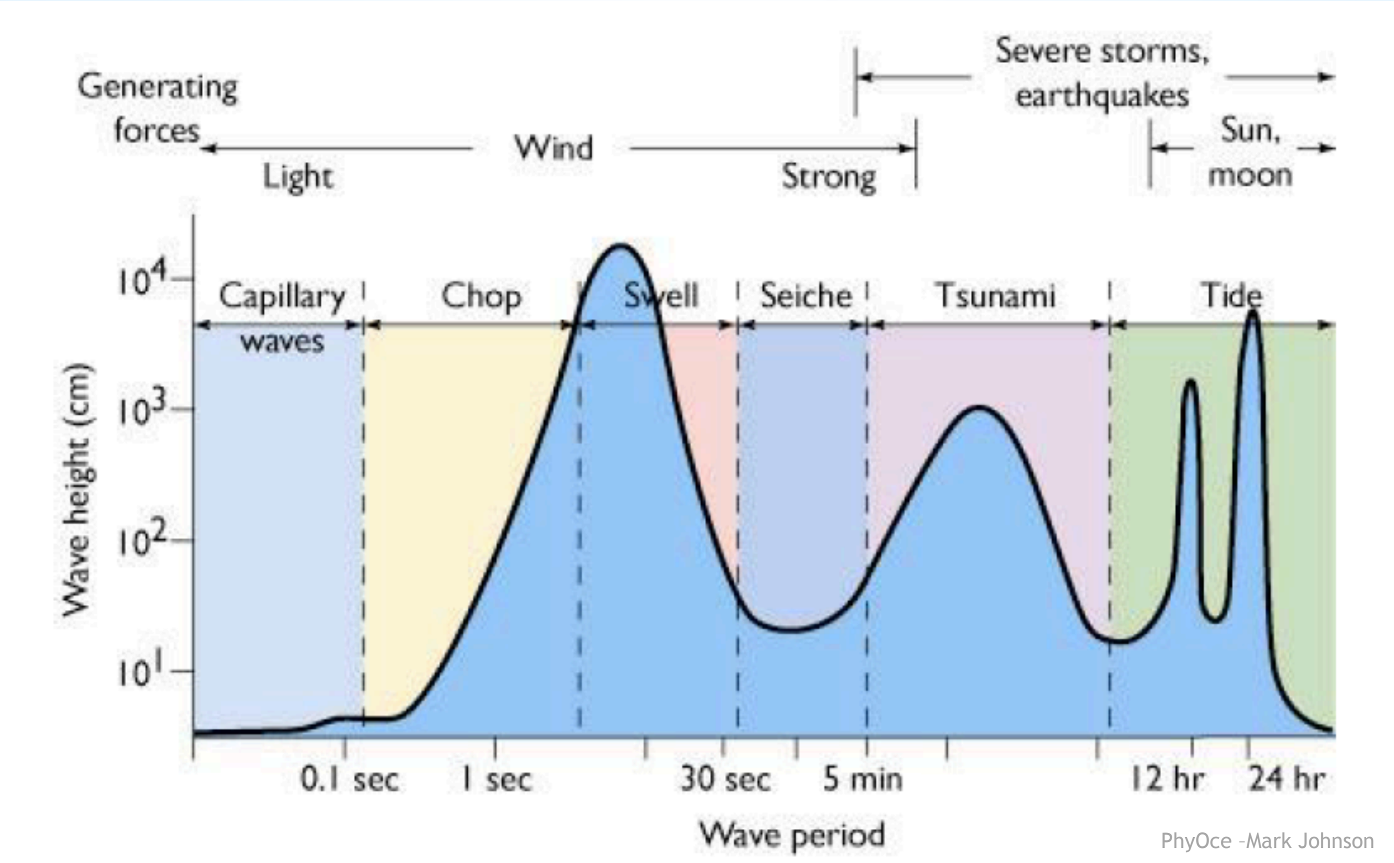
Wave motion: a process whereby energy is transported across or through a material without any significant overall transport of the material itself





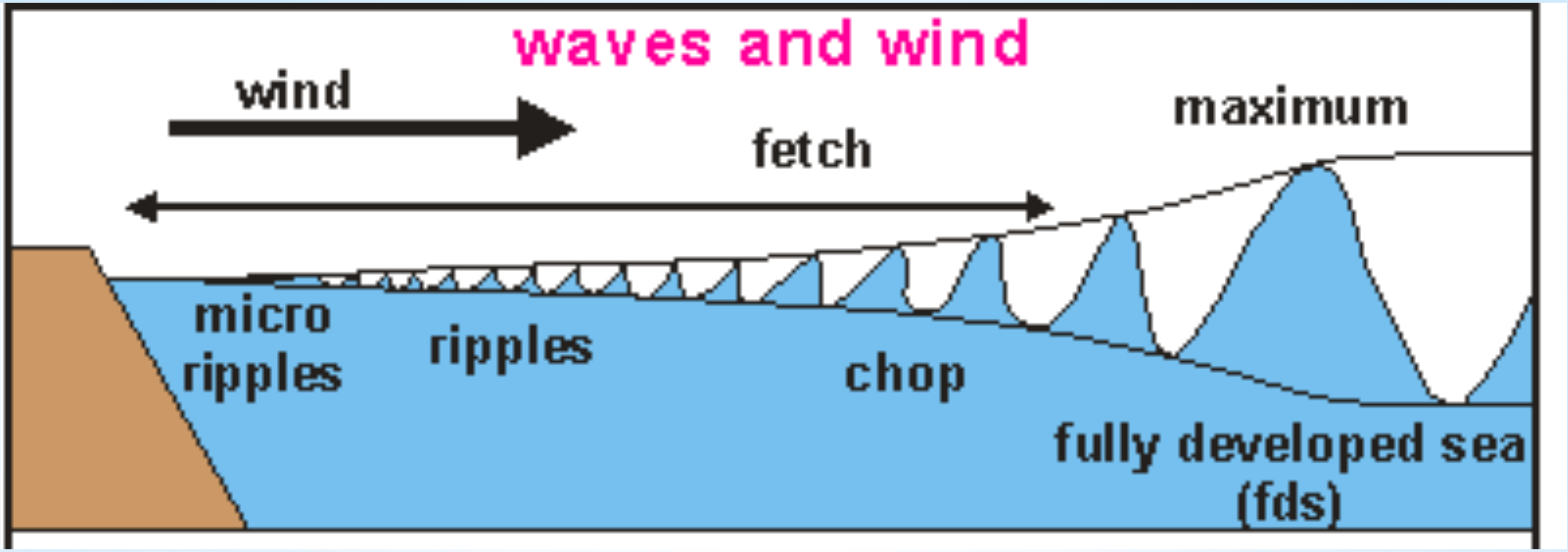
*Causes/types of waves

1) wind
2) gravity
3) violent displacement



PhyOce -Mark Johnson

* 1) Wind-driven waves



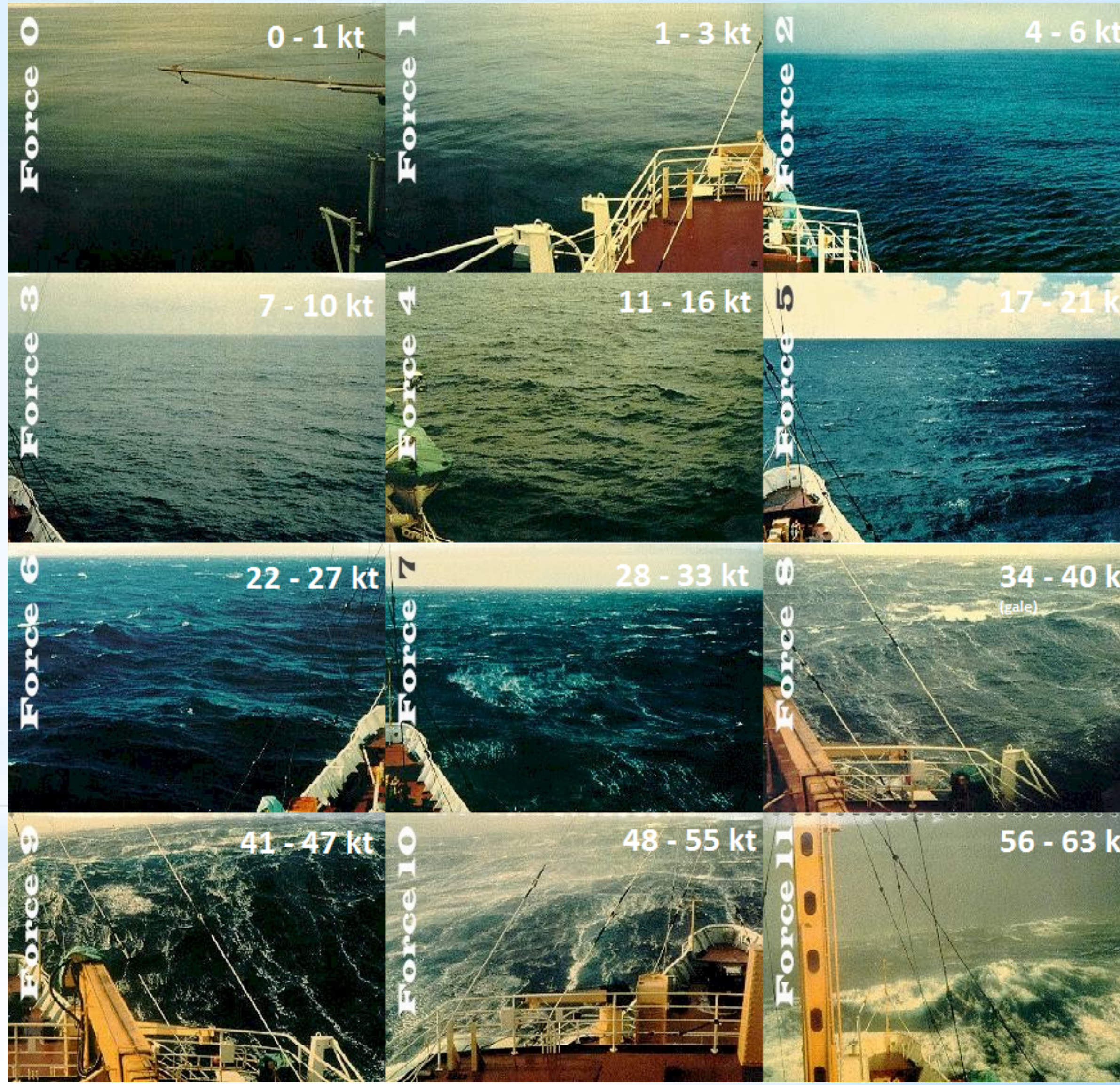
Seafriends.org.nz

Starting with flat-calm surface:

- Turbulence in wind = pressure flucuations that ‘grab’ water surface
- Small ripples develop = more surface area for wind to press against
- Energy from wind = $(\text{wind speed})^4$
- Maximum wave size reached when wave speed = wind speed
- Waves can travel faster than wind when **amplification** occurs

*Beaufort scale

Force	Knots	MPH	K/Hr	Wave Ht	Descr
0	<1	<1	<1	0 Ft 0m	Calm
1	1-3	1-4	1-5	0-1 Ft 0-.2m	Light air
2	4-6	4-7	6-11	1-2 Ft .2-.5m	Light Breeze
3	7-10	8-12	12-19	2-4 Ft .5-1m	Gentle Breeze
4	11-16	13-17	20-28	4-6 Ft 1-2m	Moderate Breeze
5	17-21	18-24	29-38	6-9 Ft 2-3m	Fresh Breeze
6	22-27	25-30	39-49	8-13 Ft 3-4m	Strong Breeze
7	28-33	31-38	50-61	13-19 Ft 4-6m	Moderate Gale
8	34-40	39–46	62-74	18-25 Ft 5-8m	Gale
9	41-47	47-54	75-88	23-32 Ft 7-10m	Strong Gale
10	48-55	55-63	89-102	29-42 Ft 9-12m	Storm
11	56-63	64-73	103-117	37-52 Ft 12-16m	Violent Storm
12	>63	>73	>117	>46 Ft >14m	Hurricane



MetService Blog

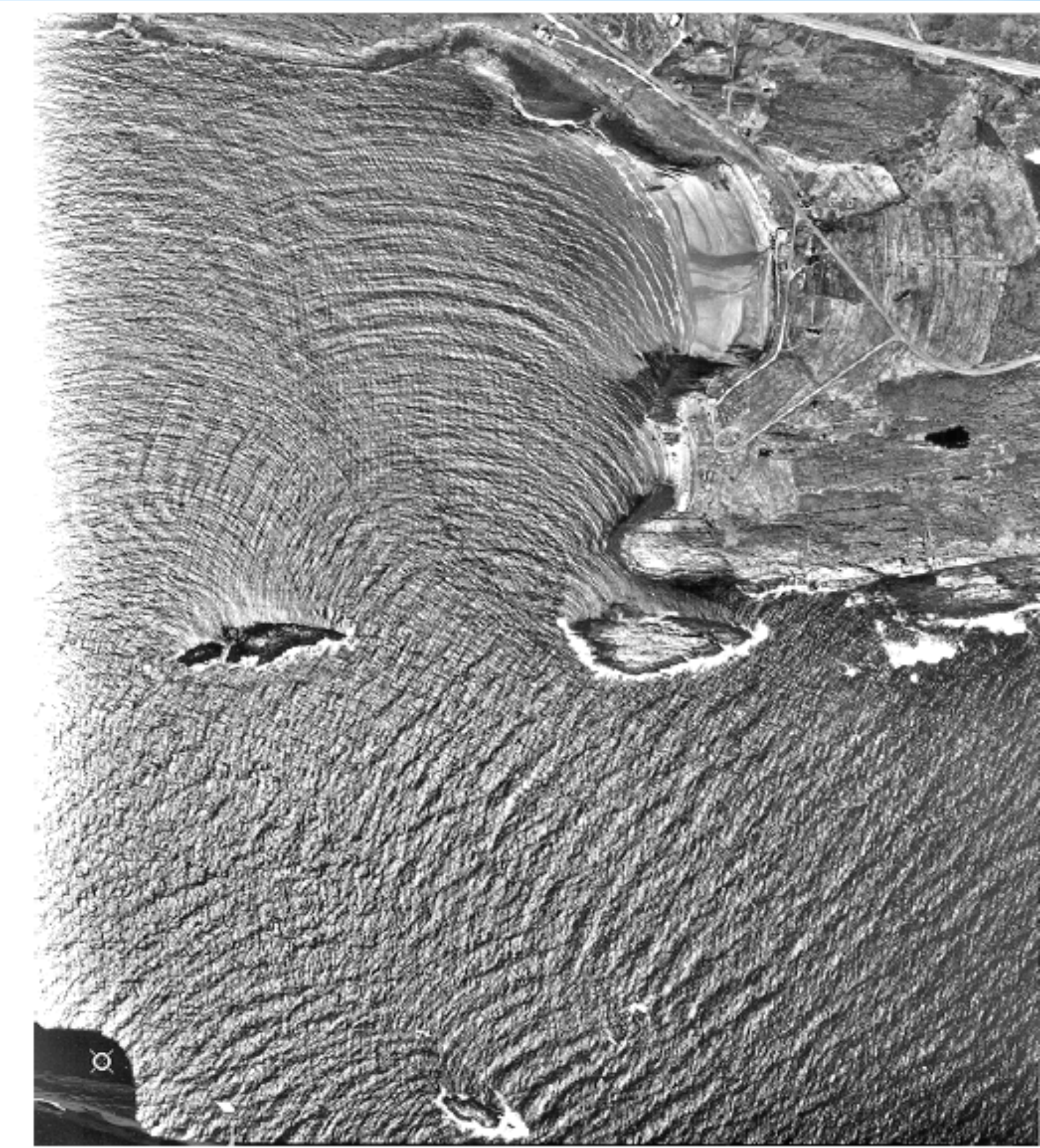
*Wave bending

math.uio.no

Wave refraction and diffraction occur as crest and troughs of wave propagate "around" obstacles

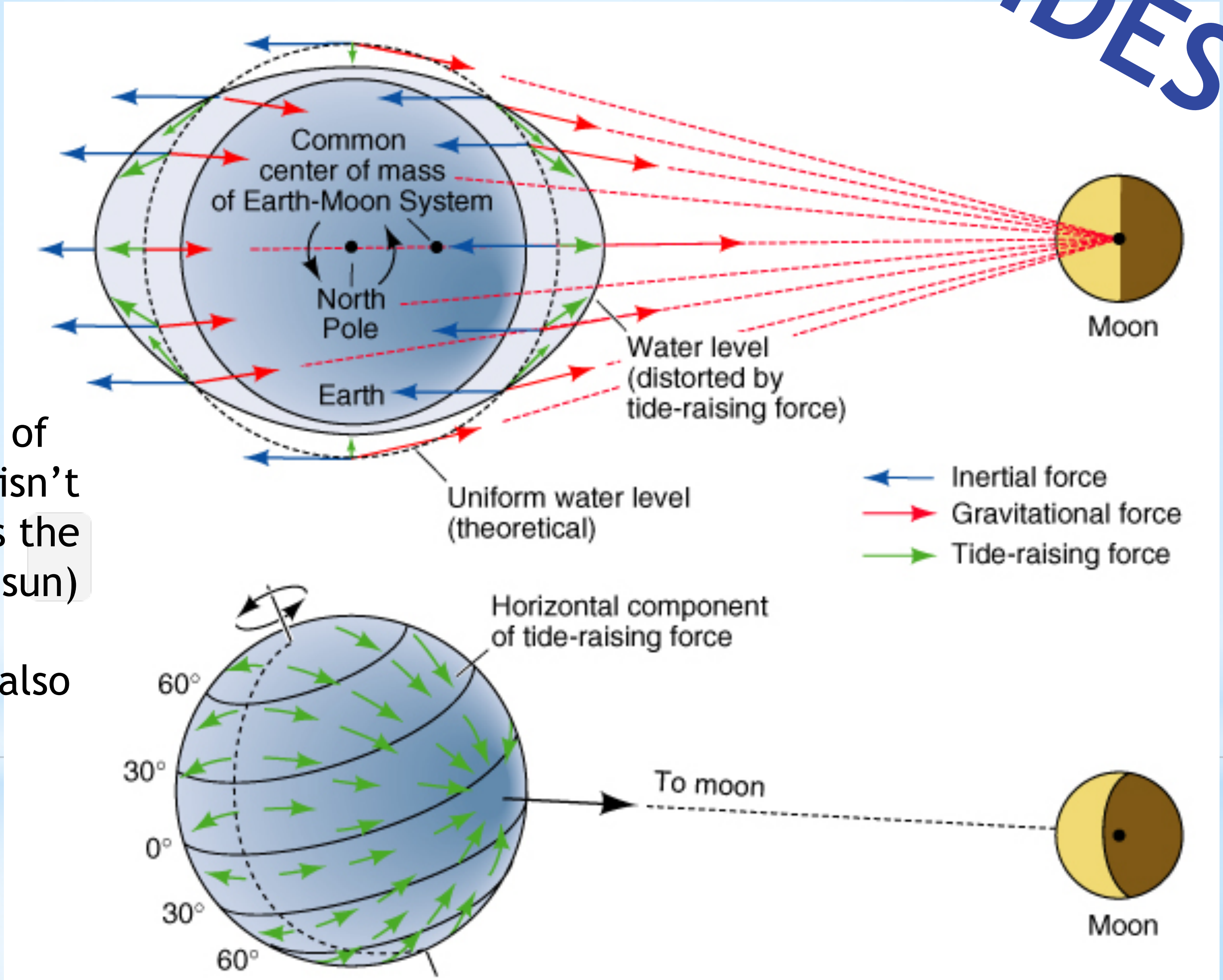
Means that wave energy can reach the lee sides of objects

Can concentrate wave energy at headlands and result in erosive action



*2) Gravity-driven waves

TIDES

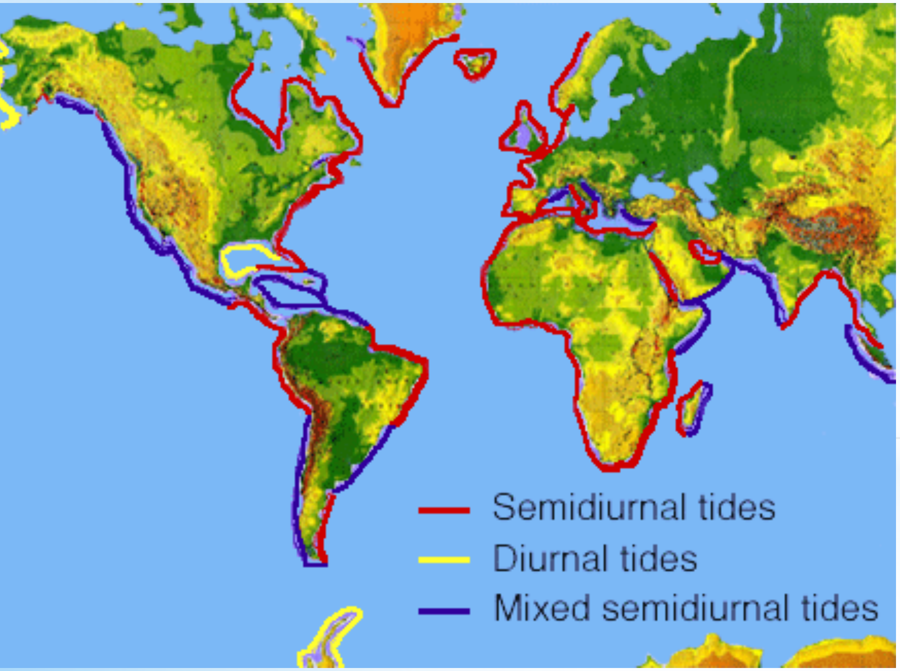


Note that all of world's water isn't pulled towards the moon (and/or sun)

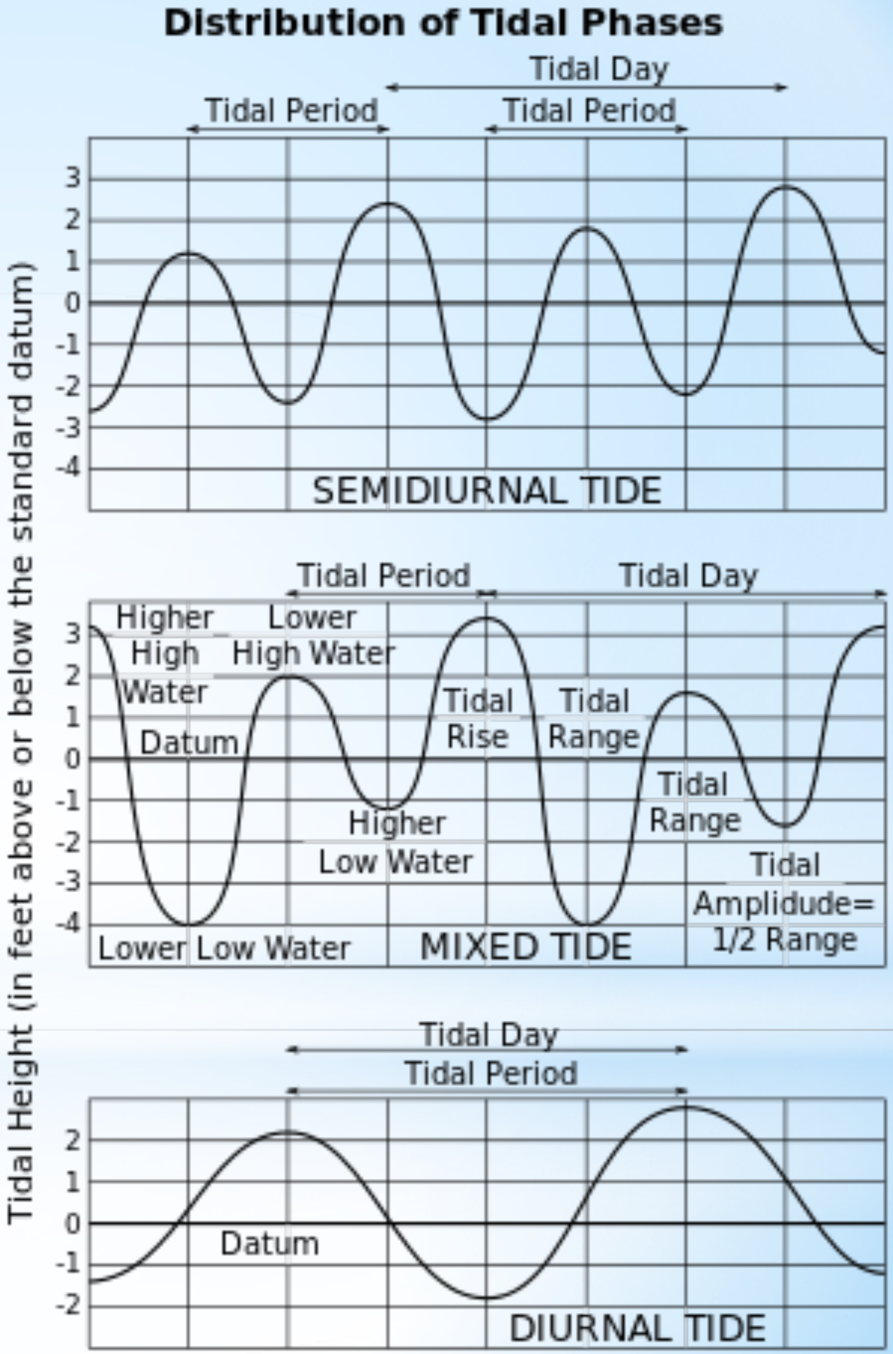
Inertial force also at play

*Tide types

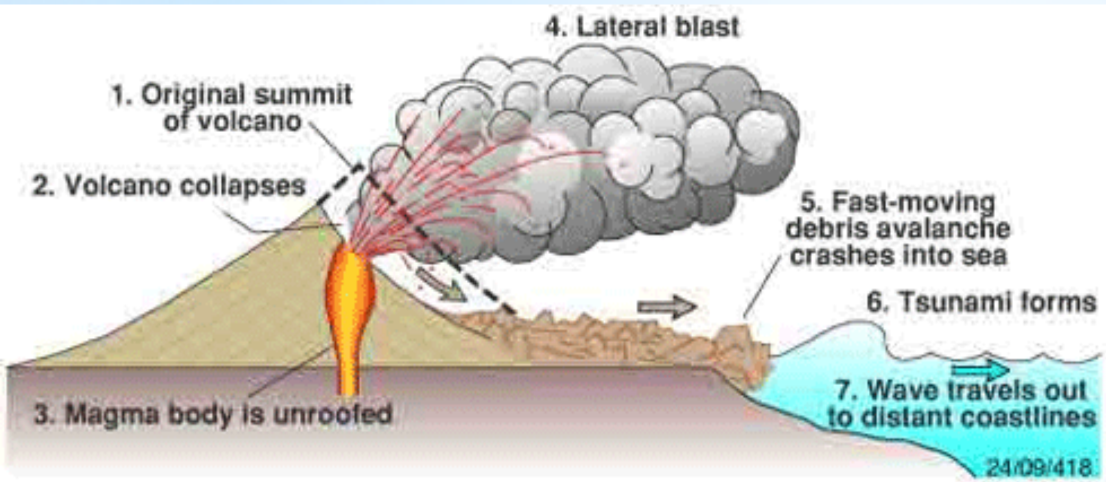
Caused by <u>continental interference</u>



OceanService NOAA



3) Violent displacement- wave formation



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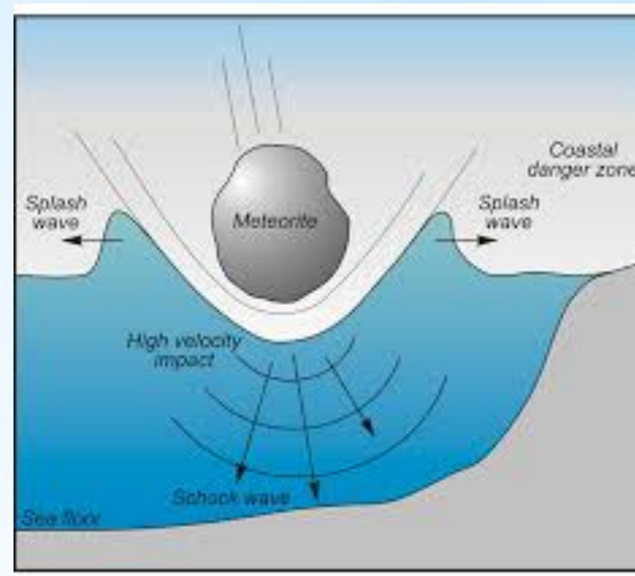
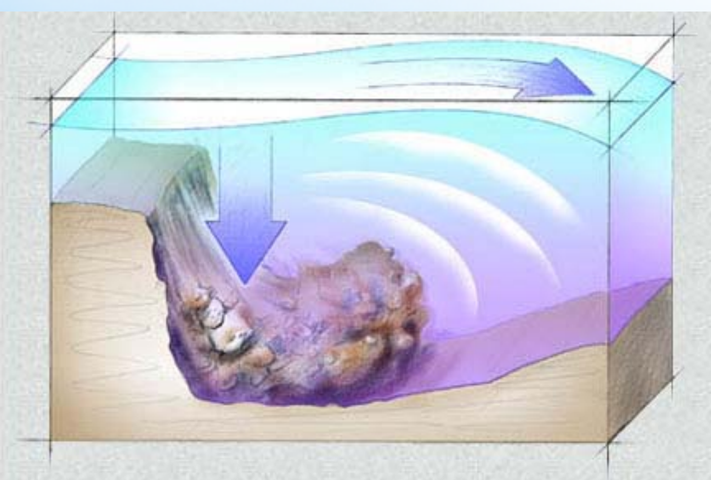
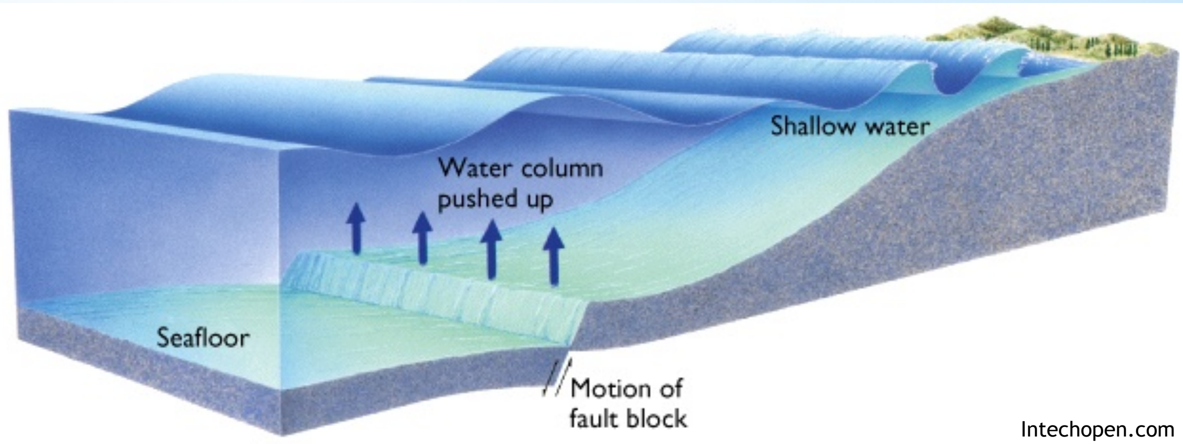


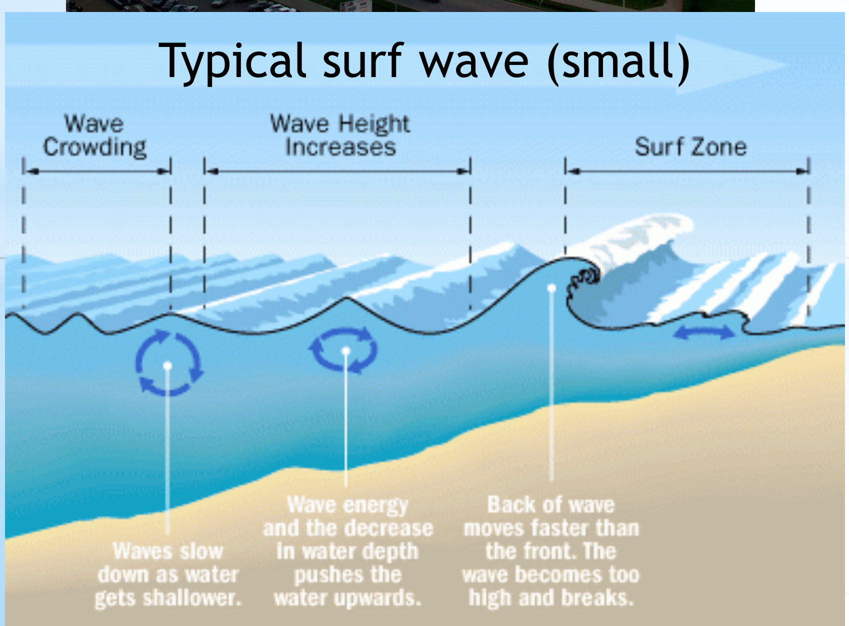




Intechopen.com

*Tsunamis at shore

Why they don't look like they do in Hollywood

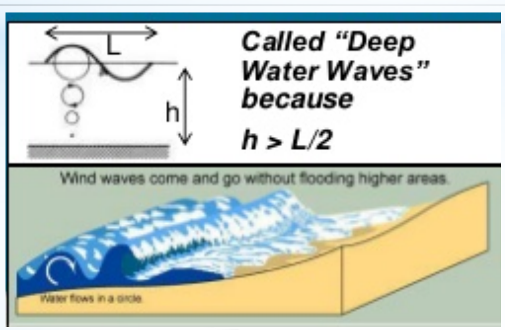


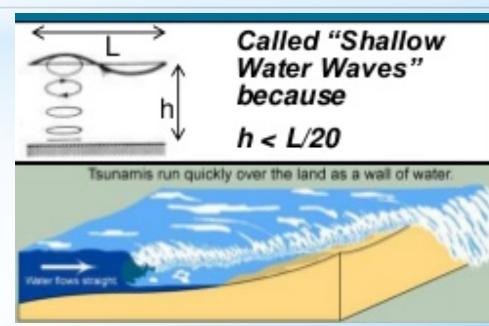
- Wave is very large (in horizontal distance)
- Lots of water mass behind shore-end of wave
- Tail-end traveling very fast when shore-end meets land
- Cannot stack up very tall – instead, becomes a thick wall of water
- Entire water column in motion, not just the top
- "Trough" of wave (beyond the tail end) still miles and miles away from shore - can't dive under to escape

In other words – don't try to surf a tsunami!

*Wave feature comparison

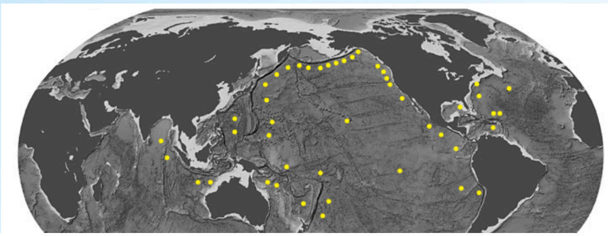
Wave feature	Wind-generated waves	Tsunami Waves
Motion	Movement only in uppermost layer of water; motion diminishes with depth	Movement of entire water column to sea floor (also true of tides)
Wave Speed	5 to 60 miles per hour 8 to 100 kilometers per hour	500 to 600 miles per hour 800 to 1000 km per hour
Wave Period	5 to 20 seconds apart	10 min to 2 hours apart
Wavelength	300-600 feet apart 100-200 meters apart	60 to 300 miles apart 100-500 km apart

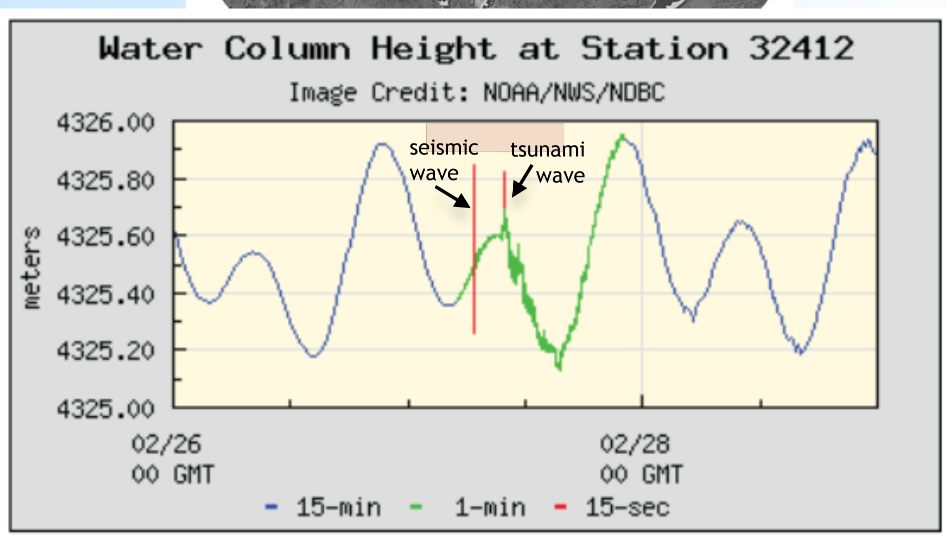




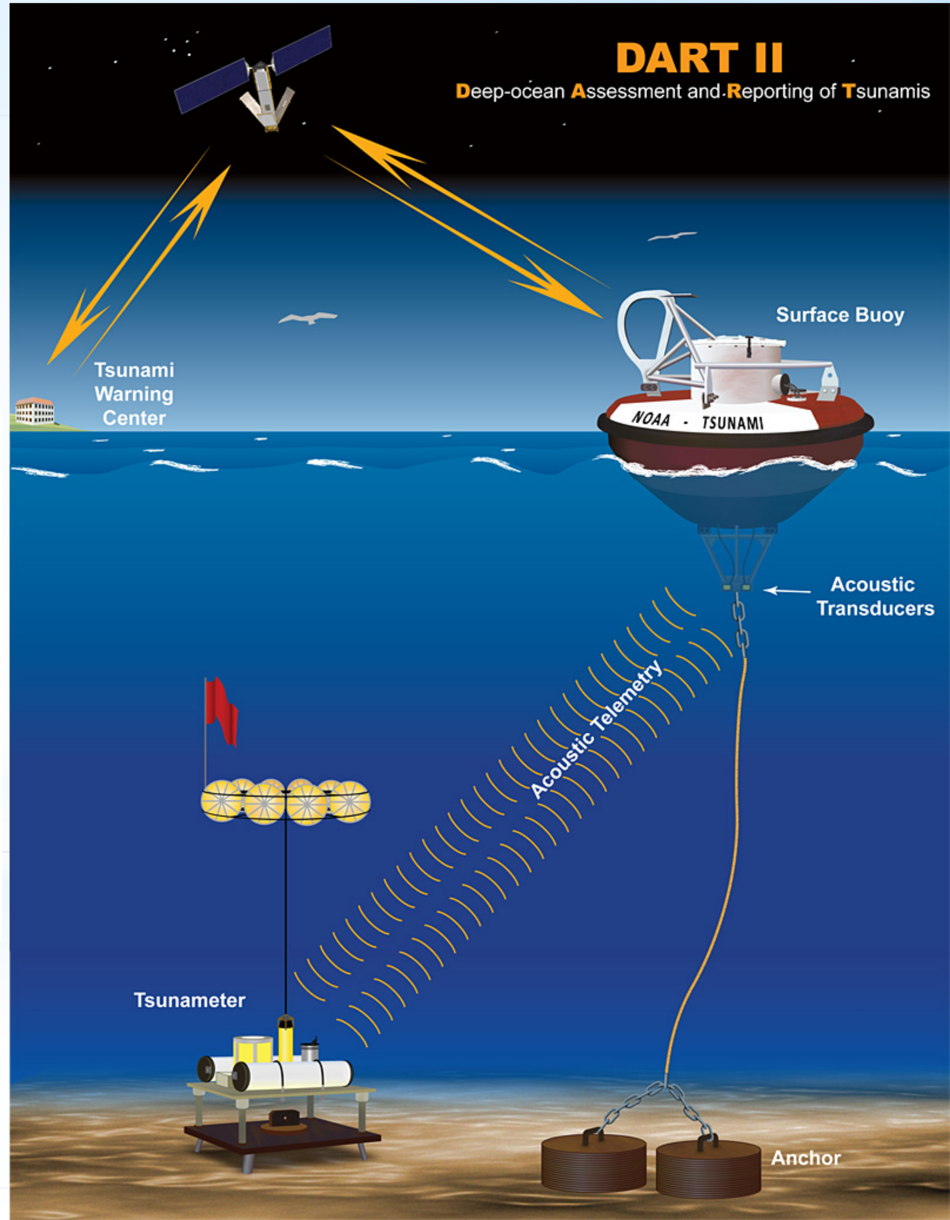
* Measuring waves

Satellites, buoys, and subsurface stations are all utilized to track changes in sea surface height



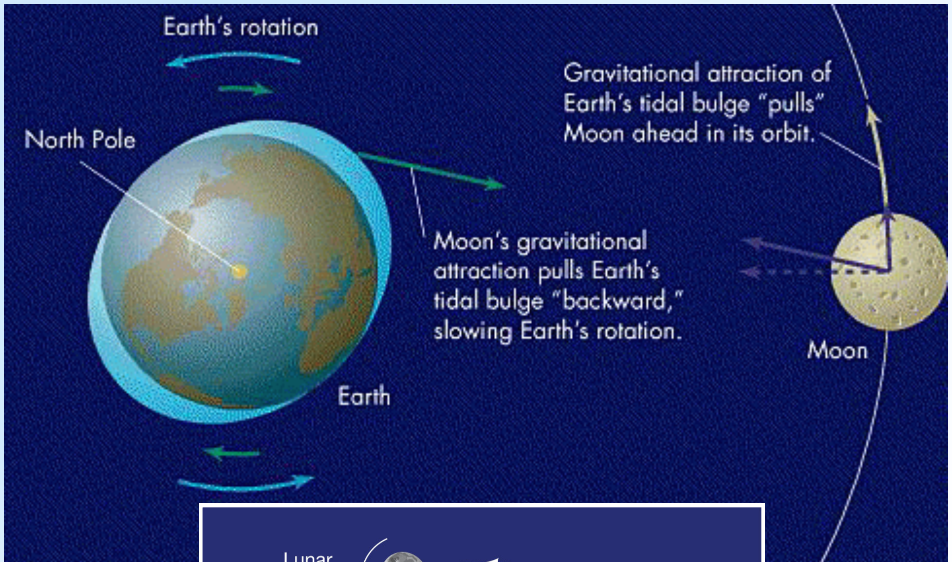


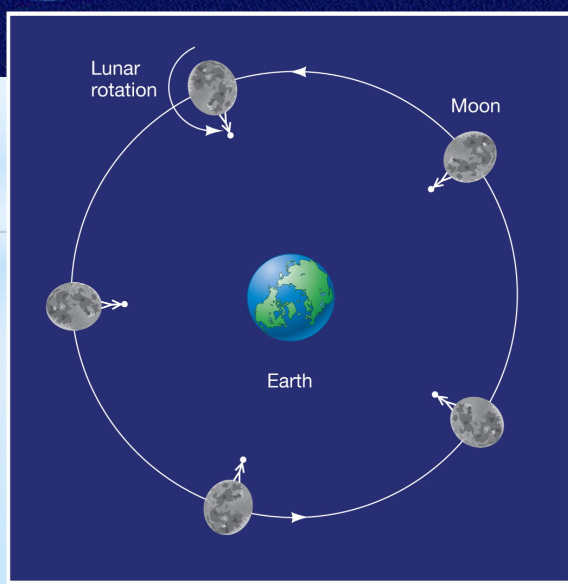
If daily tidal variation raises sea surface height far more than a passing tsunami – why are tsunamis so much more destructive?



*What do tides do?

TIDAL LOCKING





<u>Tidal forces are responsible for:</u>

- why we always see the same side of the moon (moon is "locked" to us)
- why the earth's rotation is slowing by approx. 15 microseconds per year (earth someday will "lock" to moon)

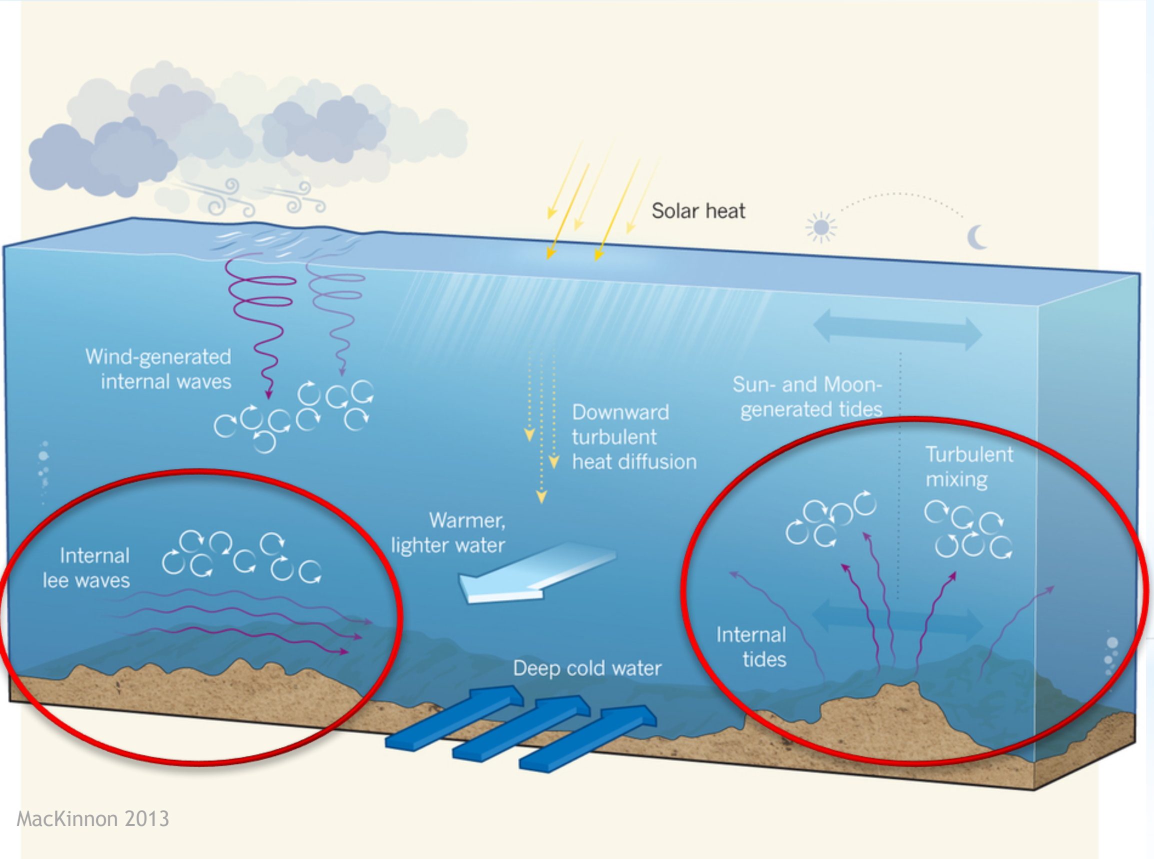
Earth and moon both induce "tidal bulges" on each other
(harder to see on moon because no water)

Earth's tidal bulges move ahead of moon's rotation - earth's rotation pulls them along

Tidal bulges torque the rotation of the two bodies around each other

*What do tides do?

DEEP-SEA MIXING



Recent research suggests that tides may be more of a deep sea “mixing spoon” than we originally thought….

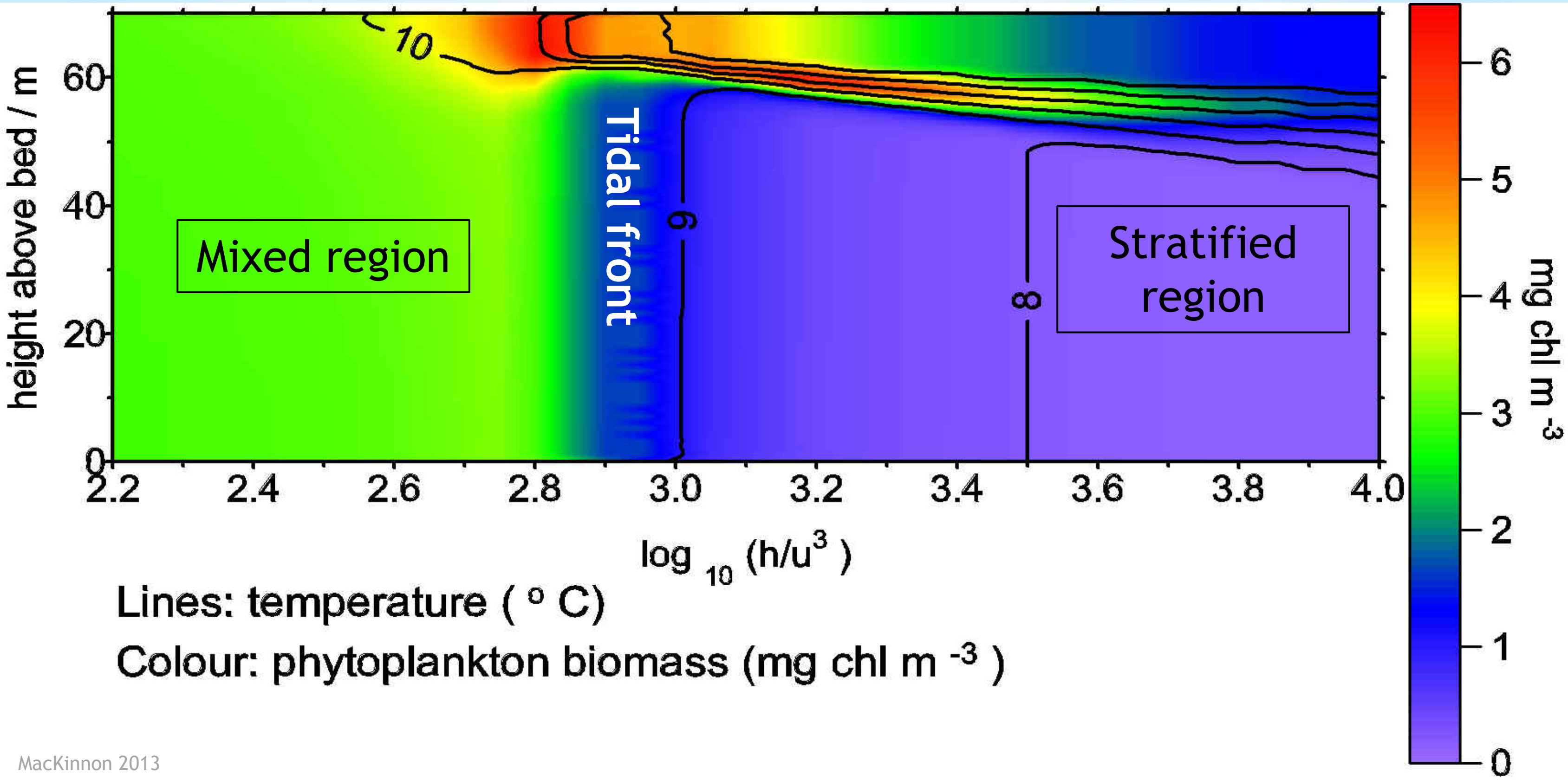
Perhaps

20-30%

of tidal energy is released into the deep sea

*What do tides do?

BOOST PLANKTON BLOOMS



Mixed layer is intermediate density – means that denser, colder, nutrient-rich water has tendency to move towards warmer, nutrient-poor water. <u>Stratification</u> good in some respects – keeps plankton up!

*What do tides do?

FLUSH INTERTIDAL SYSTEMS

Douglas Atmore

USGS

Salt marshes, estuaries, and mud flats harbor LOTS of life, but can become stagnant (anoxic) w/out tidal flushing

Carries in:

- Plankton
- Nutrients
- Oxygen
- Detritus

Carries out:

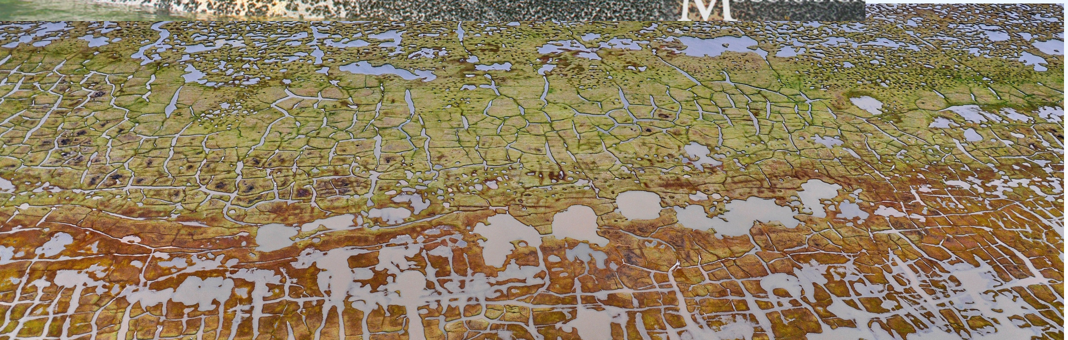
- Salt
- Heat
- Waste Products

*What do tides do?

STRUCTURE COMMUNITIES

Alaska ShoreZone

Alaska ShoreZone

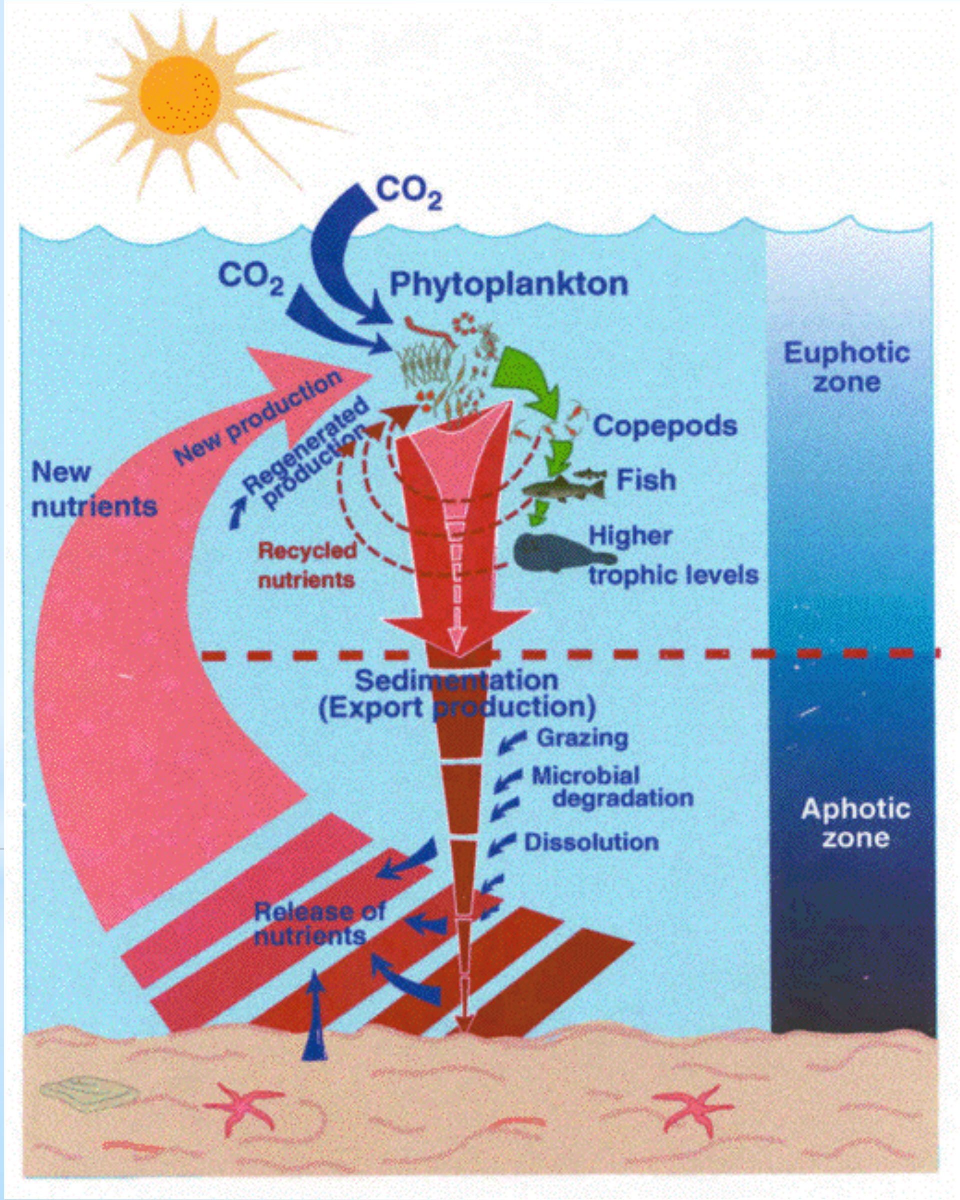


3 main factors determining species' distribution in intertidal:

- Wave shock
- Bottom types
- Exposure

All determined by interaction between: TIDES & WAVES

*Coastal/smaller-scale features



More processes of mixing and stratification

Don't lose sight of the biological implications!

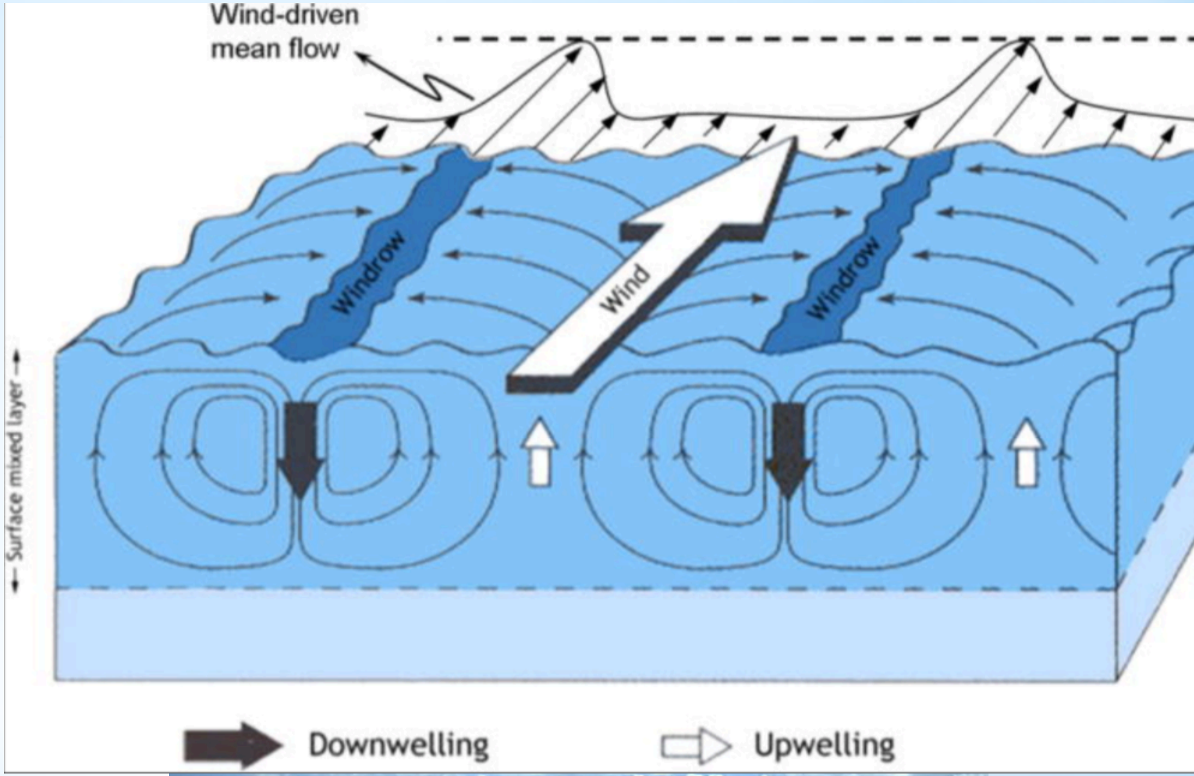
*Langmuir streaks

a.k.a. “Wind rows”

Micro-systems of upwelling and downwelling in the surface mixed layer

Wind blows across surface, sets up shallow, counter-rotating vortices

NOT A RESULT OF COROLIS, TOO SMALL-SCALE



Forms from winds blowing from 3-13 m/s, over relatively calm water

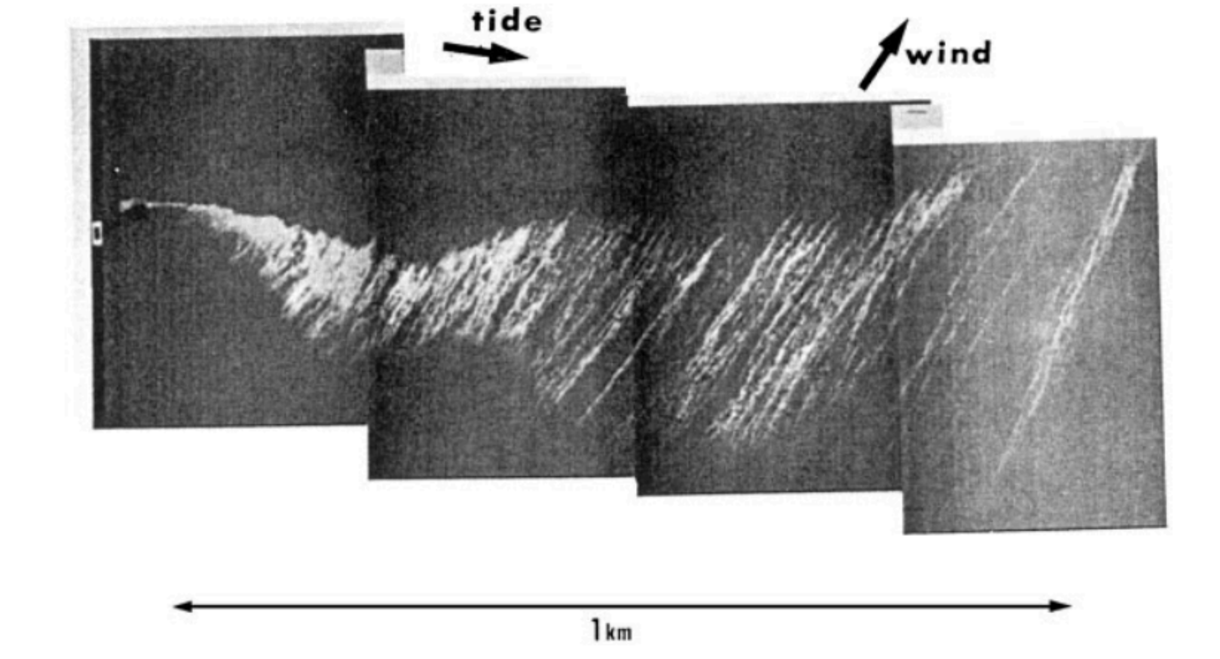
Typically doesn’t penetrate > 4-6 m, but can to 200 m

*Langmuir streaks

Biological implications:

Deepening of pycnocline in areas of downwelling
Affects movement of phytoplankton in water column
Convergence of debris, pollution at surface

Picture: spilled oil at water surface, collected in wind-rows at sites of downwelling. What impact is the tide having on the spill?



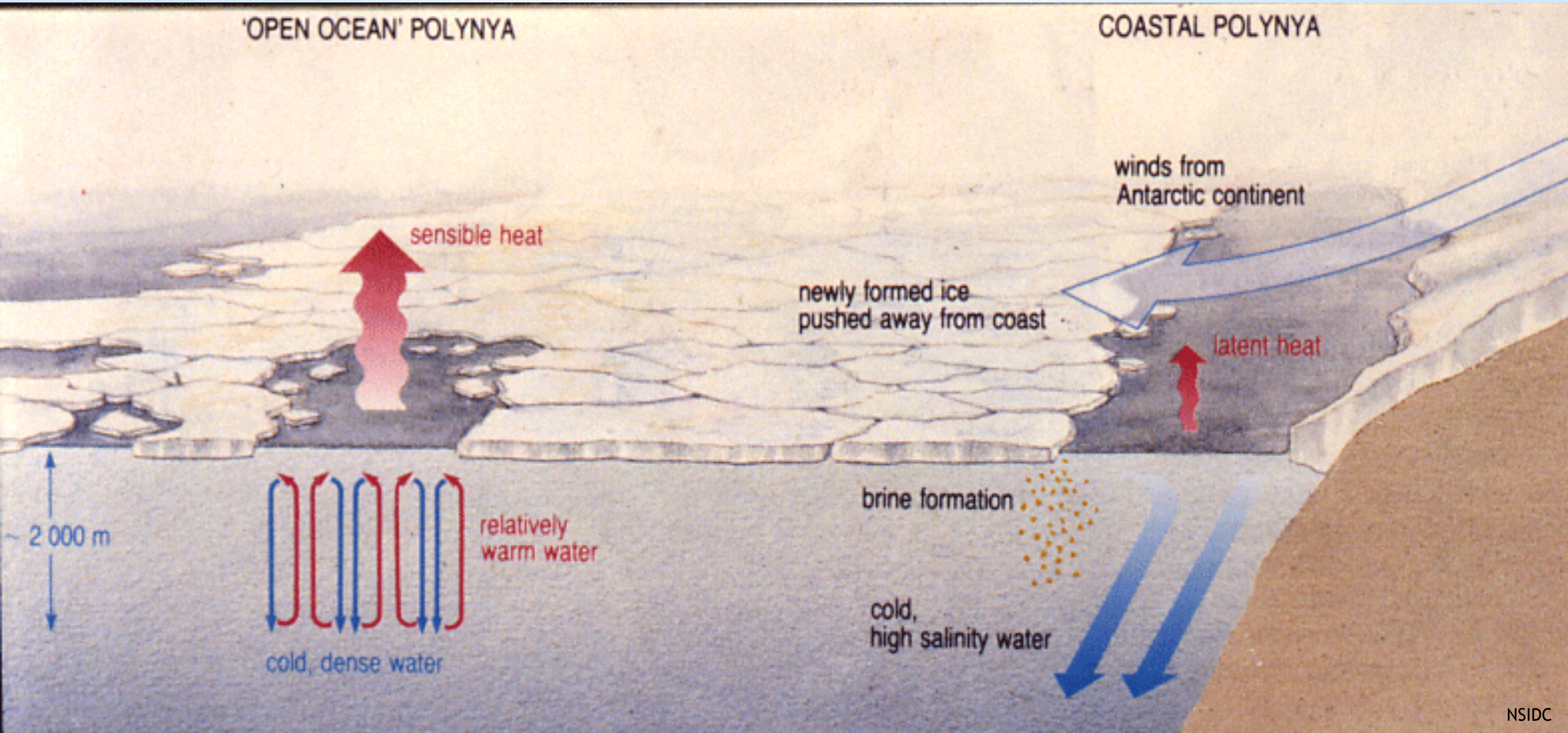
*Polynyas

An area of open water surrounded by sea ice

2 types:

Sensible heat polynya: warm water upwelling keeps surface water above freezing point – slows/stops ice production. Persistent, multi-year features.

Latent heat polynya: winds or currents drive ice away from fixed boundary – high ice production and formation of brine-rich waters. Temporally unstable features



NSIDC

*Polynyas

An area of open water surrounded by sea ice

Polynyas that occur seasonally at same time and place each year allow animals to adapt life strategies to take advantage.

- Marine mammals need air holes
- Thin/absent ice allows penetration of light: early plankton blooms!
- Very productive systems

Polynya by St. Lawrence Island & Spectacled Eiders

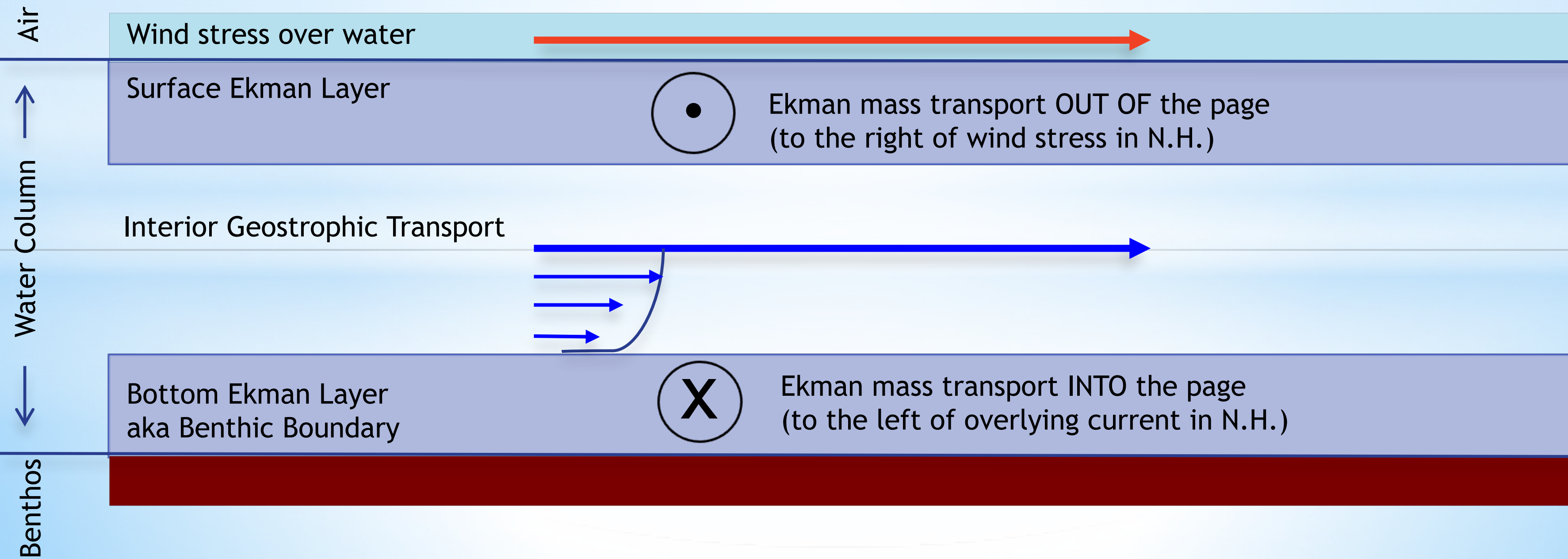
Entire world population of these eiders congregates here in winter!

*Benthic Boundary Layer

**Just like wind causes drag on water at surface,
ocean bottom causes drag on water above it**

- Mean flow in overlying water column must be brought to zero at interface with seabed due to friction
- Vertical gradients in bottom stress cause Ekman spiral UP from bottom
- Net transport in overlying water column is to the LEFT in N.H. – why?

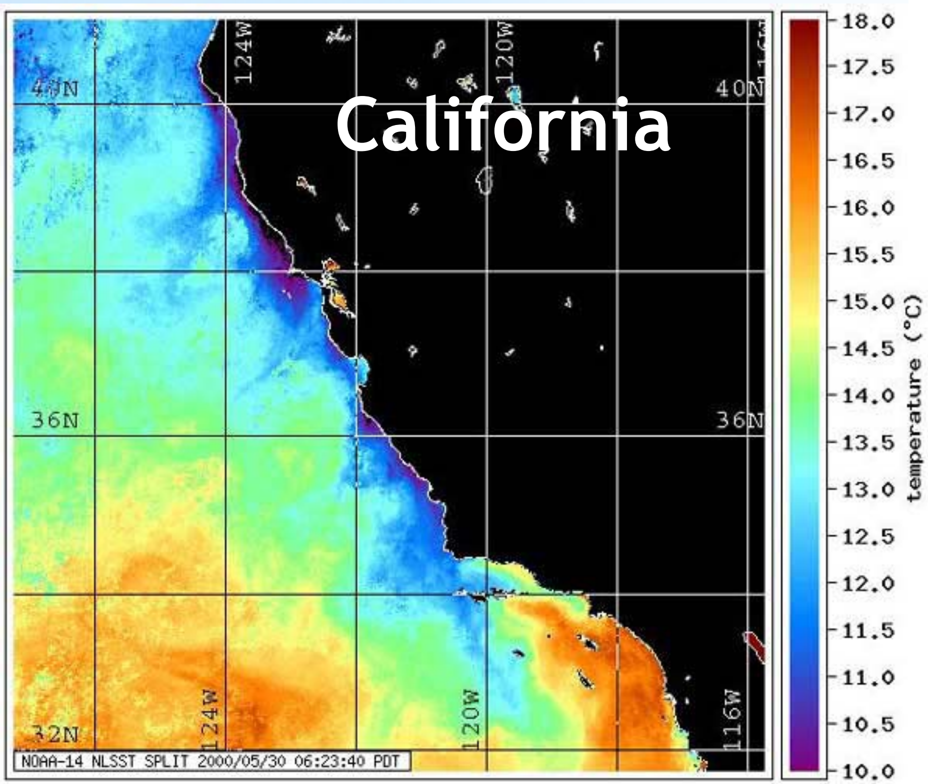
Resulting 3-dimensional flow field:

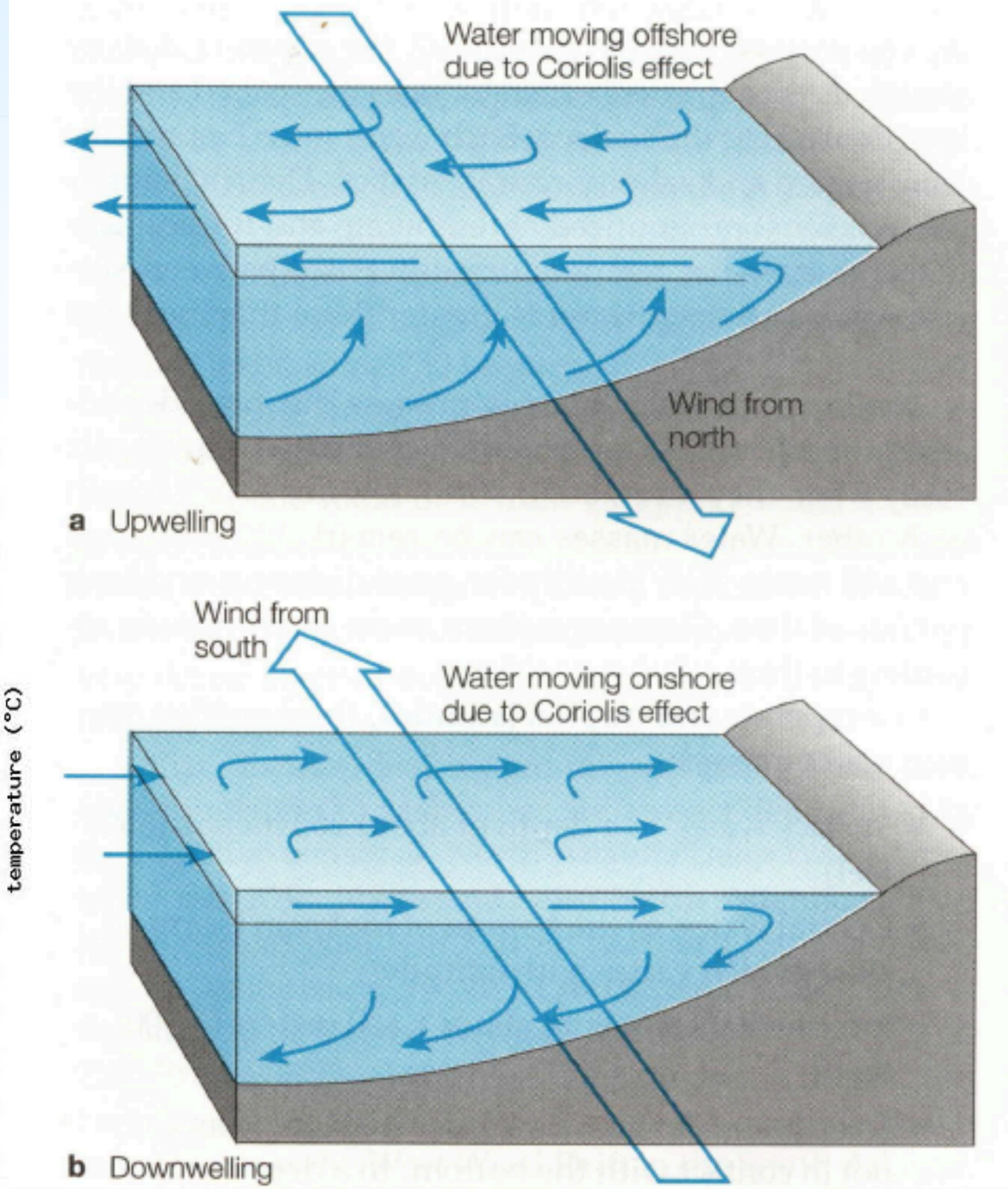


*Coastal water movement

Ekman transport of water due to winds blowing perpendicular to coast

Coastal features can influence degree of upwelling

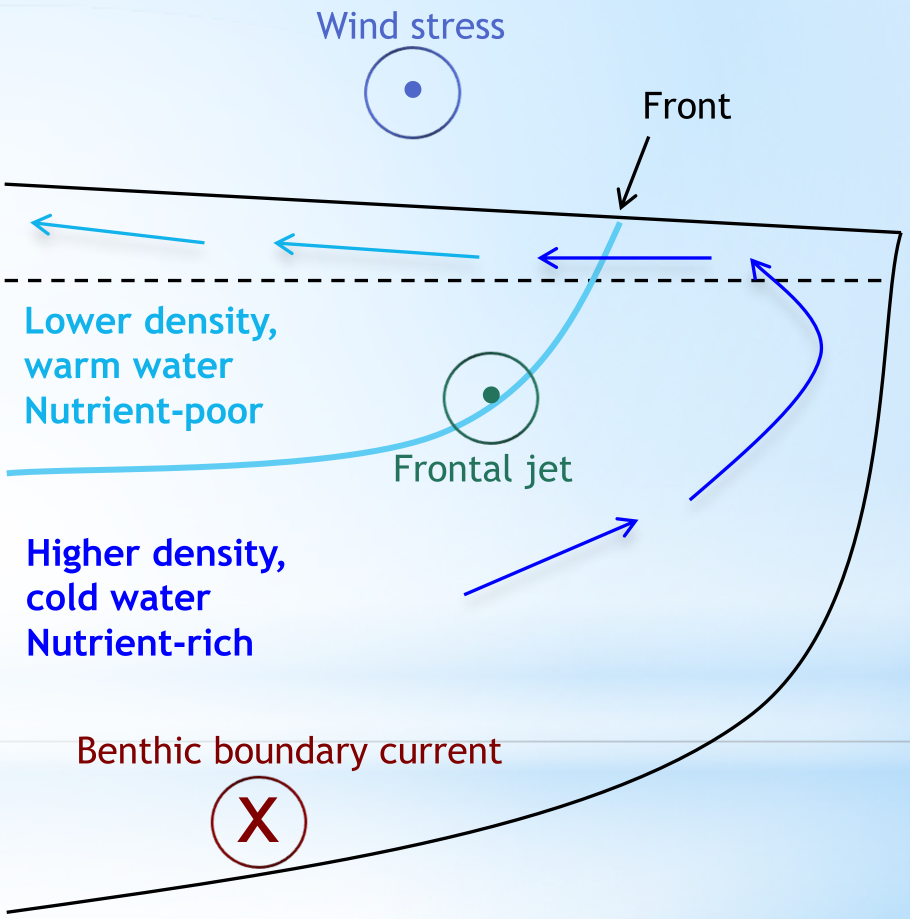




*Coastal upwelling
(not just about water moving offshore)

3D water movement, as well….

1.) Ekman transport moves surface water away from the coast
2.) This lowers sea level adjacent to the coast relative to offshore
3.) The resulting cross-shelf sea surface slope tilts downwards towards the coast.
4.) This slope drives an alongshore geostrophic flow in the **downwind** direction!
5.) The geostrophic flow eventually causes a bottom Ekman Layer to develop in which the mass transport is **opposite** to the Ekman transport in the surface layer.



*Ocean feature summary

- Most water features are some variation on a theme of interfacing density layers
- Think about how water movement either facilitates or dampens production

Near the surface, it's a BALANCE:

- ✧ Water need to be mixed enough that nutrients brought up into sunlit waters (plankton need both!)
- ✧ Also need enough stratification to keep photosynthesizing organisms aloft!

Other biological implications

- Larval dispersal versus settling in habitable spot
- "Hotspots" of concentrated marine life – does this strengthen a system? Could it make it more vulnerable?

*Oceanography and global change

Why do we need to be familiar with physical oceanography to understand the **big issues** of today?

- **Warming temperatures**
  - ✧ Thermal expansion
  - ✧ Interaction of rising sea level w/ tides and storms
- **Pollution**
  - ✧ Water motion determines where pollution goes, collects
  - ✧ Noise (also a wave) travels at different speeds at different ocean depths (i.e., at different water densities)
- **Increased run-off from land to sea**
  - ✧ Freshwater increases stratification
  - ✧ Nutrient loading and dead zones
- **Ocean acidification**
  - ✧ Vulnerable regions, exacerbating effects

WILL REVISIT THESE AT START OF NEXT CLASS
(ran out of time this session)

* MOTION OF THE OCEAN: LOCAL

Start thinking about your proctor for MIDTERM EXAM during week of Oct. 19th

If need help, talk to Emy Roles – aroles@uas.alaska.edu

See you next week – Sept 28th

Wikimedia commons