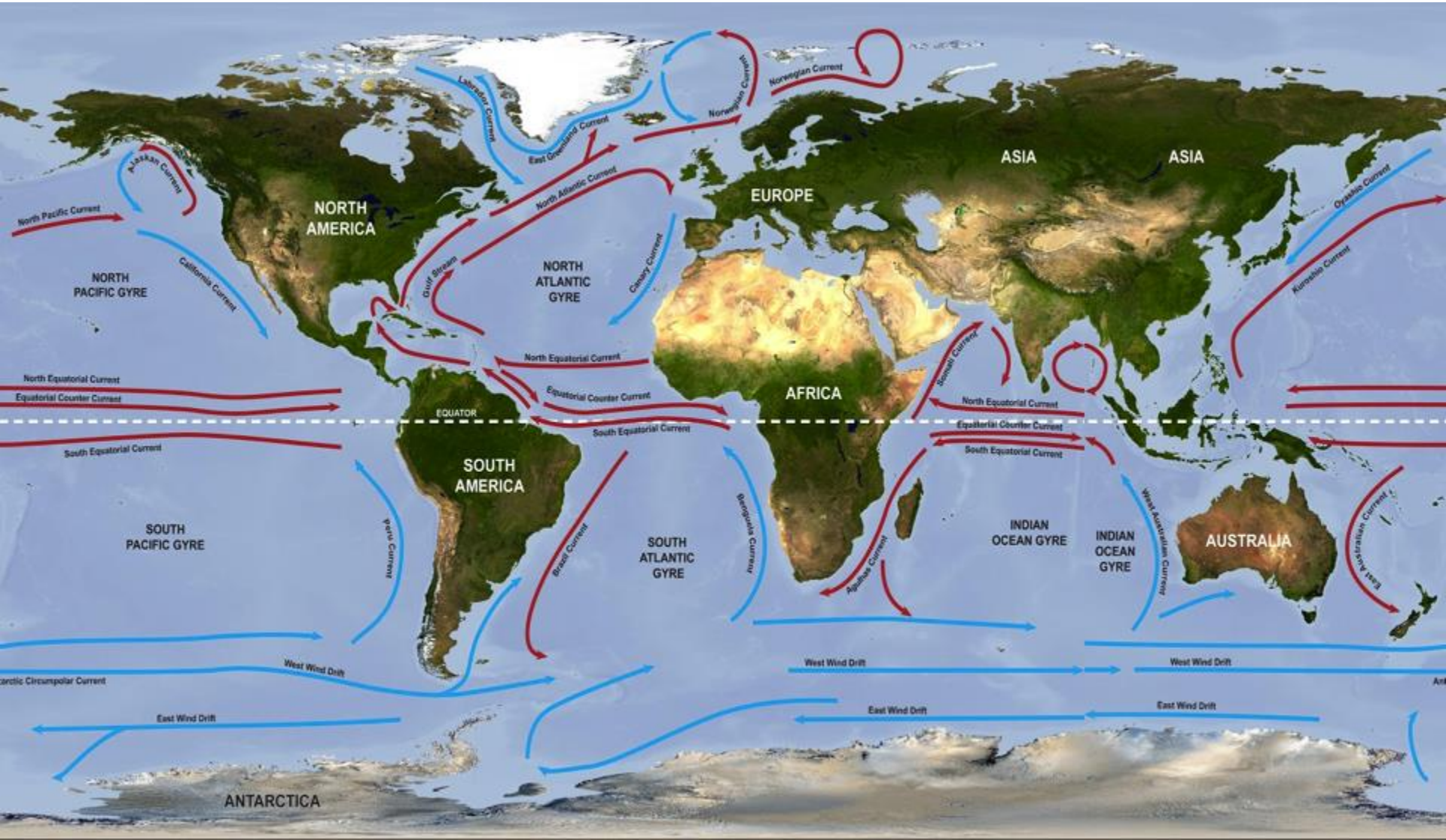
Ocean Currents!!

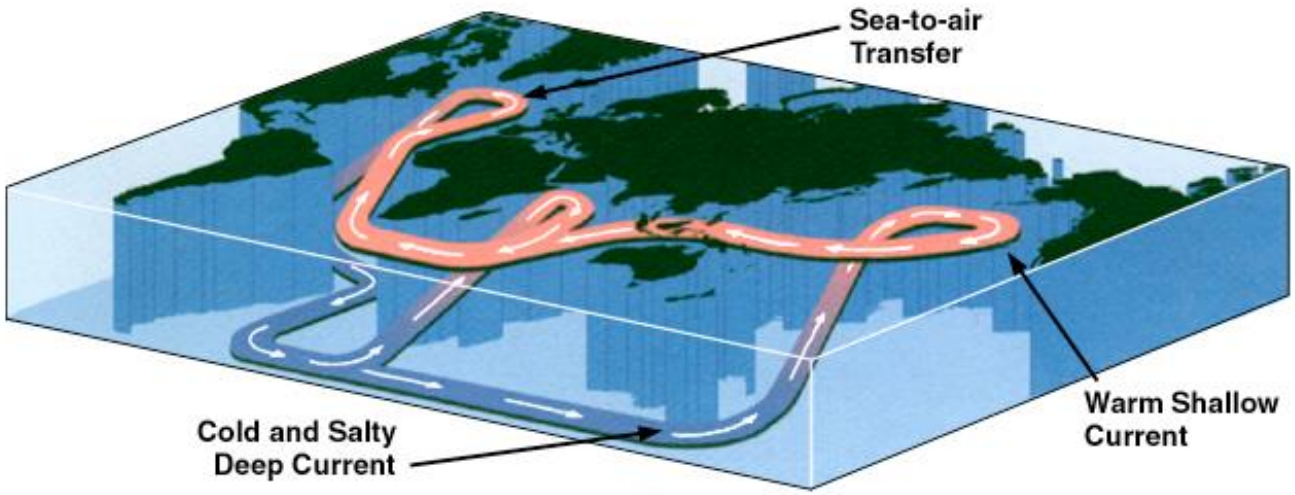


What causes ocean currents?

- Major factors:
  - Wind
  - Density differences in water masses caused by:
    - Temperature
    - Salinity
  - Gravity
  - Geologic events such as earthquakes and volcanoes
  - Seafloor topography and shape of ocean basins

Types of Currents

- Surface Currents:
  - Caused by wind, Coriolis Effect, gravity
- Deep Water Currents:
  - Caused by water density differences, gravity
  - Thermohaline circulation



Shallow vs. Deep Water

Shallow vs. Deep Water

Shallow vs. Deep Water

Water masses

Characteristic	Shallow	Deep
Temperature		
Mixing		
Nutrients		
Oxygen		
Density		
Salinity		
Wind effects?		

Shallow vs. Deep Water

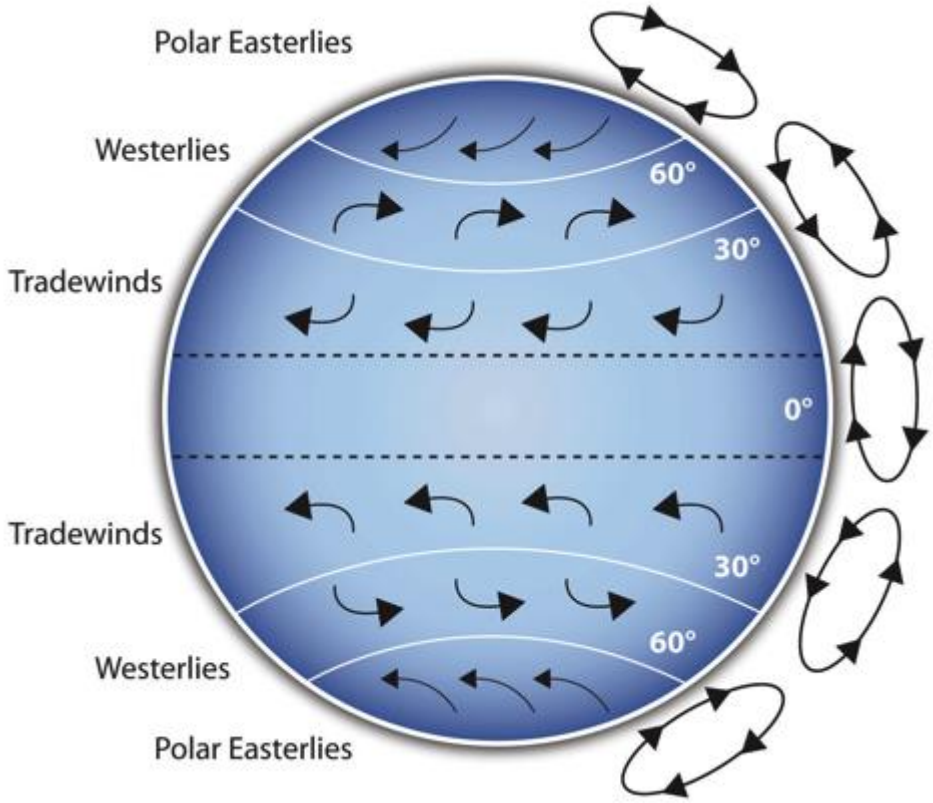
Water masses

Characteristic	Shallow	Deep
Temperature	Warmer	Cooler to really cold
Mixing	Well-mixed	Stratified
Nutrients	Limited	Abundant
Oxygen	High	Low
Density	Lower	Higher
Salinity	Lower	Higher
Wind effects?	Yes	No

Wind

- As it blows across the ocean, it moves the surface of the water due to frictional drag
- Impact of wind on surface currents dissipates at ~100m (328ft.) below the surface

Prevailing wind patterns and their deflection due to the Coriolis Effect

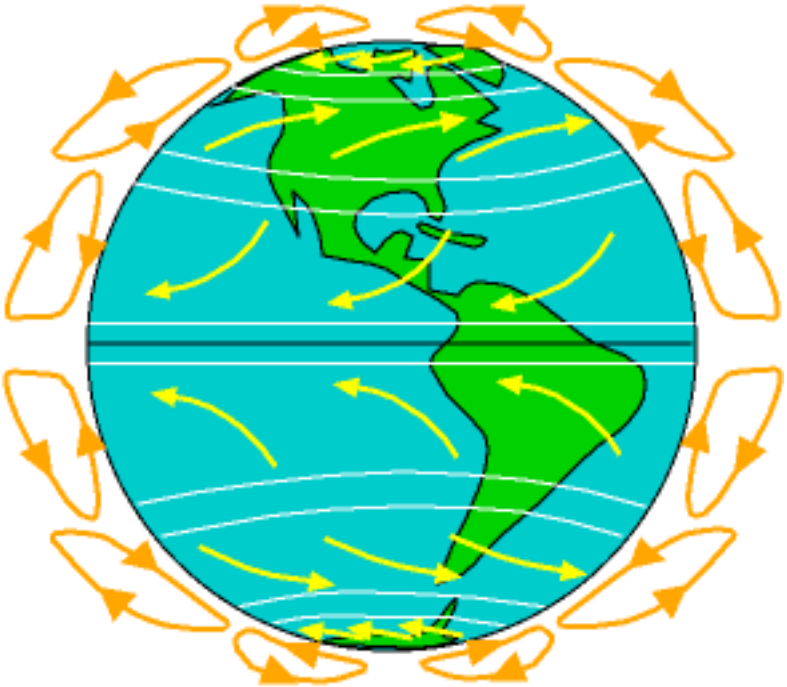


Coriolis Effect

- The apparent deflection of fluids and flying objects due to the earths rotation
  - Right in N. Hemisphere
  - Left in S. Hemisphere
- “Apparent” since the path of the fluid or object is actually straight, but the earth is rotating away from it, making it appear curved to those on earth
- Magnitude of effect increases with increasing latitude (no deflection at equator)

Coriolis Force Impact Global Wind Patterns

no rotation: no coriolis effect

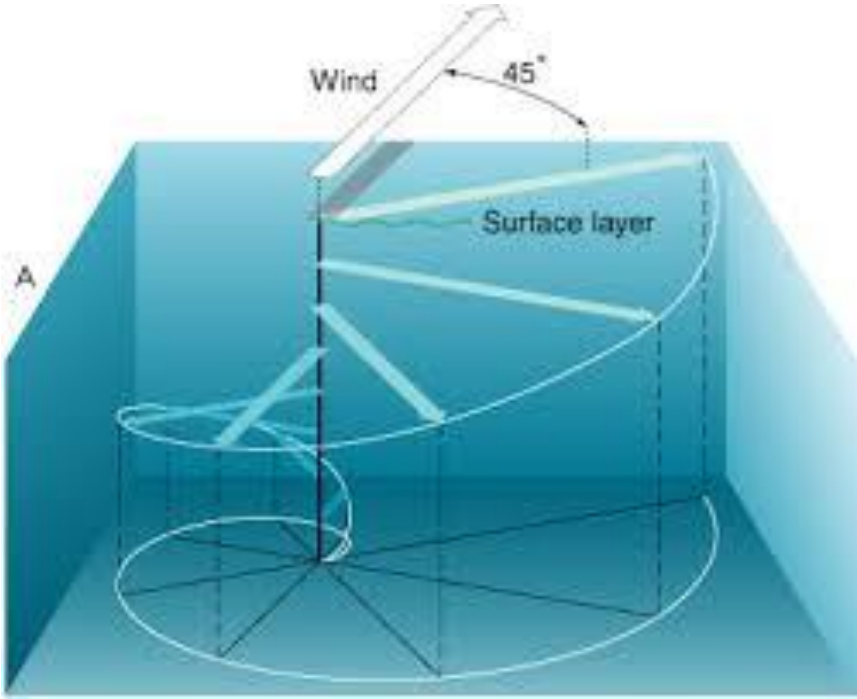


rapid rotation: significant coriolis effect

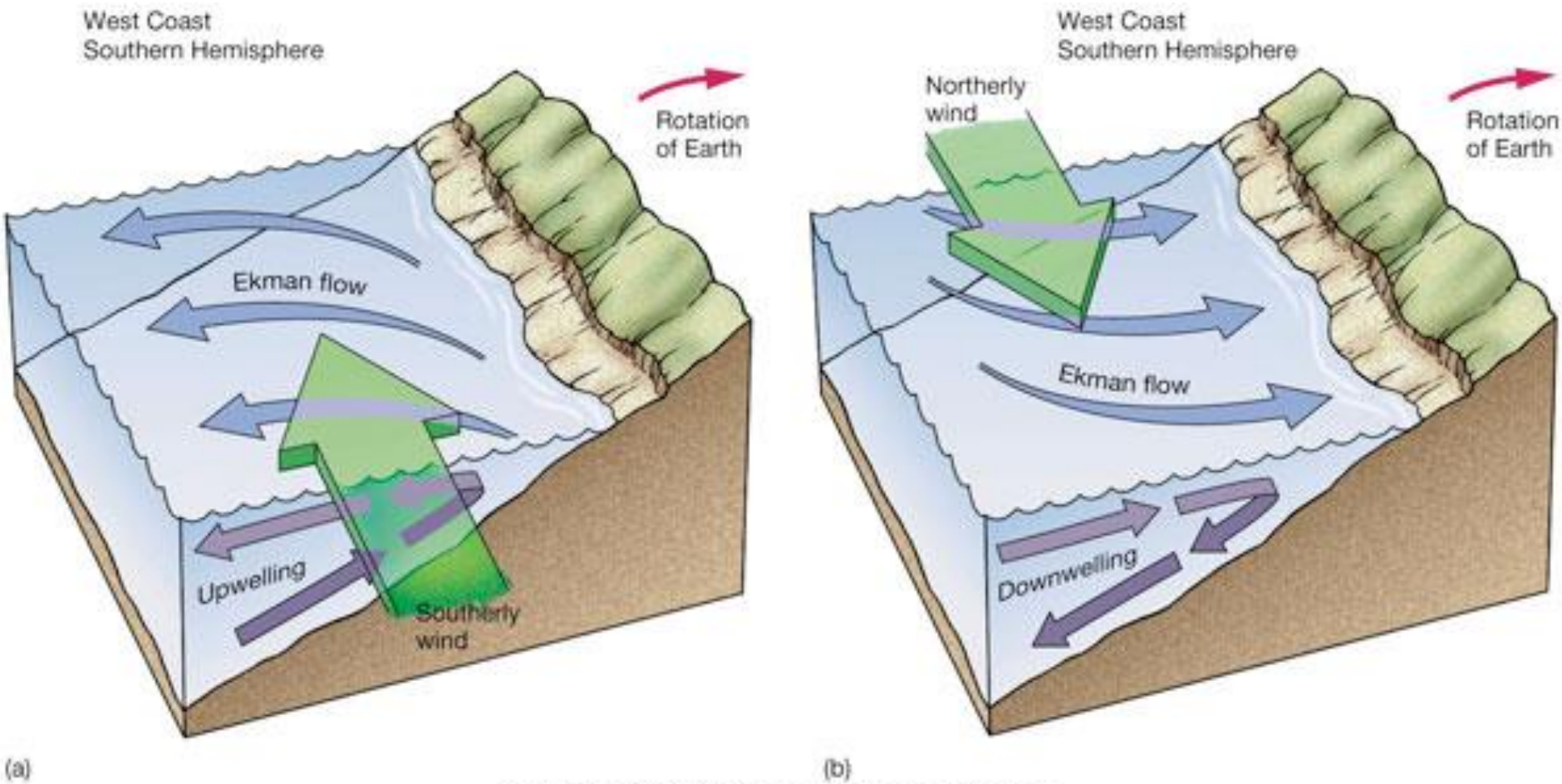
On a planet with little or no rotation, the global air circulation pattern is very simple. On a planet with rapid rotation, the coriolis effect creates large-scale eddies with belts of wind and belts of calm.

Ekman Transport

- As the wind moves a layer of water on the surface, that layer in turn pushes the layer beneath it, etc., until the frictional force dissipates
- Due to the Coriolis Force, each layer of water is deflected
- Net water movement 90° to the right of the wind (N. Hemisphere, 90° left in S. Hemisphere)
- Ekman Spiral is the result



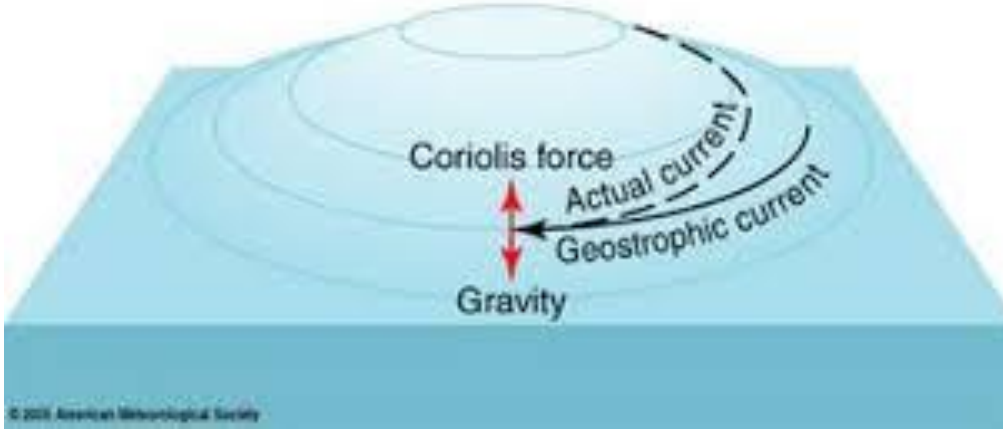
Impact of Ekman Transport



Impact of Gravity on Surface Currents

- The ocean's surface is uneven
- This creates mounds and troughs:
  - Where water meets land
  - Where 2 currents converge
  - When there are differences in water properties (temperature, salinity, density)
- Gravity causes water to move downhill away from mounds or into troughs
- Coriolis Force causes moving water to form

  gyres (spiral of water)



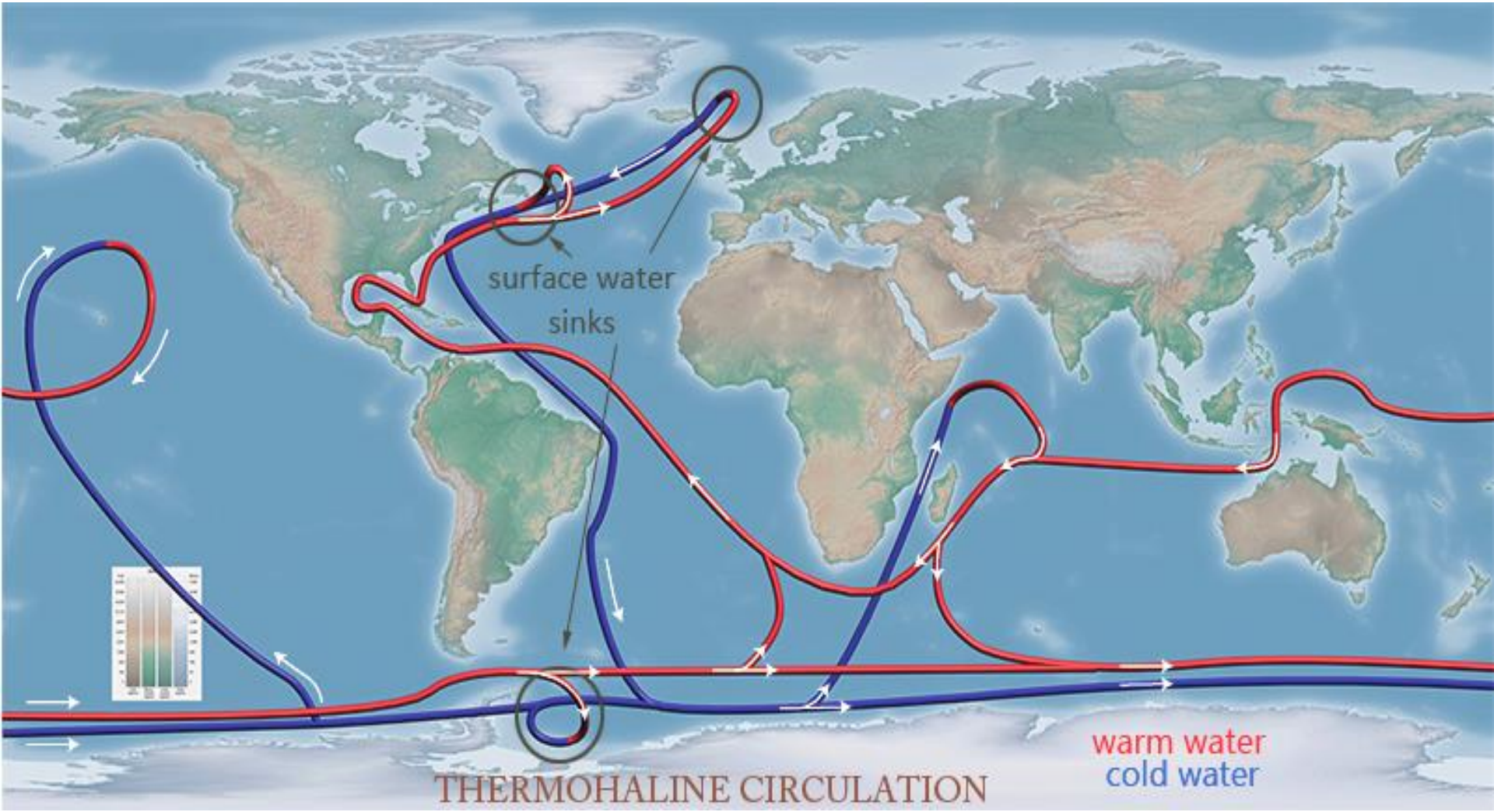
Deep Water Currents

- Occur at 400m and deeper
- 90% of the ocean is impacted by these currents
- Gravity plays a role, but these currents are mostly caused by density differences in water due to temperature and salinity

Thermohaline Circulation (AKA the Global Ocean Conveyor Belt)

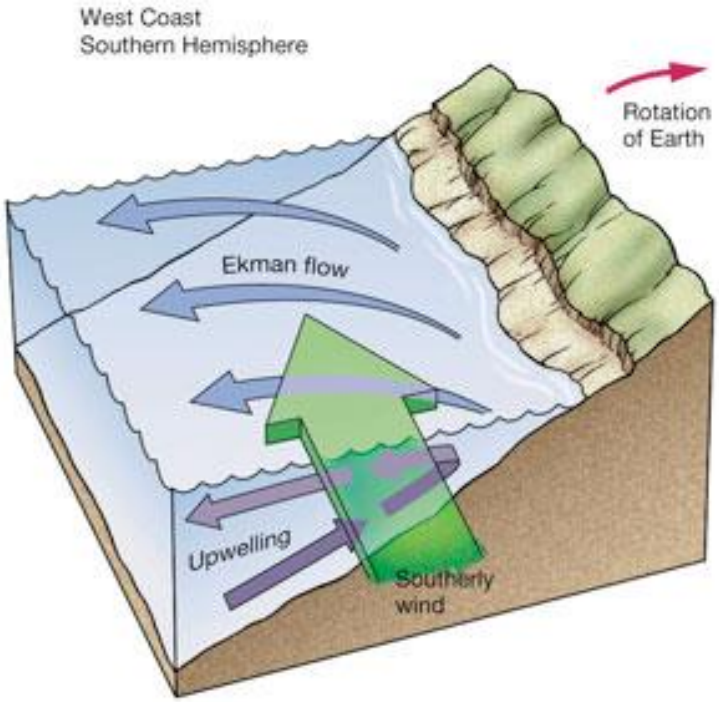
- Warm water holds less salt (and other dissolved materials)
  - Less dense, rises to the surface
- Cold water holds more salt
  - More dense, sinks to ocean floor

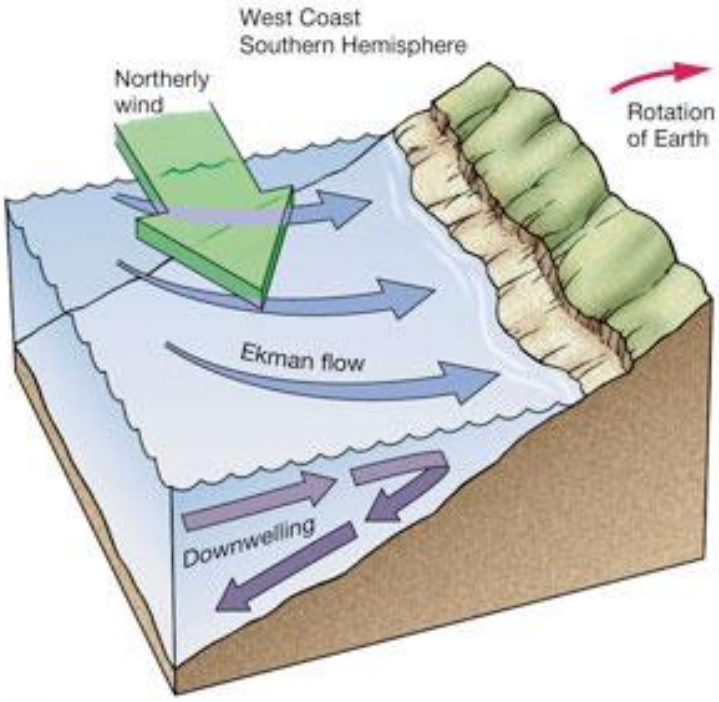
Thermohaline Circulation



Upwelling vs. Downwelling

- As warm water rises, cold water follows it to fill the space it leaves ➔ upwelling
- As cold water sinks, warm water follows it to fill the space it leaves ➔ downwelling



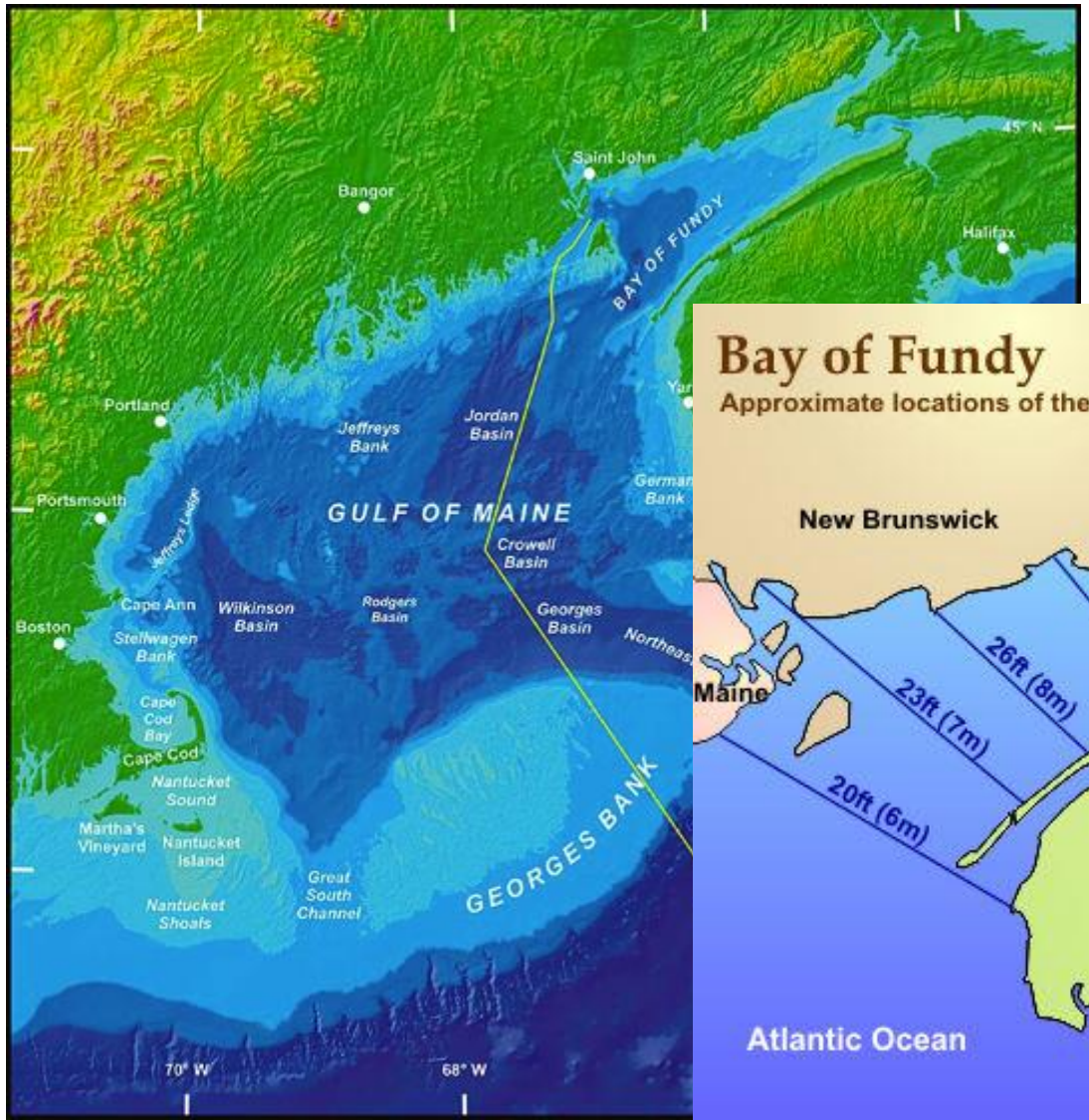


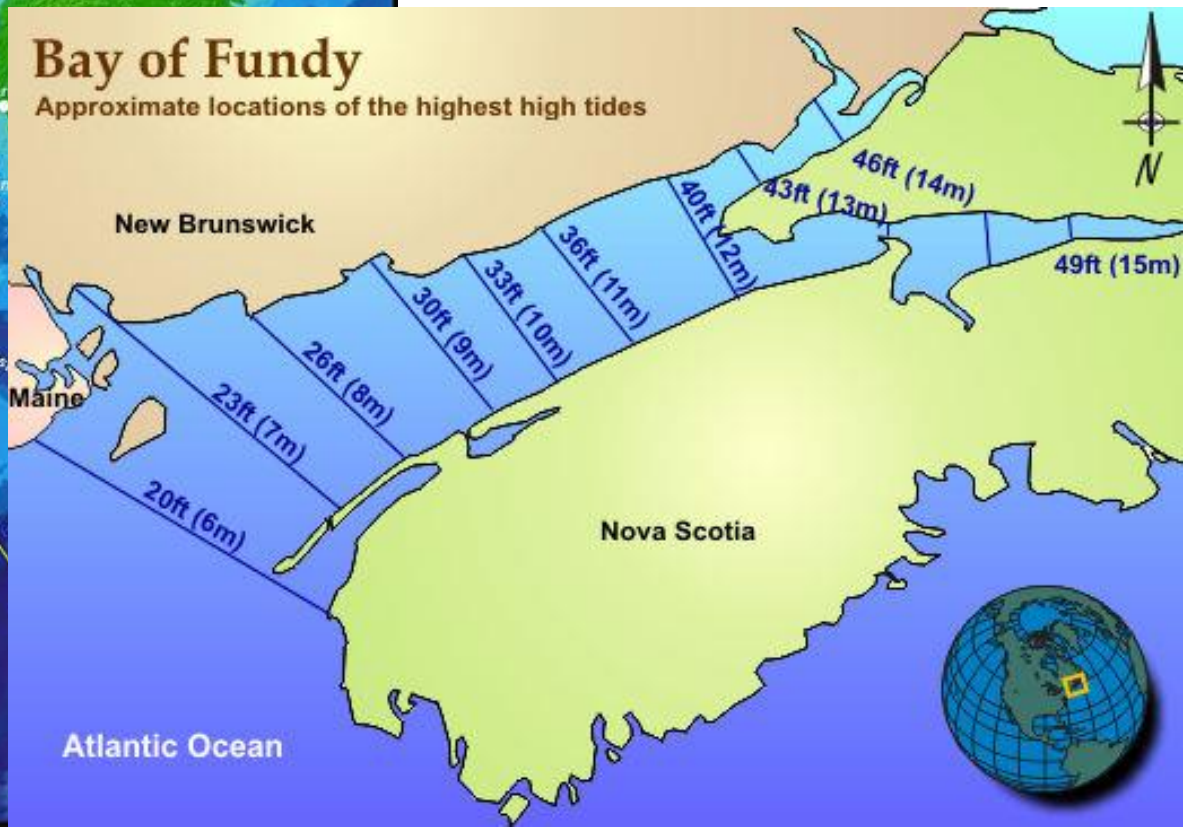
Seafloor Topography and Shape of Ocean Basins

- Impacts both surface and deep currents
- Determines how water flows from one area to another
  - Restricts flow
  - Promotes flow
  - Can you think of an example?

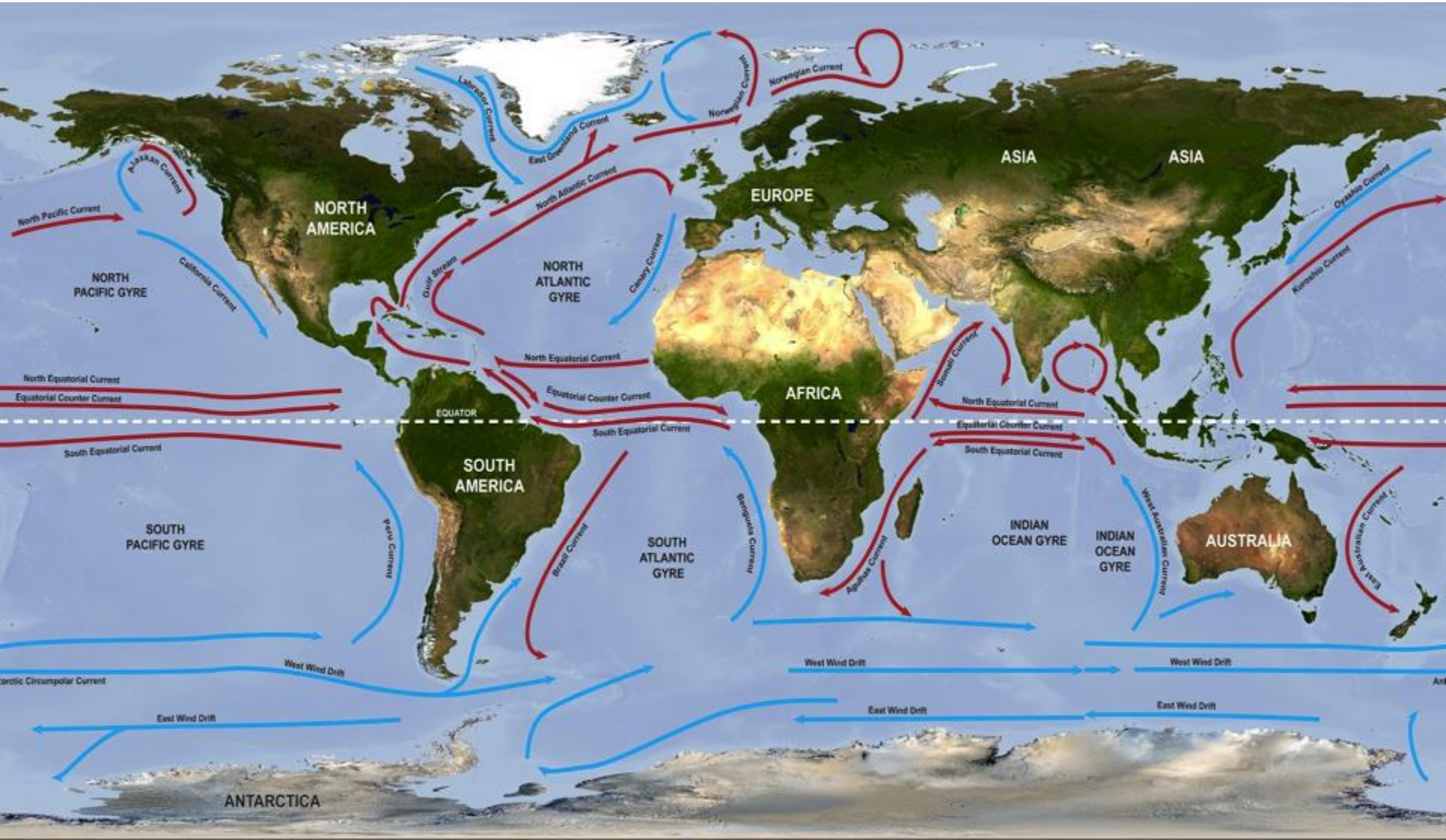
Gulf of Maine and Bay of Fundy

Shape of seafloor restricts water flow resulting in highest tides on earth

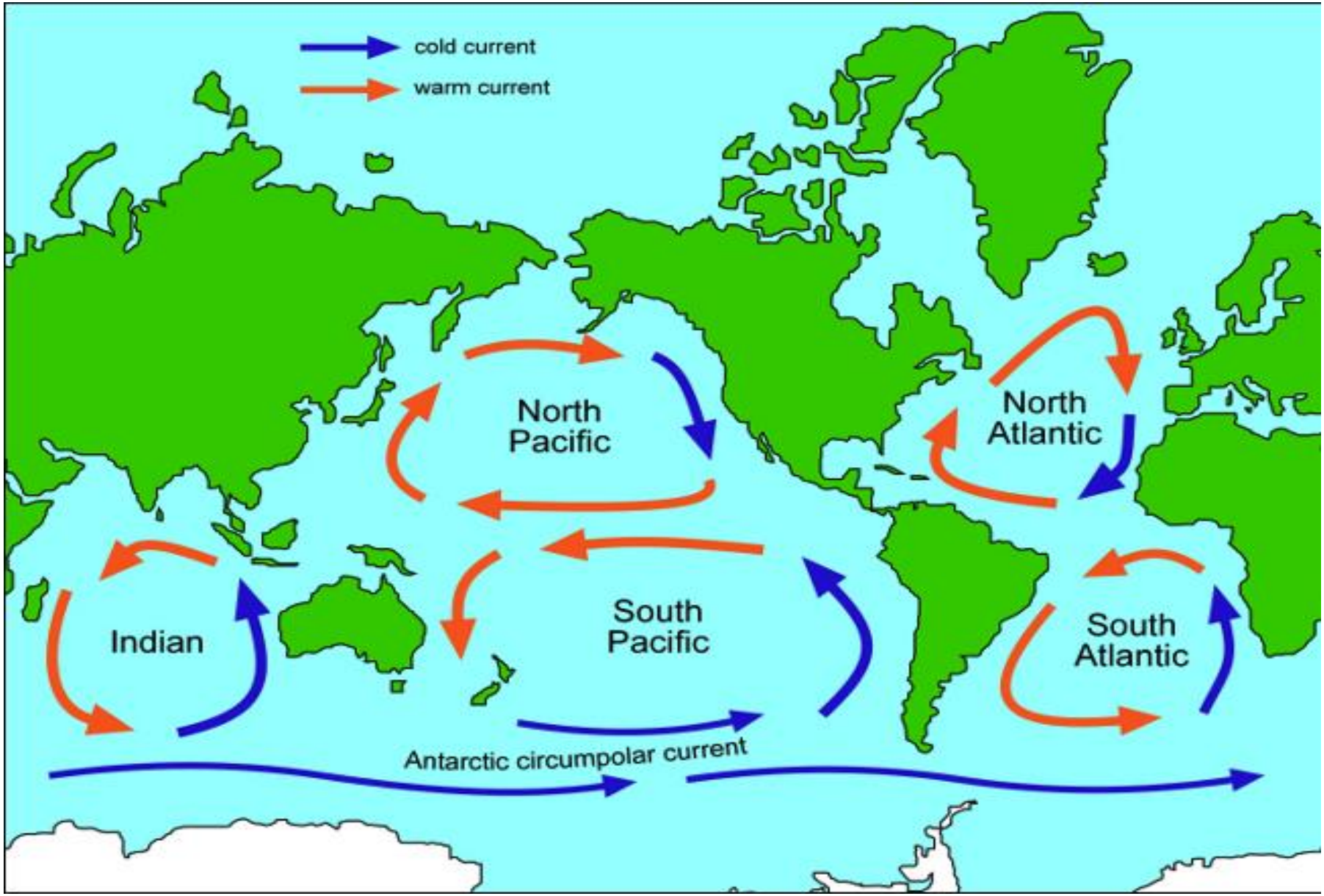




The Result:
Major Ocean Currents

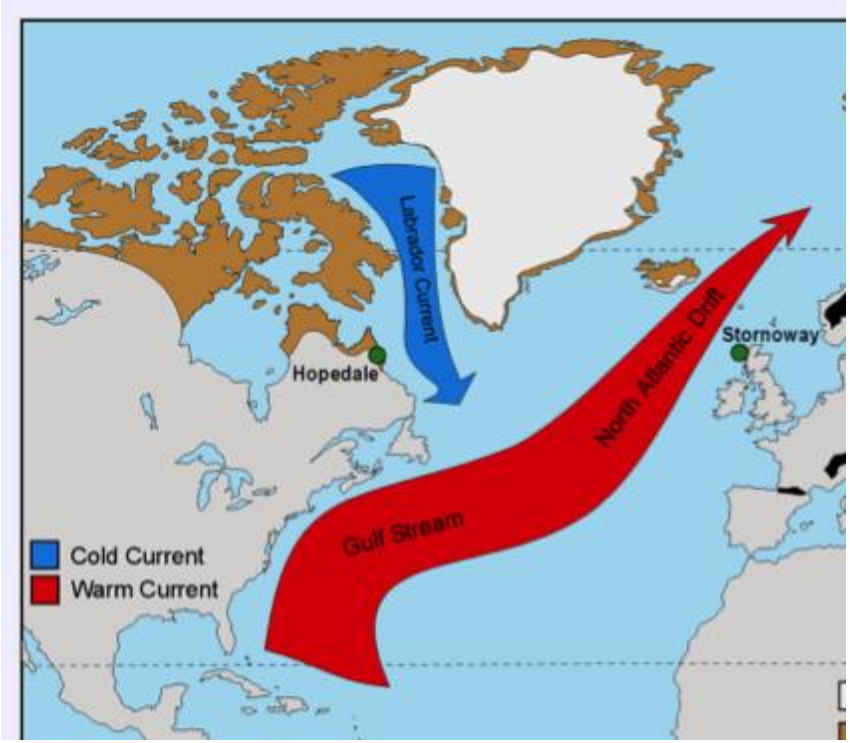


Currents Create 5 Major Ocean Gyres



Why should we care about ocean currents?

- Currents move large amounts of energy and moisture between the ocean and the atmosphere
  - Resulting impact on global weather patterns
  - Example: the Gulf Stream makes Europe warmer than other places at similar latitudes



Why should we care about ocean currents?

Impact on global weather patterns

- Example: The Humbolt Current moves cold water to bring nutrient rich water to Pacific Coast and regulate the climate of Chile
- When disrupted, the climate changes drastically (El Nino)

Why should we care about ocean currents?

- Ocean currents move debris
  - Trash islands
  - Great Pacific Garbage Patch
- Labrador Current moves icebergs into shipping lanes
  - Titanic

Why should we care about ocean currents?

- Important for ocean navigation
  - Avoid obstacles
  - Take advantage of currents to save fuel and time
- Important in the distribution of the ocean's sea life
  - Broadcast spawning – larval distribution
  - migration

How Do Ocean Currents Impact Marine Life?

- My research: how do seaweeds and animals on the rocky beach get the nutrients they need to survive

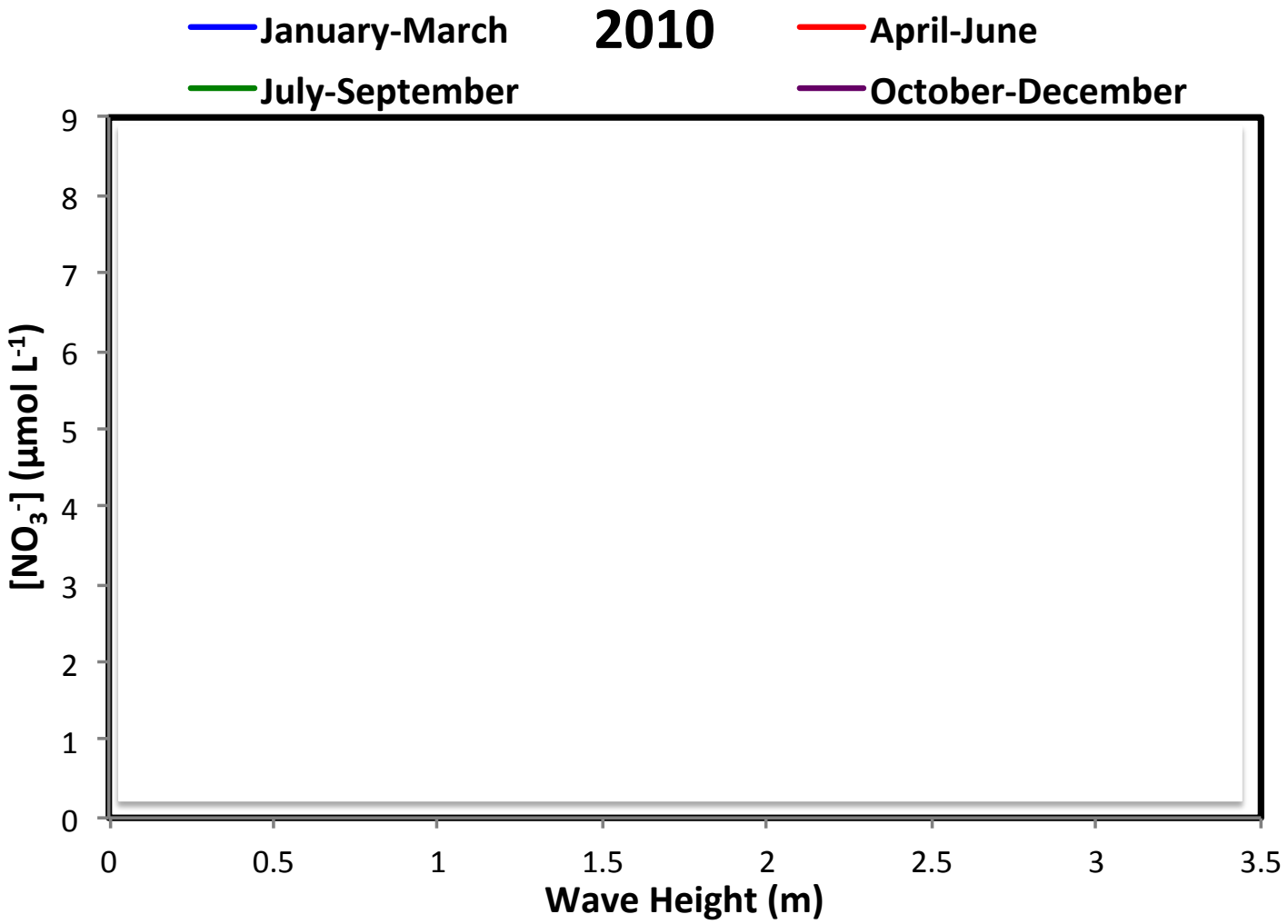
How Do Ocean Currents Impact Marine Life?

- My research: how do seaweeds and animals on the rocky beach get the nutrients they need to survive
- Essential nutrients:
  - Nitrogen
  - Phosphorus
- Trapped in sediments in the deep ocean
- How could waves/currents help to release these nutrients?

How Do Ocean Currents Impact Marine Life?

- Ocean currents combined with tides and waves bring nutrients to the shore
- What is the relationship between waves and nutrient levels?
- Measure:
  - Nutrients (collect water)
  - Waves (data logger buoy)

How Do Ocean Currents Impact Marine Life?



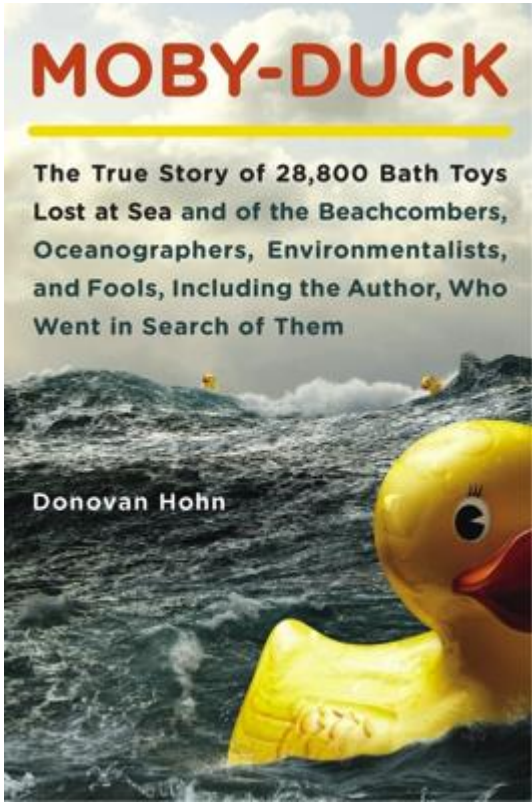
Currents as an Energy Source

- Since water is dense, it carries a large amount of energy
- Water turbines could be used to harvest this energy
- Japan, U.S., China and some European countries are researching this alternative energy source

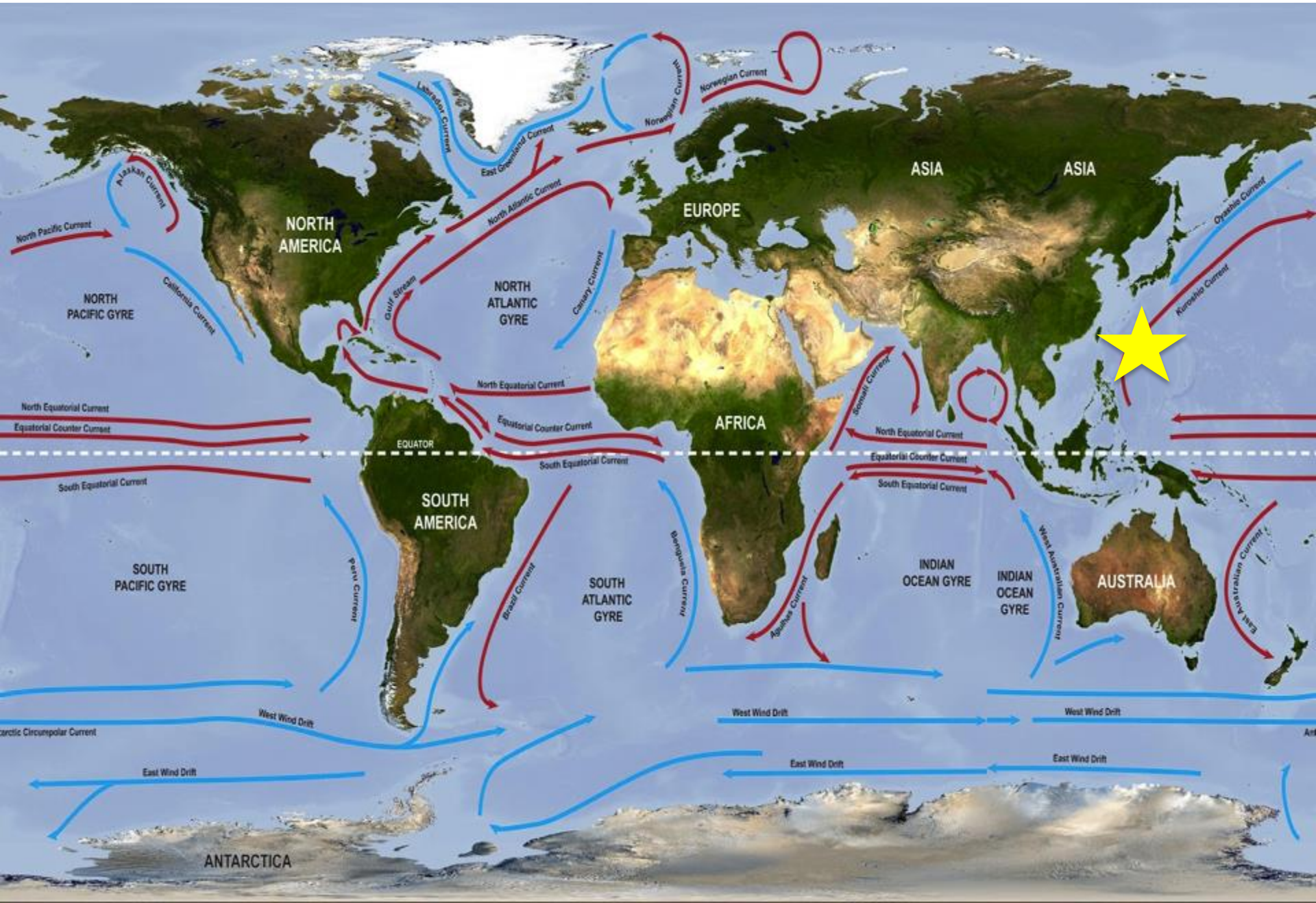
Harnessing tidal energy

The power of ocean currents: transporting flotsam and jetsam

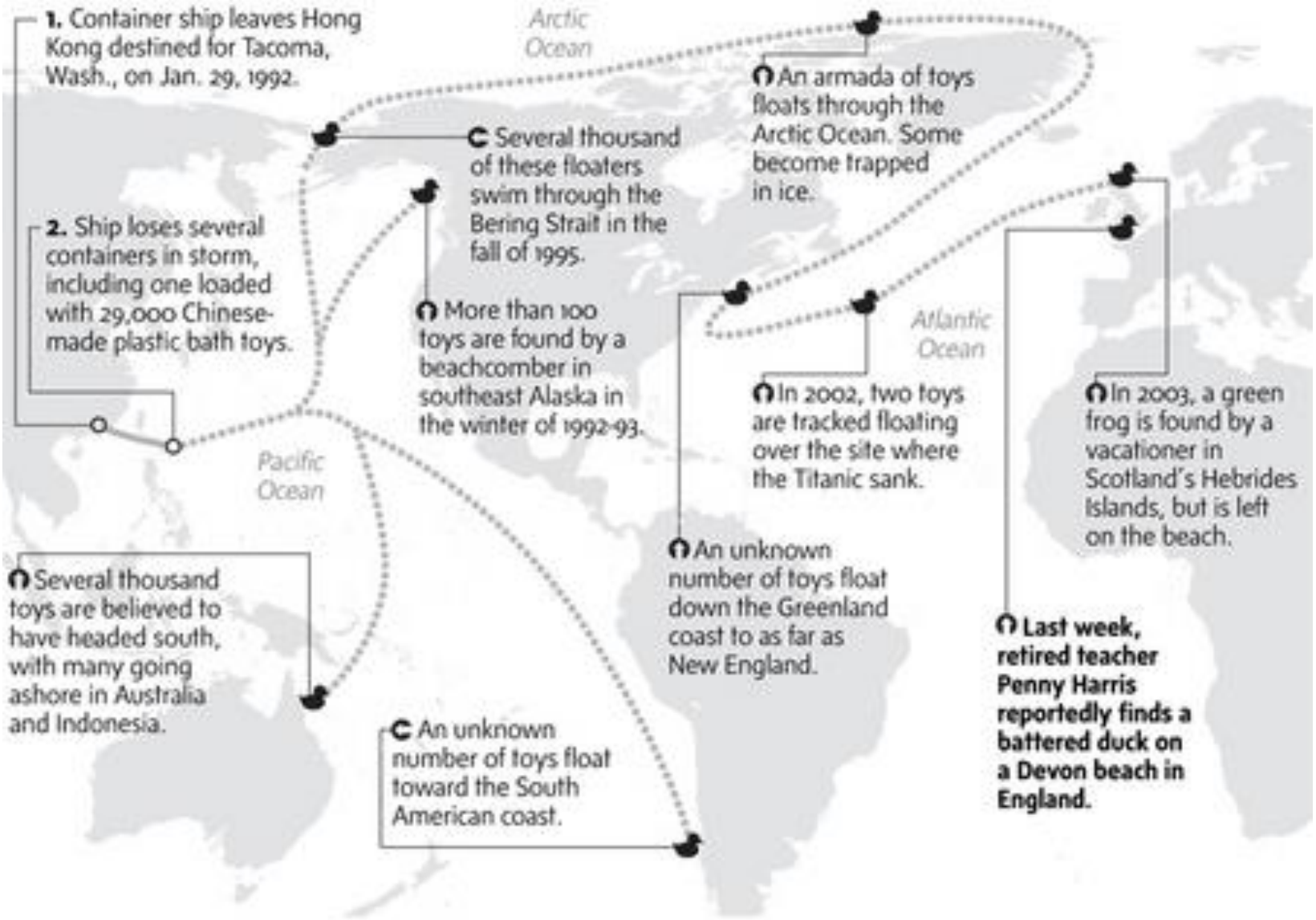
- In 1992 an cargo ship heading from China to the U.S. lost a container, dumping 28,000 plastic bath toys into the sea
- Toys were transported around the globe illustrating the power of ocean currents and inspiring Donovan Hohn's epic journey to follow the toys around the world



Where did the ducks land?



Where they ended up…



MIKE FAILLE/THE GLOBE AND MAIL ▶ SOURCE: SPIEGEL ONLINE