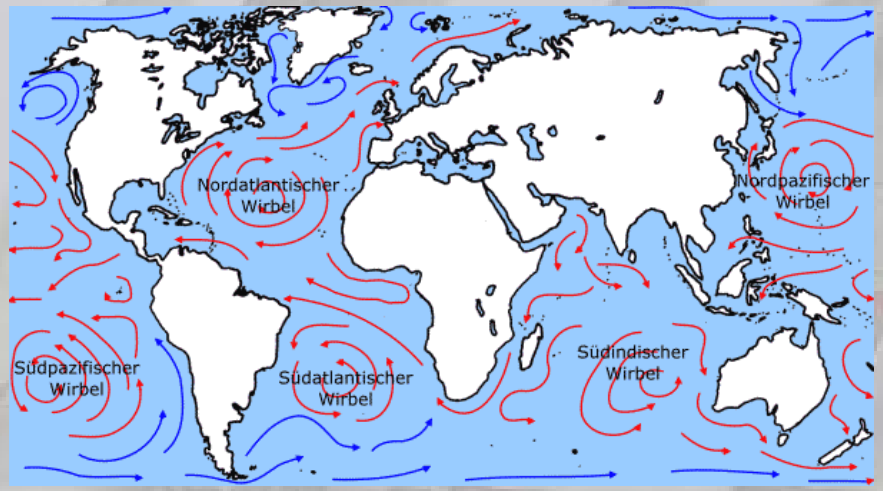
Ocean currents

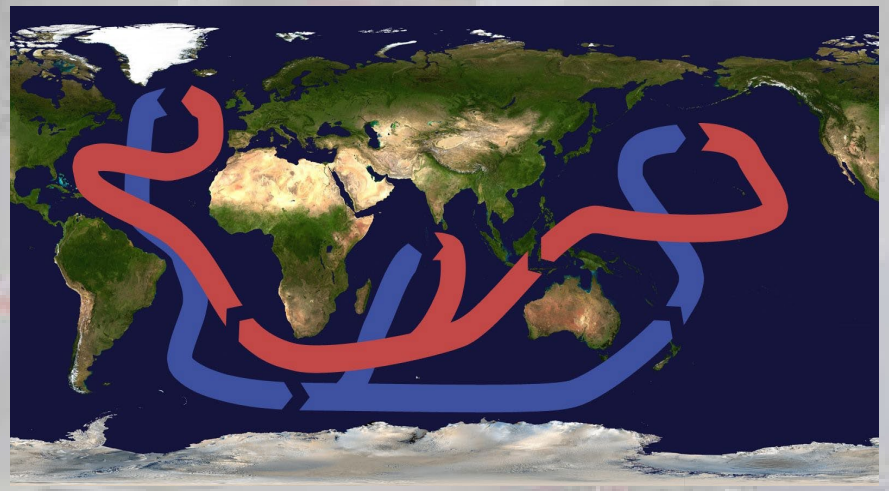
Formation of surface currents

- Wind driven by global circulation
- Tides

Formation of deep water currents

- Density differences due to water temperature and salinity
- Topographic conditions of seafloor





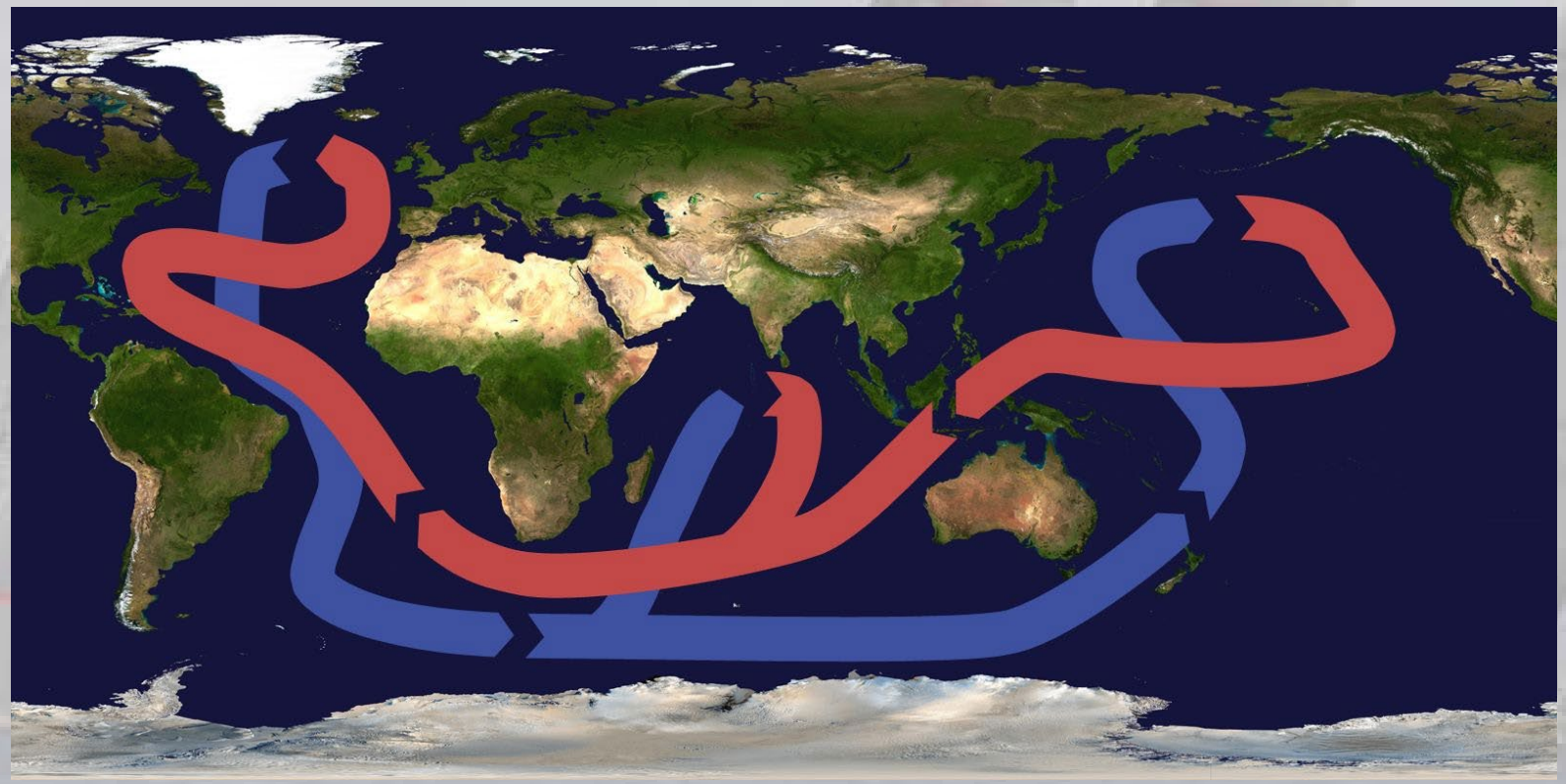
Whereas winds are designated after the direction they are blowing from, ocean currents are designated after the direction they are flowing to.

Deep water currents ‘Global Conveyor Belt‘

‘Global conveyor belt‘ is a constantly moving system of deep-ocean circulation

Formed and driven by by sinking of water of high density in Polar areas

- Low temperature
- High salinity (brine during formation of ice)
- Time for once around the world: 1000 years

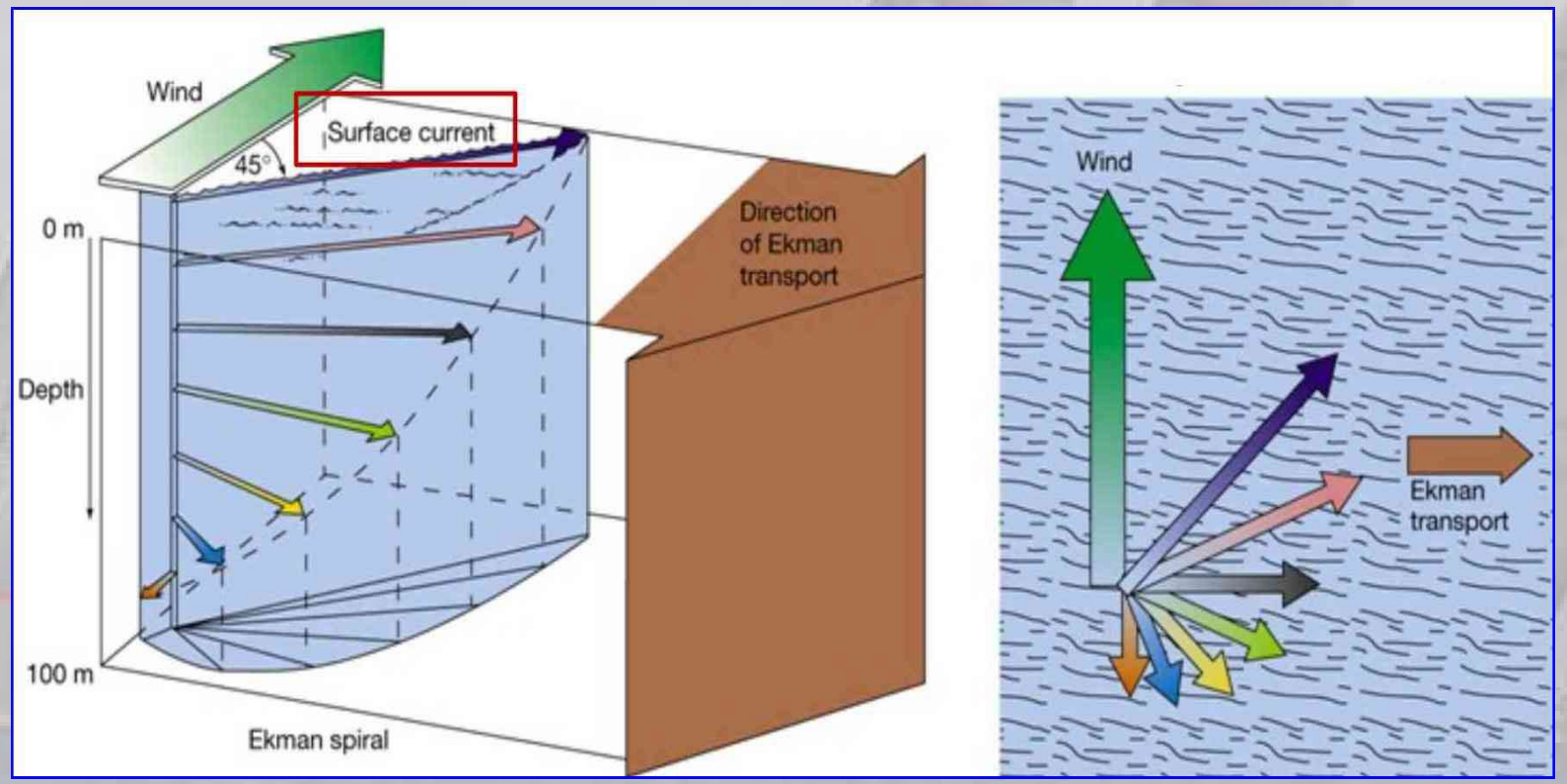


SURFACE CURRENTS EKMAN - LAYER

Wind driven surface currents

Direction of surface current due to Coriolis force — 45° to the right of wind direction (NH)

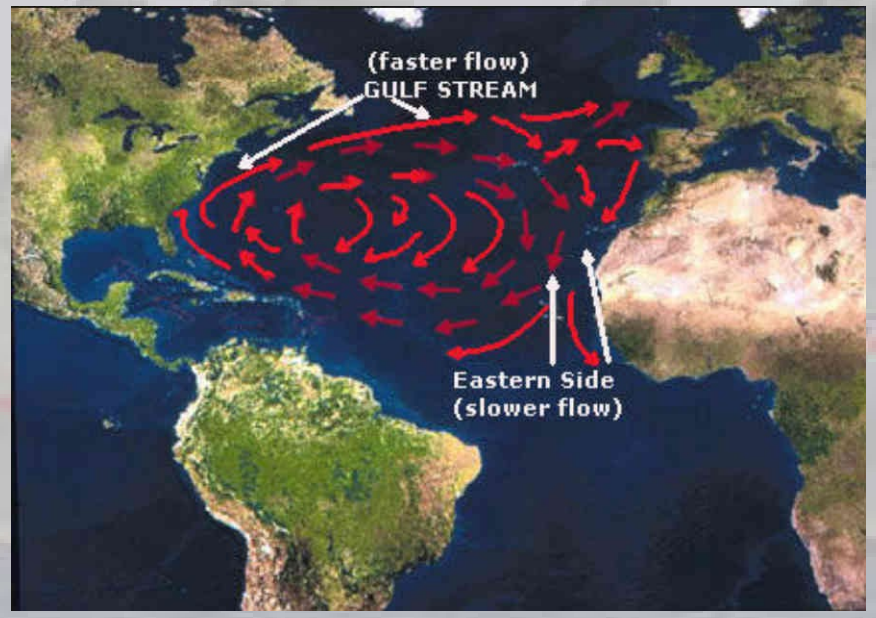
Direction of mass transport (depth 0 – 50 m) — 90° to the right of wind direction (NH)

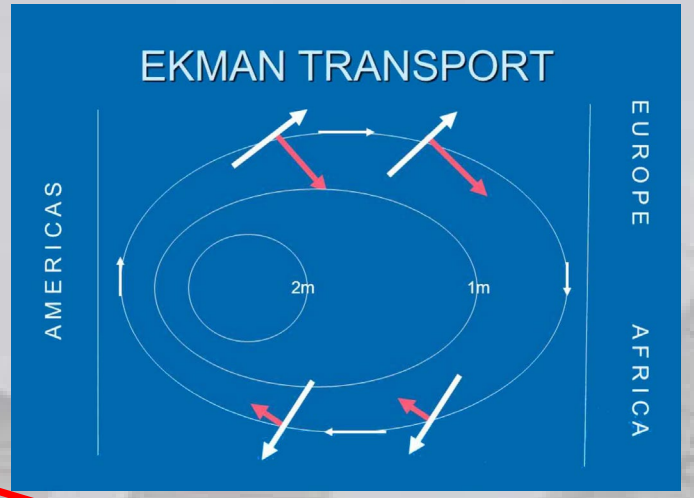


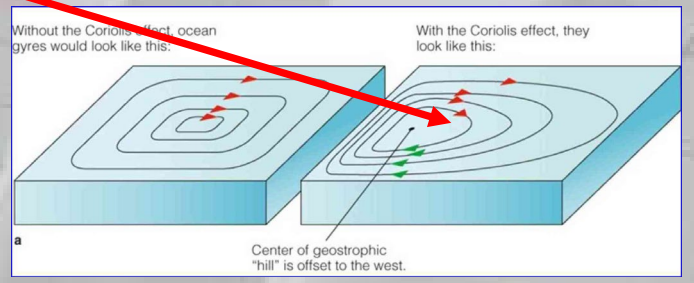
Atlantic Gyre

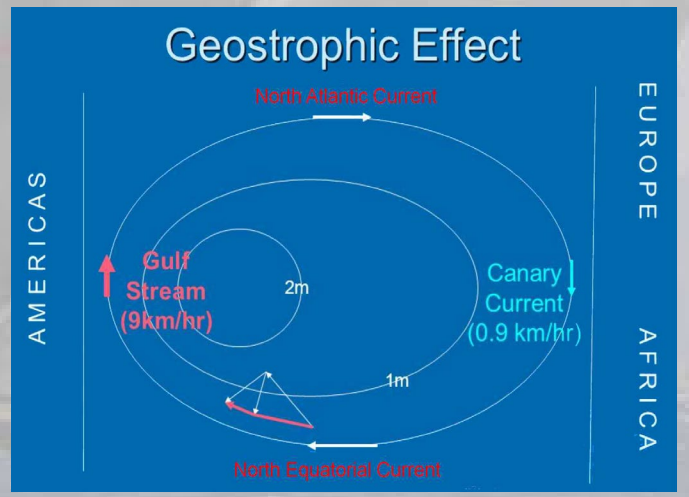
Atlantic circulation is driven by …

- Global circulation (Trade winds, West wind zone)
- Ekman transport 90° to the right
- Forming of an asymmetric water hill‘
- Resulting in higher gradients in the west
- ‘Westward Intensification‘ (auch Kuro Shio, Pazific)





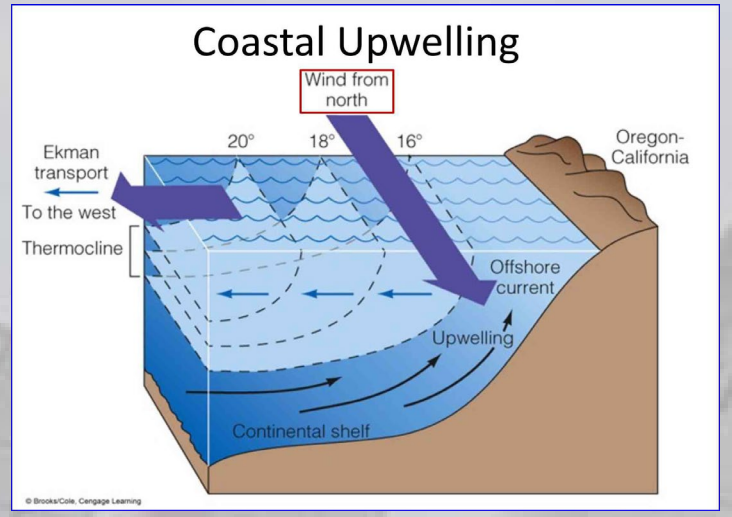




Ocean currents Upwelling

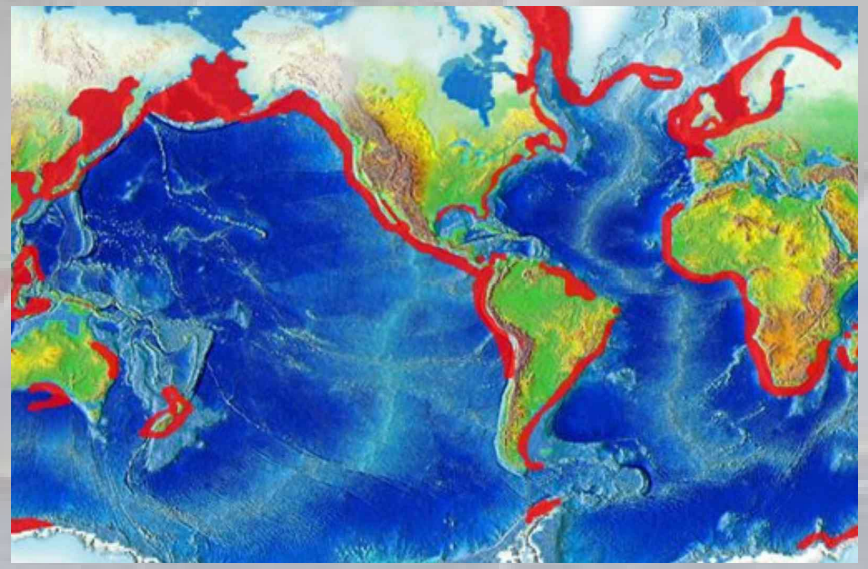
Upwelling

- Winds parallel to the coast, land to the left (NH)
- Off-shore currents driven by Ekman transport
- Upwelling of deep-water (cold), rich in nutrients
- Good for fish and fishermen …



Upwelling is the reason for the typical cold water areas

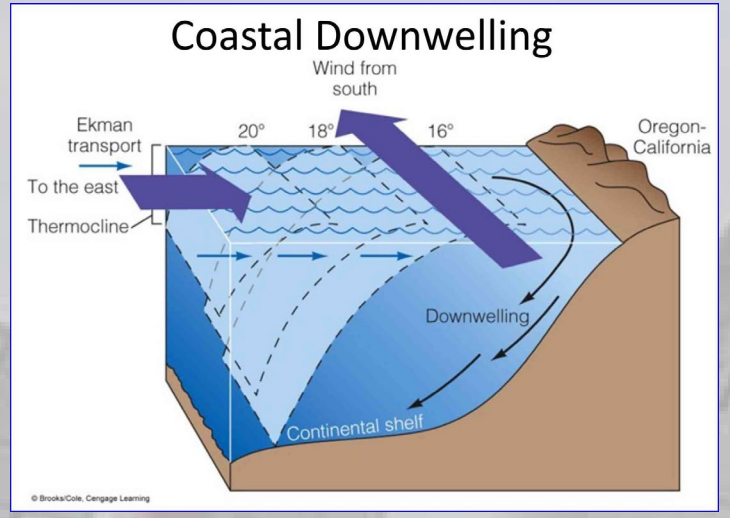
- W-Africa Canary current
- S-Africa Benguela current
- S-America Humboldt current
- N-America California current



Ocean currents Downwelling

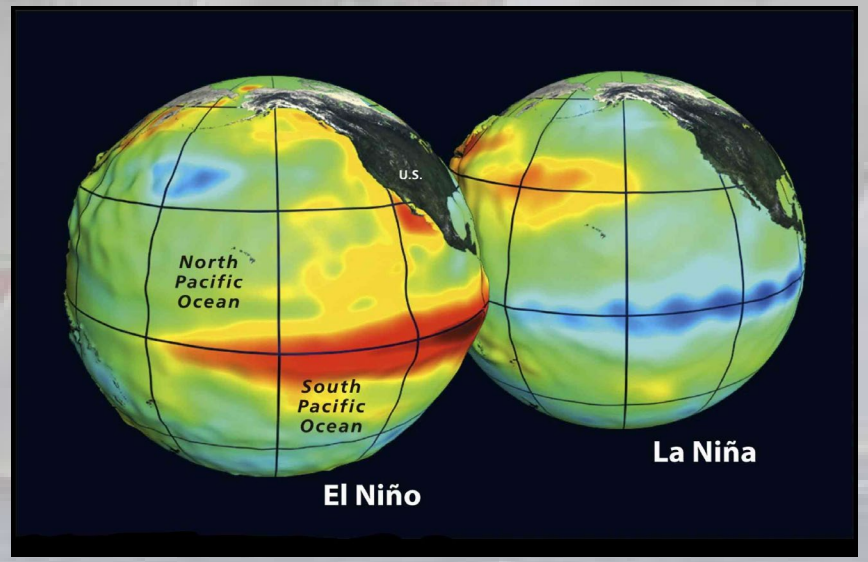
Downwelling

- Winds parallel to the coast, land to the right (NH)
- On-shore currents driven by Ekman-transport
- Downwelling of warm coastal surface water
- Non-appearance of nutritious deepwater
- Bad for fish and fishermen: low in nutrients



Downwelling is the exception due to atmospheric oscillations

- ENSO El Niño Southern Oscillation
- More rain over Peru
- Part of the global conveyor belt

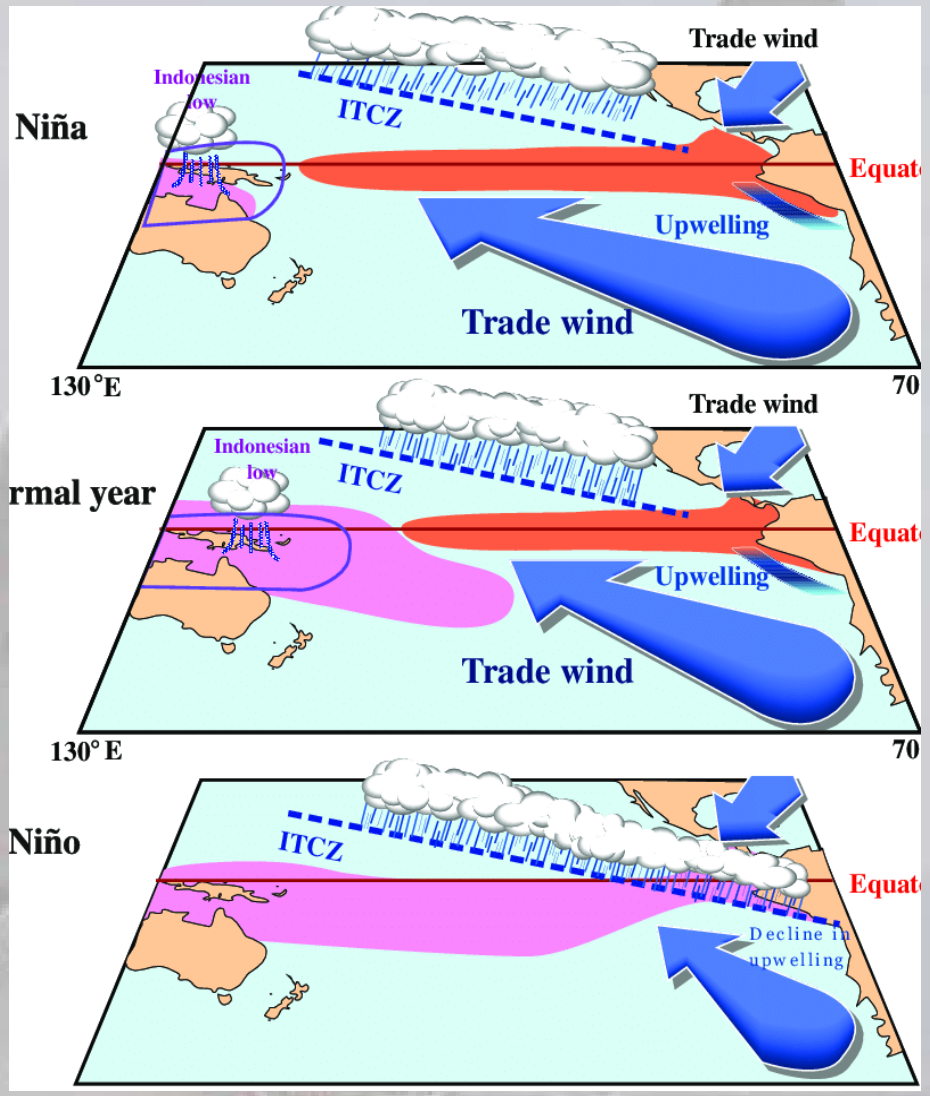


Ocean currents Downwelling

ENSO El Niño Southern Oscillation

Downwelling is the exception due to atmospheric oscillations

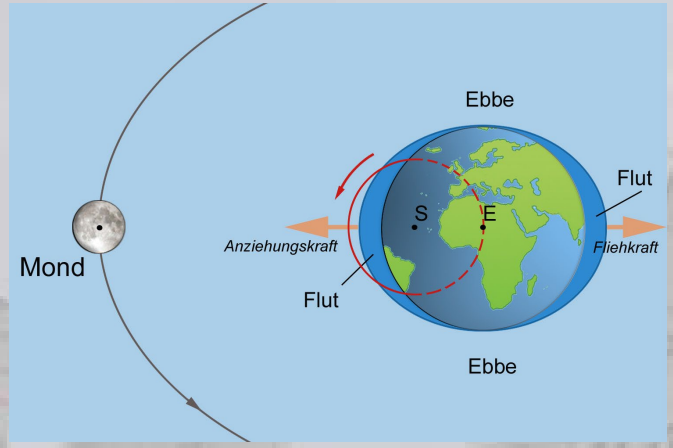
- ENSO El Niño Southern Oscillation
- El Niño is an abnormal weather pattern caused by warming of Pacific water
- During El Niño Trade winds weaken, warm water is pushed eastwards towards the coast of Peru
- During El Niño the water is less nutrious, therefore poor fishing conditions
- Upwelling during La Niña brings cold nutritious water, good for fishery
- Part of the global conveyor belt
- El Niño / La Niña in a nutshell

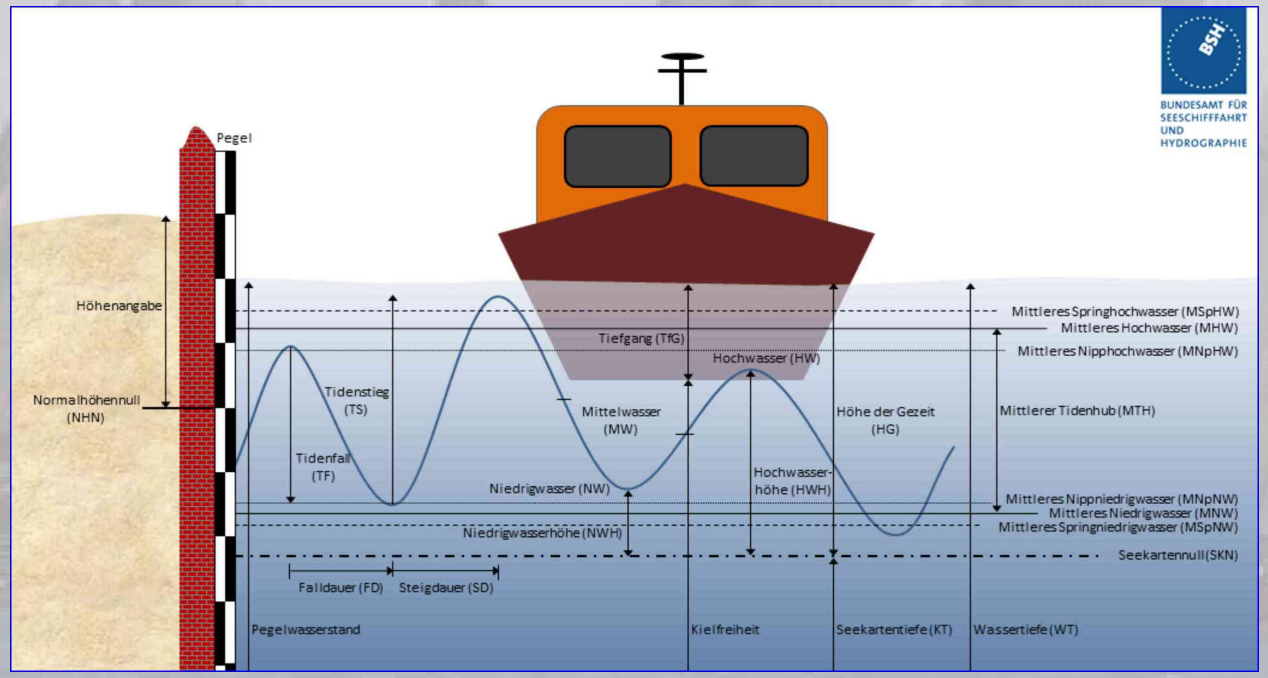


TIDES

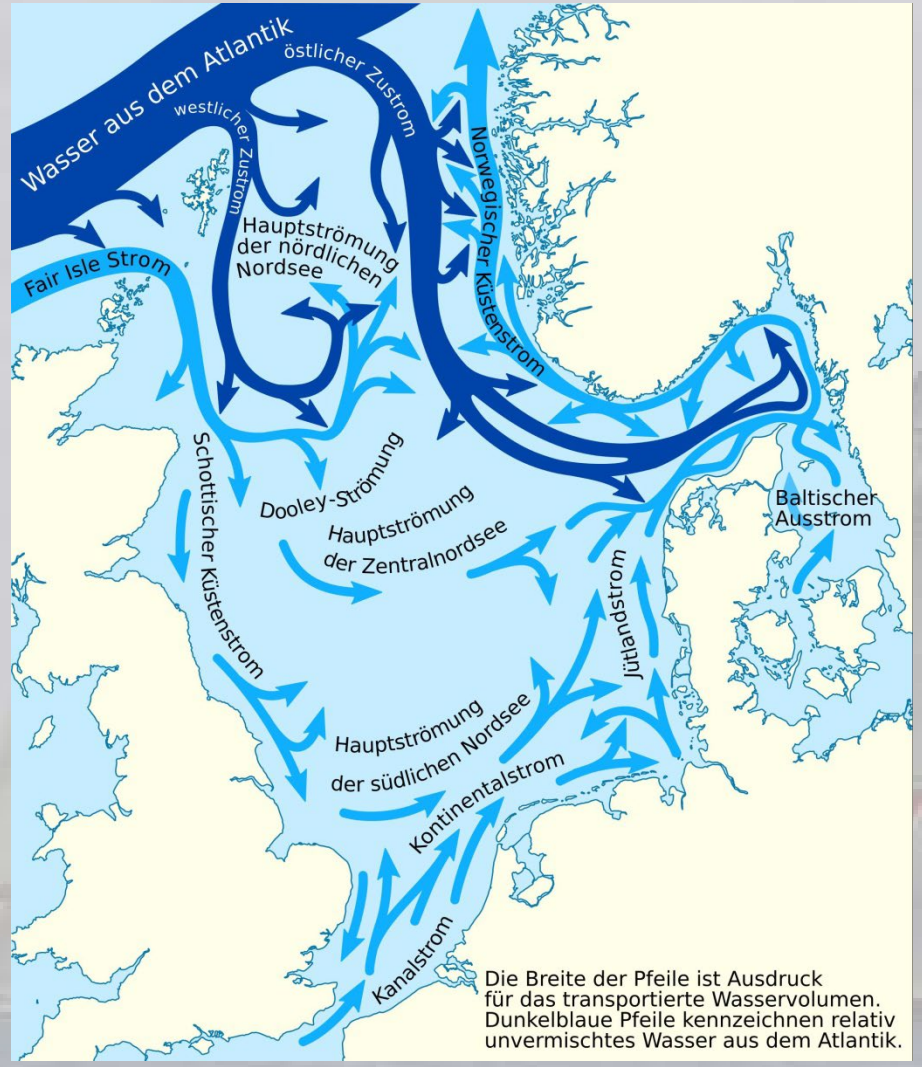
Tides …

- Cause: Gravitation of the moon
- Dead tide Sun – moon 90°
  - crescent
- Spring tide Sun – moon – Earth inline
  - Full moon and new moon
  - Difference to normal tide 10%



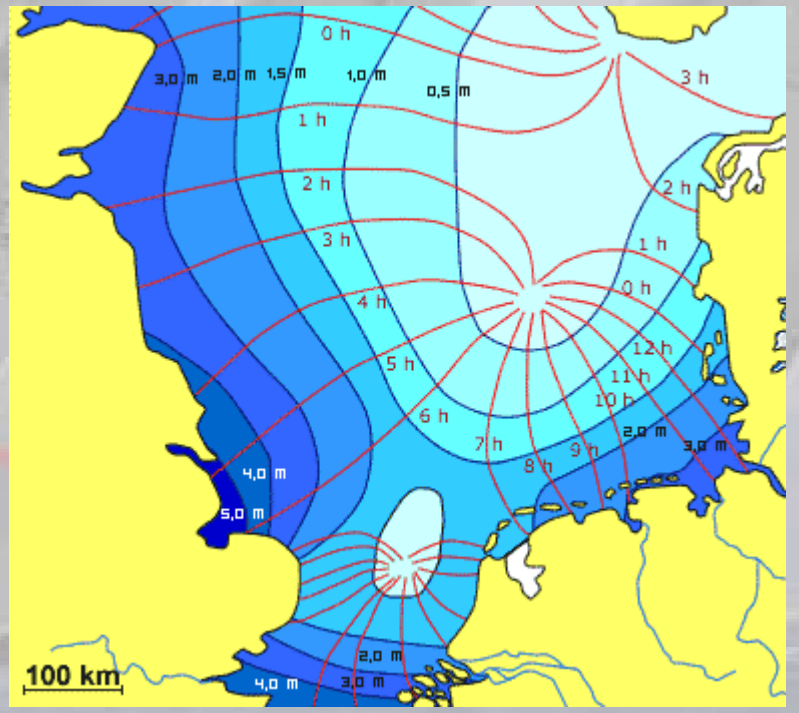


OCEAN AND TIDAL CURRENTS NORTHSEA



Different times of high tide

Amphidromic point (Tidal range = 0)

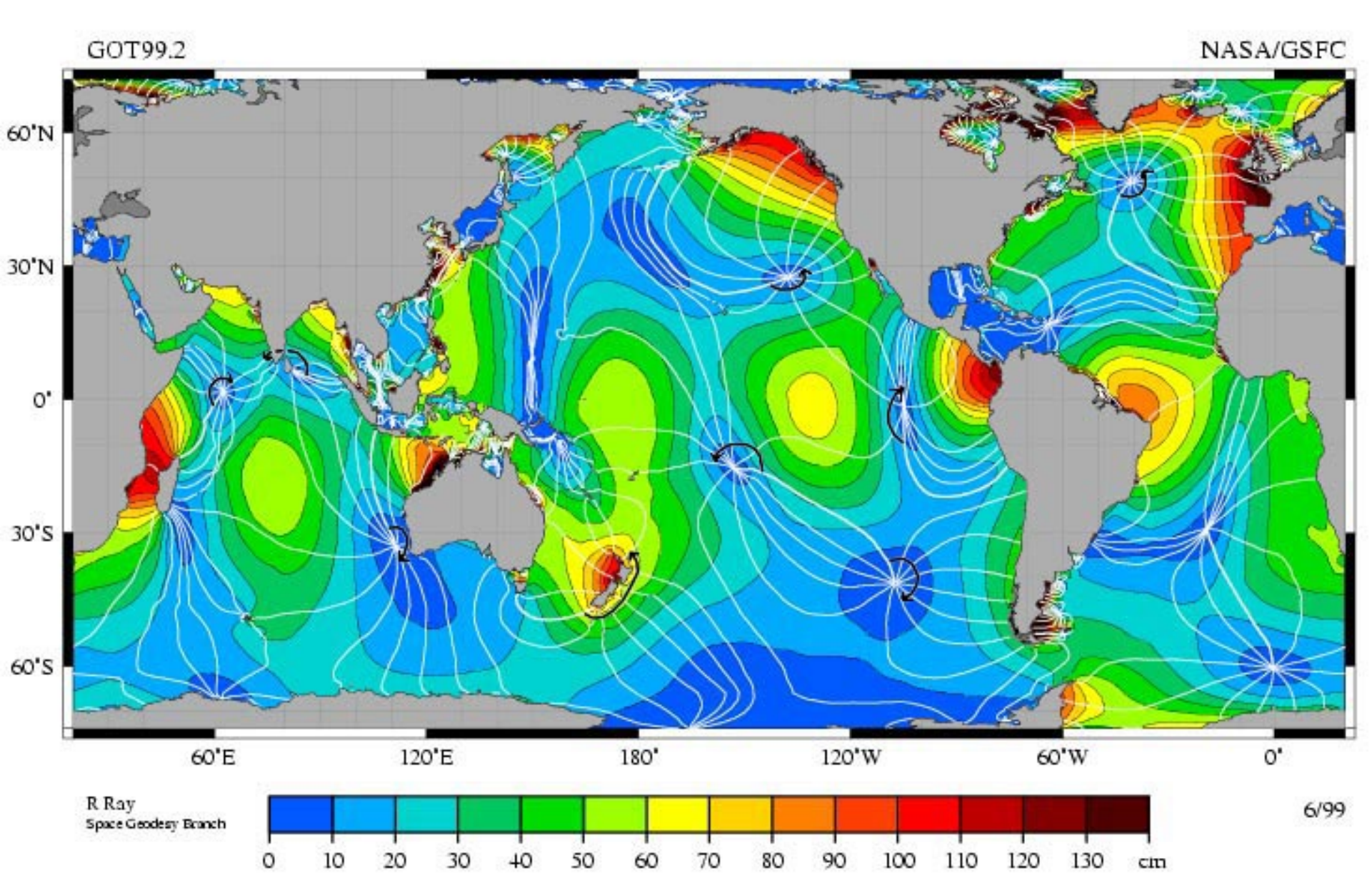


CHARACTERISTICS OF TIDAL CURRENTS

Tidal range	typical values
Baltic sea	30 cm
North sea	2-3 m
Mediterranean sea	30 cm
Saint-Malo	15 m
Fundy Bay	15 m
Chesapeak Bay	15 m

Tidal currents	
Saltraumen NOR	20 kt+
Str. of Alderney	12 kt+
Ramsey Island Wales	10 kt

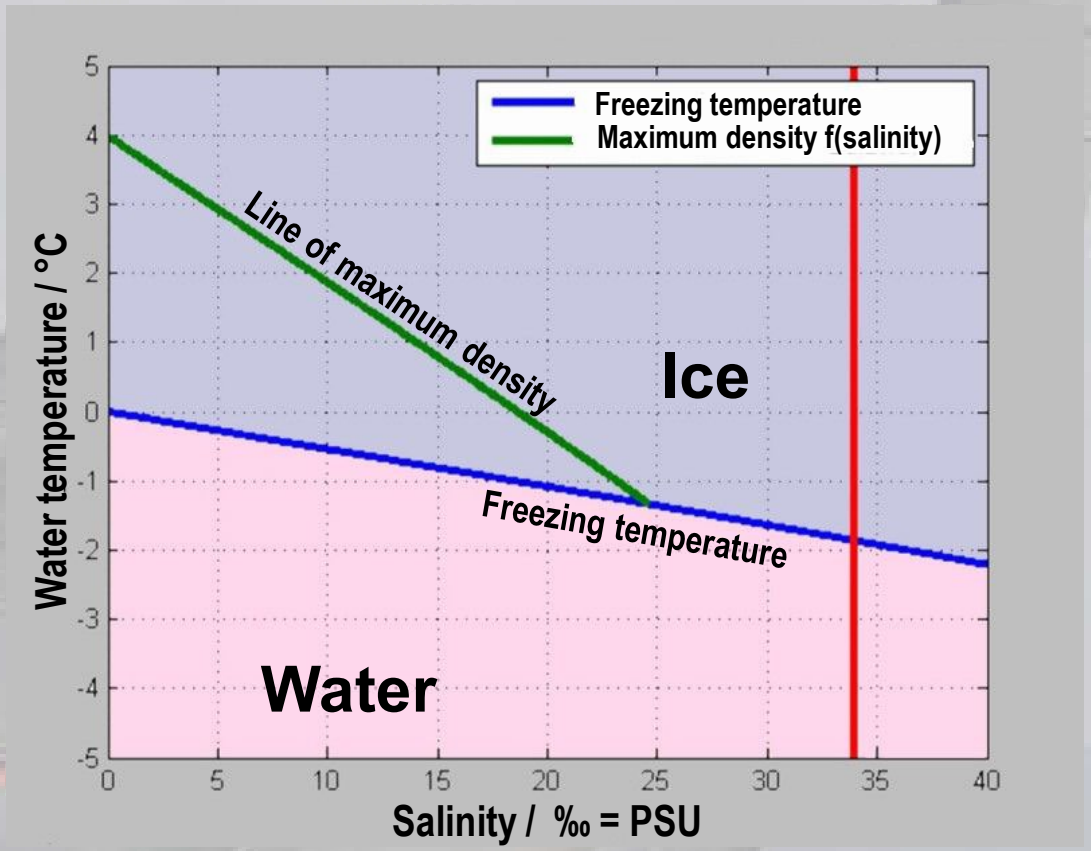
AMPHIDROMIC POINTS (TIDAL RANGE = 0)



FORMING OF SEA ICE

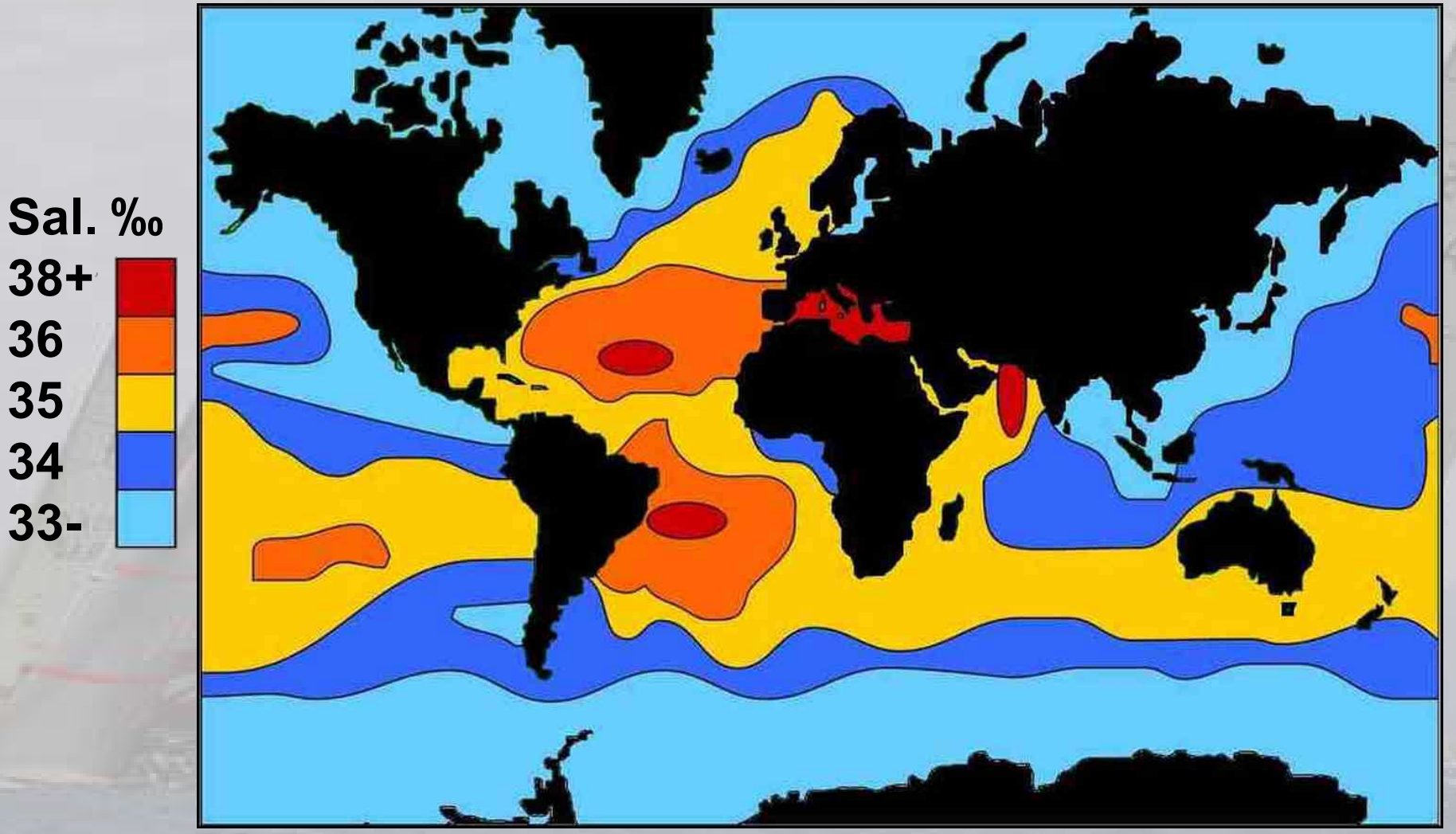
Water density f (temperature, salinity)
Freezing point f (salinity)

	Salinity	$T_{FREEZING}$
Fresh water	0 ‰	0.0 °C
Baltic sea water	5 ‰	- 0.3 °C
Sea water	35 ‰	- 1.7 °C

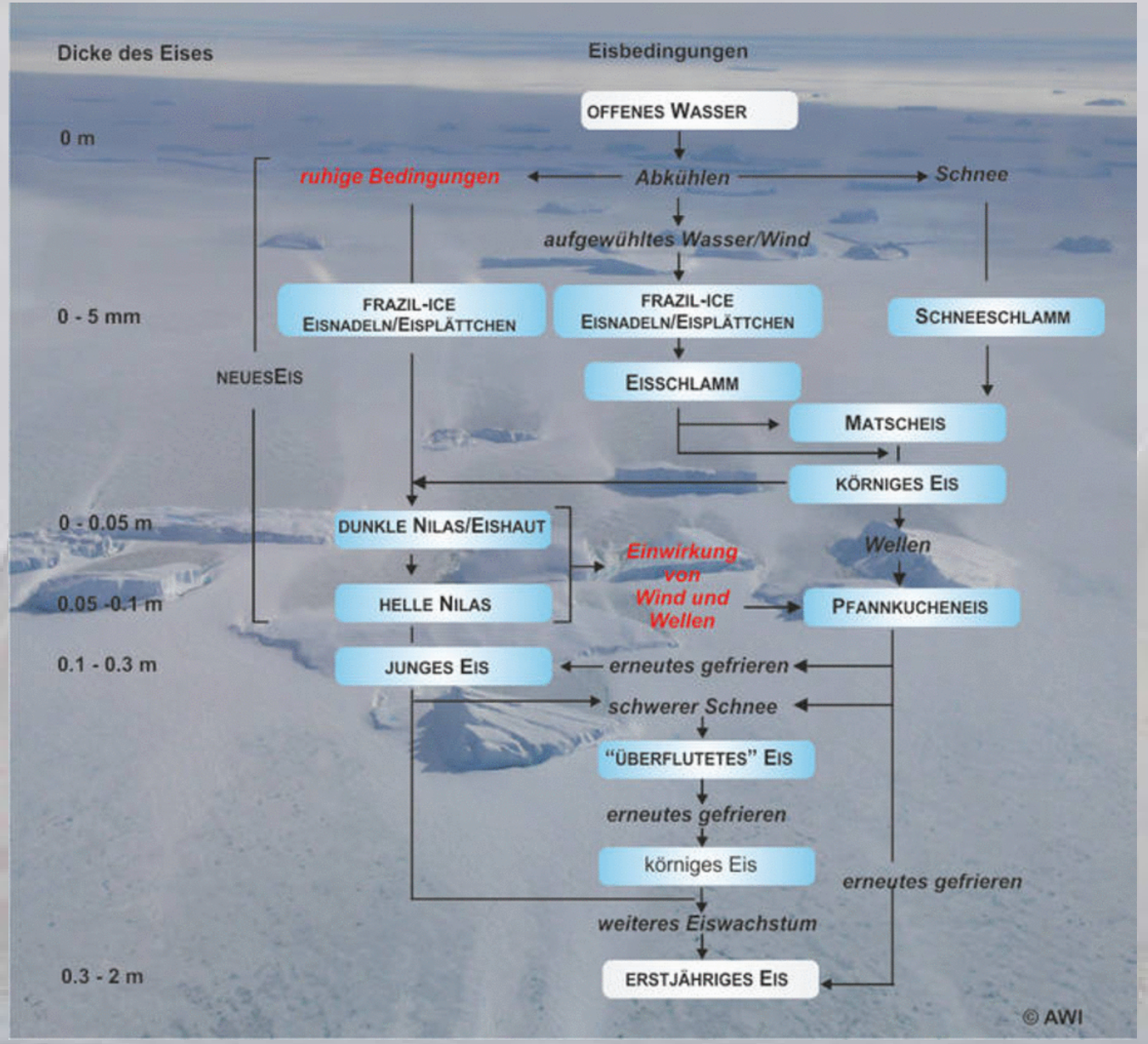


Consequence:
Baltic sea sometimes covered by ice

Salinity of Oceans

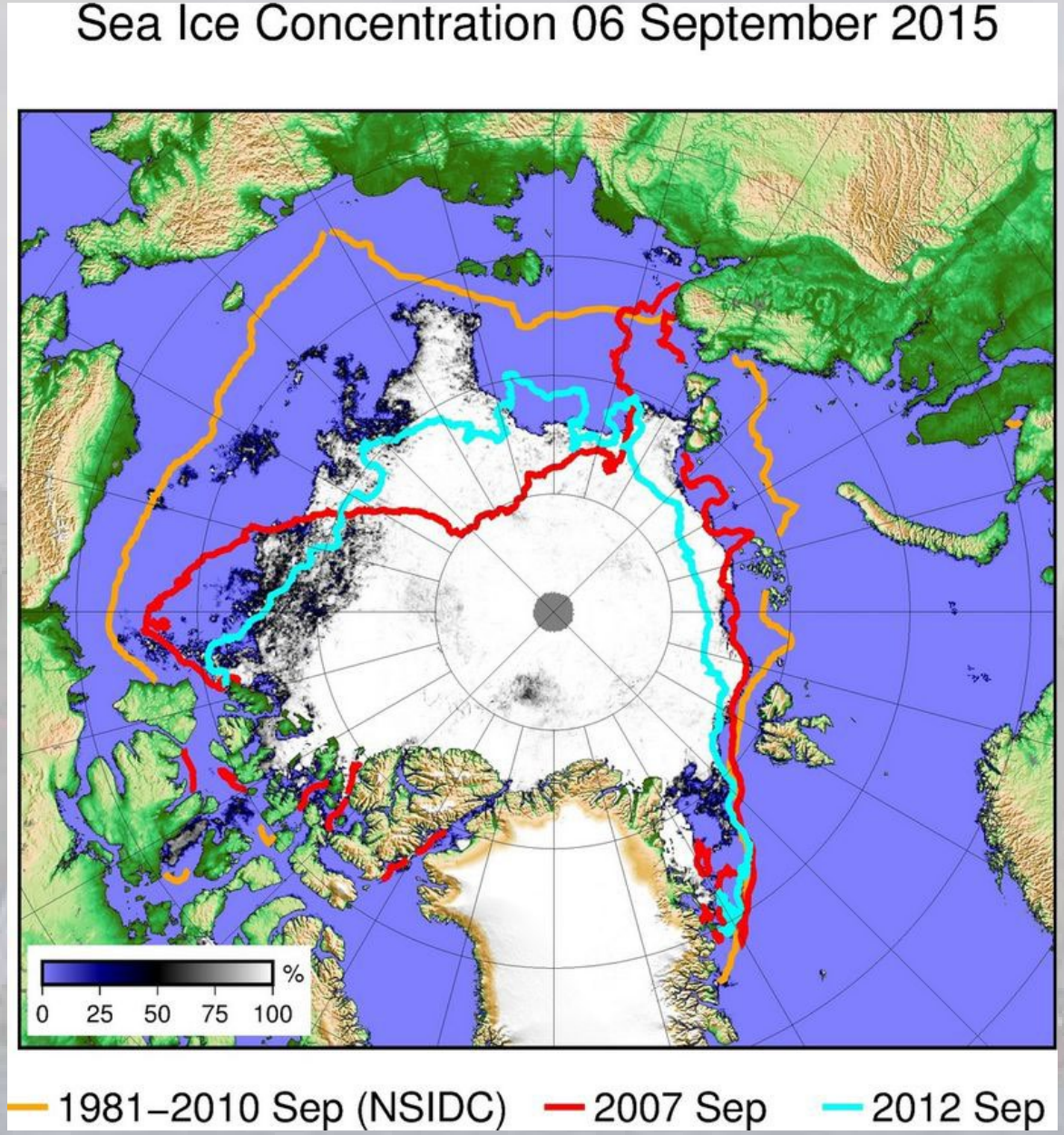


FORMING OF SEA ICE

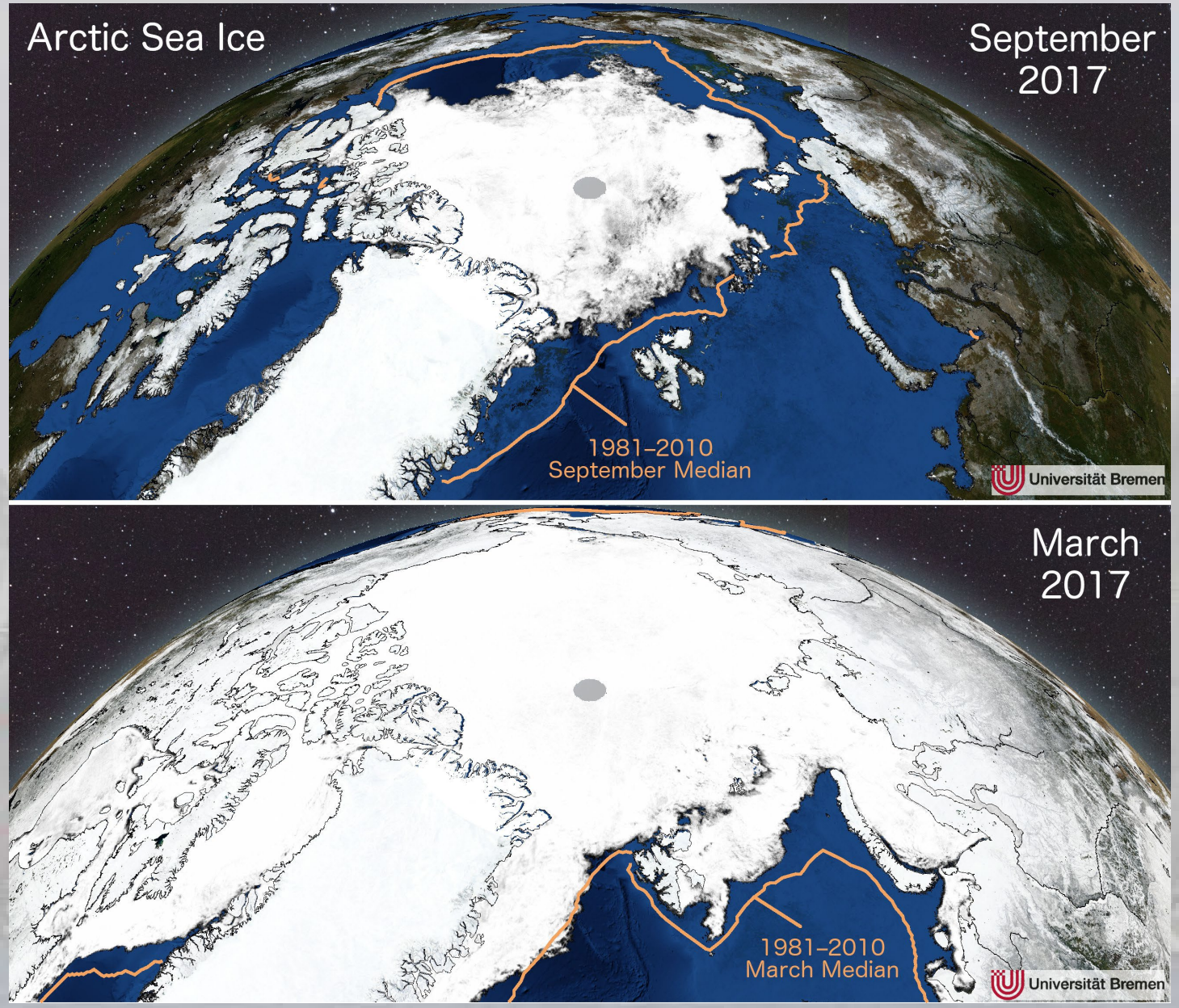


Forming of sea ice: pancake ice

ICE COVER ARCTIC 2015



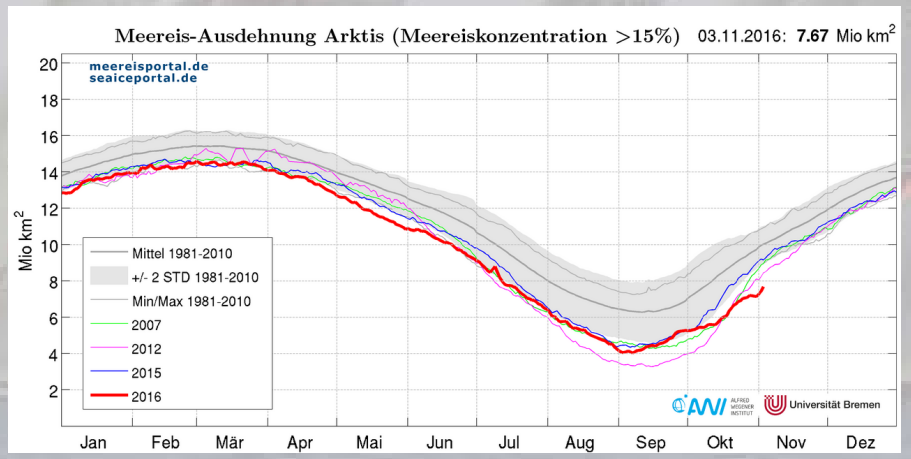
ICE COVER ARCTIC SUMMER - WINTER



CLIMATOLOGY OF ARCTIC ICE COVER

Annual variation of Arctic ice cover 1981 – 2016

Minimum in September



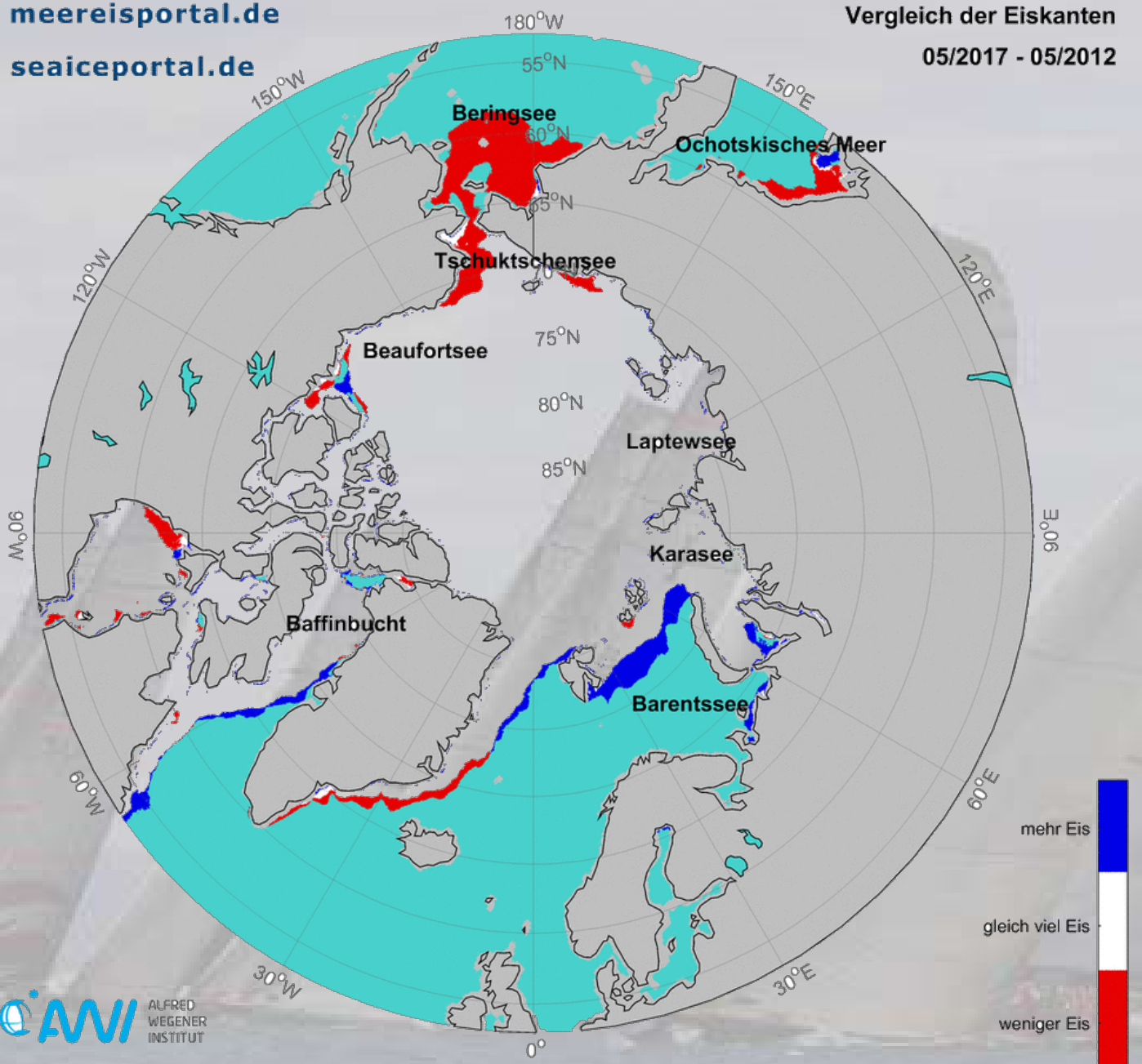

ALASKA
(USA)
KANADA
Ausdehnung am
04.09.2012
Position der
„Polarstern“
RUSSLAND
Lomonossow-Rücken
NORDPOL
Durchschnittliche
Ausdehnung am
gleichen Tag
im Zeitraum
1979-2000
GRÖNLAND
(Dänemark)
Nordwestpassage
Position der
„Maria S. Merian“
Nordostpassage

meereisportal.de

seaiceportal.de

Vergleich der Eiskanten

05/2017 - 05/2012



mehr Eis

gleich viel Eis

weniger Eis

AWI ALFRED WEGENER INSTITUT

Universität Bremen

Sensors: AMSR-E, SSMIS, AMSR2

QUESTIONS YOU SHOULD BE ABLE TO ANSWER OCEANS & CURRENTS

Please check vorticity – ENG – MISCellaneous
https://www.vorticity.de//vorticity_en.php#0_ANKER_V

- ✓ What is the Ocean Global Conveyor belt?
  - ✓ A global water circulation originating from sea ice forming in the Arctinc, which is associated with sinking of very salty (therefore higher density i.e. heavy) water (brine) – the ice formed is not salty!
  - ✓ The Global Conveyor Belt extends all over the World and goes deep to the seafloor
  - ✓ The typical time for a full cycle is thousands of years.

- ✓ What is the reason for areas of upwelling water near continental coasts?
  - ✓ Wind blowing continuously parallel to the coast (Trade winds typically) with a resulting drift (transport) of surface water away from the coast thus triggering upwelling

- ✓ Why is the direction of transport of surface water not in wind direction?
  - ✓ The Coriolis force deflects it to the right (NH!), 45° at surface, 90° upper layer down to 50m

Questions you should be able to answer Oceans & Currents

- ✓ What is Westward intensification?
  - ✓ Westward intensification describes the currents in oceanbasins, which have a higher velocity in the Western parts (e.g. Gulfstrean, Kuroshio). The reason is the Coriolis Force and the fact, that the water is pushed westward by the easterly winds on the southern edge of subtropical anticyclones

- ✓ What causes Tides
  - ✓ The gravitational force of the moon

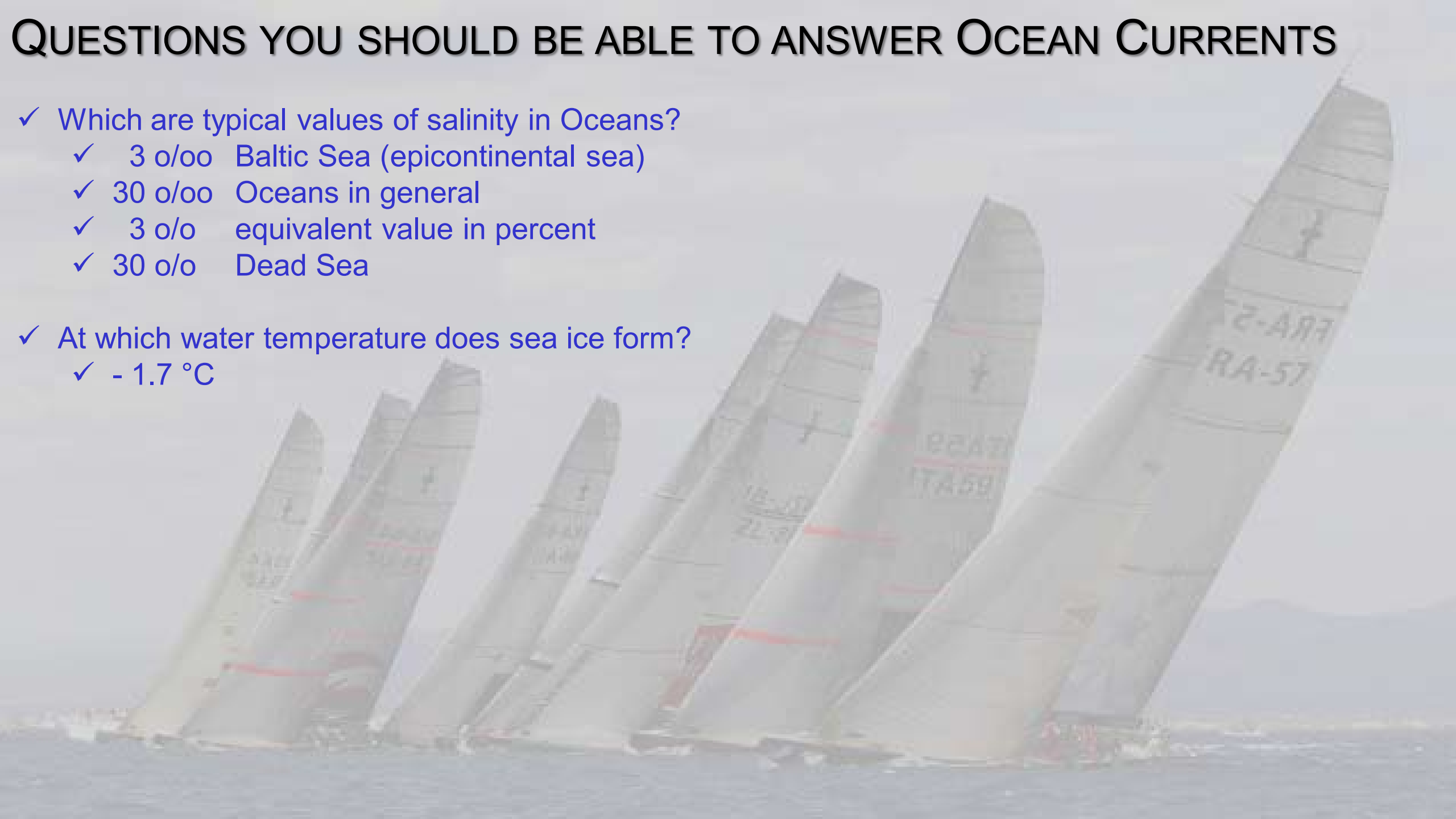
- ✓ When do spring tides and and dead tides occur?
  - ✓ Spring tides occur when Sun–Moon–Earth are in line, i.e. full moon / dead moon
  - ✓ Dead tides occur when Sun–Moon–Earth are in 90° angle, i.e. descent / crescent half moon

- ✓ What is an Amphidromic Point?
  - ✓ Amphidromic Point is a point around which the tidal currents flow and which has itself no tidal range.

Questions you should be able to answer Ocean Currents

- ✓ Which are typical values of salinity in Oceans?
  - ✓ 3 o/oo Baltic Sea (epicontinental sea)
  - ✓ 30 o/oo Oceans in general
  - ✓ 3 o/o equivalent value in percent
  - ✓ 30 o/o Dead Sea

- ✓ At which water temperature does sea ice form?
  - ✓ - 1.7 °C



QUESTIONS YOU SHOULD BE ABLE TO ANSWER

- ✓ How
  - ✓ 1.
- ✓ How
  - ✓ 1.
- ✓ How
  - ✓ 1.
- ✓ How
  - ✓ 1.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