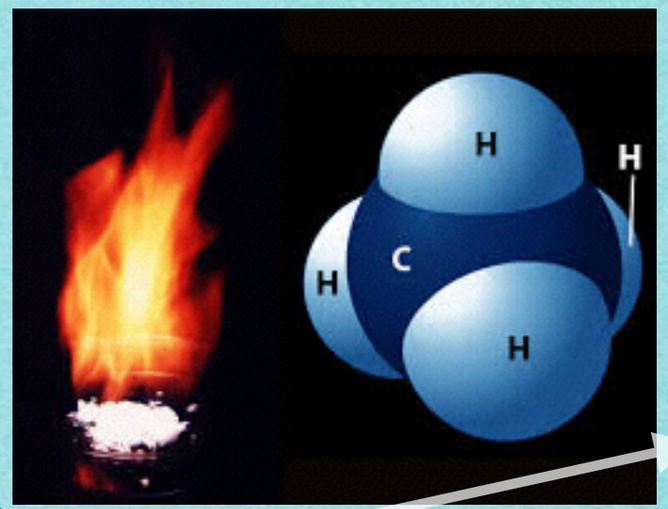
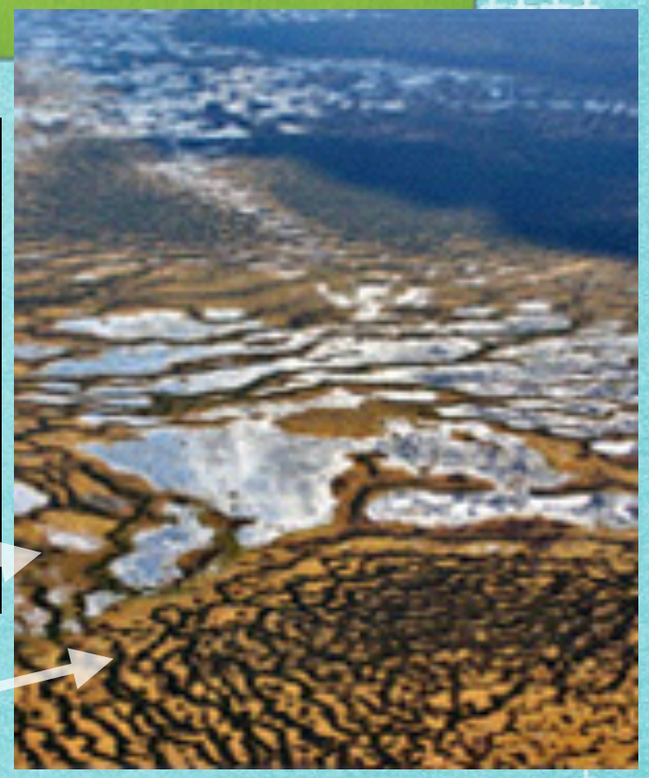
# *Boyle's Law*

*Focus: Methane (gas), which is a green house gas, is trapped in our ocean floor as a methane hydrate (solid).*

# Intro to Methane ($CH_4$)

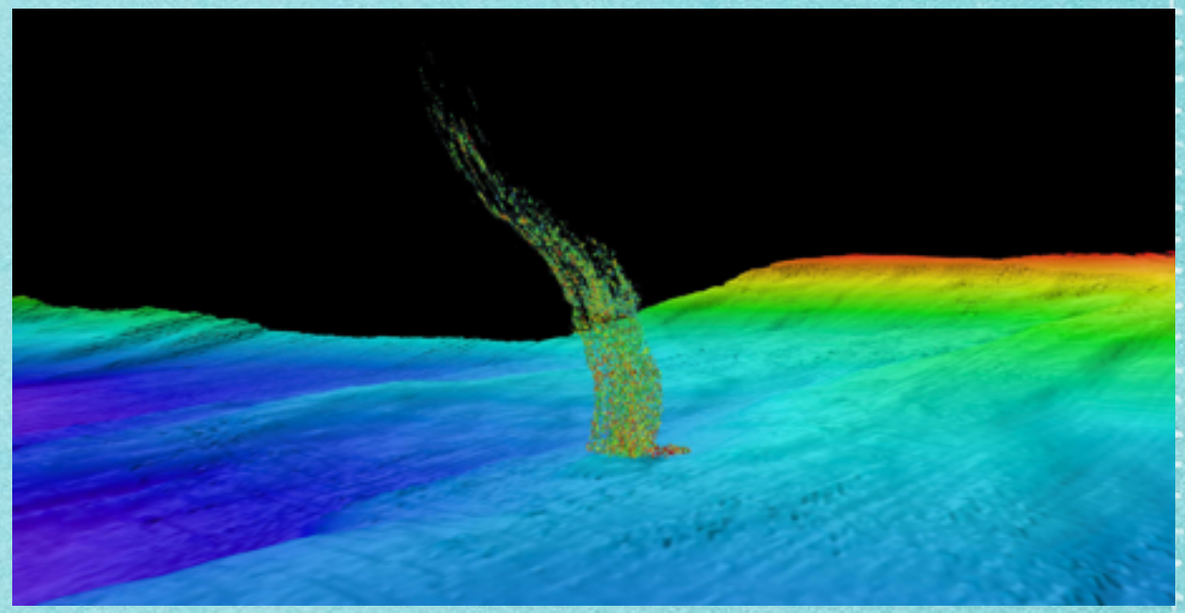
- **Methane is greenhouse gas**. What is methane gas?
- Methane molecules are dissolved in our ocean water.
- **Methane hydrate is a methane in a solid state at the bottom of shallow water depths.**
- **Methane hydrates in the ocean floor fill pores, kind of like cement.**
- **If the hydrates disappear, the shallow ocean floor becomes unstable.**



# Our current ocean condition

- The ocean temperature is rising due to global warming.
- $CO_2$ is absorbed into our oceans, which is causing it to become more acidic.
- **Natural Methane Hydrate (solid on bottom of shallow ocean floor) is "sublimating" because of warmer ocean temperatures.**
- Methane hydrates are disappearing rapidly - in Washington and in the Arctic.



- http://www.popsci.com/methane-plumes-off-west-coast-may-be-caused-by-warming-oceans

# Problem with methane hydrate in our warming oceans.

- **If methane is released rapidly from the hydrates, it could rise in the form of gas bubbles.**


- When this happens at shallow water depths where bubbles can't be absorbed by water.

- **Methane hydrates are under low pressure in the shallow ocean shelf** of the arctic area.

- Permafrost is melting, also.

# effect of methane hydrates disappearing.

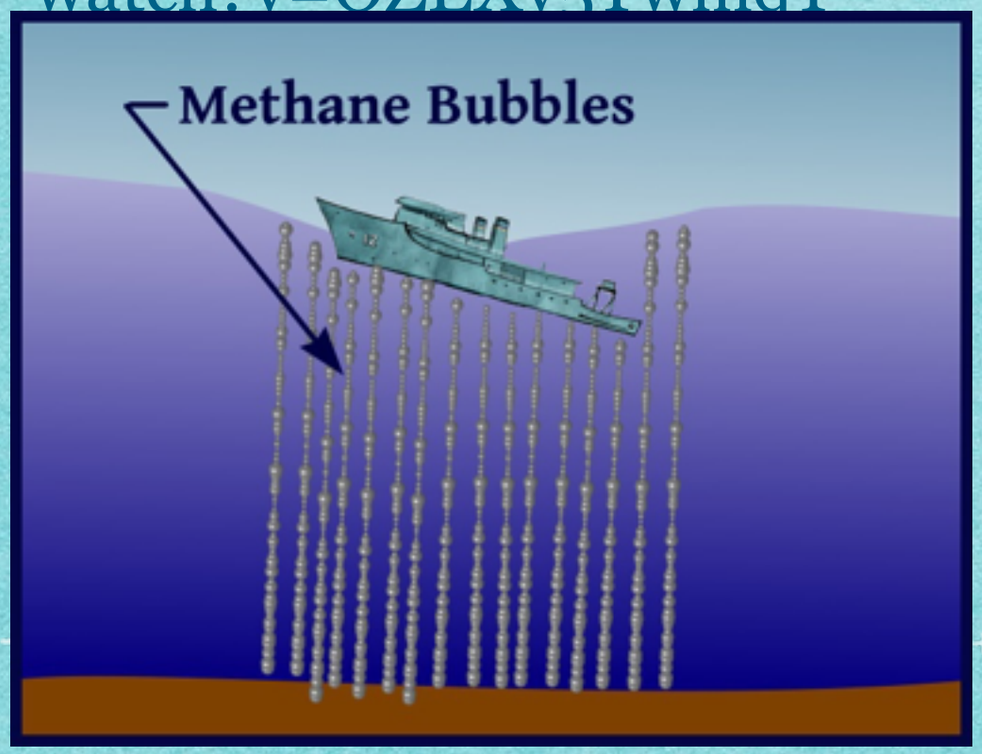
- fatal consequences:
  - methane hydrate acts as a cement as it fills pores, so as it disappears, **the ocean floor becomes unstable, causing under water landslides, which can result in tsunamis.**

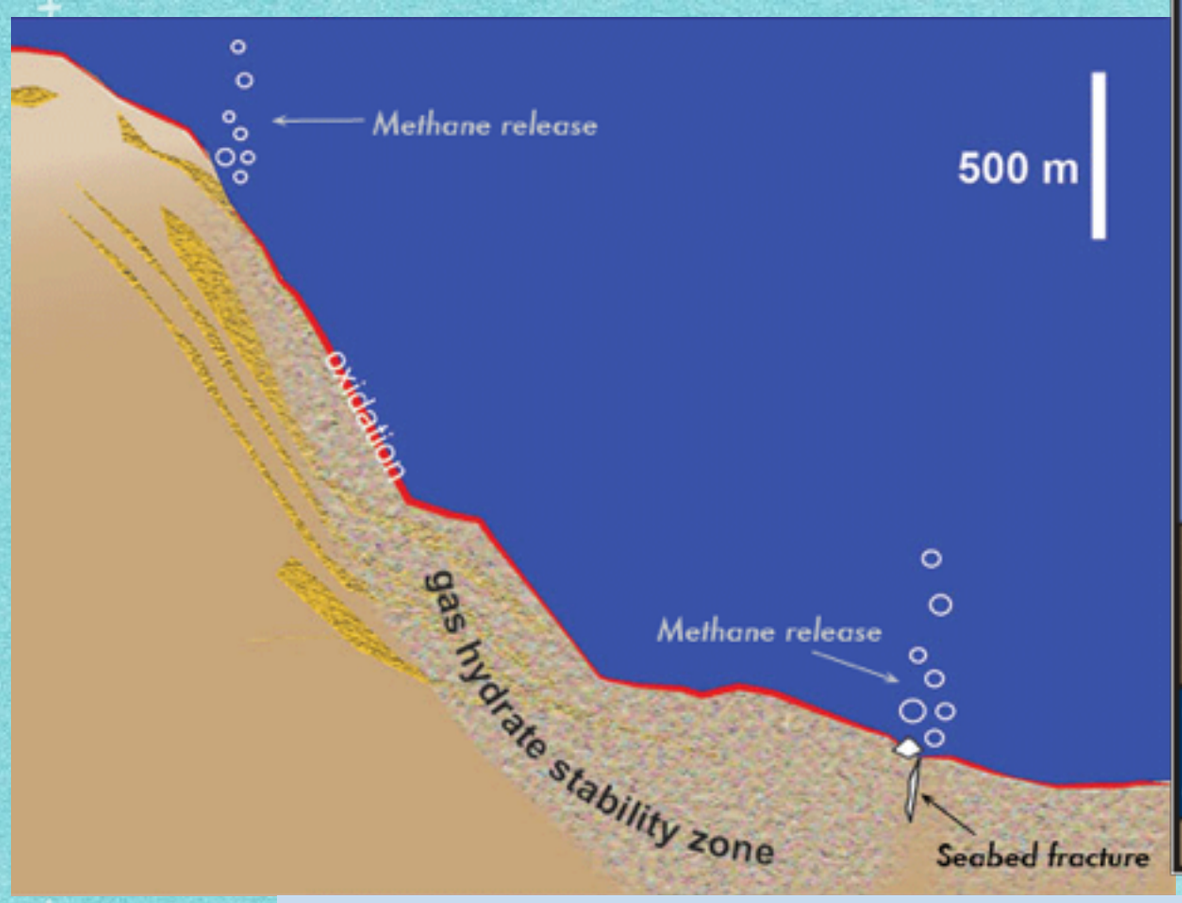
Also, **pressure decreases as gas bubbles are rising. According to Boyle's Law, these bubbles will then increase in volume.**

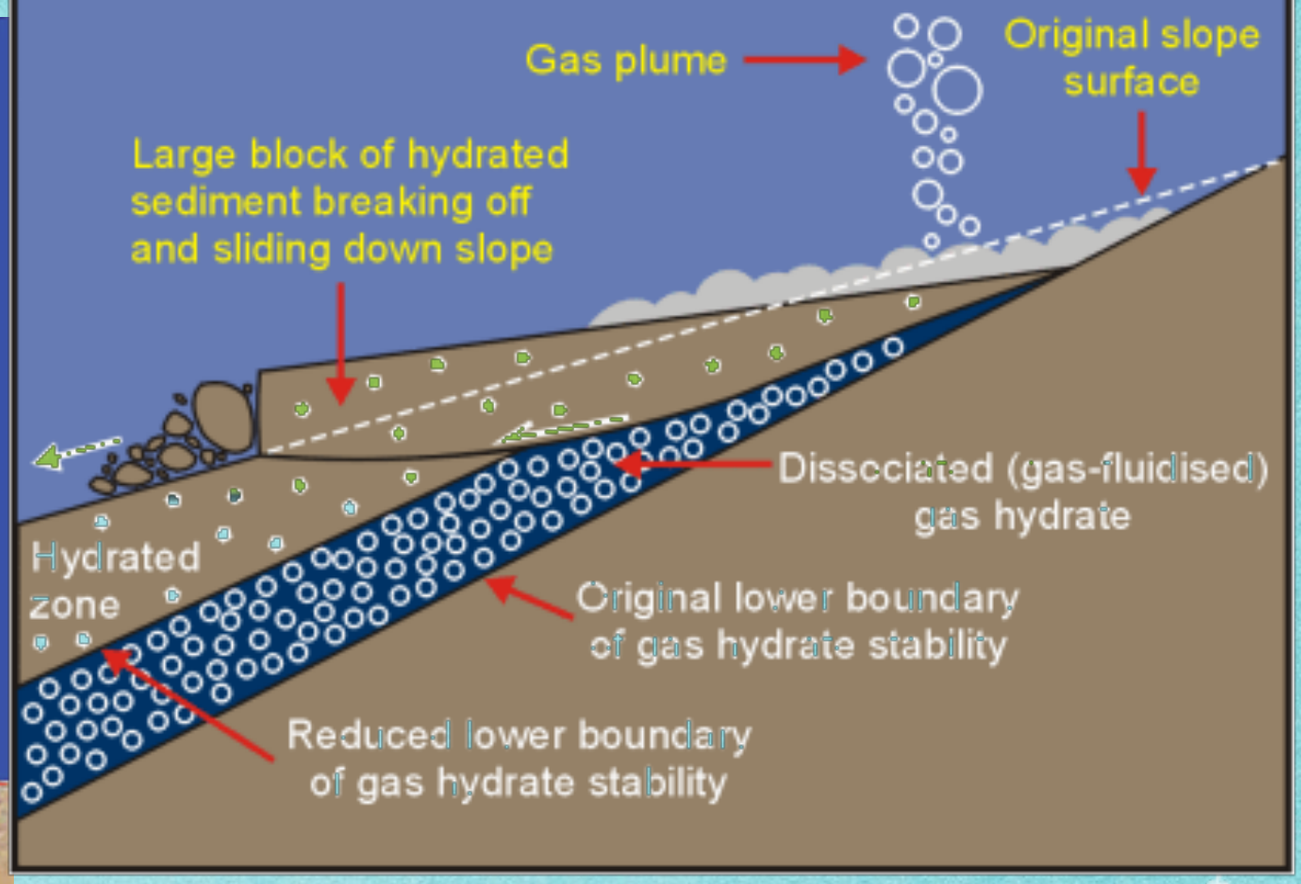
**Large bubbles rising to ocean surface changes the density of the water, and the buoyancy of ships: causing ships to sink**

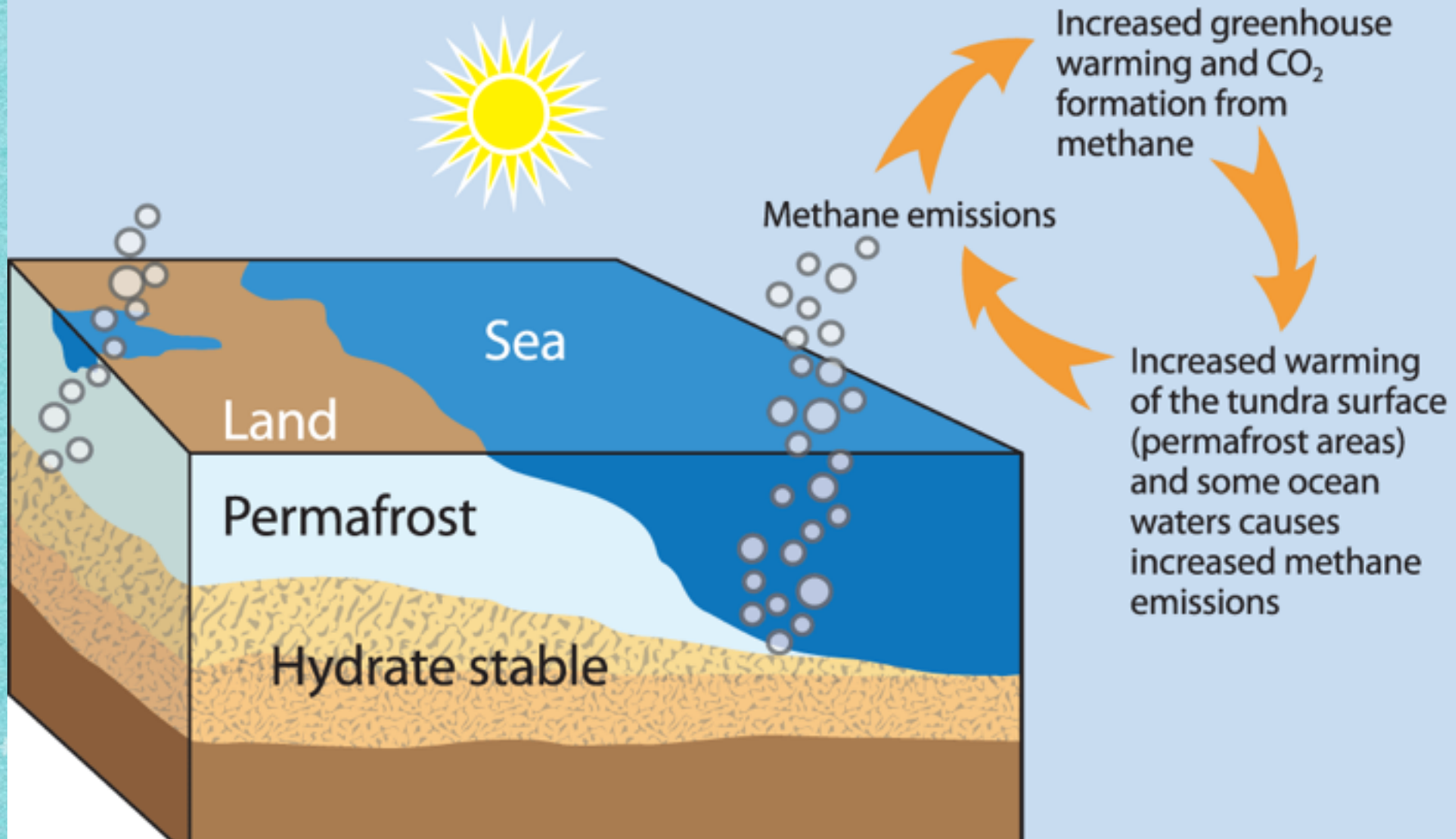
# videos of methane hydrate in ocean

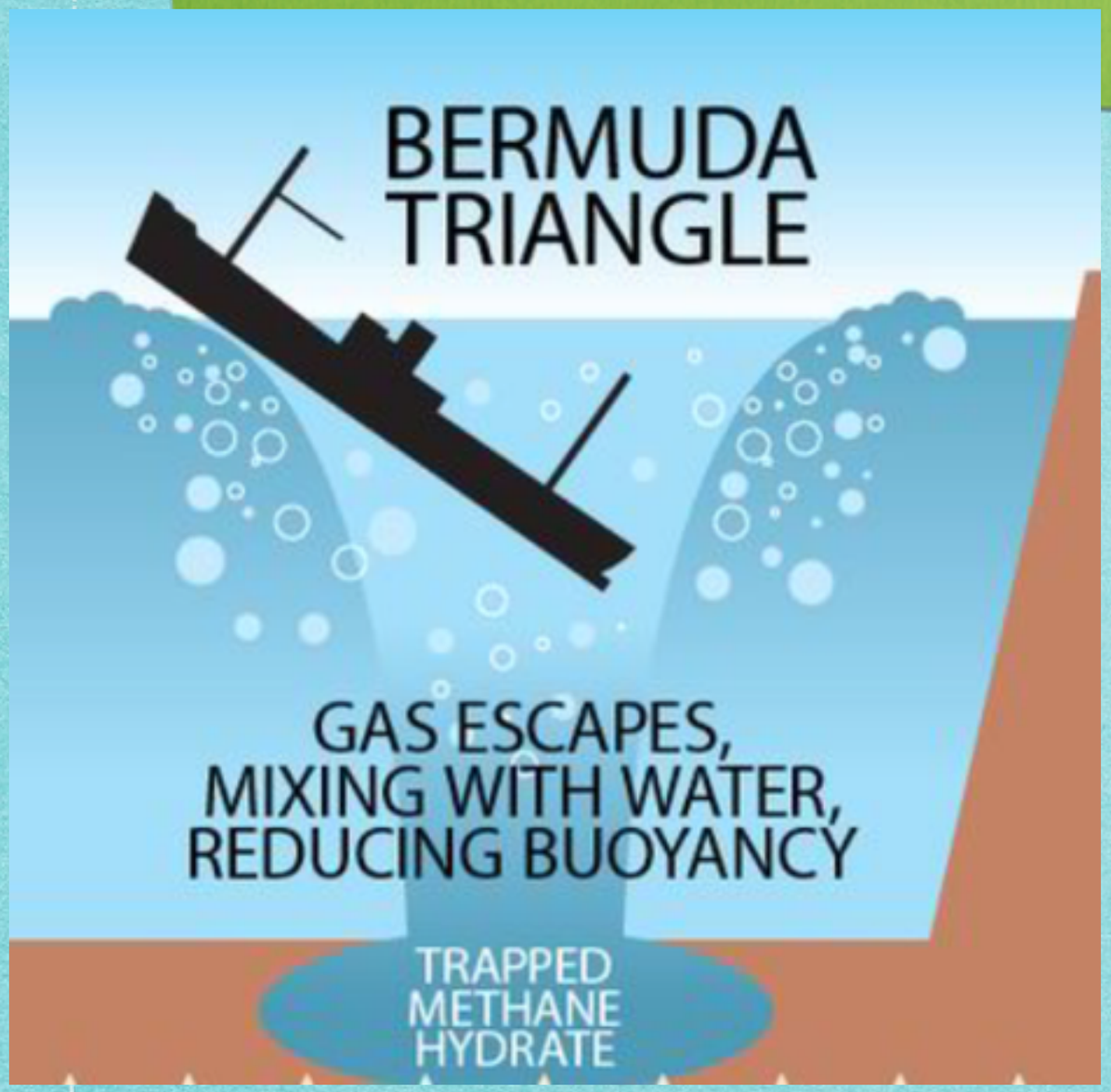
- https://www.youtube.com/watch?v=MSmAXp_BHcQ
- https://www.youtube.com/watch?v=iJQzyBqZeZc
- https://www.youtube.com/watch?v=OZEXv5YwmqY

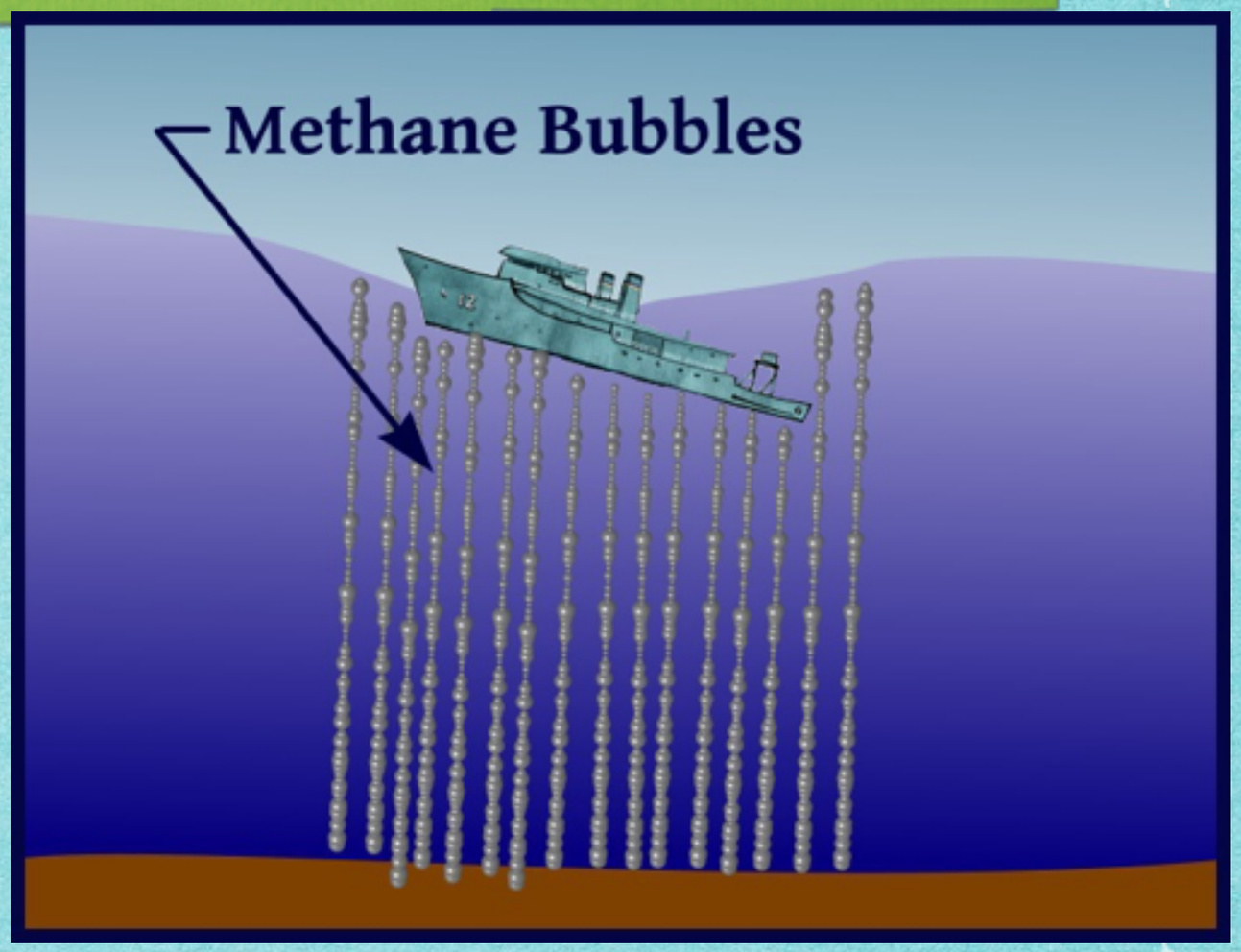




Methane release
500 m
oxidation
gas hydrate stability zone
Methane release
Seabed fracture


Gas plume
Original slope surface
Large block of hydrated sediment breaking off and sliding down slope
Disscciated (gas-fluidised) gas hydrate
Hydrated zone
Original lower boundary of gas hydrate stability
Reduced lower boundary of gas hydrate stability


Increased greenhouse warming and $CO_2$ formation from methane
Methane emissions
Increased warming of the tundra surface (permafrost areas) and some ocean waters causes increased methane emissions
Sea
Land
Permafrost
Hydrate stable


BERMUDA
TRIANGLE
GAS ESCAPES,
MIXING WITH WATER,
REDUCING BUOYANCY
TRAPPED
METHANE
HYDRATE


Methane Bubbles