

Some physical and chemical marine science

WHY IS WATER SPECIAL?

It forms oceans, & composes 50–95% of any organism – where water, life occurs also.

Jellyfish is 95% water

Forms most of earth's surface – ocean average depth = 3.8km, 2.5 if continents eroded into sea – only substance in all 3 states (solid, liquid, gas) on Earth.

MOLECULAR STRUCTURE

Molecular structure of H₂O: shared electrons cause H to be positive & O to be negative, causing polarity.

Hydrogen bonds of H⁺ to O⁻ (**behaves like a magnet**) are weak, any particular bond lasts 100 billionth of a second: H– bonds continually reform, thus it is liquid.

H–bonds cause **surface tension** due to cohesion between water molecules, which increases **viscosity** – makes it hard to move through. (reduces sinking in organisms)

THERMAL EFFECTS ON WATER – temperature

Compared to any common substance, water has the:

1) highest "**specific heat**", taking 1 calorie to raise 1g by 1_C (2x oil or alcohol, 4x air, 10x iron, only liquid ammonia is greater): 0_C = freezing, 100_C = boiling.

Heating and cooling of water occurs with the increase or decrease in speed of the water molecules. **It takes a lot of energy to increase molecular speed.**

Thus, thermal inertia is great – ocean temps vary slowly & stay rather constant. GOOD for organisms to live in a more stable thermal environment

Heat Capacity – water has great capacity for absorbing heat with out a temp increase – due to H+ bonds

Heat transfer is by **Convection** (mixing) and **conduction** (molecular exchange of heat).

2) highest heat of fusion and vaporization: at 100°C takes 450 cal to change to vapor (2X ammonia, 60X ether).

–Heat carried off is why sweating and panting cool off animals so well.

3) amount of dissolved O₂ is temperature dependent: as temperature increases, dissolved O₂ content decreases.

Temperature affects on seawater:

–heating up – H+ bonds break and molecules turn to vapors, all at once= boiling at 100°C.

–cooling down – to solid– crystals form at 0°C, water molecules far apart.

Ocean temperature change more gradually and don't boil, but they do freeze. Range is

–2°C – 30°C (28–86°F).

FIGURE – draw profile with temperature , depth and thermocline.

4) **density** is temp. dependent: as temp decreases, density increases until 4°C, then density decreases. $D=m/v$. Density of pure water = 1g/cm³, seawater =1.02468 g/cm³

–Thus, cold water sinks but ice floats. Sinking cold water means that oxygen & nutrients it contains will be mixed. Salt water sinks as it gets cold where fresh water forms ice and floats.

**** Unusual for a solid form to be less dense than the liquid. This property of water allows for insulation of underlying water and organisms to live. Keeps oceans and lakes from freezing!

Density – influences body shape, adaptations to buoyancy, swimming, Ps....

ATOC – **sound** travels rapidly and attenuated little through water but is affected by the density of the water which is mostly affected by the temperature

SALINITY – total amount of salts dissolved in seawater in g/1000g seawater.

Water is a solvent in which many things dissolve – universal solvent

Sea water contains dissolved compounds collectively called salts, at an average concentration of 35ppt, or 35‰): this amount is termed the water's salinity. Averages ~0‰) in rivers, ~40‰) in Persian Gulf: salinity lowers freezing point to -1.9°C .

High evaporation+high surface salinity (Medit)

Salts are molecules made of electrically charged particles – **ions** – $\text{Na}^+ + \text{Cl}^- = \text{NaCl}$

Salt in water – water molecules (polar) attracted to the strong charge surround in – **dissociates**.

LAW of constant proportions – relative amounts of ions the same in seawater, so changes occur by addition and removal of pure water.

Source –Solute come from terrigenous runoff and the earth's interior–vent's,volcanoes.

Measurements – refractometer – measures refractive index that changes in seawater vs.salin

Salinity is increased by evap, decreased by precipitation.

PG 22 Organisms use salts in their bodies!

Osmosis is the movement of water from an area of high solute concentration to low solute concentration.

BUFFERING capacity of the ocean.

$\text{CO}_2 + \text{H}_2\text{O} \rightleftharpoons \text{H}^+ + \text{HCO}_3^-$ Keeps PH neutral

GASES – Solubility of gases is function of T

N_2 , O_2 , CO_2 most common dissolved gases.

Oxygen greatest at surface because of diffusion & photosynthesis, decreases until oxygen minimum zone at ~500m, then slowly increases. Why does this pattern occur?

O_2 min. zone, animals and bacteria use it up too fast there, **Comes from the surface**.

CO_2 dissolves differently, since it chemically combines w/ water: this dynamic equilibrium acts to buffer changes in the pH of water.

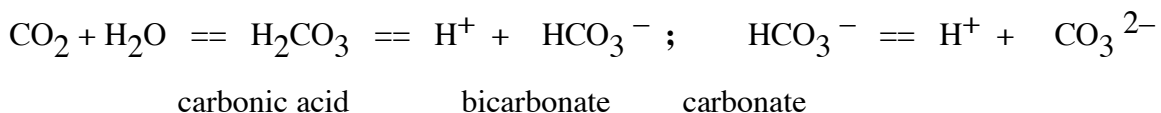


FIGURE – of density vs. temperature – from Cabrillo notes.

LIGHT – primary source of energy for most ecosystems, comes from the sun. Visible spectrum = 400–700nm. Ultraviolet light and other is absorbed in our atmosphere by O₃ –ozone. CO₂ gas absorbs light energy and heat from the earth's surface re-radiates back = warming.

Transparency – depends upon amount and type of suspended material – affects blue/green H₂O.

Light penetration is affected – color spectrum is absorbed with increased depth – red first. ROYGBIV

Some light is reflected back.

Some penetrates: **absorption, refraction.**

Photic zone (PG. 23 FIG) is imp. depth depends on suspended matter, plankton etc.,

50-100 m

Pressure – Boyle's Law – pressure x volume = constant

On earth's surface we are under 1 atmosphere of pressure – 14.7 p.s.i. This greatly increases with increases depth in the ocean where there is a 14.7psi increase with every 33 feet or 1 atmosphere.

This affects organisms that have air filled spaces as pressure affects gases but liquids are not compressible. Floats, lungs, air bladders.

Salinity/Temp/Density relationships:

Cold surface water sinks: drives ocean circulation (DESCRIBE) Salinity on surface also drives circulation.

Thermocline–rapid change of temp

Pycnocline–density change (temp or salt)

Waves and currents: wind=waves and surface currents.

fetch

wavelength

height

period

Energy motion, not water motion

when depth=1/2 wavelength, feels bottom

height/wavelength = 1/7 wave breaks.

waves shape shorelines

Tides:

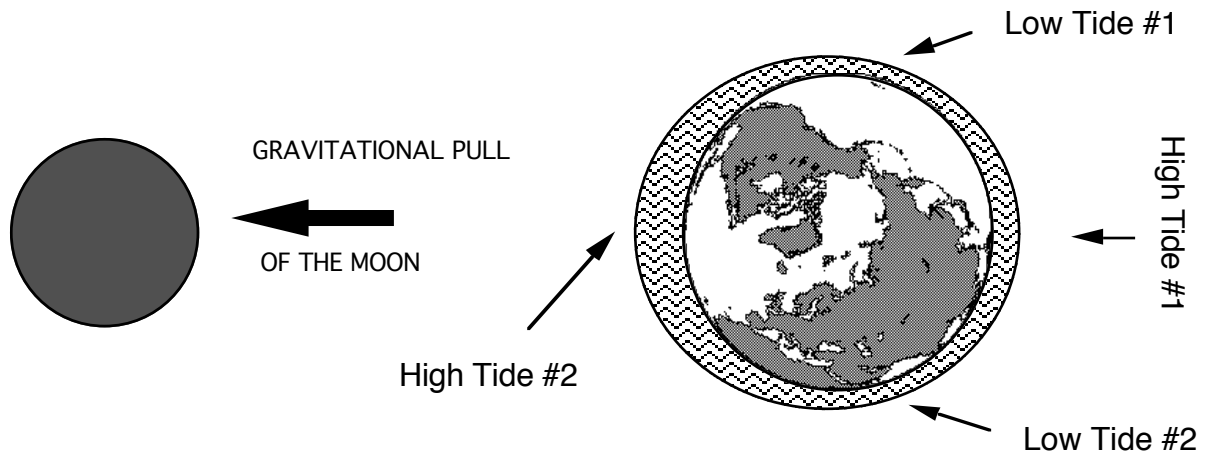
TIDES

CAUSES

2 factors cause tides: 1) **gravitational pull** (Moon's effect 2X that of Sun), & 2) **centrifugal force** of spinning earth

VARIATIONS

Gravity pulls ocean towards moon (or sun) as centrifugal force throws it out away on the other side (although the high is not as great): thus, two tides/day



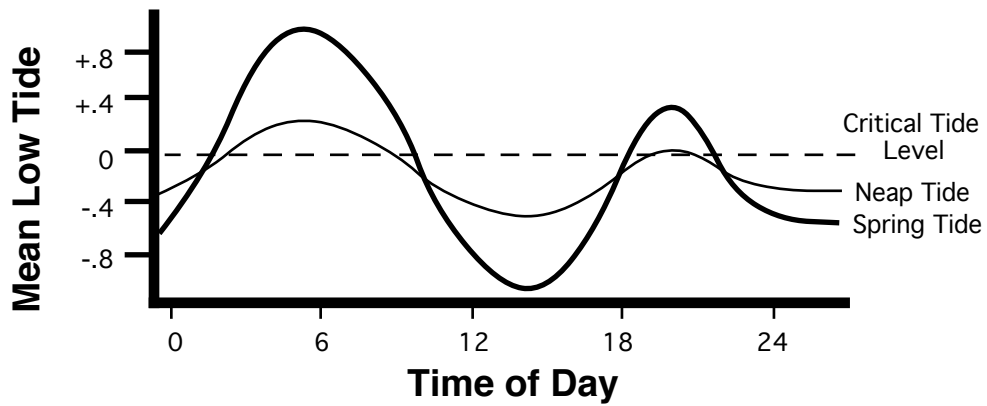
Different levels of high and low tides due to:

-Angle of Earth's axis of rotation (23.5°)

-Centrifugal High Tide (lower) vs. CHT + Gravitational High Tide (higher)

Tide day is 24hrs, 50 min due to time it takes moon to rotate around Earth.

Spring tides are extremes, **Neap tides** are similar.



EFFECTS OF TIDES

Duration of exposure determines length of time organisms undergo desiccation, thermal, or salinity stresses.

Two different peaks of tide levels set **Critical Tide Levels** (which vary not only daily but seasonally, between Neap & Spring tides)

Induces rhythmic patterns into biology of organisms

- Activity times directly affected (esp. feeding)
- Breeding times also influenced (*Mytilus*, Grunion)