

LIGHT AND SOUND IN THE OCEAN

Physics

Deals with properties of MATTER and ENERGY, how they move and interact

Ocean Physics:

Matter Energy

Sea water Light

Air Sound

Heat

Basic concepts in physics

Heat energy, temperature and heat capacity

- **Heat** is the energy created by the random vibration of atoms or molecules
- **Temperature** is the response of an object to the addition (or removal) of heat energy.
- **Heat capacity** is the amount of heat required to raise the temperature of 1 gram of substance by 1°
- The heat capacity of water is very large compared to most substances:

=> sand gets hotter than the water

Properties of waves

Wavelength: Distance from one crest to the next

Period: Time taken for one wave to pass a fixed point

Frequency: Number of waves per second that pass a fixed point

Velocity: Speed with which the waves are moving past a fixed point

Light and sound energy move as waves

Wave behaviour

- Reflection: If the density difference between the media is large and the angle of incidence of the incoming light is small then we get reflection
- Refraction: Speed of wave propagation depends on density of medium. As light enters water it slows down and changes direction
- Scattering: Wave bounces off particles within a single medium, eventually loses energy
- Absorption: Wave interacts with a molecule and transfers its energy to the molecules this generates heat energy

Light in the ocean

- Light is part of the electromagnetic spectrum. This spectrum covers everything from gamma rays to radio waves

- White light is the sum of colours that range from violet to red--that's why it appears white
- When light enters water the red end of the spectrum is absorbed first
- Blue light penetrates furthest -- it's why the ocean is blue
- Light absorption determines how deep some organisms can live => The Photic zone
- Light absorption is how the ocean is heated

Sound in the ocean

- Sound propagates by compressional waves that pass easily through air and water
- Average speed of sound in seawater is 1500 m/sec
- (3,345 mph) 5 times higher than in air
- High frequencies are absorbed most rapidly
- Speed of sound increases with higher temperature and higher pressure
- In the ocean high speed in warm surface waters, also in deep waters because of high pressure
- Lowest speed around 1,000 m

SOFAR layer

- Refraction towards slowest medium causes sound to be channelled for long distances in SOFAR channel
- Whales use the SOFAR channel to communicate over thousands of miles, they also use low frequencies because they travel further--because they took OCN 201!
- Can use time taken for sound to pass around the world in the upper ocean to tell us if the ocean is warming - ATOC Kauai
- Shallow high velocity layer at ~80m, sound diffracts away, can hide submarines from SONAR here
- Can use sound to tell us how deep the ocean is by timing a "ping"

Heat Budget of the Earth

- Light all ends up as heat, where does it go?
- On average incoming and outgoing radiation (heat) must balance or the planet would heat up or cool down
- Incoming radiation is short wave radiation
- Outgoing is long wave radiation (infrared)
- But there is no energy balance on short time scales or over small regions -- how does this all work
- The angle of the Sun hitting the surface of the Earth determines the amount of heat at each latitude
- At high latitudes sun has to penetrate more atmosphere and also illuminates more surface area

Polar regions are cold!

- In the tropics more heat: Why doesn't the ocean boil?
- The oceans and the atmosphere transport heat from the tropics to the poles, Nature the Equaliser!