• Instructors: E. Boss and MJ Perry.

• Last week's homework. Extending the amnesty.

• Class web site:
  • http://misclab.umeoce.maine.edu/boss/classes/SMS_204_2008/Syllabus.htm

• Vision
  Vision consists of a series of events:
  a. Light from the environment is sampled (may pass via lenses and reflected).
  b. Image formed in vision organ is detected by cells on which it falls.
  c. Nervous system cells pass detected information to the brain.

• Pin-hole optics (light travels in straight lines):
• Vision with lens (focus):

• Distance perception:

• Color vision

Visible range: 400-700nm (0.4-0.7μm)

• Atmospheric and oceanic interaction with light:

Atmosphere
Largely transparent.
Window in visible.
O₂, CO₂, H₂O impact spectrum.
Emitted spectrum in infra-red

water
Maximum transmission in blue.
Absorbs strongly in infra-red.
Scattering increased in blue.
Implication for organisms

- Primary production fuel
- Visual predators
- Escape strategies (daily migration)
- Other?

Sound:

- A pressure (density) wave.
- Cannot propagate in vacuum.
- Displacement in the same direction as propagation
- \( c = (\frac{dp}{dp})^{1/2} \)
• Intensity and its attenuation

\[ I = \frac{(dp_{\text{max}})^2}{(\rho_0 c^2) [W/m^2]} \]

\[ dB = 10 \log_{10} \left( \frac{I}{I_{\text{ref}}} \right) = 20 \log_{10} \left( \frac{dp}{dp_{\text{ref}}} \right) \]

Attenuation is frequency and salinity dependent.

- Frequency [Hz], \( f = \frac{c}{\lambda} \)
- \( c_{\text{water}} \sim 1500 \text{m/sec} \)
- \( c_{\text{air}} \sim 300 \text{m/sec} \)

Frequencies emitted by organisms:

Note frequency shift in marine organisms. Why?

- Differences in frequencies and source intensities result in differences in range of propagation of sound:

<table>
<thead>
<tr>
<th>Source</th>
<th>Frequency (Hz)</th>
<th>Power (W)</th>
<th>Attenuation (km(^{-1}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human speech</td>
<td>1000</td>
<td>(10^{-1})</td>
<td>30</td>
</tr>
<tr>
<td>Human yell</td>
<td>1000</td>
<td>(10^{-1})</td>
<td>30</td>
</tr>
<tr>
<td>Dolphin click</td>
<td>25000</td>
<td>(10^{1})</td>
<td>1.3</td>
</tr>
<tr>
<td>Dolphin whistle</td>
<td>10000</td>
<td>(10^{4})</td>
<td>0.25</td>
</tr>
<tr>
<td>Finback whale</td>
<td>20</td>
<td>10</td>
<td>0.0007</td>
</tr>
</tbody>
</table>
Sound propagation in the oceans:

Snell's law (wave dynamics): \( n_1 \sin(\theta_1) = n_2 \sin(\theta_2) \)

\[
n_1/n_2 = v_2/v_1
\]

Some consequences:
1. \( \theta_1 = 0 \Rightarrow \theta_2 = 0 \)
2. Total internal reflection only when moving from slow \( \Rightarrow \) fast.
3. Reciprocity principle: if light can travel from A to B it will take the same route from B to A.

Sound propagation in the oceans:

Reflected rays bend as the speed increases until total internal reflection occur.
Sound channel is centered at the minimum of sound speed.
Similar to fiber optics and other waveguides (equator for Kelvin waves).
Fish hearing: Otolith
- Several pairs per fish
- Relative motion due to differential acceleration trigger nerve cells.

How about mammals?

Doppler shift
- Change in frequency due to the motion of the source and/or the receiver
- Allows for determination of movement of target.

Stationary source:
\[ f = \frac{v}{\lambda}, \]
\[ f' = \frac{(v + u_s)}{\lambda}, \]
\[ \Delta f = \frac{su_r}{c}, \]

Stationary receiver:
\[ \Delta f = \frac{su_l}{(c + u_r)}, \]

Both moving:
\[ \Delta f = \frac{su_l}{(c + u_r)}, \]

Demo - Doppler

Resonance
- Physical construct have natural frequencies based on their dimensions.
- Forcing at these frequencies (among others) result in large response at the resonant (s) frequency (ies).

Demo - Resonance
Use of sound and light to study marine organisms

- When the organism is of the same size as the wavelength we get the most scattering per mass.

- Light: μm size organisms

- Sound: 100μm→cm size organisms

Example: fish


Comparing Zooplankton Features
