Echolocation volume calculation

Aran Garrod

10th September 2021

Calculating the volume of echolocation signals

Movement data from the tags are speed, pitch, roll, and heading. The inter-click interval is also available. From this, the volume of 'searchable range' can be calculated, given a few assumptions.

Calculating the cone volume for echolocation

Assuming speed of sound (s_s) to be 1500 m/s and with and inter-click interval ci, the maximum distance sound can reach and return to the whale (d) can be determined by

$$d = s_s \times \frac{ci}{2}$$

An additional time penalty for 'processing time' can be added that would simply subtract from ci.

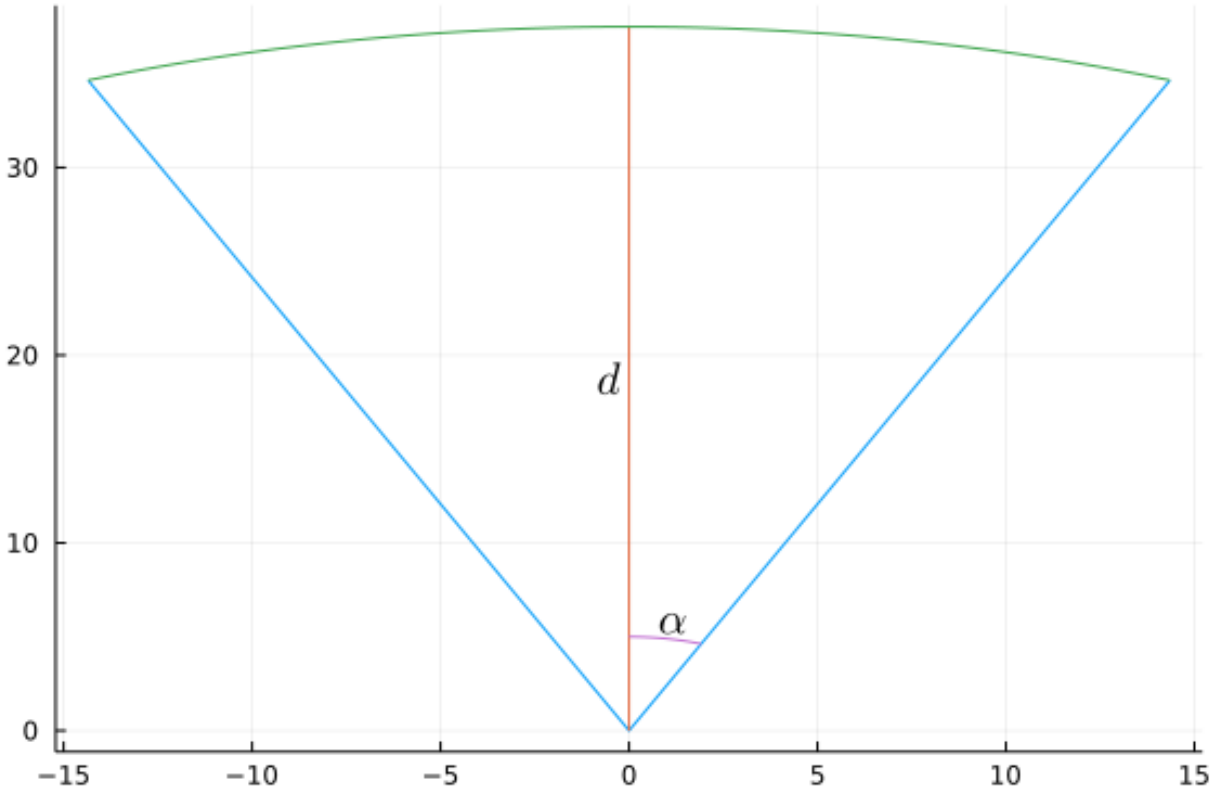
Now we have the maximum distance reachable, we can calculate the volume. This is assumed to be a section of a sphere, with angular width θ. This volume can be calculated using the equation

$$\frac{2}{3}\pi d^2 h$$

where $h = (d - d\left(cos(\frac{\theta}{2})\right)$

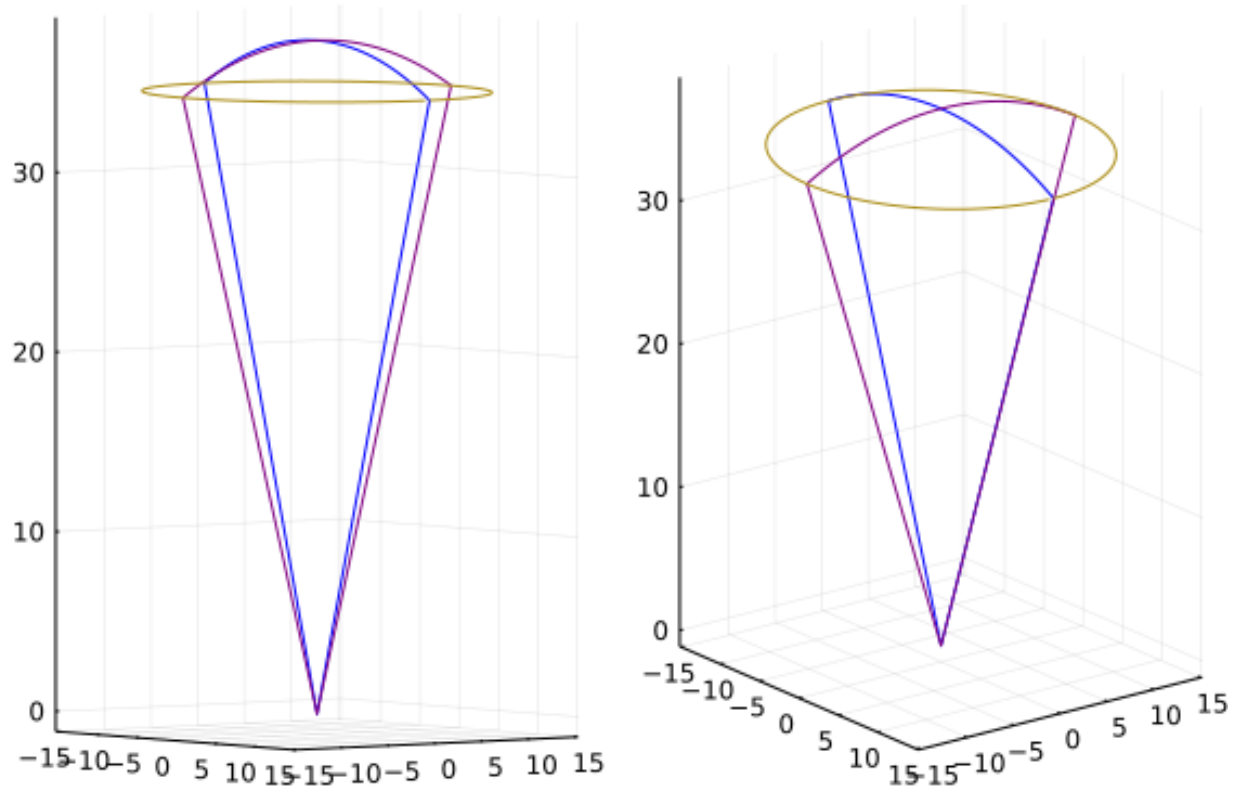
This assumes the sound is spreads via angle θ in all directions (adjustments can be made if this specification needs changing).

So, given a typical sperm whale ci of 0.05s and an angular spread of 45° (i.e. 22.5° either side of the origin), the maximum distance would be 37.5m. Plotting this in 2D space shows the following



where α is equal to $\theta/2$

Projecting this onto a 3D plane generates the following



and a volume of 2122.2 m^3. NOW CALCULATED VOLUME AS WHALE MOVES FORWARD WITH PITCH AND ROLL CHANGES.

```
81496-element Vector{Float64}:
 4.084765685216409
 4.084765685216409
 4.084765685216409
 4.084765685216409
 4.084765685216409
 4.084765685216409
 4.084765685216409
 4.084765685216409
 4.084765685216409
 4.084765685216409

 4.084765685216409
 4.084765685216409
 4.084765685216409
 4.084765685216409
 4.084765685216409
 4.084765685216409
 4.084765685216409
 4.084765685216409
 4.084765685216409
```