The Mechanics of Diving Birds: How do they do it?

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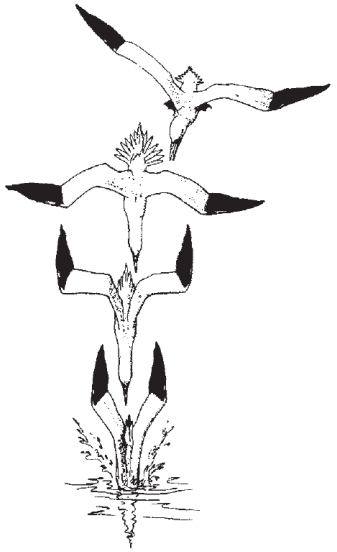
http://ngm.nationalgeographic.com/2012/08/gannets/img/03-diving-off-shetland-coast-670.jpg[1]

Outline

- The Gannet
- Diving Depths
- Human Spine Data
- Model
- Parameter Estimate
- Next Steps

The Gannet

1



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2

http://www.nhm.ac.uk/visit-us/whats-on/temporary-exhibitions/wpy/prevPhoto.do?photo=2711&year=2011&category=2[1]
http://www.youtube.com/watch?v=EwPrXOtBoVg[2]
Lee, Davis N., and Paul E. Reddish. "Plummeting gannets: a paradigm of ecological optics." *Nature* (1981)[3]

Diving Depths

Type of Bird	Diving Depths	Impact Velocity
Gannet	~5.9 m	24 m/s
Albatross	~2-3 m	-

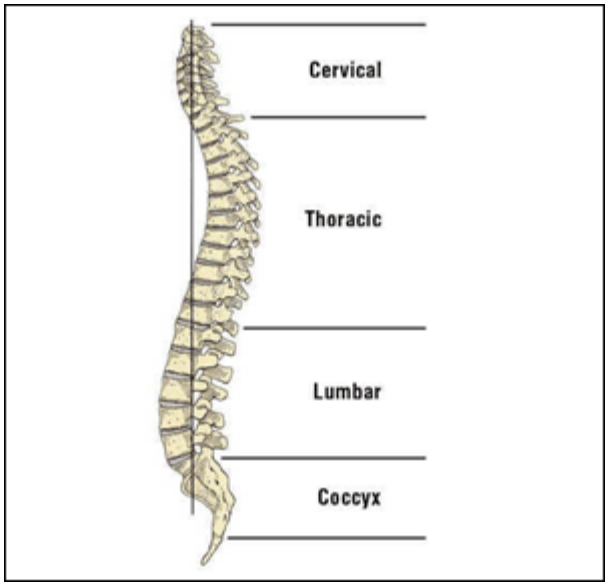
1

http://birdsbykim.com/blog/wp-content/uploads/2008/06/noga_j9m2994-b.jpg[1]

Our Assumption: Relating the Gannet spine to the Human spine

1

Gannet Spine: 21 Vertebrae



2

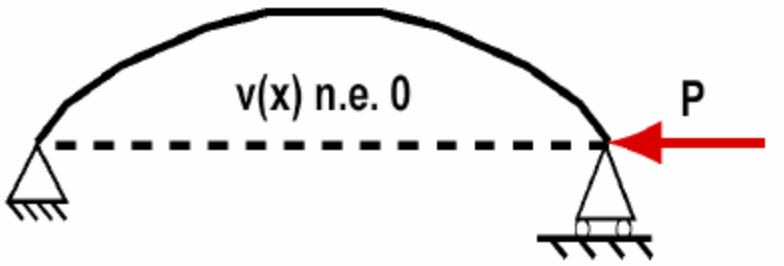
Human Spine: 33 Vertebrae

http://www.unfeatheredbird.com/theunfeatheredbird/theunfeatheredbird-gallery.html[1]
http://www.rstrust.com/wp-content/uploads/2011/01/spine.gif[2]

Model

- We plan to model two spheres connected by an elastic rod
- Euler-Bernoulli Beam theory
  - Assume geometric nonlinearity
  - Initially assume elastic

$$\rho A \frac{\partial^2 v}{\partial t^2} + \frac{\partial^2}{\partial x^2}\left(EI \frac{\partial^2 v}{\partial x^2} \right) = P$$



Critical Force

- What is the critical force that will cause buckling of the spine?
- Use steady-state equation

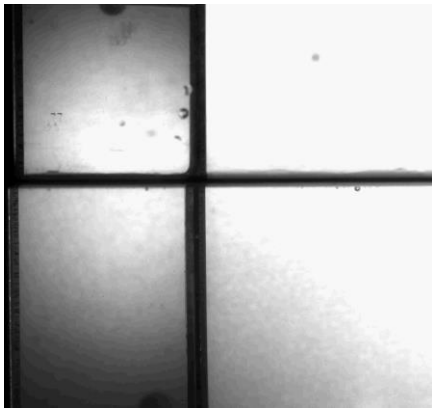
$$\frac{\partial^2}{\partial x^2}\left(EI \frac{\partial^2 v}{\partial x^2} \right) = P$$

Critical Force (cont'd)

- Assume slopes at end are 0 due to constraints of the balls (validated by experimental video)

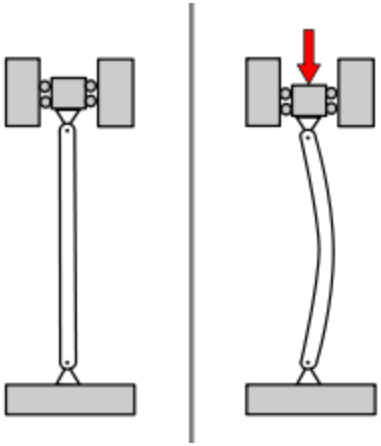
- Solving for critical force gives

$$P_{crit} = \frac{\pi^2 EI}{L^2}$$



Estimate of EI

- Use above result and experimental data to obtain estimate of EI for material
- Use this estimate to perform time-dependent simulations



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Wikimedia Commons[1]

Next Steps

- Begin by modeling dumb-bell system
  - Compare model data with experiment
  - Need to find viscoelastic constitutive relation
  - Refine model by changing angle of impact, shape of head, etc.