How seabirds plunge-dive without injuries

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In nature, several seabirds (e.g., gannets and boobies) dive into water at up to 24 m/s as a hunting mechanism; furthermore, gannets and boobies have a slender neck, which is potentially the weakest part of the body under compression during high-speed impact. In this work, we investigate the stability of the birds’ neck during plunge-diving by understanding the interaction between the fluid forces acting on the head and the flexibility of the neck. First, we use a salvaged bird to identify plunge-diving phases. Anatomical features of the skull and neck were acquired to quantify the effect of beak geometry and neck musculature on the stability during a plunge-dive. Second, physical experiments using an elastic beam as a model for the neck attached to a skull-like cone revealed the limits for the stability of the neck during the birds’ dive as a function of impact velocity and geometric factors. We find that the neck length, neck muscles, and diving speed of the bird predominantly reduce the likelihood of injury during the plunge-dive. Finally, we use our results to discuss maximum diving speeds for humans to avoid injury.