Combining matrix models with life-history theory to improve estimation of intrinsic growth for data-poor populations

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Abstract: We integrate matrix models with allometric life-history theory, allowing us to improve the precision of estimates of intrinsic growth ($r_{\max}$) for data-poor populations. This work is motivated by our research on marine megafauna (e.g. sharks, sea turtles, marine mammals, and seabirds) where better understanding of intrinsic growth is needed in order to understand the ability of these populations to withstand directed or incidental catch in fisheries. Commonly, estimation of $r_{\max}$ is done through the use of matrix population models or by modelling population trends over time. Data challenges and/or model assumptions for either approach are substantial, with empirical estimates of $r_{\max}$ being limited to a small subset of populations. An alternative approach based on life-history theory uses allometric relationships between body mass, generation time, and $r_{\max}$ to estimate intrinsic growth with few demographic parameters. The allometric approach provides estimates for many additional data-poor populations, requiring only age at first reproduction and optimal adult survival. While allometric estimates of $r_{\max}$ represent growth of average, rather than individual, populations, this approach has proven useful in conservation settings. However, for populations where survival estimates are poor (e.g. sharks), or where productivity estimates for individual, rather than average, populations are desired, none of the current methods are satisfactory. Integrating the two methods using available data, we can estimate intrinsic growth for either average or individual populations, even where survival is poorly understood. After describing the method, we apply it to sharks, particularly focussing on a species of population concern, the white shark (*Carcharodon carcharias*).