

Not Always Slow and Steady: Hawaiian Green Turtles, a New Four-Parameter Bayesian Growth Model, and the Primitive Reptilian Condition

Karla McDermid

Marine Science

Grady Weyenberg

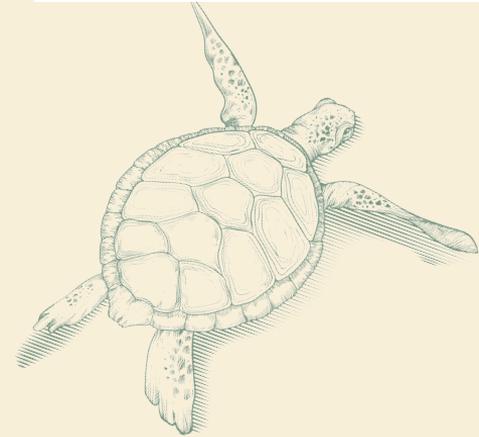
Math & Data Science

CNHS Colloquium Series

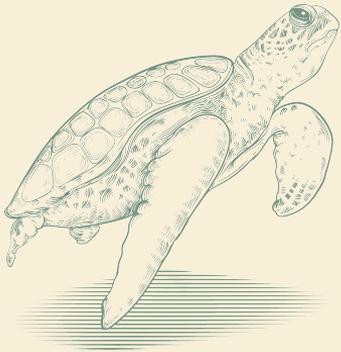
Oct. 8, 2025



UNIVERSITY
of HAWAII
HILO



Mahalo to
our
co-authors



**LONG-TERM SOMATIC GROWTH RATES AND A FOUR-PARAMETER BAYESIAN
GROWTH MODEL OF HAWAIIAN GREEN TURTLES (*CHELONIA MYDAS*) AT
PUNALU‘U BEACH, HAWAI‘I ISLAND (1976–2018)**

MADISEN K. COELHO¹, KARLA J. McDERMID^{1,5}, GRADY WEYENBERG²,
MARC R. RICE³, GEORGE H. BALAZS⁴

¹Department of Marine Science, University of Hawai‘i at Hilo, Hilo, Hawaii, USA

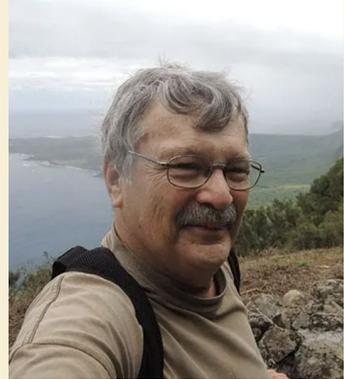
²Department of Mathematics, University of Hawai‘i at Hilo, Hilo, Hawaii, USA

³Sea Turtle Research Program, Hawai‘i Preparatory Academy, Kamuela, Hawaii, USA

⁴Golden Honu Services of Oceania, Honolulu, Hawaii, USA

⁵Corresponding author, e-mail: mcdermid@hawaii.edu

Abstract.—Growth rates, essential for understanding the demographics of sea turtle populations, vary regionally because of variability in habitat quality, food availability, turtle density, environmental conditions, and genotype. In past decades, declining Green Turtle (*Chelonia mydas*) growth rates within the Hawaiian Archipelago raised concerns about long-term population stability. From 1976 to 2018, at Punalu‘u, Hawai‘i Island, a



Green Turtles

Chelonia mydas

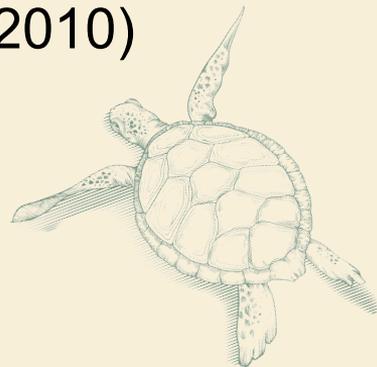


Photo: USFWS

- Most abundant turtle species in Hawaiian Islands
- 90% of Hawaiian metapopulation nest in NWHI
- Early years in open ocean
- Recruit to coastal foraging habitats
- Adults herbivorous
- Adults migrate back to nesting beach

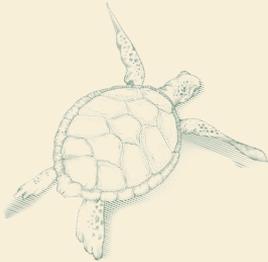
Growth Rates of Green Turtles

- Vary by location and food source (Balazs 1982)
- Hawaiian Islands green turtle population size increasing since late 1980s (Seminoff et al. 2015)
- Population density may affect growth (Wabnitz et al. 2010)



Questions

- 1) Has the average growth rate of green turtles changed over 42 years at Punalu'u?
- 2) Does the growth rate for Punalu'u green turtles fit a predictable pattern?
- 3) At what age (size) do green turtle growth rates slow and approach 0?



Punalu'u Beach, Hawai'i Island



Photo: Spatial Data Analysis and Visualization Lab, University of Hawaii at Hilo. Inset: Hawaii Statewide GIS Program.

Capture, Mark, Release, and Recapture

- 319 total turtles captured
- 186 turtles recaptured
- 127 turtles recaptured three or more times
- 7 turtles recaptured 20 or more times



Photos: G. Balazs

Tagging Data (1976–2018)

- Tag number
- Straight carapace length (SCL)
- Curved carapace length (CCL)
- Mass (kg)
- Sex
- Date



Photo: G. Balazs

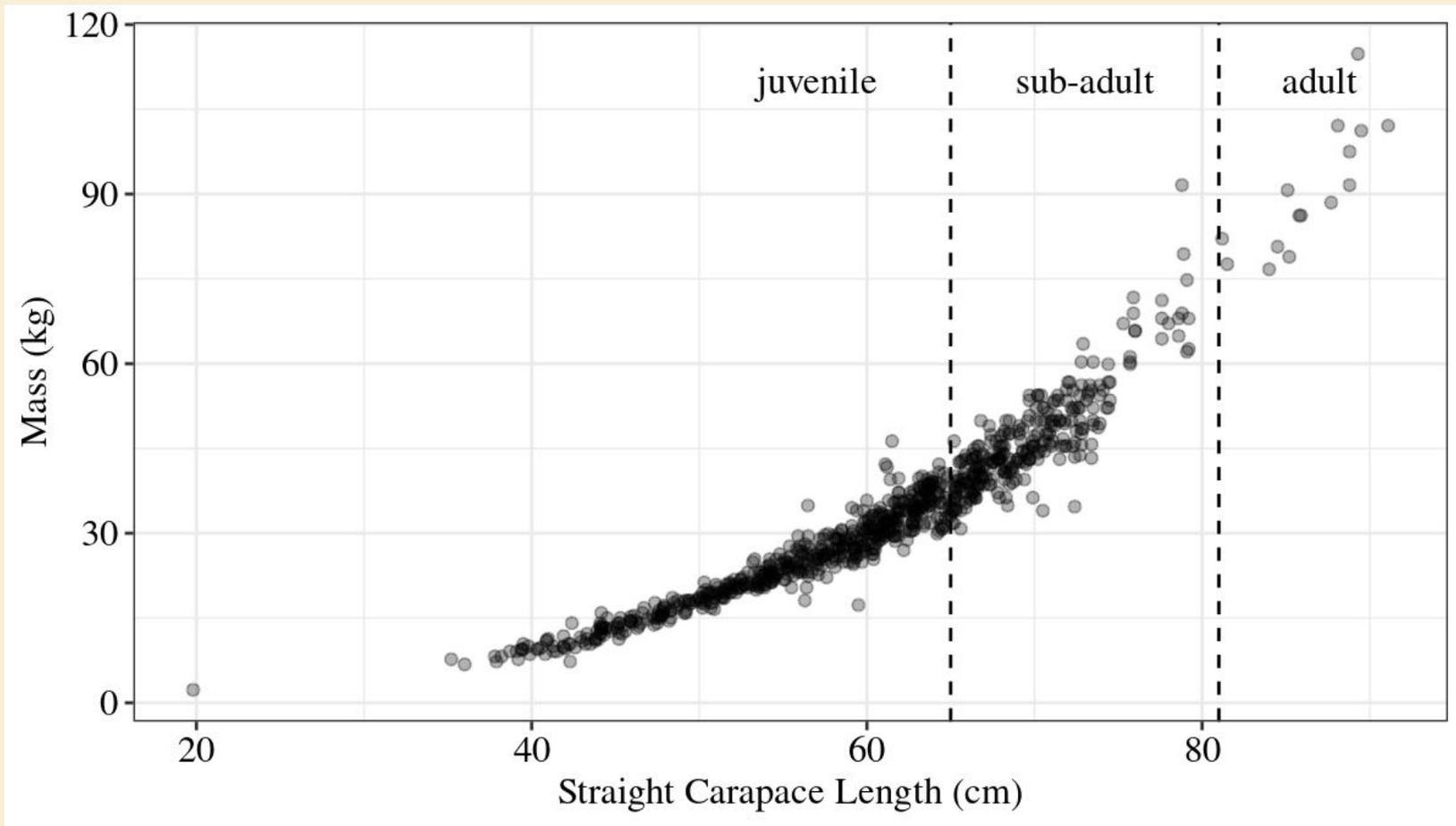
Growth Rate

$$\text{Growth Rate} = (\text{SCL final} - \text{SCL initial}) / \text{Years}$$

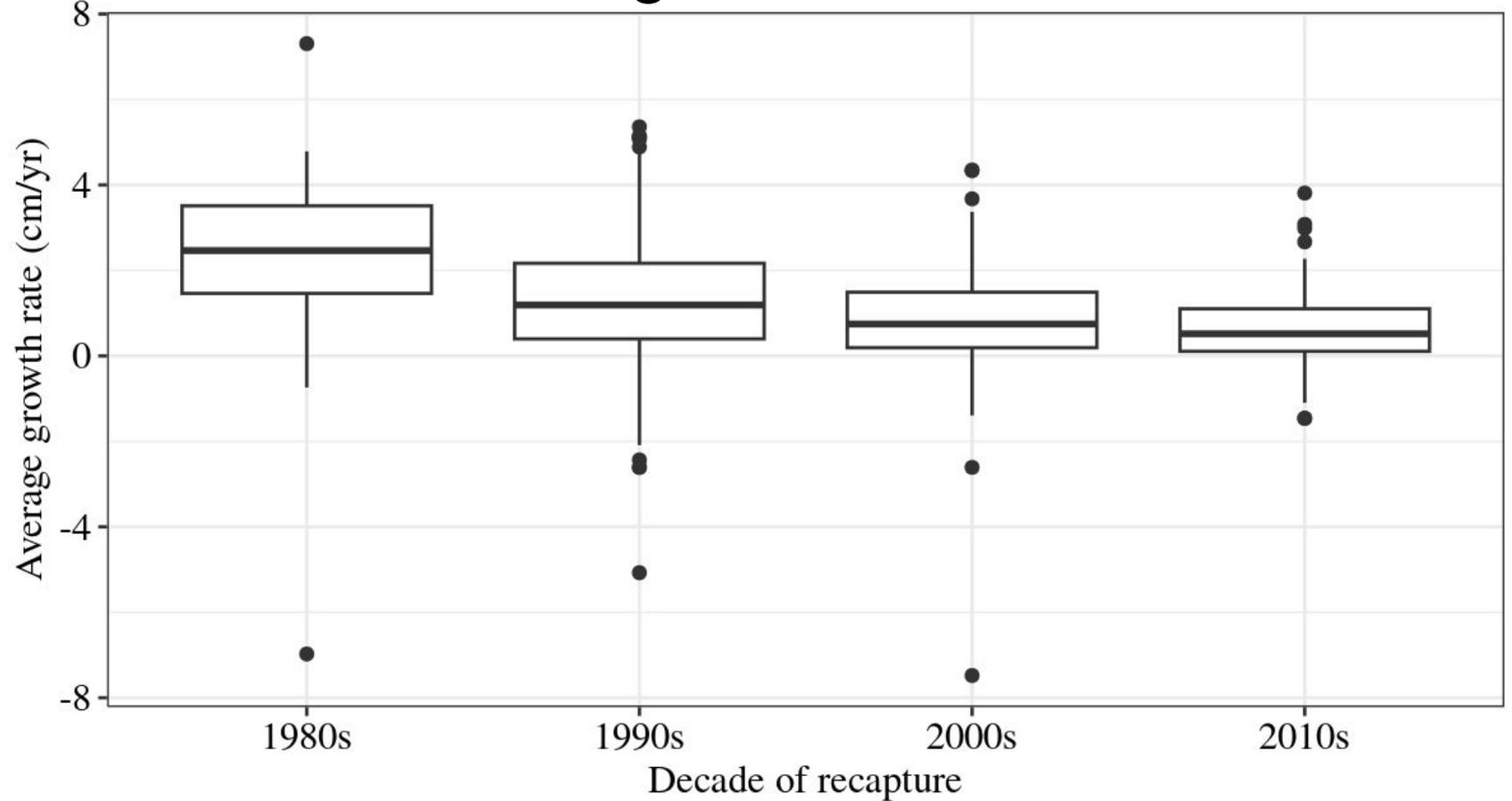


Photo: USFWS

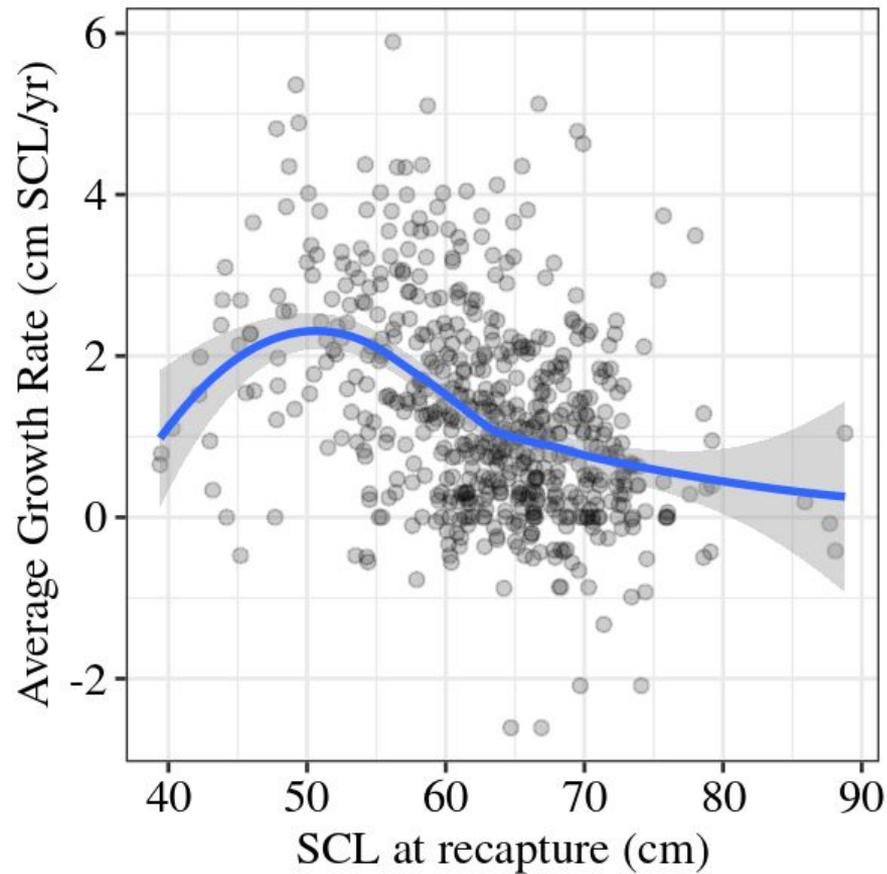
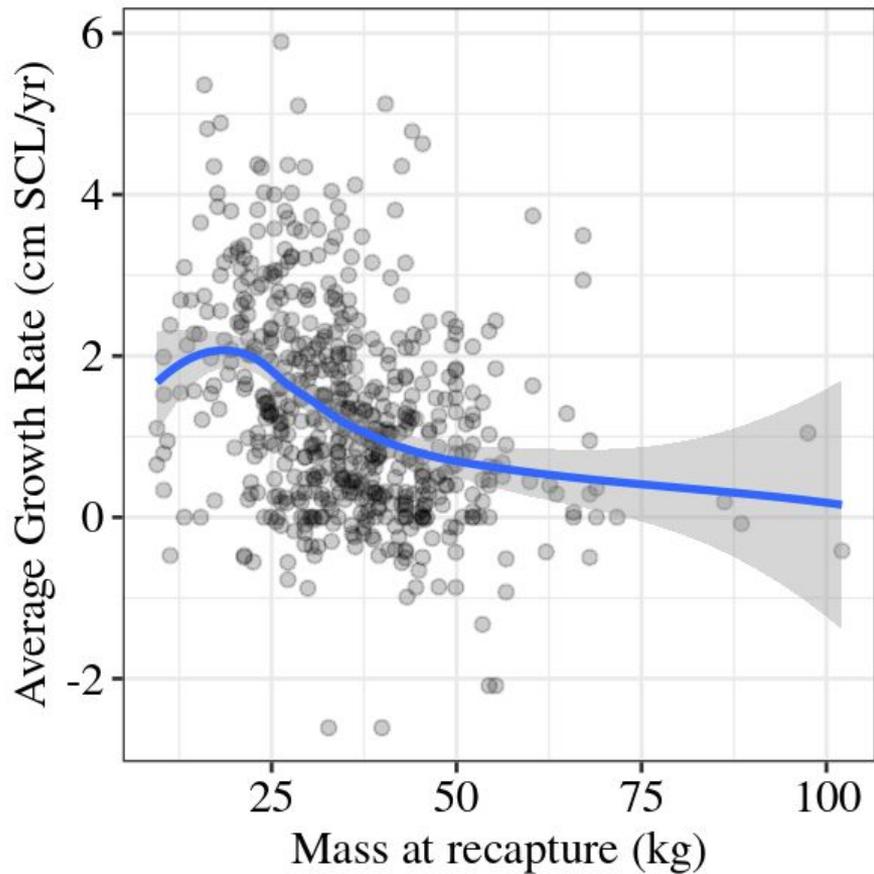
Relationship between Straight Carapace Length and Mass



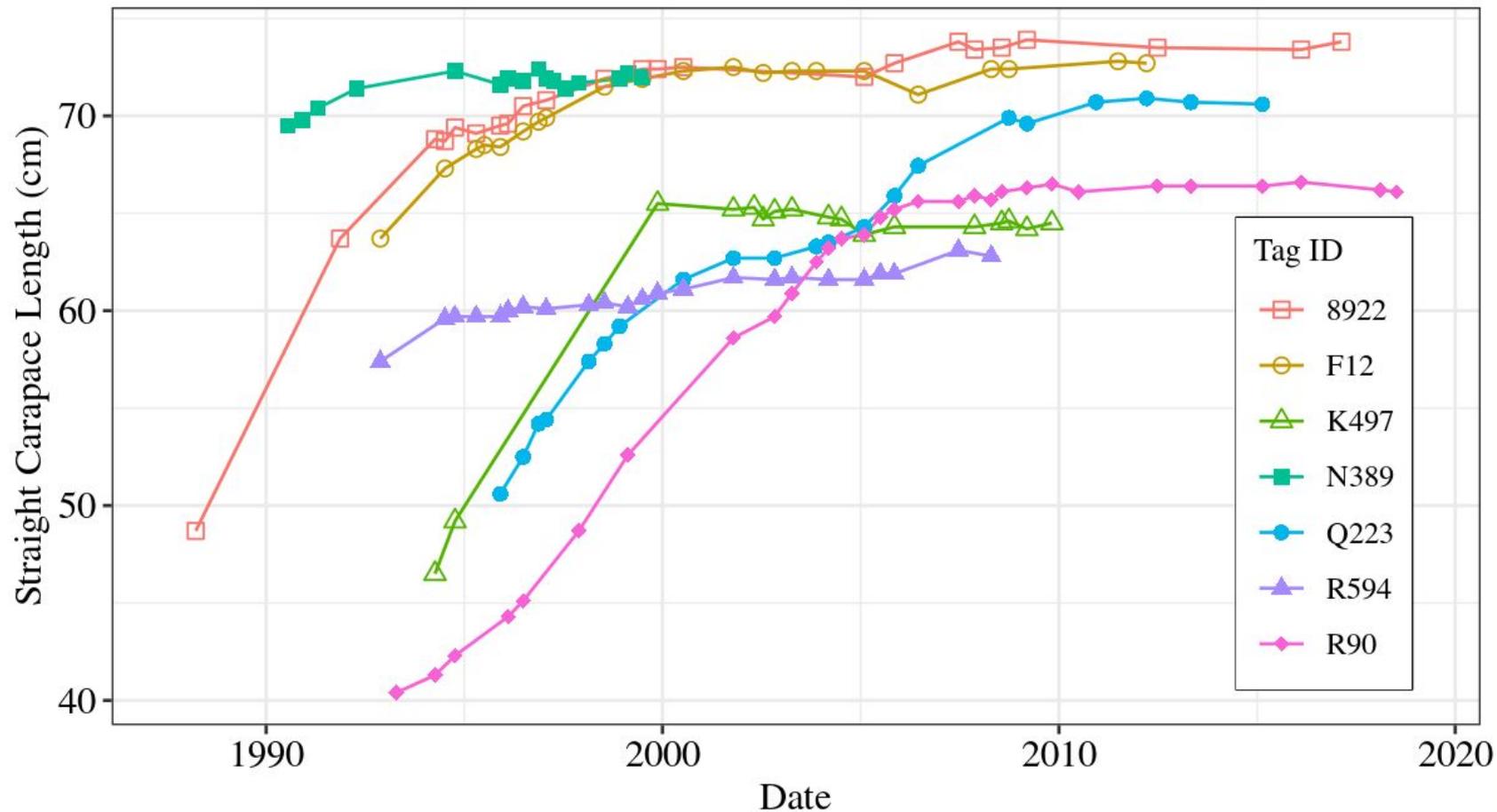
Decadal Average SCL Growth Rates



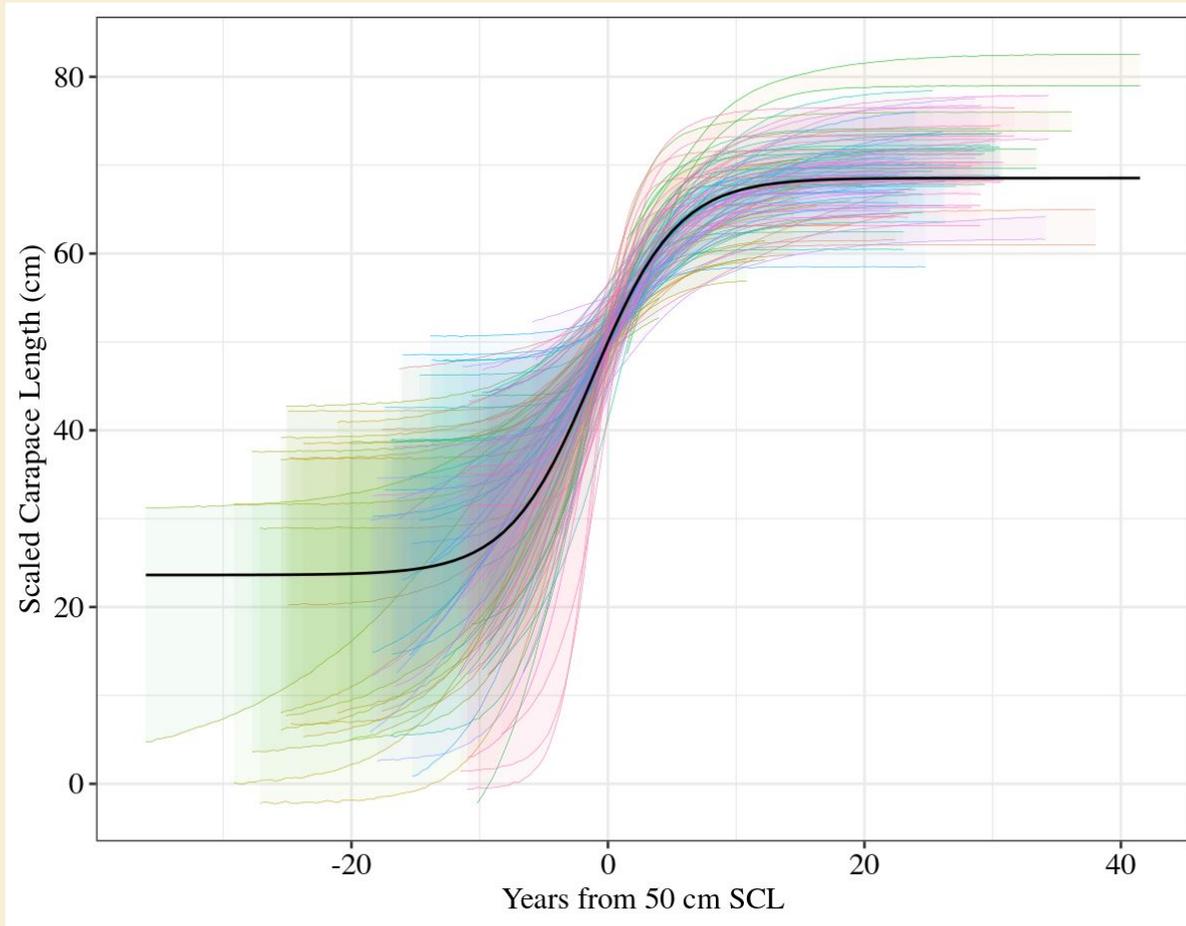
“Growth Spurt”



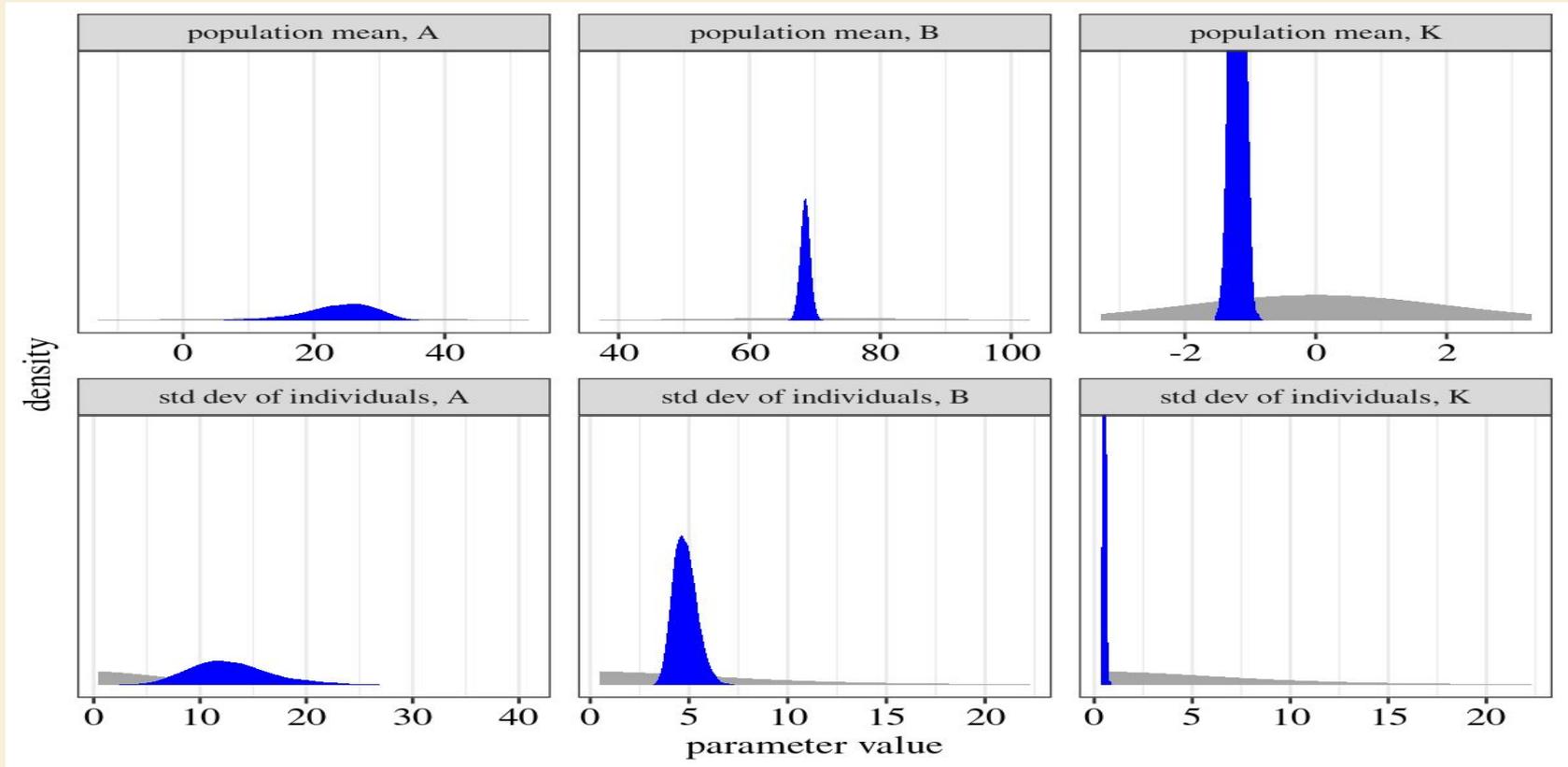
Turtles with ≥ 20 Recaptures

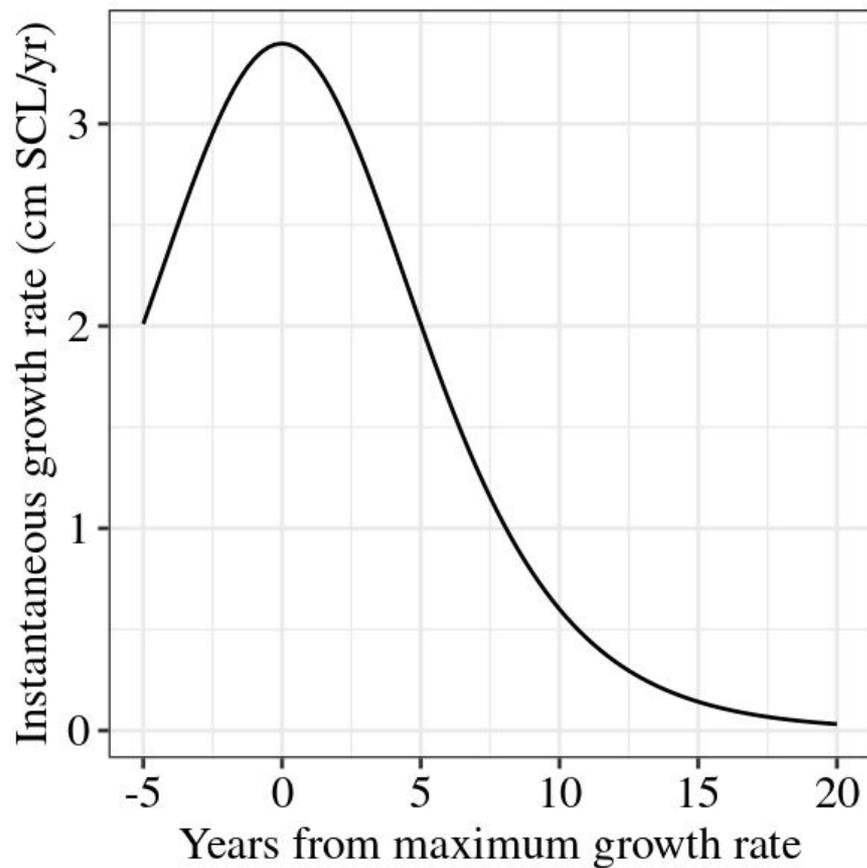
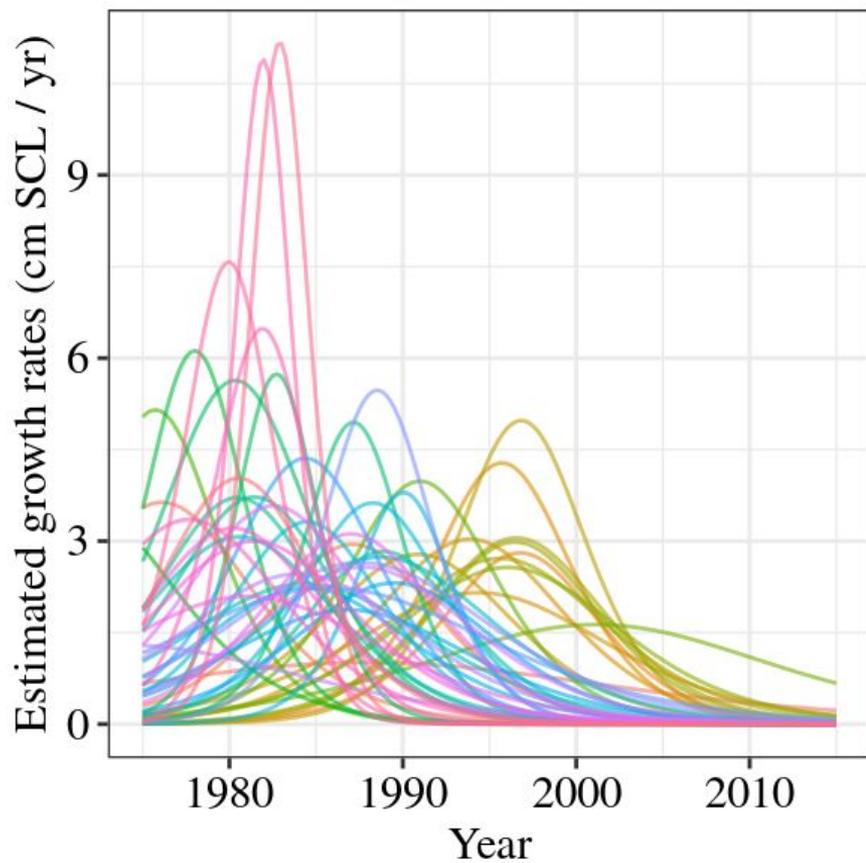


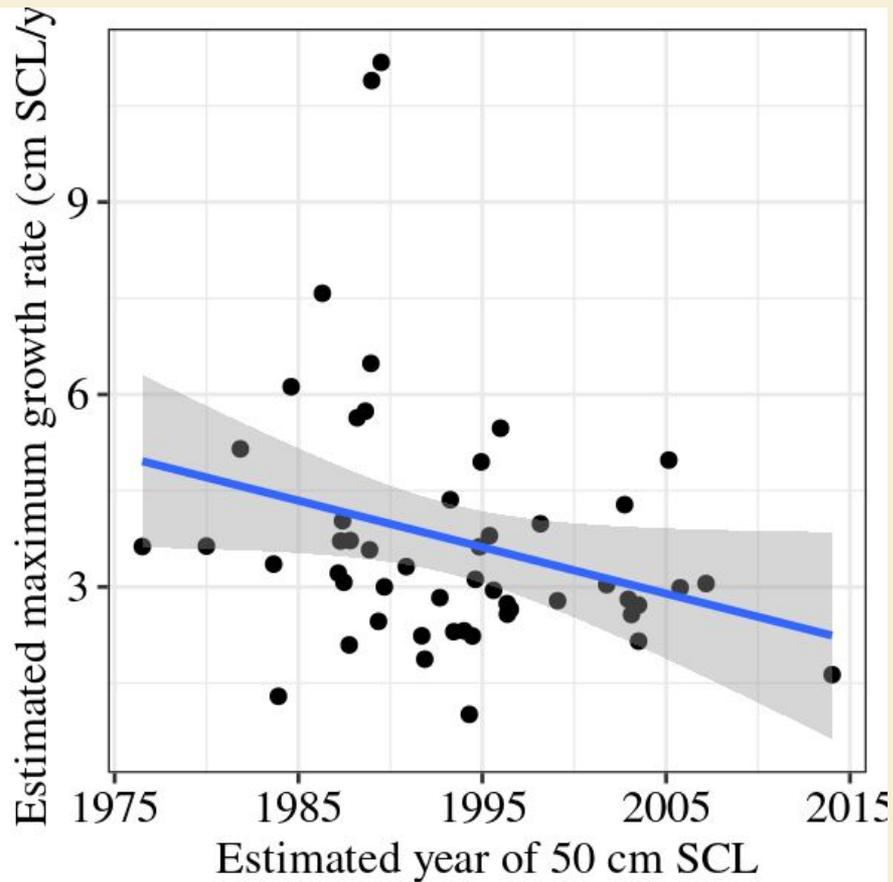
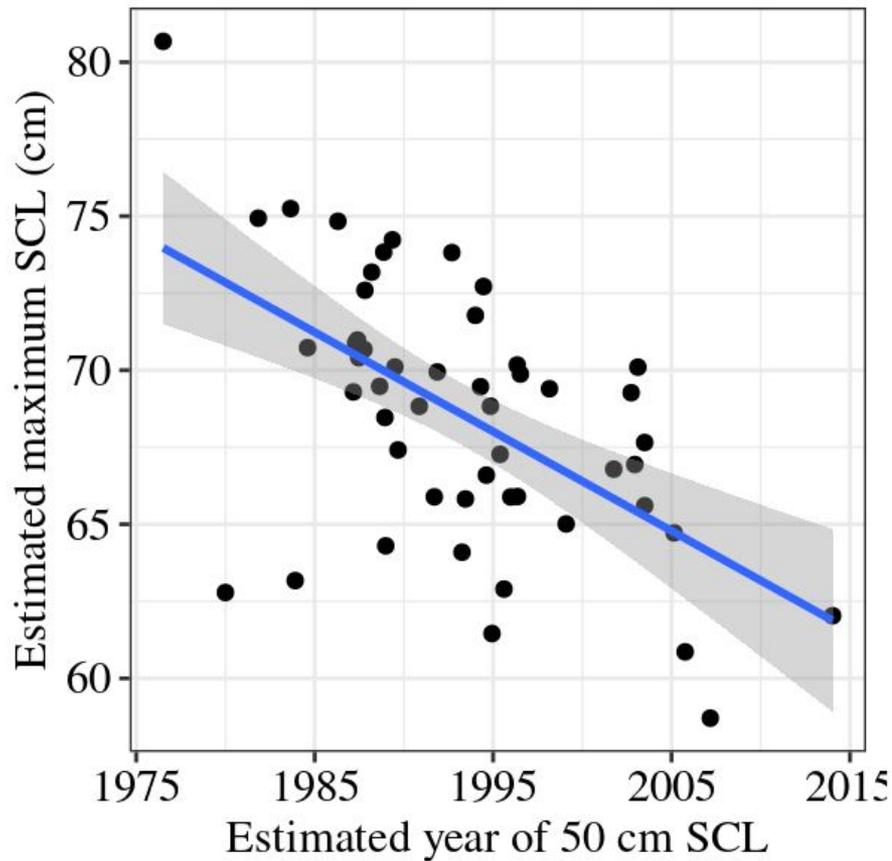
Four-Parameter Logistic Model

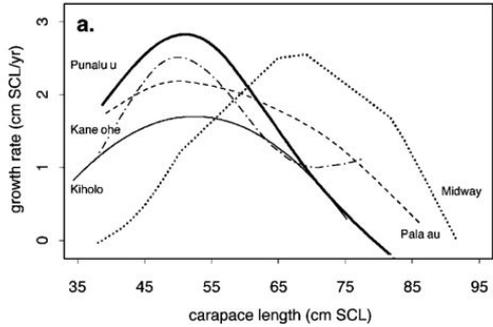


Comparison of Prior and Posterior Distributions

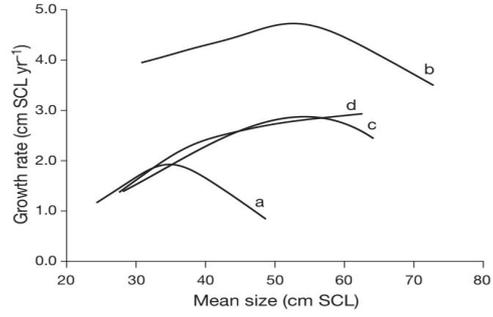




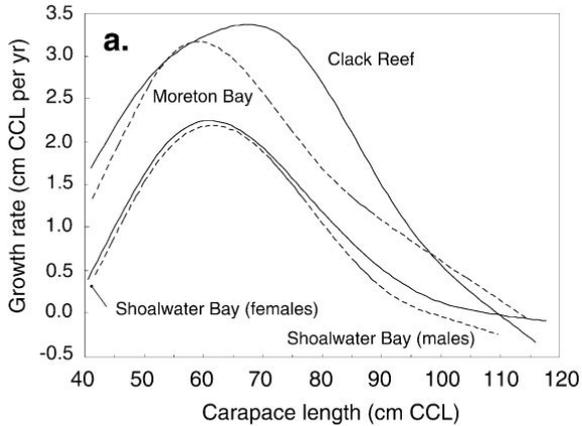




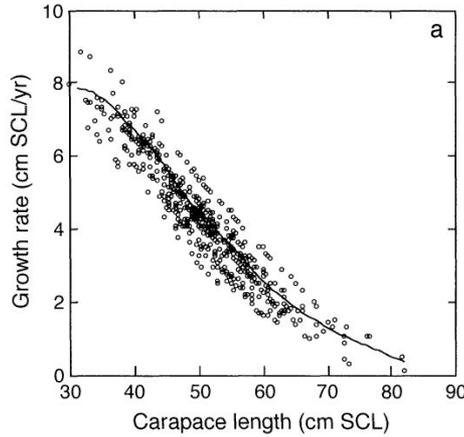
Balazs & Chaloupka 2004 HI Islands



Kubis et al. 2009 east Florida

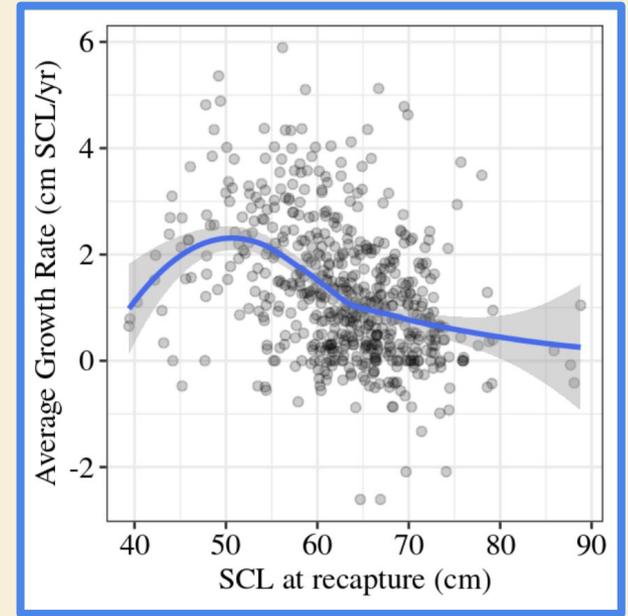


Chaloupka et al. 2004 GBR Australia



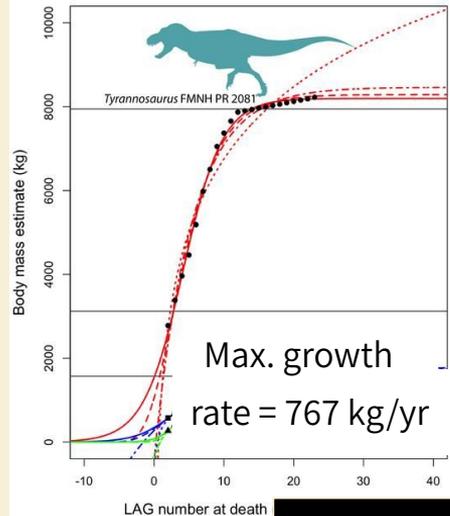
Bjorndal et al. 2000 Bahamas

Non-linear, non-monotonic growth, dome-shaped length-based growth curve



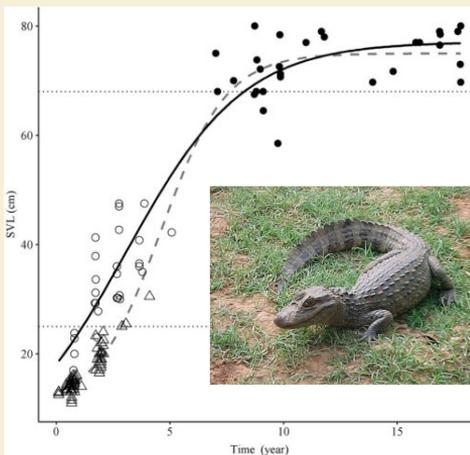
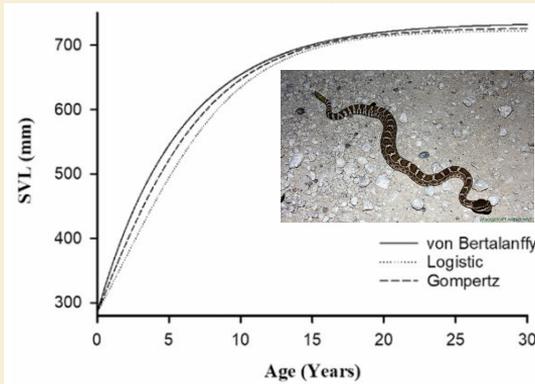
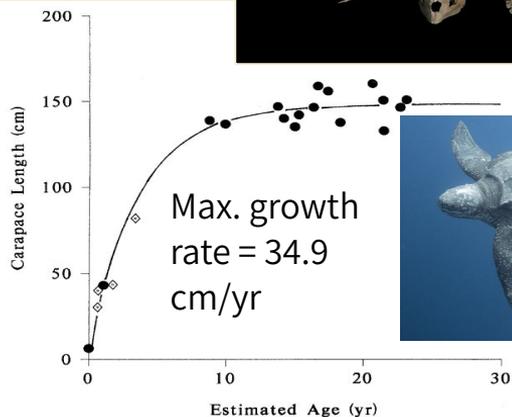
This study, Punalu'u

**Green Turtle
Somatic
Growth Model**

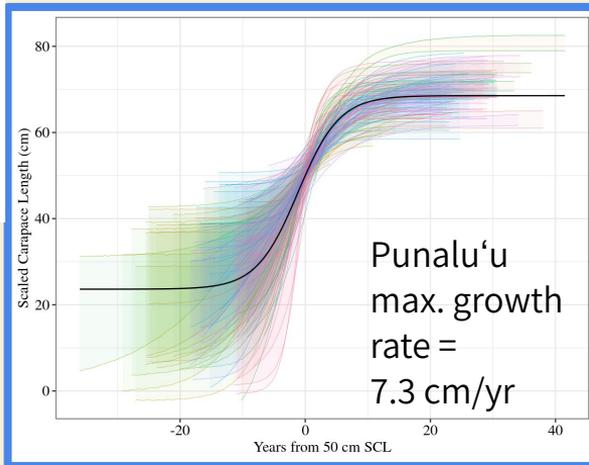


Rapid Growth Pattern and Early Sexual Maturity

Protostega gigas

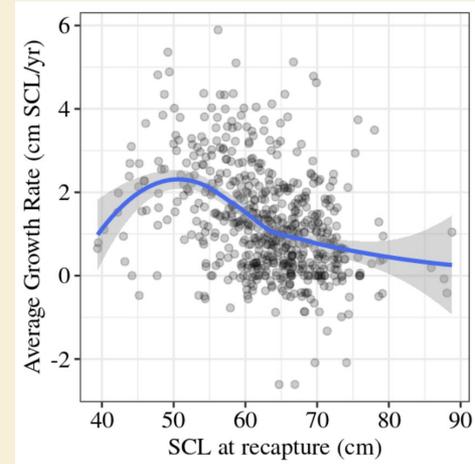


Primitive Reptilian Condition

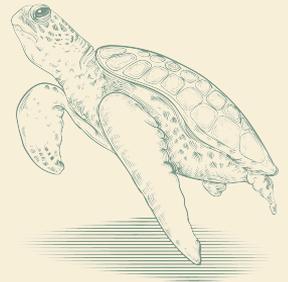
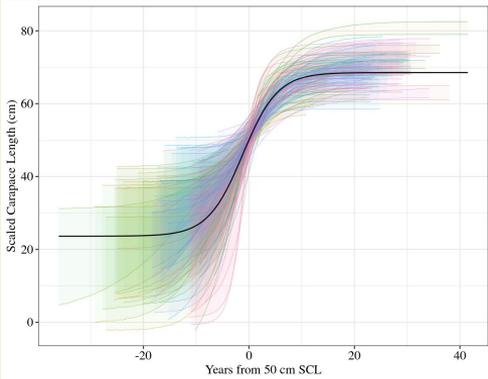


Long generation time, slow growth rate even in juveniles, late sexual maturity

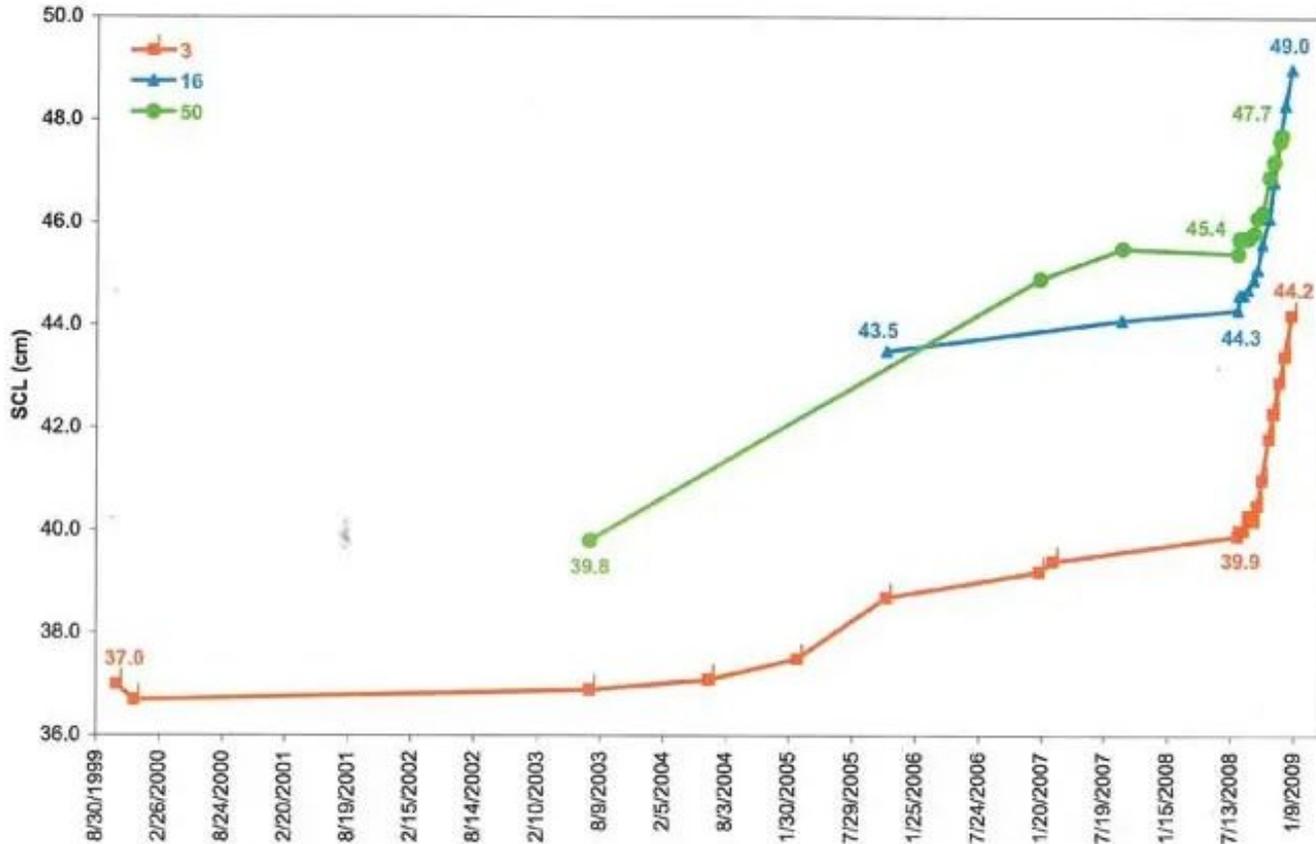
Conclusions for Punalu'u Green Turtle Population



- Average annual growth rate = 1.16 cm SCL/yr
- Maximum growth rate observed = 7.3 cm SCL/yr
- Growth rates have declined since 1980s
- Growth rate peaks around 50 cm SCL
- Four-parameter model: SCL asymptote at 68.6 cm
- “Green Turtle Somatic Growth Model”
- “Primitive Reptilian Condition”



Growth History for 3 Juvenile Hawaiian Green Turtles from Kiholo Bay Undergoing Nutritional Rehabilitation at the PIFSC KRF



**Wild Turtles
Have Capacity
to Grow Fast
When Fed**

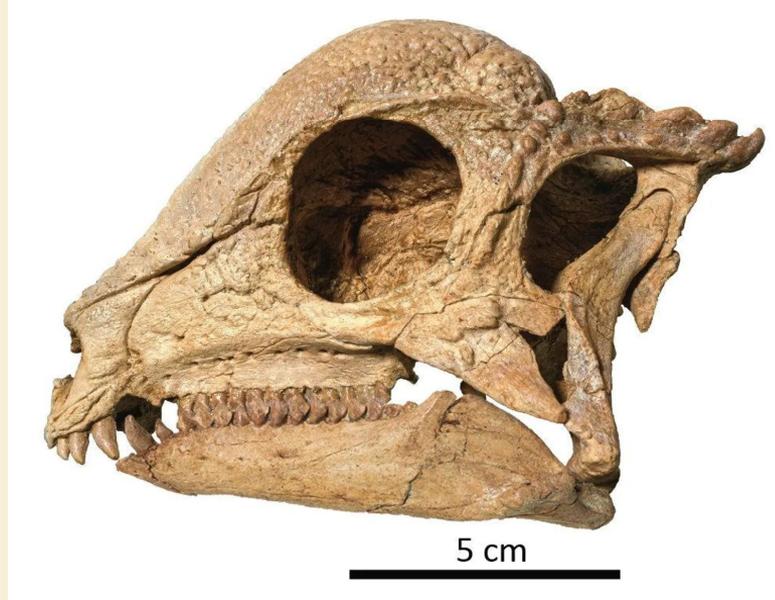
Kiholo Bay
juveniles taken
to Kewalo
Rehab Facility
and fed

Later returned
to Kiholo

Dome-headed Dinosaurs Reached Sexual Maturity Before Their Bodies Finished Growing



Sociosexual Behavior

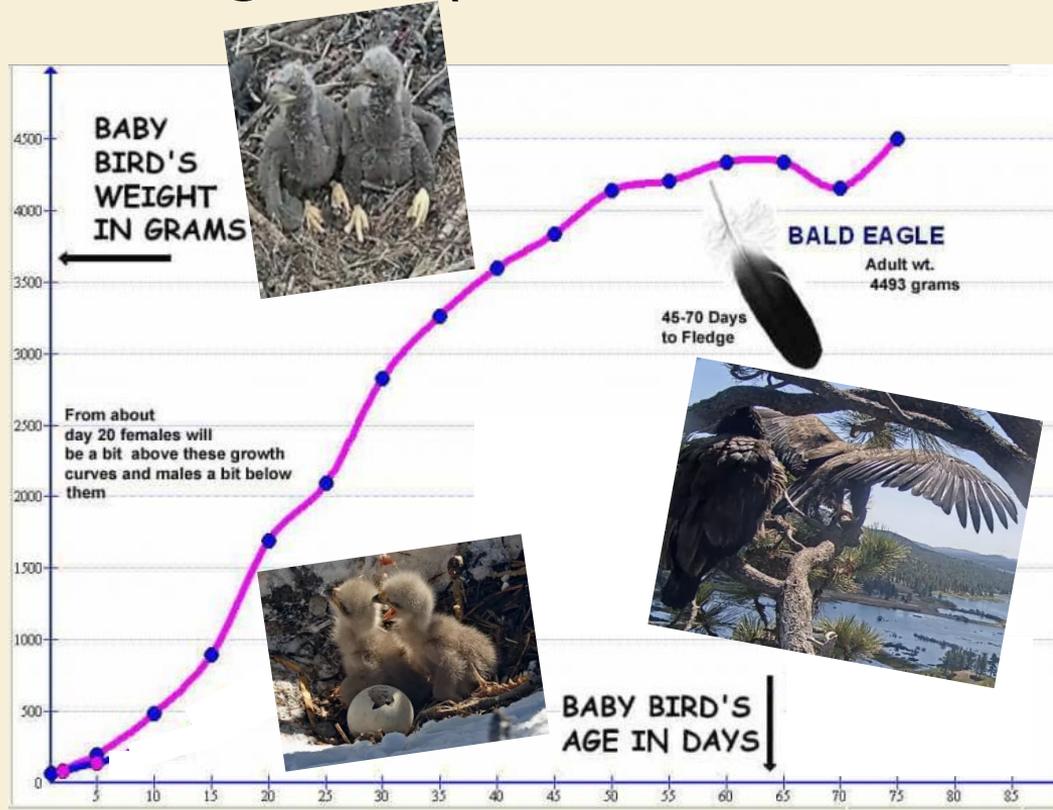


Sexually mature teenager
Zavacephale rinpoche sp.nov.
108 mya Mongolia

- Rapid Growth
- Early Dome Development
- Terminal Body Size Later

Chinzorig et al. 2025 *Nature*
Schuster 2025 *Haaretz*

Bald Eagles (Extant Dinosaurs)



- Five-fold increase in body in first week: 90-454 g
- Chick max. growth rate: 140-150 g/day
- 7.5-1000 cm long in 3 mo
- Sexually mature in 4-6 y
- Lifespan 20-30 y