Integrating drones in monitoring of harbour porpoise body condition and demographics in Danish waters

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Background

- Population size structure and body condition are key indicators of marine mammal population status *(Booth et al. 2020; Vivier et al. 2025)*
- Harbour porpoises in inner Danish waters (Belt Sea population) are declining *(Owen et al. 2024)*
- Existing size and health data are mainly from stranded/bycaught animals *(Lockyer & Kinze 2003; Siebert et al. 2022)*
- Stranding data could be biased *(Peltier et al. 2012; IJsseldijk et al. 2020)*
- Unmanned Aerial Vehicle (UAV) photogrammetry offers a non-invasive approach to assess size and condition in living cetaceans *(Christiansen et al. 2016; Vivier et al. 2025)*

Project aims

Assess the feasibility of using UAV photogrammetry to measure size structure and body condition (nutritional health) of harbour porpoises in inner Danish waters:

- Seasonal variation in population size structure (*H: no calves in spring, small calves in summer, large calves in fall)*
- Seasonal variation in body condition (*H: high BC in winter, low BC in summer)*

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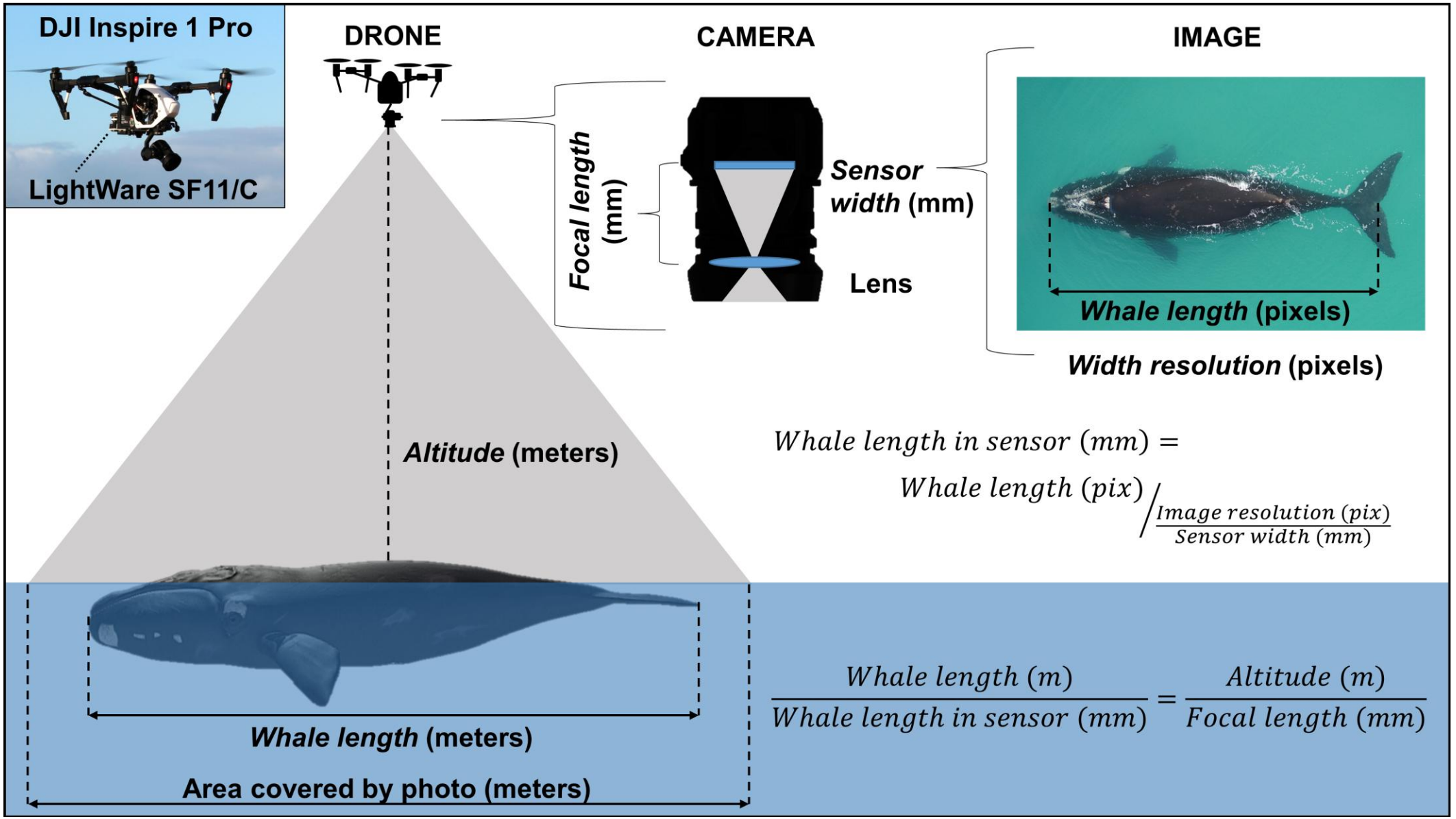
Drone photogrammetry on cetaceans



Data collection

- Inner Danish waters
- Land based and boat based
- Sampling effort:
  - 23 days of sampling:
    - 2024: 4 May – 5 Oct (6 days)
    - 2025: 26 Feb – 9 Nov (17 days)
  - 106 UAV flights
- Raw sample size:
  - 491 measurements
    - 2024: 149
    - 2025: 342

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Data filtering

- Image quality
  - Christiansen et al. (2018) protocol
  - Other issues:
    - Graininess
    - Glare
    - Wave action
- Pseudo-replication
- Filtered sample size:
  - 361 measurements
  - 228 individuals

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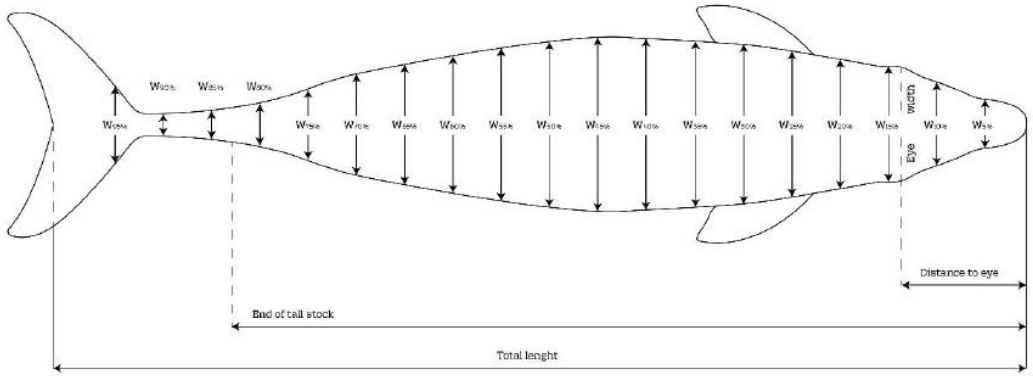
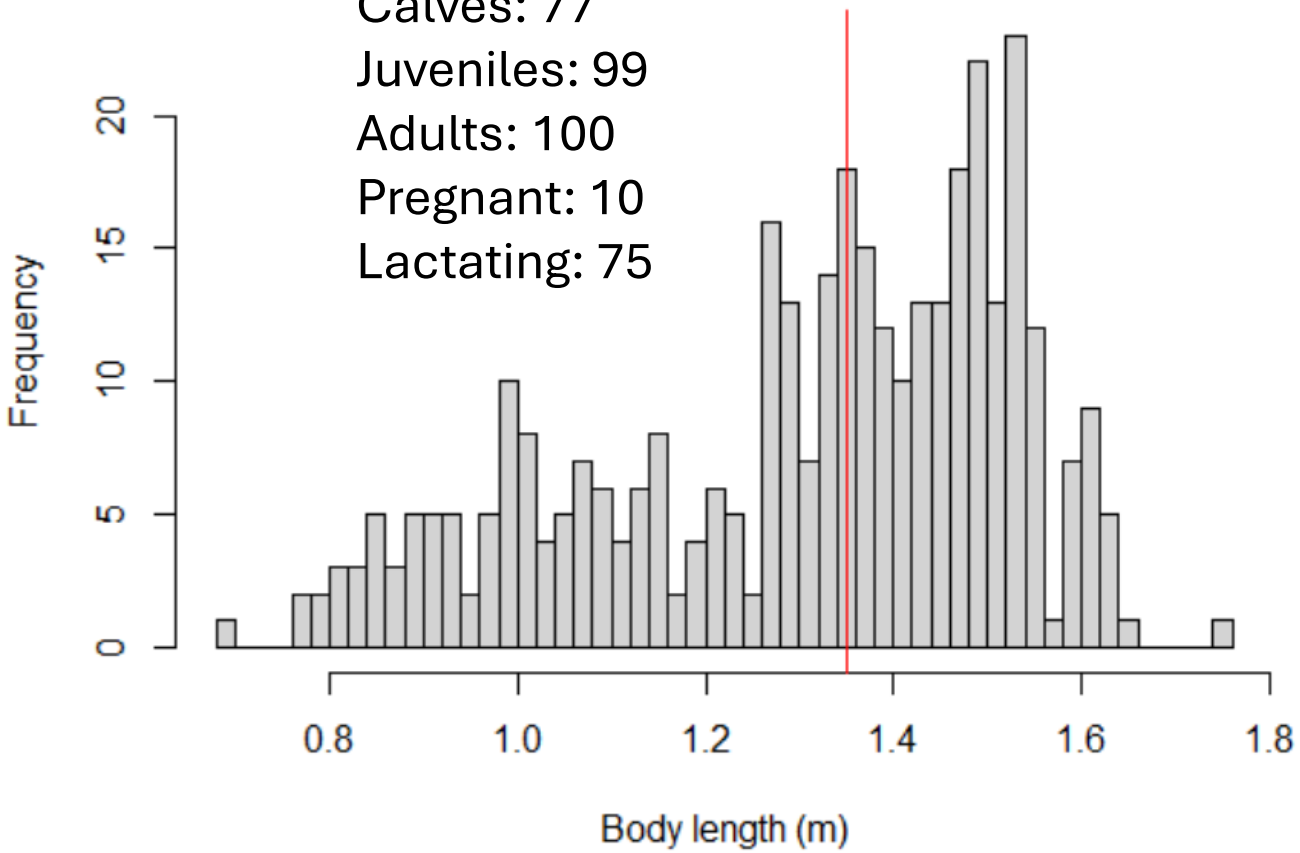
Morphometric measurements



Calves: 77
Juveniles: 99
Adults: 100
Pregnant: 10
Lactating: 75



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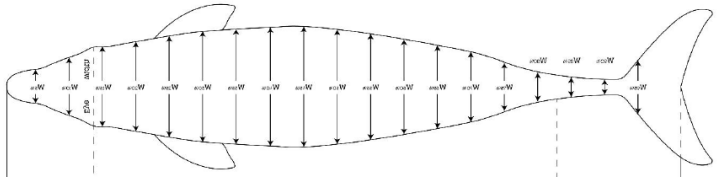
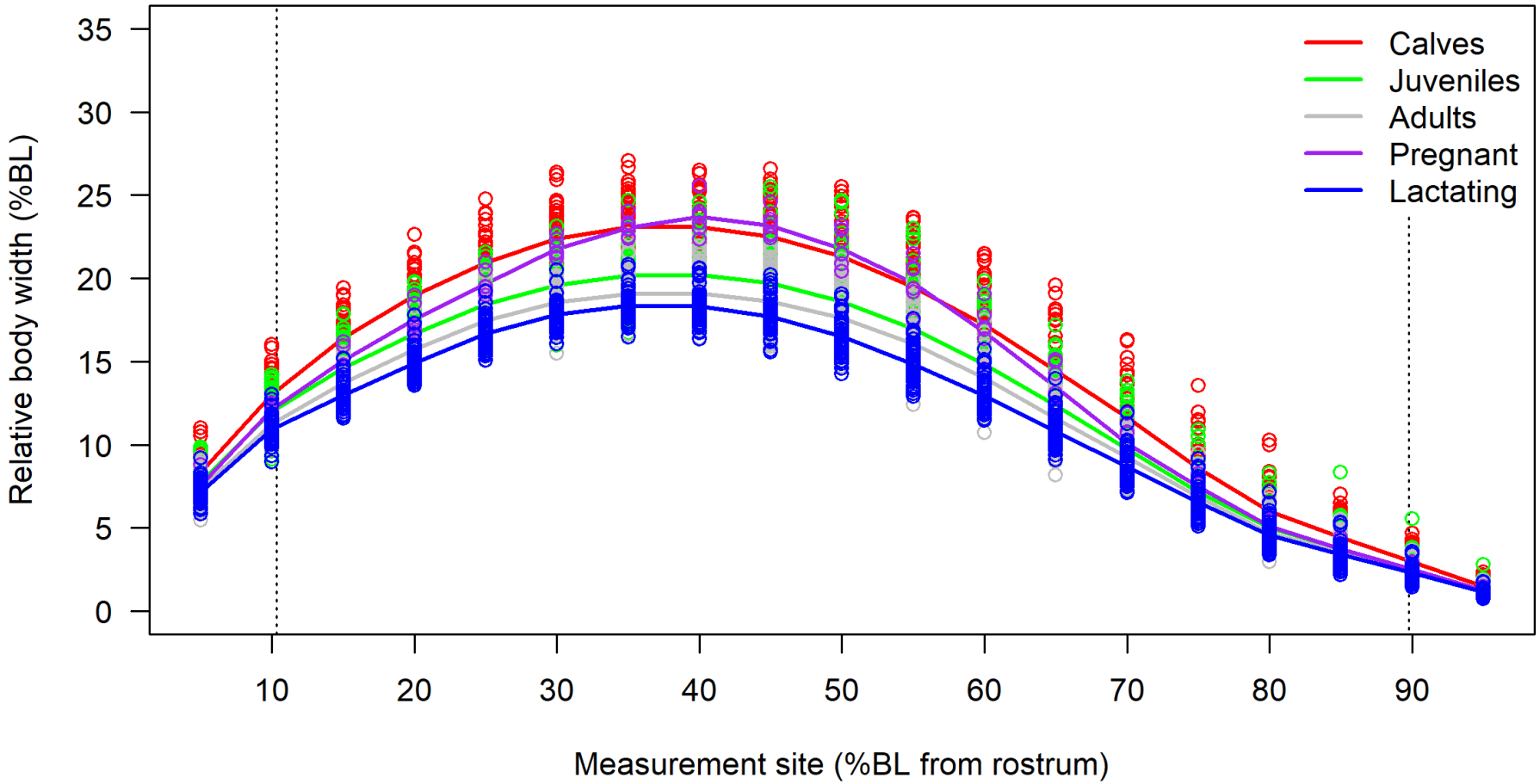
Metabolically active body region





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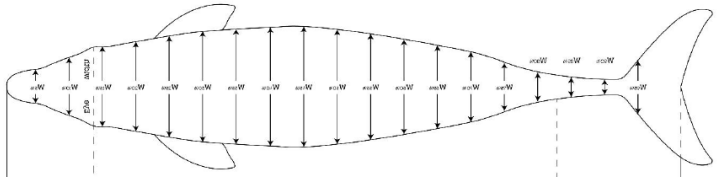

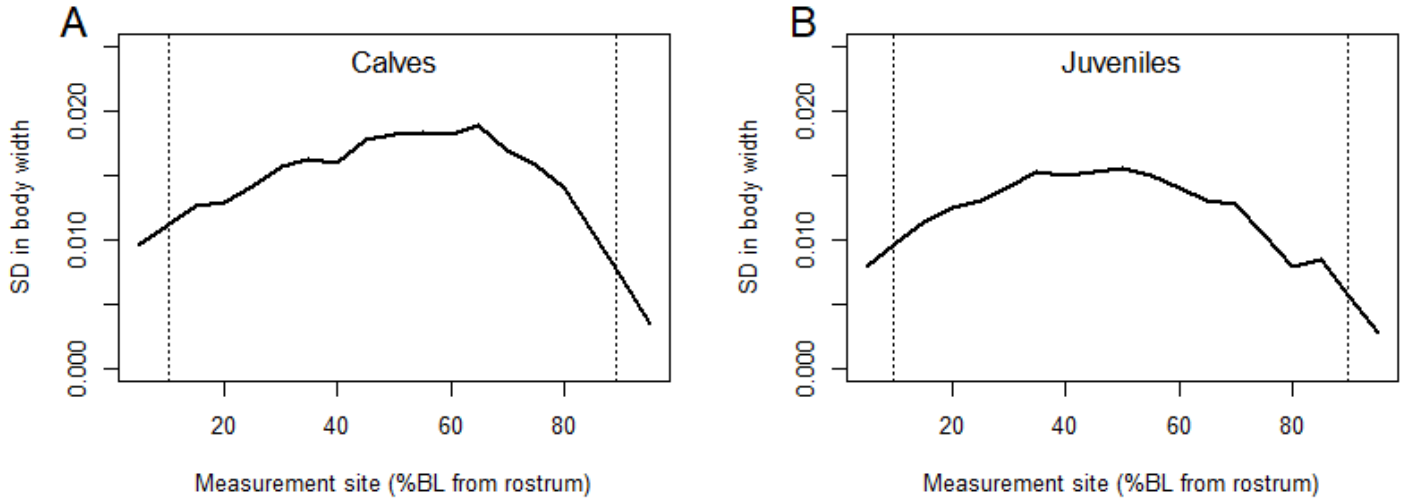

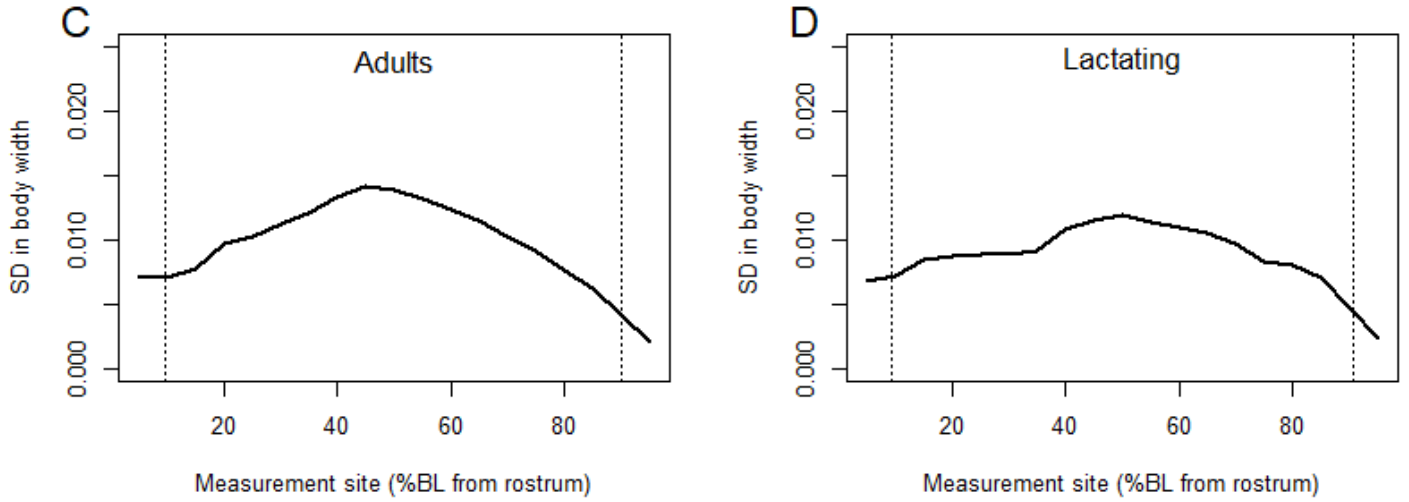

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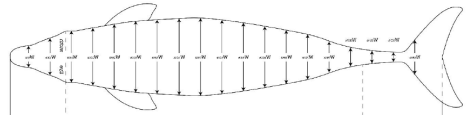
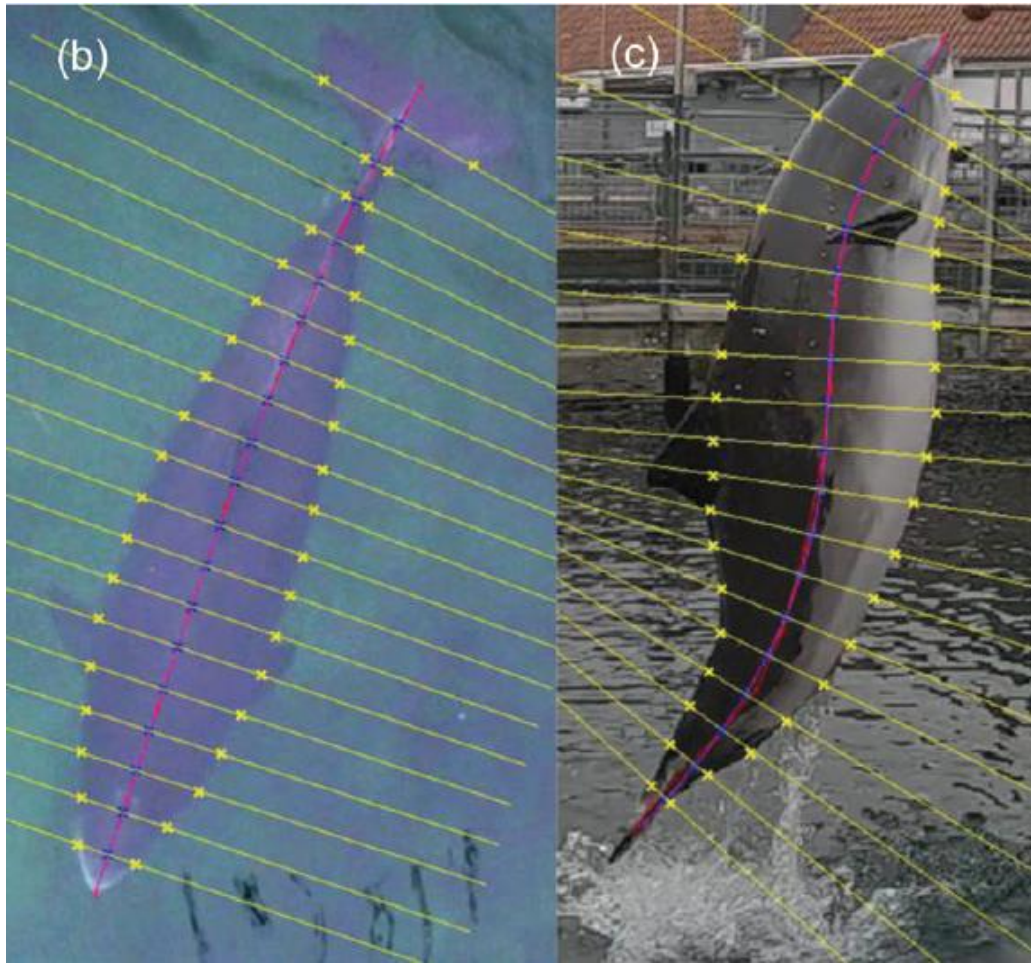
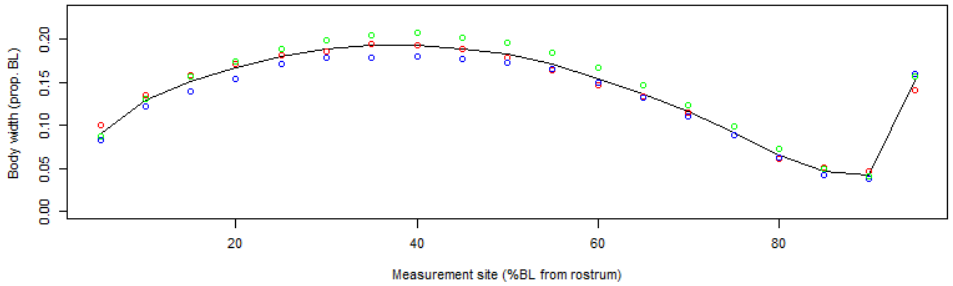
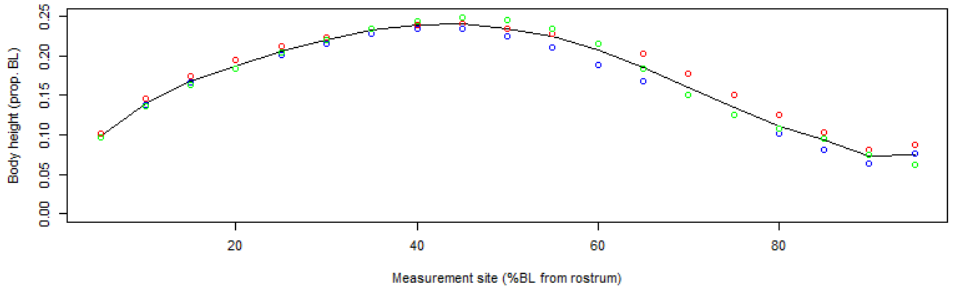
Build a 3D model for harbour porpoises

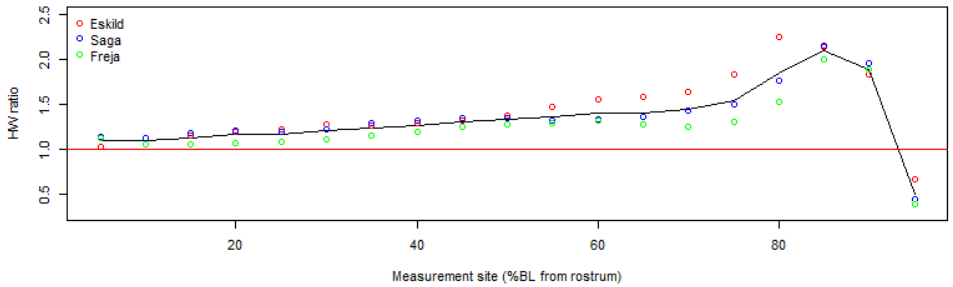


- Fjord & Bælt: 3 porpoises: Drone+Weight+Morphometrics every 2nd month (Camille Rondeau Saint-Jean)



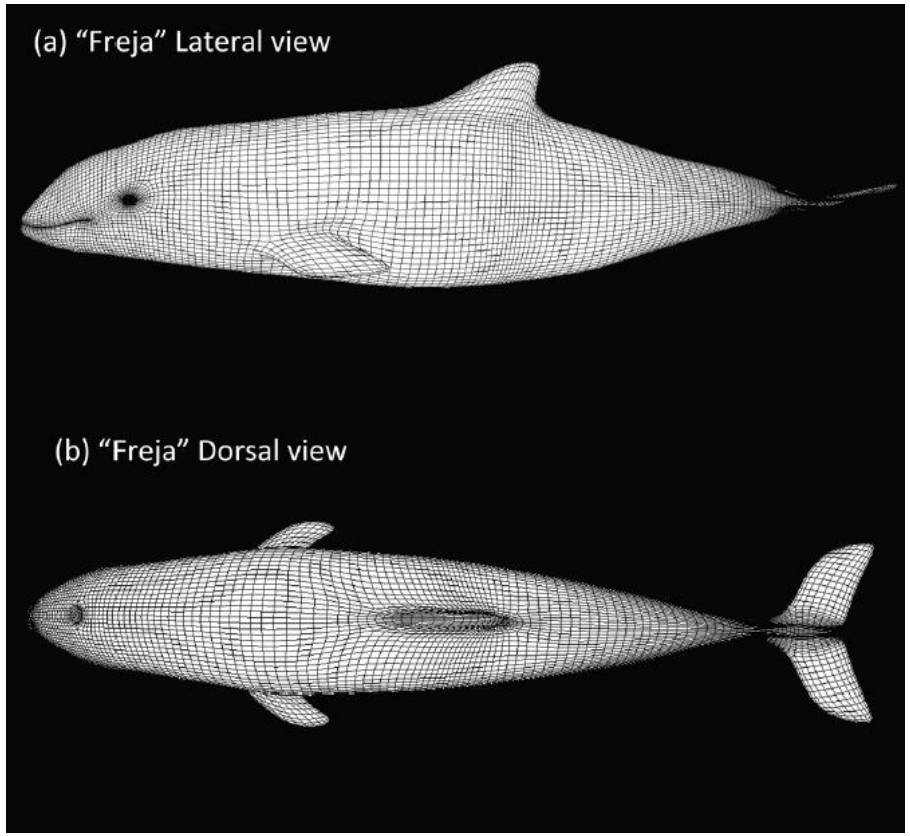


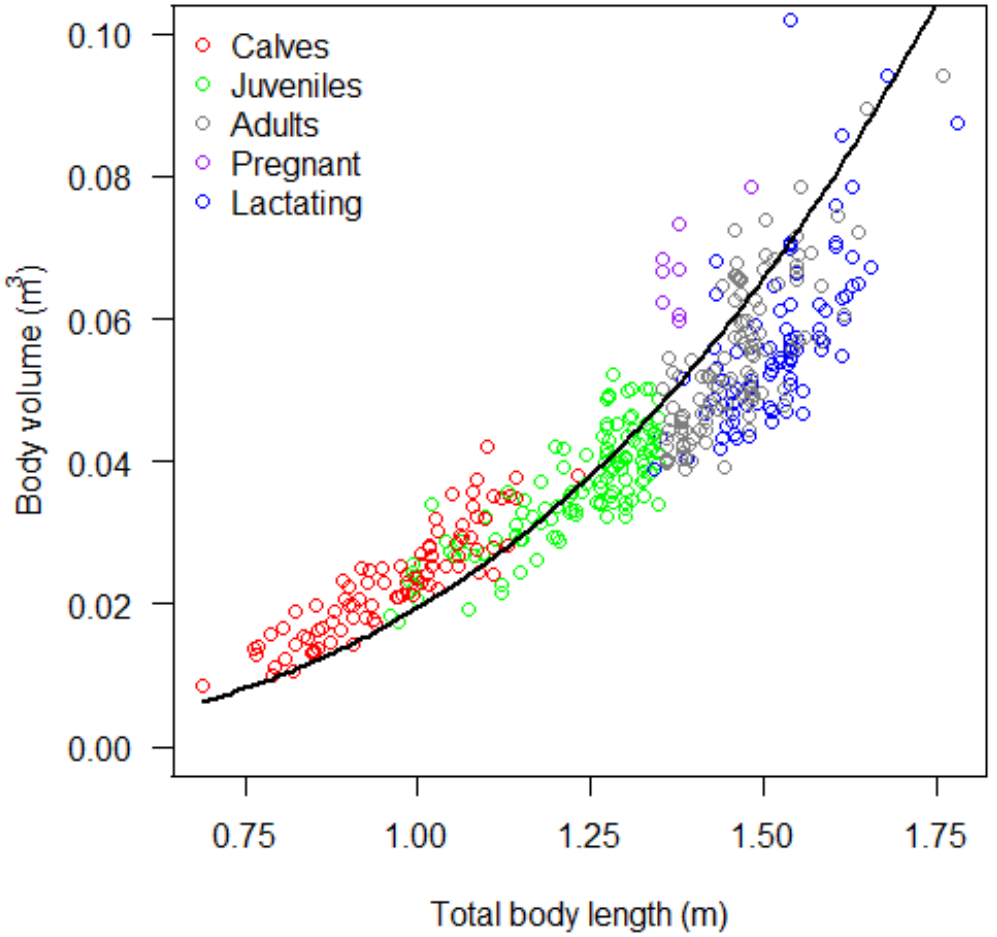




Body volume

$$BV_{s,i} = BL_i \times 0.05 \times \int_0^1 \pi \times \frac{W_{A,s,i} + (W_{P,s,i} - W_{A,s,i}) \times x}{2} \times \frac{H_{A,s,i} + (H_{P,s,i} - H_{A,s,i}) \times x}{2} dx \qquad BV_{Total,i} = \sum_{s=1}^{20} V_{s,i}$$

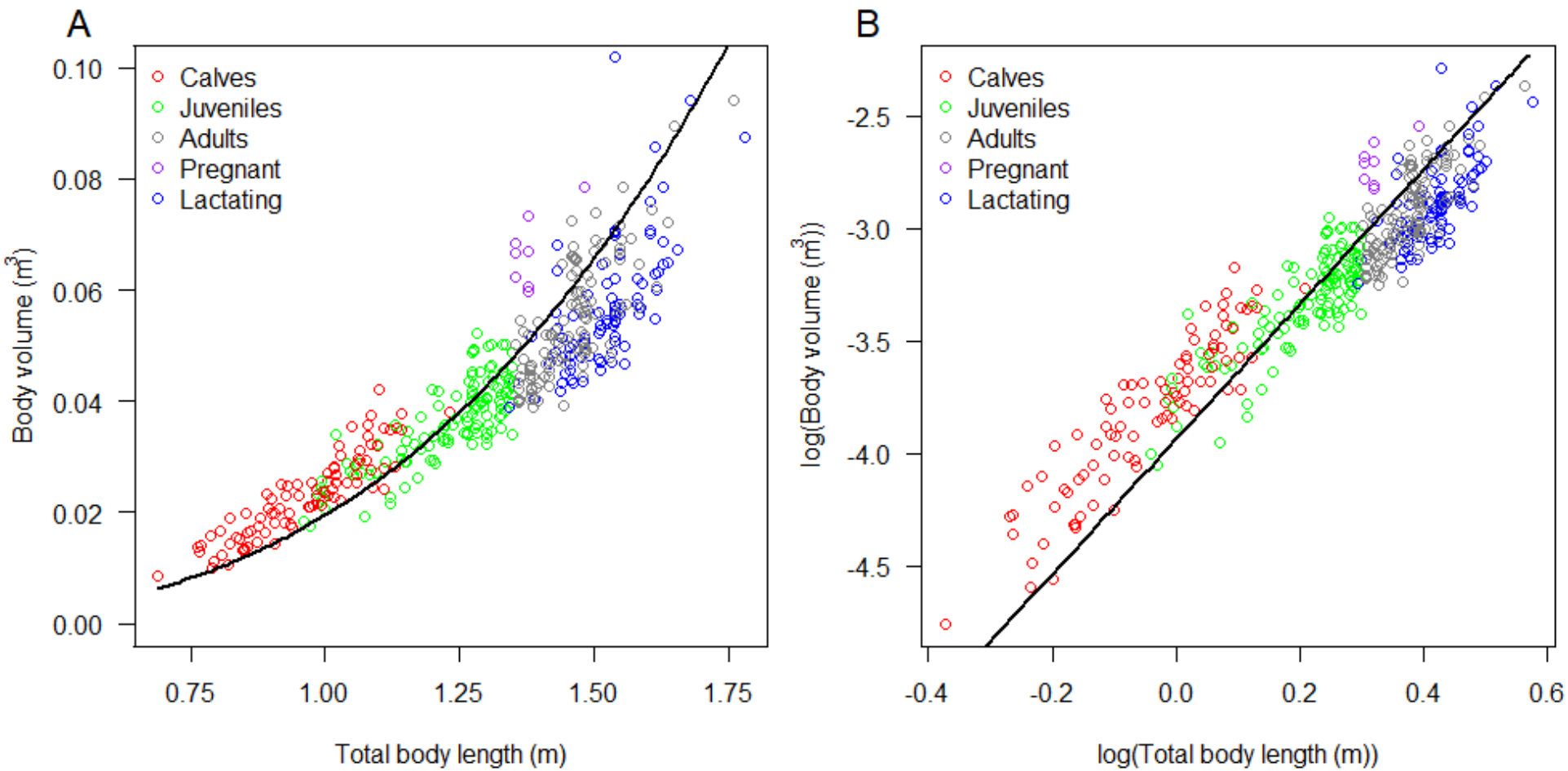




Body condition

$$BV_{(BC=0)} = 0.0194 \times BL^3$$

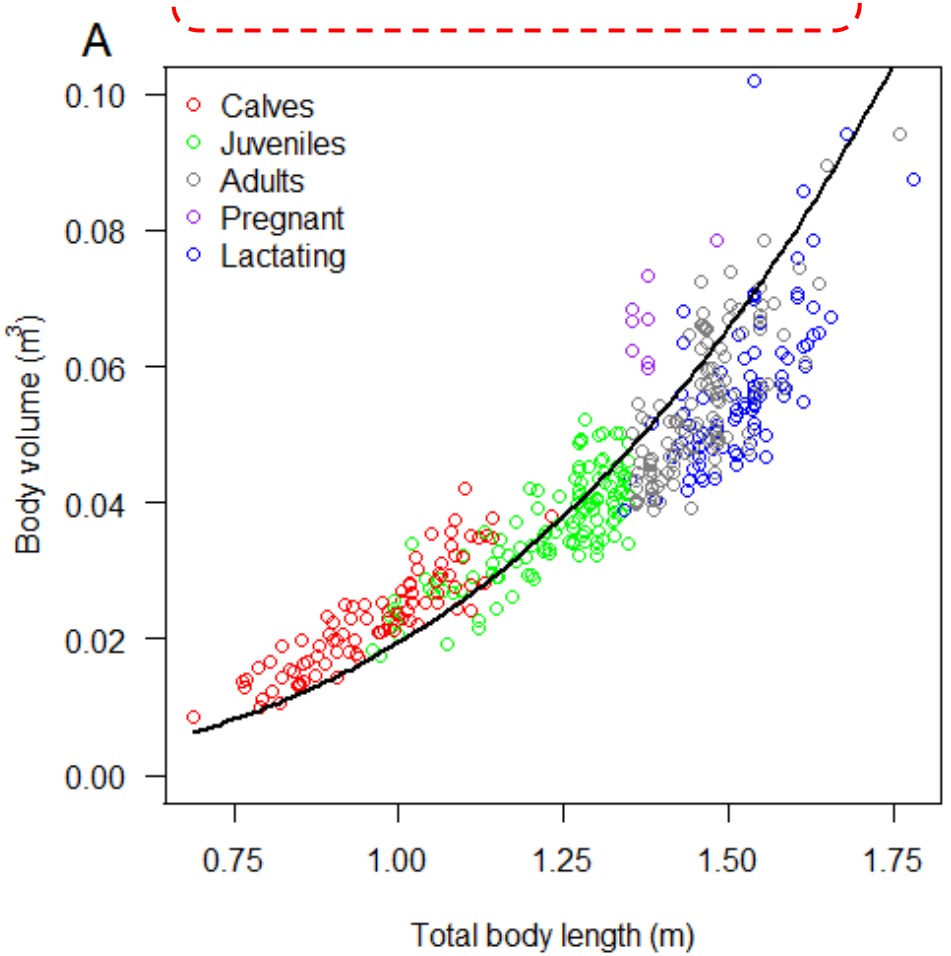
$$\log(BV_{(BC=0)}) = -3.94 + 3\,\log(BL)$$

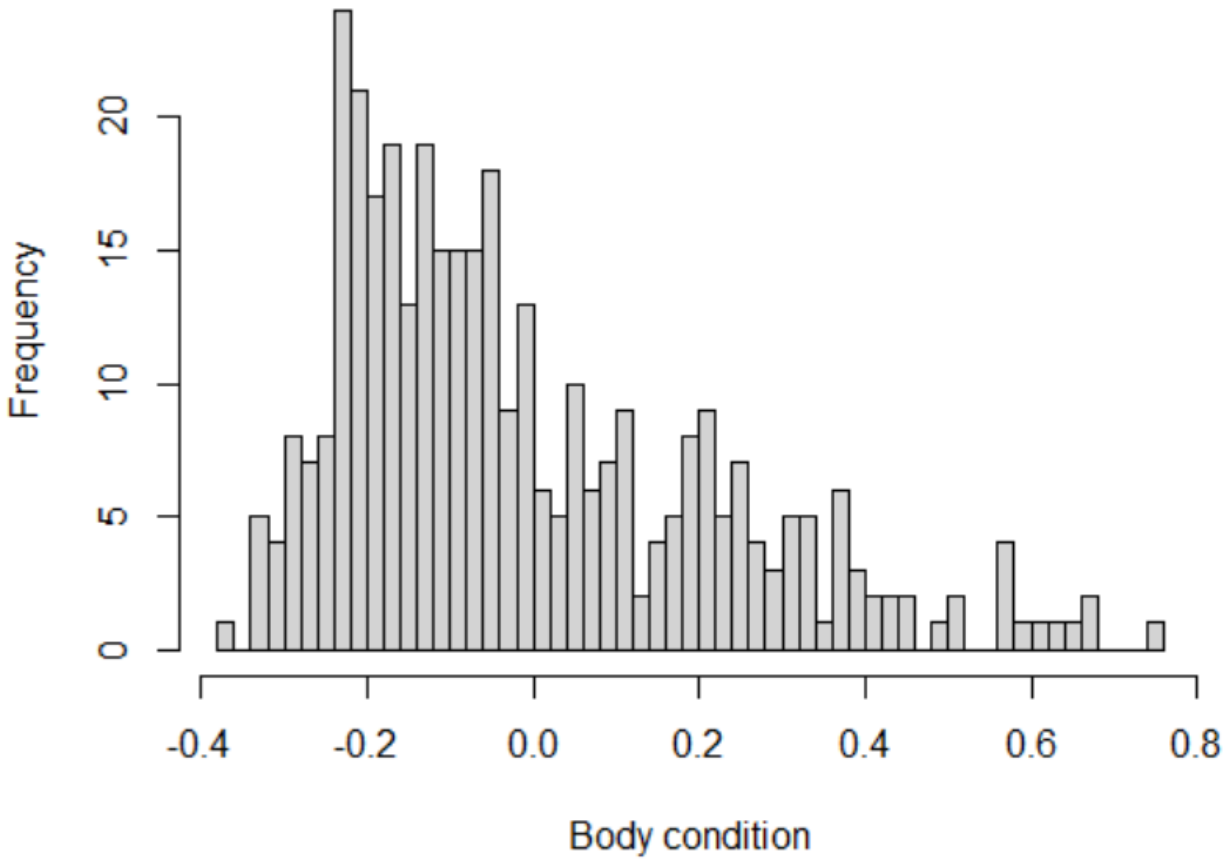


Body condition

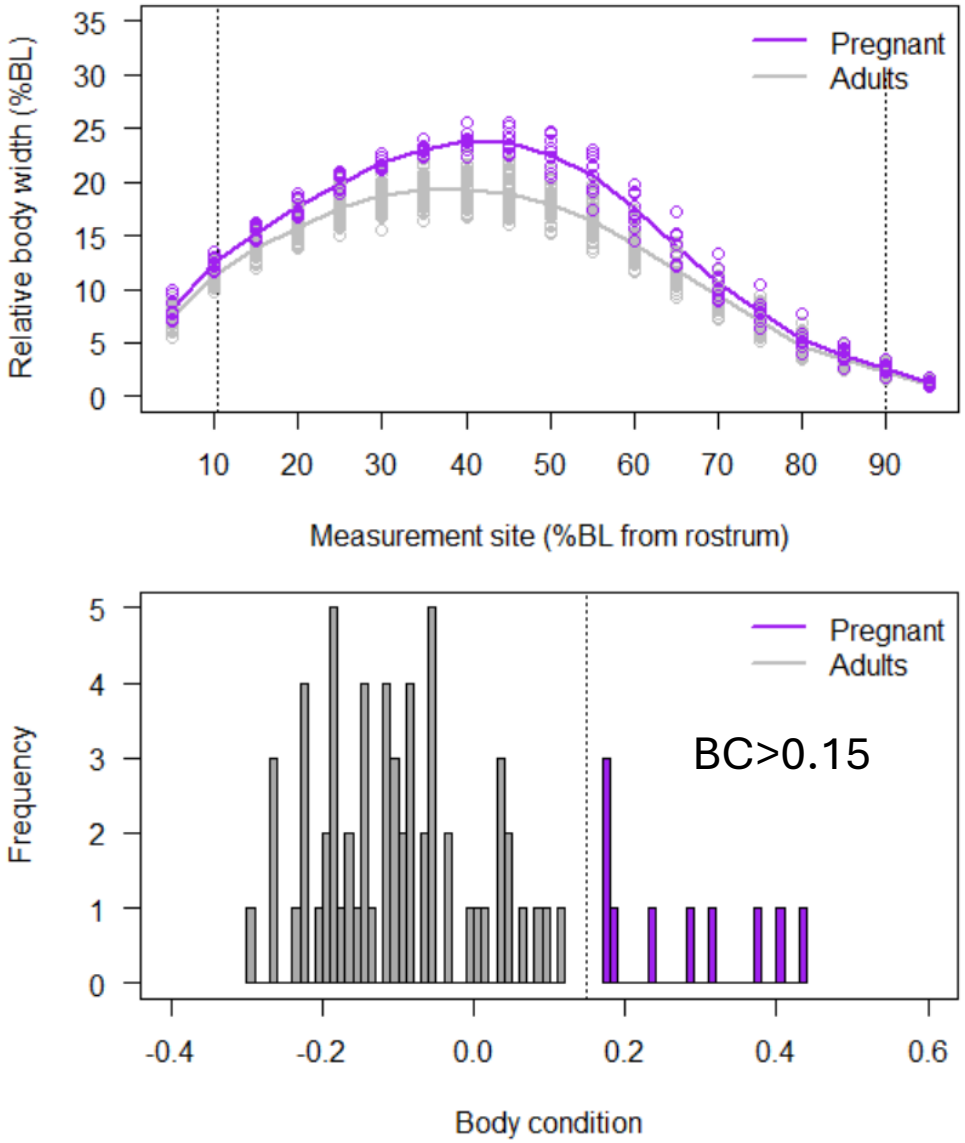
$$BV_{(BC=0)} = 0.0194 \times BL^3$$

$$\mathrm{BC}_i = \frac{\mathrm{BV}_{\mathrm{Obs},i} - \mathrm{BV}_{\mathrm{Exp},i}}{\mathrm{BV}_{\mathrm{Exp},i}},$$

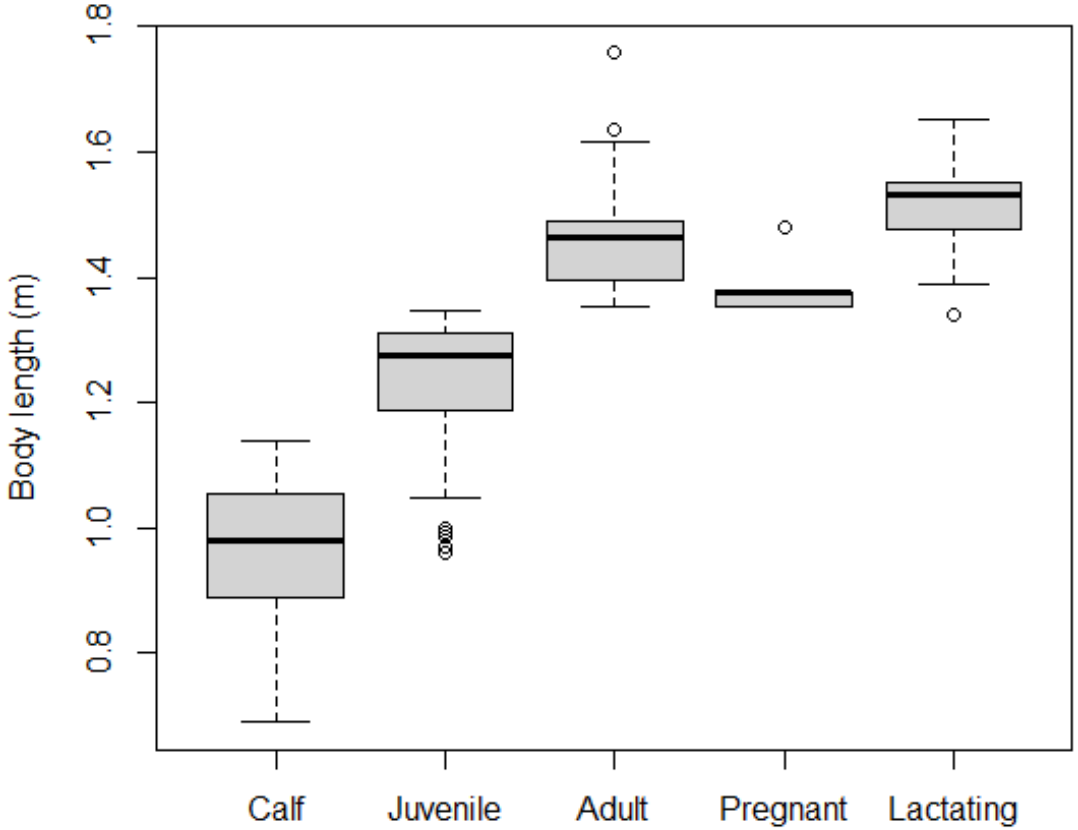


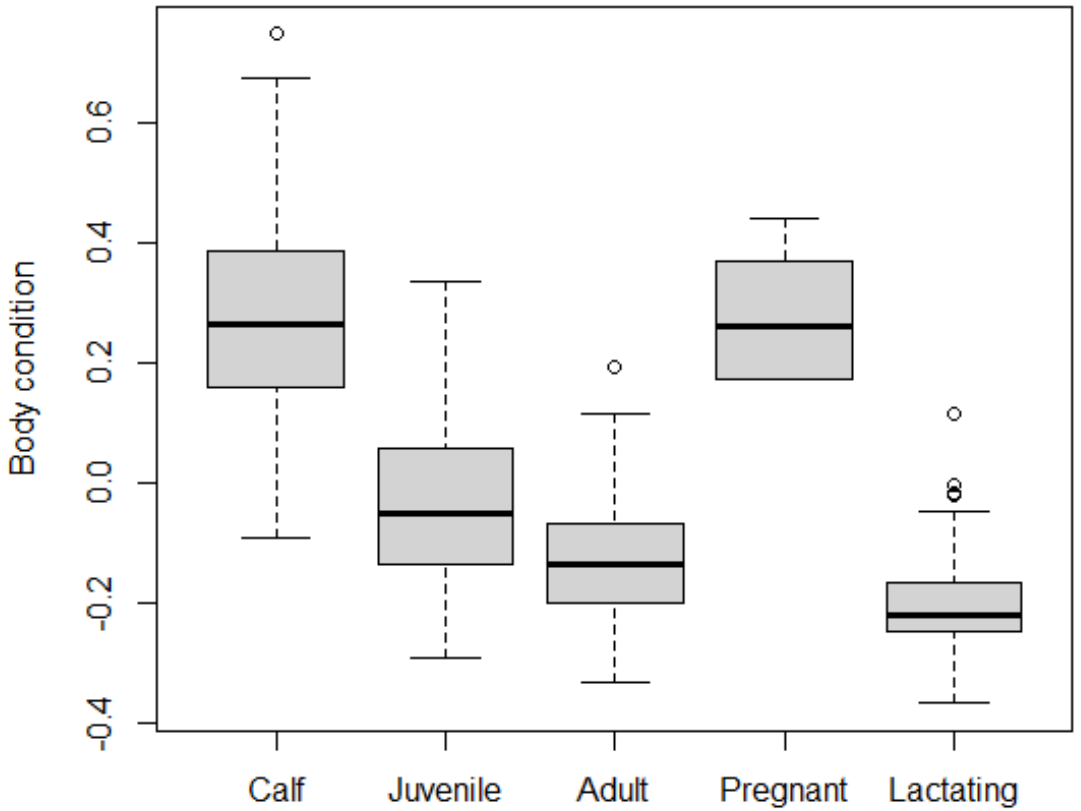


Identify pregnant females



Body length and condition by age/rep class





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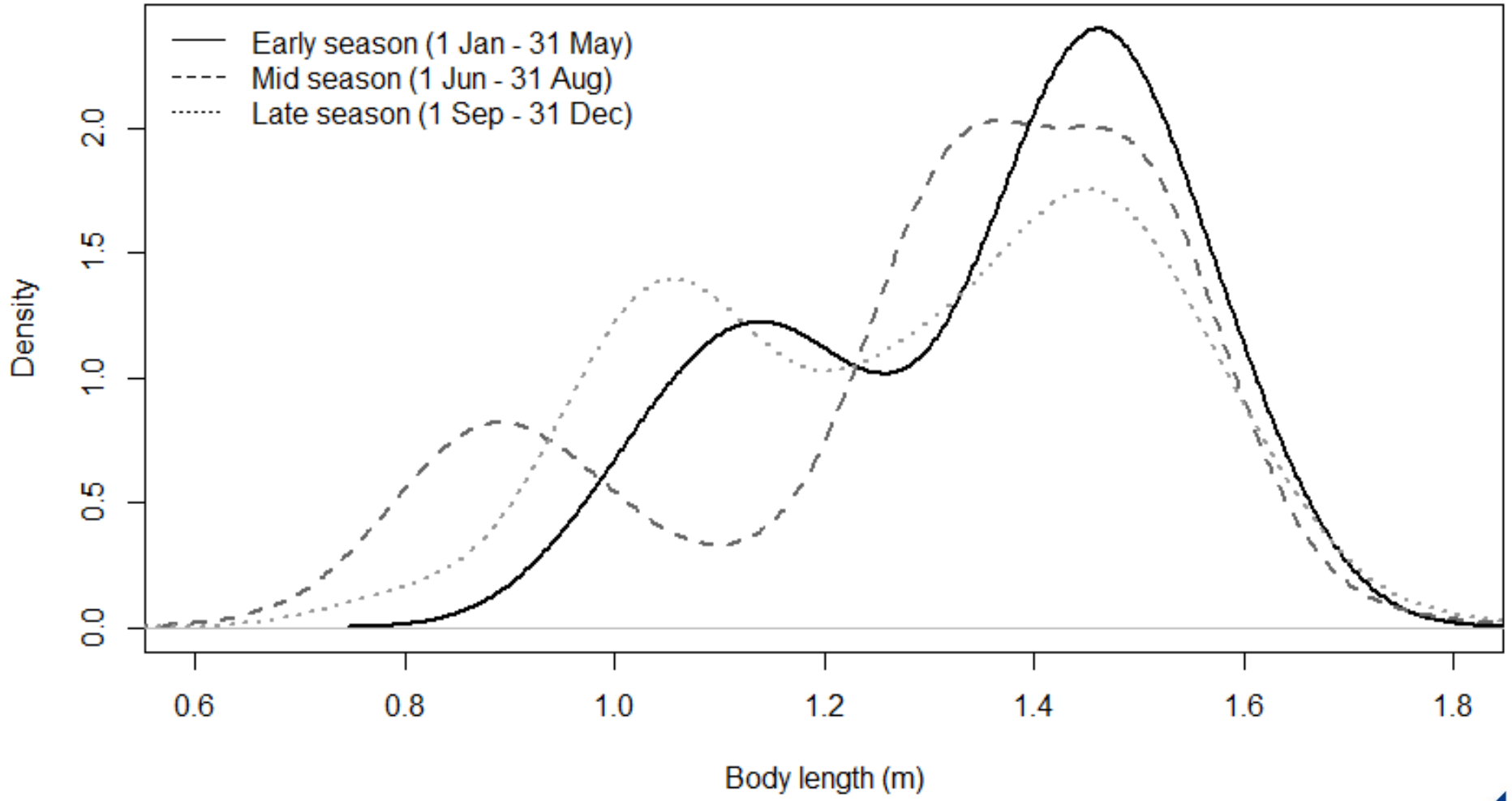
Intra-seasonal variation in size structure



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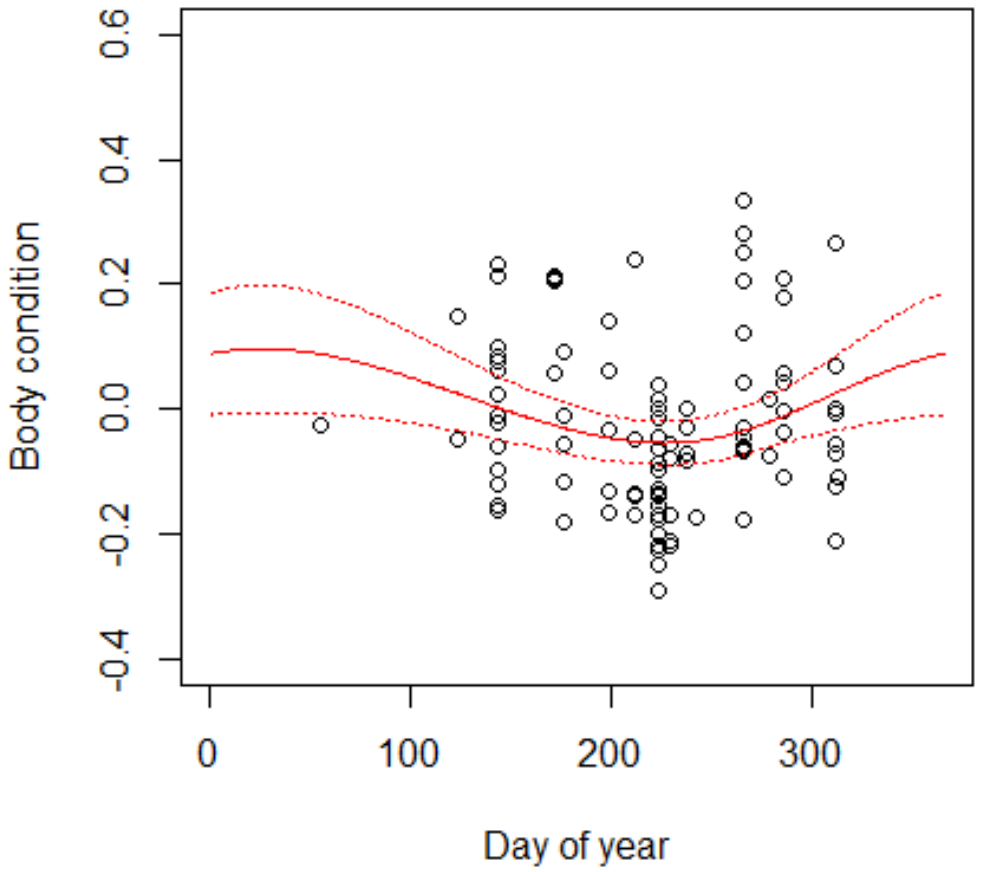
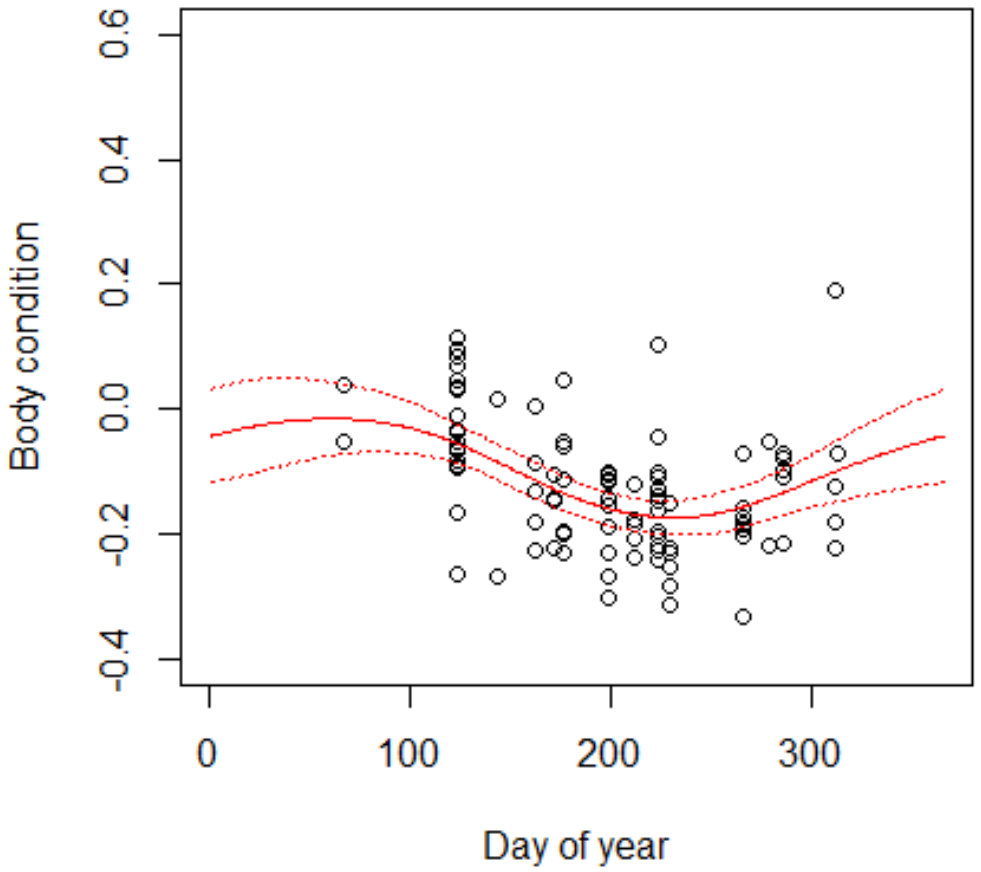
Intra-seasonal variation in body condition

Juveniles



Adults



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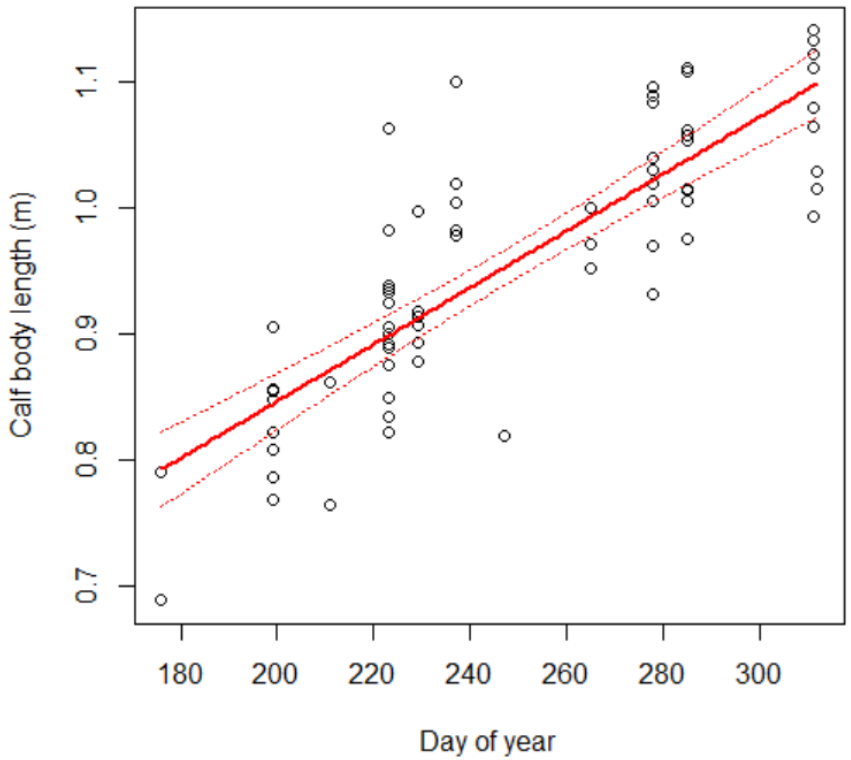
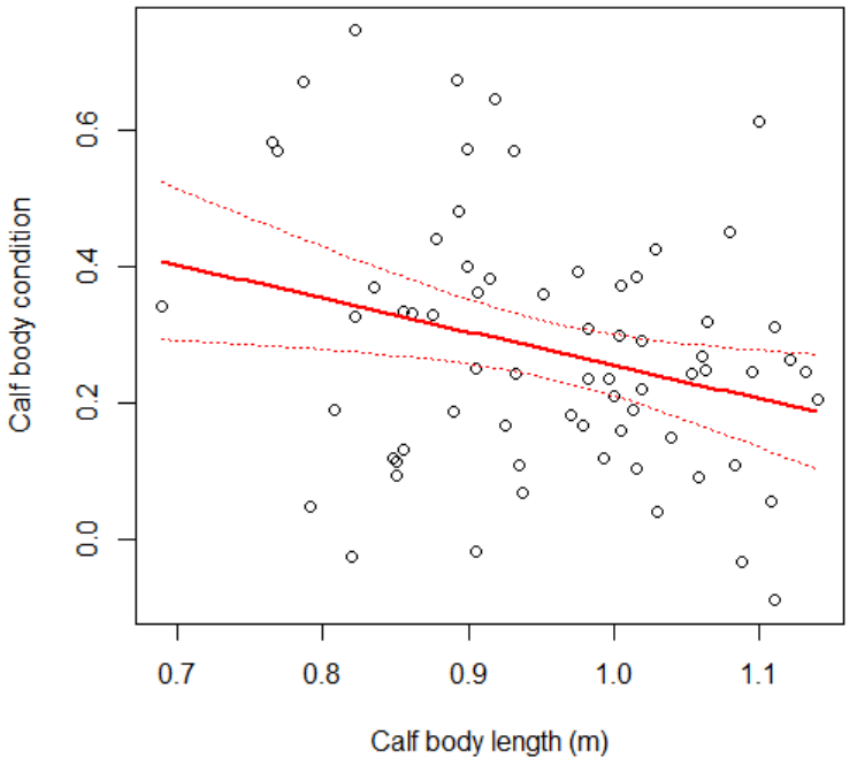
Calf body length and condition





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Conclusions

Aerial photogrammetry can be used to measure wild harbour porpoise:

- Body size
- Seasonal variation in size structure
- Body condition
- Identify pregnant females
- Seasonal variation in body condition of juveniles and adults
- Calf growth rates in body length and condition

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