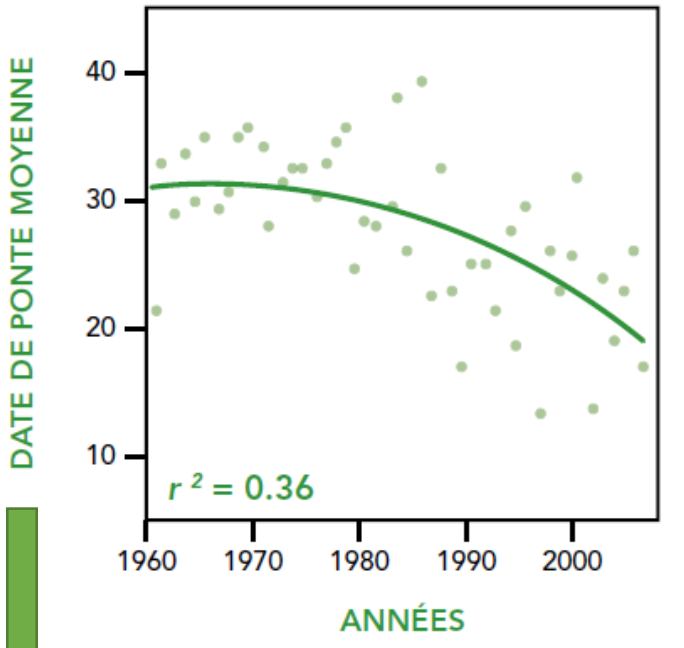
The efficiency of phenological shifts to buffer detrimental effects of rising temperatures on the incubation of eggs: A case study with Loggerheads

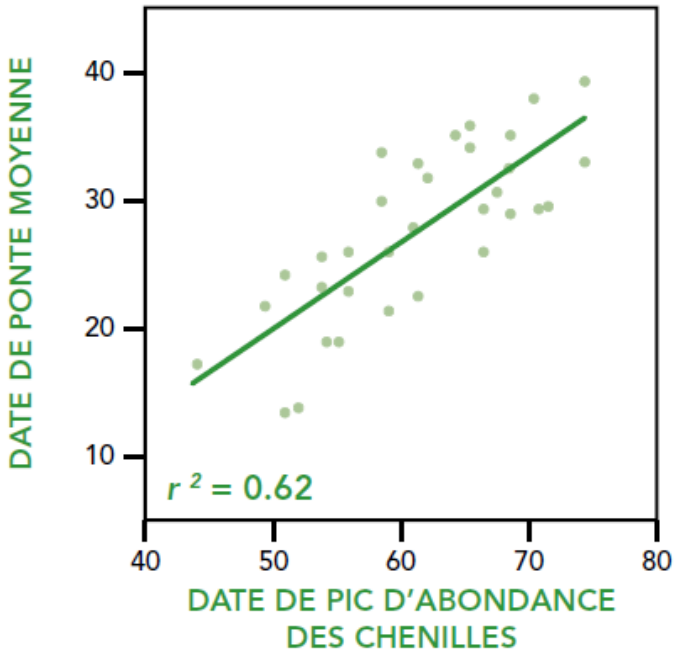
Jonathan Monsinjon and Marc Girondot

3ème Colloque National sur les Tortues Marines - 12 au 16 Novembre 2018 - Aquarium La Rochelle

Phenological Shifts

Nesting Date



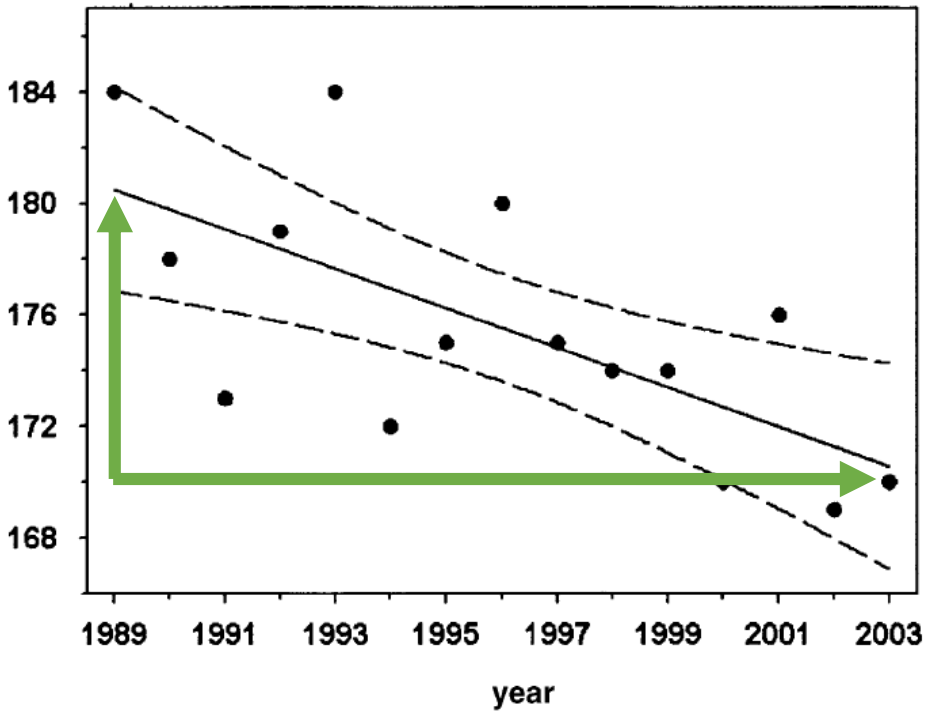


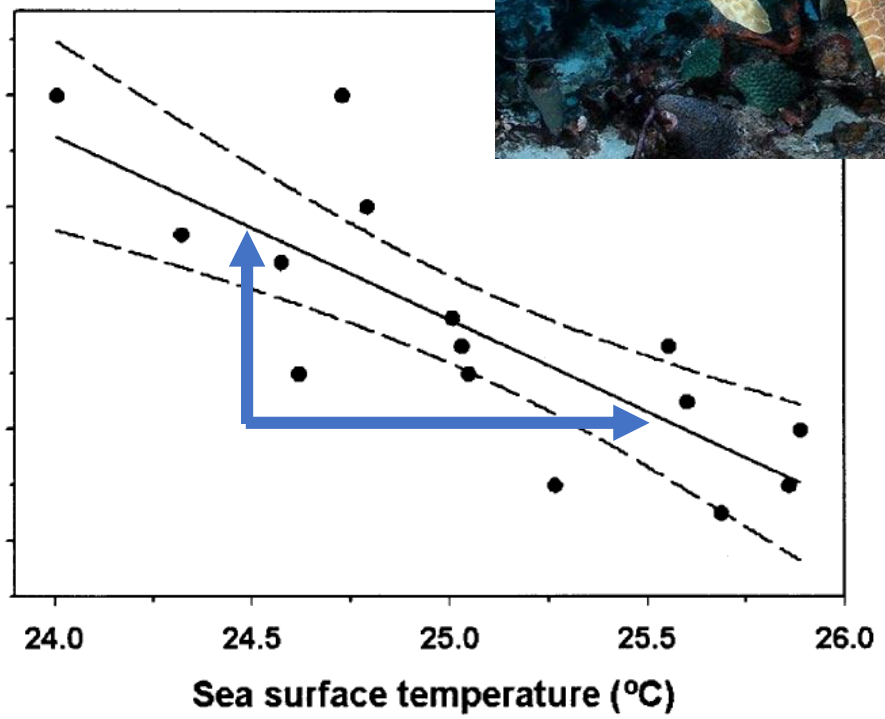
12 days earlier in 50 years → occurrence of caterpillars

Charmantier et al. (2008)

Phenological Shifts

Peak of the Season





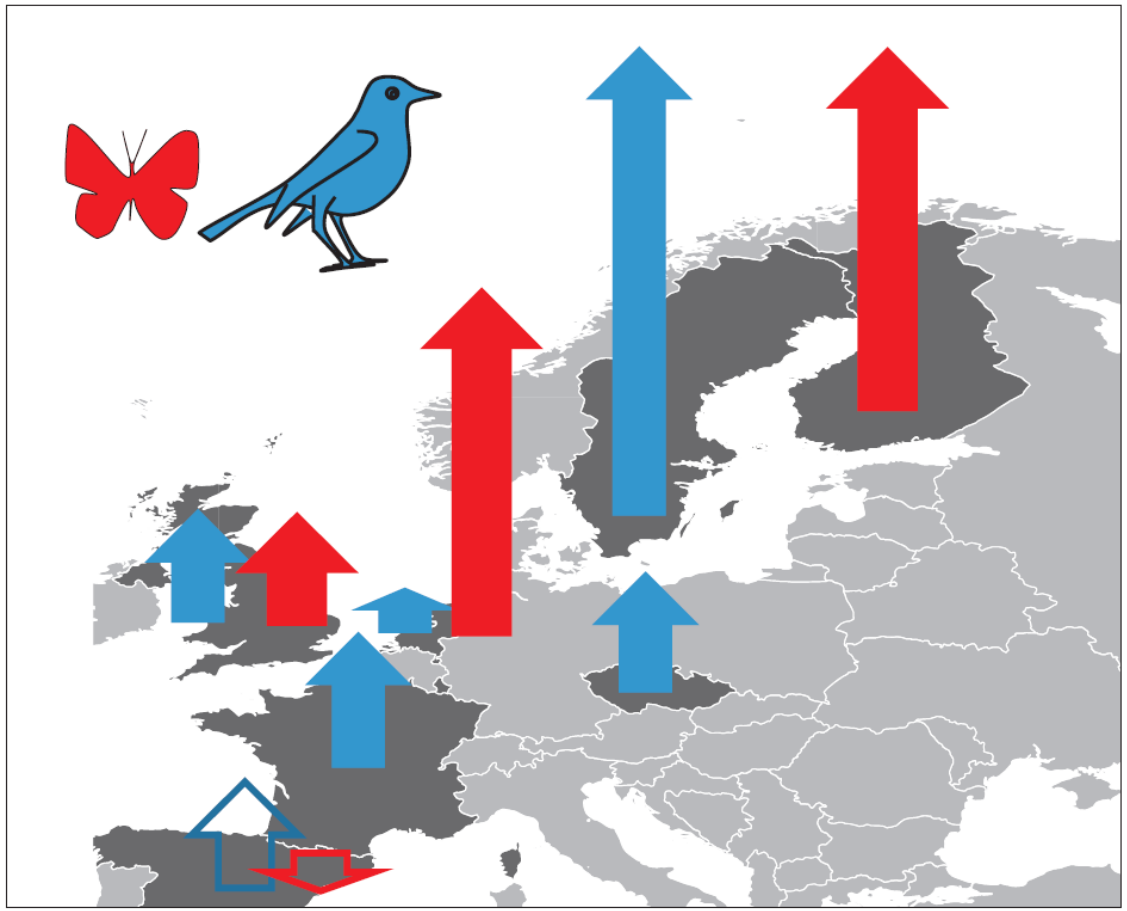
10 days earlier in 14 years → +1°C = 7 days earlier

Weishampel et al. (2004)

Do temperature-induced phenological shifts provide an effective strategy to keep within suitable thermal conditions for the incubation of eggs?

« Est-ce que les changements de phénologie consistent en une stratégie efficace pour rester dans des conditions thermiques favorables à l'incubation des œufs ? »

The Concept of Climatic Debt



Current Shift Northward:
37 km and **114 km**

Required Shift:
249 km

Climatic Debt:
249 – 37 = 212 km
249 – 114 = 135 km

9,490 of birds and **2,130 of butterflies**

Devictor et al. (2012)

Objectives

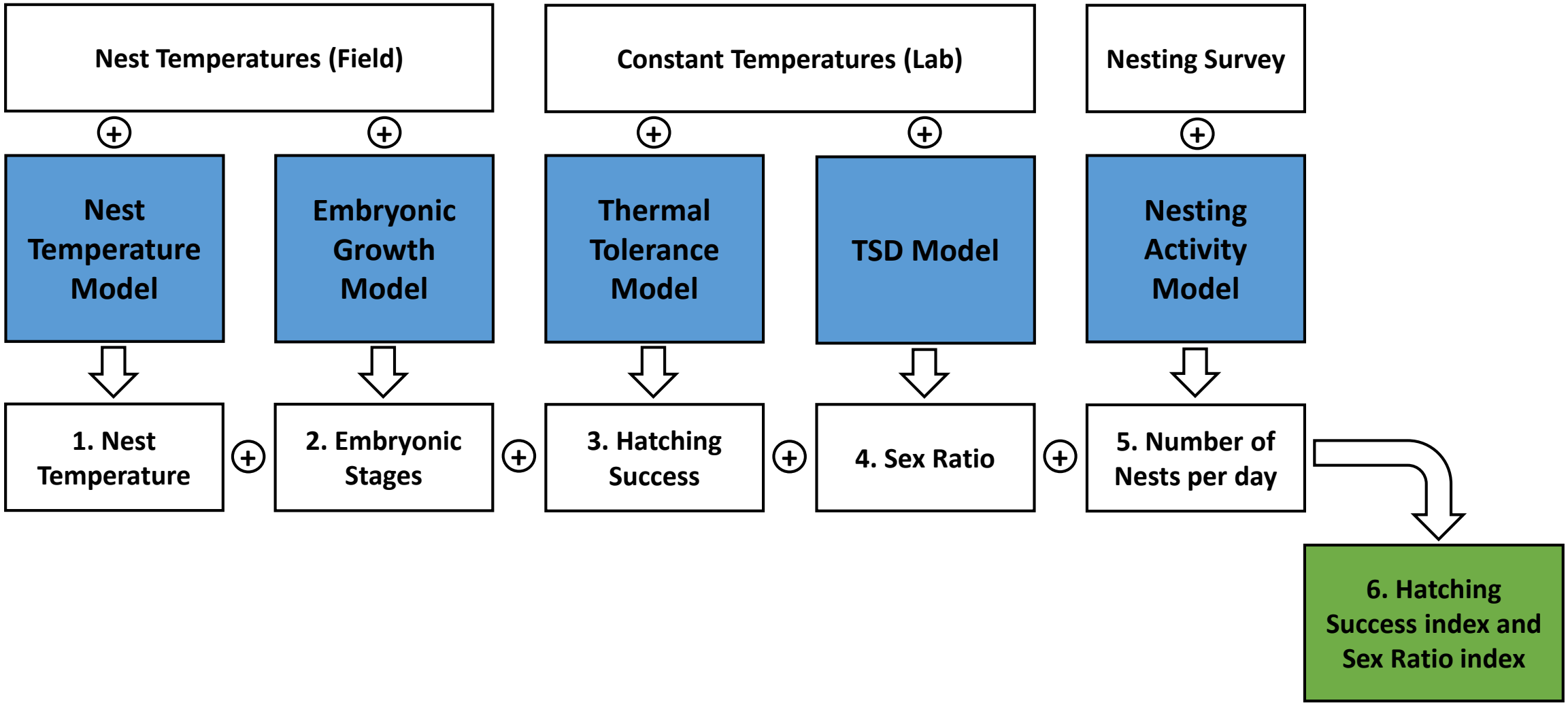
Climatic Price:

→ What shift would be required in the future for nesting populations to keep producing a hatching success and a sex ratio similar to current ones?

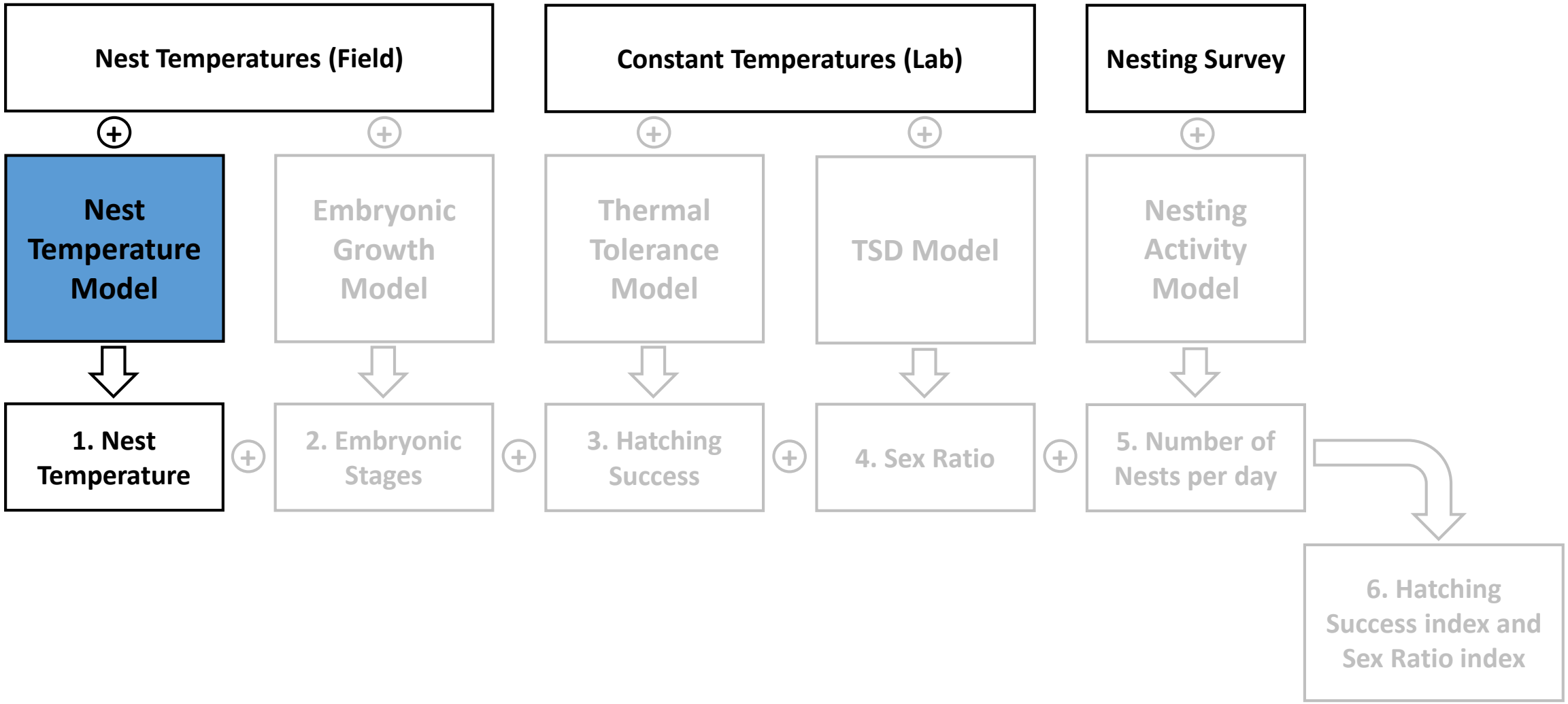
Climatic Debt:

→ What is the difference between expected phenological shifts and required ones?

Modeling Framework

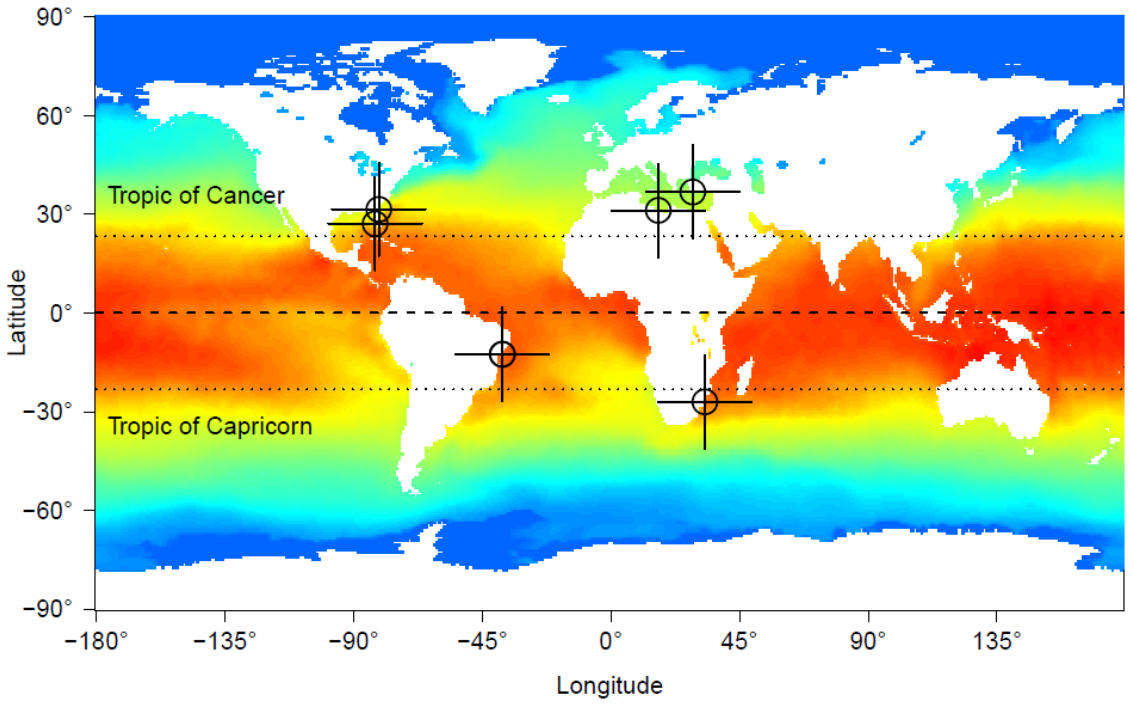


Modeling Framework

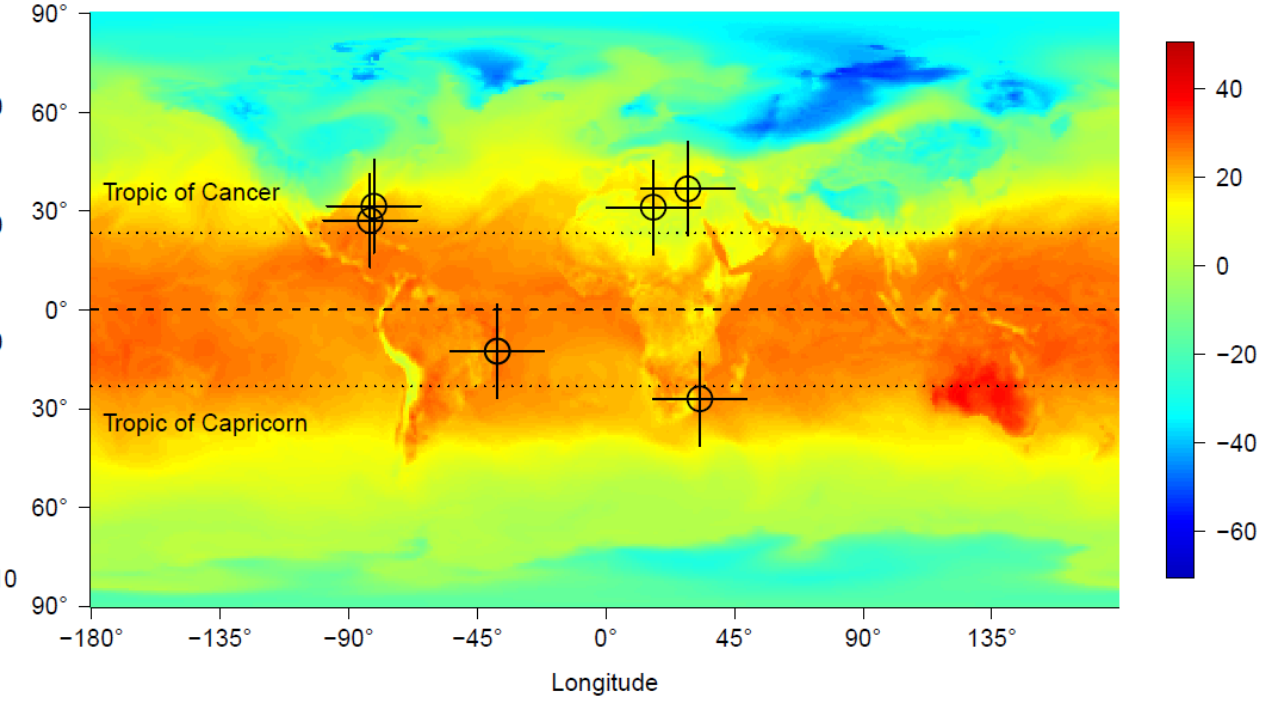


Reconstructing Nest Temperature

- ECMWF datasets *(http://apps.ecmwf.int/datasets/)*

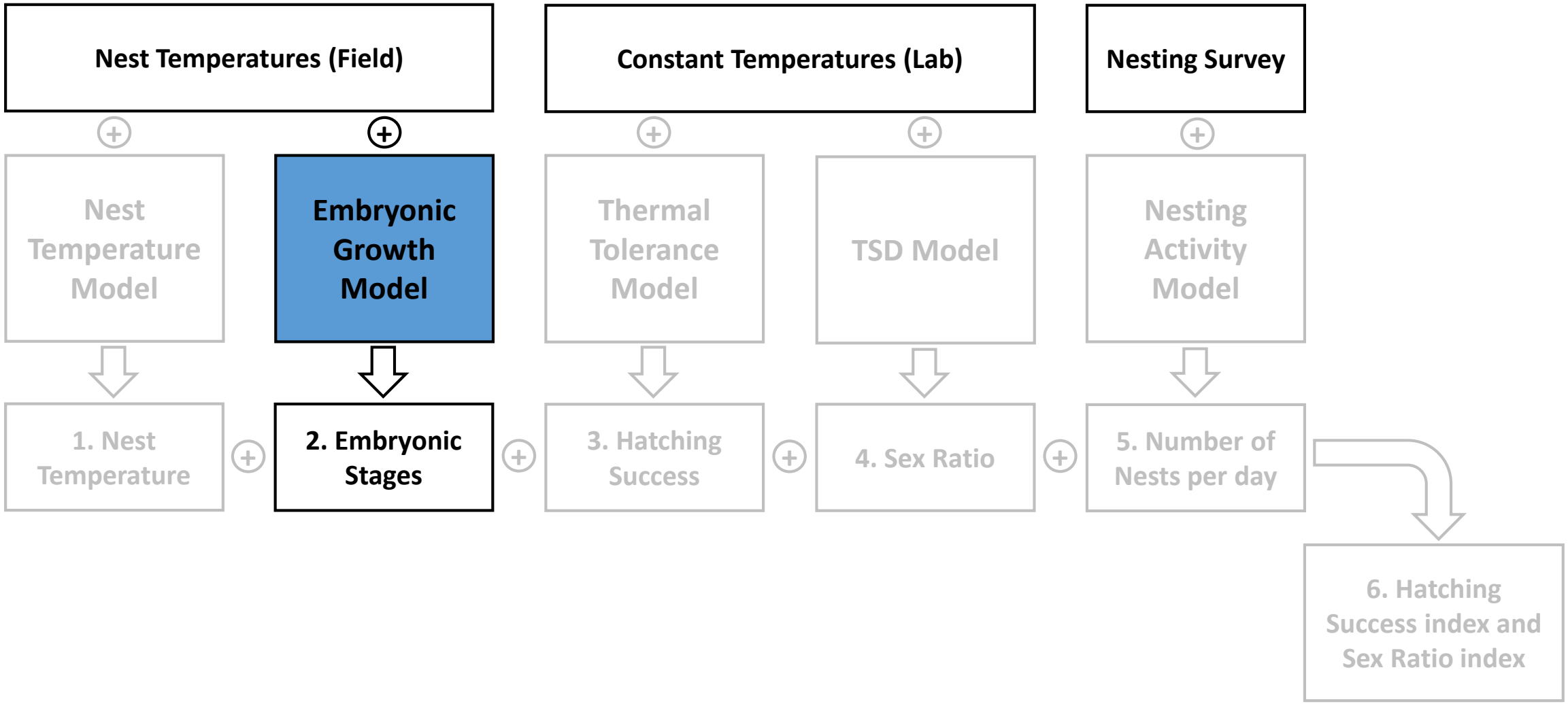


Sea Surface Temperature

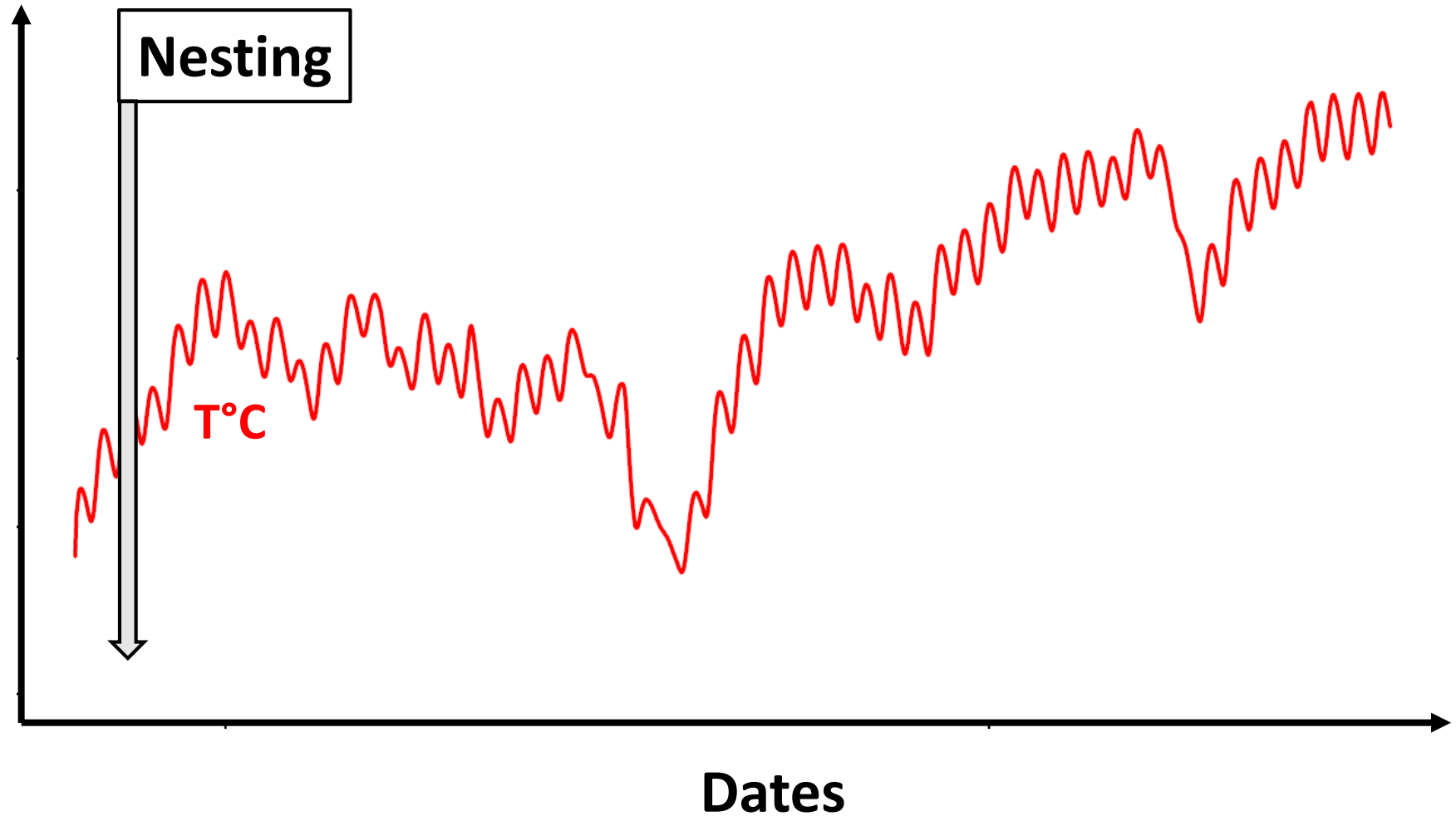


Air Temperature

Modeling Framework



Modeling Embryonic Development



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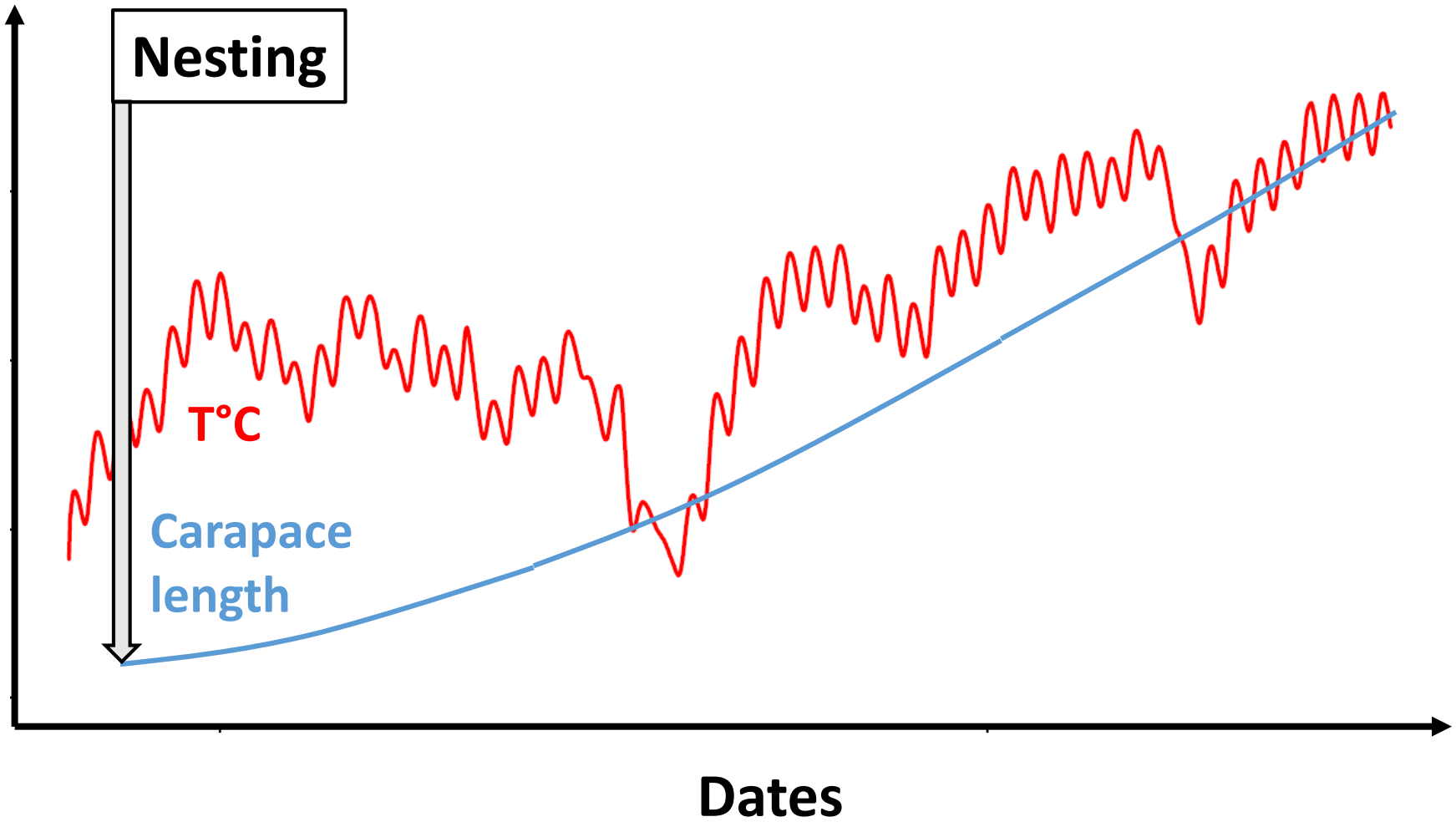

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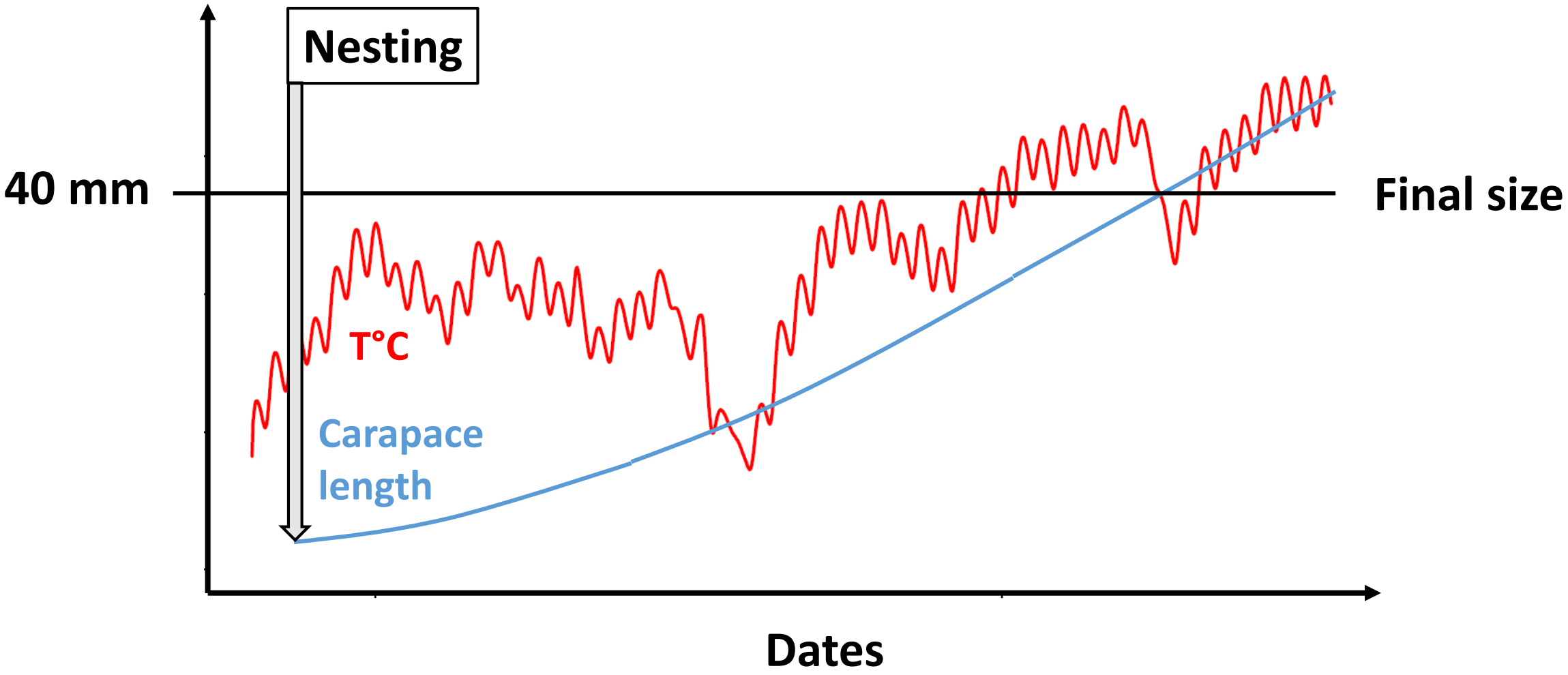

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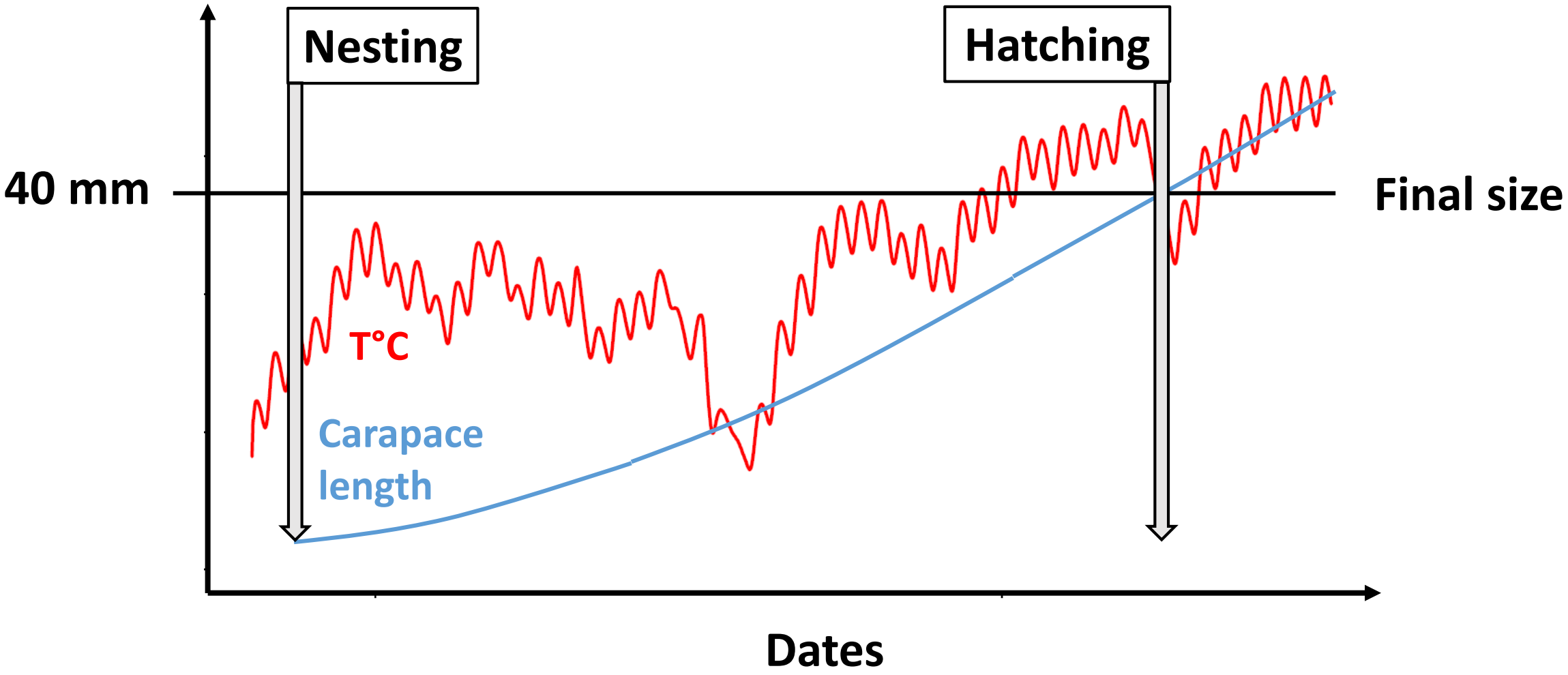

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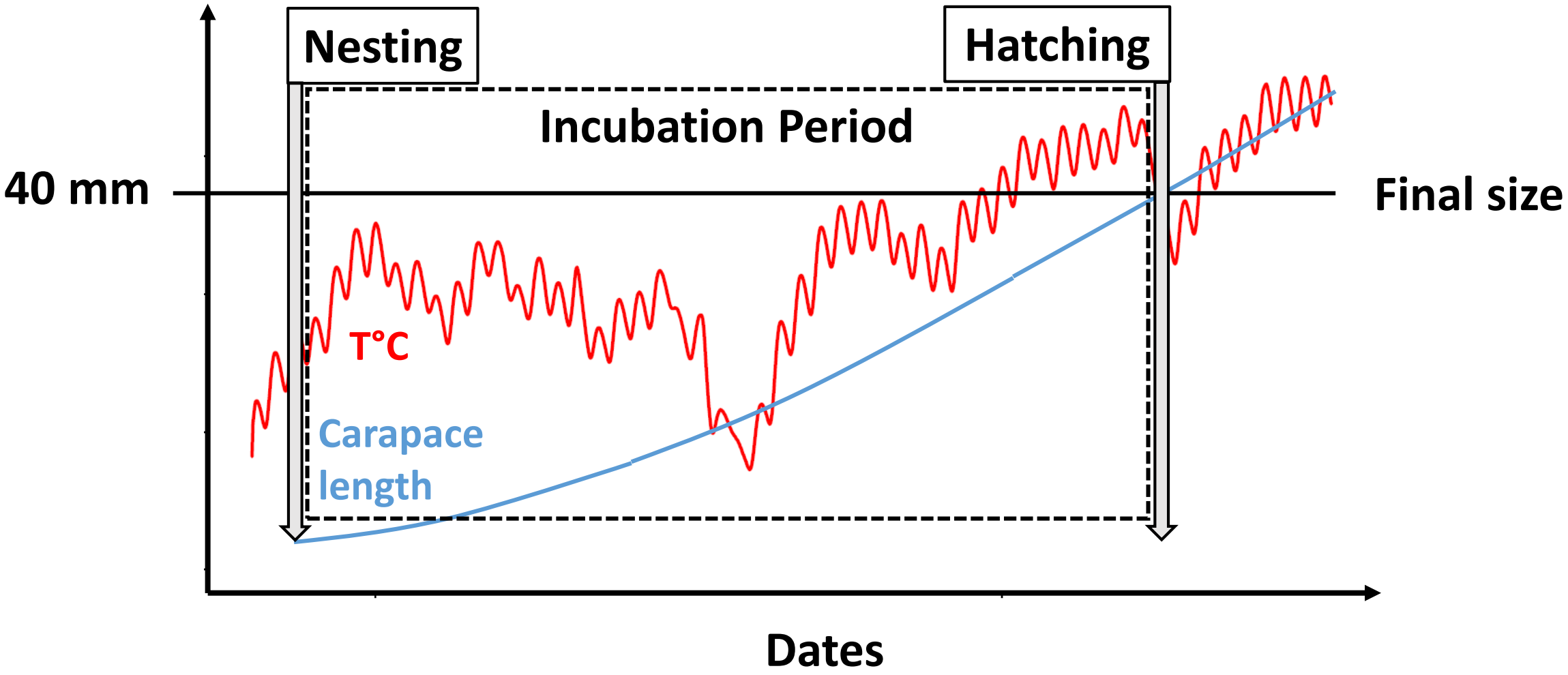

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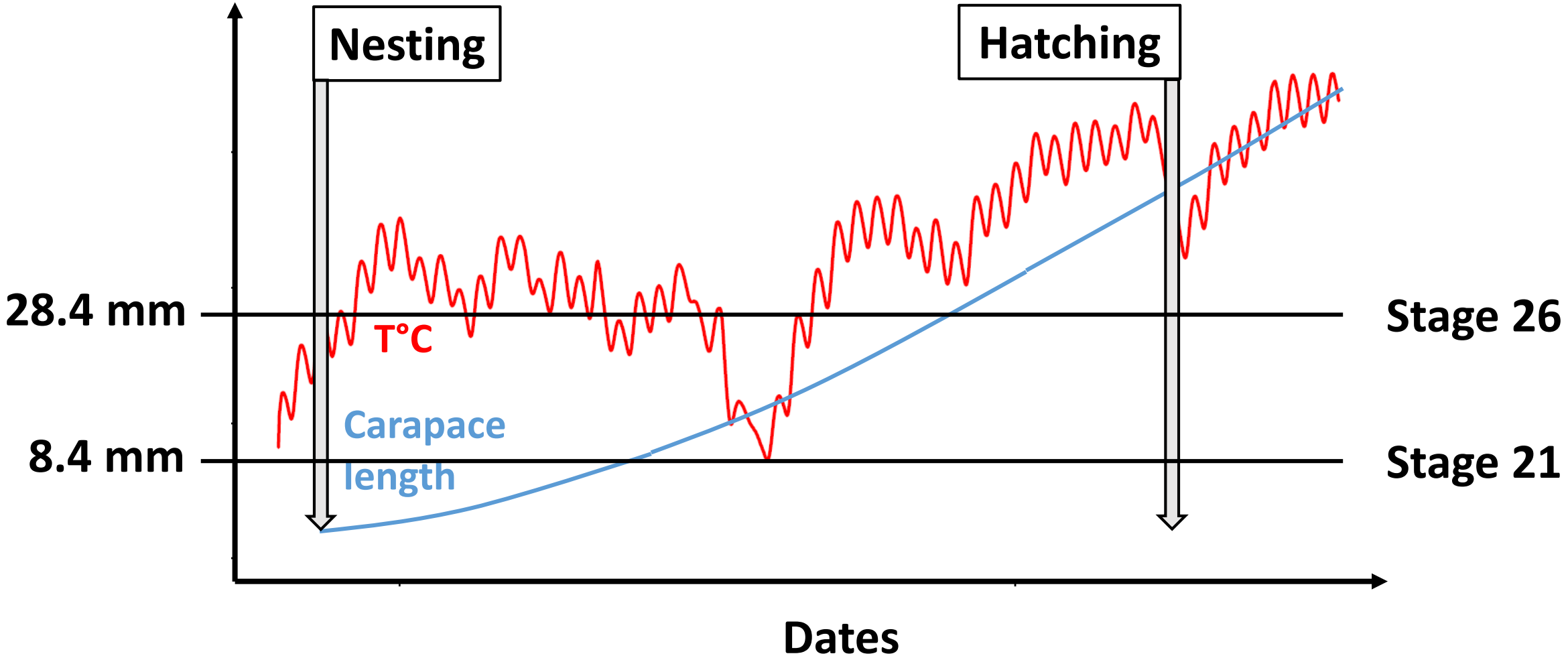
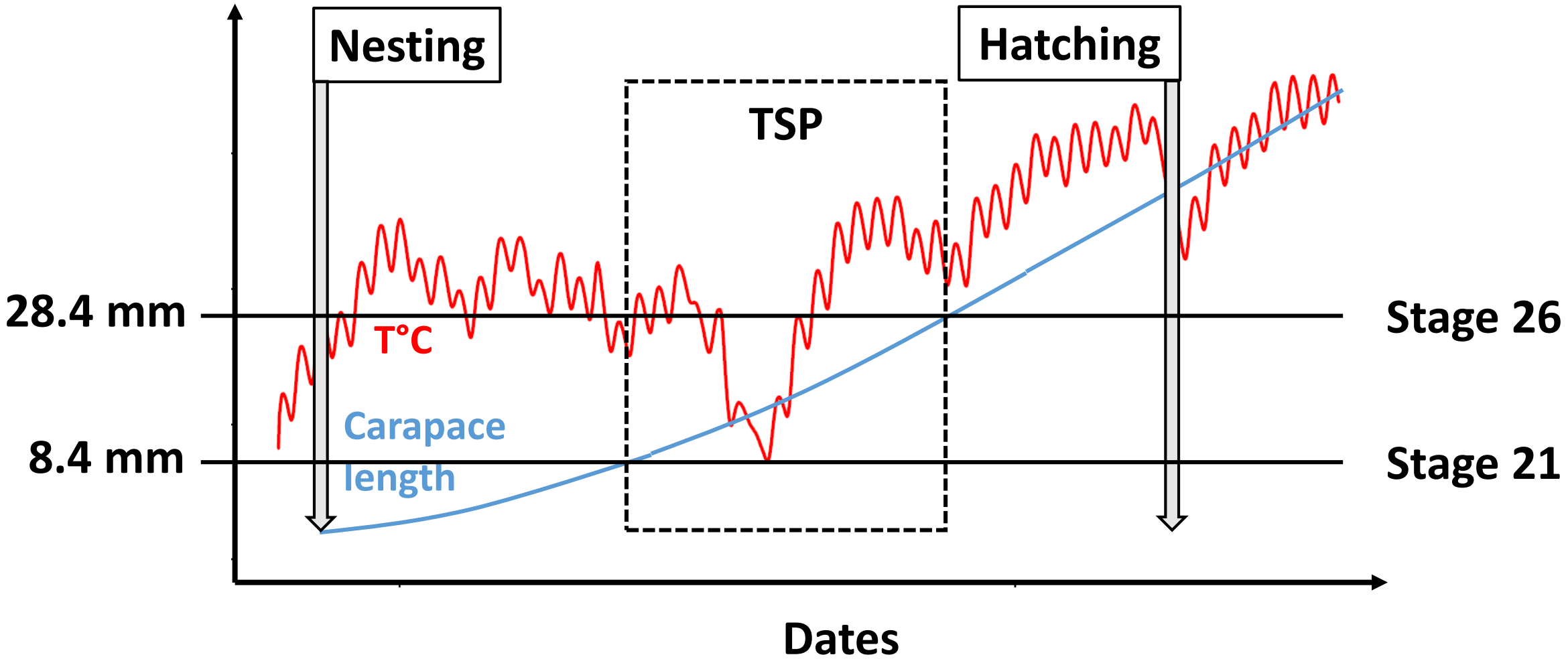


Girondot et al. (2018)

Modeling Embryonic Development



Girondot et al. (2018)

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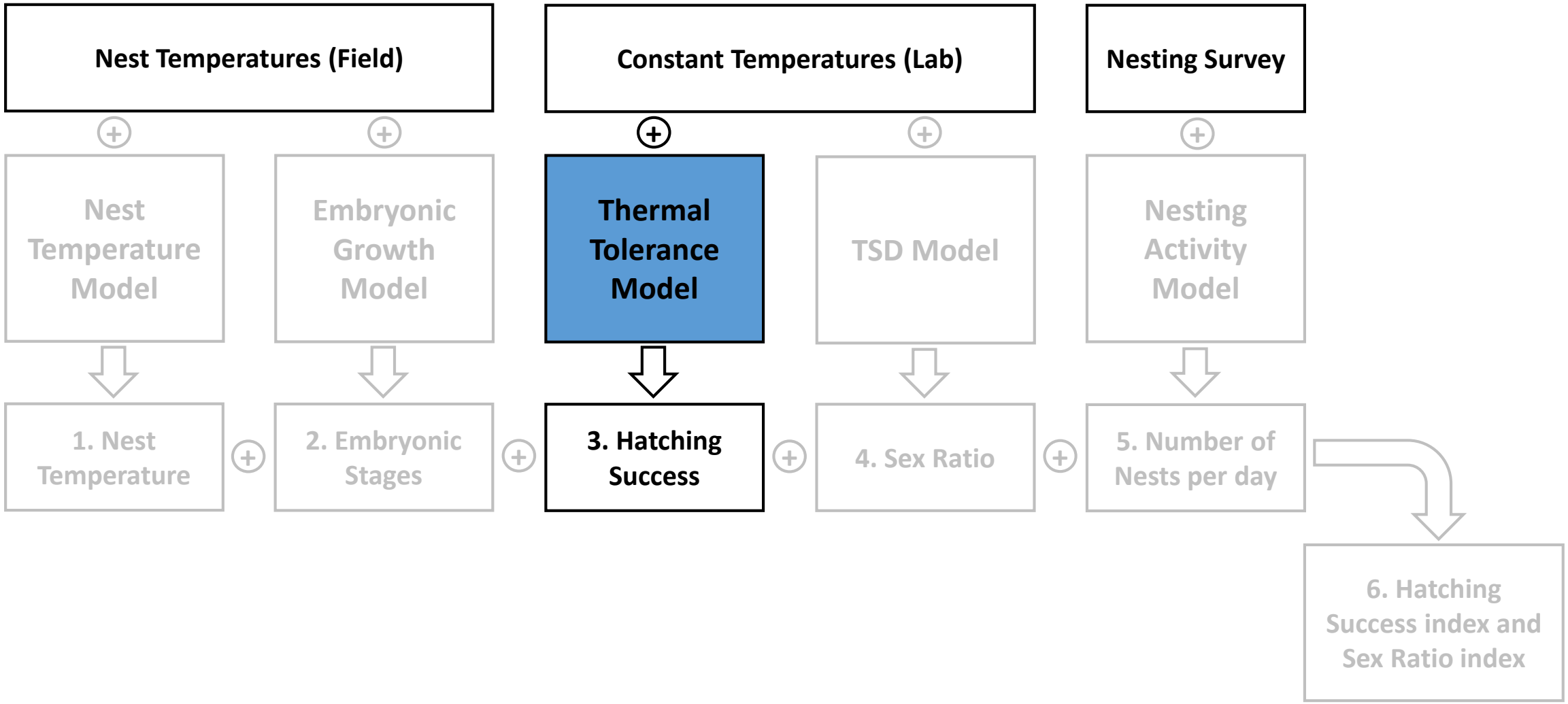
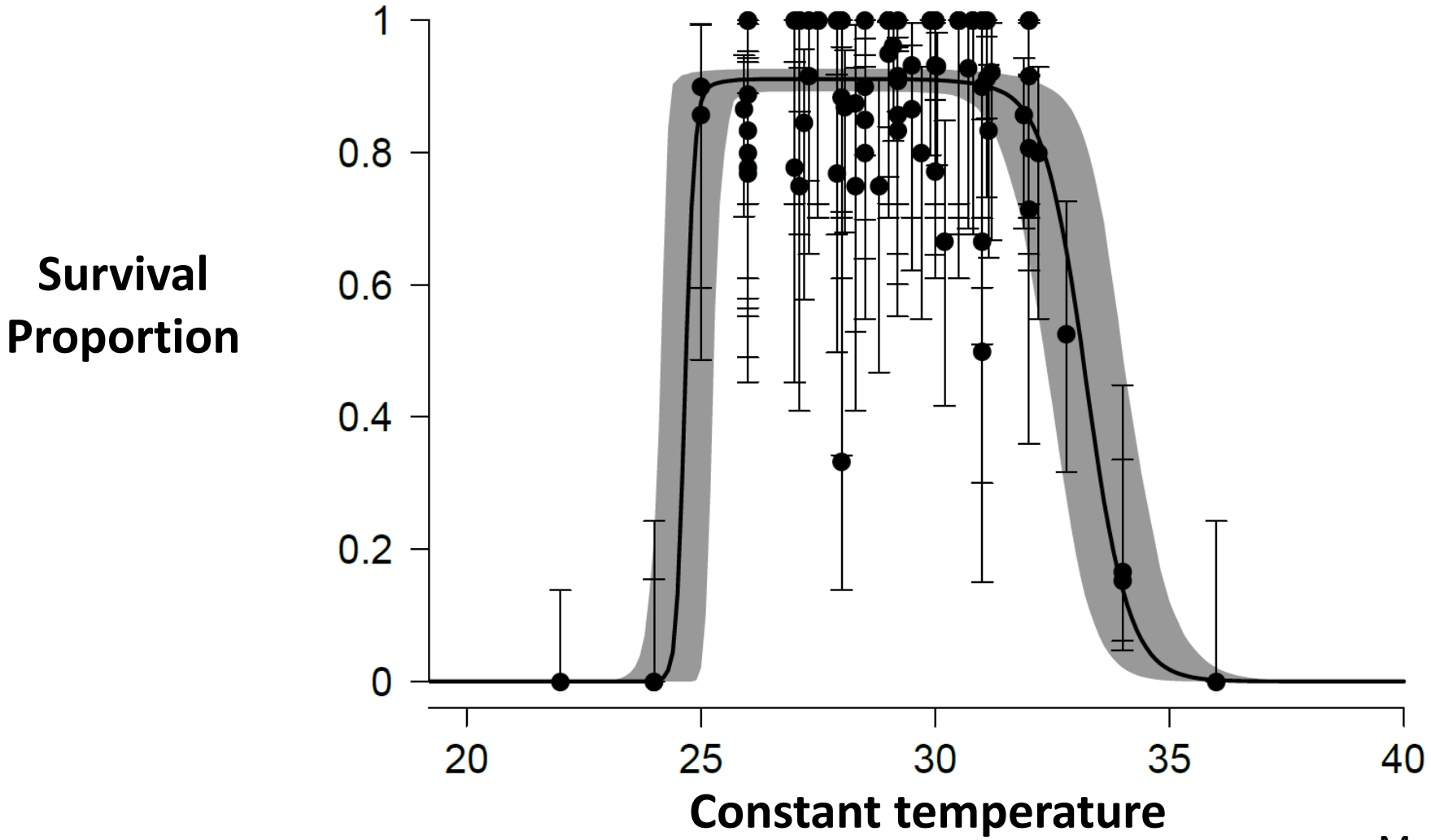
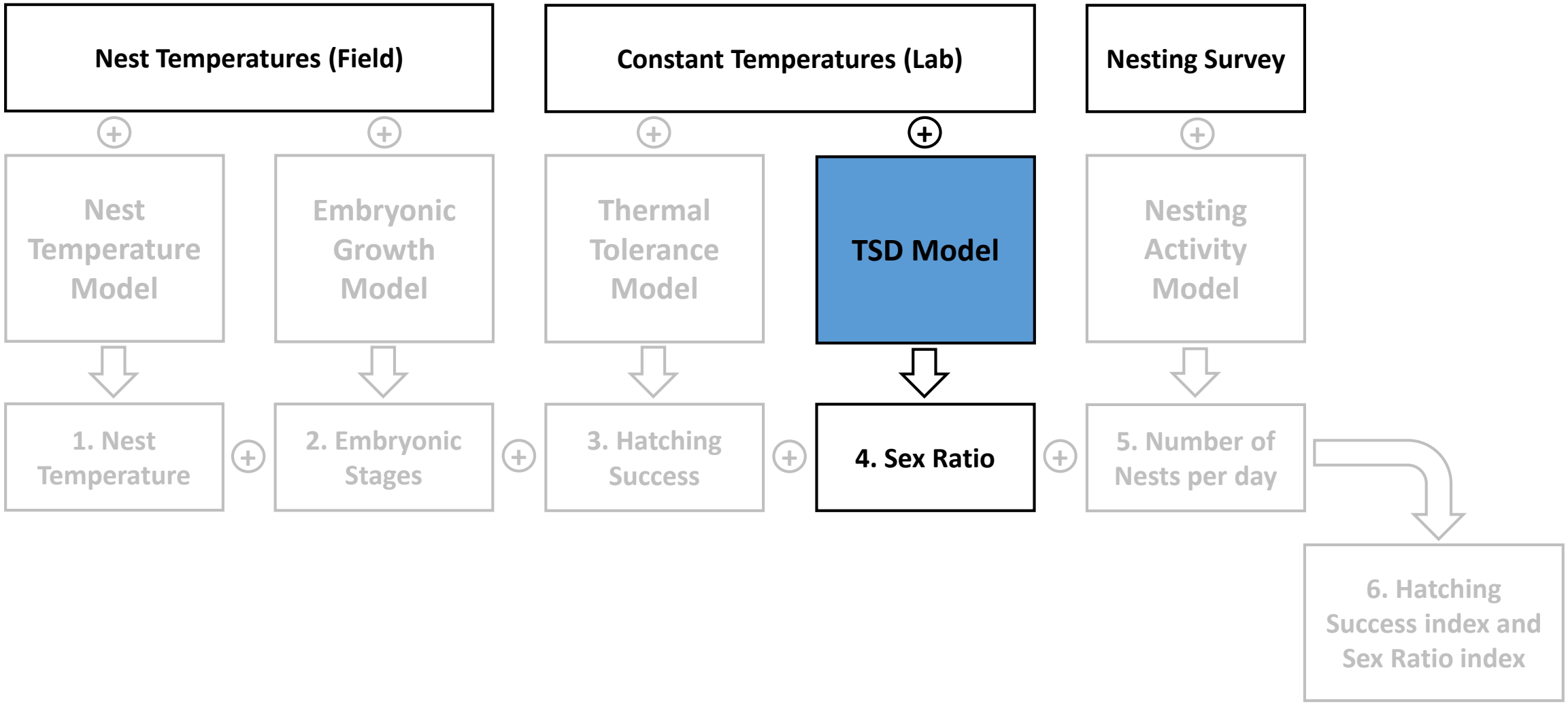


Thermal Tolerance of Embryos

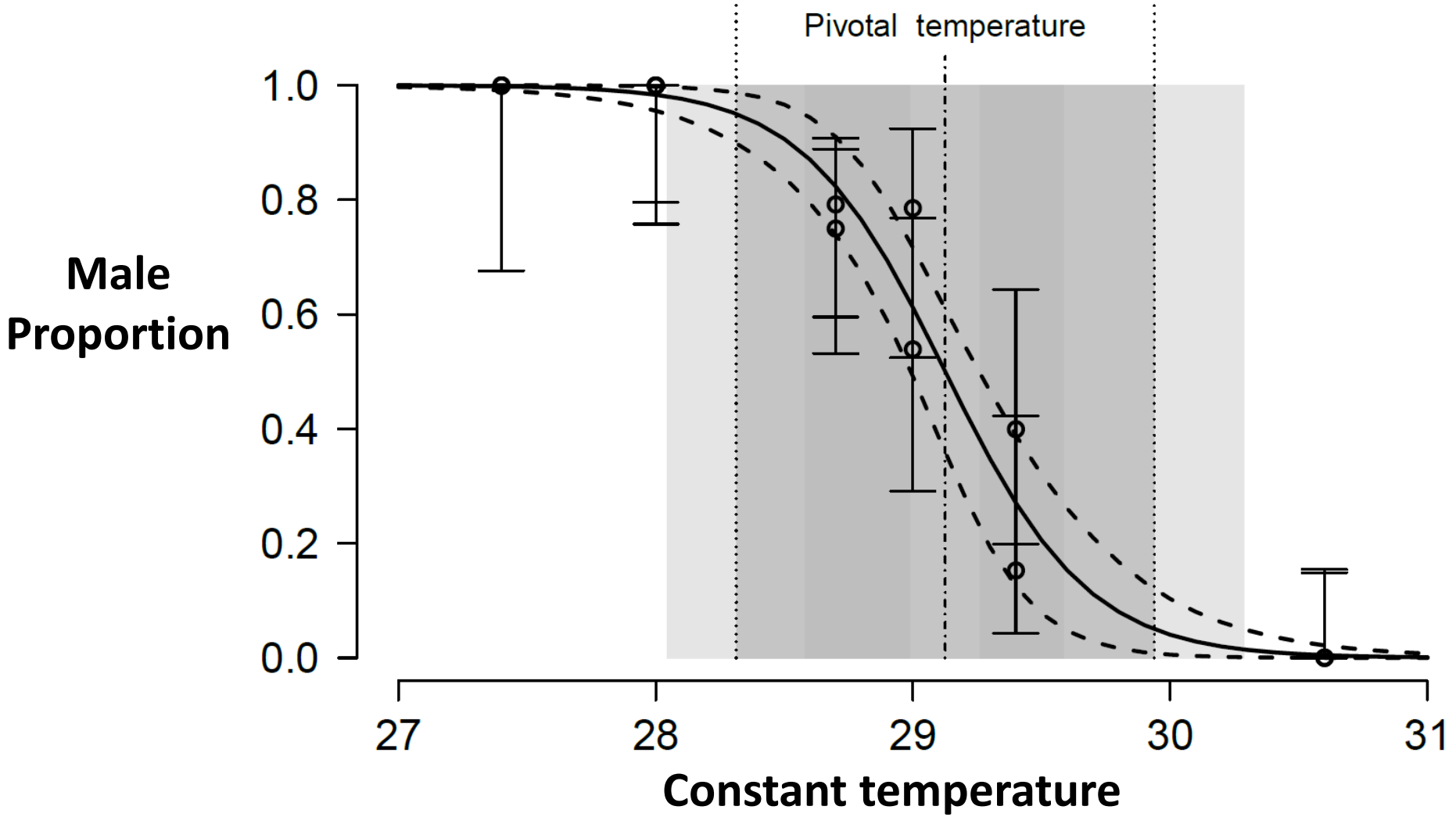


Monsinjon et al. (Submitted)

Modeling Framework

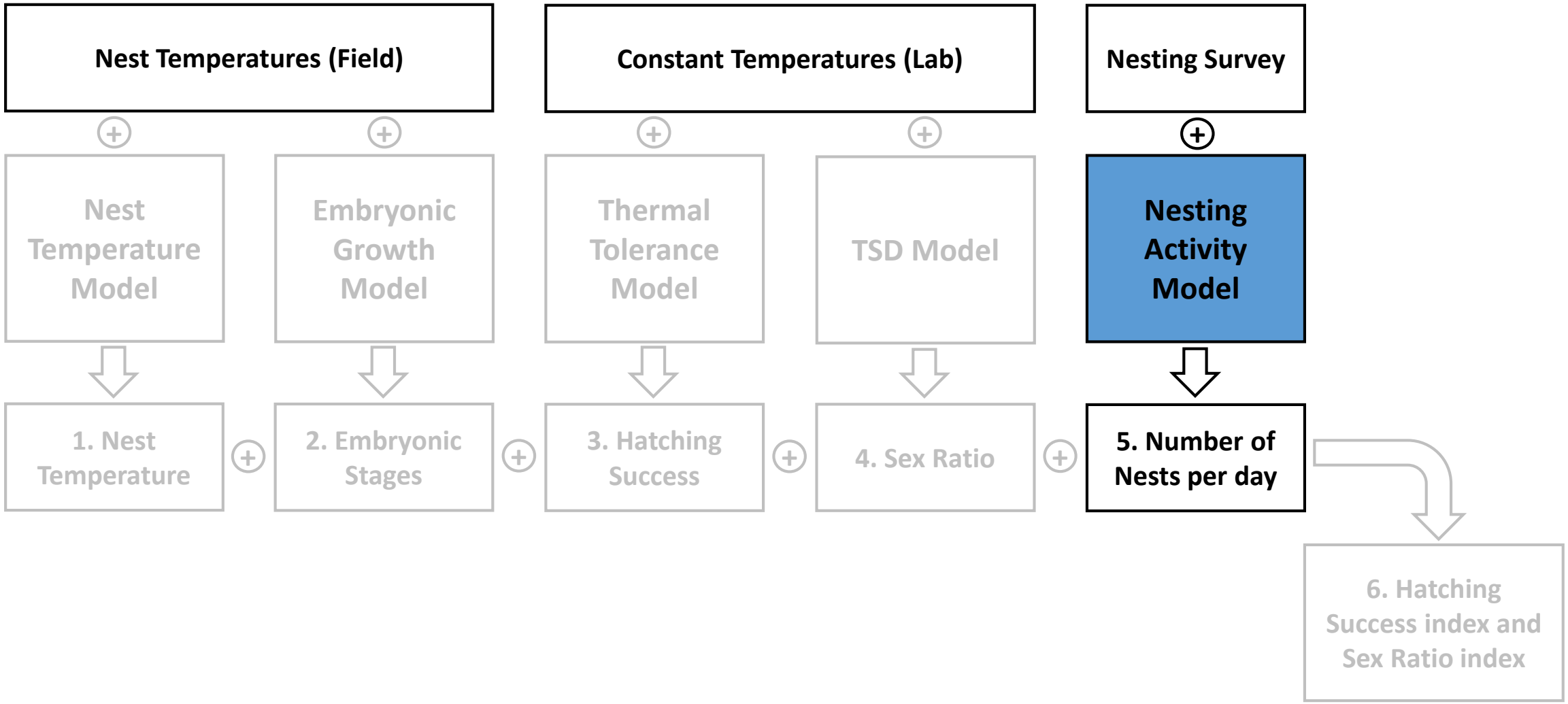


TSD Model

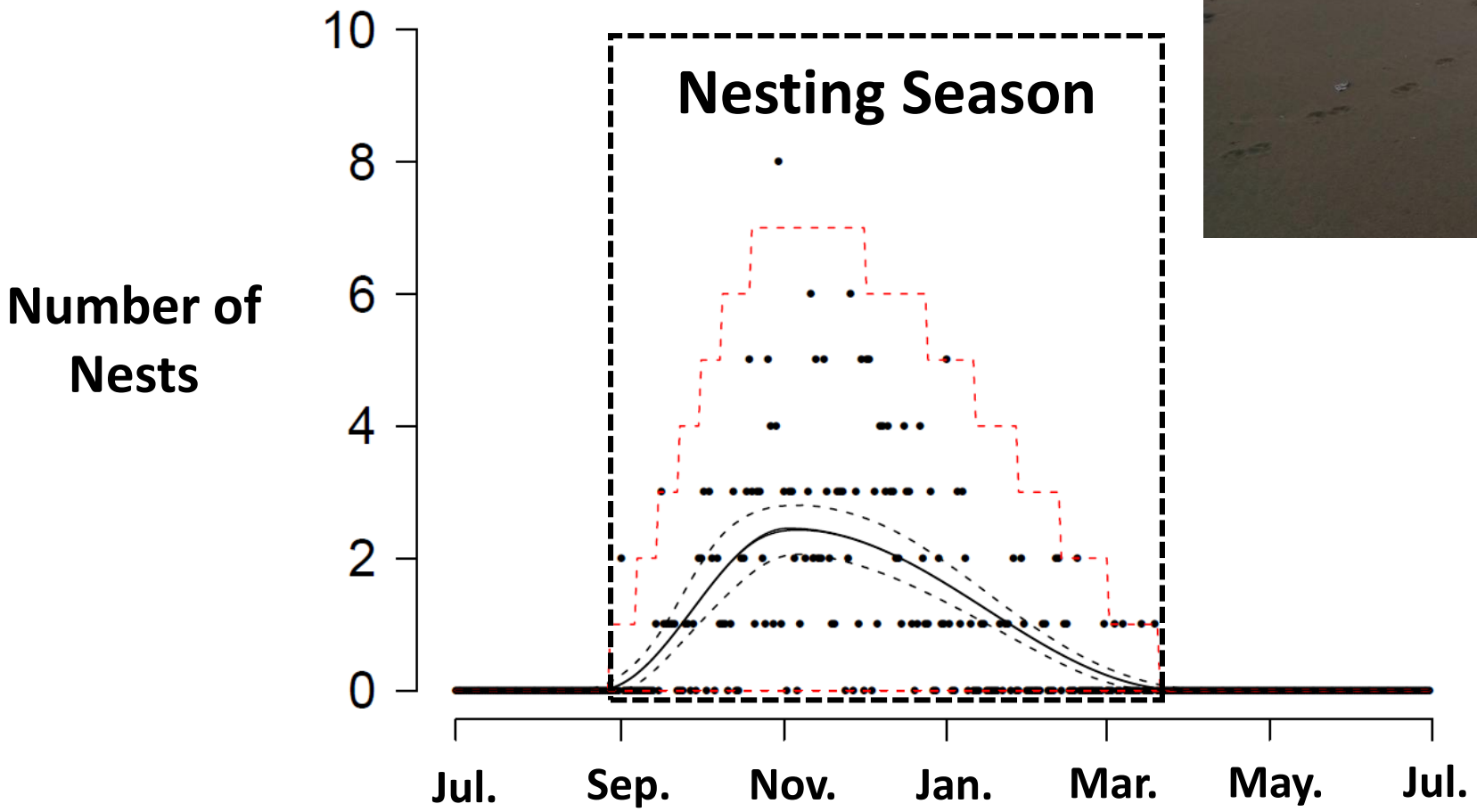


Girondot (1999)

Modeling Framework

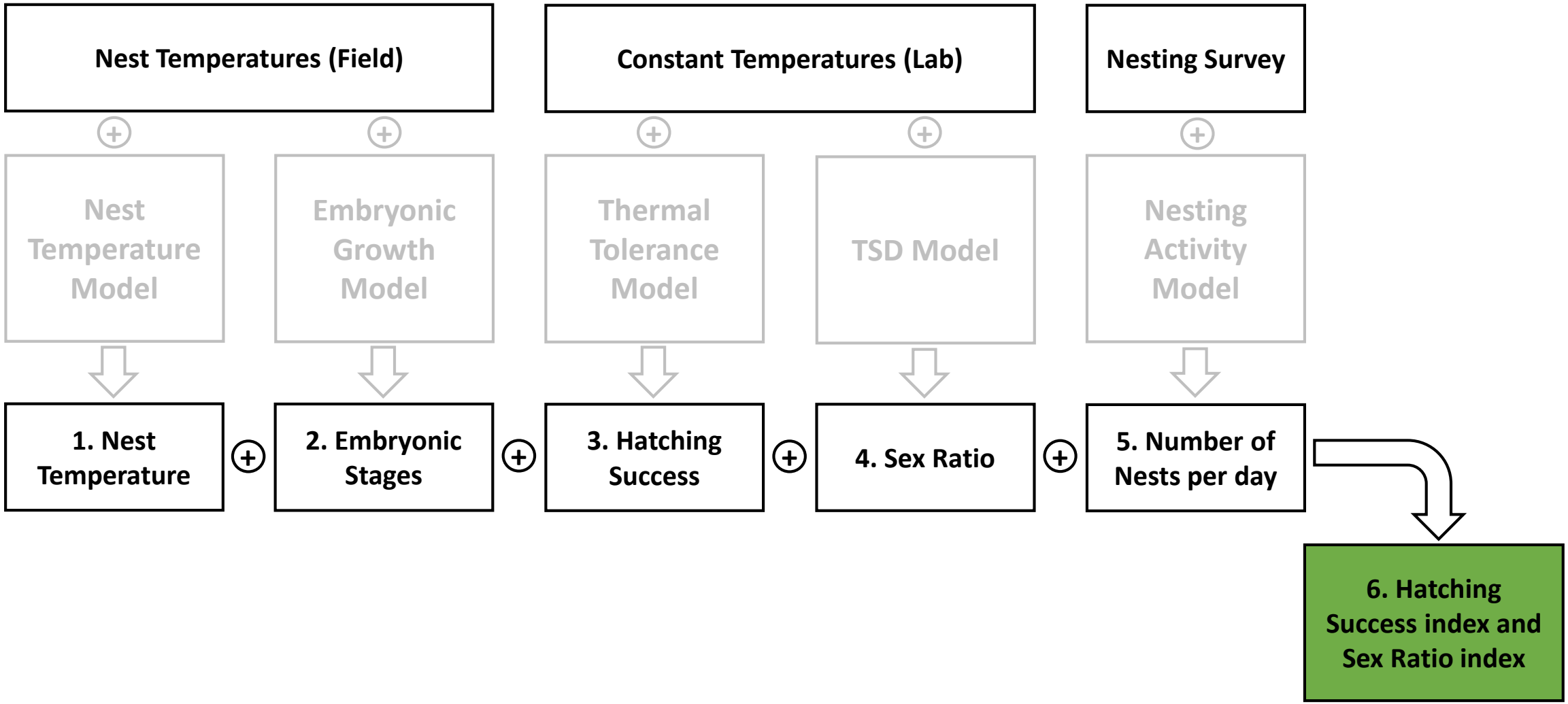


Nesting Activity Model

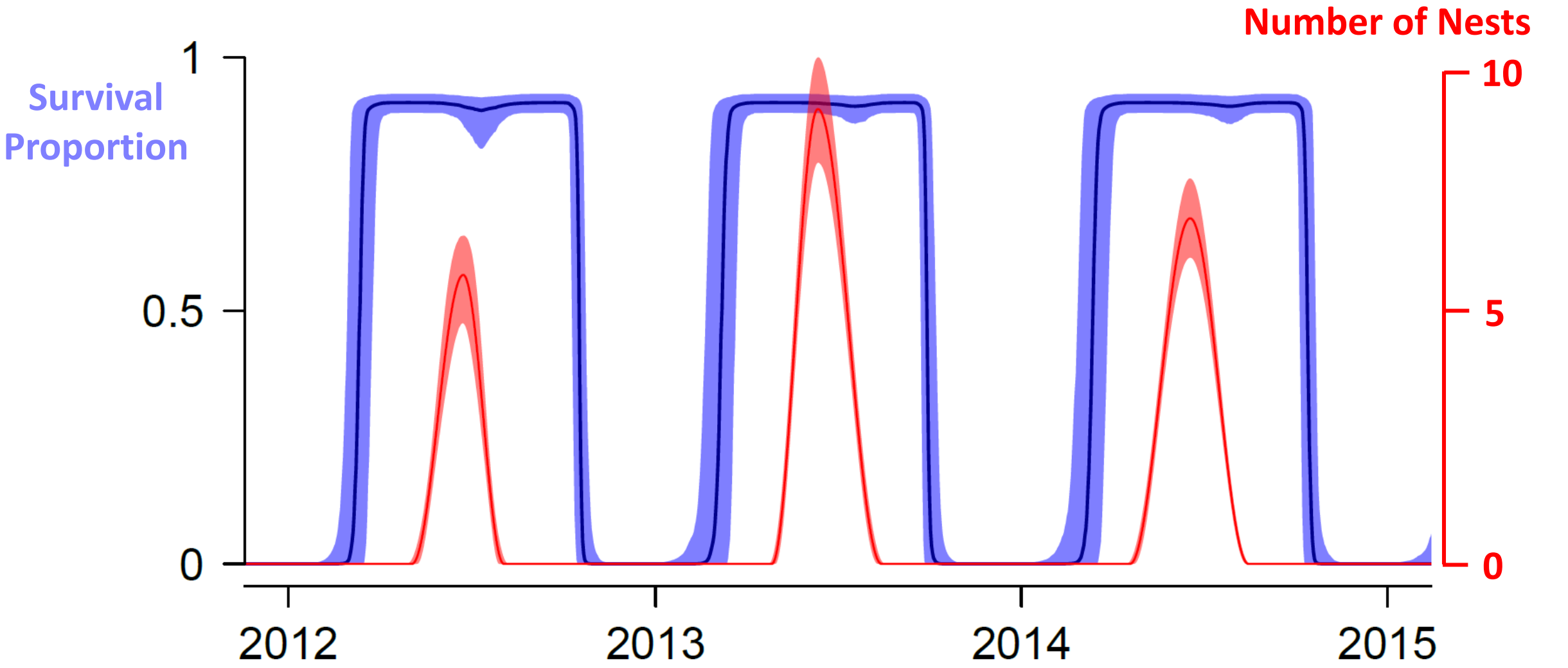


Girondot (2017)

Modeling Framework



Hatching Success Index $= \frac{\sum_{i=k}^{N} Hatched_t \times Nb.Nests_t}{\sum_{i=k}^{N} Nb.Nests_t}$



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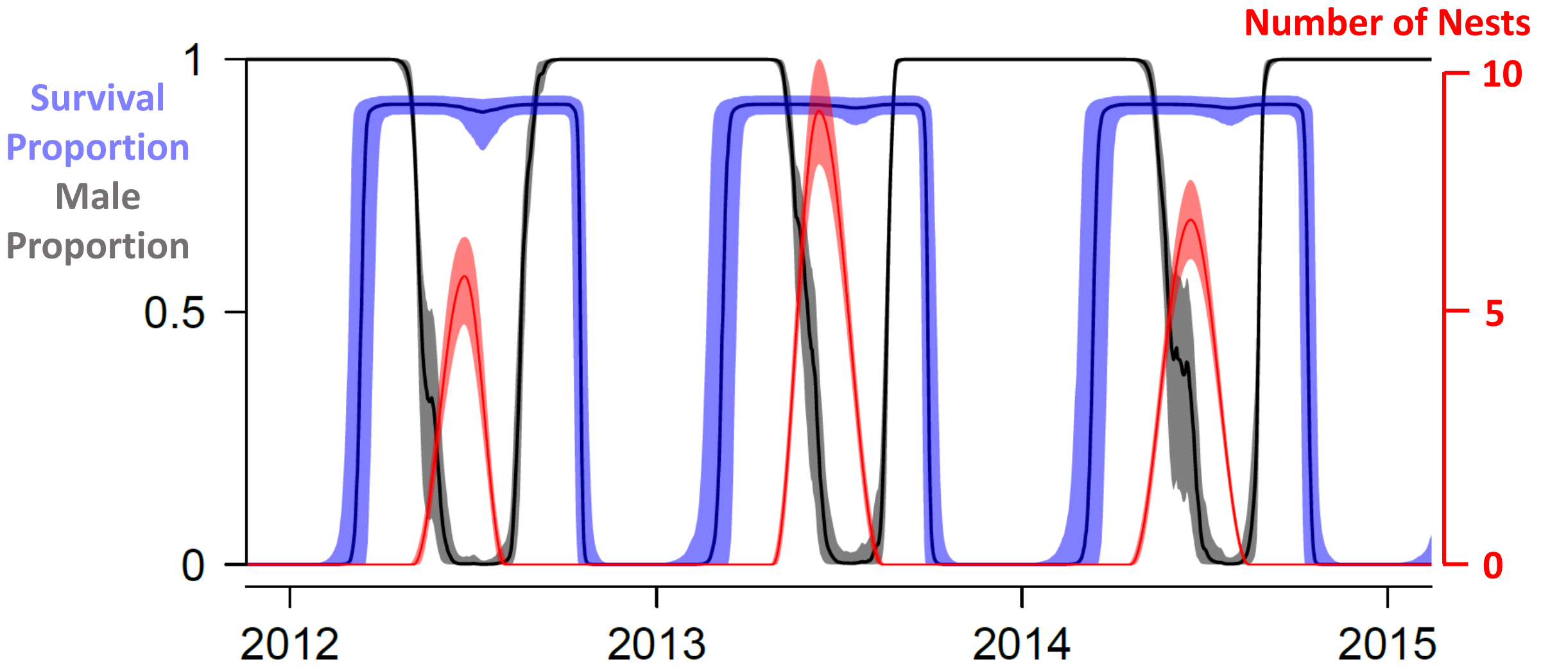
Sex Ratio Index $= \frac{\sum_{i=k}^{N} Sex\ Ratio_t \times Nb.Nests_t \times Hatched_t}{\sum_{i=k}^{N} Nb.Nests_t \times Hatched_t}$



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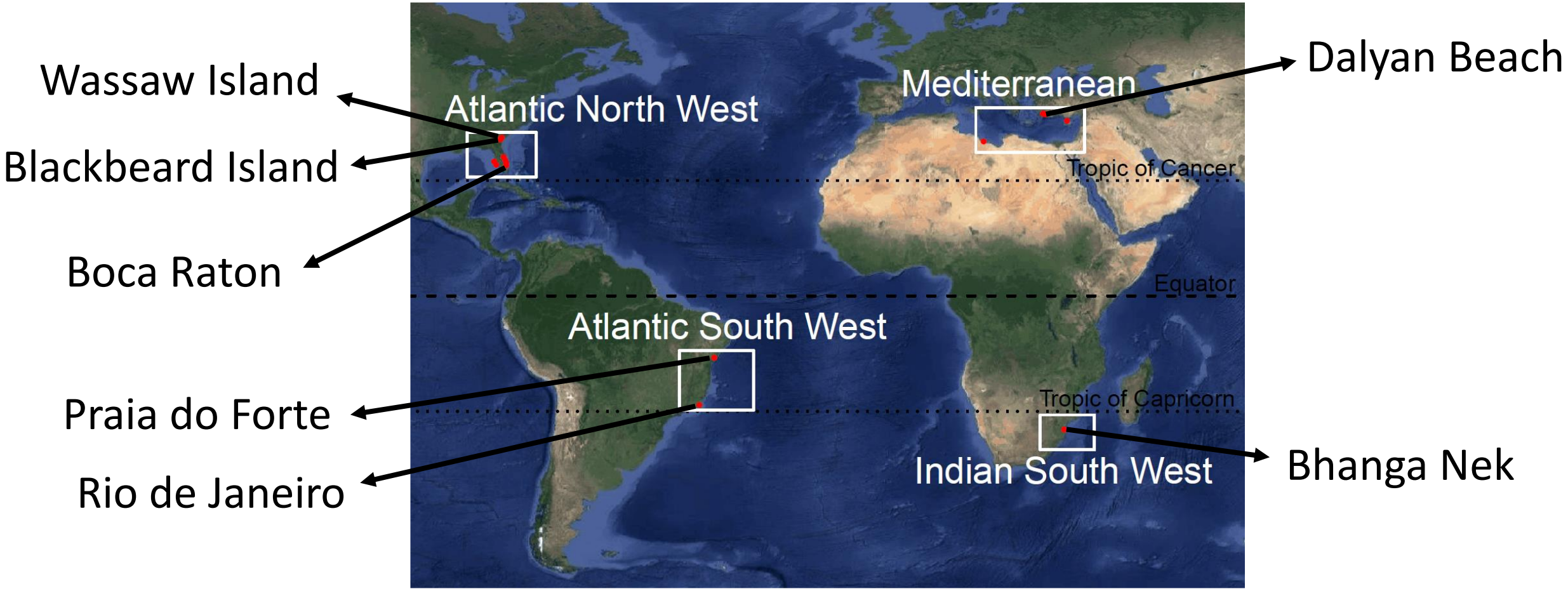
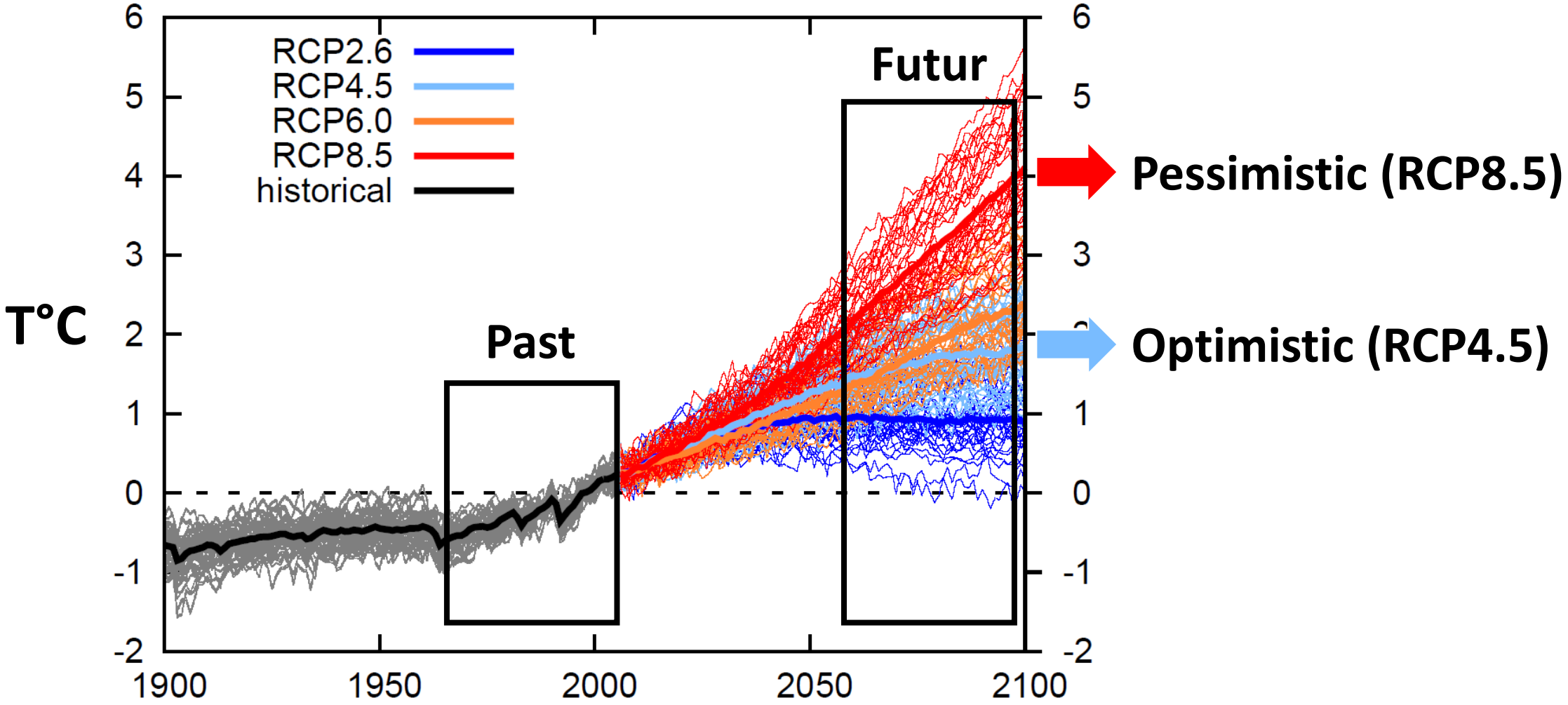
Field Data

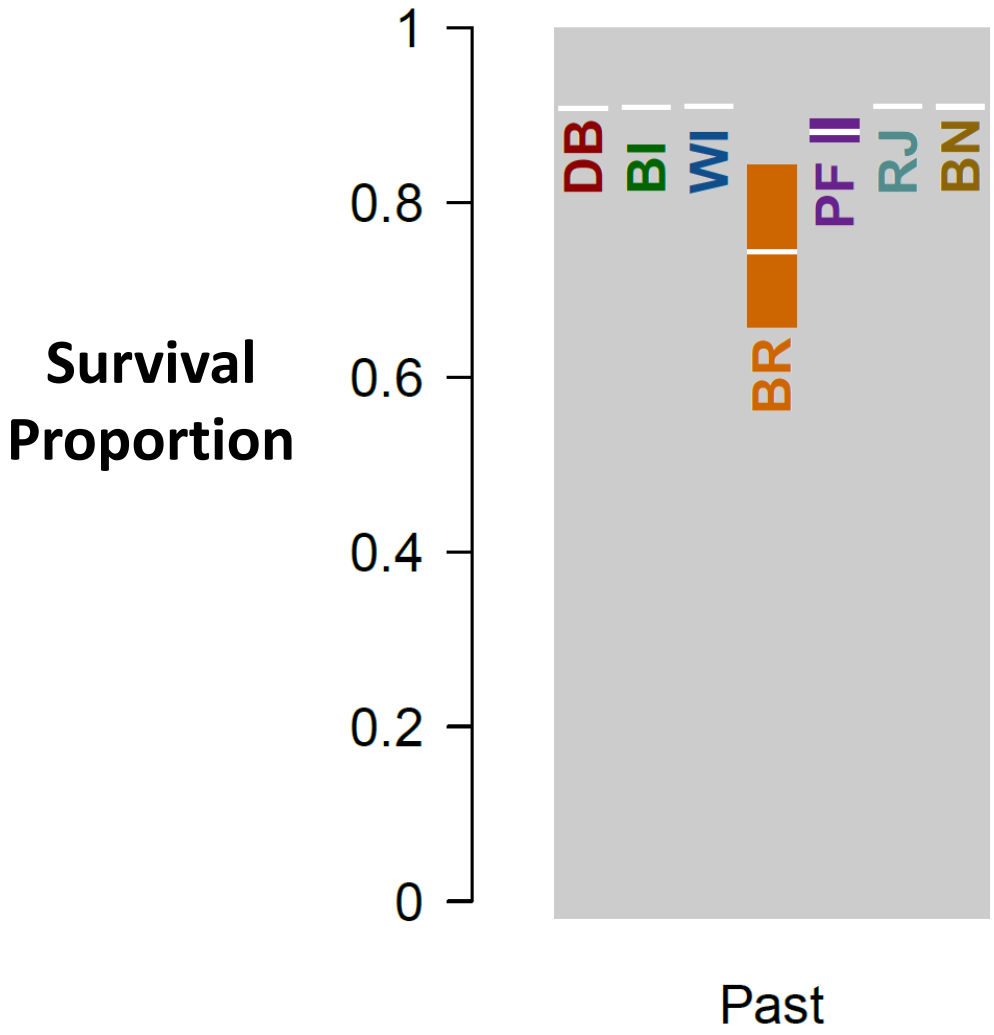

Wassaw Island
Blackbeard Island
Boca Raton
Praia do Forte
Rio de Janeiro
Atlantic North West
Mediterranean
Dalyan Beach
Tropic of Cancer
Equator
Atlantic South West
Tropic of Capricorn
Indian South West
Bhanga Nek

Climatic Scenarios



IPCC (2014)

Hatching Success Indices



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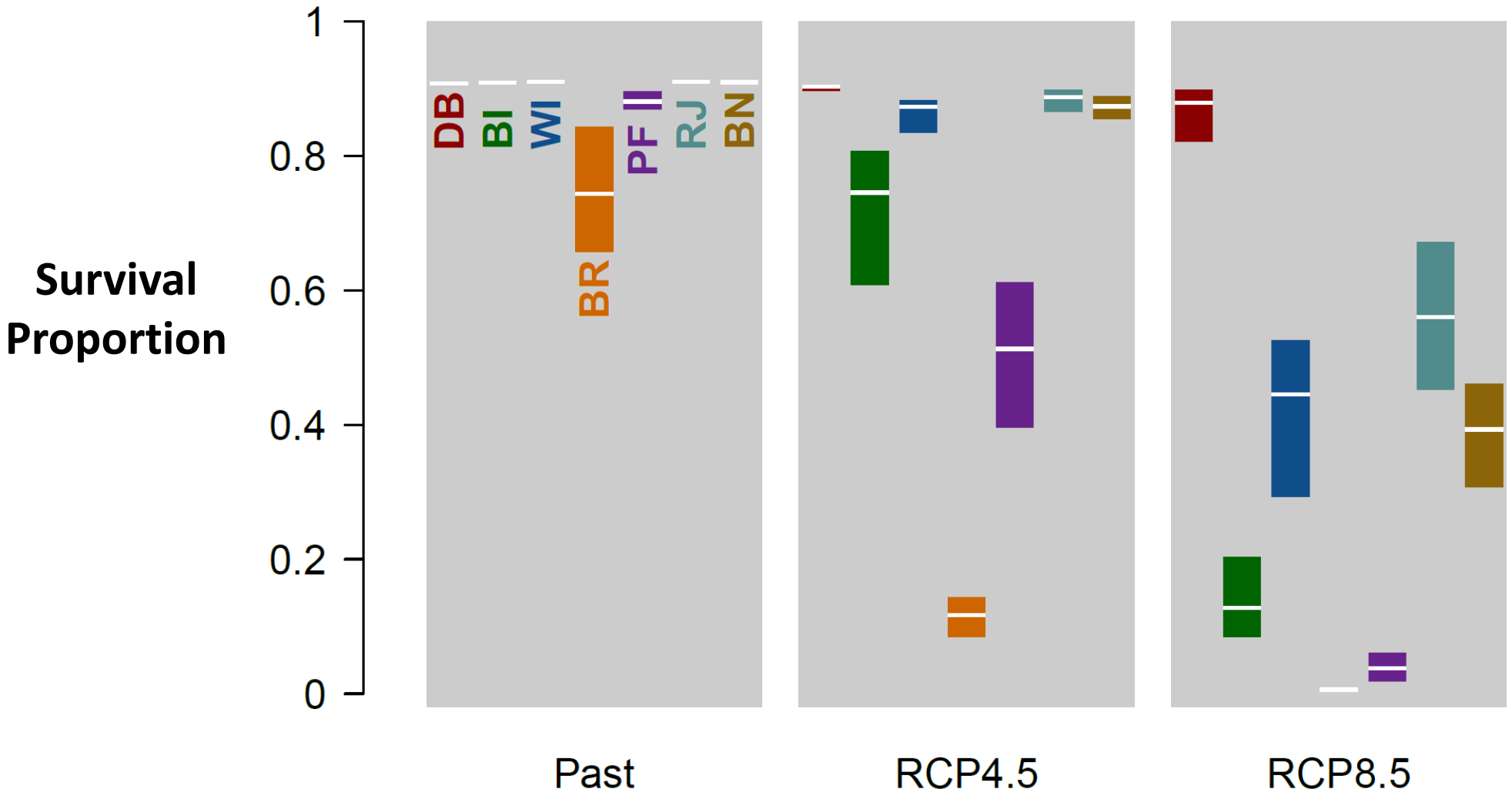

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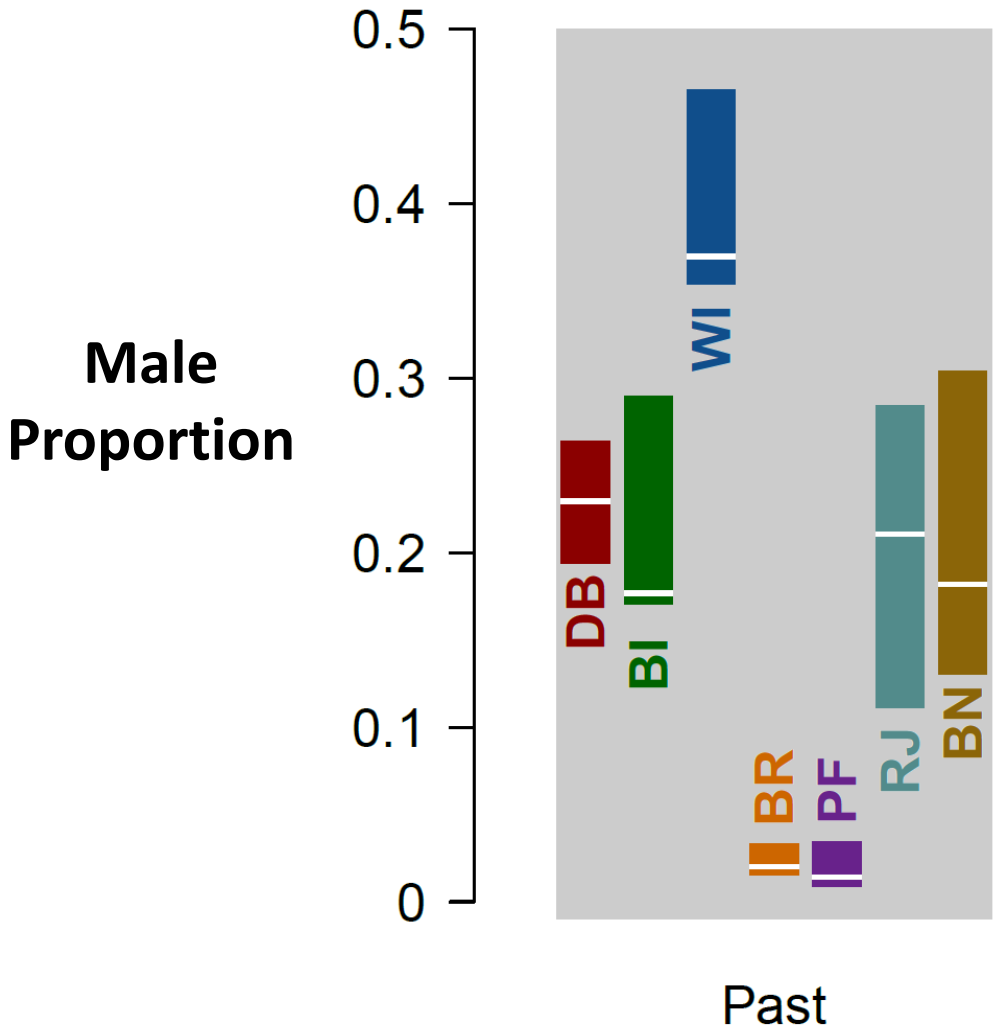
Sex Ratio Indices



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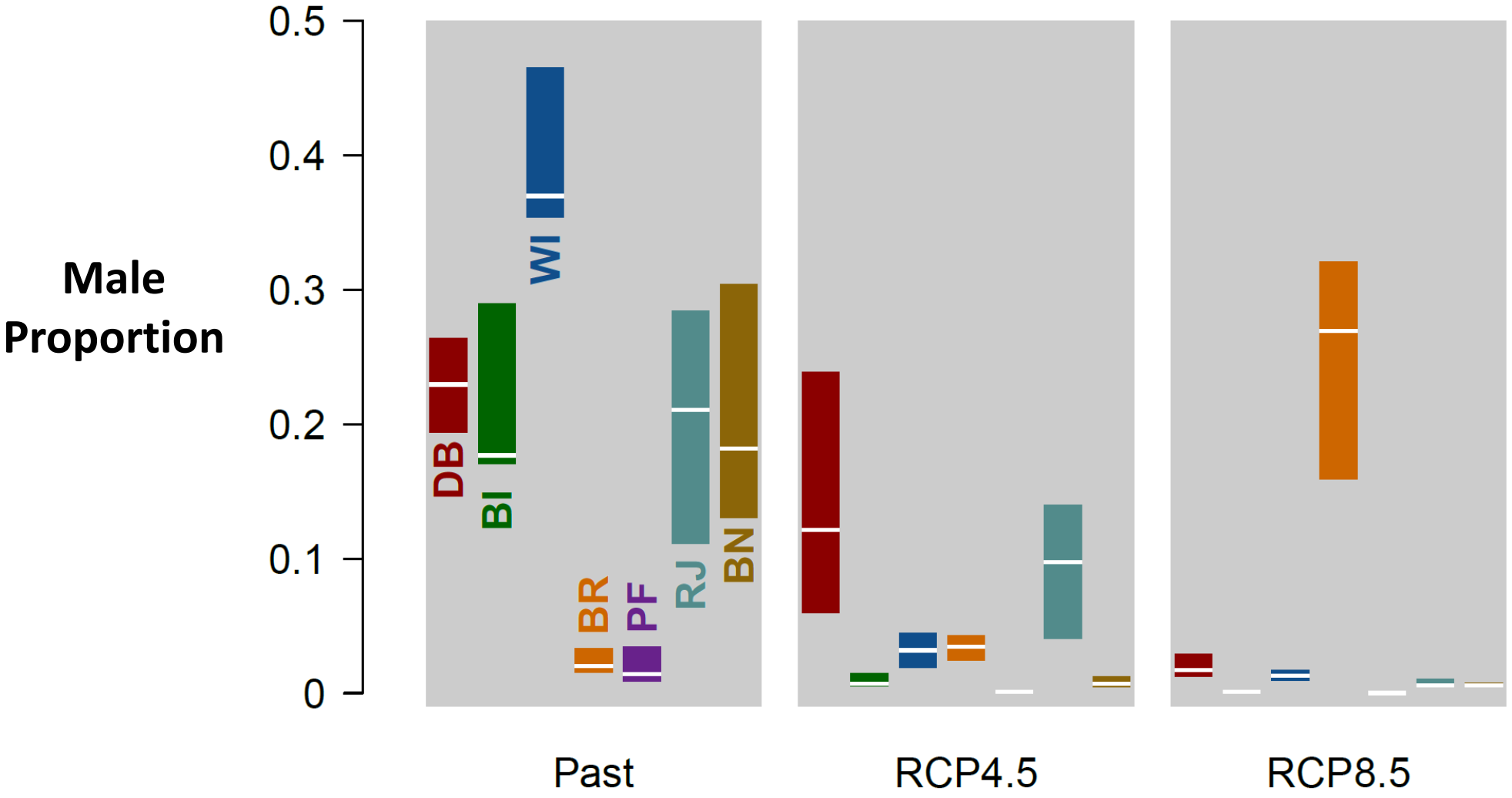

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Climatic Prices (Hatching Success)

	Optimistic (RCP4.5)	Pessimistic (RCP8.5)
Dalyan Beach	0	28
Blackbeard Island	56	81
Wassaw Island	50	76
Boca Raton	55	90
Praia do Forte	116	-
Rio de Janeiro	18	96
Bhanga Nek	25	80

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Climatic Prices (Sex Ratio)

	Optimistic (RCP4.5)	Pessimistic (RCP8.5)
Dalyan Beach	4	25
Blackbeard Island	48	66
Wassaw Island	54	73
Boca Raton	-	-
Praia do Forte	60	-
Rio de Janeiro	2	81
Bhanga Nek	30	74

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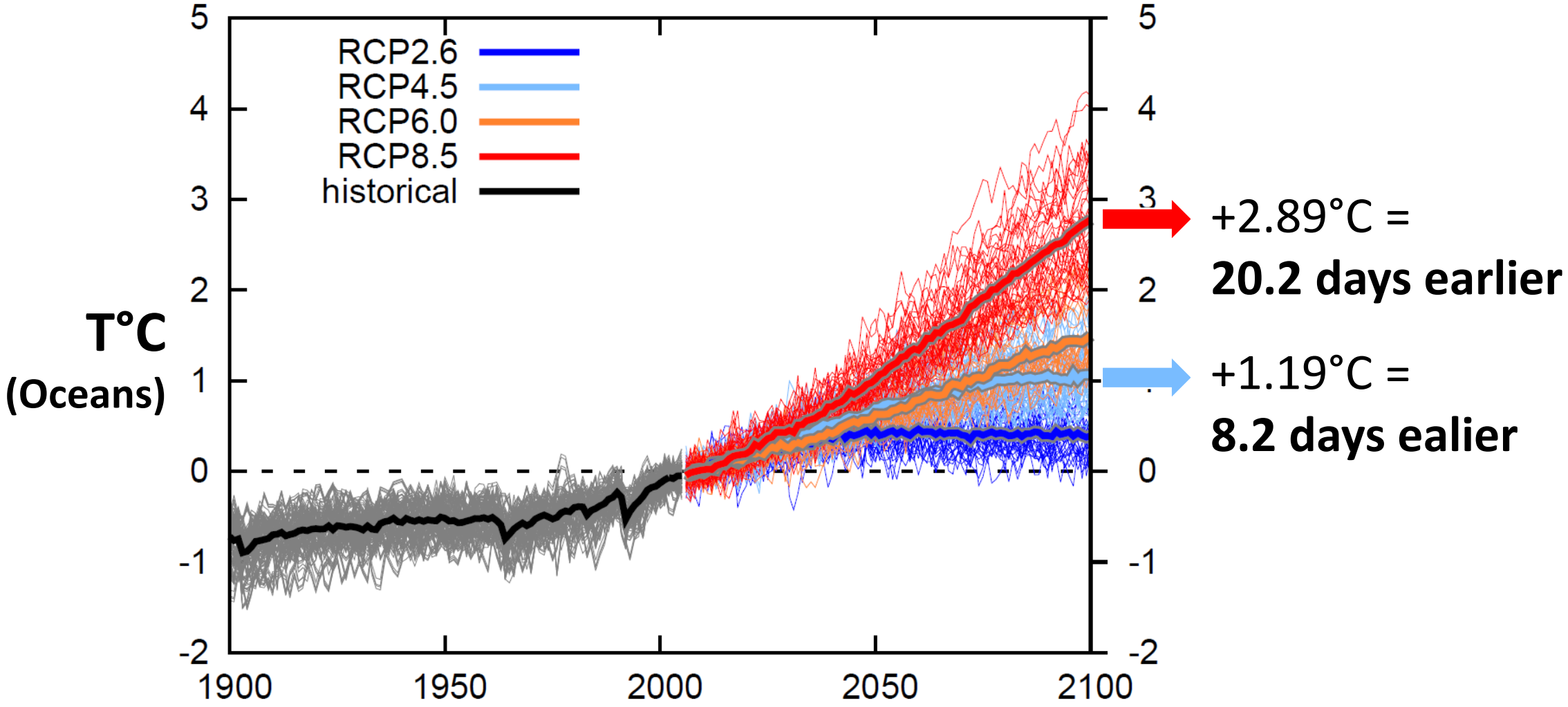
Temperature-induced Phenological Shifts



IPCC (2014)

Climatic Debts (Hatching Success)

	Optimistic (RCP4.5)	Pessimistic (RCP8.5)
Dalyan Beach	0 – 8.2 = **-8.2**	28 – 20.2 = **7.8**
Blackbeard Island	**47.8**	**60.8**
Wassaw Island	**41.8**	**55.8**
Boca Raton	**46.8**	**69.8**
Praia do Forte	**107.8**	-
Rio de Janeiro	**9.8**	**75.8**
Bhanga Nek	**16.8**	**59.8**

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Climatic Debts (Sex Ratio)

	Optimistic (RCP4.5)	Pessimistic (RCP8.5)
Dalyan Beach	4 – 8.2 = **-4.2**	25 – 20.2 = **4.8**
Blackbeard Island	**39.8**	**45.8**
Wassaw Island	**45.8**	**52.8**
Boca Raton	-	-
Praia do Forte	**51.8**	-
Rio de Janeiro	**-6.2**	**60.8**
Bhanga Nek	**21.8**	**53.8**

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Discussion

- Thermal heterogeneity at the scale of a beach

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- Precipitations and moisture levels

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- Toward more females… Is that a big deal?

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- Thermal heterogeneity at the scale of a beach
- Precipitations and moisture levels
- Toward more females… Is that a big deal?
- Low hatching success… Genetic adaptation of critical thermal limits?

Conservation Implications

- Spread water to cool down the nests?

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- Spread water to cool down the nests?
- Assisted migration of nesting sites?
- Prioritization of conservation efforts!
- Allow new nesting sites to be founded naturally!

Perhaps in France!

FRANCE 2

Take-home Message

Sea turtles have been around for millions of years and are probably able to adapt to current climatic changes.

→ But we must reduce our impact to let them do it!

- Bycatch in fisheries
- Pollution
- Coastal development
- Unreasonable poaching

Thanks a lot!

Jeanette Wyneken, Kirt Rusenko, Milagros Lopez, Paulo Lara, Alexsandro Santos, Maria A.G. dei Marcovaldi, Mariana M.P.B. Fuentes, Yakup Kaska, Jenny Tucek, Ronel Nel, Kristina L. Williams, Anne Marie LeBlanc, David Rostal, Jean-Michel Guillon and Marc Girondot