Population models for synthesis of climate effects on fish early life history stages

Klaus Huebert, Chris Chambers, Kenny Rose

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University of Maryland
CENTER FOR ENVIRONMENTAL SCIENCE
HORN POINT LABORATORY

NOAA OCEAN ACIDIFICATION PROGRAM

Winter Flounder (*Pseudopleuronectes americanus*)

- Economically important flatfish
- Coastal NW Atlantic
- Managed as 3 US & 3 Canadian stocks
- Southernmost “SNE/MA” stock overfished but no overfishing is occurring (Wood 2017)

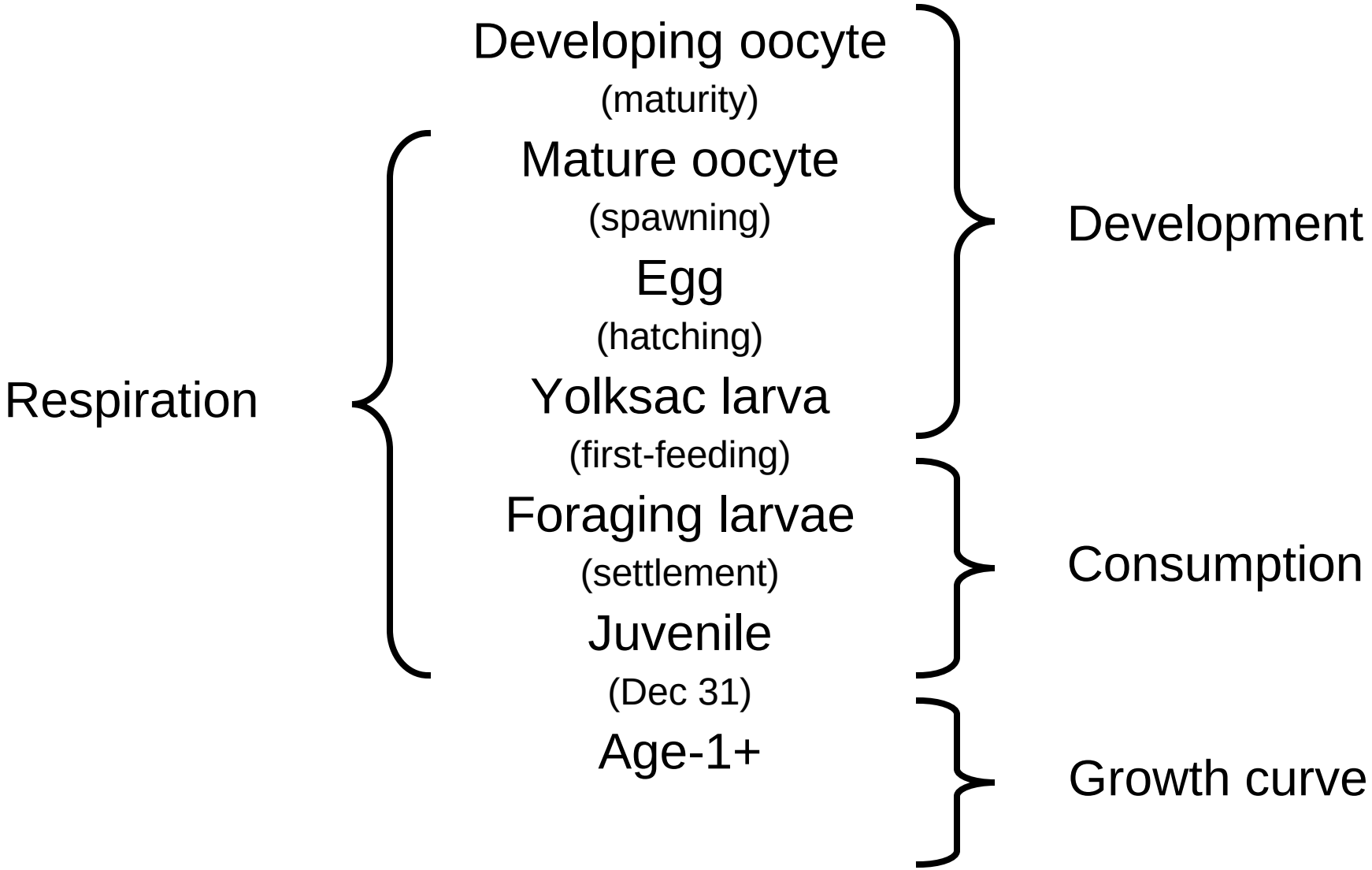
Winter Flounder (*Pseudopleuronectes americanus*)

- Mostly estuarine spawning
- Benthic eggs
- Pelagic larvae
- Benthic juveniles
- Many adults move deeper in summer (0-100 m), others stay in estuaries.

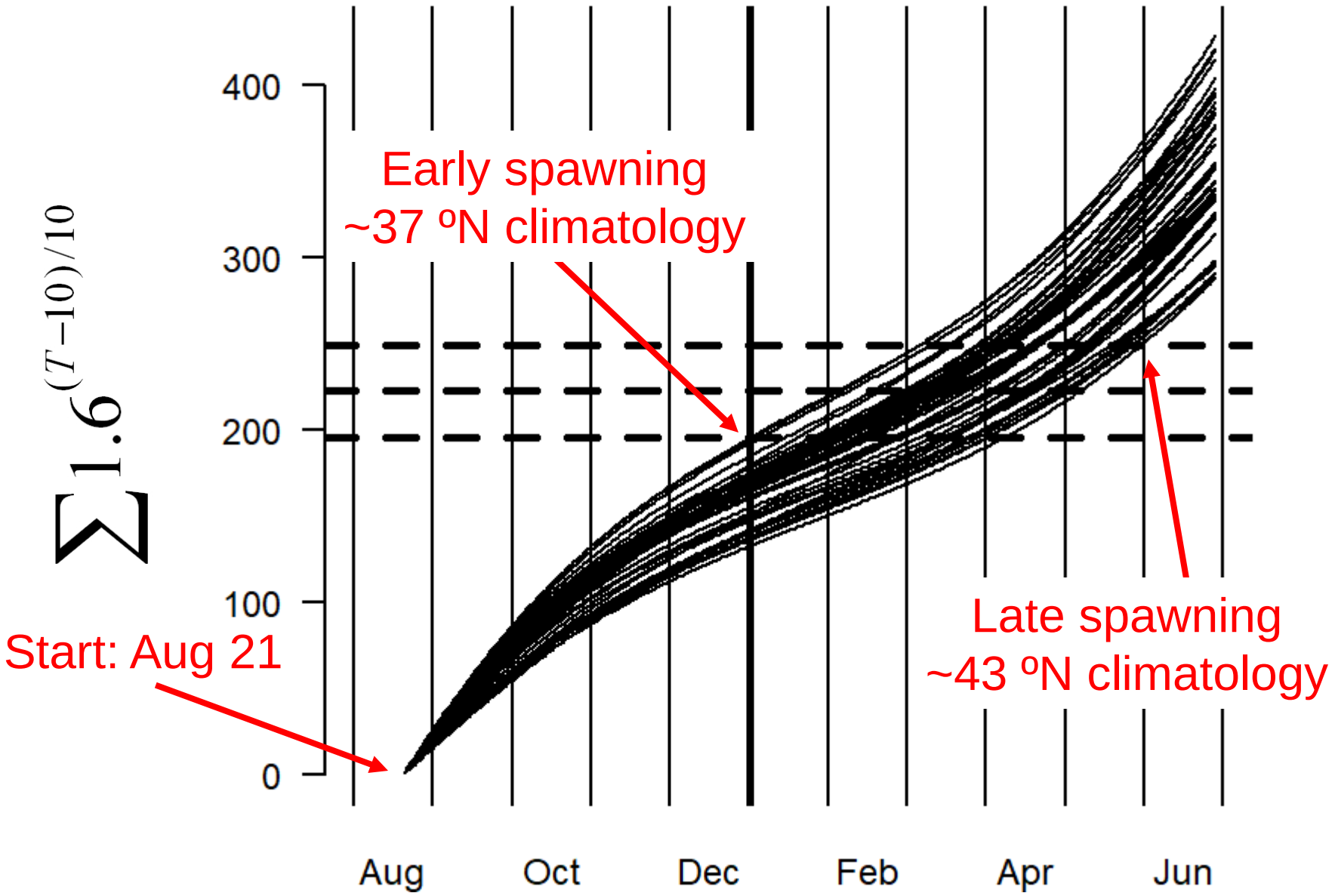
Winter Flounder Model

- Synthesis of laboratory data on biological effects of **ocean acidification** on **early life history stages**
- Loosely based on a 1990s winter flounder IBM (Rose, Chambers, et al.) and the generic, trait-based larval fish model "Quirks" (Huebert and Peck 2014)

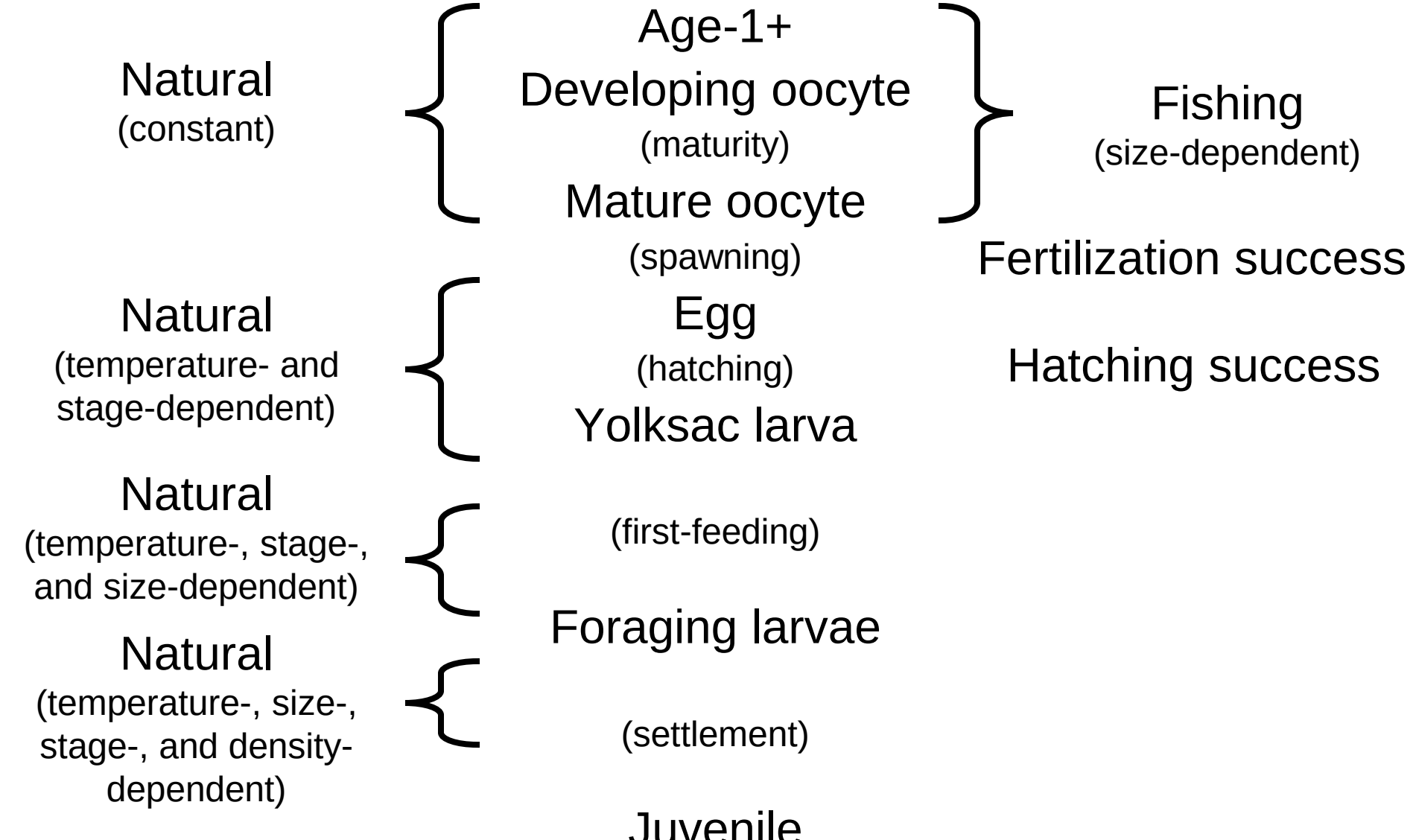
Key physiological processes



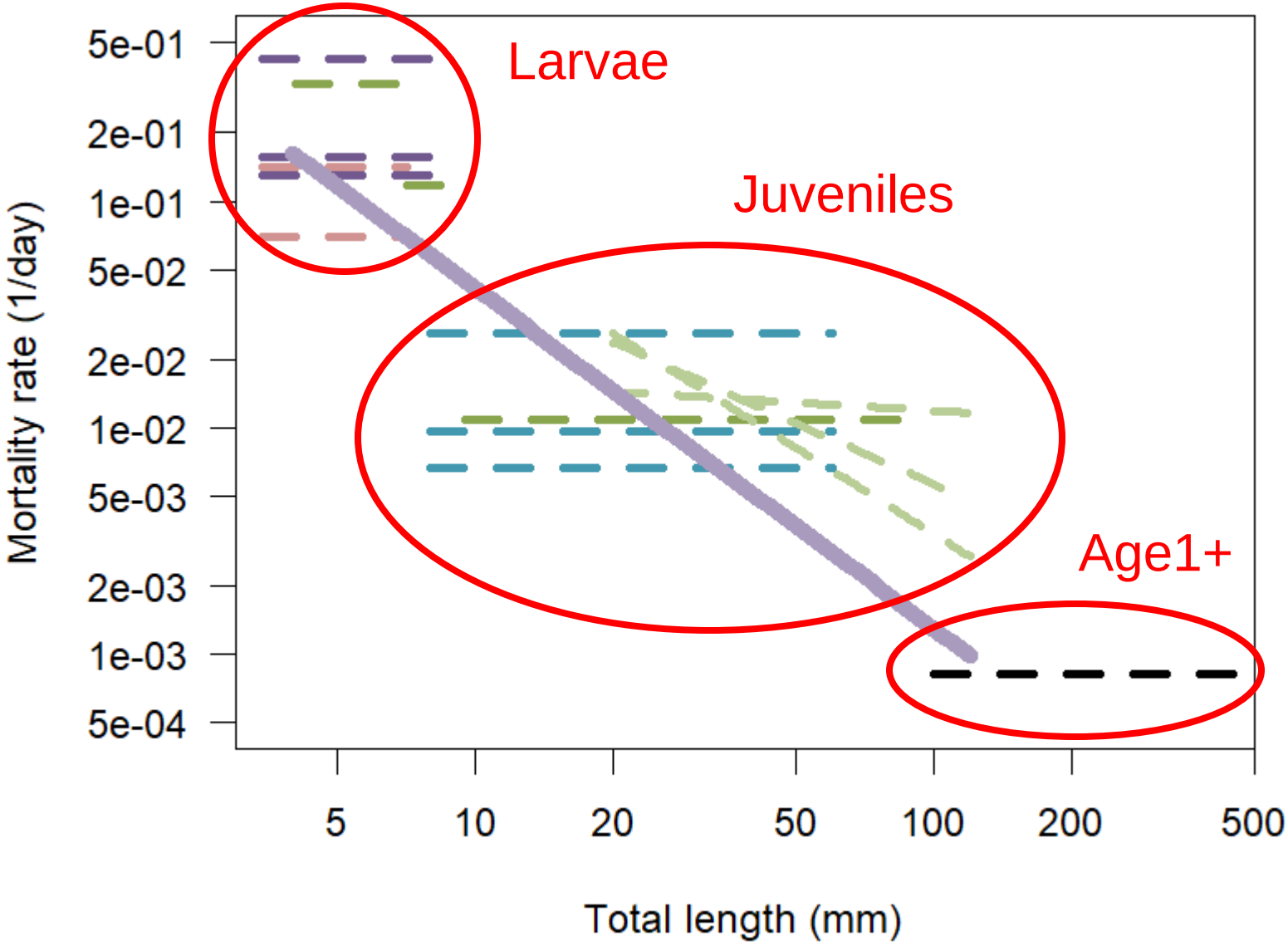
Example: oogenesis



Key mortality sources



Example: length-based mortality



Lab data to be incorporated

Temperature x CO_2 experiments

Eggs

- size variation
- fertilization rates
- development rates

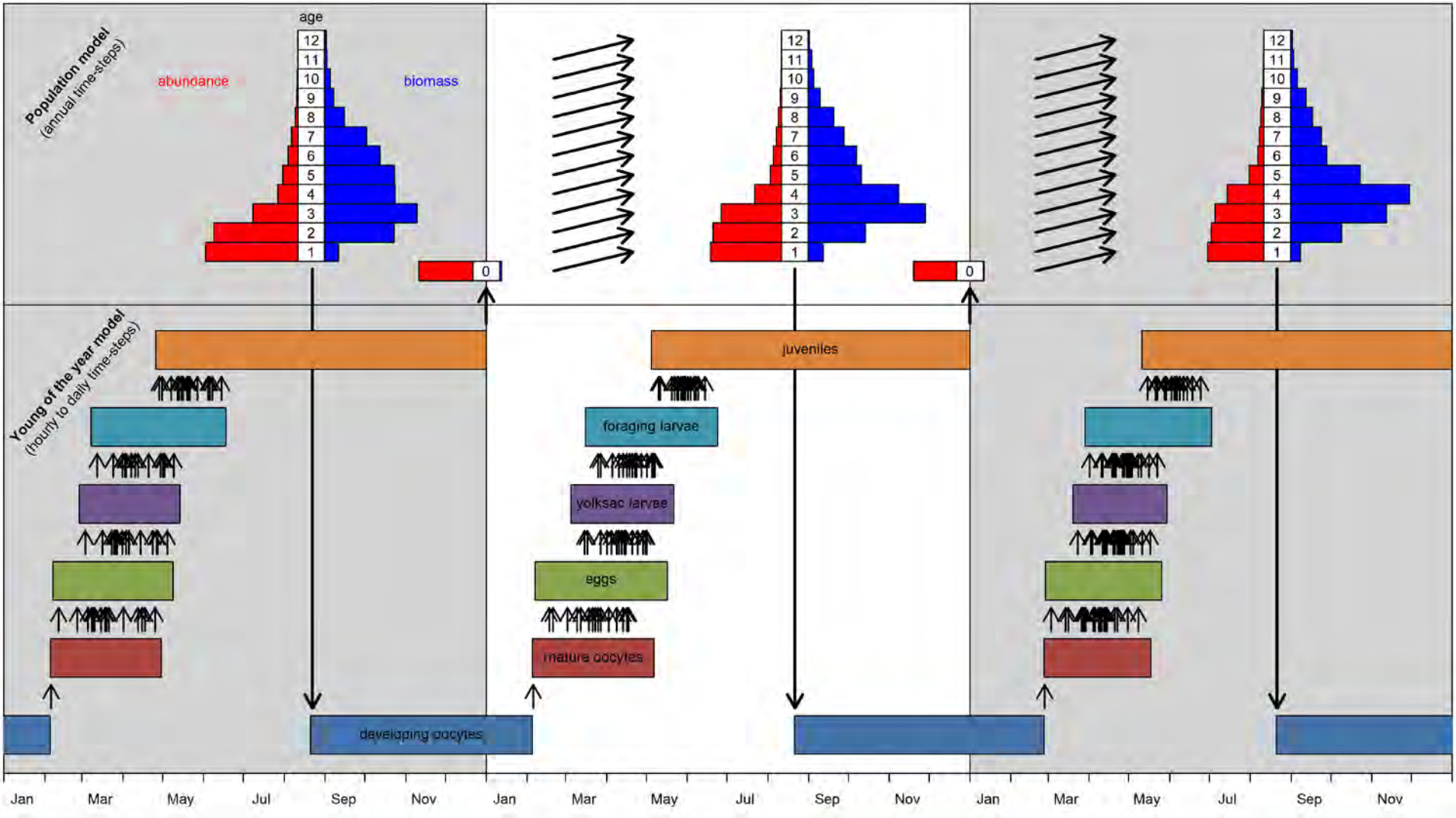
Larvae

- size at age
- size at settlement
- mortality rates

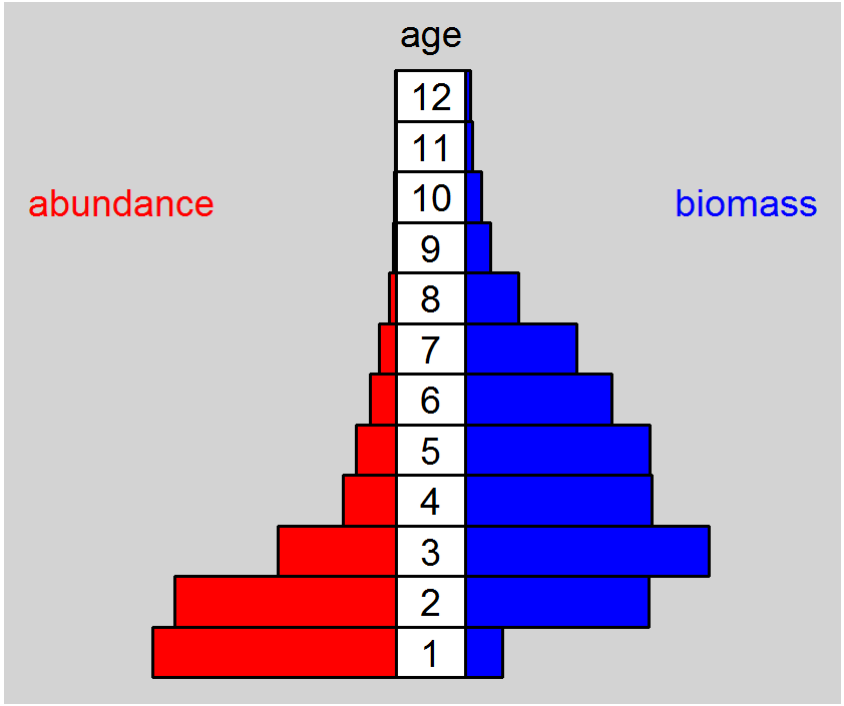
Juveniles

- prey consumption rates

Model structure

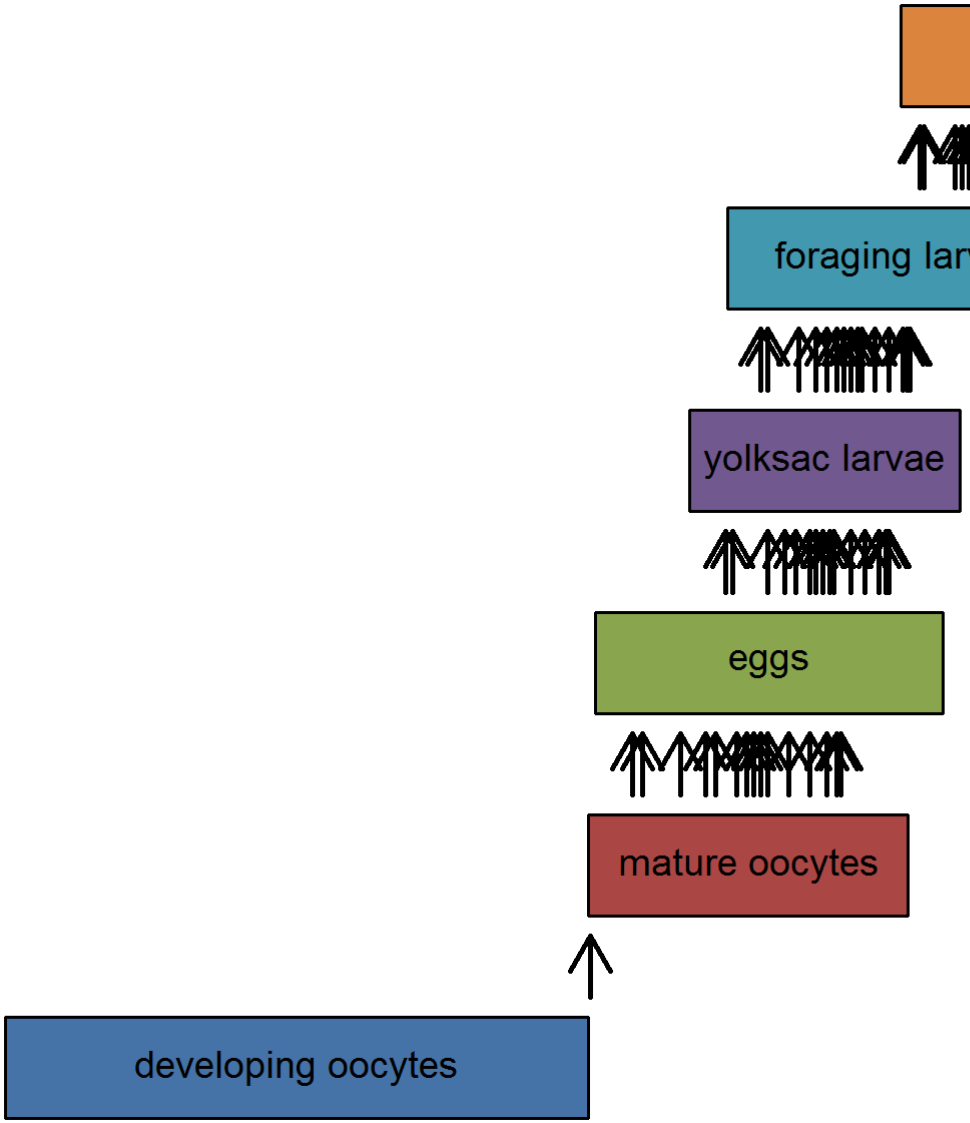


Female population model



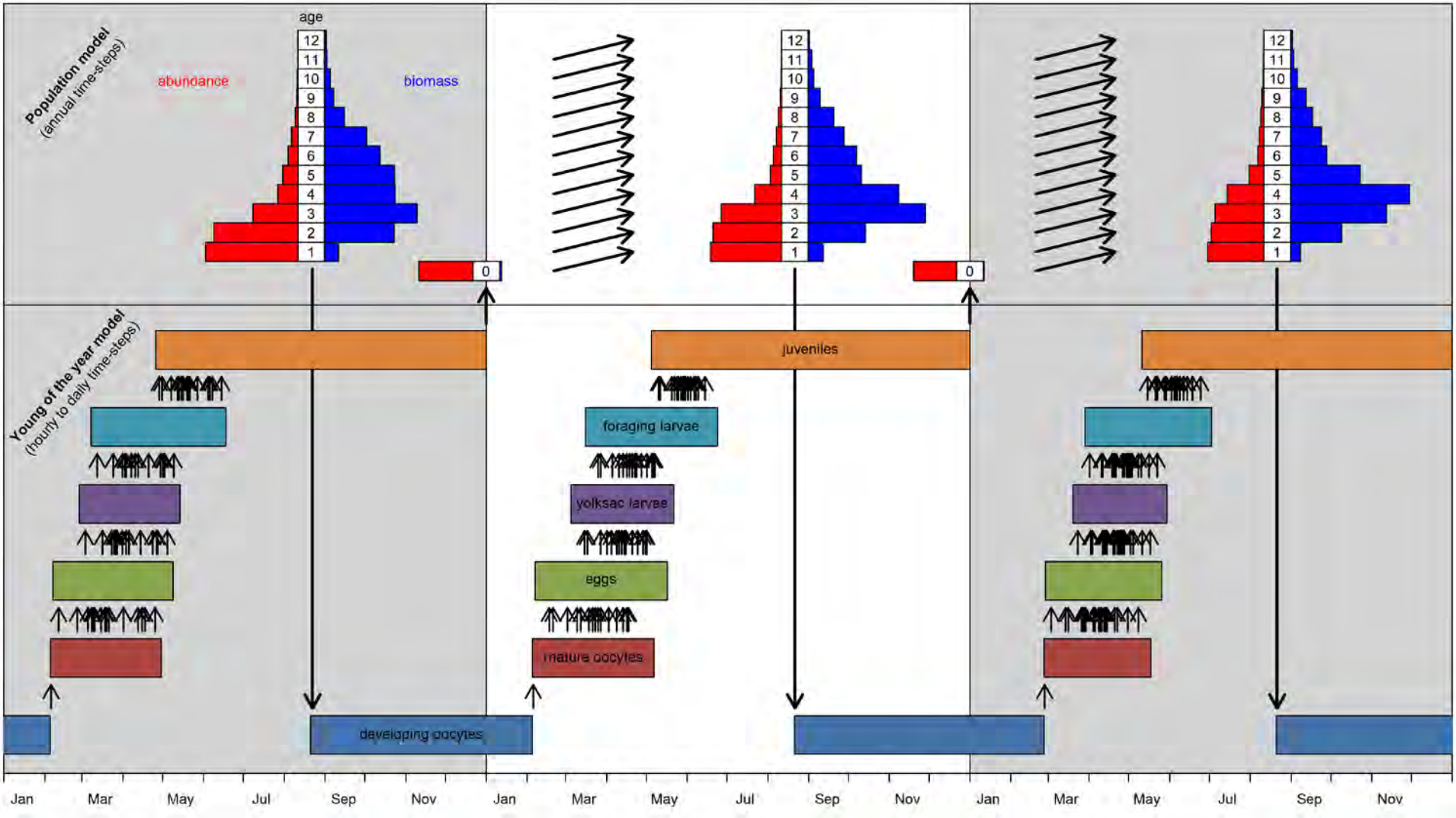
- Fixed number of super-individuals per year class
- Annual time-steps
- Senescence
- Recruitment from sub-sampled young of the year model output

Young of the year model

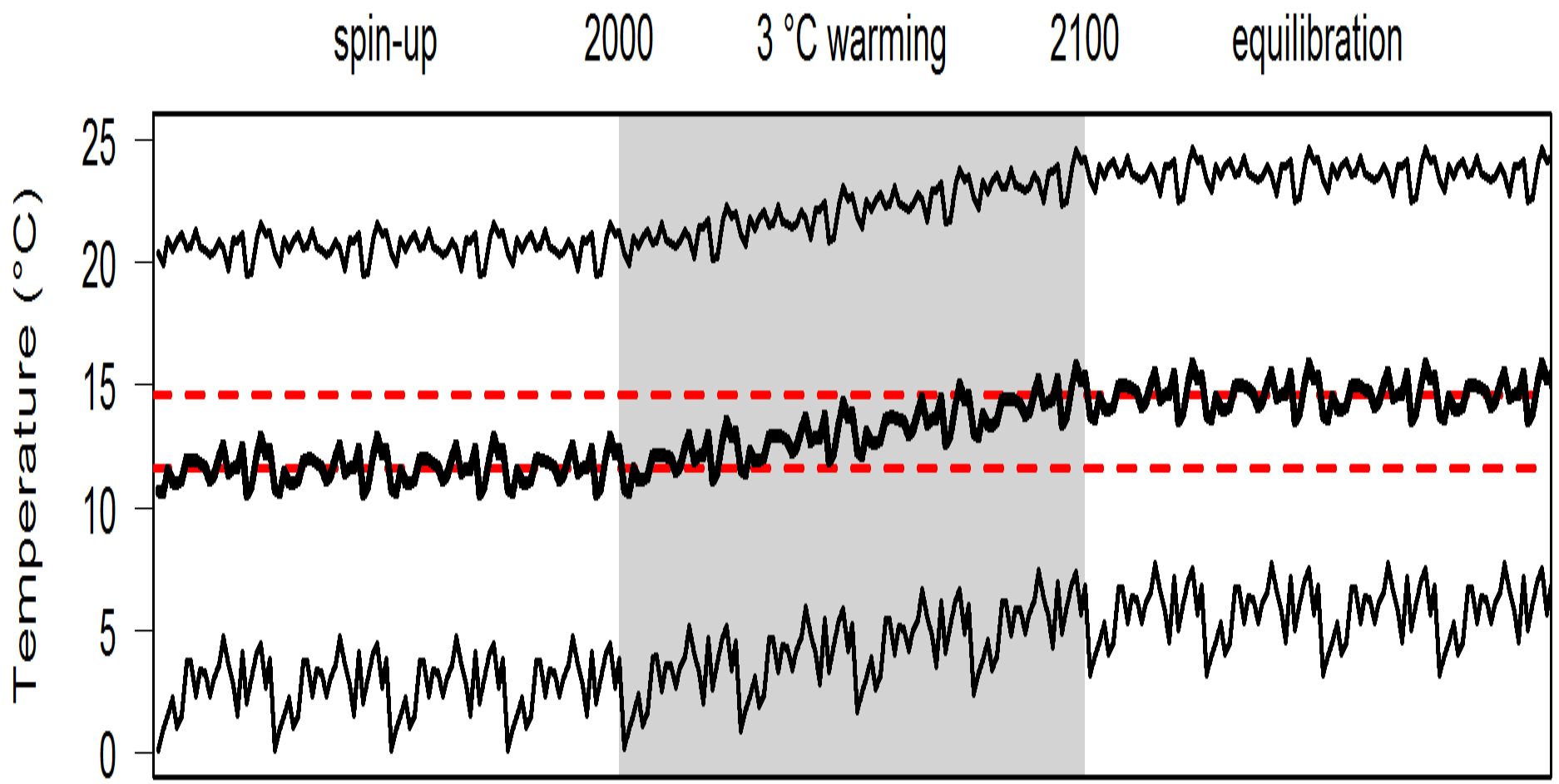


- Initially a copy of the female population model
- Daily to hourly time-steps
- August 21 of year N to December 31 of year N+1

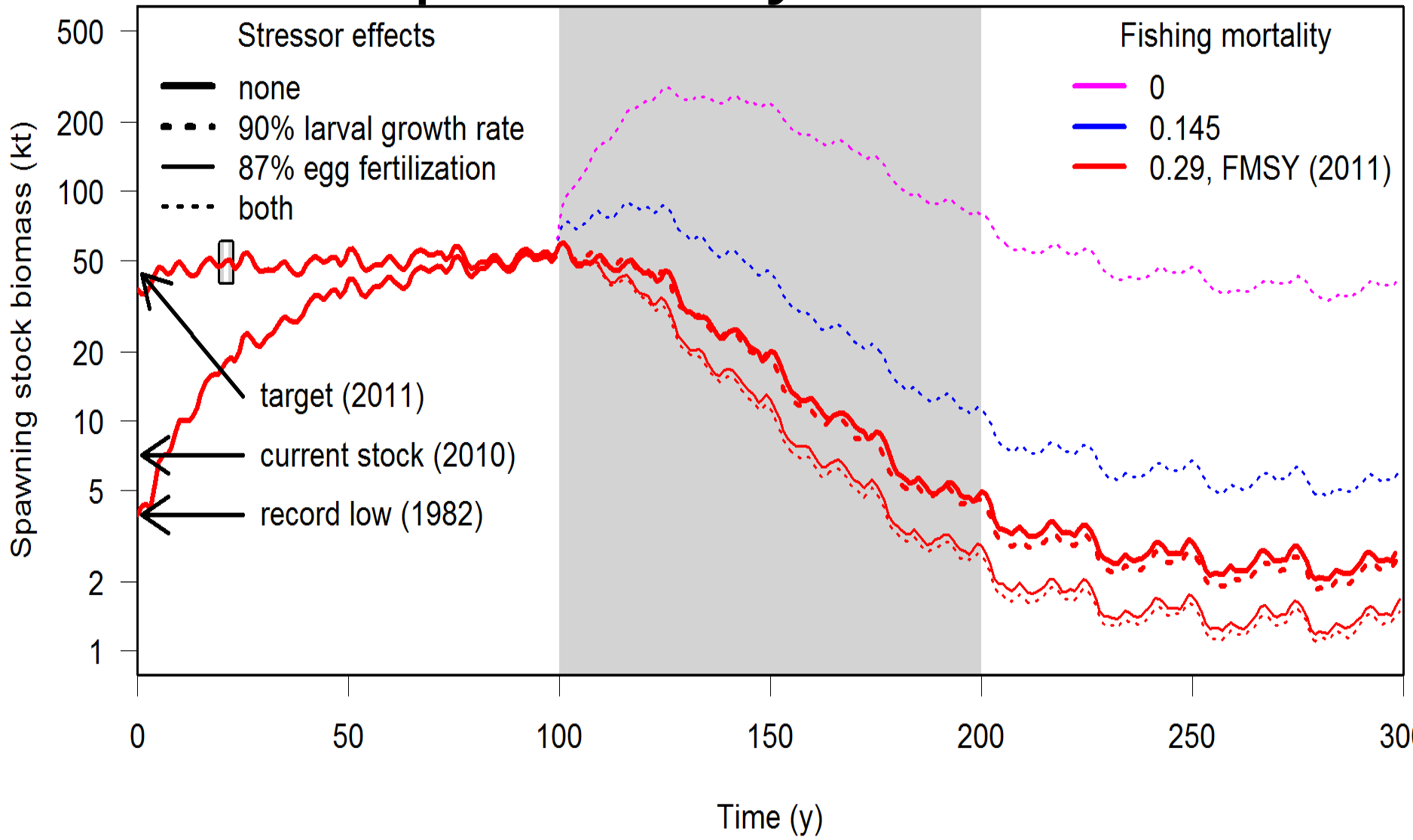
Model structure



3 ºC warming simulations
(repeated, manipulated 25-y time series)



Highly questionable (but interesting) preliminary data!



Discussion point: physiology vs. density-dependent mortality

Here:

- Stage, length, temp. effects from literature
- Density-dependence tuned to match stock assessment SSB_{MSY} at F_{MSY}

Consequence:

- Stock resilience may be wrong
- Scaling up from individual physiology to populations would be affected

Discussion point: trait variability and inheritance

Here:

- The model tracks ancestry
- Suitable for exploring adaptation, evolution, (plasticity?) in response to climate change
- (Co-)variability of traits not yet implemented

Consequence:

- Scaling from average 20th century fish to 21st century populations is problematic