The biological basis of egg production and implications for stock assessments

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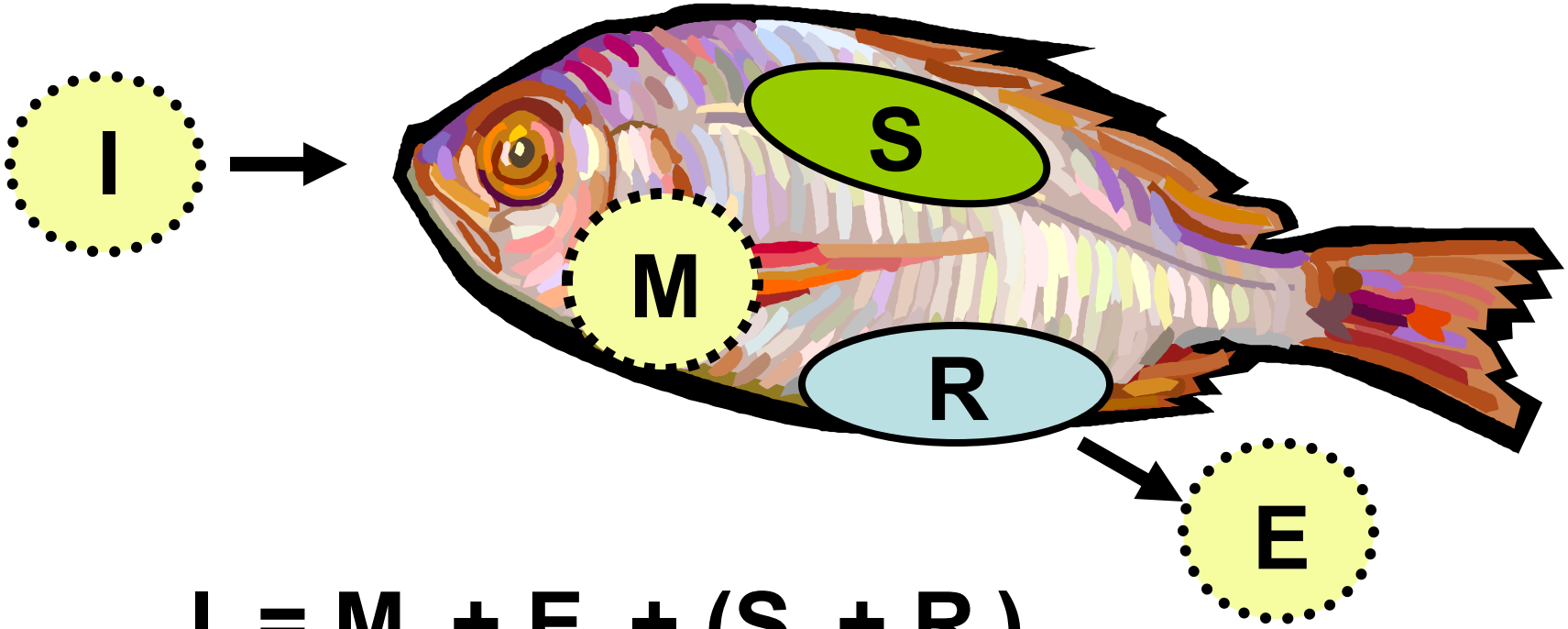
NOAA's National Marine Fisheries Service

Fish egg production – outline of the talk

- Bioenergetic basis – variations in weight
- Under the hood: fish oogenesis
- Closer look – herring & halfbeaks
- Fecundity contrasts, by batch size and batch frequency
- Define capital and income spawners
- Implications for stock assessment

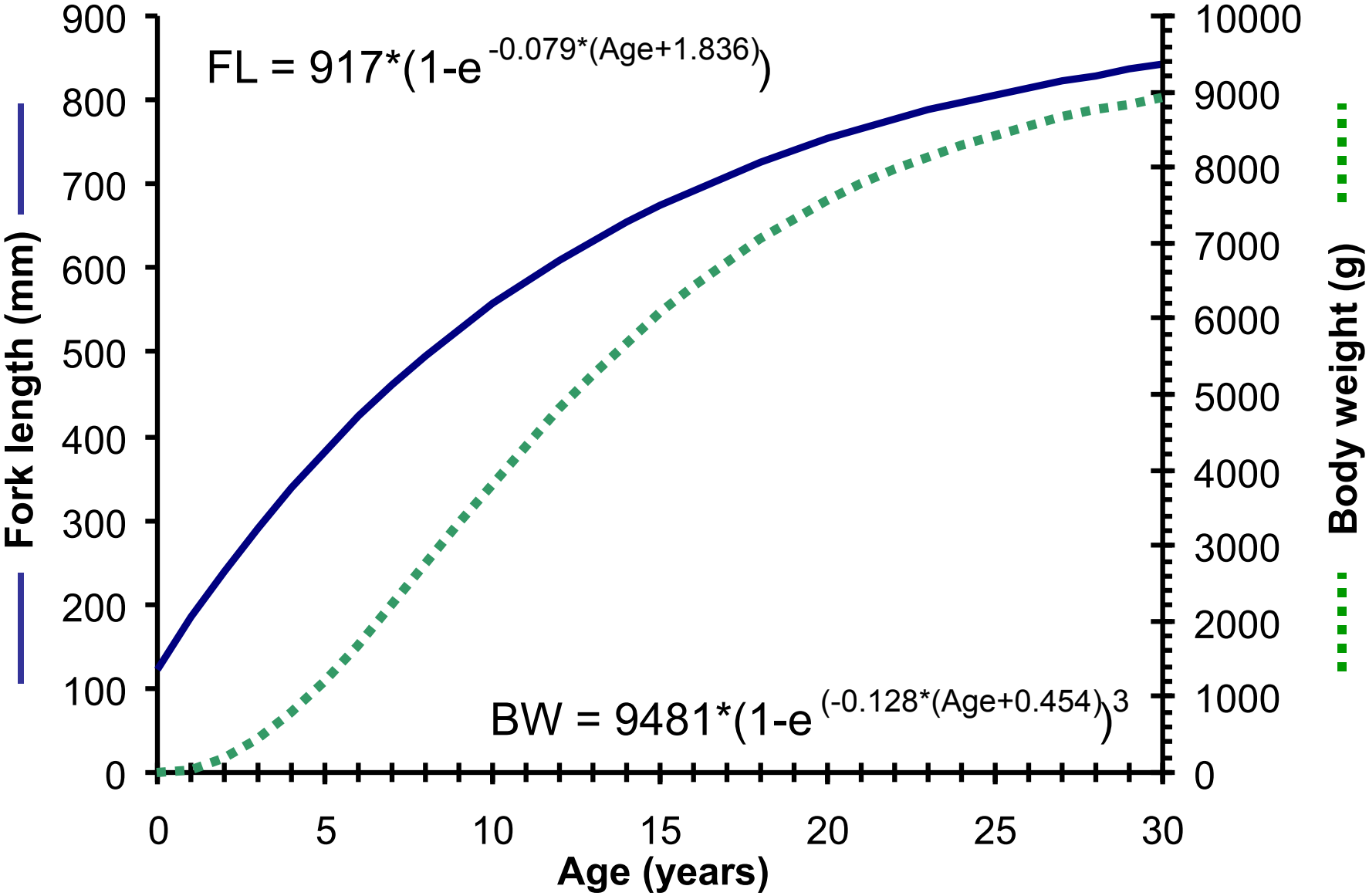


$$I_t = M_t + E_t + (S_t + R_t)$$

I = food energy
M = metabolism (routine + activity)
E = excretion & egestion
S = somatic growth
R = reproductive growth

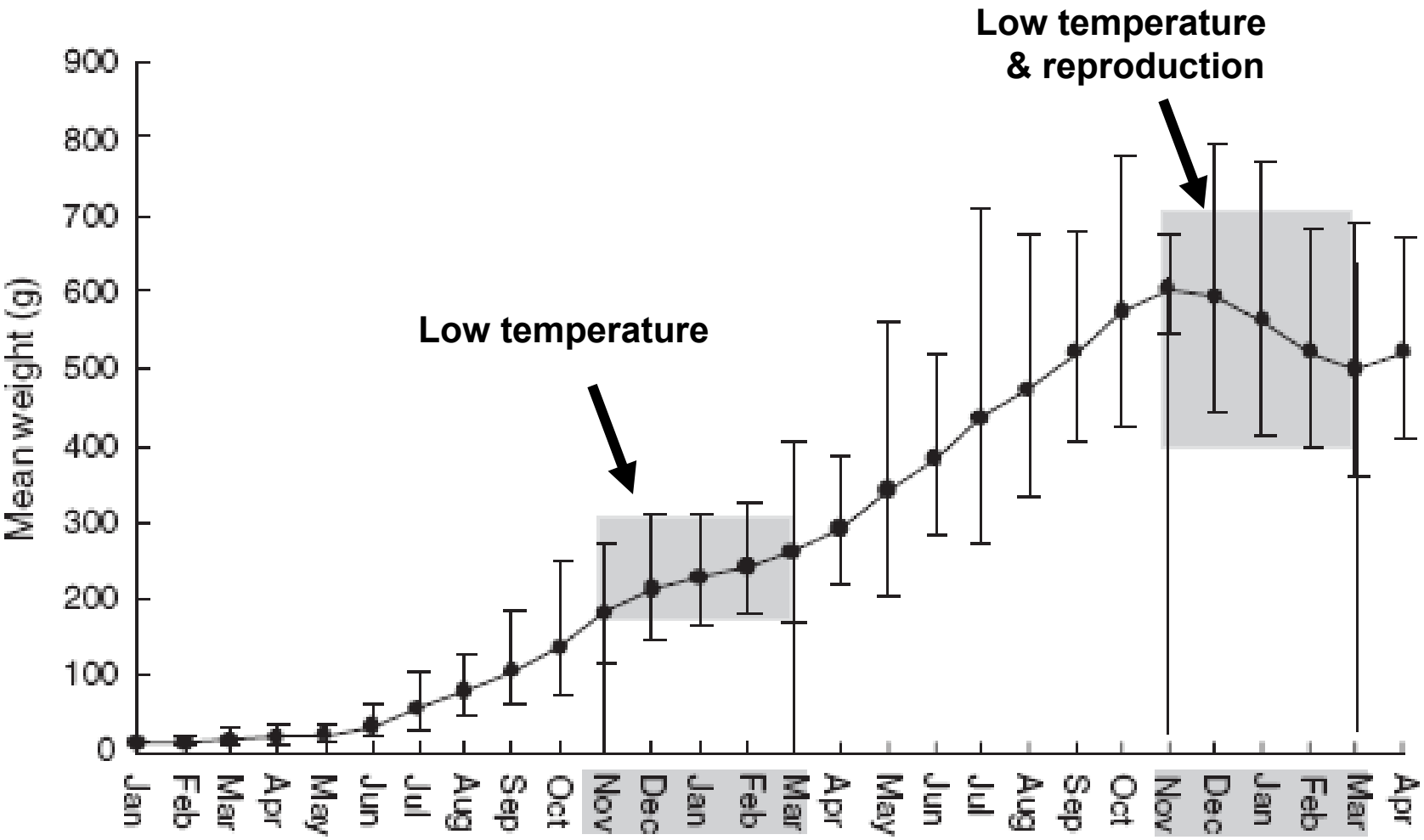
} surplus energy

Growth of Gulf of Mexico hogfish (*Lachnolaimus maximus*)



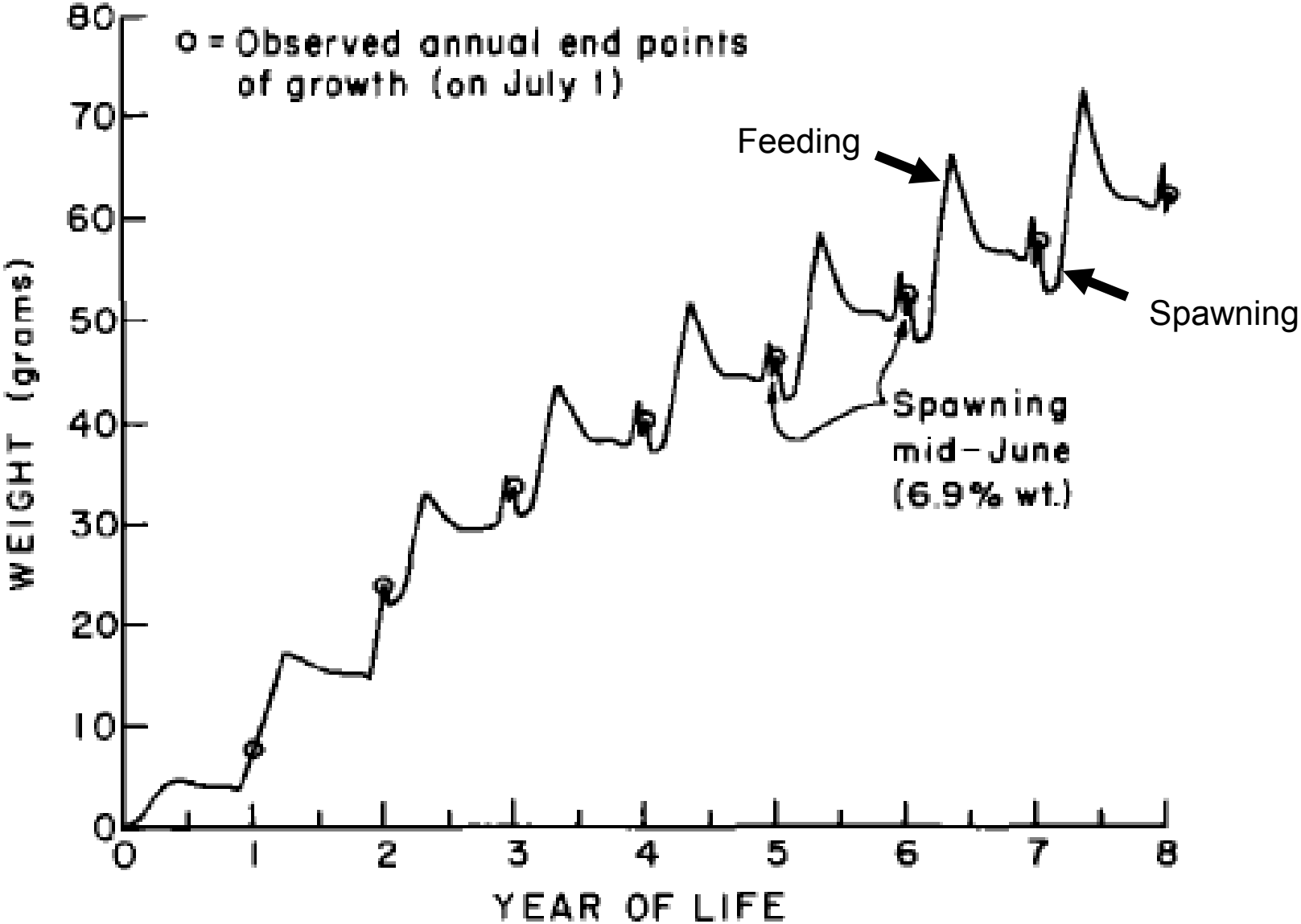
McBride and Richardson (2007); McBride et al. (2008)

Gilthead sea bream (*Sparus aurata*) in cage culture

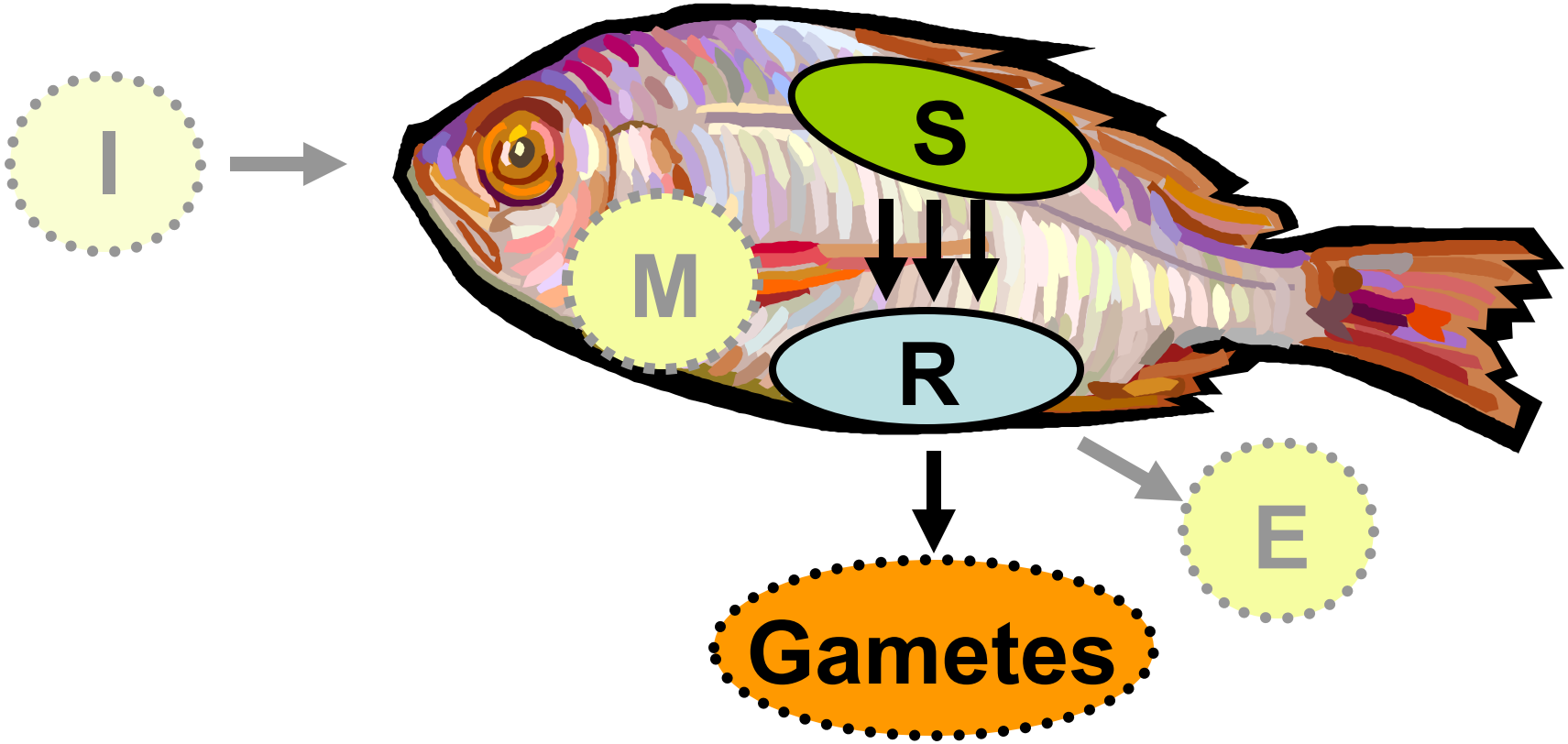


Dimitriou et al. (2007)

Simulated growth of alewife (*Alosa pseudoharengus*) in Lake Michigan
Body weight in response to feeding and spawning periods



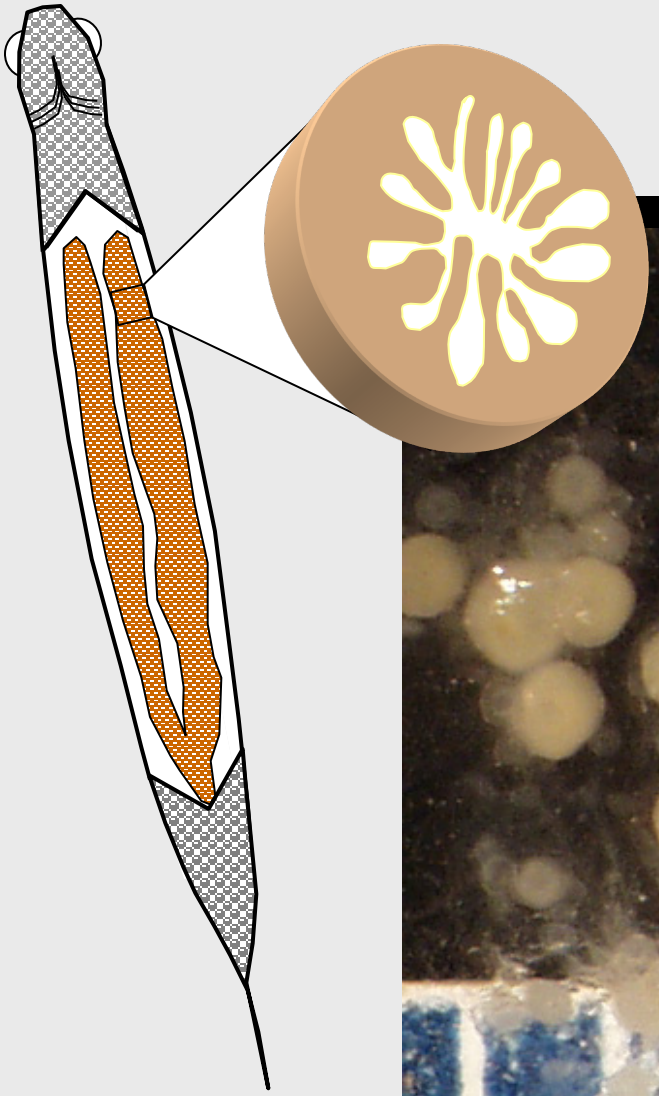
Stewart and Binkowski (1986)

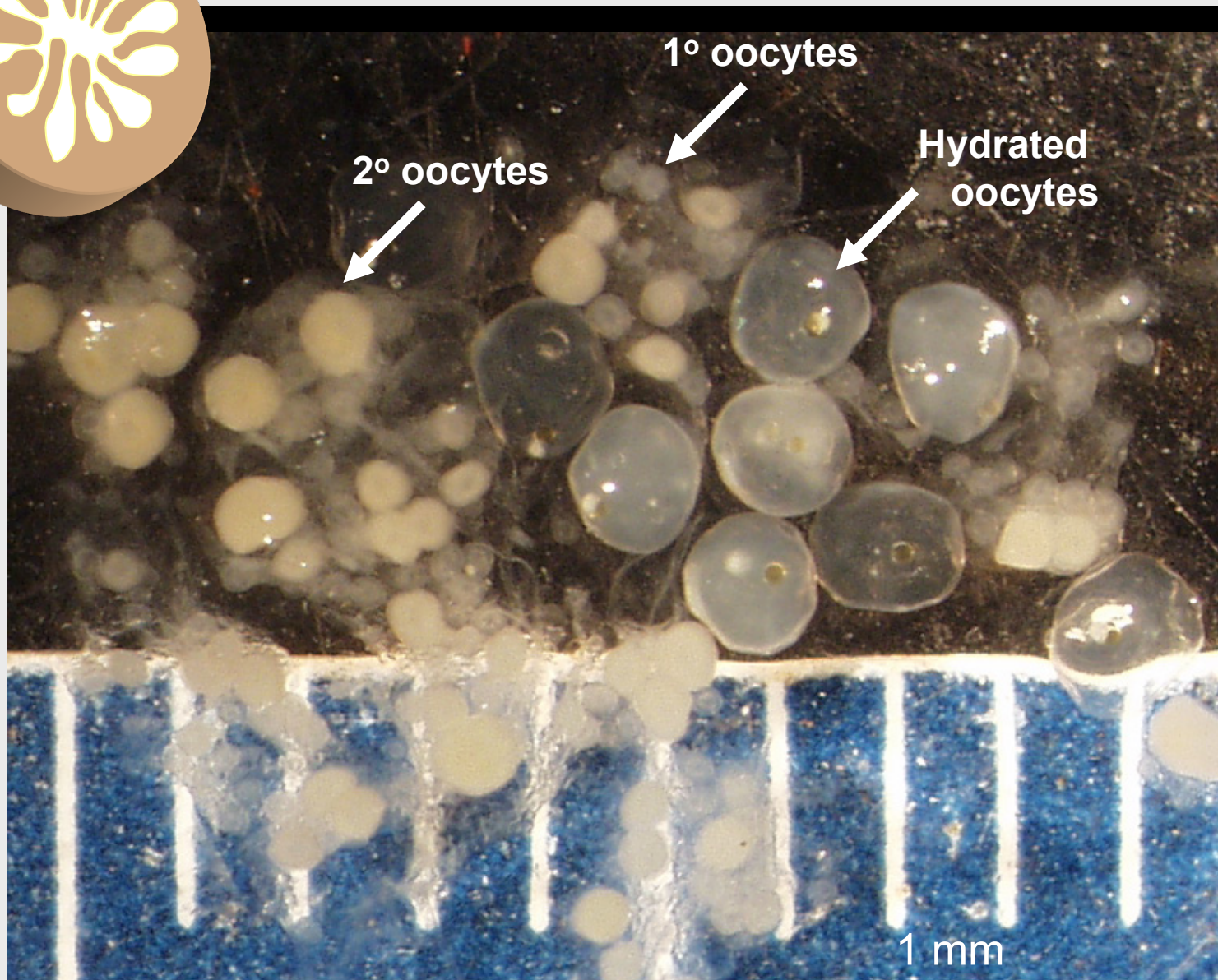


The amount of surplus energy diverted to reproduction (=reproductive potential) may not be obvious (i.e., eggs and sperm are lost from the individual)

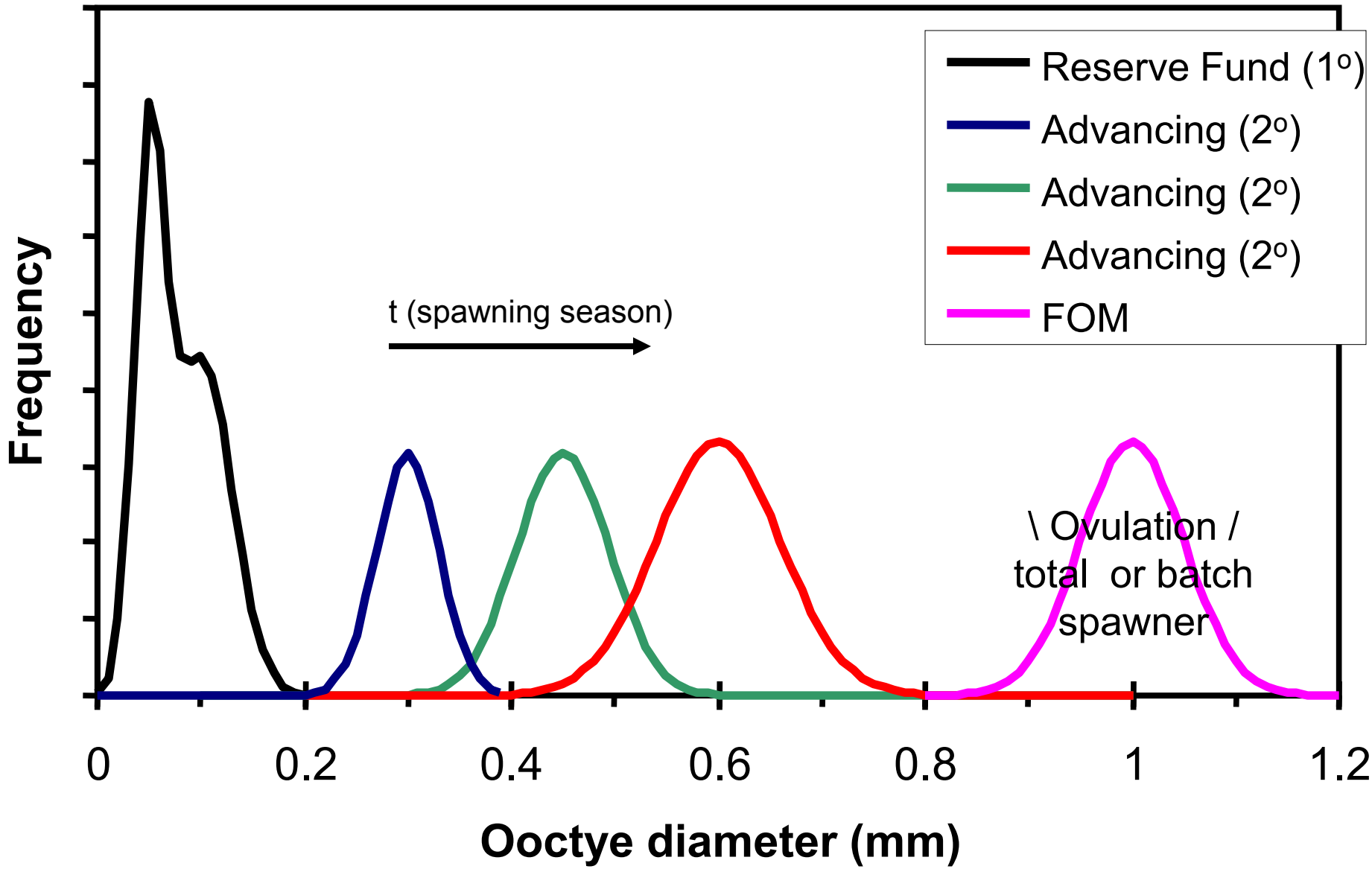
So, what's under the hood?

Ovary: female gonad, a hollow organ
Oocyte: female germ cell, a developing egg

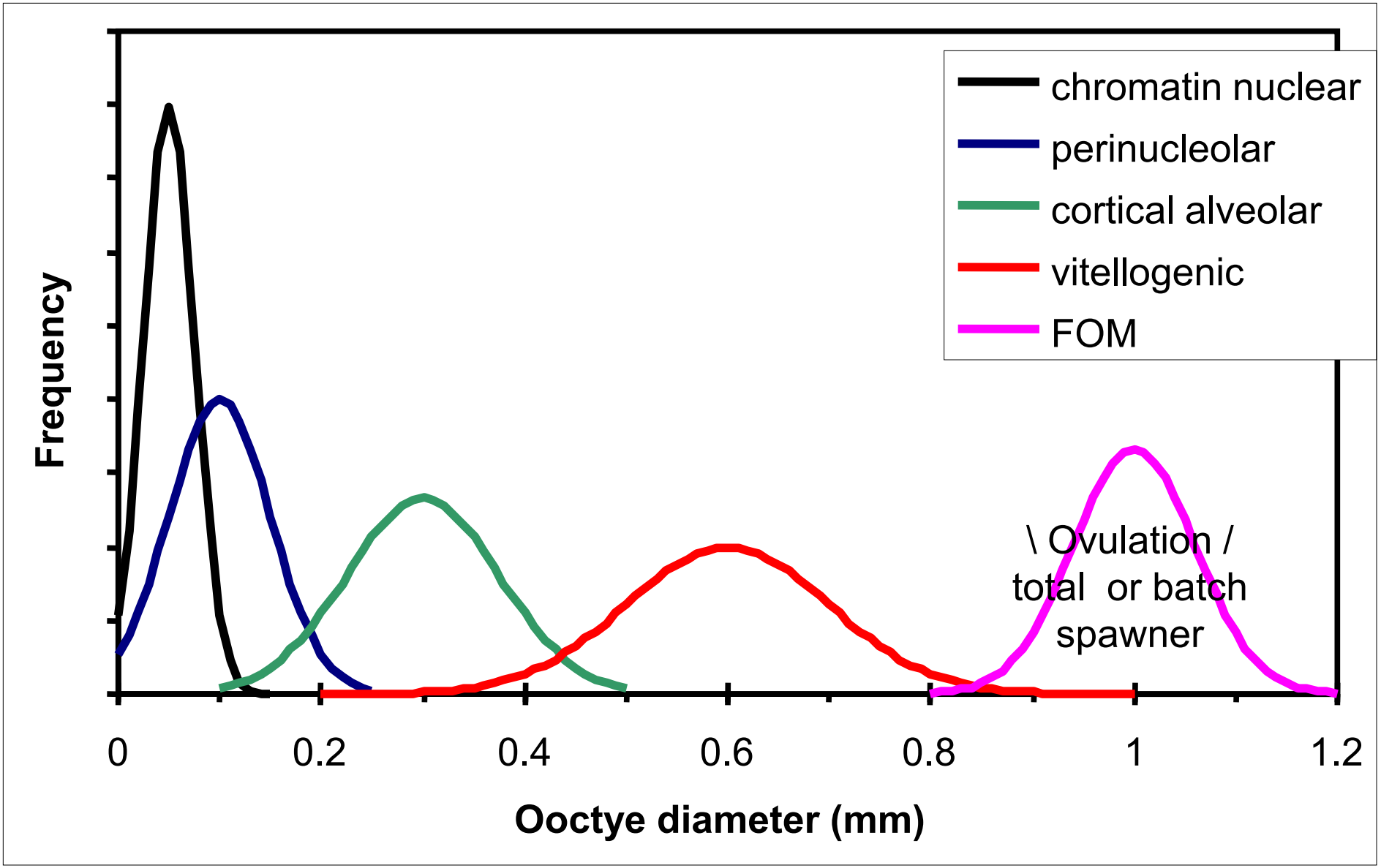




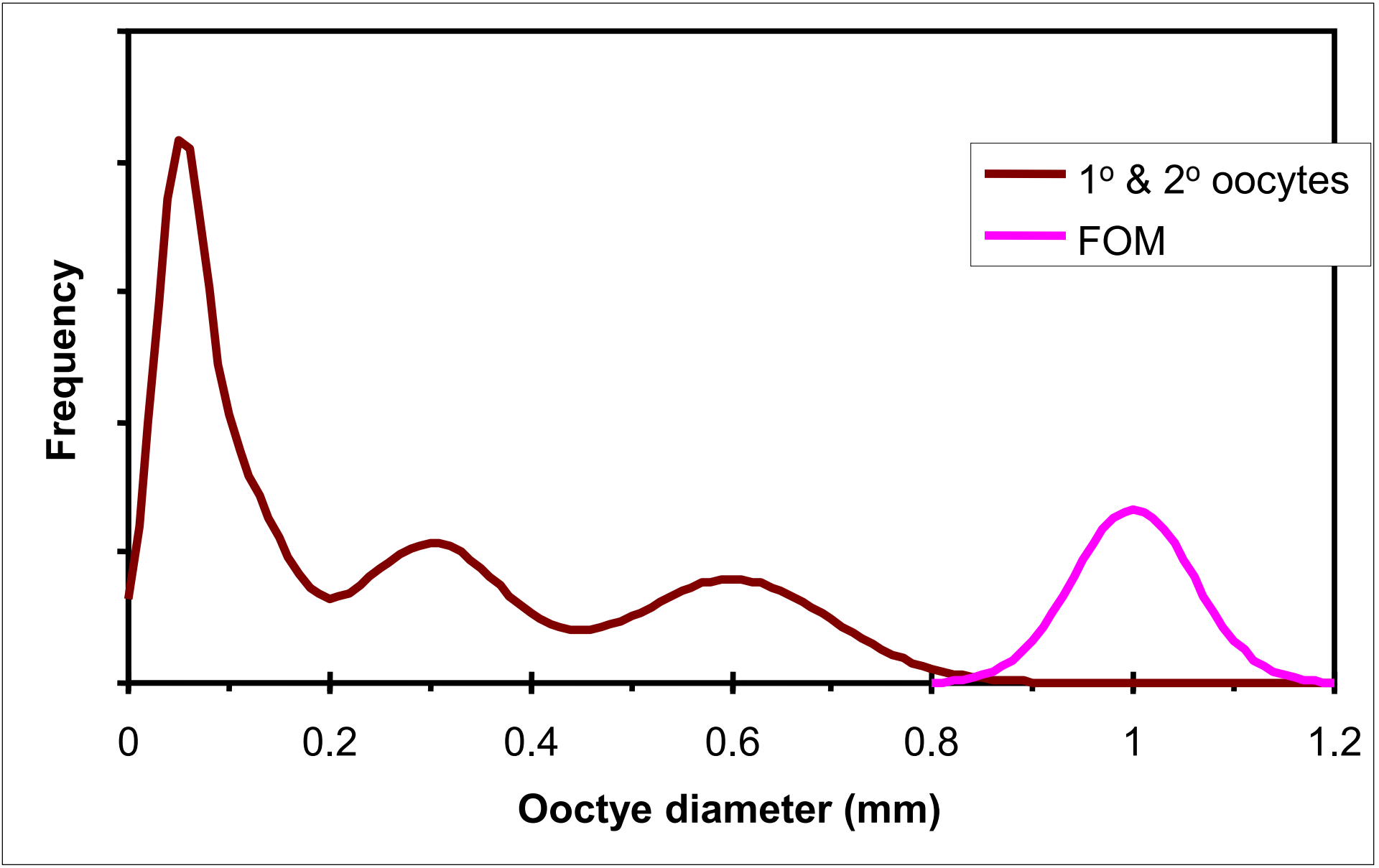
Group synchronous development (relative to recruitment to 2º oocyte stages)

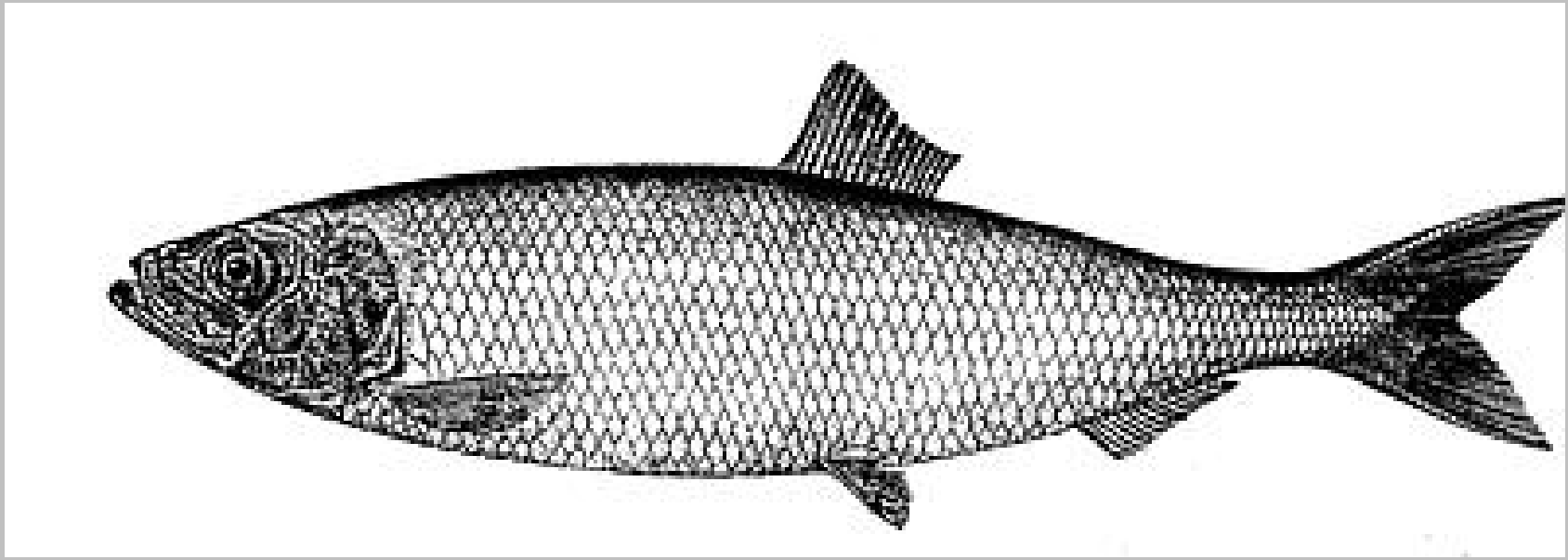


Asynchronous development (relative to recruitment to 2º oocyte stages)

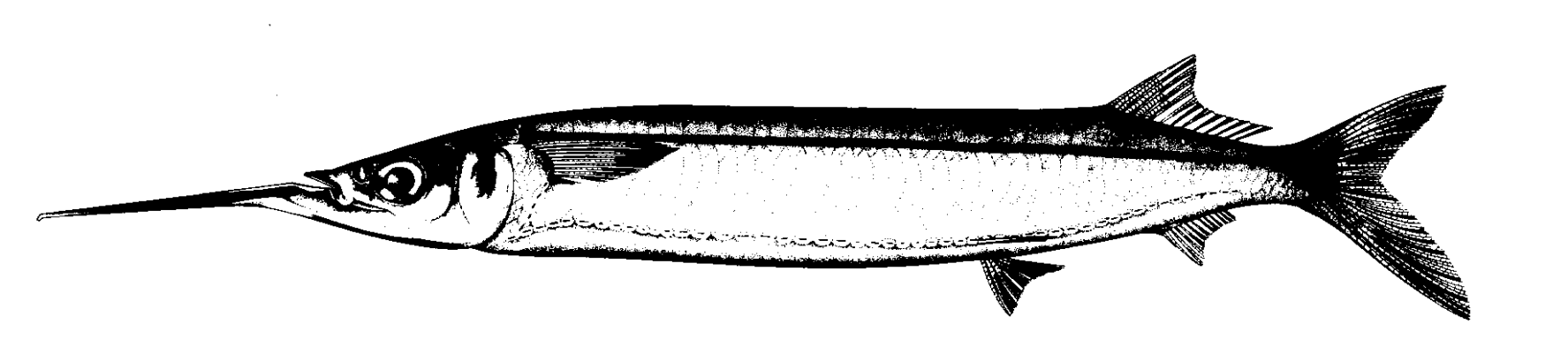


Asynchronous development (“What you see”)



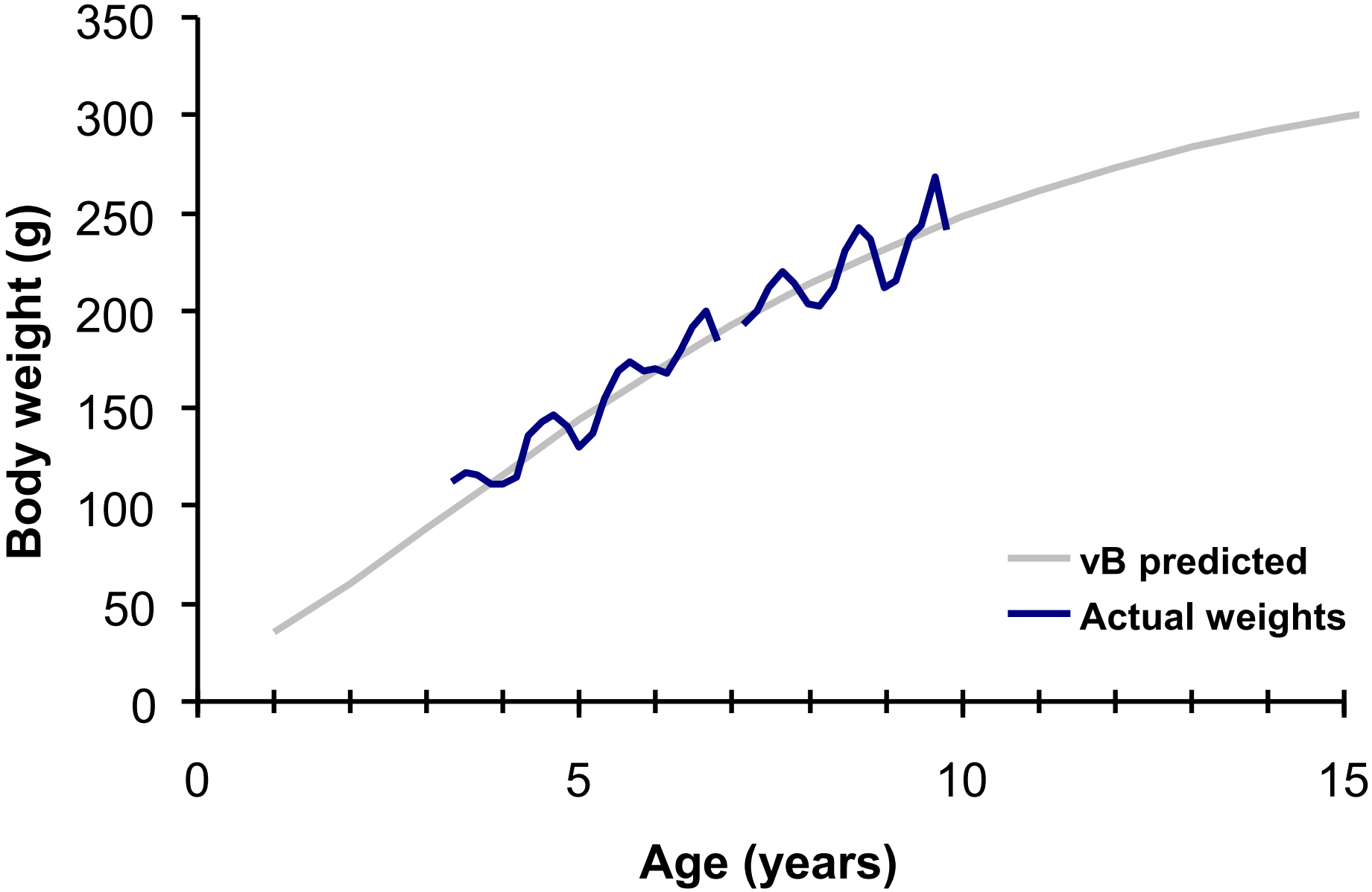


Atlantic herring, *Clupea harengus*



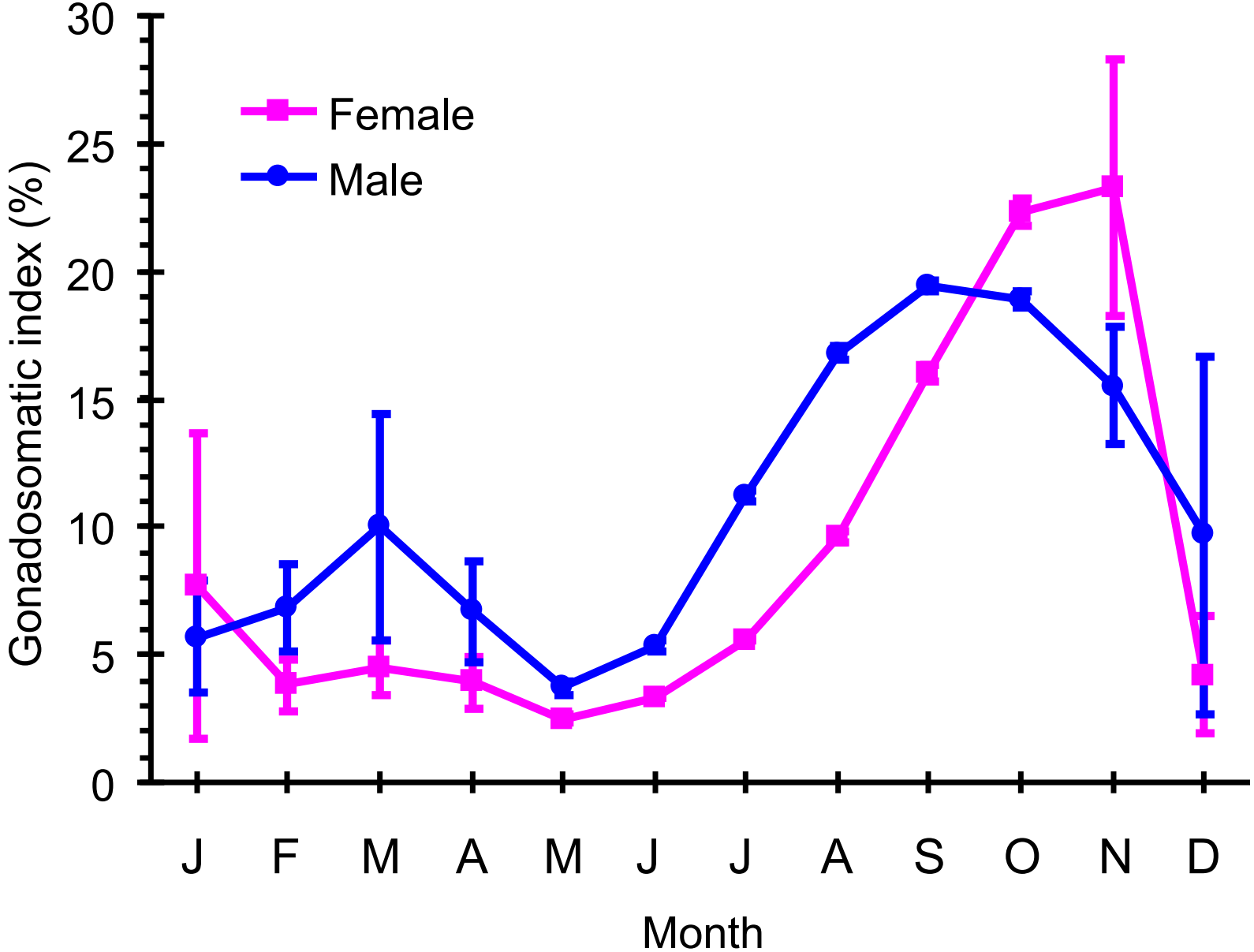
Ballyhoo, *Hemiramphus brasiliensis*

Atlantic herring (*Clupea harengus*) – Maine Commercial Catch



M. Cieri, unpublished

Atlantic herring (*Clupea harengus*) – Maine Commercial Catch



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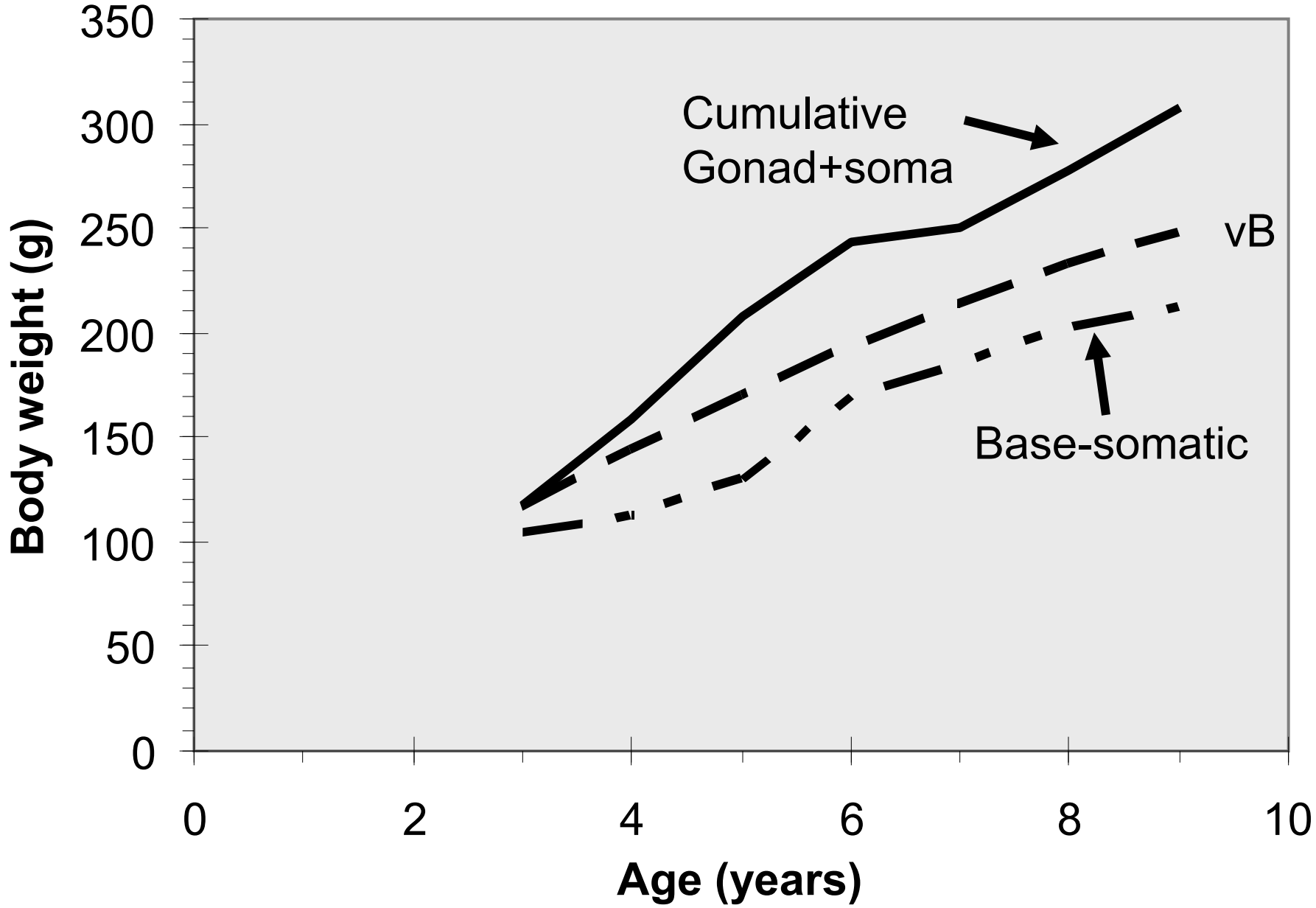
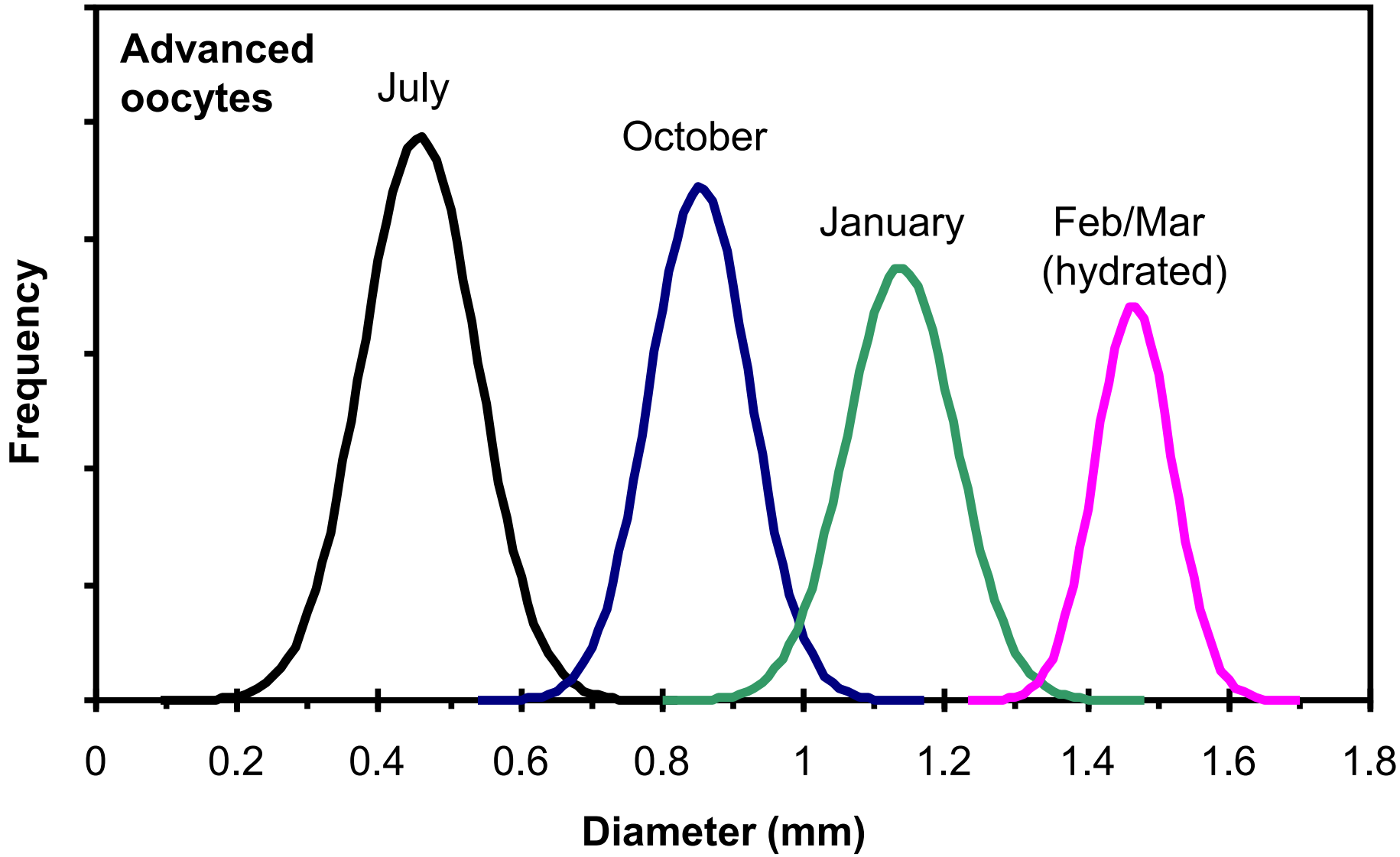
Atlantic herring (*Clupea harengus*) – Maine Commercial Catch



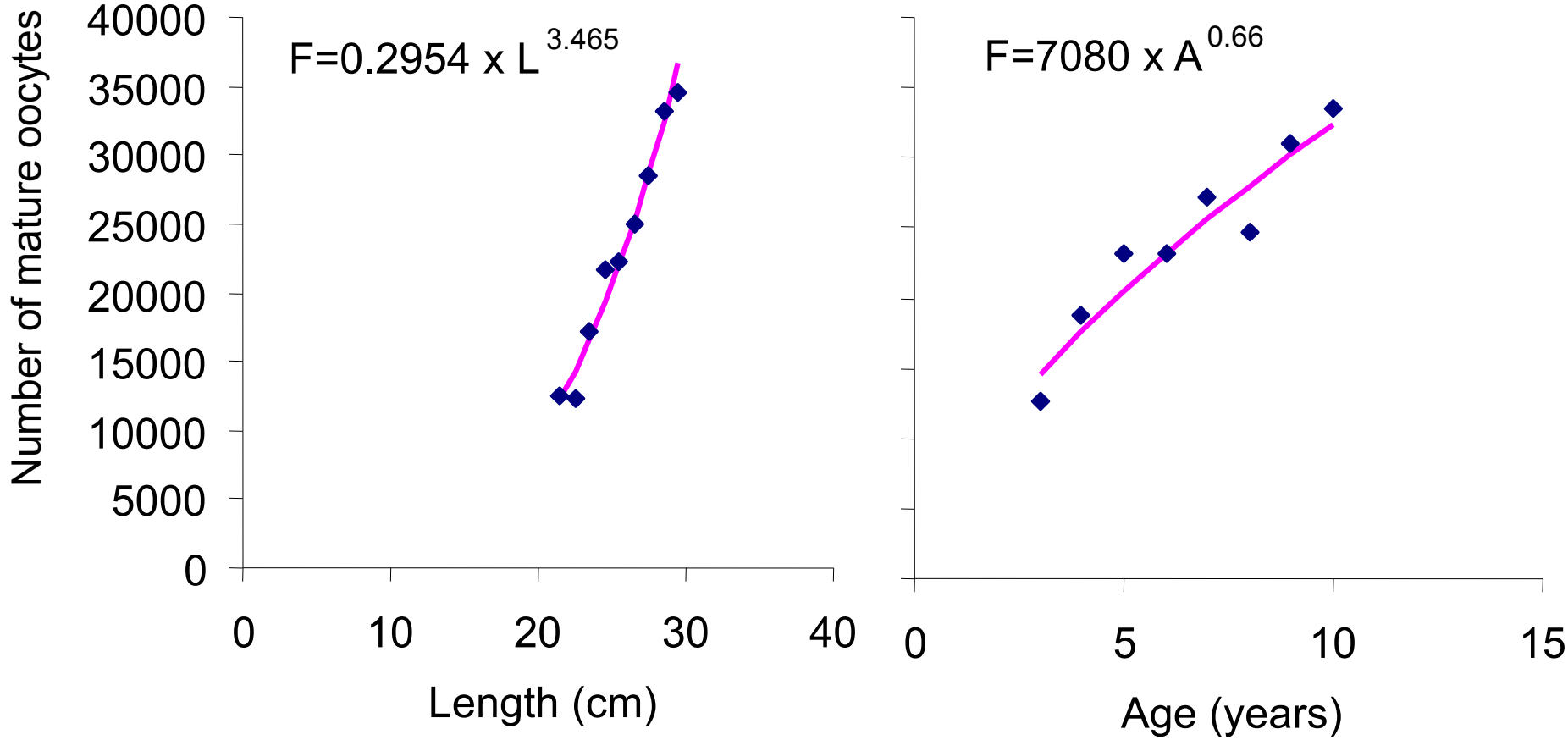
M. Cieri, unpublished

Atlantic herring (*Clupea harengus*) – Norwegian spring-spawners
Show group synchronous oocyte development



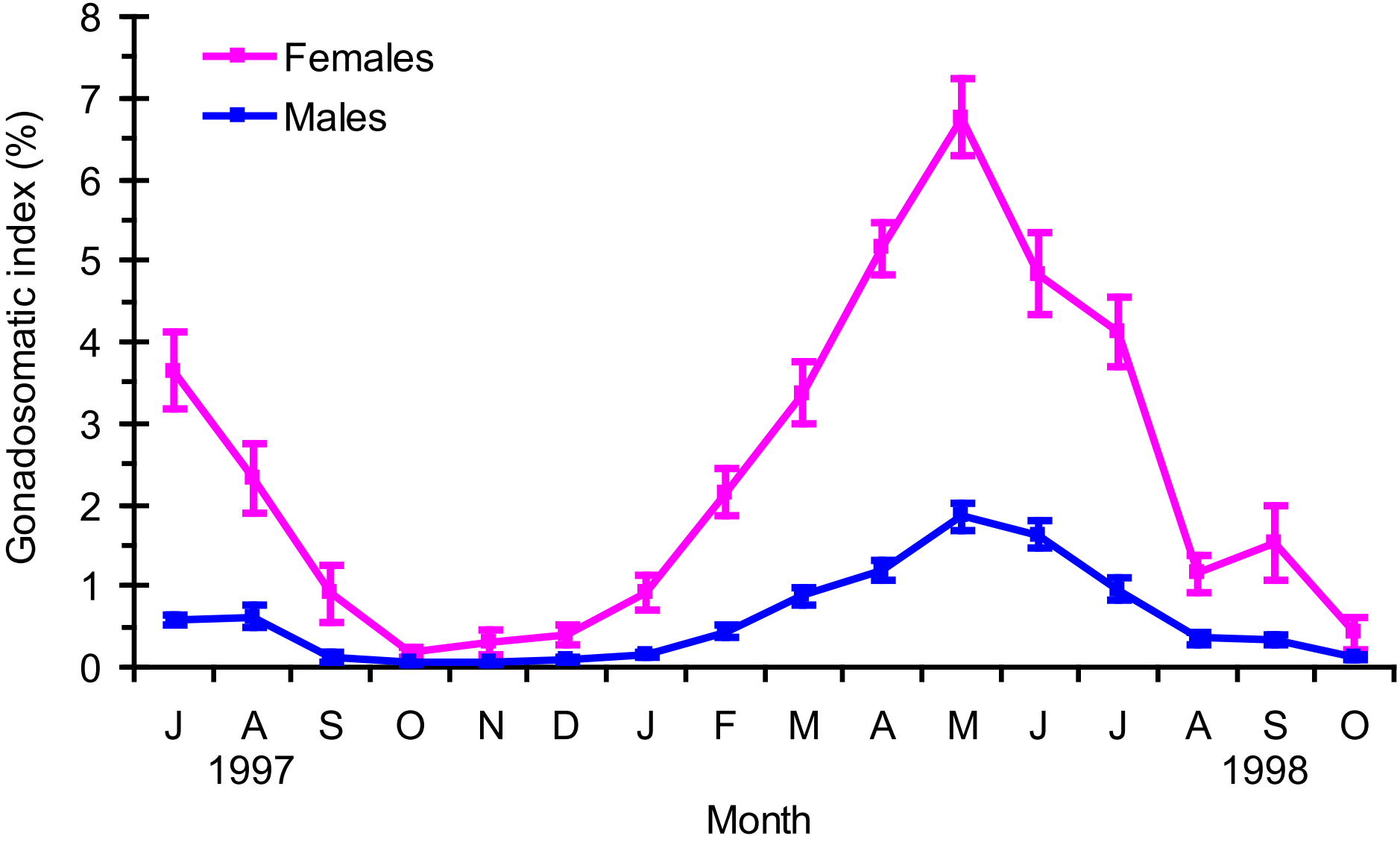
Data source: Kurita et al (2003)

Atlantic herring, *Clupea harengus* – North Sea

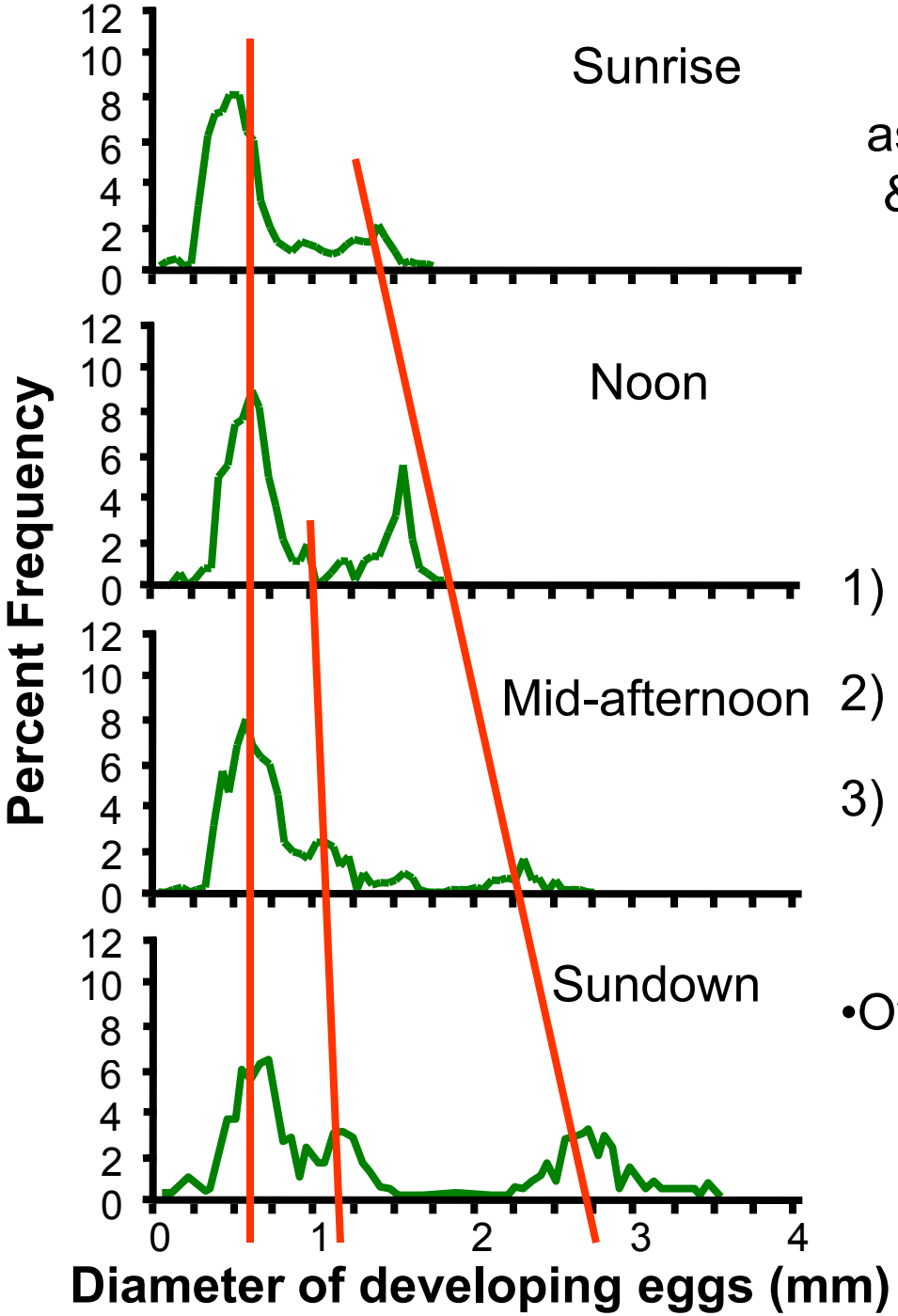


Data source: Hickling (1940)

Ballyhoo (*Hemiramphus brasiliensis*) -- Florida Commerical Catch



McBride et al. (2003)



Ballyhoo show
asynchronous oocyte development
& spawn daily during the summer

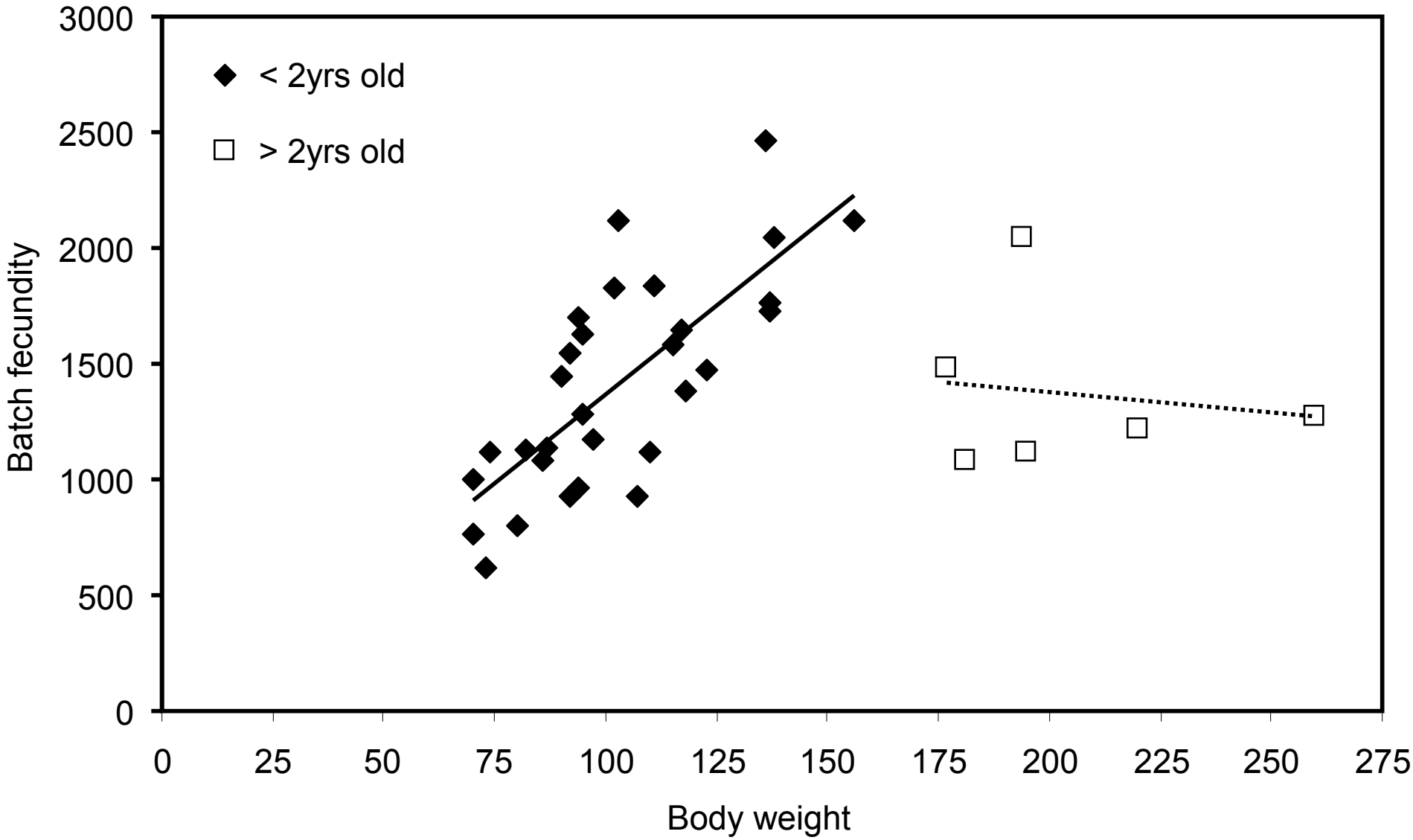
1) reservoir of 1º and 2º oocytes

2) a batch of oocytes matures

3) this batch completes hydration

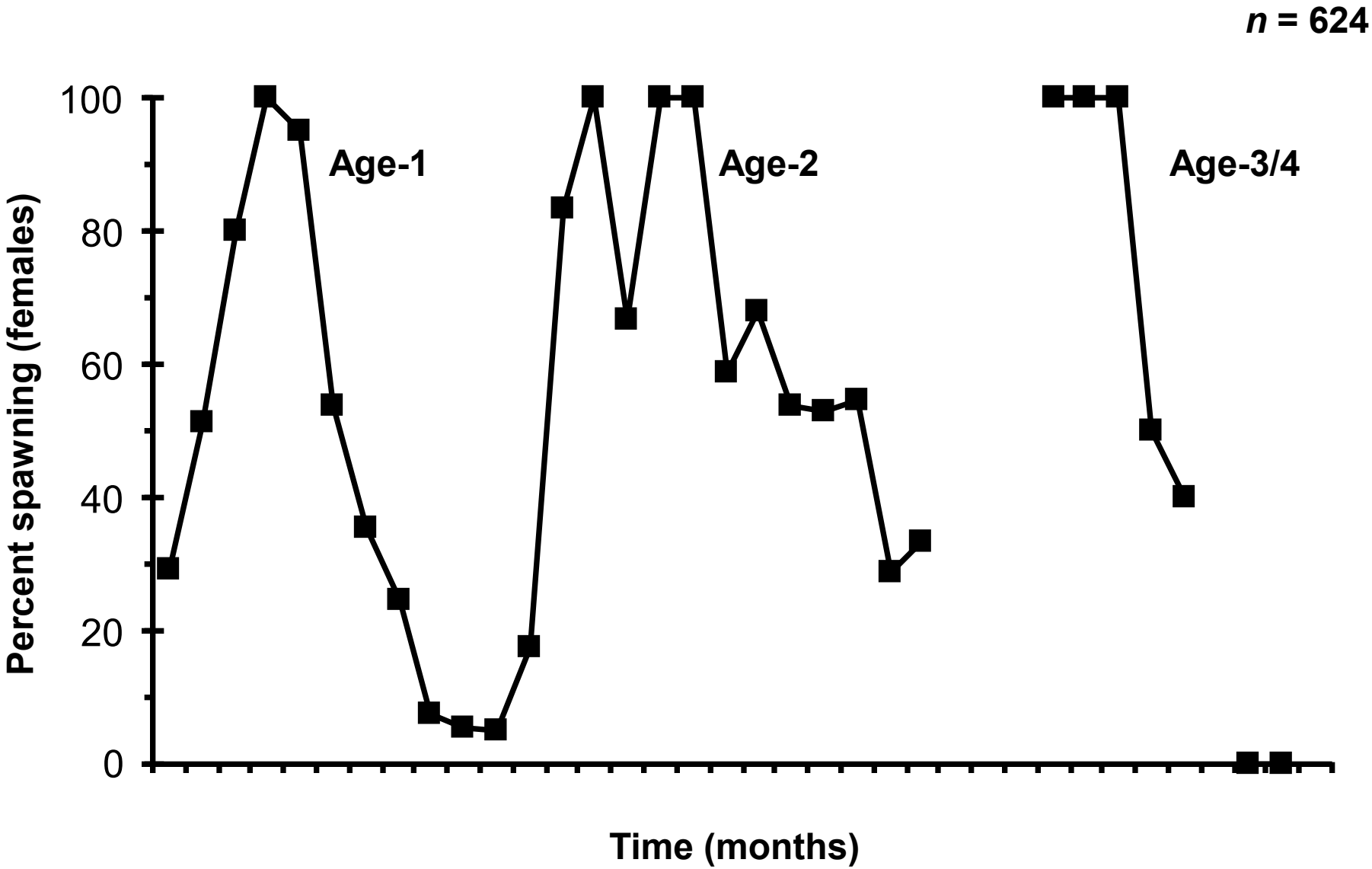
•Ovulation occurs at sundown

Ballyhoo (*Hemiramphus brasiliensis*) -- Florida Commerical Catch

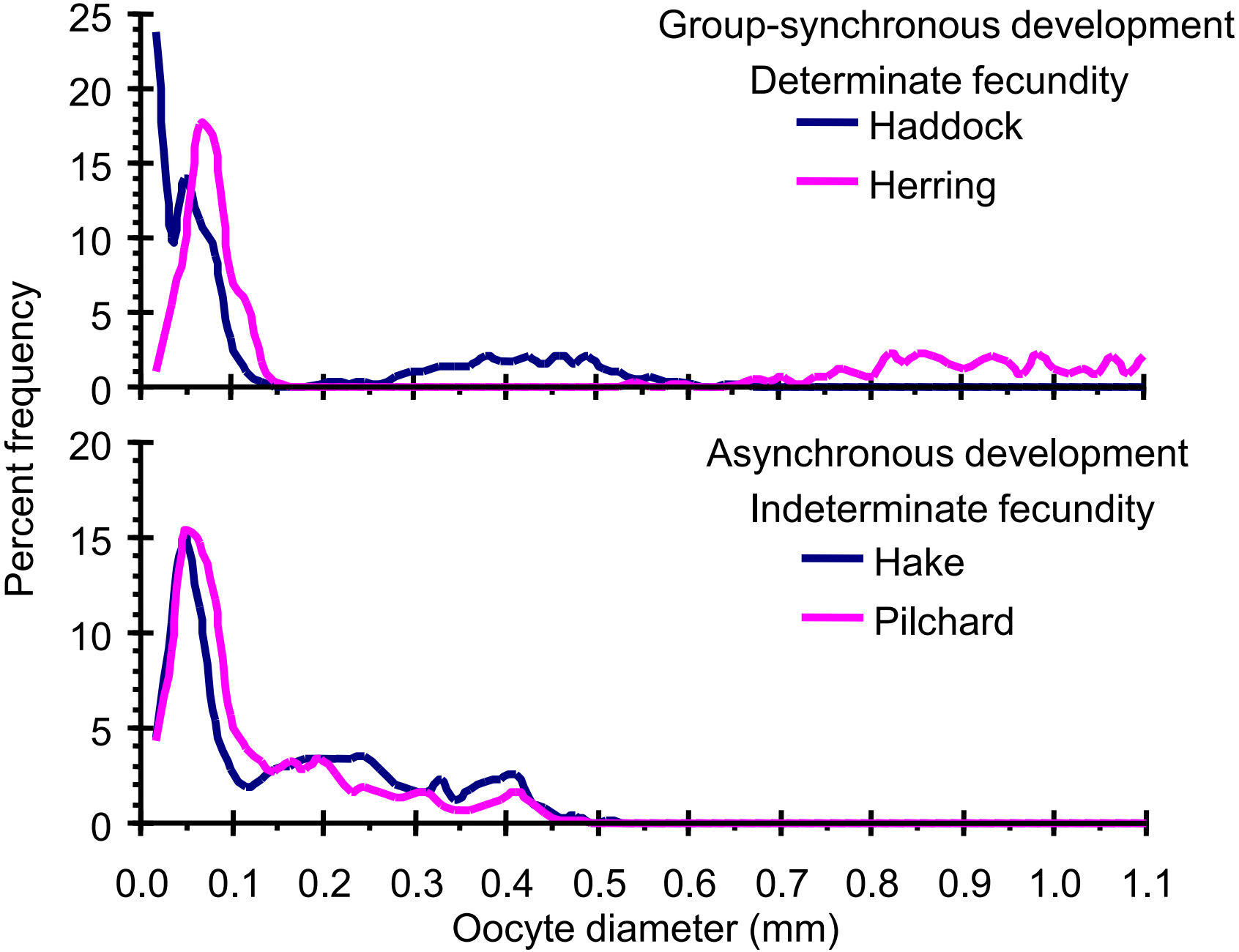


Berkeley and Houde (1978)

Ballyhoo (*Hemiramphus brasiliensis*) -- Florida Commerical Catch



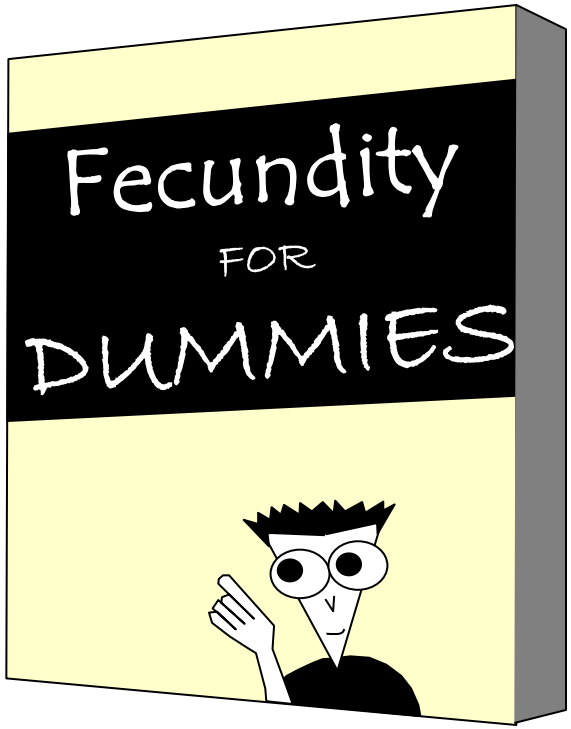
McBride and Thurman (2003)



Data source: Hickling and Rutenberg, 1936

Calculating annual fecundity

Type of oocyte development dictates how to measure fecundity



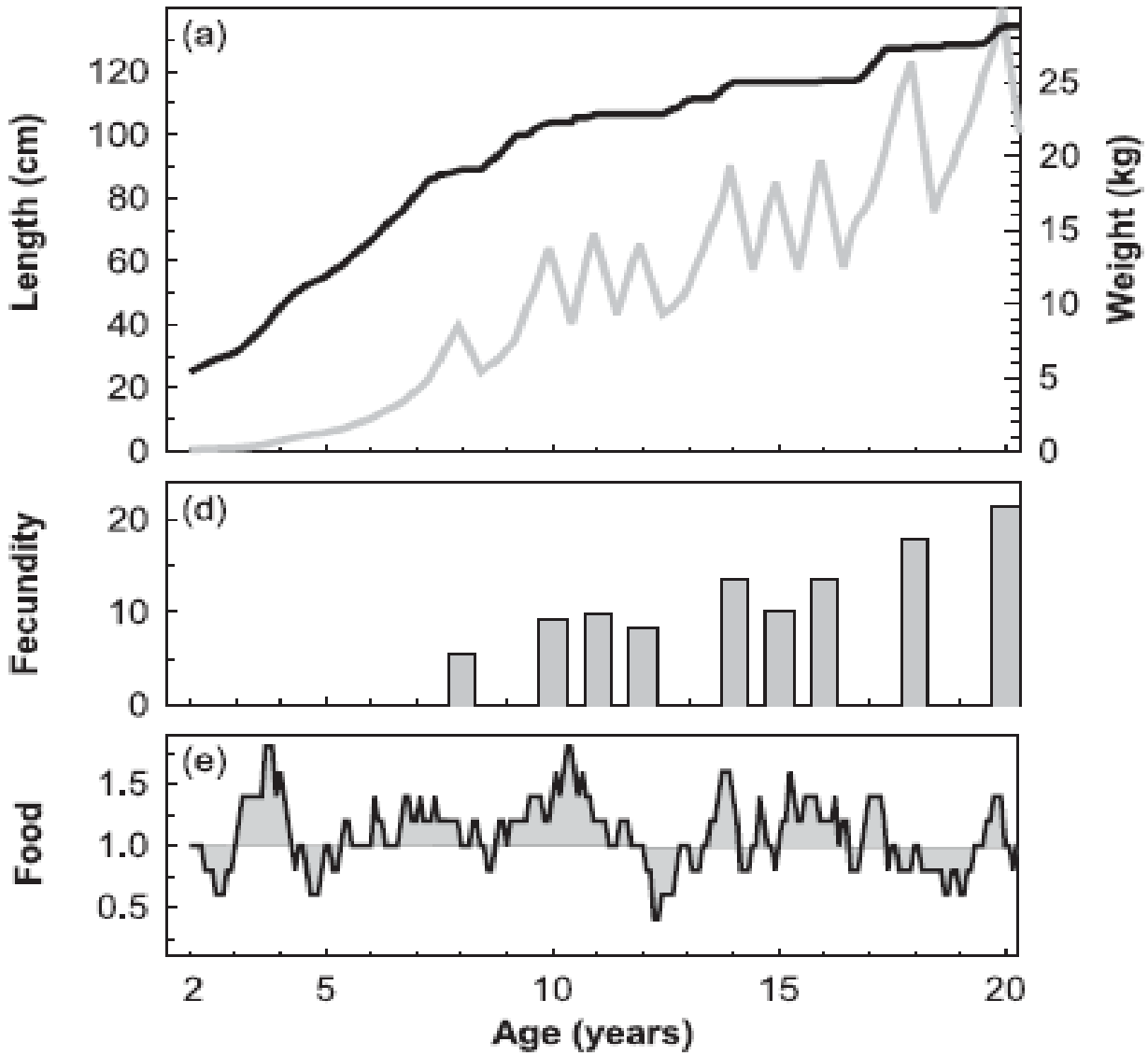
<u>1) Determinate (group synch. oocyte development)</u>

total # advanced yolked oocytes – atretic losses

<u>2) Indeterminate (asynchronous oocyte development)</u>

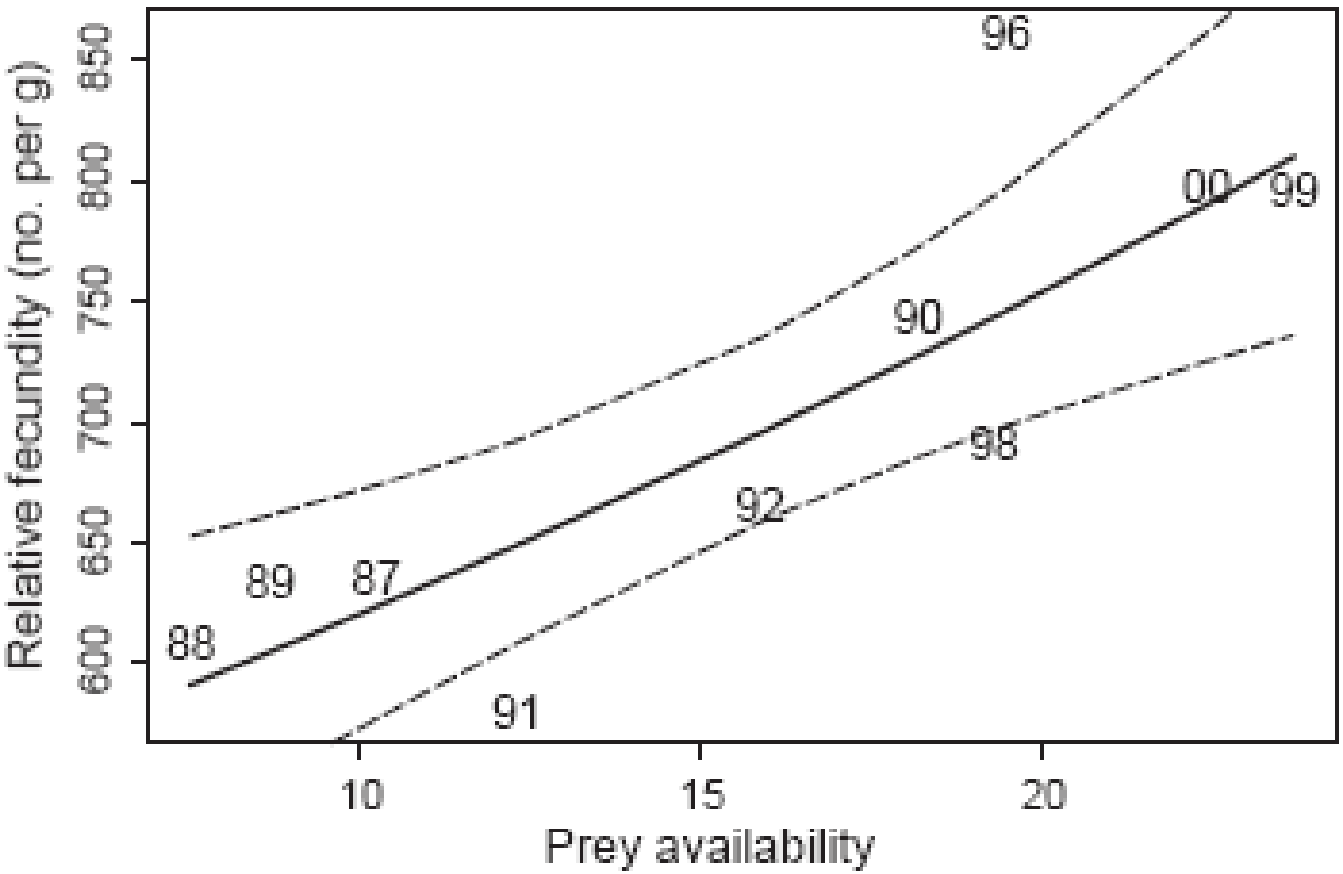
batch fecundity X number of spawns /year

Simulated growth of an individual (female) Northeast Arctic cod (*Gadus morhua*)
Length, weight, and fecundity in response to feeding conditions
Skip spawning in 4 of 13 mature years



Jørgensen, C. and Ø. Fiksen (2006).

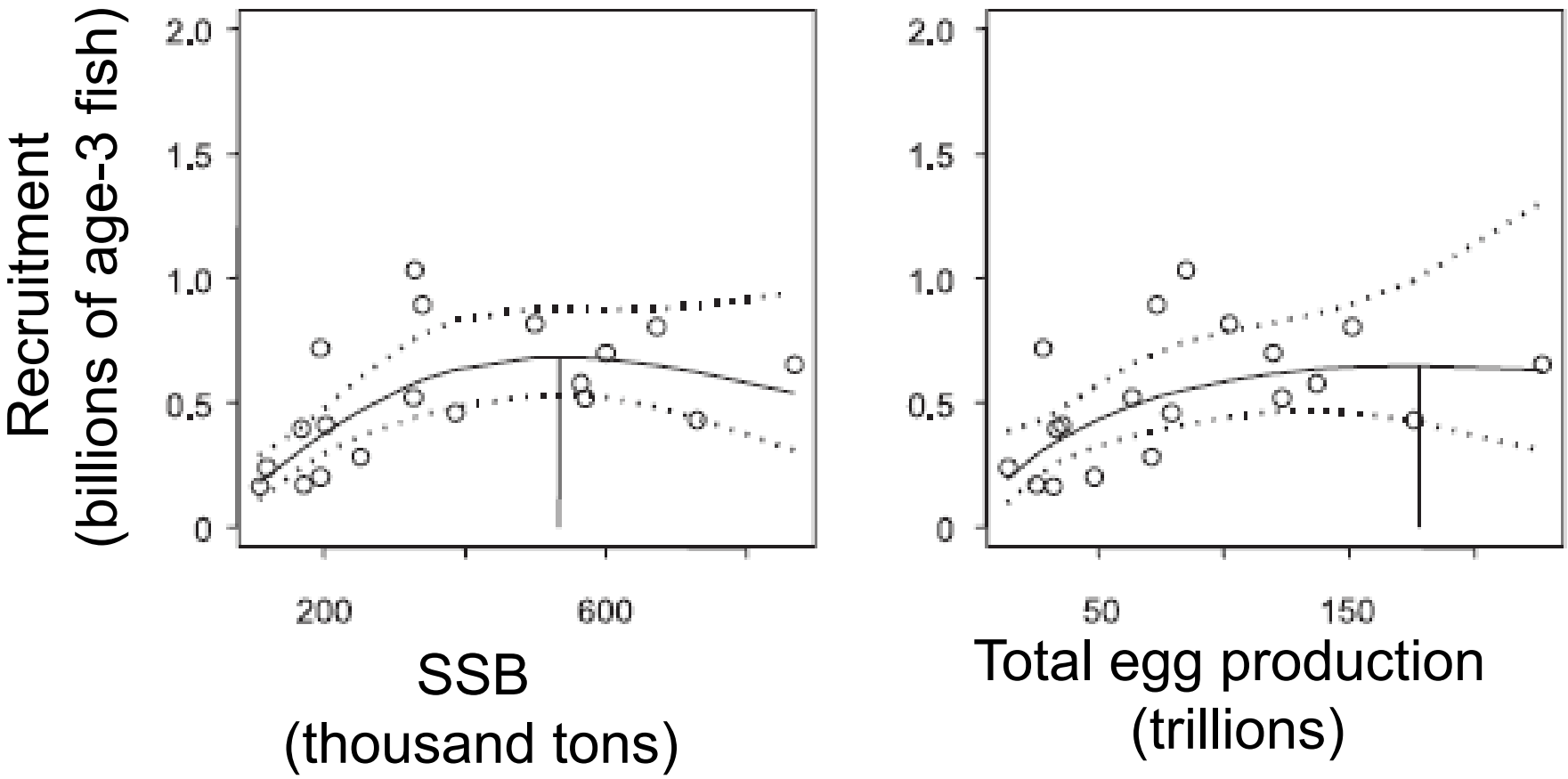
Baltic cod (*Gadus morhua*) fecundity
In relation to prey (sprat and herring) forage



- Relative fecundity (R_f) is variable (e.g., between years).
- This invalidates SBB = reproductive potential
- R_f may be set well ahead of the spawning season.

Marshall et al. (2003).

NE Arctic cod (*Gadus morhua*)
Recent, lower abundance (1980-1998)

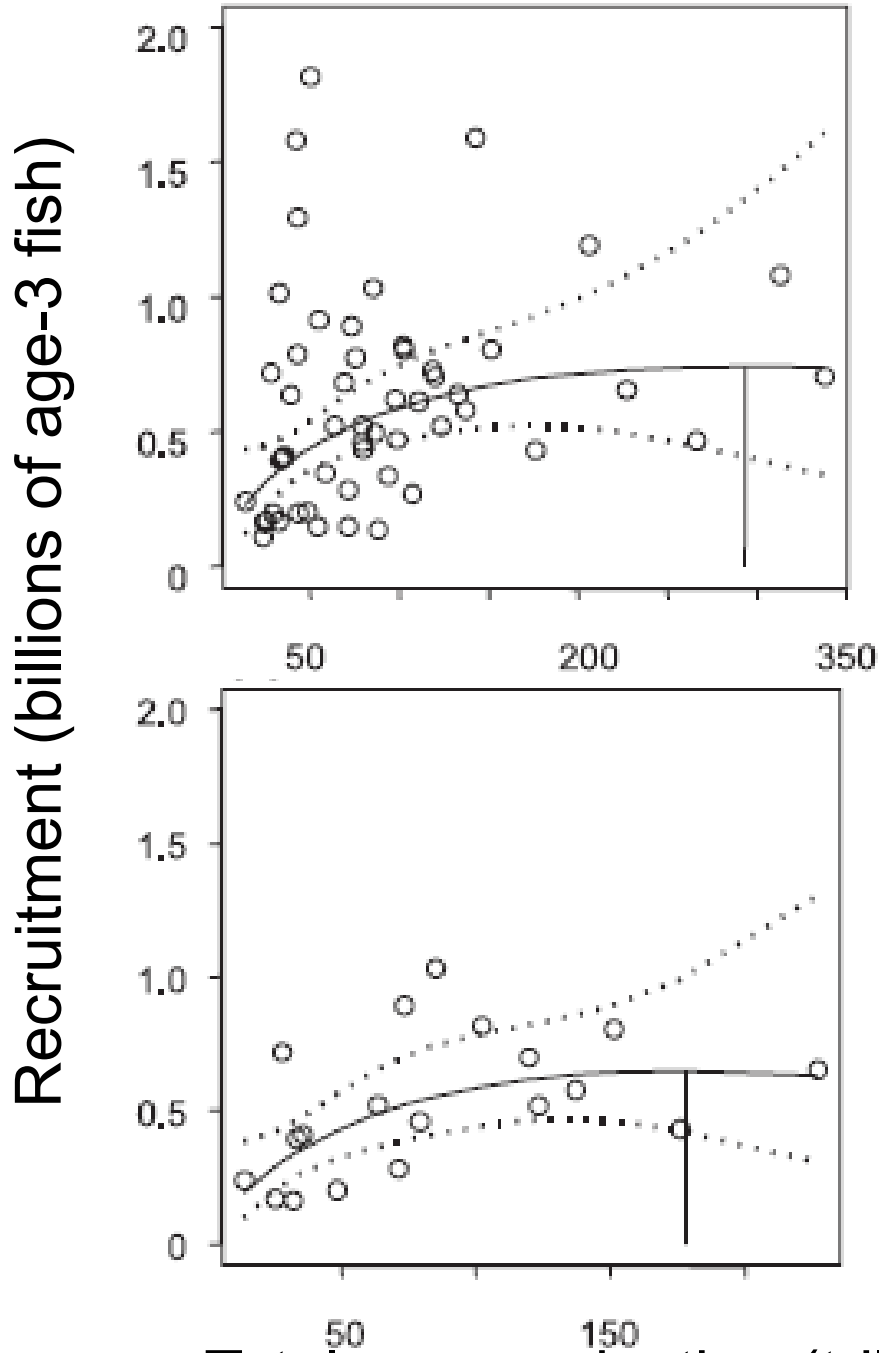


*depensatory

*overcompensatory

Marshall et al. (2006)

NE Arctic cod (*Gadus morhua*)



Full time series
1946-1998

Recent, lower abundance
1980-1998

Marshall et al. (2006)

Fini