Quantifying fitness in North Atlantic right whales

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Appropriately quantifying fitness is a crucial requirement for accurately identifying what factors are influencing the health of a population and the degree to which they are doing so. Such information is particularly important for endangered species, where proper conservation initiatives cannot be implemented, or their effects monitored, until the limiting factors have been identified and their effects quantified. Fitness can be broken down into two components: survival and reproductive success. In many short-lived species survival is often quantified as the number of years an individual was alive and reproductive fitness quantified as lifetime breeding success (LBS). However, such metrics are not possible for long-lived species, where many individuals survive and reproduce for longer than the study period. Moreover, individual effects can be masked by larger ecological changes that affect the population as a whole. A method for quantifying individual fitness that overcomes these obstacles is called the "de-lifing" approach, which quantifies the relative contribution of each individual to overall population growth (via surviving and/or reproducing) in each year. This value can then be summed across the desired number of years for each individual. We have implemented this calculation for North Atlantic right whales and show that it appropriately captures patterns in survival and reproductive success. We propose that this approach could be a very useful tool for testing hypotheses regarding factors impacting individual survival and reproductive success in this species, and for monitoring any changes therein over time.

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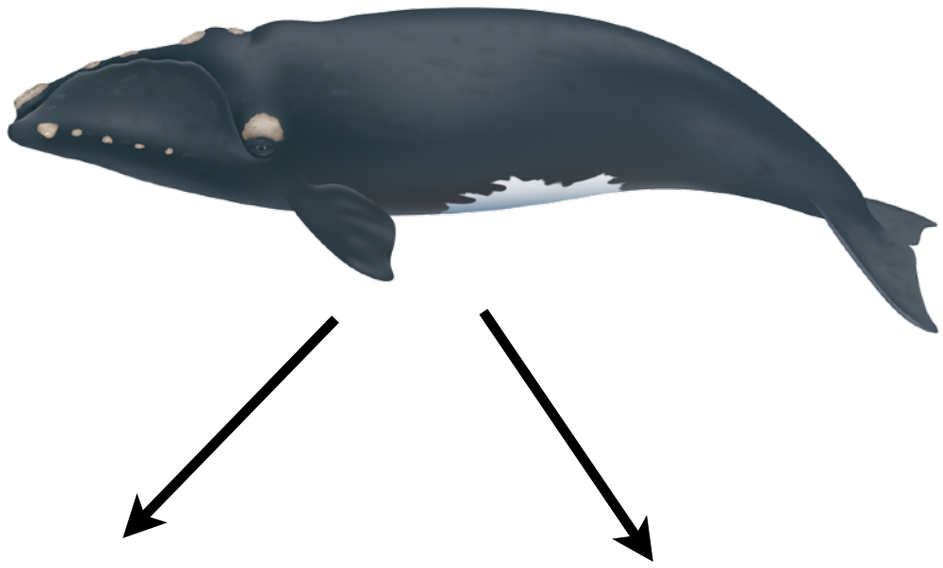
Tim Frasier[1], **Sonya Radvan**[1], Philip Hamilton[2], Scott Kraus[2]

1. Saint Mary's University

2. Anderson Cabot Center for Ocean Life at the New England Aquarium

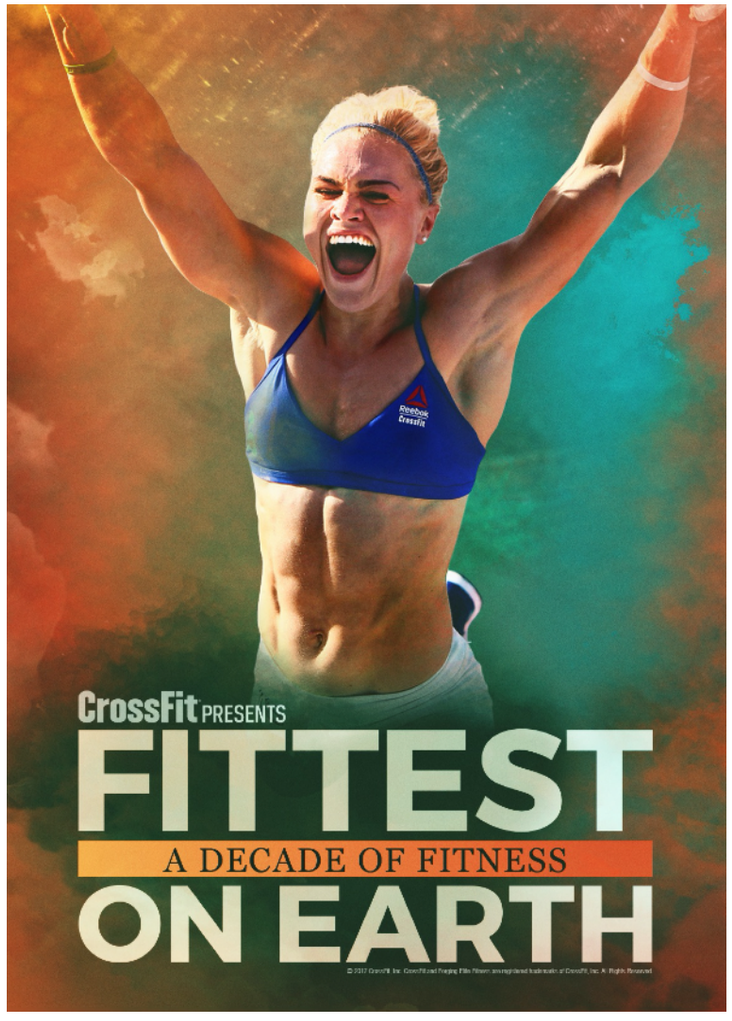
Evolutionary Fitness, Not Physical Fitness



Survival

Reproductive Success
(fecundity)

Not



Whale image used with permission from Uko Gorter

Why Quantify Individual Fitness?

1. Large-scale questions

- What factors are driving individual variation in survival and reproductive success, and to what degree?
  - It is the sum of these individual effects that drive population trends

2. Shorter-term questions

- What factors are changing individual survival and reproductive success over time, and to what degree?
  - Fitness pre- *vs* post-entanglement/ship strike

Problems Quantifying Individual Fitness?

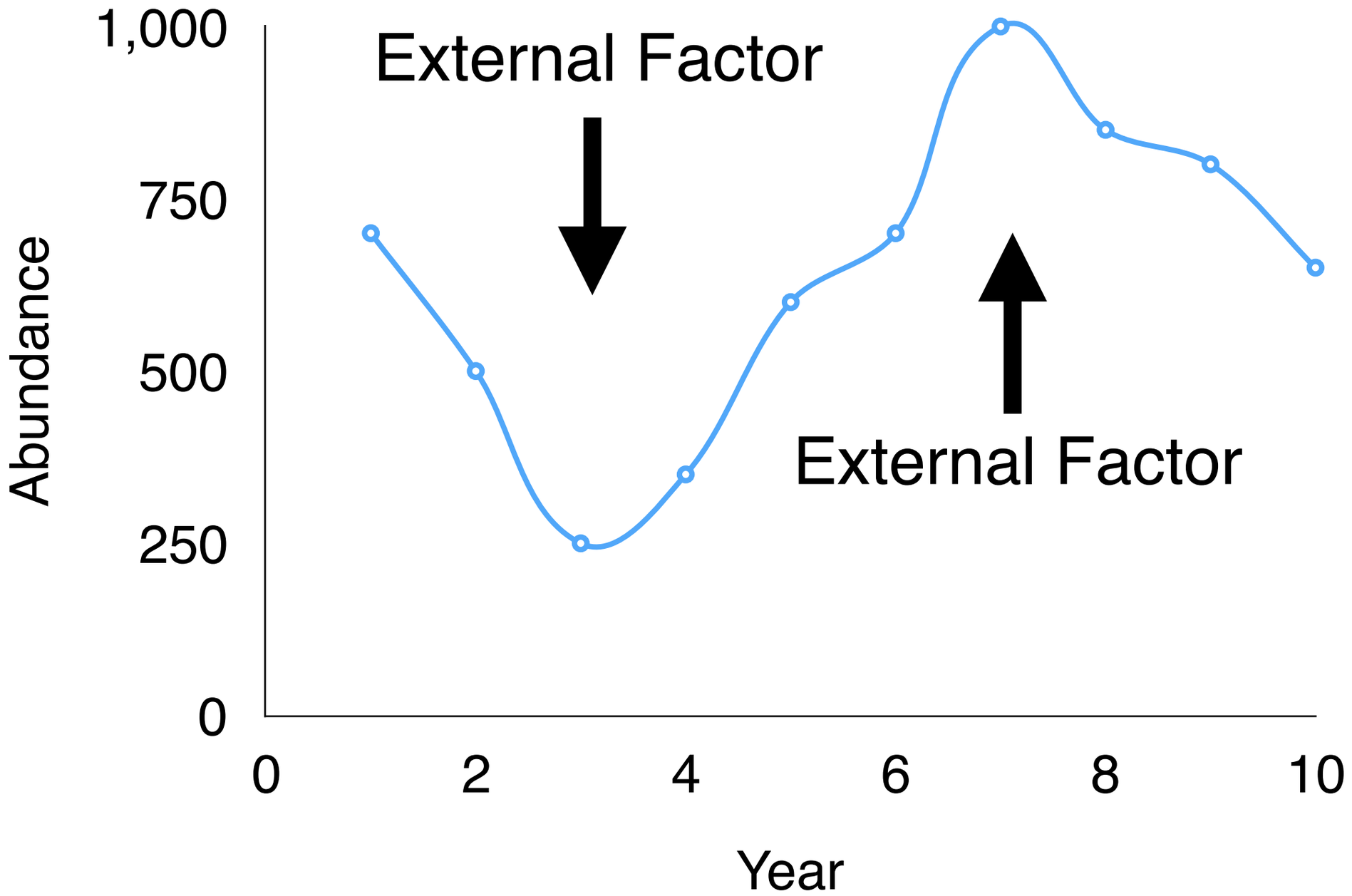
1. When study organisms live longer than you do
    - Otherwise use Lifetime Breeding Success (LBS), and survival

Problems Quantifying Individual Fitness?

1. When study organisms live longer than you do
   - Otherwise use Lifetime Breeding Success (LBS), and survival

2. Individual effects may be masked by external factors driving population-wide trends

Problems Quantifying Individual Fitness?



"De-lifing" Method

PROCEEDINGS OF THE ROYAL SOCIETY B

Proc. R. Soc. B (2006) **273**, 547–555
doi:10.1098/rspb.2005.3357
Published online 6 December 2005

Estimating individual contributions to population growth: evolutionary fitness in ecological time

T. Coulson[1,*], T. G. Benton[2], P. Lundberg[3], S. R. X. Dall[4], B. E. Kendall[5] and J.-M. Gaillard[6]

“De-lifing” Method

Quantify each individual’s relative contribution to population growth for each year

1. Survival
2. Fecundity

Sum over the years of interest

"De-lifing" Method

ID	Alive $s_{t(i)}$	Offspring $f_{t(i)}$	Survival component $\frac{s_{t(i)} - \bar{s}_t}{N_t - 1}$	Fecundity component $\frac{f_{t(i)} - \bar{f}_t}{N_t - 1}$	Contribution to population growth $p_{t(i)}$
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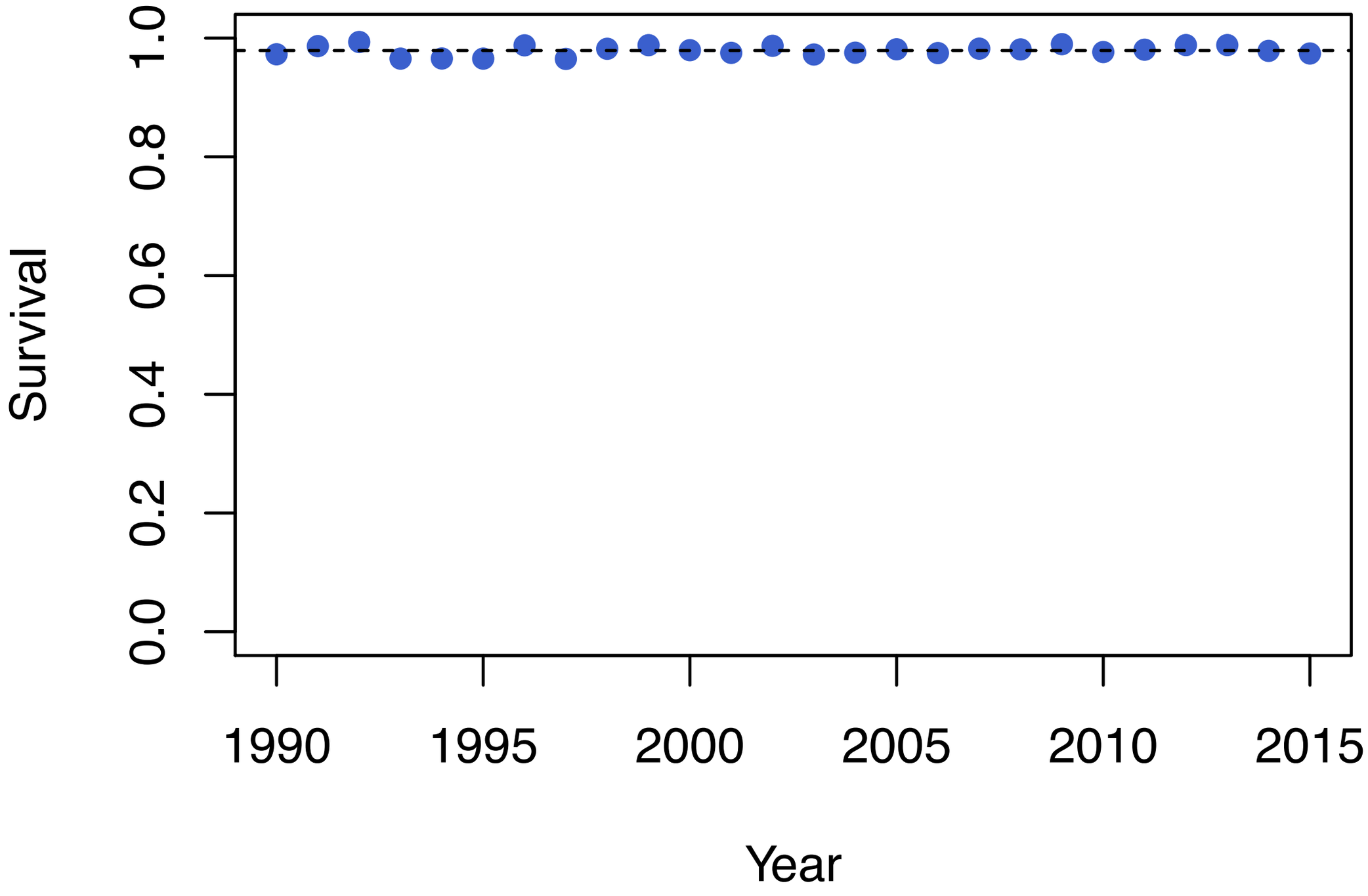
Mean Survival



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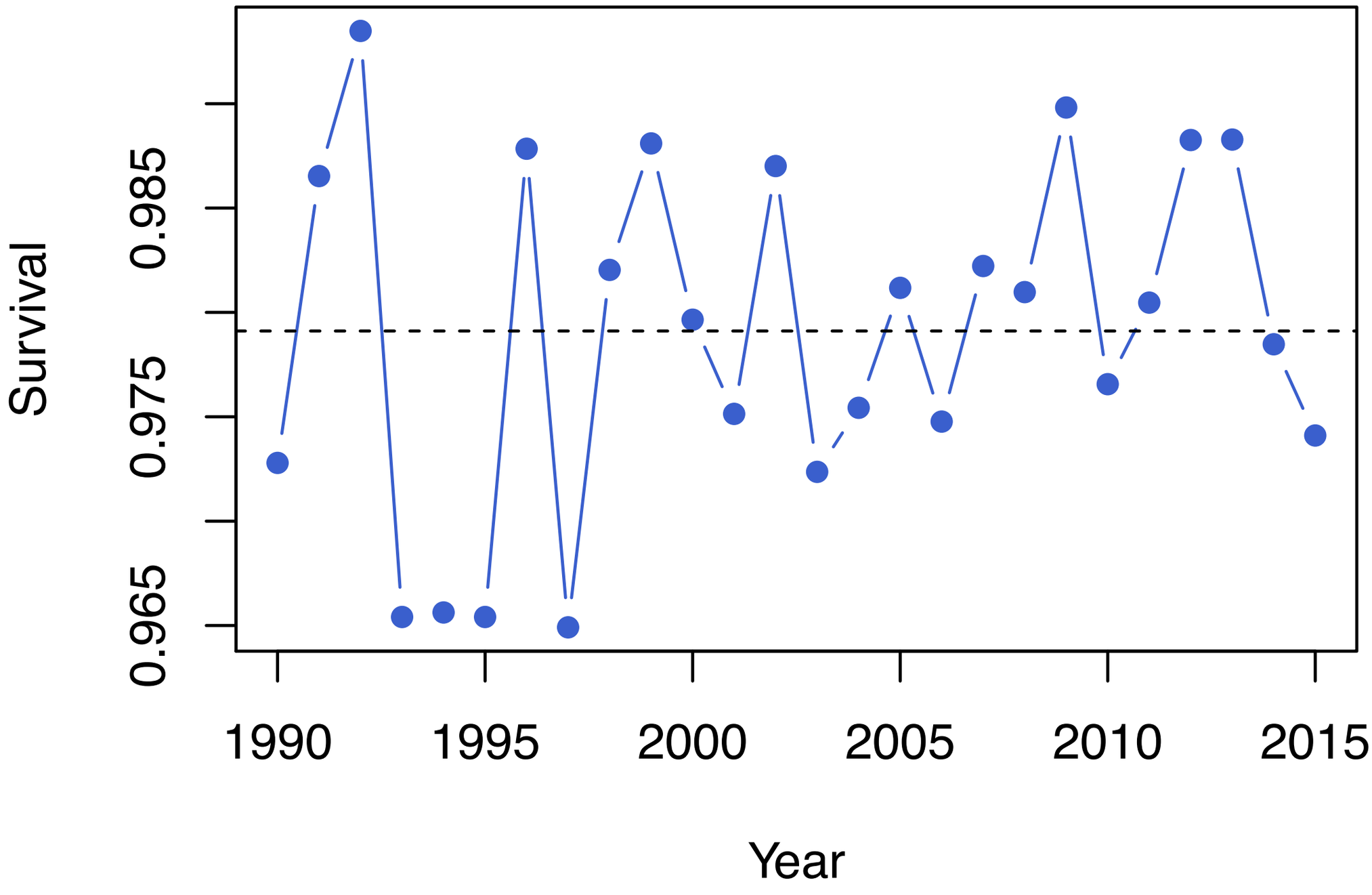
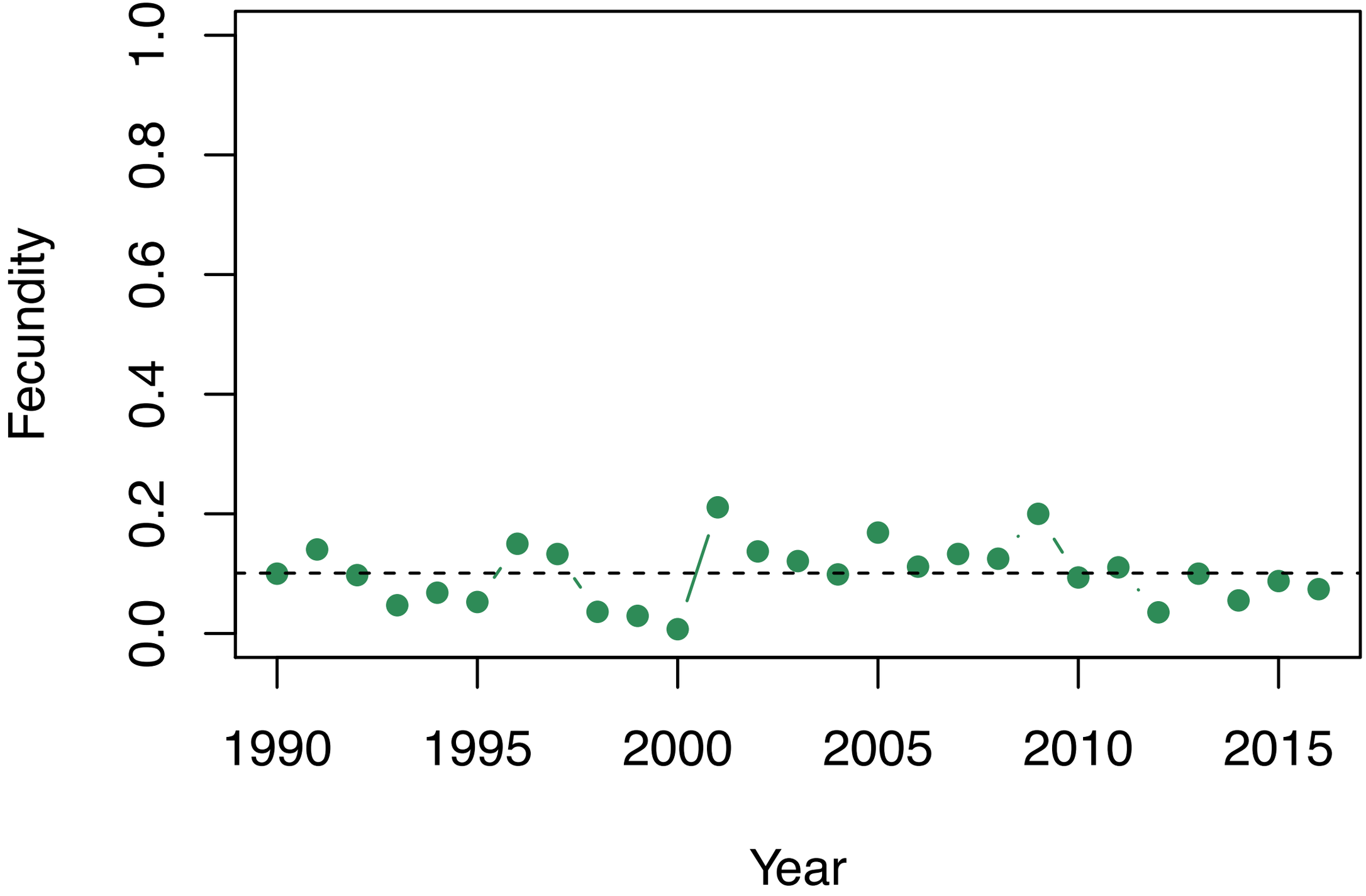


Mean Fecundity



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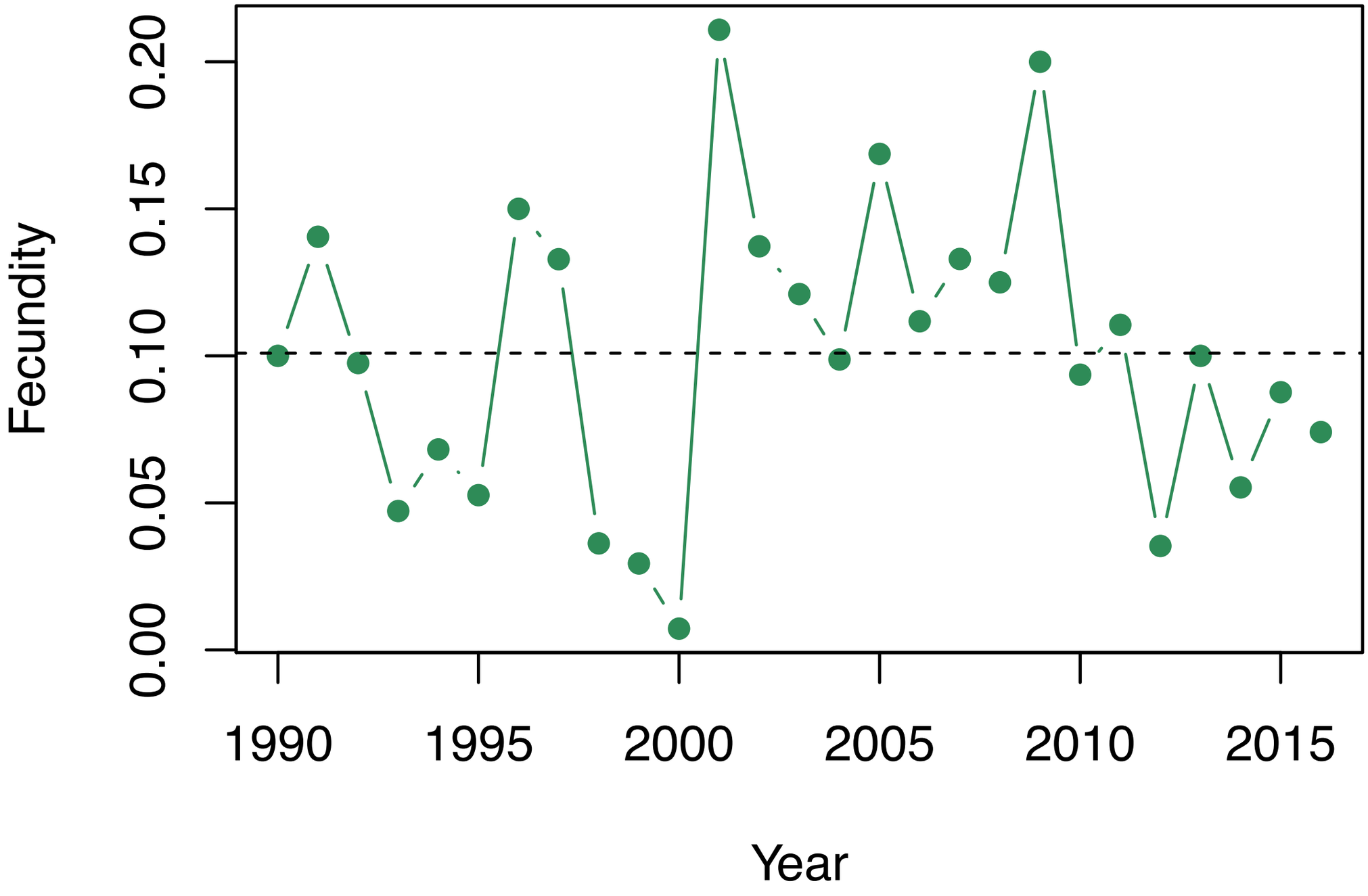


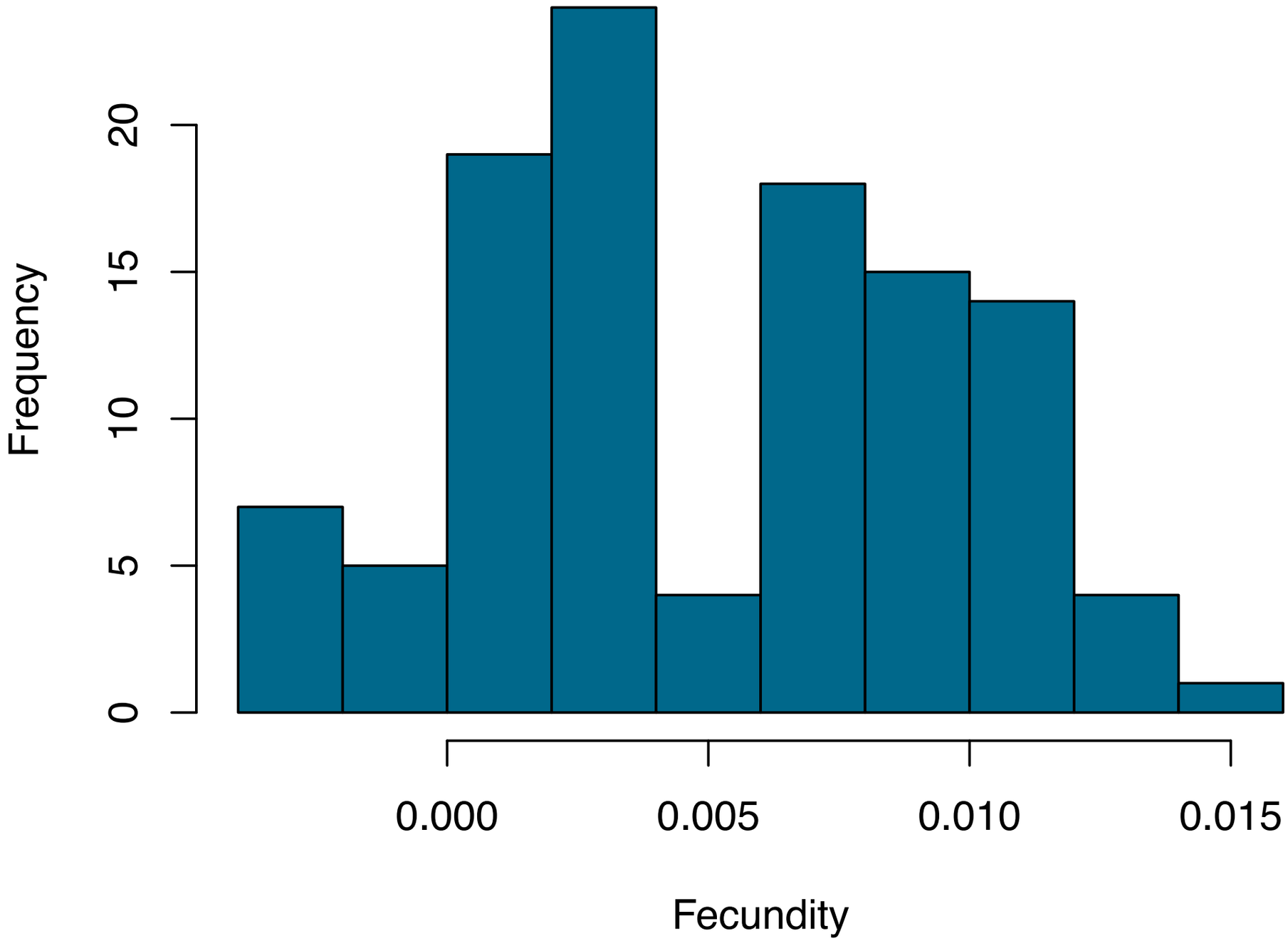
Mean Fecundity

1334
Fecundity "score" for reproducing in this year is 115% that of those who reproduced in 2001

Photograph provided by P. Hamilton & NEAq

Individual Fecundities

Females adult > 10 years



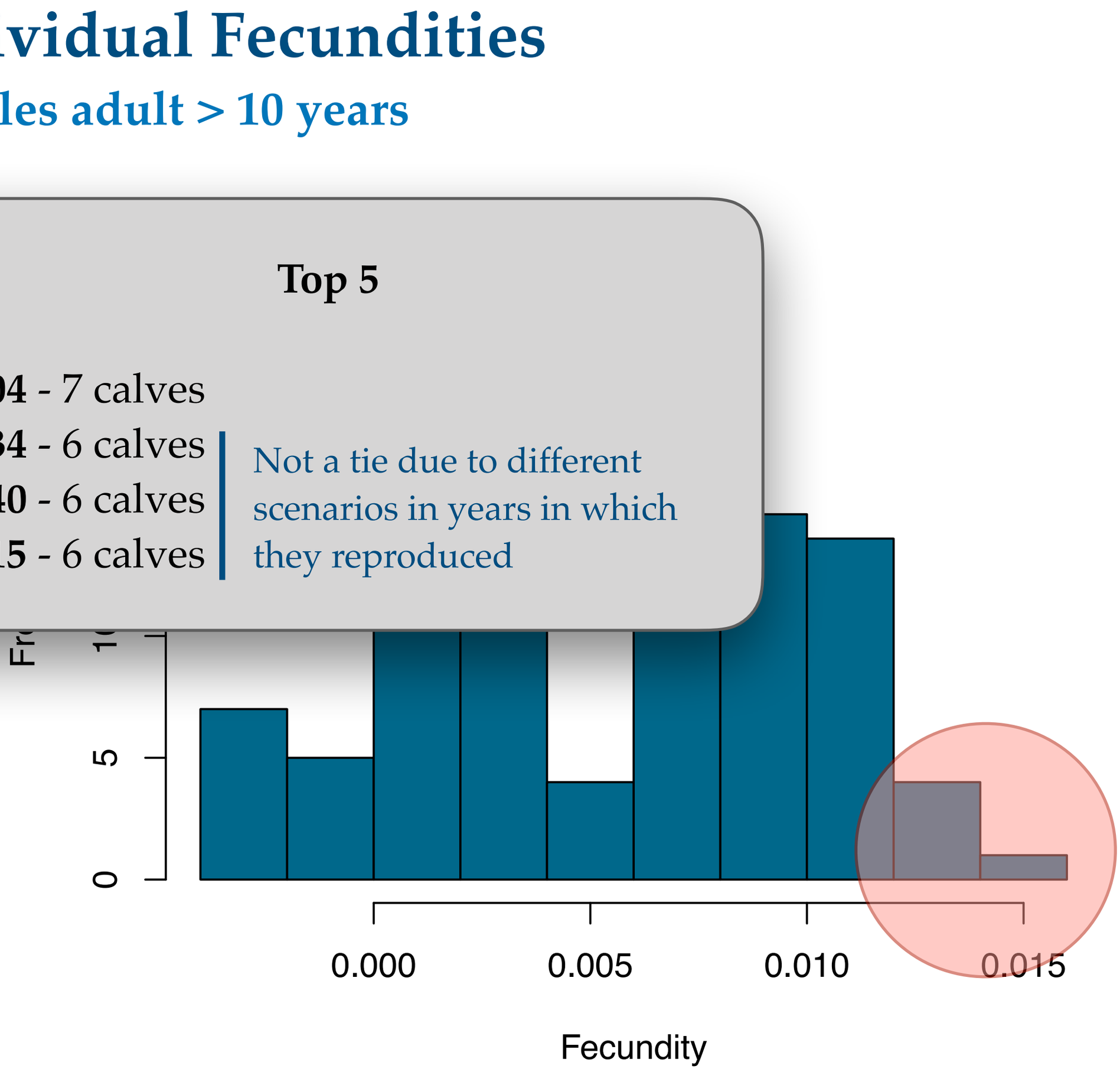
Individual Fecundities

Females adult > 10 years

Top 5

1. **1204** - 7 calves
2. **1334** - 6 calves
3. **1240** - 6 calves
4. **1315** - 6 calves

Not a tie due to different scenarios in years in which they reproduced



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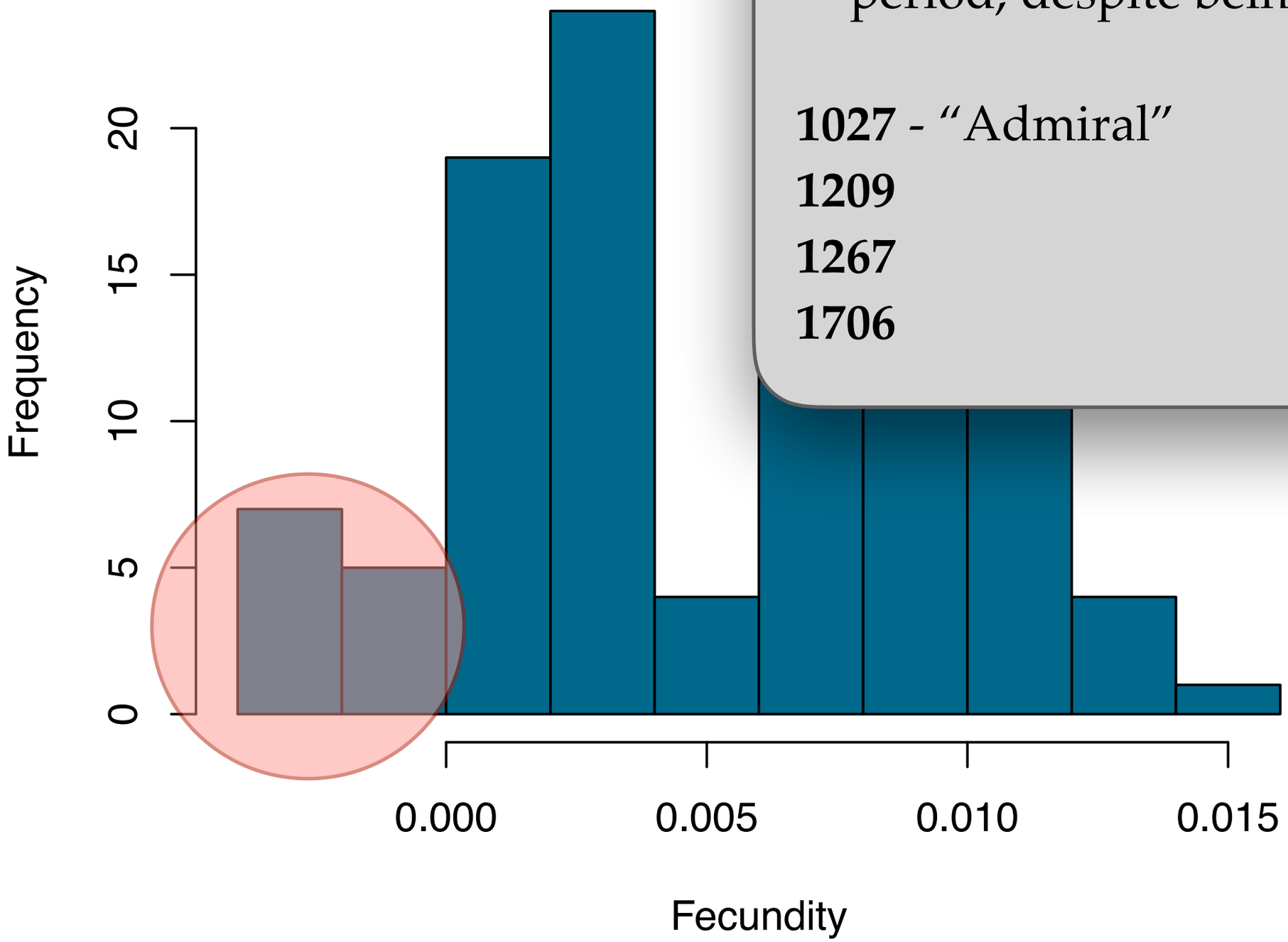

Bottom 5

(tie for several, none of who reproduced during this time period, despite being adults)

1027 - "Admiral"
1209
1267
1706

Importance

Context is important!

Calving events should not all be weighted equally

Surviving across different spans of time should not be weighted equally

Important information is contained within these data, above and beyond crude counts

Utility

Provides more accurate & precise estimates of individual fitness

R code available

- You can probably come up with more efficient code than we did

Thank You!

NARWC
THE NORTH ATLANTIC
RIGHT WHALE CONSORTIUM

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