Using surplus production models to study predation in age-structured populations

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Quantitative Ecology & Resource Management
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Why predation?

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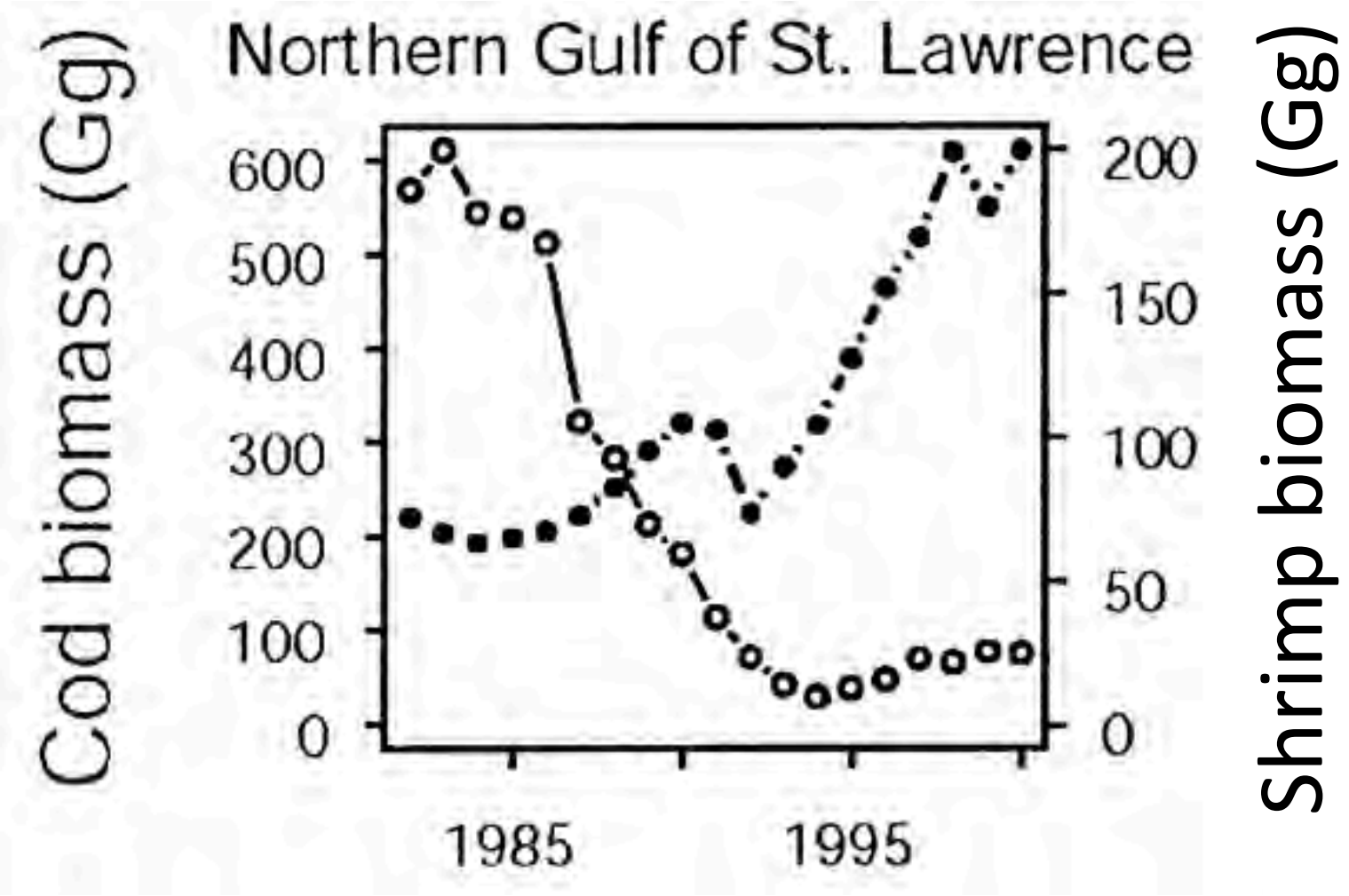
- Variable but important in marine ecosystems
- Part of ecosystem-based management
  - Trade-offs
  - Natural mortality
- Challenging to estimate precisely

Quantifying predation: the correlative approach



Worm & Myers, *Ecology*, 2003

Is surplus production better?

$$\text{Biomass}_{y+1} = \text{Biomass}_y + \text{Surplus production}_y - \text{Catch}_y$$

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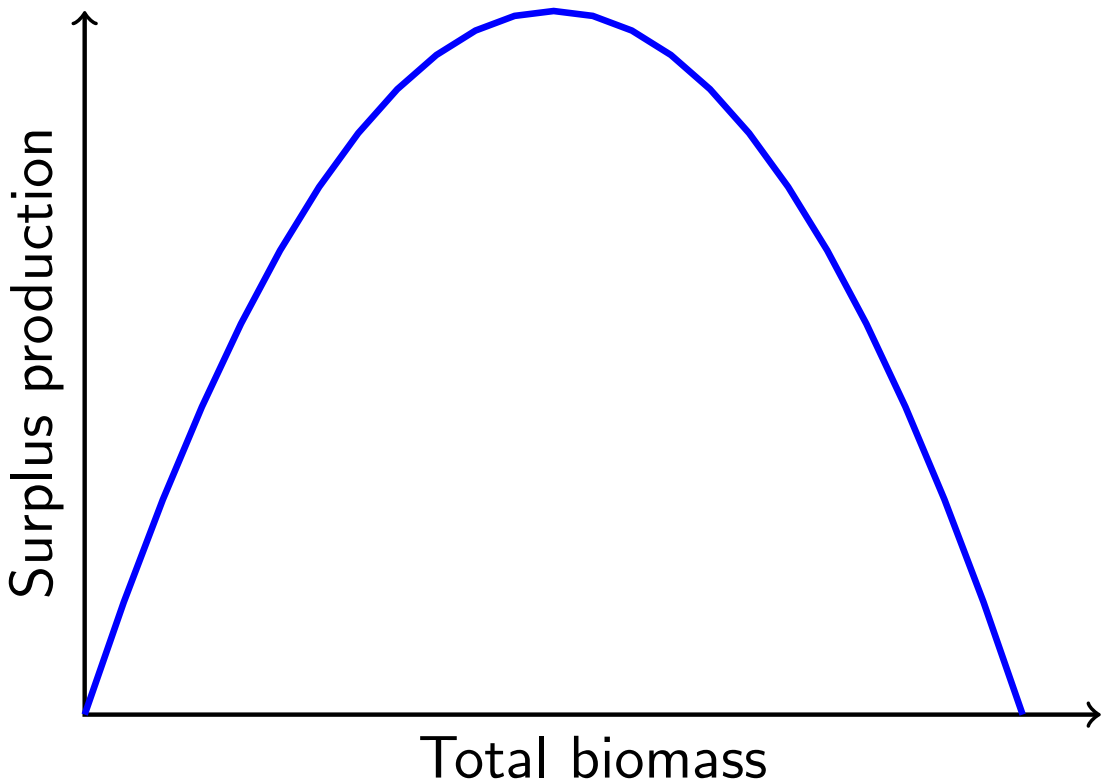
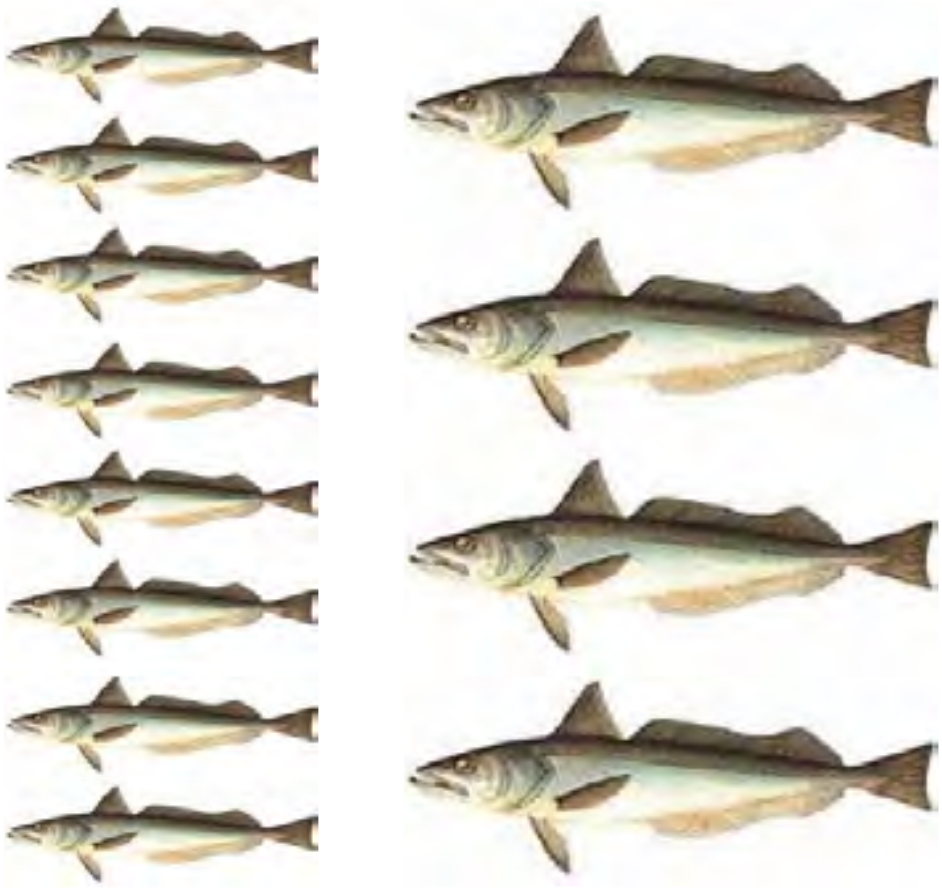
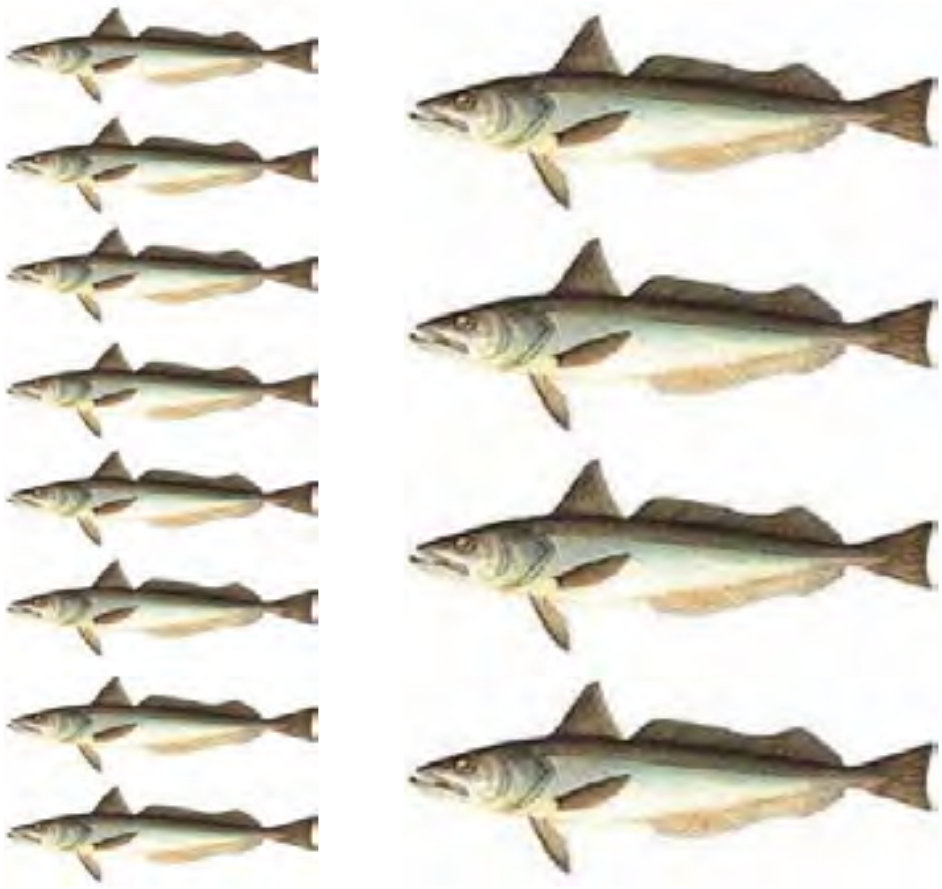


Surplus production of age-structured populations



Surplus production of age-structured populations

Low spawning potential

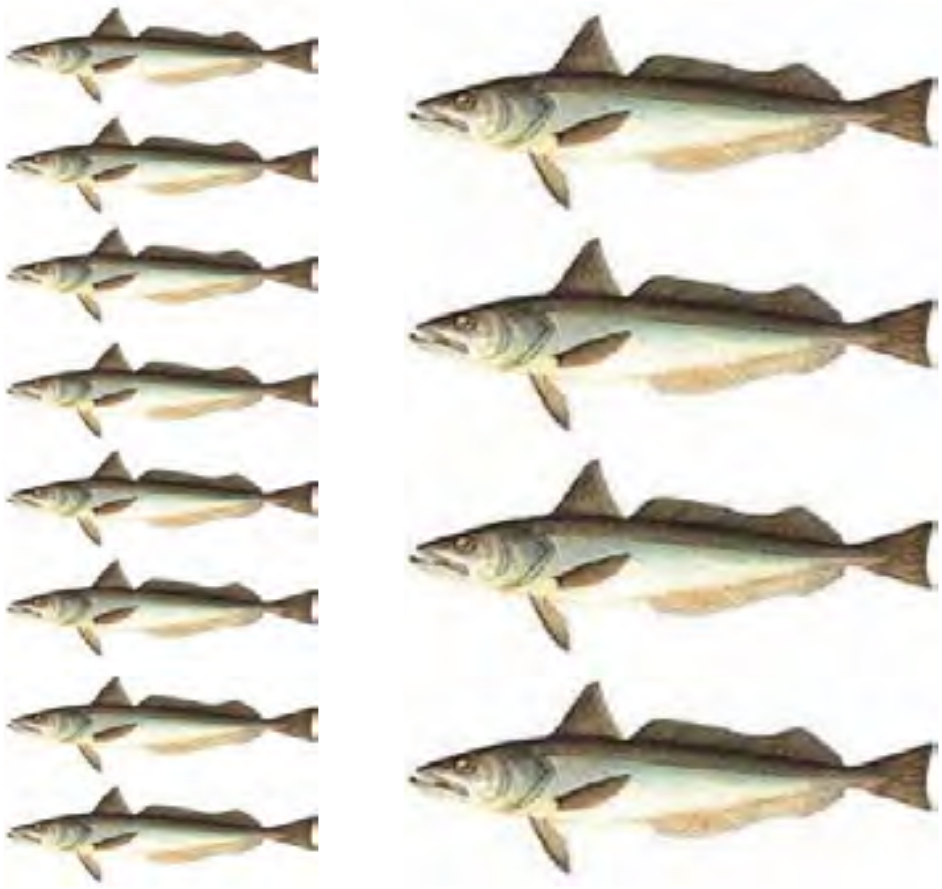


High spawning potential

Surplus production of age-structured populations

Low spawning potential

Vulnerable to predators



High spawning potential

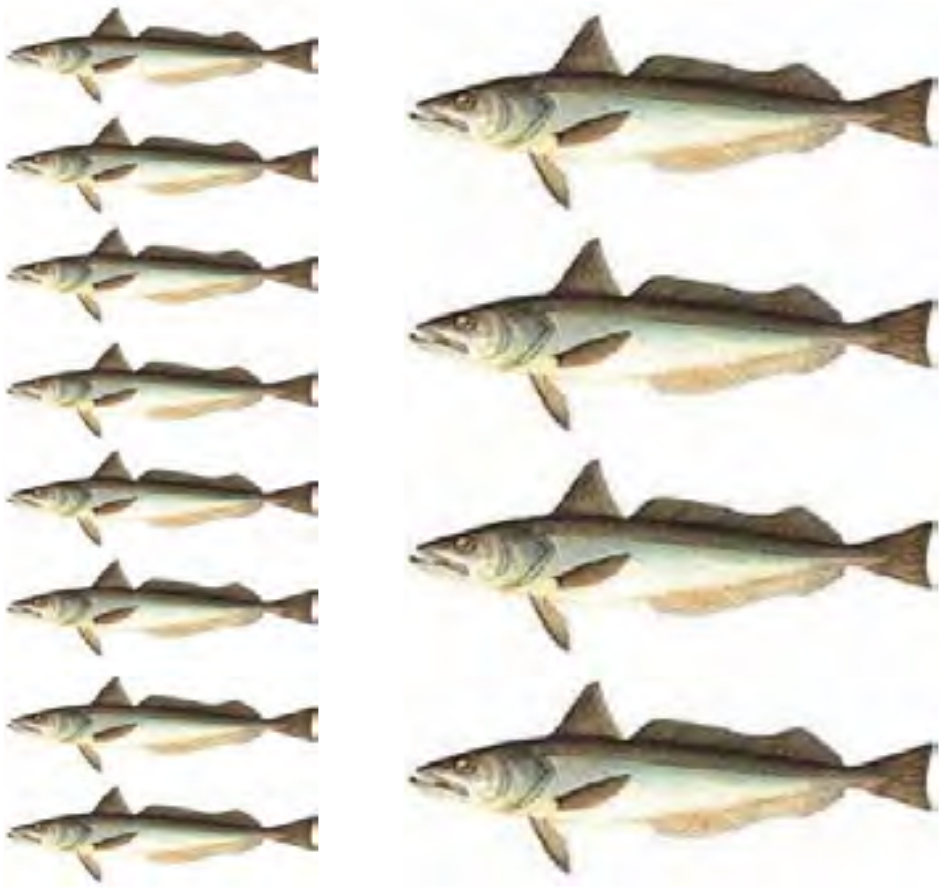
Less vulnerable to predators

Surplus production of age-structured populations

Low spawning potential

Vulnerable to predators

Low catchability



High spawning potential

Less vulnerable to predators

High catchability

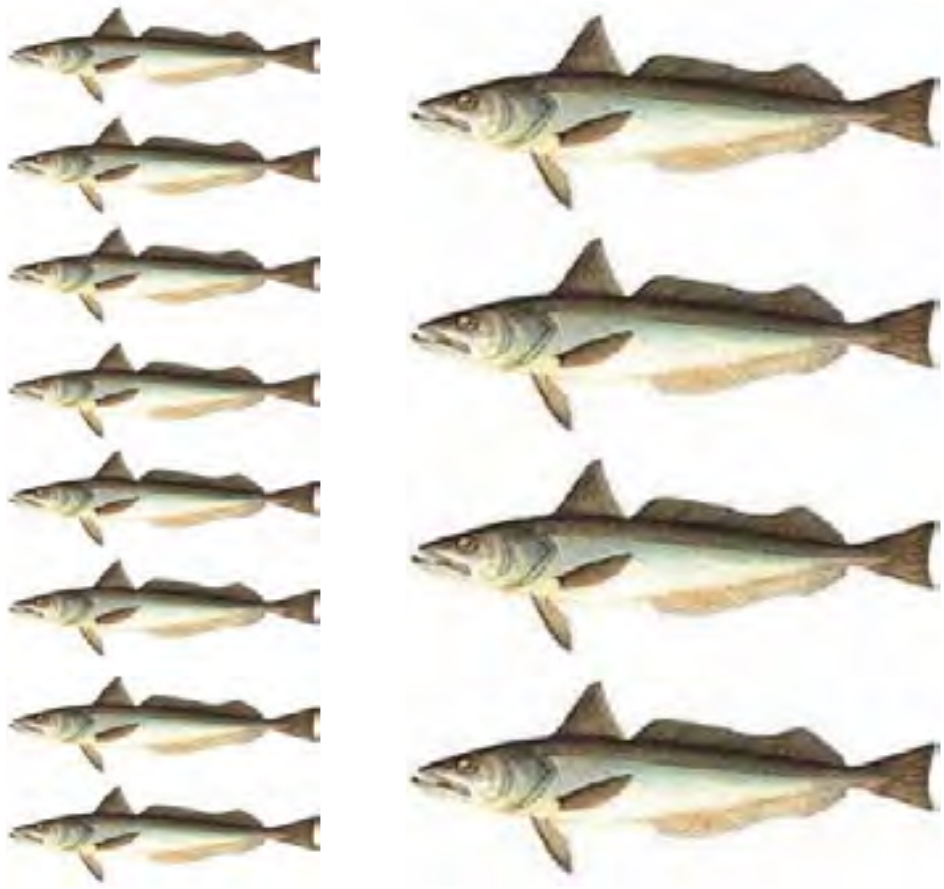
Surplus production of age-structured populations

Low spawning potential

Vulnerable to predators

Low catchability

Large growth increment



High spawning potential

Less vulnerable to predators

High catchability

Small growth increment

Surplus production of age-structured populations

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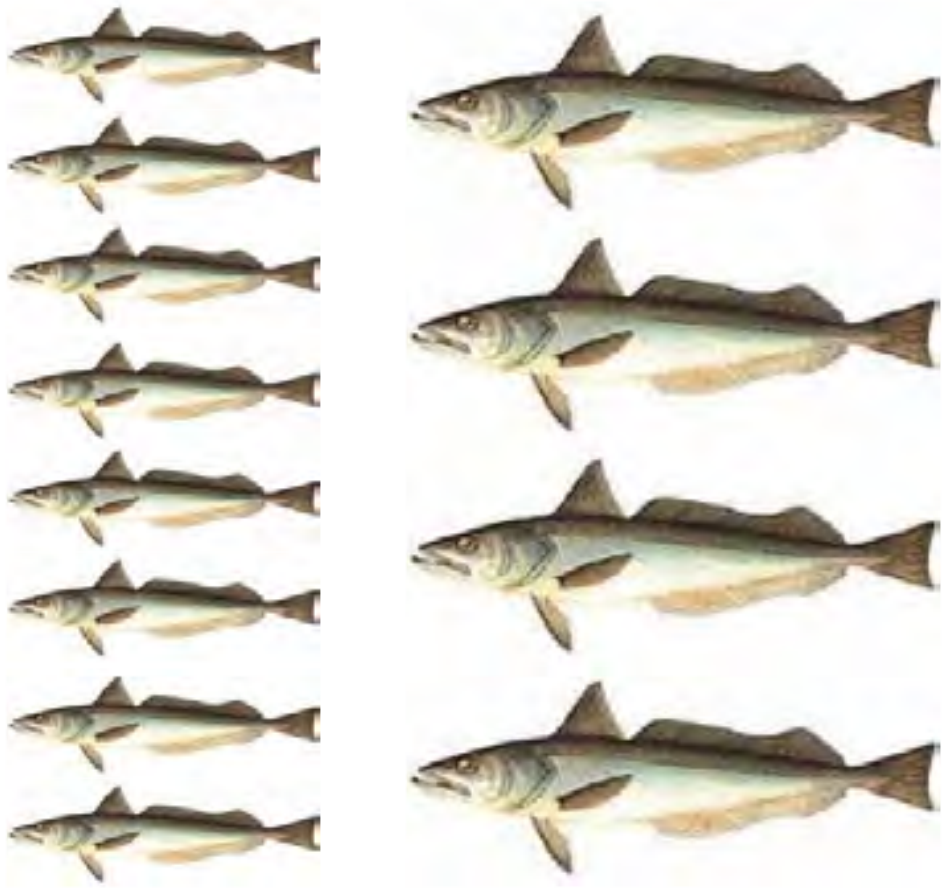

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Questions

What can we glean from surplus production models that account for predation?

- Quantify top-down predation effects
- Estimates of management reference points

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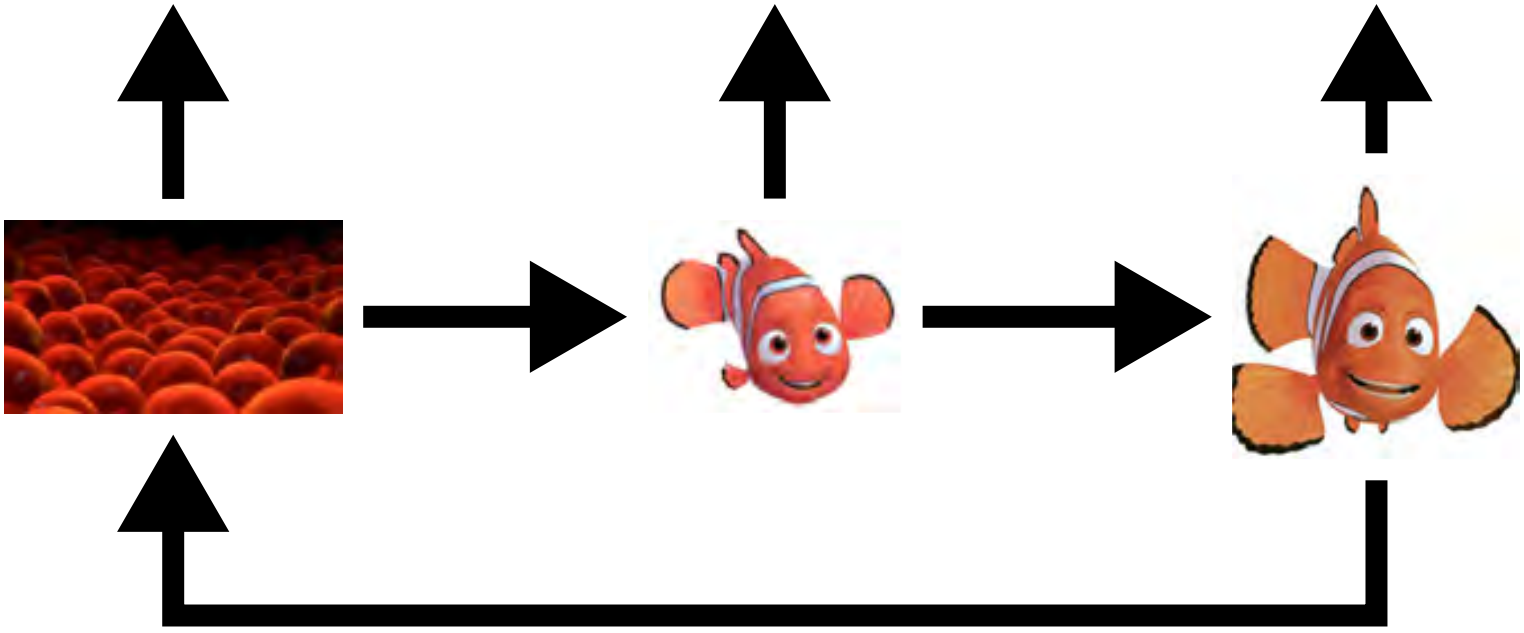
Approach

- Operating model used to simulate data
- Statistical model fit to simulated data
- Results and conclusions

Operating model



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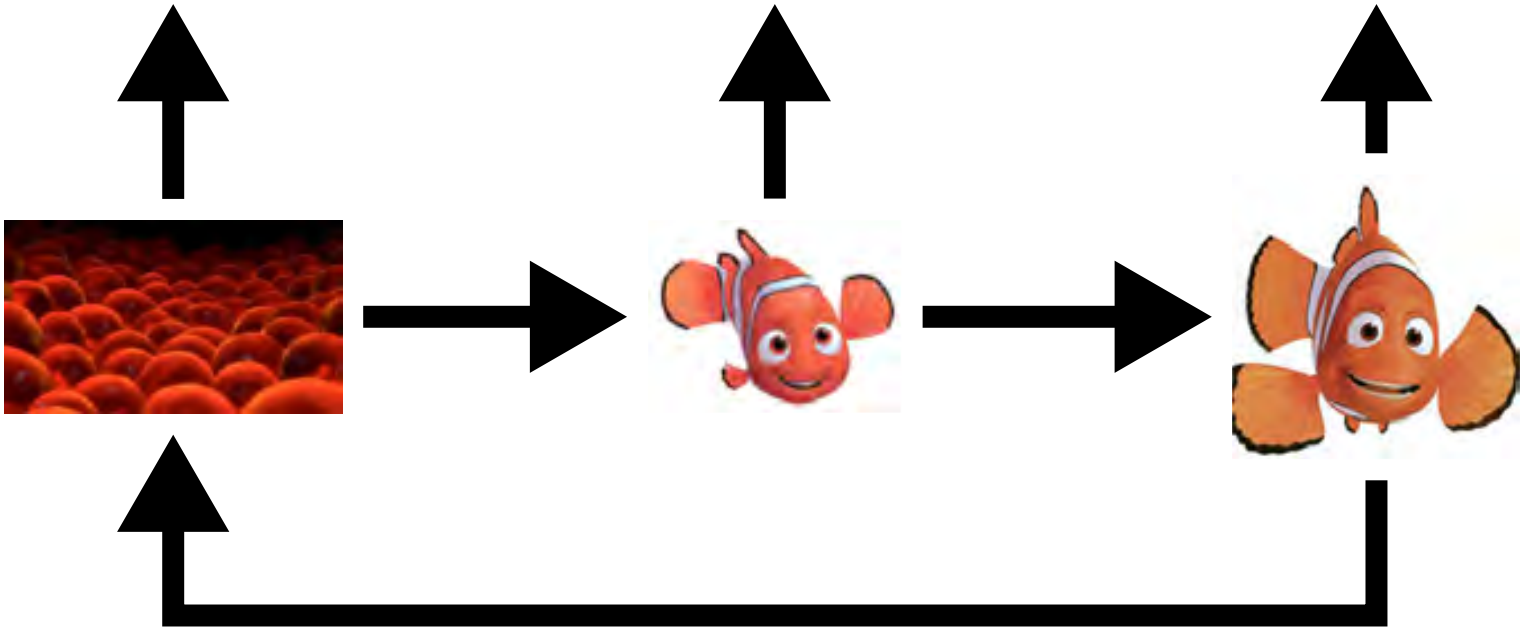

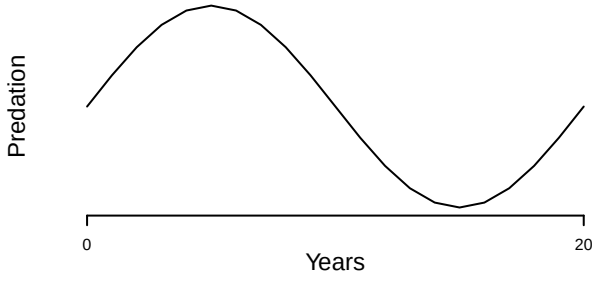

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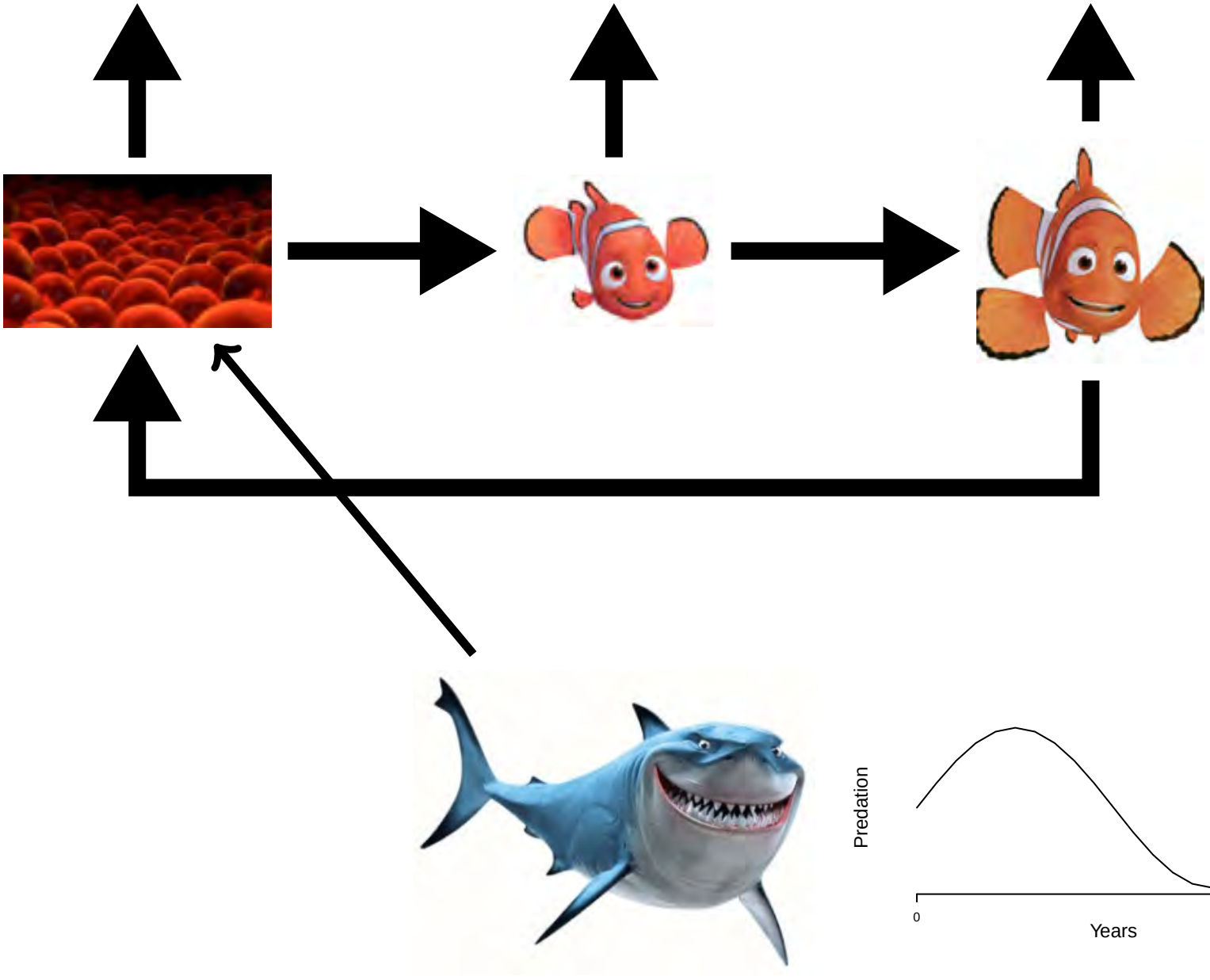

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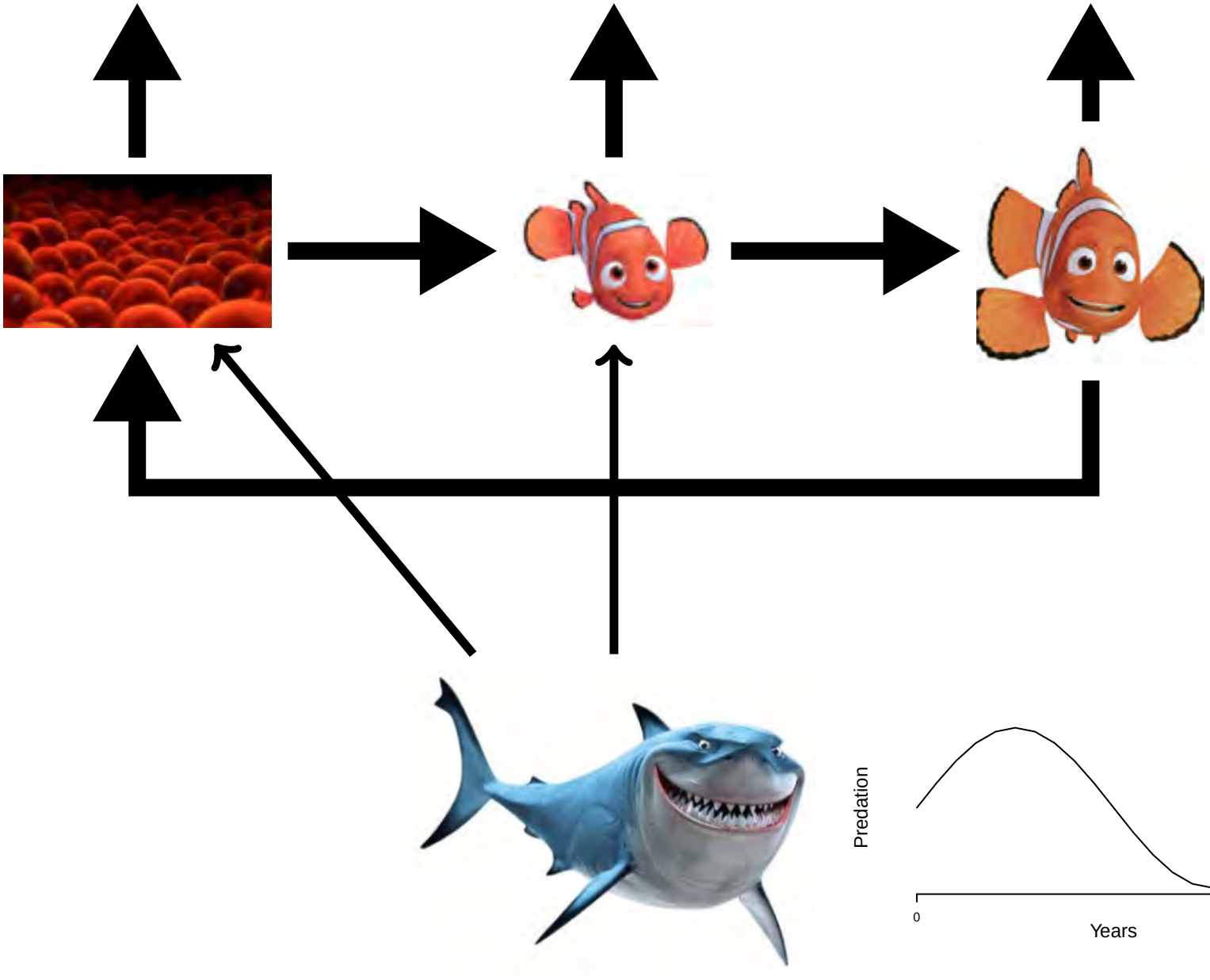

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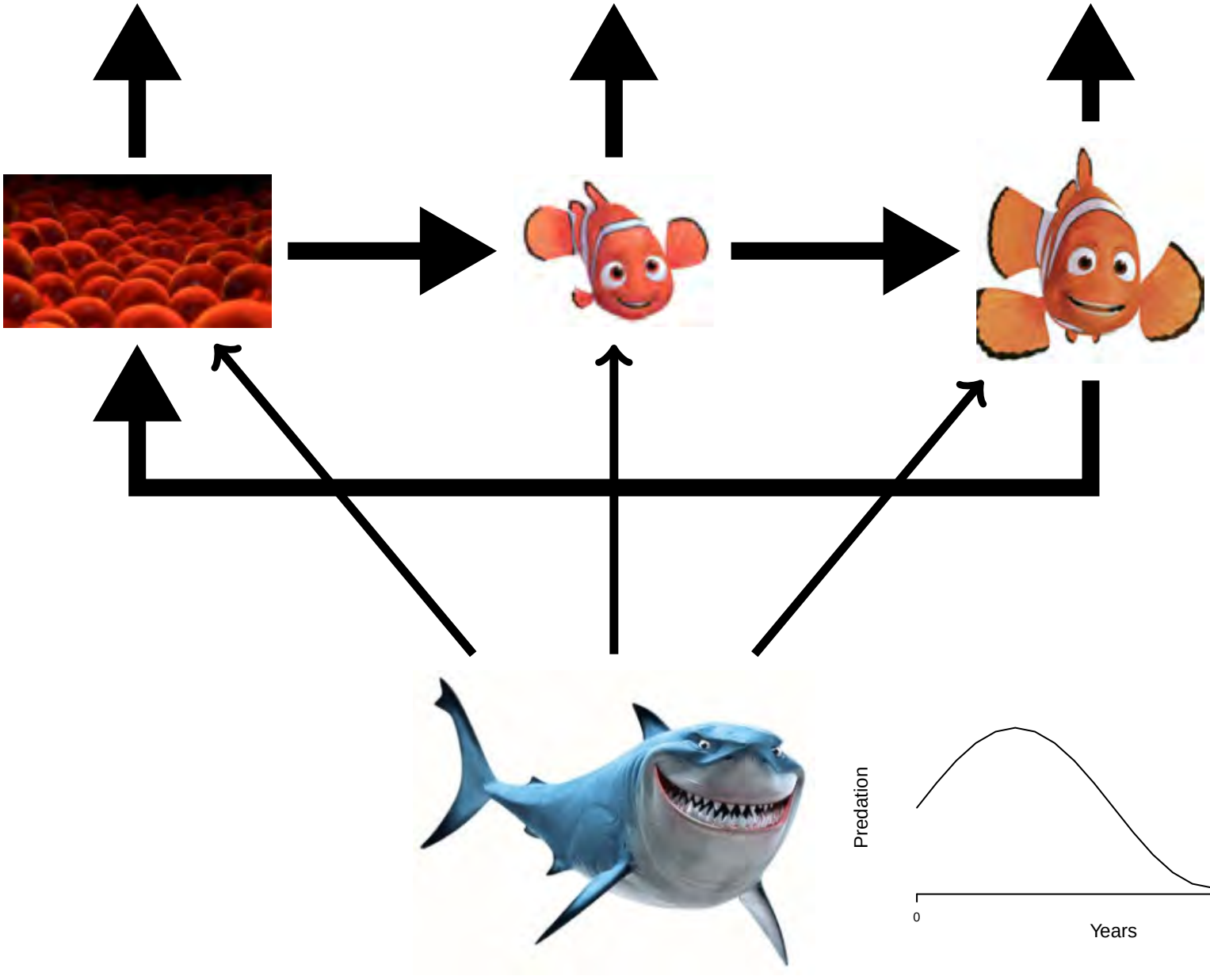
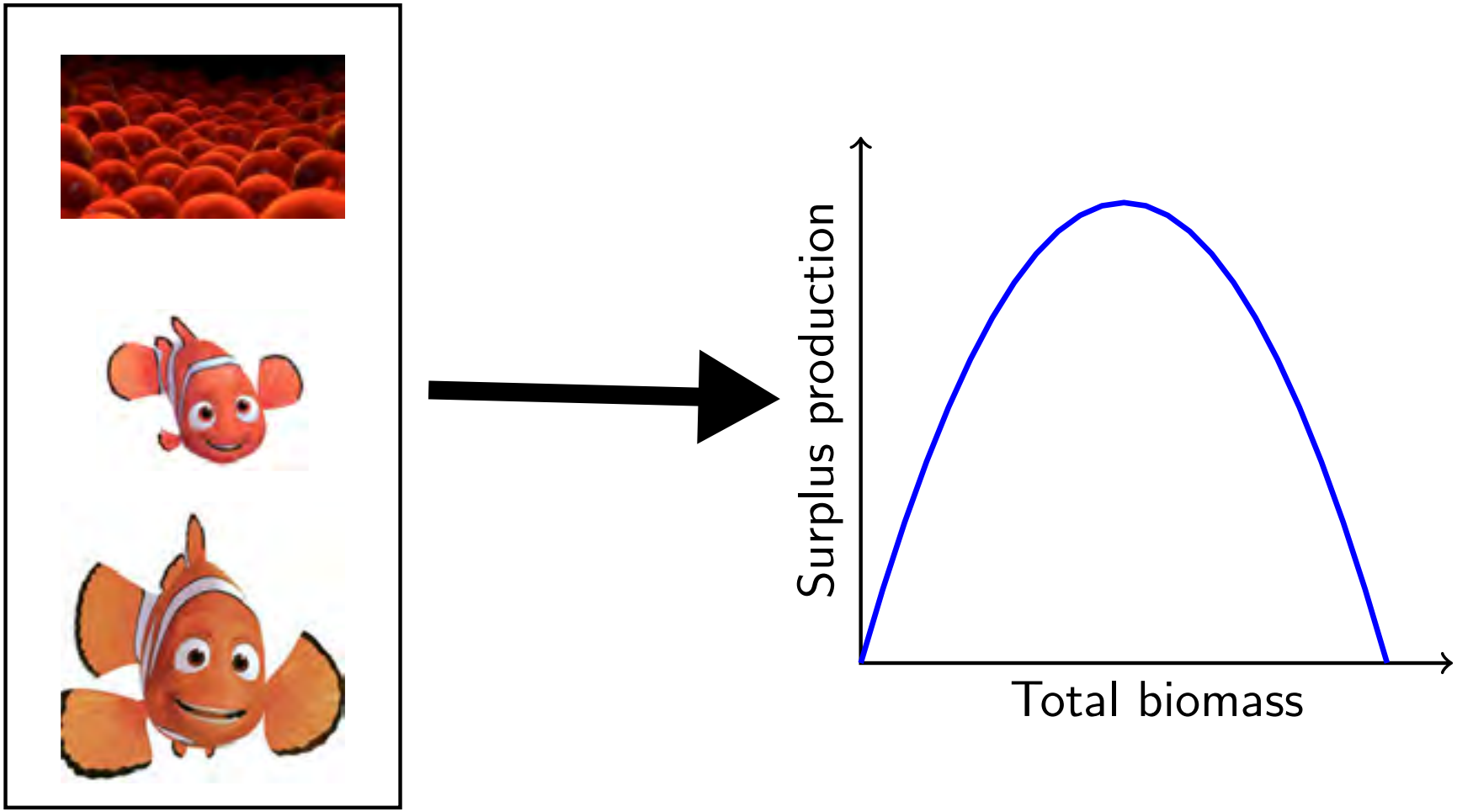


Simulated data



Four different prey life histories

Pacific sardine

- Age at 50% maturity: 1.2
- Adult natural mortality: 0.4

Silver hake

- Age at 50% maturity: 1.6
- Adult natural mortality: 0.15

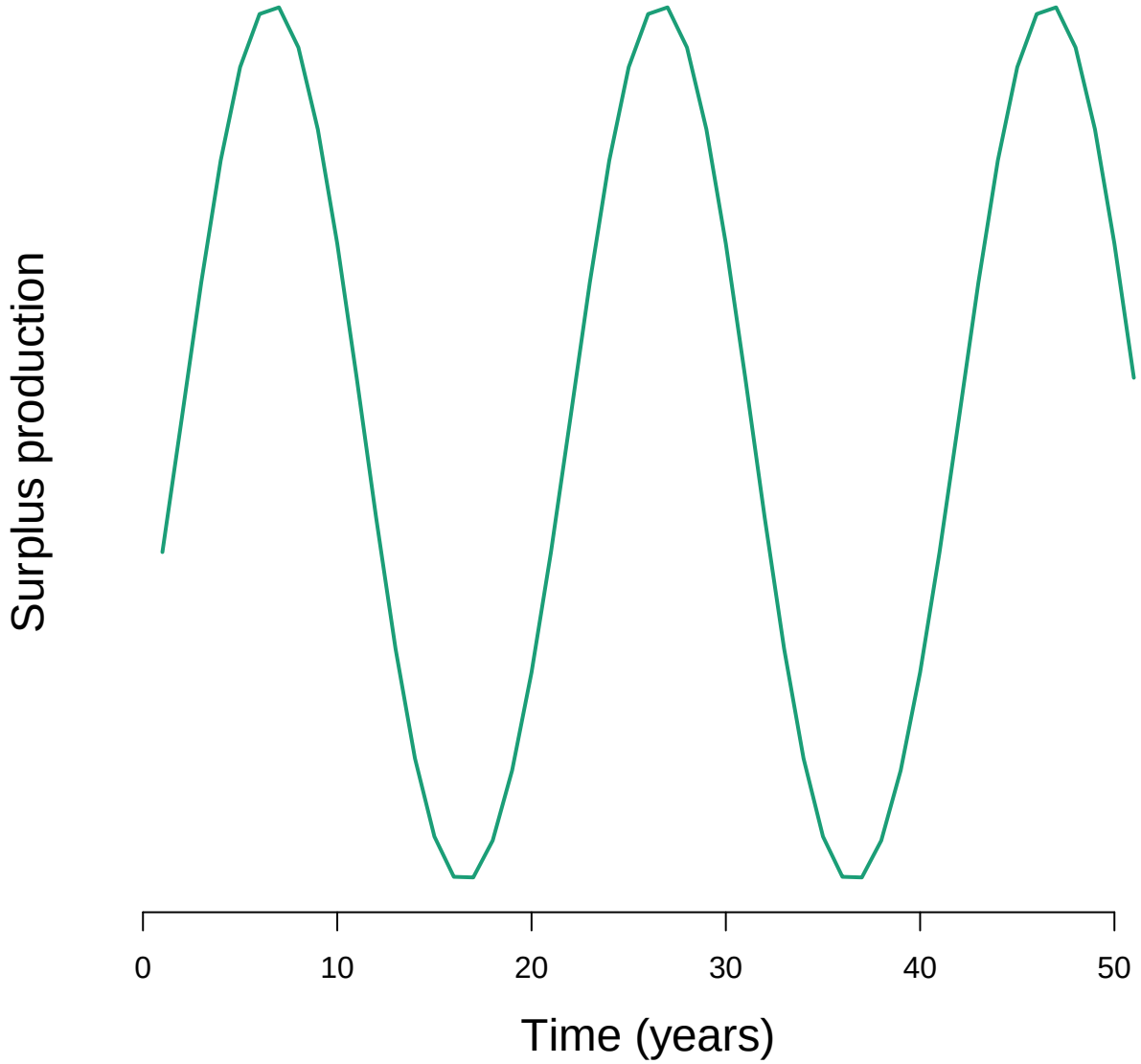
Atlantic menhaden

- Age at 50% maturity: 2.5
- Adult natural mortality: 0.47

English sole

- Age at 50% maturity: 3.5
- Adult natural mortality: 0.26

Deterministic dynamics



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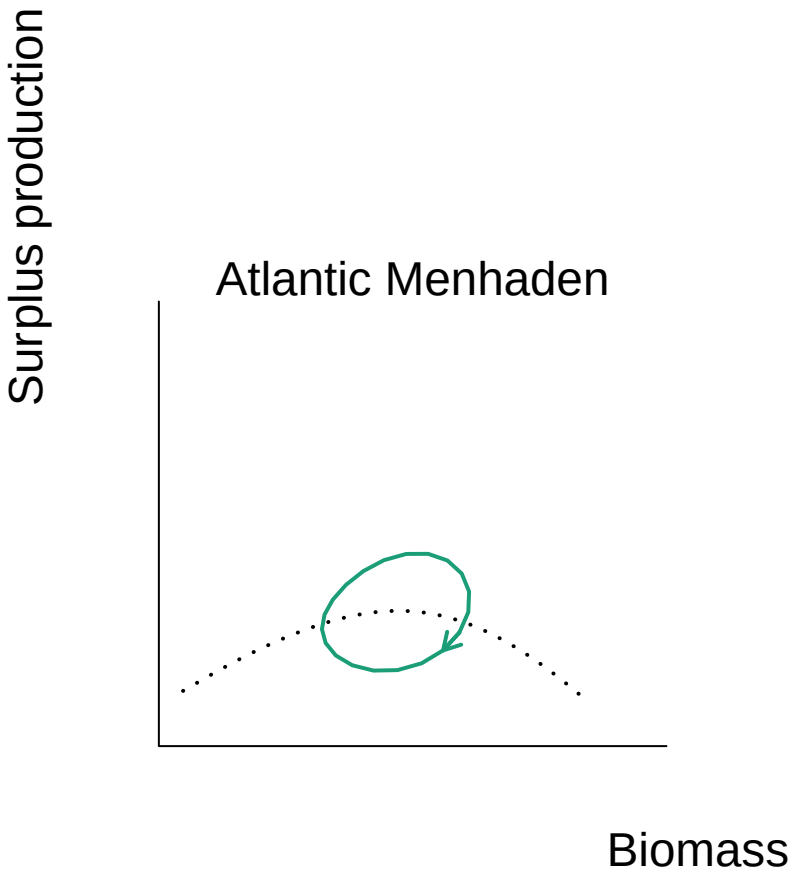

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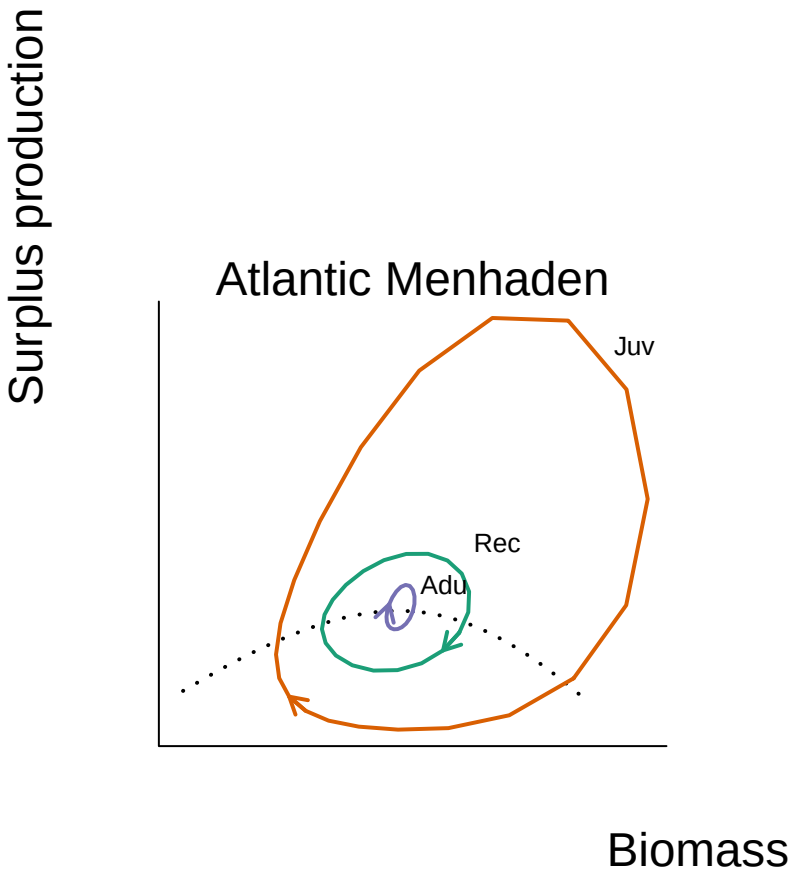

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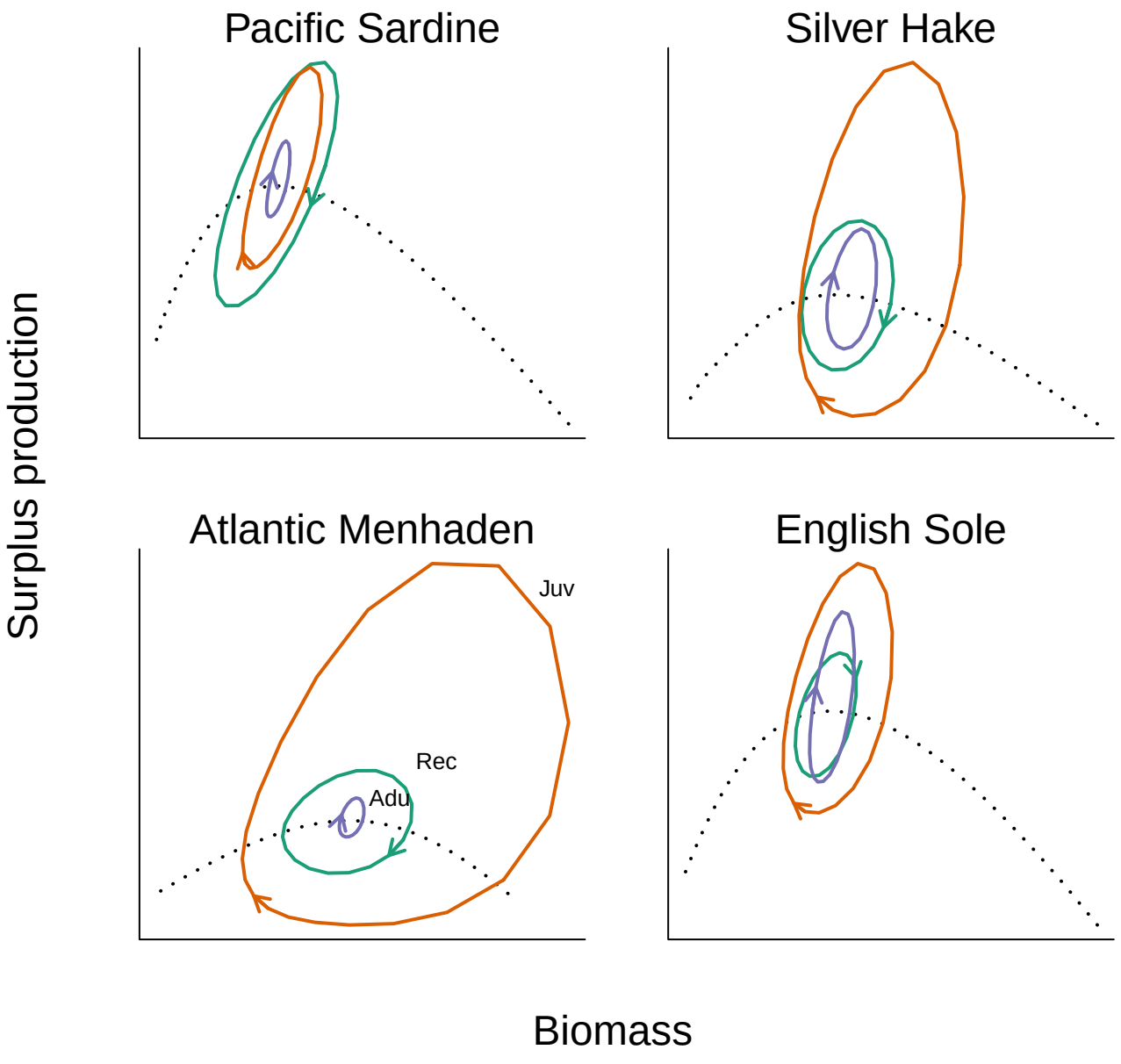
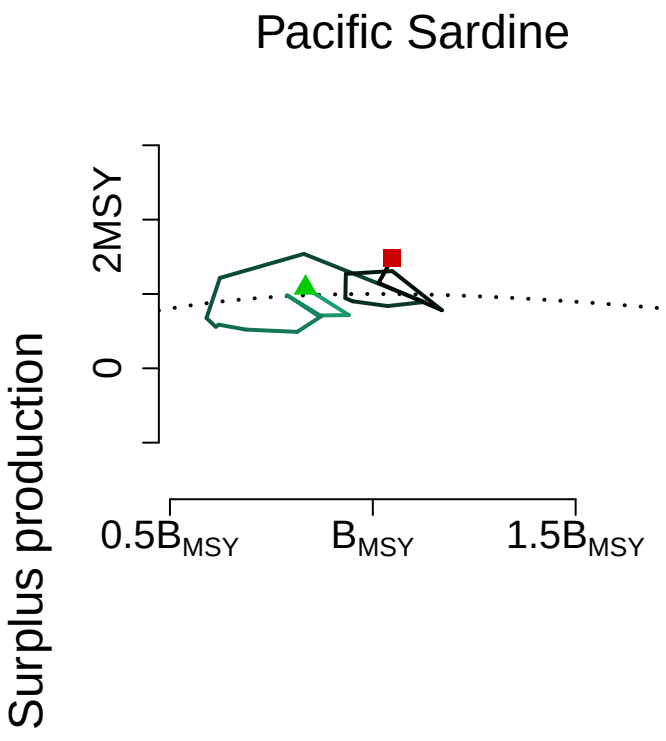
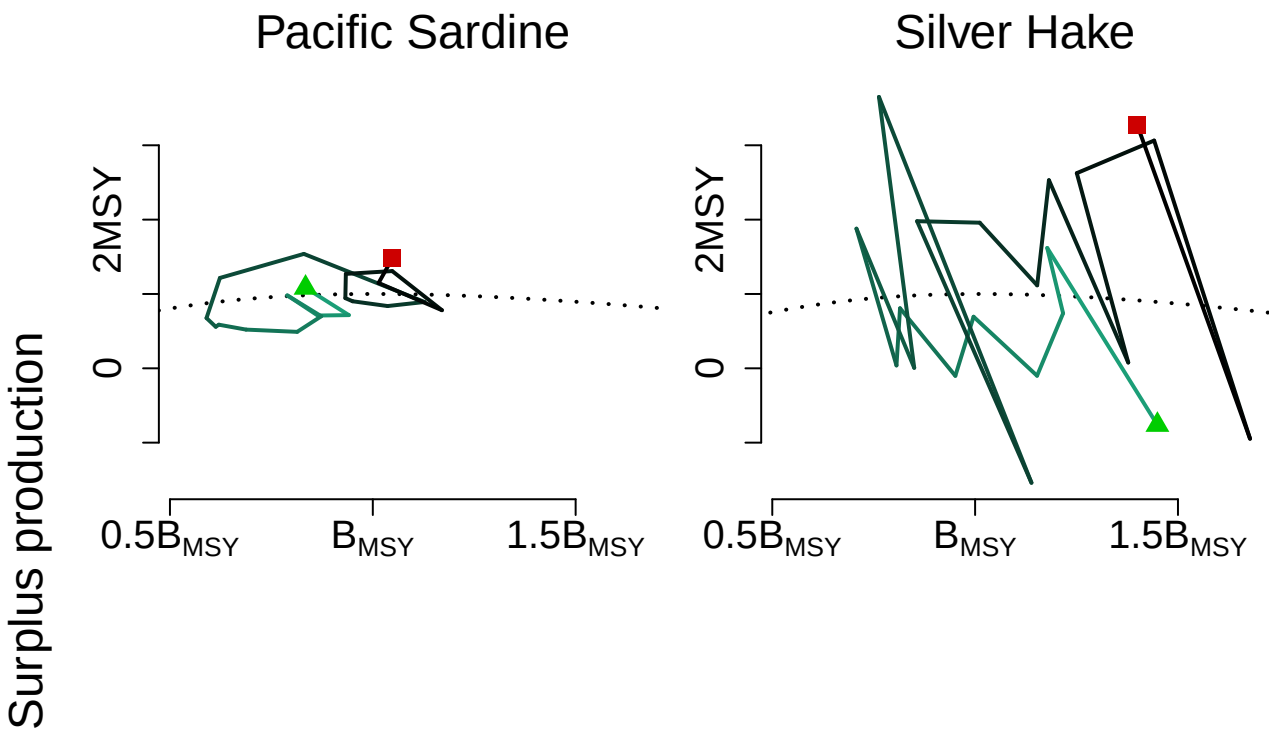


Stochastic dynamics



Stochastic dynamics



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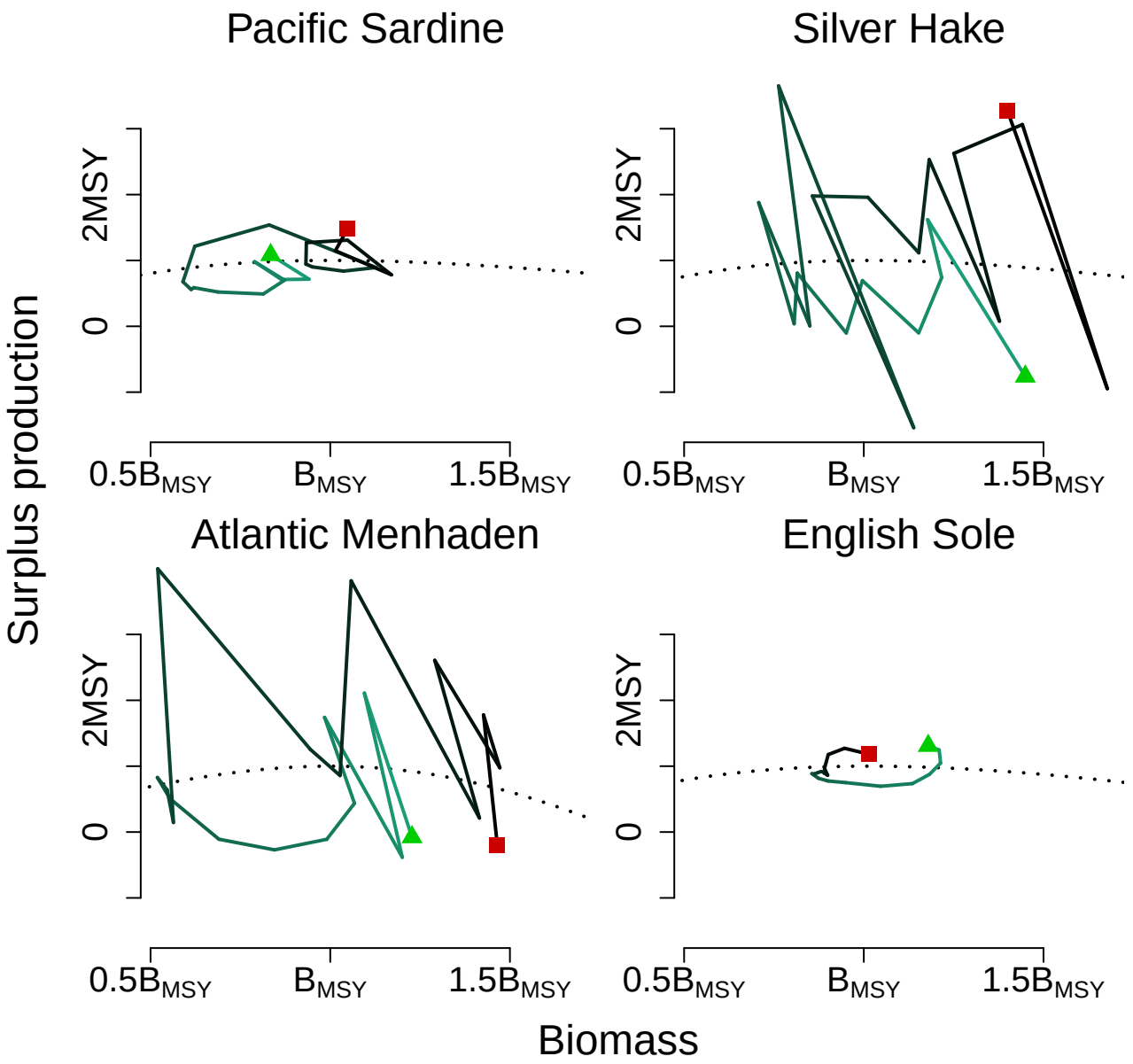

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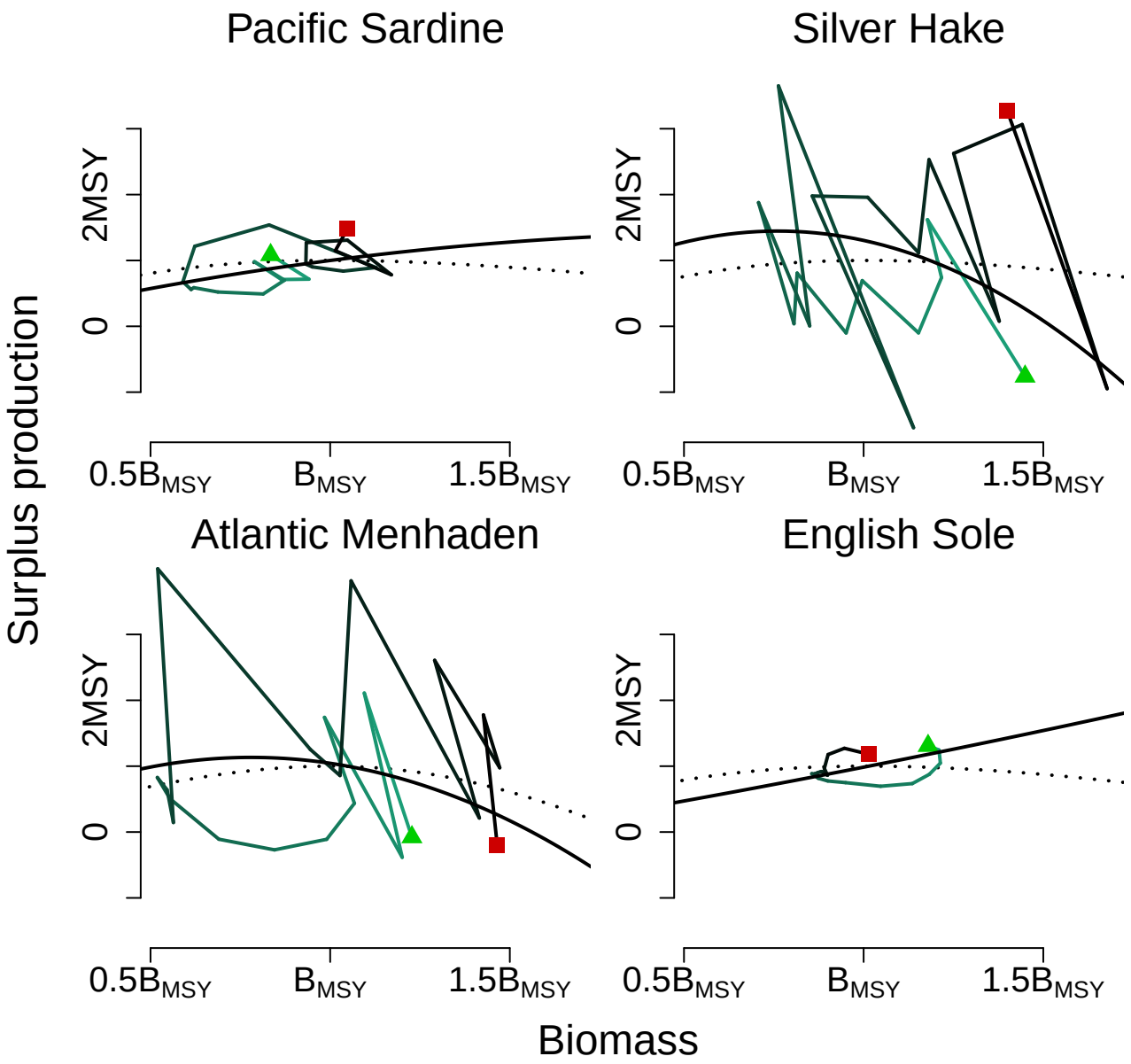
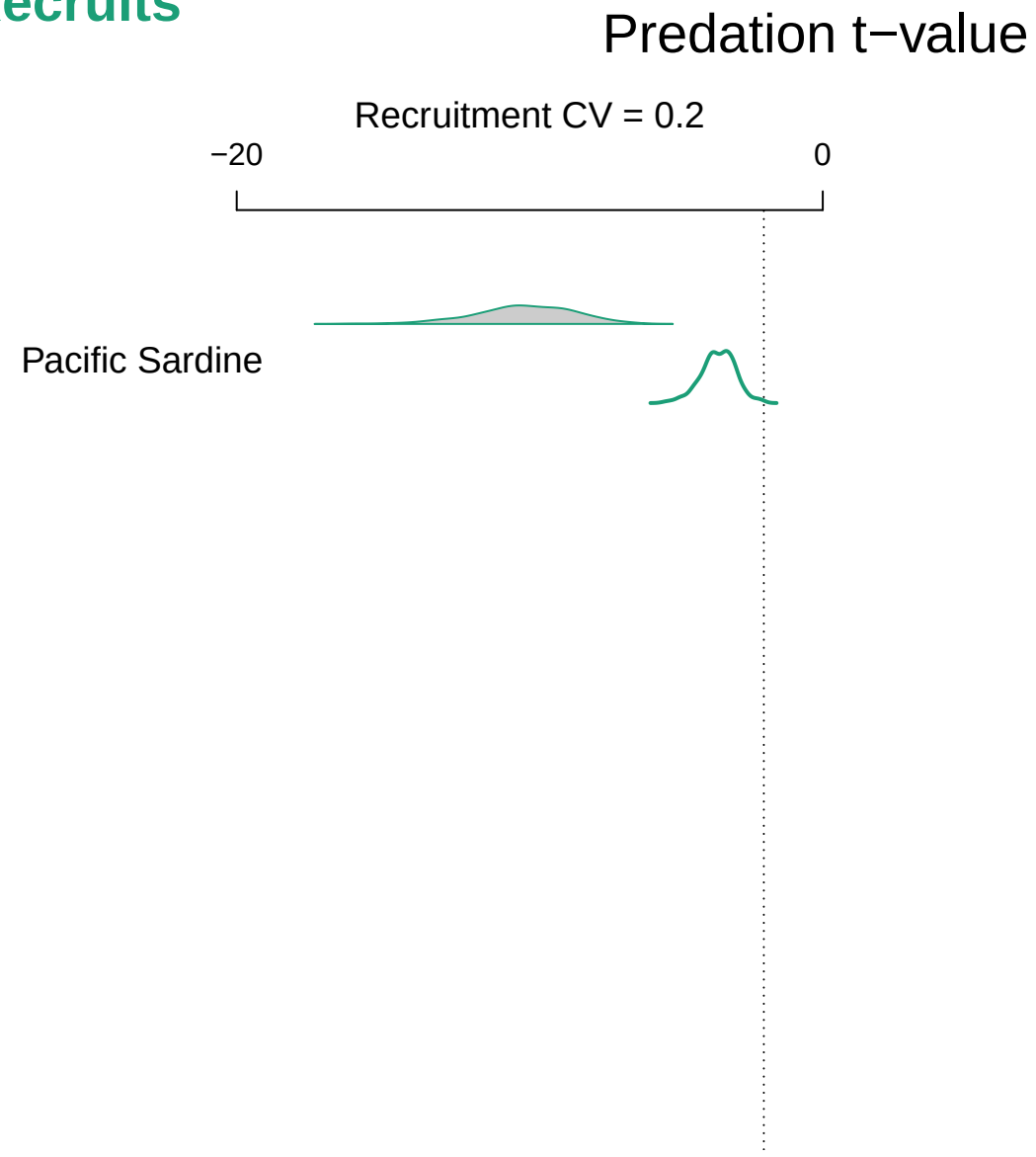


Top-down effects

Recruits



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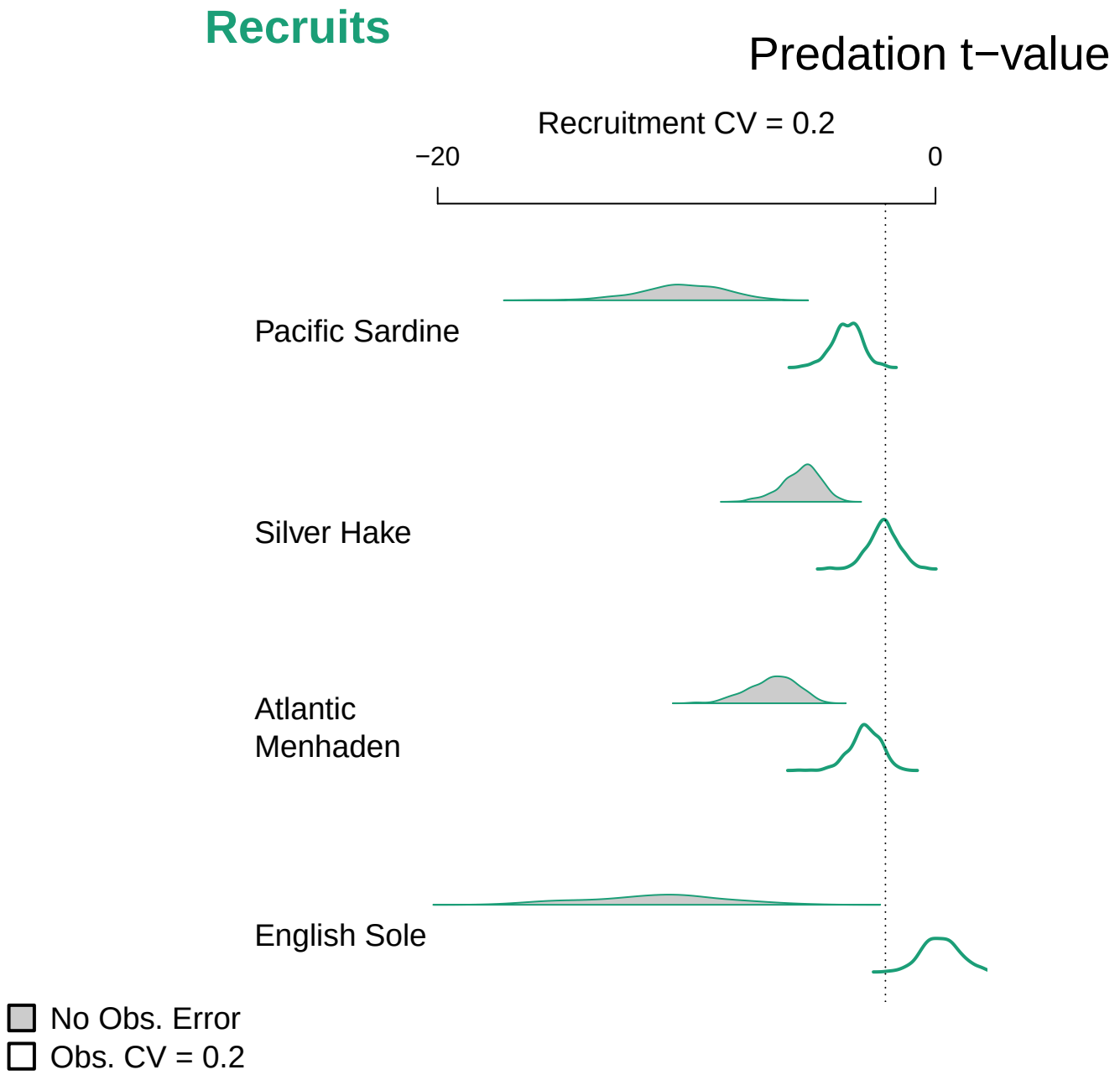

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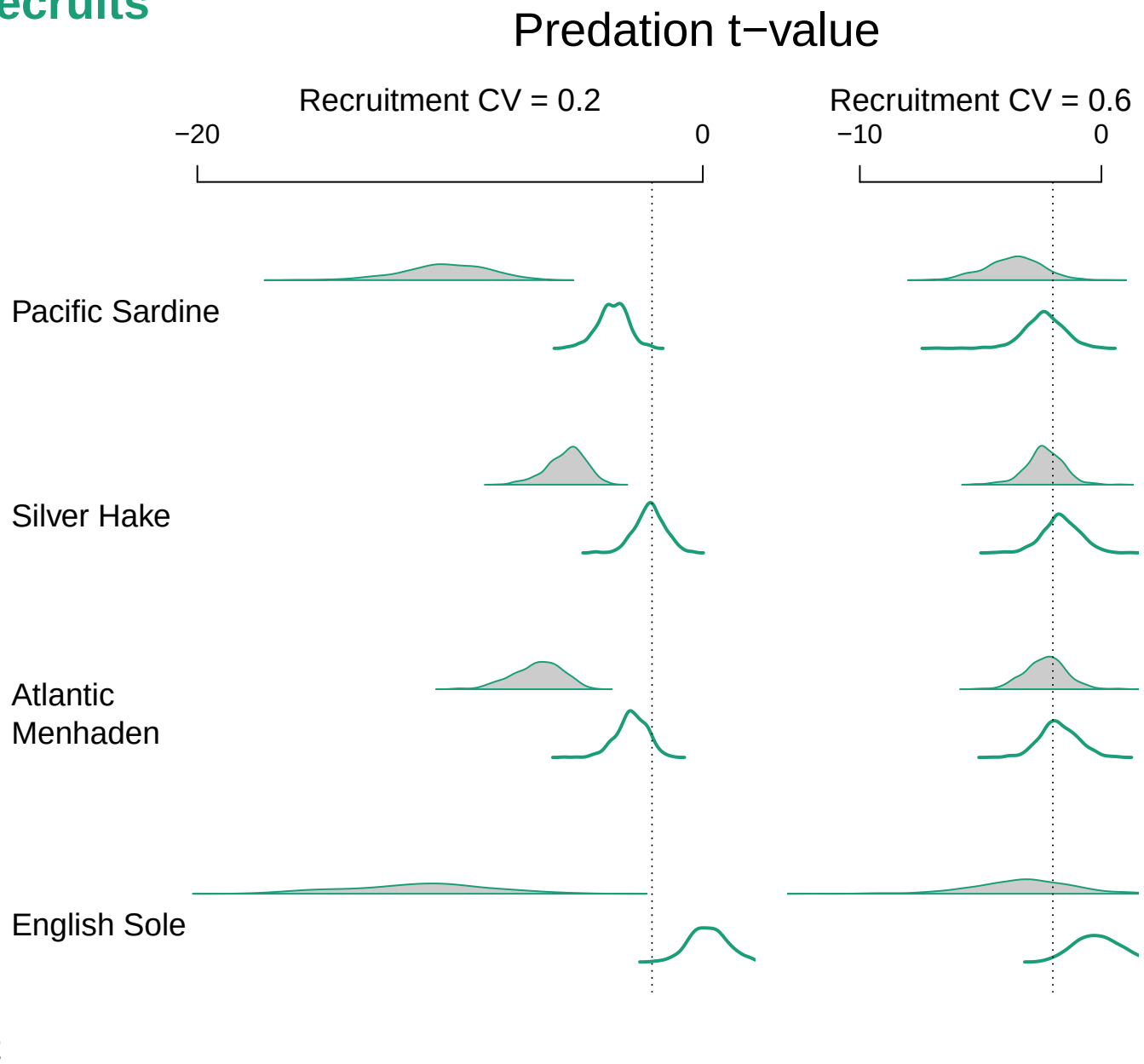
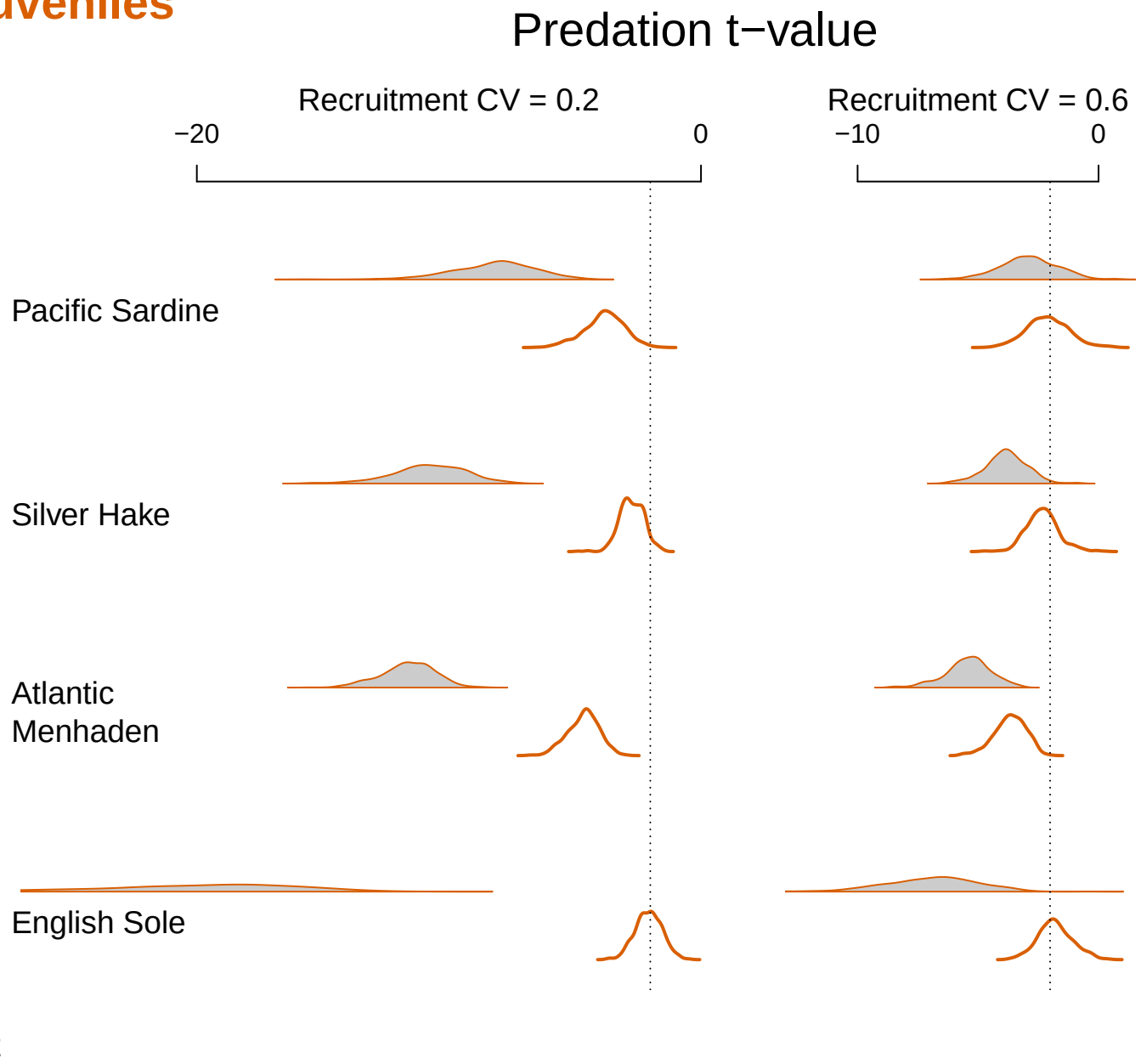


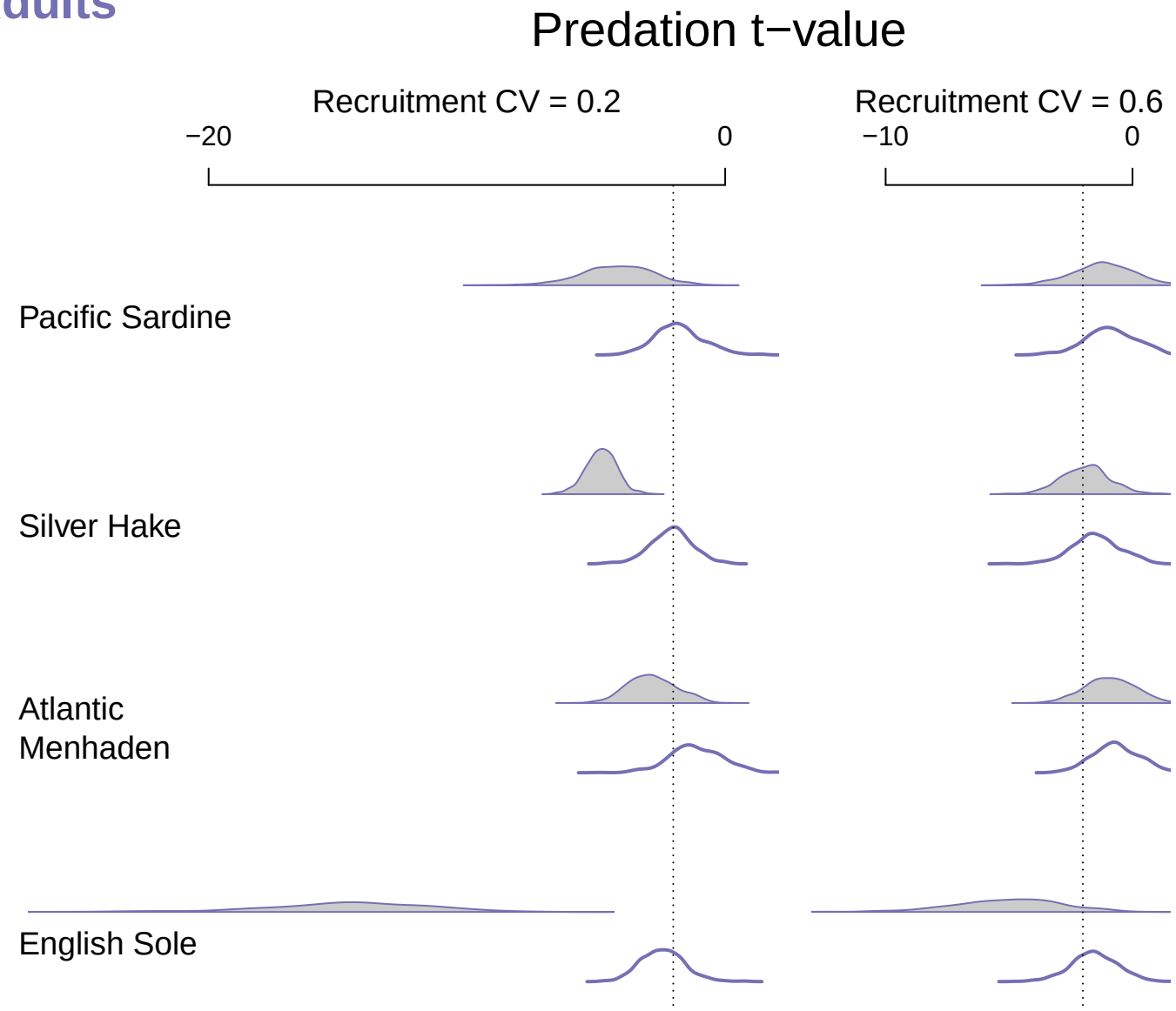
Top-down effects

Juveniles



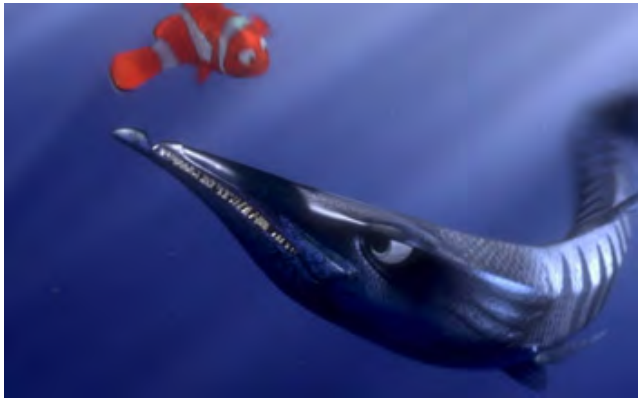
Top-down effects

Adults

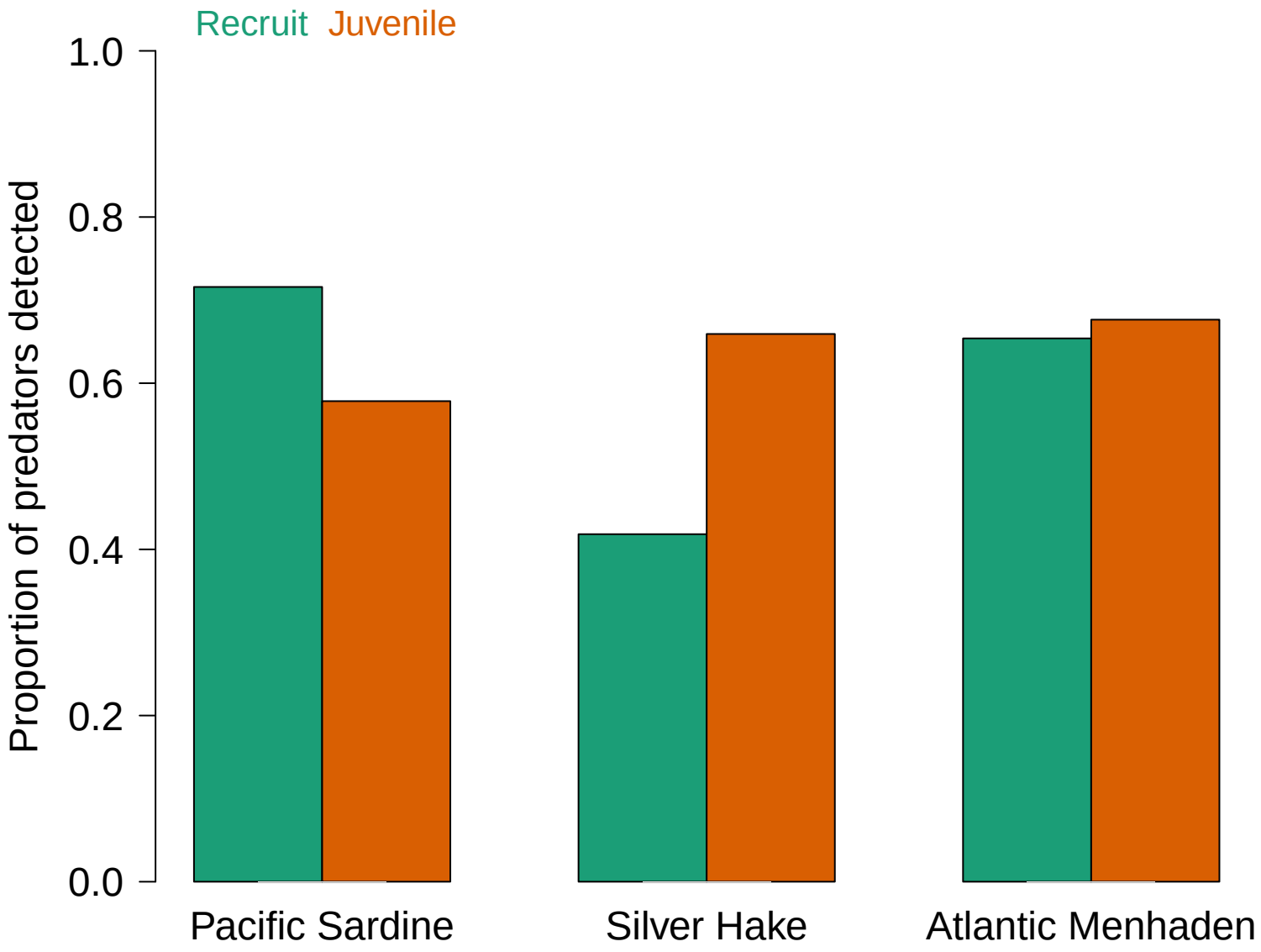


No Obs. Error
Obs. CV = 0.2

What if we add a second predator?



Multiple predators further degrades signal



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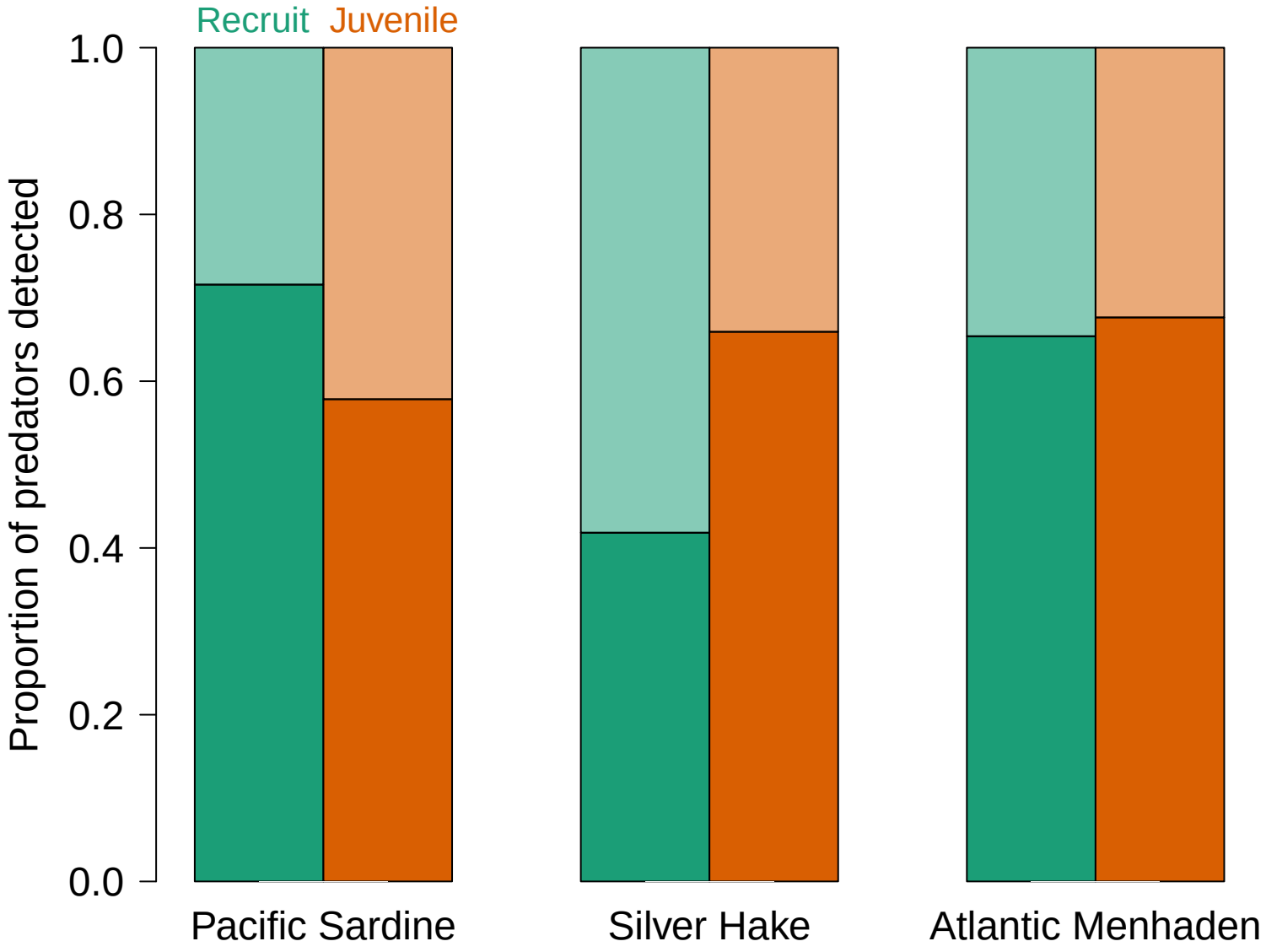

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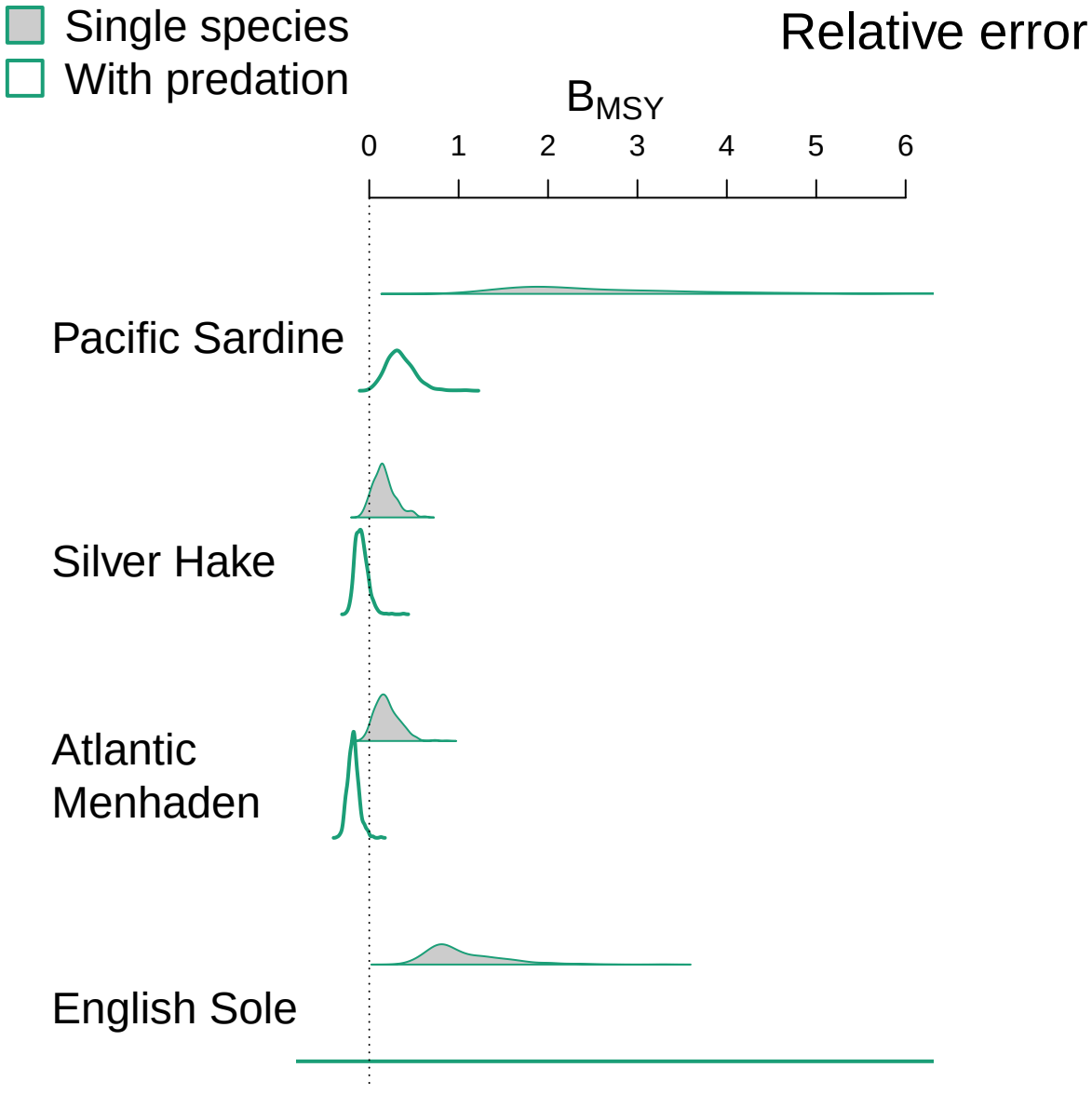
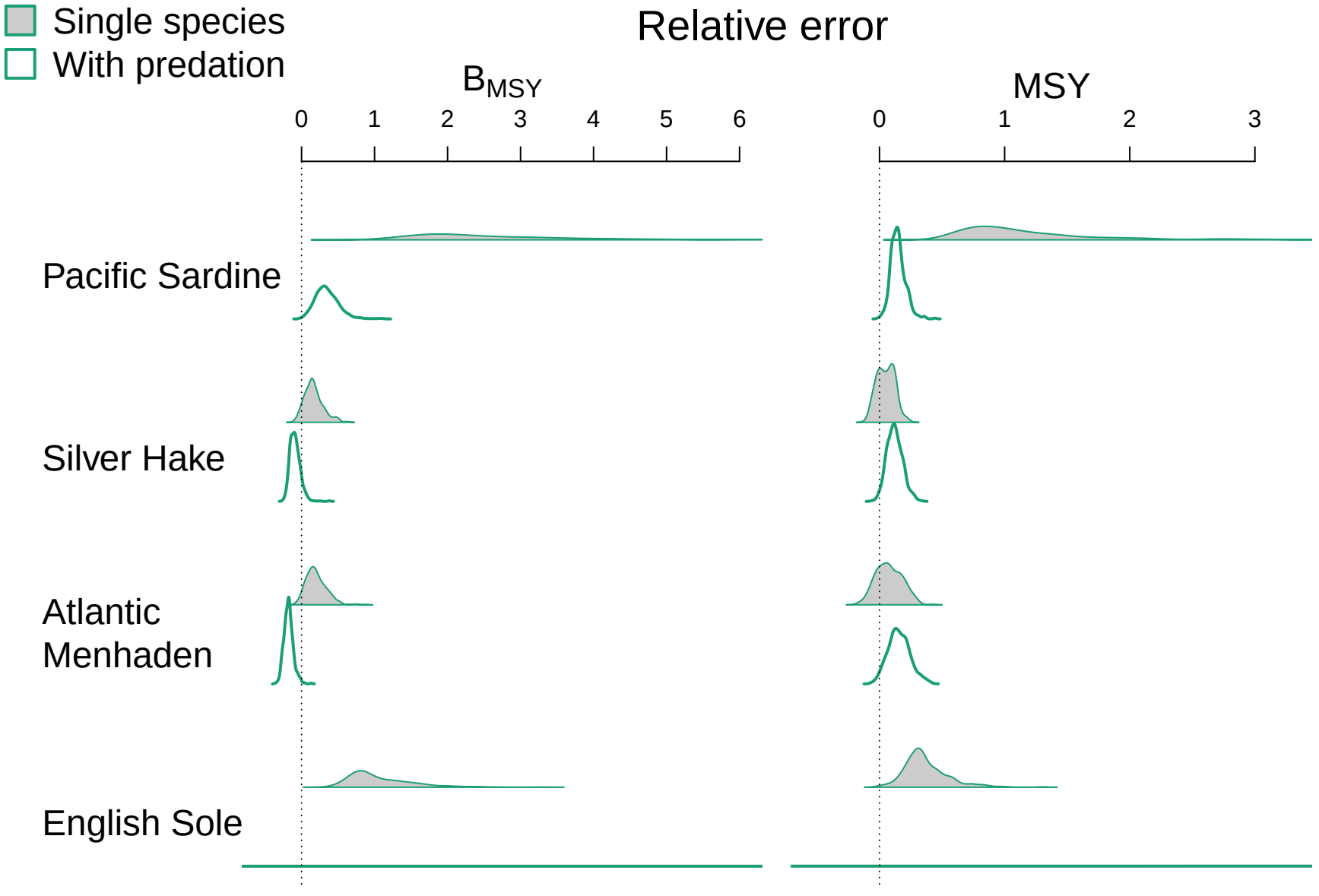


Reference point estimates unreliable



Conclusions

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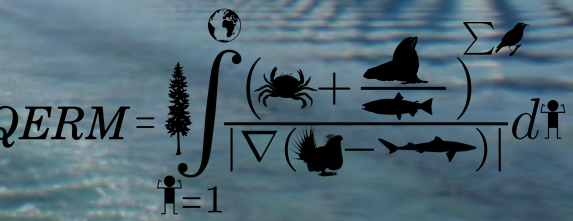
- Quantify top-down predation effects:
  - Easily masked by variability
  - Depends on life history
- Estimates of management reference points:
  - Predation can improve estimates
  - Surplus production models unreliable

Thanks!

- Trevor Branch, Jason Link, Andre Punt
- Essington lab

National Science Foundation
WHERE DISCOVERIES BEGIN



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