# **Mechanistic traits-based model captures** fish size structure on Scotian Shelf

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### Introduction

• Large predator fish slow to recover after collapse of Atlantic cod on the Scotian Shelf<sup>1</sup>.





Figure 3: Model structure highlighting competition for shared resources and the predation by large forage fish on small predators.

Figure 1: Changes in size structure of Scotian Shelf from 1970 to 2003. A moratorium on fishing was imposed in 1993.

- Hypotheses for slow recovery include:
  - -Predator-prey role reversal now numerically dominant, forage species suppress small size classes of predator species.
  - -Greater *competition* for resources among small individuals of all species.

### **Methods**

#### Data

• 23 years of abundance-at-length estimates for 13 species from DFO, Canada.

### **Model Structure**<sup>2</sup>

### Results

• Aggregate tritrophic model performs better than full model (Fig 4).



Figure 4: Best fit model (black line) with observed data (grey dots) for 2003. Left: aggregate tritrophic model. Right: full species model.

 $\frac{\partial N_i(m)}{\partial t} = -\frac{\partial}{\partial m}(g_i(m)N_i(m)) - \mu_i(m)N(m)$ where  $N_i(m, t) dm$  is the density of fish species *i* with size in [m, m + dm], and

- $g_i(m) =$  growth from consumption of smaller organisms (Fig 2),
- $\mu_i(m)$  = predation, starvation, and background mortality,
- energy towards reproduction governed by species' traits (Fig 2).



Figure 2: Left: prey selection function for a 100g predator with preferred pred/prey mass ratio ( $\beta$ ) of 100. Right: Proportion of aquired energy allocated to reproduction as a function of mass.

- Predators exert weak control over forage fish ( $\theta_{pf}$  small).
- Forage fish strongly coupled to predators ( $\theta_{fp}$  large).
- Greater flow of resources to forage fish than predators  $(\theta_{fr} > \theta_{pr}).$



## Conclusions

- Model supports predator-prey role reversal and competition as important mechanisms in shaping community structure.
- Difficult to capture small size classes greater uncertainty in the data.

We apply this model to a tri-trophic community (Fig 3), and consider:

- an aggregate three tropho-species model,
- a full model where each species is modeled separately.

Size-independent food web structure is modeled through coupling matrix  $\theta$ .

#### **Parameter Estimation**

• Estimate  $\theta$  by minimizing SSE between data and model over 10 years (1993 - 2003).

#### References

(1) Fisher et al. (2010) *Ecology*: 2499 – 2505. (2) Hartvig et al. (2011) Journal of Theoretical *Biology*: 113 – 122.

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