

Update on Ecopath with Ecosim modeling of Central Puget Sound: planktivorous fishes

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How the food web model works

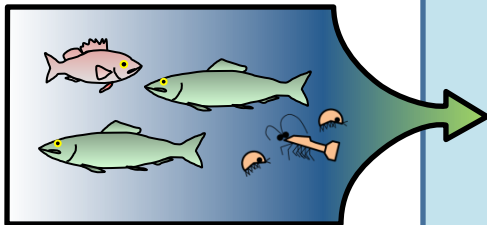
Start with one group of interest, let's say a salmon.
Use some data and basic math to ask:

How many of them are there?

How many get caught per year?

How much do they grow per year?

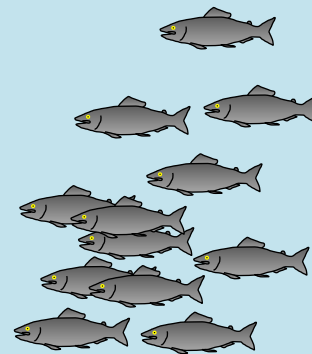
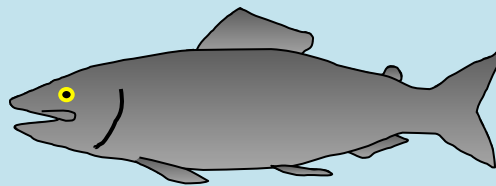
What do they eat?



How much do they eat per year?



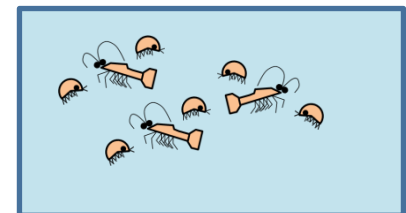
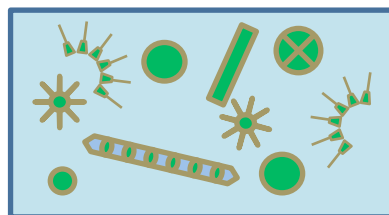
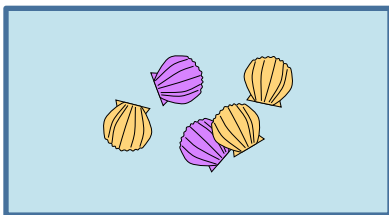
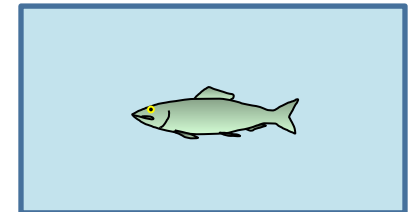
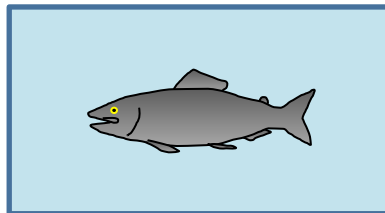
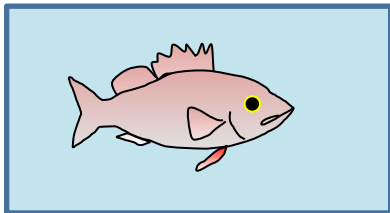
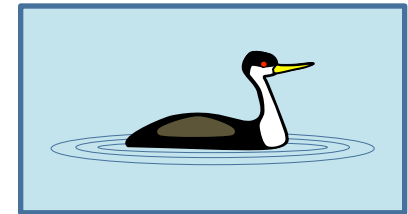
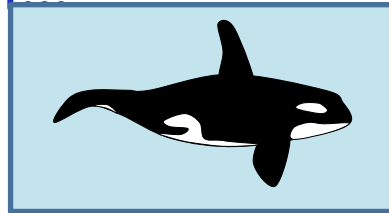
How long do they live?



How many offspring do they produce?

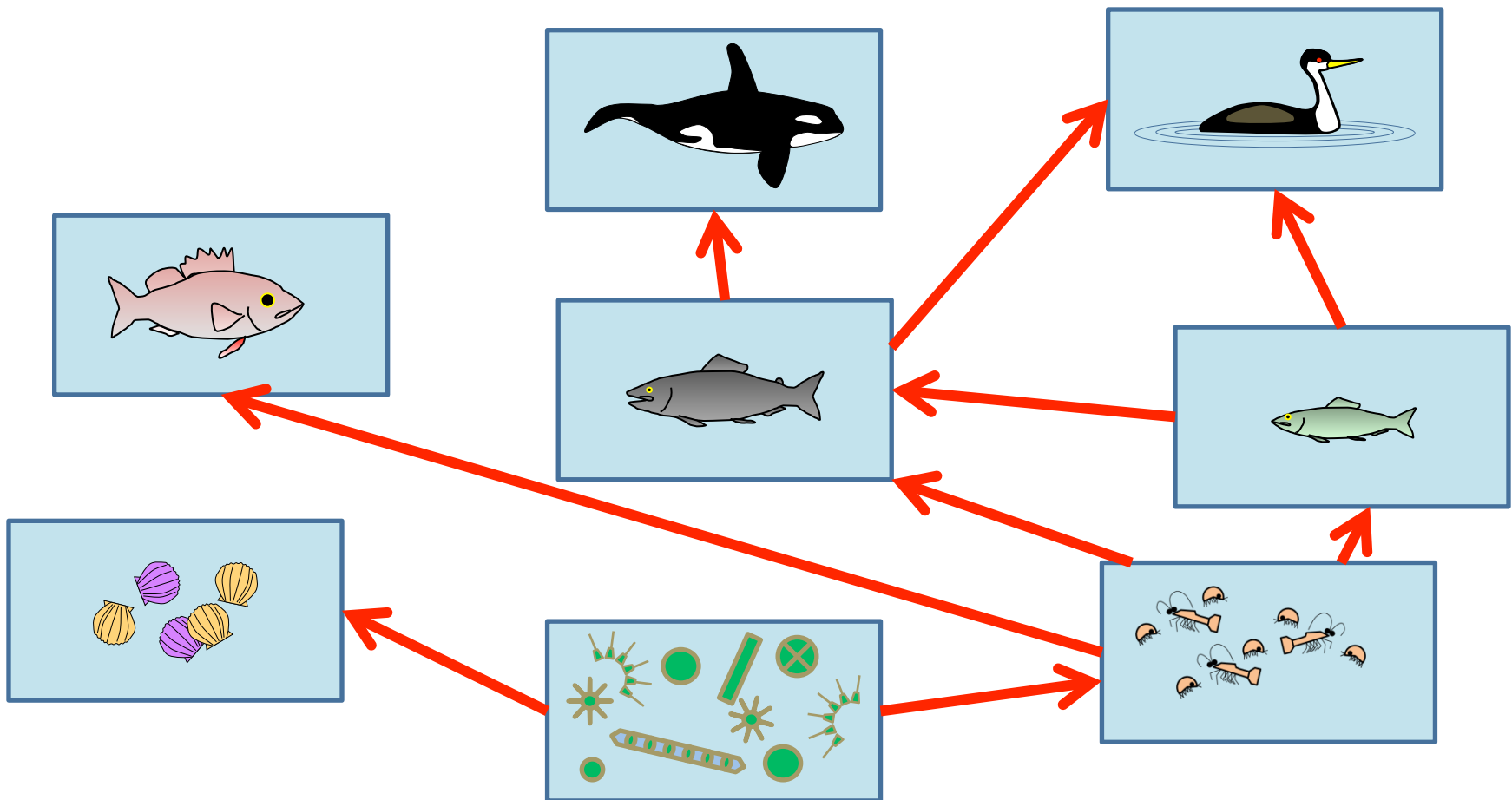
How the food web model works

Make similar calculations for other groups
you're interested in



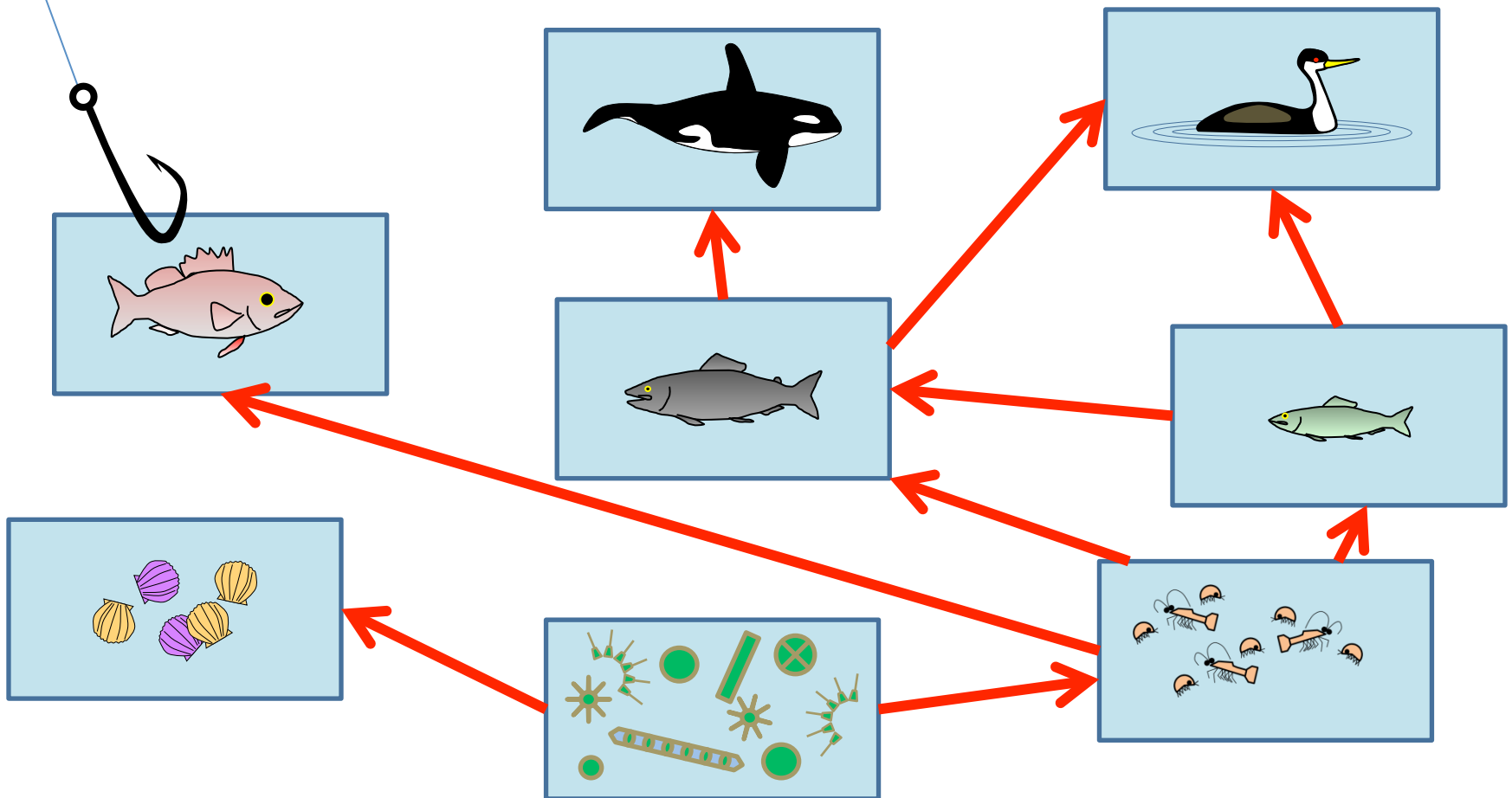
How the food web model works

...then connect them together by who eats whom:

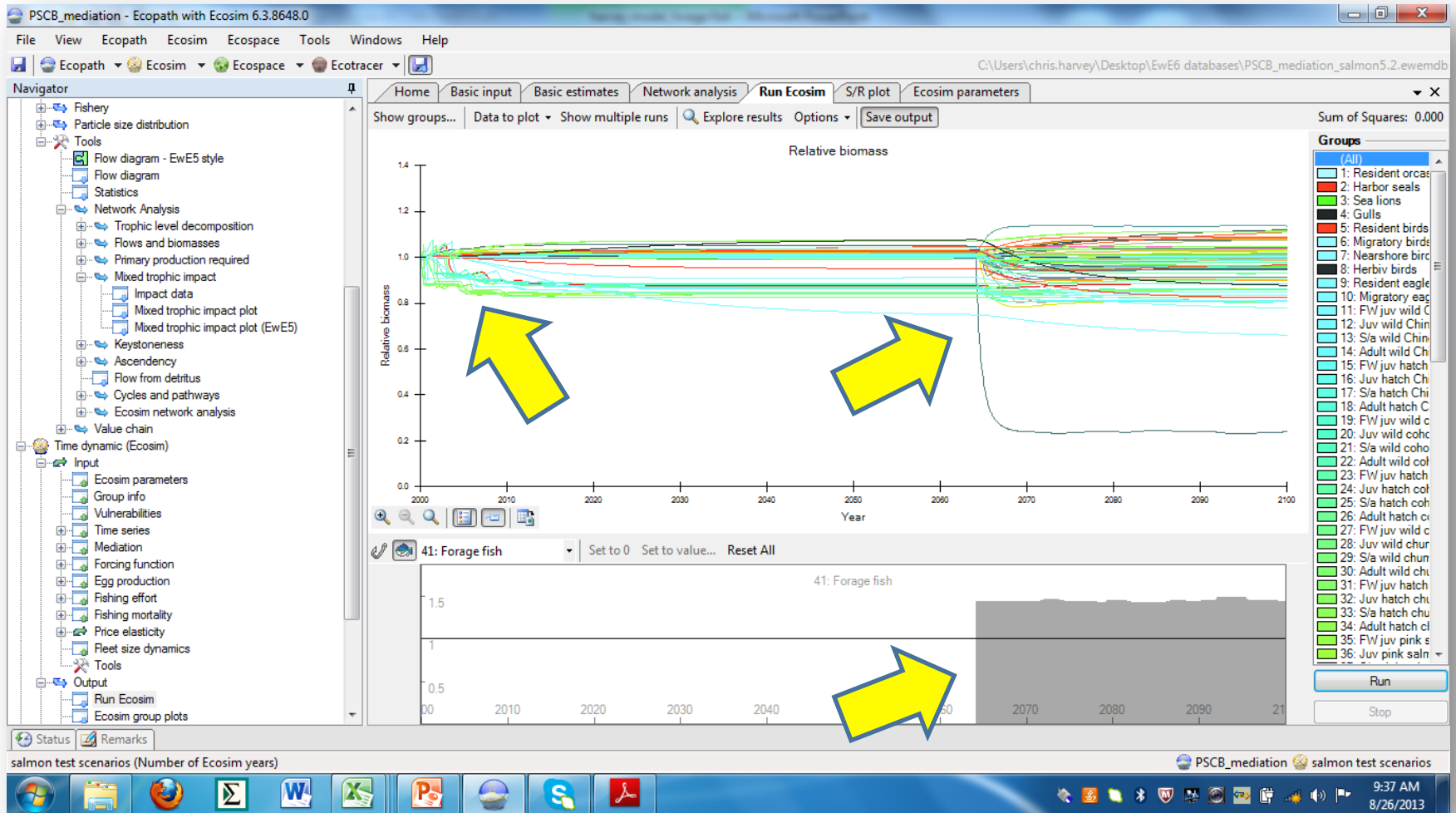


How the food web model works

Now, “perturb” the web and see how groups respond:

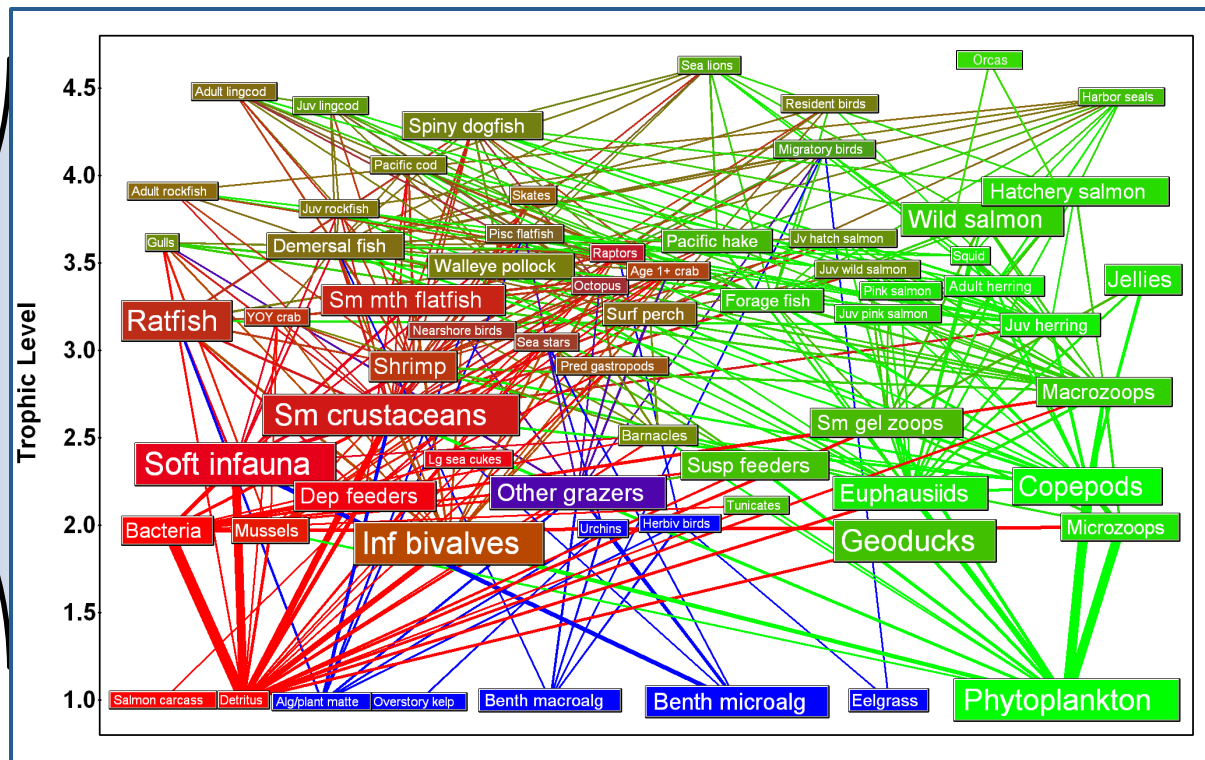


Screen capture of a model simulation



Central Puget Sound food web model

- ~70 functional groups, 15 different fishery types
- Direct links: mainly predator-prey interactions
 - 11 groups have age structure
- Model is intended for asking coarse-scale, strategic questions



Timeline of modeling progress

- 2008-2009: initial model development: Central PS circa 2000
 - NOAA tech memo (Harvey et al. 2010)
- 2010: calibration against historic time series, 1980-2000
 - Harvey et al. 2011, *Estuaries and Coasts*
- 2011-2012: scenarios related to roles of eelgrass, bald eagles, ocean acidification & tidal energy in PS
 - Plummer et al. 2012, *Ecosystems*; Harvey et al. 2012, *Canadian Journal of Zoology*; Busch et al. 2013, *ICES Journal of Marine Science*; Busch et al., *Conservation Biology*, in press
- 2013: revisiting, refining original model
 - Testing different functional forms, e.g., habitat effects
 - Improving salmon life history
 - **Forage fish**

Planktivorous fish groups in the model

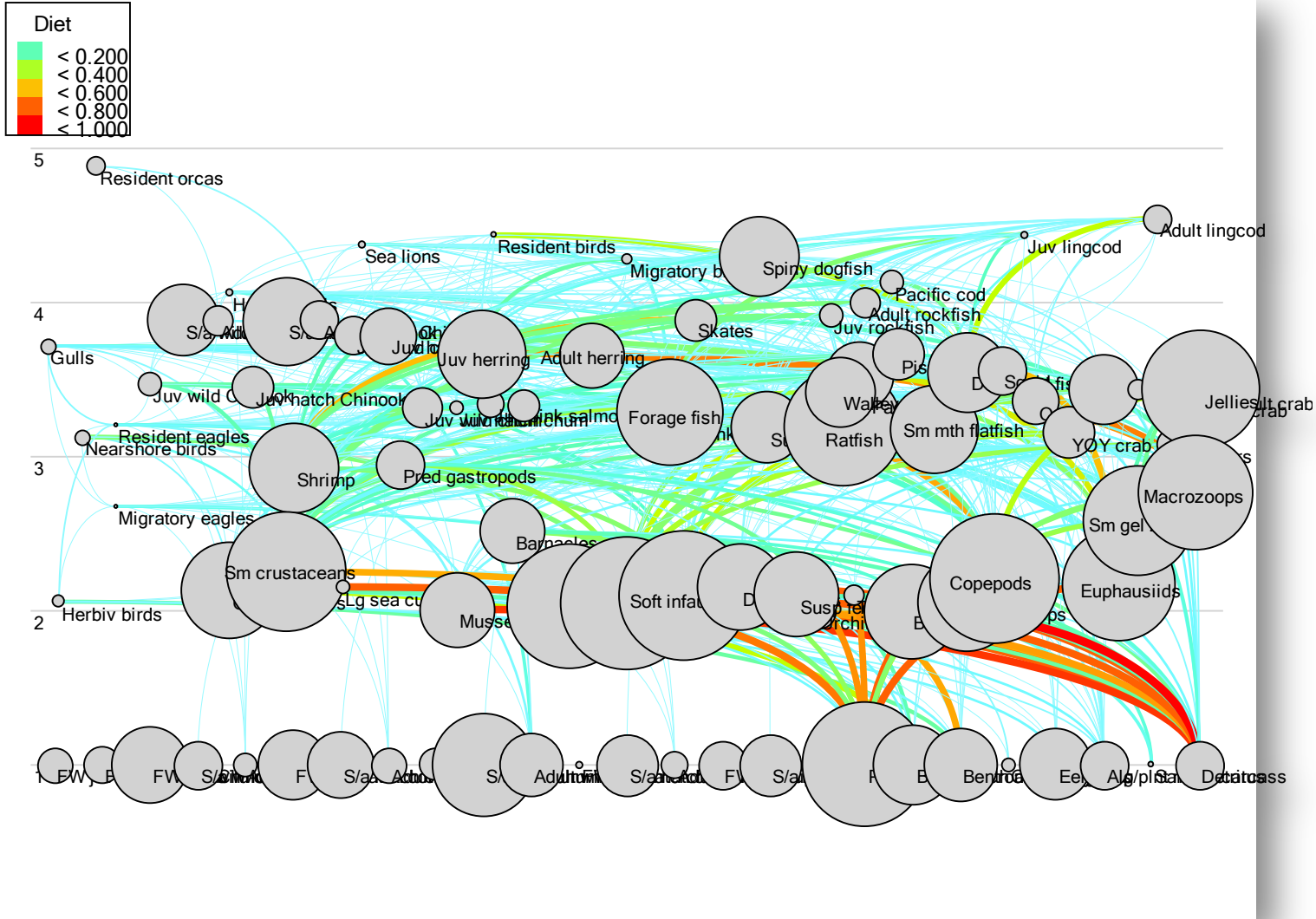
- Pacific herring, which are age-structured
 - Juvenile (< age 2)
 - Adult (age 2+)
- “Forage fish,” an aggregate group
 - Surf smelt
 - Sand lance
 - Sticklebacks
 - Etc.



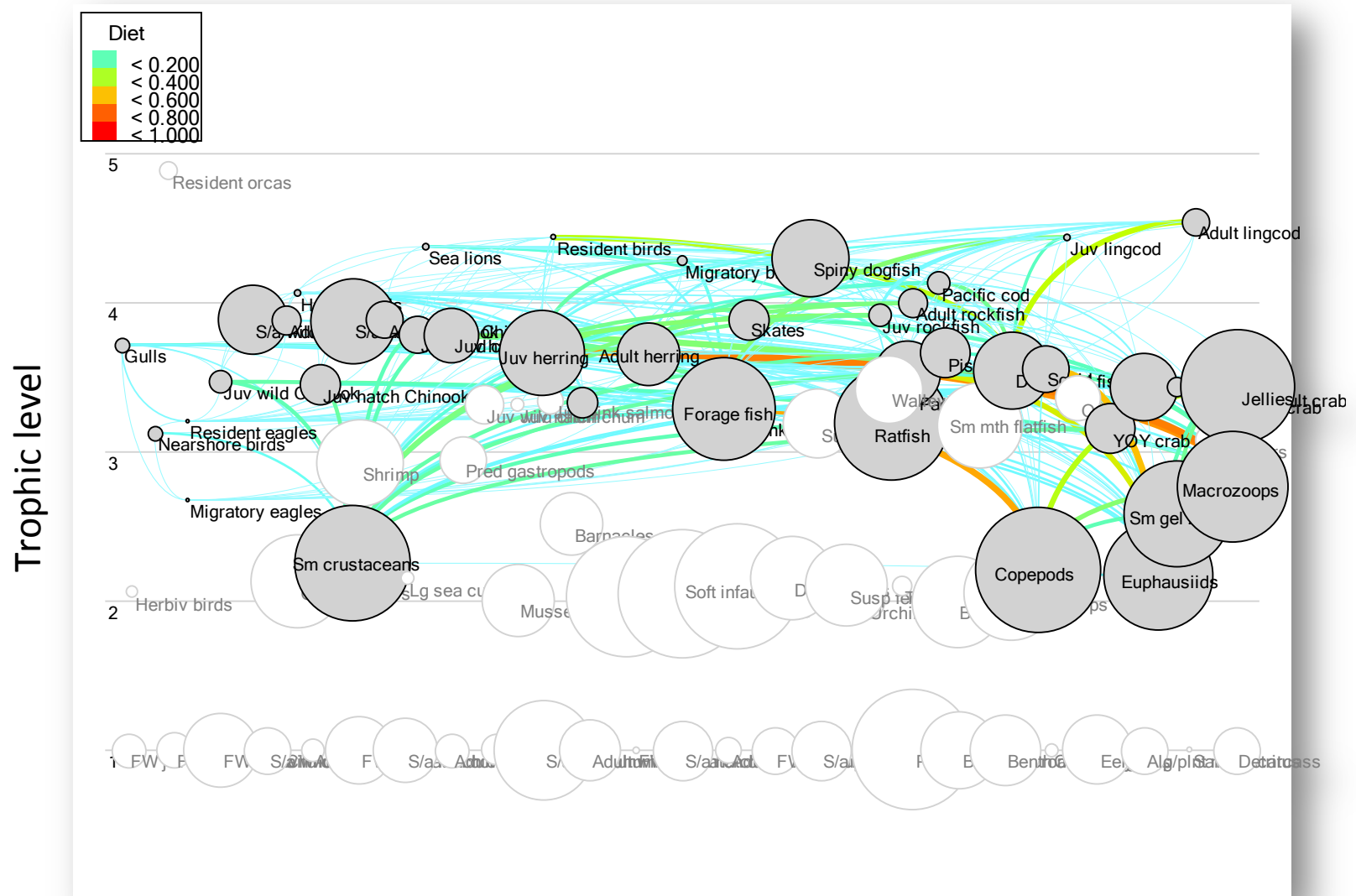
Sources of parameter estimates

Parameter/data	Juvenile herring	Adult herring	Forage fish
Life history	Stout et al. 2001, Stick 2005, Penttala 2007		Penttala 2007
Biomass	Ecopath estimate (mass balancing)	WDFW assessments (Stick 2005)	Ecopath estimate (mass balancing)
Total mortality	WDFW assessments (Stick 2005)		Derived from other EwE models
Consumption	Bioenergetics modeling (Harvey, unpub., based on Megrey et al. 2007, Beauchamp and Duffy 2011)		Derived from other EwE models
Diets	Beauchamp and Duffy 2011		Miller et al. 1977, 1980; Fresh 1981
Growth rate (VBGE)	Gunderson and Dygert 1988		n/a
Landings	M. Plummer, unpublished data (from PacFIN and RecFIN)		

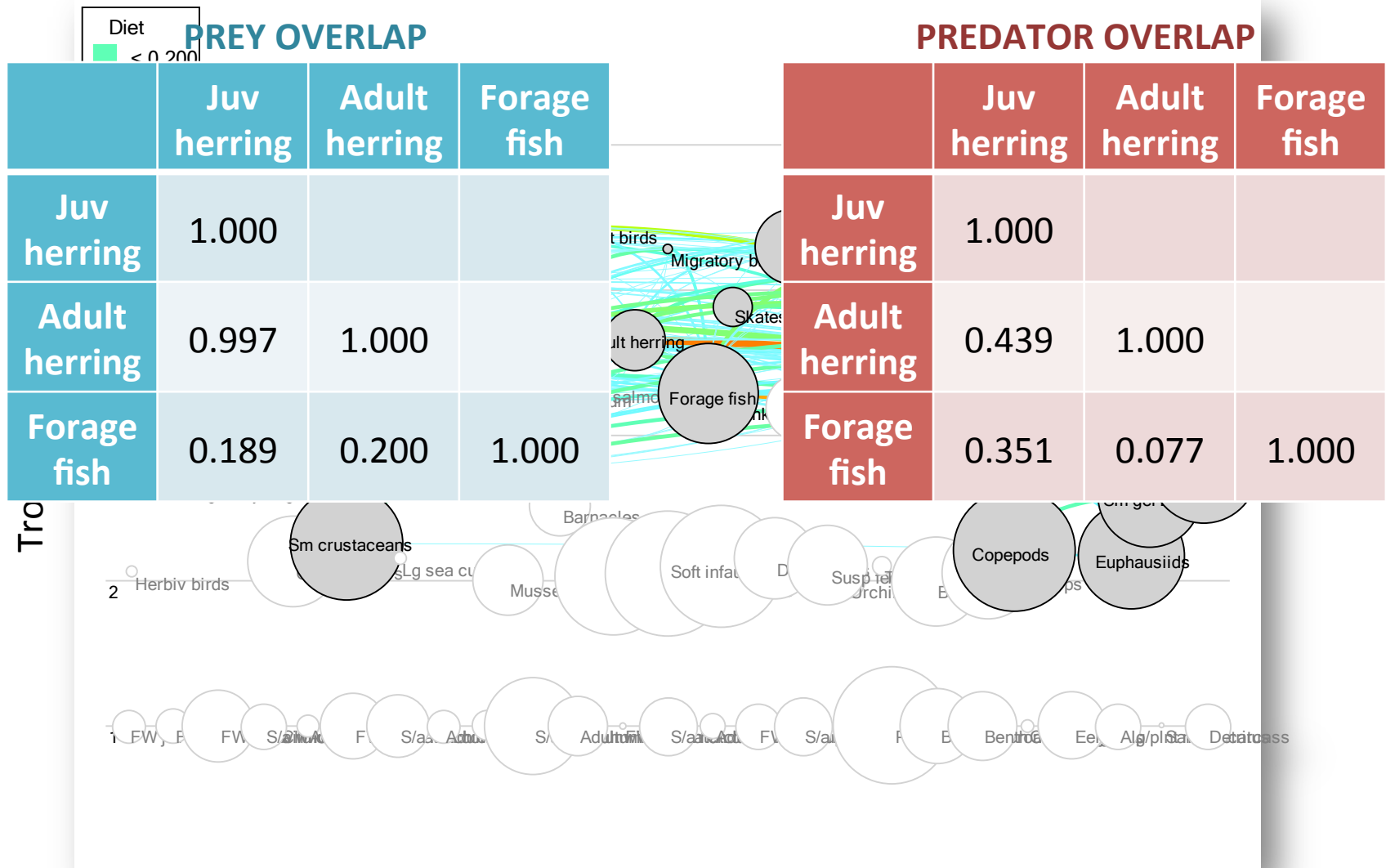
Flow diagram: whole system



Flow diagram: planktivore-focused

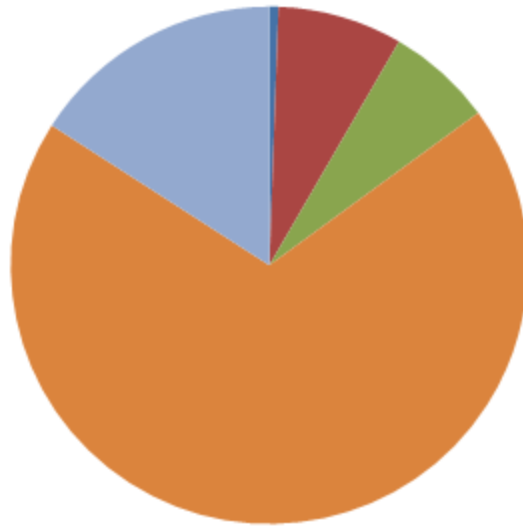


Flow diagram: planktivore-focused



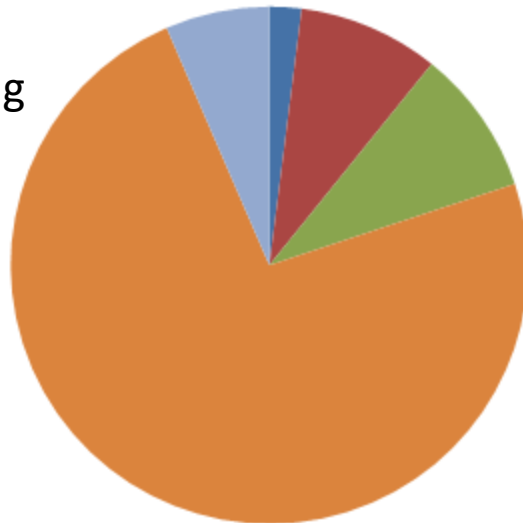
Breakdown of diets

Juvenile herring

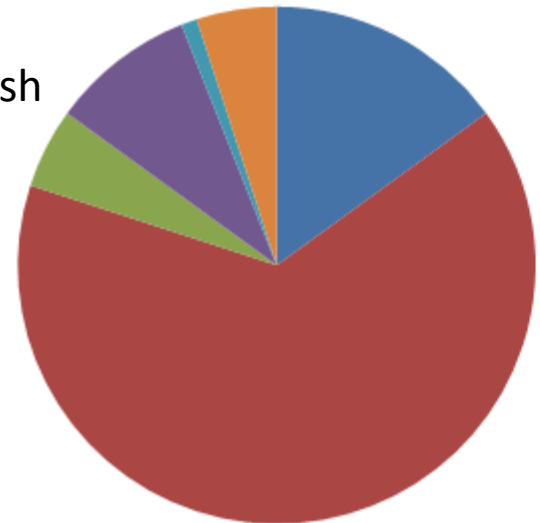


- Sm crustaceans
- Copepods
- Euphausiids
- Sm gel zoops
- Jellies
- Macrozoops
- Other ("import")

Adult herring

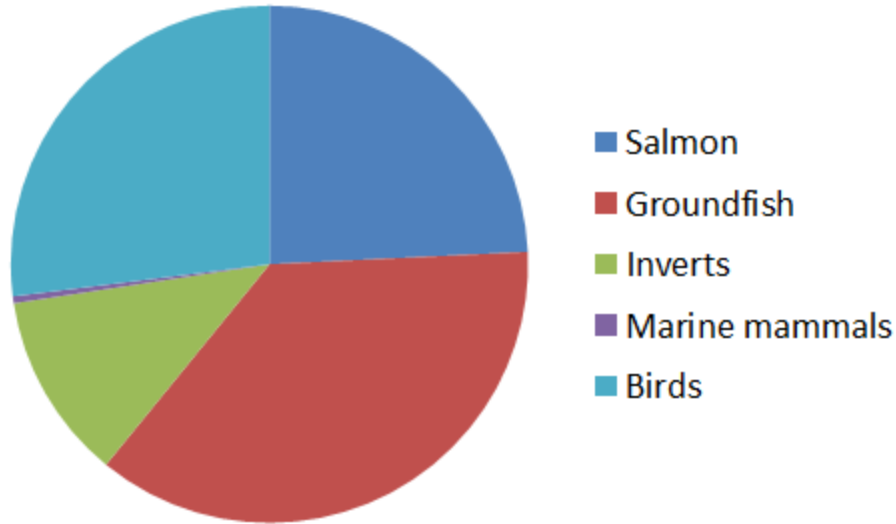


Forage fish

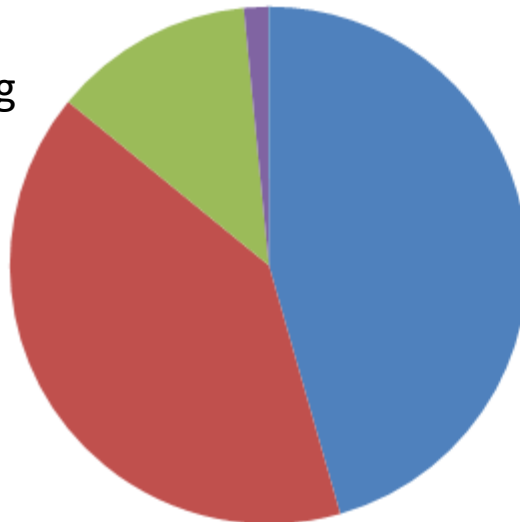


Breakdown of predation mortality

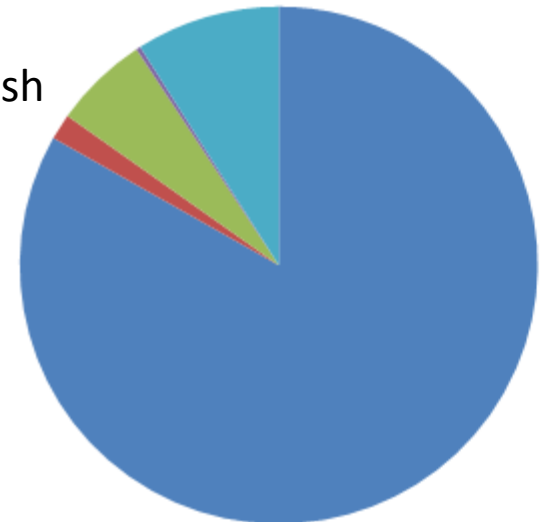
Juvenile herring



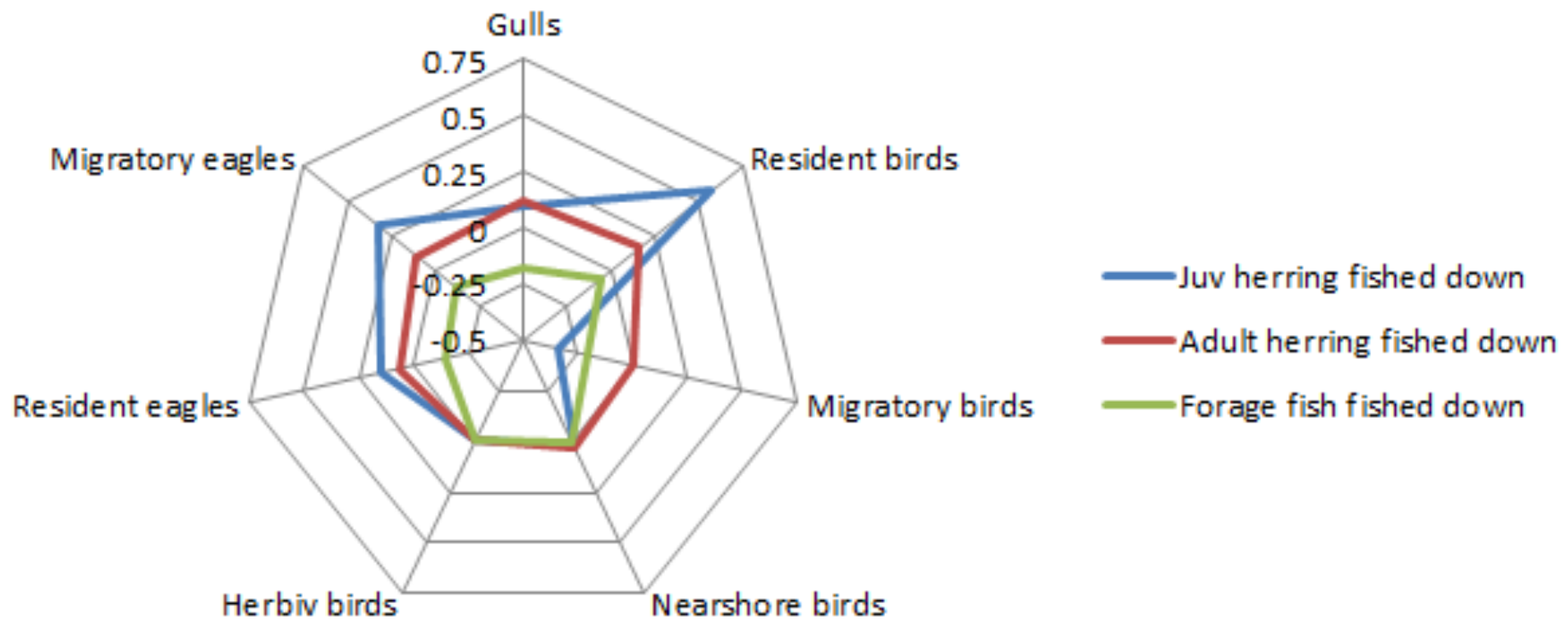
Adult herring



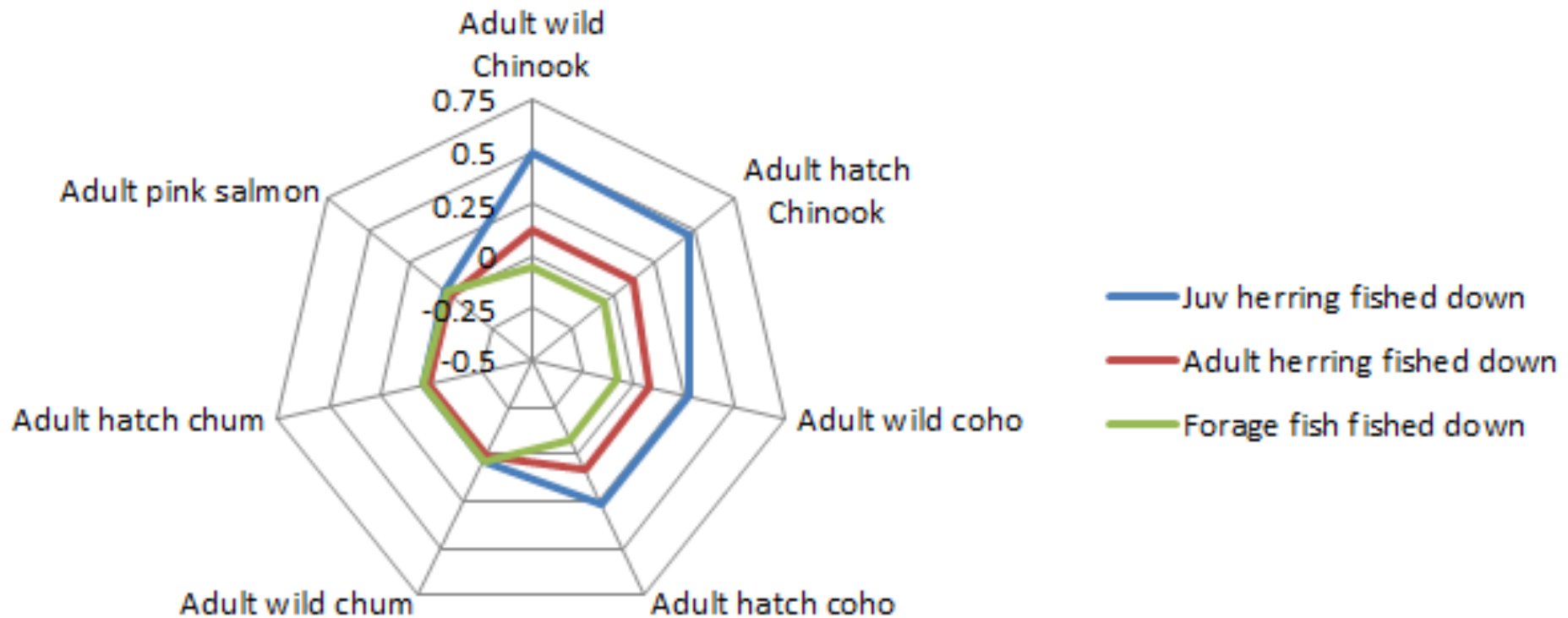
Forage fish



How consumers respond to changes

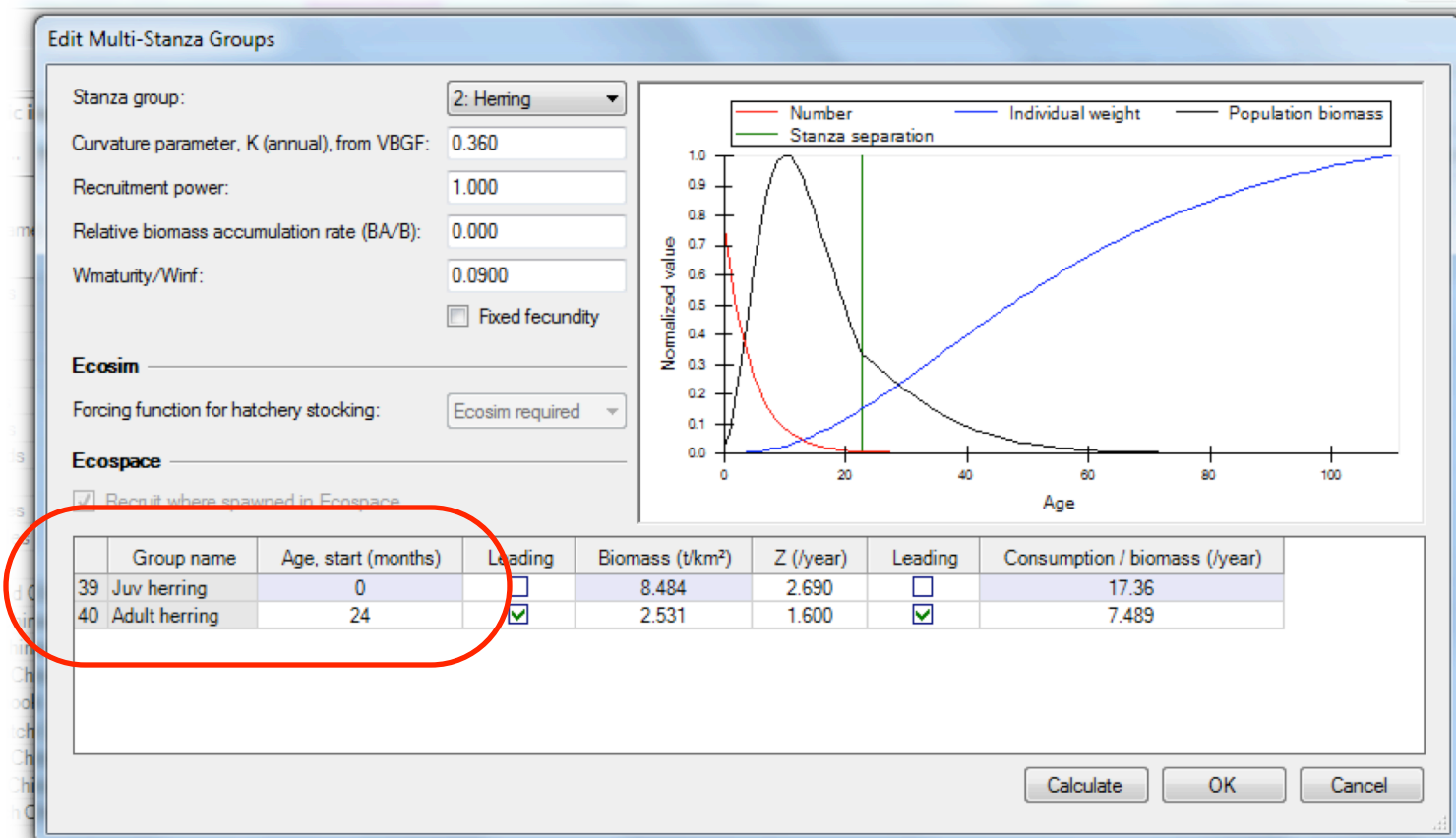


How consumers respond to changes



Multi-stanza life histories in Ecopath with Ecosim

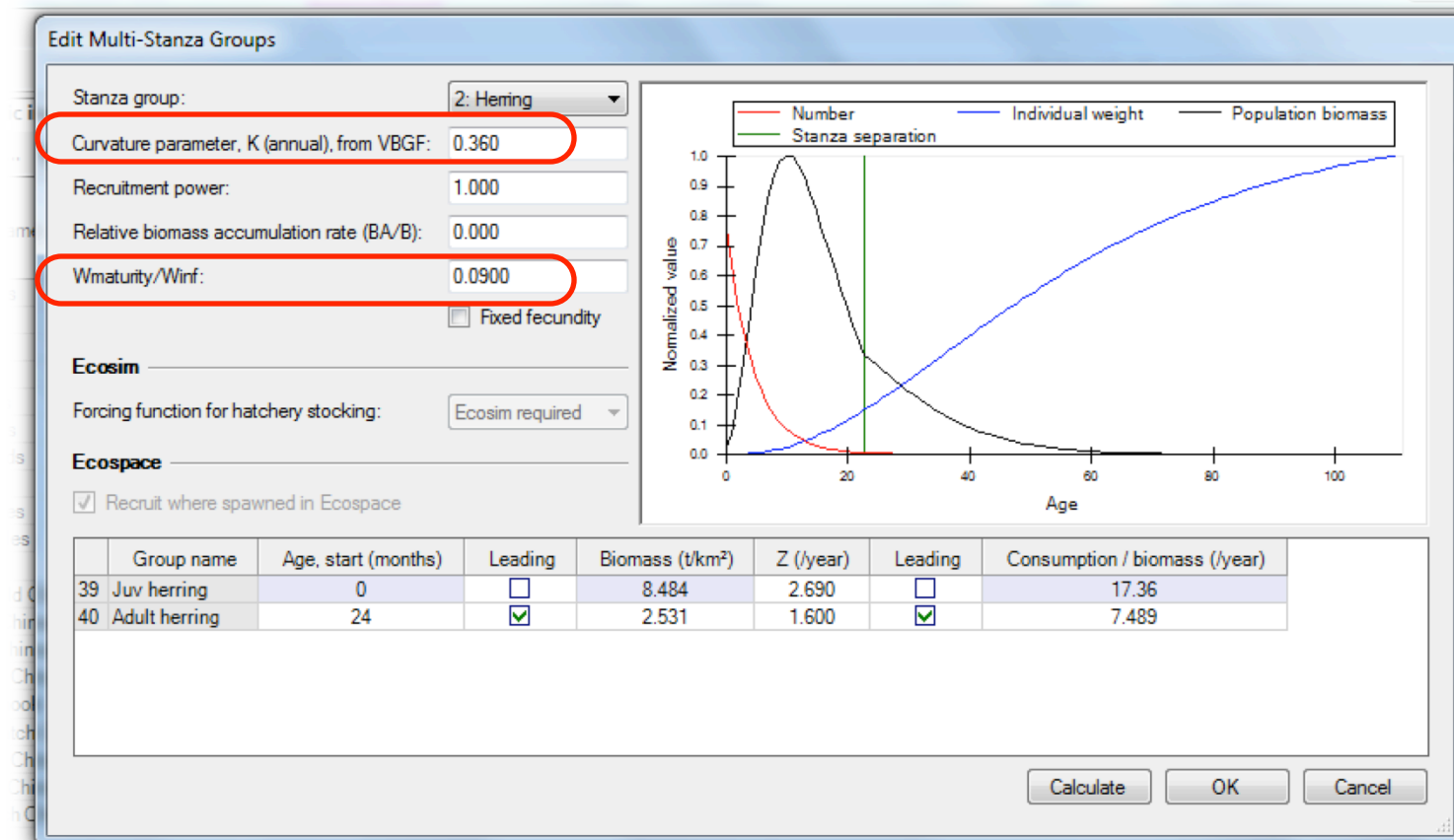
- Documentation on using multi-stanzas is not very detailed
- Model behavior is pretty sensitive to this, so I've been “experimenting” quite a bit, though mainly with salmon groups



Two age stanzas;
is that suitable?

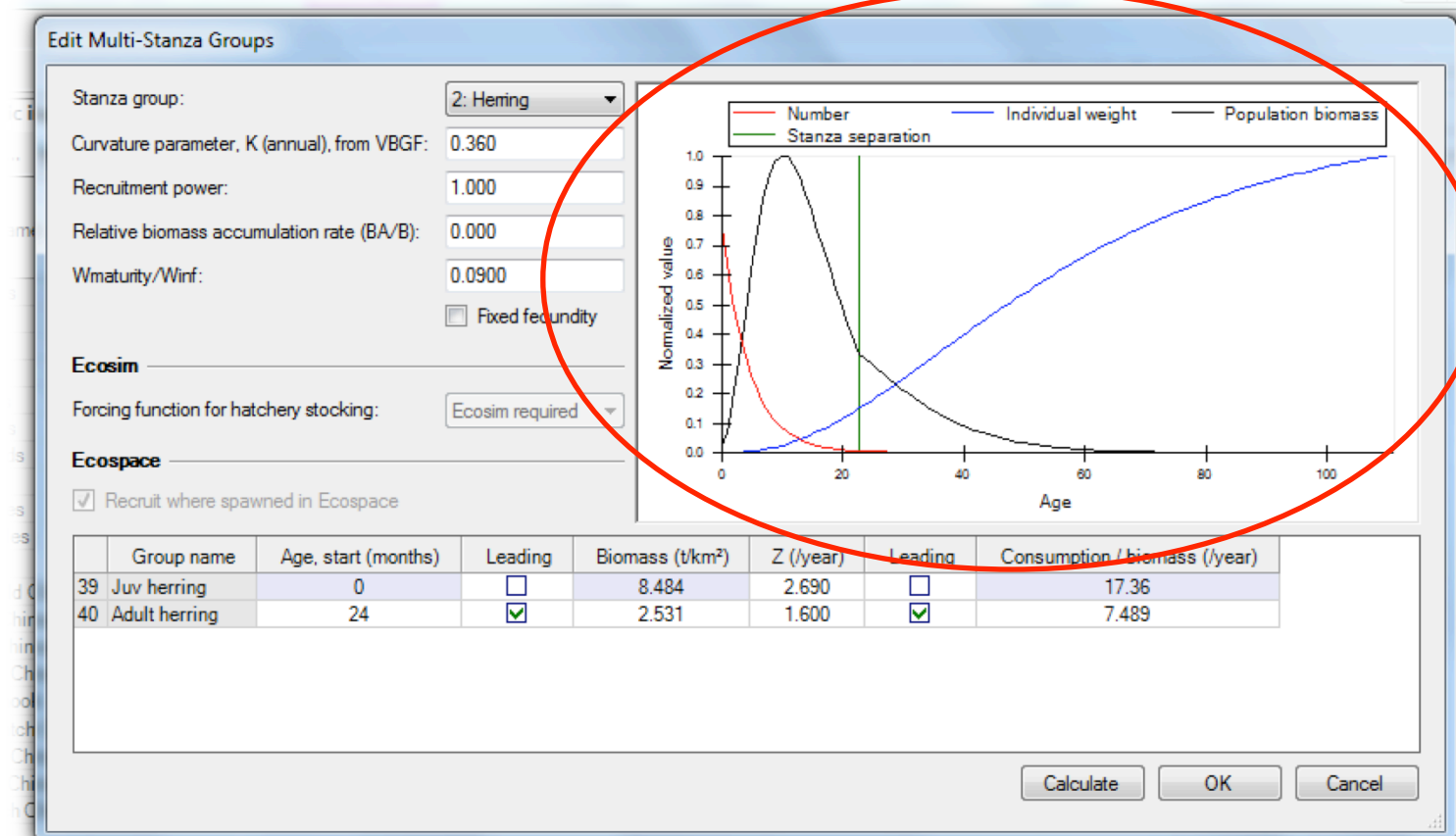
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Multi-stanza life histories in Ecopath with Ecosim

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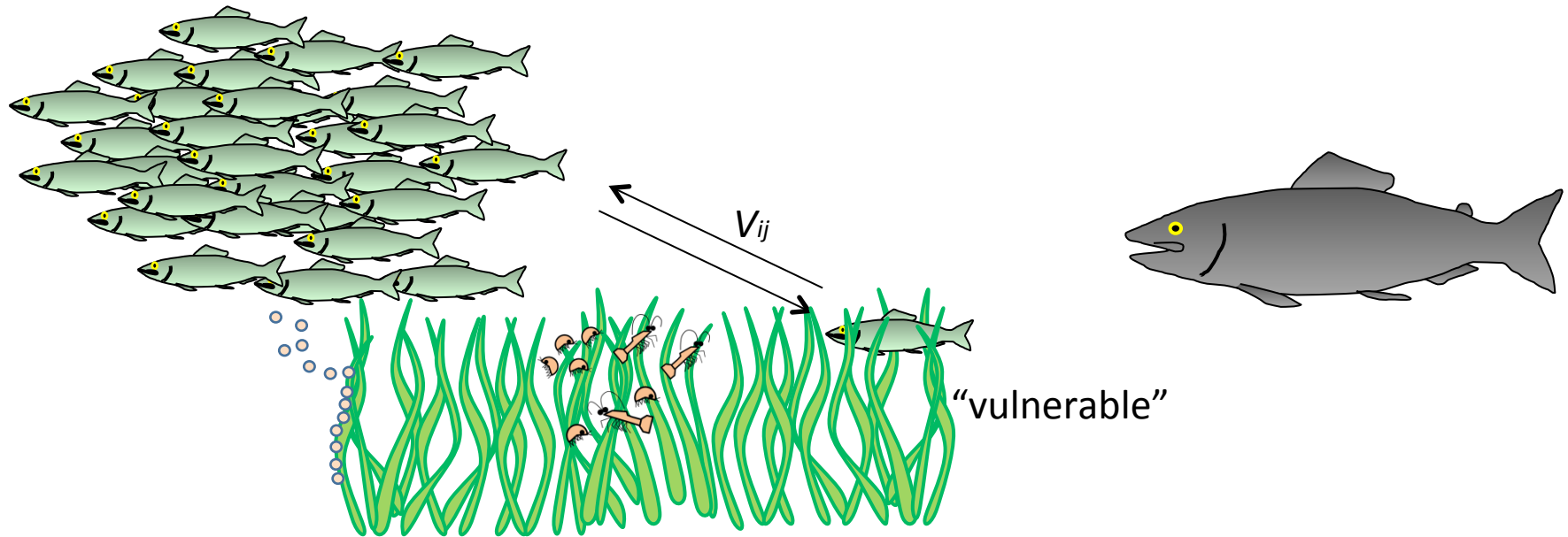




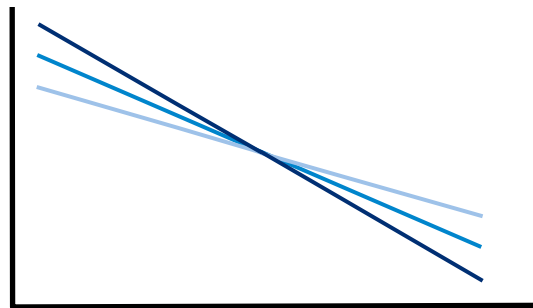
- Similarity of juvenile and adult herring diets leads to “competition”
- This has made simulating the life history dynamics complicated
 - Example: fishing adults enables juveniles to grow faster and reach reproductive size; can’t fish them to extinction even at outrageous F levels
- Solutions are awkward: e.g., making herring fecundity fixed and increasing size at maturity
- Issues this reveals:
 - Herring diet ontogeny at finer scale than is represented in model?
 - Food web dynamics and complexity at the level of NPZ-FF
 - Predator diet studies with “herring” rather than juvenile or adult herring

Mediation functions for habitat effects

“invulnerable”

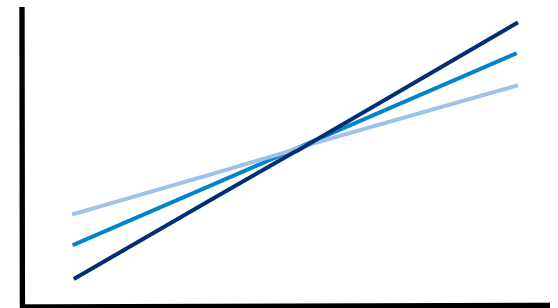


Predation
mortality rate



Biomass of eelgrass

Foraging
efficiency
or
Juvenile
production



Biomass of eelgrass

So, in a nutshell...



- This model is, and will always be, a work in progress
- Progress right now is primarily driven by:
 - Indicator questions (PSEMP working groups)
 - Salmon questions (LLTK early marine survival group)
 - Simulating contaminant flows
 - Future scenarios
- But obviously, gaps remain in my understanding and model capabilities, and model updates require sensitivity testing
- Please think of this as a flexible, collaborative tool, and of me as a collaborator, if you have ideas and see potential
- Your feedback is welcomed (Chris.Harvey@noaa.gov)