Utility of Bioenergetics Models in Grand Canyon Fisheries Research

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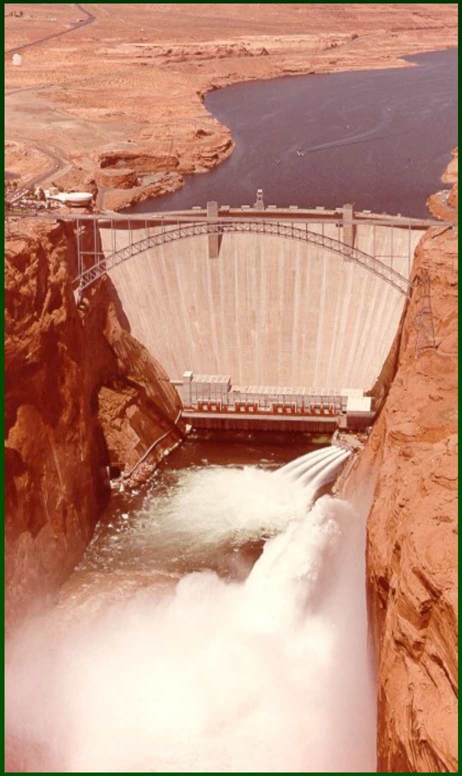
Management alternatives

- Temperature changes
- Predation by non-native fish



What temperatures are needed?

How will temperature change affect fish growth and food resources?

What interactions can be expected between temperature change, chub growth, and predation?

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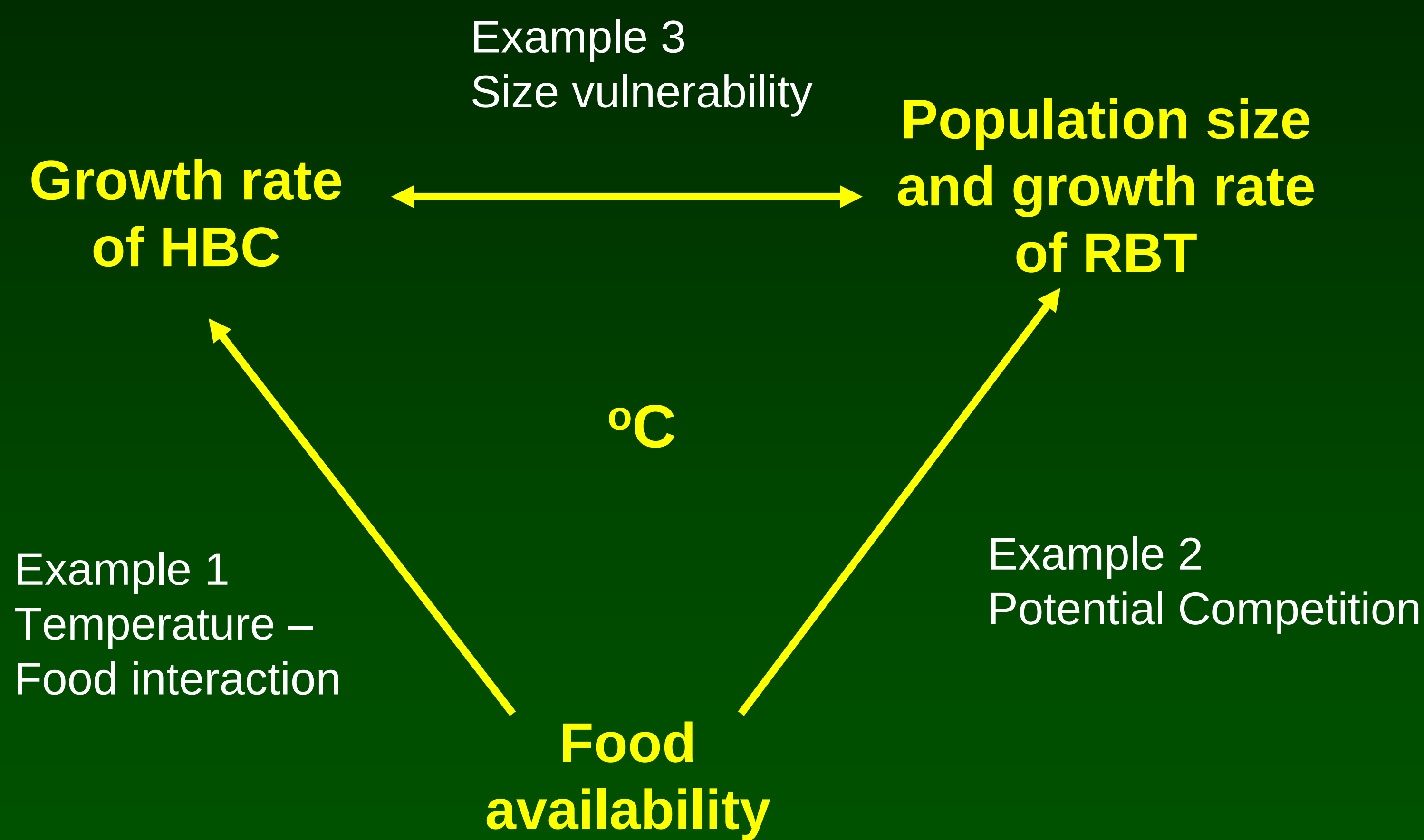
Complex questions



Bioenergetics modeling

•A tool for management and research
•Models developed for many species (48), including warm, cool, and cold-water species.
•Especially useful for evaluating questions about temperature and food limitation.



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Model structure

Growth = Consumption – (Respiration + other costs)

Consumption = aW^{b} * Food availability * f(Temperature)

Respiration = cW^{d} * f(Temperature) * Activity

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Input data for models

Growth increment
Season or period of growth
Diet
Temperature
Energy density of predator and prey

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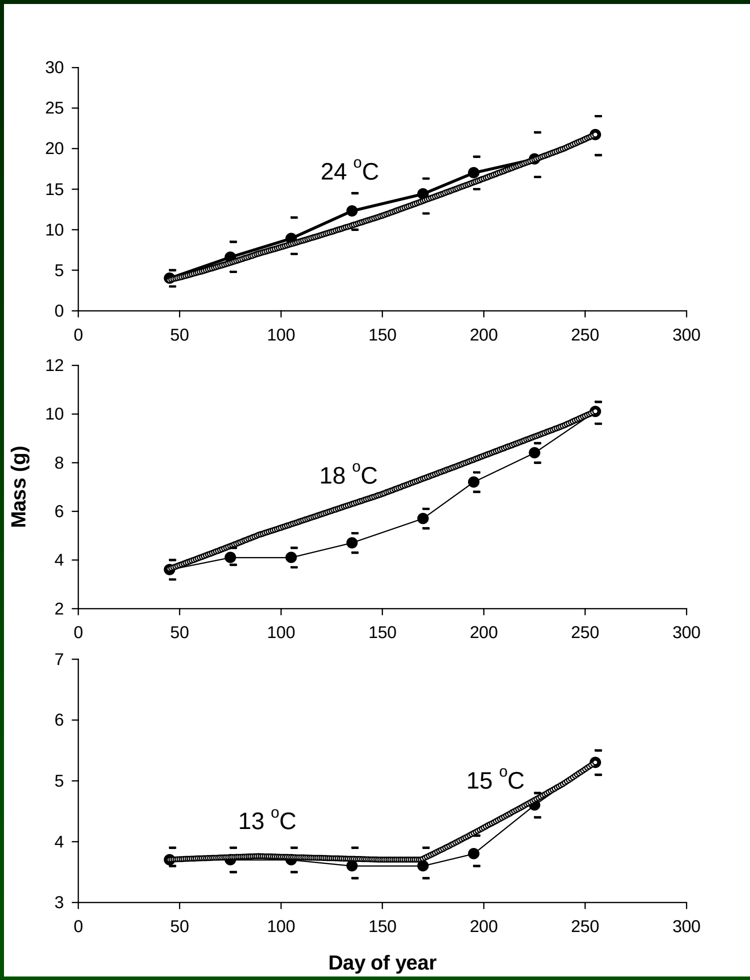
Fitting parameters for humpback chub

- Determine parameter bounds for Cyprinids and *Gila* species
- Monte Carlo filtering procedure
- Fit to laboratory growth experiments at 13 – 24 °C



Corroboration

Juvenile growth in lab
(Clarkson and Childs 2000)
Juvenile and subadult growth in LCR
(Robinson and Childs 2001)
Subadult growth in COR
(Valdez and Ryel 1995; GCMRC)

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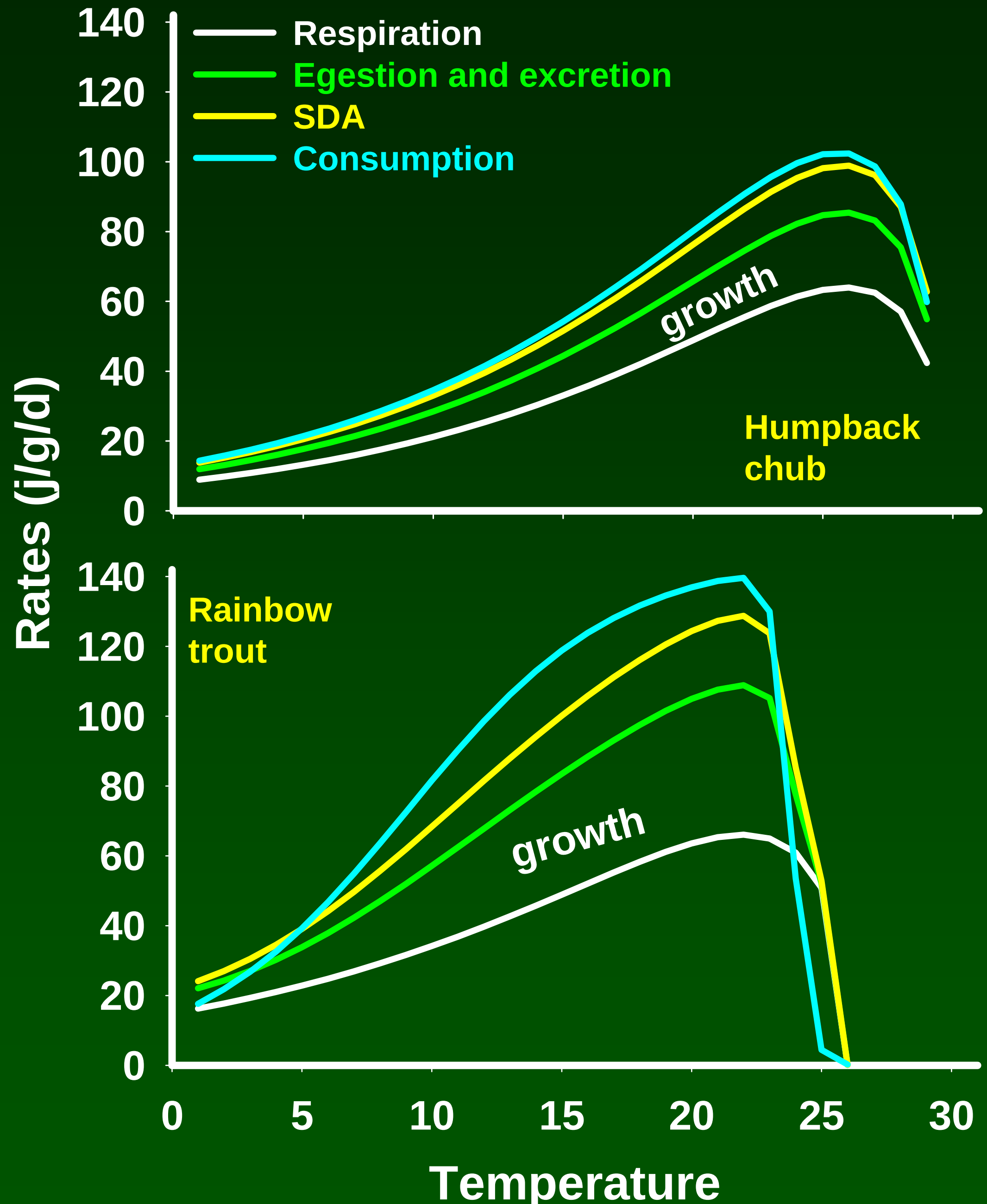
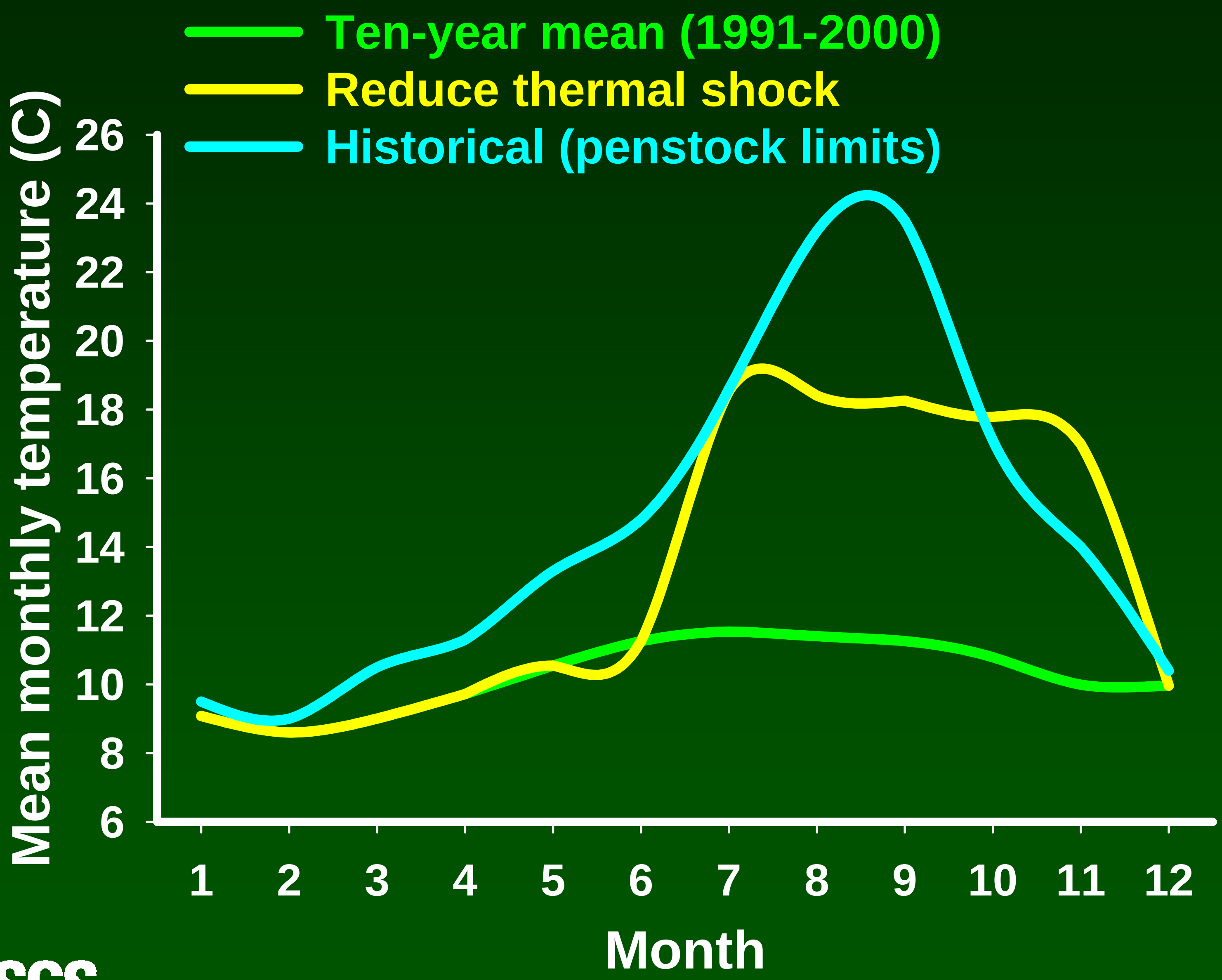

Respiration
Egestion and excretion
SDA
Consumption
growth
Humpback chub
Rainbow trout
growth
Rates (j/g/d)
0
20
40
60
80
100
120
140
0
5
10
15
20
25
30
Temperature

Temperature Scenarios



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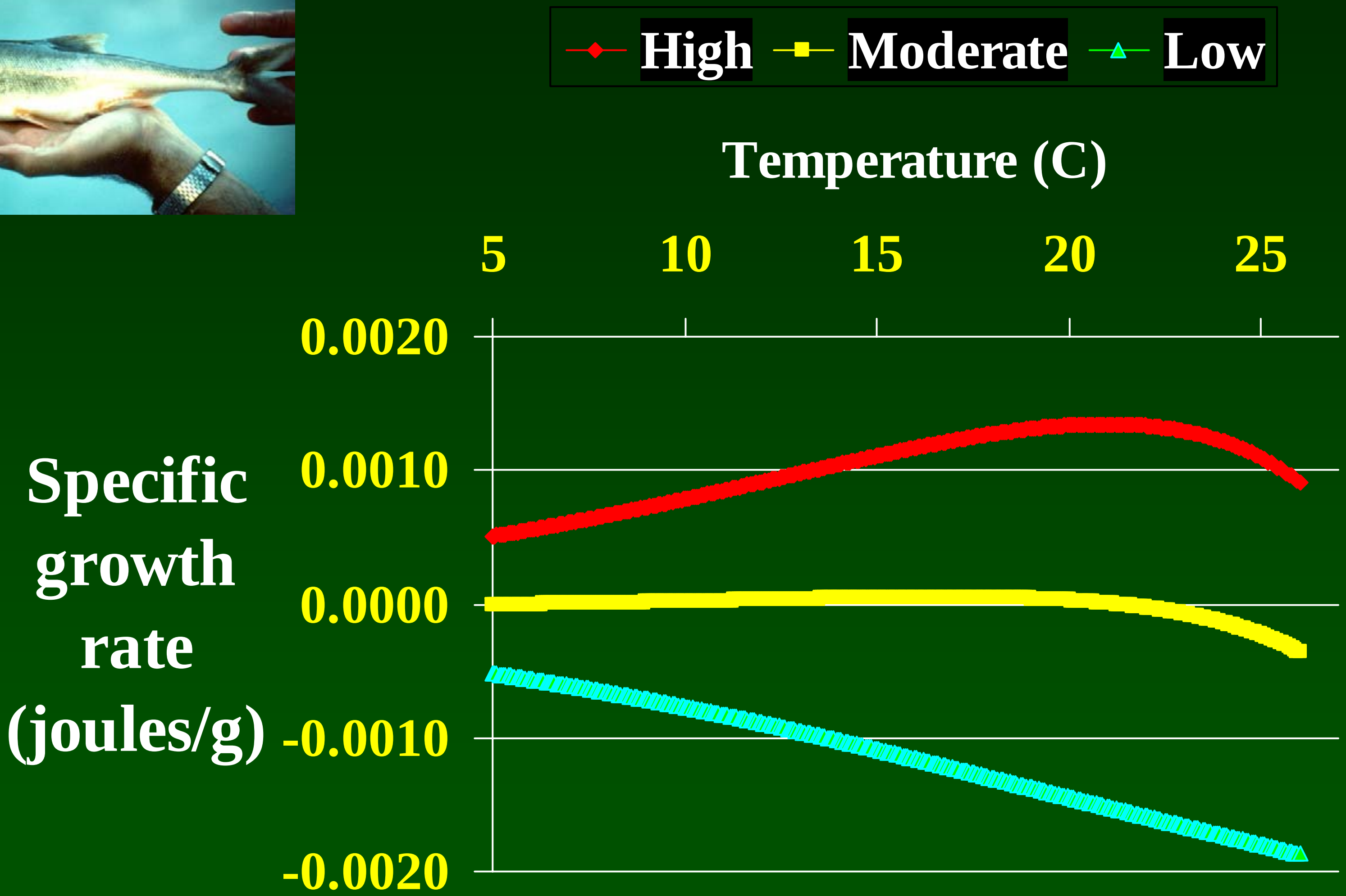
Example 1 – Food and Temperature interactions



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Example 2 – Potential Competition

Diet (%)

Taxa or group	Energy density J/g wet wt.	Subadult humpback chub	Rainbow trout
Chironomids	2744	7	5
Cladophora	1122	16	12
Gammarus	3389	32	5
Simuliids	2565	32	41
Terr. Inverts.	3050	12	33
Aqu. Inverts.	3176	1	
Other diptera	2565		4
Fish	4000		<1

Valdez and Ryel (1995)
GCMRC unpublished data

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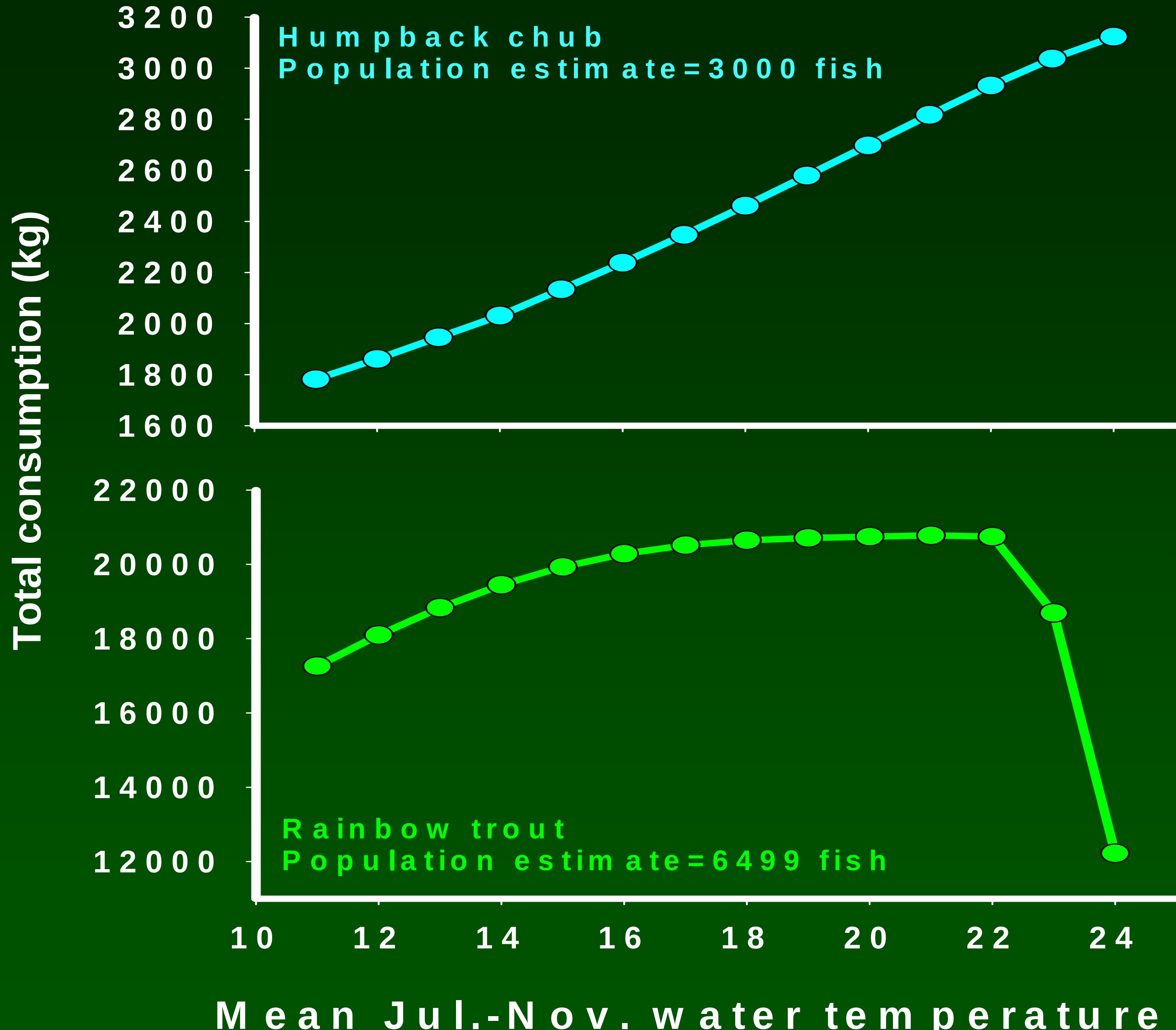
Example 2 – Potential Competition



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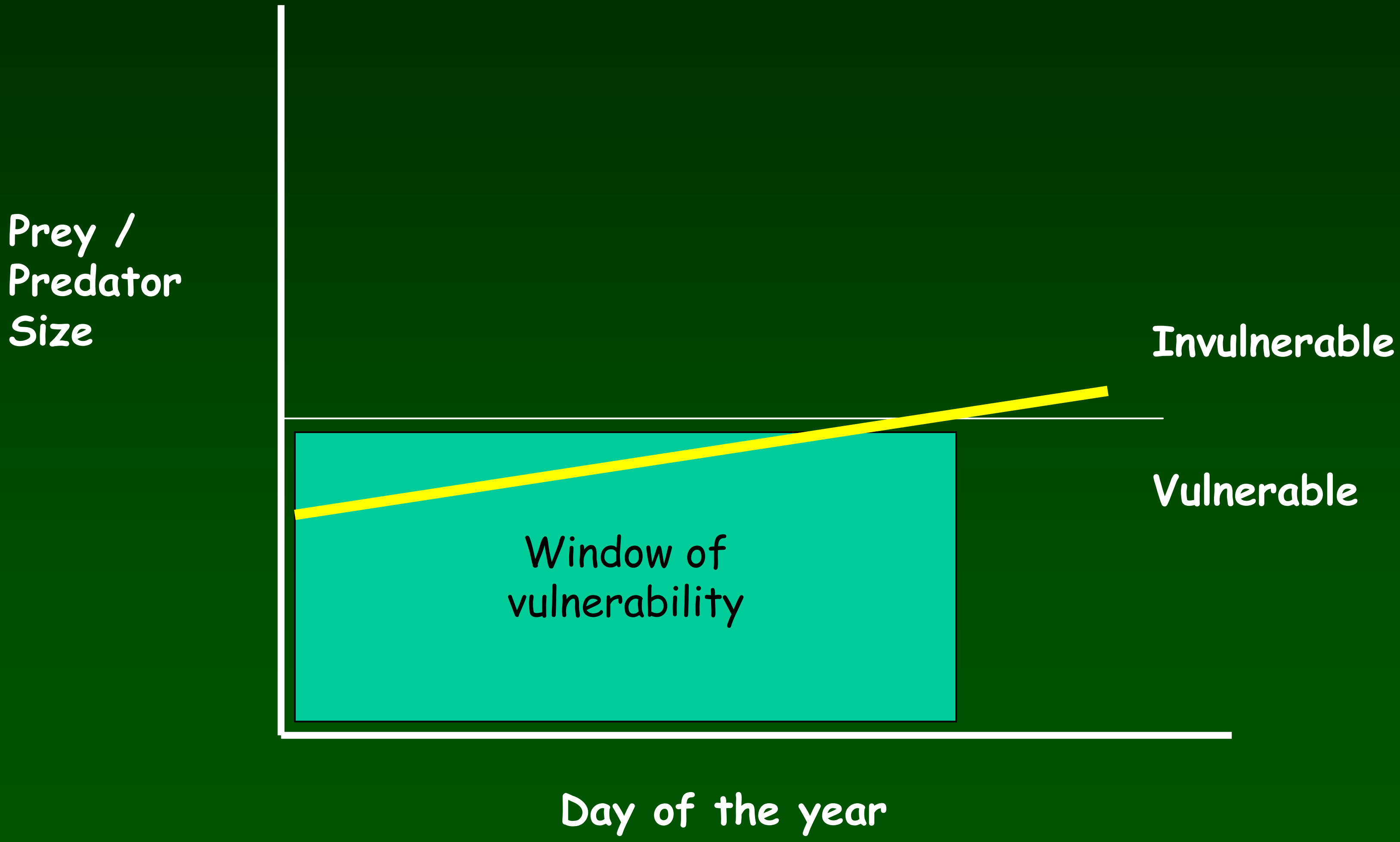
Example 3 – Size vulnerability



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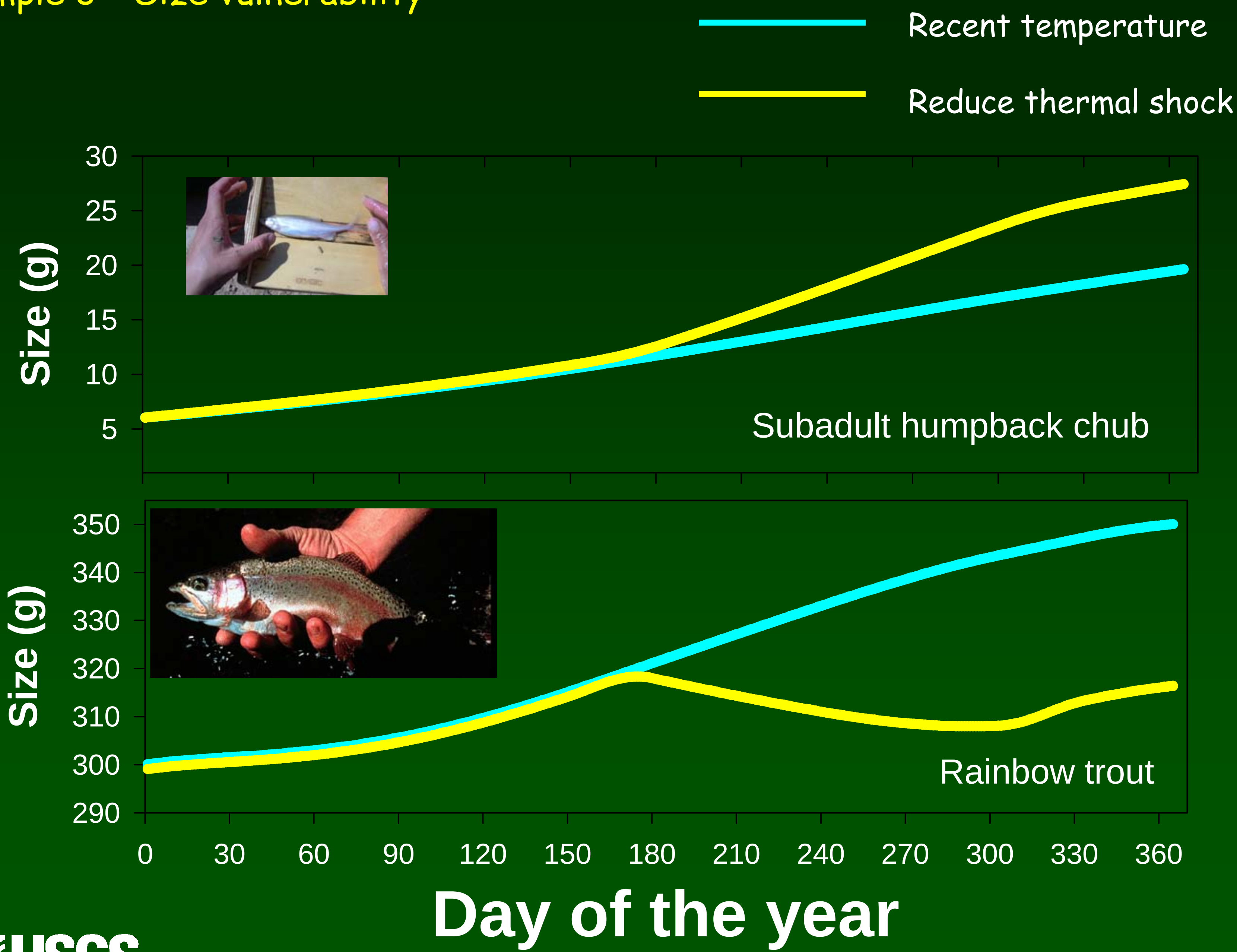
Example 3 – Size vulnerability



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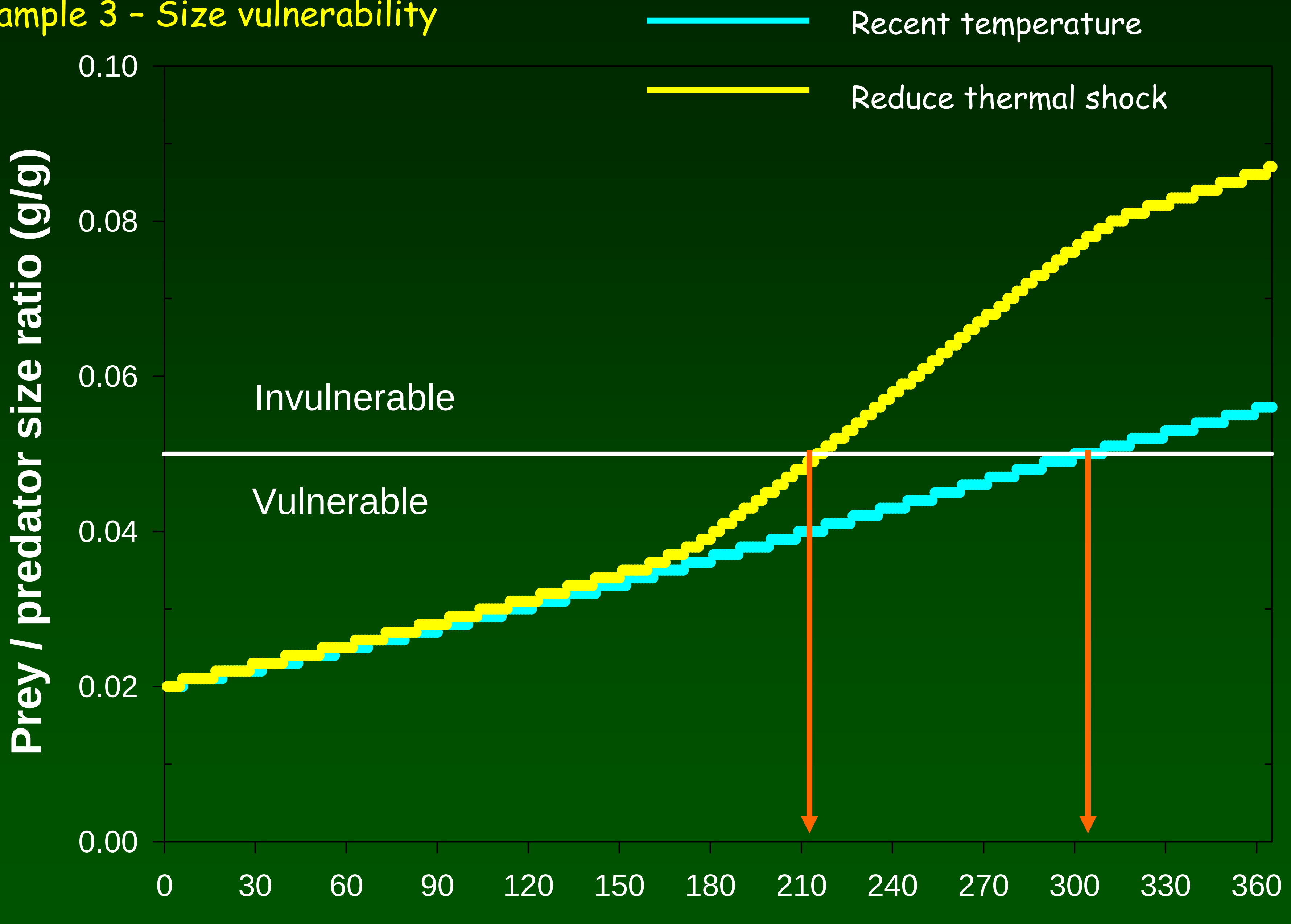
Example 3 – Size vulnerability



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Conclusions

- Bioenergetic models should be useful for evaluating various complex questions about physical change and trophic level response.
- Models may help to determine important measures or metrics to evaluate system response (e.g., humpback chub growth)
- Results can help to identify the “best” timing and magnitude of a TCD.

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Future Directions

- Publish the humpback chub model.
- Test the model sensitivity. Laboratory experiments would strength the model.
- Complete preliminary assessment of temperature and food availability.
- Consider various temperature scenarios.
- Model parameters are available for species that may invade (e.g., striped bass, smallmouth bass, brown trout).

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