Adaptation and persistence of Pacific salmon facing climate change: an individual-based modeling analysis

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Fisheries and Oceans Canada / Pêches et Océans Canada

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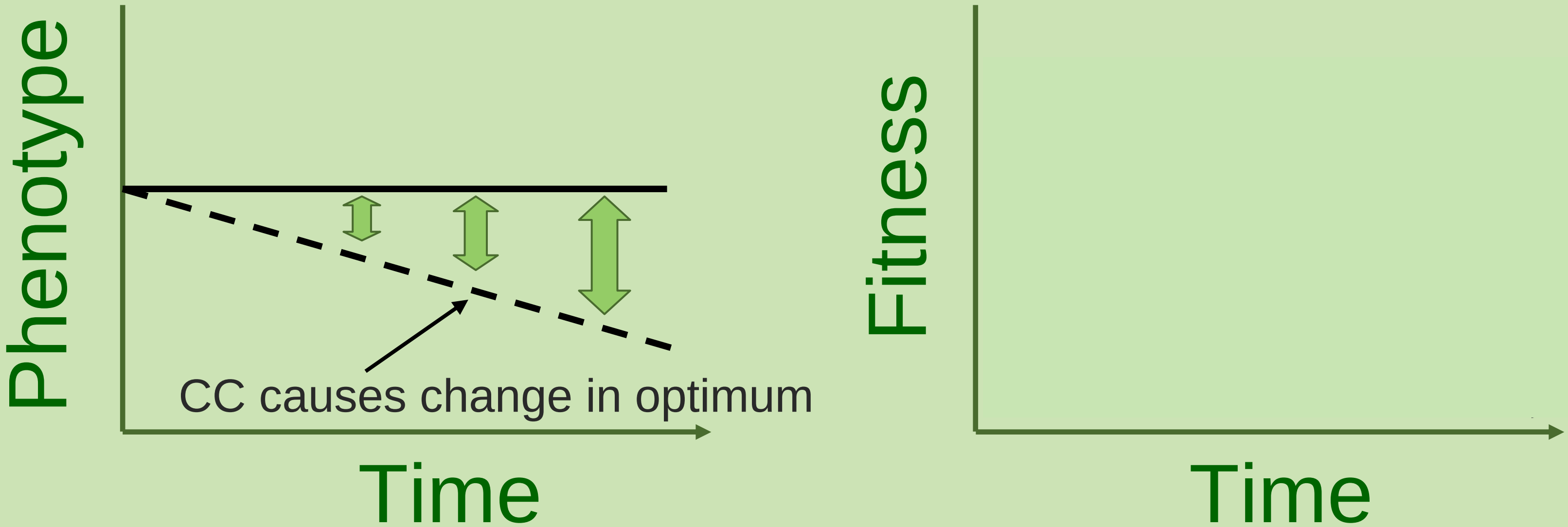
Talk outline

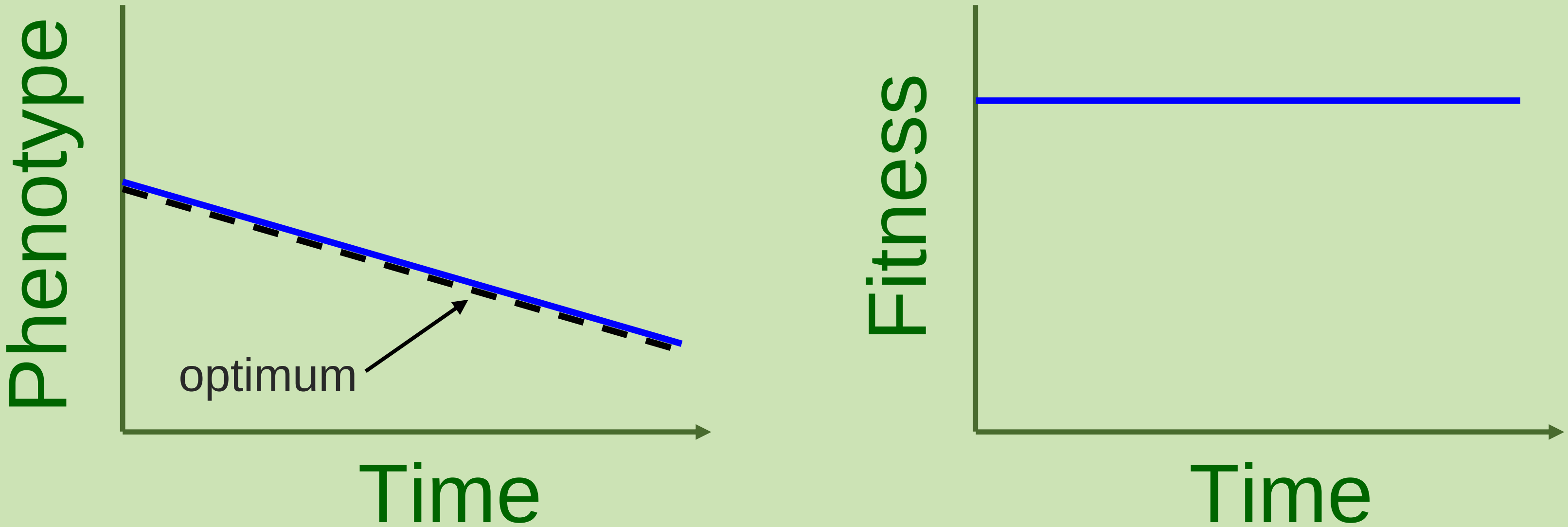
1. Conceptual overview
2. Individual-based evolutionary model
3. Applying evolutionary model to Fraser River sockeye problem
4. Preliminary results
5. Conclusions and next steps

1. Conceptual overview



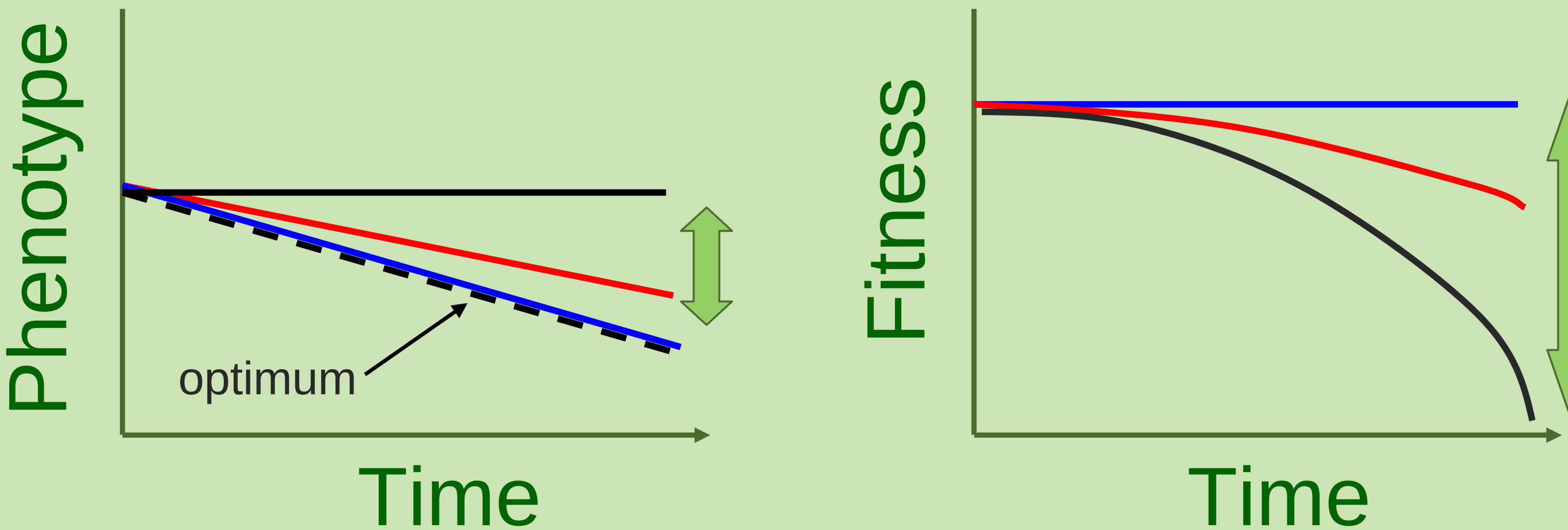
No adaptive response

1. Conceptual overview



Perfect adaptive response

1. Conceptual overview



Partial adaptive response?

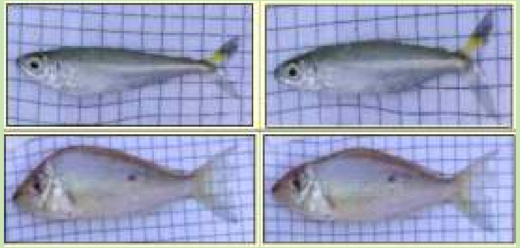
Persistence or extinction?

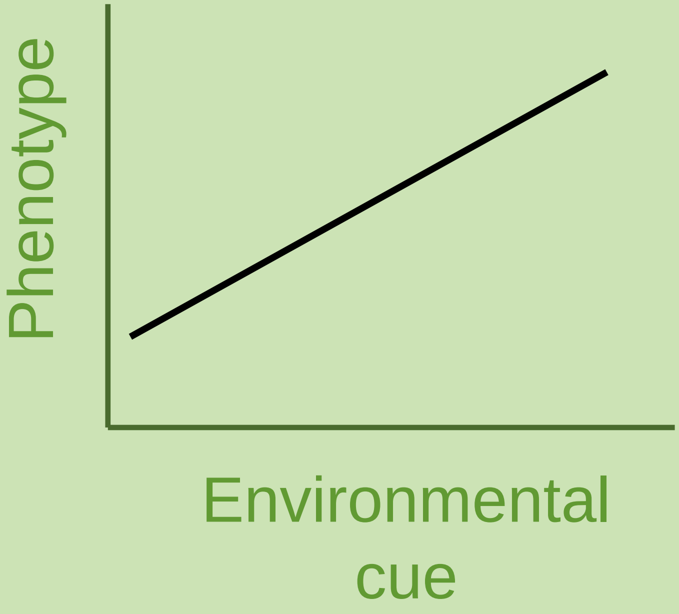
1. Conceptual overview

Mechanisms of phenotypic adaptation:

1. Phenotypic plasticity

- responses by individuals to environmental cues
- potentially adaptive, if cues remain reliable
- scope for plasticity can be limited



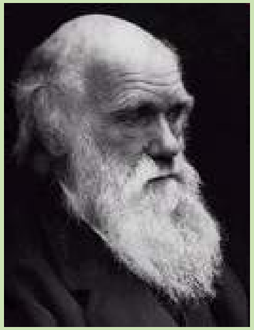


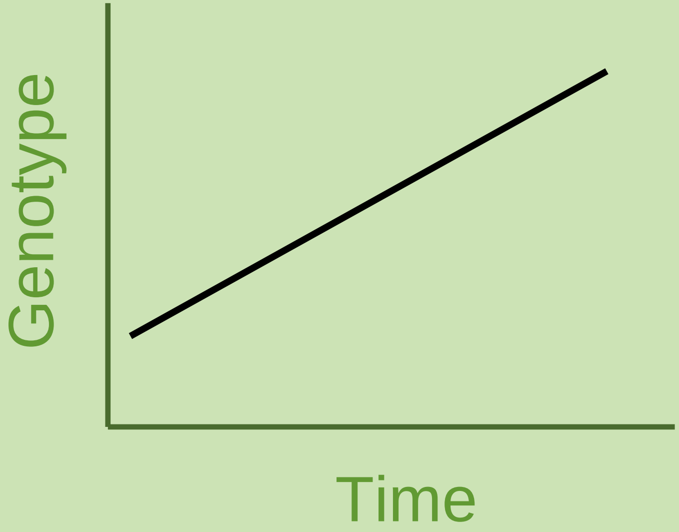
1. Conceptual overview

Mechanisms of phenotypic adaptation:

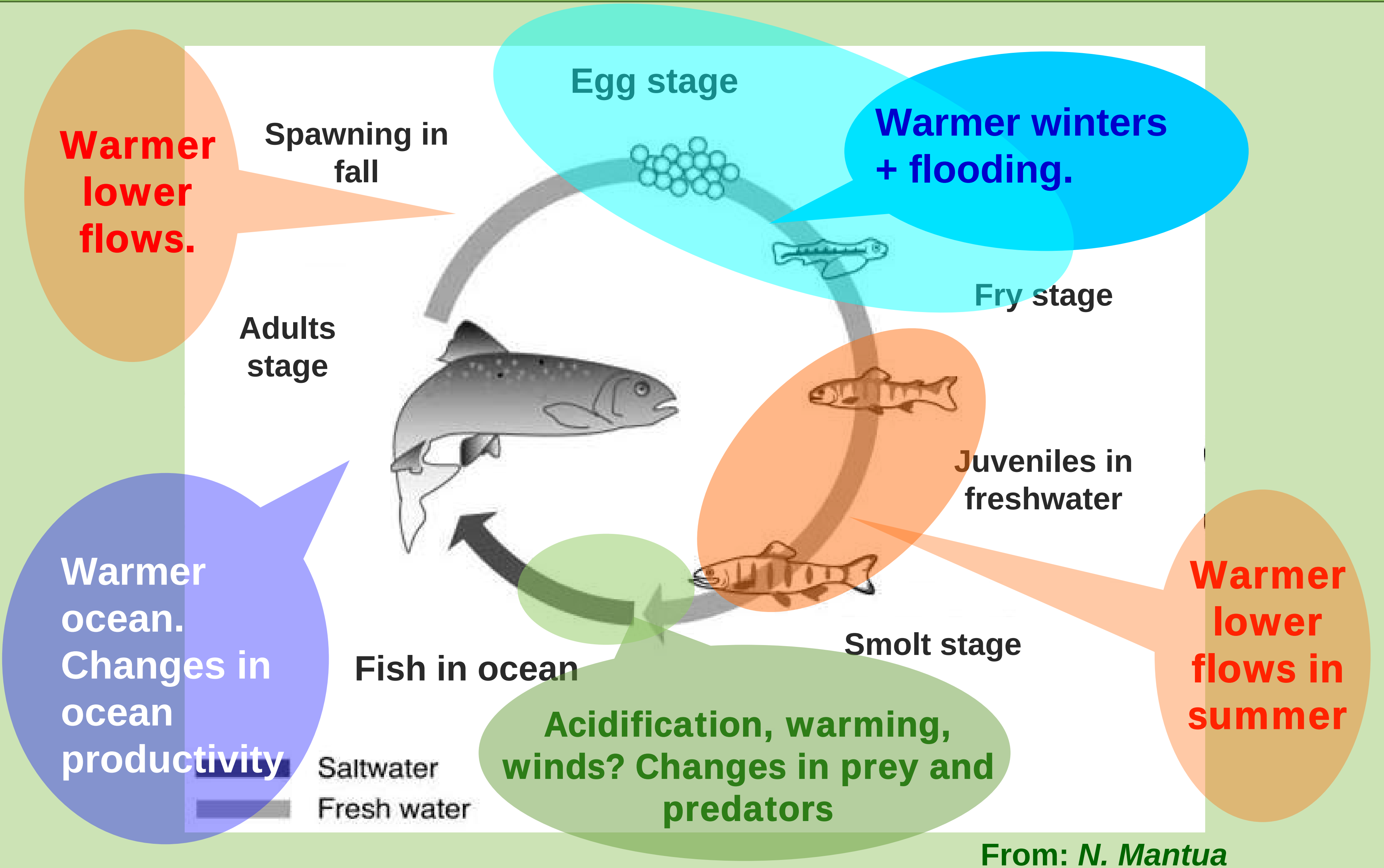
2. Microevolution

- genetic change across generations
- can facilitate population persistence
- amount of genetic variance limits rate of evolution





Multiple impacts of CC on salmon



From: *N. Mantua*

PERSPECTIVE

Potential responses to climate change in organisms with complex life histories: evolution and plasticity in Pacific salmon

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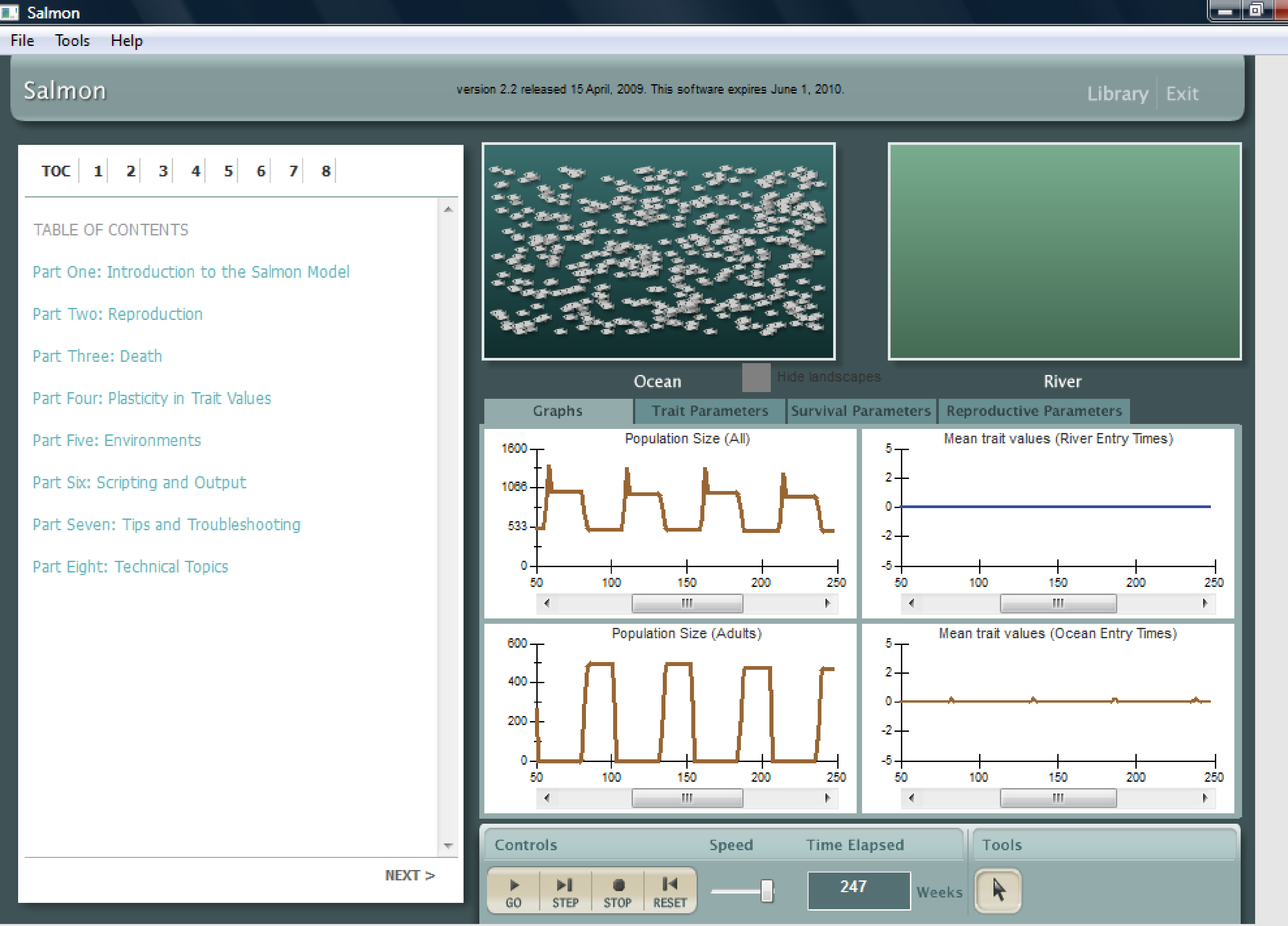
Crozier et al. (2008) Evolutionary Applications 1(2): 252-270


Salmon
File
Tools
Help
Salmon
version 2.2 released 15 April, 2009. This software expires June 1, 2010.
Library
Exit
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Part Four: Plasticity in Trait Values
Part Five: Environments
Part Six: Scripting and Output
Part Seven: Tips and Troubleshooting
Part Eight: Technical Topics
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Population Size (Adults)
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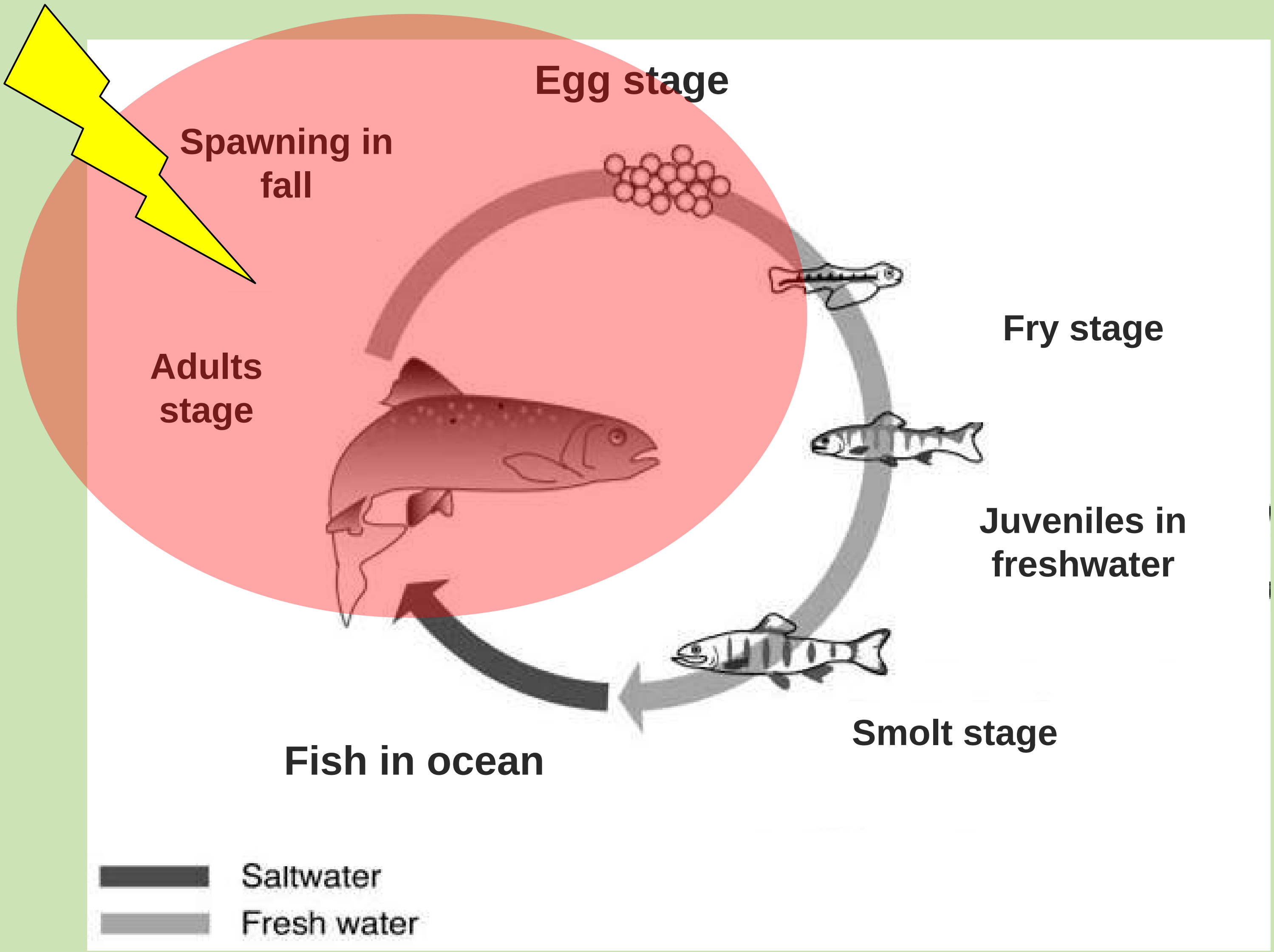
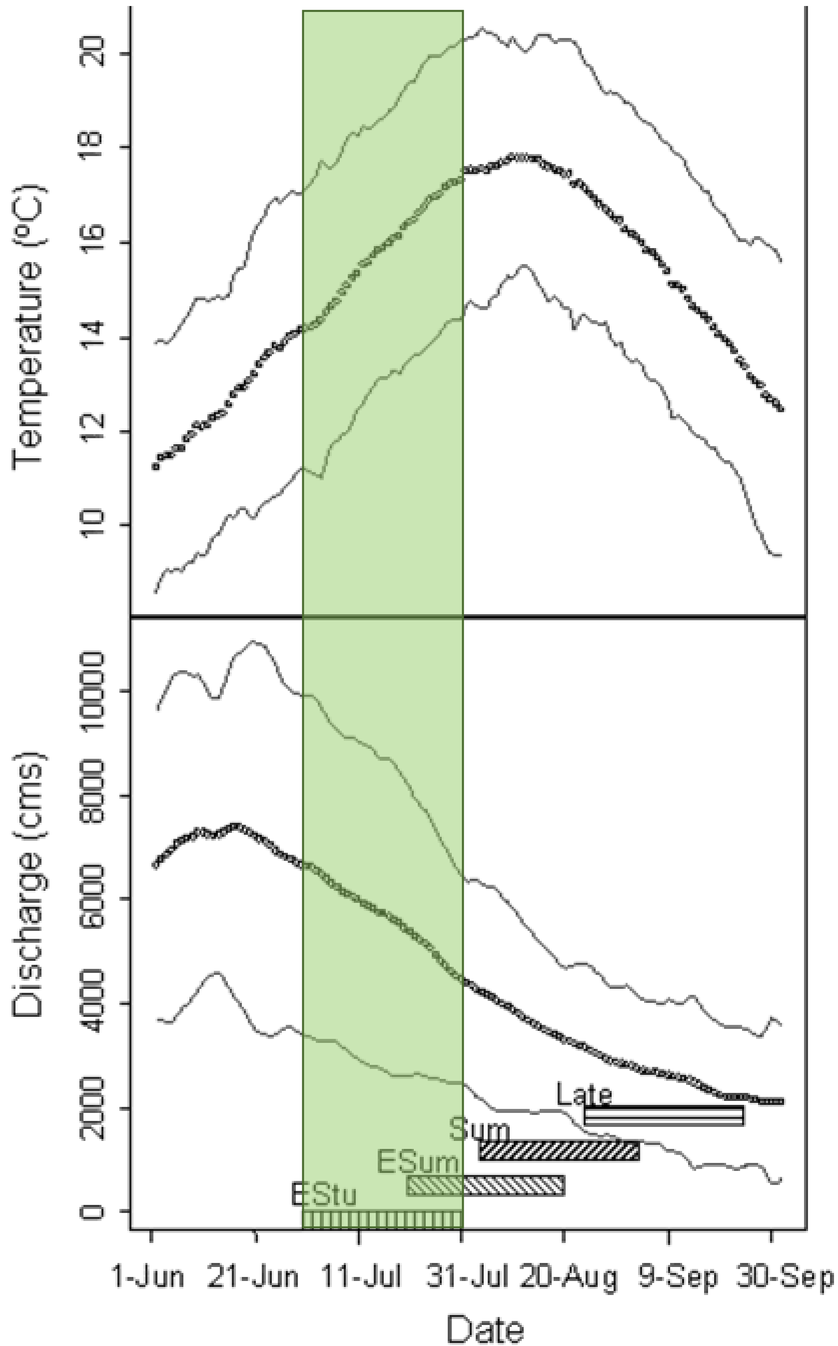
Focus on adult spawning migration stage



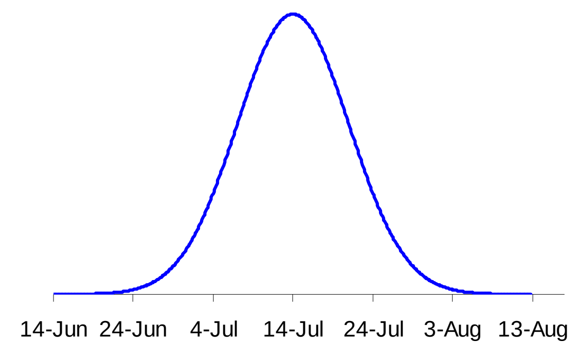
Fraser River, Canada

Oncorhynchus nerka



EARLY STUARTS:

Mean River Entry Date
= 14 July



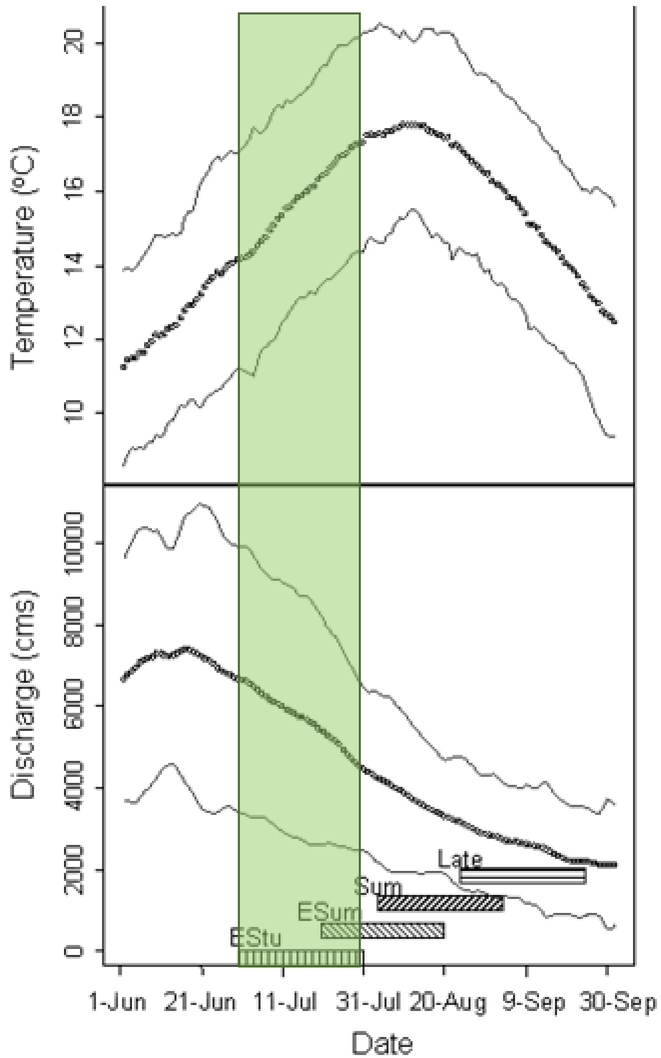
SD =`7 days

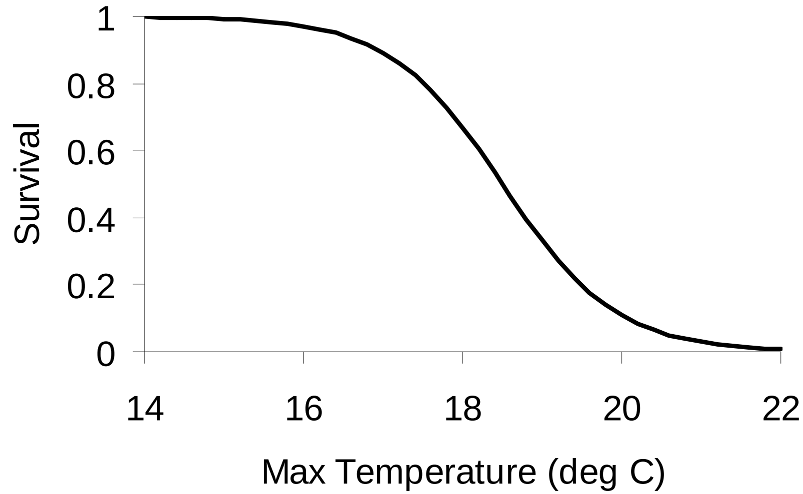
mean discharge

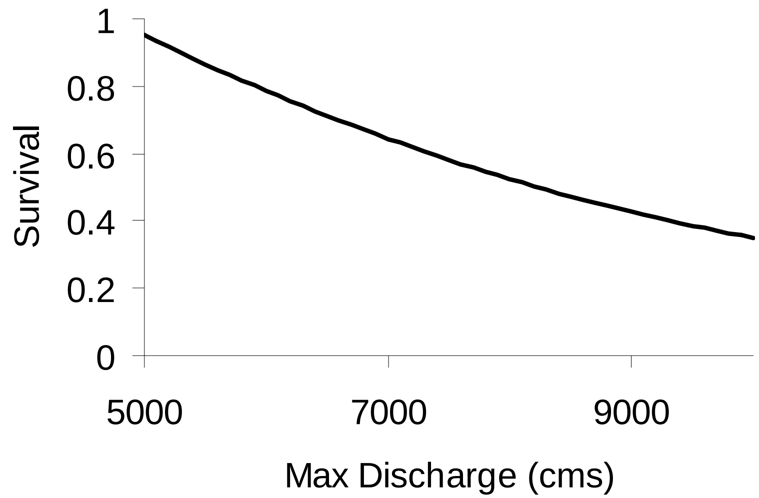
~ 5.5 cms

Discharge > 8000cms
impedes passage
through lower river

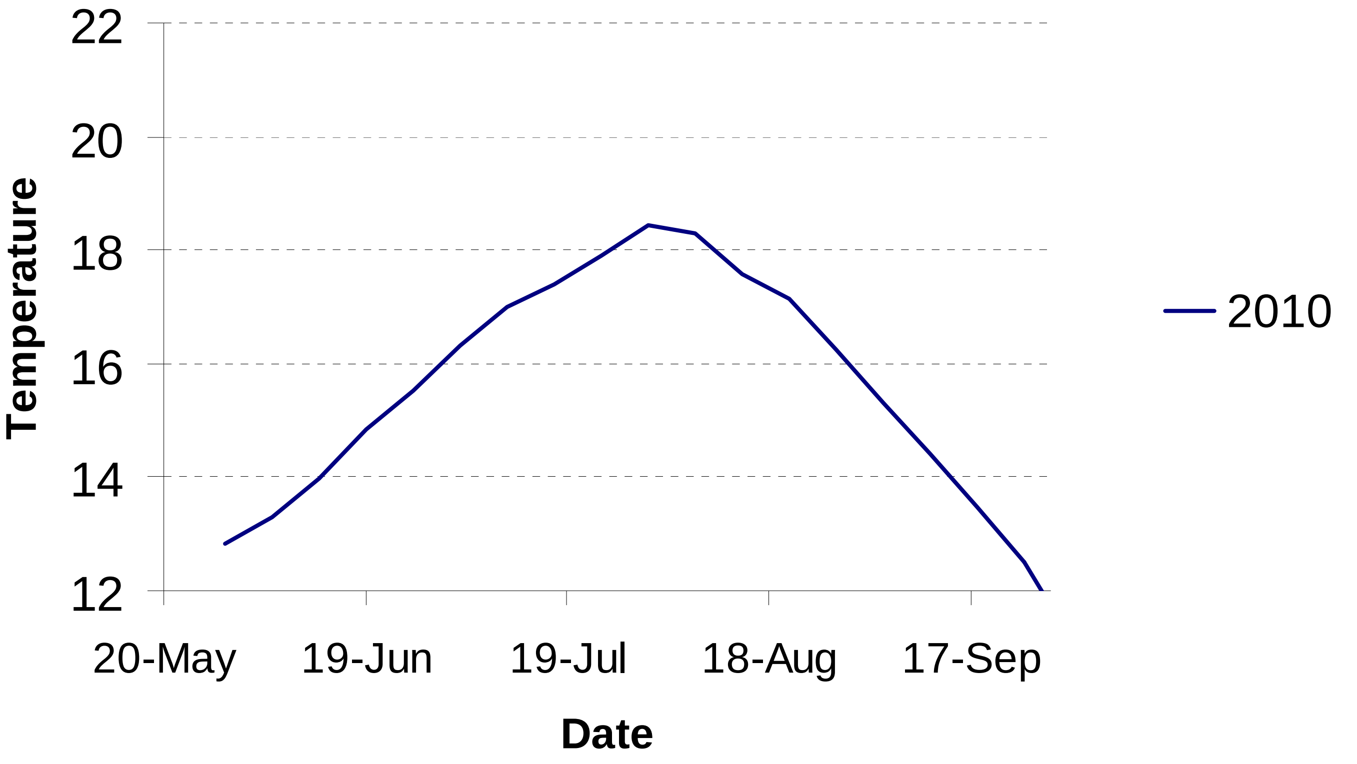
Estimated survival functions





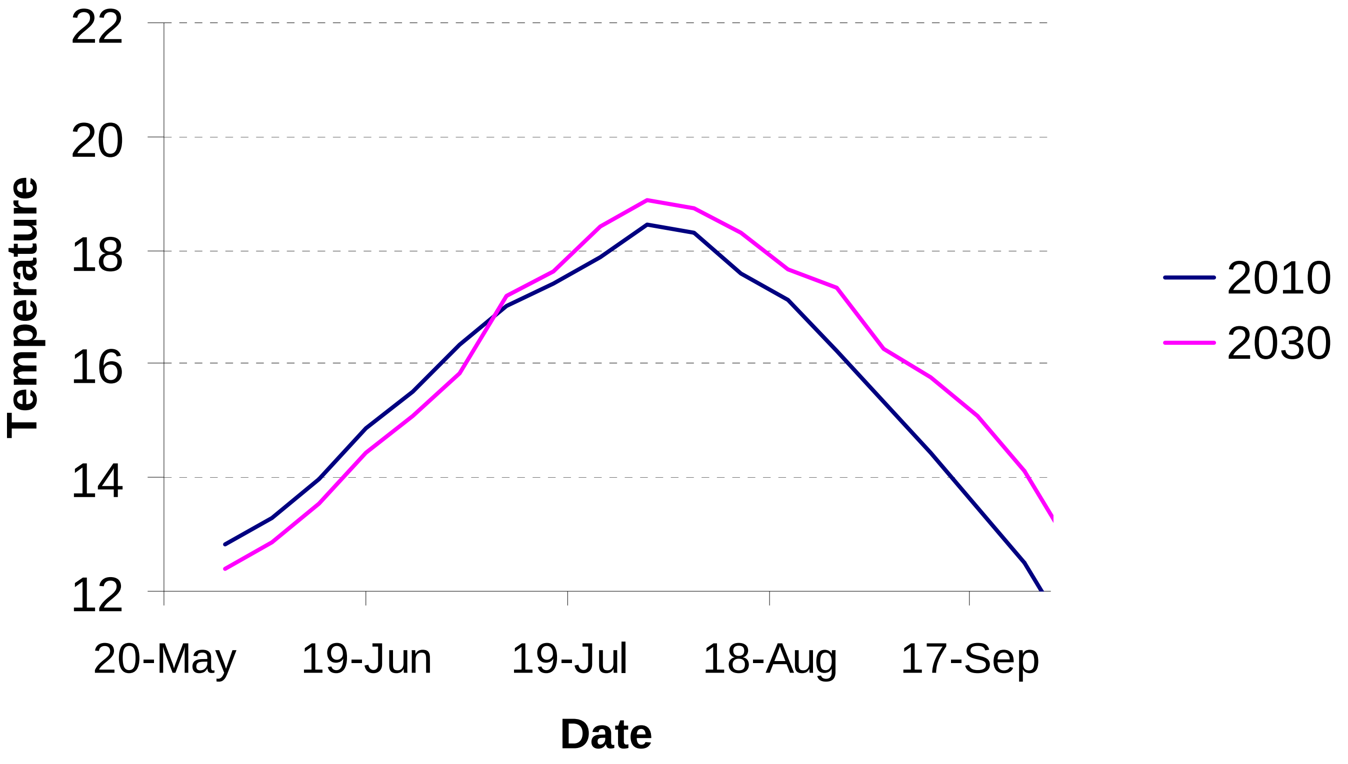


Predicted changes in temperature



From: Morrison *et al* Journal of Hydrology 263 (2002) 230-244

Predicted changes in temperature



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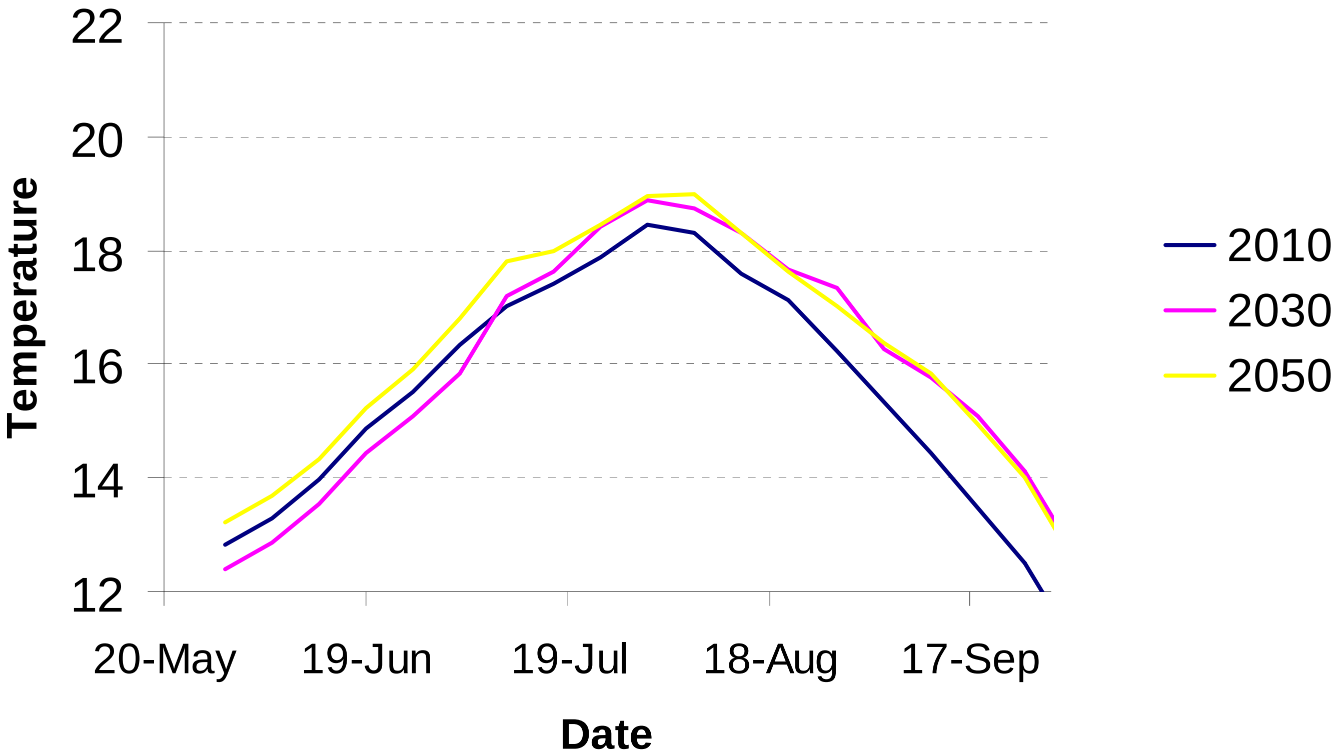

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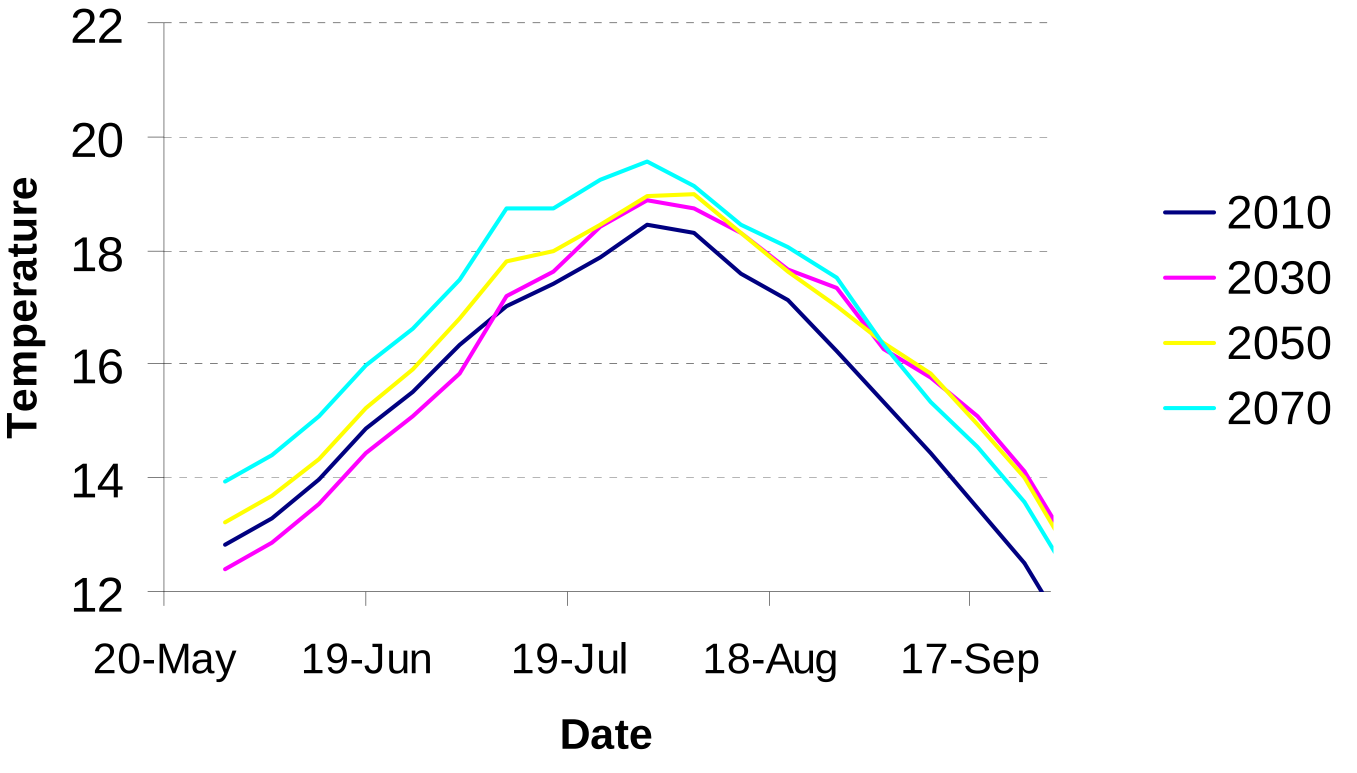

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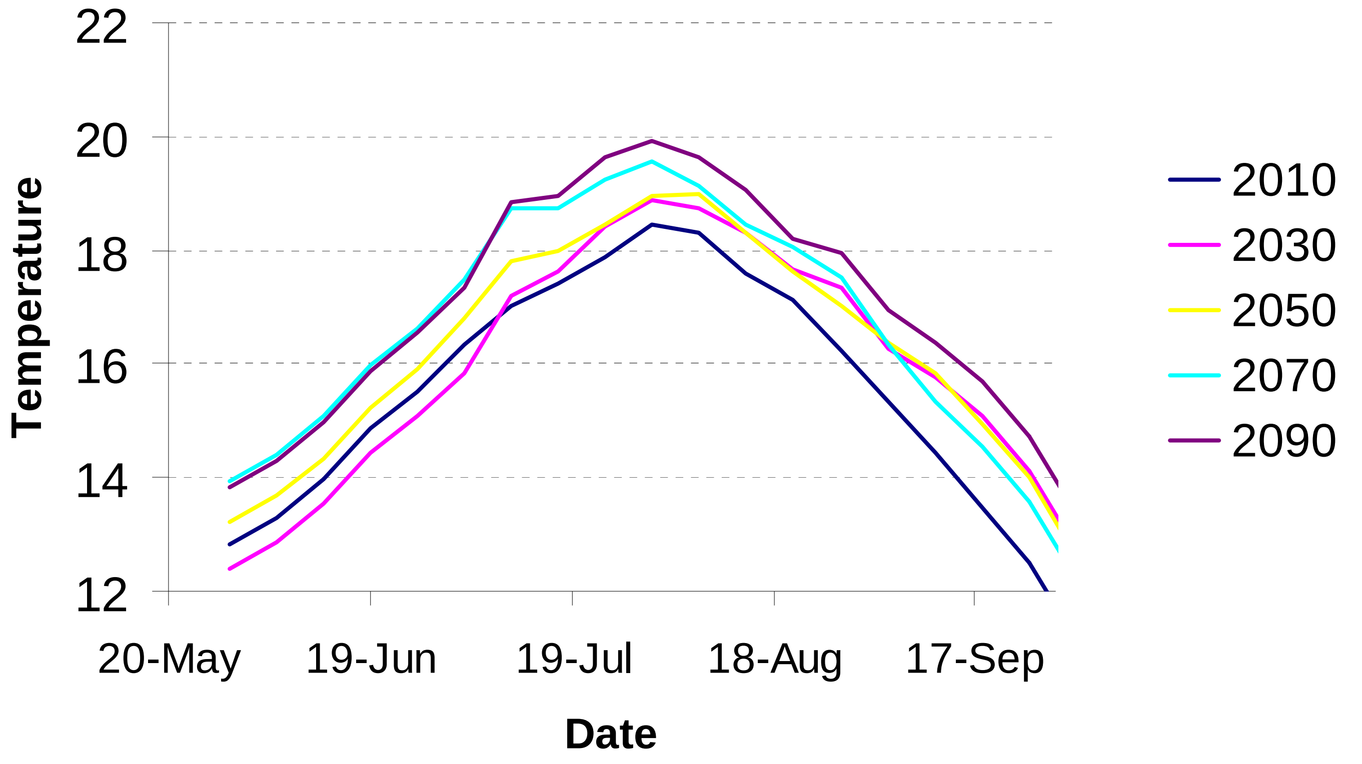

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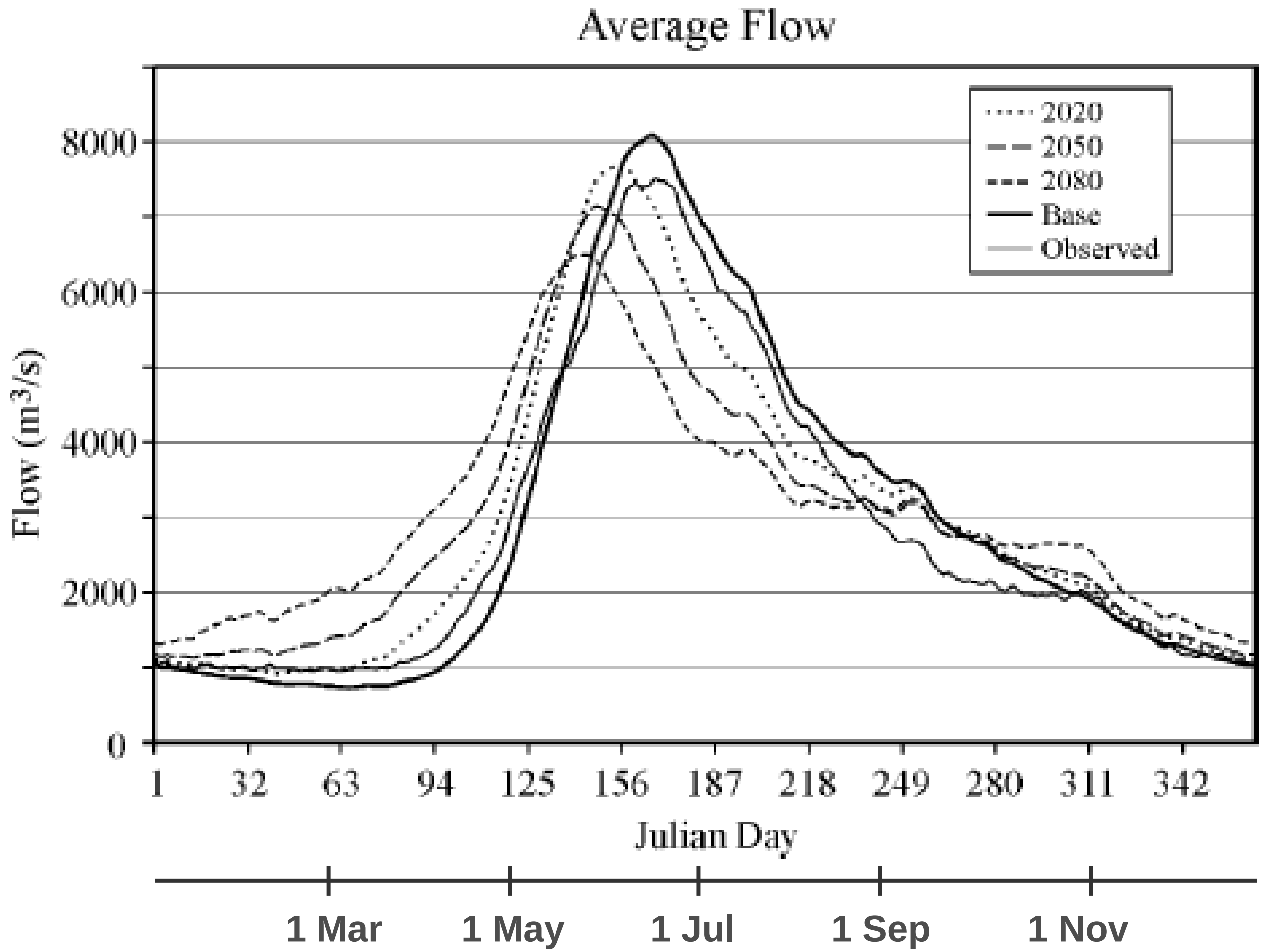
Predicted changes in discharge (flow)



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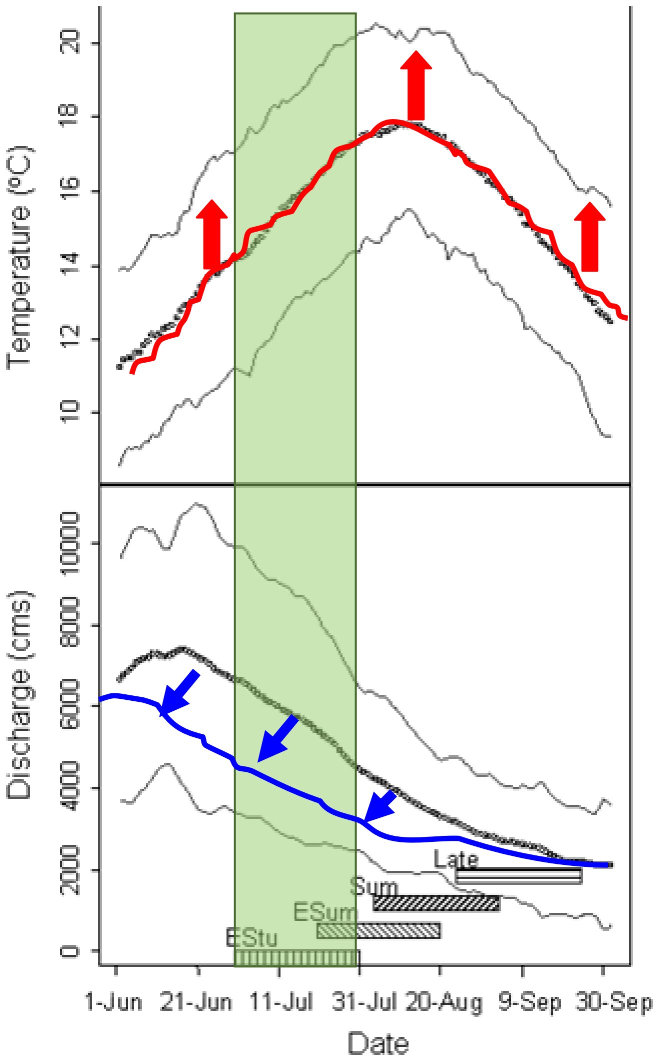
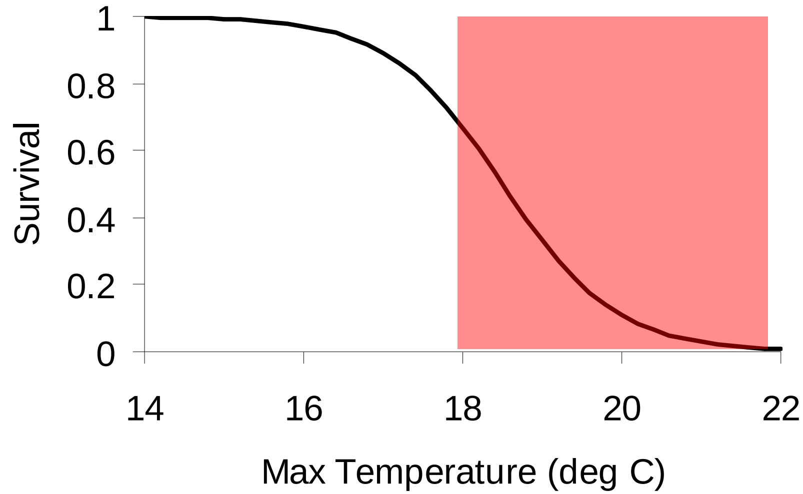
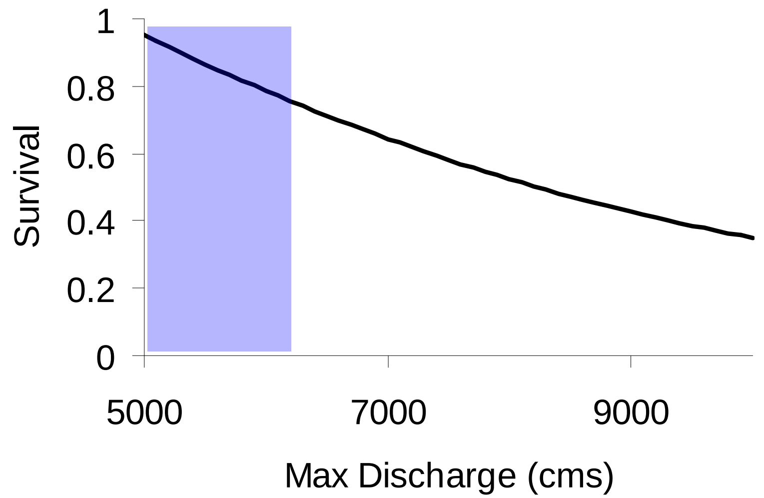
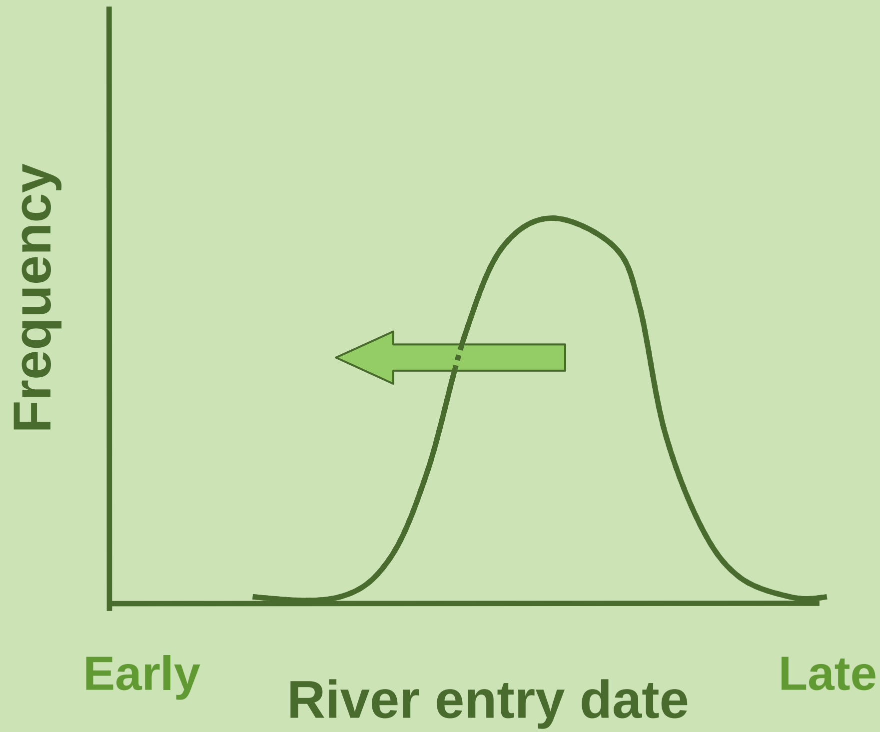
Estimated survival functions





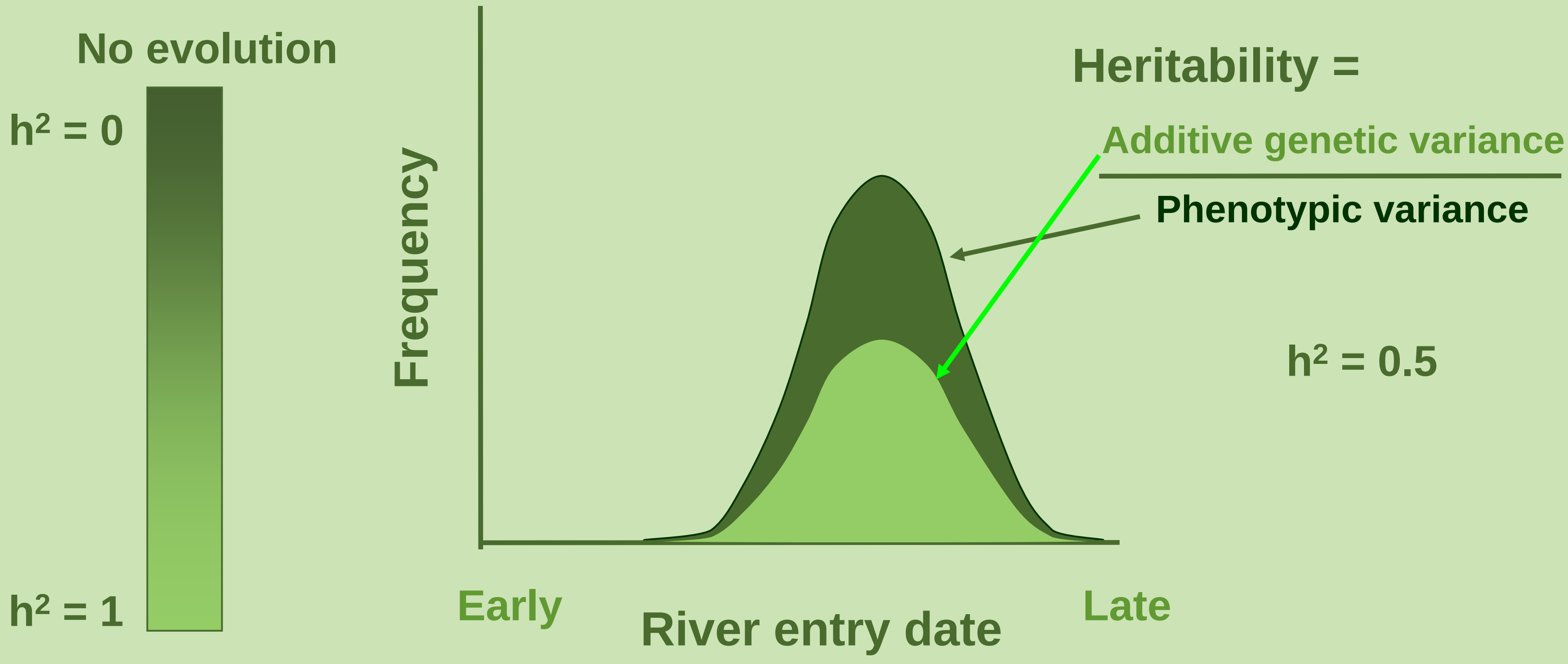


Prediction: selection for earlier river entry dates



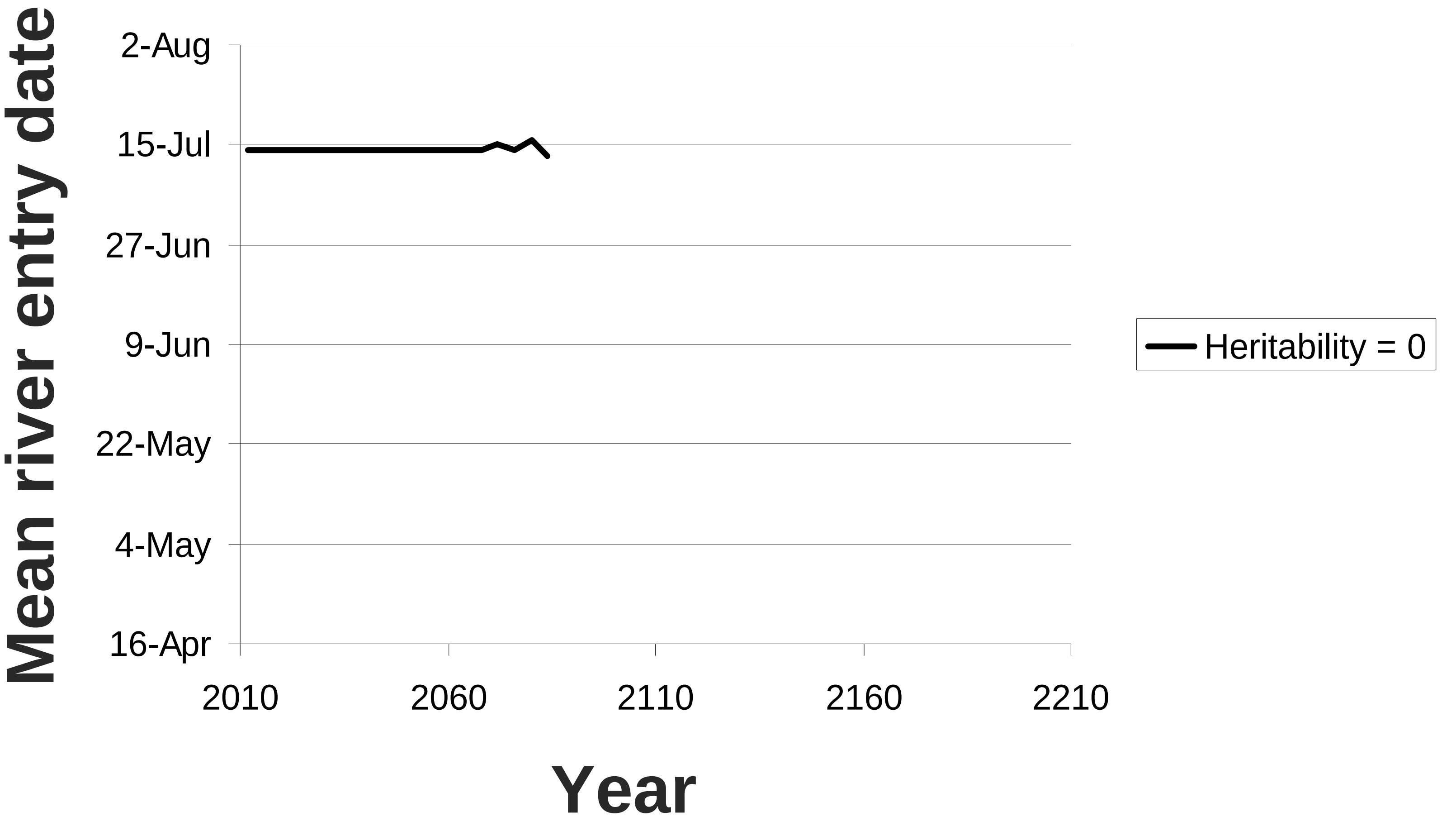
EVOLUTION ONLY IF RIVER ENTRY DATE IS HERITABLE

Prediction: selection for earlier river entry dates



EVOLUTION ONLY IF RIVER ENTRY DATE IS HERITABLE

Results – earlier river entry evolves given high heritability



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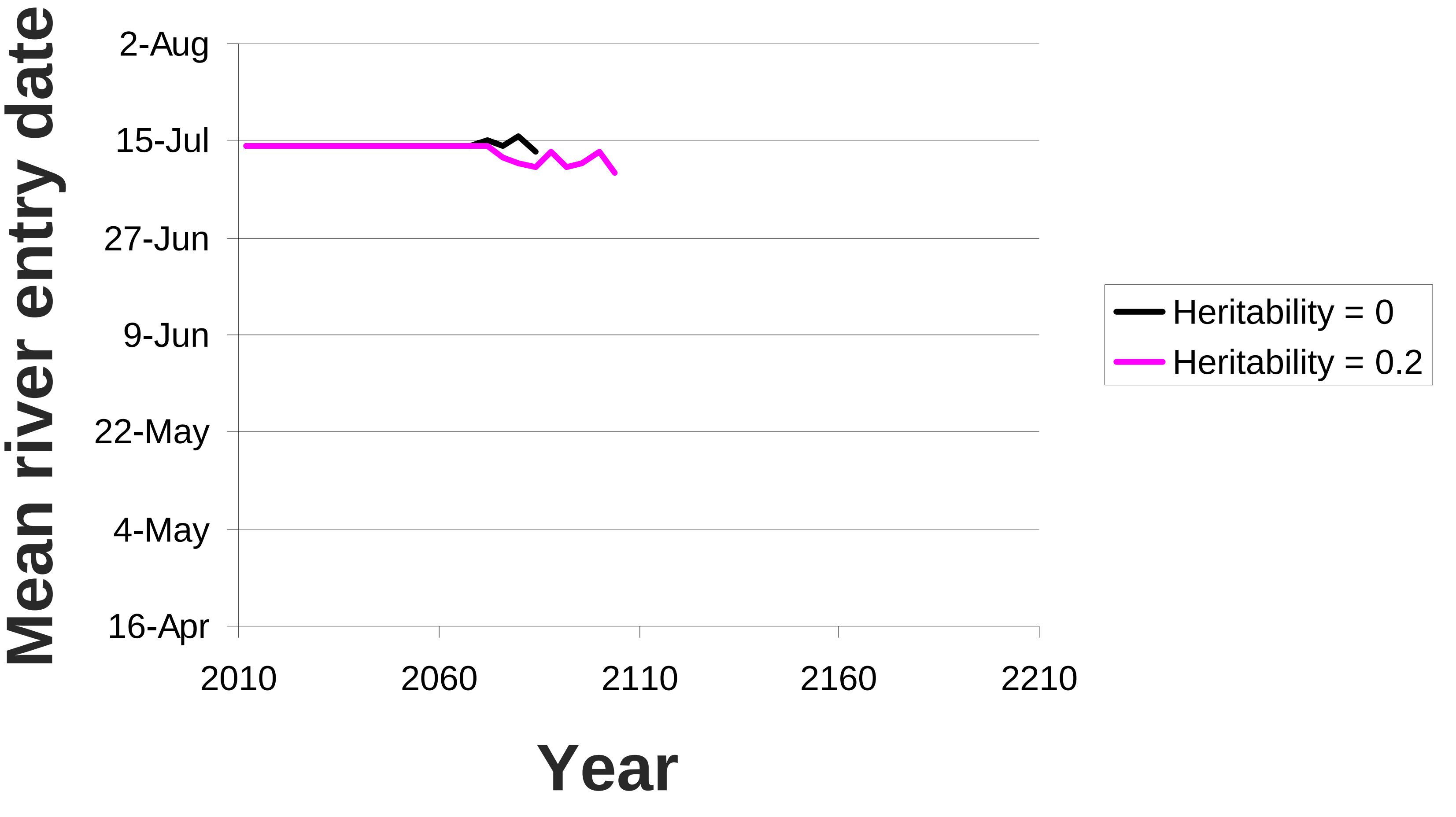

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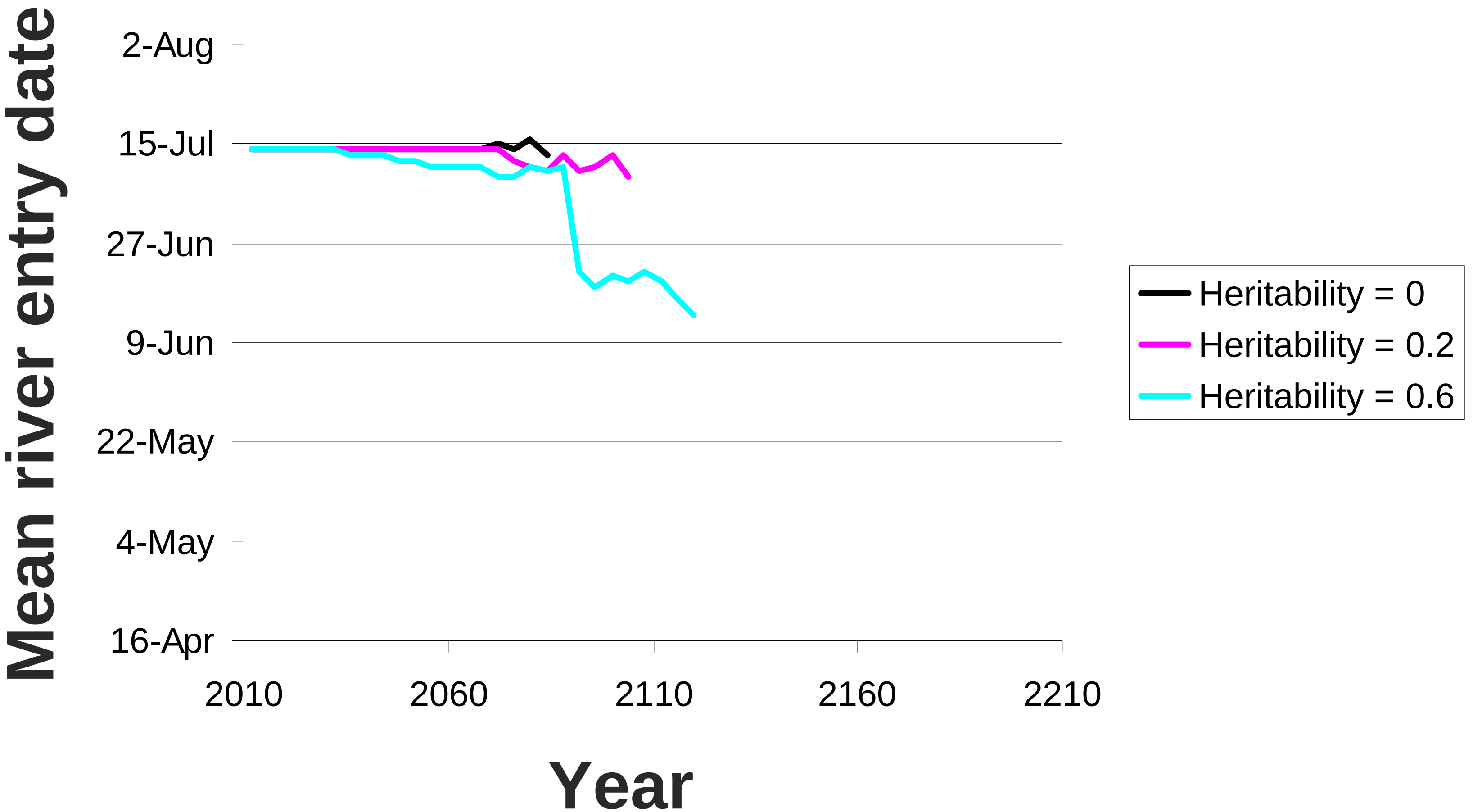
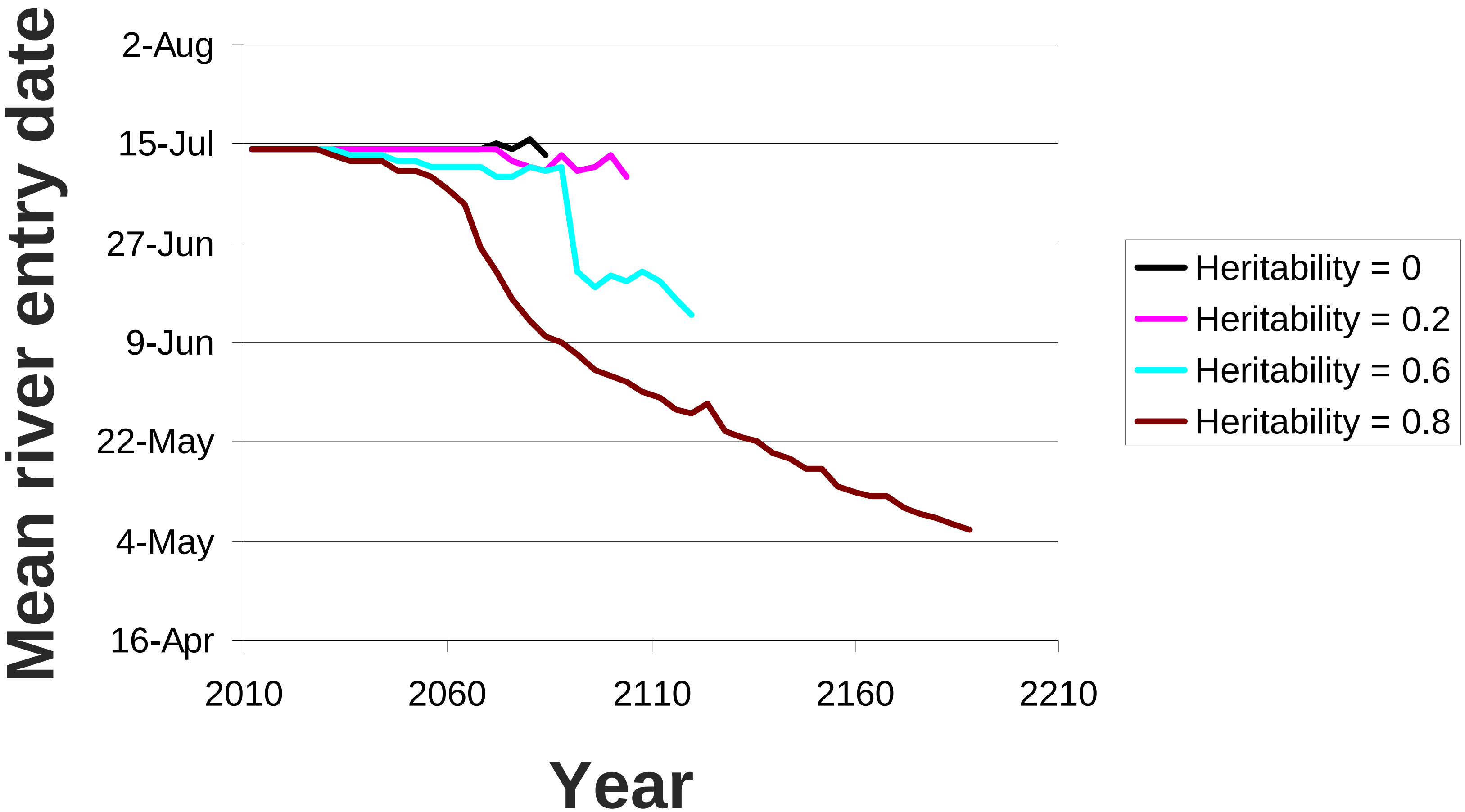
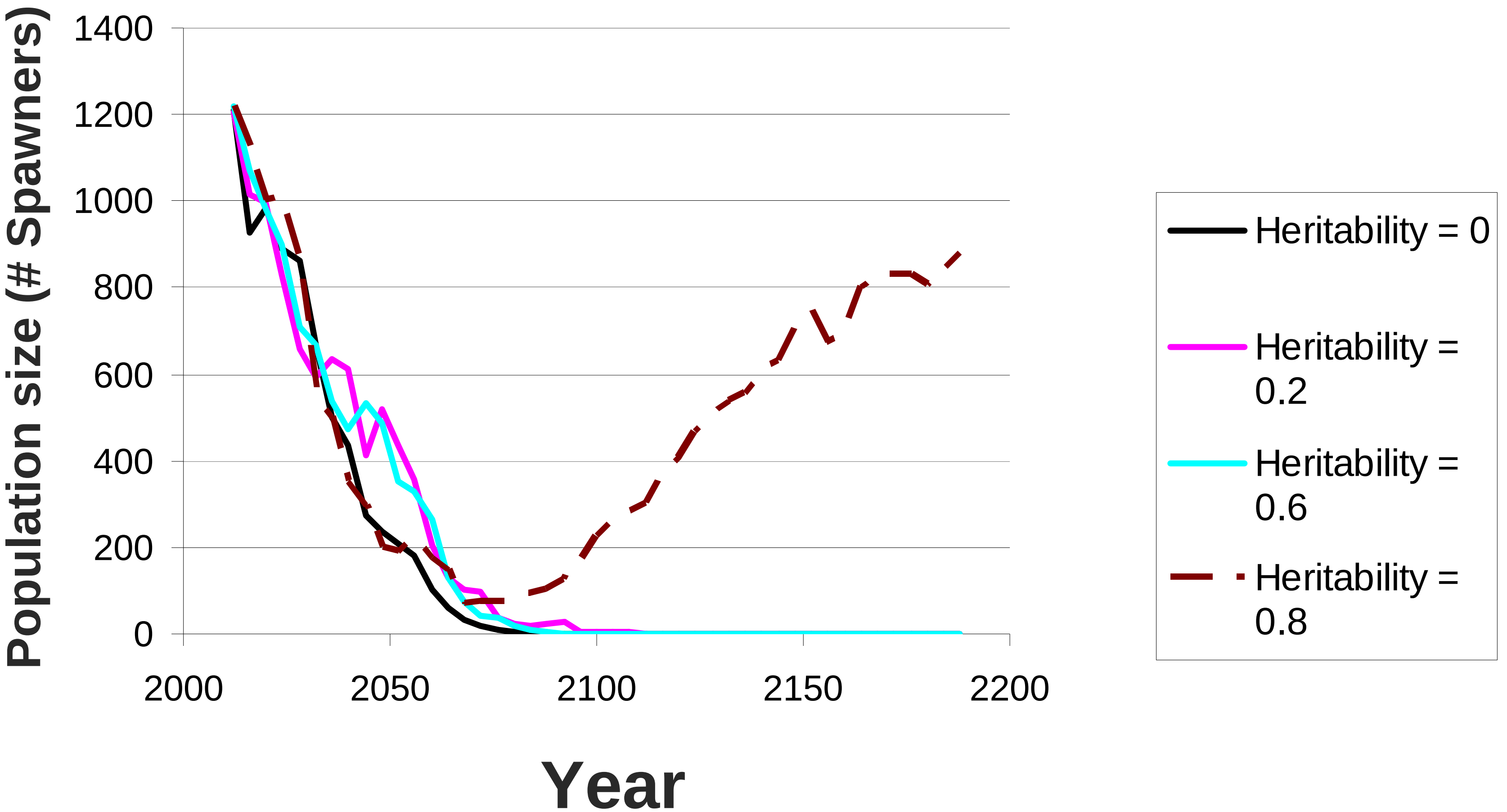


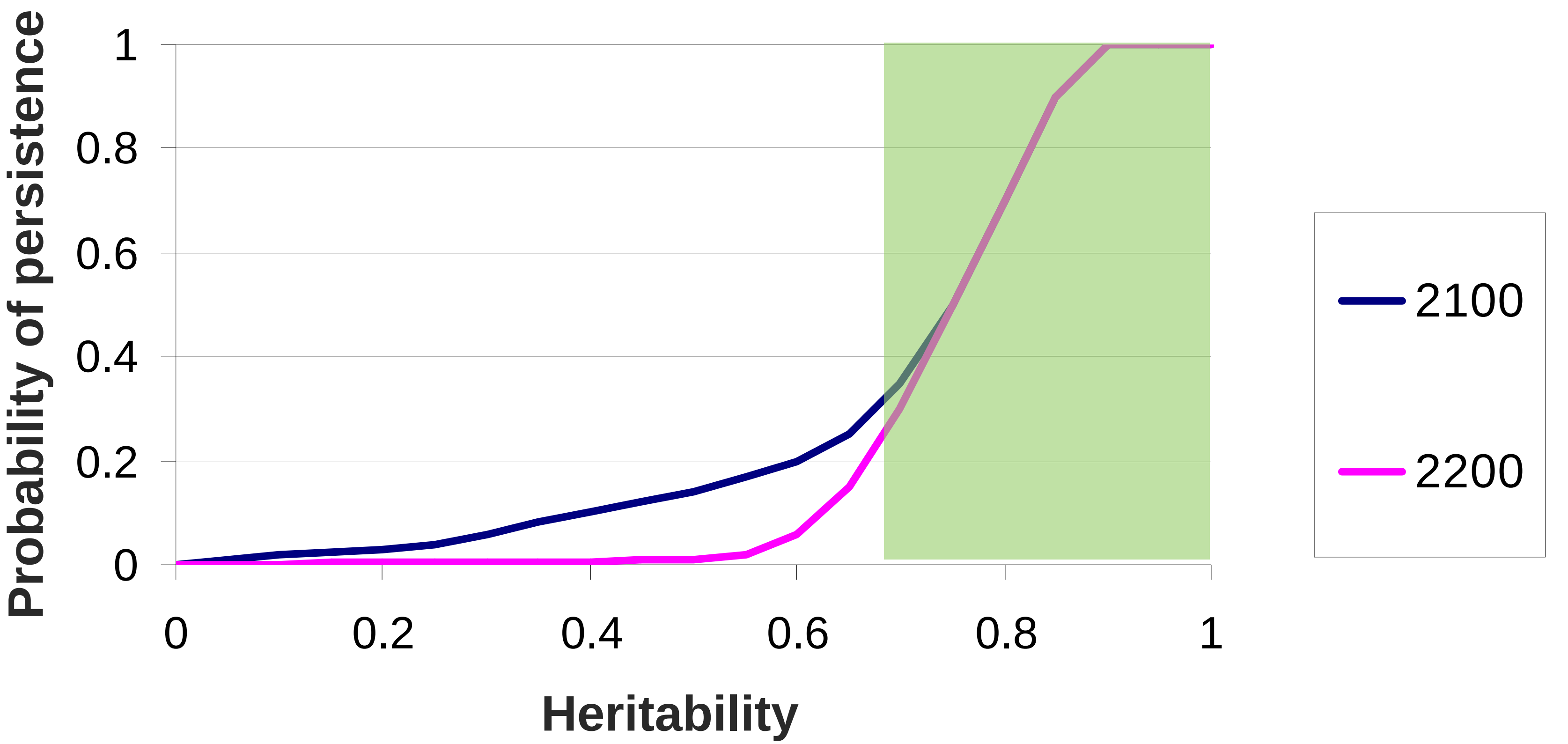
Results – earlier river entry evolves given high heritability



Results – earlier river entry mitigates population declines

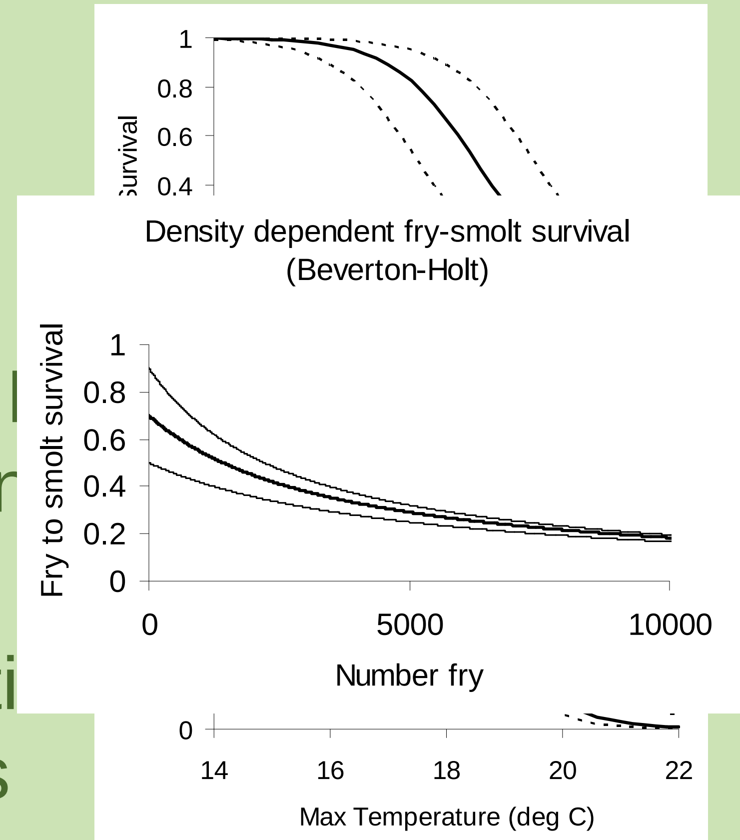


Results – high heritability enables population persistence



Next steps

- Test sensitivity of results to:
  - temperature-survival function
  - strength of density dependence
  - rate of climate change
- Apply model to other Fraser stocks (run-timing groups) ar other salmon species
- Incorporate phenotypic plasti and trade-offs between traits



Conclusions

- Evolution of earlier river entry dates can potentially help Early Stuart sockeye, but….
- Rate of climate change might outpace rate of adaptation
- Persistence of salmon populations will depend on their ability to adapt fast enough, which depends on existence of sufficient genetic variation

Photo: Tom Quinn

Thanks to:

- Lisa Crozier and Mark Scheurell at NOAA
- Nate Mantua and Tom Quinn at UW
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Gordon and Betty MOORE FOUNDATION

NCEAS

Photo: Tom Quinn