

Life-cycle models for the diverse and plastic *Oncorhynchus mykiss*: challenges and opportunities

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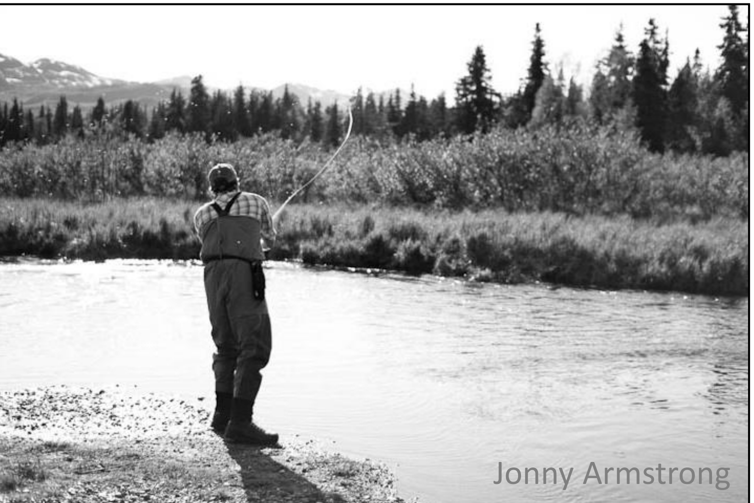
Oncorhynchus mykiss life history tactics and population dynamics

- Life history strategies influenced by environmental and anthropogenic factors

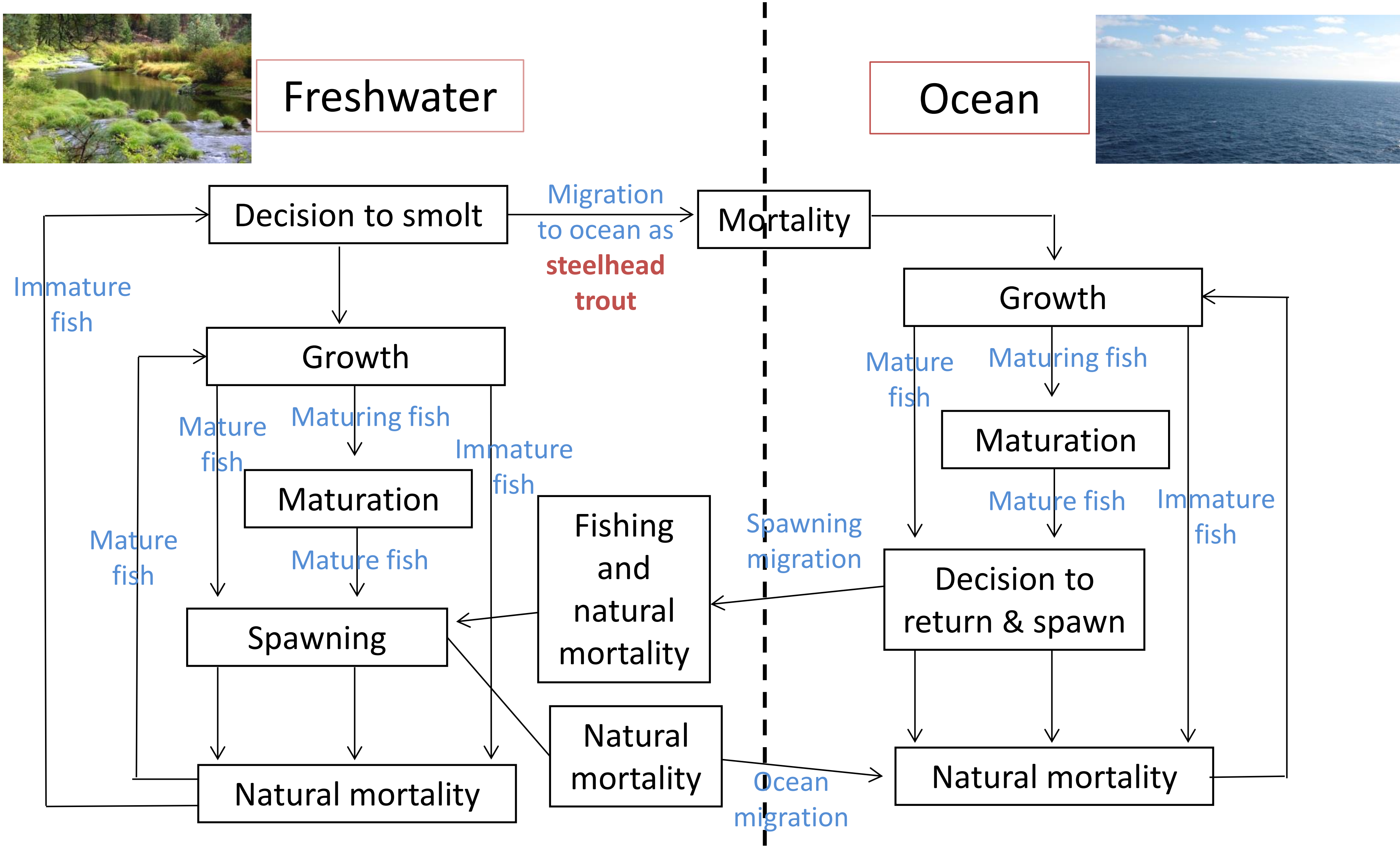
- Life-cycle models used to better understand strategies, evaluate population dynamics spatially and temporally



Purpose of a life-cycle model

- Questions to answer using the model:
  - Is anadromy expected to persist into the future?
  - Under what environmental conditions will *O. mykiss* be resident or anadromous?
  - What life history stages represent population "bottlenecks?"
  - What patterns of anadromy and residency will we see given different freshwater habitat mitigation actions?

O. mykiss life cycle models



Modified from Theriault et al. 2008

Existing models to help

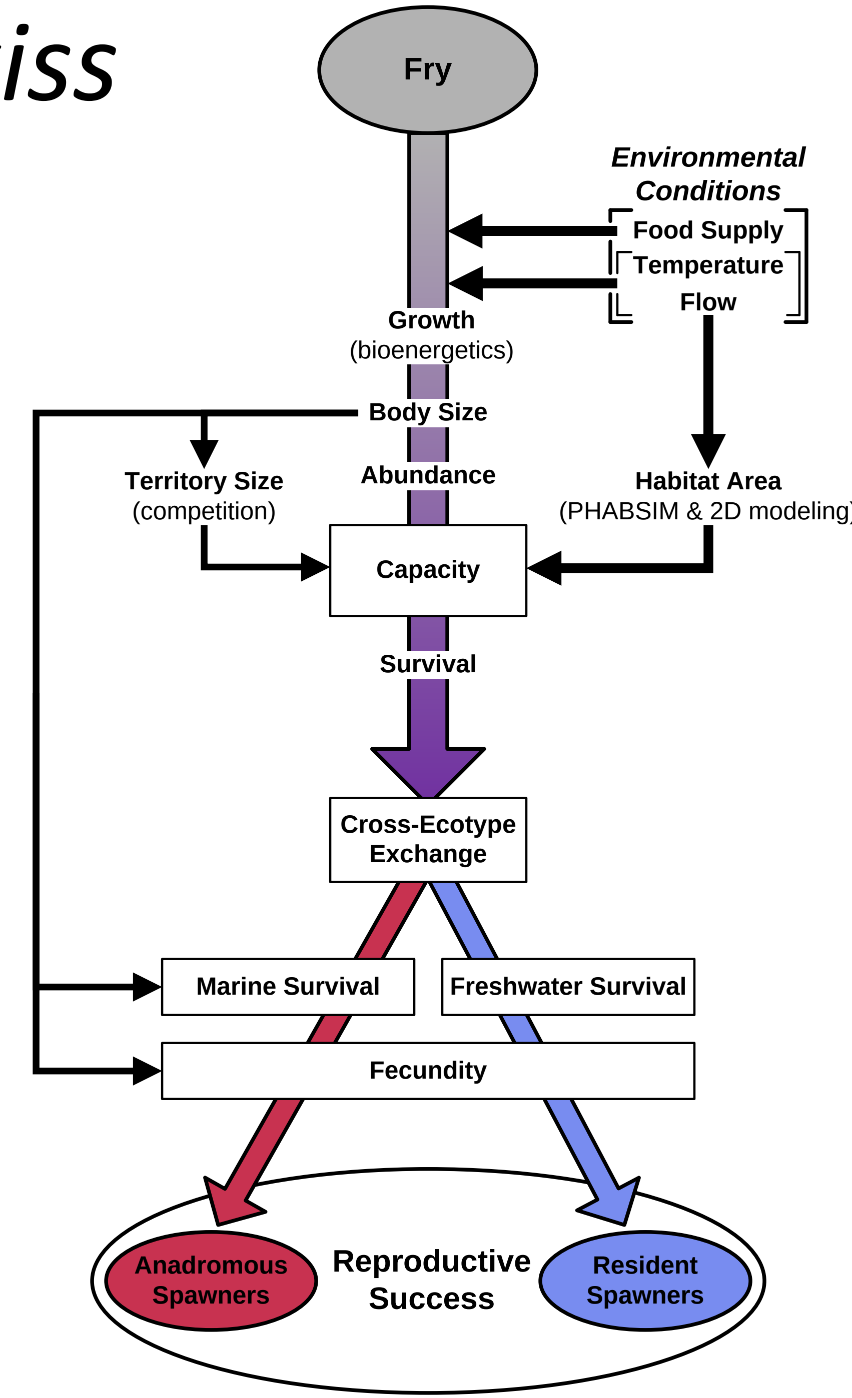
1. Yakima River, WA anadromous/resident *O. mykiss* abundance and reproductive success life-cycle models (I. Courter & C. Frederiksen et al.)

2. Anadromy/residency and smolt age decision for *O. mykiss* (originally developed for CA populations; Satterthwaite et al. 2009, 2010)

3. Chinook and *O. mykiss* life-cycle matrix models for Interior Columbia River basin (but only anadromous component; ICTRT and Zabel 2007)

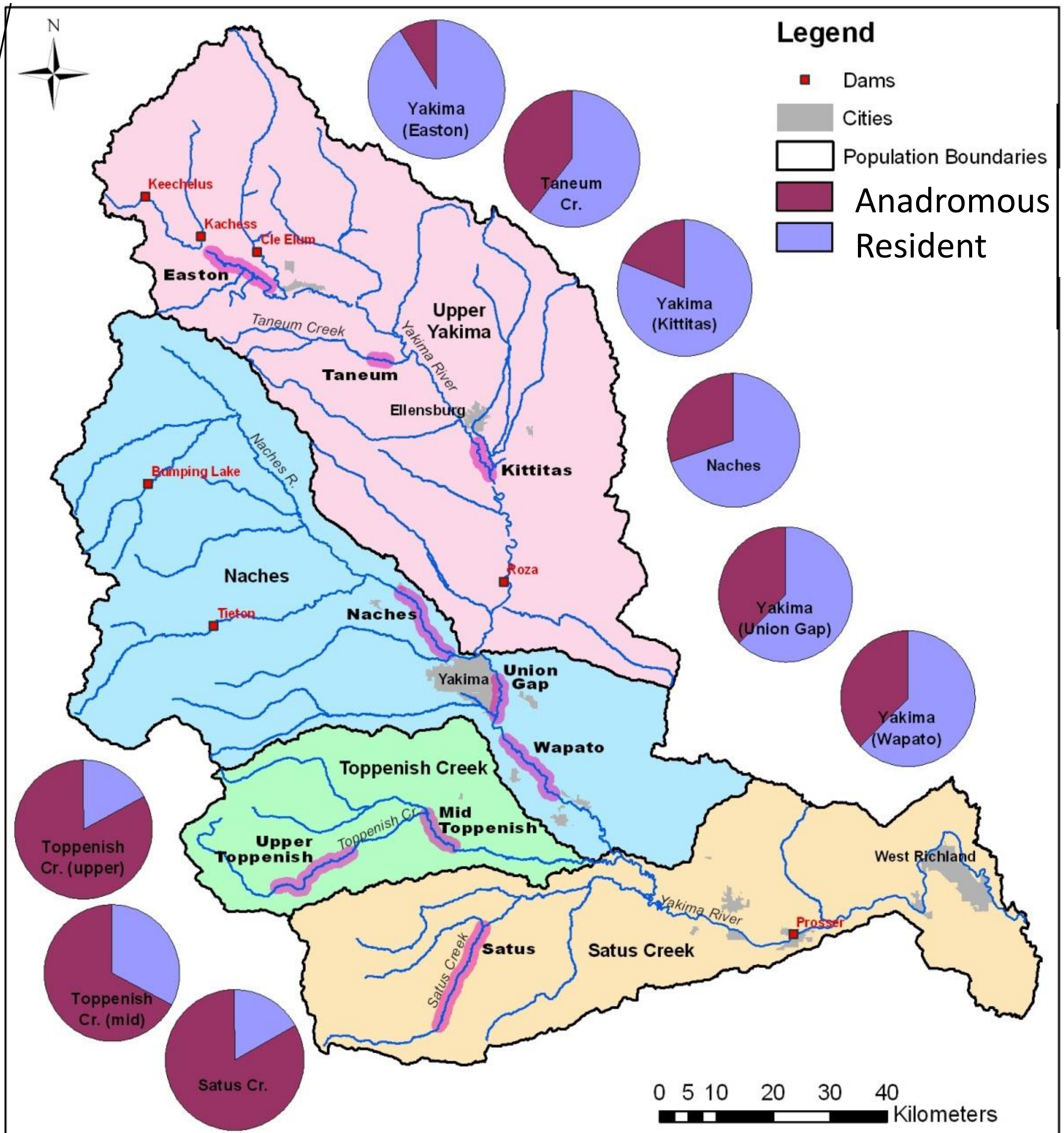
Yakima River *O. mykiss* life-cycle models

- Use freshwater food supply, flow, and temperature to predict fish growth, survival, capacity, and reproductive success by life history tactic



Courter et al. 2009

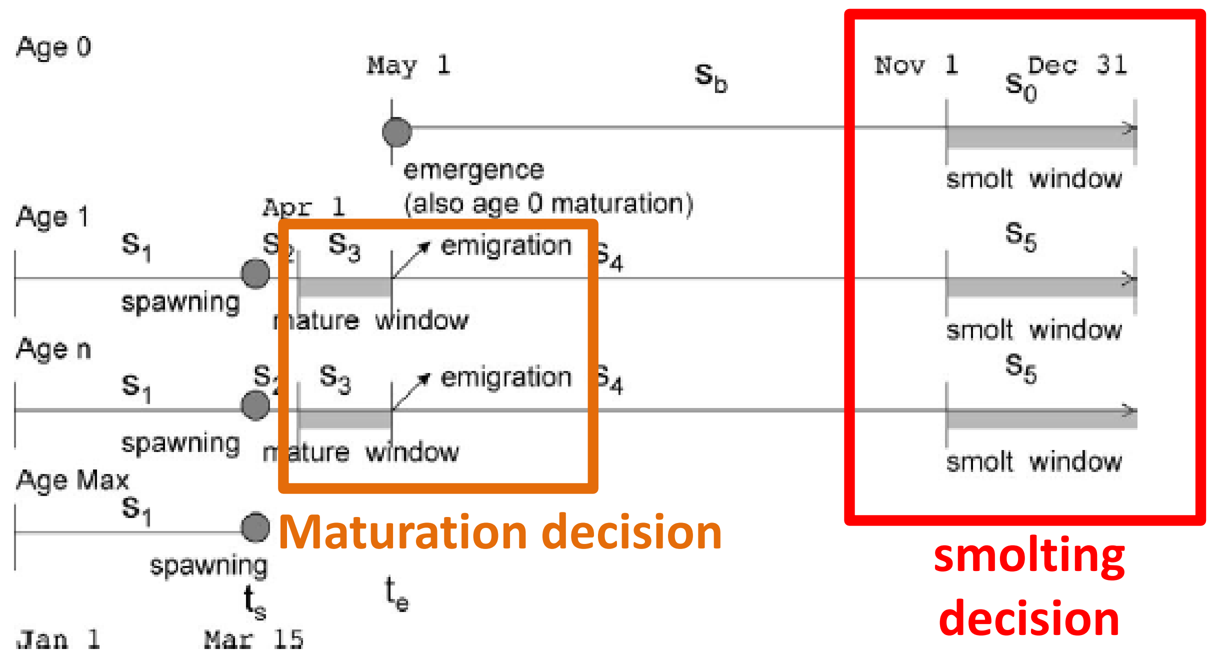
Model predictions



Courter et al. 2009

Anadromy/residency life-cycle model for *O. mykiss*

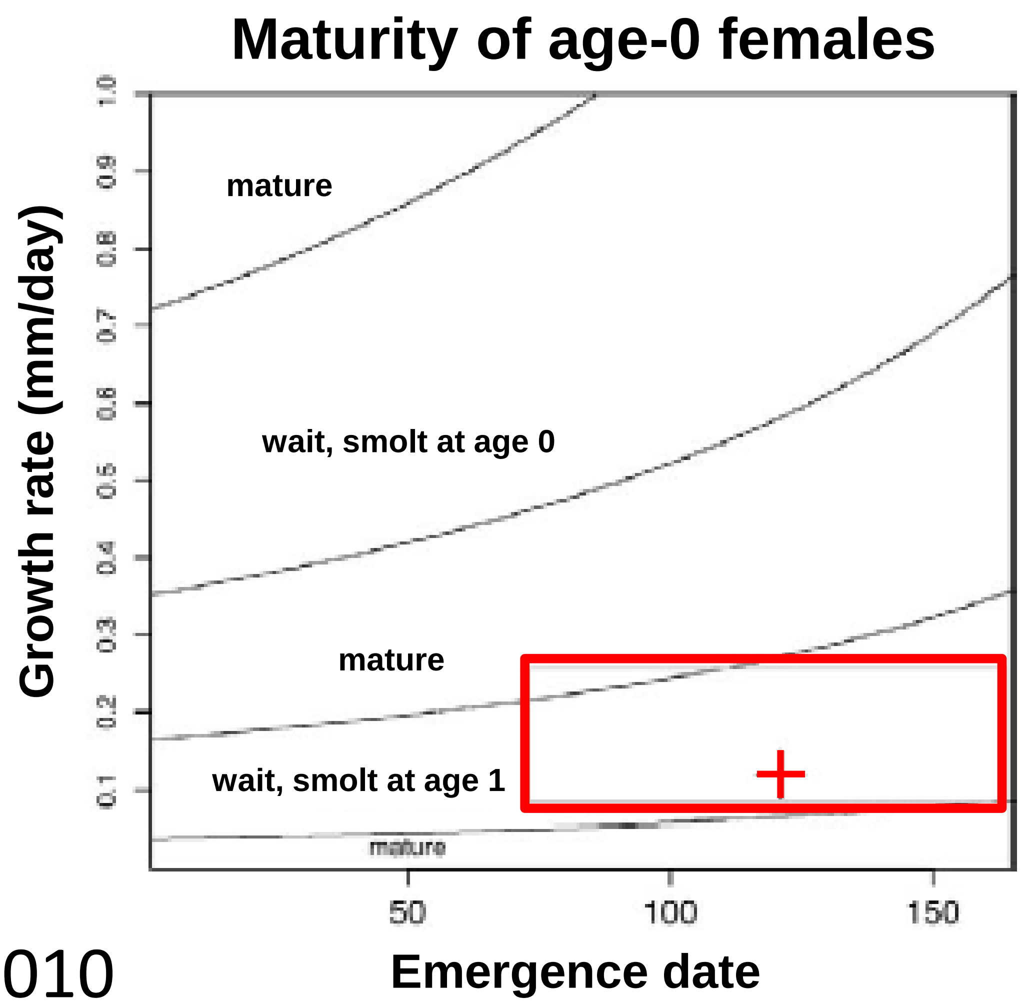
- Based on fish emergence date, freshwater growth, survival, fecundity, and overall fitness
- Predict maturation/residency and smolt age decision



Satterthwaite et al. 2009, 2010

Model predictions

- Predict maturation/ residency and smolt age decision



Satterthwaite et al. 2009, 2010

O. mykiss matrix models for Interior Columbia River basin

- Steelhead-only life-cycle model
- Beverton-Holt functions to include density-dependent survival in freshwater
- Components (adjusted in different "scenarios"):
  - Downstream survival (based on hydropower corridor passage)
  - Estuary and early marine survival (based on climate conditions)
  - Later marine survival
  - Harvest, upstream survival
  - Overwinter survival in fw

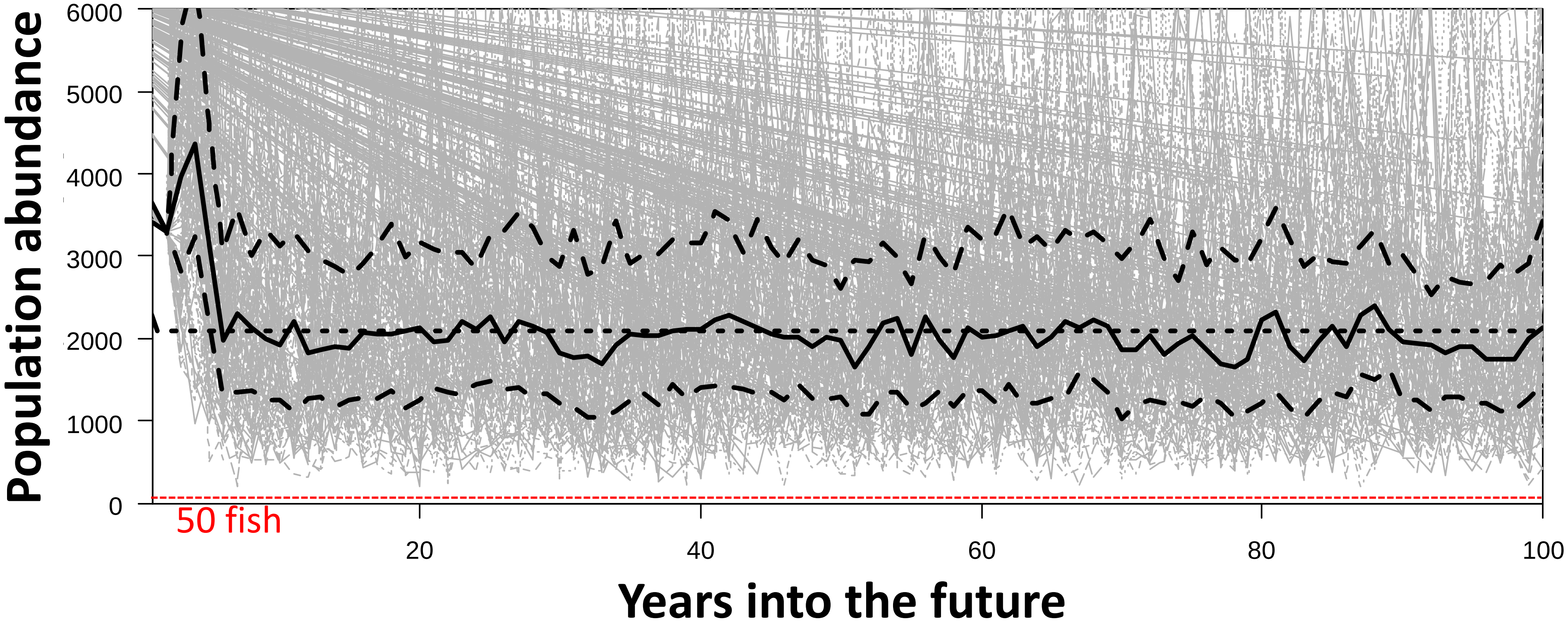
ICTRT and Zabel 2007, Zabel et al. 2013

Interior Columbia River basin populations

- Rapid River (Little Salmon River)
- Potlatch River
- Catherine Creek
- Umatilla River
- Toppenish Creek
- Naches River
- Satus Creek
- Upper Yakima River

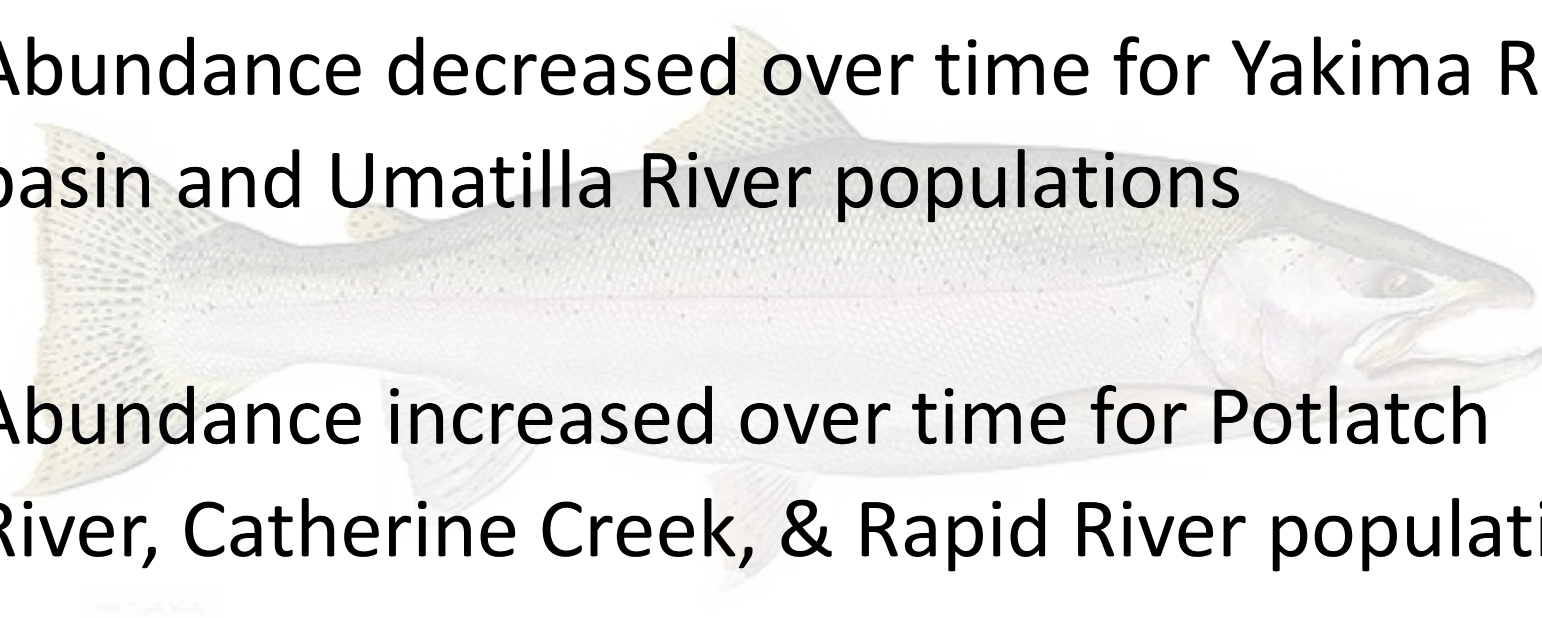
Photo: John McMillan

Example model run—Umatilla River

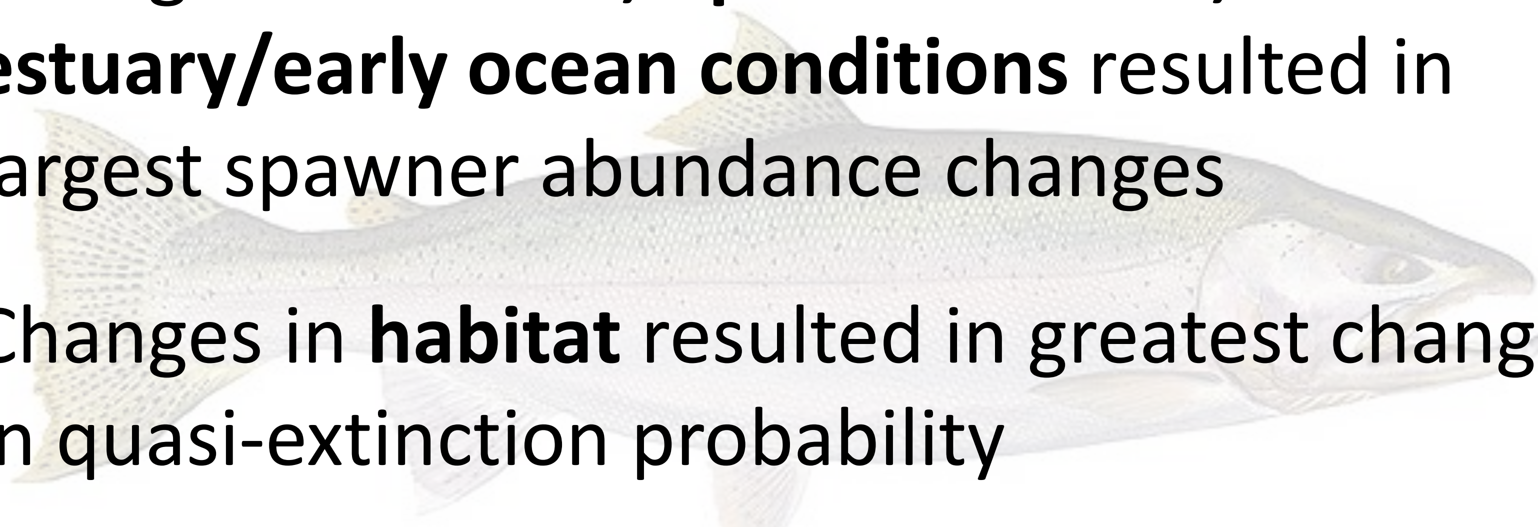


Model predictions (under baseline scenarios)

- Abundance decreased over time for Yakima River basin and Umatilla River populations
- Abundance increased over time for Potlatch River, Catherine Creek, & Rapid River populations

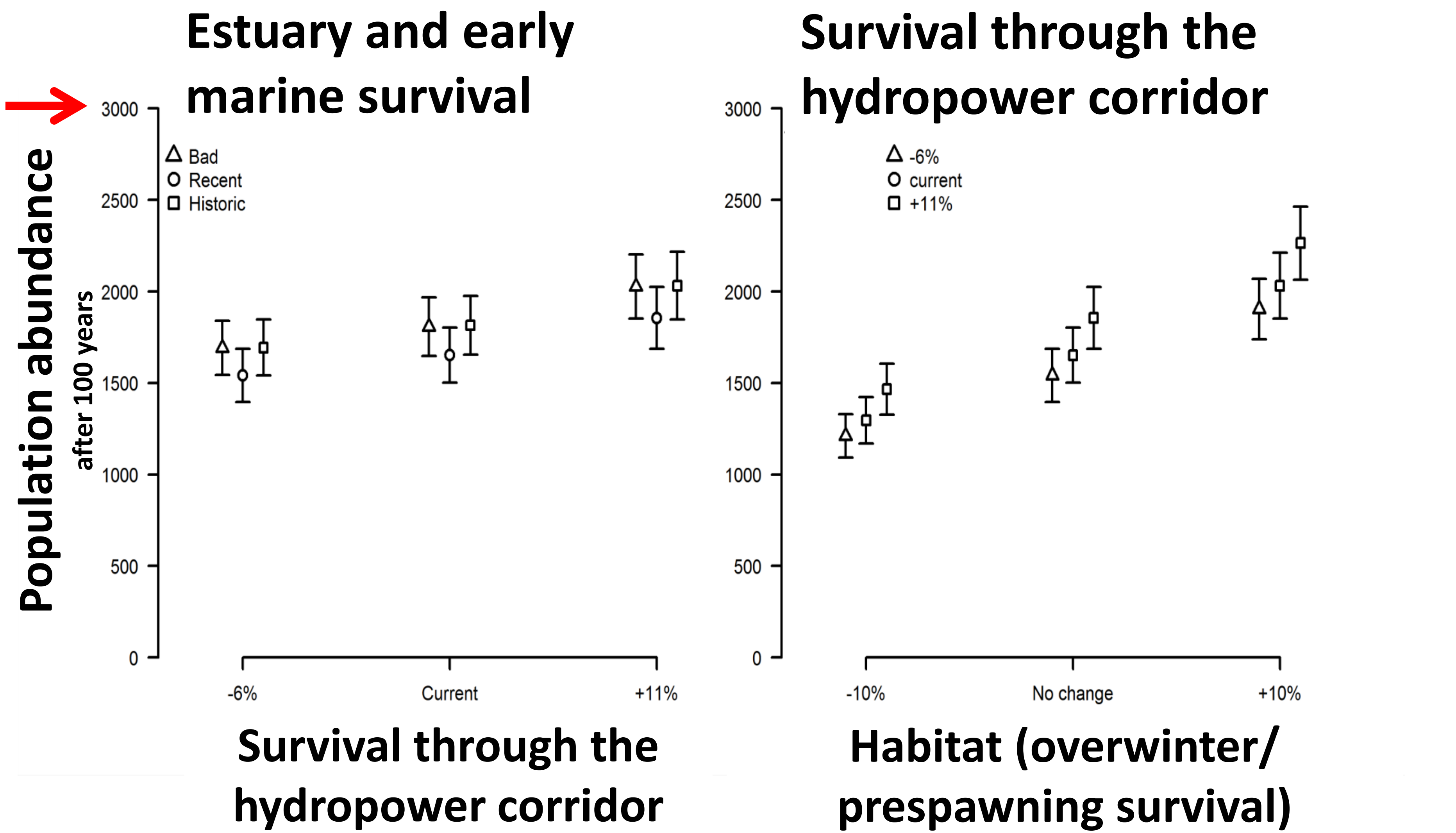


Model predictions (under varying scenarios)

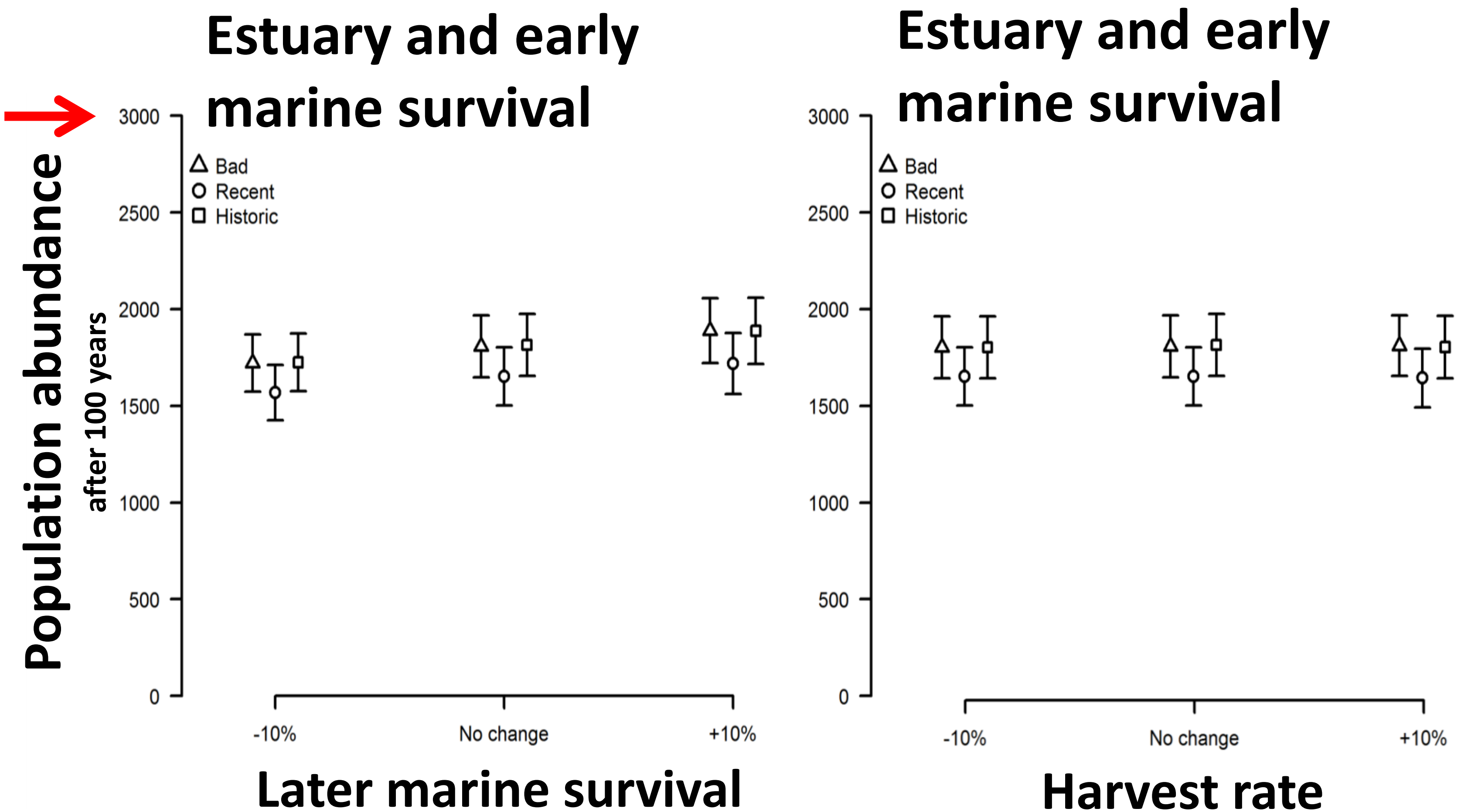


- Changes in **habitat, upriver survival, and estuary/early ocean conditions** resulted in largest spawner abundance changes
- Changes in **habitat** resulted in greatest changes in quasi-extinction probability
- Changes in harvest rates resulted in smaller abundance and extinction probability changes

Population-specific model predictions under various scenarios—Umatilla River



Population-specific model predictions under various scenarios—Umatilla River



Future work

- Combine ICTRT and Zabel matrix model with Courter & Frederiksen et al. freshwater habitat conditions determinants and Satterthwaite et al. model of anadromy/residency decision

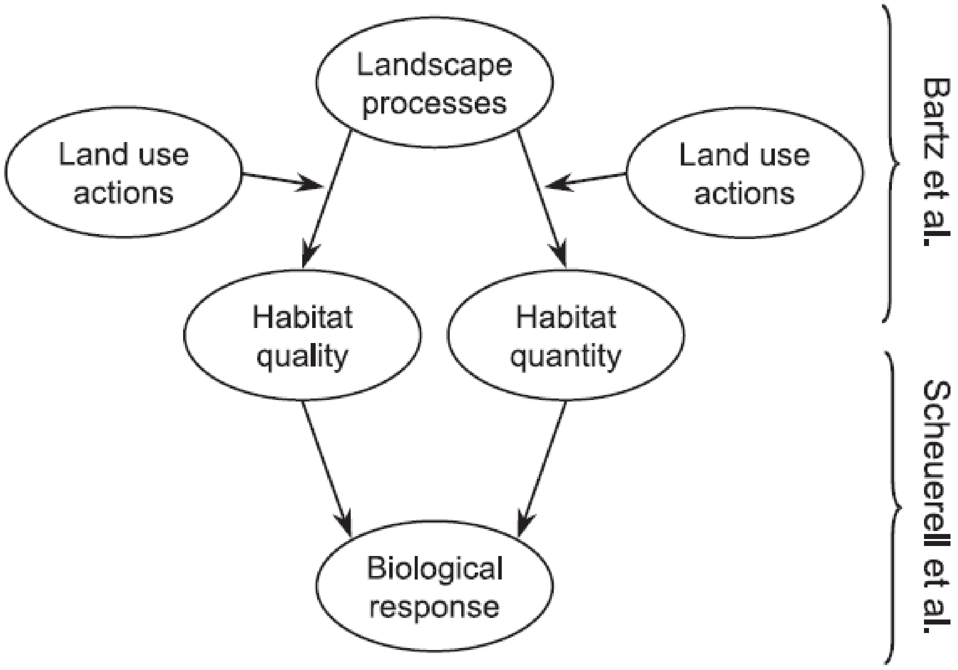
Photos: John McMillan

Habitat considerations need to be incorporated

- First establish fish-specific side of the life-cycle model
- Then incorporate freshwater habitat considerations into model
- Understand how habitat changes (climate change and human modifications including restoration) may affect abundance and viability

Incorporating habitat restoration into the models

- Develop landscape-to-habitat functional relationships
- Develop habitat-to-fish relationships
- Model habitat quality (e.g., flow and temperature) and quantity using land-use and geomorphic characteristics to estimate fish capacity and survival



Bartz et al. 2006, Scheuerell et al. 2006, Beechie et al. 2006

Acknowledgements

- National Research Council Postdoctoral Fellowship Program
- Interior Columbia TRT life-cycle modeling group
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Questions?

Oncorhynchus mykiss: one (two?) cool fish

Photo: John McMillan

Oncorhynchus mykiss: one (two?) cool fish

- Very diverse life history including migration tactics ("partial migration")
- Valuable recreational and commercial fisheries
- Many natural populations have declined in abundance and life history diversity over the past century, are ESA listed

Photos: Jonny Armstrong

Population-specific model predictions under various scenarios—Umatilla River