Life-cycle models for the diverse and plastic *Oncorhynchus mykiss* in the Yakima River basin: challenges and opportunities

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Oncorhynchus mykiss: one (two?) cool fish

Photo: John McMillan

Oncorhynchus mykiss: one (two?) cool fish

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

Photos: Jonny Armstrong

Oncorhynchus mykiss: one (two?) cool fish

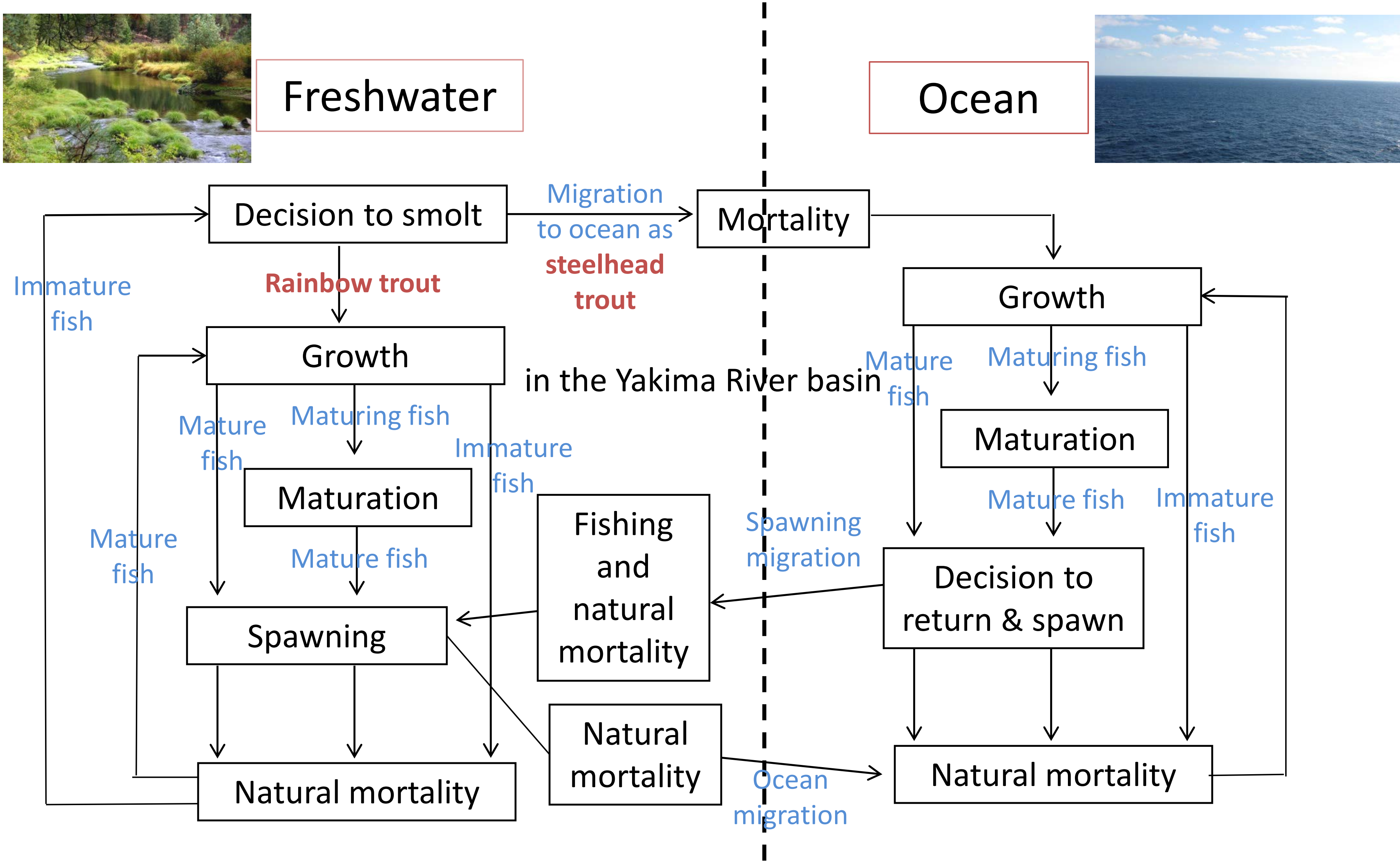
- Life history strategies, population abundance influenced by environmental and anthropogenic factors
- Life-cycle models used to better understand these strategies, evaluate population dynamics spatially and temporally

Photos: Jonny Armstrong

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 patterns of anadromy and residency will we see given different freshwater habitat mitigation actions?
  - What stages represent population “bottlenecks?”

O. mykiss life cycle models



Modified from Theriault et al. 2008

Existing models to help

1. Anadromous/resident *O. mykiss* abundance and reproductive success life-cycle models (developed for Yakima River; Ian Courter et al. 2009, 2010)

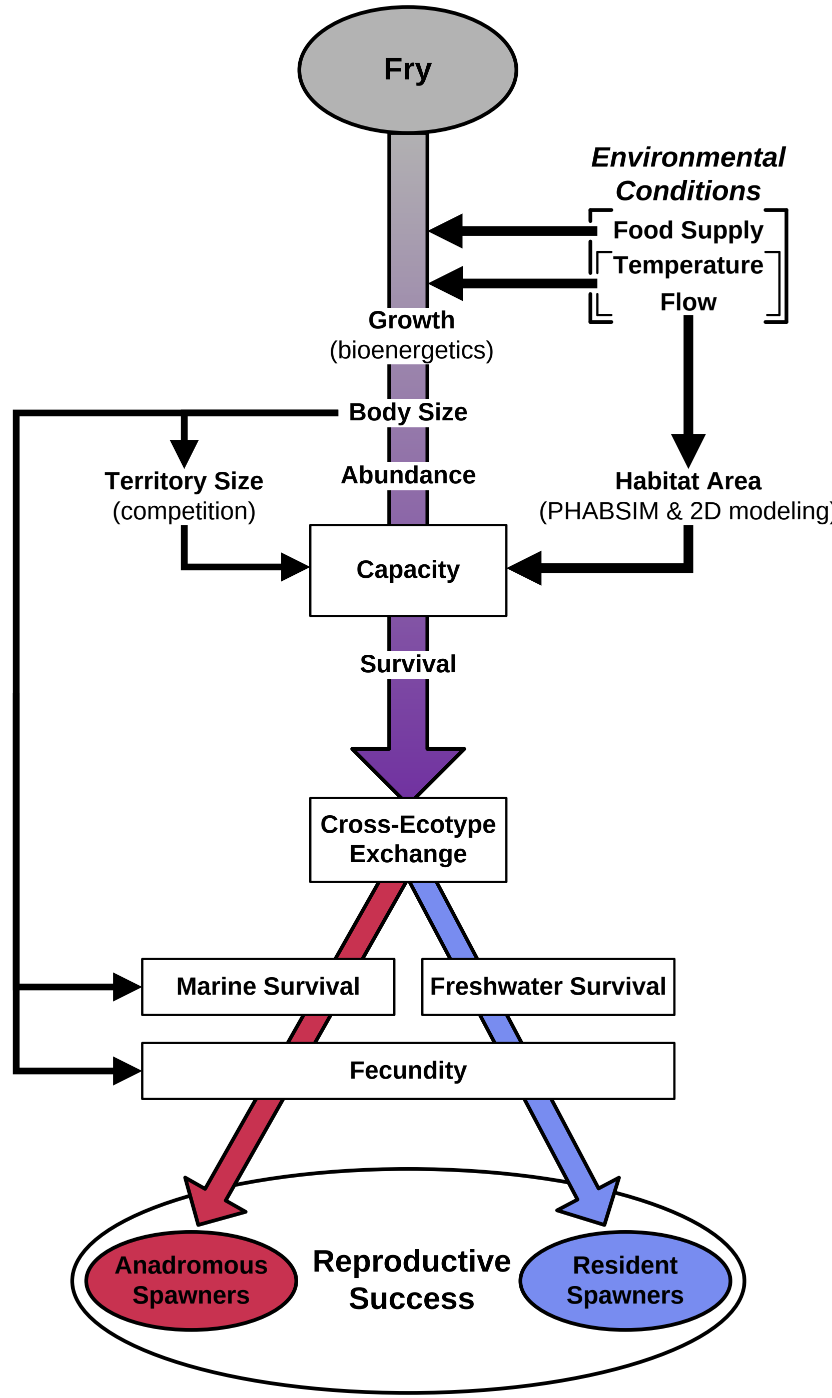
2. Anadromy/residency and smolt age decision for *O. mykiss* (developed for California populations; Satterthwaite et al. 2009, 2010)

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

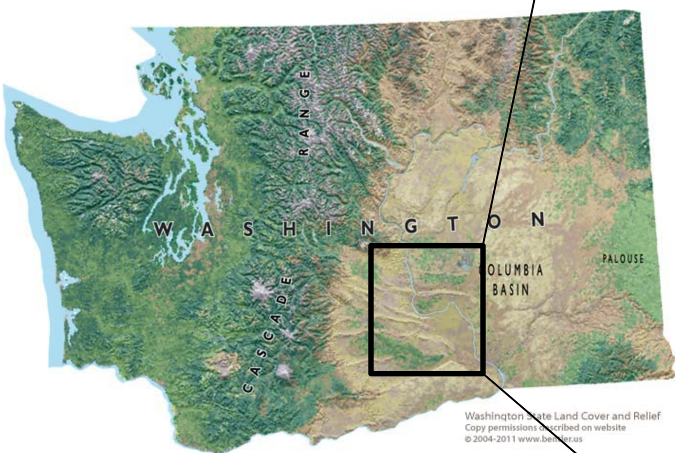
O. mykiss life-cycle models

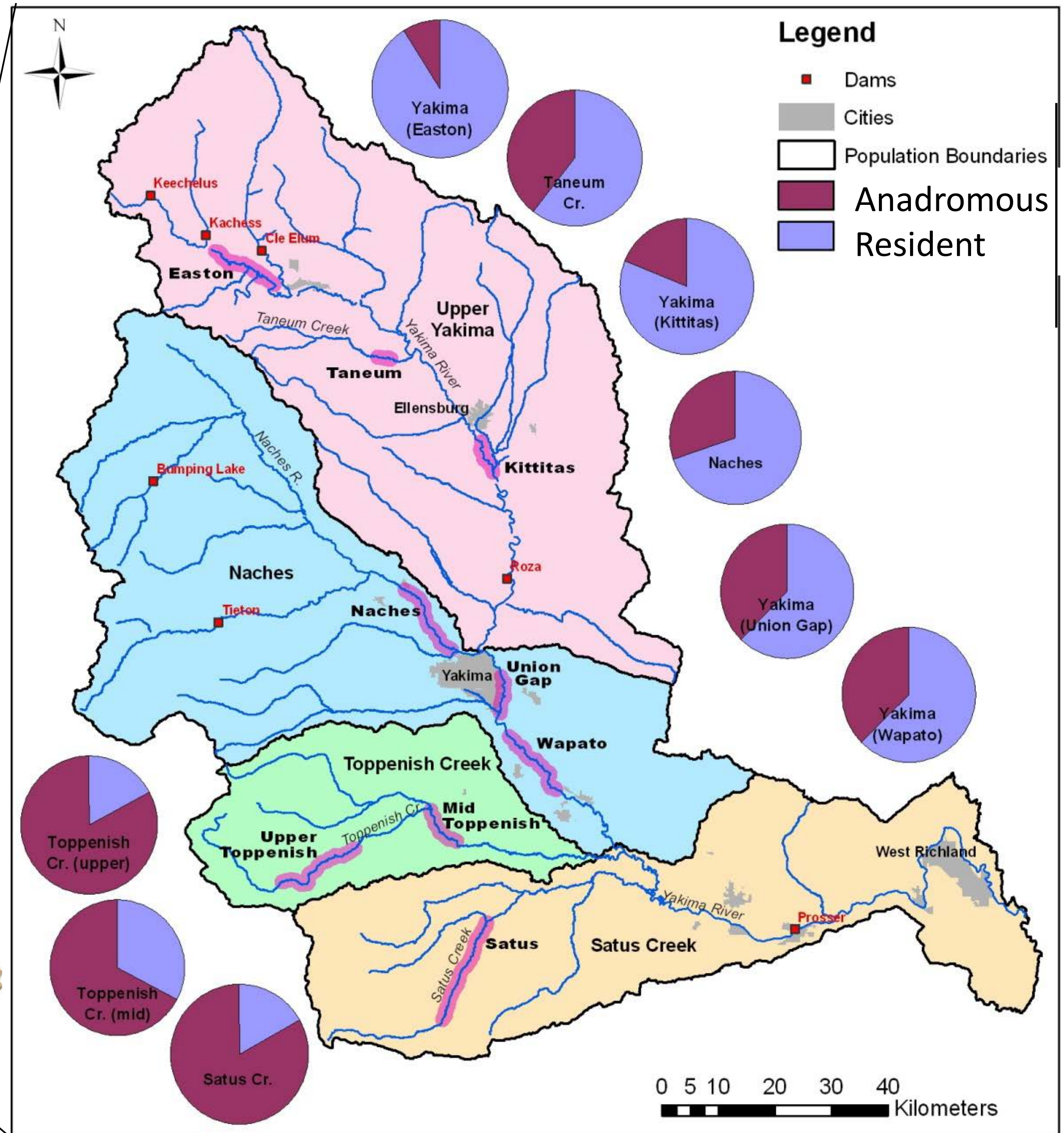
- Yakima River is flow-regulated by upstream storage reservoirs
- Use freshwater food supply, flow, and temperature to **predict** fish growth, survival, capacity, and reproductive success by life history tactic

Courter et al. 2009



Model predictions

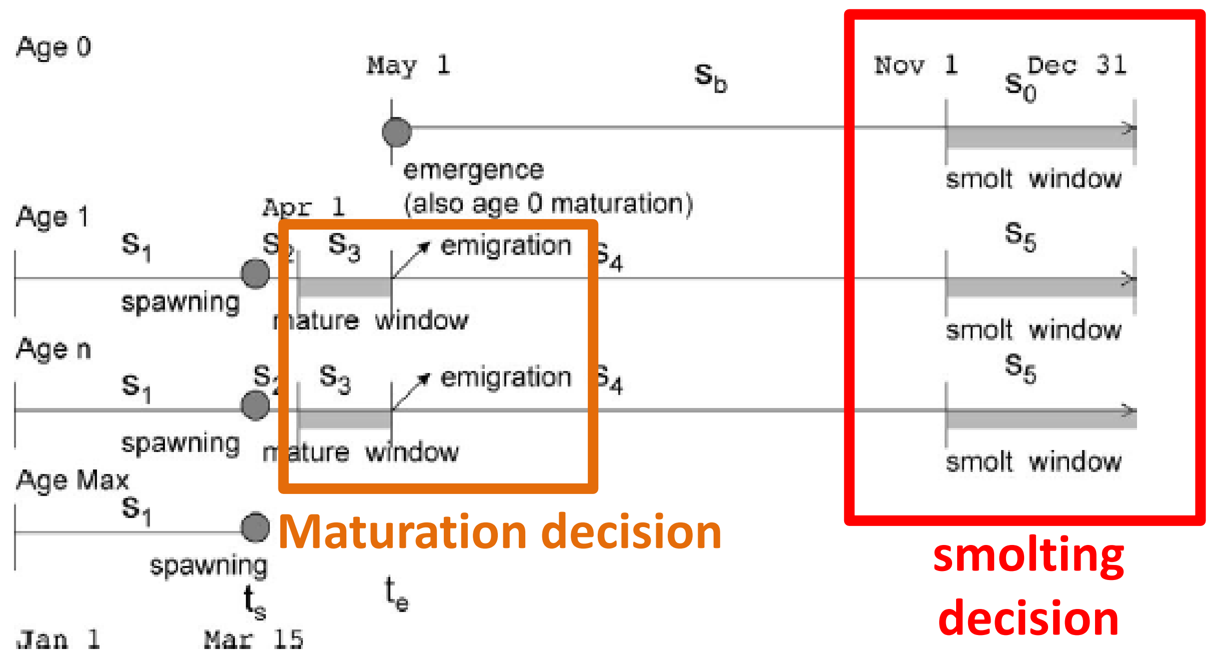




Courter et al. 2009

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

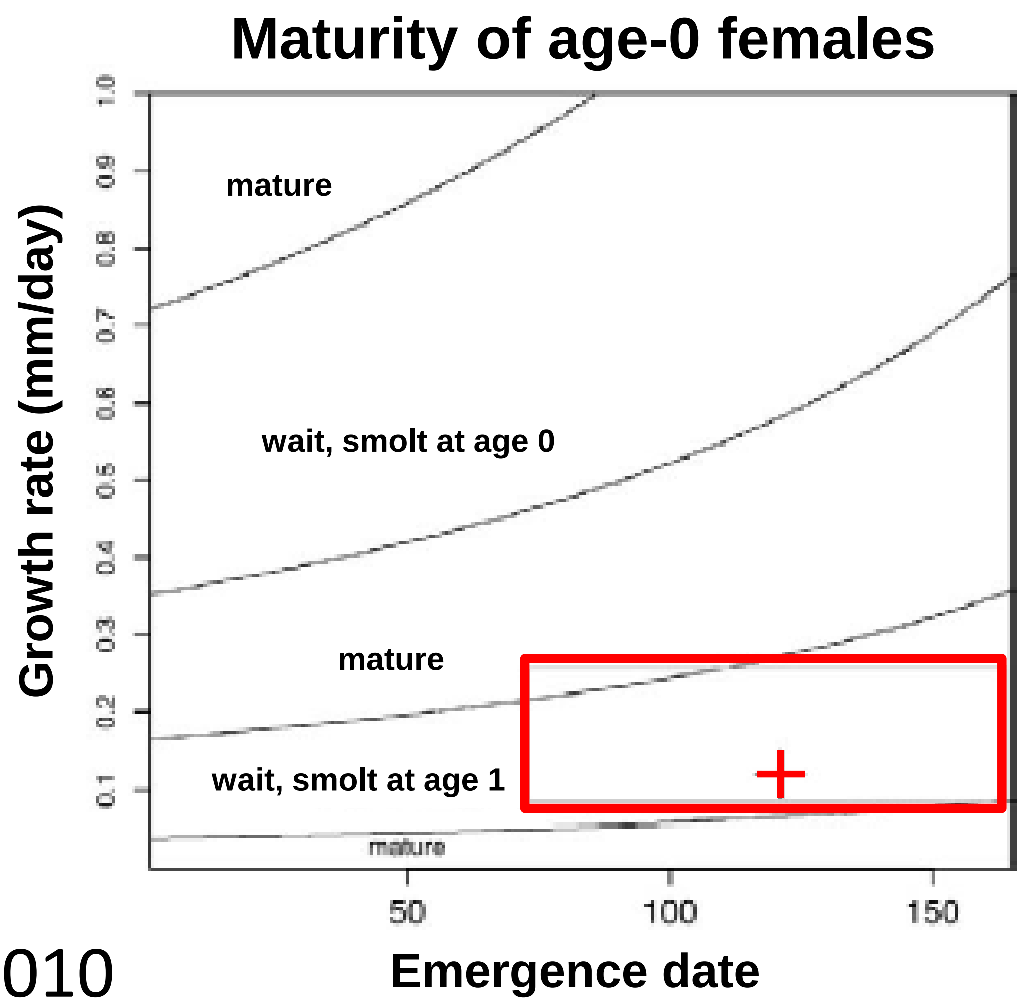
- Based on fish emergence date, freshwater growth, survival and fecundity (affecting its conditional state) along with predicted overall fitness
- **Predict** maturation/residency and smolt age decision



Satterthwaite et al. 2009, 2010

Model predictions

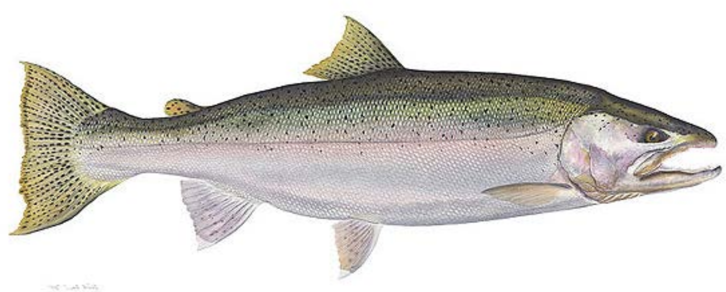
- Predict maturation/ residency and smolt age decision



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 (need spawner & smolt counts by population)
- Components (adjusted in different "scenarios"):
  - Juvenile and adult overwinter survival in freshwater ("habitat")
  - Downstream survival (based on hydropower corridor passage)
  - Estuary (based on avian predation) and early marine survival (based on "climate" conditions in various years)
  - Later marine survival
  - Upstream survival



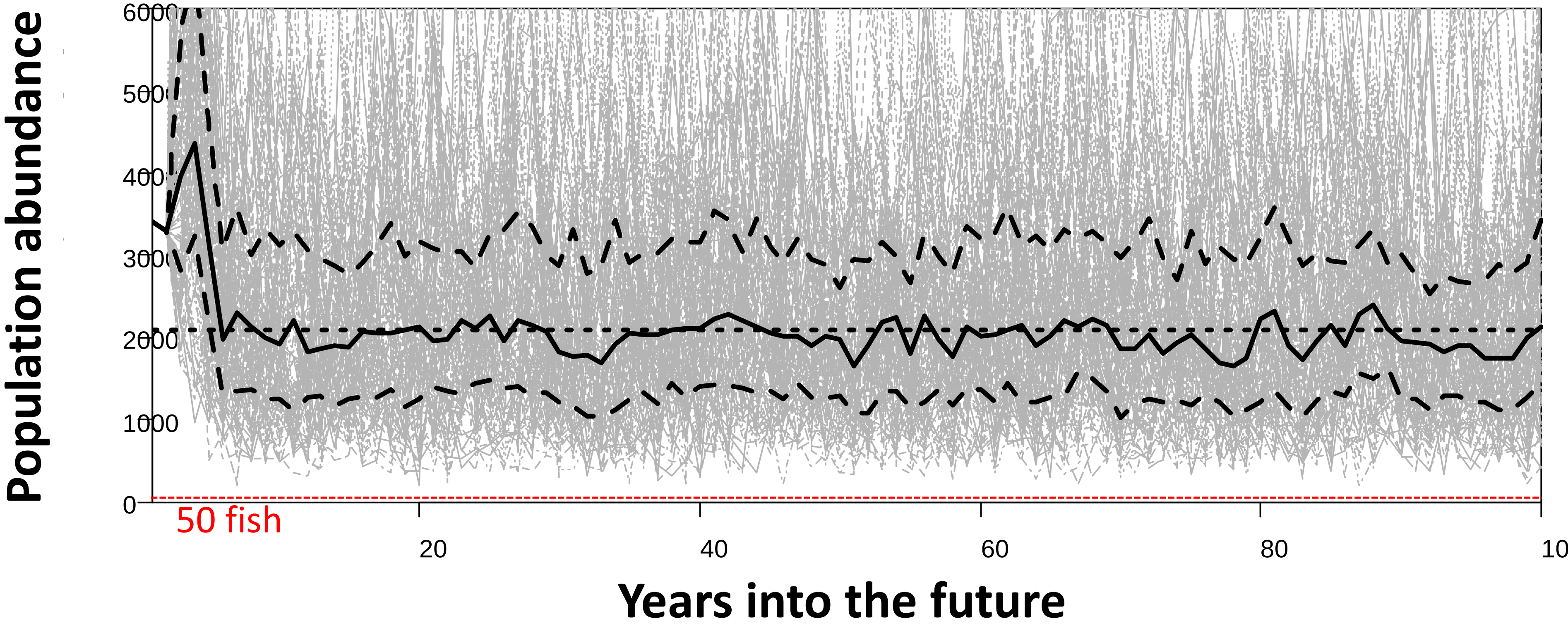
ICTRT and Zabel 2007

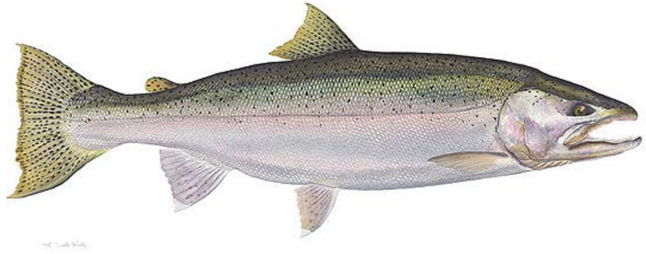
Yakima River basin populations

- Toppenish Creek
- Naches River
- Satus Creek
- Upper Yakima River

Photo: John McMillan

Example model run





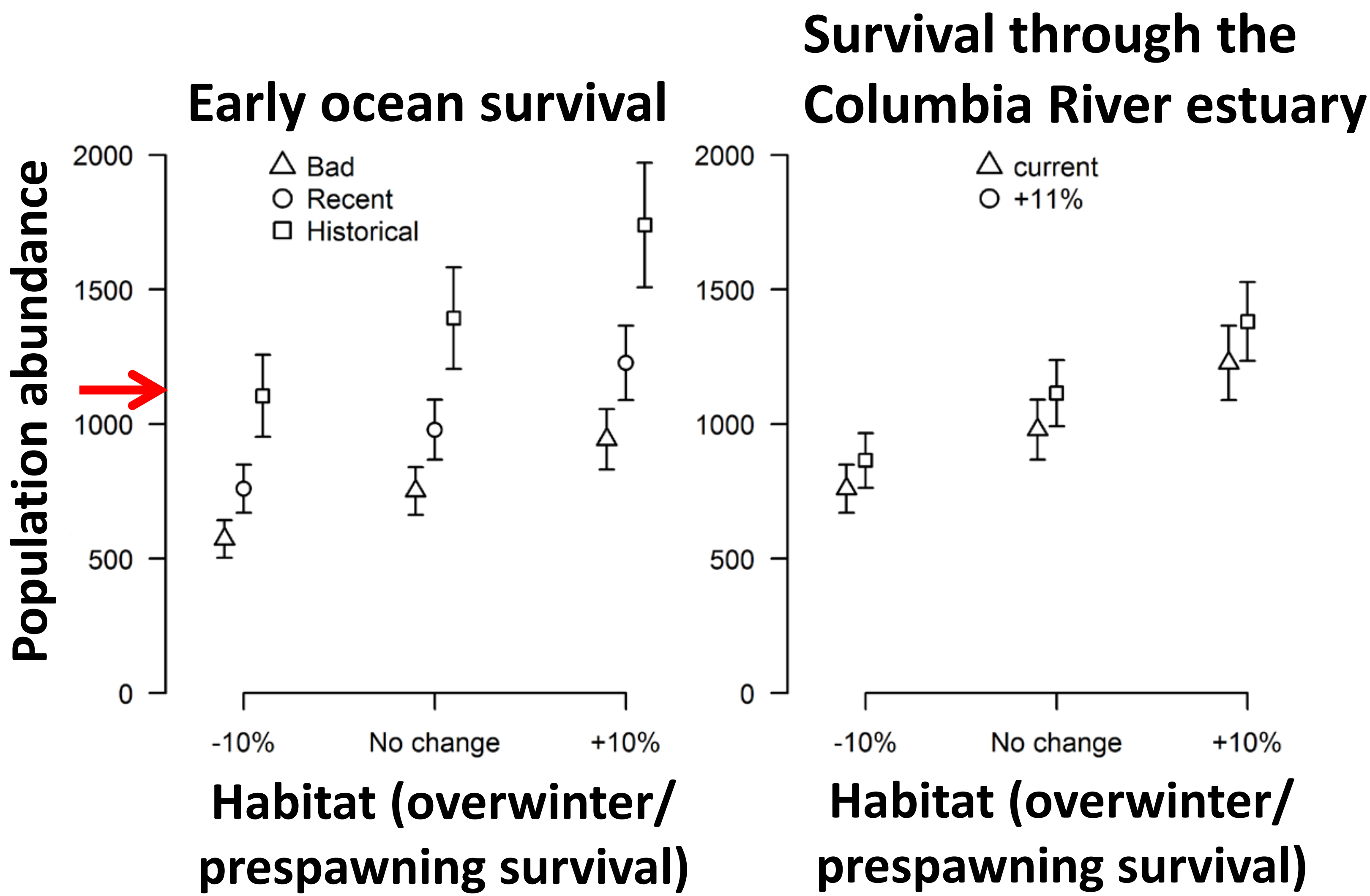
Model predictions (under baseline scenarios)

- Spawner abundance lowest for upper Yakima River, highest for Naches River
- Abundance decreased over time for Satus Creek, Naches River, and upper Yakima River populations
- Abundance increased slightly over time for Toppenish Creek
- Quasi-extinction probability after 100 years:
  0% for Toppenish & Satus creeks and Naches River,
  47% for upper Yakima

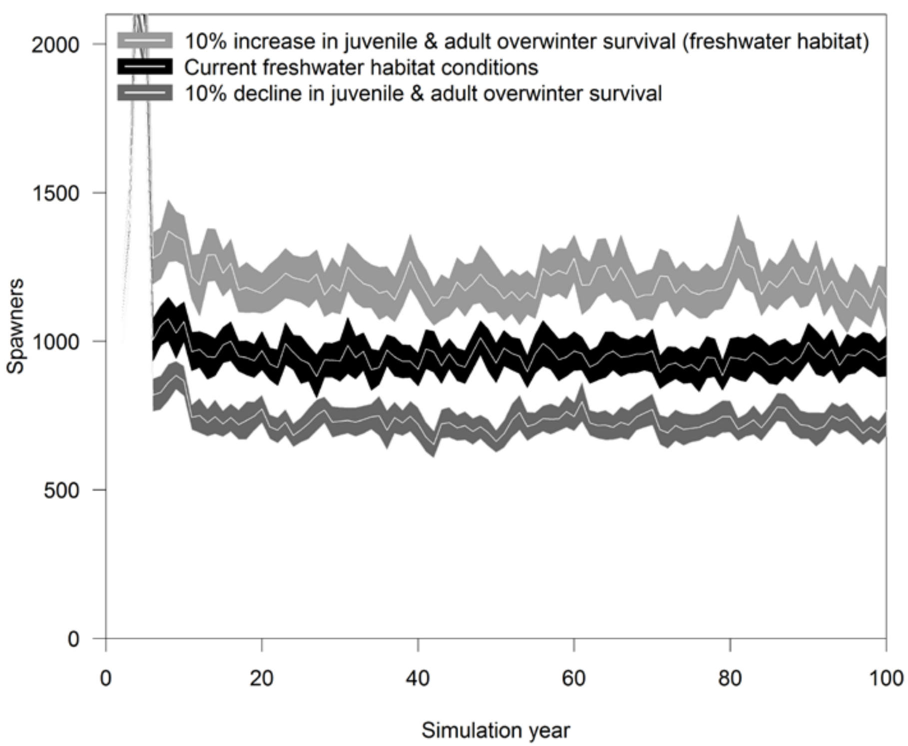
Model predictions (under varying scenarios)

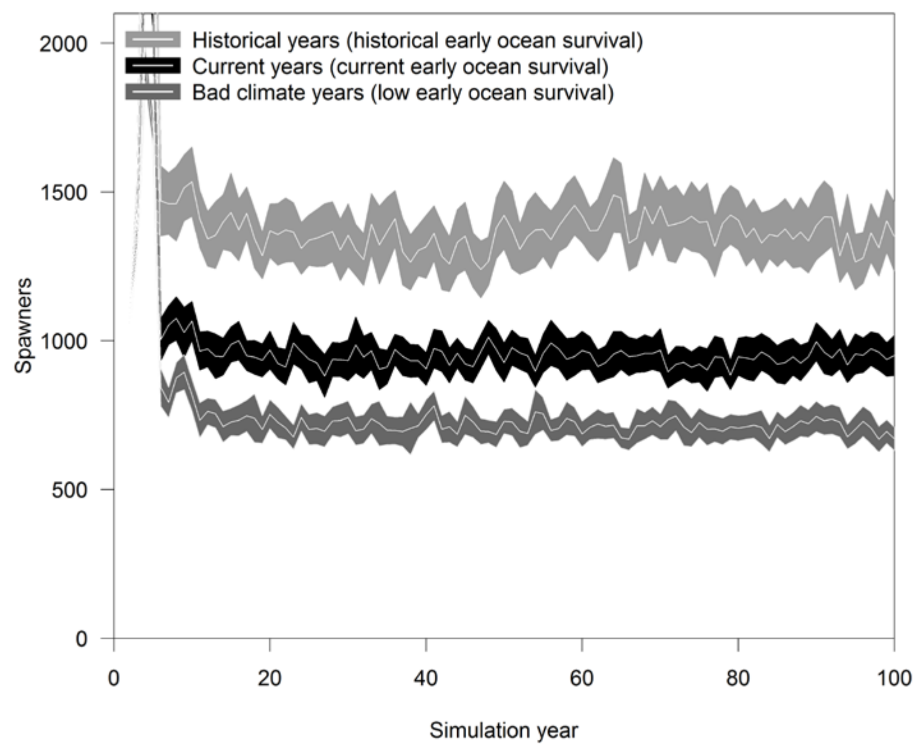
- Changes in **habitat** and **early ocean conditions** resulted in largest spawner abundance and quasi-extinction probability changes
- Changes in estuary and upriver survival resulted in moderate spawner abundance and quasi-extinction probability changes
- Changes in later ocean survival rates resulted in smaller changes

Population-specific model predictions under various scenarios—Naches River

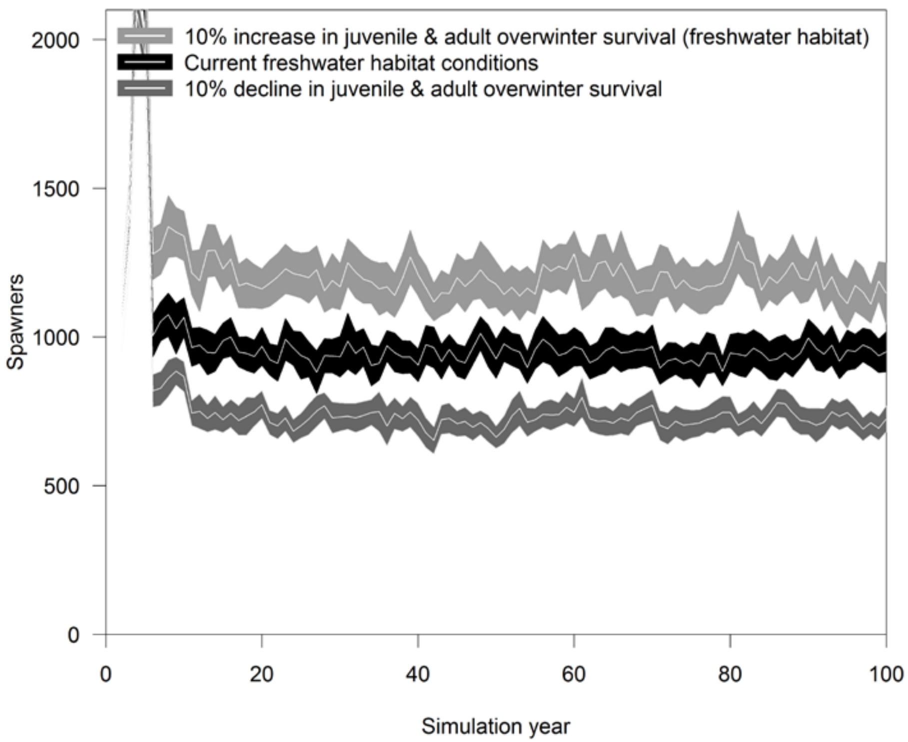


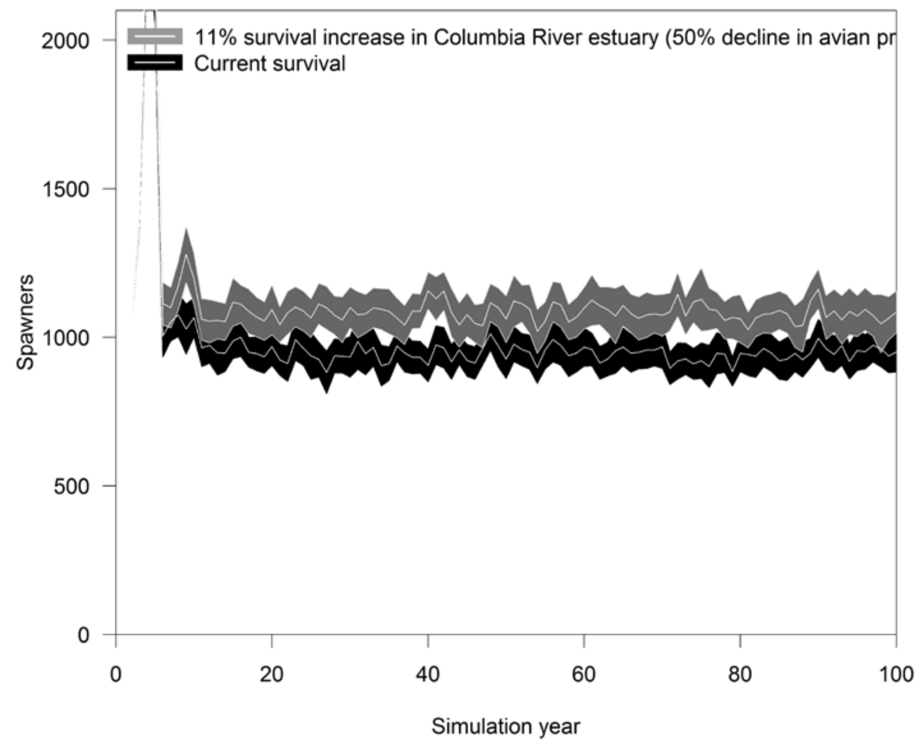
Population-specific model predictions under various scenarios—Naches River





Population-specific model predictions under various scenarios—Naches River





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) may affect abundance and viability

Additional potential future work

- Combine ICTRT and Zabel matrix model with Courter et al. freshwater habitat conditions determinants, then Satterthwaite et al. model of fish state-dependent anadromy/residency decision

Photos: John McMillan

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- NOAA Northwest Fisheries Science Center
- Washington Department of Fish and Wildlife

Photo: John McMillan

Questions?

Population-specific model predictions under various scenarios—Umatilla River