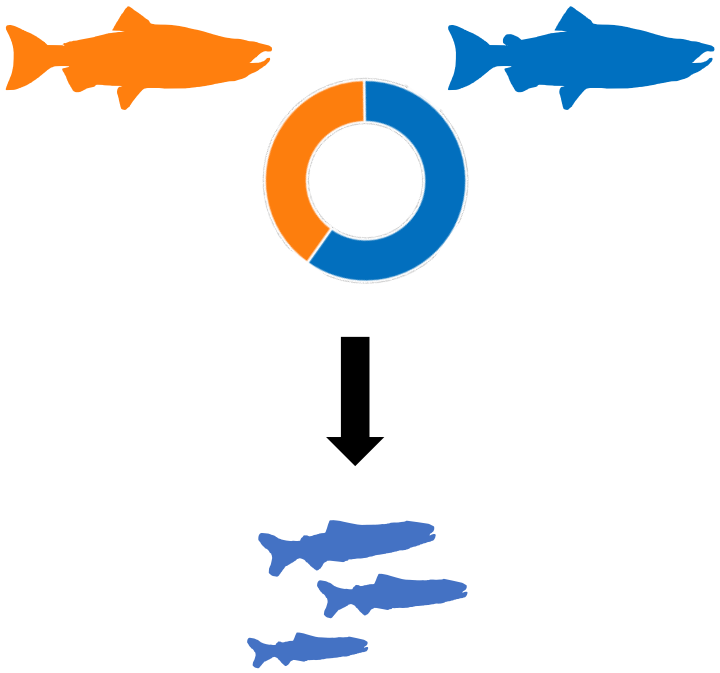
A life cycle model to evaluate scaling-down hatchery practices in response to above-dam recovery signals in Spring Chinook salmon (*Oncorhynchus tshawytscha*)

Mairin Deith, Tom Porteus, Roberto Licandeo, Eric Parkinson,
Aaron Greenberg & Murdoch McAllister
University of British Columbia
Institute for The Oceans and Fisheries

Integrated Passage Assessment

Objectives

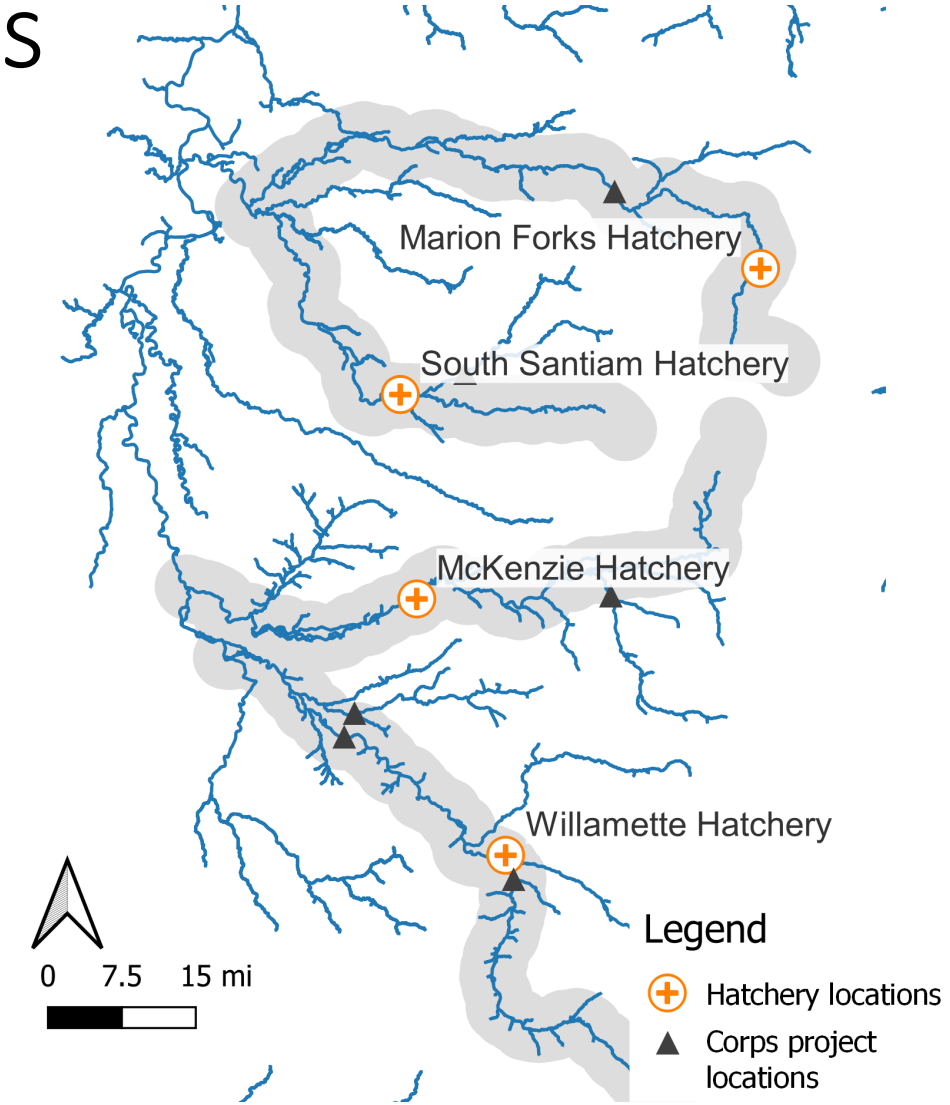


1. Hatchery supplementation in the Upper Willamette: Goals and risks
2. Introduce techniques to model genetic introgression and domestication selection
3. Present exploratory model results and outline future development

Hatchery rationale and risks

- USACE & ODFW coordinate and fund production/release of hatchery spring Chinook salmon
  - Sourced from natural origin adults native to each subbasin

USACE production rationale: mitigate for loss of habitat access above projects



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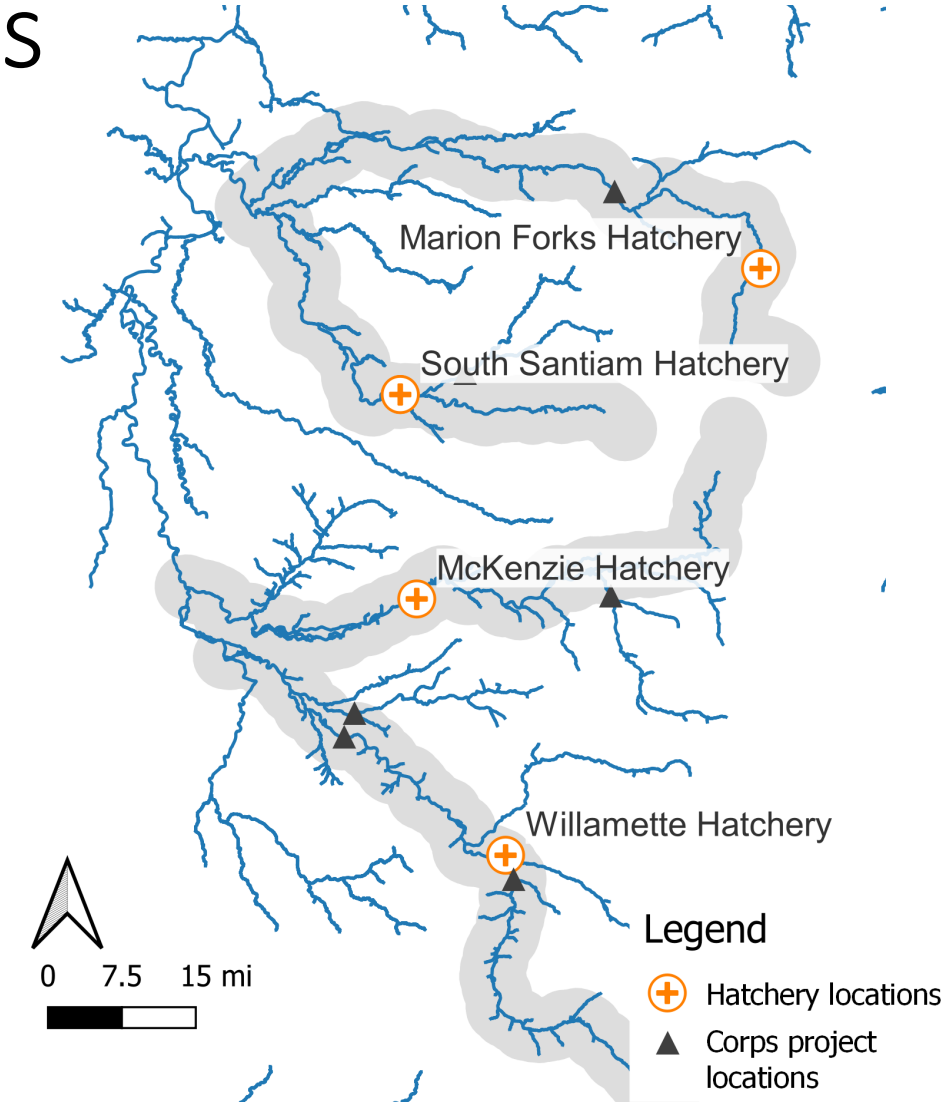
→ If improvements to dam passage observed, **opportunity to assess hatchery goals and activities**



Hatchery rationale and risks

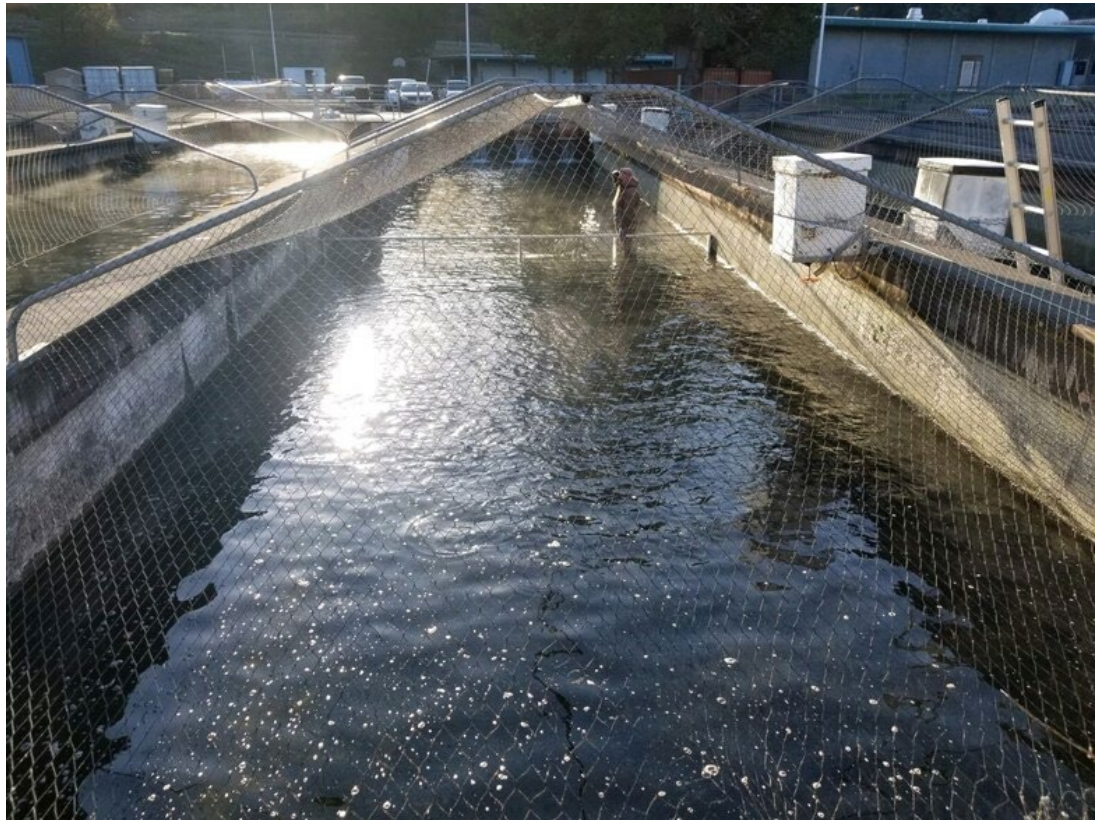
- A (brief) list of risks of hatchery supplementation in salmonids:

  Ecological (e.g., predation, competition)

  Harvest (e.g. incidental mortality)

  Genetic (e.g., domestication selection, loss of genetic diversity/adaptive traits)

  e.g. Juvenile growth rate, migration timing



Withler et al. 2018 (available from publications.gc.ca); Leitwein et al. 2021, doi:10.1111/eva.13235; Cogliati et al. 2022, doi:10.1007/s10641-022-01279-9

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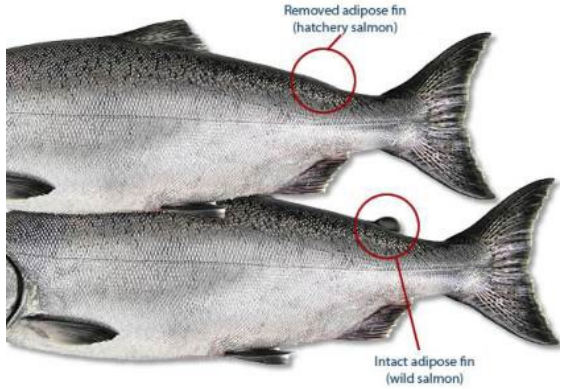
- A (brief) list of risks of hatchery supplementation in salmonids:

  Ecological (e.g., predation, competition)
  → Outplanting/release rules

  Harvest (e.g. incidental mortality)
  → Effective marking

  Genetic (e.g., domestication selection, loss of genetic diversity/adaptive traits)

→ Risks mitigated by hatchery practices
(e.g., prescribed in Hatchery Genetic Management Plans)



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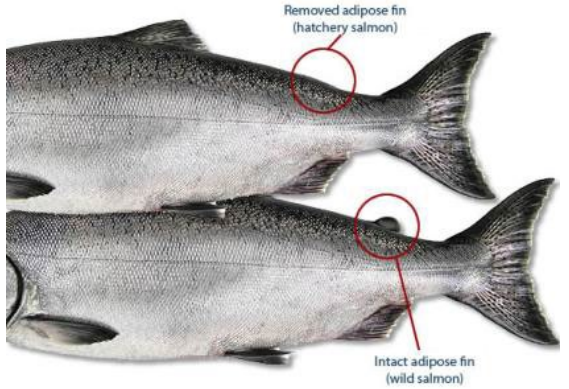

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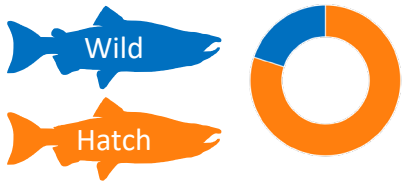

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Modelling plausible genetic consequences of hatchery supplementation

Upper Willamette Models

- IPA Model
  - No hatchery components, only above-dam NO reproduction

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  - No ability for dynamic hatchery policies
  - Non-overlapping generations
  - No juvenile/adult migrant diversity

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Modelling plausible genetic consequences of hatchery supplementation

Upper Willamette Models

- IPA Model

Adapted modules from AHA:

+ Natural & domestication selection, inheritance

And added new functionality

+ Dynamic feedback controls
+ Overlapping generations
+ Migrant type diversity

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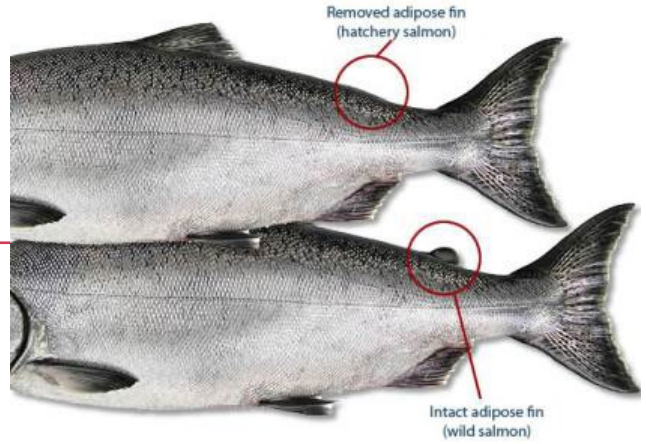

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+ NO+HO adult returns

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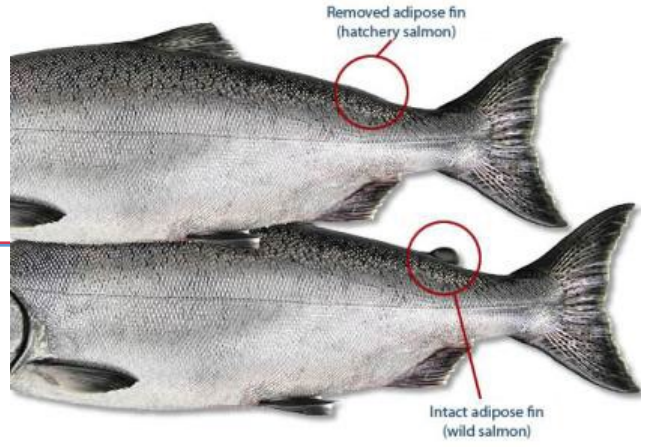

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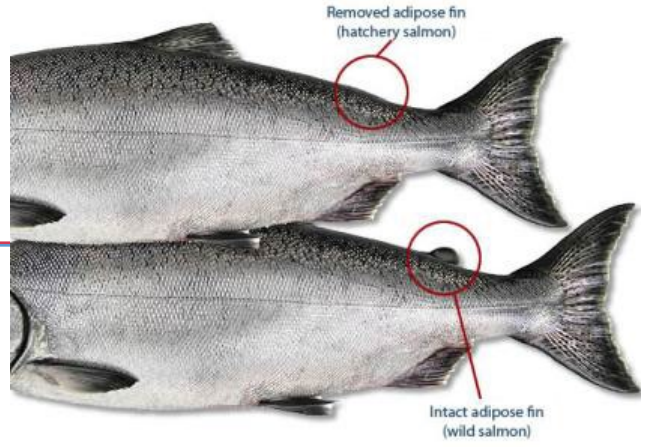

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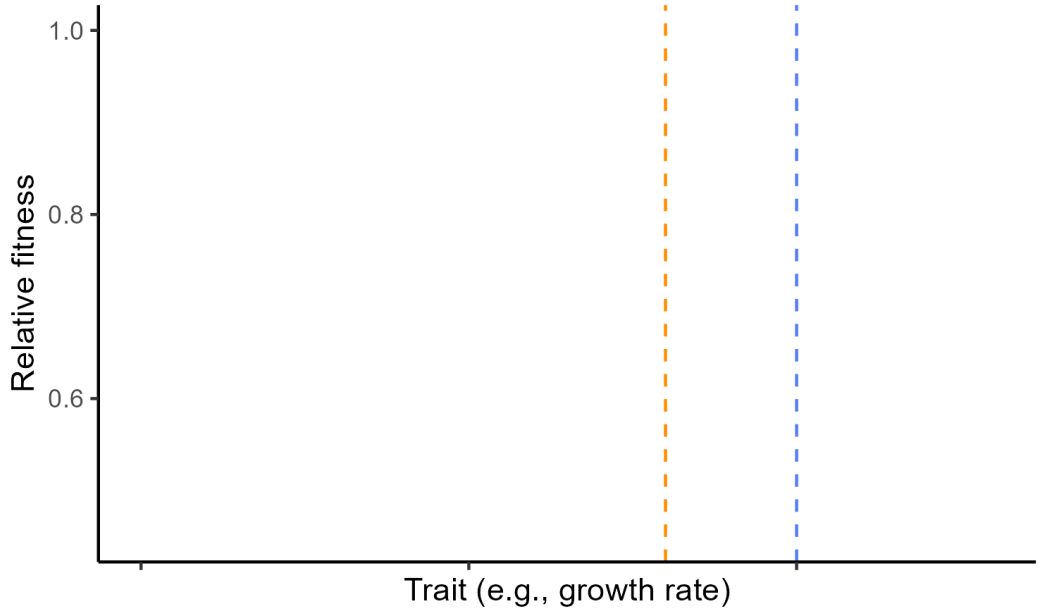
  - Trait is heritable



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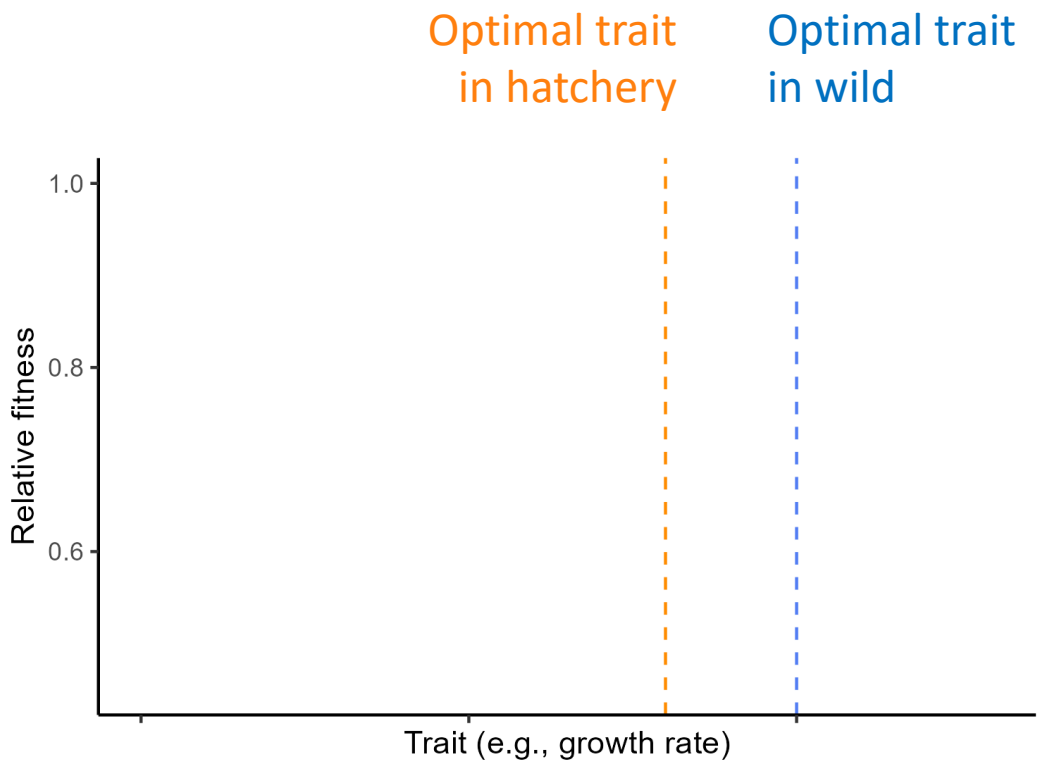

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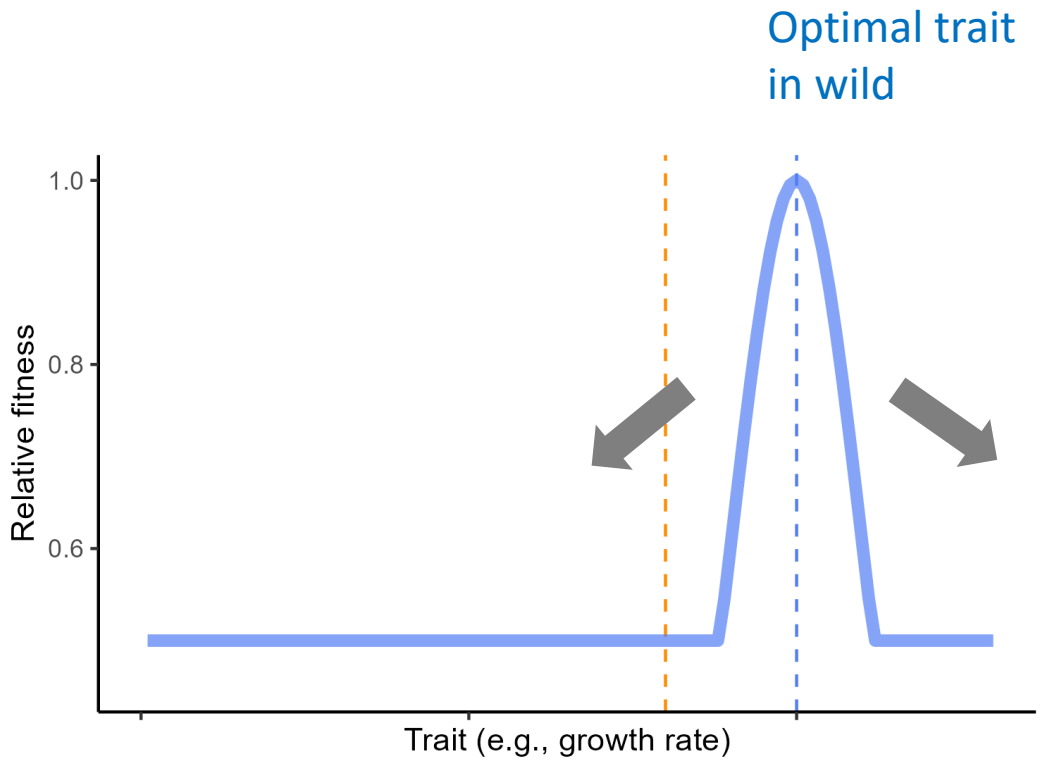

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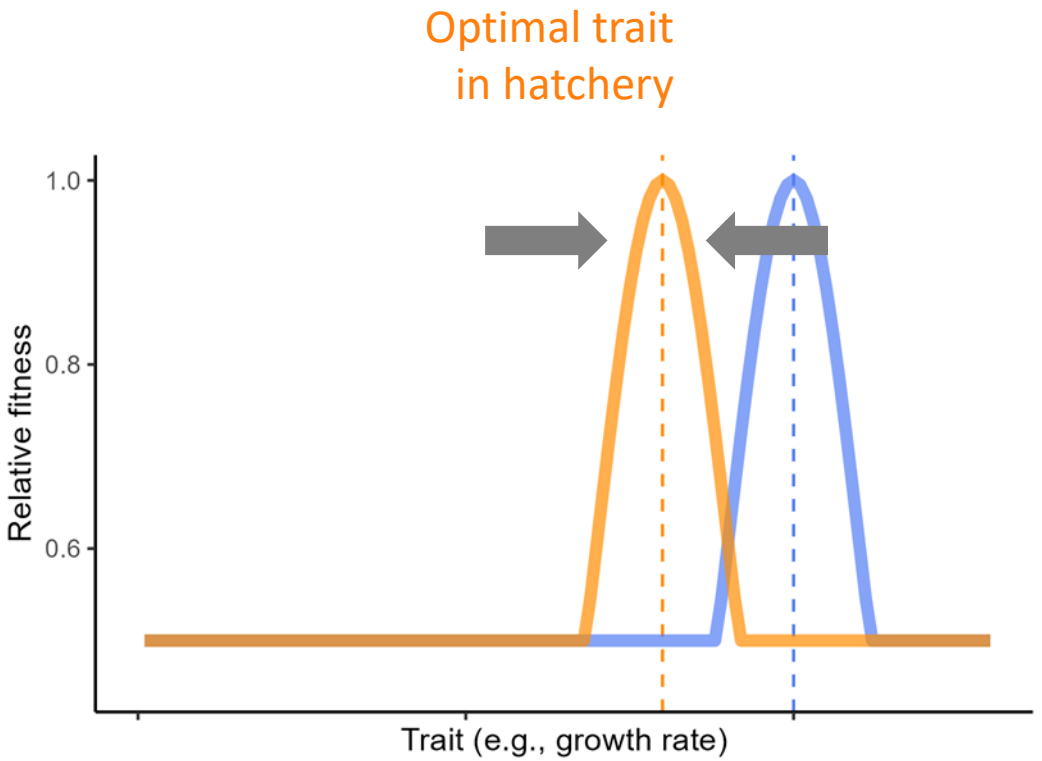
  - In the hatchery: **domestication selection** towards hatchery optimum



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Fitness and trait selection

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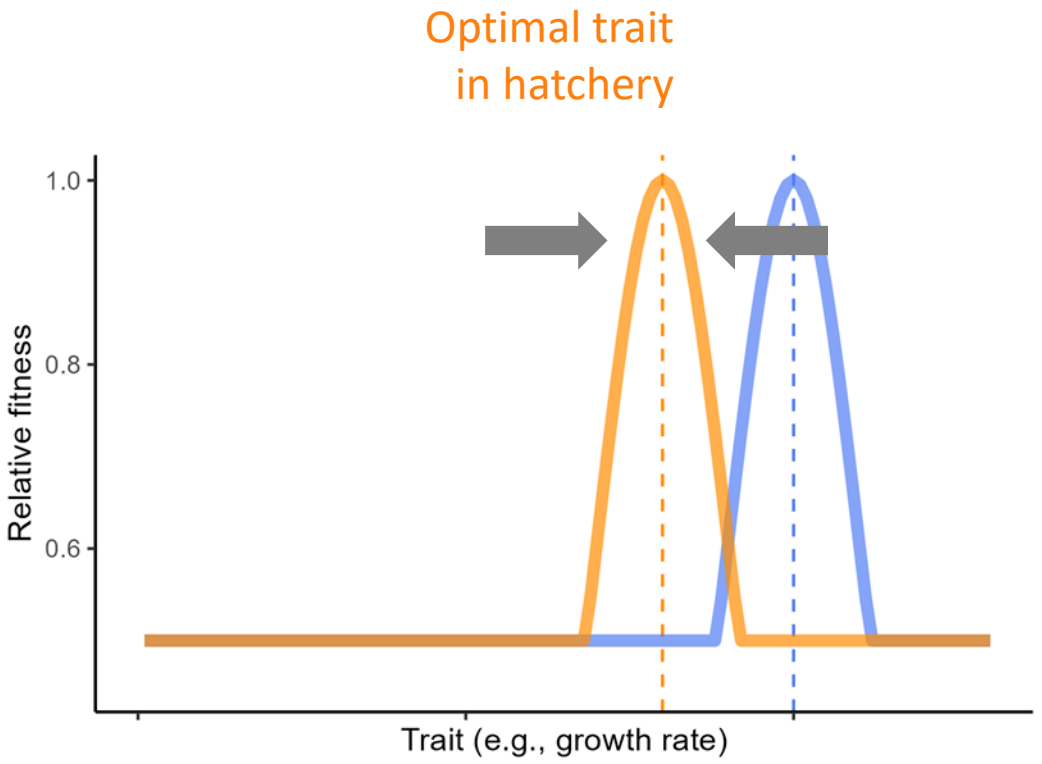
  - Trait is heritable
  - Each of the wild and hatchery environments have an optimal trait value where fitness is highest
  - **Issue arises when interbreeding allows hatchery-selected traits to dilute naturally selected traits, lowering natural population's fitness in the natural environment**



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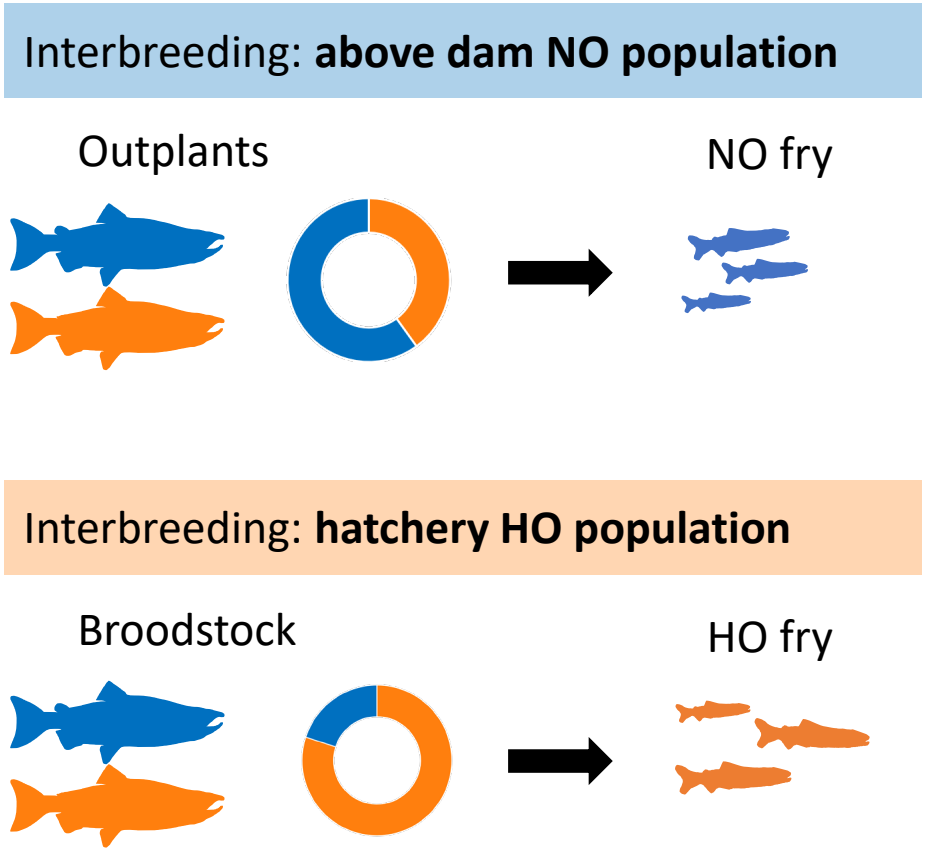
    - All-H Analyzer: non-overlapping generations



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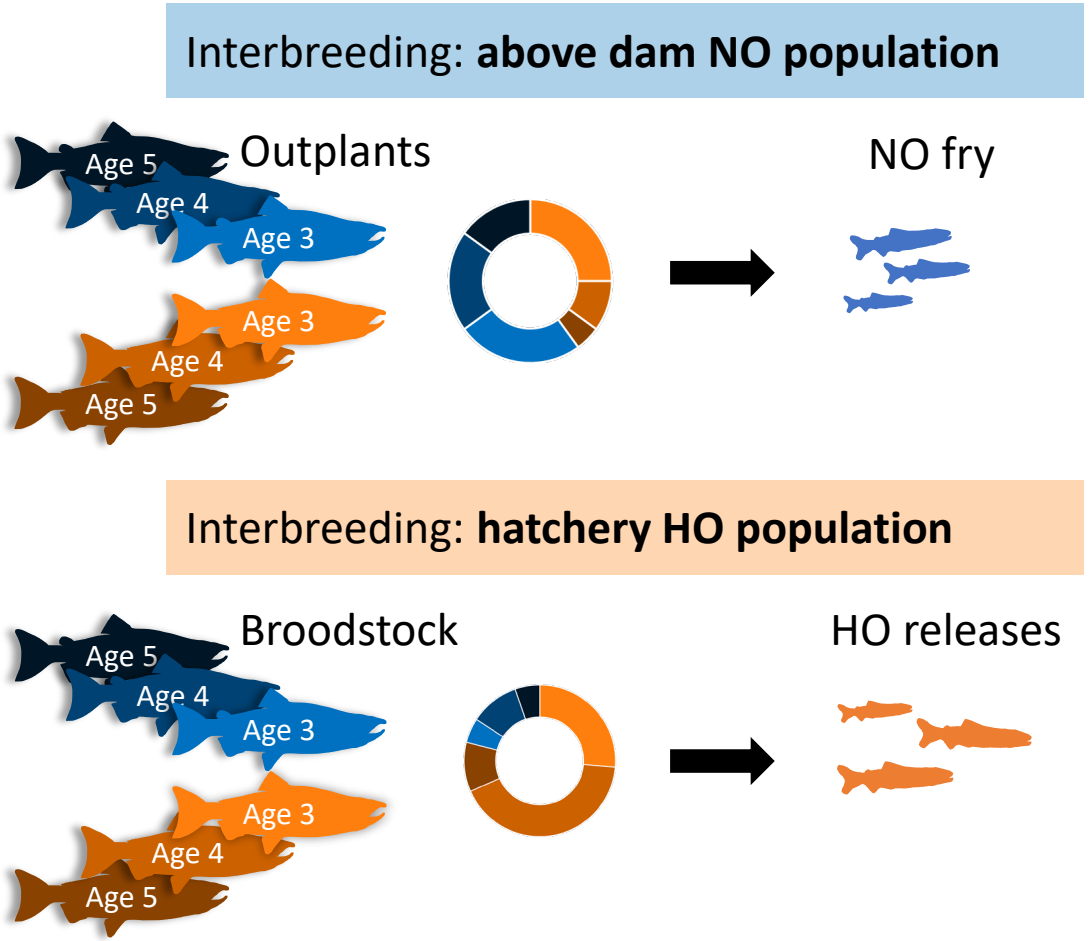
  - All-H Analyzer: non-overlapping generations
  - IPA hatchery model: multiple cohorts of parents contribute to next generation



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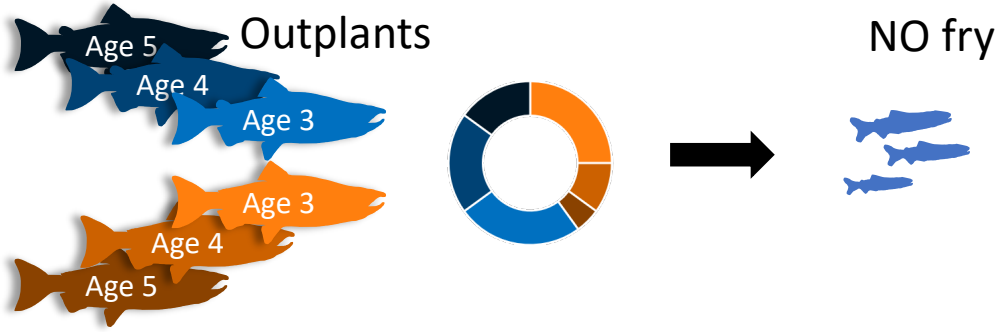
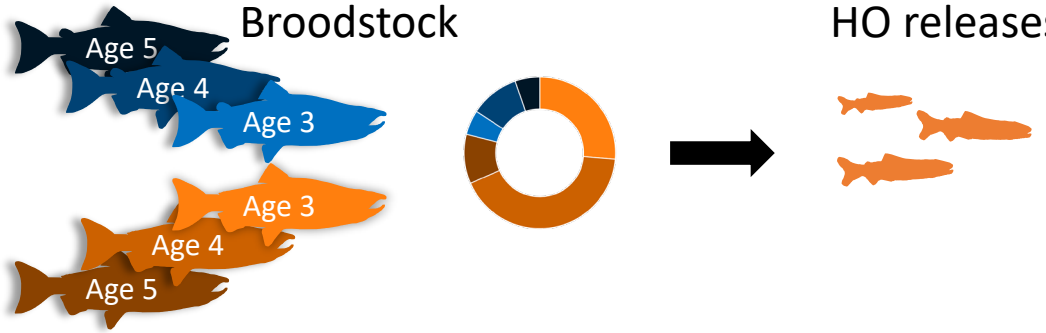
Assumptions:

- Use default, commonly applied values for heritability, selection strength, optima, other difficult to estimate parameters
- Trait is tracked as population average, **assuming random mating**

Interbreeding: **above dam NO population**



Interbreeding: **hatchery HO population**



Example results: **Informing pHOS**

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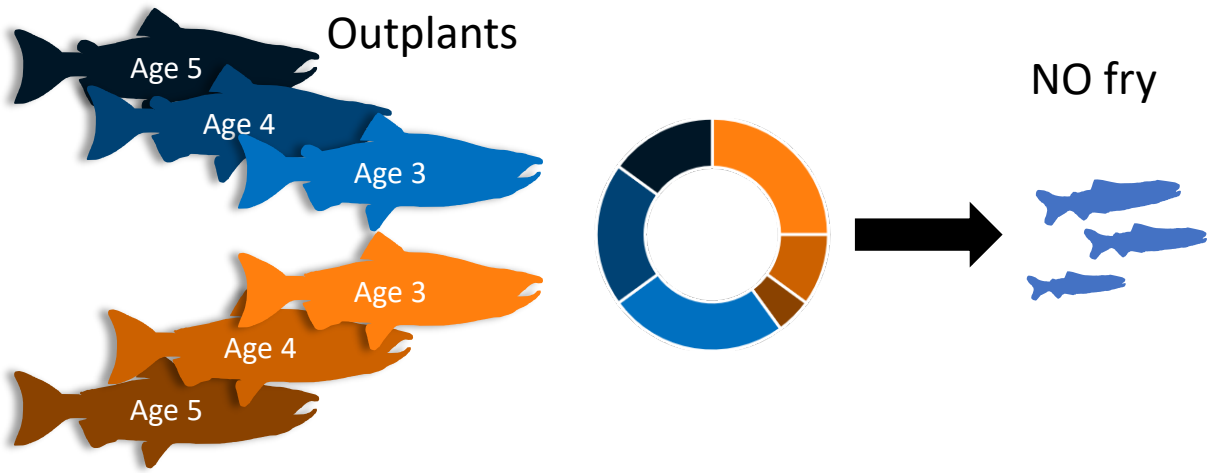


For demonstration:
Change outplant rules; **fix proportion of hatchery-origin outplants above Detroit dam, p(HO), at 0.3, 0.5, or 0.7**

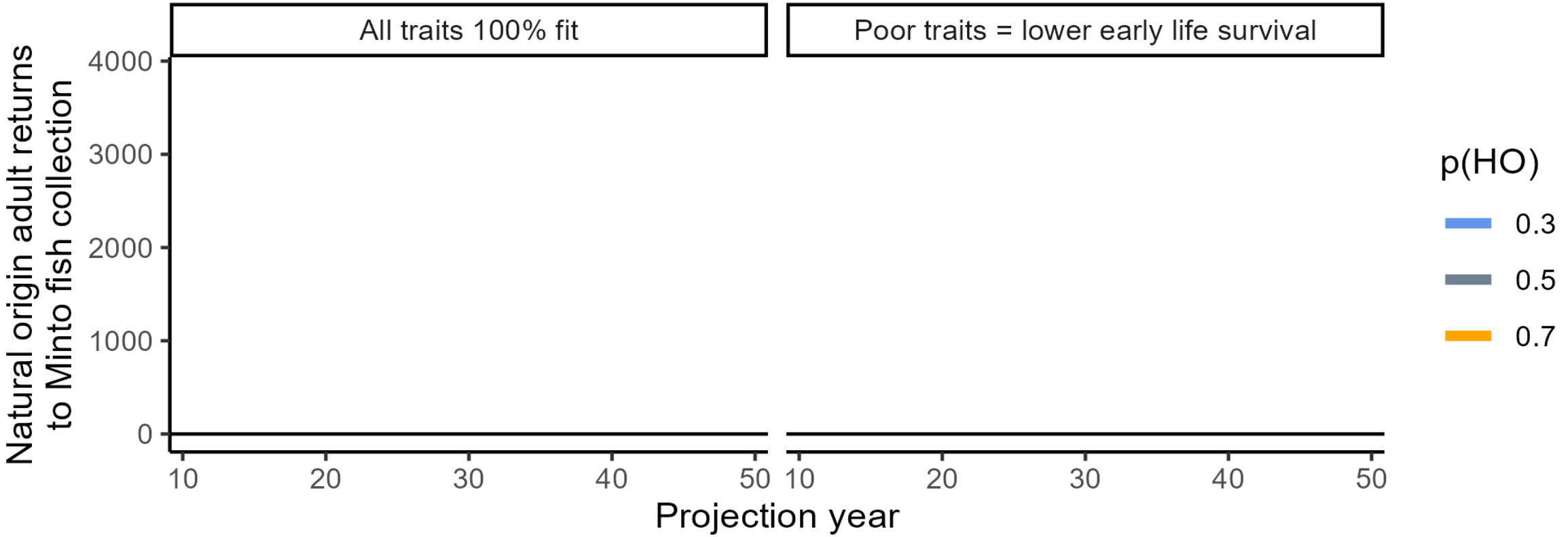
Maintaining all other HGMP practices, like broodstock collection, releases, etc.

No feedback control, fixed proportion

Example results: **Informing pHOS**

No Action Passage Alternative

No dam passage improvement, but begin outplanting
NO fish above Detroit



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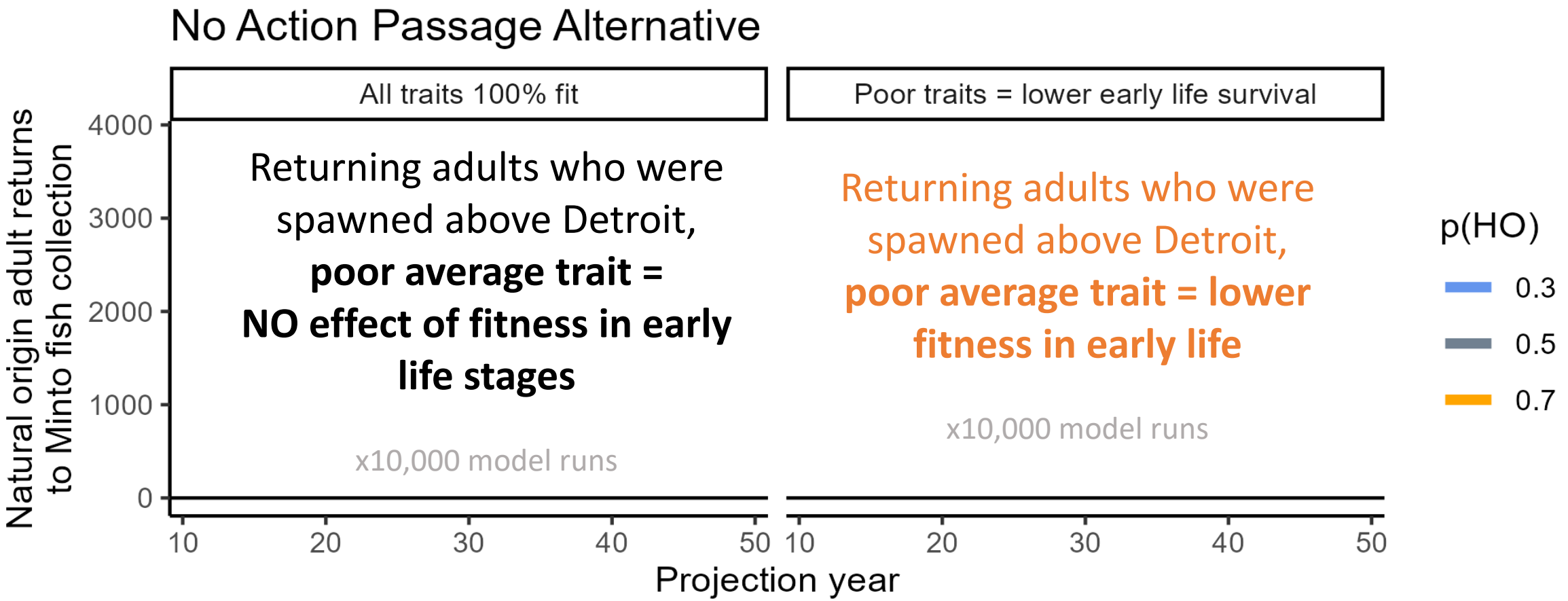

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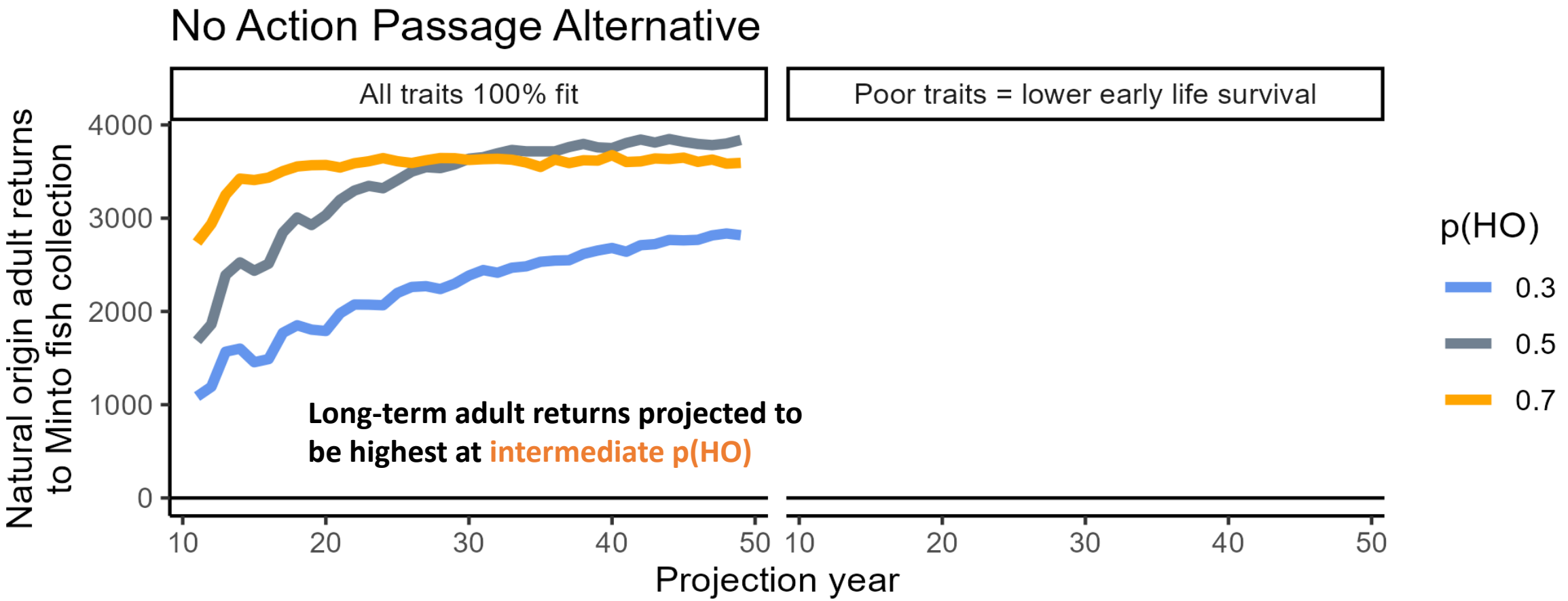

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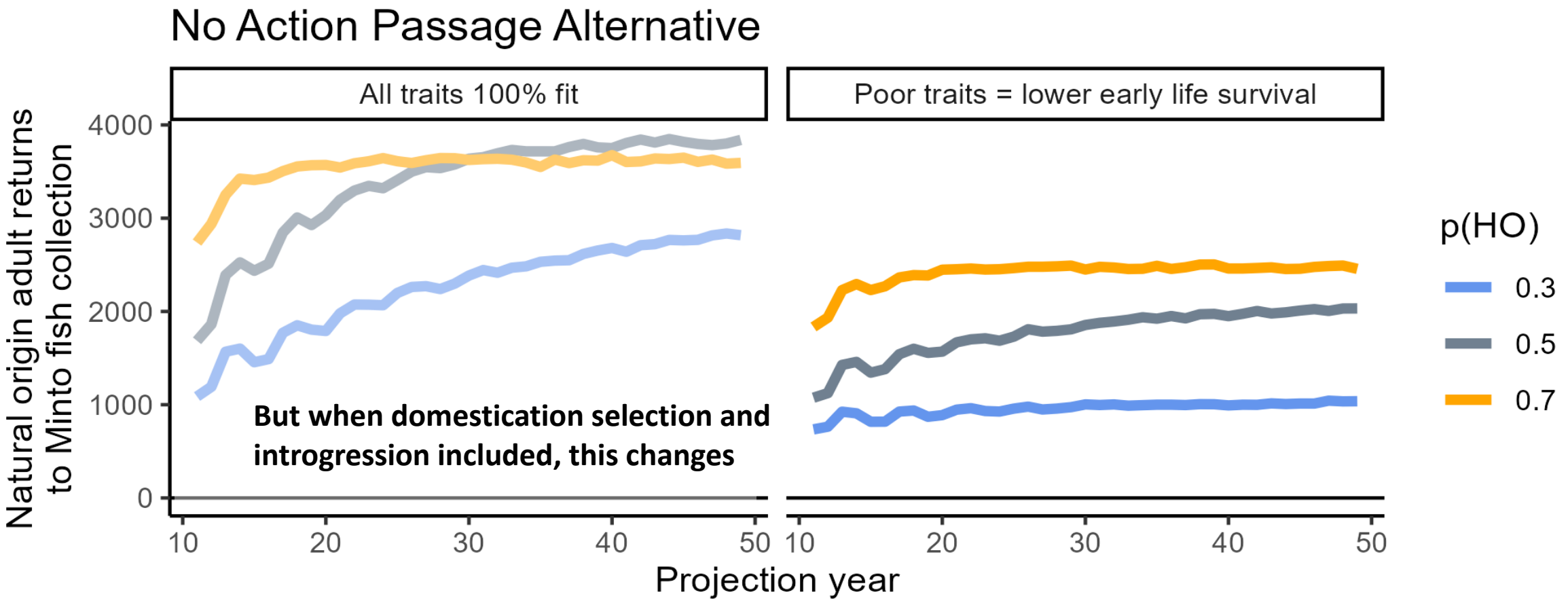

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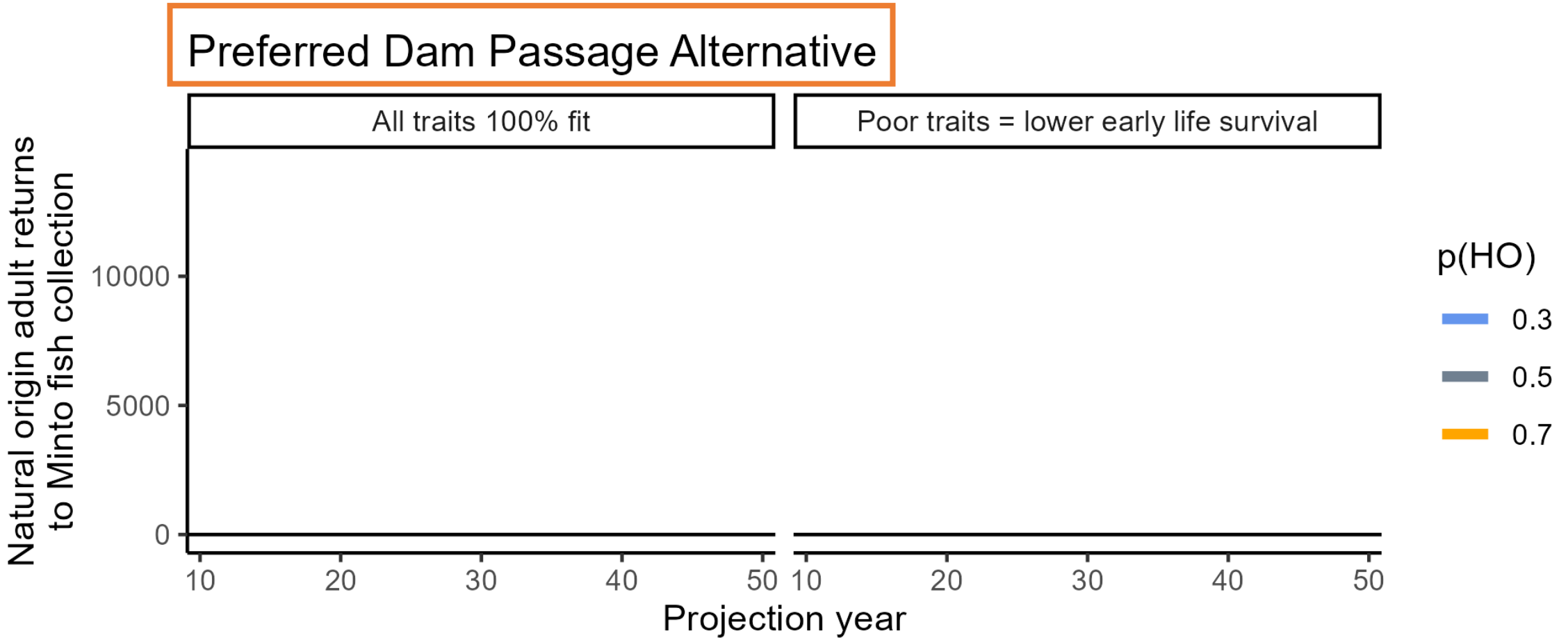

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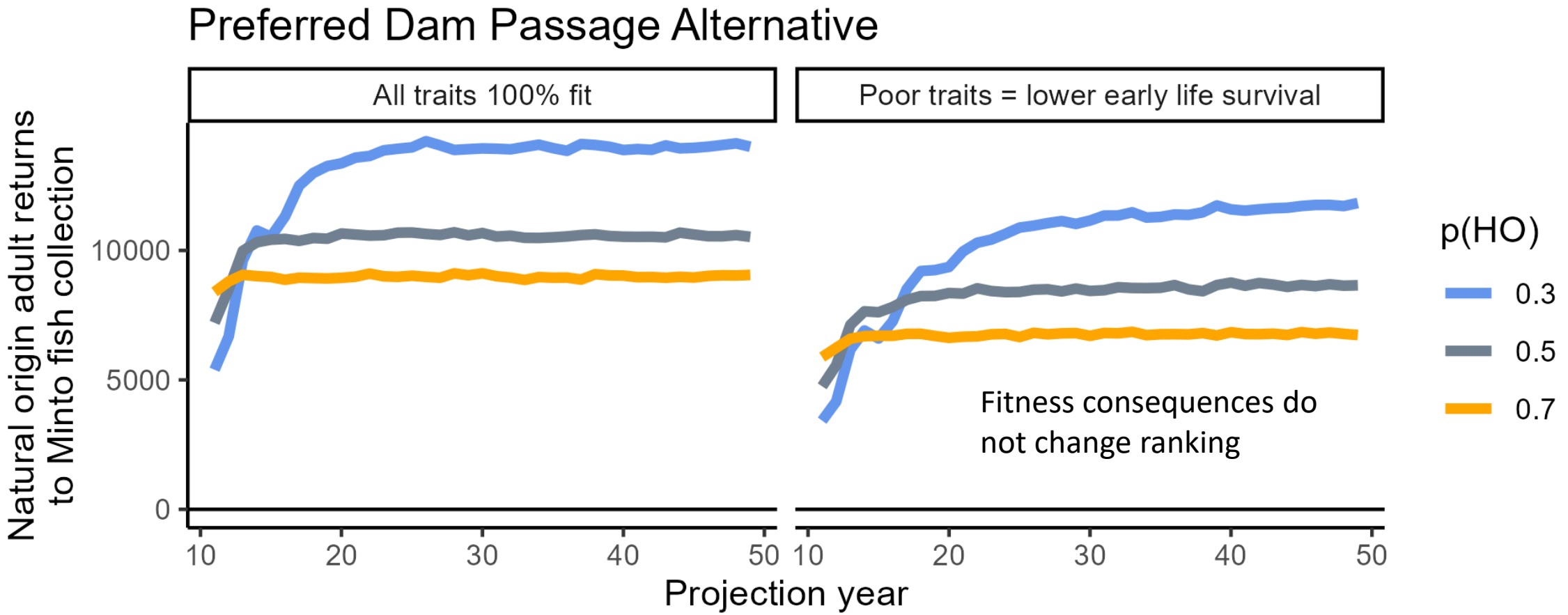

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Limitations and extensions

- To do:
  - **Additional processes:** Density dependence, below-dam spawning
  - **Parameterization:** Compile data on HO fish, estimate survival, fitness, etc.
  - **Sensitivity analysis**
- Model limitations
  - **Population-wide:** ignores individuals, assumes non-random mating
  - **No sex:origin interactions** (Evans et al. 2019; Johnson and Friesen 2011)

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- Conclusion:
  - Despite limitations, useful for exploring changes to HGMPs and inform decision-making → **generate hypotheses**

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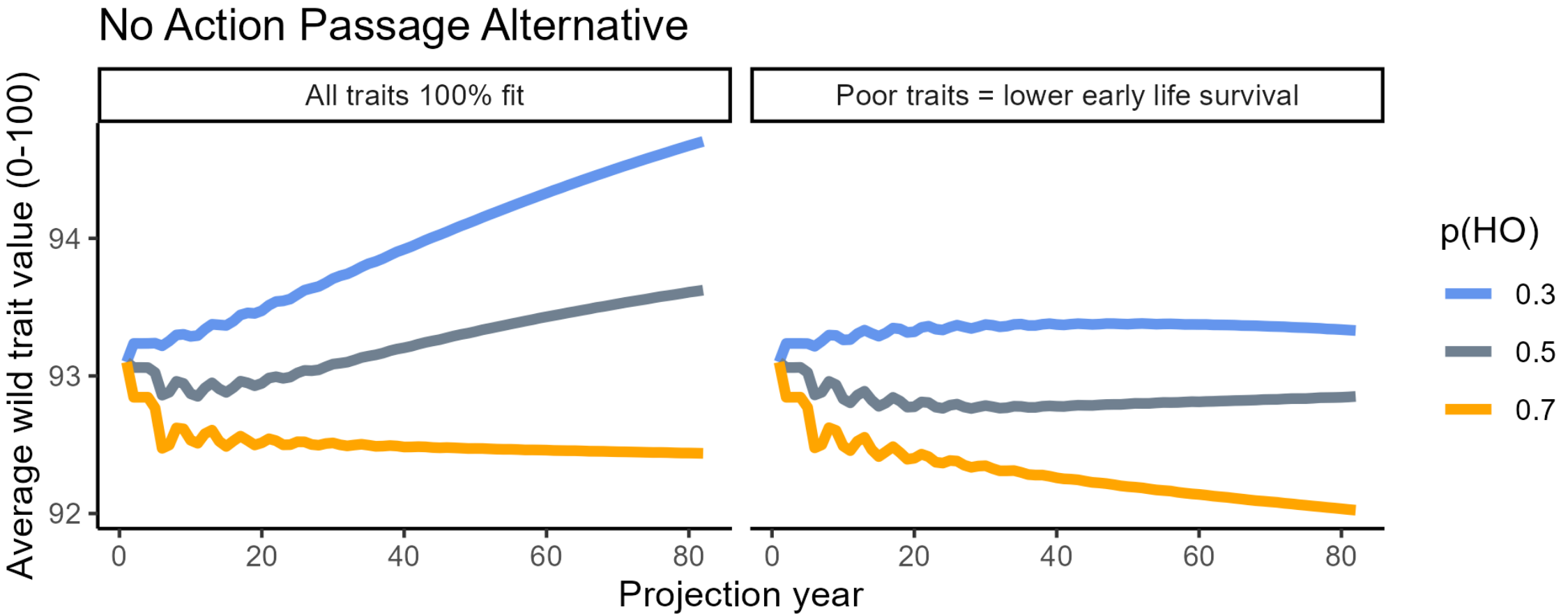

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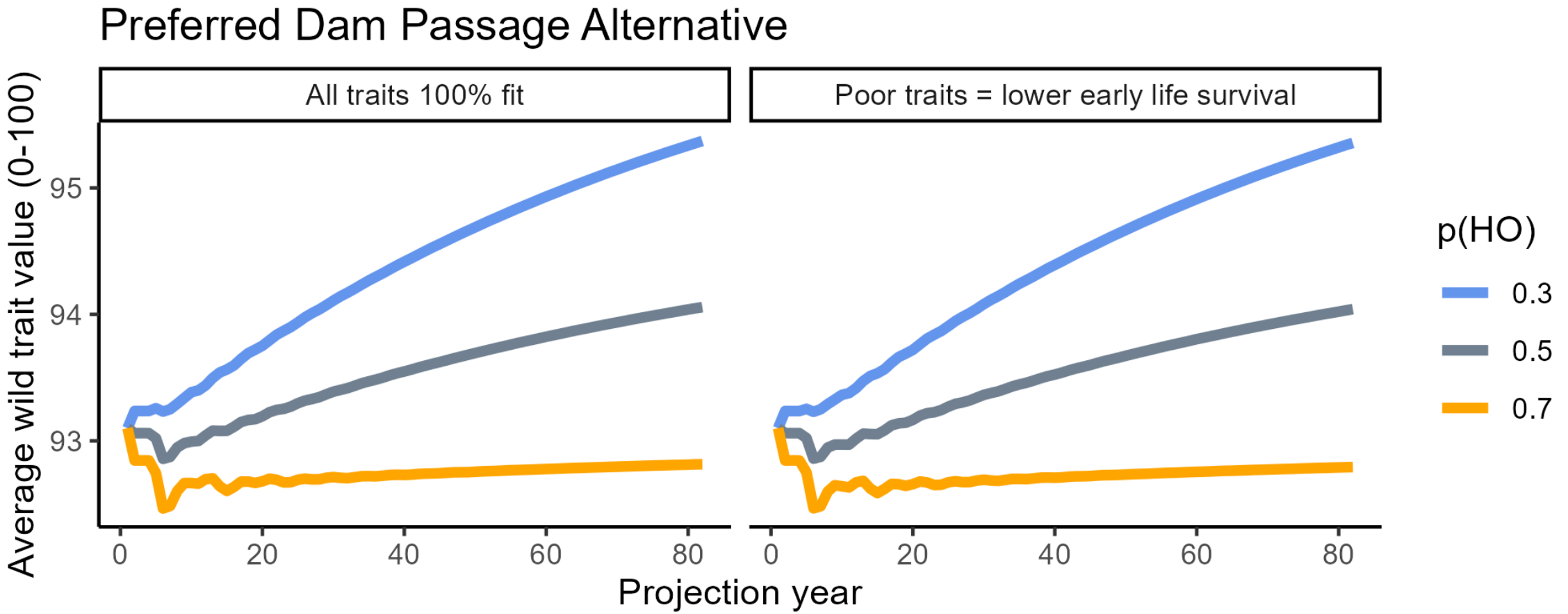

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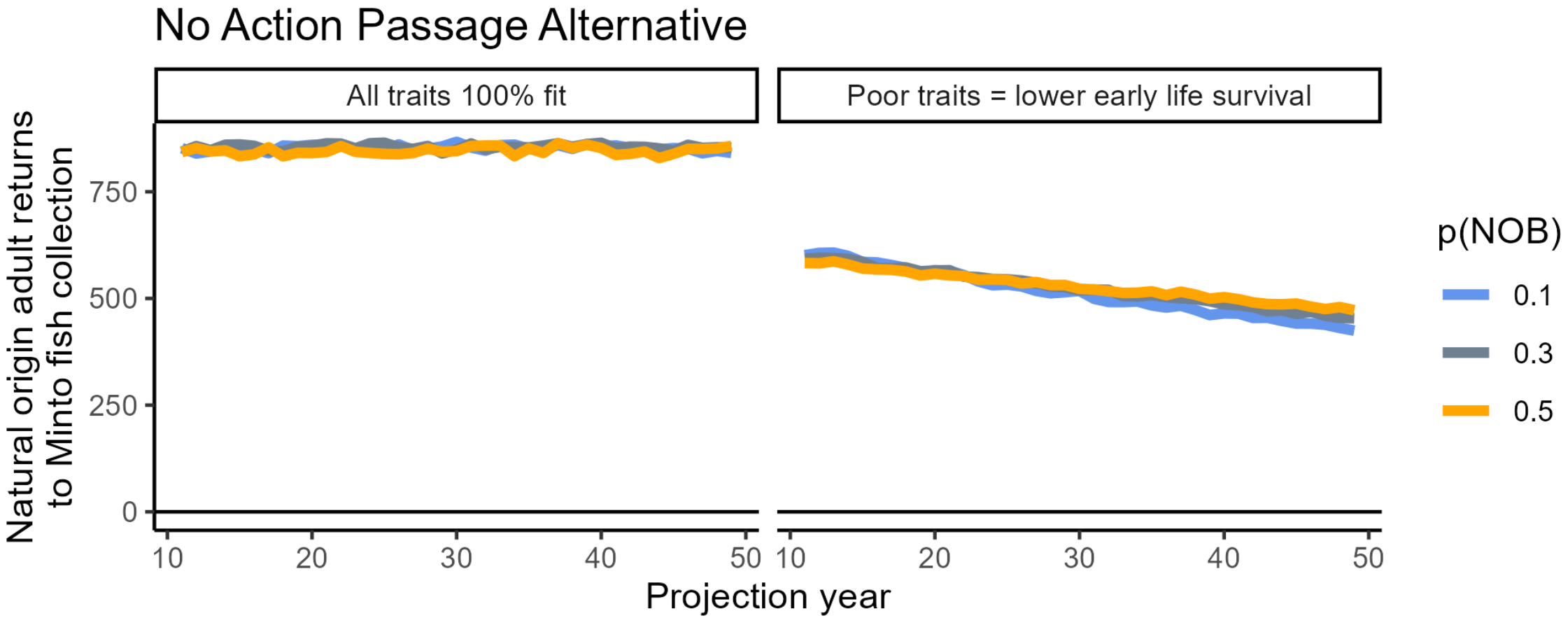

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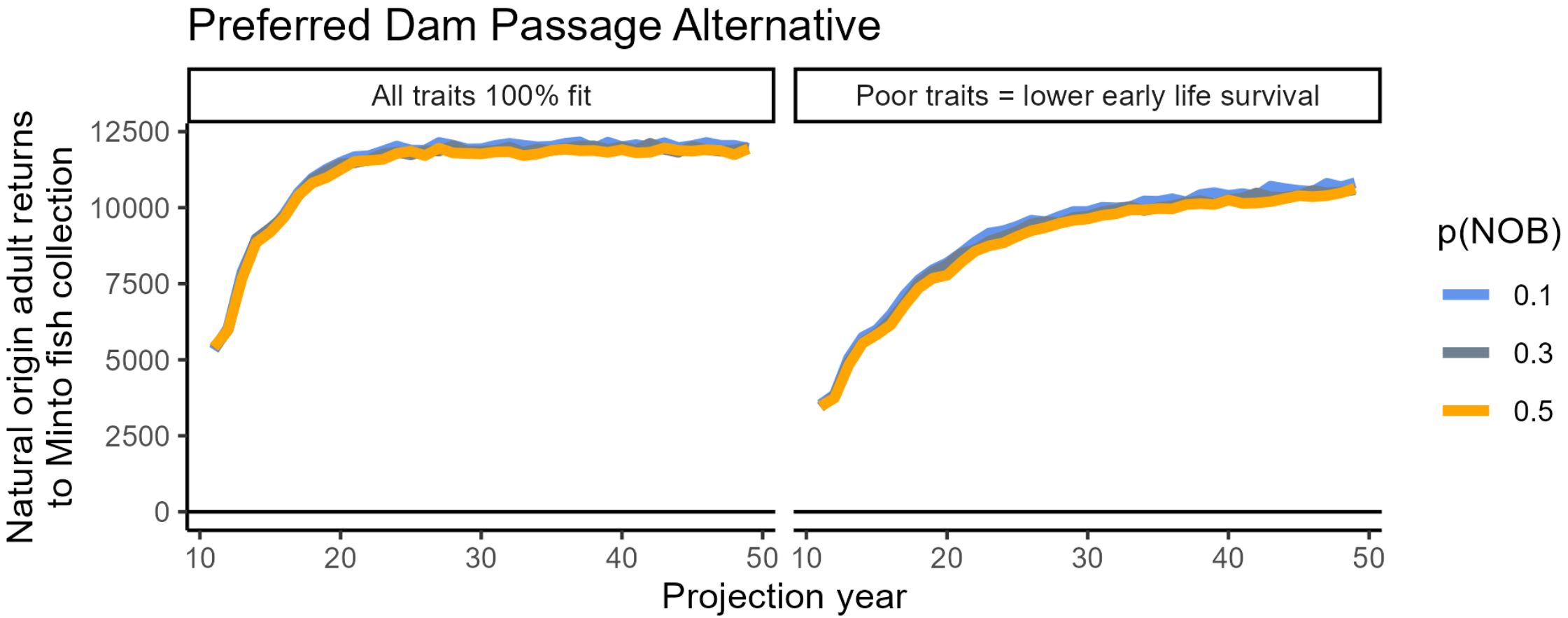

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