Quantifying the effects of hatchery management on the portfolio effect in salmon

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Diversity, stability, and connectivity

Ecology Letters, (2001) 4 :72–85

REVIEW

Biodiversity may regulate the temporal variability of ecological systems

Photo credits: http://www.villagelife.com/files/2011/03/Folsom-Dam.jpg; http://invasions.si.edu/nbic/managementpract.html

Population stability through diversity: the portfolio effect

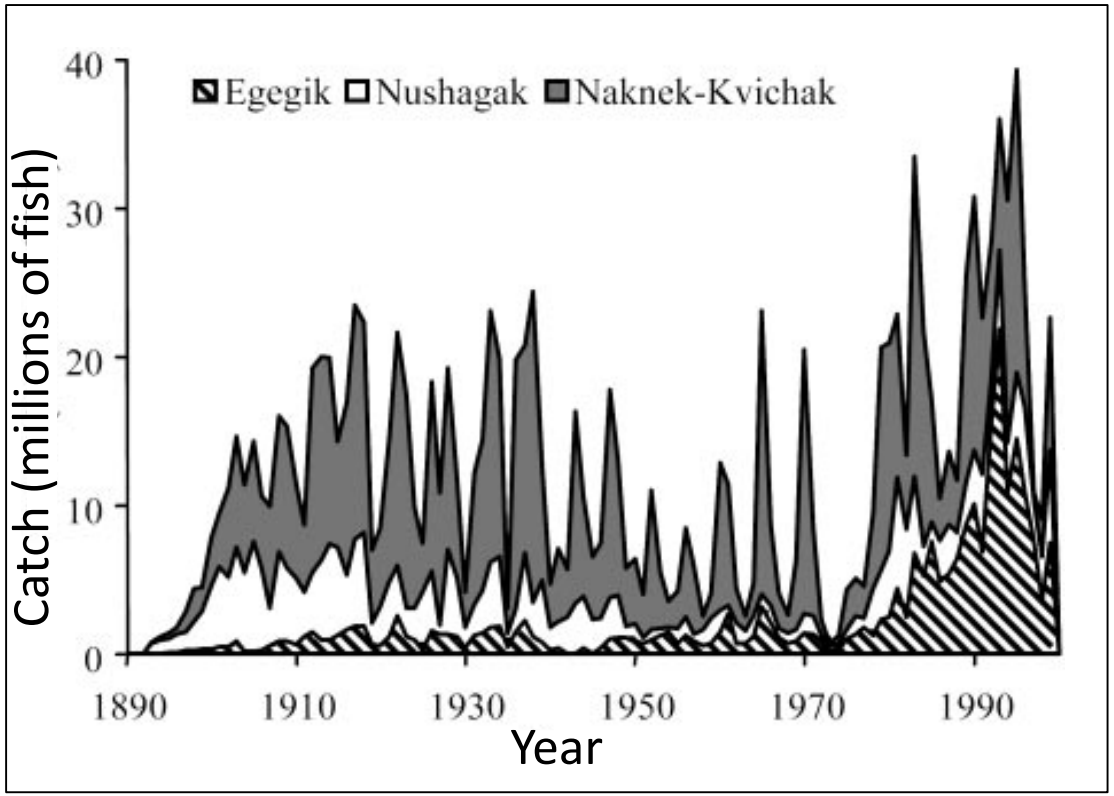
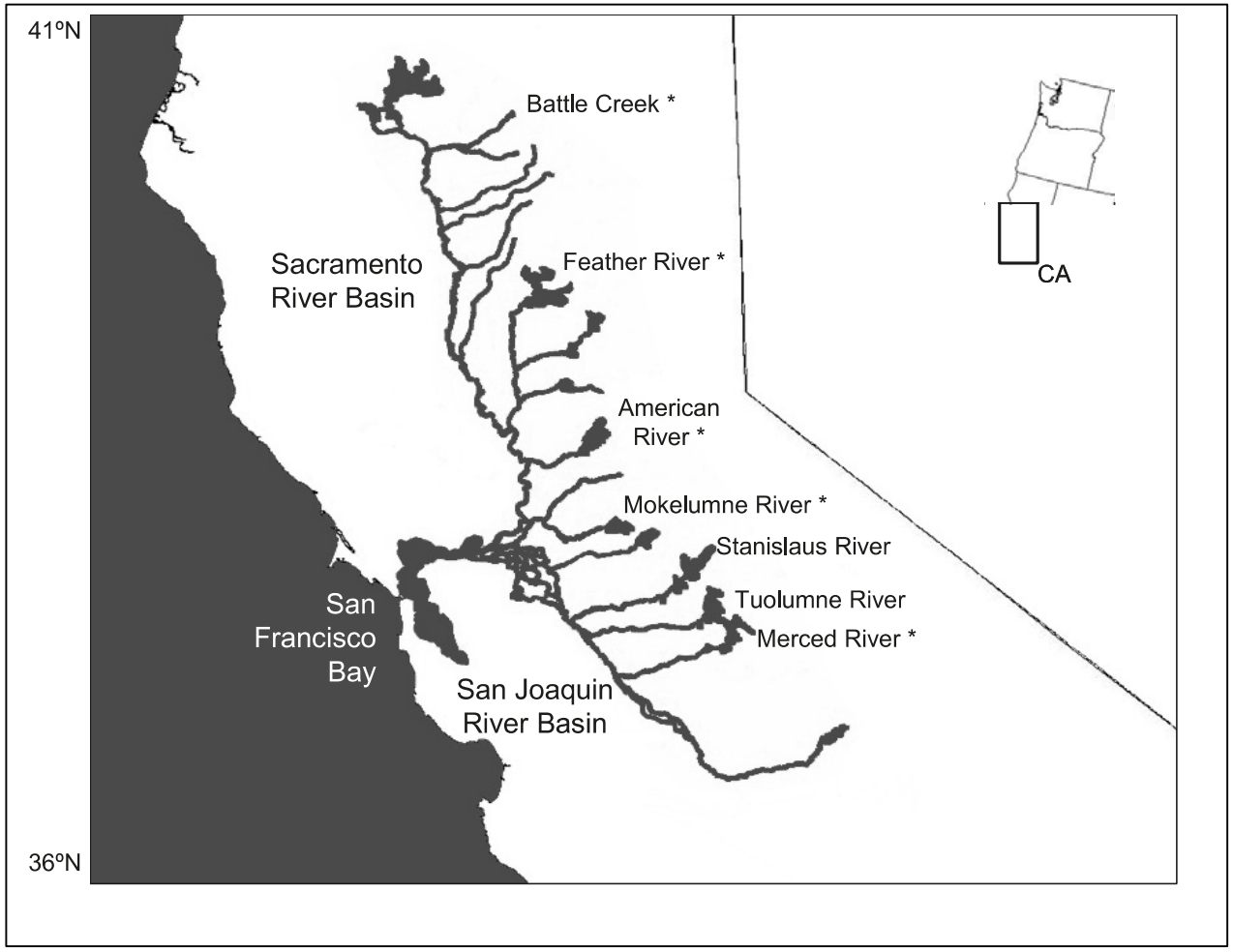


Figure 3, Hilborn et al. 2003

Portfolio effect can reduce population variability in changing conditions.

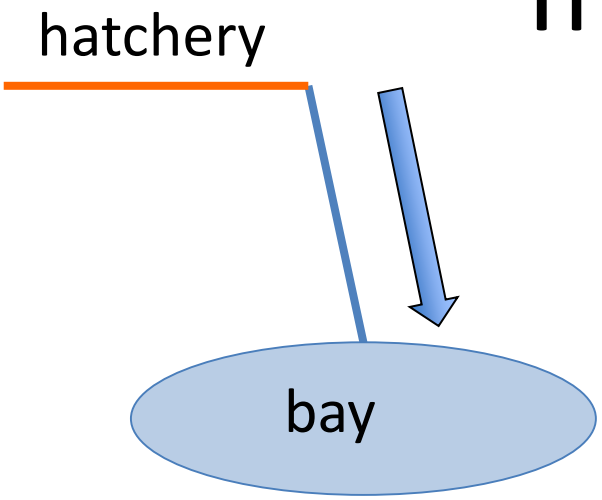
Central Valley salmon

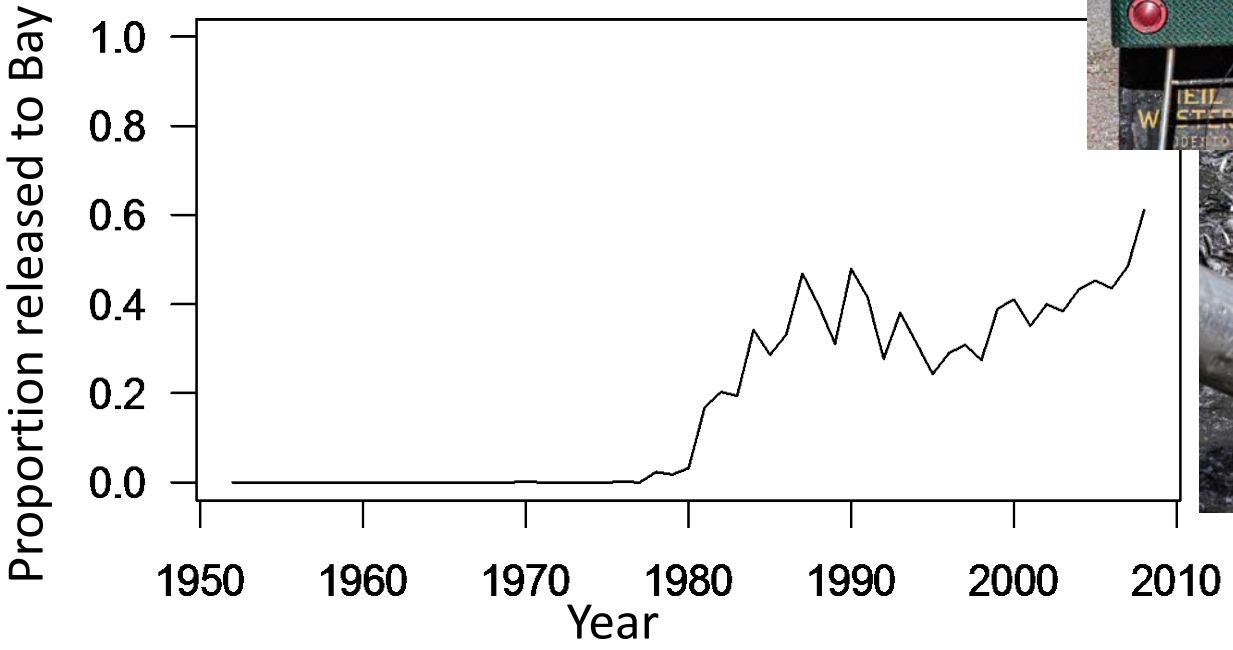


- Fishery collapse and closure in 2008 and 2009
- Evidence of weakened portfolio effect in Central Valley fall-run Chinook
- Habitat change, harvest, **hatcheries**

Figure 1, Carlson and Satterthwaite 2011

Trucking





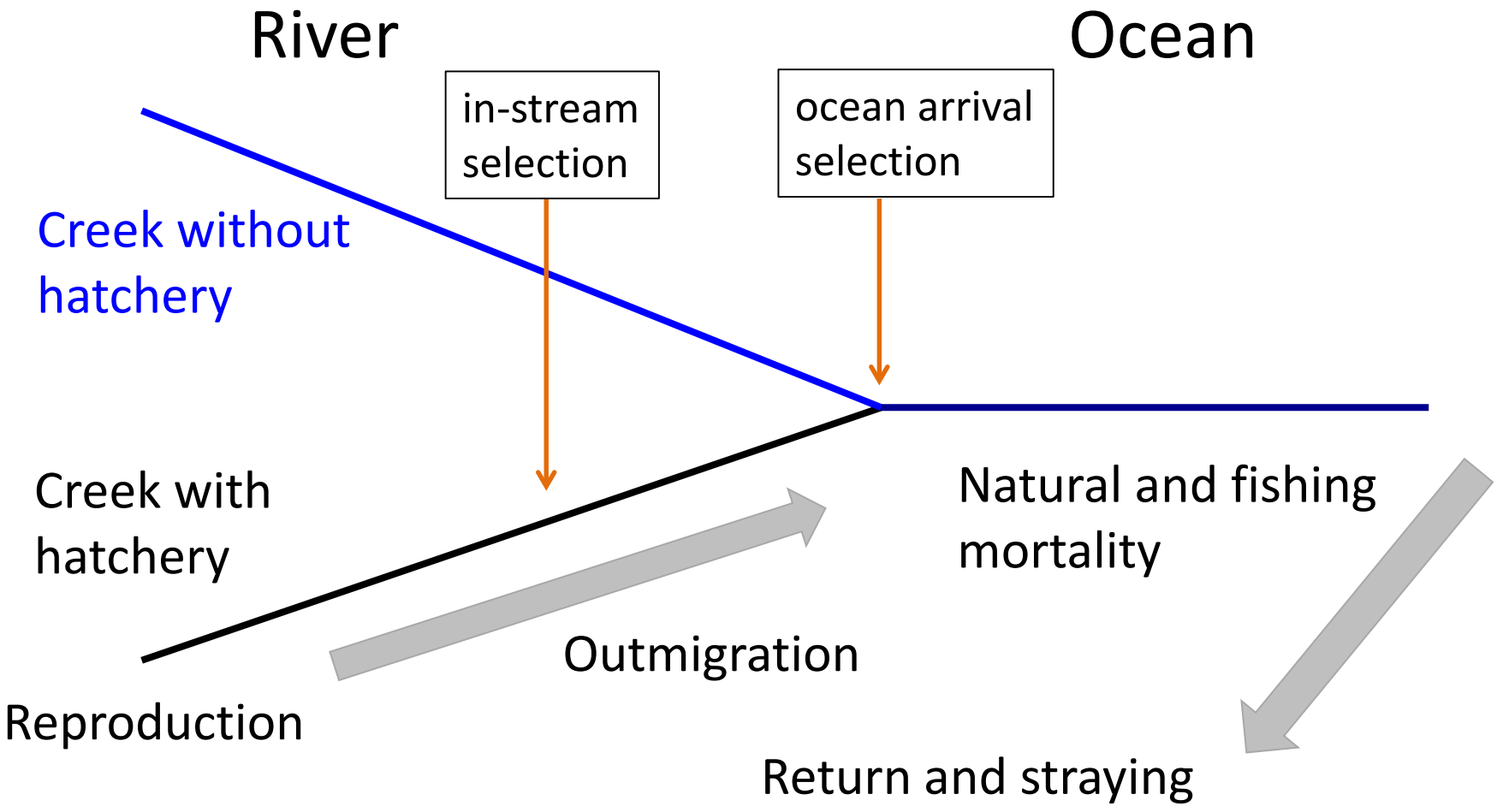
Modified from Huber and Carlson 2015, Figure 1

Photo credit: https://www.fws.gov/sfbaydelta/fisheries/salmon_trucking_and_release.htm

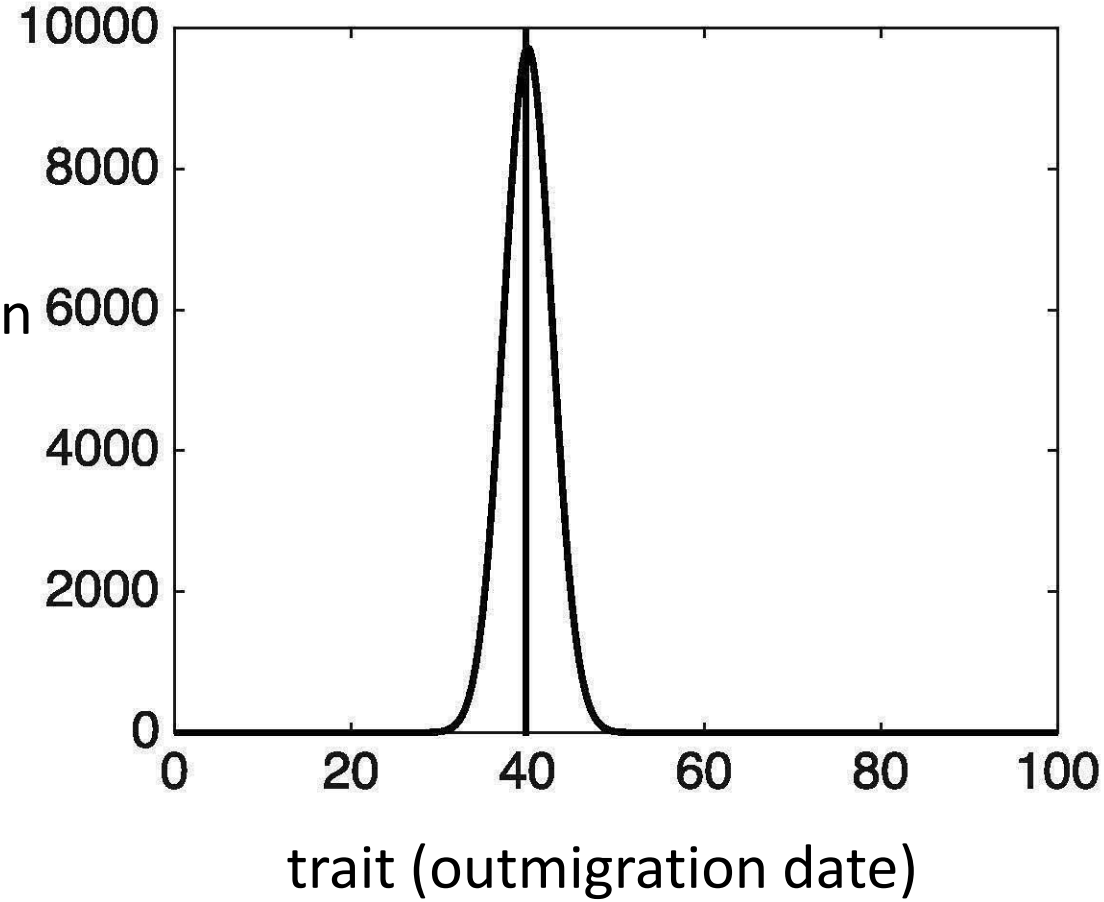
Research questions

- Can increased connectivity through trucking drive homogenization of outmigration timing across streams?
- What are the effects of trucking on population demographics?

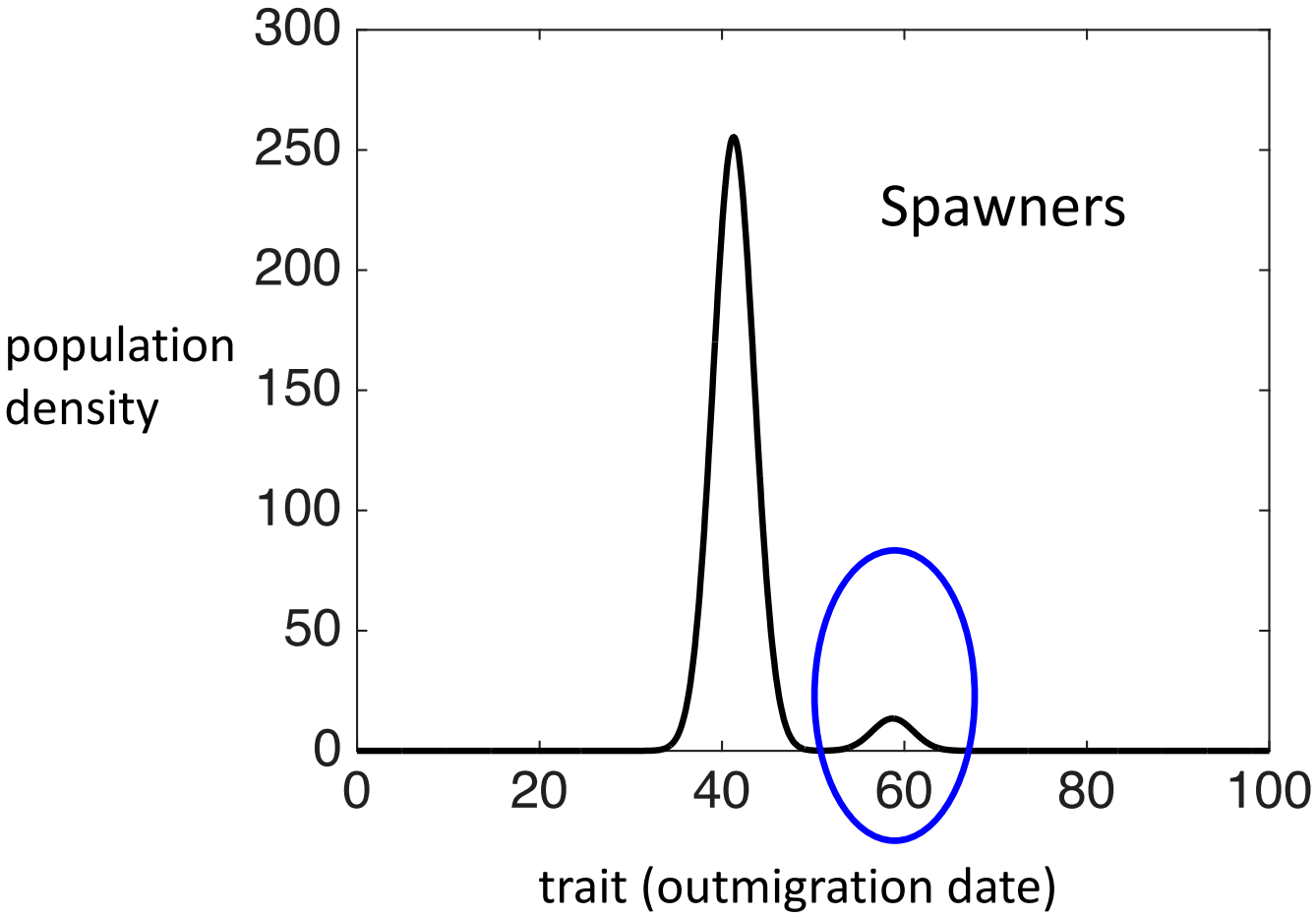
Model overview



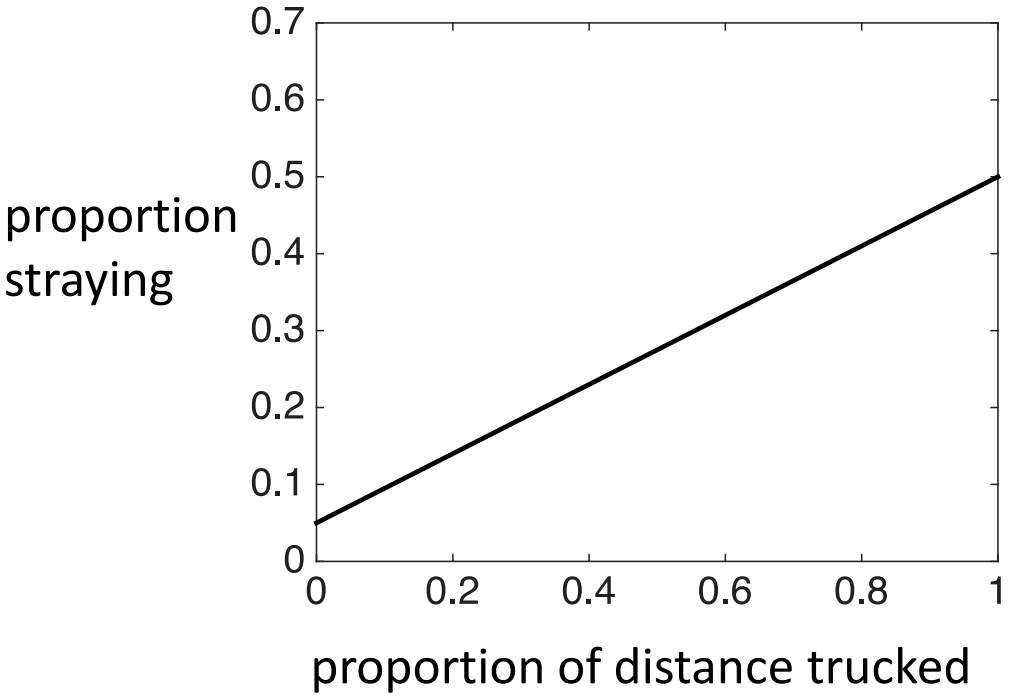
Example trait distributions



Example trait distributions



Model overview: trucking and straying

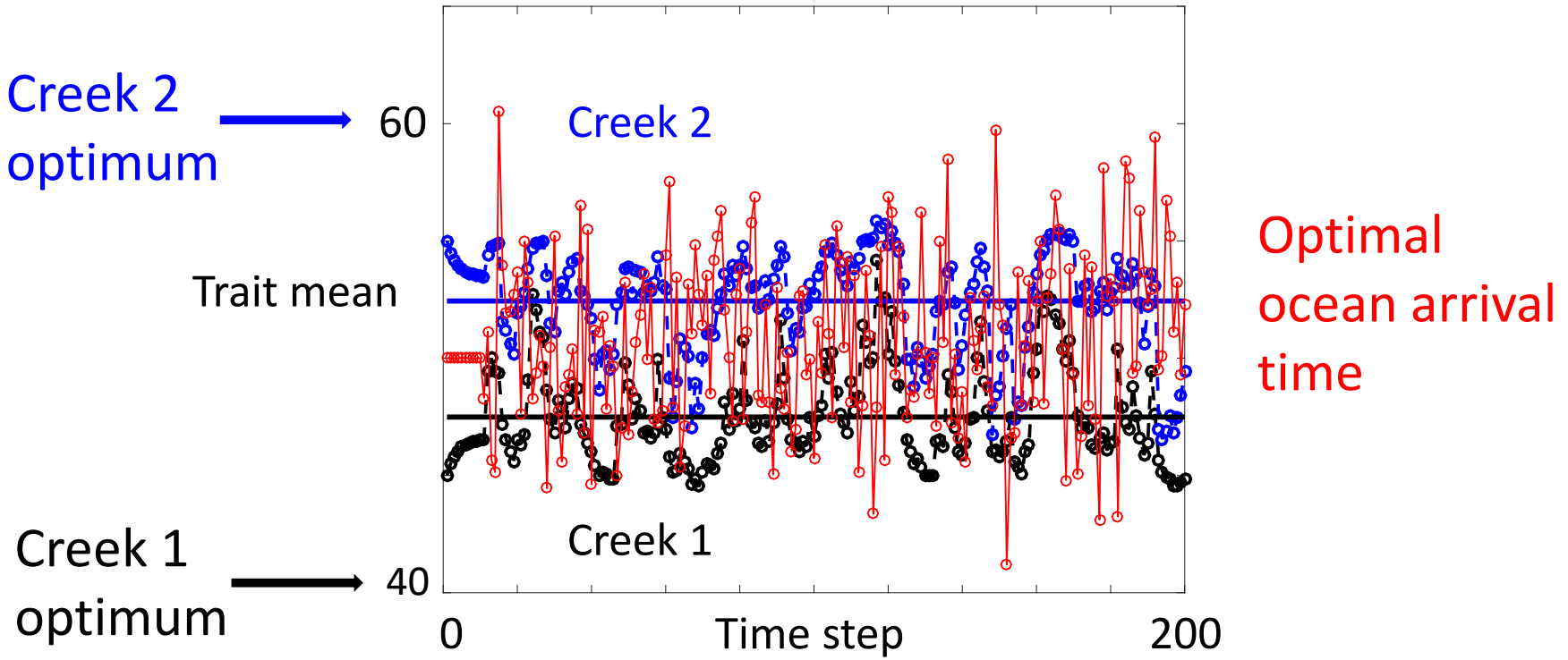


The farther hatchery fish are trucked:

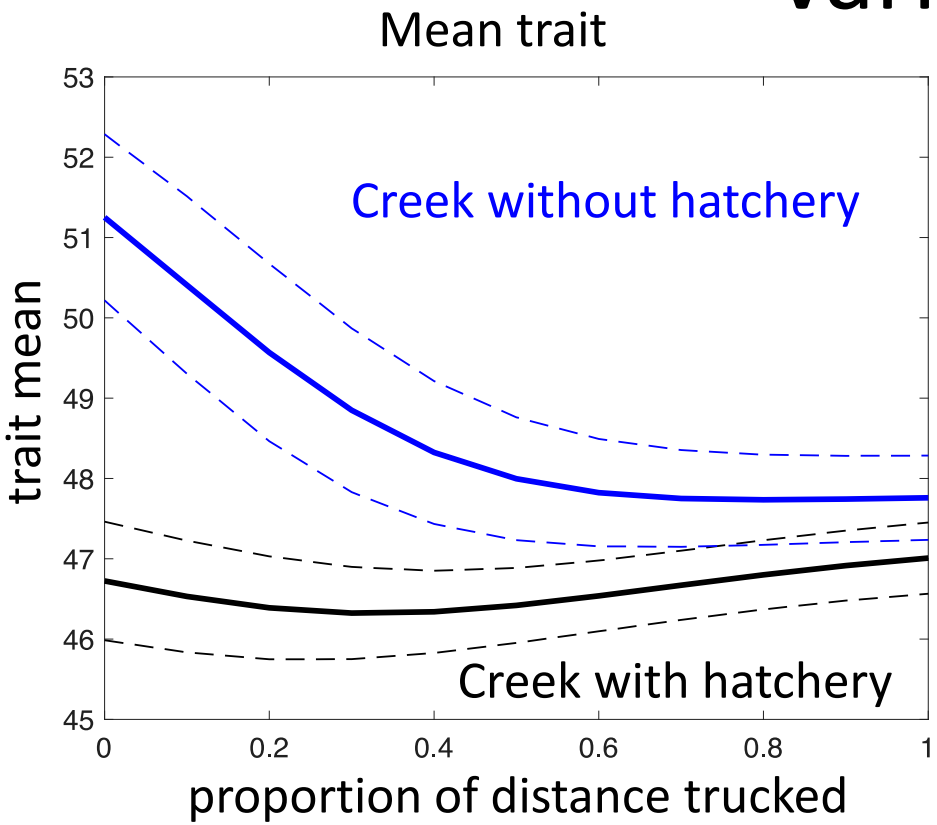
- the weaker the freshwater selection they feel
- the higher their survival through outmigration
- the more likely they are to stray as returning spawners

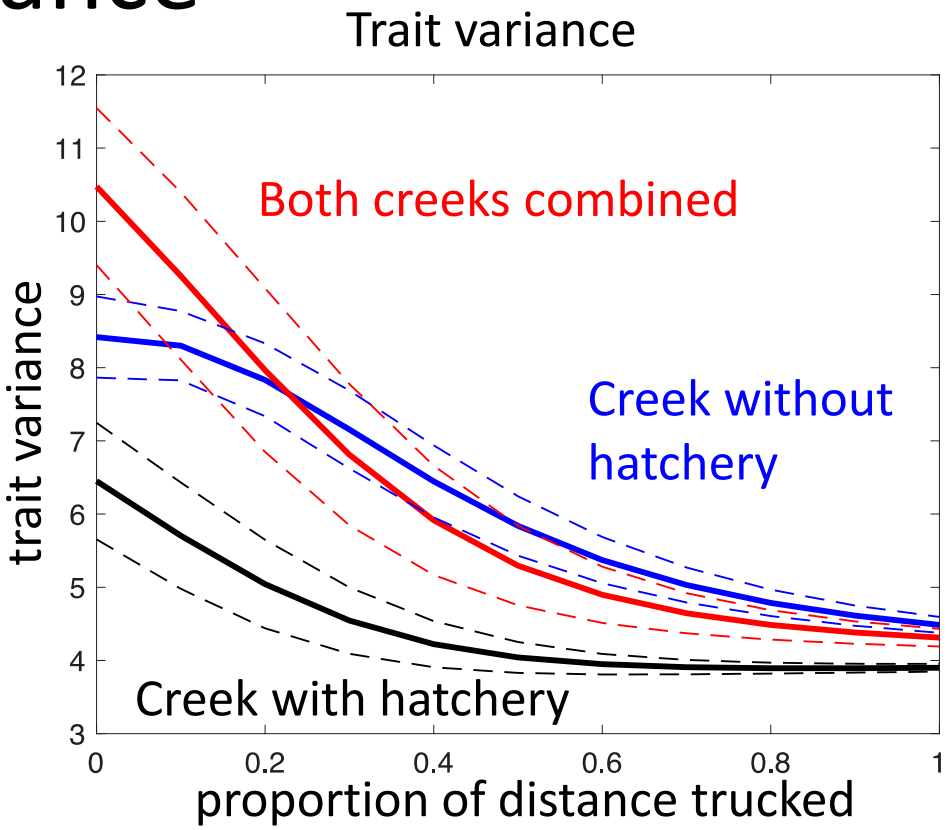
Model analysis

- Run simulations with variability in optimal ocean arrival time for different values of trucking
- Follow population size, trait mean, and trait variance for both creeks (assuming normality)



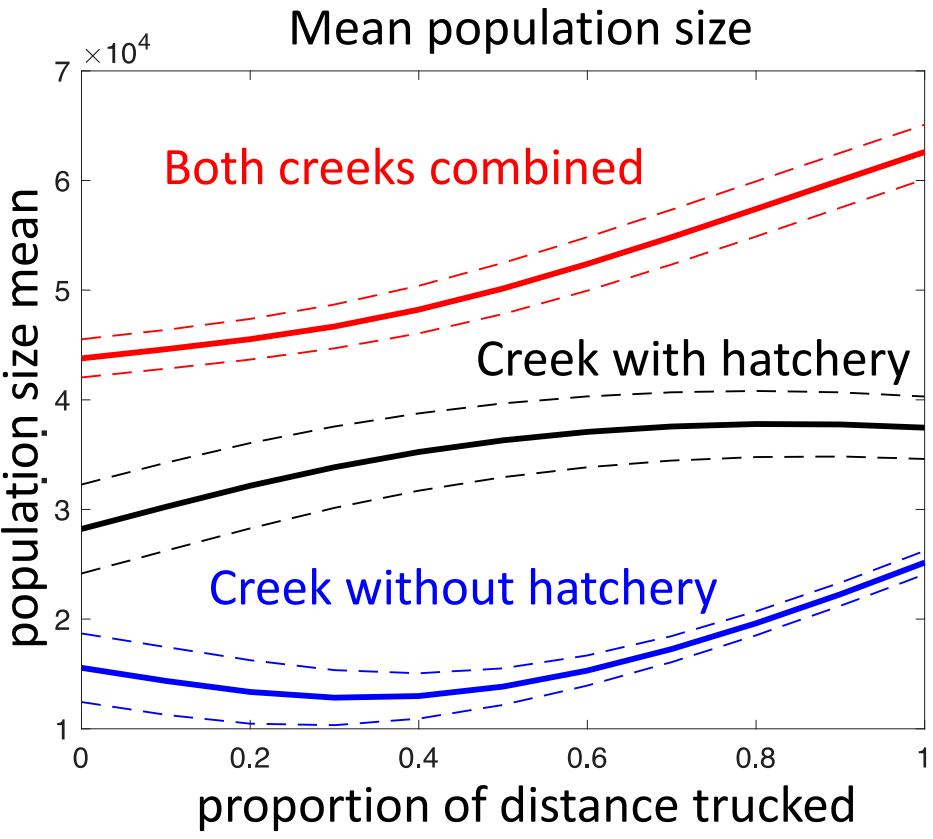
Effect of trucking on trait mean and variance

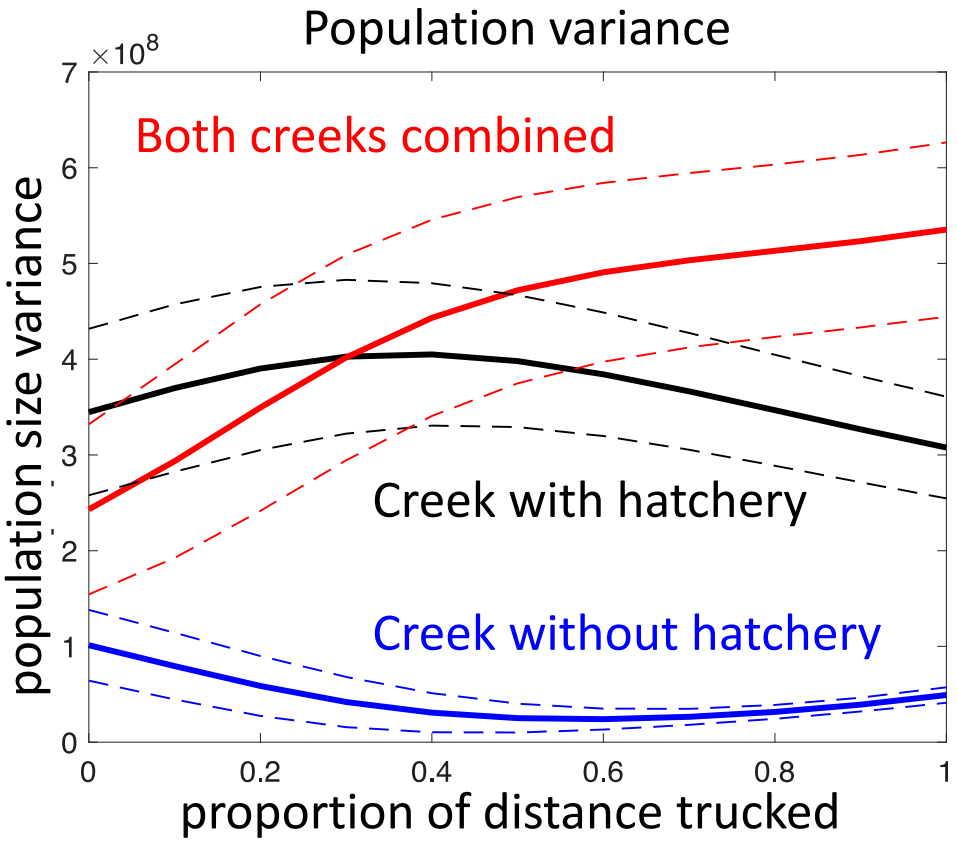




The greater the trucking distance, the more similar the mean outmigration date of the two creeks and the lower overall trait variance in the total population.

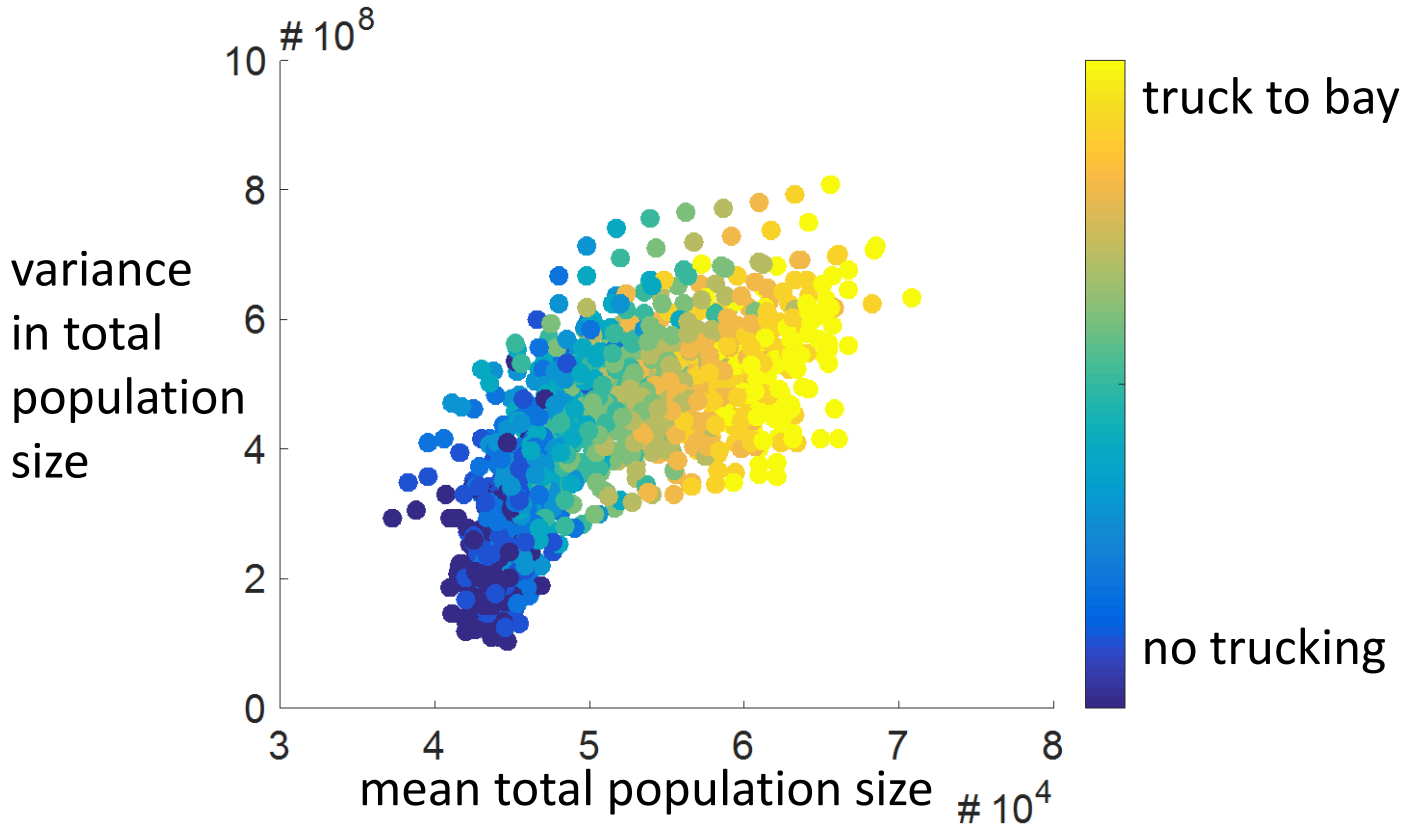
Effect of trucking on population size mean and variance





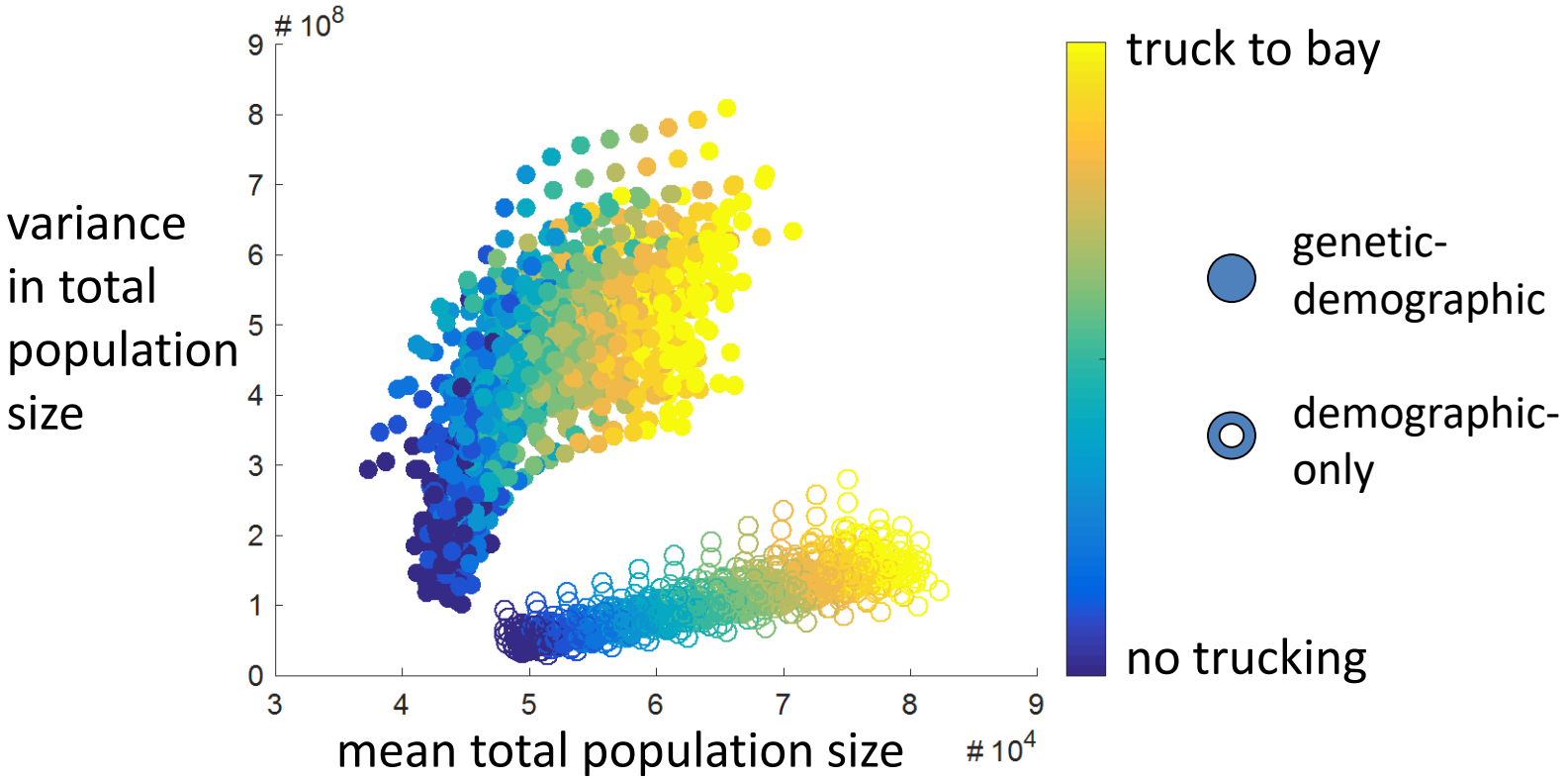
The greater the trucking distance, the higher the mean total population size and the higher the variance in total population size.

Demographic consequences of trucking



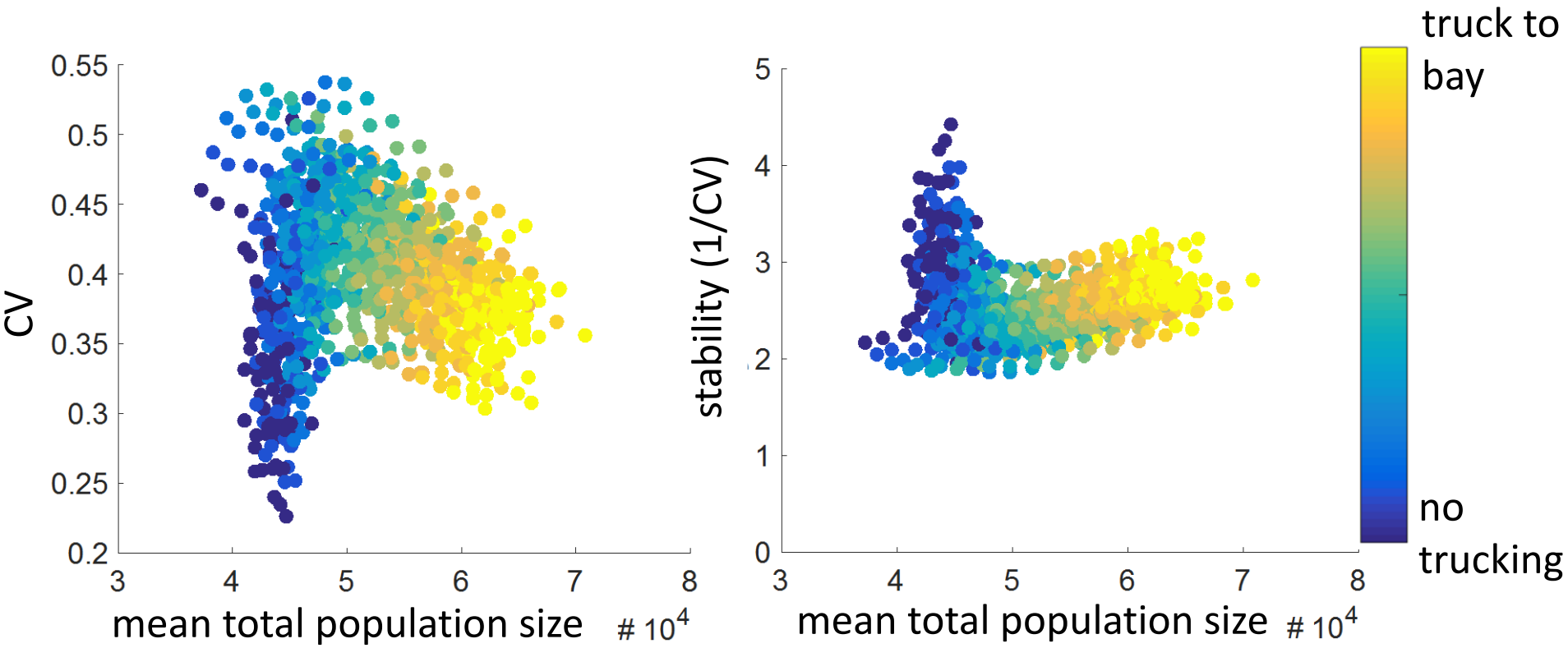
Trucking creates a tradeoff between population size and variability.

Comparing the numerical effect of hatcheries



The tradeoff between mean and variance exists with a demographic-only model but is stronger when genetic effects are also included.

Comparing PE metrics



The strength and shape of the tradeoff depends on the metric.

Conclusions

- Can trucking drive homogenization of outmigration timing across streams?
  - yes, outmigration dates become more similar between the two creeks
  - total trait variance across the population drops
- What are the effects of trucking on population demographics?
  - tradeoff between average return population size and variance through time
  - larger return on average but less stable
  - tradeoff is larger when consider both genetic and demographic effects

Future directions

Different management:

- alternate management rules: truck in response to poor ocean conditions or drought

Test assumptions:

- variability in freshwater optimal outmigration timing
- regime shift in optimal ocean timing
- overlapping generations?

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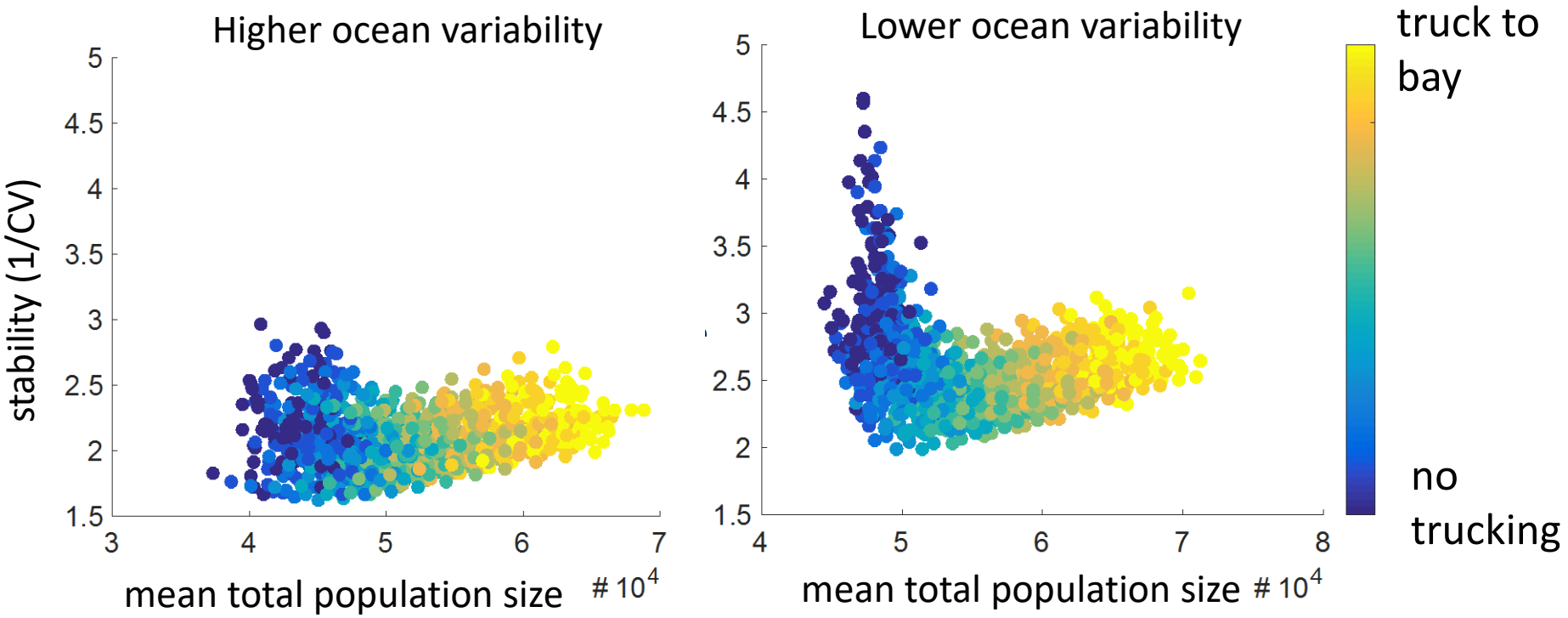
Questions?

Tradeoff sensitive to selection and ocean variance



- Possible back-up slides:
  - have plots to show comparison between FBD and NA
  - have plots to show comparison between trucking methods
  - have plots to show sensitivity to parameter values

Results: example simulation