Resident Killer Whale population viability under selected fishing scenarios

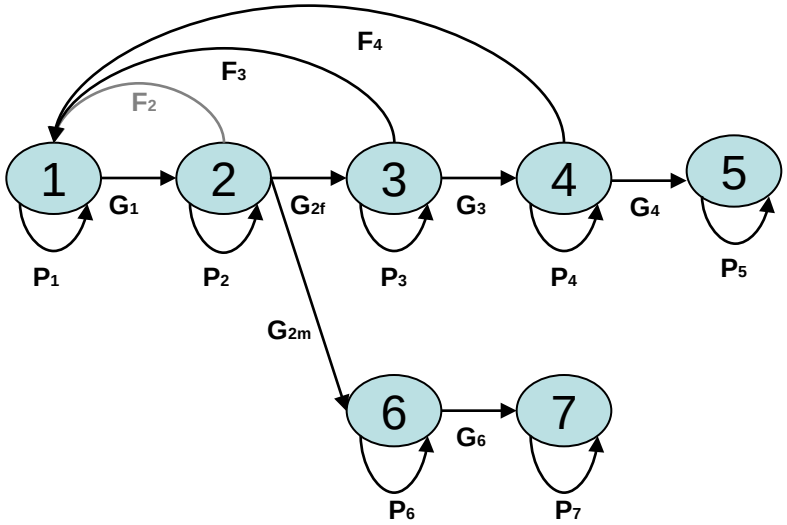
(Preliminary results)

L. Antonio Vélez-Espino, John Ford, Graeme Ellis, Chuck K. Parken, Eric Ward, Ken Balcomb, Tom Cooney, Bradley Hanson, Larrie LaVoy, Dawn Noren, and Rishi Sharma

Recap

RKW demography

1



Regressions

2

Relationships between RKW vital rates & Chinook abundance (hypothesis-oriented)

Perturbation analyses

3

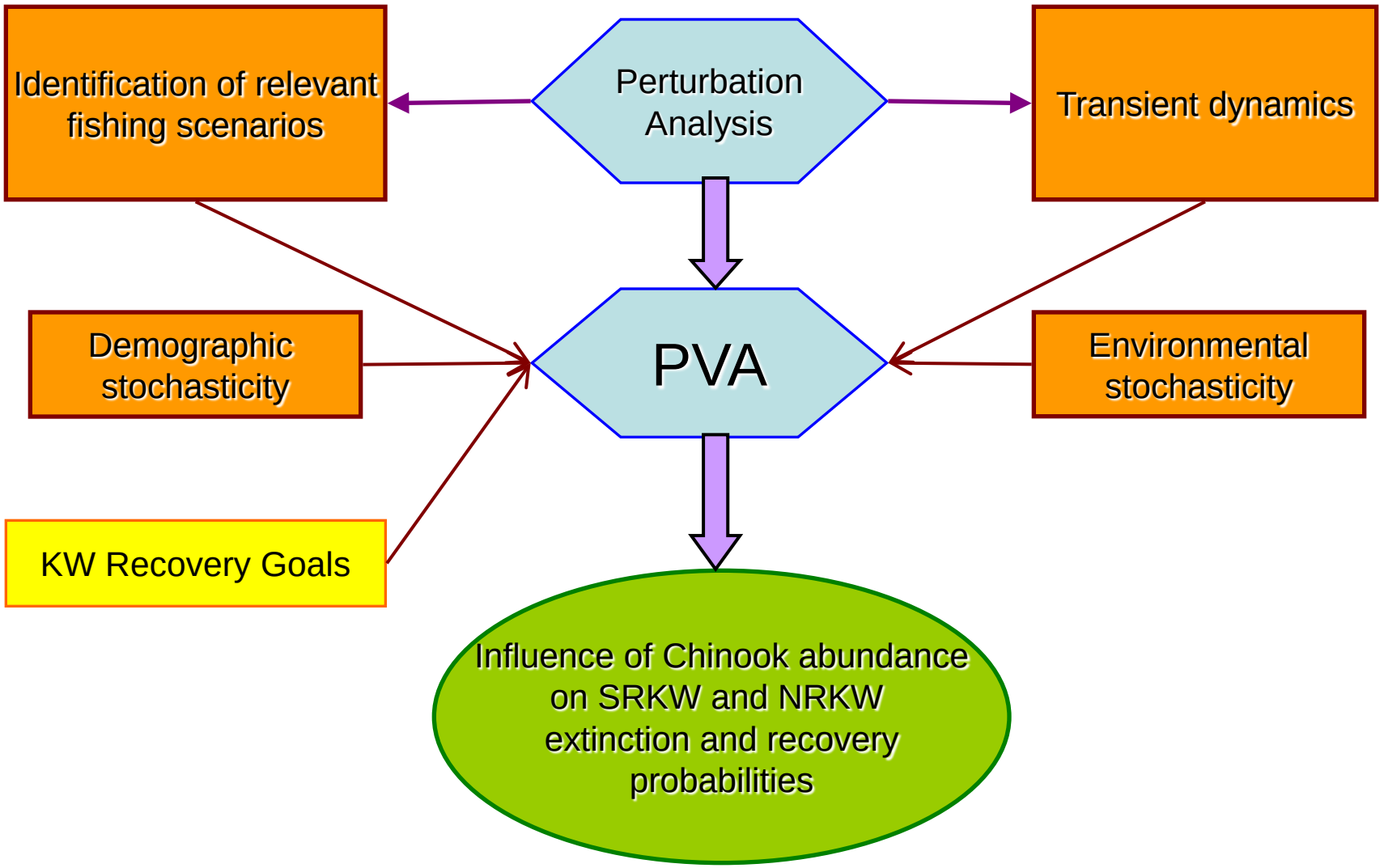
Influence of interactions on RKW population growth (prospective & retrospective)

PVA

4

Selected fishing scenarios

Linking perturbation analysis and PVA



Objectives of PVA for selected fishing scenarios

- SRKW: Recovery (maximization of effects)
  - –increase recovery probabilities & decrease extinction probabilities given alternative levels of Chinook abundance
- NRKW: Targeting equilibrium ($\lambda = 1.0$)
  - –Not in this presentation

Selected Fishing Scenarios
(maximizing effects)

Population	Scenario	Hypothesis	Objective	Characteristics	Target Vital Rate(s)
SRKW	1	n.a.	Reference	Status quo	n.a.
SRKW	2	1a	Recovery	Maximization of FE+PS Terminal Run: no ocean fishing on FE+PS	Increasing the fecundity of old reproductive females
SRKW	3	2a	Recovery	Maximization of WCVI Terminal Run: no ocean fishing on WCVI	Increasing the survival of old reproductive females
SRKW	4	2a	Recovery	75% reduction of Puget Sound ocean harvest rates	Maximizing survival of young and old reproductive females

Effects of ocean harvest on terminal run

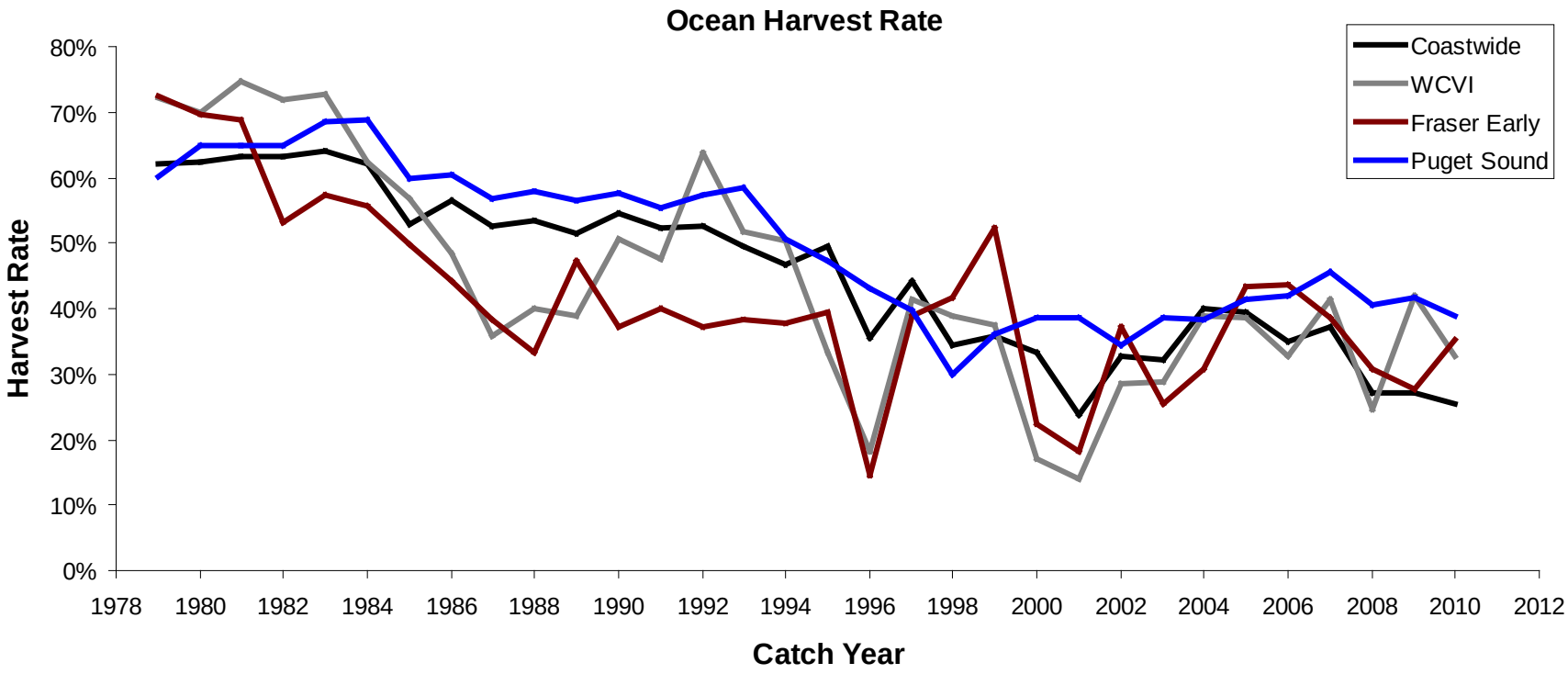
- Fishing scenarios: Terminal Run Equivalents derived from CTC exploitation rate analyses

$$TRE_{s,y} = \sum_{\text{PreTerm Fishery}} \sum_{a=3}^{6} Catch_{a,s,y} * MR_{a,s,y}$$

PVA limitations

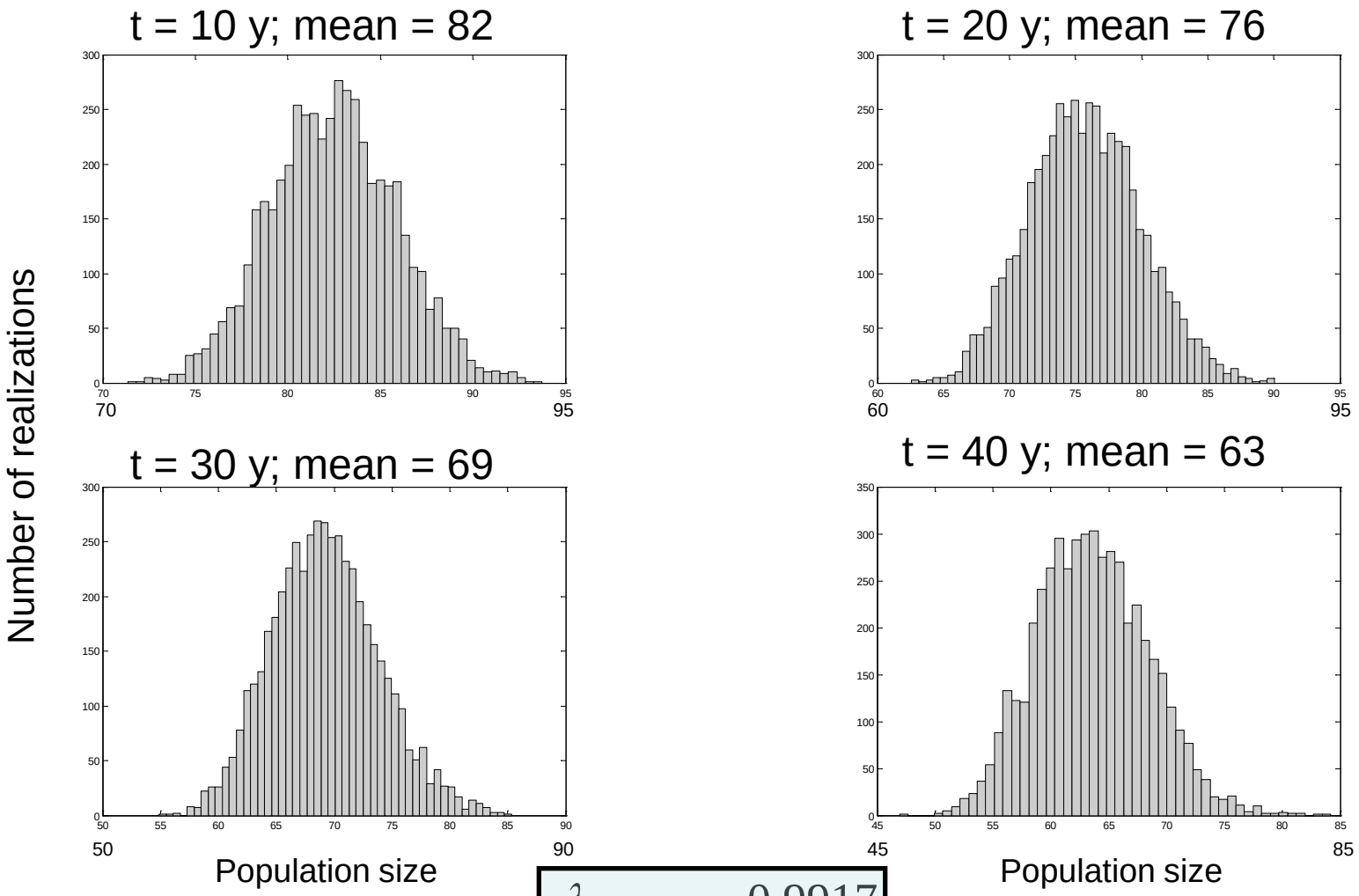
- It is not a forecast
- Environmental trends (e.g., climate change), catastrophes, and genetic factors are not incorporated
- Magnitude and variation in vital rates observed in the past are representative of the future before perturbations (e.g., fishing scenarios)
- Viability criteria are not written in stone
- Does not account for trends in ocean harvest rates

Ocean harvest rate trends



SRKW Status Quo (scenario 1)

Projections of SRKW population growth in an IID environment (5000 realizations)



$$\lambda_{stochastic} = 0.9917$$

SRKW Status Quo (scenario 1)

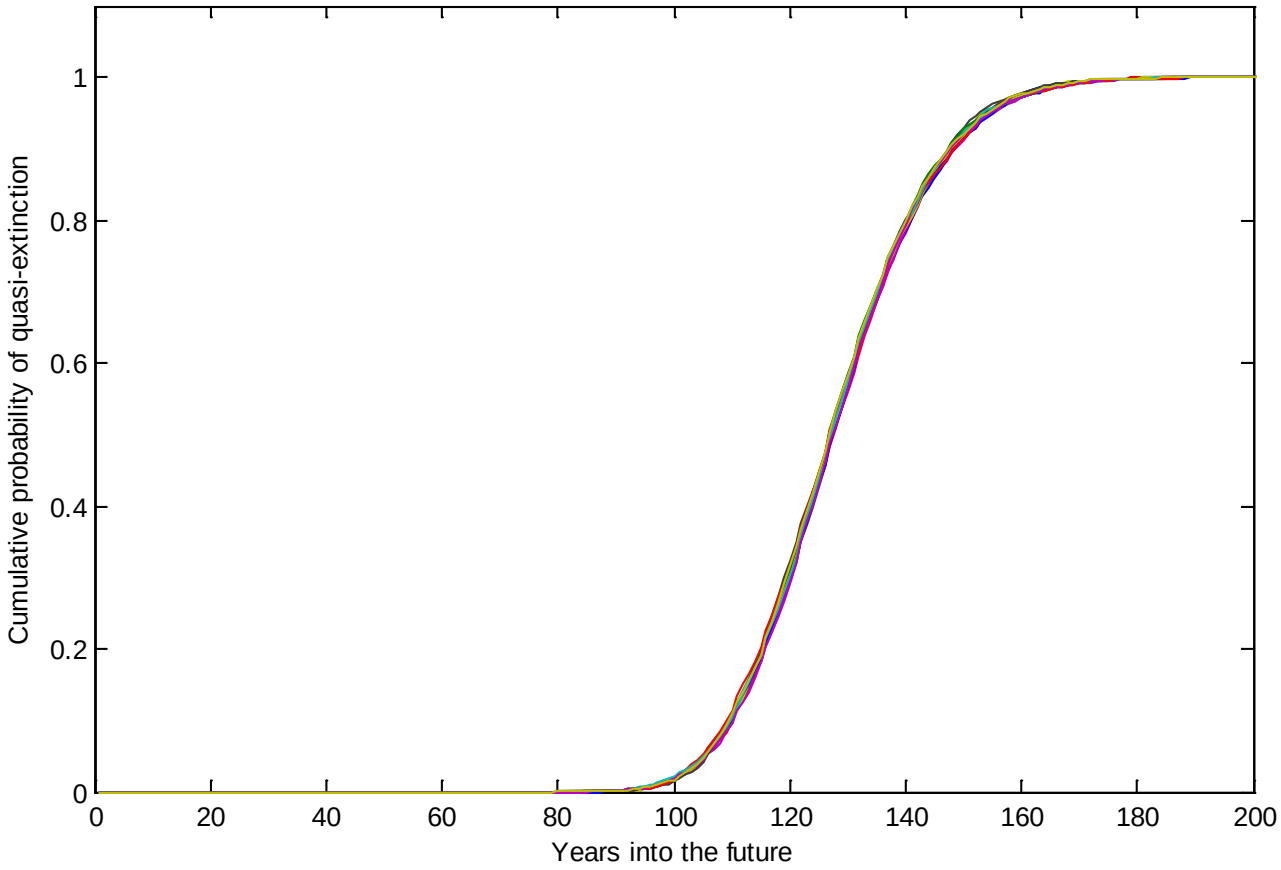
Probability of U.S. downlisting: SRKW population size = 120 in the future in an IID environment (5000 realizations; 20 runs)

U.S. Recovery target = 2.3 percent per year for 14 years
U.S. RT with initial population size of 87 = 120 individuals

Simulation showed a “zero” probability of SRKW abundance reaching 120 individuals in 14 years

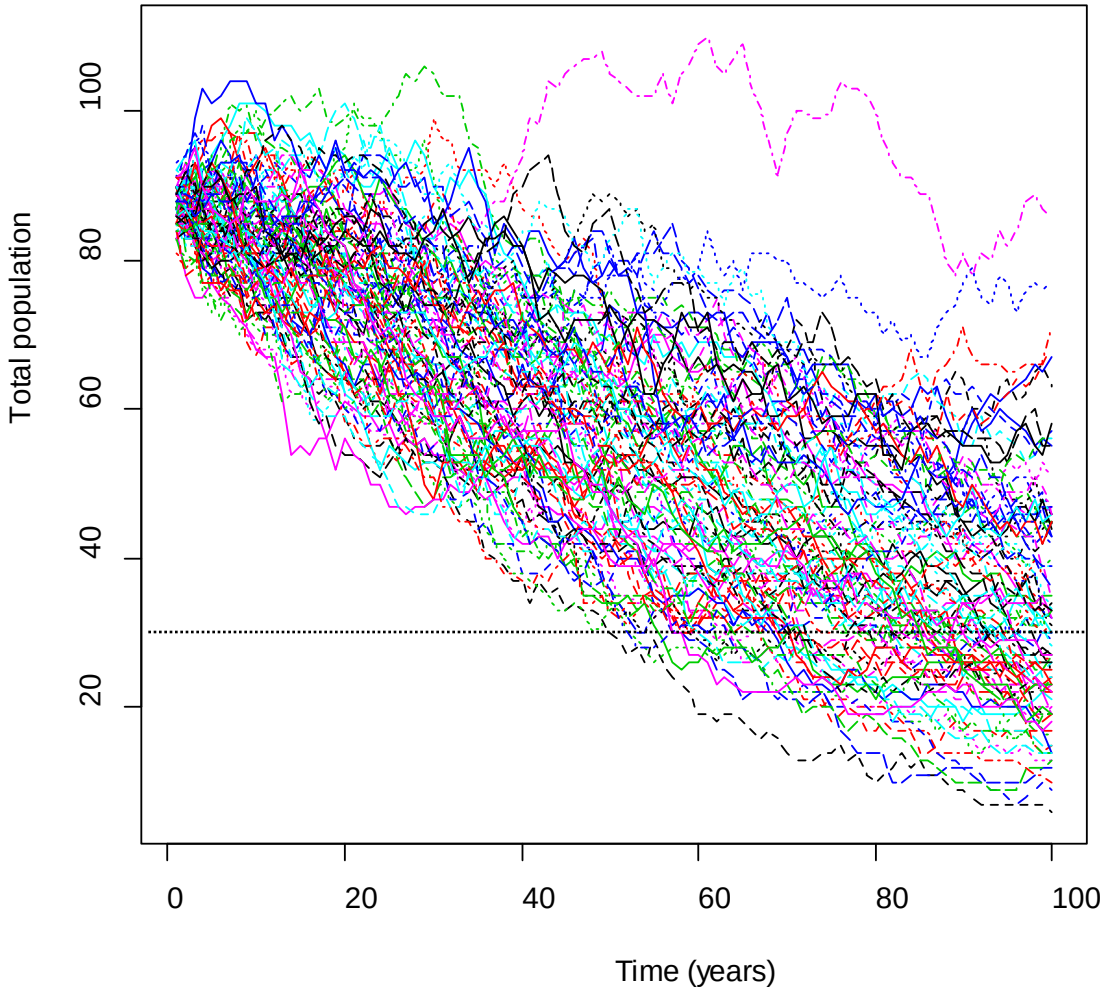
SRKW Status Quo (scenario 1)

Probability of SRKW population size < 30 in the future in an IID environment (5000 realizations; 20 runs)



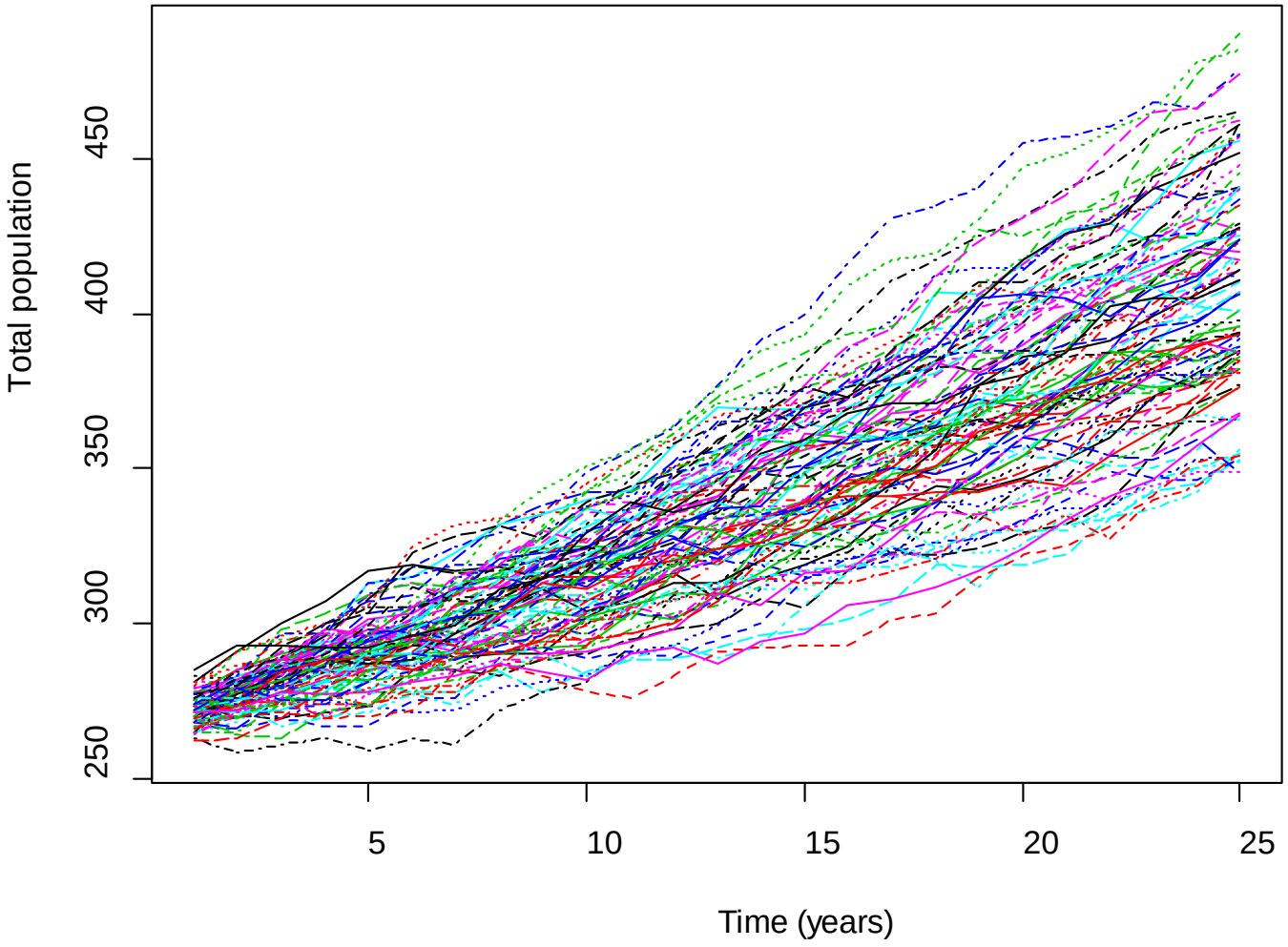
SRKW Status Quo (scenario 1)

Projections of SRKW population growth under demographic stochasticity (100 realizations)



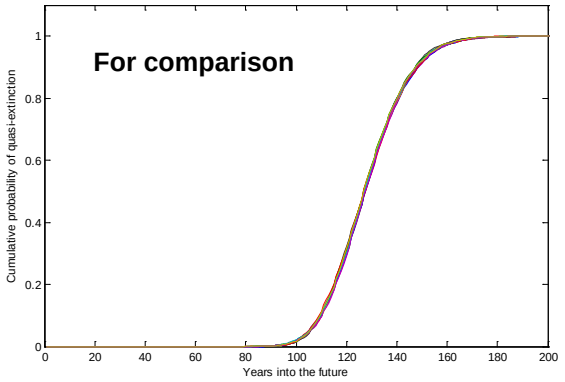
NRKW Status Quo

Projections of NRKW population growth under demographic stochasticity (100 realizations)

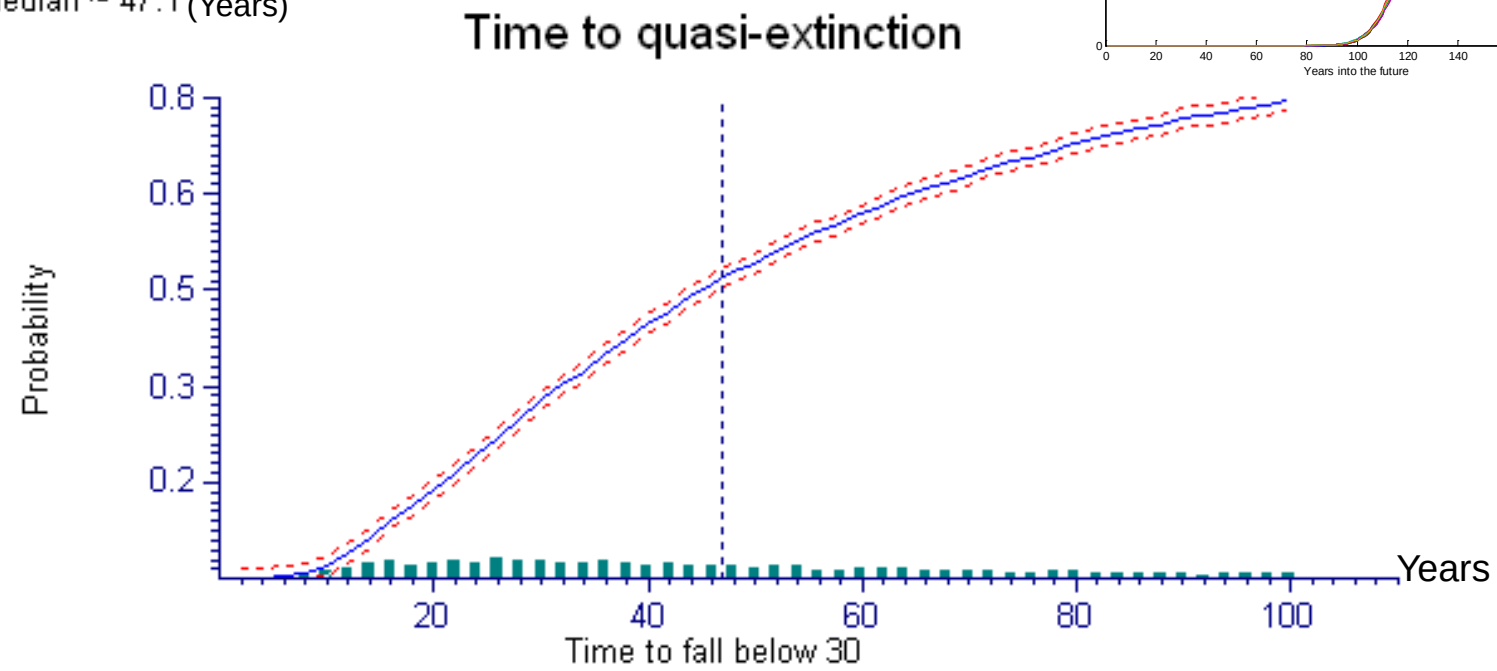


SRKW Status Quo (scenario 1)

Probability of SRKW population size < 30 in the future under environmental and demographic stochasticity (3000 realizations)

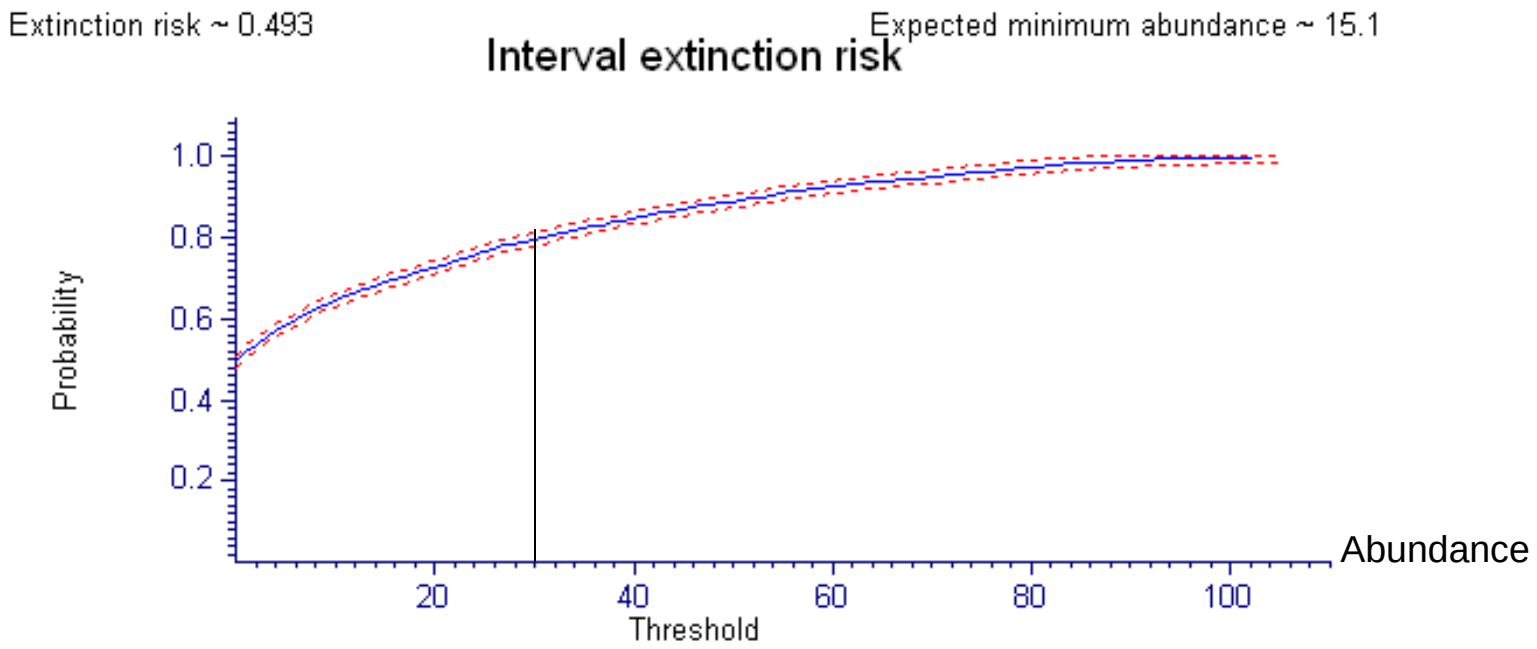


Median ~ 47.1 (Years)



SRKW Status Quo (scenario 1)

Probability of SRKW population size < 30 in 100 yr under environmental and demographic stochasticity (3000 replications)



"There is a 79.6% risk that SRKW abundance will fall below 30 at least once during the next 100 years"

PVA summary for SRKW Fishing Scenarios

Population	Scenario	Stochastic population growth	Mean abundance 20 years in the future	Extinction probability 100 years in the future	Probability of downlisting (U.S.)
SRKW	1	0.9917	76	0.493	0.000
SRKW	2	0.9918	76	0.491	0.000
SRKW	3	0.9950	82	0.419	0.000
SRKW	4	1.0053	96	0.262	0.000

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SRKW-Chinook salmon interactions (Hypothesis 1a)

Negligible effect on population growth and recovery probabilities from the interaction between FE+PS TR and SRKW vital rates

SRKW-Chinook salmon interactions (Hypothesis 2a)

- No ocean fishing on WCVI stocks produces a very small increase in population growth
  - **But** still decreasing 0.5% annually
  - 41.9% extinction risk in the next 100 years

SRKW-Chinook salmon interactions (Hypothesis 2a)

- 75% reduction in ocean harvest rates of Puget Sound stocks produces a positive population growth
  - 0.5% annual increase
  - Even under this extreme scenario, there is a “zero” probability of meeting U.S. SRKW downlisting recovery targets
  - Projections under this scenario still show a 26.2% extinction risk in next 100 years

Is Chinook abundance limiting the population growth and viability of RKW?

- There is a broader and stronger response of NRKW vital rates to Chinook salmon abundance – there is no evidence that levels of Chinook abundance are limiting NRKW population growth

- Weak interactions between SRKW vital rates and Chinook salmon abundance – other factors could be at play limiting SRKW population growth OR masking predator-prey dynamics (e.g., confounding factors)

- Demographic stochasticity is already an important factor for SRKW population viability
  - There is a high risk of inbreeding depression (Ford et al. 2011)
  - Possible disruption of mating behaviour trying to avoid inbreeding

Do these results support adjustments to fisheries?

- From Hypothesis 1a: no/negligible effects on SRKW recovery

- From Hypothesis 2a: possibly/extreme scenarios can exert positive SRKW population growth **but** future research is required to verify the main assumption in this hypothesis

What does this investigation support?

- Research to identify causes for depressed calf survival and fecundity in SRKW

- Studies of RKW diet composition in Fall, Winter and Spring to verify the uncovered interactions between RKW vital rates and Chinook (and Chum) salmon abundance
  - Moving beyond potentially spurious correlations
  - Required for cause-effect interpretations

Next steps

- Development of programming code (R) for
  - Analysis of alternative matrix models
  - Efficient incorporation of new data and alternative PVA criteria
  - Rapid exploration of fishing scenarios
- Completion Report for PSC
- Primary publications (2)