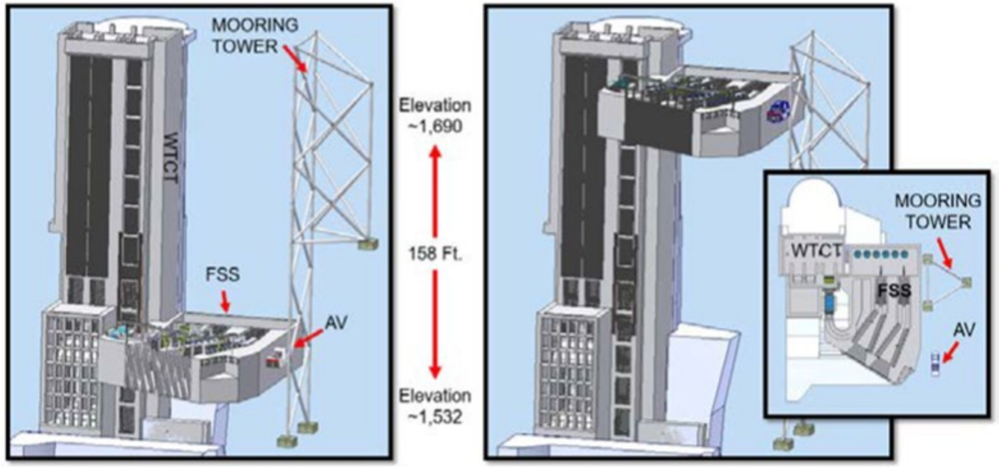
INTERSPECIFIC DIFFERENCES IN SALMONID POPULATION RESPONSES TO DAM PASSAGE MEASURES IN THE UPPER WILLAMETTE RIVER BASIN (UWR)

Murdoch McAllister, Eric Parkinson, Tom Porteus, Roberto Licandeo, Aaron Greenberg, Mairin Deith

The University of British Columbia,

Vancouver, Canada



Evaluation of alternative dam passage measures

- **Improvements to dam passage have been required to facilitate recovery of ESA listed spring Chinook salmon (*Oncorhynchus tshawytscha*) and winter steelhead (*O. mykiss*) populations in the UWR**

		Alternative Sets of Dam Passage Measures						
Sub-basin	Dam	NAA	DPM1	DPM2	DPM3	DPM4	DPM5	DPM6
North Santiam	DET		FSS	FSS	FSS	SD FD	SS FD	FSS
	BCL		Collect at DET	Collect at DET	Collect at DET	SS	SS	Collect at DET
South Santiam	FOS		MW	MW	MW			MW
	GPR		FSS	SS FD	SS FD	SS FD	SD FD	
McKenzie	CGR			FSS	SD (DT) FD (DT)	SD FD	SD (DT) FD (DT)	FSS
Middle Fork	LOP		FSS	FSC	FSC	SD FD	SS FD	FSS
	DEX					SS	SS	
	HCR					SS FD	SD FD	FSC

NAA=no action alternative, Alt=alternative, FSS=Floating Screen Structure, FSC=Floating Surface Collector, MW=Modified Fish Weir, SS=Spring Spill, SD=Spring Drawdown, FD=Fall Drawdown. Drawdowns to regulating outlets (RO) unless diversion tunnel (DT) specified. DET = Detroit, BCL = Big Cliff, FOS = Foster, GPR = Green Peter, CGR = Cougar, LOP = Lookout Point, DEX = Dexter, HCR = Hills Creek

Spring Chinook Salmon and Winter Steelhead in UWR

Spring Chinook Salmon

- Fry, subyearling and yearling juvenile life history types
- Juveniles migrate in spring and autumn
- Semelparous: all die after spawning
- Spawn mostly at ages 4 and 5
- N. Santiam, S. Santiam, McKenzie, Middle Fork Sub-basins

Winter Steelhead Trout

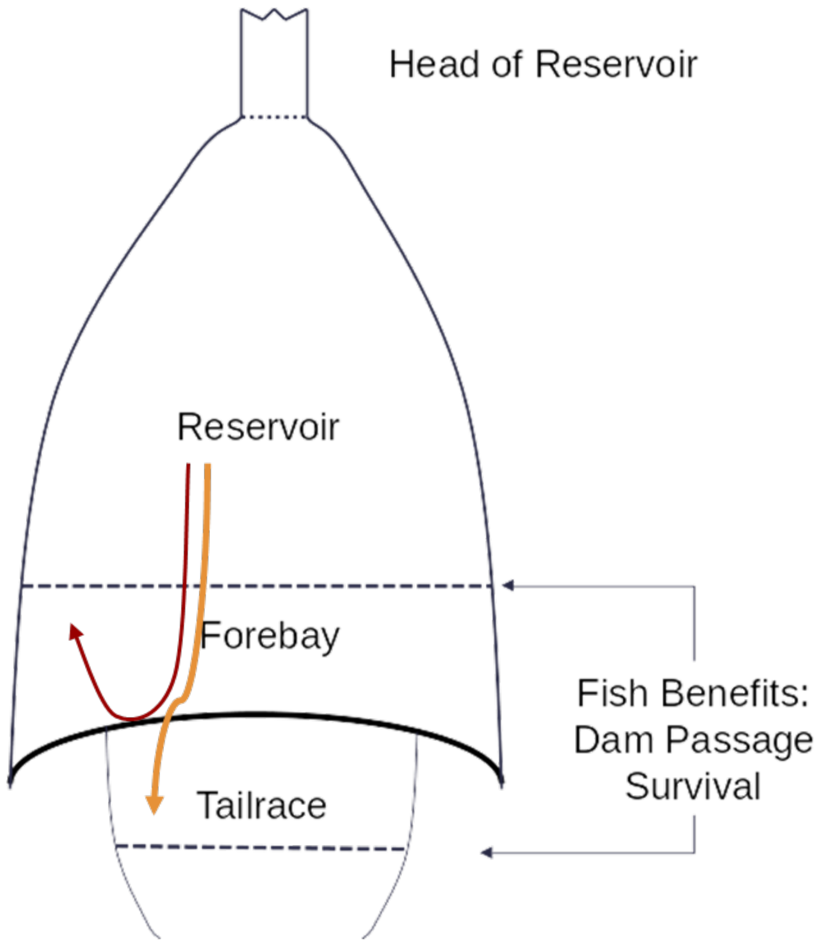
- Predominant juvenile life history smoltifies at age 2
- Juveniles migrate mainly in the spring
- Iteroparous: some survive spawning
- Spawn mostly at ages 4-5
- N. Santiam, S. Santiam Sub-basins

Questions addressed

1. **How different are predicted biological responses to DPMs between spring Chinook salmon and winter steelhead?**
2. **Could the ranking of DPMs differ between the species?**
3. **What are the potential trade-offs in DPM performance between the species?**
4. **When performance metrics for a DPM are unsatisfactory, what additional mitigative actions might be considered?**

Biological performance measures to consider in evaluating dam passage options

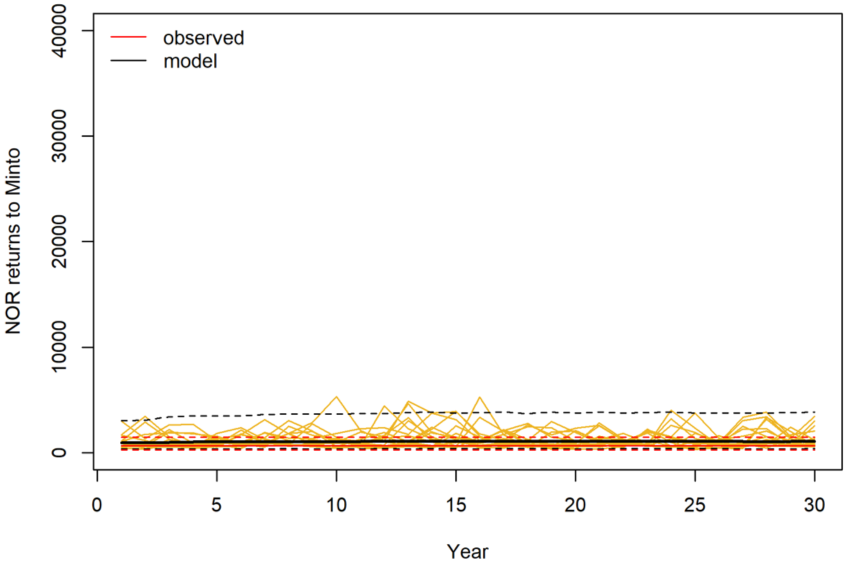
1. Dam passage metrics (Fish Benefits Workbook (FBW) Corps 2012)
   - *Efficiency at getting fish above the dam to pass through (DPE)*
     - *Fish not passing subject to in-reservoir mortality and later passage*
   - *Survival rate of juveniles that pass through the dam (DPS)*
   - *Consider also DPE*DPS*
   - *By dam operation, species, juvenile stage, fish passage specifications, water year type*



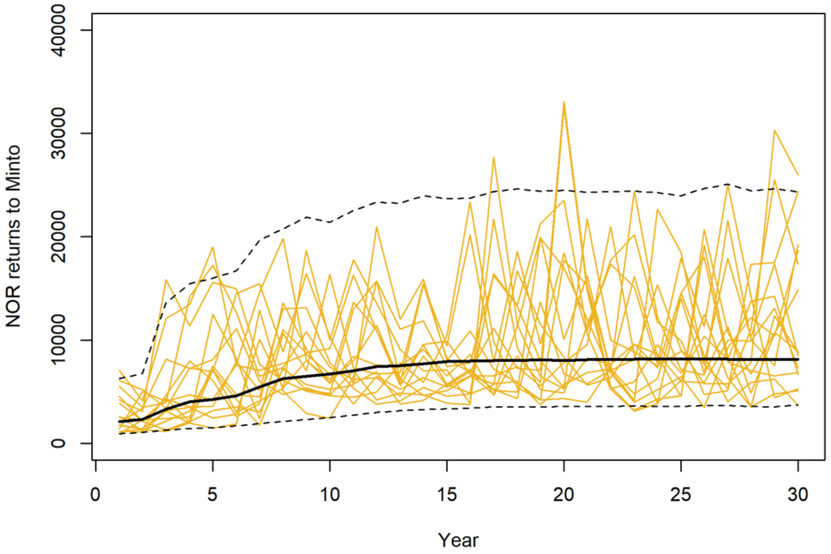
USACE Portland (2012)

Biological performance measures

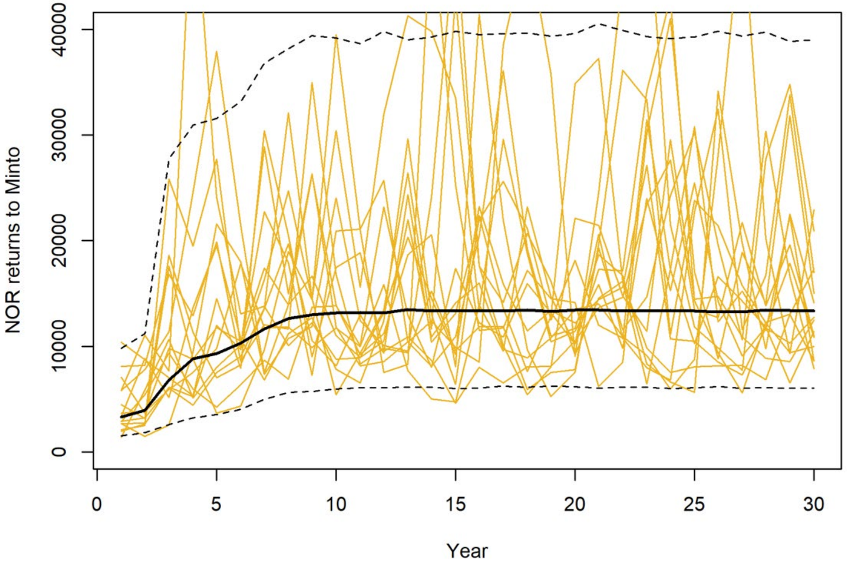
2. **Population performance metrics computed using life cycle models (LCMs – NMFS + UBC)**
    - *Average long-term abundance of natural origin (NOR) spawners*
    - *Near term population productivity*
    - *Long-term probability of quasi extinction (Prob NOR < Quasi Extinction Threshold or PQE)*
    - *Long-term juvenile life history diversity (Chinook salmon only)*



No change in dam passage



Spring, autumn drawdowns
- **8x No change**



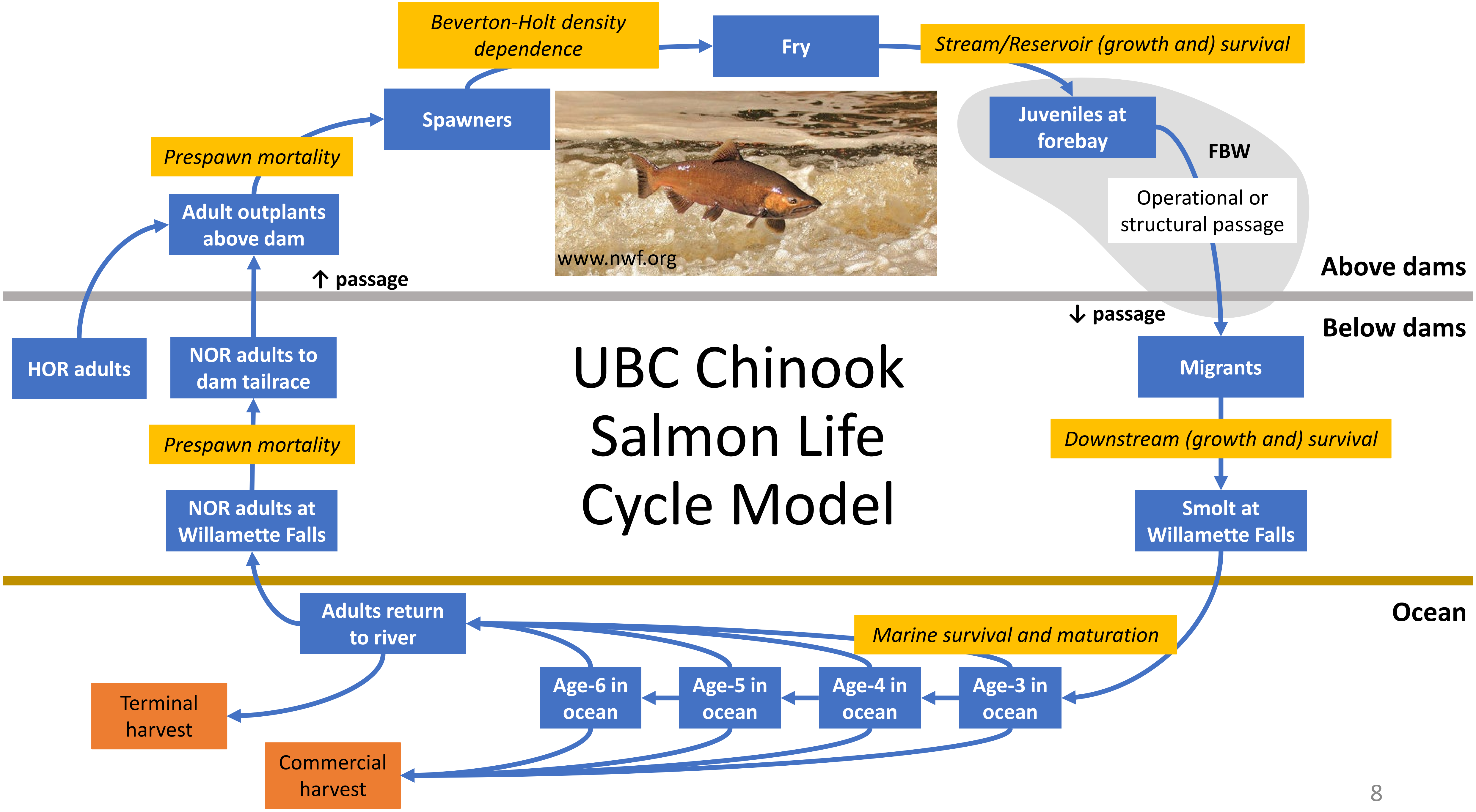
Floating Screen Structure
- **13x No change**
- **1.65x drawdowns**

Performance Metrics (PMs) from the UBC LCM for spring Chinook salmon and winter steelhead: above dam populations

Performance Metric	Description	Statistic
Abundance	NOR spawners	Geometric mean of year 16-30
Productivity	R/S SAR Fry-smolt survival	Geometric mean of year 1-5 Mean of year 1-5 Mean of year 1-5
Extinction risk	P(NOR) < QET	4-yr mean, year 16-30
Diversity (Chinook salmon only)	pHOS % migrant type smolts % migrant type adult returns Migrant type SAR	Mean of year 26-30 Year 26-30 Year 26-30 Mean of year 26-30

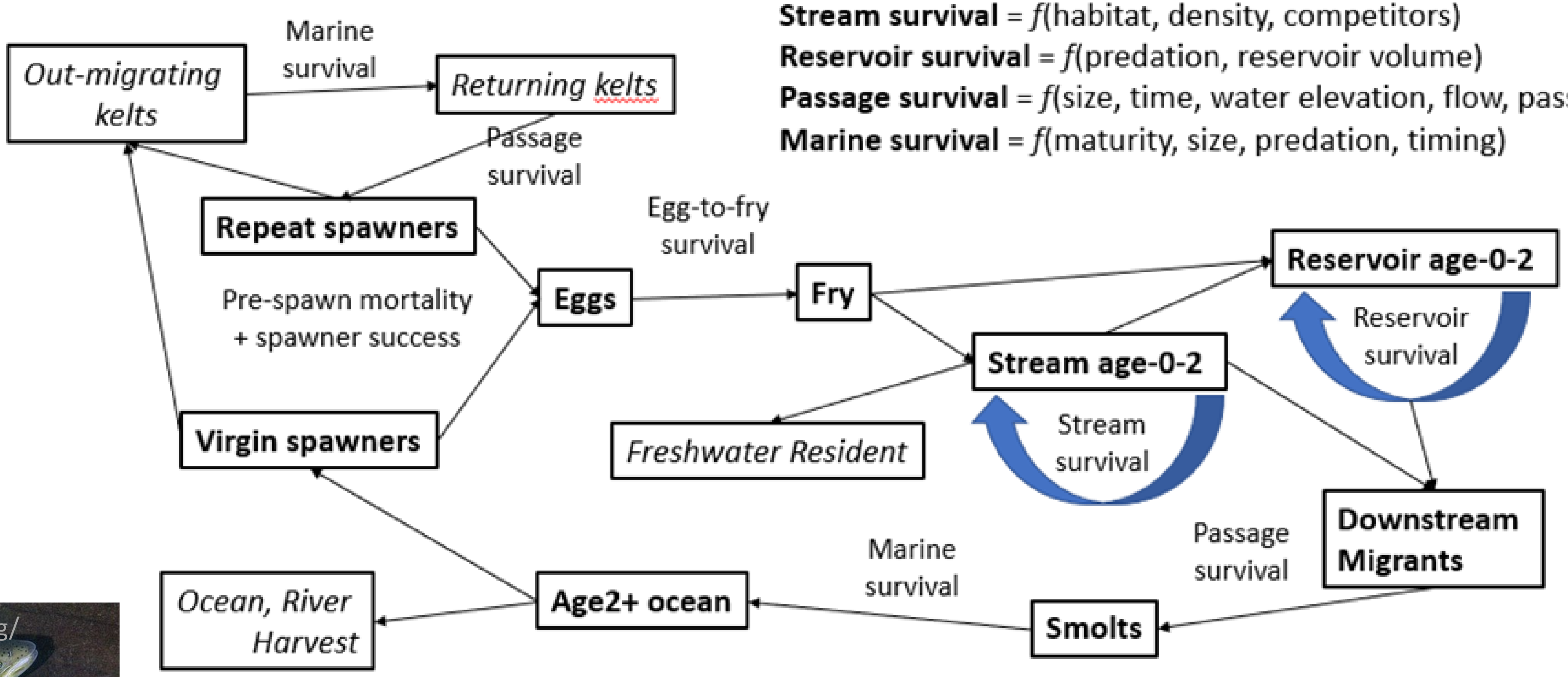
R/S = Recruits-per-spawner; SAR = smolt-adult return rate, pHOS = proportion of hatchery-origin spawners; P(NOR) < QET = probability that NOR returns are less than the Quasi-Extinction Threshold (QET).

UBC Chinook Salmon Life Cycle Model



Winter Steelhead Life Cycle

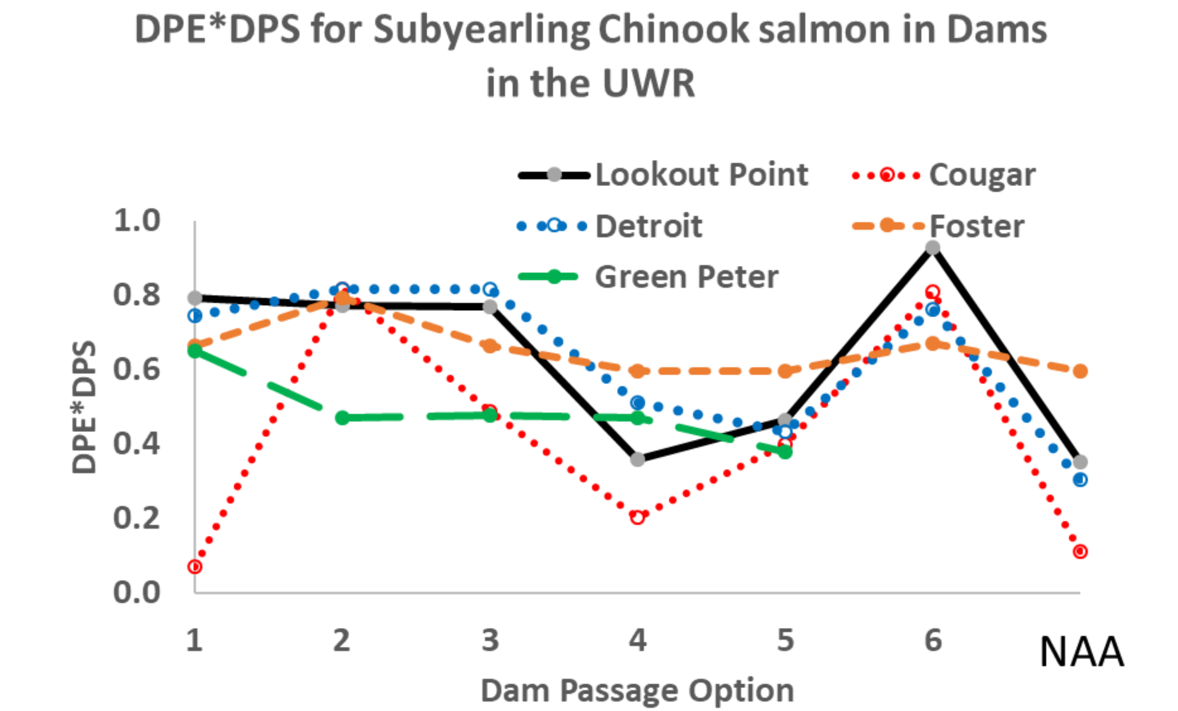
Spawner success = *f*(fecundity, %hatchery)
Egg-to-fry survival = *f*(density, temp, discharge, sediment)
Stream survival = *f*(habitat, density, competitors)
Reservoir survival = *f*(predation, reservoir volume)
Passage survival = *f*(size, time, water elevation, flow, passage route)
Marine survival = *f*(maturity, size, predation, timing)

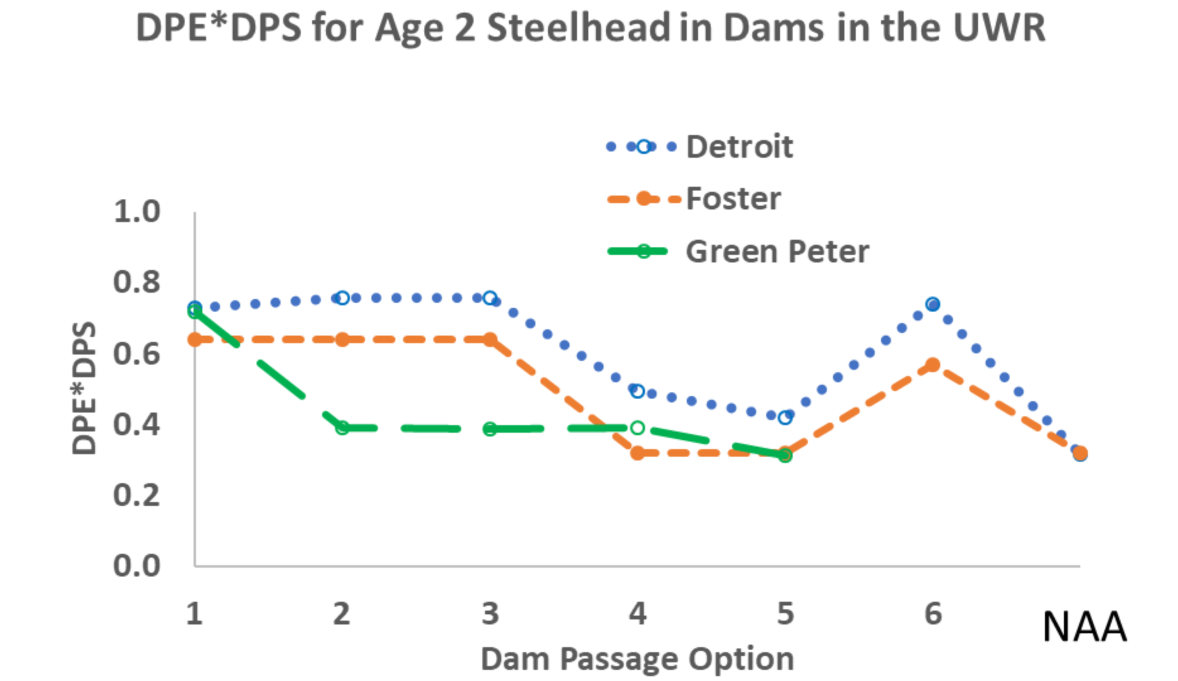


Results

Dam passage efficiency and survival

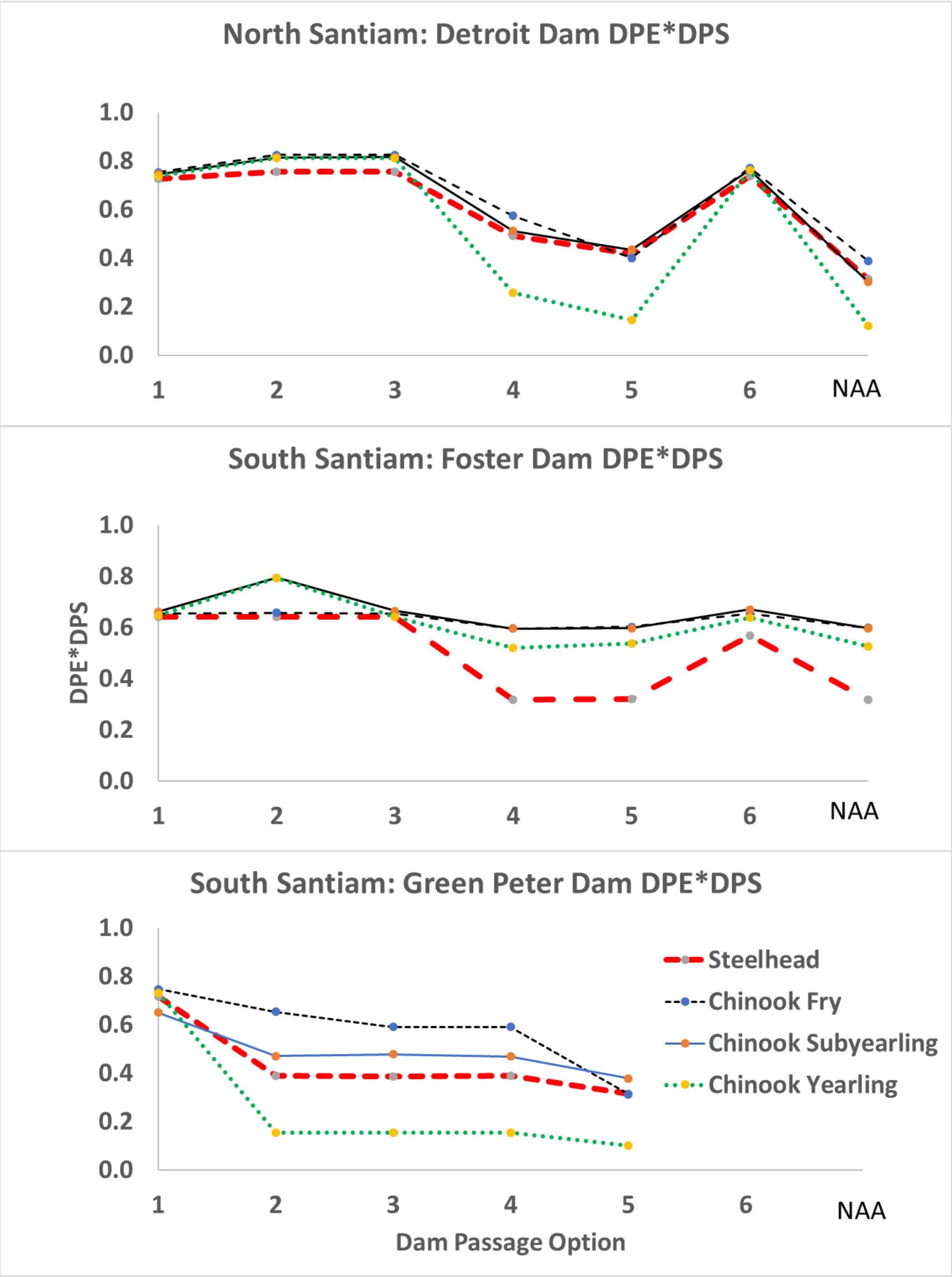
- **Dam passage survival for a DPM can differ between**
  - ***Dams for the same species and juvenile stage***
  - ***Juvenile steelhead and Chinook salmon for the same dam***
- **Spring spill, spring and fall draw downs (e.g., DPM 4,5) gave lower DPS than Floating Surface Collector and Floating Screen Structures (e.g., DPM 2, 3)**
- **Reasons for differences in DPE, DPS between species**
  - ***Different fish sizes/ behaviors at dam passage***
  - ***Different times of year of migration***





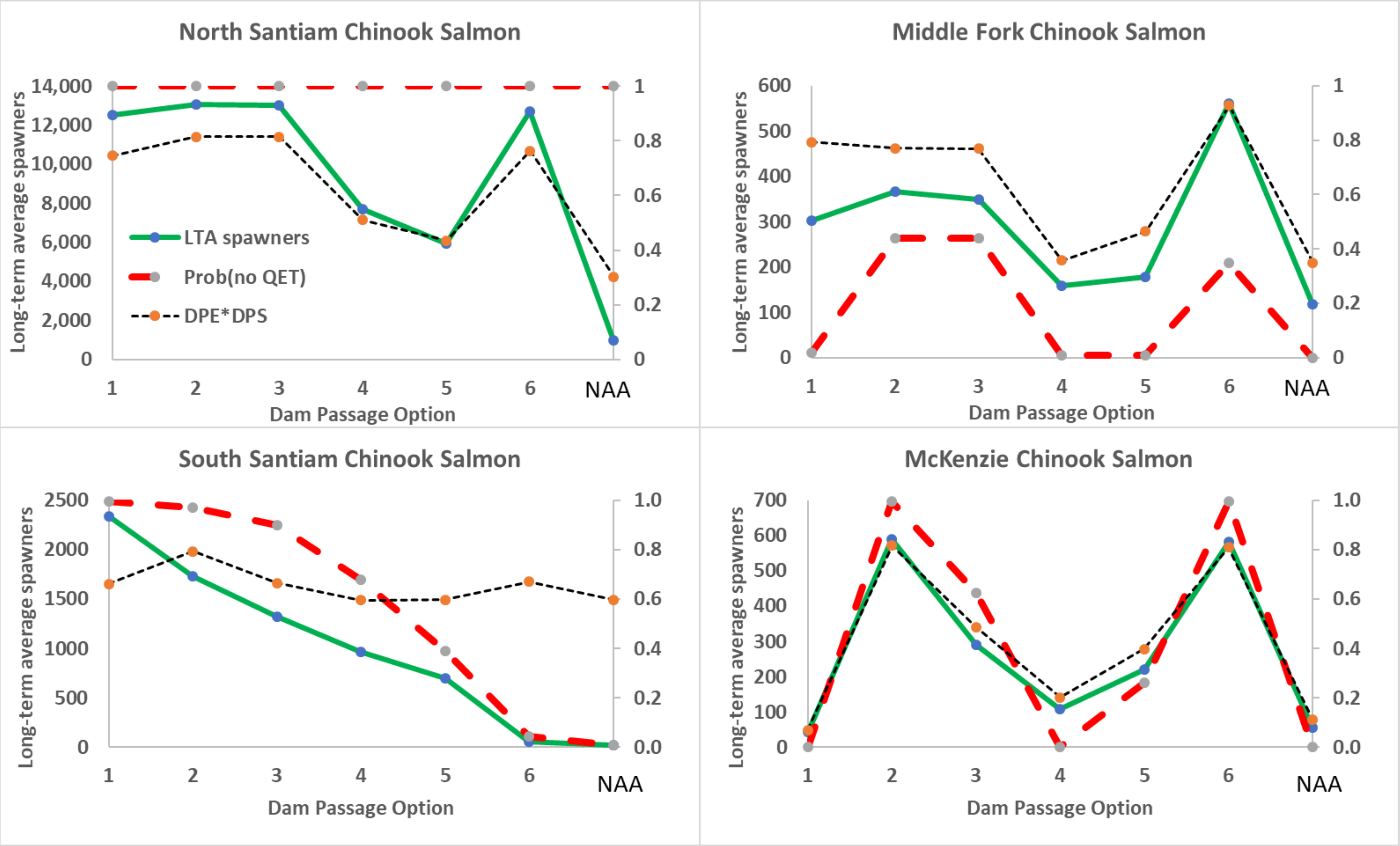
Dam passage efficiency and survival

- **Dam passage survival for a DPM can differ between life history groups for spring Chinook salmon on a given Dam**
- **DPS responses to DPMs for juvenile steelhead show no consistent similarities with the Chinook salmon life history types**
- **Could expect long-term population responses to DPMs to differ between species for the same dam**



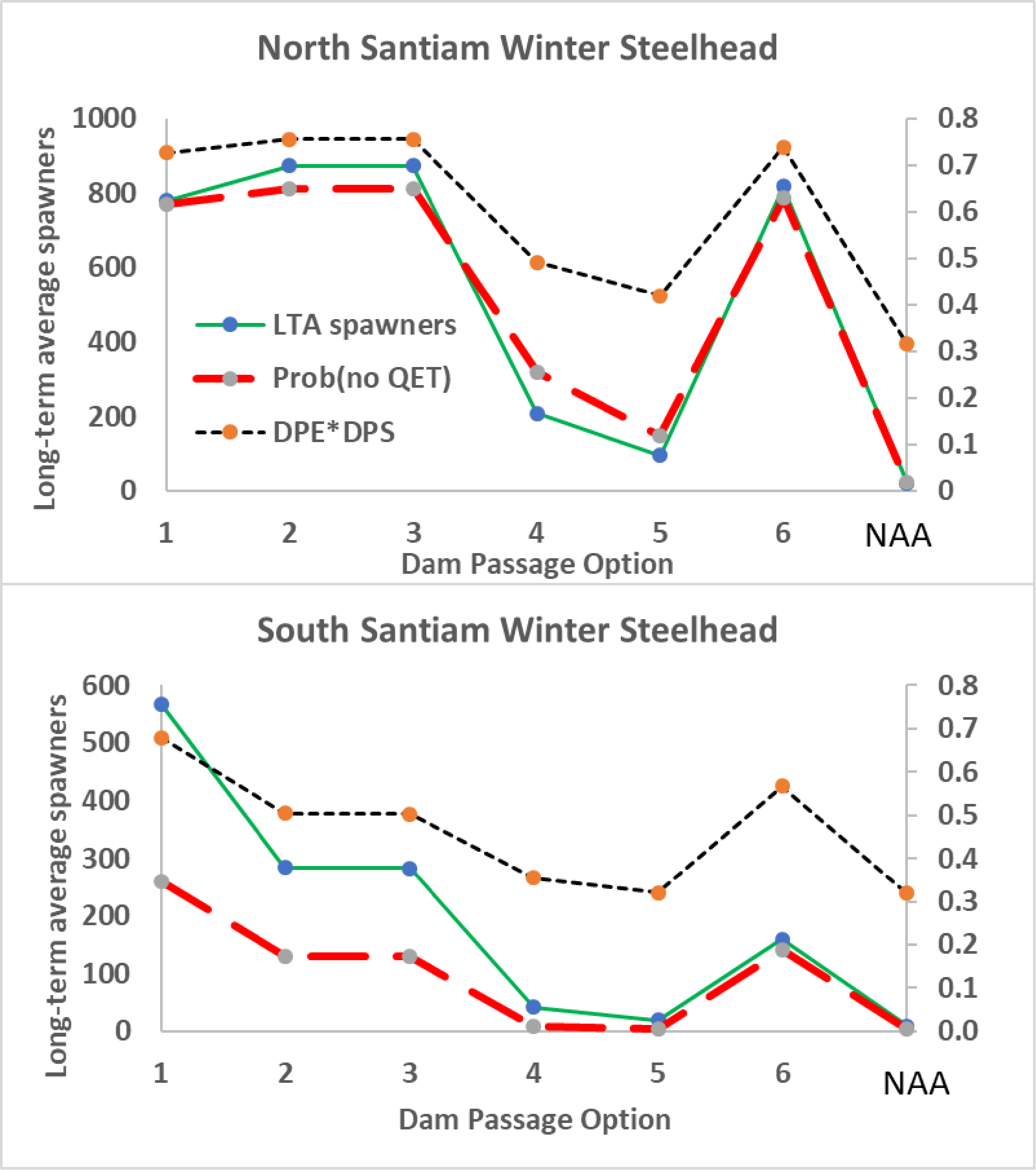
Population Performance Metrics for Spring Chinook Salmon

- **Options 1, 4, 5, 6 poor**
- **Option 3 intermediate**
- **Option 2 best overall**



Population Performance Metrics for Winter Steelhead

- **Options 4, 5 poorest**
- **Options 2, 3, 6 intermediate**
- **Option 1 best overall**
  - **P(QET) still high at 0.65 in S. Santiam**



Summary

- **Ranking of DPMs by DPE, DPS for a given species can differ from rankings by population performance metrics**
  - ***If ranked only by DPE, DPS could get inferior population outcomes***
  - ***Can obtain good population responses despite relatively low DPE*DPS, e.g., <0.7***
  - ***Appropriate to consider both DPE, DPS and population performance metrics***
- **DPE, DPS and population performance metrics can differ between species for a given DPM on a given dam**
- **Ranking of DPMs by DPS, DPE and population performance metrics for a given project and across projects can differ between species**

Summary

Reasons for differences in population responses to DPMs between species

Differences in

1. ***Mean DPE, DPS between species***
2. ***Variance in DPE, DPS between species***
3. ***Egg-smolt survival rates between sub-basins and species***
4. ***Mean historical adult abundance between species and between sub-basins***
5. ***Timing of downstream migrations – each experience different passage conditions on a given project***
6. ***Marine survival rates between sub-basins and between species***
7. ***Adult freshwater mortality: PSM affects only adult Chinook salmon and not adult winter steelhead***

Summary

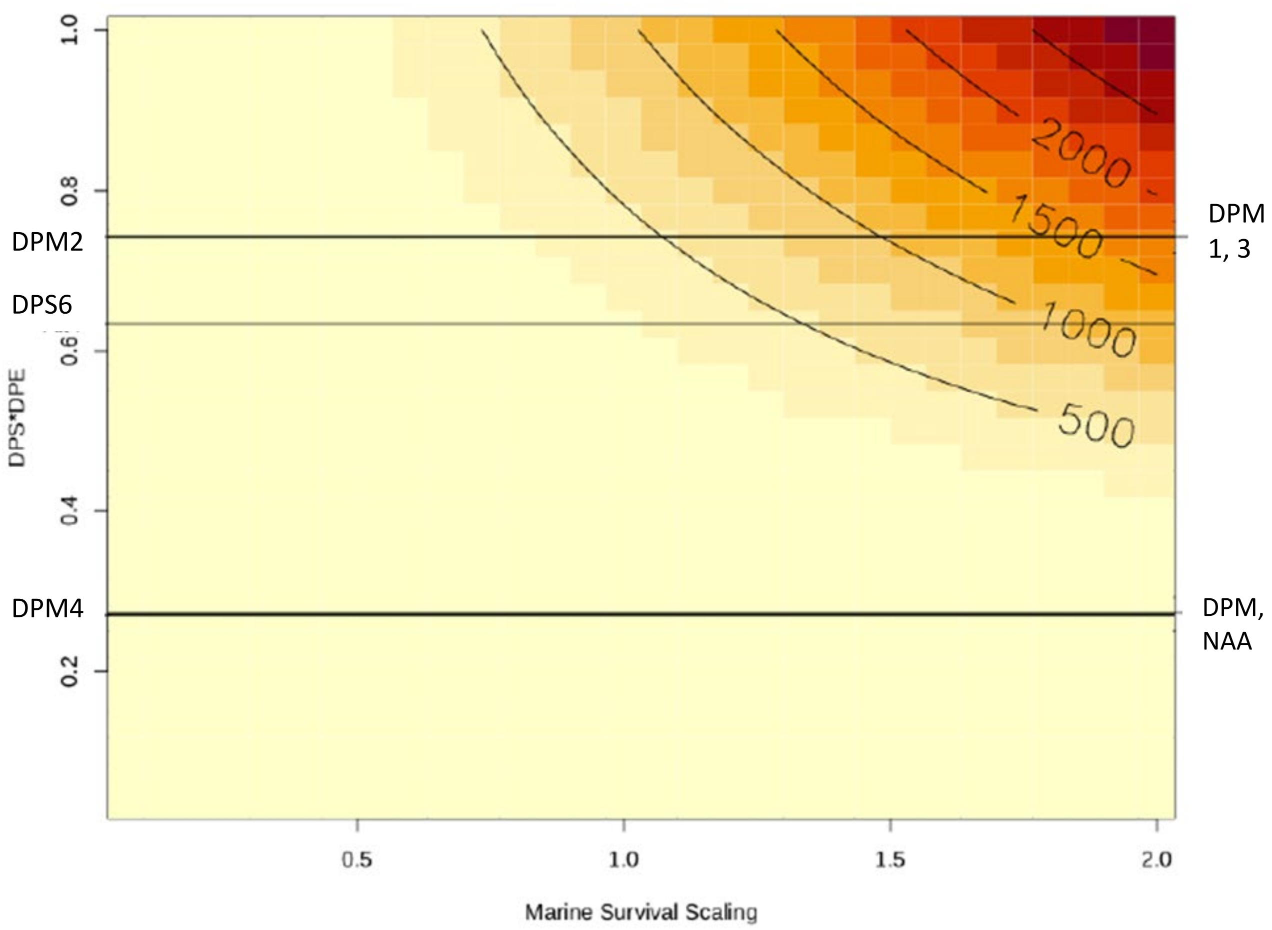
- **Tradeoffs in outcomes between the DPMs that appear best for each species**
- **DPM2 ranked overall highest for Chinook salmon**
  - ***Among lowest PQEs for Chinook salmon, highest LTA spawners***
  - ***Gave high PQE (0.83), low LTA spawners for winter steelhead in South Santiam Sub-basin***
- **DPM1 ranked overall highest for steelhead**
  - ***Gave minimum of 0.65 PQE for steelhead in GPR, among highest LTA steelhead spawners***
  - ***Gave high PQEs (0.98 and 1), low LTA spawners for Middle Fork and McKenzie Chinook salmon***
- **DPM that ranked the highest for one species gave inferior results for other**

Summary

- **Conventional decision analysis criteria would rank DPM2 higher than DPM1**
  - ***Maximum Utility, Minimax, Maximax, Minimax Regret***
- **Performance looks unsatisfactory under highest ranking DPM**
  - ***DPS still relative low, i.e., < 0.9 for some dams***
    - ***e.g., Green Peter for both species, Foster for winter steelhead***
  - ***PQE> 0.5 for S. Santiam steelhead and Middle Fork Chinook salmon under DPM2***

Additional possible actions to consider

1. ***Consider introducing additional new DPMs***
   - ***Currently, a modified fish weir considered at Foster Dam***
   - ***Add FSS at Foster Dam (FSS at GPR did better)***
2. ***Consider increasing translocation of adult steelhead to above Foster Dam***
   - ***<100 females per year 2017-2021 returning to tailrace of Foster Dam***
   - ***Modelled translocation in BA which reduced PQE***
3. ***Introduce new measures to improve downstream passage and survival rates of steelhead kelts***
   - ***Evans et al. (2008) (Snake); Trammell and Fast (2016) (Yakima)***
4. ***Increased control of pinnipeds in the lower Columbia River***
   - ***PMs sensitive to long-term average smolt-adult survival rates***



Projected Foster winter steelhead spawner abundance across a range of marine survival and dam passage rates

Acknowledgments

- Oregon State Fish and Wildlife Department for its implementation of the paired release experiments and Beach Seine study and making the PIT tag data from them available for this study
  - Luke Whitman (ODFW) for helping to provide the data
- Oregon Department of Fish and Wildlife: Dave Jepson, Greg Grenbemer, Brett Boyd
- Oregon State University: Chrissy Murphy
- The Columbia Basin PIT Tag Information System (PTAGIS)
- US Geological Survey: Tobias Kock
- National Marine Fisheries Service: Anne Mullan
- NOAA Northwest Fisheries Science Centre: Jim Myers
- Bonneville Power Administration: Daniel Spear