Differences in smolt to adult survival rates between Willamette River sub-basins and implications for the recovery potential of spring Chinook salmon

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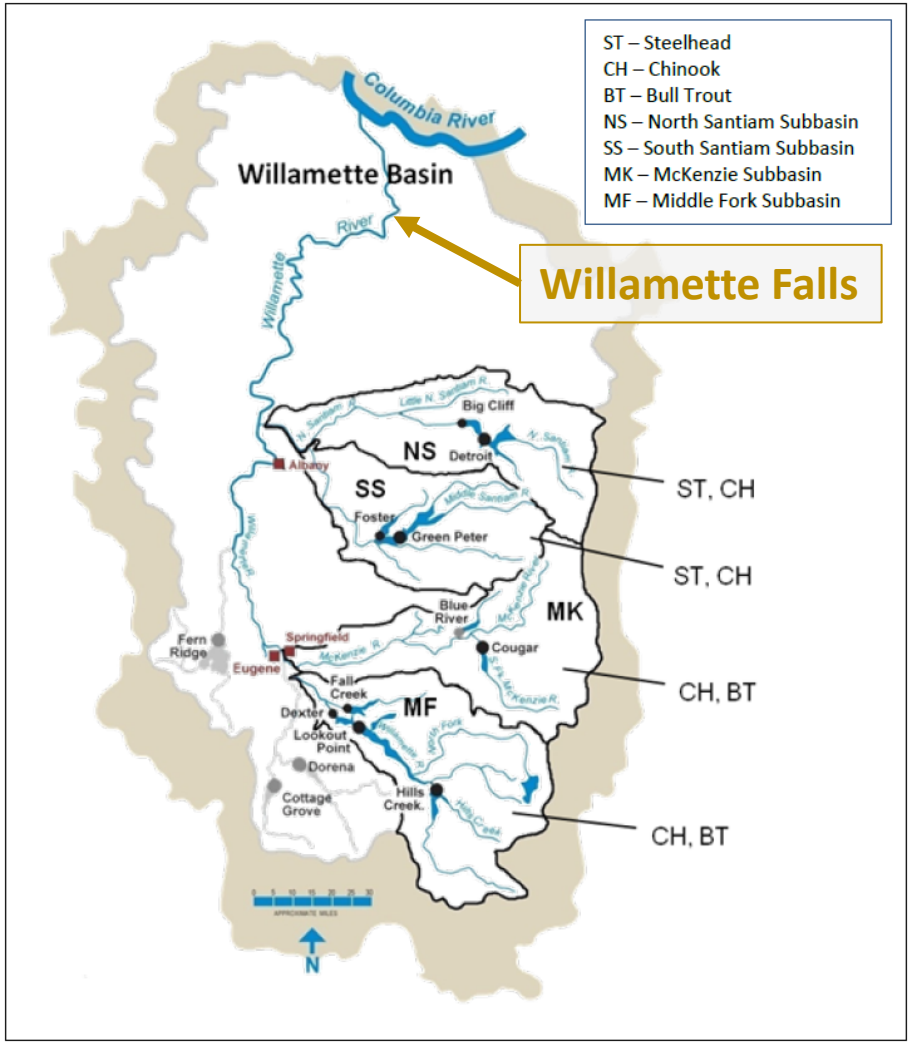
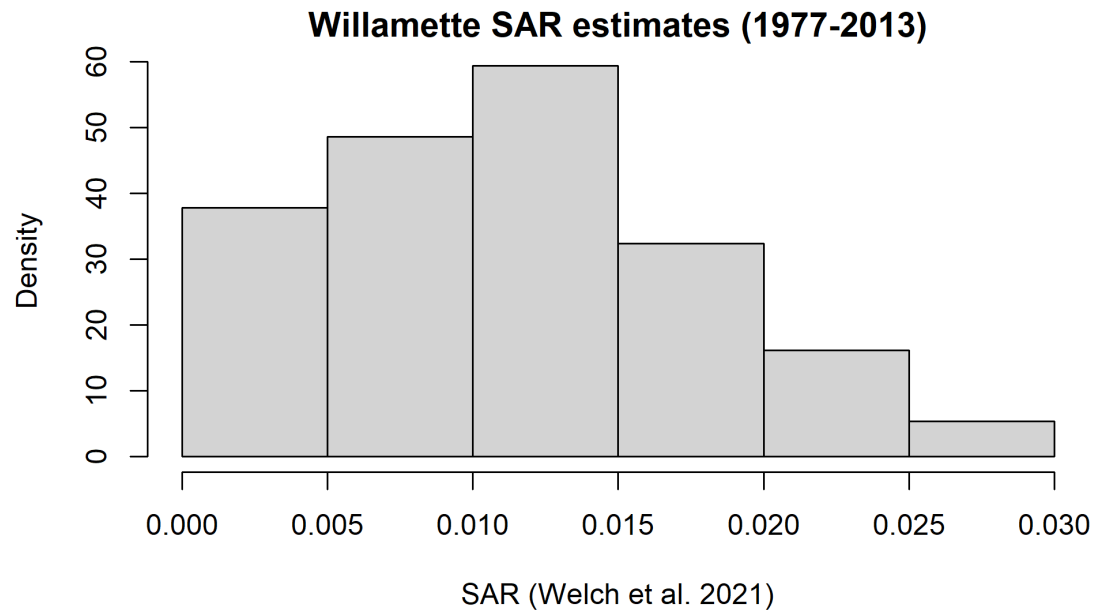
Integrated Passage Assessment (IPA) Model

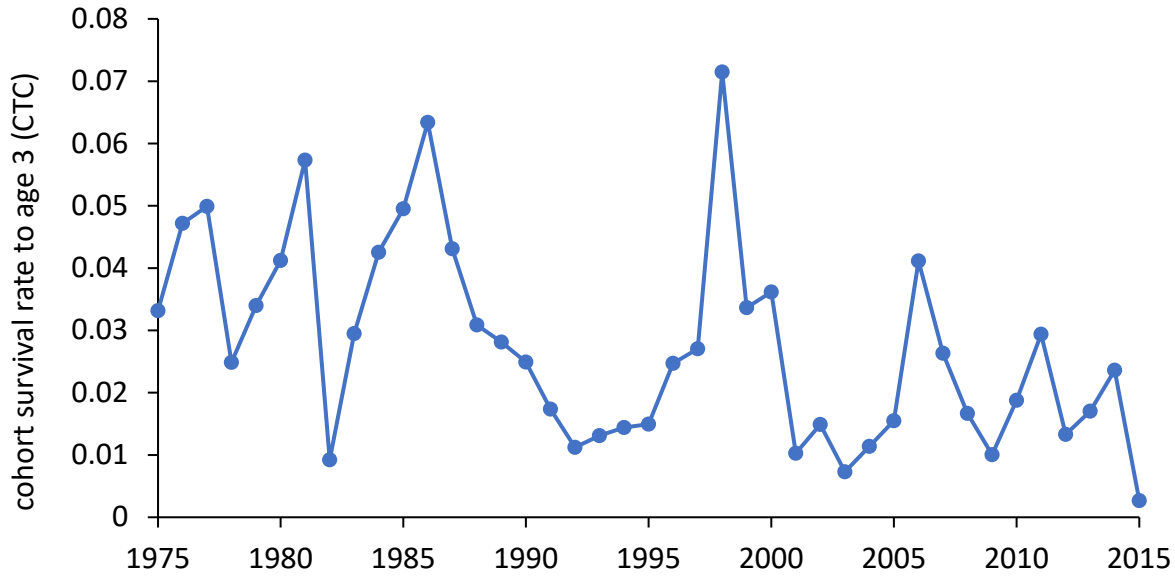
- Evaluate dam passage options in Willamette sub-basins
  - Spring Chinook salmon (*Oncorhynchus tshawytscha*)
  - Winter steelhead (*O. mykiss*)
- Integrates life cycle model features for above and below dam processes
- Survival rates key to understanding passage effects
  - e.g. reservoir survival, downstream migration survival, smolt-adult survival
- Use Bayesian framework to incorporate uncertainty into survival rate estimates from PIT tag data analysis



Willamette marine survival

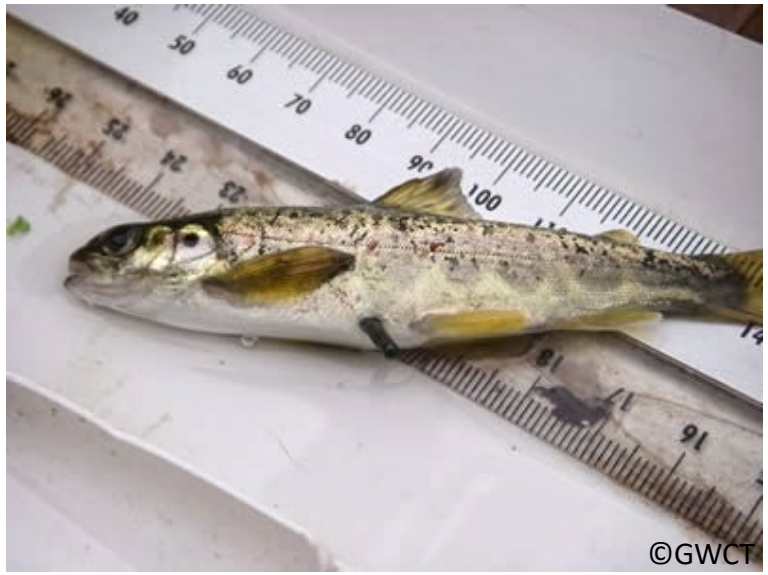
- Different definitions
  - Smolt-adult return rate (SAR)
  - Cohort survival rate to age-3
  - Smolt-adult survival rate
- Estimation methods use data generated by coded wire tags (CWT) or passive integrated transponder (PIT) tags





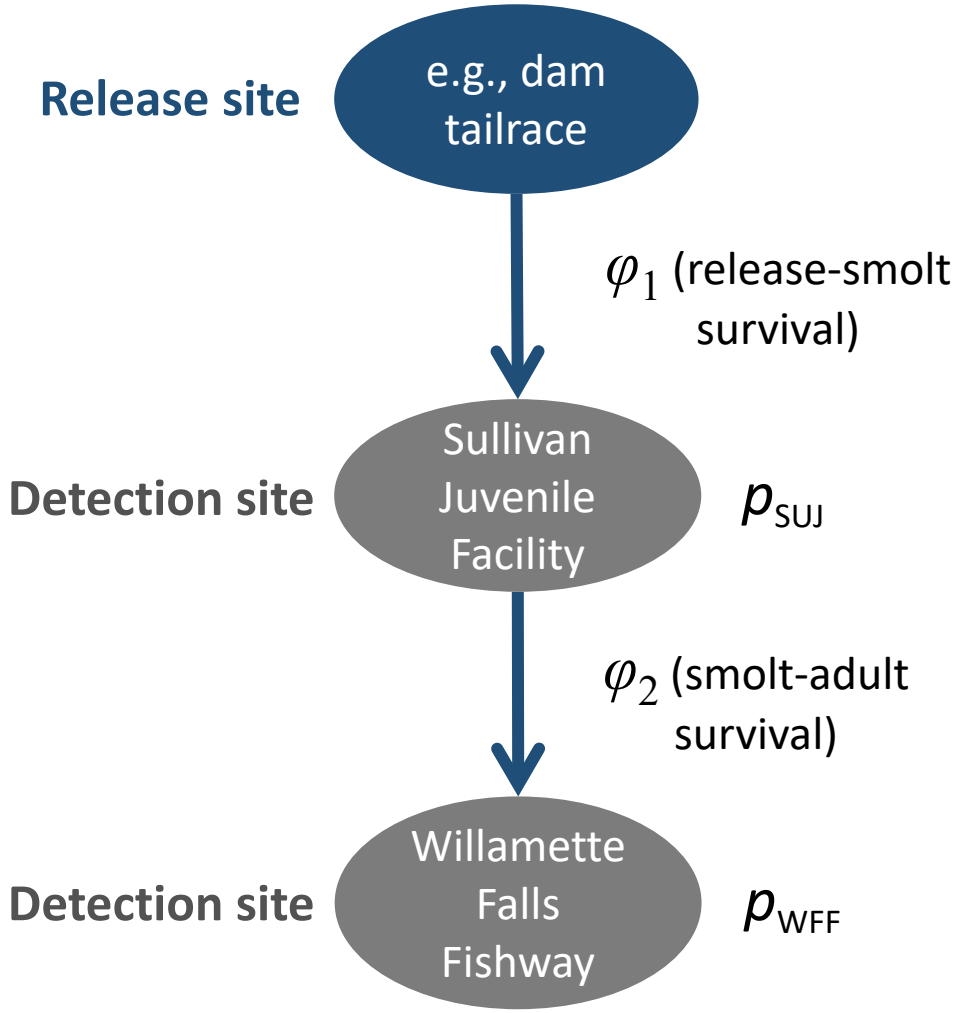
Willamette PIT Tag Data

- Multiple PIT tag studies performed in Willamette sub-basins
  - Chinook salmon and steelhead
  - Hatchery-origin (HOR) above/below dam paired releases (>>10k fish)
  - Natural-origin (NOR) captured releases (<1k fish)
- Central data repository via PTAGIS
- Analysis problems can occur with too few detections



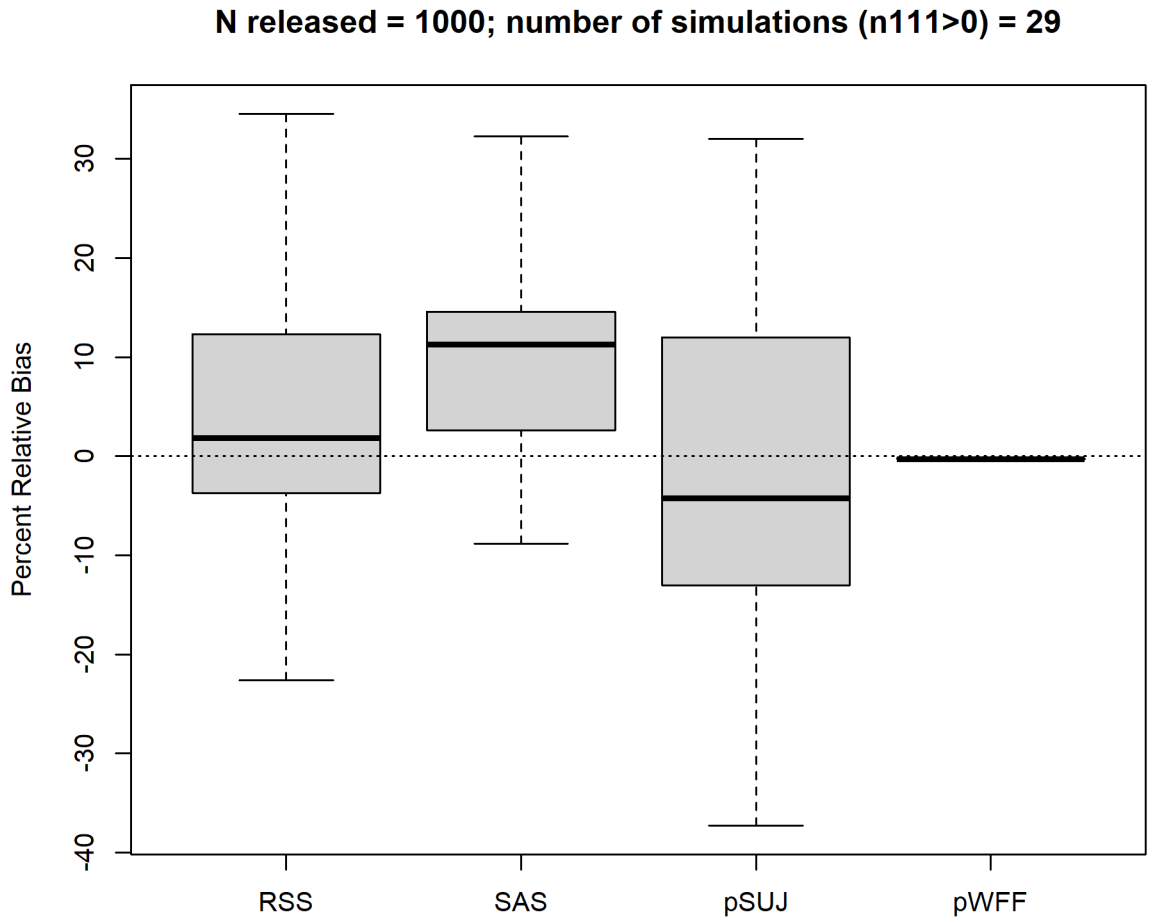
PIT Tag Survival Analysis

- Bayesian Cormack-Jolly-Seber (CJS) Model
- Apparent survival rate (φ) between release and detection locations modelled by adjusting number of detections at each location for probability of detection (p)
- Few fish detected at a location can be due to low survival or low detection probability
- Informative priors developed for all model parameters to reduce uncertainty
- Applied adjustment factor priors to infer true survival from apparent survival



Simulation-estimation study

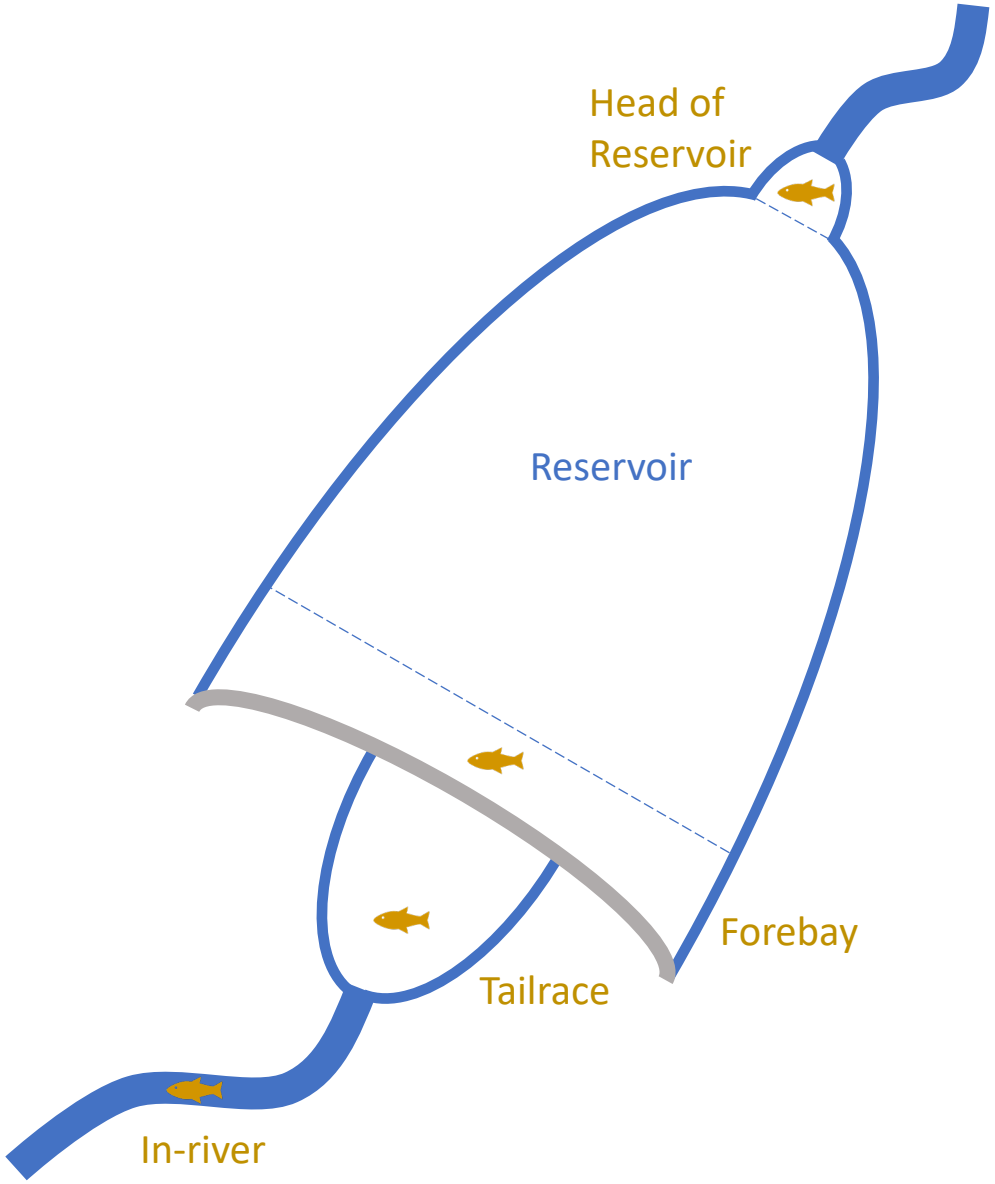
- Simulated 100 datasets with true values
  - Release-smolt survival (RSS) = 0.3
  - Smolt-adult survival (SAS) = 0.01
  - p_{SUJ} = 0.1, p_{WFF} = 0.97
- Compared reliability in recovering parameter estimates when n111=0 and n111>0
- Estimates close to true values
  - RSS = 2.6%
  - SAS = 11.3%



PIT tag data sources

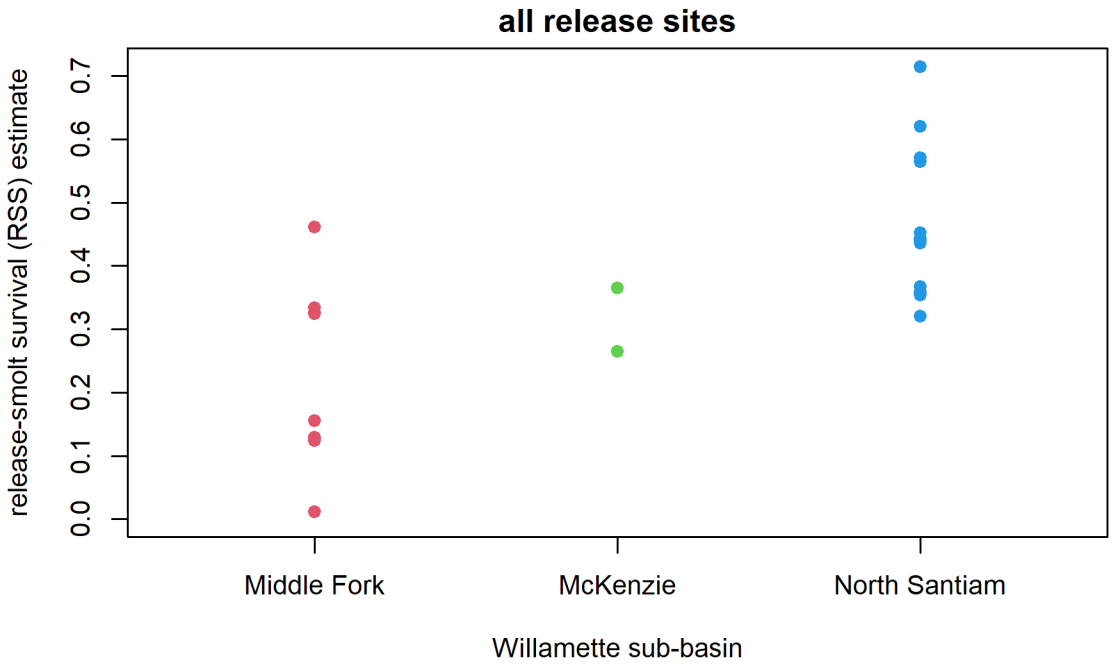
- North Santiam releases:
  - Head of Detroit reservoir (HO, 2012-2015)
  - Detroit reservoir forebay (HO, 2013-2014)
  - Big Cliff tailrace (HO, 2012-2015)
  - In-river (NO, 2010-2012)
- Middle Fork releases:
  - Head of Lookout reservoir (HO, 2011-2013)
  - Head of Fall Creek reservoir (HO, 2013)
  - Dexter tailrace (HO, 2012-2014)
- McKenzie releases:
  - Tailrace (NO, 2011-2012)

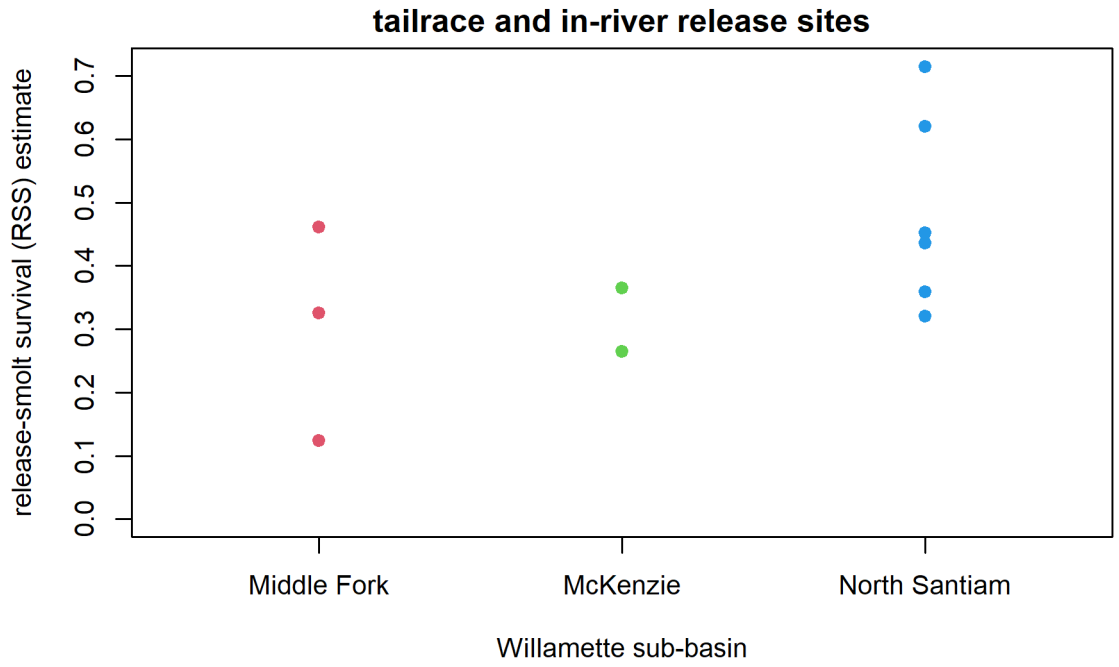
- Mostly subyearling releases, fry too small to tag



Release-smolt survival

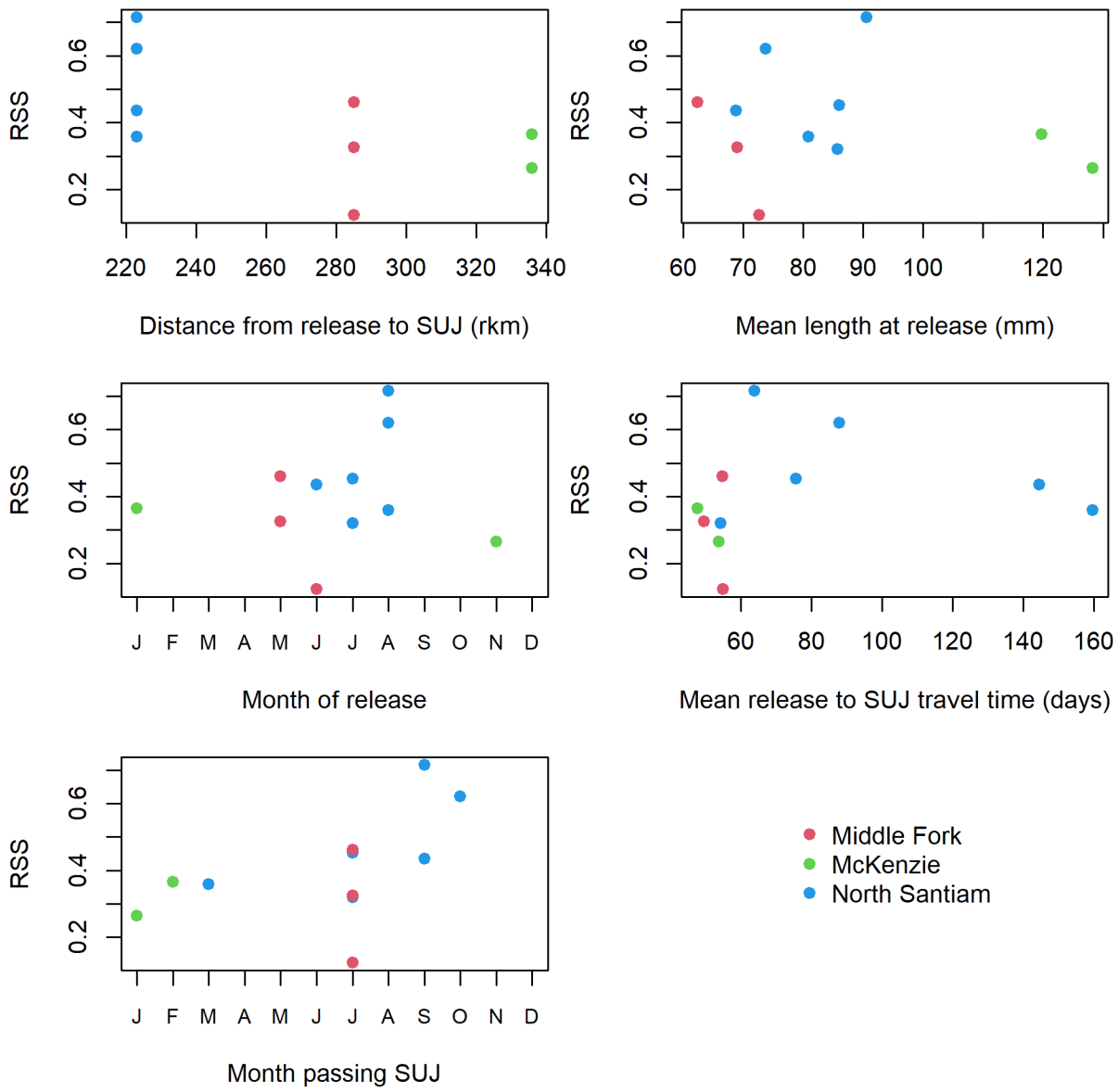
- RSS estimates from above dam release sites include reservoir survival and dam passage survival – pattern between sub-basins consistent





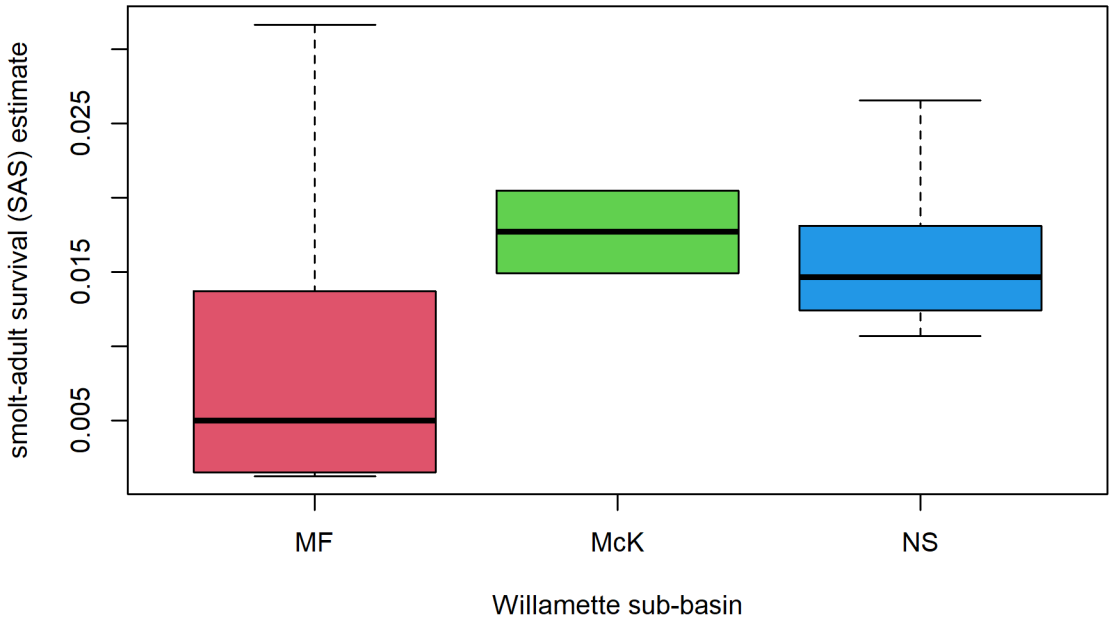
Factors affecting RSS

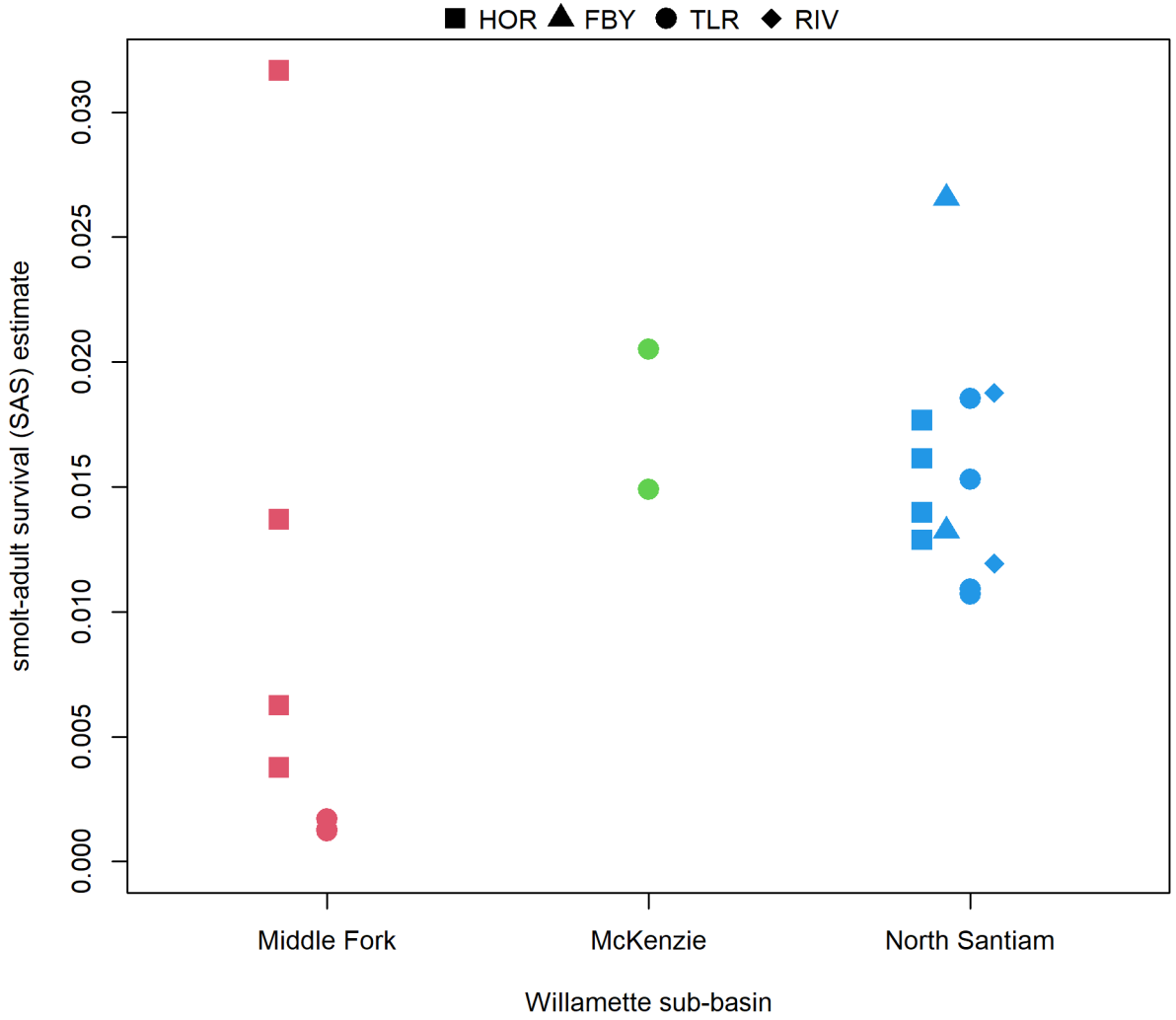
- Only compare below dam releases
- Between basins:
  - Distance from release to SUJ
  - Length at release
  - Month of release and passing SUJ
- Within basins:
  - Water year type (abundant>adequate>deficit)
  - Length at release
  - Month of release and passing SUJ



Smolt-adult survival

- Middle Fork lowest at 0.5%
- North Santiam (1.6%) and McKenzie (1.7%) higher
- Up to 10x difference above/below dams





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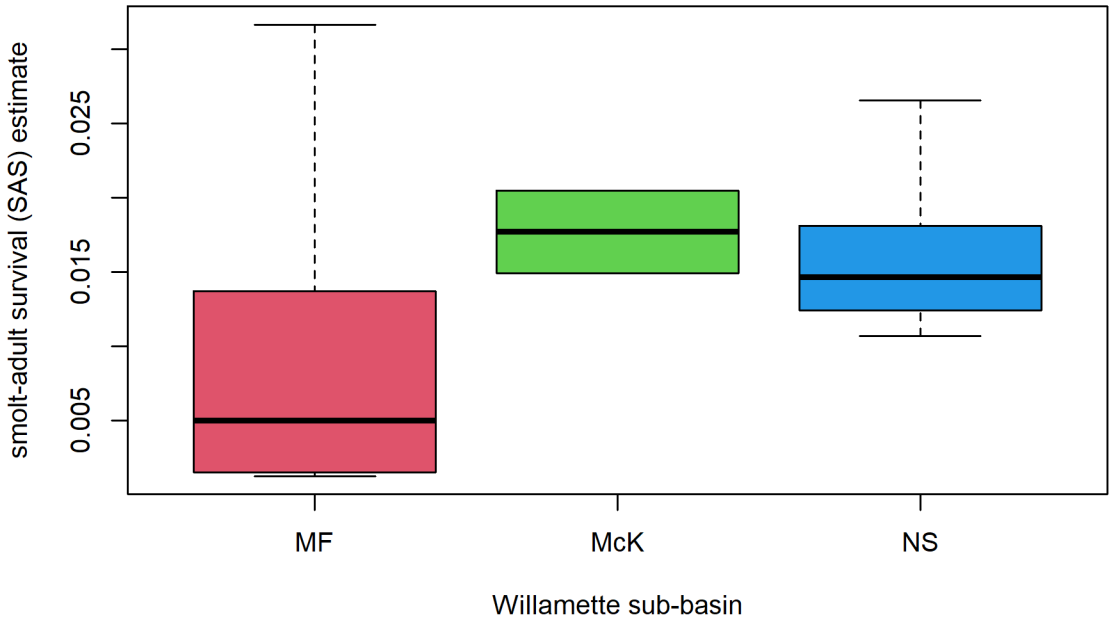
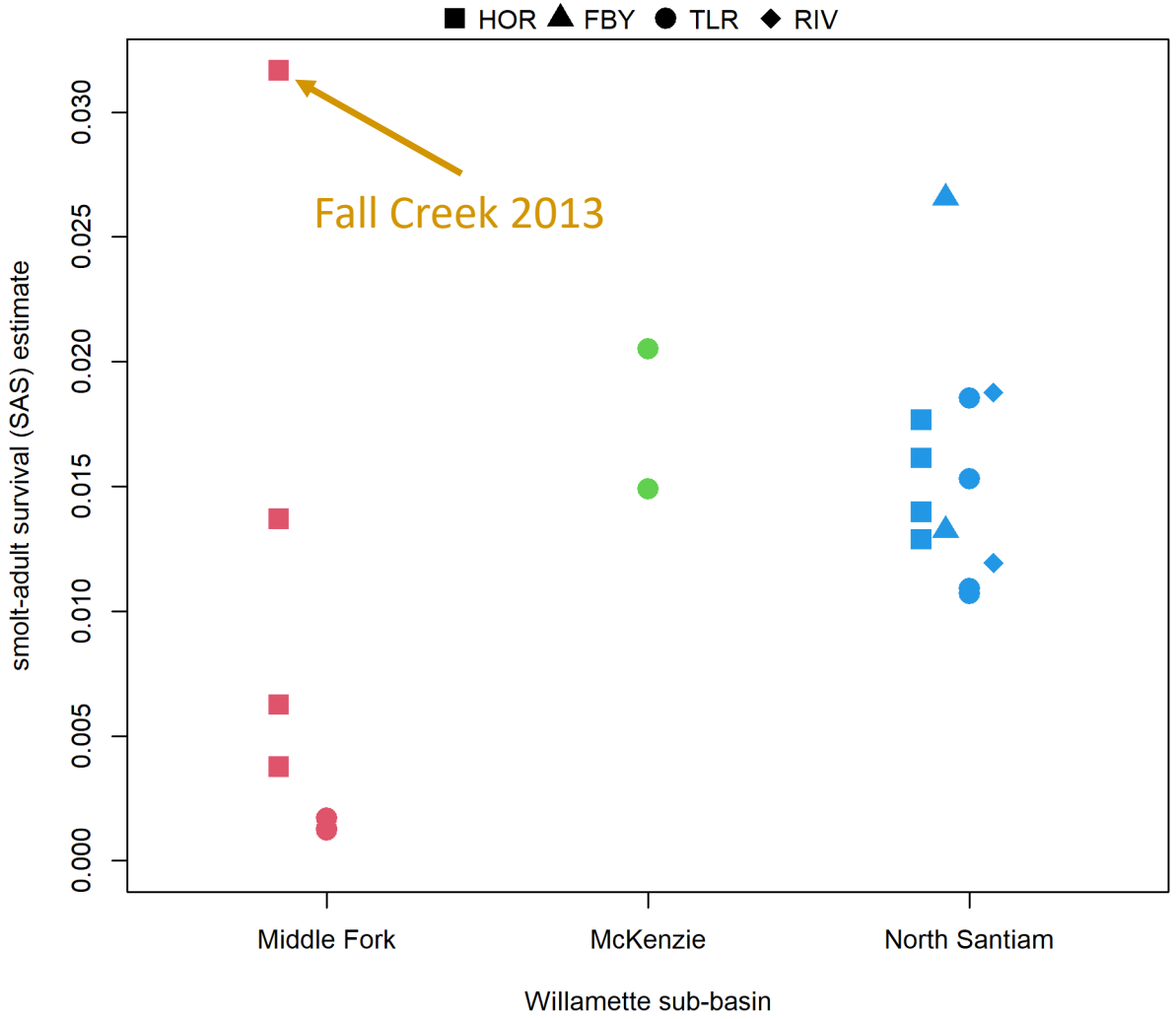
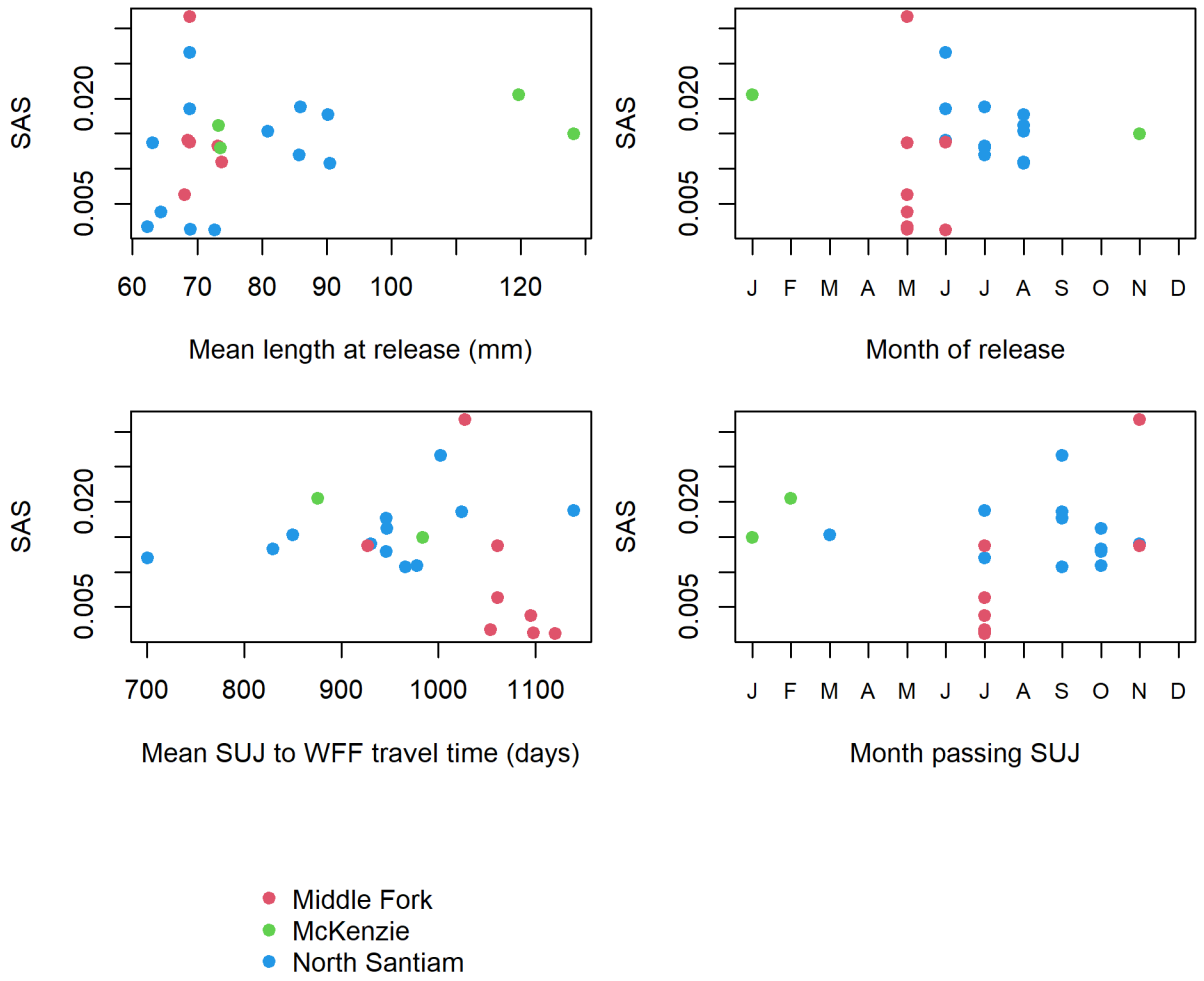
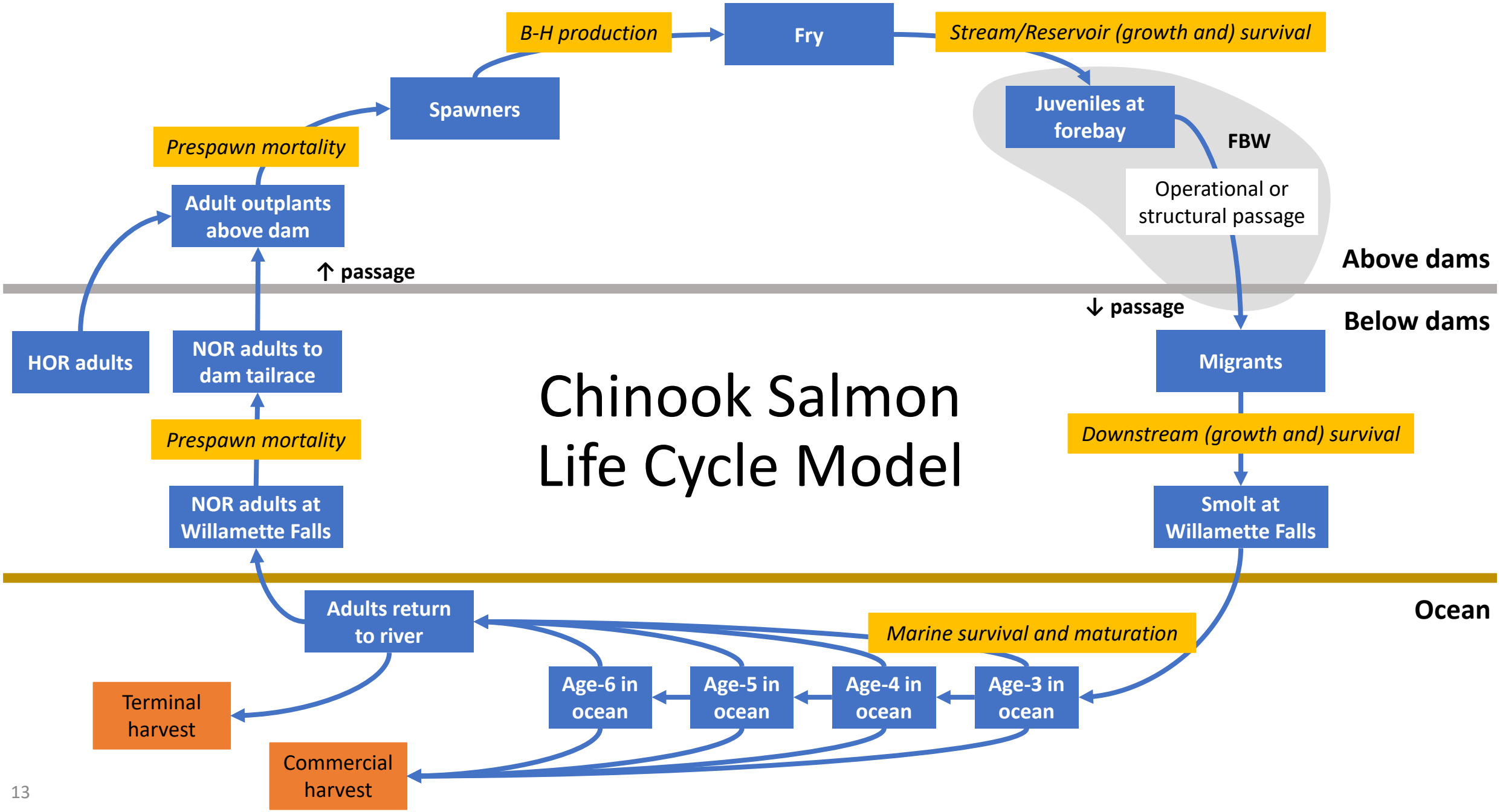




Factors affecting SAS

- Release length
- Month of release and passing SUJ
- Time spent at sea
- Release location
  - SAS higher when growth in reservoirs prior to smolting




B-H production
Fry
Stream/Reservoir (growth and) survival
Spawners
Juveniles at forebay
FBW
Operational or structural passage
Prespawn mortality
Adult outplants above dam
↑ passage
Above dams
↓ passage
Below dams
HOR adults
NOR adults to dam tailrace
Migrants
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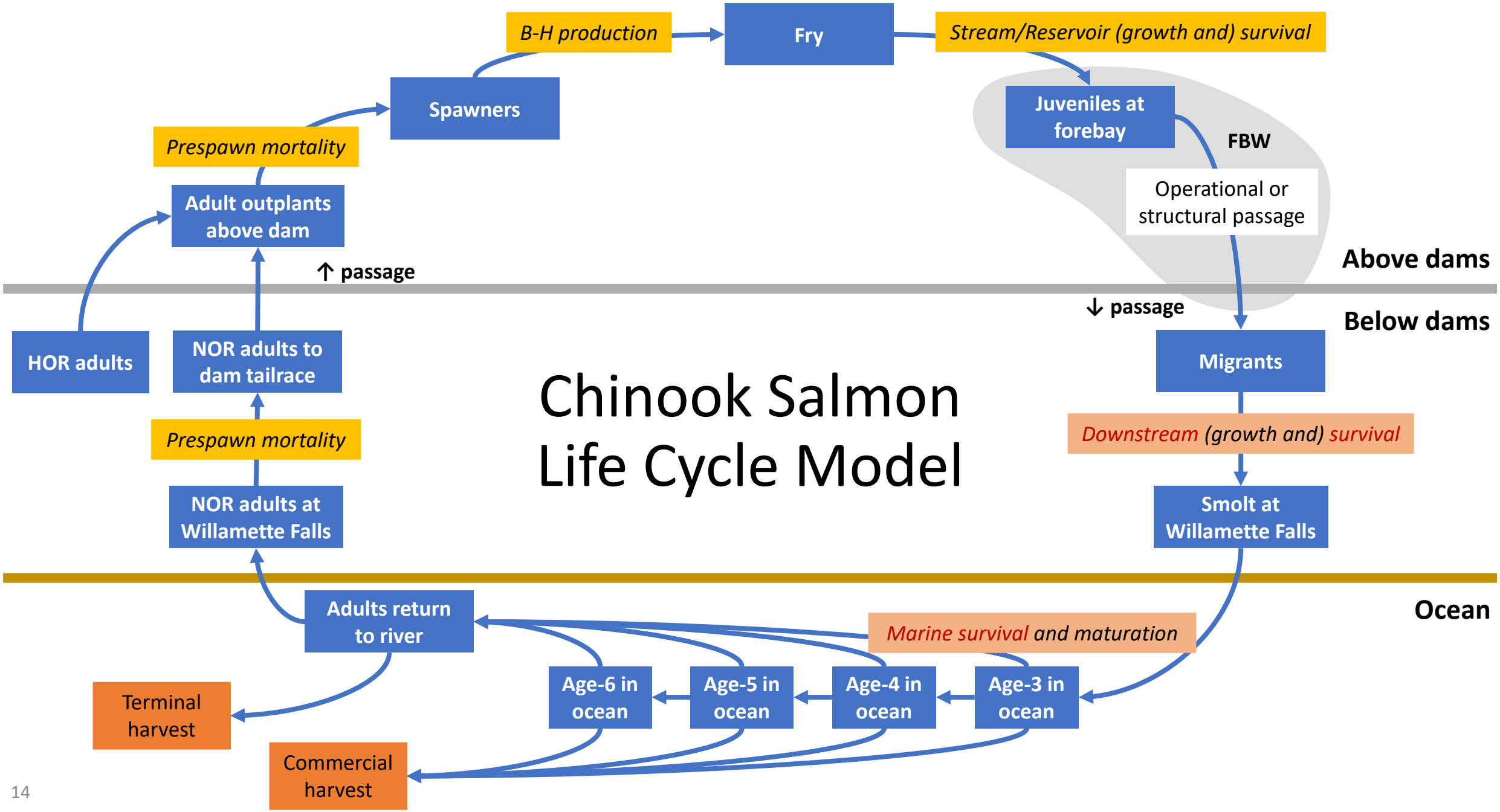
Adults return to river
Marine survival and maturation
Terminal harvest
Age-6 in ocean
Age-5 in ocean
Age-4 in ocean
Age-3 in ocean
Commercial harvest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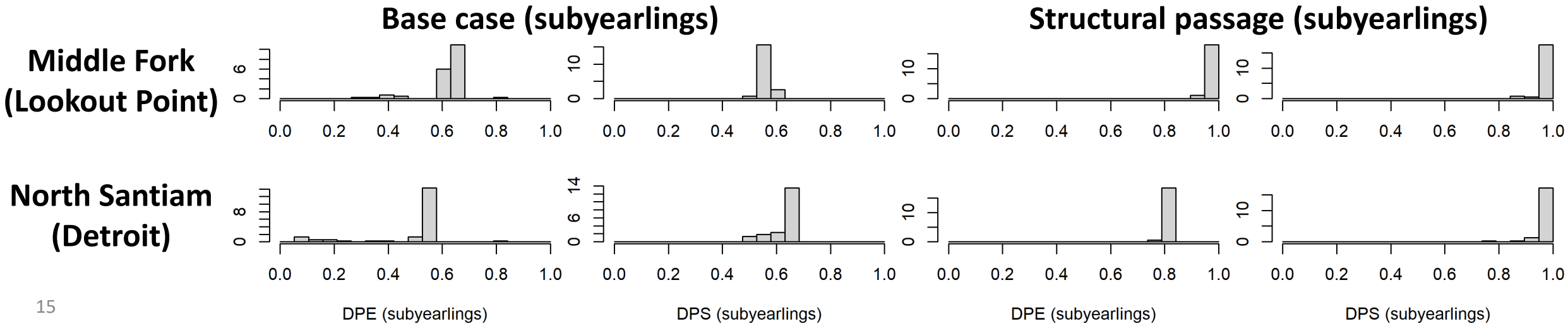
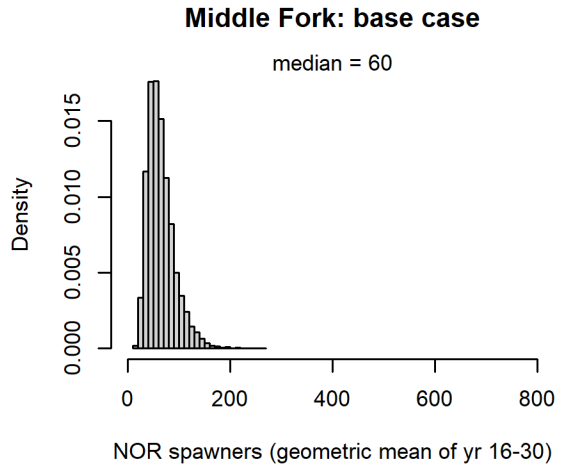
Implications for population recovery

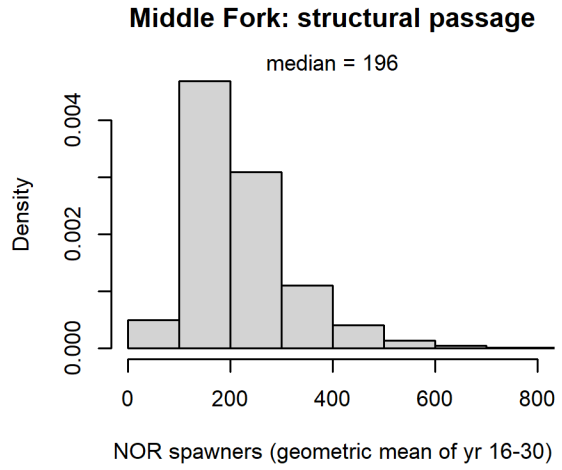
- Release-smolt survival and smolt-adult survival estimates from PIT tag analyses incorporated into UBC IPA models
- Natural-origin (NO) spawners above dams projected under dam passage options
- Dam Passage Efficiency (DPE) and Dam Passage Survival (DPS) for given passage options similar between dams so predicted differences in NO spawners due to differences in survival rates between sub-basins



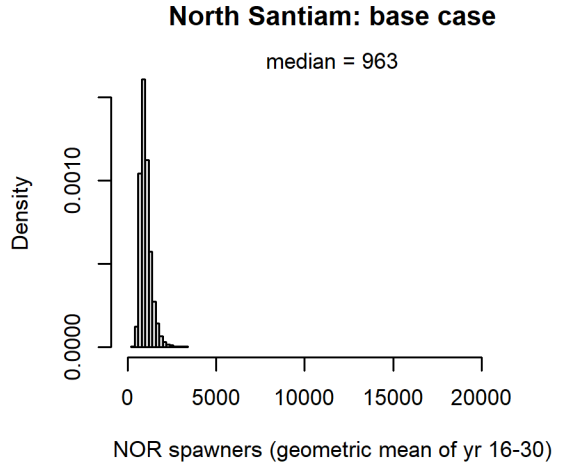
Implications for population recovery

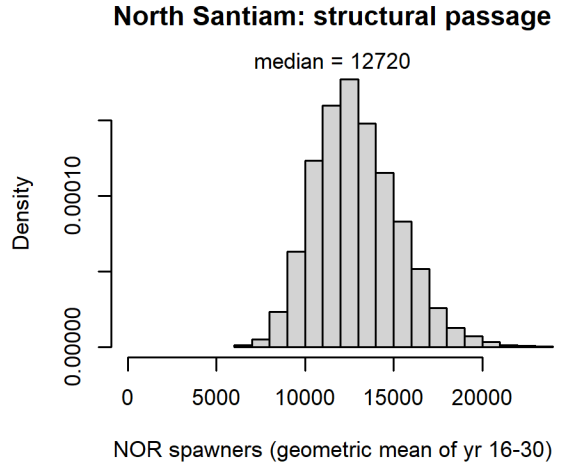
- Middle Fork
  - Compared to baseline, number of NO spawners only 3x higher under structural dam passage





- North Santiam/McKenzie
  - Compared to baseline, number of NO spawners above dams under structural dam passage over 10x higher





Conclusions

- Smolt-adult survival rate influenced potential for passage measures to result in population recovery
- Although dam passage measures can improve the status of Chinook salmon, marine survival remains an important factor in their population dynamics that is much more difficult to mitigate for
- Trade-off between marine survival and reservoir survival makes predicting effects of operational passage options difficult
- More Willamette tagging studies needed to understand changing marine survival over time and effect of size and timing of smolting
- Know little about marine survival of age-0 that smolt in spring, assumed to be very low
- Detection probability at SUJ is low and depends on flow, improvements to detection here would reduce uncertainty in RSS

Acknowledgements

- The Columbia Basin PIT Tag Information System (PTAGIS)
- Chinook Technical Committee and Pacific Salmon Commission
- Erin Rechisky (DFO, formerly at Kintama)
- USGS/ODFW/PNNL/Normandeau Associates for telemetry studies