US Army Corps of Engineers®
Portland District

WILLAMETTE VALLEY SYSTEM OPERATIONS AND MAINTENANCE

ENVIRONMENTAL IMPACT STATEMENT

APPENDIX E: FISH AND AQUATIC HABITAT ANALYSES

PART 3 – SUPPLEMENTAL WVS EIS FISH BENEFIT WORKBOOK (FBW) MODELING ASSUMPTIONS AND RESULTS

Supplemental WVS EIS Fish Benefit Workbook (FBW) Modeling Assumptions and Results

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Chapter 1

FBW Modeling Description

The fbwR R package was used for runs of two scenarios by Tom Porteus under contract with the University of British Columbia:

1) Interim Operations Measure (formerly NTOM) using RES-SIM hydrology data output provided by USACE (RES-SIM file 'FBW_Input_NTOM31MAR-0_03Apr2025_094632.xlsx'). FBW parameters same as used for the WVS EIS NAA (and Alt 3a, and 3b), included in Appendix E: FISH AND AQUATIC HABITAT ANALYSES CHAPTER 1. Run FBW for this new scenario for each dam/species/lifestage. Note: This scenario is labeled "NTOM" in this Appendix, but is actually a revised version of the Interim Operations Measure in the Willamette Valley System FEIS (USACE, 2025).

2) Alternative 6 using RES-SIM hydrology data output provided by USACE (RES-SIM file 'FBW_Input_LTM-------0_02Apr2025.xlsx'). Survival parameter to be set at 0.19 for fish passing through penstocks modified with cone valves or in-line orifices. The basis for this assumption is provided below. Other FBW parameters the same as WVS EIS Alternative 5 (which was the same as Alt 2b) and included in Appendix E: FISH AND AQUATIC HABITAT ANALYSES CHAPTER 1.

Both alternatives compared to NAA and used period of record 1947-2019 as applied in WVS EIS FBW Excel workbooks from Jan-22. There were no NAA runs for steelhead at Green Peter Dam as there would be no outplanting under this scenario; thus there are no Interim Operations Measure runs for steelhead at Green Peter Dam and comparisons of Alternative 6 runs are made to 0% survival.

Summary statistics by water year type used updated classification file 'WYtypes.csv' for NAA/NTOM/Alt6 provided by US Army Corps of Engineers. Note there are no ABUNDANT water year types in this period.

ASSUMPTIONS FOR FISH PASSAGE SURVIVAL THROUGH PENSTOCKS AS MODIFIED FOR ALTERNATIVE 6

Under Alternative 6, hydropower operations would cease at each hydropower dam, but the penstocks or intakes would be reconfigured to allow continued use of the outlet for releasing flows. The turbines dissipate the energy of the water discharged downstream and without them, an alternative method would be required to reduce this energy.

There are two feasible alternatives (with limitations) to conveying discharge through the existing penstock/powerhouse alignments (cone valves and in-line orifice) without turbines in place. Each of these approaches are discussed separately below.

1. Cone valves: New conduits would be connected to the penstocks to convey flow to a manifold of cone valves located on the tailrace deck. After passing through the cone valves water is discharged into the powerhouse tailrace. Energy is dissipated in the abrupt conversion of potential to kinetic energy at the release of flow through cone valve, resulting in a hollow cone shaped jet that is spread broadly over a large area in the tailrace. Figure 1 shows a standard cone valve and photos of the associated flow release. Figure 2 shows flow release from a hooded cone valve. Pertinent comparisons to turbine outflow include the following:
    a. A system of cone valves should be able to deliver an equivalent range of flows as turbines, unless there are space limitations on the tailrace deck or in the tailrace.
    b. Cone Valve systems were identified as potential alternatives for Detroit, Hills Creek, Green Peter and Lookout Point dams as the existing turbines do not provide any attraction flow support for adult fish facility ladder entrances. This avoids a potential issue where the turbulent flow from cone valves could attract fish away from the ladder entrances or repel them from the tailrace. Turbine discharge is ideal for adult fish facility ladder entrance attraction due to the relatively low velocity, high volume, and non-turbulent conditions. Cone valves generate high turbulence, false attraction, and would affect large areas of the tailrace; therefore, cone valves are not acceptable for flow releases adjacent to fish ladder entrances. While there are structural means to convert the cone valve discharge into outflow similar to a turbine outflow, this would require a significant structural extension into the tailrace and require large volumes of air.
    c. TDG from cone valve operations is likely higher than that of turbines, and equal to or lower than spillways or ROs. There may be a need for added TDG abatement such as downstream turbulence enhancers as in large rocks or low rock weirs in downstream river.

d. The cone valve discharges should be directed into the powerhouse tailrace channel instead of the stilling basin. This is done to provide a pass flow around the stilling basin (as the turbines currently do), so that the stilling basin can be more easily isolated for inspections or repairs. The cone valve energy dissipation structures will be a required adjunct to help contain the footprint of the flow within the powerhouse outlet channel.
e. To minimize the large area of spray around project infrastructure (particularly where subfreezing temperatures occur), hooded cone valves are preferred (Figure 2); these release flow to a reduced footprint in the form a hollow cylindrical jet.
    i. Hooded cone valves are likely to release a more concentrated energy into the tailrace likely driving TDG exceedances even higher than existing conditions; abatement strategies would be necessary.
f. Cone valves likely require less O&M than turbines. Most O&M would be attributed to the cone valves, and isolation valves to a lesser extent. Each cone valve will have a dedicated isolation valve upstream, so that failure of one cone valve does not shut down the entire system.

Figure 1-1 Standard Cone Valve with Conical Spray at Boulder Dam, Colorado.

Figure 1-2 Hooded Cone Valve Operations at Summersville Dam, West Virginia

2. In-line orifices: This reconfiguration system uses a series of in-line orifices (Figure 3) within the penstock or intake and a series of large-holed porosity plates in the draft tube to dissipate energy over a number of smaller steps. Energy is dissipated incrementally through each orifice and plate from forebay to tailrace. Pertinent comparisons to turbine outflow include the following:
    a. Flow through an in-line system will be substantially less than the flow capacity of a penstock. Facilities that are reconfigured using in-line orifices will be limited to minimum BiOp flows through each penstock/intake with about 5 - 15% upward variation per penstock depending on forebay head. Flow is adjusted with a large valve (see upper middle of Figure 3), but the valve has small effect given most energy is dissipated by the orifices. If too much energy dissipation is placed at the valve, then significant cavitation damage can be the result.
    b. TDG through an inline orifice system will be similar to turbines.
    c. Turbine discharge is ideal for attraction into the entrance ladder that feed the adult fish facilities due to the relatively low velocity and non-turbulent conditions. In-line orifices systems should deliver similar turbulence

conditions at the outlet thereby supporting the fish ladder entrance, albeit at lower flow rates. Under high river flow conditions (such as 5% daily exceedance flow),the minimum BiOp flow may be insufficient to complete with the higher spillway or RO outflows. However, most adult fish follow the shoreline (particularly under high events) and some fish may find refuge in the lower velocity flow path toward the fish ladder entrances.

d. Expect lower O&M than turbines, however access into an orifice system will likely be difficult if needed for inspection or maintenance. Holes are sized to avoid debris blockages as much as possible.

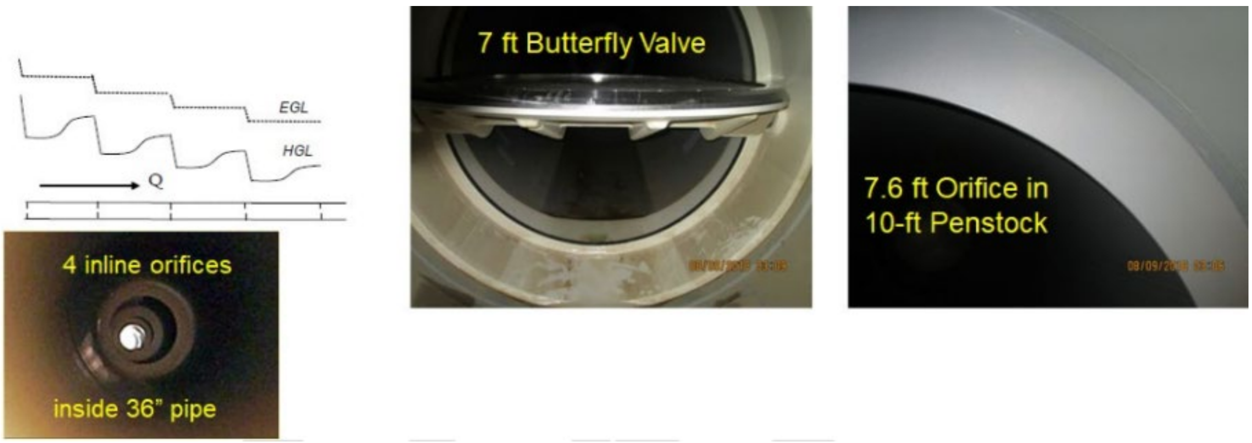

Figure 1-3 In-line Orifice Systems inside Pipelines (Seven Oaks Dam, lower left; The Dalles Dam, upper middle and right)

Fish Passage Survival Assumptions

Turbines

Estimates of turbine passage mortality for juvenile Chinook salmon and steelhead were previously summarized by Alden (2014) for application in the Fish Benefit Workbook (Tables 1-4). Updates to these estimates were then made where more recent information was available (USACE, 2025).

Cone Valves

High hydraulic head and increased water flow through dam outlets generally correlate with higher fish mortality (Fu et al. 2016). These factors can create severe hydraulic conditions, including rapid pressure changes, shear stress, turbulence, and direct impacts with turbine stay vanes, wicket gates and runner blades (Zhang and Jiang 2020). These conditions can cause injuries and mortality from barotrauma, shear trauma, and blunt trauma.

Limited information on fish survival specific to passage through cone valves was available for this analysis. Comparing cone valves to turbines, we generally assumed mortality rates would be lower. Pressure changes and fish strike probability was assumed to be higher for cone valves, and shear stress and turbulence similar, when compared to turbine passage.

A single study was found at the time of this analysis on fish survival through cone valves at Wickiup Dam, reporting an overall direct mortality of 81% (Symbiotics LLC, 2009 as referenced by Geosense 2011). They noted that dead fish showed signs of both collision and pressure induced injuries.

Due to conceptual nature of design and associated hydraulic conditions and variable operating conditions are WVS Dams, we applied the 81% mortality (19% survival) to all dams where cone valves were included under Alternative 6. Hydraulic head can be higher at WVS Dams (except Foster Dam) and valve sizes can vary, compared to Wickiup Dam (max hydraulic head of 79 feet and valve size 90 inches). Operating conditions also vary throughout the year and depend on annual hydrologic conditions. Therefore, fish passage mortality could be higher or lower at WVS Dams compared to Wickiup Dam, depending on the configuration of the dam and operating conditions. Designs have not been completed for installation of cone valves at WVS Dams. If site specific designs are completed in the future with an objective of minimizing effects to fish (i.e. reducing velocity changes, pressure changes, shear stress, strike risk and turbidity), mortality could be reduced.

Table 1-1. NAA (existing) FBW Turbine Survival Estimates of Juvenile Chinook salmon survival estimates used in FBW for Alternative 6 at projects with cone valves compared to estimates used for the NAA.

Project	**Fry**	**Subs**	**Yearlings**
Detroit	.6 @ 50cfs	.515 @ 50 cfs,	.515 @ 50 cfs,

	.6 @ 690cfs .622@1000cfs	.515 @ 690 cfs, .622 @ 1000 cfs	.515 @ 690 cfs, .622 @ 1000 cfs
Hills Creek	.64	.29	.29
Lookout Point	.60	.515	.515

Table 1-2. Penstock with Cone Valve Passage Survival Estimates of Juvenile Chinook salmon survival estimates used in FBW for Alternative 6 at projects with cone valves compared to estimates used for the NAA.

Project	**Fry**	**Subs**	**Yearlings**
Detroit	.19 all lifestages and flows	.19 all lifestages and flows	.19 all lifestages and flows
Hills Creek	.19 all lifestages and flows	.19 all lifestages and flows	.19 all lifestages and flows
Lookout Point	.19 all lifestages and flows	.19 all lifestages and flows	.19 all lifestages and flows

Table 1-3. Existing FBW Turbine Survival Estimates of Juvenile steelhead survival estimates used in FBW for Alternative 6 at projects with cone valves compared to estimates used for the NAA.

Project	**Subs**	**1-yr**	**2-yr**
Detroit	.64	.54	.52

Table 1-4. Penstock with Cone Valve Passage Survival Estimates of Juvenile steelhead survival estimates used in FBW for Alternative 6 at projects with cone valves compared to estimates used for the NAA.

Project	**Subs**	**1-yr**	**2-yr**
Detroit	.19 all lifestages and flows	.19 all lifestages and flows	.19 all lifestages and flows

In-line Orifice

Neither empirical or modeled estimates of fish survival through in-line orifices were available for this analysis. Pressure changes and strike probability were assumed higher compared to turbines, due to the presence of porosity plates and capacity of the orifices. Lacking other information, a survival rate of .19 was also applied, based on the reported estimate of 81% mortality for cone valve passage at Wickiup Dam.

Table 1-5. NAA (existing) FBW Turbine Survival Estimates of Juvenile Chinook salmon survival estimates used in FBW for Alternative 6 at projects with in-line orifices compared to estimates used for the NAA.

Project	**Fry**	**Subs**	**Yearlings**
Cougar	.63	.4 @ 50cfs, .3 @ 690cfs	.4 @ 50cfs, .3 @ 690cfs
Green Peter	.60	.52	.29
Foster	.75	.75	.5

Table 1-6. Penstock with In-line Orifice Passage Survival Estimates of Juvenile Chinook salmon survival estimates used in FBW for Alternative 6 at projects with in-line orifices compared to estimates used for the NAA.

Project	Fry	Subs	Yearlings
Cougar	.19 all lifestages and flows	.19 all lifestages and flows	.19 all lifestages and flows
Green Peter	.19 all lifestages and flows	.19 all lifestages and flows	.19 all lifestages and flows
Foster	.19 all lifestages and flows	.19 all lifestages and flows	.19 all lifestages and flows

Table 1-7. NAA (existing) FBW Turbine Survival Estimates of Juvenile steelhead survival estimates used in FBW for Alternative 6 at projects with in-line orifices compared to estimates used for the NAA.

Project	Subs	1-yr	2-yr
Green Peter	.64	.54	.52
Foster	.75	.75	.50

Table 1-8. Penstock with In-line Orifice Passage Survival Estimates of Juvenile steelhead survival estimates used in FBW for Alternative 6 at projects with in-line orifices compared to estimates used for the NAA.

Project	Subs	1-yr	2-yr
Green Peter	19 all lifestages and flows	19 all lifestages and flows	19 all lifestages and flows
Foster	19 all lifestages and flows	19 all lifestages and flows	19 all lifestages and flows

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Chapter 2 - FBW Results

North Santiam River Subbasin

Spring Chinook Salmon – Detroit Dam

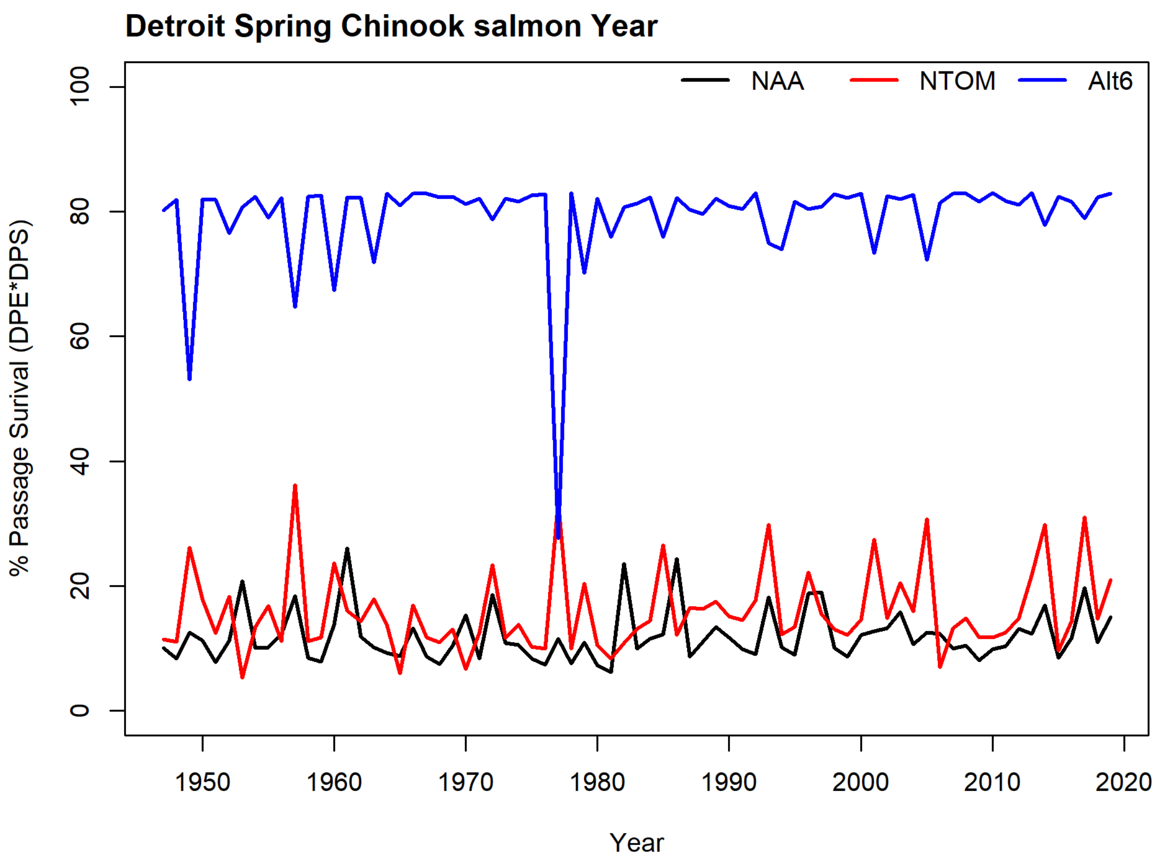

Figure 2-1 Detroit Juvenile Spring Chinook Yearling Downstream Passage Survival Under NAA, NTOM, and Alternative 6. Downstream dam passage survival at Detroit for juvenile Spring chinook yearlings under the NAA, NTOM, and Alternative 6 from the years 1948 to 2020.

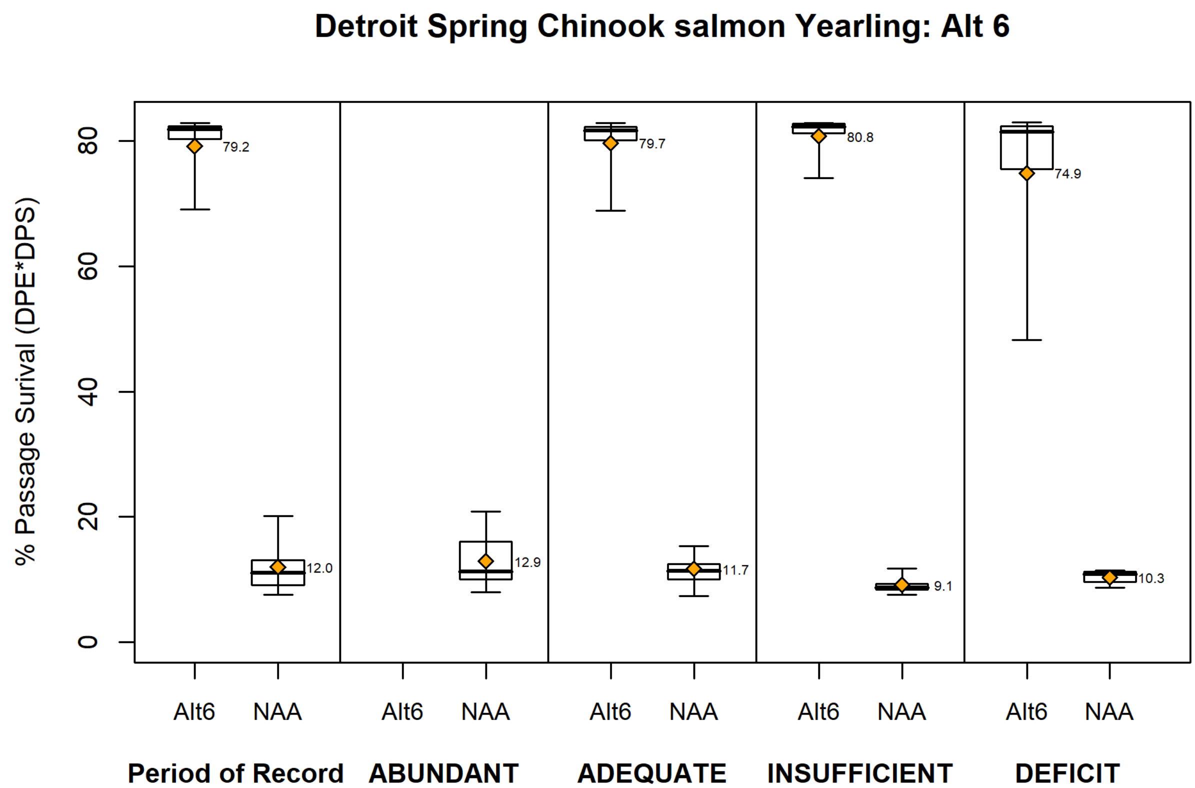

Figure 2-2 Detroit Juvenile Spring Chinook Yearling Downstream Passage Survival Under Alternative 6. Downstream dam passage survival at Detroit for juvenile Spring chinook yearlings under Alternative 6. The mean is given by the point estimate (filled dot). Survival probabilities are given for the period of record (far left), compared to abundant, adequate, insufficient, and deficit hydrologic year types denoted in each panel.

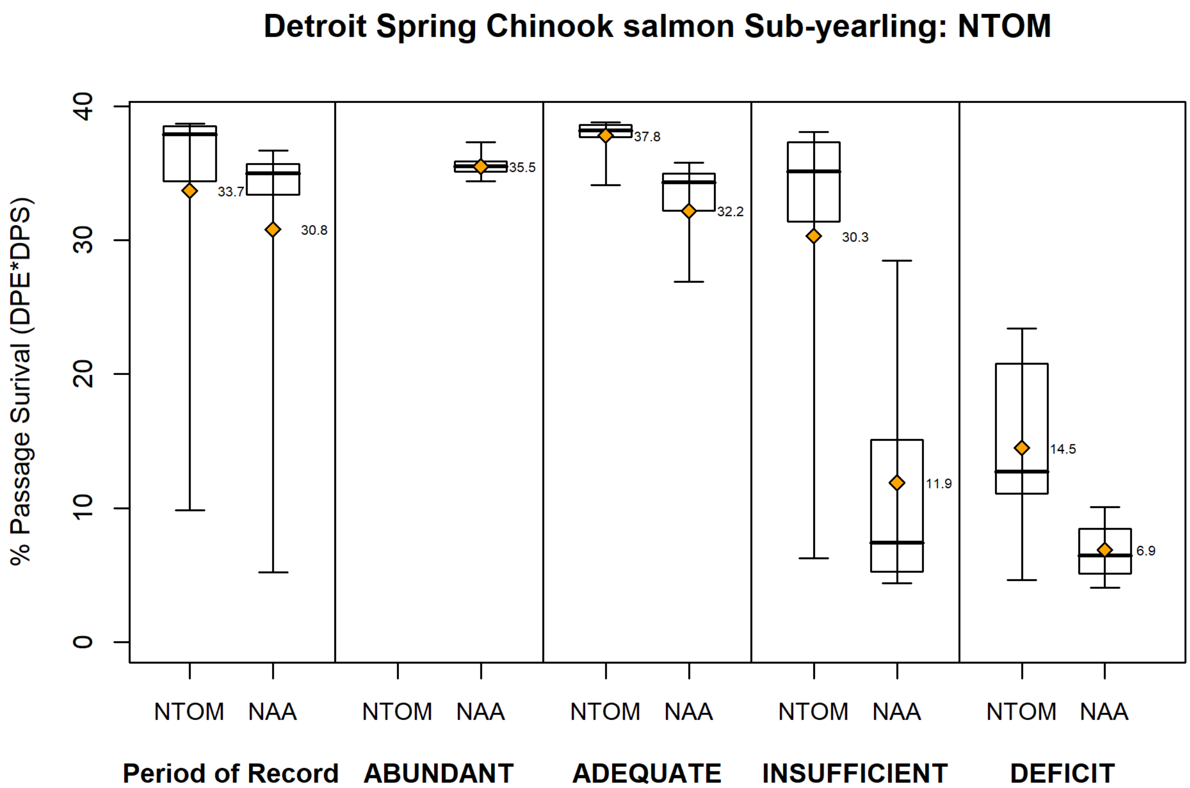

Figure 2-3 Detroit Juvenile Spring Chinook Sub-Yearling Downstream Passage Survival Under NTOM. Downstream dam passage survival at Detroit for juvenile Spring chinook sub-yearlings under NTOM. The mean is given by the point estimate (filled dot). Survival probabilities are given for the period of record (far left), compared to abundant, adequate, insufficient, and deficit hydrologic year types denoted in each panel.

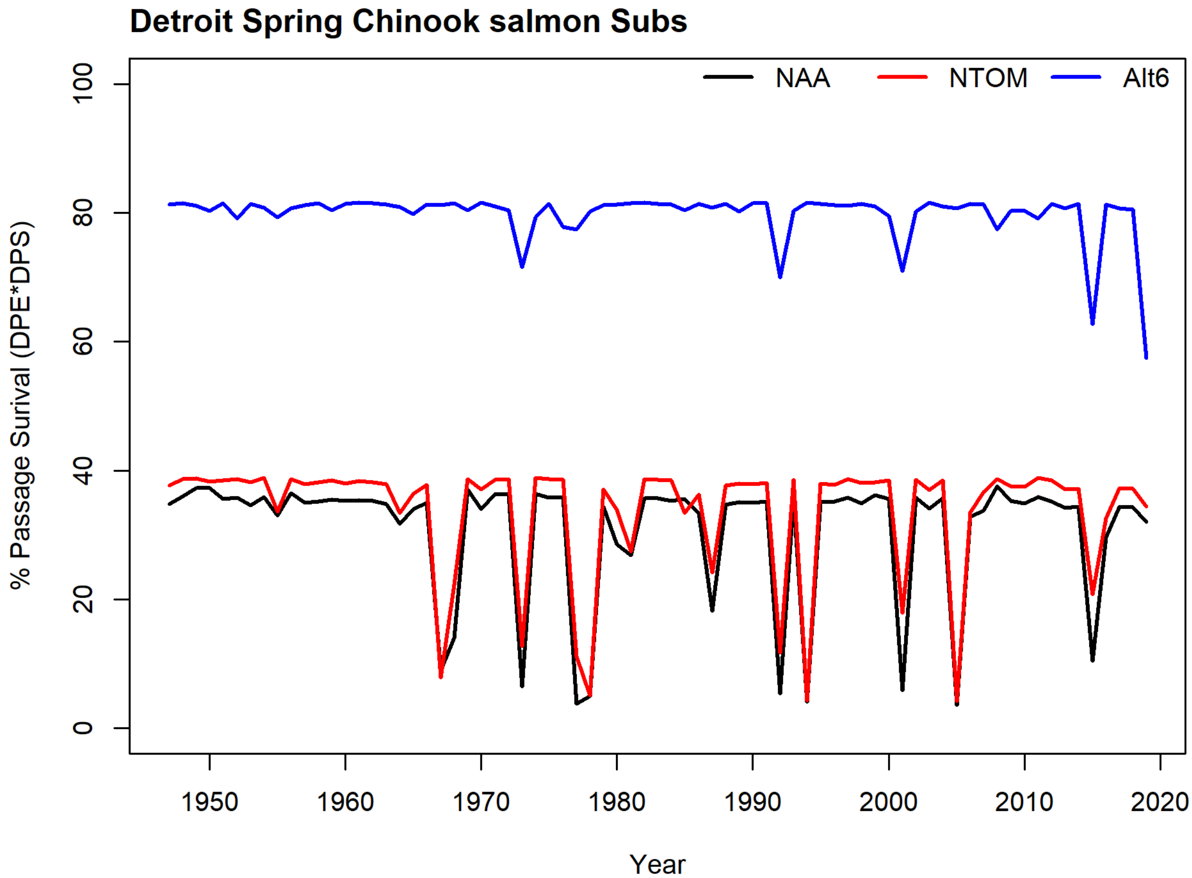

Figure 2-4 Detroit Juvenile Spring Chinook Sub-Yearling Downstream Passage Survival Under NAA, NTOM, and Alternative 6. Downstream dam passage survival at Detroit for juvenile Spring chinook sub-yearlings under the NAA, NTOM, and Alternative 6 from the years 1948 to 2020.

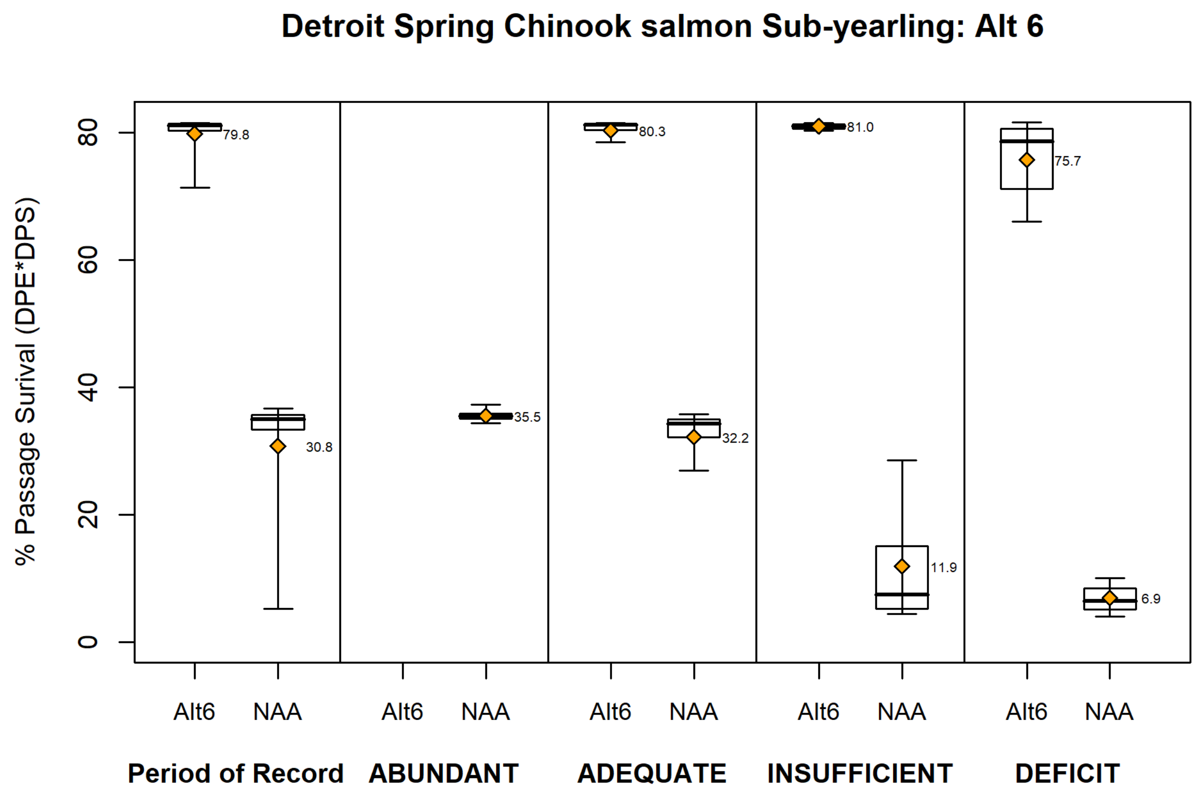

Figure 2-5 Detroit Juvenile Spring Chinook Sub-Yearling Downstream Passage Survival Under Alternative 6. Downstream dam passage survival at Detroit for juvenile Spring chinook sub-yearlings under Alternative 6. The mean is given by the point estimate (filled dot). Survival probabilities are given for the period of record (far left), compared to abundant, adequate, insufficient, and deficit hydrologic year types denoted in each panel.

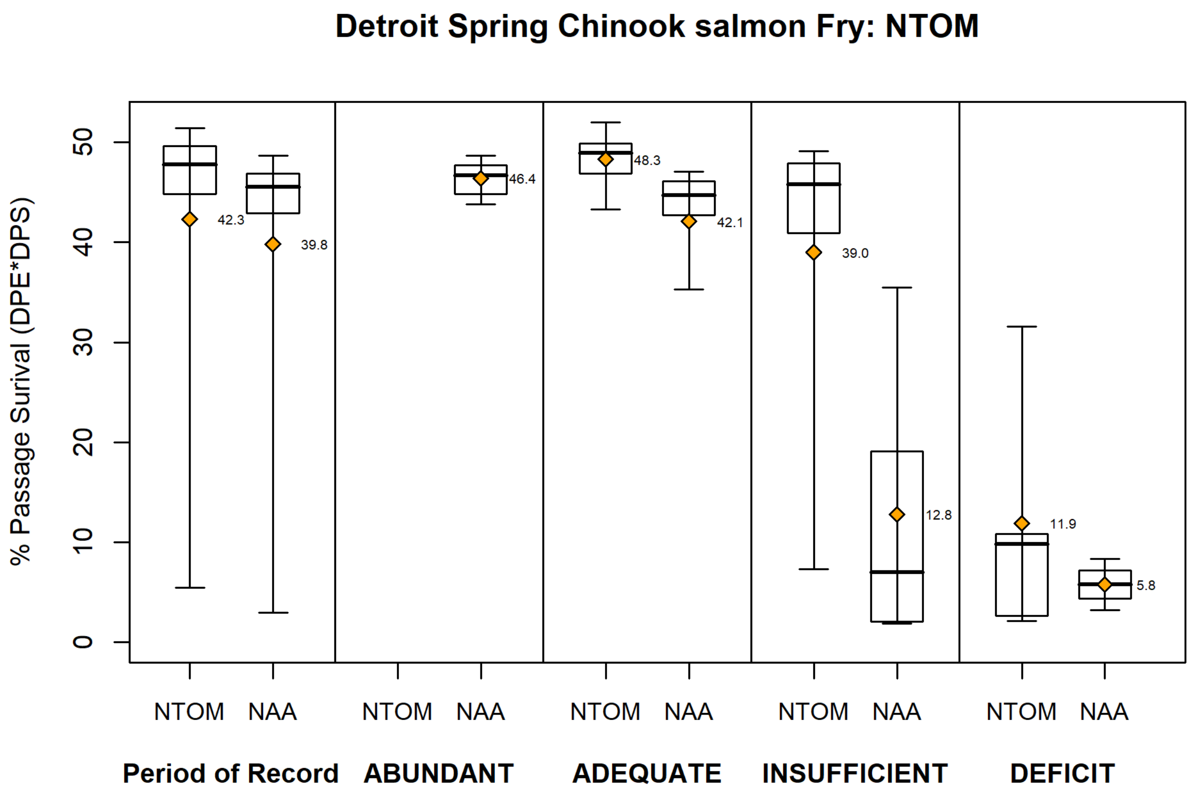

Figure 2-6 Detroit Juvenile Spring Chinook Fry Downstream Passage Survival Under NTOM. Downstream dam passage survival at Detroit for juvenile Spring chinook fry under NTOM. The mean is given by the point estimate (filled dot). Survival probabilities are given for the period of record (far left), compared to abundant, adequate, insufficient, and deficit hydrologic year types denoted in each panel.

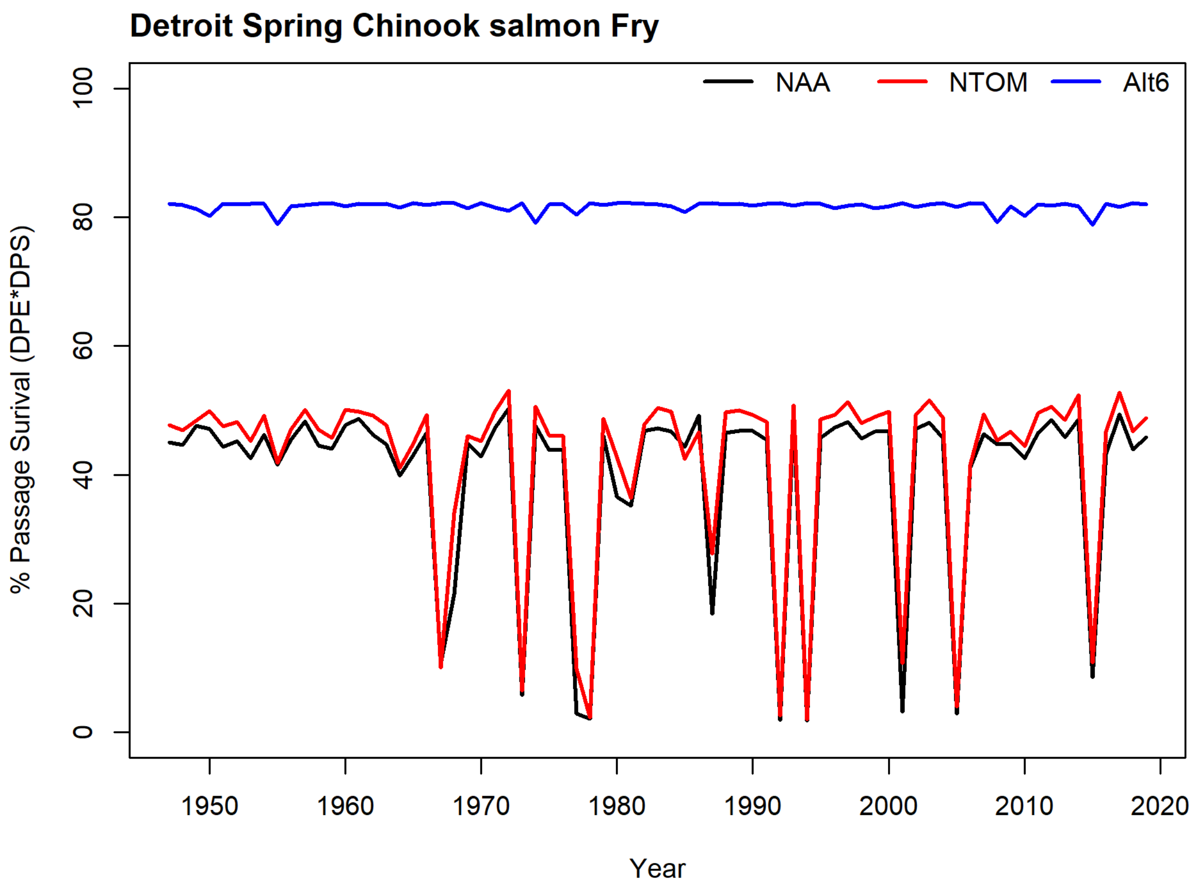

Figure 2-7 Detroit Juvenile Spring Chinook Fry Downstream Passage Survival Under NAA, NTOM, and Alternative 6. Downstream dam passage survival at Detroit for juvenile Spring chinook fry under the NAA, NTOM, and Alternative 6 from the years 1948 to 2020.

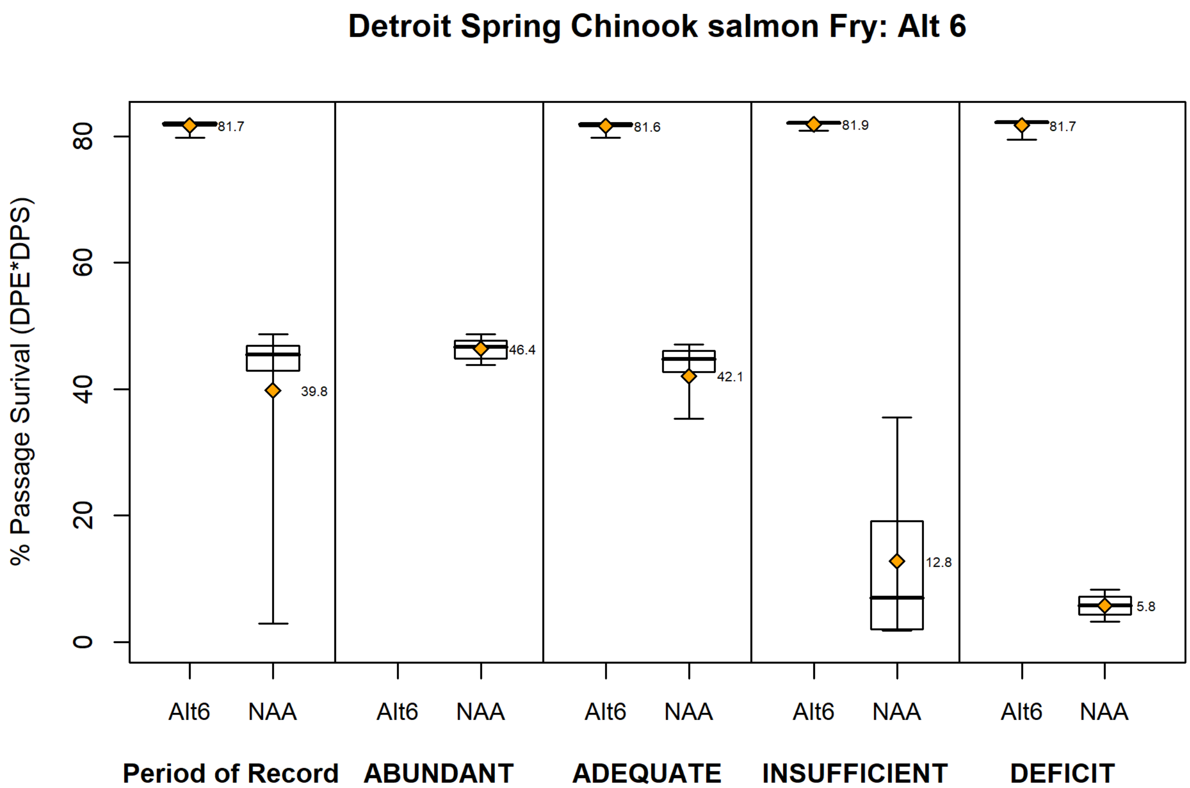

Figure 2-8 Detroit Juvenile Spring Chinook Fry Downstream Passage Survival Under Alternative 6. Downstream dam passage survival at Detroit for juvenile Spring chinook fry under Alternative 6. The mean is given by the point estimate (filled dot). Survival probabilities are given for the period of record (far left), compared to abundant, adequate, insufficient, and deficit hydrologic year types denoted in each panel.

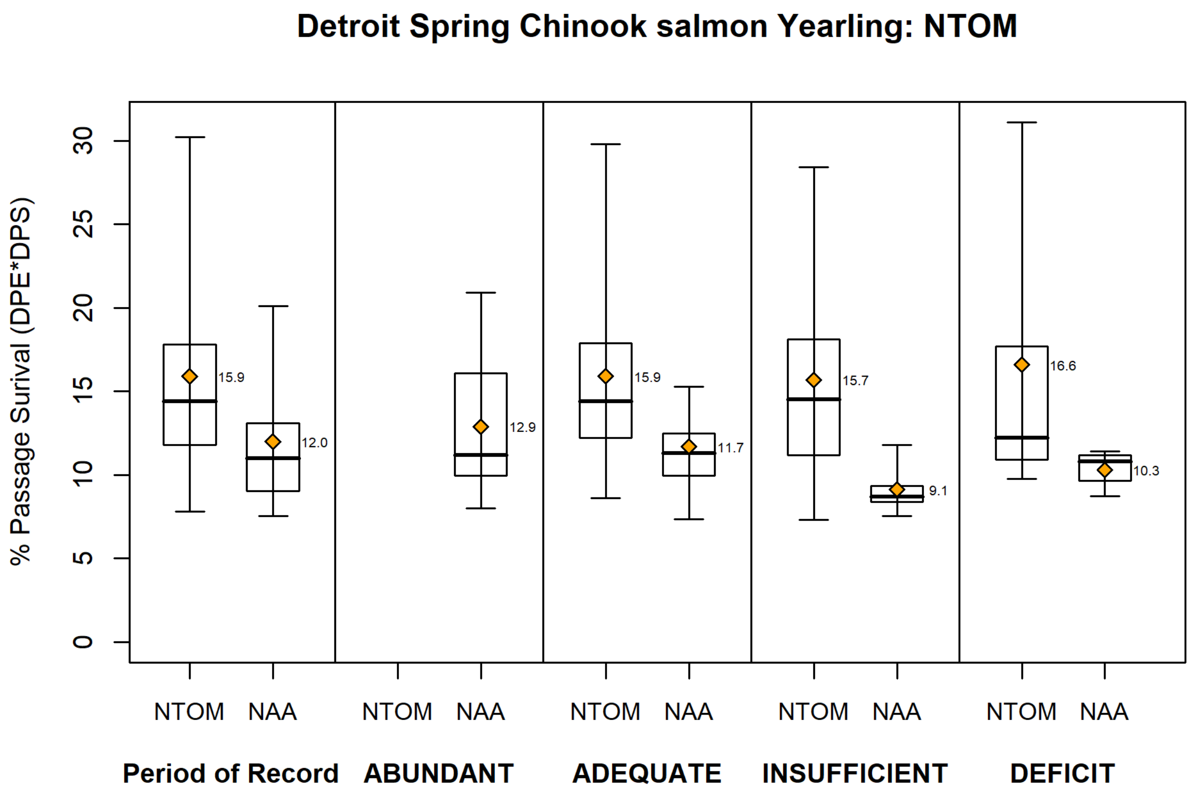

Figure 2-9 Detroit Juvenile Spring Chinook Yearling Downstream Passage Survival Under NTOM. Downstream dam passage survival at Detroit for juvenile Spring chinook yearlings under NTOM. The mean is given by the point estimate (filled dot). Survival probabilities are given for the period of record (far left), compared to abundant, adequate, insufficient, and deficit hydrologic year types denoted in each panel.

Winter Steelhead – Detroit Dam

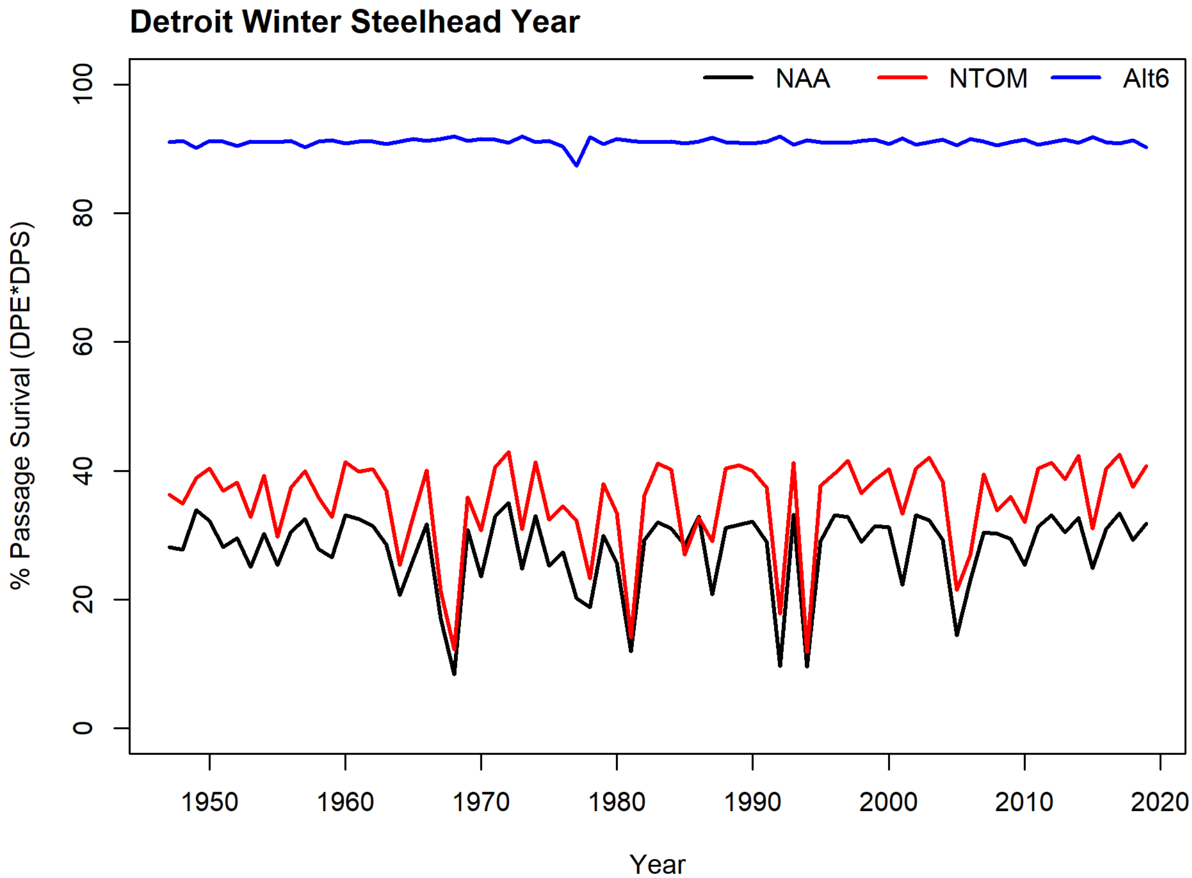

Figure 2-10 Detroit Juvenile Winter Steelhead Yearling Downstream Passage Survival Under NAA, NTOM, and Alternative 6. Downstream dam passage survival at Detroit for juvenile Winter steelhead yearlings under the NAA, NTOM, and Alternative 6 from the years 1948 to 2020.

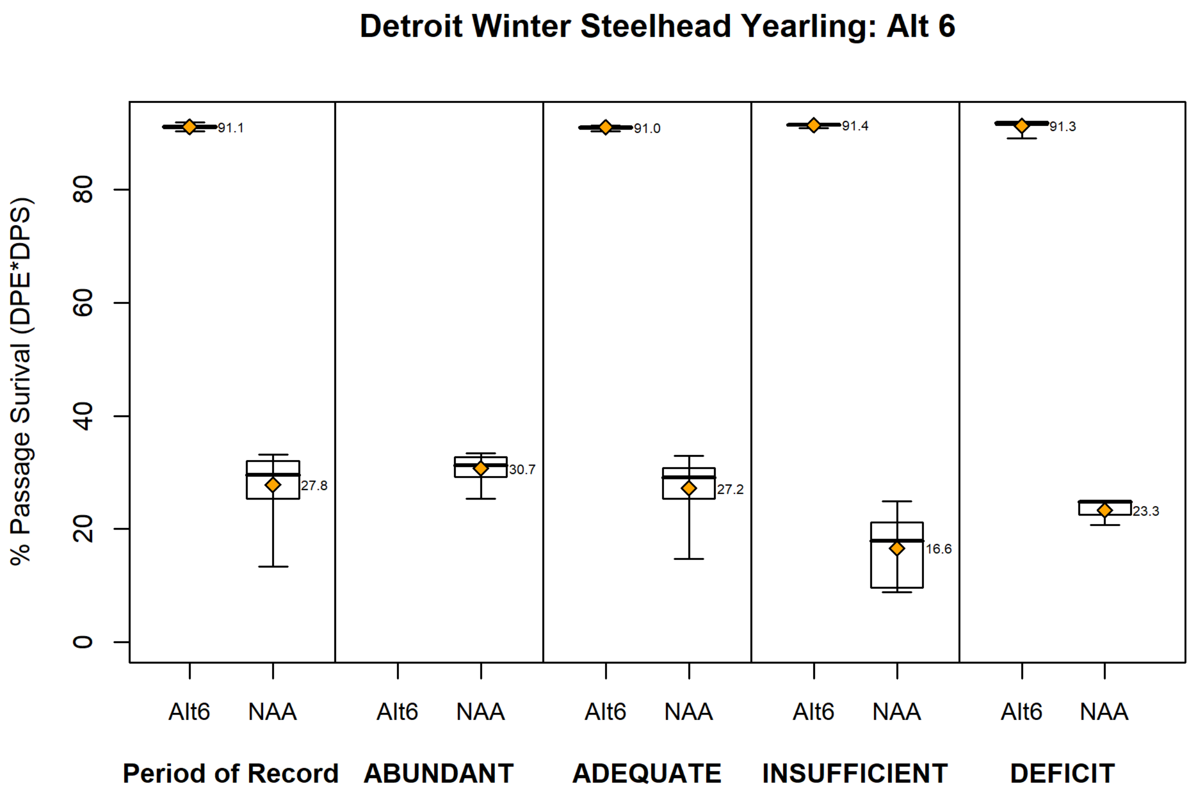

Figure 2-11 Detroit Juvenile Winter Steelhead Yearling Downstream Passage Survival Under Alternative 6. Downstream dam passage survival at Detroit for juvenile Winter steelhead yearlings under Alternative 6. The mean is given by the point estimate (filled dot). Survival probabilities are given for the period of record (far left), compared to abundant, adequate, insufficient, and deficit hydrologic year types denoted in each panel.

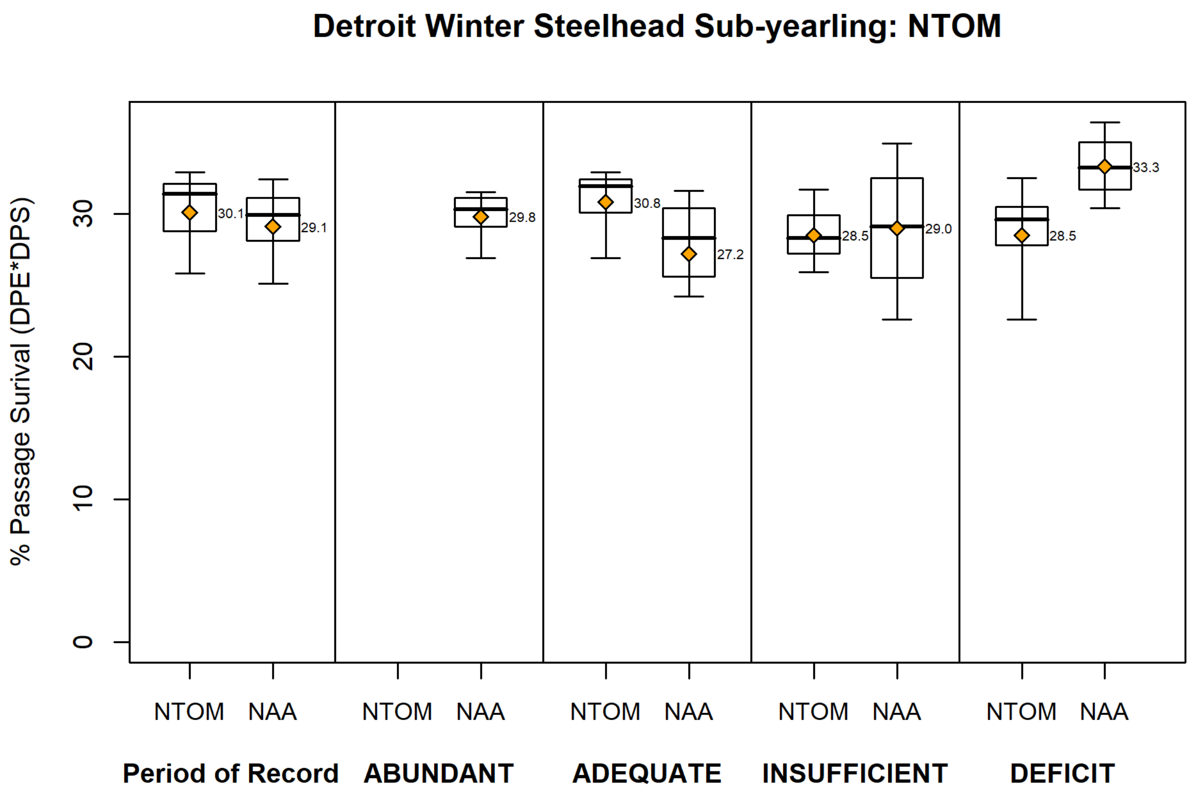

Figure 2-12 Detroit Juvenile Winter Steelhead Sub-Yearling Downstream Passage Survival Under NTOM. Downstream dam passage survival at Detroit for juvenile Winter steelhead sub-yearlings under NTOM. The mean is given by the point estimate (filled dot). Survival probabilities are given for the period of record (far left), compared to abundant, adequate, insufficient, and deficit hydrologic year types denoted in each panel.

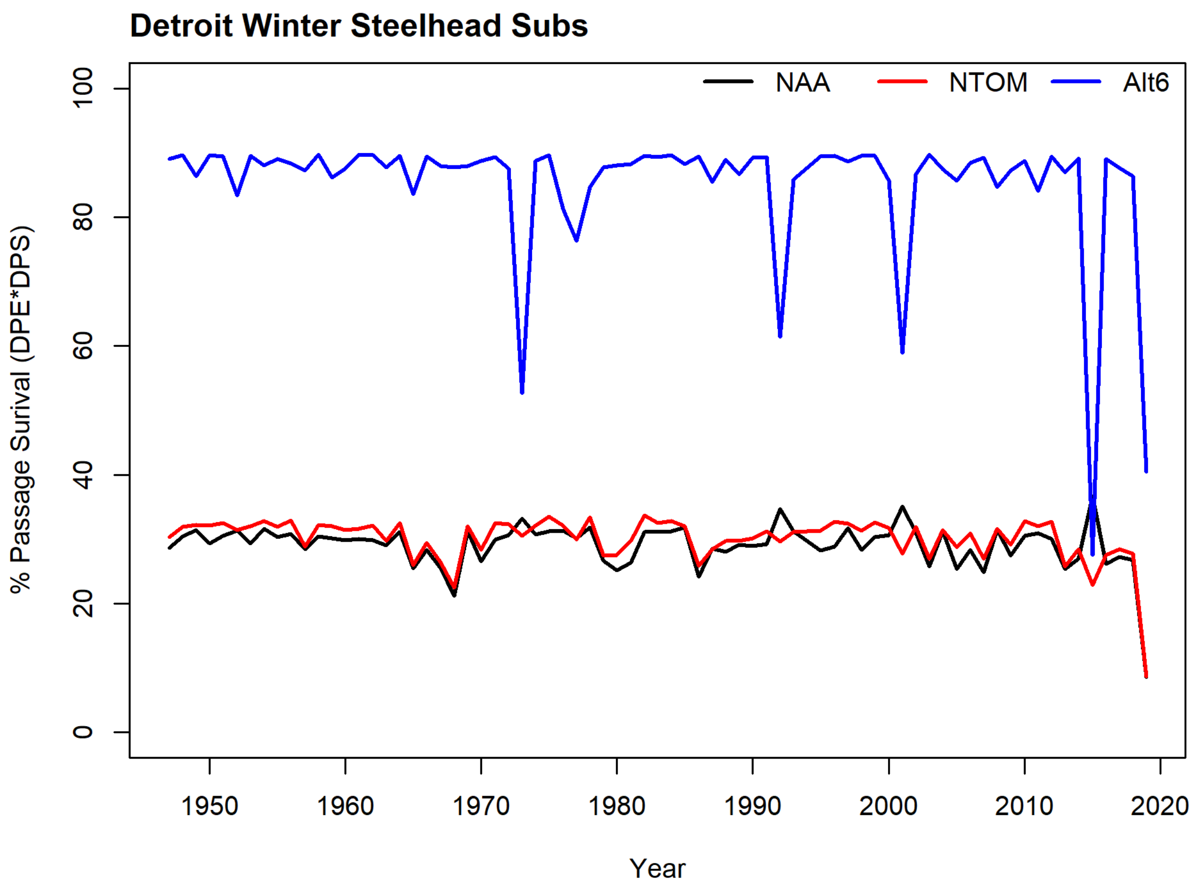

Figure 2-13 Detroit Juvenile Winter Steelhead Sub-Yearling Downstream Passage Survival Under NAA, NTOM, and Alternative 6. Downstream dam passage survival at Detroit for juvenile Winter steelhead sub-yearlings under the NAA, NTOM, and Alternative 6 from the years 1948 to 2020.

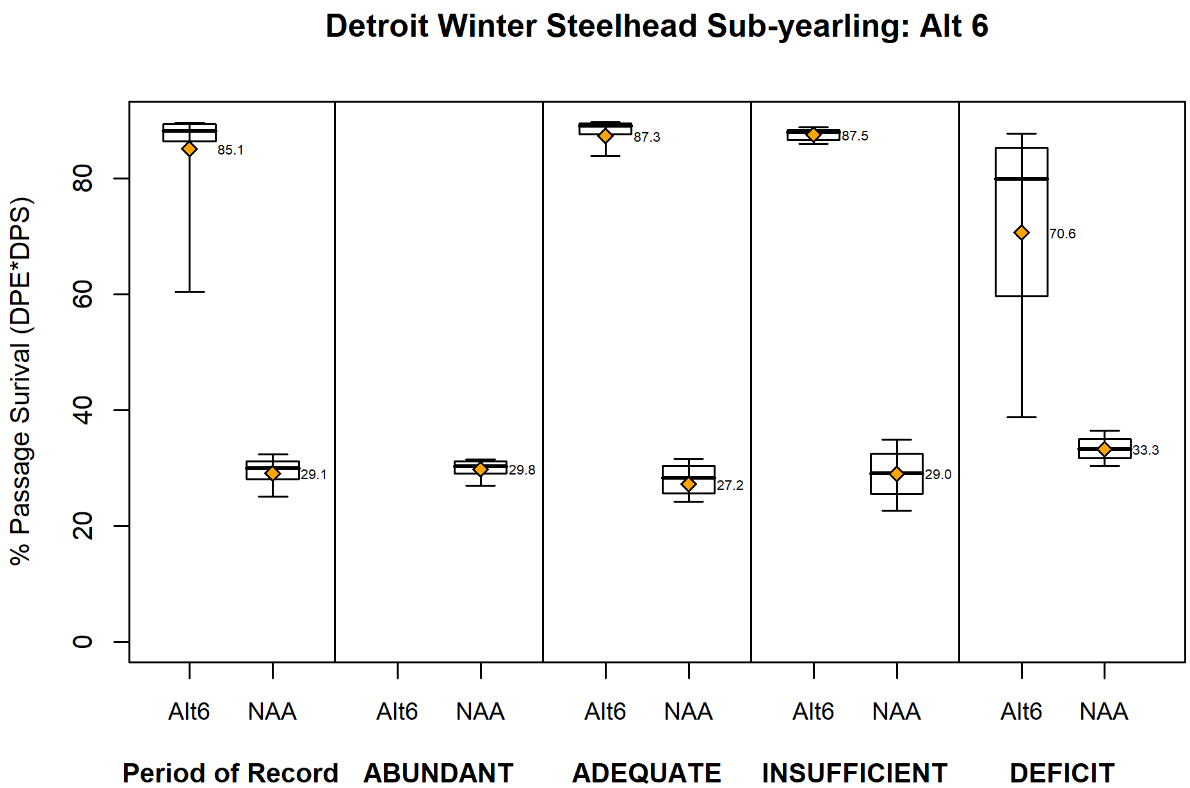

Figure 2-14 Detroit Juvenile Winter Steelhead Sub-Yearling Downstream Passage Survival Under Alternative 6. Downstream dam passage survival at Detroit for juvenile Winter steelhead sub-yearlings under Alternative 6. The mean is given by the point estimate (filled dot). Survival probabilities are given for the period of record (far left), compared to abundant, adequate, insufficient, and deficit hydrologic year types denoted in each panel.

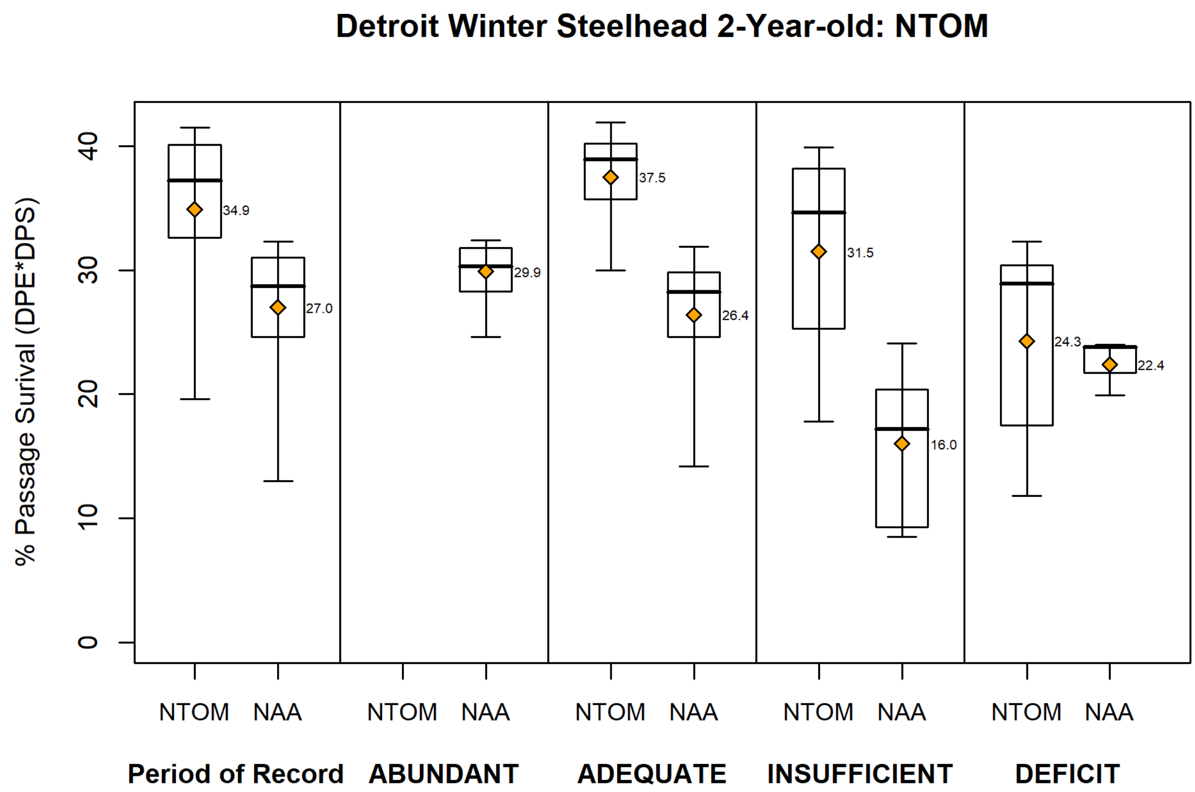

Figure 2-15 Detroit Juvenile Winter Steelhead 2-Year-Old Downstream Passage Survival Under NTOM. Downstream dam passage survival at Detroit for juvenile Winter steelhead 2-year-olds under NTOM. The mean is given by the point estimate (filled dot). Survival probabilities are given for the period of record (far left), compared to abundant, adequate, insufficient, and deficit hydrologic year types denoted in each panel.

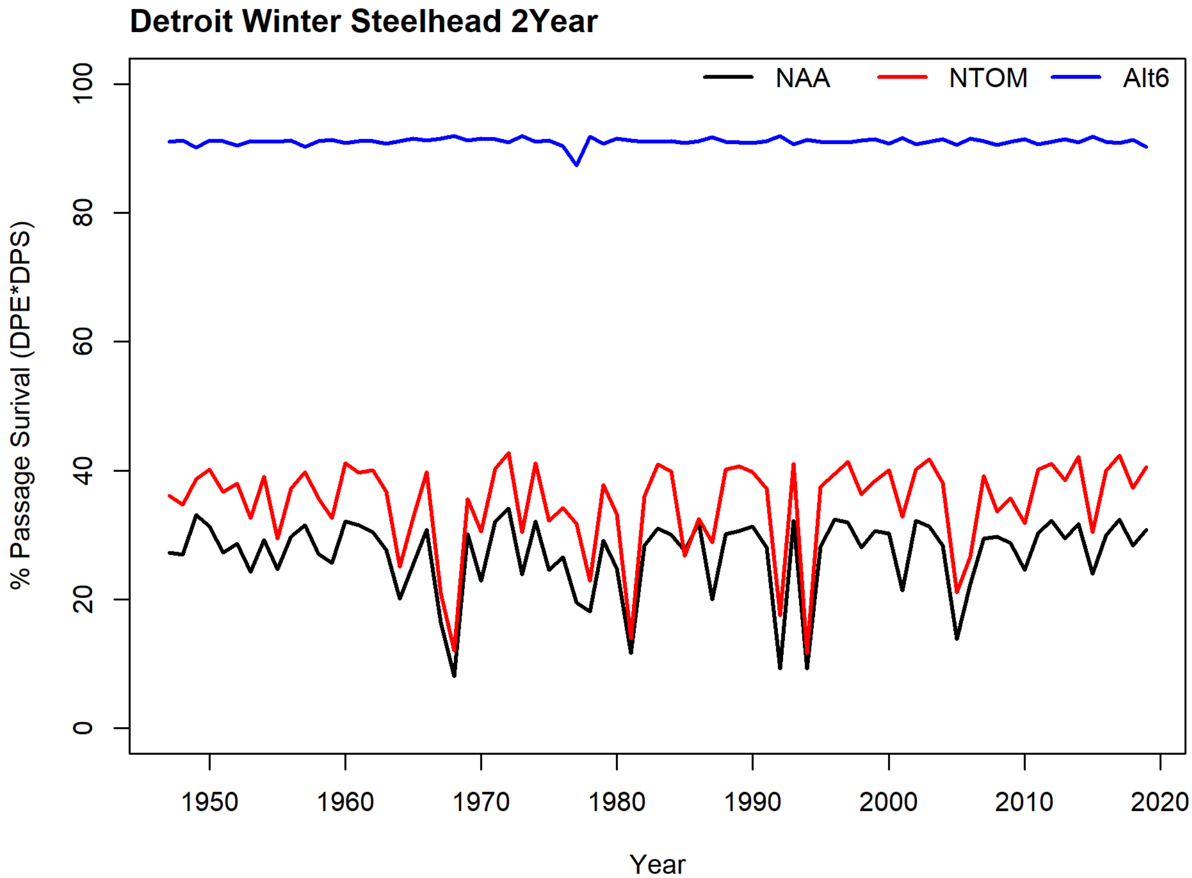

Figure 2-16 Detroit Juvenile Winter Steelhead 2-Year-Old Downstream Passage Survival Under NAA, NTOM, and Alternative 6. Downstream dam passage survival at Detroit for juvenile Winter steelhead 2-year-olds under the NAA, NTOM, and Alternative 6 from the years 1948 to 2020.

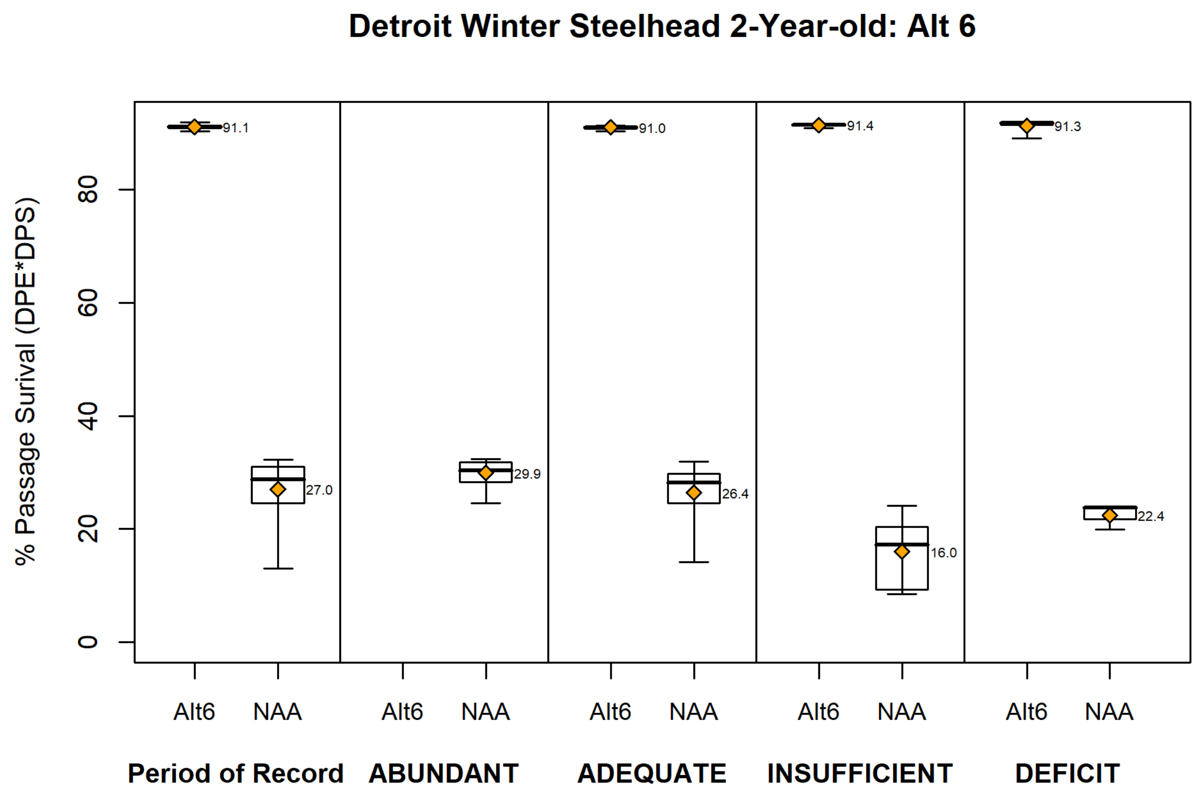

Figure 2-17 Detroit Juvenile Winter Steelhead 2-Year-Old Downstream Passage Survival Under Alternative 6. Downstream dam passage survival at Detroit for juvenile Winter steelhead 2-year-olds under Alternative 6. The mean is given by the point estimate (filled dot). Survival probabilities are given for the period of record (far left), compared to abundant, adequate, insufficient, and deficit hydrologic year types denoted in each panel.

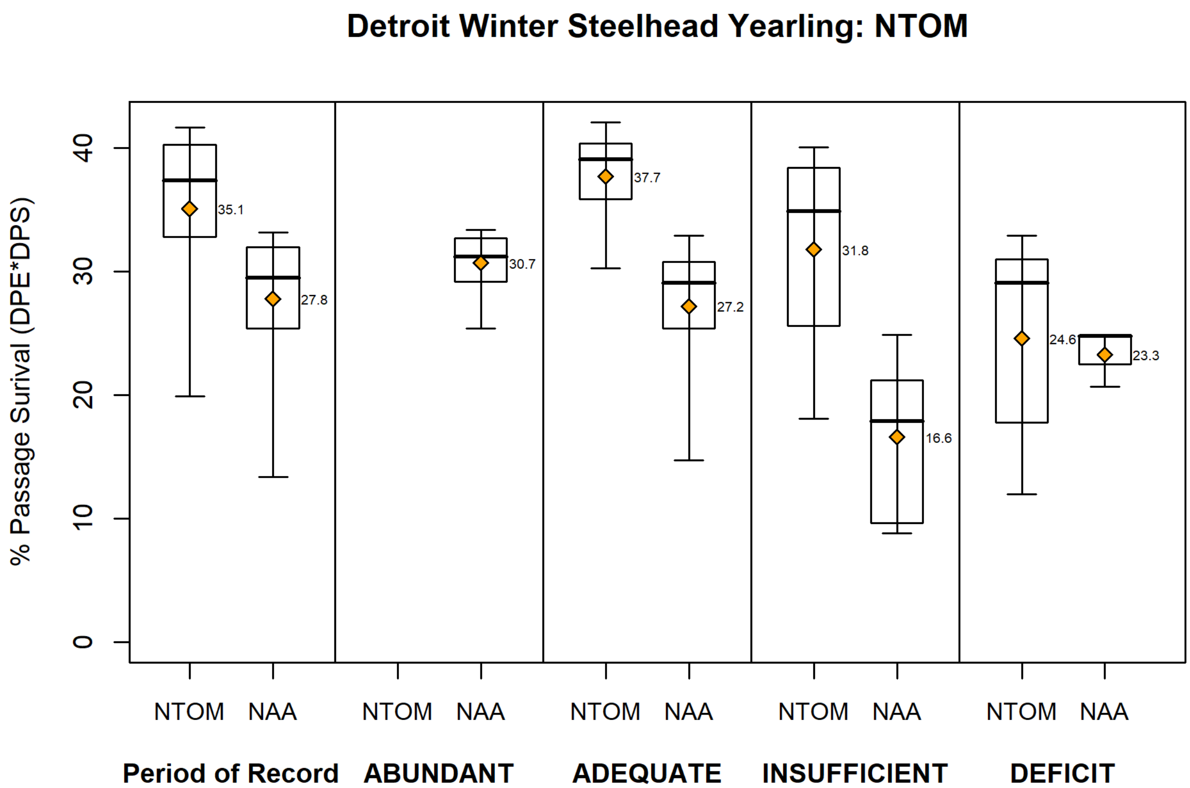

Figure 2-18 Detroit Juvenile Winter Steelhead Yearling Downstream Passage Survival Under NTOM. Downstream dam passage survival at Detroit for juvenile Winter steelhead yearlings under NTOM. The mean is given by the point estimate (filled dot). Survival probabilities are given for the period of record (far left), compared to abundant, adequate, insufficient, and deficit hydrologic year types denoted in each panel.

South Santiam Subbasin

Spring Chinook Salmon – Green Peter Dam

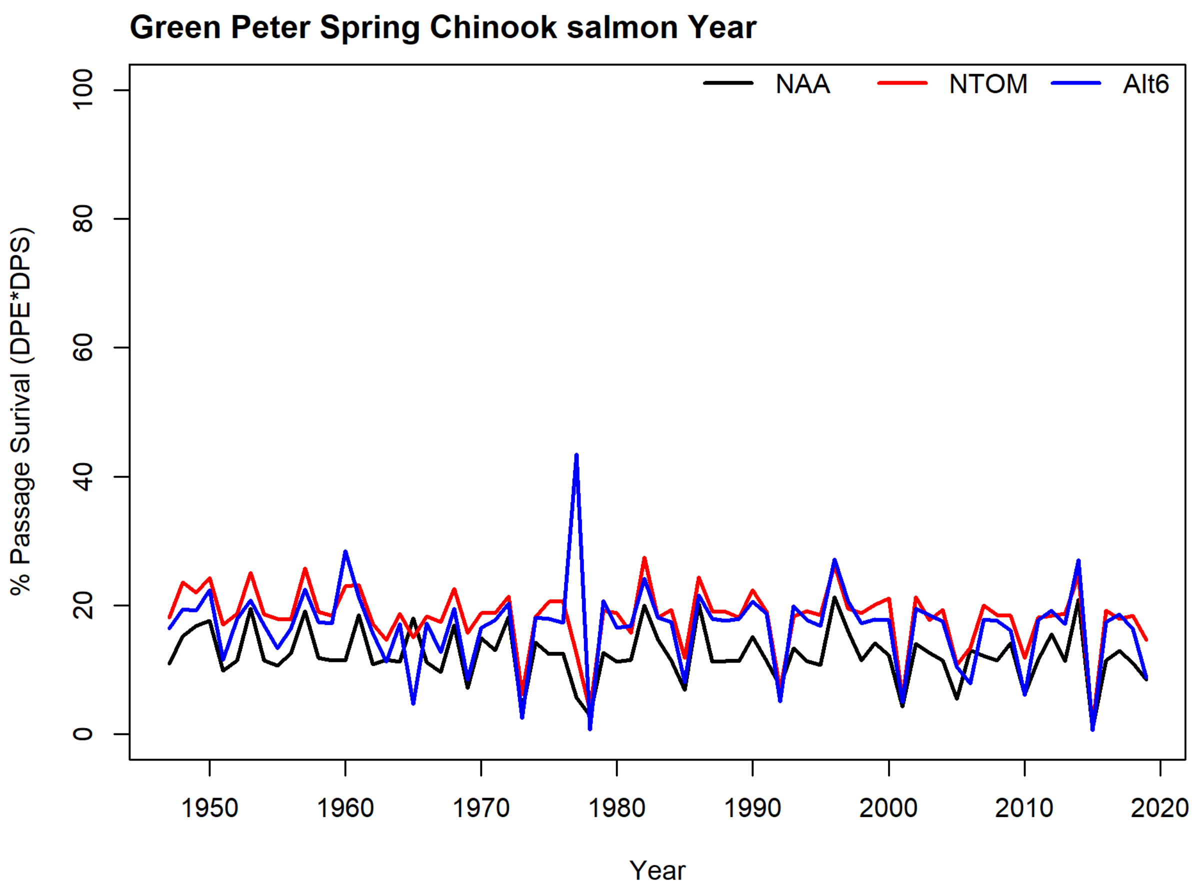

Figure 2-19 Green Peter Juvenile Spring Chinook Yearling Downstream Passage Survival Under NAA, NTOM, and Alternative 6. Downstream dam passage survival at Green Peter for juvenile Spring Chinook yearlings under the NAA, NTOM, and Alternative 6 from the years 1948 to 2020.

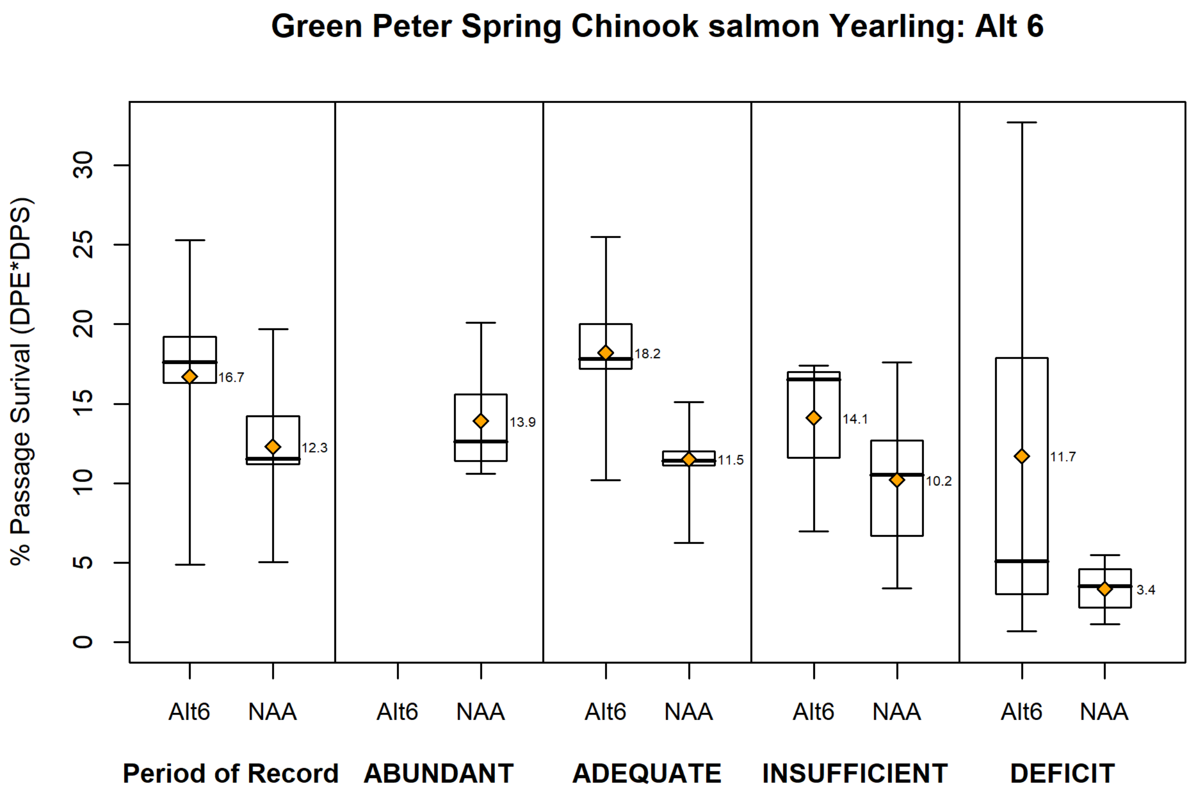

Figure 2-20 Green Peter Juvenile Spring Chinook Yearling Downstream Passage Survival Under Alternative 6. Downstream dam passage survival at Green Peter for juvenile Spring chinook yearlings under Alternative 6. The mean is given by the point estimate (filled dot). Survival probabilities are given for the period of record (far left), compared to abundant, adequate, insufficient, and deficit hydrologic year types denoted in each panel.

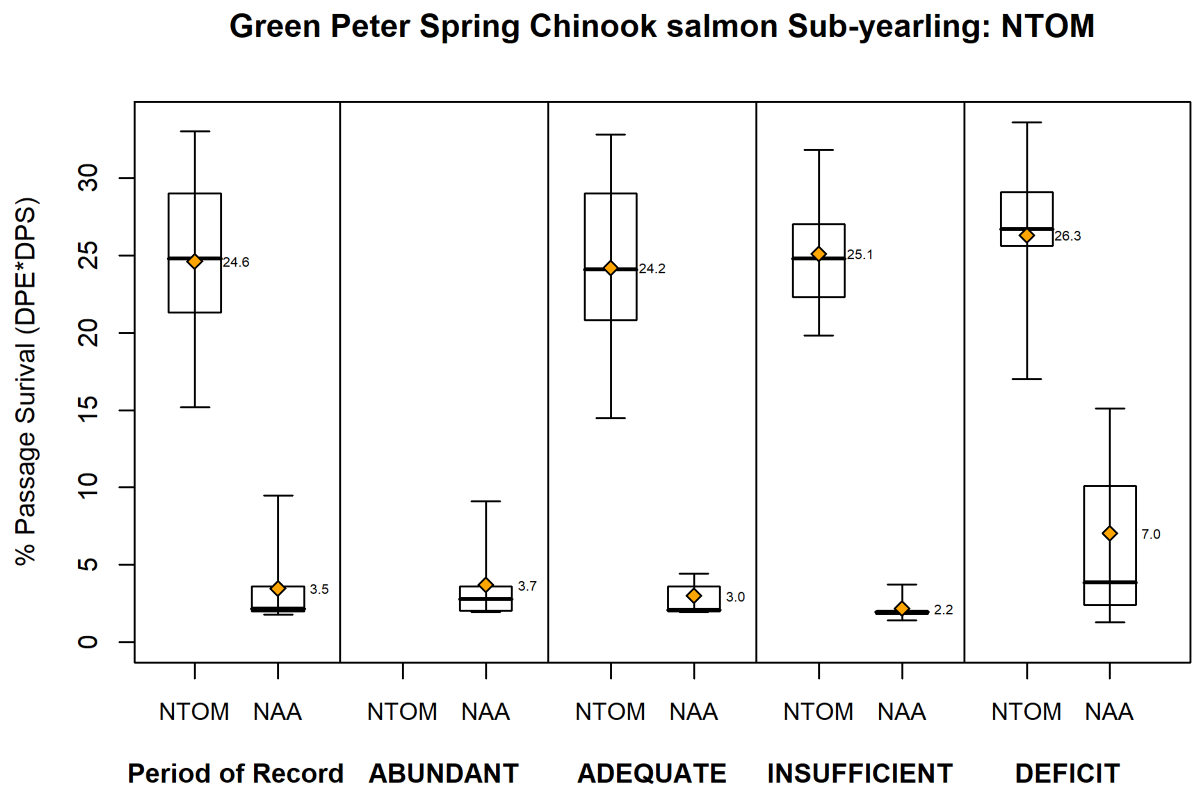

Figure 2-21 Green Peter Juvenile Spring Chinook Sub-Yearling Downstream Passage Survival Under NTOM. Downstream dam passage survival at Green Peter for juvenile Spring chinook sub-yearlings under NTOM. The mean is given by the point estimate (filled dot). Survival probabilities are given for the period of record (far left), compared to abundant, adequate, insufficient, and deficit hydrologic year types denoted in each panel.

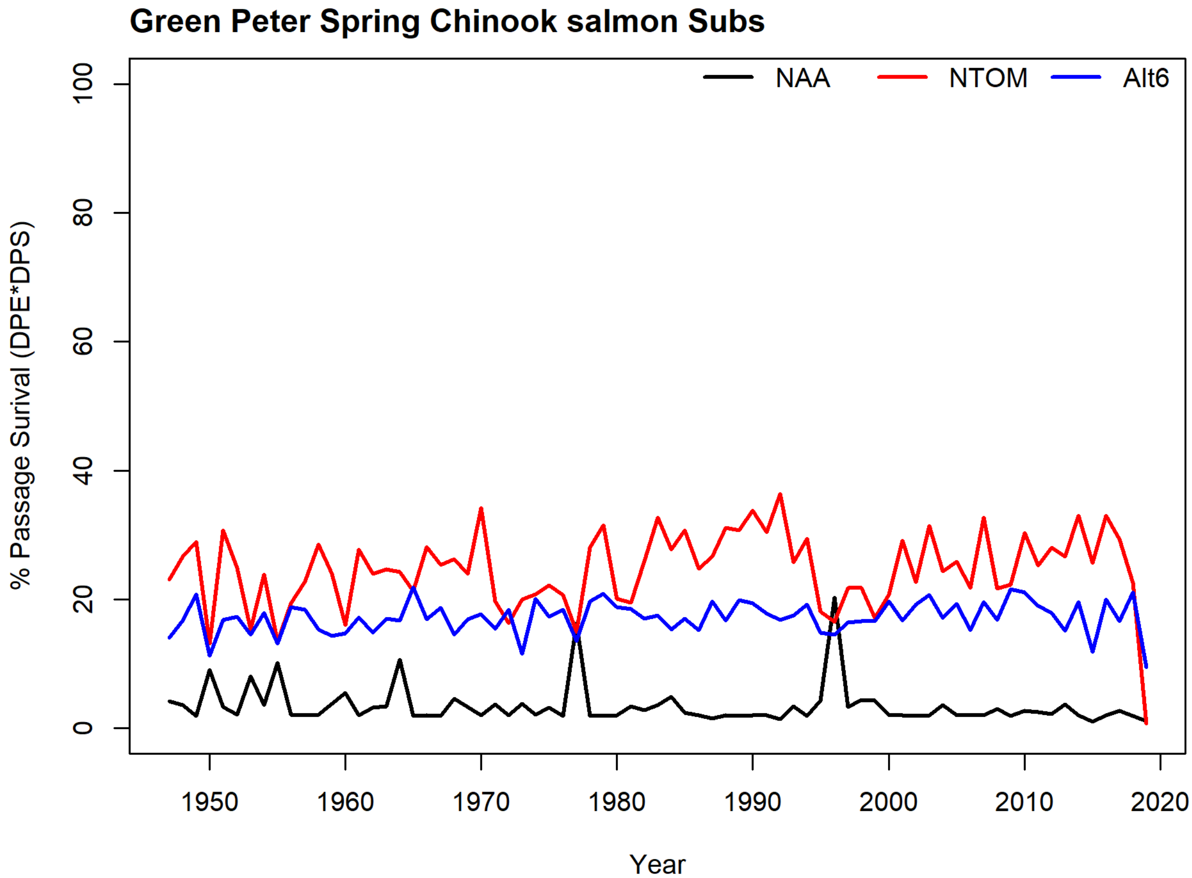

Figure 2-22 Green Peter Juvenile Spring Chinook Sub-Yearling Downstream Passage Survival Under NAA, NTOM, and Alternative 6. Downstream dam passage survival at Green Peter for juvenile Spring chinook sub-yearlings under the NAA, NTOM, and Alternative 6 from the years 1950 to 2020.

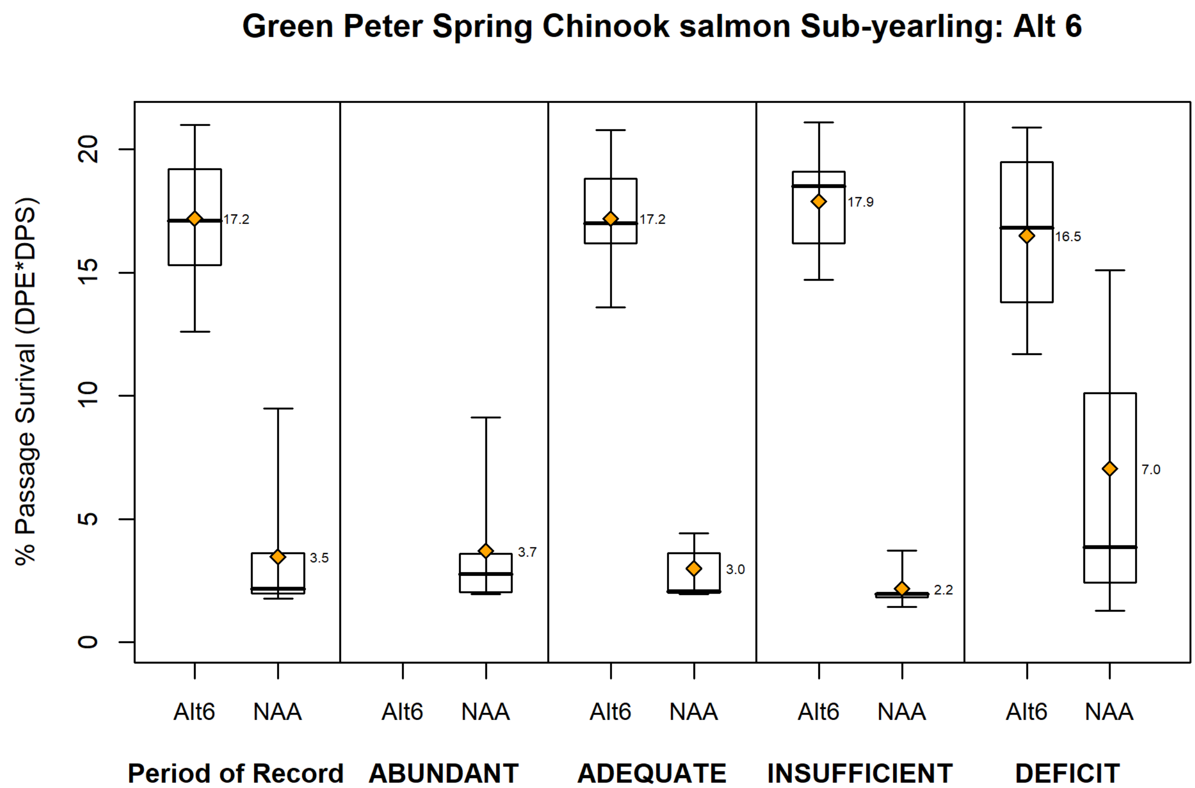

Figure 2-23 Green Peter Juvenile Spring Chinook Sub-Yearling Downstream Passage Survival Under Alternative 6. Downstream dam passage survival at Green Peter for juvenile Spring chinook sub-yearlings under Alternative 6. The mean is given by the point estimate (filled dot). Survival probabilities are given for the period of record (far left), compared to abundant, adequate, insufficient, and deficit hydrologic year types denoted in each panel.

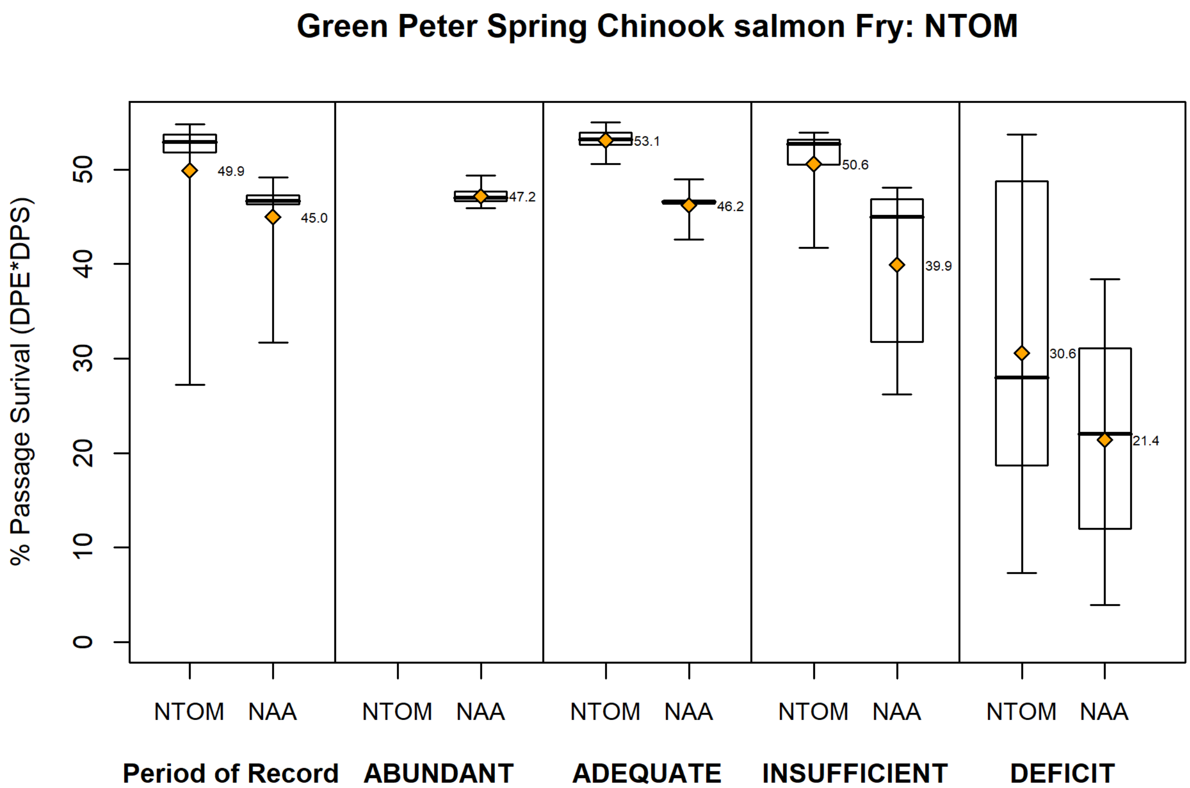

Figure 2-24 Green Peter Juvenile Spring Chinook Fry Downstream Passage Survival Under NTOM. Downstream dam passage survival at Green Peter for juvenile Spring chinook fry under NTOM. The mean is given by the point estimate (filled dot). Survival probabilities are given for the period of record (far left), compared to abundant, adequate, insufficient, and deficit hydrologic year types denoted in each panel.

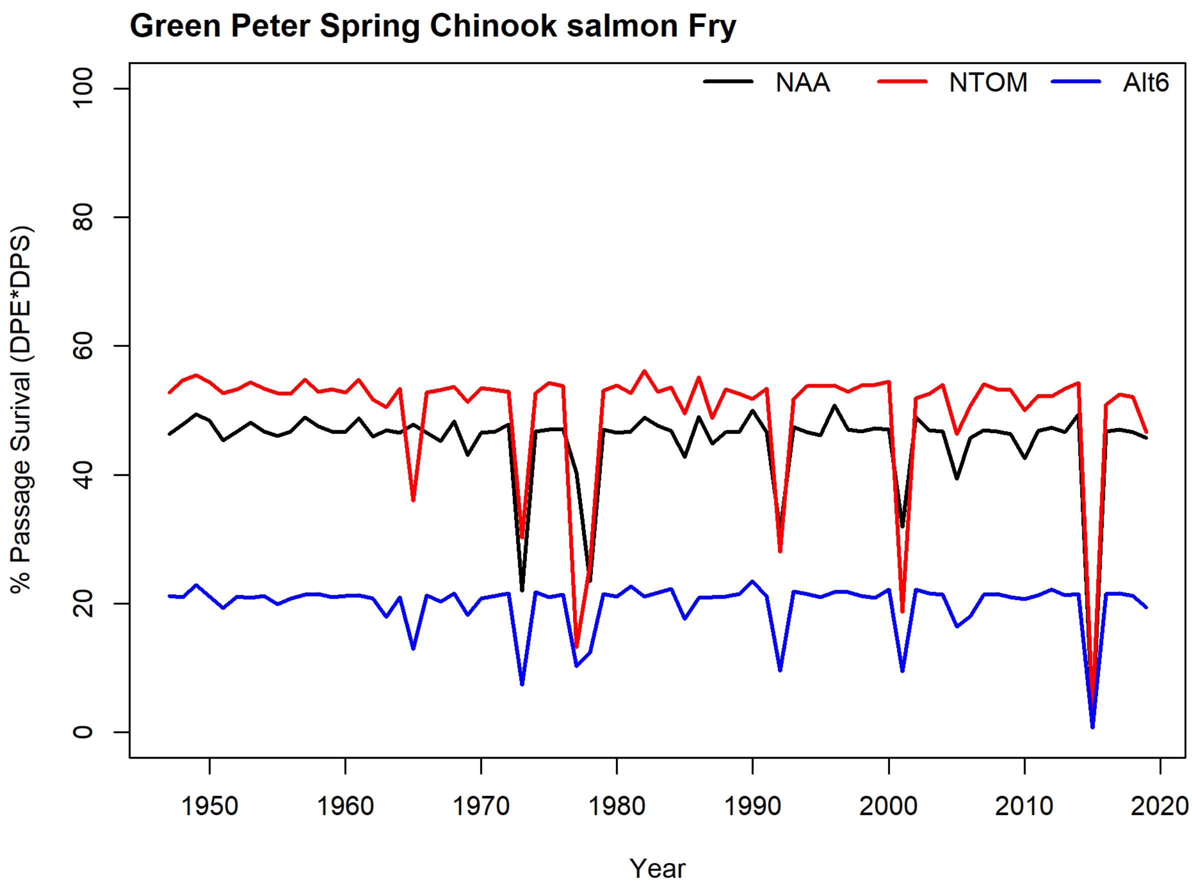

Figure 2-25 Green Peter Juvenile Spring Chinook Fry Downstream Passage Survival Under NAA, NTOM, and Alternative 6. Downstream dam passage survival at Green Peter for juvenile Spring chinook fry under the NAA, NTOM, and Alternative 6 from the years 1948 to 2020.

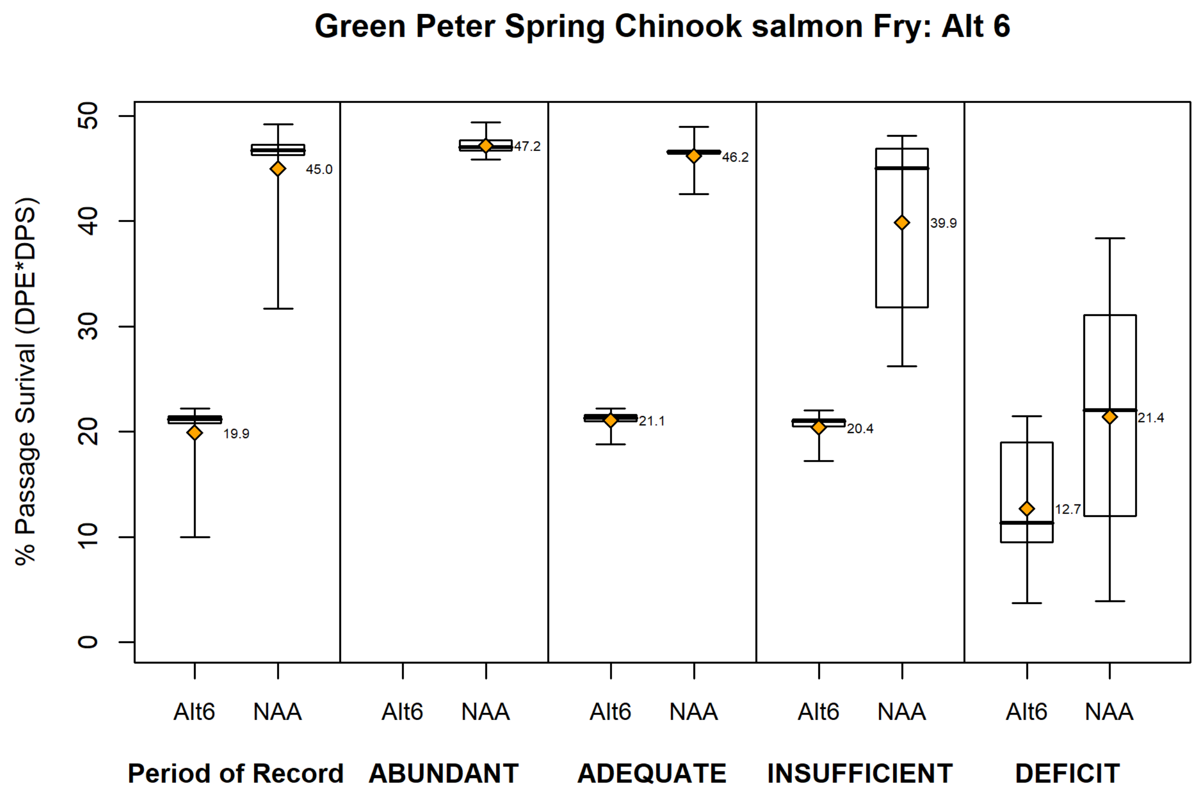

Figure 2-26 Green Peter Juvenile Spring Chinook Fry Downstream Passage Survival Under Alternative 6. Downstream dam passage survival at Green Peter for juvenile Spring chinook fry under Alternative 6. The mean is given by the point estimate (filled dot). Survival probabilities are given for the period of record (far left), compared to abundant, adequate, insufficient, and deficit hydrologic year types denoted in each panel.

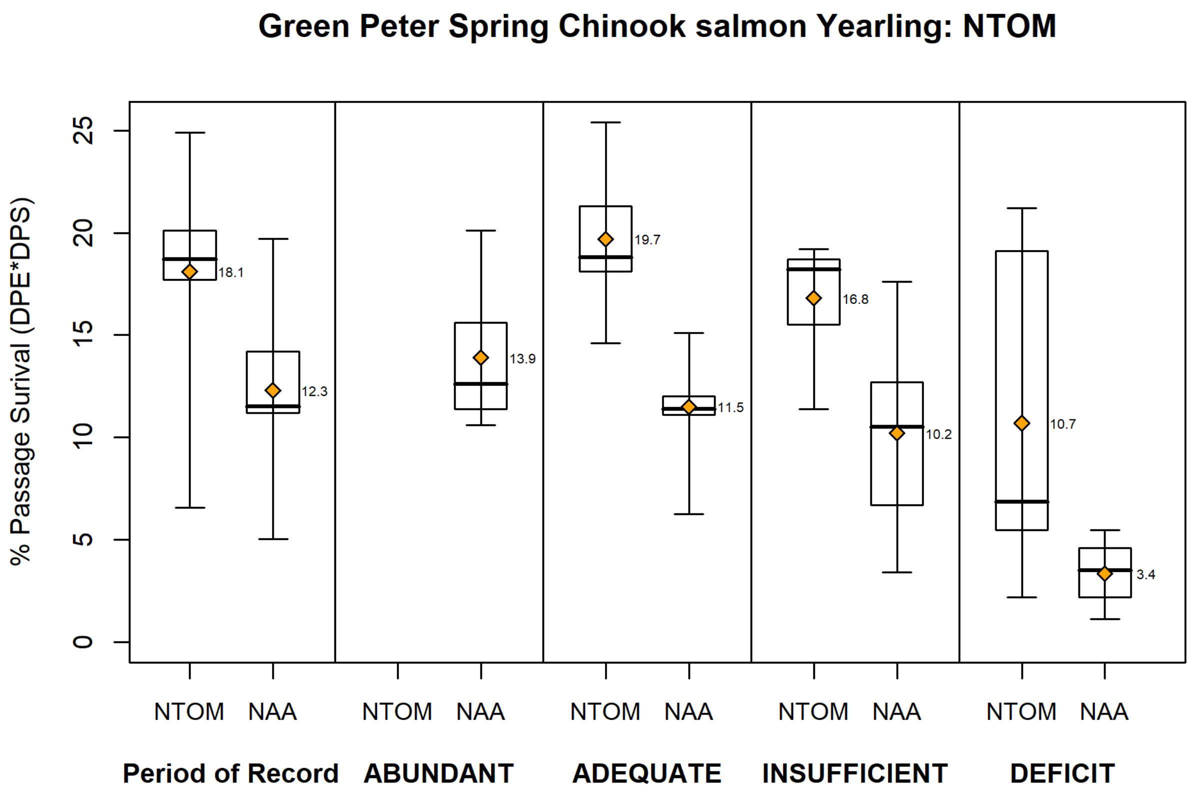

Figure** 2**-27 Green Peter Juvenile Spring Chinook Yearling Downstream Passage Survival Under NTOM. Downstream dam passage survival at Green Peter for juvenile Spring chinook yearlings under NTOM. The mean is given by the point estimate (filled dot). Survival probabilities are given for the period of record (far left), compared to abundant, adequate, insufficient, and deficit hydrologic year types denoted in each panel.

Winter Steelhead – Green Peter Dam

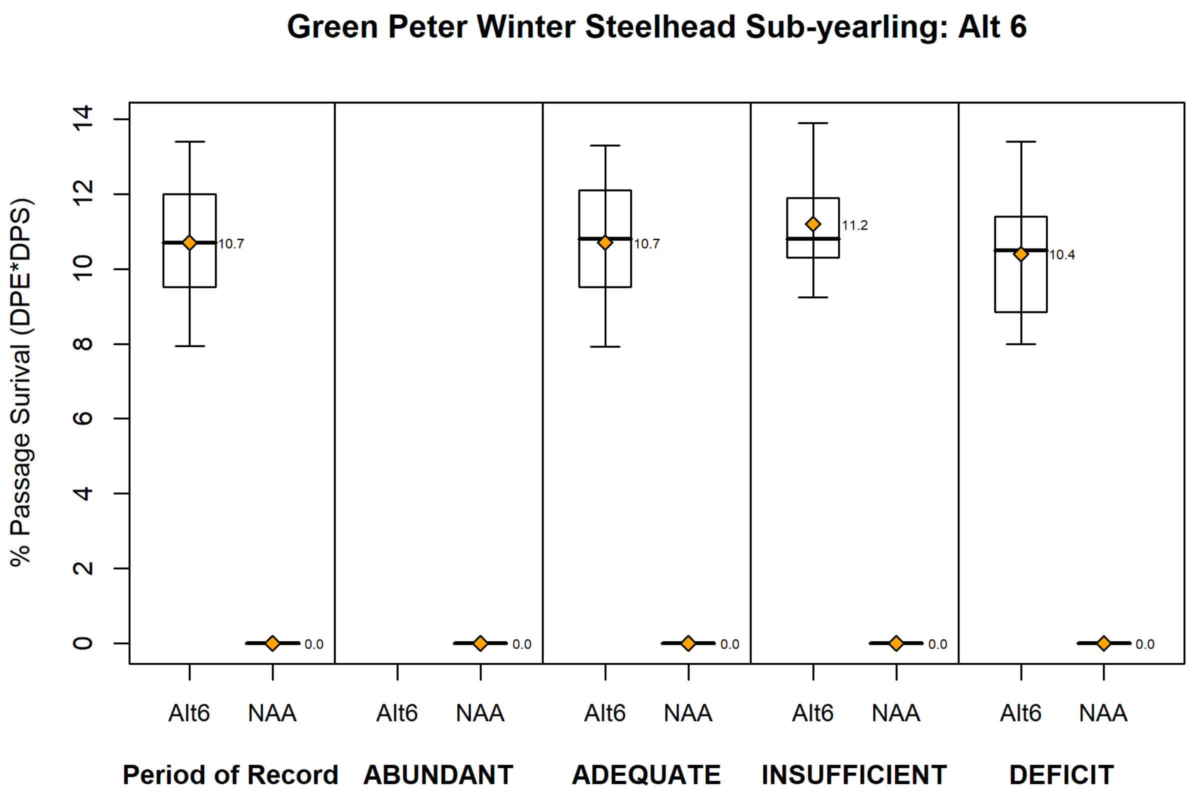

Figure 2-28 Green Peter Juvenile Winter Steelhead Sub-Yearling Downstream Passage Survival Under Alternative 6. Downstream dam passage survival at Green Peter for juvenile Winter steelhead sub-yearlings under Alternative 6. The mean is given by the point estimate (filled dot). Survival probabilities are given for the period of record (far left), compared to abundant, adequate, insufficient, and deficit hydrologic year types denoted in each panel.

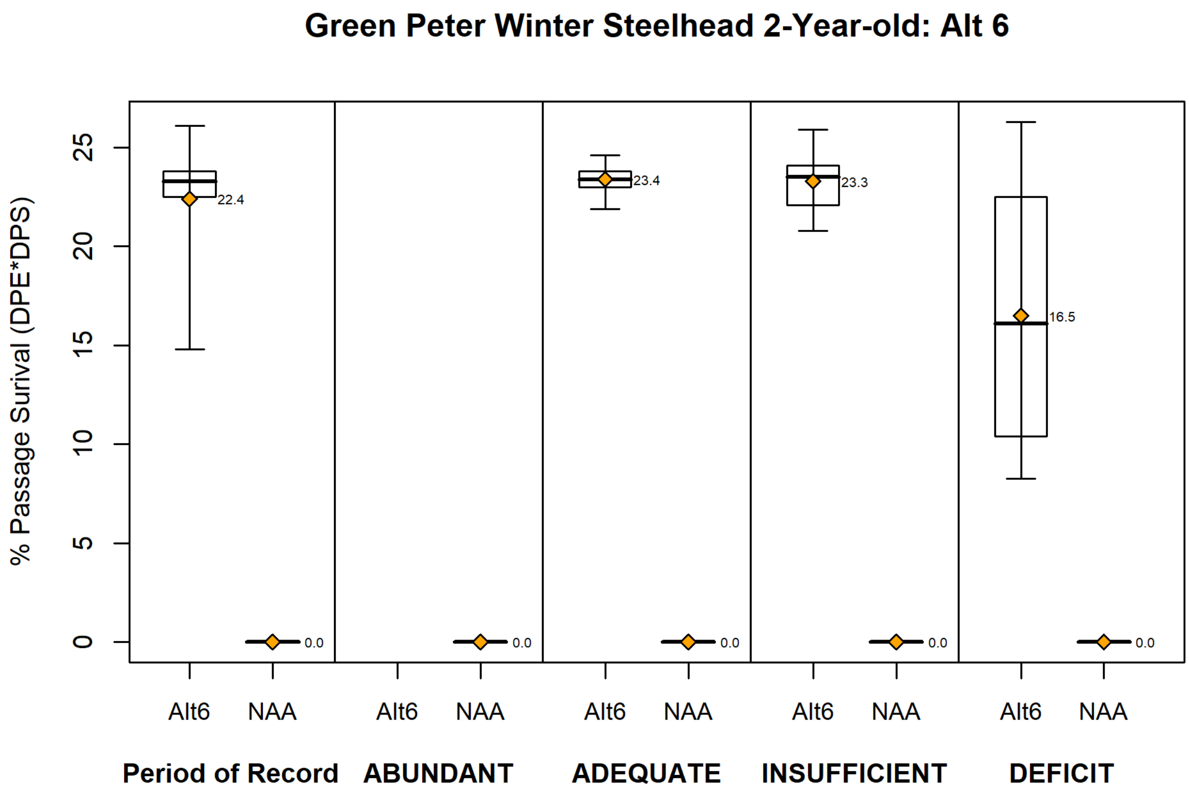

Figure 2-29 Green Peter Juvenile Winter Steelhead 2-Year-Old Downstream Passage Survival Under Alternative 6. Downstream dam passage survival at Green Peter for juvenile Winter steelhead 2-year-olds under Alternative 6. The mean is given by the point estimate (filled dot). Survival probabilities are given for the period of record (far left), compared to abundant, adequate, insufficient, and deficit hydrologic year types denoted in each panel.

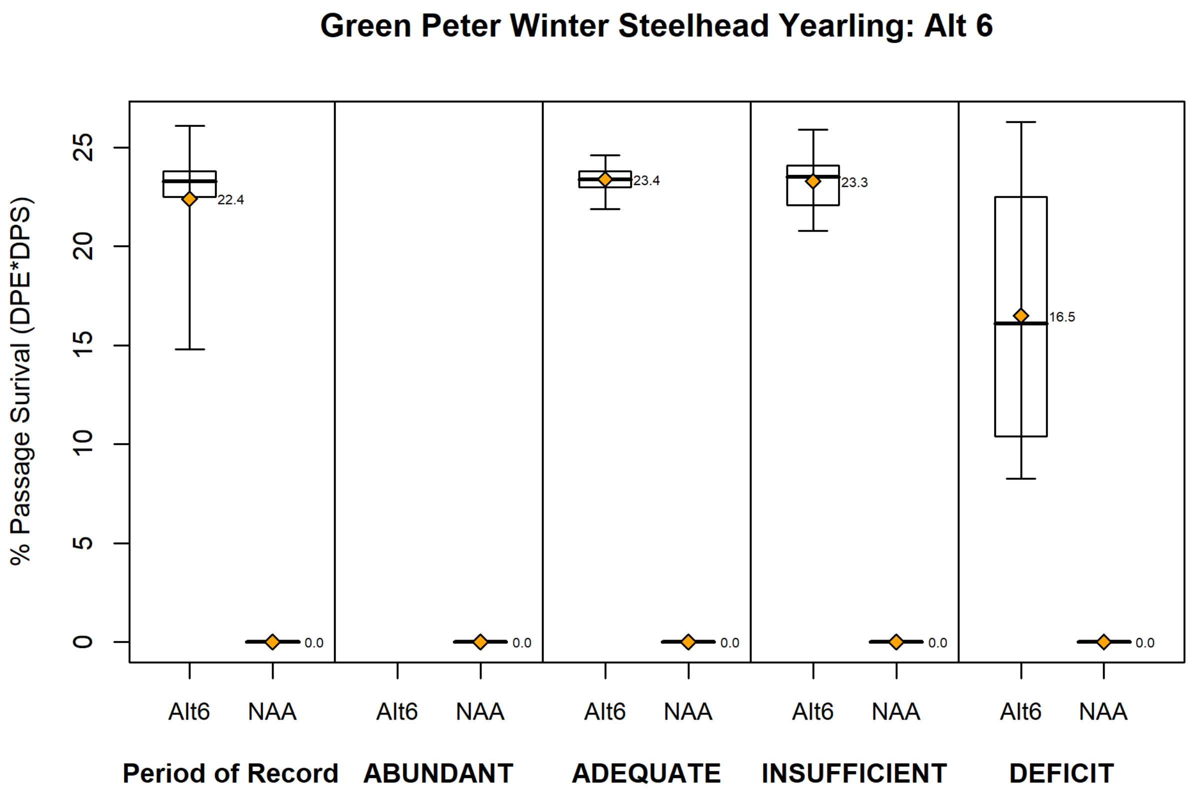

Figure 2-30 Green Peter Juvenile Winter Steelhead Yearling Downstream Passage Survival Under Alternative 6. Downstream dam passage survival at Green Peter for juvenile Winter steelhead yearlings under Alternative 6. The mean is given by the point estimate (filled dot). Survival probabilities are given for the period of record (far left), compared to abundant, adequate, insufficient, and deficit hydrologic year types denoted in each panel.

Spring Chinook Salmon – Foster Dam

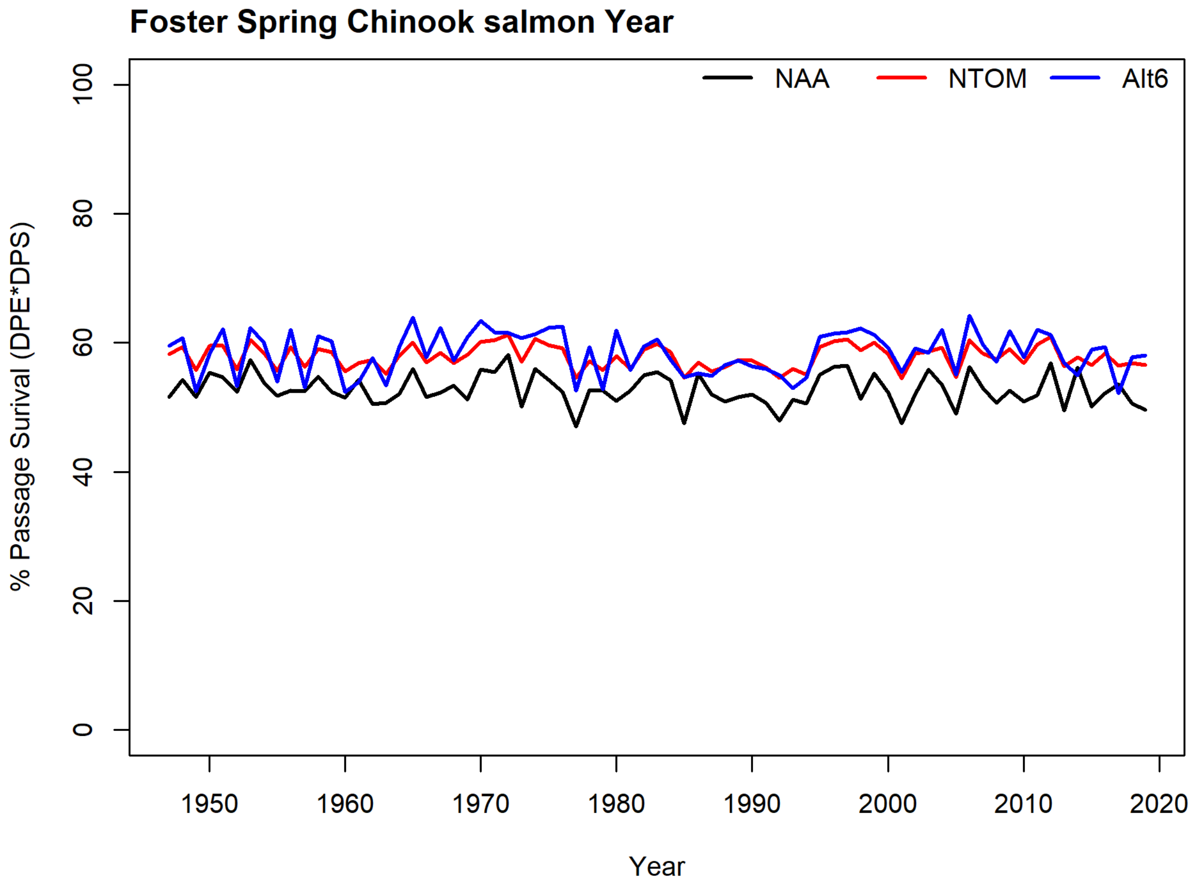

Figure 2-31 Foster Juvenile Spring Chinook Yearling Downstream Passage Survival Under NAA, NTOM, and Alternative 6. Downstream dam passage survival at Foster for juvenile Spring chinook yearlings under the NAA, NTOM, and Alternative 6 from the years 1948 to 2020.

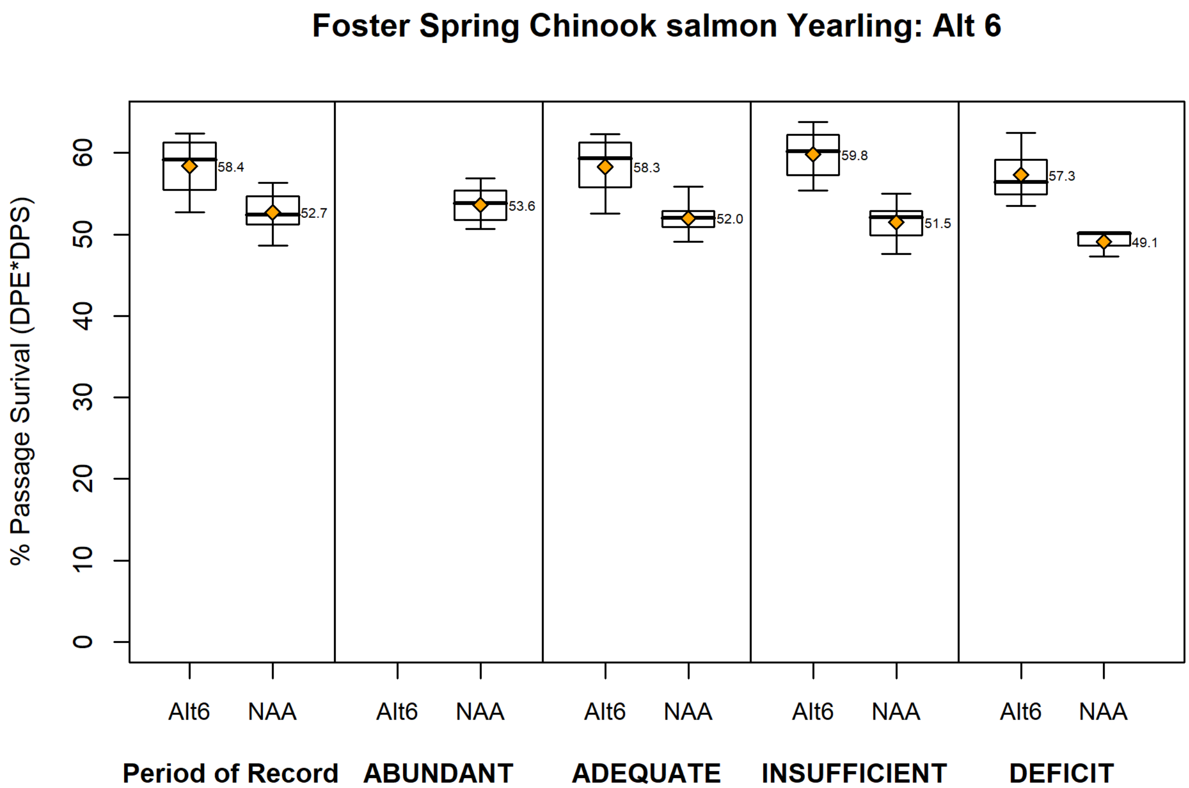

Figure 2-32 Foster Juvenile Spring Chinook Yearling Downstream Passage Survival Under Alternative 6. Downstream dam passage survival at Foster for juvenile Spring chinook yearlings under Alternative 6. The mean is given by the point estimate (filled dot). Survival probabilities are given for the period of record (far left), compared to abundant, adequate, insufficient, and deficit hydrologic year types denoted in each panel.

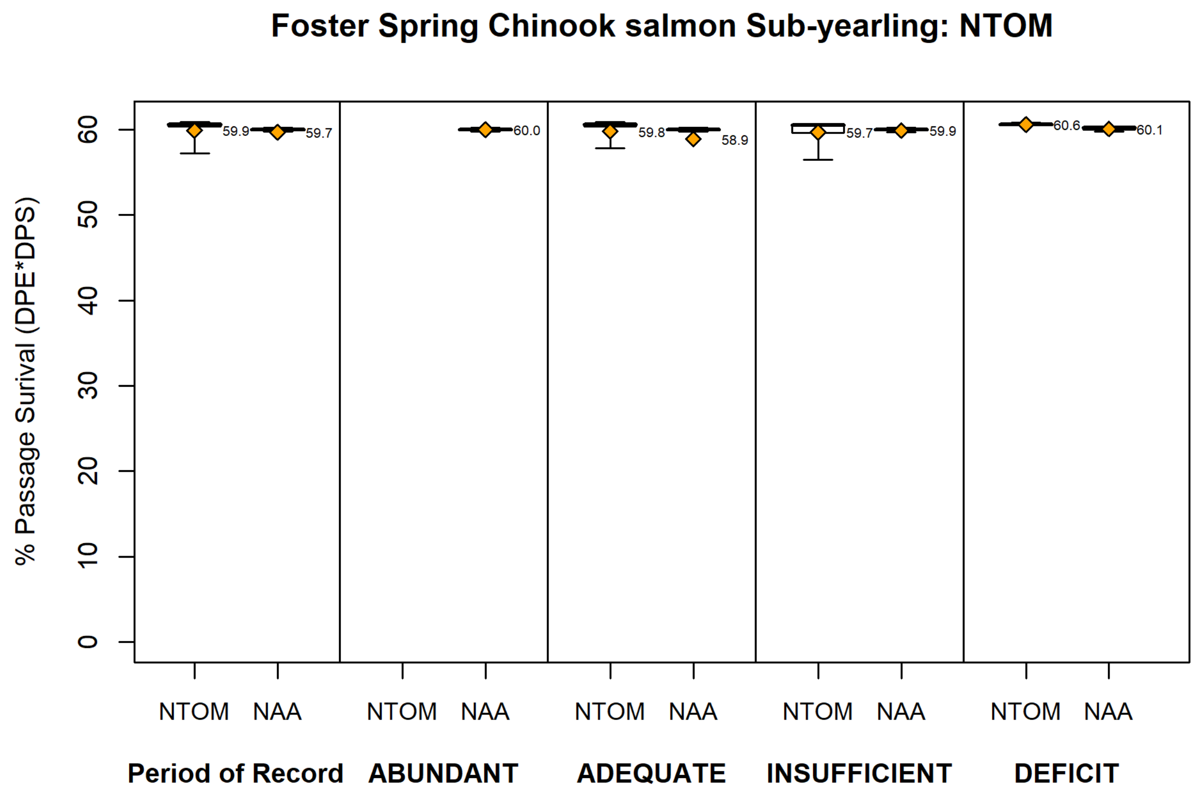

Figure 2-33 Foster Juvenile Spring Chinook Sub-Yearling Downstream Passage Survival Under NTOM. Downstream dam passage survival at Foster for juvenile Spring chinook sub-yearlings under NTOM. The mean is given by the point estimate (filled dot). Survival probabilities are given for the period of record (far left), compared to abundant, adequate, insufficient, and deficit hydrologic year types denoted in each panel.

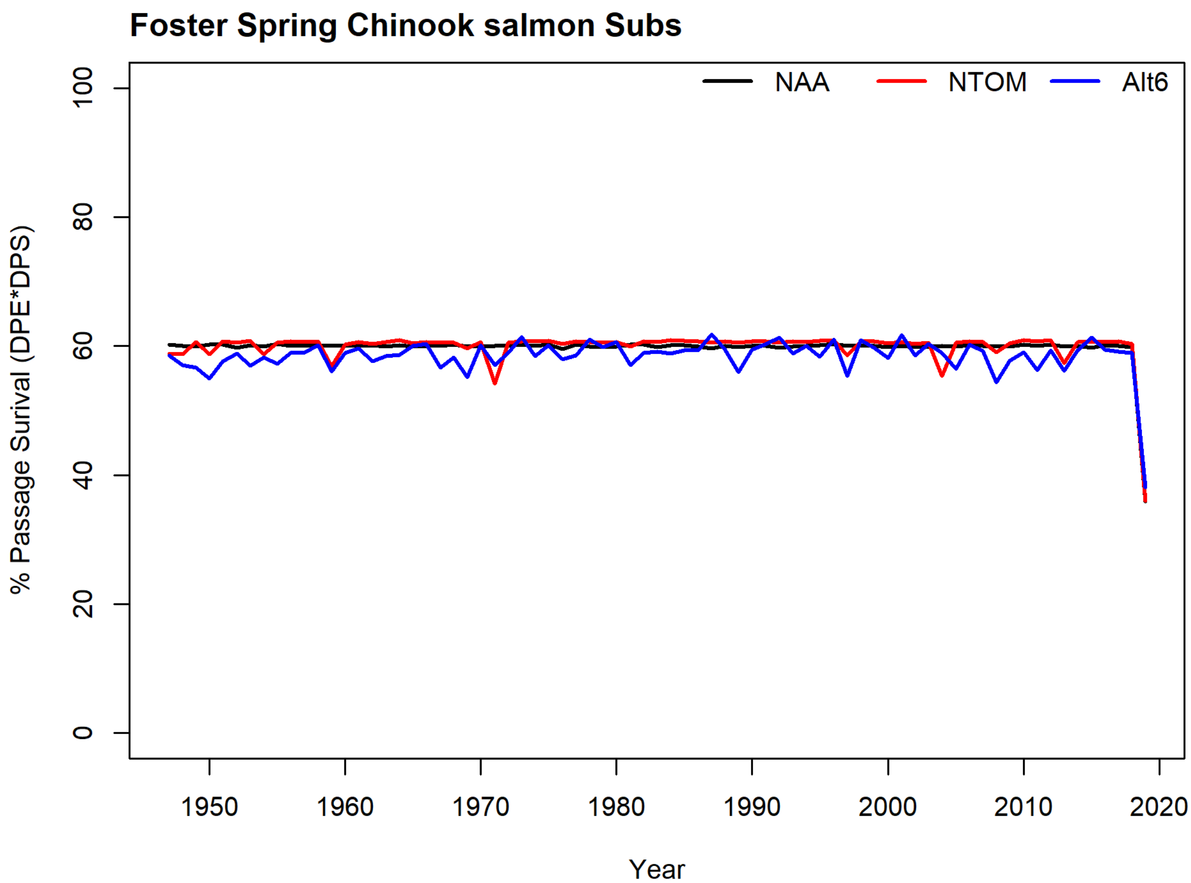

Figure 2-34 Foster Juvenile Spring Chinook Sub-Yearling Downstream Passage Survival Under NAA, NTOM, and Alternative 6. Downstream dam passage survival at Foster for juvenile Spring chinook sub-yearlings under the NAA, NTOM, and Alternative 6 from the years 1948 to 2020.

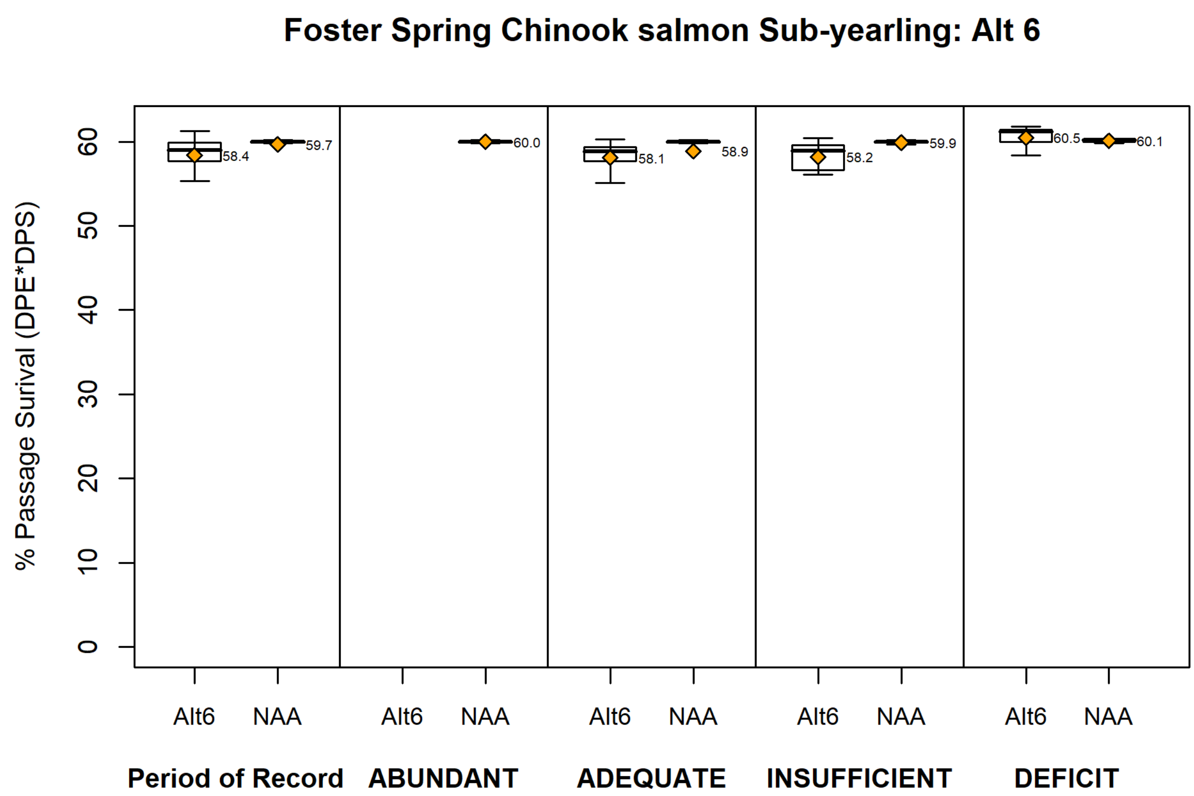

Figure 2-35 Foster Juvenile Spring Chinook Sub-Yearling Downstream Passage Survival Under Alternative 6. Downstream dam passage survival at Foster for juvenile Spring chinook sub-yearlings under Alternative 6. The mean is given by the point estimate (filled dot). Survival probabilities are given for the period of record (far left), compared to abundant, adequate, insufficient, and deficit hydrologic year types denoted in each panel.

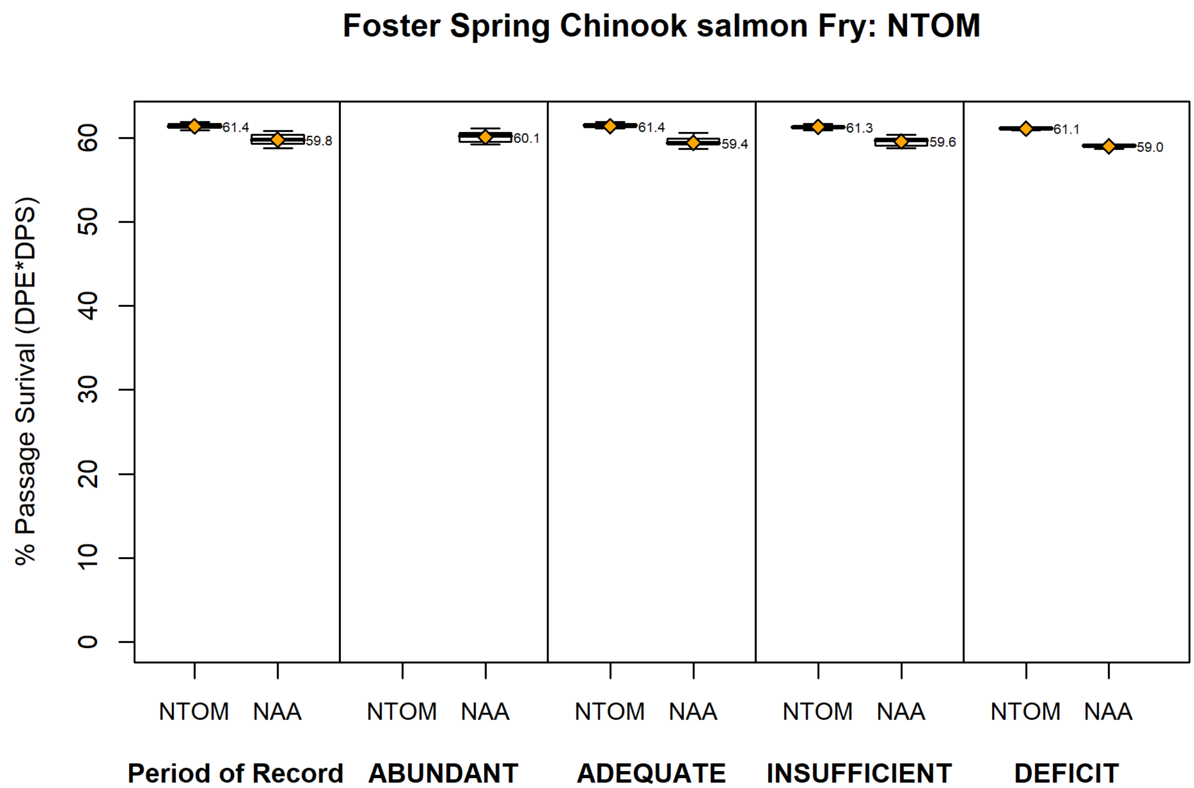

Figure 2-36 Foster Juvenile Spring Chinook Fry Downstream Passage Survival Under NTOM. Downstream dam passage survival at Foster for juvenile Spring chinook fry under NTOM. The mean is given by the point estimate (filled dot). Survival probabilities are given for the period of record (far left), compared to abundant, adequate, insufficient, and deficit hydrologic year types denoted in each panel.

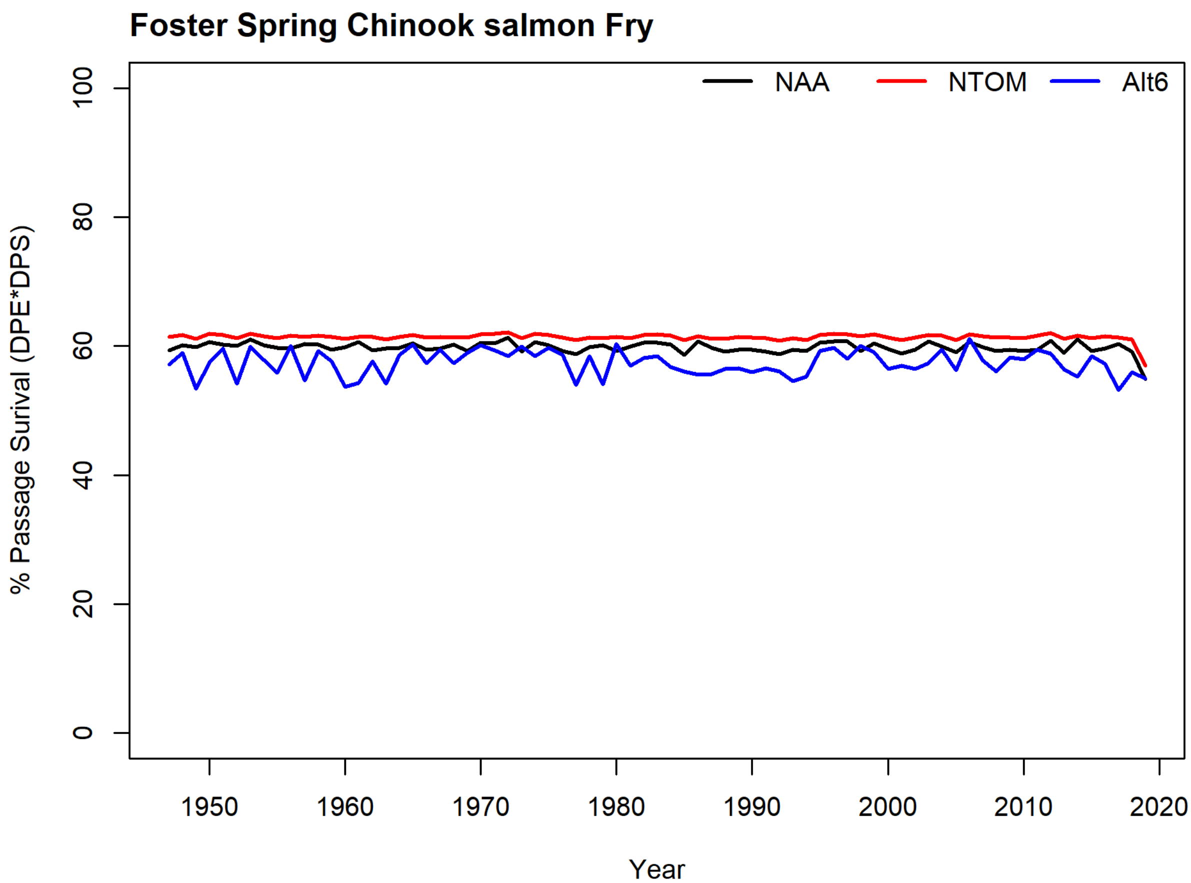

Figure 2-37 Foster Juvenile Spring Chinook Fry Downstream Passage Survival Under NAA, NTOM, and Alternative 6. Downstream dam passage survival at Foster for juvenile Spring chinook fry under the NAA, NTOM, and Alternative 6 from the years 1948 to 2020.

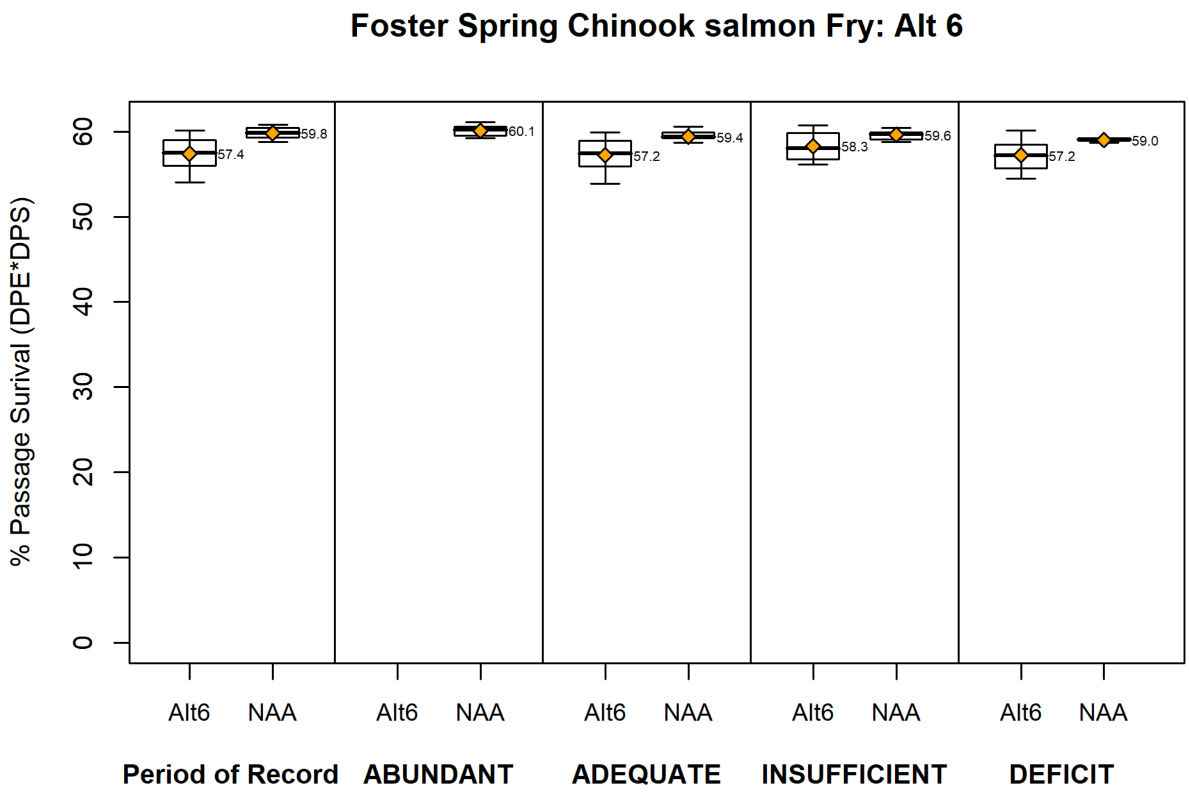

Figure 2-38 Foster Juvenile Spring Chinook Fry Downstream Passage Survival Under Alternative 6. Downstream dam passage survival at Foster for juvenile Spring chinook fry under Alternative 6. The mean is given by the point estimate (filled dot). Survival probabilities are given for the period of record (far left), compared to abundant, adequate, insufficient, and deficit hydrologic year types denoted in each panel.

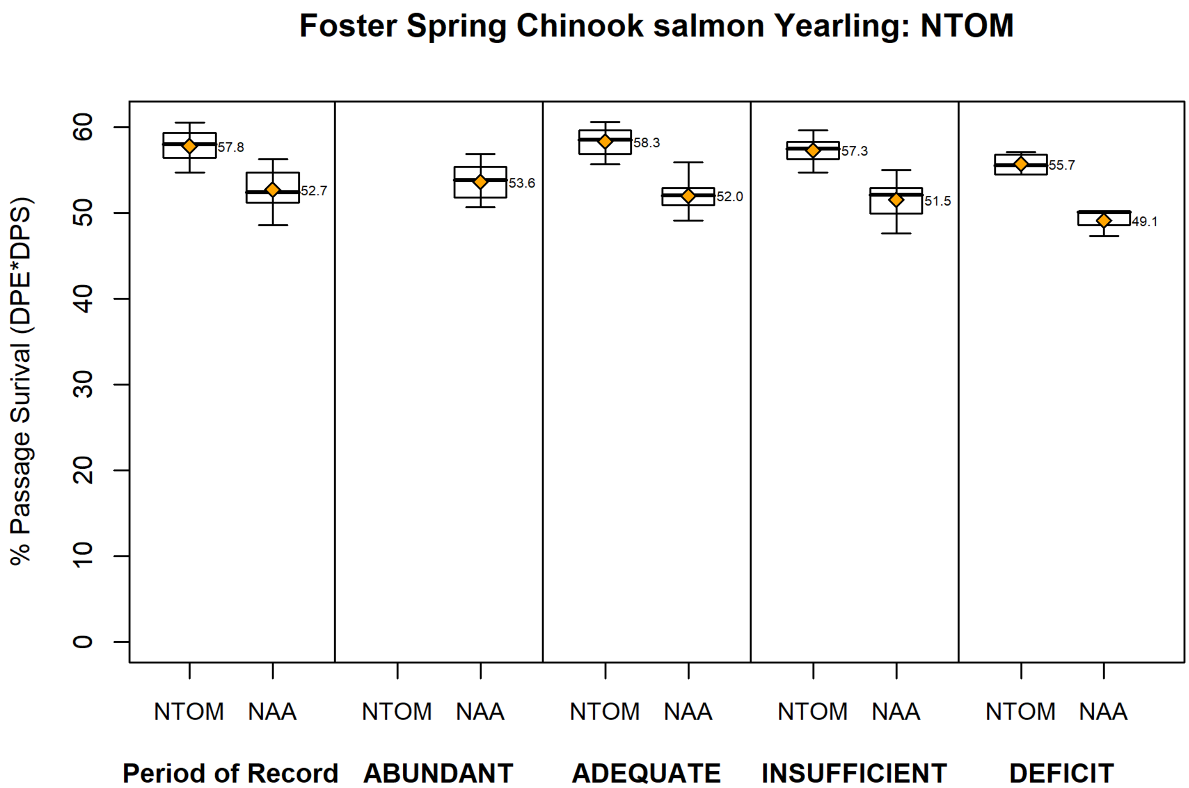

Figure 2-39 Foster Juvenile Spring Chinook Yearling Downstream Passage Survival Under NTOM. Downstream dam passage survival at Foster for juvenile Spring chinook yearlings under NTOM. The mean is given by the point estimate (filled dot). Survival probabilities are given for the period of record (far left), compared to abundant, adequate, insufficient, and deficit hydrologic year types denoted in each panel.

Winter Steelhead – Foster Dam

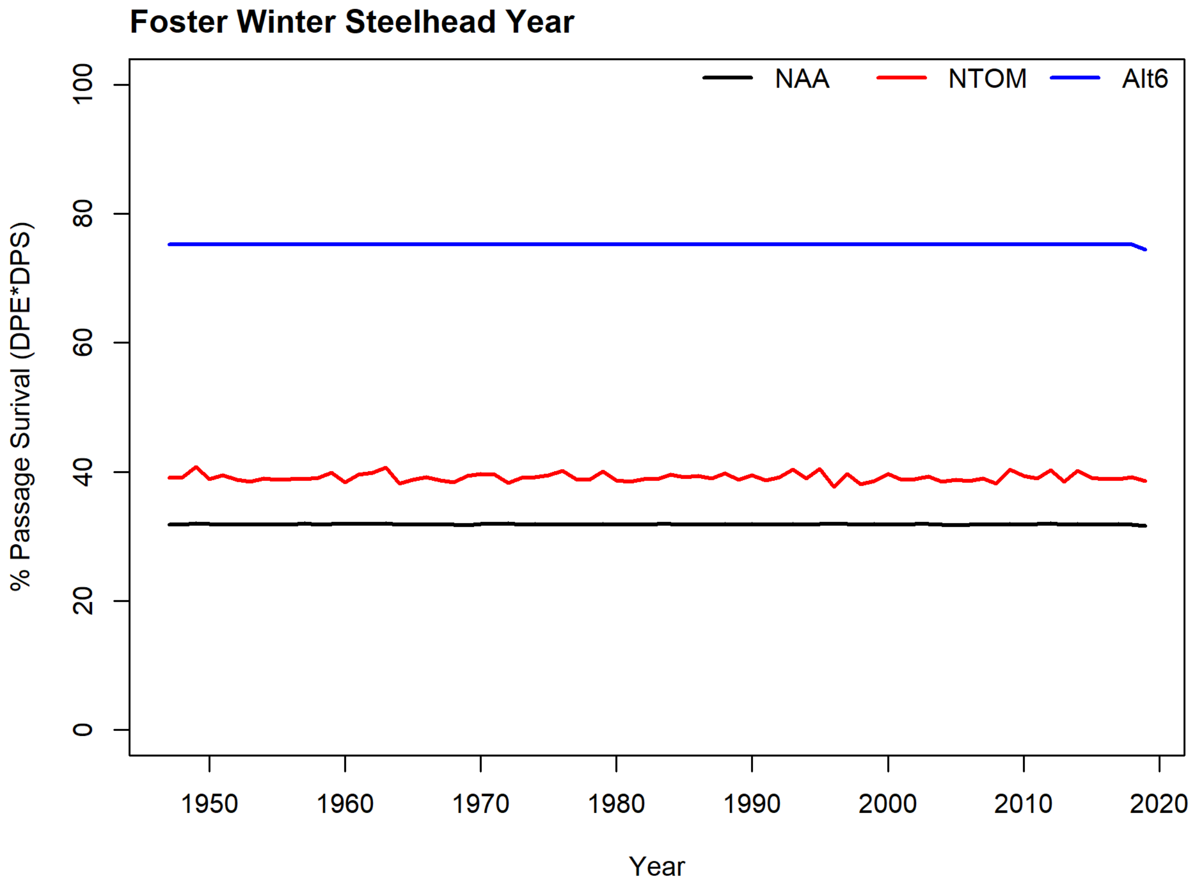

Figure 2-40 Foster Juvenile Winter Steelhead Yearling Downstream Passage Survival Under NAA, NTOM, and Alternative 6. Downstream dam passage survival at Foster for juvenile Winter steelhead yearlings under the NAA, NTOM, and Alternative 6 from the years 1948 to 2020.

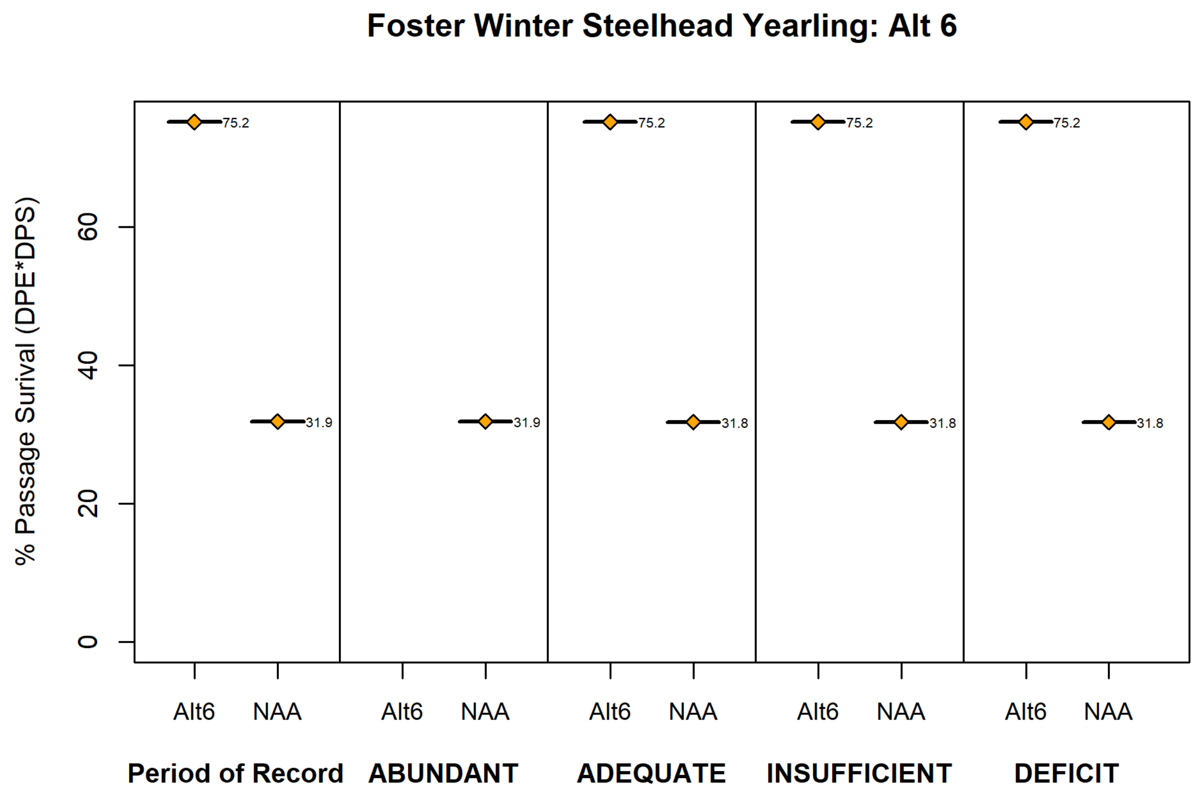

Figure 2-41 Foster Juvenile Winter Steelhead Yearling Downstream Passage Survival Under Alternative 6. Downstream dam passage survival at Foster for juvenile Winter steelhead yearlings under Alternative 6. The mean is given by the point estimate (filled dot). Survival probabilities are given for the period of record (far left), compared to abundant, adequate, insufficient, and deficit hydrologic year types denoted in each panel.

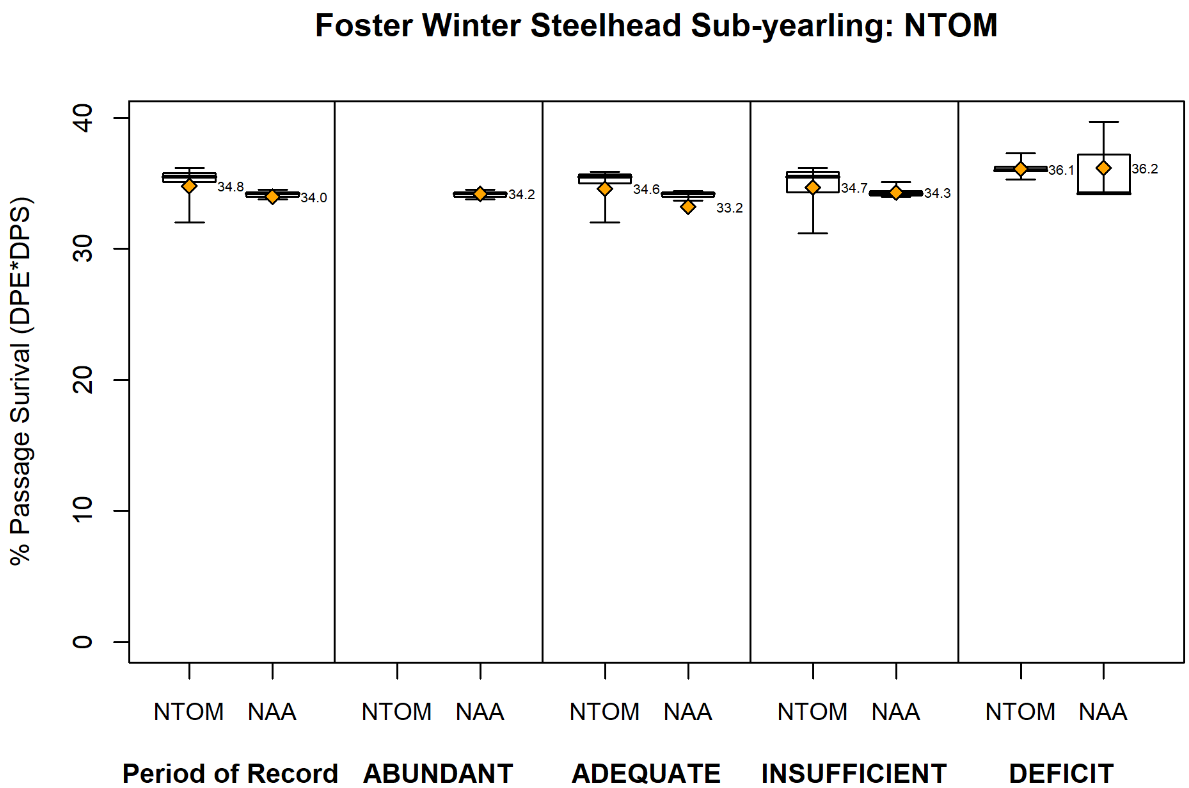

Figure 2-42 Foster Juvenile Winter Steelhead Sub-Yearling Downstream Passage Survival Under NTOM. Downstream dam passage survival at Foster for juvenile Winter steelhead sub-yearlings under NTOM. The mean is given by the point estimate (filled dot). Survival probabilities are given for the period of record (far left), compared to abundant, adequate, insufficient, and deficit hydrologic year types denoted in each panel.

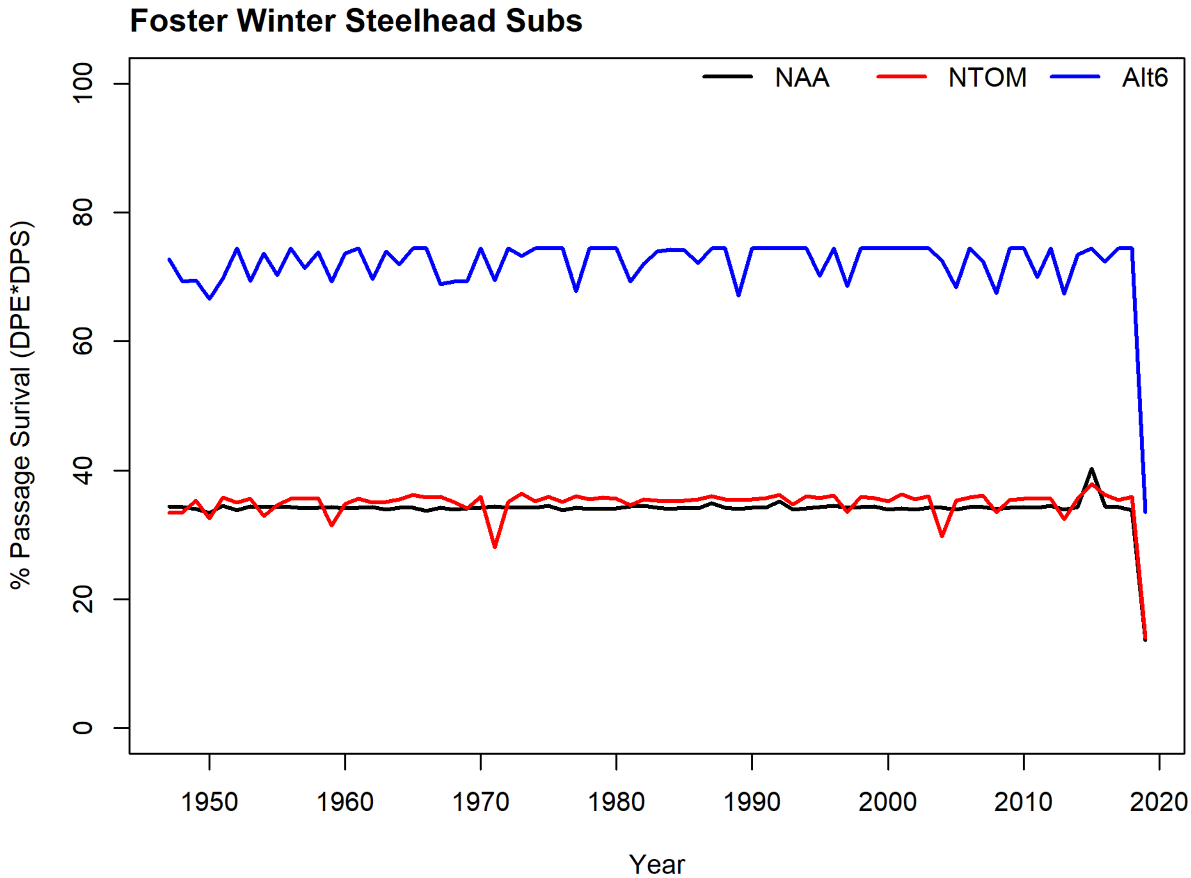

Figure 2-43 Foster Juvenile Winter Steelhead Sub-Yearling Downstream Passage Survival Under NAA, NTOM, and Alternative 6. Downstream dam passage survival at Foster for juvenile Winter steelhead sub-yearlings under the NAA, NTOM, and Alternative 6 from the years 1948 to 2020.

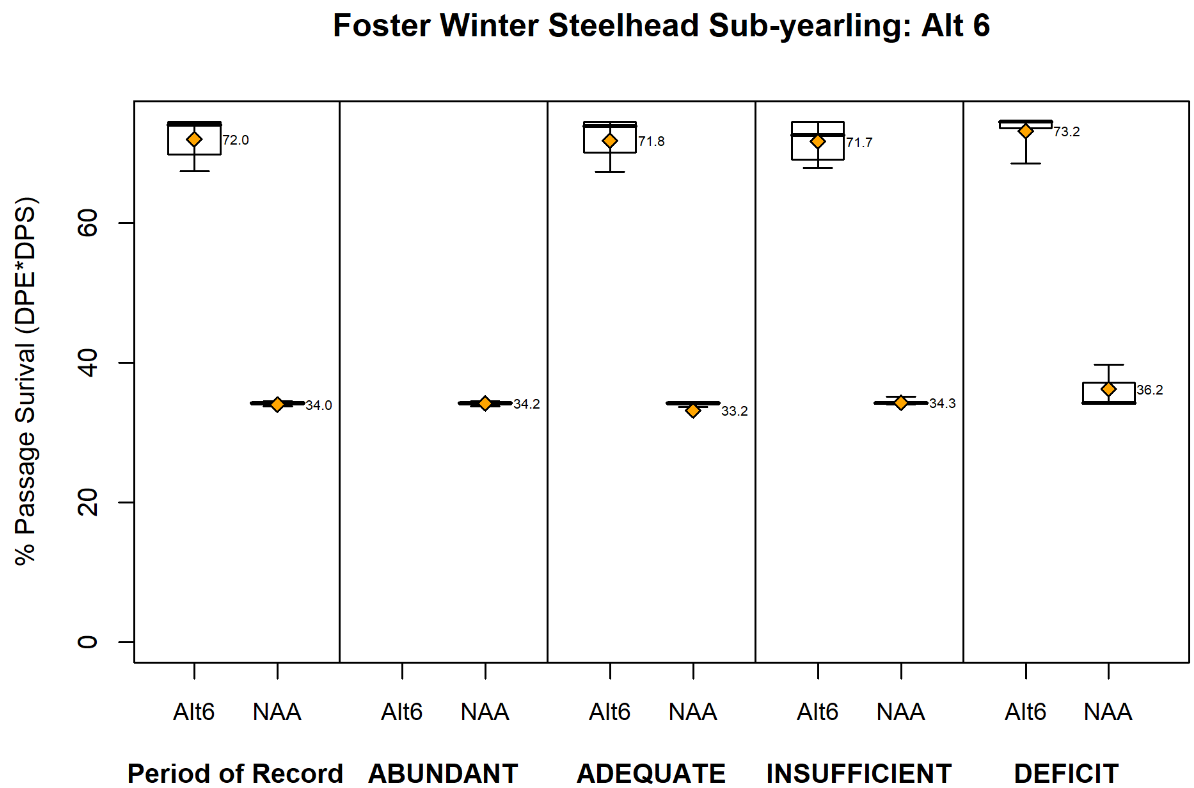

Figure 2-44 Foster Juvenile Winter Steelhead Sub-Yearling Downstream Passage Survival Under Alternative 6. Downstream dam passage survival at Foster for juvenile Winter steelhead sub-yearlings under Alternative 6. The mean is given by the point estimate (filled dot). Survival probabilities are given for the period of record (far left), compared to abundant, adequate, insufficient, and deficit hydrologic year types denoted in each panel.

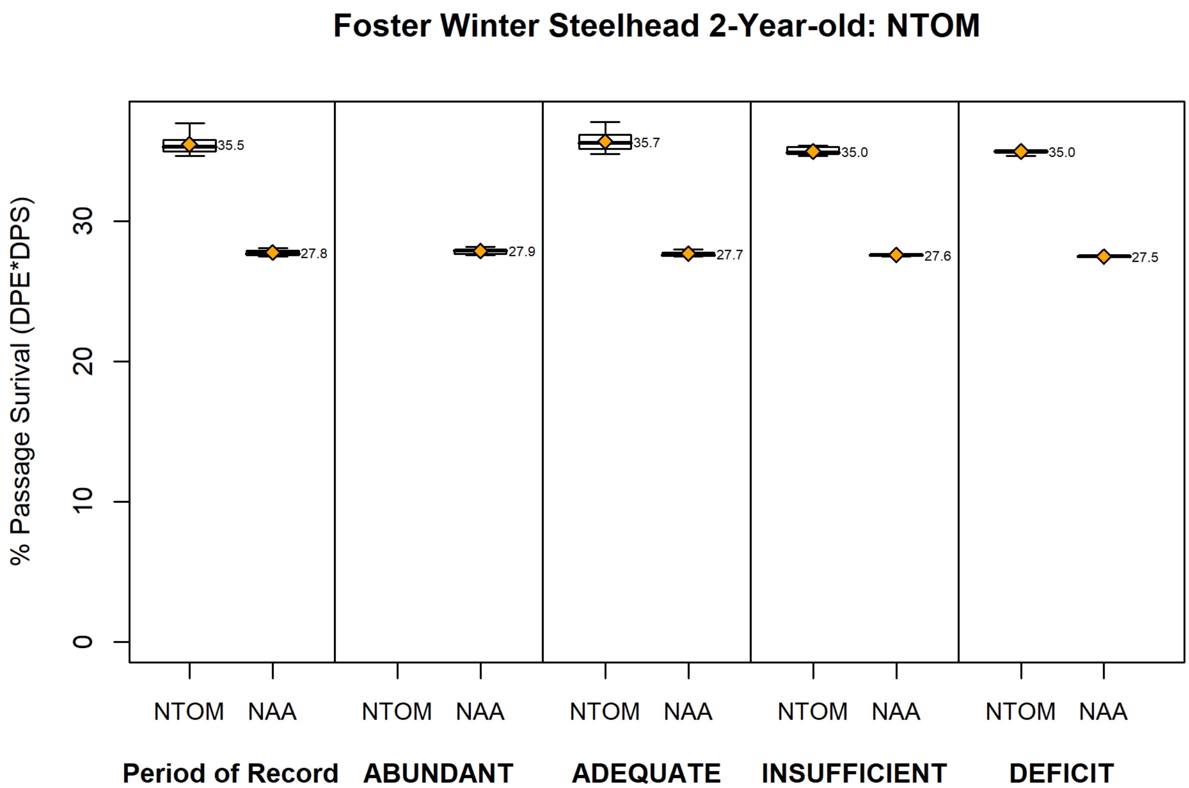

Figure 2-45 Foster Juvenile Winter Steelhead 2-Year-Old Downstream Passage Survival Under NTOM. Downstream dam passage survival at Foster for juvenile Winter steelhead 2-year-olds under NTOM. The mean is given by the point estimate (filled dot). Survival probabilities are given for the period of record (far left), compared to abundant, adequate, insufficient, and deficit hydrologic year types denoted in each panel.

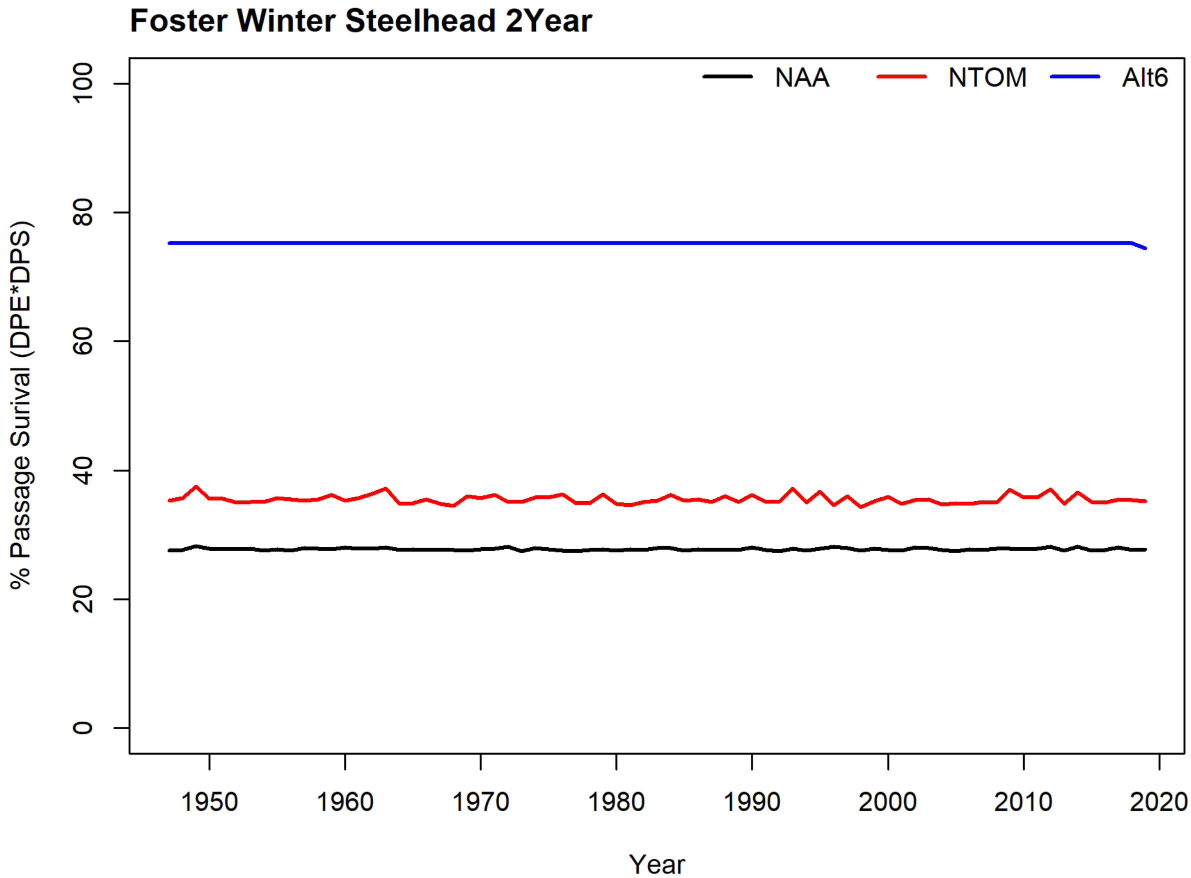

Figure 2-46 Foster Juvenile Winter Steelhead 2-Year-Old Downstream Passage Survival Under NAA, NTOM, and Alternative 6. Downstream dam passage survival at Foster for juvenile Winter steelhead 2-year-olds under the NAA, NTOM, and Alternative 6 from the years 1948 to 2020.

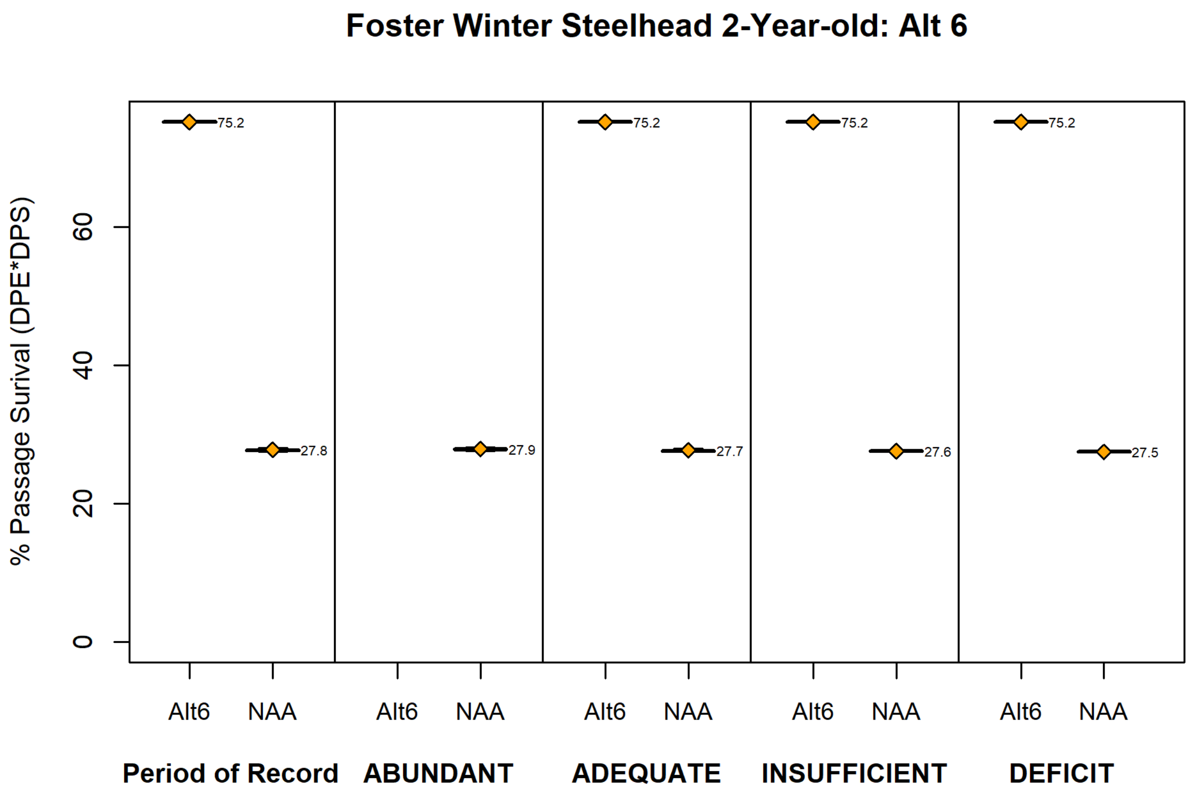

Figure 2-47 Foster Juvenile Winter Steelhead 2-Year-Old Downstream Passage Survival Under Alternative 6. Downstream dam passage survival at Foster for juvenile Winter steelhead 2-year-olds under Alternative 6. The mean is given by the point estimate (filled dot). Survival probabilities are given for the period of record (far left), compared to abundant, adequate, insufficient, and deficit hydrologic year types denoted in each panel.

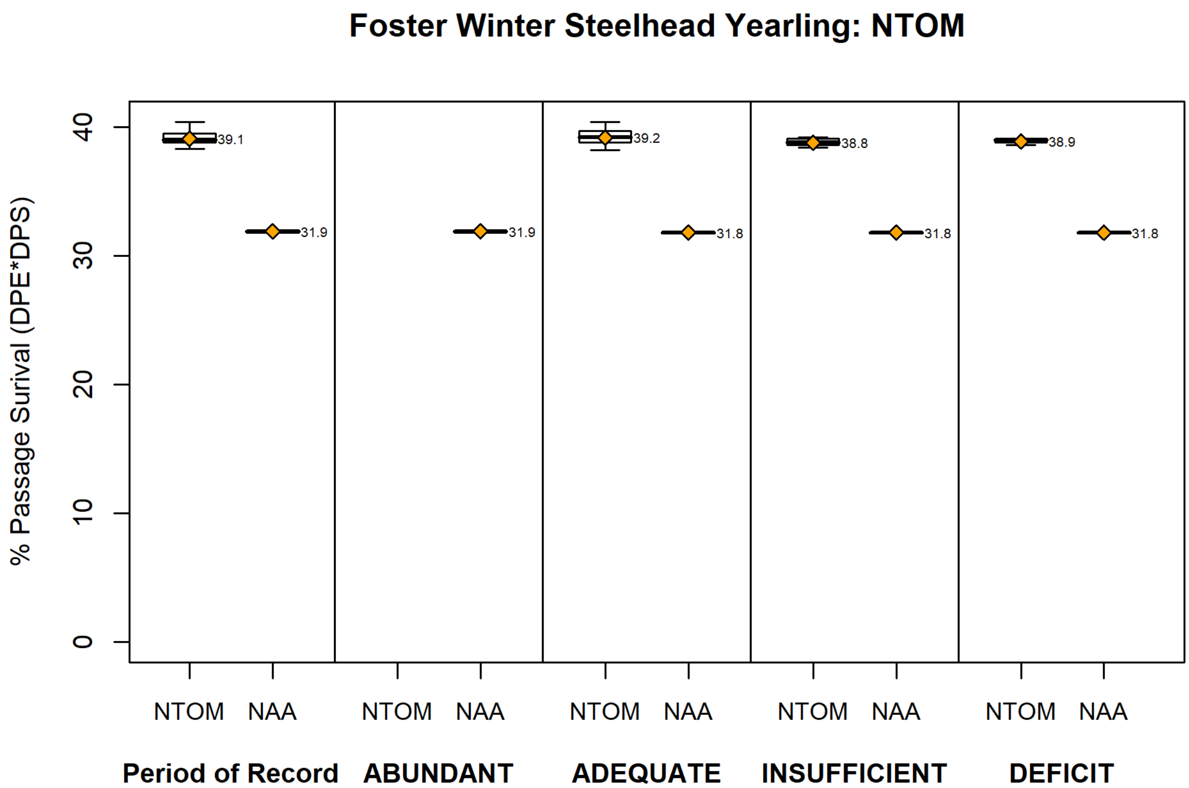

Figure 2-48 Foster Juvenile Winter Steelhead Yearling Downstream Passage Survival Under NTOM. Downstream dam passage survival at Foster for juvenile Winter steelhead yearlings under NTOM. The mean is given by the point estimate (filled dot). Survival probabilities are given for the period of record (far left), compared to abundant, adequate, insufficient, and deficit hydrologic year types denoted in each panel.

McKenzie Subbasin

Spring Chinook Salmon – Cougar Dam

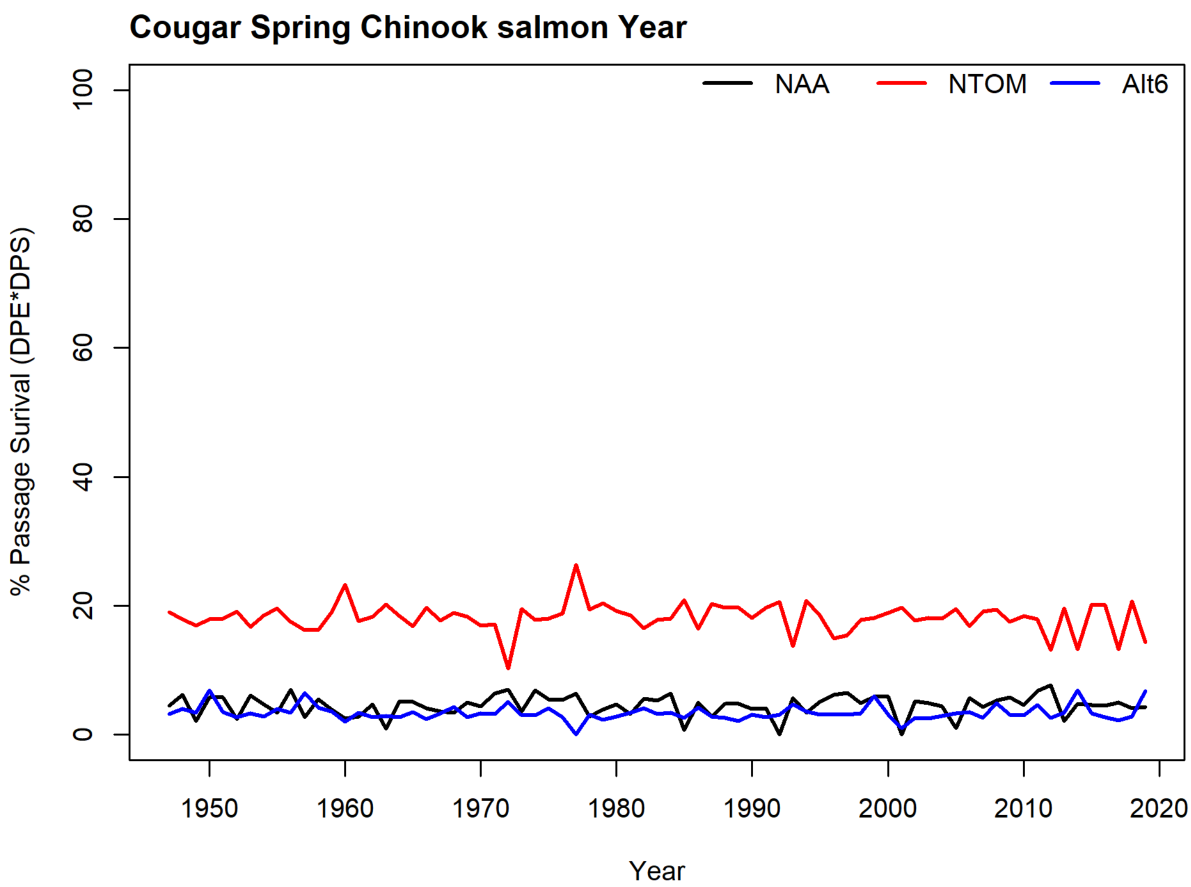

Figure 2-49 Cougar Juvenile Spring Chinook Yearling Downstream Passage Survival Under NAA, NTOM, and Alternative 6. Downstream dam passage survival at Cougar for juvenile Spring chinook yearlings under the NAA, NTOM, and Alternative 6 from the years 1948 to 2020.

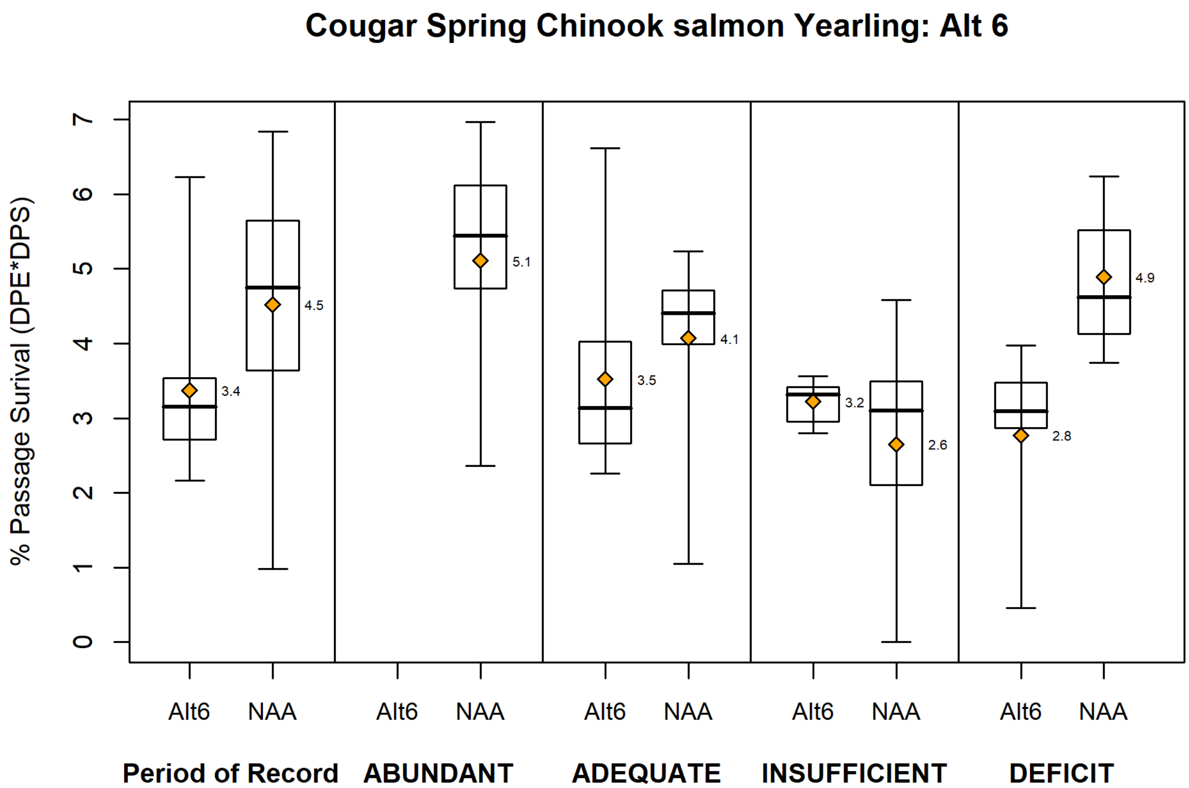

Figure 2-50 Cougar Juvenile Spring Chinook Yearling Downstream Passage Survival Under Alternative 6. Downstream dam passage survival at Cougar for juvenile Spring chinook yearlings under Alternative 6. The mean is given by the point estimate (filled dot). Survival probabilities are given for the period of record (far left), compared to abundant, adequate, insufficient, and deficit hydrologic year types denoted in each panel.

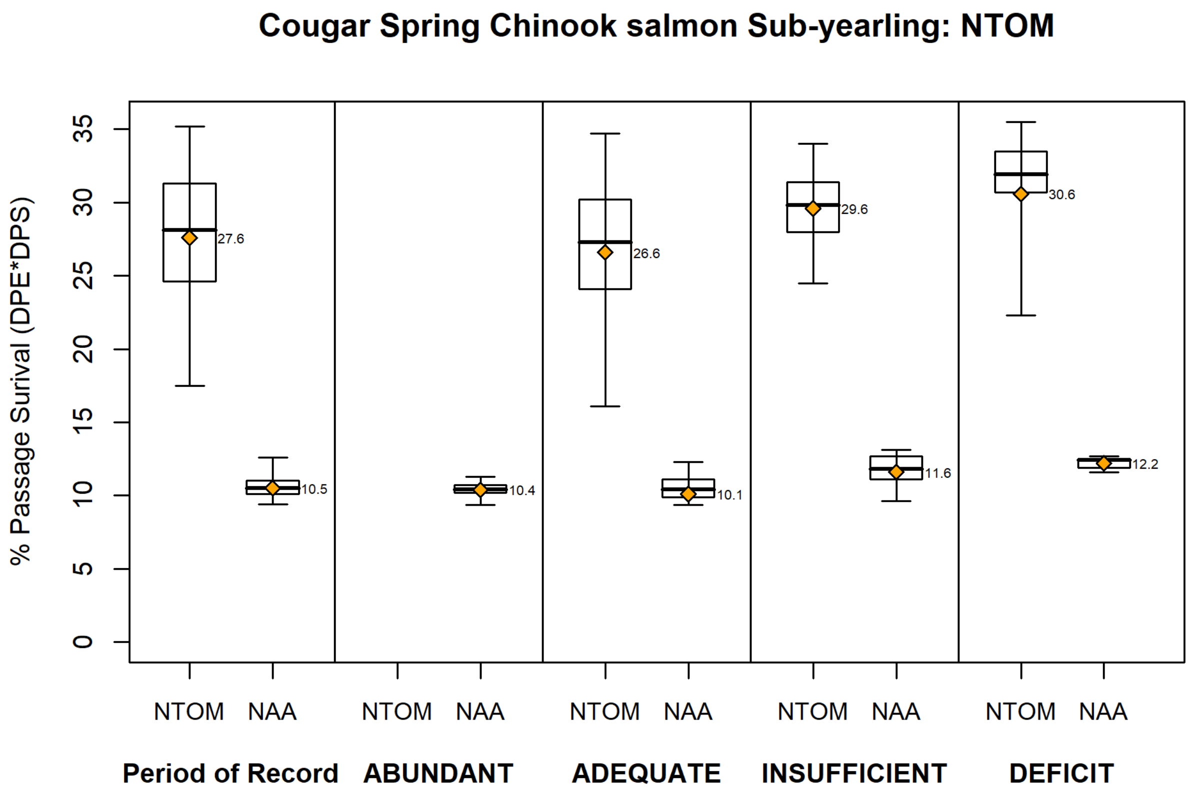

Figure 2-51 Cougar Juvenile Spring Chinook Sub-Yearling Downstream Passage Survival Under NTOM. Downstream dam passage survival at Cougar for juvenile Spring chinook sub-yearlings under NTOM. The mean is given by the point estimate (filled dot). Survival probabilities are given for the period of record (far left), compared to abundant, adequate, insufficient, and deficit hydrologic year types denoted in each panel.

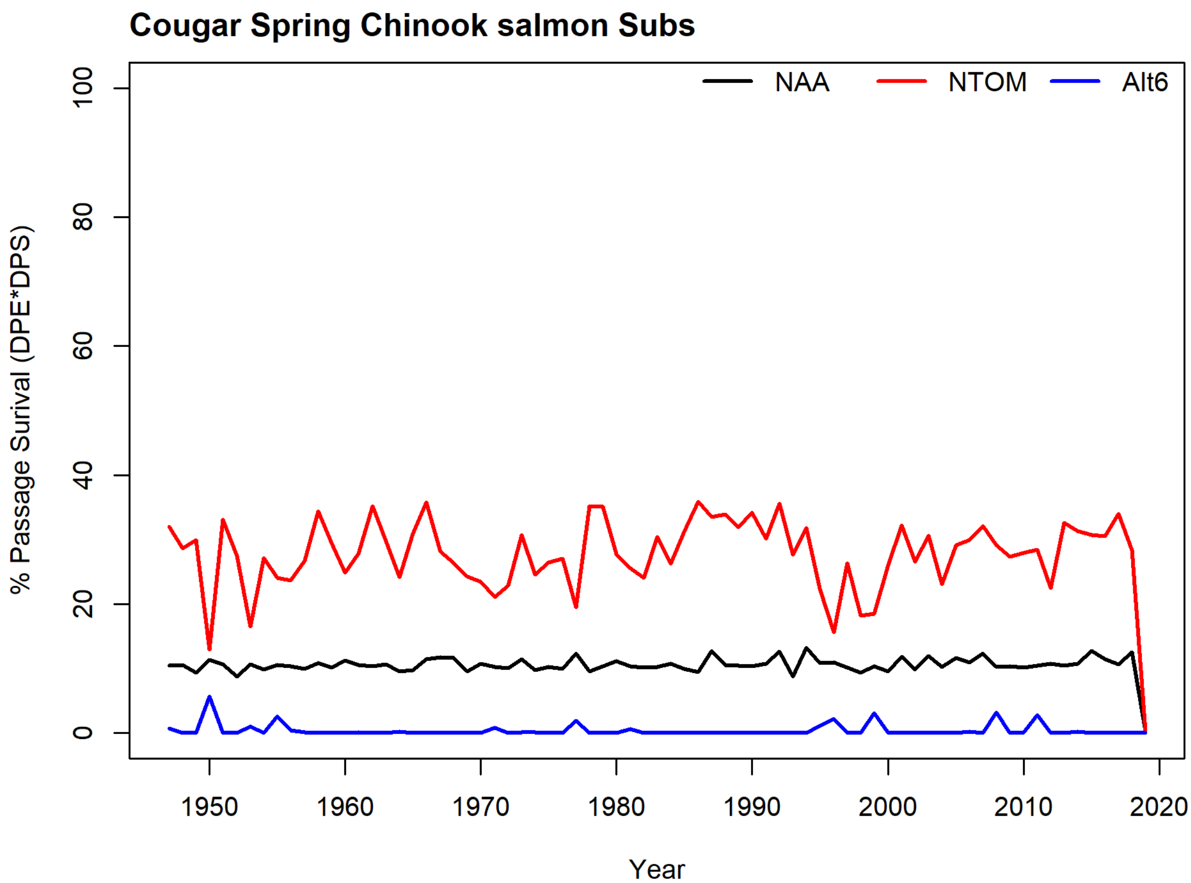

Figure 2-52 Cougar Juvenile Spring Chinook Sub-Yearling Downstream Passage Survival Under NAA, NTOM, and Alternative 6. Downstream dam passage survival at Cougar for juvenile Spring chinook sub-yearlings under the NAA, NTOM, and Alternative 6 from the years 1948 to 2020.

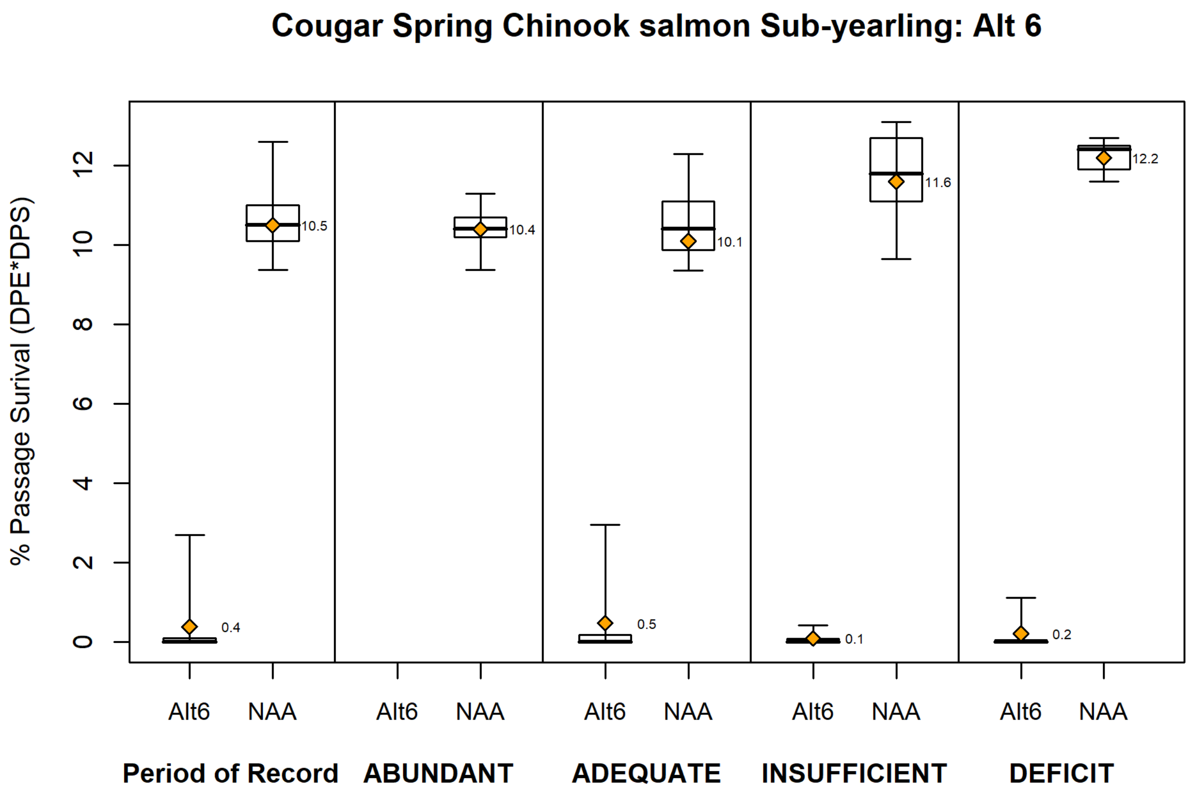

Figure 2-53 Cougar Juvenile Spring Chinook Sub-Yearling Downstream Passage Survival Under Alternative 6. Downstream dam passage survival at Cougar for juvenile Spring chinook sub-yearlings under Alternative 6. The mean is given by the point estimate (filled dot). Survival probabilities are given for the period of record (far left), compared to abundant, adequate, insufficient, and deficit hydrologic year types denoted in each panel.

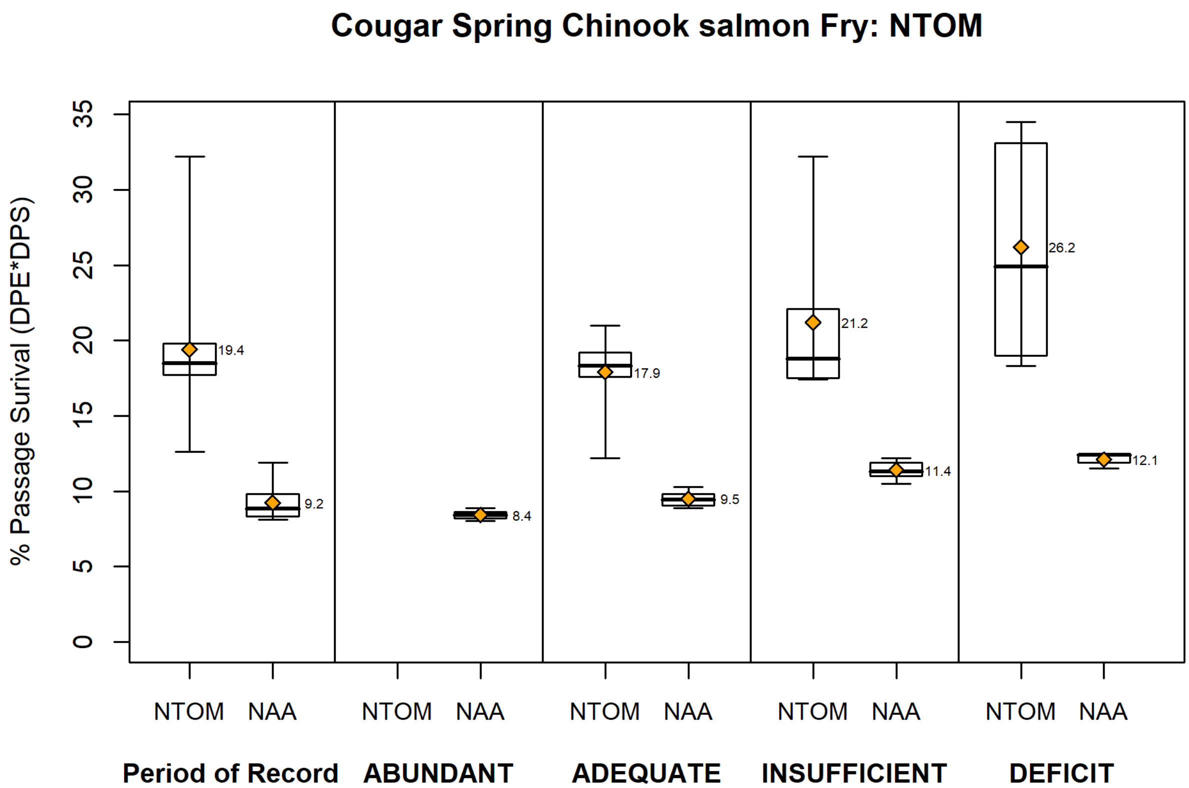

Figure 2-54 Cougar Juvenile Spring Chinook Fry Downstream Passage Survival Under NTOM. Downstream dam passage survival at Cougar for juvenile Spring chinook fry under NTOM. The mean is given by the point estimate (filled dot). Survival probabilities are given for the period of record (far left), compared to abundant, adequate, insufficient, and deficit hydrologic year types denoted in each panel.

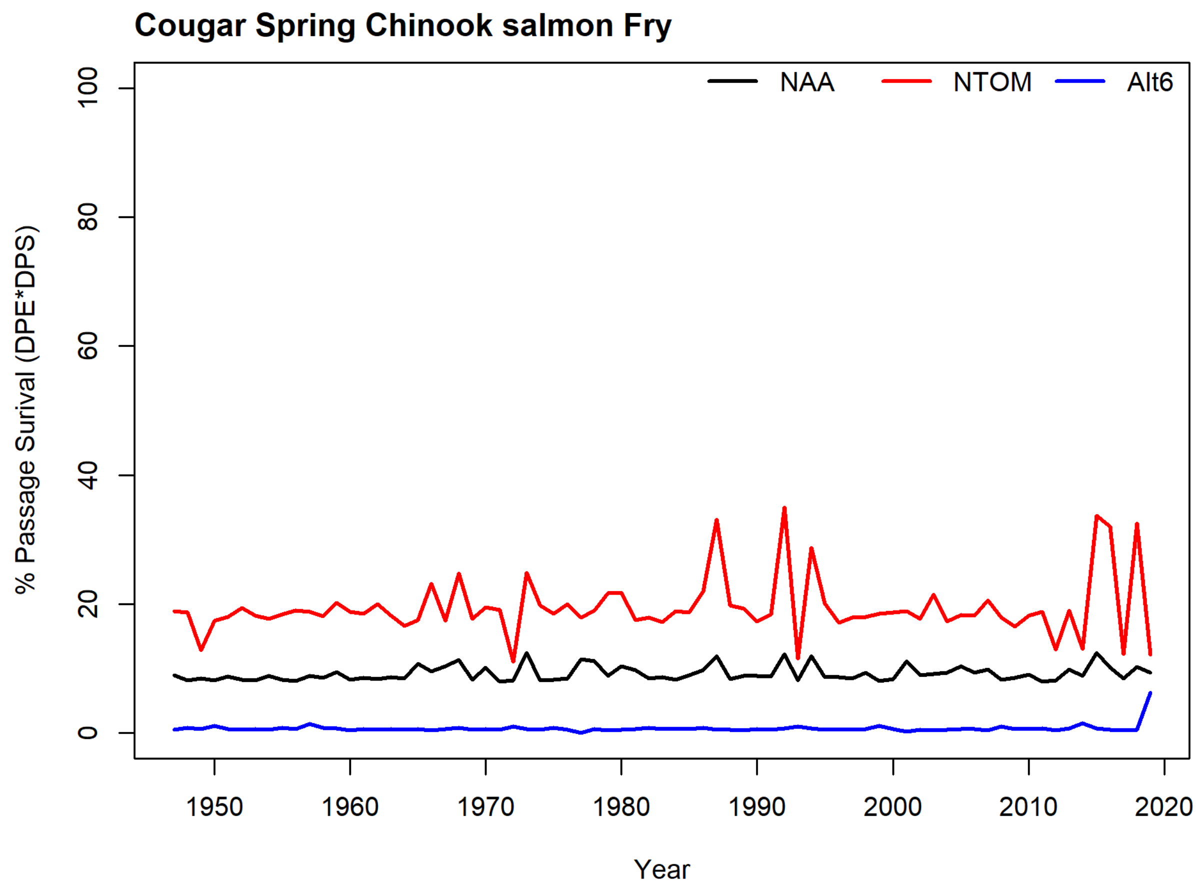

Figure 2-55 Cougar Juvenile Spring Chinook Fry Downstream Passage Survival Under NAA, NTOM, and Alternative 6. Downstream dam passage survival at Cougar for juvenile Spring chinook fry under the NAA, NTOM, and Alternative 6 from the years 1948 to 2020.

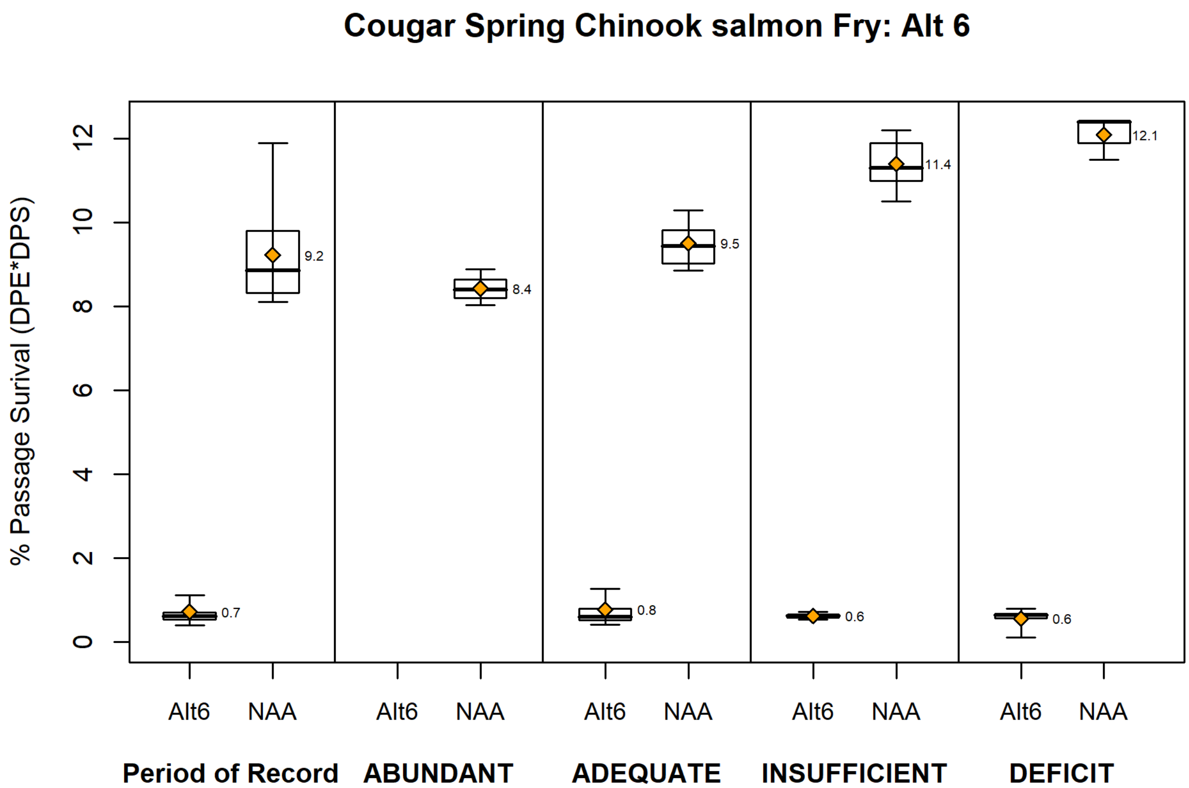

Figure 2-56 Cougar Juvenile Spring Chinook Fry Downstream Passage Survival Under Alternative 6. Downstream dam passage survival at Cougar for juvenile Spring chinook fry under Alternative 6. The mean is given by the point estimate (filled dot). Survival probabilities are given for the period of record (far left), compared to abundant, adequate, insufficient, and deficit hydrologic year types denoted in each panel.

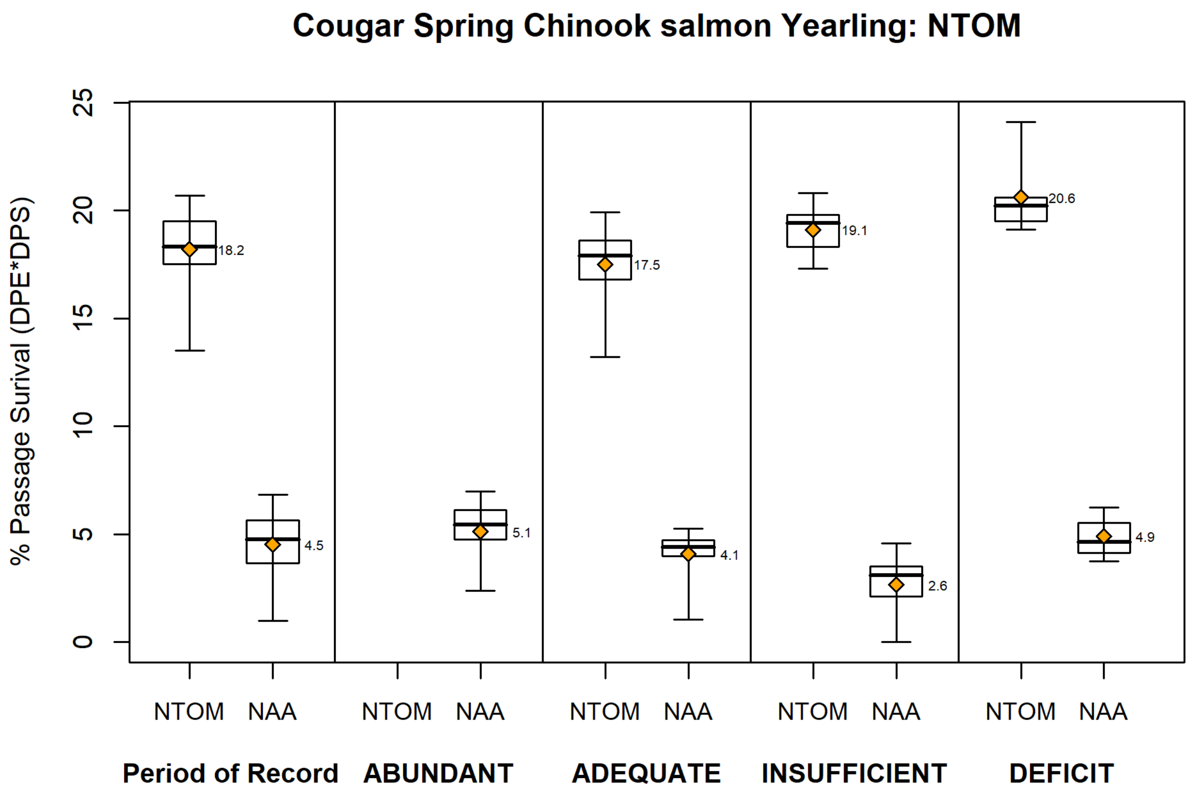

Figure 2-57 Cougar Juvenile Spring Chinook Yearling Downstream Passage Survival Under NTOM. Downstream dam passage survival at Cougar for juvenile Spring chinook yearlings under NTOM. The mean is given by the point estimate (filled dot). Survival probabilities are given for the period of record (far left), compared to abundant, adequate, insufficient, and deficit hydrologic year types denoted in each panel.

Middle Fork Subbasin

Spring Chinook Salmon – Hills Creek Dam

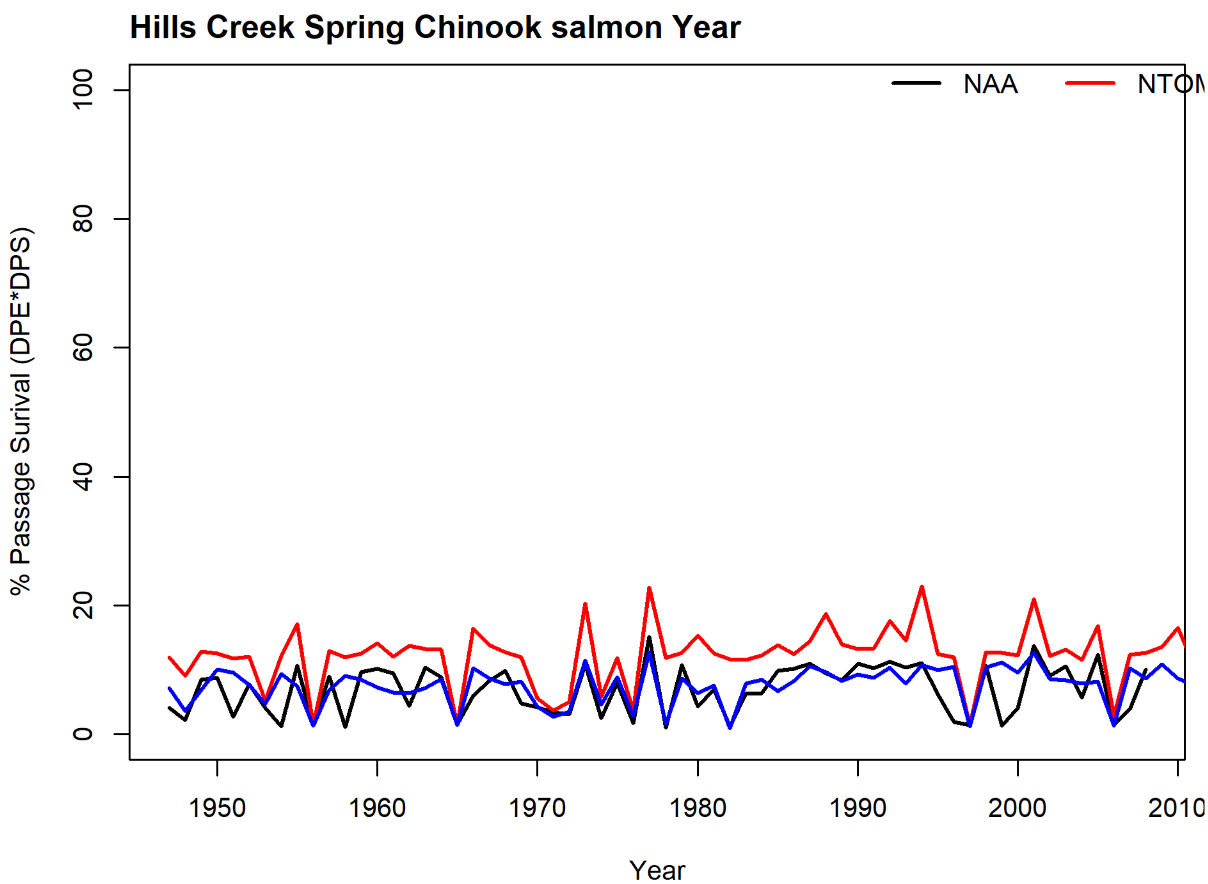

Figure 2-58 Hills Creek Juvenile Spring Chinook Yearling Downstream Passage Survival Under NAA, NTOM, and Alternative 6. Downstream dam passage survival at Hills Creek for juvenile Spring chinook yearlings under the NAA, NTOM, and Alternative 6 from the years 1948 to 2020.

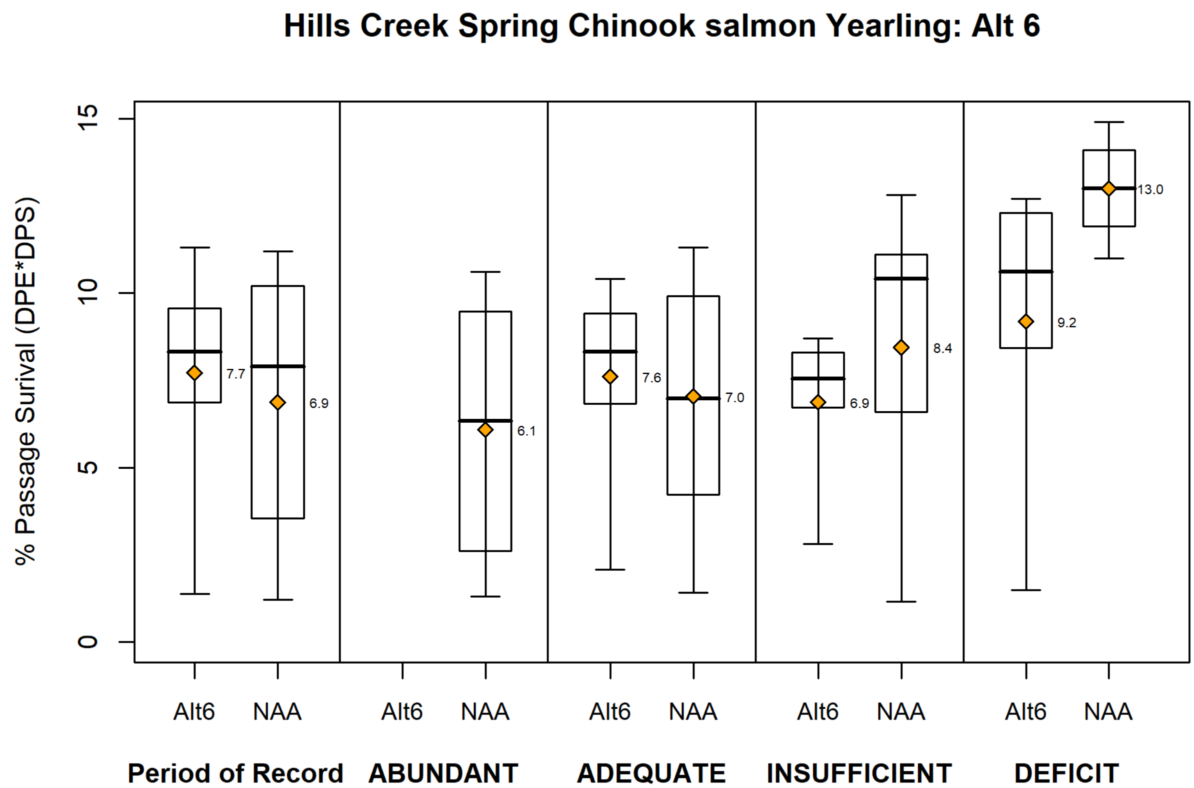

Figure 2-59 Hills Creek Juvenile Spring Chinook Yearling Downstream Passage Survival Under Alternative 6. Downstream dam passage survival at Hills Creek for juvenile Spring chinook yearlings under Alternative 6. The mean is given by the point estimate (filled dot). Survival probabilities are given for the period of record (far left), compared to abundant, adequate, insufficient, and deficit hydrologic year types denoted in each panel.

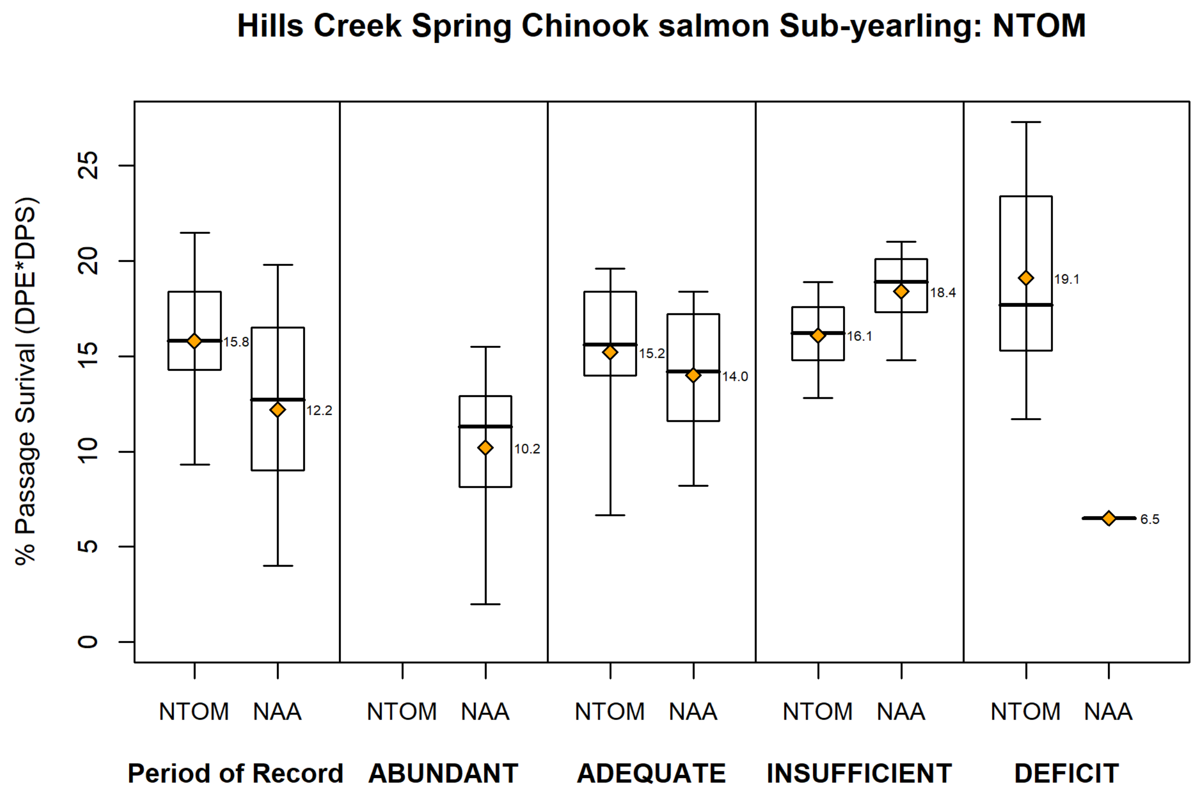

Figure 2-60 Hills Creek Juvenile Spring Chinook Sub-Yearling Downstream Passage Survival Under NTOM. Downstream dam passage survival at Hills Creek for juvenile Spring chinook sub-yearlings under NTOM. The mean is given by the point estimate (filled dot). Survival probabilities are given for the period of record (far left), compared to abundant, adequate, insufficient, and deficit hydrologic year types denoted in each panel.

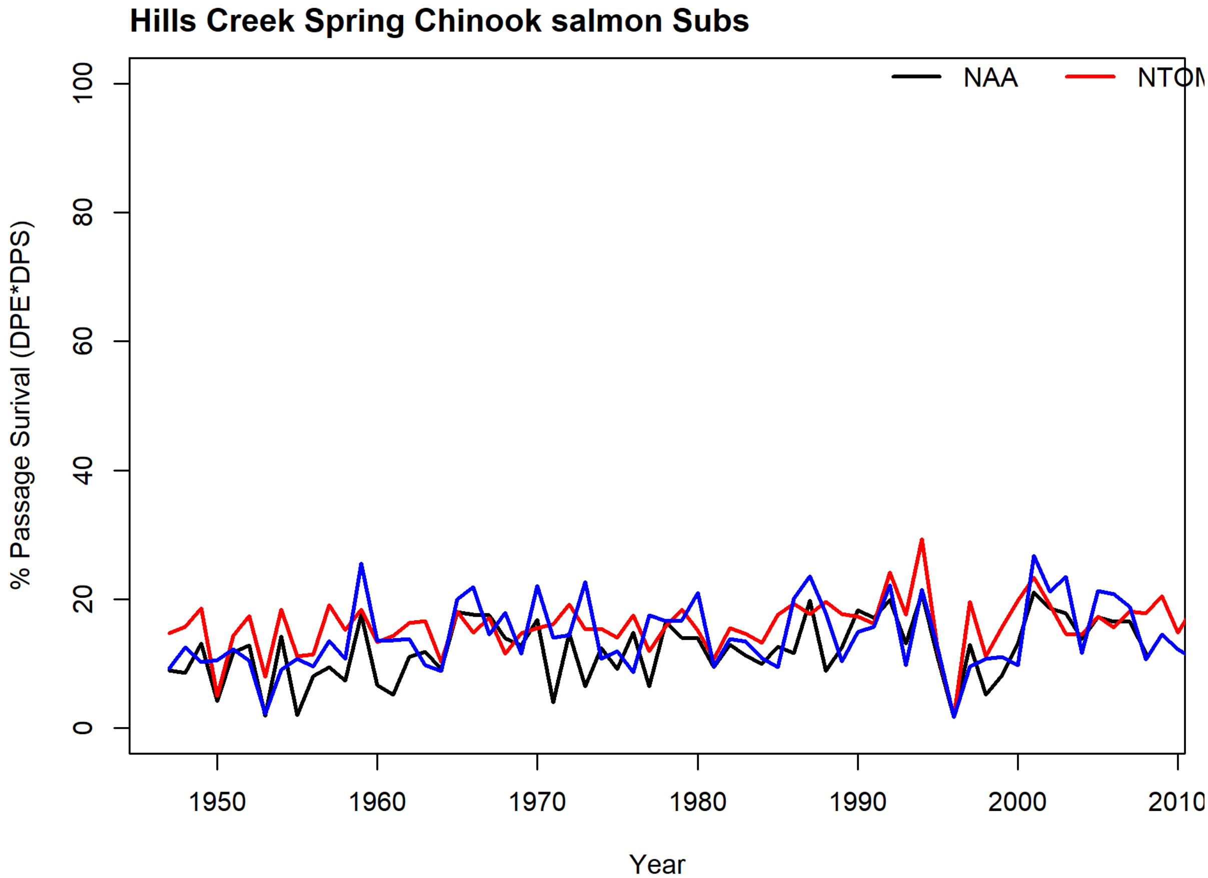

Figure 2-61 Hills Creek Juvenile Spring Chinook Sub-Yearling Downstream Passage Survival Under NAA, NTOM, and Alternative 6. Downstream dam passage survival at Hills Creek for juvenile Spring chinook sub-yearlings under the NAA, NTOM, and Alternative 6 from the years 1948 to 2020.

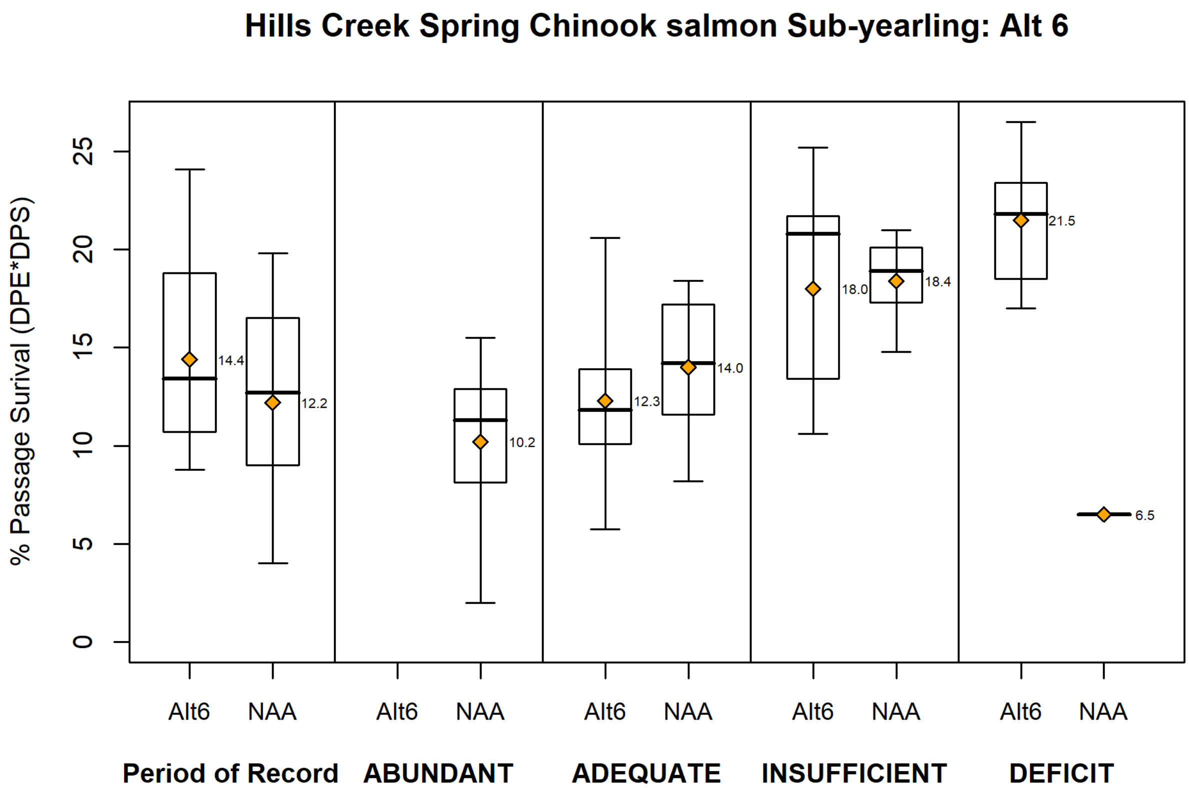

Figure 2-62 Hills Creek Juvenile Spring Chinook Sub-Yearling Downstream Passage Survival Under Alternative 6. Downstream dam passage survival at Hills Creek for juvenile Spring chinook sub-yearlings under Alternative 6. The mean is given by the point estimate (filled dot). Survival probabilities are given for the period of record (far left), compared to abundant, adequate, insufficient, and deficit hydrologic year types denoted in each panel.

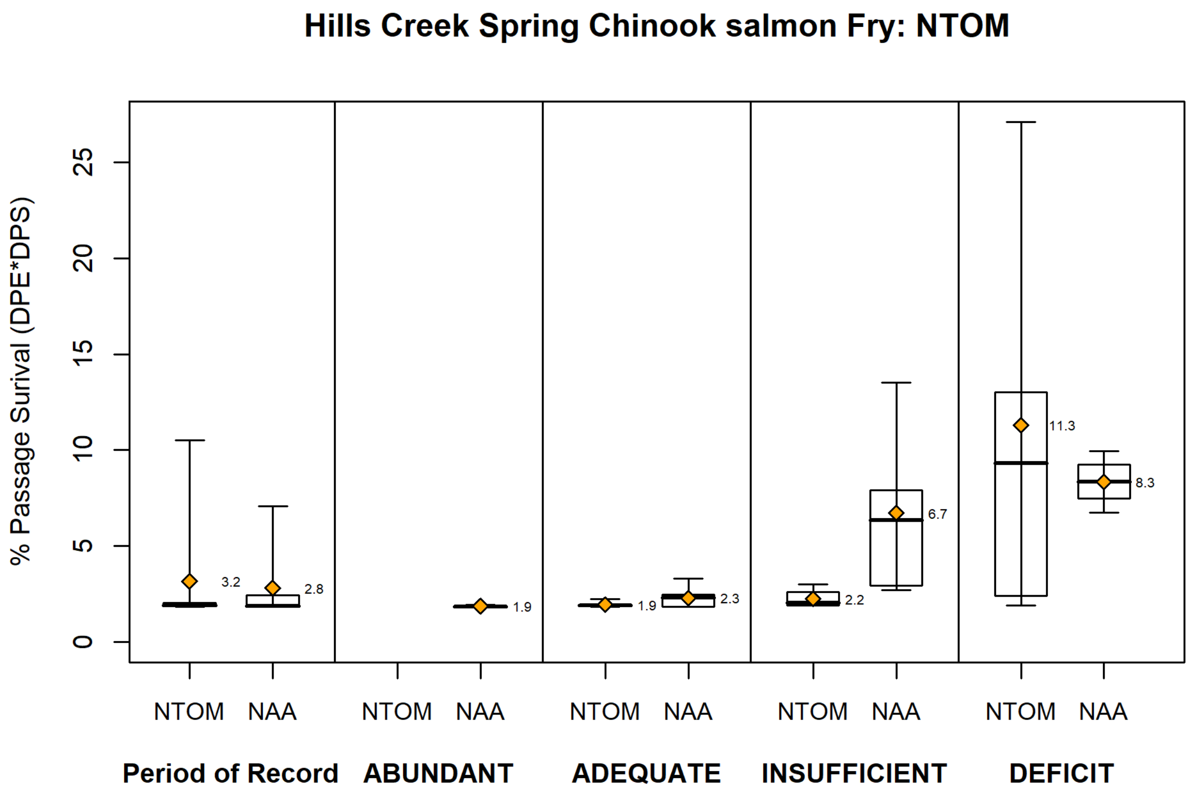

Figure 2-63 Hills Creek Juvenile Spring Chinook Fry Downstream Passage Survival Under NTOM. Downstream dam passage survival at Hills Creek for juvenile Spring chinook fry under NTOM. The mean is given by the point estimate (filled dot). Survival probabilities are given for the period of record (far left), compared to abundant, adequate, insufficient, and deficit hydrologic year types denoted in each panel.

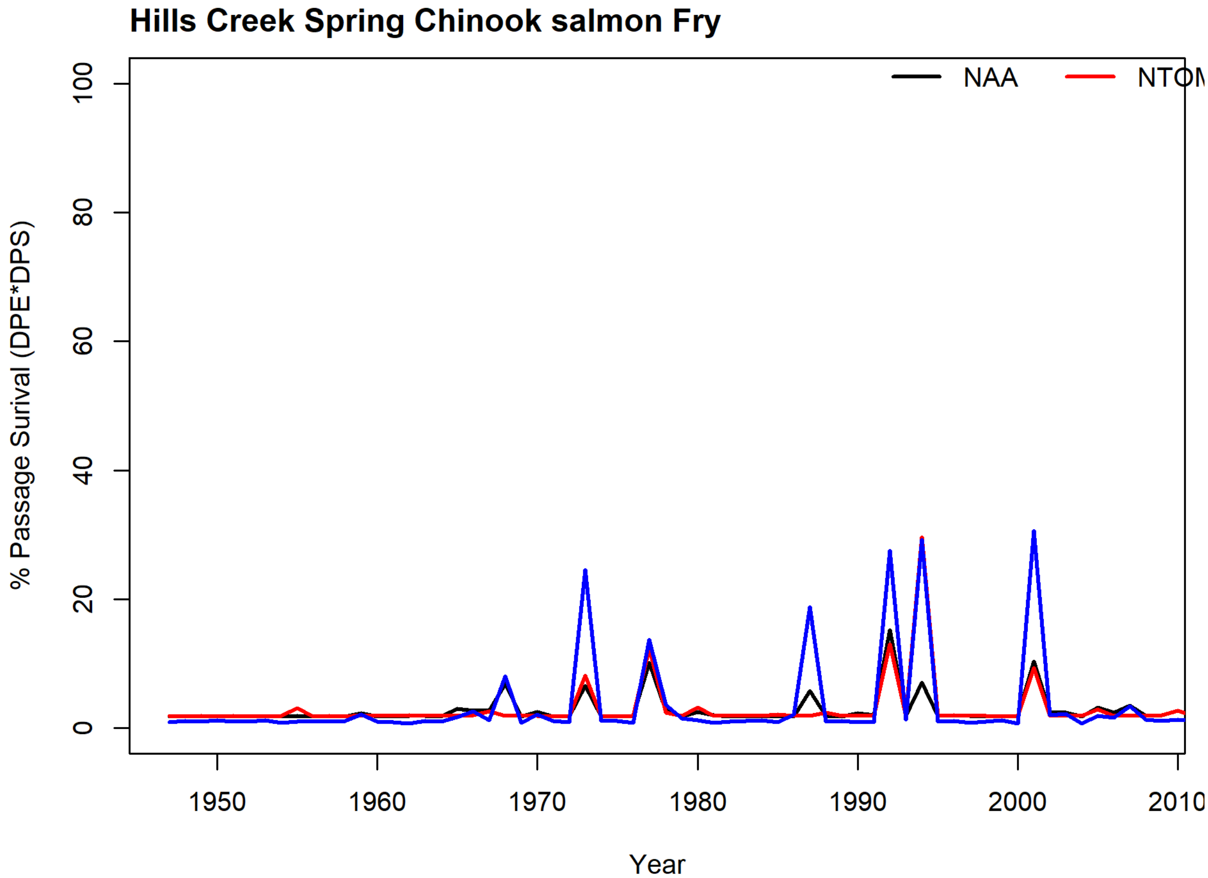

Figure 2-64 Hills Creek Juvenile Spring Chinook Fry Downstream Passage Survival Under NAA, NTOM, and Alternative 6. Downstream dam passage survival at Hills Creek for juvenile Spring chinook fry under the NAA, NTOM, and Alternative 6 from the years 1948 to 2020.

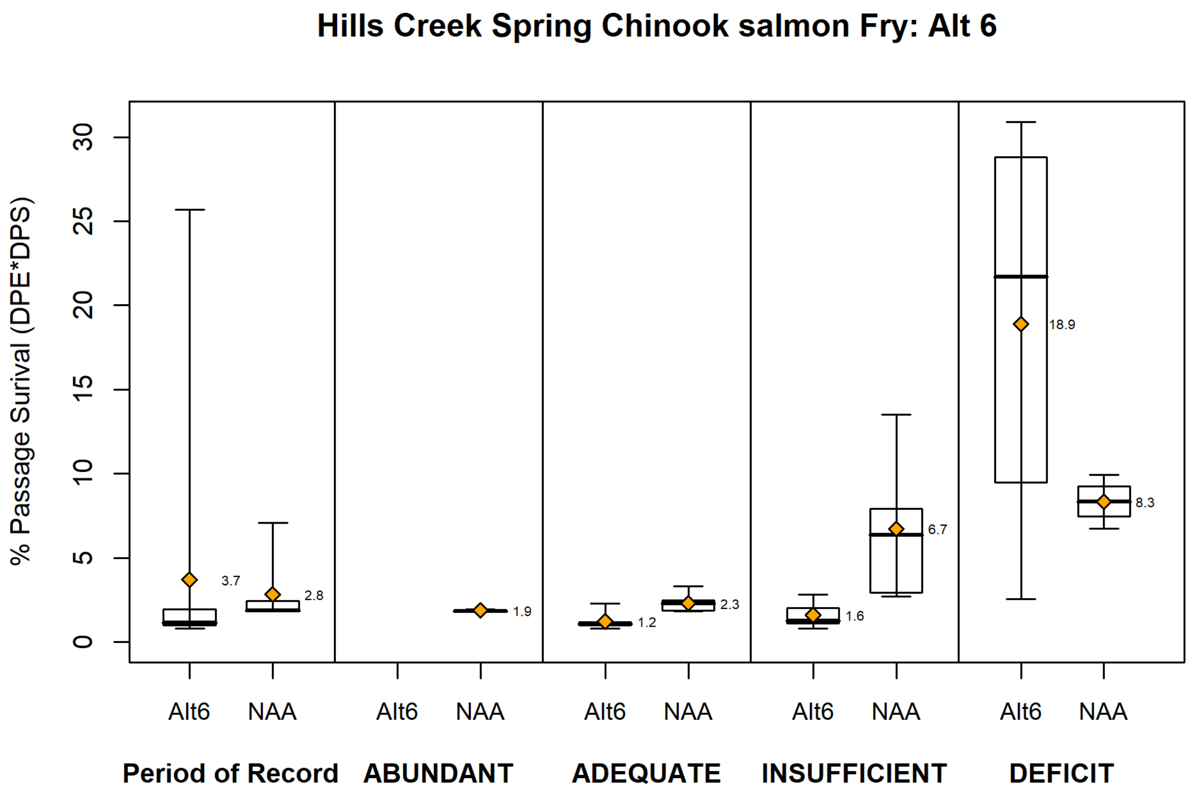

Figure 2-65 Hills Creek Juvenile Spring Chinook Fry Downstream Passage Survival Under Alternative 6. Downstream dam passage survival at Hills Creek for juvenile Spring chinook fry under Alternative 6. The mean is given by the point estimate (filled dot). Survival probabilities are given for the period of record (far left), compared to abundant, adequate, insufficient, and deficit hydrologic year types denoted in each panel.

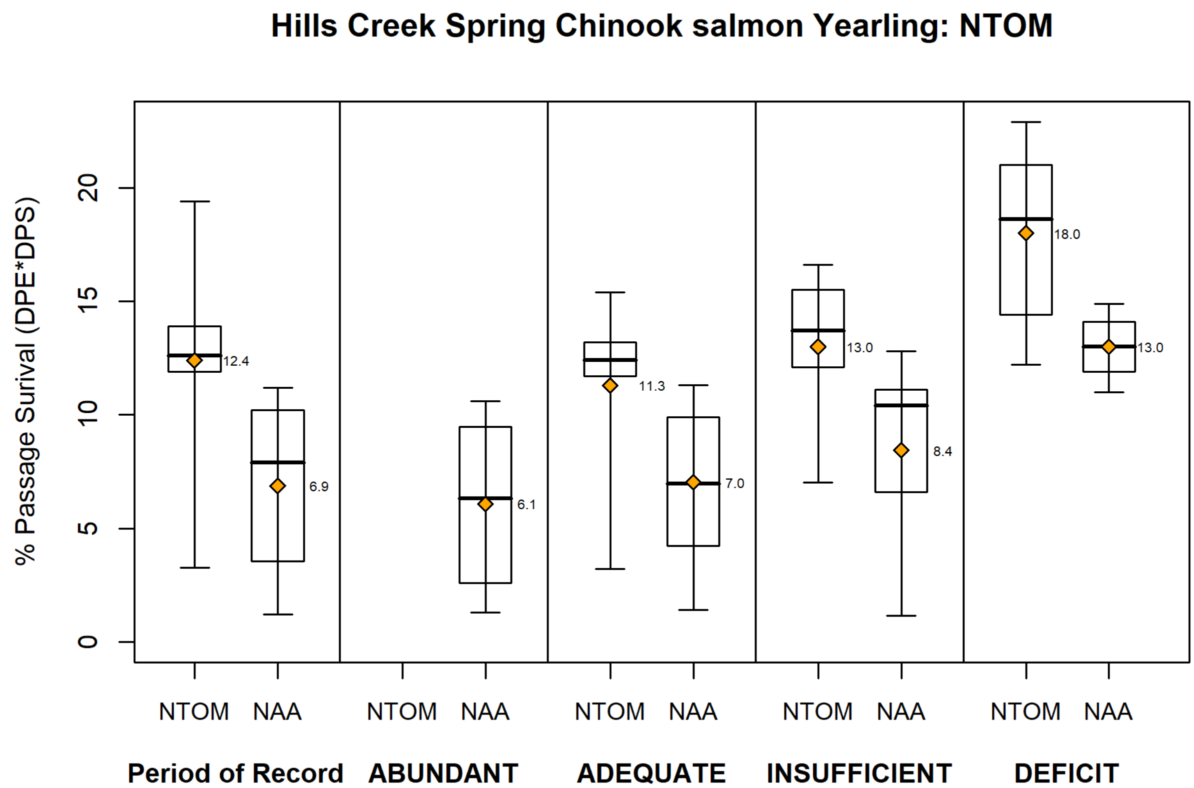

Figure 2-66 Hills Creek Juvenile Spring Chinook Yearling Downstream Passage Survival Under NTOM. Downstream dam passage survival at Hills Creek for juvenile Spring chinook yearlings under NTOM. The mean is given by the point estimate (filled dot). Survival probabilities are given for the period of record (far left), compared to abundant, adequate, insufficient, and deficit hydrologic year types denoted in each panel.

Spring Chinook Salmon – Lookout Point Dam

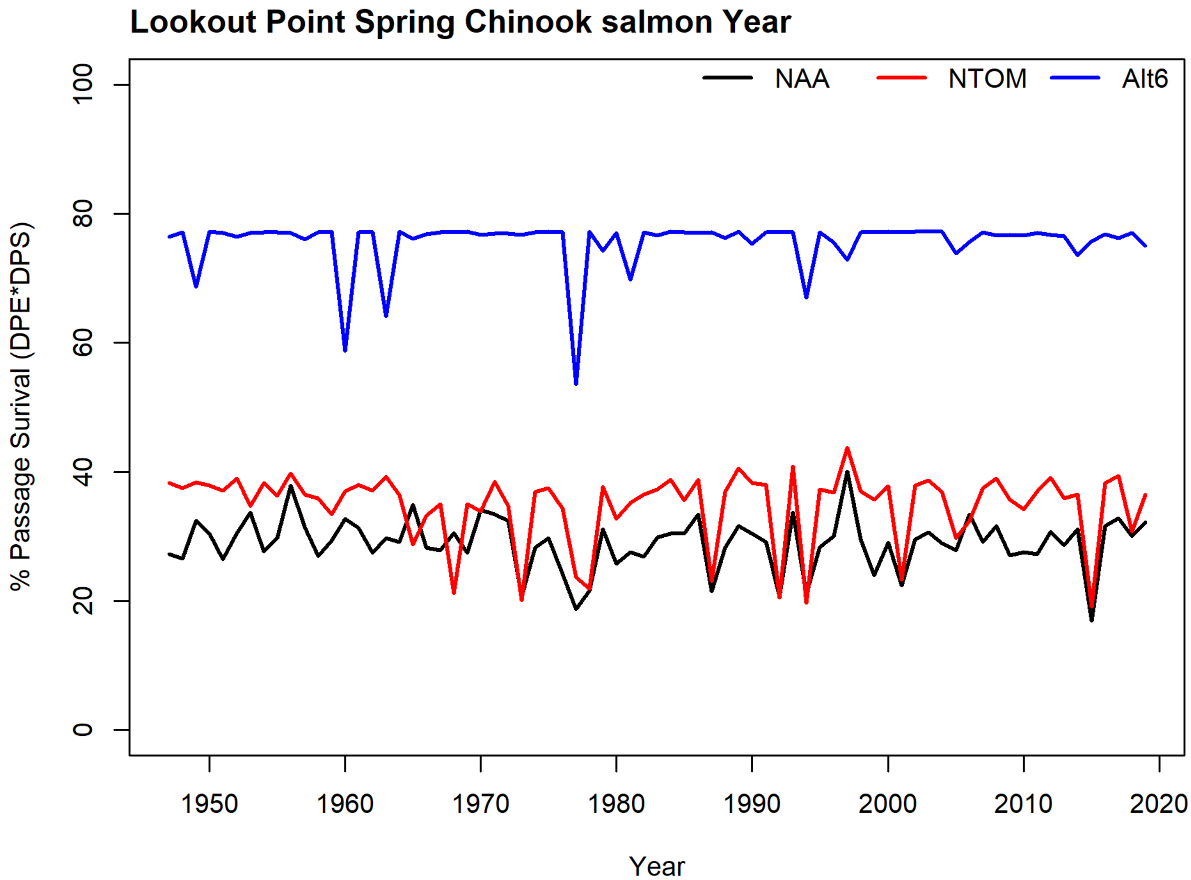

Figure 2-67 Lookout Point Juvenile Spring Chinook Yearling Downstream Passage Survival Under NAA, NTOM, and Alternative 6. Downstream dam passage survival at Lookout Point for juvenile Spring chinook yearlings under the NAA, NTOM, and Alternative 6 from the years 1948 to 2020.

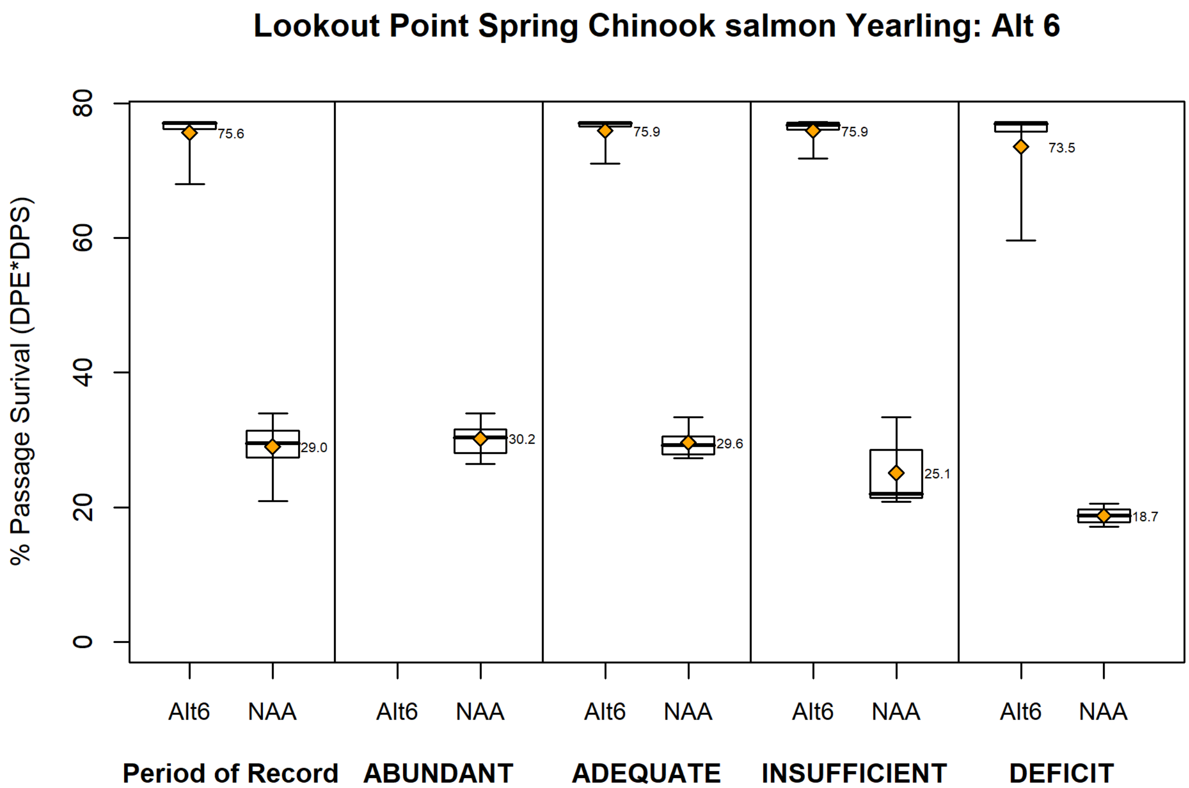

Figure 2-68 Lookout Point Juvenile Spring Chinook Yearling Downstream Passage Survival Under Alternative 6. Downstream dam passage survival at Lookout Point for juvenile Spring chinook yearlings under Alternative 6. The mean is given by the point estimate (filled dot). Survival probabilities are given for the period of record (far left), compared to abundant, adequate, insufficient, and deficit hydrologic year types denoted in each panel.

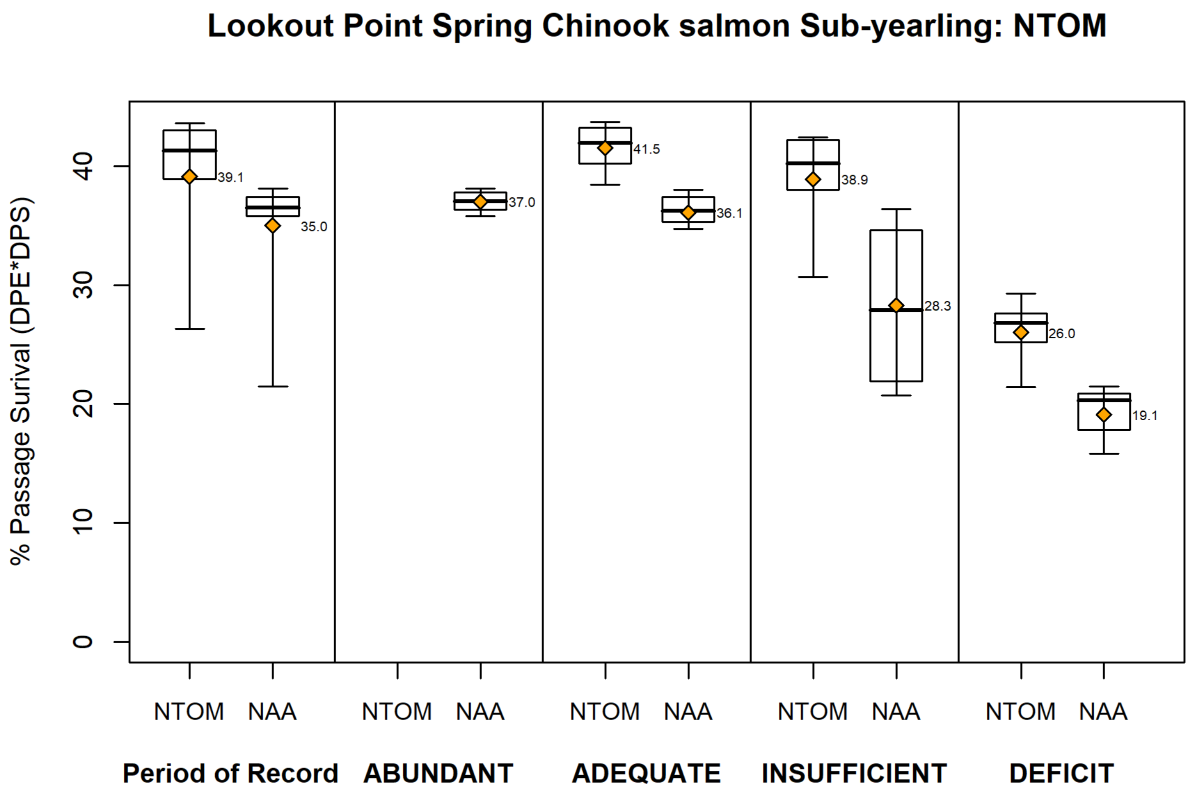

Figure 2-69 Lookout Point Juvenile Spring Chinook Sub-Yearling Downstream Passage Survival Under NTOM. Downstream dam passage survival at Lookout Point for juvenile Spring chinook sub-yearlings under NTOM. The mean is given by the point estimate (filled dot). Survival probabilities are given for the period of record (far left), compared to abundant, adequate, insufficient, and deficit hydrologic year types denoted in each panel.

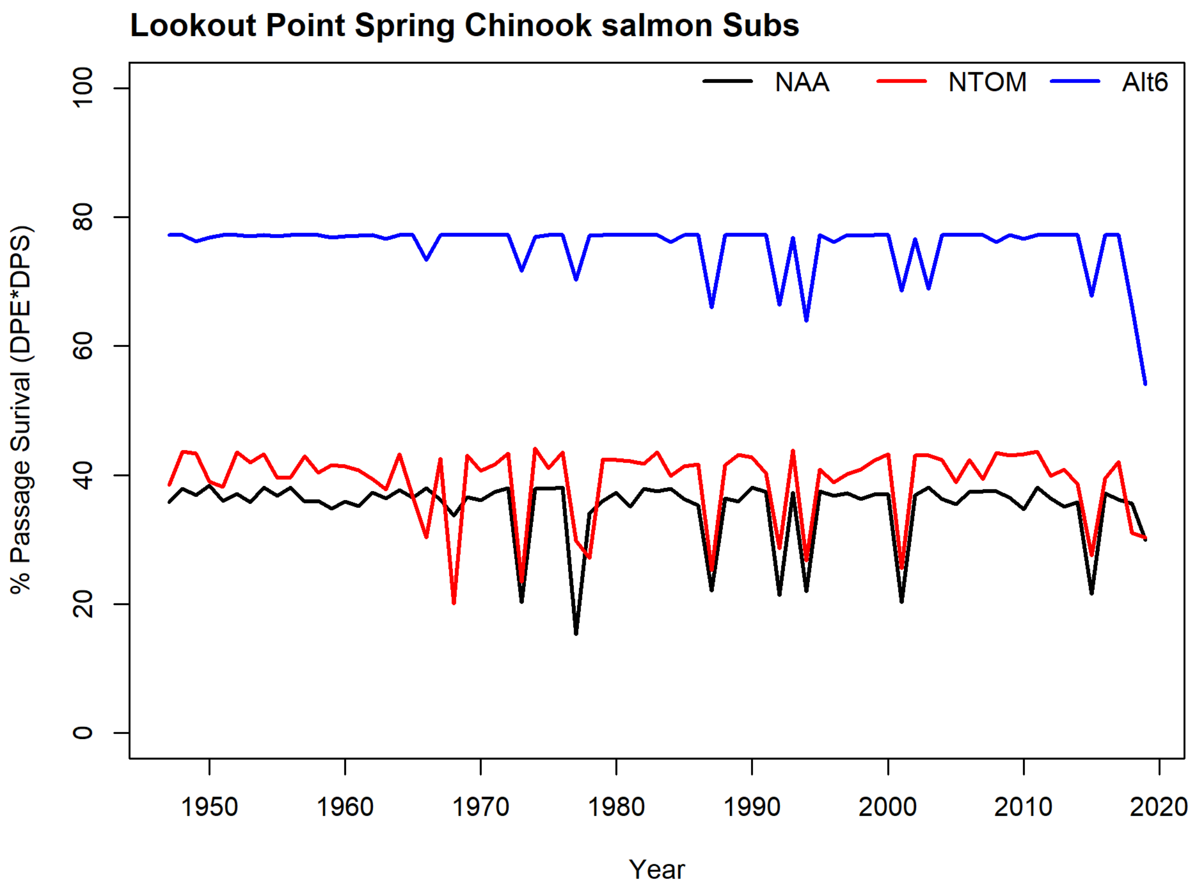

Figure 2-70 Lookout Point Juvenile Spring Chinook Sub-Yearling Downstream Passage Survival Under NAA, NTOM, and Alternative 6. Downstream dam passage survival at Lookout Point for juvenile Spring chinook sub-yearlings under the NAA, NTOM, and Alternative 6 from the years 1948 to 2020.

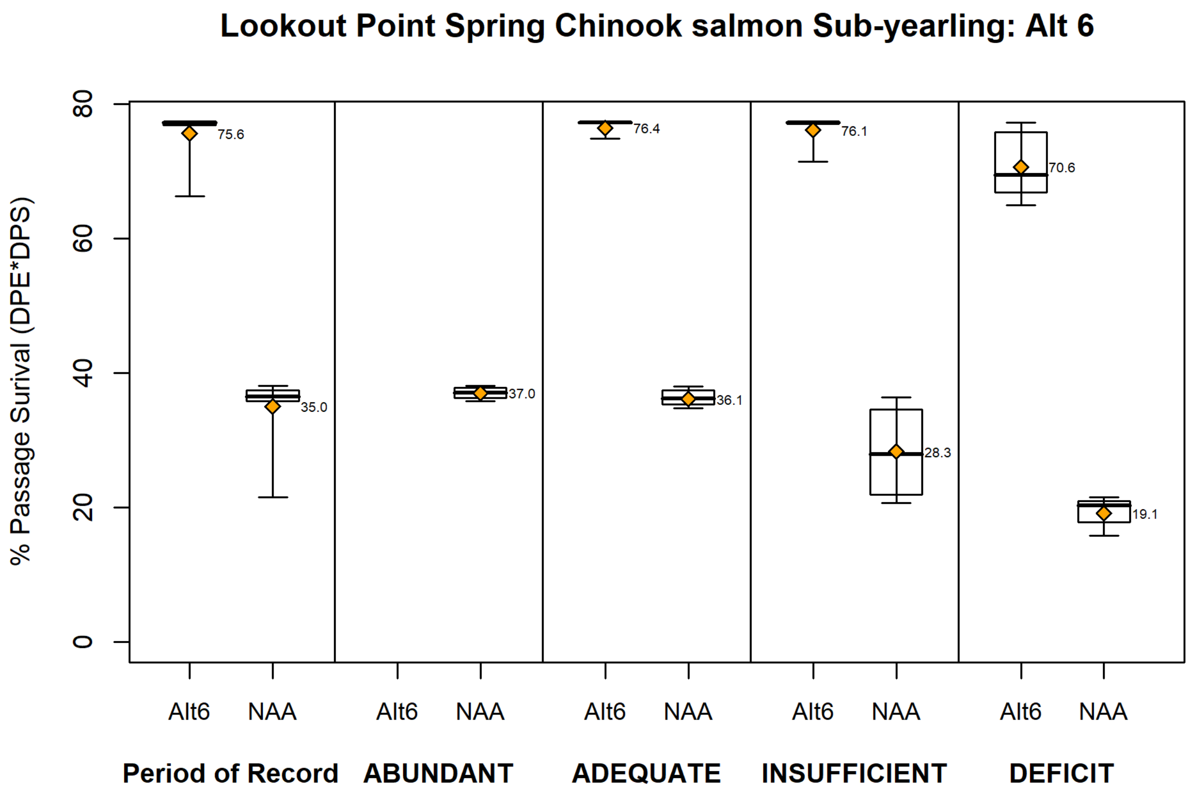

Figure 2-71 Lookout Point Juvenile Spring Chinook Sub-Yearling Downstream Passage Survival Under Alternative 6. Downstream dam passage survival at Lookout Point for juvenile Spring chinook sub-yearlings under Alternative 6. The mean is given by the point estimate (filled dot). Survival probabilities are given for the period of record (far left), compared to abundant, adequate, insufficient, and deficit hydrologic year types denoted in each panel.

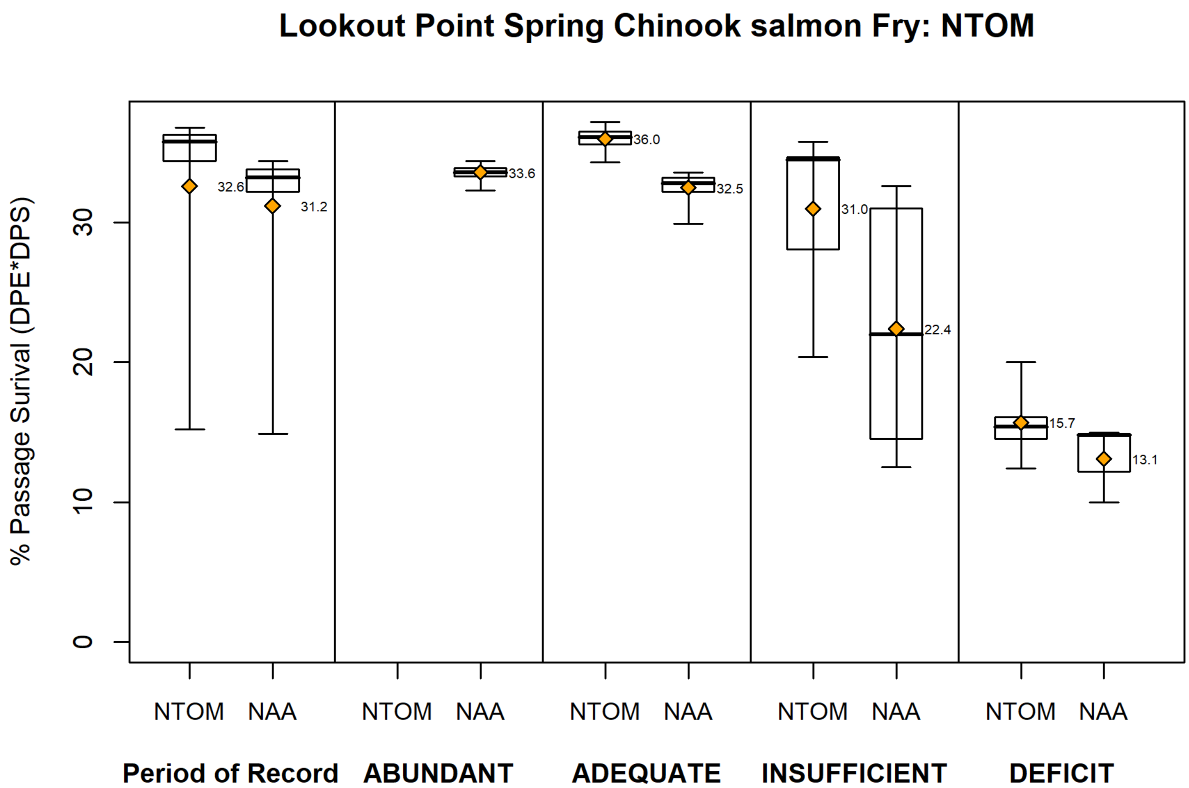

Figure 2-72 Lookout Point Juvenile Spring Chinook Fry Downstream Passage Survival Under NTOM. Downstream dam passage survival at Lookout Point for juvenile Spring chinook fry under NTOM. The mean is given by the point estimate (filled dot). Survival probabilities are given for the period of record (far left), compared to abundant, adequate, insufficient, and deficit hydrologic year types denoted in each panel.

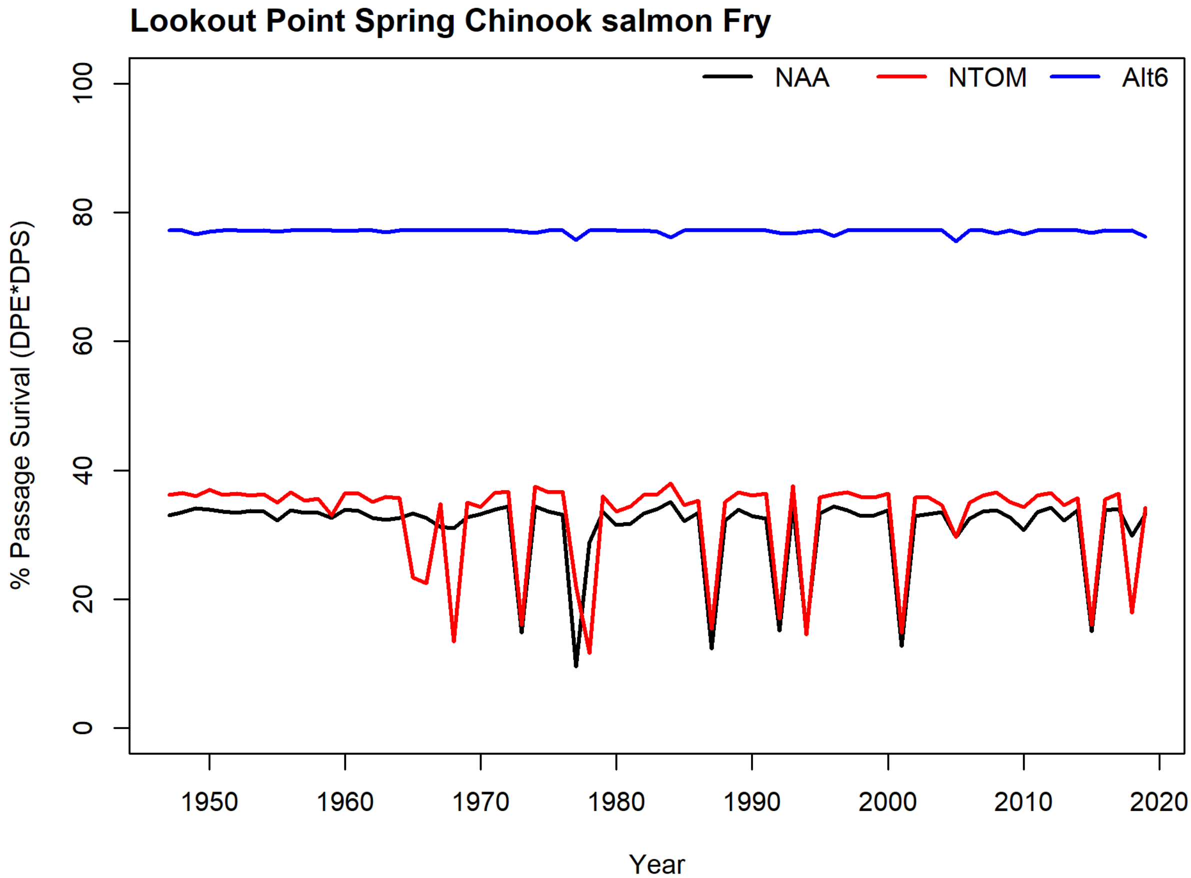

Figure 2-73 Lookout Point Juvenile Spring Chinook Fry Downstream Passage Survival Under NAA, NTOM, and Alternative 6. Downstream dam passage survival at Lookout Point for juvenile Spring chinook fry under the NAA, NTOM, and Alternative 6 from the years 1948 to 2020.

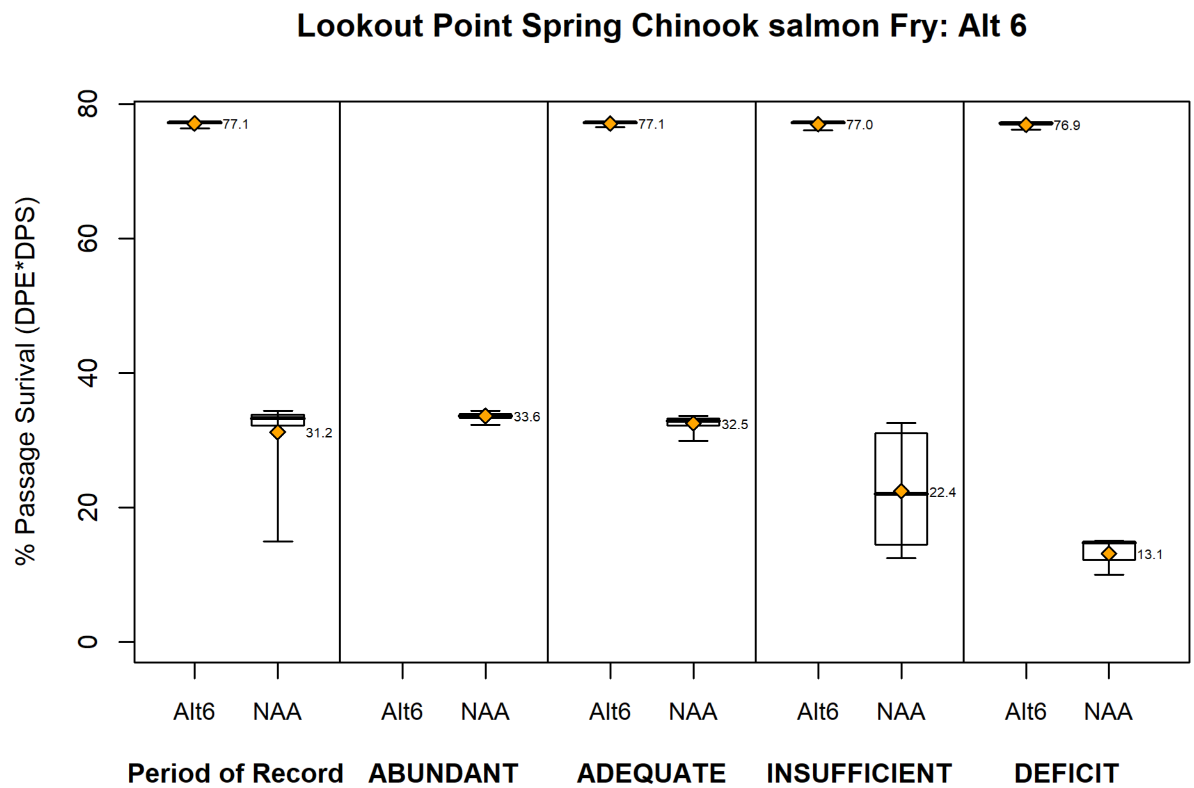

Figure 2-74 Lookout Point Juvenile Spring Chinook Fry Downstream Passage Survival Under Alternative 6. Downstream dam passage survival at Lookout Point for juvenile Spring chinook fry under Alternative 6. The mean is given by the point estimate (filled dot). Survival probabilities are given for the period of record (far left), compared to abundant, adequate, insufficient, and deficit hydrologic year types denoted in each panel.

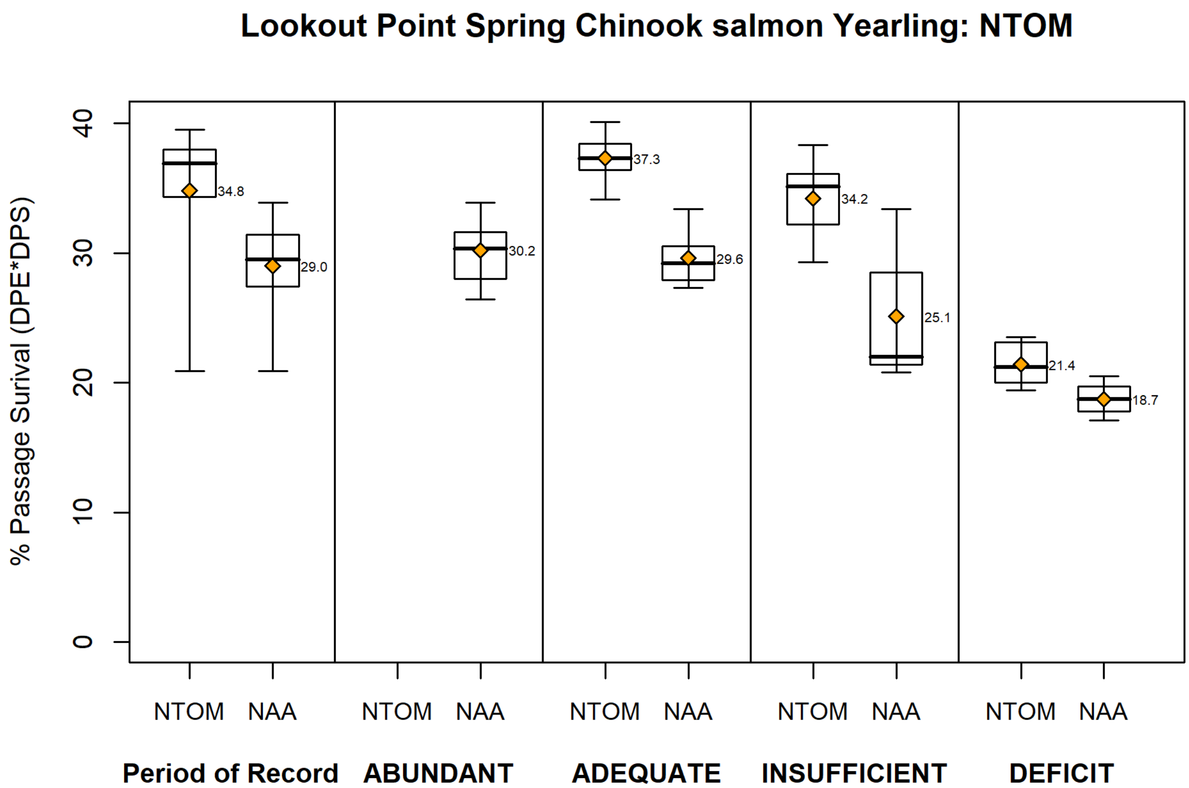

Figure 2-75 Lookout Point Juvenile Spring Chinook Yearling Downstream Passage Survival Under NTOM. Downstream dam passage survival at Lookout Point for juvenile Spring chinook yearlings under NTOM. The mean is given by the point estimate (filled dot). Survival probabilities are given for the period of record (far left), compared to abundant, adequate, insufficient, and deficit hydrologic year types denoted in each panel.