Appendix 5.E. Essential Fish Habitat Assessment

5.E Essential Fish Habitat Assessment

5.E.1 Regulatory Setting

Section 305(b) of the Magnuson-Stevens Fishery Conservation and Management Act (MSA) as amended by the Sustainable Fisheries Act of 1996 (Public Law 104-267), requires federal agencies to consult with the National Marine Fisheries Service (NMFS) on activities that may adversely affect Essential Fish Habitat (EFH) for species that are managed under federal fishery management plans for U.S. waters. Section 3 of the MSA defines EFH as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity" (16 U.S.C. Section 1802). These waters include aquatic areas and their associated physical, chemical, and biological habitat features necessary to support the entire life cycle of the species in question, and may include areas historically used by these species. Adverse effect means any impact that reduces the quality or quantity of EFH, and may include direct or indirect physical, chemical, or biological alteration of the waters or substrate and loss of (or injury to) benthic organisms, prey species and their habitat, and other ecosystem components.

The MSA also requires that NMFS designate Habitat Areas of Particular Concern (HAPCs) for each federally-managed fish species. HAPCs are subsets of EFH, which are rare, particularly susceptible to human-induced degradation, ecologically important or located in an environmentally stressed area. HAPCs are not afforded additional protection beyond that of the EFH; however, federal projects with potential adverse impacts to HAPCs will be given more scrutiny during the consultation process.

The PA constitutes a federal action requiring EFH consultation under Section 305(b) of the MSA. The PA will also require federal permitting under Section 404 of the Clean Water Act and Section 10 of the Rivers and Harbors Act. These federal actions will also require EFH consultation.

The objective of this EFH assessment is to describe potential adverse effects of the proposed project on EFH, federally-managed fish species, and the habitats upon which these species rely. This assessment also describes conservation measures proposed to avoid, minimize, or otherwise offset potential adverse effects resulting from the proposed action on EFH.

5.E.2 Proposed Action

For a full description of the Proposed Action, please see Chapter 3, *Description of the Proposed Action*.

5.E.3 EFH Species and Habitats in the Action Area

The action area occurs in habitats designated EFH for Pacific salmon, which includes Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and Central Valley fall-/late fall–run Chinook salmon. The action area is also designated as EFH for northern anchovy (Coastal Pelagic Species) and starry flounder, brown rockfish, and English sole (Pacific Coast Groundfish Species).

EFH is defined as those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity. For the purpose of interpreting the definition of EFH, “waters” include aquatic areas and their associated physical, chemical, and biological properties that are used by fish, and may include areas historically used by fish where appropriate; “substrate” includes sediment, hard bottom, structures underlying the waters, and associated biological communities; “necessary” means habitat required to support a sustainable fishery and a healthy ecosystem; and “spawning, breeding, feeding, or growth to maturity” covers a species full life cycle. The following components of EFH must be adequate for spawning, rearing, and migration:

- Substrate composition
- Water quality
- Water quantity, depth and velocity
- Depth and Velocity
- Channel gradient and stability
- Food
- Cover and habitat complexity
- Space
- Access and passage
- Habitat connectivity

The project effects on spring and winter-run Chinook salmon, which are listed under the ESA, and their designated critical habitat is described in Chapter 5, *Effects Analysis for Chinook Salmon, California Central Valley Steelhead, Green Sturgeon, and Southern Resident Killer Whale*. Similar to the NMFS (2009) SWP/CVP BiOp, these effects generally define the effects of the action on EFH relative to these ESUs. The following assessment with respect to Pacific Salmon EFH focuses on Central Valley fall/late fall-run Chinook salmon, which are not listed but covered under the MSA. The final conclusions for effects to Pacific Salmon EFH consider the effects to all ESUs as necessary.

Brown rockfish and English sole are found as far landward as Suisun Bay and English sole are rarely caught in the West Delta (only in the drought years of 1989 and 1991 [Baxter et al. 1999]). Brown rockfish have been captured only once in Suisun Bay in 1984 and in very low catch-per-unit effort (CPUE) (Baxter et al. 1999). In plots of CPUE for English sole Baxter et al. (1999) showed only trace CPUE in both the West Delta and in Suisun Bay as compared to other embayments within the San Francisco Estuary from 1980-1995. Because these areas are on the extreme margins of these species range and because the PA would only negligibly affect, if at all, conditions in their main ranges (Table 5E-1), it was concluded that there would be no effect on the EFH for these species (Table 5.E-1.). No further analysis was conducted for these species.

Table 5.E-1. Mean Monthly Modeled Salinity (ppt) at Martinez and Differences (Percent Differences) between NAA and PA

Month	WYT	NAA	PA	PA vs. NAA	
Jan	W	2.5	2.6	0.1	(4.0)
	AN	4.9	4.9	0.0	(0.0)
	BN	10.4	9.7	-0.7	(-6.7)
	D	11.6	11.3	-0.3	(-2.6)
	C	13.2	13.2	0.0	(0.0)
	All	8.5	8.3	-0.2	(-2.3)
Feb	W	1.5	1.2	-0.4	(-20.0)
	AN	2.4	2.4	0.0	(0.0)
	BN	6.0	5.8	-0.3	(-3.3)
	D	7.4	7.5	0.1	(1.3)
	C	10.5	10.7	0.2	(1.9)
	All	5.6	5.5	-0.1	(-1.8)
Mar	W	1.6	1.7	0.1	(6.3)
	AN	2.6	2.3	-0.3	(-11.5)
	BN	7.0	7.2	0.2	(2.9)
	D	6.3	7.0	0.7	(11.1)
	C	9.9	10.2	0.3	(3.0)
	All	5.5	5.7	0.2	(3.6)
Apr	W	2.4	2.4	0.0	(0.0)
	AN	3.9	3.8	-0.1	(-2.6)
	BN	7.9	8.0	0.1	(1.3)
	D	7.6	7.9	0.3	(3.9)
	C	11.1	11.2	0.1	(0.9)
	All	6.6	6.7	0.1	(1.5)
May	W	3.5	3.5	0.0	(0.0)
	AN	6.2	6.1	-0.1	(-1.6)
	BN	9.2	9.2	0.0	(0.0)
	D	9.8	9.7	-0.1	(-1.0)
	C	12.7	12.7	0.0	(0.0)
	All	8.3	8.2	0.0	(-1.2)
Jun	W	6.9	6.9	0.0	(0.0)
	AN	10.2	10.1	-0.1	(-1.0)
	BN	11.7	11.6	-0.1	(-0.8)
	D	12.1	12.0	-0.1	(-0.8)
	C	14.0	14.0	0.0	(0.0)
	All	11.0	10.9	-0.1	(-0.9)
Jul	W	10.3	10.8	0.5	(4.8)
	AN	11.7	12.5	0.8	(6.8)
	BN	13.0	13.4	0.4	(3.1)
	D	14.1	14.1	0.0	(0.0)
	C	15.3	15.4	0.1	(0.7)
	All	12.9	13.2	0.4	(2.3)

Month	WYT	NAA	PA	PA vs. NAA	
Aug	W	13.3	13.8	0.5	(3.8)
	AN	13.5	14.2	0.7	(5.2)
	BN	14.3	14.9	0.6	(4.2)
	D	14.9	15.5	0.6	(4.0)
	C	16.1	16.3	0.2	(1.2)
	All	14.4	14.9	0.5	(3.5)
Sep	W	10.3	10.4	0.1	(1.0)
	AN	13.0	13.1	0.1	(0.8)
	BN	15.5	15.9	0.4	(2.6)
	D	16.0	16.3	0.3	(1.9)
	C	16.5	16.7	0.2	(1.2)
	All	14.3	14.5	0.2	(1.4)
Oct	W	9.7	9.7	0.0	(0.0)
	AN	12.6	12.3	-0.3	(-2.4)
	BN	15.3	14.8	-0.5	(-3.3)
	D	16.2	15.8	-0.4	(-2.5)
	C	16.7	16.5	-0.2	(-1.2)
	All	14.1	13.8	-0.3	(-2.1)
Nov	W	9.1	9.2	0.1	(1.1)
	AN	11.6	11.6	0.0	(0.0)
	BN	14.9	14.4	-0.5	(-3.4)
	D	14.7	14.1	-0.6	(-4.1)
	C	16.8	16.4	-0.4	(-2.4)
	All	13.4	13.1	-0.3	(-2.2)
Dec	W	8.3	8.4	0.1	(1.2)
	AN	10.1	10.2	0.1	(1.0)
	BN	11.7	11.9	0.2	(1.7)
	D	10.4	10.4	0.0	(0.0)
	C	15.5	15.4	-0.1	(-0.6)
	All	11.2	11.3	0.1	(0.9)

Because Central Valley fall-/late fall–run Chinook salmon, northern anchovy and starry flounder are not listed under ESA, but are covered under the Magnuson-Stevens Act, their status, distribution, life history, and habitat requirements are reviewed below.

5.E.4 Description of Potentially Affected Species

5.E.4.1 Coastal Pelagic Species

5.E.4.1.1 Coastal Pelagic Species EFH in the Action Area

Coastal pelagic EFH species (northern anchovy, sardines, and jack mackerel) occurring in the action area are restricted to the estuarine and marine habitat types between Chipps Island in the west Delta and the Golden Gate Bridge. The overall extent of Coastal Pelagic EFH is based on a thermal range bordered by the geographic area where Coastal Pelagic Species occur at any life stage, where Coastal Pelagic Species have occurred historically during periods of similar environmental conditions, or where environmental conditions do not preclude colonization by Coastal Pelagic Species. Species diversity and abundance declines on an upstream gradient as determined by the tolerance of individual species for low and variable salinity conditions. Northern anchovy are the most widespread coastal pelagic species in the action area, occurring in all estuarine and marine habitats between Chipps Island and the Golden Gate Bridge. With the exception of active spawning and egg incubation in the Suisun Bay and Carquinez Strait, all life history stages are likely to be occur throughout this component of the action area. In contrast, sardines and jack mackerel are known to occur in the action area, but are present only as mature juveniles and adults at relatively low abundance and are restricted to habitats with higher salinity.

5.E.4.1.2 Northern Anchovy Status and Distribution

Northern anchovy are distributed along the West Coast from British Columbia to Baja, California (Miller and Lea 1972). The Central subpopulation, which is present in the project area, ranges from approximately San Francisco, California, to Punta Baja, Baja California. Members of the central population move north during the summer and south during the winter (Haugen and others 1969). The northern anchovy is the most abundant species in the estuary and is an important forage fish for other resident and migratory species in the system, including salmon, jacksmelt, and striped bass. It supports a moderate commercial fishery for live bait (Smith and Kato 1979). The annual abundance of northern anchovy is highly variable between years (Figure 5.E-1). The greatest densities occurred in Central, San Pablo, and South bays. Only in late summer were they collected in appreciable numbers in Suisun Bay (Figure 5.E-2).

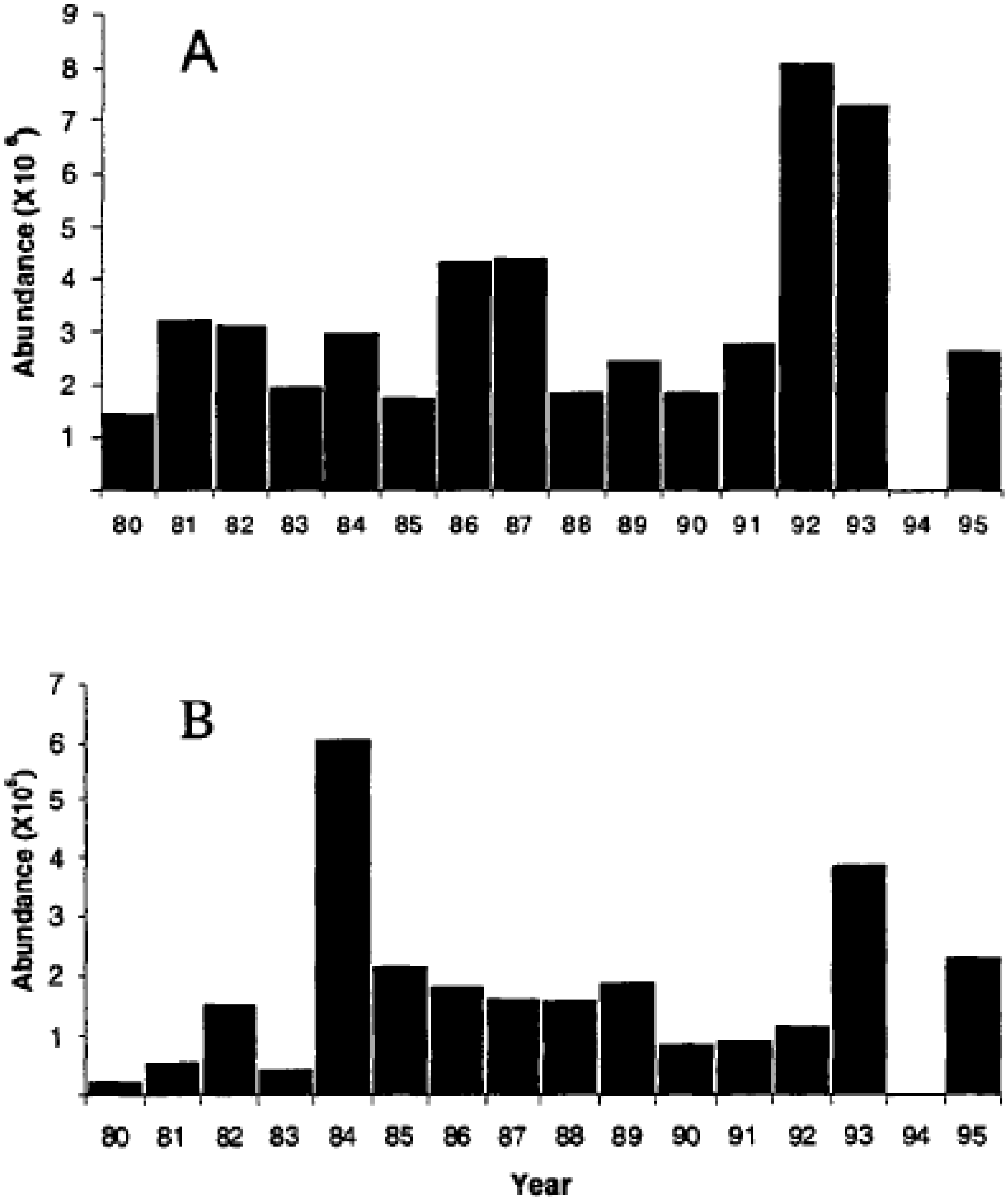

Figure 5.E-1. Annual abundance of northern anchovy: (A) age 0 and (B) age 1+, No abundance index was calculated for 1994 (From Baxter et al. 1999).

Similarly for age 1+ northern anchovy had a similar annual distribution but unlike age-0 fish, the South Bay CPUE of age-l+ fish tended to be greater than the CPUE in San Pablo Bay, especially after 1984.

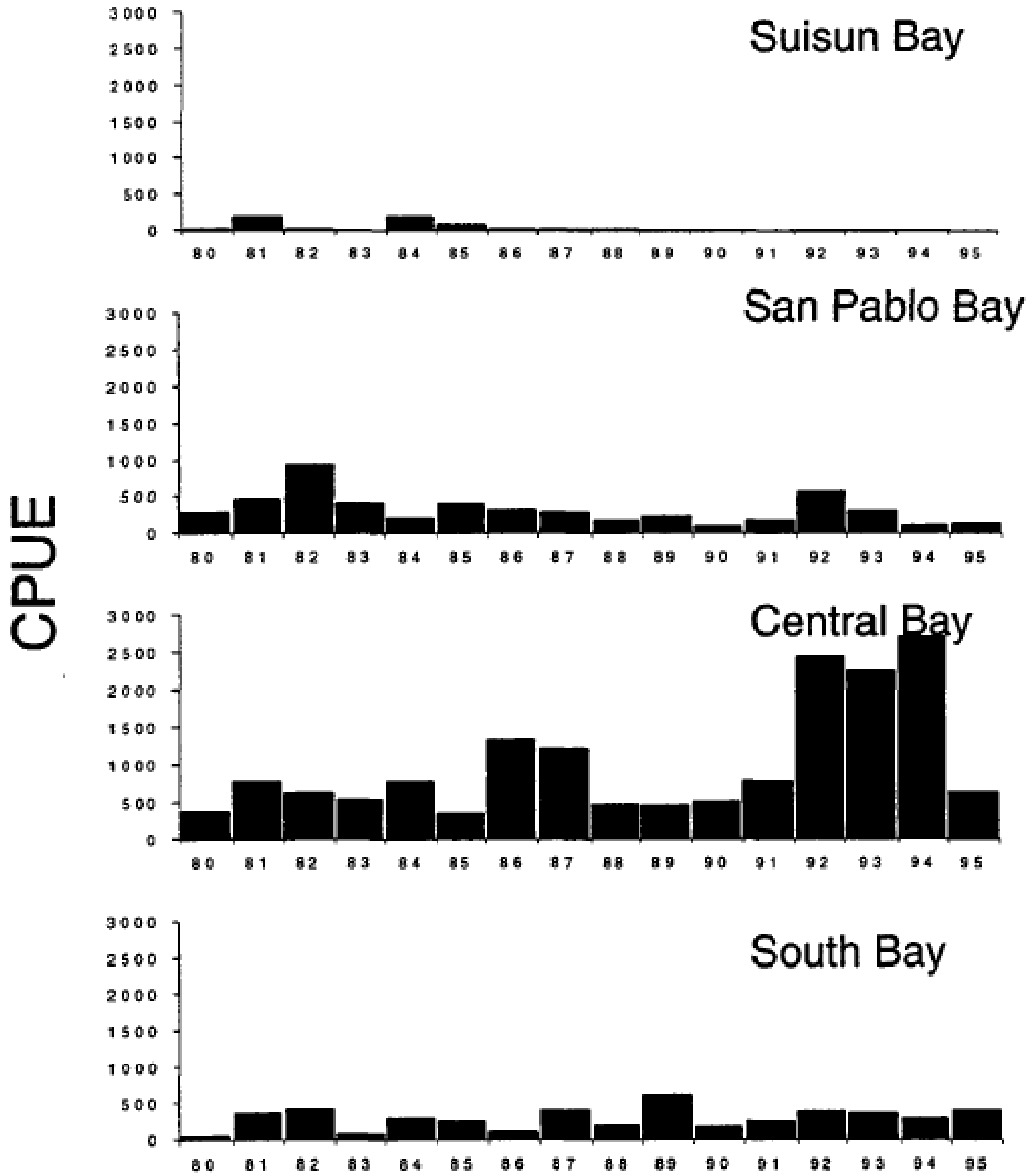

Figure 5.E-2. Catch-per-unit-effort of age 0 northern anchovy by San Francisco Embayment 1980-1995 (From Baxter et al. 1999).

5.E.4.1.3 Northern Anchovy Life History

Northern anchovy is a small, short-lived fish typically found in schools near the surface of the water. They are short lived, rarely living past 4 years of age. A portion of the population reaches maturity at the end of their first year, with about 50% by the end of their second year and all are mature by their third or fourth year (Clark and Phillips 1952). Female anchovy are batch spawners, spawning 20 to 30 thousand eggs a year in 2 or three events (Baxter 1967). Spawning can occur during every month of the year and is temperature dependent, increasing in late winter and early spring and peaking from February to April. They spawn in nearshore areas across their entire range, in the upper 50 meters of the water column. Spawning in the bay occurs at higher temperatures and lower salinities than spawning in coastal areas (McCrae 1994, Bergen and Jacobson 2001). Both northern anchovy eggs and larvae are found near the surface, and eggs need 2 to 4 days to hatch, depending on water temperatures. The San Francisco Bay is a very productive nursery area because of high abundance of food for both larvae and adults, advective losses are lower than in adjacent coastal waters, and the bay is warmer, with varying salinity allowing for eggs and larvae throughout the year (U.S. Bureau of Reclamation 2008). Anchovies feed diurnally either by filter feeding or biting, depending on the size of the food. Juvenile and adult anchovy feed at a higher trophic level than larvae, selectively feeding on larger zooplankton (mysids), fish eggs and fish larvae and have been observed to eat small fish at times, even their own (Baxter 1967).

Larvae eat phytoplankton and dinoflagellates, while larger larvae pick up copepods and other zooplankton. Larger female anchovies can consume up to 4–5 percent of their total body weight per day. Competitors with the anchovy for food include sardines and other schooling planktivores, such as jacksmelt and topsmelt. These species are also potential predators on young anchovy life stages (Goals Project 2000). All life stages of the northern anchovy are important prey for virtually every predatory fish, bird, and mammal in San Francisco Bay, including California halibut, Chinook, rockfishes, sharks, harbor seal, sea lions, brown pelican, sooty shearwater, and cormorants.

5.E.4.1.4 Factors Affecting Northern Anchovy Abundance

Factors affecting anchovy production are mostly natural influences, such as ocean temperature (CDFG 2001). Offshore within the California current, temperature, upwelling, and stable stratification of the water column are believed to work together to produce conditions that are favorable to anchovy larvae (Lasker 1975). In San Francisco Bay it is thought that salinity, or freshwater outflow variability may influence conditions. In North San Francisco Bay, conditions have become less than optimal due to the grazing of the overbite clam upon food sources of larval and adult anchovy (Kimmerer 2006).

5.E.4.2 Pacific Coast Groundfish

5.E.4.2.1 Pacific Coast Groundfish EFH in the Action Area

Pacific Groundfish species occur primarily in higher salinity areas. Species abundance and diversity declines on an upstream gradient as salinity levels decrease, restricting the upstream distribution of most Pacific Groundfish species to Sanv Pablo and Central Bays (Baxter et al

1999). A handful of Pacific Groundfish species, including starry flounder, English sole, and brown rockfish, are tolerant of lower and more variable salinity conditions as juveniles and adults. Those species are known to occur as at least as far upstream as Suisun Bay and Carquinez Strait. The overall extent of Pacific Groundfish EFH includes all water and substrate in depths that are less than or equal to 11,483 feet (3,500 meters or 1,914 fathoms) to the mean higher high water level (MHHW) or the upriver extent of saltwater intrusion (upstream area and landward where waters have salinities less than 0.5 ppt), known spawning habitat and thermal refugia, complex channels and floodplains and areas containing estuarine and marine submerged aquatic vegetation.

Pacific Coast groundfish EFH in the action area is known to support one species, the starry flounder, which occurs within the designated Estuaries Habitat Area of Particular Concern (HAPC), either in the water column (as eggs) or over/on gravel, mud, sand, or mixed mud/sand substrates as juveniles/adults (Appendix B.3 of the Groundfish Fishery Management Plan; Pacific Fishery Management Council 2014).

5.E.4.2.2 Starry Flounder Status and Distribution

The starry flounder is a flatfish that belongs to the family Pleuronectidae (Moyle 2002). Starry flounder range from north of the Bering Strait south to Los Angeles Harbor. Older juveniles and adults are found from 120 kilometers (km) upstream to the outer continental shelf at 375 meter depth, but most adults are found at less than 150 meter depth. Most juvenile fish are found in shallow, fresh to brackish water, and shift to salinities of 10–15 ppt as they mature, but appear to remain within estuaries through at least their 2nd year (Baxter et al. 1999; Moyle 2002).During the late fall and winter, mature starry flounder probably migrate to shallow coastal waters to spawn (Orcutt 1950). Adults primarily inhabit coastal marine waters (Orcutt 1950, Haertel and Osterberg 1967, Bottom and others 1984, Hieb and Baxter 1993). Distribution of age–0 juveniles within the Bay-Delta is primarily in Suisun Bay and San Pablo Bay, with lower abundance in the West Delta (Figure 5.E-3). Older (age-1+) starry flounder occur principally in San Pablo Bay, Suisun Bay, and Central Bay (Figure 5.E-4).

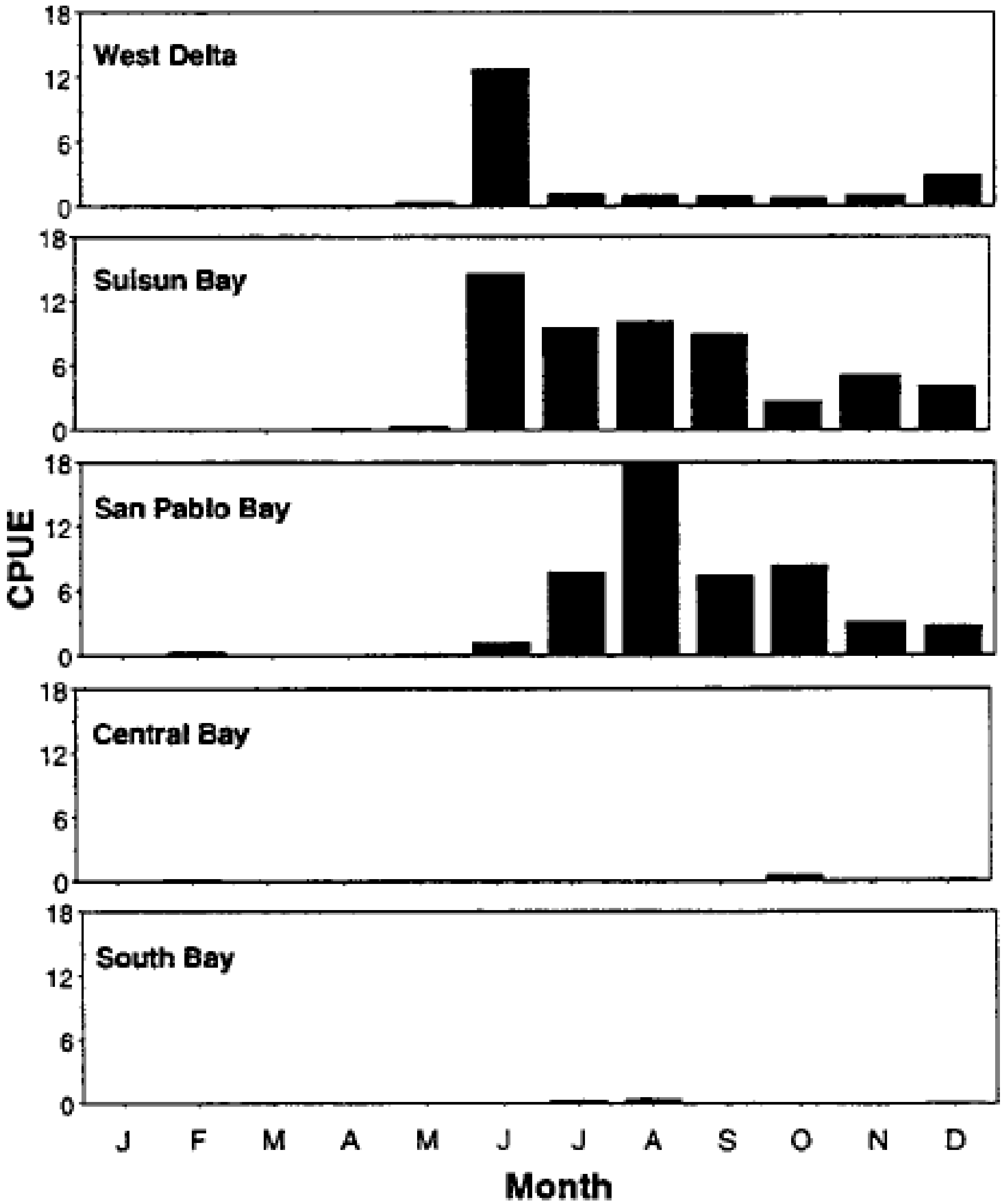

Figure 5.E-3. Catch-per-unit-effort of Age-0 Starry Flounder by San Francisco Embayment 1980-1995 (From Baxter et al. 1999).

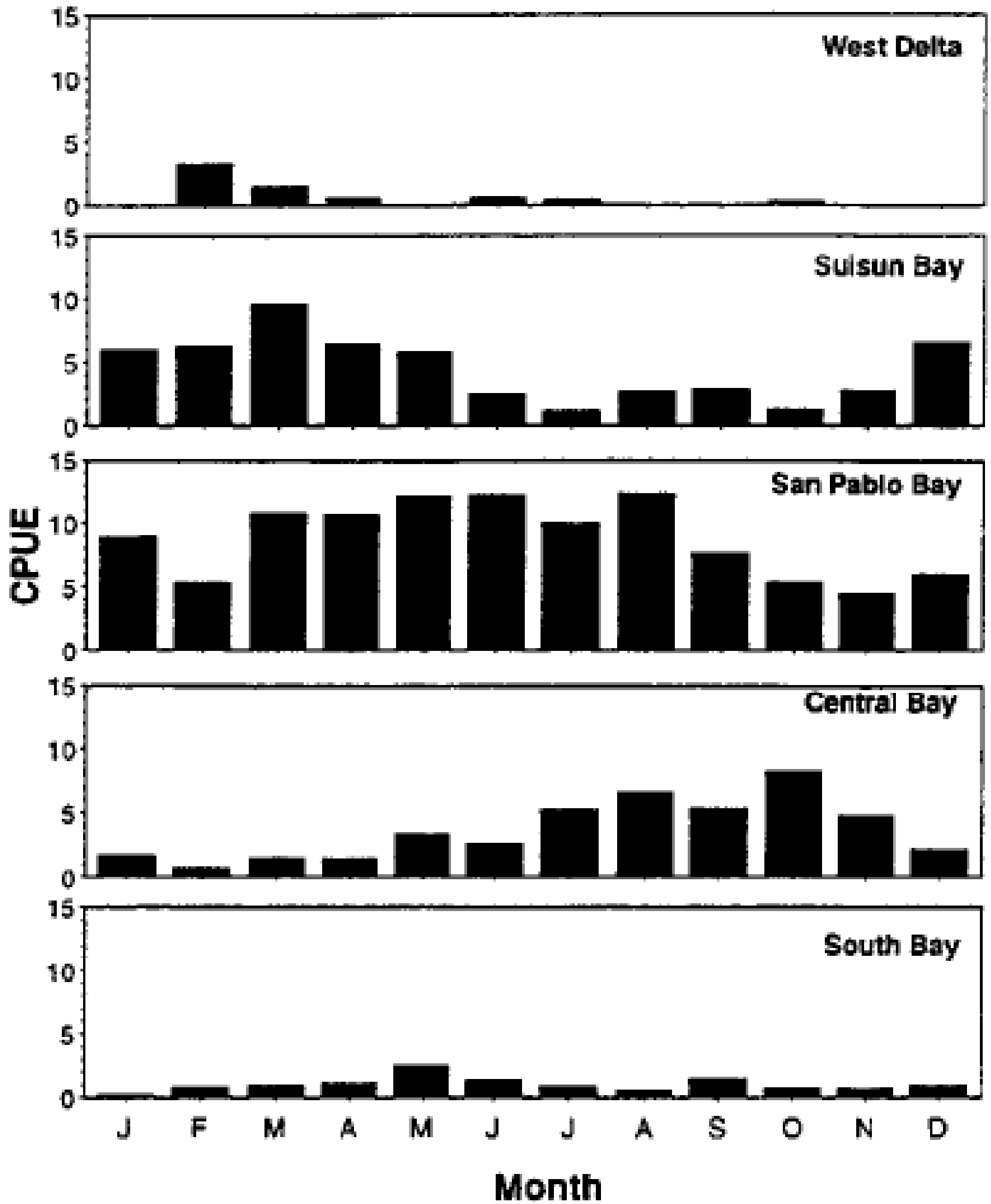

Figure 5.E-4. Catch-per-unit-effort of Age-1+ Starry Flounder by San Francisco Embayment 1980-1995 (From Baxter et al. 1999).

Though seldom targeted, the starry flounder is common in both commercial and recreational fisheries of northern and central California (Orcutt 1950, Haugen 1992, Karpov and others 1995). The best indicator of starry flounder abundance within the Delta and Suisun Bay is the number of starry flounder salvaged and the UC Davis Suisun Marsh monitoring study. Combined salvage at the pumping facilities shows a decline over time although the correlation between year and the number of starry flounder salvaged is not significant statistically (Figure 5.E-5; Spearman rank correlation, rho = -0.24, p = 0.19).

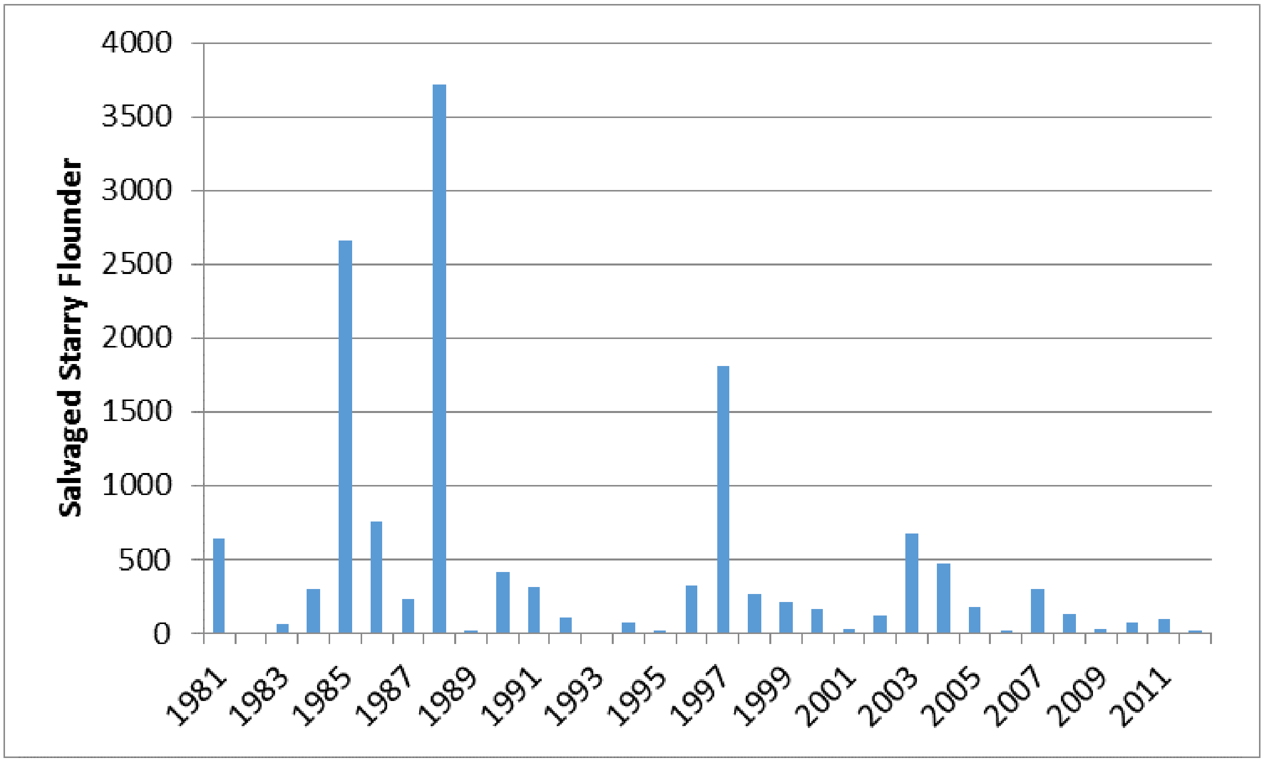

Figure 5.E-5. Salvage by Year of Starry Flounder at Pumping Facilities 1981-2012

Similar to the pumping facilities, the UC Davis Suisun Marsh monitoring study shows a negative trend by year, but the Spearman rank correlation was not statistically significant (Figure 5.E-6; Spearman rank correlation, rho = -0.15, p = 0.41).

The population status of starry flounder has not been studied, but commercial catches and recreational catches have trended downward since the 1980's. The California population is now at all-time lows. This could be the product of the relocation of adult fish associated with the 1976–1977 oceanic regime shift, or the result of overfishing of spawning adults in commercial catches. The large population declines suggested by commercial and recreational catches are substantiated by the Bay Study trawl survey that showed age-zero and age-one-plus starry founder abundance and catch-per-unit-effort dropping dramatically during the late 1980s and remaining at low levels through the 1990s (Baxter et al. 1999).

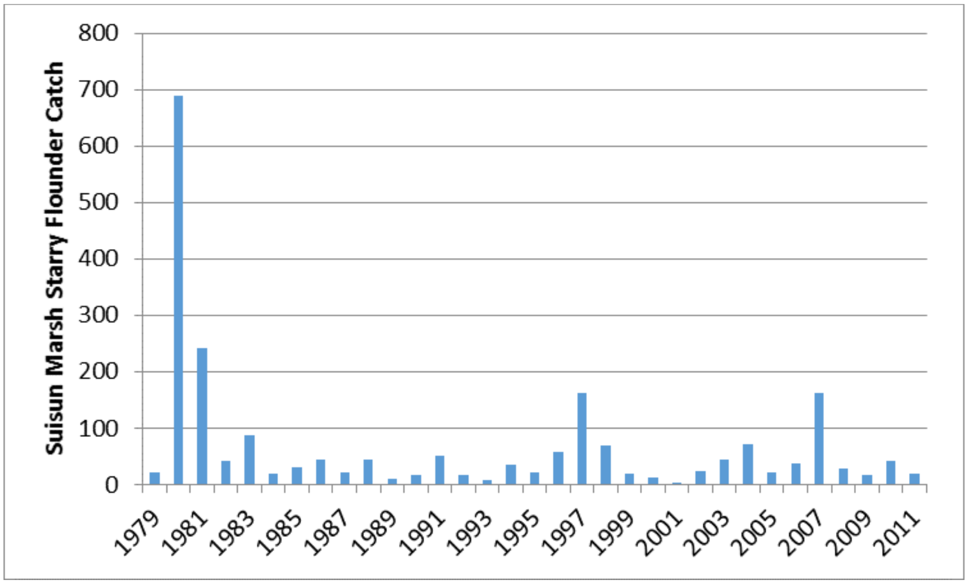

Figure 5.E-6. Total catch by year UC Davis monitoring study 1979-2011

5.E.4.2.3 Starry Flounder Life History

Starry flounder are found on different substrates including: gravel, clean shifting sand, hard stable sand, and mud substrata, but fishermen report the largest catches over soft sand. Prey from mud (sternapsid worms) and sand (Siliqua patula clams) habitats have been observed in the stomach of a single individual, suggesting fish move freely from one habitat type to another (Orcutt 1950). Starry flounder also consume crabs, shrimps, worms, clams and clam siphons, other small mollusks, small fishes, nemertean worms, and brittle stars (Hart 1973). Starry flounder are remarkable in their tolerance to low salinity conditions, i.e., they are capable of tolerating a wide range of salinities. In the Sacramento and San Joaquin Rivers, starry flounder have been observed in salinities of 0.02-0.06 ppt, i.e., essentially freshwater (Orcutt 1950) and have been collected 75 miles upstream in the Columbia River. Age 0 and 1+ starry flounder are a common species in estuarine habitats along the west coast (see Orcutt 1950, Sopher 1974, Pearson 1989, Emmett et al. 1998, Baxter et al. 1999, and Kimmerer 2002). Spawning occurs primarily during the winter months of December and January (Orcutt 1950). Starry flounder reach approximately 110 mm in length by the end of their first year. By the time they reach age-2 many fish have migrated to into ocean habitats adjacent to their natal estuaries. Starry flounder become reproductively mature at age-2 for males and age-3 for females, which equates to ~28 cm in males and ~35 cm in females. Adults may move seasonally into shallow coastal waters to spawn, perhaps in proximity to estuaries to take advantage of estuarine circlulation which would advect fertilized eggs near the bottom into nursery areas.

5.E.4.2.4 Factors Affecting Starry Flounder Abundance

The significance of estuarine rearing for age-0 and age-1 starry flounder is implied from high habitat association with fresh to mesohaline waters and from the small numbers of age-0, age-l and age-2 fish found in coastal marine areas (Rogers and others 1988; Yoklavich and others 1991).

Hieb and Baxter (1993) established specific habitat criteria for starry flounder young-of-the-year (<70 mm) in the San Francisco Estuary: 90% were collected from intertidal and subtidal habitats <7 m in depth, and with accompanying salinities of <22%. Using this standard, the amount of habitat in the estuary was positively and significantly correlated to March–June freshwater outflow (,2 = 0.917, P < 0.001, df = 9). Abundance in the estuary was also positively correlated to outflow during the same months (,2 = 0.646, P < 0. 01, df = 9).

The exclusivity of fresh and brackish water rearing habitat in age-0 and age-1 year olds coupled with the relationship between freshwater outflow and abundance makes a strong case for estuarine dependence (Emmett and others 1991, Hieb and Baxter 1993), although, spawning in coastal areas and variation in abundance during high outflow years suggest that coastal ocean conditions as well as high outflow work in conjunction to determine year class abundance (Hieb and Baxter 1993).

5.E.4.3 Pacific Salmon

5.E.4.3.1 Pacific Salmon EFH in the Action Area

The four races of Chinook salmon occurring in the action area[1] are covered under the MSA (collectively as 'Pacific salmon'). Each uses the action area extensively as juvenile rearing habitat and juvenile and adult migration corridors. Coho salmon are restricted to the mixed marine/estuarine habitats of San Pablo Bay and San Francisco Bay, which they historically used as juvenile and adult migratory corridors and foraging habitats between the ocean and natal tributaries area. However, any occurrence in the action area is expected to be rare at best because this species is believed to have been extirpated from tributaries to San Francisco and San Pablo Bay (NMFS 2012). Pacific Salmon HAPCs include all Pacific Salmon EFH within the proposed action area that can serve as spawning habitat or thermal refugia for Pacific Salmon, contain complex channels, floodplains, and estuarine and marine submerged aquatic vegetation, and occur within estuarine waters with an inland extent of ocean-derived salts measuring less than 0.5 parts per thousand (ppt) during the period of average annual low freshwater flow.

The status, distribution, life history, and habitat requirements of winter-run and spring-run, which are listed under the ESA, are reviewed in Chapter 5, *Effects Analysis for Chinook Salmon, California Central Valley Steelhead, Green Sturgeon, and Southern Resident Killer Whale*. The status, distribution, life history, and habitat requirements of fall-/late fall-run Chinook salmon, which are not listed but covered under the MSA, are reviewed below.

5.E.4.3.2 Fall-/Late Fall-Run Chinook Salmon

5.E.4.3.2.1 Status and Distribution

The fall- and late fall–run Chinook salmon includes all spawning populations of fall- and late fall–run Chinook salmon in the Sacramento and San Joaquin River basins and their tributaries east of Carquinez Strait, California (64 FR 50394). On September 16, 1999, after reviewing the best available scientific and commercial information, NMFS determined that listing CV fall- and

[1] Sacramento River winter-run, Central Valley spring-run, Central Valley fall-run, and Central Valley late-fall-run.

late fall–run Chinook salmon was not warranted. On April 15, 2004, the CV fall- and late fall–run Chinook salmon ESU was identified by NMFS as a Species of Concern (69 FR 19975).

CV fall-run Chinook salmon historically spawned in all major tributaries, as well as the mainstem of the Sacramento and San Joaquin Rivers. The historical distribution of CV late fall–run Chinook salmon is not well understood, but is thought to be less extensive than that of fall-run. Late fall–run adults most likely spawned in the upper Sacramento and McCloud Rivers in reaches now blocked by Shasta Dam, as well as in major tributaries with adequate cold water in summer. There is also some evidence they once spawned in the San Joaquin River in the Friant region and in other large San Joaquin tributaries (Yoshiyama et al. 1998).

The abundance of CV fall- and late fall–run Chinook salmon escapement before 1952 is poorly documented. Reynolds et al. (1993) estimated that production of fall- and late fall–run Chinook salmon on the San Joaquin River historically approached 300,000 adults and probably averaged approximately 150,000 adults. Calkins et al. (1940) estimated fall- and late fall–run Chinook salmon abundance at 55,595 adults in the Sacramento River basin from 1931 to 1939. In the early 1960s, adult fall- and late fall–run Chinook salmon escapement was estimated to be 327,000 in the Sacramento River basin (California Department of Fish and Game 1965). In the mid-1960s, fall- and late fall–run Chinook salmon escapement to the San Joaquin River basin was estimated to be about 2,400 fish (Reynolds et al. 1993).

Long-term trends in adult fall-run Chinook salmon escapement since 1953 indicate that abundance in the Sacramento River has been consistently higher than abundance in the San Joaquin River. Annual escapement on the Sacramento River has been characterized by relatively high variability, ranging from approximately 100,000 to over 800,000 fish. Sacramento River escapement showed a marked increase in abundance between 1990 and 2003 followed by a decline in abundance from 2004 to present. In 2009, adult fall-run Chinook salmon returns to Central Valley rivers showed a substantial decline in both the Sacramento and San Joaquin River systems (California Department of Fish and Wildlife 2016). Similar declines in adult escapement were also observed for coho salmon and Chinook salmon returning to other river systems in California (MacFarlane et al. 2008). Trends in adult fall-run Chinook salmon escapement in the San Joaquin River tributaries has been relatively low since the 1950s, ranging from several hundred adults to approximately 100,000 adults (Reynolds et al. 1993).

Adult escapement estimates for late fall–run Chinook salmon returning to the Sacramento River from 1971 through 2009 have ranged from several hundred adults to over 40,000 adults. Adult escapement showed a general trend of declining abundance between 1971 and 1997. During the late 1990s and continuing through 2006, escapement increased substantially but was characterized by high interannual variability. The 2008 and 2009 escapement estimates were lower than the previous 4 years, but were not characterized by the severe decline observed for fall-run Chinook salmon (California Department of Fish and Wildlife 2016).

Hatchery-origin fall-run and late fall-run Chinook salmon are also considered under the Pacific Coast Salmon FMP (http://www.pcouncil.org/wp-content/uploads/FMP_through_A-18_Final.pdf) and therefore are considered in the present analysis of EFH. The FMP describes the Sacramento River fall-run Chinook salmon as primarily hatchery stock with a smaller natural component, whereas the Sacramento River late fall-run Chinook salmon stock has hatchery and natural components from the upper Sacramento basin, and the San Joaquin River fall-run Chinook salmon population also has hatchery and natural components. Huber and Carlson (2015) provide a synthesis of trends in release number, location, size, and timing of fall-run Chinook salmon released from the five Central Valley hatcheries between 1946 and 2012. They found since the mid-1980s the proportion of hatchery fall-run Chinook salmon juveniles released downstream of the Delta has varied from around 20 to 60%; these fish would not be susceptible to the effects of the PA under current hatchery release practices, but they would be subject to similar migration effects as those discussed below in Section 5.E.5.3, *Pacific Salmon*, if they are increasingly released in-river instead of in the Bay.

Most of the information available for fall-run Chinook salmon comes from research and monitoring based on larger smolt migrants. However, fry and parr migrants are known to represent a substantial portion of wild fall-run Chinook salmon (Miller et al. 2010, Sturrock et al. 2015), and they may be more or less vulnerable to water exports compared with smolt migrants. Therefore, the PA may affect fry and parr migrants differently from smolt migrants, although the uncertainty in predicting and interpreting how effects of the PA may differ among life stages precludes further discussion.

5.E.4.3.2.2 Life History

Table 5.E-2 presents the timing of the upstream presence of each life stage of fall-run Chinook salmon in the Sacramento River. The months included in this table represent the periods during which the majority (more than approximately 90%) of fish in a life stage are present. Adult fall-run Chinook salmon migrate through the Delta and into Central Valley rivers from June through December. Individuals spawn in the Sacramento River and eggs and alevins are in the gravel primarily between September and January with a peak during October through December. Most individuals (83.4%) spawn upstream of Red Bluff Diversion Dam, although, unlike other races of Chinook salmon, a moderate percentage (16.6%) spawn below Red Bluff Diversion Dam (Table 5.E-3).

Table 5.E-2. Timing Table of Presence in the Sacramento River Upstream of the Delta by Life Stage, Fall-Run Chinook Salmon

Life Stage	J	F	M	A	M	J	J	A	S	O	N	D
Spawning, egg incubation, and alevins[1]												
Fry and Juvenile rearing[2]												
Juvenile emigration[3]												
Adult immigration[4]												
Adult holding[5]												
		High			Med				Low			

Sources: [1] Vogel and Marine 1991; [2] Gaines and Martin 2002, Poytress et al. 2014; [3] Martin et al. 2001, Poytress et al. 2014; [4] Vogel and Marine 1991; [5] D. Swank pers. comm.

Table 5.E-3. Spatial Distribution of Spawning Redds in the Sacramento River Based on Aerial Redd Surveys, Fall-Run Chinook Salmon, 2003–2014 (Source: CDFW)

Reach	Mean Annual Percent of Total Redds Sighted
Keswick to ACID Dam	16.3
ACID Dam to Highway 44 Bridge	5.5
Highway 44 Bridge to Airport Road Bridge	12.3
Airport Rd. Bridge to Balls Ferry Bridge	16.2
Balls Ferry Bridge to Battle Creek	10.3
Battle Creek to Jelly's Ferry Bridge	12.7
Jelly's Ferry Bridge to Bend Bridge	6.6
Bend Bridge to Red Bluff Diversion Dam	3.5
Red Bluff Diversion Dam to Tehama Br.	10.8
Tehama Br. To Woodson Bridge	3.1
Woodson Bridge to Hamilton City Br.	1.8
Hamilton City Bridge to Ord Ferry Br.	0.8
Ord Ferry Br. To Princeton Ferry.	0.1
ACID = Anderson-Cottonwood Irrigation District	

Table 5.E-4 presents the timing of the upstream presence of each life stage for fall-run Chinook salmon in the American River. The months included in this table represent the periods during which the majority (more than approximately 90%) of fish in a life stage are present. Fall-run Chinook salmon spawn in the American River and eggs and alevins remain in the gravel primarily between October and January, with a peak during November and December. It was assumed for this analysis that fall-run Chinook salmon spawn throughout the reach from Hazel Avenue to Watt Avenue.

Table 5.E-4. Timing Table of Presence in the American River by Life Stage, Fall-Run Chinook Salmon

Life Stage	J	F	M	A	M	J	J	A	S	O	N	D
Spawning, egg incubation, and alevins[1]												
Fry and juvenile rearing[2]												
Juvenile emigration[3]												
Adult immigration[1]												
		High					Med				Low	
Sources: [1] Meyers 1998; [2] Snider and Titus 2000; [3] Snider and Titus 1995												

Table 5.E-5 presents the timing of the upstream presence of each life stage late fall-run Chinook salmon in the Sacramento River. The months included in this table represent the periods during which the majority (more than approximately 90%) of fish in a life stage are present. The life history characteristics of late fall–run Chinook salmon are not well understood. Late fall-run Chinook salmon spawn in the Sacramento River and eggs and alevins are in the gravel primarily between December and June with a peak during January through March. Most adults (83.4%) spawn upstream of Red Bluff Diversion Dam, and roughly two thirds (67.6%) spawn just below Keswick Dam in the reach to the ACID Dam (Table 5.E-6).

Table 5.E-5. Timing Table of Presence in the Sacramento River Upstream of the Delta by Life Stage, Late Fall-Run Chinook Salmon

Life Stage	J	F	M	A	M	J	J	A	S	O	N	D
Spawning, egg incubation, and alevins[1]	High	High	High	Med	Med	Med						Med
Fry and Juvenile rearing[2]			Med	Med	Med	Med	Med					
Juvenile emigration[3]	Low			High	High	Med	High	High	Med	Med	Med	Low
Adult immigration[4]	Med	Med	Med	Med							Med	Med
	■	High		■	Med			■	Low			
Sources: [1] Vogel and Marine 1991; [2] Gaines and Martin 2002; [3] Gaines and Martin 2002, Poytress et al. 2014; [4] Vogel and Marine 1991												

Table 5.E-6. Spatial Distribution of Spawning Redds in the Sacramento River Based on Aerial Redd Surveys, Late Fall-Run Chinook Salmon, 2003–2014 (Source: CDFW)

Reach	Mean Annual Percent of Total Redds Sighted
Keswick to ACID Dam	67.6
ACID Dam to Highway 44 Bridge	5.0
Highway 44 Bridge to Airport Road Bridge	3.7
Airport Rd. Bridge to Balls Ferry Bridge	7.9
Balls Ferry Bridge to Battle Creek	5.2
Battle Creek to Jelly’s Ferry Bridge	2.8
Jelly’s Ferry Bridge to Bend Bridge	1.0
Bend Bridge to Red Bluff Diversion Dam	0.5
Below Red Bluff Diversion Dam	6.2
ACID = Anderson-Cottonwood Irrigation District	

Chinook salmon typically mature between 2 and 6 years of age (Myers et al. 1998). The majority of fall-run Chinook salmon spawn at age 3 (Moyle 2002).

Chinook salmon spawn in clean, loose gravel in swift, relatively shallow riffles, or along the margins of deeper river reaches where water temperatures, depths, and velocities are suitable for red construction and egg incubation.

Fall-run Chinook salmon fry (i.e., juveniles shorter than 2 inches long) in the Sacramento River generally emerge from December through March, with peak emergence occurring by the end of January. In general, fall-run Chinook salmon fry abundance in the Delta increases following high winter flows. Most fall-run Chinook salmon fry rear in fresh water from December through June, with emigration occurring from December through June and a peak from January through March (Table 5.E-2). Smolts that arrive in the estuary after rearing upstream migrate quickly through the Delta and Suisun and San Pablo Bays. A very small number (generally less than 5%) of fall-run juveniles spend over a year in fresh water and emigrate as yearling smolts the following November through April.

Fry and juvenile fall-run Chinook salmon rear in the American River primarily between January and May, with a peak during January and February. Fry and juvenile rearing occurs throughout the river up to Nimbus Dam (Table 5.E-4). Individuals migrate downstream between February and May, with a peak migration period of February and March.

Late fall–run Chinook salmon fry generally emerge from March through June. Late fall-run fry rear upstream until about July (Table 5.E-5) and in fresh water from April through the following April and emigrate as smolts from November through May.

Upon emergence from the gravel, fry swim or are displaced downstream (Healey 1991). Fry seek nearshore habitats providing shallow water, vegetation, and substrates that provide aquatic and terrestrial invertebrates, cover and shelter from predators, and slower water velocities for resting (National Marine Fisheries Service 1996a). These shallow water habitats are considered to be more productive rearing habitat than the deeper main river channels. Higher juvenile salmon growth rates associated with greater prey consumption rates and favorable water temperatures have been observed on floodplains with extensive shallow water habitats (Sommer et al. 2001).

In the Sacramento River, adult fall-run Chinook salmon migrate upstream to spawn primarily during July through December, with a peak during August and September (Table 5.E-2). Adults that reach spawning grounds early in the season during July and August may hold before spawning (D. Swank, pers. comm.).

In the American River, adult fall-run Chinook salmon migrate upstream primarily during September through December, with a peak during September and October (Table 5.E-4).

Adult late fall-run Chinook salmon migrate upstream primarily during November through April (Table 5.E-5).

5.E.4.3.2.3 Factors Affecting Abundance

Factors that contributed to the decline of CV fall-/late fall–run Chinook salmon are similar to those described for Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, and steelhead in Chapter 4 and Appendix 4.A. Access to much or all of their historical spawning habitat was eliminated by dams, although fall-run Chinook salmon were less affected by these barriers because much of their historical spawning habitat included the lower gradient reaches downstream of these dams (Reynolds et al. 1993; McEwan 2001). However, changes in the seasonal hydrologic patterns resulting from water diversions and operation of upstream reservoirs for water supply, flood control, and hydroelectric power generation have altered flows, water temperatures, and other habitat conditions for fall-run Chinook salmon and other species in these reaches (Williams 2006).

Properly functioning migration corridors for juvenile fall- and late fall–run Chinook salmon consist of a wide range of habitat types, including primary and secondary channels, stream banks, floodplains, and marshes. Much of the Sacramento and San Joaquin River corridor and Delta have been leveed, channelized, and modified with riprap for flood risk reduction, thereby reducing and degrading the value and availability of natural habitat for rearing and emigrating juvenile Chinook salmon (Brandes and McLain 2001). Modification of natural flow regimes from upstream reservoir operations has resulted in dampening of the hydrograph, reducing the extent and duration of seasonal floodplain inundation and other flow-dependent habitat used by migrating juvenile Chinook salmon (70 FR 52488; Sommer et al. 2001; California Department of Water Resources 2005). Tidal and floodplain habitat areas provide important rearing habitat for foraging juvenile salmonids, including fall-run Chinook salmon. Studies have shown that these salmonids may spend 2 to 3 months rearing in these habitat areas, and losses resulting from land reclamation and levee construction are considered to be major stressors on juvenile salmonids (Williams 2009). Similarly, channel margins provide valuable rearing and connectivity habitat along migration corridors, particularly for smaller juvenile fry, such as fall-run Chinook salmon.

Predation on juvenile salmon by nonnative fish has been identified as an important threat to fall- and late fall–run Chinook salmon in areas with high densities of nonnative fish that prey on out-migrating juvenile salmon (e.g., smallmouth and largemouth bass, striped bass, and catfish) (Lindley and Mohr 2003). The low spatial complexity and reduced habitat diversity (e.g., lack of cover) of channelized waterways in the rivers and Delta reduce refuge space for salmon from predators (Raleigh et al. 1984; Missildine et al. 2001; 70 FR 52488).

Other factors that have contributed to the current status of CV fall-run and late fall–run Chinook salmon and currently affect their abundance include harvest, artificial propagation programs (ecological and genetic effects), entrainment, and contaminants (Moyle 2002).

5.E.5 Potential Effects of Proposed Action

5.E.5.1 Coastal Pelagic Species

Coastal pelagic EFH in the action area is known to support one species, the northern anchovy. The PA is at the extreme edge of this species occurrence within the San Francisco Estuary, and it is likely that its occurrence will be infrequent and generally effect fish during their early life history stages.

To the extent that there is exposure, the proposed action has the potential to affect EFH for coastal pelagic species through the following main mechanisms:

- *Underwater noise* associated with in-water construction.
- *Structural changes* associated with temporary (construction) or permanent placement of engineered structures in habitat.
- *Water quality effects from in-water construction.*
- *Water quality effects from maintenance* of engineered in-water structures.

Far-field effects (e.g., changes in salinity) associated with operations under the proposed action. These potential effects were analyzed in the following sections.

5.E.5.1.1 Northern Anchovy

Potential action effects may include minimal short- to long-term water quality degradation (e.g., from sediment disturbance during construction) and changes in depth, food, cover and habitat complexity, and habitat connectivity. However, because there is expected to be very low overlap of northern anchovy with these near-field effects because, as discussed in Section 5.E.4.1.2, the species primarily occurs well downstream of the Delta (Figure 5.E-1 and Figure 5.E-2), with abundance even in Suisun Bay very low (as a result of reduced food availability caused by *Corbula amurensis* invasion; Kimmerer 2006). Therefore, based upon the minimal short-term impacts, the very low likelihood of species presence, and the small fraction of the habitat impacted, any potential adverse effects to EFH would be undetectable.

5.E.5.1.1.1 Effects of Water Facility Construction on Coastal Pelagic EFH

5.E.5.1.1.1.1.1 North Delta Intakes

Construction of the north Delta intakes result in result in turbidity and suspended sediment, potential contaminant exposure from spills or mobilization of contaminated sediment, underwater noise, fish stranding, direct physical injury, and temporary to long-term losses or alteration of migration and rearing habitat. However, as previously noted, such effects would be expected to be minimal, and the species principally occurs well downstream of the Delta (Figure 5.E-1 and Figure 5.E-2); therefore, any adverse effects to coastal pelagic EFH would be undetectable (represented by northern anchovy).

5.E.5.1.1.1.1.1.1 Turbidity and Suspended Sediment

Construction activities that could increase turbidity and suspended sediment include cofferdam construction (sheetpile installation and removal), levee clearing and grubbing, riprap placement, dredging, and barge operations. In-water construction would temporarily or permanently alter the condition of migratory and rearing EFH habitats in the vicinity of the construction activities. Construction activities could result in temporary increases in turbidity. These activities would occur during the expected in-water construction window (typically June 1 through October 31). Behavioral effects may include alarm reaction, altered schooling behavior, cover abandonment, and avoidance or attraction depending on the type of sediments and sediment concentration.

Such behavioral effects may be caused by changes in light penetration/scattering. Physiological effects may include changes in respiration rate, choking, coughing, abrasion and puncturing of structures (gills, epidermis), reduced feeding, reduced water filtration rates, smothering, delayed or reduced hatching of eggs, reduced larval growth/development, abnormal larval development, and reduced responses to physical stimuli. northern anchovy similar to bay anchovy would be considered as a sensitive species, with 24-hr LC10 > 1,000 mg/L and < 10,000 mg/L. A 24-hr exposure to 1,000 mg/L of suspended sediment caused mechanical damage to the epidermis of Pacific herring larvae (similar to northern anchovy), while 4,000 mg/L caused epidermal punctures and abrasion of micro-ridges on scales (Newcombe and Jensen 1996).

With the implementation of the proposed AMMs to minimize potential water quality impacts (Appendix 3.F), the potential effects of increased turbidity and suspended sediment on EFH would be limited to temporary, localized degradation of water quality and substrate in the vicinity of the intake construction sites. No substantial, long-term effects on EFH would occur and the effect would be undetectable.

5.E.5.1.1.1.1.1.2 Contaminant Exposure

Construction of the north Delta intakes could affect EFH through accidental spills of contaminants, including cement, oil, fuel, hydraulic fluids, and paint, and through disturbance and mobilization of contaminated soil or sediments within the temporary and permanent footprints of the intake facilities. The potential for contaminant exposure is highest during in-water construction activities (June 1–October 31) but some risk would exist during the entire construction period. As described in section 5.2.1 of Chapter 5, the risk of exposure of northern anchovy to contaminants would be effectively minimized by the implementation of proposed pollution prevention and control AMMs, and site-specific AMMs to minimize the mobilization of contaminated soil or sediment. No substantial, long-term effects would occur on EFH and any effects would be immeasurable.

5.E.5.1.1.1.1.1.3 Underwater Noise

Underwater noise generated by impact driving of the temporary sheet piles, intake foundation piles, and Highway 160 bridge piles would cause EFH in proximity to pile driving operations to become unsuitable because of the potential for injury or mortality of northern anchovy. The effects of pile driving noise on listed salmonids (described in section 5.2.1 of Chapter 5) are generally applicable to northern anchovy. Northern anchovy would likely occur in low abundance, as compared to overall abundance within the San Francisco Estuary during in-water construction periods in the north Delta. Cumulative noise levels sufficient in intensity and duration to cause injury and mortality would occur for several weeks at each facility and extend up to 3,280 feet away from the source piles (assuming worst-case conditions, i.e., impact driving of intake foundation piles in open water with no attenuation). Beyond this distance, impact pile driving could also result in behavioral responses that may alter normal behavior. DWR proposes to minimize the extent and duration of potentially harmful pile driving noise by using vibratory methods or other non-impact driving methods to the extent practicable, and employing a number of other physical and operational attenuation measures that will be monitored for effectiveness in accordance with an underwater sound control and abatement plan (AMM9 in Appendix 3.F).

5.E.5.1.1.1.1.1.4 Fish Stranding

Although unlikely, northern anchovy could be present in the vicinity of intake construction on the Sacramento River during the period when cofferdams are installed to isolate work areas, although this is considered unlikely due to the preference for higher salinity water. This presents the potential for entrapment and also temporary loss of EFH habitat in isolated work areas. DWR proposes to implement a fish rescue and salvage plan that will identify appropriate procedures for monitoring and implementing appropriate collection and relocation methods if special-status species are detected (Appendix 3.F, AMM 8 *Fish Rescue and Salvage Plan*).

5.E.5.1.1.1.1.1.5 Direct Physical Injury

Northern anchovy could be injured or killed by direct contact with piles, riprap, dredges, or vessels during active construction periods. Based upon the shift of the majority of northern anchovy towards San Pablo and the Central Bay during the construction period the potential for injury to northern anchovy is minimal based on the timing of in-water construction activities and likely avoidance of active construction areas because of salinity preferences.

5.E.5.1.1.1.1.1.6 Loss/Alteration of Habitat

Construction of the north Delta intakes would result in temporary to permanent losses or alteration of a small fraction of EFH for early life stages of northern anchovy, although the species inhabits the whole of the San Francisco Estuary and the loss of this EFH habitat within the PA would be a fraction of a percent of the total EFH habitat that is available to the species. In addition to the temporary effects on water quality and other construction-related hazards described above, approximately 29.9 acres of tidal perennial aquatic habitat and 13,974 linear feet of channel margin would be temporarily affected by cofferdam installation, dredging, and barge operations, all occurring outside their main range and representing only a small fraction of their EFH. Construction of the intake structure, including fish screen, transition wall structures, and levee armoring would result in the permanent loss of approximately 6.6 acres of aquatic habitat and 5,367 feet of channel margin. The effects of habitat loss or alteration on listed salmonids and their designated critical habitat (described in section 5.2.1 of Chapter 5) are generally applicable to coastal pelgaic EFH (represented by northern anchovy). DWR will implement AMM2, Construction Best Management Practices and Monitoring, to limit the extent of loss and alteration of aquatic and riparian habitat during construction, and, following construction, to restore temporarily disturbed areas to pre-construction conditions. All construction and site restoration BMPs will be subject to an approved construction and post-construction monitoring plan to ensure their effectiveness. Any unavoidable losses of designated EFH will be offset through restoration of habitat at an approved restoration site and/or the purchase of conservation credits at an approved conservation bank. Consequently, any effects are immeasurable.

5.E.5.1.1.1.1.2 Barge Landings

Construction of the barge landings could have an immeasurable effect on northern anchovy EFH through temporary increases in turbidity and suspended sediment, potential contaminant exposure, underwater noise, direct physical injury, and temporary to long-term losses or alteration of migration and rearing habitat, although the barge landings are outside the main range of northern anchovy and the amount of habitat is a very small fraction of the EFH habitat.

5.E.5.1.1.1.1.2.1 Turbidity and Suspended Sediment

Construction activates that could affect EFH through increases in turbidity and suspended sediment include in-water pile driving, riprap placement, and barge operations. The effects of increased turbidity and suspended sediment on northern anchovy would be the same as those listed above under North Delta Intakes in section 5E.1.1.2.

5.E.5.1.1.1.1.2.2 Contaminant Exposure

Construction of the barge landings poses an exposure risk to northern anchovy from potential spills of hazardous materials from construction equipment, barges and towing vessels, and other machinery, and from potential mobilization of contaminated sediment. The effects and risk would be similar to those listed above under North Delta Intakes in section 5E.1.1.3.

5.E.5.1.1.1.1.2.3 Underwater Noise

Underwater noise generated by impact driving of the dock and/or mooring piles would cause EFH in proximity to active pile driving operations to become temporarily unsuitable because of the potential for injury or mortality of northern anchovy. The effects and risk would be similar to those listed above under North Delta Intakes in section 5E.1.1.3.

5.E.5.1.1.1.1.2.4 Direct Physical Injury

Northern Anchovy could be injured or killed by direct contact with piles, riprap, dredges, or vessels during active construction periods. Based upon the shift of the majority of Northern Anchovy towards San Pablo and the Central Bay during the construction period the potential for injury to Northern Anchovy is low based on the timing of in-water construction activities and likely avoidance of active construction areas because of salinity preferences.

5.E.5.1.1.1.1.2.5 Loss/Alteration of Habitat

Construction of the barge landings would result in temporary to permanent losses or alteration of EFH for northern anchovy. In addition to the temporary effects on water quality and other construction-related hazards described above, approximately 22.4 acres of tidal perennial aquatic habitat and 5,307 linear feet of channel margin (average of 3.2 acres or 758 linear feet per barge landing) would be permanently altered by in-water and overwater structures, including piles, dolphins, docks, ramps, and/or conveyors. The effects of habitat loss or alteration on listed salmonids (described in section 5.2.1 of Chapter 5) are generally applicable to northern anchovy EFH. Similar to North Delta intakes section 5E.1.1.7 DWR will limit alteration, or loss of habitat during construction and will mitigate the loss of any EFH habitat with through the purchase of conservation credits.

5.E.5.1.1.1.1.3 Head of Old River Gate

Construction of the HOR gate will not adversely affect northern anchovy as the spatial distribution of northern anchovy does not overlap the Head of Old River Gate construction activities.

5.E.5.1.1.1.1.4 Clifton Court Forebay

Construction of the new water conveyance facilities and dredging and expansion of CCF will not adversely effect northern anchovy, because northern anchovy spatial distribution has minimal overlap with Clifton Court Forebay.

5.E.5.1.1.2 Effects of Water Facility Operations

Northern anchovy generally occur well downstream of the Delta and so far-field effects of the PA are of most relevance[2]. A comparison of modeled salinity values between the NAA and PA at Martinez indicates that there would be marginal increases and decreases in salinity (Table 5.E-1.). These potential changes in salinity are small (all differences would be <1.0 ppt) and well within the salinity tolerances of northern anchovy (Baxter et al. 1999). Kimmerer et al. (2009) showed for northern anchovy that neither indices of habitat extent nor indices of habitat extent were related to X2, an index of Delta outflow and its effects. This, coupled with the small differences in salinity between NAA and PA, suggest that the PA would have undetectable operational effects to northern anchovy and therefore to Coastal Pelagic Species EFH.

5.E.5.1.1.3 Maintenance Effects

Bank, bed and water column disturbance associated with maintenance activities have the potential to cause adverse affects to coastal pelagic EFH (as represented by northern anchovy). Effects would be most likely to occur during maintenance dredging activities around the new intakes, as this type of impact is most extensive. Suction dredging, mechanical excavation, and possible front-end loading equipment could remove food organisms and suspend contaminants into the water column. While these mechanisms are possible, the likelihood of northern anchovy exposure would be low due to the low quality of the affected habitats, coupled with low densities of northern anchovy within this EFH habitat.

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[2] Entrainment at the south Delta export facilities would be expected to be minimal under both the PA and the NAA, but because of the implementation of the NDD and less south Delta exports under the PA, entrainment would be expected to be lower under the PA (see Table 5.A.6-27 in Appendix 5.A).

5.E.5.1.1.4 Avoidance and Minimization Measures Effects

The avoidance and minimization measures effects would be the same as for Chinook salmon in section 5.9.3.5.

5.E.5.2 Pacific Coast Groundfish

Pacific Coast groundfish EFH in the action area is known to support one species, the starry flounder. Starry flounder inhabit the whole of the San Francisco Estuary and the PA represents the extreme edge of its EFH habitat. Starry flounder would likely be found only in the early juvenile life stage and would be found infrequently within the PA EFH habitat; therefore, any potential adverse effects to Pacific coast groundfish EFH would be undetectable (represented by starry flounder).

To the extent there is exposure, the proposed action has the potential to affect EFH for Pacific Coast groundfish through the following main mechanisms:

- *Underwater noise* associated with in-water construction.
- *Structural changes* associated with temporary (construction) or permanent placement of engineered structures in habitat.
- *Water quality effects from in-water construction.*
- *Water quality effects from maintenance* of engineered in-water structures.
- *Salinity changes* associated with operations under the proposed action.

5.E.5.2.1 Starry Flounder

The proposed action is expected to have short- and long-term effects on EFH for starry flounder, although the species inhabits the whole of the San Francisco Estuary and the loss of EFH habitat within the PA would be a fraction of a percent of the total EFH habitat that is available to the species. Potential action effects include short- to long-term water quality degradation and changes in depth, food, cover and habitat complexity, and habitat connectivity. Overlap of starry flounder with near-field effects (e.g., from construction) would be expected to be limited, however, because, as discussed in Section 5.E.4.2.2, the species' main range is downstream of the Delta (Figure 5.E-3 and Figure 5.E-4).

5.E.5.2.1.1 Effects of Water Facility Construction

5.E.5.2.1.1.1 North Delta Intakes

Construction of the north Delta intakes may affect starry flounder EFH through temporary increases in turbidity and suspended sediment, potential contaminant exposure from spills or mobilization of contaminated sediment, underwater noise, fish stranding, direct physical injury, and temporary to long-term losses or alteration of migration and rearing habitat, although the effect would be negligible because of the small fraction of habitat affected and the minor potential overlap with starry flounder.

5.E.5.2.1.1.1.1 Turbidity and Suspended Sediment

Because starry flounder are benthic fish and they inhabit naturally turbid waters, they are unlikely to be affected by a temporary increase in turbidity within their EFH habitat, although the suspension of contaminants within bottom substrates could affect starry flounder if the exposure is prolonged. With the implementation of the proposed AMMs to minimize potential water quality impacts (Appendix 3.F), the potential effects of increased turbidity and suspended sediment on EFH would be limited to temporary, localized degradation of water quality and substrate in the vicinity of the intake construction sites.

5.E.5.2.1.1.1.2 Contaminant Exposure

Construction-related activities may affect water quality within EFH habitat due to accidental spills of contaminants, including cement, oil, fuel, hydraulic fluids, paint, and other construction-related materials. Depending on the type and magnitude of an accidental spill, contaminants can directly affect EFH of starry flounder. The potential for contaminant exposure is highest during in-water construction activities (June 1–October 31) but some risk would exist during the entire construction period. The risk of exposure of Northern Anchovy to contaminants would be effectively minimized by the implementation of proposed pollution prevention and control AMMs, and site-specific AMMs to minimize the mobilization of contaminated soil or sediment (described in Appendix 3.F).

5.E.5.2.1.1.1.3 Underwater Noise

Underwater noise generated by impact driving of the temporary sheet piles, intake foundation piles, and Highway 160 bridge piles would cause groundfish EFH in proximity to pile driving operations to become unsuitable because of the potential for injury or mortality of starry flounder. The effects of pile driving noise on listed salmonids (described in section 5.2.1 of Chapter 5) are generally applicable to starry flounder. Age 0 and 1+ starry flounder could find EFH habitat unsuitable in the locations of the intakes and barge landings during the in-water construction period. Young-of-the-year (YOY) and juvenile starry flounder could be present near the intakes during June through September, with abundance then tapering off through December; however, as previously noted, the main range of the species is well downstream of the intakes (Figure 5.E-3 and Figure 5.E-4). Cumulative noise levels sufficient in intensity and duration to cause injury and mortality would occur for several weeks at each facility and extend up to 3,280 feet away from the source piles (assuming worst-case conditions, i.e., impact driving of intake foundation piles in open water with no attenuation). Beyond this distance, impact pile driving could also result in behavioral responses that may alter normal behavior. DWR proposes to minimize the extent and duration of potentially harmful pile driving noise by using vibratory methods or other non-impact driving methods to the extent practicable, and employing a number of other physical and operational attenuation measures that will be monitored for effectiveness in accordance with an underwater sound control and abatement plan (AMM9 in Appendix 3.F).

5.E.5.2.1.1.1.4 Fish Stranding

Starry flounder could be present in the vicinity of intake construction on the Sacramento River during the period when cofferdams are installed to isolate work areas, although this is considered unlikely due to the preference for higher salinity water (Figure 5.E-3 and Figure 5.E-4). This presents the potential for entrapment and also temporary loss of EFH habitat in isolated workareas. DWR proposes to implement a fish rescue and salvage plan that will identify appropriate procedures for monitoring and implementing appropriate collection and relocation methods if special-status species are detected (Appendix 3.F, AMM 8 Fish Rescue and Salvage Plan).

5.E.5.2.1.1.1.5 Direct Physical Injury

Starry flounder could be injured or killed by direct contact with piles, riprap, dredges, or vessels during active construction periods. This presents the potential for entrapment and also temporary loss of EFH habitat in isolated workareas. DWR proposes to implement a fish rescue and salvage plan that will identify appropriate procedures for monitoring and implementing appropriate collection and relocation methods if special-status species are detected (Appendix 3.F, AMM 8 Fish Rescue and Salvage Plan).

5.E.5.2.1.1.1.6 Loss/Alteration of Habitat

Construction of the north Delta intakes would result in temporary to permanent losses or alteration of EFH for early life stages of starry flounder. In addition to the temporary effects on water quality and other construction-related hazards described above, approximately 29.9 acres of tidal perennial aquatic habitat and 13,974 linear feet of channel margin would be temporarily affected by cofferdam installation, dredging, and barge operations. Construction of the intake structure, including fish screen, transition wall structures, and levee armoring would result in the permanent loss of approximately 6.6 acres of aquatic habitat and 5,367 feet of channel margin. The effects of habitat loss or alteration on listed salmonids and their designated critical habitat (described in section 5.2.1 of Chapter 5) are generally applicable to Pacific coast groundfish EFH. DWR will implement AMM2, Construction Best Management Practices and Monitoring, to limit the extent of loss and alteration of aquatic and riparian habitat during construction, and, following construction, to restore temporarily disturbed areas to pre-construction conditions. All construction and site restoration BMPs will be subject to an approved construction and post-construction monitoring plan to ensure their effectiveness. Any unavoidable losses of EFH will be offset through restoration of habitat at an approved restoration site and/or the purchase of conservation credits at an approved conservation bank.

5.E.5.2.1.1.2 Barge Landings

Construction of the barge landings could affect Pacific coast groundfish EFH (represented by starry flounder) through temporary increases in turbidity and suspended sediment, potential contaminant exposure, underwater noise, direct physical injury, and temporary to long-term losses or alteration of migration and rearing habitat, although the effect would be negligible because of the small fraction of habitat affected and the minor potential overlap with starry flounder.

5.E.5.2.1.1.2.1 Turbidity and Suspended Sediment

Construction activities that could affect Pacific coast groundfish EFH through increases in turbidity and suspended sediment include in-water pile driving, riprap placement, and barge operations. The effects of increased turbidity and suspended sediment on northern anchovy would be the same as those listed above under North Delta Intakes in section 5E.5.2.3.

5.E.5.2.1.1.2.2 Contaminant Exposure

Construction of the barge landings poses an exposure risk to starry flounder from potential spills of hazardous materials from construction equipment, barges and towing vessels, and other machinery, and from potential mobilization of contaminated sediment. The effects on starry flounder EFH would be similar to those listed above under North Delta Intakes in section 5E.5.2.4.

5.E.5.2.1.1.2.3 Underwater Noise

Underwater noise generated by impact driving of the dock and/or mooring piles would cause EFH in proximity to active pile driving operations to become temporarily unsuitable because of the potential for injury or mortality of starry flounder. The effects to starry flounder EFH would be similar to those listed above under North Delta Intakes in section 5E.2.5.

5.E.5.2.1.1.2.4 Direct Physical Injury

Starry flounder could be injured or killed by direct contact with piles, riprap, dredges, or vessels during active construction periods. This presents the potential for entrapment and also temporary loss of EFH habitat in isolated workareas. DWR proposes to implement a fish rescue and salvage plan that will identify appropriate procedures for monitoring and implementing appropriate collection and relocation methods if special-status species are detected (Appendix 3.F, AMM 8 Fish Rescue and Salvage Plan).

5.E.5.2.1.1.2.5 Loss/Alteration of Habitat

Construction of the barge landings would result in temporary to permanent losses or alteration of EFH for starry flounder. In addition to the temporary effects on water quality and other construction-related hazards described above, approximately 22.4 acres of tidal perennial aquatic habitat and 5,307 linear feet of channel margin (average of 3.2 acres or 758 linear feet per barge landing) would be permanently altered by in-water and overwater structures, including piles, dolphins, docks, ramps, and/or conveyors. The effects of habitat loss or alteration on listed salmonids (described in section 5.2.1 of Chapter 5) are generally applicable to northern anchovy EFH. Similar to North Delta intakes section 5E.1.1.7 DWR will limit alteration, or loss of habitat during construction and will mitigate the loss of any EFH habitat with through the purchase of conservation credits.

5.E.5.2.1.1.3 Head of Old River Gate

Construction of the HOR gate will not adversely affect starry flounder as the spatial distribution of starry flounder does not overlap the Head of Old River Gate construction activities.

5.E.5.2.1.1.4 Clifton Court Forebay

Construction activities associated with the dredging and expansion of CCF may affect Pacific coast groundfish EFH through temporary increases in turbidity and suspended sediment, potential contaminant exposure from spills or mobilization of contaminated sediment, underwater noise, fish stranding, direct physical injury, and temporary to long-term losses or alteration of migration and rearing habitat.

5.E.5.2.1.1.4.1 Turbidity and Suspended Sediment

Construction activities that would result in increases in turbidity and suspended sediment at CCF include cofferdam construction (sheet pile installation and removal), barge operations, levee clearing/armoring, dredging, and inundation of the SCCF expansion area. Dredging of CCF and in-water driving of the temporary sheet piles to construct the divider and perimeter embankments would be the principal sources of turbidity and suspended sediment, potentially affecting water quality in CCF for up to 5 years. All other sediment-disturbing activities within cofferdams, upland areas, or non-fish-bearing waters pose little or no risk to starry flounder. The effects of increased turbidity and suspended sediment on starry flounder would be similar to those listed for the North Delta Intakes section 5.E.5.2.3.

As described in section 5.2.4 of Chapter 5, increases in turbidity and suspended sediment levels during in-water construction activities at CCF will be temporary, affect only portions of the waters available to juvenile starry flounder in Old River and CCF at any given time, and not be expected to reach levels causing direct injury. In addition to the erosion and sediment control AMMs described in Appendix 3.F, DWR proposes to limit the extent of dredging impacts in CCF by restricting daily operations to two dredges operating for 10-hour periods (daylight hours) within 200-acre cells enclosed by silt curtains (affecting less than 10% of total surface area of CCF at any given time). In addition, dredging will be monitored and regulated through implementation of a Disposal and Reuse of Spoils, Reusable Tunnel Material, and Dredged Material Plan, which includes preparation of a sampling and analysis plan, compliance with NPDES and SWRCB water quality requirements during dredging activities, and compliance with applicable in-water work windows established by CDFW, NMFS, and USFWS.

5.E.5.2.1.1.4.2 Contaminant Exposure

Construction activities at CCF could affect EFH through accidental spills of contaminants, including cement, oil, fuel, hydraulic fluids, and paint, and through disturbance and mobilization of contaminated soil or sediments within CCF and the footprints of the new water conveyance facilities. The potential for contaminant exposure is highest during in-water construction activities (June 1–November 30) but some risk would exist during the entire construction period. As described in section 5.2.3 of Chapter 5, the risk of exposure of starry flounder to contaminants would be effectively minimized by implementation of proposed pollution prevention and control AMMs, and site-specific AMMs to minimize the mobilization of contaminated soil or sediment.

5.E.5.2.1.1.4.3 Underwater Noise

Underwater noise generated by impact driving of the temporary sheet piles and foundation piles for the new water conveyance facilities and embankments at CCF would cause EFH in proximity to pile driving operations to become unsuitable because of the potential for injury or mortality of starry flounder.

Currently, pile driving information is available only for the embankments, siphon at NCCF outlet, and siphon at Byron Highway (Appendix 3.E). Pile driving for the Byron Highway siphon is not expected to affect starry flounder or EFH because all pile driving would be conducted on land and more than 200 feet from water potentially containing starry flounder (CCF). As described in section 5.2.4 in Chapter 5, the temporary sheet piles for the embankment cofferdams would take 450 days to install and produce cumulative noise levels sufficient in intensity and duration to cause injury of fish up to 2,814 feet away from the source piles (assuming worst-case conditions, i.e., impact driving of sheet piles and foundation piles in open water with no attenuation). During installation of foundation piles for the siphon at the NCCF outlet, the potential for injury would extend up to 1,774 feet away over a period of 72 days. Beyond these distances, impact pile driving could also result in behavioral responses that may alter normal behavior.

Starry flounder juveniles that are entrained into CCF would have the highest risk of injury from pile driving noise because of their proximity to and limited ability to avoid pile driving noise within the forebay. DWR proposes to minimize the extent and duration of potentially harmful pile driving noise by using vibratory methods or other non-impact driving methods to the extent practicable, and employing a number of other physical and operational attenuation measures that will be monitored for effectiveness in accordance with an underwater sound control and abatement plan (Appendix 3.F, AMM9 Underwater Sound Control and Abatement Plan).

5.E.5.2.1.1.4.4 Fish Stranding

There is risk of stranding of starry flounder because of the timing of cofferdam construction, but the likelihood of avoidance of active construction areas is not known. DWR proposes to implement a fish rescue and salvage plan that will identify appropriate procedures for monitoring and implementing appropriate collection and relocation methods if special-status species are detected (Appendix 3.F, AMM 8 Fish Rescue and Salvage Plan).

5.E.5.2.1.1.4.5 Direct Physical Injury

Starry flounder could be injured or killed by direct contact with piles, riprap, dredges, or vessels during active construction periods. This presents the potential for entrapment and also temporary loss of EFH habitat in isolated workareas. DWR proposes to implement a fish rescue and salvage plan that will identify appropriate procedures for monitoring and implementing appropriate collection and relocation methods if special-status species are detected (Appendix 3.F, AMM 8 Fish Rescue and Salvage Plan).

5.E.5.2.1.1.4.6 Loss/Alteration of Habitat

Construction of the new water conveyance facilities would result in temporary to permanent losses or alteration of EFH in the CCF for early life stages of starry flounder. In addition to the temporary effects on water quality and other construction-related hazards described above, dredging, cofferdam installation, levee clearing/armoring, and barge operations would affect an estimated 1,932 acres of tidal perennial aquatic habitat in CCF (Mapbook M3.A), resulting in negligible effects on EFH given the small fraction of total EFH affected and the location of the effect being outside the main range for starry flounder.

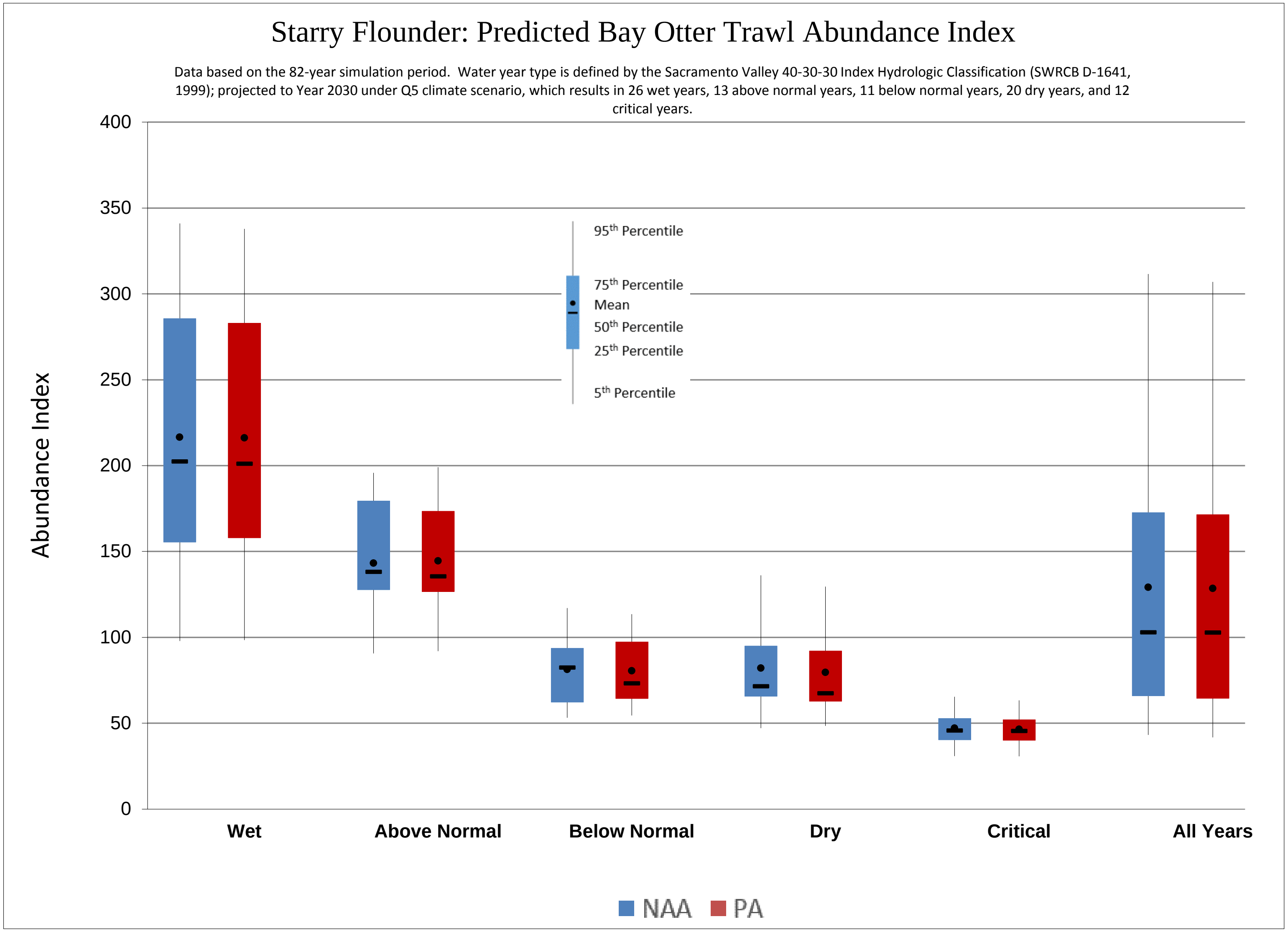
5.E.5.2.1.2 Effects of Water Facility Operations

As with Coastal Pelagic Species, far-field effects of water facility operations have most relevance to starry flounder.[3] A comparison of modeled salinity values between the NAA and PA at Martinez indicates that there would be marginal increases and decreases in salinity (Table 5.E-1.), These potential changes in salinity are small (all differences would be <1.0 ppt) and well within the salinity tolerances of starry flounder (Baxter et al. 1999). Kimmerer et al. (2009) found a significant negative relationship between annual mean March–June X2 (an index of Delta outflow) and annual mean starry flounder bay otter trawl abundance indices, which they suggested could be related to an increase in residual circulation in the San Francisco Estuary with increasing Delta outflow; if such an increase translates to more rapid or more complete

[3] Entrainment at the south Delta export facilities would be expected to be low under both the PA and the NAA, but because of the implementation of the NDD and less south Delta exports under the PA, entrainment would be expected to be lower under the PA (see Table 5.A.6-27 in Appendix 5.A).

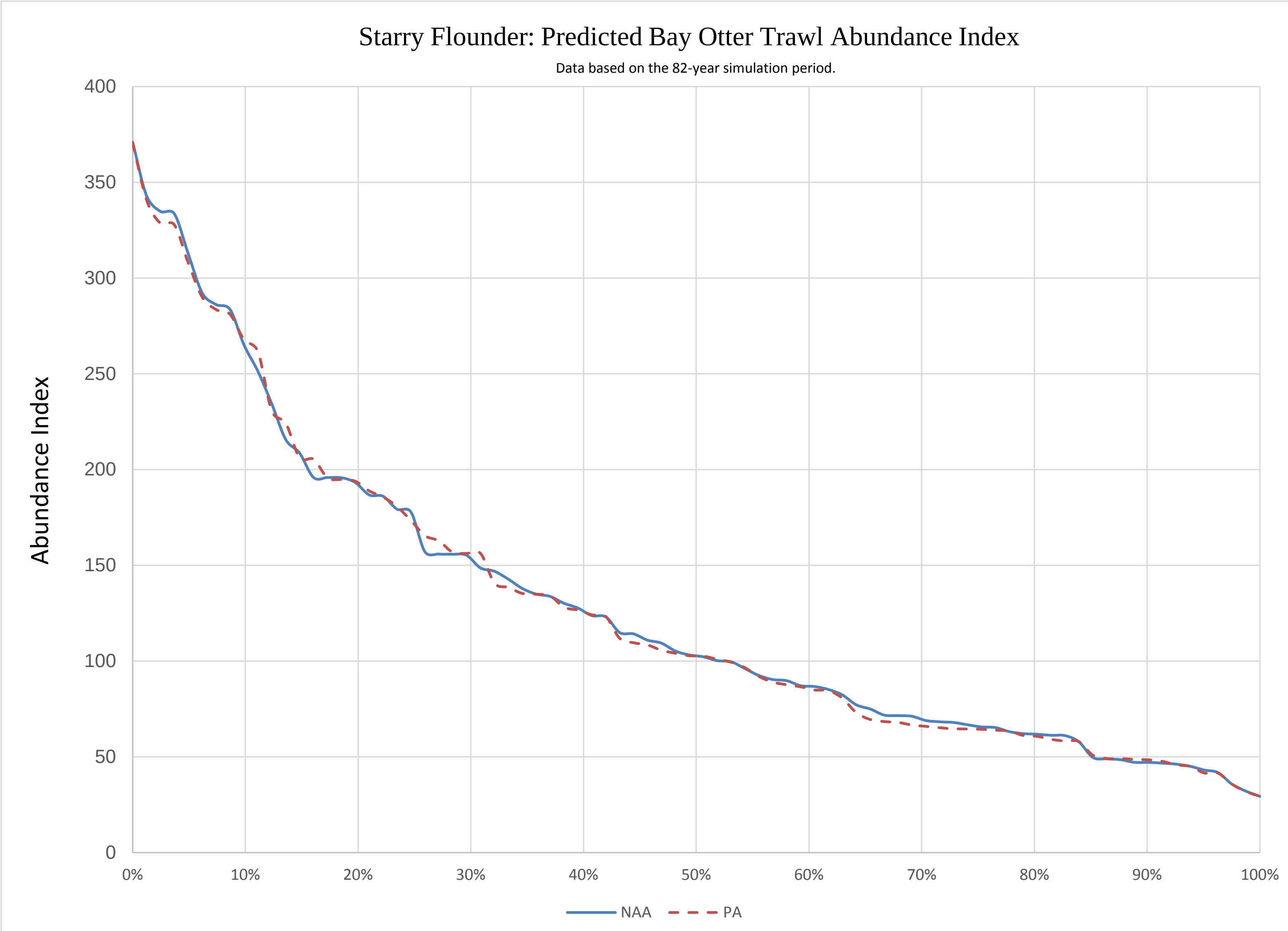
entrainment of starry flounder early life stages into the estuary, or more rapid transport to their rearing grounds, then presumably, survival from hatching to settlement would be higher under high-flow conditions (Kimmerer et al. 2009: 385). A comparison of predicted bay otter trawl indices for the NAA and PA scenarios as a function of modeled X2 was undertaken using the regression coefficients presented by Kimmerer et al. (2009: their Table 2). This confirmed that there would be very little difference in abundance indices expected for NAA and PA as a function of X2 (Figure 5.E-7; Figure 5.E-8; Table 5.E-7). Calculation of the 95% confidence intervals of the estimates, based on the 95% confidence intervals of the slope and step change coefficients, emphasizes the minimal differences between NAA and PA, because the 95% confidence intervals of NAA and PA predicted abundance indices overlapped in all 82 years of the simulation (Figure 5.E-9). Therefore this suggests that there would be essentially no detectable difference in starry flounder abundance (an index of Pacific Groundfish EFH operational effects) between NAA and PA based on differences in X2[4].

[4] As noted in the independent review panel report for the working draft BA, it is possible that the true annual values could lie near the bottom boundary of the confidence interval for PA and near the top boundary of the confidence interval for NAA (Simenstad et al. 2016). This would result in greater differences than suggested by the comparison of annual mean values. By the same rationale, it is also possible that the true annual values could lie near the top boundary of the confidence intervals for both PA and NAA, in which case the differences would be more similar to the differences between means.



Note: Plot only includes annual mean responses and does not consider model uncertainty.

Figure 5.E-7. Box Plots of Predicted Starry Flounder Bay Otter Trawl Abundance Index as a Function of Mean March-June X2 (Kimmerer et al. 2009), Grouped by Water Year Type.

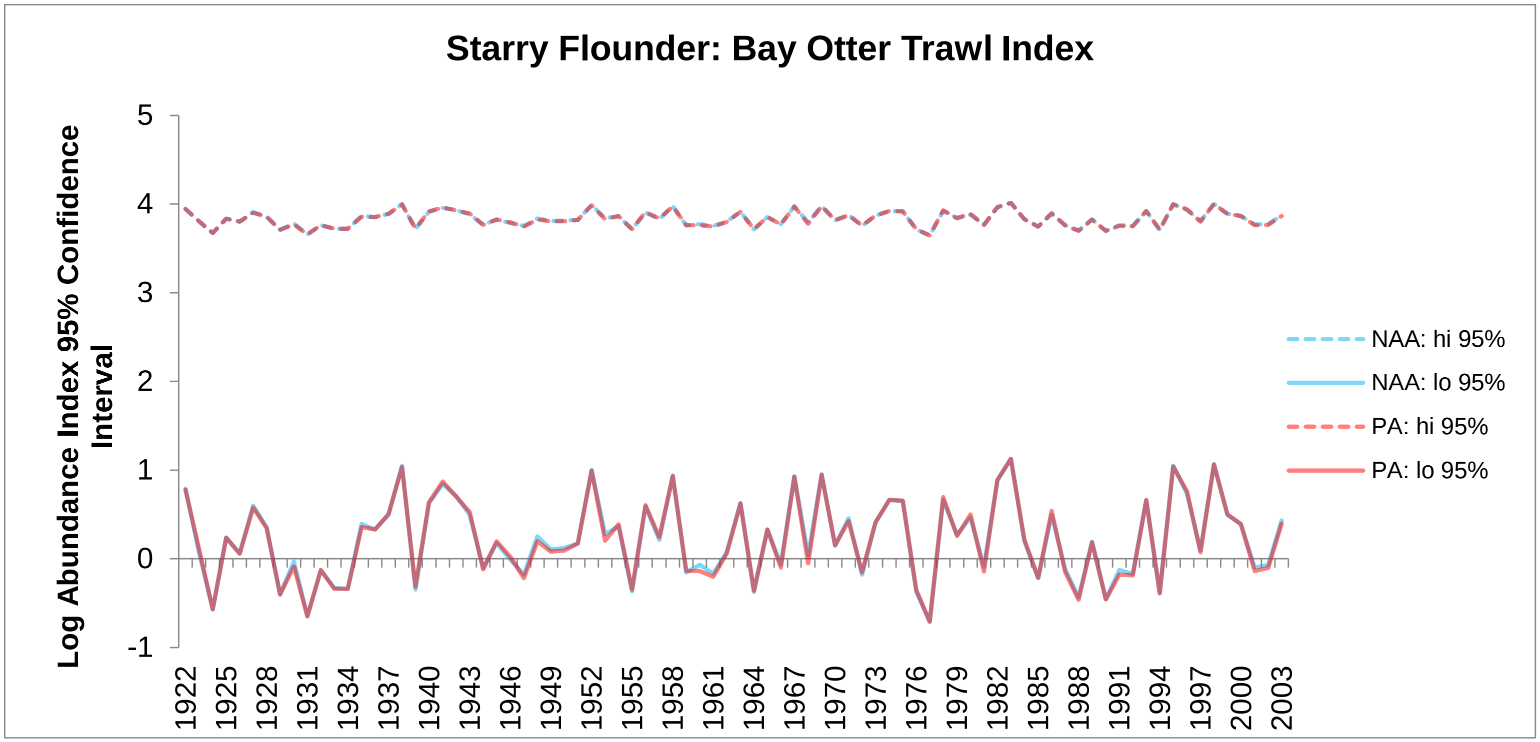


Note: Plot only includes annual mean responses and does not consider model uncertainty.

Figure 5.E-8. Exceedance Plot of Predicted Starry Flounder Bay Otter Trawl Abundance Index as a Function of Mean March-June X2 (Kimmerer et al. 2009).

Table 5.E-7. Predicted Starry Flounder Bay Otter Trawl Abundance Index as a Function of Mean March-June X2 (Kimmerer et al. 2009), Grouped by Water Year Type.

WY Type	NAA	PA	PA vs. NAA
W	216	216	0 (0%)
AN	143	144	1 (1%)
BN	81	80	-1 (-1%)
D	82	80	-2 (-3%)
C	47	46	-1 (-1%)



Note: Plot does not include 95% prediction intervals because these were not reported by Kimmerer et al. (2009).

Figure 5.E-9. Time Series of 95% Confidence Interval Predicted Starry Flounder Bay Otter Trawl Abundance Index as a Function of Mean March-June X2 (Kimmerer et al. 2009).

5.E.5.2.1.3 Maintenance Effects

Bank, bed and water column disturbance associated with maintenance activities have the potential to cause adverse affects to EFH habitat of starry flounder. Effects would be most likely to occur during maintenance dredging activities around the new intakes. Suction dredging, mechanical excavation, and possible front-end loading equipment could remove food organisms and suspend contaminants into the water column. While these mechanisms are possible, the likelihood of starry flounder exposure would be low due to the low quality of the affected habitats and the timing of maintenance activities, coupled with low densities of starry flounder within this EFH habitat.

5.E.5.2.1.4 Avoidance and Minimization Measures Effects

The avoidance and minimization measures effects would be the same as for Chinook salmon in section 5.9.3.5.

5.E.5.3 Pacific Salmon

Pacific salmon EFH in the action area is known to support four ESUs of one species, Chinook salmon. As previously noted, this assessment of Pacific salmon EFH follows the NMFS (2009) SWP/CVP BiOp in concluding that the effects analysis for winter-run and spring-run Chinook salmon presented in Chapter 5 of this BA generally is expected to apply to Pacific salmon EFH. The analysis presented below focuses on fall-/late fall-run Chinook salmon, with conclusions for Pacific salmon EFH considering all races together, including hatchery-origin fish.

The proposed action has the potential to affect EFH for Pacific salmon through the following main mechanisms:

- *Underwater noise* associated with in-water construction.
- *Structural changes* associated with temporary (construction) or permanent placement of engineered structures in habitat.
- *Water quality effects from in-water construction*.
- *Water quality effects from maintenance* of engineered in-water structures.
- *Near-field (e.g., entrainment) and far-field (e.g., changes in river flow leading to changes in survival) effects associated with operations under the proposed action.*
- *Effects upstream of the Delta related to changes in reservoir operations, instream flows, and water temperatures*

5.E.5.3.1 Fall/Late Fall-Run Chinook Salmon

5.E.5.3.1.1 Effects of Water Facility Construction

Construction of the north Delta intakes, barge landings, HOR gate, and modifications at CCF could affect Pacific salmon EFH through temporary increases in turbidity and suspended sediment, potential contaminant spills or mobilization of contaminated sediment, underwater noise, fish stranding, direct physical injury, and temporary to long-term losses or alteration of migration and rearing habitat.

The effects on fall/late-fall-run Chinook salmon resulting from construction of the north Delta intakes is the same as described for winter-run and spring-run Chinook salmon with differences in the potential for exposure due to differences in when fall/late-fall run may be present in the affected areas. Overall, the implementation of AMMs and the conservation measures proposed in Appendix 3.F and Chapter 3.4 would avoid, minimize, and offset construction-related effects on Pacific salmon EFH.

5.E.5.3.1.2 Effects of Water Facility Operations

5.E.5.3.1.2.1 In-Delta Effects

In-Delta[5] operational effects to fall-run and late fall-run Chinook salmon followed the framework for analyses of listed salmonids presented in Chapter 5. The methods for evaluating potential in-Delta effects on fall- and late fall-run Chinook salmon include some of the same methods described in Appendix 5.D, *Quantitative Methods and Detailed Results for Effects Analysis of Chinook Salmon, Central Valley Steelhead, Green Sturgeon, and Killer Whale*. The EFH analysis presented herein cross-references analyses in Chapter 5, wherein cross-references to Appendix 5.D methods and results are presented. Additional methods for fall-run and late fall-run Chinook for the analysis of EFH are described in the subsequent sections of this appendix as necessary.

5.E.5.3.1.2.1.1 Near-Field Effects

5.E.5.3.1.2.1.1.1 North Delta Exports

Entrainment

As described in Section 5.4.1.3.1.1.1.1 of Chapter 5, juvenile salmonids greater than 22-mm standard length (SL) would be expected to be excluded by the NDD's 1.75-mm-opening fish screens; based on the sizes of fall-run Chinook salmon fry entering the Delta, all or nearly all individuals would be expected to be effectively screened (Kjelson et al. 1982; although note that this study was based on sampling with a 3.2-mm mesh beach seine, which would have excluded smaller individuals if present).

Impingement, Screen Contact, and Screen Passage Time

As described in Section 5.4.1.3.1.1.1.2 of Chapter 5, juvenile salmonids would have the potential to contact and be impinged on the screens of the NDD, although laboratory studies found that despite Chinook salmon experiencing frequent contact with a simulated fish screen they were rarely impinged and impingement was not related to any of the experimental variables examined (Swanson et al. 2004). The proposed NDD intake screens would have a smooth screen surface and frequent screen cleaning (cycle time no more than 5 minutes) would provide additional protection to minimize screen surface impingement of juvenile Chinook salmon. The smooth surface also would serve to reduce the risk of abrasion and scale loss for any fish that does come

[5] Note that although this section is titled "In-Delta Effects", analyses do consider adjacent areas (e.g., Suisun Bay/Suisun Marsh and San Francisco Bay) as necessary.

into contact with the screens, although there remains the risk of injury. In addition, the NDD intakes would be operated to maintain fish screen sweeping and approach velocities to minimize fish contact with screens.

As described in Section 5.4.1.3.1.1.1.2 of Chapter 5, passage times of juvenile Chinook salmon along the NDD intake screens may be considerable, which may prolong the risk of effects such as screen contact/injury or predation. The smallest size of Chinook salmon examined in laboratory trials was 4.4-cm SL, for which screen passage time was 70-100 minutes with a sweeping velocity of 0.5 ft/s at 12°C (see Figure 5.4.1-1 in Chapter 5). Such passage times may be representative of fall-run Chinook salmon fry occurring in winter/early spring. Provision of refugia along the screens would provide potential places for Chinook salmon fry to rest before continuing movement downstream. Screen passage times may be relatively rapid for larger Chinook salmon juveniles moving downstream in spring (e.g., fall-run Chinook salmon smolts), when laboratory studies showed that warmer water began to result in positive rheotaxis (movement downstream with the flow, as opposed to swimming against the flow in colder temperatures).

Predation

As described in Section 5.4.1.3.1.1.1.3 of Chapter 5, there may be a predation risk associated with the NDD for juvenile Chinook salmon moving past the fish screen. As discussed in some detail in that section, there is uncertainty regarding the extent to which predation greater than baseline levels would occur. There is also uncertainty in the extent to which *Localized Reduction of Predatory Fishes to Minimize Predator Density at North and South Delta Export Facilities* (see Appendix 3.H) would reduce the potential for predation at the NDD; for this effects analysis it is not assumed that this would be effective.

5.E.5.3.1.2.1.1.2 South Delta Exports

Entrainment

As described in Section 5.4.1.3.1.1.2.1.1 of Chapter 5, potential changes in entrainment loss at the south Delta export facilities were assessed with the salvage-density method, which functions primarily to illustrate south Delta export differences between the NAA and PA scenarios. Detailed results by month, facility, and water-year type are presented for fall-run Chinook salmon and late fall-run Chinook salmon in Sections 5.D.1.1.2.1.4.3 and 5.D.1.1.2.1.4.4 in Appendix 5.D. The results of the salvage-density method showed that, based on modeled south Delta exports, mean entrainment loss at the south Delta export facilities would be lower under PA than NAA in all water year types for fall-run and late fall-run Chinook salmon (Table 5.E-8 and Table 5.E-9). The differences between PA and NAA generally were greater in wetter water years, as a result of less south Delta export pumping facilitated by operation of the NDD. For fall-run Chinook salmon, the differences ranged from 8% less under PA at the CVP in critical years to 75% less under PA at the CVP in wet years (Table 5.E-8). For late fall-run Chinook salmon, the differences ranged from 8% less under PA at the CVP in critical years to 68% less under PA at the CVP in below normal years (Table 5.E-9).

Table 5.E-8. Estimated Mean Entrainment Index (Number of Fish Lost, Based on Nonnormalized Salvage Data) of Juvenile Fall-Run Chinook Salmon for NAA and PA Scenarios at the CVP/SWP Salvage Facilities, By Water Year Type

Water Year Type	State Water Project				Central Valley Project		
	NAA	PA	PA vs. NAA[1]		NAA	PA	PA vs. NAA[1]
Wet	49,787	14,556	-35,231 (-71%)		36,402	9,251	-27,150 (-75%)
Above Normal	22,854	8,522	-14,332 (-63%)		9,619	2,521	-7,098 (-74%)
Below Normal	9,875	5,898	-3,977 (-40%)		7,218	5,168	-2,050 (-28%)
Dry	26,548	16,601	-9,947 (-37%)		3,390	2,479	-911 (-27%)
Critical	5,093	3,808	-1,285 (-25%)		2,333	2,146	-187 (-8%)

Notes: [1]Negative values indicate lower entrainment loss under the proposed action (PA) than under the no action alternative (NAA).

Table 5.E-9. Estimated Mean Entrainment Index (Number of Fish Lost, Based on Nonnormalized Salvage Data) of Juvenile Late Fall-Run Chinook Salmon for NAA and PA Scenarios at the CVP/SWP Salvage Facilities, By Water Year Type

Water Year Type	State Water Project				Central Valley Project		
	NAA	PA	PA vs. NAA[1]		NAA	PA	PA vs. NAA[1]
Wet	306	228	-78 (-25%)		54	29	-25 (-47%)
Above Normal	280	195	-85 (-30%)		54	34	-20 (-37%)
Below Normal	23	11	-13 (-54%)		12	4	-8 (-68%)
Dry	150	121	-29 (-20%)		32	26	-5 (-17%)
Critical	41	37	-4 (-9%)		9	8	-1 (-8%)

Notes: [1]Negative values indicate lower entrainment loss under the proposed action (PA) than under the no action alternative (NAA).

Predation

As described in Section 5.4.1.3.1.1.2.2 of Chapter 5, considerable predation of juvenile salmonids occurs at the south Delta export facilities (Gingras 1997; Clark et al. 2009). Less entrainment of juvenile fall-run and late fall-run Chinook salmon, as estimated in the preceding sections with the salvage-density method, would be expected to result in less entrainment-related predation loss. To the extent that the localized reduction of predatory fishes, discussed further in Chapter 5's Section 5.5.2, *Localized Reduction of Predatory Fishes to Minimize Predator Density at North and South Delta Export Facilities*, reduces predator abundance in Clifton Court Forebay, predation risk to juvenile salmonids could be further reduced under the PA relative to the NAA. However, as noted in Section 5.4.1.3.1.1.2.2 of Chapter 5, there is uncertainty in the efficacy of localized reduction of predatory fishes, given that previous efforts did not yield measurable changes in predator population size within the Forebay (Brown et al. 1996). For this effects analysis it is therefore not assumed that localized reduction of predatory fishes will be effective.

5.E.5.3.1.2.1.1.3 Head of Old River Gate

Predation

As described further in Section 5.4.1.3.1.1.3.1 of Chapter 5, the HOR gate could create hydrodynamic conditions providing opportunities for predators to ambush passing (possibly disoriented) juvenile fall-run Chinook salmon emigrating from the San Joaquin River basin. The extent to which any near-field predation at the HOR gate would offset the anticipated beneficial effects of a greater proportion of fish and flow remaining in the San Joaquin River is unclear, although the available data for juvenile fall-run Chinook salmon suggest that in general the presence of a barrier improves through-Delta survival (see review by Hankin et al. 2010 and comparison of 2012 [rock barrier] versus 2013 [no barrier] by Brandes and Buchanan 2016; however, see also comments by Anderson et al. [2012] with specific reference to the uncertainty in the effectiveness of the 2012 HOR rock barrier implementation in protecting out-migrating salmonid smolts).

Upstream Passage

As described in Section 5.4.1.3.1.1.3.2 of Chapter 5 for steelhead, adult fall-run Chinook salmon returning to natal tributaries in the San Joaquin River basin via Old River could experience migration delay when encountering the HOR gate during its October-November RTO (real time operations) period. The HOR gate would include a fish passage structure meeting NMFS and USFWS guidelines in order to allow passage of upstream migrating salmonids, including fall-run Chinook salmon. The existing fall rock barrier includes a 30-foot-wide notch at elevation 2.3 feet NAVD, which is intended to allow passage of upstream-migrating salmonids. NMFS (2013: 89) considered that this notch would result in minimal delay to upstream migrating steelhead, which is also likely to be the case for adult fall-run Chinook salmon.

5.E.5.3.1.2.1.1.4 Delta Cross Channel

The principal effect of the DCC would be to influence the proportion of juvenile fall-run and late fall-run Chinook salmon entering the interior Delta, where survival is lower. This is discussed in detail as part of the far-field effects analysis in Section 5.E.5.3.1.2.1.2.1 (section: Entry into Interior Delta).

As described for the listed salmonids in Section 5.4.1.3.1.1.4 of Chapter 5, an additional potential effect of the DCC is delayed upstream migration of fall-run and late fall-run Chinook salmon returning to the Sacramento River basin. The upstream migration periods of fall-run Chinook salmon (August-November, per Vogel and Marine 1991: 4) and late fall-run Chinook salmon upstream migration period (November-February; Vogel and Marine 1991: 4) overlap with periods when the DCC gates would be open more often under the PA than NAA (see Table 5.A.6-31 in Appendix 5.A), for the various reasons described for the listed salmonids in Section 5.4.1.3.1.1.4 of Chapter 5. This could result in greater proportion of fall-run and late fall-run Chinook salmon that are destined for the Sacramento River basin entering the central Delta and moving up the Mokelumne River system, therefore delaying migration somewhat, particularly if the DCC gates are subsequently closed. However, given that the differences between NAA and

PA in the number of days open generally were not considerable[6], and adult fall-run and late fall-run Chinook salmon that are migrating to the Sacramento River basin have the ability to drop back and swim around the DCC gates (NMFS 2009: 406), any effects to EFH would be undetectable.

In addition to physically affecting upstream passage of upstream migrating salmonids, the DCC may affect straying of Mokelumne River fall-run Chinook salmon into the Sacramento River basin; this topic is discussed under Olfactory Cues for Upstream Migration in Section 5.E.5.3.1.2.1.2.2.

5.E.5.3.1.2.1.1.5 Suisun Marsh Facilities

Suisun Marsh Salinity Control Gates

As described in more detail for listed salmonids in Section 5.4.1.3.1.1.5.1 of Chapter 5, the SMSCG would be expected to have low potential for effects to Pacific salmon and their EFH. Any effects would be expected to be similar between NAA and PA because operations would be very similar (see Table 5.B.5-29 in Appendix 5.B).

Roaring River Distribution System

The fish screens of the RRDS intake culverts would be expected to minimize the potential for entrainment of juvenile fall-run and late fall-run Chinook salmon, as discussed in more detail for listed salmonids in Section 5.4.1.3.1.1.5.2 of Chapter 5. Although fall-run Chinook salmon fry may be considerably smaller than winter-run and spring-run Chinook salmon smolts, the 3/32-inch (2.4-mm) openings on the screens would be expected to exclude individuals of around 30 mm and greater[7], i.e., all or nearly all fall-run fry based on sizes observed by Kjelson et al. (1982; although note that this study was based on sampling with a 3.2-mm mesh beach seine, which would have excluded smaller individuals if present).

Morrow Island Distribution System

NMFS (2009: 438) described that entrainment monitoring at MIDS in 2004–2006 found two fall-run Chinook salmon fry (39–44 mm), indicating that entrainment by the unscreened intake culverts does occur. NMFS (2009: 438) noted that MIDS is not on a migratory corridor for listed salmonids; this may limit the potential for entrainment for non-listed fall-run and late fall-run Chinook salmon. Operations of MIDS would not differ between NAA and PA (see Tables 5.B.5-31, 5.B.5-32, and 5.B.5-33 in Appendix 5.B), so no effects to EFH from the PA are expected.

Goodyear Slough Outfall

Similar to the analysis for listed salmonids presented in Section 5.4.1.3.1.1.5.4 of Chapter 5, the Goodyear Slough outfall would be unlikely to affect EFH for fall-run or late fall-run Chinook

[6] Note that the operational criteria for gate openings do not differ between NAA and PA, but there may be differences in the number of days open between NAA and PA from following these criteria, as reflected in the modeling.

[7] Based on a conservative body fineness ratio of 10 (from Delta Smelt estimates by Young et al. 1997) and applying the equations of Young et al. (1997).

salmon because of its location and design, and per NMFS (2009: 438) may benefit juvenile salmonids by improving water quality and increasing foraging opportunities.

5.E.5.3.1.2.1.1.6 North Bay Aqueduct

As noted for listed salmonids in Section 5.4.1.3.1.1.6 in Chapter 5, the fish screens on the North Bay Aqueduct Barker Slough intake and its location far from expected juvenile salmonid migrational corridors suggest that there would be minimal effects to EFH for fall-run and late fall-run Chinook salmon from its operations.

5.E.5.3.1.2.1.1.7 Other Facilities

Contra Costa Canal Rock Slough Intake

As described for listed salmonids in Section 5.4.1.3.1.1.7.1 of Chapter 5, the Rock Slough intake's fish screen is intended to prevent entrainment of listed fishes, but has experienced reduced effectiveness caused by aquatic vegetation fouling. Actions to test new methods to resolve these problems are underway, and any implementation of solutions would be similar under the NAA and PA. Modeled pumping suggested that diversions under the PA generally would be similar to NAA, with the exception of April and May, when diversions would be greater under the PA (see Table 5,B, 5-36 in Appendix 5.B). This could result in a greater likelihood of any juvenile fall-run Chinook salmon in Rock Slough encountering the intake and therefore could affect EFH, although the slough is off the main migratory pathway for juvenile salmonids, as noted in Section 5.4.1.3.1.1.7.1 of Chapter 5 for listed salmonids. In addition, resolution of the aforementioned issues with screen effectiveness would be expected to reduce any potential adverse effects to immeasurable levels.

Clifton Court Forebay Aquatic Weed Control Program

As described for listed salmonids in Section 5.4.1.3.1.1.7.2 of Chapter 5, the timing of copper-based herbicide treatments (July–August) in Clifton Court Forebay would be expected to limit the potential for effects to juvenile fall-run and late fall-run Chinook salmon, in addition to less south Delta export pumping likely leading to less entrainment into the Forebay under the PA relative to the NAA (see Tables 5.D-11 to 5.D-20 in Appendix 5.D).

As discussed in more detail for listed salmonids in Section 5.4.1.3.1.1.7.2 of Chapter 5, mechanical removal of aquatic weeds on an as-needed basis within Clifton Court Forebay could affect juvenile fall-run and late fall-run Chinook salmon (e.g., from physical contact leading to injury), but the action would also be expected to benefit these species by reducing predator habitat and increasing salvage efficiency.

5.E.5.3.1.2.1.2 Far-Field Effects

5.E.5.3.1.2.1.2.1 Indirect Mortality within the Delta

Channel Velocity

As described more fully in Section 5.4.1.3.1.2.1.1 of Chapter 5, the PA has the potential to both adversely and beneficially change channel flows in the Delta through changes in north and south Delta export patterns in relation to the NAA. North Delta exports would reduce Sacramento River flows downstream of the NDD, while reduced south Delta exports would allow greater south and central Delta channel flows. Detailed analysis of changes in velocity is presented in Section 5.4.1.3.1.2.1.1 of Chapter 5.

Overall, the results of the analysis of channel velocity suggest the potential for adverse effects to migrating juvenile fall-run and late fall-run Chinook salmon migrating downstream through the north Delta from the Sacramento River basin, and beneficial effects for San Joaquin River fall-run and late fall-run Chinook salmon. The effects for Sacramento River Chinook would result from lower overall velocity, somewhat greater negative velocity, and a greater proportion of time with negative velocity, which may delay migration and result in greater repeated exposure to entry into migration routes with lower survival, particularly because of entry into Georgiana Slough (see also discussion of flow routing into channel junctions). Juvenile fall-run Chinook salmon emigrating from the San Joaquin River basin would be expected to benefit from the HOR gate, which would increase overall velocity and reduce negative velocity in the San Joaquin River, as well as reducing the daily proportion of negative velocity; these effects would be greatest farther upstream.

Salmonids from both the Sacramento and San Joaquin River basins generally would be expected to benefit from interior Delta channel velocity (e.g., Old River downstream of the south Delta export facilities) that would be somewhat more positive and less frequently negative. The summary of Delta hydrodynamic conditions based on DSM2 modeling does not account for real-time operations that would be done in order to limit potential operational effects, by assessing flow conditions in the context of fish presence, e.g., by using monitoring data from at or upstream of the Delta periphery (e.g., Knights Landing on the Sacramento River or Mossdale on the San Joaquin River).

Entry into Interior Delta

As described further in Section 5.4.1.3.1.2.1.2 of Chapter 5, the PA has the potential to result in changes in interior Delta entry on the Sacramento River and the San Joaquin River. Less flow in the Sacramento River (as would occur because of exports by the NDD) leads to a greater tidal influence at the Georgiana Slough/DCC junction (Perry et al. 2015) and a greater proportion of flow entering the junction (Cavallo et al. 2015); installation of a nonphysical barrier at the Georgiana Slough junction would aim to minimize this effect. Installation of the HOR gate under the PA would greatly reduce entry into Old River from the San Joaquin River. These factors are discussed in this section.

Flow Routing into Channel Junctions

A detailed analysis of flow routing into channel junction based on DSM2-HYDRO data is presented in Section 5.4.1.3.1.2.1.2.1 of Chapter 5. Overall, the analysis suggested that juvenile fall-run and late fall-run Chinook salmon migrating down the Sacramento River would have somewhat greater potential to enter the interior Delta through Georgiana Slough, which may result in adverse effects from the relatively low survival probability in that migration route. Minimization of this adverse effect would be undertaken with the installation of a nonphysical barrier at the Georgiana Slough junction (discussed in the next section). As previously noted, the summary of Delta hydrodynamic conditions based on DSM2 does not account for real-time operations that would be done in order to limit potential operational effects, by assessing flow conditions in the context of fish presence. Juvenile fall-run Chinook salmon migrating down the San Joaquin River would, based on flow routing, be expected to benefit from a HOR gate, which would considerably reduce entry into Old River and therefore reduce entrainment at the south Delta export facilities. Effects of the HOR gate in terms of near-field effects were discussed in Section 5.E.5.3.1.2.1.1.3 of this appendix.

Nonphysical Fish Barrier at Georgiana Slough

As described in more detail in Section 5.4.1.3.1.2.1.2.2 of Chapter 5, installation of a nonphysical fish barrier at the Georgiana Slough junction would aim to minimize the potential for greater entry into the junction caused by hydrodynamic changes because of the NDD. Existing studies on late fall-run Chinook salmon suggest that entry into Georgiana Slough could be reduced by half to two thirds of the rate that otherwise would occur (typically 20-25%) (California Department of Water Resources 2015). There are uncertainties associated with how representative the test studies are for smaller fall-run Chinook salmon juveniles of wild origin, given that large, hatchery-origin fish were tested.

Through-Delta Survival

Various analytical tools were used to provide greater biological context for the previously described operations-related differences in Delta hydrodynamics (channel velocity and entry into interior Delta) between the NAA and PA. The tools included the Delta Passage Model, analyses based on Newman (2003) and Perry (2010), and the SalSim Through-Delta Survival Function.

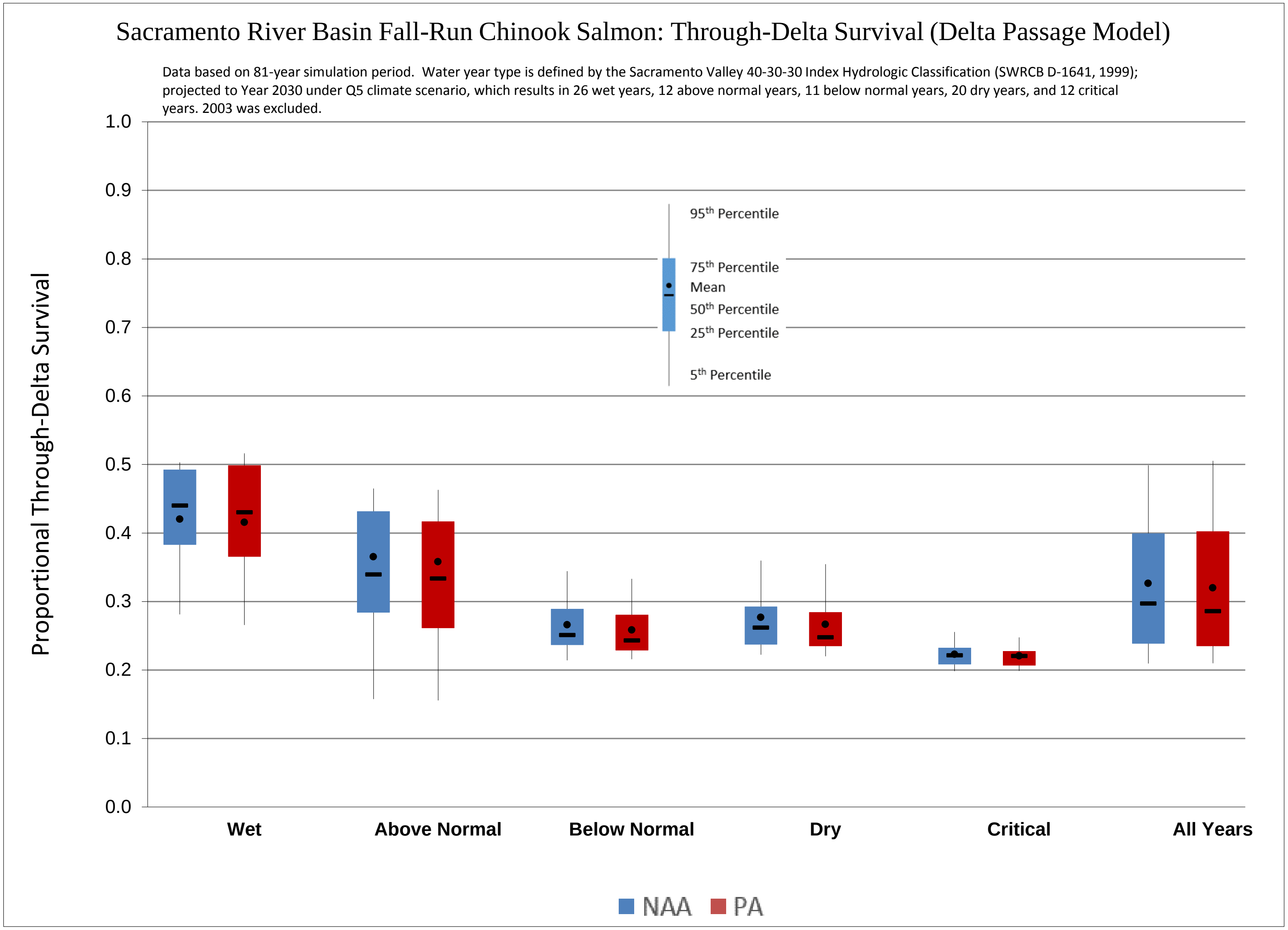
Delta Passage Model: Fall-Run and Late Fall-Run Chinook Salmon

As described in Section 5.4.1.3.1.2.1.3.1 of Chapter 5, the Delta Passage Model (DPM) integrates operational effects of the NAA and PA that could influence survival of migrating juvenile fall-run and late fall-run Chinook salmon through the Delta: differences in channel flows (flow-survival relationships), differences in routing based on flow proportions (e.g., entry into the interior Delta, where survival is lower), and differences in south Delta exports (export-survival relationships).

For fall-run Chinook salmon emigrating from the Sacramento River basin[8], the DPM results suggested that total through-Delta survival would be similar or marginally lower under the PA than the NAA (Figure 5.E-10 and Figure 5.E-11). Mean total through-Delta survival under the PA ranged from 0.20 in critical years to 0.38 in wet years, with a range of 1% less than NAA in critical, dry, and below normal years to 3% less in above normal years (Table 5.E-10). Mean survival down the mainstem Sacramento River route under the PA ranged from 0.21 in critical years to 0.41 in wet years, and the difference from NAA ranged from 1% less in critical years to 5% less in wet and above normal years, reflecting the influence of less river flow downstream of the NDD under the PA. As would be expected given that both scenarios assumed a notched Fremont Weir, Yolo Bypass entry was very similar between NAA and PA scenarios, and survival was identical (because the random draws from the route-specific survival distribution [Appendix 5.D, *Quantitative Methods and Detailed Results for Effects Analysis of Chinook Salmon, Central Valley Steelhead, Green Sturgeon, and Killer Whale,* Section 5.D.1.2.2.2.5.4]

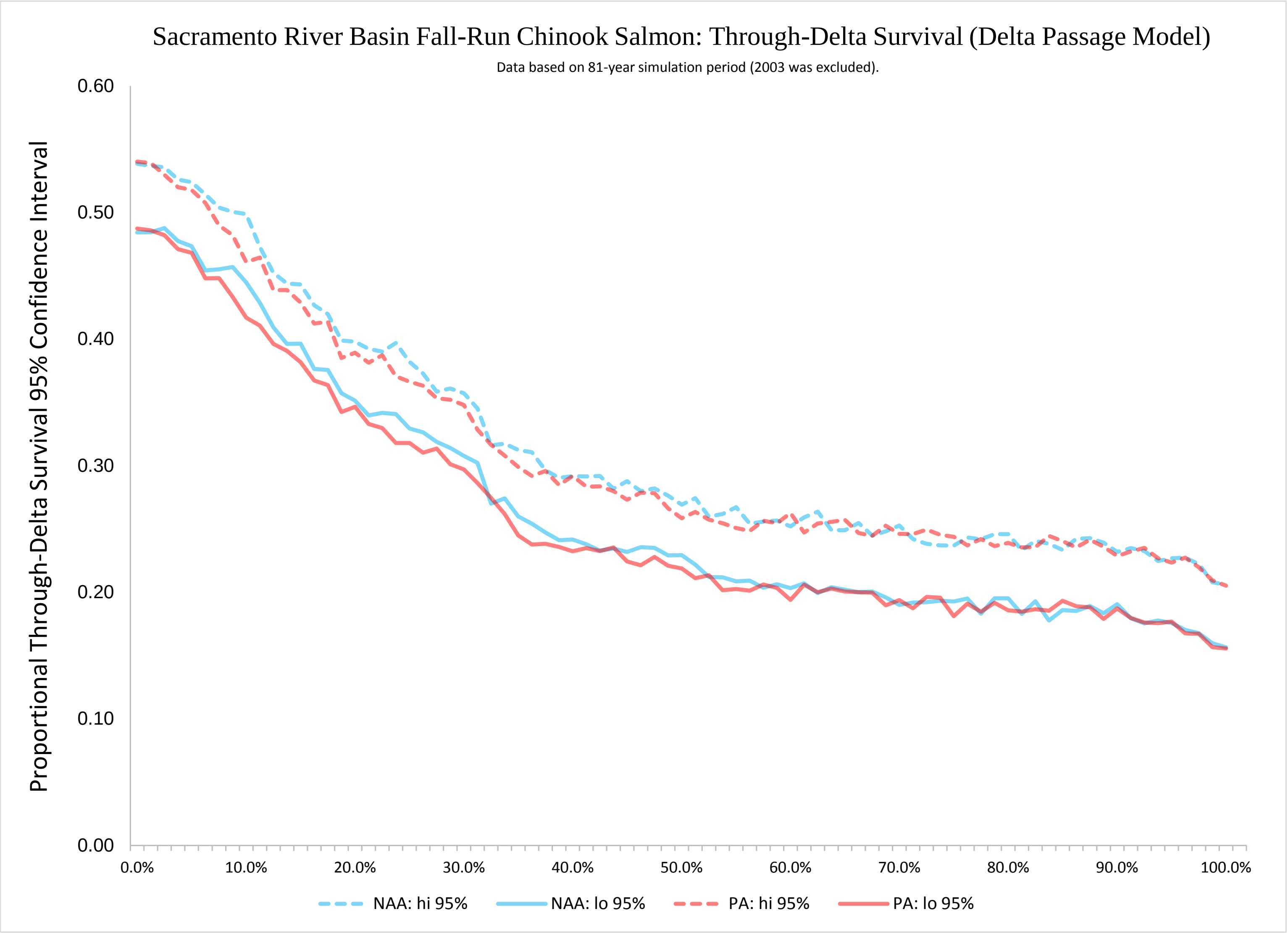
[8] Note that the DPM includes entry into the Yolo Bypass via Fremont Weir and therefore overall survival results reflect the fact that a portion of the population enters the relatively high survival Yolo Bypass migration route; this would be less likely for fall-run Chinook salmon emigrating from the Feather River and American River because these two tributaries meet the Sacramento River downstream of the Fremont Weir.

were the same for NAA and PA). A similar or marginally lower (0–2%) proportion of fish entered Sutter and Steamboat Sloughs under the PA compared to NAA (reflecting the flow routing into junctions; see Table 5.4.1-8 in Section 5.4.1.3.1.2.1.2.1, *Flow Routing into Channel Junctions* in Chapter 5), and the difference in mean survival for this route between PA and NAA was similar to that of the mainstem Sacramento River, reflecting the similar flow-survival relationships in the relevant reaches (see Section 5.D.1.2.2.2.5.5 in Appendix 5.D). A similar or slightly greater (0–2%) proportion of fish used the interior Delta migration route under the PA compared to NAA (again reflecting the flow routing into junctions; see Table 5.4.1-8 in Section 5.4.1.3.1.2.1.2.1, *Flow Routing into Channel Junctions*, of Chapter 5), and mean survival in this route was appreciably greater (14%) in wet years, which reflected appreciably less south Delta exports under the PA. The closeness of the estimates in total through-Delta survival between NAA and PA was emphasized by the 95% confidence intervals of the annual estimates overlapping in all years of the simulation period (Figure 5.E-12). As previously stated in the analysis of channel velocity and entry into the interiod Delta, the DPM analysis does not account for real-time operational adjustments that would be made in response to fish presence, which would aim to lessen any potential adverse effects.



Note: Plot only includes annual mean responses and does not consider model uncertainty.

Figure 5.E-10. Box Plots of Sacramento River Basin Fall-Run Chinook Salmon Annual Through-Delta Survival Estimated from the Delta Passage Model, Grouped by Water Year Type.



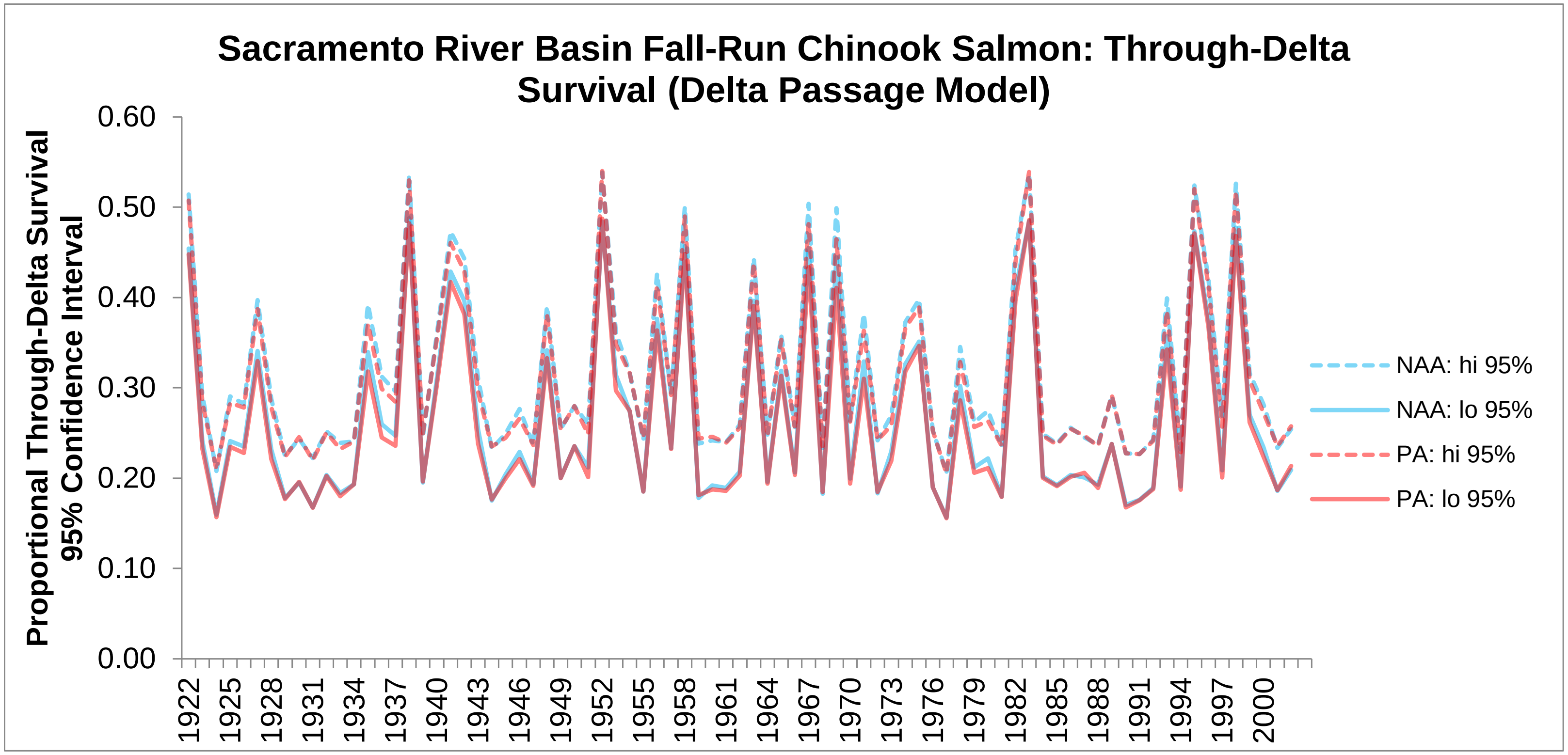
Note: Data are sorted by mean estimate, with only 95% confidence intervals shown.

Figure 5.E-11. Exceedance Plot of Sacramento River Basin Fall-Run Chinook Salmon Annual Through-Delta Survival Estimated from the Delta Passage Model.

Table 5.E-10. Delta Passage Model: Sacramento River Basin Fall-Run Chinook Salmon Mean Through-Delta (Total) Survival, Mainstem Sacramento River survival, and Proportion Using and Surviving Other Migration Routes.

WY	Total Survival			Mainstem Sacramento River Survival			Yolo Bypass					
							Proportion Using Route			Survival		
	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
W	0.39	0.38	-0.01 (-2%)	0.43	0.41	-0.02 (-5%)	0.08	0.08	0.00 (0%)	0.47	0.47	0.00 (0%)
AN	0.29	0.28	-0.01 (-3%)	0.31	0.29	-0.02 (-5%)	0.04	0.05	0.00 (6%)	0.47	0.47	0.00 (0%)
BN	0.24	0.24	0.00 (-1%)	0.26	0.26	-0.01 (-2%)	0.03	0.03	0.00 (0%)	0.47	0.47	0.00 (0%)
D	0.24	0.23	0.00 (-1%)	0.25	0.25	0.00 (-2%)	0.03	0.03	0.00 (-5%)	0.47	0.47	0.00 (0%)
C	0.20	0.20	0.00 (-1%)	0.22	0.21	0.00 (-1%)	0.03	0.03	0.00 (-2%)	0.47	0.47	0.00 (0%)
WY	Sutter/Steamboat Sloughs						Interior Delta (Via Georgiana Slough/DCC)					
	Proportion Using Route			Survival			Proportion Using Route			Survival		
	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
W	0.31	0.31	0.00 (-1%)	0.47	0.45	-0.02 (-4%)	0.26	0.26	0.00 (1%)	0.20	0.23	0.03 (14%)
AN	0.30	0.30	-0.01 (-2%)	0.35	0.33	-0.01 (-4%)	0.28	0.28	0.00 (2%)	0.16	0.17	0.01 (4%)
BN	0.29	0.29	0.00 (0%)	0.30	0.29	-0.01 (-2%)	0.29	0.29	0.00 (0%)	0.14	0.14	0.00 (2%)
D	0.29	0.29	0.00 (0%)	0.29	0.29	0.00 (-2%)	0.30	0.30	0.00 (0%)	0.13	0.14	0.00 (3%)
C	0.26	0.26	0.00 (0%)	0.26	0.26	0.00 (-1%)	0.32	0.32	0.00 (0%)	0.12	0.12	0.00 (1%)

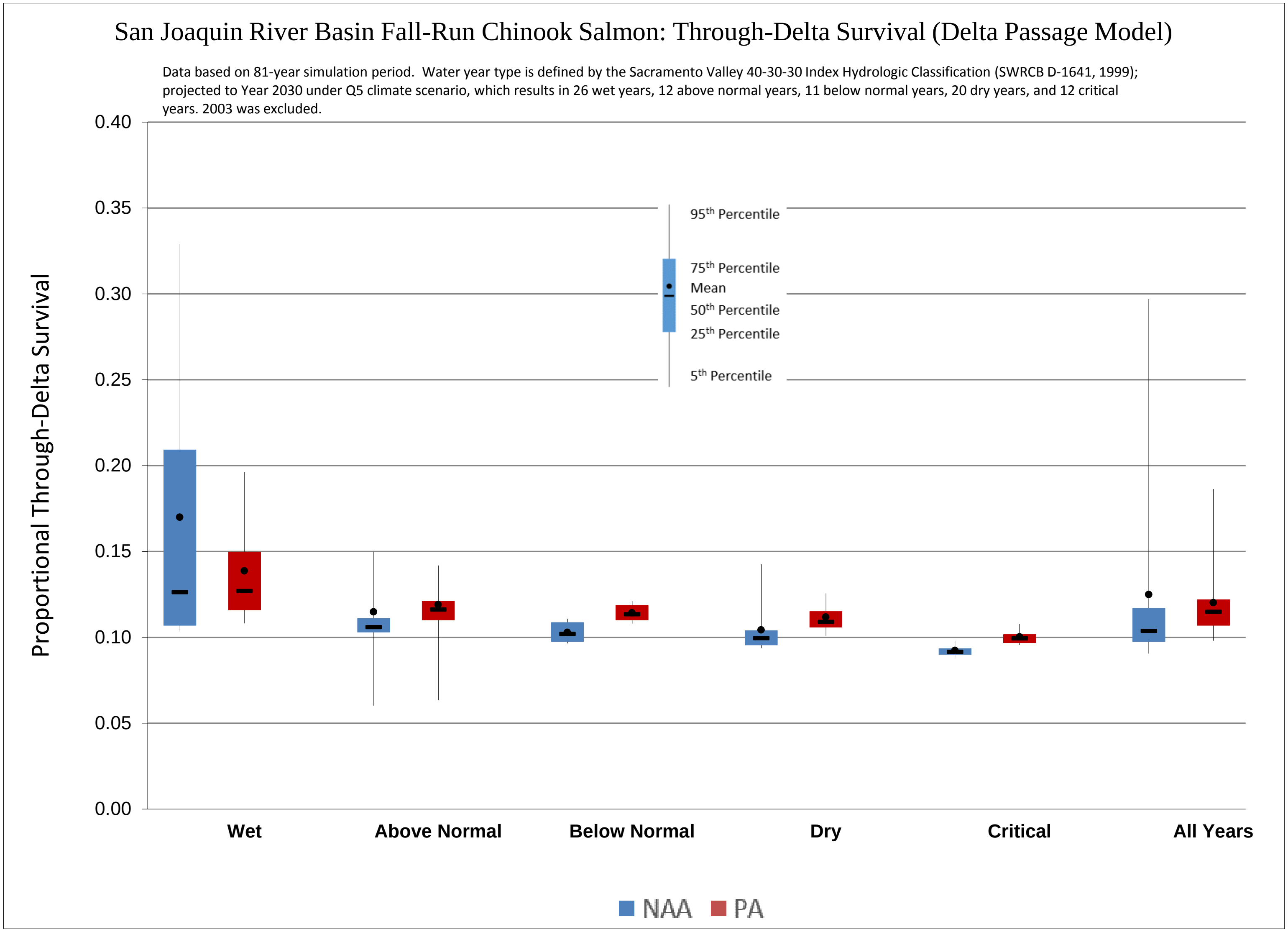
Note: Survival in Sutter/Steamboat Sloughs and Interior Delta routes includes survival in the Sacramento River prior to entering the channel junctions.



Note: Lines indicate 95% confidence intervals from the 75 iterations of the DPM.

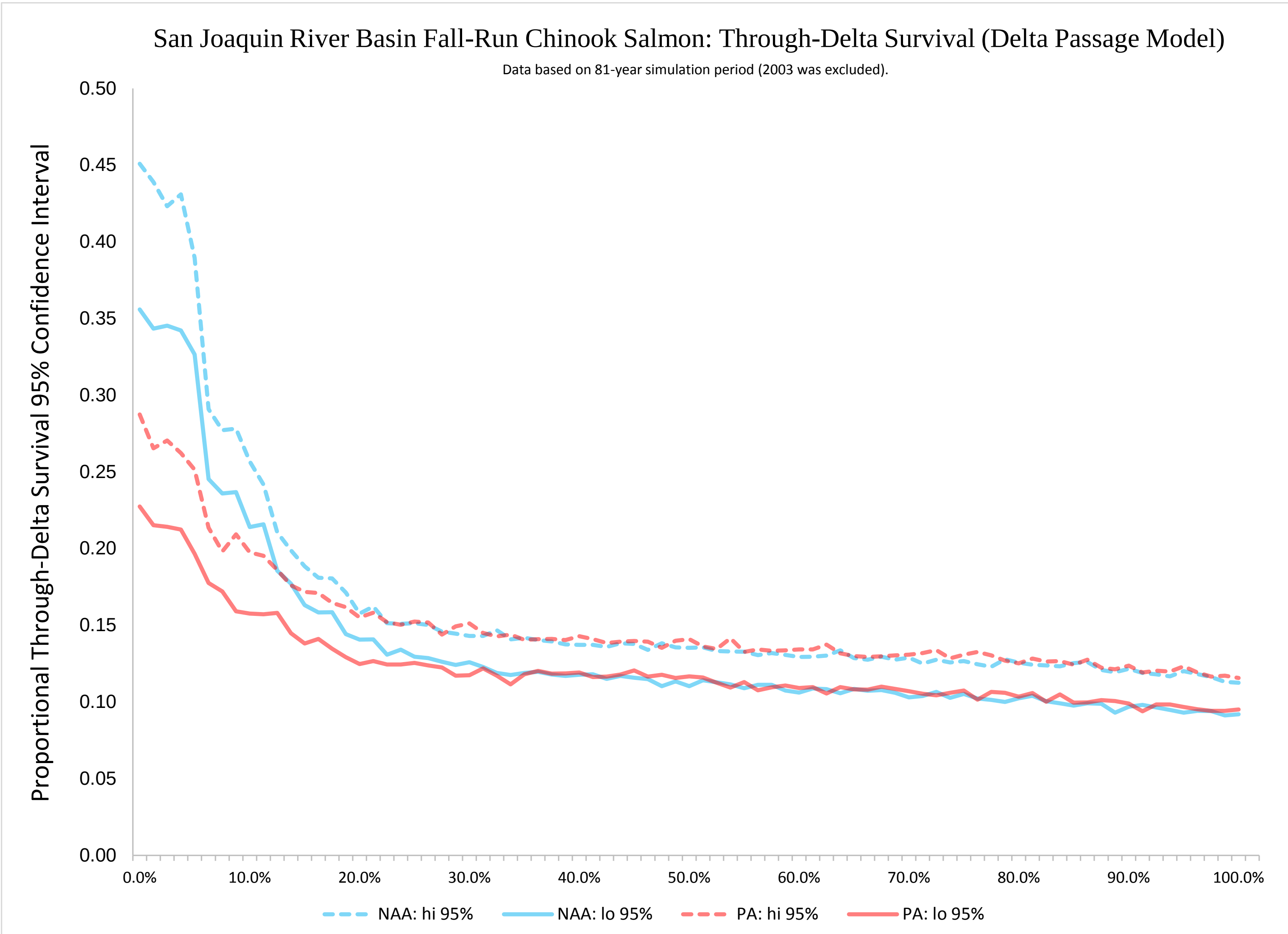
Figure 5.E-12. Time Series of 95% Confidence Interval Annual Juvenile Sacramento River Basin Fall-Run Chinook Salmon Through-Delta Survival, Estimated from the Delta Passage Model.

The results for through-Delta survival of fall-run Chinook salmon emigrating from the San Joaquin River basin revealed data-based limitations of the DPM. The DPM results suggested that total through-Delta survival generally would be similar or higher under the PA than the NAA, with the exception of wet years when survival would be higher under the NAA (Figure 5.E-13 and Figure 5.E-14; Table 5.E-11). Mean total through-Delta survival under the PA ranged from 0.10 in critical years to 0.14 in wet years, with a range of 18% less than NAA in wet years to 11% more than NAA in above normal years (Table 5.E-11). Mean survival down the mainstem San Joaquin River route under the PA ranged from 0.11 in critical years to 0.16 in wet years, and the difference from NAA ranged from 21% less in wet years to 4% more in dry years. As would be expected given the assumptions regarding the HOR gate, which for modeling purposes was assumed to be 50% open during the main fall-run Chinook salmon migration period, around 45–50% less entry into Old River occurred under PA. In wet years, entry into Old River was estimated to be ~30% less under PA than NAA, which reflects the HOR gate often not being closed during wet years because of exceedance of the 10,000-cfs Vernalis flow criterion permitting its closure; in these years, less fish would use the main stem San Joaquin River pathway under the PA than otherwise would occur if the HOR gate were closed. In such years, south Delta exports would be much lower under the PA than NAA because of greater operation of the north Delta intakes, which in the DPM results in estimated survival that is lower under PA than NAA because of the DPM's positive relationship between survival and south Delta exports, based on the relationships in the model (see Section 5.D.1.2.2.2.5.5 in Appendix 5.D). These types of years were the only ones for which the through-Delta survival 95% confidence intervals did not overlap between NAA and PA scenarios (Figure 5.E-15); survival was less under the PA in all 12 years in which the confidence intervals did not overlap. However, there is considerable uncertainty in PA effects on San Joaquin River fall-run Chinook salmon survival because the studies upon which the DPM flow- and export-survival relationships are based did not include the very low levels of south Delta exports that would be possible under the PA with implementation of the NDD. An alternative analysis to the DPM is provided with the through-Delta survival function of SalSim, as discussed later in the subsequent section on "SalSim Through-Delta Survival Function: Fall-Run Chinook Salmon".



Note: Plot only includes annual mean responses and does not consider model uncertainty.

Figure 5.E-13. Box Plots of San Joaquin River Basin Fall-Run Chinook Salmon Annual Through-Delta Survival Estimated from the Delta Passage Model, Grouped by Water Year Type.

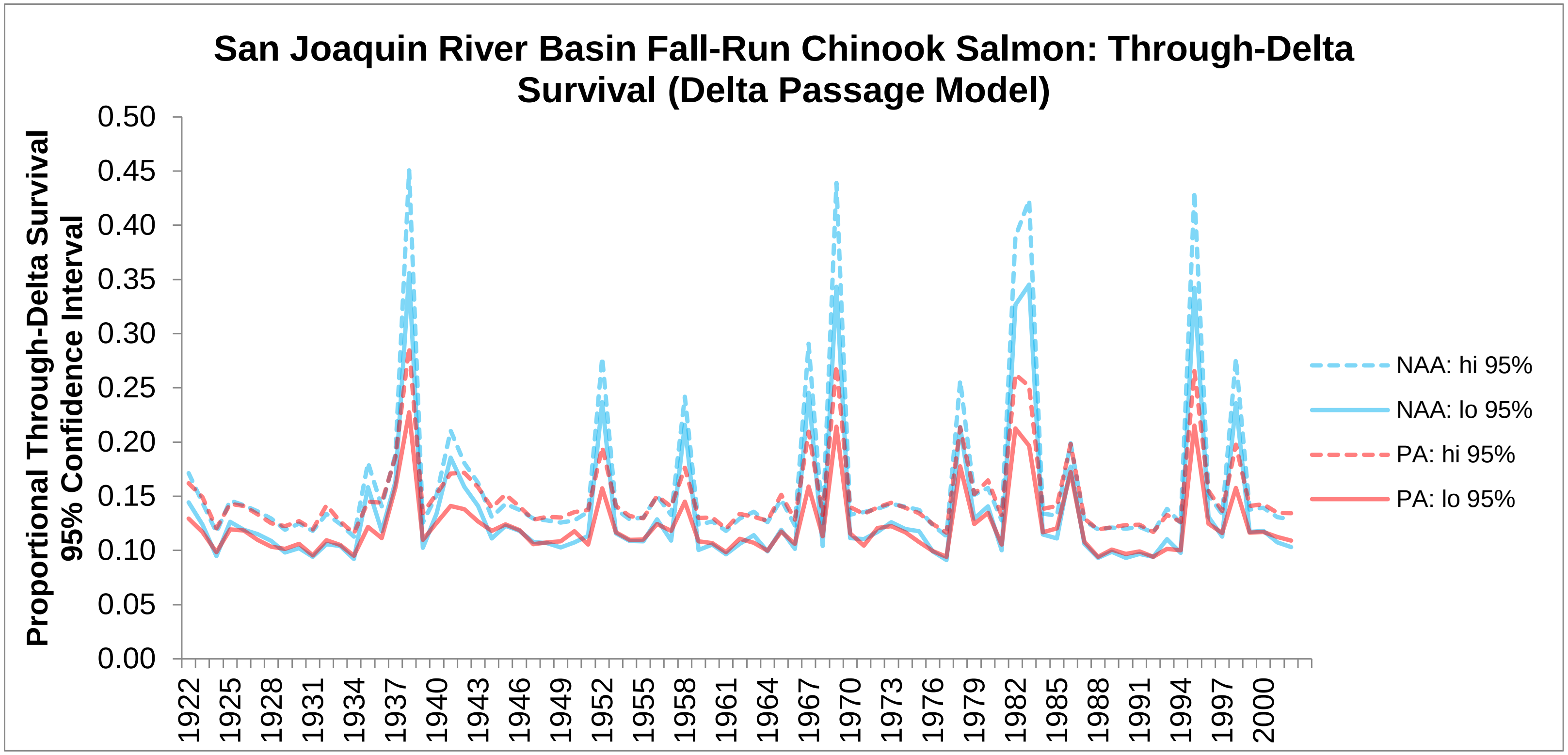


Note: Data are sorted by mean estimate, with only 95% confidence intervals shown.

Figure 5.E-14. Exceedance Plot of San Joaquin River Basin Fall-Run Chinook Salmon Annual Through-Delta Survival Estimated from the Delta Passage Model.

Table 5.E-11. Delta Passage Model: San Joaquin River Basin Fall-Run Chinook Salmon Mean Through-Delta (Total) Survival, Mainstem San Joaquin River survival, and Proportion Using and Surviving the Old River Migration Route.

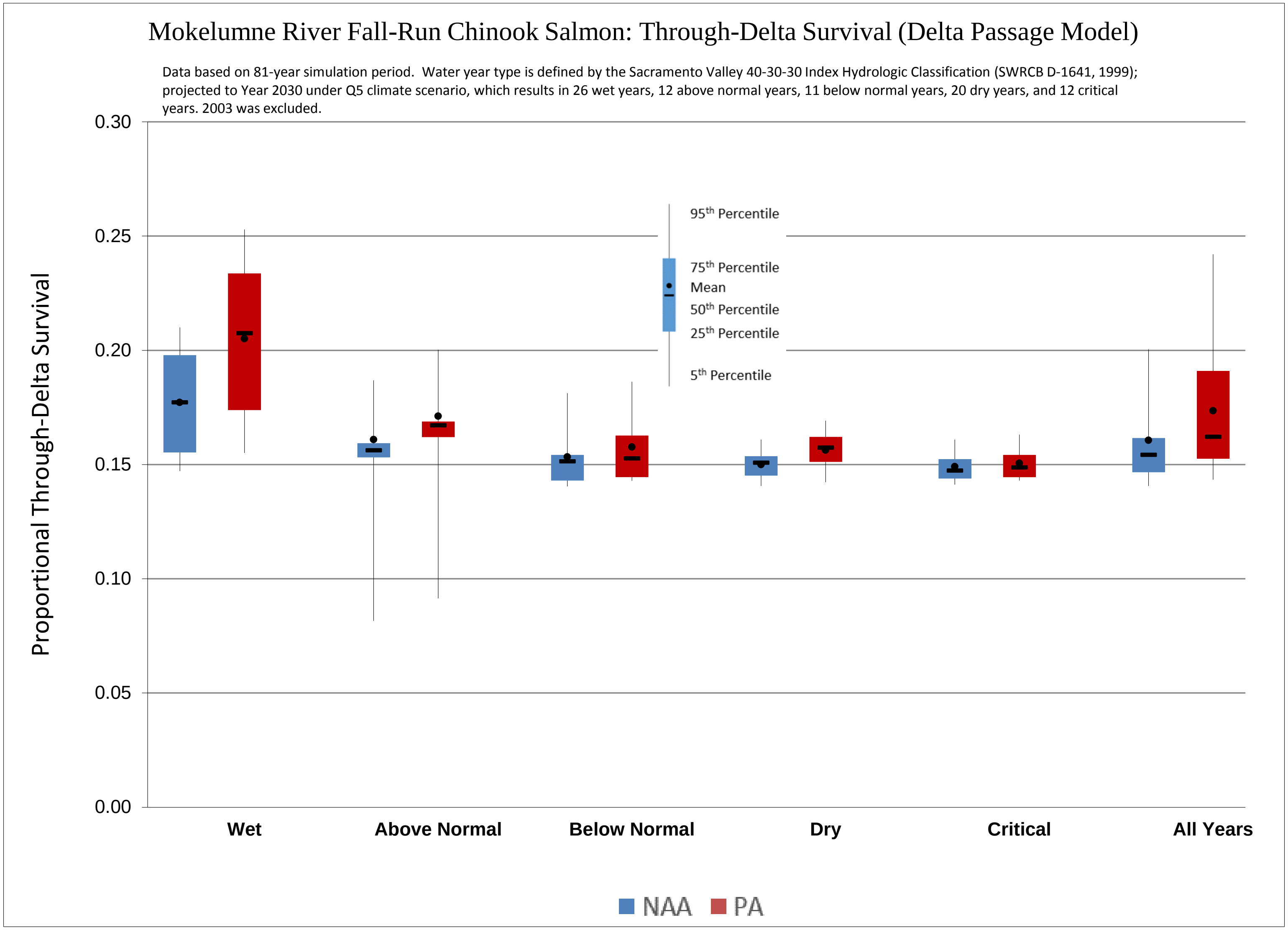
WY	Total Survival			Mainstem San Joaquin River Survival			Old River					
							Proportion Using Route			Survival		
	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
W	0.17	0.14	-0.03 (-18%)	0.20	0.16	-0.04 (-21%)	0.50	0.34	-0.16 (-31%)	0.13	0.10	-0.03 (-26%)
AN	0.11	0.12	0.00 (4%)	0.14	0.13	0.00 (-3%)	0.52	0.27	-0.25 (-48%)	0.09	0.08	-0.01 (-13%)
BN	0.10	0.11	0.01 (11%)	0.12	0.13	0.00 (4%)	0.55	0.27	-0.28 (-51%)	0.09	0.08	-0.01 (-6%)
D	0.10	0.11	0.01 (7%)	0.12	0.12	0.00 (0%)	0.58	0.30	-0.28 (-48%)	0.09	0.08	-0.01 (-7%)
C	0.09	0.10	0.01 (9%)	0.11	0.11	0.00 (2%)	0.61	0.34	-0.27 (-44%)	0.08	0.08	0.00 (-2%)



Note: Lines indicate 95% confidence intervals from the 75 iterations of the DPM.

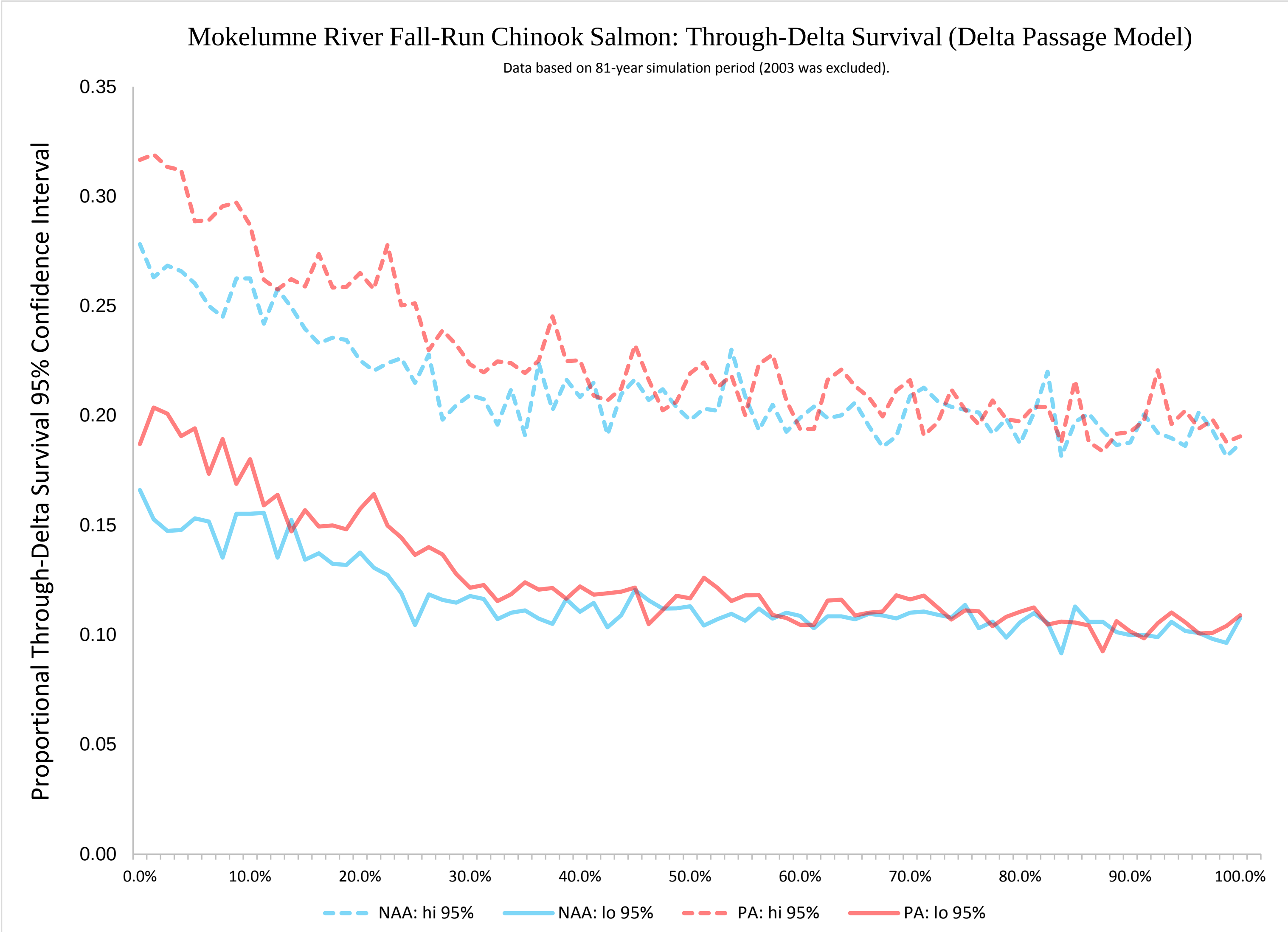
Figure 5.E-15. Time Series of 95% Confidence Interval Annual Juvenile San Joaquin River Basin Fall-Run Chinook Salmon Through-Delta Survival, Estimated from the Delta Passage Model.

The DPM analyses for fall-run Chinook salmon from the Mokelumne River suggested the potential for through-Delta survival to be greater under the PA than NAA in wetter water year types (Figure 5.E-16; Figure 5.E-17; Table 5.E-12). This is the result of less south Delta exports under the PA relative to NAA. However, the uncertainty in the south Delta exports-survival relationship that these fish are all subject to (see Figure 5.D-47 in Appendix 5.D) meant that 95% confidence intervals in the annual estimates of survival for NAA and PA overlapped in all 81 years that were simulated (Figure 5.E-18). This suggests that statistical differences in through-Delta survival may be challenging to detect during implementation of the PA, e.g., during monitoring.



Note: Plot only includes annual mean responses and does not consider model uncertainty.

Figure 5.E-16. Box Plots of Mokelumne River Fall-Run Chinook Salmon Annual Through-Delta Survival Estimated from the Delta Passage Model, Grouped by Water Year Type.

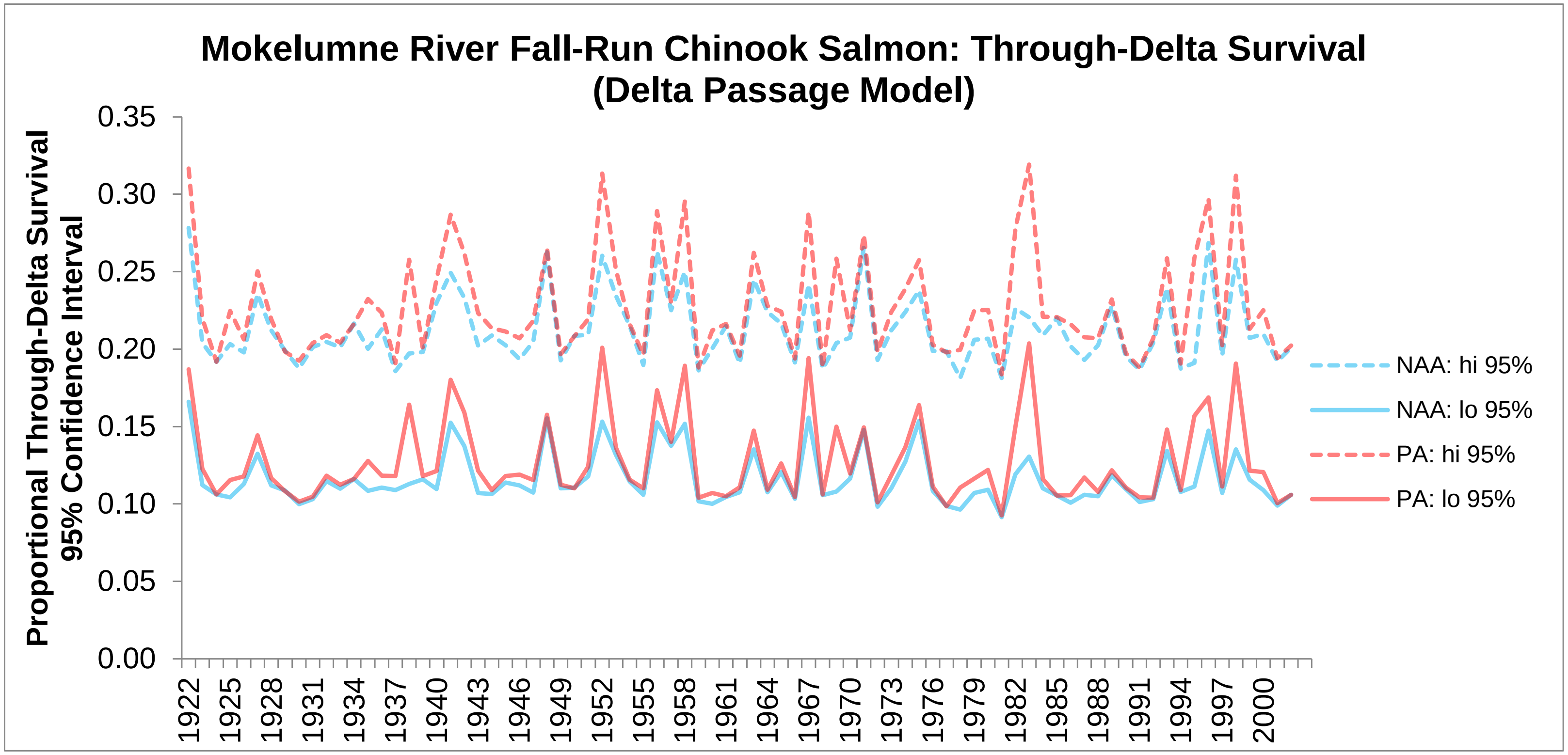


Note: Data are sorted by mean estimate, with only 95% confidence intervals shown.

Figure 5.E-17. Exceedance Plot of Mokelumne River Fall-Run Chinook Salmon Annual Through-Delta Survival Estimated from the Delta Passage Model.

Table 5.E-12. Delta Passage Model: Mokelumne River Fall-Run Chinook Salmon Mean Through-Delta (Total) Survival By Water Year Type.

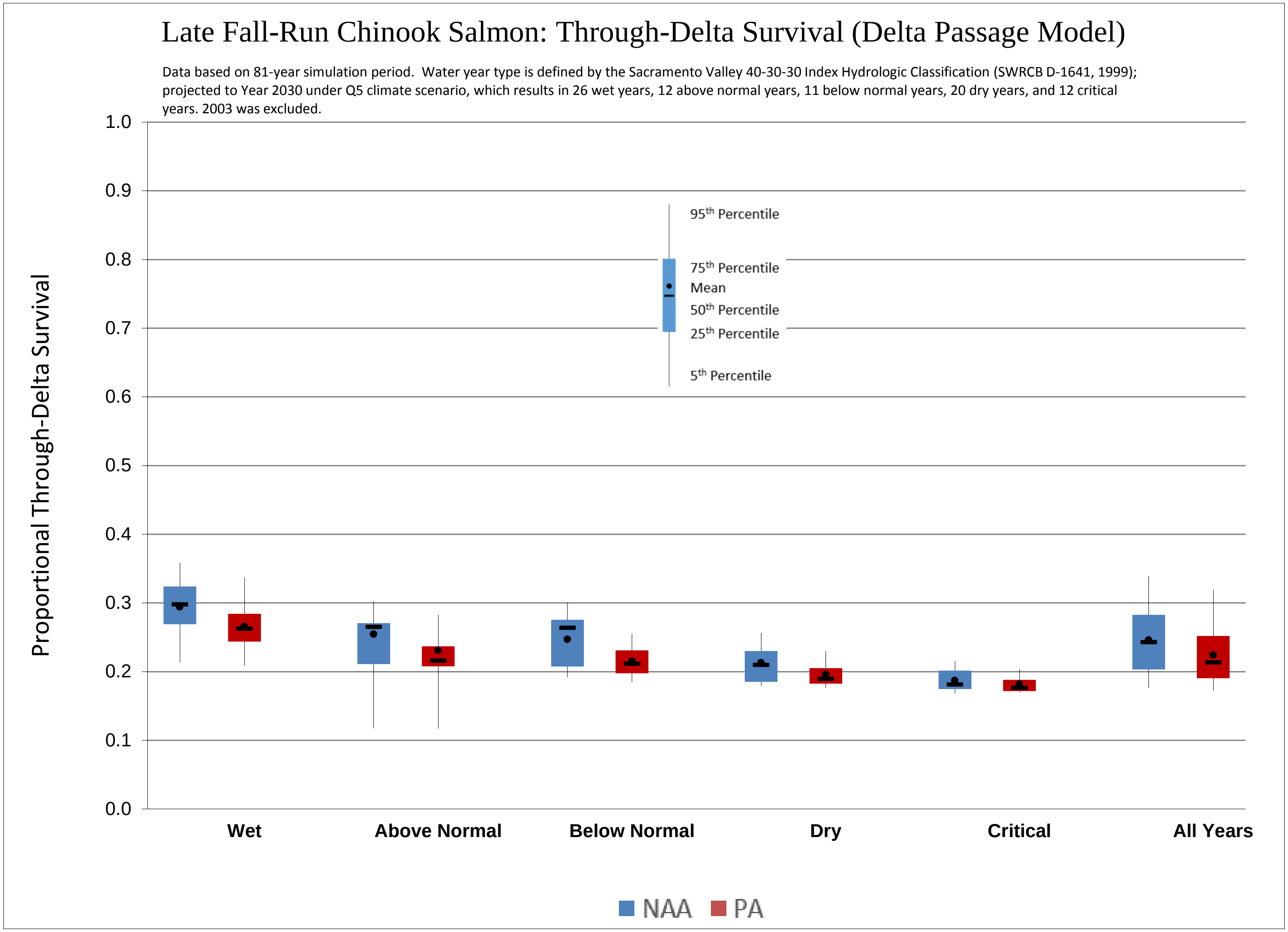
WY	Total Survival		
	NAA	PA	PA vs. NAA
W	0.18	0.21	0.03 (16%)
AN	0.16	0.17	0.01 (6%)
BN	0.15	0.16	0.00 (3%)
D	0.15	0.16	0.01 (4%)
C	0.15	0.15	0.00 (1%)



Note: Lines indicate 95% confidence intervals from the 75 iterations of the DPM.

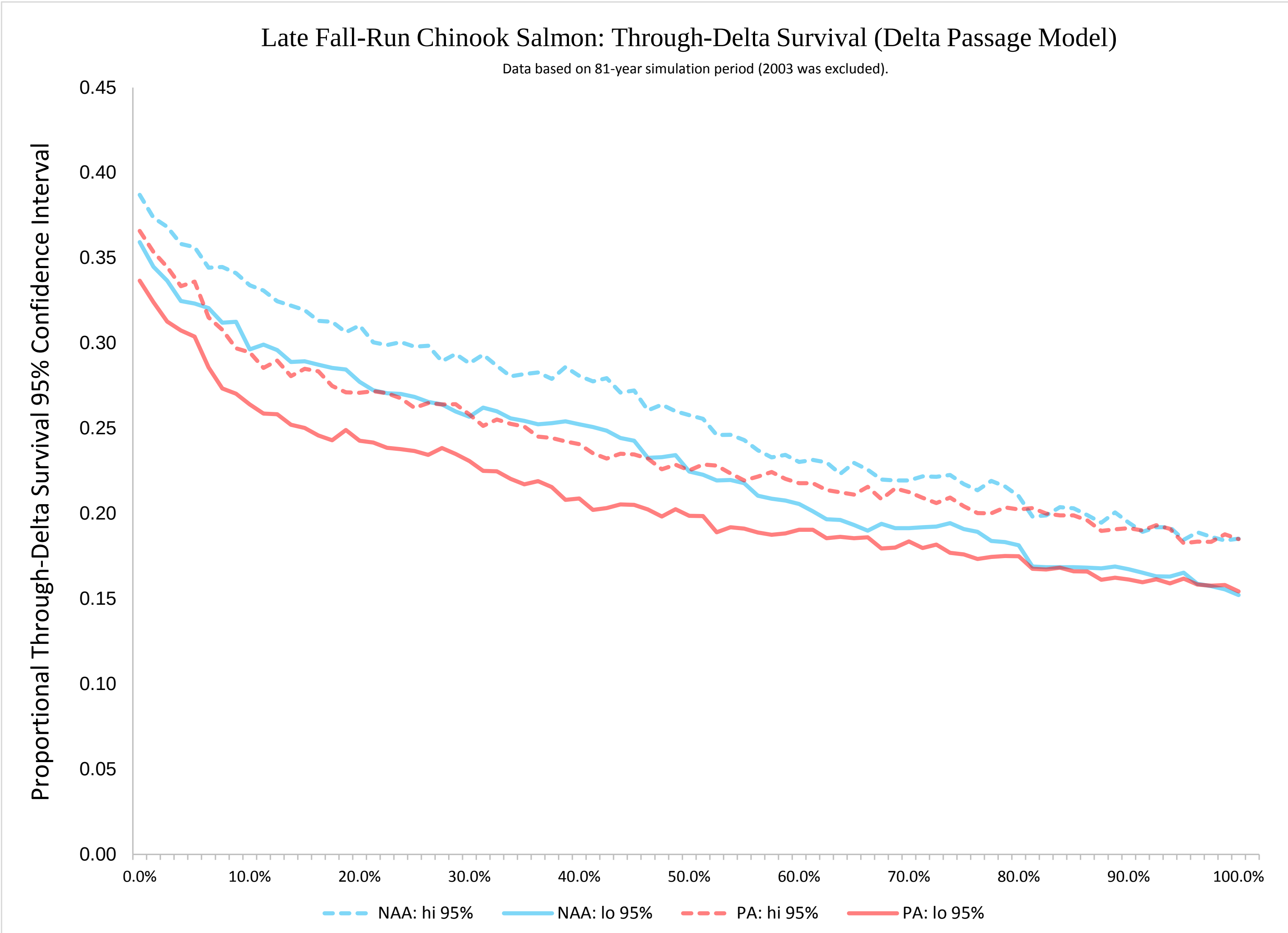
Figure 5.E-18. Time Series of 95% Confidence Interval Annual Juvenile Mokelumne River Fall-Run Chinook Salmon Through-Delta Survival, Estimated from the Delta Passage Model.

The DPM results for late fall-run Chinook salmon stood in contrast to those of the other Chinook salmon runs in suggesting that total through-Delta survival generally would be appreciably lower under the PA than the NAA (Figure 5.E-19 and Figure 5.E-20; Table 5.E-13). The 95% confidence intervals for through-Delta survival did not overlap in 32 of 81 modeled years, and in all 32 of these years the estimate was lower under PA than NAA (Figure 5.E-21). The results for late fall-run Chinook salmon were driven by the entry distribution assumed in the DPM, which is broad, beginning in August and ending in February/March (see Figure 5.D-42 in Chapter 5). Overlap with the August-November period results in greater proportional diversion at the NDD being possible, for bypass flows are required to be 5,000 cfs (July–September) or 7,000 cfs (October–November), whereas at other times bypass flow constraints are greater (see Section 3.3.2.1 of Chapter 3). As a result, the mean long-term (1922–2002) ratio of flow entering the Sacramento River below Georgiana Slough weighted by the proportional presence of late fall-run Chinook salmon under the PA is 0.78, compared to 0.87-0.95 for the other Chinook salmon runs. This, combined with the flow-survival relationship being steeper at lower flows (see Figure 5.D-45 in Appendix 5.D), gives appreciably lower survival under the NAA. In addition, overlap with September-November gave somewhat less closure of the DCC gates under the PA than NAA (see Table 5.A.6-31 in Appendix 5.A), as a result of several operational criteria described in Section 5.A.5.1.4.2 of Appendix 5.A. First, in September of ~20% of years, sufficient water was exported by the NDD that the 25,000-cfs threshold for closure of the DCC is not exceeded, whereas it is exceeded under the NAA in the same years and results in closure of the DCC more than under PA. Second, in October-November, reservoir releases later in the year under the NAA triggered the 7,500-cfs Sacramento River at Wilkins Slough threshold assumed to coincide with juvenile salmon migration into the Delta, which resulted in a greater number of days with DCC closed under NAA; such differences between NAA and PA would be lessened in November if real-time reservoir operational adjustments to minimize potential upstream effects were undertaken. Last, the DCC may also have been open more under the PA to maintain water quality conditions per D-1641 (Rock Slough salinity standard), which could be managed by real-time operations in order to achieve DCC opening frequency under the PA that is more similar to NAA.



Note: Plot only includes annual mean responses and does not consider model uncertainty.

Figure 5.E-19. Box Plots of Late Fall-Run Chinook Salmon Annual Through-Delta Survival Estimated from the Delta Passage Model, Grouped by Water Year Type.

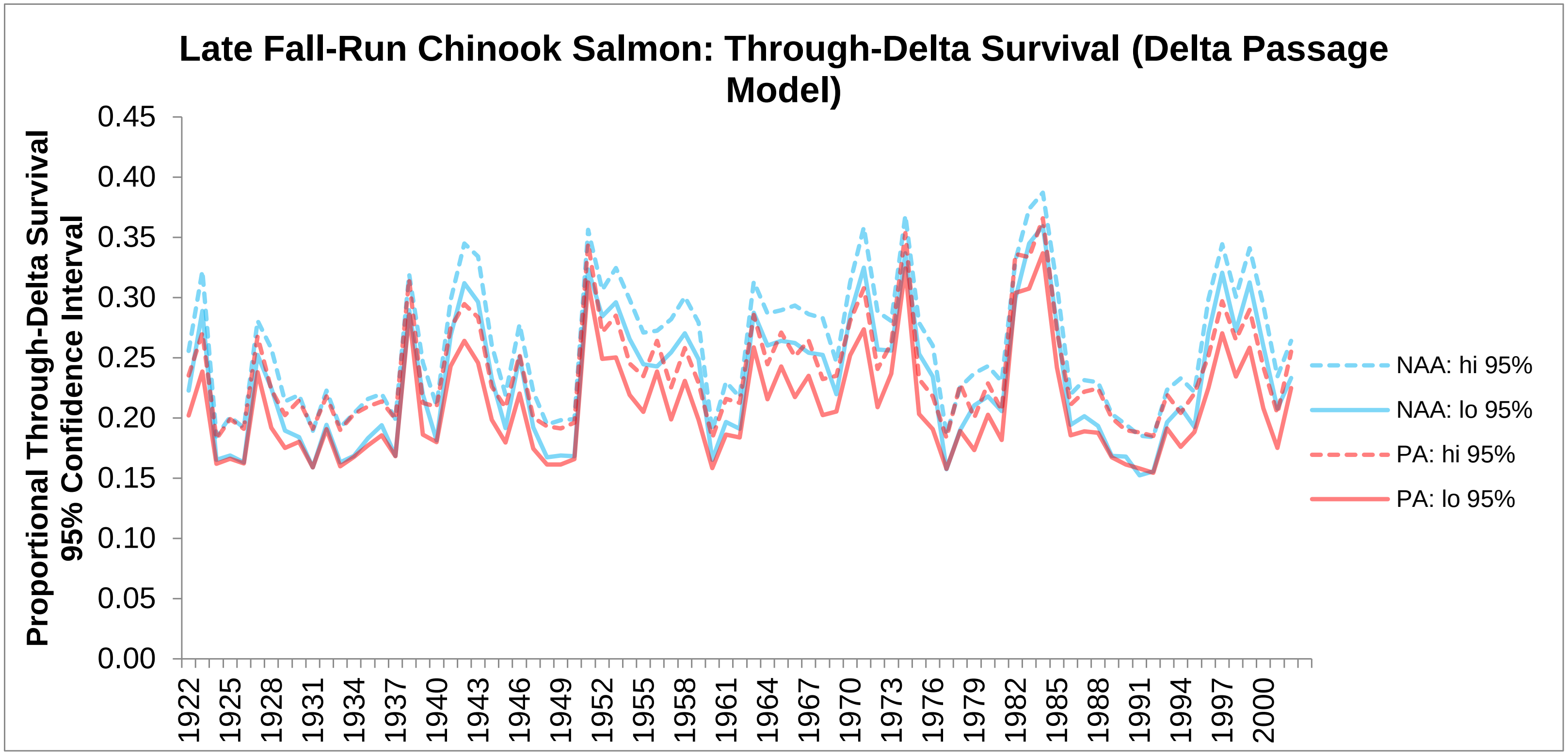


Note: Data are sorted by mean estimate, with only 95% confidence intervals shown.

Figure 5.E-20. Exceedance Plot of Late Fall-Run Chinook Salmon Annual Through-Delta Survival Estimated from the Delta Passage Model.

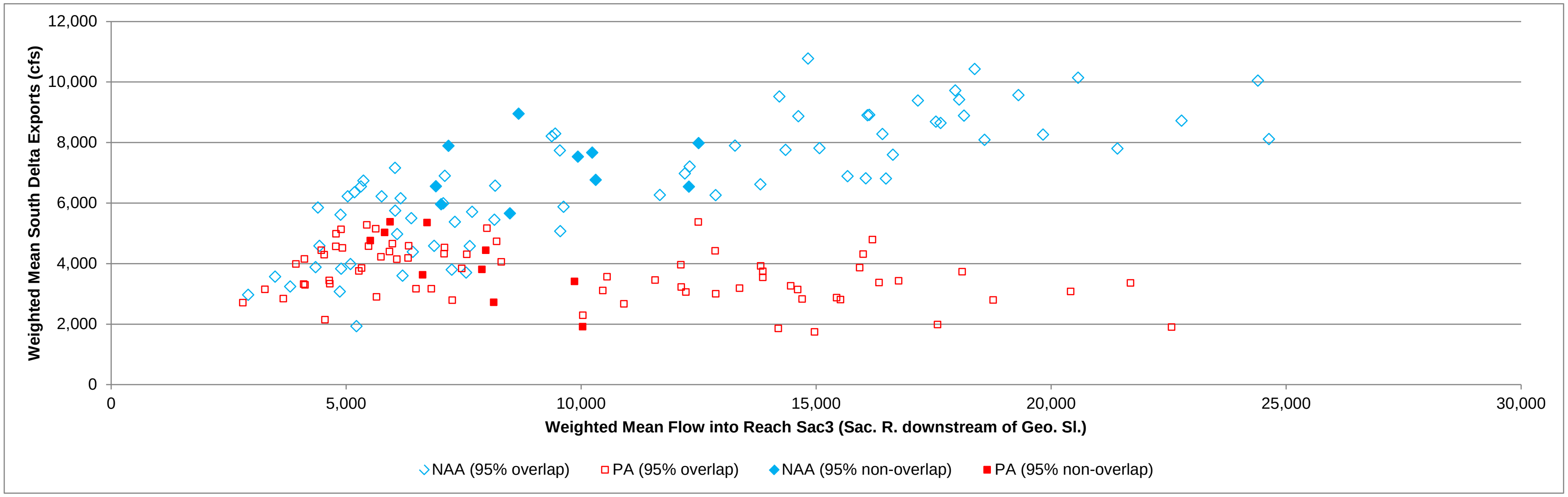
Table 5.E-13. Delta Passage Model: Late Fall-Run Chinook Salmon Mean Through-Delta (Total) Survival, Mainstem Sacramento River survival, and Proportion Using and Surviving Other Migration Routes.

WY	Total Survival			Mainstem Sacramento River Survival			Yolo Bypass					
							Proportion Using Route			Survival		
	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
W	0.29	0.27	-0.03 (-10%)	0.33	0.29	-0.04 (-13%)	0.05	0.06	0.00 (1%)	0.47	0.47	0.00 (0%)
AN	0.25	0.23	-0.02 (-9%)	0.29	0.26	-0.04 (-12%)	0.03	0.03	0.00 (0%)	0.47	0.47	0.00 (0%)
BN	0.25	0.21	-0.03 (-13%)	0.29	0.24	-0.05 (-16%)	0.02	0.02	0.00 (6%)	0.47	0.47	0.00 (0%)
D	0.21	0.20	-0.02 (-8%)	0.25	0.22	-0.03 (-11%)	0.02	0.02	0.00 (5%)	0.47	0.47	0.00 (0%)
C	0.19	0.18	-0.01 (-3%)	0.22	0.21	-0.01 (-5%)	0.02	0.02	0.00 (0%)	0.47	0.47	0.00 (0%)
WY	Sutter/Steamboat Sloughs						Interior Delta (Via Georgiana Slough/DCC)					
	Proportion Using Route			Survival			Proportion Using Route			Survival		
	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
W	0.29	0.27	-0.02 (-6%)	0.38	0.34	-0.04 (-10%)	0.30	0.32	0.02 (7%)	0.12	0.13	0.01 (11%)
AN	0.28	0.26	-0.02 (-6%)	0.34	0.31	-0.03 (-10%)	0.32	0.34	0.02 (6%)	0.11	0.12	0.01 (9%)
BN	0.28	0.26	-0.02 (-8%)	0.33	0.28	-0.04 (-13%)	0.32	0.35	0.03 (9%)	0.11	0.11	0.01 (9%)
D	0.26	0.24	-0.02 (-6%)	0.29	0.26	-0.03 (-9%)	0.35	0.37	0.02 (5%)	0.10	0.10	0.01 (8%)
C	0.24	0.23	-0.01 (-2%)	0.26	0.25	-0.01 (-4%)	0.38	0.38	0.00 (1%)	0.09	0.10	0.00 (5%)
Note: Survival in Sutter/Steamboat Sloughs and Interior Delta routes includes survival in the Sacramento River prior to entering the channel junctions.												



Note: Lines indicate 95% confidence intervals from the 75 iterations of the DPM.

Figure 5.E-21. Time Series of 95% Confidence Interval Annual Juvenile Late Fall-Run Chinook Salmon Through-Delta Survival, Estimated from the Delta Passage Model)



Note: 95% overlap and non-overlap refers to years with overlapping and non-overlapping confidence intervals from DPM.

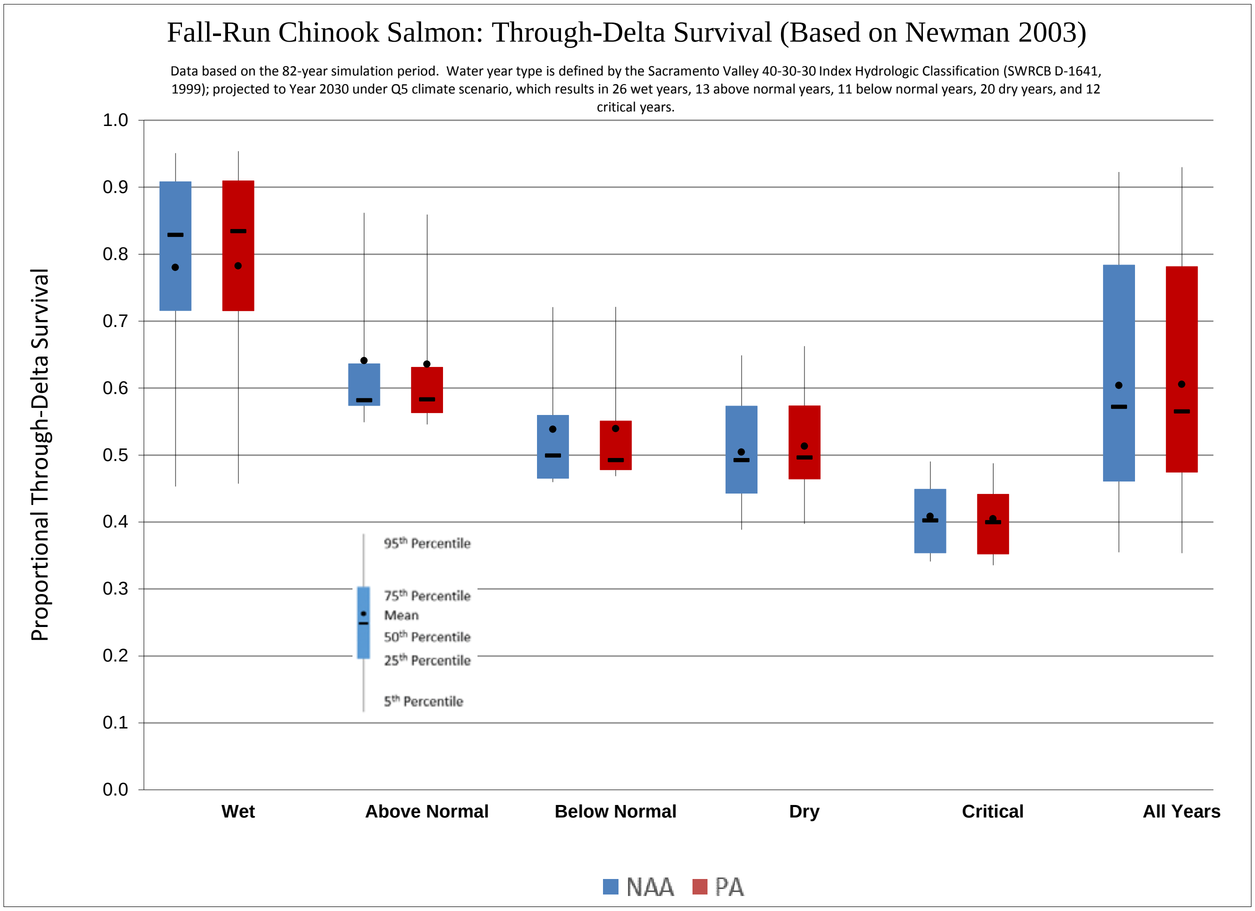
Figure 5.E-22. Delta Passage Model: Annual mean Sacramento River Flow into Reach Sac3 (Downstream of Georgiana Slough) and South Delta Exports, Weighted by Proportional Entry into the Delta of Winter-Run Chinook Salmon, Classified into Years of Overlapping and Non-overlapping Through-Delta Survival 95% Confidence Intervals.

Analysis Based on Newman (2003): Fall-Run Chinook Salmon

As described in Section 5.4.1.3.1.2.1.3.2 of Chapter 5 for spring-run Chinook salmon, the analysis based on Newman (2003) assesses the potential effect of the PA on juvenile fall-run Chinook salmon migrating through the Delta from the Sacramento River basin as a function of river flow (Sacramento River below the NDD, to capture flow-survival effects), south Delta exports, and other covariates, including salinity, turbidity, DCC position, and water temperature.

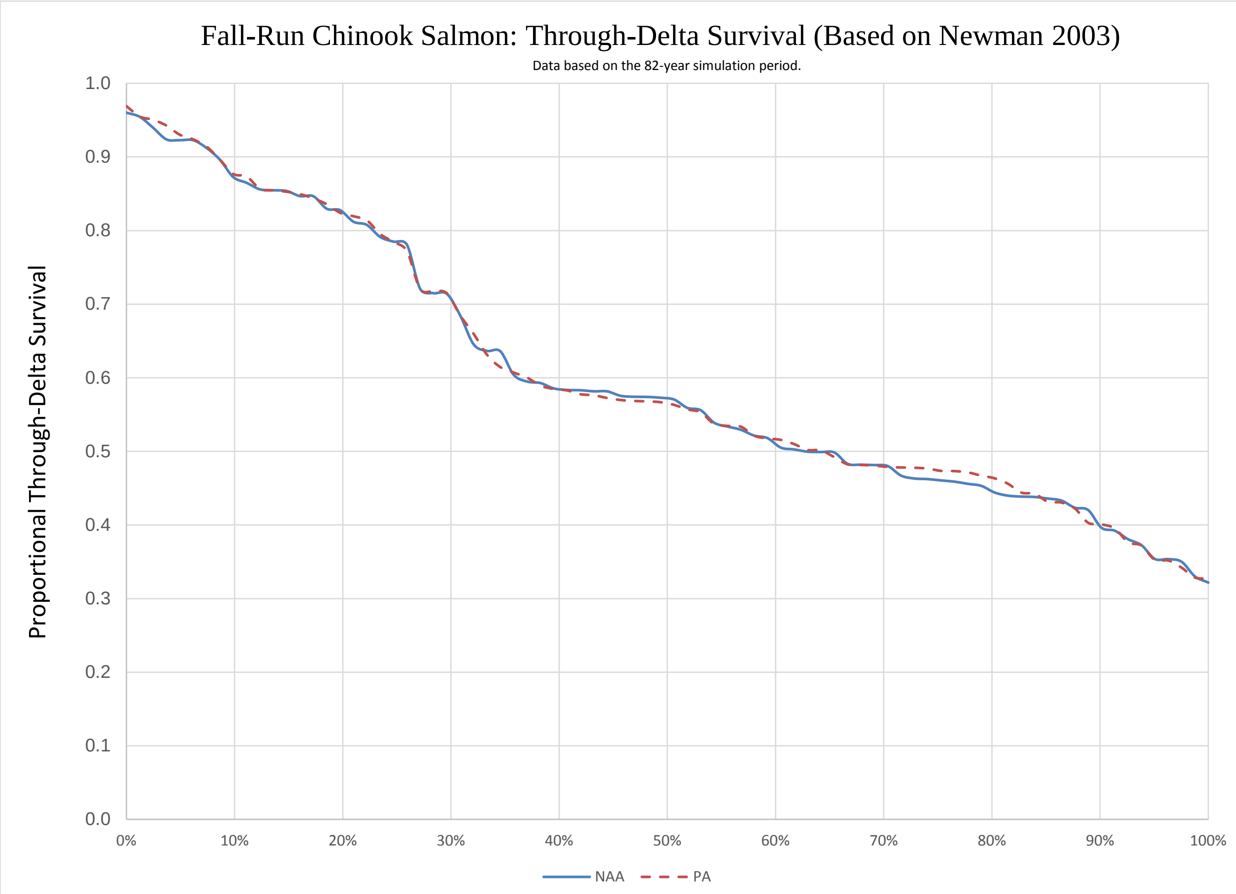
The results of the analysis based on Newman (2003) were similar to those found for spring-run Chinook salmon in that they suggested that there would be very little difference in overall mean survival between the NAA and PA for fall-run Chinook salmon across all water year types (Figure 5.E-23; Figure 5.E-24; Figure 5.E-25). When examined by NDD bypass flow level, the minor differences between NAA and PA were also clear (Table 5.E-14).

The results are explained by the timing of fall-run Chinook salmon entry into the Delta and the operations occurring during that time. The entry distribution of fall-run Chinook salmon was assumed to be the same as that used for the DPM, for which entry occurs during spring (principally April-June), with a pronounced unimodal peak in May (Figure 5.D-42 in Appendix 5.D, *Quantitative Methods and Detailed Results for Effects Analysis of Chinook Salmon, Central Valley Steelhead, Green Sturgeon, and Killer Whale*). During April-June under the PA, south Delta exports and Sacramento River flow downstream of the NDD are very similar in their absolute differences from the NAA (Table 5.E-15; for additional south Delta exports information, see also Figures 5.A.6-27-1 to 5.A.6-27-6, Figures 5.A.6-27-7 to 5.A.6-27-19, and Table 5.A.6-27 in Appendix 5.A, *CalSim II Modeling and Results*). As noted for spring-run Chinook salmon in Section 5.4.1.3.1.2.1.3.2 of Chapter 5, less Sacramento River flow downstream of the NDD is offset by less south Delta exports, given that Delta outflow is very similar between NAA and PA in these months (see Table 5.A.6-26 in Appendix 5.A). The analysis based on Newman (2003) includes a rate of change in juvenile Chinook salmon survival per unit of flow that is similar for the Sacramento River and south Delta exports (see Figure 5.D-61 in Appendix 5.D), so that a similar change in Sacramento River flows (less under PA) and south Delta exports (also less under PA) results in similar survival, as the analysis showed. This contrasts with the results for the DPM, for which survival under PA was marginally lower than under NAA because the flow survival-relationship generally is stronger than the export survival relationship and only fish entering the interior Delta at Georgiana Slough/DCC experience the export-survival relationship (see further discussion in Section 5.4.1.3.1.2.1.3.1 of Chapter 5 for spring-run Chinook salmon).



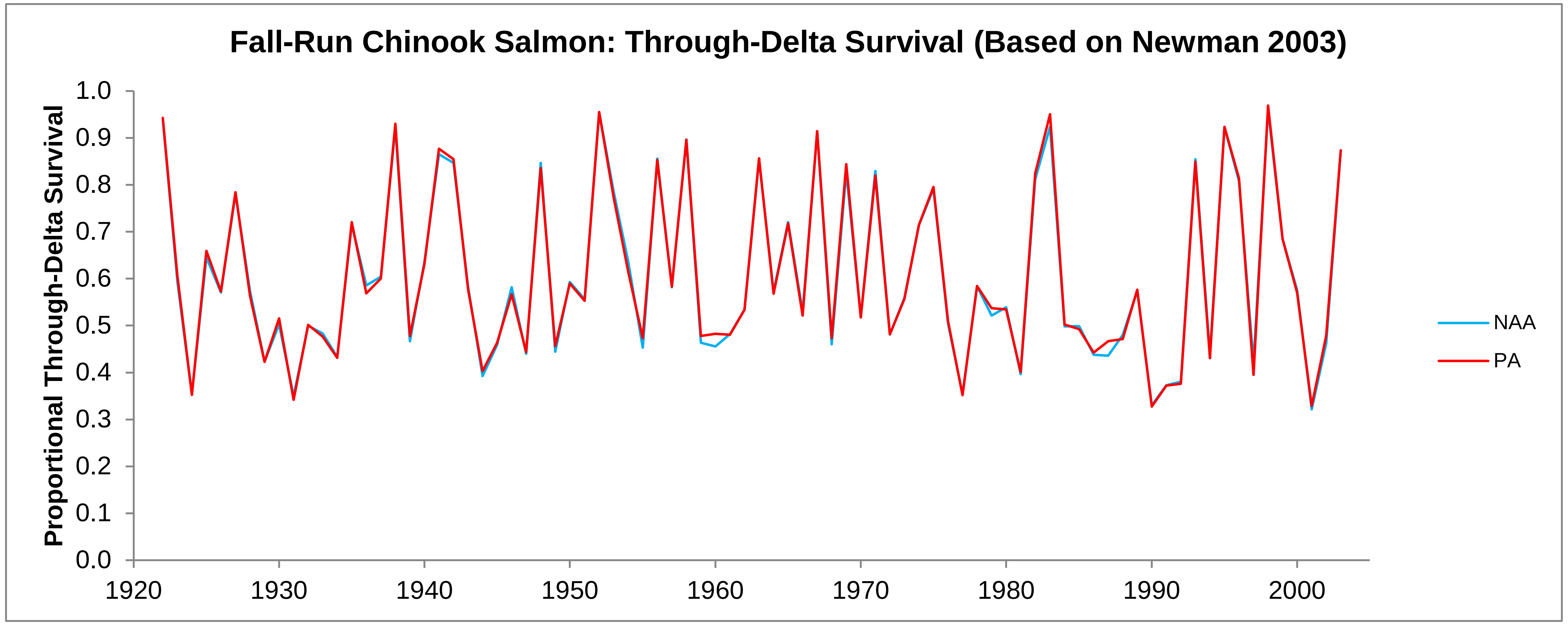
Note: Plot only includes annual mean responses and does not consider model uncertainty.

Figure 5.E-23. Box Plots of Fall-Run Chinook Salmon Annual Through-Delta Survival Estimated from the Analysis Based on Newman (2003), Grouped by Water Year Type.



Note: Plot only includes annual mean responses and does not consider model uncertainty.

Figure 5.E-24. Exceedance Plot of Fall-Run Chinook Salmon Annual Through-Delta Survival Estimated from the Analysis Based on Newman (2003).



Note: Plot only includes annual mean responses and does not consider model uncertainty.

Figure 5.E-25. Time Series of Fall-Run Chinook Salmon Annual Through-Delta Survival Estimated from the Analysis Based on Newman (2003).

Table 5.E-14. Mean Annual Fall-Run Chinook Salmon Weighted Annual Through-Delta Survival Estimated from the Analysis Based on Newman (2003), Divided into Each NDD Bypass Flow Level.

WY	Pulse protection flows			Level 1 bypass flows			Level 2 bypass flows			Level 3 bypass flows			Total		
	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
W	0.00	0.00	0.00 (0%)	0.00	0.00	0.00 (0%)	0.02	0.02	0.00 (1%)	0.76	0.76	0.00 (0%)	0.78	0.78	0.00 (0%)
AN	0.00	0.00	0.00 (0%)	0.00	0.00	0.00 (0%)	0.04	0.04	0.00 (0%)	0.60	0.59	-0.01 (-1%)	0.64	0.64	0.00 (1%)
BN	0.00	0.00	0.00 (0%)	0.21	0.21	0.00 (0%)	0.24	0.24	0.00 (1%)	0.10	0.09	0.00 (0%)	0.54	0.54	0.00 (0%)
D	0.00	0.00	0.00 (0%)	0.14	0.14	0.00 (2%)	0.28	0.29	0.00 (2%)	0.08	0.08	0.00 (1%)	0.50	0.51	0.00 (-1%)
C	0.00	0.00	0.00 (-1%)	0.34	0.33	0.00 (-1%)	0.07	0.07	0.00 (-1%)	0.00	0.00	0.00 (0%)	0.41	0.40	0.00 (-1%)

Table 5.E-15. Mean South Delta Exports and Sacramento River Flow Downstream of the NDD in April-June, by Water-Year Type (cfs), from CalSim Modeling.

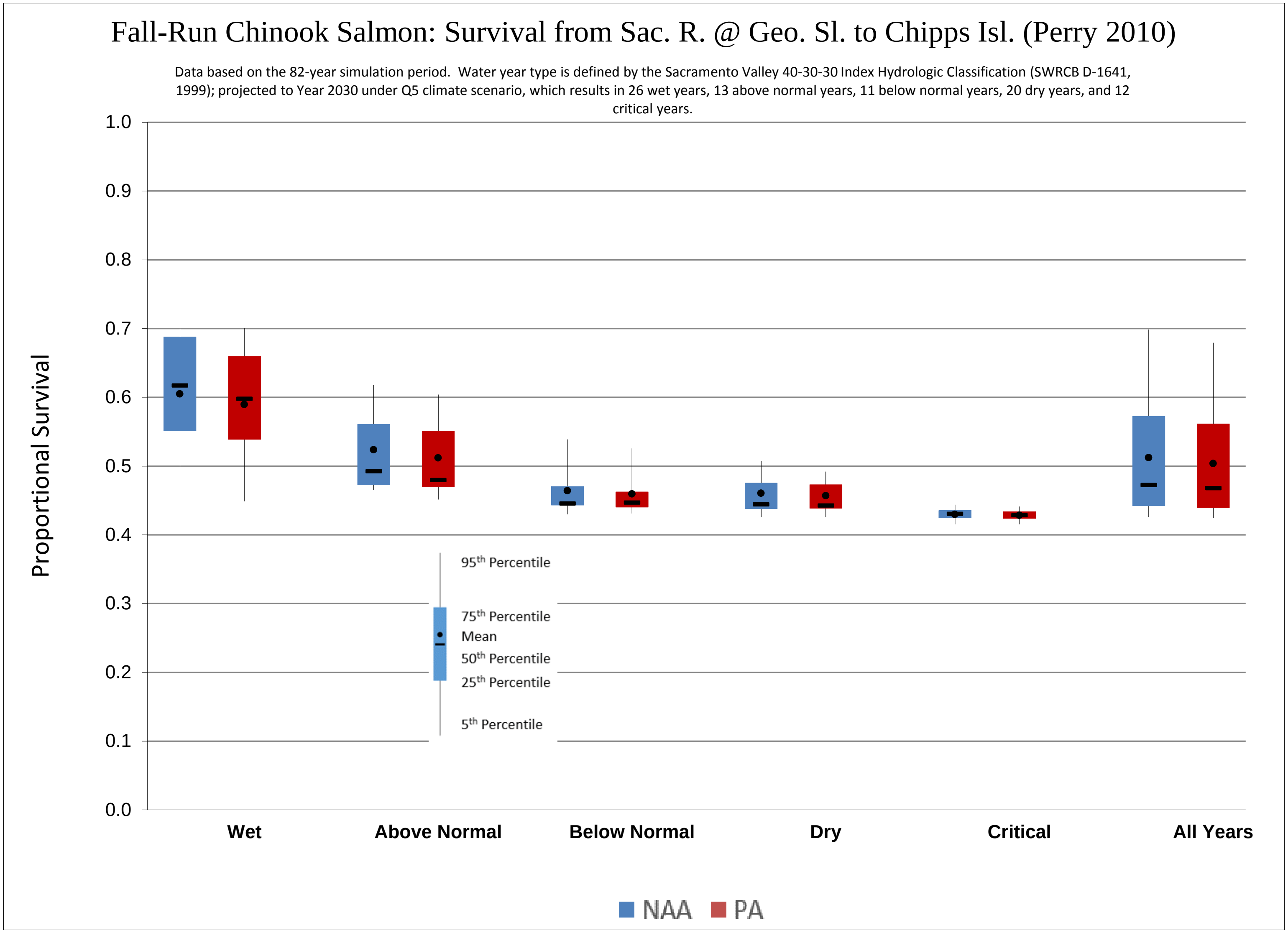
WY	South Delta Exports									Sacramento River Flow Downstream of the NDD (Bypass Flows)								
	April			May			June			April			May			June		
	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
W	2,977	395	-2,582 (-87%)	3,378	570	-2,808 (-83%)	7,349	2,853	-4,496 (-61%)	34,998	32,406	-2,592 (-7%)	29,839	26,747	-3,092 (-10%)	19,958	15,110	-4,848 (-24%)
AN	1,801	369	-1,432 (-80%)	1,720	411	-1,309 (-76%)	5,241	2,931	-2,309 (-44%)	24,080	22,944	-1,136 (-5%)	16,711	15,444	-1,266 (-8%)	13,413	11,467	-1,946 (-15%)
BN	1,774	1,340	-435 (-24%)	1,624	1,034	-590 (-36%)	3,506	2,558	-947 (-27%)	14,076	13,607	-469 (-3%)	12,460	12,027	-433 (-3%)	12,773	12,021	-752 (-6%)
D	2,052	1,493	-559 (-27%)	2,054	1,337	-717 (-35%)	3,155	2,106	-1,049 (-33%)	14,895	14,348	-547 (-4%)	11,633	11,382	-251 (-2%)	12,608	11,547	-1,061 (-8%)
C	1,430	1,267	-163 (-11%)	1,415	1,207	-208 (-15%)	851	646	-205 (-24%)	10,290	10,144	-147 (-1%)	8,214	8,031	-184 (-2%)	9,334	9,078	-256 (-3%)

Analysis Based on Perry (2010): Fall-Run and Late Fall-Run Chinook Salmon

As noted in Section 5.4.1.3.1.2.1.3.3 of Chapter 5 for winter-run and spring-run Chinook salmon, the analysis based on Perry (2010) allowed estimation of survival from the Sacramento River at Georgiana Slough to Chipps Island, based on the implementation of the Perry (2010) flow-survival relationship from the DPM, with particular focus on differences by bypass flow level.

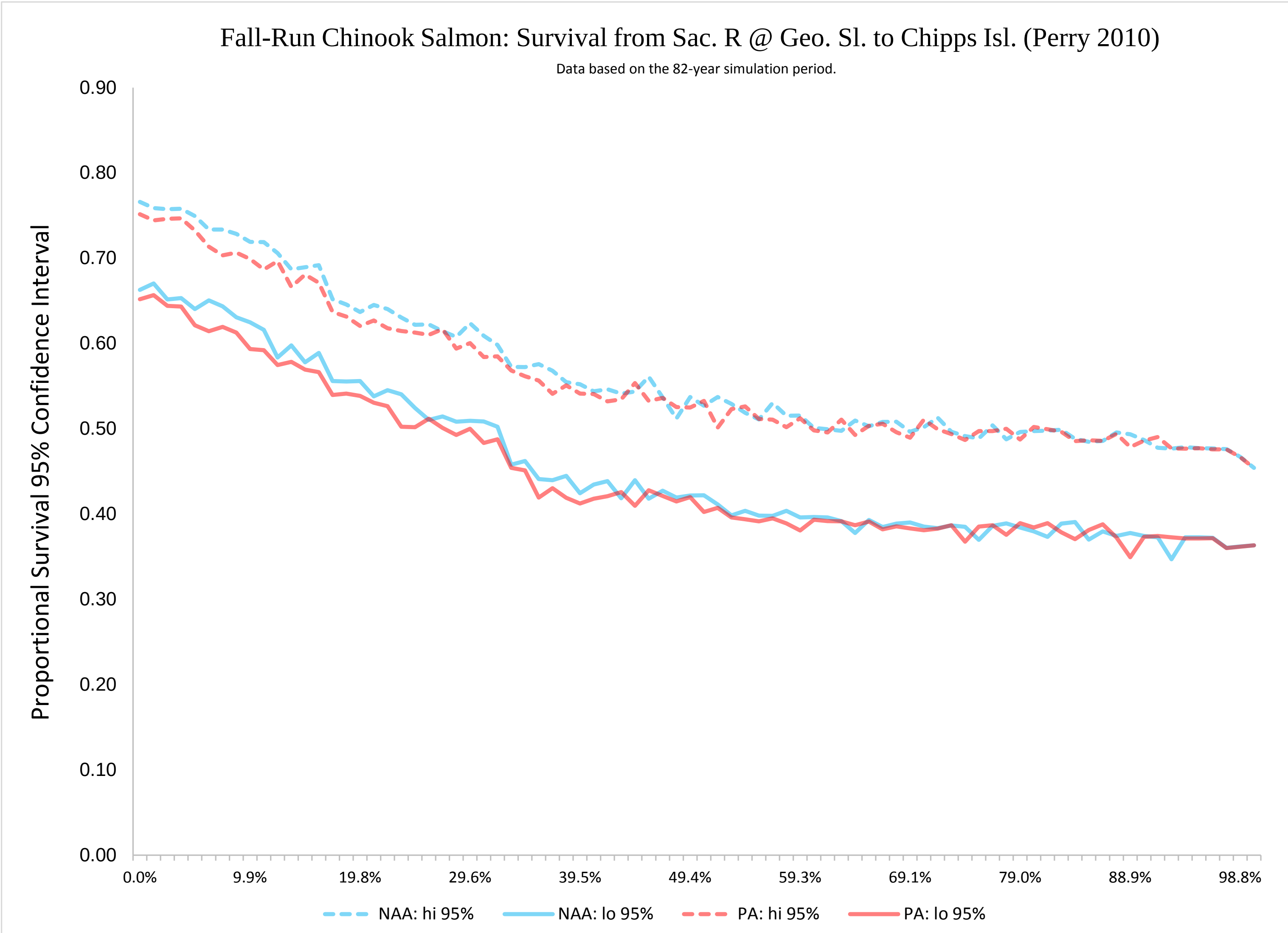
The results of the analysis based on Perry (2010) suggested that annual survival in the Sacramento River from Georgiana Slough to Chipps Island would be similar or slightly lower under the PA relative to the NAA for fall-run Chinook salmon (Figure 5.E-26 and Figure 5.E-27; Table 5.E-16). There was little overlap of fall-run Chinook salmon with the pulse protection flow period, which is as expected given the primarily April-June entry distribution, which resulted in greatest coincidence with level 3 bypass flows (in wetter years) or level 1 or 2 bypass flows (in drier years) (Table 5.E-16). Relative differences in survival between PA and NAA scenarios were greater under level 3 bypass flows than level 1 or 2 bypass flows, as would be expected given fewer constraints on proportion of flow that could be diverted with level 3 bypass flows. As noted for winter-run and spring-run Chinook salmon in Section 5.4.1.3.1.2.1.3.3 of Chapter 5, there is appreciable variability in the underlying relationship between Sacramento River flow and survival, as represented in the analysis based on Perry (2010) (Figure 5.D-65 in Appendix 5.D, *Quantitative Methods and Detailed Results for Effects Analysis of Chinook Salmon, Central Valley Steelhead, Green Sturgeon, and Killer Whale*). Plots of annual estimated weighted survival and 95% confidence intervals showed considerable overlap in the survival estimate for the NAA and PA scenarios, with the 95% confidence intervals overlapping in all years (Figure 5.E-28). As noted for winter-run and spring-run Chinook salmon, this suggests that although the results show potentially less survival under the PA relative to the NAA in some years, it might be challenging to statistically detect this small magnitude of difference during PA monitoring, for example.

For late fall-run Chinook salmon, the analysis based on Perry (2010) suggested that there would be somewhat greater differences between PA and NAA than for fall-run Chinook salmon, with survival from the Sacramento River at Georgiana Slough to Chipps Island generally being less under the PA (Figure 5.E-29 and Figure 5.E-30; Table 5.E-17). Given the same entry timing as for the DPM (see Section 5.D.1.2.4.2 in Appendix 5.D), the results are explained by the same factors as those previously discussed for the results of DPM: overlap of the late fall-run Delta entry period with low-flow months during which greater proportions of Sacramento River water can be diverted by the NDD and greater frequency of DCC opening under the PA as a result of the operational criteria detailed in Section 5.A.5.1.5.2. Although the results suggested that there would be a greater difference between PA and NAA for late fall-run Chinook than other races of Chinook salmon examined with the analysis based on Perry (2010), the 95% confidence intervals of the annual estimates for PA and NAA overlapped in all years, again suggesting that the magnitude of difference might not be readily distinguished statistically.



Note: Plot only includes annual mean responses and does not consider model uncertainty.

Figure 5.E-26. Box Plots of Juvenile Fall-Run Chinook Salmon Annual Total Survival from the Sacramento River at Georgiana Slough to Chipps Island, Estimated from the Analysis Based on Perry (2010), Grouped by Water Year Type.



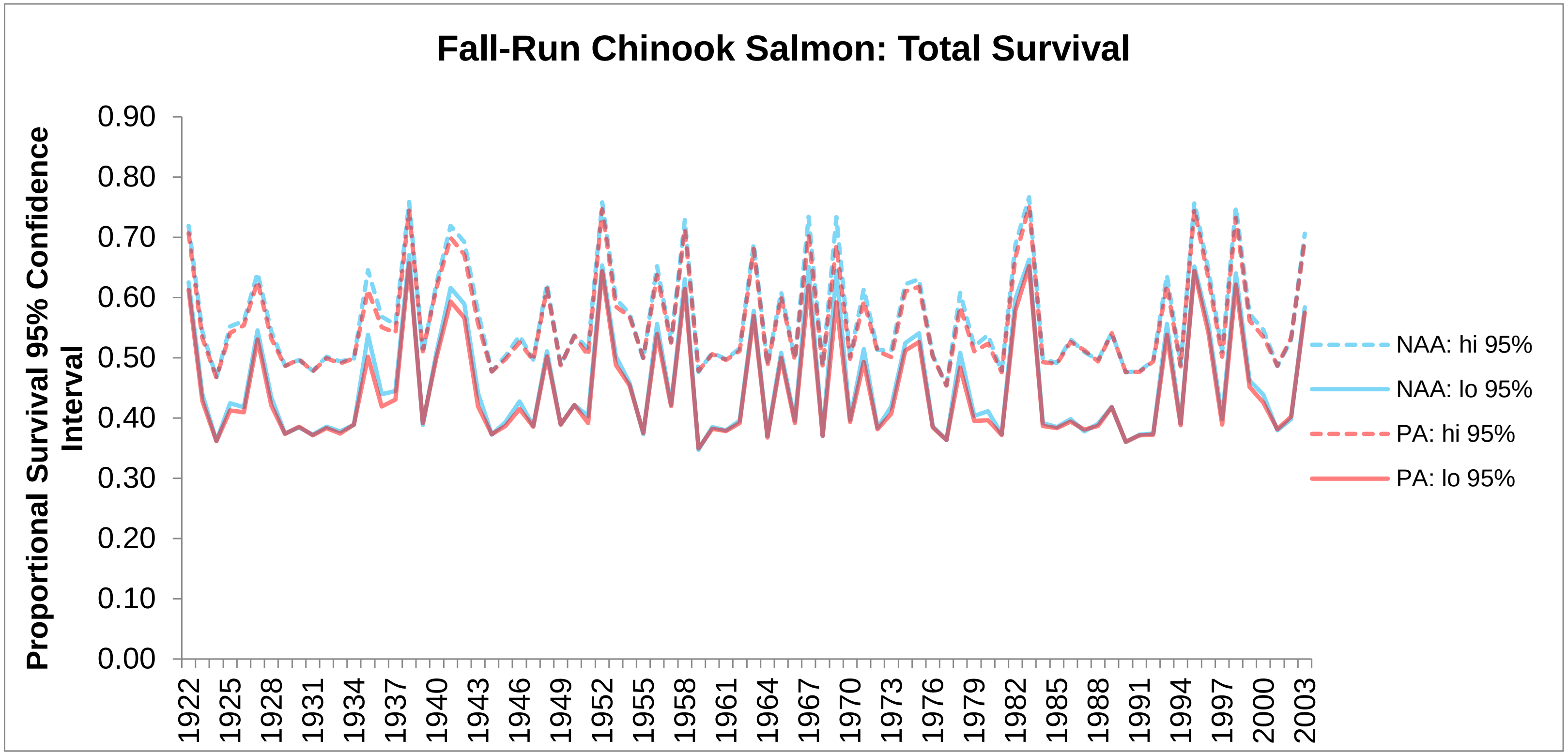
Note: Data are sorted by mean estimate, with only 95% confidence intervals shown.

Figure 5.E-27. Exceedance Plot of Juvenile Fall-Run Chinook Salmon Annual Total Survival from the Sacramento River at Georgiana Slough to Chipps Island, Estimated from the Analysis Based on Perry (2010).

Table 5.E-16. Mean Annual Juvenile Fall-Run Chinook Salmon Weighted Survival from the Sacramento River at Georgiana Slough to Chipps Island By Water Year Type Estimated from the Analysis Based on Perry (2010), Divided into Each NDD Bypass Flow Level.

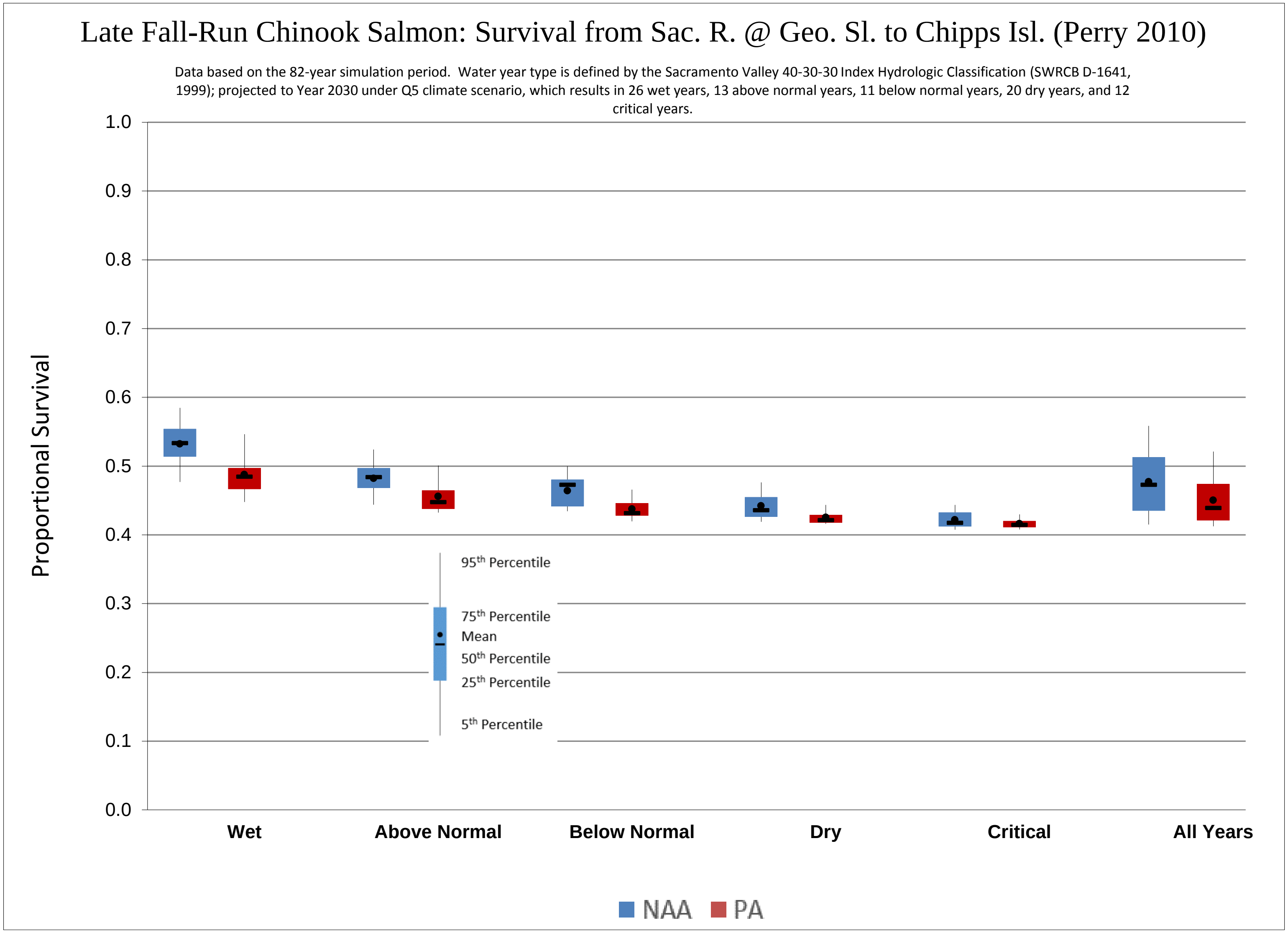
WY	Pulse protection flows			Level 1 bypass flows			Level 2 bypass flows			Level 3 bypass flows			Total		
	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
W	0.00	0.00	0.00 (0%)	0.00	0.00	0.00 (0%)	0.02	0.02	0.00 (-1%)	0.59	0.57	-0.02 (-3%)	0.60	0.59	-0.02 (-3%)
AN	0.00	0.00	0.00 (0%)	0.00	0.00	0.00 (-10%)	0.04	0.04	0.00 (0%)	0.49	0.48	-0.01 (-2%)	0.52	0.51	-0.01 (-2%)
BN	0.00	0.00	0.00 (0%)	0.17	0.17	0.00 (0%)	0.21	0.21	0.00 (-1%)	0.09	0.08	0.00 (-2%)	0.46	0.46	0.00 (-1%)
D	0.00	0.00	0.00 (0%)	0.13	0.13	0.00 (0%)	0.25	0.25	0.00 (-1%)	0.07	0.07	0.00 (-3%)	0.46	0.46	0.00 (-1%)
C	0.00	0.00	0.00 (-3%)	0.36	0.36	0.00 (0%)	0.07	0.07	0.00 (0%)	0.00	0.00	NA	0.43	0.43	0.00 (0%)

Note: Survival for a given flow level is weighted by the proportion of the juvenile population occurring during that flow level. NA indicates there were no level 3 bypass flows in critical years.



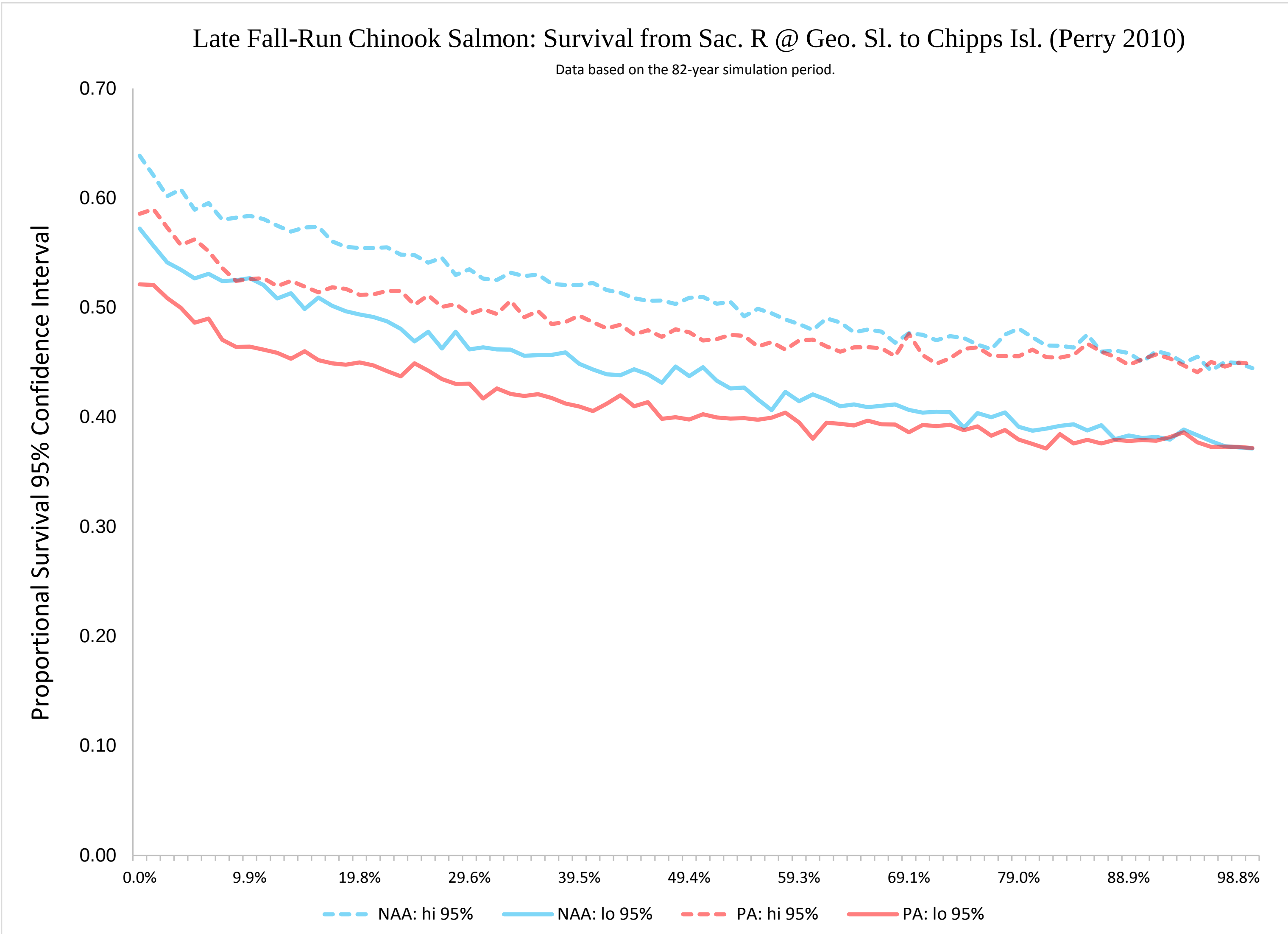
Note: Lines indicate 95% confidence intervals from the 75 iterations of the DPM's implementation of the Perry (2010) flow-survival relationship.

Figure 5.E-28. Time Series of 95% Confidence Interval Annual Juvenile Fall-Run Chinook Salmon Total Survival from the Sacramento River at Georgiana Slough to Chipps Island, Estimated from the Analysis Based on Perry (2010).



Note: Plot only includes annual mean responses and does not consider model uncertainty.

Figure 5.E-29. Box Plots of Juvenile Late Fall-Run Chinook Salmon Annual Total Survival from the Sacramento River at Georgiana Slough to Chipps Island, Estimated from the Analysis Based on Perry (2010), Grouped by Water Year Type.



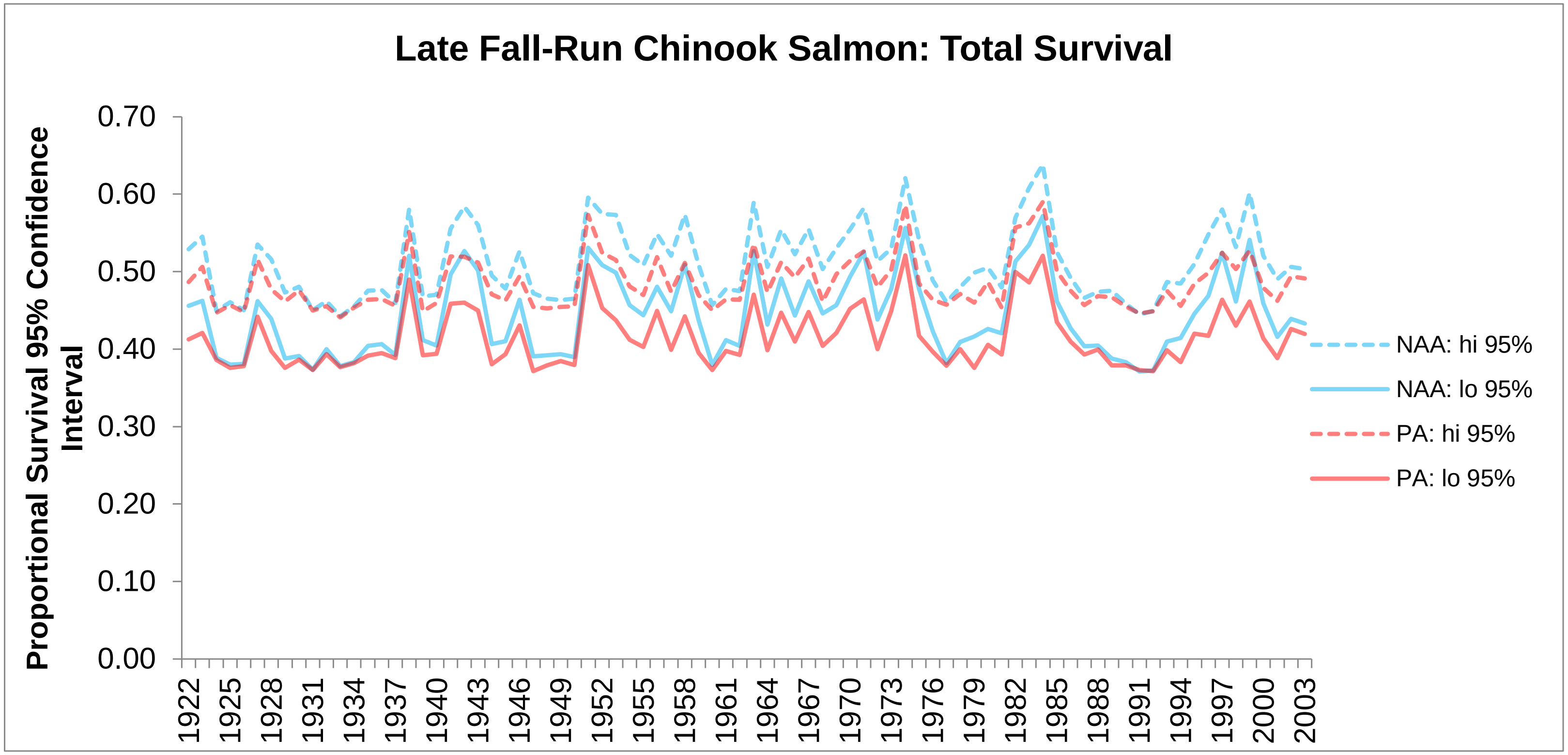
Note: Data are sorted by mean estimate, with only 95% confidence intervals shown.

Figure 5.E-30. Exceedance Plot of Juvenile Late Fall-Run Chinook Salmon Annual Total Survival from the Sacramento River at Georgiana Slough to Chipps Island, Estimated from the Analysis Based on Perry (2010).

Table 5.E-17. Mean Annual Juvenile Late Fall-Run Chinook Salmon Weighted Survival from the Sacramento River at Georgiana Slough to Chipps Island By Water Year Type Estimated from the Analysis Based on Perry (2010), Divided into Each NDD Bypass Flow Level.

WY	Pulse protection flows			Level 1 bypass flows			Level 2 bypass flows			Level 3 bypass flows			Total		
	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
W	0.07	0.07	0.00 (-1%)	0.34	0.31	-0.02 (-7%)	0.02	0.01	0.00 (-6%)	0.11	0.09	-0.02 (-17%)	0.53	0.49	-0.04 (-8%)
AN	0.04	0.04	0.00 (-2%)	0.34	0.32	-0.02 (-5%)	0.01	0.01	0.00 (-6%)	0.09	0.08	-0.01 (-8%)	0.48	0.46	-0.03 (-5%)
BN	0.04	0.04	0.00 (-3%)	0.36	0.34	-0.02 (-6%)	0.05	0.05	0.00 (-6%)	0.02	0.01	0.00 (-7%)	0.46	0.44	-0.03 (-6%)
D	0.02	0.02	0.00 (-2%)	0.37	0.35	-0.01 (-4%)	0.05	0.04	0.00 (-3%)	0.01	0.01	0.00 (-4%)	0.44	0.43	-0.02 (-4%)
C	0.01	0.01	0.00 (-2%)	0.40	0.39	-0.01 (-1%)	0.01	0.01	0.00 (-1%)	0.00	0.00	NA	0.42	0.42	-0.01 (-1%)

Note: Survival for a given flow level is weighted by the proportion of the juvenile population occurring during that flow level. NA indicates there were no level 3 bypass flows in critical years.



Note: Lines indicate 95% confidence intervals from the 75 iterations of the DPM's implementation of the Perry (2010) flow-survival relationship.

Figure 5.E-31. Time Series of 95% Confidence Interval Annual Juvenile Late Fall-Run Chinook Salmon Total Survival from the Sacramento River at Georgiana Slough to Chipps Island, Estimated from the Analysis Based on Perry (2010).

<u>SalSim Through-Delta Survival Function: Fall-Run Chinook Salmon</u>

As previously noted, the results of the DPM suggest considerably less through-Delta survival of fall-run Chinook salmon juveniles from the San Joaquin River basin under the PA than NAA in wetter years when the HOR gate would not be closed, as a result of proposed operations that are very different than those that have been observed in reality and upon which the modeled relationships are based. To provide additional perspective on through-Delta survival for fall-run Chinook salmon from the San Joaquin River basin, the survival function from the Juvenile Delta Module of the Salmon Simulator (SalSim; AD Consultants 2014). Whereas SalSim is a standalone life cycle modeling tool, the coefficients of the survival function from its Delta Module were used in a spreadsheet to compare potential survival differences between NAA and PA.

Methods

Per the SalSim documentation, juvenile survival through the Delta is a function of flow entering the Stockton Deepwater Ship Channel, abundance of striped bass in the Delta, and water temperature at Mossdale, in addition to various multipliers (AD Consultants 2014: 54-63). Survival is calculated based on an exponential function with a linear input (the formula below excludes additional terms found in the documentation that are not applicable):

Base survival probability = $\min(\exp(a_0 + a_1 \times Q + a_2 \times \text{stripers} + a_3 \times T + a_4 \times \text{releaseCode}), 0.99)$

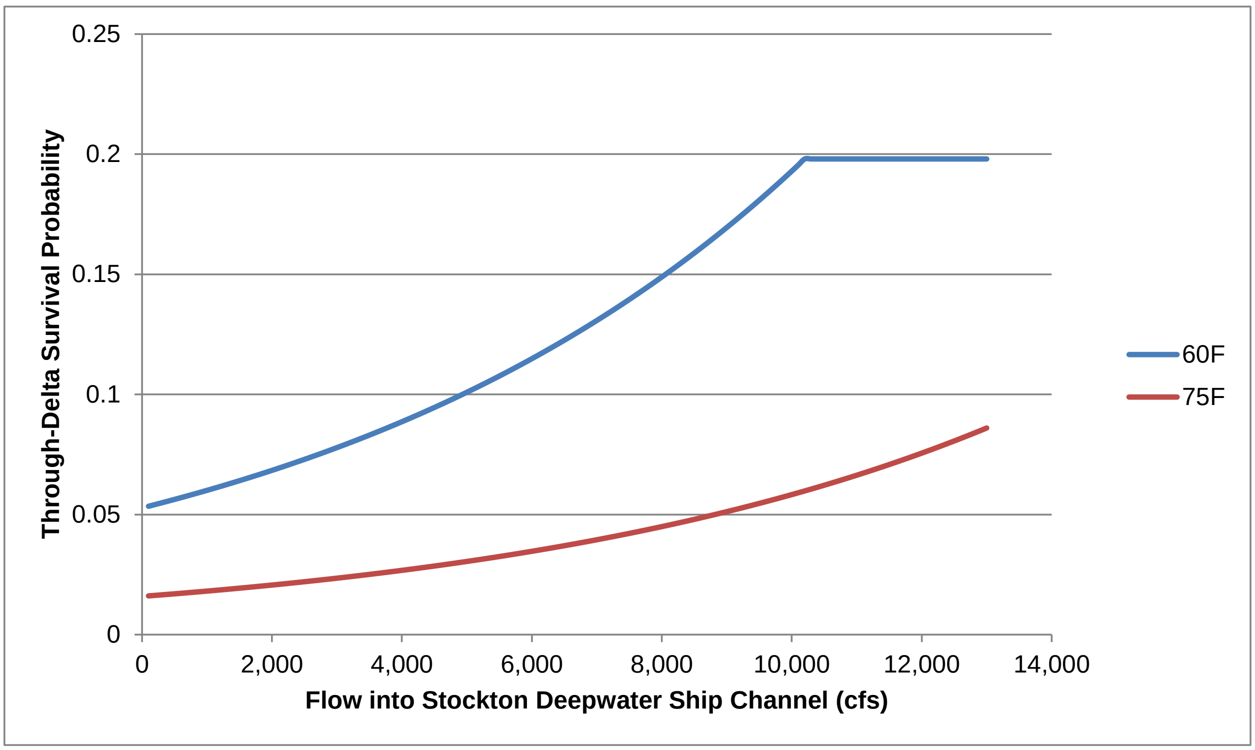
Where the variables Q, stripers, and T are defined as described in Table 5.E-18, which also includes the data used to provide the inputs for the analysis of EFH comparing PA to NAA.

Table 5.E-18. SalSim Through-Delta Survival Variables, Coefficients, and Input Data Used for the Analysis of Effects on EFH.

Parameter	Variable	Description	Coefficient Value	Input data	Notes
a_0	N/A	constant	3.493422	N/A	
a_1	Q	Mean daily flow at the Stockton Deepwater Ship Channel on day of entry to Delta (cfs)	0.1296343	DSM2-HYDRO: RSAN058	Divided by 1,000
a_2	stripers	Abundance of striped bass in the Delta	-0.0297244	File stripers.csv in SalSim documentation appendices (www.salsim.com)	Divided by 1,000,000. Used mean of 2000-2009 (1,316,315) for all years (both scenarios).
a_3	T	Mean of 7-day maximum water temperature at Mossdale on day of entry into Delta (°F)		DSM2-QUAL: Daily mean water temperature data from RSAN087 (Mossdale)	Divided by 10. Daily mean from DSM2-QUAL was converted into daily maximum based on a regression of CDEC data from Mossdale (April 1-June 29, 2002-2015: daily max. = 1.0343×daily mean – 0.9287; r^2 = 0.9903; n = 1,208)
a_4	releaseCode	Release location of fish in the Delta (always = 1 for SalSim, i.e., Mossdale)	-0.38105	N/A	

Per the SalSim documentation, the base survival probability is multiplied by various factors to account for the origin of the fish (overallFactor), whether the migrating cohort consists of fry (fryFactor), and whether the fish are of Merced River Hatchery origin (MRHfactor). The analysis presented herein was focused on wild-origin (MRHFactor = 1) smolts (fryFactor = 1), and because the Stanislaus River (overallFactor = 0.2) has the largest escapement, the overall multiplier of the base survival probability was 1 × 1 × 0.2 = 0.2.

The exponential nature of the relationship between flow and through-Delta survival when applying the SalSim function is illustrated in Figure 5.E-32, which shows that at 60°Fand just over 10,000 cfs, survival plateaus at 0.198; this is the maximum allowed through-Delta survival probability (0.99) multiplied by the factor of 0.2 previously described. Note that in contrast to the DPM, the through-Delta survival function in SalSim does not account for different survival probability in San Joaquin River versus Old River, nor does it account for routing of fish into these channels. The function only considers flow into the Stockton Deepwater Ship Channel (in addition to striped bass abundance and water temperature), so that the effects of the HOR gate are only expressed in terms of keeping more flow in the San Joaquin River.



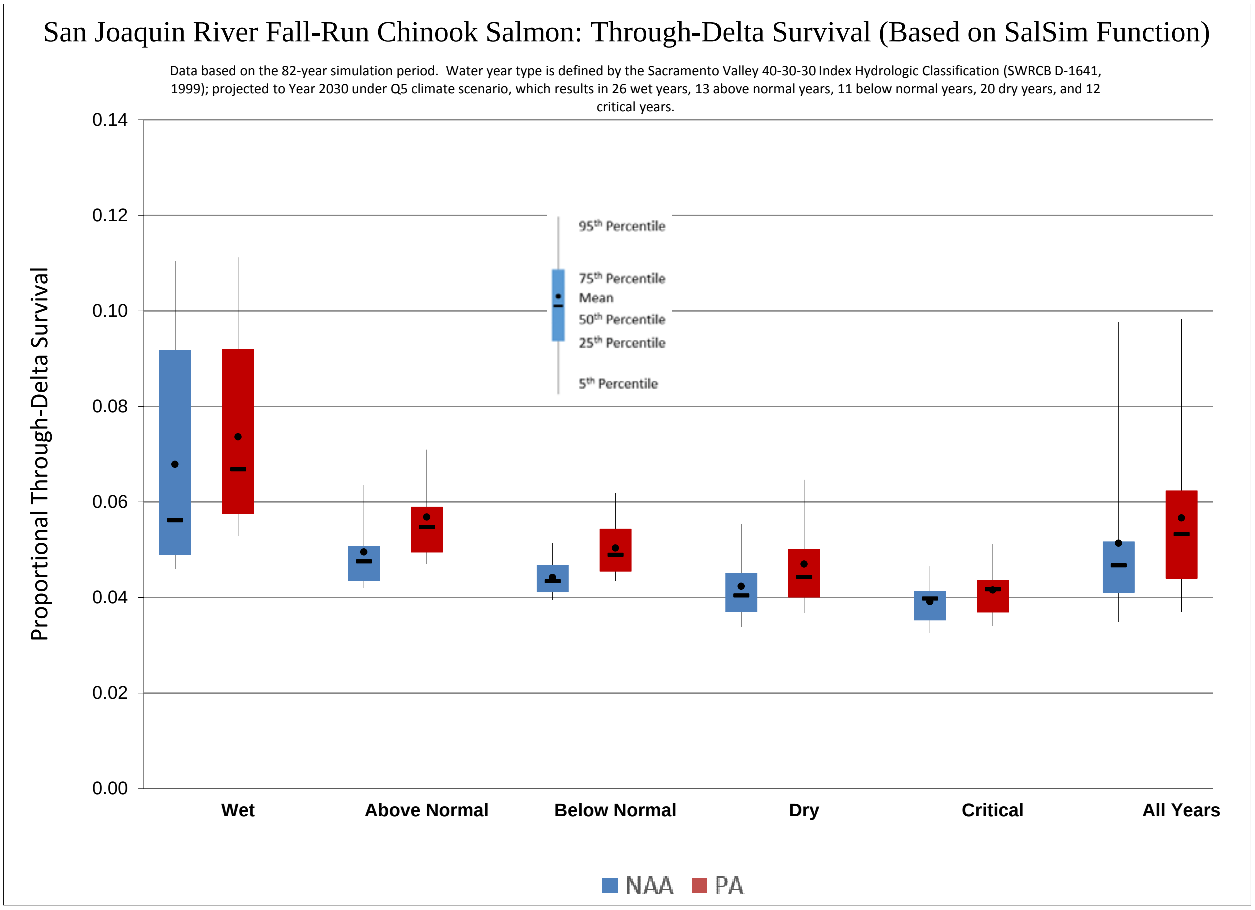
Note: Survival was calculated for striped bass abundance of 1,316,315 (the mean for 2000-2009).

Figure 5.E-32. Predicted Through-Delta Survival from SalSim's Juvenile Delta Module at Two Representative Temperatures (60°F and 75°F).

The survival on each day was calculated using the survival function previously described. Daily survival was multiplied by the assumed proportion of the San Joaquin River fall-run Chinook salmon smolt population entering the Delta on each day, which was the same distribution developed for the DPM based on Mossdale trawl data (see Figure 5.D-42 in Appendix 5.D). Daily survival multiplied by the proportion of fish entering the Delta on that day was summed for each water year in order to facilitate comparisons between scenarios (NAA and PA) over the water years (1922–2003) in the DSM2 simulation period. Note that the SalSim documentation does not provides measures of variability around the coefficients for the survival function, so it was not possible for this effects analysis to incorporate these in the same manner as was done for the DPM, for example.

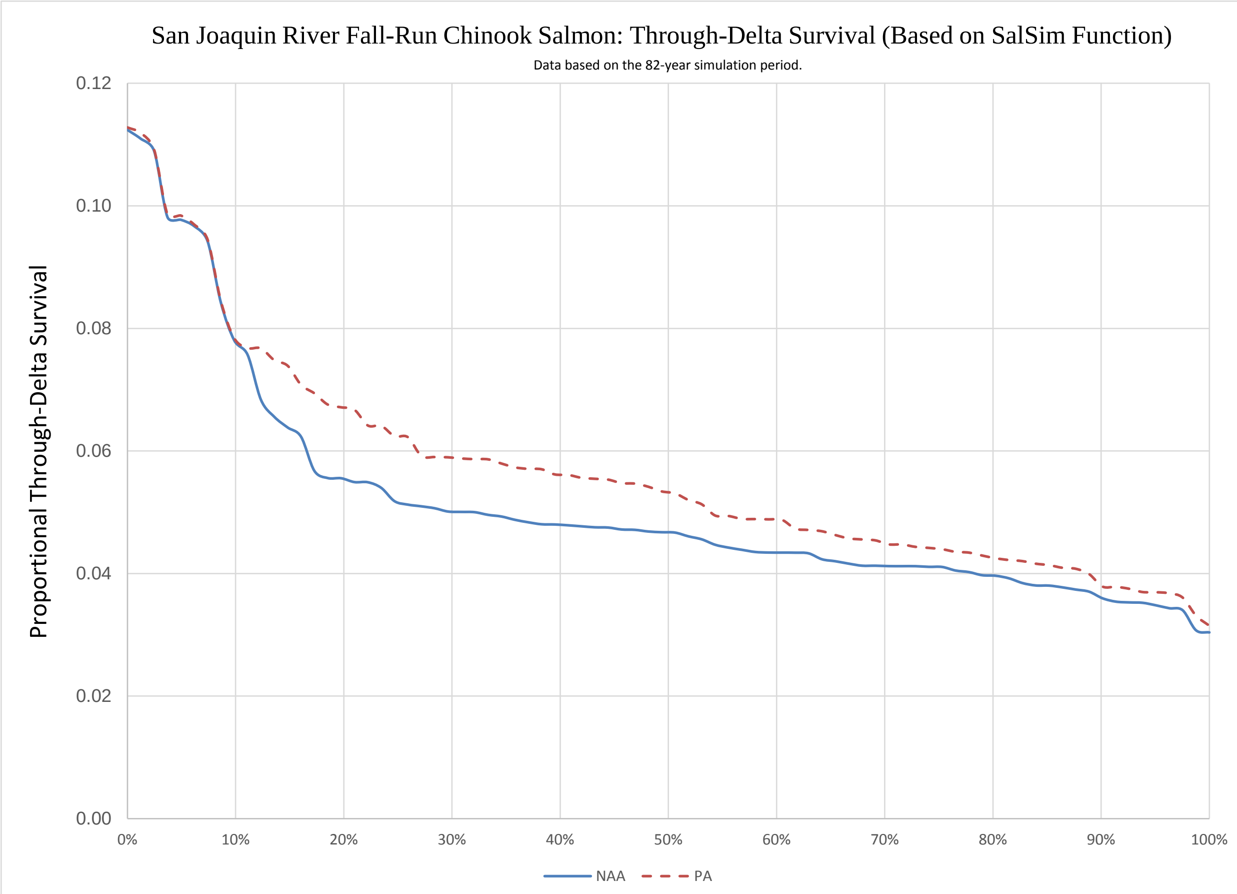
Results

The results of the analysis suggested that the through-Delta survival of San Joaquin River fall-run Chinook salmon under the PA would be greater under the PA than NAA (Figure 5.E-33 and Figure 5.E-34; Table 5.E-19). This is the result of the implementation of the HOR gate, which was assumed to be 50% closed during the main period of fall-run Chinook salmon migration, with the result that flow into the Stockton Deepwater Ship Channel is considerably greater under the PA (Table 5.E-19). The relative differences in survival between NAA and PA were greatest in intermediate water-year types (above normal, below normal, and dry), as a result of two factors. First, and as previously discussed for the DPM, the HOR gate is assumed not to be closed when Vernalis flow is greater than 10,000 cfs; this results in the top 10% of survival estimates being identical between NAA and PA (Figure 5.E-34), which limits the overall differences in wet years. Second, in critical years when flows are very low and water temperature would be high, the rate of change in survival is considerably less than with more flow and lower temperature, as shown in the flatness of the flow-survival curve in Figure 5.E-32. Overall, the analysis based on the SalSim Juvenile Delta Module survival function suggested that the PA would provide a beneficial effect to San Joaquin River fall-run Chinook salmon EFH in the Delta.



Note: Plot only includes annual mean responses and does not consider model uncertainty.

Figure 5.E-33. Box Plots of San Joaquin River Fall-Run Chinook Salmon Smolt Annual Through-Delta Survival Estimated from the Juvenile Delta Module Survival Function of SalSim, Grouped by Water Year Type.



Note: Plot only includes annual mean responses and does not consider model uncertainty.

Figure 5.E-34. Exceedance Plot of San Joaquin River Fall-Run Chinook Salmon Smolt Annual Through-Delta Survival Estimated from the Juvenile Delta Module Survival Function of SalSim.

Table 5.E-19. Mean Annual San Joaquin River Fall-Run Chinook Salmon Smolt Annual Through-Delta Survival Estimated from the Juvenile Delta Module Survival Function of SalSim, Together with Weighted-Mean Flow into the Stockton Deepwater Ship Channel, Grouped by Water Year Type.

Water Year Type	Through-Delta Survival Probability				Flow into Stockton Deepwater Ship Channel (cfs) Weighted by Proportion of Fish Entering the Delta		
	NAA	PA	PA vs. NAA		NAA	PA	PA vs. NAA
W	0.068	0.074	0.006 (8%)		4,254	5,029	775 (18%)
AN	0.049	0.057	0.007 (15%)		2,227	3,292	1,065 (48%)
BN	0.044	0.050	0.006 (14%)		1,437	2,391	953 (66%)
D	0.042	0.047	0.005 (11%)		1,120	1,855	735 (66%)
C	0.039	0.042	0.002 (6%)		474	901	427 (90%)

5.E.5.3.1.2.1.2.2 Habitat Suitability

Bench Inundation

As discussed in section 5.4.1.3.1.2.2.1 of Chapter 5, the PA's diversion of Sacramento River water at the NDD has the potential to affect inundation of riparian and wetland benches that were restored during bank protection actions. This potential effect is of particular importance to fall-run Chinook salmon fry that could rear on these benches during winter/spring. As described in detail in section 5.4.1.3.1.2.2.1.1 of Chapter 5, less flow downstream of the NDD would be expected to principally affect the riparian benches, which are at higher elevation, which was estimated to result in bench inundation indices as much as 20-30% lower in some water year types at some locations (see Table 5.4.1-17 in Chapter 5). As described in Section 5.4.1.3.1.2.2.1.2 of Chapter 5, channel margin enhancement would be undertaken to offset these deficits.

Water Temperature (DSM2-QUAL)

As described in more detail in Section 5.4.1.3.1.2.2.2 of Chapter 5, there were few differences evident in water temperature between NAA and PA, based on DSM2-QUAL modeling results; this reflects water temperature in the Delta generally being dictated more by air temperature than operations. The main potential difference was in the San Joaquin River at the Stockton Deep Water Ship Channel during spring, as discussed further in Section 5.4.1.3.1.2.2.2 of Chapter 5 for steelhead, which would also have relevance for fall-run Chinook salmon emigrating from the San Joaquin River; however, given that juvenile Chinook salmon have higher thermal tolerance than juvenile steelhead (Moyle et al. 2008), any adverse effects would be limited to June as temperature is above 19-20°C[9] in this month (see Figure 5.B.5.43-1 in Appendix 5.B). However, as noted for steelhead in Section 5.4.1.3.1.2.2.2 of Chapter 5, this may have little biological effect on fall-run Chinook salmon juveniles because of the small magnitude of temperature differences between the PA and NAA scenarios and the high frequency of June temperatures that exceed the optimal temperature range for both the PA and NAA, indicating temperatures would be above optimal under both scenarios.

Selenium

As described in Section 5.4.1.3.1.2.2.3 of Chapter 5, the increase in the proportion of San Joaquin River water entering the Delta because of less south Delta exports under the PA would be expected to increase the selenium concentration in west Delta water. However, the analyses of potential effects on trophic level 3 species, which would include fall-run and late fall-run Chinook salmon, showed essentially no difference between PA and NAA scenarios in particulate, invertebrate, or whole-body estimates of selenium concentration (see Appendix 5.F). Therefore, effects of the PA in terms of selenium on EFH for Pacific salmon in the Delta would be undetectable.

[9] Moyle et al. (2008: 128) suggest that 20°C is the upper threshold for optimal rearing conditions, while 19°C is the upper threshold for optimal smoltification conditions.

Olfactory Cues for Upstream Migration

As described in more detail in Section 5.4.1.3.1.2.2.4 of Chapter 5, olfactory cues are important to adult Chinook salmon; under the PA, the percentage of Sacramento River water in the Delta would be somewhat lower because of the NDD, whereas the percentage of San Joaquin River water would be greater because of less south Delta exports. During the main months of fall-run Chinook salmon upstream migration to the Sacramento River (August–November, per Vogel and Marine 1991: 4), there was estimated to be up to 11% less (19% less in relative terms) Sacramento River water at Collinsville (see Table 5.4.1-18 in Chapter), which is close to the 20% change in olfactory cues that adult sockeye salmon detected and behaviorally responded to (Fretwell 1989). The differences in water composition between NAA and PA during the main late fall-run Chinook salmon upstream migration period (November-February; Vogel and Marine 1991: 4) were less than for fall-run Chinook salmon. This suggests that effects on Pacific salmon EFH from changes to olfactory cues for Sacramento River basin fall-run and late fall-run Chinook salmon would be immeasurable.

As noted in Section 5.4.1.3.1.2.2.4 of Chapter 5, less use of the south Delta export facilities under the PA would result in a greater amount of San Joaquin River reaching the confluence area (Table 5.4.1-19 in Chapter 5), which may increase the olfactory cues available for upstream migrating adult salmonids from the San Joaquin River basin, including fall-run Chinook salmon. As shown by Marston et al. (2012), relatively small changes in the ratio of south Delta exports to San Joaquin River inflow can affect the straying rate of upstream migrating adult fall-run Chinook salmon. The several-fold increase in San Joaquin River flow reaching the Sacramento/San Joaquin confluence area under the PA (Table 5.4.1-19 in Chapter 5) has the potential to improve homing of adult fall-run Chinook salmon to the San Joaquin River basin. There is uncertainty in the extent to which the changes would result in less straying, because the quantitative study of this issue by Marston et al. (2012) did not include any years with zero south Delta exports, which is what is proposed under the PA during the D-1641 fall pulse flow period (see Section 3.3.2.2 in Chapter 3 and Section 5.A.5.2.4.4 in Appendix 5.A). There is also uncertainty in the relative or combined importance of San Joaquin River flow and south Delta exports explaining straying rates (Marston et al. 2012); as noted by Marston et al. (2012), statistically speaking, the results of their analysis suggested San Joaquin River flows were more important than south Delta exports (with the latter not being statistically significant at $P < 0.05$), but because little if any pulse flow leaves the Delta when south Delta exports are elevated, exports in combination with pulse flow may be of importance. Application of equation 2 of Marston et al. (2012) would predict essentially zero straying with a south Delta exports to San Joaquin River inflow ratio of zero during the D-1641 flow pulse, which compares to an mean observed rate of 18.0% (range 0.0-70.3%) (Marston et al. 2012: Table 3 of their Methods Appendix). This suggests a potential beneficial effect on Pacific salmon EFH related to adult upstream migration cues for fall-run Chinook salmon returning to the San Joaquin River basin.

Return of fall-run Chinook salmon to the Mokelumne River could be influenced by PA operations, e.g., by differences in Sacramento River inflow to the interior Delta through the DCC/Georgiana Slough (caused by the NDD under the PA, and DCC gate closure differences between NAA and PA) and by less south Delta exports under the PA. Analysis of NAA and PA with DSM2-QUAL fingerprinting analysis shows that the percentage of water at Collinsville contributed by the eastern Delta rivers (Mokelumne, Cosumnes, and Calaveras) under the PA would be greater than NAA during the main October–November Mokelumne River fall-run

Chinook salmon upstream migration period (Table 5.E-20). This suggests that EFH in terms of olfactory cues for migrating adult fall-run Chinook salmon returning to the Mokelumne River would be immeasurable. However, the DCC may be open somewhat more often under the PA during the fall-run Chinook salmon upstream migration period, for the reasons discussed in Section 5.4.1.3.1.1.4 in Chapter 5. This could slightly increase the potential for straying of adult Mokelumne River fall-run Chinook salmon into the Sacramento River. Should temporary October closures of the DCC to reduce straying of Mokelumne River fall-run Chinook salmon be implemented in the future, as are currently being tested (Reclamation 2012), these closures would occur under the NAA and PA with the aim of lessening the potential for straying.

Table 5.E-20. Mean Percentage of Water at Collinsville Originating in the Mokelumne, Cosumnes, and Calaveras Rivers, from DSM2-QUAL Fingerprinting.

Month	Wet			Above Normal			Below Normal			Dry			Critical		
	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
Jan	1.1	1.9	0.8 (40%)	0.5	0.8	0.3 (36%)	0.7	0.9	0.3 (28%)	1.1	1.4	0.3 (20%)	0.4	0.5	0.1 (17%)
Feb	2.1	3.1	1.0 (33%)	1.5	2.2	0.7 (32%)	1.5	2.4	0.9 (38%)	0.7	1.1	0.4 (39%)	0.4	0.5	0.1 (26%)
Mar	2.6	3.8	1.2 (31%)	1.9	3.5	1.5 (44%)	2.1	3.2	1.1 (34%)	1.6	2.3	0.7 (31%)	1.0	1.3	0.3 (22%)
Apr	4.0	4.1	0.1 (2%)	3.8	4.5	0.7 (17%)	2.9	3.5	0.6 (16%)	2.6	3.1	0.4 (14%)	1.4	1.6	0.3 (16%)
May	5.3	5.4	0.1 (1%)	4.8	4.7	-0.1 (-2%)	3.9	3.9	0.0 (0%)	3.2	3.3	0.0 (1%)	1.3	1.4	0.1 (6%)
Jun	4.9	6.1	1.2 (19%)	3.9	4.4	0.5 (10%)	3.0	3.1	0.1 (5%)	2.2	2.4	0.1 (6%)	1.1	1.2	0.0 (3%)
Jul	2.3	3.8	1.4 (38%)	1.2	2.2	1.0 (45%)	0.8	1.4	0.6 (40%)	0.7	1.1	0.3 (31%)	0.6	0.7	0.1 (11%)
Aug	0.7	1.6	0.9 (58%)	0.2	0.7	0.5 (77%)	0.1	0.4	0.3 (72%)	0.2	0.3	0.2 (56%)	0.2	0.3	0.1 (20%)
Sep	0.1	1.0	0.9 (85%)	0.0	0.3	0.3 (88%)	0.0	0.2	0.2 (82%)	0.1	0.1	0.1 (63%)	0.1	0.1	0.0 (20%)
Oct	0.4	1.8	1.4 (78%)	0.0	0.6	0.5 (91%)	0.0	0.2	0.2 (89%)	0.0	0.1	0.1 (81%)	0.0	0.0	0.0 (26%)
Nov	0.5	1.8	1.4 (75%)	0.1	0.9	0.8 (90%)	0.1	0.4	0.3 (87%)	0.1	0.3	0.2 (64%)	0.0	0.1	0.0 (43%)
Dec	0.8	1.6	0.8 (49%)	0.3	0.8	0.6 (65%)	0.2	0.4	0.2 (42%)	0.5	0.7	0.2 (25%)	0.1	0.1	0.0 (10%)

San Pablo Bay Fall-Run Chinook Salmon Fry Rearing Habitat

As part of the analysis of potential effects of the PA on EFH for Pacific salmon, NMFS requested inclusion of an analysis of fall-run Chinook salmon fry rearing habitat in San Pablo Bay (Marcinkevage pers. comm.). NMFS noted that "Fall-run fry-sized fish (<70mm FL) have been found in the Delta during January to March of every year in which data were collected. Monitoring in San Francisco (SF) Bay has shown that fry-sized fish also occur in San Pablo Bay during some years. Unlike smolts, which are physiologically ready for seawater migration, fry cannot tolerate full ocean salinity (>33 ppt) and therefore will survive better in environments with fresher water" (Marcinkevage pers. comm.: page 2). Further, NMFS noted that "High Delta outflows are the likely mechanism that facilitates fry migration to a Bay that, with reduced salinity, has become suitable for rearing (Kjelson et al. 1982)" (Marcinkevage pers. comm.: page 3). While there is no evidence that rearing in San Pablo Bay is beneficial in and of itself, studies have indicated parr and fry residing in brackish waters can recruit to adult returns (e.g., Miller et al. 2010). In addition, diversity in available habitat, including regions such as San Pablo, is beneficial in providing a portfolio of suitable rearing habitat area, although the quality of fry rearing habitat in San Pablo Bay is uncertain. The quality of available habitat, in addition to its extent, is a key consideration as well. On the basis of fry presence in beach seines in San Pablo Bay, NMFS proposed an analysis to examine the frequency of occurrence of three levels of Delta outflow that would indicate optimal, sub-optimal, and unsuitable salinity conditions. NMFS described that "The emphasis of this analysis is to assess what outflows are needed to sustain suitable salinity conditions following high flow events, allowing emigrating fry to gradually assimilate to the higher salinity levels of ocean water" (Marcinkevage pers. comm.: page 3). The longevity and connectivity of "tolerable" salinity habitat in the Bay during these events is not known, but it can be conservatively hypothesized from salinity tolerance tests of fall run and would be of critical importance given the rearing mechanism assumed in this analysis.

Several factors should be considered when estimating the importance of brackish habitat in San Pablo Bay to rearing fall-run fry. These include the degree to which fry observed in San Pablo represent a unique life-history variant, the mechanisms driving the limited observations we have, and the degree to which evidence supports that individuals in these circumstances recruited to the adult spawning population.

The analysis presented below focuses on USFWS Delta Juvenile Fish Monitoring Program fry capture data from San Pablo Bay; however, it does not consider the presence of fry in other parts of the estuary (e.g., Suisun Marsh). The UC Davis Fish Monitoring Program has captured fry in the Suisun Marsh region in most years sampling has occurred (including the same time periods as USFWS sampling) indicating fry utilize habitat at several locations throughout the Marsh. There was no apparent trend in fry abundance based on water year type, suggesting fry are present in Suisun Marsh under a variety of hydrological conditions. However, actual fry abundance in Suisun during these periods is likely underrepresented by these capture data because of limited sampling locations and effort under the UC Davis Fish Monitoring Program. In addition, extensive fry rearing throughout the Delta and upstream habitats has been observed through numerous monitoring efforts. This suggests the extent of suitable fry-rearing habitat would ideally be assessed on a broader geographic scale, integrating all of the diverse estuarine habitat parameters that are conducive to fry rearing.

Sturrock et al. (2015) studied relative survival and contribution of migratory phenotypes using otolith strontium isotopes from adult Chinook salmon returning to the Stanislaus River and found greater fry contribution in the wetter year 2000 (23% vs, 10%) and greater smolt contribution in the drier year 2003 (13% vs 44%). Greater survival and transport for early life-stages is likely related to wetter hydrology and increased flow which, in turn, affects the probability of both occurrence and detection of fall-run fry in brackish downstream areas of the Bay-Delta. Although fall-run fry under 70 mm have been captured as far west as Benicia in drier periods with lower river flows (Hatton and Clark 1942, cited by Williams 2012), fry-sized juveniles entering the Bays are captured more frequently in wetter years (Brandes and McLain 2001).

Salinity is recognized as one of several physical parameters that influence the quality of habitat available for rearing Chinook salmon fry, and salinity tolerance is one physiological form in which phenotypic diversity across the population can be expressed. Laboratory studies have demonstrated that fry can survive in variable salinity levels (up to 30 ppt) (Clarke and Shelbourn 1985), with limited effects to growth rate at salinities as high as 20 ppt (Clarke et al. 1981). Miller et al. (2010) estimated the contribution of various migratory phenotypes to returning adult Central Valley Chinook salmon and found that approximately 20 % emigrated from fresh water at sizes ≤ 55 mm (fry) and approximately 48 % emigrated between the size of 56 to 75 mm (parr). The study also showed evidence that some of these individuals spent time rearing in brackish conditions during their fresh-saltwater transition. Considering the vast majority of hatchery fish are not stocked at sizes below 55 mm, these fish likely represent wild production.

The analysis framework proposed by NMFS focuses on assessing the frequency of occurrence of three levels of Delta outflow, with Delta outflow perhaps being an indicator of transport flows to reach San Pablo Bay as well as an indicator of maintaining suitable salinity conditions within San Pablo Bay. However, PA operations would only begin following construction of the NDD, by which time the relationship of Delta outflow to salinity in San Pablo Bay is anticipated to be different because of sea level rise (higher salinity for a given level of Delta outflow). Therefore an analysis related to salinity is more appropriate. As opposed to examining three levels of Delta outflow, the present analysis derives a probability of occurrence in San Pablo Bay across the range of electrical conductivity, which is a surrogate for salinity, at Martinez. Because suitable fry-rearing habitat throughout the geographic scope (e.g., from fresh to salt water) is not the focus of this analysis, but rather a geographic region (i.e., San Pablo Bay) which is assumed to vary in quality based on salinity, other habitat parameters beyond salinity were not considered here. It is important to note that while only salinity was analyzed as a predictor of habitat quality, other habitat attributes contribute to the availability and extent of suitable fry-rearing habitat.

<u>Methods</u>

NMFS requested that the occurrence of fall-run Chinook salmon fry (< 70 mm fork length) be examined for three USFWS Delta Juvenile Fish Monitoring Program beach seine locations in San Pablo Bay (Point Pinole East, China Camp, and McNear's Beach; Figure 5.E-35). Beach seine data covered the period January–March 1997–2015, and one or more fish having been captured in any of the beach seines in a given month was noted as a presence. Hourly mean electrical conductivity (EC) data for Martinez were obtained for CDEC station Martinez (MRZ), from which was calculated mean monthly EC in the same months as the beach seine data. Martinez was chosen because it represented the most seaward location available from DSM2-QUAL modeling data of NAA and PA scenarios, for the subsequent evaluation of potential EFH effects from the PA. The probability of fry presence (capture) in San Pablo Bay beach seines as a function of Martinez EC was evaluated using PROC GENMOD in SAS/STAT software, Version 9.4 of the SAS System for Windows,[10] based on a generalized linear model with binomial distribution and logistic link function. This illustrated that EC at Martinex was a highly statistically significant predictor of presence in San Pablo Bay (P = 0.0007), with the probability of presence steeply increasing below EC of ~12,000 µS/cm (Figure 5.E-36). Note that water quality parameter data collected by the USFWS Delta Juvenile Fish Monitoring Program indicated fry were captured at much higher EC levels than were recorded at Martinez, ranging from approximately 4,400–35,000 µS/cm at the time and location of capture in San Pablo Bay—the Martinez location was used as an index of these conditions based on availability from DSM2 modeling.

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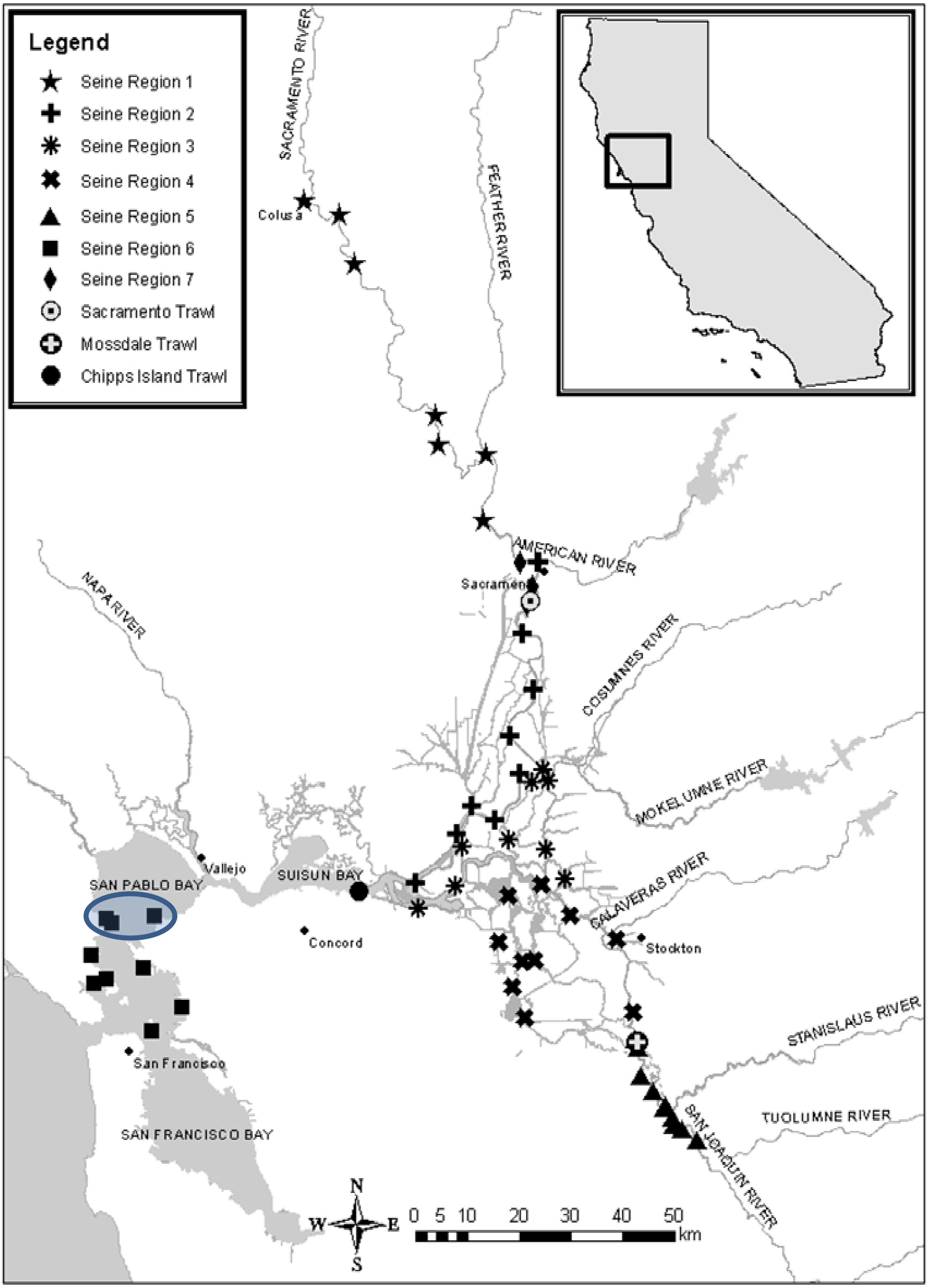
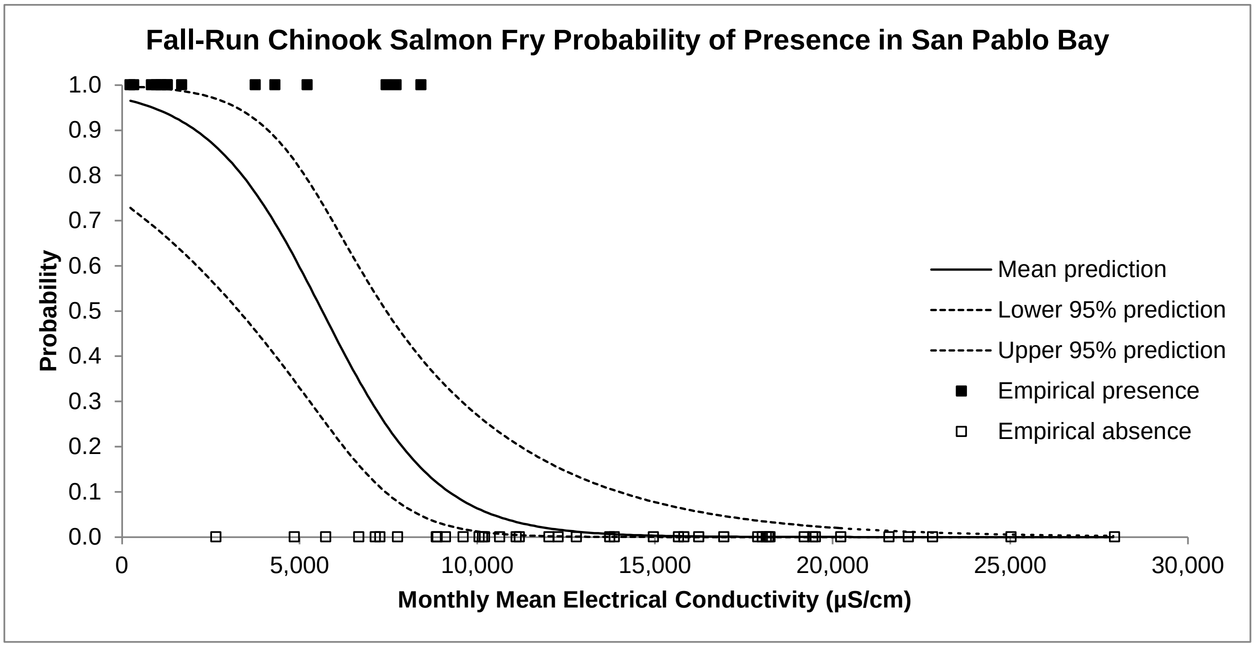


Source: Adapted from USFWS (2014).

Figure 5.E-35. San Pablo Bay Beach Seine Sites (Blue Oval) Used to Develop Relationship of Probability of Fall-Run Chinook Salmon Fry Presence as a Function of Salinity (Electrical Conductivity) at Martinez.



Note: Upper and lower 95% predictions are based on the 95% confidence intervals for the model, rather than the 95% prediction intervals (which are not available for logistic models in the SAS software).

Figure 5.E-36. Predicted Probability of Presence of Fall-Run Chinook Salmon Fry (< 70 mm) In San Pablo Beach Seines as a Function of Monthly Mean Electrical Conductivity at Martinez.

For the comparison of NAA and PA scenarios to assess potential effects of the PA on EFH, monthly mean DSM2-QUAL data for Sacramento River at Martinez (RSAC054) were calculated for the months of January, February, and March, 1922–2003. PROC PLM in SAS was then used to estimate the mean probability of presence of Chinook salmon fry (with 95% confidence interval) in each month of each year for the NAA and PA scenarios, using the relationship between probability of presence and EC (Figure 5.E-36).

Results

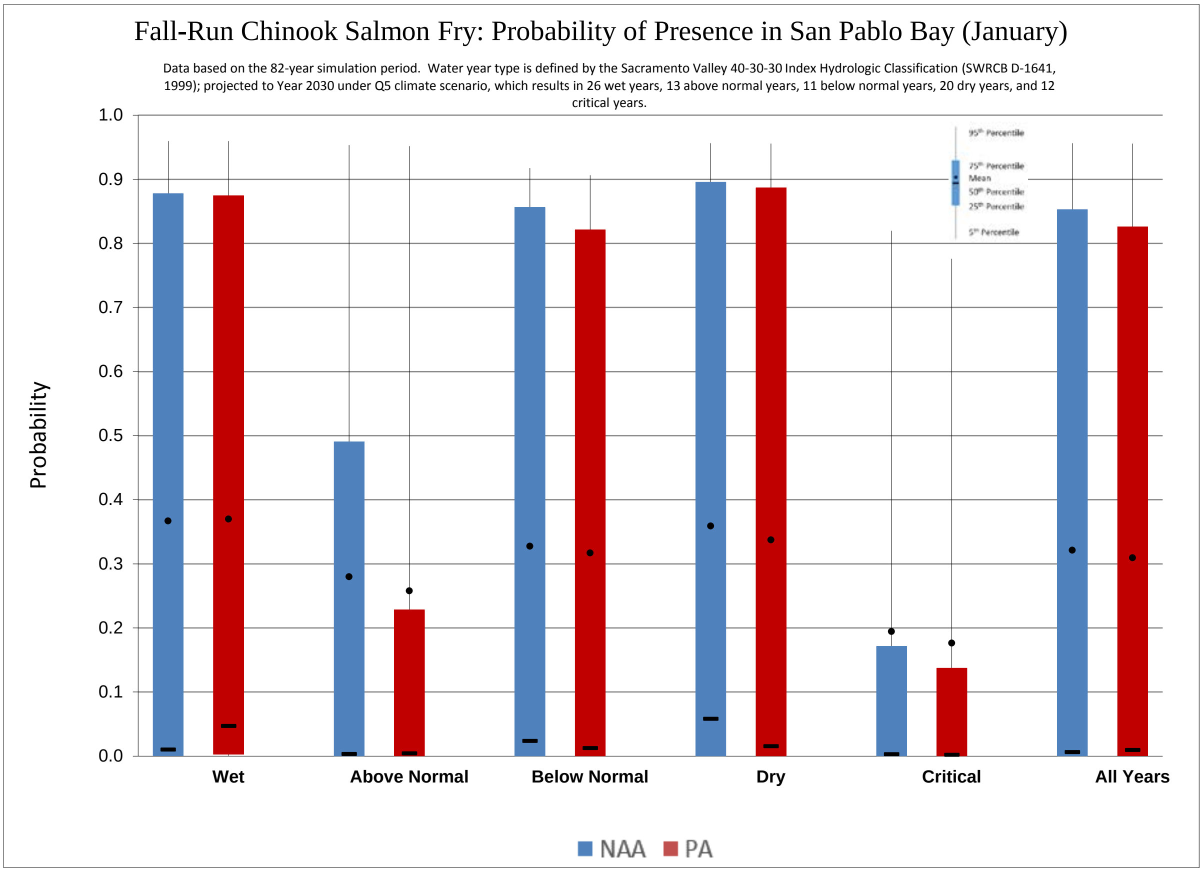
The analysis of the probability of presence of fall-run Chinook salmon fry in San Pablo as a function of EC suggested limited potential of the PA to affect this aspect of EFH for Pacific salmon (Figure 5.E-37, Figure 5.E-38, Figure 5.E-39, Figure 5.E-39, Figure 5.E-41, and Figure 5.E-42; Table 5.E-21). In January that there was no clear pattern of differences in probability of presence between water year types (Figure 5.E-43 and Table 5.E-21), whereas in February and March the probability of presence went down as water year types became drier (Figure 5.E-40 and Figure 5.E-41). This is because January occurs at the end of the DSM2-modeled water year that began in the previous February[11], and there generally is little connection between the hydrologic conditions occurring during January and the hydrologic conditions in the previous winter/spring that led to the classification of the water year. The exceedance plots for all months illustrate that there was little to no difference in probability of presence of Chinook salmon fry between PA and NAA during the years when the probability was highest (e.g., greater than

[11]As described in Appendix 5.A, *CalSim II Modeling and Results*, in CalSim II an individual water year spans from February of the current year through January of the subsequent year.

probability of 0.5-0.6) (Figure 5.E-38, Figure 5.E-40, and Figure 5.E-42). There were greater differences between NAA and PA during years when the probability of presence was least, e.g., 0.04 less (27% less in relative terms) during below normal years in March (Table 5.E-21). During this year, the probability of presence was very low in both the NAA and PA, although there were relatively large percentage differences.

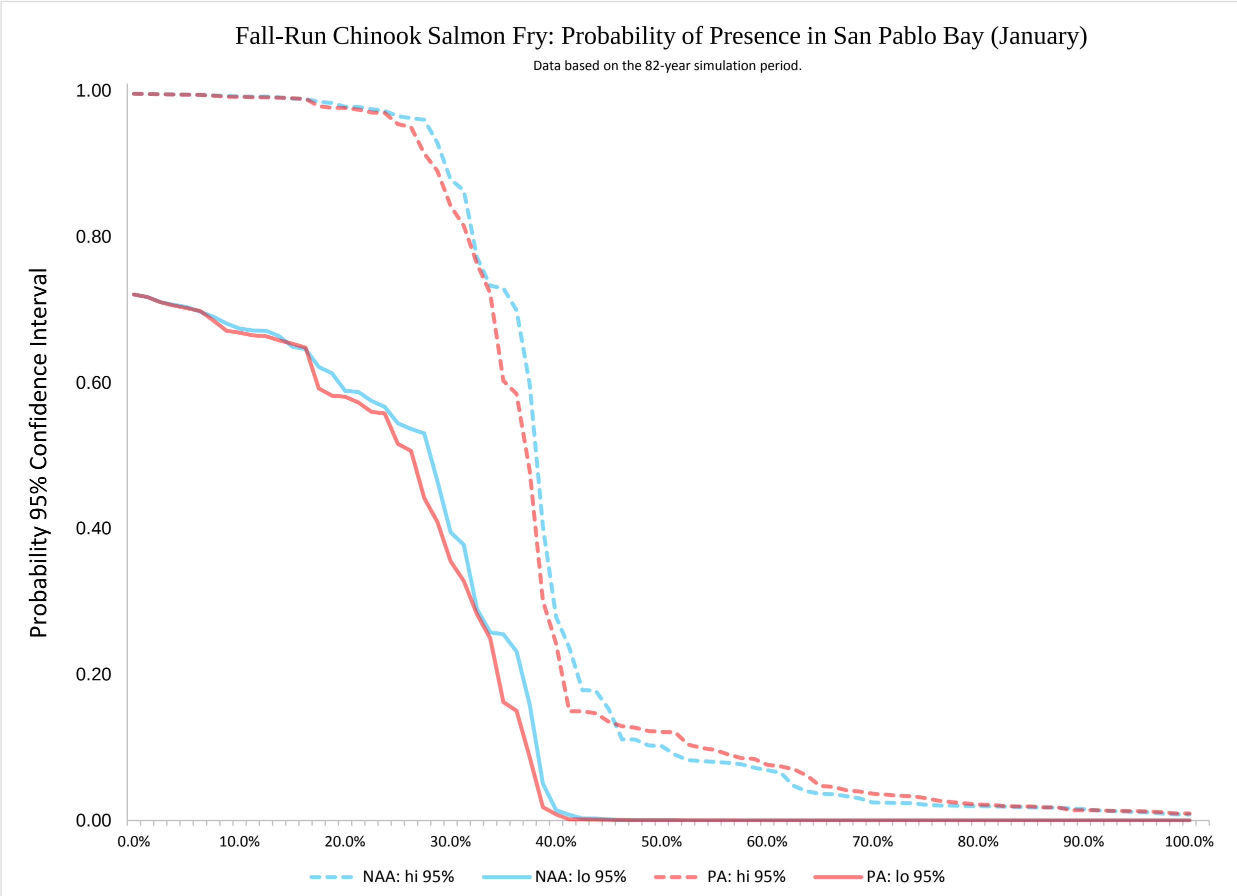
The estimates of probability of presence for NAA and PA had overlapping 95% confidence intervals in January-March of all years (1922–2003) included in the DSM2-QUAL simulation (Figure 5.E-43, Figure 5.E-44, and Figure 5.E-45). This suggests that any differences between scenarios that were suggested from the analysis of annual probability of presence estimates would be challenging to detect statistically, e.g., during monitoring of PA implementation[12]. Overall, this suggests that the differences in any salinity-induced changes in fall-run rearing in San Pablo Bay between NAA and PA would be very small or difficult to detect, and therefore that any effect to EFH in San Pablo Bay would be undetectable. Given the limited spatial and temporal occurrence of Fall-run fry in San Pablo Bay, any effects would be limited to only a fraction of the fry life stage and would not be expected to have a population level effect. In addition, while protecting diverse habitats as a representation of diversity in life history characteristics is important, there is no empirical evidence that Fall-run fry rearing in San Pablo imparts any benefits to the ESU. Combined with the appreciable extent of rearing habitat for fall-run Chinook salmon fry that is upstream of San Pablo Bay, e.g., Suisun Bay/Marsh, which would also be available for occupation, no salinity-related effects on EFH would occur as a result of the PA.

[12] As noted in the independent review panel report for the working draft BA, it is possible that the true annual values could lie near the bottom boundary of the confidence interval for PA and near the top boundary of the confidence interval for NAA (Simenstad et al. 2016). This would result in greater differences than suggested by the comparison of annual mean values. By the same rationale, it is also possible that the true annual values could lie near the top boundary of the confidence intervals for both PA and NAA, in which case the differences would be more similar to the differences between means.



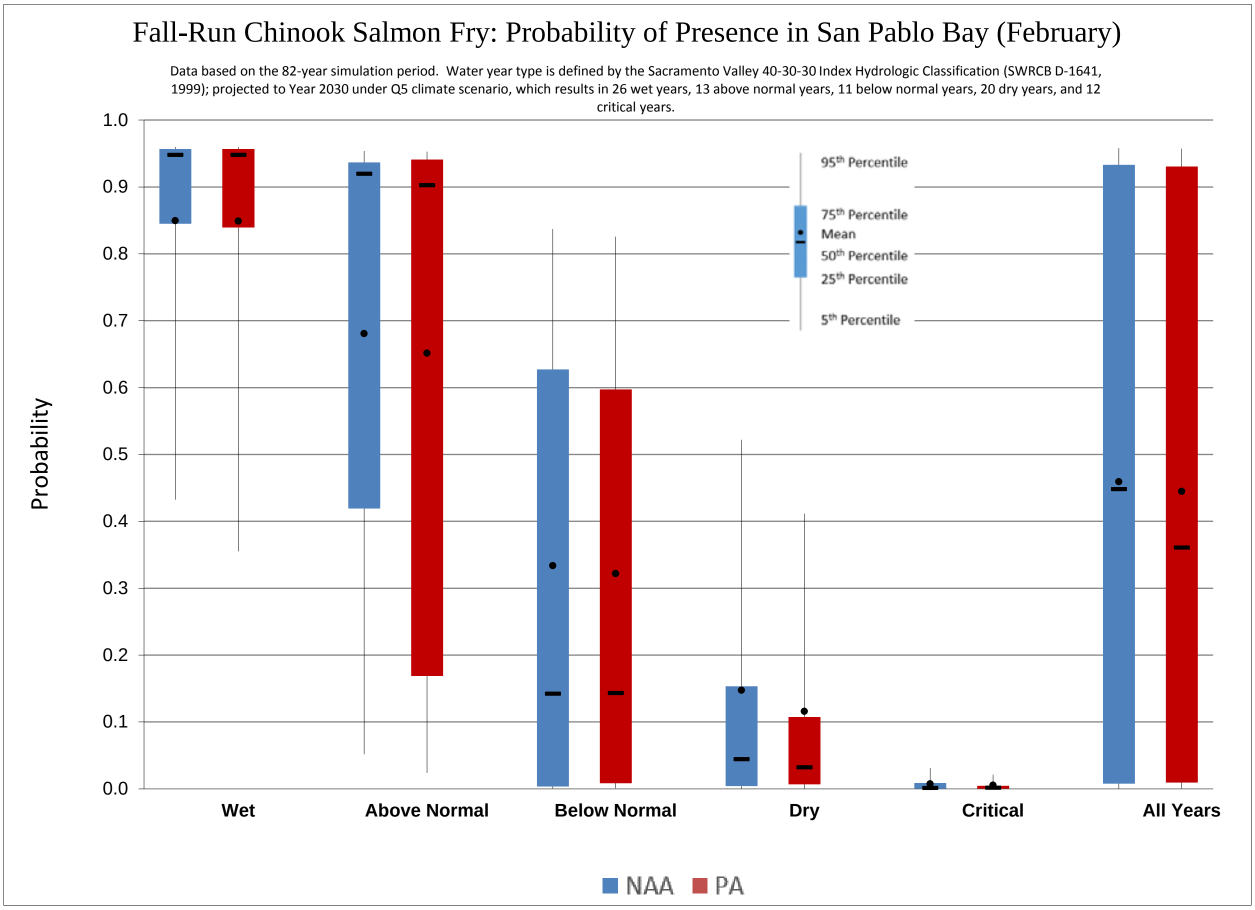
Note: Plot only includes annual mean responses and does not consider model uncertainty.

Figure 5.E-37. Box Plots of Probability of Presence of Fall-Run Chinook Salmon Fry in San Pablo Bay During January as a Function of Martinez Electrical Conductivity, Grouped by Water Year Type.



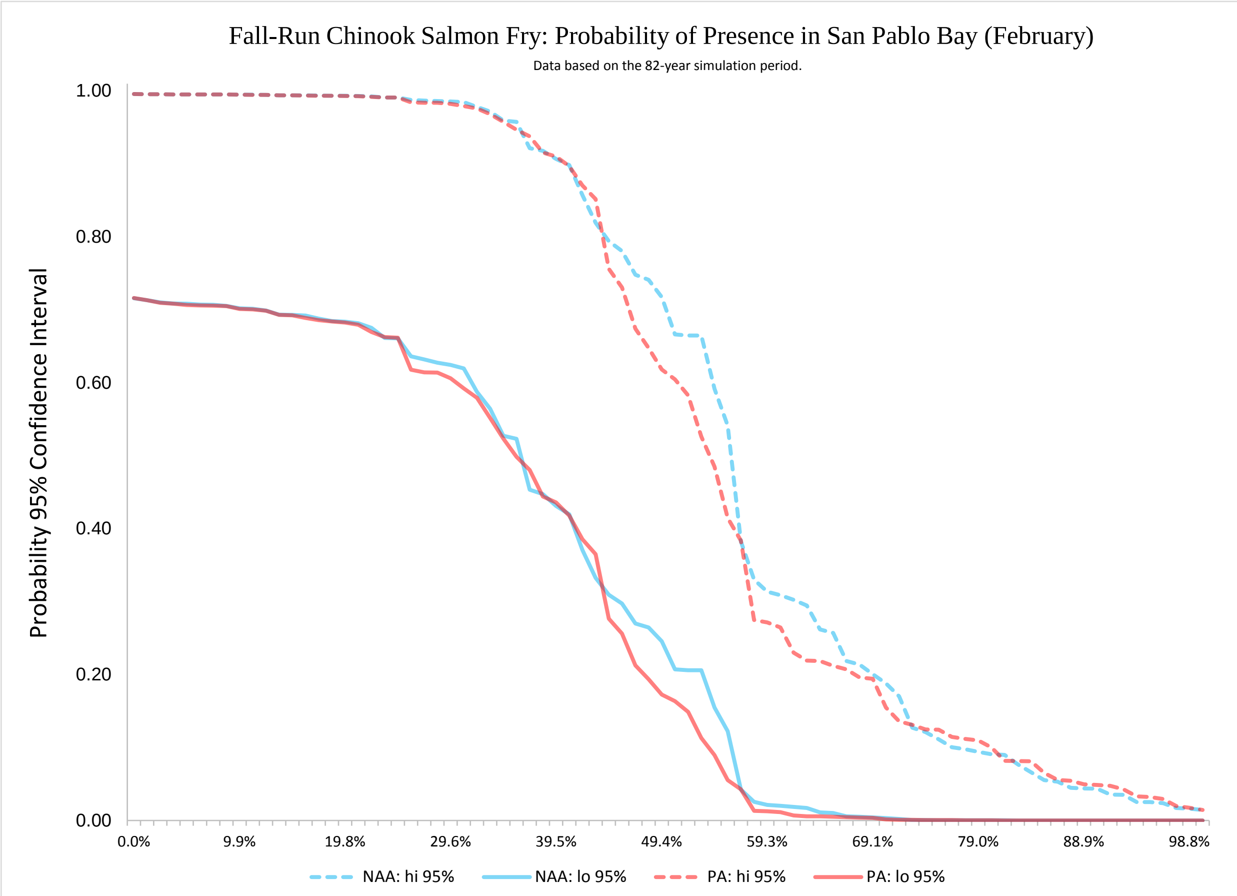
Note: Data are sorted by mean estimate, with only 95% confidence intervals shown. 95% prediction intervals would be wider, but are not available in the SAS software for logistic regression.

Figure 5.E-38. Exceedance Plot of 95% Confidence Interval Probability of Presence of Fall-Run Chinook Salmon Fry in San Pablo Bay During January as a Function of Martinez Electrical Conductivity.



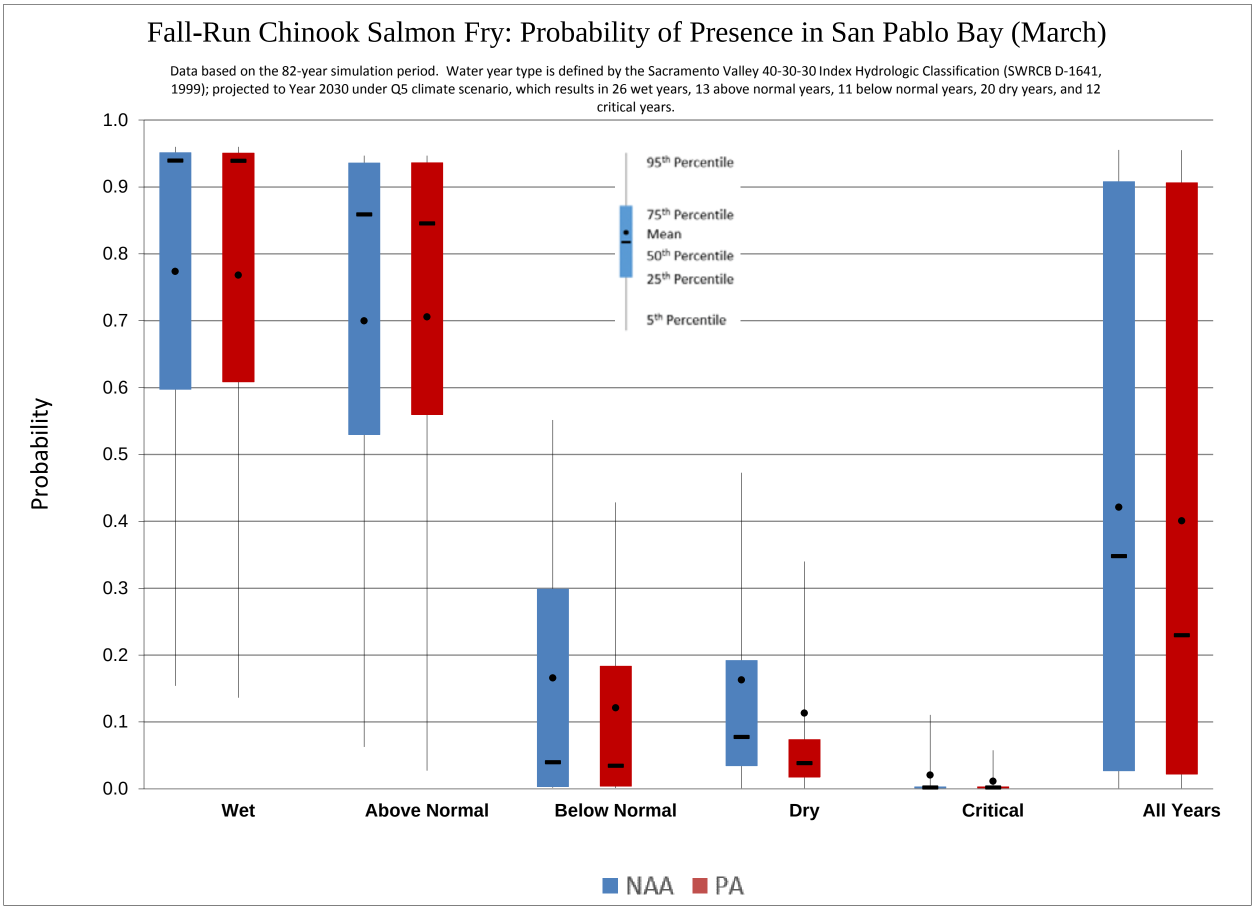
Note: Plot only includes annual mean responses and does not consider model uncertainty.

Figure 5.E-39. Box Plots of Probability of Presence of Fall-Run Chinook Salmon Fry in San Pablo Bay During February as a Function of Martinez Electrical Conductivity, Grouped by Water Year Type.



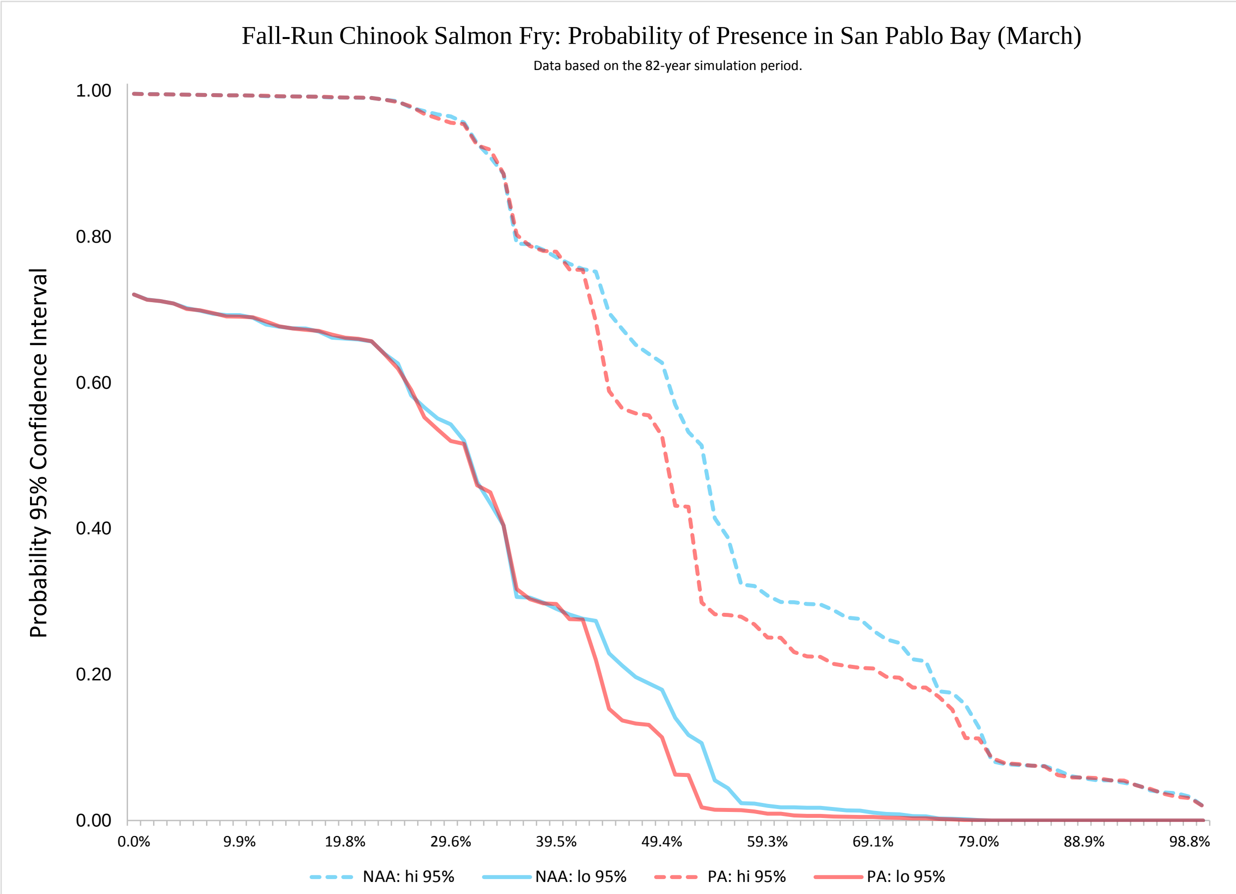
Note: Data are sorted by mean estimate, with only 95% confidence intervals shown. 95% prediction intervals would be wider, but are not available in the SAS software for logistic regression.

Figure 5.E-40. Exceedance Plot of 95% Confidence Interval Probability of Presence of Fall-Run Chinook Salmon Fry in San Pablo Bay During February as a Function of Martinez Electrical Conductivity.



Note: Plot only includes annual mean responses and does not consider model uncertainty.

Figure 5.E-41. Box Plots of Probability of Presence of Fall-Run Chinook Salmon Fry in San Pablo Bay During March as a Function of Martinez Electrical Conductivity, Grouped by Water Year Type.

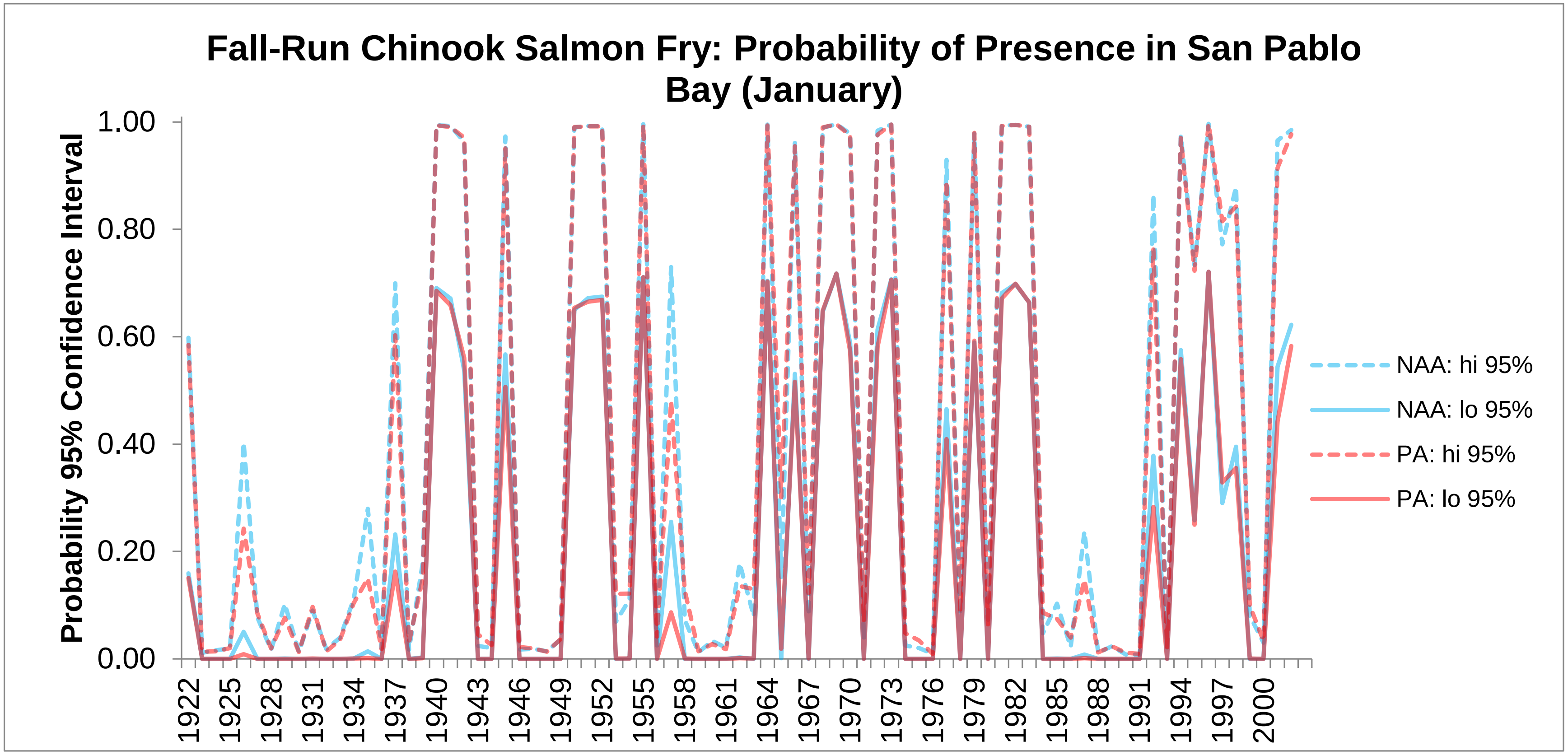


Note: Data are sorted by mean estimate, with only 95% confidence intervals shown. 95% prediction intervals would be wider, but are not available in the SAS software for logistic regression.

Figure 5.E-42. Exceedance Plot of 95% Confidence Interval Probability of Presence of Fall-Run Chinook Salmon Fry in San Pablo Bay During March as a Function of Martinez Electrical Conductivity.

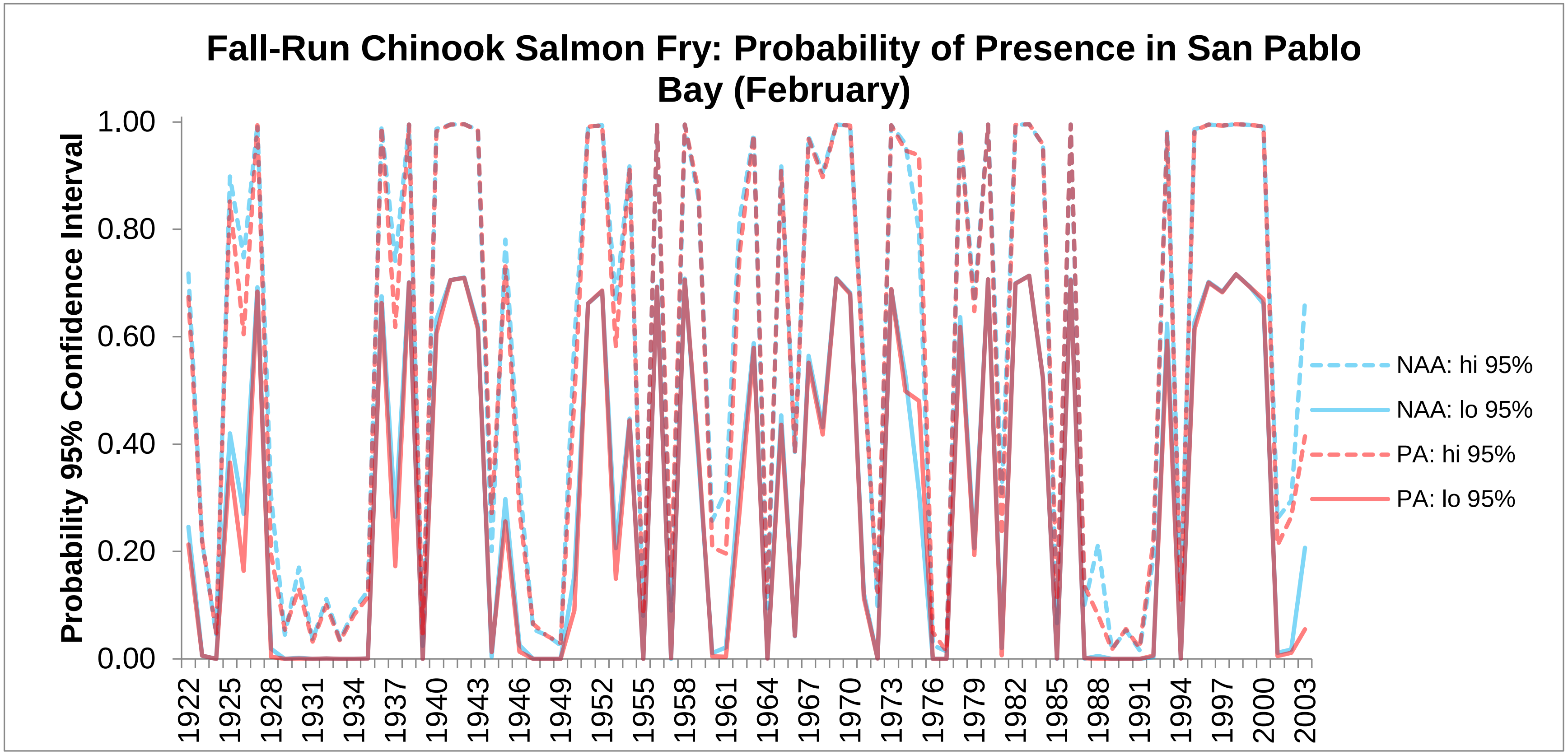
Table 5.E-21. Mean Annual Probability of Presence of Fall-Run Chinook Salmon Fry in San Pablo Bay as a Function of Martinez Electrical Conductivity, Grouped by Water Year Type.

Water Year Type	January				February				March		
	NAA	PA	PA vs. NAA		NAA	PA	PA vs. NAA		NAA	PA	PA vs. NAA
W	0.37	0.37	0.00 (1%)		0.85	0.85	0.00 (0%)		0.77	0.77	-0.01 (-1%)
AN	0.28	0.26	-0.02 (-8%)		0.68	0.65	-0.03 (-4%)		0.70	0.71	0.01 (1%)
BN	0.33	0.32	-0.01 (-3%)		0.33	0.32	-0.01 (-4%)		0.17	0.12	-0.04 (-27%)
D	0.36	0.34	-0.02 (-6%)		0.15	0.12	-0.03 (-21%)		0.16	0.11	-0.05 (-31%)
C	0.19	0.18	-0.02 (-9%)		0.01	0.01	0.00 (-28%)		0.02	0.01	-0.01 (-46%)



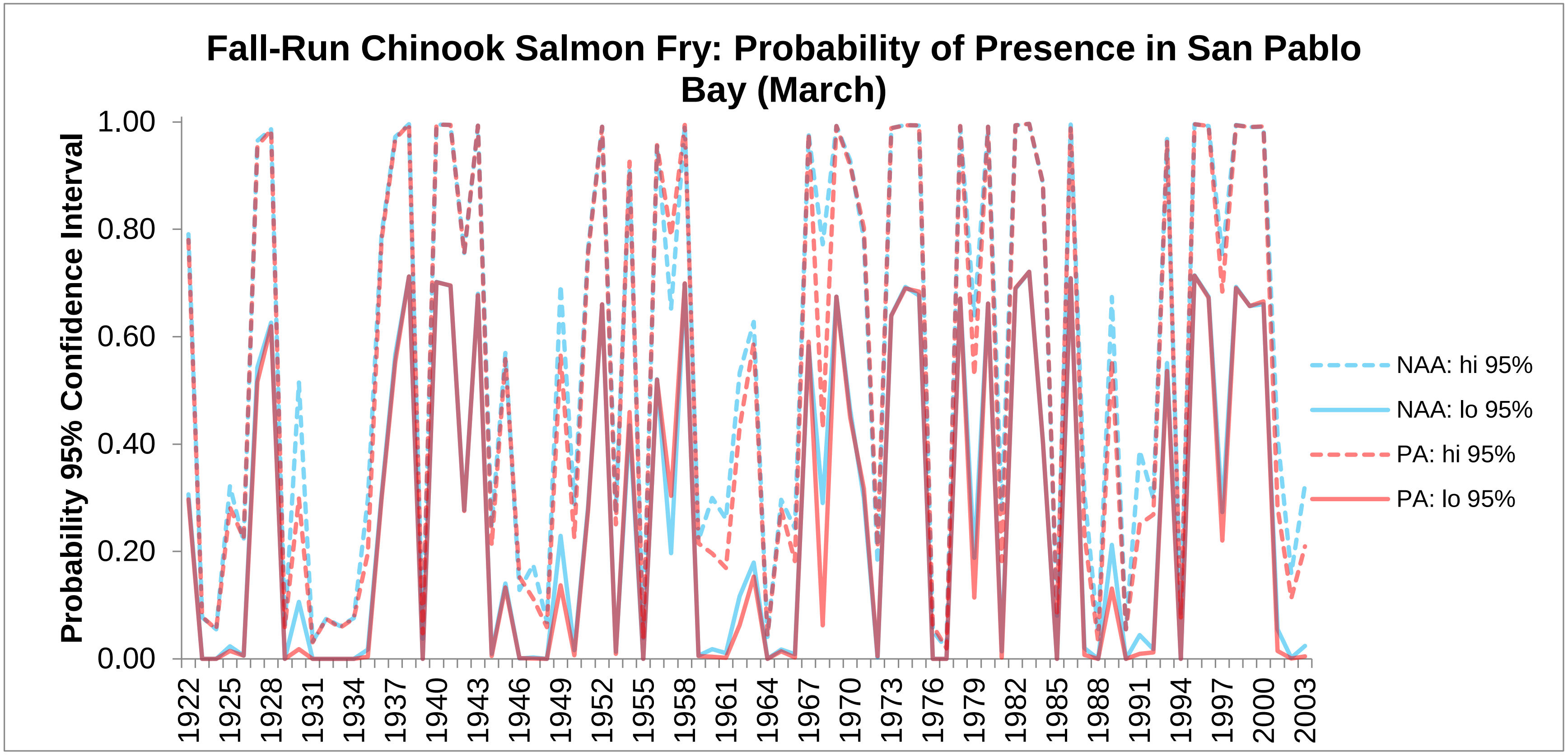
Note: 95% confidence intervals are shown; 95% prediction intervals would be wider, but are not available in the SAS software for logistic regression.

Figure 5.E-43. Time Series of 95% Confidence Interval Probability of Presence of Fall-Run Chinook Salmon Fry in San Pablo Bay During January as a Function of Martinez Electrical Conductivity.



Note: 95% confidence intervals are shown; 95% prediction intervals would be wider, but are not available in the SAS software for logistic regression.

Figure 5.E-44. Time Series of 95% Confidence Interval Probability of Presence of Fall-Run Chinook Salmon Fry in San Pablo Bay During February as a Function of Martinez Electrical Conductivity.



Note: 95% confidence intervals are shown; 95% prediction intervals would be wider, but are not available in the SAS software for logistic regression.

Figure 5.E-45. Time Series of 95% Confidence Interval Probability of Presence of Fall-Run Chinook Salmon Fry in San Pablo Bay During March as a Function of Martinez Electrical Conductivity.

5.E.5.3.1.2.2 Upstream Effects

5.E.5.3.1.2.2.1 Methods

The methods for evaluating potential effects on fall- and late fall-run Chinook salmon are generally the same as those described in Appendix 5.D, *Quantitative Methods and Detailed Results for Effects Analysis of Chinook Salmon, Central Valley Steelhead, Green Sturgeon, and Killer Whale*, with five exceptions.

First, although the methods and thresholds used in the water temperature thresholds analysis were the same as those described in Appendix 5.D, *Quantitative Methods and Detailed Results for Effects Analysis of Chinook Salmon, Central Valley Steelhead, Green Sturgeon, and Killer Whale*, Section 5.D.2.1, *Water Temperature Methods*, the EFH analysis used timing and locations specific to fall- and late fall-run Chinook salmon. This information is provided in Table 5.E-23.

Table 5.E-22. Water Temperature Thresholds Used for Water Temperature Threshold Analyses for Fall-run and Late Fall-Run Chinook Salmon, Sacramento and American Rivers

Species	Life Stage	Period	Location	7DADM1 Threshold (°F)	Sources/Notes
Sacramento River					
Fall-run	Spawning, egg incubation, and alevins	Sep-Jan	Keswick	55.4	USEPA 2003
			Clear Creek	55.4	USEPA 2003
			Balls Ferry	55.4	USEPA 2003
			Bend Bridge	55.4	USEPA 2003
			Red Bluff	55.4	USEPA 2003
	Fry and Juvenile Rearing and Emigration	Dec-Jun	Keswick	61	USEPA 2003; core juvenile rearing
			Clear Creek	61	USEPA 2003; core juvenile rearing
			Balls Ferry	61	USEPA 2003; core juvenile rearing
			Bend Bridge	61	USEPA 2003; core juvenile rearing
			Red Bluff	61	USEPA 2003; core juvenile rearing
			Knights Landing	64	USEPA 2003; non-core juvenile rearing
	Adult Immigration	Jul-Dec	Keswick	68	USEPA 2003
			Bend Bridge	68	USEPA 2003
			Red Bluff	68	USEPA 2003
	Adult Holding	Jul-Aug	Keswick	61	USEPA 2003
			Balls Ferry	61	USEPA 2003
			Red Bluff	61	USEPA 2003
Late-Fall Run	Spawning, egg incubation, and alevins	Dec-Jun	Keswick	55.4	USEPA 2003
			Clear Creek	55.4	USEPA 2003
			Balls Ferry	55.4	USEPA 2003
			Bend Bridge	55.4	USEPA 2003
			Red Bluff	55.4	USEPA 2003
	Fry and Juvenile Rearing and Emigration	Mar-Jul	Keswick	61	USEPA 2003; core juvenile rearing
			Clear Creek	61	USEPA 2003; core juvenile rearing
			Balls Ferry	61	USEPA 2003; core juvenile rearing
			Bend Bridge	61	USEPA 2003; core juvenile rearing
			Red Bluff	64	USEPA 2003; non-core juvenile rearing
			Knights Landing	64	USEPA 2003; non-core juvenile rearing

Species	Life Stage	Period	Location	7DADM1 Threshold (°F)	Sources/Notes
	Adult Immigration	Nov-Apr	Keswick	68	USEPA 2003
			Bend Bridge	68	USEPA 2003
			Red Bluff	68	USEPA 2003
American River					
Fall-run	Spawning, egg incubation, and alevins	Oct-Jan	Hazel Avenue	55.4	USEPA 2003
			Watt Avenue	55.4	USEPA 2003
	Fry and Juvenile Rearing and Emigration	Jan-May	Hazel Avenue	61	USEPA 2003; core juvenile rearing
			Watt Avenue	64	USEPA 2003; non-core juvenile rearing
	Adult Immigration	Sep-Dec	Hazel Avenue	68	USEPA 2003
			Watt Avenue	68	USEPA 2003
	Adult Holding	Jul-Dec	Hazel Avenue	61	USEPA 2003
			Watt Avenue	61	USEPA 2003

Second, the SALMOD analysis for fall- and late fall-run Chinook salmon in the Sacramento River was conducted in the same way as described in Appendix 5.D, *Quantitative Methods and Detailed Results for Effects Analysis of Chinook Salmon, Central Valley Steelhead, Green Sturgeon, and Killer Whale*, Section 5.D.2.1, *Water Temperature Methods*, except that the juvenile production values used to assess the frequency of worst case scenario years was different for fall- and late fall-run Chinook salmon. The values used are presented in Table 5.E-23.

Table 5.E-23. Juvenile Production Values Used to Define Worst Case Scenarios for SALMOD for Fall- and Late Fall-Run Chinook Salmon.

Race	Potential Eggs[1]	5% of Eggs	10% of Eggs
Fall-run Chinook Salmon	56,115,000	2,805,750	5,611,500
Late Fall-run Chinook Salmon	13,325,000	666,250	1,332,500
[1]These values are pre-defined in SALMOD			

Third, although the spawning Weighted Usable Habitat analyses for fall- and late fall-run Chinook salmon were conducted in the same way as described in Appendix 5.D, *Quantitative Methods and Detailed Results for Effects Analysis of Chinook Salmon, Central Valley Steelhead, Green Sturgeon, and Killer Whale*, Section 5.D.2.2, *Spawning Flows Methods*, the spawning WUA curves for late fall-run Chinook salmon from USFWS 2003a and American River fall-run Chinook salmon from USFWS 2003b are not provided in Section 5.D.2.2, *Spawning Flows Methods*. These spawning WUA curves are given below (Figure 5.E-46 and Figure 5.E-47). Note that the Sacramento River fall-run Chinook salmon spawning and rearing WUA curves and the late fall-run Chinook salmon rearing WUA curves are provided in Appendix 5.D, *Quantitative Methods and Detailed Results for Effects Analysis of Chinook Salmon, Central Valley Steelhead, Green Sturgeon, and Killer Whale*, Section 5.D.2.2, *Spawning Flows Methods* and 5.D.2.3, *Rearing Flows Methods* because, as discussed in these sections, they are used as proxies for Sacramento River spring-run Chinook salmon spawning and rearing WUA curves and the CCV steelhead rearing WUA curves.

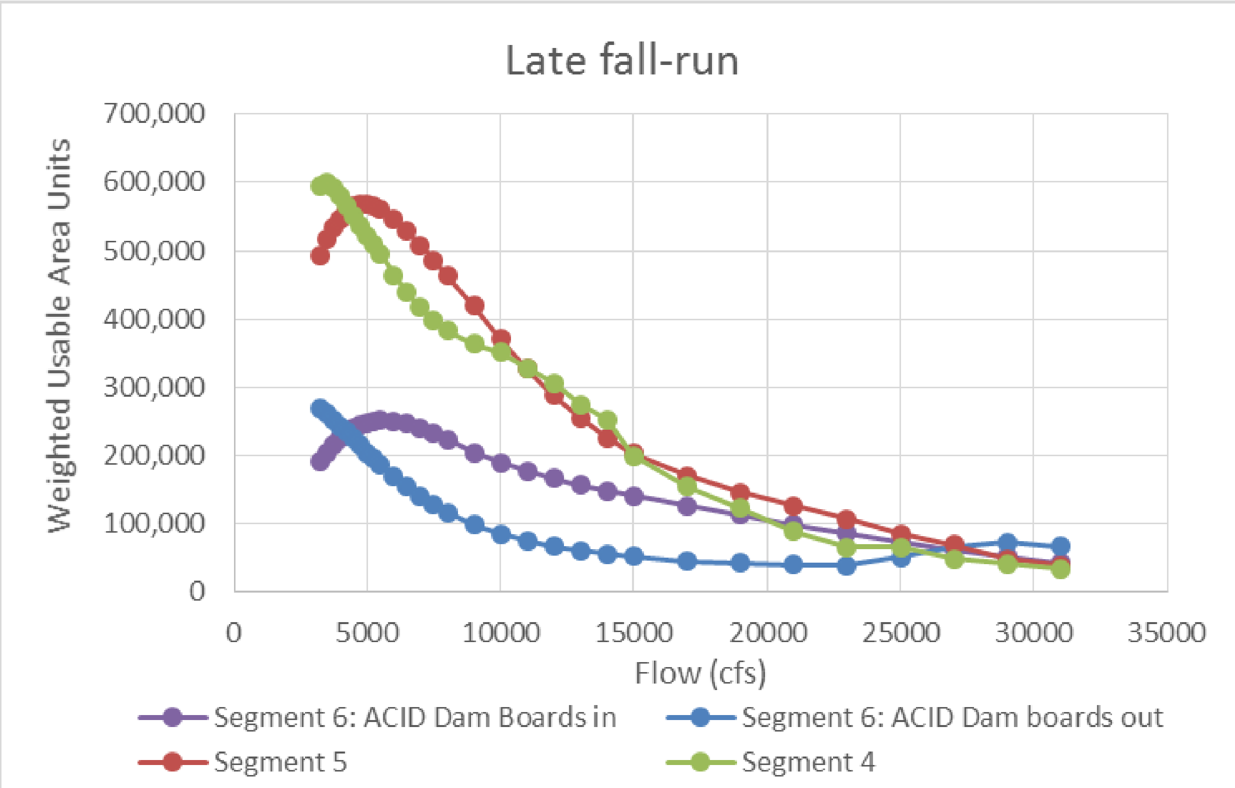


Figure 5.E-46. Spawning WUA Curves for Late Fall-Run Chinook Salmon in the Sacramento River, Segments 4 to 6. ACID = Anderson-Cottonwood Irrigation District

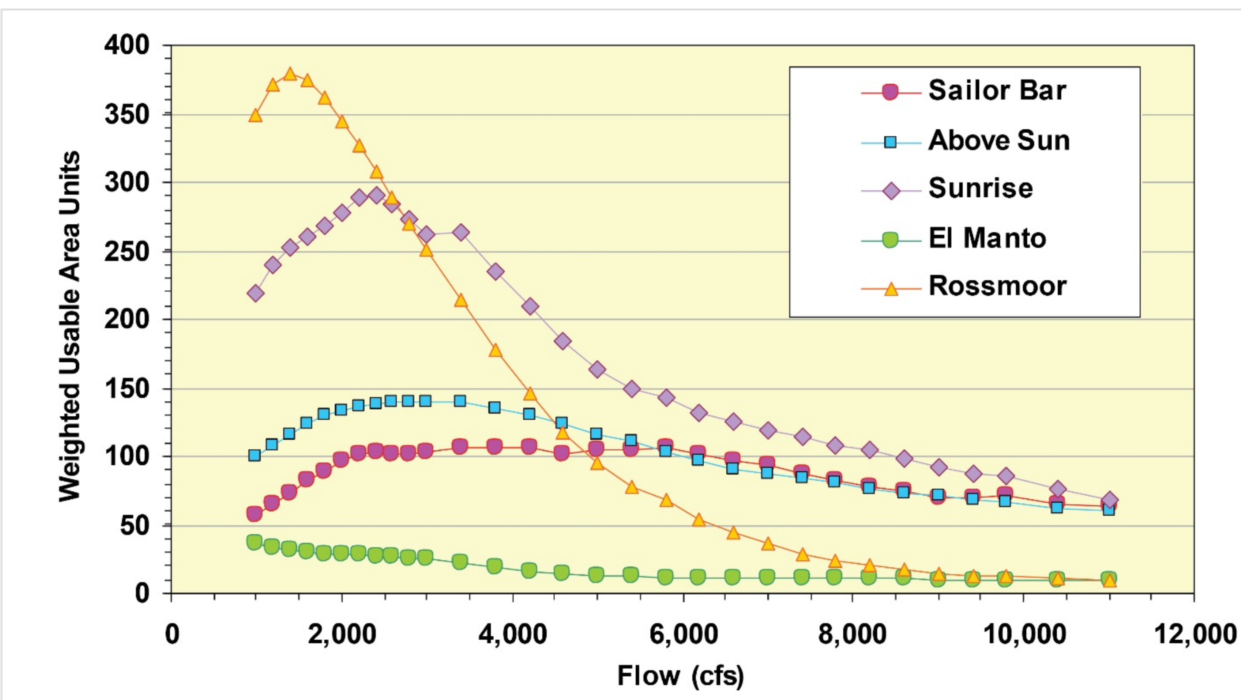


Figure 5.E-47. Spawning WUA Curves for Fall-run Chinook Salmon in the American River.

Fourth, although the rearing Weighted Usable Habitat analyses for fall- and late fall-run Chinook salmon were conducted in the same way as described in Appendix 5.D, *Quantitative Methods and Detailed Results for Effects Analysis of Chinook Salmon, Central Valley Steelhead, Green Sturgeon, and Killer Whale*, Section 5.D.2.3, *Rearing Flows Methods*, the fry and juvenile rearing periods for fall- and late fall-run Chinook salmon are not provided in Section 5.D.2.3, *Rearing Flows Methods*. These periods are shown below (Table 5.E-24).

Table 5.E-24. Fry and Juvenile Rearing Periods for Weighted Usable Area Analysis.

Race/Species	Fry (<60 mm)	Juvenile (>60 mm)
Fall-run Chinook salmon	December–March	February–June
Late fall-run Chinook salmon	March–June	May–July

Note: fry periods assume fry emerge 3 months after egg deposition and grow for 2 months before reaching juvenile size. Abbreviations: mm = millimeters.

Fifth, although the redd dewatering analysis for late fall-run Chinook salmon was conducted in the same way as described in Appendix 5.D, *Quantitative Methods and Detailed Results for Effects Analysis of Chinook Salmon, Central Valley Steelhead, Green Sturgeon, and Killer Whale*, Section 5.D.2.2, *Spawning Flows Methods,* the redd dewatering tables for late fall-run Chinook salmon from USFWS 2006 are not provided in Section 5.D.2.2, *Spawning Flows Methods*. These tables are provided below (Table 5.E-25 and Table 5.E-26). Note that the fall-run Chinook salmon redd dewatering tables are provided in Appendix 5.D, *Quantitative Methods and Detailed Results for Effects Analysis of Chinook Salmon, Central Valley Steelhead, Green Sturgeon, and Killer Whale*, Section 5.D.2.2, *Spawning Flows Methods* because, as discussed in this section, the fall-run Chinook salmon dewatering tables are used as proxies for the spring-run Chinook salmon redd dewatering analysis.

Table 5.E-25. Percent Redd Dewatered Look-up Table for Late Fall-Run Chinook Salmon with ACID Dam Boards Out (the percent of redds dewatered are looked up at the intersection of the "Spawning Flow" columns and "Dewatering Flow" rows).

		Spawning Flow															
Dewatering Flow		3,500	3,750	4,000	4,250	4,500	4,750	5,000	5,250	5,500	6,000	6,500	7,000	7,500	8,000	9,000	10,000
	3,250	0.9	1.5	2.6	3.6	4.9	6.3	8	9.8	11.7	15.9	20.1	24.1	28	31.5	37.8	42.7
	3,500		0.9	1.6	2.4	3.4	4.5	6	7.6	9.3	13.1	17.1	21	24.9	28.2	35	40.2
	3,750			0.8	1.1	2	2.9	4.1	5.5	7	10.5	14.2	17.8	21.6	25	32	37.5
	4,000				0.7	1.2	2	3	4.2	5.5	8.8	12.1	15.6	19.2	22.5	29.5	35.3
	4,250					0.6	1.1	1.9	3	4.1	6.9	10	13.4	16.9	20.1	27.3	33.3
	4,500						0.6	1.2	2.1	3.1	5.5	8.3	11.3	14.6	17.7	24.8	30.8
	4,750							0.6	1.3	2	4	6.3	9	11.8	14.7	21.5	27.6
	5,000								0.5	1	2.6	4.6	7	9.6	12.2	18.9	25.2
	5,250									0.5	1.8	3.5	5.6	7.9	10.4	16.9	23.1
	5,500										1.3	2.7	4.6	6.7	8.9	15.3	21.5
	6,000											0.9	2.3	3.8	5.5	11.2	17.1
	6,500												1	2.1	3.5	8.3	13.4
	7,000													0.8	1.8	5.9	10.4
	7,500														0.7	3.9	7.9
	8,000															2.2	5.5
	9,000																1.7
	10,000																
	11,000																
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	29,000																

Table 5.E-25. (cont.)

		Spawning Flow												
		11,000	12,000	13,000	14,000	15,000	17,000	19,000	21,000	23,000	25,000	27,000	29,000	31,000
Dewatering Flow	3,250	45.6	47.8	48.9	50.6	52.6	55.5	57.5	61.6	67.3	73.5	79.8	86.6	91.1
	3,500	43.3	45.6	46.8	48.6	50.7	53.6	55.5	59.6	65.4	71.5	78.3	85.4	90.1
	3,750	40.7	43.3	44.6	46.5	48.6	51.5	53.3	57.4	63.3	69.6	76.6	83.9	88.5
	4,000	38.7	41.5	42.8	44.8	46.9	49.9	51.8	55.9	61.8	68.3	75.6	82.9	87.6
	4,250	36.8	39.7	41.1	43.1	45.3	48.4	50.2	54.3	60.2	66.6	74.2	81.7	86.5
	4,500	34.5	37.5	38.9	41	43.3	46.5	48.3	52.4	58.1	64.5	72.2	80.2	85
	4,750	31.5	34.6	36.6	38.5	40.9	44.2	46	50.1	55.3	62.4	70.2	78.4	83.3
	5,000	29.3	32.6	34.3	36.7	39.1	42.6	44.5	48.6	54.2	60.8	68.9	77.3	82.3
	5,250	27.4	30.8	32.5	34.9	37.5	41.1	42.9	47	52.6	58.9	67	76	81.1
	5,500	25.8	29.4	31.2	33.2	36.1	39.7	41.6	45.7	51.2	57.7	65.9	74.9	80
	6,000	21.7	25.5	27.5	29.9	32.6	36.4	38.3	42.3	47.7	54.1	62.7	72.1	77.3
	6,500	17.6	21.7	23.8	26.4	29.1	33.1	35.1	39.2	44.5	50.9	59.7	69.1	74
	7,000	14.4	18.6	20.7	23.2	26.1	30.3	32.4	36.4	41.6	48	57	66.6	71.6
	7,500	11.5	16	18.4	21.1	24	28.3	30.4	34.5	39.6	46.3	55.4	65.2	70.3
	8,000	8.9	13.3	16	18.9	21.9	26.3	28.3	32.5	37.6	44.3	53.7	63.7	69
	9,000	3.9	7.8	10.5	13.6	16.7	21.5	23.7	28.1	33.2	40.2	50	60.5	65.9
	10,000	1.2	3.1	5.6	8.8	12.1	17	19.6	24	29.8	36.7	46.7	57.4	62.9
	11,000		2.3	4.1	6.7	10	15.2	17.4	21.8	26.9	34	44.2	55.1	60.7
	12,000			1.2	3.4	6.5	11.7	14.2	18.7	24.5	31.8	42.2	53.3	58.9
	13,000				1.1	3.4	8.3	11.3	16.2	22.7	29.9	40.3	51.5	57.2
	14,000					1.9	6.4	9.8	14.6	21.1	28.3	38.8	50.1	55.9
	15,000						3.3	6.7	11.7	18.8	26	36.7	48.2	54.1
	17,000							3.5	7	13.1	20.3	31.1	42.9	49.1
	19,000								2.5	7.1	14.4	25.2	36.9	43.2
	21,000									3.1	9.3	20	32.1	39.1
	23,000										5.1	14.5	25.7	32.6
	25,000											1.8	5.2	9.4
	27,000												1.4	4.4
	29,000													1.6

Table 5.E-26. Percent Redd Dewatered Look-up Table for Late Fall-Run Chinook Salmon with ACID Dam Boards In (the percent of redds dewatered are looked up at the intersection of the "Spawning Flow" columns and "Dewatering Flow" rows).

		Spawning Flow															
Dewatering Flow		3,500	3,750	4,000	4,250	4,500	4,750	5,000	5,250	5,500	6,000	6,500	7,000	7,500	8,000	9,000	10,000
	3,250	0.9	1.7	2.6	3.7	4.9	6.2	7.8	9.5	11.3	15.1	18.9	22.5	26	29.1	34.9	39.4
	3,500		0.9	1.6	2.4	3.4	4.5	5.9	7.4	9	12.5	16.1	19.6	23.1	26.1	32.3	37.1
	3,750			0.8	1.1	2	2.9	4.1	5.5	6.9	10.1	13.4	16.7	20.1	23.1	29.5	34.6
	4,000				0.7	1.3	2	3	4.2	5.4	8.4	11.5	14.7	17.9	20.9	27.3	32.7
	4,250					0.7	1.2	2	3	4.1	6.7	9.6	12.6	15.8	18.7	25.2	30.8
	4,500						0.6	1.3	2.1	3.1	5.3	7.9	10.7	13.6	16.4	22.9	28.4
	4,750							0.6	1.3	2.1	3.9	6	8.5	11.1	13.7	19.9	25.4
	5,000								0.6	1.1	2.6	4.4	6.6	8.9	11.3	17.4	22.9
	5,250									0.5	1.7	3.3	5.2	7.3	9.5	15.3	20.7
	5,500										1.2	2.5	4.3	6.1	8.1	13.7	19.1
	6,000											0.9	2.1	3.4	5	10	15.1
	6,500												0.9	1.9	3.1	7.4	11.8
	7,000													0.8	1.6	5.2	9.1
	7,500														0.7	3.5	6.9
	8,000															2	4.9
	9,000																1.5
	10,000																
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Table 5.E-26. (cont.)

	Spawning Flow												
Dewatering Flow	11,000	12,000	13,000	14,000	15,000	17,000	19,000	21,000	23,000	25,000	27,000	29,000	31,000
3,250	42.3	44.6	46	47.9	50.1	53.4	55.4	59.2	63.7	66.8	69.7	74.4	79.1
3,500	40.1	42.6	44	46	48.2	51.5	53.5	57.2	61.8	64.6	67.8	72.6	77.3
3,750	37.8	40.5	42	44	46.3	49.6	51.5	55.1	59.7	62.6	65.6	70.4	75.1
4,000	36	38.8	40.4	42.4	44.8	48.1	50	53.6	58.3	61.1	64.3	68.9	73.5
4,250	34.2	37.1	38.7	40.8	43.2	46.5	48.3	51.9	56.4	59	62.2	66.9	71.5
4,500	32	34.9	36.5	38.6	41.1	44.4	46.1	49.6	53.9	56.3	59.2	64.1	68.7
4,750	29.1	32.2	33.8	36	38.5	41.9	43.5	46.8	50.6	53.2	55.9	60.6	65.1
5,000	26.7	29.8	31.4	33.5	35.9	39.1	40.5	43.6	47.5	49.3	51.9	56.3	60.6
5,250	24.4	27.5	28.9	30.9	33.2	36.3	37.3	40.2	43.6	44.8	46.9	51.4	55.5
5,500	22.8	25.9	27.3	28.9	31.4	34.2	35.1	37.8	41	42.1	43.9	48	51.9
6,000	19	22.2	23.7	25.6	27.7	30.6	31.3	33.7	36.4	37	38.6	42.4	45.9
6,500	15.4	18.8	20.3	22.3	24.5	27.4	28.1	30.5	33	33.3	34.5	37.8	40.8
7,000	12.5	16	17.6	19.6	21.8	24.9	25.5	27.8	30.2	30.2	31.1	34.3	37.1
7,500	9.9	13.7	15.5	17.6	20	23.1	23.8	26	28.3	28.4	29.2	32.2	35.2
8,000	7.7	11.4	13.5	15.7	18.1	21.3	21.8	24.1	26.3	26.2	27	30.1	33.1
9,000	3.3	6.6	8.7	11.1	13.6	17	17.7	20.1	22.2	22.1	22.8	25.8	28.7
10,000	1	2.7	4.6	7	9.8	13.3	14.3	16.7	19.3	19	19.4	22.3	25.1
11,000		2	3.4	5.4	8.1	12	12.6	16.6	17	16.7	17	19.9	22.6
12,000			0.9	2.7	5.3	9.1	10	12.3	15	14.7	14.9	17.7	20.5
13,000				0.9	2.8	6.5	7.8	10.4	13.7	13.3	13.6	16.3	19
14,000					1.7	5.1	6.7	9.2	12.4	12.1	12.4	15	17.7
15,000						2.5	4.2	6.9	10.6	10.3	10.8	13.3	16
17,000							2.4	4.3	7.5	7.7	8.2	10.6	13.2
19,000								1.7	4.2	5.1	5.8	8.1	10.5
21,000									2	2.7	3.5	5.8	8.4
23,000										1.1	2.1	4.3	7.4
25,000											1.3	3.4	6.4
27,000												1.3	4
29,000													1.5

Sixth, although the redd dewatering analyses for fall-run and late fall-run Chinook salmon were conducted in the same way as described in Appendix 5.D, *Quantitative Methods and Detailed Results for Effects Analysis of Chinook Salmon, Central Valley Steelhead, Green Sturgeon, and Killer Whale*, Section 5.D.2.2, *Spawning Flows Methods*, the spawning periods for fall- and late fall-run Chinook salmon, not including the months that egg and larval incubation continues after spawning, are not provided in Section 5.D.2.3, *Rearing Flows Methods*. These periods are shown below (Table 5.E-27).

Table 5.E-27. Spawning Periods Used for Redd Dewatering Analyses

River	Race	Spawning Period
Sacramento River	Fall-run Chinook salmon	Sep-Nov
	Late fall-run Chinook salmon	Dec-Apr
American River	Fall-run Chinook salmon	Oct-Nov

5.E.5.3.1.2.2.2 Results - Sacramento River

5.E.5.3.1.2.2.2.1 Fall-Run Chinook Salmon

Spawning, Egg Incubation, and Alevins

<u>Flow-Related Effects</u>

Mean monthly flow rates and reservoir storage volumes were examined for the PA and NAA during the September through January spawning and incubation period, with peak occurrence during October through December, for fall-run Chinook salmon (Table 5.E-23). Changes in flow can affect the instream area available for spawning and egg incubation, along with the quality of the habitat, and can result in dewatering or scour of the redds.

Shasta Reservoir storage volume at the end of September influences flow rates below the dam during much of the fall-run Chinook salmon spawning and egg incubation period (Appendix 5.A, *CALSIM Methods and Results*, Table 5.A.6-3). Mean Shasta September storage under the PA would be similar (less than 5% difference) to storage under NAA for all water year types, except for 7% higher mean storage during critical water years under the PA.

Mean flow due to the PA at the Keswick and Red Bluff locations in the Sacramento River would be lower than flow under the NAA during November of wet and above normal water year types, with 26% lower flows for both water year types under the PA than under the NAA at Keswick Dam and 21% lower flows at Red Bluff (Appendix 5.A, *CALSIM Methods and Results*, Table 5.A.6-10, Table 5.A.6-35)). Flow would also be lower during October of wet years, with 11% lower flow at Keswick and 10% lower flow at Red Bluff. During the majority of the remaining months and water year types of the spawning period, changes in mean flow would be minor (less than 5% difference) or would be greater under the PA, including, at Keswick, 17% and 7% greater flow in October of below normal and dry years, 13% greater flow in November of critical years, and 8% and 18% greater flow in January of wet and critical water years, respectively. Flow increases at Red Bluff would be similar to those at Keswick, but smaller. There would be no flow differences greater than 5% during December at either location. October and November, are in the peak fall-run spawning period.

Spawning WUA. Spawning weighted usable area (WUA) provides a metric of spawning habitat availability that accounts for the spawning requirements of the fish with respect to water depth, flow velocity, and substrate. Spawning WUA for fall-run Chinook salmon was determined by USFWS (2003a, 2005a, 2006) for a range of flows in five segments of the Sacramento River between Keswick Dam and the Deer Creek confluence (Appendix 5.D.2.2, *Spawning Flows Methods*). Segment 2 covers 19 miles from Deer Creek to the Red Bluff Diversion Dam; Segment 3 covers 12 miles from upper Lake Red Bluff to Battle Creek; Segment 4 stretches 8 miles from Battle Creek to the confluence with Cow Creek; Segment 5 reaches 16 miles from Cow Creek to the A.C.I.D. Dam; and Segment 6 covers 2 miles from A.C.I.D. Dam to Keswick Dam. Table 5.E-3 shows the distribution of fall-run Chinook salmon in the upper Sacramento River based on CDFW aerial survey results. The Cow Creek confluence is about midway between the Airport Road Bridge and Balls Ferry locations in Table 2 and the Deer Creek confluence is a mile downstream of Woodson Bridge. Therefore, about 16% of fall-run redds occur within Segment 6, about 26% are found within Segment 5, about 18% are in Segment 4, 23% are in Segment 3, and most of the rest occur in Segment 2. To estimate changes in spawning WUA that would result from the PA, the flow-versus-spawning habitat WUA relationship developed for each of these segments was used with mean monthly CALSIM II flow estimates for the midpoint of each segment under the PA and the NAA during the fall-run Chinook salmon spawning and egg incubation period. Further information on the WUA analysis methods is provided in Appendix 5.D.2.2, *Spawning Flows Methods*.

Differences in fall-run Chinook salmon spawning WUA under the PA and NAA were examined using exceedance plots of monthly mean WUA for the spawning period in each of the river segments for each water year type and all water year types combined. The exceedance curves for the PA for all water years combined are similar to or slightly higher than those for the NAA for all five river segments (Figure 5.E-48, Figure 5.E-54, Figure 5.E-60, Figure 5.E-66, and Figure 5.E-72). With the curves broken out by water year type, increases in WUA under the PA are evident in all five river segments for wet and above normal water year types (Figure 5.E-49, Figure 5.E-50, Figure 5.E-55, Figure 5.E-56, Figure 5.E-61, Figure 5.E-62, Figure 5.E-67, Figure 5.E-68, Figure 5.E-73, and Figure 5.E-74), and reductions in WUA are evident in Segment 6 for critical water years (Figure 5.E-53).

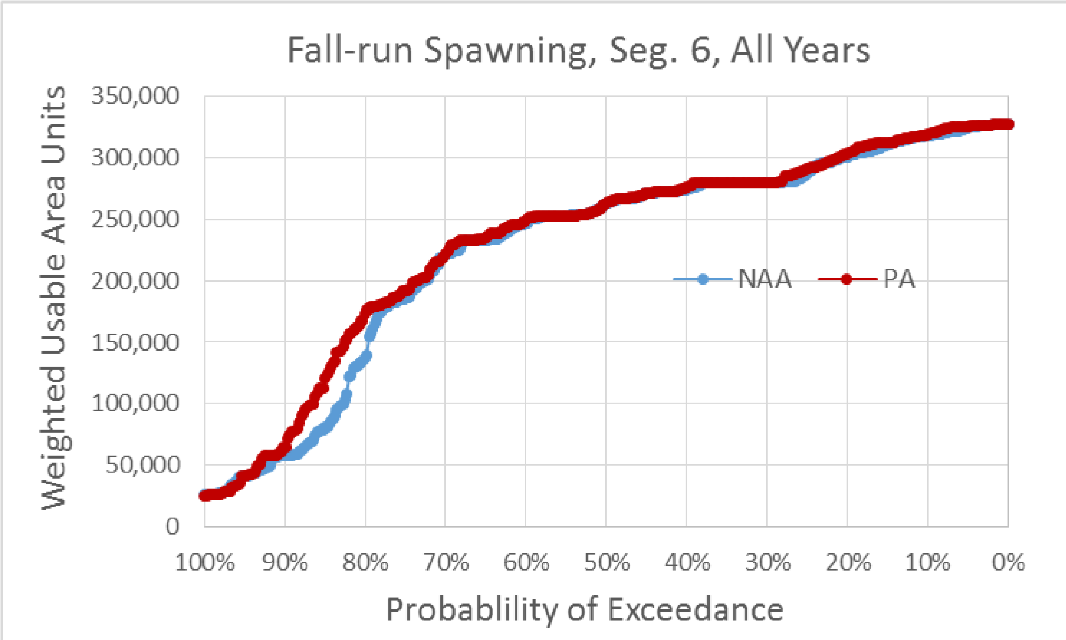


Figure 5.E-48. Exceedance Plot of Fall-Run Chinook Salmon Spawning Weighted Usable Area for NAA and PA Model Scenarios in River Segment 6, All Water Years

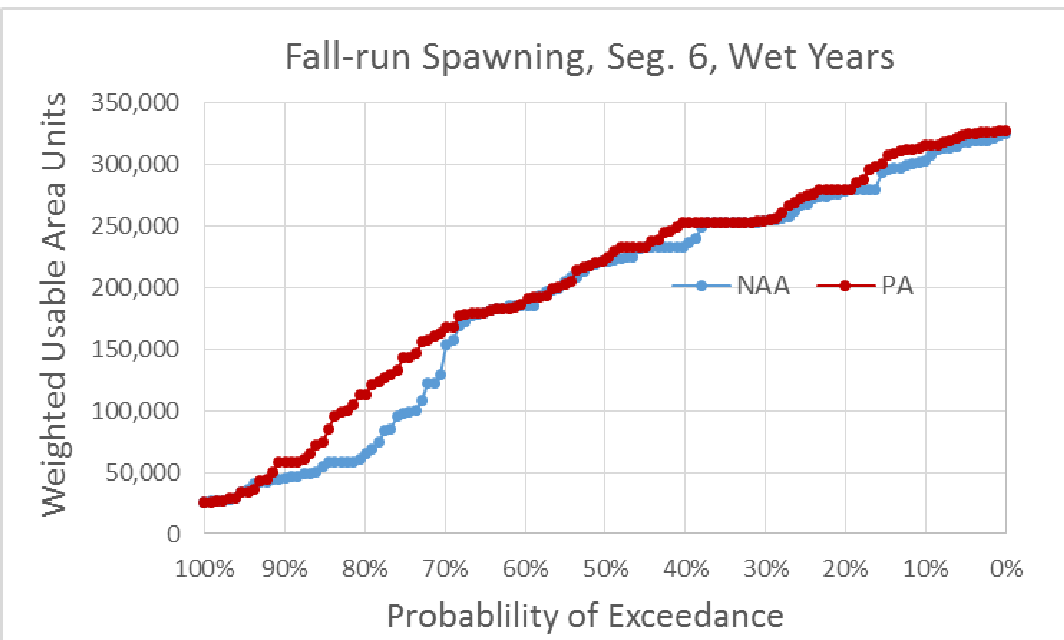


Figure 5.E-49. Exceedance Plot of Fall-Run Chinook Salmon Spawning Weighted Usable Area for NAA and PA Model Scenarios in River Segment 6, Wet Water Years

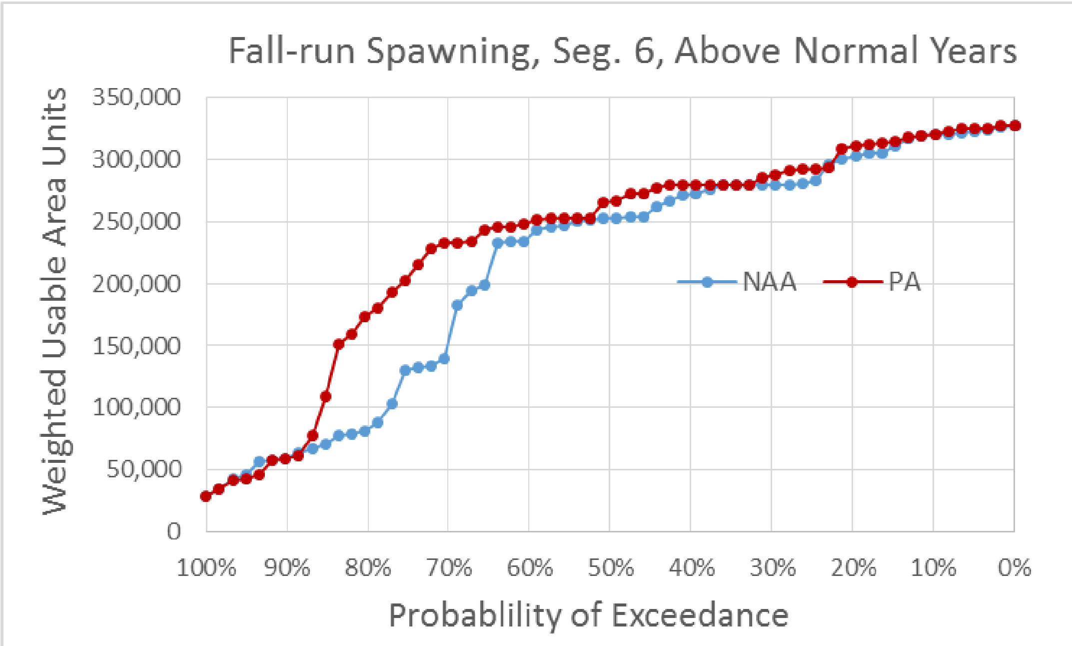


Figure 5.E-50. Exceedance Plot of Fall-Run Chinook Salmon Spawning Weighted Usable Area for NAA and PA Model Scenarios in River Segment 6, Above Normal Water Years

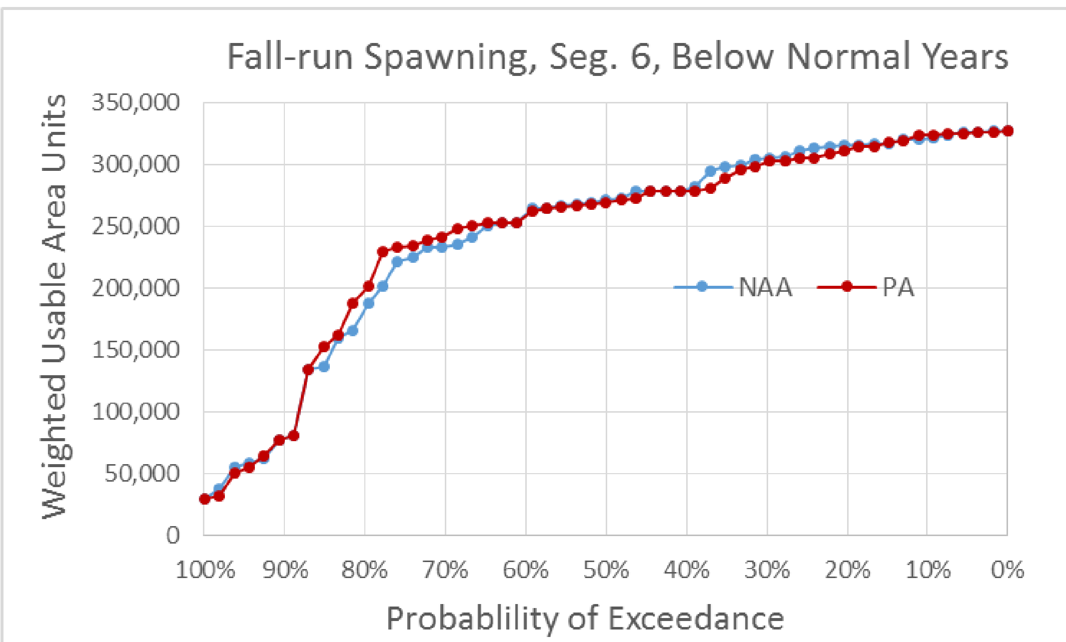


Figure 5.E-51. Exceedance Plot of Fall-Run Chinook Salmon Spawning Weighted Usable Area for NAA and PA Model Scenarios in River Segment 6, Below Normal Water Years

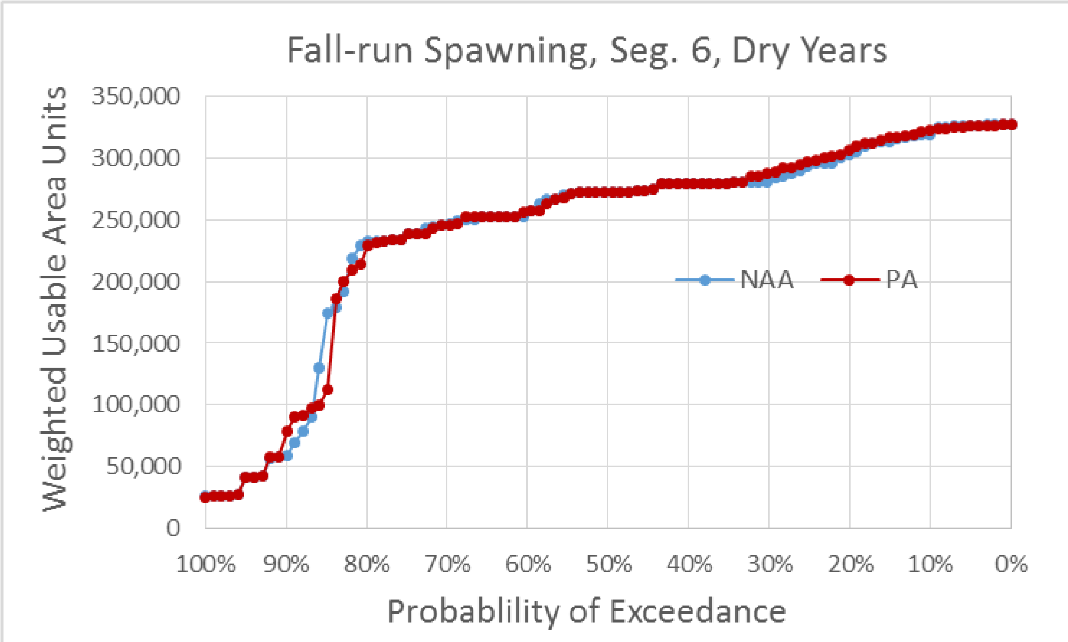


Figure 5.E-52. Exceedance Plot of Fall-Run Chinook Salmon Spawning Weighted Usable Area for NAA and PA Model Scenarios in River Segment 6, Dry Water Years

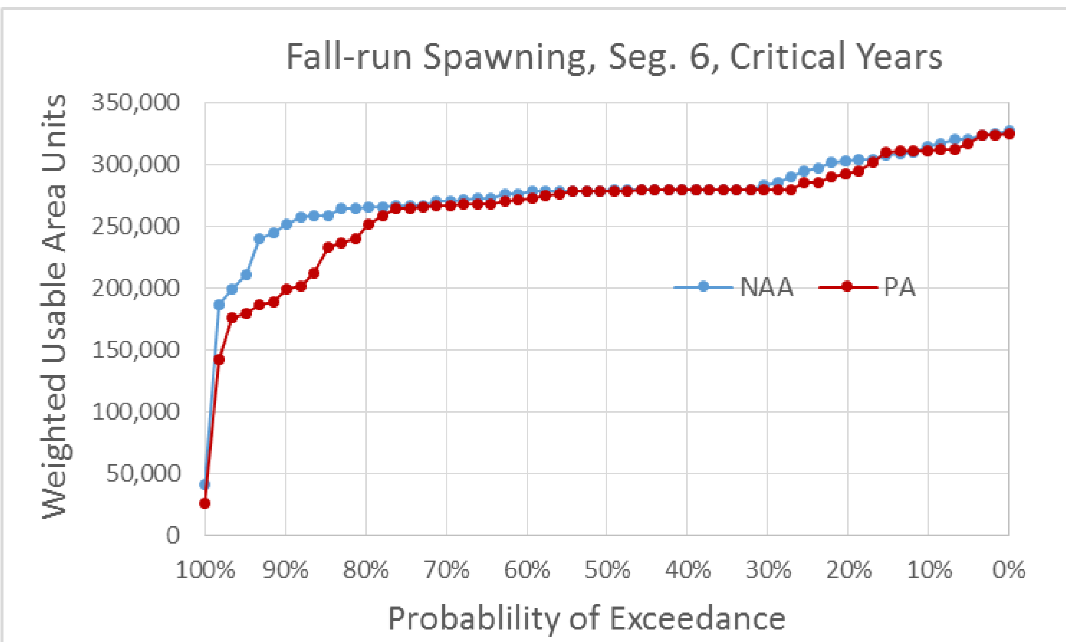


Figure 5.E-53. Exceedance Plot of Fall-Run Chinook Salmon Spawning Weighted Usable Area for NAA and PA Model Scenarios in River Segment 6, Critical Water Years

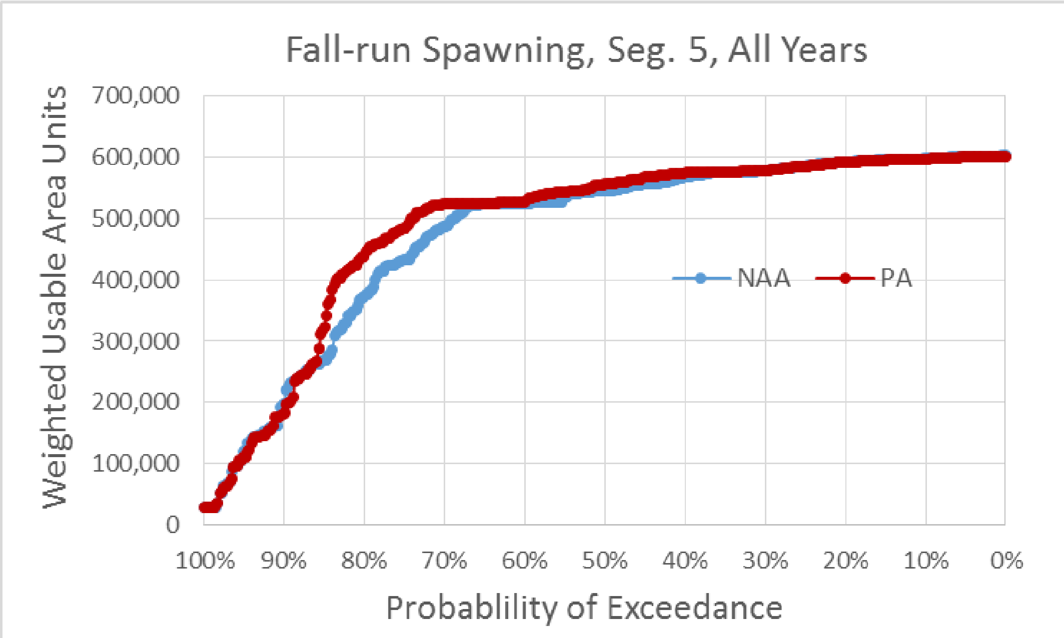


Figure 5.E-54. Exceedance Plot of Fall-Run Chinook Salmon Spawning Weighted Usable Area for NAA and PA Model Scenarios in River Segment 5, All Water Years

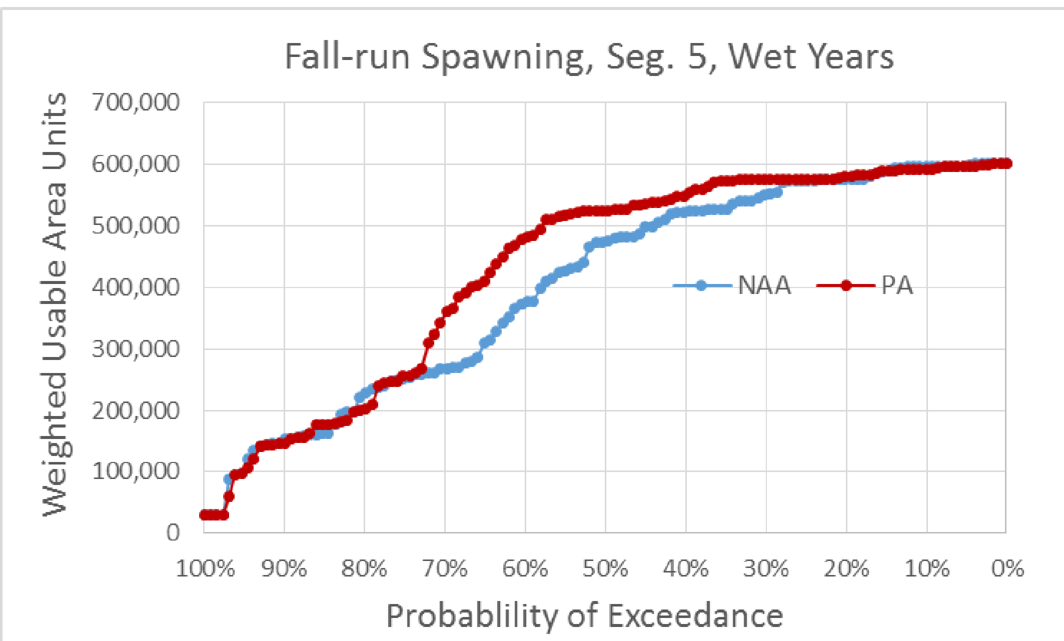


Figure 5.E-55. Exceedance Plot of Fall-Run Chinook Salmon Spawning Weighted Usable Area for NAA and PA Model Scenarios in River Segment 5, Wet Water Years

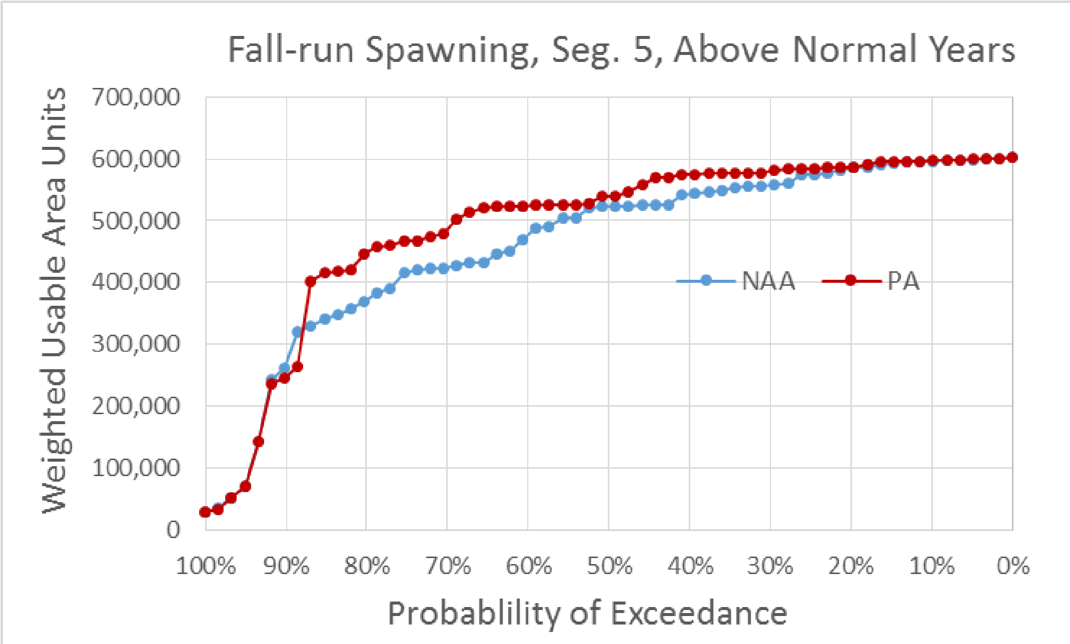


Figure 5.E-56. Exceedance Plot of Fall-Run Chinook Salmon Spawning Weighted Usable Area for NAA and PA Model Scenarios in River Segment 5, Above Normal Water Years

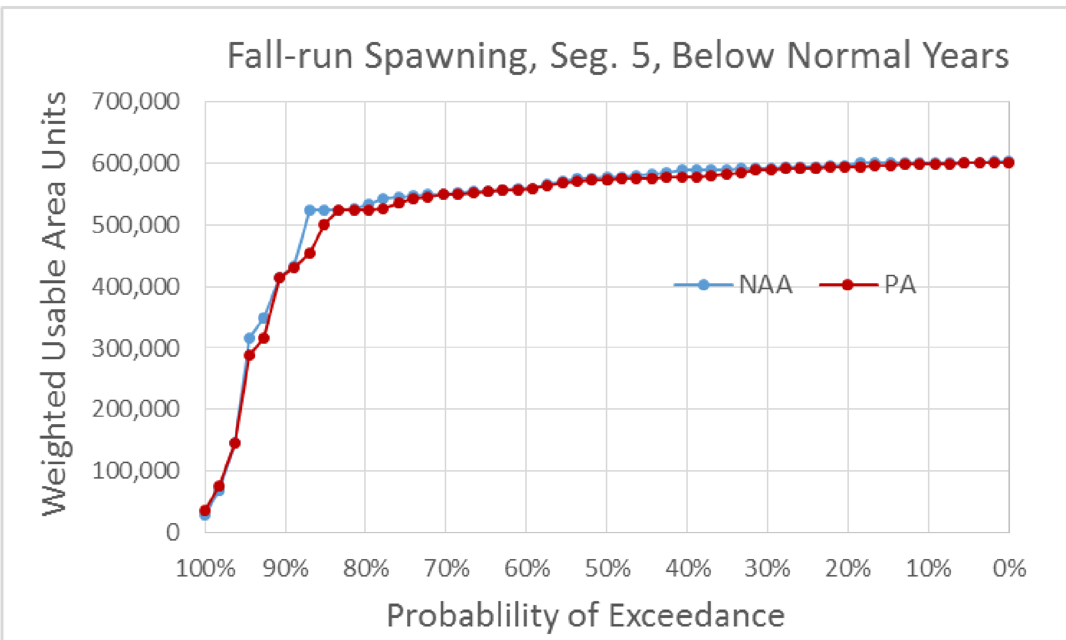


Figure 5.E-57. Exceedance Plot of Fall-Run Chinook Salmon Spawning Weighted Usable Area for NAA and PA Model Scenarios in River Segment 5, Below Normal Water Years

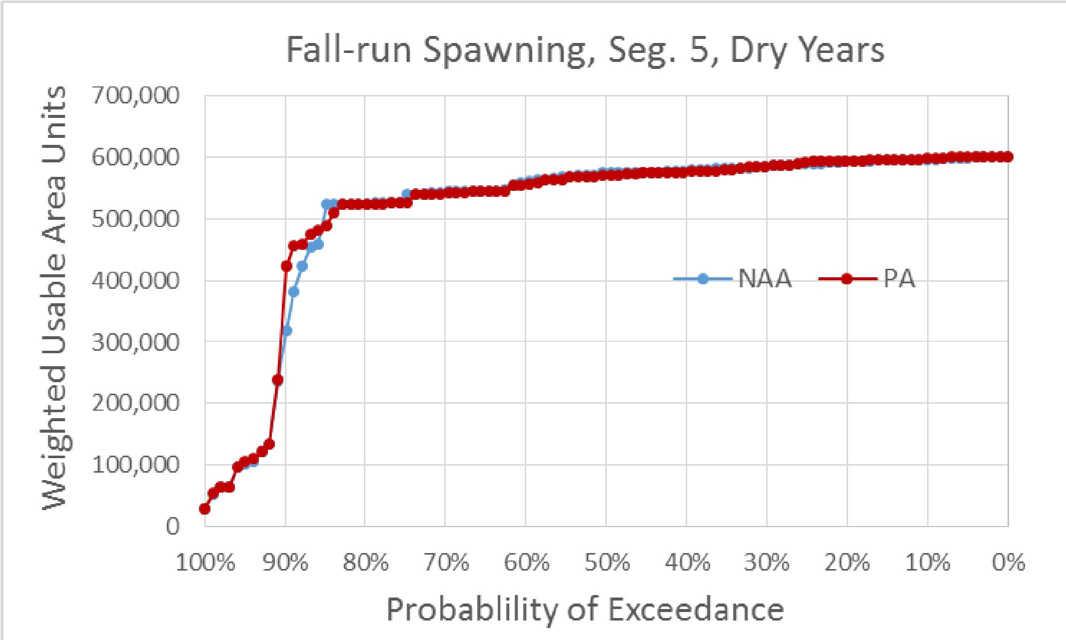


Figure 5.E-58. Exceedance Plot of Fall-Run Chinook Salmon Spawning Weighted Usable Area for NAA and PA Model Scenarios in River Segment 5, Dry Water Years

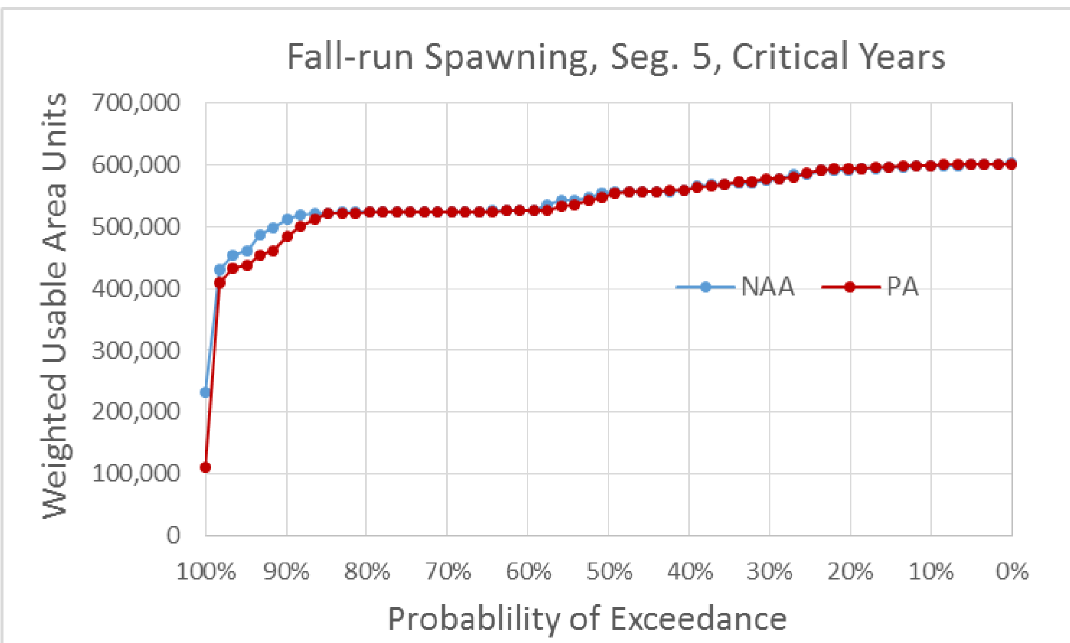


Figure 5.E-59. Exceedance Plot of Fall-Run Chinook Salmon Spawning Weighted Usable Area for NAA and PA Model Scenarios in River Segment 5, Critical Water Years

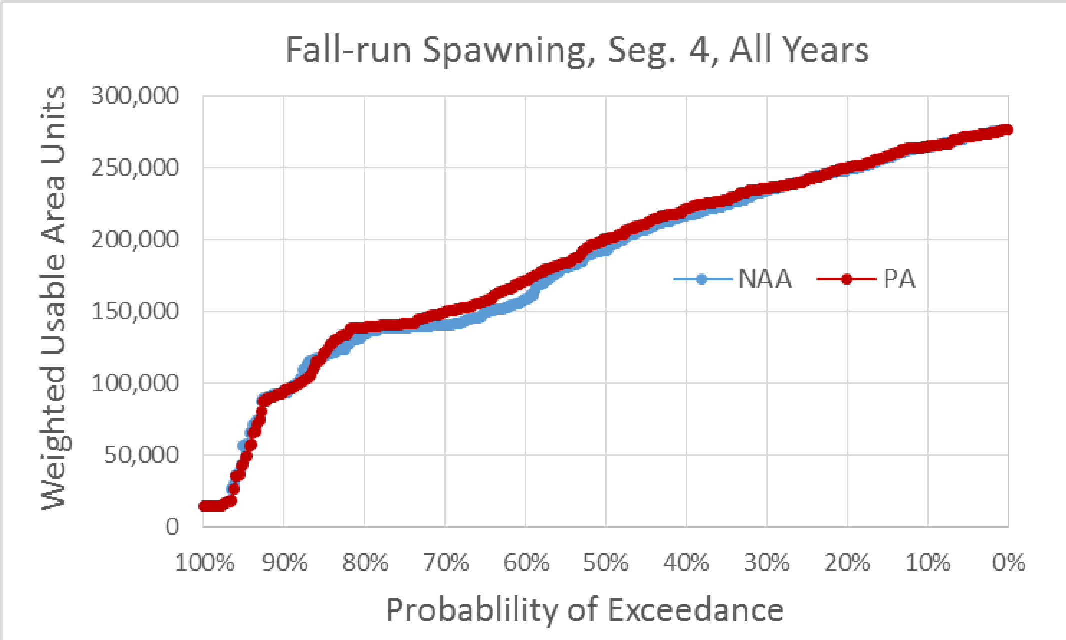


Figure 5.E-60. Exceedance Plot of Fall-Run Chinook Salmon Spawning Weighted Usable Area for NAA and PA Model Scenarios in River Segment 4, All Water Years

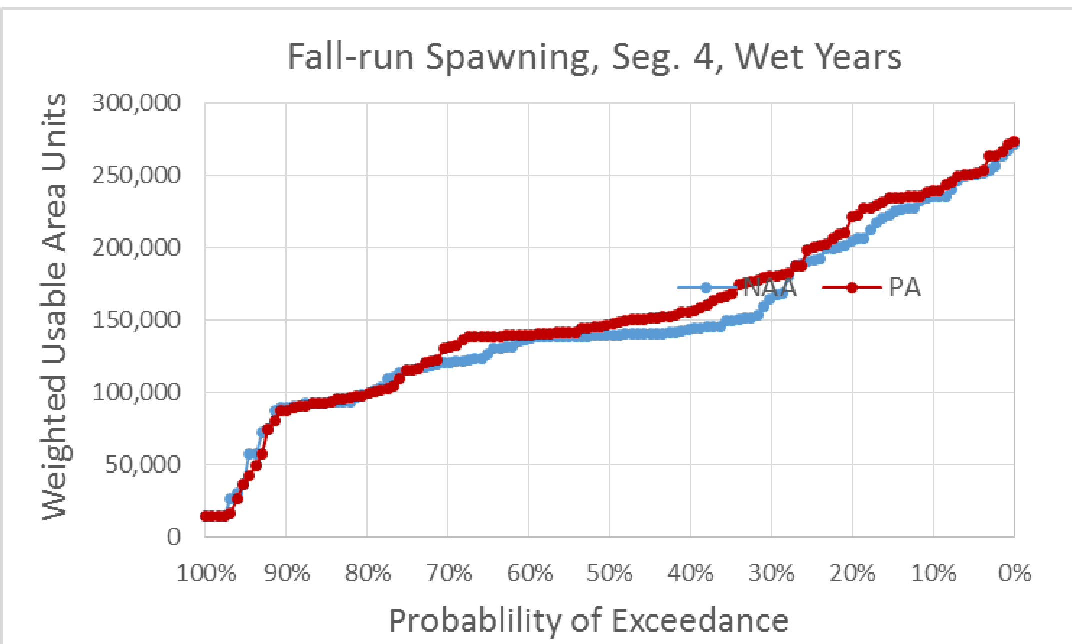


Figure 5.E-61. Exceedance Plot of Fall-Run Chinook Salmon Spawning Weighted Usable Area for NAA and PA Model Scenarios in River Segment 4, Wet Water Years

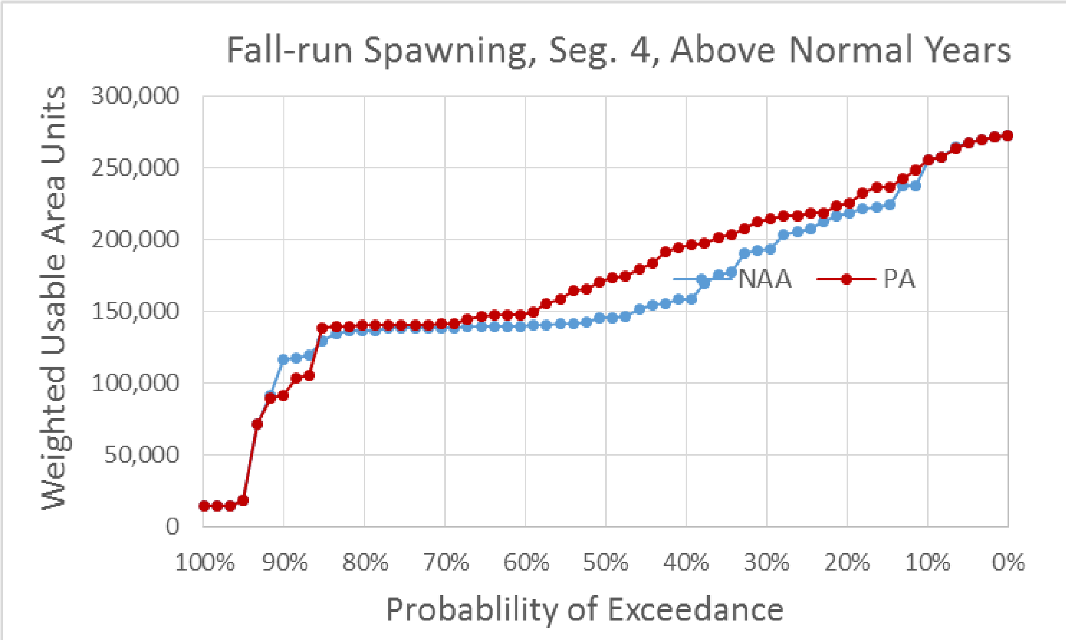


Figure 5.E-62. Exceedance Plot of Fall-Run Chinook Salmon Spawning Weighted Usable Area for NAA and PA Model Scenarios in River Segment 4, Above Normal Water Years

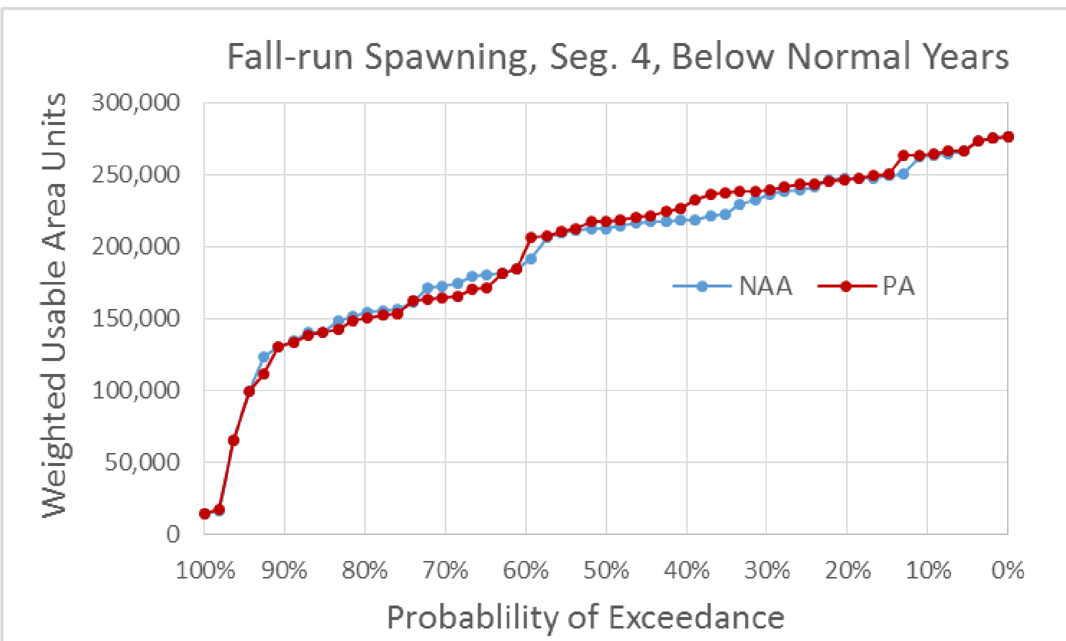


Figure 5.E-63. Exceedance Plot of Fall-Run Chinook Salmon Spawning Weighted Usable Area for NAA and PA Model Scenarios in River Segment 4, Below Normal Water Years

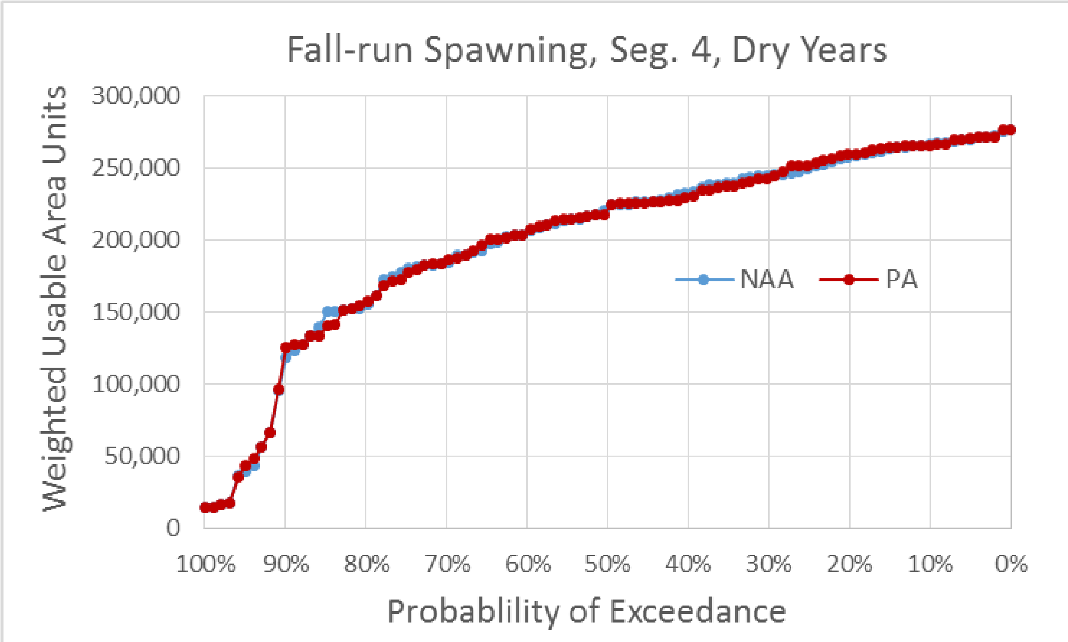


Figure 5.E-64. Exceedance Plot of Fall-Run Chinook Salmon Spawning Weighted Usable Area for NAA and PA Model Scenarios in River Segment 4, Dry Water Years

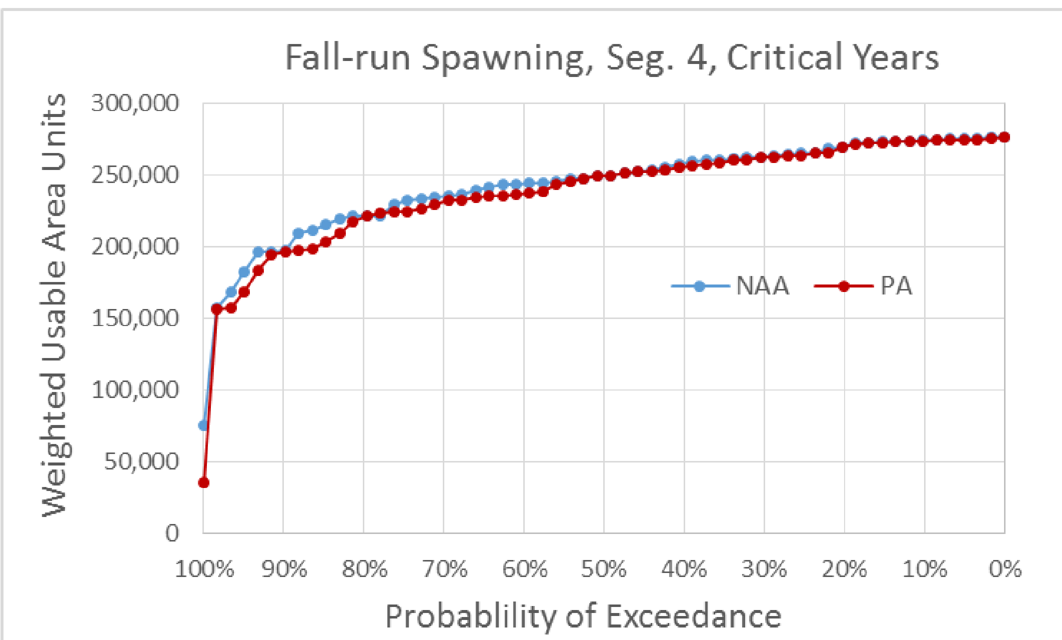


Figure 5.E-65. Exceedance Plot of Fall-Run Chinook Salmon Spawning Weighted Usable Area for NAA and PA Model Scenarios in River Segment 4, Critical Water Years

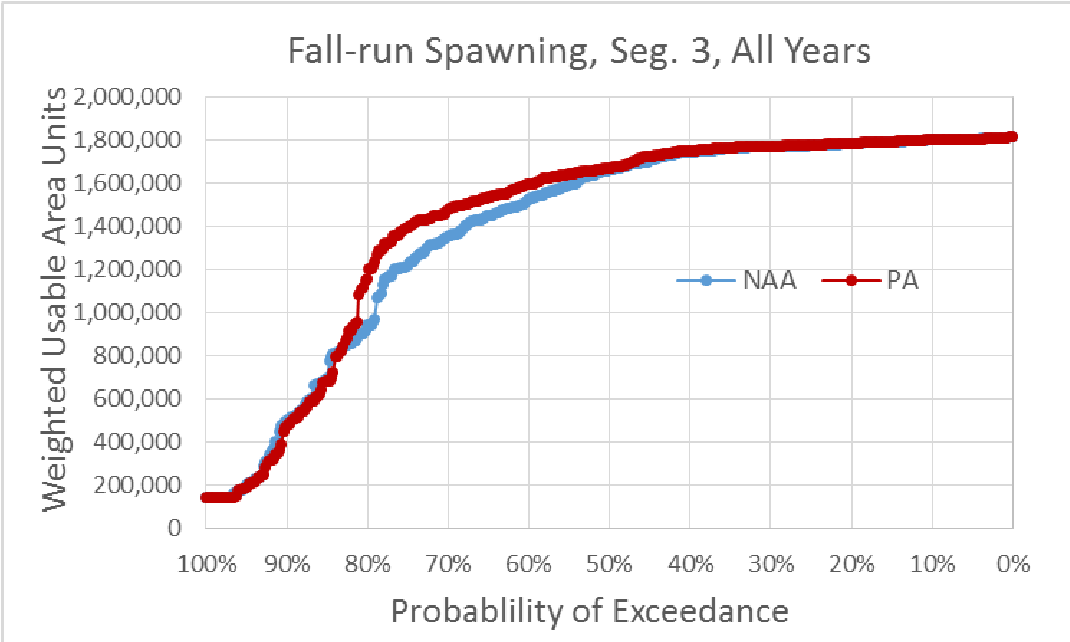


Figure 5.E-66. Exceedance Plot of Fall-Run Chinook Salmon Spawning Weighted Usable Area for NAA and PA Model Scenarios in River Segment 3, All Water Years

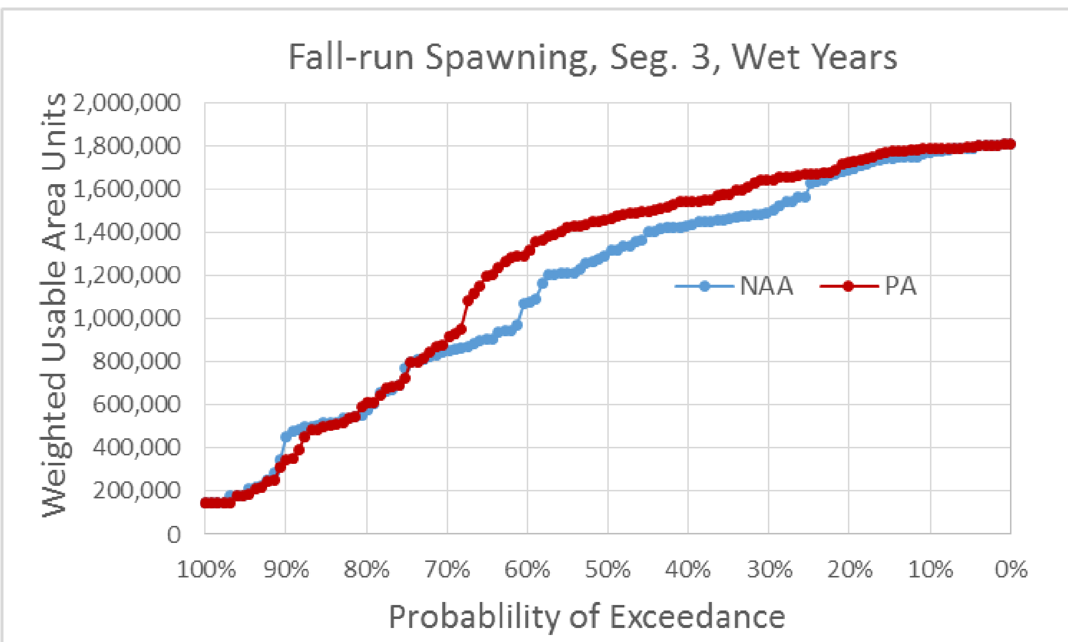


Figure 5.E-67. Exceedance Plot of Fall-Run Chinook Salmon Spawning Weighted Usable Area for NAA and PA Model Scenarios in River Segment 3, Wet Water Years

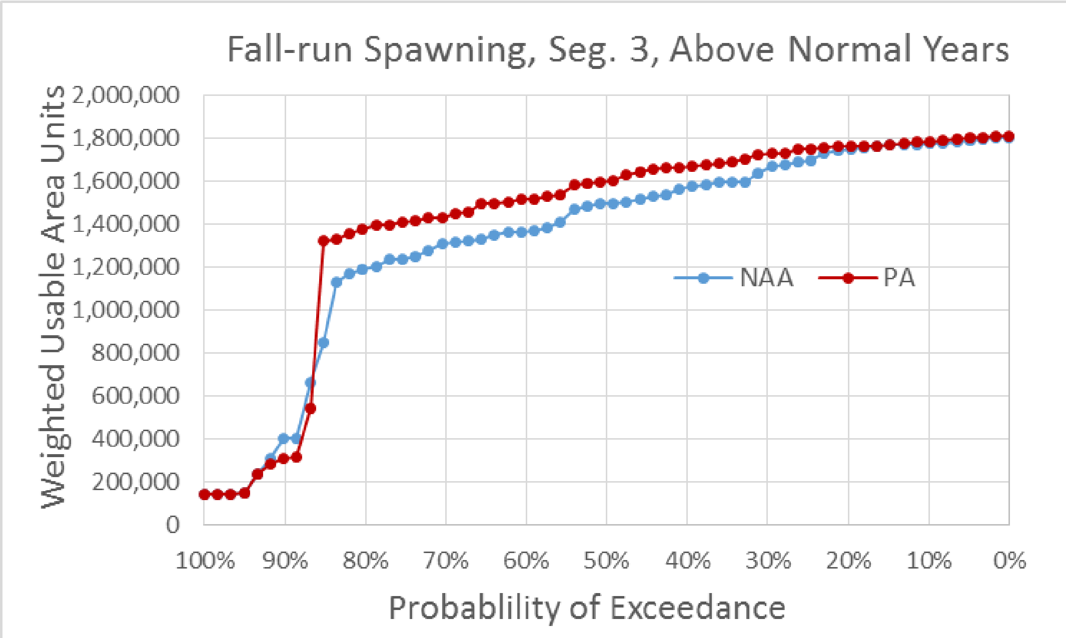


Figure 5.E-68. Exceedance Plot of Fall-Run Chinook Salmon Spawning Weighted Usable Area for NAA and PA Model Scenarios in River Segment 3, Above Normal Water Years

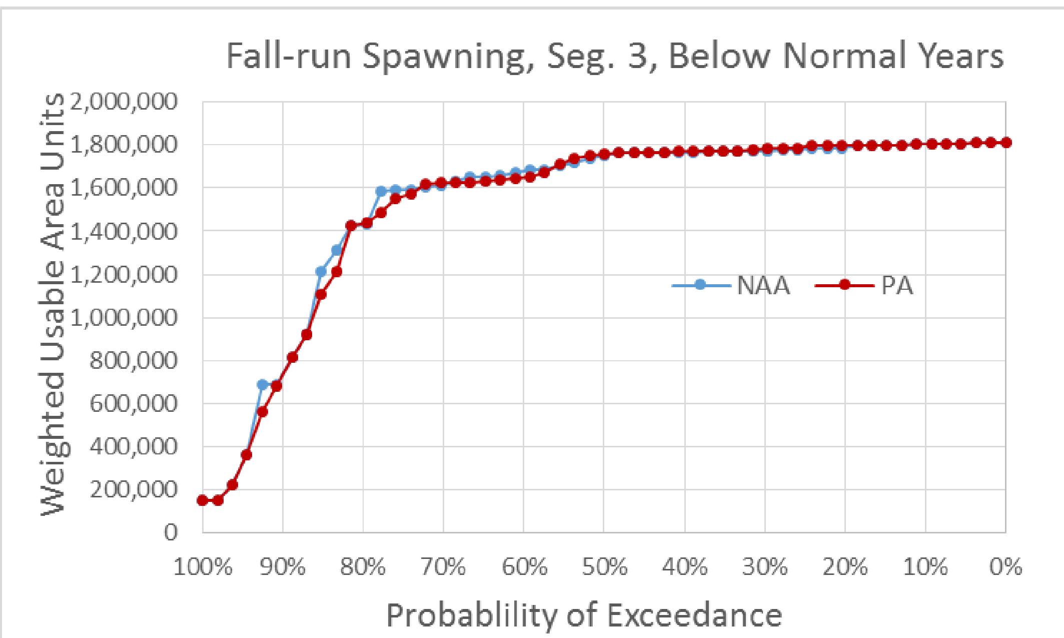


Figure 5.E-69. Exceedance Plot of Fall-Run Chinook Salmon Spawning Weighted Usable Area for NAA and PA Model Scenarios in River Segment 3, Below Normal Water Years

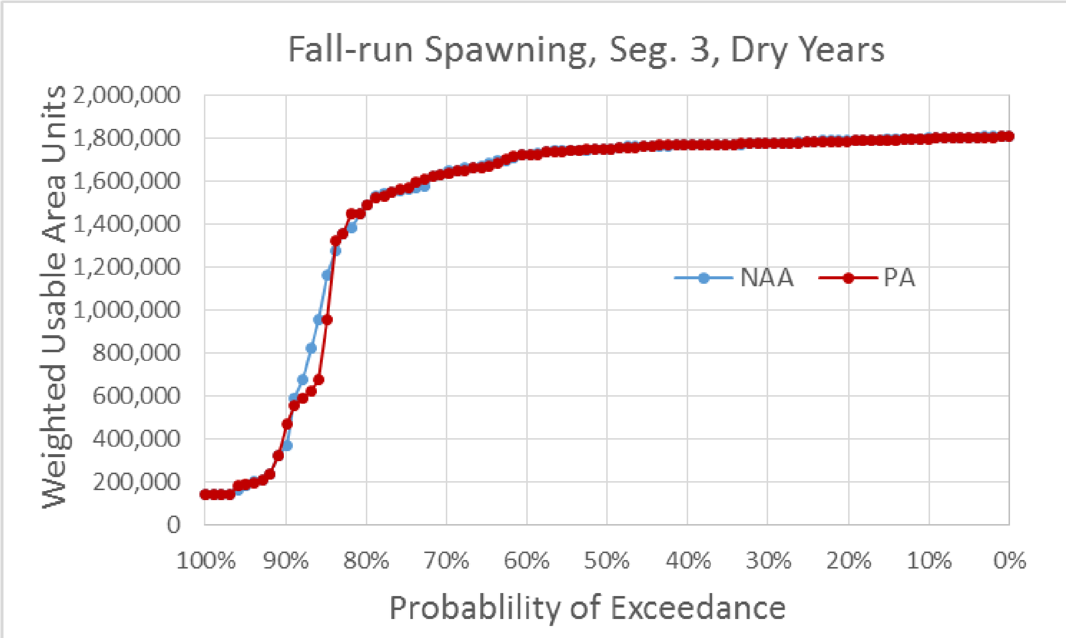


Figure 5.E-70. Exceedance Plot of Fall-Run Chinook Salmon Spawning Weighted Usable Area for NAA and PA Model Scenarios in River Segment 3, Dry Water Years

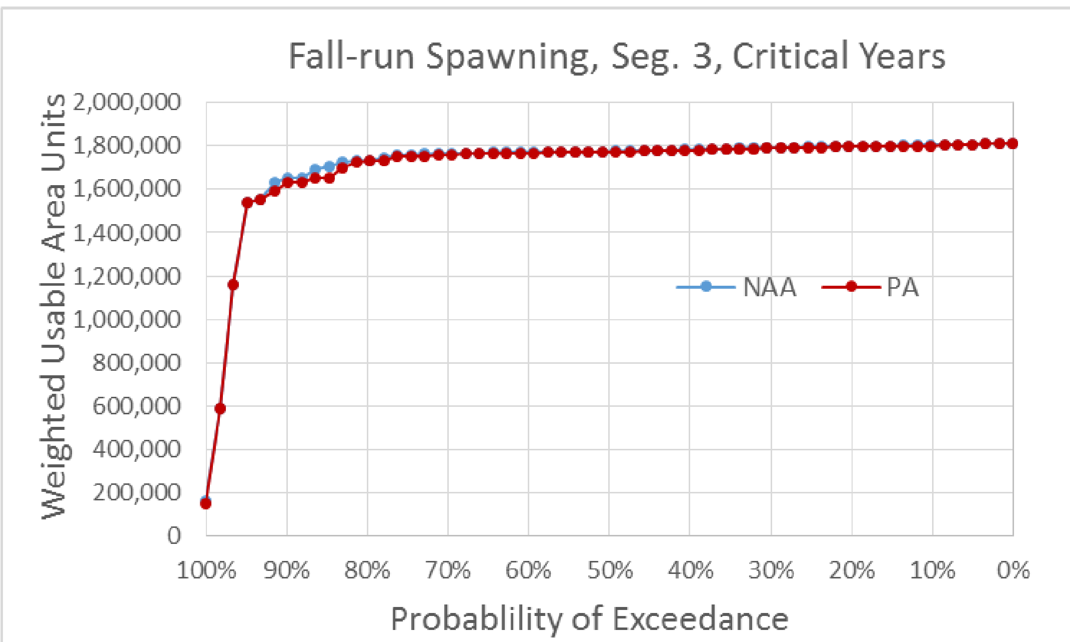


Figure 5.E-71. Exceedance Plot of Fall-Run Chinook Salmon Spawning Weighted Usable Area for NAA and PA Model Scenarios in River Segment 3, Critical Water Years

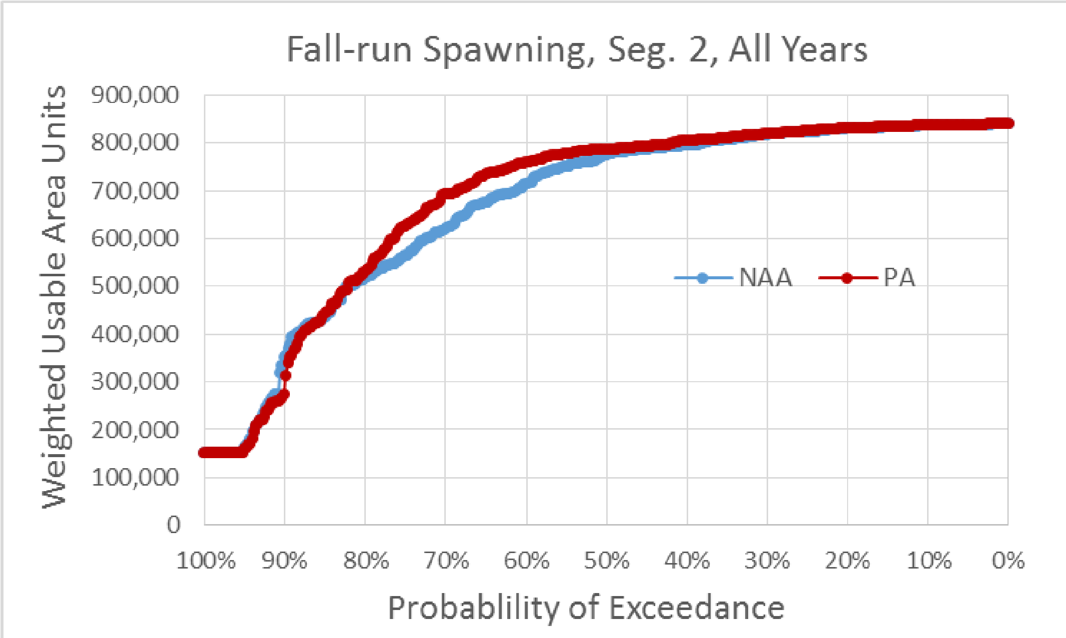


Figure 5.E-72. Exceedance Plot of Fall-Run Chinook Salmon Spawning Weighted Usable Area for NAA and PA Model Scenarios in River Segment 2, All Water Years

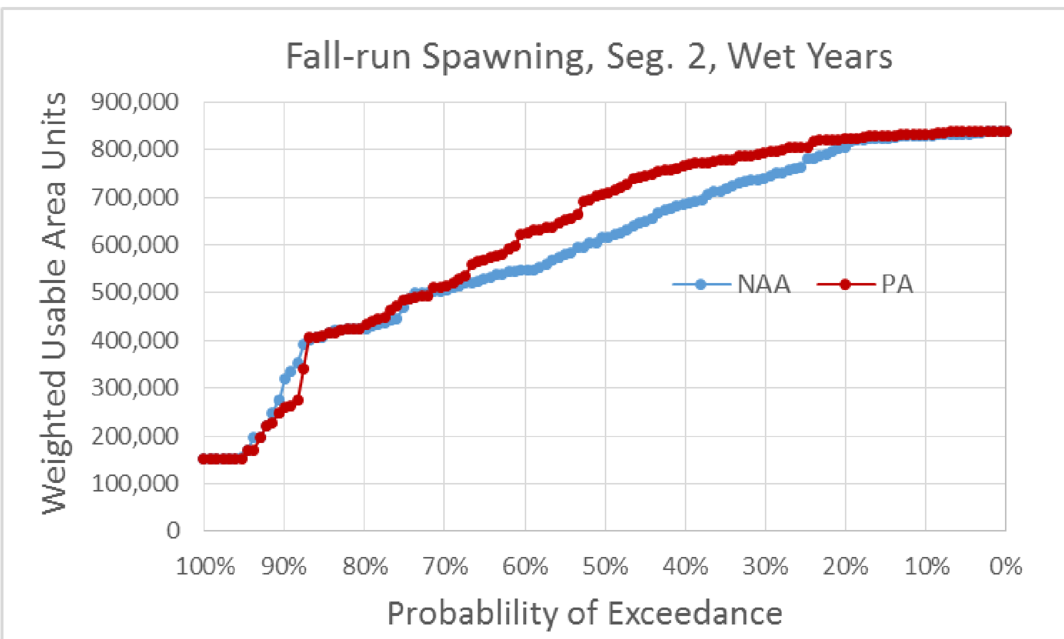


Figure 5.E-73. Exceedance Plot of Fall-Run Chinook Salmon Spawning Weighted Usable Area for NAA and PA Model Scenarios in River Segment 2, Wet Water Years

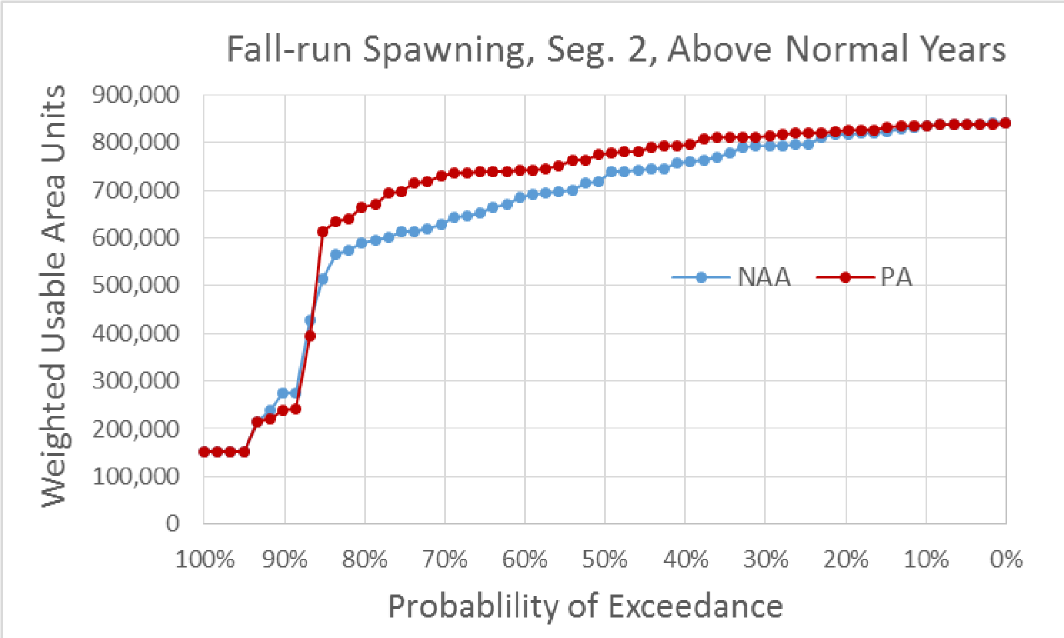


Figure 5.E-74. Exceedance Plot of Fall-Run Chinook Salmon Spawning Weighted Usable Area for NAA and PA Model Scenarios in River Segment 2, Above Normal Water Years

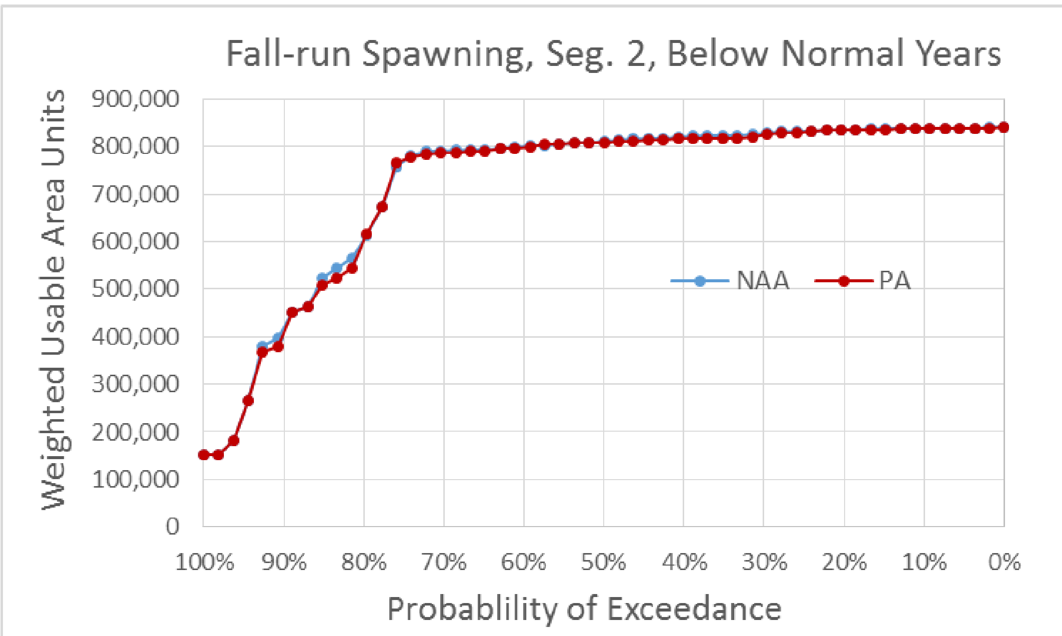


Figure 5.E-75. Exceedance Plot of Fall-Run Chinook Salmon Spawning Weighted Usable Area for NAA and PA Model Scenarios in River Segment 2, Below Normal Water Years

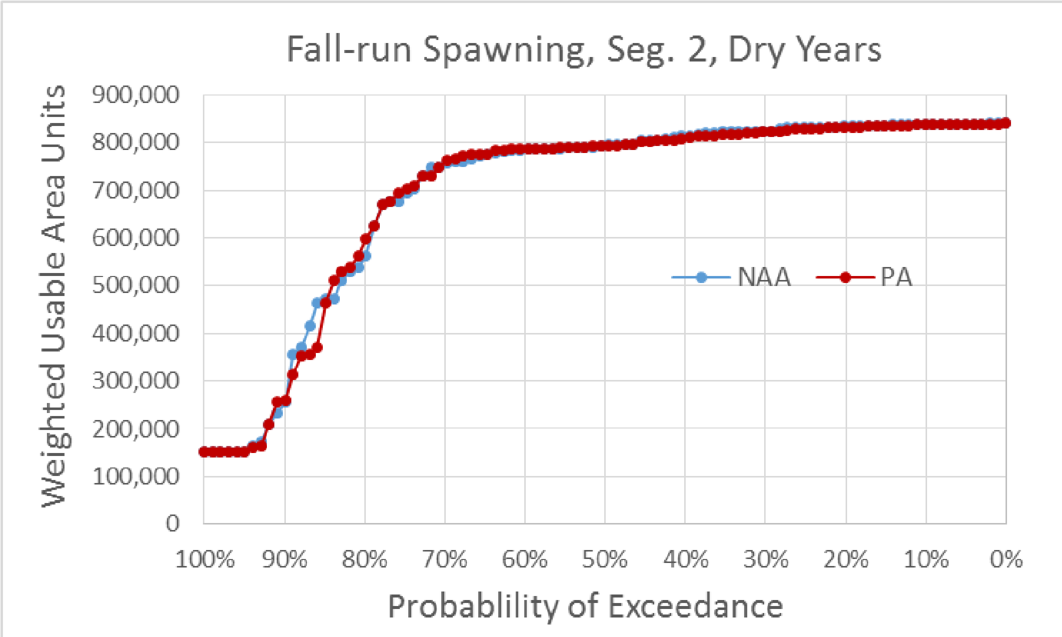


Figure 5.E-76. Exceedance Plot of Fall-Run Chinook Salmon Spawning Weighted Usable Area for NAA and PA Model Scenarios in River Segment 2, Dry Water Years

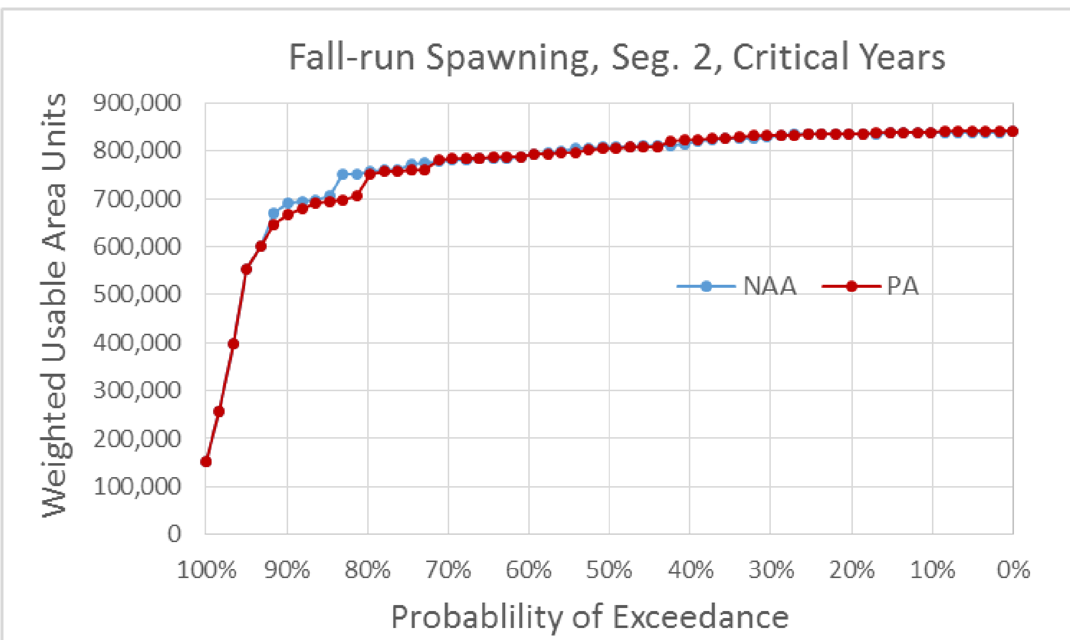


Figure 5.E-77. Exceedance Plot of Fall-Run Chinook Salmon Spawning Weighted Usable Area for NAA and PA Model Scenarios in River Segment 2, Critical Water Years

Differences in spawning WUA in each river segment under the PAA and NAA were also examined using the grand mean spawning WUA for each month of the fall-run Chinook salmon spawning period by water year type and all water year types combined (Table 5.E-28 to Table 5.E-32). Mean WUA would increase under the PA during November of wet and above normal years in all five segments by 18% to 84%. As noted above, mean flows in the Sacramento River are expected to be 21% to 26% lower under the PA during November of wet and above normal years, showing that reduced flow may enhance spawning WUA under some conditions. Mean WUA under the PA would also increase up to 14% in September of above normal years in all segments except Segment 4 and would increase up to 8% in October of wet years in all segments except Segment 6. Mean WUA would be 5% lower under the PA than under the NAA during September of critical year types in Segment 6 (Table 5.E-28) and up to 13% lower during October of below normal and dry water year types in Segment 4 (Table 5.E-30). Mean WUA would be 6% lower under the PA than under the NAA in November of critical water years in Segment 6 (Table 5.E-28) and December of above normal years in Segment 5 (Table 5.E-29). Mean WUA would also be up to 12% lower in January of wet years in all segments except Segment 2. October through November are the peak spawning months for fall-run Chinook salmon.

Table 5.E-28. Fall-Run Chinook Salmon Spawning Weighted Usable Areas and Differences (Percent Differences) in River Segment 6 between Model Scenarios (green indicates PA is at least 5% higher [raw difference] than NAA; red indicates PA is at least 5% lower)

Month	WYT	NAA	PA	PA vs. NAA
September	Wet	211,699	214,296	2598 (1%)
	Above Normal	276,118	295,892	19774 (7%)
	Below Normal	310,740	302,440	-8300 (-3%)
	Dry	297,451	292,461	-4990 (-2%)
	Critical	295,609	280,631	-14979 (-5%)
	All	268,392	267,828	-564 (0%)
October	Wet	299,153	309,714	10561 (4%)
	Above Normal	314,152	310,779	-3373 (-1.1%)
	Below Normal	315,959	316,970	1010 (0.3%)
	Dry	304,903	313,978	9075 (3%)
	Critical	285,343	276,228	-9115 (-3%)
	All	303,031	306,949	3918 (1.3%)
November	Wet	85,349	144,206	58856 (69%)
	Above Normal	98,745	181,551	82805 (84%)
	Below Normal	205,611	218,534	12923 (6%)
	Dry	226,866	229,131	2266 (1%)
	Critical	263,119	246,772	-16348 (-6%)
	All	164,944	195,997	31052 (19%)
December	Wet	189,341	192,905	3565 (2%)
	Above Normal	186,103	186,289	186 (0.1%)
	Below Normal	198,802	198,407	-395 (-0.2%)
	Dry	192,969	189,522	-3447 (-2%)
	Critical	274,875	276,177	1303 (0.5%)

Month	WYT	NAA	PA	PA vs. NAA
	All	203,713	204,173	460 (0.2%)
January	Wet	173,954	152,539	-21414 (-12%)
	Above Normal	195,125	195,034	-91 (-0.05%)
	Below Normal	189,221	188,736	-484 (-0.3%)
	Dry	190,323	188,347	-1976 (-1%)
	Critical	257,603	244,933	-12670 (-5%)
	All	195,592	186,387	-9205 (-5%)

Table 5.E-29. Fall-Run Chinook Salmon Spawning Weighted Usable Areas and Differences (Percent Differences) in River Segment 5 between Model Scenarios (green indicates PA is at least 5% higher [raw difference] than NAA; red indicates PA is at least 5% lower)

Month	WYT	NAA	PA	PA vs. NAA
September	Wet	236,285	242,981	6696 (3%)
	Above Normal	430,088	490,178	60089 (14%)
	Below Normal	585,549	589,389	3840 (0.7%)
	Dry	579,037	577,758	-1280 (-0.2%)
	Critical	579,158	563,100	-16058 (-3%)
	All	447,637	457,140	9502 (2.1%)
October	Wet	498,680	538,887	40207 (8%)
	Above Normal	552,311	545,589	-6721 (-1%)
	Below Normal	585,179	557,994	-27185 (-5%)
	Dry	572,802	575,143	2341 (0.4%)
	Critical	567,178	551,594	-15584 (-3%)
	All	546,822	553,309	6488 (1.2%)
November	Wet	380,656	520,050	139394 (37%)
	Above Normal	422,460	533,933	111473 (26%)
	Below Normal	587,346	586,203	-1143 (-0.2%)
	Dry	564,042	569,862	5820 (1%)
	Critical	539,474	552,498	13024 (2%)
	All	483,727	548,197	64470 (13%)
December	Wet	475,398	457,821	-17577 (-4%)
	Above Normal	493,732	461,657	-32075 (-6%)
	Below Normal	475,415	470,507	-4908 (-1%)
	Dry	432,047	432,627	580 (0.1%)
	Critical	535,780	532,304	-3475 (-0.6%)
	All	476,358	464,926	-11432 (-2%)
January	Wet	429,329	399,400	-29929 (-7%)
	Above Normal	421,568	421,649	81 (0.02%)
	Below Normal	434,715	435,207	492 (0.1%)
	Dry	429,255	429,913	658 (0.2%)
	Critical	500,881	493,769	-7112 (-1%)
	All	439,274	428,983	-10291 (-2%)

Table 5.E-30. Fall-Run Chinook Salmon Spawning Weighted Usable Areas and Differences (Percent Differences) in River Segment 4 between Model Scenarios (green indicates PA is at least 5% higher [raw difference] than NAA; red indicates PA is at least 5% lower)

Month	WYT	NAA	PA	PA vs. NAA
September	Wet	110,983	111,256	272 (0.2%)
	Above Normal	146,690	152,626	5936 (4%)
	Below Normal	219,170	240,628	21457 (10%)
	Dry	242,792	252,590	9798 (4%)
	Critical	242,618	252,566	9948 (4%)
	All	182,569	190,321	7751 (4%)
October	Wet	155,097	167,335	12237 (8%)
	Above Normal	168,198	169,618	1420 (1%)
	Below Normal	194,636	169,106	-25530 (-13%)
	Dry	203,681	188,415	-15266 (-7%)
	Critical	233,616	231,468	-2148 (-1%)
	All	186,036	182,620	-3416 (-2%)
November	Wet	131,699	156,053	24354 (18%)
	Above Normal	131,743	172,295	40553 (31%)
	Below Normal	198,448	210,003	11555 (6%)
	Dry	211,308	216,165	4858 (2%)
	Critical	261,540	245,589	-15950 (-6%)
	All	179,662	193,893	14231 (8%)
December	Wet	182,846	186,060	3215 (2%)
	Above Normal	183,340	184,920	1579 (1%)
	Below Normal	193,754	192,608	-1146 (-1%)
	Dry	176,833	179,354	2521 (1%)
	Critical	248,662	250,069	1407 (1%)
	All	192,666	194,607	1941 (1%)
January	Wet	155,897	146,240	-9657 (-6%)
	Above Normal	181,555	181,588	34 (0.02%)
	Below Normal	177,265	177,352	87 (0.05%)
	Dry	173,308	171,154	-2154 (-1%)
	Critical	223,684	210,431	-13253 (-6%)
	All	176,998	171,488	-5510 (-3%)

Table 5.E-31. Fall-Run Chinook Salmon Weighted Usable Areas and Differences (Percent Differences) in River Segment 3 between Model Scenarios (green indicates PA is at least 5% higher [raw difference] than NAA; red indicates PA is at least 5% lower)

Month	WYT	NAA	PA	PA vs. NAA
September	Wet	783,305	807,827	24522 (3%)
	Above Normal	1,373,640	1,488,572	114932 (8%)
	Below Normal	1,751,014	1,790,645	39631 (2%)
	Dry	1,768,634	1,779,451	10817 (1%)
	Critical	1,785,529	1,780,449	-5079 (-0.3%)
	All	1,393,701	1,426,908	33207 (2%)
October	Wet	1,472,200	1,564,505	92305 (6%)
	Above Normal	1,589,079	1,579,276	-9802 (-1%)
	Below Normal	1,685,553	1,582,783	-102769 (-6%)
	Dry	1,705,555	1,676,538	-29017 (-2%)
	Critical	1,768,991	1,764,739	-4252 (0%)
	All	1,620,077	1,626,503	6426 (0%)
November	Wet	1,084,415	1,430,809	346394 (32%)
	Above Normal	1,209,385	1,521,900	312515 (26%)
	Below Normal	1,684,612	1,715,017	30406 (2%)
	Dry	1,659,522	1,666,356	6834 (0.4%)
	Critical	1,789,851	1,780,802	-9049 (-1%)
	All	1,430,948	1,592,911	161963 (11%)
December	Wet	1,319,809	1,309,293	-10516 (-1%)
	Above Normal	1,294,225	1,280,280	-13945 (-1%)
	Below Normal	1,377,282	1,365,866	-11416 (-1%)
	Dry	1,237,675	1,218,397	-19278 (-2%)
	Critical	1,738,437	1,742,668	4231 (0.2%)
	All	1,365,563	1,354,438	-11125 (-1%)
January	Wet	1,123,810	1,040,760	-83050 (-7%)
	Above Normal	1,242,752	1,243,189	437 (0.04%)
	Below Normal	1,153,517	1,153,429	-89 (-0.01%)
	Dry	1,175,701	1,172,663	-3038 (-0.3%)
	Critical	1,455,114	1,436,490	-18624 (-1%)
	All	1,207,792	1,178,050	-29742 (-2%)

Table 5.E-32. Fall-Run Chinook Salmon Weighted Usable Areas and Differences (Percent Differences) in River Segment 2 between Model Scenarios (green indicates PA is at least 5% higher [raw difference] than NAA; red indicates PA is at least 5% lower)

Month	WYT	NAA	PA	PA vs. NAA
September	Wet	508,170	514,649	6480 (1%)
	Above Normal	690,860	744,109	53249 (8%)
	Below Normal	815,545	818,820	3275 (0%)
	Dry	807,548	803,684	-3864 (-0.5%)
	Critical	804,114	785,123	-18990 (-2%)
	All	694,694	701,908	7214 (1%)
October	Wet	735,548	774,191	38643 (5%)
	Above Normal	783,304	776,042	-7262 (-1%)
	Below Normal	807,412	780,879	-26533 (-3%)
	Dry	812,473	809,924	-2549 (-0.3%)
	Critical	798,671	786,251	-12420 (-2%)
	All	780,728	785,983	5255 (0.7%)
November	Wet	558,516	690,437	131921 (24%)
	Above Normal	597,262	733,288	136027 (23%)
	Below Normal	794,611	804,780	10169 (1%)
	Dry	759,477	764,592	5116 (1%)
	Critical	794,010	805,258	11248 (1%)
	All	680,826	747,634	66808 (10%)
December	Wet	638,297	632,070	-6227 (-1%)
	Above Normal	632,715	621,919	-10797 (-2%)
	Below Normal	633,945	631,190	-2755 (-0.4%)
	Dry	563,035	559,039	-3997 (-1%)
	Critical	777,908	778,126	218 (0.03%)
	All	638,979	634,052	-4927 (-1%)
January	Wet	538,763	514,773	-23991 (-4%)
	Above Normal	594,341	594,592	251 (0.04%)
	Below Normal	558,892	558,881	-11 (0%)
	Dry	548,707	547,562	-1144 (-0.2%)
	Critical	651,065	654,928	3862 (1%)
	All	569,134	561,852	-7282 (-1%)

Redd Scour. The probability of flows occurring under the PA and the NAA that would be high enough to mobilize sediments and scour fall-run Chinook salmon redds was estimated from CALSIM II estimates of mean monthly flows, using a relationship determined from the historical record between actual mean monthly flow and maximum daily flow (Appendix 5D.2.2, *Spawning Flows Methods*). The actual monthly and daily flow data used in the analysis are from gage records just below Keswick Dam and at Bend Bridge, and the CALSIM II estimates used to compare probabilities of redd scour for the PA and the NAA are for the Keswick and Red Bluff locations. As discussed in Appendix 5D.2.2, *Spawning Flows Methods*, 40,000 cfs is treated as the minimum daily flow at which redd scour occurs in the Sacramento River. The analysis of the Keswick Dam gage data shows that for months with a mean monthly flow of at least 27,300 cfs, the maximum daily flow is always at least 40,000 cfs. The Bend Bridge gage data show that for months with a mean flow of at least 21,800 cfs, the maximum daily flow is always 40,000 cfs. Therefore, redd scour probabilities for the PA and the NAA were evaluated by comparing frequencies of CALSIM II flows greater than 27,300 cfs at Keswick or greater than 21,800 cfs at Red Bluff during the fall-run Chinook salmon September through January spawning and incubation period. Further information on the redd scour analysis methods is provided in Appendix 5D.2.2, *Spawning Flows Methods*.

Table 5.E-33 shows that about 2% of months at Keswick and about 8% of months at Red Bluff would have flows above the redd scouring thresholds during the September through January spawning and incubation period of fall-run Chinook salmon. The moderately high percentage of scouring flows in the fall-run spawning and incubation period is expected, given that the period includes December and January, two of the wettest months of the year. The percentage of scouring flows under the PA would be about 11% lower at Keswick and 6% greater at Red Bluff than under the NAA on a relative scale, but the differences are less than 1% on a raw scale.

Table 5.E-33. Percent of Months during Fall-run Chinook Salmon Spawning and Incubation Period with CALSIM II Flow Greater than Redd Scouring Threshold Flow at Keswick (27,300 cfs) and Red Bluff (21,800 cfs) between Model Scenarios

Species/Race	Keswick			Red Bluff		
	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
Fall-run Chinook salmon	2.2	2.0	-0.2 (-11%)	7.8	8.3	0.5 (6%)
Late fall-run Chinook salmon	4.4	4.4	0 (0%)	12.4	13.1	0.7 (6%)

Note that SALMOD also predicts redd scour risk for fall-run Chinook salmon in the Sacramento River, although it is combined with redd dewatering and reported as “Incubation” mortality. Please see Table 5.E-33 below for these results.

Redd Dewatering. The percentage of fall-run Chinook salmon redds dewatered by reductions in Sacramento River flow was estimated from CALSIM II estimates of monthly mean flows during the 3 months following each month of spawning (Appendix 5D.2.2, *Spawning Flows Methods*). This analysis employed functional relationships developed in field studies by USFWS (2006) that predicted percentages of redds dewatered from an array of paired spawning and dewatering flows. CALSIM II flows for the three upstream river segments (Segments 4, 5 and 6) were used to estimate redd dewatering under the PA and NAA. Note that unlike the analyses used to model weighted usable area, the analysis used to model redd dewatering combines the field observations of water depth, flow velocity, and substrate from the three river segments and, therefore, differences in redd dewatering estimates among the segments result only from differences in the CALSIM II flows, Further information on the redd dewatering analysis methods is provided in Appendix 5D.2.2, *Spawning Flows, Methods*.

Differences in fall-run Chinook salmon redd dewatering under the PA and NAA were examined using exceedance plots of mean monthly percent dewatered for the September through November months of spawning. As noted above for spawning weighted usable area, fall-run Chinook salmon spawning peaks in river Segment 5, so conclusions regarding effects are primarily based on the Segment 5 results (Figure 5.E-84 through Figure 5E-89).The exceedance curves for the PA generally show consistently lower redd dewatering percentages than those for the NAA for all water year types combined, and for wet and above normal water year types (Figure 5.E-84 through Figure 5.E-86). The biggest differences in the dewatering curves are predicted for wet water years, with about 61% of all months having greater than 20% of redds dewatered under the NAA, but only 40% of all months having greater than 20% of redds dewatered under the PA (Figure 5.E-85). Results for Segment 6 (Figure 5.E-78 through Figure 5.E-83) and Segment 4 (Figure 5.E-89 through Figure 5.E-95) are similar to those for Segment 5.

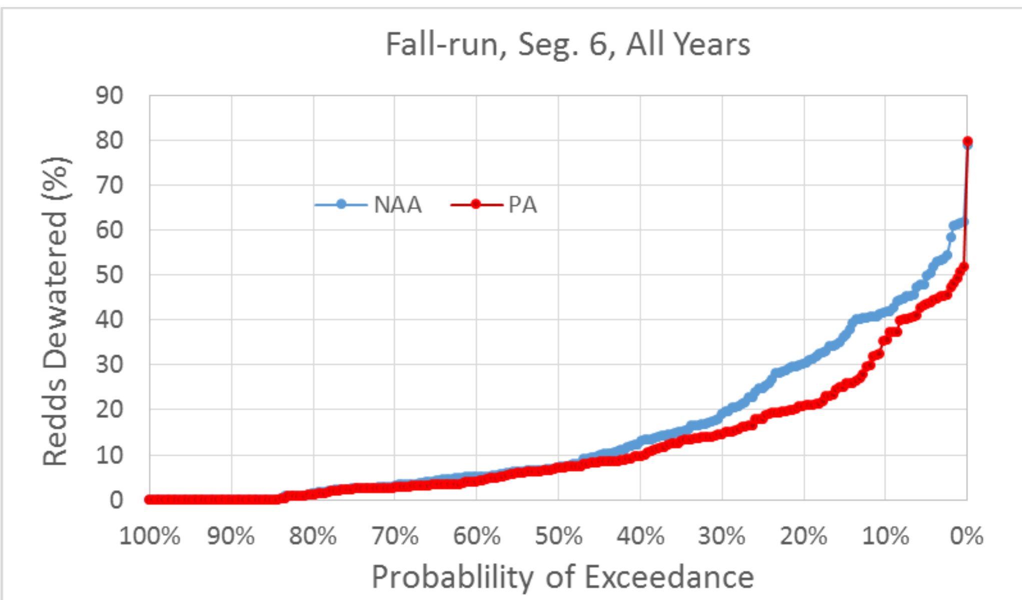


Figure 5.E-78. Exceedance Plot of Fall-Run Chinook Salmon Percent of Redds Dewatered for NAA and PA Model Scenarios in River Segment 6, All Water Years

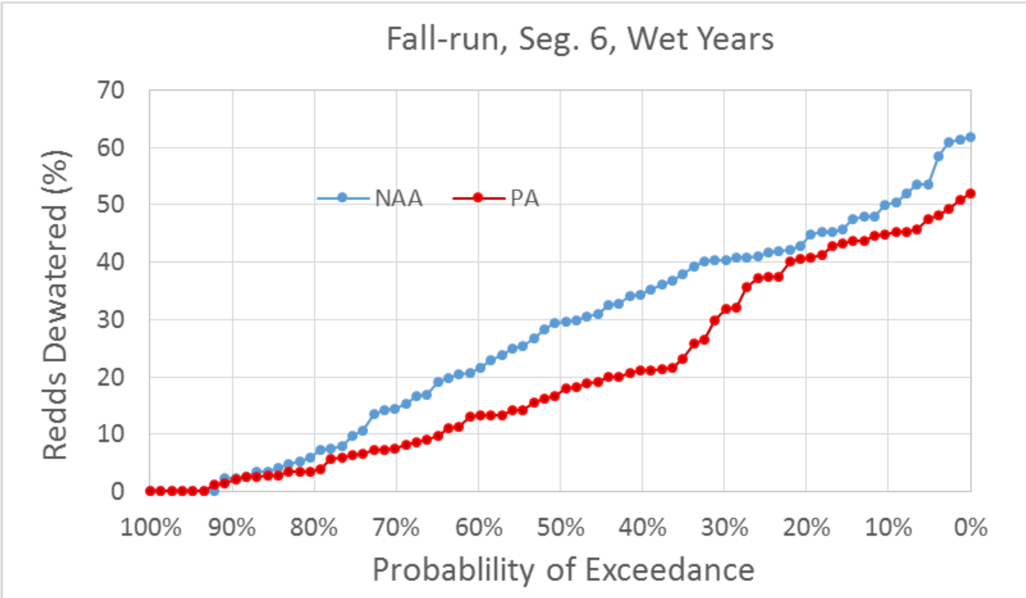


Figure 5.E-79. Exceedance Plot of Fall-Run Chinook Salmon Percent of Redds Dewatered for NAA and PA Model Scenarios in River Segment 6, Wet Water Years

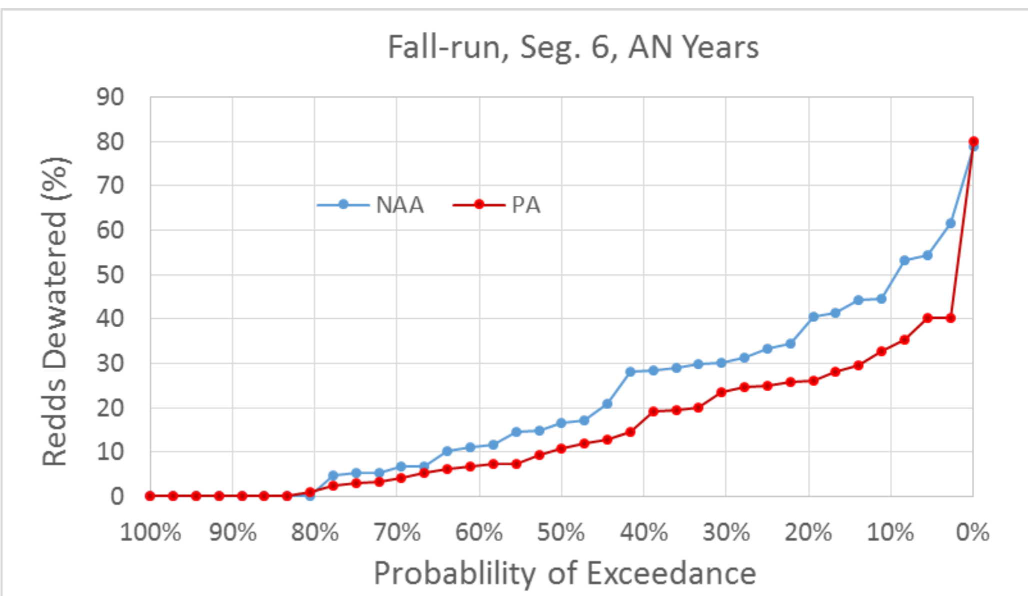


Figure 5.E-80. Exceedance Plot of Fall-Run Chinook Salmon Percent of Redds Dewatered for NAA and PA Model Scenarios in River Segment 6, Above Normal Water Years

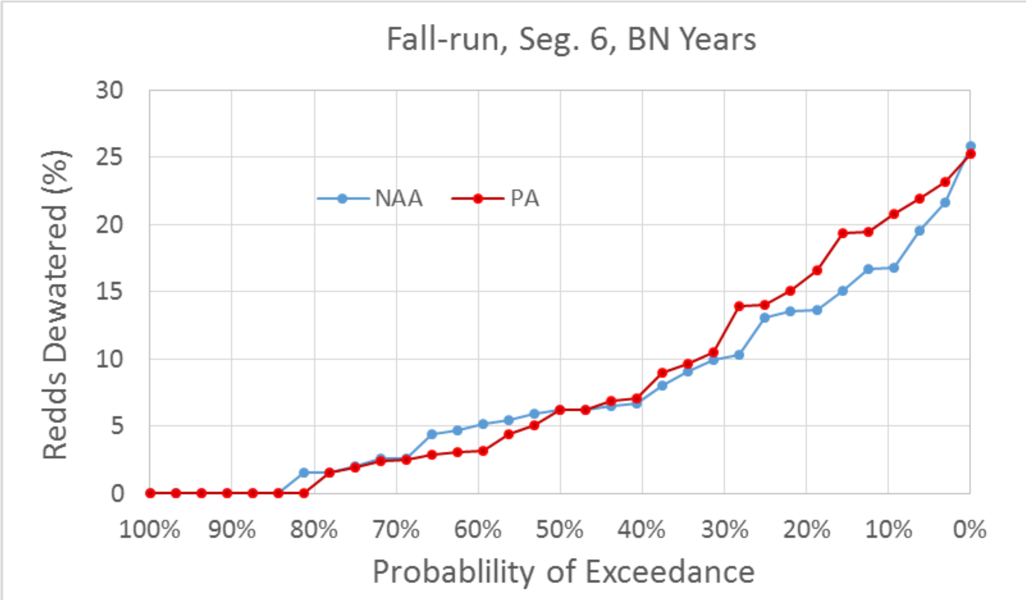


Figure 5.E-81. Exceedance Plot of Fall-Run Chinook Salmon Percent of Redds Dewatered for NAA and PA Model Scenarios in River Segment 6, Below Normal Water Years

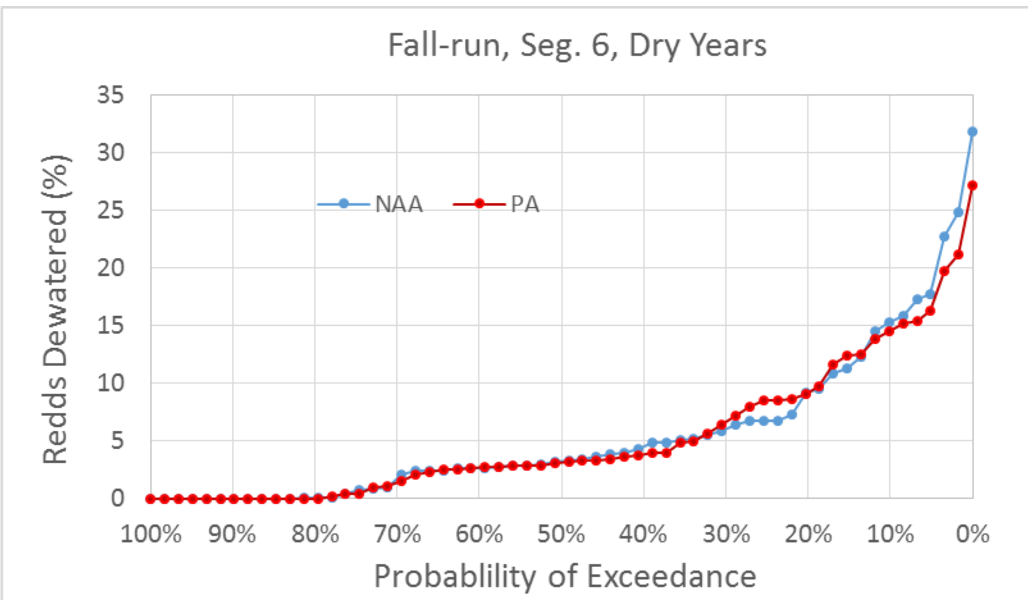


Figure 5.E-82. Exceedance Plot of Fall-Run Chinook Salmon Percent of Redds Dewatered for NAA and PA Model Scenarios in River Segment 6, Dry Water Years

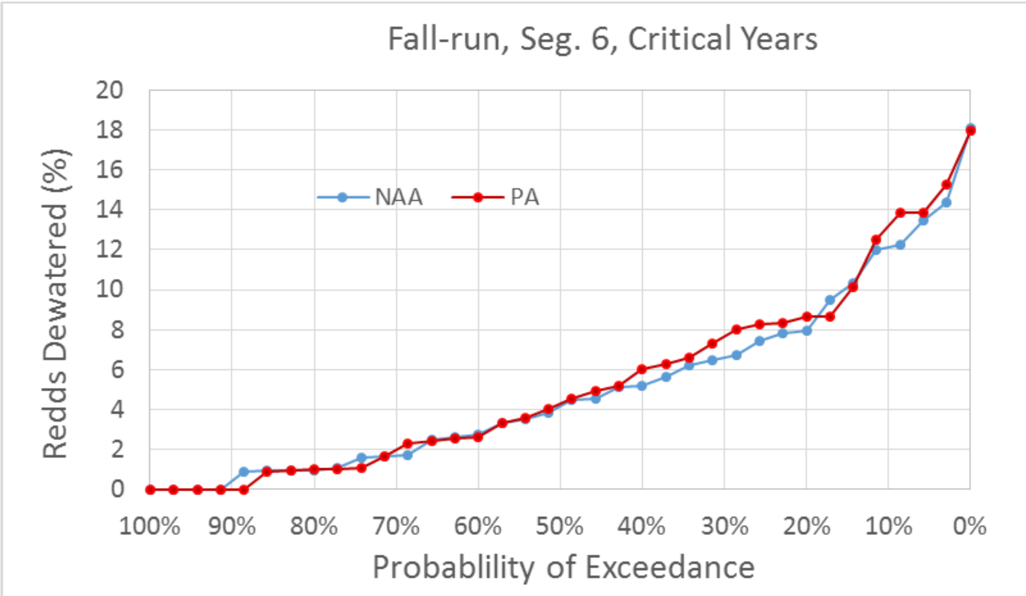


Figure 5.E-83. Exceedance Plot of Fall-Run Chinook Salmon Percent of Redds Dewatered for NAA and PA Model Scenarios in River Segment 6, Critical Water Years

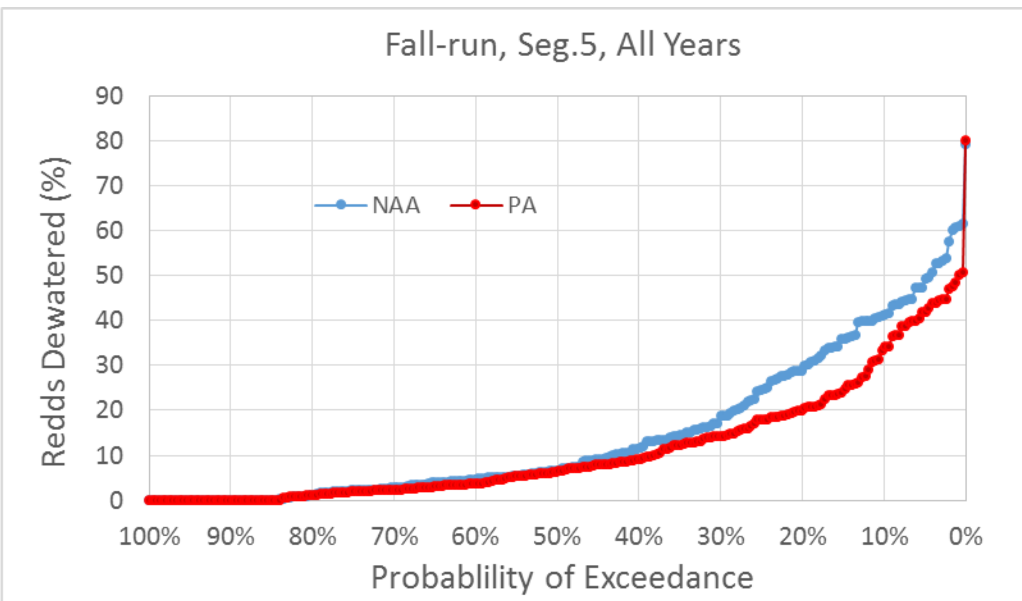


Figure 5.E-84. Exceedance Plot of Fall-Run Chinook Salmon Percent of Redds Dewatered for NAA and PA Model Scenarios in River Segment 5, All Water Years

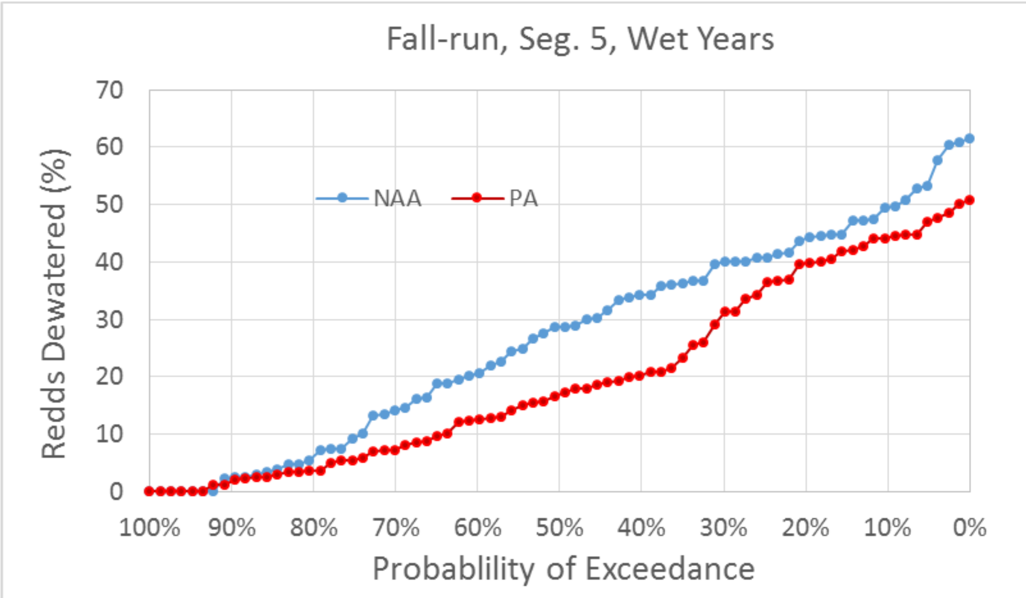


Figure 5.E-85. Exceedance Plot of Fall-Run Chinook Salmon Percent of Redds Dewatered for NAA and PA Model Scenarios in River Segment 5, Wet Water Years

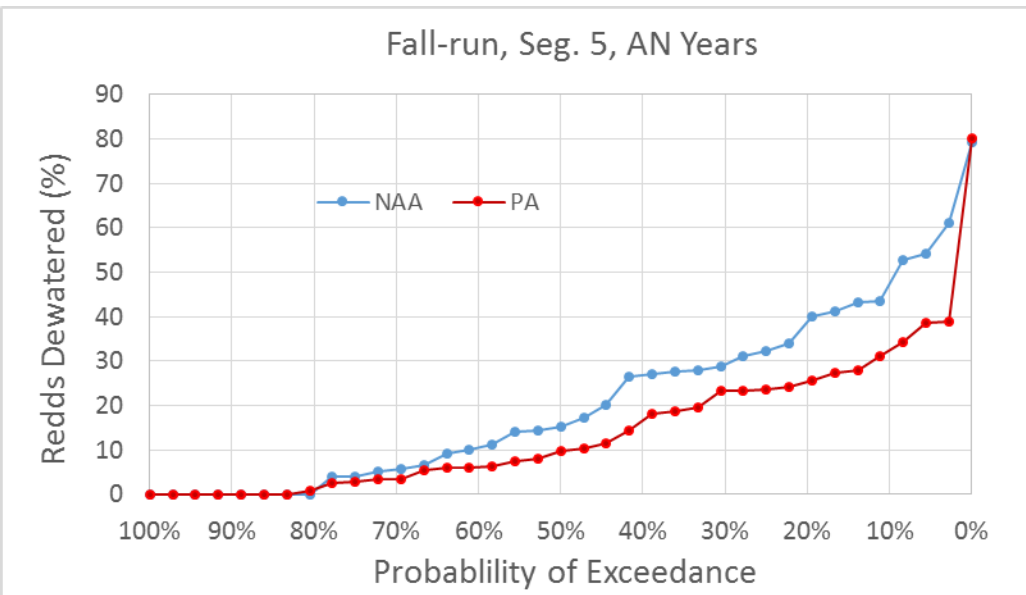


Figure 5.E-86. Exceedance Plot of Fall-Run Chinook Salmon Percent of Redds Dewatered for NAA and PA Model Scenarios in River Segment 5, Above Normal Water Years

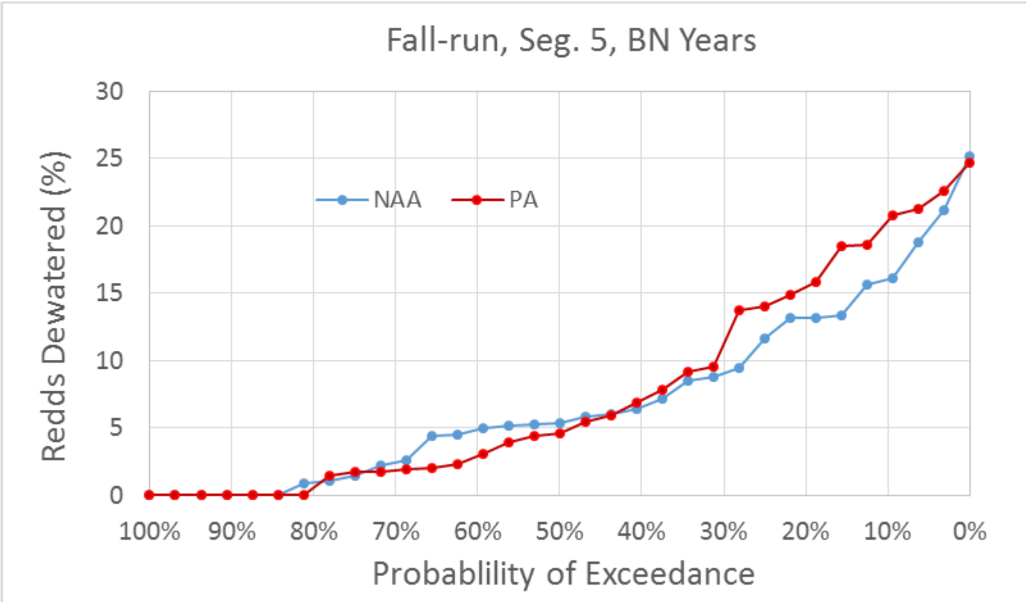


Figure 5.E-87. Exceedance Plot of Fall-Run Chinook Salmon Percent of Redds Dewatered for NAA and PA Model Scenarios in River Segment 5, Below Normal Water Years

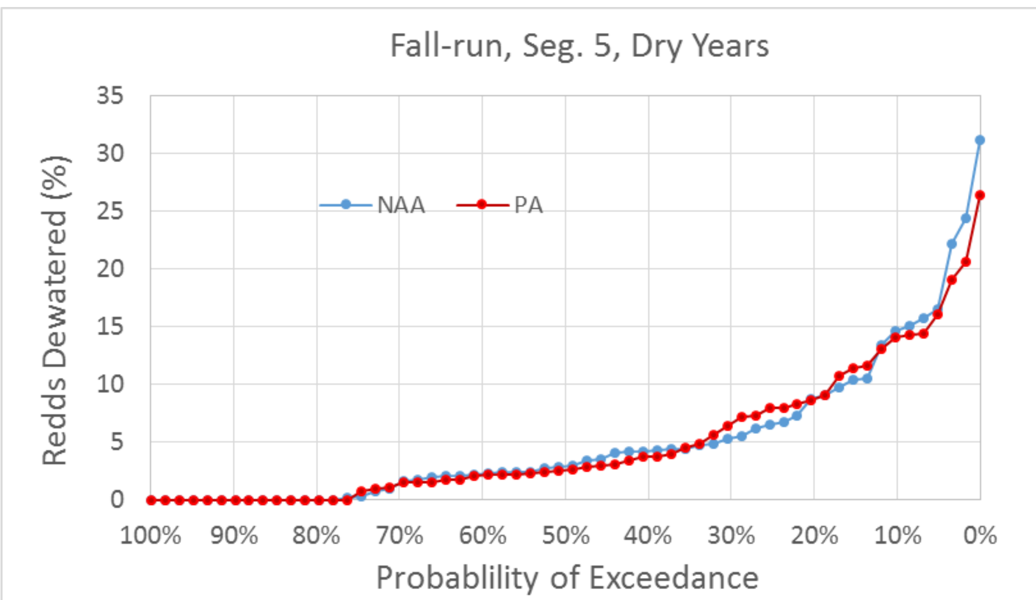


Figure 5.E-88. Exceedance Plot of Fall-Run Chinook Salmon Percent of Redds Dewatered for NAA and PA Model Scenarios in River Segment 5, Dry Water Years

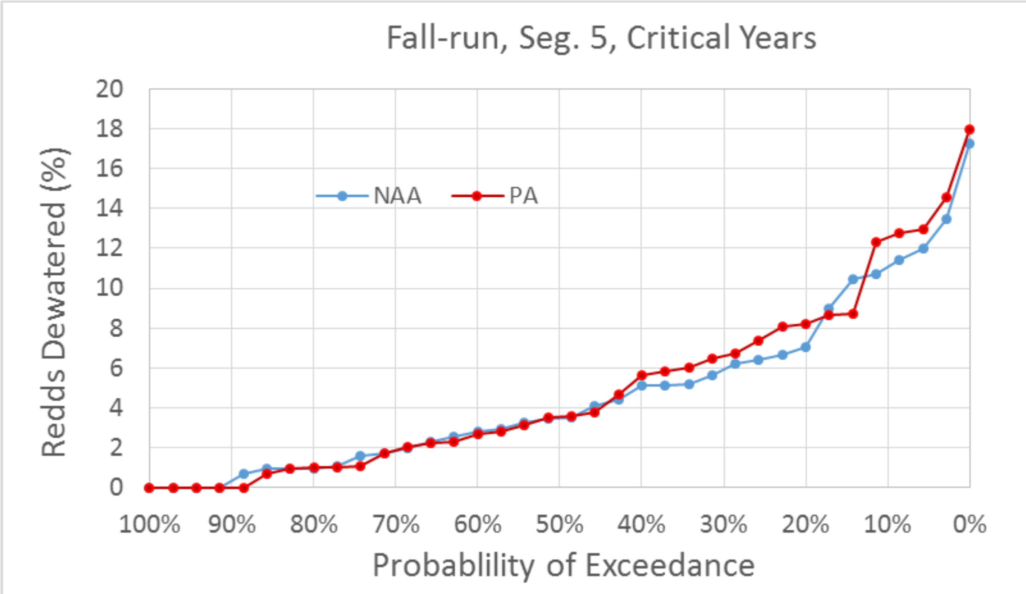


Figure 5.E-89. Exceedance Plot of Fall-Run Chinook Salmon Percent of Redds Dewatered for NAA and PA Model Scenarios in River Segment 5, Critical Water Years

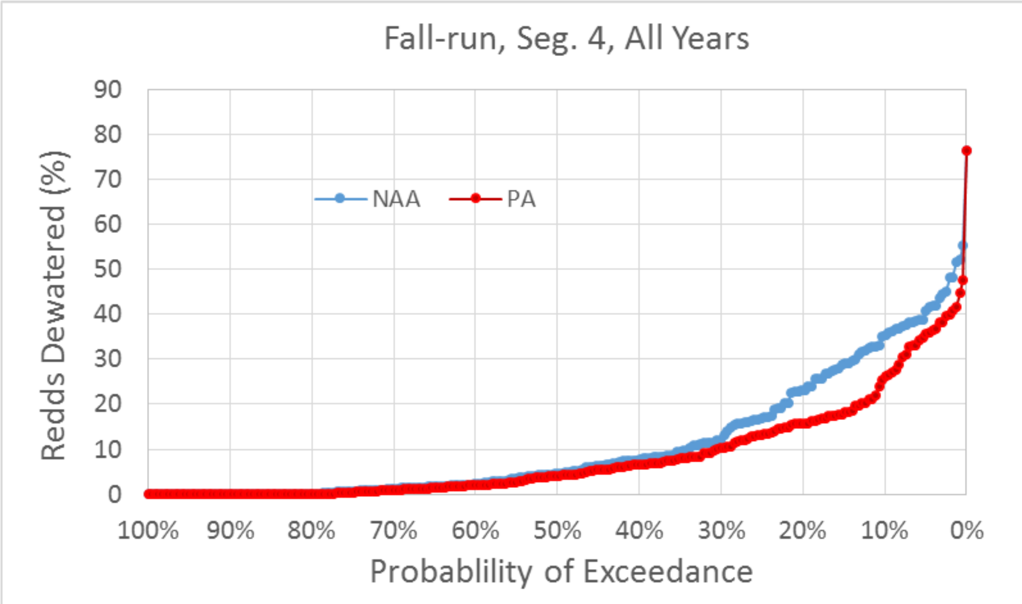


Figure 5.E-90. Exceedance Plot of Fall-Run Chinook Salmon Percent of Redds Dewatered for NAA and PA Model Scenarios in River Segment 4, All Water Years

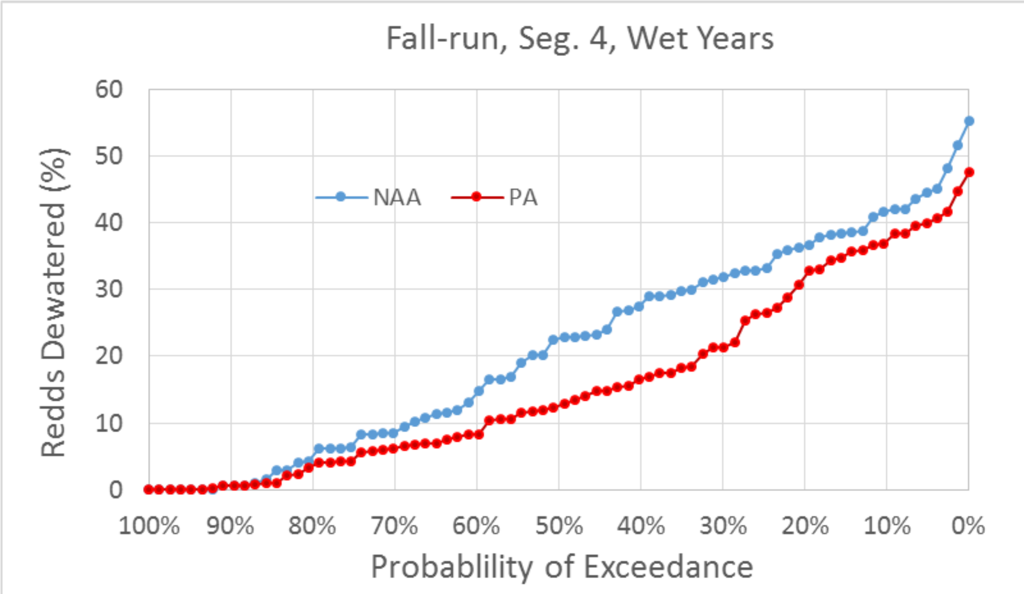


Figure 5.E-91. Exceedance Plot of Fall-Run Chinook Salmon Percent of Redds Dewatered for NAA and PA Model Scenarios in River Segment 4, Wet Water Years

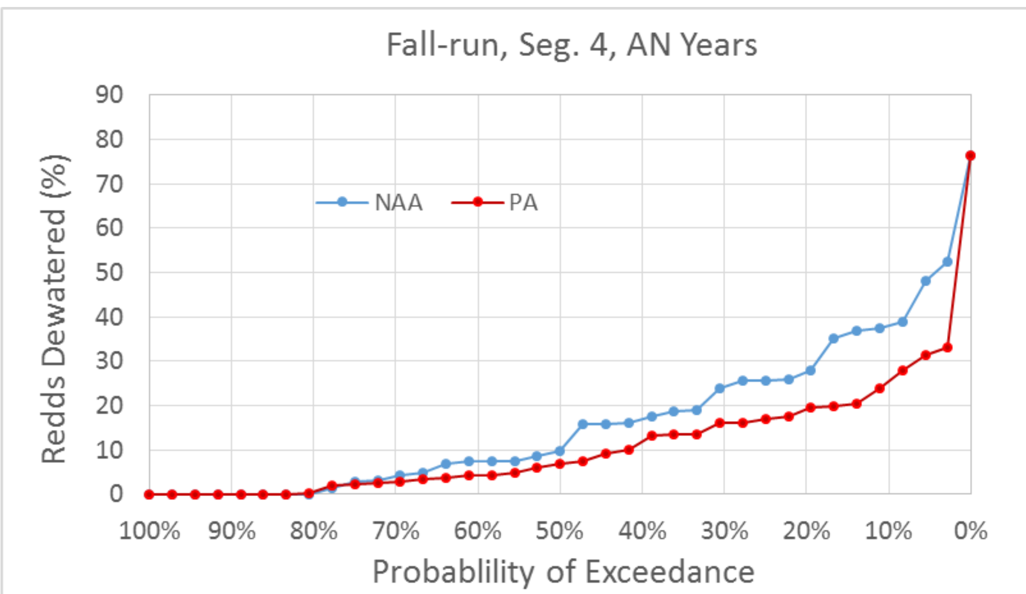


Figure 5.E-92. Exceedance Plot of Fall-Run Chinook Salmon Percent of Redds Dewatered for NAA and PA Model Scenarios in River Segment 4, Above Normal Water Years

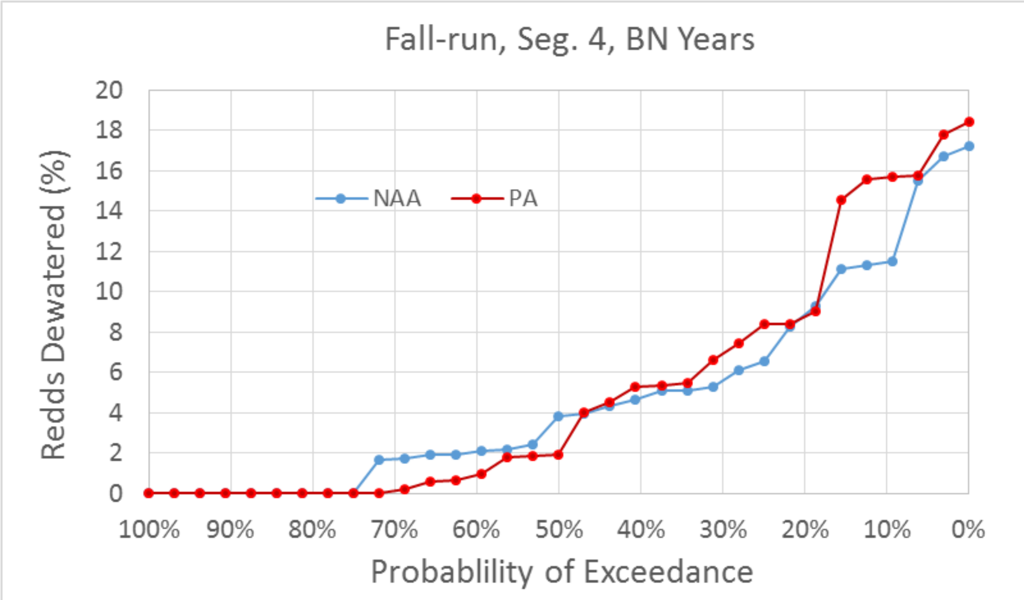


Figure 5.E-93. Exceedance Plot of Fall-Run Chinook Salmon Percent of Redds Dewatered for NAA and PA Model Scenarios in River Segment 4, Below Normal Water Years

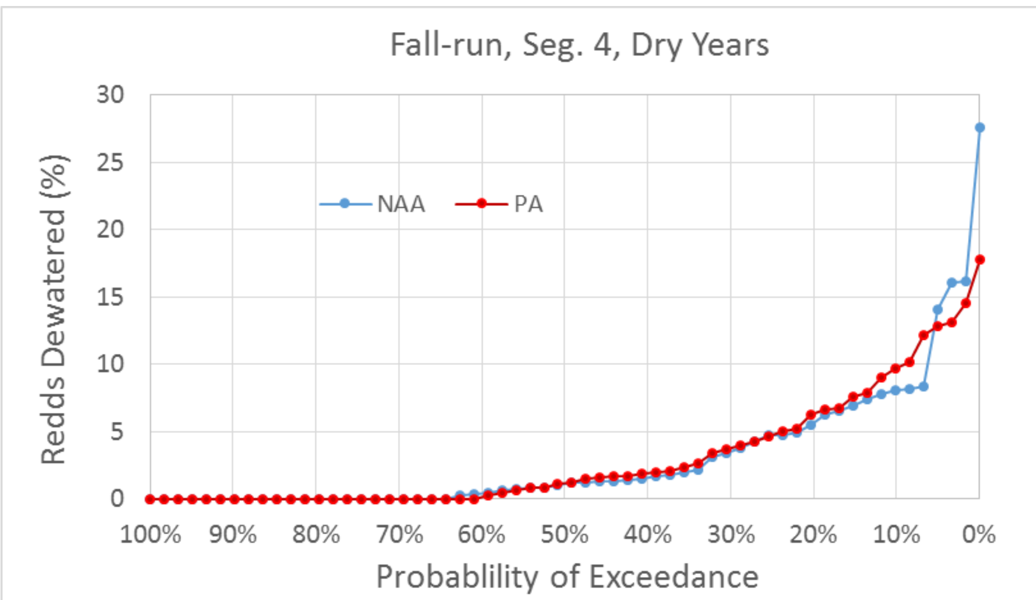


Figure 5.E-94. Exceedance Plot of Fall-Run Chinook Salmon Percent of Redds Dewatered for NAA and PA Model Scenarios in River Segment 4, Dry Water Years

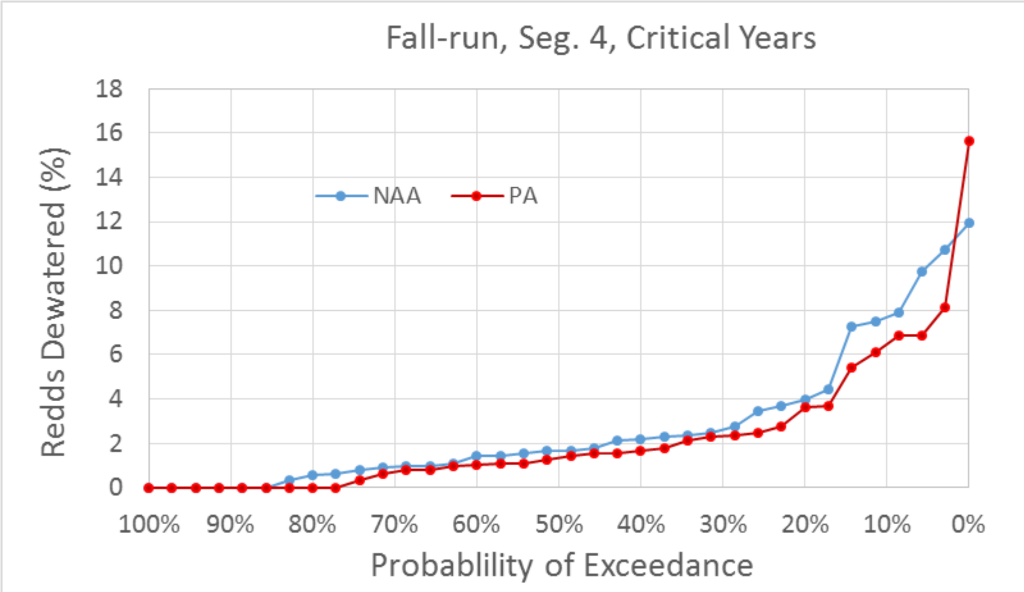


Figure 5.E-95. Exceedance Plot of Fall-Run Chinook Salmon Percent of Redds Dewatered for NAA and PA Model Scenarios in River Segment 4, Critical Water Years

Differences in the mean percentage of redds dewatered in each river segment for each month of spawning under each water year type and all water year types combined indicate that fall-run Chinook salmon redd dewatering would be little affected by the PA, except for moderate reductions in the mean percent of redds dewatered during November of wet and above normal water year types in all three river segments and a small increase in October of below normal years in river Segments 5 and 6 (Table 5.E-35 through Table 5.E-36). The percent differences between the PA and the NAA in the percent of redds dewatered range up to a 208% increase under the PA for November of critical water years in Segment 4 (Table 5.E-36), but this increase and most of the large relative changes in percent of redds dewatered are artifacts of the low percentages of redds dewatered under both scenarios that were used in computing the percent changes.

Table 5.E-34. Fall-run Chinook Salmon Percent of Redds Dewatered (Percent of Total Redds) and Differences (Percent Differences) in River Segment 6 between Model Scenarios (green indicates PA is at least 5% lower [raw difference] than NAA; red indicates PA is at least 5% higher)

Month	WYT	NAA	PA	PA vs. NAA
September	Wet	31.1	33.0	2 (6%)
	Above Normal	19.0	17.7	-1.25 (-7%)
	Below Normal	6.5	3.4	-3 (-47%)
	Dry	3.9	2.6	-1.3 (-33%)
	Critical	6.9	5.3	-1.6 (-24%)
	All	15.7	15.2	-0.5 (-3%)
October	Wet	15.0	10.3	-4.7 (-32%)
	Above Normal	13.0	13.6	0.7 (5%)
	Below Normal	9.5	15.9	6.4 (67%)
	Dry	8.2	10.3	2.1 (25%)

Month	WYT	NAA	PA	PA vs. NAA
	Critical	7.0	6.4	-0.6 (-8%)
	All	11.1	11.0	-0.1 (-1%)
November	Wet	35.9	18.7	-17.2 (-48%)
	Above Normal	33.9	15.2	-18.7 (-55%)
	Below Normal	7.2	5.4	-1.8 (-25%)
	Dry	4.7	3.2	-1.5 (-31%)
	Critical	1.6	4.5	2.9 (176%)
	All	18.9	10.4	-8.5 (-45%)

Table 5.E-35. Fall-run Chinook Salmon Percent of Redds Dewatered (Percent of Total Redds) and Differences (Percent Differences) in River Segment 5 between Model Scenarios (green indicates PA is at least 5% lower [raw difference] than NAA; red indicates PA is at least 5% higher)

Month	WYT	NAA	PA	PA vs. NAA
September	Wet	30.2	31.9	1.7 (6%)
	Above Normal	17.9	16.5	-1.5 (-8%)
	Below Normal	5.6	2.7	-2.9 (-52%)
	Dry	3.1	1.9	-1.2 (-38%)
	Critical	6.0	4.4	-1.6 (-26%)
	All	14.8	14.2	-0.6 (-4%)
October	Wet	14.5	9.9	-4.6 (-32%)
	Above Normal	12.4	13.1	0.6 (5%)
	Below Normal	9.1	15.4	6.3 (70%)
	Dry	7.9	9.9	2 (26%)
	Critical	6.7	6.1	-0.6 (-9%)
	All	10.7	10.6	-0.1 (-1%)
November	Wet	35.6	18.5	-17.1 (-48%)
	Above Normal	33.7	15.2	-18.5 (-55%)
	Below Normal	7.0	5.2	-1.8 (-25%)
	Dry	4.7	3.3	-1.4 (-30%)
	Critical	1.6	4.5	2.9 (178%)
	All	18.8	10.4	-8.4 (-45%)

Table 5.E-36. Fall-run Chinook Salmon Percent of Redds Dewatered (Percent of Total Redds) and Differences (Percent Differences) in River Segment 4 between Model Scenarios (green indicates PA is at least 5% lower [raw difference] than NAA; red indicates PA is at least 5% higher)

Month	WYT	NAA	PA	PA vs. NAA
September	Wet	24.9	26.5	1.6 (6%)
	Above Normal	13.5	12.2	-1.39 (-10%)
	Below Normal	3.1	1.2	-1.9 (-63%)
	Dry	1.0	0.6	-0.4 (-37%)
	Critical	3.5	1.7	-1.8 (-51%)
	All	11.2	10.9	-0.3 (-3%)
October	Wet	9.3	6.6	-2.7 (-29%)
	Above Normal	8.9	10.0	1.1 (12%)
	Below Normal	6.4	10.9	4.4 (69%)
	Dry	5.0	6.2	1.3 (25%)
	Critical	4.0	2.8	-1.3 (-31%)
	All	7.0	7.0	0 (0%)
November	Wet	29.8	15.3	-14.5 (-49%)
	Above Normal	28.2	12.6	-15.6 (-55%)
	Below Normal	5.1	3.5	-1.6 (-31%)
	Dry	3.4	2.5	-0.9 (-27%)
	Critical	0.8	2.6	1.7 (208%)
	All	15.4	8.2	-7.2 (-46%)

SALMOD flow-related outputs. The SALMOD model provides predicted flow-related mortality of fall-run Chinook salmon spawning, eggs, and alevins in the Sacramento River. The SALMOD results for flow-related mortality are presented in Table 5.E-37, together with results for the other sources of mortality of fall-run Chinook salmon predicted by SALMOD and discussed in other sections of this document. The flow-related mortality of fall-run Chinook salmon spawning, eggs, and alevins is split up as “incubation” (which refers to redd dewatering and scour) and “superimposition” (of redds) mortality (see Attachment 5.D.2, *SALMOD Model*). The annual exceedance plot of flow-related mortality of fall-run Chinook salmon spawning, eggs, and alevins is presented in Figure 5.E-96. The results in Table 5.E-37 indicate that there would be a 10% increase under the PA relative to the NAA in flow-related mortality of fall-run Chinook salmon spawning, eggs, and alevins from superimposition in wet years and a 50% increase from incubation-related factors in above normal water years. Differences for other water year types would be less than 5% for both mortality factors.

Table 5.E-37. Mean Annual Fall-Run Chinook Salmon Mortality[1] (# of Fish/Year) Predicted by SALMOD

	Spawning, Egg Incubation, and Alevins							Fry and Juvenile Rearing									
	Temperature-Related Mortality			Flow-Related Mortality				Temperature-Related Mortality				Flow-Related Mortality					
Analysis Period	Pre-Spawn	Eggs	Subtotal	Incubation	Super-imposition	Subtotal	Life Stage Total	Fry	Pre-smolt	Immature Smolt	Subtotal	Fry	Pre-smolt	Immature Smolt	Subtotal	Life Stage Total	Grand Total
All Water Year Types[1]																	
NAA	5,144,855	809,484	5,954,338	1,451,660	511,012	1,962,672	7,917,010	150	4,296	6,055	10,501	4,694,051	266,976	40,366	5,001,393	5,011,894	12,928,904
PA	5,022,884	660,993	5,683,877	1,477,164	550,222	2,027,386	7,711,263	160	3,305	5,350	8,814	4,716,470	267,867	41,632	5,025,968	5,034,783	12,746,046
Difference	-121,970	-148,491	-270,461	25,504	39,210	64,714	-205,747	10	-991	-705	-1,687	22,419	891	1,265	24,575	22,889	-182,859
Percent Difference[3]	-2	-18	-5	2	8	3	-3	6	-23	-12	-16	0	0	3	0	0	-1
Water Year Types[2]																	
Wet (32.5%)																	
NAA	224,282	724,794	949,076	4,013,334	1,304,607	5,317,941	6,267,017	419	4,344	1,216	5,980	5,142,369	77,086	14,964	5,234,419	5,240,399	11,507,415
PA	81,977	213,648	295,625	4,066,702	1,436,450	5,503,152	5,798,777	472	4,231	1,943	6,645	5,194,728	75,562	16,386	5,286,676	5,293,321	11,092,098
Difference	-142,305	-511,146	-653,451	53,368	131,843	185,212	-468,240	52	-113	726	666	52,359	-1,525	1,422	52,256	52,922	-415,318
Percent Difference	-63	-71	-69	1	10	3	-7	13	-3	60	11	1	-2	10	1	1	-4
Above Normal (12.5%)																	
NAA	9,090,676	497,965	9,588,640	63,475	688,815	752,290	10,340,930	20	2,720	987	3,726	5,001,065	116,203	25,093	5,142,361	5,146,087	15,487,018
PA	9,476,226	106,985	9,583,211	94,913	675,539	770,452	10,353,663	19	2,397	1,086	3,502	5,134,558	124,860	26,228	5,285,646	5,289,147	15,642,810
Difference	385,550	-390,980	-5,430	31,439	-13,276	18,162	12,732	-1	-322	99	-224	133,493	8,656	1,135	143,284	143,060	155,792
Percent Difference	4	-79	0	50	-2	2	0	-5	-12	10	-6	3	7	5	3	3	1
Below Normal (17.5%)																	
NAA	57,594	127,629	185,223	306,984	0	306,984	492,207	0	571	872	1,443	5,201,156	404,885	55,474	5,661,515	5,662,958	6,155,165
PA	57,234	124,986	182,221	303,758	0	303,758	485,979	0	514	911	1,426	5,188,265	397,816	61,171	5,647,252	5,648,678	6,134,656
Difference	-360	-2,643	-3,003	-3,226	0	-3,226	-6,228	0	-56	39	-18	-12,890	-7,070	5,697	-14,263	-14,281	-20,509
Percent Difference	-1	-2	-2	-1	0	-1	-1	0	-10	4	-1	0	-2	10	0	0	0
Dry (22.5%)																	
NAA	4,432,070	732,312	5,164,382	364,687	0	364,687	5,529,069	65	2,706	1,662	4,434	4,607,491	443,967	57,263	5,108,721	5,113,155	10,642,224
PA	4,421,190	1,145,829	5,567,018	374,597	0	374,597	5,941,615	38	1,957	841	2,837	4,464,993	455,957	56,178	4,977,128	4,979,965	10,921,580
Difference	-10,880	413,517	402,637	9,910	0	9,910	412,546	-27	-749	-821	-1,597	-142,498	11,990	-1,086	-131,593	-133,190	279,356
Percent Difference	0	56	8	3	0	3	7	-41	-28	-49	-36	-3	3	-2	-3	-3	3
Critical (15%)																	
NAA	17,301,522	2,051,093	19,352,615	363,933	0	363,933	19,716,548	0	11,836	33,277	45,112	3,132,461	391,949	66,552	3,590,961	3,636,073	23,352,621
PA	16,417,771	1,830,250	18,248,020	377,779	0	377,779	18,625,799	0	7,087	28,295	35,382	3,288,656	378,908	67,477	3,735,041	3,770,423	22,396,222
B Difference	-883,752	-220,843	-1,104,595	13,846	0	13,846	-1,090,749	0	-4,748	-4,982	-9,730	156,195	-13,040	926	144,080	134,350	-956,399
Percent Difference	-5	-11	-6	4	0	4	-6	0	-40	-15	-22	5	-3	1	4	4	-4

1 Mortality values do not include base mortality
2 Based on the 80-year simulation period
3 Relative difference of the Annual average
4 As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB 1995). Water years may not correspond to the biological years in SALMOD.
5 NA = Unable to calculate because dividing by 0

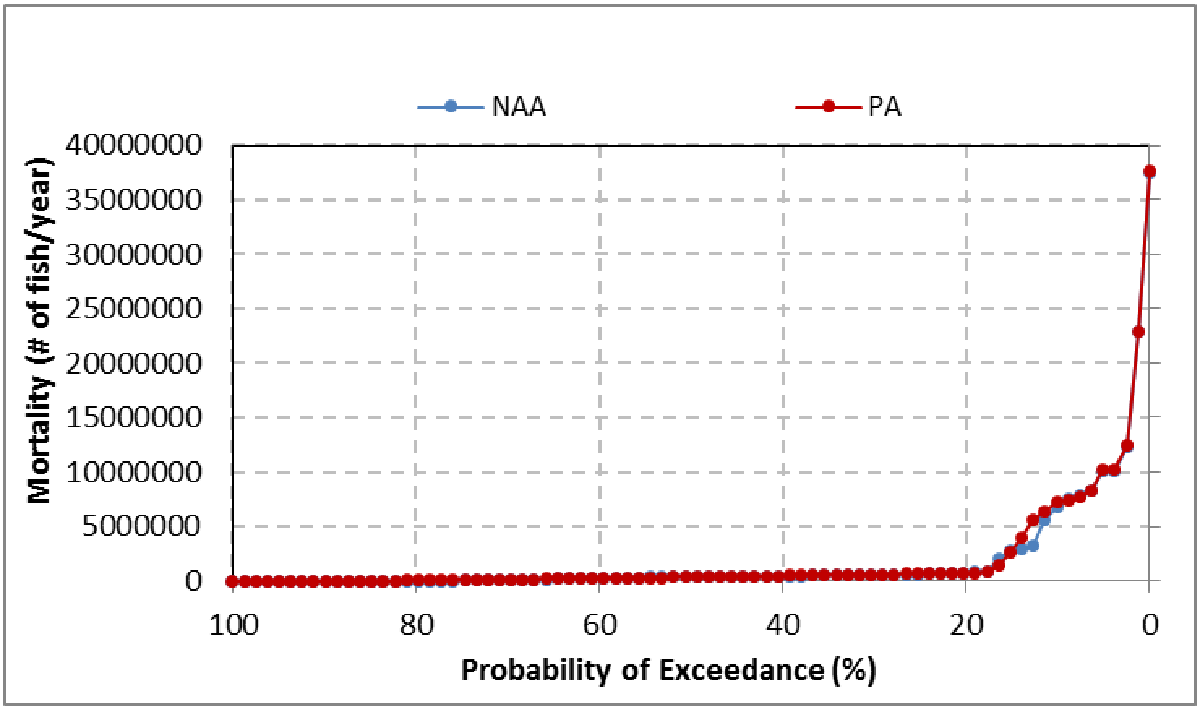


Figure 5.E-96. Exceedance Plot of Annual Flow-Based Mortality (#of Fish/Year) of Fall-Run Chinook Salmon Spawning, Egg Incubation, and Alevins

Water Temperature-Related Effects

Mean monthly water temperatures during the September through January spawning, egg incubation, and alevins period for fall-run Chinook salmon, with peak presence of October through December (3) are presented in Appendix 5.C, *Upstream Water Temperature Methods and Results*, Section 5.C.7, *Upstream Water Temperature Modeling Results*, Table 5.C.7-3, Table 5.C.7-4, Table 5.C.7-5, Table 5.C.7-7, Table 5.C.7-8. Overall, the PA would change mean water temperatures very little (predominantly less than 1°F, or approximately a 1% change) from Keswick to Red Bluff in all months of the period and water year types. The largest increase in mean monthly water temperatures under the PA relative to the NAA would be 0.6°F, or up to 1.1%, and would occur at Red Bluff in above and below normal years during September; and at Bend Bridge in below normal years during September. These largest increases would not occur during the period of peak presence of spawners, eggs, and alevins.

Exceedance plots of monthly mean water temperatures were examined during each month and water year type throughout the spawning and incubation period (Appendix 5.C, *Upstream Water Temperature Methods and Results*, Section 5.C.7, *Upstream Water Temperature Modeling Results*, Figure 5.C.7.3-7, Figure 5.C.7.4-7, Figure 5.C.7.5-7, Figure 5.C.7.7-7, Figure 5.C.7.8-7). The curves for the PA generally overlap those of the NAA. Further examination of above normal (Figure 5.E-97) and below normal years during September at Red Bluff (Figure 5.E-98) and in below normal years during September at Bend Bridge (Figure 5.E-99), where the largest modeled increases in mean monthly water temperatures were found, reveals that there is a general trend towards marginally higher temperatures under the PA.

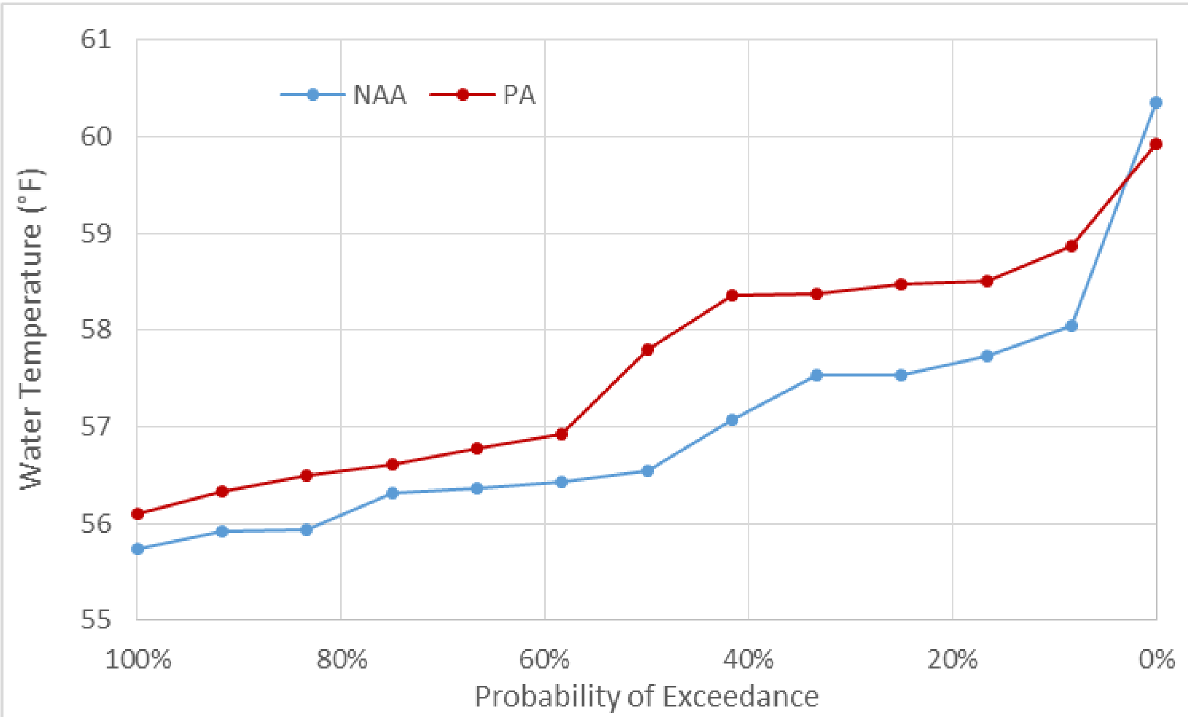


Figure 5.E-97. Exceedance Plot of Mean Monthly Water Temperatures (°F) in the Sacramento River at Red Bluff in September of Above Normal Water Years

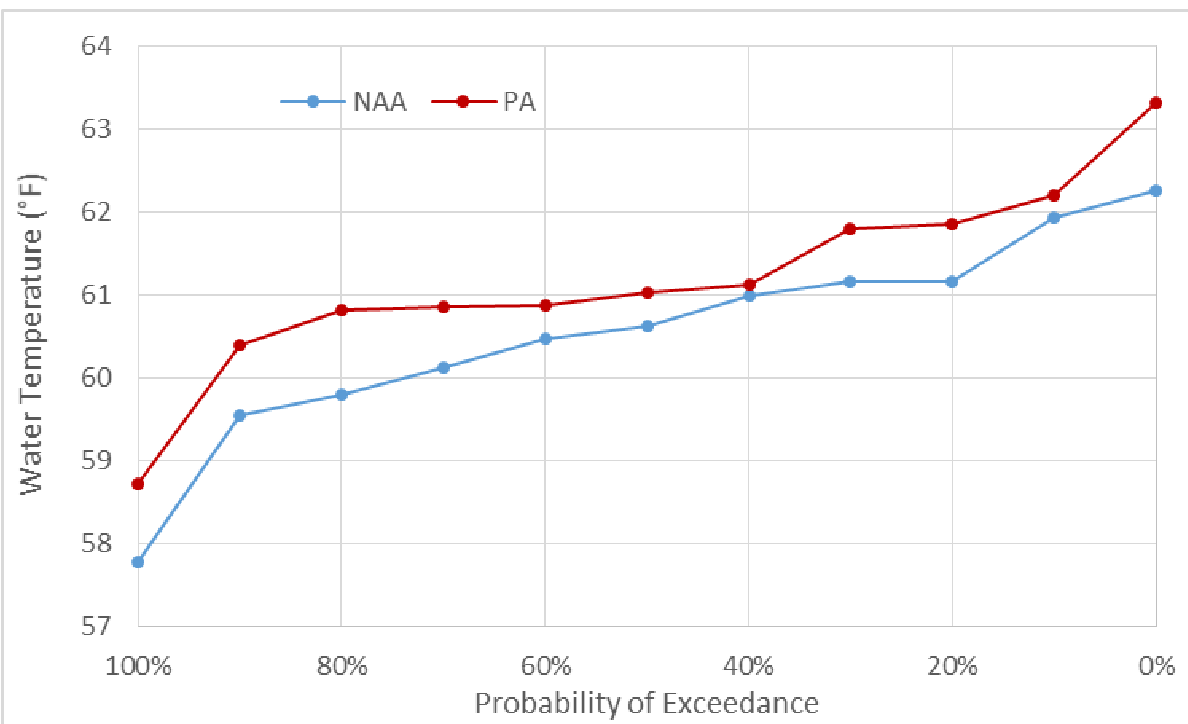


Figure 5.E-98. Exceedance Plot of Mean Monthly Water Temperatures (°F) in the Sacramento River at Red Bluff in September of Below Normal Water Years

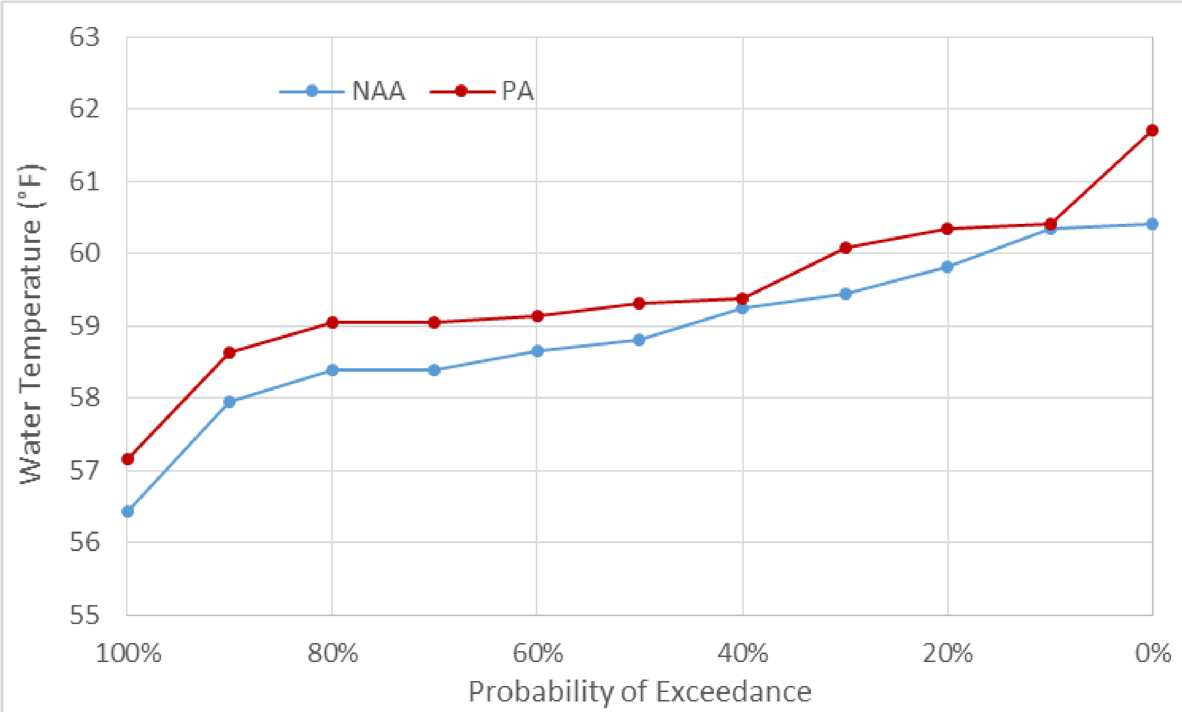


Figure 5.E-99. Exceedance Plot of Mean Monthly Water Temperatures (°F) in the Sacramento River at Bend Bridge in September of Below Normal Water Years

The exceedance of temperature thresholds in the Sacramento River presented in Table 5.E-22 by modeled daily water temperatures were evaluated based on thresholds identified from the literature and the USEPA's temperature water quality guidance (U.S. Environmental Protection Agency 2003). For spawning, egg incubation, and alevins presence, the threshold used was from the USEPA's 7-day average daily maximum (7DADM) value of 55.4°F, converted by month to function with daily model outputs for each month separately (Appendix 5.D, *Quantitative Methods and Detailed Results for Effects Analysis of Chinook Salmon, Central Valley Steelhead, Green Sturgeon, and Killer Whale*, Section 5.D.2.1, *Water Temperature Analysis Methods*, Table 5.D-4).

Results of the water temperature thresholds analysis are presented in Attachment 5.E.1, *Fall-/Late Fall-Run Chinook Salmon Water Temperature Threshold Analysis Results*, Table 5.E.1-1 through Table 5.E.1-5. At Keswick, there would be no months or water year types in which there would be 5% more days under the PA compared to the NAA on which temperatures would exceed the threshold and no more-than-0.5°F difference in the magnitude of average daily exceedance (Attachment 5.E.1, *Fall-/Late Fall-Run Chinook Salmon Water Temperature Threshold Analysis Results*, Table 5.E.1-1).

At Clear Creek, the percent of days exceeding the 55.4°F 7DADM threshold under the PA would be more than 5% higher than under the NAA during September of below normal years (6.4%), and October and November of dry years (7.3%) (Attachment 5.E.1, *Fall-/Late Fall-Run Chinook Salmon Water Temperature Threshold Analysis Results*, Table 5.E.1-2). There would be no concomitant difference between the NAA and PA in average daily exceedance of more than

0.5°F during the months and water year types. Therefore, it was concluded that any adverse effects would be undetectable.

At Balls Ferry, the percent of days exceeding the 55.4°F 7DADM threshold under the PA would be more than 5% higher than under the NAA during September of above normal years (16.7%) (Attachment 5.E.1, *Fall-/Late Fall-Run Chinook Salmon Water Temperature Threshold Analysis Results*, Table 5.E.1-3). There would be no concomitant difference between the NAA and PA in average daily exceedance of more than 0.5°F during the months and water year types. Therefore, it was concluded that any adverse effects would be undetectable.

At Bend Bridge, the percent of days exceeding the 55.4°F 7DADM threshold under the PA would be more than 5% higher than under the NAA during September of above normal years (Attachment 5.E.1, *Fall-/Late Fall-Run Chinook Salmon Water Temperature Threshold Analysis Results*, Table 5.E.1-4).There would be an increase in the degrees per day above the threshold in September of below normal water years (0.58°F). However, in neither of these situations would both criteria be met. Therefore, it was concluded that any adverse effects would be undetectable at Bend Bridge.

At Red Bluff, there would be no months or water year types in which there would be 5% more days under the PA compared to the NAA on which temperatures would exceed the threshold (Attachment 5.E.1, *Fall-/Late Fall-Run Chinook Salmon Water Temperature Threshold Analysis Results*, Table 5.E.1-5). There would be an increase in the degrees per day above the threshold in September of above normal (0.62°F) and below normal water years (0.65°F). However, there would be no concurrent increase in the percent of days exceeding the threshold. Therefore, it was concluded that any adverse effects would be undetectable at Red Bluff.

Overall, the thresholds analysis indicates that any adverse effects on spawning, egg incubation, and alevins fall-run Chinook salmon would be undetectable in the Sacramento River.

The Reclamation Egg Mortality Model provides temperature-related estimates of fall-run egg mortality in the Sacramento River (see Attachment 5.D.1, *Egg Mortality Model*, for full model description). Results of the model are presented in Table 5.E-30 and Figure 5.E-100 through Figure 5.E-105. Because the egg life stage has the highest potential effect on the propagation of population size in a life cycle context, a more conservative value of a more-than-2% change in percent of total individuals (on a raw scale) was considered a detectable effect.

These results indicate that any increases in egg mortality under the PA relative to the NAA would be undetectable. The relative differences between the PA and NAA were within 2% in all water year types, and the raw differences in years with the highest reduction in egg mortality under the PA (below normal and critical) are very small (less than 1% difference) (Table 5.E-30).

Table 5.E-38. Fall-Run Chinook Salmon Egg Mortality (Percent of Total Individuals) and Differences (Percent Differences) between Model Scenarios, Reclamation Egg Mortality Model

WYT	NAA	PA	PA vs. NAA
Wet	10.7	11.0	0.3 (2%)
Above Normal	10.6	10.6	0 (0%)
Below Normal	15.3	15.0	-0.3 (-2%)
Dry	17.2	17.4	0.2 (1%)
Critical	38.1	37.4	-0.7 (-2%)
All	17.0	17.0	0 (0%)

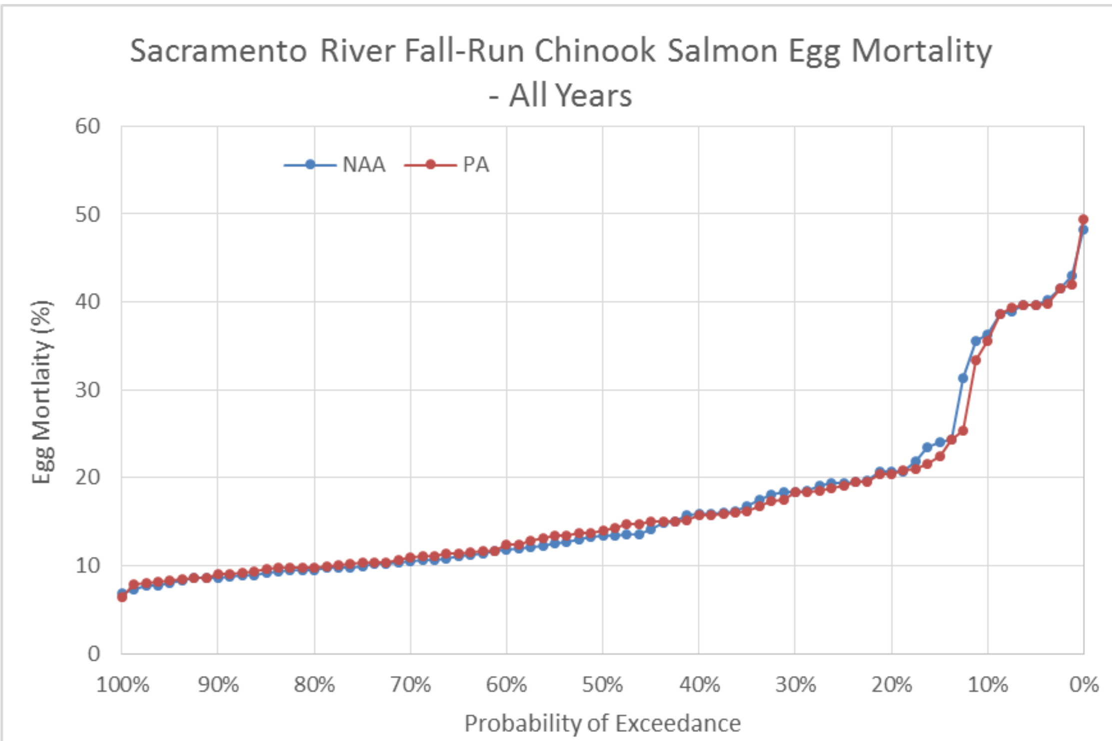


Figure 5.E-100. Exceedance Plot of Fall-Run Chinook Salmon Egg Mortality for NAA and PA Model Scenarios, Reclamation Egg Mortality Model, All Water Years

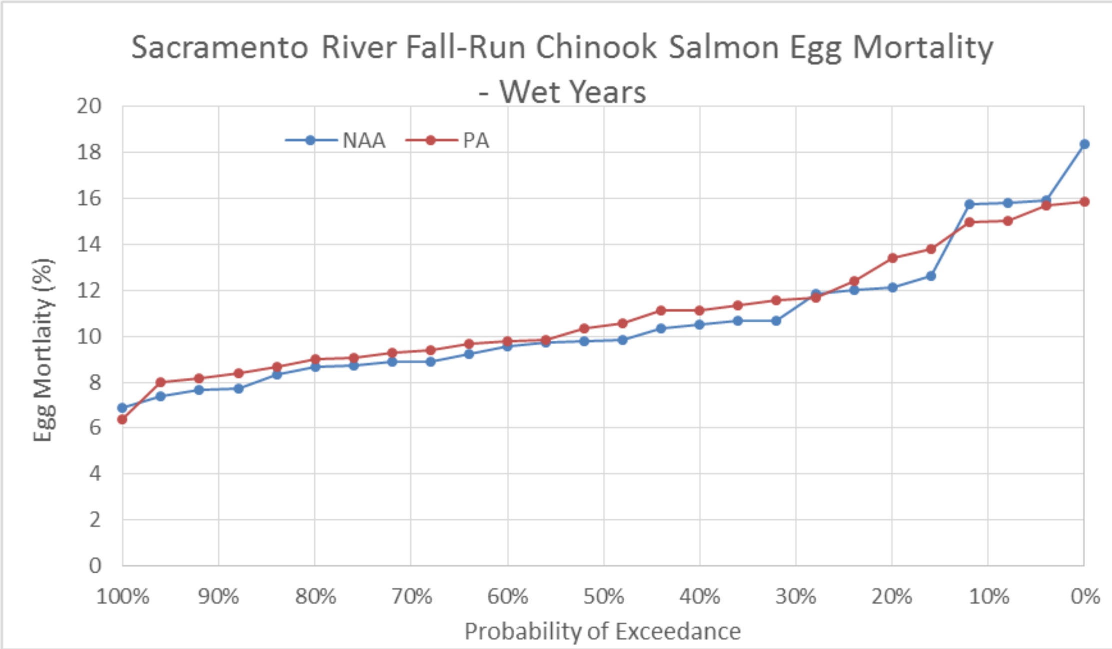


Figure 5.E-101. Exceedance Plot of Fall -Run Chinook Salmon Egg Mortality for NAA and PA Model Scenarios, Reclamation Egg Mortality Model, Wet Water Years

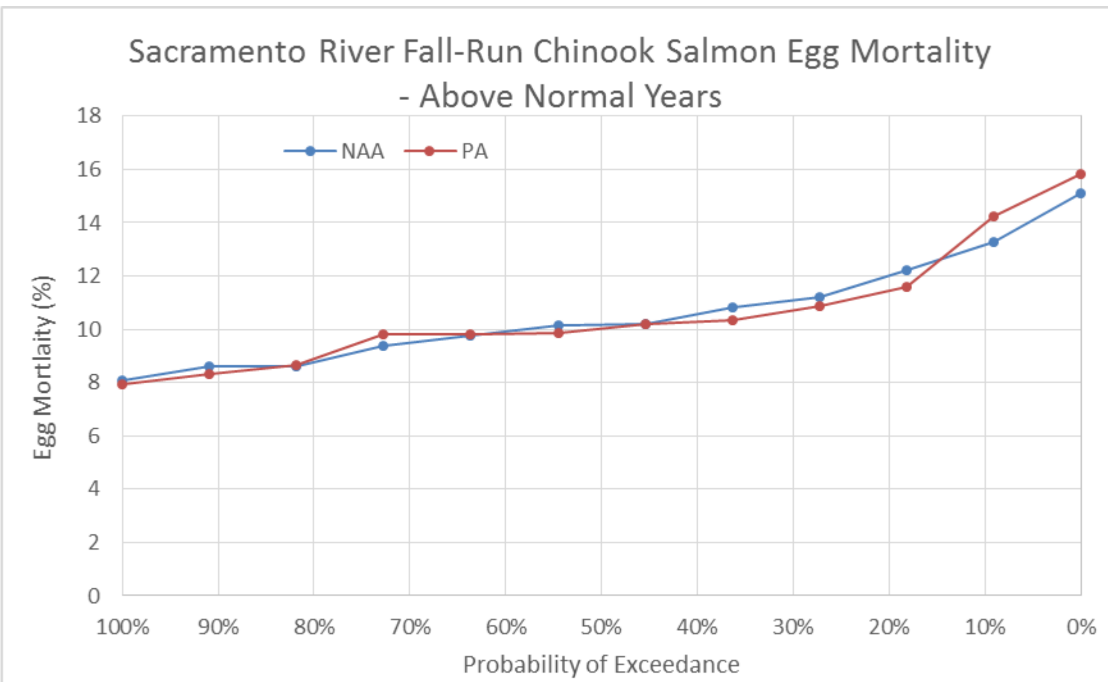


Figure 5.E-102. Exceedance Plot of Fall -Run Chinook Salmon Egg Mortality for NAA and PA Model Scenarios, Reclamation Egg Mortality Model, Above Normal Water Years

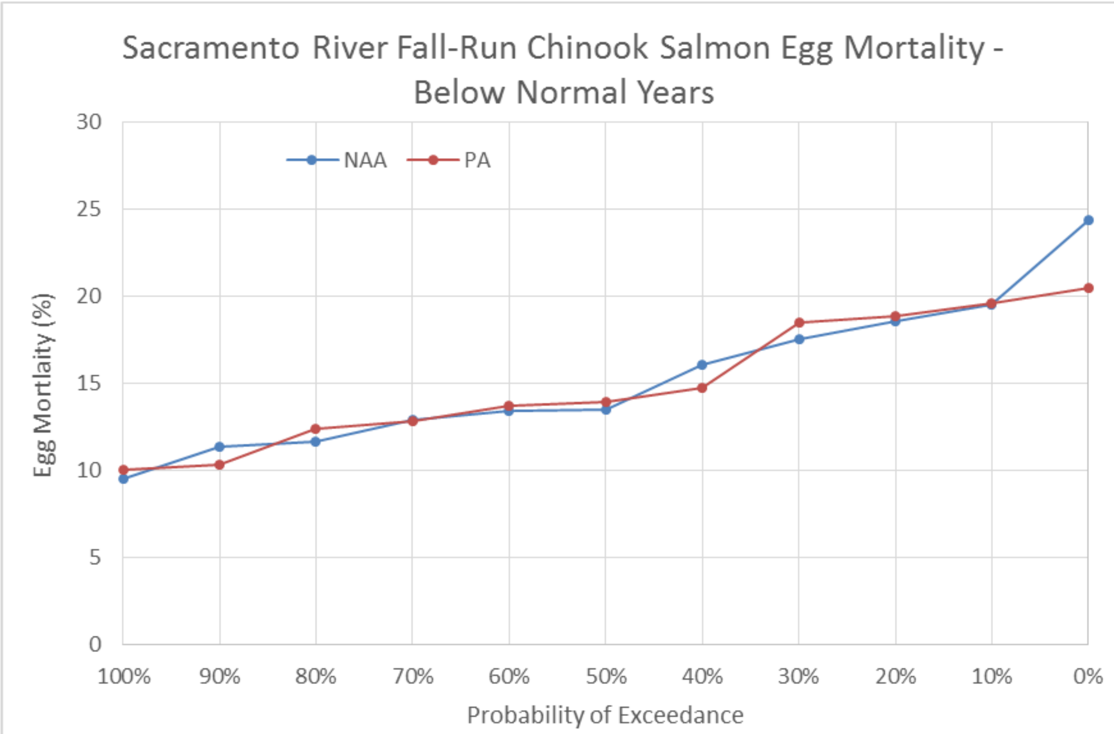


Figure 5.E-103. Exceedance Plot of Fall -Run Chinook Salmon Egg Mortality for NAA and PA Model Scenarios, Reclamation Egg Mortality Model, Below Normal Water Years

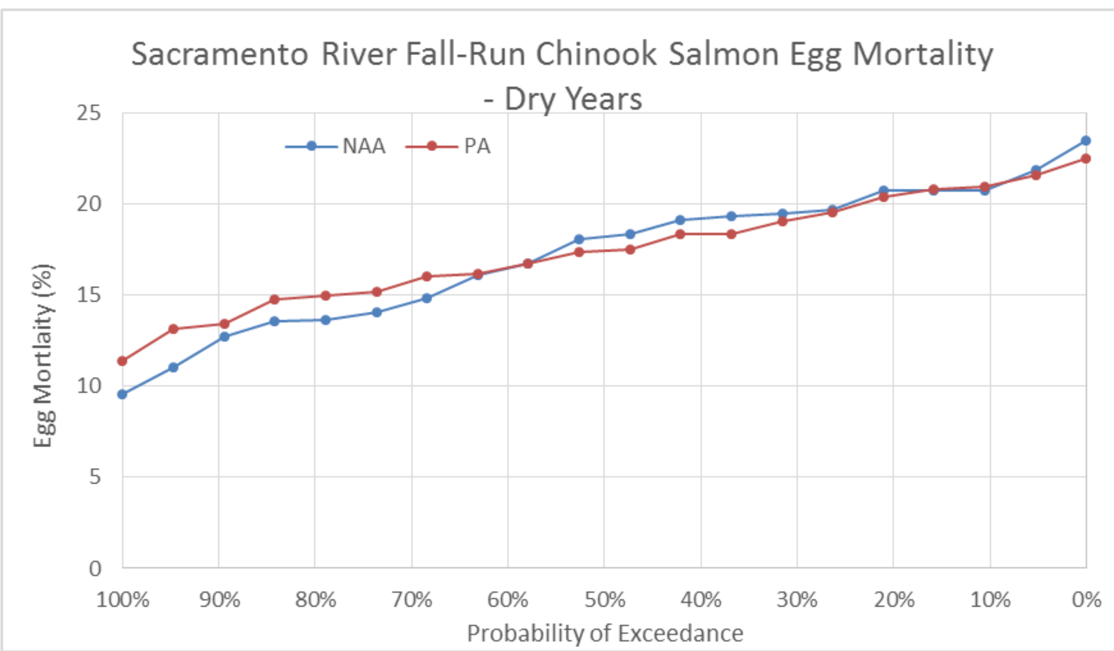


Figure 5.E-104. Exceedance Plot of Fall -Run Chinook Salmon Egg Mortality for NAA and PA Model Scenarios, Reclamation Egg Mortality Model, Dry Water Years

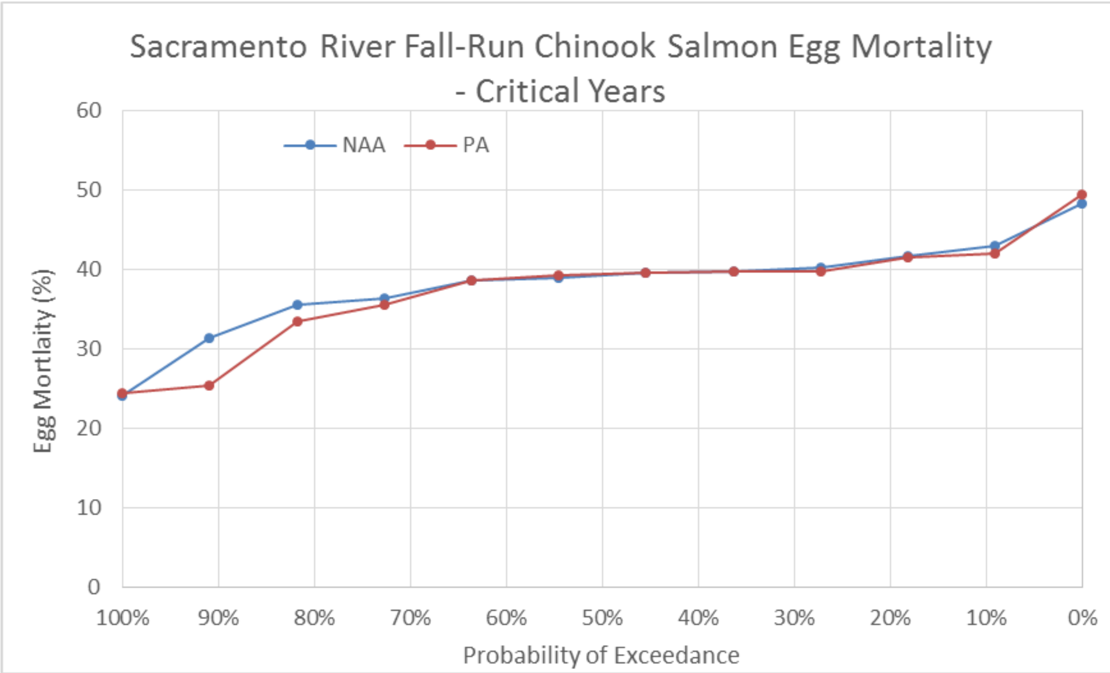


Figure 5.E-105. Exceedance Plot of Fall -Run Chinook Salmon Egg Mortality for NAA and PA Model Scenarios, Reclamation Egg Mortality Model, Critical Water Years

The SALMOD model provides predicted water temperature-related mortality of fall-run Chinook salmon eggs and alevins the Sacramento River. This water temperature-related mortality of fall-run Chinook salmon eggs and alevins is split up as *pre-spawn* (in vivo, or in the mother before spawning) and *egg* (in the gravel) mortality (see Attachment 5.D.2, *SALMOD Model*, for a full description). Table 5.E-37 presents results for water temperature-related mortality of spawning, eggs, and alevins, in addition to all sources of mortality for fall-run Chinook salmon predicted by SALMOD discussed in other sections of this document. The annual exceedance plot of temperature-related mortality of fall-run Chinook salmon eggs and alevins for all water years combined is presented in Figure 5.E-106. These results indicate that, combining all water year types, there would be no substantial temperature-related mortality of fall-run Chinook salmon eggs and alevins under the PA relative to the NAA and, in fact, mortality would slightly decrease (270,461 fish, or 5%) under the PA. Water temperature-related mortality under the PA would be similar to or lower than that under the NAA in all water years except for dry. In dry water years, there would be an increase in mortality of 8%. This difference in mortality would be due almost entirely to differences in the egg stage (56% increase under the PA). This negative water temperature-related effect under the PA on egg mortality in dry water years is not seen in the temperature threshold analysis or egg mortality model results described above.

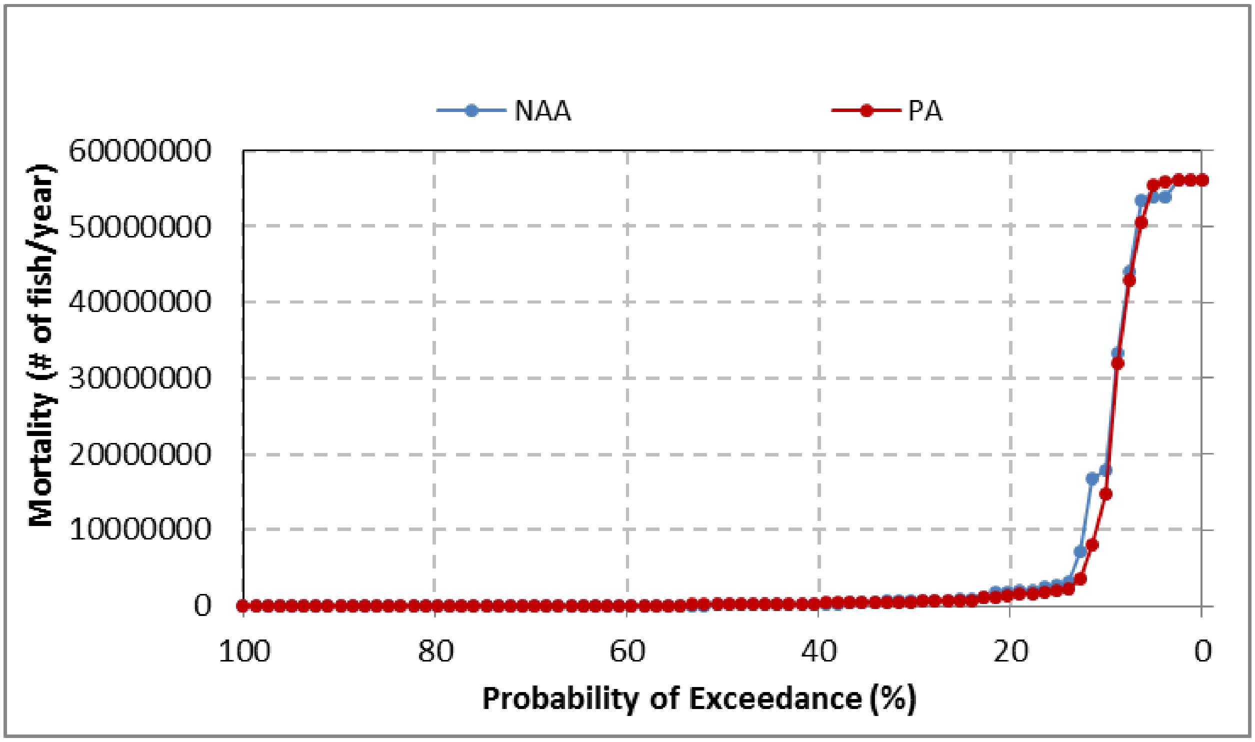


Figure 5.E-106. Exceedance Plot of Annual Water Temperature-Based Mortality (# of Fish/Year) of Fall-Run Chinook Salmon Spawning, Egg Incubation, and Alevins.

Fry and Juvenile Rearing

Flow-Related Effects

Mean monthly flow rates and reservoir storage volumes were examined for the PA and NAA in the Sacramento River at the Keswick to Red Bluff locations during the December through June fry and juvenile rearing period for fall-run Chinook salmon, with peak occurrence during December through February (Table 5.E-3). Changes in flow can affect the instream area available for rearing, along with habitat quality, and can affect stranding of fry and juveniles, especially in side-channel habitats.

Shasta Reservoir storage volume at the end of September may influence flow rates in the Sacramento River early in the rearing period and Shasta storage volume at the end of May influences flow in June. Mean Shasta September storage under the PA would be similar (less than 5% difference) to storage under NAA for all water year types, except for 7% higher mean storage during critical water years under the PA (Appendix 5.A, *CALSIM Methods and Results*, Table 5.A.6-3). Mean Shasta May storage under the PA would be similar (less than 5% difference) to storage under NAA for all water year types.

In general, mean flow due to the PA at the Keswick and Red Bluff locations in the Sacramento River flow would be similar to (less than 5% difference) or higher than flow due to the NAA during the fall-run Chinook salmon fry and juvenile rearing period (Appendix 5.A, *CALSIM Methods and Results*, Table 5.A.6-10, Table 5.A.6-35). Mean flow under the PA would be similar to (less than 5% difference) or greater than flow under the NAA for all months and water year types of the period, except for 13% and 7% lower flow during February of critical water years at Keswick and Red Bluff, respectively. Flow increases during the period would range up to 18% for January of critical years. During June, mean flow would be more than 5% higher under the PA than the NAA in all water year types except wet years.

Rearing WUA for fall-run Chinook salmon fry and juveniles was determined by USFWS (2005b) for a range of flows in three segments of the Sacramento River between Keswick Dam and the Battle Creek confluence (Appendix 5D.2.3, *Rearing Flows Methods*). The three river segments are the three most upstream segments used for the spawning habitat WUA studies: Segment 4 from Battle Creek to the confluence with Cow Creek, Segment 5 from Cow Creek to ACID Dam, and Segment 6 from ACID Dam to Keswick Dam (USFWS 2003a, 2006). To estimate changes in rearing WUA that would result from the PA relative to the NAA, the rearing habitat WUA curves developed for each of these segments was used with mean monthly CALSIM II flow estimates under the PA and the NAA for the midpoint of each segment during each month of the fall-run Chinook salmon fry and juvenile rearing periods (Table 5.E-24 [see page 10, above]). For this analysis, fry were defined as fish less than 60 mm, and juveniles were those greater than 60 mm. Further information on the rearing WUA analysis methods is provided in Appendix 5D.2.3, *Rearing Flows Methods*.

Differences under the PA and NAA in rearing WUA for fall-run Chinook salmon fry and juveniles were examined using exceedance plots of mean monthly WUA for the fry (Figure 5.E-107 to Figure 5.E-124) and juvenile (Figure 5.E-125 to Figure 5.E-142) rearing periods in each of the river segments for each water year type and all water year types combined. The PA exceedance curves for both fry and juvenile rearing WUA for all water years combined are similar to those for the NAA for all three river segments (Figure 5.E-107, Figure 5.E-113, Figure 5.E-119, Figure 5.E-125, Figure 5.E-131, and Figure 5.E-137). With the curves broken out by water year type, slight decreases in fry rearing habitat WUA under the PA are evident in Segments 5 during wet and below normal years (Figure 5.E-114 and Figure 5.E-116), and small increases in juvenile rearing WUA under the PA are evident in Segment 4 during dry and critical years (Figure 5.E-141 and Figure 5.E-142). The WUA modeling indicates that the PA would reduce fall-run Chinook salmon rearing habitat in Segments 4 and 5 in a few months and water year types.

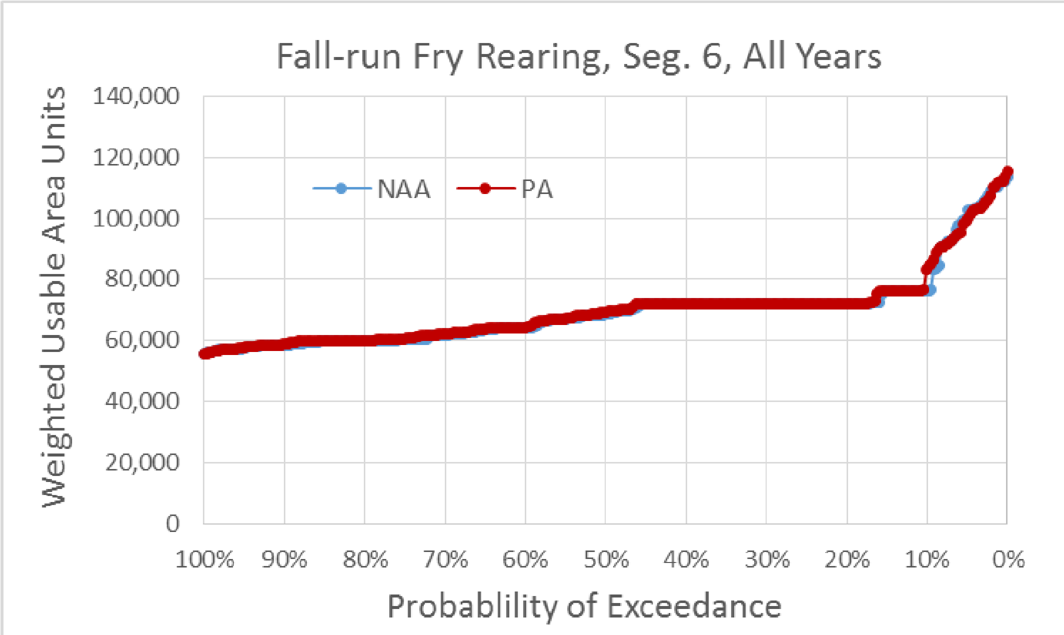


Figure 5.E-107. Exceedance Plot of Fall-Run Chinook Salmon Fry Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 6, All Water Years

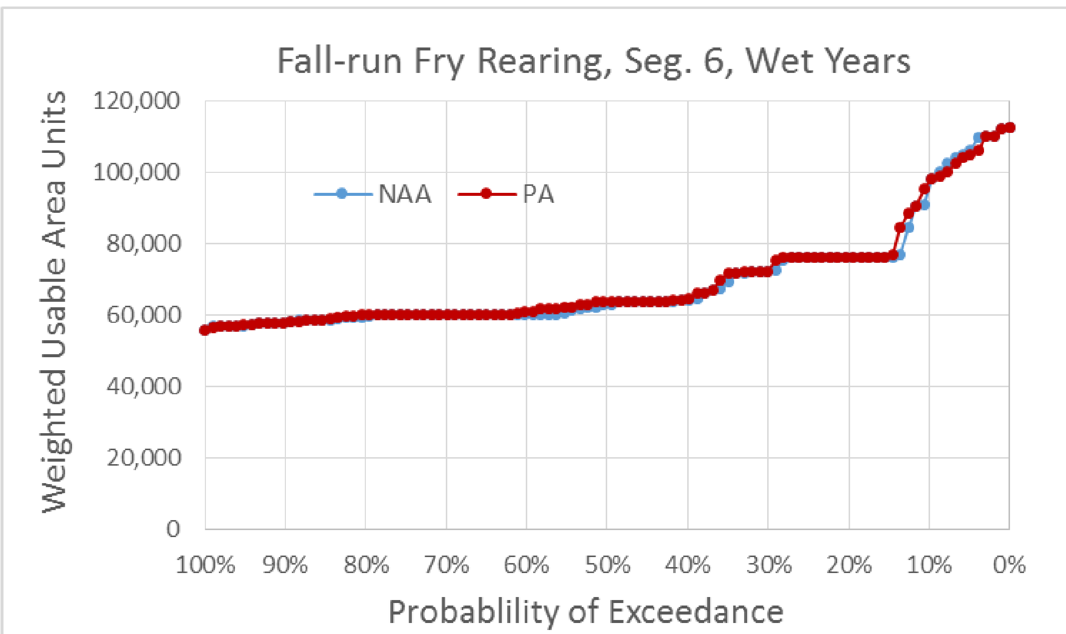


Figure 5.E-108. Exceedance Plot of Fall-Run Chinook Salmon Fry Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 6, Wet Water Years

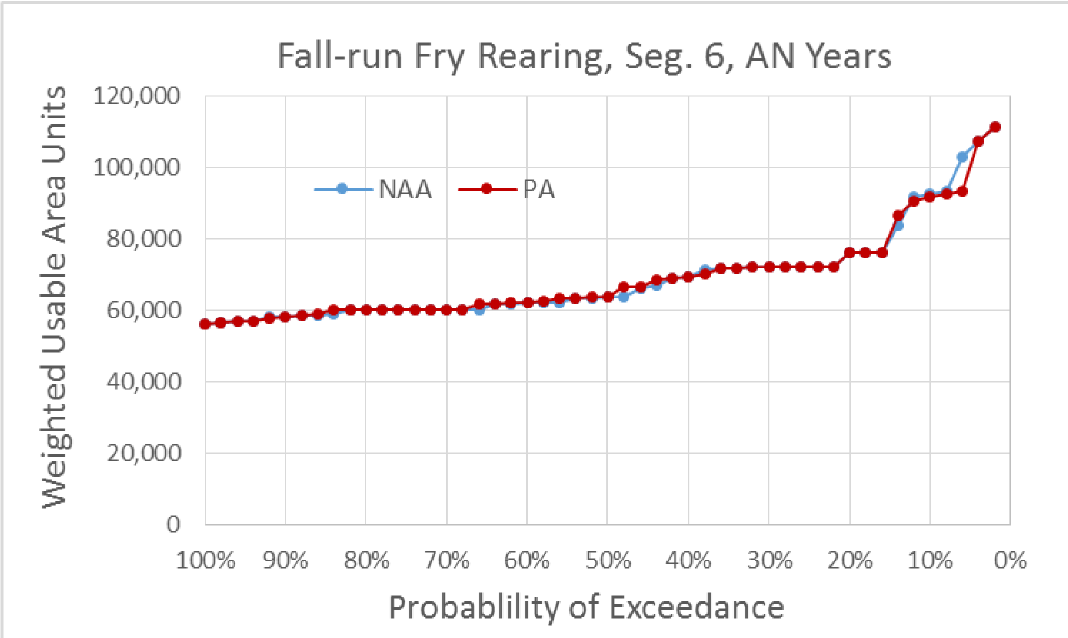


Figure 5.E-109. Exceedance Plot of Fall-Run Chinook Salmon Fry Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 6, Above Normal Water Years

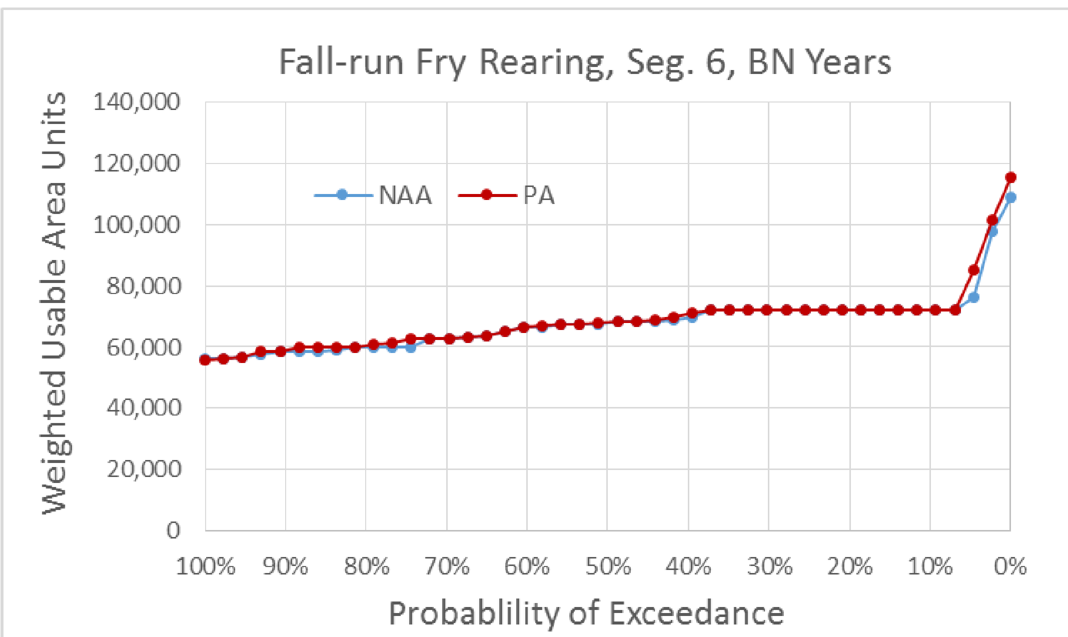


Figure 5.E-110. Exceedance Plot of Fall-Run Chinook Salmon Fry Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 6, Below Normal Water Years

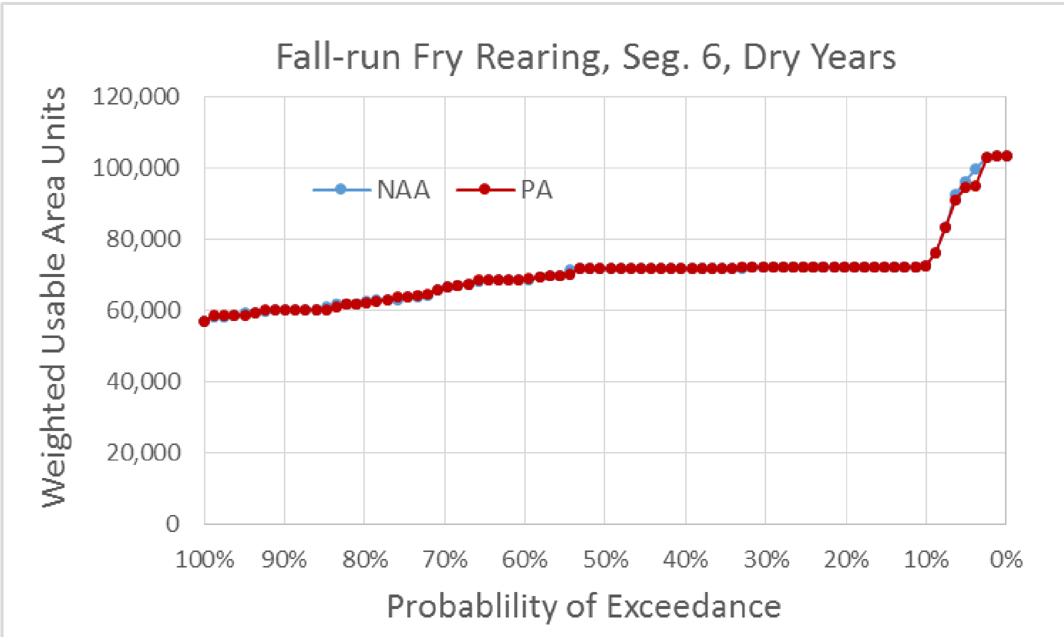


Figure 5.E-111. Exceedance Plot of Fall-Run Chinook Salmon Fry Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 6, Dry Water Years

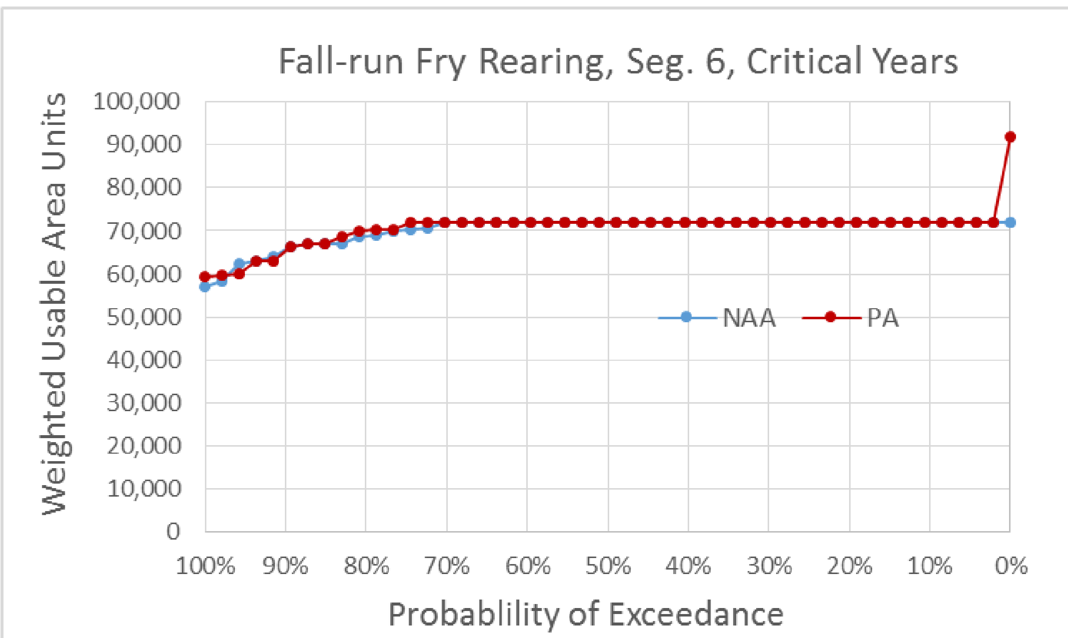


Figure 5.E-112. Exceedance Plot of Fall-Run Chinook Salmon Fry Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 6, Critical Water Years

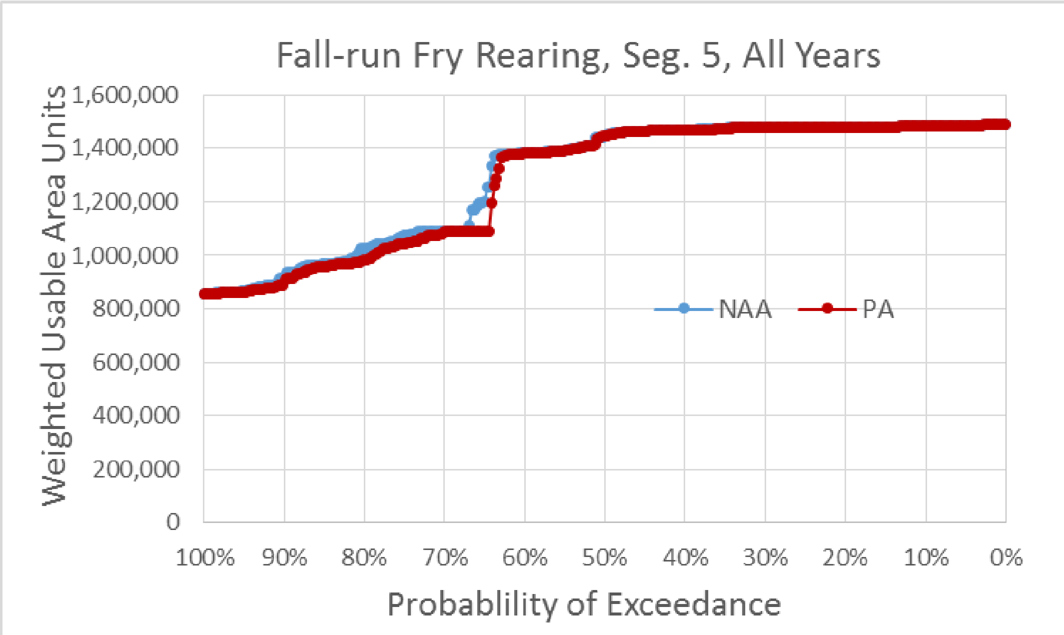


Figure 5.E-113. Exceedance Plot of Fall-Run Chinook Salmon Fry Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 5, All Water Years

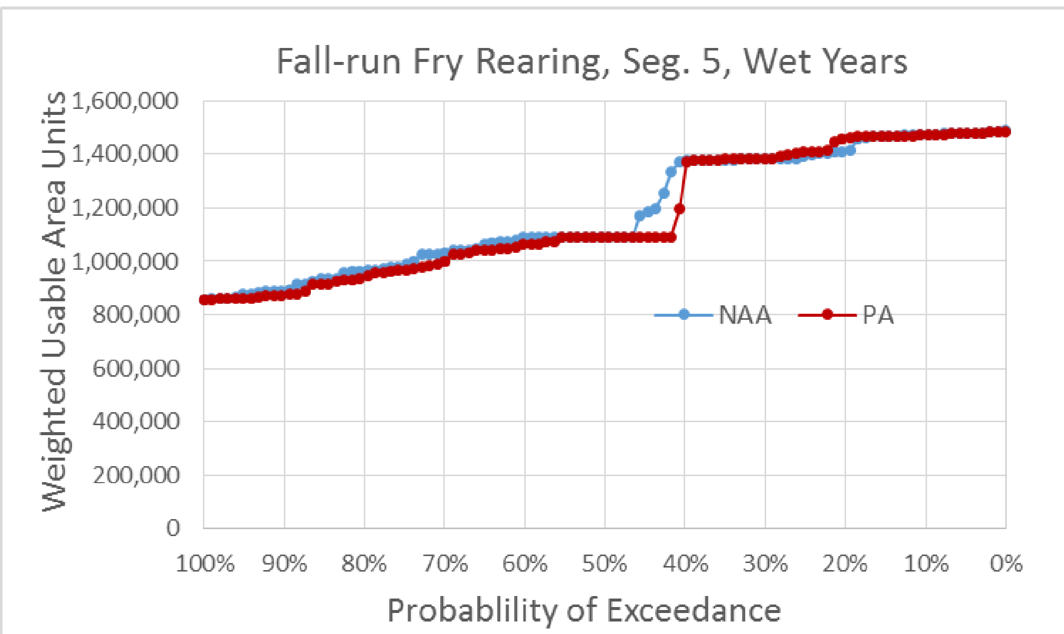


Figure 5.E-114. Exceedance Plot of Fall-Run Chinook Salmon Fry Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 5, Wet Water Years

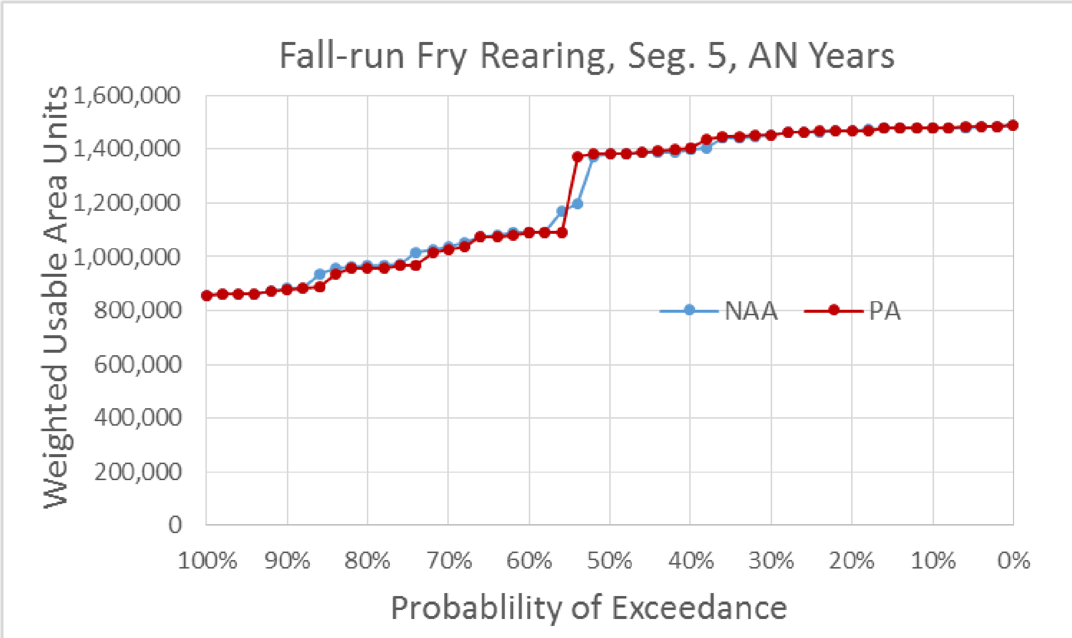


Figure 5.E-115. Exceedance Plot of Fall-Run Chinook Salmon Fry Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 5, Above Normal Water Years

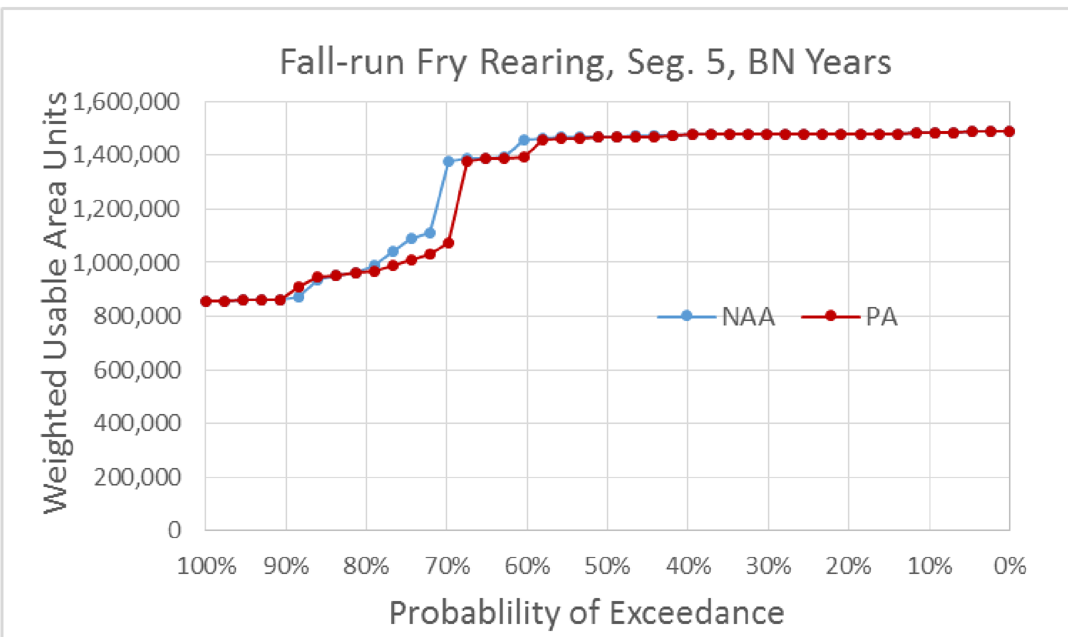


Figure 5.E-116. Exceedance Plot of Fall-Run Chinook Salmon Fry Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 5, Below Normal Water Years

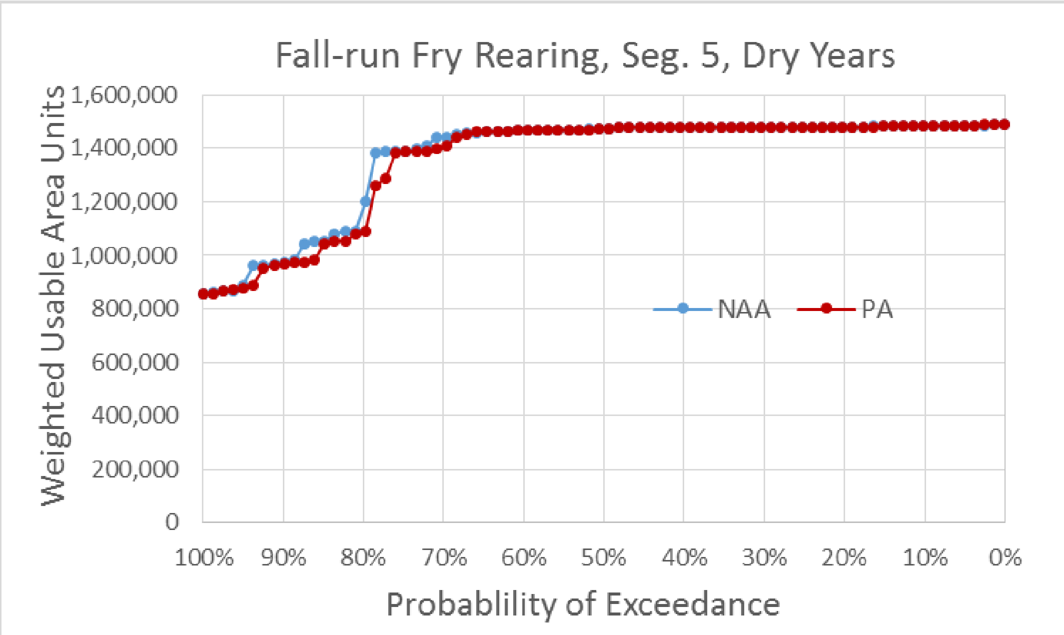


Figure 5.E-117. Exceedance Plot of Fall-Run Chinook Salmon Fry Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 5, Dry Water Years

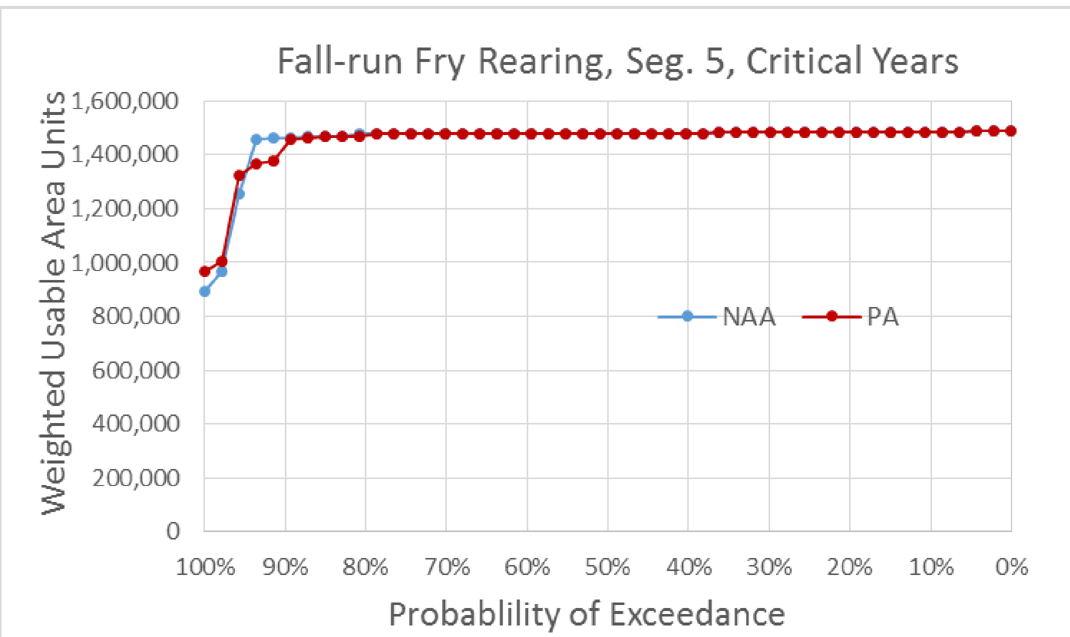


Figure 5.E-118. Exceedance Plot of Fall-Run Chinook Salmon Fry Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 5, Critical Water Years

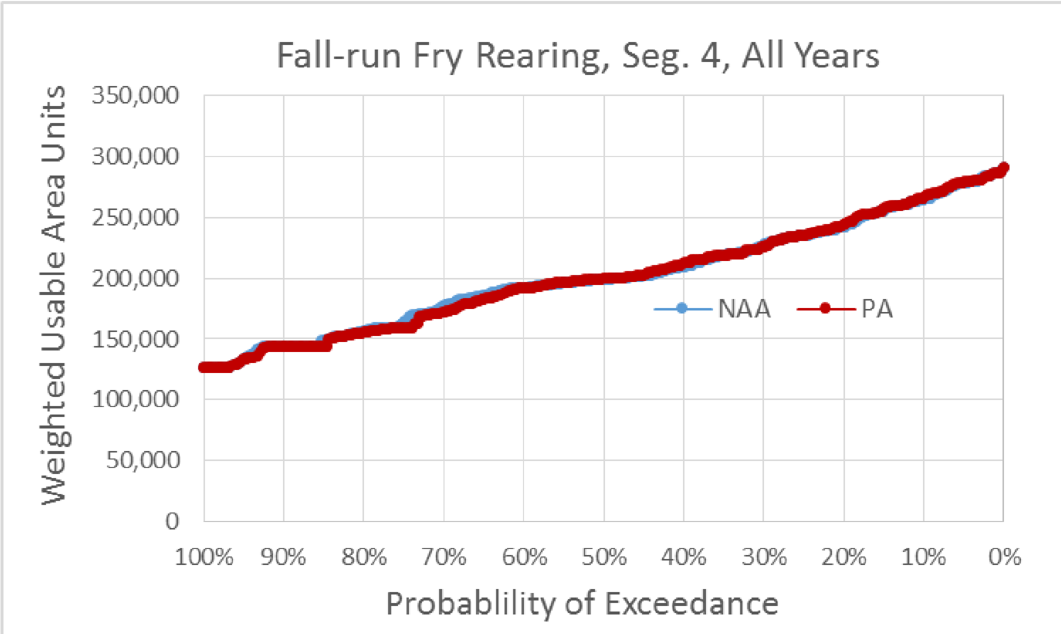


Figure 5.E-119. Exceedance Plot of Fall-Run Chinook Salmon Fry Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 4, All Water Years

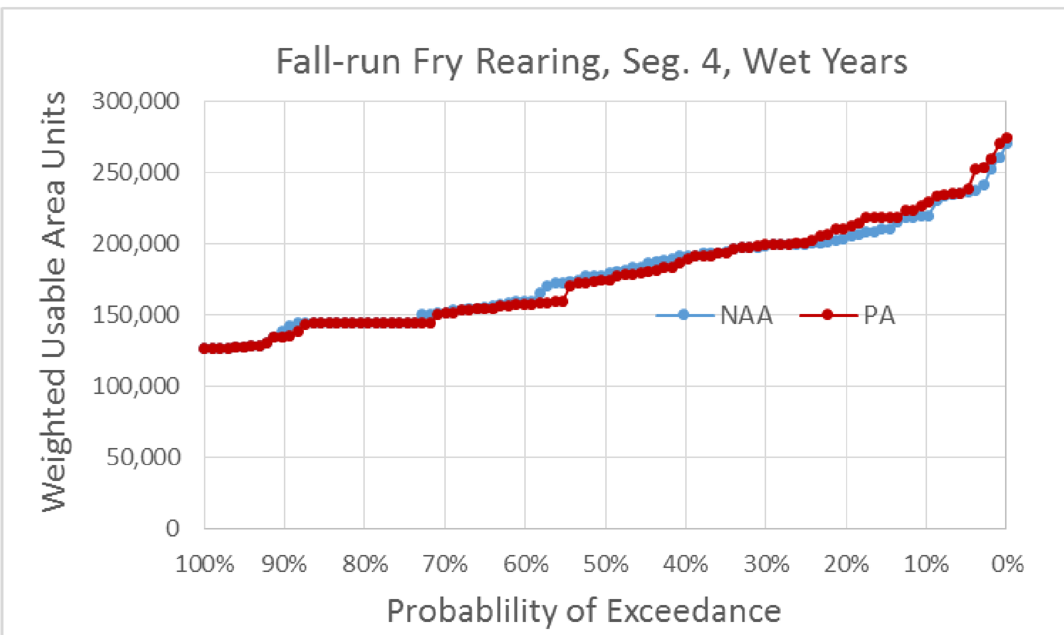


Figure 5.E-120. Exceedance Plot of Fall-Run Chinook Salmon Fry Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 4, Wet Water Years

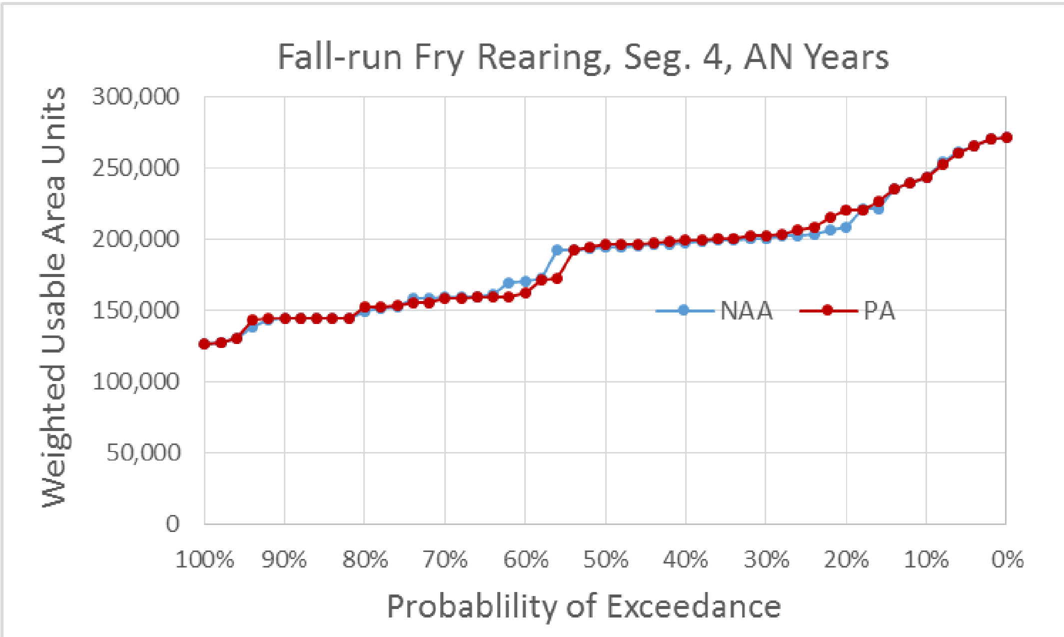


Figure 5.E-121. Exceedance Plot of Fall-Run Chinook Salmon Fry Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 4, Above Normal Water Years

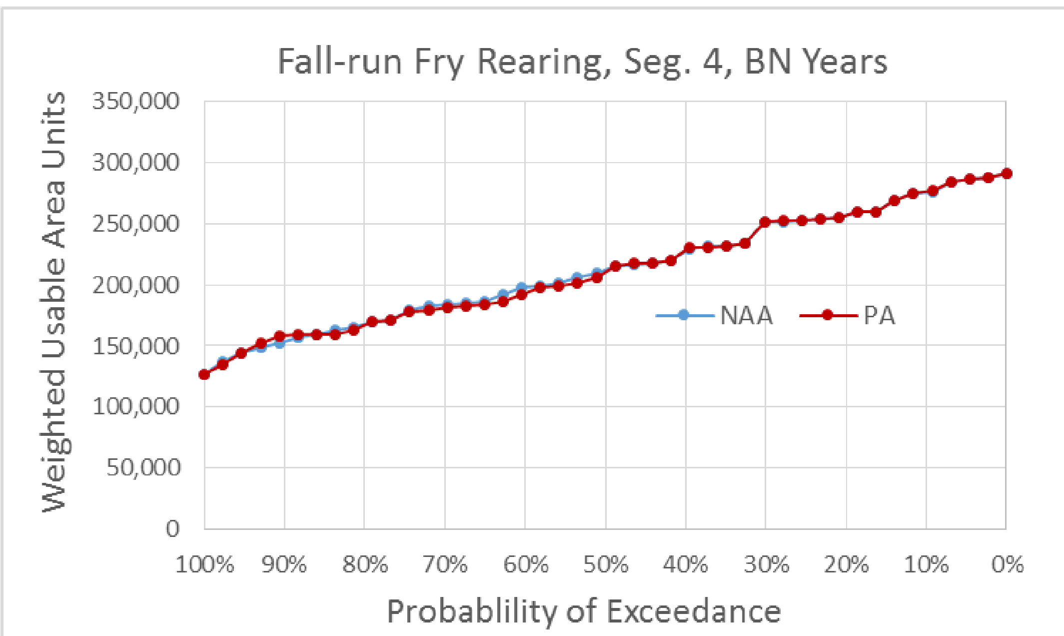


Figure 5.E-122. Exceedance Plot of Fall-Run Chinook Salmon Fry Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 4, Below Normal Water Years

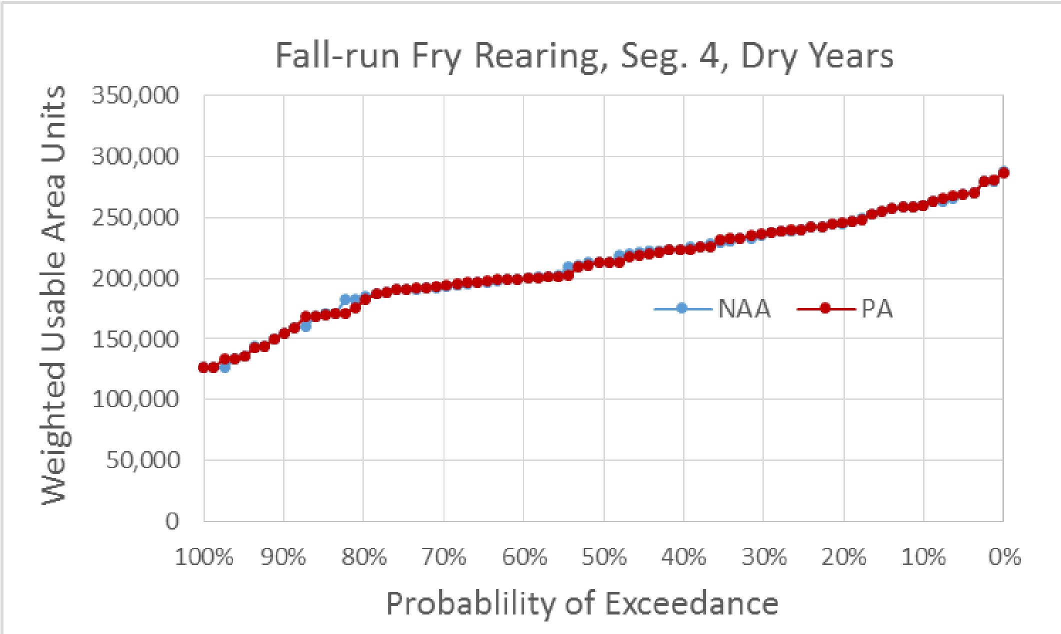


Figure 5.E-123. Exceedance Plot of Fall-Run Chinook Salmon Fry Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 4, Dry Water Years

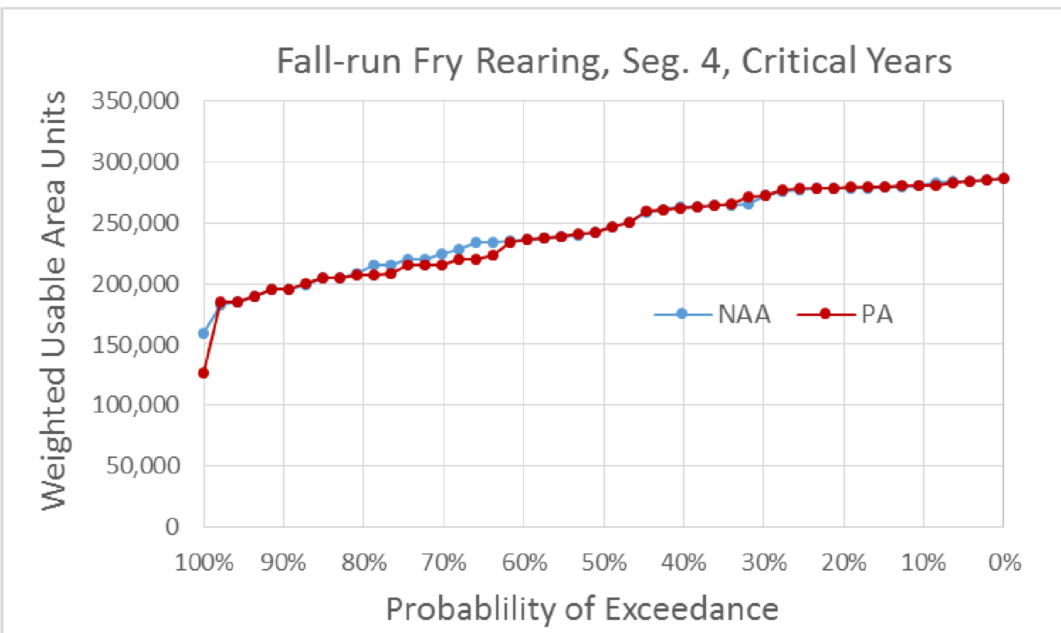


Figure 5.E-124. Exceedance Plot of Fall-Run Chinook Salmon Fry Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 4, Critical Water Years

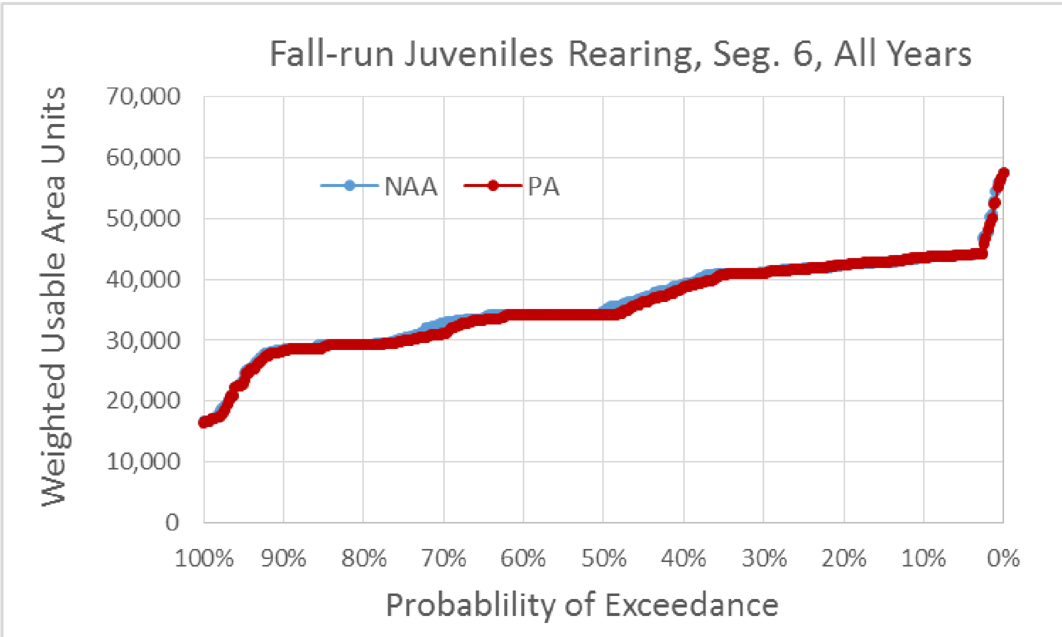


Figure 5.E-125. Exceedance Plot of Fall-Run Chinook Salmon Juvenile Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 6, All Water Years

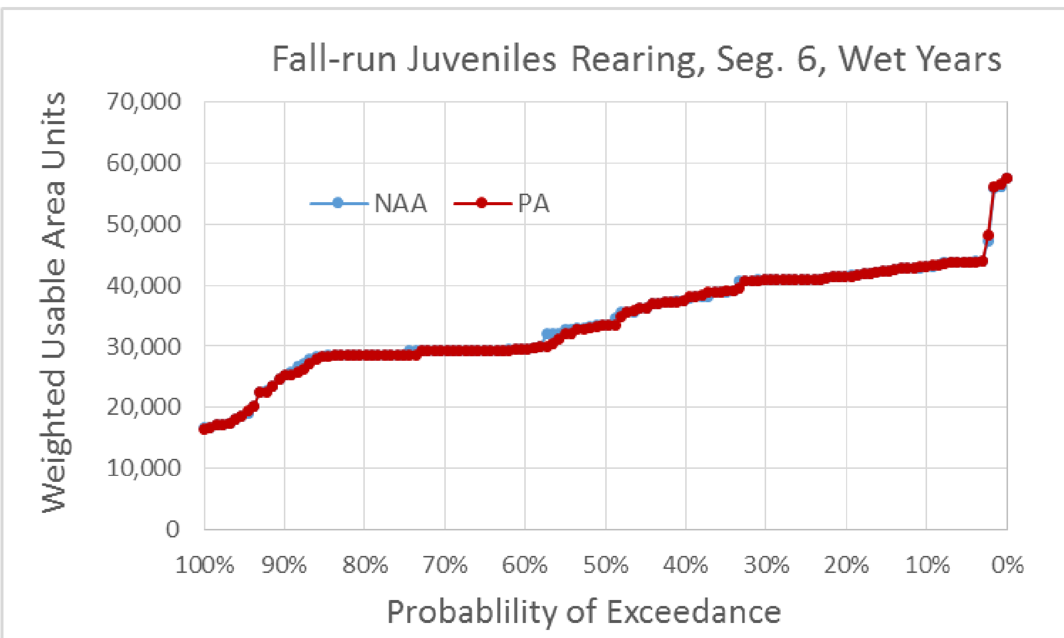


Figure 5.E-126. Exceedance Plot of Fall-Run Chinook Salmon Juvenile Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 6, Wet Water Years

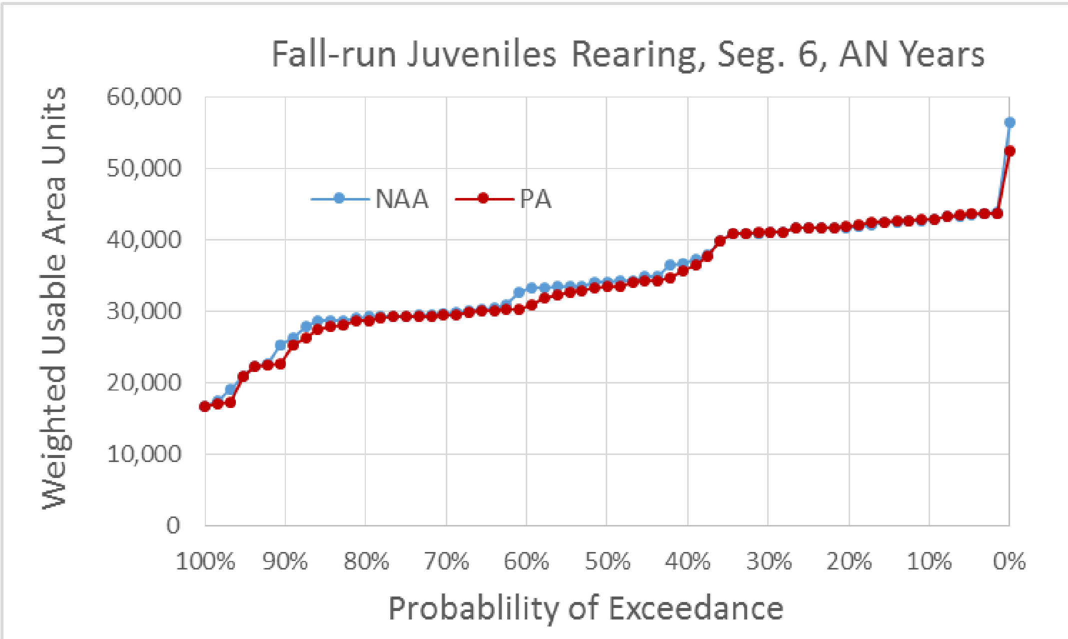


Figure 5.E-127. Exceedance Plot of Fall-Run Chinook Salmon Juvenile Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 6, Above Normal Water Years

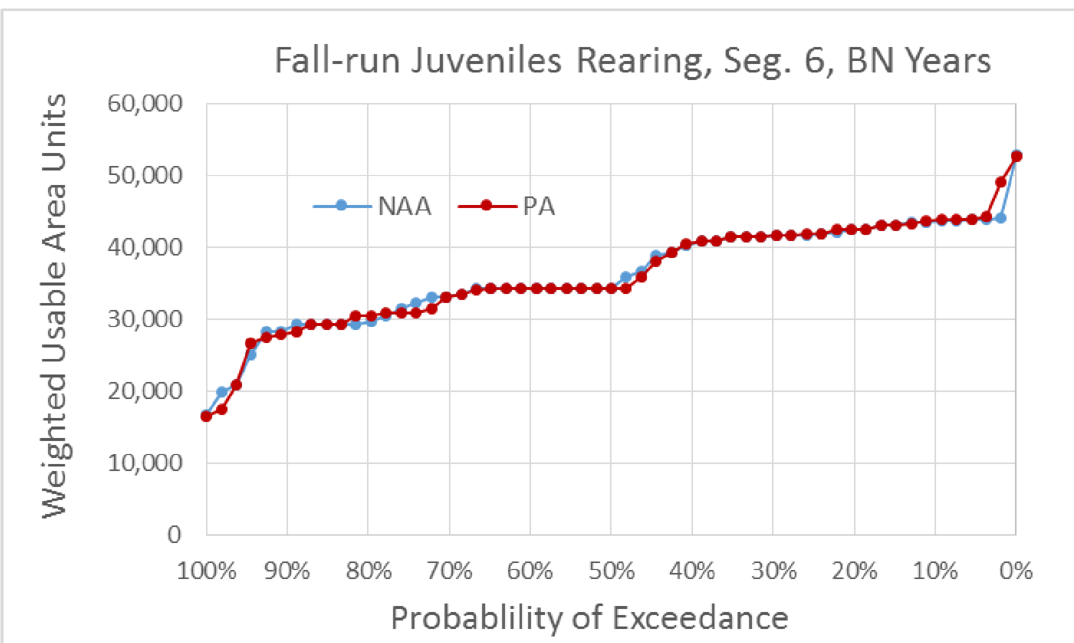


Figure 5.E-128. Exceedance Plot of Fall-Run Chinook Salmon Juvenile Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 6, Below Normal Water Years

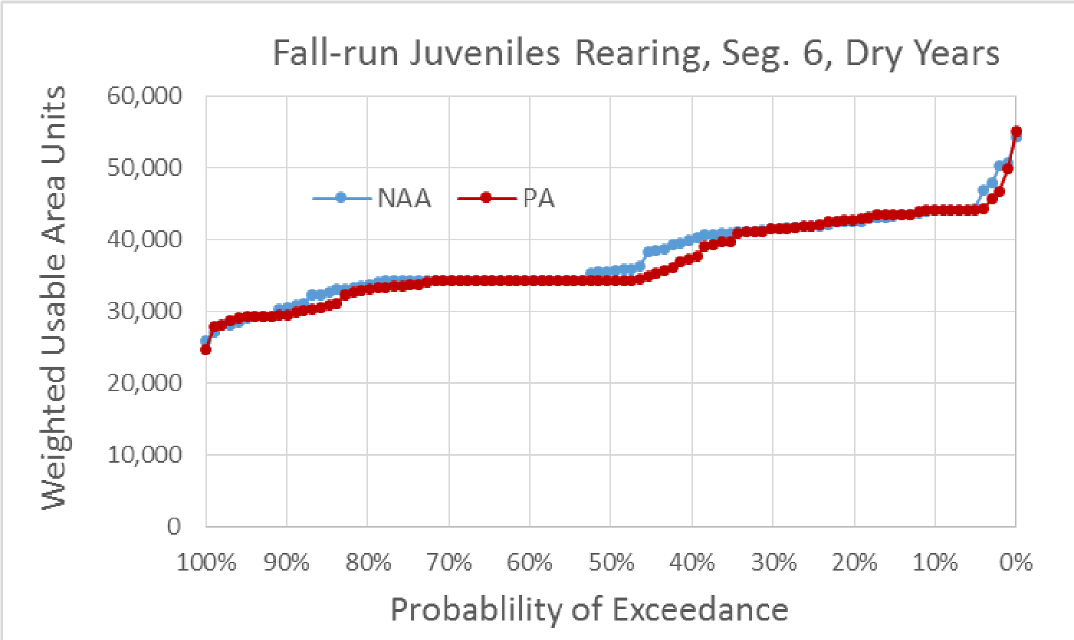


Figure 5.E-129. Exceedance Plot of Fall-Run Chinook Salmon Juvenile Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 6, Dry Water Years

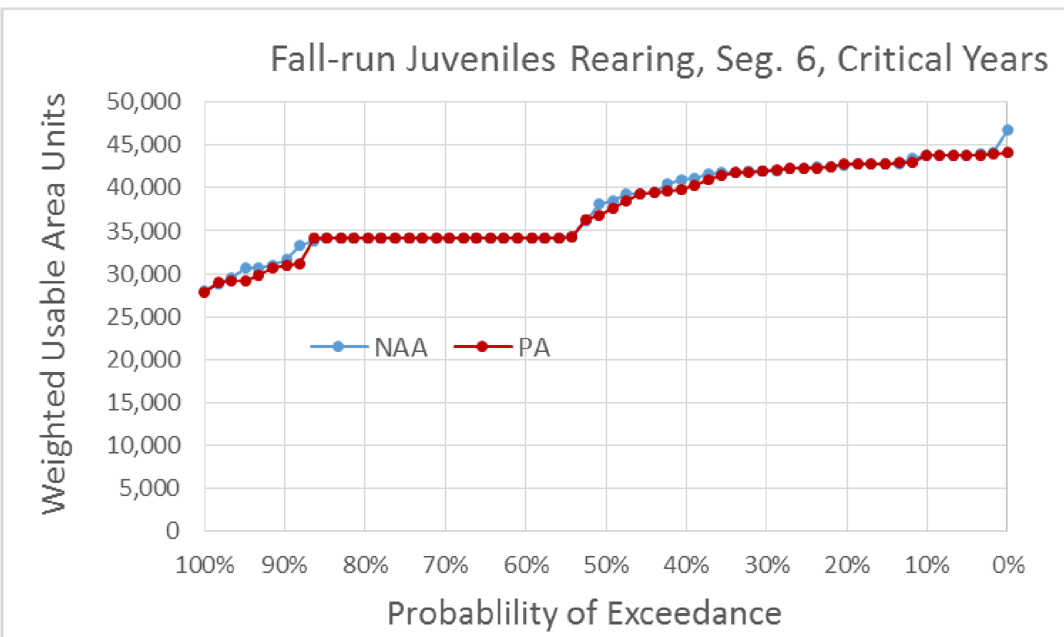


Figure 5.E-130. Exceedance Plot of Fall-Run Chinook Salmon Juvenile Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 6, Critical Water Years

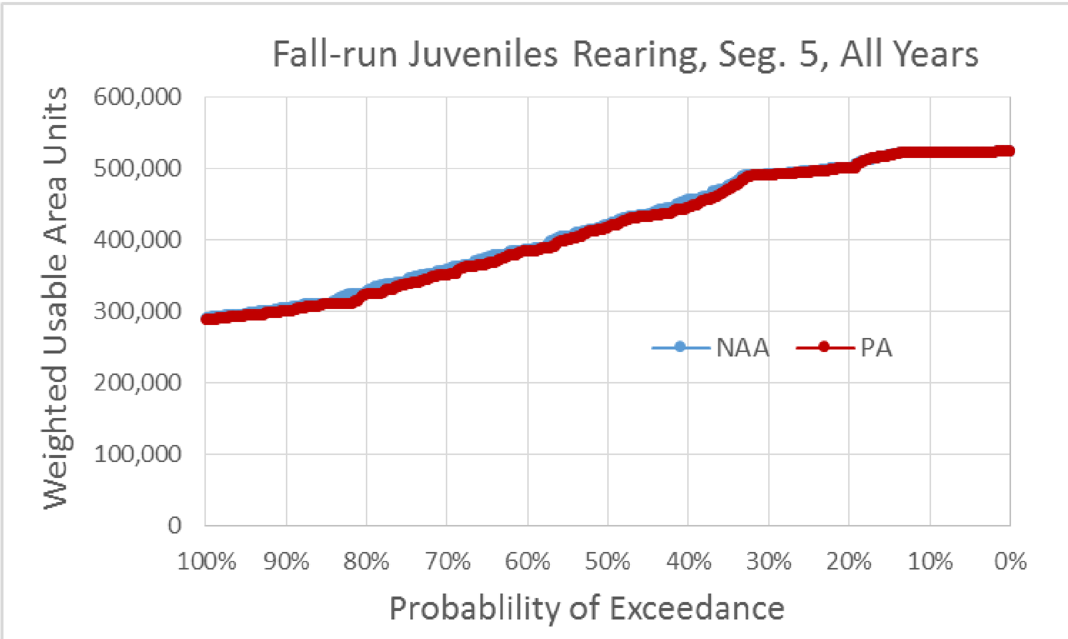


Figure 5.E-131. Exceedance Plot of Fall-Run Chinook Salmon Juvenile Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 5, All Water Years

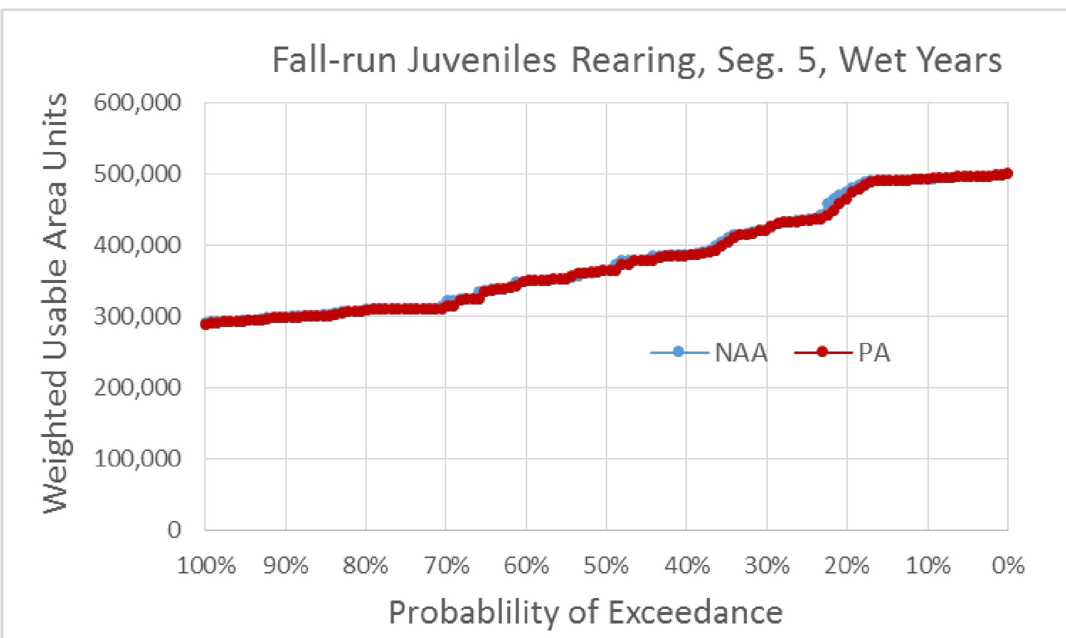


Figure 5.E-132. Exceedance Plot of Fall-Run Chinook Salmon Juvenile Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 5, Wet Water Years

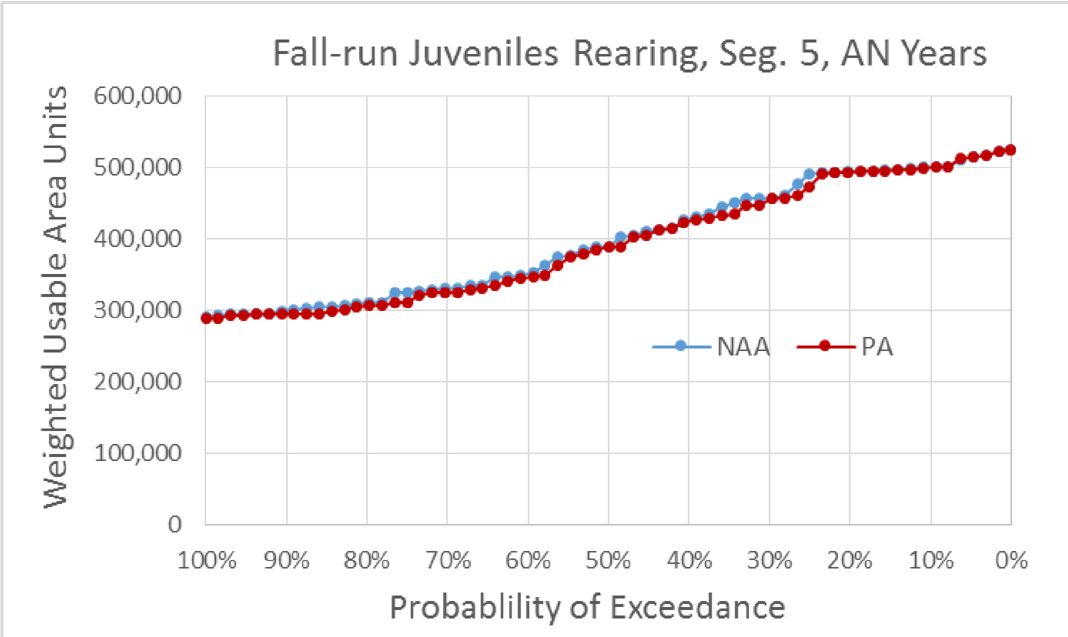


Figure 5.E-133. Exceedance Plot of Fall-Run Chinook Salmon Juvenile Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 5, Above Normal Water Years

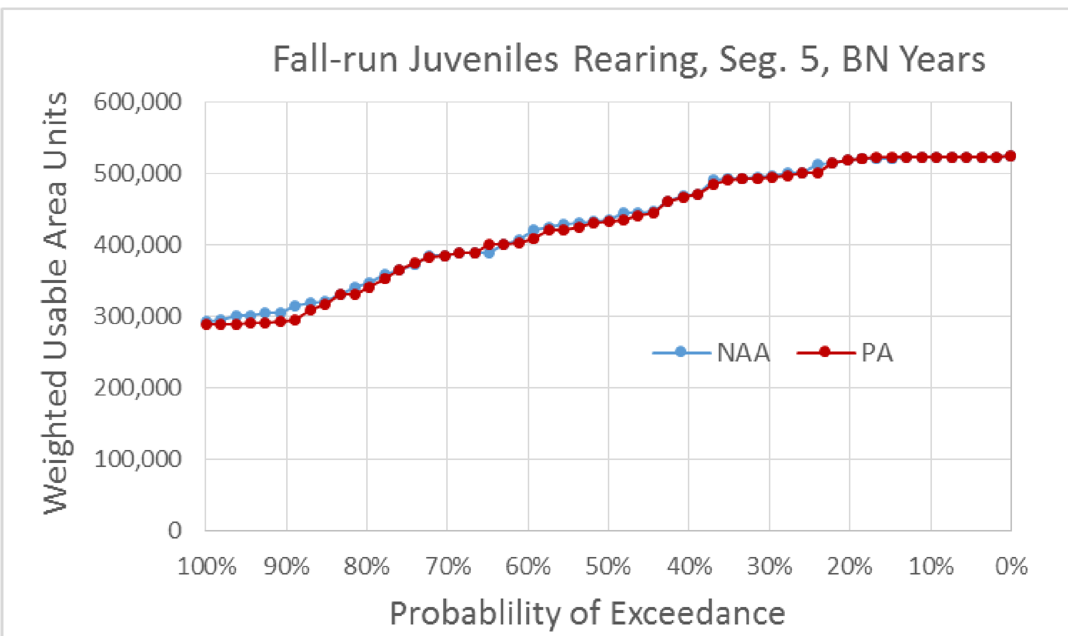


Figure 5.E-134. Exceedance Plot of Fall-Run Chinook Salmon Juvenile Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 5, Below Normal Water Years

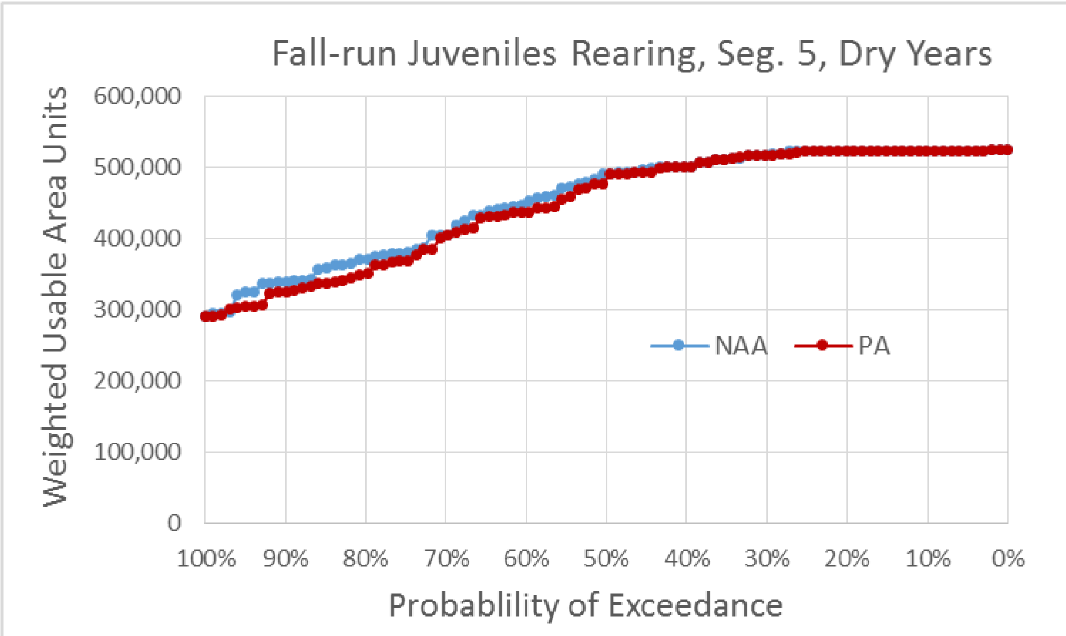


Figure 5.E-135. Exceedance Plot of Fall-Run Chinook Salmon Juvenile Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 5, Dry Water Years

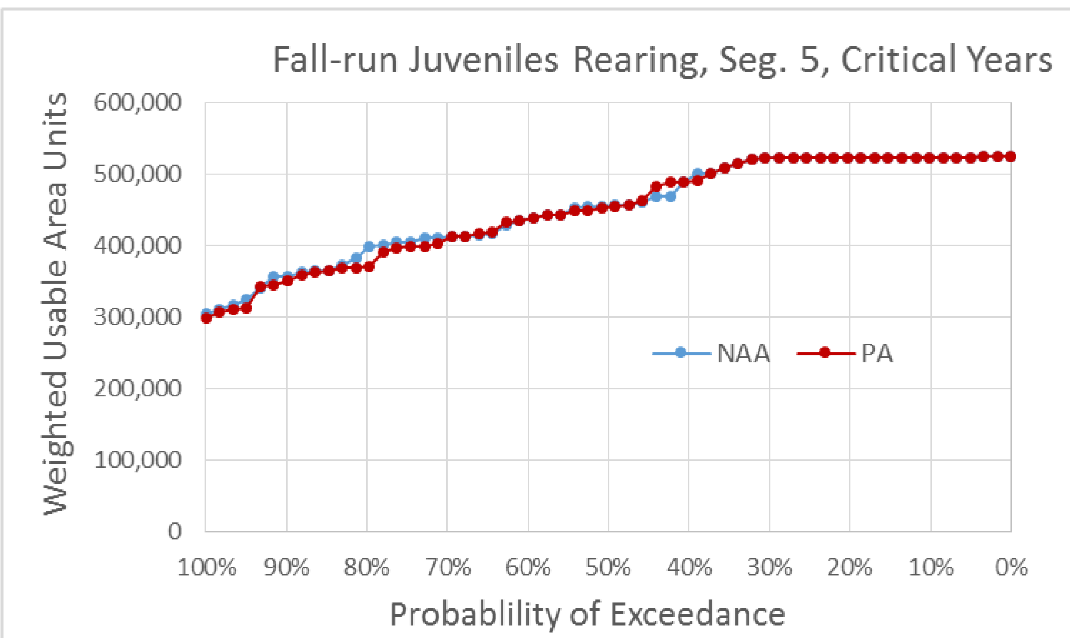


Figure 5.E-136. Exceedance Plot of Fall-Run Chinook Salmon Juvenile Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 5, Critical Water Years

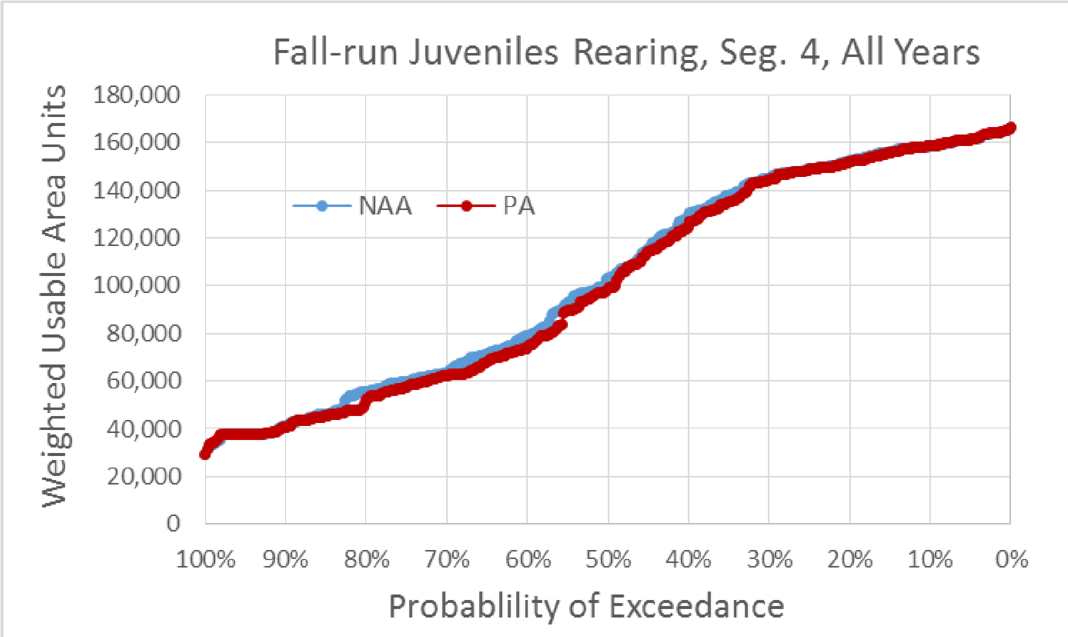


Figure 5.E-137. Exceedance Plot of Fall-Run Chinook Salmon Juvenile Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 4, All Water Years

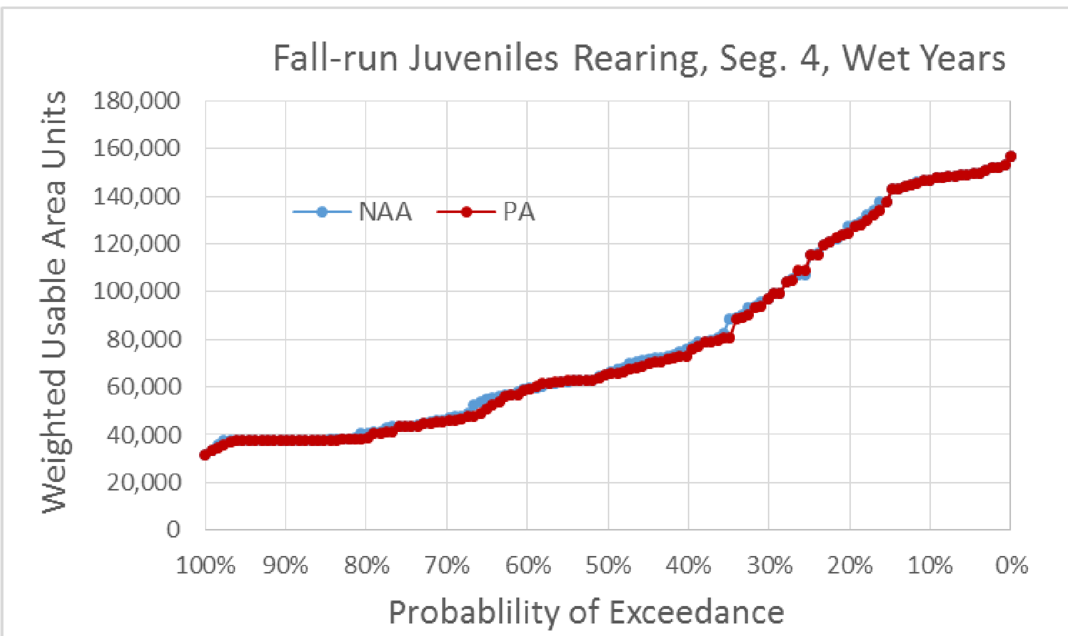


Figure 5.E-138. Exceedance Plot of Fall-Run Chinook Salmon Juvenile Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 4, Wet Water Years

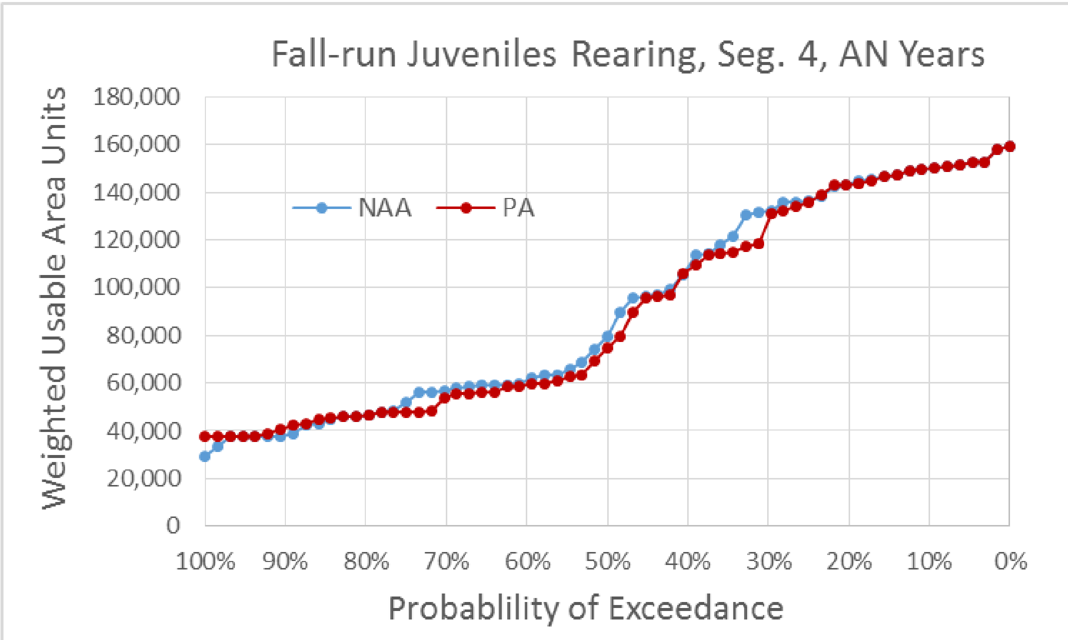


Figure 5.E-139. Exceedance Plot of Fall-Run Chinook Salmon Juvenile Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 4, Above Normal Water Years

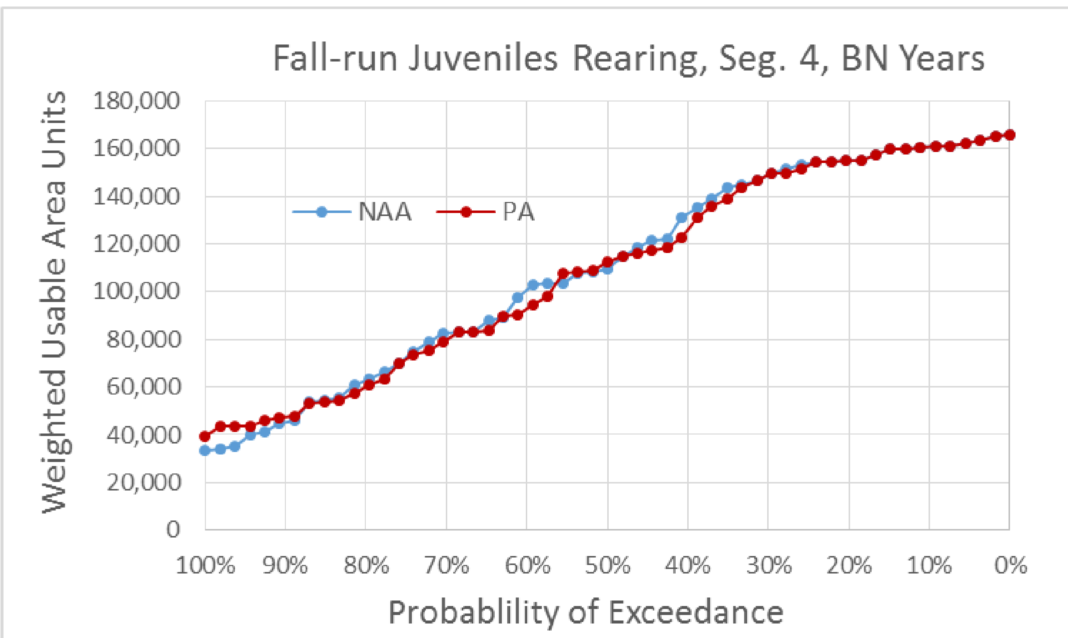


Figure 5.E-140. Exceedance Plot of Fall-Run Chinook Salmon Juvenile Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 4, Below Normal Water Years

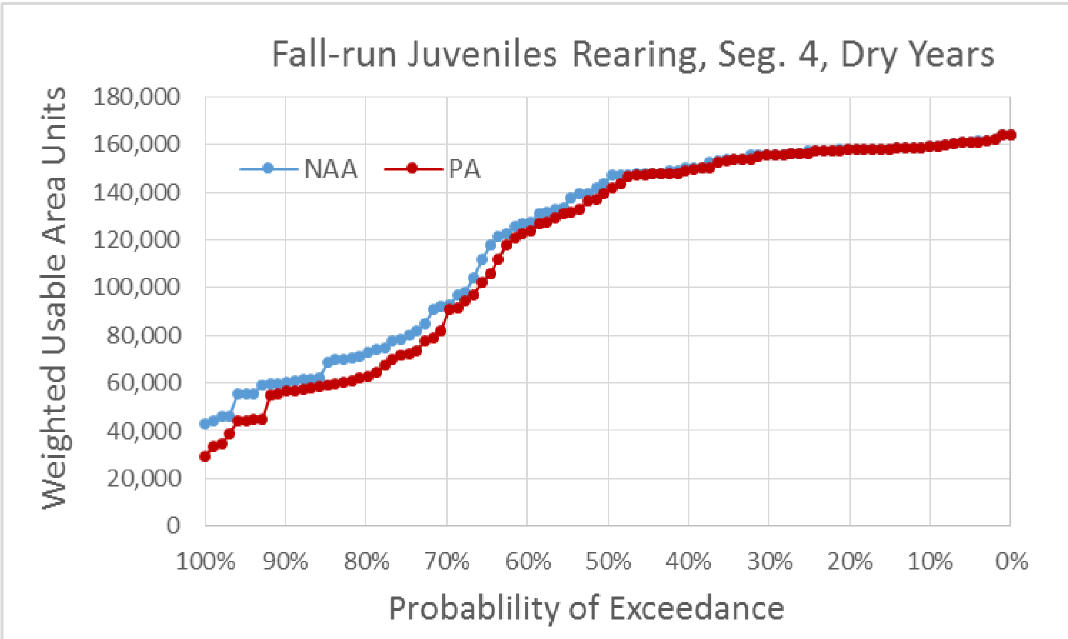


Figure 5.E-141. Exceedance Plot of Fall-Run Chinook Salmon Juvenile Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 4, Dry Water Years

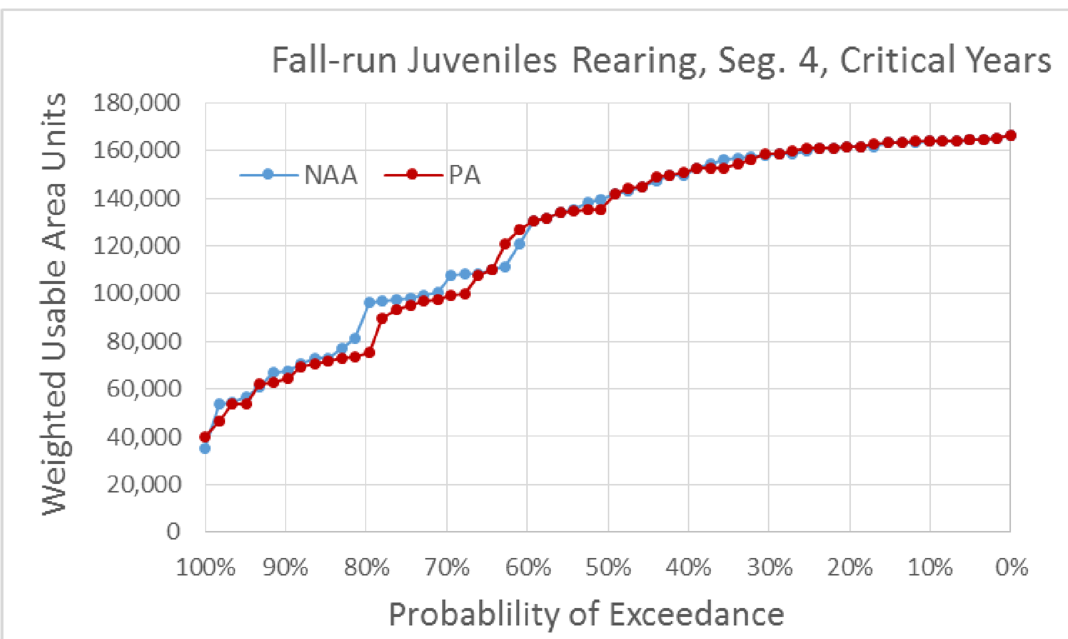


Figure 5.E-142. Exceedance Plot of Fall-Run Chinook Salmon Juvenile Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 4, Critical Water Years

Differences in fall-run Chinook salmon fry and juvenile rearing WUA in each segment under the PAA and NAA were also examined using the grand mean rearing WUA for each month of the fry and juvenile rearing periods under each water year type and all water year types combined (Table 5.E-39 to Table 5.E-44). The means for fry rearing WUA differed by less than 5% for all months and water year types in Segments 6 and 5 (Table 5.E-39 and Table 5.E-40). In Segment 4, means differed by 5% or more only for February and March of critical water years (6% increase and 5% reduction, respectively, under the PA) (Table 5.E-41). The means for juvenile rearing WUA differed by less than 5% for all months and water year types in Segment 5 (Table 5.E-43) and most months and water year types in Segments 6 and 4 (Table 5.E-42 and Table 5.E-44). In Segment 6, the mean WUA for juvenile rearing under the PA was 5% lower than that under the NAA during June of dry years (Table 5.E-42) and in Segment 4 it was 6% lower during March of above normal years, 5% lower during May of dry years, and 13% and 8% lower during June of dry and critical years, respectively (Table 5.E-44). As indicated above for the WUA exceedance plot results, the WUA modeling indicates that the PA could reduce fall-run Chinook salmon rearing habitat in a few months and water year types, although real-time unstream operations could minimize or eliminate this effect.

Table 5.E-39. Fall-run Chinook Salmon Fry Rearing Weighted Usable Areas (WUA) and Differences (Percent Differences) between Model Scenarios in River Segment 6 (green indicates PA is at least 5% higher [raw difference] than NAA; red indicates PA is at least 5% lower)

Month	Water Year Type	NAA	PA	PA vs. NAA
December	Wet	65,548	66,992	1444 (2%)
	Above Normal	66,635	66,829	194 (0.3%)
	Below Normal	65,809	66,446	637 (1%)
	Dry	72,907	72,256	-651 (-0.9%)
	Critical	70,121	70,661	540 (0.8%)
	All	68,239	68,737	498 (0.7%)
January	Wet	68,569	68,470	-100 (-0.1%)
	Above Normal	68,778	68,771	-6 (-0.01%)
	Below Normal	69,865	70,433	568 (0.8%)
	Dry	70,819	70,945	126 (0.2%)
	Critical	70,170	72,298	2128 (3%)
	All	69,559	69,945	386 (0.6%)
February	Wet	74,671	74,615	-56 (-0.1%)
	Above Normal	78,836	77,904	-932 (-1.2%)
	Below Normal	68,593	70,799	2205 (3%)
	Dry	69,051	69,175	124 (0.2%)
	Critical	70,032	71,994	1963 (3%)
	All	72,466	72,914	448 (0.6%)

Month	Water Year Type	NAA	PA	PA vs. NAA
March	Wet	68,969	68,959	-10 (-0.01%)
	Above Normal	65,666	66,332	666 (1%)
	Below Normal	67,559	66,943	-616 (-0.9%)
	Dry	69,088	69,040	-47 (-0.1%)
	Critical	70,461	68,172	-2288 (-3%)
	All	68,503	68,177	-326 (-0.5%)

Table 5.E-40. Fall-run Chinook Salmon Fry Rearing Weighted Usable Areas (WUA) and Differences (Percent Differences) between Model Scenarios in River Segment 5 (green indicates PA is at least 5% higher [raw difference] than NAA; red indicates PA is at least 5% lower)

Month	Water Year Type	NAA	PA	PA vs. NAA
December	Wet	1,279,311	1,299,436	20126 (2%)
	Above Normal	1,235,383	1,272,981	37598 (3%)
	Below Normal	1,285,634	1,284,178	-1457 (-0.1%)
	Dry	1,302,331	1,284,844	-17487 (-1%)
	Critical	1,478,631	1,478,842	211 (0.01%)
	All	1,308,875	1,316,421	7546 (0.6%)
January	Wet	1,243,402	1,184,743	-58659 (-5%)
	Above Normal	1,315,155	1,315,630	475 (0.04%)
	Below Normal	1,270,988	1,269,935	-1053 (-0.1%)
	Dry	1,284,618	1,275,452	-9167 (-0.7%)
	Critical	1,432,288	1,399,043	-33245 (-2%)
	All	1,296,173	1,270,407	-25766 (-2%)
February	Wet	1,129,301	1,109,445	-19856 (-2%)
	Above Normal	1,180,418	1,181,957	1539 (0.1%)
	Below Normal	1,283,450	1,283,647	197 (0.02%)
	Dry	1,454,111	1,441,233	-12879 (-0.9%)
	Critical	1,418,711	1,480,899	62188 (4%)
	All	1,279,658	1,279,592	-66 (-0.01%)
March	Wet	1,091,404	1,091,258	-146 (-0.01%)
	Above Normal	1,195,601	1,156,287	-39314 (-3%)
	Below Normal	1,404,991	1,353,652	-51339 (-4%)
	Dry	1,422,520	1,421,968	-552 (-0.04%)
	Critical	1,479,729	1,449,590	-30139 (-2%)
	All	1,287,578	1,269,866	-17711 (-1%)

Table 5.E-41. Fall-run Chinook Salmon Fry Rearing Weighted Usable Areas (WUA) and Differences (Percent Differences) between Model Scenarios in River Segment 4 (green indicates PA is at least 5% higher [raw difference] than NAA; red indicates PA is at least 5% lower)

Month	Water Year Type	NAA	PA	PA vs. NAA
December	Wet	197,730	203,064	5334 (3%)
	Above Normal	198,735	200,701	1967 (1%)
	Below Normal	212,080	211,503	-576 (-0.3%)
	Dry	200,937	202,090	1153 (0.6%)
	Critical	241,605	243,986	2380 (1%)
	All	207,119	209,682	2563 (1%)
January	Wet	188,718	184,053	-4666 (-2%)
	Above Normal	205,594	205,565	-28 (-0.01%)
	Below Normal	204,395	204,175	-220 (-0.1%)
	Dry	198,053	196,521	-1532 (-0.8%)
	Critical	230,927	219,761	-11166 (-5%)
	All	201,950	198,429	-3521 (-2%)
February	Wet	162,338	161,481	-857 (-0.5%)
	Above Normal	167,556	168,140	584 (0.3%)
	Below Normal	209,012	210,031	1020 (0.5%)
	Dry	224,619	224,143	-476 (-0.2%)
	Critical	245,154	259,482	14328 (6%)
	All	196,736	198,675	1939 (1%)
March	Wet	164,252	164,530	278 (0.2%)
	Above Normal	179,503	178,029	-1475 (-0.8%)
	Below Normal	225,589	222,993	-2596 (-1.2%)
	Dry	222,306	222,330	24 (0.01%)
	Critical	255,117	242,329	-12788 (-5%)
	All	202,355	199,996	-2359 (-1.2%)

Table 5.E-42. Fall-run Chinook Salmon Juvenile Rearing Weighted Usable Areas (WUA) and Differences (Percent Differences) between Model Scenarios in River Segment 6 (green indicates PA is at least 5% higher [raw difference] than NAA; red indicates PA is at least 5% lower)

Month	Water Year Type	NAA	PA	PA vs. NAA
February	Wet	28,792	28,607	-186 (-0.6%)
	Above Normal	28,233	28,133	-100 (-0.4%)
	Below Normal	29,268	29,101	-166 (-0.6%)
	Dry	33,062	33,018	-44 (-0.1%)
	Critical	33,245	34,224	978 (3%)
	All	30,460	30,496	35 (0.1%)
March	Wet	25,414	25,390	-24 (-0.1%)
	Above Normal	27,393	26,663	-731 (-3%)
	Below Normal	31,873	31,373	-500 (-2%)
	Dry	32,863	32,806	-58 (-0.2%)
	Critical	33,622	32,647	-975 (-3%)
	All	29,612	29,265	-347 (-1%)
April	Wet	39,471	39,526	55 (0.1%)
	Above Normal	41,850	41,523	-327 (-0.8%)
	Below Normal	42,342	43,080	738 (2%)
	Dry	42,862	43,323	461 (1%)
	Critical	42,321	42,262	-59 (-0.1%)
	All	41,478	41,646	168 (0.4%)
May	Wet	40,927	40,990	63 (0.2%)
	Above Normal	41,545	41,674	129 (0.3%)
	Below Normal	43,144	42,896	-248 (-0.6%)
	Dry	43,171	41,734	-1437 (-3%)
	Critical	42,326	42,435	108 (0.3%)
	All	42,074	41,747	-328 (-0.8%)
June	Wet	37,291	36,889	-402 (-1%)
	Above Normal	34,123	32,682	-1441 (-4%)
	Below Normal	34,136	34,230	94 (0.3%)
	Dry	35,461	33,581	-1880 (-5%)
	Critical	37,656	36,318	-1338 (-4%)
	All	35,973	34,975	-998 (-3%)

Table 5.E-43. Fall-run Chinook Salmon Juvenile Rearing Weighted Usable Areas (WUA) and Differences (Percent Differences) between Model Scenarios in River Segment 5 (green indicates PA is at least 5% higher [raw difference] than NAA; red indicates PA is at least 5% lower)

Month	Water Year Type	NAA	PA	PA vs. NAA
February	Wet	373,821	368,986	-4834 (-1%)
	Above Normal	378,117	377,920	-197 (-0.1%)
	Below Normal	450,190	445,515	-4674 (-1%)
	Dry	513,604	510,977	-2627 (-0.5%)
	Critical	508,642	522,494	13852 (3%)
	All	438,570	437,765	-805 (-0.2%)
March	Wet	366,405	366,379	-26 (-0.01%)
	Above Normal	424,177	410,918	-13258 (-3%)
	Below Normal	497,733	487,596	-10137 (-2%)
	Dry	506,508	505,929	-579 (-0.1%)
	Critical	519,295	512,383	-6912 (-1%)
	All	449,727	445,104	-4623 (-1%)
April	Wet	420,914	420,134	-780 (-0.2%)
	Above Normal	443,907	443,595	-311 (-0.1%)
	Below Normal	456,425	459,248	2823 (0.6%)
	Dry	478,483	474,249	-4234 (-0.9%)
	Critical	436,575	433,844	-2731 (-0.6%)
	All	445,656	444,306	-1350 (-0.3%)
May	Wet	394,060	394,839	779 (0.2%)
	Above Normal	413,996	413,087	-909 (-0.2%)
	Below Normal	413,934	415,744	1810 (0.4%)
	Dry	427,754	416,004	-11750 (-3%)
	Critical	432,727	429,645	-3082 (-0.7%)
	All	413,763	410,792	-2971 (-0.7%)
June	Wet	353,610	350,912	-2698 (-0.8%)
	Above Normal	333,162	323,726	-9436 (-3%)
	Below Normal	335,110	328,009	-7101 (-2%)
	Dry	339,645	326,841	-12804 (-4%)
	Critical	359,134	348,083	-11051 (-3%)
	All	345,289	337,245	-8044 (-2%)

Table 5.E-44. Fall-run Chinook Salmon Juvenile Rearing Weighted Usable Areas (WUA) and Differences (Percent Differences) between Model Scenarios in River Segment 4 (green indicates PA is at least 5% higher [raw difference] than NAA; red indicates PA is at least 5% lower)

Month	Water Year Type	NAA	PA	PA vs. NAA
February	Wet	72,975	70,412	-2563 (-4%)
	Above Normal	82,159	82,191	32 (0.04%)
	Below Normal	115,508	114,052	-1456 (-1%)
	Dry	150,024	148,480	-1544 (-1%)
	Critical	154,053	160,903	6850 (4%)
	All	110,794	110,417	-377 (-0.3%)
March	Wet	74,330	74,044	-287 (-0.4%)
	Above Normal	101,342	95,175	-6167 (-6%)
	Below Normal	146,884	139,687	-7197 (-5%)
	Dry	145,837	145,714	-123 (-0.1%)
	Critical	160,506	157,978	-2528 (-2%)
	All	118,397	115,963	-2434 (-2%)
April	Wet	100,706	100,259	-447 (-0.4%)
	Above Normal	114,559	114,471	-87 (-0.1%)
	Below Normal	125,936	128,216	2281 (2%)
	Dry	141,034	137,514	-3520 (-2%)
	Critical	123,099	121,151	-1948 (-2%)
	All	119,400	118,406	-993 (-0.8%)
May	Wet	84,773	85,296	522 (0.6%)
	Above Normal	103,129	102,211	-918 (-0.9%)
	Below Normal	102,810	103,712	901 (0.9%)
	Dry	113,644	107,550	-6093 (-5%)
	Critical	120,533	117,678	-2855 (-2%)
	All	102,378	100,615	-1763 (-2%)
June	Wet	64,501	63,511	-990 (-2%)
	Above Normal	55,834	54,584	-1250 (-2%)
	Below Normal	55,813	58,223	2411 (4%)
	Dry	61,880	53,985	-7895 (-13%)
	Critical	72,830	66,683	-6147 (-8%)
	All	62,541	59,527	-3014 (-5%)

As noted in Appendix 5D.2.3, *Rearing Flows Methods*, the stranding of juvenile salmonids by reductions in river flow is an important potential effect of the PA that is not evaluated in the effects analysis. If the PA were to result in more frequent rapid reductions in flow during the rearing periods of the target species, especially when side-channel rearing habitats are inundated, juvenile stranding mortality would be expected to increase. However, juvenile stranding generally results from reductions in flow that occur over short periods of time, and the CALSIM modeling used to evaluate flow in this effects analysis has a monthly time step, which is too long for any meaningful analysis of juvenile stranding. Operations of both the Sacramento and American Rivers include ramping rate restrictions, designed to minimize juvenile stranding, that limit the rate at which river flow can be changed (please see Appendix 5.D, Section 5.D.2.3, *Rearing Flow Methods*, for detail of these rates). These restrictions would be kept in place for the PA.

The SALMOD model provides predicted flow-related mortality of fall-run Chinook salmon fry and juvenile in the Sacramento River. The SALMOD results for flow-related mortality are presented in Table 5.E-37, together with results for the other sources of mortality of fall-run Chinook salmon predicted by SALMOD and discussed in other sections of this document. The flow-related mortality of fall-run Chinook salmon fry and juveniles includes categories for fry, pre-smolts, and immature smolts (see Attachment 5.D.2, *SALMOD Model*). The annual exceedance plot of flow-related mortality of fall-run Chinook salmon for the three life stages combined is presented in Figure 5.E-143. The results in Table 5.E-37 indicate that there would be 10% increases under the PA relative to the NAA in flow-related mortality of fall-run Chinook salmon immature smolts in wet and below normal years and a 7% increase in pre-smolt mortality in above normal years. Differences for other water year types would be less than 5% for all three stages.

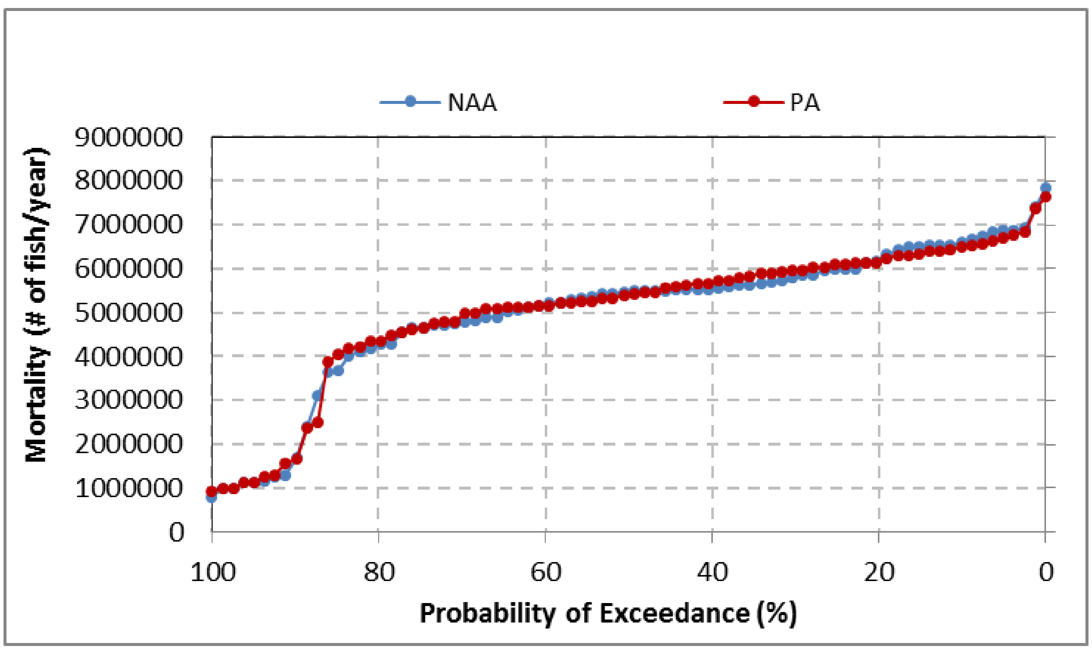


Figure 5.E-143. Exceedance Plot of Annual Flow-Based Mortality (#of Fish/Year) of Fall-Run Chinook Salmon Fry and Juveniles

Water Temperature-Related Effects

Mean monthly water temperatures during the December through June fry and juvenile rearing period for fall-run Chinook salmon in the Sacramento River upstream of the Delta (Table 5.E-23) are presented in Appendix 5.C, *Upstream Water Temperature Methods and Results*, Section 5.C.7, *Upstream Water Temperature Modeling Results*, Table 5.C.7-3, Table 5.C.7-4, Table 5.C.7-5, Table 5.C.7-7, Table 5.C.7-8, Table 5.C.7-10[13]. Overall, the PA would change mean water temperatures very little (less than 1°F, or approximately 1%) throughout the juvenile rearing reach of Keswick to Knights Landing in all months and water year types in the period. The largest increase in mean monthly water temperatures under the PA relative to NAA would be 0.3°F (0.5% to 0.7%), and would occur at Keswick, above Clear Creek, Balls Ferry, and Bend Bridge in below normal years during May. May is outside the peak period of presence for fall-run Chinook salmon fry and juveniles.

Exceedance plots of monthly mean water temperatures were examined during each month and water year type throughout the juvenile rearing period (Appendix 5.C, *Upstream Water Temperature Methods and Results,* Section 5.C.7, *Upstream Water Temperature Modeling Results*, Figure 5.C.7.3-7, Figure 5.C.7.4-7, Figure 5.C.7.5-7, Figure 5.C.7.7-7, Figure 5.C.7.8-7, Figure 5.C.7.10-7[14]). The curves for the PA generally match those of the NAA.

For purposes of this analysis, the water temperature thresholds analysis for fall-run Chinook salmon juvenile rearing and emigration have been combined and the period of December through June was evaluated. The threshold used was from the USEPA's 7DADM value of 61°F for the core juvenile rearing reach from Keswick to Red Bluff and 64°F for the non-core juvenile rearing reach at Knights Landing (Table 5.E-22). The 7DADM values were converted by month to function with daily model outputs (see Appendix 5.D, *Quantitative Methods and Detailed Results for Effects Analysis of Chinook Salmon, Central Valley Steelhead, Green Sturgeon, and Killer Whale*, Section 5.D.2.1, *Water Temperature Analysis Methods*, Table 5.D-4).

Results of the water temperature thresholds analysis are presented in Attachment 5.E.1, *Fall-/Late Fall-Run Chinook Salmon Water Temperature Threshold Analysis Results*, Tables 5.E.1-6 through 5.E.1-11. At all locations, there would be no months or water year types in which there would be both more than 5% more days under the PA compared to the NAA on which temperatures would exceed the threshold and a more-than-0.5°F difference in the magnitude of average daily exceedance. Therefore, the thresholds analysis indicates that any adverse effects would be undetectable on fall-run Chinook salmon juvenile rearing and emigration.

The SALMOD model provides predicted water temperature-related fry and juvenile fall-run Chinook salmon mortality, which is a combination of mortality of the fry, pre-smolt, and immature smolt life stages (see Attachment 5.D.2, *SALMOD Model*, for full model description). Results for water temperature-related mortality of these life stages are presented in Table 5.E-37 and the annual exceedance plot for all water year types combined is presented in Figure 5.E-144. These results indicate that there would generally be no increased water temperature-related

[13] Water temperature results for Wilkins Slough were used to represent Knights Landing for this analysis
[14] Water temperature results for Wilkins Slough were used to represent Knights Landing for this analysis

mortality under the PA relative to the NAA for each water year type separately and for all water year types combined.

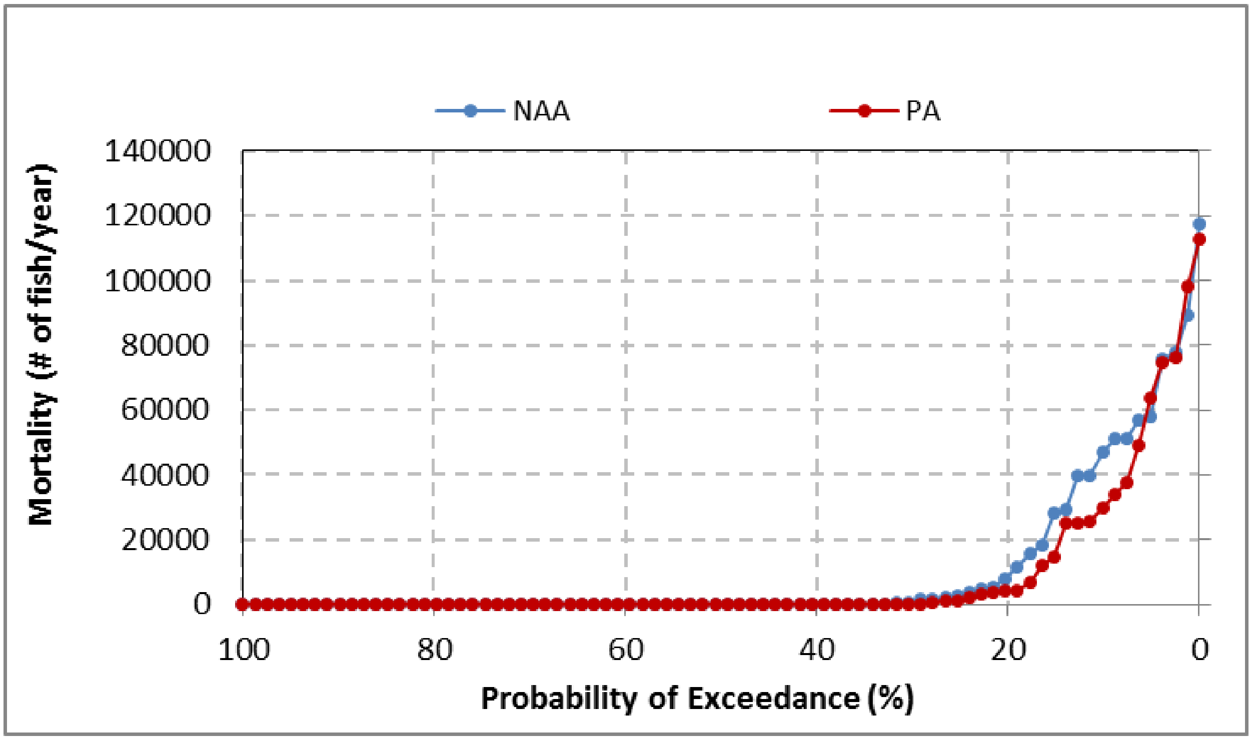


Figure 5.E-144. Exceedance Plot of Annual Water Temperature-Based Mortality (# of Fish/Year) of Fall-Run Chinook Salmon Fry and Juveniles

Juvenile Emigration

Flow-Related Effects

Mean monthly flows were evaluated in the Sacramento River at four locations along the downstream migration corridor of juvenile fall-run Chinook salmon; Keswick, Red Bluff, Wilkins Slough and Verona, during the December through June emigration period, with peak migration during January through March (Table 5.E-23). Changes in flow potentially affect emigration of juveniles, including the timing and rate of emigration, and conditions for feeding, protective cover, resting, temperature, turbidity, and other habitat factors, and can affect crowding and stranding, especially in side-channel habitats (Quinn 2005, Williams 2006, del Rosario et al. 2013). Quantitative relationships between flow and downstream migration generally are highly variable and poorly understood and, therefore, as described in Appendix 5.D.2.4, *Migration Flows Methods*, it is assumed for the purposes of this effects analysis that increased flow would improve conditions for emigration of juvenile fall-run Chinook salmon.

Shasta storage volume at the end of September may influence flow rates in the Sacramento River early in the juvenile emigration period and Shasta storage volume at the end of May influences flow in June. Mean Shasta September storage under the PA would also be similar (less than 5% difference) to storage under NAA for all water year types, except for 7% higher mean storage during critical water years under the PA (Appendix 5.A, *CALSIM Methods and Results,* Table 5.A.6-3). Mean Shasta May storage under the PA would be similar (less than 5% difference) to storage under NAA for all water year types.

Mean flow under the PA would be similar to (less than 5% difference) or greater than flow under the NAA during almost all months and water year types of the December through June fall-run Chinook salmon juvenile emigration period (3). Flows would be more than 5% lower under the PA than the NAA only during February of critical water years, for which flows would be 6% to 13% lower, depending on location, except at Verona (Appendix 5.A, *CALSIM Methods and Results,* Table 5.A.6-10, Tables 5.A.6-14, Table 5.A.6-35, Table 5.A.6-36). During December and April, all differences in flow at the four locations in all water year types would be less than 5%. During January, flow would range up to 18% higher under the PA than under the NAA in critical water years at Keswick and would be 7% higher in critical years at Red Bluff. During March, at Keswick only, flow would be 9% greater under the PA in above normal and below normal years and would be 8% higher in critical years. During June, flow under the PA would be greater at all locations, including all water year types at Verona and all water year types except wet years at the other locations. The June increases for all water year types would be greater at Wilkins Sough and Verona than those at Keswick and Red Bluff, ranging up to 25% greater flow under the PA for above normal years at Verona.

Water Temperature-Related Effects

Mean monthly water temperatures were evaluated in the Sacramento River in the reach from Keswick to Knights Landing[15] during the December through June juvenile emigration period for fall-run Chinook salmon, with a peak during December through February (Table 5.E-23). Overall, the PA would change mean water temperatures very little (less than 1°F, or approximately 1%) throughout the juvenile rearing reach of Keswick to Knights Landing in all months and water year types in the period (Appendix 5.C, *Upstream Water Temperature Methods and Results*, Section 5.C.7, *Upstream Water Temperature Modeling Results,* Table 5.C.5-3, Table 5.C.5-4, Table 5.C.5-5, Table 5.C.5-7, Table 5.C.5-8, Table 5.C.7-10). The largest increase in mean monthly water temperatures under the PA relative to NAA would be 0.3°F (0.5% to 0.7%), and would occur at Keswick, above Clear Creek, Balls Ferry, and Bend Bridge in below normal years during May. May is outside the peak period of presence for fall-run Chinook salmon fry and juveniles.

Exceedance plots of monthly mean water temperatures were examined during each month and water year type throughout the juvenile rearing period (Appendix 5.C, *Upstream Water Temperature Methods and Results,* Section 5.C.7, *Upstream Water Temperature Modeling Results*, Figure 5.C.7.3-7, Figure 5.C.7.4-7, Figure 5.C.7.5-7, Figure 5.C.7.7-7, Figure 5.C.7.8-7, Figure 5.C.7.10-7). The curves for the PA generally match those of the NAA.

Please see the discussion of water temperature thresholds for juvenile fall-run Chinook salmon emigration in the fry and juvenile rearing section above, which concludes that there would be no detectable water temperature-related effects of the PA on fall-run Chinook salmon juvenile rearing and emigration.

[15] Water temperature results for Wilkins Slough were used to represent Knights Landing for this analysis

Adult Immigration

Flow-Related Effects

Mean monthly flows were evaluated in the Sacramento River at four locations along the upstream migration corridor of adult fall-run Chinook salmon; Keswick, Red Bluff, Wilkins Slough, and Verona, during the July through December immigration period, with peak migration during August and September (Table 5.E-23). Changes in flow potentially affect conditions for upstream migration of adults, including bioenergetic cost, water quality, crowding, cues for locating natal streams, and passage conditions, but the quantitative relationship between flow and upstream migration is poorly understood (Quinn 2005, Milner et al. 2012). As described in Appendix 5.D.2.4, *Migration Flows Methods*, it is assumed for the purposes of this effects analysis that increased flow would improve conditions for upstream migration of adult fall-run Chinook salmon.

Shasta Reservoir storage volume at the end of May influences flow rates in the Sacramento River during the first part of the fall-run Chinook salmon immigration period, and Shasta storage volume at the end of September influences flows during the last part of the immigration period. Mean Shasta May storage under the PA would also be similar (less than 5% difference) to storage under NAA for all water year types (Appendix 5.A, *CALSIM Methods and Results*, Table 5.A.6-3). Mean Shasta September storage under the PA would be similar (less than 5% difference) to storage under NAA for all water year types, except for 7% higher mean storage during critical water years under the PA.

Mean flow under the PA at the Keswick, Red Bluff, Wilkins Slough and Verona locations in the Sacramento River would be similar to (less than 5% difference) or lower than flow under the NAA during the majority of months and water year types of the fall-run Chinook salmon adult migration period (Appendix 5.A, *CALSIM Methods and Results,* Table 5.A.6-10, Tables 5.A.6-14, Table 5.A.6-35, Table 5.A.6-36). During July of critical water years, flow would be 10% and 13% lower under the PA than under the NAA at Wilkins Slough and Verona, respectively. During August, mean flow in below normal years would be lower at all four locations, including up to 18% lower flow at Wilkins Slough, but during dry and critical years, flow under the PA would be greater (up to 10% greater) at Wilkins Slough and Verona. Mean flow during September would be lower for most water year types at all the locations, ranging up to 24% lower in below normal years at Verona. The differences in flow during August and September occur during the peak of the adult immigration period. During October, flow under the PA would lower at all the locations in wet years, ranging from 7% to 11% lower, but would be up to 17% higher in below normal and dry years. During November of wet and above normal water years, flow would be 26% lower under the PA than under the NAA at Keswick Dam, 21% lower at Red Bluff, up to 24% lower at Wilkins Slough, and up to 17% lower at Verona, but in critical water years flow would be greater at all the locations (up to 13% greater in Keswick). During December, all differences in flow at the four locations in all water year types would be less than 5%. Further discussion regarding flow-related effects during the June through November period is provided in Section 5.4.2.3, *Summary of Upstream Effects*.

As described in Appendix 5.D.2.4, *Migration Flows Methods*, mean monthly flow below about 3,250 cfs is considered to have potentially adverse effects on Chinook salmon, CCV steelhead, and green sturgeon adult immigration conditions in the Sacramento River. The effect of the PA on the frequency of flows below this threshold was evaluated by comparing CALSIM flows between the PA and the NAA at three of the migration corridor locations in the river: Keswick, Red Bluff, and Wilkins Slough. Of the 492 months within the fall-run Chinook salmon migration period, mean flow at Keswick was less than 3,250 cfs for 6 months under the NAA and 5 months under the PA. Mean flow at Red Bluff was less than 3,250 cfs only in one month under the PA and mean flow at Wilkins Slough was less than 3,250 cfs in 1 month under the NAA and 3 months under the NAA (Table 5.E-45).

Table 5.E-45. Number and Percent of the 492 Months within the Fall-run Chinook Salmon Adult Immigration Period from the 82-Year CALSIM Record with Flow < 3,250 cfs

	Months with Mean Flow < 3,250 cfs		**Percent with Mean Flow < 3,250 cfs**		**Difference in Months and Percent Difference**
Location	NAA	PA	NAA	PA	PA vs. NAA
Keswick	6	5	1.2	1.0	-1 (-17%)
Red Bluff	0	1	0.0	0.2	1 (NA[1])
Wilkins Slough	1	3	0.2	0.6	2 (200%)

[1]NA = Could not calculate because dividing by 0

These results indicate that any adverse flow-related effects would be undetectable to fall-run Chinook salmon adult immigration conditions in the Sacramento River.

Water Temperature-Related Effects

Mean monthly water temperatures were evaluated in the Sacramento River at Keswick, Bend Bridge, and Red Bluff during the July through December adult immigration period for fall-run Chinook salmon (Table 5.E-23). Overall, the PA would change mean water temperatures very little (less than 1°F, or approximately 1%) at these locations in all months and water year types in the period (Appendix 5.C, *Upstream Water Temperature Methods and Results*, Section 5.C.7, *Upstream Water Temperature Modeling Results*, Table 5.C.7-3, Table 5.3.7-7, Table 5.C.7-8). The largest increase in mean monthly water temperatures under the PA relative to NAA would be 0.6°F (0.9% to 1.1%), and would occur at Bend Bridge in below normal years during September and at Red Bluff in below normal years during August and above normal and below normal water years during September.

Exceedance plots of monthly mean water temperatures were examined during each month and water year type throughout the adult immigration period (Appendix 5.C, *Upstream Water Temperature Methods and Results*, Section 5.C.7, *Upstream Water Temperature Modeling Results*, Figure 5.C.7.3-7, Figure 5.C.7.7-7, Figure 5.C.7.8-7). The curves for the PA generally match those of the NAA. For the cases with the highest increase in mean monthly water temperatures under the PA, temperatures under the PA would be consistently higher than those under the NAA by 0.5°F to 1°F across the range of temperatures (Figure 5.E-146, Figure 5.E-145, Figure 5.E-147, Figure 5.E-148).

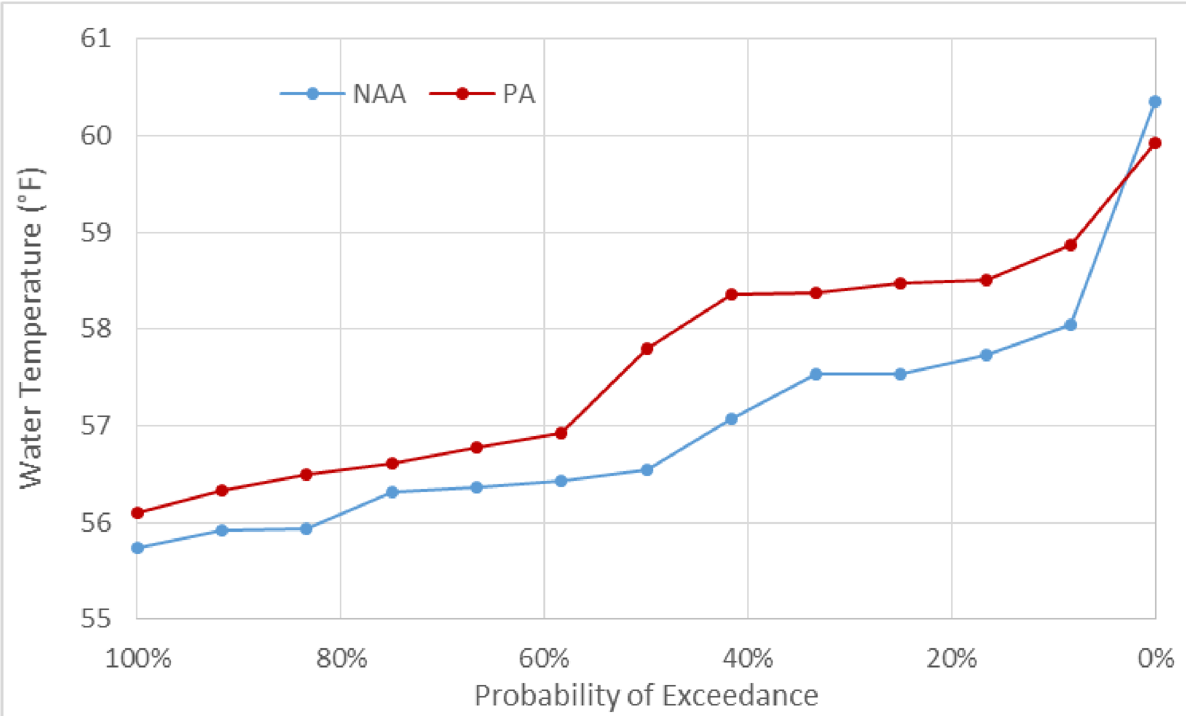


Figure 5.E-145. Exceedance Plot of Mean Monthly Water Temperatures (°F) in the Sacramento River at Red Bluff in September of Above Normal Water Years

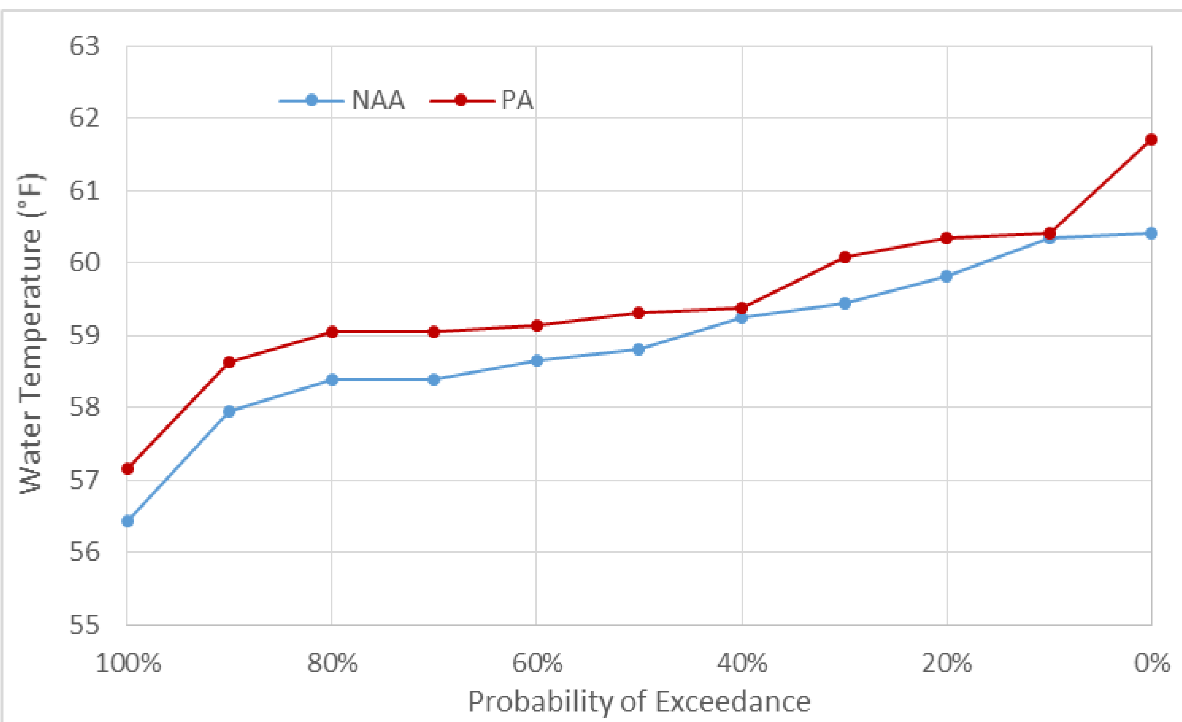


Figure 5.E-146. Exceedance Plot of Mean Monthly Water Temperatures (°F) in the Sacramento River at Bend Bridge in September of Below Normal Water Years

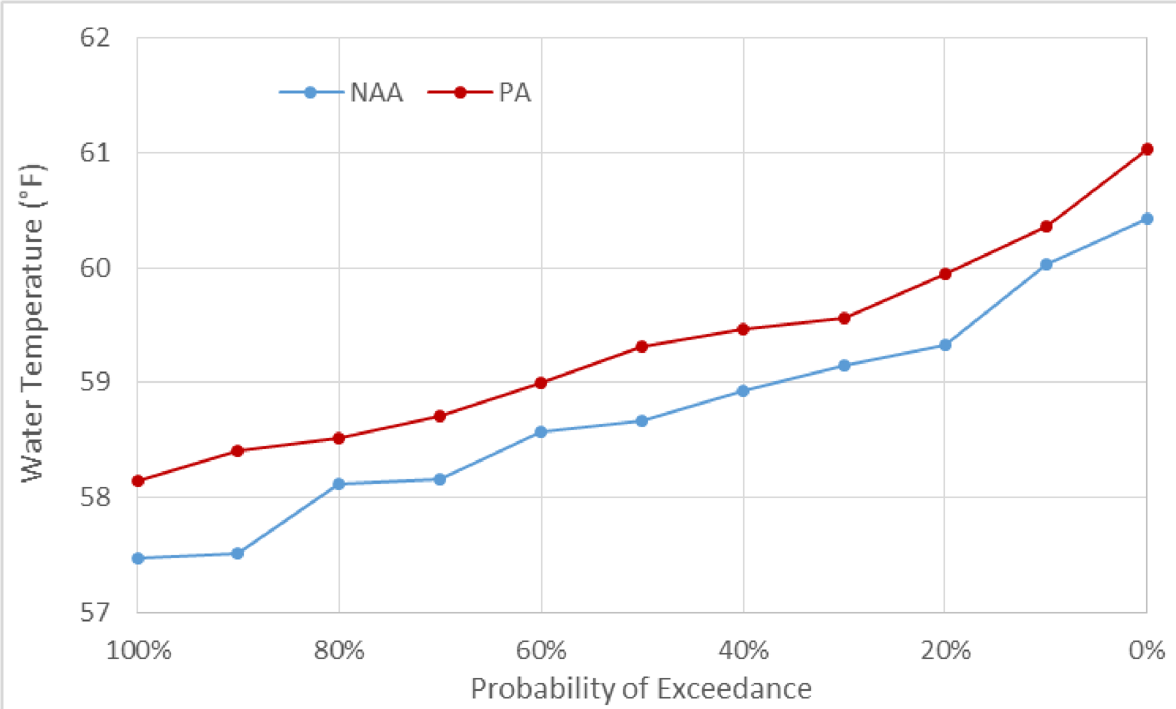


Figure 5.E-147. Exceedance Plot of Mean Monthly Water Temperatures (°F) in the Sacramento River at Red Bluff in August of Below Normal Water Years

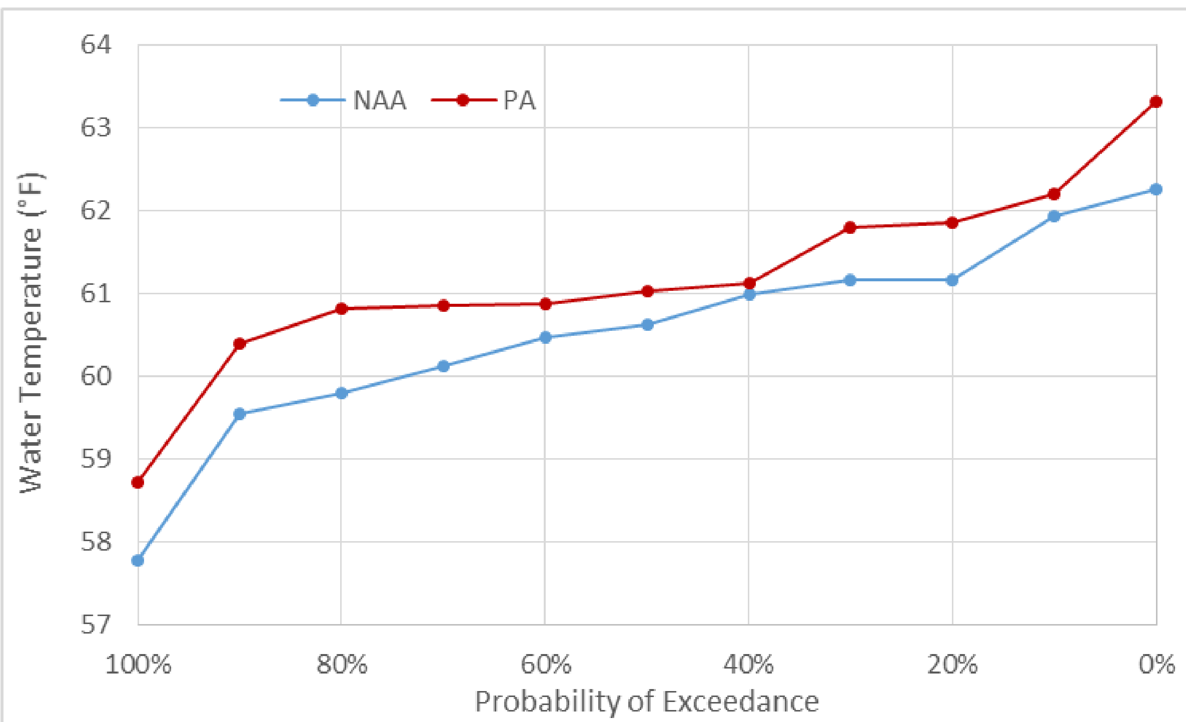


Figure 5.E-148. Exceedance Plot of Mean Monthly Water Temperatures (°F) in the Sacramento River at Red Bluff in September of Below Normal Water Years

The USEPA's 7DADM threshold value of 68°F was used to evaluate water temperature threshold exceedance during the fall-run Chinook salmon adult immigration life stage at Keswick, Bend Bridge, and Red Bluff (Table 5.E-22). The threshold was converted to function with daily model outputs for each month separately (Appendix 5.D, *Quantitative Methods and Detailed Results for Effects Analysis of Chinook Salmon, Central Valley Steelhead, Green Sturgeon, and Killer Whale*, Section 5.D.2.1, *Water Temperature Analysis Methods*, Table 5.D-4).

Results of the water temperature thresholds analysis are presented in Attachment 5.E.1, *Fall-/Late Fall-Run Chinook Salmon Water Temperature Threshold Analysis Results*, Table 5.E-12 through 5.E-14. At Keswick and Red Bluff, there would be no months or water year types in which there would be 5% more days under the PA compared to the NAA on which temperatures would exceed the threshold, and no more-than-0.5°F difference in the magnitude of average daily exceedance (Attachment 5.E.1, *Fall-/Late Fall-Run Chinook Salmon Water Temperature Threshold Analysis Results*, Table 5.E.1-12 and Table 5.E.1-14).

At Bend Bridge, there would be two instances during which the percent of days exceeding the 68°F DADM under the PA would be more than 5% higher than under the NAA: August in critical years (5.1% higher under the PA) and September of critical years (5.3% higher under the PA) (Attachment 5.E.1, *Fall-/Late Fall-Run Chinook Salmon Water Temperature Threshold Analysis Results*, Table 5.E.1-13). However, there would be a negligible (less than 0.1°F) difference in average daily exceedance in both instances. Therefore, it was concluded that any adverse effects on fall-run adult immigration would be undetectable.

Overall, these temperature threshold analysis results indicate that any adverse water temperature-related effects of the PA relative to the NAA on fall-run Chinook salmon adult immigration conditions in the Sacramento River would be undetectable.

Adult Holding

<u>Flow-Related Effects</u>

Mean monthly flow rates and reservoir storage volumes were examined for the PA and NAA in the Sacramento River at the Keswick and Red Bluff locations during the July and August adult holding period for fall-run Chinook salmon (Table 5.E-23). Changes in flow likely affect holding habitat, with higher flows potentially providing greater depths and improved water quality in pools. Shasta Reservoir storage volume at the end of May influences flow rates below the dam during the holding period. Mean Shasta May storage under the PA would be similar (less than 5% difference) to storage under NAA for all water year types (Appendix 5.A, *CALSIM Methods and Results*, Table 5.A.6-3). During the July and August holding period, PA would result in no changes (less than 5% difference) in mean flow in the Sacramento River, except for 10% lower flow during August of below normal years at both the Keswick and Red Bluff locations (Appendix 5.A, *CALSIM Methods and Results*, Table 5.A.6-10, Table 5.A.6-35).

<u>Water Temperature-Related Effects</u>

Mean monthly water temperatures were evaluated in the Sacramento River at Keswick, Balls Ferry, and Red Bluff during the July and August adult holding period for fall-run Chinook salmon (Table 5.E-23). Overall, the PA would change mean water temperatures very little (less than 1°F, or approximately 1%) at these locations in all months and water year types in the period (Appendix 5.C, *Upstream Water Temperature Methods and Results*, Section 5.C.7, *Upstream Water Temperature Modeling Results*, Table 5.C.7-3, Table 5.C.7-5, Table 5.C.7-8). The largest increase in mean monthly water temperatures under the PA relative to NAA would be 0.6°F (0.9%), and would occur at Red Bluff in below normal years during August.

Exceedance plots of monthly mean water temperatures were examined during each month and water year type throughout the adult holding period (Appendix 5.C, *Upstream Water Temperature Methods and Results*, Section 5.C.7, *Upstream Water Temperature Modeling Results*, Figure 5.C.7.3-7, Figure 5.C.7.5-7, Figure 5.C.7.8-7). The curves for PA generally match those of the NAA. For below normal water years in August at Red Bluff, where the largest increase in mean monthly water temperature was seen, the PA curve is consistently higher than the NAA curve by approximately 0.5°F (Figure 5.E-147).

To evaluate water temperature threshold exceedance during the adult holding life stage at Keswick, Balls Ferry, and Red Bluff, the USEPA's 7DADM threshold value of 61°F was used (Table 5.E-22) (U.S. Environmental Protection Agency 2003). The threshold was converted to function with daily model outputs for each month separately (Appendix 5.D, *Quantitative Methods and Detailed Results for Effects Analysis of Chinook Salmon, Central Valley Steelhead, Green Sturgeon, and Killer Whale*, Section 5.D.2.1, *Water Temperature Analysis Methods*, Table 5.D-4).

Results of the water temperature thresholds analysis are presented in Attachment 5.E.1, *Fall-/Late Fall-Run Chinook Salmon Water Temperature Threshold Analysis Results*, Table 5.E.1-15 through Table 5.E.1-17. At Keswick, there would be no months or water year types in which there would be 5% more days under the PA compared to the NAA on which temperatures would exceed the threshold and no more-than-0.5°F difference in the magnitude of average daily exceedance (Attachment 5.E.1, *Fall-/Late Fall-Run Chinook Salmon Water Temperature Threshold Analysis Results*, Table 5.E.1-15).

At Balls Ferry, the percent of days exceeding the 61°F DADM threshold for adult holding habitat under the PA would not differ by more than 5% in any month or water year type (Attachment 5.E.1, *Fall-/Late Fall-Run Chinook Salmon Water Temperature Threshold Analysis Results*, Table 5.E.1-16). The average daily exceedance under the PA would increase by 0.7°F in August of all water year types combined. However, combined, these results indicate that any adverse effects would be undetectable at Balls Ferry.

At Red Bluff, the percent of days exceeding the 61°F 7DADM threshold for adult holding habitat under the PA would be more than 5% higher than under the NAA during July (6.5%) of critical water years and during August of below normal water years (9.4%) (Attachment 5.E.1, *Fall-/Late Fall-Run Chinook Salmon Water Temperature Threshold Analysis Results*, Table 5.E.1-17). However, in none of these situations would there also be a more than 0.5°F difference in the magnitude of average daily exceedance. Therefore, it was concluded that any adverse effects would be undetectable.

Overall, the thresholds analysis indicates that any adverse effects would be unlikely on fall-run Chinook salmon adults holding in the Sacramento River.

SALMOD

The SALMOD model is not a life cycle model, but behaves like a life cycle model in that it integrates all early life stages of a Chinook salmon race together on an annual basis and provides an *Annual Potential Production* value (Attachment 5.D.2, *SALMOD Model*). This value represents all individuals that survive from the *pre-spawn egg* stage through the *immature smolt* stage in each year of the 80-year simulation period. Individual years are independent of one another and, therefore, effects through time cannot be evaluated as a time series.

Mean fall-run Chinook salmon production values and differences between scenarios are presented in Table 5.E-46 and an exceedance plot is provided in Figure 5.E-149. Overall, these results indicate that changes in fall-run Chinook salmon production under the PA relative to the NAA would be negligible. This result is consistent among water year types and when all water year types are combined.

Table 5.E-46. Mean Annual Potential Production of Fall-Run Chinook Salmon and Differences between Model Scenarios, SALMOD

Analysis Period	Annual Potential Production (# of Fish/year)
All Water Year Types Combined	
Full Simulation Period[1]	
NAA	16,824,420
PA	16,875,132
Difference	50,711
Percent Difference[2]	0
Water Year Types[3]	
Wet (32.5%)	
NAA	16,446,645
PA	16,576,495
Difference	129,850
Percent Difference	1
Above Normal (12.5%)	
NAA	16,075,201
PA	15,988,318
Difference	-86,883
Percent Difference	-1
Below Normal (17.5%)	
NAA	19,280,526
PA	19,296,176
Difference	15,650
Percent Difference	0
Dry (22.5%)	
NAA	17,979,387
PA	17,883,009
Difference	-96,378
Percent Difference	-1
Critical (15%)	

Analysis Period	Annual Potential Production (# of Fish/year)
NAA	14,184,298
PA	14,485,020
Difference	300,722
Percent Difference	2

[1] Based on the 80-year simulation period
[2] Relative difference of the annual average
[3] As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (State Water Resources Control Board 1995). Water years may not correspond to the biological years in SALMOD.

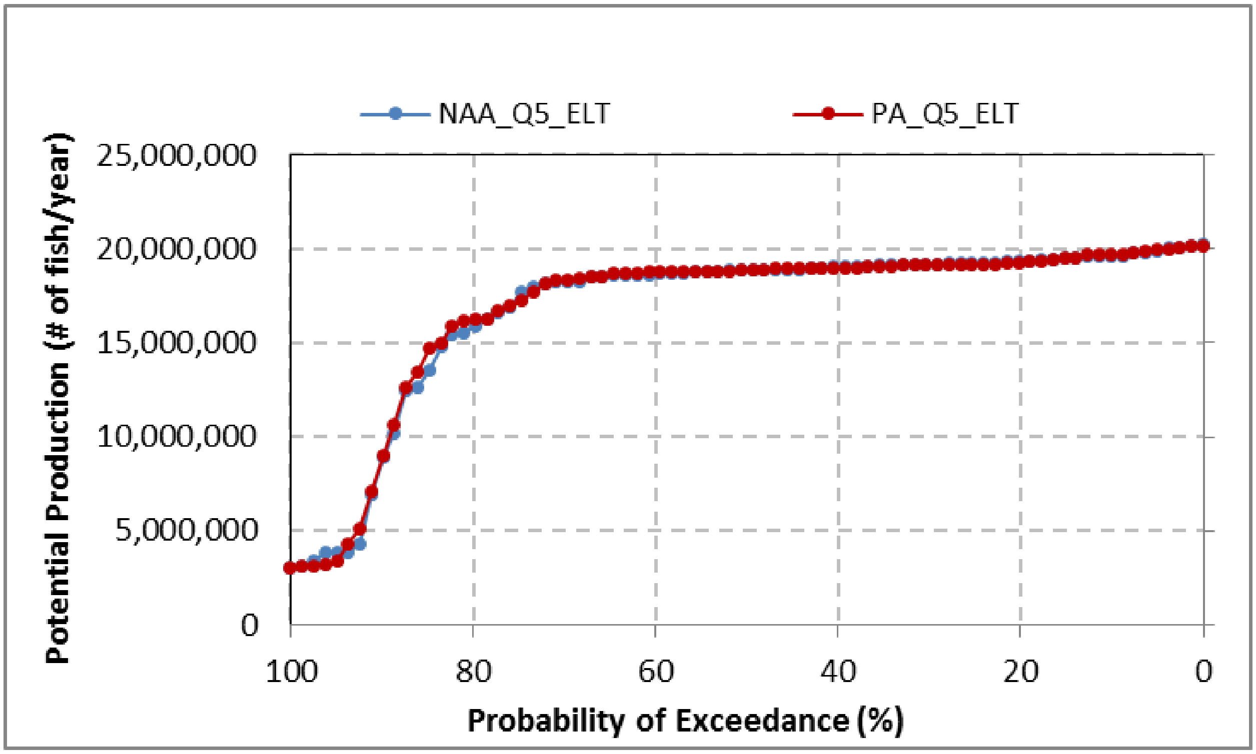


Figure 5.E-149. Exceedance Plot for Annual Potential Production (# of Fish/Year) of Fall-Run Chinook Salmon, SALMOD

The frequency at which annual production was below minimum production thresholds was evaluated as a measure of a worst-case scenario for fall-run Chinook salmon. Thresholds were determined as 5% and 10% of the number of eggs used as inputs into the model. The initial egg value was 56,115,000 for both NAA and PA and, therefore, the 5% and 10% values were 2,805,750 fish per year and 5,611,500 fish per year, respectively. Results are presented in Table 5.E-47. There would be 0 and 7 years during which production would be below the 5% (2,805,750 fish) and 10% (5,611,500 fish) thresholds, respectively, under both the NAA and PA. Therefore, the PA would have no negative effects on the frequency of worst-case scenario years for fall-run Chinook salmon.

Table 5.E-47. Number of Years during which Fall-Run Chinook Salmon Production Would be Lower than Production Thresholds and Differences (Percent Differences) between Model Scenarios, SALMOD

Production Threshold (# of Fish)	NAA (# of Years)	PA (# of Years)	PA vs. NAA (# of Years [%])
2,805,750 (based on 5% of eggs)	0	0	0 (NA)
5,611,500 (based on 10% of eggs)	7	7	0 (0%)

5.E.5.3.1.2.2.2.2 Late Fall-Run Chinook Salmon

Spawning, Egg Incubation, and Alevins

Flow-Related Effects

Mean monthly flow rates and reservoir storage volumes were examined for the PA and NAA during the December through June spawning and incubation period, with peak occurrence during January through March, for late fall-run Chinook salmon (Table 5.E-5). Changes in flow can affect the instream area available for spawning and egg incubation, along with the quality of the habitat, and can result in dewatering or scour of the redds. Shasta Reservoir storage volume at the end of September may influence flow rates in the Sacramento River early in the spawning and incubation period and Shasta storage volume at the end of May influences flow in June. Mean Shasta September storage under the PA would be similar (less than 5% difference) to storage under NAA for all water year types, except for 7% higher mean storage during critical water years under the PA (Appendix 5.A, *CALSIM Methods and Results,* Table 5.A.6-3). Mean Shasta May storage under the PA would be similar (less than 5% difference) to storage under NAA for all water year types.

Flows under the PA during December through June late fall-run Chinook salmon spawning incubation period would be similar to (less than 5% difference) or greater than those under the NAA for all months and water year types, except for 13% and 7% lower flow during February of critical water years at Keswick and Red Bluff, respectively (Appendix 5.A, *CALSIM Methods and Results*, Table 5.A.6-10, Table 5.A.6-35). Flow increases during the same months would range up to 18% for January of critical years. There would be no differences in flow during December for either location. At Keswick, flow under the PA would be 9% greater than flow under the NAA during March of above normal and below normal water years and would be 8% greater in critical years, but there would be no differences at Red Bluff. During June, flows would be more than 5% higher under the PA than the NAA in all water year types except wet years.

Spawning WUA. Spawning WUA for late fall-run Chinook salmon was determined by USFWS (2003a, 2005a, 2006) for a range of flows in three segments of the Sacramento River between Keswick Dam and the Battle Creek confluence (Appendix 5.D.2.2, *Spawning Flows Methods*). Segment 4 covers 8 miles from Battle Creek to the confluence with Cow Creek; Segment 5 stretches 16 miles from Cow Creek to the A.C.I.D. Dam; and Segment 6 covers 2 miles from A.C.I.D. Dam to Keswick Dam. Table 5.E-6 shows the distribution of late fall-run Chinook salmon in the upper Sacramento River based on CDFW aerial survey results. The Cow Creek confluence is about midway between the Airport Road Bridge and Balls Ferry locations in the table. Therefore, about 68% of late fall-run Chinook salmon redds occur within Segment 6, about 12% are found within Segment 5, and most of the rest occur in Segment 4. To estimate changes in spawning WUA that would result from the PA, the flow-versus-spawning habitat WUA relationship developed for each of these segments was used with mean monthly CALSIM II flow estimates for the midpoint of each segment under the PA and the NAA during the late fall-run Chinook salmon spawning and egg incubation period. Further information on the WUA analysis methods is provided in Appendix 5.D.2.2, *Spawning Flows Methods*.

Differences in late fall-run Chinook salmon spawning WUA under the PA and NAA were examined using exceedance plots of monthly mean WUA for the spawning period in each of the river segments for each water year type and all water year types combined. The exceedance curves for the PA for all water years combined are similar to or slightly lower than those for the NAA for all five river segments (Figure 5.E-150, Figure 5.E-156, Figure 5.E-162). With the curves broken out by water year type, slight reductions in WUA under the PA are evident for most of the water year types in all three river segments (Figure 5.E-151 to Figure 5.E-155, Figure 5.E-157 to Figure 5.E-161, and Figure 5.E-163 to Figure 5.E-167).

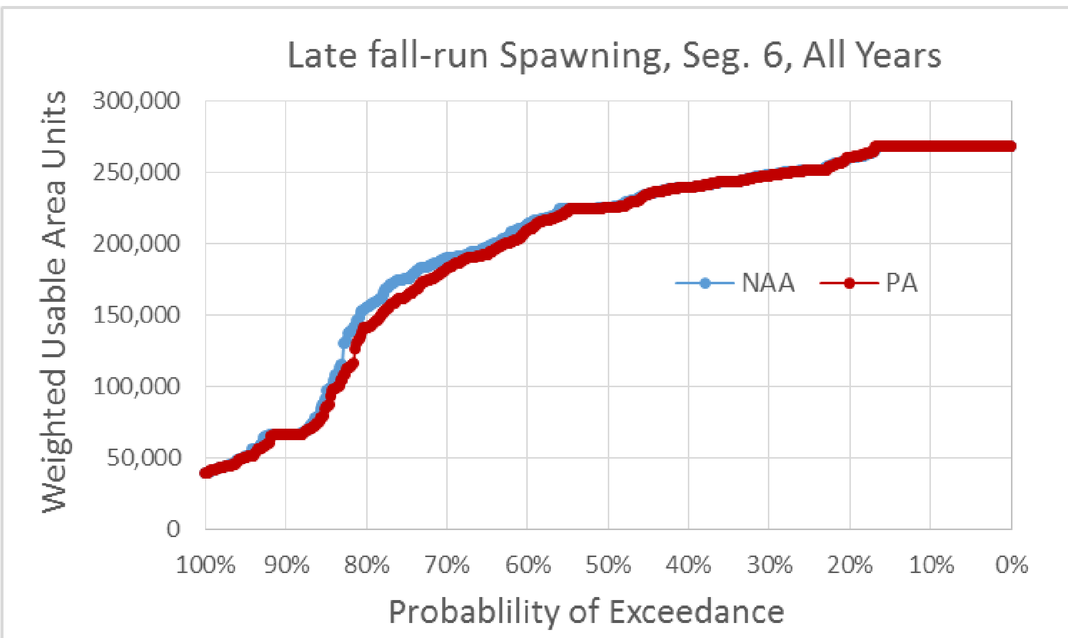


Figure 5.E-150. Exceedance Plot of Late Fall-Run Chinook Salmon Spawning Weighted Usable Area for NAA and PA Model Scenarios in River Segment 6, All Water Years

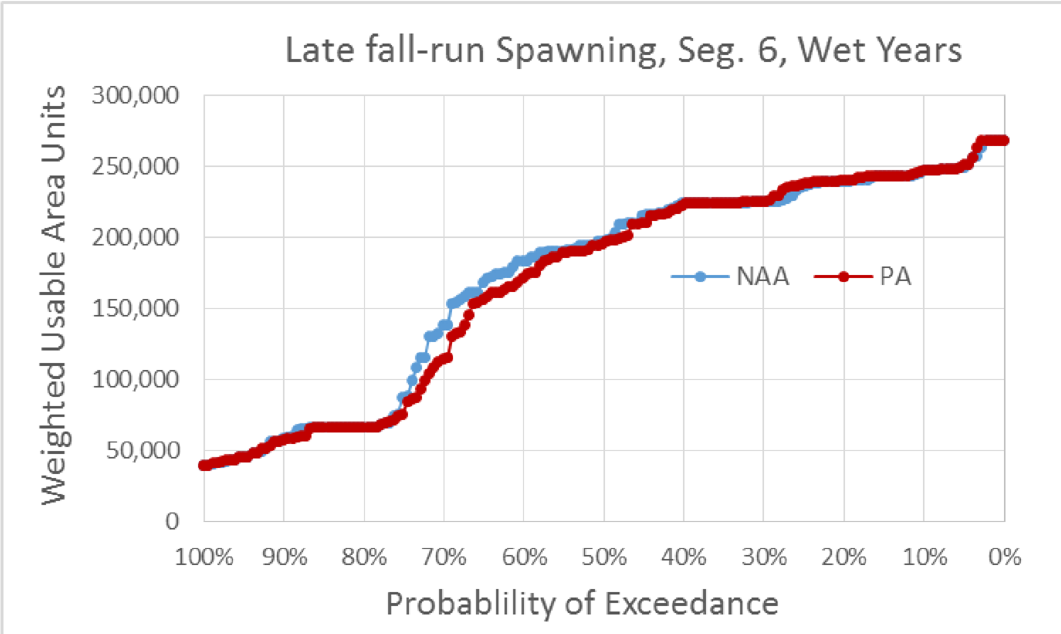


Figure 5.E-151. Exceedance Plot of Late Fall-Run Chinook Salmon Spawning Weighted Usable Area for NAA and PA Model Scenarios in River Segment 6, Wet Water Years

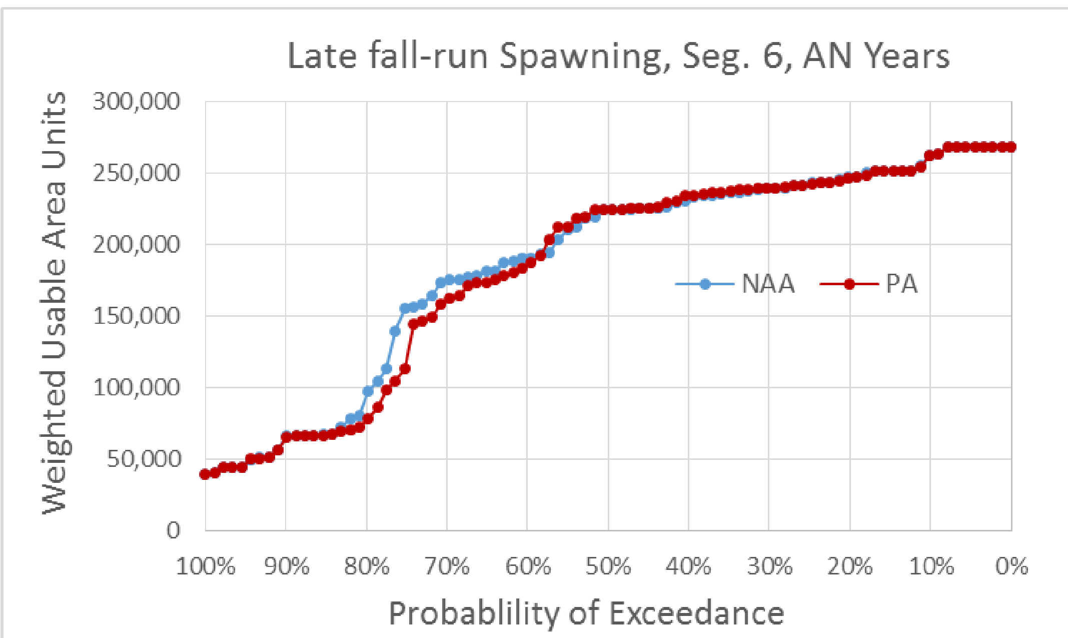


Figure 5.E-152. Exceedance Plot of Late Fall-Run Chinook Salmon Spawning Weighted Usable Area for NAA and PA Model Scenarios in River Segment 6, Above Normal Water Years

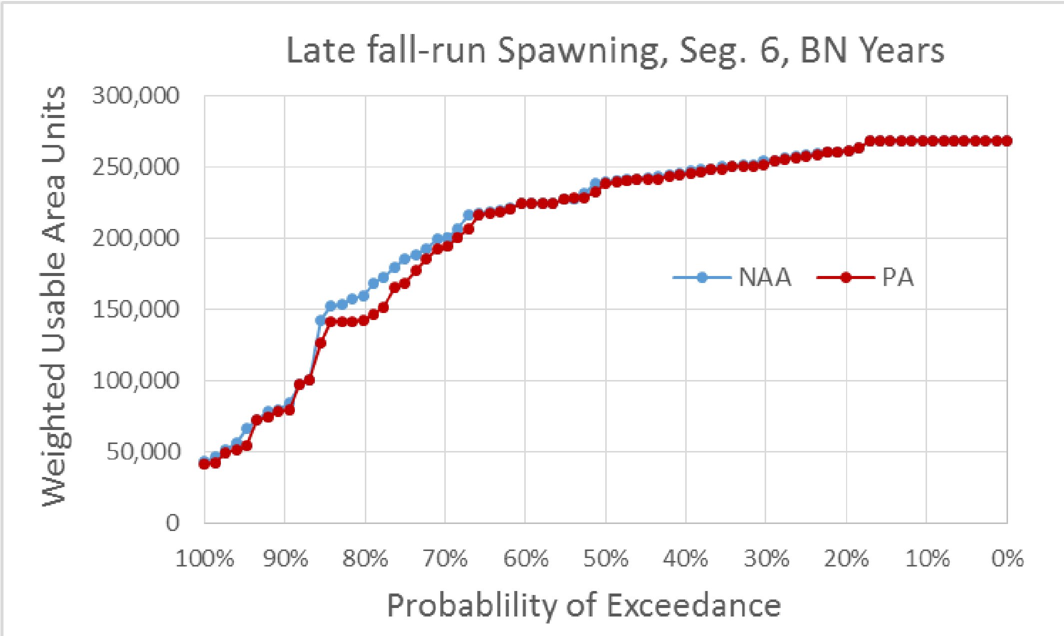


Figure 5.E-153. Exceedance Plot of Late Fall-Run Chinook Salmon Spawning Weighted Usable Area for NAA and PA Model Scenarios in River Segment 6, Below Normal Water Years

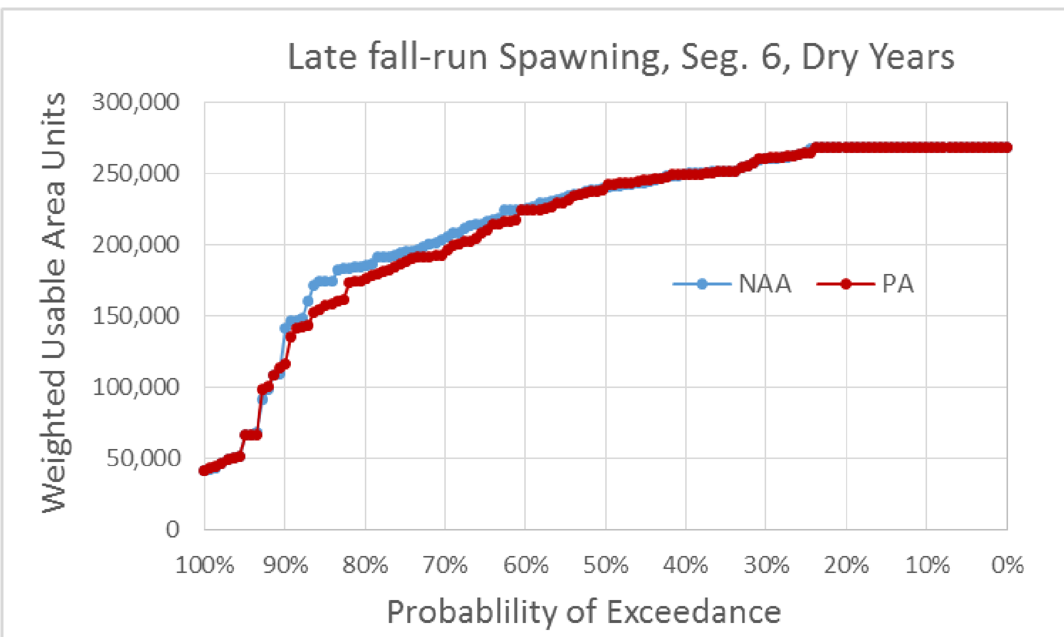


Figure 5.E-154. Exceedance Plot of Late Fall-Run Chinook Salmon Spawning Weighted Usable Area for NAA and PA Model Scenarios in River Segment 6, Dry Water Years

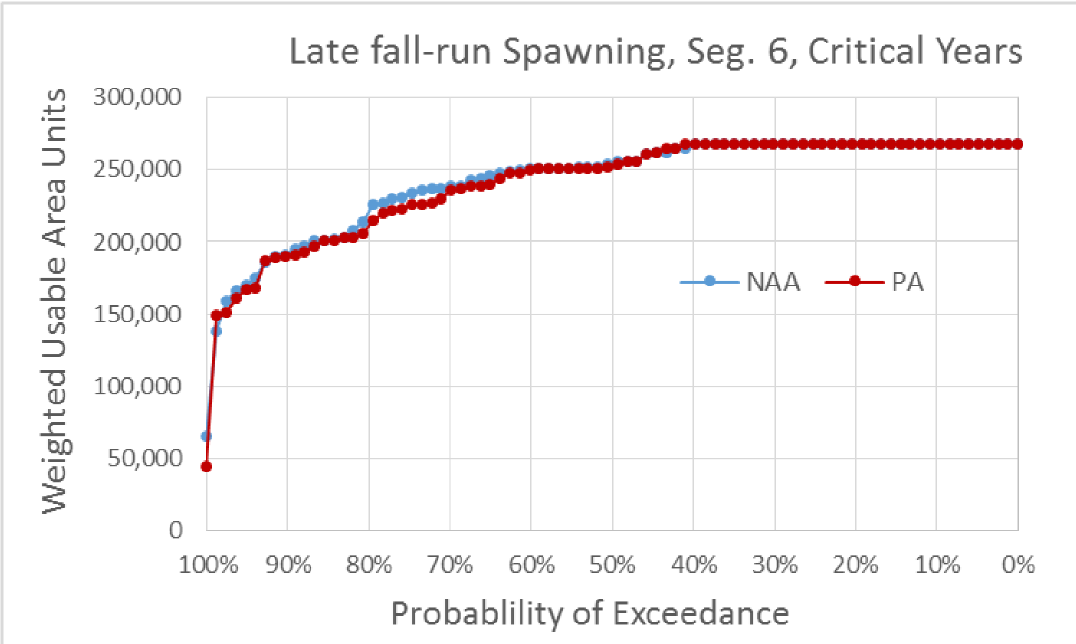


Figure 5.E-155. Exceedance Plot of Late Fall-Run Chinook Salmon Spawning Weighted Usable Area for NAA and PA Model Scenarios in River Segment 6, Critical Water Years

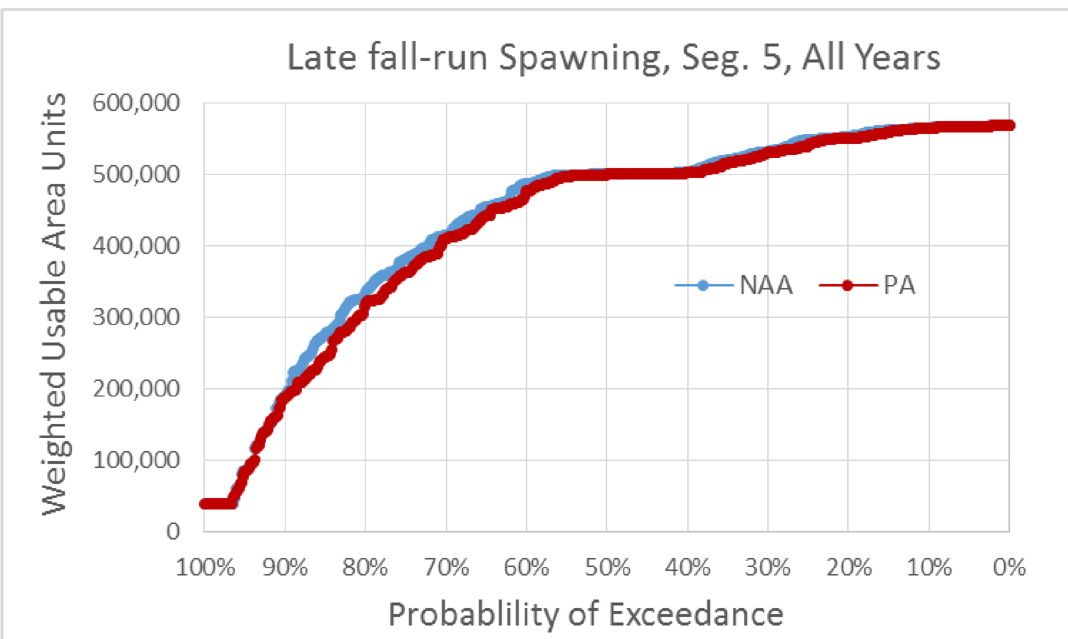


Figure 5.E-156. Exceedance Plot of Late Fall-Run Chinook Salmon Spawning Weighted Usable Area for NAA and PA Model Scenarios in River Segment 5, All Water Years

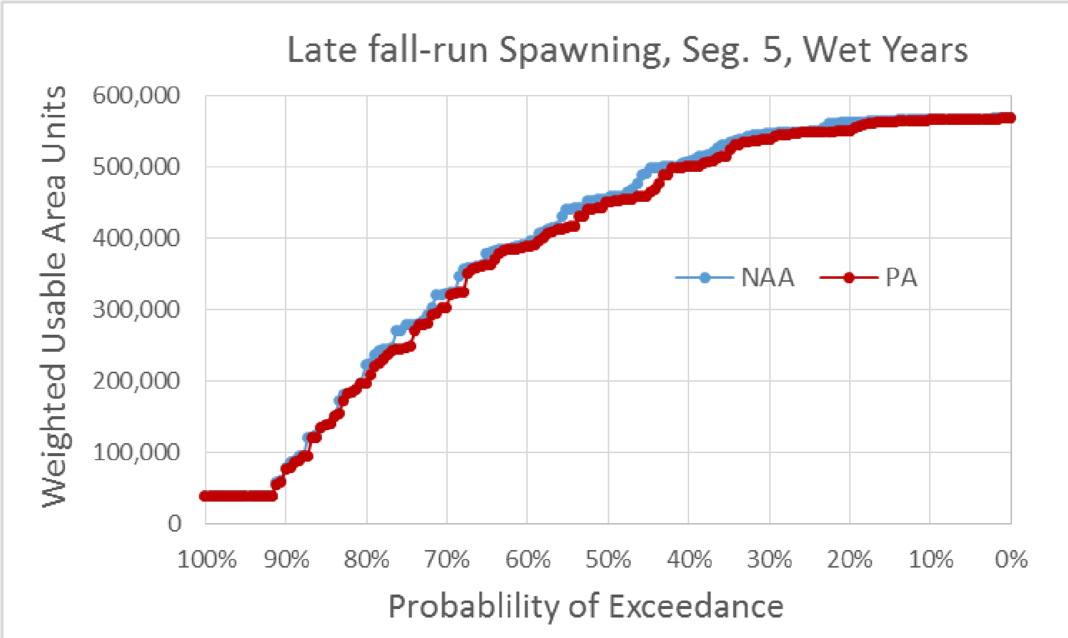


Figure 5.E-157. Exceedance Plot of Late Fall-Run Chinook Salmon Spawning Weighted Usable Area for NAA and PA Model Scenarios in River Segment 5, Wet Water Years

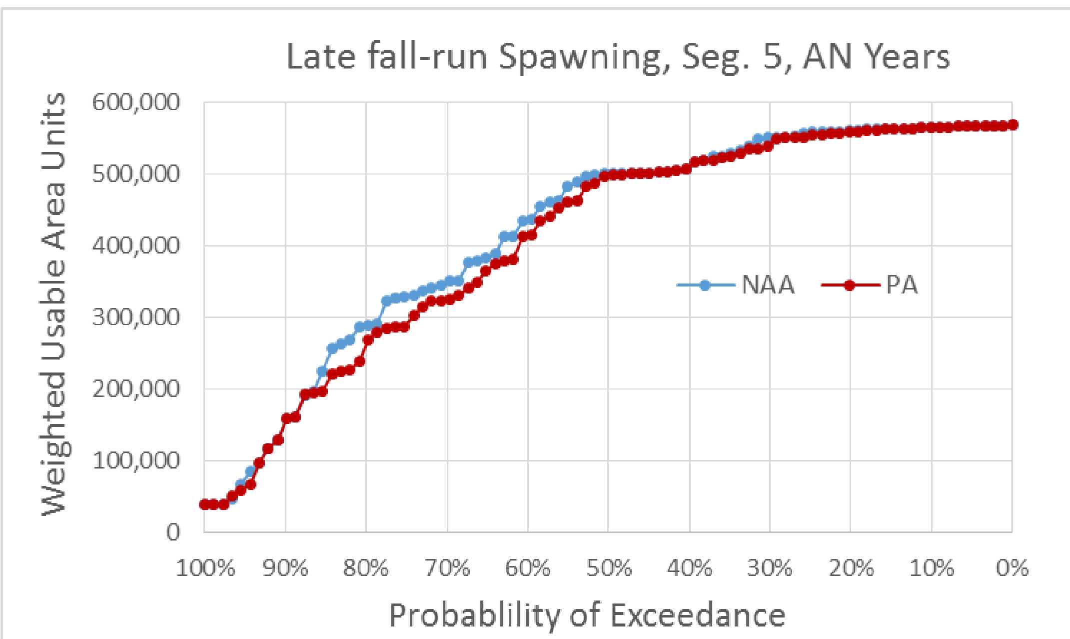


Figure 5.E-158. Exceedance Plot of Late Fall-Run Chinook Salmon Spawning Weighted Usable Area for NAA and PA Model Scenarios in River Segment 5, Above Normal Water Years

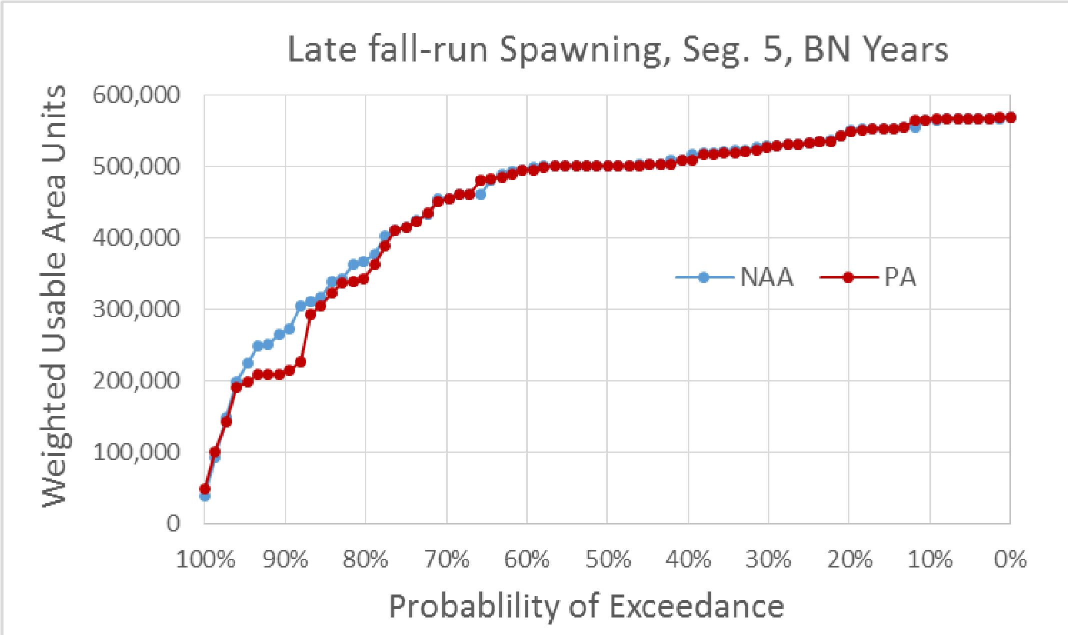


Figure 5.E-159. Exceedance Plot of Late Fall-Run Chinook Salmon Spawning Weighted Usable Area for NAA and PA Model Scenarios in River Segment 5, Below Normal Water Years

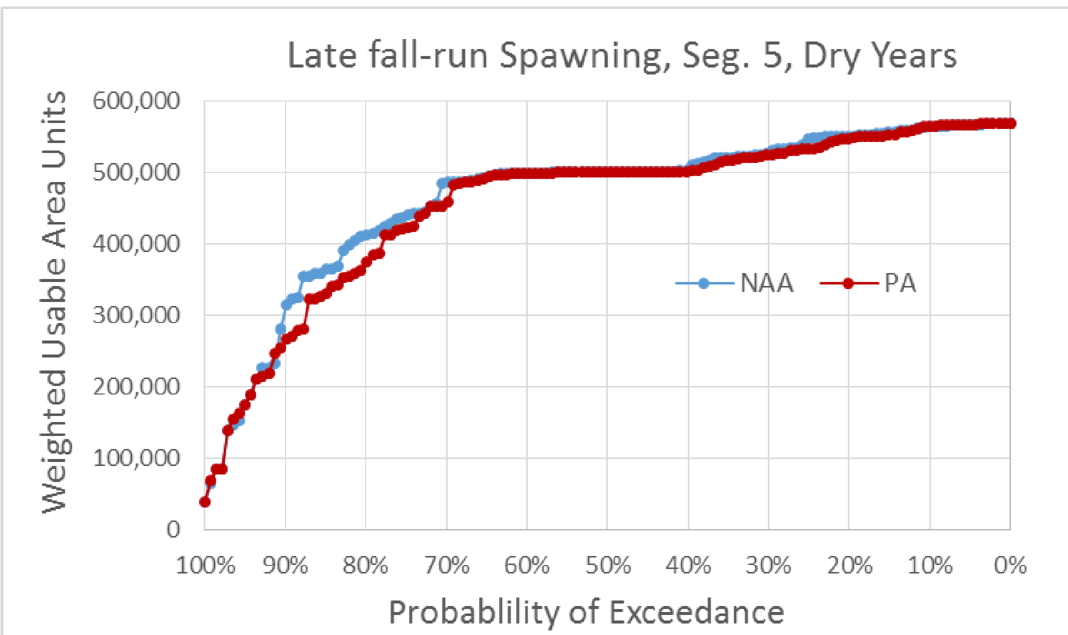


Figure 5.E-160. Exceedance Plot of Late Fall-Run Chinook Salmon Spawning Weighted Usable Area for NAA and PA Model Scenarios in River Segment 5, Dry Water Years

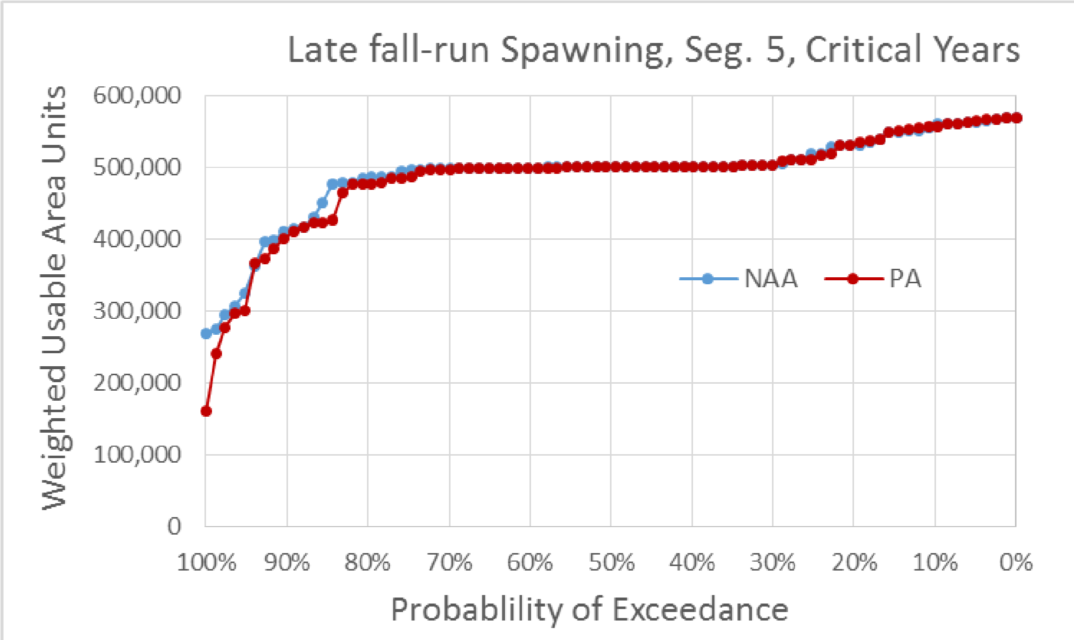


Figure 5.E-161. Exceedance Plot of Late Fall-Run Chinook Salmon Spawning Weighted Usable Area for NAA and PA Model Scenarios in River Segment 5, Critical Water Years

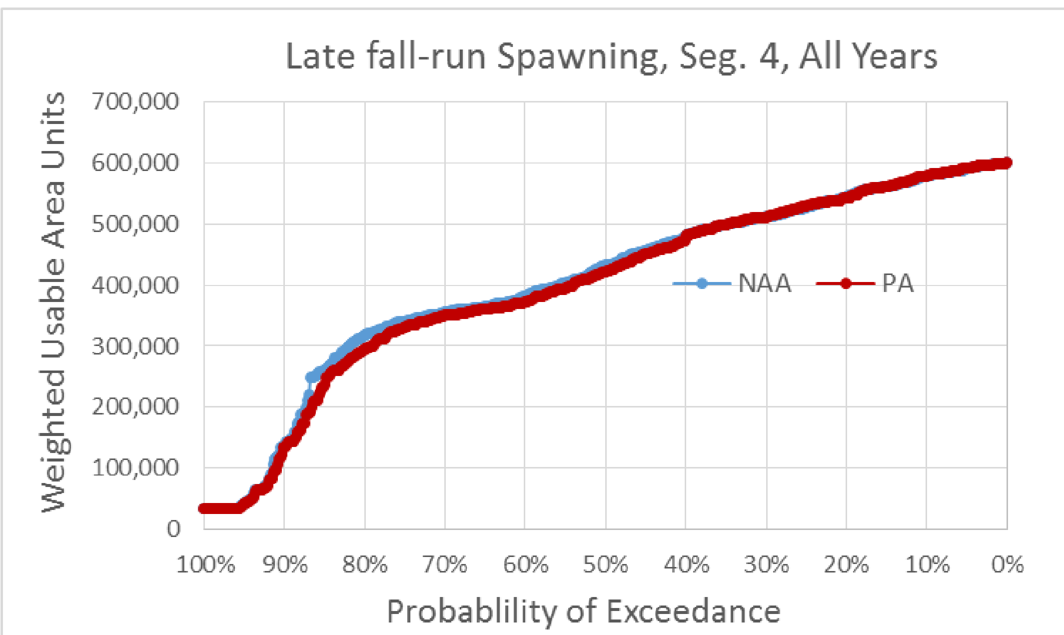


Figure 5.E-162. Exceedance Plot of Late Fall-Run Chinook Salmon Spawning Weighted Usable Area for NAA and PA Model Scenarios in River Segment 4, All Water Years

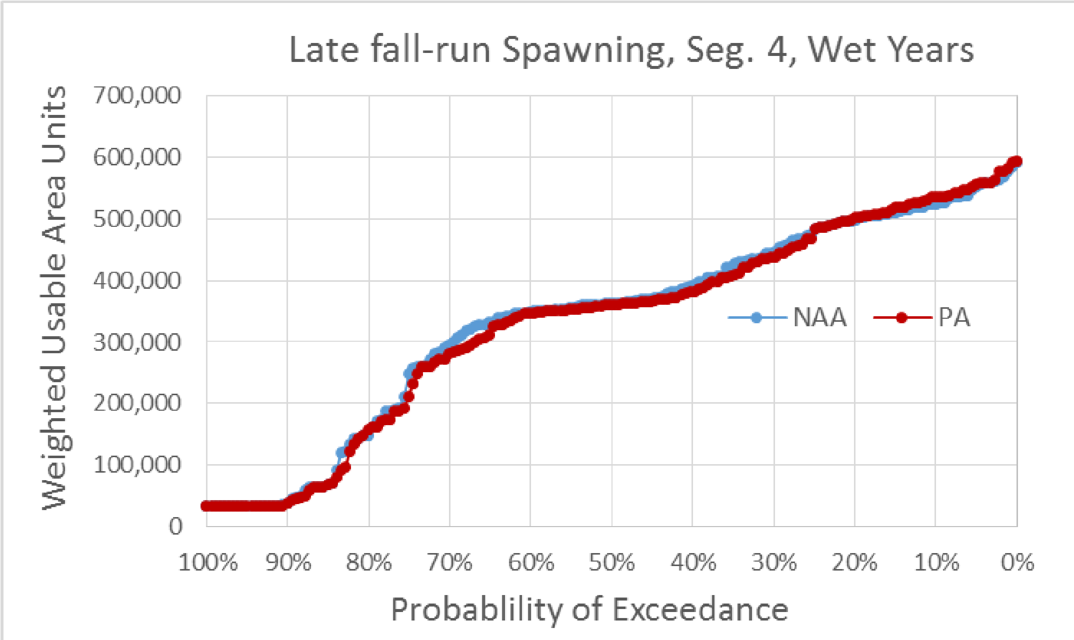


Figure 5.E-163. Exceedance Plot of Late Fall-Run Chinook Salmon Spawning Weighted Usable Area for NAA and PA Model Scenarios in River Segment 4, Wet Water Years

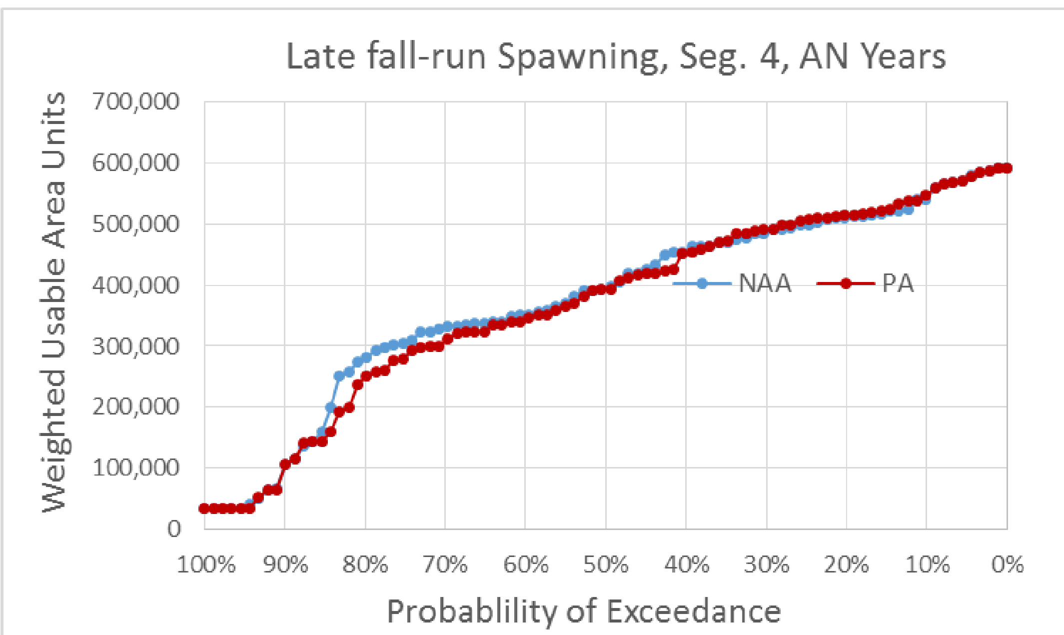


Figure 5.E-164. Exceedance Plot of Late Fall-Run Chinook Salmon Spawning Weighted Usable Area for NAA and PA Model Scenarios in River Segment 4, Above Normal Water Years

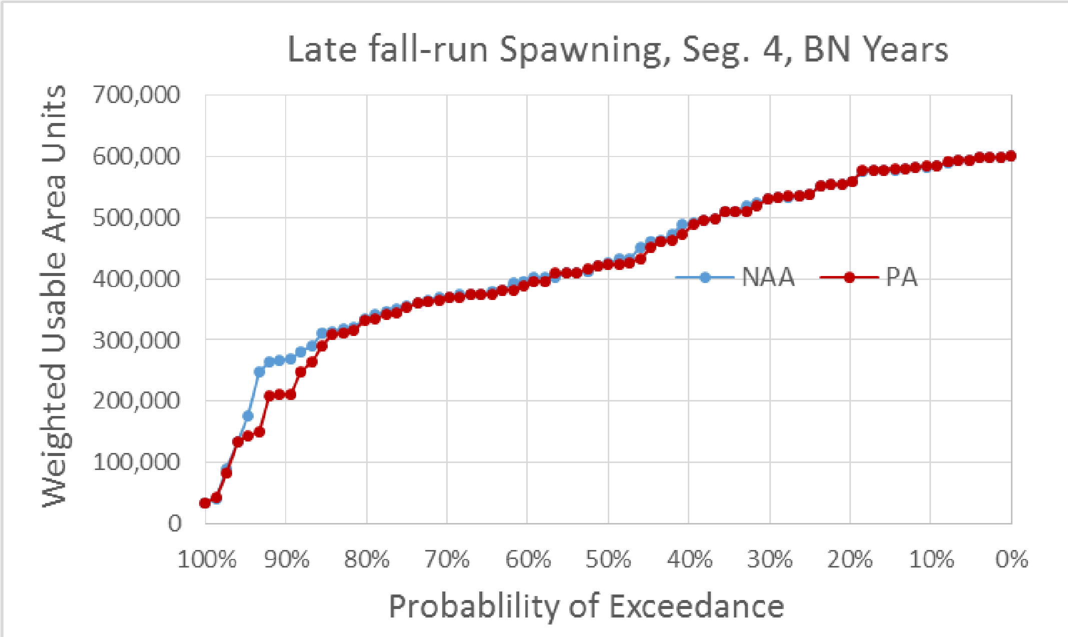


Figure 5.E-165. Exceedance Plot of Late Fall-Run Chinook Salmon Spawning Weighted Usable Area for NAA and PA Model Scenarios in River Segment 4, Below Normal Water Years

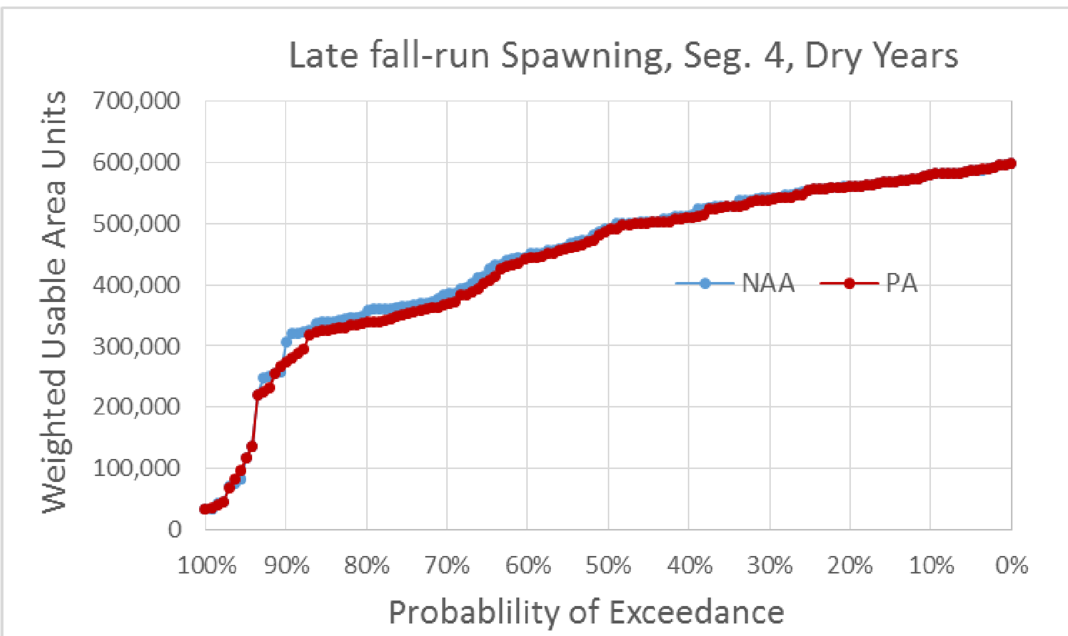


Figure 5.E-166. Exceedance Plot of Late Fall-Run Chinook Salmon Spawning Weighted Usable Area for NAA and PA Model Scenarios in River Segment 4, Dry Water Years

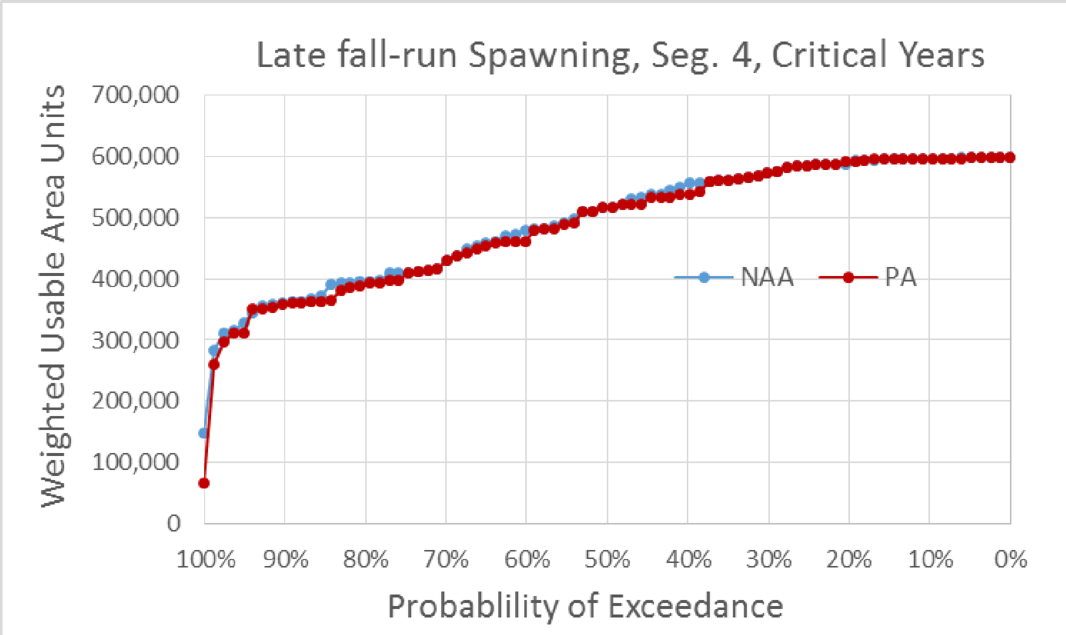


Figure 5.E-167. Exceedance Plot of Late Fall-Run Chinook Salmon Spawning Weighted Usable Area for NAA and PA Model Scenarios in River Segment 4, Critical Water Years

Differences in late fall-run Chinook salmon spawning WUA in each river segment under the PAA and NAA were also examined using the grand mean spawning WUA for each month of the spawning period under each water year type and all water year types combined (Table 5.E-48 to Table 5.E-50). For most river segments, months, and water year types, there would be no differences (less than 5% difference) between the PA and the NAA in mean WUA. However, mean WUA was slightly lower (up to 9% lower) under the PA during June of all water year types except wet and critical years in Segments 4 (Table 5.E-50) and all water year types except wet years in Segment 5 (Table 5.E-49). Mean WUA was also lower during January of wet years in all three river segments, ranging up to 10% lower in Segment 6 (Table 5.E-48), and was slightly lower during March of above normal and below normal years in Segment 6 and above normal years of Segment 4 (Table 5.E-50). Mean spawning WUA was greater (6% greater) under the PA relative to the NAA only for February of critical years in Segment 6. January through March are the peak spawning months for late fall-run Chinook salmon. Further discussion regarding flow-related effects during the June through November period is provided in Section 5.E.5.3.1.2.2.4, *Summary of Upstream Effects*.

Table 5.E-48. Late Fall-Run Chinook Salmon Spawning Weighted Usable Areas and Differences (Percent Differences) in River Segment 6 between Model Scenarios (green indicates PA is at least 5% higher [raw difference] than NAA; red indicates PA is at least 5% lower)

Month	WYT	NAA	PA	PA vs. NAA
December	Wet	187,938	191,304	3365 (2%)
	Above Normal	185,688	186,267	579 (0.3%)
	Below Normal	197,367	197,128	-239 (-0.1%)
	Dry	190,704	188,173	-2531 (-1%)
	Critical	263,739	265,028	1289 (0.5%)
	All	200,798	201,498	700 (0.3%)
January	Wet	174,109	156,130	-17979 (-10%)
	Above Normal	192,973	192,883	-90 (-0.05%)
	Below Normal	189,268	188,851	-417 (-0.2%)
	Dry	189,398	187,549	-1850 (-1%)
	Critical	249,461	237,768	-11693 (-5%)
	All	193,889	185,956	-7933 (-4%)
February	Wet	117,286	112,485	-4801 (-4%)
	Above Normal	126,477	127,976	1499 (1%)
	Below Normal	195,841	190,967	-4873 (-2%)
	Dry	257,214	254,092	-3122 (-1%)
	Critical	251,820	268,127	16307 (6%)
	All	183,097	182,784	-313 (-0.2%)
March	Wet	113,000	113,114	114 (0.1%)
	Above Normal	165,661	152,814	-12847 (-8%)
	Below Normal	241,170	229,080	-12090 (-5%)
	Dry	249,200	248,752	-448 (-0.2%)
	Critical	263,401	253,530	-9870 (-4%)
	All	193,771	188,596	-5176 (-3%)
April	Wet	209,496	209,720	225 (0.1%)
	Above Normal	228,842	228,846	3 (0%)
	Below Normal	235,280	235,404	123 (0.1%)
	Dry	226,285	225,988	-298 (-0.1%)
	Critical	227,433	227,753	320 (0.1%)
	All	222,742	222,804	63 (0.03%)
May	Wet	218,365	218,798	433 (0.2%)
	Above Normal	231,894	232,204	311 (0.1%)
	Below Normal	231,781	231,969	188 (0.08%)
	Dry	229,577	225,438	-4139 (-1.8%)
	Critical	240,929	239,492	-1437 (-0.6%)
	All	228,346	227,338	-1008 (-0.4%)
June	Wet	192,473	190,344	-2129 (-1%)
	Above Normal	178,799	171,609	-7190 (-4%)
	Below Normal	179,996	173,650	-6347 (-4%)
	Dry	182,424	173,376	-9048 (-5%)
	Critical	198,253	190,114	-8139 (-4%)
	All	187,026	180,962	-6064 (-3%)

Table 5.E-49. Late Fall-Run Chinook Salmon Spawning Weighted Usable Areas and Differences (Percent Differences) in River Segment 5 between Model Scenarios (green indicates PA is at least 5% higher [raw difference] than NAA; red indicates PA is at least 5% lower)

Month	WYT	NAA	PA	PA vs. NAA
December	Wet	462,534	447,498	-15035 (-3%)
	Above Normal	475,792	453,059	-22733 (-5%)
	Below Normal	458,633	455,362	-3270 (-0.7%)
	Dry	423,370	423,575	205 (0.05%)
	Critical	512,117	508,659	-3457 (-0.7%)
	All	461,644	452,544	-9100 (-2%)
January	Wet	418,567	393,549	-25019 (-6%)
	Above Normal	412,957	413,032	76 (0.02%)
	Below Normal	427,988	428,744	756 (0.2%)
	Dry	420,601	420,612	11 (0%)
	Critical	482,872	474,746	-8126 (-2%)
	All	428,848	419,842	-9006 (-2%)
February	Wet	283,326	277,527	-5799 (-2%)
	Above Normal	273,983	272,721	-1262 (-0.5%)
	Below Normal	442,454	427,133	-15321 (-3%)
	Dry	516,627	513,589	-3039 (-1%)
	Critical	506,444	500,419	-6026 (-1%)
	All	392,745	387,029	-5717 (-1%)
March	Wet	310,775	310,713	-62 (-0.02%)
	Above Normal	436,487	415,019	-21468 (-5%)
	Below Normal	501,025	496,928	-4097 (-1%)
	Dry	508,128	506,923	-1205 (-0.2%)
	Critical	507,653	520,480	12827 (3%)
	All	433,172	430,783	-2389 (-0.6%)
April	Wet	452,435	452,443	8 (0%)
	Above Normal	509,658	509,440	-218 (-0.04%)
	Below Normal	531,597	534,025	2428 (0.5%)
	Dry	528,817	525,176	-3640 (-1%)
	Critical	503,350	502,208	-1141 (-0.2%)
	All	498,207	497,446	-761 (0%)
May	Wet	457,106	458,491	1384 (0.3%)
	Above Normal	496,405	495,860	-545 (-0.1%)
	Below Normal	498,838	499,738	900 (0.2%)
	Dry	501,671	486,308	-15363 (-3%)
	Critical	526,174	521,948	-4226 (-0.8%)
	All	489,912	486,019	-3892 (-0.8%)
June	Wet	385,533	378,397	-7135 (-2%)
	Above Normal	341,256	315,394	-25862 (-8%)
	Below Normal	340,944	318,598	-22346 (-7%)
	Dry	352,571	320,900	-31671 (-9%)
	Critical	397,030	373,212	-23818 (-6%)
	All	366,175	345,604	-20570 (-6%)

Table 5.E-50. Late Fall-Run Chinook Salmon Spawning Weighted Usable Areas and Differences (Percent Differences) in River Segment 4 between Model Scenarios (green indicates PA is at least 5% higher [raw difference] than NAA; red indicates PA is at least 5% lower)

Month	WYT	NAA	PA	PA vs. NAA
December	Wet	424,021	425,945	1924 (0.5%)
	Above Normal	432,482	426,694	-5789 (-1%)
	Below Normal	447,612	445,148	-2463 (-1%)
	Dry	405,078	407,698	2619 (1%)
	Critical	556,853	559,024	2170 (0.4%)
	All	443,480	443,874	394 (0%)
January	Wet	368,133	344,902	-23230 (-6%)
	Above Normal	409,011	409,080	69 (0.02%)
	Below Normal	409,970	410,293	323 (0.08%)
	Dry	402,896	399,605	-3291 (-0.8%)
	Critical	506,800	484,723	-22077 (-4%)
	All	408,997	397,653	-11345 (-3%)
February	Wet	228,372	224,730	-3642 (-2%)
	Above Normal	238,693	238,658	-34 (-0.01%)
	Below Normal	423,910	409,101	-14809 (-3%)
	Dry	530,273	528,217	-2055 (-0.4%)
	Critical	553,543	578,125	24582 (4%)
	All	377,459	377,409	-51 (-0.01%)
March	Wet	257,485	257,291	-194 (-0.08%)
	Above Normal	379,846	360,103	-19743 (-5%)
	Below Normal	526,410	512,032	-14378 (-3%)
	Dry	521,614	521,140	-474 (-0.09%)
	Critical	575,682	559,638	-16044 (-3%)
	All	423,946	416,362	-7584 (-2%)
April	Wet	374,005	373,309	-696 (-0.2%)
	Above Normal	436,667	436,371	-295 (-0.07%)
	Below Normal	457,938	462,647	4709 (1%)
	Dry	499,842	492,210	-7632 (-2%)
	Critical	459,222	453,511	-5712 (-1%)
	All	438,361	436,028	-2333 (-1%)
May	Wet	370,310	371,331	1021 (0.3%)
	Above Normal	401,733	399,503	-2231 (-1%)
	Below Normal	407,008	408,009	1001 (0.2%)
	Dry	434,521	422,095	-12426 (-3%)
	Critical	437,869	432,977	-4892 (-1%)
	All	405,763	402,120	-3642 (-1%)
June	Wet	340,217	335,188	-5029 (-1%)
	Above Normal	328,202	310,691	-17511 (-5%)
	Below Normal	323,044	299,195	-23849 (-7%)
	Dry	329,459	311,216	-18243 (-6%)
	Critical	354,578	342,910	-11668 (-3%)
	All	335,486	321,759	-13727 (-4%)

Redd Scour. The probability of flows occurring under the PA and the NAA that would be high enough to mobilize sediments and scour late fall-run Chinook salmon redds was estimated from CALSIM II estimates of mean monthly flows, using a relationship determined from the historical record between actual mean monthly flow and maximum daily flow (Appendix 5.D.2.2, *Spawning Flows Methods*). The actual monthly and daily flow data used in the analysis are from gage records just below Keswick Dam and at Bend Bridge, and the CALSIM II estimates used to compare probabilities of redd scour for the PA and the NAA are for the Keswick and Red Bluff locations. As discussed in Appendix 5.D.2.2, *Spawning Flows*, *Methods*, 40,000 cfs is treated as the minimum daily flow at which redd scour occurs in the Sacramento River. The analysis of the Keswick Dam gage data shows that for months with a mean monthly flow of at least 27,300 cfs, the maximum daily flow is always at least 40,000 cfs. The Bend Bridge gage data show that for months with a mean flow of at least 21,800 cfs, the maximum daily flow is always at least 40,000 cfs. Therefore, redd scour probabilities for the PA and the NAA were evaluated by comparing frequencies of CALSIM II flows greater than 27,300 cfs at Keswick or greater than 21,800 cfs at Red Bluff during the late fall-run December through June spawning and incubation period. Further information on the redd scour analysis methods is provided in Appendix 5.D.2.2, *Spawning Flows*, *Methods*.

Table 5.E-33 shows that about 4% of months at Keswick and 12% to 13% of months at Red Bluff would have flows above the redd scouring thresholds during the December through June spawning and incubation period of late fall-run Chinook salmon. The moderately high percentage of scouring flows in this period is expected, given that it includes the wettest months of the year. There would be no difference between the PA and the NAA in the percentage of scouring flows at Keswick and the percentage of scouring flows under the PA would be 6% greater at Red Bluff. The difference at Red Bluff is less than 1% on a raw scale.

Note that SALMOD also predicts redd scour risk for late fall-run Chinook salmon in the Sacramento River, although it is combined with redd dewatering and reported as “Incubation” mortality. Please see Table 5.E-54 below for these results.

Redd Dewatering. The percentage of late fall-run Chinook salmon redds dewatered by reductions in Sacramento River flow was estimated from CALSIM II estimates of monthly mean flows during the 3 months following each month of spawning (Appendix 5.D.2.2, *Spawning Flows*, *Methods,* Table 5-4-2). This analysis employed functional relationships developed in field studies by USFWS (2006) that predicted percentages of redds dewatered from an array of paired spawning and dewatering flows. CALSIM II flows for the three upstream river segments (Segments 4, 5 and 6) were used to estimate redd dewatering under the PA and NAA. Note that unlike the analyses used to model weighted usable area, the analysis used to model redd dewatering combines the field observations of water depth, flow velocity, and substrate from the three river segments and, therefore, differences in redd dewatering estimates among the segments result only from differences in the CALSIM II flows. Further information on the redd dewatering analysis methods is provided in Appendix 5.D.2.2, *Spawning Flows*, *Methods*.

Differences in late fall-run Chinook salmon redd dewatering under the PA and NAA were examined using exceedance plots of mean monthly percent dewatered for the December through April spawning months (Figure 5.E-168 through Figure 5.E-173). As noted above for spawning weighted usable area, late fall-run Chinook salmon spawning peaks in river Segment 6, so conclusions regarding effects are primarily based on the Segment 6 results (Figure 5.E-156 through Figure 5E-161).The exceedance curves show little difference between the PA and the NAA in the percentage of redds dewatered for all water years combined or for individual water year types, except for marginally greater redd dewatering under the PA for wet years (Figure 5.E-169). Results for Segments 5 and 4 (Figure 5.E-162 through Figure 5.E-173) are similar to those for Segment 6.

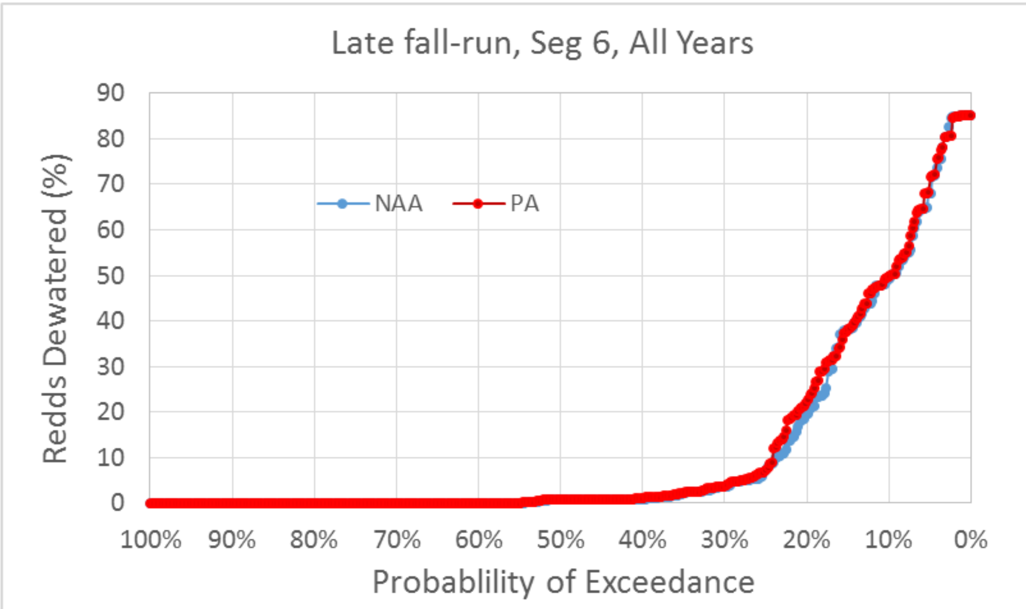


Figure 5.E-168. Exceedance Plot of Late Fall-Run Chinook Salmon Percent of Redds Dewatered for NAA and PA Model Scenarios in River Segment 6, All Water Years

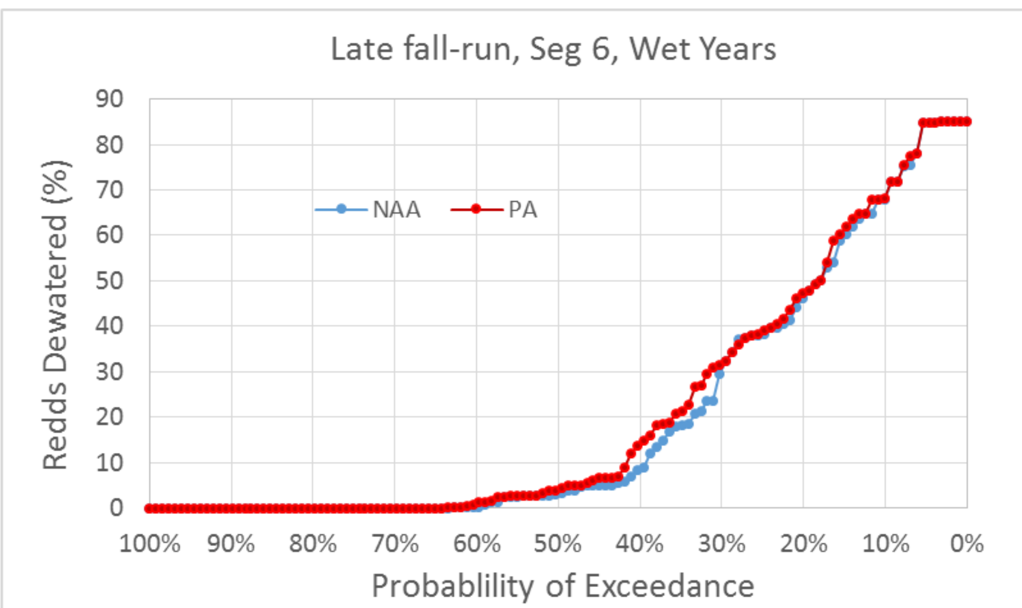


Figure 5.E-169. Exceedance Plot of Late Fall-Run Chinook Salmon Percent of Redds Dewatered for NAA and PA Model Scenarios in River Segment 6, Wet Water Years

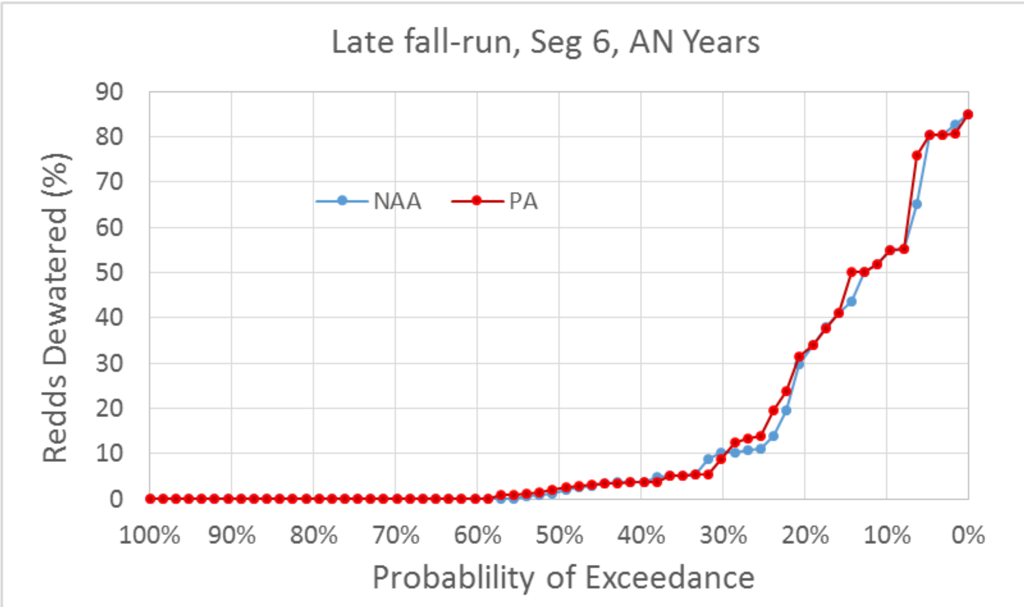


Figure 5.E-170. Exceedance Plot of Late Fall-Run Chinook Salmon Percent of Redds Dewatered for NAA and PA Model Scenarios in River Segment 6, Above Normal Water Years

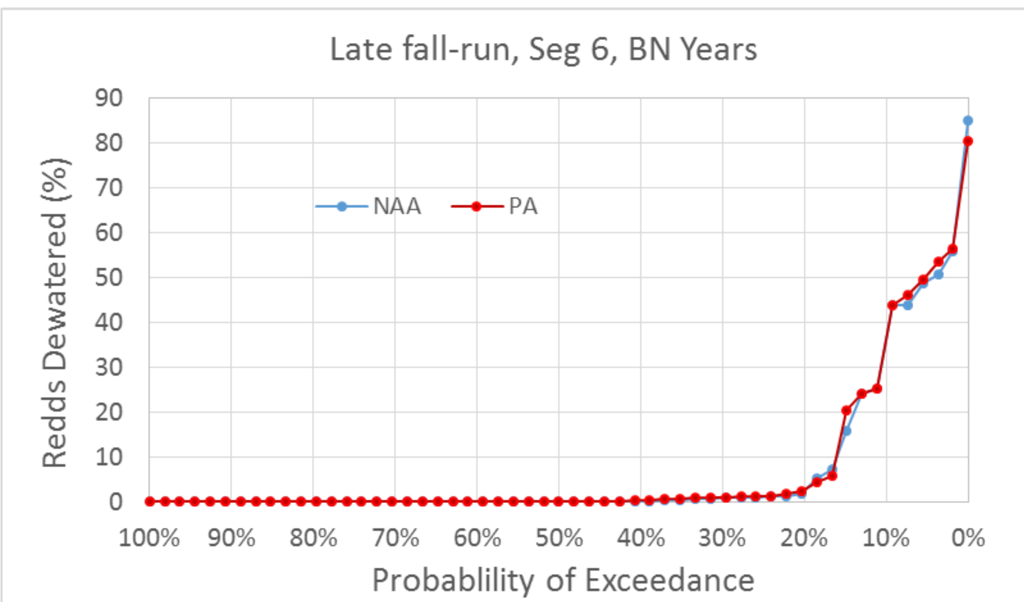


Figure 5.E-171. Exceedance Plot of Late Fall-Run Chinook Salmon Percent of Redds Dewatered for NAA and PA Model Scenarios in River Segment 6, Below Normal Water Years

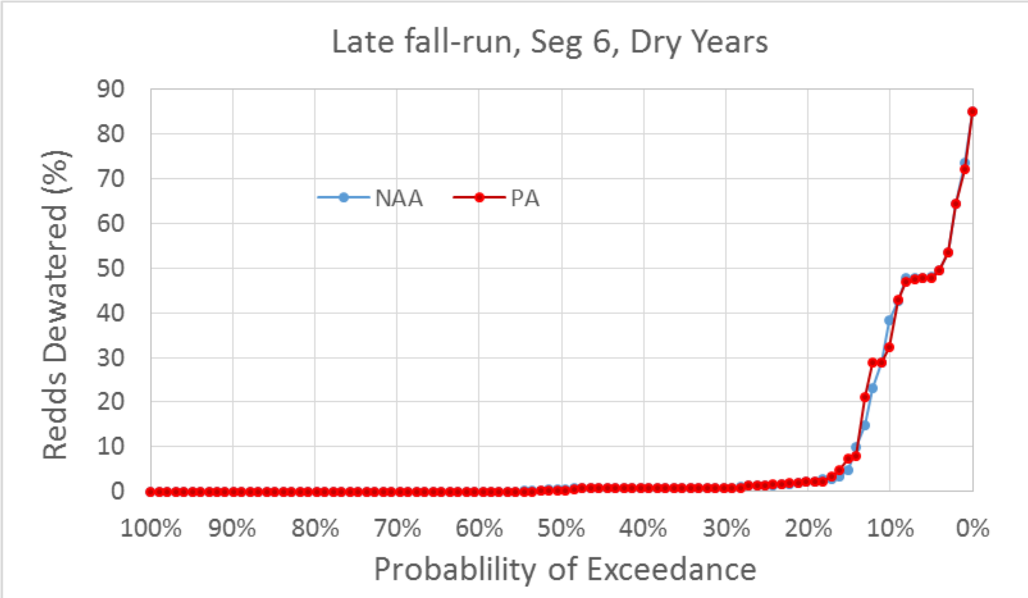


Figure 5.E-172. Exceedance Plot of Late Fall-Run Chinook Salmon Percent of Redds Dewatered for NAA and PA Model Scenarios in River Segment 6, Dry Water Years

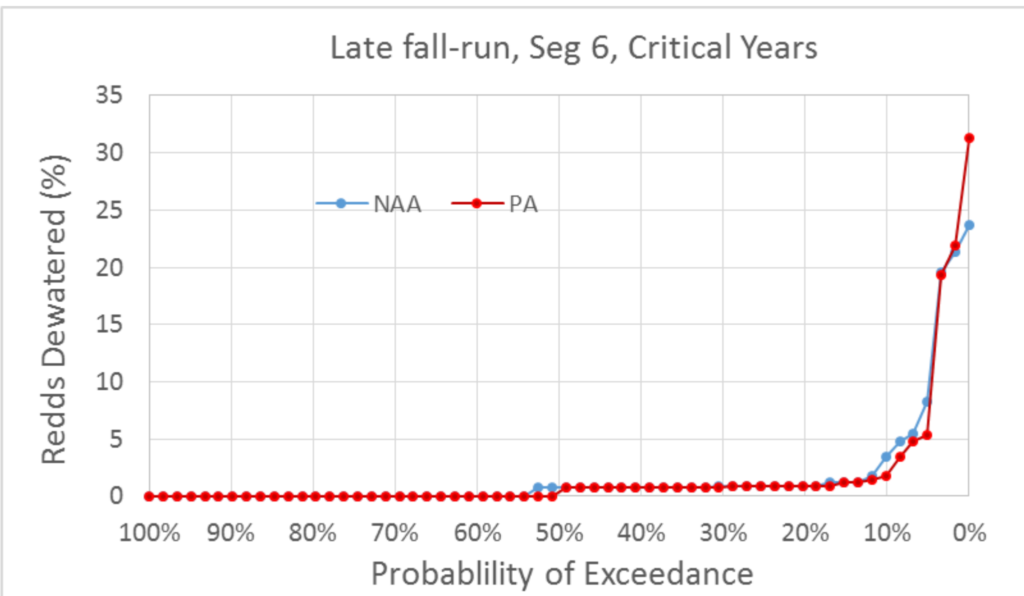


Figure 5.E-173. Exceedance Plot of Late Fall-Run Chinook Salmon Percent of Redds Dewatered for NAA and PA Model Scenarios in River Segment 6, Critical Water Years

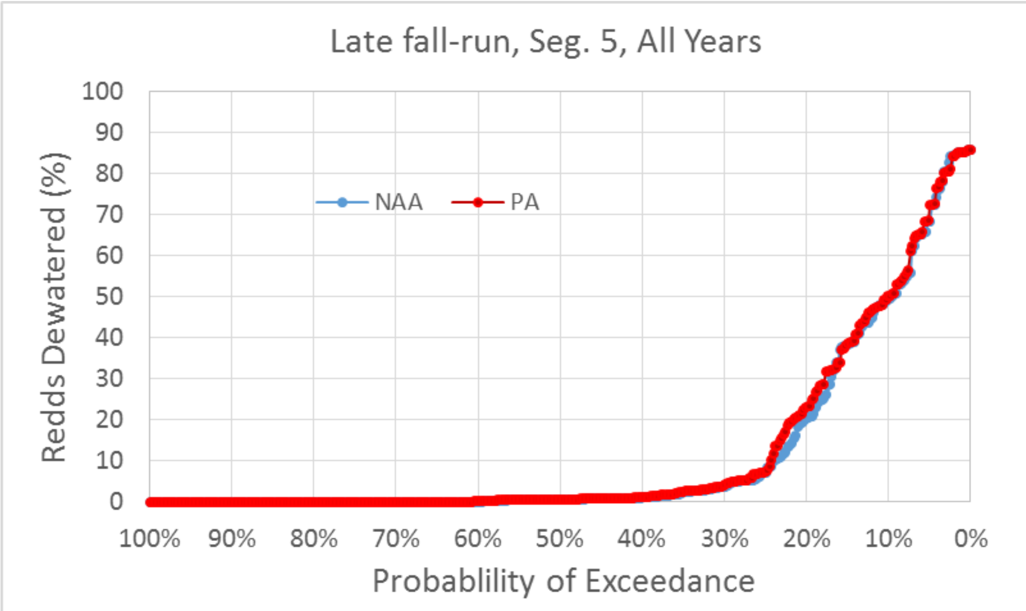


Figure 5.E-174. Exceedance Plot of Late Fall-Run Chinook Salmon Percent of Redds Dewatered for NAA and PA Model Scenarios in River Segment 5, All Water Years

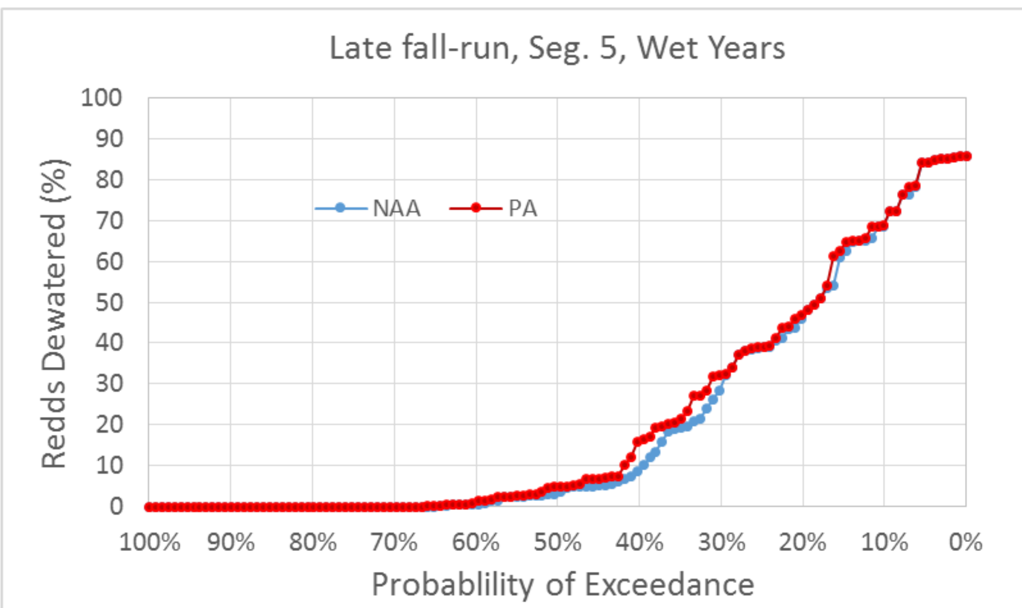


Figure 5.E-175. Exceedance Plot of Late Fall-Run Chinook Salmon Percent of Redds Dewatered for NAA and PA Model Scenarios in River Segment 5, Wet Water Years

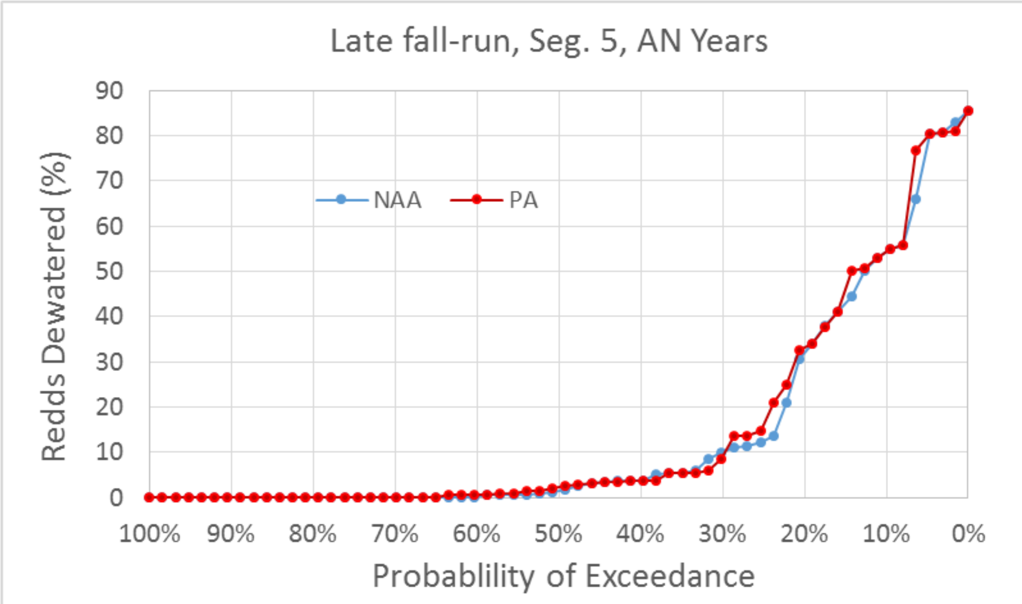


Figure 5.E-176. Exceedance Plot of Late Fall-Run Chinook Salmon Percent of Redds Dewatered for NAA and PA Model Scenarios in River Segment 5, Above Normal Water Years

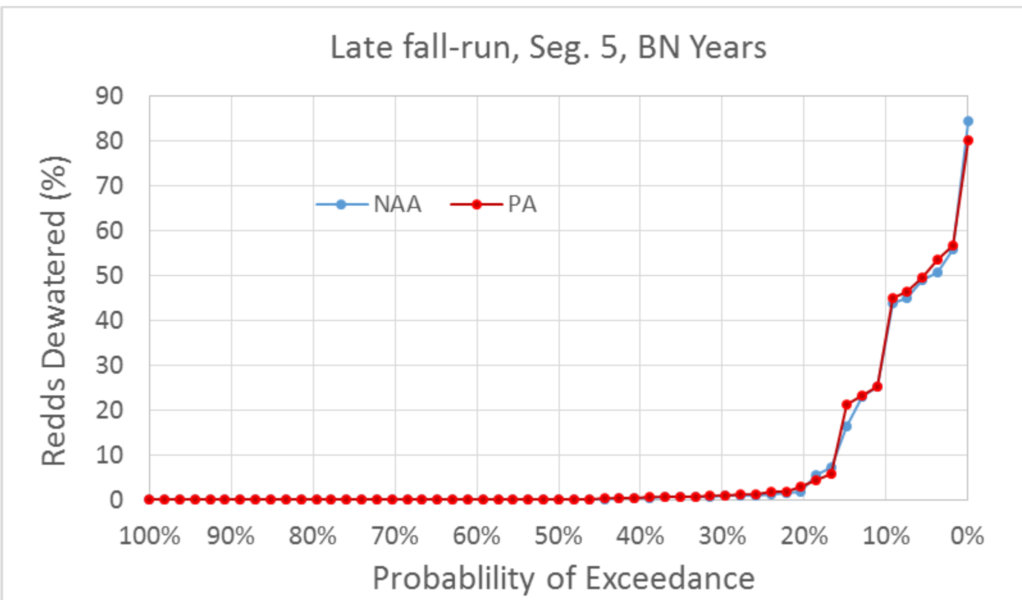


Figure 5.E-177. Exceedance Plot of Late Fall-Run Chinook Salmon Percent of Redds Dewatered for NAA and PA Model Scenarios in River Segment 5, Below Normal Water Years

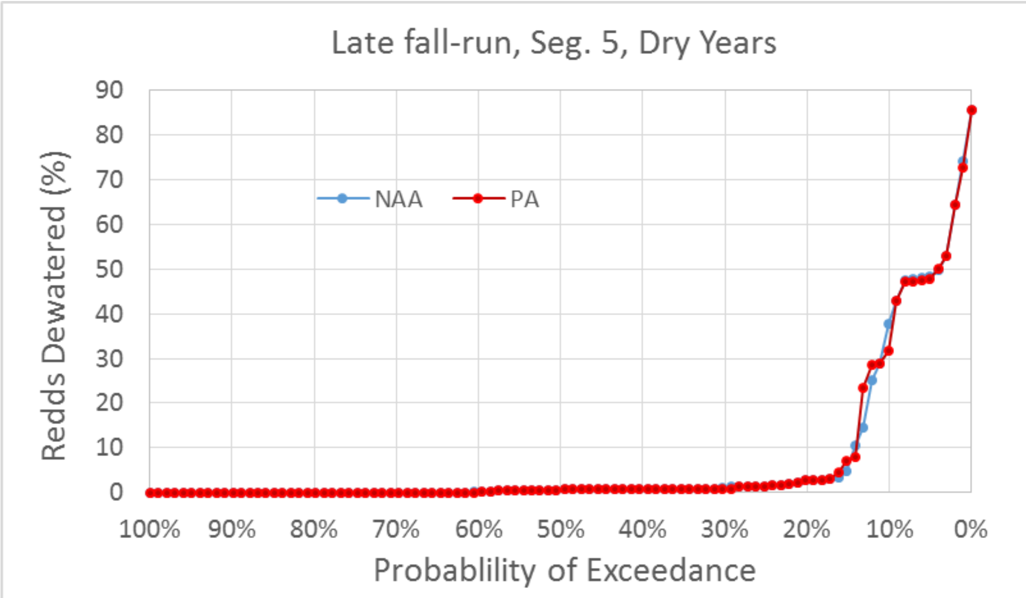


Figure 5.E-178. Exceedance Plot of Late Fall-Run Chinook Salmon Percent of Redds Dewatered for NAA and PA Model Scenarios in River Segment 5, Dry Water Years

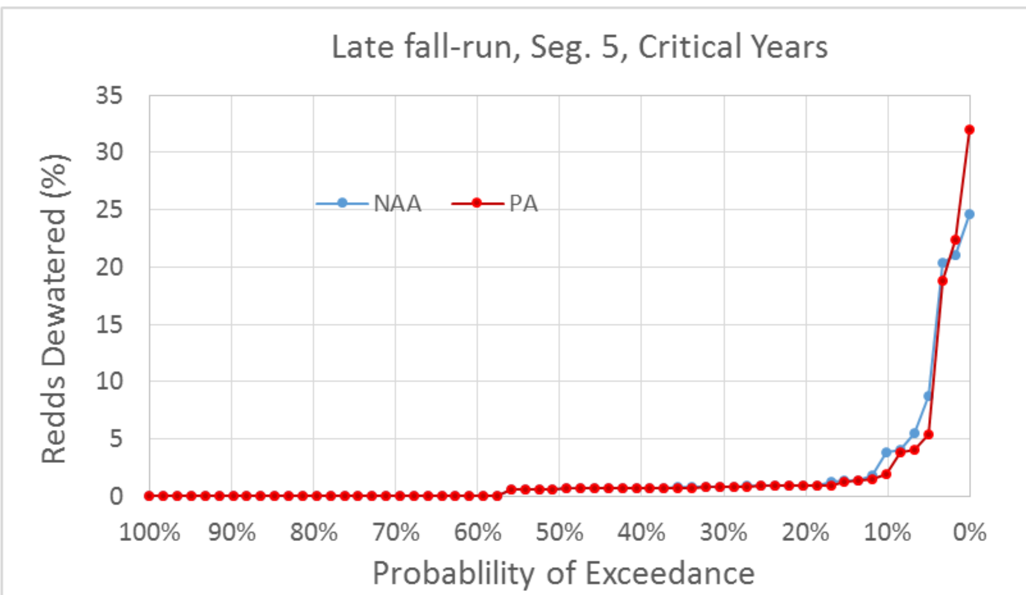


Figure 5.E-179. Exceedance Plot of Late Fall-Run Chinook Salmon Percent of Redds Dewatered for NAA and PA Model Scenarios in River Segment 5, Critical Water Years

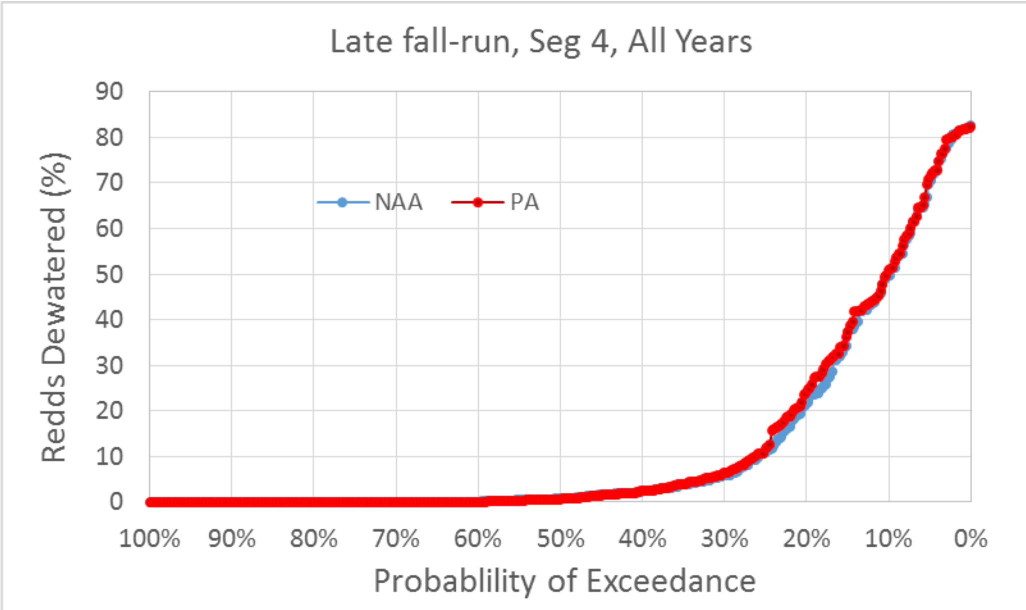


Figure 5.E-180. Exceedance Plot of Late Fall-Run Chinook Salmon Percent of Redds Dewatered for NAA and PA Model Scenarios in River Segment 4, All Water Years

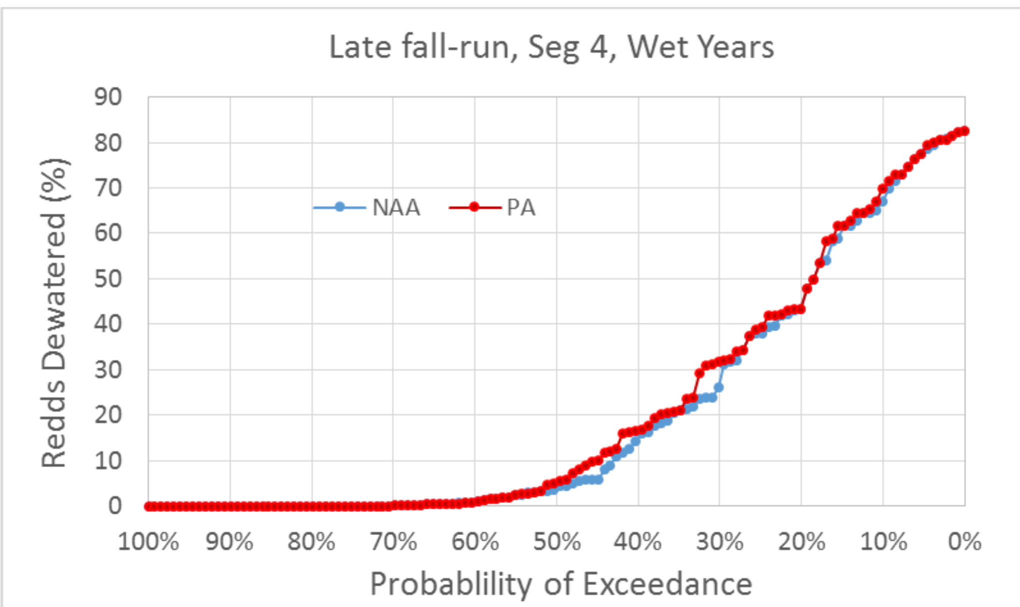


Figure 5.E-181. Exceedance Plot of Late Fall-Run Chinook Salmon Percent of Redds Dewatered for NAA and PA Model Scenarios in River Segment 4, Wet Water Years

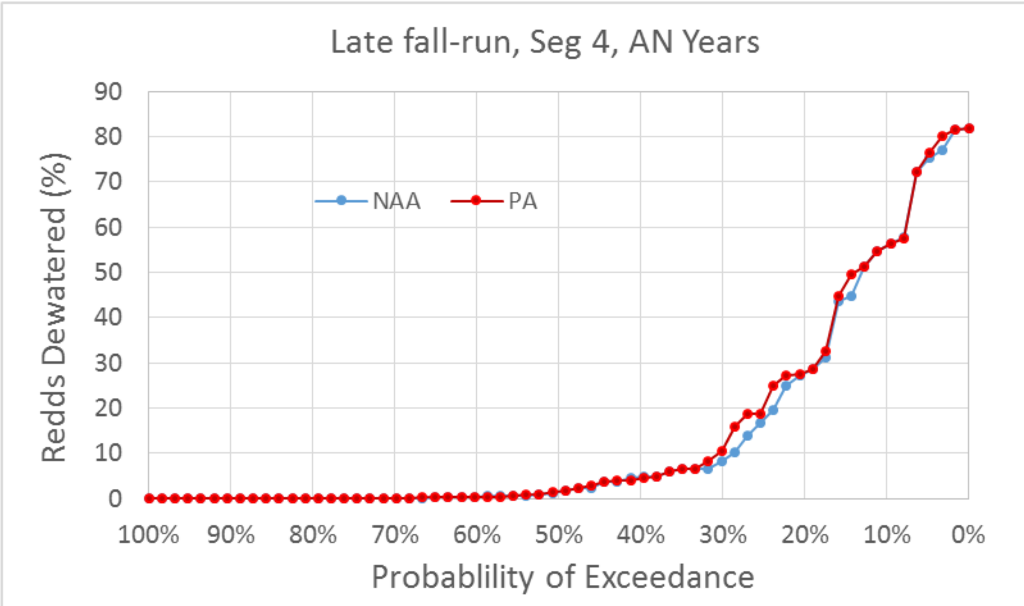


Figure 5.E-182. Exceedance Plot of Late Fall-Run Chinook Salmon Percent of Redds Dewatered for NAA and PA Model Scenarios in River Segment 4, Above Normal Water Years

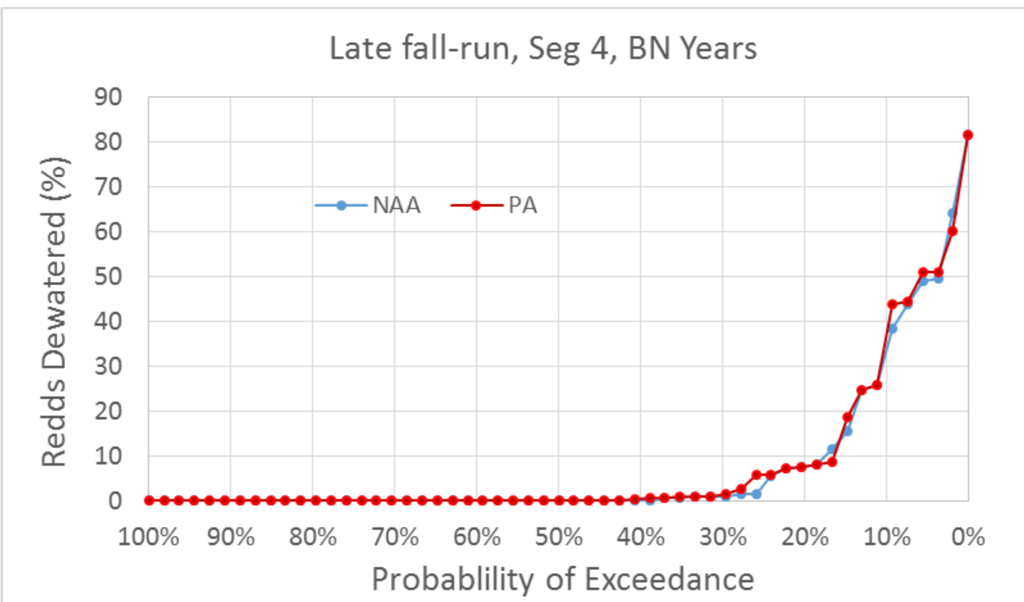


Figure 5.E-183. Exceedance Plot of Late Fall-Run Chinook Salmon Percent of Redds Dewatered for NAA and PA Model Scenarios in River Segment 4, Below Normal Water Years

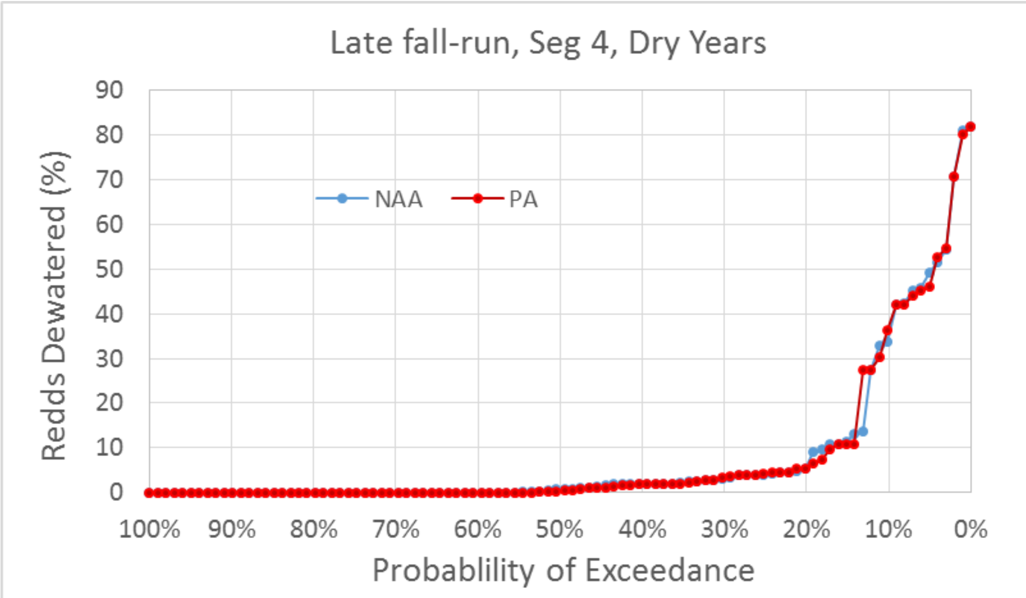


Figure 5.E-184. Exceedance Plot of Late Fall-Run Chinook Salmon Percent of Redds Dewatered for NAA and PA Model Scenarios in River Segment 4, Dry Water Years

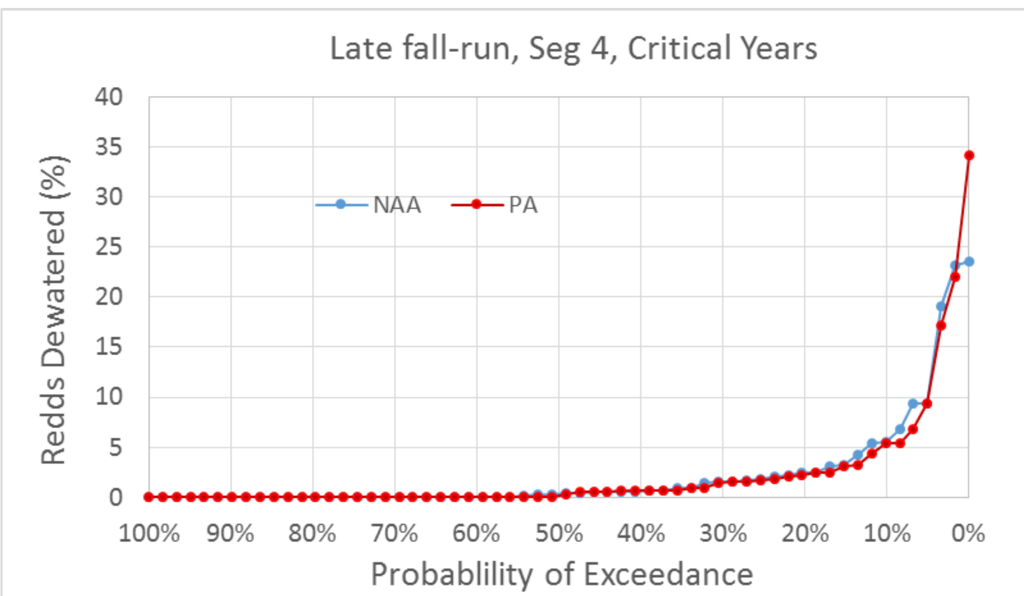


Figure 5.E-185. Exceedance Plot of Late Fall-Run Chinook Salmon Percent of Redds Dewatered for NAA and PA Model Scenarios in River Segment 4, Critical Water Years

Differences in the mean percentage of redds dewatered in each river segment for each month of spawning under each water year type and all water year types combined indicate that late fall-run Chinook salmon redd dewatering would be little affected by the PA (Table 5.E-51 through Table 5.E-51). The percent of redds dewatered under the PA was little different from that under the NAA for all months and water year types, ranging up to 2.9% greater under the PA for January of wet years in Segment 5 (Table 5.E-51). The percent differences in the percent of redds dewatered between the PA and the NAA range up to a 130% increase under the PA for January of critical water years in Segment 6 (Table 5.E-49), but this increase and the other large relative changes in percent of redds dewatered are artifacts of the low percentages of redds dewatered under both scenarios that were used in computing the percent differences.

Table 5.E-51. Late Fall-run Chinook Salmon Percent of Redds Dewatered (Percent of Total Redds) and Differences (Percent Differences) in River Segment 6 between Model Scenarios (green indicates PA is at least 5% lower [raw difference] than NAA; red indicates PA is at least 5% higher)

Month	WYT	NAA	PA	PA vs. NAA
December	Wet	11.1	12.0	0.9 (8%)
	Above Normal	7.4	6.3	-1.1 (-15%)
	Below Normal	11.1	10.7	-0.4 (-3%)
	Dry	16.4	16.8	0.4 (2%)
	Critical	0.8	0.6	-0.2 (-22%)
	All	10.3	10.5	0.1 (1%)
January	Wet	18.7	21.5	2.8 (15%)
	Above Normal	11.3	11.4	0.1 (1%)
	Below Normal	11.3	10.9	-0.5 (-4%)
	Dry	16.9	17.2	0.4 (2%)
	Critical	2.1	4.8	2.7 (130%)
	All	13.7	15.0	1.3 (10%)
February	Wet	36.7	37.5	0.8 (2%)
	Above Normal	37.5	38.2	0.7 (2%)
	Below Normal	13.7	14.8	1 (7%)
	Dry	0.6	0.6	0.1 (10%)
	Critical	3.0	0.4	-2.6 (-87%)
	All	20.0	20.1	0.1 (1%)
March	Wet	29.0	28.9	-0.1 (-0.2%)
	Above Normal	13.6	16.1	2.5 (18%)
	Below Normal	1.4	2.1	0.6 (45%)
	Dry	1.5	1.3	-0.2 (-12%)
	Critical	0.1	0.1	0 (0%)
	All	11.9	12.4	0.4 (4%)
April	Wet	6.7	6.7	0 (0%)
	Above Normal	1.6	1.8	0.2 (11%)
	Below Normal	0.1	0.0	-0.1 (-69%)
	Dry	0.9	0.4	-0.4 (-50%)
	Critical	3.1	3.0	0 (-2%)
	All	3.1	3.0	-0.1 (-3%)

Table 5.E-52. Late Fall-run Chinook Salmon Percent of Redds Dewatered (Percent of Total Redds) and Differences (Percent Differences) in River Segment 5 between Model Scenarios (green indicates PA is at least 5% lower [raw difference] than NAA; red indicates PA is at least 5% higher)

Month	WYT	NAA	PA	PA vs. NAA
December	Wet	11.1	12.0	0.9 (8%)
	Above Normal	7.5	6.5	-1.01 (-14%)
	Below Normal	11.0	10.6	-0.4 (-3%)
	Dry	16.5	16.8	0.3 (2%)
	Critical	0.8	0.7	-0.1 (-7%)
	All	10.4	10.5	0.2 (2%)
January	Wet	18.8	21.7	2.9 (15%)
	Above Normal	11.5	11.6	0.1 (1%)
	Below Normal	11.4	10.9	-0.5 (-4%)
	Dry	17.0	17.3	0.3 (2%)
	Critical	2.2	5.0	2.8 (125%)
	All	13.8	15.1	1.4 (10%)
February	Wet	37.1	37.9	0.8 (2%)
	Above Normal	37.7	38.5	0.8 (2%)
	Below Normal	13.9	14.9	1 (7%)
	Dry	0.7	0.8	0.1 (14%)
	Critical	3.1	0.4	-2.7 (-86%)
	All	20.2	20.4	0.2 (1%)
March	Wet	29.6	29.6	-0.1 (-0.2%)
	Above Normal	14.0	16.5	2.6 (19%)
	Below Normal	1.5	2.2	0.7 (47%)
	Dry	1.7	1.5	-0.2 (-10%)
	Critical	0.1	0.1	0 (0.2%)
	All	12.2	12.7	0.5 (4%)
April	Wet	7.2	7.2	0 (-0.2%)
	Above Normal	1.7	1.9	0.2 (11%)
	Below Normal	0.1	0.0	-0.1 (-65%)
	Dry	0.9	0.5	-0.5 (-49%)
	Critical	3.0	3.0	-0.1 (-2%)
	All	3.2	3.1	-0.1 (-3%)

Table 5.E-53. Late Fall-run Chinook Salmon Percent of Redds Dewatered (Percent of Total Redds) and Differences (Percent Differences) in River Segment 4 between Model Scenarios (green indicates PA is at least 5% lower [raw difference] than NAA; red indicates PA is at least 5% higher)

Month	WYT	NAA	PA	PA vs. NAA
December	Wet	11.1	12.2	1 (9%)
	Above Normal	6.9	6.5	-0.45 (-6%)
	Below Normal	10.4	10.4	0 (0%)
	Dry	17.4	17.6	0.1 (1%)
	Critical	1.4	1.4	-0.1 (-4%)
	All	10.5	10.8	0.3 (3%)
January	Wet	19.1	21.7	2.6 (13%)
	Above Normal	11.9	12.0	0 (0%)
	Below Normal	13.9	13.3	-0.6 (-4%)
	Dry	17.3	17.7	0.4 (2%)
	Critical	3.4	6.1	2.7 (79%)
	All	14.6	15.8	1.2 (8%)
February	Wet	37.4	38.1	0.7 (2%)
	Above Normal	36.8	37.2	0.4 (1%)
	Below Normal	14.0	15.1	1.1 (8%)
	Dry	1.9	2.0	0.1 (5%)
	Critical	3.6	0.9	-2.7 (-74%)
	All	20.6	20.6	0.1 (0%)
March	Wet	28.5	28.4	-0.1 (-0.3%)
	Above Normal	14.9	17.4	2.6 (17%)
	Below Normal	1.5	2.4	0.8 (53%)
	Dry	3.2	2.8	-0.3 (-10%)
	Critical	0.5	0.5	0 (1.6%)
	All	12.4	12.9	0.4 (3%)
April	Wet	6.8	6.8	0 (-0.1%)
	Above Normal	2.0	2.2	0.2 (8%)
	Below Normal	0.2	0.1	-0.1 (-70%)
	Dry	1.1	0.7	-0.4 (-38%)
	Critical	2.5	2.4	-0.1 (-5%)
	All	3.1	3.0	-0.1 (-4%)

SALMOD flow-related outputs. The SALMOD model provides predicted flow-related mortality of late fall-run Chinook salmon spawning, eggs, and alevins in the Sacramento River. The SALMOD results for flow-related mortality are presented in Table 5.E-54, together with results for the other sources of mortality of late fall-run Chinook salmon predicted by SALMOD and discussed in other sections of this document. The flow-related mortality of late fall-run Chinook salmon spawning, eggs, and alevins is split up as “incubation” (which refers to redd dewatering and scour) and “superimposition” (of redds) mortality (see Appendix 5.D, Attachment 5.D.2, *SALMOD Model*). The annual exceedance plot of flow-related mortality of late fall-run Chinook salmon spawning, eggs, and alevins is presented in Figure 5.E-186. The results in Table 5.E-54 indicate that there would be a 7% increase under the PA relative to the NAA in flow-related mortality of late fall-run Chinook salmon spawning, eggs, and alevins from superimposition in above normal years and a 7% increase from incubation-related factors in critical water years. Differences for other water year types would be less than 5% for both mortality factors.

Table 5.E-54. Mean Annual Late Fall-Run Chinook Salmon Mortality[1] (# of Fish/Year) Predicted by SALMOD

	Spawning, Egg Incubation, and Alevins							Fry and Juvenile Rearing									
	Temperature-Related Mortality			Flow-Related Mortality				Temperature-Related Mortality				Flow-Related Mortality					
Analysis Period	Pre-Spawn	Eggs	Subtotal	Incubation	Super-imposition	Subtotal	Life Stage Total	Fry	Pre-smolt	Immature Smolt	Subtotal	Fry	Pre-smolt	Immature Smolt	Subtotal	Life Stage Total	Grand Total
All Water Year Types[1]																	
NAA	0	9,621	9,621	170,413	310,055	480,468	490,089	3,759	68,139	38,185	110,083	1,776,744	14,419	567	1,791,729	1,901,812	2,391,902
PA	0	9,608	9,608	172,486	316,959	489,444	499,052	4,467	73,593	37,878	115,939	1,782,912	13,171	524	1,796,606	1,912,545	2,411,597
Difference	0	-14	-14	2,072	6,904	8,976	8,962	708	5,454	-306	5,856	6,168	-1,248	-43	4,877	10,733	19,695
Percent Difference[3]	0	0	0	1	2	2	2	19	8	-1	5	0	-9	-8	0	1	1
Water Year Types[2]																	
Wet (32.5%)																	
NAA	0	11,882	11,882	482,104	814,510	1,296,614	1,308,495	64	16	11	91	1,524,182	4,222	69	1,528,473	1,528,563	2,837,059
PA	0	11,880	11,880	486,545	824,230	1,310,775	1,322,656	63	20	5	88	1,502,838	3,095	69	1,506,002	1,506,090	2,828,746
Difference	0	-1	-1	4,441	9,720	14,162	14,160	-1	4	-6	-3	-21,344	-1,128	1	-22,471	-22,473	-8,313
Percent Difference	0	0	0	1	1	1	1	-1	28	-57	-3	-1	-27	1	-1	-1	0
Above Normal (12.5%)																	
NAA	0	7,815	7,815	22,967	370,137	393,103	400,918	110	37	19	166	1,843,097	1,583	28	1,844,708	1,844,874	2,245,792
PA	0	7,340	7,340	23,302	395,912	419,214	426,554	108	9	0	117	1,776,429	2,595	36	1,779,061	1,779,178	2,205,732
Difference	0	-475	-475	335	25,775	26,110	25,636	-2	-28	-19	-48	-66,668	1,012	8	-65,647	-65,696	-40,060
Percent Difference	0	-6	-6	1	7	7	6	-2	-75	-100	-29	-4	64	28	-4	-4	-2
Below Normal (17.5%)																	
NAA	0	1,186	1,186	30,443	0	30,443	31,630	0	872	2,684	3,556	1,958,331	16,897	713	1,975,940	1,979,496	2,011,126
PA	0	3,836	3,836	30,838	0	30,838	34,674	2	2,136	5,243	7,380	2,076,131	10,865	707	2,087,704	2,095,084	2,129,758
Difference	0	2,649	2,649	395	0	395	3,044	2	1,264	2,558	3,824	117,800	-6,032	-5	111,763	115,588	118,632
Percent Difference	0	223	223	1	0	1	10	0	145	95	108	6	-36	-1	6	6	6
Dry (22.5%)																	
NAA	0	10,840	10,840	29,324	0	29,324	40,163	137	4,347	8,912	13,396	1,868,390	9,467	824	1,878,681	1,892,076	1,932,240
PA	0	10,538	10,538	30,352	0	30,352	40,890	101	4,144	8,692	12,937	1,898,772	13,579	938	1,913,290	1,926,227	1,967,117
Difference	0	-301	-301	1,028	0	1,028	727	-36	-203	-220	-459	30,383	4,112	114	34,609	34,151	34,878
Percent Difference	0	-3	-3	4	0	4	2	-26	-5	-2	-3	2	43	14	2	2	2
Critical (15%)																	
NAA	0	12,420	12,420	31,960	0	31,960	44,380	24,592	446,147	237,209	707,948	1,917,364	54,477	1,579	1,973,420	2,681,368	2,725,748
PA	0	10,879	10,879	34,110	0	34,110	44,990	29,370	481,708	233,221	744,298	1,910,995	46,172	1,099	1,958,266	2,702,564	2,747,554
Difference	0	-1,541	-1,541	2,151	0	2,151	610	4,779	35,560	-3,989	36,350	-6,369	-8,305	-481	-15,154	21,196	21,806
Percent Difference	0	-12	-12	7	0	7	1	19	8	-2	5	0	-15	-30	-1	1	1

1 Based on the 80-year simulation period
2 As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB 1995). Water years may not correspond to the biological years in SALMOD.
3 Relative difference of the Annual average
4 Mortality values do not include base mortality

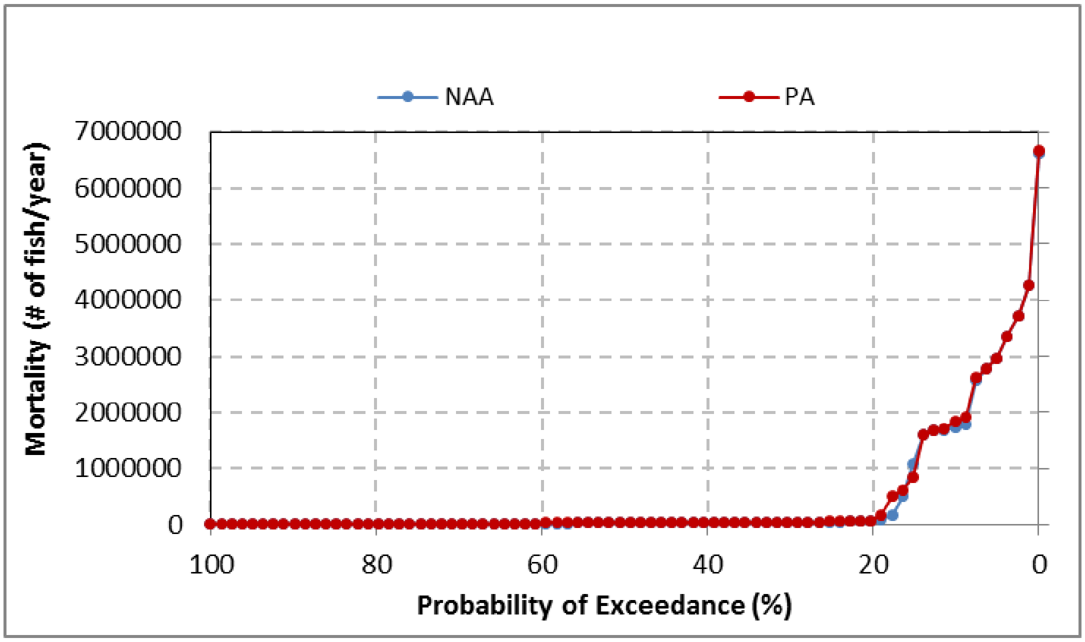


Figure 5.E-186. Exceedance Plot of Annual Flow-Based Mortality (#of Fish/Year) of Late Fall-Run Chinook Salmon Spawning, Egg Incubation, and Alevins

Water Temperature-Related Effects

Mean monthly water temperatures were evaluated during the December through June spawning, egg incubation, and alevin period for late fall-run Chinook salmon (Table 5.E-5). Overall, the PA would change mean water temperatures very little (predominantly less than 1°F, or approximately 1%) throughout the spawning reach of Keswick to Red Bluff in all months of the period and water year types (Appendix 5.C, *Upstream Water Temperature Methods and Results*, Section 5.C.7, *Upstream Water Temperature Modeling Result*, Table 5.C.7-3, Table 5.C.7-4, Table 5.C.7-5, Table 5.C.7-7, Table 5.C.7-8). The largest increase in mean monthly water temperatures under the PA relative to NAA would be 0.3°F, or up to 0.7%, and would occur during May of below normal water years at Keswick, above Clear Creek, Balls Ferry, and Bend Bridge. These largest increases during May would not occur during the period of peak presence of spawners, eggs, and alevins.

Exceedance plots of monthly mean water temperatures were examined during each month and water year type throughout the spawning and incubation period (Appendix 5.C, *Upstream Water Temperature Methods and Results*, Section 5.C.7, *Upstream Water Temperature Modeling Result*, Figure 5.C.7.3-7, Figure 5.C.7.4-7, Figure 5.C.7.5-7, Figure 5.C.7.7-7, Figure 5.C.7.8-7). The curves for the PA generally match those of the NAA. Further examination of below normal years during May at Keswick (Figure 5.E-187), above Clear Creek (Figure 5.E-188), Balls Ferry (Figure 5.E-189), and Bend Bridge (Figure 5.E-190), where the largest increases in mean monthly water temperatures were seen, reveals that the curves were mostly similar overall. The 0.3°F increase under the PA is the result of 1 year at Keswick, above Clear Creek, and Balls Ferry, and the result of 2 years at Bend Bridge. Further examination of these months and years reveals that this is appears to be due to CALSIM II attempting to balance storage levels among the CVP reservoirs and there is no practical reason why real operations under the PA would be different from those under the NAA in these months and years.

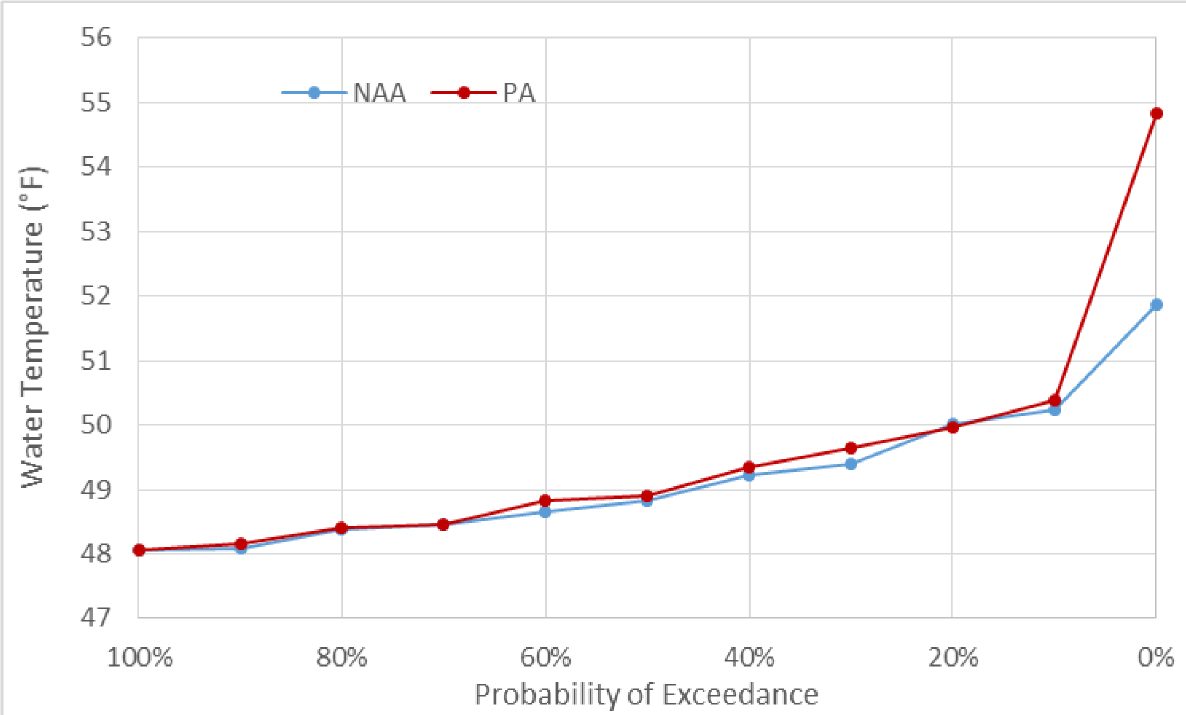


Figure 5.E-187. Exceedance Plot of Mean Monthly Water Temperatures (°F) in the Sacramento River at Keswick in May of Below Normal Water Years

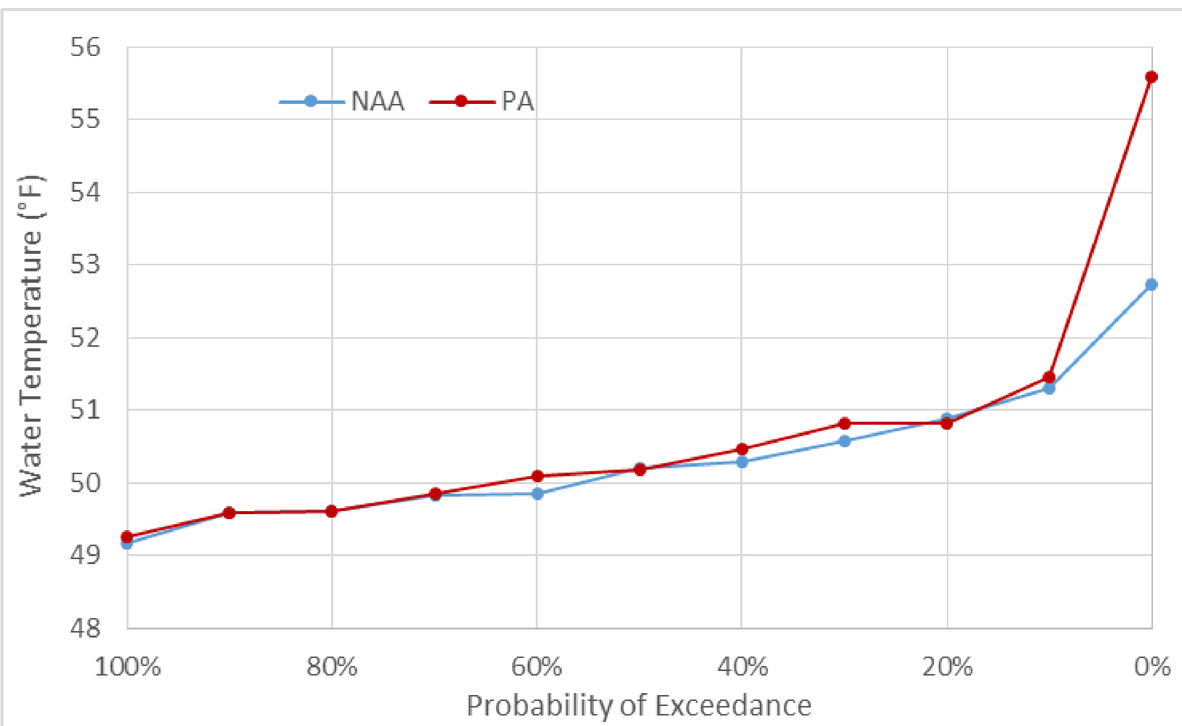


Figure 5.E-188. Exceedance Plot of Mean Monthly Water Temperatures (°F) in the Sacramento River above Clear Creek in May of Below Normal Water Years

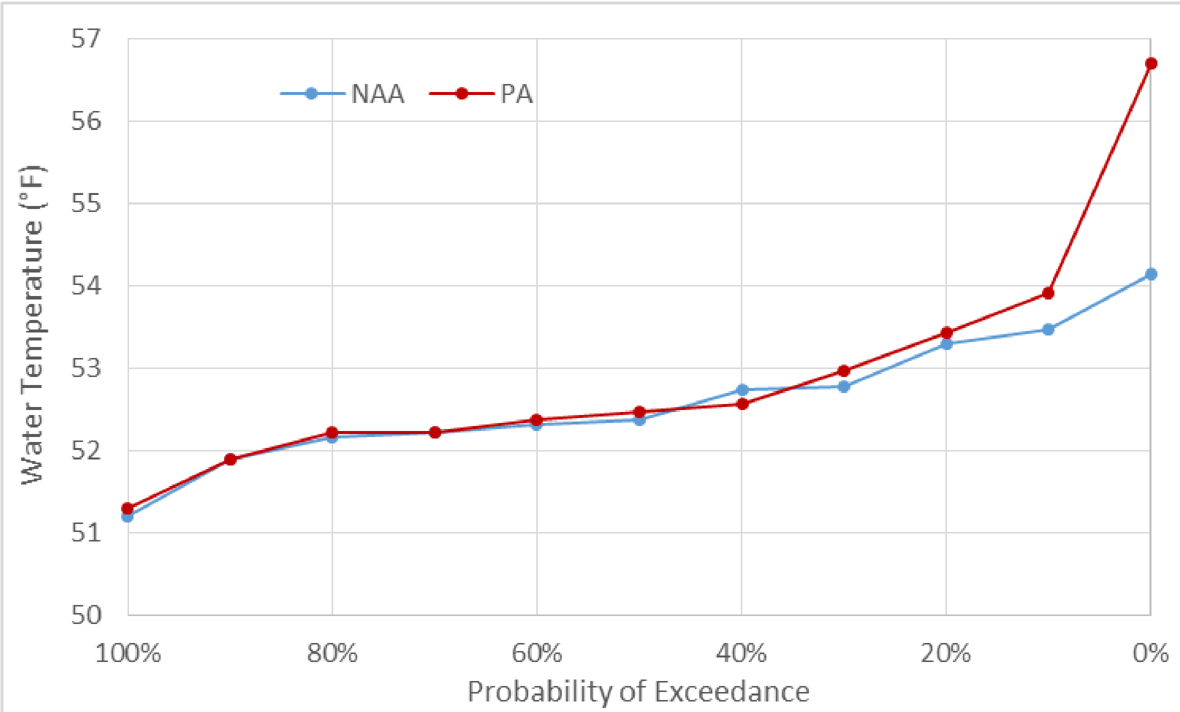


Figure 5.E-189. Exceedance Plot of Mean Monthly Water Temperatures (°F) in the Sacramento River at Balls Ferry in May of Below Normal Water Years

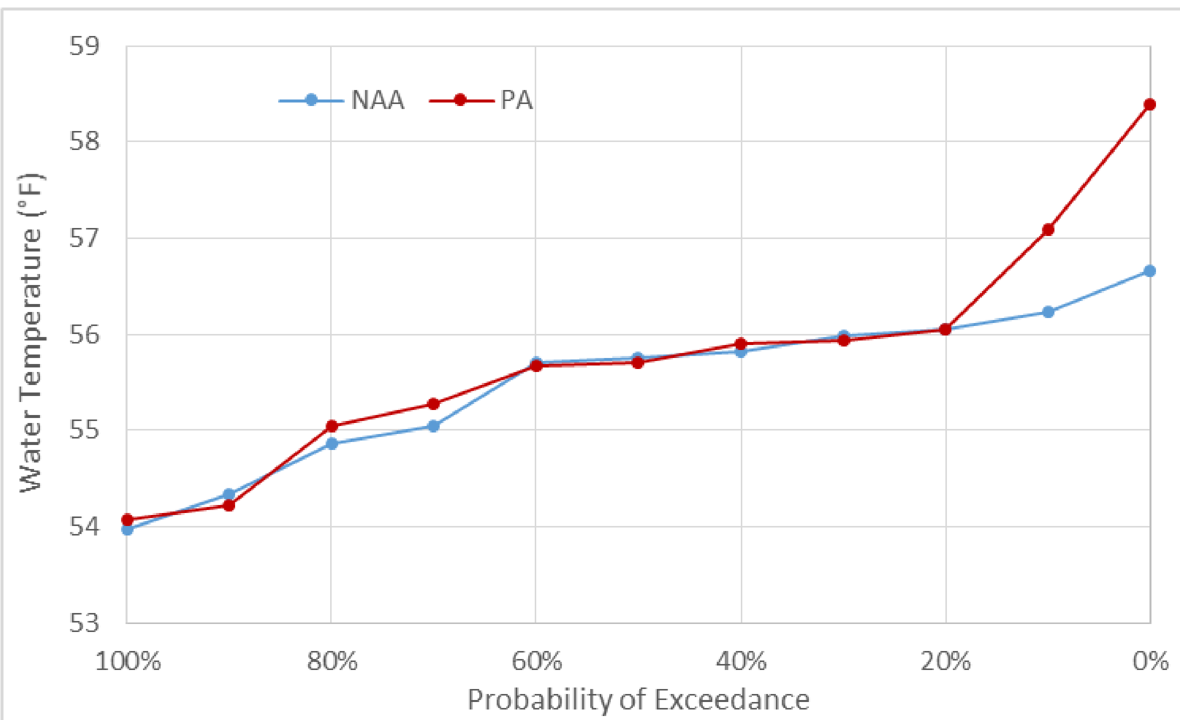


Figure 5.E-190. Exceedance Plot of Mean Monthly Water Temperatures (°F) in the Sacramento River at Bend Bridge in May of Below Normal Water Years

To evaluate water temperature threshold exceedance during the spawning, egg incubation, and alevin life stages between Keswick and Red Bluff, the USEPA's 7DADM threshold value of 55.4°F was used (Table M-2) (U.S. Environmental Protection Agency 2003). The threshold was converted to function with daily model outputs for each month separately (Table M-4).

Results of the water temperature thresholds analysis are presented in Attachment 5.E.1, *Fall-/Late Fall-Run Chinook Salmon Water Temperature Threshold Analysis Results*, Table 5.E.1-18 through Table 5.E.1-22. At Keswick, there would be no months or water year types in which there would be 5% more days under the PA compared to the NAA on which temperatures would exceed the threshold (Attachment 5.E.1, *Fall-/Late Fall-Run Chinook Salmon Water Temperature Threshold Analysis Results*, Table 5.E.1-18). Therefore, it was concluded that there would be no effect at Keswick.

At Clear Creek, the percent of days exceeding the 55.4°F 7DADM threshold under the PA would be more than 5% higher than under the NAA during May of below normal years (6.2%) (Attachment 5.E.1, *Fall-/Late Fall-Run Chinook Salmon Water Temperature Threshold Analysis Results*, Table 5.E.1-19). There would also be a 1.32°F increase in the magnitude of average daily exceedance under the PA relative to the NAA during May of below normal years. Further examination of model outputs reveals that it is largely the result of a single year (1923), but there is no reason why the reservoir could not operated similar to the NAA during real time operations, particularly because water temperatures during June under the PA would be lower than those under the NAA. As a result, it was concluded that CALSIM provided spurious results for May of 1923 and, in reality, there would be no effect at Clear Creek.

At Balls Ferry, the percent of days exceeding the 55.4°F 7DADM threshold under the PA would be more than 5% higher than under the NAA during May of below normal years (6.2%) (Attachment 5.E.1, *Fall-/Late Fall-Run Chinook Salmon Water Temperature Threshold Analysis Results*, Table 5.E.1-20). There would also be a 0.55°F increase in the magnitude of average daily exceedance under the PA relative to the NAA during May of below normal years. Further examination of model outputs reveals that it is largely the result of a single year (1923), but there is no reason why the reservoir could not be operated similar to the NAA during real time operations, particularly because water temperatures during June under the PA would be lower than those under the NAA. As a result, it was concluded that CALSIM provided spurious results for May of 1923 and, in reality, there would be no effect at Clear Creek.

At Bend Bridge and Red Bluff, there would be no months or water year types in which there would be either 5% more days under the PA compared to the NAA on which temperatures would exceed the threshold or a more-than-0.5°F difference in the magnitude of average daily exceedance (Attachment 5.E.1, *Fall-/Late Fall-Run Chinook Salmon Water Temperature Threshold Analysis Results*, Table 5.E.1-21 and Table 5.E.1-22). Therefore, it was concluded that there would be no effect at Bend Bridge or Red Bluff.

Overall, the thresholds analysis indicates that any water temperature-related effects on late fall-run Chinook salmon spawning, egg incubation, and alevins would be unlikely.

The Reclamation Egg Mortality Model provides temperature-related estimates of late fall-run egg mortality in the Sacramento River (see Attachment 5.D.1, *Reclamation Egg Mortality Model*, for full model description). Results of the model are presented in Table 5.E-55 and Figure 5.E-191 through Figure 5.E-196. Because the egg life stage has the highest potential effect on the propagation of population size in a life cycle context, a conservative value of a more-than-2% change in percent of total individuals (on a raw scale) was considered a detectable effect. The results indicate that there would be negligible differences in mortality (<0.3%) between the NAA and PA for all water year types combined and for each water year type separately.

Table 5.E-55. Late Fall-run Chinook Salmon Egg Mortality (Percent of Total Individuals) and Differences (Percent Differences) between Model Scenarios, Reclamation Egg Mortality Model

WYT	NAA	PA	PA vs. NAA
Wet	3.1	2.9	-0.1 (-5%)
Above Normal	2.4	2.1	-0.3 (-13%)
Below Normal	2.5	2.4	-0.1 (-5%)
Dry	2.7	2.6	-0.03 (-1%)
Critical	4.8	4.7	-0.1 (-2%)
All	3.0	2.9	-0.1 (-4%)

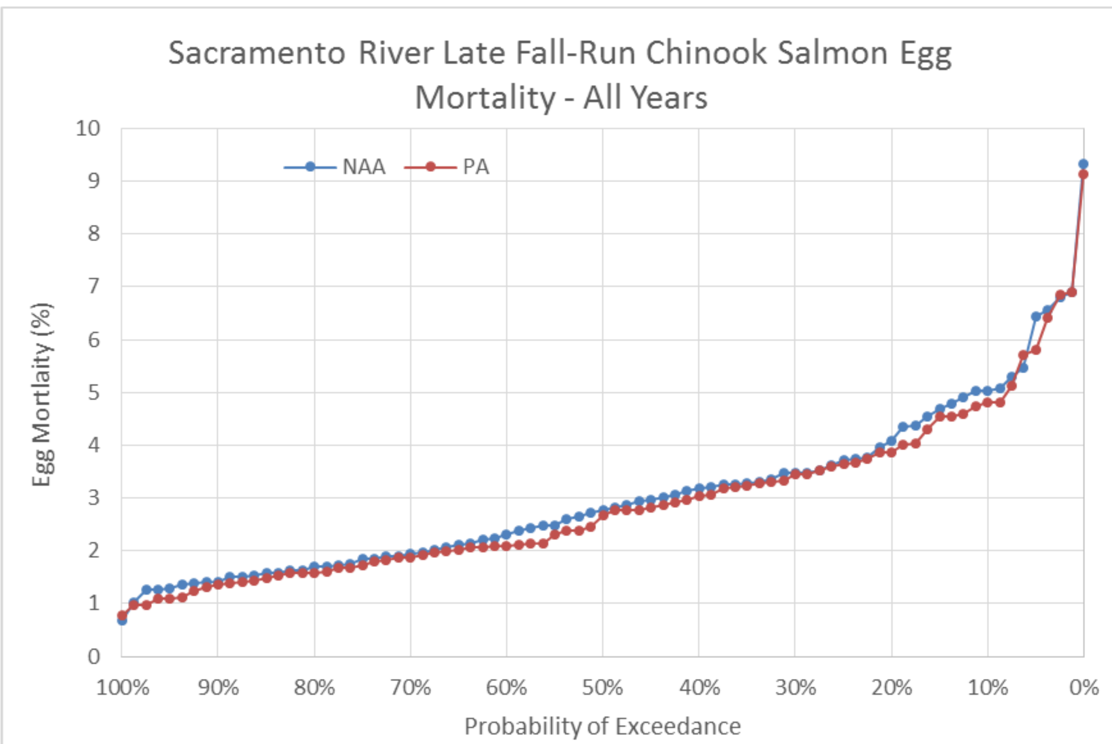


Figure 5.E-191. Exceedance Plot of Late Fall-Run Chinook Salmon Egg Mortality for NAA and PA Model Scenarios, Reclamation Egg Mortality Model, All Water Years

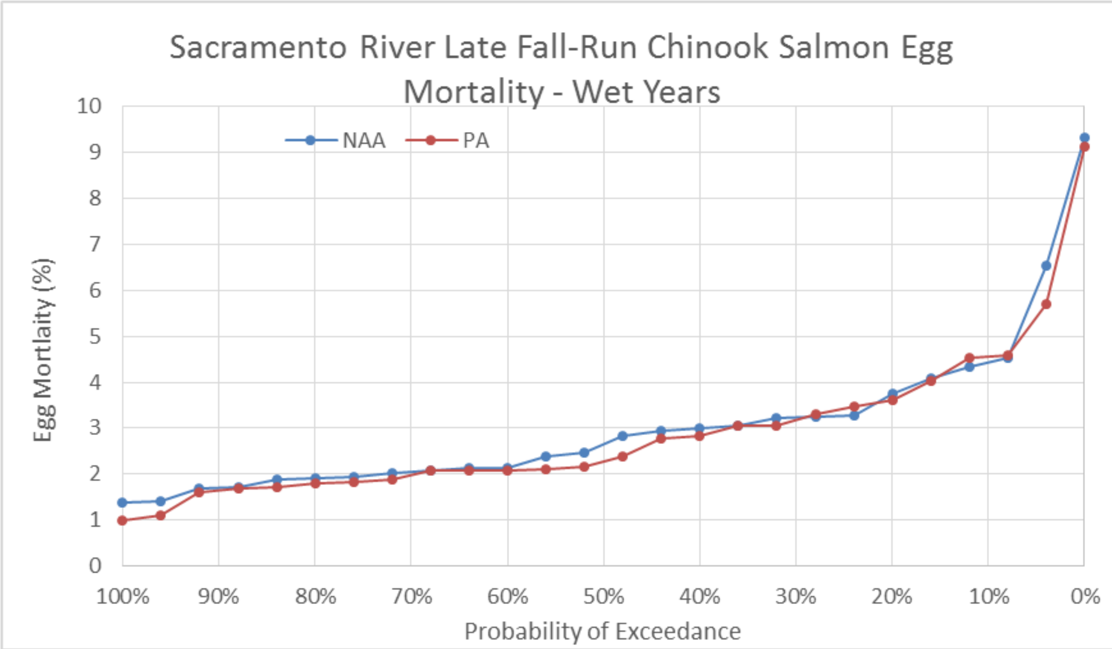


Figure 5.E-192. Exceedance Plot of Late Fall -Run Chinook Salmon Egg Mortality for NAA and PA Model Scenarios, Reclamation Egg Mortality Model, Wet Water Years

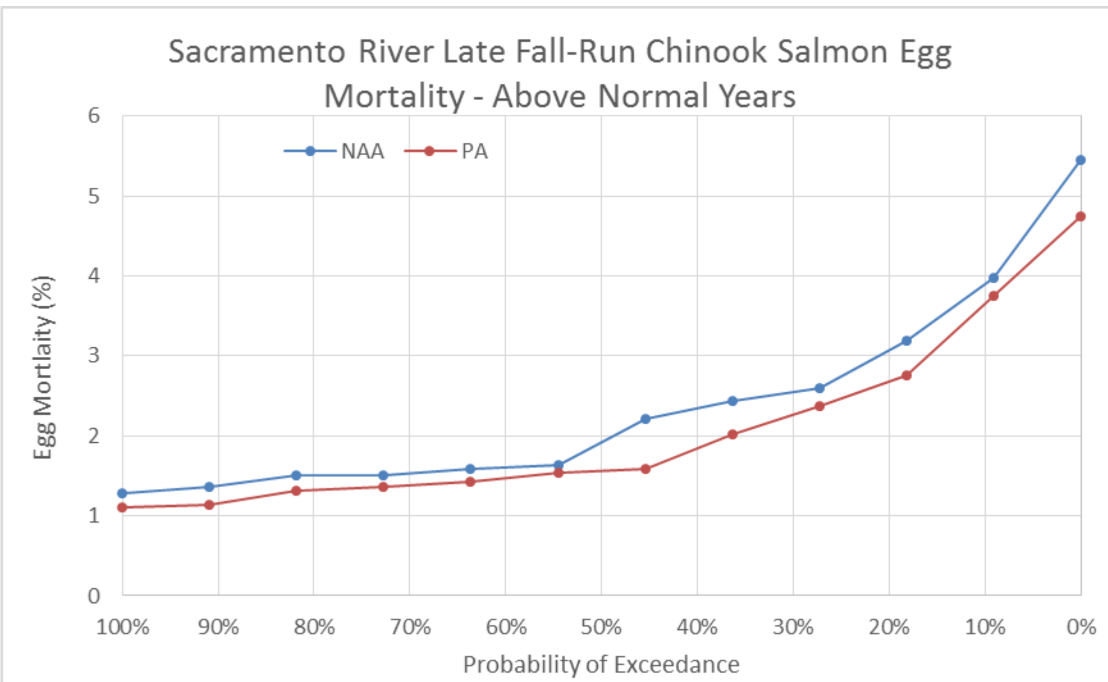


Figure 5.E-193. Exceedance Plot of Late Fall -Run Chinook Salmon Egg Mortality for NAA and PA Model Scenarios, Reclamation Egg Mortality Model, Above Normal Water Years

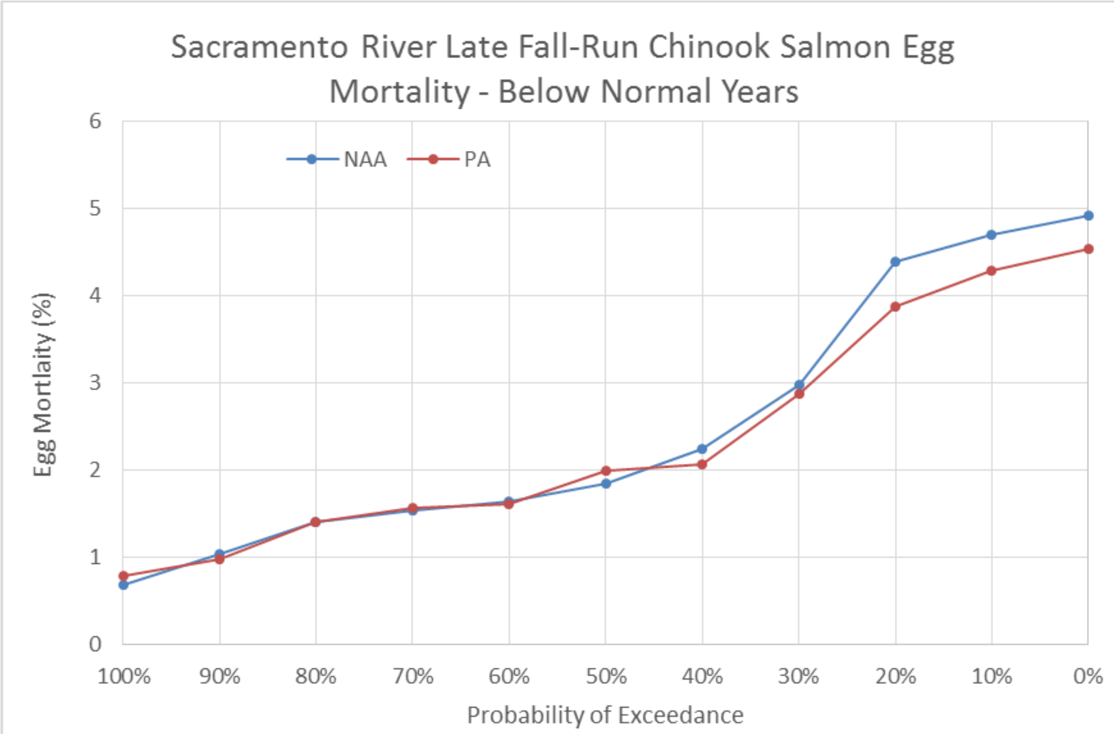


Figure 5.E-194. Exceedance Plot of Late Fall -Run Chinook Salmon Egg Mortality for NAA and PA Model Scenarios, Reclamation Egg Mortality Model, Below Normal Water Years

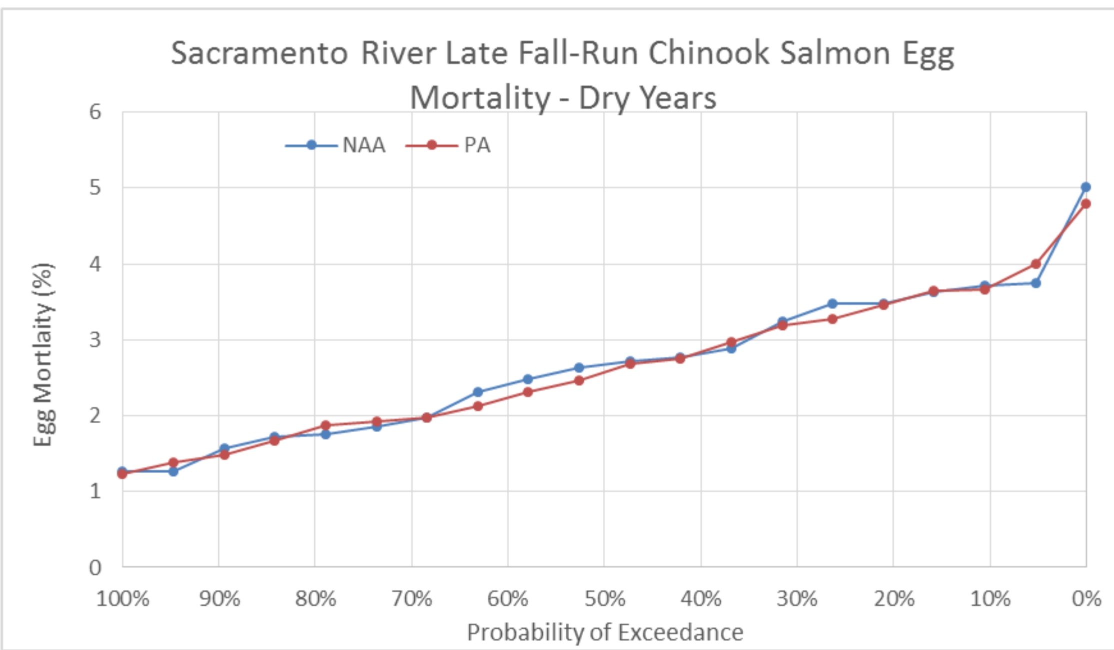


Figure 5.E-195. Exceedance Plot of Late Fall -Run Chinook Salmon Egg Mortality for NAA and PA Model Scenarios, Reclamation Egg Mortality Model, Dry Water Years

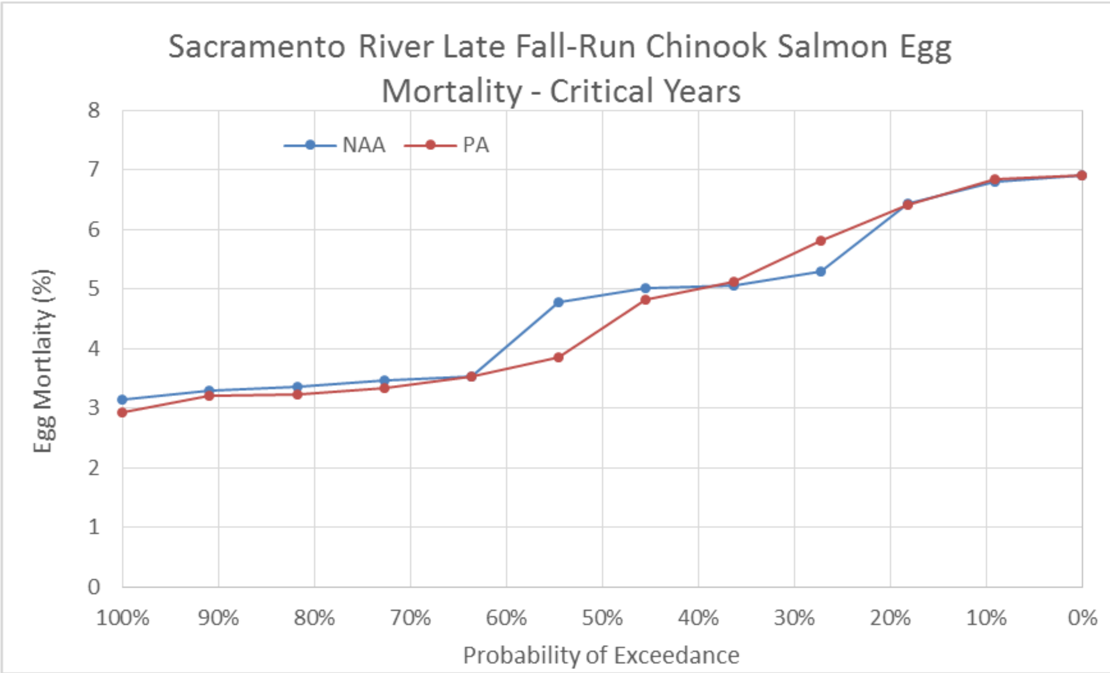


Figure 5.E-196. Exceedance Plot of Late Fall -Run Chinook Salmon Egg Mortality for NAA and PA Model Scenarios, Reclamation Egg Mortality Model, Critical Water Years

The SALMOD model provides predicted water temperature-related mortality of late fall-run Chinook salmon eggs and alevins the Sacramento River. This water temperature-related mortality of late fall-run Chinook salmon eggs and alevins is split up as *pre-spawn* (in vivo, or in the mother before spawning) and *egg* (in the gravel) mortality (see Attachment 5.D.2, *SALMOD Model*, for full details). Results are presented in Table 5.E-54. The annual exceedance plot of temperature-related mortality of late fall-run Chinook salmon eggs and alevins is presented in Figure 5.E-197. The model indicates that, combining all water year types, water temperature-related mortality of the egg and alevin life stages would decrease by 14 fish (~0%) under the PA relative to the NAA. Within this life stage, there would be no difference in pre-spawn mortality (0 fish in both scenarios, and a decrease in egg mortality of 14 fish (~0%). Within individual water year types, only below normal water years would have an increase in mortality (2,649 eggs, or 223%), which is a negligible quantity of eggs considering the starting value of eggs is 13,325,000. As a result, it is concluded that the SALMOD Model shows that there would be no detectable temperature related effects to late fall-run Chinook salmon eggsand alevins.

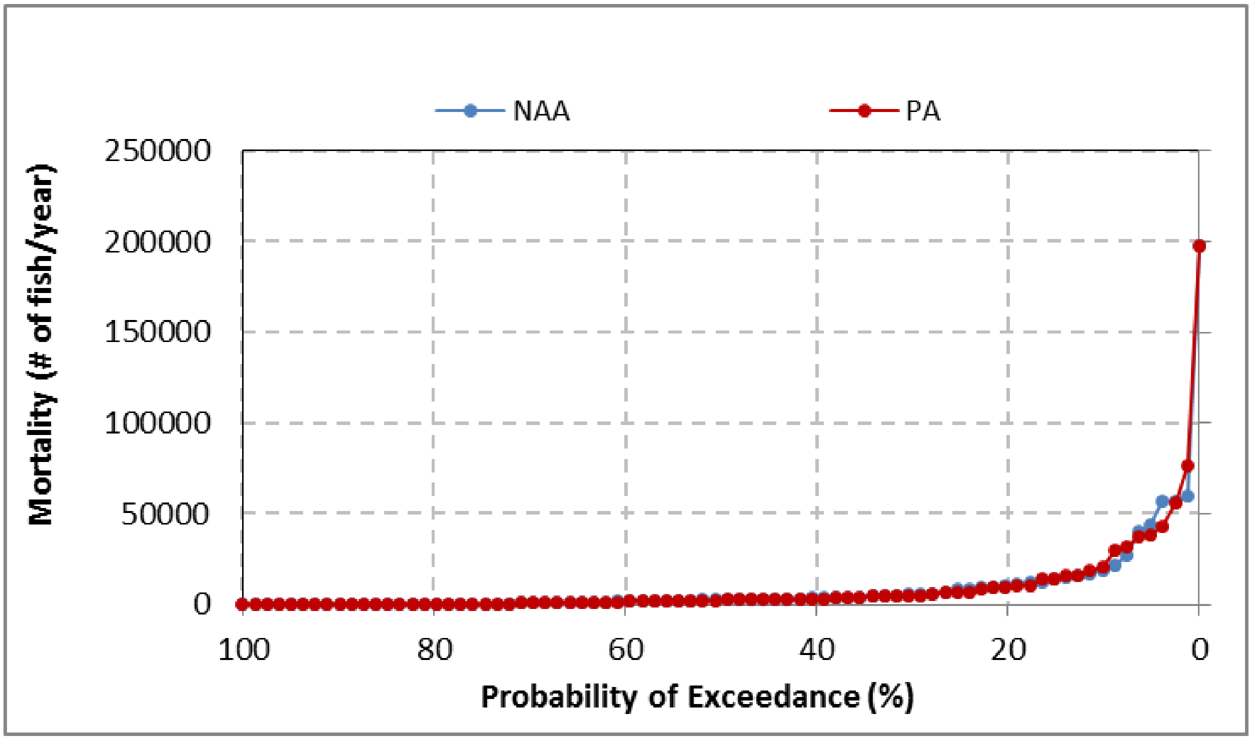


Figure 5.E-197. Exceedance Plot of Annual Water Temperature-Based Mortality (#of Fish/Year) of Late Fall-Run Chinook Salmon Spawning, Egg Incubation, and Alevins

Fry and Juvenile Rearing

Flow-Related Effects

Mean monthly flow rates and reservoir storage volumes were examined for the PA and NAA in the Sacramento River at the Keswick to Red Bluff locations during the March through July fry and juvenile rearing period for late fall-run Chinook salmon (Table 5.E-5). Changes in flow can affect the instream area available for rearing, along with the quality of the habitat for feeding, protective cover, resting, temperature, and other requirements, and can affect stranding of fry and juveniles, especially in side-channel habitats.

Shasta Reservoir storage volume at the end of May influences flow rates in the Sacramento River below the dam during the last two months of the late fall-run Chinook salmon rearing period. Mean Shasta May storage under the PA would be similar (less than 5% difference) to storage under NAA for all water year types (Appendix 5.A *CALSIM Methods and Results*, Table 5.A.6-3). Mean flow under the PA would be similar to (less than 5% difference) or greater than flow under the NAA during all months and water year types of the March through July late fall-run Chinook salmon juvenile rearing period at both river locations*Result*. During March, at Keswick only, flow would be 9% greater under the PA in above normal and below normal years and would be 8% higher in critical years. Flow under the PA would be up to 6% greater during May of dry years (Appendix 5.A, *CALSIM Methods and Results*, Table 5.A.6-10, Table 5.A.6-35). During June, flow under the PA would be greater at both locations for all water year types except wet years. There would be no differences (less than 5% difference) during April and July at either location.

Rearing WUA for late fall-run Chinook salmon fry and juveniles was determined by USFWS (2005b) for a range of flows in three segments of the Sacramento River between Keswick Dam and the Battle Creek confluence (Appendix 5.D.2.3, *Rearing Flows Methods*). The river segments are the same as those used for the spawning habitat WUA studies: Segment 4 from Battle Creek to the confluence with Cow Creek, Segment 5 from Cow Creek to ACID Dam, and Segment 6 from ACID Dam to Keswick Dam (USFWS 2003a, 2006). To estimate changes in rearing WUA that would result from the PA relative to the NAA, the rearing habitat WUA curves developed for each of these segments was used with mean monthly CALSIM II flow estimates under the PA and the NAA for the midpoint of each segment during each month of the late fall-run Chinook salmon fry and juvenile rearing periods (Table 5.E-24). For this analysis, fry were defined as fish less than 60 mm, and juveniles were those greater than 60 mm. Further information on the rearing WUA analysis methods is provided in Appendix 5.D.2.3, *Rearing Flows Methods*.

Differences under the PA and NAA in rearing WUA for late fall-run Chinook salmon fry and juveniles were examined using exceedance plots of mean monthly WUA for the fry (Figure 5.E-198 to Figure 5.E-215) and juvenile (Figure 5.E-216 to Figure 5.E-233) rearing periods in each of the river segments for each water year type and all water year types combined. The PA exceedance curves for both fry and juvenile rearing WUA for all water types years combined are similar to those for the NAA for all three river segments (Figure 5.E-198, Figure 5.E-204, Figure 5.E-210, Figure 5.E-216, Figure 5.E-222, and Figure 5.E-228). With the curves broken out by water year type, minor reductions in fry and juvenile rearing habitat WUA under the PA are evident in one or more water year types for each river segment. These reductions include dry and critical water years for fry (Figure 5.E-202, Figure 5.E-203, Figure 5.E-208, Figure 5.E-209, Figure 5.E-214, and Figure 5.E-215) and dry water years for juveniles (Figure 5.E-220, Figure 5.E-226, and Figure 5.E-232) in all three river segments, above normal years in Segment 6 (Figure 5.E-230) and critical years in Segment 4 (Figure 5.E-233) for juveniles. The WUA modeling indicates that the PA would slightly reduce late fall-run Chinook salmon rearing habitat in some water year types in each river segment. Further discussion regarding flow-related effects during the June through November period is provided in Section 5.E.5.3.1.2.2.4, *Summary of Upstream Effects*.

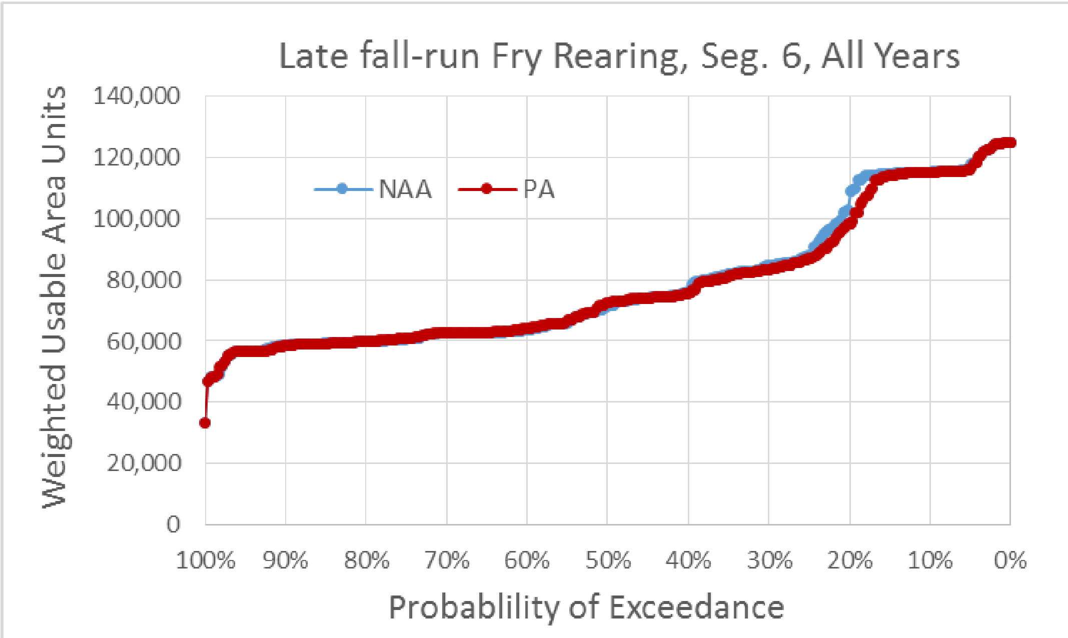


Figure 5.E-198. Exceedance Plot of Late Fall-Run Chinook Salmon Fry Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 6, All Water Years

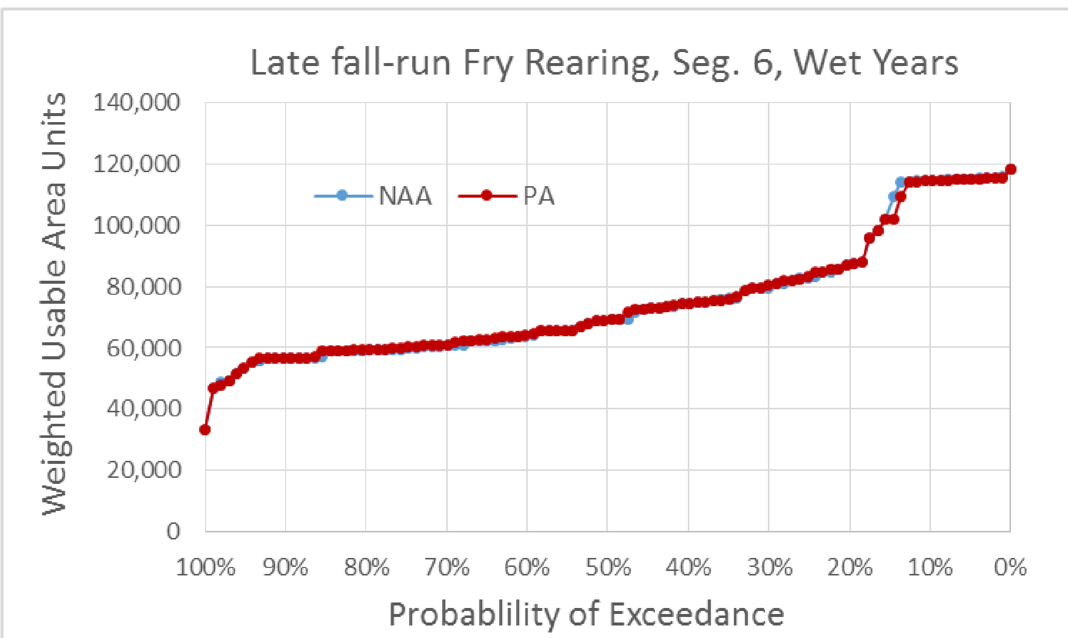


Figure 5.E-199. Exceedance Plot of Late Fall-Run Chinook Salmon Fry Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 6, Wet Water Years

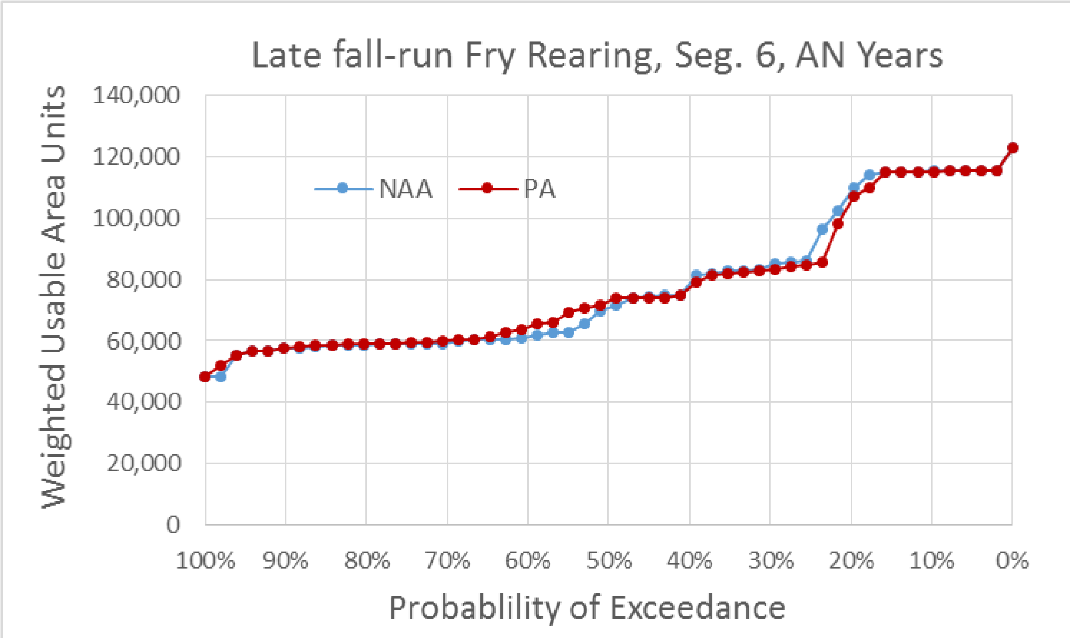


Figure 5.E-200. Exceedance Plot of Late Fall-Run Chinook Salmon Fry Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 6, Above Normal Water Years

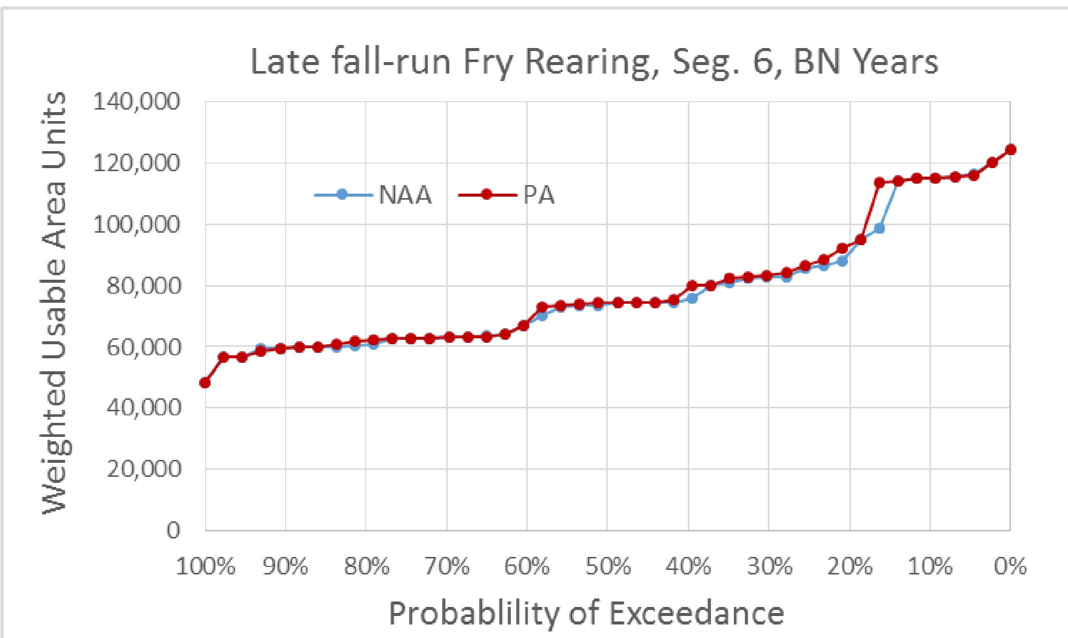


Figure 5.E-201. Exceedance Plot of Late Fall-Run Chinook Salmon Fry Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 6, Below Normal Water Years

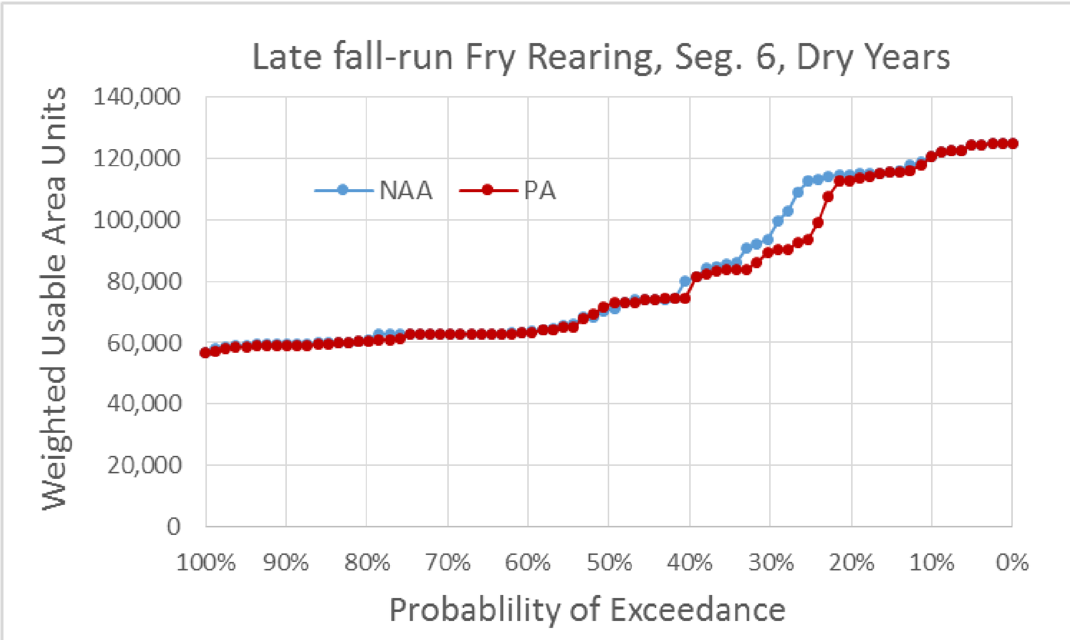


Figure 5.E-202. Exceedance Plot of Late Fall-Run Chinook Salmon Fry Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 6, Dry Water Years

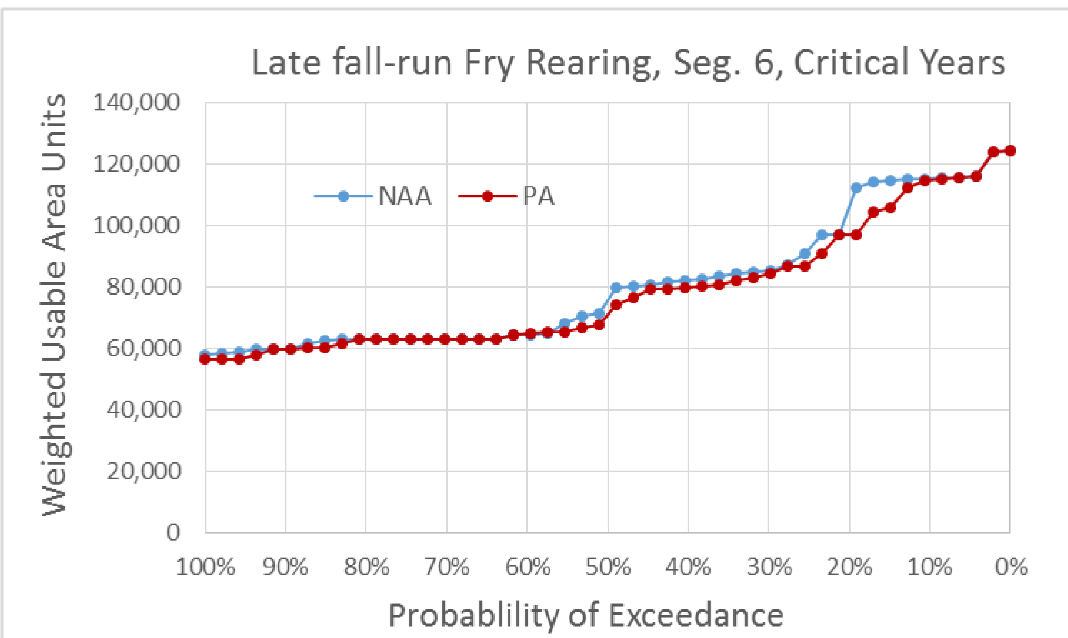


Figure 5.E-203. Exceedance Plot of Late Fall-Run Chinook Salmon Fry Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 6, Critical Water Years

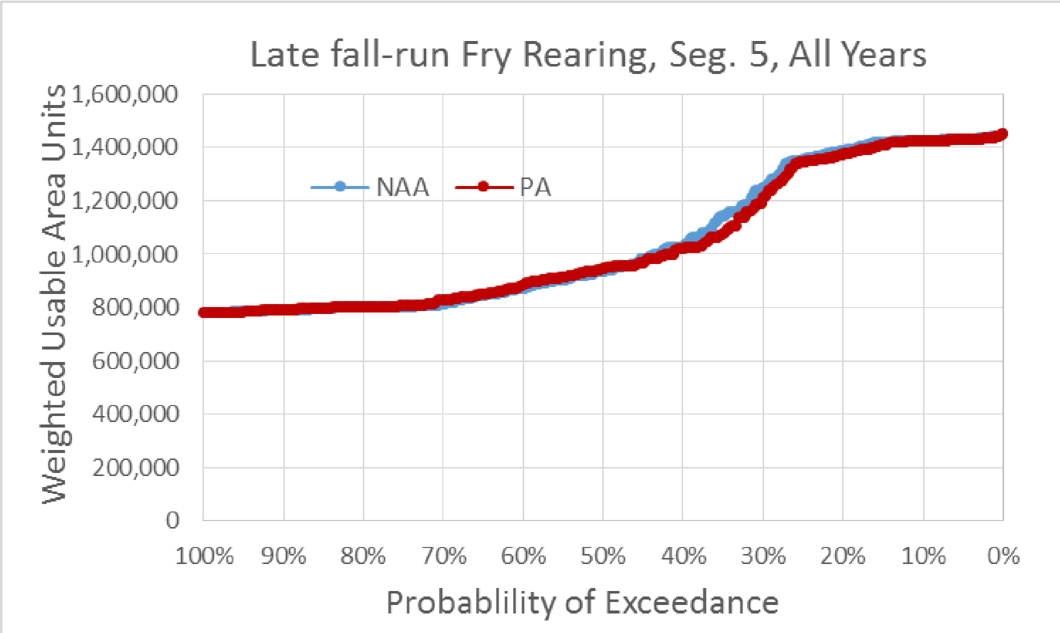
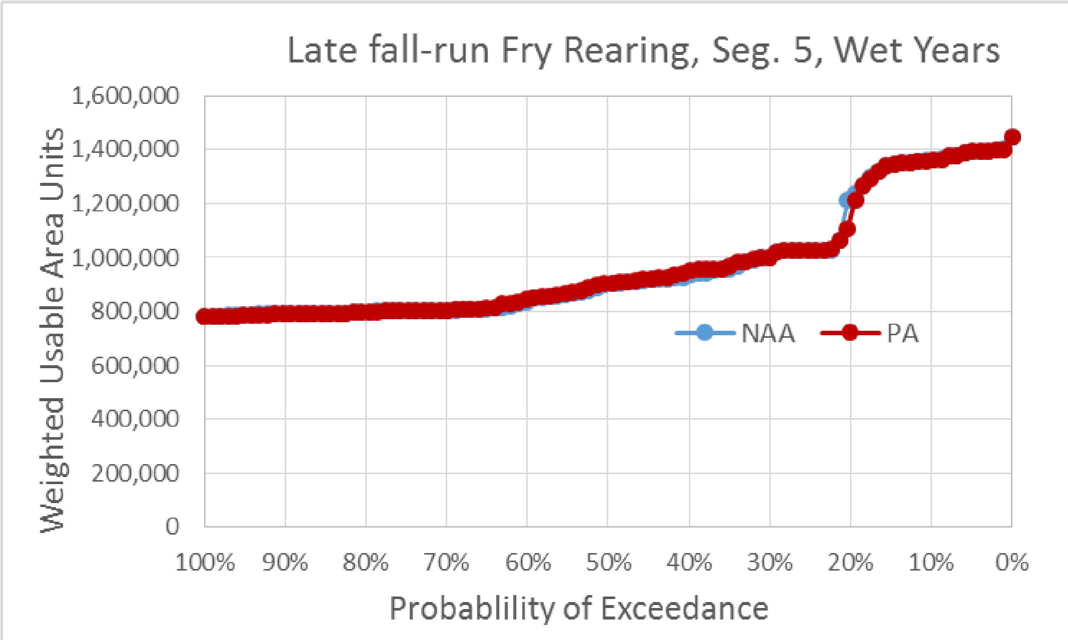


Figure 5.E-204. Exceedance Plot of Late Fall-Run Chinook Salmon Fry Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 5, All Water Years



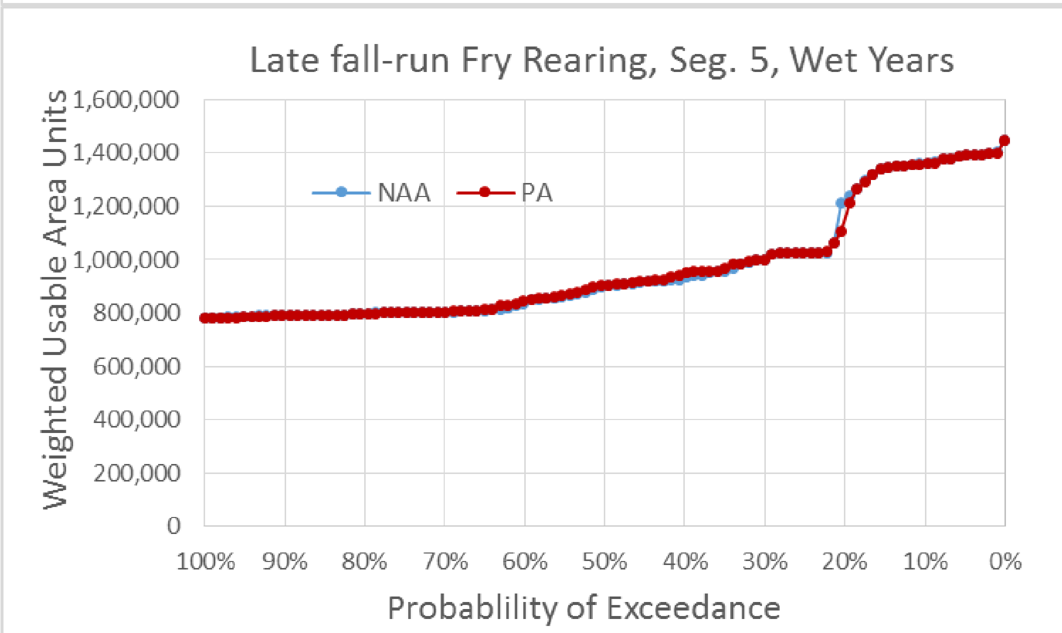


Figure 5.E-205. Exceedance Plot of Late Fall-Run Chinook Salmon Fry Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 5, Wet Water Years

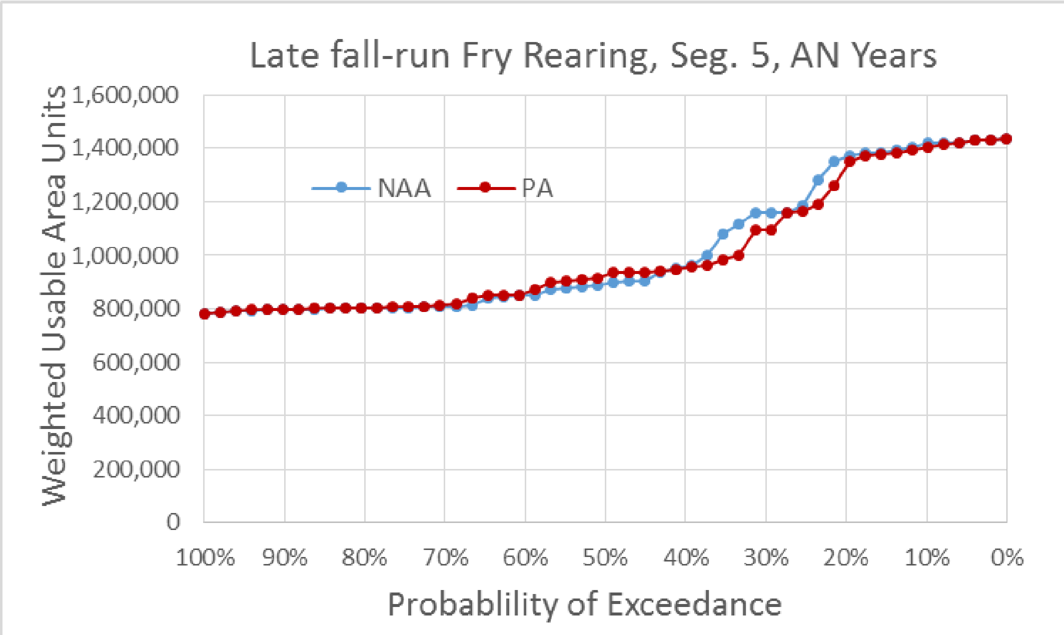


Figure 5.E-206. Exceedance Plot of Late Fall-Run Chinook Salmon Fry Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 5, Above Normal Water Years

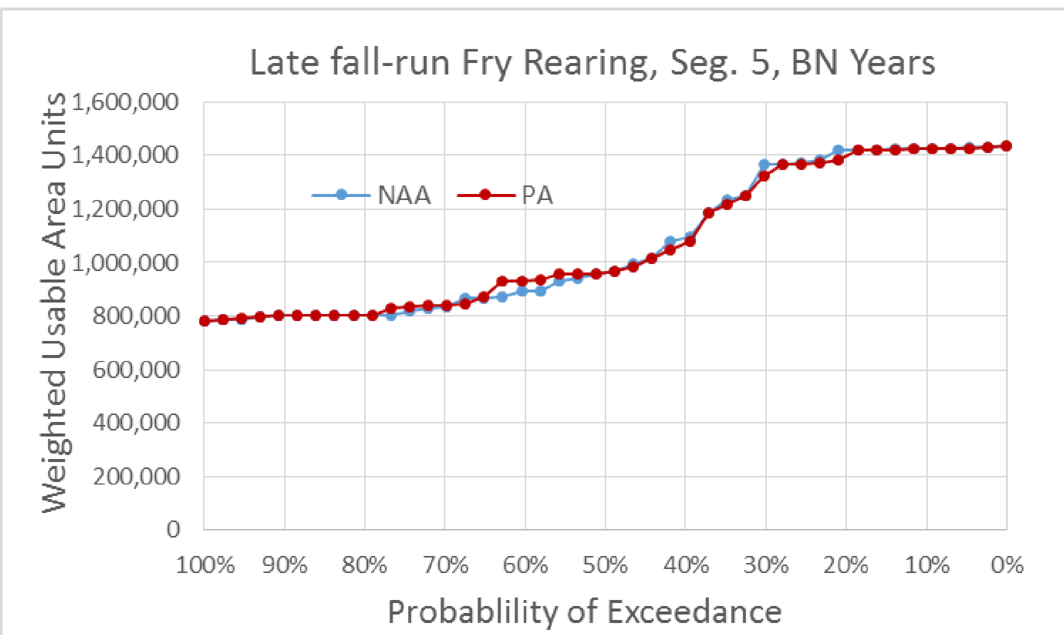


Figure 5.E-207. Exceedance Plot of Late Fall-Run Chinook Salmon Fry Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 5, Below Normal Water Years

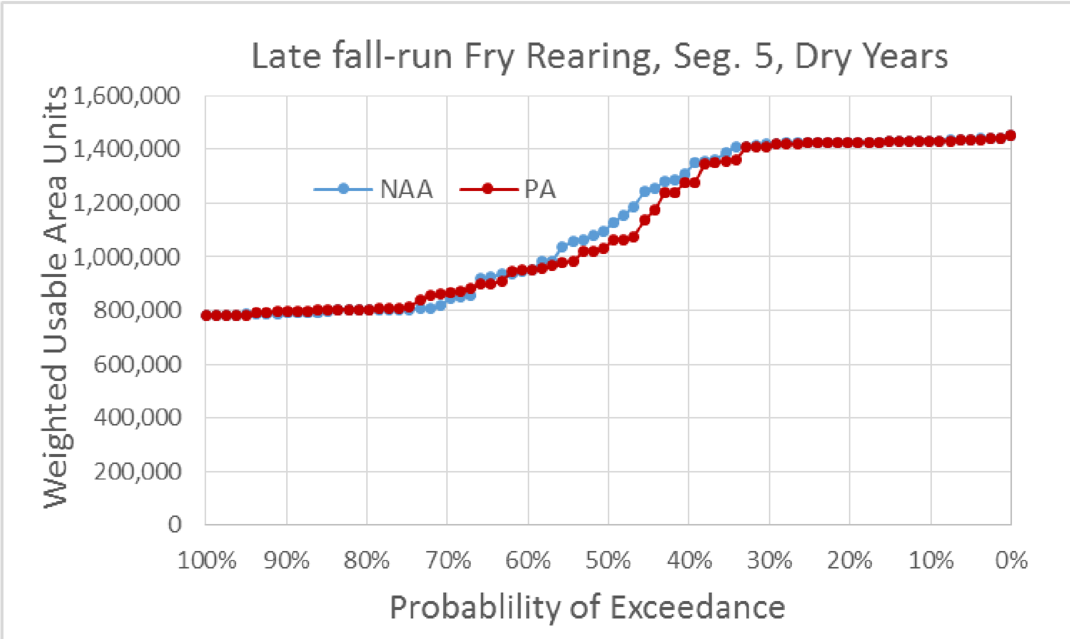


Figure 5.E-208. Exceedance Plot of Late Fall-Run Chinook Salmon Fry Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 5, Dry Water Years

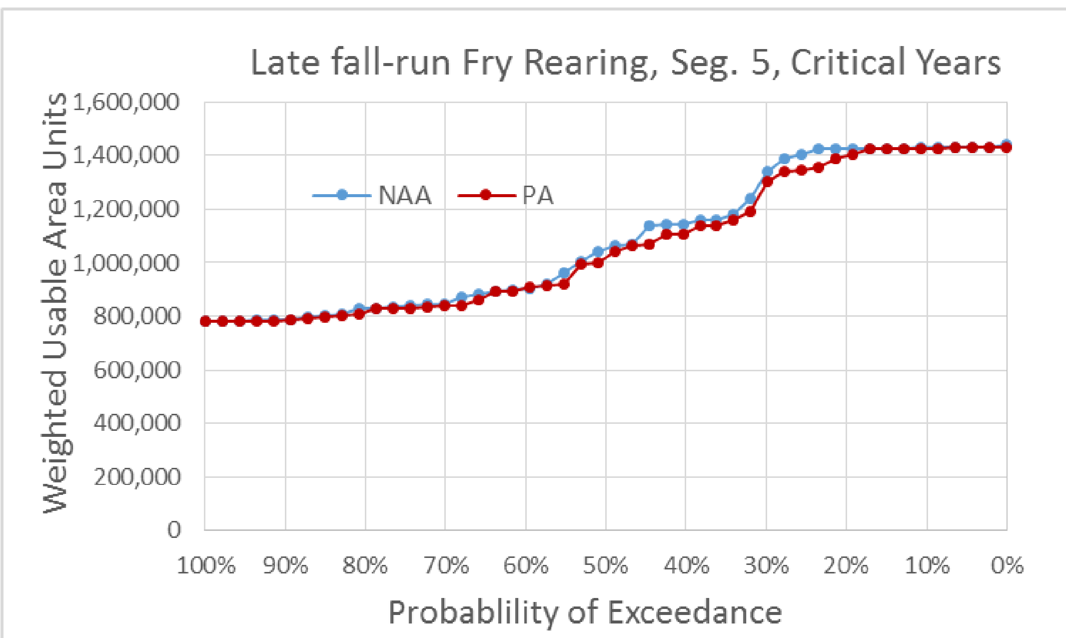


Figure 5.E-209. Exceedance Plot of Late Fall-Run Chinook Salmon Fry Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 5, Critical Water Years

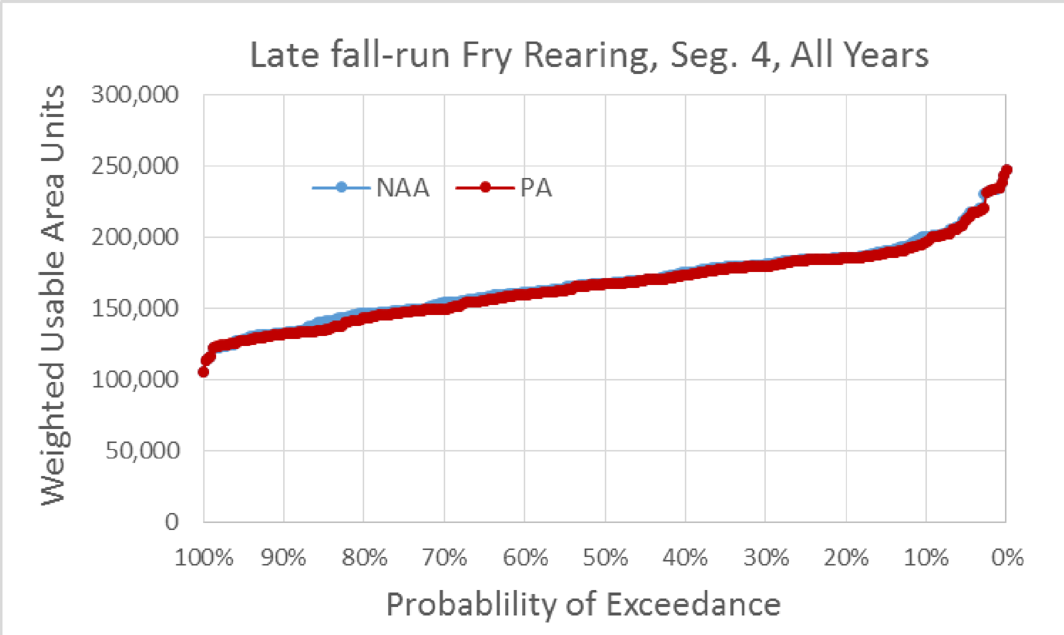


Figure 5.E-210. Exceedance Plot of Late Fall-Run Chinook Salmon Fry Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 4, All Water Years

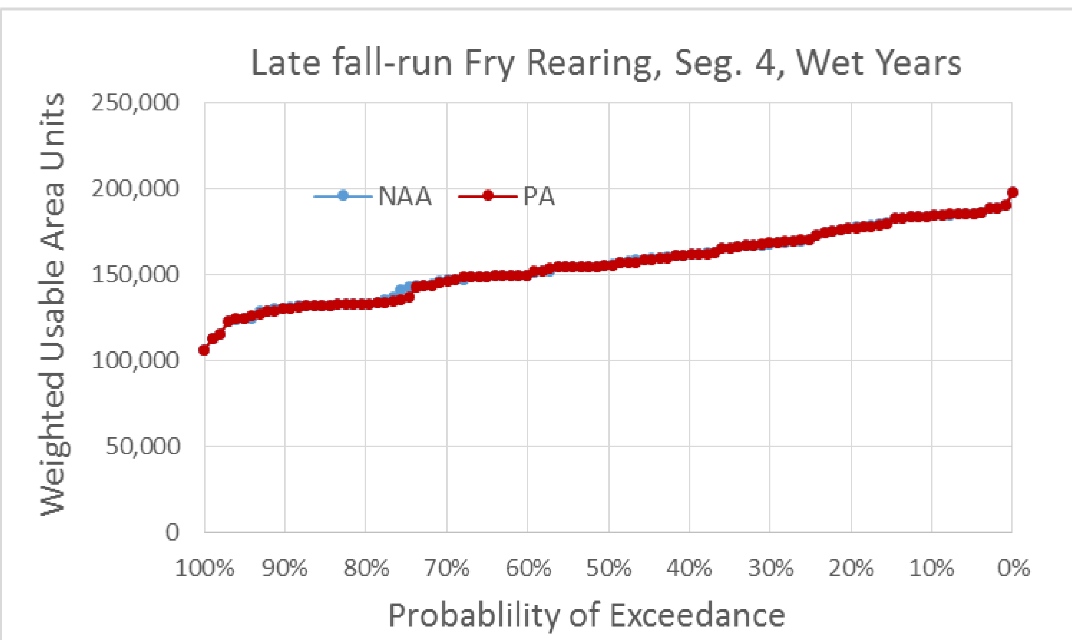


Figure 5.E-211. Exceedance Plot of Late Fall-Run Chinook Salmon Fry Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 4, Wet Water Years

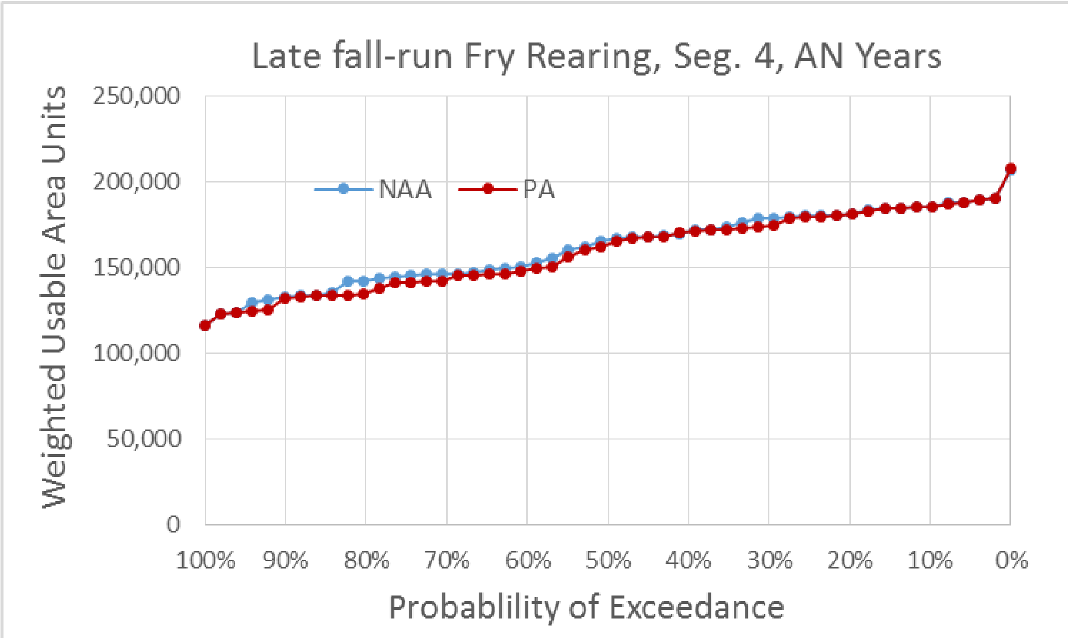


Figure 5.E-212. Exceedance Plot of Late Fall-Run Chinook Salmon Fry Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 4, Above Normal Water Years

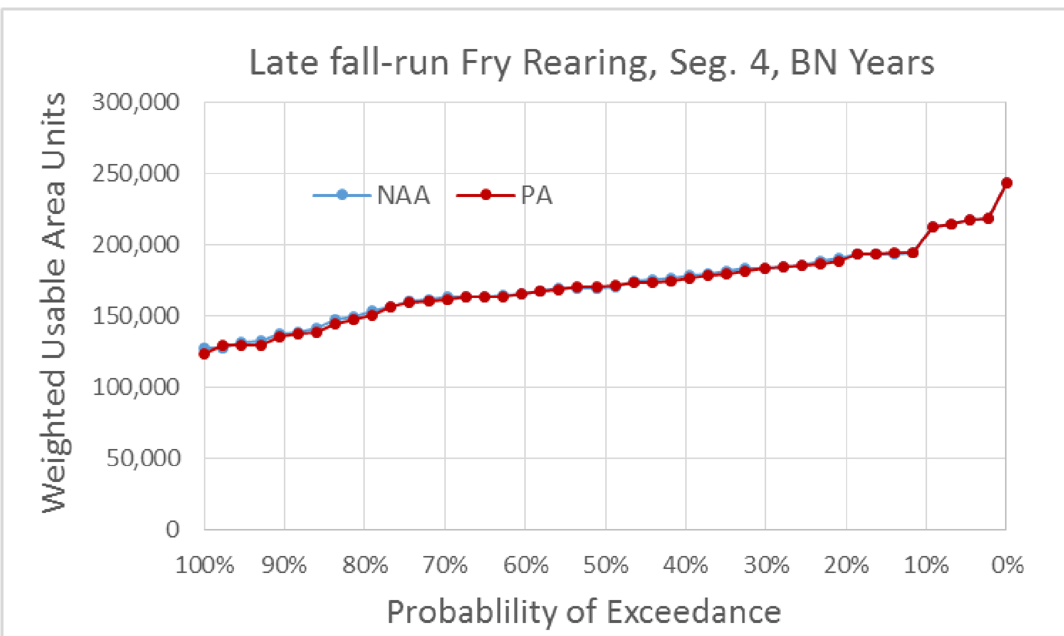


Figure 5.E-213. Exceedance Plot of Late Fall-Run Chinook Salmon Fry Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 4, Below Normal Water Years

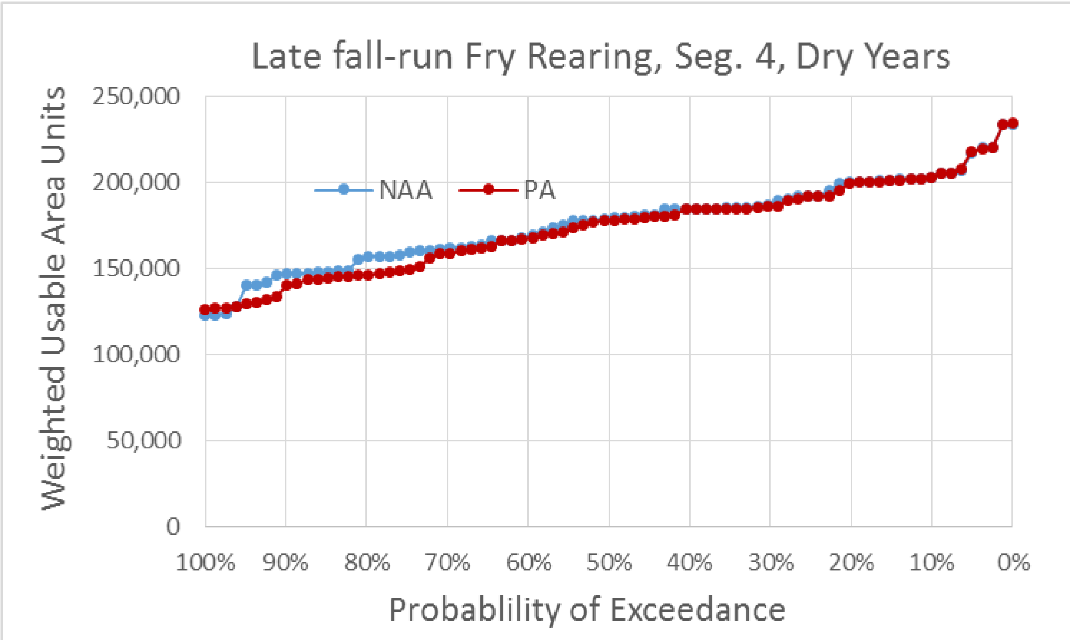


Figure 5.E-214. Exceedance Plot of Late Fall-Run Chinook Salmon Fry Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 4, Dry Water Years

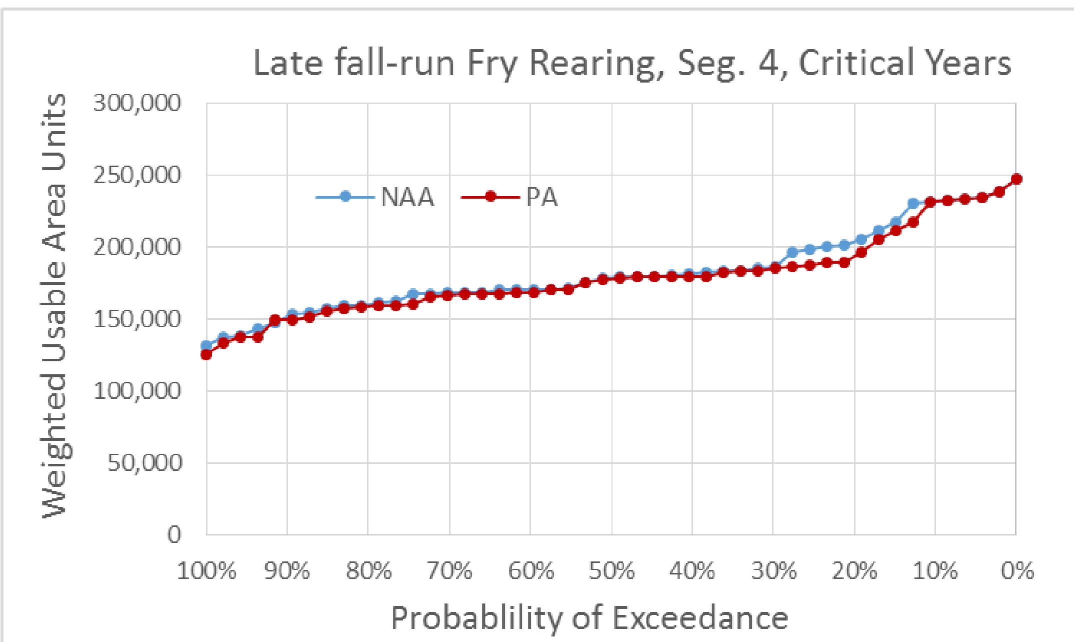


Figure 5.E-215. Exceedance Plot of Late Fall-Run Chinook Salmon Fry Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 4, Critical Water Years

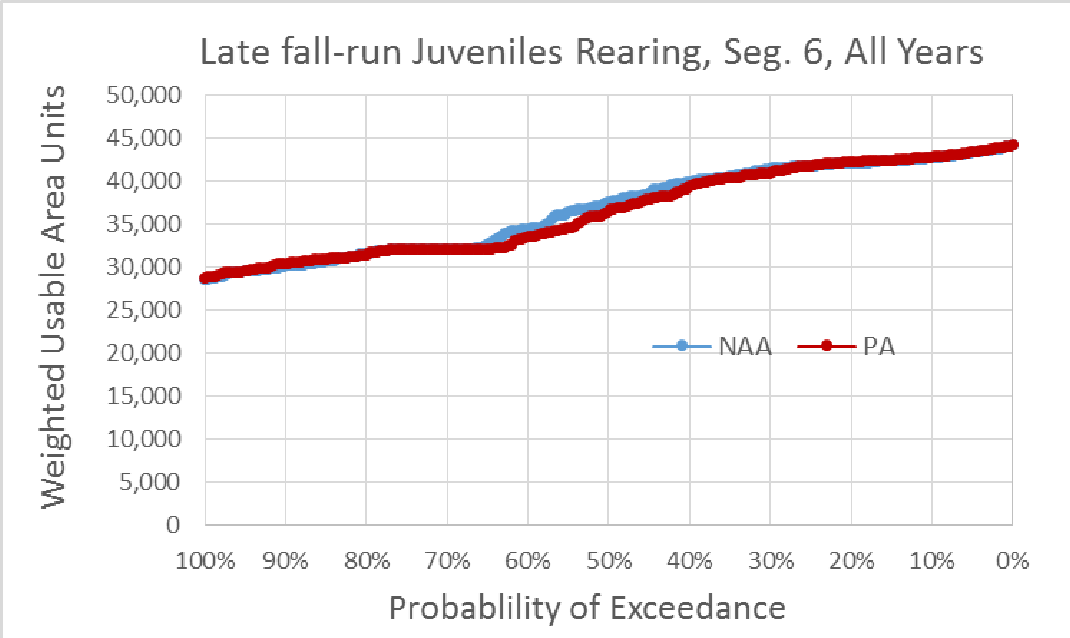


Figure 5.E-216. Exceedance Plot of Late Fall-Run Chinook Salmon Juvenile Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 6, All Water Years

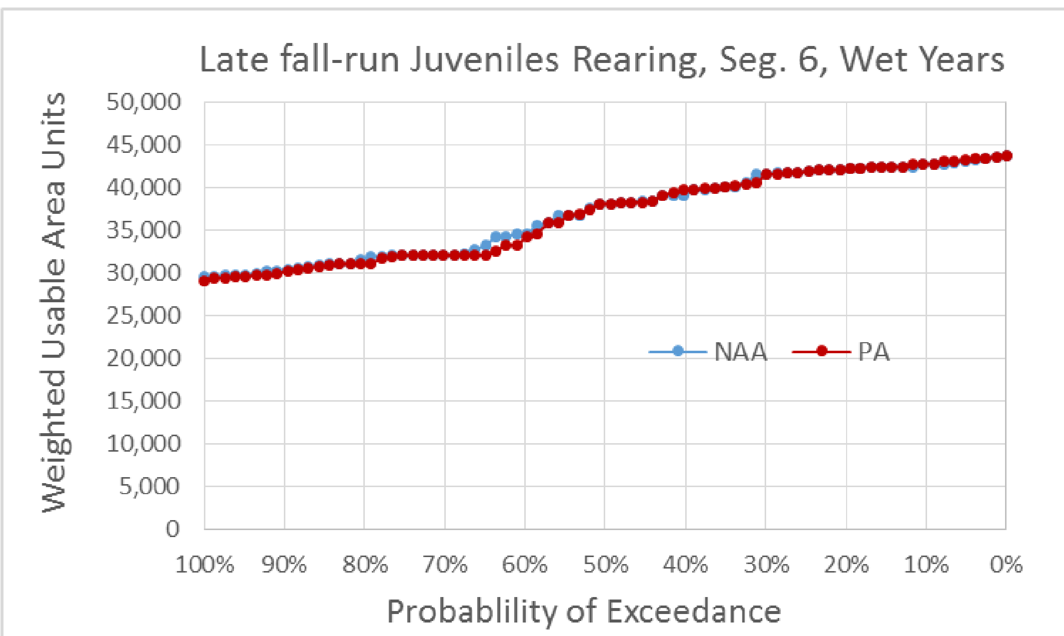


Figure 5.E-217. Exceedance Plot of Late Fall-Run Chinook Salmon Juvenile Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 6, Wet Water Years

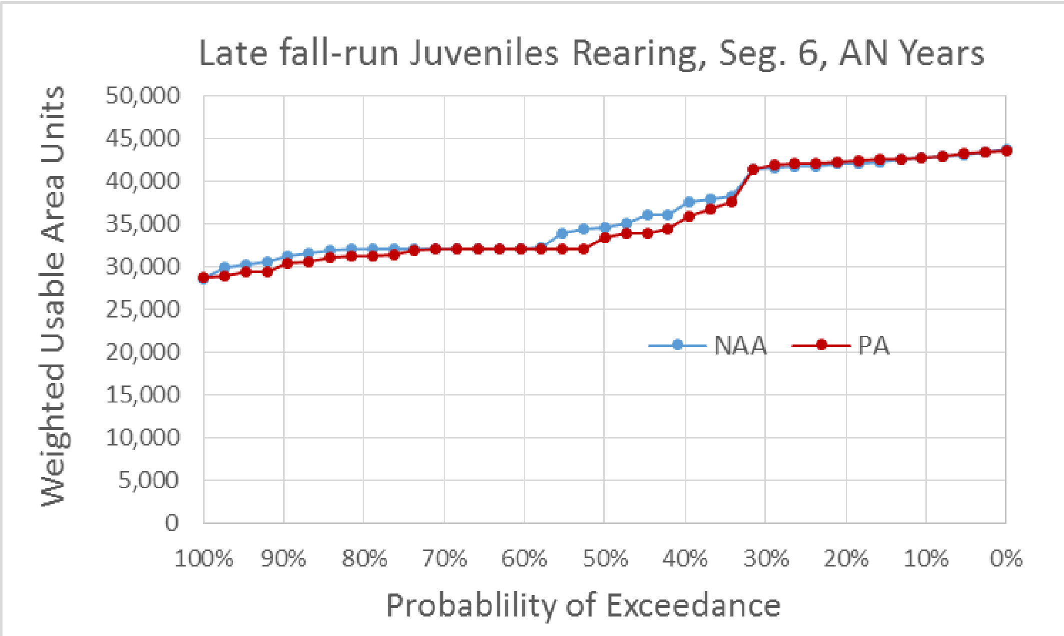


Figure 5.E-218. Exceedance Plot of Late Fall-Run Chinook Salmon Juvenile Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 6, Above Normal Water Years

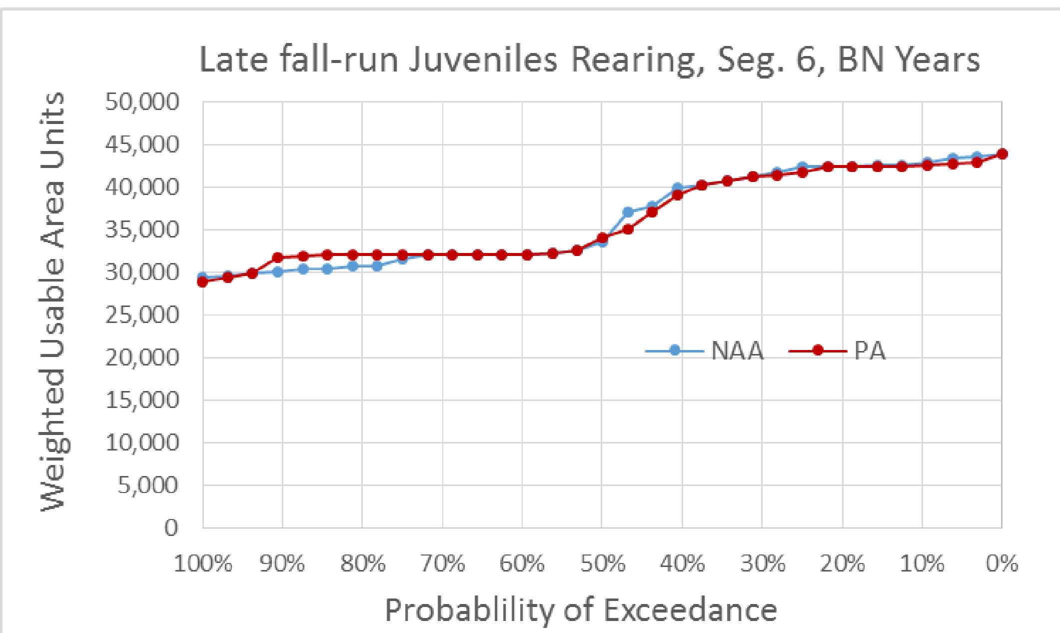


Figure 5.E-219. Exceedance Plot of Late Fall-Run Chinook Salmon Juvenile Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 6, Below Normal Water Years

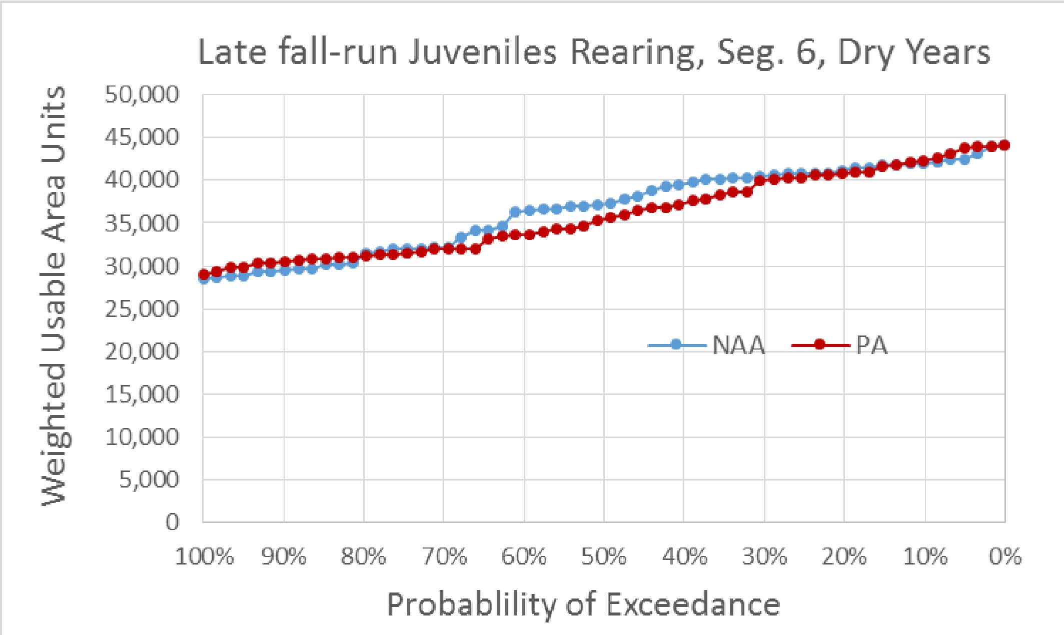


Figure 5.E-220. Exceedance Plot of Late Fall-Run Chinook Salmon Juvenile Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 6, Dry Water Years

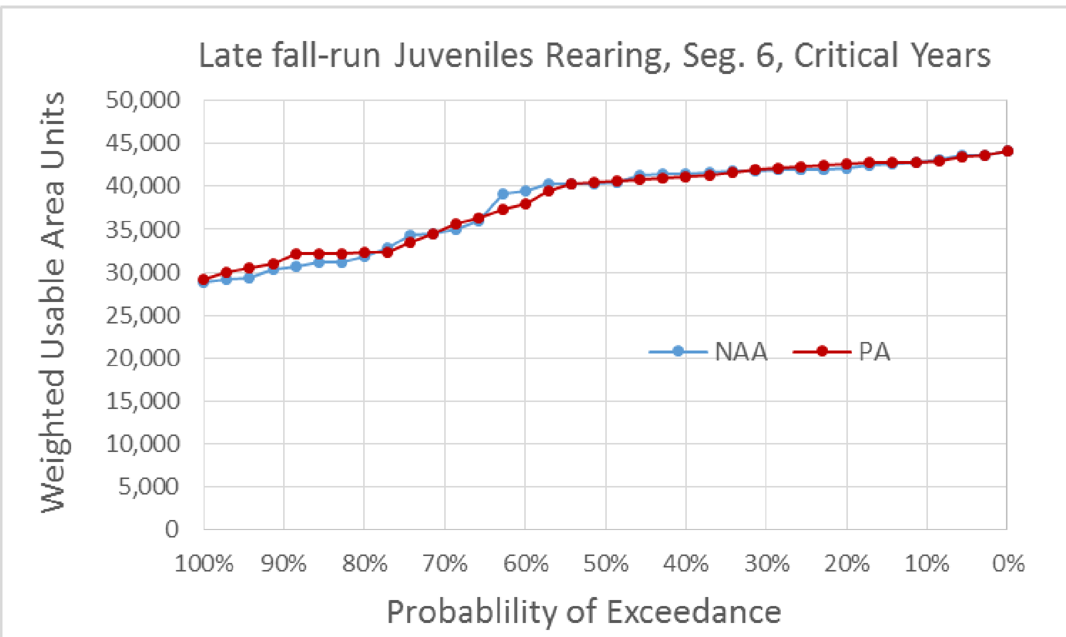


Figure 5.E-221. Exceedance Plot of Late Fall-Run Chinook Salmon Juvenile Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 6, Critical Water Years

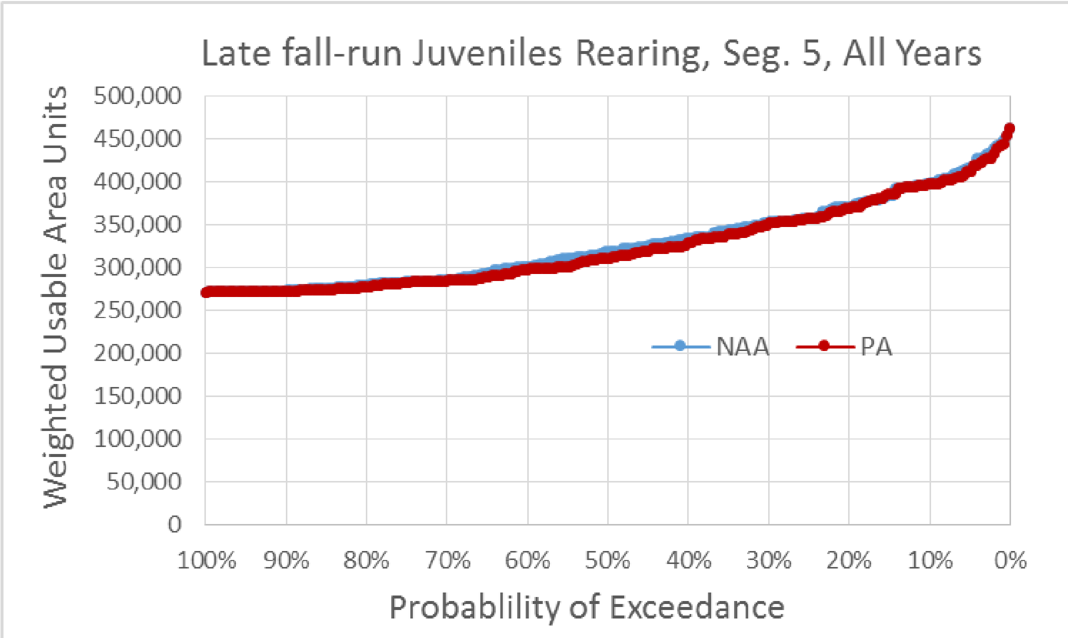


Figure 5.E-222. Exceedance Plot of Late Fall-Run Chinook Salmon Juvenile Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 5, All Water Years

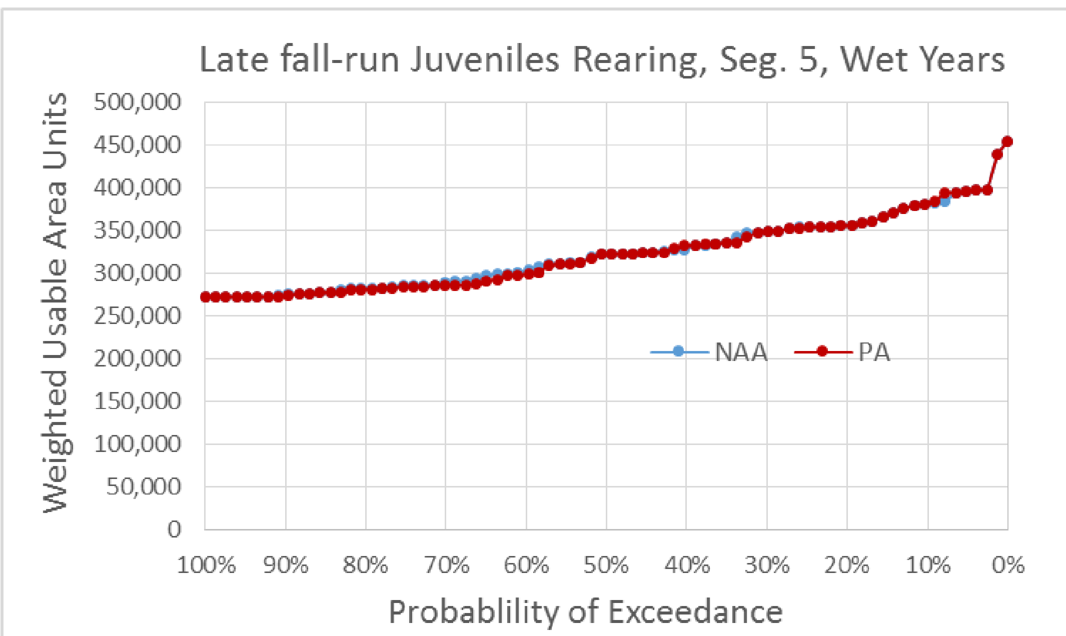


Figure 5.E-223. Exceedance Plot of Late Fall-Run Chinook Salmon Juvenile Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 5, Wet Water Years

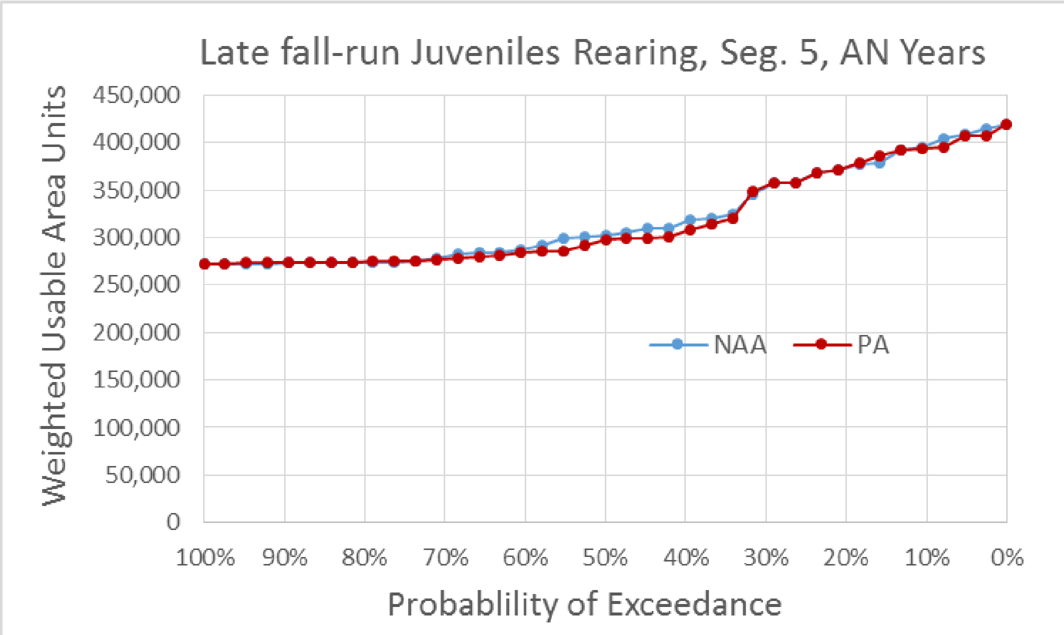


Figure 5.E-224. Exceedance Plot of Late Fall-Run Chinook Salmon Juvenile Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 5, Above Normal Water Years

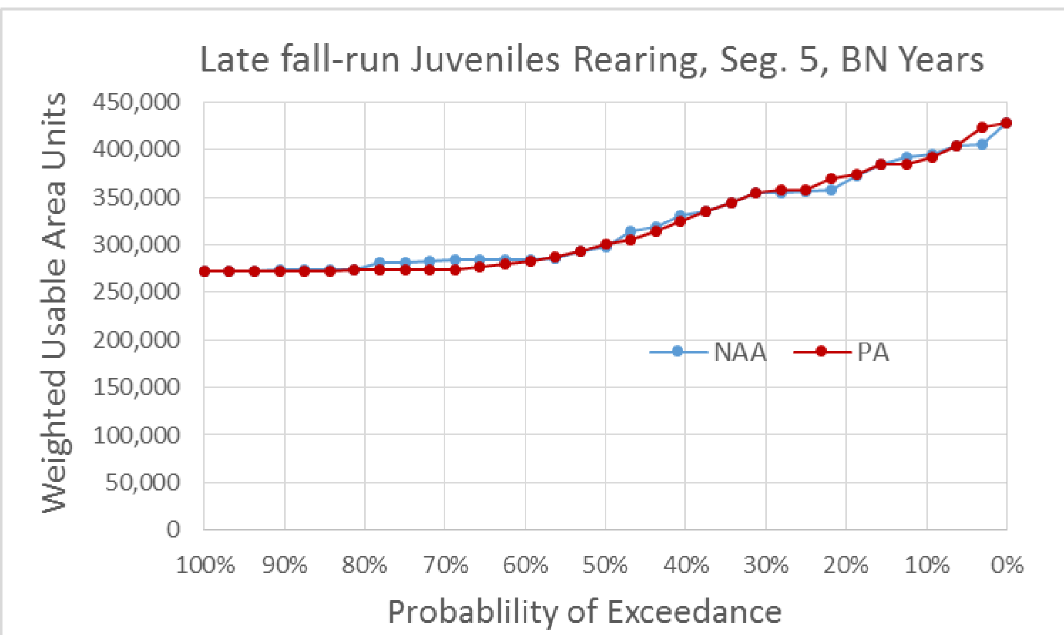


Figure 5.E-225. Exceedance Plot of Late Fall-Run Chinook Salmon Juvenile Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 5, Below Normal Water Years

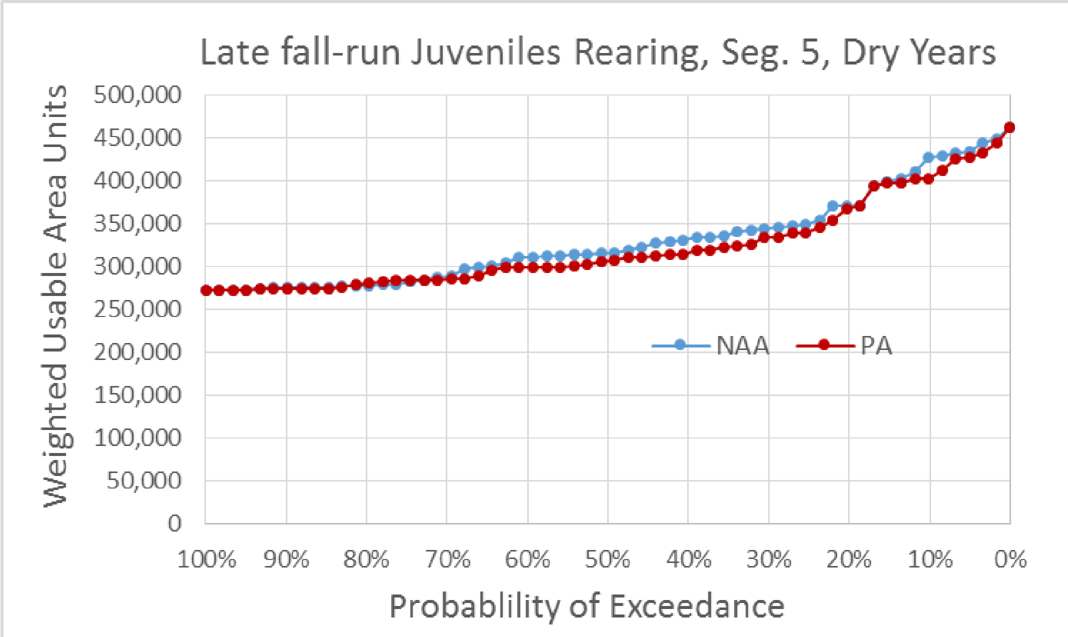


Figure 5.E-226. Exceedance Plot of Late Fall-Run Chinook Salmon Juvenile Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 5, Dry Water Years

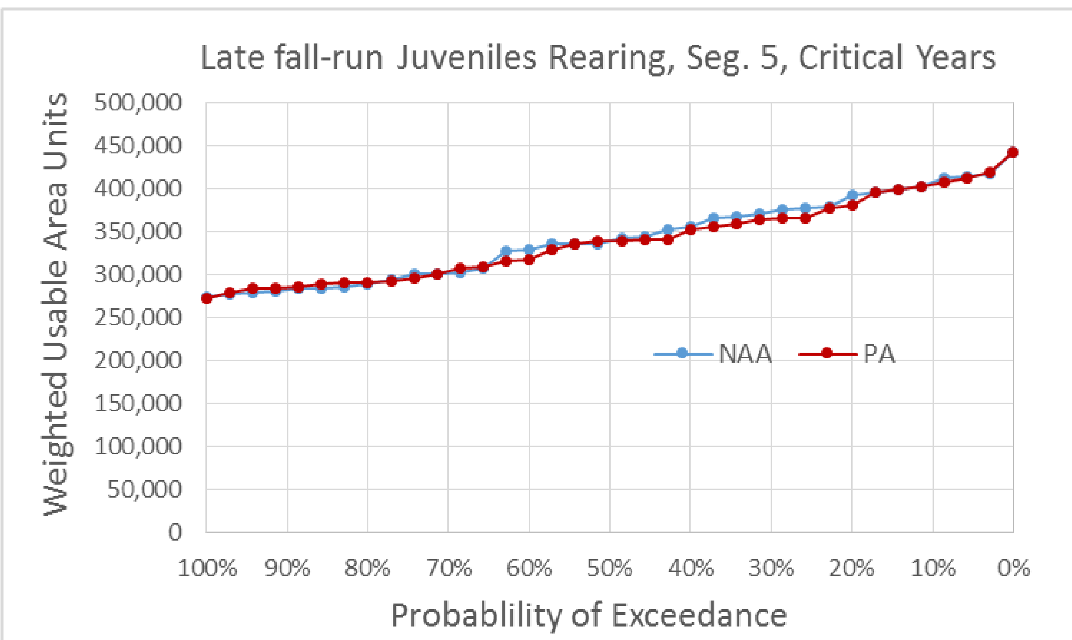


Figure 5.E-227. Exceedance Plot of Late Fall-Run Chinook Salmon Juvenile Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 5, Critical Water Years

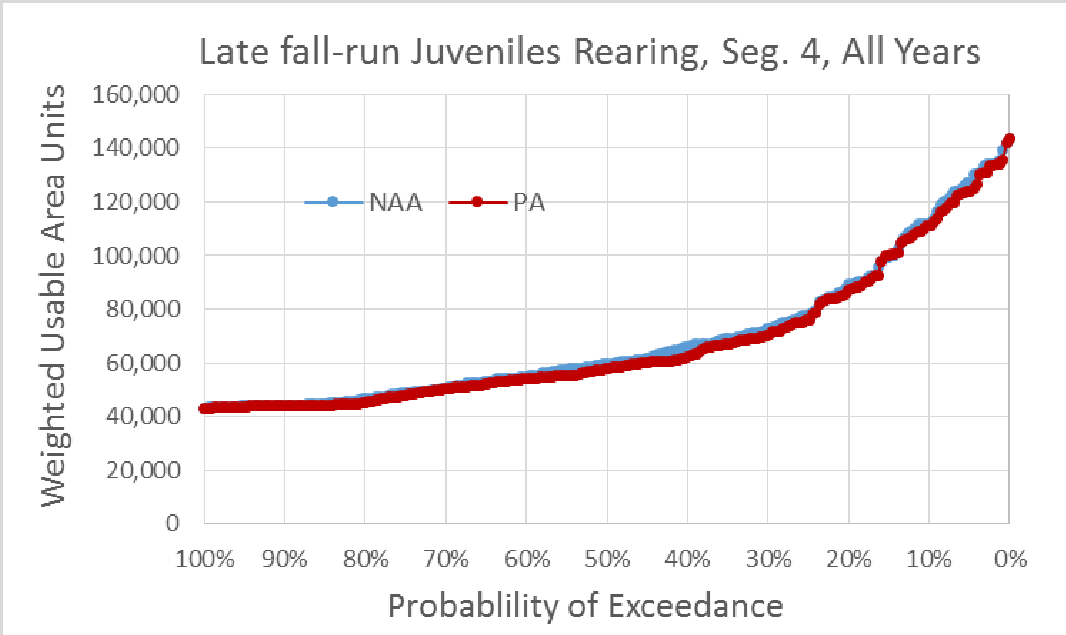


Figure 5.E-228. Exceedance Plot of Late Fall-Run Chinook Salmon Juvenile Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 4, All Water Years

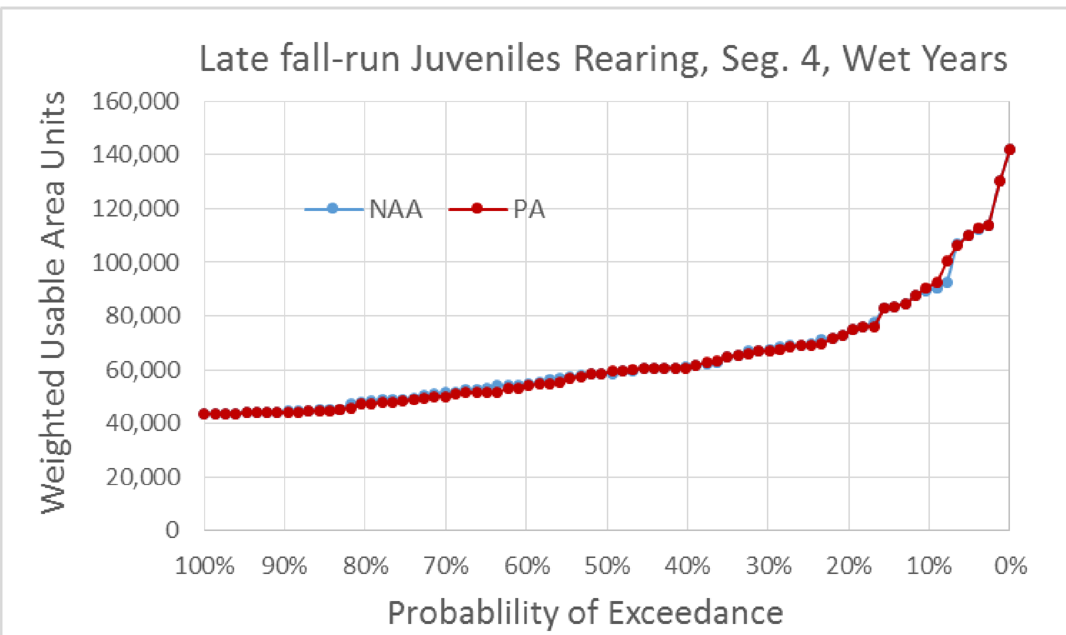


Figure 5.E-229. Exceedance Plot of Late Fall-Run Chinook Salmon Juvenile Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 4, Wet Water Years

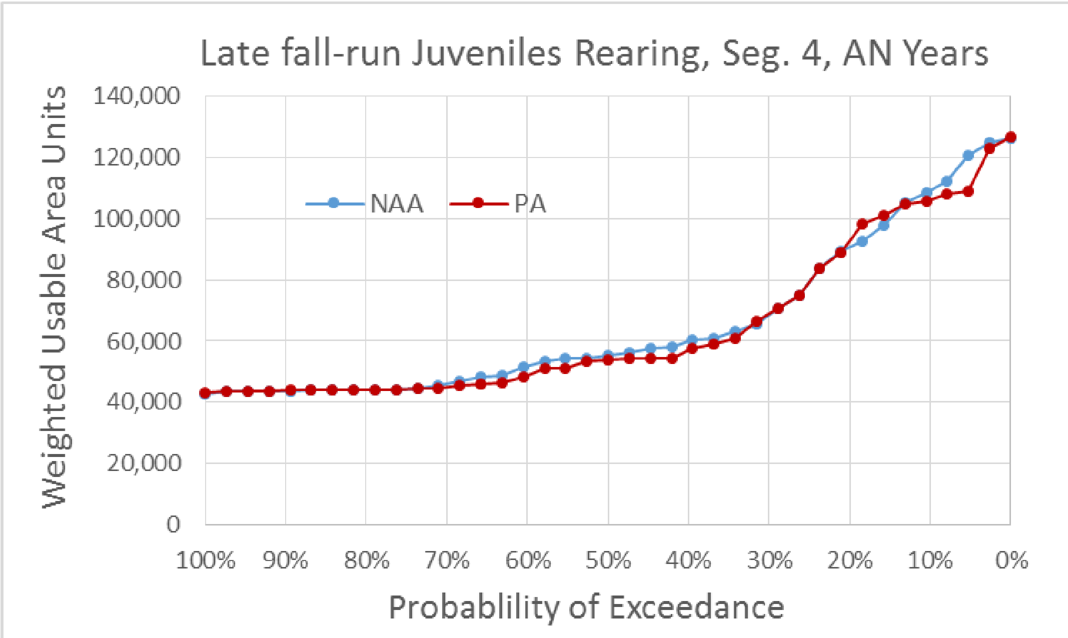


Figure 5.E-230. Exceedance Plot of Late Fall-Run Chinook Salmon Juvenile Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 4, Above Normal Water Years

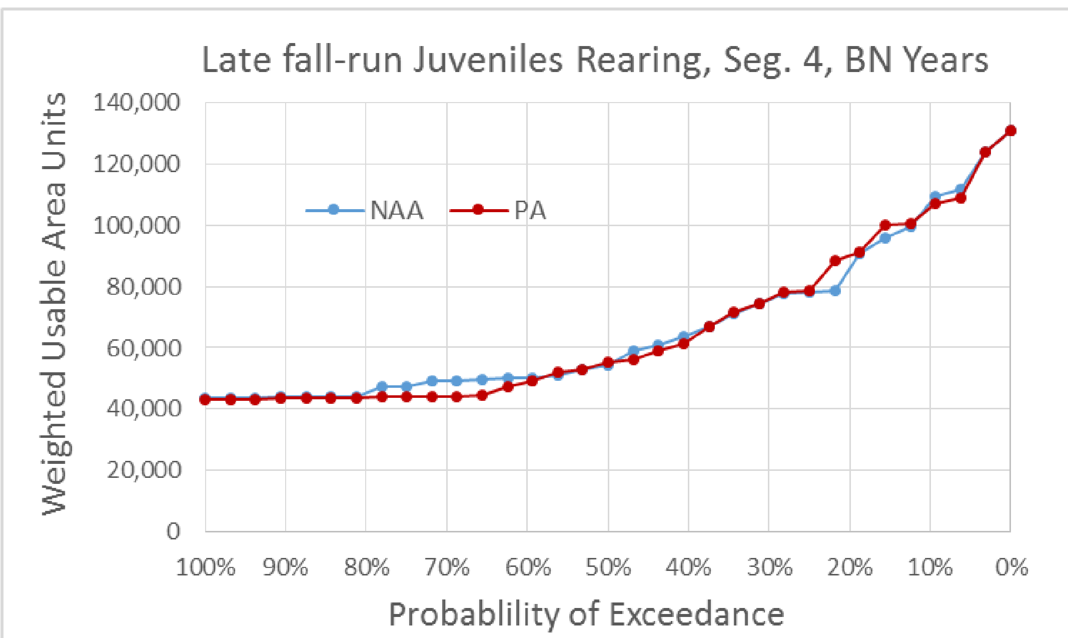


Figure 5.E-231. Exceedance Plot of Late Fall-Run Chinook Salmon Juvenile Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 4, Below Normal Water Years

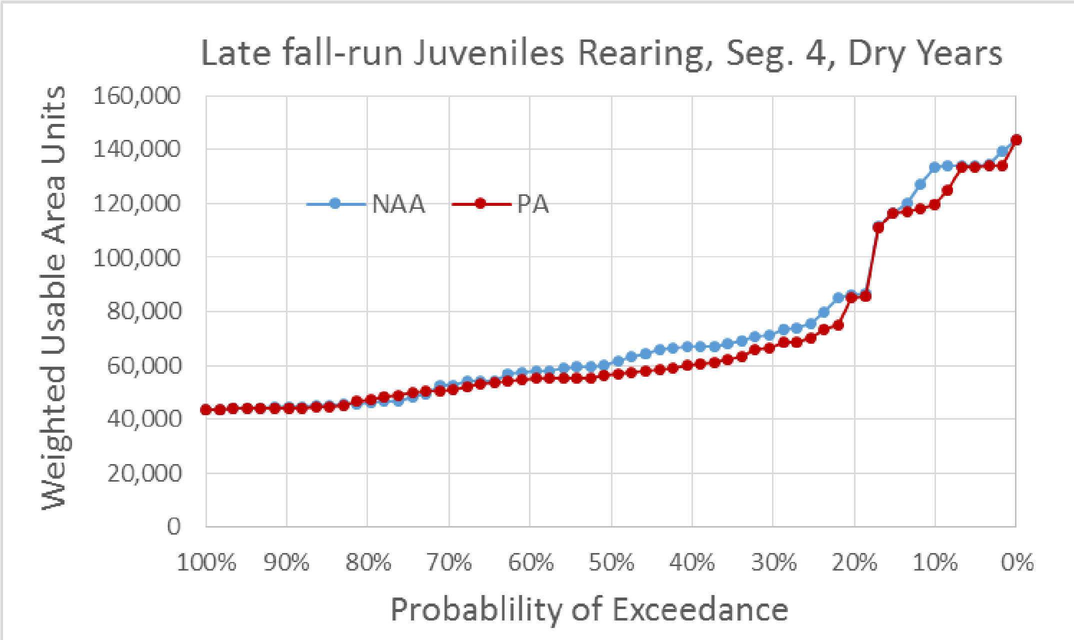


Figure 5.E-232. Exceedance Plot of Late Fall-Run Chinook Salmon Juvenile Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 4, Dry Water Years

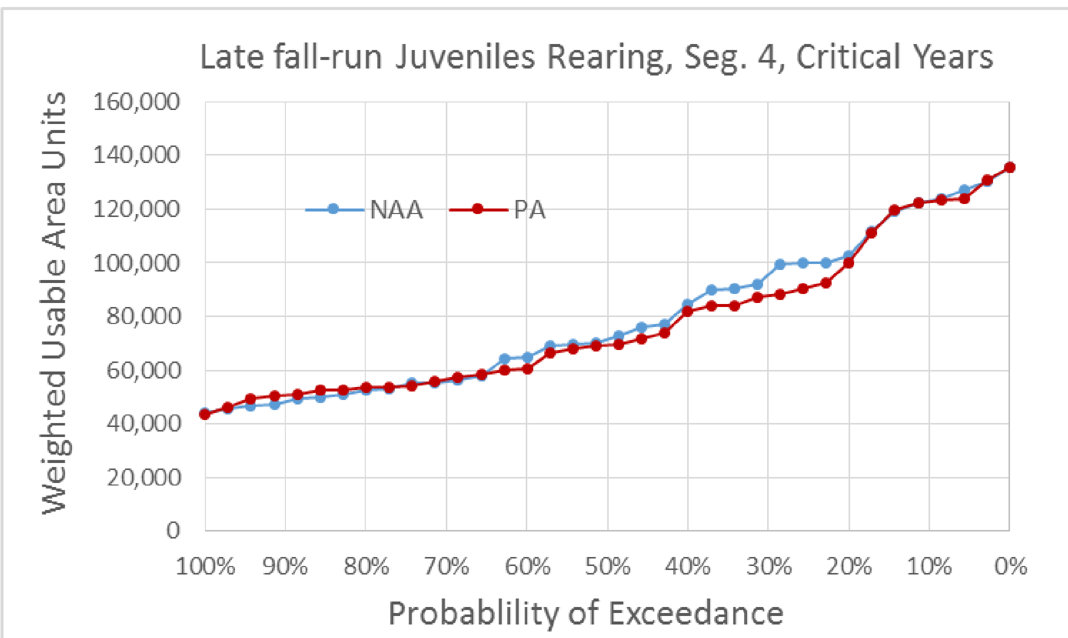


Figure 5.E-233. Exceedance Plot of Late Fall-Run Chinook Salmon Juvenile Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 4, Critical Water Years

Differences in late fall-run Chinook salmon fry and juvenile rearing WUA in each segment under the PAA and NAA were also examined using the grand mean rearing WUA for each month of the fry and juvenile rearing periods under each water year type and all water year types combined (Table 5.E-56 to Table 5.E-61). The means for fry rearing WUA differed by less than 5% for all months and water year types in Segments 5 and 4 (Table 5.E-57 and Table 5.E-58). In

Segment 6, means differed by 5% or more only for May of dry water years (5% reduction under the PA) (Table 5.E-56). The means for juvenile rearing WUA differed by less than 5% for all months and water year types in Segment 5 (Table 5.E-60) and most months and water year types in Segments 6 and 4 (

Table 5.E-59 and Table 5.E-61). In Segment 6, the mean WUA for juvenile rearing under the PA was 5% lower than that under the NAA during June of dry years (

Table 5.E-59) and in Segment 4 it was 5% lower during May of dry years and 7% and 8% lower during June of dry and critical years, respectively (Table 5.E-61). As indicated above for the WUA exceedance plot results, the WUA modeling indicates that the PA would reduce late fall-run Chinook salmon rearing habitat in a few months and water year types. Further discussion regarding flow-related effects during the June through November period is provided in Section 5.E.5.3.1.2.2.4, *Summary of Upstream Effects*.

Table 5.E-56. Late Fall-run Chinook Salmon Fry Rearing Weighted Usable Areas (WUA) and Differences (Percent Differences) between Model Scenarios in River Segment 6 (green indicates PA is at least 5% higher [raw difference] than NAA; red indicates PA is at least 5% lower)

Month	Water Year Type	NAA	PA	PA vs. NAA
March	Wet	64,102	64,136	34 (0.1%)
	Above Normal	60,879	62,045	1165 (2%)
	Below Normal	59,793	60,116	322 (0.5%)
	Dry	61,619	61,505	-114 (-0.2%)
	Critical	62,082	60,942	-1140 (-2%)
	All	62,112	62,156	44 (0.1%)
April	Wet	91,860	91,331	-529 (-0.6%)
	Above Normal	98,286	98,308	22 (0.02%)
	Below Normal	101,393	102,071	678 (0.7%)
	Dry	110,620	107,689	-2931 (-3%)
	Critical	98,133	95,152	-2981 (-3%)
	All	99,651	98,427	-1224 (-1%)
May	Wet	78,212	78,465	253 (0.3%)
	Above Normal	88,580	86,221	-2359 (-3%)
	Below Normal	83,535	85,377	1842 (2%)
	Dry	92,012	87,286	-4726 (-5%)
	Critical	94,167	92,417	-1750 (-2%)
	All	86,270	84,815	-1455 (-2%)
June	Wet	65,827	66,313	486 (0.7%)
	Above Normal	63,190	64,701	1511 (2%)
	Below Normal	67,810	68,363	553 (0.8%)
	Dry	64,715	66,098	1383 (2%)
	Critical	68,869	66,765	-2103 (-3%)
	All	65,849	66,346	498 (0.8%)

Table 5.E-57. Late Fall-run Chinook Salmon Fry Rearing Weighted Usable Areas (WUA) and Differences (Percent Differences) between Model Scenarios in River Segment 5 (green indicates PA is at least 5% higher [raw difference] than NAA; red indicates PA is at least 5% lower)

Month	Water Year Type	NAA	PA	PA vs. NAA
March	Wet	1,046,678	1,046,819	141 (0%)
	Above Normal	1,149,168	1,110,060	-39108 (-3%)
	Below Normal	1,358,136	1,303,846	-54290 (-4%)
	Dry	1,371,907	1,371,289	-618 (-0.05%)
	Critical	1,429,713	1,405,462	-24,251 (-2%)
	All	1,240,086	1,222,948	-17,138 (-1%)
April	Wet	1,123,545	1,118,918	-4,627 (-0.4%)
	Above Normal	1,140,259	1,138,996	-1,263 (-0.1%)
	Below Normal	1,144,277	1,164,535	20,258 (2%)
	Dry	1,259,182	1,230,999	-28,183 (-2%)
	Critical	1,065,349	1,040,715	-24,634 (-2%)
	All	1,153,542	1,144,113	-9,429 (-0.8%)
May	Wet	906,548	908,702	2,154 (0.2%)
	Above Normal	958,558	948,654	-9,904 (-1%)
	Below Normal	941,548	951,632	10,083 (1%)
	Dry	1,039,173	1,005,901	-33,272 (-3%)
	Critical	1,027,540	1,009,911	-17,630 (-2%)
	All	969,542	959,313	-10,230 (-1%)
June	Wet	808,492	814,600	6,108 (0.8%)
	Above Normal	817,851	842,319	24,468 (3%)
	Below Normal	833,385	861,610	28,225 (3%)
	Dry	823,897	840,314	16,417 (2%)
	Critical	819,046	819,597	550 (0.1%)
	All	818,617	832,304	13,687 (2%)

Table 5.E-58. Late Fall-run Chinook Salmon Fry Rearing Weighted Usable Areas (WUA) and Differences (Percent Differences) between Model Scenarios in River Segment 4 (green indicates PA is at least 5% higher [raw difference] than NAA; red indicates PA is at least 5% lower)

Month	Water Year Type	NAA	PA	PA vs. NAA
March	Wet	150,795	151,042	247 (0.2%)
	Above Normal	161,121	158,569	-2552 (-2%)
	Below Normal	197,140	194,502	-2638 (-1%)
	Dry	195,232	195,162	-70 (-0.04%)
	Critical	215,950	209,421	-6530 (-3%)
	All	179,022	177,370	-1653 (-0.9%)
April	Wet	163,985	163,897	-88 (-0.1%)
	Above Normal	172,564	172,563	-1 (-0.001%)
	Below Normal	180,540	181,257	717 (0.4%)

Month	Water Year Type	NAA	PA	PA vs. NAA
	Dry	189,289	187,614	-1674 (-0.9%)
	Critical	184,159	183,685	-474 (-0.3%)
	All	176,690	176,280	-410 (-0.2%)
May	Wet	159,078	159,267	189 (0.1%)
	Above Normal	167,272	166,856	-417 (-0.2%)
	Below Normal	168,883	168,866	-18 (-0.01%)
	Dry	173,321	169,780	-3541 (-2%)
	Critical	174,839	174,413	-426 (-0.2%)
	All	167,473	166,538	-935 (-0.6%)
June	Wet	150,908	149,685	-1222 (-0.8%)
	Above Normal	144,046	139,418	-4628 (-3%)
	Below Normal	143,881	142,247	-1635 (-1%)
	Dry	146,725	141,883	-4841 (-3%)
	Critical	154,535	150,129	-4407 (-3%)
	All	148,388	145,222	-3166 (-2%)

Table 5.E-59. Late Fall-run Chinook Salmon Juvenile Rearing Weighted Usable Areas (WUA) and Differences (Percent Differences) between Model Scenarios in River Segment 6 (green indicates PA is at least 5% higher [raw difference] than NAA; red indicates PA is at least 5% lower)

Month	Water Year Type	NAA	PA	PA vs. NAA
May	Wet	40,564	40,642	77 (0.2%)
	Above Normal	41,482	41,616	133 (0.3%)
	Below Normal	42,164	41,799	-365 (-0.9%)
	Dry	41,111	40,807	-304 (-0.7%)
	Critical	42,067	42,348	281 (0.7%)
	All	41,278	41,241	-36 (-0.1%)
June	Wet	38,289	37,899	-390 (-1%)
	Above Normal	35,211	33,831	-1380 (-4%)
	Below Normal	35,207	35,327	120 (0.3%)
	Dry	36,548	34,685	-1863 (-5%)
	Critical	38,428	37,290	-1137 (-3%)
	All	36,983	36,036	-947 (-3%)
July	Wet	31,828	31,661	-167 (-0.5%)
	Above Normal	31,739	31,436	-303 (-1%)
	Below Normal	31,399	31,770	371 (1%)
	Dry	32,171	32,536	365 (1%)
	Critical	34,132	35,246	1115 (3%)
	All	32,177	32,378	201 (0.6%)

Table 5.E-60. Late Fall-run Chinook Salmon Juvenile Rearing Weighted Usable Areas (WUA) and Differences (Percent Differences) between Model Scenarios in River Segment 5 (green indicates PA is at least 5% higher [raw difference] than NAA; red indicates PA is at least 5% lower)

Month	Water Year Type	NAA	PA	PA vs. NAA
May	Wet	360,972	361,641	669 (0.2%)
	Above Normal	378,137	377,364	-773 (-0.2%)
	Below Normal	378,041	379,629	1589 (0.4%)
	Dry	389,954	379,530	-10424 (-3%)
	Critical	394,079	391,549	-2530 (-0.6%)
	All	377,897	375,287	-2610 (-0.7%)
June	Wet	325,990	323,761	-2229 (-0.7%)
	Above Normal	307,768	299,977	-7791 (-3%)
	Below Normal	309,967	304,453	-5514 (-2%)
	Dry	313,749	302,796	-10953 (-3%)
	Critical	330,817	321,164	-9653 (-3%)
	All	318,673	311,907	-6766 (-2%)
July	Wet	284,079	283,073	-1006 (-0.4%)
	Above Normal	274,903	275,756	853 (0.3%)
	Below Normal	277,076	277,024	-53 (-0.02%)
	Dry	288,136	288,370	234 (0.1%)
	Critical	302,335	307,296	4961 (2%)
	All	285,346	285,938	592 (0.2%)

Table 5.E-61. Late Fall-run Chinook Salmon Juvenile Rearing Weighted Usable Areas (WUA) and Differences (Percent Differences) between Model Scenarios in River Segment 4 (green indicates PA is at least 5% higher [raw difference] than NAA; red indicates PA is at least 5% lower)

Month	Water Year Type	NAA	PA	PA vs. NAA
May	Wet	79,767	80,228	461 (0.6%)
	Above Normal	95,889	95,087	-802 (-0.8%)
	Below Normal	95,374	96,155	782 (0.8%)
	Dry	104,706	99,470	-5236 (-5%)
	Critical	110,769	108,284	-2485 (-2%)
	All	95,036	93,519	-1517 (-2%)
June	Wet	63,094	62,254	-840 (-1%)
	Above Normal	56,914	54,112	-2802 (-5%)
	Below Normal	58,642	56,280	-2362 (-4%)
	Dry	59,726	55,659	-4067 (-7%)
	Critical	70,307	64,770	-5537 (-8%)
	All	61,751	58,921	-2830 (-5%)
July	Wet	48,887	48,468	-419 (-0.9%)

Month	Water Year Type	NAA	PA	PA vs. NAA
	Above Normal	44,821	45,170	349 (0.8%)
	Below Normal	46,166	45,746	-421 (-0.9%)
	Dry	50,575	50,839	263 (0.5%)
	Critical	57,109	59,671	2562 (4%)
	All	49,492	49,798	305 (0.6%)

The SALMOD model provides predicted flow-related mortality of late fall-run Chinook salmon fry and juveniles in the Sacramento River. The SALMOD results for flow-related mortality are presented in Table 5.E-54, together with results for the other sources of mortality of late fall-run Chinook salmon predicted by SALMOD and discussed in other sections of this document. The flow-related mortality of late fall-run Chinook salmon fry and juveniles includes categories for fry, pre-smolts, and immature smolts (Attachment 5.D.2, *SALMOD Model*). The annual exceedance plot of flow-related mortality of late fall-run Chinook salmon for the three life stages combined is presented in Figure 5.E-234. The results in Table 5.E-54 indicate that there would be large differences in flow-related mortality of fry and juveniles between the PA and the NAA that include both increases and reductions in mortality under the PA. The differences for pre-smolts include 64% and 43% increases under the PA for above normal and dry years and 27%, 36% and 15% reductions under the PA for wet, below normal, and critical water years, respectively. The differences for immature smolts include 28% and 14% increases under the PA for above normal and dry years and a 30% reduction under the PA for critical years. The largest differences in flow-related mortality under the PA for fry is 6% in below normal water years. For all water year types combined, mortality under the PA would be 9% lower for pre-smolts and 8% lower for immature smolts.

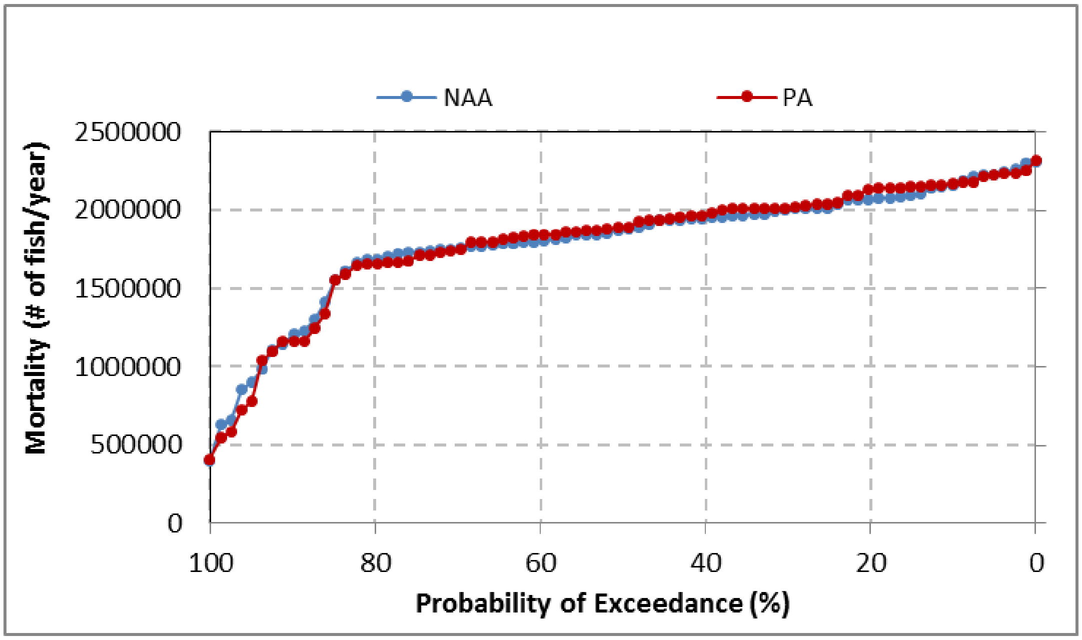


Figure 5.E-234. Exceedance Plot of Annual Flow-Based Mortality (#of Fish/Year) of Late Fall-Run Chinook Salmon Fry and Juveniles

Water Temperature-Related Effects

Mean monthly water temperatures were evaluated during the March through July fry and juvenile primary rearing period for late fall-run Chinook salmon in the Sacramento River upstream of the Delta (Table 5.E-5). Overall, the PA would change mean water temperatures very little (predominantly less than 0.4°F, or less than 1%) throughout the fry and juvenile rearing reach of Keswick to Knights Landing[16] in all months and water year types in the period (Appendix 5.C, *Upstream Water Temperature Methods and Results*, Section 5.C.7, *Upstream Water Temperature Modeling Results*, Table 5.C.7-3, Table 5.C.7-4, Table 5.C.7-5, Table 5.C.7-7, Table 5.C.7-8, Table 5.C.7-10). The largest increase in mean monthly water temperatures under the PA relative to NAA would be 0.4°F (0.6%), and would occur at Knights Landing in critical water years during July.

Exceedance plots of monthly mean water temperatures were examined during each month and water year type throughout the juvenile rearing period (Appendix 5.C, *Upstream Water Temperature Methods and Results*, Section 5.C.7, *Upstream Water Temperature Modeling Results*, Figure 5.C.7.3-7, Figure 5.C.7.4-7, Figure 5.C.7.5-7, Figure 5.C.7.7-7, Figure 5.C.7.8-7, Figure 5.C.7.10-7). The curves for the PA generally match those of the NAA. Further examination of critical water years in July at Knights Landing, where the largest increase in mean monthly water temperature was seen, indicates that water temperatures under the PA would be higher than those under NAA for the middle portion of the exceedance range (approximately 40% to 80%) by up to approximately 1°F and similar between scenarios throughout the remainder of the exceedance range (Figure 5.E-235).

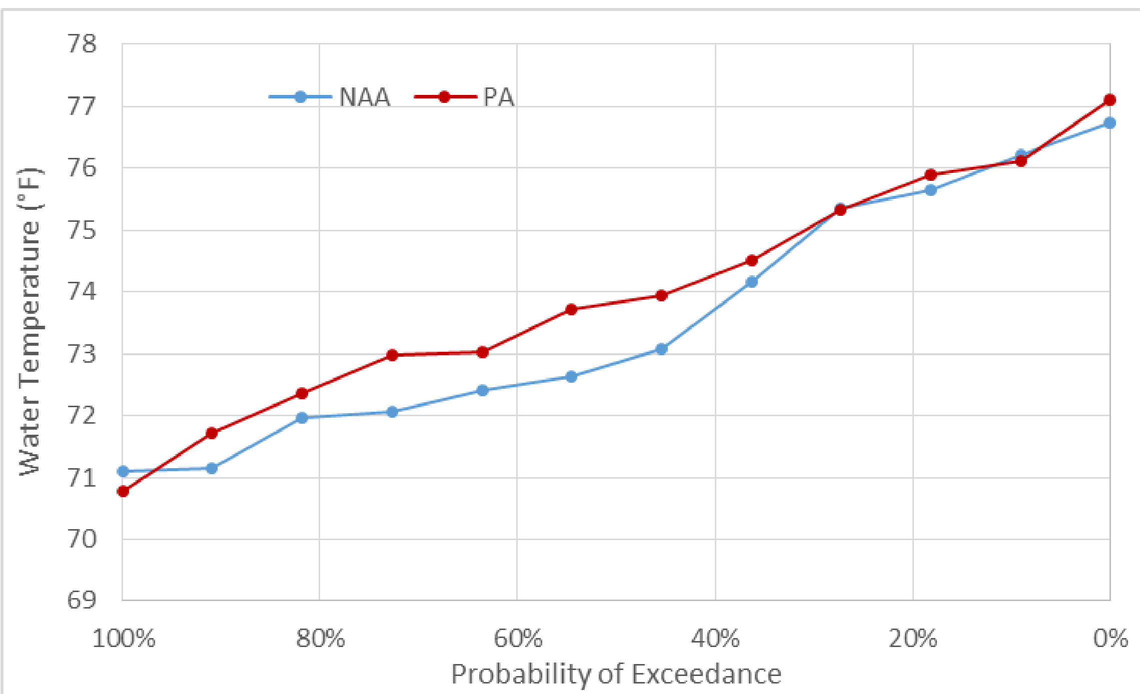


Figure 5.E-235. Exceedance Plot of Mean Monthly Water Temperatures (°F) in the Sacramento River at Knights Landing in July of Critical Water Years

[16] Water temperature results for Wilkins Slough were used to represent Knights Landing for this analysis

For purposes of this analysis, the water temperature thresholds analysis for fry and juvenile rearing and emigration were combined and the period of March through January was evaluated. For this analysis, the thresholds used were from the USEPA's 7DADM value of 61°F for core juvenile rearing reach from Keswick to Red Bluff and 64°F for the non-core juvenile rearing reach at Knights Landing (Table 5.E-22). The 7DADM values were converted to function with daily model outputs for each month separately (Appendix 5.D, *Quantitative Methods and Detailed Results for Effects Analysis of Chinook Salmon, Central Valley Steelhead, Green Sturgeon, and Killer Whale*, Section 5.D.2.1, *Water Temperature Analysis Methods*, Table 5.D-4).

Results of the water temperature thresholds analysis are presented in Attachment 5.E.1, *Fall-/Late Fall-Run Chinook Salmon Water Temperature Threshold Analysis Results*, Table E.2-23 through Table 5.E-298. At Keswick, there would be no months or water year types in which there would be 5% more days under the PA compared to the NAA on which temperatures would exceed the threshold (Attachment 5.E.1, *Fall-/Late Fall-Run Chinook Salmon Water Temperature Threshold Analysis Results*, Table 5.E.1-23). There would be two instances in which average daily exceedance would be 0.5°F: September of critical years and September for all water year types combined (reflecting that the only differences in threshold exceedance among water year types during September would occur during critical years). However, there would be no concomitant increase in the percent of days exceeding the threshold in these instances. Therefore, it was concluded that there would be no effect at Keswick.

At Clear Creek, there would be no months or water year types in which there would be both 5% more days under the PA compared to the NAA on which temperatures would exceed the threshold, and a more-than-0.5°F difference in the magnitude of average daily exceedance (Attachment 5.E.1, *Fall-/Late Fall-Run Chinook Salmon Water Temperature Threshold Analysis Results*, Table 5.E.1-24). However, the percent of days exceeding the threshold under the PA would be more than 5% lower than under the NAA during September and October of critical water years (6.7% and 11.8%, respectively). Despite this reduction during September of critical water years, the difference in mean daily exceedance would increase by 0.67°F. This indicates that the frequency of days above the threshold would decrease under the PA, but exceedances per day would be higher on average.

At Balls Ferry, there would be no months or water year types in which there would be 5% more days under the PA compared to the NAA on which temperatures would exceed the 61°F 7DADM threshold, and no more-than-0.5°F difference in the magnitude of average daily exceedance (Attachment 5.E.1, *Fall-/Late Fall-Run Chinook Salmon Water Temperature Threshold Analysis Results*, Table 5.E.1-25). Therefore, it was concluded that there would be no effect. There are also two situations at Balls Ferry during which the percent of days exceeding the threshold under the PA would be more than 5% lower than under the NAA during September and October of critical water years (10% and 14%, respectively). Despite this reduction during September of critical water years, the difference in mean daily exceedance would increase by 0.71°F. This indicates that the frequency of days above the threshold would decrease under the PA, but exceedances per day would be higher on average.

At Bend Bridge, the percent of days exceeding the 61°F 7DADM threshold under the PA would be more than 5% higher than under the NAA during July of critical water years (7.8%), August (5.9%) and September of below normal (15.8%) and dry (8.0%) water years (Attachment 5.E.1, *Fall-/Late Fall-Run Chinook Salmon Water Temperature Threshold Analysis Results*, Table 5.E.1-26). There would also be a reduction in the percent of days exceeding the threshold of 8.4% and 11.6% in August of dry and critical water years, respectively, and of 11% in October of critical water years. There would not be an increase in average daily exceedance except in August of critical water years. This indicates that the frequency of days above the threshold would decrease under the PA, but exceedances per day would be higher on average.

At Red Bluff, the percent of days exceeding the 61°F 7DADM threshold under the PA would be more than 5% higher than under the NAA during July of critical water years (6.5%), August of below normal years (9.4%), and September of above normal (7.7%), below normal (10.3%), and dry (5.5%) water years (Attachment 5.E.1, *Fall-/Late Fall-Run Chinook Salmon Water Temperature Threshold Analysis Results*, Table 5.E.1-27). However, in no month or water year type would there be a more-than-0.5°F difference in the magnitude of average daily exceedance. Therefore, it was concluded that there would be no effect at Red Bluff.

At Knights Landing, the percent of days exceeding the 64°F 7DADM threshold for non-core rearing and emigration habitat under the PA would be more than 5% higher than under the NAA during October of wet water years (6.9%) (Attachment 5.E.1, *Fall-/Late Fall-Run Chinook Salmon Water Temperature Threshold Analysis Results*, Table 5.E.1-28). There would also be a 7.9% reduction in the percent of days exceeding the threshold during October of below normal water years. However, in neither of these situations would there also be a more than 0.5°F difference in the magnitude of average daily exceedance. Therefore, it was concluded that there would be no effect.

Overall, the thresholds analysis indicates that any adverse water temperature-related effects of the PA relative to the NAA on late fall-run Chinook salmon juvenile rearing and emigration would be undetectable.

The SALMOD model provides predicted water temperature-related fry and juvenile late fall-run Chinook salmon mortality, which is a combination of mortality of the fry, pre-smolt, and immature smolt life stages (see Attachment 5.D.2, *SALMOD Model*, for full model description). Results for water temperature-related mortality of these life stages are presented in Table 5.E-54 and the annual exceedance plot is presented in Figure 5.E-236. These results indicate that there would be a 5,856 fish (5%) increase in water temperature-related mortality of late fall-run Chinook salmon fry and juveniles under the PA compared to the NAA. This increase would be seen mostly in below normal water years (3,824 fish, or 108%, increase). However, considering that the number of fish produced in the model each year is 13,325,000, these values of mortality would be very small and any adverse effects of the PA relative to the NAA on late fall-run Chinook salmon would be undetectable.

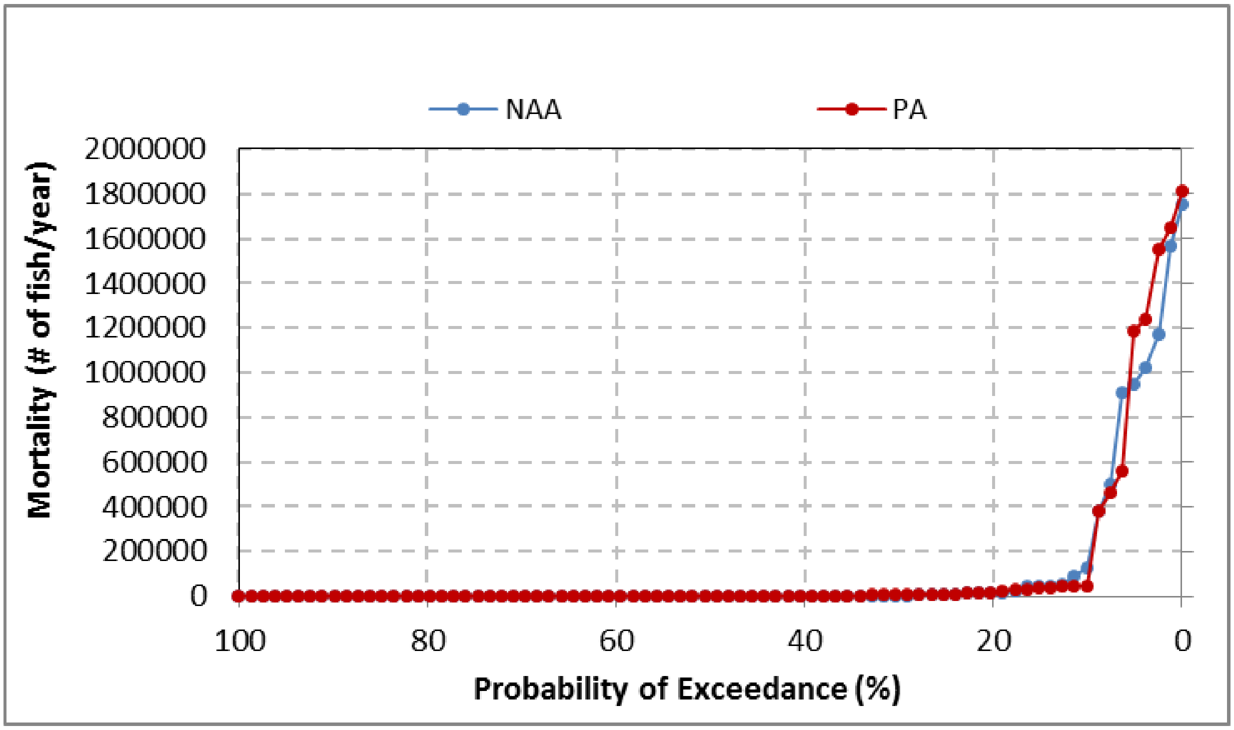


Figure 5.E-236. Exceedance Plot of Annual Water Temperature-Based Mortality (# of Fish/Year) of Late Fall-Run Chinook Salmon Fry and Juveniles

Juvenile Emigration

Flow-Related Effects

Mean monthly flows were evaluated in the Sacramento River at four locations along the downstream migration corridor of juvenile late fall-run Chinook salmon; Keswick, Red Bluff, Wilkins Slough, and Verona, during the April through January emigration period, with peak migration during April and May and July and August (Table 5.E-5). Changes in flow potentially affect emigration of juveniles, including the timing and rate of emigration, and conditions for feeding, protective cover, resting, temperature, turbidity, and other habitat factors, and can affect crowding and stranding, especially in side-channel habitats (Quinn 2005, Williams 2006, del Rosario et al. 2013). Quantitative relationships between flow and downstream migration generally are highly variable and poorly understood and, therefore, as described in Appendix 5.D.2.4, *Migration Flows Methods*, it is assumed for the purposes of this effects analysis that increased flow would improve conditions for emigration of juvenile late fall-run Chinook salmon.

Shasta Reservoir storage volume at the end of May influences flow rates in the Sacramento River during the early part of the juvenile emigration period and Shasta storage volume at the end of September influences flow during the last four months of the period. Mean Shasta May storage under the PA would be similar (less than 5% difference) to storage under NAA for all water year types. Mean Shasta September storage under the PA would be similar (less than 5% difference) to storage under NAA for all water year types, except for 7% higher mean storage during critical water years under the PA (Appendix 5.A *CALSIM Methods and Results*, Table 5.A.6-3).

In general, mean flow under the PA at the Keswick, Red Bluff, Wilkins Slough, and Verona locations in the Sacramento River would be similar to (less than 5% difference) or greater than flow under the NAA during April through June and December and January, and would be similar to or greater than flow under the NAA during July through November, with exceptions (Appendix 5.A *CALSIM Methods and Results*, Table 5.A.6-10, Table 5.A.6-14, Table 5.A.6-35, Table 5.A.6-36). During December and April, all differences in flow at the four locations in all water year types would be less than 5%. During May, the only difference greater than 5% would be increases under the PA of up to 8% in dry years at all the locations except Verona. During June, flow under the PA would be greater at all locations, including all water year types at Verona and all water year types except wet years at the other locations. The June increases for all water year types would be greater at Wilkins Sough and Verona than those at Keswick and Red Bluff, ranging up to 25% greater flow under the PA for above normal years at Verona. During July, mean flow in critical water years under the PA would be 10% and 13% lower than under the NAA at Wilkins Slough and Verona, respectively, but the flows would be similar (less than 5% difference) at Keswick and Red Bluff. During August, mean flow in below normal years would be lower at all four locations, ranging up to 18% lower flow at Wilkins Slough, but during dry and critical, at Wilkins Slough and Verona only, flow under the PA would be greater (up to 10% greater). Mean flow during September would be lower for most water year types at all the locations, ranging up to 24% lower in below normal years at Verona. During October, flow under the PA would be 7% to 11% lower in wet years at all the locations, but would be up to 17% higher in below normal and dry years. During November of wet and above normal water years, flow would be 26% lower under the PA than under the NAA at Keswick Dam, 21% lower at Red Bluff, up to 24% lower at Wilkins Slough, and up to 17% lower at Verona, but in critical water years flow would be greater at all the locations (up to 13% greater at Keswick). During January, mean flow under the PA at Keswick would be 18% greater than under the NAA in critical water year types and 8% greater in wet years. At Red Bluff, the mean January flow of critical years would be 7% greater under the PA and at the other two locations all differences in January flow would be less than 5%. Further discussion regarding flow-related effects during the June through November period is provided in Section 5.4.2.3, *Summary of Upstream Effects*.

Water Temperature-Related Effects

Mean monthly water temperatures were evaluated in the Sacramento River in the reach from Keswick to Knights Landing[17] during the April through January juvenile emigration period for late fall-run Chinook salmon (Table 5.E-5). Generally, the PA would change mean water temperatures very little (less than 1°F, or approximately 1%) throughout the Sacramento River upstream of the Delta in all months and water year types in the period (Appendix 5.C, *Upstream Water Temperature Methods and Results*, Section 5.C.7, *Upstream Water Temperature Modeling Results*, Table 5.C.7-3, Table 5.C.7-4, Table 5.C.7-5, Table 5.C.7-7, Table 5.C.7-8, Table 5.C.7-10). The largest increase in mean monthly water temperatures under the PA relative to NAA would be 1.0°F (1.4%), and would occur at Knights Landing in below normal years during August.

Exceedance plots of monthly mean water temperatures were examined during each month and water year type throughout the late fall-run Chinook salmon juvenile emigration period (Appendix 5.C, *Upstream Water Temperature Methods and Results*, Section 5.C.7, *Upstream Water Temperature Modeling Results*, Figure 5.C.7.3-7, Figure 5.C.7.4-7, Figure 5.C.7.5-7, Figure 5.C.7.7-7, Figure 5.C.7.8-7, Figure 5.C.7.1-70). The curves for PA generally match those of the NAA, except in below normal water years in August at Knights Landing, for which water temperatures under the PA would be higher than those under NAA for most of the exceedance range by up to approximately 2.2°F, particularly in the colder end of the range (Figure 5.E-128). Water temperatures predicted for Knights Landing during August of below normal water years would be greater than the 64°F 7DADM threshold on 100% of days under both the NAA and PA; therefore, conditions would already be unsuitable for late fall-run Chinook salmon juvenile emigration for reasons that are independent of the PA.

[17] Water temperature results for Wilkins Slough were used to represent Knights Landing for this analysis

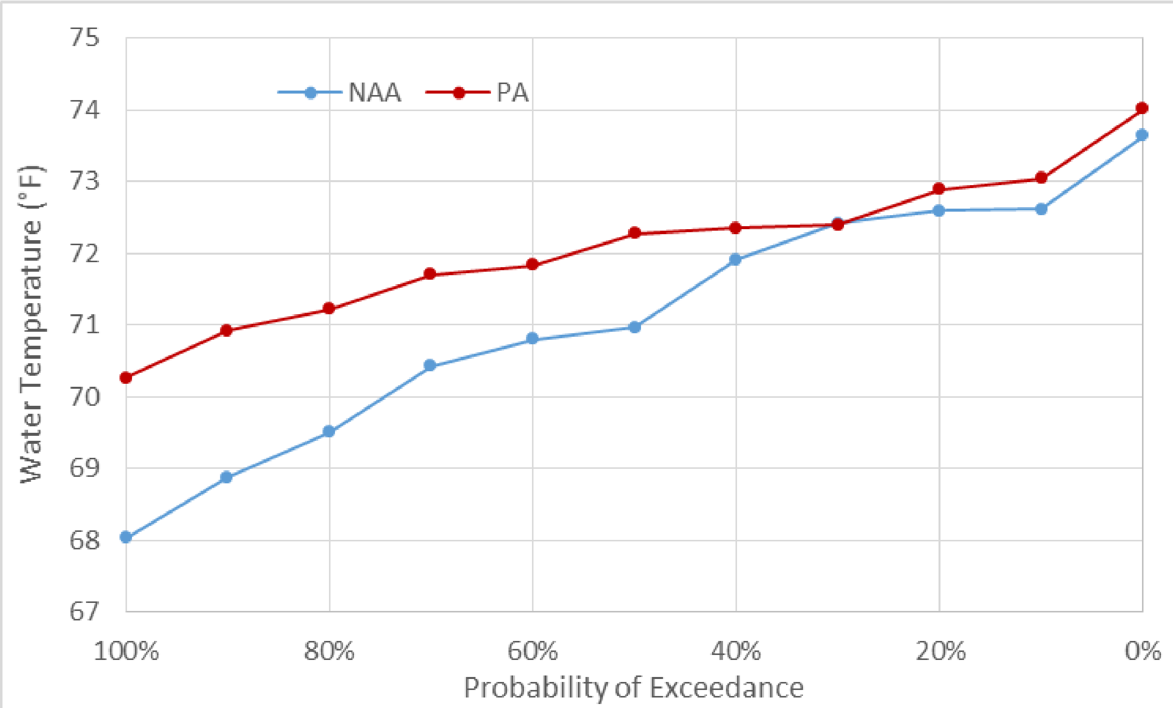


Figure 5.E-237. Exceedance Plot of Mean Monthly Water Temperatures (°F) in the Sacramento River at Knights Landing in August of Below Normal Water Years

Please see the discussion of water temperature thresholds for juvenile late fall-run Chinook salmon emigration in *Fry and Juvenile Rearing* section above, which concludes that there would be no water temperature-related effects of the PA on late fall –run Chinook salmon juvenile rearing and emigration.

Adult Immigration

<u>Flow-Related Effects</u>

Mean monthly flows were evaluated in the Sacramento River at four locations along the upstream migration corridor of adult late fall-run Chinook salmon; Keswick, Red Bluff, Wilkins Slough and Verona, during the November through April immigration period (Table 5.E-5). Changes in flow potentially affect conditions for upstream migration of adults, including bioenergetic cost, water quality, crowding, cues for locating natal streams, and passage conditions, but quantitative relationships between flow and such conditions are generally poorly understood (Quinn 2005, Milner et al. 2012). As described in Appendix 5.D.2.4, *Migration Flows Methods*, it is assumed for the purposes of this effects analysis that increased flow would improve conditions for upstream migration of adult late fall-run Chinook salmon.

Shasta Reservoir storage volume at the end of September may influence flow rates in the Sacramento River during the first part of the late fall-run Chinook salmon immigration period. Mean Shasta September storage under the PA would be similar (less than 5% difference) to storage under NAA for all water year types, except for 7% higher mean storage during critical water years under the PA (Appendix 5.A, *CALSIM Methods and Results*, Table 5.A.6-3).

For most months and water year types of the adult immigration period, mean flow at Keswick, Red Bluff, Wilkins Slough and Verona would be similar (less than 5% difference) between the PA and the NAA or would be greater under the PA, (Appendix 5.A *CALSIM Methods and Results*, Table 5.A.6-10, Table 5.A.6-14, Table 5.A.6-35, Table 5.A.6-36). However, during November of wet and above normal water years, flow would be 26% lower under the PA than under the NAA at Keswick Dam, 21% lower at Red Bluff, up to 24% lower at Wilkins Slough, and up to 17% lower at Verona. During November of critical water years, flow would be greater at all the locations (up to 13% greater in Keswick). During December and April, all differences in flow at the four locations in all water year types would be less than 5%. During January, mean flow under the PA at Keswick would be 18% greater than under the NAA in critical water years and 8% greater in wet years, and at Red Bluff the flow would be 7% greater in critical years. At the other two locations, all differences in January flow would be less than 5%. During February of critical water years, mean flow would be lower (up to 13% lower at Keswick) under the PA than the NAA at all locations except Verona. During March, flow under the PA at Keswick would be 9% greater in above normal and below normal years and 8% greater in critical years, but there would be no differences greater than 5% at the other locations. Further discussion regarding flow-related effects during the June through November period is provided in Section 5.4.2.3, *Summary of Upstream Effects*.

As described in Appendix 5.D.4, *Migration Flows Methods*, mean monthly flow below about 3,250 cfs is considered to have potentially adverse effects on Chinook salmon, CCV steelhead, and green sturgeon adult immigration conditions in the Sacramento River. The effect of the PA on the frequency of flows below this threshold was evaluated by comparing CALSIM flows between the PA and the NAA at three of the migration corridor locations in the river: Keswick, Red Bluff, and Wilkins Slough. Of the 492 months within the late fall-run Chinook salmon immigration period, mean flow at Keswick was less than 3,250 cfs for 3 months under the NAA and 2 months under the PA (Table 5.E-62). There were no months with mean flows below 3,250 cfs at either of the other two locations.

Table 5.E-62. Number and Percent of the 492 Months within the Late Fall-run Chinook Salmon Adult Immigration Period from the 82-Year CALSIM Record with Flow < 3,250 cfs

	Months with Mean Flow < 3,250 cfs		**Percent with Mean Flow < 3,250 cfs**		**Difference in Months and Percent Difference**
Location	NAA	PA	NAA	PA	PA vs. NAA
Keswick	3	2	0.6	0.4	-1 (-33%)
Red Bluff	0	0	0.0	0.0	0 (0%)
Wilkins Slough	0	0	0.0	0.0	0 (0%)

These results indicate that any adverse effects of the PA relative to the NAA t on late fall-run Chinook salmon adult immigration conditions in the Sacramento River would be undetectable using the frequency of flow below the 3,250 cfs threshold.

Water Temperature-Related Effects

Mean monthly water temperatures were evaluated in the Sacramento River at Keswick, Bend Bridge, and Red Bluff during the November through April adult immigration period for late fall-run Chinook salmon (Table 5.E-5). Overall, the PA would change mean water temperatures very little (less than 1°F, or approximately 1%) at these locations in all months and water year types in the period (Appendix 5.C, *Upstream Water Temperature Methods and Results*, Section 5.C.7, *Upstream Water Temperature Modeling Results*, Table 5.C.7-3, Table 5.C.7-7, Table 5.C.7-8).

The largest increase in mean monthly water temperatures under the PA relative to NAA would be 0.2°F, or 0.4%, and would occur at Bend Bridge and Red Bluff in critical water years during February. Despite the increase, water temperatures would remain less than 52°F in both locations under both scenarios during this time, which is well below a temperature range of concern (see Table 5.E-22).

Exceedance plots of monthly mean water temperatures were examined during each month and water year type throughout the spawning and incubation period (Appendix 5.C, *Upstream Water Temperature Methods and Results*, Section 5.C.7, *Upstream Water Temperature Modeling Results*, Figure 5.C.7.3-7, Figure 5.C.7.7-7, Figure 5.C.7.8-7). The curves for the PA generally match those of the NAA. For critical years during February at Bend Bridge and Red Bluff, where the largest increase in mean monthly water temperature was seen, curves would be nearly identical between the NAA and PAA, except for 2 years in which the PA would be approximately 1°F higher (Figure 5.E-238, Figure 5.E-239). However, water temperatures would not differ in the large majority of years at both locations. Therefore, it is concluded that there would be no substantial water temperature differences between NAA and PA in February of critical water years at either location.

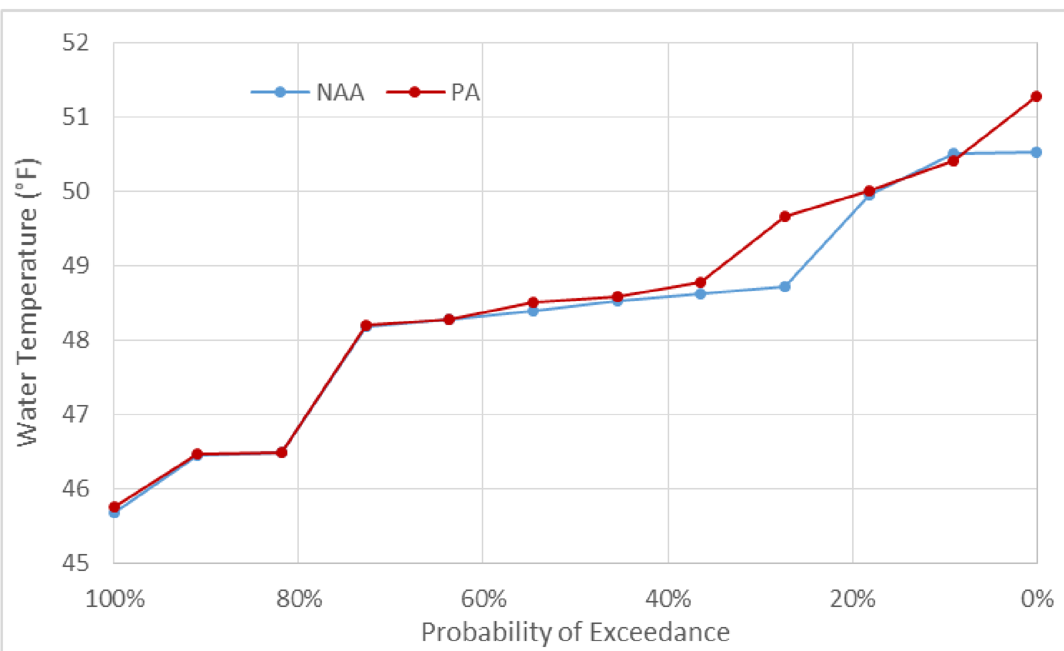


Figure 5.E-238. Exceedance Plot of Mean Monthly Water Temperatures (°F) in the Sacramento River at Bend Bridge in February of Critical Water Years

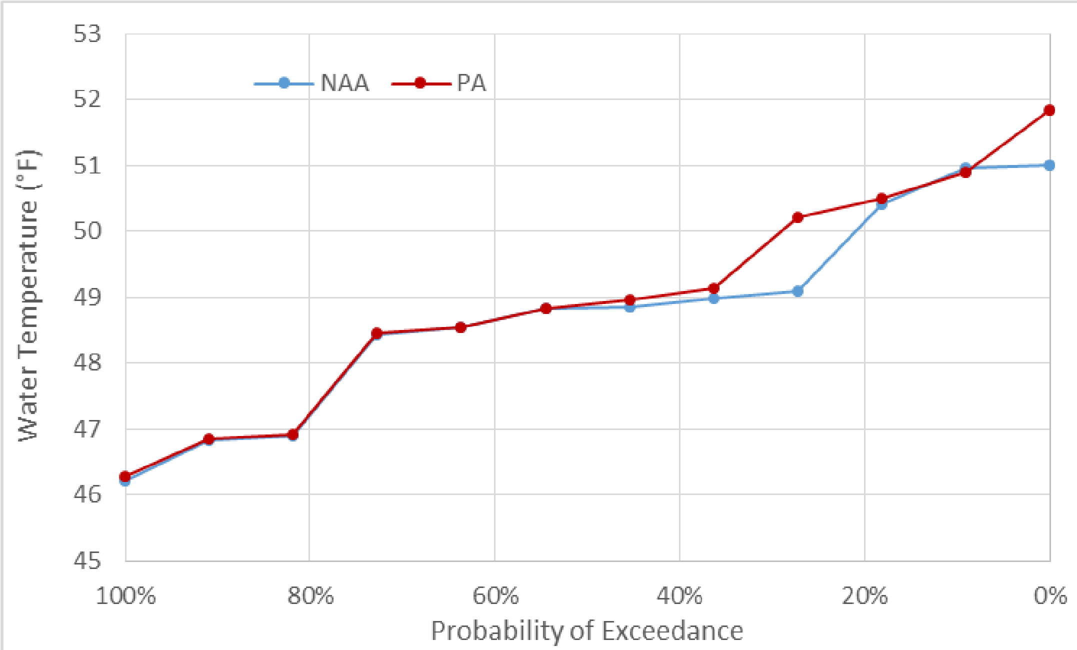


Figure 5.E-239. Exceedance Plot of Mean Monthly Water Temperatures (°F) in the Sacramento River at Red Bluff in February of Critical Water Years

To evaluate water temperature threshold exceedance during the adult immigration life stage at Keswick, Bend Bridge, and Red Bluff, the USEPA's 7DADM threshold value of 68°F was used (Table 5.E-22). The threshold was converted to function with daily model outputs for each month separately (Appendix 5.D, *Quantitative Methods and Detailed Results for Effects Analysis of Chinook Salmon, Central Valley Steelhead, Green Sturgeon, and Killer Whale*, Section 5.D.2.1, *Water Temperature Analysis Methods*, Table 5.D-4).

Results of the water temperature thresholds analysis are presented in Attachment 5.E.1, *Fall-/Late Fall-Run Chinook Salmon Water Temperature Threshold Analysis Results*, Table 5.E-29 through 5.E-31. At all three locations, there would be no months or water year types in which there would be 5% more days under the PA compared to the NAA on which temperatures would exceed the threshold or a more-than-0.5°F difference in the magnitude of average daily exceedance.

Overall, these temperature threshold analysis results indicate that any water temperature-related adverse effects of the PA relative to the NAA on late fall-run Chinook salmon adult immigration conditions in the Sacramento River would be undetectable.

SALMOD

The SALMOD model integrates all early life stages of late fall-run Chinook salmon race on an annual basis and provides an *Annual Potential Production* value (Attachment 5.D.2, *SALMOD Model*). This value represents all individuals that survive from the pre-spawn egg stage through the immature smolt stage in each year of the 80-year simulation period. Individual years are independent of one another and, therefore, effects through time cannot be evaluated as a time series.

Mean late fall-run Chinook salmon production values and differences between scenarios are presented in Table 5.E-63 and an exceedance plot is provided in

Figure 5.E-240. Overall (all water year types), these results indicate that changes in late fall -run Chinook salmon production under the PA relative to the NAA would be negligible (1% difference). This result is consistent for the separate water year types (3% difference or less) as well.

Table 5.E-63. Mean Annual Potential Production of Late Fall-Run Chinook Salmon and Differences between Model Scenarios, SALMOD

Analysis Period	Annual Potential Production (# of Fish/year)
All Water Year Types Combined	
Full Simulation Period[1]	
NAA	1,810,410
PA	1,797,449
Difference	-12,961
Percent Difference[2]	-1
Water Year Types[3]	
Wet (32.5%)	
NAA	1,983,169
PA	1,963,584
Difference	-19,584
Percent Difference	-1
Above Normal (12.5%)	
NAA	1,639,594
PA	1,633,821
Difference	-5,773
Percent Difference	0
Below Normal (17.5%)	
NAA	2,069,244
PA	2,019,856
Difference	-49,389
Percent Difference	-2
Dry (22.5%)	
NAA	1,801,338
PA	1,775,288
Difference	-26,050

Analysis Period	Annual Potential Production (# of Fish/year)
Percent Difference	-1
Critical (15%)	
NAA	1,399,166
PA	1,448,020
Difference	48,854
Percent Difference	3

[1] Based on the 80-year simulation period
[2] Relative difference of the annual average
[3] As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (State Water Resources Control Board 1995). Water years may not correspond to the biological years in SALMOD.

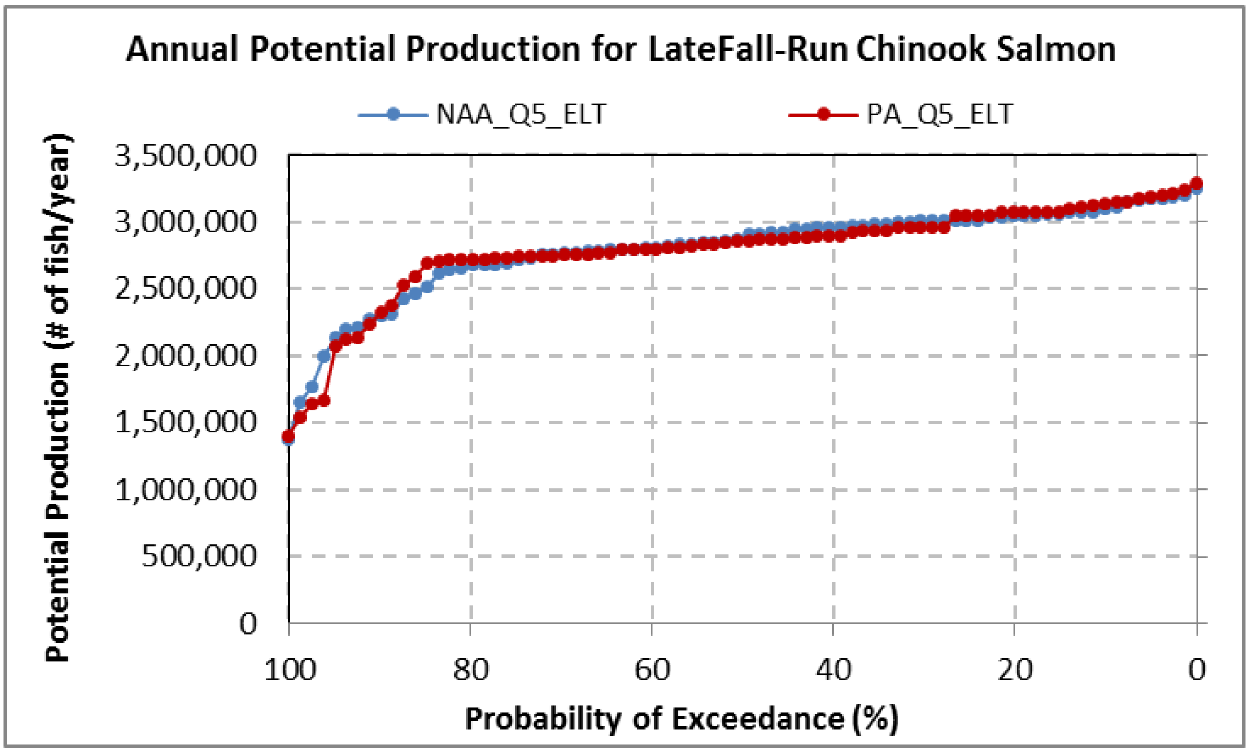


Figure 5.E-240. Exceedance Plot for Annual Potential Production (# of Fish/Year) of Late Fall-Run Chinook Salmon, SALMOD

The frequency at which annual production was below minimum production thresholds was evaluated as a measure of a worst-case scenario for late fall-run Chinook salmon. Thresholds were determined as 5% and 10% of the number of eggs used as inputs into the model. The initial egg value was 13,325,000 for both NAA and PA and, therefore, the 5% and 10% values were 666,250 fish per year and 1,332,500 fish per year, respectively. Results are presented in Table 5.E-64. There would be 1 less year (11% lower) under the PA compared to the NAA during which production would be below the 5% (666,250 fish) threshold. There would be 2 fewer years (20% lower) under the PA compared to the NAA during which production would be below the 10% (1,332,500 fish) threshold. Therefore, the PA would have no negative effects on the frequency of worst-case scenario years for late fall-run Chinook salmon.

Table 5.E-64. Number of Years during which Late Fall-Run Chinook Salmon Production Would be Lower than Production Thresholds and Differences (Percent Differences) between Model Scenarios, SALMOD

Production Threshold (# of Fish)	NAA (# of Years)	PA (# of Years)	PA vs. NAA (# of Years [%])
666,250 (based on 5% of eggs)	0	0	0 (NA[1])
1,332,500 (based on 10% of eggs)	0	0	0 (NA[1])
[1]NA = Could not be calculated because dividing by 0			

5.E.5.3.1.2.2.3 Results - American River

5.E.5.3.1.2.2.3.1 Fall-Run Chinook Salmon

Spawning, Egg Incubation, and Alevins

Flow-Related Effects

Mean monthly flow rates and reservoir storage volumes were examined for the PA and NAA during the October through January spawning and incubation period for fall-run Chinook salmon, with peak occurrence in November and December (5). Changes in flow can affect the instream area available for spawning and egg incubation, along with the quality of the habitat, and can result in dewatering or scour of the redds.

Folsom Reservoir storage volume at the end of September generally influences flow rates in the lower American River during the fall-run Chinook salmon spawning and egg incubation period Table 5.E-4). Mean Folsom September storage under the PA would be similar (less than 5% difference) to storage under NAA for all water year types, except for 8% lower mean storage during dry water years under the PA. Most fall-run Chinook salmon spawning in the American River occurs within the first several miles downstream of Nimbus Dam (Appendix 5.A, *CALSIM Methods and Results*, Table 5.A.6-16). During January at Nimbus Dam, mean flow due to the PA would be similar to (less than 5% difference) flow under the NAA for all water year types, but during the other months of the spawning period there would be differences between the scenarios for at least two of the water year types. Flow during October would be 14% and 8% higher under the PA in critical and below normal years, respectively, and would be 13% lower in wet years. During November, flow under the PA would be more than 5% lower than flow under the NAA in all water year types except below normal water years, ranging up to 13% lower in wet years. Flows under the PA would be 5% higher in wet and below normal years during December.

Spawning WUA. Spawning WUA for fall-run Chinook salmon in the American River was determined by USFWS (2003b) for several river segments located within about 6 miles of Nimbus Dam, where most fall-run Chinook salmon spawning occurs. To evaluate the effects of the PA on spawning habitat, spawning WUA was estimated for CALSIM II flows at Nimbus Dam under the NAA and the PA during the October through January spawning period for all of the river segments combined (see Appendix 5.D.2.2, *Spawning Flow Methods*).

Differences in fall-run Chinook salmon spawning WUA under the PA and NAA were examined using exceedance plots of monthly mean WUA during the spawning period for each water year type and all water year types combined. The exceedance curves with all water years combined are similar between the PA and the NAA (Figure 5.E-241). The exceedance curves broken out by water year type are roughly similar between the PA and the NAA for most water year types, but show slightly more WUA under the PA for wet and dry years (Figure 5.E-242 and Figure 5.E-245) and slightly less WUA for below normal years (Figure 5.E-244).

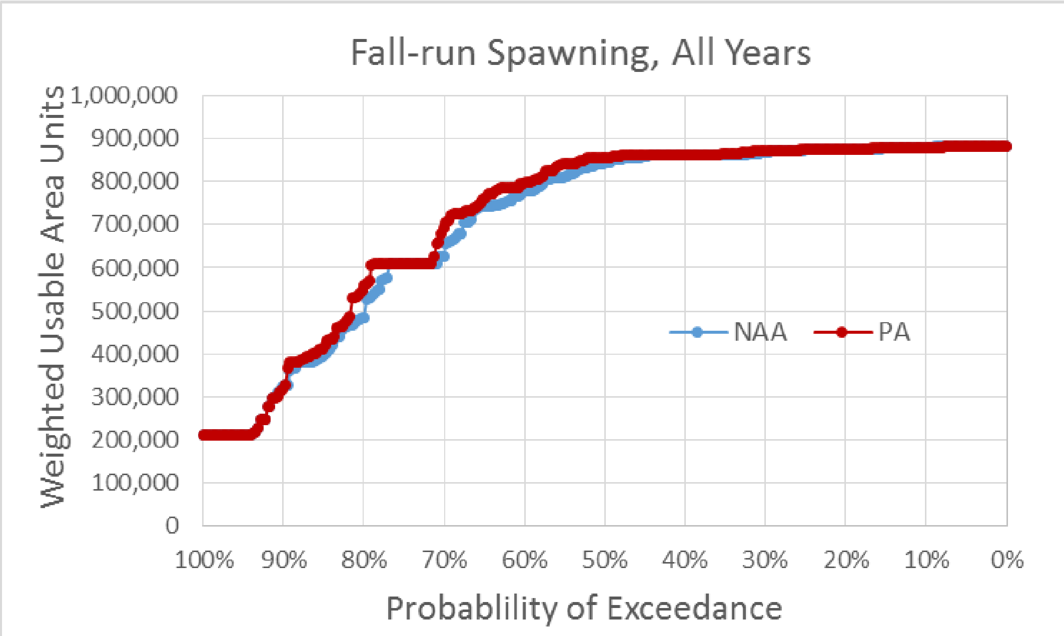


Figure 5.E-241. Exceedance Plot of Fall-Run Chinook Salmon Spawning Weighted Usable Area for NAA and PA Model Scenarios, All Water Years

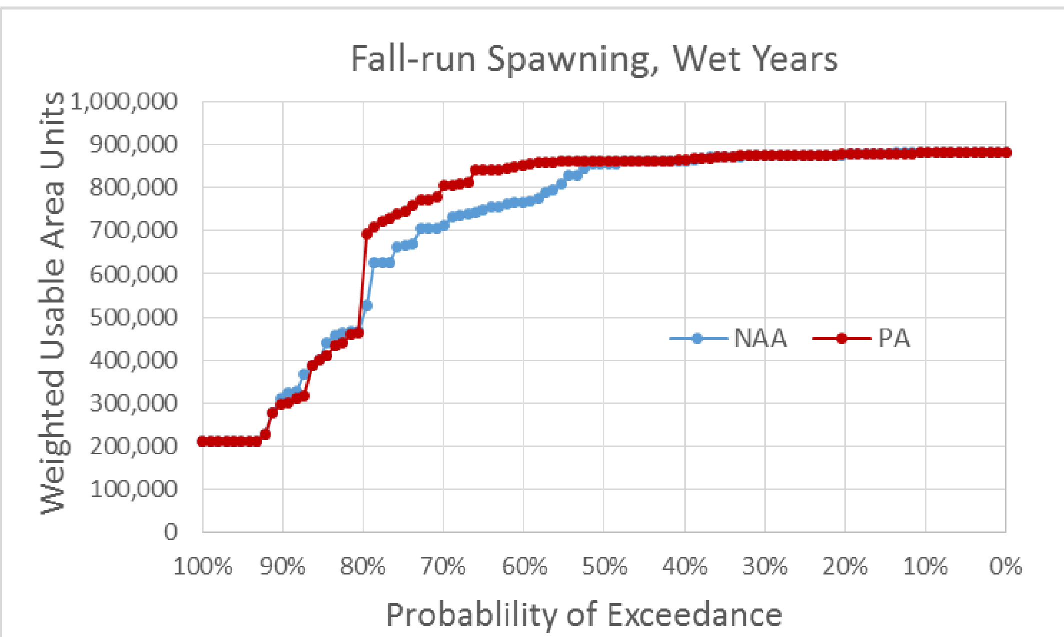


Figure 5.E-242. Exceedance Plot of Fall-Run Chinook Salmon Spawning Weighted Usable Area for NAA and PA Model Scenarios, Wet Water Years

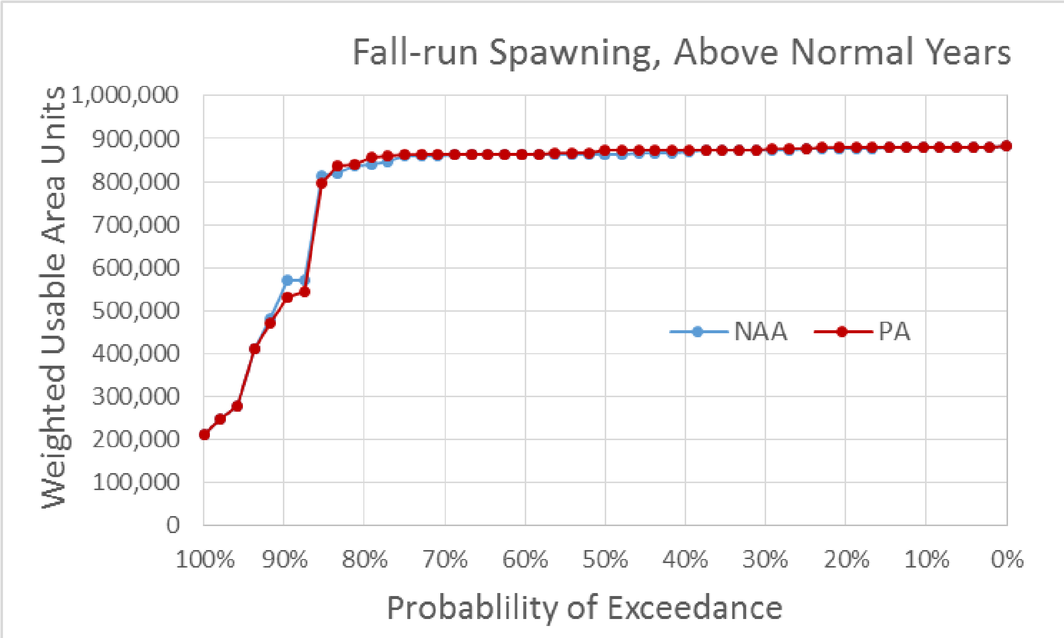


Figure 5.E-243. Exceedance Plot of Fall-Run Chinook Salmon Spawning Weighted Usable Area for NAA and PA Model Scenarios, Above Normal Water Years

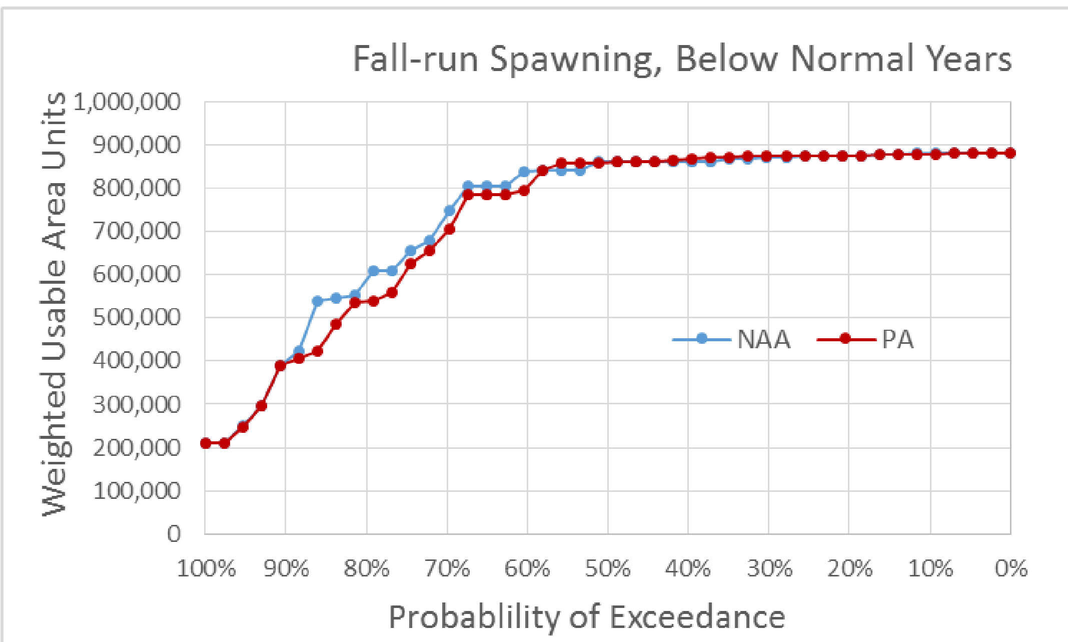


Figure 5.E-244. Exceedance Plot of Fall-Run Chinook Salmon Spawning Weighted Usable Area for NAA and PA Model Scenarios, Below Normal Water Years

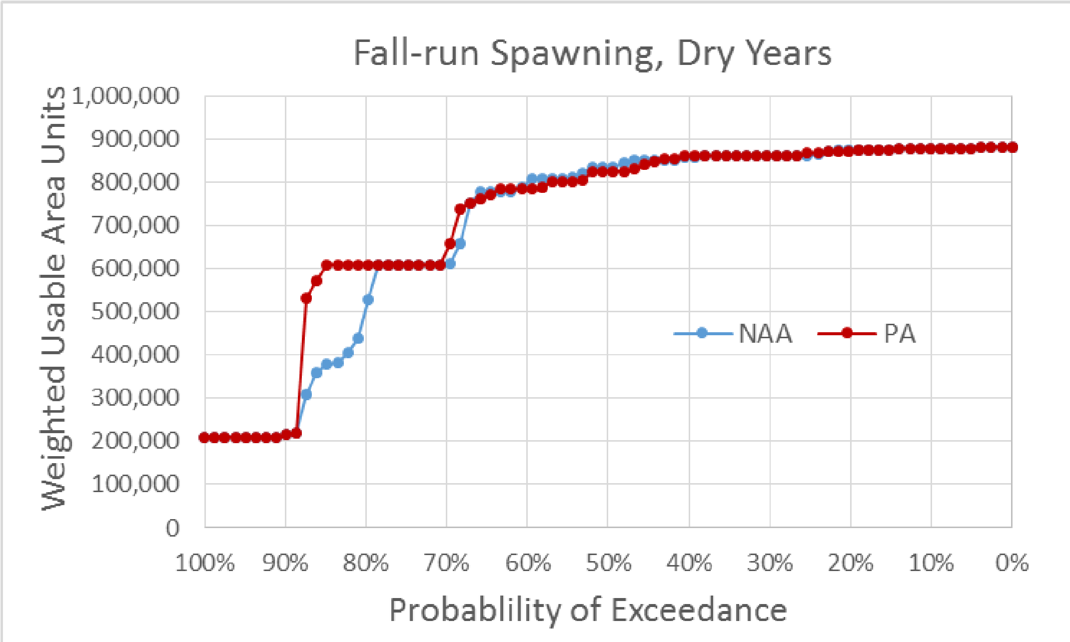


Figure 5.E-245. Exceedance Plot of Fall-Run Chinook Salmon Spawning Weighted Usable Area for NAA and PA Model Scenarios, Dry Water Years

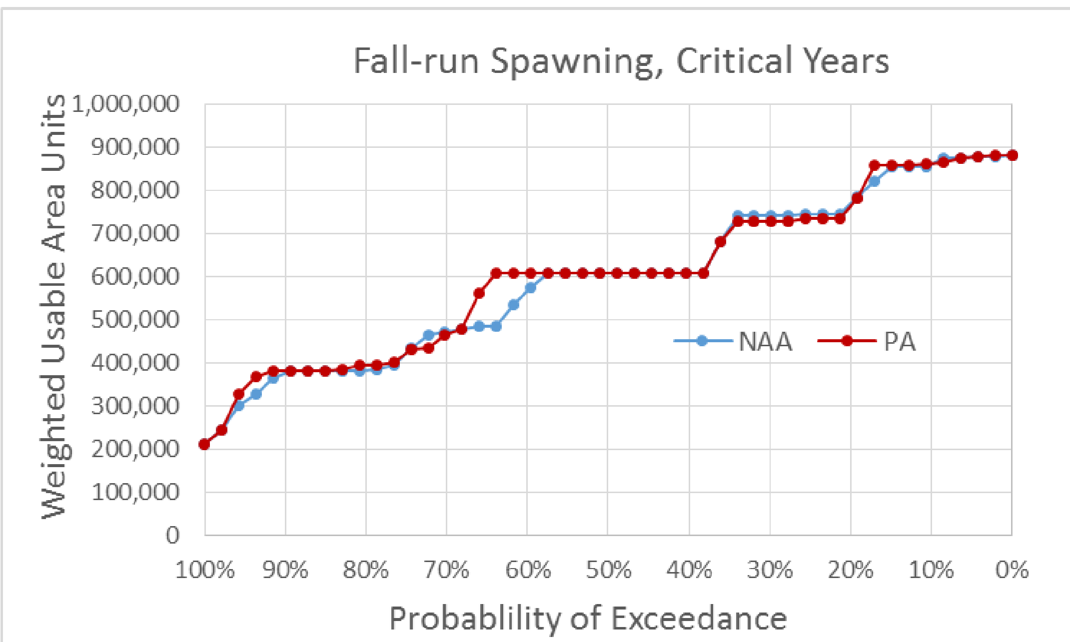


Figure 5.E-246. Exceedance Plot of Fall-Run Chinook Salmon Spawning Weighted Usable Area for NAA and PA Model Scenarios, Critical Water Years

Differences in the grand mean spawning WUA for the months of the spawning period under each water year type and all water year types combined also indicate that spawning WUA would be little affected by the PA (less than 5% difference), except for a 10% increase in mean WUA during November of wet years and a 7% increase in mean WUA during January of dry years (Table 5.E-65).

Table 5.E-65. Fall-run Chinook Salmon Spawning Weighted Usable Areas and Differences (Percent Differences) between Model Scenarios (green indicates PA is at least 5% higher [raw difference] than NAA; red indicates PA is at least 5% lower)

Month	WYT	NAA	PA	PA vs. NAA
October	Wet	824,163	853,116	28,953 (4%)
	Above Normal	860,336	860,123	-213 (-0.02%)
	Below Normal	816,299	809,179	-7,120 (-0.9%)
	Dry	804,543	800,793	-3,751 (0%)
	Critical	587,867	608,444	20,577 (4%)
	All	789,478	799,766	10,288 (1%)
November	Wet	720,254	791,379	71,125 (10%)
	Above Normal	844,047	850,233	6,185 (0.7%)
	Below Normal	811,686	793,530	-18,156 (-2.2%)
	Dry	755,881	785,066	29,185 (4%)
	Critical	631,255	621,235	-10,020 (-2%)
	All	747,810	774,559	26,749 (4%)
December	Wet	720,266	704,698	-15,568 (-2%)
	Above Normal	777,172	771,961	-5,211 (-0.7%)
	Below Normal	743,454	725,867	-17,587 (-2.4%)
	Dry	677,896	675,889	-2,007 (0%)
	Critical	615,578	609,115	-6,463 (-1%)
	All	706,744	697,187	-9,557 (-1%)
January	Wet	618,736	615,475	-3,261 (-0.5%)
	Above Normal	727,455	728,675	1,220 (0.2%)
	Below Normal	589,163	590,072	909 (0.2%)
	Dry	579,306	621,554	42,248 (7%)
	Critical	547,229	570,427	23,198 (4.2%)
	All	611,924	624,904	12,981 (2.1%)

Redd Scour. The probability of flows in the American River occurring under the PA and the NAA that would be high enough to mobilize sediments and scour fall-run Chinook salmon redds was estimated from CALSIM II estimates of mean monthly flows, using a relationship determined from the historical record between actual mean monthly and maximum daily flow (Appendix 5.D.2.2, *Spawning Flow Methods*). The actual monthly and daily flow data used in the analysis are from gage records at Hazel Avenue, and the CALSIM II estimates used to compare probabilities of redd scour for the PA and the NAA are for the Nimbus Dam location. As discussed in Appendix 5.D.2.2, *Spawning Flow Methods*, 40,000 cfs is treated as the minimum daily flow at which redd scour occurs in the American River. The analysis of the Hazel Avenue gage data shows that for months with a mean monthly flow of at least 19,350 cfs, the maximum daily flow is always at least 40,000 cfs. Therefore, redd scour probabilities for the PA and the NAA were evaluated by comparing frequencies of CALSIM II flows greater than 19,350 cfs at Nimbus during the fall-run Chinook salmon October through January spawning and incubation period. Further information on the redd scour analysis methods is provided in Appendix 5.D.2.2, *Spawning Flow Methods*.

Of the months in the CALSIM II record during the spawning and incubation period of fall-run Chinook salmon in the American River (December through April), 1.5% would have flows of more than 19,350 cfs at Hazel Avenue under both the PA and the NAA.

Redd Dewatering. The percentage of fall-run Chinook salmon redds dewatered by reductions in American River flow was estimated from CALSIM II estimates of monthly mean flows during the 3 months following each of the months that fall-run Chinook salmon spawn (Section 5.D.2.2, *Spawning Flow Methods*, Table 5-4-2). No model for predicting percentages of redds dewatered, such as that developed for the Sacramento River (USFWS 2006), has been developed for the American River. Therefore, the maximum reduction in American River flow for the 3 months following each of the months during which fall-run Chinook salmon spawn was used as a proxy for percent of redds dewatered. CALSIM II flows at Nimbus were used for this analysis. Larger maximum reductions are assumed to increase the percent of redds dewatered and, therefore, to have a negative effect on fall-run Chinook salmon. Further information on the redd dewatering analysis methods is provided in Appendix 5.D.2.2, *Spawning Flow Methods*.

Differences in maximum flow reductions under the PA and NAA were examined using exceedance plots of mean monthly maximum flow reductions, expressed as a percentage of the spawning flows, for the months that American River fall-run Chinook salmon spawn (October and November) (Figure 5.E-247 through Figure 5.E-252). The exceedance curves for all water year types combined (Figure 5.E-247) and those for wet and above normal years (Figure 5.E-248 and Figure 5.E-249) indicate that the PA would generally have lower flow reductions than the NAA. Differences for the other three water year types would be minor (Figure 5.E-250 through Figure 5.E-252).

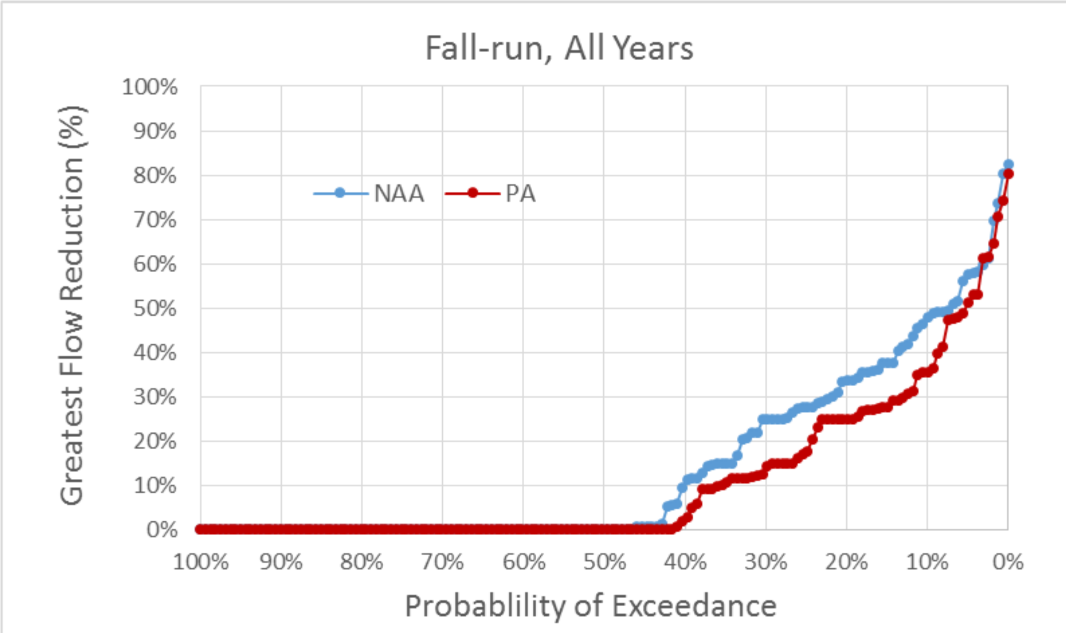


Figure 5.E-247. Exceedance Plot of Maximum Flow Reductions (%) for 3-Month Period after Fall-Run Chinook Salmon Spawning for NAA and PA Model Scenarios, All Water Years

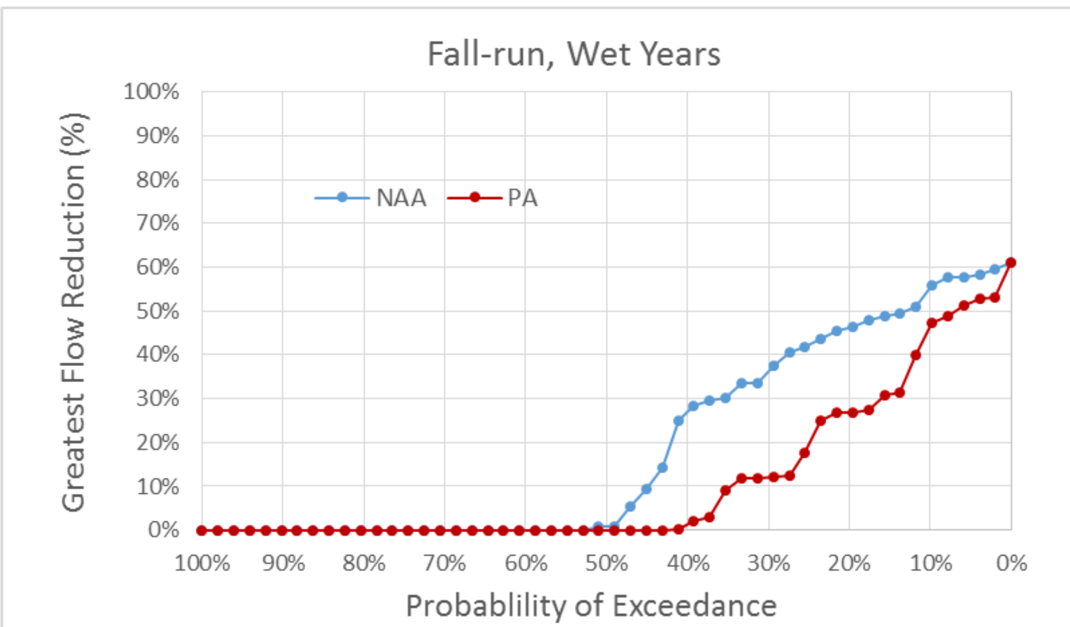


Figure 5.E-248. Exceedance Plot of Maximum Flow Reductions (%) for 3-Month Period after Fall-Run Chinook Salmon Spawning for NAA and PA Model Scenarios, Wet Water Years

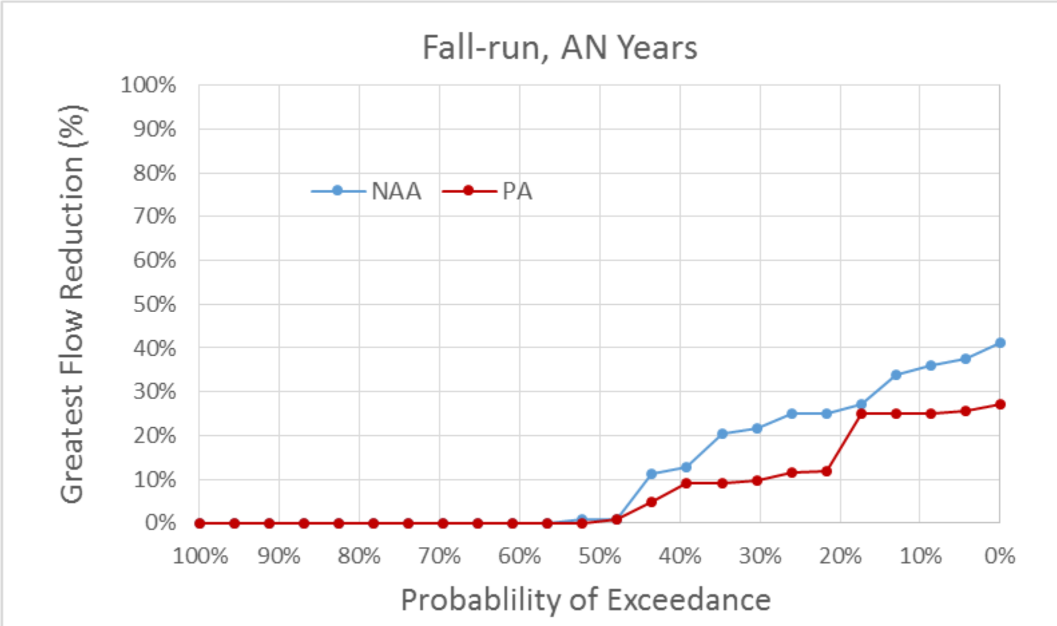


Figure 5.E-249. Exceedance Plot of Maximum Flow Reductions (%) for 3-Month Period after Fall-Run Chinook Salmon Spawning for NAA and PA Model Scenarios, Above Normal Water Years

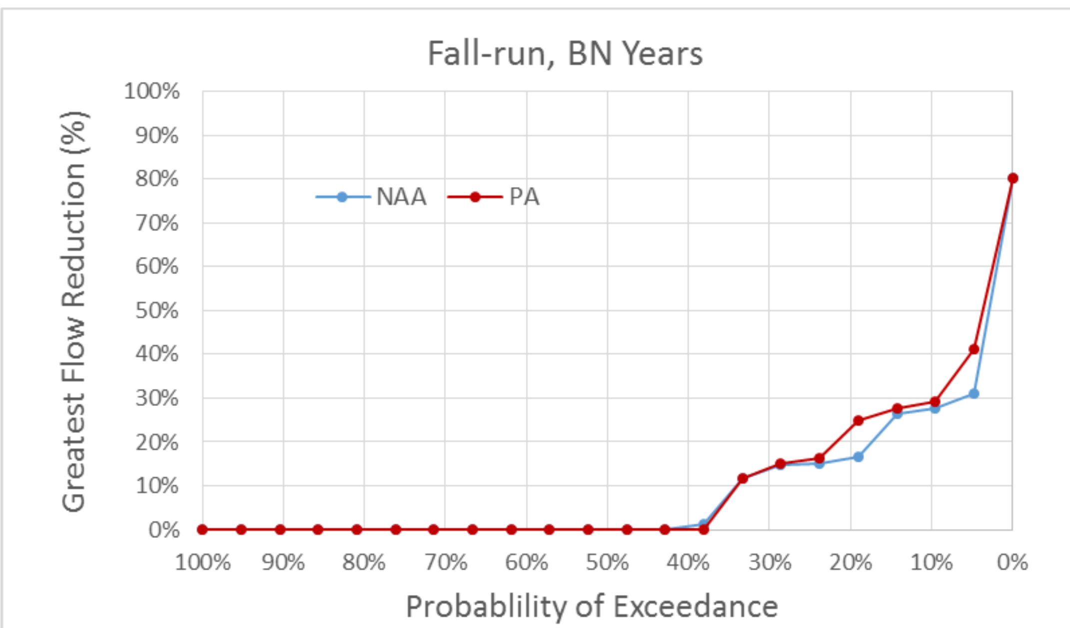


Figure 5.E-250. Exceedance Plot of Maximum Flow Reductions (%) for 3-Month Period after Fall-Run Chinook Salmon Spawning for NAA and PA Model Scenarios, Below Normal Water Years

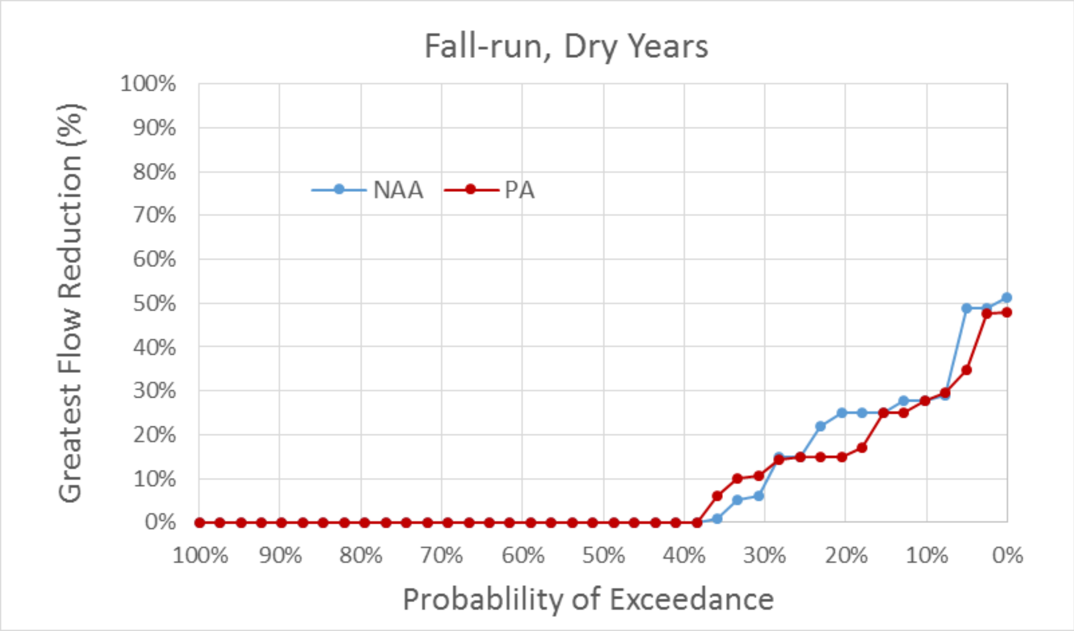


Figure 5.E-251. Exceedance Plot of Maximum Flow Reductions for 3-Month Period after Fall-Run Chinook Salmon Spawning for NAA and PA Model Scenarios, Dry Water Years

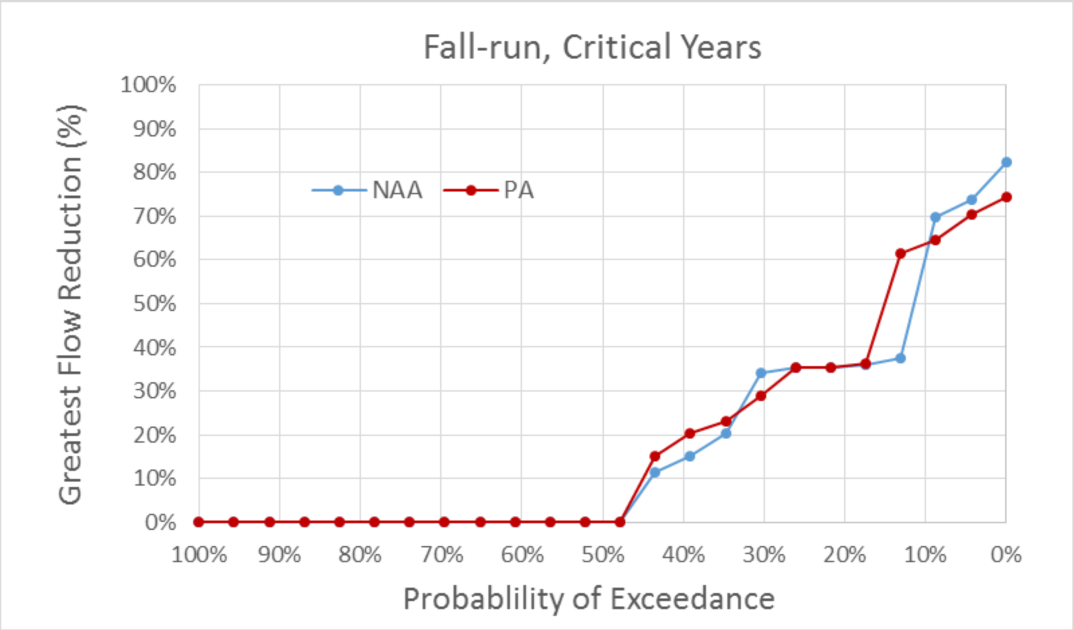


Figure 5.E-252. Exceedance Plot of Maximum Flow Reductions for 3-Month Period after Fall-Run Chinook Salmon Spawning for NAA and PA Model Scenarios, Critical Water Years

Differences in the mean maximum flow reduction, expressed as a percentage of the spawning flow, for each month of spawning under each water year type and all water year types combined indicate that fall-run Chinook salmon redd dewatering would generally be little affected by the PA (less than 5% raw difference), except for a 6% increase in the maximum flow reduction for October of critical years and 11% and 7% decreases in the maximum flow reduction for

November of wet and above normal years, respectively (Table 5.E-66). As previously noted, increases in flow reduction are assumed to increase redd dewatering, negatively affecting fall-run Chinook salmon.

Table 5.E-66. Maximum Flow Reductions (cfs) for 3-Month Period after Central Valley Steelhead Spawning, and Differences in the Maximums (Percent Differences) between Model Scenarios (green indicates PA is at least 5% lower [raw difference] than NAA; red indicates PA is at least 5% higher)[1]

Month	WYT	Mean Greatest Flow Reduction, as Percent		Raw Difference	Relative (Percent) Difference
		NAA	PA	PA vs. NAA	PA vs. NAA
October	Wet	10.9%	6.0%	-4.9%	-45.2
	Above Normal	4.2%	2.3%	-2.0%	-46.0
	Below Normal	5.4%	7.8%	2.4%	44.2
	Dry	6.8%	5.6%	-1.2%	-17.3
	Critical	14.6%	20.2%	5.7%	39.0
	All	8.7%	7.7%	-1.0%	-11.5
November	Wet	28.1%	17.2%	-10.9%	-38.8
	Above Normal	20.3%	13.1%	-7.1%	-35.3
	Below Normal	15.0%	14.6%	-0.4%	-2.7
	Dry	11.8%	11.4%	-0.4%	-3.5
	Critical	23.1%	18.5%	-4.5%	-19.6
	All	20.4%	15.0%	-5.4%	-26.4

Water Temperature-Related Effects

Mean monthly water temperatures were evaluated during the October through January spawning, egg incubation, and alevin period for fall-run Chinook salmon in the American River reach between Hazel Avenue and Watt Avenue (Table 5.E-45). Overall, the PA would change mean water temperatures very little (less than 1°F, or less than 1%) throughout the reach in all months and water year types of the period (Appendix 5.C, *Upstream Water Temperature Methods and Results*, Section 5.C.7, *Upstream Water Temperature Modeling Results*, Table 5.C.7-14, Table 5.C.7-15). The largest increase in mean monthly water temperatures under the PA relative to NAA would be 0.2°F, or 0.4%, and would occur at both Hazel Avenue and Watt Avenue during above normal water years during October. This greatest increase would occur outside of the peak spawning, egg incubation, and alevin period (November and December).

Exceedance plots of monthly mean water temperatures were examined during each month and water year type throughout the spawning and incubation period (Appendix 5.C, *Upstream Water Temperature Methods and Results*, Section 5.C.7, *Upstream Water Temperature Modeling Results*, Figure 5.C.7.14-7, Figure 5.C.7.15-7). The curves for the PA generally match those of the NAA period. Further examination of October of above normal water years at Hazel Avenue (Figure 5.E-253) and Watt Avenue (Figure 5.E-254), where the largest increases in mean monthly water temperatures were seen, reveals that the curves were largely similar overall and that the difference of 0.2°F in mean monthly temperatures between NAA and PA would cause no substantial effects on the curves. One exception would be at Hazel Avenue in October of above normal water years, in which there would be 2 years during which water temperatures under the

PA would be approximately 1°F higher than those under the NAA (Figure 5.E-253). Further examination of these years reveals that this is a modeling artifact and there is no practical reason why actual operations under the PA would be different from those under the NAA in these months and years.

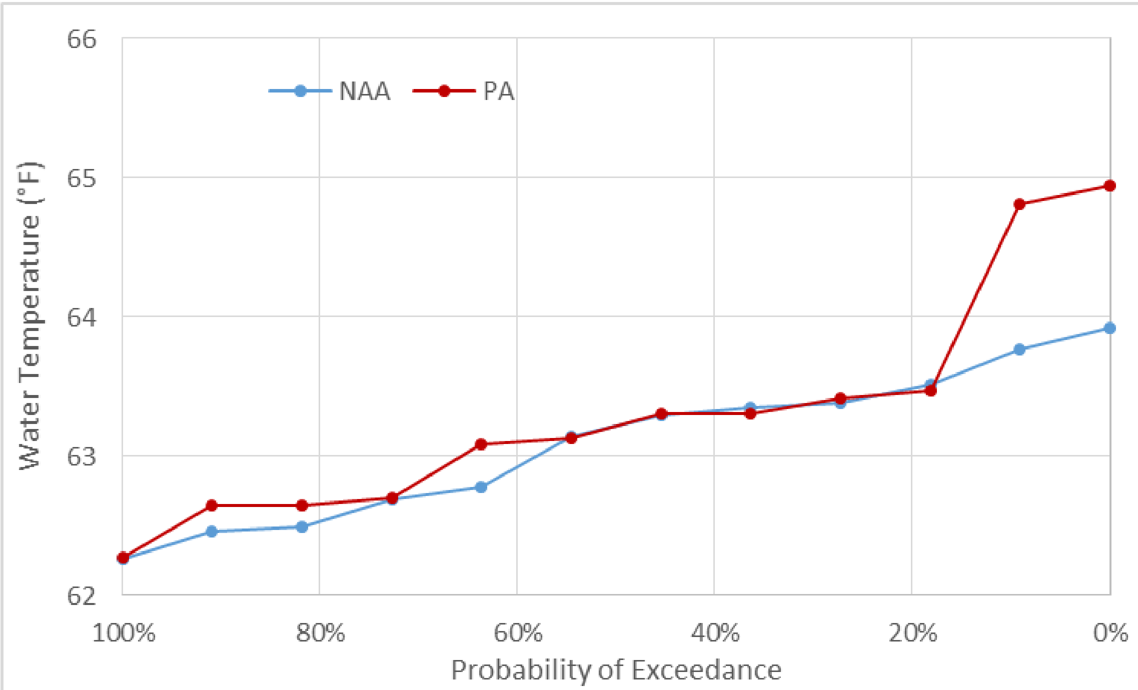


Figure 5.E-253. Exceedance Plot of Mean Monthly Water Temperatures (°F) in the American River at Hazel Avenue in October of Above Normal Water Years

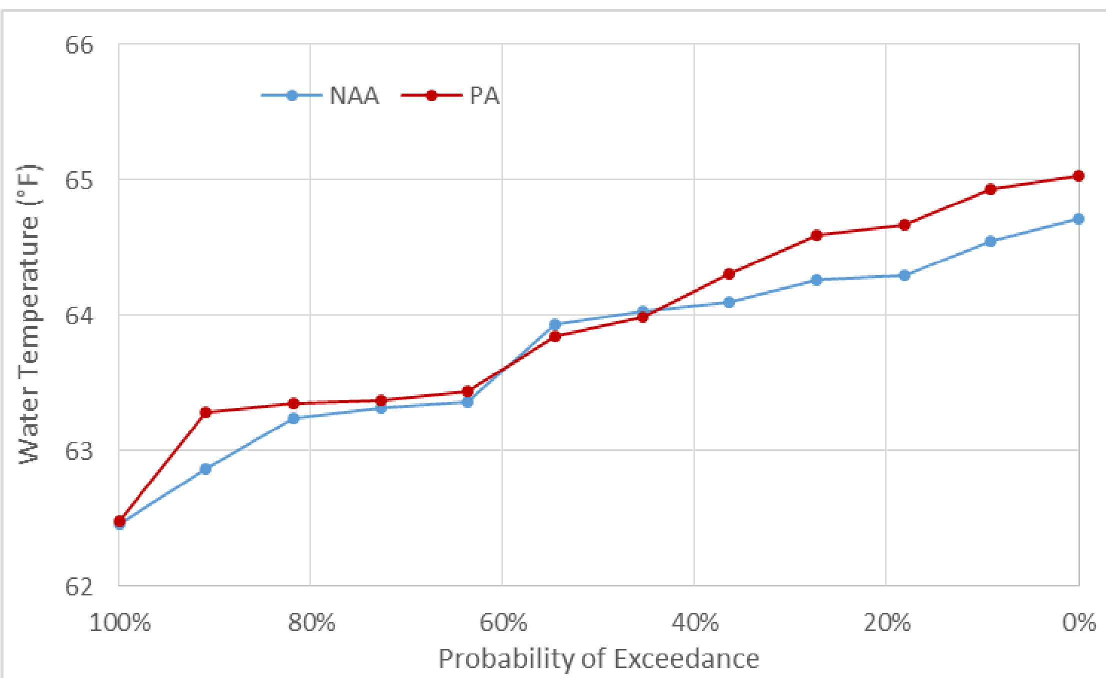


Figure 5.E-254. Exceedance Plot of Mean Monthly Water Temperatures (°F) in the American River at Watt Avenue in October of Above Normal Water Years

The exceedance of temperature thresholds in the American River presented in Appendix, *Methods*, Table 5.E-22 by modeled daily water temperatures were evaluated based on thresholds identified from the literature and the USEPA's temperature water quality guidance (U.S. Environmental Protection Agency 2003). For spawning, egg incubation, and alevin presence, the threshold used was from the USEPA's 7-day average daily maximum (7DADM) value of 55.4°F, converted by month to function with daily model outputs for each month separately (Appendix 5.D, *Quantitative Methods and Detailed Results for Effects Analysis of Chinook Salmon, Central Valley Steelhead, Green Sturgeon, and Killer Whale*, Section 5.D.2.1, *Water Temperature Analysis Methods*, Table 5.D-4).

Results of the water temperature thresholds analysis are presented in Attachment 5.E-2, *Fall-/Late Fall-Run Chinook Salmon Water Temperature Threshold Analysis Results*, Table 5.E.1-32 through Table 5.E.1-33. At both Hazel Avenue and Watt Avenue, there would be no months or water year types in which there would be 5% more days under the PA compared to the NAA on which temperatures would exceed the threshold or a more-than-0.5°F difference in the magnitude of average daily exceedance. Therefore, it was concluded that any adverse water temperature-related effects of the PA relative to the NAA on fall-run Chinook salmon spawning, egg incubation, and alevins in the American River would be undetectable.

The Reclamation Egg Mortality Model provides temperature-related estimates of fall-run Chinook salmon egg mortality in the American River (see Attachment 5.D.1, *Reclamation Egg Mortality Model*, for full model description). Results of the model are presented in Table 5.E-67 and Figure 5.E-255 through Figure 5.E-260. Because the egg life stage has the highest potential effect on the propagation of population size in a life cycle context, a more conservative value of a more-than-2% change in percent of total individuals (on a raw scale) was considered a detectable effect.

These results indicate that there would be no detectable increases in fall-run Chinook salmon egg mortality in the American River under the PA relative to the NAA.

Table 5.E-67. Fall-Run Chinook Salmon Egg Mortality (Percent of Total Individuals) and Differences (Percent Differences) between Model Scenarios in the American River, Reclamation Egg Mortality Model

WYT	NAA	PA	PA vs. NAA
Wet	22.7	21.9	-0.8 (-3%)
Above Normal	22.5	22.5	0 (0%)
Below Normal	23.4	23.1	-0.3 (-1%)
Dry	22.9	22.4	-0.6 (-2%)
Critical	24.8	24.7	-0.1 (-0.3%)
All	23.1	22.7	-0.4 (-2%)

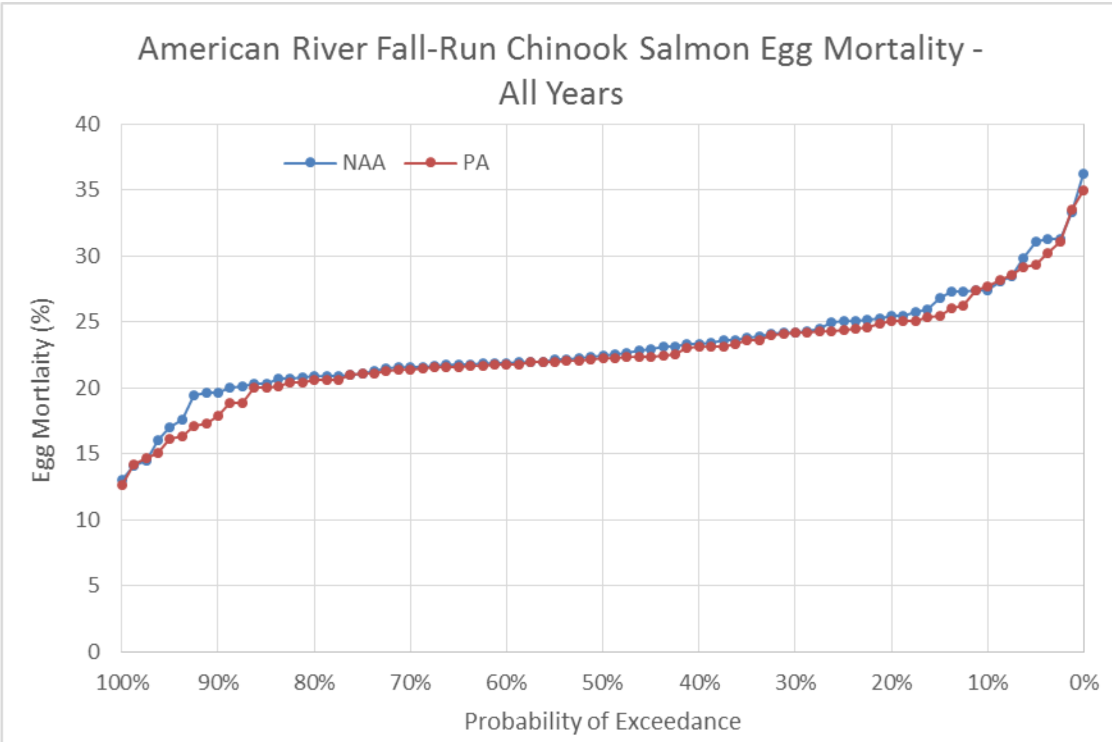


Figure 5.E-255. Exceedance Plot of Fall-Run Chinook Salmon Egg Mortality for NAA and PA Model Scenarios in the American River, Reclamation Egg Mortality Model, All Water Years

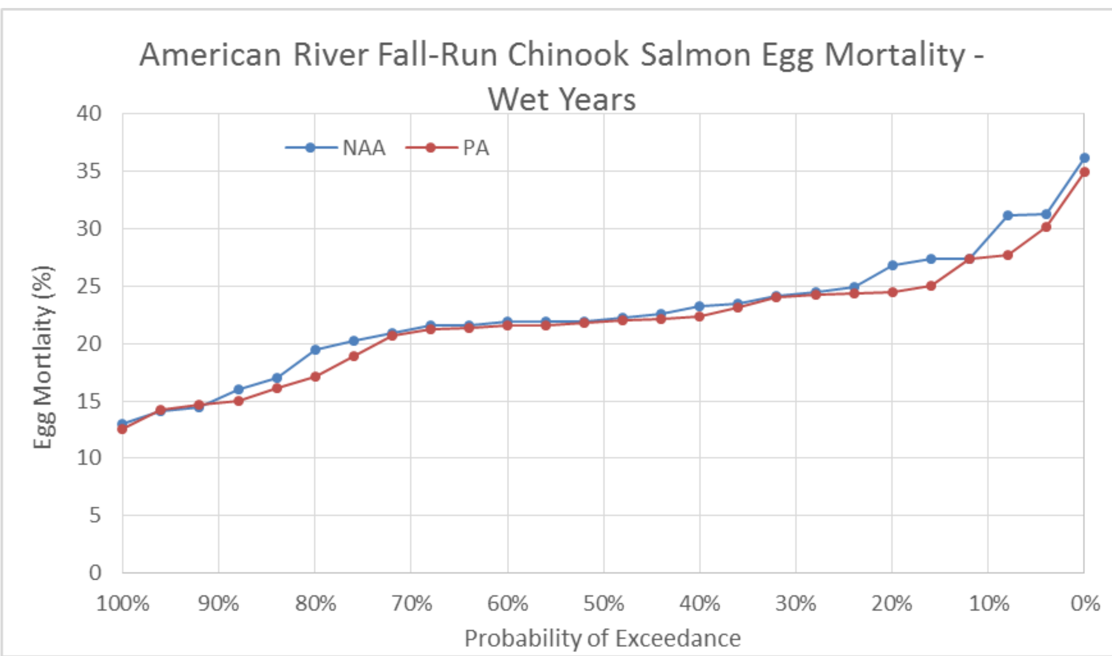


Figure 5.E-256. Exceedance Plot of Fall -Run Chinook Salmon Egg Mortality for NAA and PA Model Scenarios in the American River, Reclamation Egg Mortality Model, Wet Water Years

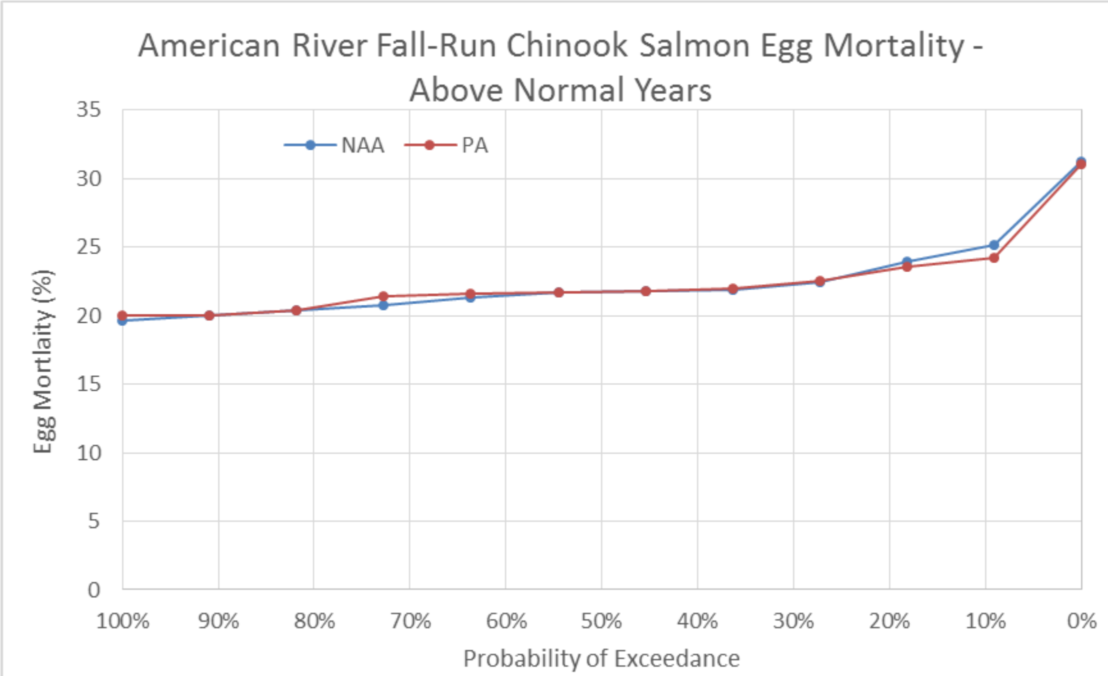


Figure 5.E-257. Exceedance Plot of Fall -Run Chinook Salmon Egg Mortality for NAA and PA Model Scenarios in the American River, Reclamation Egg Mortality Model, Above Normal Water Years

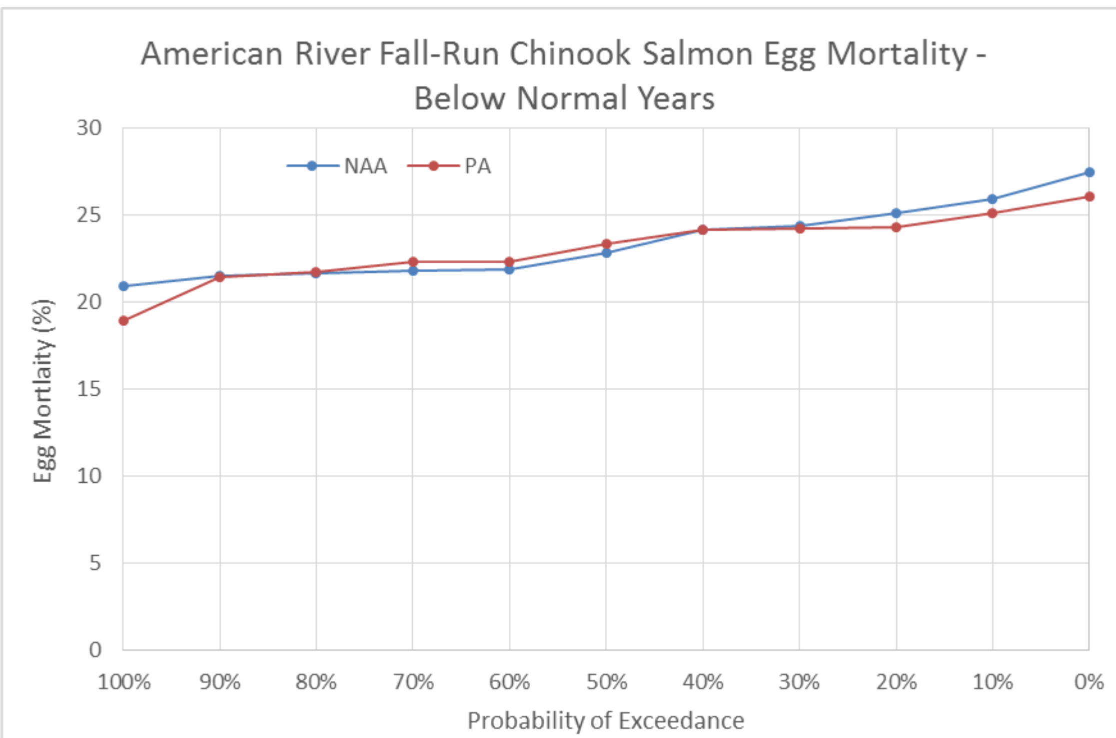


Figure 5.E-258. Exceedance Plot of Fall -Run Chinook Salmon Egg Mortality for NAA and PA Model Scenarios in the American River, Reclamation Egg Mortality Model, Below Normal Water Years

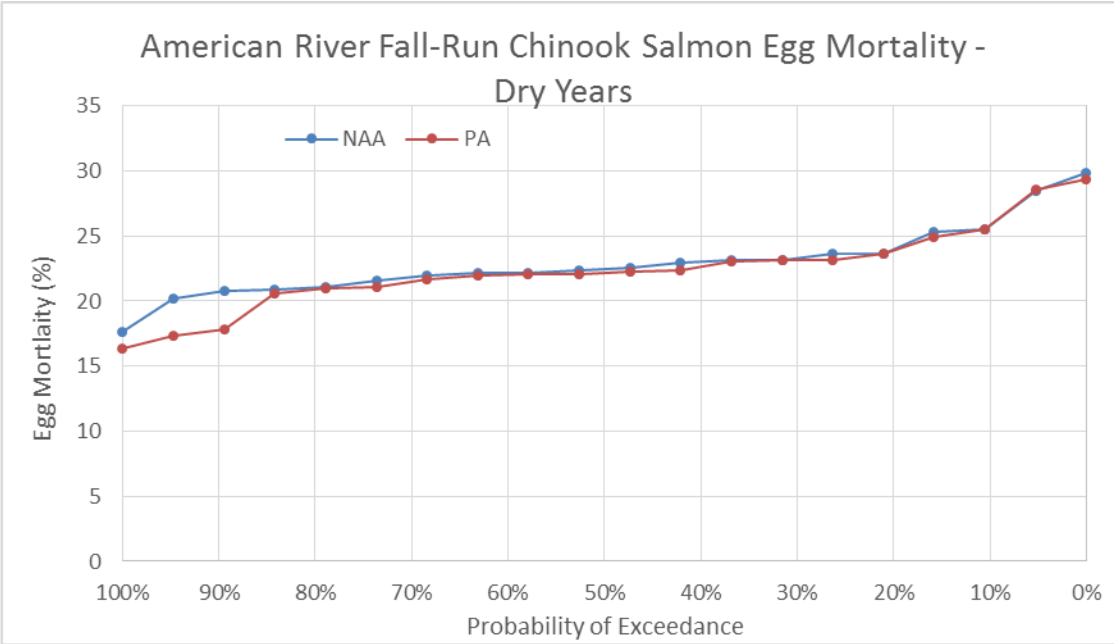


Figure 5.E-259. Exceedance Plot of Fall -Run Chinook Salmon Egg Mortality for NAA and PA Model Scenarios in the American River, Reclamation Egg Mortality Model, Dry Water Years

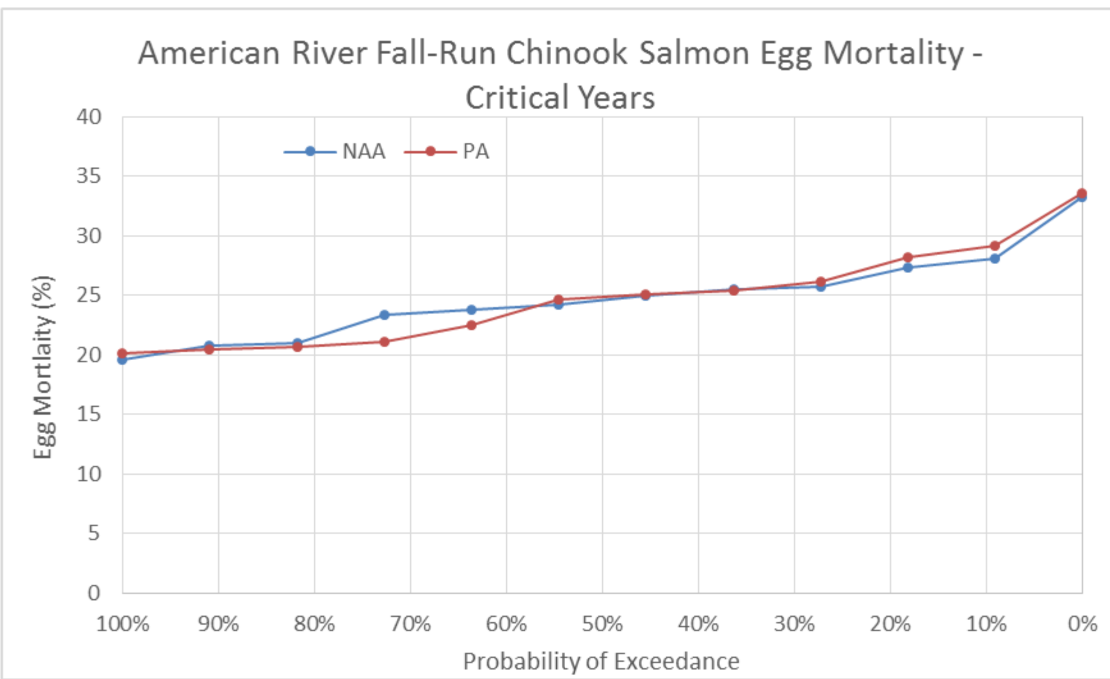


Figure 5.E-260. Exceedance Plot of Fall -Run Chinook Salmon Egg Mortality for NAA and PA Model Scenarios in the American River, Reclamation Egg Mortality Model, Critical Water Years

Fry and Juvenile Rearing

Flow-Related Effects

Mean monthly flow rates and reservoir storage volumes were examined for the PA and NAA in the American River at the Nimbus Dam and confluence with the Sacramento River locations during the fall-run Chinook salmon January through May juvenile rearing period, with a peak in January and February (5). Changes in flow can affect the instream area available for rearing, along with habitat quality, and stranding of juveniles, especially in side-channel habitats.

Folsom Reservoir storage volume at the end of September may influence flow rates in the Lower American River during the fall-run Chinook salmon rearing period. Mean Folsom September storage under the PA would be similar to (less than 5% difference) storage under NAA for all water year types, except for 8% lower mean storage during dry water years under the PA (Appendix 5.A, *CALSIM Methods and Results,* Table 5.A.6-5).

Mean flow due to the PA at the Nimbus Dam and confluence locations would generally be similar to (less than 5% difference) flow under the NAA during the fall-run Chinook salmon rearing period, with exceptions (Appendix 5.A, *CALSIM Methods and Results*, Table 5.A.6-16, Table 5.A.6-17). Difference in flow between the scenarios would consistently be slightly greater at the confluence than at Nimbus Dam, so all results described herein are for the confluence location. Flow under the PA during January and February would be similar to (less than 5% difference) those under the NAA for all months and water year types, except for 7% higher flow in February of below normal years. Flow during March through May would be similar to (less than 5% difference) flow under the NAA for all months and water year types, except for March and April of critical water years, when flows would be up to 11% lower under the PA. As described in Appendix 5.D.2.3, *Rearing Flows Methods*, no rearing habitat WUA curves were available for fall-run Chinook salmon or any other salmonid in the American River and, therefore, effects of flow on rearing habitat for fall-run Chinook salmon in the American River were evaluated qualitatively, using the flow predictions described above for the fall-run Chinook salmon rearing period. Although, as evidenced by the rearing habitat WUA curves for Sacramento River Chinook salmon provided in Appendix 5.D.2.3, *Rearing Flows Methods,* effects of river flow on rearing habitat are generally complex, it is assumed for the purposes of this effects analysis that increased flow would increase the availability and quality of rearing habitat and thereby benefit fall-run Chinook salmon. As such, no effects (less than 5% difference) of the PA on fall-run Chinook salmon rearing habitat are expected for most months and water year types, but a small increase is expected for February of below normal years and small reductions are expected for April and May of critical water years. The February increase would occur during the peak of the rearing period. It should be noted that the assumed monotonically increasing relationship between flow and fall-run Chinook salmon rearing habitat, on which the above conclusions are based, has low certainty.

Water Temperature-Related Effects

Mean monthly water temperatures were evaluated during the January through May juvenile rearing period for fall-run Chinook salmon in the American River between Hazel Avenue and Watt Avenue, with a peak period during January and February (Table 5.E-5). Overall, the PA would change mean water temperatures very little (less than 1°F, or approximately 1%) throughout the fry and juvenile rearing reach in all months and water year types (Appendix 5.C, *Upstream Water Temperature Methods and Results*, Section 5.C.7, *Upstream Water Temperature Modeling Results*, Table 5.C.7-14, Table 5.C.7-15). The largest increase in mean monthly water temperatures under the PA relative to NAA would be 0.2°F, or 0.4%, and would occur at Watt Avenue in critical water years during March, outside the peak period of rearing.

Exceedance plots of monthly mean water temperatures were examined during each month and water year type throughout the fry and juvenile rearing period (Appendix 5.C, *Upstream Water Temperature Methods and Results*, Section 5.C.7, *Upstream Water Temperature Modeling Results*, Figure 5.C.7.14-7, Figure 5.C.7.15-7). The curves for the PA generally match those of the NAA. Further examination of critical water years during March at Watt Avenue, where the largest increase in mean monthly water temperature was seen, reveals that the curves were similar overall and that that the difference of 0.2°F in mean monthly temperatures between NAA and PA would cause no substantial effects on the curves (Figure 5.E-261).

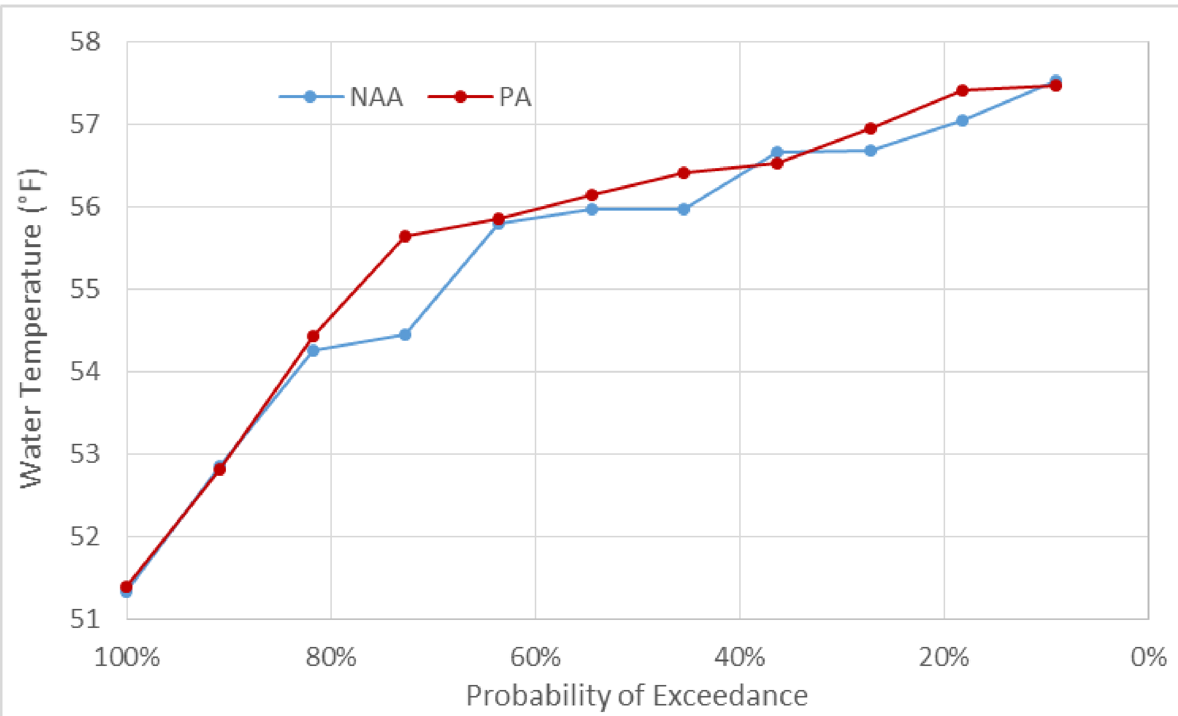


Figure 5.E-261. Exceedance Plot of Mean Monthly Water Temperatures (°F) in the American River at Watt Avenue in March of Critical Water Years

For purposes of this analysis, the water temperature thresholds analysis for fall-run Chinook salmon juvenile rearing and emigration have been combined and the period of December through June was evaluated. The threshold used was from the USEPA's 7DADM value of 61°F for the core juvenile rearing reach represented by Hazel Avenue and 64°F for the non-core juvenile rearing reach represented by Watt Avenue (Table 5.E-22). The 7DADM values were converted by month to function with daily model outputs (Appendix 5.D, *Quantitative Methods and Detailed Results for Effects Analysis of Chinook Salmon, Central Valley Steelhead, Green Sturgeon, and Killer Whale*, Section 5.D.2.1, *Water Temperature Analysis Methods*, Table 5.D-4).

Results of the water temperature thresholds analysis are presented in Attachment 5.E.1, *Fall-/Late Fall-Run Chinook Salmon Water Temperature Threshold Analysis Results*, Table 5.E-34 through 5.E-35. At both Hazel Avenue and Watt Avenue, there would be no months or water year types in which there would be 5% more days under the PA compared to the NAA on which temperatures would exceed the threshold or a more-than-0.5°F difference in the magnitude of average daily exceedance. Therefore, it was concluded that any adverse water temperature-related effects of the PA relative to the NAA on fall-run Chinook salmon fry and juvenile rearing in the American River would be undetectable.

Juvenile Emigration

Flow-Related Effects

Mean monthly flows were evaluated in the American River at Nimbus Dam and the confluence with the Sacramento River, during the February through May juvenile emigration period, with peak migration during February and March (Table 5.E-5). Changes in flow potentially affect emigration of juveniles, including the timing and rate of emigration, and conditions for feeding, protective cover, resting, temperature, turbidity, and other habitat factors, and can affect crowding and stranding, especially in side-channel habitats (Moyle 2002, Quinn 2005, Williams 2006). Quantitative relationships between flow and downstream migration generally are highly variable and poorly understood and, therefore, as described in Appendix 5.D.2.4, *Migration Flows Methods*, it is assumed for the purposes of this effects analysis that increased flow would improve conditions for emigration of fall-run Chinook salmon.

Folsom storage volume at the end of September potentially influences flows in the American River during the juvenile emigration period. Mean Folsom September storage under the PA would be similar (less than 5% difference) to storage under NAA for all water year types, except for 8% lower mean storage during dry water years under the PA (Appendix 5.A, *CALSIM Methods and Results*, Table 5.A.6-5).

Differences in mean flow between the PA and the NAA would be consistently similar at the Nimbus and confluence locations (Appendix 5.A, *CALSIM Methods and Results*, Table 5.A.6-16, Table 5.A.6-17). In general, mean flow under the PA would be similar to (less than 5% difference) flow under the NAA during most months and water year types of the fall-run Chinook salmon juvenile emigration period. Flow under the PA during February would be similar to (less than 5% difference) flow under the NAA for all months and water year types, except for 7% higher flow in below normal years. Flow during March through May would be similar to (less than 5% difference) that under the NAA for all months and water year types, except for March and April of critical water years, when flow would be up to 11% lower under the PA.

Water Temperature-Related Effects

Mean monthly water temperatures were evaluated in the American River in the reach from Hazel Avenue to Watt Avenue during the February through May juvenile emigration period, with a peak during February and March (5). Overall, the PA would change mean water temperatures very little (less than 1°F, or approximately 1%) throughout the American River in the reach from Hazel Avenue to Watt Avenue in all months and water year types in the period (Appendix 5.C, *Upstream Water Temperature Methods and Results*, Section 5.C.7, *Upstream Water*

Temperature Modeling Results, Table 5.C.7-14, Table 5.C.7-15). The largest increase in mean monthly water temperatures under the PA relative to NAA would be 0.2°F, or 0.4%, and would occur at Watt Avenue in critical water years during March. This largest increase in water temperature is within the peak period of juvenile emigration.

Exceedance plots of mean monthly water temperatures were examined during each month and water year type throughout the smolt emigration period (Appendix 5.C, *Upstream Water Temperature Methods and Results*, Section 5.C.7, *Upstream Water Temperature Modeling Results*, Figure 5.C.7.14-7, Figure 5.C.7.15-7). The curves for the PA generally match those of the NAA. Further examination of critical water years during March at Watt Avenue, where the largest increase in mean monthly water temperature was seen, reveals that the curves were similar overall and that that the difference of 0.2°F in mean monthly temperatures between NAA and PA would cause no substantial effects on the curves (Figure 5.E-261).

Please see the discussion of water temperature thresholds for juvenile fall-run Chinook salmon emigration in Fry and Juvenile Rearing above, which concludes that there would be no water temperature-related effects of the PA on late fall -run Chinook salmon juvenile rearing and emigration.

Adult Immigration

<u>Flow-Related Effects</u>

Mean monthly flows were evaluated in the American River at Nimbus Dam and the confluence with the Sacramento River, during the September through December immigration period of American River fall-run Chinook salmon, with peak migration during September and October (Table 5.E-4). Changes in flow potentially affect conditions for upstream migration of adults, including bioenergetic cost, water quality, crowding, cues for locating natal streams, and passage conditions, but the quantitative relationship between flow and upstream migration is poorly understood (Quinn 2005, Milner et al. 2012). As described in Appendix 5.D.2.4, *Migration Flows Methods*, it is assumed for the purposes of this effects analysis that increased flow would improve conditions for upstream migration of adult fall-run Chinook salmon.

Folsom storage volume at the end of September influences flows in the American River during much of the immigration period. Mean Folsom September storage under the PA would be similar (less than 5% difference) to storage under NAA for all water year types, except for 8% lower mean storage during dry water years under the PA (Appendix 5.A, *CALSIM Methods and Results*, Table 5.A.6-5).

Differences in mean flow between the PA and the NAA would be consistently similar at the Nimbus and confluence locations (Appendix 5.A, *CALSIM Methods and Results*, Table 5.A.6-16, Table 5.A.6-17). During September, mean flow under the PA would be 19% lower at the confluence location and 17% lower at Nimbus than flow under the NAA in critical water years and would be 5% lower and 11% lower at both locations in wet and above normal years, respectively. In below normal and dry years, the September flows would be similar (less than 5% difference). During November, mean flow under the PA would be lower in all water year types (up to 13% lower at Nimbus and 14% lower at the confluence in wet years), except below normal years, for which there would be little difference in flow. Flow would also be 13% lower in October of wet years. The largest increases in flow would occur during October of critical years (14% greater at Nimbus and 15% greater at the confluence) and below normal years (8% greater flow at both locations). During December, mean flow would be 6% and 5% greater under the PA in wet and below normal years, respectively. The September and October differences in flow between the PAA and the NAA coincide with the peak of the adult immigration period. Further discussion regarding flow-related effects during the June through November period is provided in Section 5.E.5.3.1.2.2.4, *Summary of Upstream Effects*.

As described in Appendix 5.D.2.4, *Migration Flows Methods*, mean monthly flow below about 1,000 cfs is considered to have potentially adverse effects on fall-run Chinook salmon adult immigration conditions in the American River. The effect of the PA on the frequency of flows below this threshold was evaluated by comparing CALSIM flows between the PA and the NAA at Nimbus Dam and the confluence with the Sacramento River. Mean flow at Nimbus Dam was less than 1,000 cfs for 62 of the 328 months (18.9%) within the fall-run Chinook salmon immigration period under the NAA and for 61 months (18.6%) of the migration period under the PA. Mean flow at the confluence was less than 1,000 cfs in 70 months (21.3%) under the NAA and 63 months (19.2%) under the PA (Table 5.E-68).

Table 5.E-68. Number and Percent of the 574 Months within the CCV Fall-Run Adult Immigration Period from the 82-Year CALSIM Record with Flow < 1,000 cfs

	Months with Mean Flow < 1,000 cfs		Percent with Mean Flow < 1,000 cfs		Difference in Months and Percent Difference
Location	NAA	PA	NAA	PA	PA vs. NAA
Nimbus	62	61	18.9	18.6	-1 (-2%)
Confluence	70	63	21.3	19.2	-7 (-10%)

These results indicate that any adverse effect of the PA relative to the NAA on fall-run Chinook salmon adult immigration conditions in the American River would be undetectable using the frequency of flow below the 1,000 cfs threshold.

Water Temperature-Related Effects

Mean monthly water temperatures were evaluated in the American River at Hazel Avenue and Watt Avenue during the September through December April adult immigration period for fall-run Chinook salmon, with a peak of September and October (Table 5.E-4). Overall, the PA would change mean water temperatures very little (less than 1°F, or approximately 1%) at these locations in all months and water year types in the period (Appendix 5.C, *Upstream Water Temperature Methods and Results*, Section 5.C.7, *Upstream Water Temperature Modeling Results*, Table 5.C.7-14, Table 5.C.7-15). The largest increase in mean monthly water temperatures under the PA relative to NAA would be 0.3°F (0.4%), and would occur at Hazel Avenue during September of below normal water years, within the peak period of adult immigration.

Exceedance plots of monthly mean water temperatures were examined during each month and water year type throughout the adult immigration period (Appendix 5.C, *Upstream Water Temperature Methods and Results*, Section 5.C.7, *Upstream Water Temperature Modeling Results*, Figure 5.C.7.14-7, Figure 5.C.7.15-7). The curves for the PA generally match those of the NAA period. Further examination of September of below normal water years at Hazel Avenue, where the largest increases in mean monthly water temperatures were seen, reveals that there would be a consistent small (generally less than 0.5°F) temperature difference between NAA and PA scenarios in most years (Figure 5.E-262).

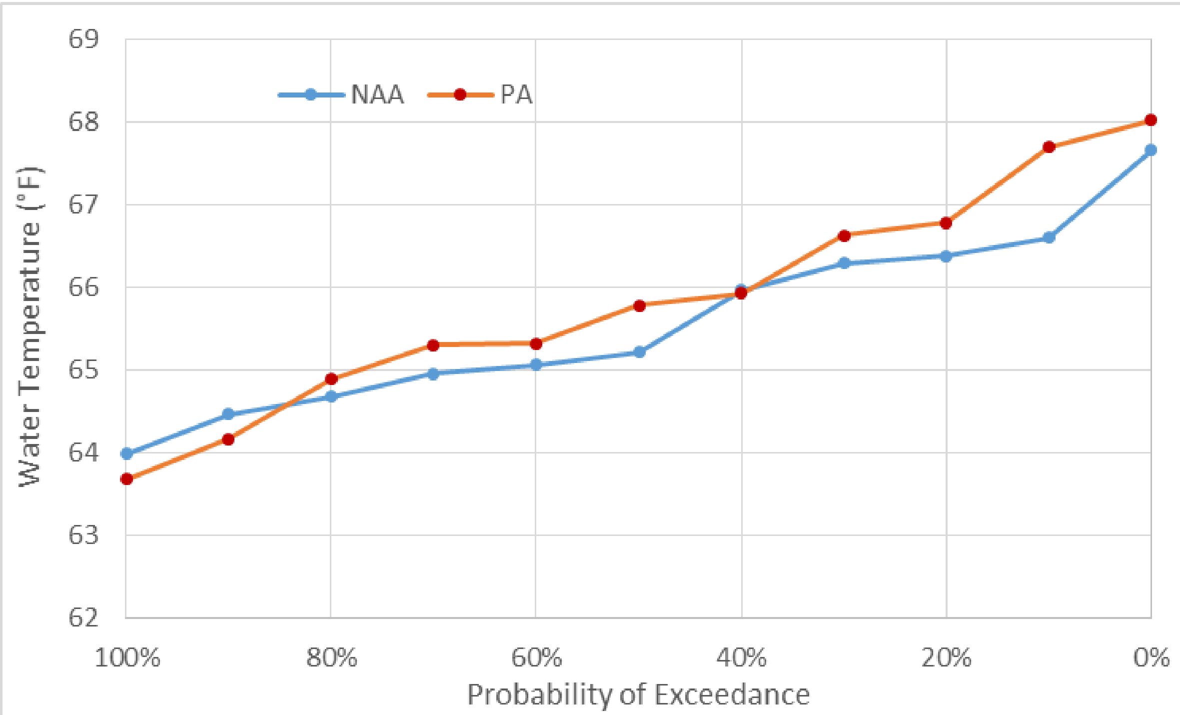


Figure 5.E-262. Exceedance Plot of Mean Monthly Water Temperatures (°F) in the American River at Hazel Avenue in September of Below Normal Water Years

The USEPA's 7DADM threshold value of 68°F was used to evaluate water temperature threshold exceedance during the fall-run Chinook salmon adult immigration life stage at Keswick, Bend Bridge, and Red Bluff (Table 5.E-22). The threshold was converted to function with daily model outputs for each month separately (Appendix 5.D, *Quantitative Methods and Detailed Results for Effects Analysis of Chinook Salmon, Central Valley Steelhead, Green Sturgeon, and Killer Whale*, Section 5.D.2.1, *Water Temperature Analysis Methods*, Table 5.D-4).

Results of the water temperature thresholds analysis for adult steelhead immigration are presented in Attachment 5.E.1, *Fall-/Late Fall-Run Chinook Salmon Water Temperature Threshold Analysis Results*, Table 5.E-36 and 5.E-37. At Hazel Avenue, there would be one month and water year type (below normal water years during September) in which there would be a more-than-5% increase in the percent of total days exceeding the threshold under the PA relative to the NAA (8.8%), but there would not be a more-than-0.5°F difference in the magnitude of average daily exceedance. At Watt Avenue, there would be no months or water types in which there would be a more-than-5% increase in the percent of total days exceeding the threshold under the PA relative to the NAA or a more-than-0.5°F difference in the magnitude of average daily exceedance. Therefore, it was concluded that any adverse l water temperature-related effects of the PA relative to the NAA on adult fall-run Chinook salmon immigration would be undetectable.

5.E.5.3.1.2.2.4 Summary of Upstream Effects

The results of upstream effects described above indicate that, overall, upstream effects of the PA on fall-/late fall-run Chinook salmon EFH will predominantly be negligible and the PA will continue to meet the criteria set forth in the current BiOp governing upstream operations (NMFS 2009). There are a few particular modeled changes described here that are noteworthy because physical conditions under the PA may potentially cause degraded conditions relative to the NAA for these species, although there is considerable uncertainty in the likelihood of a biological effect resulting from the changes in the physical conditions.

These changes include: (1) increased frequency of water temperature threshold exceedances during September and October, partially coinciding with the fall-run spawning and late fall-run Chinook salmon spawning period; (2) decreased rearing WUA during June in some portions of the Sacramento River for fall- and late fall-run Chinook salmon, if population numbers were high enough that habitat could be limiting[18]; and (3) reduced flows in the Sacramento River in above normal, below normal, and dry water years during September that could affect fall-run Chinook salmon adult and late fall-run Chinook salmon juvenile migration, and in wet and above normal water years during November that could affect fall-run Chinook salmon adult and late fall-run Chinook salmon juvenile and adult migration. The reduced Shasta releases associated with the PA's operational modeling likely leads to the modeled increased frequency of the water temperature threshold exceedances during September. Modeling of the cold-water pool volume, which is more indicative of temperature management suggests PA end-of-September (EOS) storage similar to that of the NAA cold-water reduced PA (Appendix 5.C, *Upstream Water Temperature Methods and Results*, Table 5.C.7.21-1, *Shasta Cold Water Pool Volume*). If real-time cold-water pool management efforts under the PA use similar decision-making tools and criteria as currently utilized (i.e., NAA), then releases from Shasta Lake under the PA will actually be sustained at similar levels as the NAA during September. Thus, it is likely that the PA will not result in higher water temperatures relative to the NAA during September, as was modeled in this analysis.

All upstream quantitative analyses are based on CalSim II modeling and the uncertainties associated with using CalSim II outputs must be considered in interpreting biological analyses (Appendix 5.A, *CALSIM Methods and Results)*. CalSim II simulates a generalized representation of likely long-term operations under each scenario and does not necessarily take into account all of the factors involved in determining September reservoir releases. These factors include, but are not limited to, temperature control requirements, in-basin use requirements including Delta flow requirements, forecasted hydrology, and demands. Many of these factors involve seasonal planning decisions as well as day-to-day decision-making by the CVP/SWP operators taking into account the recommendations from many of the decision-making/advisory teams, such as the Sacramento River Temperature Technical Group (SRTTG), Water Operations Management

[18] Habitat limitation has not been a concern in recent years due to low population size, but it could be in the future if population size was to increase or there was a strong year class. Awareness of the effects to be managed in the best interest of the species is necessary, regardless of variability in population size

Team (WOMT), b2 interagency team (B2IT) and American River Operations Group. The decision-making processes and the advisory groups that currently exist will continue to exist and will be improved under the PA (Chapter 3, Section 3.3.2, *Proposed Operational Criteria*). The revised process will be implemented through the existing decision-making process and related technical work teams identified in Section 3.1.6.5 *Groups Involved in Real-Time Decision Making and Information Sharing*. In addition, a separate real time operations coordination team (RTOCT) will meet to assist DWR and Reclamation in fulfilling their responsibility to inform the SWP and CVP participants regarding available information and real-time decisions. This revised process will allow for minimization of modeled effects identified above under future operations of the PA.

In addition, Reclamation will work with NMFS and other state and Federal agencies to adjust the RPA Action Suite 1.2, as described in Section 3.1.4.5, *Annual/Seasonal Temperature Management Upstream of the Delta*. The adjustment will be made pursuant to the 2009 NMFS BiOp section 11.2.1.2. *Research and Adaptive Management*, where it states: "After completion of the annual review, NMFS may initiate a process to amend specific measures in this RPA to reflect new information, provided that the amendment is consistent with the Opinion's underlying analysis and conclusions and does not limit the effectiveness of the RPA in avoiding jeopardy to listed species or adverse modification of critical habitat." This process is anticipated to conclude in the fall of 2016, and may include refinements and additions to the existing annual/seasonal temperature management processes, including spring storage targets, revised temperature compliance criteria and a range in summertime Keswick release rates. The adjusted RPA Action Suite I.2 will apply to Reclamation's Shasta operations. This RPA revision process is intended to improve egg-to-fry survival of winter-run Chinook salmon to Red Bluff, but would likely improve survival of other races of Chinook salmon.

5.E.5.3.1.3 Maintenance Effects

Bank, bed and water column disturbance associated with maintenance activities have the potential to cause direct affects to EFH habitat of Chinook salmon. Effects would be most likely occur during maintenance dredging activities around the new intakes. Suction dredging, mechanical excavation, and possible front-end loading equipment could remove food organisms and suspend contaminants into the water column. While these mechanisms are possible, the likelihood of Chinook exposure would be low due to the nature of the affected habitats and the timing of maintenance activities. Chinook salmon use main channel areas and the upper water column, which limits exposure to suction dredging. Moreover, dredging activities would be limited to periods when Chinook salmon are least likely to be present in the affected habitats. A maintenance window of June 1 through October 31 would be in place for the North Delta intakes and barge landings. Maintenance on the Head of Old River Barrier would occur from August 1 through November 30 and maintenance of Clifton Court Forebay would occur from June 1 through November 30. Collectively, this would be expected to significantly reduce exposure potential. Effects would be minimized by implementation of avoidance and minimization measures described in Appendix 3F, avoidance and minimization measures. These avoidance and minimization measures (AMMs) in Appendix 3.F: Worker Awareness Training (AMM1) ; Construction Best Management Practices and Monitoring (AMM2); Stormwater Pollution Prevention Plan (AMM3); Erosion and Sediment Control Plan (AMM4); Spill Prevention, Containment, and Countermeasure Plan (AMM5); Disposal and reuse of spoils, reusable tunnel material (RTM), and dredged material (AMM6); Barge Operations Plan (AMM7); Fish rescue and salvage plan (AMM8); Underwater sound control and abatement plan (AMM9)Avoidance and Minimization Measures Effects

5.E.5.3.1.4 Avoidance and Minimization Measures Effects

The avoidance and minimization measures (AMMs) described here have been developed to avoid and minimize effects on listed species[19] that could result from the proposed action. These AMMs will be implemented as specified in the project description (Chapter 3). AMMs are implemented at all phases of a project, from siting through design, construction, and on to operations and maintenance, as described in Section 3.F.1.2, *Applying Avoidance and Minimization through the Project Life Cycle*.

AMMs vary depending on the protected resource, with different approaches used for wildlife and fish. Biological differences between listed species of wildlife and fish species result in very different AMMs. Fish are generally not known to occur in a given site; rather if the site is known to provide suitable habitat, fish are assumed to be potentially present, at least at certain times of the year. Therefore, AMMs for fish are heavily focused on protecting their habitat from stresses such as water quality impairment, dewatering, and/or underwater noise. Wildlife species, on the other hand, often have very specific habitat requirements, and the individual animals can often be detected through application of established survey protocols, making field surveys a key component of wildlife AMMs. The organization of AMMs reflects these differences.

Table 5.E-69. Summary of Avoidance and Minimization Measures.

Number	Title	Summary
AMM1	Worker Awareness Training	Includes procedures and training requirements to educate construction personnel on the types of sensitive resources in the project area, the applicable environmental rules and regulations, and the measures required to avoid and minimize effects on these resources.
AMM2	Construction Best Management Practices and Monitoring	Standard practices and measures that will be implemented prior, during, and after construction to avoid or minimize effects of construction activities on sensitive resources (e.g., species, habitat), and monitoring protocols for verifying the protection provided by the implemented measures.
AMM3	Stormwater Pollution Prevention Plan	Includes measures that will be implemented to minimize pollutants in stormwater discharges during and after construction related to covered activities, and that will be incorporated into a stormwater pollution prevention plan to prevent water quality degradation related to pollutant delivery from project area runoff to receiving waters.
AMM4	Erosion and Sediment Control Plan	Includes measures that will be implemented for ground-disturbing activities to control short-term and long-term erosion and sedimentation effects and to restore soils and vegetation in areas affected by construction activities, and that will be incorporated into plans developed and implemented as part of the National Pollutant Discharge Elimination System permitting process for covered activities.
AMM5	Spill Prevention, Containment, and Countermeasure Plan	Includes measures to prevent and respond to spills of hazardous material that could affect navigable waters, as well as emergency notification procedures.

[19] Listed species are defined to be species listed in Table 1-3 of the main biological assessment document.

Number	Title	Summary
AMM6	Disposal and Reuse of Spoils, Reusable Tunnel Material, and Dredged Material	Includes measures for handling, storage, beneficial reuse, and disposal of excavation or dredge spoils and reusable tunnel material, including procedures for the chemical characterization of this material or the decant water to comply with permit requirements, and reducing potential effects on aquatic habitat, as well as specific measures to avoid and minimize effects on species in the areas where reusable tunnel material would be used or disposed.
AMM7	Barge Operations Plan	Includes measures to avoid or minimize effects on aquatic species and habitat related to barge operations, by establishing specific protocols for the operation of all project-related vessels at the construction and/or barge landing sites. Also includes monitoring protocols to verify compliance with the plan and procedures for contingency plans.
AMM8	Fish Rescue and Salvage Plan	Includes measures that detail procedures for fish rescue and salvage to avoid and minimize the number of Chinook salmon, steelhead, green sturgeon, and other covered fish stranded during construction activities, especially during the placement and removal of cofferdams at the intake construction sites.
AMM9	Underwater Sound Control and Abatement Plan	Includes measures to minimize the effects of underwater construction noise on fish, particularly from impact pile–driving activities. Potential effects of pile driving will be minimized by restricting work to the least sensitive period of the year and by controlling or abating underwater noise generated during pile driving.
AMM28	Geotechnical Studies	Conduct geotechnical investigations to identify the types of soil avoidance or soil stabilization measures that should be implemented to ensure that the facilities are constructed to withstand subsidence and settlement and to conform to applicable state and federal standards.
AMM29	Design Standards and Building Codes	Ensure that the standards, guidelines, and codes, which establish minimum design criteria and construction requirements for project facilities, will be followed. Follow any other standards, guidelines, and code requirements that are promulgated during the detailed design and construction phases and during operation of the conveyance facilities.
AMM30	Transmission Line Design and Alignment Guidelines	Design the alignment of proposed transmission lines to minimize impacts on sensitive terrestrial and aquatic habitats when siting poles and towers. Restore disturbed areas to preconstruction conditions. In agricultural areas, implement additional BMPs. Site transmission lines to avoid greater sandhill crane roost sites or, for temporary roost sites, by relocating roost sites prior to construction if needed. Site transmission lines to minimize bird strike risk.
AMM31	Noise Abatement	Develop and implement a plan to avoid or reduce the potential in-air noise impacts related to construction, maintenance, and operations.
AMM32	Hazardous Material Management	Develop and implement site-specific plans that will provide detailed information on the types of hazardous materials used or stored at all sites associated with the water conveyance facilities and required emergency-response procedures in case of a spill. Before construction activities begin, establish a specific protocol for the proper handling and disposal of hazardous materials.
AMM34	Construction Site Security	Provide all security personnel with environmental training similar to that of onsite construction workers, so that they understand the environmental conditions and issues associated with the various areas for which they are responsible at a given time.
AMM35	Fugitive Dust Control	Implement basic and enhanced control measures at all construction and staging areas to reduce construction-related fugitive dust and ensure the project commitments are appropriately implemented before and during construction, and that proper documentation procedures are followed.
AMM36	Notification of Activities in Waterways	Before in-water construction or maintenance activities begin, notify appropriate agency representatives when these activities could affect water quality or aquatic species.

5.E.6 Conclusions

5.E.6.1 Effects of Water Facility Construction and Maintenance

Construction and maintenance of water facilities under the PA has the potential to affect EFH for coastal pelagic species, Pacific Coast groundfish, and Pacific salmon. The effects of construction activities will be minimized through avoidance and minimization measures and temporary and permanent habitat losses will be offset by habitat creation and enhancement through channel margin enhancement and tidal wetland restoration.

Underwater noise generated by impact pile driving in or near surface waters will result in temporary reductions in habitat suitability in the vicinity of the pile driving. This will be minimized by implementation of Appendix 3.F *General Avoidance and Minimization Measures*, AMM9 *Underwater Sound Control and Abatement Plan*.

Structural changes associated with temporary (construction) or permanent placement of engineered structures in habitat include placement of in-water pilings and over-water structures. Such structures may offer cover for predators, and may locally reduce foraging habitat quality. These effects will be minimized by implementation of measures described in Appendix 3.F *General Avoidance and Minimization Measures*. Additionally, these effects will be offset by habitat creation at ratio of 3 acres created for each acre affected, to be provided at an approved NMFS mitigation bank.

Water quality effects from in-water construction may occur as a result of turbidity, disturbance of existing contaminated sediments, or due to accidental spills of contaminants such as cement, oil, fuel, hydraulic fluid, paint, or other construction-related materials. These potential effects will be minimized by implementing Appendix 3.F *General Avoidance and Minimization Measures*, including AMM2 *Construction Best Management Practices and Monitoring,* AMM3 *Stormwater Pollution Prevention Plan,* AMM4 *Erosion and Sediment Control Plan,* AMM5 *Spill Prevention, Containment, and Countermeasure Plan,* and AMM6 *Disposal and Reuse of Spoils, Reusable Tunnel Material, and Dredged Material*.

Northern anchovy, starry flounder, or Chinook salmon could be present in the vicinity of intake construction on the Sacramento River during the period when cofferdams are installed to isolate work areas. This presents the potential for entrapment within the isolated work areas and the subsequent blockage of their use of their total EFH habitat. Effects would also be minimized through the implementation of avoidance and minimization measures in appendix 3F, principally AMM8 *Fish Rescue and Salvage Plan*.

Water quality effects from maintenance can affect EFH, primarily due to maintenance dredging around the new intakes. Effects will be similar to those resulting in turbidity during in-water construction, and will be minimized through the dredging procedures described in Appendix 3.F *General Avoidance and Minimization Measures,* AMM6 *Disposal and Reuse of Spoils, Reusable Tunnel Material, and Dredged Material*.

In summary, the expected construction and maintenance effects to EFH for coastal pelagic species, Pacific Coast groundfish, and Pacific salmon primarily would be temporary, localized, and for Pacific Coast groundfist and coastal pelagic species, well outside the species' main range. Permanent habitat changes associated with new in-water structures would be offset by creation of equal or higher quality habitat, at a NMFS-approved location or mitigation bank. Therefore, the effects of construction and maintenance of the proposed action on EFH would be negligible.

5.E.6.2 Effects of Water Facility Operations

The principal potential effect of proposed action water facility operations on EFH for coastal pelagic species and Pacific Coast groundfish would be far-field effects on Delta outflow and therefore salinity. However, the analyses presented in Sections 5.E.5.1.1.2 and 5.E.5.2.1.2 of this appendix illustrated that the differences attributable to the PA would be minimal in relation to the NAA, and would not affect the value of this EFH to these species. Therefore any potentially adverse effects water facility operations could have upon designated EFH for coastal pelagic species and Pacific Coast groundfish would be negligible.

The overall effect of operations on Pacific salmon EFH is not adverse with the implementation of the conservation measures proposed (Chapter 3.4). Of all of the Pacific Coast Salmon EFH, alterations to the Sacramento River, Delta and downstream estuary, represent changes to a fraction of the habitat (both spatially and temporally) supporting California Chinook Salmon, which itself represents only a portion of the total Pacific coast salmon population (e.g. sockeye, pink, coho, occurring in other basins and states). Within the Delta, the PA has the potential for adverse operational effects in the near field (primarily predation at the NDD) and far field for Chinook salmon emigrating through the Delta from the Sacramento River basin. The far-field effects primarily include NDD water diversions leading to lower velocity and therefore greater potential for predation; potential for greater entry into the interior Delta via Georgiana Slough (a lower survival route than the main stem Sacramento River); and less inundation of restored riparian bench habitats along the Sacramento River. These effects generally[20] are more likely during the Delta occurrence periods of juvenile winter-run Chinook salmon and, to a lesser extent, spring-run Chinook salmon, and would be minimized by real-time operations (flow adjustments in response to hydrological triggers and monitoring of fish). In addition, any other potential adverse effects to Pacific salmon EFH (including winter-run and spring-run Chinook salmon, as well as fall-/late fall-run Chinook salmon) would be addressed by the proposed conservation measures: channel margin restoration to offset less inundation of riparian benches and a Georgiana Slough nonphysical fish barrier to reduce interior Delta entry. For the south Delta, the PA would be expected to have less operational effects on Pacific salmon EFH compared to the NAA based on improved south Delta channel flows, less entrainment, and less entry into the interior Delta because of the HOR gate. Actions taken in compliance with NMFS (2009) and the proposed operational criteria for south Delta, NDD, and DCC provide protection during the winter and spring, thereby reducing the impact of CVP/SWP Delta operations on Chinook salmon. The RTO and CSAMP included in the PA provide additional opportunities for

[20] Note, however, that the assumed distribution of juvenile late fall-run Chinook salmon in the DPM partly includes late summer/fall, when operational criteria would be less protective of outmigrating salmonids, which suggests the potential for greater effects than for other runs; see results discussion in the *Delta Passage Model: Fall-Run and Late Fall-Run Chinook Salmon* subsection of Section 5.E.5.3.1.2.1.2.1, *Indirect Mortality Within the Delta*.

adjustments to CVP/SWP Delta operations to minimize salvage and other effects related to exports. Projected operation of other Delta facilities (for example, the North Bay Aqueduct, Rock Slough Intake, and the Suisun Marsh Salinity Control Gates [SMSCG]) is not expected to affect Chinook salmon substantially. For upstream effects, the instances in which modeled differences between PA and NAA show a potential for adverse effects, the decision-making processes and the advisory groups that currently exist will continue to exist and will be improved under the PA, which will allow for minimization of modeled effects identified in this appendix and in Chapter 5 to Pacific salmon EFH under future operations of the PA. In summary, with implementation of real-time operations and the conservation measures outlined above, effects from water facility operations on EFH for Pacific salmon would be negligible.

5.E.7 References

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