Appendix 9I

Oncorhynchus Bayesian Analysis (OBAN) Model Documentation

This appendix provides information about the methods and assumptions used for the Coordinated Long-Term Operation of the Central Valley Project (CVP) and State Water Project (SWP) Environmental Impact Statement (EIS) analysis using the Oncorhynhchus Bayesian Analysis (OBAN) model. This appendix is organized into two sections:

- Section 9I.1: Oncorhynchus Bayesian Analysis Model Methodology and Assumptions
  - The winter-run Chinook Salmon analysis uses the OBAN model to quantify escapement of winter-run Chinook Salmon from the Sacramento River and overall survival, including ocean survival. This section briefly describes the analytical approach and assumptions of the OBAN model.
- Section 9I.2: Oncorhynchus Bayesian Analysis Model Results
  - This section presents the escapement and overall survival of winter-run Chinook Salmon from the Sacramento River. Results are presented in a series of figures for each comparison between alternatives.

9I.1 Oncorhynchus Bayesian Analysis Model Methodology and Assumptions

9I.1.1 Oncorhynchus Bayesian Analysis Model Methodology

Water operations in the Sacramento and San Joaquin Rivers and delta affect the hydrologic environment and therefore have the potential to affect the populations of fish that reside there. These effects may not be observed directly, however, and life-cycle models may be useful to evaluate the potential effects of water operations on fish population dynamics. To understand how anthropogenic factors in the freshwater and marine portions of the life history may affect winter-run Chinook Salmon (*Oncorhynchus tshawytscha*), the winter-run OBAN model was developed. A version of the OBAN model with updated parameter estimates in 2015 was used to evaluate the alternatives.

9I.1.1.1 OBAN Model Structure

- The winter OBAN model integrates sources of mortality across the life cycle by calculating escapement.
- The OBAN model also calculates survival through the early life stages in the Sacramento River, survival through the delta, and survival in the ocean.
- For the evaluation of the scenarios, all sources of mortality after the delta are exactly the same to focus to be on the river and delta portions of the life cycle.

- The winter OBAN model is sensitive to water temperature in the incubation stage (July –September) and minimum flows in the fry rearing stage (August – November).
- The winter OBAN model is less sensitive to Delta Cross Channel Gates (DCC) position, exports, and Yolo operations.

9I.1.2 Physical Data

Physical data including temperature, flows, and exports were supplied for each of the scenarios in daily and monthly intervals, depending on the physical data. These data were compiled in the format appropriate for the covariates in the OBAN model. For example, daily temperature data from Bend Bridge were summarized into a monthly average from July through September to define alevin survival rates.

In general, the physical parameters developed for each scenario for use in the OBAN model clustered into two groups. The No Action Alternative and Alternative 5 scenarios had similar temperature (Figure 9I.1), flow (Figure 9I.2), exports (Figure 9I.3), and Delta Cross Channel configuration (Figure 9I.5), whereas the Second Basis and Alternative 3 scenarios had similar physical characteristics. In all four scenarios, the Yolo bypass flows were almost equivalent, with some slight differences over simulation years 1995 through 1998 (Figure 9I.4). The ocean productivity (Figure 9I.6) and Age-3 harvest rates (Figure 9I.7) were constant across scenarios.

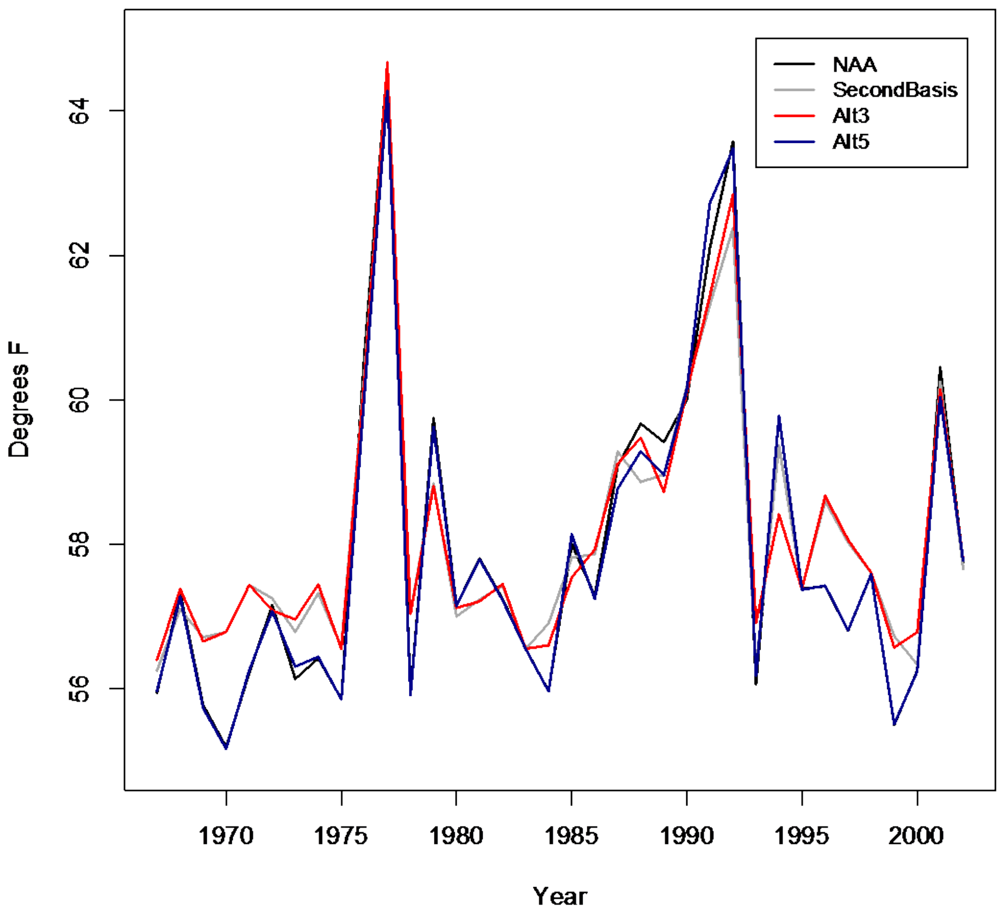

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Figure 9I.1 Average Water Temperature from July through September at Bend Bridge

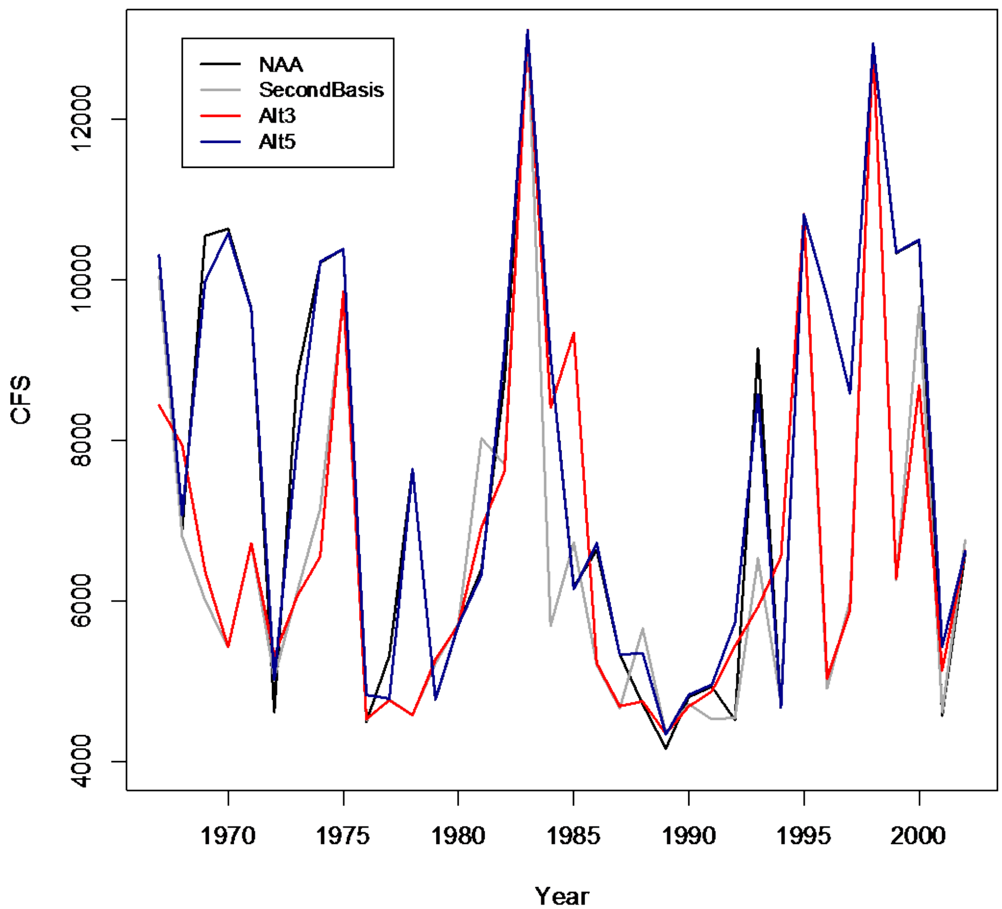

Figure 9I.2 Minimum of Monthly Average Flow from August through November at Bend Bridge

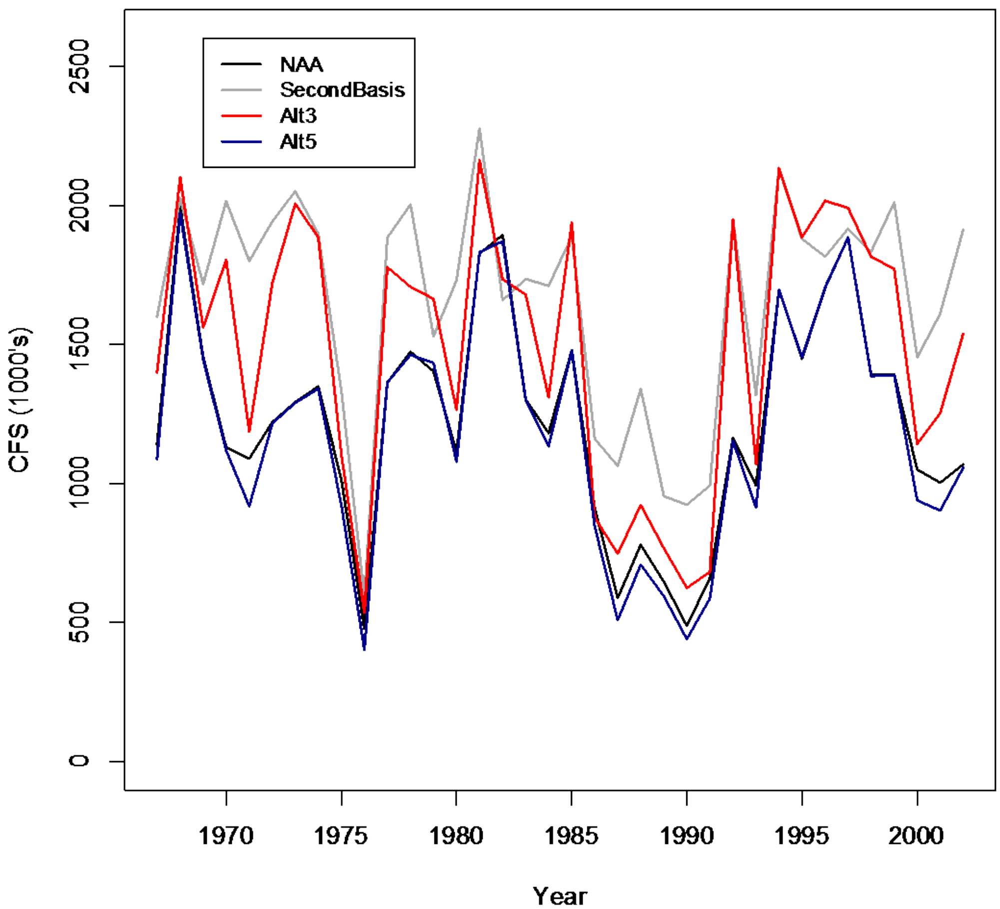

Figure 9I.3 Total Exports from December through June

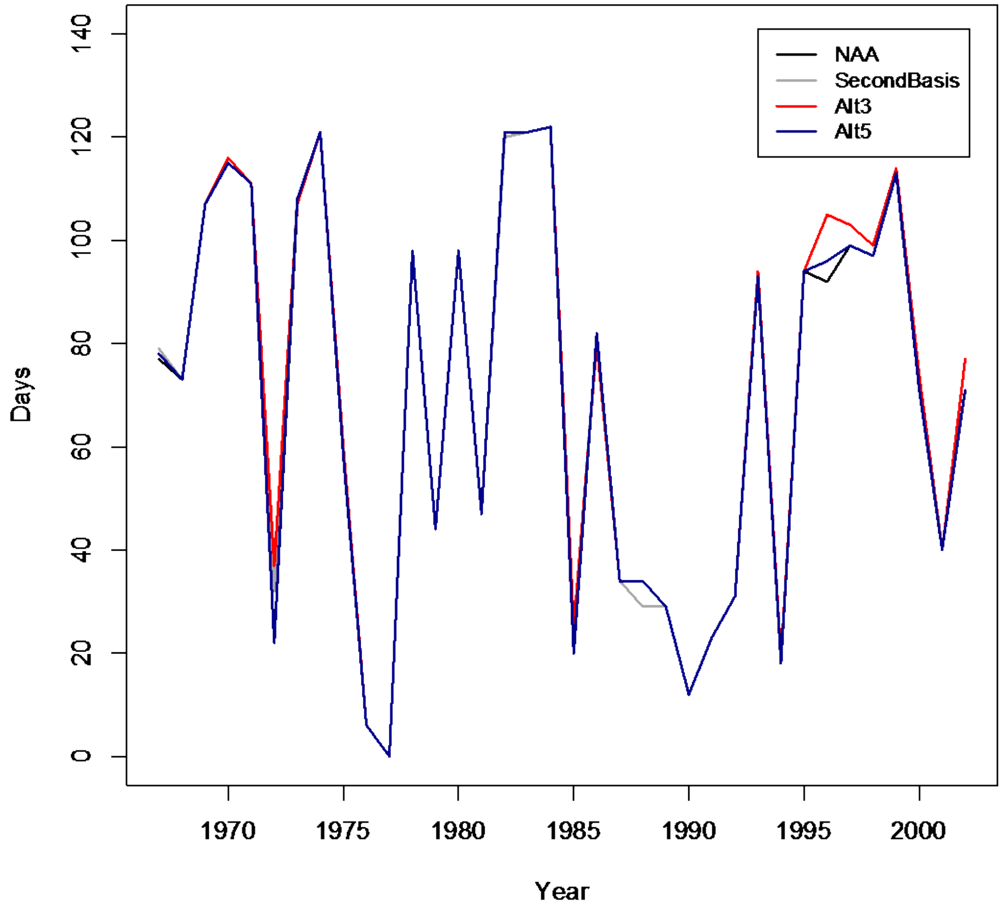

Figure 9I.4 Number of Days when Flow over the Fremont Weir is Greater than 100 Cubic Feet per Second from December through March

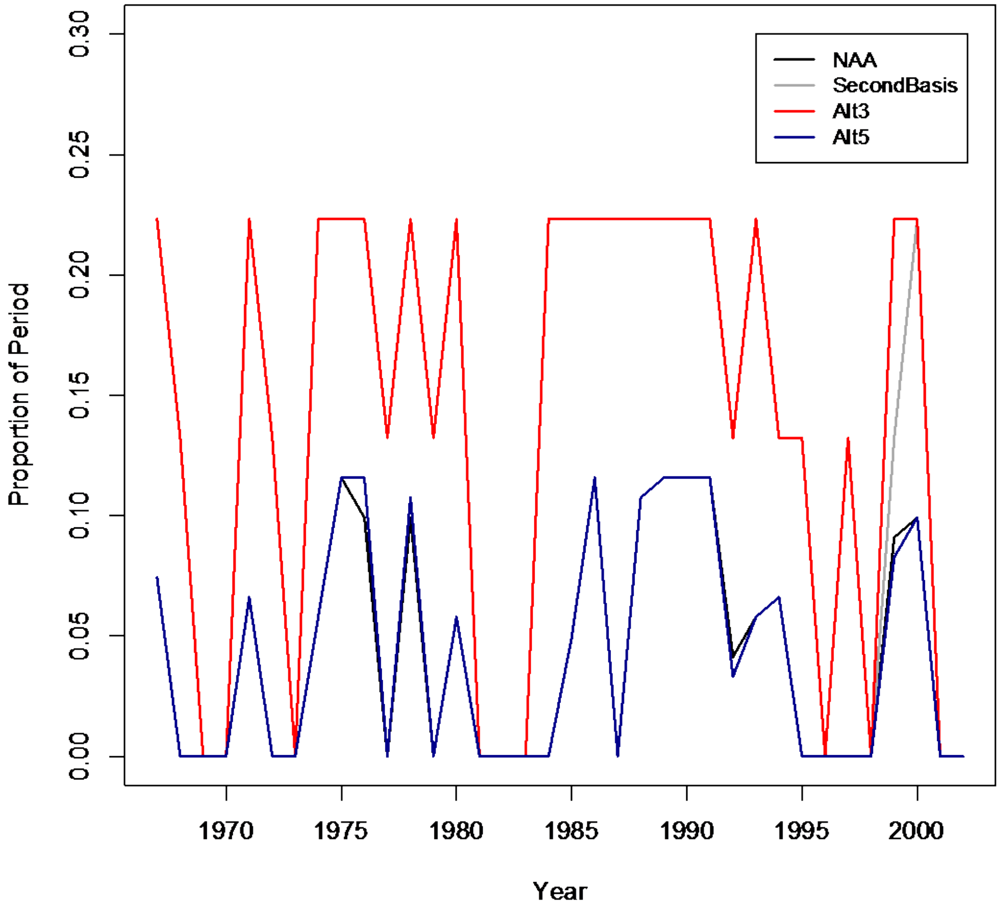

Figure 9I.5 Proportion of Period from December through March when Delta Cross Channel Gates are Open

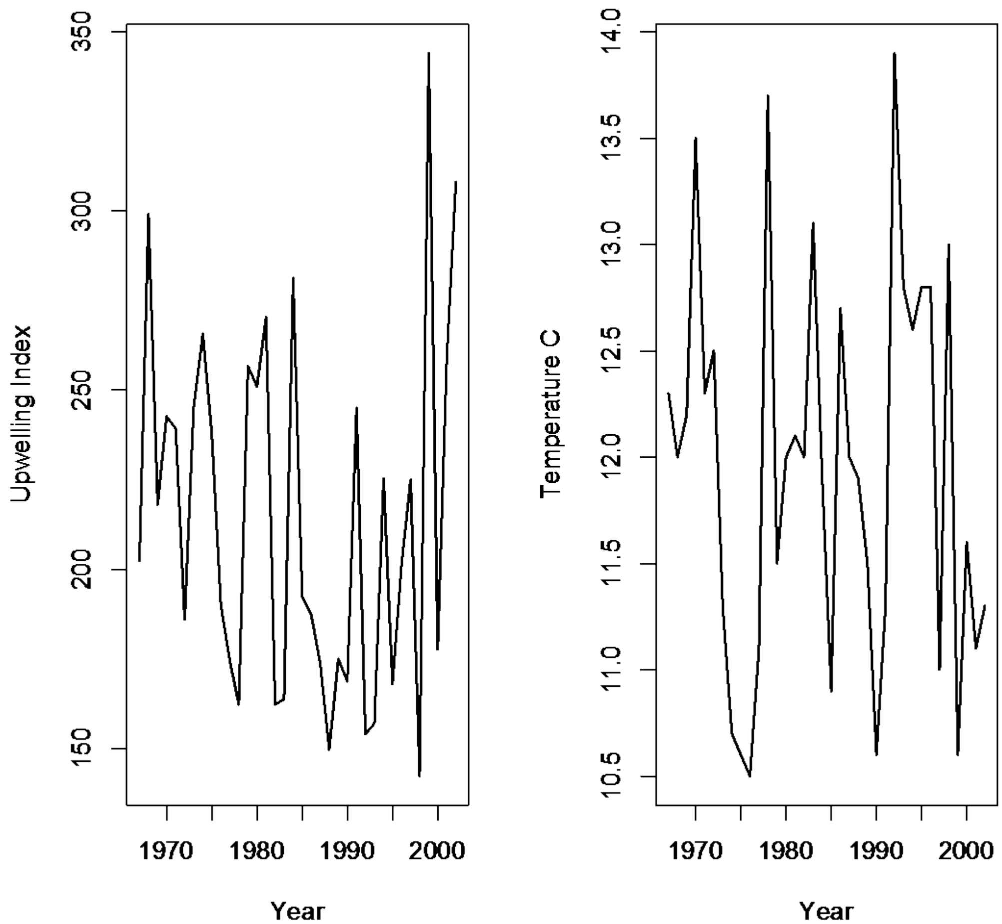

Figure 9I.6 Upwelling Index during Spring (left) and Farallon Temperatures in Spring (right) (Indicators of Ocean Productivity)

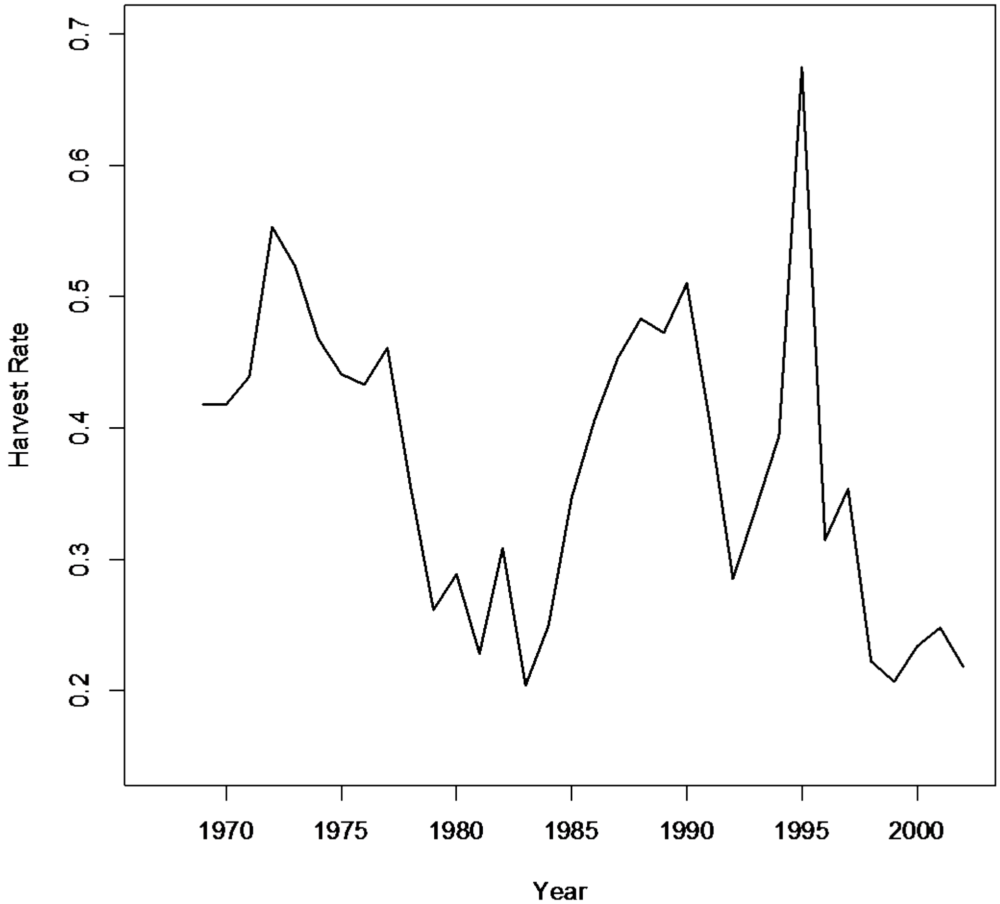

Figure 9I.7 Age 3 Harvest Rate

9I.2 Oncorhynchus Bayesian Analysis Model Results

This section describes the OBAN model results for the No Action Alternative, Second Basis of Comparison, and other alternatives.

Results are provided separately for each of the following runs:

- No Action Alternative
- Second Basis of Comparison
- Alternative 1
- Alternative 3
- Alternative 5

The OBAN model, like many other forecasting models, provides inference for future conditions on a relative basis. That is, the forecasts are not accurate in an absolute sense, but do provide important information when evaluating scenarios relative to each other. The pairwise comparisons obtained from OBAN model runs were:

- Alternative 1 compared to No Action Alternative
- Alternative 3 compared to No Action Alternative
- Alternative 5 compared to No Action Alternative
- No Action Alternative compared to Second Basis of Comparison
- Alternative 1 compared to Second Basis of Comparison
- Alternative 3 compared to Second Basis of Comparison
- Alternative 5 compared to Second Basis of Comparison

For comparison of alternatives, the relative difference between two alternatives was calculated as:

*(proposal – base)/base * 100 percent*

The alternative listed first was the proposal and the alternative listed second was the base. The OBAN model produces forecasts of escapement and delta survival rates for simulation years 1967 to 2002, and incorporates parameter uncertainty in each of these outputs. As a result, the scenario comparisons also include uncertainty, and both median, 50 percent, and 90 percent probability intervals were calculated.

9I.2.1 OBAN Simulation Results

The OBAN results indicated generally declining escapement levels until 1997, with a small recovery afterward (Figure 9I.1). Similar trends in median escapement between the No Action Alternative and Alternative 5 scenarios were forecast over the simulation period (Figure 9I.8). Similarly, the Alternative 3 and Second Basis model runs had similar escapement levels, with the Second Basis having slightly lower median escapement than the Alternative 3 scenario during some simulation years (for example, 1985 through 1990).

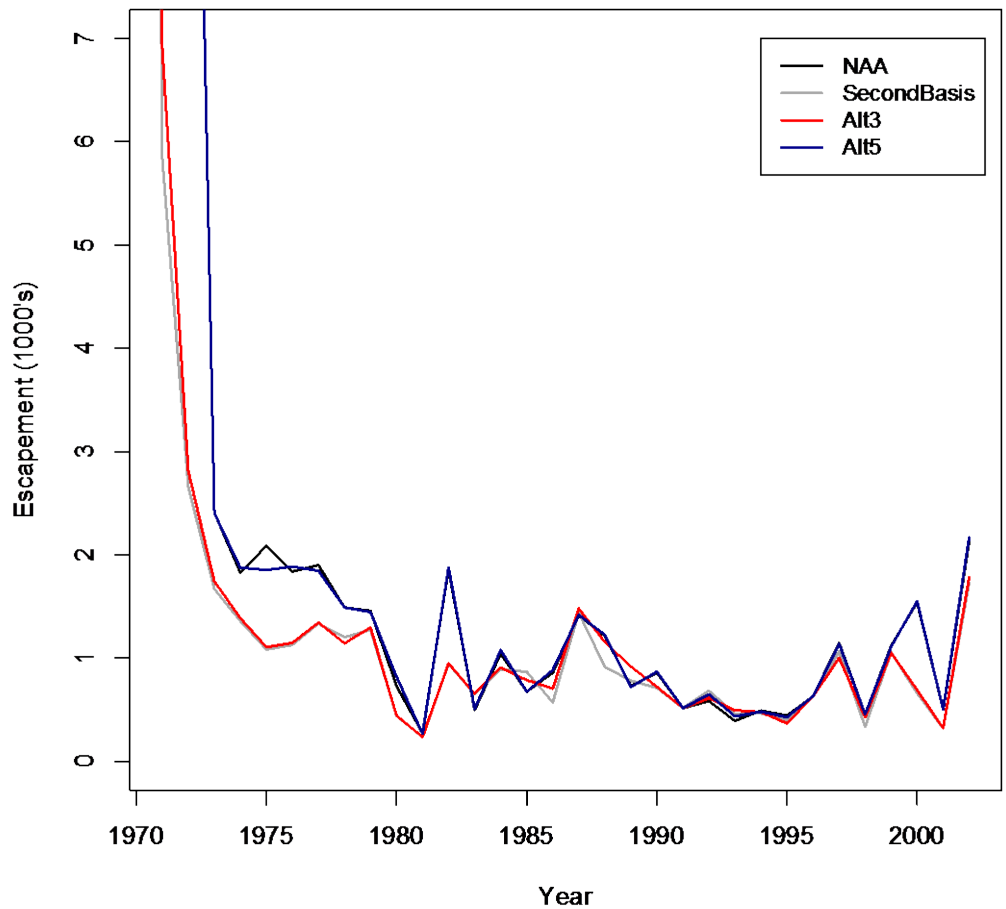

Figure 9I.8 Median Escapement under the Alternatives and Second Basis of Comparison

Median delta survival was generally highest under the Alternative 5 and No Action Alternative scenarios (Figure 9I.9). This is not the absolute survival through the delta, because it also includes some survival in the ocean; thus, the relative survival across scenarios is the important comparison.

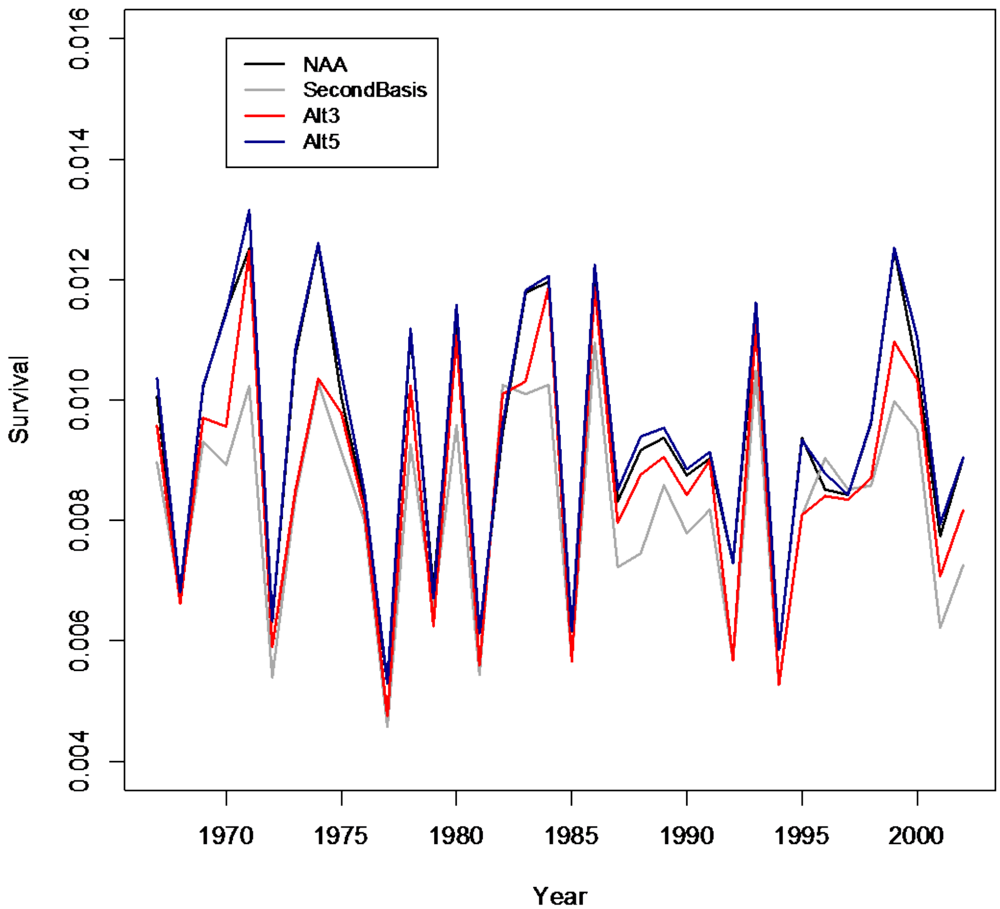

Figure 9I.9 Delta Survival under the Alternatives and Second Basis of Comparison

The probability of exceeding a quasi-extinction threshold of 200 spawners was highest when the median escapement was at low levels (Figure 9I.10). The Alternative 3 and Second Basis scenarios typically had the highest probability of quasi-extinction among the scenarios evaluated.

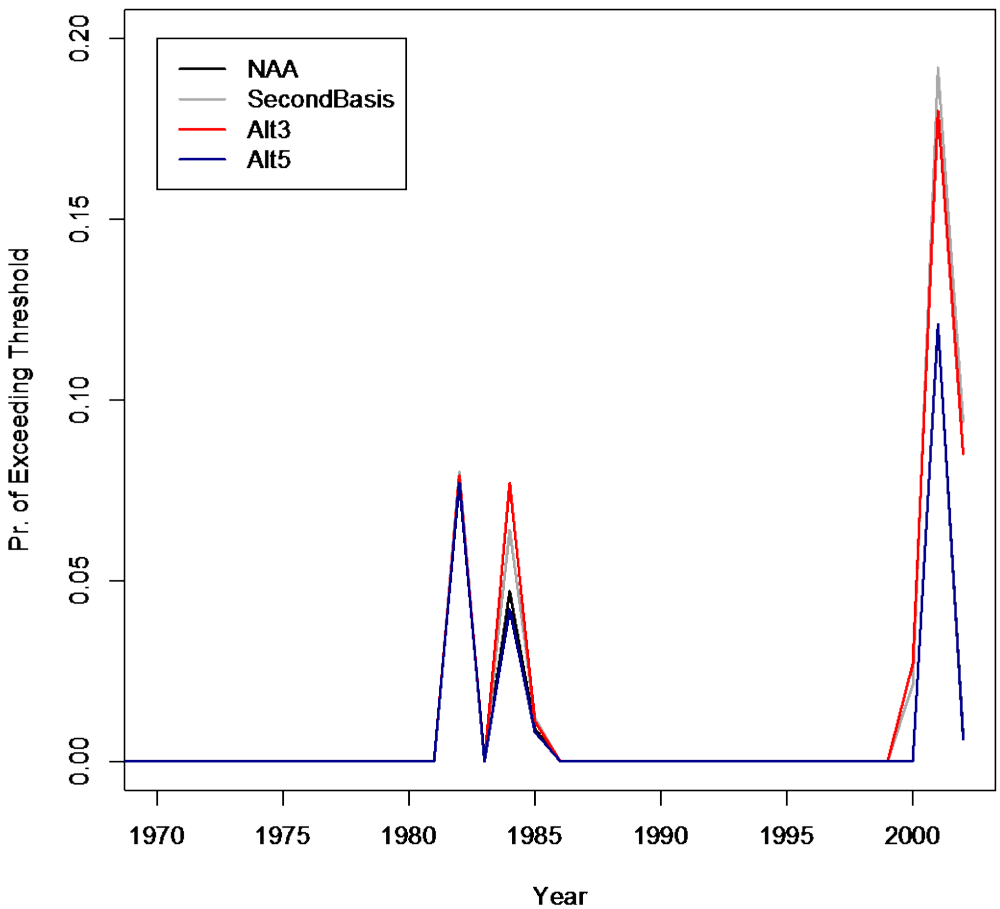

Figure 9I.10 Probability of Exceeding Quasi-Extinction Threshold of 200 Spawners under the Alternatives and Second Basis of Comparison

The escapement estimates incorporating uncertainty in simulation year 1985 indicated slightly higher median escapement of approximately 200 fish for the Second Basis and Alternative 3 scenarios relative to the No Action Alternative and Alternative 5. There was also a low probability (that is, probability of approximately 0.05) for greater abundances under the Second Basis and Alternative 3 scenarios relative to the other scenarios (Figure 9I.11).

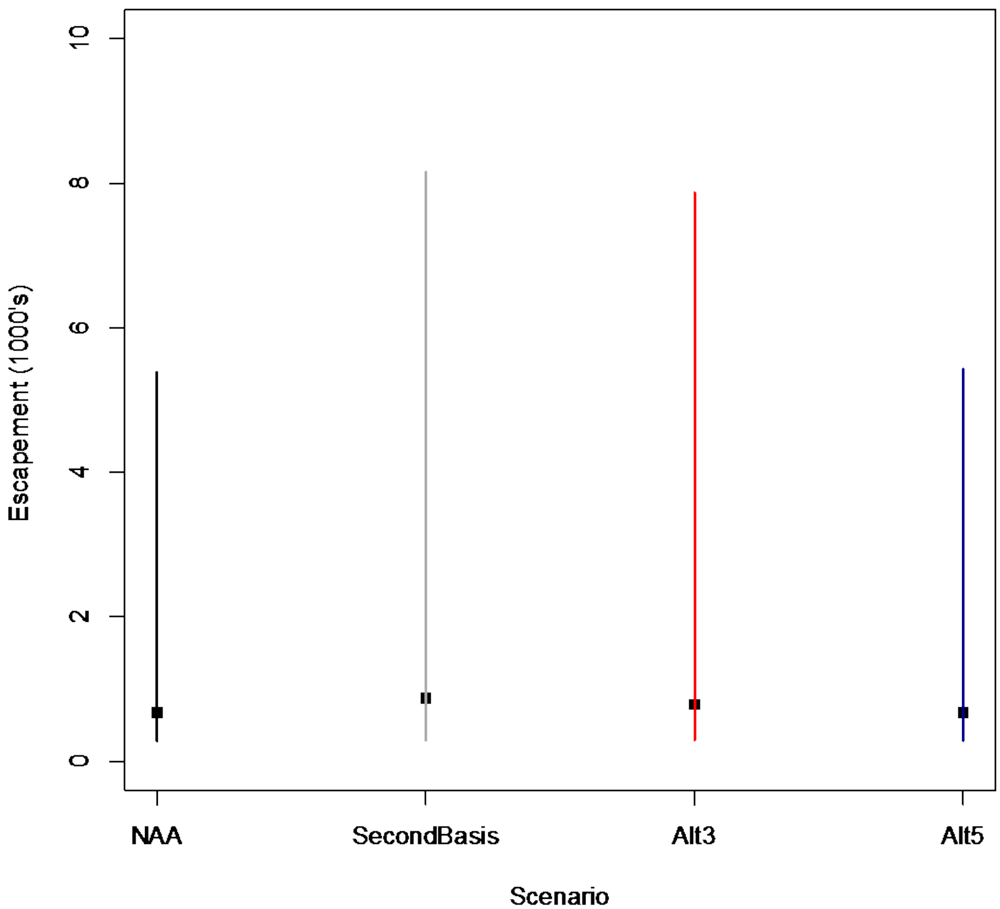

Figure 9I.11 Escapement in Simulation Year 1985 under the Alternatives and Second Basis of Comparison

Note:Squares are median values and lines are 90 percent probability intervals

Comparison of abundances after recovery from the low escapement years of 1992 through 1996 (simulation year 2002) indicated higher median abundances of approximately 300 fish under the No Action Alternative and Alternative 5 scenarios than for the Second Basis and Alternative 3 scenarios (Figure 9I.12).

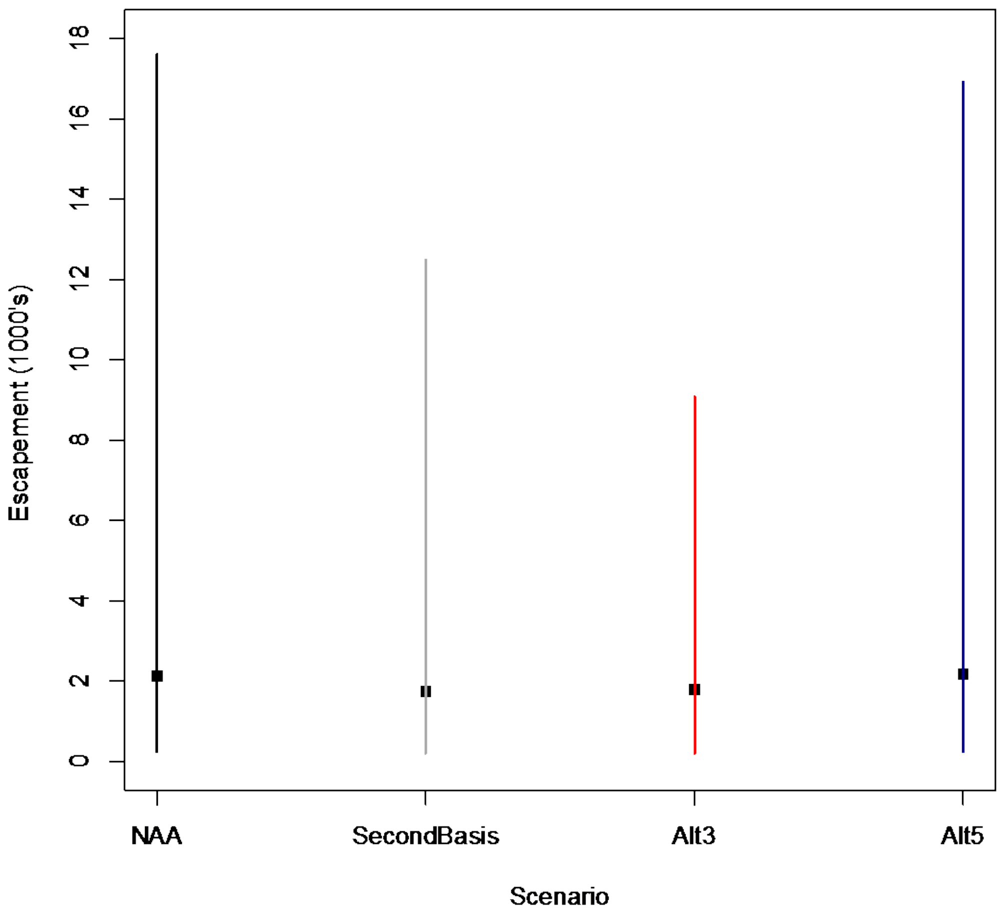

Figure 9I.12 Escapement in Simulation Year 2002 under the Alternatives and Second Basis of Comparison

Note: Squares are median values and whiskers are 90 percent probability intervals

9I.2.2 OBAN Alternative Comparisons

9I.2.2.1 No Action Alternative Compared to the Second Basis of Comparison

Escapement was generally higher for the No Action Alternative than for the Second Basis (Figure 9I.13). The median abundance under the Second Basis was higher in only 3 of the 32 years of simulation (1971 through 2002), and the Second Basis of Comparison values exceeded the No Action Alternative values in less than 25 percent of simulation years (that is, the dark gray area was below the dashed line in most years).

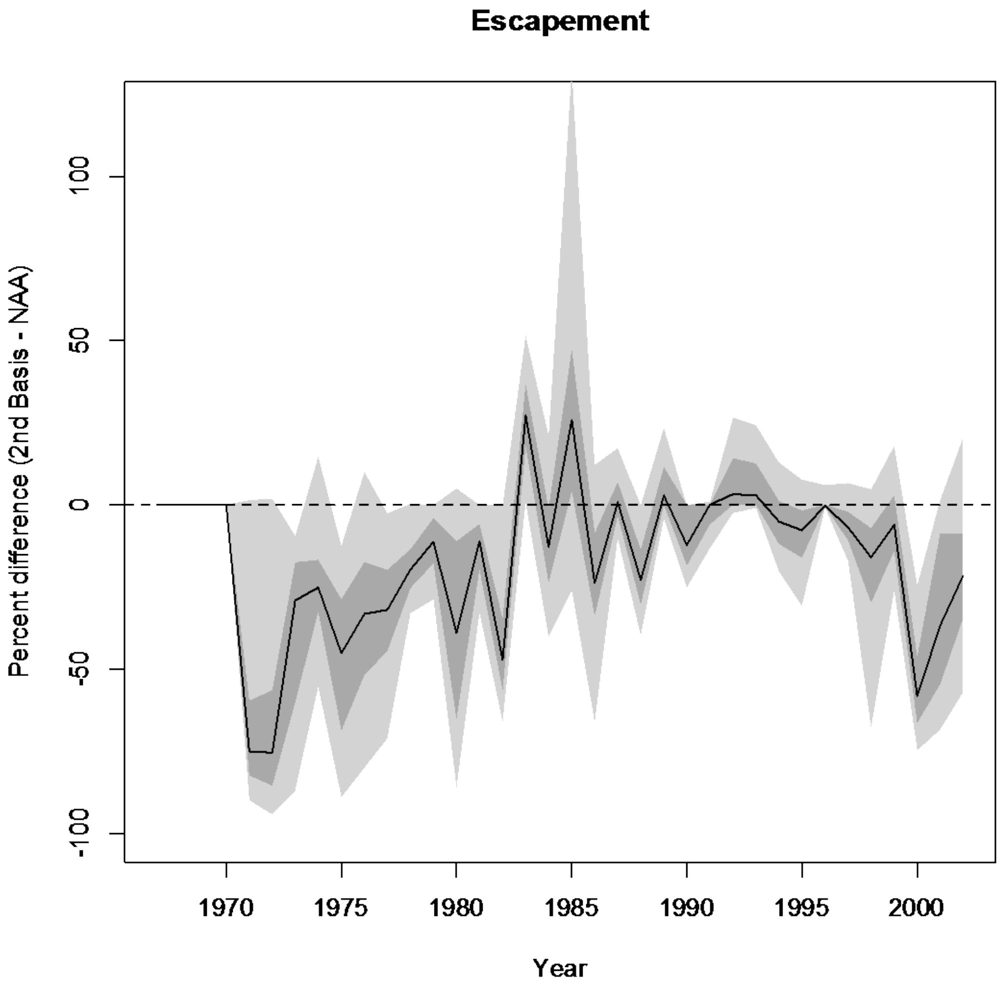

Figure 9I.13 Percent Difference in Escapement between the Second Basis of Comparison and the No Action Alternative

Note: Median difference (solid line) with 50 percent probability intervals (dark gray) and 90 percent probability intervals (light gray) and reference line of no difference (dashed line) displayed

Median delta survival was approximately 12 percent lower under the Second Basis than it was under the No Action Alternative (Figure 9I.14). The differences in survival were not consistent across the uncertainty in the parameter values, however, and there was a high probability of no difference between scenarios (dashed line of no difference lies within the dark gray central 0.50 probability interval).

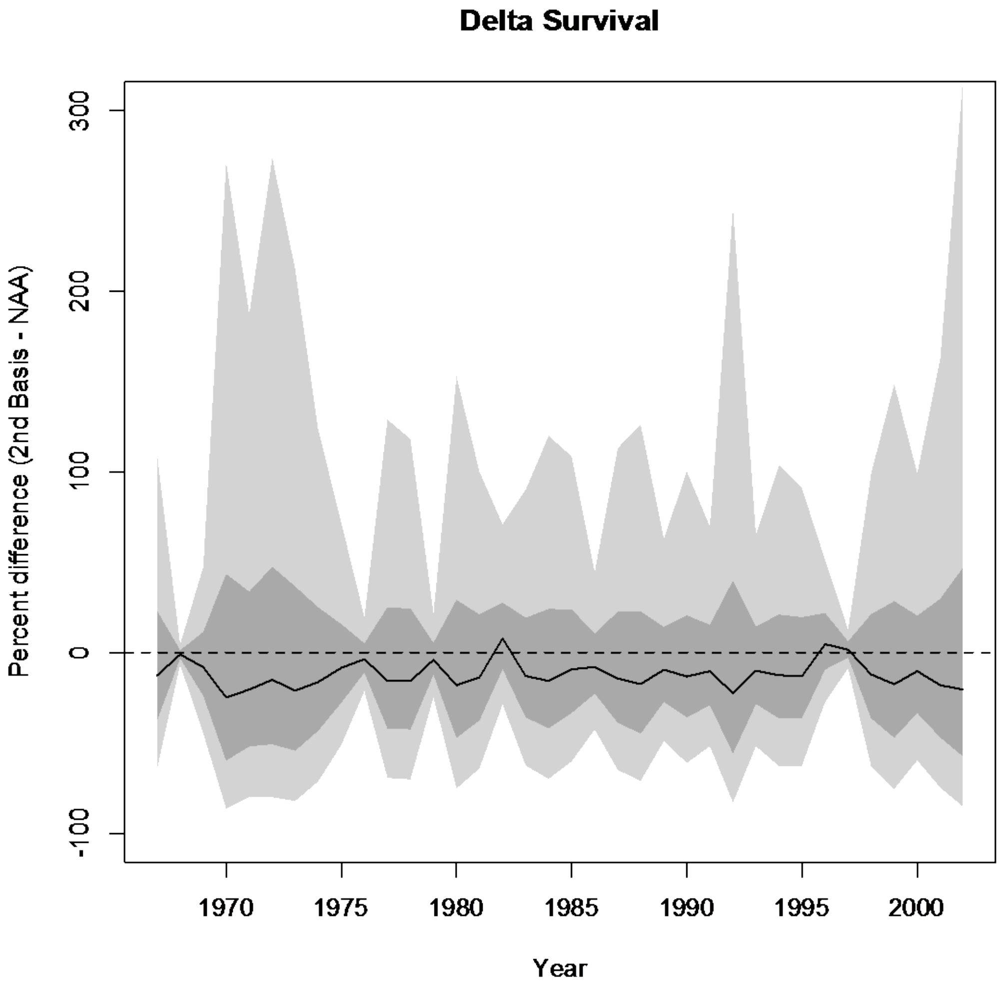

Figure 9I.14 Percent Difference in Delta Survival between the Second Basis of Comparison and the No Action Alternative

Note: Median difference (solid line) with 50 percent probability intervals (dark gray) and 90 percent probability intervals (light gray) and reference line of no difference (dashed line) displayed

9I.2.2.2 Comparison of Alternative 3 versus No Action Alternative

Alternative 3 generally had lower escapement values than the No Action Alternative scenario during the early and late portion of the time series (Figure 9I.15). In general, the temporal pattern was similar to the Second Basis of Comparison (Figure 9I.13).

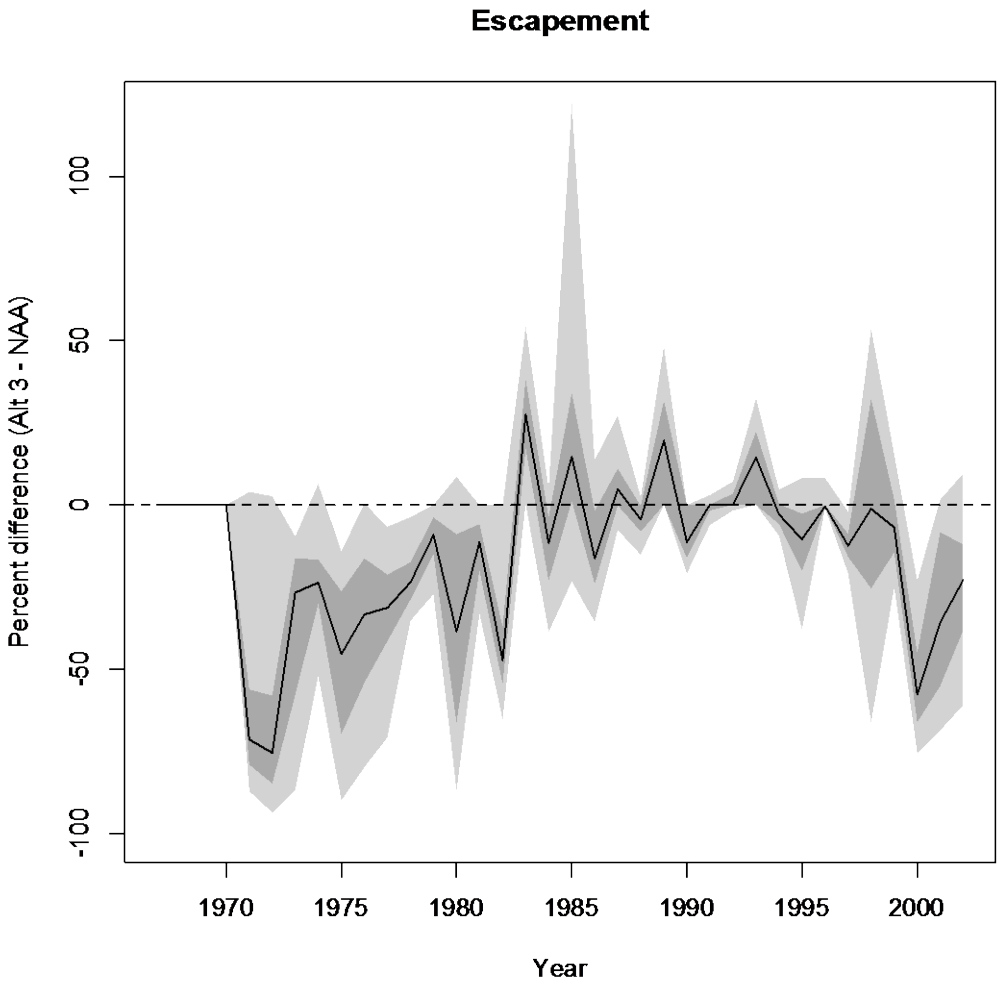

Figure 9I.15 Percent Difference in Escapement between Alternative 3 and the No Action Alternative

Note: Median difference (solid line) with 50 percent probability intervals (dark gray) and 90 percent probability intervals (light gray) and reference line of no difference (dashed line) displayed

Median delta survival rates were consistently lower (-7 percent) under Alternative 3 than under the No Action Alternative, yet the probability intervals indicated that no difference between scenarios was also a likely outcome (Figure 9I.16), as indicated by the dashed line located in the dark gray, central 0.50 probability region). Thus delta survival was not responsible for the temporal patterns in relative escapement. Because the ocean conditions were equivalent across, scenarios, the differences resulted from differences in survival in the stages upstream of the delta (that is, caused by due to temperature and flow at Bend Bridge).

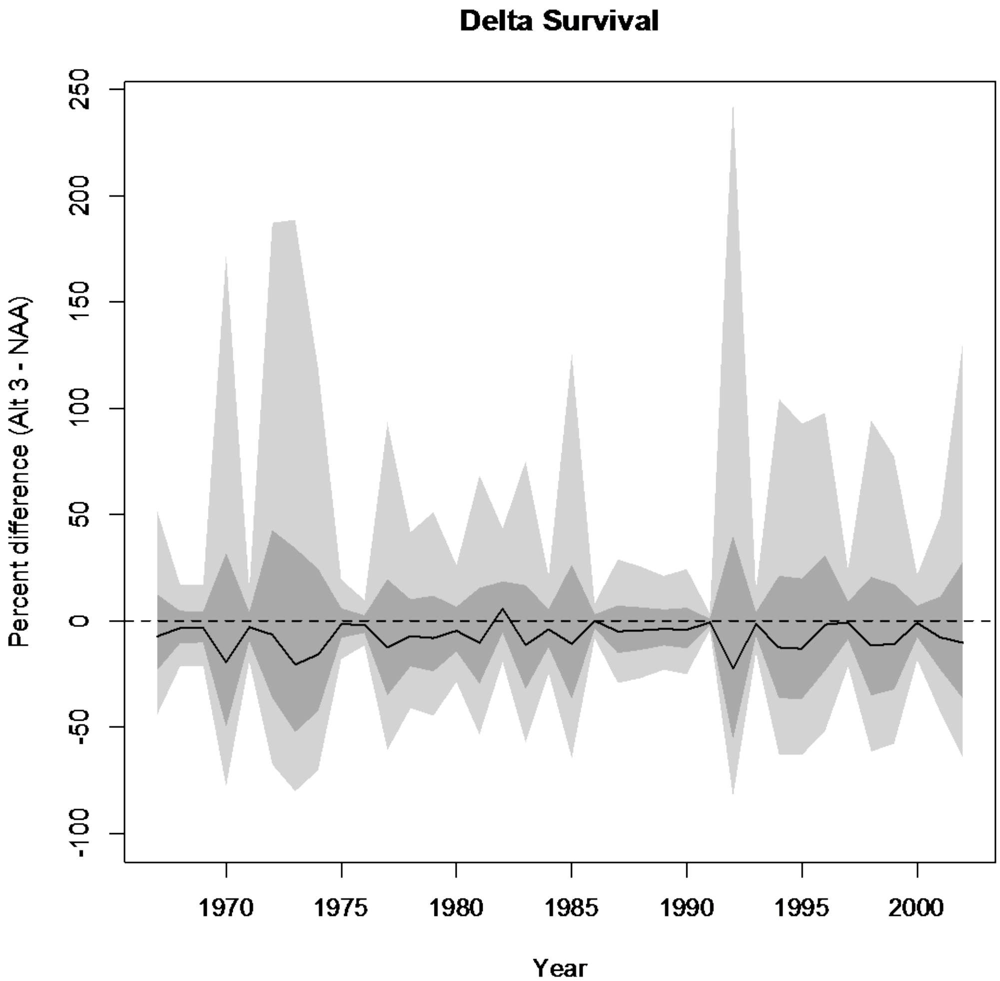

Figure 9I.16 Percent Difference in Delta Survival between Alternative 3 and the No Action Alternative

Note: Median difference (solid line) with 50 percent probability intervals (dark gray) and 90 percent probability intervals (light gray) and reference line of no difference (dashed line displayed

9I.2.2.3 Comparison of Alternative 3 versus Second Basis of Comparison

Differences in escapement between Alternative 3 and the Second Basis scenarios were moderately small (Figure 9I.17). Escapement was generally greater for Alternative 3 than for the Second Basis, and was consistently greater over the 1986 through 1988 simulation period (dark gray and light gray areas above the dashed line). In most other years the difference in escapement estimates included 0 (that is, dashed line located in the dark gray, central 0.50 probability region).

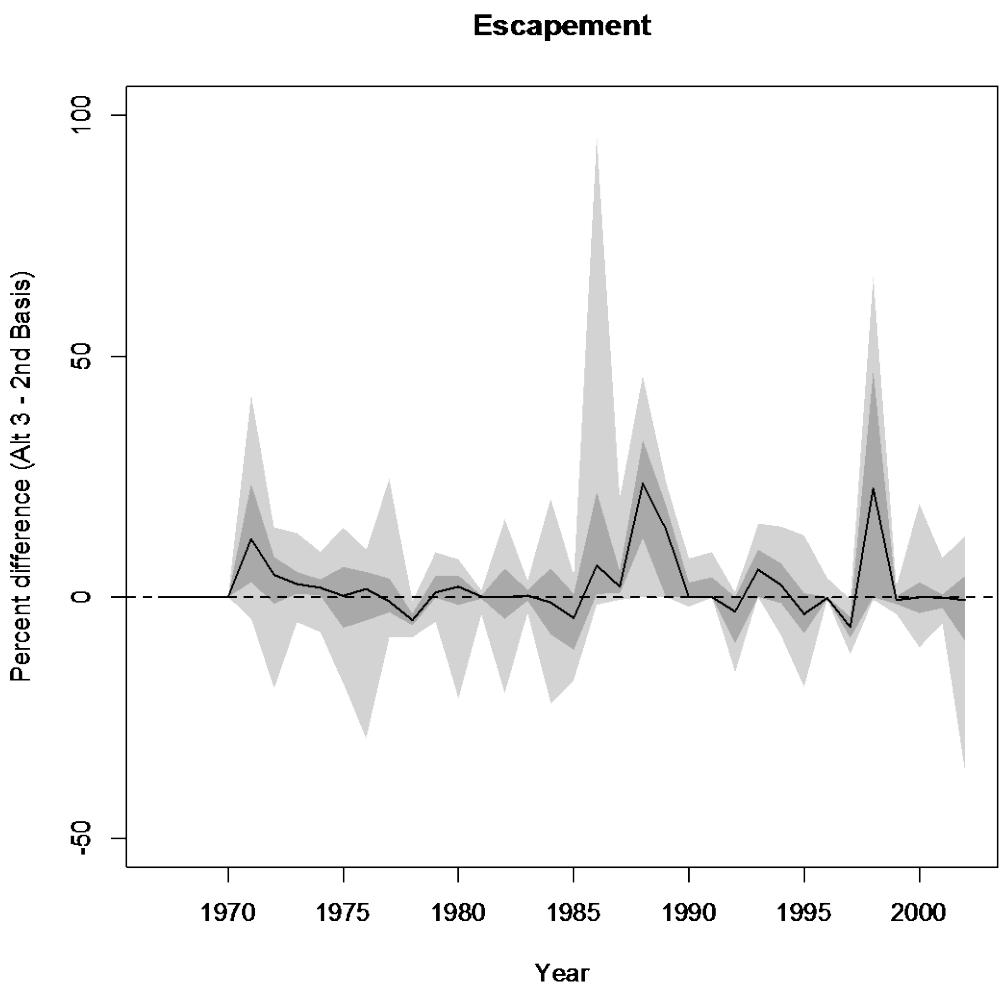

Figure 9I.17 Percent Difference in Escapement between Alternative 3 and the Second Basis of Comparison

Note: Median difference (solid line) with 50 percent probability intervals (dark gray) and 90 percent probability intervals (light gray) and reference line of no difference (dashed line) displayed

The median delta survival was slightly higher for Alternative 3 than it was for the Second Basis scenario (6 percent), although the probability of no difference between alternatives was generally high throughout the simulation time period (Figure 9I.18).

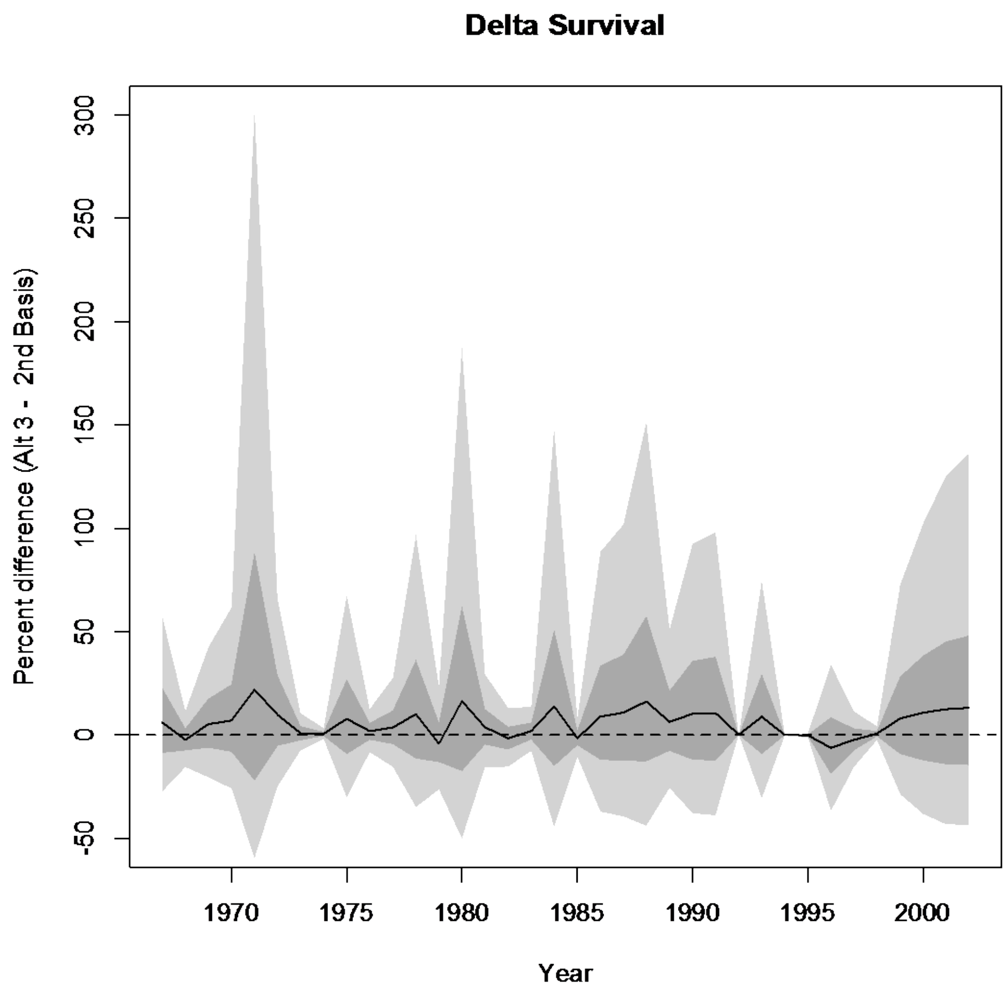

Figure 9I.18 Percent Difference in Delta Survival between Alternative 3 and the Second Basis of Comparison

Note: Median difference (solid line) with 50 percent probability intervals (dark gray) and 90 percent probability intervals (light gray) and reference line of no difference (dashed line) displayed

9I.2.2.4 Comparison of Alternative 5 versus No Action Alternative

Little difference in escapement estimates was evident between the No Action Alternative scenario and the Alternative 5 scenario (Figure 9I.19). The scale of each figure has been altered to incorporate the 90 percent probability intervals, and the intervals in this comparison are smaller than other escapement estimate figures (for example, Figures 9I.17 and 9I.13). Still, there is consistently higher relative abundance in 1980, 1992, and 1993, and consistently lower abundance in 1975 (Figure 9I.19).

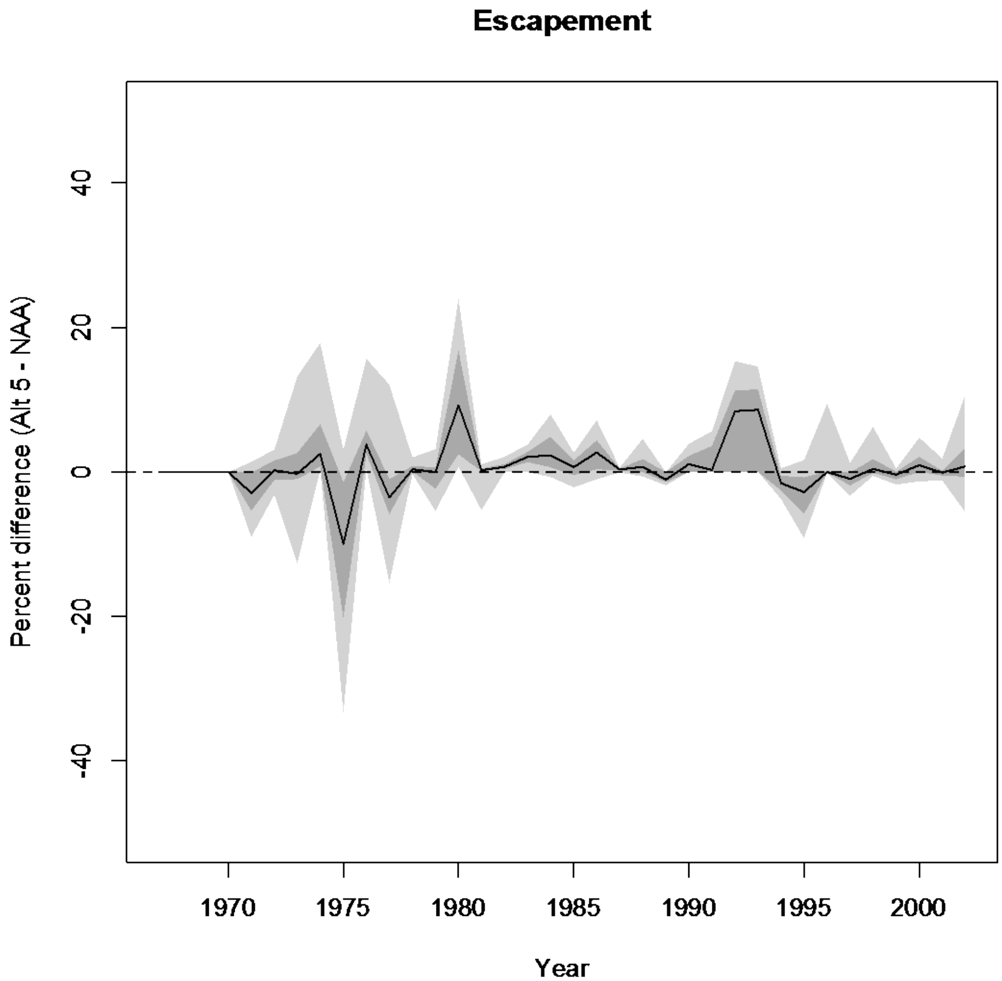

Figure 9I.19 Percent Difference in Escapement between Alternative 5 and the No Action Alternative

Note: Median difference (solid line) with 50 percent probability intervals (dark gray) and 90 percent probability intervals (light gray) and reference line of no difference (dashed line) displayed

Survival in the delta was similar between the No Action Alternative and Alternative 5 scenarios, with a slight improvement in median values of delta survival (1 percent) under Alternative 5 compared to the No Action Alternative. The 0.50 probability intervals and the 0.90 probability intervals are both centered on the value of 0 (dashed line in Figure 9I.20), suggesting that no difference between alternatives is highly probable in most years.

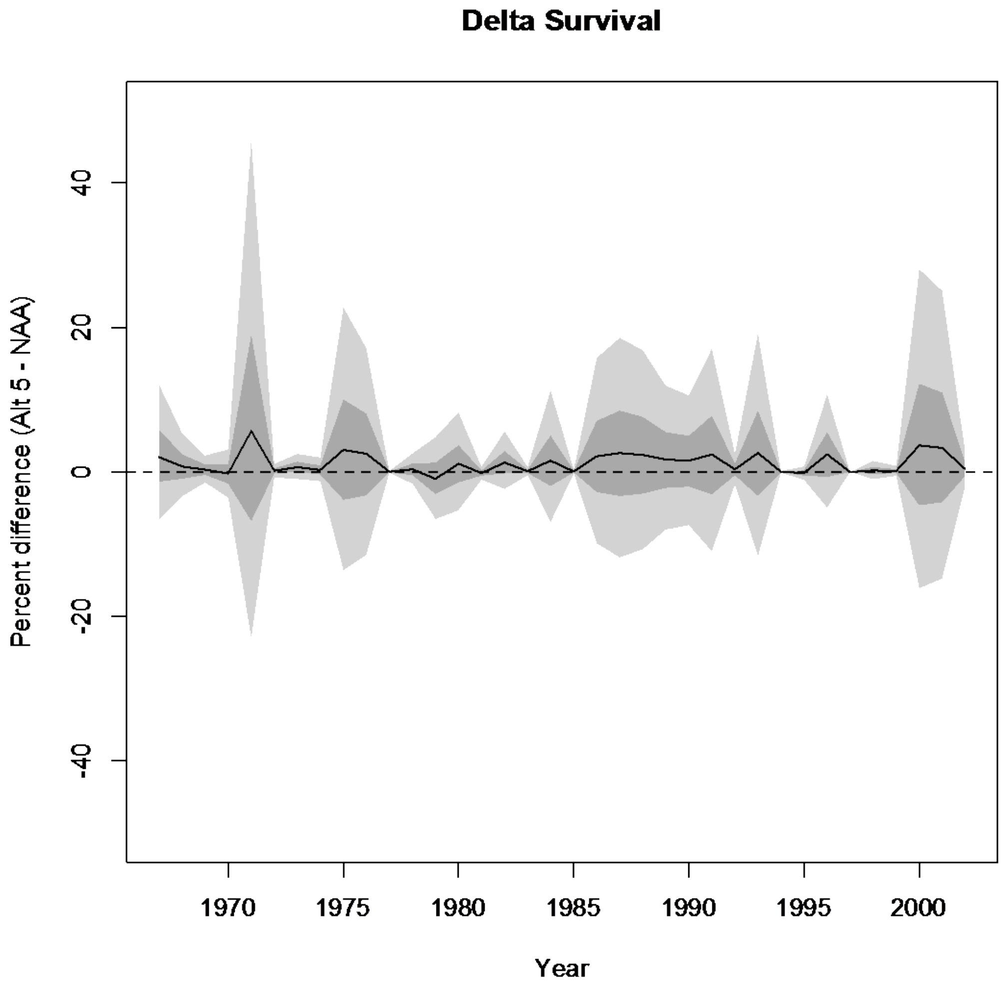

Figure 9I.20 Percent Difference in Delta Survival between Alternative 5 and the No Action Alternative

Note: Median difference (solid line) with 50 percent probability intervals (dark gray) and 90 percent probability intervals (light gray) and reference line of no difference (dashed line) displayed

9I.2.2.5 Comparison of Alternative 5 versus Second Basis

Differences between Alternative 5 and the Second Basis were moderate (Figure 9I.21). In years prior to 1983 and after 1995, the median escapement values were higher under the Alternative 5 scenario than it was under the Second Basis scenario. In many of the simulation years, the central 0.50 probability interval did not include 0, and in a few years the central 0.90 interval did not include 0, suggesting consistently higher escapement under Alternative 5 than under the Second Basis scenario, despite uncertainty in model parameter values.

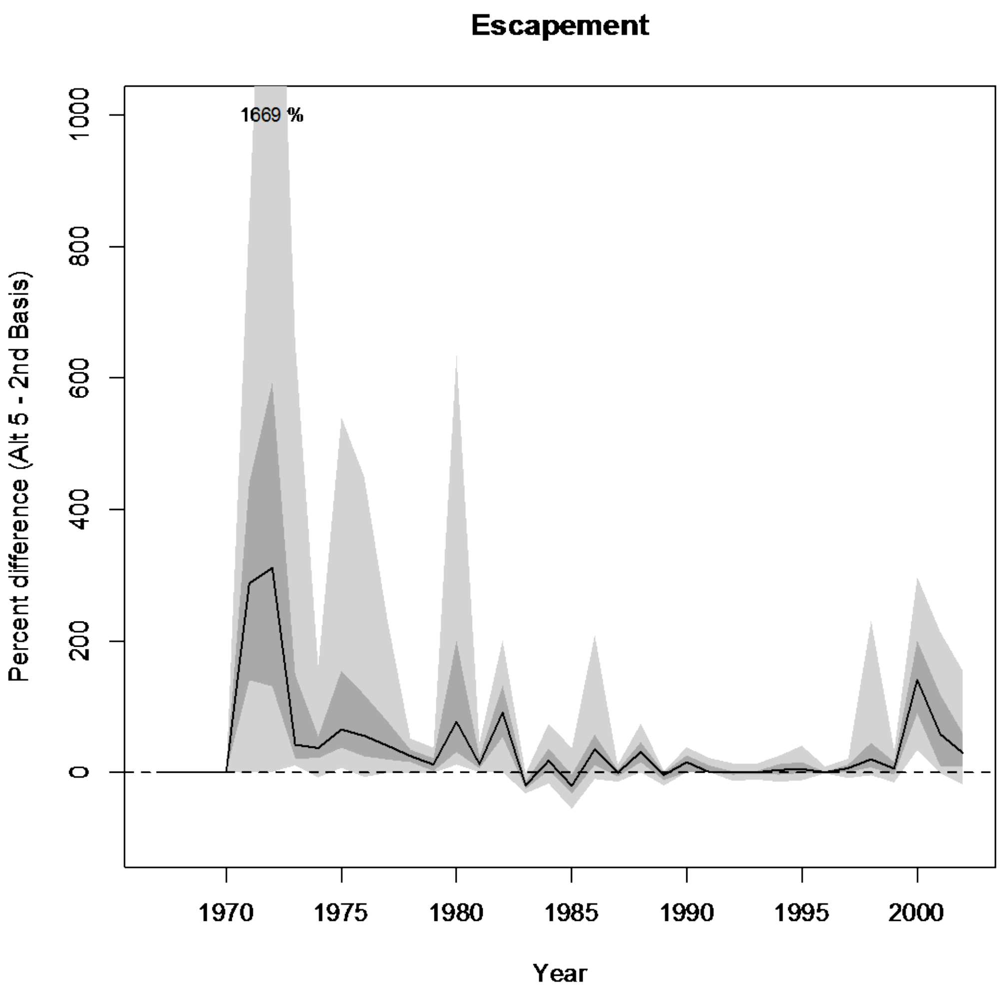

Figure 9I.21 Percent Difference in Escapement between Alternative 5 and the Second Basis of Comparison

Note: Median difference (solid line) with 50 percent probability intervals (dark gray) and 90 percent probability intervals (light gray) and reference line of no difference (dashed line) displayed)

Delta survival was generally higher under Alternative 5 than it was under the Second Basis scenario (15 percent). All years, however, had 0.50 and 0.90 probability intervals that included no difference between scenarios (Figure 9I.22).

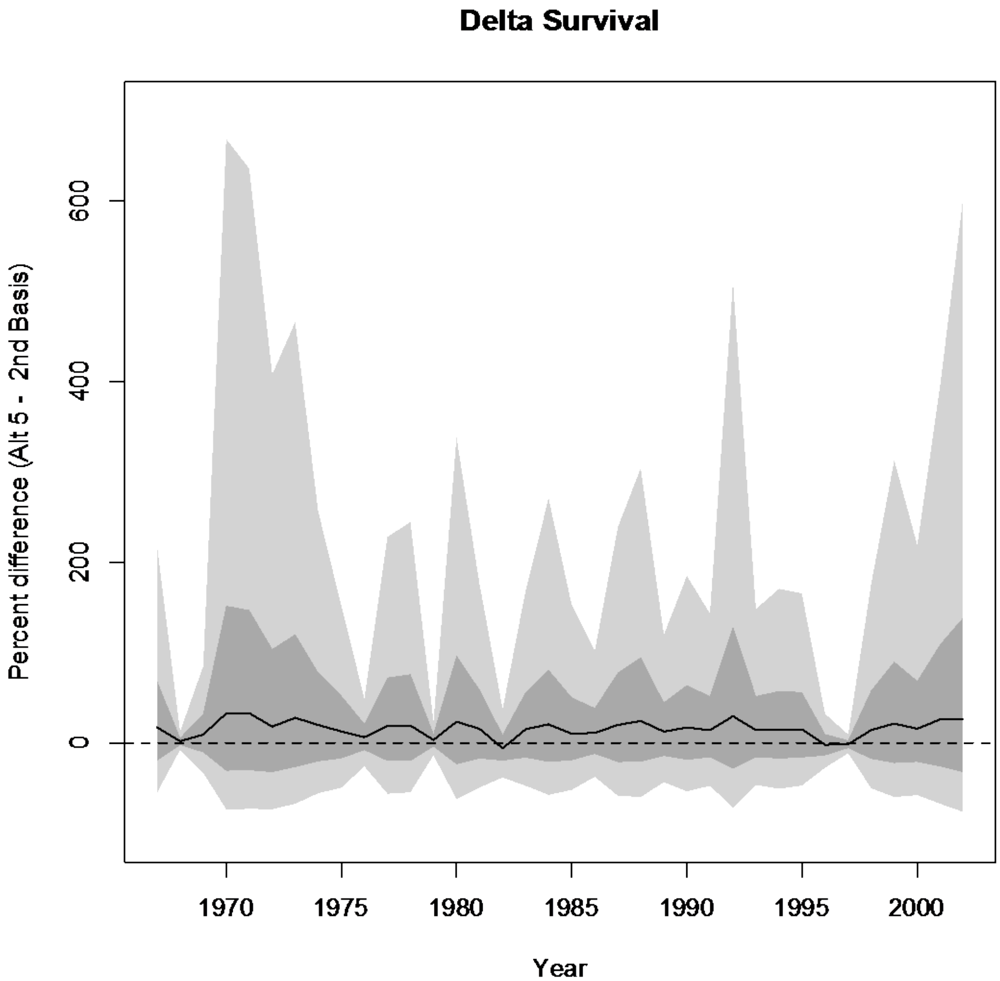

Figure 9I.22 Percent Difference in Delta Survival between Alternative 5 and the Second Basis of Comparison

Note: Median difference (solid line) with 50 percent probability intervals (dark gray) and 90 percent probability intervals (light gray) and reference line of no difference (dashed line) displayed

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