Performance Measure 4.6: Doubling Goal for Central Valley Chinook Salmon Natural Production

Performance Measure (PM) Component Attributes

Type: Outcome Performance Measure

Description

Increase in Central Valley Chinook salmon population recovery with natural production to reach the state and federal doubling goal.

Expectations

The annual average natural production of Central Valley Chinook salmon runs increases long-term to double the 1967–1991 levels for all runs combined, and for individual run types on select rivers: fall, late-fall, spring, and winter.

Metric

Annual average natural production of all Central Valley Chinook salmon runs and for individual run types on select rivers: fall, late-fall, spring, and winter. Census will be conducted annually for the general population in the Central Valley and select rivers.

Baseline

Set by the Central Valley Project Improvement Act (CVPIA), the baseline is the 1967–1991 Chinook salmon natural production annual average of 497,054 for all Central Valley runs (Figure 1), and for individual run types on select rivers, the baseline values are specified in Table 1.[1]

[1] The baseline values in Table 1 do not add up to the baseline for all runs because not all tributaries are included. The Council will only track individual run types for the select rivers specified in Table 1.

Targets

The 15-year rolling annual average of natural production for all Central Valley Chinook salmon runs increases for the period of 2035–2065, and reaches 990,000 fish by 2065, and for each run on select rivers, the target values are specified in Table 1.[2]

Table 1. Central Valley Chinook Salmon Natural Production Baseline and Target Levels by Run Type and Selected Rivers

Baseline (1967–1991)		**Target (2065)**	
Sacramento River Watershed	San Joaquin River Watershed	Sacramento River Watershed	San Joaquin River Watershed
Sacramento River mainstem Fall: 115,369 Late-Fall: 33,941 Spring: 29,412 Winter: 54,316	Tuolumne River Fall: 18,949	Sacramento River mainstem Fall: 230,000 Late-Fall: 68,000 Spring: 59,000 Winter: 110,000	Tuolumne River Fall: 38,000
American River Fall: 80,874	Merced River Fall: 9,005	American River Fall: 160,000	Merced River Fall: 18,000
Feather River Fall: 86,028	Stanislaus River Fall: 10,868	Feather River Fall: 170,000	Stanislaus River Fall: 22,000
	Mokelumne River Fall: 4,680		Mokelumne River Fall: 9,300

Basis for Selection

Enacted by the U.S. Congress in 1992, the Central Valley Project Improvement Act (CVPIA) requires improvements to water management to protect fish and wildlife, including achieving the state and federal doubling goal for Central Valley Chinook salmon natural production, relative to 1967–1991 levels. U.S. Fish and Wildlife Service (1995) defines natural production as: “Title 34 defines natural production as: ‘... fish produced to adulthood without direct human intervention in the spawning, rearing, or migration processes’ (Section 3403[h]).” Although the CVPIA spurred much action and changes to water management, extensive drought periods have contributed to decreased salmon natural production levels since 1992: the 1992–2015 average was 381,368 compared to the 1967–1991 baseline average of 497,054 (Figure 1) for all Chinook salmon runs. Given the importance of this species for commercial and recreational fishing, and its cultural value, there is considerable interest in tracking its status. Moreover, salmon are a strong indicator species of ecosystem health and of the effectiveness of habitat restoration and water-quality improvement projects because

[2] The targets in Table 1 do not add up to the target for all runs because not all tributaries are included. The Council will only track individual run types for the select rivers specified in Table 1.

these anadromous fish use the vast range of aquatic ecosystems, from headwaters to the ocean (NMFS 2014). Salmon also play an important ecological role during their migration upstream to spawn by transferring nutrients from the ocean to wildlife and vegetation in the Central Valley (Merz and Moyle 2006). They are a critical food resource for terrestrial predators and scavengers, connecting ocean and forest habitats hundreds of miles apart (Wilson et al. 1998). Therefore, declines in the capacity of a watershed to support all stages of salmon can indicate declining ecosystem health (Cummins et al. 2008).

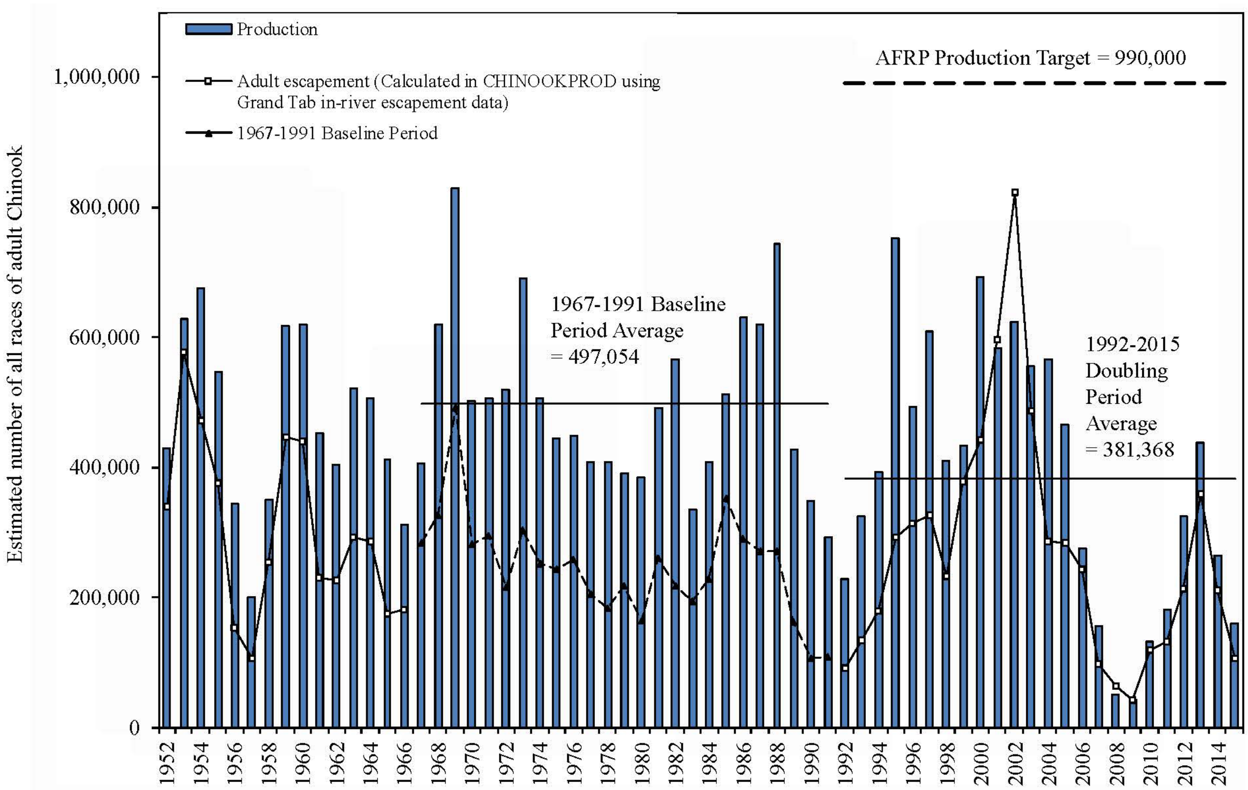

Figure 1. Estimated Yearly Natural Production and In-River Escapement of all Races of Adult Chinook Salmon in the Central Valley Rivers and Streams

This chart illustrates the estimated annual natural production and in-river escapement of all races of adult Chinook salmon in the Central Valley rivers and streams. Chinook salmon escapement is defined as fish that migrate from the ocean to spawn in freshwater streams. The x-axis shows time, starting from 1952 through 2014 in two-year increments. The y-axis shows the estimated number of all races of adult Chinook, ranging from 0 to 1,000,000, in increments of 200,000. Vertical bars represent annual production of all races of Chinook, while a line graph represents the annual adult escapement. The escapement estimates were calculated in ChinookProd using Grand Tab in-river escapement data.

Figure 1. Estimated Yearly Natural Production and In-River Escapement of all Races of Adult Chinook Salmon in the Central Valley Rivers and Streams (contd.)

The chart shows that both production and adult escapement are variable, but that they tend to increase and decrease together. Production and escapement both rose by roughly 200,000 adult Chinook between 1952 and 1953. Production increased the following year, while escapement dropped slightly. Both production and escapement fell in the subsequent three years, to a regional low in 1956 of roughly 200,000 adult Chinook produced and roughly 100,000 escaped. Production and escapement both rose over the next two years, and then varied in concert with one another, peaking in 1969 at more than 800,000 produced and 500,000 escaped. In 1992, production and escapement hit a regional low at less than 250,000 adult Chinook produced and roughly 100,000 escaped. Between 1992 and 2002, both production and escapement generally increased. Production hit a regional peak of more than 750,000 in 1995 and escapement peaked in 2002 at more than 800,000 adult Chinook. Both production and escapement then declined to a low of roughly 50,000 Chinook produced and escaped in 2009. Production and escapement increased between 2009 and 2013 to a regional high of roughly 450,000 produced and 350,000 escaped, then dropped over the next two years.

The central message of the chart is conveyed through comparison of a baseline period average, a doubling period average, and a production target. The chart shows that the 1967–1991 baseline period average equals 497,054 adult Chinook. The chart shows the 1992–2015 doubling period average equals 381,368. The target for the doubling period was 990,000 fish. The chart illustrates that the 1992–2015 average falls well below the target.

Source: USFWS Anadromous Fish Restoration Program 2016

Salmon populations are dependent on a wide variety of factors in the rivers, Delta, and ocean, including suitability of spawning and rearing habitat, predation, and food availability (USFWS and Reclamation 2011). They can be sensitive to changes in water quality, flow, turbidity, and temperature. Moreover, stressors affect various salmon life stages differently (NMFS 2014). Degrading conditions in recent decades have caused major declines in Central Valley Chinook salmon populations, resulting in listing of winter-run Chinook salmon as an endangered species and spring-run Chinook salmon as a threatened species under the federal Endangered Species Act.

Salmon population dynamics are dependent on many factors that occur outside the Delta (e.g., spawning habitat, water temperatures) that can be managed through flow and nonflow management actions such as water operations, fishing regulations, habitat restoration, as well as other factors that cannot be managed (e.g., ocean food-web productivity). Management of water operations, habitat restoration, and increased coordination among agencies in the Delta can help contribute towards the salmon doubling goal (Cummins et al. 2008, Herbold et al. 2018, Dahm et al. 2019). Current ecosystem management seeks to improve the adaptive capacity of salmon in response to climate change by reconnecting and restoring habitats to facilitate ecosystem processes, providing refuge from temperature stress and predation risk, and by increasing food availability (Crozier et al. 2019).

In 2018, the State Water Resources Control Board (SWRCB) charged an Independent Scientific Advisory Panel with developing methods for formulating biological goals for the Bay-Delta Water Quality Control Plan. The Advisory Panel concluded that the baseline for the doubling goal overestimated the natural-origin population (by underestimating hatchery-origin Chinook salmon in total returns) and therefore the doubling goal for natural-origin salmon might also be overestimated (Dahm et al. 2019). Because of the uncertainty in the baseline calculations, an increase in the natural production (positive trend) may provide a better goal, rather than the goal to double the natural production (Dahm et al. 2019). Since 2007, the Constant Fractional Marking program conducted by CDFW has helped increase the accuracy of fall-run natural production estimates. Therefore, in addition to the main doubling goal target, there will be two submetrics that address the limitations of the current datasets and compliments the overall intentions of the doubling goal.

These submetrics are: 1) an increase in natural-origin population as a positive slope of the 15-year rolling annual average for the period of 2035–2065; 2) a positive slope of the 15-year rolling annual average of natural production using CFM data from 2010–2065. These values will be calculated for each tributary and Chinook run listed in the targets section (above).

Linkages to Delta Reform Act and the Coequal Goals

Delta Reform Act

Achieving the target of positive slope in the 15-year annual average of natural production for all Chinook salmon is a measure of “Conditions conducive to meeting or exceeding the goals in existing species recovery plans and state and federal goals with respect to doubling salmon populations” (Water Code section 85802(c)(5)).

This performance measure works together with other performance measures—Fish Migration Barriers (PM 4.13), Increase Seasonal Inundation (PM 4.15), Acres of Natural Communities Restored (PM 4.16), and Subsidence Reversal for Tidal Reconnection (PM 4.12)—to assess the status and trends in “the health of the Delta’s estuary and wetland ecosystem for supporting viable populations of Delta fisheries and other aquatic organisms” (Water Code section 85211(a)).

Delta Plan Core Strategy

4.4 Protect Native Species and Reduce Impact of Nonnative Invasive Species.

Methods

Baseline Methods

The baseline is the average number of annual natural production of all Central Valley Chinook from 1967–1991 which is 497,054 fishes. This was set by the Central Valley Project Improvement Act (CVPIA) of Public Law 102-575, passed by Congress in 1992.

Target Methods

The target is doubling the baseline to 990,000 by 2065, expressed as the 15-year rolling annual average of natural production for all Chinook salmon runs. The 15-year rolling average represents the time frame for about five salmon generations and is intended to account for short-term variability of salmon production.

Data Sources

Primary Data Sources

The primary data sources listed below will be used for tracking this performance measure:

1. U.S. Fish and Wildlife Service (USFWS) ChinookProd. Assesses progress toward the CVPIA doubling goal for natural production. These data are based upon California Department of Fish and Wildlife (CDFW) Grand Tab data. Estimates of adult salmon are based on counts entering hatcheries and migrating past dams, carcass surveys, live fish counts, and ground and aerial redd counts.
    a. Content: ChinookProd is a spreadsheet database maintained by the USFWS Anadromous Fish Restoration Program, which calculates natural production of each salmon run along with the combined value of all runs (Figure 1). ChinookProd is both a data source and an analytical tool.
    b. Update frequency: Updated annually.
2. CDFW Grand Tab. Provides estimates of adult salmon escapement (returning spawners) for different run types and watersheds. Estimates are provided by the CDFW; USFWS; California Department of Water Resources; East Bay Municipal Utilities District, U.S. Department of the Interior, Bureau of Reclamation (Reclamation); Lower Yuba River Management Team; and Fisheries Foundation of California. Grand Tab does not characterize whether fish are wild or hatchery origin, just whether the adults are spawning in-river (natural) or in-hatchery.

Escapement data and visualizations are available through the Central Valley Prediction and Assessment of Salmon website (SacPAS).

a. Content: Tabular reports of salmon escapements by salmon run and rivers.

b. Update frequency: Updated annually.

Alternative Data Sources

Alternative data sources will be used if the primary data sources become unavailable or insufficient. Alternative data sources may be used concurrently with the primary data sources depending on best available science and the availability of the primary source.

1. CDFW Constant Fractional Marking.https://www.fws.gov/cno/fisheries/CAMP/Documents-Reports/CDFW Constant Fractional Marking. Until 2007, only experimental releases of hatchery fall-run Chinook salmon were marked and tagged, resulting in lack of data on hatchery impacts on natural production. Since 2007, the constant fractional marking (CFM) program coded-wire tagging and adipose fin-clipping of at least 25 percent of all CV hatchery Chinook salmon. Each CWT contains a binary or alpha-numeric code that identifies a specific release group of salmon (e.g., agency, species, run, brood year, hatchery or wild stock, release size, release date(s), release location(s), number tagged and untagged). CFM provides a more accurate estimate of the relative contribution of hatchery fish to total natural production.
    a. Content: Tabular reports of salmon escapements by salmon run and rivers.
    b. Update frequency: Updated annually
2. USFWS Comprehensive Assessment and Monitoring Program Annual Report. USFWS Comprehensive Assessment and Monitoring Program Annual Report.
    a. Content: Annual report that provides updates on progress of the Anadromous Fish Restoration Program and the salmon doubling goal.
    b. Update frequency: Updated annually.

Process

Data Collection and Analysis

Every year, Council staff will update the status of this performance measure by:

a. Downloading data from primary data source #1 every October 1. Council staff will contact the data owner, USFWS, for quality assurance-quality control questions, if necessary.

b. Calculating the 15-year rolling annual average of natural production for all Chinook salmon runs.

c. Calculating the slope (linear regression) of 15-year rolling annual averages of natural production for all Chinook salmon runs.

d. Displaying results such as bar graphs (e.g., Figure 1) showing the rolling annual natural production of all salmon runs and the status, compared to the baseline. The 15-year rolling averages will be plotted against year and a slope will be calculated to measure if the salmon population is growing (positive slope).

Interim Performance Assessment

In order to provide a short-term assessment of progress toward the doubling target, and to address limitations of the current datasets, interim milestones are set using two submetrics:

1. Positive slope of the 15-year rolling annual average of Central Valley Chinook salmon natural production, calculated and evaluated annually. The interim milestone is a positive slope of the 15-year rolling annual average to be achieved by 2035.
2. Positive slope of the 15-year rolling annual average of natural production using the Constant Fractional Marking (CFM) data which is available from 2010 onwards. The interim milestone is a positive slope of the 15-year rolling annual average by 2035.

Annually, the linear regression and associated slope for the regression line will be calculated and compared to the baseline and to the previous year values. The 15-year rolling average was chosen to represent five Chinook salmon generations to provide long enough trends to conclude whether populations are in recovery or not (USFWS 1995).

The interim metrics are calculated by each run and by selected rivers where production data is available. Interpretation of short-term performance milestones assessments will include consideration of external factors beyond management control (e.g., ocean and climate conditions) and the relative importance of the Delta as the migration corridor and rearing habitat within the salmon life cycle.

Process Risks and Uncertainties

Current monitoring efforts do not adequately characterize whether fish are wild or of hatchery-origin. Consistently and comprehensively estimating the contribution of hatchery-origin salmonids in the catch and spawning grounds is the greatest deterrent to reasonably accurate production estimates of natural-origin salmonids (Dahm et al. 2019).

The USFWS ChinookProd estimates of annual natural production of each Chinook salmon run from each watershed includes four components:

1. In-river spawner abundance (i.e., escapement): In-river spawner abundance is based on the CDFW Grand Tab report. If there is a salmon hatchery in a watershed, hatchery returns are quantified by counting the number of salmon that enter those fish hatcheries. In-river harvest is estimated using best professional judgment based on CDFW angler harvest surveys.
2. Hatchery returns.
3. In-river harvest by anglers.
4. Ocean harvest is based on reporting by the Pacific Fishery Management Council.

Along with adult numbers returning to spawn, a critical component to increasing natural production is natural-origin juvenile abundances and survival through the Delta, Bay, and into the ocean. For productivity to increase, the number of returning adults produced per parent spawner must exceed one, as estimated in stock-recruitment curves (Dahm et al. 2019). However, juvenile survival rate in various Delta habitats is not well documented, and further studies are needed to better understand the effect of restored habitat on juvenile survival. In order to address this gap, Delta Plan Ecosystem Restoration Recommendation 9 (ER R9) recommends increased coordination among researchers studying juvenile anadromous fish migration pathways and survival upstream of, and within the Delta waterways to improve synthesis of results across research efforts and application to adaptive management actions

Estimating the number of juveniles migrating downstream is required to establish stock-recruitment relationships that help estimate how management actions and changing environmental conditions impact the ratio of spawners to progeny. Rotary screw traps are typically used to estimate the abundances of migrating juvenile populations, but these programs need large sample sizes to make reliable population estimates (Dahm et al. 2019). Other challenges in gathering juvenile salmon data include misinterpreting run types since juveniles from different runs may be migrating downstream at the same time. Compared to adults, determining attributes (hatchery vs. natural-origin, age, size, release location, etc.) of migrating juveniles is more difficult because internally inserted coded wire tags that contain the information can only be acquired from carcasses. More complexities arrive since various juvenile life history stages likely contribute differently to adult returns.

Climate change poses another uncertainty to reaching salmon doubling targets. To help address this, Council staff will work with SWRCB and other agencies to track abundance as well as density-dependence survival rates, distribution, diversity, and life stage survival rates of Central Valley salmon in order to better adaptively manage their populations. Moreover, there is a need to investigate how these population parameters are affected by management actions.

Reporting

Every year, Council staff will report the status of this performance measure by:

1. Posting updates on the Performance Measures Dashboard.
2. Providing results in the Council's annual report (published in January).
3. Communicating management-relevant results at Council and Delta Plan Interagency Implementation Committee (DPIIC) public meetings.
4. Presenting findings at technical interagency groups, professional gatherings, and conferences.

Every five years, Council staff will assess and report the status of this performance measure by:

1. Communicating findings in the five-year review of the Delta Plan.
2. Informing the Council's adaptive management process, and other decision-making.

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